

Facsimile Processes

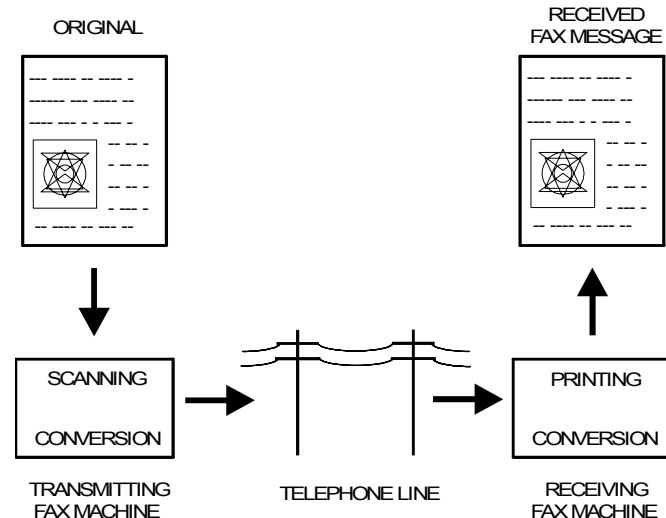
Fax Basics

What is a Fax Machine?

Facsimile, commonly known as fax, is used for sending written, printed, or graphic information from one location to another. The communication can be across the room or across the world. A simple block diagram of fax operation is on the right.

Facsimile machines combine scanner and printer technology with telephone equipment to send copies to a remote location. There are three basic steps in a facsimile transmission.

- A light source scans the writing and drawings on the original, and converts the information into an electrical signal.
- This signal is sent over the telephone line to a receiving fax machine.
- The receiving machine converts the incoming signal into a copy of the original.



Fax Basics
Transmission
Reception
Fax Circuit Update
Compression Techniques
Modulation Techniques
Protocol
Faxing From a PC
Fax Troubleshooting
Common Fax Features

Facsimile machines can transmit alphanumeric and graphic characters. Anything that can be put on paper, from handwritten notes to photographs, can be sent by fax.

Mechanical Processes

A fax machine contains a scanner and a printer. The mechanisms are basically the same as those used in copiers.

Data Path

This section outlines the path of data through the machine in transmission and reception modes.

Components

The following components of the fax video data path are not used in copiers.

SAF Memory (Store And Forward Memory)

When a user stores a fax message in the memory for sending later or transmission to more than one destination, the message goes into the SAF memory. Also, incoming confidential messages and 'substitute' receptions (data coming in when the printer is not working) are held in this memory.

Line Buffer

This memory buffer ensures synchronization of video data transfer between different components of the circuit. If the line buffer is too small, the scanner mechanism will have to keep stopping and starting, leading to excessive noise. A line buffer size of four or eight lines is typical.

Data Compressor and Reconstructor (DCR)

This circuit compresses the data before sending it out over the telephone line. It also reconstructs compressed data coming in from the telephone line

ECM Memory (Error Correction Mode Memory)

ECM is an optional extension to Group 3 protocol that provides a more reliable way to send data over noisy lines. Using ECM, data is assembled into protocol frames. ECM requires RAM for assembly into and extraction from protocol frames. This memory is the ECM memory.

With ECM, image data is arranged in protocol frames (256 bytes in each frame), and transmitted in blocks made up of 256 frames. Therefore, each block is 64 kbytes. Normally, one page of compressed image data can be sent in one block, but more than one may be needed if halftone mode was used when scanning the original.

Single Buffer and Double Buffer ECM Memory

Single Buffer (64 kbytes): This memory is only large enough to hold one block. After receiving a block of compressed facsimile data from the remote terminal into ECM memory, the data is reconstructed

and printed. The next block cannot be received until printing has finished. The first block is deleted from memory after printing.

Double Buffer (128 kbytes): This memory can hold two blocks. While one block is being printed, the next block can be received into the other half of the double buffer memory. This ensures continuous operation, saving time and overall communication charges. In some machines with a single buffer only, SAF memory or hard disk memory are used to provide double buffer capability.

ECM is explained in more detail in the Protocol section. For full details, see ITU-T recommendation T.30.

FIFO Memory (First-In First-Out Memory)

The FIFO synchronizes the transfer of video data to the modem (transmission) or from the modem (reception). It also acts as a buffer, ensuring that there is always some data for the modem to pick up, modulate, and send out.

The FIFO also has some unique functions, in addition to synchronizing data transfer from the cpu to the modem, as explained in the Transmission section (see the part entitled Data Transmission).

Modem

During transmission, the modem converts the data into a form that can be sent out on the telephone line in accordance with the appropriate ITU-T V-series recommendations; this process is called Modulation.

During reception, the modem converts incoming data into a form that the machine can work with; this process is called Demodulation.

The term 'modem' is derived from these two processes; **MO**dulation/**DE**Modulation. The different types of modulation encountered in fax machines are described in the Modulation section (for full details see the ITU-T V-series recommendations).

Network Interface Circuits

The filters, relays, attenuators and other components in these circuits interface the machine with the public telephone network. These circuits ensure that the machine connects to the line and that it dials in the correct way. They also ensure that the machine and the network equipment do not damage each other. Some of the components are included in an assembly called the "Hybrid IC" (HIC).

Voice Message Processor

This converts recorded voice messages from analog (audio) to digital for storage in the memory. It also retrieves the message for memory when it is needed for sending out over the telephone line.

Transmission

This section explains the path of data through the machine during transmission. The main description is for memory transmission with ECM. Following this main description are diagrams showing the differences between memory transmission with ECM and the following modes:

- Memory transmission without ECM

- Immediate transmission with ECM
- Immediate transmission without ECM

Scanning

This is the same as for digital copiers. Fax machine scanners either contain a CCD (Charge Coupled Device) or a CIS (Contact Image Sensor).

Data Processing

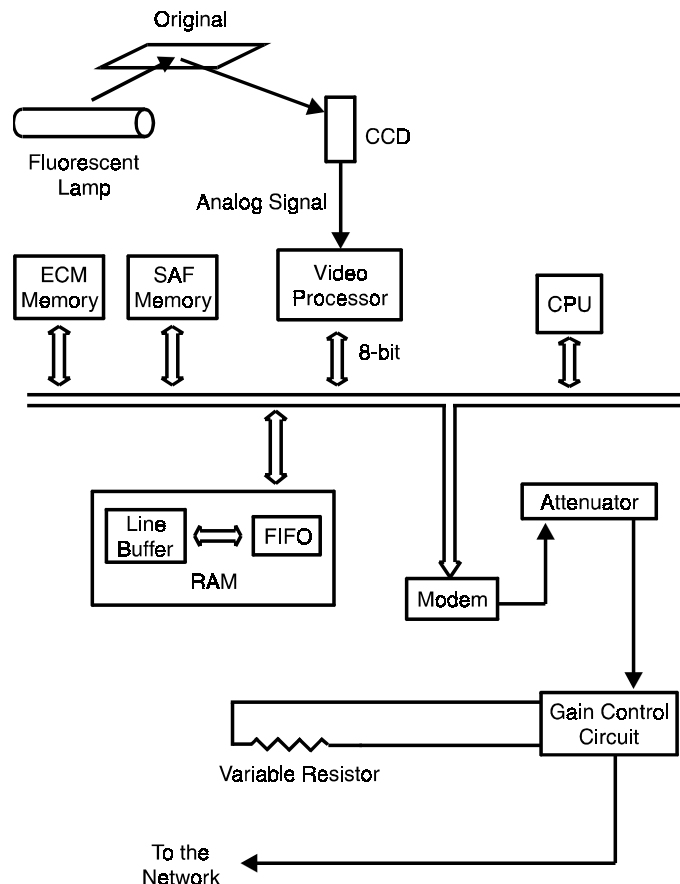
CCD and Analog Video Processing

This is the same as for digital copiers.

Digital Video Processing

This is the same as for digital copiers.

If the original is wider than the paper in the printer at the other end, data will be deleted in the main scan and sub-scan directions to make the data fit on the paper at the other end. This process is known as reduction.



Storage to SAF Memory

After leaving the Video Processor, the data is compressed and then stored in the SAF memory.

The compression method used varies from model to model. A simple compression technique such as MH gives fast data storage, but the data takes up more room in the memory. More complex compression techniques such as MR or MMR compress the data more effectively so that less memory space is used, but they increase the scanning time.

If a line takes up more space after compression, it is stored in raw uncompressed format.

Retrieval from SAF Memory

When it is time to send the data, the data comes out of the memory into the cpu. The cpu reconstructs the raw data, and passes it to the line buffer.

(Lines of data that were stored without compression go from the memory straight to the line buffer.

Compression

The cpu then compresses the data in accordance with the method agreed in the set-up protocol that was exchanged between the two machines.

ECM Data Frame Assembly

Using the ECM memory, the cpu assembles the data into ECM data frames, which are sent to the modem and the line.

Modulation

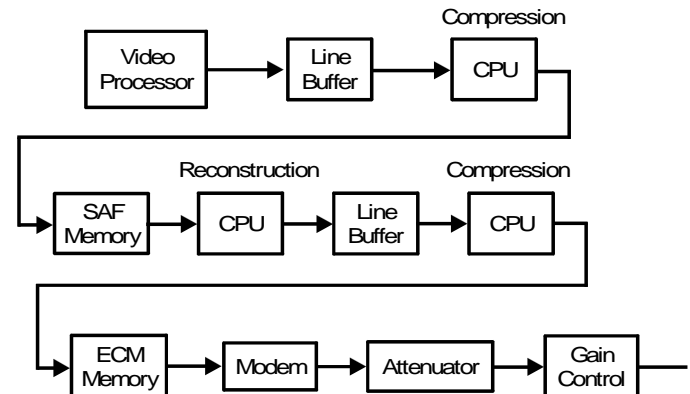
The modem converts the data to serial and modulates it.

Attenuation

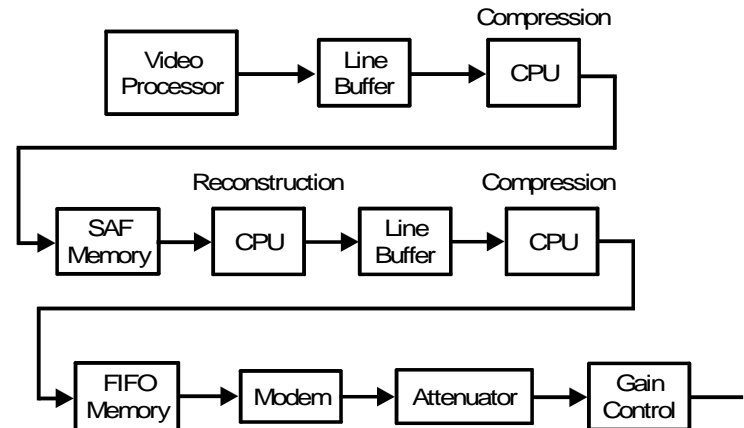
The data then passes through an attenuator, which adjusts the tx level (this is the output power of the data signal). It then passes through a variable resistor on the NCU, which can be used to adjust the tx level. The data then passes to the network.

Flow charts for the different transmission modes are given below.

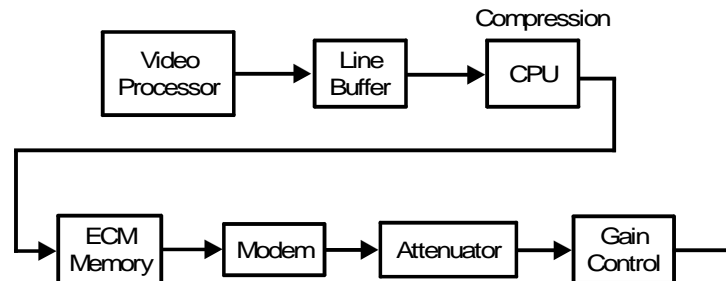
Memory Transmission, with ECM



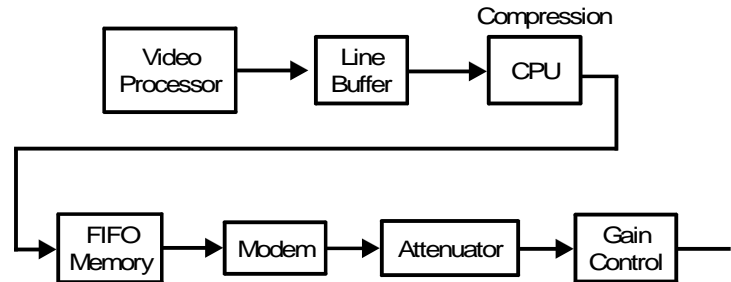
Memory Transmission, without ECM



Immediate Transmission, with ECM



Immediate Transmission, without ECM



Reception

This section explains the path of data through the machine during reception. The data paths for thermal printers and laser printers are explained separately.

The main description is for basic reception without ECM. Following this main description are diagrams showing the differences between basic reception with ECM and the following modes:

- Basic reception without ECM
- Memory reception without ECM
- Memory reception with ECM

Common Processes

Filtering and Demodulation –

Data from the line passes through a filter to remove unwanted frequencies. Then it goes to the modem, which demodulates the data.

Reconstruction

From the modem, the data goes to the SAF memory, where it is held in case the printer jams or runs out of paper or toner; after the user corrects the fault, the message will be printed out from the memory and no data will be lost.

The data coming from the modem is compressed data. From the SAF memory, the data passes to the cpu where it is reconstructed using the line buffer.

After this, the path depends on the type of printer inside the machine.

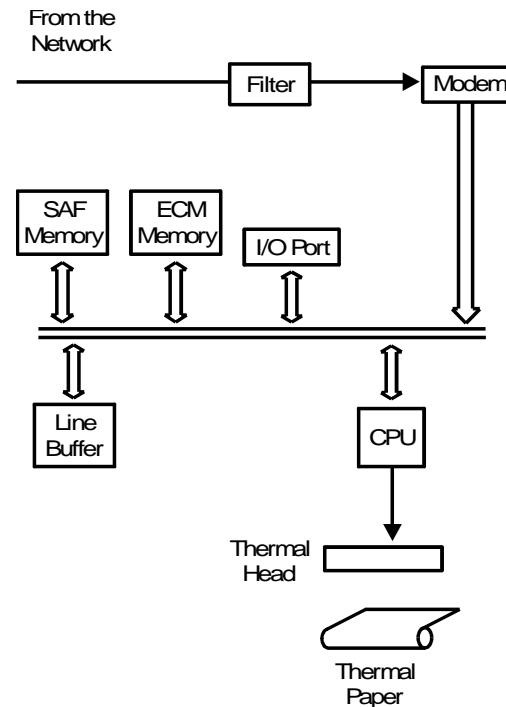
Thermal and Ink Jet Printers

Smoothing

The cpu then smooths the data, to remove jagged edges from the data. The resolution of the received data is upgraded into the highest that the printer can print; this is typically 8 x 7.7 dots per mm.

Printing

The cpu passes the data to the thermal head or ink jet print head through the line buffer.



Laser Printers

Page Assembly

The data then goes through the slave cpu to the page memory. When a full page of data has been assembled in the page memory, the data goes to the LIF (Laser Interface). If the page is too long for the paper in the cassette, the data is split into two pages and/or reduced in the page memory.

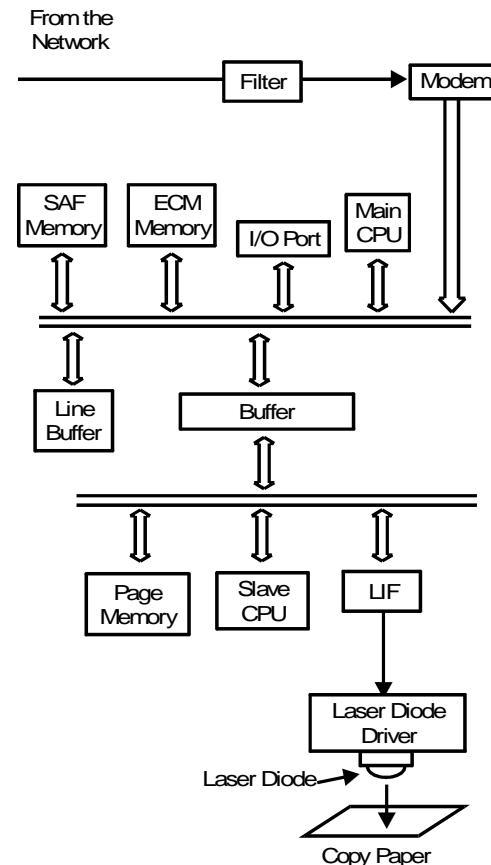
Smoothing

The LIF smooths the data. Smoothing removes jagged edges, converting the resolution of the received image into the highest resolution that the printer can accept. This is typically 8 x 15.4 dots per mm or 16 x 15.4 dots per mm for a laser printer.

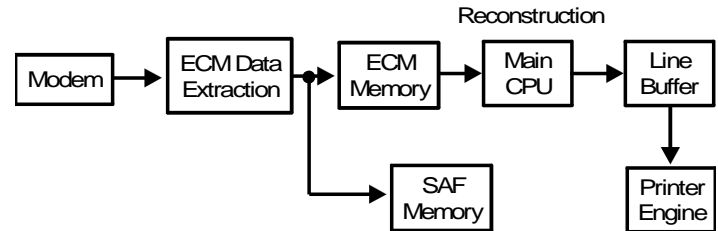
Printing

The laser beam switches on/off in accordance with the data signal, and forms a latent image on the master surface.

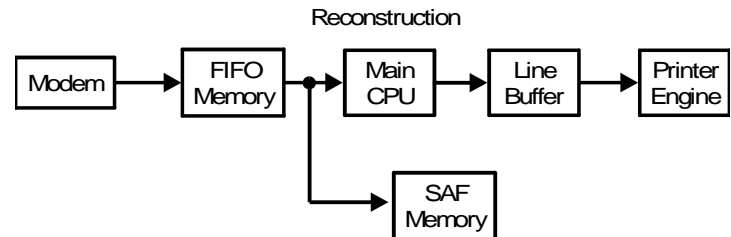
Flow charts for different reception modes are on the next two pages.



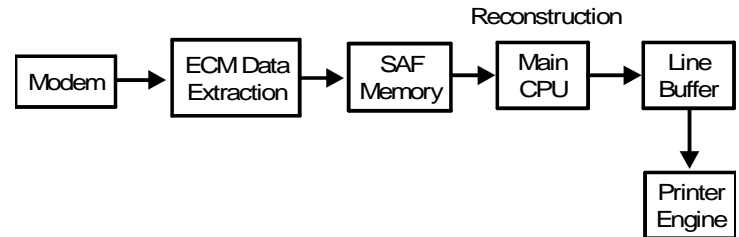
Basic Reception with ECM



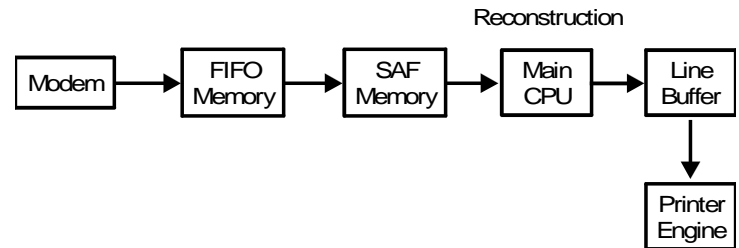
Basic Reception without ECM



Memory Reception with ECM



Memory Reception without ECM



Transmission

Overview

This section explains the communication control circuits for transmission.

When they leave the factory, most machines that have memory are set up for automatic dialing and transmission from memory. The main part of this section is based on the steps taken by this type of machine. Other modes, such as transmission without memory, send later, automatic dialing from behind a PABX, and manual dialing will be explained at the end of this section.

Below, there follows a brief outline of the individual steps for memory transmission with automatic dialing. These steps are basically the same for most machines.

Document Detection—The user places the document in the feeder, and the CPU turns on the fluorescent lamp when it detects the document. *This process is not described in this section.*

Document Feed—The machine feeds the document through the scanner. *This process is not described in this section.*

Video Processing—The machine scans the document, converts the scanned data to digital, and passes it through the video processing circuits. *This process is not described in this section.*

Call Collision Prevention—After the document has been scanned, the machine checks whether a fax message is coming in. (The machine cannot dial while a message is coming in.)

DC Loop Closure and Line Monitoring—If there is no incoming call, the machine closes the circuit between itself and the telephone exchange. The machine will monitor the line for dial tone and/or line current if required by local conditions (this is required in some European countries).

Dialing—The machine dials the other party.

Signal Detection—The machine then waits for a signal from the other party before going into tx mode, if required by local conditions (this is required in some European countries).

Data Transmission—The data passes from the memory out to the line through the modem and network interface circuits.

Return to Standby—The machine returns to standby mode.

The circuits for European and Asian models are different from those for North American models. Because of this, two separate sections have been prepared.

North American Models

Call Collision Prevention

Overview

After placing an original in the feeder, the user enters the telephone number at the operation panel's ten-key pad, then presses the Start key. The machine then scans the document and stores it in the SAF memory. The machine then prepares to dial.

Note: Remember that for transmissions that do not use the memory, the order of events is different. After the user presses Start, the document is fed partway into the scanner and the machine dials. Scanning and storing is done after the other end has been reached. See Immediate Transmission for details.

However, before the machine dials, it must check whether another call is in progress or not, to prevent a collision of incoming and outgoing signals. If the machine detects that a call is already in progress, it will wait until the line is clear before dialing.

There are two criteria for detecting whether a call is in progress.

1. Has a ringing signal been detected, or is a potential ringing signal still being analyzed?
2. Is the local loop with the local telephone exchange closed?

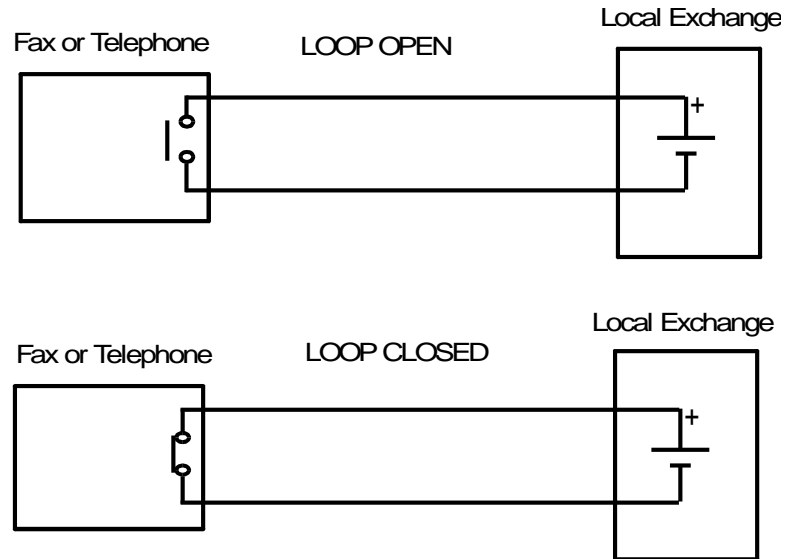
To understand this, we need to understand how a fax machine connects to a PSTN (Public Switched Telephone Network). This explanation begins on the next page. The explanation is based on network conditions in the USA; details differ from country to country.

PSTN Circuit

DC Loop Overview

Every telephone or fax machine is connected to a local exchange of the PSTN through a two-wire pair. One wire is called "Tip" and the other is called "Ring"; these names refer to the tip and ring parts of the plugs used in manual switchboards (in Europe, L1 and L2 are often preferred). This two-wire circuit is known as the "dc loop", or "local loop".

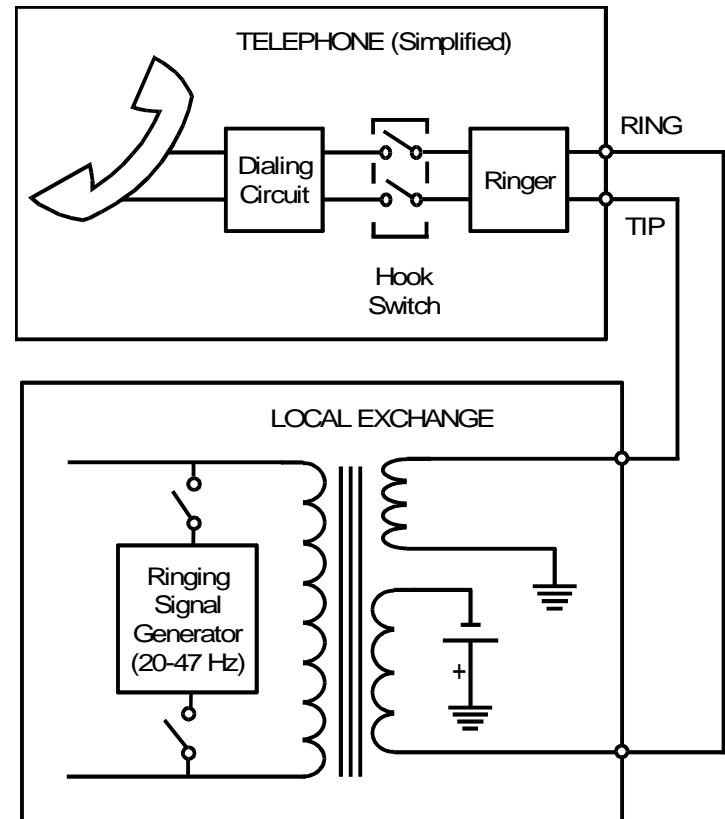
Each telephone and fax machine contains a switch which opens and closes the local loop. When the switch is closed, dc generated by the local exchange flows through the dc loop. The voltage on the dc loop varies from area to area; for example, in the USA, it is about 48 V.



DC Loop through Telephone

When the telephone is on-hook, the hook switch connecting it to the local exchange is open, and dc from the local exchange cannot pass through the dc loop. However, the telephone's ringer is connected (the ringer does not allow the dc from the exchange to pass, but allows the ac ringing signal to pass).

When the handset is picked up, pressure on the hook switch is released, and the switch closes. Then, dc from the local exchange passes through the dc loop.

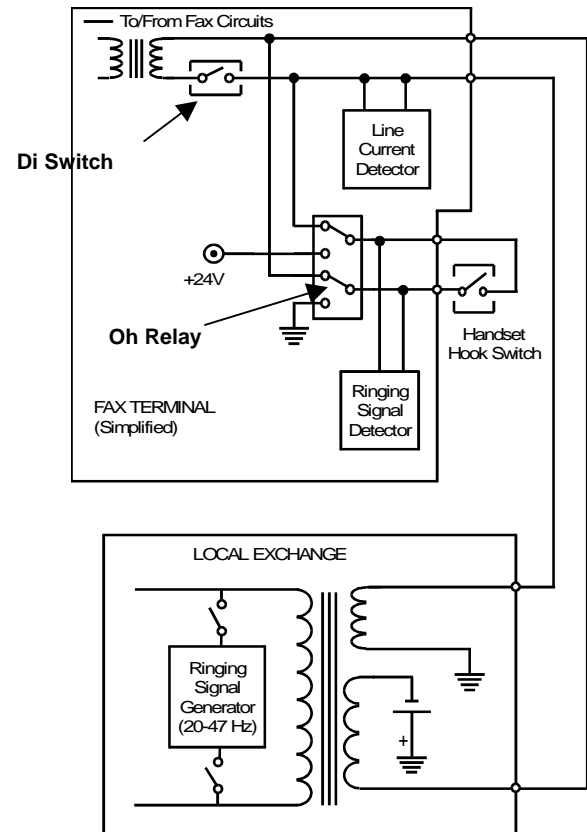


DC Loop through Fax Machine with External Telephone

Inside the fax machine, there are two components, called the Oh relay and the Di switch. These act as the fax machine's hook switch.

When the machine is in standby mode (as shown above), the Oh relay is set up so that the network is connected to the external telephone (commonly known as the handset); in this set-up, the handset can be used as a normal telephone, as explained on the previous page. The dc loop is open, because the handset's hook switch is open. However, the ringing signal detector in the fax machine and the ringer in the handset are both connected to the line.

When the machine closes the dc loop, it switches over the Oh relay to disconnect the handset from the line. Then it closes the Di switch to connect the fax machine to the dc loop. The fax machine's CPU will be able to detect the presence of dc by monitoring the line current detector.



Call Collision Prevention in Fax Machines

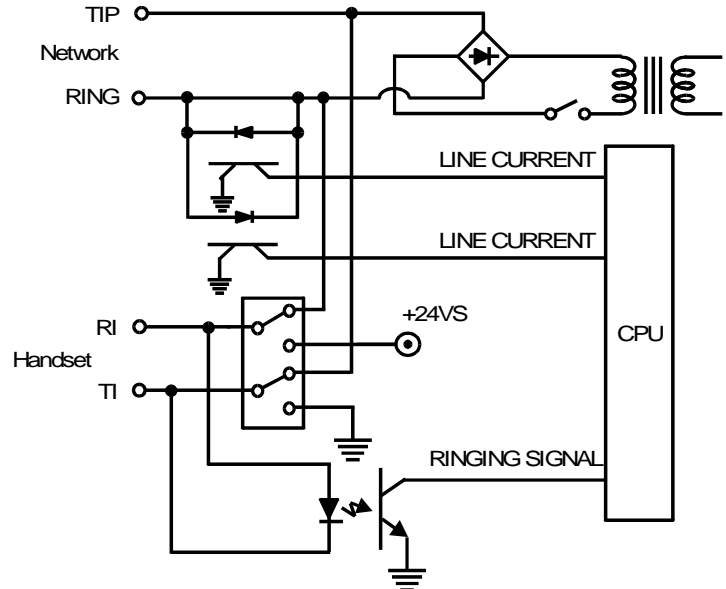
For 0.2 s after the user presses Start, the CPU monitors the ringing signal detector and the line current detector to check that the local loop has not already been closed (if the local loop has been closed, there will be current on the telephone line).

If a possible ringing signal is still being analyzed when the user presses Start, the CPU will wait for 8 seconds, then check whether the signal is still being analyzed.

The diagram shows the call collision prevention circuits. The position of the relays in standby mode depends on the reception mode being used. See Reception for diagrams.

Ringing signal detector: This circuit consists of some zener diodes and a photocoupler. If the voltage of an incoming signal is high enough, it turns on the photocoupler. Then, the CPU detects that its connection to the ringing signal detector has been grounded.

Line current detector: This is a pair of photocouplers. The CPU detects line current when one of the sensor outputs is grounded; the output that is grounded depends on the polarity of the dc on the loop.



DC Loop Closure and Line Monitoring

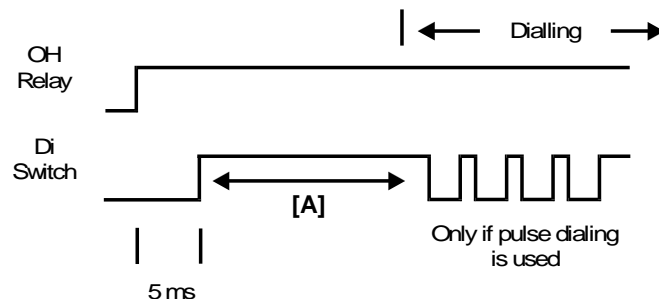
After it has been confirmed that there is no possibility of call collision, the machine automatically closes the circuit between itself and the local exchange; this circuit is commonly called the dc loop, or the local loop. Closing the dc loop is the fax machine's way of going off-hook before dialing.

In some areas, dialing cannot begin until the machine has checked for dial tone and line current. This is known as "line monitoring".

DC Loop Closure

The fax machine closes the dc loop after checking for incoming calls. If there is no incoming call, the cpu closes the dc loop by activating the Oh relay to disconnect the handset from the line. Then, after 5 ms, it closes the Di switch to connect the fax machine to the line.

The cpu then waits for the 'PSTN wait interval' [A] of about 2 s before starting to dial.

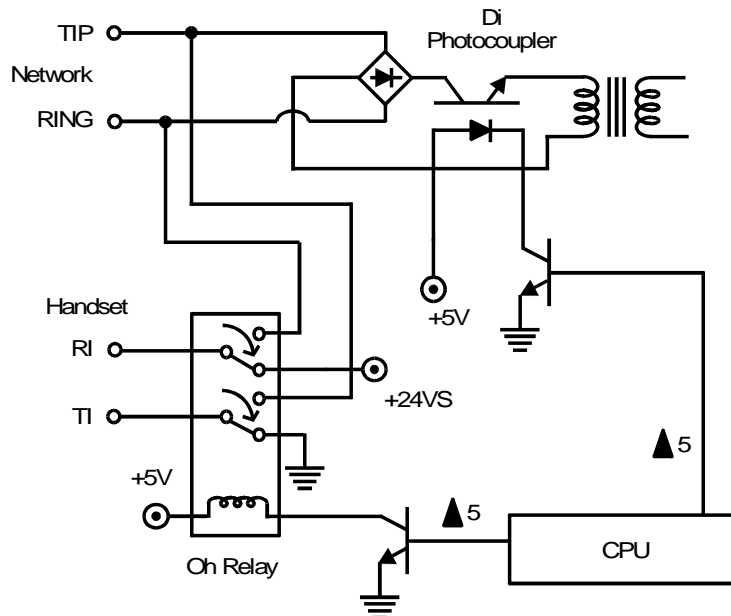


On the circuit diagram, curved arrows show the relays switching over from standby mode to close the dc loop. The Di switch is a photocoupler.

The standby position of the Oh relay depends on the reception mode selected. See Reception for details.

Note

PSTN wait interval: This can normally be adjusted by RAM address.



Line Monitoring

Before starting to dial, conditions in parts of Europe require that the machine monitors the line current detector for line current, and signals on the line for dial tone.

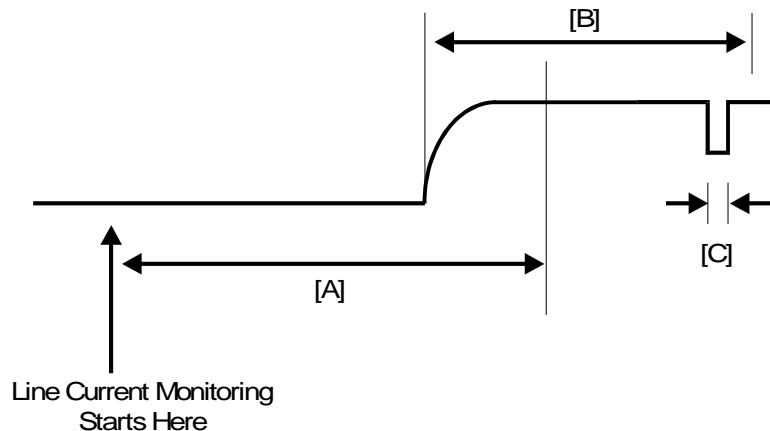
Therefore, in Europe/Asia models, the PSTN wait interval can be replaced by dial tone and line current detection, if required by local conditions. (Dial tone and line current detection are also available in USA versions of some of the more complex models.)

Line Current Monitoring

Line current detection allows the machine to check whether the dc loop has been closed. If there is no line current, the dc loop may still be open.

The machine uses the following parameters to detect line current.

- Line current wait time [A]
- Line current detection time [B]
- Line current drop detection time [C]



[A] starts when the dc loop closes. [B] starts when the line current first reaches the machine.

The machine checks for line current during [A]. Line current must be on the line for [B] or longer before it is recognized by the CPU. If the CPU has not recognized line current during the interval [A], the machine disconnects. However, if the line current has started but has not been on for [B] when [A] expires (as shown below), detection continues until it has been on for [B].

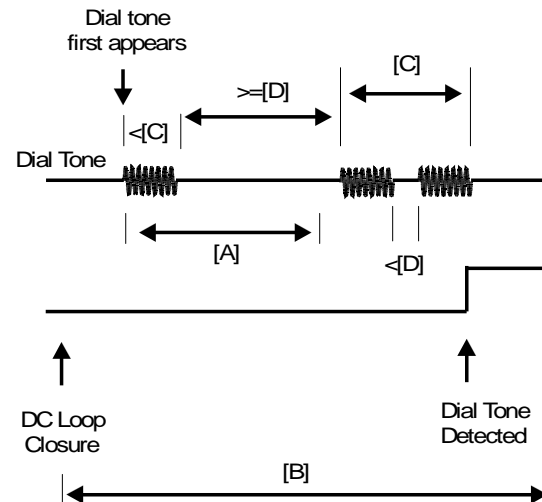
After starting [B], the machine continually checks the line current for interruptions. If any single interruption lasts for [C] or longer, the line is cut, [A] and [B] are reset, and the machine returns to standby.

Dial Tone Monitoring

The local exchange sends a dial tone to inform the user that the exchange can accept a telephone number. Dial tone monitoring allows the fax machine to check for this tone before dialing; if there is no dial tone, the exchange may not be ready to accept a telephone number.

The machine uses the following parameters to detect dial tone.

- Acceptable frequency range
- Dial tone detection time [A]
- Reset time [B]
- Continuous tone time [C]
- Permissible drop time [D]



[B] starts when the dc loop is closed. Dial tone must appear before [B] expires. If dial tone appears just as [B] expires, detection continues and the deadline at the end of [B] is ignored.

The machine detects a dial tone when the tone continues for [C] or longer without interruption. Also, [A] must have passed since the dial tone first appeared. Interruptions shorter than [D] are ignored.

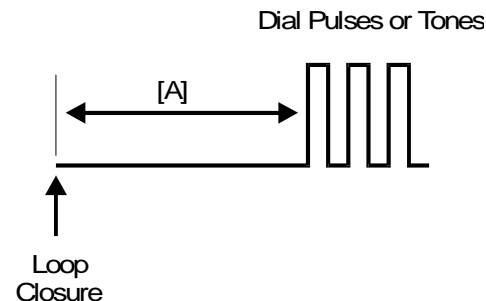
Switching Line Monitoring On/Off

A nation that requires line monitoring has the necessary parameters programmed in the ROM; they are normally activated when the country code (normally a bit switch setting) is set to the code for that nation.

However, if required, line current and dial tone can be disabled; the way to do this varies from model to model.

Similarly, in countries which normally have line monitoring disabled, line current and dial tone detection can be enabled; however, the parameters for detection will have to be stored in the appropriate RAM addresses.

When line monitoring is disabled, the machine waits for the PSTN wait interval [A] before starting to dial.



Note

The following parameters can be programmed by RAM address.

Line Current Monitoring

Line current wait time

Line current detection time

Line current drop detection time

Line current monitoring on/off

Dial Tone Monitoring

Acceptable frequency range

Dial tone detection time

Reset time

Continuous tone time

Permissible drop time

Dial tone monitoring on/off

Other

PSTN wait interval

Dialing

Overview

After the dc loop has been closed, the machine can dial. In automatic dialing mode, the machine dials in accordance with the number entered by the user at the operation panel, either in full, or as a Quick Dial or Speed Dial.

There are two types of dialing: pulse dialing, and tone dialing. The dialing method must match the dialing mode that can be accepted by the local exchange, or the machine will not be able to dial out.

The dialing method can be chosen by a user function in most countries.

Pulse Dialing

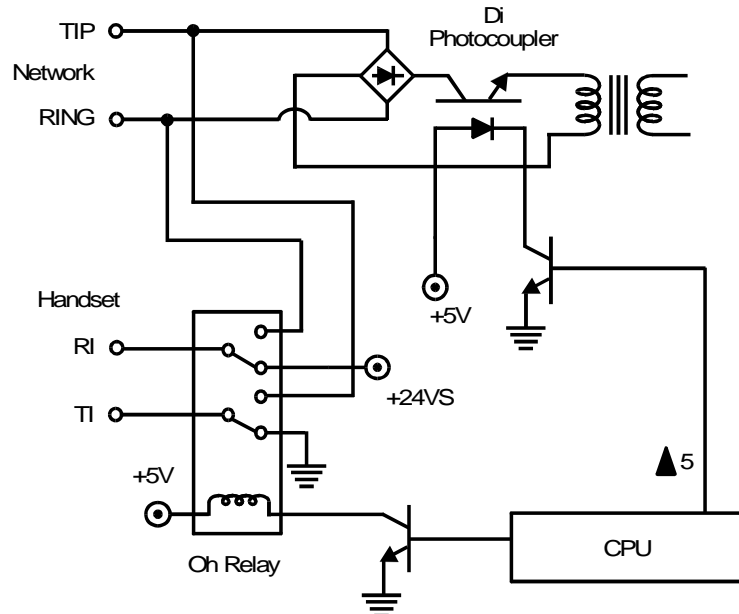
Pulse dialing was originally developed to operate mechanical switching systems in the local exchanges.

The machine sends voltage pulses to the local exchange by interrupting the dc loop. It does this by opening and closing the Di switch. Each digit is represented as a different number of pulses. For example, to dial a "2", the machine sends out 2 pulses.

The Oh relay remains fixed during dialing (it does not move until the machine returns to standby mode).

The Di switch is a photocoupler. Photocouplers are compact and inexpensive.

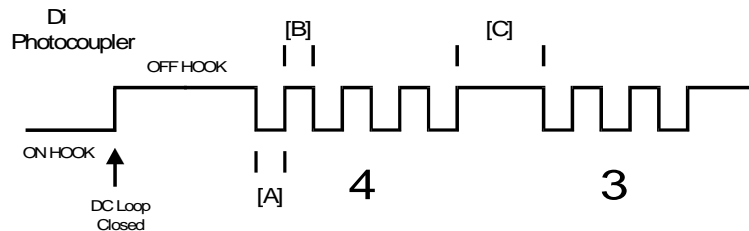
Each digit of the telephone number is sent out as a pulse train. The cpu sends out the dial pulses by opening and closing the Di photocoupler on/off.



The time that the Di photocoupler opens is called the break time [A] and the time that it closes is called the make time [B]. Each pulse sent out on the line is made by opening and closing the Di photocoupler.

A minimum pause [C] is required between each digit, regardless of whether the user pressed the pause key while dialing.

Example: Dialing 43



Notes

Most countries dial in the same way (the number of pulses sent out [P] is the same as the number dialed [N]). However, some areas require different types of pulse dial signals. For example, in Oslo, P must be $10 - N$, and in Sweden, P must be $N + 1$. The required mode can be selected by bit switch adjustment.

Pulse dialing can be done at two rates: 10 pulses per second (pps) or 20 pps. If the local exchange can only handle 10 pps dialing, the machine must not be set to dial at 20 pps. The dial pulse rate can usually be adjusted by bit switch.

Parameters A to C illustrated on the diagrams in this section are programmable.

For pulse dialing at 10 pps, the times stored in the NCU parameters are used as explained in this section. However, at 20 pps, only half the values in parameters A and B are used, and three-quarters of the value in parameter C.

Tone Dialing

Overview

Each dialed digit is sent out as a DTMF (Dual Tone Multi Frequency) tone, which is a mixture of two frequencies. The following diagram shows what frequencies are generated for each digit on a typical telephone keypad. For example, a '5' is represented by a 770 Hz tone combined with a 1,336 Hz tone.

The DTMF tone frequencies are the same throughout the world. They were carefully chosen so as not to coincide with other frequencies that may occur on the line.

In some types of telephone equipment, the DTMF circuit remains on line after the call has been connected. This allows the use of DTMF tones for giving orders to the remote terminal (e.g., extracting information from a remote database).

The advantages of using DTMF over pulse dialing are as follows.

- Dialing is faster
- DTMF tone generation circuits are compact solid-state circuits
- There can be end-to-end signaling after call connection, as mentioned in the previous paragraph

	1209	1366	1477
697	1	2	3
770	4	5	6
852	7	8	9
941	*	0	#

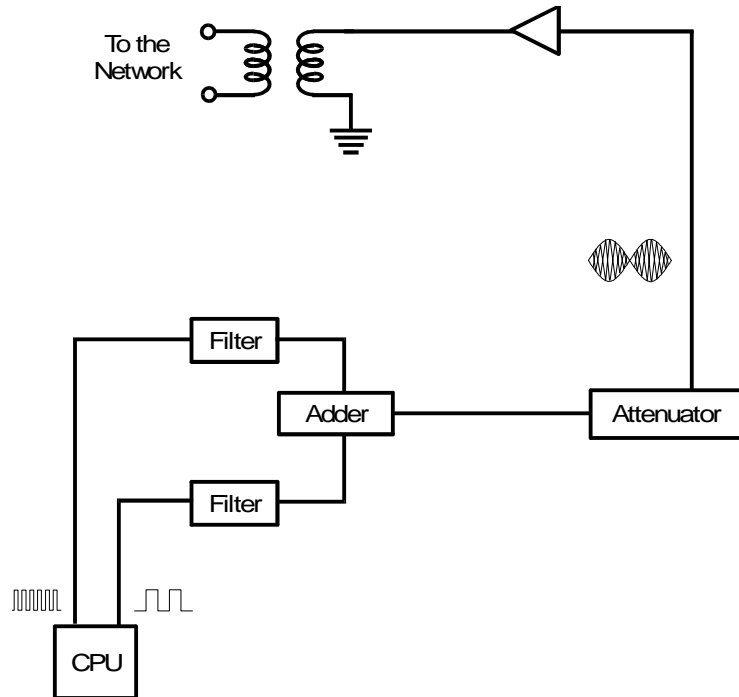
DTMF Tone Generation

The diagram shows how DTMF tones are generated in fax machines.

The cpu generates two square waves of the required frequencies. These each pass through a low pass filter to remove noise, and are added together.

In the attenuator, the DTMF tone is attenuated. The attenuation value is different from that used for the attenuation of facsimile data.

The DTMF tone is then amplified to compensate for the signal loss between the attenuator and the telephone line. The tone then passes to the line through the Di switch and Oh relay, which remain fixed during tone dialing.



Attenuation of DTMF Tones

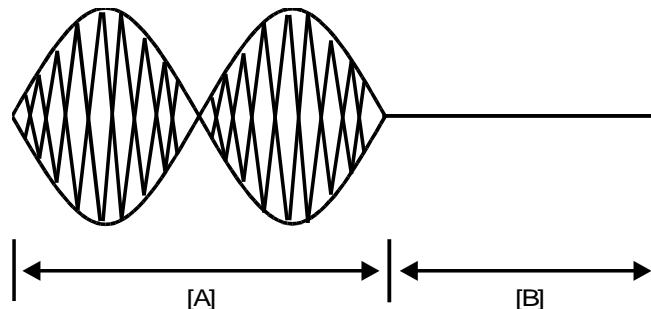
The machine always uses permissive attenuation for DTMF tones, even if programmable attenuation has been selected. (See *Data Transmission* concerning permissive and programmable attenuation. Programmable attenuation is only done in older models, some of which may still be in the field.)

Note: The DTMF tone attenuation value can be adjusted by RAM address. However, unlike the attenuation value for facsimile data, it cannot be adjusted using dedicated transmission parameters or bit switches.

Timing

DTMF tones are sent out in accordance with the timing shown in the diagram.

Note: The DTMF tone on time [A] and off time [B] can be adjusted by RAM address.



Pauses

If the user dials a pause using the Pause key, the machine waits for a pre-programmed interval before sending the next tone or pulse.

Note: The pause interval can be changed using a RAM address adjustment.

Signal Detection

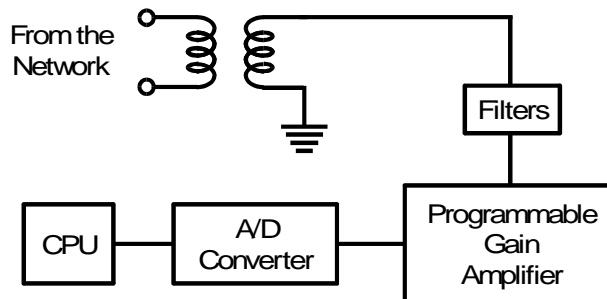
Overview

After dialing, the machine waits for the response from the other end. The response is usually either a CED tone, a busy tone, or a ringback tone. These tones are known as progress tones. Instead of a progress tone, a protocol signal such as NSF or DIS may be detected at this time.

The received signal passes through two filters. A high pass filter (with a cut off of about 300 Hz) removes low frequencies, such as noise from the fax machine's power supply, and a low pass filter (with a cut off of about 2100 Hz) removes high frequencies, such as noise from overhead railway power cables.

The signal then passes to a programmable gain amplifier, which raises the signal level enough for the machine's hardware to analyze it. The minimum signal level on the line will vary from country to country, so the amplifier is programmable. For example, in typical USA models, the amplifier is set up so that signals weaker than -53 dBm are not detected.

The amplified signal is converted to digital, then passed to the tone detector in the cpu.



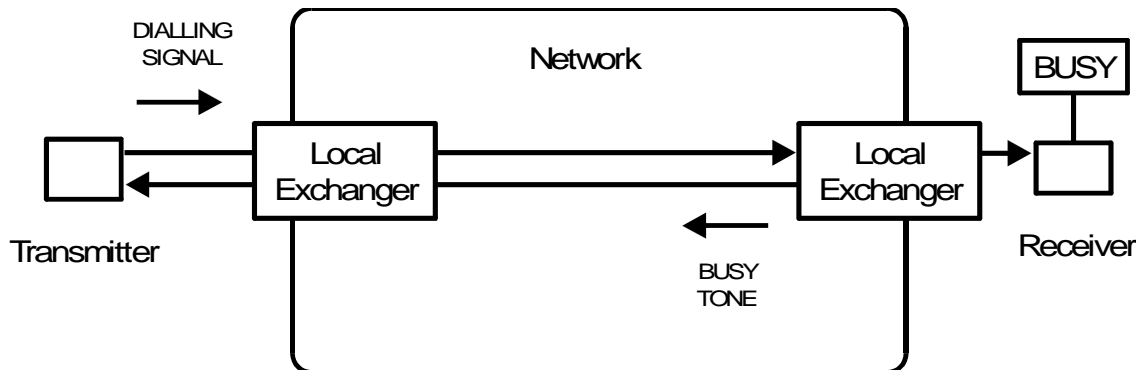
The incoming signal may determine whether or not the machine goes into transmit mode. Most machines have bit switch or other settings to determine when the machine goes into transmit mode. The choices are typically as follows:

- After dialing
- After receiving NSF or DIS
- After receiving CED

Note: The gain of the amplifier depends on the country code (the country code is selected by a bit switch adjustment). However, the gain can be changed by a RAM address adjustment; in most machines, there are 4 possible values to choose from.

Busy Tone Detection

If the call has gone through and if the called terminal is already off hook (i.e., the other end is busy), the local exchange at the other end sends back a busy tone.



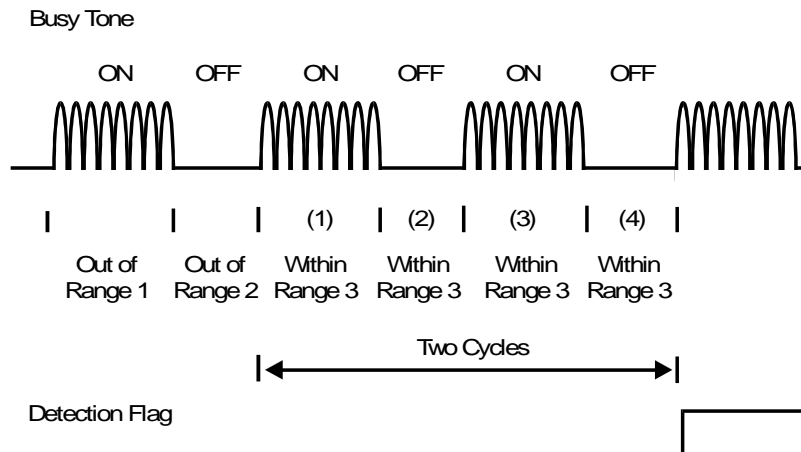
If the machine detects busy tone, it will disconnect the line. The number will be redialed (see Redialing), unless the maximum number of redials have already been made.

If busy tone detection is disabled and the line is busy, the machine will hold the line until the ITU-T T1 timer (about 1 minute) runs out. So busy tone detection can reduce the amount of time the machine holds the line.

Busy Tone with Cadence

In many countries, the busy tone has a cadence (a fixed on-off cycle), so the machine measures the on and off times of the received signal and compares them with values programmed in the RAM.

RAM addresses specify four permissible lengths for each signal state. The machine first checks if the signal has a length within range 1. If it does not, then range 2 is selected, and so on. An example is shown to the right, in which the on-off time durations are found to be within range 3.



Note

The following values are stored in RAM.

- Range 1, ON time Range 1, OFF time
- Range 2, ON time Range 2, OFF time
- Range 3, ON time Range 3, OFF time
- Range 4, ON time Range 4, OFF time
- The number of cycles required for detection (for example, a setting of 4 means that ON-OFF-ON or OFF-ON-OFF must be detected twice).

- ON or OFF time tolerance (+/-), for ranges 1 to 4.
- Acceptable signal frequency range

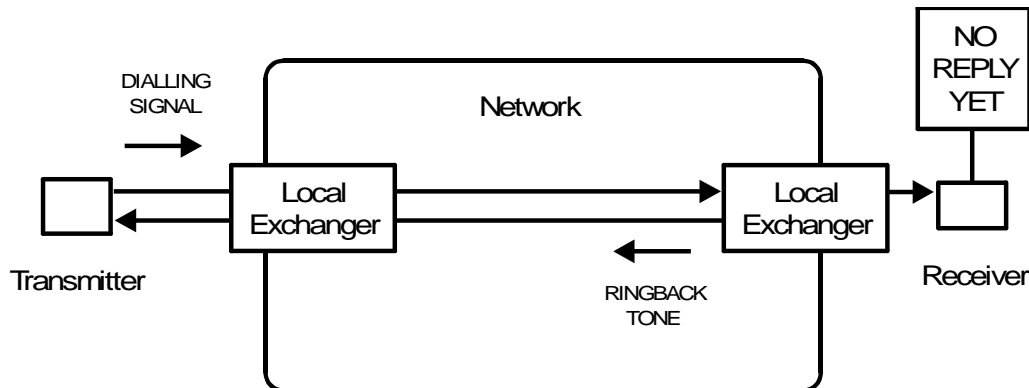
Continuous Busy Tone

In some countries, such as the UK, the busy signal is not a cadence. The busy tone must continue for a certain time before the machine detects it.

Note: The minimum time required for continuous busy tone detection is stored in RAM.

Ringback Tone Detection

If the call has gone through and if the called terminal is on hook, the local exchange at the other end sends a ringing signal to the called party; at the same time it sends a ringback signal back to the caller.



Ringback tone detection is always switched on in Austria. Ringback tone is detected if the ringback tone is longer than the minimum ringback tone detection time (0.1 s), which is stored in RAM.

- If the machine at the other end is a telephone -

When the phone rings at the other end, the transmitting machine detects ringback tone. The other party picks up the handset when the phone rings, and replaces it when there is no voice on the line. Then, the local exchange at the receiving end sends back a busy tone to the transmitter (this is normal in Austria).

When the transmitter detects this busy tone, it immediately disconnects the line without waiting for the ITU-T T1 time to expire. Ringback tone and busy tone were both detected on this call; in such cases, the software in the transmitter disables automatic redialing for this number.

Note: In Austria, it is necessary to prevent a fax machine from redialing addresses for which the T1 timer expired on the first attempt.

- If the machine at the other end is a fax machine -

In Austria, the receiving fax machine will close the dc loop after it has detected one ringing signal. (So, the ringback tone to the transmitter will be short, but not too short for detection.)

Immediately after closing the dc loop, the receiving machine will send CED. If the user at the receiving end presses Stop after this, both machines will disconnect immediately.

The transmitter will not receive busy tone from the other end, as it has already disconnected, so the number can be redialed automatically.

Note

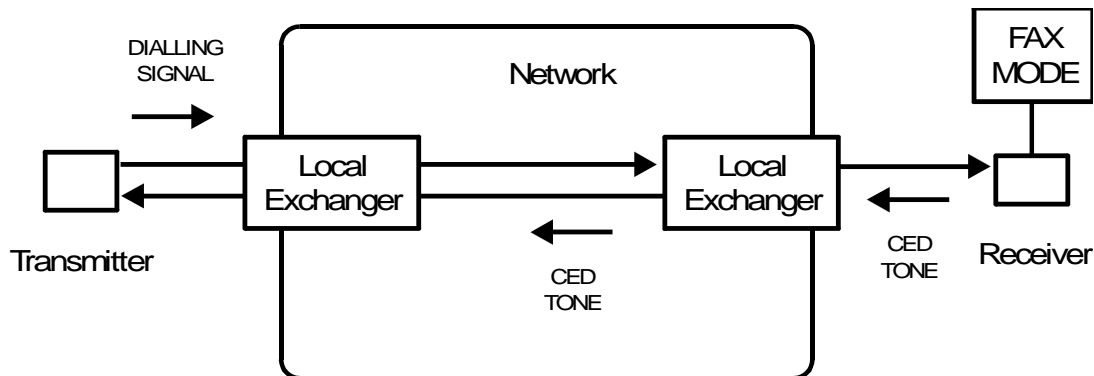
The ringback tone has the same frequency as the busy tone.

The only RAM address that must be programmed for ringback tone detection is as follows.

Ringback tone detection time

CED Detection

If the receiver is a fax terminal in Auto Receive (Fax) mode, it will emit a 2100 Hz tone called CED.



This signal informs the caller that they have connected to a fax machine. CED is the high-pitched tone that prompts the user to press the Start key when using Manual Dialing.

In automatic dialing mode, the transmitting fax terminal confirms CED detection when the CED tone continues for 200 ms or more. Then it starts to scan the document.

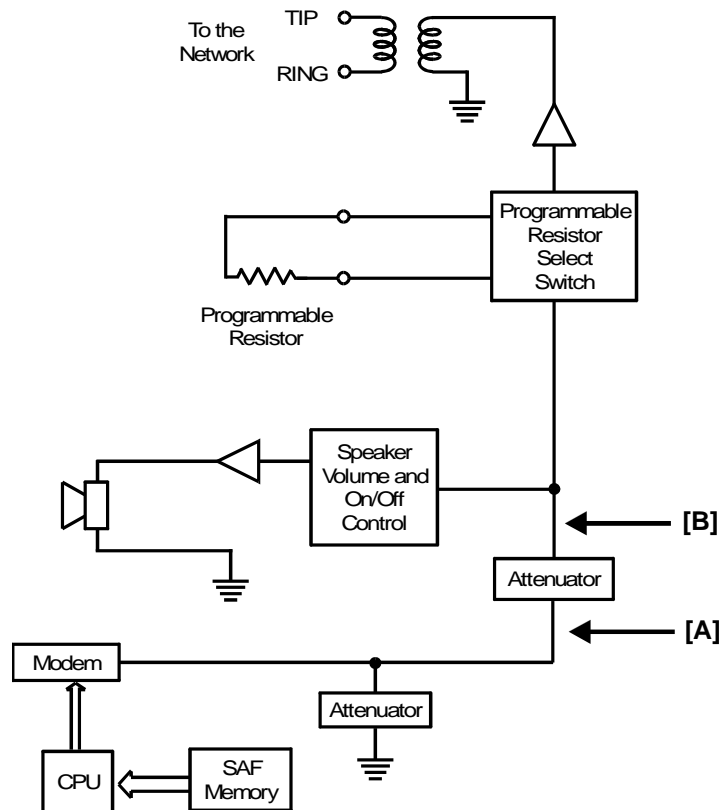
Data Transmission

The data transmission circuit is shown above. The cpu retrieves the data from the SAF memory, processes it, and passes it to the modem. The modem modulates the data to convert it into a form that is suitable for transmission over the public telephone network. The data is then attenuated to the correct signal strength for transmission.

The major steps are explained on the following pages.

Processing in the CPU

The cpu retrieves the data from the SAF memory and reconstructs it (if it was compressed before storage into the SAF). The cpu then processes the data before sending it to the modem. The signal to the modem is eight-bit parallel, with one bit representing one picture element (unless the data was reduced—see the Digital Processes chapter for details on reduction).



Compression

Compression reduces the number of bits in the data signal, and therefore the transmission time for one page.

MH, MR, and MMR compression are done according to ITU-T standards.

A proprietary procedure called EFC (Estimated Fillbit Control) may be applied to the compressed data. EFC is not strictly a compression technique, but it improves the efficiency of data transfer by controlling the number of fill bits inserted by the transmitter at the end of each line of data (see below).

The data is compressed in accordance with the method agreed in the protocol between the transmitting and receiving machines. In Group 2 and Group 1 modes, the data is not compressed before transmission.

Brief explanations of the different coding types follow. MH and MR coding are explained in detail in the ITU-T recommendations for Group 3 facsimile.

MH—Every line is MH coded.

MR—Data is treated in blocks of 2 lines (in Standard or Detail resolution) or in blocks of 4 lines (in Fine resolution). The first line of each block is MH coded, then the remaining lines in the block are MR coded using the first line as the reference line.

SMR—This is similar to MR coding except that data is treated in blocks of 8 lines (in Standard or Detail resolution) or in blocks of 16 lines (in Fine resolution).

MMR—Data is treated by the page (or the ECM block if the page needs more than one block). The first line of the page is MH coded, then all the following lines on the page are MR coded using the first line as the reference line. In some models, MMR is only done for storing data into memory, or if ECM is being used.

EFC—The sending machine only includes fill bits in the data stream when the FIFO memory in the receiver is full (normally fill bits are always added to the end of any line that is sent out in less than the time specified by the I/O rate).

New EFC—Fill bits are never added to the data, and the receiver uses the SAF memory or hard disk instead of the FIFO memory. If the receiver's memory is full, it sends PIN and the line is disconnected.

If ECM (the extension to Group 3 protocol known as Error Correction Mode) is used, EFC and New EFC are not used.

The compressed data goes out to the modem on the data bus.

Compression is described in more detail in the section on [compression](#).

Data Transfer to the Modem

I/O rate: The I/O (input/output) rate is the amount of time needed for the scanner or printer to process one scan line of image data (modulation and demodulation are not included in this time). On the transmitting side, it indicates the time needed to scan, process, and compress a scan line. On the receiving side, it indicates the time needed to reconstruct, process, and print a scan line. In Group 3 transmission without ECM, I/O rates of the communicating machines must be the same. If ECM is used, I/O rate is not used (0 ms/line is assumed).

Without ECM

The FIFO synchronizes the transfer of video data to the modem (transmission) or from the modem (reception). It also acts as a buffer, ensuring that there is always some data for the modem to pick up, modulate, and send out.

The FIFO has some unique functions, in addition to synchronizing data transfer from the CPU to the modem, as explained below.

Without EFC (Estimated Fillbit Control): During the protocol exchange, I/O rate capabilities are compared. The I/O rates of both terminals must be the same during communication. The maximum I/O rate of the slower machine is used. Say that the chosen I/O rate is 10 ms/line. If the sending machine takes less than 10 ms to scan, process, and compress a particular scan line, it adds fill bits (zeros) to the end of the compressed scan line to make up the extra time. This keeps the two machines synchronized.

With EFC: If EFC is used, the two terminals' FIFO sizes are compared during the protocol exchange, as well as the I/O rates. During transmission, the sending machine continually estimates how much space remains in the receiver's FIFO (the I/O rate, receiver's FIFO size, and amount of data sent are used in this estimation). Fill bits are not added to the end of each scan line, unless the receiver's FIFO seems to be getting full; the transmitter then sends fill bits (zeros) until there is some space in the FIFO. This system speeds up data transfer between the terminals.

With ECM

All compressed image data for an ECM block (normally one page, unless halftone is used) are held in the ECM memory, and assembled into protocol frames before transmission.

At the receiving end, printing does not start until the whole block of data has been received. Therefore, there is no need to synchronize the scan line I/O rate of the two machines.

The FIFO is not needed for ECM; the ECM memory at each end acts as a buffer memory.

Printing is not done until a block of data has been assembled in the receiver's ECM memory. Therefore, there is no real time synchronization of the scan line I/O rate of the two machines. Because of this, no fill bits need to be exchanged between the terminals. This means that EFC is not used with ECM.

Note: In laser printers, the I/O rate is also 0 ms/line during reception. This is because the data is assembled in a page memory before printing.

ECM is described in more detail in the section on fax protocol, and EFC is described in more detail in the section on compression.

Modulation

The data passes to the modem on the data bus as 8-bit parallel data. The modem converts this to serial and modulates it before passing it on to the network interface circuits.

Modulation techniques are described in detail in another section.

Attenuation

The signal is then attenuated and passed to the line.

Permissive Attenuation

For G3 and V.21 protocol signals, the attenuator ensures that the signal level output to the line matches the value programmed in the bit switches for tx signal level.

If the number is dialed as a Speed or Quick Dial, any value stored for tx level in the dedicated transmission parameters for this address will be used instead of the bit switch value.

Note: For G2, G1, and PIS (462 Hz) signals (these are all now obsolete), the output to the line is slightly different than for G3. For example, if the bit switches specify -9 dBm, the different types of signal will have the following level on entering the network.

G3, V.21: -9 dB

G2, PIS (462 Hz): -8 dB

G1: -12 dB.

The above values differ from model to model.

Programmable Attenuation

Programmable attenuation is only done in older models, some of which may still be in the field.

If programmable attenuation is required (which is not very often), a technician from the telephone company will visit the location and measure the output level from the machine. The technician will then connect a programmable resistor to the rear of the machine; the resistor value is selected carefully to ensure that the machine's output level is between 0 and -15 dBm.

Programmable attenuation must then be switched on by a bit switch adjustment.

The bit switches and dedicated transmission parameters for signal level are ignored. The attenuation between points [A] and [B] on the circuit diagram is fixed (see the beginning of this section). For example:

G3, V.21: -5 dB

G2, PIS (462 Hz): -4 dB

G1: -8 dB

The above values differ from model to model.

G1 and G2 are now obsolete.

Exit to the Network

The signal then passes through an amplifier, which raises the signal level to make up for the signal loss as the data passes out to the line through the network interface circuits. The data then passes to the line through the Di and Oh Relays, which do not change position during data transmission.

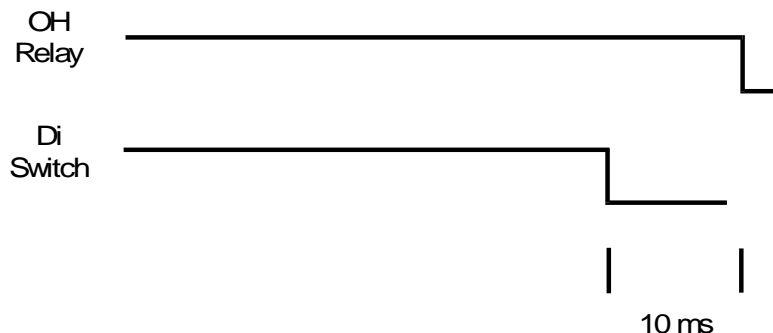
Notes

1. The transmission level can be changed by bit switch, if local line conditions make it necessary.
2. Dedicated transmission parameters are three bytes of settings, that can be programmed for each Quick Dial Key and Speed Dial Code. The settings include transmission level, and initial modem rate. The settings can be programmed to suit the line conditions normally encountered when sending to the terminal stored in the Quick Dial Key or Speed Dial Code.
3. In older models programmable or permissive attenuation can be selected by a bit switch adjustment.
4. ECM is normally on. In some models, it can be switched off for a particular destination using dedicated tx parameters, or for all destinations by bit switch adjustment.
5. If transmitted signals are degraded (especially at higher frequencies) because of the length of wire between the modem and the local exchange, try adjusting the cable equalizer by bit switch. There are normally four values available, including zero (off). If the cable equalizer is switched on, high frequencies are made louder and low frequencies are made softer. The cable equalizer characteristic may vary depending on the modem in use. Modems used in fax machines generally raise the levels of frequencies between 1700 Hz and 3000 Hz, and reduce the levels of frequencies between 300 Hz and 1700 Hz. If the cable equalization is overcorrected, output signals will be degraded again, leading to unnecessary modem rate fallback during training.

Return to Standby

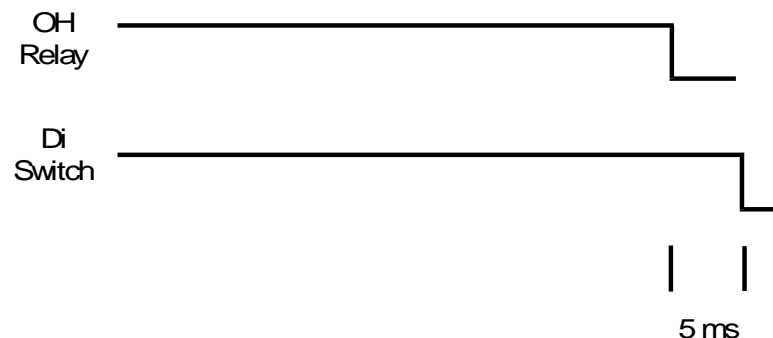
After transmission, the next step depends on the status of the handset hook switch.

If the handset is on hook at the end of the communication, the cpu turns off the Di switch to disconnect the fax machine from the dc loop, then the Oh relay in accordance with the following diagram on the right.



If the handset is off hook (for example, if the Voice Request feature was being used), the Oh relay switches off before the Di switch, as shown on the right.

Note: The difference in timing is to meet PTT requirements in some European countries.



Finally, the cpu turns off the power supply for all components except those needed for monitoring the machine and telephone line in standby mode. The machine is now back in standby mode.

Note

The machine must wait for a minimum amount of time before dialing the next number. This interval is normally stored in RAM and can be adjusted. However, there may be a government requirement regarding the value, as for most of the adjustable communication parameters that are discussed in this manual.

Others

Manual Dialing

An outline of the steps taken follows.

Document Detection: The user places the document in the feeder, and the tx motor feeds the document to the scan line.

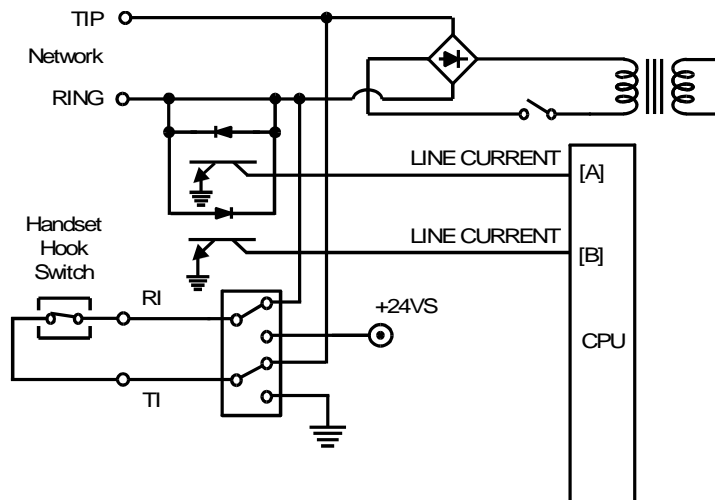
Document Feed, Video Processing: These steps are the same as for automatic dialing.

DC Loop Closure, Dialing, and Signal Detection: The user picks up the handset. The handset hook switch closes the circuit between the machine and the telephone exchange (known as the dc loop). The user listens for dial tone then dials. The user presses Start after hearing a signal from the other end. There is no automatic call collision prevention after the user presses Start.

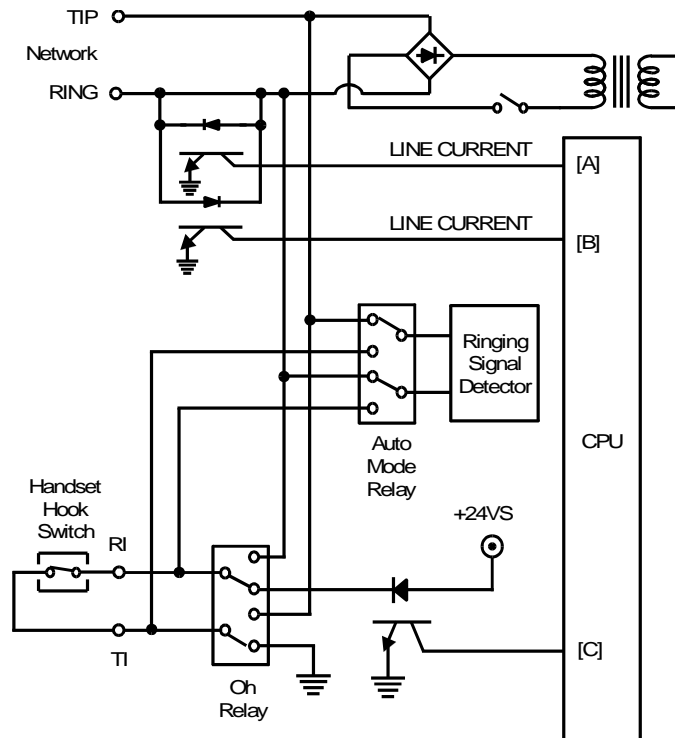
Data Transmission, Return to Standby: These steps are the same as for automatic dialing

Circuits

Machines without Auto Select Mode



Machines with Auto Select Mode



Picking up the Handset

After placing the document in the feeder, the user picks up the handset. The hook switch in the handset closes the dc loop between itself and the local exchange.

Auto or Manual Receive modes: The cpu detects dc loop closure when pin A or pin B goes low; the pin that goes low depends on the polarity of the circuit.

Auto Select mode: The cpu detects that the handset is off hook when the signal on pin C changes state. When the cpu detects this, it switches over the Auto Mode and Oh relays. (The above diagram shows the relays in standby mode for Auto Select mode.)

The +24V signal used here must remain on during standby mode. This is because pin A is also used for detecting when the handset is picked up in Auto Select mode.

Dialing

When the cpu detects the dc loop, the operation panel LED prompts the user to dial.

Dialing from the handset: The dial switch or tone generator in the handset sends the dial signal out to the line. The user presses Start after hearing a signal from the other end.

Dialing from the ten-key pad: When the first number is input at the ten-key pad, the Oh relay switches into the down position (see the previous diagram). After the dial pulses or tones have gone out to the network, the Oh relay switches over again to connect the handset to the line. The user presses Start after hearing a signal from the other end.

The cpu then connects the line to the fax machine by turning on the Di switch then switching over the Oh relay 10 ms later. This is the opposite of the dc loop closure procedure for automatic dialing.

The reason for the above is as follows. If the Oh relay is closed first, the dc loop already established between the handset and the local exchange would be disconnected and the call would be terminated. So, the Di switch is closed first. There are now two dc loops; one to the handset, and one through the fax circuit. Then the Oh relay disconnects the handset to leave the fax machine connected to the local exchange. In automatic dialing, there is no dc loop formed with the local exchange at this time, so the Oh relay can be switched over first without disconnecting the call.

Document feed, video processing, data transmission, and return to standby then proceed as previously described.

The user may pick up the handset during communication (for a voice request), or before a document is placed in the feeder (for example, to make a phone call).

When the user picks up the handset, the hook switch inside the handset closes.

If this is done in standby mode, the dc loop then forms through the hook switch in the handset. The cpu detects line current, which informs it that the handset has been picked up.

If the user picks up the handset after the dc loop has been closed (for example, to answer a voice request), the cpu cannot directly detect that the handset has been picked up. The user has to press the Stop key after picking up the handset. Then the Oh relay switches over to connect the handset to the local exchange.

Immediate Transmission

An outline of the procedure follows.

Document Detection: The user places the document in the feeder, and the CPU turns on the scanner lamp when it detects the document.

Call Collision Prevention, DC Loop Closure, Line Monitoring, Dialing, and Signal Detection: After the user has pressed Start on the operation panel, the machine feeds the first page partway into the scanner. The machine then dials the other party, before scanning the document.

Document Feed: When the other terminal has been reached and handshaking and modem training have been done, the machine scans the document. When document stamping is switched on, the page is stamped if transmission was successful.

Video Processing: While the machine scans the document, it converts the scanned data from analog to digital, and passes it through the video processing circuits.

Data Transmission: The data passes to the telephone line through the modem and network interface circuits.

Return to Stand-by: After all data has been transmitted, the page is fed out. The machine returns to stand-by.

Redialing

If there is a line failure, or if the line is busy, the machine can redial the same number automatically, as defined by parameters stored in RAM. (Also, the user can redial immediately by pushing the Redial key.)

There are RAM addresses to control the following:

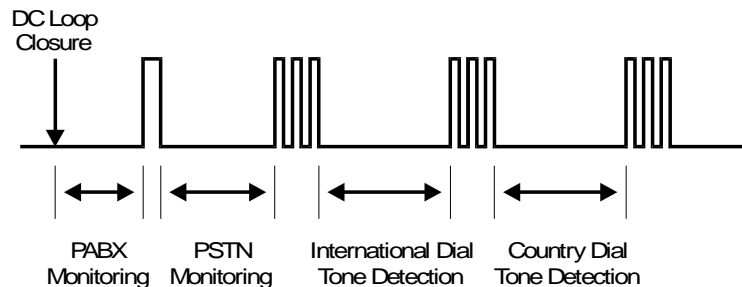
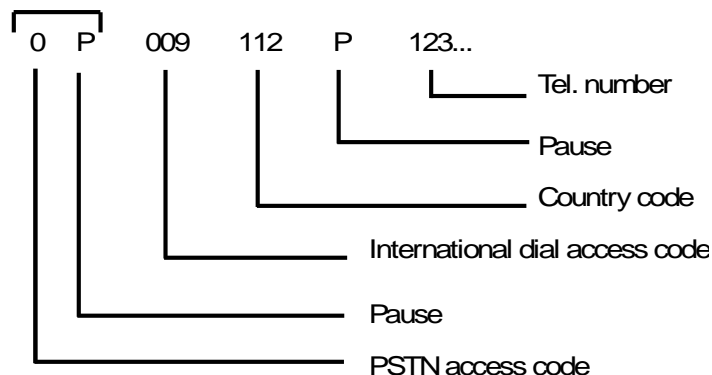
- Redialing (memory transmission)
- Redialing (immediate transmission)

International Dialing

Some national PTTs require automatic detection of international dial and country dial tones.

International numbers are dialed as follows.

If behind PABX



International dial tones and country dial tones are detected in the same way as PSTN dial tones, except that the timers and frequency limits are different.

Note: The necessary parameters are held in RAM.

International Dial Tone

Acceptable frequency range

Reset time

Permissible drop time

Detection time

Continuous tone time

Wait interval

Country Dial Tone

Acceptable frequency range

Reset time

Permissible drop time

Detection time

Continuous tone time

Wait interval

Other

International dial access code

Auto Dialing from behind a PABX

Outline

The procedure is as follows.

Document Detection, Document Feed, Video Data Processing, Call Collision Prevention, DC Loop Closure: These are the same as for transmission without PABX. When the machine goes into transmit mode, it checks for incoming calls, then it connects to the PABX by switching over the Di switch and Oh relay.

Line Monitoring: Some local conditions require the machine to monitor the line for PABX line current, dial tones, busy tone, and ringback tone. If line monitoring is disabled, the machine waits for the PABX wait interval before going on to the next step (in the USA, this interval is 2 s).

Access to the PSTN: The machine must gain access to the PSTN through the PABX by dialing an access code.

Line Monitoring, Telephone Number Dialing, Signal Detection, Data Transmission, Return to Standby: These are the same as for transmission without PABX.

Line monitoring and access to the PSTN are explained in more detail on the following pages.

Line Monitoring

1. Line Current

This is the same as for PSTN line current detection.

2. Dial Tone

The machine monitors the line for PABX dial tone in the same way as when it monitors the line for PSTN dial tone. However, the following parameters for dial tone detection are different and are stored in separate RAM addresses.

- Acceptable frequency range
- Detection time
- Reset time
- Continuous tone time
- Permissible drop time

If PABX line monitoring is enabled and parameters are already programmed, you can disable dial tone detection. The method differs from model to model.

If PABX dial tone detection is disabled, the machine will wait for the PABX wait interval (see the next page) before dialing the PSTN access code. This interval is stored in RAM.

3. Busy Tone Detection

This is the same as for basic transmission, except that the following parameter has a separate RAM address.

- Acceptable frequency range

4. Ringback Tone Detection

This is the same as for basic transmission, except that the following parameter has a separate RAM address.

- Detection time

Access to the PSTN

The machine sends out the first digit of the phone number, which should be the PSTN access code. The PSTN access code is programmed by bit switch.

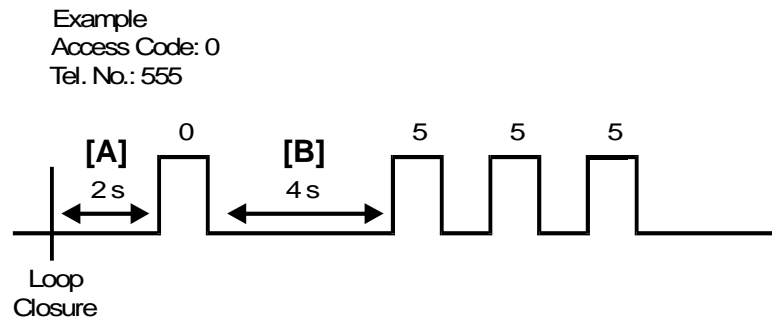
If this first digit is the same as the value specified by the bit switch, the cpu recognizes the access code and starts to monitor the line from the PABX.

Note that the PSTN access code can be a two-digit code. In this case, the cpu monitors the line for line current and dial tone after the user dials the two-digit code specified by the access code bit switch.

If line monitoring is disabled, the cpu waits for preset intervals before dialing. The intervals are:

- [A]: PABX wait interval
- [B]: PSTN wait interval; this is the same as the interval discussed in DC Loop Closure.

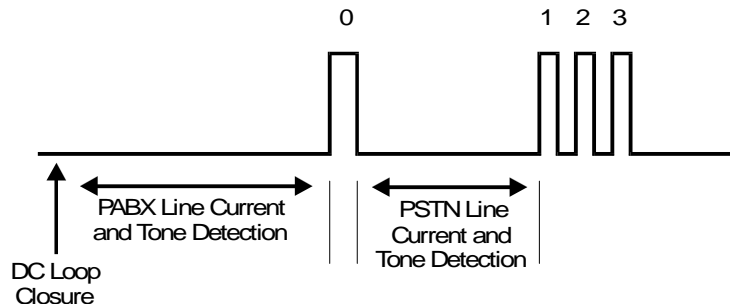
Both intervals are stored in RAM and can be adjusted. The above diagram shows the set-up for the USA; A is 2 s and B is 4 s.



The next step depends on the PSTN access mode selected. There are three types: loop start, ground start, and flash start.

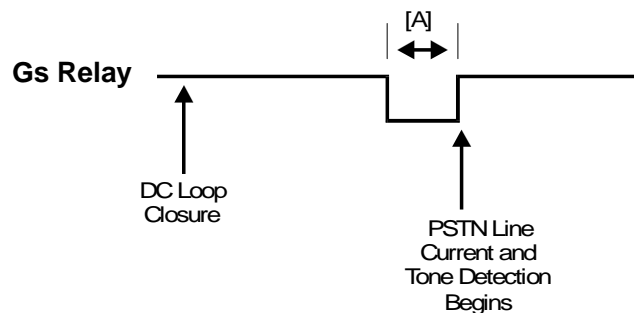
1. Loop Start

After the cpu recognizes the PSTN access code, it monitors the line for line current and dial tone, then starts to dial the destination telephone number.



2. Ground Start

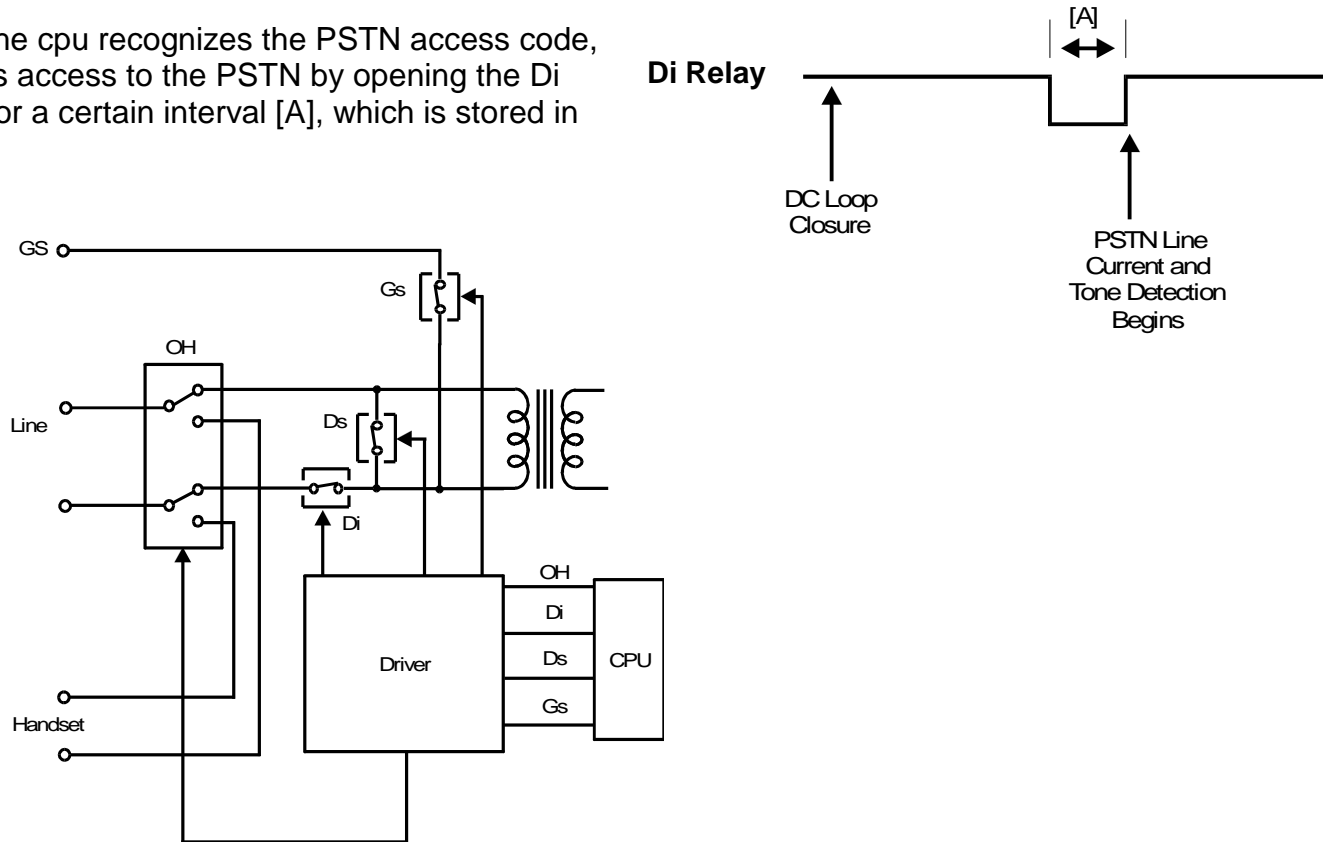
After the cpu recognizes the PSTN access code, it gains access to the line by closing the Gs relay for a certain interval [A], which is stored in RAM.



3. Flash Start

After the cpu recognizes the PSTN access code, it gains access to the PSTN by opening the Di relay for a certain interval [A], which is stored in RAM.

Circuit



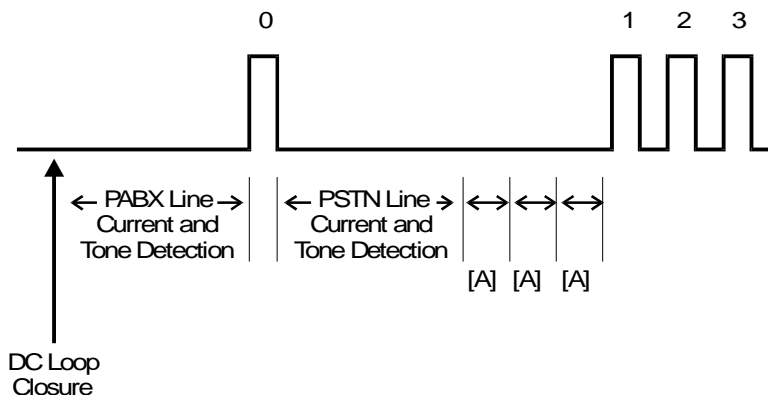
4. Pauses

If the user enters one or more pauses after the access code, the machine monitors the PSTN then waits for the PABX pause time (stored in RAM) for each pause dialed. Then it dials the number.

However, the machine will wait for only one pause:

- If the pause key was pushed more than 8 times consecutively
- If the pause time RAM address contains FF.

Example: 0PPP123



Notes

The access method can be selected by bit switch. The following settings are available; no PABX, loop start, ground start, and flash start.

The PSTN access code can be programmed by bit switch.

The PABX pause time ([A] in the above diagram) can be changed by a RAM address adjustment.

EUROPEAN/ASIAN MODELS

Call Collision Prevention

Overview

After placing a document in the feeder, the user enters the telephone number at the operation panel's ten-key pad, then presses the Start key. The machine then scans the document and stores it in the SAF memory. The machine then prepares to dial.

Note: Remember that for transmissions that do not use the memory, the order of events is different. After the user presses Start, the document is fed partway into the scanner and the machine dials. Scanning and storing is done after the other end has been reached. See Immediate Transmission for details.

However, before the machine dials, it must check whether another call is in progress or not, to prevent a collision of incoming and outgoing signals. If the machine detects that a call is already in progress, it will wait until the line is clear before dialing.

There are two criteria for detecting whether a call is in progress.

1. Has a ringing signal been detected, or is a potential ringing signal still being analysed?
2. Is the local loop with the local telephone exchange closed?

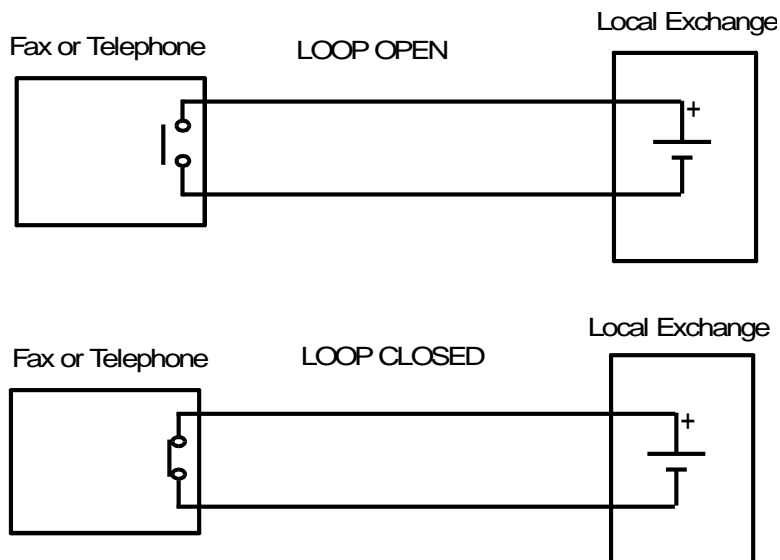
To understand this, we need to understand how a fax machine connects to a PSTN (Public Switched Telephone Network). This explanation begins on the next page.

PSTN Circuit

DC Loop Overview

Every telephone or fax machine is connected to a local exchange of the PSTN through a two-wire pair. One wire is called "Tip" and the other is called "Ring"; these names refer to the tip and ring parts of the plugs used in manual switchboards (in Europe, L1 and L2 are often preferred). This two-wire circuit is known as the "dc loop", or "local loop".

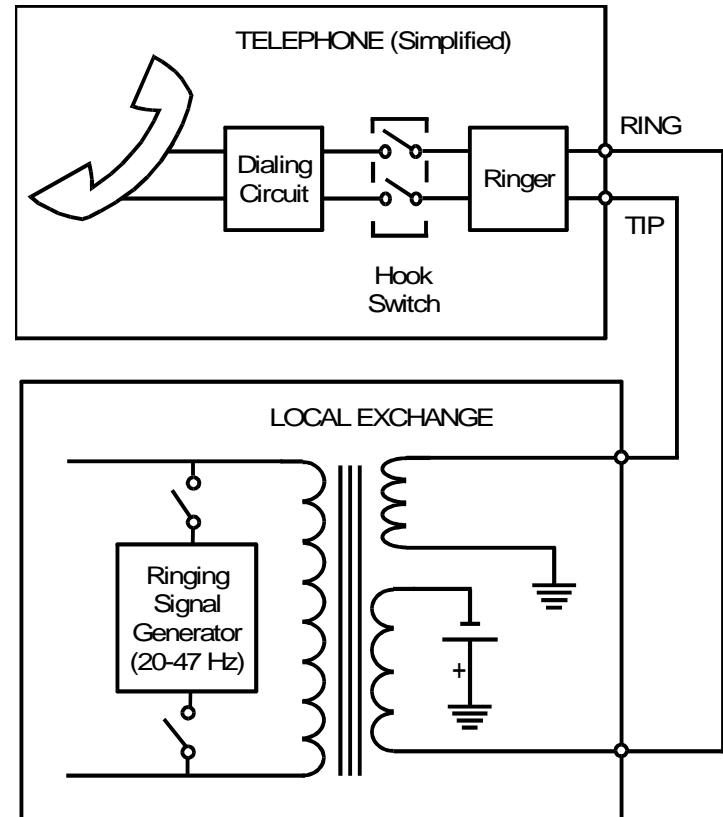
Each telephone and fax machine contains a switch which opens and closes the local loop. When the switch is closed, dc generated by the local exchange flows through the dc loop. The voltage on the dc loop varies from area to area; for example, in the USA, it is about 48 V.



DC Loop through Telephone

When the telephone is on-hook, the hook switch connecting it to the local exchange is open, and dc from the local exchange cannot pass through the dc loop. However, the telephone's ringer is connected (the ringer does not allow the dc from the exchange to pass, but allows the ac ringing signal to pass).

When the handset is picked up, pressure on the hook switch is released, and the switch closes. Then, dc from the local exchange passes through the dc loop.



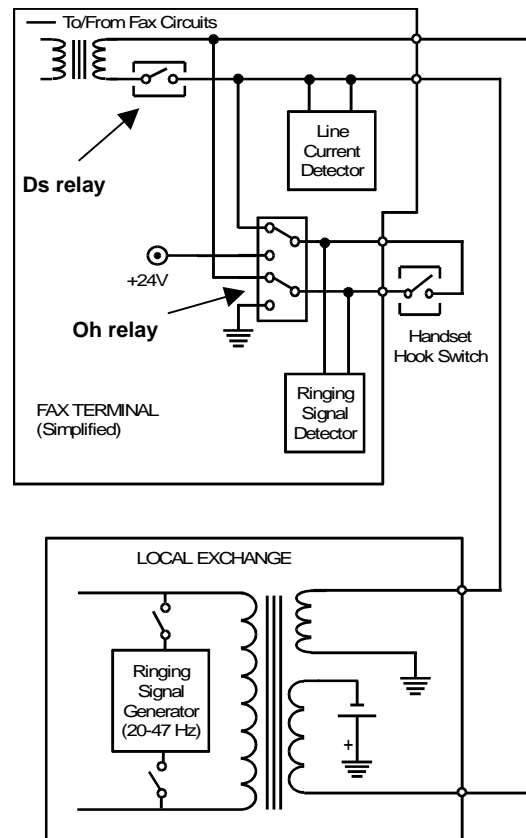
DC Loop through Fax Machine with External Telephone

Inside the fax machine, two components (called the Oh relay and the Ds relay) act as the fax machine's hook switch.

When the machine is in standby mode (as shown above), the Oh relay is set up so that the network is connected to the external telephone (commonly known as the handset); in this set-up, the handset can be used as a normal telephone, as explained on the previous page. The dc loop is open, because the handset's hook switch is open. However, the ringing signal detector in the fax machine and the ringer in the handset are both connected to the line.

When the machine closes the dc loop, it switches over the Oh relay to disconnect the handset from the line. Then it closes the Ds relay to connect the fax machine to the dc loop. The fax machine's cpu will be able to detect dc by monitoring the line current detector.

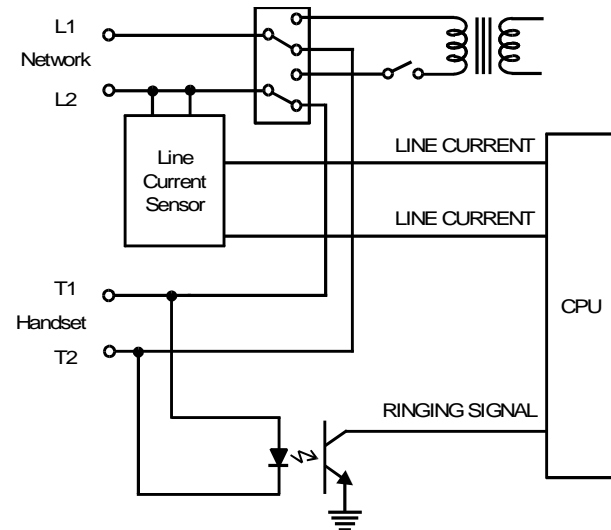
Note: In France, the Di switch is in series with the Oh relay instead of the Ds relay, and the Di relay closes the dc loop.



Call Collision Prevention in Fax Machines

For 0.2 s after the user presses Start, the cpu monitors the ringing signal detector and the line current detector to check that the local loop has not already been closed (if the local loop has been closed, there will be current on the telephone line). If a possible ringing signal is still being analyzed when the user presses Start, the cpu will wait for 8 s, then check whether the signal is still being analyzed.

The call collision prevention circuit is shown below. The circuit shown is for a fax machine in standby mode.



Ringing signal detector: This circuit consists of some zener diodes and a photocoupler. It is adjustable, to allow for variations in ringing signals within Europe. If the voltage of an incoming signal is high enough, it turns on the photocoupler. Then, the cpu detects that its connection to the ringing signal detector has been grounded.

Line current detector: This is a Hall effect sensor. The cpu detects line current when one of the sensor outputs is grounded; the output that is grounded depends on the polarity of the dc on the loop.

DC Loop Closure and Line Monitoring

After it has been confirmed that there is no possibility of call collision, the machine automatically closes the circuit between itself and the local exchange; this circuit is commonly called the dc loop, or the local loop. Closing the dc loop is the fax machine's way of going off-hook before dialing.

In some areas, dialing cannot begin until the machine has checked for dial tone and line current. This is known as "line monitoring".

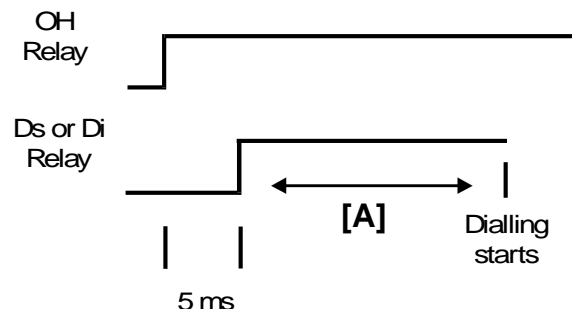
DC Loop Closure

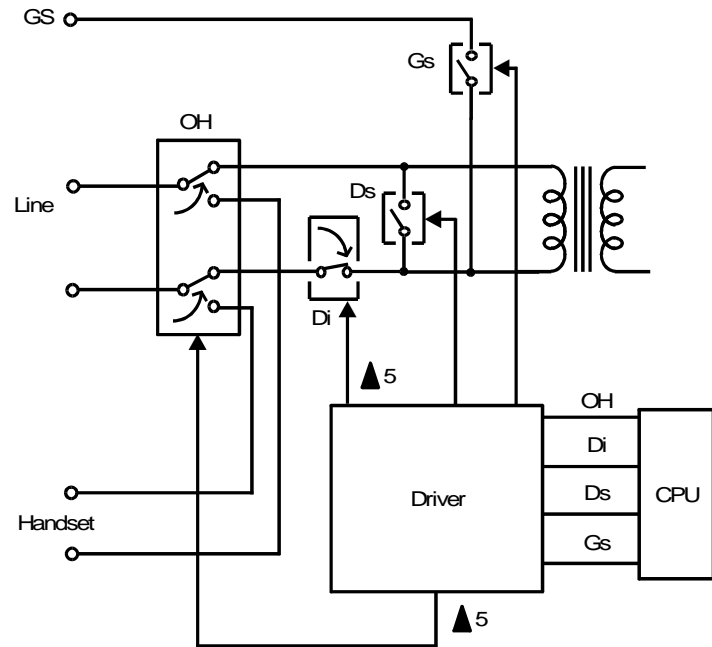
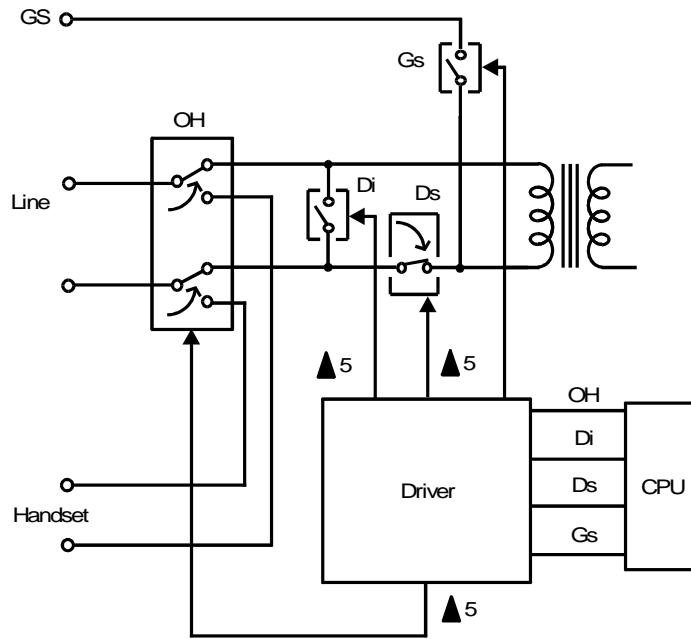
The fax machine closes the dc loop after checking for incoming calls. If there is no incoming call, the cpu closes the dc loop by activating the Oh relay to disconnect the handset from the line. Then, after 5 ms, it closes the Ds relay to connect the fax machine to the line.

The cpu then waits for the 'PSTN wait interval' [A] of about 2 s before starting to dial.

The PSTN wait interval can normally be adjusted by RAM address.

On the following circuit diagrams, curved arrows show the relays switching over from standby mode to close the dc loop.





In most countries, the circuit is as shown in the left-hand diagram (the Ds relay closes the dc loop). In France, the circuit is as shown in the right-hand diagram (the Di relay closes the dc loop). The Gs relay is not used for dc loop closure; it is only shown for reference in these diagrams.

Line Monitoring

Before starting to dial, conditions in parts of Europe require that the machine monitors the line current detector for line current, and signals on the line for dial tone.

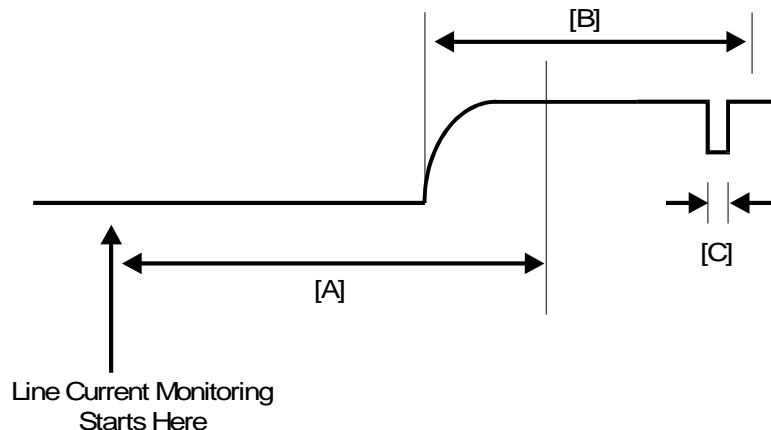
Therefore, in Europe/Asia models, the PSTN wait interval can be replaced by dial tone and line current detection, if required by local conditions. (Dial tone and line current detection are also available in USA versions of some of the more complex models.)

Line Current Monitoring

Line current detection allows the machine to check whether the dc loop has been closed. If there is no line current, the dc loop may still be open.

The machine uses the following parameters to detect line current.

- Line current wait time [A]
- Line current detection time [B]
- Line current drop detection time [C]



[A] starts when the dc loop closes. [B] starts when the line current first reaches the machine.

The machine checks for line current during [A]. Line current must be on the line for [B] or longer before it is recognized by the cpu. If the cpu has not recognized line current during the interval [A],

the machine disconnects. However, if the line current has started but has not been on for [B] when [A] expires, detection continues until it has been on for [B].

After starting [B], the machine continually checks the line current for interruptions. If any single interruption lasts for [C] or longer, the line is cut, [A] and [B] are reset, and the machine returns to stand-by.

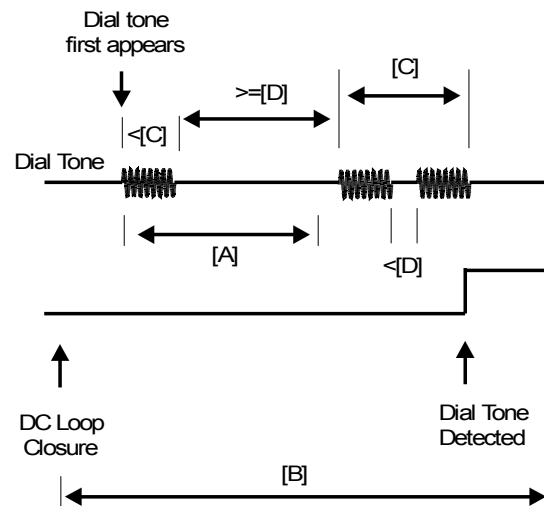
Dial Tone Monitoring

The local exchange sends a dial tone to inform the user that the exchange can accept a telephone number. Dial tone monitoring allows the fax machine to check for this tone before dialing; if there is no dial tone, the exchange may not be ready to accept a telephone number.

The machine uses the following parameters to detect dial tone.

- Acceptable frequency range
- Dial tone detection time [A]
- Reset time [B]
- Continuous tone time [C]
- Permissible drop time [D]

[B] starts when the dc loop is closed. Dial tone must appear before [B] expires. If dial tone appears just as [B] expires, detection continues and the deadline at the end of [B] is ignored.



The machine detects a dial tone when the tone continues for [C] or longer without interruption. Also, [A] must have passed since the dial tone first appeared. Interruptions shorter than [D] are ignored.

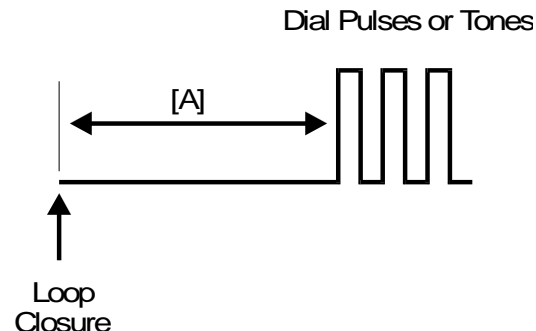
Switching Line Monitoring On/Off

A nation that requires line monitoring has the necessary parameters programmed in the ROM; they are normally activated when the country code (normally a bit switch setting) is set to the code for that nation.

However, if required, line current and dial tone can be disabled; the way to do this varies from model to model.

Similarly, in countries which normally have line monitoring disabled, line current and dial tone detection can be enabled; however, the parameters for detection will have to be stored in the appropriate RAM addresses.

When line monitoring is disabled, the machine waits for the PSTN wait interval [A] before starting to dial.



Note:

The following parameters can be programmed by RAM address.

Line Current Monitoring

Line current wait time

Line current detection time

Line current drop detection time

Line current monitoring on/off

Dial Tone Monitoring

Acceptable frequency range

Dial tone detection time

Reset time

Continuous tone time

Permissible drop time

Dial tone monitoring on/off

Other

PSTN wait interval

Dialing

Overview

After the dc loop has been closed, the machine can dial. In automatic dialing mode, the machine dials in accordance with the number entered by the user at the operation panel, either in full, or as a Quick Dial or Speed Dial.

There are two types of dialing: pulse dialing, and tone dialing. The dialing method must match the dialing mode that can be accepted by the local exchange, or the machine will not be able to dial out.

The dialing method can be chosen by a user function in most countries.

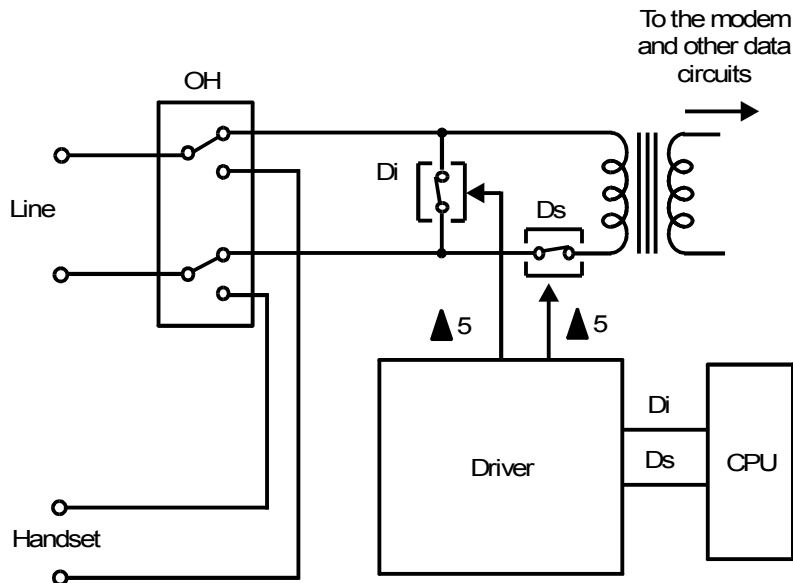
Pulse Dialing

Pulse dialing was originally developed to operate mechanical switching systems in the local exchanges.

The machine sends voltage pulses to the local exchange by interrupting the dc loop. It does this by opening and closing the Di switch. Each digit is represented as a different number of pulses. For example, to dial a "2", the machine sends out 2 pulses.

The Oh Relay remains fixed during dialing (it does not move until the machine returns to stand-by mode). The Di switch is a relay. This is because of PTT requirements in some areas. (PTTs are national telephone network administrative bodies.)

When the Di relay is opened and closed, there are sharp voltage peaks at the leading and trailing edges of the dial pulses, which could damage circuits in the machine. Because of this, an extra relay is added to the dialing circuit; this relay is known as the Ds relay. The Ds relay is opened while the Di relay is dialing, to prevent voltage spikes from damaging the machine.

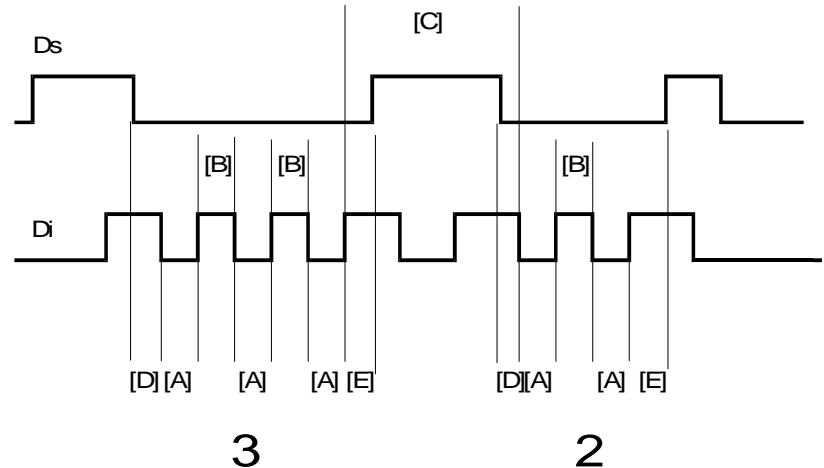


Each digit of the telephone number is sent out as a pulse train. The cpu sends out the dial pulses by switching the Di and Ds relays in accordance with the following timing.

Example: Dialing 32

The time that the Di relay opens is called the break time [A] and the time that it closes is called the make time [B]. Each pulse sent out on the line is made by opening and closing the Di relay.

A minimum pause [C] is required between each digit, regardless of whether the user pressed the pause key while dialing.



Notes:

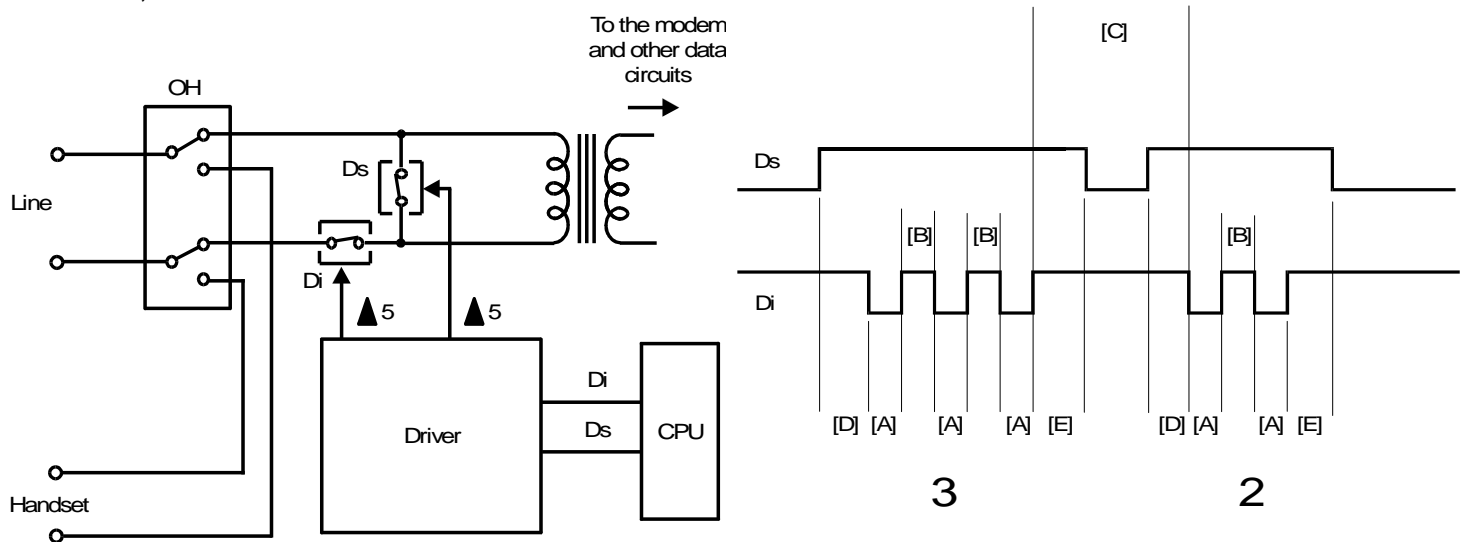
Most countries dial in the same way (the number of pulses sent out [P] is the same as the number dialed [N]). However, some areas require different types of pulse dial signals. For example, in Oslo, P must be $10 - N$, and in Sweden, P must be $N + 1$. The required mode can be selected by bit switch adjustment.

Pulse dialing can be done at two rates: 10 pulses per second (pps) or 20 pps. If the local exchange can only handle 10 pps dialing, the machine must not be set to dial at 20 pps. The dial pulse rate can usually be adjusted by bit switch.

Parameters A to E illustrated on the diagrams in this section are programmable.

For pulse dialing at 10 pps, the times stored in the NCU parameters are used as explained in this section. However, at 20 pps, only half the values in parameters A, B, D, and E are used, and three-quarters of the value in parameter C.

In France, the relay circuit and the relay timing are different, as already mentioned. The principle is the same, however.



Tone Dialing

Overview

Each dialed digit is sent out as a DTMF (Dual Tone Multi Frequency) tone, which is a mixture of two frequencies. The following diagram shows what frequencies are generated for each digit on a typical telephone keypad. For example, a '5' is represented by a 770 Hz tone combined with a 1,336 Hz tone.

The DTMF tone frequencies are the same throughout the world. They were carefully chosen so as not to coincide with other frequencies that may occur on the line.

In some types of telephone equipment, the DTMF circuit remains on line after the call has been connected. This allows the use of DTMF tones for giving orders to the remote terminal (e.g., extracting information from a remote database).

The advantages of using DTMF over pulse dialing are as follows.

- Dialing is faster
- DTMF tone generation circuits are compact solid-state circuits
- There can be end-to-end signalling after call connection, as mentioned in the previous paragraph

	1209	1366	1477
697	1	2	3
770	4	5	6
852	7	8	9
941	*	0	#

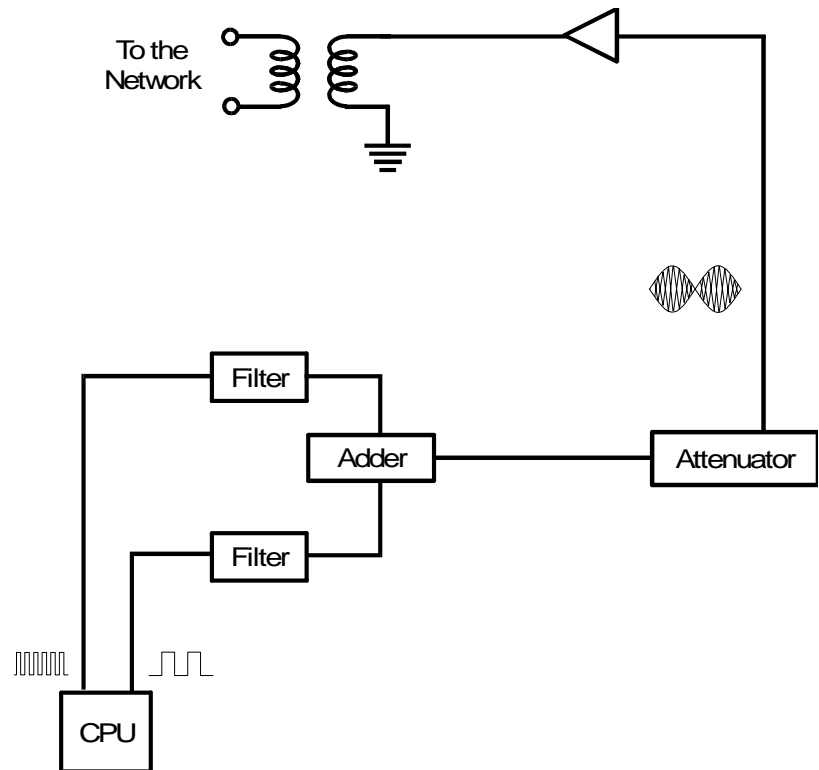
DTMF Tone Generation

The diagram shows how DTMF tones are generated in fax machines.

The cpu generates two square waves of the required frequencies. These each pass through a low pass filter to remove noise, and are added together.

In the attenuator, the DTMF tone is attenuated. The attenuation value is different from that used for the attenuation of facsimile data.

The DTMF tone is then amplified to compensate for the signal loss between the attenuator and the telephone line. The tone then passes to the line through the Ds or Di relay and the Oh relay, which remain fixed during tone dialing.



Attenuation of DTMF Tones

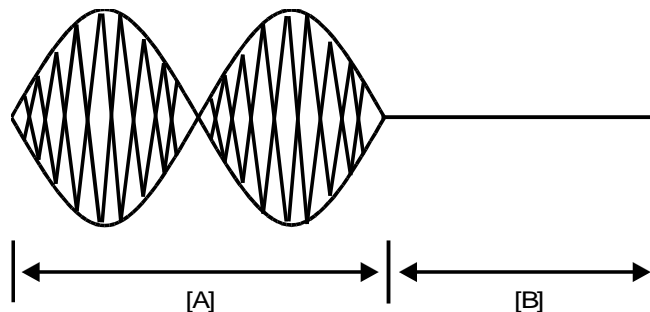
A variable resistor can be used to adjust the signal level within a range of about 2 dB.

Note: The DTMF tone attenuation value can be adjusted by RAM address. However, unlike the attenuation value for facsimile data, it cannot be adjusted using dedicated transmission parameters or bit switches.

Timing

DTMF tones are sent out during the DTMF on time [A] as shown in the diagram.

Note: The DTMF tone on time [A] and off time [B] can be adjusted by RAM address.



Pauses

If the user dials a pause using the Pause key, the machine waits for a pre-programmed interval before sending the next tone or pulse.

Note: The pause interval can be changed using a RAM address adjustment.

Signal Detection

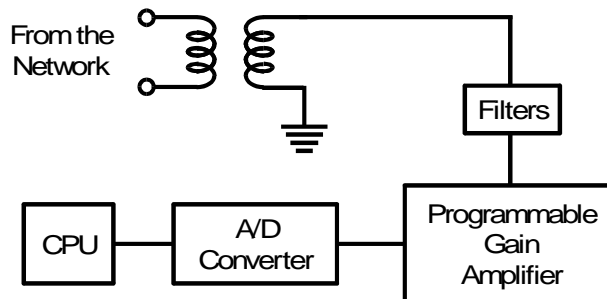
Overview

After dialing, the machine waits for the response from the other end. The response is usually either a CED tone, a busy tone, or a ringback tone. These tones are known as progress tones. Instead of a progress tone, a protocol signal such as NSF or DIS may be detected at this time.

The received signal passes through two filters. A high pass filter (with a cut off of about 300 Hz) removes low frequencies, such as noise from the fax machine's power supply, and a low pass filter (with a cut off of about 2100 Hz) removes high frequencies, such as noise from overhead railway power cables.

The signal then passes to a programmable gain amplifier, which raises the signal level enough for the machine's hardware to analyze it. The minimum signal level on the line will vary from country to country, so the amplifier is programmable. For example, in typical USA models, the amplifier is set up so that signals weaker than -53 dBm are not detected.

The amplified signal is converted to digital, then passed to the tone detector in the cpu.



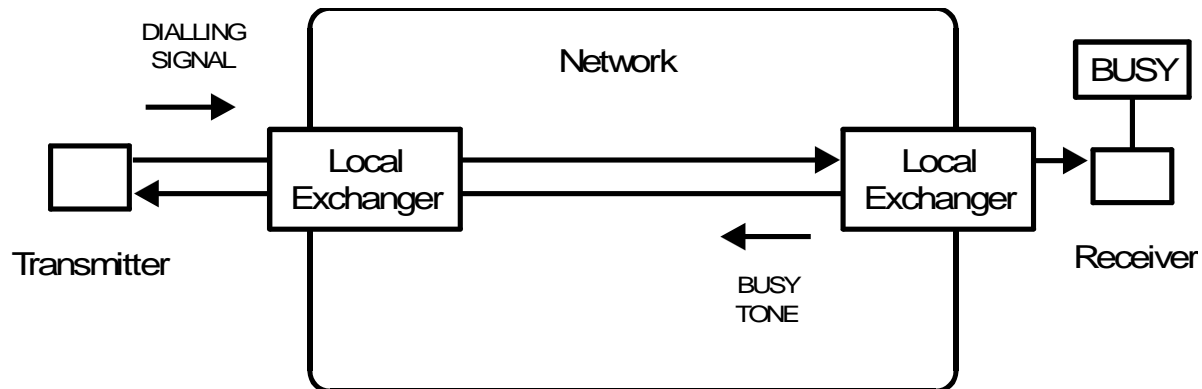
The incoming signal may determine whether or not the machine goes into transmit mode. Most machines have bit switch or other settings to determine when the machine goes into transmit mode. The choices are typically as follows:

- After dialing
- After receiving NSF or DIS
- After receiving CED

Note: The gain of the amplifier depends on the country code (the country code is selected by a bit switch adjustment). However, the gain can be changed by a RAM address adjustment; in most machines, there are 4 possible values to choose from.

Busy Tone Detection

If the call has gone through and if the called terminal is already off hook (i.e., the other end is busy), the local exchange at the other end sends back a busy tone.



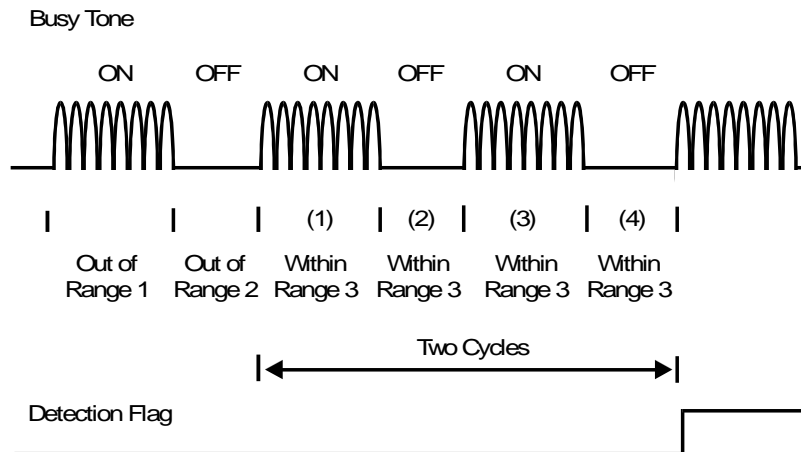
If the machine detects busy tone, it will disconnect the line. The number will be redialed (see Redialing), unless the maximum number of redials have already been made.

If busy tone detection is disabled and the line is busy, the machine will hold the line until the ITU-T T1 timer (about 1 minute) runs out. So busy tone detection can reduce the amount of time the machine holds the line.

- Busy Tone with Cadence -

In many countries, the busy tone has a cadence (a fixed on-off cycle), so the machine measures the on and off times of the received signal and compares them with values programmed in the RAM.

RAM addresses specify four permissible lengths for each signal state. The machine first checks if the signal has a length within range 1. If it does not, then range 2 is selected, and so on. An example is shown below, in which the on-off time durations are found to be within range 3.



Note

The following values are stored in RAM.

- Range 1, ON time Range 1, OFF time
- Range 2, ON time Range 2, OFF time
- Range 3, ON time Range 3, OFF time
- Range 4, ON time Range 4, OFF time
- The number of cycles required for detection (for example, a setting of 4 means that ON-OFF-ON or OFF-ON-OFF must be detected twice).

- ON or OFF time tolerance (+/-), for ranges 1 to 4.
- Acceptable signal frequency range

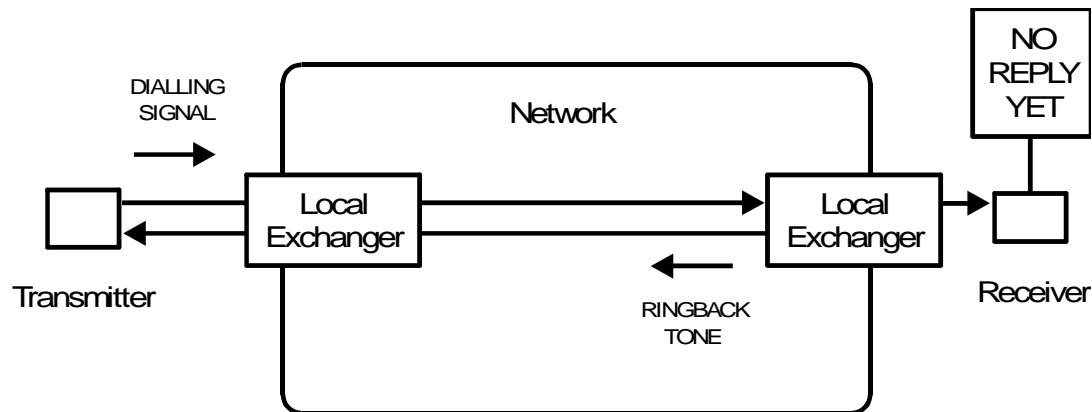
- Continuous Busy Tone -

In some countries, such as the UK, the busy signal is not a cadence. The busy tone must continue for a certain time before the machine detects it.

Note: The minimum time required for continuous busy tone detection is stored in RAM.

Ringback Tone Detection

If the call has gone through and if the called terminal is on hook, the local exchange at the other end sends a ringing signal to the called party; at the same time it sends a ringback signal back to the caller.



Ringback tone detection is always switched on in Austria. Ringback tone is detected if the ringback tone is longer than the minimum ringback tone detection time (0.1 s), which is stored in RAM.

- If the machine at the other end is a telephone -

When the phone rings at the other end, the transmitting machine detects ringback tone. The other party picks up the handset when the phone rings, and replaces it when there is no voice on the line. Then, the local exchange at the receiving end sends back a busy tone to the transmitter (this is normal in Austria).

When the transmitter detects this busy tone, it immediately disconnects the line without waiting for the ITU-T T1 time to expire. Ringback tone and busy tone were both detected on this call; in such cases, the software in the transmitter disables automatic redialing for this number.

Note: In Austria, it is necessary to prevent a fax machine from redialing addresses for which the T1 timer expired on the first attempt.

- If the machine at the other end is a fax machine -

In Austria, the receiving fax machine will close the dc loop after it has detected one ringing signal. (So, the ringback tone to the transmitter will be short, but not too short for detection.)

Immediately after closing the dc loop, the receiving machine will send CED. If the user at the receiving end presses Stop after this, both machines will disconnect immediately.

The transmitter will not receive busy tone from the other end, as it has already disconnected, so the number can be redialed automatically.

Note

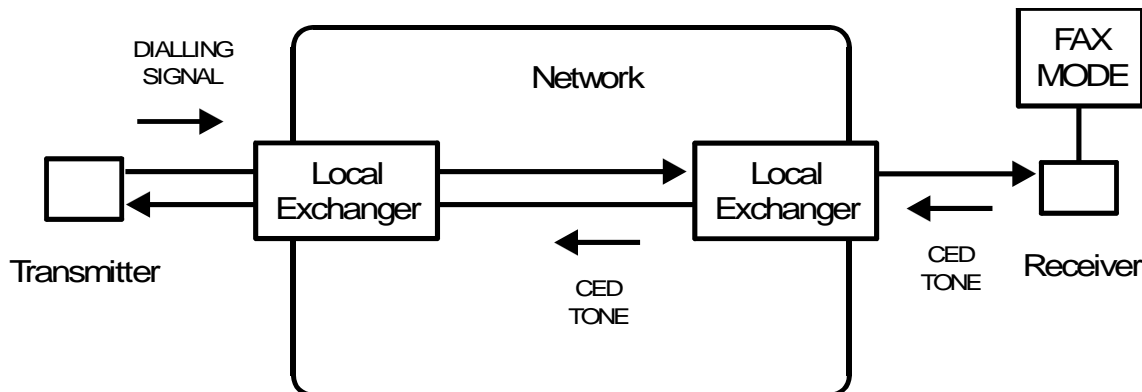
The ringback tone has the same frequency as the busy tone.

The only RAM address that must be programmed for ringback tone detection is as follows.

Ringback tone detection time

CED Detection

If the receiver is a fax terminal in Auto Receive (Fax) mode, it will emit a 2100 Hz tone called CED.



This signal informs the caller that they have connected to a fax machine. CED is the high-pitched tone that prompts the user to press the Start key when using Manual Dialing.

In automatic dialing mode, the transmitting fax terminal confirms CED detection when the CED tone continues for 200 ms or more. Then it starts to scan the document.

Data Transmission

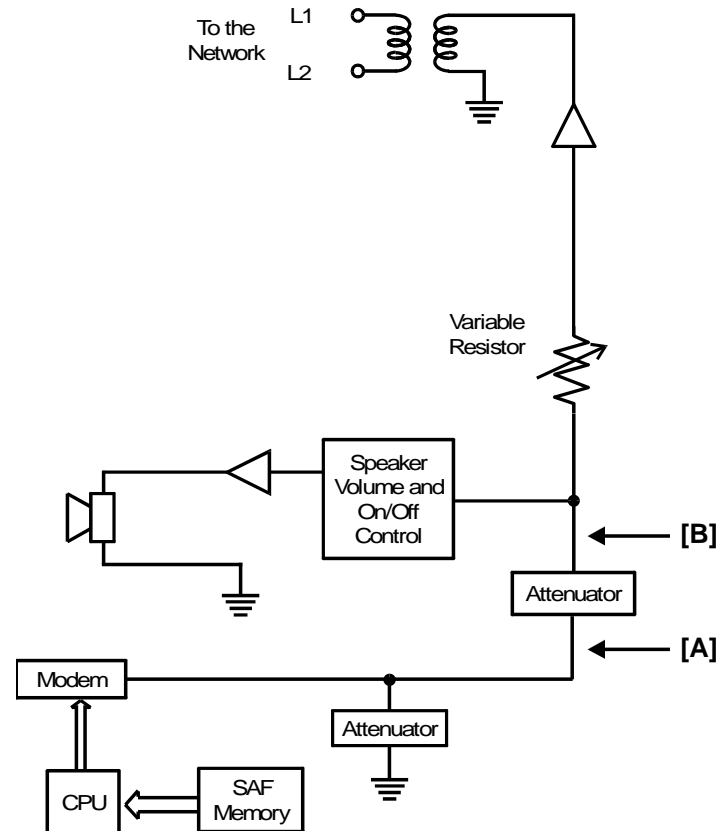
The data transmission circuit is shown on the right. The cpu retrieves the data from the SAF memory, processes it, and passes it to the modem. The modem modulates the data to convert it into a form that is suitable for transmission over the public telephone network. The data is then attenuated to the correct signal strength for transmission.

Details of the major steps follow.

Processing in the CPU

Outline

The cpu retrieves the data from the SAF memory and reconstructs it (if it was compressed before storage into the SAF). The cpu then processes the data before sending it to the modem. The signal to the modem is eight-bit parallel, with one bit representing one picture element (unless the data was reduced—see *Digital Processing* for details on reduction).



Compression

Compression reduces the number of bits in the data signal, and therefore the transmission time for one page.

MH, MR, and MMR compression are done according to ITU-T standards.

A proprietary procedure called EFC (Estimated Fillbit Control) may be applied to the compressed data. EFC is not strictly a compression technique, but it improves the efficiency of data transfer by controlling the number of fill bits inserted by the transmitter at the end of each line of data (see below).

The data is compressed in accordance with the method agreed in the protocol between the transmitting and receiving machines. In the obsolete Group 2 and Group 1 modes, the data is not compressed before transmission.

Brief explanations of the different coding types follow. MH and MR coding are explained in detail in the ITU-T recommendations for Group 3 facsimile.

MH—Every line is MH coded.

MR—Data is treated in blocks of 2 lines (in Standard or Detail resolution) or in blocks of 4 lines (in Fine resolution). The first line of each block is MH coded, then the remaining lines in the block are MR-coded using the first line as the reference line.

SMR—This is similar to MR coding except that data is treated in blocks of 8 lines (in Standard or Detail resolution) or in blocks of 16 lines (in Fine resolution).

MMR—Data is treated by the page (or the ECM block if the page needs more than one block). The first line of the page is MH coded, then all the following lines on the page are MR coded using the first line as the reference line. In some models, MMR is only done for storing data into memory, or if ECM is being used.

EFC—The sending machine only includes fill bits in the data stream when the FIFO memory in the receiver is full (normally fill bits are always added to the end of any line that is sent out in less than the time specified by the I/O rate).

New EFC—Fill bits are never added to the data, and the receiver uses the SAF memory or hard disk instead of the FIFO memory. If the receiver's memory is full, it sends PIN and the line is disconnected.

If ECM (the extension to Group 3 protocol known as Error Correction Mode) is used, EFC and New EFC are not used.

The compressed data goes out to the modem on the data bus.

Compression is described in more detail in the section on [compression](#).

Data Transfer to the Modem

I/O rate: The I/O rate is the amount of time needed for the scanner or printer to process one scan line of image data (modulation and demodulation are not included in this time). On the transmitting side, it indicates the time needed to scan, process, and compress a scan line. On the receiving side, it indicates the time needed to reconstruct, process, and print a scan line. In Group 3 transmission without ECM, I/O rates of the communicating machines must be the same. If ECM is used, I/O rate is not used (0 ms/line is assumed).

Without ECM

The FIFO synchronizes the transfer of video data to the modem (transmission) or from the modem (reception). It also acts as a buffer, ensuring that there is always some data for the modem to pick up, modulate, and send out.

The FIFO has some unique functions, in addition to synchronizing data transfer from the CPU to the modem, as explained below.

Without EFC (Estimated Fillbit Control): During the protocol exchange, I/O rate capabilities are compared. The I/O rates of both terminals must be the same during communication. The maximum I/O rate of the slower machine is used. Say that the chosen I/O rate is 10 ms/line. If the sending machine takes less than 10 ms to scan, process, and compress a particular scan line, it adds fill bits (zeros) to the end of the compressed scan line to make up the extra time. This keeps the two machines synchronized.

With EFC: If EFC is used, the two terminals' FIFO sizes are compared during the protocol exchange, as well as the I/O rates. During transmission, the sending machine continually estimates how much

space remains in the receiver's FIFO (the I/O rate, receiver's FIFO size, and amount of data sent are used in this estimation). Fill bits are not added to the end of each scan line, unless the receiver's FIFO seems to be getting full; the transmitter then sends fill bits (zeros) until there is some space in the FIFO. This system speeds up data transfer between the terminals.

With ECM

All compressed image data for an ECM block (normally one page, unless halftone is used) are held in the ECM memory, and assembled into protocol frames before transmission.

At the receiving end, printing does not start until the whole block of data has been received. Therefore, there is no need to synchronize the scan line I/O rate of the two machines.

The FIFO is not needed for ECM; the ECM memory at each end acts as a buffer memory.

Printing is not done until a block of data has been assembled in the receiver's ECM memory. Therefore, there is no real time synchronization of the scan line I/O rate of the two machines. Because of this, no fill bits need to be exchanged between the terminals. This means that EFC is not used with ECM.

Note: In laser printers, the I/O rate is also 0 ms/line during reception. This is because the data is assembled in a page memory before printing.

ECM is described in more detail in the section on fax protocol, and EFC is described in more detail in the section on compression.

Modulation

The data passes to the modem on the data bus as 8-bit parallel data. The modem converts this to serial and modulates it before passing it on to the network interface circuits.

Modulation techniques are described in detail in another section.

Attenuation

The signal is then attenuated and passed to the line.

For G3 and V.21 protocol signals, the attenuator ensures that the signal level output to the line matches the value programmed in the bit switches for tx signal level.

If the number is dialed as a Speed or Quick Dial, any value stored for tx level in the dedicated transmission parameters for this address will be used instead of the bit switch value.

Note: For G2, G1, and PIS (462 Hz) signals, the output to the line is slightly different than for G3. For example, if the bit switches specify -9 dBm, the different types of signal will have the following level on entering the network. The following values differ from model to model.

G3, V.21: -9 dB

G2, PIS (462 Hz): -8 dB

G1: -12 dB

There is also a variable resistor, which can be used to adjust the signal level within a small range, typically 2dB.

Exit to the Network

The signal then passes through an amplifier, which raises the signal level to make up for the signal loss as the data passes out to the line through the network interface circuits. The data then passes to the line through the Di (or Ds) and OH relays, which do not change position during data transmission.

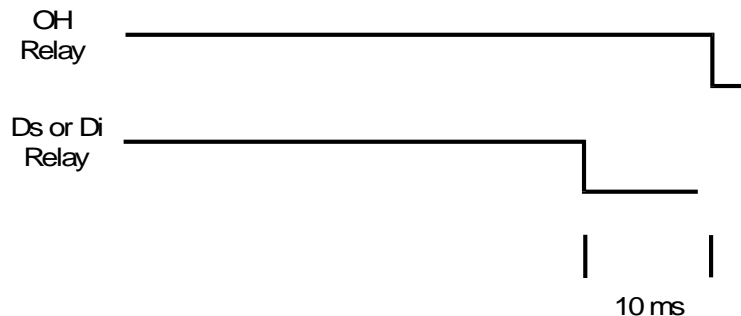
Notes

1. The transmission level can be changed by bit switch, if local line conditions make it necessary.
2. Dedicated transmission parameters are three bytes of settings, that can be programmed for each Quick Dial Key and Speed Dial Code. The settings include transmission level, and initial modem rate. The settings can be programmed to suit the line conditions normally encountered when sending to the terminal stored in the Quick Dial Key or Speed Dial Code.
3. ECM is normally on. In some models, it can be switched off for a particular destination using dedicated tx parameters, or for all destinations by bit switch adjustment.
4. If transmitted signals are degraded (especially at higher frequencies) because of the length of wire between the modem and the local exchange, try adjusting the cable equalizer by bit switch. There are normally four values available, including zero (off).
If the cable equalizer is switched on, high frequencies are made louder and low frequencies are made softer. The cable equalizer characteristic may vary depending on the modem in use. Modems used in fax machines generally raise the levels of frequencies between 1700 Hz and 3000 Hz, and reduce the levels of frequencies between 1700 Hz and 300 Hz.
If the cable equalization is overcorrected, output signals will be degraded again, leading to unnecessary modem rate fallback during training.

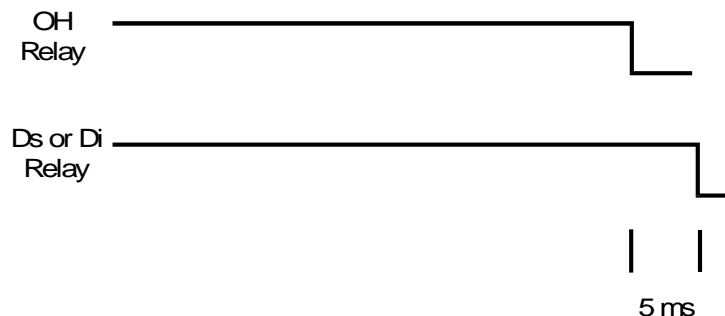
Return to Standby

After transmission, the next step depends on the status of the handset hook switch.

If the handset is on hook at the end of the communication, the cpu turns off the Ds relay to disconnect the fax machine from the dc loop, then the Oh relay in accordance with the timing diagram on the right.



If the handset is off hook (for example, if the Voice Request feature was being used), the Oh relay switches off before the Ds relay, as shown on the right.



Notes:

- The difference in timing is to meet PTT requirements in some European countries.
- In France, the Di relay opens the dc loop instead of the Ds relay.

Finally, the cpu turns off the power to all components except those needed for monitoring the machine and telephone line in standby mode. The machine is now back in standby mode.

Note: The machine must wait for a minimum amount of time before dialing the next number. This interval is normally stored in RAM and can be adjusted. However, there may be a government requirement regarding the value, as for most of the adjustable communication parameters that are discussed in this manual.

Others

Manual Dialing

Outline

An outline of the steps taken follows.

Document Detection: The user places the document in the feeder, and the tx motor feeds the document to the scan line.

Document Feed, Video Processing: These steps are the same as for automatic dialing.

DC Loop Closure, Dialing, and Signal Detection: The user picks up the handset. The handset hook switch closes the circuit between the machine and the telephone exchange (known as the dc loop). The user listens for dial tone then dials. The user presses Start after hearing a signal from the other end. There is no automatic call collision prevention after the user presses Start.

Data Transmission, Return to Standby: These steps are the same as for automatic dialing.

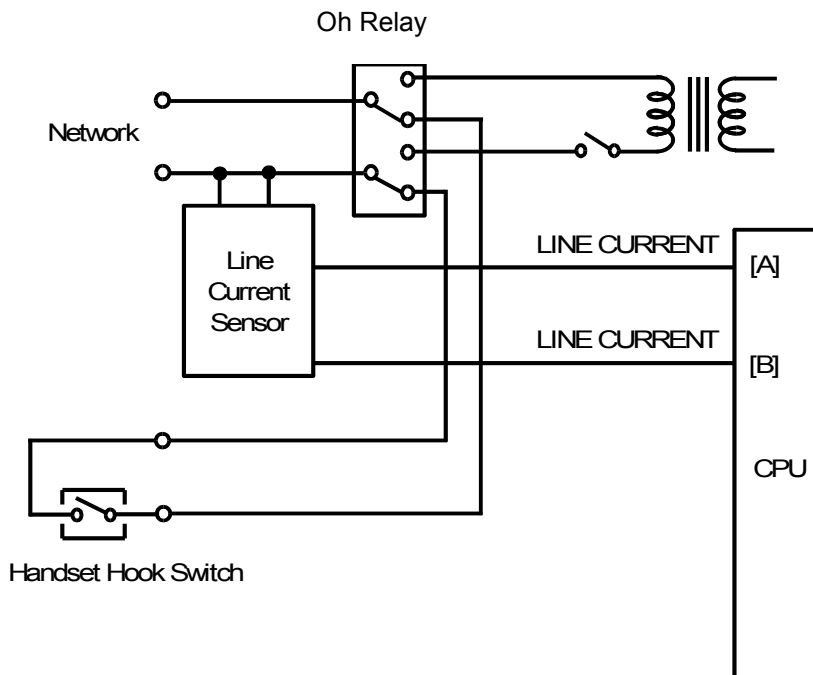
Picking up the Handset

After placing the document in the feeder, the user picks up the handset. The hook switch in the handset closes the dc loop between itself and the local exchange. The CPU detects dc loop closure when pin [A] or pin [B] goes low; the pin that goes low depends on the polarity of the circuit.

Dialing

When the CPU detects the dc loop, the operation panel LED prompts the user to dial.

- **Dialing from the handset:** The dial switch or tone generator in the handset sends the dial signal out to the line. The user presses Start after hearing a signal from the other end.
- **Dialing from the ten-key pad:** When the first number is input at the ten-key pad, the Oh Relay switches into the up position (see the previous diagram). After the dial pulses or tones have gone



out to the network, the Oh relay switches over again to connect the handset to the line. The user presses Start after hearing a signal from the other end.

The cpu then connects the line to the fax machine by turning on the Ds relay (or Di relay in France) then switching over the Oh relay 10 ms later. This is the opposite of the dc loop closure procedure for automatic dialing.

The reason for the above is as follows. If the Oh relay is closed first, the dc loop already established between the handset and the local exchange would be disconnected and the call would be terminated. So, the Ds relay is closed first. There are now two dc loops; one to the handset, and one through the fax circuit. Then the Oh relay disconnects the handset to leave the fax machine connected to the local exchange. In automatic dialing, there is no dc loop formed with the local exchange at this time, so the Oh relay can be switched over first without disconnecting the call. See the DC Loop Closure and Dialing sections for details of the automatic dialing circuit.

Document feed, video processing, data transmission, and return to standby then proceed as previously described.

The user may pick up the handset during communication (for a voice request), or before a document is placed in the feeder (for example, to make a phone call).

When the user picks up the handset, the hook switch inside the handset closes.

If this is done in standby mode, the dc loop then forms through the hook switch in the handset. The cpu detects line current, which informs it that the handset has been picked up.

If the user picks up the handset after the dc loop has been closed (for example, to answer a voice request), the cpu cannot directly detect that the handset has been picked up. The user has to press

the Stop key after picking up the handset. Then the Oh relay switches over to connect the handset to the local exchange.

Immediate Transmission

An outline of the procedure follows.

Document Detection: The user places the document in the feeder, and the cpu turns on the fluorescent lamp when it detects the document.

Call Collision Prevention, DC Loop Closure, Line Monitoring, Dialing, and Signal Detection:

After the user has pressed Start on the operation panel, the machine feeds the first page partway into the scanner. The machine then dials the other party, before scanning the document.

Document Feed: When the other terminal has been reached and handshaking and modem training have been done, the machine scans the document. The page is stamped if transmission was successful.

Video Processing: While the machine scans the document, it converts the scanned data to digital, and passes it through the video processing circuits.

Data Transmission: The data passes to the telephone line through the modem and network interface circuits.

Return to Standby: After all data has been transmitted, the page is fed out. The machine returns to standby.

Redialing

If there is a line failure, or if the line is busy, the machine can redial the same number automatically, as defined by parameters stored in RAM. (Also, the user can redial immediately by pushing the Redial key.)

There are RAM addresses to control the following:

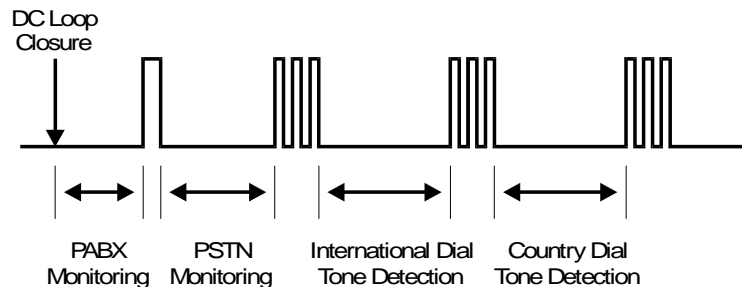
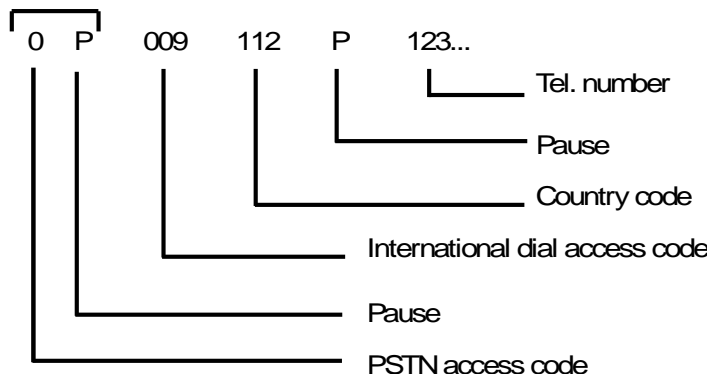
- Redialing (memory transmission)
- Redialing (immediate transmission)

International Dialing

Some national PTTs require automatic detection of international dial and country dial tones.

International numbers are dialed as follows.

If behind PABX



International dial tones and country dial tones are detected in the same way as PSTN dial tones, except that the timers and frequency limits are different.

Note:

The necessary parameters are held in RAM.

International Dial Tone

Acceptable frequency range

Reset time

Permissible drop time

Detection time

Continuous tone time

Wait interval

Country Dial Tone

Acceptable frequency range

Reset time

Permissible drop time

Detection time

Continuous tone time

Wait interval

Other

International dial access code

Auto Dialing from behind a PABX

Outline

The procedure is as follows.

Document Detection, Document Feed, Video Data Processing, Call Collision Prevention, DC Loop Closure: These are the same as for transmission without a PABX. When the machine goes into transmit mode, it checks for incoming calls, then it connects to the PABX by switching over the Ds relay (or Di relay in France) and the Oh relay.

Line Monitoring: Some local conditions require the machine to monitor the line for PABX line current, dial tones, busy tone, and ringback tone. If line monitoring is disabled, the machine waits for the PABX wait interval before going on to the next step (in the USA, this interval is 2 s).

Access to the PSTN: The machine must gain access to the PSTN through the PABX (by dialing an access code for example).

Line Monitoring, Telephone Number, Dialing, Signal Detection, Data Transmission, Return to Standby: These are the same as for transmission without a PABX.

Line monitoring and access to the PSTN are explained in more detail on the following pages.

Line Monitoring

1. Line Current

This is the same as for PSTN line current detection.

2. Dial Tone

The machine monitors the line for PABX dial tone in the same way as when it monitors the line for PSTN dial tone. However, the following parameters for dial tone detection are different and are stored in separate RAM addresses.

- Acceptable frequency range
- Detection time
- Reset time
- Continuous tone time
- Permissible drop time

If PABX line monitoring is enabled and parameters are already programmed, you can disable dial tone detection. The method differs from model to model.

If PABX dial tone detection is disabled, the machine will wait for the PABX wait interval (see the next page) before dialing the PSTN access code. This interval is stored in RAM.

3. Busy Tone Detection

This is the same as for basic transmission, except that the following parameter has a separate RAM address.

- Acceptable frequency range

4. Ringback Tone Detection

This is the same as for basic transmission, except that the following parameter has a separate RAM address.

- Detection time

Access to the PSTN

The machine sends out the first digit of the phone number, which should be the PSTN access code. The PSTN access code is programmed by bit switch.

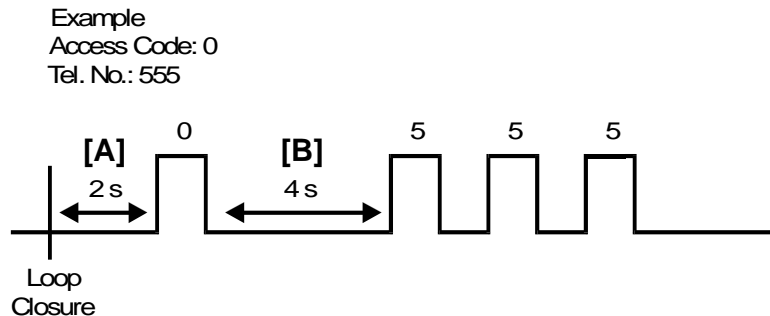
If this first digit is the same as the value specified by the bit switch, the cpu recognizes the access code and starts to monitor the line from the PABX.

Note that the PSTN access code can be a two-digit code. In this case, the cpu monitors the line for line current and dial tone after the user dials the two-digit code specified by the access code bit switch.

If line monitoring is disabled, the cpu waits for preset intervals before dialing. The intervals are:

- [A]: PABX wait interval
- [B]: PSTN wait interval; this is the same as the interval discussed in DC Loop Closure.

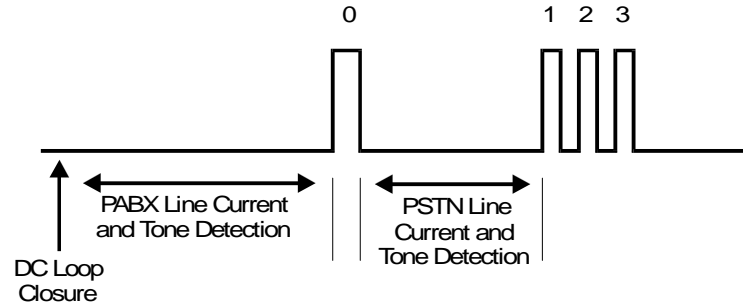
Both intervals are stored in RAM and can be adjusted. The above diagram shows the set-up for the USA; A is 2 s and B is 4 s.



The next step depends on the PSTN access mode selected. There are three types: loop start, ground start, and flash start.

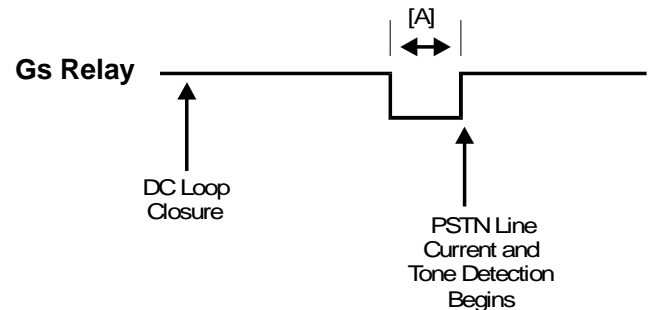
1. Loop Start

After the cpu recognizes the PSTN access code, it monitors the line for line current and dial tone, then starts to dial the destination telephone number.



2. Ground Start

After the cpu recognizes the PSTN access code, it gains access to the line by closing the Gs relay for a certain interval [A], which is stored in RAM.



After the cpu recognizes the PSTN access code, it gains access to the PSTN by opening the Ds relay for a certain interval [A], which is stored in RAM. (In France, the circuit is different; the Di relay is used. See DC Loop Closure.)

cpu recognizes the PSTN access code, access to the PSTN by opening the Ds a certain interval [A], which is stored in France, the circuit is different; the Di used. See DC Loop Closure.)

The diagram illustrates the internal circuitry of a Ds Relay and its timing sequence. The circuit includes a transformer with two windings. The primary winding is connected to a 'Line' input through a switch labeled 'OH'. The secondary winding is connected to a 'Driver' block, which in turn controls a switch labeled 'Ds'. The 'Ds' switch is connected to a 'CPU' block, which has four output lines labeled 'OH', 'Di', 'Ds', and 'Gs'. The 'Di' line is connected to a switch labeled 'Di', which is connected to the 'Line' input. The 'Gs' line is connected to a switch labeled 'Gs', which is connected to the 'Line' input. The 'Handset' is connected to the 'Line' input. The timing diagram shows the 'Ds Relay' output as a square wave. The 'DC Loop Closure' occurs when the relay output transitions from high to low. The 'PSTN Line Current and Tone Detection Begins' interval, labeled [A], starts when the relay output transitions from low to high.

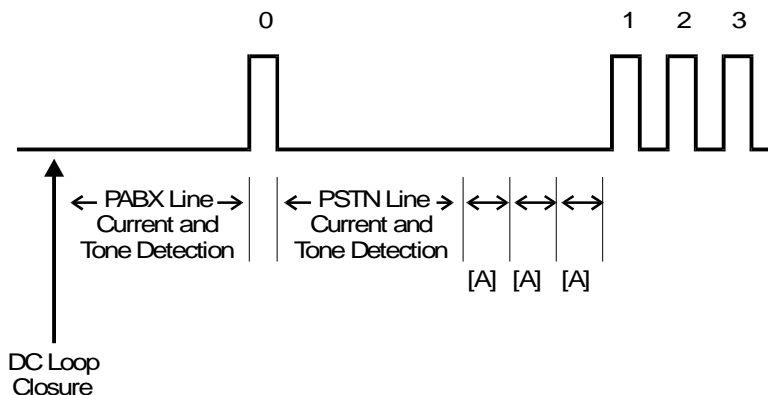
4. Pauses

If the user enters one or more pauses after the access code, the machine monitors the PSTN then waits for the PABX pause time (stored in RAM) for each pause dialed. Then it dials the number.

However, the machine will wait for only one pause:

- If the pause key was pushed more than 8 times consecutively
- If the pause time RAM address contains FF.

Example: 0PPP123



Notes

The access method can be selected by bit switch. The following settings are available; no PABX, loop start, ground start, and flash start.

The PSTN access code can be programmed by bit switch.

The PABX pause time ([A] in the above diagram) can be changed by a RAM address adjustment.

Reception

Overview

This section explains how a fax machine receives a fax message. The base of the description will be for Auto Receive (Fax) Mode. Points concerning Manual Receive (Tel) Mode and Auto Select (Auto) Mode are discussed in the relevant sections. In addition, a section at the end explains additional features.

Below follows a brief summary of the individual steps for Auto Receive Mode. These steps are basically the same for most machines.

Ringing Signal Detection—When someone sends the unit a fax, the local exchange sends a ringing signal to the unit. The CPU monitors the ringing signal detector. If Manual Receive Mode has been selected, ringing signal detection is disabled.

Loop Closure—When the CPU confirms that the incoming signal is a ringing signal, it closes the dc loop with the local exchange. If the caller is not a fax machine, the unit will send out the pre-programmed voice message, if it has been enabled (some models do not have this feature). This section also explains how the machine treats an incoming call if the machine is in Manual Receive Mode or Auto Select Mode.

Data Reception—Data from the line passes to the modem and to the CPU.

Printing – The machine prints the fax message and feeds it out. *This process is not described in this section.*

Return to Standby—After the final page has come in, the unit disconnects the line. After printing has finished, the unit disconnects the dc loop (in exactly the same way as for the end of transmission). Note that if the message is received to memory first, printing takes place after the whole message has been received and the machine has disconnected itself from the telephone line. *This is explained in the Transmission section.*

The circuits for European and Asian models are different from those for North American models. Because of this, two separate sections have been prepared.

North American Models

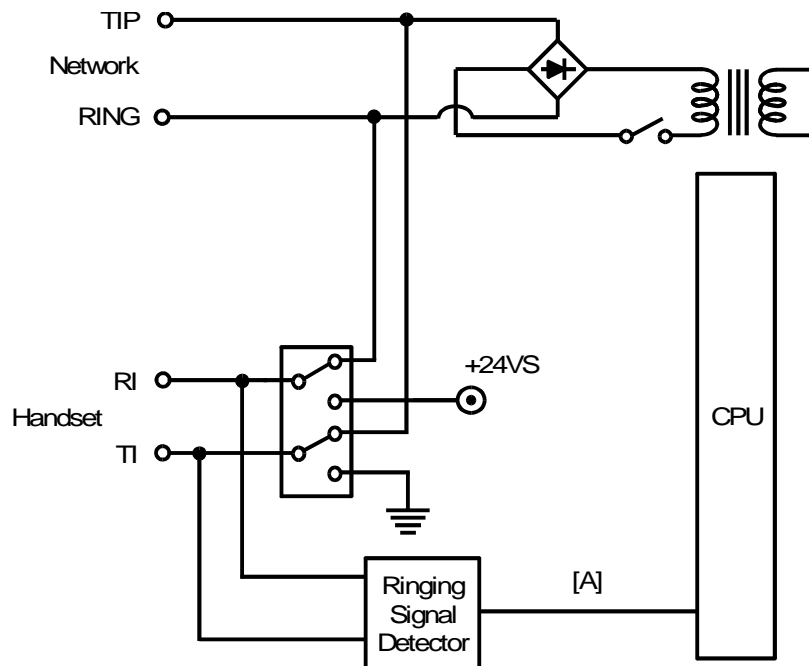
Ringing Signal Detection

Monitoring the Line

The ringing signal detector is a circuit containing a photocoupler and some zener diodes. The cpu constantly monitors the output [A] for a ringing signal unless the printer is in use or the dc loop is already closed.

An incoming signal switches the photocoupler on/off if the voltage is higher than a certain voltage. The cpu analyzes the signal [A].

The above circuit is for machines that do not have Auto Select Mode. The circuit for machines that have Auto Select Mode is discussed on the next page.



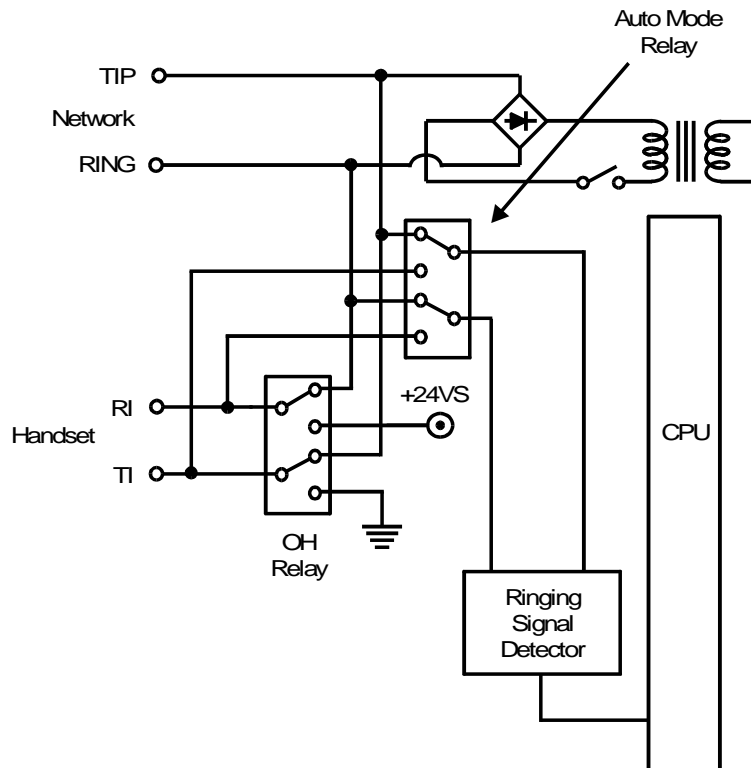
Auto Select Mode

Machines that have this extra reception mode have an extra relay in the network interface, called the Auto Mode relay. The circuit is shown below.

When the machine is standing by in Auto Receive mode, the relays are as shown above.

When the machine is standing by in Manual Receive mode, the Oh relay is in the up position and the Auto Mode relay is in the down position.

When the machine is standing by in Auto Select mode, the Oh relay is in the down position and the Auto Mode relay is in the up position.



Silent Ringing Detection

If Auto Select mode is used, the Oh relay is in the down position, so the handset cannot ring. This means that the machine makes no noise when a call comes in, unless the incoming call is from a telephone; if CNG is not detected, the cpu rings the fax machine's internal buzzer.

If Auto Receive mode is used, the user may have the option to enable silent ringing detection. In this case, the Oh relay will be in the down position, disconnecting the handset ringer from the line.

Signal Analysis

A ringing signal must satisfy three basic criteria: frequency, number of rings, and continuity. In all models, the principles of ringing signal detection are the same. A few models differ slightly from the explanation given below.

Frequency

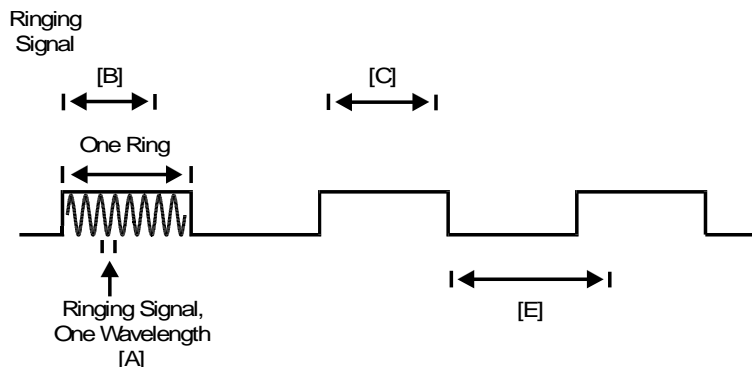
When the cpu detects a signal, it measures the frequency. If the frequency is within the limits specified by the parameters [A] programmed in the memory, the cpu determines that it is a possible ringing signal.

Number of Rings

Ringing signals have a cadence, consisting of rings and intervals between rings, as shown on the previous page. The cpu counts the rings.

However, the cpu does not increment the ring counter unless the ring was long enough. The first ring must be longer than the interval [B], and subsequent ones must be longer than the interval [C].

A certain number of rings [D] must be detected before the cpu confirms that the incoming signal is a ringing signal. When the count reaches the required value, the cpu confirms that the signal is a



ringing signal. The machine then goes into receive mode, and the cpu turns on the power supply for all components.

Continuity

The ringing signal must also satisfy a continuity test. The time between the end of a ring and the start of the next ring must not exceed the interval [E]. Otherwise, ringing detection flags will be reset and the next ring detected will be treated as the start of a new ringing signal.

Note: Parameters A to E described in this section can be adjusted.

DC Loop Closure

Auto Receive (FAX) Mode

After confirming the ringing signal, the cpu closes the dc loop by switching over the Oh relay then turning on the Di switch. The timing is the same as for transmission. The machine sends CED to the transmitting machine, to inform it that it has connected to a fax terminal.

Manual Receive (TEL) Mode

In manual receive mode, automatic ringing signal detection and loop closure are not done. The user picks up the handset after hearing it ring; this closes the dc loop. The user then presses Start after hearing the fax signal from the other end. Then the fax machine connects to the line by closing the Di switch then switching over the Oh relay. The timing is exactly the same as for manual dialing.

Auto Select (AUTO) Mode

The machine detects the ringing signal in the same way as for Auto Receive Mode. However, the Oh relay is in the down position in standby mode, so the handset does not ring.

If the machine detects CNG (which means that the other end is an auto-dialing fax machine), it closes the dc loop and sends out CED. From this point, the machine behaves in the same way as if it was in Auto Receive Mode.

If the machine does not detect CNG after 2 s, it will send out a voice message (if the machine has this function). Then, if CNG has still not come in within a certain time (let us call it [A]), the machine will emit an alarm to alert the user. From this point, the machine must detect CNG or the user must pick up the handset within a certain time (let us call it [B]). If the other party hangs up during this interval, the machine will also hang up. If the interval [B] expires, the machine sends out CED. If the other party is a fax machine in manual dialing mode, the other party will press Start, and fax communication can go ahead in the same way as for Manual Receive Mode. If the other party hangs up instead, this machine will also hang up.

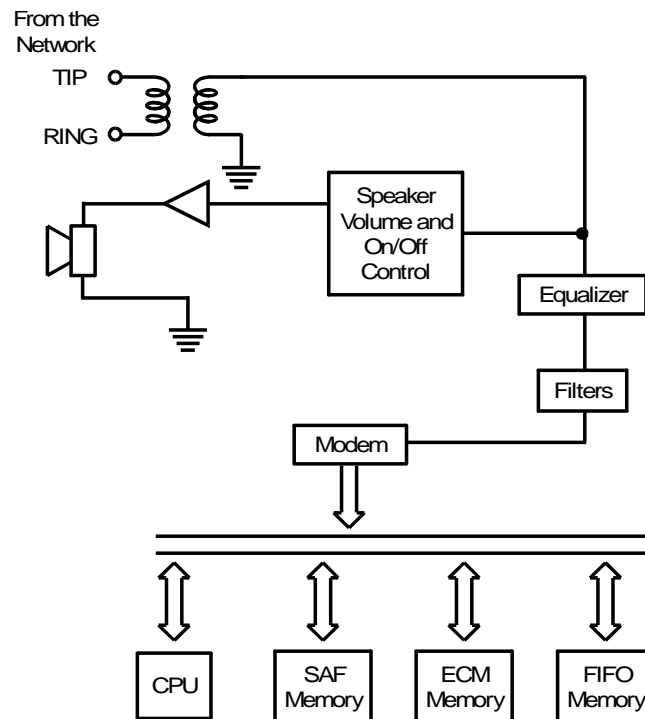
Note: Timers A and B can be adjusted.

Data Reception

This section explains the path of data from the telephone line to the cpu (non-memory transmission) or the SAF memory (memory transmission).

Data from the line first passes to an amplitude equalizer, which raises the level of frequencies above about 1000 Hz, and lowers the level of frequencies below about 1000 Hz. This makes the signal profile as flat as possible. The data is then filtered to remove low frequency noise (such as from the power supply) and high frequency noise (such as that caused by overhead power lines for railways). The data then passes to the modem.

The modem demodulates the incoming data and converts it to parallel.



The data is extracted from the ECM data frames in the ECM memory and passed to the cpu for data reconstruction (the opposite of compression). If ECM is disabled, the data passes through the FIFO memory instead of the ECM memory.

- Machines with SAF Memory -

Machines with SAF memory store the message in the SAF at the same time as the data passes to the cpu for decoding. This protects against data being lost as a result of a printing error (such as a jam). If memory reception is used (e.g., confidential mode), the data is held in the SAF memory until the user prints the data.

Note: If transmitted signals are degraded because of the distance between the modem and the local exchange, try adjusting the cable equalizer. This is normally a bit switch adjustment.

Note concerning ECM

In receive mode, both buffers of the double buffer memory are used, so if a page has to be split into two blocks, the second block can be received while the first block is still being printed. (In transmit mode, only a single buffer is used; if a page has to be split into two blocks, the first block must be sent and erased before the second block can be stored in the ECM memory)

ECM reception of MMR coded data—If the printer jams or runs out of paper while receiving the second block, the second block will be erased from memory. This is because the data at the beginning of the second block cannot be reconstructed, as the line at the end of the first block has already been erased. An Error Report is printed, which contains a message for the user to contact the sender for retransmission.

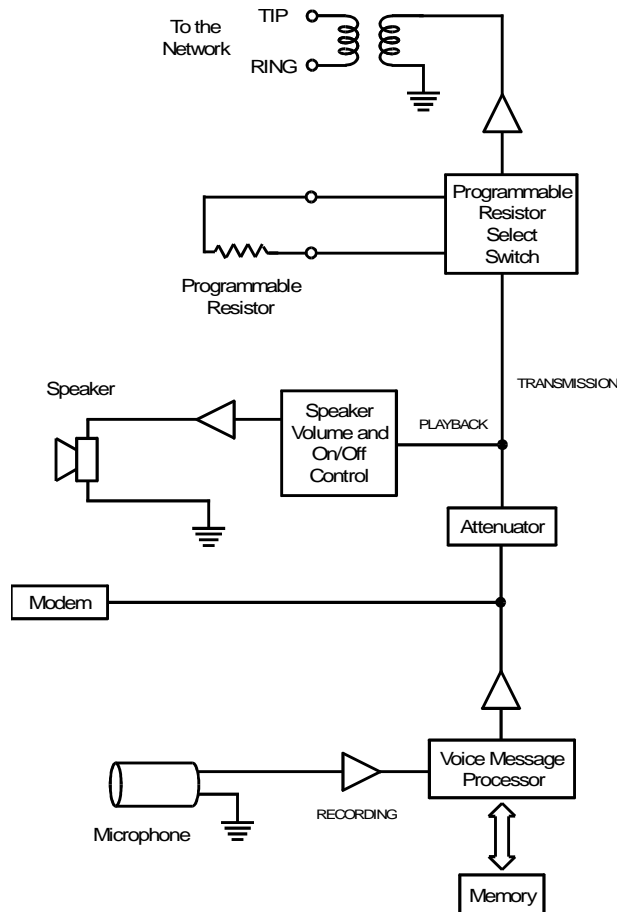
Others

Voice Message

Voice Message Types

There are two types of voice message that can be recorded. One is for use with the Notify function (to inform the Notify destination that a fax message has come in), and the other is for use in Auto Receive mode (to warn any telephone caller that they have connected to a fax machine). In most models, only the Auto Answer voice message is available.

The diagram shows the circuits for storing, playing back, and transmitting a voice message.



Storing the Voice Message

To record a voice message, the user speaks into the microphone, which is either in the handset or built into the operation panel. The diagram on the previous page shows the circuit when a microphone is used.

The signal is amplified. Then, it passes to the Voice Message Processor, which converts the voice signal to digital and stores it in the memory. The voice message memory normally has battery back-up.

Note: In some models, the user speaks into the handset microphone. When the user selects voice message recording, a relay connects the handset microphone to the voice message processor.

Playing Back the Voice Message

To play back a voice message, the Voice Message Processor reads the digitized message from the memory and converts it back to an audio signal. The signal is then amplified.

The signal passes through the speaker volume control, which the user can normally adjust. The signal is then amplified before going to the speaker.

Voice Message Transmission in Auto Receive Mode

If the Voice Message has been programmed and switched on, the unit sends it out immediately before the CED tone if it does not receive CNG; if CNG is not received, the calling machine is not an automatic dialing fax terminal. Total communication time is increased by the length of the voice message.

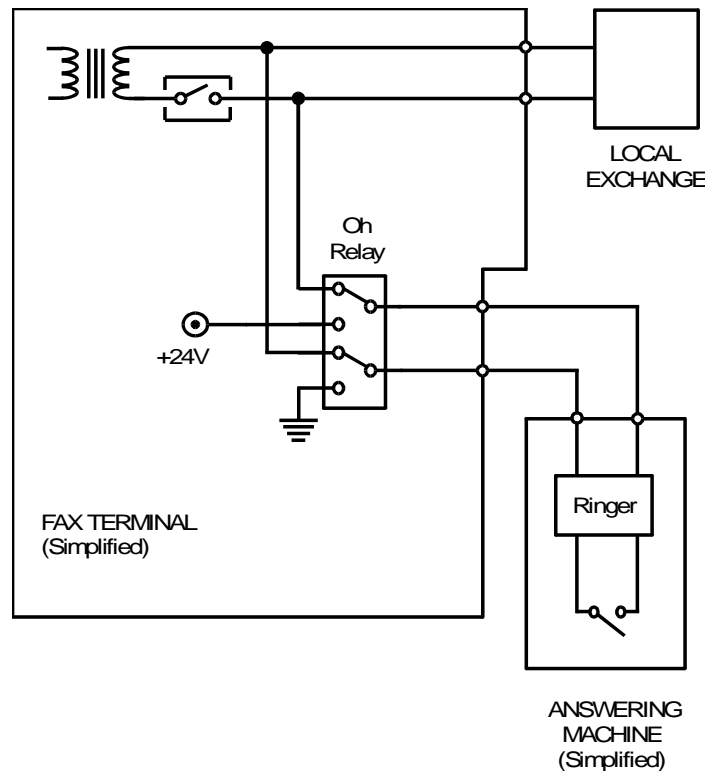
The Voice Message Processor converts the stored Voice Message into a voice signal. The Voice Message is attenuated and passed to the line in the same way as transmitted data.

Reception with Answering Machine

Overview

The answering machine is connected to the rear of the fax machine, in the same place as a handset.

In standby mode, the Oh relay connects the answering machine to the line. The hook switch in the answering machine is open, so there is no dc loop. However, the ringer in the answering machine can detect ac ringing signals coming from the local exchange.

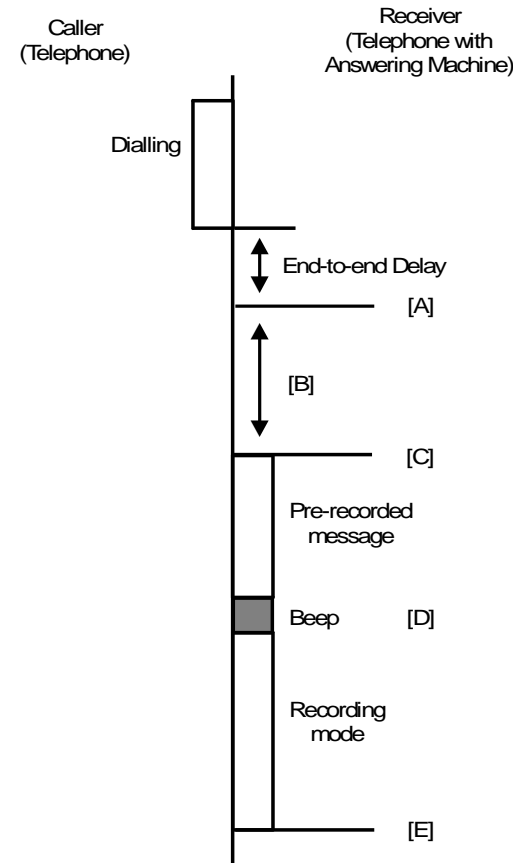


Answering Machine with Telephone

When an answering machine with a telephone answers an incoming call, the call proceeds as shown in the diagram.

When a ringing signal comes in from the local exchange, the answering machine starts to ring [A]. While the answering machine is still ringing [B], the call can still be answered if someone picks up the handset.

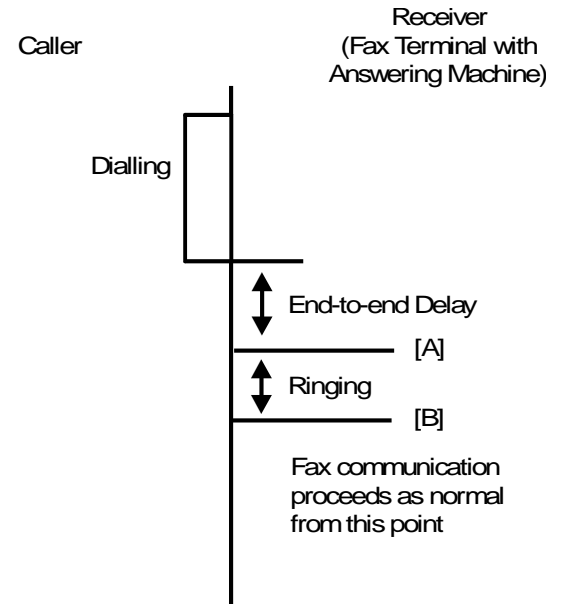
If by point [C] the handset has not been picked up, the answering machine connects to the line and starts to send the pre-recorded message, with a beep at the end [D]. The caller then has a chance to record a message, before the line is disconnected [E].



*Answering Machine with Fax Terminal***Auto Receive (Fax) Mode**

When a ringing signal comes in [A], the answering machine starts ringing and the fax machine begins ringing signal detection. As soon as the fax machine detects the ringing signal, it closes the dc loop [B], disconnecting the answering machine.

Therefore, as long as the fax machine closes the dc loop before the answering machine can react ([C] in the diagram on the previous page), the answering machine does not affect the fax machine's operation.



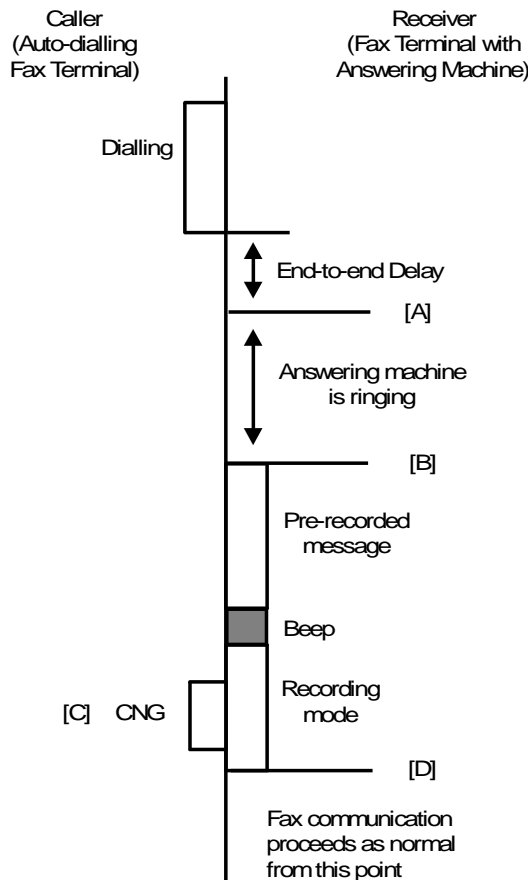
Manual Receive (Tel) Mode

As just explained, the answering machine has no effect on the fax machine when it is in Fax Mode. Therefore, the user must set the fax machine up in Tel Mode to use an answering machine. The operation of the fax machine then depends on what type of equipment is calling it.

a) Receiving from a fax machine in automatic dial mode

First, the ringing signal comes in [A]. The fax machine is in manual receive mode, so it ignores this. Because the fax machine ignores the ringing signal, the answering machine answers the line [B], and proceeds in the same way as if it were connected to a telephone (see "2. Answering Machine with Telephone").

The recorded message should contain the following instructions: "If you want to leave a recorded message, speak after you hear the beep. If you want to send a fax message, press 2 after you hear the beep, then press Start on your fax machine after you hear a high-pitched tone."
(The number the person at the other end has to press depends on the answering machine.)



While this is going on, the other end sends CNG [C]. When the receiving fax machine detects CNG, it switches over the Oh relay to disconnect the answering machine [D], and closes the Di relay to connect itself to the line.

The answering machine does not have any effect on the operation of the machine, unless there is a problem with CNG detection.

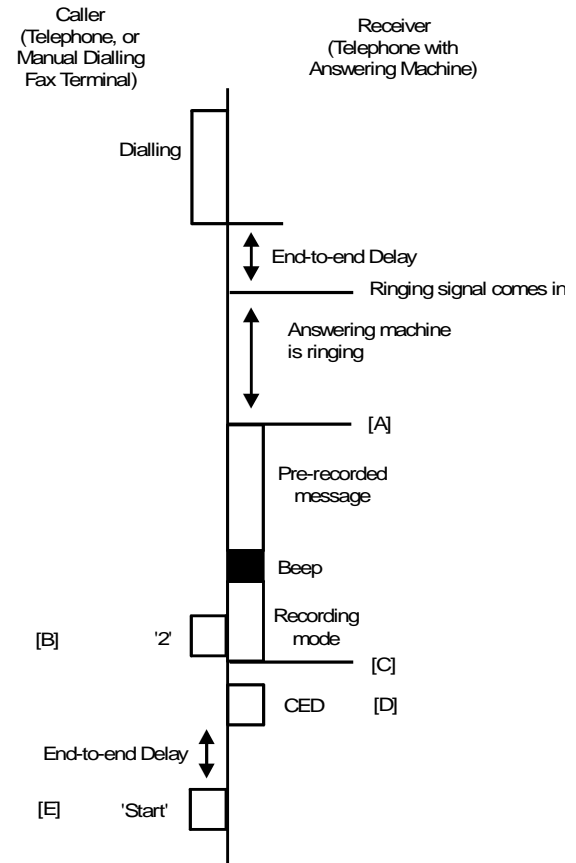
If the fax machine cannot detect CNG, it cannot connect to the line. For example, CNG cannot be detected if it comes in at the same time as the answering machine's recorded message is going out. Because of this, the best time for the fax machine to detect CNG is while the answering machine is in recording mode, after sending out the beep (see the previous diagram).

Note: Some problems have been experienced in this area, as different types of terminal transmit CNG at different times, due to variations in interpretation of ITU-T recommendations.

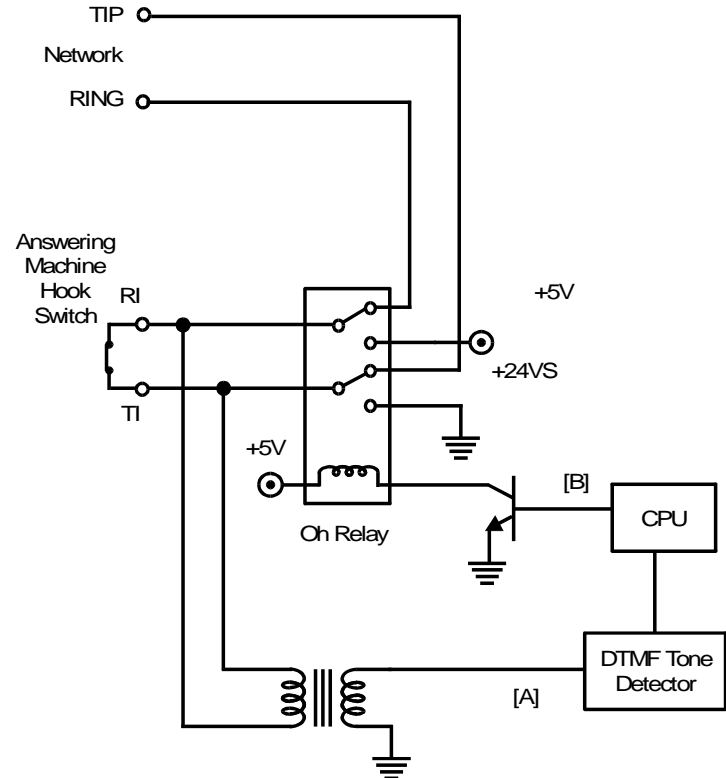
b) Receiving from a fax in manual dial mode or a telephone

There is no CNG, so the answering machine has control of the line. When the answering machine detects a ringing signal [A], it sends out a recorded message. This message should contain the following instructions: "If you want to leave a recorded message, speak after you hear the beep. If you want to send a fax message, press 2 after you hear the beep, then press Start on your fax machine after you hear a high-pitched tone." (The number the other end has to press depends on the answering machine; see the Note at the end of this section.)

When the fax machine detects this '2' from the other end [B], it switches over the Oh relay to disconnect the answering machine, and closes the Di switch to connect itself to the line [C]. Then it sends CED to the caller [D]. When the caller hears this high-pitched tone, the caller presses Start [E], and fax-to-fax communication can go ahead.



The caller must use a DTMF tone dialing telephone. The cpu detects the tone at [A]. Then the cpu will switch the machine into auto receive mode using [B], and the other end will be able to send the fax message.



Remote Control

Remote control features do not use the same circuit to detect the codes input at the remote telephone or fax machine. In remote control mode, the machine closes the dc loop, so DTMF tones from the other end pass to the cpu along the same route as received fax data signals.

Using remote control, the fax machine is controlled from a remote location through the telephone network using a telephone or fax machine. The user dials the fax machine and selects a feature by inputting some numbers. The fax machine then executes the selected function.

When the receiving machine detects a ringing signal, it closes the dc loop and sends out CED. The user at the other end then presses the required button on his ten-key pad, and transmits DTMF tones to the receiver (the caller must use a DTMF tone dialing telephone or fax machine). The receiving side's cpu detects the DTMF tones.

European/Asian Models

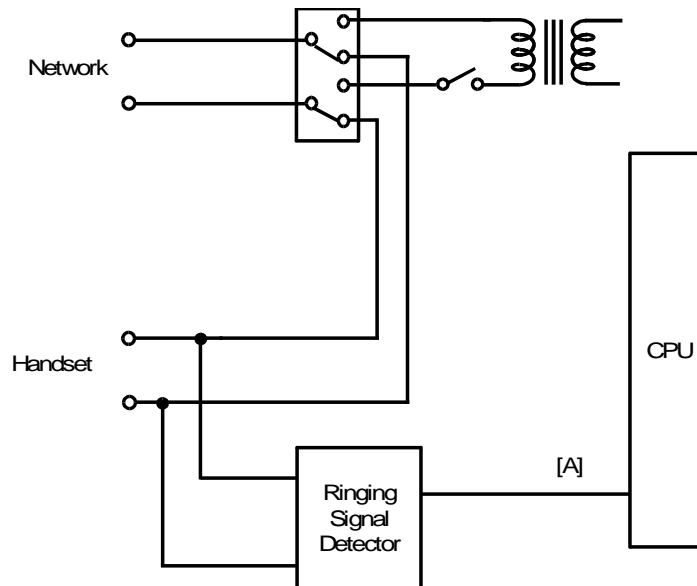
Ringling Signal Detection

Monitoring the Line

The ringing signal detector is a circuit containing a photocoupler and some zener diodes. The cpu constantly monitors the output [A] for a ringing signal unless the printer is in use or the dc loop is already closed.

An incoming signal switches the photocoupler on/off if the voltage is higher than a certain voltage. The cpu analyzes the signal [A].

The circuit contains a variety of resistors, capacitors, and jumpers to ensure compliance with a wide range of PTT requirements.



Signal Analysis

A ringing signal must satisfy three basic criteria: frequency, number of rings, and continuity. In all models, the principles of ringing signal detection are the same. A few models differ slightly from the explanation given below.

- Frequency -

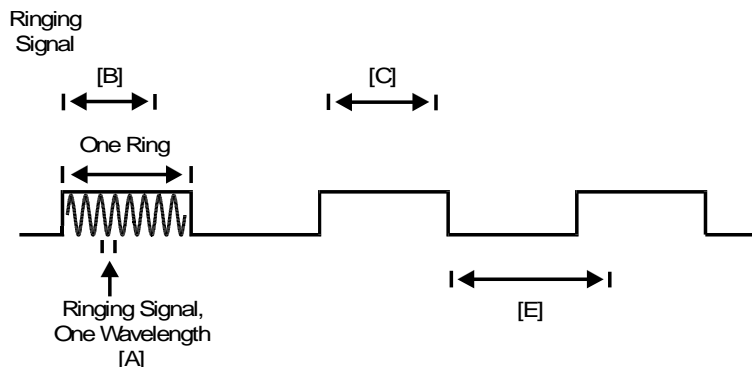
When the cpu detects a signal, it measures the frequency. If the frequency is within the limits specified by the parameters [A] programmed in the memory, the cpu determines that it is a possible ringing signal.

- Number of Rings -

Ringing signals have a cadence, consisting of rings and intervals between rings, as shown on the previous page. The cpu counts the rings.

However, the cpu does not increment the ring counter unless the ring was long enough. The first ring must be longer than the interval [B], and subsequent ones must be longer than the interval [C].

A certain number of rings [D] must be detected before the cpu confirms that the incoming signal is a ringing signal. When the count reaches the required value, the cpu confirms that the signal is a



ringing signal. The machine then goes into receive mode, and the cpu turns on the power supply for all components.

- Continuity -

The ringing signal must also satisfy a continuity test. The time between the end of a ring and the start of the next ring must not exceed the interval [E]. Otherwise, ringing detection flags will be reset and the next ring detected will be treated as the start of a new ringing signal.

Note: Parameters A to E described in this section can be adjusted.

DC Loop Closure

Auto Receive (FAX) Mode

After confirming the ringing signal, the cpu closes the dc loop by switching over the Oh relay then turning on the Di or Ds relay. The timing is the same as for transmission. The machine sends CED to the transmitting machine, to inform it that it has connected to a fax terminal.

Manual Receive (TEL) Mode

In manual receive (TEL) mode, automatic ringing signal detection and loop closure are not done. The user picks up the handset after hearing it ring; this closes the dc loop. The user then presses Start after hearing the fax signal from the other end. Then the fax machine connects to the line by closing the Di or Ds relay then switching over the Oh relay. The timing is exactly the same as for manual dialing.

Auto Select (AUTO) Mode

When the machine detects the ringing signal, it closes the dc loop in the same way as for Auto Receive Mode.

If the machine detects CNG (which means that the other end is an auto-dialing fax machine), it sends out CED. From this point, the machine behaves in the same way as if it was in Auto Receive Mode.

If the machine does not detect CNG after 2 s, it will send out a voice message (if the machine has this function). Then, if CNG has still not come in within a certain time (let us call it [A]), the machine

will emit an alarm to alert the user. From this point, the machine must detect CNG or the user must pick up the handset within a certain time (let us call it [B]). If the other party hangs up during this interval, the machine will also hang up.

If the interval [B] expires, the machine sends out CED. If the other party is a fax machine in manual dialing mode, the other party will press Start, and fax communication can go ahead in the same way as for Manual Receive Mode. If the other party hangs up instead, this machine will also hang up.

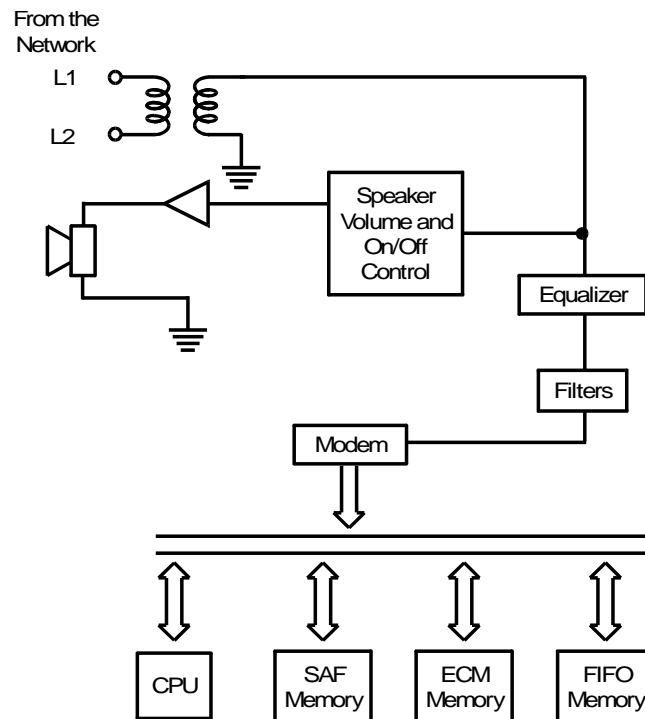
Note: Timers A and B can be adjusted.

Data Reception

This section explains the path of data from the telephone line to the cpu (non-memory transmission) or the SAF memory (memory transmission).

Data from the line first passes to an amplitude equalizer, which raises the level of frequencies above about 1000 Hz, and lowers the level of frequencies below about 1000 Hz. This makes the signal profile as flat as possible. The data is then filtered to remove low frequency noise (such as from the power supply) and high frequency noise (such as that caused by overhead power lines for railways). The data then passes to the modem.

The modem demodulates the incoming data and converts it to parallel.



The data is extracted from the ECM data frames in the ECM memory and passed to the cpu for data reconstruction (the opposite of compression). If ECM is disabled, the data passes through the FIFO memory instead of the ECM memory.

- Machines with SAF Memory -

Machines with SAF memory store the message in the SAF at the same time as the data passes to the cpu for decoding. This protects against data being lost as a result of a printing error (such as a jam). If memory reception is used (e.g., confidential mode), the data is held in the SAF memory until the user prints the data.

Note: If transmitted signals are degraded because of the distance between the modem and the local exchange, try adjusting the cable equalizer. This is normally a bit switch adjustment.

Note concerning ECM

In receive mode, both buffers of the double buffer memory are used, so if a page has to be split into two blocks, the second block can be received while the first block is still being printed. (In transmit mode, only a single buffer is used; if a page has to be split into two blocks, the first block must be sent and erased before the second block can be stored in the ECM memory)

ECM reception of MMR coded data—If the printer jams or runs out of paper while receiving the second block, the second block will be erased from memory. This is because the data at the beginning of the second block cannot be reconstructed, as the line at the end of the first block has already been erased. An Error Report is printed, which contains a message for the user to contact the sender for retransmission.

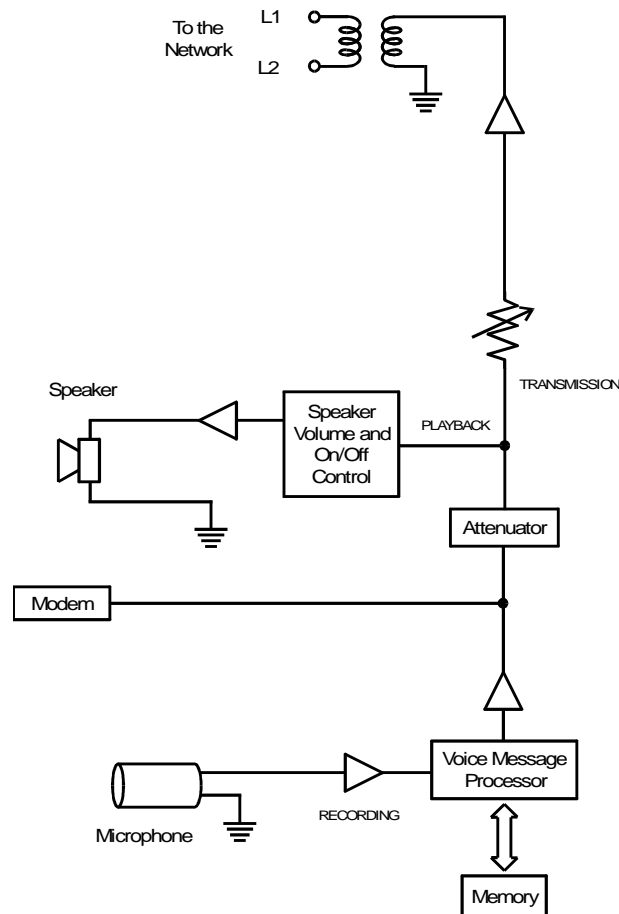
Others

Voice Message

Voice Message Types

There are two types of voice message that can be recorded. One is for use with the Notify function (to inform the Notify destination that a fax message has come in), and the other is for use in Auto Receive mode (to warn any telephone caller that they have connected to a fax machine). In most models, only the Auto Answer voice message is available.

The diagram shows the circuits for storing, playing back, and transmitting a voice message.



Storing the Voice Message

To record a voice message, the user speaks into the microphone, which is either in the handset or built into the operation panel. The diagram on the previous page shows the circuit when a microphone is used.

The signal is amplified. Then, it passes to the Voice Message Processor, which converts the voice signal to digital and stores it in the memory. The voice message memory normally has battery back-up.

Note: In some models, the user speaks into the handset microphone. When the user selects voice message recording, a relay connects the handset microphone to the voice message processor.

Playing Back the Voice Message

To play back a voice message, the Voice Message Processor reads the digitized message from the memory and converts it back to an audio signal. The signal is then amplified.

The signal passes through the speaker volume control, which the user can normally adjust. The signal is then amplified before going to the speaker.

Voice Message Transmission in Auto Receive Mode

If the Voice Message has been programmed and switched on, the unit sends it out immediately before the CED tone if it does not receive CNG; if CNG is not received, the calling machine is not an automatic dialing fax terminal. Total communication time is increased by the length of the voice message.

The Voice Message Processor converts the stored Voice Message into a voice signal. The Voice Message is attenuated and passed to the line in the same way as transmitted data (see section 2-8 for details).

Remote Control

Using remote control, the fax machine is controlled from a remote location through the telephone network using a telephone or fax machine. The user dials the fax machine and selects a feature by inputting some numbers. The fax machine then executes the selected function.

When the receiving machine detects a ringing signal, it closes the dc loop and sends out CED. The user at the other end then presses the required button on his ten-key pad, and transmits DTMF tones to the receiver (the caller must use a DTMF tone dialing telephone or fax machine). The receiving side's cpu detects the DTMF tones.

Fax Circuit Update

North American Models

The descriptions in the Core Technology Manual ([Facsimile Processes – Transmission – North American Models](#), [Facsimile Processes – Reception – North American Models](#)) are based on the [C series models \(H081 series\)](#). There have been a few small changes since these models.

Changed Names

The following components have new names. There is no change in the function of these components. These new names took effect from the [F/L series models \(H516/H521 series\)](#).

Old	New
Oh relay	CML relay, Relay
Di switch	OHDI switch

Changes to the Circuit

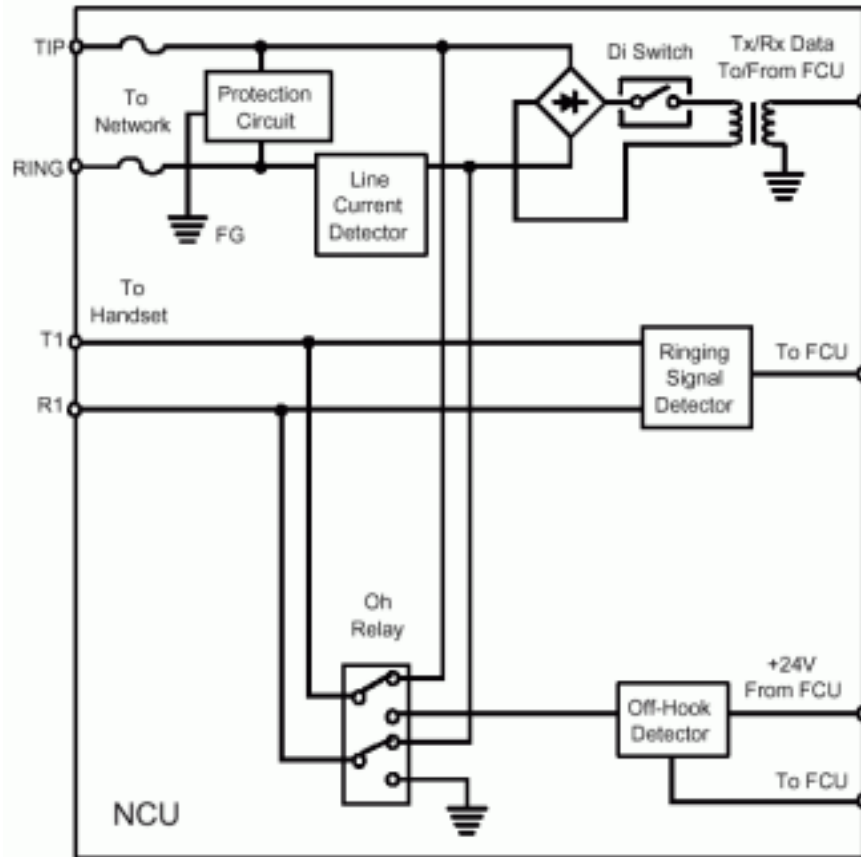
In some NCUs, there is no Off-hook Detection circuit.

DC Loop: This new circuit, between the OHDI switch and the exit to the fax main board prevents dc from entering the fax main board from the NCU.

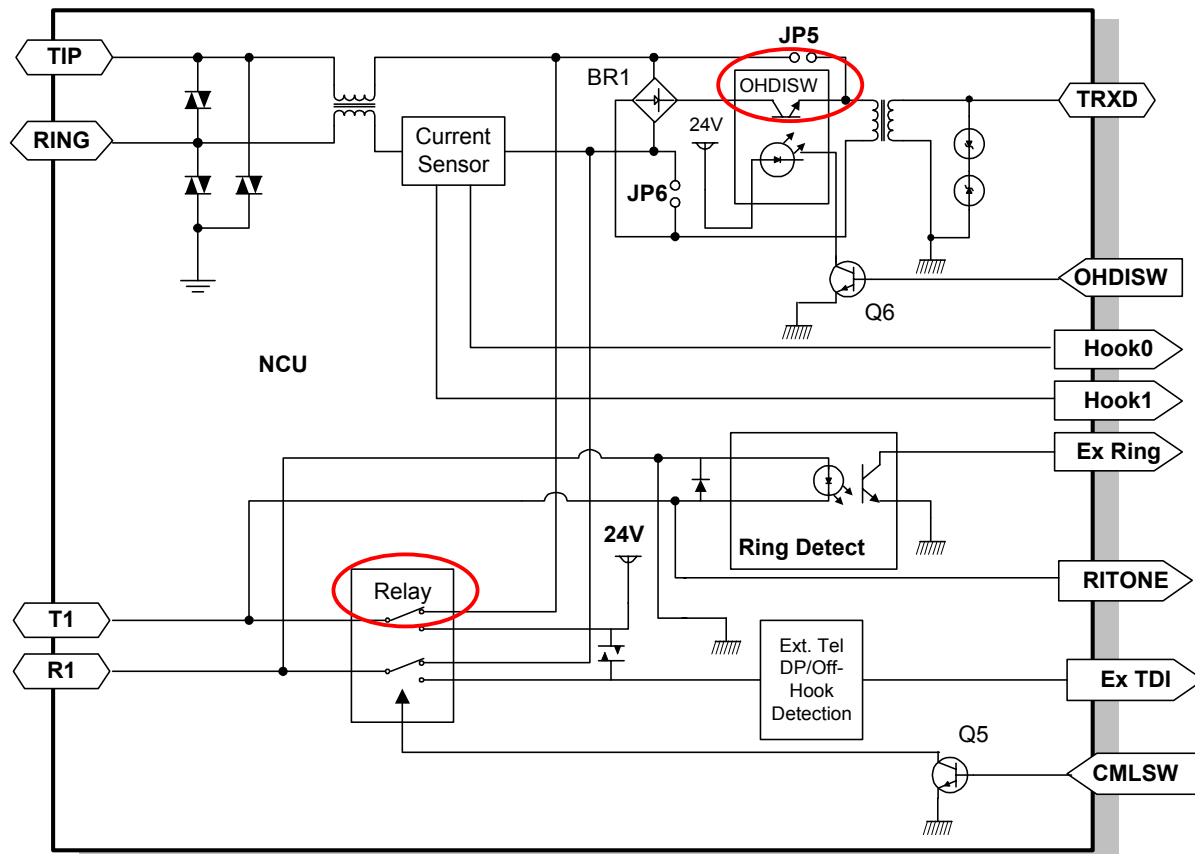
CML relay: In some NCUs, the wiring between this relay and the telephone line has been altered, but there is no change in how the machine dials out, because PTT requirements have not changed.

Some example block diagrams are shown on the next few pages.

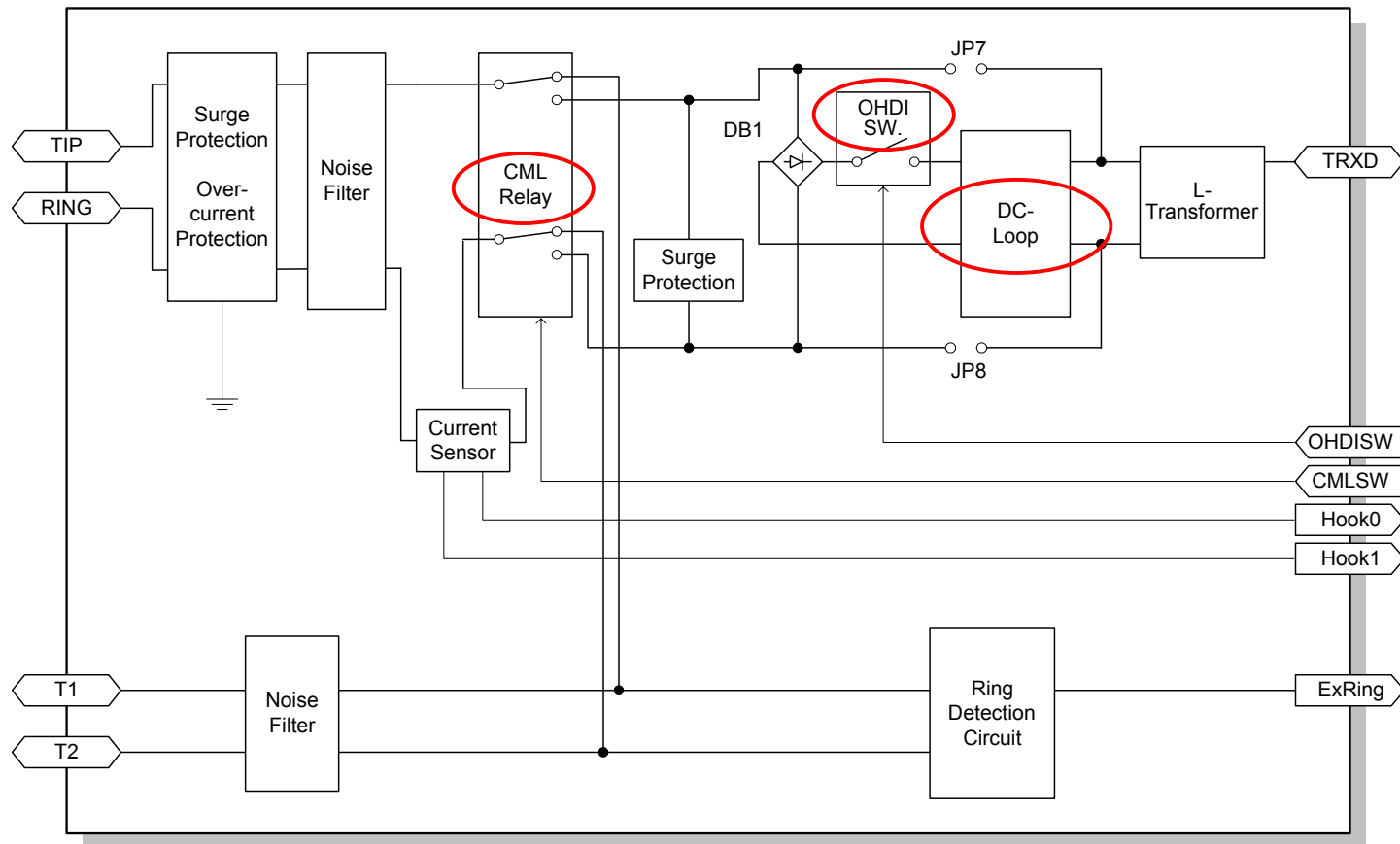
C series (H081 series): Old names, as used in the main text of the core technology manual



Schmidt 3 (H547): Changed names, but no changes to the circuits



Schmidt 4 (H535): Changed names, and changes to the circuits



European/Asian Models

The fax circuit descriptions in the Core Technology Manual ([Facsimile Processes – Transmission – European/Asian Models](#), [Facsimile Processes – Reception– European/Asian Models](#)) are based on the [C series models \(H081 series\)](#). There have been a few small changes since these models. These changes are listed below.

Changed Names

The following components have new names. There is no change in the function of these components. These new names took effect from the [F/L series models \(H516/H521 series\)](#).

Old	New
Oh relay	CML relay
Di switch, Di relay	OHDi switch
Ds switch, Ds relay	DO switch

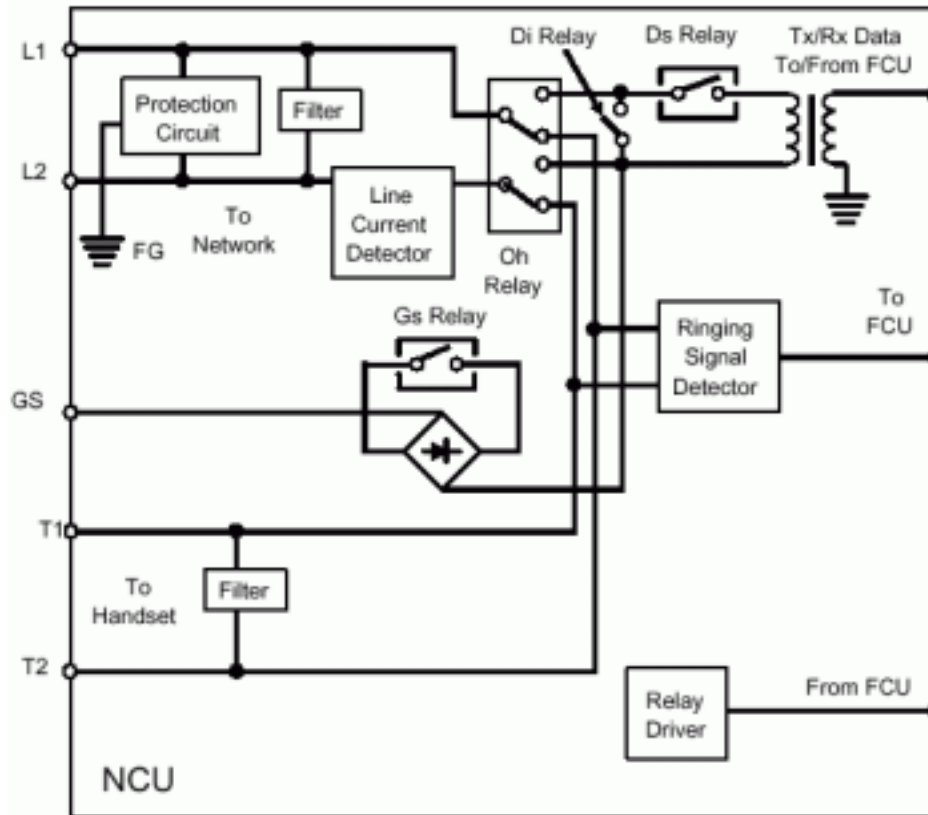
Changes to the Circuit

DC Loop: This new circuit, between the OHDi switch and the exit to the fax main board prevents dc from entering the fax main board from the NCU.

- ☐ In some NCUs, there is a control signal (DCLSW) to this 'DC Loop' circuit. This signal adjusts the maximum level of dc that passes out of the machine through the NCU to the line. In TBR21 nations, the limit is 60 mA. For other European nations, the limit is 120 mA.

Some example block diagrams are shown on the next few pages.

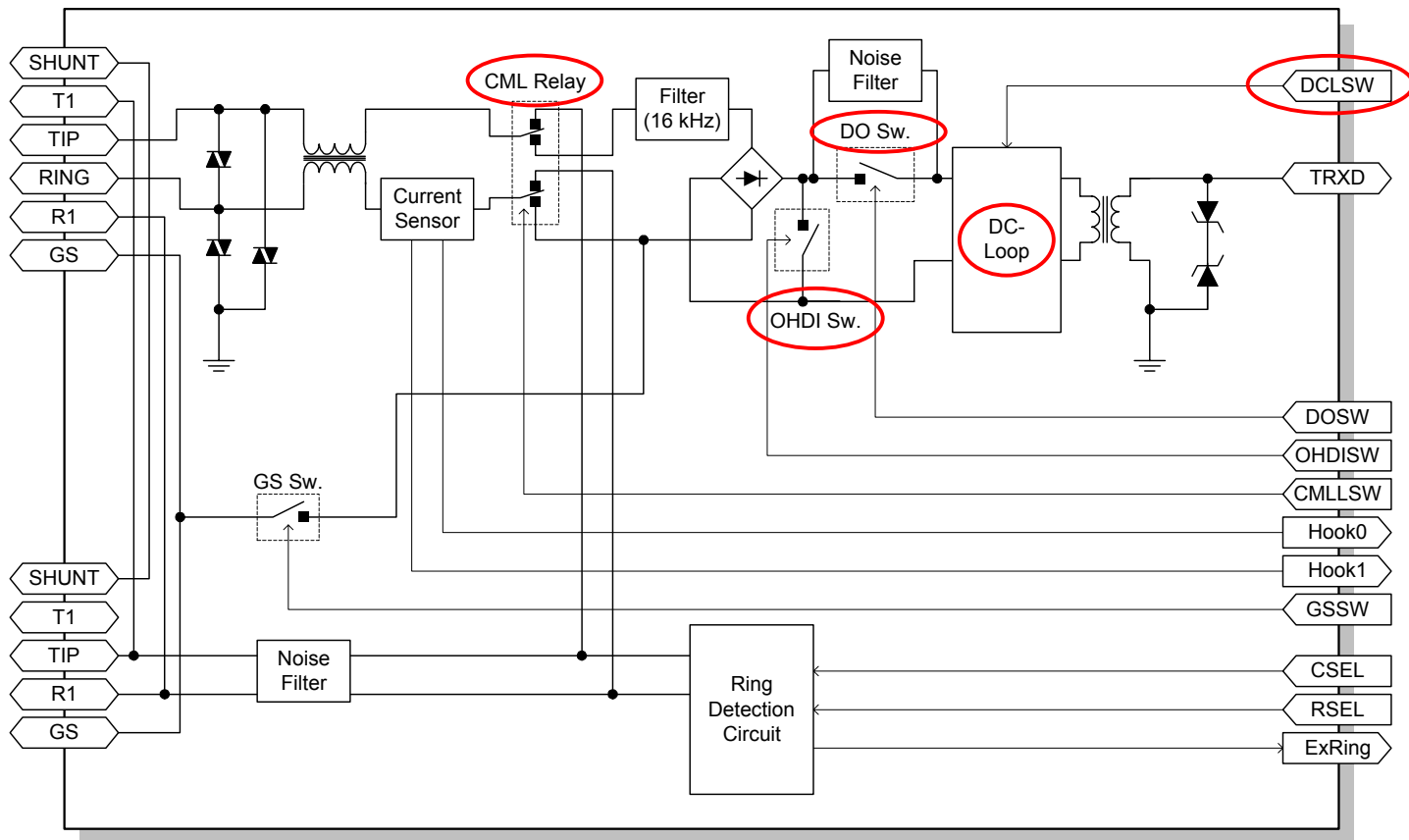
C series (H081 series): Old names, as used in the main text of the core technology manual



The schematic diagram illustrates the CML system for the 1000 Series. It shows the following components and connections:

- Input/Output Terminals (Left):** SHUNT, T1, TIP, RING, R1, GS (top); SHUNT, T1, TIP, RING, R1, GS (bottom).
- Internal Components:**
 - JP24:** A terminal block with a ground connection.
 - GS Sw.:** A switch connected to the GS line and ground.
 - Current Sensor:** A sensor connected to the CML Relay and the Ring Detection Circuit.
 - CML Relay:** A relay with a coil and contacts, connected to the CMLSW terminal.
 - Filter (16Hz):** A low-pass filter connected to the CML Relay and the DO Sw.
 - DO Sw.:** A switch connected to the DO SW. terminal.
 - OHD Sw.:** A switch connected to the OHD SW. terminal.
 - Loop Closure Circuit:** A circuit connected to the OHD Sw. and the TRXD terminal.
 - Ring Detection Circuit:** A circuit connected to the RING, R1, and GS lines, and the CN5, CN7, CSEL0, CSEL1, RSEL, and ExRing terminals.
- Output Terminals (Right):** TRXD, DOSW, OHDISW, CMLSW, Hook0, Hook1, GSSW, CSEL0, CSEL1, RSEL, ExRing.

Schmidt 4 (H535): Changed names, and changes to the circuits



Compression Techniques

Overview

Compression and Reconstruction

Digital machines compress image data for two purposes.

- To reduce the amount of memory or hard disk space required for storage
- To reduce the amount of time needed to transmit the image data by fax.

This section will deal mainly with fax data compression and reconstruction. For fax communication, data is compressed in accordance with internationally-agreed standards. However, for temporary storage on hard disk, other techniques may be used.

An analog facsimile machine takes a long time to transmit all the black and white pixels of a scanned original. Therefore, to reduce transmission time, the high-speed facsimile compresses the scanned data before transmission.

Compression: Reduces the volume of scanned data

Reconstruction: Converts the compressed data back into the original data

Encoding Scheme for Compression

If an A4-size document (216 mm x 297 mm, very approximately equal to a Letter size document) is scanned at standard resolution (8 dots per mm across the page and 3.85 dots per mm down the page), a large number of pixels are generated. The actual number is:

$$216 \times 8 \times 297 \times 3.85 = 1,975,882 \text{ pixels.}$$

If these pixels are sent out at 9,600 bits per second, it takes about 3 minutes and 40 seconds to send the page.

To reduce this time, an encoding system was developed to achieve high-speed transmission which reduces the transmission time to 1/6 - 1/7th of that required for uncompressed data.

Modified Huffman (MH) coding is the basic compression technique for facsimile data transmission. It looks at run lengths, that is, the consecutive numbers of pixels that have the same color.

For example, if a sample of data is "white, white, white, black, black, black", it can be considered as "3 white, 3 black". Modified Huffman coding specifies a code of "1000" for "3 white", and "10" for "3 black".

The designers of MH coding determined the most common run lengths and gave them the shortest codes; "3 black" is one of the most common sequences. Less frequent run lengths were given longer codes. In this way, a code table was constructed with regard to the various occurrence rates of run lengths, to minimize the total number of bits in the transmitted data.

The ITU-T T.4 recommendation contains the run length code tables, as shown on the following pages. The code table consists of "terminating codes" to replace run lengths of 0 to 63, and "make-up codes" to replace run lengths of multiples of 64 bits. Scanned data is compressed by replacing each run length with either:

- A terminating code (for black or white run lengths less than 64)
- A make-up code followed by a terminating code (for black or white run lengths of 64 or greater)

Terminating Codes

White Run Length		Black Run Length	
0	00110101	0	0000110111
1	000111	1	010
2	0111	2	11
3	1000	3	10
4	1011	4	011
5	1100	5	0011
6	1110	6	0010
7	1111	7	00011
8	10011	8	000101
9	10100	9	000100
10	00111	10	0000100
11	01000	11	0000101
12	001000	12	0000111
13	000011	13	00000100
14	110100	14	00000111

White Run Length		Black Run Length	
15	110101	15	000011000
16	101010	16	0000010111
17	101011	17	0000011000
18	0100111	18	0000001000
19	0001100	19	00001100111
20	0001000	20	00001101000
21	0010111	21	00001101100
22	0000011	22	00000110111
23	0000100	23	00000101000
24	0101000	24	00000010111
25	0101011	25	00000011000
26	0010011	26	000011001010
27	0100100	27	000011001011
28	0011000	28	000011001100
29	00000010	29	000011001101
30	00000011	30	000001101000
31	00011010	31	000001101001
32	00011011	32	000001101010
33	00010010	33	000001101011
34	00010011	34	000011010010
35	00010100	35	000011010011
36	00010101	36	000011010100
37	00010110	37	000011010101
38	00010111	38	000011010110
39	00101000	39	000011010111
40	00101001	40	000001101100
41	00101010	41	000001101101

White Run Length		Black Run Length	
42	00101011	42	000011011010
43	00101100	43	000011011011
44	00101101	44	000001010100
45	00000100	45	000001010101
46	00000101	46	000001010110
47	00001010	47	000001010111
48	00001011	48	000001100100
49	01010010	49	000001100101
50	01010011	50	000001010010
51	01010100	51	000001010011
52	01010101	52	000000100100
53	00100100	53	000000110111
54	00100101	54	000000111000
55	01011000	55	000000100111
56	01011001	56	000000101000
57	01011010	57	000001011000
58	01011011	58	000001011001
59	01001010	59	000000101011
60	01001011	60	000000101100
61	00110010	61	000001011010
62	00110011	62	000001100110
63	00110100	63	000001100111

Make-up codes

White Run Length		Black Run Length	
64	11011	64	0000001111
128	10010	128	000011001000
192	010111	192	000011001001
256	0110111	256	000001011011
320	00110110	320	000000110011
384	00110111	384	000000110100
448	01100100	448	000000110101
512	01100101	512	0000001101100
576	01101000	576	0000001101101
640	01100111	640	0000001001010
704	011001100	704	0000001001011
768	011001101	768	0000001001100
832	011010010	832	0000001001101
896	011010011	896	0000001110010
960	011010100	960	00000001110011
1024	011010101	1024	0000001110100
1088	011010110	1088	0000001110101
1152	011010111	1152	0000001110110
1216	011011000	1216	0000001110111
1280	011011001	1280	0000001010010
1344	011011010	1344	0000001010011
1408	011011011	1408	0000001010100
1472	010011000	1472	0000001010101
1536	010011001	1536	0000001011010
1600	010011010	1600	0000001011011

White Run Length		Black Run Length	
1664	011000	1664	0000001100100
1728	010011011	1728	0000001100101
EOL	000000000001	EOL	000000000001

Note: A scan line for A4-width paper at the normal 8-pixel/mm resolution requires 1728 bits. However, some machines can scan wider paper. The following table gives the make-up codes used for wider paper.

Additional make-up codes for wide paper

Run Length (White or Black)	Make-up codes
1792	00000001000
1856	0000001100
1920	00000001101
1984	000000010010
2048	000000010011
2112	000000010100
2176	000000010101
2240	000000010110
2304	000000010111
2368	000000011100
2432	000000011101
2496	000000011110
2560	000000011111

Modified Huffman (MH) Method

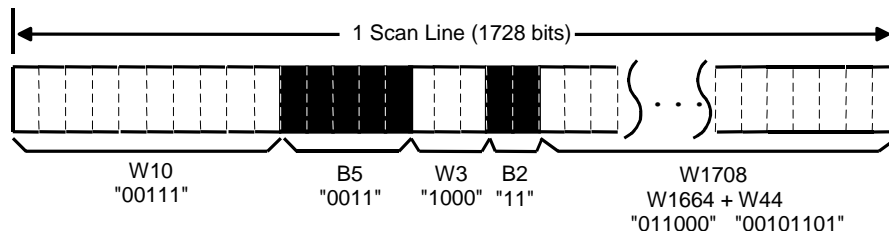
One-dimensional Coding

MH coding is often referred to as a “one-dimensional” coding scheme. This refers to the fact that MH codes the data on a scan line without referring to the data on adjacent lines. Modified Read (MR) coding uses a reference scan line to encode the scan line, and is thus known as “two-dimensional” coding.

MR coding is dealt with in a later section. This section explains how MH coding is implemented in facsimile communications.

Encoding Example

The following diagram shows a 1728-bit scan line. If MH coded, "10 white" is encoded as "00111", "5 black" as "0011", "3 white" as "1000", "2 black" as "11", and "1708 white" as a combination of the make-up code for 1664 white ("011000") and the terminating code for 44 white ("00101101").



All data lines begin with a white run length, in order for the receiving terminal to ensure synchronization of color. If, however, the actual scan begins with a black run length, a white run length with length of 0 is transmitted.

End of line encoding (EOL)

EOL (End of Line) : 000000000001

At the end of each scan line of data, an EOL code is added. This is a unique code than can never be generated within a line of MH coded data. EOL ensures that the communicating machines can resynchronize if a noisy telephone line causes data errors. There is also an EOL at the start of the page, before the first line.

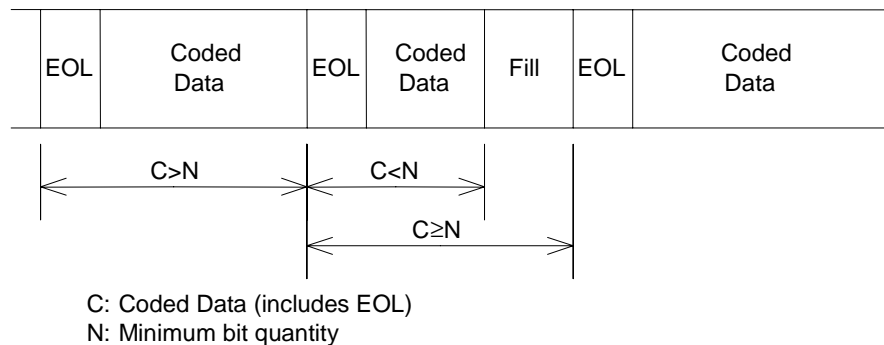
The receiving terminal uses the following rules to reconstruct the line of original data between EOL codes:

- EOL is always followed by a white run length.
- A black run length always follows a white run length, and a white run length always follows a black run length.
- A make-up code is always followed by a terminating code.
- The number of bits in a scan line is either 1,728 (for A4 size), 2,048 (for B4 size), or 2,376 (for A3 size).

Fill Data

Fill data: A variable length string of 0s.

Using MH coding, it is possible that a line of encoded data is very short, and the next line is sent out before the receiving machine has processed that short line of data. To solve this problem, each line must take a minimum time to send. This must equal the receiver's I/O processing time. If the line of data ends before the I/O processing time, fill bits (all zeroes) are inserted between the encoded data and the EOL code until the I/O processing time is reached.

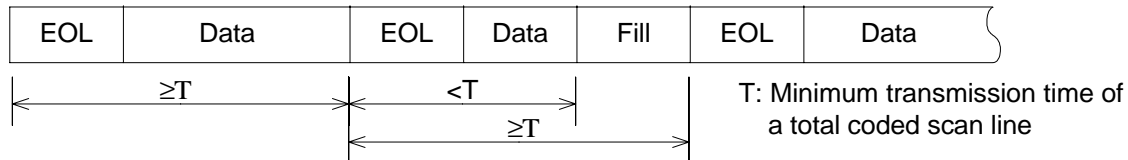


The I/O processing time is determined as a minimum number of bits as shown in the following table. It depends on the modem transmission rate, the I/O rate (for an A4-width scan line), and the paper width.

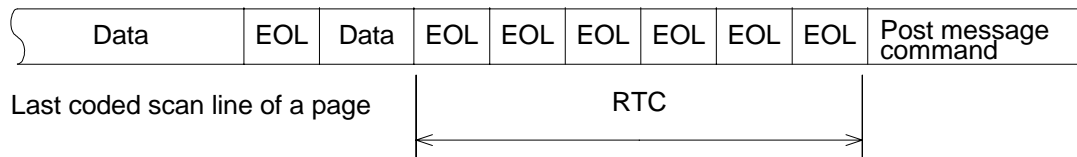
I/O rate Paper Width Modem rate	40 ms		20 ms		10 ms	
	A4	B4	A4	B4	A4	B4
9,600 bps			193	229	97	115
7,200 bps			145	173	73	87
4,800 bps	193	229	97	115	49	59
2,400 bps	96	115	49	59	25	31

Return to Control (RTC)

The end of a page is indicated by transmitting six consecutive EOL codes. This is known as RTC (return to control).



Several scan lines of data at the beginning of a page.



— ITU-T Recommendation —

Recommendation T.4 includes the following descriptions:

- Minimum transmission time per line (also known as the I/O rate)

'One line' refers to one encoded scan line and is defined as the sum of data bits, required fill bits, and EOL bits.

- a. 20 milliseconds : recommended standard
- b. 40 milliseconds : approved option.
10 milliseconds : approved option.
5 milliseconds : approved option.

These are applicable to standard resolution (3.85 lines/mm down the page) and high resolution (7.7 lines/mm).

- Maximum transmission time per line

The maximum transmission time per one encoded scan line is 5 seconds. When the transmission time exceeds 5 seconds, the receiving terminal must proceed to disconnect the line.

- Encoding system

Two encoding systems are available: a one-dimensional run length encoding method (MH) and a two-dimensional encoding method (MR), which is approved as an option.

Modified Read (MR) Method

Overview

The MR method is an expanded form of the one-dimensional run length encoding method and is considered an option of that encoding method. The method is described in detail in this section.

While the MH method encodes pixels in the pixel scanning direction, the MR method also takes notice of the pixels running in the feed direction. The MR method compares the pixels in the current line with the pixels in the preceding line, and transmits information on the relationship between these two lines.

When dealing with relatively simple characters such as those contained in the alphabet, encoding based on the MH method remains effective. However, when dealing with more complex characters, like Chinese-based characters, the encoding efficiency falls. This is where the two-dimensional coding method, the MR method, is more effective. The MR encoding method bases itself on the Relative Address Designation Encoding Method (READ) which combines NTT's Edge Different Coding (EDIC) method and KDD's Relative Address Coding (RAC) method. Slight modifications were made to this method.

In two-dimensional coding, the first line is MH coded, and is treated as a reference line for coding the second line. The second line is expressed as the difference between itself and the reference line. Then, the second line becomes the reference line for the third line, and so on.

K Parameter

The weakness of this method is that if an error occurs, all data after the line with the error will be decoded wrongly, and the rest of the page will be garbled. To counter this, a limit is placed on the number of consecutive lines that are MR coded. When this limit is reached, the next line is MH coded, and this line becomes the reference line for the next block of consecutive MR-coded lines. In this way, if an error occurs, only the block containing the error will be lost.

The limit on the number of consecutive MR-coded lines is the K parameter. Every Kth line is MH coded. Following each MH-coded line, the number of consecutive MR-coded lines is K-1. The maximum K value is as shown below:

- Standard vertical resolution (for regular characters): $K = 2$
- Optional higher resolution (for fine characters): $K = 4$

Two-dimensional Encoding Scheme

In two-dimensional coding, the positions of pixels that change color (known as changing pixels) are coded with respect to the position of a reference element. The reference element can be either on the coding line (the line being coded) or on the reference line (directly above the coding line)

Changing Pixels

Changing pixels are pixels with color (black or white) different to the pixel immediately before on the same line. See the following diagram.

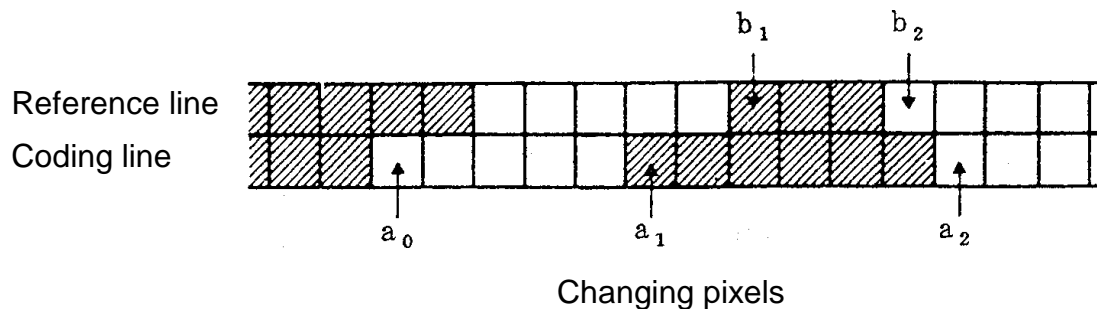
a0: Reference or initial changing pixel along the coding line

a1: First changing pixel to the right of a0 on the coding line

a2: First changing pixel to the right of a1 on the coding line

b1: First changing pixel on the reference line to the right of a0 and of opposite color to a0

b2: First changing pixel to the right of b1 on the reference line



Coding Modes

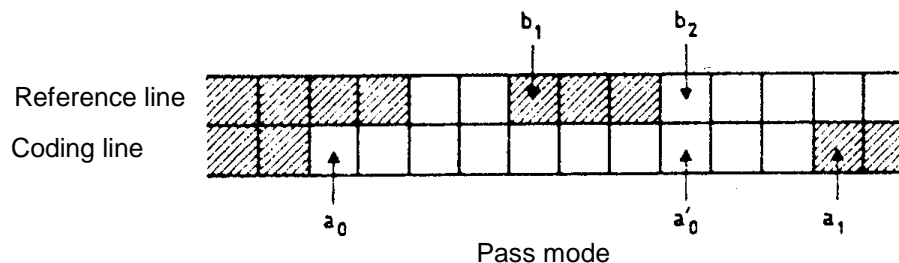
When encoding the position of a changing pixel on the coding line, one of the three modes shown below must be selected.

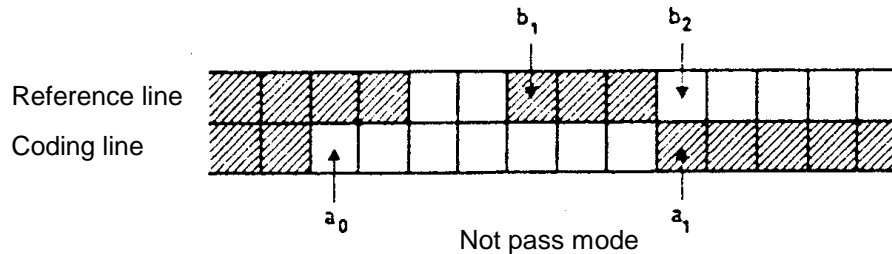
- Pass Mode
- Vertical Mode
- Horizontal Mode

- Pass Mode -

If b_2 is to the left of a_1 , pass mode is used. The pixel is represented by the code for Pass Mode (0001; see the *Two-dimensional Code Table* later in this section). After encoding, a_0 becomes the pixel directly beneath b_2 , to prepare for the next encoding procedure.

Note that if b_2 is located directly above a_1 , pass mode is not selected (see the following diagrams).





- Vertical Mode -

Vertical mode is used if the distance between a_1 and b_1 is three pixels or fewer.

The pixel is represented by one of the following codes: V(0), VR(1), VR(2), VR(3), VL(1), VL(2), VL(3). The appended characters, R and L, represent whether a_1 is to the right or the left of b_1 , while the figures in parentheses represent the distance. The codes are listed in the *Two-dimensional Code Table* (later in this section).

After encoding in vertical mode, a_0 is set in the a_1 position to prepare for the next encoding procedure.

- Horizontal Mode -

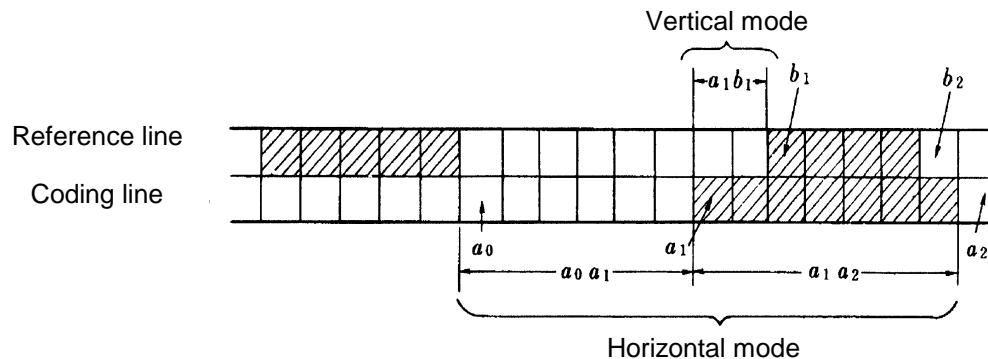
Horizontal mode is used if the distance between a_1 and b_1 is more than three pixels.

In this mode, the run lengths a_0a_1 and a_1a_2 are encoded by the following formula:

$$H + M(a_0a_1) + M(a_1a_2)$$

H is the horizontal mode flag code 001. $M(a_0a_1)$ and $M(a_1a_2)$ represent the run length and color of each, and are encoded using one-dimensional coding.

After encoding in horizontal module, a_0 is set in the a_2 position.



Vertical Mode and Horizontal Mode

The following table shows the codes used in the three modes explained above.

Two-dimensional Code Table

Mode	Elements to be coded		Notation	Code word
Pass	b_1, b_2		P	0001
Horizontal	a_0a_1, a_1a_2		H	$001 + M(a_0a_1) + M(a_1a_2)$
Vertical	a_1 just under b_1	$a_1b_1 = 0$	$V(0)$	1
	a_1 to the right of b_1	$a_1b_1 = 1$	$V_R(1)$	011
		$a_1b_1 = 2$	$V_R(2)$	000011
		$a_1b_1 = 3$	$V_R(3)$	0000011
	a_1 to the left of b_1	$a_1b_1 = 1$	$V_L(1)$	010
		$a_1b_1 = 2$	$V_L(2)$	000010
		$a_1b_1 = 3$	$V_L(3)$	0000010

Coding Procedure

Coding is conducted in accordance with the flow chart shown in the *Two-dimensional coding flow diagram* on the next page.

When the required coding mode has been identified (using Step 1 or 2 as explained below), the code word is selected from the *Two-dimensional Code Table* on the previous page.

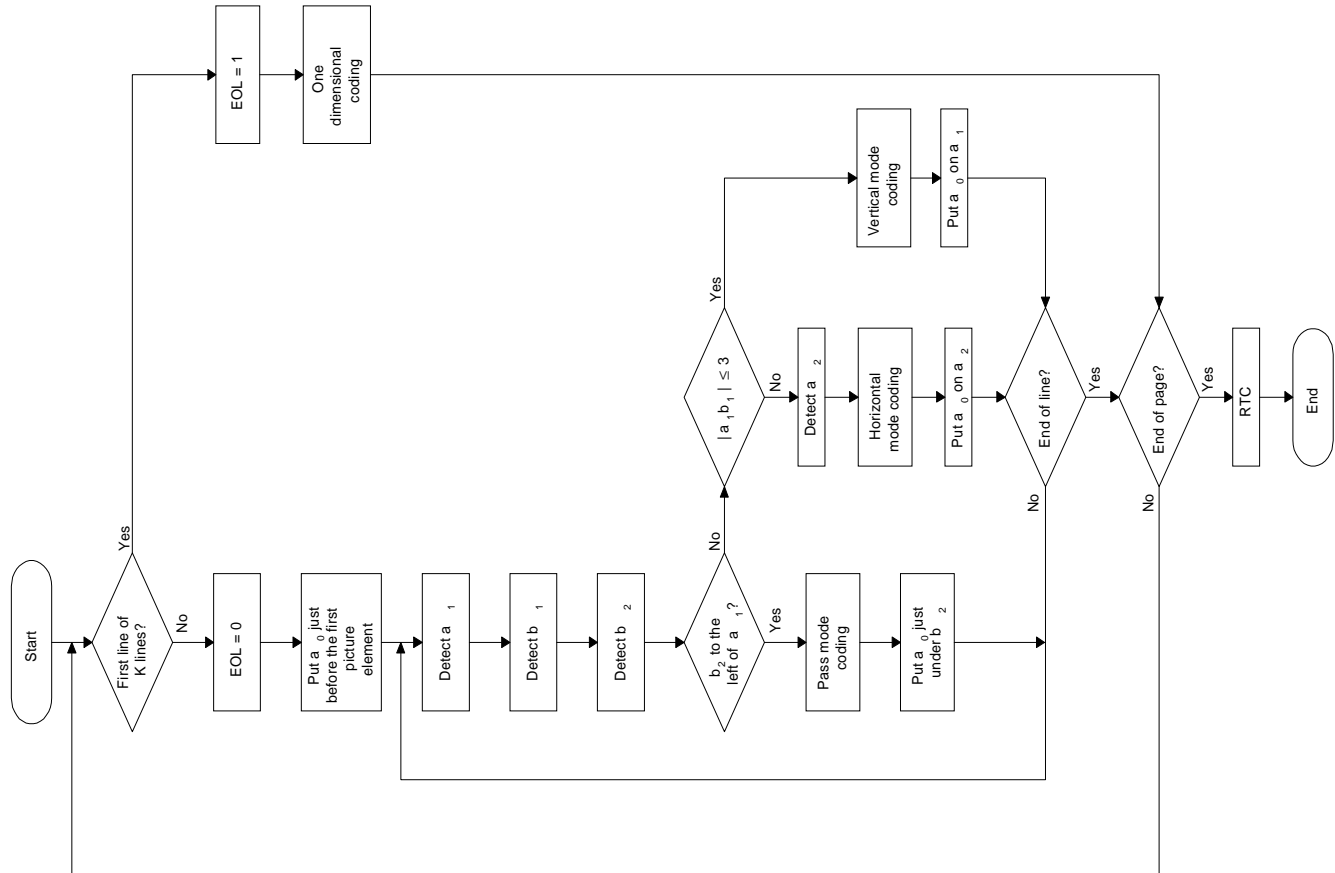
Step 1

- If a pass mode is detected, this is coded as 0001. Then, a0 is set directly beneath b2 to prepare for the next encoding procedure.
- If a pass mode is not detected, go to step 2.

Step 2

- If the distance between a1 and b1 is three or fewer pixels, vertical mode is used. Then, a0 is set in the a1 position to prepare for the next encoding procedure.
- If the distance between a1 and b1 is more than three pixels, horizontal mode is used. Then, a0 is set in the a2 position to prepare for the next encoding procedure.

Two-dimensional coding flow diagram



Processing the first and last pixels in a line

(A) Processing the first pixel

The first initial reference pixel a_0 along each coding line is imagined to be immediately before the first pixel and is considered to be a white pixel.

The first run length a_0a_1 is replaced by $a_0a_1 - 1$. Therefore, when the first run is black, and the line is encoded using horizontal mode, then $M(a_0a_1)$ corresponds to a white run of zero length.

(B) Processing the last pixel

The machine continues until it has encoded the position of the changing pixel imagined to be immediately after the last actual pixel. This pixel is encoded either as a_1 or a_2 . Also, if b_1 and/or b_2 are not detected on this line, they will be placed on the imaginary changing pixel immediately after the last actual pixel on the reference line.

Line synchronization code

EOL will be added at the end of the line. After the EOL, a tag bit will be added to indicate whether one-dimensional encoding or two-dimensional encoding will be used for the next line.

EOL + 1: The next line will go through one dimensional encoding.

EOL + 0: The next line will go through two dimensional encoding.

Fill

To ensure that the encoded data is not shorter than the per-line minimum transmission time, fill will be inserted between the data and the line synchronization code. Fill bits are not inserted in the middle of data.

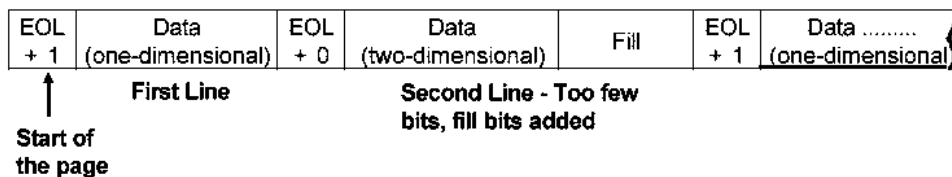
Format : Variable length string of 0s

Return to control (RTC)

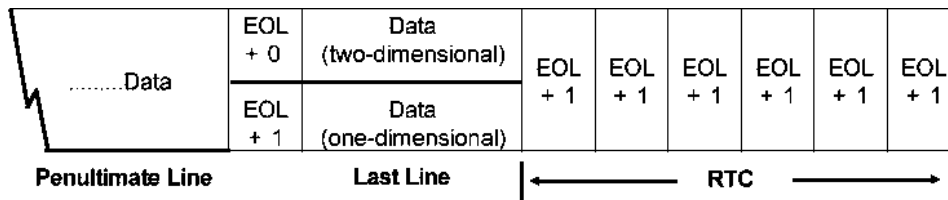
At the end of a page, six EOL + 1 signals are transmitted.

Summary

In summary, transmitted data will look something like the following after MR coding.



At the end of the page, the data will appear as follows.



Simple Modified Read (SMR) Method

This is the same as MR coding except that K is 8 for Standard and Detail resolution, and 16 for Fine resolution. This compresses data more effectively, but more data will be lost if line errors occur.

Modified MR (MMR) Method

The modified MR (MMR) encoding method uses the same algorithm as the MR method explained previously. The differences between the MMR and MR methods are as follows:

- i. K parameter = ∞ : This means that all lines are encoded by two-dimensional encoding. The first line of the page, the reference line, is a white line added to the top of the page, and MH coded. All lines on the page are coded with reference to this imaginary white line.
- ii. EOL is the line synchronization signal.
- iii. No fill bits are used.
- iv. RTC: Transmission of two consecutive EOL signals (also known as EOFB)
- v. After EOFB, when it is necessary to arrange the information into a certain block size (such as to make up a complete ECM data frame), pad bits are added. Pad bits are a variable length row of 0s.
- vi. If there is a change in coding mode from MMR to something else, an 'extension code' is used. The format of the extension code is 0000001xxx, where xxx depends on which coding mode is used instead of MMR after the extension code.

Because an error can result in the loss of a lot of data, MMR is only used where data transmission is highly reliable, such as on high-quality digital networks (Group 4 Facsimile), or if ECM is in use. MMR may also be used when storing data to SAF memory, for the most efficient use of the memory space.

Estimated Fillbit Control (EFC)

Overview

Estimated Fillbit Control (EFC) was developed by Ricoh to improve the efficiency of MH, MR, and MMR coding. To reduce transmission time, EFC controls the number of fill bits inserted at the end of each line of compressed data.

EFC is not strictly a compression technique, but it improves the efficiency of data transfer by controlling the number of fill bits inserted by the transmitter at the end of each line of data.

There are several proprietary EFC techniques on the market. The techniques used by this manufacturer include EFC, New EFC, and SSC (Super Speed Coding).

Basic EFC

This method works as follows: while data is being received into memory, it passes through a FIFO (first-in first-out) memory. However, because of memory capacity limitations, the transmission side must be controlled so that the FIFO memory in the receiving terminal will not overflow. The transmission side controls the number of fillbits by estimating the status of the receiver's memory.

For the MH method, the minimum number of bits (number of bits per line after encoding + fill bits) is defined by the following equation:

- Minimum no. of bits = (Modem speed x I/O rate) + 1

However, with the EFC method, the minimum number of bits is such that:

- Minimum no. of bits \geq Modem speed x Minimum reproduction processing time

The I/O rate shows the time needed by the receiver to process a line, but the full duration may not always be needed, so:

- I/O speed \geq Minimum reproduction processing time

Therefore, the number of fillbits will be smaller than with the MH or MR method. Consequently, it is possible to achieve a reduction in transmission time.

Furthermore, EFC comes in two kinds, EFC and New EFC. While machines with EFC capability can exchange a page in 13 seconds, a boosted buffer memory allows machines with New EFC to transmit a page in 12 seconds (from memory to memory).

EFC Without Consecutive Flag Transmission

This is also known as EFC plus Short Preamble.

This method is an improvement in terms of transmission control. With the preamble set at one second, transmission time is further reduced.

The receiving terminal can ignore carrier interruption signals transmitted from the modem until data processing within the memory is completed.

Normally, the post-message command can be received immediately after the page of image data.. However, depending on the contents of the data, processing the data stored in the reception memory takes some time, occasionally causing the post-message command to be received only on the second try.

Super Speed Coding (SSC) Method

The Super Speed Coding (SSC) method combines EFC plus Short Preamble and white line double-speed processing to achieve a further reduction in transmission time.

White-Line Double Speed Processing

When the data is all white, this method reduces the minimum number of bits to half that of the conventional bit number.

On the reception side, when a white line is transmitted, the printer motor is fast forwarded to skip the line.

Both terminals must have this feature, or it will not work.

JBIG Method

What is JBIG?

JBIG (Joint Bi-Level Image Expert Group) is a working group which consists of members of ITU-T T.82 and ISO11544. The JBIG compression method allows lossless compression of bi-level (black-and-white) images. Data compression is approximately 1.2 to 1.3 times better than the MMR method in text mode, and 2 to 10 times in halftone mode.

How is it Done?

JBIG compression consists of four processes:

- Conversion to bi-level data (if the original data is more than one-bit-per-pixel (i.e., if the output contains greyscales)
- Progressive coding (sending a low resolution image first, then increasing the resolution by sending more data to enhance the image)
- Division into stripes
- Coding (using a process known as 'arithmetic coding')

Conversion to Bi-level Data

Multi-level data is converted to bitplanes using a process known as Grey coding. Each bitplane consists of an image made up of bi-level pixels (0 or 1). Each bitplane will then undergo the remaining steps of the JBIG compression process.

The number of bitplanes generated increases with the number of greyscales in the image. Because of this, if there are more than 8 bits per pixel, other compression techniques may be more efficient than JBIG.

Progressive Coding

With progressive coding, an image is sent gradually instead of all at once. A low resolution image is sent first, then more detail is sent, and the receiver can progressively build up a higher-resolution image. With JBIG, the resolution doubles with each level of detail.

Division into Stripes

The image is then divided into stripes, and each stripe is coded and sent separately. There are two modes for JBIG compression.

- Standard mode: The transmitted data stripe consists of 128 lines.
- Optional mode: the transmitted data stripe consists of one page (transmission speed with this mode is faster).

The mode used is determined during handshaking, and can be set by bit switch adjustments.

Coding

MH, MR, and MMR are based on run-length coding. JBIG is based on a different process, known as 'arithmetic coding'. Arithmetic coding is done by a device known as a 'Q-coder'.

Arithmetic coding looks at the patterns of pixels (known as 'contexts') surrounding each pixel. The algorithm contains a library of contexts, and for each context, there is a prediction as to

whether the central pixel is black or white. For example, if the context consists of all white pixels, it is likely that the target pixel is also white.

As for MH coding, the Q-coder assigns short codes to the most probable combinations of pixels, and long codes to the least likely combinations. In this way, maximum compression is achieved if each target pixel is always equal to the predicted pixel value for their context.

Other Points about JBIG

When is JBIG used?

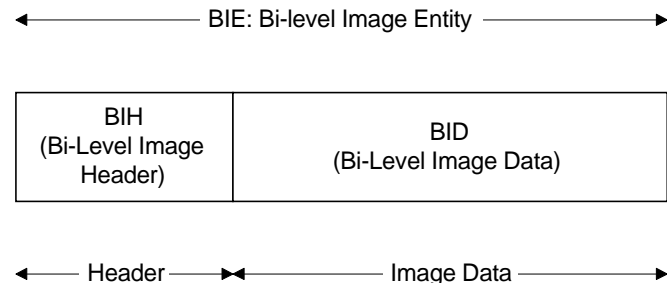
JBIG compression is disabled when any of the following conditions occur.

- When JBIG compression is turned off
- When ECM is turned off
- When the receiving terminal does not have the JBIG feature.
- When the receiving terminal does not have the ECM feature.

What is the Data Format?

JBIG compressed data is referred to as a Bi-level Image Entity (BIE).

The BIE consists of a header frame (BIH: Bi-level Image Header) and a compressed data frame (BID: Bi-level Image Data).



The BIH frame contains information such as main scan width (pixels), sub-scan length, and compression mode (standard/optional).

The BID frame contains the actual data.

What are the Strengths and Weaknesses?

Strengths

- Superior compression for bi-tonal images than MMR, especially for complex images containing shading for example.
- Smaller files for greyscale images than JPEG.

Weaknesses

- Takes twice as long to decompress as Group 4 MMR.
- JPEG is better for photographs

Modulation Techniques

Introduction

Fax machines communicate with each other by emitting a wave of a certain frequency onto the telephone line. This wave is called the **carrier**. The data signal from the fax machine is known as the **modulating signal**. To transmit data using this carrier wave, the fax machine superimposes the modulating signal onto the carrier wave by varying the frequency, amplitude, or phase (or a combination of these) in a standard manner. This process is known as **modulation**. The machine receiving this modulated signal can recover the original data by **demodulating** the signal. Demodulation also includes noise removal and compensation for distorted waveforms.

A device called a modem carries out modulation and demodulation. The modem outputs the carrier wave. The characteristics of the carrier wave are based on the following formula.

$$E = A \sin (2\pi ft + \theta)$$

A: Amplitude, f: Frequency, θ : Phase, t: Time, E: Output

The modem transmits data by modulating either A, f, or θ , or a combination of these.

For example, the V.29 modem sending at 9,600 bps modulates A and θ . The frequency of the wave is fixed at 1,700 Hz. At any point on the wave, the wave has one value of A and one value of θ . The V.29 modem can output 2 possible values of A and 8 possible values of θ . This means that the V.29 modem can output 16 different waves. Each of these 16 waves can be made to represent a different combination of bits; 0000, 0001, 0010, and so on up to 1111 can be represented with a unique waveform.

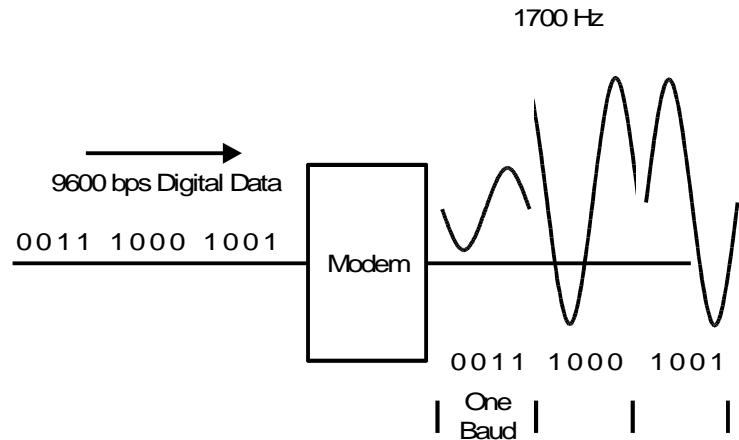
A simple example of how a V.29 modem converts digital data into an analog signal is illustrated here. The receiving modem decodes the signal by measuring the amplitude of the wave and the phase of the wave at the start of each Baud.

Baud Rate

Each of the individual waveforms shown in the previous diagram is known as a Baud. The Baud rate is the number of bits per second divided by the number of bits per Baud. For a 9600 bps (bits per second) modem, each Baud represents 4 bits. Therefore, the Baud rate is 2400. This means that the V.29 9,600 bps modem sends out 2,400 waveforms per second.

Another way to think of the Baud is that it is the number of times per second that the signal from the modem changes.

Do not confuse the Baud rate with bps when considering the machine's data speed.



Generally, public telephone networks can only communicate using frequencies that are within the voice band, that is, between 300 and 3,400 Hz. Therefore, the carrier wave must be somewhere within these limits (the frequency of the carrier differs depending on the modulation method used).

In facsimile communication, several types of modulation are used. This section will describe these methods briefly. Details of the methods are given in the following ITU-T recommendations.

- **V.21:** Specifies conditions for signalling (protocol signals) at 300 bps, using frequency shift keying (FSK).
- **V.27ter:** Specifies conditions for signalling (fax data) at 2,400 and 4,800 bps, using polyphase shift keying (PSK).
- **V.29:** Specifies conditions for signalling (fax data) at 7,200 and 9,600 bps, using quadrature amplitude modulation (QAM).
- **V.32/V.17:** Specifies conditions for signalling (fax data) at 9,600 bps using trellis code modulation (TCM); this is used in machines that communicate at speeds of up to 14,400 bps, if they have to step down to 9,600 bps.
- **V.33 (V.32bis)/V.17:** Specifies conditions for signalling (fax data) at 12,000 and 14,400 bps.
- **V.8/V.34:** Specifies conditions for signalling (fax data) at up to 28,800 bps
- **V.8/V.34bis:** Specifies conditions for signalling (fax data) at up to 33,600 bps

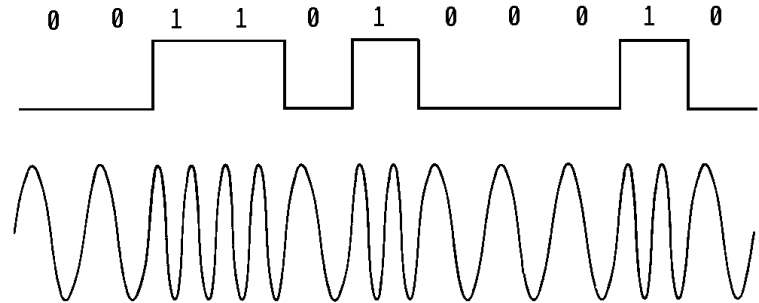
As will be seen, a more complex modulation type allows more information to be carried on the same wave, which leads to a higher data speed. This is illustrated by the fact that the data rate for the 9,600 bps modem is higher than for the 7,200 bps modem, even though the Baud rate is the same (refer to Quadrature Amplitude Modulation).

Note

- bps is the data rate in bits per second
- Hz (Hertz) is the frequency of a wave in cycles per second

V.21–Frequency Shift Keying (FSK)

Frequency shift keying (FSK) is a type of frequency modulation that is used for transmitting digital signals. In basic frequency modulation (FM), the modulating signal changes the frequency of the carrier wave. In the example in the diagram, an analog signal is modulating the carrier wave. Notice how the phase of the wave changes when the value of the data signal changes from 0 to 1 and from 1 to 0.



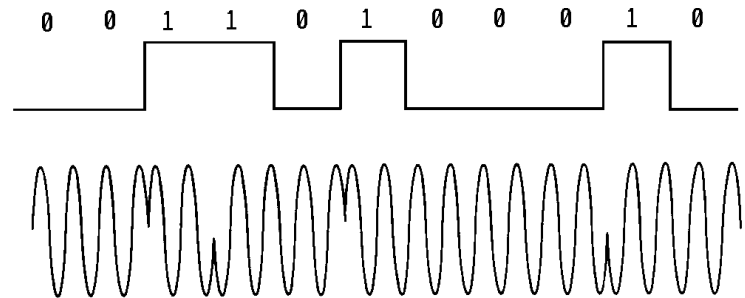
In fax machines, the modulating signal is a 300 bps digital signal (for example, an NSF protocol signal). Fax machines use the FSK method outlined in ITU-T recommendation V.21. If the signal is a 0, the transmitted frequency is 1,850 Hz. If the signal is a 1, the transmitted frequency is 1,650 Hz.

The Baud rate is 300 Baud, and there is only one bit per Baud.

V.27TER–Polyphase Shift Keying (PSK)

Overview

Polyphase shift keying (PSK) is a type of phase modulation (PM). In PM, data is modulated by altering the phase of the carrier wave. The frequency is kept constant. See the diagram for a simple example. A one is represented by a 180 ° phase shift, and a zero is represented by the phase staying the same.



PSK under the V.27ter specifications uses a carrier frequency of 1,800 Hz. However, the data rate of 4,800 bps is considerably faster than the carrier wave frequency. To fit the data onto the carrier wave, the carrier wave must be modulated in such a way that more than one bit is being transmitted at any time.

To do this, V.27ter specifies two types of phase modulation.

PSK at 2,400 bps

Data is sent two bits at a time. The phase of the signal is varied in accordance with the data. There are four possible signals, as shown in the following table.

Two-bit value	Phase
00	0 °
01	90 °
11	180 °
10	270 °

PSK at 4,800 bps

Data is sent three bits at a time. The phase of the signal is varied in accordance with the data. There are eight possible signals, as shown below.

Three-bit value	Phase	Three-bit value	Phase
001	0 °	111	180 °
000	45 °	110	225 °
010	90 °	100	270 °
011	135 °	101	315 °

The two-bit and three-bit groups described above are known as Bauds. The Baud rate is the number of Bauds transmitted per second. Do not confuse the data rate with the Baud rate.

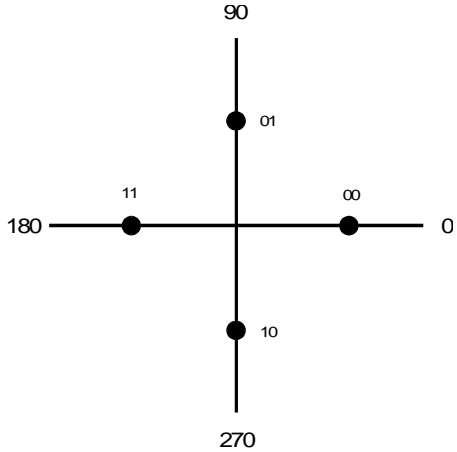
Using V.27ter PSK, at a data rate of 2,400 bps, the Baud rate is 1,200 Baud, and at 4,800 bps, the Baud rate is 1,600 Baud.

Note: In PM, the phase change is the actual change in the signal phase between a Baud and the Baud following it.

Summary

V.27 PSK modulation is summarized in the following table.

Modem Type	Data Speed	Carrier Freq.	Baud Rate	Modem Type	Eye Pattern
V.27 ter	4800 bps	1800 Hz	1600 Baud	8 ϕ PSK	

Modem Type	Data Speed	Carrier Freq.	Baud Rate	Modem Type	Eye Pattern
V.27 ter	2400 bps	1800 Hz	1200 Baud	4 ϕ PSK	

V.29–Quadrature Amplitude Modulation (QAM)

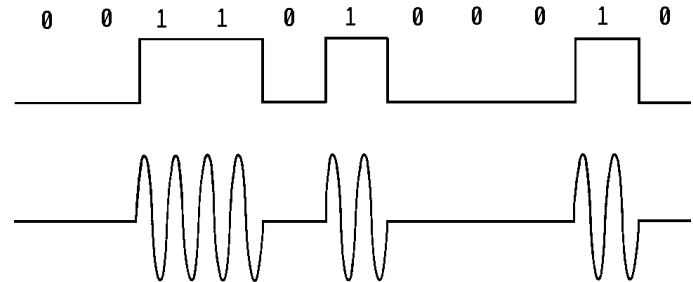
Overview

Quadrature amplitude modulation (QAM) is a combination of amplitude modulation (AM) and phase modulation (PM).

PM has already been described (see the previous section). In AM, the amplitude of the wave varies with the data signal. In the following example, a digital signal modulates the carrier. The amplitude is high when the digital signal is at 1, and low when it is 0. The frequency is kept constant.

AM is a relatively simple technique, however, it is susceptible to noise.

QAM under the V.29 specifications uses a carrier frequency of 1,700 Hz. V.29 specifies two types of modulation.



QAM at 9,600 bps

Data is sent four bits at a time. The phase and amplitude of the signal are varied in accordance with the data. There are 16 possible signals, as shown in the following table.

Four-bit value	Phase	Amplitude
0001	0 °	3
0000	45 °	$\sqrt{2}$
0010	90 °	3
0011	135 °	$\sqrt{2}$
0111	180 °	3
0110	225 °	$\sqrt{2}$
0100	270 °	3
0101	315 °	$\sqrt{2}$
1001	0 °	5
1000	45 °	$3\sqrt{2}$
1010	90 °	5
1011	135 °	$3\sqrt{2}$
1111	180 °	5
1110	225 °	$3\sqrt{2}$
1100	270 °	5
1101	315 °	$3\sqrt{2}$

QAM at 7,200 bps

Data is sent three bits at a time. There are eight possible signals.

Three-bit value	Phase	Amplitude
001	0 °	3
000	45 °	$\sqrt{2}$
010	90 °	3
011	135 °	$\sqrt{2}$
111	180 °	3
110	225 °	$\sqrt{2}$
100	270 °	3
101	315 °	$\sqrt{2}$

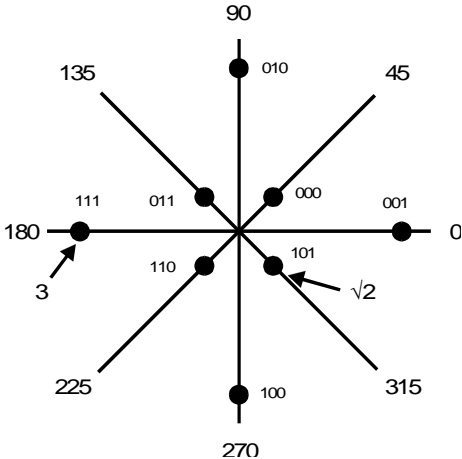
The phase change in the above tables refers to the actual change in the signal phase between a Baud and the Baud following it. The amplitude in the above tables is a relative amplitude value.

Note: V.29 also gives a recommendation for faxing at 4,800 bps. However, in fax machines, V.27ter modulation is used at this data rate.

Summary

V.29 QAM is summarized in the following table.

Modem Type	Data Speed	Carrier Freq.	Baud Rate	Modem Type	Eye Pattern
V.29	9600 bps	1700 Hz	2400 Baud	16pt QAM	

Modem Type	Data Speed	Carrier Freq.	Baud Rate	Modem Type	Eye Pattern
V.29	7200 bps	1700 Hz	2400 Baud	8 ϕ QAM	 <p>The diagram shows an 8-PSK constellation with eight points arranged in a circle. The points are labeled with 3-bit binary values: 000 (0°), 001 (45°), 010 (90°), 011 (135°), 100 (180°), 101 (225°), 110 (270°), and 111 (315°). The axes are labeled with angles: 0, 45, 90, 135, 180, 225, 270, and 315. Two arrows point to specific points: one labeled '3' points to the 101 point (225°), and another labeled $\sqrt{2}$ points to the 011 point (135°).</p>

V.17/V.32–Trellis Code Modulation (TCM)

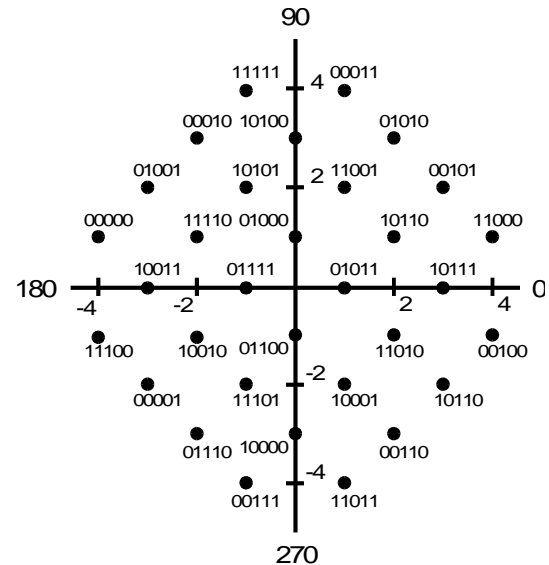
Trellis code modulation (TCM) uses QAM. However, part of the data signal is encoded, using Trellis Coding, for error correction purposes.

TCM at 9,600 bps

The data signal is divided into groups of 4 bits (Q1, Q2, Q3, Q4). The first two bits of the group (Q1, Q2) are encoded into Y1 and Y2. The result of the encoding depends on the previous Y1 and Y2 bits.

Y1 and Y2 are then encoded again. Y1 and Y2 emerge unchanged, but an extra 'redundant' bit Y0 has been generated. The original four bit group has been converted into a five-bit group. The algorithm for generating Y0, Y1, and Y2 is rather complex, and is known as Trellis Coding. Please refer to the ITU-T V.32 and V.32bis recommendations for full details.

The five-bit group is then modulated by QAM in accordance with the following diagram (the array of dots is known as a 'signal constellation'). The five-bit groups in the diagram are listed in the following order: Q4, Q3, Y2, Y1, Y0.



TCM at 12,000 bps (V.32 bis)

The data signal is divided into groups of 5 bits (Q1, Q2, Q3, Q4, Q5). The first two bits of the group (Q1, Q2) are converted to three bits (Y0, Y1, Y2) in the same way as for TCM at 9,600 bps (see above). The original five-bit group is now a six-bit group.

The six-bit group is then modulated by QAM in a similar way to that shown on the previous page for TCM at 9,600 bps. A similar diagram can be drawn, but for TCM at 12,000 bps, there are 64 points on the diagram.

TCM at 14,400 bps (V.32 bis)

The data signal is divided into groups of 6 bits (Q1, Q2, Q3, Q4, Q5, Q6). The first two bits of the group (Q1, Q2) are converted to three bits (Y0, Y1, Y2) in the same way as for TCM at 9,600 bps (see above). The original six-bit group is now a seven-bit group.

The seven-bit group is then modulated by QAM in a similar way to that shown on the previous page for TCM at 9,600 bps. A similar diagram can be drawn, but for TCM at 14,400 bps, there are 128 points on the diagram.

Note: For all three data rates discussed in this section, the Baud rate is 2,400 Baud. Each Baud contains four bits (at 9,600 bps), five bits (at 12,000 bps), or six bits (at 14,400 bps). The redundant bit is not included as part of the Baud.

V.8/V.34: Adaptive Bandwidth

Overview

ITU-T introduced the following recommendations for facsimile communication at higher speeds.

- V.8 (1994): Procedures for starting sessions.
- V.34 (1994): Specifications for modulation and protocol for modems operating at up to 28,800 bps (modified in 1996 to allow data rates of up to 33,600 bps)

V.34 introduces a lot more technical changes compared with the previous speed upgrade from V.29 to V.17.

Signals used in V.34 procedures include tone signals, and data signals at 300 bps, 600 bps, 1200 bps, and from 2.4 kbps to 33.6 kbps.

- T.30 (1996): This recommendation has been modified to include changes to protocol signaling as a result of V.8 procedure implementation (see 'Protocol – V.8/V.34 Protocol' for details).

The 'Protocol – V.8/V.34' section contains more information on V.8/V.34 modulation, with an emphasis on protocol.

Principal Characteristics

The principal characteristics of V.34 procedure are as follows:

1. The use of Error Correction Mode (ECM) is mandatory.
2. Facsimile machines with a V.34 modem must support V.8. If a communication is not started with V.8 procedures, V.34 protocol cannot be used.
3. If V.34 is selected for communication between two terminals, V.17, V.29, V.27ter are not applied.

For best results, good line condition is required. Transmission time can be halved in these cases.

Bandwidth

The theoretical maximum data rate for a telephone line of bandwidth 3000 Hz and S/N ratio of about 30 dB is about 30 kbps.

For 26.4 kbps, a bandwidth of 3000 Hz is required.

For 28.8 kbps, a bandwidth of 3200 Hz is required.

For 33.6 kbps, a bandwidth of 3429 Hz is required.

As we can see from this, V.8/V.34 modulation approaches the limits of what is possible on a conventional telephone line, and the highest data rates may only rarely be observed in the field.

Noise Level

The bandwidth required for a certain data speed depends on signal-to-noise ratio (S/N)
For 28.8 kbps, the signal-to-noise (S/N) ratio must be 32-34 dB or better.

Summary of V.8/V.34 Technologies

The following is a list of the technologies used to implement V.8/V.34. This section will explain them in outline.

- V.8 Handshaking
- Line Probing
- Precoding
- Pre-emphasis
- Power Control
- Trellis Coding

V.8 Handshaking

V.8 handshaking is the first thing that happens in a V.8/V.34 communication. This procedure uses 300 bps V.21 signaling to establish whether the other party is V.8/V.34 compatible. If the other end is not compatible, then communication can drop back to a slower modem type, such as V.27ter.

Line Probing

The receiver sends out a complex series of signals to analyze the condition of the telephone line. The results of this process determine what the carrier frequency will be for the communication,

the bandwidth that is available (and thus the possible range of data speeds that can be used), and the pre-emphasis and power control parameters.

Line probing is done at the start of every communication, and whenever retraining has to be done during a communication.

Pre-coding

V.8/V.34 modulation approaches the theoretical data capacity limit for a telephone line.

Therefore, an adaptation of the most effective receiver equalization technique for analog voice grade modems is used. This technique is known as Decisions Feedback Equalization (DFE).

However, this technique does not always work well with Trellis Coding. To get around this, the receiving terminal calculates the best equalizer parameters in the usual way, but sends them back to the sending terminal. The sending terminal then equalizes the signal before transmission, and can employ Trellis Coding on this signal without any problem.

The term 'pre-coding' refers to something that is done before Trellis Coding.

Pre-emphasis

Pre-emphasis corrects the signal for distortion by boosting signals in some parts of the waveband and attenuating others. The frequencies boosted and attenuated depend on the results of line probing.

Power Control

High transmitting power leads to a good S/N ratio at the receiving end but can cause echo effects. Power control selects the best transmitting power based on the results of line probing, to attain the best possible receiving side S/N with minimal echoes.

Trellis Coding

Trellis coding was introduced in V.17/V.32 modulation. V.34 uses a more complex form, known as 'four-dimensional' trellis coding. (V.17 used 'two-dimensional' trellis coding.)

The signal constellation contains many more points than the ones for V.17/V.32, but the principle is similar.

However, the signal constellation is intentionally warped to counter non-linear distortion (also known as harmonic distortion), which can cause a lot of problems with high-speed data communications, where the difference in phase and amplitude between different points in the signal constellation is quite small. The warping technique increases the distance between the points in the outer margins of the constellation (where the effects of non-linear distortion are the greatest), but brings those near the center closer together.

Protocol

Introduction

People often find it hard to relate to each other and exchange information without some kind of formal introduction. Fax machines have similar problems.

Standard signalling procedures for fax machines have been developed so that any pair of fax machines can communicate with each other, regardless of their makers or countries of origin.

Facsimile machine protocol allows handshaking between the two machines before and after data transmission. Handshaking allows the machines to exchange identification and information on what features they are equipped with. Also, the protocol allows the machines to determine the optimum transmission speed for the communication.

The most commonly used signalling procedure is known as ITU-T Group 3.

Protocol. This protocol was developed by the ITU-T (International Telecommunications Union – Telecom) and implemented in 1980.

The ITU-T was previously known as the CCITT (Consultative Committee for International Telephony and Telegraphy).

ITU-T Protocol Categories

There are four types of facsimile protocol.

Group 1 (also known as G1)

This was implemented in 1972. It allows analog fax machines to send a letter-size or A4 page in about 6 minutes, with an optional 4-minute transmission speed. Group 1 transmits data using frequency modulation (FM). Group 1 protocol does not allow handshaking.

Group 2 (also known as G2)

This was implemented in 1976. It allows analog fax machines to send a letter-size or A4 page in about 3 minutes, with an optional 2-minute transmission speed. Group 2 transmits data using amplitude modulation (AM), frequency modulation (FM), and vestigial sideband modulation (VSB).

Group 3 (also known as G3)

This was implemented in 1980, and is the most commonly used mode of facsimile communication world-wide. It allows digital fax machines to send a letter-size or A4 page in about 30 seconds to 1 minute. Group 3 transmits data using phase modulation (PM), frequency shift keying (FSK), quadrature amplitude modulation (QAM), and trellis code modulation (TCM). The Group 3 signals have a digital structure, so that information such as machine type and capabilities can be exchanged during the handshaking procedure.

Basic Group 3 uses V.21/V.27ter/V.29 modem standards to communicate at 9,600, 7,200, 4,800, and 2,400 bps. V.17/V.33 modem standards allow speeds of 12,000 and 14,400 bps. In addition, V.8/V.34 standards allow speeds up to 33,600 bps.

Group 4 (also known as G4)

This was implemented in 1984. It allows digital fax machines to send a letter-size or A4 page in about 3 seconds. Group 4 was designed for use on high-speed data networks and ISDNs, allowing data communication at high speeds such as 56 kbps or 64 kbps.

This manual will outline the Group 3 protocol system. For full details of ITU-T Group 3 protocol signalling, refer to the following ITU-T recommendations.

- **T.30:** Describes the various protocol signals, and their uses.
- **T.35:** Provides ITU-T member codes for various countries so that they can implement non-standard features.

This section will first describe the basic T.30 G3 protocol at speeds of up to 14,400 bps, without ECM. Examples of use will be given, showing how fax features such as Polling are implemented.

Error Correction Mode (ECM) will then be described)

After that, the modifications to T.30 that allow high speeds of up to 33,600 bps using V.8/V.34 will be described.

Standard Group 3 Protocol (Without ECM)

Phases A to E

The ITU-T T.30 recommendation divides facsimile communication into five phases.

Phase A: Call setup

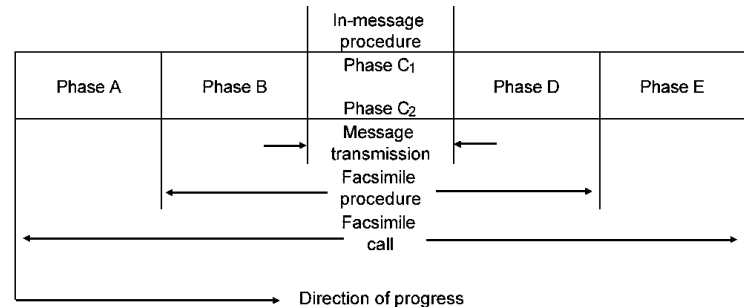
This phase is from the start of the call until the fax machines have connected to the telephone line.

Phase B: Pre-message procedure

During this phase, the two machines exchange information on their capabilities, the transmission parameters selected for this communication, and confirmation of the parameters that both machines can accept.

Modem training also takes place during Phase B.

In addition, the use of optional features and non-standard features can be informed to the other end during Phase B.



Phase C: Data communication

This phase is divided into two parts. Signals from each of these parts are transmitted during Phase C.

- Phase C1: In-message procedure. This controls in-message signalling techniques, such as message synchronization and error detection.
- Phase C2: Message transmission. This controls the exchange of data.

Phase D: Post-message procedure

Signalling during this phase informs whether the data was received correctly, and whether or not there are more pages to follow.

Phase E: Call release

This phase ends when both machines have released the line.

This five-phase description can be illustrated best by a simple one-page transmission, as shown below. However, note that in more complex communications, the situation is not so straightforward. For example, between pages of a transmission, the procedure will go back to phase B or C after phase D.

	Transmitting side		Receiving side
Phase A	Calls the receiving side	→ The line is connected	The bell rings and the machine enters receive mode.
Phase B	Informs the receiver of the settings that will be used for transmission, and sends a short training message	← → ←	Sends the receiving side's identity and capabilities Confirms that training was successful
Phase C	Phase C ₂ : Message transmission	Fax message is sent →	Phase C ₂ : Message reception
	Phase C ₁ : In-message procedure	←	Phase C ₁ : In-message procedure
Phase D	Tells the receiver what is happening next	No more pages → OK ←	Sends the message reception result
Phase E	The line is released.	←	The line is released.

An Example Communication

In this section, we shall examine the G3 protocol procedure and introduce some of the signals by looking at a single-page transmission using Group 3 standard protocol.

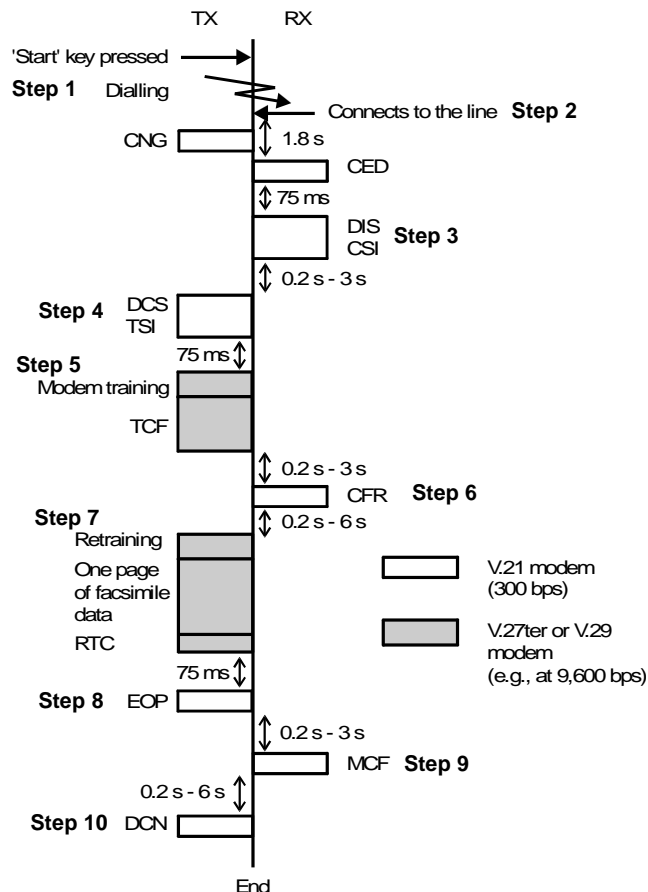
Step 1

The transmitting machine (TX) dials the other party. This happens either after the user has pressed Start (automatic dialling) or dialled the other party on an external handset (manual dialling). When the receiving machine (RX) has detected the incoming call, it connects itself to the line.

Step 2

If the TX side is an automatic dialling fax machine, it will send out a 1100 Hz signal called CNG after dialling. CNG informs the receiver that a fax machine is calling. The tone has a cadence; it is on for 0.5 s and off for 3 s. CNG will be transmitted intermittently until the machine at the other end returns a signal.

About 1.8 s after connecting to the line, the RX side sends out a 2100 Hz tone to the TX side. This is the CED tone; it informs the TX side that they have



connected to a fax machine. The CED tone lasts for 2.4 to 4.6 s. If the TX side is a manual dialler, the operator at the TX side will press the Start key and hang up the handset upon hearing CED, which is a continuous high-pitched tone.

Step 3

After CED, the RX side pauses for 75 ms. Then it transmits two signals: DIS and CSI. Note that CSI is not a compulsory signal; some makers may not implement this signal in their products.

DIS contains information about the RX side's capabilities, such as the types of modem installed, the maximum resolution, the printer paper width, and the data compression/reconstruction methods available. CSI contains the telephone number of the RX side, to identify itself to the operator at the TX side.

The information in the DIS, CSI, and other protocol signals is digitally coded at 300 bps using a type of frequency modulation known as FSK; a '0' is represented by 1,850 Hz, and a '1' is represented by 1,650 Hz.

Step 4

After about 200 ms, the TX side sends out DCS and TSI (TSI is not a compulsory signal). DCS informs the RX side of how the TX side is set up; it includes the resolution that will be used to send the message, the document width, the starting modem rate for facsimile data transmission, and the compression method that will be used. TSI contains the telephone number of the transmitting side, for identification purposes.

Step 5

After about 75 ms, the TX side begins modem training, to check that the V.27ter and V.29 modems in both machines are functioning normally; this training check prevents data from being sent out through a defective modem, which would cause the data to be garbled. Modem training starts at the maximum modem rate (normally 9,600 bps).

During modem training, the TX side modem first transmits a standard test pattern to the RX side to synchronize the modems (the standard patterns are described in V.27ter for 2,400/4,800 bps training and V.29 for 7,200/9,600 bps training). The RX side's modem must be able to detect the standard pattern correctly from the received signal. Then the TX side modem sends a signal called TCF. TCF is a string of zeros lasting for up to 1.5 s. The RX side monitors 0.9 s of this signal, and checks if any of the zeros have been changed to ones.

Step 6

After about 0.3 s, the RX side replies with the result of the modem training. If training was successful, the RX side sends a CFR signal. If training was unsuccessful (too many errors due to a malfunctioning modem or a noisy telephone line), the RX side sends an FTT signal. The procedure then resumes from step 4, at a lower data rate. If training fails at the lowest data rate (2,400 bps), the line is disconnected as fax communication is impossible. When CFR has been sent, the CSI is displayed on the TX side's machine, and the TSI is displayed on the RX side's machine.

Note: Most machines have a pair of bit switch settings to specify how many bit errors are acceptable in the TCF signal (this setting is known as the training error tolerance).

Step 7

After about 0.2 s, the TX side is ready to send facsimile data. First, a short modem training pattern is sent to confirm modem synchronization (this signal is known as retraining). Then the facsimile data is sent at the modem rate for which modem training was successful.

At the end of the data, an RTC code is sent. This consists of six consecutive EOL (000000000001) codes. RTC informs the other end that the page of data has ended. (For more about EOL codes, refer to "Compression Techniques".)

Step 8

After transmitting the end of the page of data, the TX side pauses for about 75 ms. Then the TX side sends a post message command to the RX side, to inform it of what is going to happen next. In our example, there are no more pages, so the TX side sends an EOP signal. In other situations, the TX side might send MPS (indicating that there is another page to come, and it will be transmitted using the same settings as the previous page; the next page is sent from step 7) or EOM (indicating that there is another page to come, but it will be transmitted using different settings from the previous page; the procedure goes back to step 3).

Step 9

After about 0.2 s, the RX side sends back a post-message response, to inform whether the page was received correctly or not. If the page was received correctly, the RX side sends out MCF. If the page was not received correctly, the RX side sends out RTN; an alarm sounds at the TX side and an error report may be printed.

Step 10

After about 0.2 ms, the TX side sends a DCN signal to inform the RX side that it is going to disconnect from the telephone line. Both machines then return to standby mode. The communication is over.

Notes:

- 75 ms interval - This interval is required whenever the machine has to switch between signals from the V.21 to the V.27ter/V.29 modems (or vice versa).
- 0.2 - 3 s interval - This interval occurs whenever communication is handed over to the other terminal in expectation of a command from the other end. If the terminal does not receive a command within 3 s (the value of the ITU-T T4 timer), it will resend the signal. However, after DIS/CSI or after EOP, if a reply is still not received at the third try, the machine will send DCN and a Line Fail will be detected.
- 0.2 - 6 s interval - This interval occurs whenever communication is handed over to the other terminal in expectation of a response to a command. If the terminal does not get a response within 6 s (the value of the ITU-T T2 timer), it will send DCN and a Line Fail will be detected.

Non-Standard Group 3 Protocol

Standard Group 3 protocol provides the framework for Group 3 facsimile communication, and a few features such as Free Polling. However, some manufacturers who wish to introduce new features consider that ITU-T standard Group 3 protocol is limited. Therefore, these manufacturers have used optional signals provided by the T.30 recommendation to implement their own additional features, such as Transfer Request and Confidential Transmission. Usually, these features only work between fax machines that were produced by the same maker.

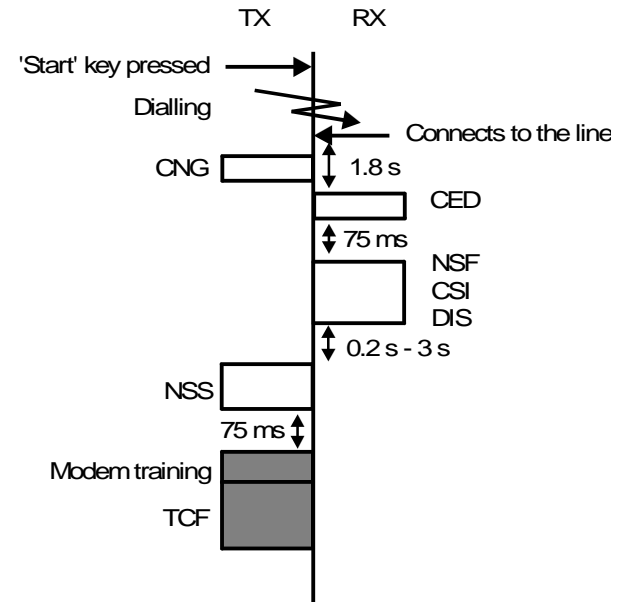
The use of these optional signals is illustrated in the protocol sequence on the right, which is for a single-page transmission.

The rest of the transmission (after TCF) is the same as for standard Group 3 protocol as shown in the previous section.

The new signals are as follows.

NSF: This informs the transmitting side of who the manufacturer is, and what non-standard features are available.

NSS: This informs the receiving side of what non-standard features will be used for the transmission. If the maker of the TX side is different from that of the RX



side, NSS will not be sent. DCS and TSI will be sent, and standard Group 3 protocol will be followed.

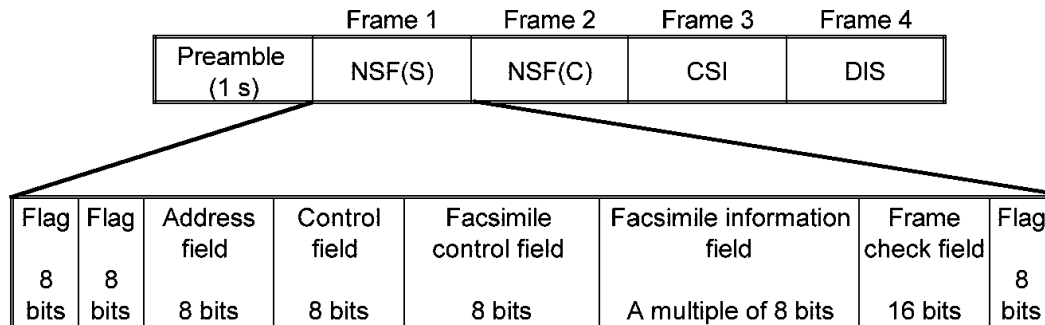
Note: NSF is divided into two parts: NSF(S) first, then NSF(C). NSF(S) contains information on the machine's non-standard capabilities, and NSF(C) contains the RTI, which is an alternative to the CSI as a means of identification. Similarly, NSS is also divided into NSS(S) and NSS(C).

Protocol Signals

HDLC Frames

Protocol signals such as CED and CNG are just single tones transmitted for a certain period of time; these have no structure. However, signals that consist of digital information, such as DIS, NSF, and so on, have a frame-like structure known as HDLC (High-level Data Link Control).

The basic HDLC frame structure consists of a number of frames, each of which is subdivided into a number of fields. An example is shown below, in which a block of four protocol frames (NSF(S), NSF(C), CSI, and DIS) is transmitted in sequence.



Each of the fields is described below.

Preamble

A preamble will be sent before any digitally coded signal if the direction of communication has just changed. The preamble assures that all elements of the communication circuit, such as echo suppressors, are properly conditioned so that the following data can be passed without being damaged. The preamble consists of a sequence of flags transmitted for about 1 s.

Flag: Code 01111110

Flags show the start and end of each frame, and establish bit and frame synchronization.

Address Field (AF): Code 11111111

This is intended to provide station identification in a multi-point network. For communication over the public telephone network, the address field is fixed at 11111111.

Control Field (CF): Code 1100X000

If another signal immediately follows this one, X is 0. If this is the last signal, and a response is expected from the other end, X is 1.

Facsimile Control Field (FCF)

This eight bit code identifies the protocol signal. There is information on all the Group 3 protocol signals later in this section.

Facsimile Information Field (FIF)

This field has bit assignments to show the settings of various features, such as resolution. This field is used in NSF, CSI, DIS, NSC, CIG, DTC, NSS, DCS, and TSI frames, and some of the ECM protocol signals. The bit assignments for some signals are given in the ITU-T T.30 recommendation. Assignments for NSF, NSS, and NSC will vary from maker to maker, and are confidential.

Cyclic Redundancy Check (CRC)

This is also known as the Frame Check Field. This is a 16-bit checksum based on the contents of the AF, CF, FCF, and FIF fields. When receiving a frame, the receiver makes an identical checksum calculation based on the received data and checks the result with the received CRC code to determine whether there have been any errors. The method of calculating the CRC code is given in ITU-T recommendation T.30.

Table of Group 3 Protocol Signals

The following table shows all the Group 3 protocol signals and a brief description of what they do. Some examples will be shown in the following section. This section covers only the basic Group 3 signals; ECM signals are described later.

Stage: At the start of reception

Name	Full Name	FCF Code	Use
CED	<u>C</u> alled <u>S</u> tation Identification	None	The machine is ready to receive. CED is a 2100 Hz single frequency signal.
DIS	<u>D</u> igital <u>I</u> nformation <u>S</u> ignal	0000 0001	DIS informs the TX side of the RX side's capabilities (modem type, I/O rate, printer paper width, and so on).
NSF	<u>N</u> on- <u>s</u> tandard <u>F</u> acilities	0000 0100	NSF is an optional signal. It informs the TX side of any features that the RX side's has that are not ITU-T standard (for example, confidential communication, transfer request).
CSI	<u>C</u> alled <u>S</u> tation <u>I</u> dentification	0000 0010	This contains the RX side's tel. number to identify itself to the TX side's operator.

Stage: At the start of transmission

Name	Full Name	FCF Code	Use
CNG	<u>C</u> alling <u>T</u> one	None	The machine is ready to transmit. CNG is an 1100 Hz tone with the following cadence: on for 0.5 s and off for 3 s.
DCS	<u>D</u> igital <u>C</u> ommand <u>S</u> ignal	X100 0001	DCS tells the RX side what settings will be used to transmit the fax message (such items as modem rate resolution and document width are included).
NSS	<u>N</u> on- <u>s</u> tandard Facilities <u>S</u> et-up	X100 0100	NSS is an optional signal. It informs the RX side of any non-standard features that the TX side will be using for the transmission.
TSI	<u>T</u> ransmitting <u>S</u> tation <u>I</u> dentification	X100 0010	This contains the TX side's tel. number to identify itself to the RX side operator.

Stage: During polling reception

Name	Full Name	FCF Code	Use
DTC	<u>D</u> igital <u>T</u> ransmit <u>C</u> ommand	1000 0001	Informs the called machine of the calling machine's capabilities and requests polling reception.
NSC	<u>N</u> on- <u>s</u> tandard Facilities <u>C</u> ommand	1000 0100	The same as DTC except that it informs non-standard features.
CIG	<u>C</u> alling <u>S</u> tation <u>I</u> dentification	1000 0010	This contains the calling side's telephone number to identify itself to the called side's operator.

Stage: During modem training

Name	Full Name	FCF Code	Use
	Modem training	None	The TX side sends a standard test pattern to check whether both modems are functioning properly. The test pattern is described in ITU-T recommendations V.27ter and V.29.
TCF	<u>T</u> raining <u>C</u> heck <u>F</u> ield	None	This modem training signal is a series of zeros lasting for 1.5 s. It is not a HDLC frame.
CFR	<u>C</u> onfirmation to <u>R</u> eceive	X010 0001	This informs the TX side that modem training was successful.
FTT	<u>F</u> ailure <u>t</u> o <u>T</u> rain	X010 0010	This informs the TX side that modem training was not successful.

Stage: After transmitting a page of data

Name	Full Name	FCF Code	Use
EOP	<u>E</u> nd of <u>P</u> rocedure	X111 0100	This informs the RX side that there are no more pages to send.
EOM	<u>E</u> nd of <u>M</u> essage	X111 0001	This informs the RX side that the settings for the next page (resolution, for example), will be different from those for the page that was just sent.
MPS	<u>M</u> ulti <u>P</u> age <u>S</u> ignal	X111 0010	This informs the RX side that the settings for the next page will be the same as for the page that was just sent.

Stage: When making a voice request

Name	Full Name	FCF Code	Use
PRI-EOP	<u>P</u> rocedure <u>I</u> nterrupt - <u>E</u> nd of <u>P</u> rocedure	X111 1100	This is the same as EOP, except that it indicates that a voice request has been made.
PRI-EOM	<u>P</u> rocedure <u>I</u> nterrupt - <u>E</u> nd of <u>M</u> essage	X111 1001	This is the same as EOM, except that it indicates that a voice request has been made.
PRI-MPS	<u>P</u> rocedure <u>I</u> nterrupt - <u>M</u> ulti <u>P</u> age <u>S</u> ignal	X111 1010	This is the same as MPS, except that it indicates that a voice request has been made.

Stage: Response after receiving a page of data

Name	Full Name	FCF Code	Use
MCF	<u>M</u> essage <u>C</u> onfirmation	X011 0001	This informs the TX side that the page of data and the post-message command were received correctly.
RTP	<u>R</u> etrain <u>P</u> ositive	X011 0011	This informs the TX side that the page of data was received correctly, but that additional pages can only be sent after NSS/DCS and training.
RTN	<u>R</u> etrain <u>N</u> egative	X011 0010	This informs the TX side that the page of data was not received correctly.
PIP	<u>P</u> rocedural <u>I</u> nterrupt <u>P</u> ositive	X011 0101	This informs the TX side that the page of data was received correctly, but further transmission is not possible without the presence of the operator.
PIN	<u>P</u> rocedural <u>I</u> nterrupt <u>N</u> egative	X011 0100	This informs the TX side that the page of data was not received correctly, and that the operator's presence is required.

Stage: At any time, whenever necessary

Name	Full Name	FCF Code	Use
CRP	Command Repeat	X101 1000	This requests retransmission of the previous signal.
DCN	Disconnect	X101 1111	This informs that the machine is about to release the line.

- Notes:**
- In the FCF code, X is 1 on the side that received DIS or NSF.
 - The FCF as indicated in this table is transmitted from the **left** side first.
 - Like NSF and NSS, NSC consists of two parts: NSC(S) and NSC(C).
 - If more pages follow after a voice request, the protocol resumes from CED then NSF/DIS after the conversation.

Comparison of Standard and Non-standard Group 3 Signals

	Capability information			Identifier		
	RX side	TX side	Polling rx requester	RX side	TX side	Polling rx requester
Non-std	NSF(S)	NSS(S)	NSC(S)	NSF(C)	NSS(C)	NSC(C)
Standard	DIS	DCS	DTC	CSI	TSI	CIG

The identifier in standard mode is the data programmed into the CSI. In non-standard mode, it is the data programmed into the RTI.

ITU-T Timers

ITU-T T1 Time

Just after transmitting side finishes dialling the other end, T1 time starts and the machine waits for a signal, such as identification (NSF/DIS/CSI), from the receiving end. If the T1 time runs out before a response is detected, the machine disconnects the line.

For the receiving side, T1 starts when it has sent out NSF/DIS/CSI, and is waiting for a response. While waiting, the machine retransmits NSF/DIS/CSI.

The ITU-T standard value of the T1 timer is $35\text{ s} \pm 5\text{ s}$.

ITU-T T2 Time

After sending a response to training (CFR or FTT) or a response to a received page (such as MCF), the T2 timer starts. If T2 runs out before image data or a command signal is received, the machine disconnects the line. The ITU-T standard value of T2 is $6\text{ s} \pm 1\text{ s}$.

ITU-T T3 Time

T3 starts when the machine calls the operator (after it has detected PIN, PIP, or PRI-Q; e.g., the other side made a voice request). If the operator does not answer within T3, the machine will continue with the facsimile communication procedure that was interrupted. The value of the T3 timer is $10\text{ s} \pm 5\text{ s}$.

ITU-T T4 Time

T4 starts when a machine sends out a command (such as NSF/DIS/CSI, TCF, or EOP). If the transmitting terminal does not receive a reply within T4, it will resend the signal. However, if waiting for a response to NSF/DIS/CSI or EOP/EOM/MPS, it will disconnect the line if a reply has not been received after the signal has been sent out three times. The values of the T4 timer are as follows:

- Automatic receiving fax machines: $3.0 \text{ s} \pm 15\%$
- Manual receiving fax machines: $4.5 \text{ s} \pm 15\%$

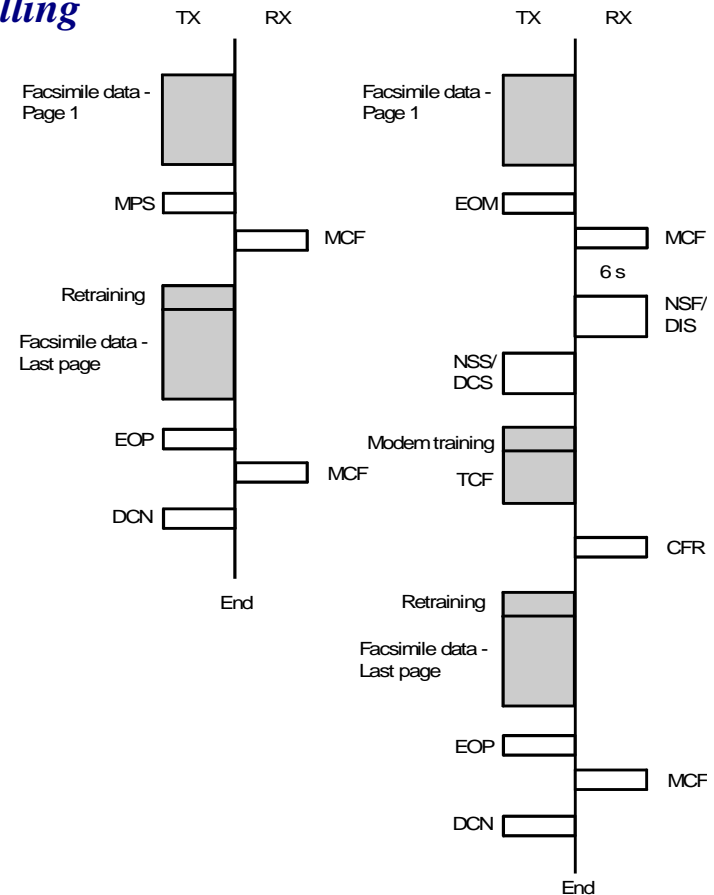
ITU-T T5 Time

This is used with ECM. The transmitting terminal starts T5 when it detects the first RNR and resets it when it detects MCF or ERR. If T5 runs out before MCF or ERR are detected, the transmitter sends DCN. Examples are shown later in this section. The value of the T5 timer is $60 \text{ s} \pm 5 \text{ s}$.

Example Uses Of Group 3 Protocol Signalling

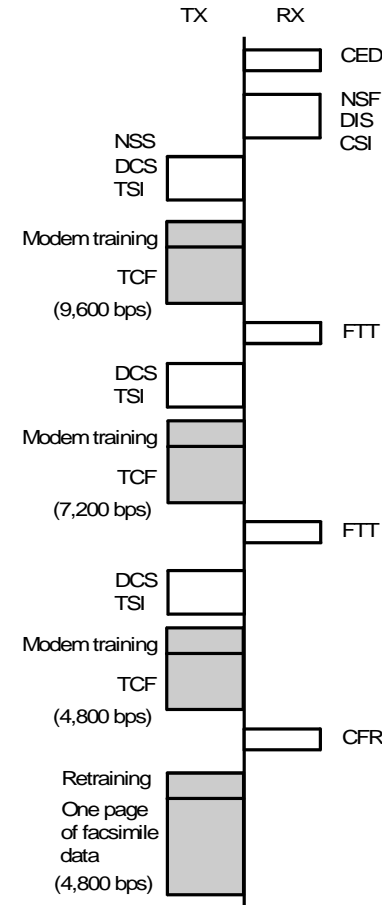
Two-page Transmission

The left side of the diagram shows what happens when the second page is transmitted with the same settings as the first page. However, the right side of the diagram shows what happens if the transmitter's operator changes the settings for the second page, for example, by selecting a different resolution. The diagrams begin half-way through the first page. Until that point, the protocol is the same as for one-page transmission.



Automatic Fallback

The diagram shows how automatic fallback is achieved. Automatic fallback occurs if modem training cannot be done successfully, and the transmitter has to use a slower modem rate. In the example shown, training fails at 9,600 and 7,200 bps, but succeeds at 4,800 bps. The protocol is only shown up to the transmission of facsimile data.

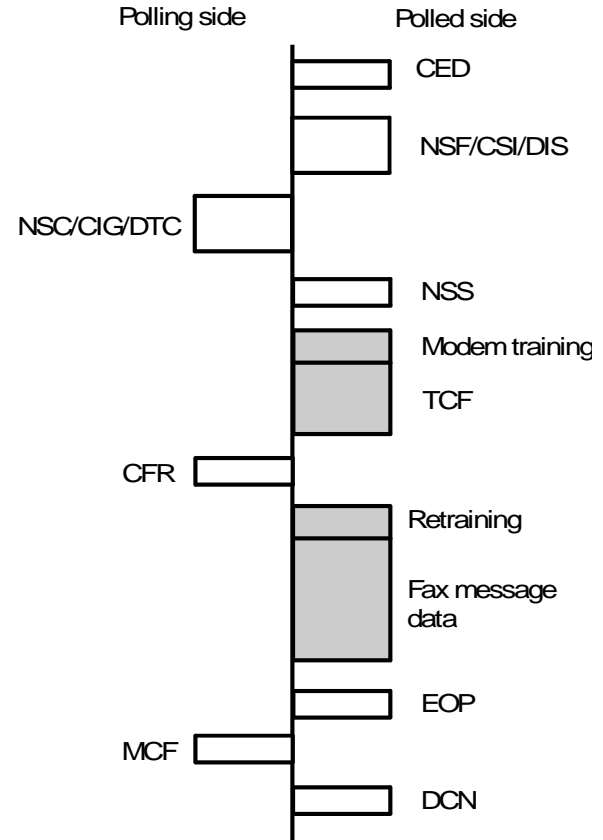


Polling

The diagram shows how polling is done.

- Polling will only work if:
- Both terminals have compatible polling features.
- The ID codes are the same, unless free polling has been selected. (Free polling is a ITU-T standard procedure, using DIS, DTC, CIG, and DCS. However, polling using ID codes is non-standard, using NSF, NSS, and NSC, and can only be guaranteed between models produced by the same maker.)
- The polled side is ready for polling (it must have a document ready on polling standby).

Note how the direction of the communication changes after the polling side has sent out NSC or CIG/DTC.



Voice Request

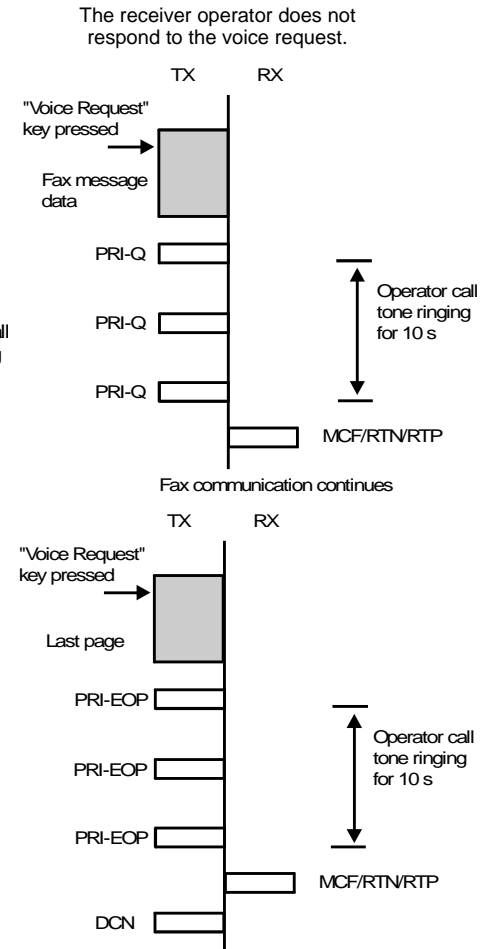
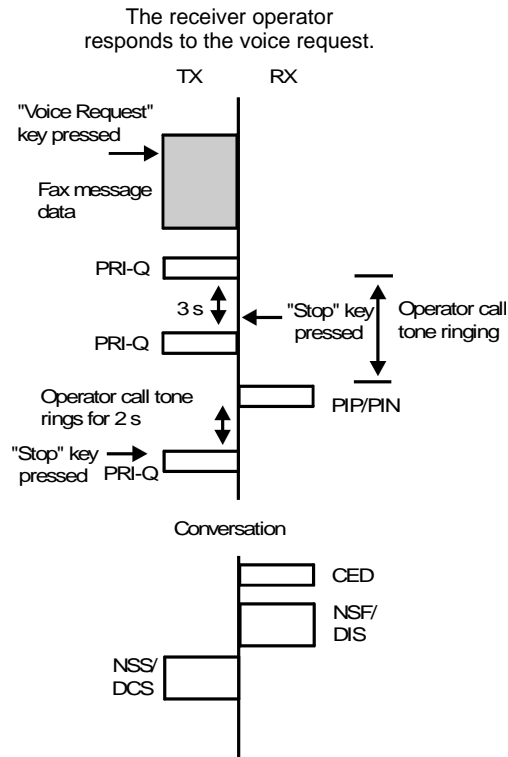
The following diagrams show how the transmitting side makes a voice request to the receiving side.

Voice request does not work when the other end does not have the voice request function.

PRI-Q refers to PRI-EOM, PRI-EOP, or PRI-MPS, whichever is applicable in the circumstances.

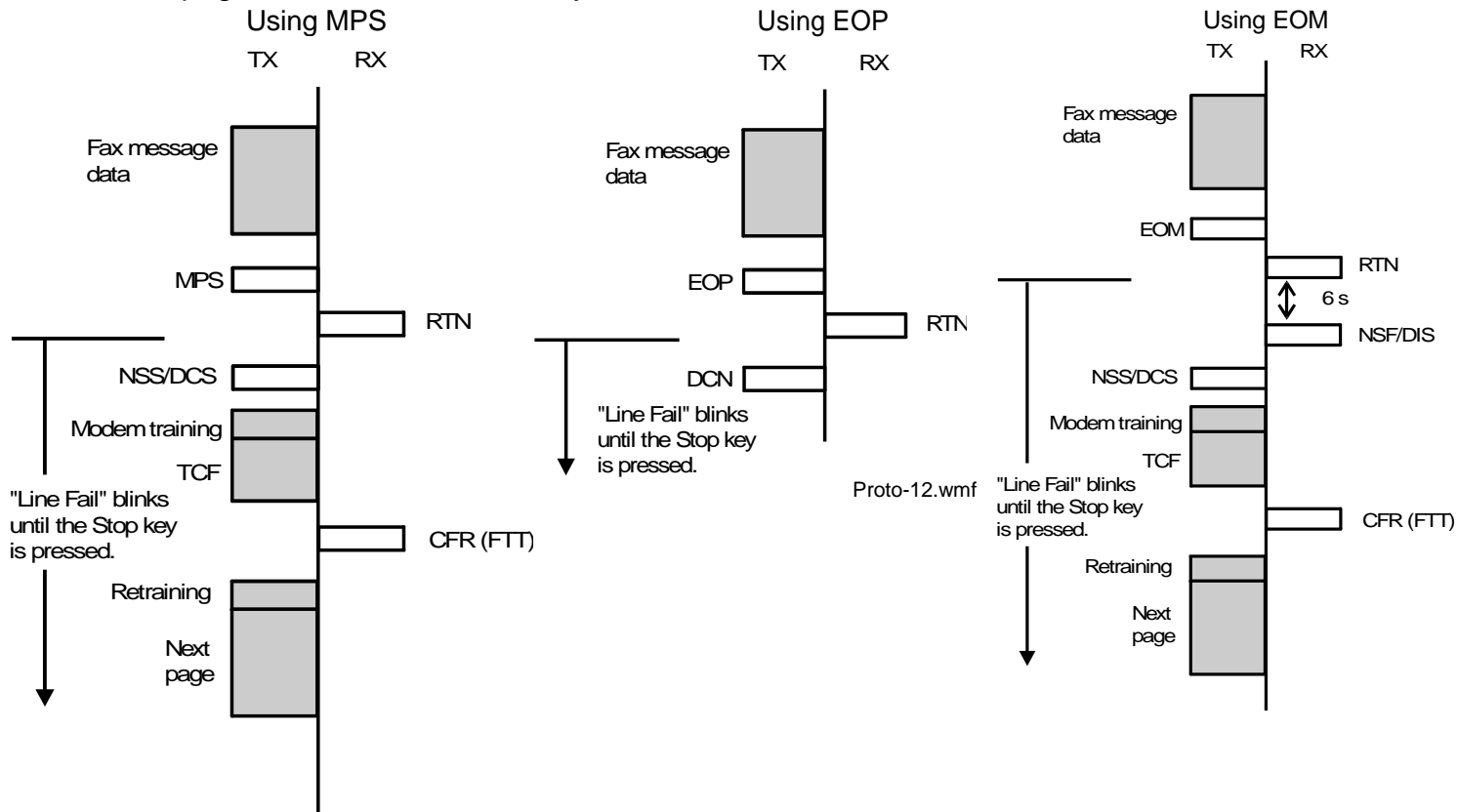
PIP/PIN means either PIP or PIN.

The diagrams are for ITU-T standard procedure. In non-standard procedure, PRI-Q is sent up to 6 times. If there is still no response, Q is sent.



Commonly Occurring Problems

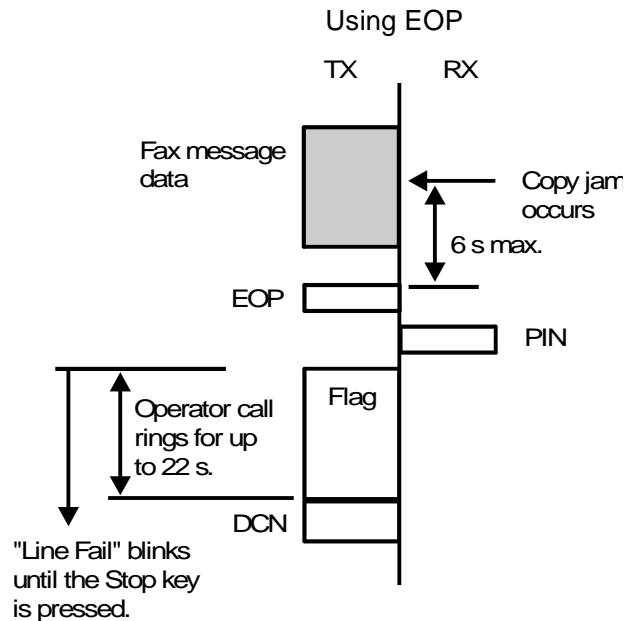
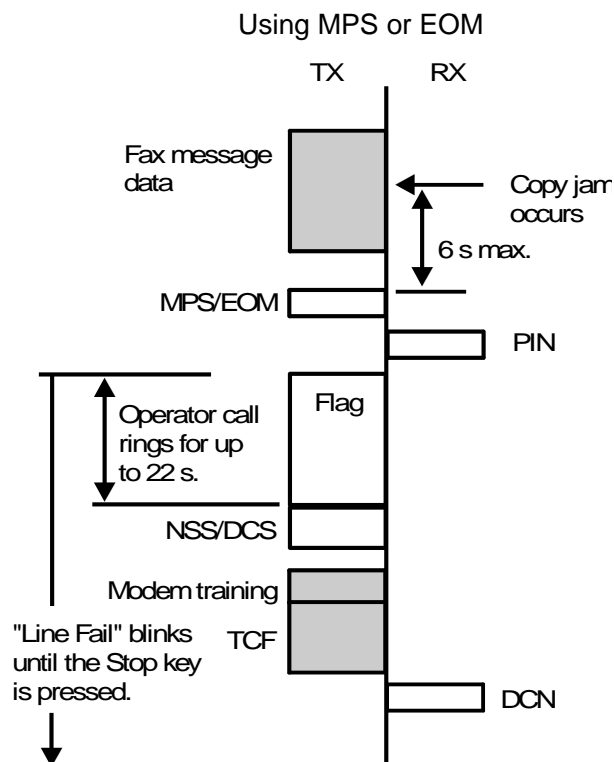
- When the page is not received correctly -



RTN may make older terminals release the line. Newer models continue as shown, even though "Line Fail" blinks. For example, if page 3 in a five-page transmission fails, the machine will continue to send pages 4 and 5. The fact that page 3 failed will be output on an error report.

If the transmitting machine is using memory transmission (without ECM), and a page fails, the same page will be retransmitted using the above protocol procedure (or using EOP or EOM if required).

- When there is a copy jam or paper runs out during reception -



If the RX side does not detect MPS/EOM/EOP within 6 s of the jam occurring, it will disconnect the line.

The operator call rings for 22 s in non-standard mode, but only for 10 s in ITU-T standard Group 3 mode.

The diagrams on the previous page show what happens when the receiving machine has no memory. If the receiving machine does have SAF memory, the incoming data can be stored in that memory using a process known as Substitute Reception. This is explained on the next page.

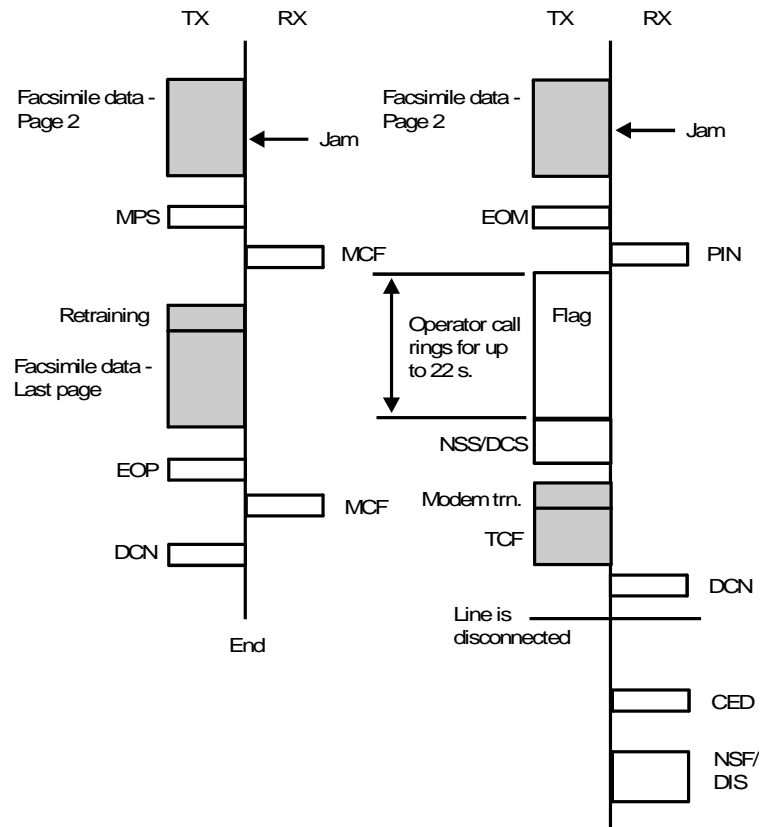
Substitute Reception

There are two procedures for substitute reception. Some models have a bit switch setting to select one or the other of these. Both procedures are shown.

In the left-hand procedure, data is stored in memory as it comes in. So, if the printer has a problem, the data is already saved, and any more incoming pages are automatically saved to memory.

In the right-hand procedure, the data is not stored during reception. If a problem occurs, the receiver sends out PIN and the communication stops; the last page of the communication is lost. Substitute reception only takes place from the next communication.

The operator call rings for 22 s in non-standard mode, but only for 10 s in ITU-T standard Group 3 mode.



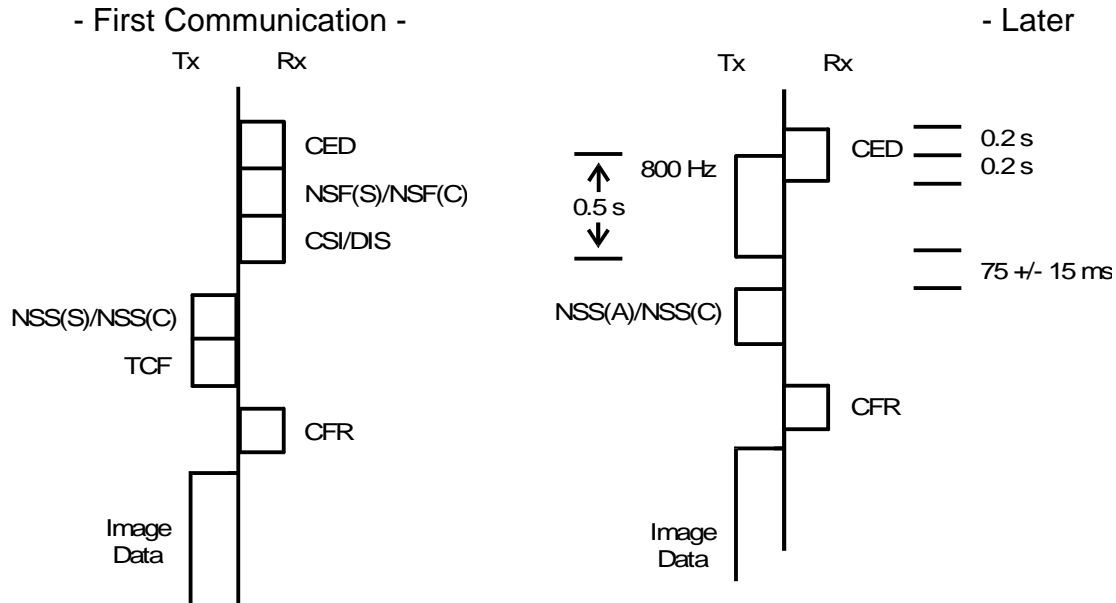
AI Short Protocol

Overview

AI (Artificial Intelligence) Short Protocol reduces the time required for the protocol exchange between terminals. When the machine communicates with a particular fax terminal for the first time, protocol proceeds as normal. However, the communication parameters agreed during the protocol exchange are stored, and so is the modem rate that was used for sending the last page of the message. Then, when the same number is called again some time later, these parameters are immediately put into effect, eliminating most of the handshaking and training procedures.

This feature is only available with numbers that are stored as Quick or Speed Dials.

Notes: This feature may not be effective for international communication because of the line delay caused by satellite links. The delay means that the rx side may not be able to receive the AI Short Protocol trigger signal (800 Hz) before it has finished sending CED.

Basic Protocol Procedures

Communications -

1. After it detects CED, the tx side will send out an 800 Hz signal for 0.5 s. Then, it will send NSS(A) and NSS(C). If the RTI is not programmed, NSS(C) will not be sent.

2. When it detects 800 Hz, the rx side enters AI Short Protocol mode. It will stop sending CED 0.2 s after it detects the 800 Hz signal, and it will not send out NSF or DIS.
3. If the CRC data in the rx side's own NSF(S) signal is the same as that of the received NSS(A) signal, the rx side will send CFR.
If the CRC is different, the rx side will send FTT and NSF. Then normal G3 protocol resumes with NSS(S). In this case, the overall communication time will be longer.
4. After receiving CFR, the tx side will send image data at the modem rate determined by the AI Short Protocol Algorithm (see below).

*Communication Using AI Short Protocol**- First Recording -*

The machine recognizes it as a first communication if the AI Short Protocol data for that Quick/Speed Dial contains no NSF(S) or RTI/CSI information.

Data is recorded for use with AI Short Protocol if:

- The number is a Quick or Speed Dial
- The remote terminal has the AI Short Protocol feature (bits 1, 2, and 3 of NSF(S) must be on)
- NSF(S) was received correctly, even if the protocol failed elsewhere

In the first communication, data will not be recorded if a closed network transmission failed due to an ID Code mismatch.

AI Short Protocol data can be recorded for any transmission mode (such as multi-page transmission, transfer request, and so on).

During communication, the following takes place:

- Any modem rate data in the AI Short Protocol memory for that Quick/Speed Dial is deleted
- The CRC data of the received NSF(S) is stored

- The modem rate for the final page is stored
- Later Communications –

AI Short Protocol takes place if:

- The remote terminal's number is stored as a Quick or Speed Dial
- AI Short Protocol data exists for that number
- A 2100 Hz signal (CED) is received<R>

AI Short Protocol data is deleted from the memory if:

- The machine at the other end has been replaced with a machine that does not have AI Short Protocol (if NSF indicates the absence of this feature, or if DIS is received)
- If the Quick/Speed Dial is reprogrammed

AI Short Protocol data is replaced if:

- The response to NSS(A) is NSF/DIS
- Multipage transmission, voice request, page retransmission

NSS(A) Frame Format

HDLC				FIF						
Flag	AF	CF	FCF	ITU-T Code	Maker Code	P. ID	ID Code	NSS(A)	FCS	Flag

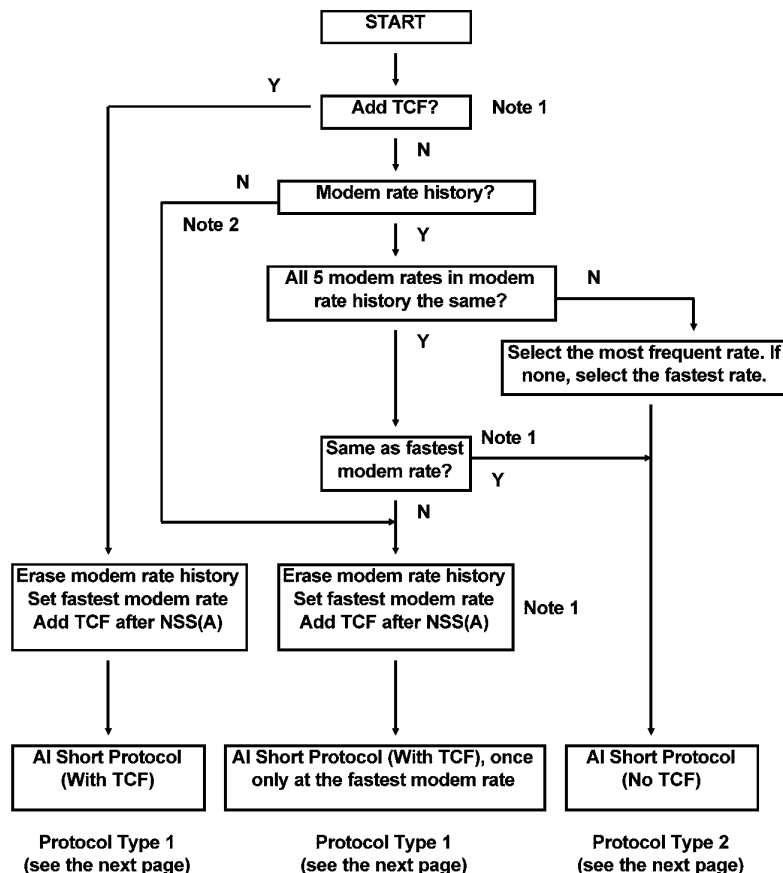
- Protocol ID (P. ID) for NSS(A) = 04[H]
- ID Code = ID Code for Polling, Transfer Request, and so on
- NSS(A): CRC data and feature information (see below)

NSS(A) Frame Bit Assignment

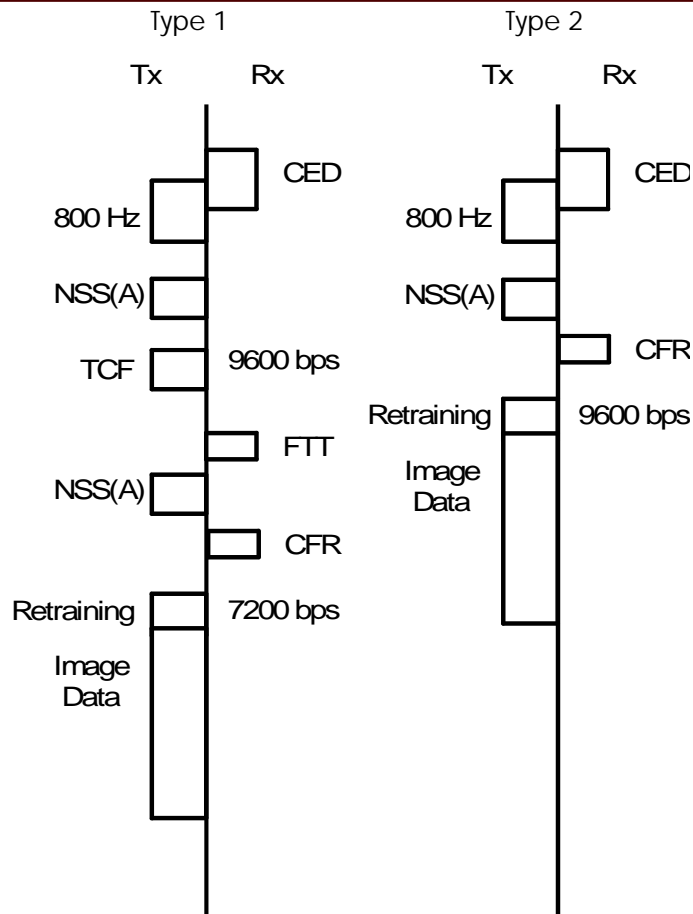
Bits	Contents
1-8	Contents of CRC in other terminal's NSF(S): Low byte
9-16	Contents of CRC in other terminal's NSF(S): High byte
17-40	Facsimile feature information

At the receiving terminal, the CRC data in the received NSS(A) signal is compared with the CRC data of its own NSF(S) signal.

- If these are the same, the receiving machine prepares to receive, without sending out NSF(S).
- If these are not the same, the receiving machine will send out FTT then NSF(S). At the transmitting side, the AI Short Protocol data for this machine will be replaced.

AI Short Protocol Algorithm

- Notes:**
1. This depends on a RAM address or dedicated transmission parameter setting. If line conditions are not constant, TCF should be added after NSS(A).
 2. First Communication: If the communication fails due to third try fail or modem rate fallback failure, no modem rate history is stored for that number. However, in later communications, 800 Hz will be sent, because the NSF(S) and RTI/CSI data are present.



Short Preamble

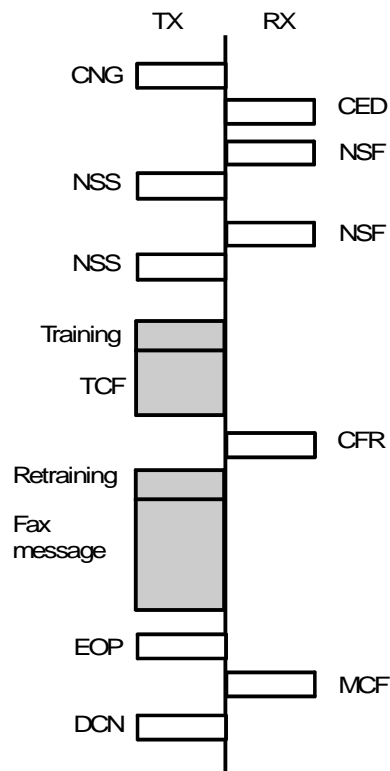
If both communicating machines have the Short Preamble feature, the time required by the protocol procedure can be reduced, as explained below.

- In standard Group 3 protocol, there is a one-second preamble at the start of each signal or group of signals (see section 5 "Protocol Signals"). If Short Preamble is used, this is reduced to 0.2 second.
- Normally there is a minimum 0.2 pause in the signalling whenever communication is handed over to the other terminal (see section 3 "Standard Group 3 Protocol"). If Short Preamble is used, the minimum becomes 0.1 s.

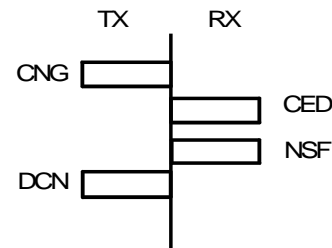
As a result, about 4 seconds can be shaved off the protocol time during a one-page transmission.

Secure Transmission

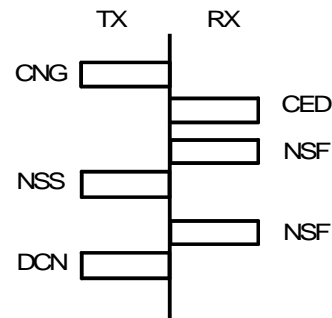
With Secure Transmission, the data is scrambled before transmission. The two communicating machines check whether the Secure IDs are the same, and whether the machine can do Secure Transmission or Secure Reception.



If the Rx side is not equipped with this feature.



If the Rx side does not have the same Secure ID as the Tx side.



Error Correction Mode (ECM)

Background

ECM is an optional extension to Group 3 Protocol. It was recommended in 1986 as a countermeasure to the frequent data errors that occur in areas that suffer from noisy telephone lines.

Transmitters that have SAF memory are able to resend data without using ECM. However, as the whole page is resent, the communication takes a lot longer. With ECM, only the damaged parts of the data are resent, so although there is extra protocol overhead, time can be saved in areas where errors are frequent. Also, a large SAF memory is not needed for retransmitting data, as long as the machine has a small memory set aside for ECM (this is known as the ECM memory).

Principle

Data Structure

Without ECM, fax message data is sent as a continuous stream of bits, in units of a page. However, in ECM, a HDLC frame structure is used to send fax message data as well, as for the protocol signals.

ECM works with four units: the octet, the frame, the block, and the page.

Each HDLC **frame** consists of 256 **octets** (8-bit groups) of facsimile data (64 octets is an optional size), and 8 octets for the other parts of the HDLC frame (flags, address field, control field, and so on).

If a **page** of compressed data needs more than 256 frames, the page is divided into blocks<D>. Each of these **blocks**, also known as "partial pages", consists of 256 HDLC frames. Each new page starts with a new block.

An average compressed page takes up about 320,000 bits. Therefore, assuming a 256-octet frame size, an average page takes up about half a block. If halftone is used, a lot more bits will be generated, and more than one block may be required for a page.

Procedure

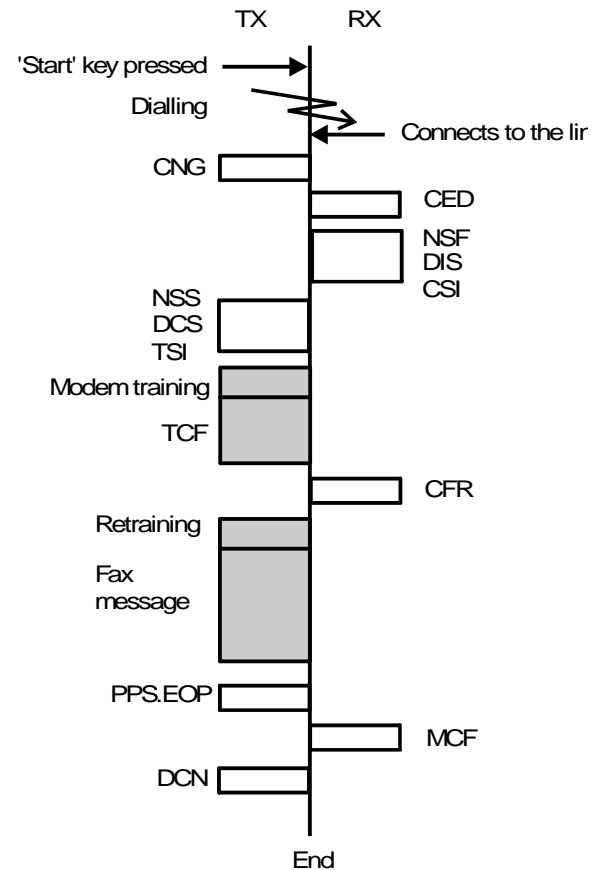
The page is sent in units of one block; each block is a sequence of up to 256 HDLC frames. After receiving the block, the receiver informs whether the block was received with or without errors. If there were errors, the receiver informs which HDLC frames contained the errors, and asks the transmitter to resend those frames.

Basic Protocol

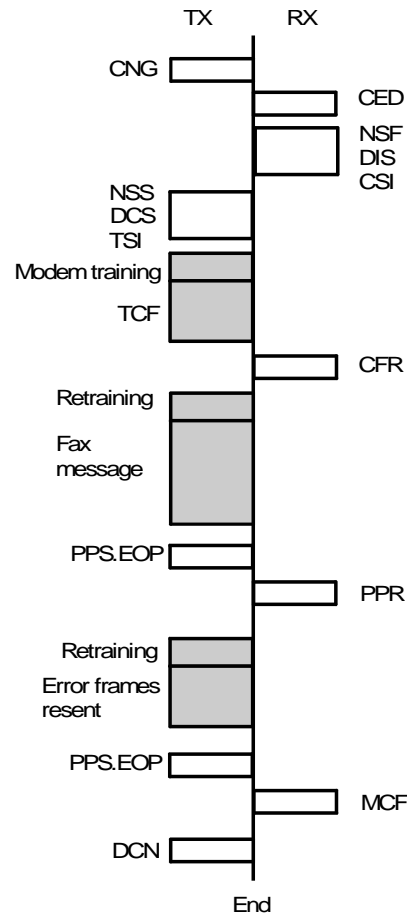
The diagram shows the transmission of a one-page fax message, with no errors. The page is small enough to fit into 256 frames (or one block).

The procedure is basically the same as for Group 3 without ECM, except for the HDLC frame structure of the fax message data, which will be explained soon, and the new signal PPS.EOP replacing EOP. The new signals PPS.EOP, PPS.EOM, PPS.MPS, and PPS.PRI-Q are equivalent to EOP, EOM, MPS, and PRI-Q as used in Group 3 protocol without ECM (see the previous pages).

If the page requires more than 256 data frames and must be divided into more than one block, a signal called PPS.NULL is used instead.



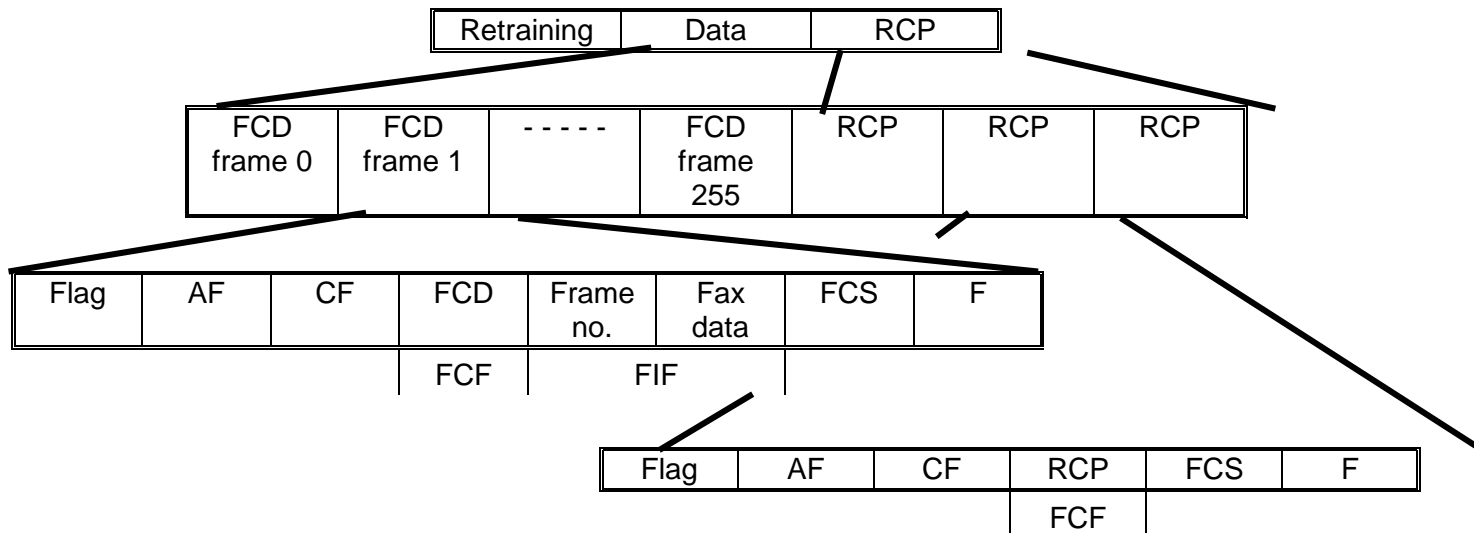
If the receiver detects errors in the data, the protocol procedure begins to look quite different. This page shows what happens. In this example, the errors are corrected at the first attempt.



HDLC Data Frame Structure

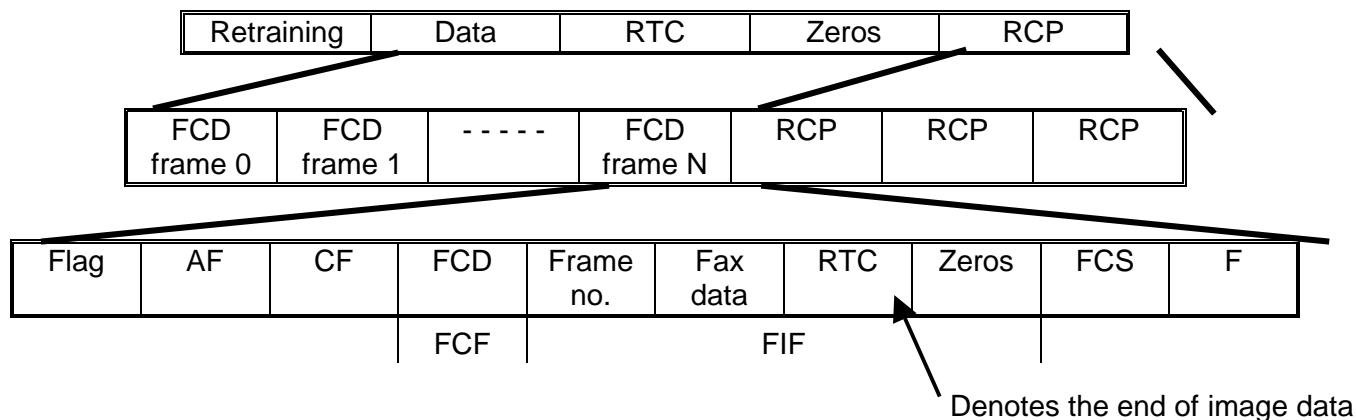
When ECM is used, compressed facsimile data is sent in blocks made up of HDLC frames. The name of the data signal is FCD. The facsimile message data is transmitted in the Facsimile Information Field (FIF) of this FCD signal.

The following diagram shows the structure of a block of ECM data, and the frames in that block.



Three consecutive RCP frames signify the end of a block. After RCP, error correction signalling is done, then error frames are resent or the next block is sent.

The above diagram shows a full block of 256 full data frames. If the final block in a page is only partly full, or if the page does not need a full block, zeros are used to fill up the frame where the data ended. Then the three RCP frames follow. The data structure is as follows.



ECM Protocol Signals

Name	Full Name	FCF Code	Use
CTC	Continue to Correct	X100 1000	The TX side informs the RX side that it will continue attempting to correct this block of data after receiving CTR from the RX side.
CTR	Response to CTC	X010 0011	The RX side acknowledges receipt of CTC, and states that it is ready to receive.
EOR	End of Retransmission	X111 0011	The TX side informs the RX side that it will not continue attempting to correct this block of data, and that it will go on to the next block after receiving ERR from the RX side.
ERR	Response to EOR	X011 1000	The RX side acknowledges receipt of EOR, and states that it is ready to receive.
FCD	Facsimile Coded Data	0110 0000	The FIF of this signal contains fax message data. Up to 256 of these frames can be sent consecutively as one block of data.

Name	Full Name	FCF Code	Use
PPS	Partial Page Signal	X111 1101	This tells the RX side that a block of data has just been sent. PPS also informs the page number, block number, and the number of frames in the block.
PPR	Partial Page Request	X011 1101	This informs the TX side that the block just received contained errors. It informs which frames contained the errors and asks for these frames to be retransmitted.
RCP	Return to Control for Partial Page	0110 0001	This informs the RX side that there is no more data in the current block.
RR	Receive Ready	X111 0110	The TX side asks the RX side whether it is ready to receive data.
RNR	Receive Not Ready	X011 0111	The RX side informs that it is not ready to receive data, perhaps because the ECM memory still holds some data.

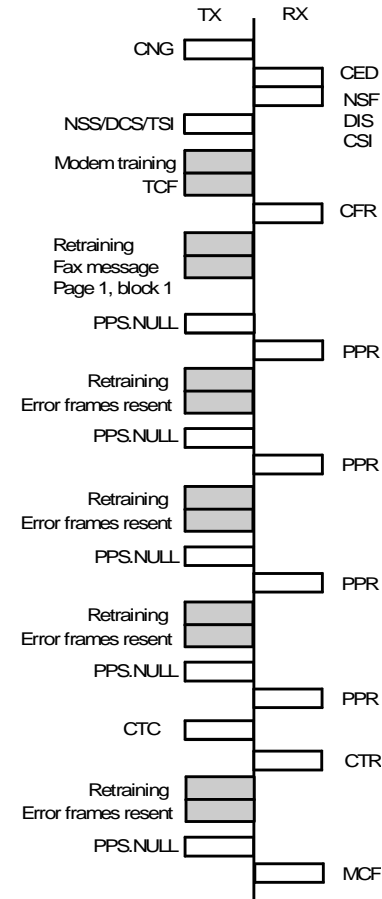
- Notes:**
- MCF is only returned when the RX side has received a block without errors, or when all errors for the block have been corrected.
 - MPS, EOM, EOP, and PRI-Q are not used between blocks. Instead, PPS and EOR have an extra Facsimile Control Field to carry a NULL, EOP, EOM, MPS, or PRI-Q signal. For example, PPS.NULL means that the page has not finished (at least one more block is needed), and PPS.EOP means that this is the last page of the fax message. Refer to the ECM protocol examples in this section to see the usage of this type of signal.

Examples of ECM Protocol Procedures

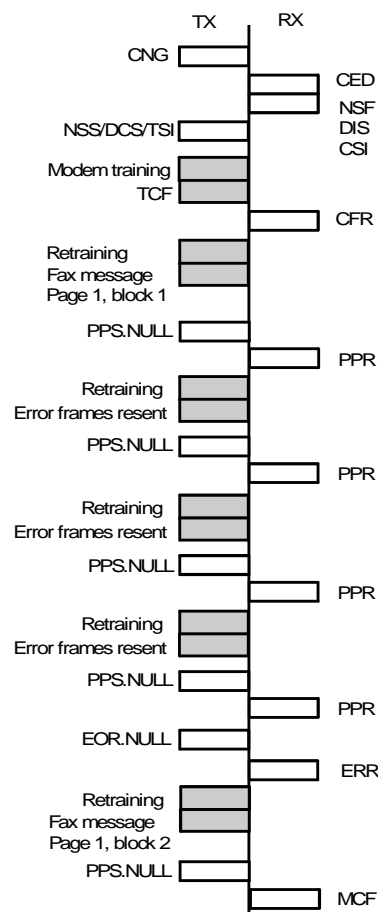
We have already seen the simplest case. Now let us examine some more complex situations. NSF and NSS are not shown in these diagrams.

Error Correction

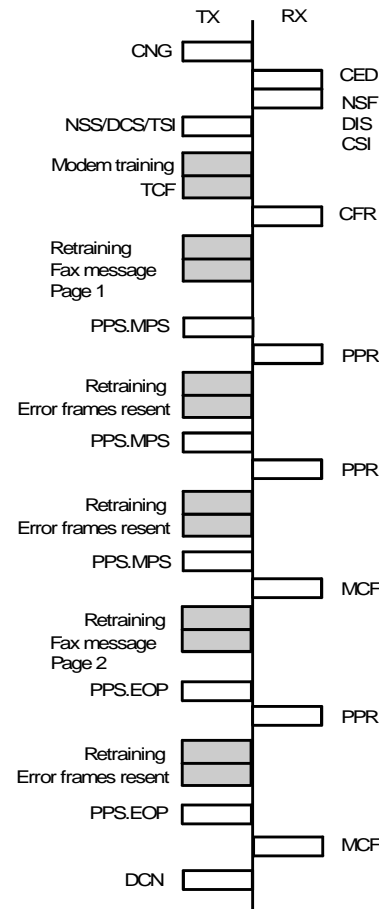
In this example, page 1 has more than 1 block, so PPS.NULL is used after sending data. After 4 attempts at 9,600 bps, CTC informs the RX side that the next attempt will be at 7,200 bps. This attempt succeeds immediately. This usage of CTC to indicate fallback varies from maker to maker.



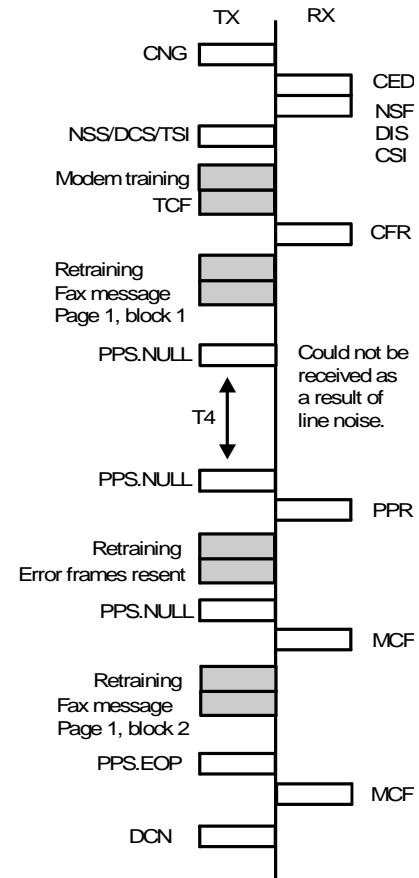
Page 1 has more than one block, and the first block cannot be sent. However, in this example, the machine does not use CTC to reduce the modem rate after four failures, and the TX side states to the next block. Instead of EOR.NULL, the TX side could send EOR.MPS and go on to the next page, skipping remaining blocks in page 1 completely.



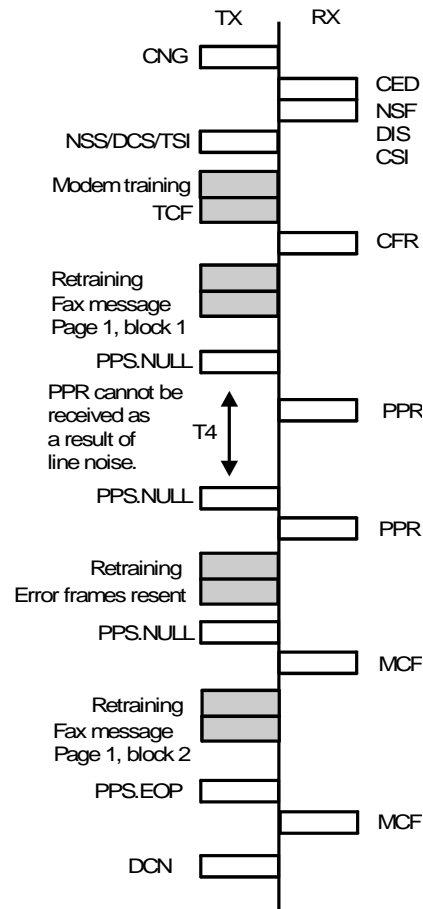
In this example, a two-page message is sent. Each page has only one block. Note the use of PPS.MPS and PPS.EOP, which is similar to the use of MPS and EOP in Group 3 protocol without ECM.



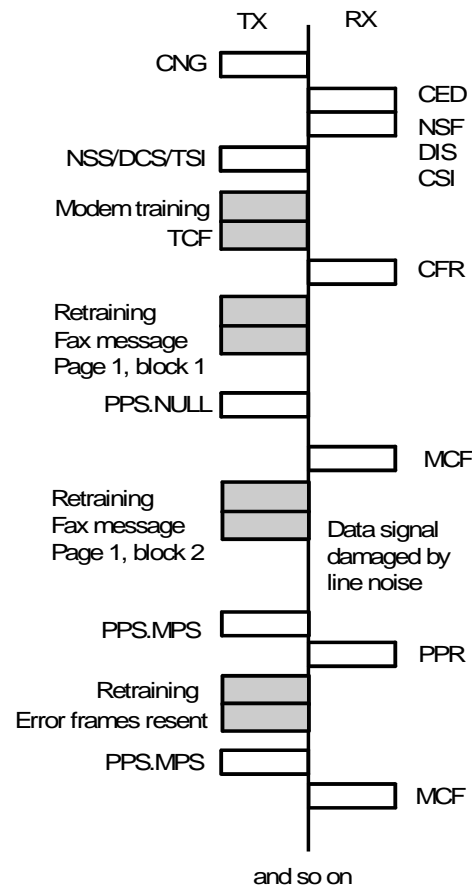
Here, the TX side sends a two-block page. While sending PPS.NULL, some noise on the line stops the RX side from detecting it. The TX side resends the signal if the ITU-T T4 timer expires before a reply is detected. The ITU-T timers are explained later in this section.



In this example, the TX side cannot detect PPR because of noise on the line. After T4 elapsed without detection anything the previous signal is sent out again.



In this case, line noise has damaged the data.
If the data signal is totally destroyed, the RX side can check the block and page counters to see which part of the fax message is missing.

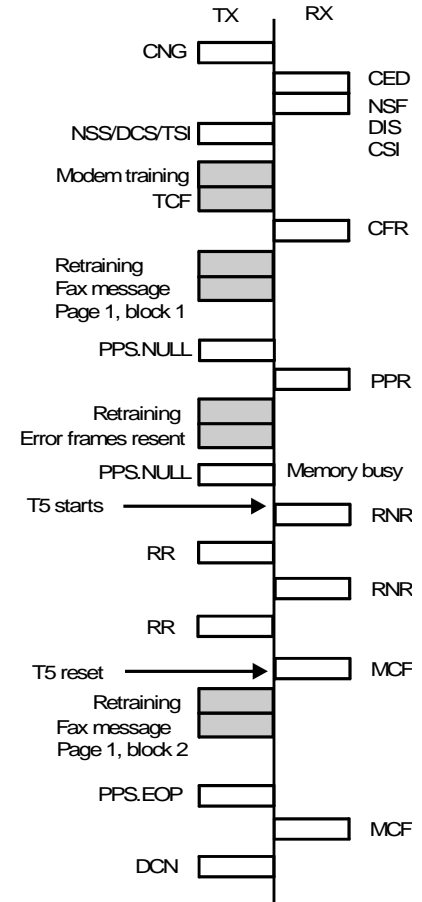


Flow Control

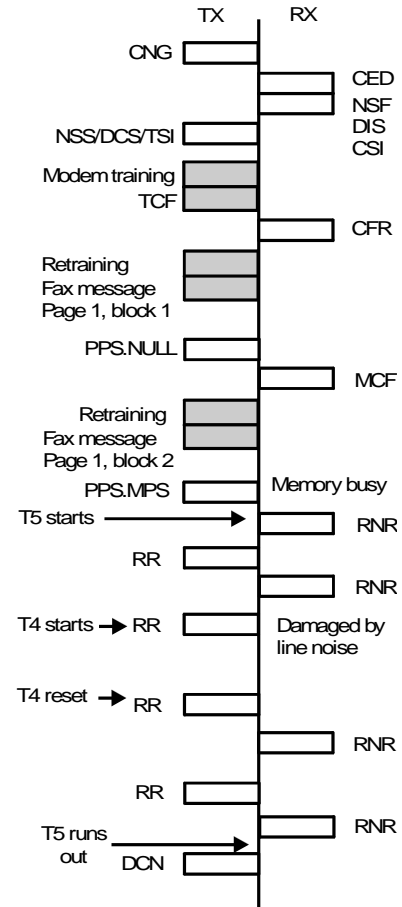
On the transmitting side, data flow is controlled by sending consecutive flags before the first frame, or between frames as long as the ITU-T T1 timer is not exceeded.

On the receiving side, flow is controlled using the RNR signal, as shown in the following examples.

The TX side starts the T5 timer when it first detects RNR. The TX side repeatedly asks the RX side whether it is ready to receive, using RR. If T5 runs out before the TX side detects MCF or ERR, the TX side sends DCN.

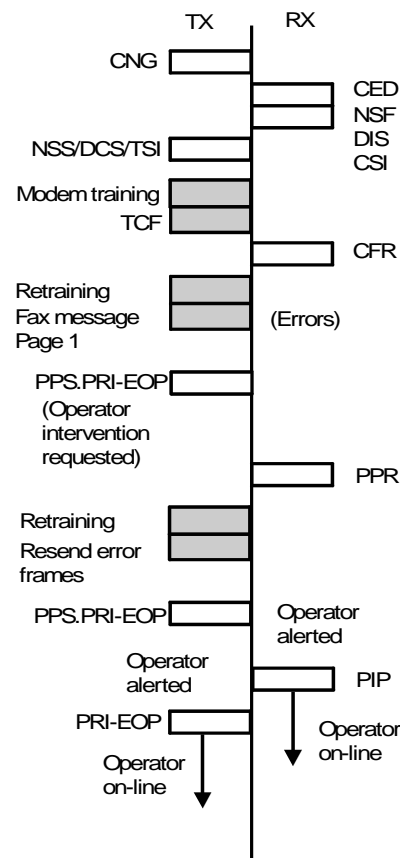


In this example, T5 runs out so the TX side sends DCN. Also, if the TX side cannot detect any reply to RR comes after three attempts, the TX side will send DCN.

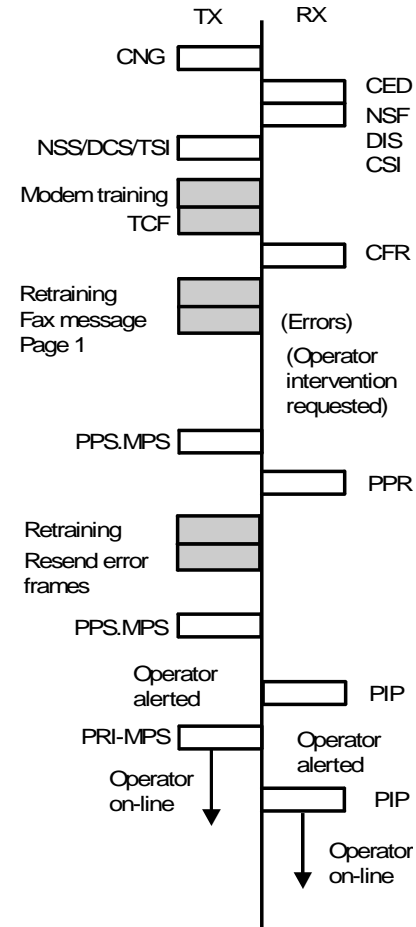


Procedural Interrupts

This shows what happens when the TX side operator makes a voice request.



This shows what happens when the RX side operator makes a voice request.



Flexible Implementation of ECM Protocol

The ITU-T standard for ECM allows some flexibility, and manufacturers may implement ECM in slightly different ways. The following notes explain how this manufacturer has implemented some of the more flexible rules.

Frame size

The machines are set up for a frame size of 256 octets.

In receive mode, the machines adopt whichever of the two optional frame sizes (256 or 64) is being used by the sender.

Some makers may use non-standard frame size options. This manufacturer's machines can communicate with terminals that use non-standard frame sizes lower than 256 octets. However, communication is impossible if the other terminal's non-standard frame size is higher.

Block size

This is always 256 except for the following cases

- A block at the end of a page
- When resending error frames
- When RNR was received partway through a block and then T5 runs out.

If a page needs two blocks, or if T5 runs out, the page is separated into two blocks.

EOR vs CTC

This manufacturer's machines use EOR as little as possible.

If all frames within a block cannot be corrected within four tries (this includes the original attempt and three retries), the machine will send CTC and modem rate fallback will be used.

After fallback, if the block is sent correctly, the next block will be sent either at the original rate before fallback or at the successful rate (after fallback). There is an adjustment to select which method is used.

If the modem rate is 2,400 bps and the data still cannot be sent correctly, the machine will send EOR, and will go on to send the next block of data.

Page printout timing

Normally, data is printed while it is received. However, if an error frame is received, printout stops at that point. When the error frames are resent, the page is printed again from the point where it left off.

If one of this manufacturer's machines receives EOR, the block is printed up to the first error frame, then the line is cut.

SEP/PWD/SUB/SID Signals

The ITU-T recommendations were changed in 1996 to allow polling and confidential communications. Before, these could only be done between Ricoh-made terminals, using NSF/NSS. Now, these features can be used between any maker's machines, using the SEP, SUB, and other new signals.

Secured Polling using SEP/PWD

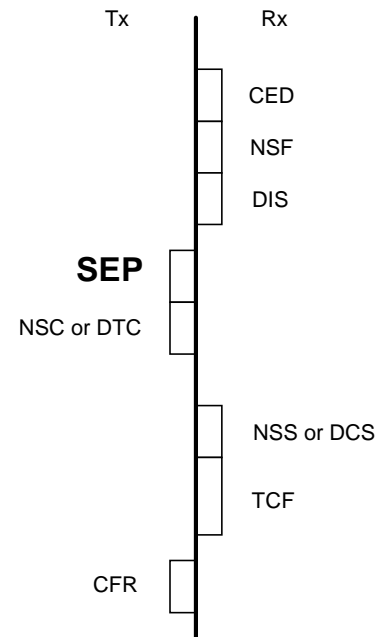
SEP Signal: When the Rx terminal receives the SEP signal with the NSC or DTC signal, the Rx terminal switches over to secured polling transmission using the SEP ID. The SEP (Selective polling) signal must contain four digits as an ID.

The Rx terminal automatically disconnects the line when any of the following conditions occurs (error code 0-15).

- When the SEP ID is other than four digits
- When anything other than numbers is included in the ID

The communication becomes free polling when the SEP ID is 0000.

PWD Signal: When the PWD (password) signal is transmitted together with the SEP signal, the PWD programmed is used as an ID code for stored ID override.



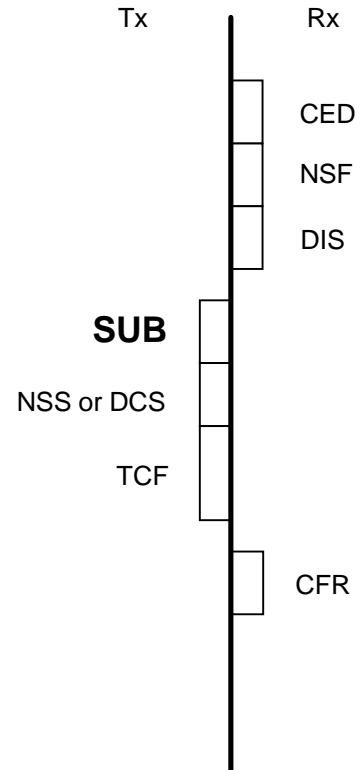
Confidential ID Override using SUB/SID

SUB Signal: The SUB (sub-address) signal transmitted from the Tx terminal contains a confidential ID. A stored message can be printed using the SUB ID as confidential ID override.

The SUB ID must contain four digits. The receiving terminal automatically disconnects the line when any of the following conditions occurs (error code 0-15).

- When the SUB ID is other than four digits
- When anything other than numbers is included in the ID
- When a confidential ID is not programmed in the Rx terminal and when the transmitted SUB ID is 0000

A stored message can be printed using the (normal) confidential ID stored in the machine when the SUB ID sent from the transmitter is 0000.



V.8/V.34 Protocol

Overview

New Recommendations

ITU-T modified T.30 in 1996 to include changes to protocol signaling as a result of V.8 procedure implementation.

If V.8/V.34 signaling is used, ECM must also be used.

Phases Of The V.34 Procedure

The protocol procedure for a V.34 fax communication consists of 6 phases. The following explain the phases briefly.

Phase 1: V.8 Sequence

The calling and called terminals exchange available modulation modes (fax or data modem) and data transmission direction information, and decide a communication mode.

Phase 2: Line Probing

The receiving terminal determines the available bandwidth for the fax data transmission channel (known as the primary channel) based on the analysis of line probing signals sent from the transmitting terminal. This bandwidth is informed to the transmitting side as a symbol rate.

Phase 3: Primary Channel Equalizer Training

The receiving terminal adjusts its equalizer etc., while receiving training signals from the sender. The tx side uses the data transmission modulation parameters informed by the rx side at the end of phase 2.

Phase 4: Control Channel Start-up

Both terminals determine a data rate for the primary channel (in other words, for data transmission).

Phase 5: Control Channel

Both terminals exchange T.30 protocol signals (DIS/DCS, NSF/NSS) to determine transmission parameters (this equivalent to phases B and C of T.30 protocol)

Phase 6: Primary Channel

The sending terminal sends fax image data at the data rate that was determined with the receiver in phase 4. One ECM block is sent at a time.

Post Message Procedure

After the primary channel has finished, both terminals restart the control channel to exchange post message signals, as former fax machines do in phase E of T.30 protocol.

If there is another ECM block to send, the machines then start the primary channel again, otherwise they disconnect the line.

Protocol Overview

This shows a one page fax transmission with no special features and no errors.

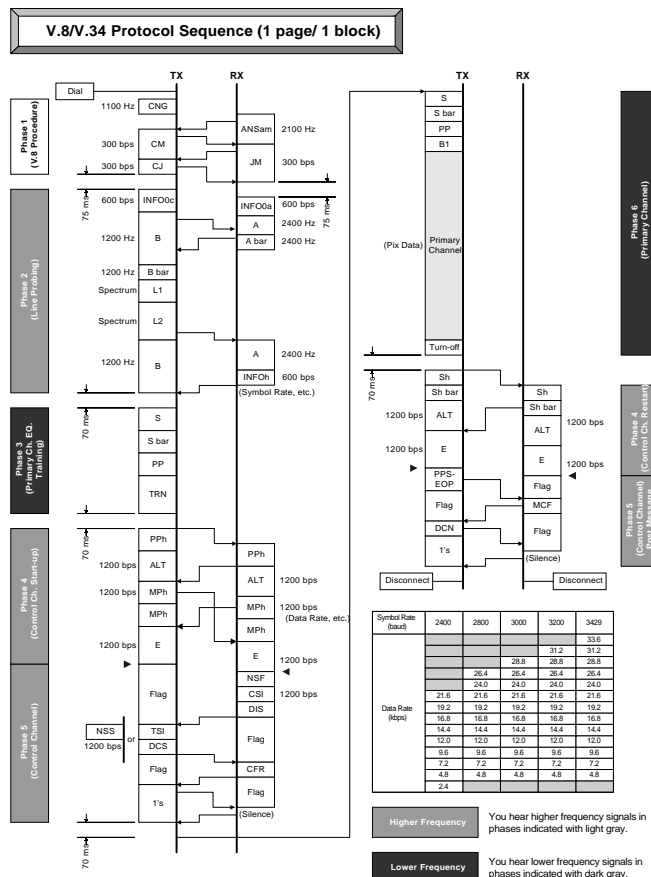
The time required for the communication (one ECM block) is approximately as follows:

Until the end of phase 5: About 6 to 7 s

Phase 6: About 3 s

Post-message: About 2 s

Total: About 11 to 12 s



Basic Procedure

Phase 1: V.8 Sequence

Overview

V.8 protocol establishes communication between the calling modem and the answering modem. The general communication functions and modulation modes are exchanged. The best modulation mode for the calling and answering modems is determined upon the exchange of call menu (CM) and joint menu (JM) signals.

ANSam

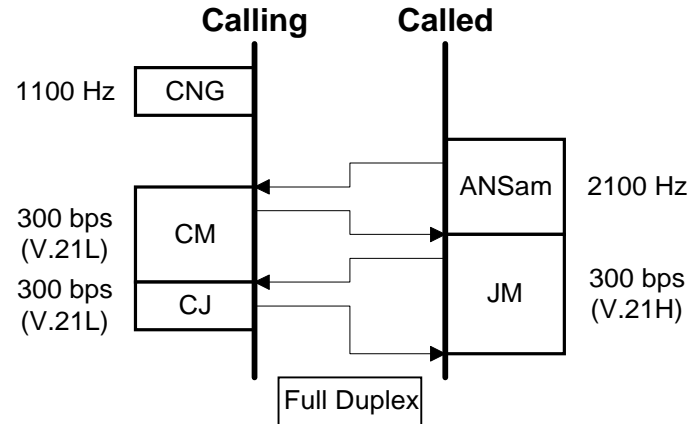
- 2100Hz, amplitude modulated using 15Hz cosine wave, phase inverted every 450 ms

CM (V.21L)/JM (V.21H)

- Full duplex
- Modulation mode
- Data direction

CJ (V.21L)

- Phase 1 end



Signals

CNG (Call indicator)	Transmitted from the calling terminal to indicate the start of a communication.
ANSam	Amplitude-modulated, phase inverted 2100 Hz signal.
CM (Call menu signal)	Transmitted from the calling terminal primarily to indicate its available modulation modes, and to inform whether it is sending data or wishes to receive data by polling.
JM (Joint menu signal)	Transmitted from the receiving terminal primarily to indicate the modulation modes available in both terminals.
CJ (CM terminator)	Acknowledges the detection of a JM signal and indicates the end of the CM signal. CJ ends this phase of the communication.

Procedure

Calling Terminal	Called Terminal
After dialing, the machine sends CNG signal and waits for an ANSam signal.	After ring detection, the called terminal sends ANSam signal for up to 3.2 s, while waiting for a CM signal from the calling terminal. (See the note after the table.)
After ANSam detection, the machine sends CM, while waiting for a JM. CM settings: <ul style="list-style-type: none"> • Normal transmission: 81 85 D4 • Polling reception: A1 85 D4 	After CM detection, the machine sends JM, while waiting for a CJ. JM Settings <ul style="list-style-type: none"> • Normal reception: 81 85 D4 • Polling transmission: A1 85 D4
After JM detection, the machine sends CJ.	
Both terminals go into phase 2 (line probing) 75 ms after CJ .	

- ANSam -

After detecting CNG, the called terminal sends ANSam. This starts the V.8 sequence.

The ANSam signal is a 2100 Hz tone signal that is amplitude modified with a 15Hz-cosine wave. Also, the signal phase of ANSam inverts every 450 ms. The frequency is the same as the CED tone.

Some fax machines cannot detect the 15Hz cosine wave modulation and phase inversion, and think that ANSam is a CED tone.

- CM, JM -

The exchange of CM and JM signals is next. These are sent in accordance with V.21 modulation. CM is sent with a low carrier frequency (V.21L), and JM is sent at a higher frequency (V.21H). Because of this, the CM/JM exchange is full duplex (the signals are sent at the same time, because they do not interfere with each other).

- Digital networks that have a sampling rate of 8 kbps cannot pass CM and JM. CM cannot reach the called terminal, so the called terminal falls back to V.17 mode. V.34 communication will not be possible.

The machines inform what type of modem they have (fax modem or data modem). If a communication mode (e.g., V.34 fax communication to calling terminal to called terminal) is available at both terminals, the terminals communicate using that communication mode for the subsequent phases.

- If no communication mode is commonly available at both sides (for example, if a fax modem has called a data modem), both terminals disconnect the line after the JM and CM signals.

The calling terminal informs whether it wants to send data or receive data. From this point, the data sender becomes the Tx terminal, and the receiver becomes the Rx terminal. Note that for polling, the calling terminal becomes the Rx terminal.

- The communication ends if the receiver of a polling request does not have files on polling standby.

- CJ -

This signals the end of the CM/JM exchange.

After 75 ms, phase 2 will begin

Refer to Advanced Procedures – Various V.8 Sequences for examples of various V.8 sequences.

NOTE: The ITU-T recommendation for the ANSam length is 2.6 to 4.0 s. Ricoh uses 3.2 s (as of February, 1998).

If no response to an ANSam signal is detected within the maximum signal duration, it is assumed that V.8 protocol is not supported, and communication takes place in accordance with recommendation T.30.

Error Codes

- 0-70: Refer to Possible Errors – Phase 1.
- 0-74: Refer to Possible Errors – Phase 1.
- 0-75: Refer to Possible Errors – Phase 1.
- 0-76: Refer to Possible Errors – Phase 1.
- 0-77: Refer to Possible Errors – Phase 1.

Phase 2: Line Probing

Overview

Phase 2 establishes the condition of the line, which decides the bandwidth available for the communication.

INFO0c/INFO0a

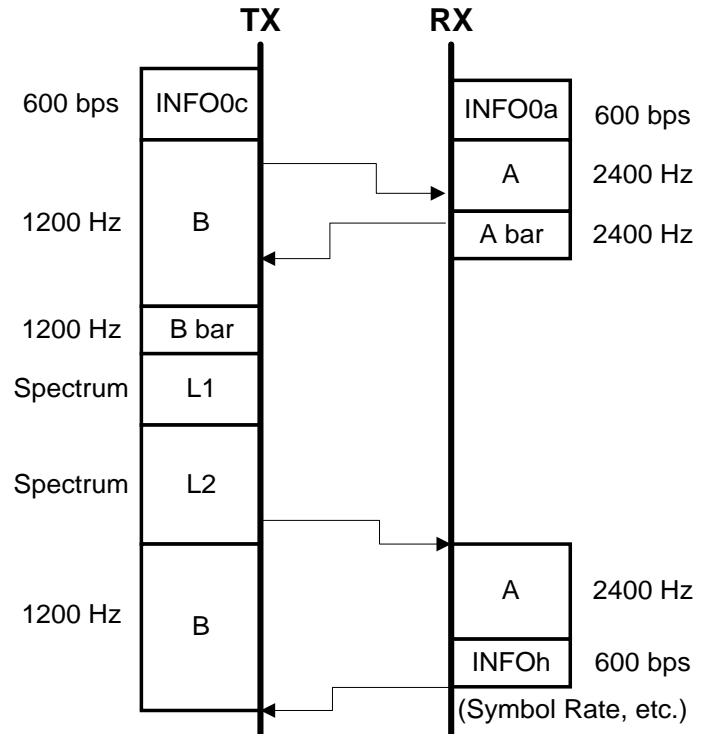
- Modem capabilities
- Modulation parameters

L1/L2

- Probing tone
- $L1 > L2$ (by 6dB)

INFOh

- Symbol rate (carrier frequency)
- Pre-emphasis
- Power reduction



The aim of phase 2 is to determine a set of modulation parameters that will be used in phase 6 (the primary channel) for image data transmission.

Both modems exchange information about their capabilities and modulation parameters using INFO0c and INFO0a signals. Then the transmitting terminal sends L1 and L2, which are known as probing tones. These tones allow the receiving modem to analyze the network qualities, such as bandwidth and noise level.

Based on its analysis of how well the network passed the probing tones, the receiving modem informs a set of modulation parameters, such as symbol rate, pre-emphasis, and power reduction, using the INFOh signal.

Both modems then go into phase 3 (equalizer training) 70 ms after INFOh.

Signals

INFO0c	A signal transmitted from the calling terminal to indicate its available modem capabilities and data mode modulation parameters.
INFO0a	A signal transmitted from the receiving terminal to indicate its available modem capabilities and data mode modulation parameters.
B	A modem control signal of 1200 Hz.
B bar	The same as B, but with phase inverted.
A	A modem control signal of 2400 Hz.
A bar	The same as A, but with phase inverted.
L1	A line probing signal to analyze line characteristics. L1 is 6 dB higher than L2. This signal is used to check the amplitude distortion.
L2	A line probing signal to analyze line characteristics. This signal is used to check the amplitude distortion.
INFOh	A signal used by the receiving terminal to inform the results of line probing. The symbol rate is informed by this signal.

Procedure

Sender Terminal	Receiver Terminal
75 ms after the end of phase 1, the machine sends INFO0c.	75 ms after the end of phase 1, the machine sends INFO0a.
When the machine detects an INFO0a, it stops INFO0c and sends B and B bar tones.	When the machine detects an INFO0c, it stops INFO0a and sends A and A bar tones.
When the machine detects A bar, it sends line-probing signals (L1 and L2).	When the machine detects B bar, it starts waiting for line-probing signals (L1 and L2).
After L2 has finished, the machine sends B tone again.	After L2 reception has finished, the machine sends A tone again followed by INFOh signal
When the machine receives an INFOh signal, it stops B.	
Both terminals go into phase 3 (control channel start-up) 70 ms after above steps.	

- INFO0c, INFO0a -

The two machines exchange their modem capabilities and the available modulation parameters.

- A, A bar, B, B bar -

The two machines exchange 2400Hz and 1200Hz tones with phase reversals.

- V.34 provides for full duplex and half duplex modes for fax communication. In full duplex mode, these signals determine any delay to signal round trip time caused by line conditions.

However, current fax machines use half-duplex only, so the round trip time calculation is not used.

- L1, L2 -

The tx side transmits a series of tones, in a very short period of time, ranging from 150 Hz to 3750 Hz. These are known as probing tones.

The table shows the range of frequencies that the tx side sends to the rx side in the L1 and L2 signals. As can be seen, the phase sometimes reverses.

The rx side analyses how the signals are received. Based on the results, the rx side does the following:

- Decides the available bandwidth for data transfer, by specifying a symbol rate. The poorer the line, the narrower the bandwidth.
- Requests the tx side to adjust the pre-emphasis and power reduction parameters, so that the rx side can optimize reception across the bandwidth.

The rx side informs the above to the tx side in the INFOh signal.

$\cos(2\pi ft + \phi)$			
f (Hz)	ϕ (degrees)	f (Hz)	ϕ (degrees)
150	0	2250	180
300	180	2550	0
450	0	2700	180
600	0	2850	0
750	0	3000	180
1050	0	3150	180
1350	0	3300	180
1500	0	3450	180
1650	180	3600	0
1950	0	3750	0
2100	0		

- INFOh -

The receiving terminal informs the results of the line probing.

70 ms later, phase 3 begins.

The results include pre-emphasis, power reduction, and symbol rate.

Symbol Rate

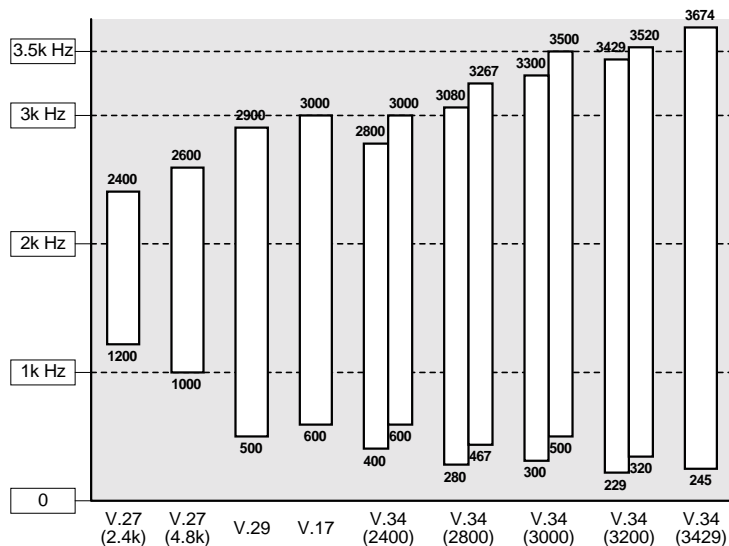
The symbol rate is a baud rate. However, the data can be modulated in different ways using this symbol rate to achieve different data rates. If the line condition is good, a higher data rate will be selected. The data rate is selected in phase 4 (see the section on phase 4).

This means that the actual data rate for fax communication has not been decided yet.

The maximum data rate of 33.6 kbps is only possible if a symbol rate of 3429 can be used.

ITU-T also lists 2743 as a possible symbol rate. However, at the time of writing, the two makers of V.34 modems (Panasonic, Rockwell) did not support this symbol rate.

The following table and diagram show the required bandwidths for V.27, V.29, V.17, and the various V.34 symbol rates. Bandwidth is one of the important factors the modems use to select a symbol rate. As shown in the table, the faster the modulation, the wider the required bandwidth. This is because required bandwidth for a modulation depends on symbol rate and carrier frequencies.



Modem	Symbol Rate (baud)	Carrier Low/High	Required Bandwidth (Hz)
V.34	3429	1959/1959 Hz	245 - 3674 Hz
	3200	1829/1920 Hz	229 - 3429 Hz (L) 320 - 3520 Hz (H)
	3000	1800/2000 Hz	300 - 3300 Hz (L) 500 - 3500 Hz (H)
	2800	1680/1867 Hz	280 - 3080 Hz (L) 467 - 3267 Hz (H)
	2400	1600/1800 Hz	400 - 2800 Hz (L) 600 - 3000 Hz (H)
V.17	2400	1800 Hz	600 - 3000 Hz
V.29	2400	1700 Hz	500 - 2900 Hz
V.27 (4800)	1600	1800 Hz	1000 - 2600 Hz
V.27 (2400)	1200	1800 Hz	1200 - 2400 Hz

Other factors determining the symbol rate are signal to noise levels.

Pre-emphasis

This is a linear equalization method where the transmitted signal spectrum is shaped to compensate for attenuation distortion.

Power reduction

When the received signal is too strong, the rx side asks the tx side to reduce the tx level by up to 7 dB.

Error Codes

- 0-80: Refer to Possible Errors – Line Probing and Training

Phase 3: Primary Channel Equalizer Training

Overview

The tx side sends training signals using the data transmission modulation parameters informed by the rx side at the end of phase 2.

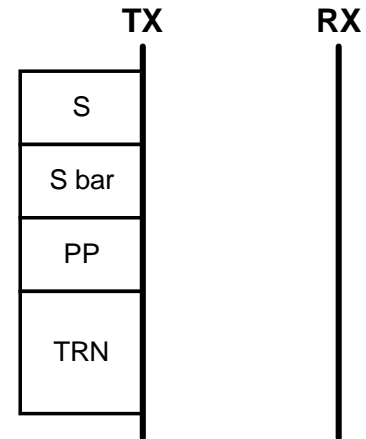
The fax data transmission channel is known as the primary channel.

Tx side

- Sends training signals using the modulation parameters decided in INFOh.

Rx side

- Modem equalizer training
- Data rate determination
- AGC adjustment



Signals

S, S bar	Training signals
PP	
TRN	

The receiver modem monitors the phase 3 signals and adjusts its equalizers and AGC (Automatic Gain Control).

In addition, the receiving modem selects a data rate (bps) from the possible range specified by the agreed symbol rate – this will be used in phase 6 (primary channel). However, at this point, the tx side still is not aware of the rate that has been decided - it is not informed until the next phase.

Both modems then go into phase 4 (control channel start-up) 70 ms after TRN.

Recovery Procedure

If the receiving modem does not detect S within 2 seconds or if a TRN error is detected, the receiving modem goes back to the last part of phase 2 to restart sending signal A.

After detection of signal B, the receiving modem sends INFOh and tries again to detect S.

Error Codes

- 0-81: Refer to Possible Errors – Line Probing and Training.

Phase 4: Control Channel Start-Up

Overview

The aim of control channel start-up is to decide the modulation parameters that will be used in the control and primary channels.

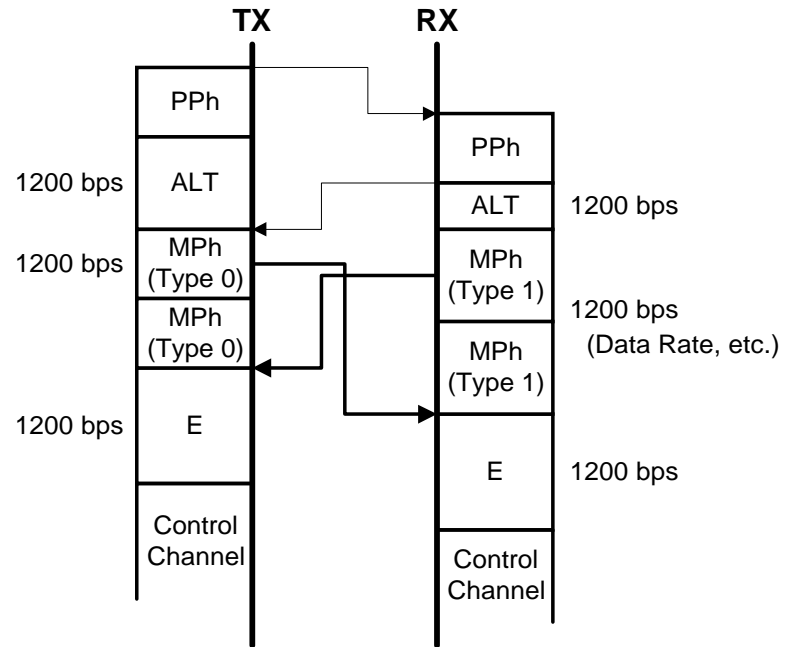
- Control channel: T.30 fax control protocol
- Primary channel: Fax data transmission

MPh

- MPh from rx side determines modulation parameters
- Primary ch. data rate
- Control ch. data rate
- Type 0: Tx to Rx
- Type 1: Rx to Tx

E

- Start of control channel



Signals

PPh	PPh is a signal for control channel receiver initialization and resynchronization.
ALT	A scrambled series of alternating 0s and 1s at 1200 bps.
MPh	MPh contains the modulation parameters that will be used for data mode transmission, such as control channel data rate and primary channel data rate. The sender uses type 0 only., and the receiver uses type 0 or type 1. The type 1 MPh contains additional parameters to the type 0 MPh.
E	E is a 20-bit scrambled signal to inform the beginning of the control channel (phase 5).

The sending terminal informs its of modulation parameter capabilities using a type 0 MPh signal. Using a type 0 or type 1 MPh signal, the receiver informs the set of modulation parameters that it decided while receiving training signals in phase 3.

The MPh sent from the tx side is a Type 0 MPh, and from the Rx side it is a Type 0 or Type 1 MPh (mostly, it is Type 1).

- The Type 1 signal contains some coefficients that will be used for pre-coding (pre-coding is a non-linear equalization technique).

If the initial transmission or reception data rate is changed by bit switches or dedicated tx parameters, the new setting is reported in the MPh signals.

The signals in this phase use 1200 bit/s, 600 symbols/s QAM modulation.

Procedure

Sender Terminal	Receiver Terminal
70 ms after the end of phase 3, the machine sends PPh and ALT.	After detecting a PPh from the sender, the machine sends PPh and ALT
The machine sends MPh signals while waiting for MPh from the other machine.	The machine sends MPh signals while waiting for MPh from the other machine.
After detecting a MPh from the receiver, the machine stops MPh and sends E.	After detecting a MPh from the sender, the machine stops MPh and sends E.
Both terminals go into phase 5 (control channel).	

- MPh -

The rx side informs the data rate that it decided as a result of phase 3. The data rate will be one of those possible with the previously agreed symbol rate (see the next page).

The control channel rate is always set to 1200 bps. There is an option for 2400 bps, but it is not used at the moment.

The final MPh from the rx side contains the data rate information.

- NOTE:** 1) If the sender receives signal A while waiting for an MPh signal, it goes back to phase 2, and sends signal B and prepares to receive INFOh.
- 2) If either terminal fails to start up the control channel, it sends AC tone. Refer to 'Possible Errors – Control Channel Start-up – Error Recovery Using the AC Tone' for details on the recovery sequence after the AC tone.

Data Rates and Symbol Rates

The above table shows the available data rates for each symbol rate.

In the MPh signals, both terminals must inform a data rate that is available with the symbol rate which was decided in phase 2 (INFOh signal).

Error Codes

- 0-82: Refer to Possible Errors – Control Channel Start-up/Restart.
- 0-84: Refer to Possible Errors – Control Channel Start-up/Restart.
- 0-86: Refer to Possible Errors – Control Channel Start-up/Restart.

Symbol Rate (baud)	2400	2800	3000	3200	3429
Data Rate (kbps)					33.6
				31.2	31.2
			28.8	28.8	28.8
		26.4	26.4	26.4	26.4
		24.0	24.0	24.0	24.0
	21.6	21.6	21.6	21.6	21.6
	19.2	19.2	19.2	19.2	19.2
	16.8	16.8	16.8	16.8	16.8
	14.4	14.4	14.4	14.4	14.4
	12.0	12.0	12.0	12.0	12.0
	9.6	9.6	9.6	9.6	9.6
	7.2	7.2	7.2	7.2	7.2
	4.8	4.8	4.8	4.8	4.8
	2.4				

Phase 5: Control Channel

Overview

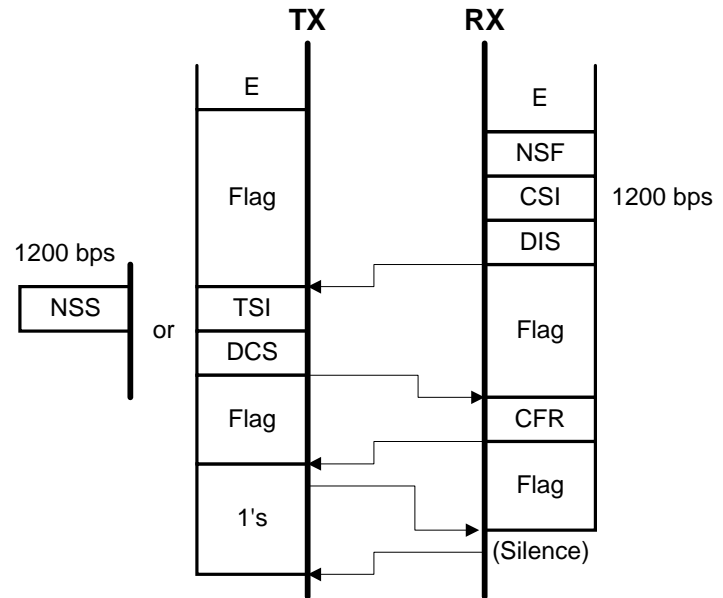
In the control channel, both terminals exchange T.30 protocol signals. However, the data rate is 1200 bps, as opposed to the 300 bps used with V.21 signaling.

Since both terminals (modems) have determined a modulation mode and a set of modulation parameters in the previous phases, the machines do not repeat those settings in the NSF or DIS signals.

"0000" is set in bits 11 to 14 of the DIS/DCS signals (initial modem rate).

In this phase, a flag sequence is transmitted whenever there is no data to transmit (this applies to both Tx and Rx terminals).

Silence (or the absence of flags) from the Rx side indicates the end of this phase.



Procedure

The procedure in this phase is the same as phases B and C of T.30 protocol, except the following.

- The receiver terminal always responds with CFR. It never uses the training signal responses TCF and FTT.
- Modem type and speed are not included in the negotiated parameters. However, machine capabilities are exchanged (such as paper size, the availability of duplex printing, and so on).
- Both machines sends flags while they do not send data.
- When the tx side detects CFR, it starts to send 1's. When the rx side has detected 40 consecutive 1's, it stops flag transmission and prepares to receive fax data.
- When the tx side has detected silence from the other side, it starts the next phase

Phase 6: Primary Channel

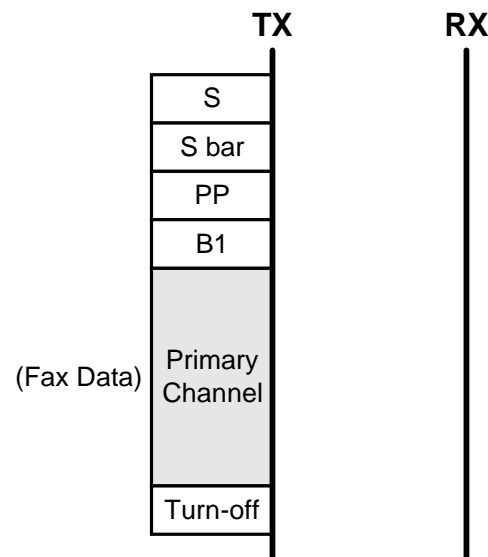
Overview

S, S bar, PP	Training signals
B1	A signal to inform the beginning of user data.

The primary channel is used for image data communication. It uses the data rate which was determined in phase 4 (MPH) and the symbol rate that was specified in phase 2 (INFOh).

One primary channel contains one ECM block. If a page is split into two blocks, it requires two primary channels to be transmitted. (Refer to Multi-page Control for details on how this is done.)

- Note that it is split up into ECM blocks, not pages.



An ITU-T chart takes about 3 seconds.

- This is from the S signal to the turn-off.
- Group 4 is also specified as 3 seconds for one ITU-T #1 chart, but the resolution is different.
V.34 Group 3: Standard resolution 8 x 3.85 dots/mm
Group 4: Detail resolution 200 x 200 dpi
Group 4 sends twice as much image data in the same time.

Error Code

- 0-87: Refer to Possible Errors – Primary Channel.

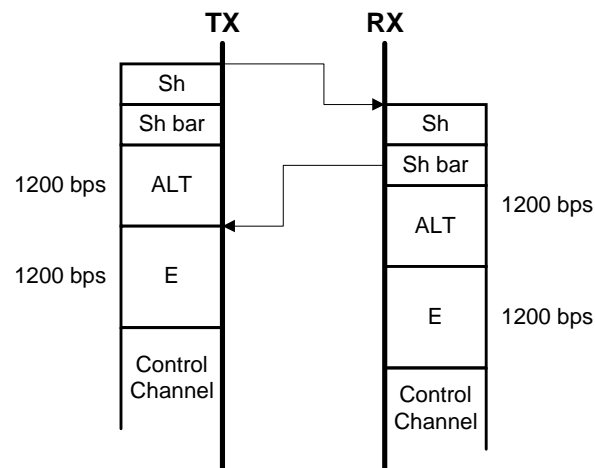
Control Channel Restart

Overview

After an ECM block has been sent, the control channel restarts so that the terminals can exchange post-message signals.

Signals

Sh, Sh bar	Training signals, similar to S and S bar, but sent using the control channel modulation
PPh	PPh is a sequence for control channel receiver initialization and resynchronization. This is used instead of Sh if a change in modulation parameters is desired for the next page.
ALT	A scrambled series of alternating 0s and 1s at 1200 bps
E	E is a 20-bit scrambled sequence of 1s at 1200 bps to signal the beginning of control channel data.



This phase is similar to phase 4. The signals are similar to phase 4, except instead of using a PPh – MPh sequence, an Sh sequence is used.

During control channel restart, either terminal can request a change in the data rate. In such cases, the requesting terminal will send PPh instead of Sh, and MPh will be used to decide the new data rates for the next block of fax data.

NOTE: Also, if an error occurs during control channel restart, a PPh – MPh sequence is used instead of Sh.

Procedure

Sender Terminal	Receiver Terminal
70 ms after the end of phase 6, the machine sends Sh, Sh bar, and ALT.	After detecting a Sh from the sender, the machine sends Sh, Sh bar, and ALT
After detecting a Sh bar from the receiver, the machine stops ALT and sends E.	After detecting a Sh bar from the sender, the machine stops ALT and sends E.
Both terminals go into the post message procedure (control channel).	

NOTE: If the sender receives signal A while waiting for an MPh signal, it goes back to phase 2, and sends signal B and prepares to receive INFOh.

Error Codes

- 0-83: Refer to Possible Errors – Control Channel Start-up/Restart.
- 0-85: Refer to Possible Errors – Control Channel Start-up/Restart.

Post Message Procedure (Control Channel)

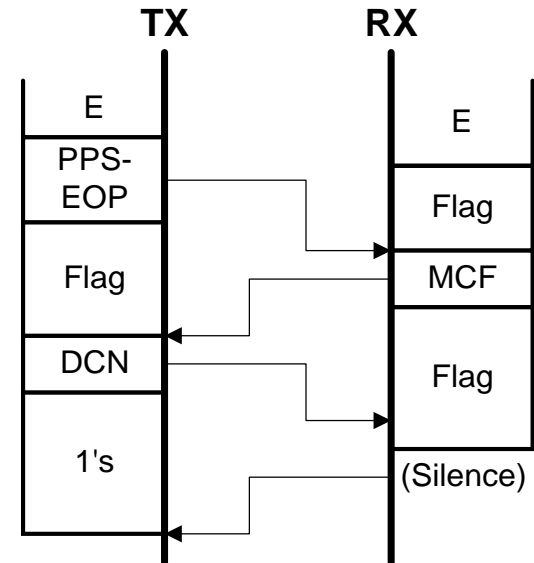
Overview

This phase is similar to phase 5.

In this phase, both terminals use the control channel to exchange T.30 end-of-page or end-of-message signals (T.30 phase E protocol).

Data communication errors are reported using ECM protocol, and retransmission of parts with errors is requested.

When the sender detects silence, it stops sending the closing "1's" and disconnects the line.



Procedure

Procedure in this phase is the same as phase E of T.30 protocol, except the following.

- Both machines sends flags while they do not send data.
- When the receiving terminal detects 40 consecutive “1’s”, it stops flag transmission.

If there were errors, there is a PPS – PPR exchange in accordance with T.30 ECM protocol, then the error frames are resent in the primary channel. Then the control channel is restarted and the line is disconnected (or the next ECM block prepared for).

If there are no more ECM blocks to send, the sender terminal transmits DCN. Then the receiver stops flag transmission and disconnects the line.

For the multi-block transmission sequences, using PPS-MPS and PPS-EOM, refer to Advanced Procedures – Multi-page Control.

Advanced Procedures

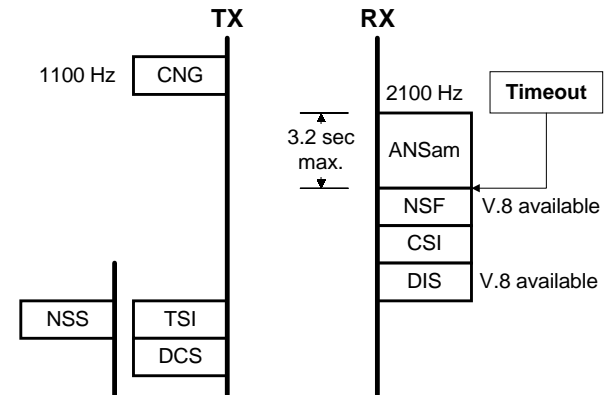
Various V.8 Sequences

Non-V.8 to V.8

The called V.8 terminal transmits ANSam until the timer expires, then falls back to V.17 to transmit NSF/CSI/DIS.

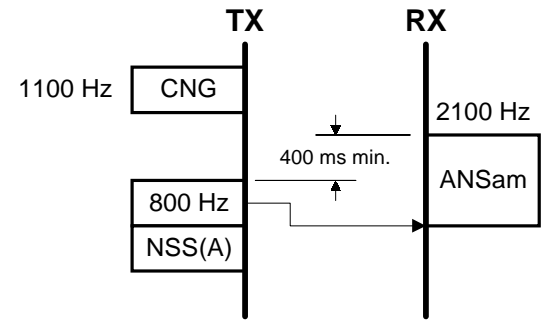
- The calling side (non-V.8) thinks that ANSam is CED, and waits for NSF/DIS as usual for T.30 procedure.
- When the called side cannot detect JM in reply to ANSam within 3.2 s, it drops back to V.17/T.30 and sends NSF/CSI/DIS.

NOTE: The ANSam timeout can be anything from 2.6 s to 4.0 s. Ricoh has decided on 3.2 s as a result of various evaluation and compatibility tests.



If the calling terminal has a communication record for the receiver using AI short protocol, the communication can step down to V.17/T.30 more quickly. The Tx side sends an 800Hz tone immediately after detecting 2100Hz. The called V.8 terminal then stops ANSam to receive NSS(A), which follows immediately.

NOTE: The machine needs 0.4 s to detect 2100Hz.

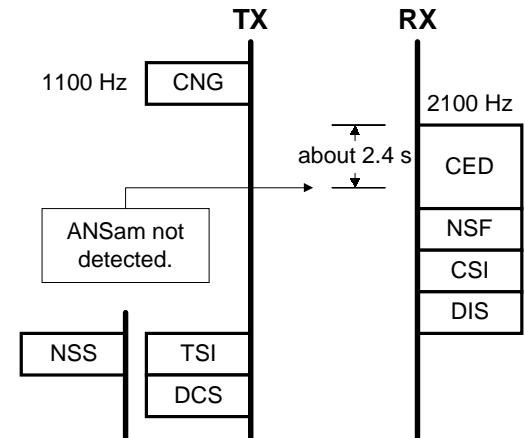


V.8 to Non-V.8

The calling side checks the 2100Hz signal for amplitude modulation and phase inversion to see if it is an ANSam.

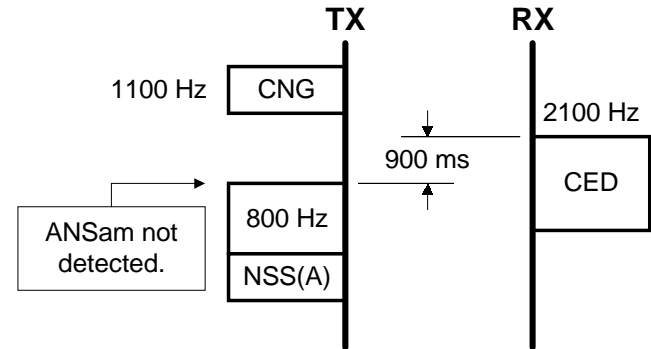
If the calling side cannot detect ANSam within 2 s, it falls back to V.17 and waits for an NSF or DIS signal.

NOTE: The machine needs 0.4 s to detect 2100Hz, then waits for 2 more seconds (2.4 s in total) while trying to detect ANSam characteristics (such as phase reversals).



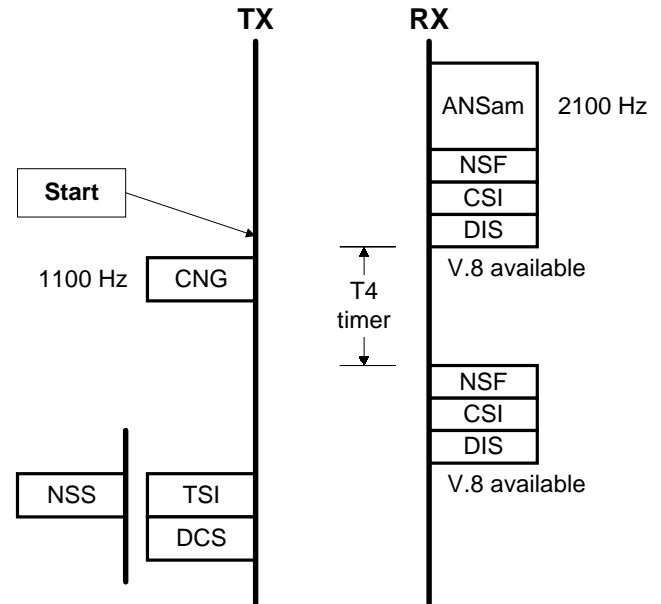
If the calling V.8 terminal has a communication record for the receiver using AI short protocol, the communication can step down to V.17/T.30 more quickly. The calling V.8 terminal sends an 800Hz tone 500 ms after 2100Hz detection, instead of after 2 seconds.

NOTE: The machine needs 0.4 s to detect 2100Hz, then waits for 0.5 more seconds (0.9 s in total) while trying to detect ANSam characteristics.



Manual Tx (Non-V.8 to V.8)

Manual transmission from a non-V.8 terminal is the same as former T.30 protocol.

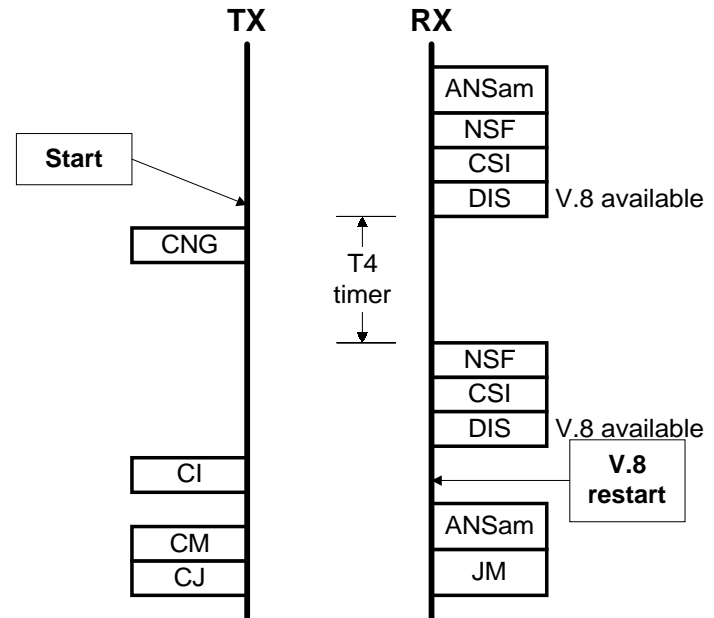


Manual Tx (V.8 to V.8)

The calling side misses the first ANSam and the communication drops out of V.8 mode to V.17.

However, if the calling side detects that V.8 is available (the V.8 bit in NSF/DIS is on), it asks the called side to restart V.8 from the beginning with a CI (Call Initiation) signal.

NOTE: As of February 1998, Ricoh V.34 fax machines do not support V.8 in manual transmission. Fax machines from other manufacturers may support this sequence.

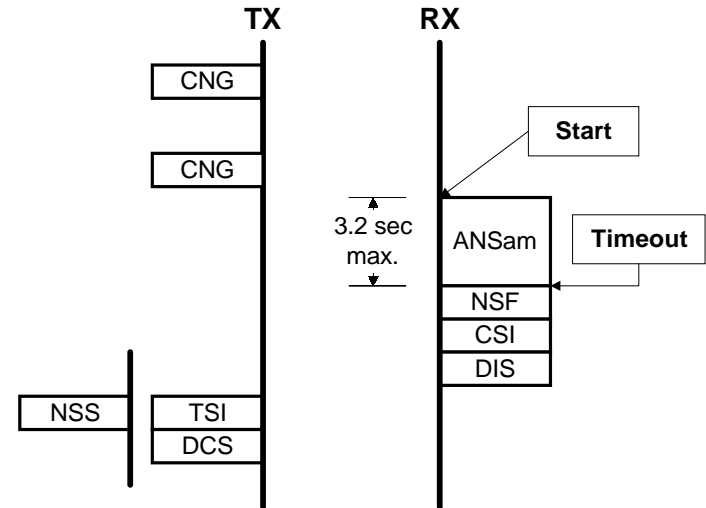


Manual Rx (Non-V.8 to V.8)

This is the same as non-V.8 to V.8 fax communication (described earlier)

Immediately after the operator at the called side presses Start, the called side sends ANSam for 3.2 s, then drops back to V.17 communication because there is no V.8 response from the caller.

- NOTE:** 1) The ITU-T recommendation of the ANSam length is 2.6 to 4.0 s. Ricoh uses 3.2 s (as of February 1998).
2) V.8 sequence in manual reception is a machine specific function (as of February 1998). Refer to the machine's service manual for the availability of V.8 in manual reception

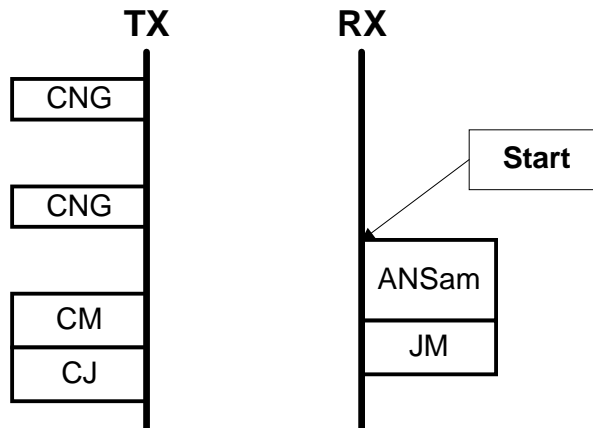


Manual Rx (V.8 to V.8)

Immediately after the operator at the called side presses Start, the called side sends ANSAm.

The calling side immediately sends CM if it is a V.8 terminal, and V.8 signalling can continue.

NOTE: V.8 sequence in manual reception is a machine specific function (as of February 1998). Refer to the machine's service manual for the availability of this function.



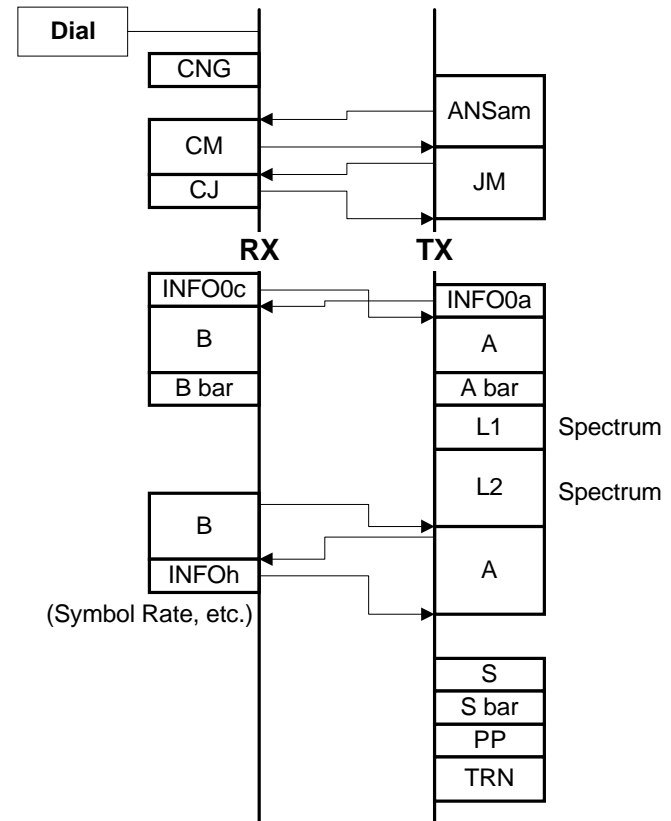
Polling

In phase 1, the calling terminal uses the CM signal to indicate polling reception, and the receiving terminal acknowledges it in the JM signal. Then the direction of communication is reversed (the called side becomes a transmitter and the calling side becomes a receiver).

In phase 2, the called terminal (sender) transmits line-probing signals, L1 and L2, and the calling terminal (receiver) transmits INFOh. All other signals go in the same direction as normal V.34 communication.

In phases 3 and 6, the data goes from the called terminal to the calling terminal.

Note that polling is the only fax feature to be informed in phase 1. All the others (confidential tx, etc.) are informed in phase 5. If polling with ID is to be used, this is informed in phase 5.



Multi-Page Control

Strictly speaking, this is multi-ECM-block control, as each primary channel transmission sends one ECM block. If a page requires more than one ECM block, it will be divided into two primary channels.

PPS-MPS

If the sender does not want to use new settings for the next block, it sends PPS-MPS in the control channel. The receiver then responds with MCF or PPR (see below).

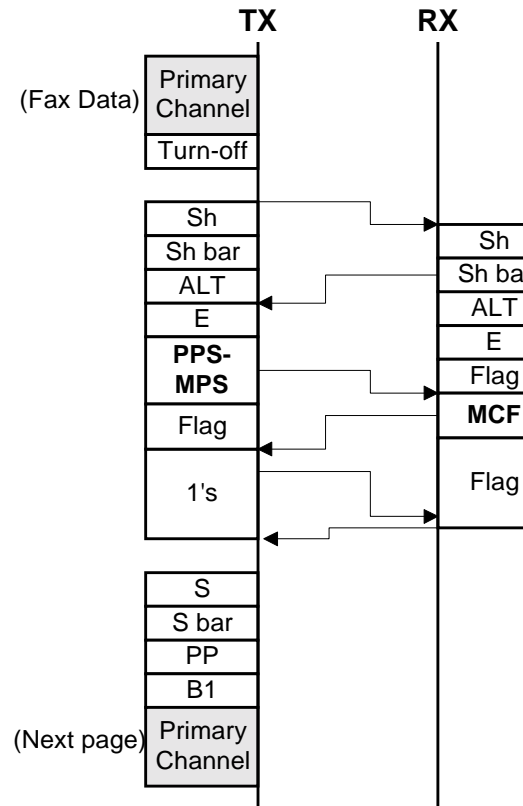
Then, both terminals close the control channel restart phase. Then, the Tx side restarts the primary channel..

- *MCF (Message Confirmation)* -

If the receiver received previous the ECM block completely (with no errors), it sends MCF. Image data in the next primary channel will be the next ECM block.

- *PPR (Partial Page Request)* -

If the receiver did not receive the previous ECM block completely, it sends PPR. Image data in the next primary channel will be retransmitted error frames from the same ECM block.



PPS-EOM

If the sender terminal has another block and wants to change the settings, it sends PPS-EOM in the control channel. The receiver then responds to the sender with either of the following.

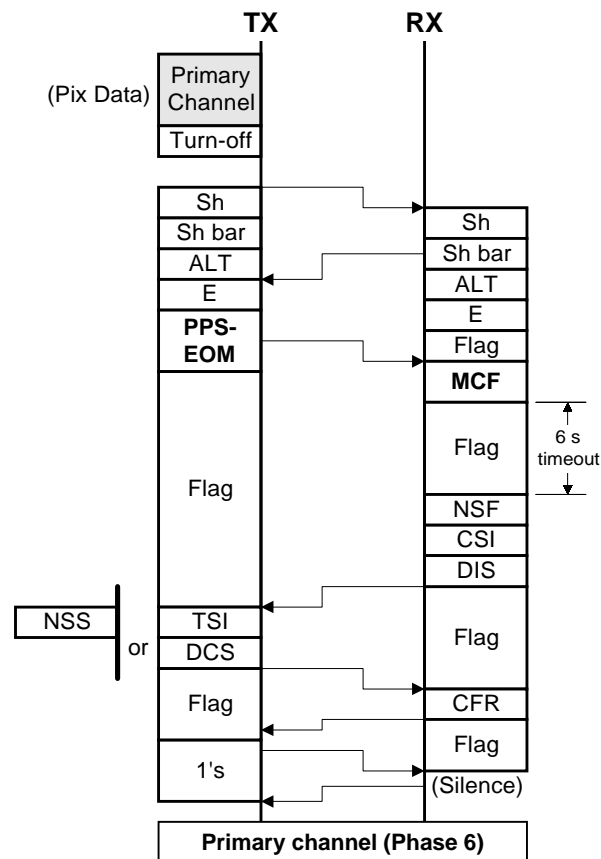
- *MCF (Message Confirmation)* -

If the receiver received the previous ECM block completely, it sends MCF. After the T2 timer (6 s) expires, the receiver sends T.30 phase B signals (NSF/DIS) to exchange new communication settings again. The following procedure is the same as phase 5.

Image data in the next primary channel will be the next block.

- *PPR (Partial Page Request)* -

If the receiver did not receive the previous ECM block completely, it sends PPR. The receiver then goes back to the primary channel to resend the error frames. There is no change of communication settings at this time.



Data Rate Change Request

Overview

According to ITU-T recommendations, either the sender or the receiver can initiate a rate change request in the control channel restart phase using a PPh – MPh sequence, during a communication. However, the recommendation does not specify any request conditions. So, the conditions depend on each manufacturer.

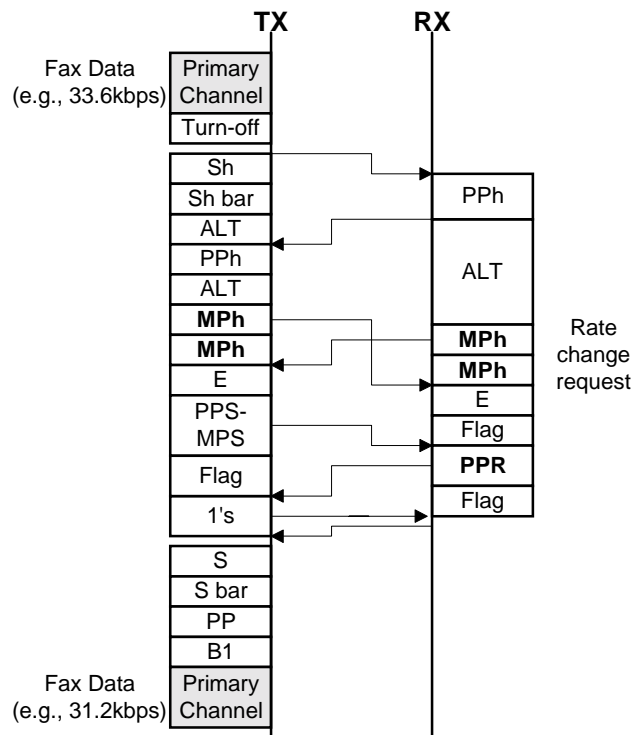
NOTE: This section explains how either terminal requests a rate change, but does not explain request conditions. Refer to the machine's service manual for the condition in which the machine requests a rate change.

Request from Receiving Terminal

This is an example of a one-step shift-down request from the receiving terminal due to several partial page requests (there were a lot of errors in the received data).

The sender restarts the control channel using an Sh sequence. Then, the receiver responds to it with PPh instead of an Sh. This signifies that a rate change request is coming up. The sender can then start a PPh – MPh sequence. The MPh signals from the rx side determine the new data rate.

Both terminals then exchange modulation parameters again to decide a new data rate for the next primary channel. The new rate must be available using the same symbol rate as the previous data rate. (The line conditions have not been tested again with L1 and L2, so it is unsafe to try a wider bandwidth.)

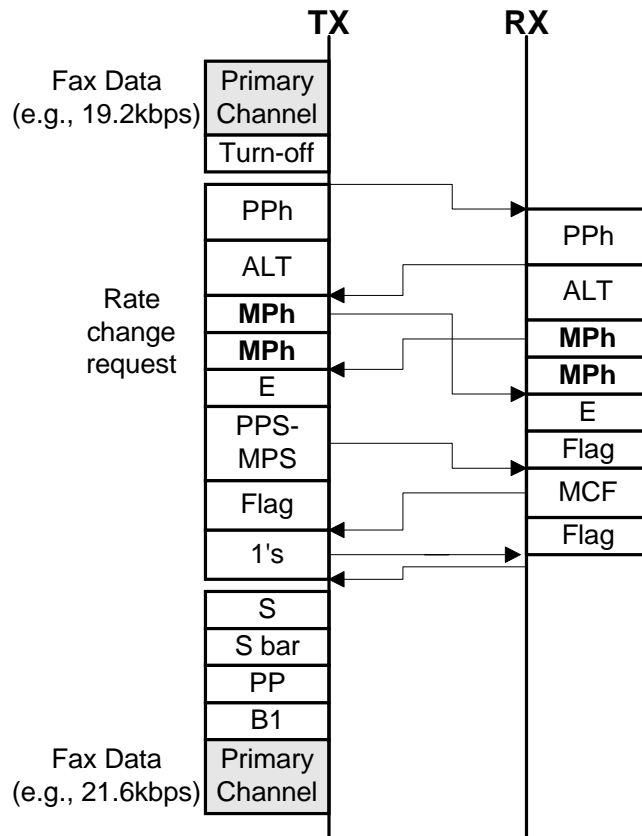


Request from Sending Terminal

This is an example of a one-step shift-up request from the sender terminal.

The sender restarts the control channel using a PPh sequence instead of an Sh. Then, the receiver responds to it with PPh, which enables the sender to start a PPh – MPh sequence as both terminals did in phase 4.

Both terminals then exchange modulation parameters again to decide a new data rate for the next primary channel. The new rate may be higher or lower, depending on how previous blocks were received. It must be available using the same symbol rate.



Possible Errors

Phase 1 (V.8)

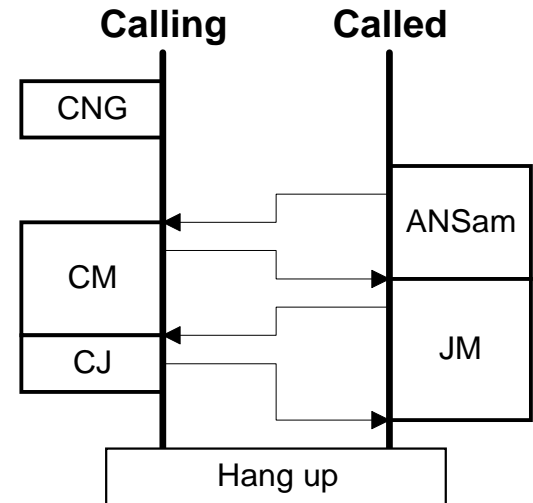
Error Code 0-70

NOTE: This error code can be generated by either the calling or called terminal.

If the communication modes specified in CM and JM do not match, both terminals disconnect the line after the V.8 sequence.

This error can occur in the following cases.

- A V.34 fax terminal called a V.34 data terminal, or vice versa.
(JM = C1 05 10 10 for a data terminal)
- The calling terminal requested polling reception, but the called terminal did not have a polling transmission file (or document).



Error Code 0-74

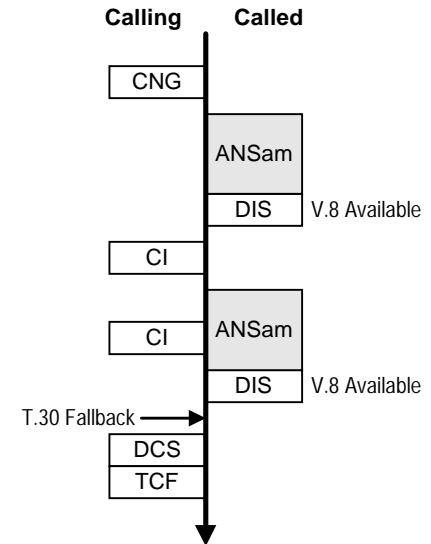
NOTE: This error code can be generated by the calling terminal only.

Because the calling terminal could not receive the first ANSAm, or the called terminal could not receive CM, the called terminal fell back to T.30 mode.

After detecting in the NSF or DIS signal that V.8 is enabled, the calling terminal transmitted CI (Call Initiation) to restart the V.8 sequence.

But, the called terminal could not detect CI signals, and finally the calling terminal also fell back to T.30 mode.

CM, CJ and CI signals from the sender use V.21(L) modulation. If the network cannot pass these signals, this problem could occur.



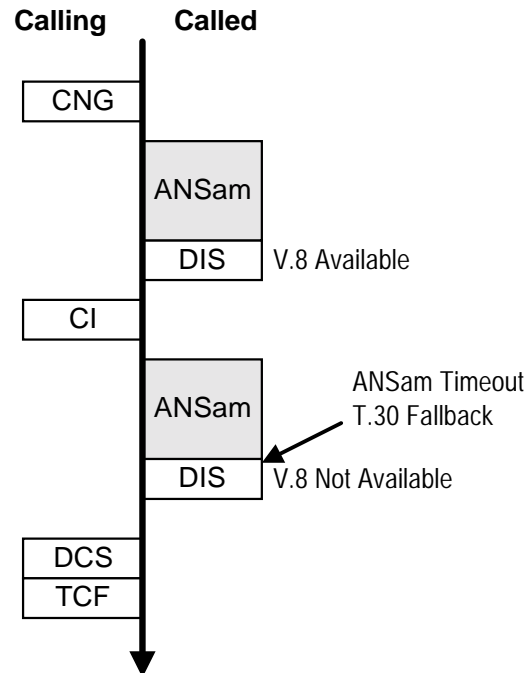
Error Code 0-75 (ANSam Timeout)

NOTE: This error code can be generated by the called terminal only.

The called terminal restarted the V.8 sequence after receiving a CI signal. However, it could not detect a response to ANSam within 3.2 s.

As a result, the called terminal then transmits NSF and DIS using T.30/V.17, signalling that V.8 is disabled.

The receiver may have a problem detecting ANSam, or the network may have a problem transferring ANSam.

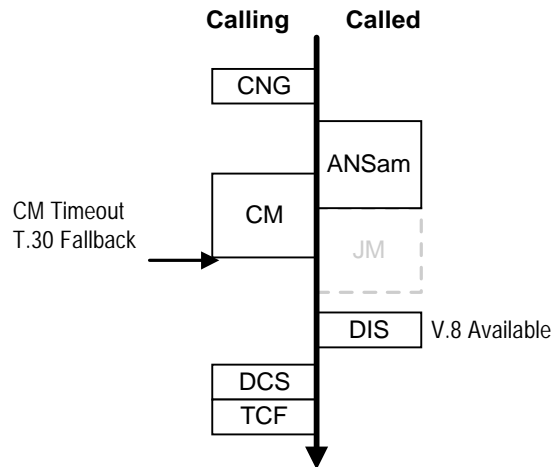


Error Code 0-76 (CM Timeout)

NOTE: This error code can be generated by the calling terminal only.

The calling terminal sent CM in response to ANSam, but it could not detect a JM within 3 s, so it fell back to V.17/T.30 mode.

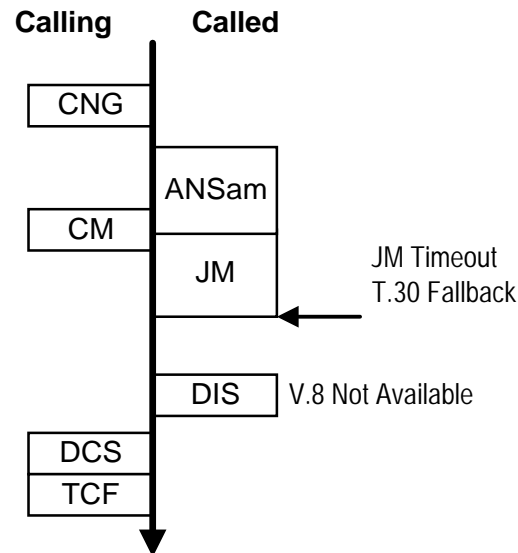
The receiver may have a problem detecting CM, or the network may have a problem transferring V.21(L) signals.



Error Code 0-77 (JM Timeout)

NOTE: This error code can be generated by the called terminal only.

The called terminal sent JM in response to CM, but it could not receive CJ within 3 s, so it fell back to V.17/T.30 mode.



Line Probing and Training

Error Code 0-80 (Phase 2 Timeout)

The line probing sequence was not completed within 35 s from the start of phase 2.

Error Code 0-81 (Phase 3 Timeout)

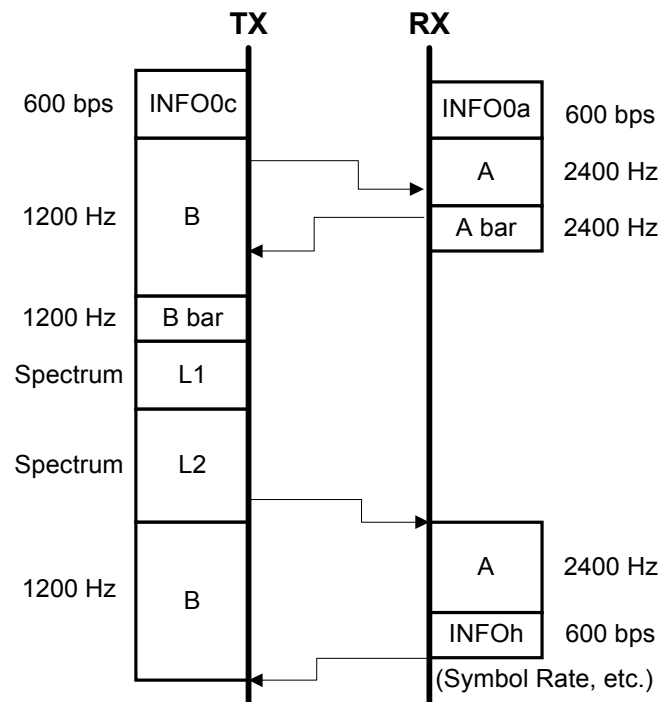
Equalizer training was not completed within 35 s after the start of phase 3.

In phase 3, if the rx level has almost reached the -20dBm threshold for ACG to switch on, the modem adjusts the gain control to amplify the signal.

But the resulting rx level may become too high for rx to continue. So, phase 3 cannot be completed, and the process goes back to the end of phase 2.

There is an A - B exchange, and the rx side sends INFOh and goes back to phase 3. But the same error occurs again, and we are stuck in a loop. A protocol dump list shows repeated INFOh signals. Error code 0-81 prevents this repetitive cycle.

To solve the problem, the tx level at the sender should be increased by 1 or 2 dB.



Control Channel Start-up/Restart***Error Code 0-82***

The sender terminal could not start the control channel within 10 s, or the receiver terminal could not start the control channel within 35 s.

A relatively low signal reception level or a high signal-to-noise ratio could cause this problem.

Normally, this occurs at the receiving terminal. If this occurred, check the reception level using technical data print on the TCR/Journal, and ask the sender to adjust the signal transmission level.

Error Code 0-83

The sender terminal could not restart the control channel within 10 s, or the receiver terminal could not restart the control channel within 11 to 35 s. The timer setting for Rx depends on the data rate and data re-send status.

A relatively lower signal reception level or a high signal-to-noise ratio could cause this problem. Normally, this occurs at the receiving terminal. If this occurred, check the reception level using technical data print on the TCR/Journal, and ask the sender to adjust the signal transmission level.

Error Code 0-84

The modem did not finish transmitting a signal within 10 s (during phase 4 – control channel startup).

Try switching the machine off/on to reset the modem. Upgrading the modem's firmware may be necessary in some cases.

Error Code 0-85

The modem did not finish transmitting a signal within 10 s (during control channel restart).

Try switching the machine off/on to reset the modem. Upgrading the modem's firmware may be necessary in some cases.

Error Code 0-86

The other terminal specified a data rate that is not supported by the current symbol rate.

The other terminal is not behaving in accordance with V.8/V.34 standards.

Error Recovery using AC Tone

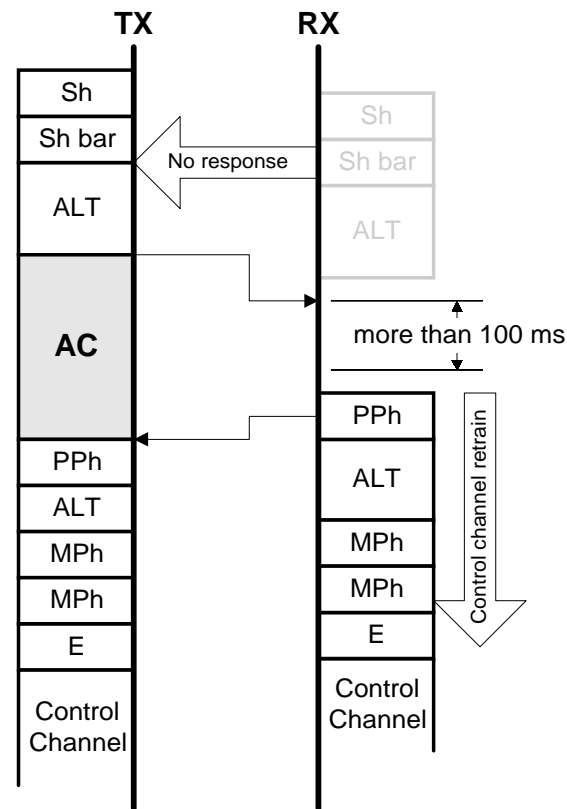
If one of the modems could not detect a response to the control channel restart signals, it can send an AC tone to ask the other modem restart the control channel. In the example diagram, the tx side could not detect control channel signals, so it sends AC.

If the other modem detects an AC tone for more than 100 ms, it responds with a PPh – ALT – MPh sequence even in the control channel restart phase (normally, an Sh sequence is used in the restart phase, not PPh).

If there is no PPh in response to the AC tone, the AC tone transmitter disconnects the line.

If AC tone is frequent to (or from) a certain terminal, adjust the transmission level or equalizer settings.

The AC tone may occur on noisy lines.



Primary Channel

Error Code 0-87

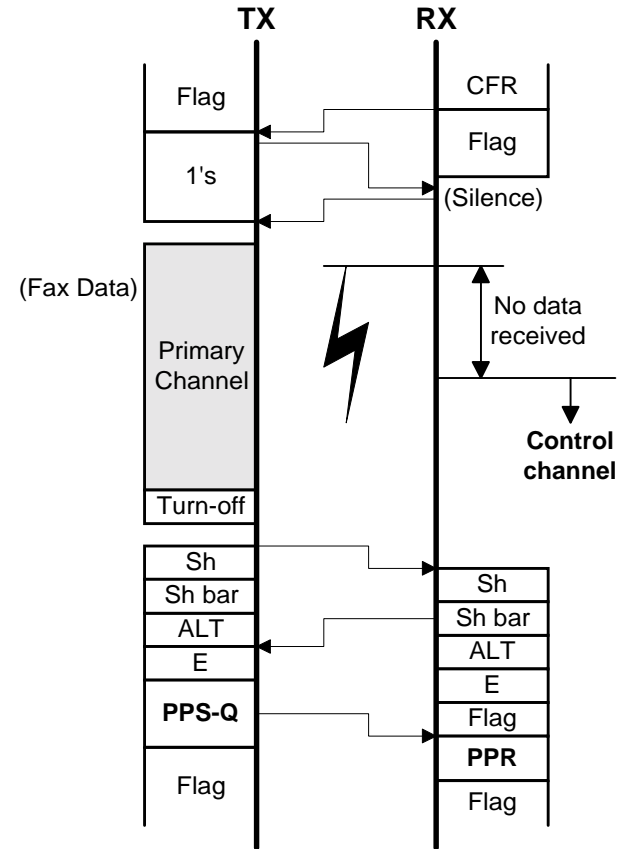
NOTE: This error code is generated by the receiving terminal.

If the rx side cannot receive primary channel data (fax data), it drops back into the control channel and waits for control channel signals (Sh or PPh) from the sender.

- This error could have been a temporary carrier drop, for example.

When the control channel restarts, the rx side requests all frames to be sent again in the PPR signal.

Note that the rx side may receive all the frames properly after this, but error code 0-87 is still generated.



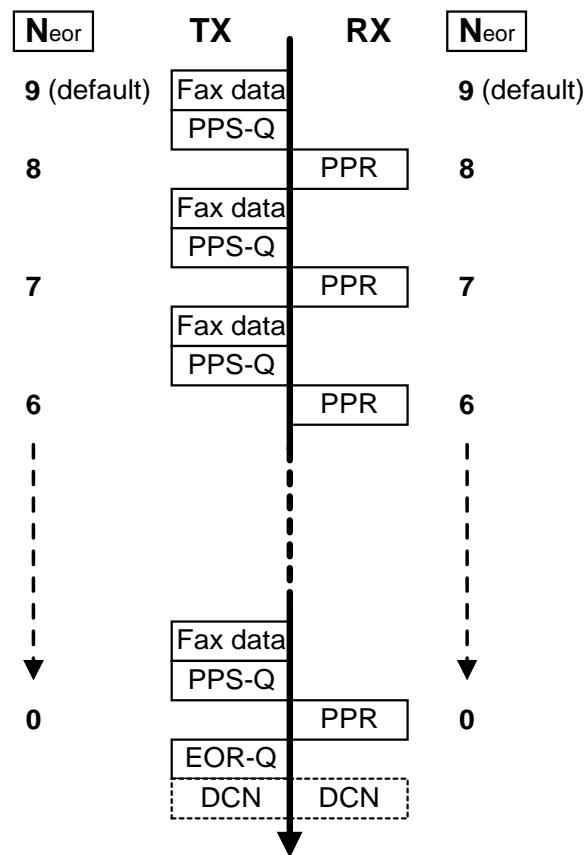
Error Code 0-88

When nine PPRs have been sent back to the tx side within the same ECM block, the line is disconnected.

PPS-Q means any of the PPS signals (such as PPS-EOP, PPS-MPS, and PPS-NULL). It is standard notation for T.30 ECM protocol.

NOTE: Line disconnection after nine PPRs is a Ricoh-specific function.

N eor = No. of PPRs before EOR is sent.



Faxing From a PC

Fax Modems

Overview

This section deals with boards installed in fax machines to allow a fax application package on a PC to send a fax through the fax machine to the telephone line.

EIA/TIA (Electronic Industries Association/Telecommunications Industry Association) has two modem standards for PCs to interface with fax machines. These are known as Class 1 and Class 2.

Class 1 is a bare-bones standard, providing just enough support to allow a PC to send a fax.

Class 2 adds a wide range of modem commands based on the Hayes modem signaling standards. These commands are known as AT commands (AT is short for 'Attention').

AT Commands

The AT commands that are implemented depend on the model.

Internet/LAN Fax Boards

Overview

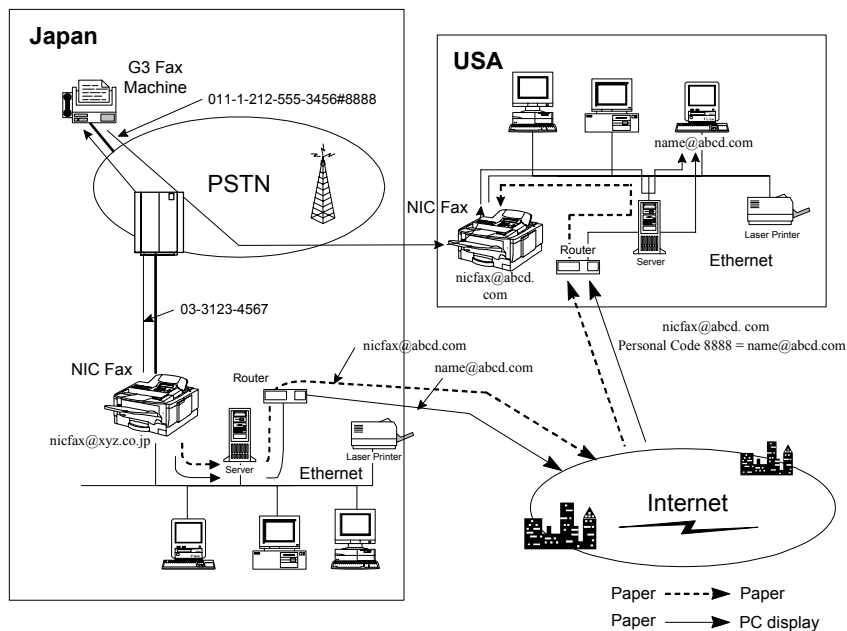
What is an Internet fax?

If a fax machine contains a network interface board and is connected to a LAN, the machine can send faxes over the Internet as well as using PSTN G3. This section explains how a fax machine can send fax messages to PCs and fax machines over a LAN or the Internet.

An Internet fax machine is also known as a 'NIC Fax' or an 'IFAX'.

Using the Internet for faxing can reduce telephone line charges and paper consumption.

The drawing outlines some of the network operations that a typical Internet fax can support (see the next page for an explanation).



The NIC Fax at nicfax@xyz.co.jp can send a G3 fax message to a G3 fax machine inside Japan (at the top of the diagram), by dialing a telephone number.

The NIC Fax can also send a fax message over the Internet by specifying an e-mail address (nicfax@abcd.com) instead of the telephone number. The NIC fax can also send the message to a PC (name@abcd.com).

Depending on the type of protocol used for reception, the received message will be either:

- ☐ Stored in the network server at the remote end, until the PC picks it up (this is reception using POP or IMAP)
- ☐ Sent to the destination directly without being stored in a server at the receiving end (this is reception using SMTP)

How is it done? Protocol and Standards

IETF (Internet Engineering Task Force) and ITU-T have standardized procedures for sending fax messages over the Internet as e-mail attachments.

The message is sent as a TIFF-F format image file attached to a MIME format e-mail message. (Some older models can also send DCX image files, depending on a user setting).

To receive a fax by e-mail, a MIME-compatible mail reader is needed. To view the fax, a TIFF-F viewer is needed. (For some models, the viewer should also be able to view DCX files.)

The NIC fax must be connected to a LAN and set up correctly in order to use Internet fax functions. There is no need to set up a special server. Existing servers on the LAN can be used. TCP/IP

protocol is used. There must be an SMTP server to send mail, and either a POP3, IMAP4, or DNS server to receive mail.

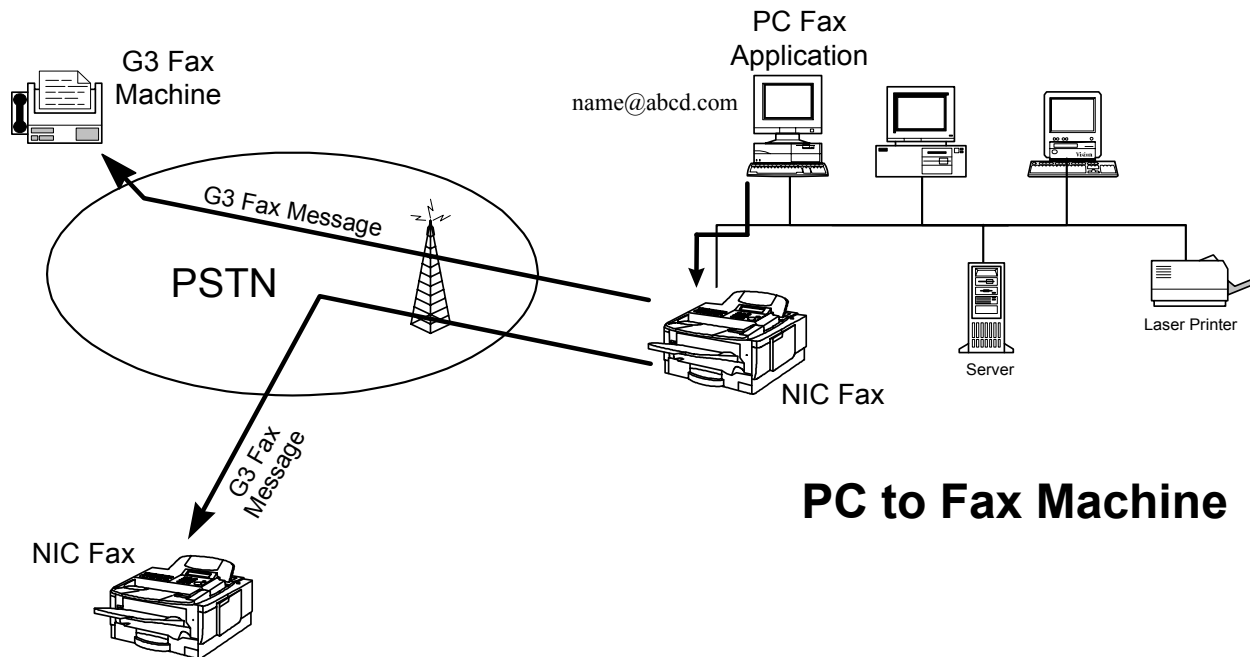
For people that do not have servers, the **H535 model** has an optional PDU unit that allows the mail transmission and reception to be done using servers at the Internet Service Provider.

Software installed on the PC (such as a Web Browser) can be used to check the settings and status of a NIC fax from a PC.

Limitations

- ☐ An Internet fax does not contact the other party directly when sending a fax by e-mail. It only communicates with the local server, which passes the message through the network to a server at the other end, and the remote terminal picks it up from the server.
- ☐ Except for errors during SMTP procedures, information about errors during e-mail communication will not be fed back to the sending Internet fax. Users have to confirm with the other end that important messages have got through.
- ☐ Users are recommended not to send confidential material over the Internet. The level of security for Internet communications is low.
- ☐ The Internet can get congested at times. If the message is time sensitive, use PSTN G3.
- ☐ Voice communications are not supported over a LAN.

The next few sections explain in outline what functions are available with an Internet fax. They will be explained in more detail after sections describing some basics concerning e-mail and networks.

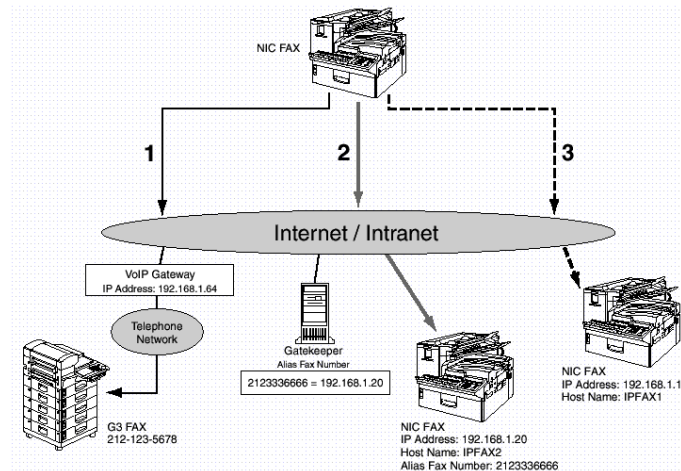
LAN Fax**PC to Fax Machine**

The PC can use a fax application send a G3 fax message to G3 and Internet destinations through the Internet fax (also known as a NIC fax). Internet transmission is not shown in the diagram, but it can be done.

The NIC fax will then send the fax message to the destination, which could be either a PSTN G3 fax or an e-mail address.

Points to note about this feature are:

- When sending a fax using the Internet, the receiving party can be another Internet fax or a computer. The user inputs an e-mail address as the destination instead of a telephone number.
- Received faxes can be sent directly to a PC by e-mail.
- Fax messages can be sent from any PC (by e-mail or by Group 3 PSTN) on the same network as the fax machine. (The machine is like a shared fax modem, with G3 PSTN and Internet capability.)
- No paper is required at the transmitting side.
- Software required on the PC depends on the model

IP Fax

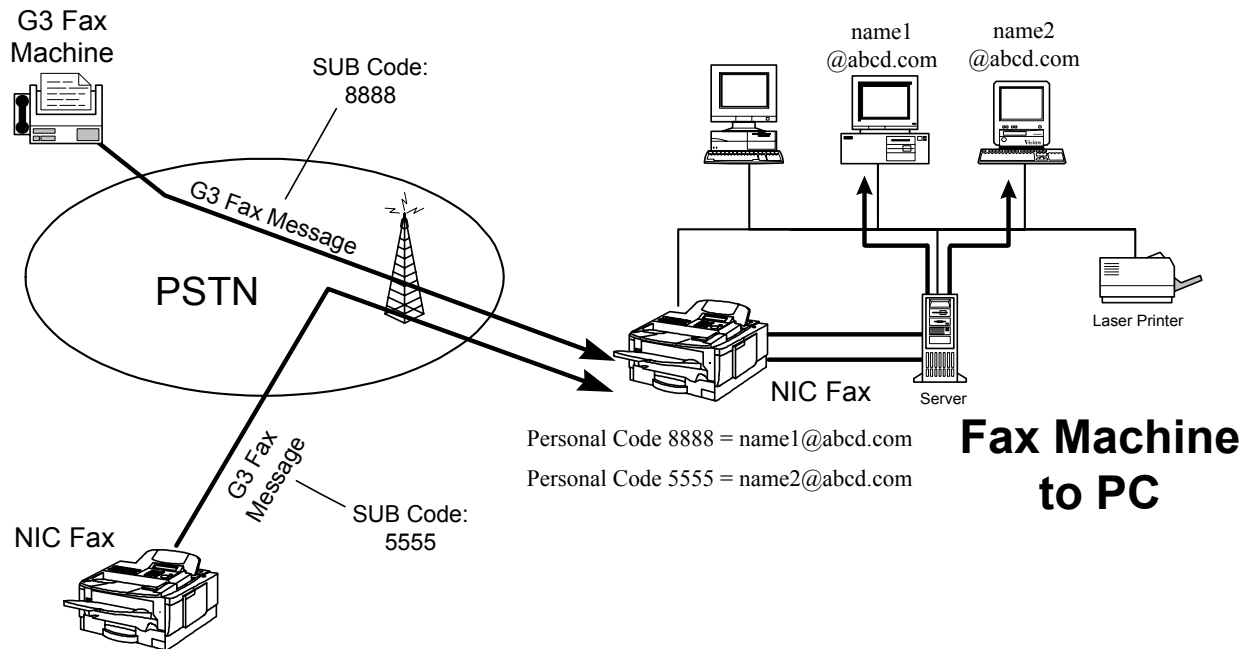
This feature allows you use TCP/IP to communicate with fax machines. The other party can be on the same TCP/IP network as your machine, or it can be on the Internet anywhere in the world.

- It can also be on a PSTN, if your intranet has a Gateway to interface with the PSTN. No e-mail server is required (compare with internet fax).

Use the IP address (or host name) to dial the destination machine, instead of the fax number.

- If there is a Gatekeeper on your intranet, you can use the 'alias number' stored in the gatekeeper. The gatekeeper stores a look up table of 'alias fax numbers' and actual IP addresses.

Autorouting



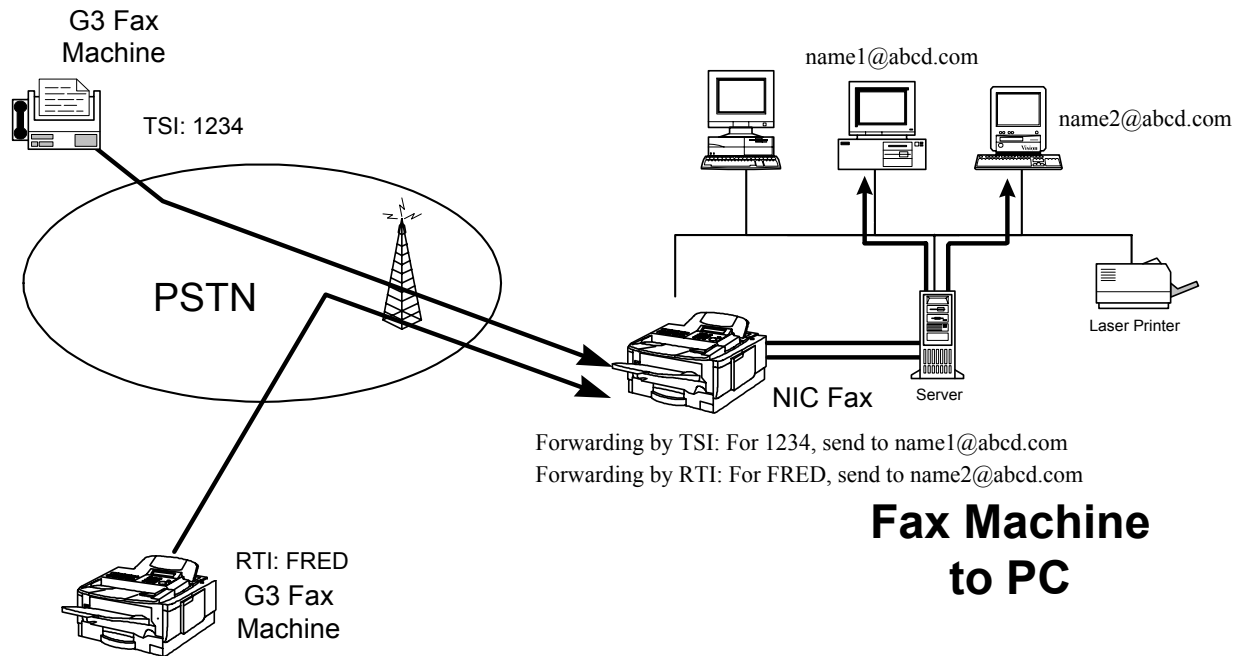
The NIC fax routes incoming fax messages to client PCs on the same network, using the code included in the SUB signal.

1. The sender must specify a code when sending a fax message. This code is transmitted using the SUB protocol signal (see 'Protocol' for more details on this signal).
2. Personal codes must be stored in the receiving NIC fax in advance, and associated with e-mail addresses on the same LAN. To do this, the machine uses the SUB code that is received, and the 'Personal Box' and 'Transfer Box' features.
Personal Box: If the code in the received SUB signal specifies a Personal Box, the NIC fax routes the incoming message to the address that is stored with that Personal Box.
Example: In the above diagram, if a received message has a SUB code of 5555, it is forwarded to name2@abcd.com
Transfer Box: If the code in the received SUB signal specifies a Transfer Box, the NIC fax routes the incoming message to all the addresses that are stored with that Transfer Box.
3. The client PC receives the fax as an e-mail message with an image file attached.

If a machine cannot send a SUB code, the Forwarding feature must be used for that machine (this is the next feature to be described).

Advantages of this are:

- Fax messages are delivered directly to the mail server for the client PC to pick up.
- No paper is used.

Forwarding

The NIC fax routes incoming fax messages to client PCs on the same network, based on the contents of the RTI or TSI. In this way, a message from a certain sender can always be forwarded to a certain location.

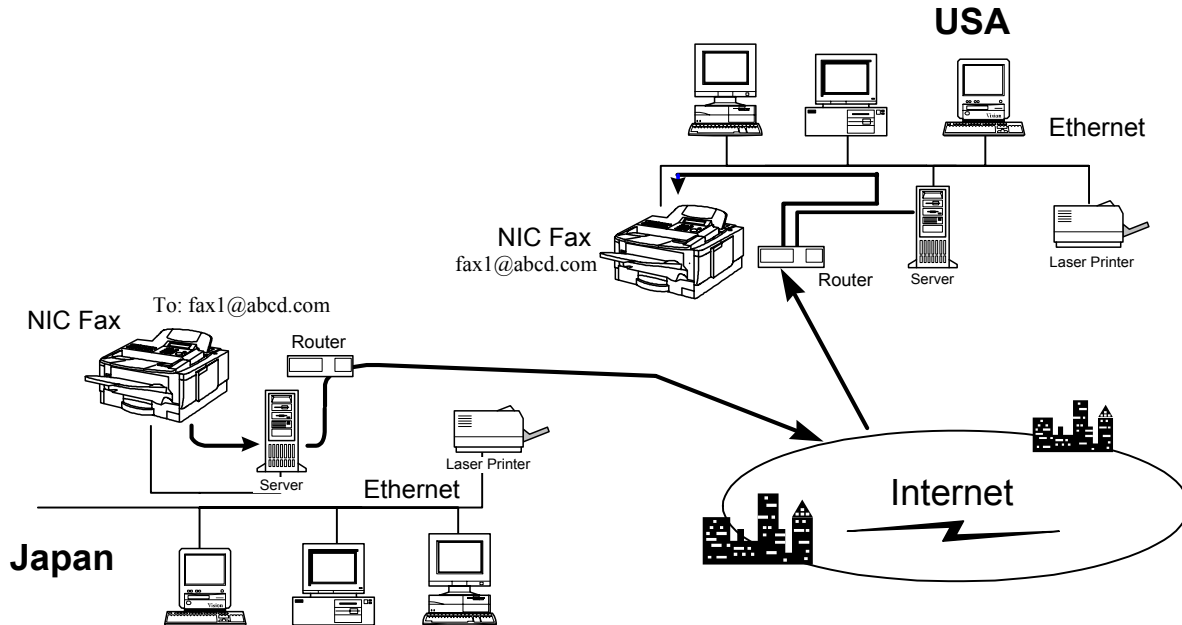
1. The sender must have a TSI or RTI programmed.
2. RTIs and TSIs of expected senders must be stored in the receiving NIC fax in advance, and associated with e-mail addresses on the same LAN. If the received RTI or TSI is the same as one of those stored, the NIC fax routes the incoming message to the associated address.

Example: In the above diagram, if a received message has an RTI of FRED, it is forwarded to name2@abcd.com

3. The client PC receives the fax as an e-mail message with an image file attached.

Advantages of this are:

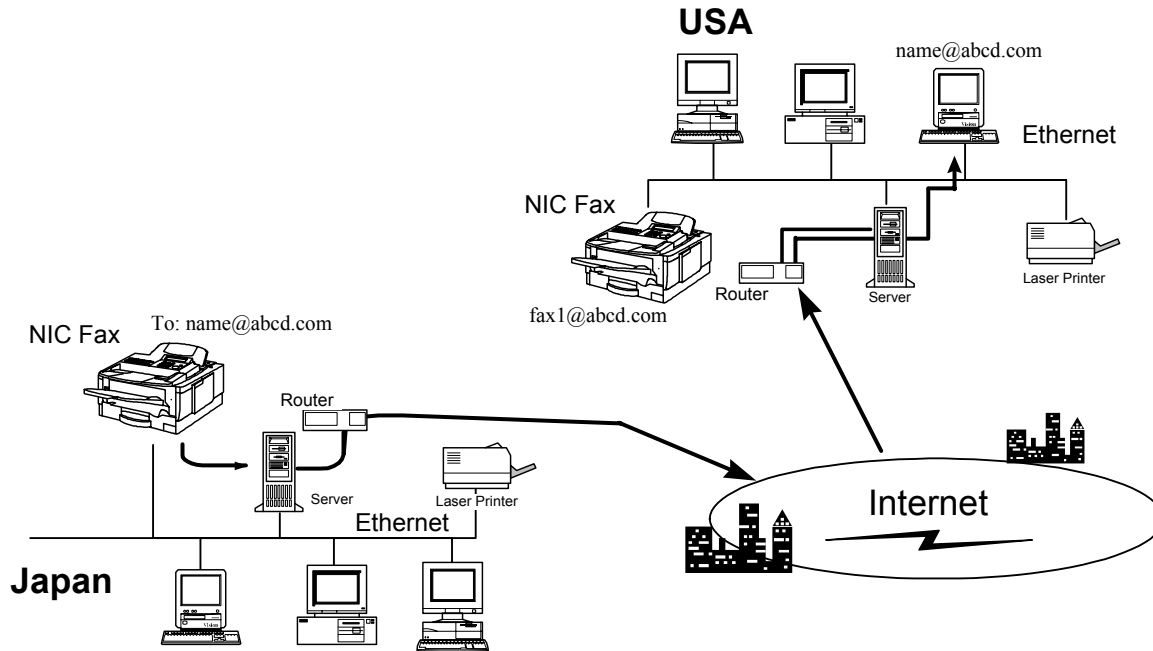
- No SUB code is required for forwarding (some machines cannot send SUB codes).
- Fax messages are delivered directly to the mail server for the client PC to pick up.
- No paper is used.

Internet Fax (Paper to Paper)

1. Instead of a PSTN telephone number, an e-mail address is specified when sending a fax message.
2. The fax message goes through the Internet to the receiver, and is printed.

NOTE: The time required to send a fax over the Internet depends on the traffic conditions at the time of transmission. Also, the sending machine has no way to know whether the message arrived intact at the other end.

The advantage of this is that it is cost-saving.

Internet Fax (Paper to PC)

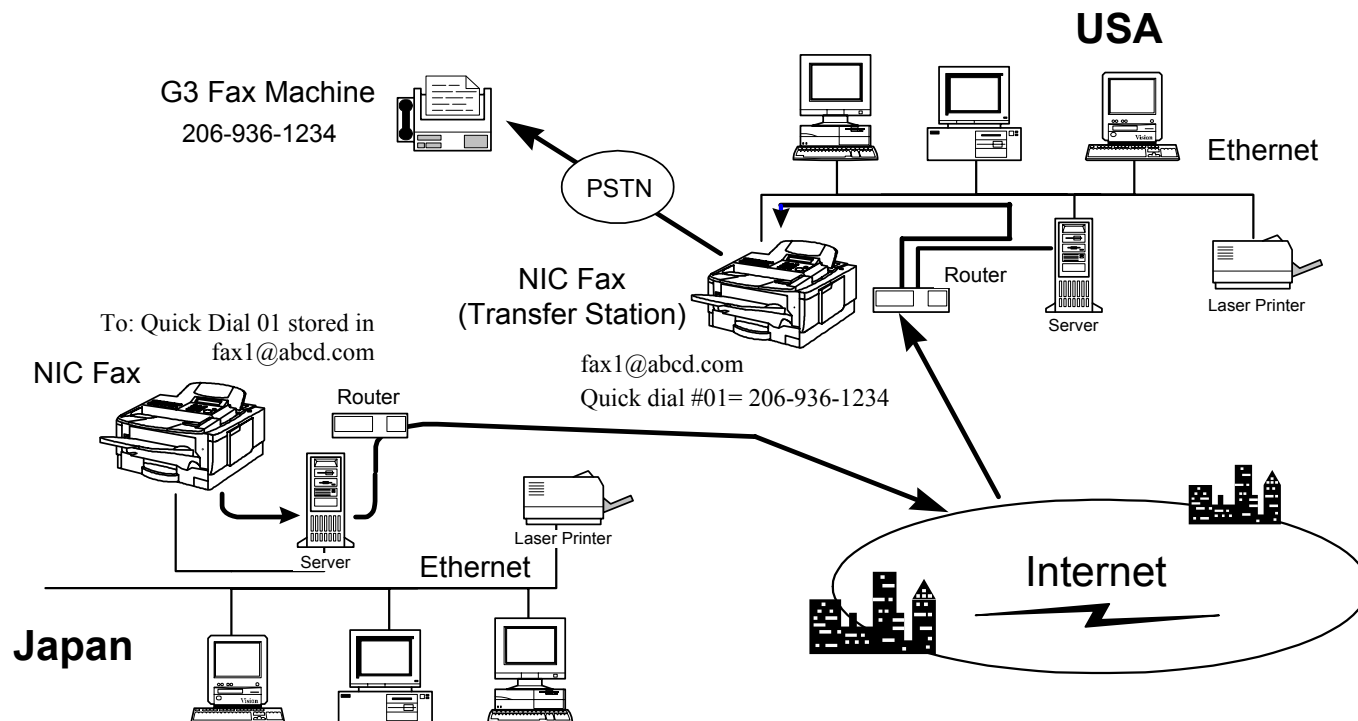
1. An e-mail address is specified when sending a fax message.
2. An e-mail message is sent to the client PC with the fax message attached.

The PC must have:

- E-mail software to pick up the e-mail from the server
- A TIFF-F or DCX file viewer to read the image

The advantages of this are:

- Cost-saving
- No paper is used

Transfer Request through the Internet

A fax message can be transferred over the Internet and then forwarded to a G3 facsimile, using the NIC fax as a transfer station.

1. The sender specifies the end receivers using the quick dials, speed dials, and group dials that are stored in the transfer station.
2. The fax message is sent to the transfer station over the Internet and the LAN at the remote location. Then it is transferred to the destination over the local PSTN. It can also be transferred by e-mail over a LAN or the internet, if the transfer station is a NIC fax.

This saves costs for long-distance communications.

LAN Basics

Before we look at Internet fax features in more detail, it is important to know a bit about Local Area Networks (LANs) and e-mail. This section will deal with LANs, and the following section will deal with e-mail.

LAN Configurations

Overview

A LAN (Local Area Network) links computers within an installation such as a building or factory. It consists of communications hardware such as interface boards and cables, and software for the computers that are to be connected.

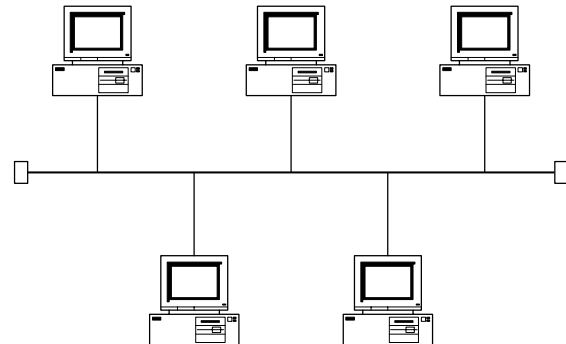
Basic Types

The following three configurations are available for linking computers. The different wiring configurations are often referred to as 'topologies

With all three topologies, signals sent from one computer go to all other computers. An address is included at the start of the data so that it is ignored by all computers except the destination.

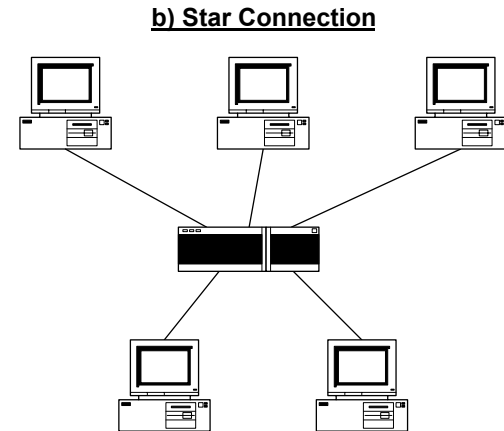
Bus Configuration

One central cable is installed, with computers connected to it in branch fashion. All data is sent via the central cable.

Network Topology**a) Bus Connection**

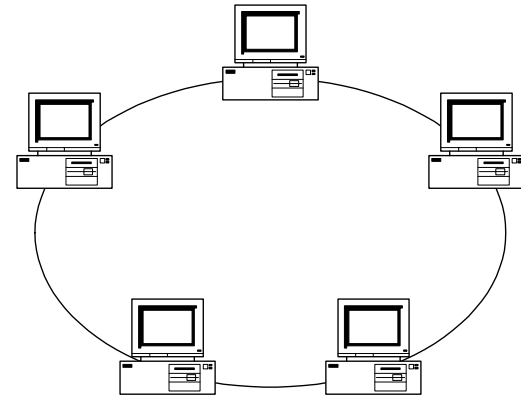
Star Configuration

A central hub is used, with computers connected around it. All data is sent from the central hub.



Ring Configuration

Computers are connected in a ring.

c) Ring Connection

Because the data sent by one computer reaches all the others, only one computer may send data at any one time, or there will be a collision of data on the circuit. If one computer continues sending data, it will occupy the LAN to the exclusion of all others. To prevent this problem, data is limited to a length of a few kbytes. These small units of data are referred to as 'packets' or 'frames'.

Avoiding Data Collision

Collisions occur when data is sent from a number of computers simultaneously. Two methods are employed to prevent this.

- (a) The computers detect whether there is any data on the LAN, and only send when the LAN is free. There are several ways to do this. A typical method is CSMA/CD, which is used with Ethernet applications.

CSMA/CD (Carrier Sensing Multiple Access/Collision Detection)

A method by which multiple computers have access to the transmission route (referred to as 'multiple access'). The computers monitor the transmission route for data (carrier sensing), and send data if none is currently being sent. If a data collision is detected, the data is resent after a randomly determined wait time.

- (b) Token passing, in which collision of data is avoided before the event. Tokens ensure that the data only goes to the intended computer.

The various connection configurations and ways of avoiding data collision have resulted in a number of different types of LANs. The different types are incompatible when directly connected to each other, thus requiring the use of relay devices.

Main LAN Types and Their Characteristics

Type		Cable connection configuration	Transmission speed	Cables	Access control (collision avoidance)	Remarks
Ethernet	10Base-5	Bus	10 Mbits/s	Thick coaxial	CSMA/CD	The original Ethernet configuration
	10Base-2	Bus	10 Mbits/s	Thin coaxial	CSMA/CD	A simplified version of 10Base-5
	10Base-T	Star	10 Mbits/s	Twisted-pair	CSMA/CD	Currently the main type in use
Token ring		Star	4 Mbits/s or 16 Mbits/s	Twisted-pair	Token passing	IBM standard LAN
FDDI		Ring and star	100 Mbits/s	Optical fiber, twisted-pair	Token appending	Used primarily for trunk lines
Local Talk		Daisy chain	230 kbits/s	Twisted-pair	Proprietary	Fitted as standard to Macintosh PCs

* The NIC fax uses 10Base-T.

Ethernet

Overview

Ethernet is currently the commonly-used LAN. It was originally developed by DEC, Intel, and Xerox. The original Ethernet standard incorporated what is now known as the 10Base-5 specialized Ethernet coaxial cable.

The IEEE802.2 standard was based on the Ethernet standard. Specifications for hardware components such as cables, were revised.

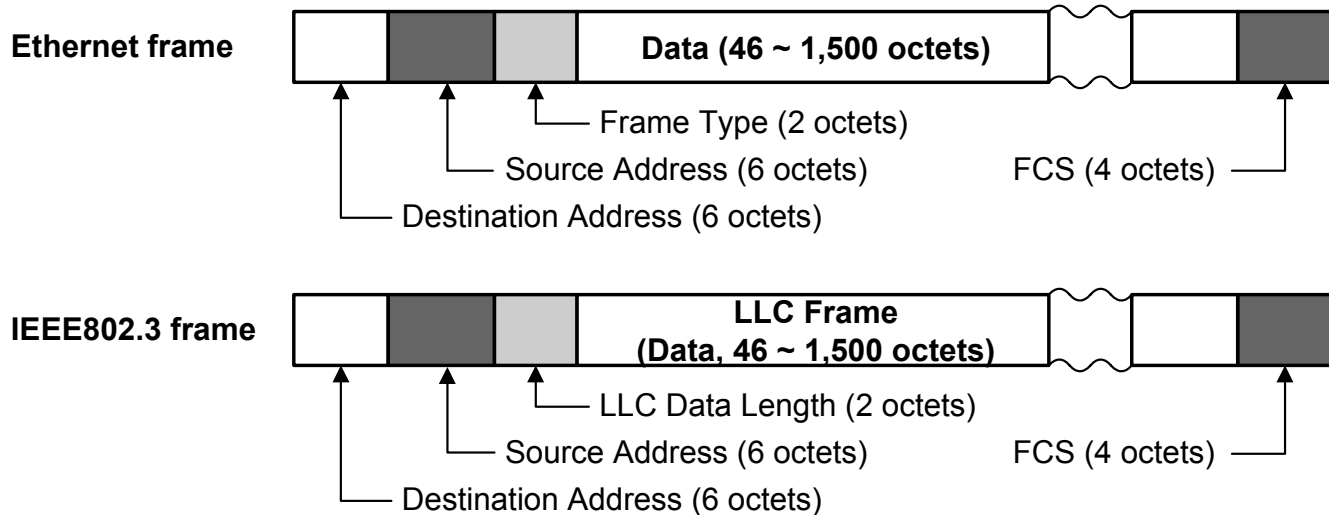
IEEE802.3 was then developed for use with media other than 10Base-5. 10Base-2, 10Base-F, and the most widely used 10Base-T, were subsequently developed.

In contrast to the Ethernet standard data transfer speed of 10 Mbps, IEEE802.3 allows data transfer at speeds between 1 and 20 Mbps.

Ethernet Frame Structure

Ethernet frames consist of the addresses of the source and destination computers, an identifier for the type of protocol used, the data, and finally the FCS (which is used to check whether or not the data has been correctly sent and received).

Compare the Ethernet frame type and the IEEE802.3 frame type in the following diagram.



- **FCS (Frame Check Sequence):**
A CRC (Cyclic Redundancy Check) is employed to check whether or not the received data is correct. The receiving device (receiving node) reconstitutes the FCS from the received data. If it does not match the sent FCS, that frame is discarded as corrupted.
- **Identifier:**
Indicates the type of data that follows. The identifier is referenced by the receiving node to determine the type of protocol used to send the data.
- **Octet:**
A unit employed to indicate network data size. 1 octet is 8 bits (1 byte).
The term is used to make a clear division into 8-bit units from a continuous stream of 1s and 0s with no inherent division into bytes.
- **LLC (Logical Link Control):**
The name of the data frame defined in IEEE802.3.
- **Node**
A computer or printer connected to the network.

MAC Addresses

To allow each node in the network to communicate with others, it must have a unique identifier. In the Ethernet standard, a 48-bit address known as the MAC (Media Access Control) address is assigned to each computer. Each data frame contains the MAC addresses of the source and destination computers.

The MAC address is a fixed physical address that is set on the network card. It is six bytes in length for the Ethernet standard. The first three bytes are a header code which is controlled and allocated by the IEEE, and the last three bytes are a code independently controlled with each header (to prevent duplication). This ensures that the physical address of each Ethernet card is unique.

Under the Ethernet standard, frames are sent and received using these addresses (see 'Ethernet Frame Structure').

LAN Hardware

Overview

The basic LAN configuration consists of four hardware items.

- Interface boards - also known as LAN boards or Network Interface Cards (NICs):
Convert digital data into electrical signals, prevent data collision, and transmit data on cables
- Cables:
Primarily unshielded twisted-pair (UTP) and optical fiber cables
- Hubs:
Distribute signals
- Relay devices:
Connect LANs for the transmission of data to remote locations

LAN devices are regulated by IEEE (Institute of Electrical and Electronic Engineers) standards.

In addition to hardware, the following types of software are also needed.

- Transmission protocol software that can transmit data via a variety of relay devices
- Applications (database, e-mail), to provide the data in a format usable by the operator

Relay Devices

Relay devices are required to expand LANs. These devices do the following.

Extending the Connection Distance

LANs allow high-speed transmission of data, achieved by sending high frequency signals over the cables. High frequency signals are considerably attenuated when transmitted over the cables, and signal waveforms are easily distorted, resulting in difficulties when transmitting over long distances (the maximum distance for transmission using twisted-pair cables to connect the hub and terminals with 10Base-T is 100m).

When expanding a LAN, relay devices are used to amplify the attenuated signals. Distorted signals are first converted back to digital format and regenerated to remove the distortion.

To cover even more remote locations, telecommunications companies provide dedicated lines, PSTN lines, and ISDN lines for connection to remote LANs.

Connection between Networks of Different Standards

As the types of cable used, and the signal and data format differ between different LAN systems, such systems cannot be connected directly. When a LAN system has to be connected to a different system, a relay device that can convert between the two systems is employed.

Conversion between different LAN systems involves first converting the signals back to digital format, and resending them in a format appropriate for the destination LAN.

Control of High-speed Transmission Routes

As the network grows, the number of connected computers increases, and so does the volume of data transmitted. There is a limit to the amount of data that can be transmitted on the network. When this is exceeded, the flow of data is impeded and communications are no longer possible.

There are a number of ways to increase the speed of data transmission on a LAN. A high-speed LAN may be used to prevent network congestion when the amount of data to be transmitted is large. When connecting LANs of different transmission speeds, relay devices are required that can convert between the two LAN types.

By-pass circuits may be installed when connecting LANs with relay devices. When there is a complex web-like interconnection of networks, there are a number of routes to the destination, so that busy parts of the network can be by-passed.

Filtering

There are also relay devices that can check the data on the network and remove all except that which is necessary. This is referred to as 'filtering'.

Controls which pass only specific protocols (used for the transmission of data and voice between terminals on networks such as TCP/IP, IPX/SPX, AppleTalk) are used to alleviate congestion in the relay circuits.

As the number of users increases, the network is used for greater variety of purposes, resulting in the entry of data through illegal access. Relay devices to limit access and to maintain security become necessary.

Types of Relay Devices and Gateways

Relay devices may be of various types - repeaters, bridges, switches, routers - depending upon their purpose and principles of operation.

Types of Relay Devices and their Functions

Function	Repeater	Bridge	Switch	Router
Cable extension	○	○	○	○
Connection with remote sites	✗	○	✗	○
Connection with different LAN types	✗	○	○	○
Avoiding congestion	✗	○	○	○
Restricting access	✗	✗	✗	○

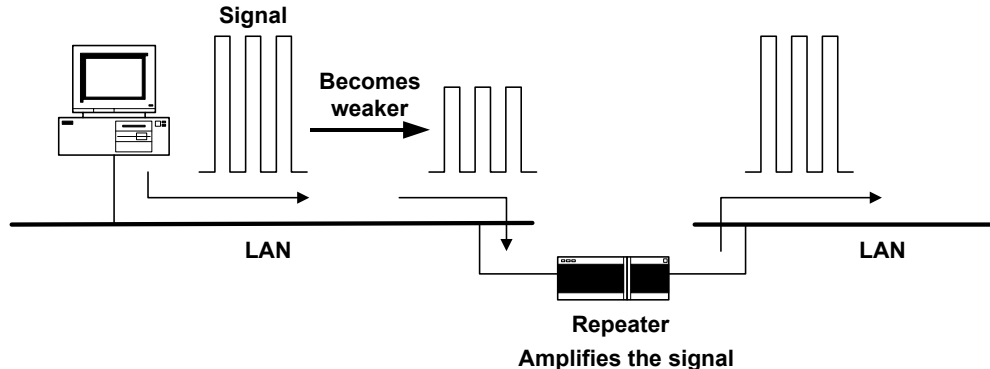
Repeaters

A repeater amplifies signals. It is normally connected to a number of LANs, and amplifies signals from one LAN (one segment) and outputs it to another LAN (another segment).

It is considerably cheaper than a bridge or router, and does not require special setup. After power is switched on, the repeater connects to the two networks.

As distortion occurs when signals are amplified, the number of repeaters is limited to two with Ethernet.

Repeaters have no ability to store data, and are unable to prevent collisions when sending signals. Therefore, they have no effect on relieving congestion in a network.



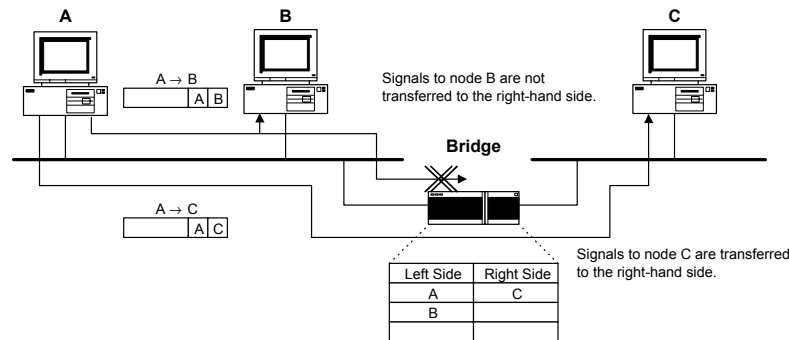
Bridges

In the same way as a repeater, a bridge converts received electrical signals back to digital format, and then regenerates the original electrical signals for transmission, thus preventing signal distortion.

Bridges can also filter out unnecessary data, and can act to alleviate congestion on the network. The bridge records the source MAC address in the header of the arriving data packets. In this way, the bridge builds up a picture of the location of each node (PC and printer).

In the example shown below, data sent from A to B also reaches the bridge. The bridge automatically records this data and remembers that A is located in the left-hand segment. When data is subsequently sent from B to A the bridge does not relay it to the right-hand segment. This process is referred to as filtering.

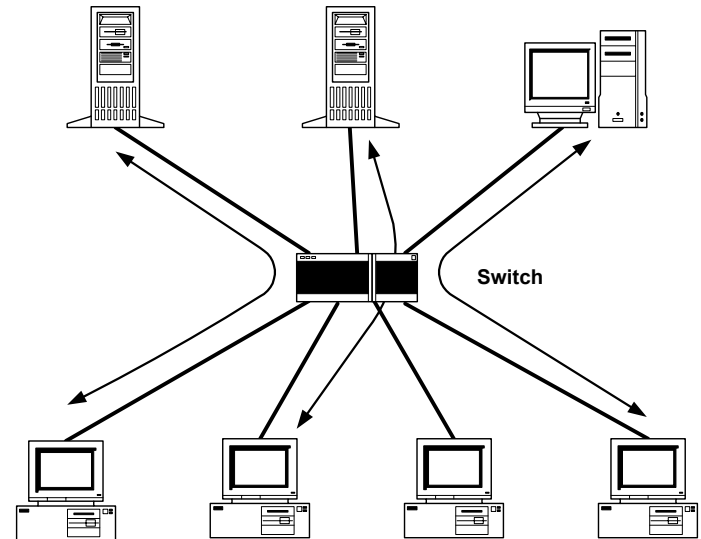
The bridge does not require special setup. After power is switched on, the bridge connects to the two networks.



Switches

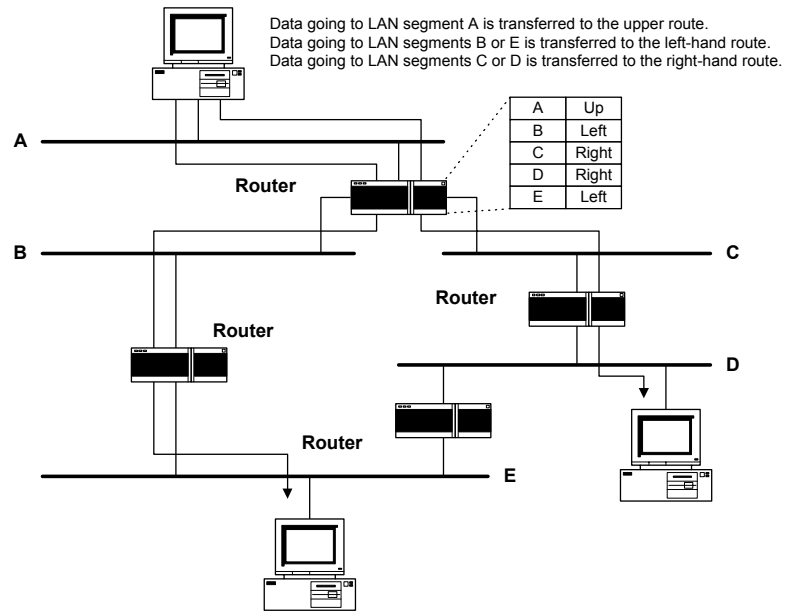
Switches have the same filtering function as bridges, however they also support simultaneous connection of multiple LANs, and allow parallel relaying.

Relay processing time is reduced in comparison to bridges, and operation is therefore faster.



Routers

A router checks the destination information in the headers of the data packets on the network and determines which LAN it has to be sent to. The router contains a table which records the destinations.



In contrast to repeaters and bridges, simply switching power on and connecting to the networks does not make ready the router for operation. Software appropriate for the communications protocol must first be installed, the network configuration checked, and the setup completed.

While filtering with bridges is implemented primarily by the checking of addresses, filtering with a router is implemented by the communications protocol.

Depending upon the application protocol, the router may be set to pass e-mail data, but not to transfer files.

Routers support considerably more sophisticated functions than bridges. For example, they may be set up to allow high priority data to be passed more quickly (priority control). Different LAN types have different formats for the destinations. The router makes sure that the destination is in the correct format for the next network.

When there are multiple routes to the destination, bridges and switches cannot be employed to reduce congestion since the data is sent via all routes. Routers, on the other hand, employ a number of routes set beforehand in accordance with the amount of data to distribute the load throughout the network (while bridges divide up the network with MAC addresses, routers achieve this, in the case of a TCP/IP protocol, by analyzing IP addresses and sub-nets).

The router is a device central to the configuration of the network, and as such router functions are implemented in software in PC LAN servers and UNIX machines.

NOTE: In the NIC fax, the device setting the IP address as the default gateway is in practice a default router. When data is sent from the network belonging to the local machine to other networks, the device at the exit from the network is referred to as the default router.

Gateways

While repeaters, bridges, and routers are available as dedicated hardware for network use, gateways are available as server and client software packages. They analyze all network communications protocols, and convert data, thus allowing connection of different networks. The Netware Gateway Service supplied with the Windows NT Server is an example of this software.

Network Protocols

Overview

Network protocols are standard procedures for transmitting data over a network. There are different protocols for different stages of the communication.

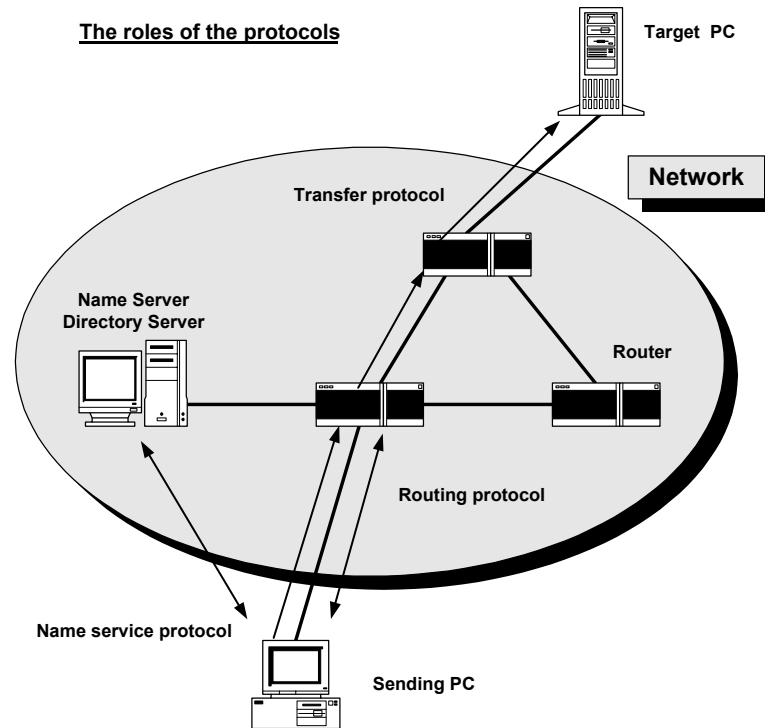
Data Transmission

Data is sent using the following procedures.

- (1) Finding the destination
- (2) Determining the route to the destination
- (3) Sending the data

A number of protocols must be used in combination in order to execute each procedure. The TCP/IP protocol used with the Internet, the Netware IPX/SPX protocol, and the Macintosh AppleTalk protocol, are combinations of protocols designed to achieve various specific procedures.

Protocols used for steps (1), (2), and (3) listed above are referred to as (1) the name service protocol, (2) the routing protocol, and (3) the transfer protocol respectively.



Name Service Protocol

A computer name is normally assigned to the computer. However, for the purposes of transmitting data, the name is converted to an address indicating its location on the network. The name service protocol provides lists of all names when the destination computer name is unknown.

The address is an identifier used in distinguishing between terminals and nodes on the network. The most common addresses are IP addresses and MAC addresses.

An IP address consists of a network address (to identify the network to which the terminal belongs) and a host address (to identify the terminal within the same network), both of which are set by the user.

A MAC address is registered in the memory of the network interface board by the manufacturer. Each MAC address is unique (no two are alike throughout the world).

Routing Protocol

The routing protocol is used in determining the route used to transmit the data. A preset network route may be necessary, or it may be determined automatically by communication between routers.

If relay devices are to be added or moved, it is convenient to have a method of automatically determining new routes. The routing protocol provides this ability.

Transfer Protocol

The transfer protocol is used in the transmission of data. It first checks for errors in the received data, and resends it if an error is detected. It also controls the rate at which data is transmitted, by communication between the source and destination.

In addition to these basic protocols, there are also various other protocols which provide for notification of network congestion, notification of errors, and so on.

Protocols Used with Different LAN Types

	Name Service Protocol	Routing Protocol	Transfer Protocol
Protocols used with the Internet (TCP/IP)	DNS	RIP OSPF	IP TCP UDP
Protocols used with Netware (IPX/SPX)	SAP NDS	RIP NLSP	IPX SPX
Protocols used with Macintosh (AppleTalk)	NBP ZIP	RTMP	DDP ASP

DNS: Domain Name Service**RIP: Routing Information Protocol****OSPF: Open Shortest Path First****IP: Internet Protocol****TCP: Transmission Control Protocol****UDP: User Datagram Protocol****SAP: Service Advertisement Protocol****NDS: NetWare Directory Service****NLSP: NetWare Link State Protocol****IPX: Internetwork Packet Exchange****SPX: Sequenced Packet Exchange****NBP: Name Binding Protocol****ZIP: Zone Information Protocol****RTMP: Routing Table Maintenance Protocol****DDP: Datagram Delivery Protocol****ASP: AppleTalk Session Protocol**

TCP/IP

Overview

TCP/IP is the standard Internet protocol, and is supported as a standard by Windows 95. It allocates 32-bit network addresses (IP addresses) to the nodes. As the addressing system does not depend upon physical media, TCP/IP provides for considerable flexibility in selection of routes.

The use of TCP/IP is not limited to Ethernet, but allows use of a variety of physical media.

TCP/IP is a combination of the TCP protocol and IP protocol.

Communications with IP protocol

The IP protocol divides data into packets. When the destinations may be on several different LANs, the router selects the appropriate route for each packet before it is sent. This process is repeated until all data arrives at the destination network.

IP Address

Communications with IP protocol requires that network devices such as PCs and routers using TCP/IP be assigned a 32-bit IP address as a means of identification.

When used in a single closed network, the IP addresses (referred to as private addresses in this case) may be used freely. However, when connected to the Internet, global addresses which are unique throughout the world must be used. Global addresses are managed by the Internet Assigned Numbers Authority (IANA), and are assigned upon receipt of an IP address.

IP Address Format

IP addresses are 32 bits in length, and are normally converted to decimal notation in four 8-bit blocks as shown below.

Example of IP Address Notation**133. 139. 212. 11**

Host portion (16 bits)

Network portion (16 bits)

The IP address consists of host and network blocks as shown above. The network block represents a logical collection of hosts (a network), and the host block specifies a unique host within the network.

In the example above, a maximum of 65,534 (the maximum number of combinations of 16 bits) hosts may be allocated to that particular network block.

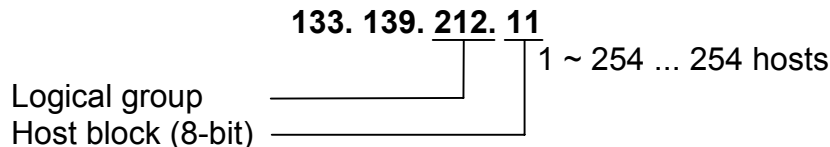
As TCP/IP involves the routing of packets using the address in this network block, the network block must be unique (no two can be alike throughout the world). On the other hand, the address within the host block is up to the user.

Subnet and Subnet Masks

Subnet masks divide the host block into sub-nets. In the example above, there are 65,534 possible host addresses, and it is difficult to manage all with one network.

The host address block is therefore subdivided into the upper and lower 8 bits, with the upper 8 bits handled as a logical group address. In this way, the IP addresses assigned to a company for its networks can be divided up into sub-nets of about 250 hosts for ease of management (each department of the company can be allocated a different logical group number, for example).

Example: Sub-net



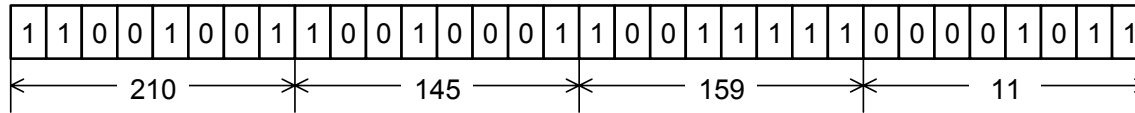
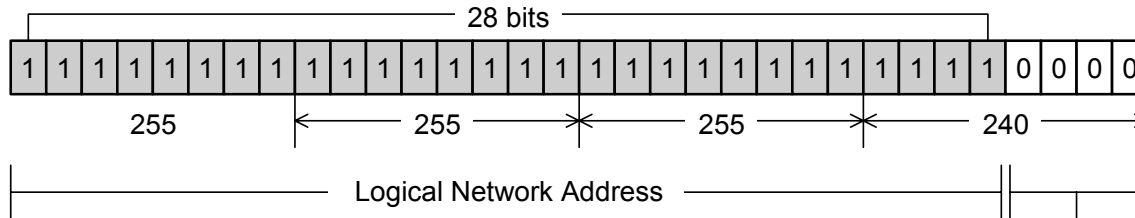
The final part of the IP address (the host block) cannot be 0 or 255.

The dividing is done using a parameter known as the subnet mask. The subnet mask blocks off addresses, only permitting certain addresses to be used in a subnet.

A logical AND operation is done using the subnet mask to find the range of allowed sub-net addresses.

If your computer has the IP address 210.145.159.11, and the subnet mask is 255.255.255.0, the server can recognize that machines with an IP address of 210.145.159.* are on the same LAN, so messages are sent to it directly. Any IP address with a different value at the start has to be accessed through a router.

The following diagram shows how the AND operation can be used to limit the size of the subnet to a few IP addresses.

IP address and Subnet mask**IP Address (4 octets)****Subnet mask**

14 hosts are available

The address "0000" and "1111" cannot be used

TCP and UDP

While data is formatted into packets and sent to the desired node on the Internet using IP, communications applications (eg e-mail) do not control data transmission in packets.

The host requires a procedure for passing IP packets to the desired application. This requirement is satisfied with TCP (Transmission Control Protocol) and UDP (User Datagram Protocol).

E-Mail Basics

Principles

Overview

Electronic mail (E-mail) is a system by which messages in the form of digital data are sent and received between computers. A variety of types of electronic mail are available - Internet e-mail, Microsoft Mail as used with the exchange client under Windows95, and Lotus Notes Mail.

E-mail works as follows.

- Messages are stored at some location.
- Users generally have equal privileges, and are able to both send and receive messages.

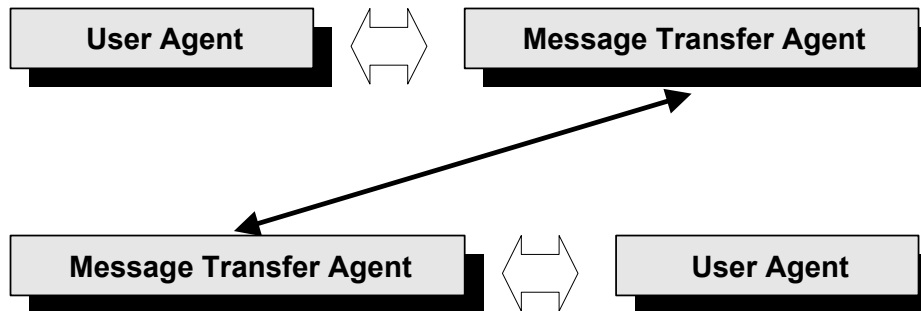
A telephone system requires that users are able talk to each other simultaneously. In the case of e-mail, the user first receives the message, and may then read it at any time, and send a reply if necessary.

Sending And Receiving

E-mail generally supports the following functions.

- A UA (User Agent) for creating e-mail and displaying received mail.
- An MTA (Message Transfer Agent) to handle transfer of messages.

The mail created by the sending UA is sent from the sending MTA to the receiving MTA, and displayed by the receiving UA.



The simplest e-mail system is one in which messages are stored at a location accessible by all users. Each user has his/her own mailbox, and the sender puts messages in the recipient's mailbox. The recipient checks his/her mailbox to receive mail.

The mailboxes are normally at one location, often referred to as a “post office”, and the process of sending e-mail approximates that of sending mail at the post office.

When the post office is accessible from all computers connected to the network, the system constitutes an e-mail system.

Microsoft Mail as used in Windows95, and Lotus Cc: Mail employ this system, as does the UNIX local mail system (i.e., not connected to the Internet, etc.).

E-Mail Networks

As the number of users increases, and geographically distant users are connected to the network, multiple post offices must be established, and users are no longer able to use the same post office for sending and receiving mail. A system which connects post offices for the purpose of exchanging mail (a transfer system) then becomes necessary.

In this case, the destination of mail is checked at the post office, separated into the various destination post offices, and passed it to the transfer system. The transfer system then communicates with the transfer systems of other post offices, and transfers the mail to the appropriate post offices. Mail sent from other post offices is sorted into the appropriate mailboxes at the receiving post office.

The above is a general description of an e-mail system. These functions are implemented with the exchange server software packages for Microsoft Mail and CC: Mail using optional gateway software.

The fundamental principles of Internet mail are the same, and are implemented in the UNIX SendMail program under UNIX.

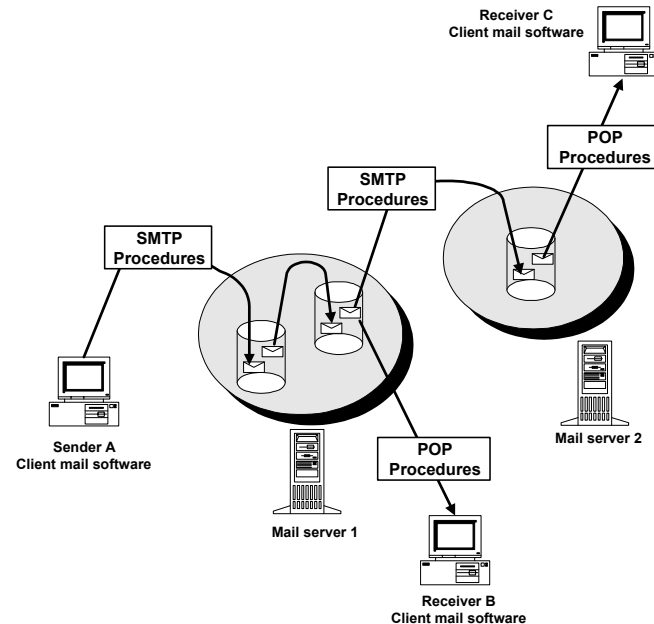
The following diagram shows what happens when somebody sends mail from a PC to a receiver with an account in the same post office and to a receiver with an account in another post office.

Machines A and B both have accounts in mail server 1. Machine C has an account in mail server 2.

When machine A sends the message, it goes to the local mail server using SMTP protocol. SMTP is based on TCP/IP. The post office transfers the message to receiver B's mail box. Receiver B picks the mail up from there, using POP procedures (POP is also based on TCP/IP).

To get to receiver C, the server sends the mail to mail server 2, using SMTP procedures. Mail server 2 puts the incoming mail into receiver C's mail box. Receiver C picks it up using POP procedures.

SMTP and POP are both procedures for Internet mail based on TCP/IP. If there is no SMTP server on the LAN, the fax machine cannot send e-mail. If there is no POP server on the LAN,



the fax machine cannot receive e-mail. Some more detail on SMTP and POP follow later in this section.

Internet Mail

Overview

Internet e-mail (hereafter referred to as Internet mail) is a system for creating text messages in accordance with a set of standards, the messages then being sent to destinations using SMTP (Simple Mail Transfer Protocol).

NOTE: SMTP is a protocol for sending and receiving mail as defined in RFC821. It was originally developed for sending and receiving mail between servers. However it is currently used for sending mail from client environments using POP (Post Office Protocol – discussed in a separate section).

Character Codes

Messages consist of a header and the main text, both being subject to restrictions on usable character codes.

Specifications for data exchanged on the Internet are determined within the organization of the Internet, and do not necessarily conform to ISO (International Standards Organization) requirements. However, these organizations have codified these specifications to the extent that they are now the default standards organizations.

For example, the main text of a message created Japanese using JIS character codes must satisfy a particular set of requirements for transmission on the Internet. However, if it is to be sent on a

network within a particular company, the unique requirements of that system may mean that the JIS codes are not always used.

Message Address Notation

The UA attaches the required header to the main text and sends it to the MTA. The MTA then adds to or changes the header as required to ensure that the message transfer route is recorded, and that the addresses of the destination and sender are correct.

Internet mail employs an 'address' to specify the message destination. The address format is generally as follows.

user name @ domain name

The mailbox name is generally employed as the 'user name'.

The MTA uses the 'domain name' to check the destination IP address with the DNS, and then sends the mail using SMTP.

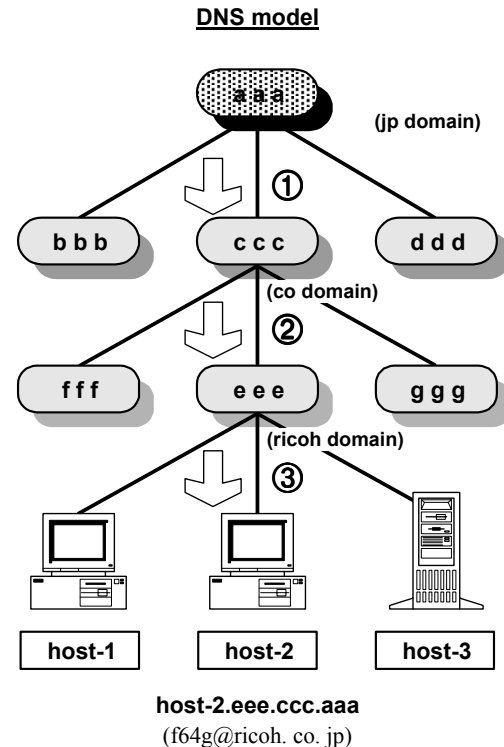
NOTE: DNS (Domain Name System) is a service which enables the IP address to be obtained from the host name under the TCP/IP network environment.

DNS and Domains

The IP address allows destinations within the Internet to be identified. This IP address is, however, a string of numbers not easily remembered by the user. To resolve this problem, a corresponding name is added so that the user need only specify the name in order to identify the destination.

DNS was developed for this purpose. Internet domain names are distributed among organizations in a hierarchical manner, with lower order domains being managed by the higher order domain. All organizations participating in the Internet have a domain name. The domain name first identifies countries, and is subsequently further divided in a tree structure to identify organizations.

The name server (DNS server) located in each domain holds the information about the domains and hosts under its management. When the client communicates using a host name or domain name, an inquiry is made to the DNS to obtain the destination IP address. Note that this domain name structure is independent of the physical structure of the network. The items in brackets below are examples of domain and mail addresses.



Internet Fax and DNS

A NIC fax can use the Domain Names for the SMTP and POP3/IMAP4 server instead of the actual IP addresses, if there is a DNS server on the same LAN as the SMTP server, POP3/IMAP4 server, and the NIC fax. If the NIC fax does not support DNS, the user must input the actual IP addresses of the SMTP and POP3/IMAP4 servers.

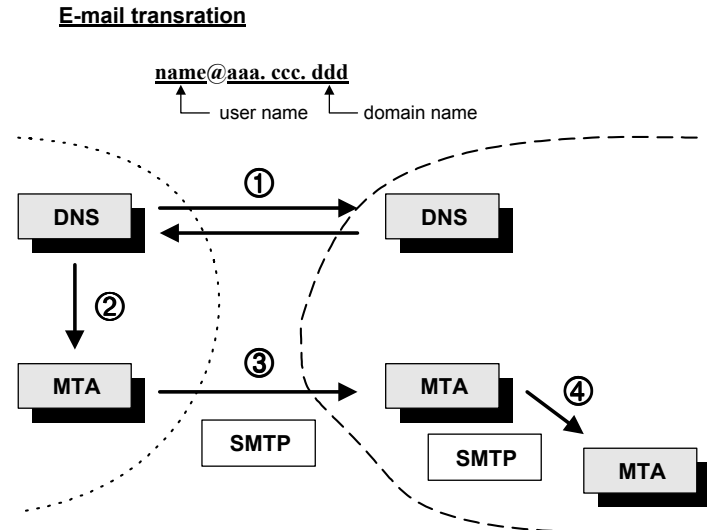
Transfer Of Incoming Mail

In some cases, incoming mail may be transferred to another server using SMTP and then stored on another mail server.

The UA used by the user receiving this mail detects its arrival (e.g., by monitoring the contents of the directory designated to contain mail) and informs the user.

The UA then extracts the mail in accordance with instructions from the user and displays it.

The mail stored on the server is transferred to the user's PC using POP.



The mail address consists of a host name (mailbox name) and domain name. Mail is distributed by first finding the IP address of the destination with the DNS, and then transferring the message using SMTP.

1. The mail destination within the relevant domain is checked using the domain portion of the mail address.
2. The MTA then connects to the destination mail server using the mail address thus obtained.
3. The mail is transferred to the destination MTA using SMTP.
4. Depending upon the size of the organization, the message may be further transferred to an internal MTA (not visible from outside the domain).

NOTE: POP (Post Office Protocol) is a protocol used to read the content of the mail spooler using TCP/IP protocol. It is specified in RFC1725 (see a later section for more details).

Verifying Incoming Mail

Arrival of mail at the intended destination on the Internet is not guaranteed. In the worst case, it may disappear at some unknown location. Furthermore, it is impossible to verify whether sent mail has been read or not.

Mail sent on the Internet passes through multiple servers and networks, and computers used within the Internet are of a variety of architectures. The network therefore contains a wide variety of hardware environments, in addition to the wide variety of software employed for mail transfer.

While there are no problems in most cases, it is obvious that arrival of mail cannot be completely guaranteed within this complex environment.

Message headers

Requests for Comments

The basic protocols used for transmission of messages on the Internet are defined in RFC822. RFC822 primarily defines the header information for e-mail, with the details of the main text of the message being defined in MIME (RFC2045 - 2047).

- NOTE:** 1) An RFC (Request For Comments) is a document formally released by the Internet Engineering Task Force (IETF). The IETF has released a wide variety of RFCs on technical matters (e.g., network protocols) related to the Internet environment.
- 2) MIME (Multipurpose Internet Mail Extensions) is a protocol which removed such restrictions as the number of characters per line, and the maximum size of an e-mail transmission. It also made possible the transmission of non-character data (e.g., programs and bitmaps).

Header Format

The header of an e-mail message consists of a header and the main text. A blank line is inserted between this header and the main text (the blank line is not included in the header).

The header is defined as a collection of fields, with the field format as follows.

field name ":" content

An example of the 'To' field, indicating the destination, is as follows.

To:XXX@ricoh.com

Header Example:

Received: from F64G.shinyoko.rioh.co.jp ([133.139.167.30]) by bb.shinyoko.rioh.co.jp (4.1/2.8Wb-91Jan07)

id AA15193; Sun, 15 Feb 98 14:53:50 JST

Return-Path: <f64g@shinyoko.rioh.co.jp>

Message-Id: <9802150553.AA15193@bb.shinyoko.rioh.co.jp>

Date: 15 Feb 1998 14:54:06 +0900

X-Mailer: ICFAH Version 1.0

Mime-Version: 1.0

Content-Type: multipart/mixed; boundary = "--ICFAH_60670AE6CB--"

To: hanako@shinyoko.rioh.co.jp

From: f64g@shinyoko.rioh.co.jp

Subject: Fax Message NO.0003 from "+81454771786"

("RICOH SERVICE")

Header Types

While a number of header fields are possible, the following three must be present.

- Date
- From
- To

Message Header Table (fields defined in RFC822)

Field	Field name	Meaning	Description
Date	Date	Date that the mail was created	Date and time in specified format Syntax: <address>
Person submitting mail	From	Person submitting mail	Mail address (including comments) Syntax: <address>
Address	Sender	Person sending mail	Mail address (including comments) Syntax: <address>
	Reply-To	Destination when a reply is sent	Mail address (including comments) Syntax: <address>
	To	Mail destination	Mail address (including comments) Syntax: <address>
	Cc	Destination of carbon copy	Mail address (including comments) Syntax: <address>

Field	Field name	Meaning	Description
Address	Bcc	Destination addressees not covered by To and CC	Mail address (including comments) Syntax: <address>
Reference	Message-Id	Message ID	Message identification
	In-Reply-To	Source of reply	Message ID of original mail
	References	Referenced mail	Message ID of referenced mail
	Keywords	Keywords for search purposes	Any character string
Other	Subject	Mail title (summary)	Any character string
	Comments	Mail comment	Any character string
	Encrypted	Encryption algorithm specification	Defined word (defined in separate RFC)
Route	Return-Path	Route for return of mail	Mail address
	Received	Transfer record added by MTA	Describes transfer destination, transfer source, and protocol etc with From, By, With, etc
User defined		Fields defined by user	Field names beginning with X-. May be any character string, definition is up to the user.

* Other fields are available defined by separate RFCs (e.g., MIME).

*Fields for Sending E-Mail***- From Field -**

The From field indicates the person sending the mail. The difference between the From and Sender fields is that between 'the person creating the message' and 'the person actually sending the message'. These two fields are used when the two differ. When the From field is omitted, the Sender field is added automatically.

When a error occurs, a error notification is sent to the destination in the Sender field. When the Sender field has been omitted, the notification is sent to the destination in the From field.

Fields containing mail addresses may also include real names as a comment (the same applies to the Person Sending Mail and Addressee fields). In both cases below , 'IC FAX' is handled as a comment, and f64g@ricoh.com is recognized as the address.

Example 1 From: IC FAX <f64g@ricoh.com>

Example 2 From: f64g@ricoh.com (IC FAX)

Multiple mail addresses may be delineated by commas, and both address formats may be used together.

- Reply-To Field -

Reply-To clearly specifies the address to which the reply is to be sent. As this field may be omitted, it is possible that mail may be sent with this field blank. In such cases, the mail is returned to the address in the From field.

When both the From and Reply-To fields are used, the latter has priority.

The Return-Path field appears to have a similar function at first glance. However it is not for return of mail, but is automatically added by the transfer system to specify the person submitting the mail, and is used to investigate the mail route when an error occurs.

Addressee Fields

- To Field -

The To field specifies the addressee for the mail. As with the From field, multiple mail addresses may be delineated with commas. The To field differs from the Cc field in that only the name of the person sending the message is specified.

- CC Field -

Mail is sent to the addresses in the Cc (carbon copy) field in the same way as to the address in the To field. The difference only with the To field is whether the name is in the To field or the Cc field of the received mail.

- BCC Field -

Bcc means Blind Carbon Copy. The Bcc field is deleted in mail sent to the addressees in the To and Cc fields. It is most commonly used when the address of the person sending the mail (the user in the From field) is to be entered in order to leave a copy of the sent mail.

As some mail software saves a copy of the sent mail, it may not be possible to specify the Bcc field in some cases.

Exceptions

The addressee fields do not always contain the addressee's name when mail is received. This is because since the actual addressee for the mail is specified by the MTA, when an alias is used to create a virtual addressee (in a local system, for example), the virtual address remains in the To field. This also occurs in cases such as mailing lists in which mail is sent to all on the mailing list.

- NOTE:** 1) An alias is a group address. Mail sent to the group address is sent to all members in the group.
- 2) A mailing list is a form of electronic conference using e-mail. E-mail sent to a mailing list is transferred to each member of the list. As such, it provides the same service as available with a PC-based centralized host-type bulletin board system in a distributed network environment.

Date

The Date field indicates the date on which the mail was created (not the date it was sent). The date is in the following format.

Day, date month year hour: minute: second zone

Zone indicates the local time used in the system in which the mail was created, and is expressed as GMT+/-hhmm.

*Miscellaneous***- Received Field -**

The Received field is used by the MTA sending the mail, to record the status of the mail. This field shows the route over which the mail was sent, and the computers which handled it prior to delivery.

In addition to information showing when and where the mail originated, and where it was sent to, some systems add further information (e.g., host IP address, software version) as a comment.

- Message-ID Field -

Internet mail adds an internationally unique message ID. This ID is created automatically, and is normally a combination of the time the message was sent and the name of the mail server.

SMTP

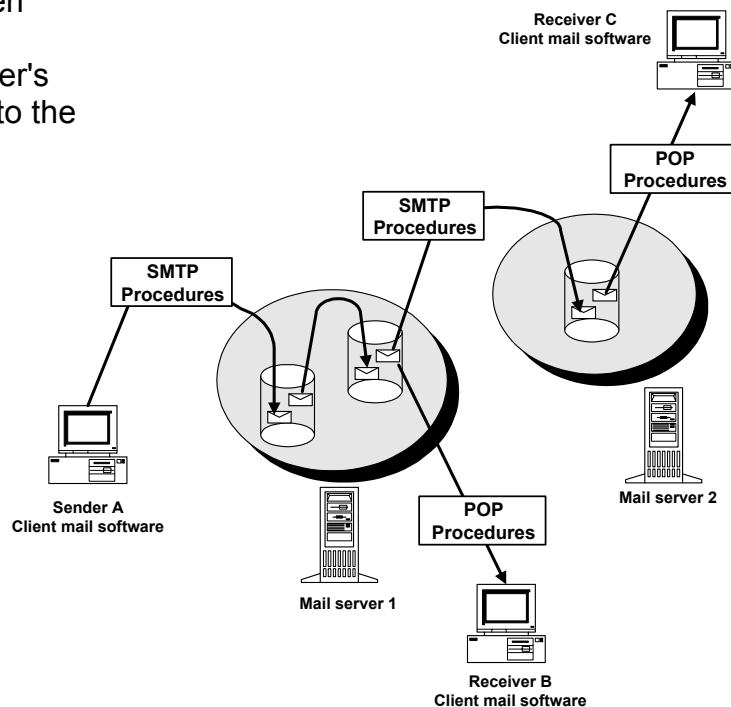
Overview

SMTP (Simple Mail Transfer Protocol) is used as the protocol for communication between Internet mail MTAs. It is defined in RFC821, which covers 8-bit data communications and message size negotiation, etc. SMTP is expanded upon in RFC1651 and RFC1653 as ESMTP.

SMTP uses text-based commands and responses between the client and server. In practice, it is a protocol used under TCP/IP, and data is therefore sent and received under TCP. Retry processing with communications errors is therefore handled at the TCP/IP level, and SMTP therefore needs only to handle sending and receiving of data, and command errors.

SMTP Commands

SMTP commands are sent, and responses received, between the client and server when sending Internet mail. This communication involves sending of the domain name, sender's name, destination name, and main text etc to the server, and user verification.



POP

Overview

E-mail on the Internet was originally transferred between hosts using SMTP, with the computer receiving the mail being operated all day long under the control of SMTP.

In practice, the use of dial-up IP connections to connect to the mail server via telephone lines, and the fact that the power supply may be switched off when the user returns home in the case of PC clients, means that mail cannot be transferred until the user connects to the server.

POP (Post Office Protocol) servers are used in such cases, i.e., when the connection is not permanently established.

Pop Server Configuration

The POP server is a computer which receives user mail using SMTP. The mail for the user includes a setting to ensure that it is directed to the POP server.

Following connection to the Internet, the user receives e-mail directed to the server with POP procedures.

As with SMTP, POP is text-based, and as such sends command lines and receives responses, as well as sending instructions for user identification by clients, transmission of passwords, acquisition of mail, and deletion of mail on the server.

MIME

Overview

Audio messages and image files cannot be sent without further processing, if mail is restricted solely to characters.

MIME (Multipurpose Internet Mail Extensions) is a specification for the inclusion of various types of data in e-mail, and currently supported by almost all e-mail software for attachment of files.

MIME is defined in RFCs 2045 - 2049.

Mime Functions

MIME supports the following functions.

- Inclusion of multiple objects in e-mail. other than text, each able to be handled at the receiving end.
- Binary encoding.
- Insertion of non-ASCII code characters (eg names in Japanese) in the header.

As MIME is a set of conventions which dictate how the main text of the message is to be handled, it employs a character string, referred to as the MIME header, to specify the content and method of encoding used, and to identify whether or not MIME is used in the mail.

Mime Header

Messages using MIME contain a header field as follows.

MIME-Version: 1.0

The use or not of this field determines whether or not the main text of the message follows the MIME conventions. Currently, only Version 1.0 of MIME exists.

MIME Header

Header	Meaning	Format
MIME-Version	Indicates that the message uses MIME	MIME-Version: 1.0
Content-Type	Message data type	Content-Type: Type/Subtype [;parameter]
Content-Transfer-Encoding	Encoding method used when sending data	Content-Transfer-Encoding: Encodingtype
Content-ID	A unique data ID. Uses the message ID.	Content-ID: Message ID
Content-Description	Data description	Content-Description: "This is MIME Data"
Content-	MIME header for future expansion	—

[Content-Type] is added to the header to indicate that a message is in MIME format. The [Content-Transfer-Encoding] header is also added as necessary to indicate how the data has been encoded. As some types of data do not require encoding, the [Content-Transfer-Encoding] header is not always required.

The [Content-Description] header is used when including comments. The content of this header is interpreted as comments referring to the content of the message, and has no effect on operation of the software.

Data Types Supported with Mime

The following data types may be specified in the [Content-Type] header.

- Text: Information consisting of characters. The ISO-2022-JP character code set is used in Japan, while US-ASCII is used for ASCII codes.
- Image: Still images such as GIF and JPEG data.
- Audio: Audio information.
- Video: Digital animation such as animation and MPEG.
- Application: Various application files and standard data formats.
- Multipart: Main text which includes multiple objects. A MIME header is also added within the message to record other messages. Use of this data type allows sound, animation, and messages to be included in the same e-mail message.
- Message: Text message information.

Multipart

Multipart is a data type which allows inclusion of multiple data items (objects). It allows for the inclusion of text and attached files in messages, and is the most commonly used type.

Multipart indicates the inclusion of multiple parts (data) in the main text, while the Contents-Type header indicates how the individual parts are handled.

Multipart supports the following sub-types to indicate the relationship between the individual parts.

- **Mixed:** The message consists of multiple independent parts.
 - **Alternative:** The message consists of multiple parts of the same content, but in different format.
 - **Parallel:** The message consists of multiple parts which are reproduced and displayed simultaneously.
 - **Digest:** A collection of RFC822-format messages in digest format.

Example: Received Multipart Mail Header

Received: from f64g.shinyoko.ricoh.co.jp ([133.139.167.30]) by bb.shinyoko.ricoh.co.jp (4.1/2.8Wb-91Jan07)

id AA15193; Sun, 15 Feb 98 14:53:50 JST

Return-Path: <f64g@shinyoko.ricoh.co.jp>

Message-Id: <9802150553.AA15193@bb.shinyoko.ricoh.co.jp>

Date: 15 Feb 1998 14:54:06 +0900

X-Mailer: ICFAX Version 1.0

Mime-Version: 1.0

Content-Type: multipart/mixed; boundary = "--ICFAX_60670AE6CB--"

To: taro@shinyoko.ricoh.co.

From: f64g@shinyoko.ricoh.co.jp

Mail header

Subject: Fax Message NO.0003 from "+81454771786"

("RICOH SERVICE")

text message here

---ICFAX_60670AE6CB--

Content-Type: image/tiff; name = "FAX.TIF"

Content-Transfer-Encoding: base64

Part header

Content-Discription: "FAX.TIF"

SUkqAAgAAAAARAP4ABAABAAAAAgAAAAABBAABAAAAAwAYAAAEBBAABAAAAAggQAAAIbAwABAAAAA
QAAAAMBawABAAAAAwAAAAyBAwABAAAAAaAoBAwABAAAAAgAAABEBBAABAAAA6gAAABUBA
wABAAAAQAAABYBBAABAAAAggQAABcBBAABAAAA7FwAABoBBQABAAAA2gAAABsBBQABAAAA4gA
AACQBBAABAAAAABAAAAcGBawABAAAAAgAAACkBAwACAAAAAABADEBAGAEAAAAICAgIAAAAAADIA
AAAAQAAAGQAAAABAAAAAICWUG1JAYCWUG1JAYA6XQIVNAqxa5L5Sa8AgEktODg4IWwuCCGOPMJQp
VUFgSUU0risFhyDBBMRXPRSM0czZRVlJhLoRid2yafCjODgCNYmUCHEpR8AgEmxOC7H5ThDwedZLzHXqpfk
9bOjWQGAslkBgLJZAYCyWQGAslkBgLJZAYCyWQGAslkBgLJZAYCyWQGAslkBgLJZAYCyWQGAslkBgLJZA
YCyWQGAslkBgLJZAYCyWQGAslkBgLJZAYCyWQGAslkBgLJZAYCyWQGAslkBgLJZAYCyWQGAslkBgLJZA
YCyWQGAslkBgLJZAYCyWQGAslkBAA==

----ICFAX_60670AE6CB----

A Multipart message contains multiple parts, with the strings which delineate these parts being specified with the boundary parameter.

Each part is delineated with

--boundary_string

and the final part is indicated with

--boundary_string--

Binary Data Encoding

The binary data must be encoded as character strings in order to insert a binary file into a text message. In Internet mail, non-ASCII data such as single-byte Katakana in Japanese is not sent correctly.

This encoding method is indicated in the [Content-Transfer-Encoding] field in the MIME header. The following encoding methods may be specified in the [Content-Transfer-Encoding] field.

- 7-bit: 7-bit code (8th not used)
- 8-bit: Full 8 bits used
- Binary: Binary data
- Base64: Encoding of binary data in base64 notation
- Quoted Printable: Encoding of character subject binary data

Of the above, only 7-bit, Quoted Printable, and Base64 are normally used with e-mail. Other encoding methods cannot be used unless they are supported over the network.

BASE 64

Base 64 is commonly supported in e-mail application software for the transmission of binary data.

This method of encoding takes each six bits of the original binary data and converts it to numbers between 0 and 63, each of these numbers being assigned to one of 64 characters (26 upper case characters of the alphabet, 26 lower case characters of the alphabet, the numbers 0~9, and the + and / symbols).

Now that we have covered e-mail basics, we can look at some of the features of an Internet fax in more detail. All examples are taken from the Internet fax option for *model H551*.

This following sections show how the fax machine communicates with other terminals using G3 and e-mail.

*Mail Protocol**SMTP Commands*

Command	Syntax	Responses
HELO (Hello)	HELO <domain>	S:250 <domain> E:500,501,421
	<p>This command is used to identify the sender-SMTP to the receiver-SMTP. The argument field contains the host name of the sender-SMTP.</p> <p>The receiver-SMTP identifies itself to the sender-SMTP in the connection greeting reply, and in the response to this command.</p> <p>This command and an OK reply to it confirm that both the sender-SMTP and the receiver-SMTP are in the initial state, that is, there is no transaction in progress and all state tables and buffers are cleared.</p>	
MAIL (Mail)	MAIL FROM:<reverse-path>	S:250 F:552, 451, 452
	<p>This command tells the SMTP-receiver that a new mail transaction is starting and to reset all its state tables and buffers, including any recipients or mail data. It gives the reverse-path which can be used to report errors. If accepted, the receiver-SMTP returns a 250 OK reply. The <reverse-path> can contain more than just a mailbox. The <reverse-path> is a reverse source routing list of hosts and source mailbox. The first host in the <reverse-path> should be the host sending this command.</p>	

Command	Syntax	Responses
RCPT (Recipient)	RCPT TO:<forward-path>	S:250, 251 F:550, 551, 552, 553, 450, 451, 452 E:500,501,503
	<p>This command gives a forward-path identifying one recipient. If accepted, the receiver-SMTP returns a 250 OK reply, and stores the forward-path. If the recipient is unknown the receiver-SMTP returns a 550 Failure reply. This second step of the procedure can be repeated any number of times.</p> <p>The <forward-path> can contain more than just a mailbox. The <forward-path> is a source routing list of hosts and the destination mailbox. The first host in the <forward-path> should be the host receiving this command.</p>	

Command	Syntax	Responses
DATA (Data)	DATA	<p>I:354 F:451, 554 E:500, 501, 503, 421 after transmitting data; S:250 F:552, 554, 451, 452</p> <p>If accepted, the receiver-SMTP returns a 354 Intermediate reply and considers all succeeding lines to be the message text. When the end of text is received and stored the SMTP-receiver sends a 250 OK reply.</p> <p>Since the mail data is sent on the transmission channel the end of the mail data must be indicated so that the command and reply dialog can be resumed. SMTP indicates the end of the mail data by sending a line containing only a period. A transparency procedure is used to prevent this from interfering with the user's text.</p> <p>NOTE: The mail data includes the memo header items such as Date, Subject, To, Cc, From [2].</p> <p>The end of mail data indicator also confirms the mail transaction and tells the receiver-SMTP to now process the stored recipients and mail data. If accepted, the receiver-SMTP returns a 250 OK reply. The DATA command should fail only if the mail transaction was incomplete (for example, no recipients), or if resources are not available.</p>

Command	Syntax	Responses
SEND (Send)	SEND FROM:<reverse-path>	S:250 F:552, 451, 452 E:500, 501, 502, 421
	The SEND command requires that the mail data be delivered to the user's terminal. If the user is not active (or not accepting terminal messages) on the host a 450 reply may returned to a RCPT command. The mail transaction is successful if the message is delivered the terminal.	
SOML (Send or mail)	SOML FROM:<reverse-path>	S:250 F:552, 451, 452 E:500, 501, 502, 421
	The Send Or Mail command requires that the mail data be delivered to the user's terminal if the user is active (and accepting terminal messages) on the host. If the user is not active (or not accepting terminal messages) then the mail data is entered into the user's mailbox. The mail transaction is successful if the message is delivered either to the terminal or the mailbox.	
SAML (Send and mail)	SAML FROM:<reverse-path>	S:250 F:552, 451, 452 E:500, 501, 502, 421
	The Send And Mail command requires that the mail data be delivered to the user's terminal if the user is active (and accepting terminal messages) on the host. In any case the mail data is entered into the user's mailbox. The mail transaction is successful if the message is delivered the mailbox.	

Command	Syntax	Responses
RSET (Reset)	RSET	S:250 E:500, 501, 504, 421
	This command specifies that the current mail transaction is to be aborted. Any stored sender, recipients, and mail data must be discarded, and all buffers and state tables cleared. The receiver must send an OK reply.	
VRFY (Verify)	VRFY <user name>	S:250, 251 <full name of user> F:550, 551, 533 E: 500, 501, 502, 504, 421
	This command asks the receiver to confirm that the argument identifies a user. If it is a user name, the full name of the user (if known) and the fully specified mailbox are returned. This command has no effect on any of the reverse-path buffer, the forward-path buffer, or the mail data buffer.	
EXPN (Expand)	EXPN <mailing list>	S:250 F:550 E: 500, 501, 502, 504, 421
	This command asks the receiver to confirm that the argument identifies a mailing list, and if so, to return the membership of that list. The full name of the users (if known) and the fully specified mailboxes are returned in a multiline reply. This command has no effect on any of the reverse-path buffer, the forward-path buffer, or the mail data buffer.	

Command	Syntax	Responses
HELP (Help)	HELP [command]	S:211, 214 E: 500, 501, 502, 504, 421
	This command causes the receiver to send helpful information to the sender of the HELP command. The command may take an argument (e.g., any command name) and return more specific information as a response. This command has no effect on any of the reverse-path buffer, the forward-path buffer, or the mail data buffer.	
NOOP (No operation)	NOOP	S:250 E:500, 421
	This command does not affect any parameters or previously entered commands. It specifies no action other than that the receiver send an OK reply. This command has no effect on any of the reverse-path buffer, the forward-path buffer, or the mail data buffer.	
QUIT (Quit)	QUIT	S:221 E:500
	This command specifies that the receiver must send an OK reply, and then close the transmission channel. The receiver should not close the transmission channel until it receives and replies to a QUIT command (even if there was an error). The sender should not close the transmission channel until it send a QUIT command and receives the reply (even if there was an error response to a previous command). If the connection is closed prematurely the receiver should act as if a RSET command had been received (canceling any pending transaction, but not undoing any previously completed transaction), the sender should act as if the command or transaction in progress had received a temporary error (4xx).	

Command	Syntax	Responses
TURN (Turn)	TURN	S:250 F:502 E:500, 503
	<p>This command specifies that the receiver must either (1) send an OK reply and then take on the role of the sender-SMTP, or (2) send a refusal reply and retain the role of the receiver-SMTP.</p> <p>If program-A is currently the sender-SMTP and it sends the TURN command and receives an OK reply (250) then program-A becomes the receiver-SMTP. Program-A is then in the initial state as if the transmission channel just opened, and it then sends the 220 service ready greeting.</p> <p>If program-B is currently the receiver-SMTP and it receives the TURN command and sends an OK reply (250) then program-B becomes the sender-SMTP. Program-B is then in the initial state as if the transmission channel just opened, and it then expects to receive the 220 service ready greeting.</p> <p>To refuse to change roles the receiver sends the 502 reply.</p>	

Remarks:

S: Successful

E: Error

F: Failure

I: Intermediate

SMTP Response Commands

Reply codes	Meaning
211	System status, or system help reply
214	Help message [Information on how to use the receiver or the meaning of a particular non-standard command; this reply is useful only to the human user]
220	<domain> Service ready
221	<domain> Service closing transmission channel
250	Requested mail action okay, completed
251	User not local; will forward to <forward-path>
354	Start mail input; end with <CRLF>.<CRLF>
421	<domain> Service not available, closing transmission channel [This may be a reply to any command if the service knows it must shut down]
450	Requested mail action not taken: mailbox unavailable [E.g., mailbox busy]
451	Requested action aborted: local error in processing
452	Requested action not taken: insufficient system storage
500	Syntax error, command unrecognized [This may include errors such as command line too long]
501	Syntax error in parameters or arguments
502	Command not implemented

Reply codes	Meaning
503	Bad sequence of commands
504	Command parameter not implemented
550	Requested action not taken: mailbox unavailable [E.g., mailbox not found, no access]
551	User not local; please try <forward-path>
552	Requested mail action aborted: exceeded storage allocation
553	Requested action not taken: mailbox name not allowed [E.g., mailbox syntax incorrect]
554	Transaction failed

POP Commands

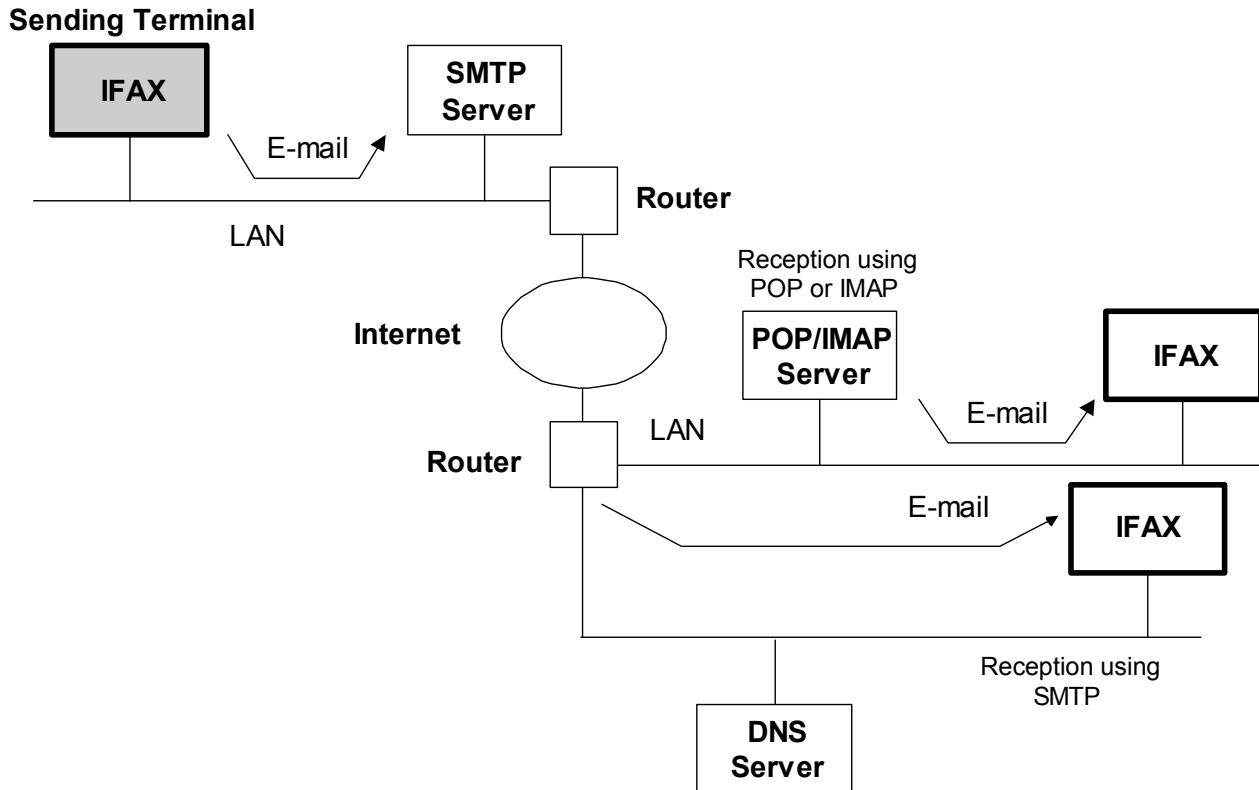
Command	Syntax	Responses
USER	USER <name>	+OK name is a valid mailbox -ERR never heard of mailbox name
	<p>To authenticate using the USER and PASS command combination, the client must first issue the USER command. If the POP3 server responds with a positive status indicator ("+OK"), then the client may issue either the PASS command to complete the authentication, or the QUIT command to terminate the POP3 session. If the POP3 server responds with a negative status indicator ("-ERR") to the USER command, then the client may either issue a new authentication command or may issue the QUIT command.</p> <p>The server may return a positive response even though no such mailbox exists. The server may return a negative response if mailbox exists, but does not permit plain text password authentication.</p>	
PASS	PASS <password>	+OK maildrop locked and ready -ERR invalid password -ERR unable to lock maildrop
	<p>When the client issues the PASS command, the POP3 server uses the argument pair from the USER and PASS commands to determine if the client should be given access to the appropriate maildrop.</p> <p>Since the PASS command has exactly one argument, a POP3 server may treat spaces in the argument as part of the password, instead of as argument separators.</p>	

Command	Syntax	Responses
QUIT	QUIT	+OK -ERR some deleted messages not removed
	<p>The POP3 server removes all messages marked as deleted from the maildrop and replies as to the status of this operation. If there is an error, such as a resource shortage, encountered while removing messages, the maildrop may result in having some or none of the messages marked as deleted be removed. In no case may the server remove any messages not marked as deleted.</p> <p>Whether the removal was successful or not, the server then releases any exclusive-access lock on the maildrop and closes the TCP connection.</p>	
STAT	STAT	+OK nn mm
	<p>The POP3 server issues a positive response with a line containing information for the maildrop. This line is called a "drop listing" for that maildrop.</p> <p>In order to simplify parsing, all POP3 servers are required to use a certain format for drop listings. The positive response consists of "+OK" followed by a single space, the number of messages in the maildrop, a single space, and the size of the maildrop in octets. This memo makes no requirement on what follows the maildrop size. Minimal implementations should just end that line of the response with a CRLF pair. More advanced implementations may include other information.</p> <p>Note that messages marked as deleted are not counted in either total.</p>	

Command	Syntax	Responses
LIST	LIST [message number]	+OK scan listing follows -ERR no such message
	<p>If an argument was given and the POP3 server issues a positive response with a line containing information for that message. This line is called a "scan listing" for that message. If no argument was given and the POP3 server issues a positive response, then the response given is multi-line. After the initial +OK, for each message in the maildrop, the POP3 server responds with a line containing information for that message. This line is also called a "scan listing" for that message. If there are no messages in the maildrop, then the POP3 server responds with no scan listings--it issues a positive response followed by a line containing a termination octet and a CRLF pair.</p> <p>Note that messages marked as deleted are not counted in either total.</p>	
RETR	RETR <message number>	+OK message follows -ERR no such message
	<p>If the POP3 server issues a positive response, then the response given is multi-line. After the initial +OK, the POP3 server sends the message corresponding to the given message-number, being careful to byte-stuff the termination character (as with all multi-line responses).</p>	
DELE	DELE <message number>	+OK message deleted -ERR no such message
	<p>The POP3 server marks the message as deleted. Any future reference to the message-number associated with the message in a POP3 command generates an error. The POP3 server does not actually delete the message until the POP3 session enters the UPDATE state.</p>	
NOOP	NOOP	+OK
	The POP3 server does nothing, it merely replies with a positive response.	

Command	Syntax	Responses
LAST	LAST	+OK nn
	The POP3 server issues a positive response with a line containing the highest message number which accessed. Zero is returned in case no message in the maildrop has been accessed during previous transactions. A client may thereafter infer that messages, if any, numbered greater than the response to the LAST command are messages not yet accessed by the client.	
RSET	RSET	+OK
	If any messages have been marked as deleted by the POP3 server, they are unmarked. The POP3 server then replies	
TOP	TOP <message number> <number of lines>	+OK top of message follows -ERR no such message
	If the POP3 server issues a positive response, then the response given is multi-line. After the initial +OK, the POP3 server sends the headers of the message, the blank line separating the headers from the body, and then the number of lines of the indicated message's body, being careful to byte-stuff the termination character (as with all multi-line responses). Note that if the number of lines requested by the POP3 client is greater than the number of lines in the body, then the POP3 server sends the entire message.	

Command	Syntax	Responses
APOP	APOP <name> <digest>	+OK maildrop locked and ready -ERR permission denied
	<p>Normally, each POP3 session starts with a USER/PASS exchange. This results in a server/user-id specific password being sent in the clear on the network. For intermittent use of POP3, this may not introduce a sizable risk. However, many POP3 client implementations connect to the POP3 server on a regular basis -- to check for new mail. Further the interval of session initiation may be on the order of five minutes. Hence, the risk of password capture is greatly enhanced.</p> <p>An alternate method of authentication is required which provides for both origin authentication and replay protection, but which does not involve sending a password in the clear over the network. The APOP command provides this functionality.</p>	

Mail Transmission

Procedure

Scanned documents are sent as electronic mail (e-mail).

All messages are sent using memory transmission. When a backup mail address (Bcc address, also known as Blind carbon copy) has been stored with the NIC Fax user settings, the machine also sends the message to all the Bcc address.

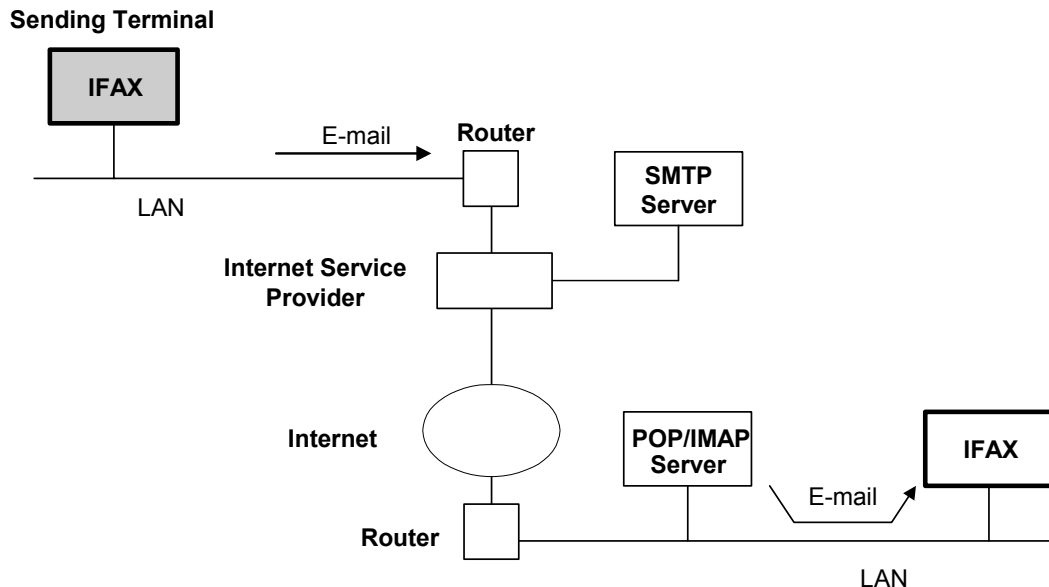
All e-mail transmissions are controlled using Simple Mail Transfer Protocol (SMTP) procedures. There must be an SMTP server on the same LAN as the sending machine, or the machine will not be able to send e-mail (it is not necessary to set up an SMTP account).

NOTE: 'IFAX' is the same as 'NIC FAX'. Some models use the name 'IFAX'. Others use the name 'NIC FAX'.

Mail Transmission using a PDU (PSTN Dial-up Unit)

As explained above, you cannot send e-mail using the NIC fax if you do not have an SMTP server on your LAN. A customer using the **H535 model** can send mail without an SMTP server if you install the optional PDU kit.

The PDU controls protocols for communication between the Internet Service Provider (ISP) and the fax machine. The PDU also converts scanned image data to MIME format for e-mail.



The fax machine sends the mail to the ISP, and the SMTP server at the ISP sends the mail over the internet to the destination.

During transmission, the FCU detects a dial tone and then dials the telephone number for the ISP. After connecting to the ISP, the NCU changes the data line relay from the FCU to the PDU. This connects the PDU to the PSTN line.

Data Formats

The scanned data is converted into a TIFF-F formatted file (only MH compression can be used). Some models also allow DCX; in these models, the file format depends on a user setting (for more on image file formats, see *Image Files*).

The fields of the e-mail and their contents depend on the model (see below).

Example: H551

Field	Content
From	Mail address of the sender
Reply-To	Mail address to be replied
To	Mail address of the destination
Bcc	Blind carbon copy address (backup mail address)
X-Mailer	ICFAX Version 1.0 (ICFAX is a Ricoh mail utility - IC means Image Communication)
Subject	Fax message no. xxxx (file number) from the TSI (see the notes below this table)

Field	Content
Content-Type	Multipart/mixed Attached files: image/tiff, application/octet-stream
Content-Transfer-Encoding	Base 64
Message Body	MIME-converted DCX or TIFF-F (MIME standards specify how files are attached to e-mail messages)

- NOTE:** 1) The message no. will exist in the subject field if no TSI or RTI is registered.
- 2) The label of the personal code and RTI will appear at the end of the subject field, if the personal code is entered.
- 3) The file number can be checked on the TCR/Journal.

Errors

An error report will be generated if an error occurs during the communication between the machine and the SMTP server. However, it is possible that the sender will not receive notice of errors that occurred between the SMTP server and the receiving terminal.

For what happens when an error occurs when the machine is receiving, refer to the Mail Reception section.

Secure Internet Transmission

To transmit e-mail via the Internet more securely, use SMTP authentication, and POP before SMTP for IFAX.

SMTP Authentication. SMTP Authentication requires user authentication before they can access the server. This prevents unauthorized access to the server. To use SMTP authentication, your server must support CRAM-MD5, PLAIN, or LOGIN. The account name and password specified in the “Mail Server” settings are used for SMTP authentication. Other account names and passwords cannot be specified.

POP Before SMTP. Prevents unauthorized access to the SMTP server and requires users to access and log onto the POP3 server before sending e-mail.

Mail Reception – Overview

Internet fax machines support three types of e-mail reception:

- POP3 (Post Office Protocol Version 3.)
- IMAP4 (Internet Messaging Access Protocol Version 4)
- SMTP (Simple Mail Transfer Protocol).

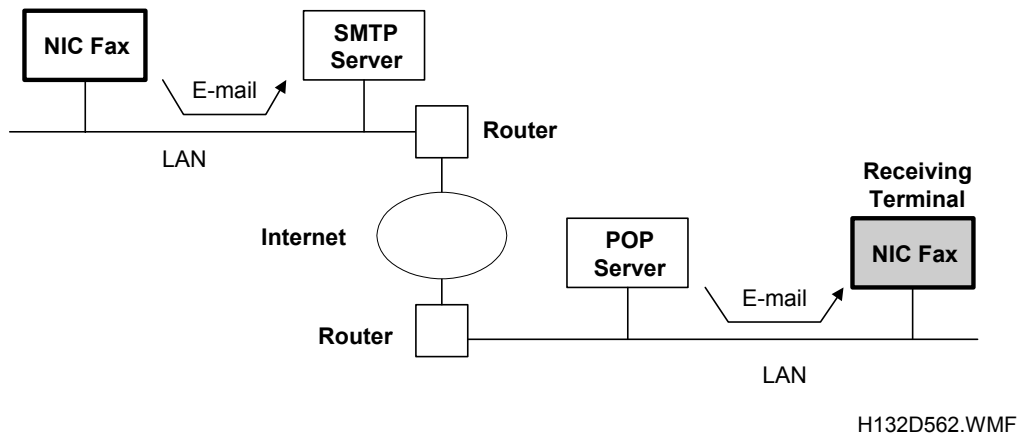
POP3 picks up the mail from a POP3 server and deletes it from the server. The machine can be adjusted to keep the mail on the server. IMAP4 also picks up the mail from a server, but does not delete the mail from the server.

- Concerning the deletion of mail after reception, the server's settings may take priority over the machine's settings.

With SMTP, a mail server is not needed. However, the network administrator must register the NIC fax machine as an SMTP server in the MX record of the DNS server. Then the NIC fax will receive the mail automatically without the machine having to pick it up from a server.

The machine can be adjusted to select one of these types of reception. However, if SMTP is selected and the machine is not registered in the MX record of the DNS server, then either IMAP4 or POP3 will be used.

Some older models only support reception using POP3.

Mail Reception – POP3*Procedure*

In order for the fax machine to receive e-mail, 1) there must be a POP3 server on the same LAN as the NIC Fax, and 2) an account must be set up for the fax machine.

There are two ways to receive mail from the server: automatic, and manual.

Automatic E-Mail Reception

The machine calls the POP server at a regular interval to check if any e-mail has come in. The interval is adjustable. The default setting is normally 3 minutes.

Manual E-mail Reception

The manual e-mail reception function can be stored in a Quick Operation Key. When the key is pressed, the machine calls the POP3 server immediately.

The timer for automatic e-mail reception is not reset when the machine calls the POP3 server manually.

Here is an example of the sequence

- Automatic e-mail reception interval: 30 minutes.
- The machine calls the POP3 server (automatic e-mail reception)
- 10 minutes later, the user calls the POP3 server (manual e-mail reception)
- The machine will call the POP3 server again automatically after 20 minutes.

Reception Process

When new e-mail is detected, the server receives the mail.

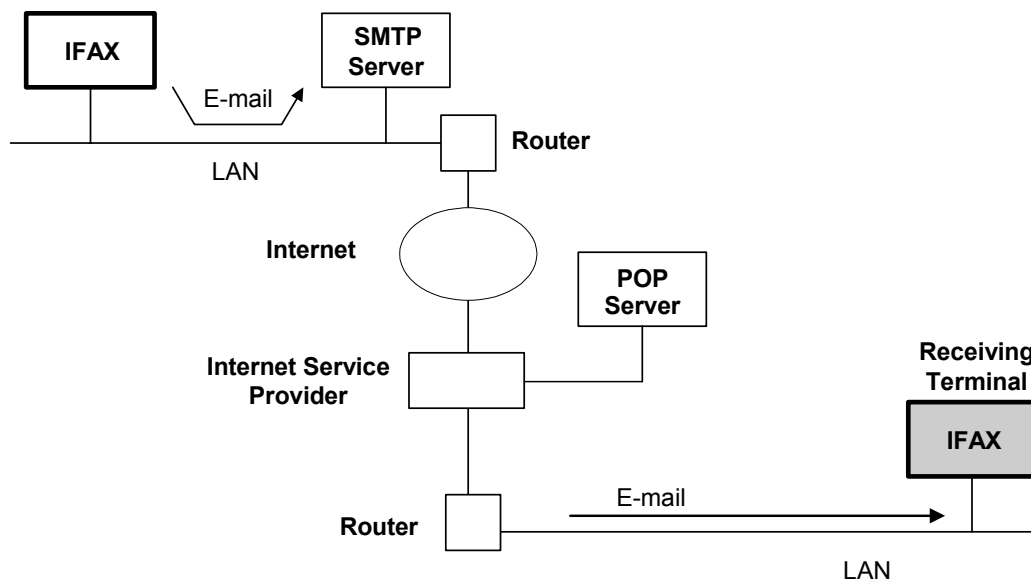
If the POP server is holding several e-mails for the NIC fax, the machine picks up the e-mails one at a time, in the order of arrival at the server. Mail is not picked up if memory is low. The machine will wait until sufficient memory is free.

E-mail reception is done in accordance with Post Office Protocol version 3.0 (POP3) procedures.

Mail Reception using a PDU (PSTN Dial-up Unit)

As explained above, you cannot receive e-mail using the NIC fax if you do not have a POP server on your LAN. A customer using the **H535 model** can receive mail without a server if you install the optional PDU kit

The PDU controls protocols for communication between the Internet Service Provider (ISP) and the fax machine. The PDU also converts scanned image data to MIME format for e-mail.



For more about the PDU kit, please refer to [Mail Transmission using a PDU](#).

Characteristics of POP3/IMAP4 Reception

Here are some general characteristics of POP3 receiving. They also apply to reception using IMAP4.

No MX record registration. There is no need to register the machine in the MX record of the DNS server.

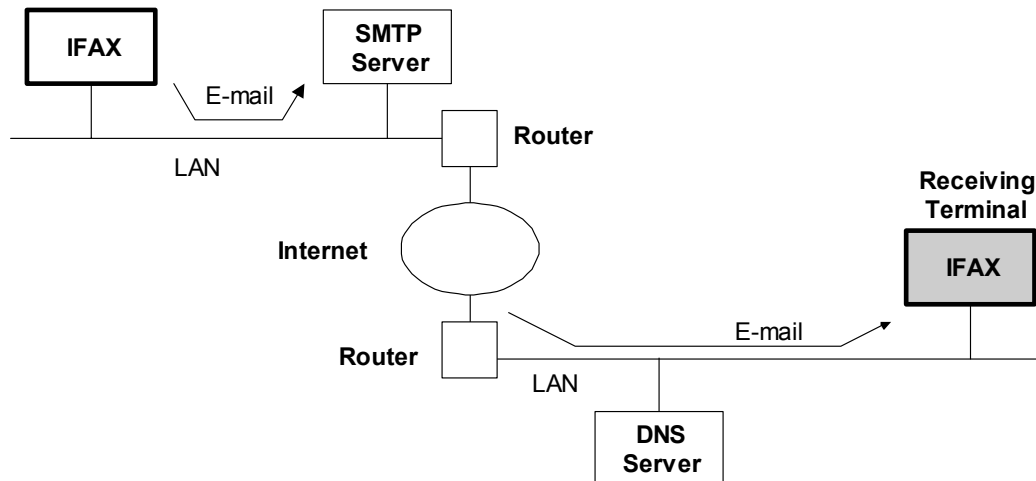
Power can be switched off. As long as the machine is not receiving mail, mail stored in the mail server is not lost when the power is switched off. With SMTP reception, if the machine is switched off, the SMTP server sends an error report back to the sender, and the machine will not receive the mail unless the sender sends it again after the machine is switched on.

Dial-up compliance. POP3 can be accessed spontaneously, making it ideal for dial-up operation.

Mail Reception – IMAP4

The descriptions in the previous section (Mail Reception - POP3) also apply for reception using IMAP4, except for the following.

- E-mail reception is done in accordance with IMAP4 procedures.
- There must be an IMAP4 server on the same LAN as the fax machine.
- IMAP4 does not automatically delete the mail from the server after picking it up.

Mail Reception – SMTP*SMTP Mail Reception Procedure*

By registering the IFAX as an SMTP server in the MX record of the DNS server, you can enable direct receiving of mail from the SMTP server. The fax machine does not call the server to pick up the mail (as is done in the POP/IMAP protocol using either automatic or manual e-mail reception).

Also, with SMTP, the received mail can be routed to another fax (this is known as 'delivery').

NOTE: 'IFAX' is the same as 'NIC FAX'. Some models use the name 'IFAX'. Others use 'NIC FAX'.

Required Settings

- The IFAX must be registered as an SMTP server in the MX record of the DNS server, and the address of the received mail must specify the IFAX.
- SMTP reception must be enabled on the fax machine (normally a user tool).
However, if SMTP reception is selected and the machine is not registered in the MX record of the DNS server, then either IMAP4 or POP3 is used, depending on the setting:

SMTP Reception Characteristics

- **Delivery of received mail.** The 'Off Ramp Gateway' feature allows expansion for RX mail delivery to a G3 fax. The machine transfers incoming mail is sent to the G3 fax specified by the local part. For example, in a destination address specified as:

`fax=0454778907@c101.dom1.ricoh.co.jp`

the 'local part' is **0454778907**.

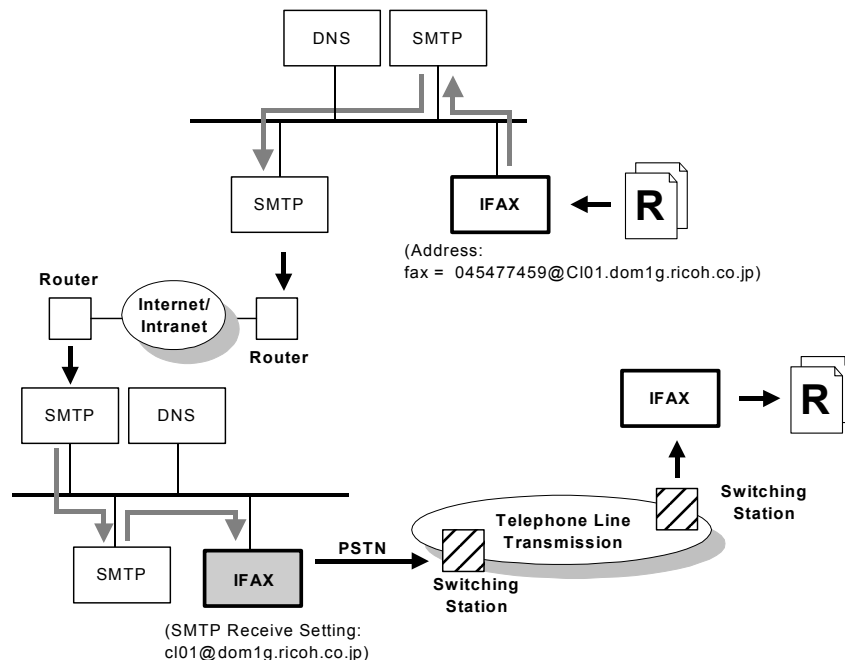
- **A POP3/IMAP4 server is not required.** For example, in an environment where there is only a UNIX server or in an intranet environment where Notes is used for mail, mail received from outside is handled via the SMTP gateway.
- **Immediacy of response is slightly better.** There is no interval in the acquisition of mail as with POP3/IMAP4, thus slightly improving the response time.
- **Easier error handling.** When an error occurs with POP3/IMAP4, the receiving terminal sends an error mail back to the sender in order to inform them that an error has occurred. With SMTP mail reception, however, in almost all cases the SMTP server sends the error mail to the sender.
- **Disadvantage:** If the machine's power is switched off when mail comes in, the SMTP server receiving the mail will send an error report back to the sender and delete the mail. It will not keep it for the machine to pick up next time it switches on. The sender has to resend the mail.

The user may be able to check a log on the SMTP server to see if any mail came in and was sent back during the night. Nothing can be done on the NIC fax machine.

With POP3 and IMAP4, the user can switch the machine off and the server keeps the mail.

*Delivery: Transferring Mail Received With SMTP (Off Ramp Gateway)**Overview*

If the address of the mail received with SMTP contains the following information, it can be delivered to another G3 fax: **Fax = " Delivery Number"@IFAX Host Name.Domain"**



How to Set Up Mail Delivery

The sender must set the mail address in the following format:

1) When dialing using a fax number

fax=<Delivery Destination Fax Number>@<IFAX Host Name>.<Domain Name>

Example:

fax=0454771459@cl01.dom1g.ricoh.co.jp → Delivers to fax number 0454771459

2) When dialing using a Quick dial destination

fax=<# Quick Dial Number>@<IFAX Host Name>.<Domain Name>

Example:

fax=#001@cl01.dom1g.ricoh.co.jp → Delivers to the number registered for Quick Dial key 001.

3) When dialing using a Group destination

fax=<#Group Dial Number>@<IFAX Host Name>.<Domain Name>**

Example:

fax=#**05@cl01.dom1g.ricoh.co.jp → Delivers to numbers registered for Group dial key 05.

Mail Delivery Conditions

- 1) The machine must be set up for SMTP mail delivery:
- 2) If the user wishes to limit this feature so that the machine will only deliver mail from designated senders, the machine's "Auth. E-mail RX" feature must be selected
- 3) If SMTP reception has been disabled, and if there is mail designated for delivery, then the machine responds with an error.
- 4) The "fax=" setting does not distinguish between upper and lower case letters.
- 5) More than one destination cannot be specified in the mail address. A Group counts as 1 destination.
- 6) If the quick dial, speed dial, or group dial entry is incorrect, the mail transmission is lost, and the Internet fax machine issues an error to the SMTP server and outputs an error report.

Authorized E-mail Reception

Authorized e-mail reception prevents all except certain specified senders from using your NIC fax machine. To limit access to mail delivery, the addresses of senders must be limited using the Access Limit Entry.

1) Access Limit Entry

For example, to limit access to @ifax.ricoh.co.jp:

gts@ifax.ricoh.co.jp	Matches and is delivered.
gts@ifax.abcde.co.jp	Does not match and is not delivered.
ifax@ricoh.co.jp	Does not match and is not delivered.

2) Conditions

- If the Access Limit Entry address and the mail address of the incoming mail do not match, the incoming mail is discarded and not delivered, and the SMTP server responds with an error. However, in this case an error report is not output.
- If the Access Limit Entry address is not registered, and if the incoming mail specifies a delivery destination, then the mail is delivered unconditionally.

Other Points Concerning E-Mail Reception

Errors during reception

Errors during POP3/IMAP4 procedures

When an error of this type occurs, the machine stops receiving and the message stays in the server. An error report is output. After a prescribed interval, the machine calls the server and starts to receive, starting with the interrupted message. If there is an incomplete received message in memory, it will be erased.

Abnormal Files

When an error of this type occurs, the machine stops receiving and commands the server to erase the message. Then the machine prints an error report out and sends information about the error by e-mail to the sender's address (in the "From" or "Reply-to" field of the message). If there is an incompletely received message in the machine's memory, it will be erased.

The machine prints an error message when it fails to send a message after a certain number of attempts.

Abnormal files are as follows:

1. The e-mail has an unsupported MIME header.
Supported types of MIME header depend on the model.

Example: H551

Header	Supported Types
Content-Type	Multipart/mixed, text/plain, message/rfc822 Image/tiff, application/octet-stream
Charset	US-ASCII, ISO-2022-JP, Others are determined to be US-ASCII.
Content-Transfer-Encoding	Base 64, 7-bit, 8-bit

2. MIME decoding error
3. The machine cannot recognize the file format as TIFF-F (some older models also accept DCX).
4. The resolution, document size, or compressed type cannot be accepted.

Remaining SAF Capacity Error

The machine **CALLS** the server but does not receive e-mail if the remaining SAF capacity is less than a certain value (the value depends on a bit switch setting). The e-mail will be received when the SAF capacity increases (for example, after substitute reception files have been printed).

Also, if the capacity of the SAF memory goes down to zero during reception, the machine acts in the same way as when receiving an abnormal file (refer to 'Abnormal files').

Paper Size

1. If the incoming message is wider than the maximum paper width specification for the machine, an error is generated. The procedure is the same as when receiving an abnormal file.
2. When the machine receives a message that is wider than the paper currently in the paper trays (but within machine specs for image width), the machine reduces the data to fit on the paper in the tray and prints it.

Printing

When a line of text is longer than the paper width, the excess data will be deleted.

Multi-part

When a multi-part e-mail message contains several text parts and binary files, the message will be divided with boundaries. Then, each part will be printed separately. If the machine cannot determine where the boundary is, it will generate an error report and print, then send error information e-mail back to the sender.

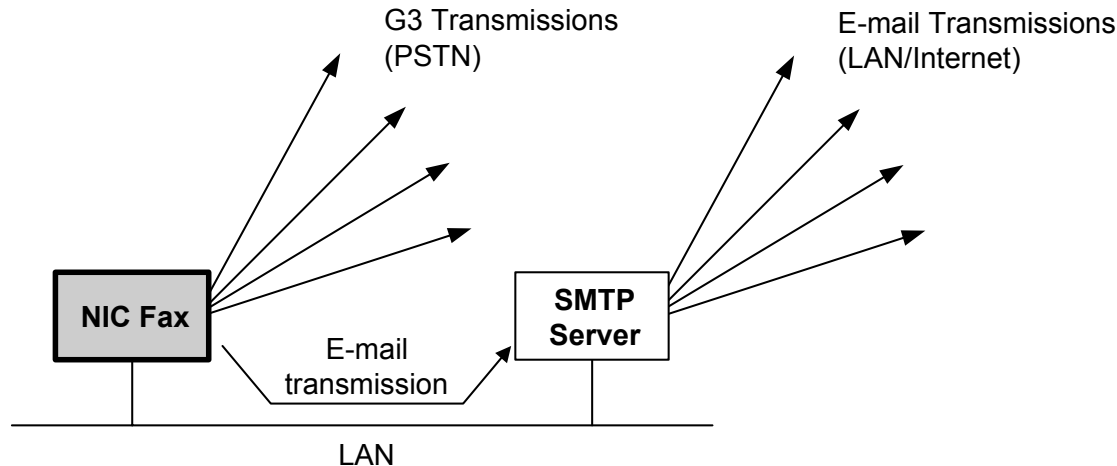
Secure Internet Reception

APOP. Passwords are encrypted when e-mail is received, making it safer than POP3 authentication (clear text), which is not encrypted. APOP requires a POP server that supports APOP.

IMAP-AUTH (Mail Reception). If the IMAP Server supports the AUTHENTICATE command (CRAM-MD5, PLAIN, or LOGIN confirmation), then higher-level security confirmation can be implemented for users logging in.

These features can be enabled with user tools.

Security is needed for reception using POP/IMAP, because the mail is stored in the POP/IMAP server and the machine must call and pick it up. Security ensures that the mail goes to the correct machine. For reception using SMTP, the mail goes directly to the destination address (it is not held on a server), so this type of security is not needed.

Mail Broadcasting (e-Mail and G3 FAX are combined)

The machine can send the same message to several destinations in one operation. Some destinations can be G3 fax and some can be e-mail. For the G3 fax transmissions, each address has to be dialled separately. However, all the e-mail addresses can be sent with the message to the SMTP server in one transmission. The SMTP server then sends the message to each destination.

The following example for broadcasting to three e-mail destinations and two G3 fax destinations shows how G3 fax messages are each sent individually, but the e-mail destinations are all sent to the server at the same time.

- Order of inputting the addresses at the operation panel
G3 fax (1) - mail (1) - G3 fax (2) - mail (2) - mail (3)
- Order of transmission
G3 fax (1) - mail (1), (2), (3) [these 3 sent to the server at the same time] - G3 fax (2)

The SMTP server cannot broadcast the message if a feature included individual information for each terminal in the transmitted data (such as label insertion). If this type of feature was used, the machine sends the e-mails to the server one by one.

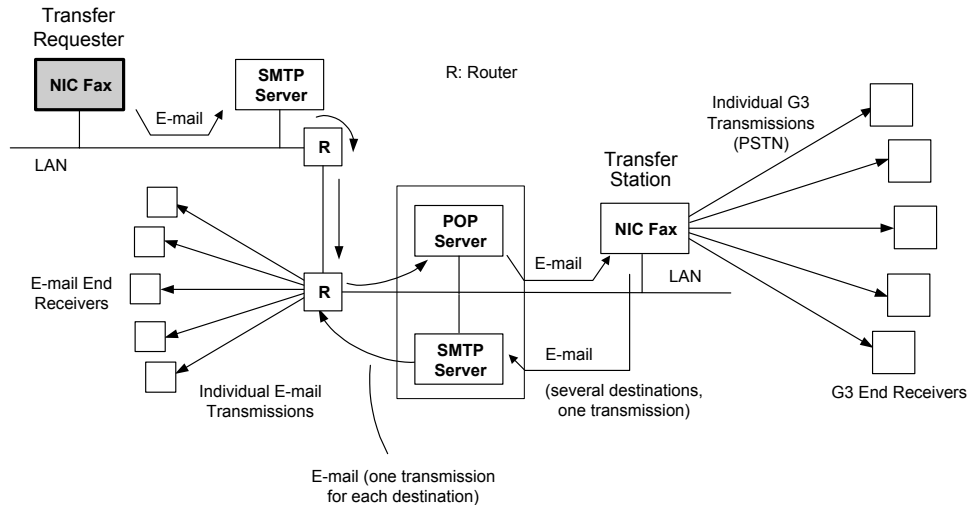
To send the messages to the server at the same time, the batch transmission feature must be enabled in the Internet fax machine.

The maximum number of e-mail destinations in a broadcast depends on the mail server's limits.

Transfer Request

Operation at the Transfer Requester

Making a Transfer Request by E-Mail



The requesting terminal dials the transfer station, and requests it to transfer the message to end receivers stored as quick dials, speed dials, and group dials in the transfer station. A quick dial number is indicated by a “#” and two or more digits, a speed dial is indicated by “#”, “*”, and two or more digits, and a group dial is indicated by “#” and “***” and two or more digits. This is the same as for transfer request in a normal fax machine.

The destinations can be a mixture of e-mail and G3 fax addresses. However, only an Internet fax can be specified as a transfer station if the end receivers include e-mail addresses.

The transfer request goes to the SMTP server as an e-mail message. The quick/speed/group dials (and the ID code) are included in the mail body field of the e-mail as text. The message arrives at the POP server of the transfer station.

The transfer station then does the following (see Operation at the Transfer Station for details).

- The transfer station picks up the transfer request.
- The transfer station sends the message to the G3 destinations one-by-one.
- The transfer station sends the message to its SMTP server once. The SMTP server sends the message to the e-mail destinations one-by-one.

The transfer station sends back a transfer result report. The original may be attached to the transfer result report, depending on the G3 settings of the fax machine. For transmissions to e-mail end receivers, the transfer result report only indicates whether the message was successfully transmitted from the transfer station to its SMTP server.

The transfer station sends an error report to the requester if it fails to transfer the message to an end receiver. However, if the selected transfer station cannot handle transfer requests, or cannot handle e-mail, no error report is returned to the transfer requester.

The fields of the e-mail and their contents depend on the model.

Example: H551

Field	Content
From	E-mail address of the requesting terminal
To	Destination address (transfer station's address)
Bcc	Blind carbon copy address (backup mail address)
X-Mailer	ICFAX version 1.0
Subject	Fax Message No. xxxx (file number) from the TSI
Content-Type	Multipart/mixed Text/Plain (for a text part), image/tiff or application/octet-stream (for attached files)
Content-Transfer-Encoding	Base 64
Mail body (text part)	RELAY-ID-: xxxx (xxxx: 4 digits for an ID code) RELAY: #01#*01#**01....
Message body	MIME-converted TIFF-F or DCX

Making a Transfer Request by G3 FAX

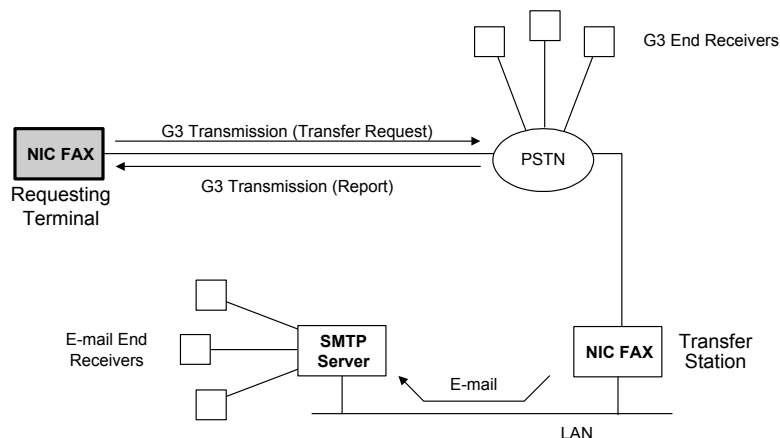
The procedures are the same as for a normal G3 fax machine. The requesting NIC fax contacts the transfer station by G3 over the PSTN.

The requesting terminal dials the transfer station, and requests it to transfer the message to end receivers stored as quick dials, speed dials, and group dials in the transfer station.

Using NSF, the machine sends an ID code and the machine's own telephone number. Up to 30 end receivers can be requested.

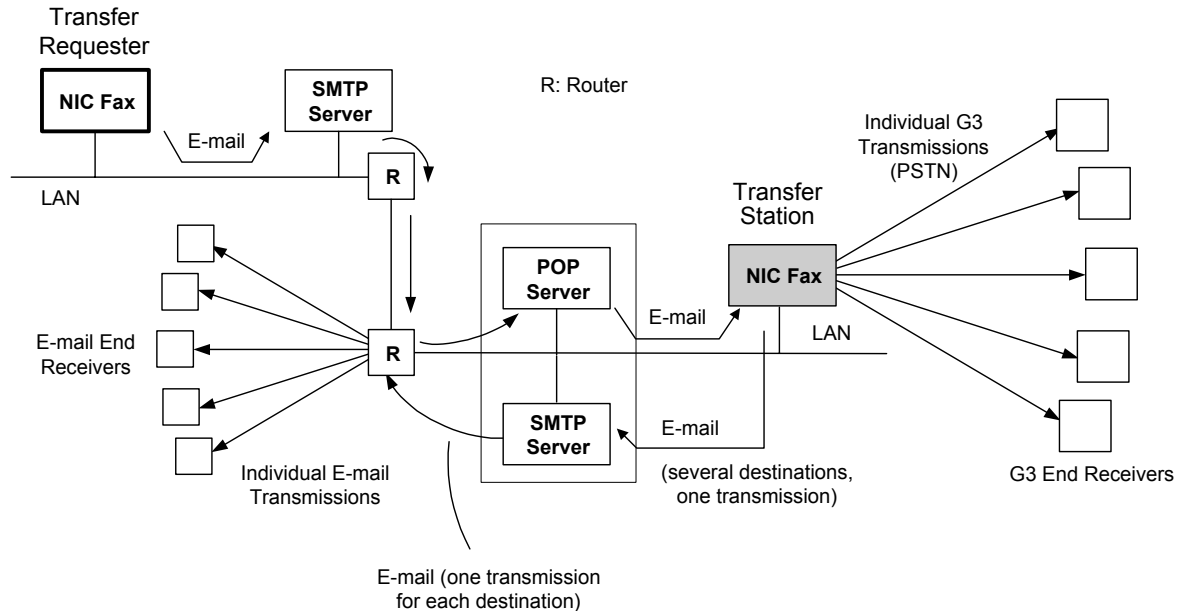
End receiver destinations can also be selected using tonal signals, in the same way as for other recent fax models. E-mail address can also be selected in this way, as end receivers and as the destination for receiving the transfer result report.

The receiving NIC fax machine receives the transfer request on the PSTN connection. It then handles the transfer request in the same way as explained in "Making a Transfer Request by E-Mail".



Operation at the Transfer Station

Handling a Transfer Request Received by E-Mail



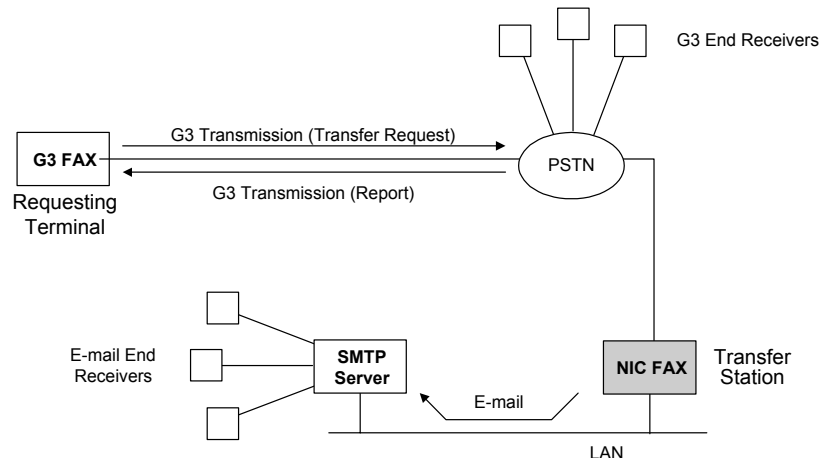
The NIC fax polls the POP server at regular intervals, as mentioned in a previous section. If the server has received a transfer request, the fax machine receives it from the server in the form of an e-mail message. The end receivers are included in the text part of the message. The machine then sends the message to the end receivers by G3 fax or e-mail, depending on the type of end receiver address, in the same way as described for Broadcasting.

The NIC fax sends each G3 fax as an individual transmission. However, for the e-mail, the NIC fax sends the message to the SMTP server once, and the server broadcasts the message to the e-mail end receivers one at a time.

The transfer station sends back a transfer result report to the address in the From field of the received e-mail. If an administrator's address is registered, the result report is also sent to that address. The original may be attached to the transfer result report, depending on the G3 settings of the fax machine.

For transmission to e-mail end receivers, the transfer result report only indicates whether the message was successfully transmitted from the transfer station to its SMTP server (the transfer station does not know if the messages were received successfully at the end receivers).

The transfer station prints an error report if it cannot send the result report to its SMTP server.

Handling a Transfer Request Received by Fax

When the machine receives a transfer request by G3 fax, it sends the message to the various e-mail and G3 end receivers in the same way as for a request received by e-mail.

The machine sends back the transfer result report to the requesting terminal's telephone number, which it specified in the NSF signal. If the machine cannot send this report back to the requesting terminal, it prints the report itself, so that the user can contact the other party.

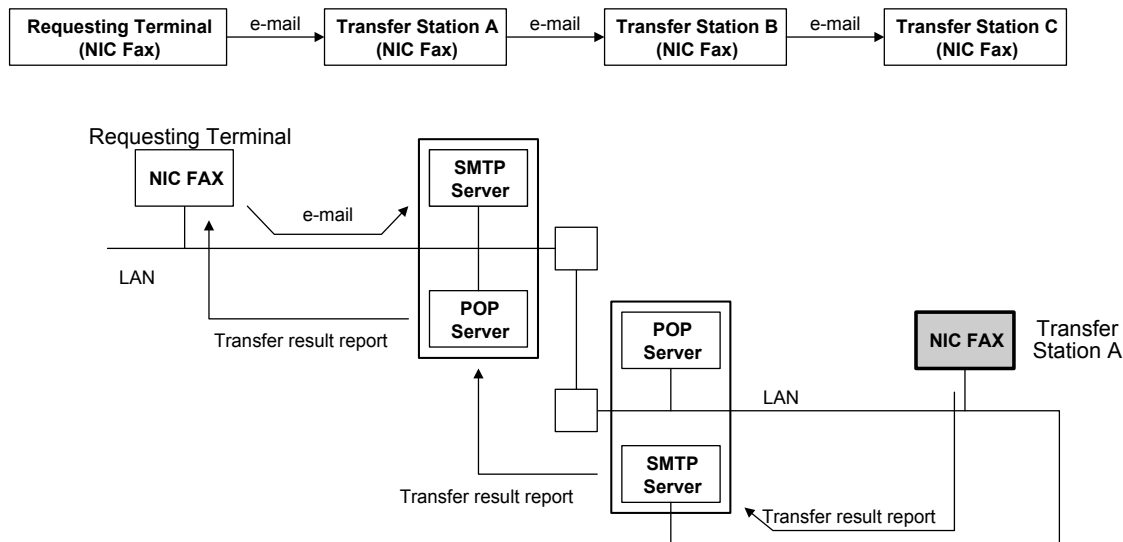
The NIC Fax can accept end receiver destinations and transfer result report destinations that were sent from the requester as DTMF tones. This applies for e-mail or PSTN G3 addresses.

Transfer Result Reports for Multi-step Transfer

If All Links Are By E Mail

After it has passed on the transfer request to the next transfer station, each transfer station sends a transfer result report back to the previous transfer station in the chain by e-mail. The main point is that the reports are only sent back one link in the chain. The requesting terminal has no idea what happened further along the chain.

The bottom part of the drawing shows details of the route from Transfer Station A back to the requesting machine.



The procedure is as follows.

1. The requesting terminal requests transfer station A to transfer a message.
2. Transfer station A passes the request on to transfer station B.
3. Transfer station A sends a transfer result report back to the requesting machine.
4. Transfer station B passes the request on to transfer station C.
5. Transfer station B sends a transfer result report back to transfer station A.

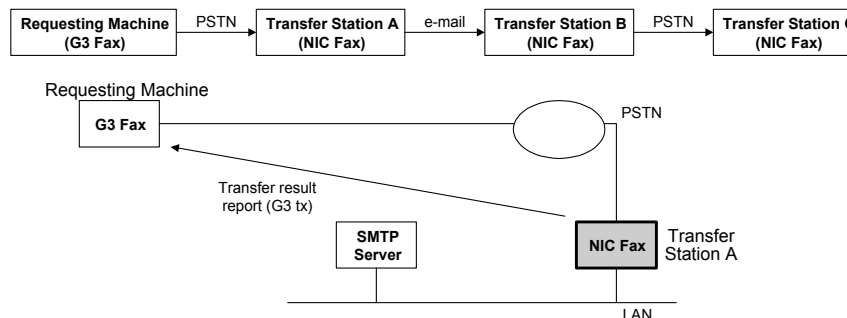
6. The broadcasting station (transfer station C) sends the message to its SMTP server (e-mails) and to the G3 destinations.
7. Transfer station C sends a transfer result report to transfer station B (for e-mail end receivers, it only indicates whether the message was successfully passed on to transfer station C's SMTP server).

NOTE: The requesting machine's own telephone number is not included in a transfer request message by e-mail, so the transfer station at the end of the chain cannot send a report back directly to the requesting machine. The requesting terminal only receives a report of how the communication went between transfer stations A and B.

If Some Links Are G3 Fax

This example shows that even if there is only one e-mail link in the chain, the transfer result report from the final transfer station cannot get back to the requesting terminal.

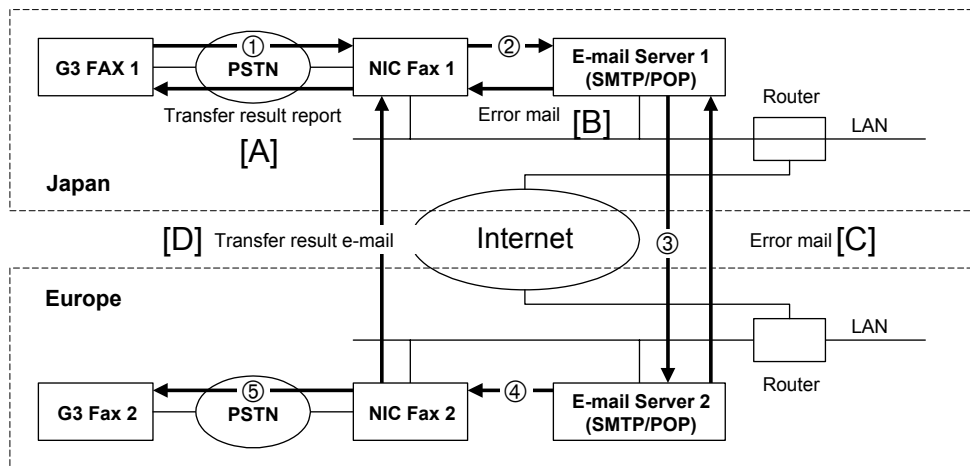
(The bottom part of the drawing shows details of the route from Transfer Station A back to the requesting machine.)



The procedure is exactly the same as for a request by e-mail, as described on the previous page.

However, if there are two or more consecutive PSTN links in the chain, the transfer station at the end of the PSTN chain will be able to send a transfer result report back to the machine at the start of the PSTN chain. For example, if only the link between transfer stations B and C is e-mail, transfer station B will be able to send a report all the way back to the requesting terminal.

If there is even one e-mail link, continuity is broken. The requesting terminal can only get a report from the final transfer station if all links are G3.

Example of a Transfer Request and Result Report

The steps of the transfer request are as follows:

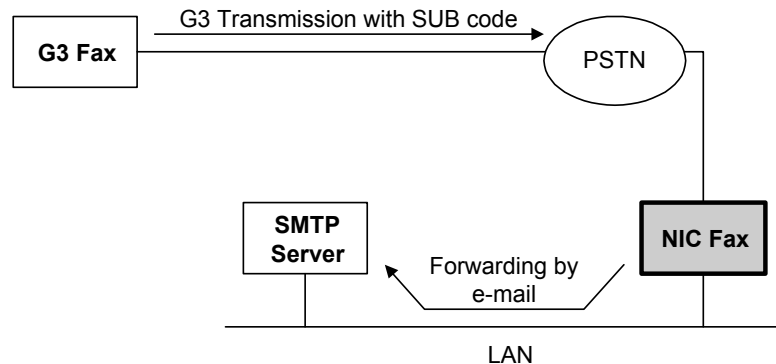
1. G3 Fax 1 sends a transfer request to NIC Fax 1 by G3 fax (① in the diagram).
2. NIC Fax 1 sends e-mail to E-mail Server 1 (② in the diagram).
3. E-mail Server 1 sends e-mail to E-mail server 2 (③ in the diagram).
4. E-mail server 2 sends e-mail to NIC Fax 2 (④ in the diagram).

NOTE: Steps 2 to 4 assume that NIC Fax 1 sends the transfer request to NIC Fax 2 by e-mail, and not G3 fax.

5. NIC Fax 2 sends a G3 fax message to G3 Fax 2 (⑤ in the diagram).

The steps for sending the transfer result report and any mail reporting errors is as follows:

1. NIC Fax 1 sends a transfer result report [A] to G3 Fax 1 after ① in the diagram.
2. When an error occurs at ③, e-mail server 1 sends e-mail reporting an error [B] to NIC Fax 1. Error mail is also sent to the administrator if the address has been registered in NIC Fax 1.
3. When an error occurs at ④, e-mail server 2 sends e-mail reporting an error [C] to NIC Fax 1. Error mail [C] is also sent to the administrator if the address has been registered in NIC Fax 1.
4. NIC Fax 2 send a transfer result report [D] to NIC Fax 1 through e-mail server 1 and e-mail server 2 after transferring the message to the end receivers (after ⑤ in the diagram).

Autorouting

The sending G3 fax machine appends a code to the telephone number. This code is sent in G3 protocol to the NIC Fax in the SUB code.

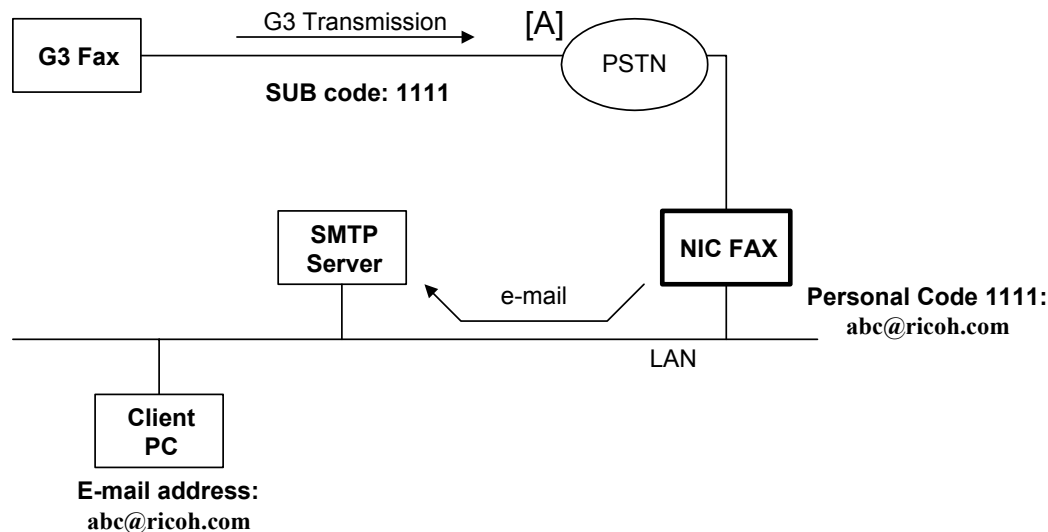
When a G3 fax message is received with a SUB code, the machine compares the SUB code with the personal codes stored with Personal Boxes and Transfer Boxes in the machine. If there is a match, the machine routes the message to the e-mail address in the Personal Box by e-mail. (If the SUB code corresponds to a Transfer Box, the machine routes the message to all the addresses in the Transfer Box).

A communication failure report will be printed if a transmission error occurs between the machine and the SMTP server.

Conditions

1. E-mail addresses for autorouting must be registered in the machine with personal codes in Personal Boxes and/or Transfer Boxes.
2. If the received SUB code specifies confidential reception, the message at the NIC fax can be received using confidential reception. However, when this message is forwarded by e-mail, the 'confidential' attribute is not passed on – you cannot specify confidential reception by e-mail.
3. The RTI or CSI of the forwarding machine is indicated in the subject field of the forwarded e-mail.
4. Autorouting only works for incoming G3 faxes. It does not work for incoming e-mails, because there are no SUB codes in the e-mail protocol.

- Example -



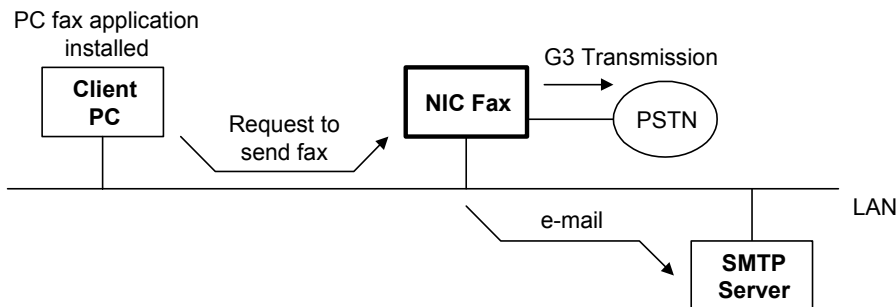
1. The sending terminal sends a fax message with a SUB code "1111" to the NIC Fax.
2. Personal code 1111 in the receiving NIC fax has been allocated to a PC on the network. The NIC fax makes an e-mail out of the incoming fax message, then sends the e-mail to that PC.

Forwarding

Forwarding is a similar feature to autorouting, useful when the sending machine cannot send SUB codes.

- The sending machine must have the RTI and CSI programmed.
- The receiving machine must have already specified a destination PC e-mail address for messages received with that RTI/CSI.
- The message can only be forwarded to one destination.

LAN Fax Transmission



This section shows how a PC on the same network can:

- Send a document created with a PC application, through the NIC fax, to another fax machine by G3 or by e-mail. The destination fax machine does not need a NIC fax card, because the message goes out over the PSTN.
- Print out a document created with a PC application, using the NIC fax as a printer. Normally, this is not so effective as installing a printer controller option. There are fewer features and resolution settings available with the LAN fax driver.

This feature is known as LAN Fax. The following items and settings are required to use this feature:

- A NIC Fax and a PC connected to a LAN.
- The initial settings set up correctly on the NIC FAX (such as the IP Address, Subnet Mask, and Default Gateway settings). Refer to the documentation for the model.
- Software installed on the PC (depends on the model)

Example: H231: SmartNet Monitor for Client, the LAN Fax driver, and an Address Book

IP-Fax

What is IP-Fax?

This feature allows you use TCP/IP to communicate with fax machines. The other party can be on the same TCP/IP network as your machine, or it can be on the internet anywhere in the world.

- It can also be on a public telephone network, if your intranet has a Gateway to interface with the public telephone network. Modem speed in this case is below V.17.
- If the other fax machine is connected directly to a TCP/IP network, it must use T.38 protocol.

IP-Fax uses a Group 3 style fax protocol, but in packets to conform to TCP/IP.

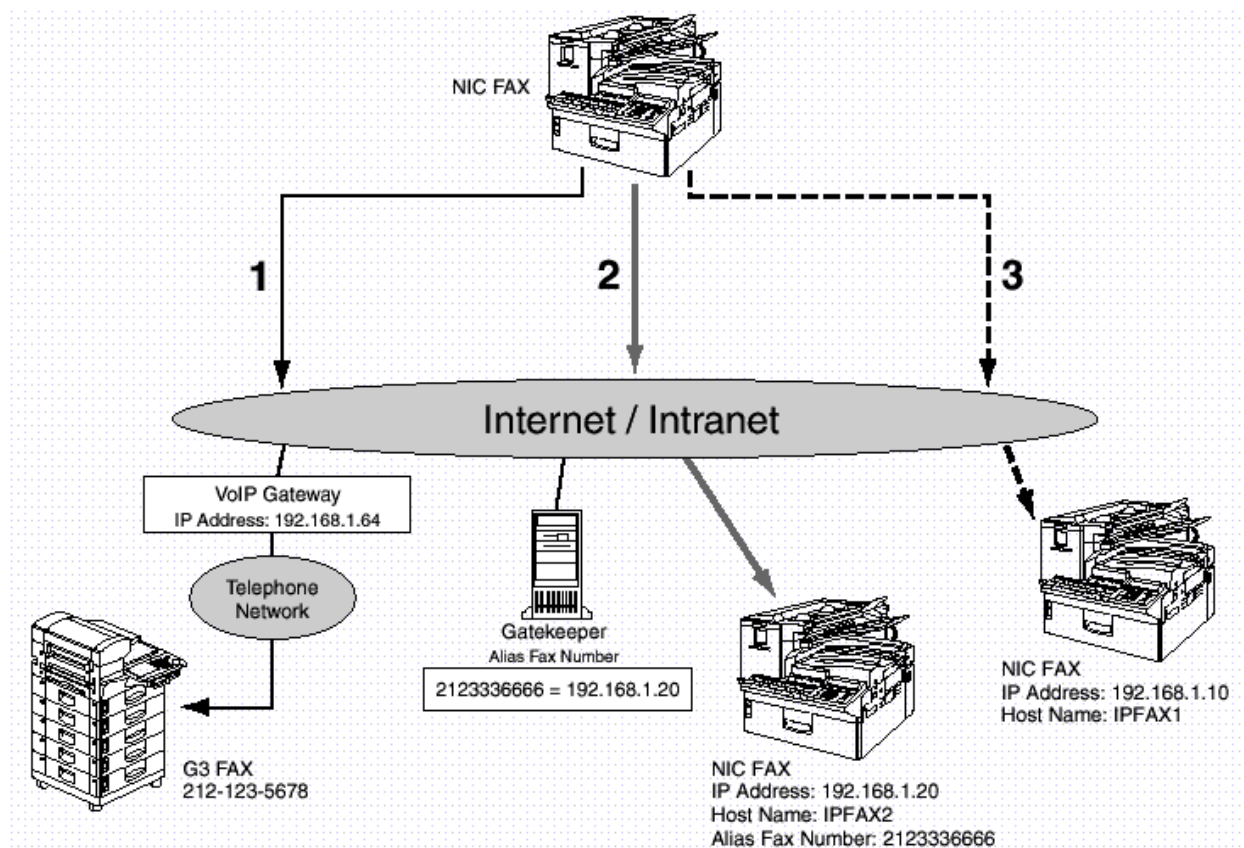
No e-mail server is required (compare with internet fax).

Use the IP address (or host name) to dial the destination machine, instead of the fax number.

- If there is a Gatekeeper on your intranet, you can use the 'alias number' stored in the gatekeeper. The gatekeeper stores a look up table of 'alias fax numbers' and actual IP addresses. IP-Fax is faster than PSTN.

Direct connection with the other party's machine is possible, so function capability information can be exchanged and transactions can be confirmed.

The diagram below shows the three methods of data transmission.



Note how cases ❶, ❷, and ❸ operate in the illustration above:

- Case ❶: The NIC Fax, connected to the Internet/Intranet via a VoIP gateway connected to telephone network, sends a transmission through the Gateway (address: 192.168.1.64) to the destination fax number (212 123 5678). (The Host Name can be substituted for the IP Address.)
- Case ❷: The NIC Fax, connected to the Internet/Intranet using a VoIP gatekeeper, sends a transmission to the destination with the alias fax number 212 333 6666 through VoIP gatekeeper 192.168.1.20.
- Case ❸: The NIC Fax, connected to the Internet/Intranet, sends a transmission to IP Address 192.168.1.10 or to Host Name IPFAX1 (192.168.1.10). The IP Address and Host Name must be previously registered on the DNS server.

Note the difference between the 'gateway' and the 'gatekeeper'.

A **gatekeeper** contains a list of IP addresses of destinations, and an 'alias number' for each one.

The alias numbers allow you to use telephone numbers instead of IP addresses when sending a message. This may be more convenient for many people.

When you specify one of these alias numbers as the destination, the gatekeeper wakes up and passes your fax to the destination over your LAN or the Internet.

To set up your machine for using a gatekeeper, do the following:

1. Store the gatekeeper's IP address in the NIC fax machine.
2. Store your 'own fax number'. This will be your NIC fax machine's alias number. It is convenient to use the machine's telephone number, but any number will do.

3. Make sure that your NIC fax machine's IP address is stored already in the NIC fax machine with the user tools.
4. Your machine will then automatically contact the gatekeeper, and your machine's IP address and alias number will be registered with the gatekeeper.
This works even if the gatekeeper is on a different LAN, or over the internet, as long as the gatekeeper's IP address is input correctly.

To set up an 'alias number' network of NIC fax machines on different LAN segments or internet locations, all machines will have to register with the gatekeeper using the above procedure. There only needs to be one gatekeeper in this network.

The gatekeeper system will not work if there are any firewalls in the network.

A VoIP **gateway** interfaces your LAN with the public telephone network. If you input the IP address of the gateway and the destination fax number, the gateway will handle things from there, converting the TCP/IP frames into T.30 fax protocol.

- VoIP: Voice over IP. This allows voice frequency tones to be send out over TCP/IP. Internet telephones use this technology. However, with the NIC fax, voice message transmission is not possible.

Features of IP-Fax

IP-Fax provides these features:

- Compliance with ITU-T T.38 Standards.
- Employs TCP/IP communication protocols.
- Allows destinations to be identified by the IP Address, Host Name, or an Alias Telephone Number.

The main advantages of IP-Fax are:

- Costs are reduced as the main method of communication is over the Internet.
- All transactions can be confirmed because the machine is connected directly to the other party.
- Extremely high speed because IP-Fax can operate over a 10/100Base LAN.

The disadvantages of IP-Fax are:

- Communication through firewalls is not possible.
- Communication via gateway is the only method of transmission.
- High visibility (poor security).

NOTE: The transmission speed of IP-Fax is affected by the condition of the network (distance of wiring, packet loss, etc.). IP-Fax operates in real time, so IP-Fax must occupy one line until the other party's machine breaks communication.

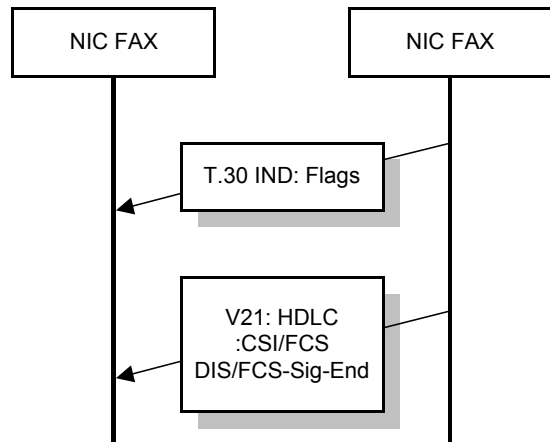
IP-Fax can use all G3 fax features except the following:

- Sending: Memory file transfer, batch transmission
- Receiving: Batch reception

T.38 Transmission Protocol

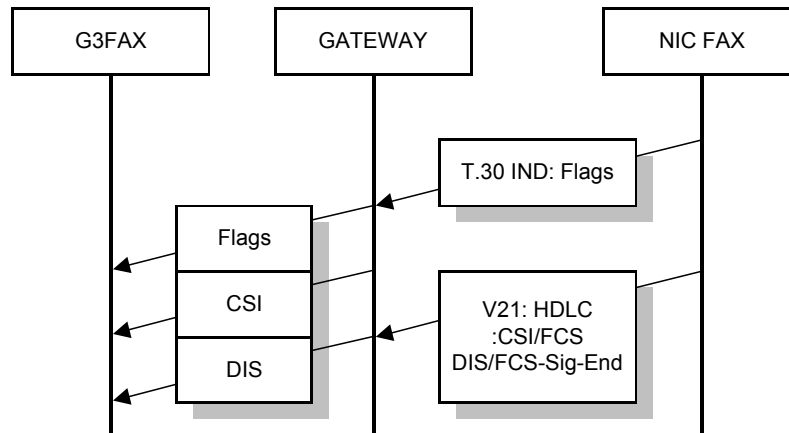
The T.38 transmission protocol handles data in packets in order to allow IP-Fax to transmit with a T.30 G3 fax protocol network.

(1) Transactions in an Intranet



H231D923.WMF

(2) Transactions Between PSTN and Intranet



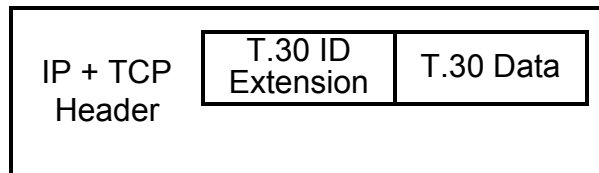
H231D924.WMF

Packet Format

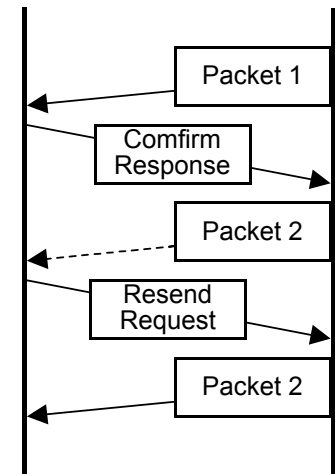
Fax communications are conducted with T.38 IFP (Internet Fax Protocol) packet exchange via the Internet. TCP or UDP (protocols that employ two different packet formats) can be selected for transmission. TCP is selected by default for NIC Fax; you can change this to UDP with a bit switch adjustment.

TCP Packet Format

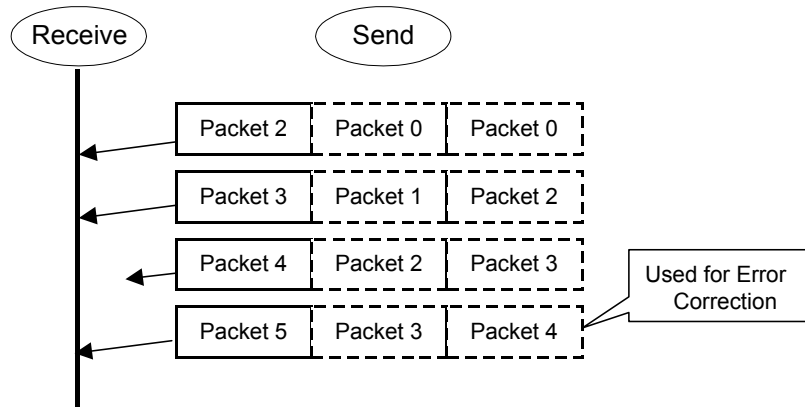
TCP requires more time because it requires a confirmation response. However, TCP is more reliable because it always demands an affirmative response and requests a retry in response to an error.



H231D926.WMF



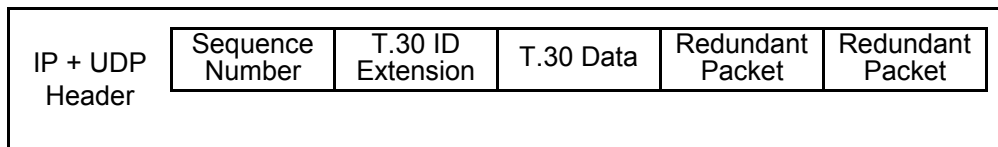
H231D925.WMF

UDP Packet Format

H231D927.WMF

UDP is output without establishing the session. The UDP protocol does not correct errors or attempt re-sending. While it is much faster, generally its reliability is lower. However, on the receiving side with IP-Fax the speed is forced lower to prevent data overflow, making UDP slower than TCP.

NOTE: As a general rule, UDP is faster than TCP but slightly less reliable. On the other hand, TCP is more reliable than UDP but slightly slower.



H231D928.WMF

UDP appends a redundant packet to the data packet and sends both. At the NIC Fax, the redundant packet is attached to only Phase C and the post message. The number of redundant packets can be changed as shown below. However, increasing the number of redundant packets increases the size of the data and slows down the speed of the transmission.

UDP Related Adjustments

IP FAX Delay Level

Raise the level by selecting a higher setting if too many transmission errors are occurring on the network.

If TCP/UDP is enabled on the network, raise this setting on the T.30 machine. Increasing the delay time allows the recovery of more lost packets.

If only UDP is enabled, increase the number of redundant packets.

Level 1~2: 3 Redundant packets

Level 3: 4 Redundant packets

E-Mail Options

Subject and Level of Importance

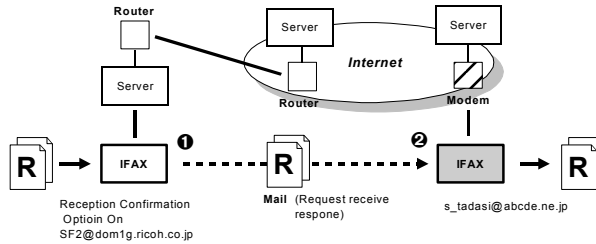
You can enter a subject message with a user tool.

The Subject entry for the mail being sent is limited to 64 characters. The subject can also be prefixed with an “Urgent” or “High” notation.

E-mail Messages

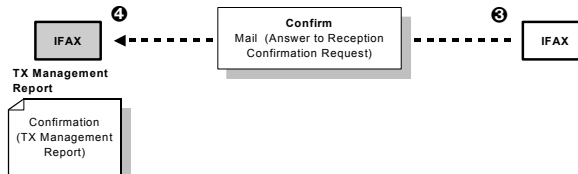
After entering the subject, you can enter a message with a user tool.

Message Disposition Notification (MDN)



1 *** JOURNAL ***

Time	ADDRESS	Mode	Time	PAGE	RESULT
10:17AM	s_tadasi@abcde.ne.jp	MailSMQ	0'09"	2	--



3 *** JOURNAL ***

Time	ADDRESS	Mode	Time	PAGE	RESULT
10:18AM	SF2@dom1g.ricoh	MailSMA	0'09"	2	--

4 *** JOURNAL ***

Time	ADDRESS	Mode	Time	PAGE	RESULT
10:17AM	s_tadasi@abcde.ne.jp	MailSMQ	0'09"	2	OK

OK

The network system administrator can confirm whether a sent mail has been received correctly or not. This confirmation is done in four steps.

1. Send request for confirmation of mail reception. Enable or disable this request with a user tool.
2. Mail reception (receive confirmation request)
3. Send confirmation of mail reception
4. Receive confirmation of mail reception

The other party's machine will not respond to the request unless the two conditions below are met:

- The other party's machine must support MDN (Message Disposition Notification).
- The other party's machine must be set up to respond to the confirmation request. To do this:
 - 1) The 'Disposition Notification To' field is in the received mail header (automatically inserted in the 4th line in the upper table on the previous page, if MDN is enabled), and
 - 2) Sending the disposition notification must be enabled. The content of the response is as follows:

Normal reception: "Return Receipt (dispatched)" in the Subject line

Optional response (bit switch adjustment) "Return Receipt (displayed)" in the Subject line

Error: "Return Receipt (processed/error)" in the Subject line

*Handling Mail***- Handling Mail on the Send Side -**

When mail is sent, a “Disposition Notification To” notation is included in the header as a request for confirmation that the mail was received.

```
X-Mozilla Status      : 0001
X-Mozilla Status2     : 00000000
Message-ID            : <3A23379A.81BE0ABD@domlg.ricoh.co.jp>
Disposition-Notification-To : T.Suzuki <s_tadashi@domlg.ricoh.co.jp>
Date                  : Tue, 28 Nov 2000 13:4203 +0900
From                  : T.Suzuki <s_tadashi@domlg.ricoh.co.jp>
X-Mailer              : Mozilla 4.73 [ja]C-CCK-MCD BDP jm-Sony 3
                       (Win95: U)
X-Accept-Language     : ja
MIME-Version          : 1.0
To                    : fuser_01@domlg.ricoh.co.jp
Subject               : Mail Request for Reception Confirmation
Content-Type          : text/plain: charset=iso-2022-jp
Content-Transfer-Encoding : 7bit
```

- Handling Mail on the Receive Side -

Return Path: <>

Received : From fuser_01 ([133.139.157.20]) by domlg.ricoh.co.jp (post office MTA V1.9.3 ID# 0100110-37392) with SMTP id AAA163 for<S_tadasi@domlg.ricoh.co.jp>

Date : 28 Nov 2000 13:4236 +0900

X-Mailer : ICFAX Version 1.0

MIME-Version : 1.0

Content-Type : multipart/report: report-type=disposition-notification: boundary="--ICFAX_000000EF48--"

To : T.Suzuki <s_tadashi@domlg.ricoh.co.jp>

Message-ID : <20001128133423664.ICFAX-XFC9BE-X26986@133.139.157.20>

From : fuser_01@domlg.ricoh.co.jp

Subject : From @81454771459" ("RICOH GTS) (Return Receipt) (dispatched)

X-Mozilla-status : 8001

X-Mozilla-Status2 : 00000000

X-UIDL : 20001128044713447.AAA163@fuser_01

This is a Return Receipt for the mail that you sent to "fuser_01@domlg.ricoh.co.jp"

Final Receipt: rfc822:fuser_01#domlg.ricoh.co.jp

Original Message ID: <3A23379A.81BE0ABD@domlg.ricoh.co.jp

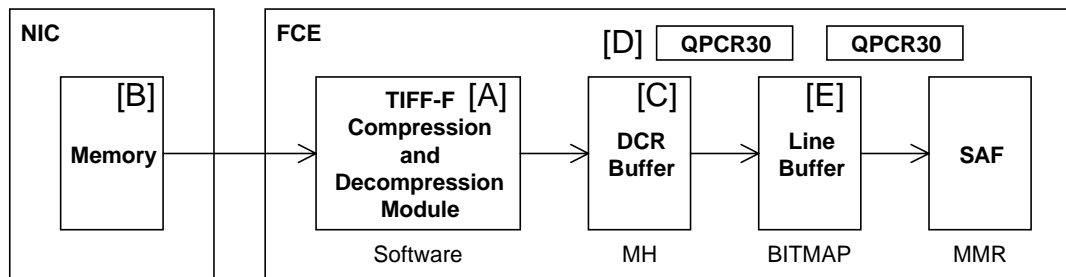
Disposition: automatic action/MDN-send-automatically: dispatched

Respond Mail Text

Image Data Path

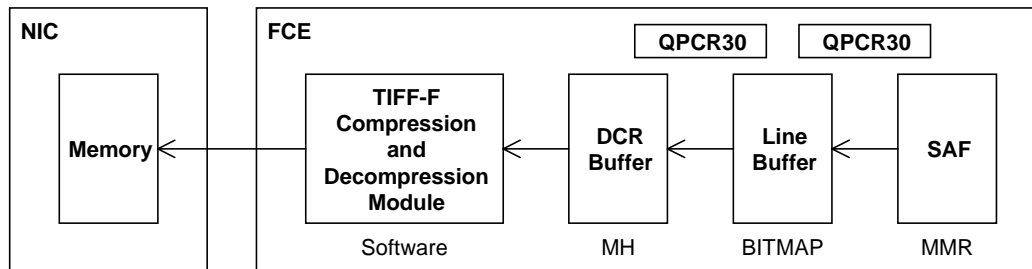
TIFF-F format

Reception



The software module [A] receives TIFF-F data from the memory [B] on the NIC board. After decompression, the directory information for the data (resolution, file size) and image data are transferred to the DCR buffer [C] in blocks. The data is then MH compressed.

The MH compressed image data in the DCR buffer is decompressed to bitmap data in the QPCR30 [D] and transferred to the line buffer [E]. The data is MMR compressed in the QPCR30 then stored in the SAF.

Transmission

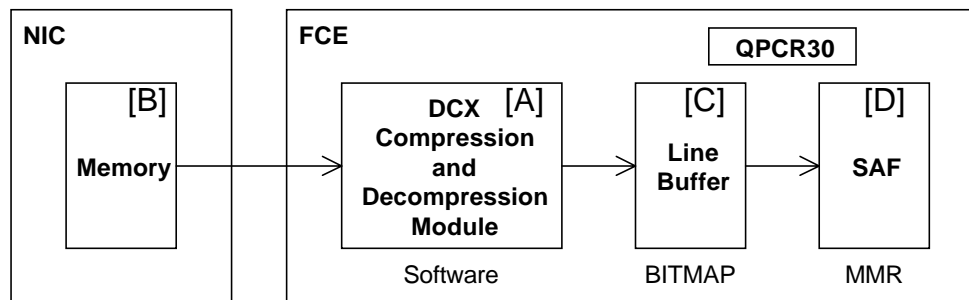
Data from the SAF data is decompressed into bitmap data in the QPCR30 and stored in the line buffer. Then, it is MH compressed in the QPCR30 and transferred to the DCR buffer.

The software module makes a TIFF-F formatted file with directory information from the image data, then transfers this file to the memory on the NIC board.

NOTE: The TIFF (Tagged Image File Format) was developed by Aldus and Microsoft as an extensible common file format for the exchange of image files.

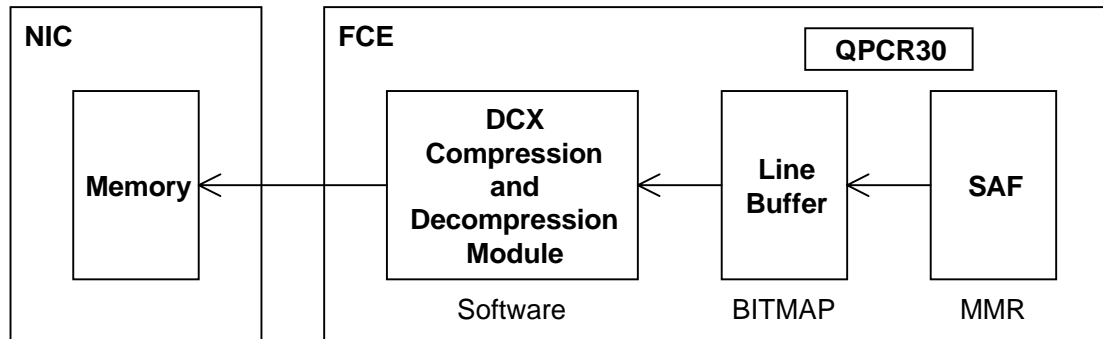
In order to increase the portability of TIFF files, various classes of TIFF files have been defined in order to clarify the requirements of readers and writers to ensure compatibility. Class F TIFF files are used for the exchange of fax images and are a subset of Class B (bi-level or black & white) TIFF images.

MH, MR, and MMR compressions can be used to make a TIFF-F file.

*DCX format**Reception*

The software module [A] receives DCX data from the memory [B] on the NIC board. The DCX file is divided into PCX images (one PCX image for each page). The data is decompressed into bitmap data, then transferred to the line buffer [C].

The data is MMR compressed in the QPCR30, and stored in the SAF [D].

Transmission

Data from the SAF is decompressed into bitmap format in the QPCR30, and stored in the line buffer. The software module makes PCX and DCX data and headers and transfers these to the memory on the NIC board.

NOTE: The DCX format was developed by Microsoft. It is an enhancement to the PCX format which allows multi-page images.

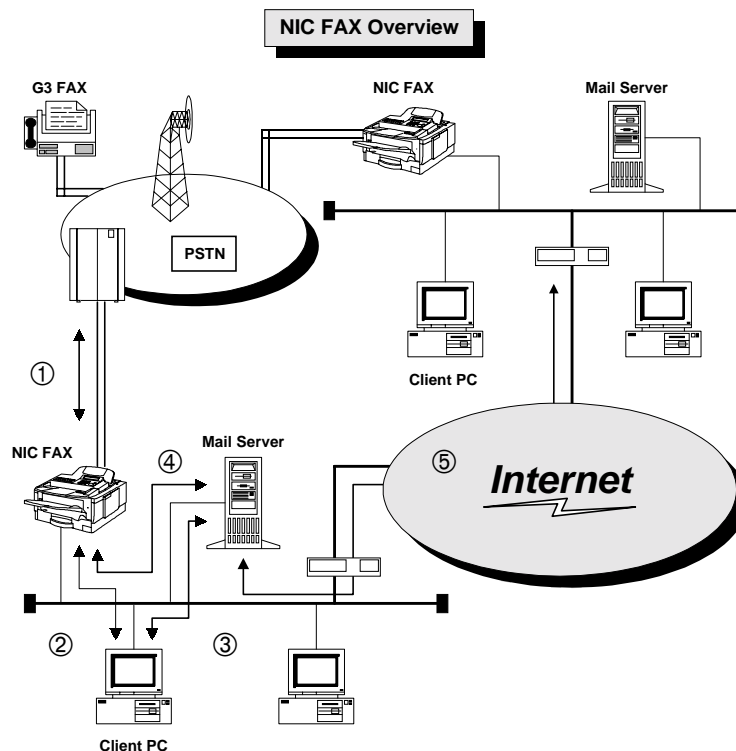
Troubleshooting Procedures

Overview

To resolve problems, a basic understanding of networking is required.

The drawing shows the route used for the various features used by this machine.

- LAN fax tx: ②-①
- 200-dpi printer: ②
- 200-dpi scanner: ④-③
- Autorouting: ①-④-③
- Forwarding: ①-④-③
- Internet fax (paper to paper): ④-⑤
- Internet fax (paper to PC): ④-⑤
- IC Fax Monitor: ②
- IC Viewer: On PC only



Troubleshooting procedures

Use the following procedures to determine whether the machine or another part of the network is causing the problem.

Communication Route	Item	Action	Remarks
General LAN	1. Connection with the LAN	<ul style="list-style-type: none">• Check that the LAN cable is connected to the machine.• Check that the LEDs on the NIC board and the hub are lit.	
	2. LAN activity	<ul style="list-style-type: none">• Check that other devices connected to the LAN can communicate through the LAN.	
① G3 communication	Refer to G3 fax troubleshooting		

Communication Route	Item	Action	Remarks
② Between NIC Fax and PC	1. Com Redirector	<ul style="list-style-type: none"> • Check the modem settings in Windows 95 • Check the port setting in Windows 95 • Make sure that the IP address registered in the machine is the same as the address stored in Com Redirector. • Is the target NIC fax running? 	<ul style="list-style-type: none"> • Is the modem set up in Windows 95 control panel set up the same way as described in the operation manual? • Are the printer properties in Windows 95 control panel created by the fax application software set up as in the operation manual?
	2. Application fax software	<ul style="list-style-type: none"> • Check the transmission port setting. • Check whether a PSTN access number is required. 	<ul style="list-style-type: none"> • Refer to the operation manual for the application.
	3. Network settings on the PC	<ul style="list-style-type: none"> • Check the Windows 95 network settings on the PC. 	<ul style="list-style-type: none"> • Is the IP address registered in the TCP/IP properties in the Windows 95 network setup correct? Check the IP address with the administrator of the network.

Communication Route	Item	Action	Remarks
	4. Check that PC can connect with the machine	<ul style="list-style-type: none"> • Use the “ping” command on the PC to contact the machine. 	<ul style="list-style-type: none"> • At the MS-DOS prompt, type ping then the IP address of the machine, then press Enter.
	5. LAN settings in the machine	<ul style="list-style-type: none"> • Check the LAN parameters • Check if there is an IP address conflict with other PCs. 	<ul style="list-style-type: none"> • Use “LAN parameters” in service function 20. • If there is an IP address conflict, inform the administrator.
③ Between PC and e-mail server	1. E-mail application software	<ul style="list-style-type: none"> • Use the application to check if transmission and reception are possible with destinations other than the NIC fax machine. • When an error message appears in the application, solve it first. 	<ul style="list-style-type: none"> • Inform the LAN administrator of the problem so that it can be dealt with.
	2. Network settings on the PC	<ul style="list-style-type: none"> • Check the PC’s Windows 95 network settings. 	<ul style="list-style-type: none"> • Is the IP address registered in the TCP/IP properties in the Windows 95 network setup correct? Check the IP address with the administrator of the network.

Communication Route	Item	Action	Remarks
	3. E-mail account on the server	<ul style="list-style-type: none"> • Make sure that the PC can log into the e-mail server. • Check that the account and password stored in the server are the same as in the machine. 	<ul style="list-style-type: none"> • Ask the administrator to check.
	4. E-mail server	<ul style="list-style-type: none"> • Make sure that the client devices which have an account in the server can send/receive e-mail. 	<ul style="list-style-type: none"> • Ask administrator to check. • Send test e-mail with the machine's own number as the destination. The machine receives returned e-mail when the communication is performed successfully.
④ Between machine and e-mail server	1. LAN settings in the machine	<ul style="list-style-type: none"> • Check the LAN parameters • Check if there is an IP address conflict with other PCs. 	<ul style="list-style-type: none"> • Use "LAN parameters" in service function 20. • If there is an IP address conflict, inform the administrator.

Communication Route	Item	Action	Remarks
	2. E-mail account on the server	<ul style="list-style-type: none"> • Make sure that the machine can log into the e-mail server. • Check that the account and password stored in the server are the same as in the machine. 	<ul style="list-style-type: none"> • Ask the administrator to check.
④ Between machine and e-mail server	3. E-mail server	<ul style="list-style-type: none"> • Make sure that the client devices which have an account in the server can send/receive e-mail. 	<ul style="list-style-type: none"> • Ask the administrator to check. • Send test e-mail with the machine's own number as the destination. The machine receives returned e-mail when the communication is performed successfully.
⑤ Between e-mail server and internet	1. E-mail account on the Server	<ul style="list-style-type: none"> • Make sure that the PC can log into the e-mail server. • Check that the account and password stored in the server are the same as in the machine. 	<ul style="list-style-type: none"> • Ask the administrator to check.

Communication Route	Item	Action	Remarks
	2. E-mail server	<ul style="list-style-type: none"> • Make sure that the client devices which have an account in the server can send/receive e-mail. 	<ul style="list-style-type: none"> • Ask the administrator to check. • Send test e-mail with the machine's own number as the destination. The machine receives returned e-mail when the communication is performed successfully.
	3. Destination e-mail address	<ul style="list-style-type: none"> • Make sure that the e-mail address is actually used. • Check that the e-mail address contains no incorrect characters such as spaces. 	
	4. Router settings	<ul style="list-style-type: none"> • Use the "ping" command to contact the router. • Check that other devices connected to the router can sent data over the router. 	<ul style="list-style-type: none"> • Ask the administrator of the server to check.

Communication Route	Item	Action	Remarks
	5. Error message by e-mail from the network of the destination.	<ul style="list-style-type: none">• Check whether e-mail can be sent to another address on the same network, using the application e-mail software.• Check the error e-mail message.	<ul style="list-style-type: none">• Inform the administrator of the LAN.

Symptoms For Troubleshooting

Internet fax machines use procedures which are not the same as the fax machines we are familiar with. The following can help solve problems in the field.

Decoding error during reception (1)

-- Possible Cause -

When the machine receives e-mail with attached files that are not in TIFF-F or DCX format, a decoding error occurs because the machine cannot decode the files. The error occurs even if a text file is attached.

- Explanation/Action -

ITU-T and IETF require a TIFF-F formatted file to be attached for an Internet fax message. The sender should send the e-mail again, with a TIFF-F formatted file attached.

Decoding error during reception (2)

- Possible Cause -

The received e-mail has an attached file that has an unsupported resolution or page size. Messages of up to A4 width and up to 200 x 200 dpi resolution can be received.

- Explanation/Action -

ITU-T and IETF specify a maximum size of A4 width for an attached file. The sender should resend the e-mail, with an A4 size file attached. The paper size is not negotiated during Internet fax handshaking.

E-mail Transmission with Incorrect LAN Parameters

(The machine can send e-mail even though the host name and domain name are not stored in the machine's LAN parameters.)

- Possible Cause -

During transmission to the SMTP server, the host name and domain name stored in the machine are used in the argument of the SMTP "HELO" command. However, the SMTP server can receive the "HELO" command without the argument, so the machine does not check whether the host name and domain name are stored.

- Explanation/Action -

At installation, the host name and the domain name are not required if they are unknown at the time. If incorrect names are stored, the SMTP server does not accept the HELO command and the machine cannot send e-mail to the SMTP server. Then, the machine fails to resend the correct number of times and prints an e-mail transmission error report.

*Error in the first part of the e-mail transmission procedure***- Possible Cause -**

There is no domain name in the destination e-mail address (e.g., “123” is used instead of an e-mail address).

- Explanation/Action -

When an e-mail address is sent to the SMTP server without a domain name (the address is blank is after the “@” symbol), the server searches for the same user name in the local server. The server fails to find the user name then the transmission is rejected in accordance with SMTP procedures. This is done in the first part of the e-mail transmission SMTP procedure.

NOTE: The following describes what happens if the domain name of the destination is correct but the user name of the destination is incorrect.

- 1) When an e-mail with a domain name which is different from the local domain name is sent, the SMTP server accepts the transmission and forwards the e-mail to the next SMTP server even if the user name of the e-mail address is incorrect. The local SMTP server cannot check user names in a remote server.
- 2) After that, the destination SMTP server checks the user name to see if that user has an account with the server. If there is no account, the server creates an e-mail error report and sends it to the sender, and this report is printed by the machine.

LAN Parameters not listed after NIC Replacement

LAN parameters are not listed on the system parameter list after the NIC board is replaced.

- Possible Cause -

Poor electrical contact between NIC board and machine

- Explanation/Action -

When the machine does not recognize the NIC board, the NIC board does not initialize and LAN parameters are not listed. The NIC board should be installed again.

Communication Error—E-mail Server Down

A communication error is indicated on the operation panel because the e-mail server is down.

- Possible Cause -

The machine attempts to receive e-mail from the POP server by POP procedures at a regular interval. When the machine cannot contact the server, a POP error occurs in the machine. A POP error also occurs if the LAN cable is pulled out of the machine or if the network is down.

When there is a POP error, a communication error is indicated on the display and the communication error LED is lit.

- Explanation/Action -

The machine recovers from a POP error when either the next POP procedure or the next SMTP procedure with the server is performed successfully. The user does not have to press the Stop key.

Transmission Error with Comma-separated Addresses

When a number of e-mail addresses separated with commas are stored for transmission, a transmission error occurs. (eg. aaa@bbb.com, ccc@ddd.com, ddd@eee.com)

- Possible Cause -

An SMTP error occurs in the above case.

- Explanation/Action -

When storing more than one e-mail address, the user must press the Yes key after storing each address.

Fax Troubleshooting Techniques

Introduction

This section describes methods of solving commonly-occurring communication problems. Concerning copy quality and mechanical problem troubleshooting, specific troubleshooting procedures for each model are given in the Service Manuals.

Basic Troubleshooting Philosophy

Discuss the problem and its symptoms with the customer in detail

There are many types of problem that can be encountered.

- Performance/operation errors
- Document jams (ADF problems)
- Copy paper jams
- Copy quality problems
- Communication problems

Understand when, where, how, and in what conditions the problem occurs. To do this, ask the user about the following aspects of the problem and the machine's location of installation.

Location	Office/warehouse
	Clean/dusty
	Temperature and humidity
	Power source (stability, dedicated/shared)
Line	Direct connection to the telephone company line
	PABX connection
	Dedicated/branched
	Tone dialling (DTMF)/pulse dialling
Settings	DTMF/pulse dial
	CSI (full 20 digits)
Operation	Auto dialling/manual dialling
	Auto reception/manual reception
Others	Type of model at the other end

Study the symptoms by making communication tests (Tx and Rx)

- At the user's site -

Make tests with the terminal that the user was communicating with when the problem arose. Then, make tests with terminals that the user communicates with regularly. It is also helpful to call these terminals from a telephone in order to find out about the line condition (echoes, noise, and other line problems can be heard).

After that, make tests with your test centre. Have your test centre observe the protocol sequence, modem rate, level, and line condition with an oscilloscope and other equipment.

- At the test centre -

Make tests with the user end at first. Then, make tests with the other end that the user was communicating with when the problem arose.

During these tests, observe the protocol sequence, etc.

Make up a drawing of the protocol sequence using these observations.

Try to adjust the terminal settings

Try to solve the problem by adjusting bit switch or RAM address settings in the machine.

Sources of Line Problems in Telephone Circuits

Overview

Sources of problems affecting the quality of data transmission over the telephone network can be roughly classified into two groups, as shown below, in accordance with their character.

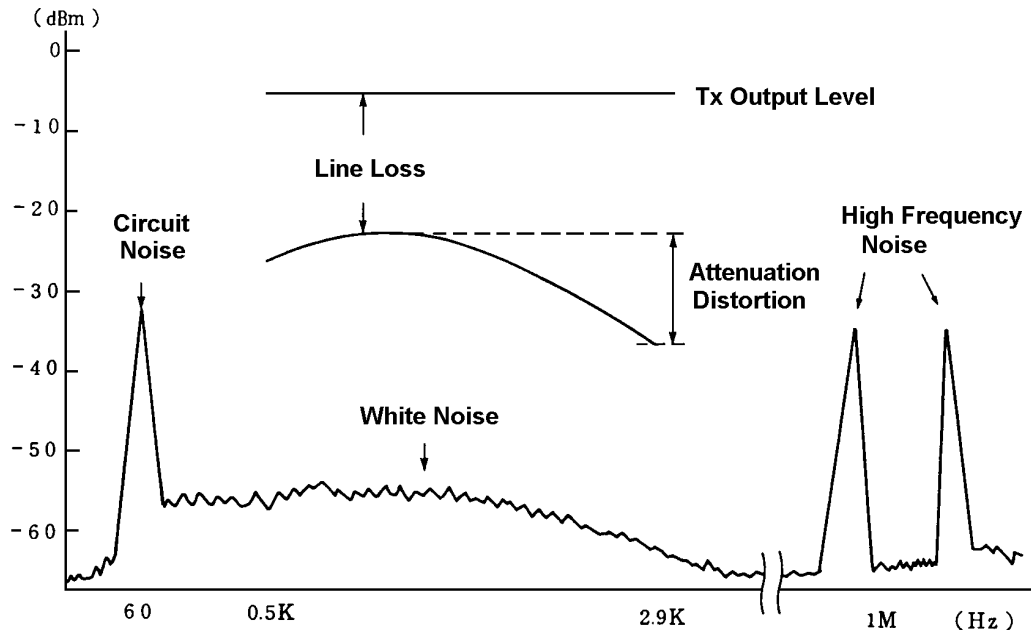
Constant sources	These include transmission loss, attenuation distortion, envelope delay, frequency deviation, echo, circuit noise, and non-linear distortion.
Unpredictable sources	These include impulse noise, dropouts, phase hits, and gain hits.

It is necessary to consider the following characteristics of the telephone network when using data transmission equipment.

- Separate calls between the same terminals may be connected along different paths in the telephone network, thus causing differences in various transmission characteristics because of the difference in the connected links or types of exchange.
- Impulse noise, dropout and other types of interference having a great influence on data transmission and telephone communication are unpredictable both in their occurrence and in their effects.
- The characteristics of the communication network are continually being improved by the introduction of new systems or equipment. However, the mixture of new and old switches and various types of transmission equipment makes transmission characteristics irregular.

The following pages contain explanations of some sources of line problems. First, however, it is important to understand some of the terminology concerning the relationship between the data signal and noise. The following diagram illustrates the most important terms that are used on the next few pages.

The diagram covers a wide frequency spectrum. However, the frequency range of modems in typical fax machines is only from 500Hz to 2900Hz.



Another important term is the Signal to Noise ratio (S/N). To calculate the S/N (Signal to Noise) ratio, do the following.

1. Measure the level in dBm of the transmitted (or received) V21 protocol signal or V27/V29 document data signal.
2. Measure the white noise level in dBm.
3. To calculate the S/N ratio (dB), subtract the white noise level from the signal level.

For example:

Received signal level	= -25 dBm
White noise level	= -50 dBm
\Rightarrow S/N ratio	$= -25 - (-50) \text{ dB}$
	$= 25 \text{ dB}$

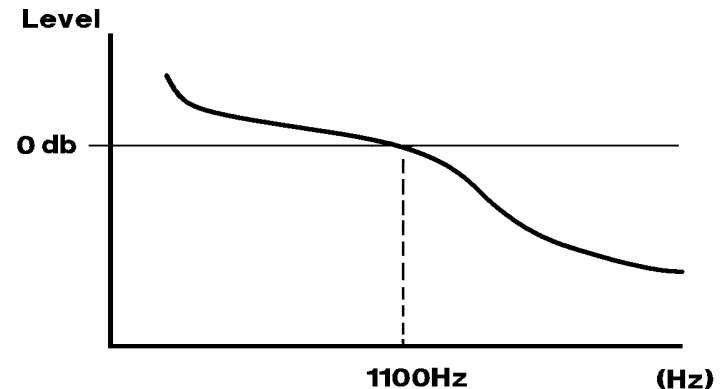
The S/N margin of a modem is the S/N ratio below which the modem cannot separate the data signal from the noise.

Transmission Loss

Transmitted signals are attenuated by the resistance of the telephone circuit, mainly due to the long copper cables. This weakening is known as transmission loss. Different sections of the circuit cause different amounts of transmission loss.

Attenuation Distortion

Signal levels at high frequencies level may be reduced by resistance and the length of the line. Cable equalizers can be used to counteract this problem. However, if the cable equalizer is overcorrected, the machine may be forced to fall back to a lower modem rate during training.



White Noise and Circuit Noise

Circuit noise includes power supply noise and noise generated by components such as tubes and transistors.

White noise is the major contributor to the background noise level at the receiving end and is the basic parameter used to determine the S/N margin of the modulation system.

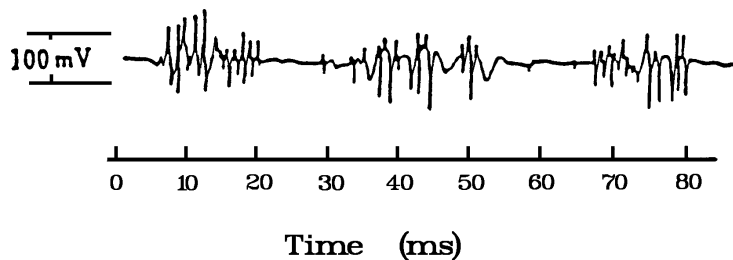
Data errors may be caused by a low S/N ratio but this is not the only cause of data transmission errors. Data transmission over a circuit with an S/N ratio that exceed the S/N margin for the modem is susceptible to interference such as impulse noise or envelope delay.

Impulse Noise

Impulse noise is unpredictable in generation interval and in amplitude. Therefore, the analysis of its generation, the method of measurement, and the evaluation of the effect on data signals are different from circuit noise.

In data communication, impulse noise may alter the data signal, possibly causing an error.

The diagram shows typical impulse noise clicks caused by a step-by-step switch. These clicks occur at irregular intervals.

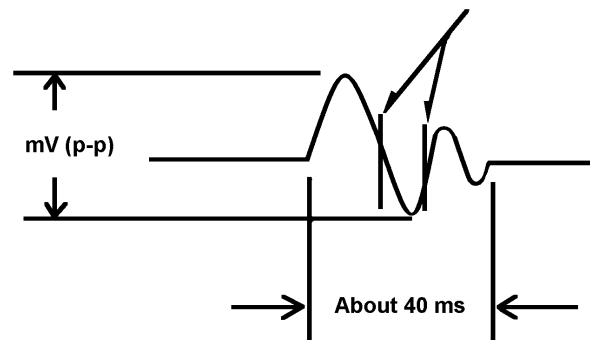


Time Unit Signal

Time unit signals are generated by the trunk exchange switchboard on the calling side and can be observed at the Tip and Ring (L1 and L2) terminals on the fax machine.

The drawing shows an example of this type of signal. The charge billed to the caller is determined by the number of pulses generated by the trunk exchange switchboard.

Pulses of long wavelengths cause no problems, but interference within the voice band may cause errors to the data.

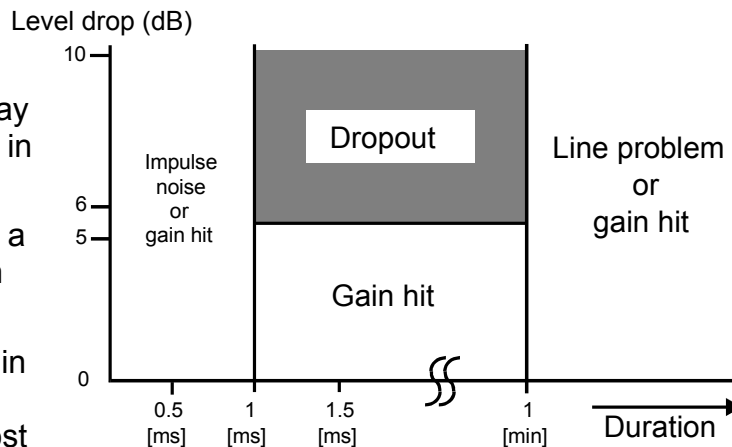


Dropouts And Gain Hits

A dropout is a sharp decline of the received signal level in a relatively short time. This may have been caused by a line problem, a fault in a terminal, or another cause.

In the ITU-T recommendations, a dropout is a drop in level of 6 dB or more over a duration of between 1 ms and 1 minute.

A gain hit is a sudden increase or decrease in signal level. A dropout is a special case of gain hit, where the signal may become almost undetectable.



CCITT definition of dropouts and gain hits

Envelope Delay

Voice, data, and other transmitted electric signals take some time to reach the receiving side. The received signal may be out of phase with the transmitted signal. The phase difference is known as envelope delay.

If different envelope delays occur with different carrier frequencies, this is known as envelope delay distortion.

Generally, the attenuation and phase characteristics of the transmission line vary depending on the signal frequency.

Effects of Line Problems on Copy Quality

The two major effects of line problems on copy quality are:

- Missing lines, causing shrinkage in the sub scan direction
- Cutoff, with the data abruptly stopping in the middle of the page.

These are illustrated in the following set of diagrams.

ABCDEFGHIJKLMN 1234567890

OPQRSTUVWXYZ 0987654321

Original

Tshoot6.wmf

ABCDEFGHIJKLMN 1234567890

OPQRSTUVWXYZ 0987654321

Missing Lines

Tshoot7.wmf

ABCDEFGHIJKLMN 1234567890

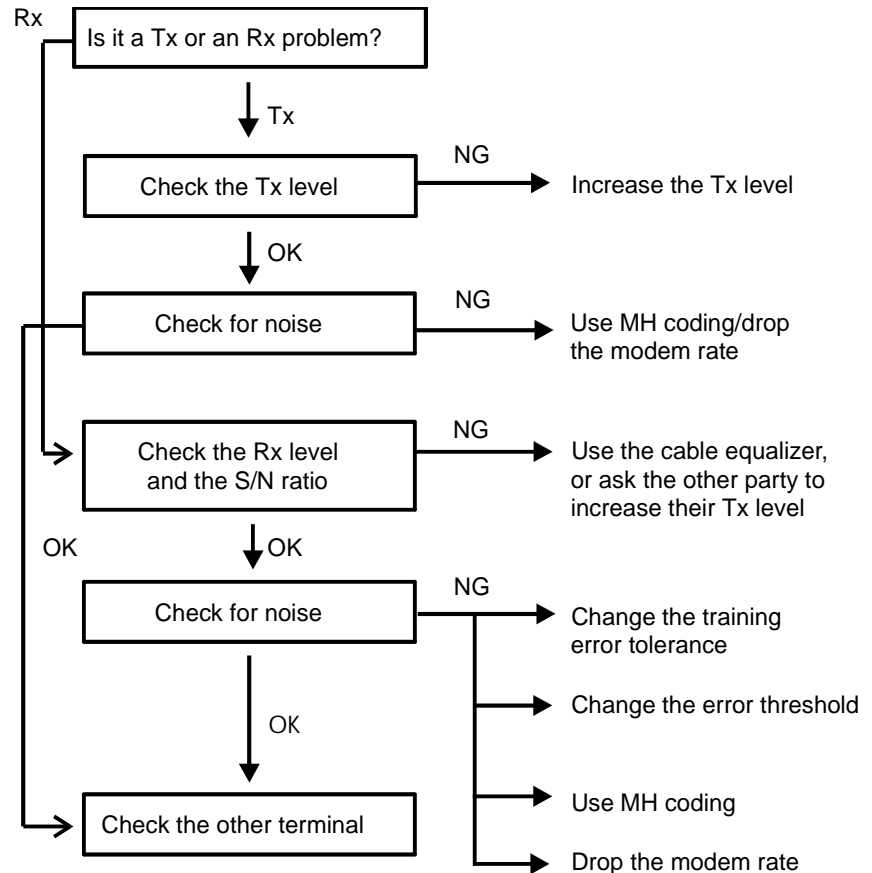
OPQRSTUVWXYZ 0987654321

Cutoff

Test Procedures

General

The diagram shows the basic testing procedure when dealing with line noise.



Other problems that may occur are as follows:

- If the T1 timer runs out before a CED signal comes in from the other end, increase the T1 time. This problem may occur on international calls.
- If there are echoes on the line, switch on the echo countermeasure.
- If the other terminal is a fax board or other PC controlled device, you may have to change the reconstruction time of the 1st line from 6 s to 10 s.

The adjustments mentioned above can be made in most models by bit switch. Some parameters can be changed using dedicated transmission parameters; these allow a technician to change a parameter for a particular destination only (for example, if echoes are frequently encountered when dialling a particular destination). For details on a particular model, refer to the Service Manual for that model.

Decibel Level Measurement

Signal levels are measured in decibels. The decibel is the logarithm of the ratio of the output signal power (P_1) to the input signal power (P_2).

$$\text{dB} = 10 \log_{10}(P_1/P_2)$$

Logarithms are the most effective way to measure signal levels because:

- The ear responds to sound in a roughly logarithmic manner.
- The ratio between two levels, such as the S/N ratio, can be obtained simply by subtracting the two signal levels, instead of dividing.

For measuring signal levels on telephone circuits, a standard reference value of 1 milliwatt (mW) is taken for P_2 . Signals measured in this way are quoted in dBm (decibels relative to 1 mW).

$$\text{dB} = 10 \log_{10} (\text{Signal Power [in mW]}/1 \text{ mW})$$

A signal of 1 mW is quoted as 0 dBm. Each telephone circuit contains a 0 dBm reference point at the output of the telephone exchange at the sending end of the circuit. This reference point may also be referred to as the zero transmission level point (OTLP).

Signal levels measured at any point in a circuit can be measured in dBm. For example, if a signal is delivering 100 mW of power, its level is 20 dBm. However, if you wish to quote relative gain or loss between two points in the circuit, the value must be stated in the dB unit. Also, ratios of signal levels, such as the S/N ratio, are quoted in dB.

To measure signal levels, you can use an oscilloscope. For example, to measure the level of signals entering and leaving the fax machine, connect the oscilloscope across the Tip and Ring (L1 and L2) terminals on the fax machine. Measure the peak-to-peak level in millivolts (mVp-p) and convert it to dBm using the following table.

dBm	mVp-p	dBm	mVp-p
10	6.931	-11	0.617
9	6.176	-12	0.551
8	5.506	-13	0.492
7	4.907	-14	0.438
6	4.372	-15	0.390
5	3.897	-16	0.348
4	3.473	-17	0.308
3	3.097	-18	0.277
2	2.760	-19	0.246
1	2.458	-20	0.221
0	2.192	-22	0.175
-1	1.954	-24	0.139
-2	1.742	-26	0.110
-3	1.553	-28	0.088
-4	1.383	-30	0.071
-5	1.233	-32	0.054
-6	1.097	-34	0.042
-7	0.978	-36	0.034
-8	0.874	-38	0.028
-9	0.777	-40	0.023
-10	0.693		

Signal levels vary from country to country in accordance with local regulations. However, transmitted signals are usually between 0 and -15 dBm, and received signals are normally in the region of -20 to -34 dBm.

CAUTION: Do not place grounded test equipment across the Tip and Ring (L1 and L2) terminals. This will cause an imbalance in the phone line, leading to erroneous readings or even line disconnection. If the test equipment is grounded, bypass the ground by plugging the three-pin plug into an adapter that converts the plug into a two-pin plug (do not cut off the ground plug of the power cord).

Back-to-back Tests

If you wish to test communication between two fax machines directly, without having to connect them through any type of exchanger or switching device, you can carry out a back-to-back test. The procedure is as follows.

1. In both of the machines, enable back-to-back test mode. This is normally done by adjusting a bit switch; refer to the Service Manual for the machine for details.
2. Connect the two machines together with a line cord. Do not connect a switching device between the machines.
3. Place a document in the feeder of one of the machines.
4. Press the Start key on both machines at about the same time.
5. After finishing the test, put the back-to-back test mode bit switch back to the default setting in both machines.

Note

Normally, a battery must be connected somewhere in the circuit between the two machines to supply line voltage. This voltage simulates the voltage supplied by the telephone network. However, some machines have a circuit to generate this voltage. If both machines in the test have such a circuit, then activate the circuit in both machines before starting the test, and deactivate it after the test. There is no need to connect a battery. Refer to the model's Service Manual for details on how to activate this circuit for each model.

Common Fax Features

This section contains technical descriptions of some fax features that are common to most models.

Auto Service Calls

Service Call Conditions

The machine makes an automatic service call to the service station telephone number when an error code occurs. The error codes specified for this feature may differ from model to model.

Periodic Service Call

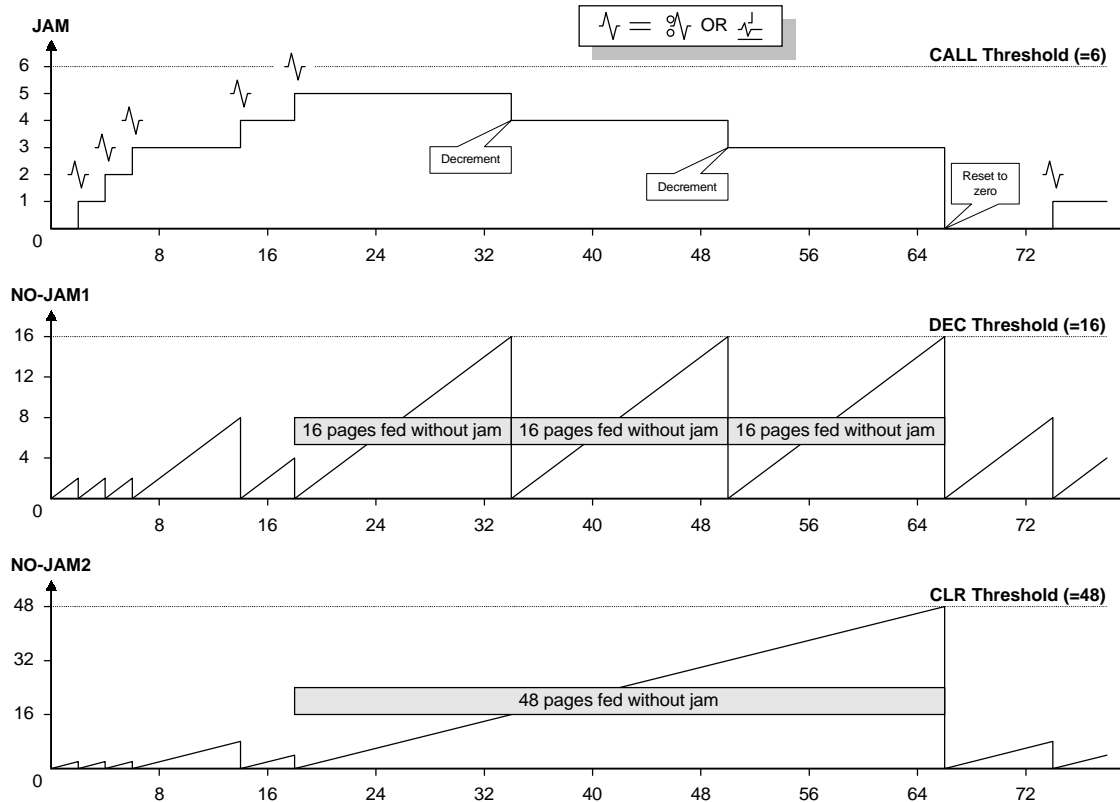
The periodic service call notifies the condition of the machine to the service station. The call is made periodically at a time interval programmed in RAM.

The Call Service indicator does not light for a periodic service call, so that the machine can be operated normally after it has sent the service call.

PM Call

If PM call is enabled, the machine will make an automatic service call when the PM counter reaches the PM call interval in RAM.

The Call Service indicator does not light for a PM service call, and the machine can be operated normally after it has made the service call.

Excessive Jam Alarms

The excessive jam alarm automatically notifies the service station when the machine's scanner or printer frequently has jam problems.

Each type of jam has three counters allocated to it (JAM, NO-JAM1, NO-JAM2). Each of these counters has a threshold value (CALL, DEC, and CLR respectively; these can be adjusted.) The machine uses these counters to monitor jams as follows.

- JAM: Jam counter used to place a service call
- NO-JAM1: Counter used for JAM counter decrement
- NO-JAM2: Counter used for clearing the JAM counter

Each time a jam occurs: The JAM counter is increased by 1, and NO-JAM1 and NO-JAM2 are both set to zero. When JAM reaches CALL (6 by default), the machine sends an Auto Service Report with a System Parameter List.

If a sheet of paper is fed without a jam occurring: NO-JAM1 and NO-JAM2 are both incremented by 1. When NO-JAM1 reaches DEC (16 by default), NO-JAM1 is set to zero, and JAM is decremented by 1. When NO-JAM2 reaches CLR (48 by default), NO-JAM2 and JAM are both reset to zero.

The CALL, DEC, and CLR thresholds can be adjusted for each type of jam.

The Call Service indicator does not light for an excessive jam alarm, and the machine can be operated normally after the automatic service call has been made.

Effective Term of Service Calls

If a time limit for the effectiveness of service calls is programmed, the machine stops making automatic service calls after the time limit.

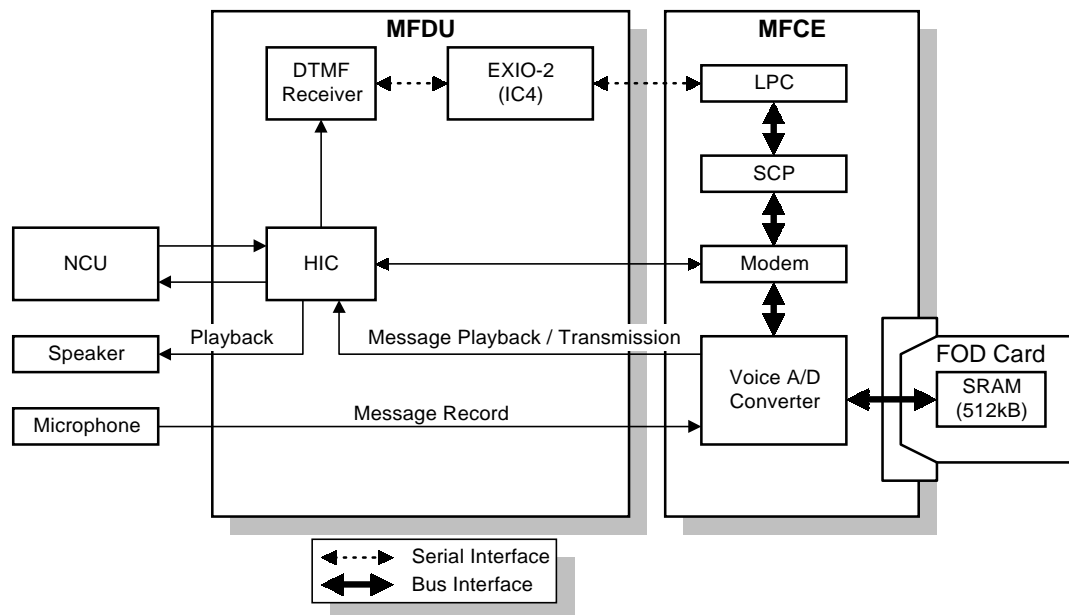
Fax On Demand

Overview

Fax On Demand is a polling application with pre-recorded voice assistance. A caller can get one or more fax messages in one polling operation using a DTMF tone sequence. A password (Remote ID) can be used to secure the information from unauthorized access.

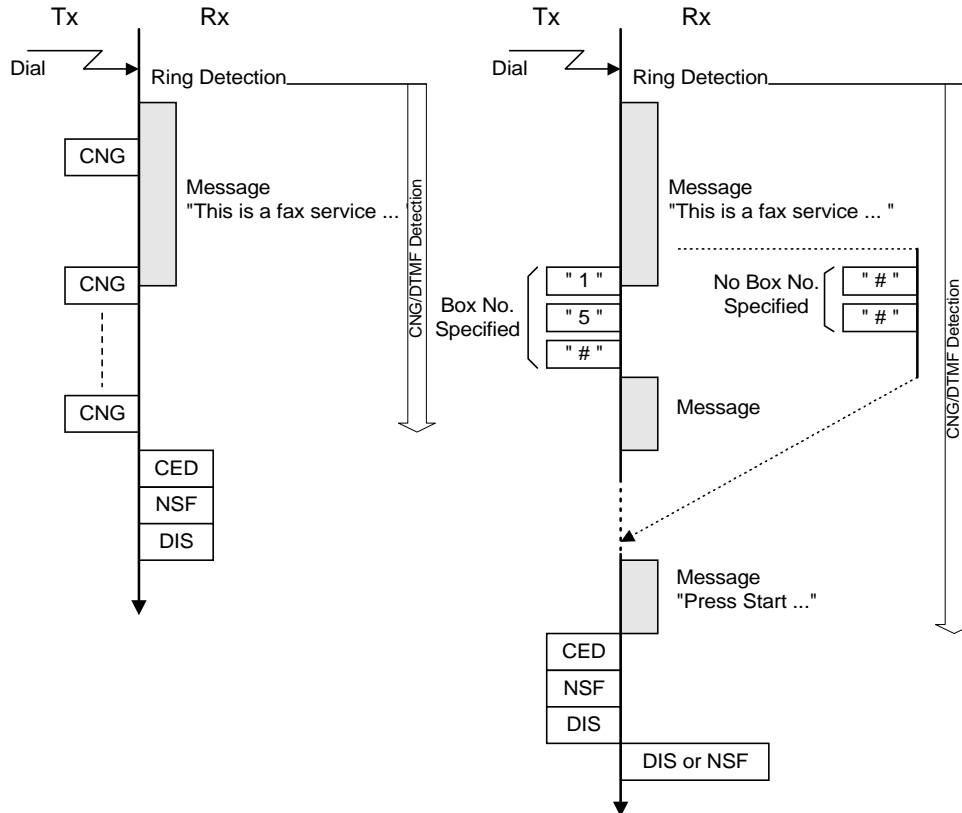
Circuit

Example: H515



The machine can have several voice messages to instruct the caller. The voice messages are recorded using the microphone, then the Voice A/D Converter on the MFCE converts them into digital format and stores them in the SRAM inside the Fax On Demand card. When playing back a message or transmitting it to a caller, the Voice A/D Converter converts the digitized message back to an analog voice message and sends it to the speaker or the NCU through the HIC on the MFDU.

The SRAM on the Fax On Demand card is backed up by a battery on the card.

Protocol

After ringing detection, the machine sends a pre-recorded message, and at the same time, starts to detect CNG signals or DTMF tones from the caller. The dedicated DTMF receiver on the MFDU is used to detect both CNG signals and DTMF tones.

If the machine detects CNG signals, the machine goes into fax reception mode. If the machine detects DTMF tone signals, the machine then sends some more messages to instruct the caller what to do. After the last message has been sent to the caller, the machine goes into fax transmission mode.

Sometimes the machine might not detect DTMF signals while the machine is transmitting a voice message. To avoid this, the messages should instruct the caller to send DTMF signals after the message has been finished.

While Fax On Demand is enabled, the machine disables receiving Transfer Request using DTMF tones, because it may use the same key sequence.

Line Type Change

When the machine is initially used only with the PSTN, the line type programmed with phone numbers in Quick Dials and the Speed Dials is stored as PSTN G3.

Later, if the line connection is changed so that G3 is to be used only with the ISDN, the communication port for all stored Quick and Speed Dials must be changed to ISDN G3.

This feature allows the communication mode and port to be changed for all stored numbers at once.

Procedure:

1) Change the following data in RAM.

- Current line type setting
- Line type to be used after this procedure

2) Turn the main switch off and on.

Then, the machine checks all phone numbers stored in Quick Dials, Speed Dials, AI Redial, and Forwarding Stations. If the communication mode and the port setting for a number are the same as specified for the “current line type setting” above, the machine changes these to the new setting.

Do not use this procedure if there are any files stored in the memory awaiting transmission.

Parallel Memory Transmission

Using memory transmission, normally the machine starts dialing after the document has been completely scanned. Using Parallel Memory Transmission, the machine starts dialing at the same time the machine starts scanning. If the document has multiple pages, the machine scans them into memory and sends them at the same time.

The following table shows the differences between normal memory transmission and parallel memory transmission.

	Memory tx	Parallel memory tx
File Reserve Report	Printed, if automatic report printout is enabled.	Not printed.
If the other terminal is busy	Tries to resend the message later.	Continues scanning the document into memory, and tries to resend it later.
If transmission failed	Tries to resend the remaining pages later.	Tries to resend the remaining pages later.
If memory overflows during scanning	Stops scanning and erases all the scanned pages from memory, if the user agrees to erase them.	Stops scanning and hangs up the communication when memory overflow is detected. Then erases all the scanned pages from memory without

		notifying the user.
If a document jam occurred during scanning	Stops scanning and deletes all the scanned pages from memory.	Stops scanning and hangs up the communication when a document jam is detected.
How and when the scanned message is erased from memory	The complete message is erased after all the pages have been sent.	Each page is erased after the page has been successfully sent.
Memory threshold to start scanning into memory	Depends on the setting of communication switch 0D. H515 Default setting – 24kB	Depends on the setting of system switch 10. H515 Default setting – 512 kB
Meaning of the stamp mark	Successfully stored.	Successfully stored.
Batch numbering (P. x/x)	Enabled	Not available unless the number of pages is programmed manually.

Using G4 transmission, parallel memory transmission is normally disabled because the transmission speed is much faster than the scanning speed.

Transmission using parallel memory transmission is about twice as long as normal memory transmission (using an ITU-T #1 test chart).

However, if the document contains pages with complicated images or when sending a photo document using halftone, using parallel memory transmission may be faster than normal memory transmission.

If the user commonly sends this type of fax message, enable parallel memory transmission for G4 transmission by changing system switch 11, bit 7 to 1.

Page Separation and Sub-scan Reduction

Introduction

In fax machines that use cut paper (such as laser fax machines), there is a problem if the incoming message is longer than the copy paper. This section explains the settings that control how the machine deals with this problem.

The two techniques used are:

- Page separation: Printing the received page on two or more sheets of copy paper.
- Sub-scan reduction: Reducing the data in the sub-scan direction so that it will fit on the page. This means that the image will appear to be squashed.

The methods used so far can be classified into two types (there is no special reason for having two different methods). These will be described separately

- Method 1 (normally used in standalone fax machines)
- Method 2 (normally used in fax board options for digital copiers)

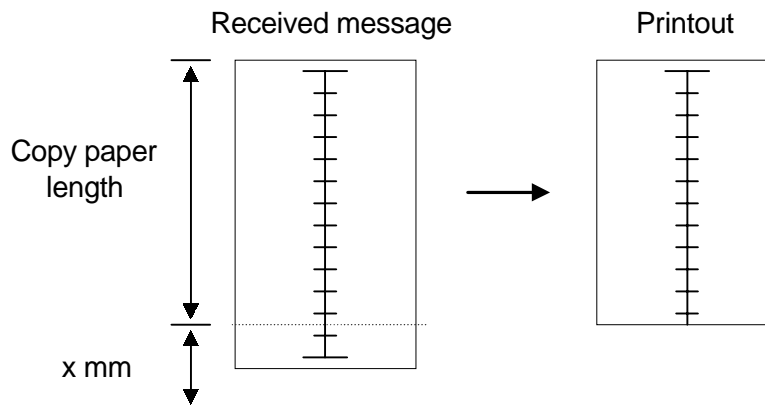
Method 1

Example: H515

The process depends on whether reduction is enabled or disabled. This is a bit switch adjustment.

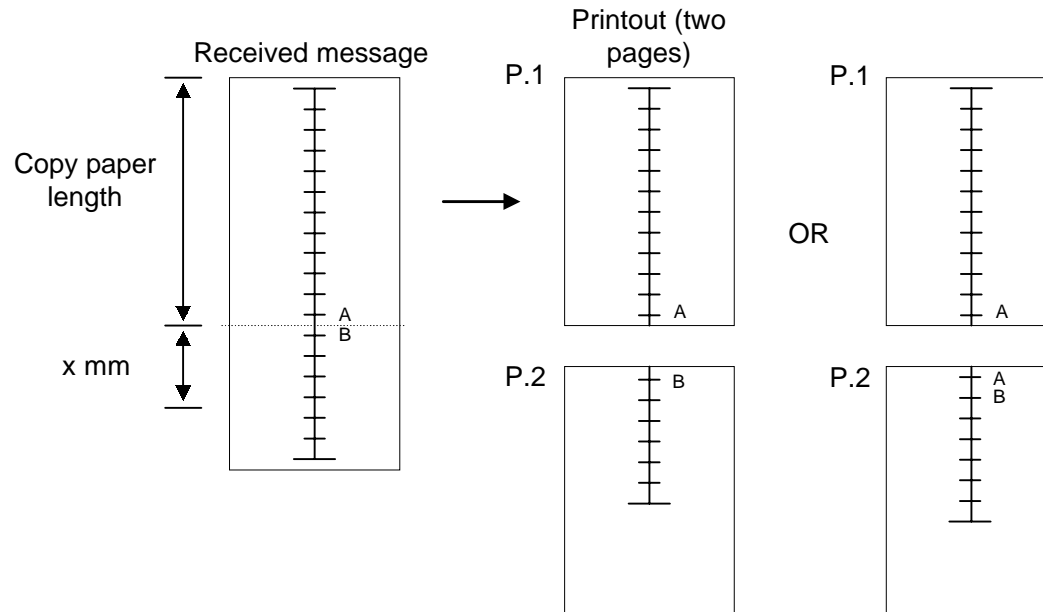
If reduction is disabled

Case 1: If the incoming page is up to x mm longer than the copy paper, the excess portion will not print.



- The value of x is adjusted by bit switch. It can be between 0 and 15 mm.

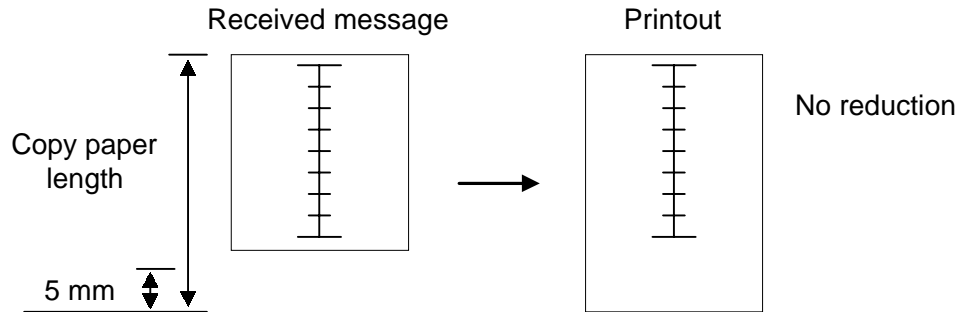
Case 2: If the incoming page is more than x mm longer than the copy paper, the message is printed on more than one sheet of paper.



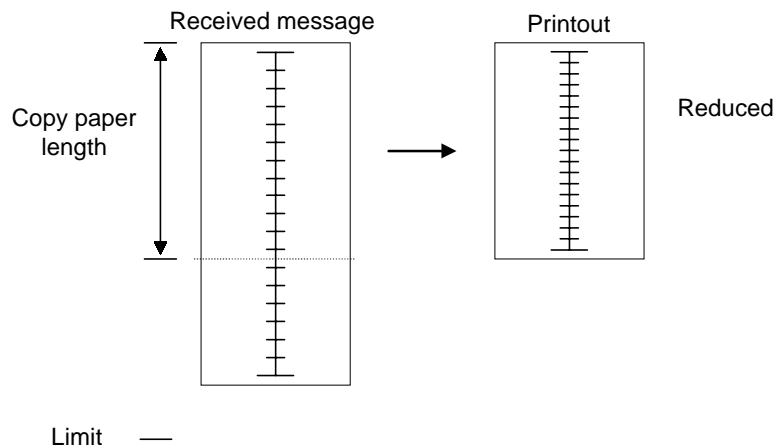
- The last few lines of the first page can be repeated at the top of the second page, or not (look at points A and B in the above diagram). This is another bit switch adjustment.
- A mark can be printed on incoming messages that have been printed on more than one page.

If reduction is enabled:

Case 1: If the incoming message is more than 5 mm shorter than the copy paper, there is no reduction. This 5 mm is a fixed value.



Case 2: If the incoming message is within 5 mm shorter than the copy paper and a certain maximum limit, the page is reduced in the sub-scan direction.



- This maximum limit depends on the copy paper size, and the reduction ratio selected for that copy paper size. (Example: For A4 at a reduction ratio of 4/3, this limit is 388.8 mm.) Beyond this maximum limit, the incoming data cannot be reduced to fit on the copy paper.
- The reduction ratio for each copy paper size can be adjusted with bit switches.

The following tables show the limits for each copy paper size. These have been the same in all recent models.

USA Models

- Resolution: lines/mm -

Copy Type	Printable Page Length	Maximum Limit		
		Ratio = 4/3	Ratio = 8/7	Ratio = 12/11
Letter	279.2 mm	365.2 mm	313.0 mm	298.7 mm
Legal	355.6 mm	467.0 mm	400.3 mm	382.1 mm

- Resolution: lines/inch -

Copy Type	Printable Page Length	Maximum Limit		
		Ratio = 4/3	Ratio = 8/7	Ratio = 12/11
Letter	279.4 mm	365.8 mm	313.4 mm	299.2 mm
Legal	355.6 mm	467.4 mm	400.6 mm	382.3 mm

Europe/Asia Models

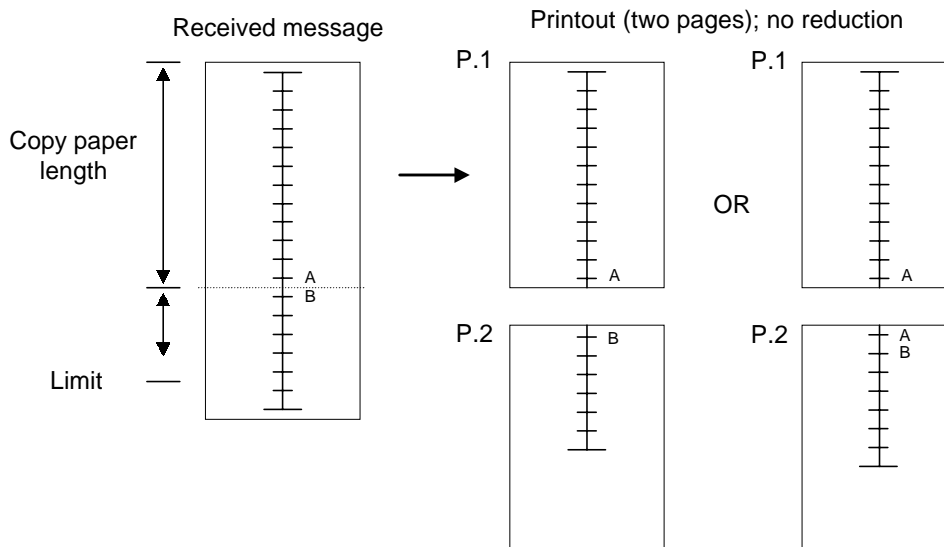
- Resolution: lines/mm -

Paper Type	Printable Page Length	Maximum Reducible Incoming Page Length		
		Ratio = 4/3	Ratio = 8/7	Ratio = 12/11
A5 Sideways	147.8 mm	190.1 mm	162.9 mm	155.3 mm
A4	296.9 mm	388.8 mm	333.2 mm	318.2 mm
F4	330.1 mm	433.2 mm	371.2 mm	354.3 mm

- Resolution: lines/inch -

Paper Type	Printable Page Length	Maximum Reducible Incoming Page Length		
		Ratio = 4/3	Ratio = 8/7	Ratio = 12/11
A5 Sideways	147.8 mm	190.2 mm	163.4 mm	155.7 mm
A4	296.9 mm	388.9 mm	333.5 mm	318.3 mm
F4	330.2 mm	433.3 mm	371.3 mm	354.6 mm

Case 3: If the incoming message is longer than the maximum limit, it is not reduced. It is printed on more than one sheet of paper, in a similar manner to case 2 when reduction is disabled (see above).



- The last few lines of the first page can be repeated at the top of the second page, or not (look at points A and B in the above diagram). This is another bit switch adjustment.
- A mark can be printed on incoming messages that have been printed on more than one page.

Bit Switch Summary

- General -

- Reduction, enable/disable

- If reduction is disabled -

- Page separation threshold
- Repetition of the last few lines of the previous page at the top of the next page
- Page separation mark

- If reduction is enabled -

In addition to the above three switches for when reduction is disabled, there is the following:

- Reduction ratio for each copy paper size

Each paper size can have a separate reduction ratio. Example: H545, Printer switches 04 and 05
In each of the two bit switches, there is one bit for each possible paper size. The combination of the bit settings determines the ratio for that paper size.

Bit No. Switch No.	Bit 7 Not used	Bit 6 Not used	Bit 5 Legal	Bit 4 F4	Bit 3 A4	Bit 2 Letter	Bit 1 Not used	Bit 0 A5 sideways
Sw 04	0: 4/3		1: 4/3		0: 8/7		1: 12/11	
Sw 05	0:		0:		1:		1:	

For example, bit 3 in switches 04 and 05 determine the reduction ratio for A4.

If bit 3 is 1 in switch 04 and 0 in switch 05, the reduction ratio for A4 is 4/3.

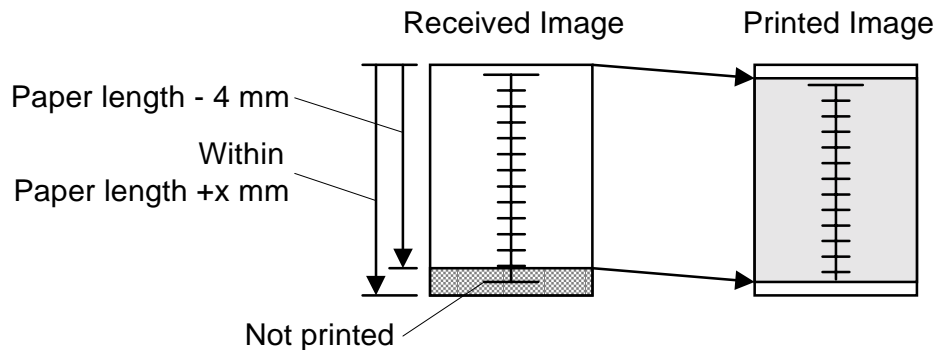
Method 2

Example: A891

The process depends on whether reduction is enabled or disabled. This is a bit switch adjustment.

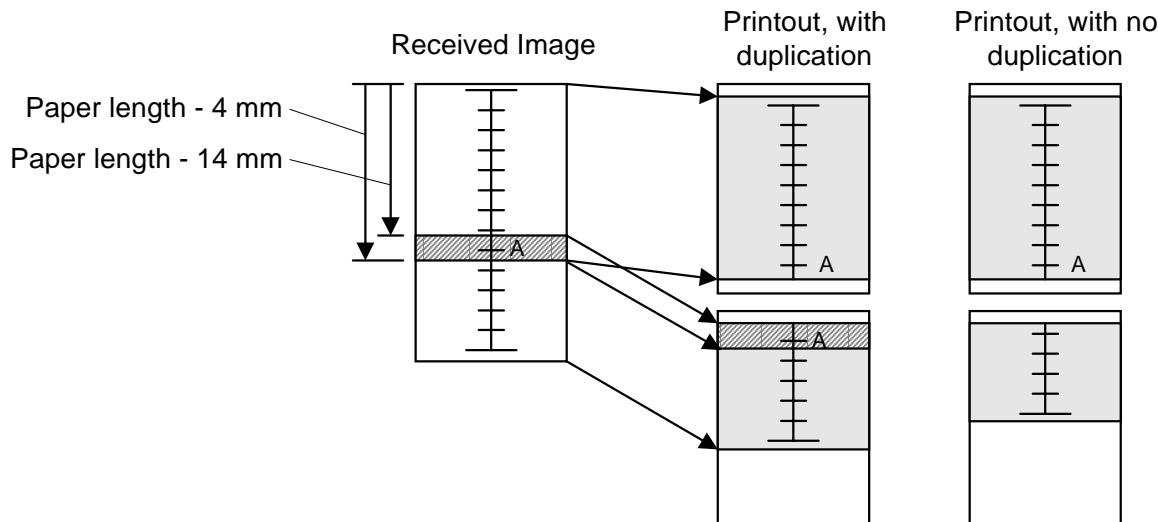
If reduction is disabled

Case 1: If the incoming page is shorter than the copy paper length + x mm but longer than the paper length - 4 mm, the part of the image after paper length - 4 mm will be lost



- The value of x is adjusted by bit switch. It can be between 0 and 15 mm. It is known as the 'page separation threshold'.
- The 2 mm gaps at the leading and trailing edges depend on the leading and trailing edge margin settings.

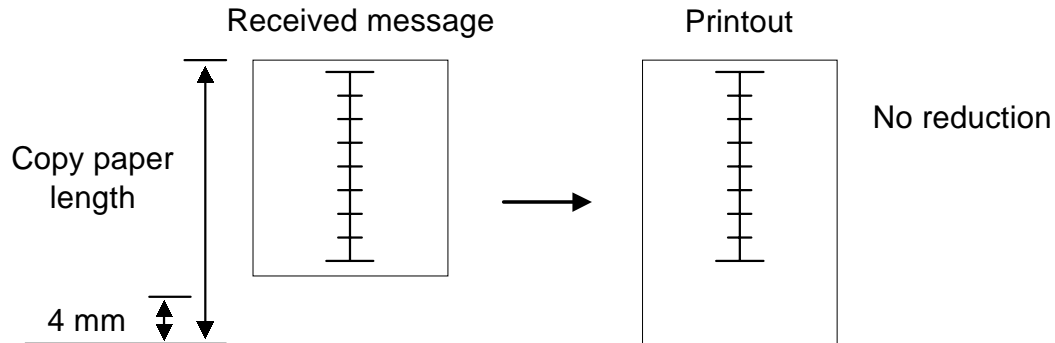
Case 2: If the image is longer than the copy paper length + x mm, it is printed on more than one sheet of paper.



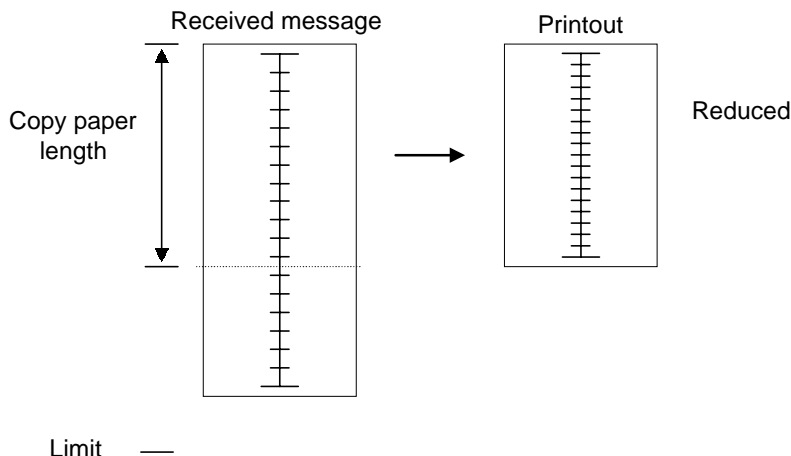
- The last few mm of the first page can be repeated at the top of the second page, or not (note the repetition or non-repetition of A in the diagram). This is another bit switch adjustment.
- The amount of repeated data can also be adjusted by bit switch. In the above diagram, it is 10 mm. The bottom of the repeated part of the data is always at 'paper length - 4 mm'. If the amount of duplicated data is 10 mm, then the top of the data is at 'paper length - 14 mm'.
- A mark can be printed on incoming messages that have been printed on more than one page.

If reduction is enabled:

Case 1: If the incoming message is more than 4 mm shorter than the copy paper, there is no reduction. This 4 mm is a fixed value.



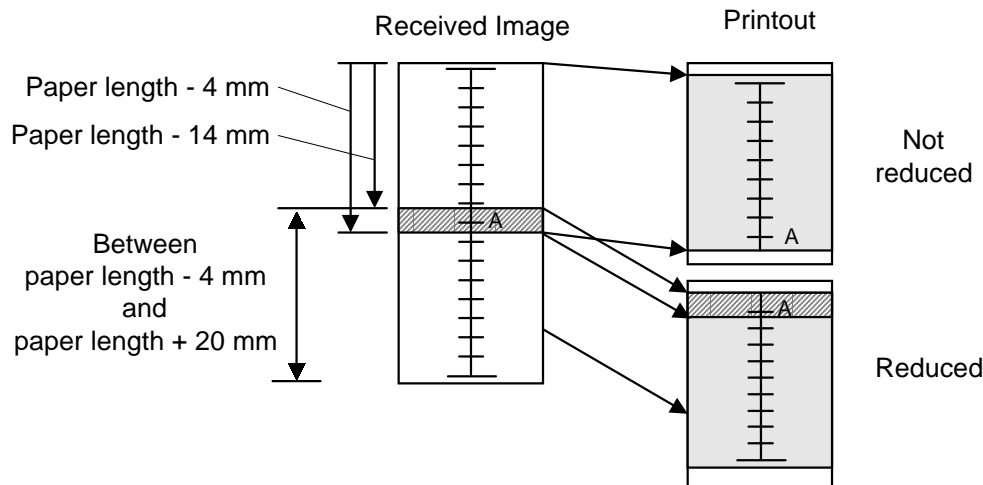
Case 2: If the incoming message is within 5 mm shorter than the copy paper and a certain maximum limit, the page is reduced in the sub-scan direction.



- This maximum limit depends on a bit switch setting. Typically, it can be between 0 and 155 mm, with a default setting of 20 mm. This limit is also known as the 'page separation threshold' (there is a different threshold for when reduction is disabled). It is used for all paper sizes.
- The size of the limit determines the maximum reduction ratio that is used. A larger value allows greater reduction. However, the actual reduction that is used depends on the length of the message; the message is always reduced to fit on the copy paper exactly, so the ratio will differ from case to case.

Case 3: If the length of the incoming message exceeds the maximum limit, a feature called reduction rate equalization comes into play. If this is switched off, the incoming page is printed on more than one page. However, reduction is only used in the final page.

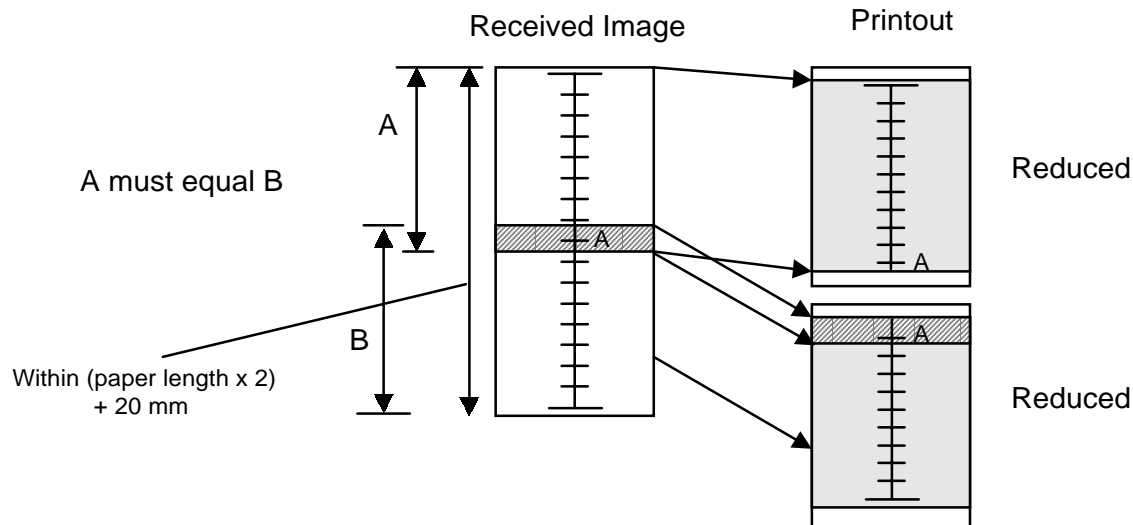
The diagram shows an example where duplication is enabled, the amount of duplicated data is 10 mm, and the maximum limit is 20 mm. Again, the maximum reduction rate for the final page depends on the value of this limit, and the actual reduction rate used depends on the amount of data that has to fit on the final page of copy paper.



1. The data up to [page length - 4 mm] will be printed on page 1, without reduction.
2. The last 10 mm of this data will be repeated at the top of the next page (this length can be adjusted or repetition can be switched off).
3. The remaining data will be printed on page 2, with reduction, if it is within [paper length - 4 mm] [paper length + 20 mm]. The 20 mm limit can be adjusted with bit switches.
4. If it is longer than this, page separation is done again. Data up to [paper length - 4 mm] will be printed on page 2, without reduction.
5. The process for page 3 and subsequent pages will repeat from step 2.

Case 4: If the length of the incoming message exceeds the maximum limit, and reduction rate equalization is on, the incoming page is printed on more than one page. Reduction is used on all pages of the output, at the same reduction ratio.

The diagram shows an example where duplication is enabled, the amount of duplicated data is 10 mm, and the maximum limit is 20 mm.



1. The machine determines how many pages will be needed to print the message, taking the following into account:

The final page (n) is such that the received image length is within (paper length x n) + 20 mm

The data must be reduced to fit on pages of length (paper length - 4 mm), with an equal reduction rate for each page.

The last 10 mm of the previous page will be repeated at the top of the next page (this length can be adjusted or repetition can be disabled).

2. The machine prints all the pages, at the same reduction rate.

Bit Switch Summary

- General -

- Reduction, enable/disable

- If reduction is disabled -

- Page separation threshold for when reduction is disabled
- Repetition of the last few mm of the previous page at the top of the next page
- Amount of repeated data (if repetition is enabled)
- Page separation mark
- Page separation, on/off

- If reduction is enabled -

- Page separation threshold for when reduction is enabled
- Reduction rate equalization, on/off
- Repetition of the last few mm of the previous page at the top of the next page
- Amount of repeated data (if repetition is enabled)
- Page separation mark
- Page separation, on/off

Note that there is a switch to disable page separation. If page separation is disabled, any message requiring this feature is kept in the SAF memory (using Substitute Reception) until a paper size is installed that can be used to print the message without page separation.