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STANDARDIZATION OF FREEZE FRAME TV CODECS

JUNE, 1990

OFFICE OF THE MANAGER
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Standardization of Freeze Frame TV Codecs

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The purpose of this report is to recommend a protocol and a compression technique to be considered as the standard for freeze frame teleconferencing equipment. Freeze frame technology as used in this report is a technique by means of which images normally requiring a wide band communication circuit for transmission can be transmitted over narrow band circuits.

Freeze Frame TV Codec
Group 3 Facsimile
Video Teleconferencing
90

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STANDARDIZATION OF FREEZE FRAME TV CODECS

JUNE 1990

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FOREWORD

Among the responsibilities assigned to the Office of the Manager, National Communications System, is the management of the Federal Telecommunication Standards Program. Under this program, the NCS, with the assistance of the Federal Telecommunication Standards Committee identifies, develops, and coordinates proposed Federal Standards which either contribute to the interoperability of functionally similar Federal telecommunication systems or to the achievement of a compatible and efficient interface between computer and telecommunication systems. In developing and coordinating these standards, a considerable amount of effort is expended in initiating and pursuing joint standards development efforts with appropriate technical committees of the Electronics Industries Association, the American National Standards Institute, the International Organization for Standardization, and the International Telegraph and Telephone Consultative Committee of the International Telecommunication Union. This Technical Information Bulletin presents an overview of an effort which is contributing to the development of compatible Federal, national, and international standards in the area of Video Teleconferencing. It has been prepared to inform interested Federal activities of the progress of these efforts. Any comments, inputs or statements of requirements which could assist in the advancement of this work are welcome and should be addressed to:

Office of the Manager
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STANDARDIZATION OF

FREEZE FRAME TV CODECS

JUNE, 1990

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STANDARDIZATION OF FREEZE FRAME TV CODECS

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STANDARDIZATION OF FREEZE FRAME TV CODECS

1.0 INTRODUCTION

1.1 PURPOSE OF THE REPORT

The purpose of this report is to recommend a protocol and a compression technique to be considered as the standard for freeze frame teleconferencing equipments. The recommendation in Section 4 is based on;

a) an analysis of freeze frame teleconferencing equipments presently in use,

b) consideration of previous and presently on-going standardization efforts in related areas by respected technical organizations, and

c) the unique requirements teleconferencing places on freeze frame technology; ie, compression, transmission, resolution, gray scale, storage, and display.

1.2 DEFINITION OF FREEZE FRAME TV CODEC

Freeze frame technology as used in this report is a technique by means of which images normally requiring a wide band communication circuit for transmission can be transmitted over narrow band circuits. This is accomplished by selecting individual frames or fields from a television signal train for transmission. The concept of motion is, of course, lost, but the information content of a frame is conveyed in its entirety (up to the specifications of the codec). The trade-off is channel bandwidth versus transmission time.

The most common source of images for a freeze frame system is a conventional TV camera. Since this source continuously generates TV frames at a rate of 30 per second (and fields at a rate of 60 per second) the freeze frame codec must have a memory in which to store the "grabbed" frame or field for transmission to prevent smear due to subject motion.

The most common display device for a freeze frame system is a conventional TV monitor. This device requires a continuous TV signal for display. Therefore the receive codec must also have a frame memory in which to store the received image and from which the monitor display can be refreshed continuously.

Thus the codec grabs a single TV frame or field, stores it in a memory, and transmits the stored image at the communication

channel data rate to the receive codec.

The receive codec receives the transmitted image usually pel by pel and reassembles the image in its frame memory from which a conventional still TV signal is generated for display refresh.

1.3 NEED FOR FREEZE FRAME STANDARDIZATION

Freeze frame technology grew out of the need to convey single images electronically and display them at geographically separated locations for a variety of applications. Unique equipments were designed for several of these applications and these designs were later adapted to satisfy the needs of many additional applications. There was no real need to communicate between equipments customized for different applications.

However, when used in a teleconferencing situation, it is essential for all equipments involved to be compatible so that they can communicate with each other either in pairs or in networks with many simultaneous users. Without this compatibility, the user is restricted to communicating only with like models of the same manufacturer. If all freeze frame equipments use the same standards, the user has access to all teleconferees using freeze frame equipments regardless of model or manufacturer.

This compatibility is essential for freeze frame teleconferencing if it is to expand.

1.4 TYPES OF FREEZE FRAME EQUIPMENTS

There are two categories of equipments currently being used to accomplish various forms of freeze frame teleconferencing with various levels of capabilities;

Terminals designed solely for freeze frame teleconferencing, and

Personal computers with frame capture peripheral circuit boards and freeze frame application software.

Each of the above freeze frame equipments provides its own level of functionality as a codec. They were originally developed for quite different purposes, usually unique requirements, so that their protocols and compression techniques are incompatible except for like terminals.

This report is directed to the terminals designed specifically for freeze frame teleconferencing. However, if the other equipments applicable to freeze frame wish to interoperate

with the dedicated terminals, they too must comply with the standards adopted.

1.4.1 Terminals Designed Solely for Freeze Frame Teleconferencing

Terminals designed solely for freeze frame teleconferencing provide comparatively user friendly dedicated controls to simplify the function of acquiring and transmitting an image. These controls can be used during a teleconference without distracting the conferee/operator. These terminals are further similar in that they use conventional video sources and displays; that is, the input and output video signals are often in RS-170 or RS-170A format.

The video almost always provides gray scale capability with resolution in the general range of 512 x 480 to 256 x 240 although other formats exist. Color is often an option. Communication is typically via the Public Switched Telephone Network (PSTN) at 9600 b/s but digital systems operating up to 500 Kbps are available.

There is generally compatibility/interoperability among the models produced by any one manufacturer, but interoperability does not exist between models of different manufacturers. The incompatibility encompasses at least communication standard, protocol, resolution, gray levels, compression, and field/frame mode.

Since these terminals were acquired specifically for visual conferences, it is clear that standardization would greatly increase the value and usefulness of the terminal by enhancing interoperability and assuring the owner of an ever increasing population of potential conferees.

1.4.2 PC's With Frame Capture Boards and Freeze Frame Application Programs

Freeze frame or frame grabber boards were originally intended to be used with personal computers as an input for desk top publishing and for image analysis systems. They fit physically into the PC and plug into the PC bus just as any other option cards.

The capabilities of frame grab boards analyzed range widely; resolution is typically in the 512 x 480 pixel range although 1280 x 1024 is not uncommon, nor is 256 x 240. Gray scale capability generally exceeds teleconferencing requirements being typically 8-bits. Again, both higher and lower precisions are Communication is accomplished through the serial RS-232 port on

the PC at data rates up to 9.6 Kbps. Special communication cards are available to provide data rates as high as 56 Kbps.

However, the frame grab board adapted to freeze frame teleconferencing has a major drawback to date in that the system is controlled from the keyboard and requires the operator's attention for keyboard command entry to initiate any function such as frame grab, transmit, store, etc. This is highly distracting to the conferee and to the teleconference compared to the usual single stroke command entry on a custom control pad normally provided with a freeze frame teleconference system.

The PC frame grab approach to freeze frame is generally not optimized for teleconferencing; therefore, little will be said about it in the subsequent text except that the standardization described could also be applied to these equipments to include them in the global realm of compatible equipments.

2.0 ANALYSIS OF FREEZE FRAME EQUIPMENTS

A comparison of several freeze frame teleconferencing equipments is made in Table 2-1. A tabulation of typical characteristics of a PC based freeze frame system with a frame grab board as input is also provided for reference. These "typical" parameters are based on a number of equipment specifications analyzed. The equipments tabulated include the following.

MANUFACTURER	MODEL	DEVICE NAME
Kodak	SV9600	Still Video Transceiver
Colorado Video, Inc.	286	Digital Transceiver
Image Data Corp.	CP-200	Photophone
Interand Corp.		DISCON Imagephone
Generic		Frame capture board

The parameters compared in Table 2-1 are major parameters which require standardization to foster interoperability. Functional niceties, operational controls, and packaging are not included. Examination of the data tabulated for just these few sample systems will clearly show the need for standardization if interoperability is to be achieved. The following parameters are tabulated.

Device name
Model number
Manufacturer
BW / multi-level / color
Field/Frame Modes
Video input format

TABLE 2-1: FREEZE FRAME EQUIPMENT COMPARISON

DEVICE NAME	Still Video Transceiver	Digital Transceiver	PHOT ing CP-2
MODEL NUMBER	SV9600	286	
MANUFACTURER	Kodak	Colorado Video, Inc.	Imag
BW/MULTI-LEVEL/COLOR	256-level, color	64-level, color 256-level option	12b-
MODES	Frame, Field	Frame, Field	
VIDEO INPUT	NTSC video; 1.0 V p-p, 75 Ohms RGB video; 0.7 V p-p, 75 Ohms	Color; NTSC video B/W; RS-170 US Std or 625-line European Std.	RS-1
VIDEO OUTPUT	NTSC video; 1.0 V p-p, 75 Ohms RGB video; 0.7 V p-p, 75 Ohms	Memory video; 1V p-p, 75 Ohms	RS-1
STORAGE	Solid state; 3,145,728 bits Luminance; 512 x 512 x 8 Color diff; 2 - 128 x 512 x 8	Solid state Resolution dependent, see below	
TRANSMISSION	PSTN dial-up circuit Internal modem 9600, 7200, 4800, 2400 bps	Color; up to 200 kbps Mono; up to 500 kbps External modem;RS-232/V.24, V.35 Option;RS-422, MIL-STD 188C	
RESOLUTION	Luminance; 512 x 512 Chrominance; 128 x 512	Memory configuration Color; Frame, 512 x 480 x 8 512 x 480 x 6 Field, 512 x 240 x 8 512 x 240 x 6 Multi-level; Frame, 256 x 480 x 8 256 x 480 x 6 Field, 256 x 240 x 8 256 x 240 x 6	Fast Pictu Docur
COMPRESSION	Transmission < 1 min at 9600 Implies 3,145,728/576,000=5.5	None; PCM transmission	Estim missi Fast Pictu Docum
TRANSMISSION TIME	Less than 1 minute at 9600 bps	Transmission time in seconds Color; 512 x 480 (6-bit / 8-bit), 512 x 240 (6-bit / 8-bit) 9600: 165 / 220 / 83 / 111 56 kbps: 28 / 38 / 14 / 19 200 kbps: 7.9 / 10.5 / 4.0 / 5.3 Mono; 512 x 480 (6-bit / 8-bit), 512 x 240 (6-bit / 8-bit) 9600: 77 / 103 / 39 / 52 56 kbps: 13 / 18 / 6.7 / 8.9 500 kbps: 1.5 / 2.0 / 0.75 / 1.0	At 96 Fast Pictu Docum
PROTOCOL	Proprietary, with error recovery by retransmission	Proprietary	Propr error
IMAGE BUILD-UP	Sequential	Sequential	

PHOTOPHONE Video Teleconferencing Work Station CP-200	DISCON Imagephone	GENERIC Frame Capture Board for Use in Personal Computers Various
Image Data Corporation	Interand Corporation	Available from a large number of manufacturers.
128-levels	16/256 levels	Most common; 256-level. Fewer levels as well as up to 24-bit color are available.
RS-170, 1 V p-p, 75 Ohm	RS-170, 1 V p-p, 75 Ohm	Frame, field. NTSC from TV cameras. Optionally from conventional and high resolution scanners.
RS-170	RS-170	NTSC, RGB.
	Not specified	Solid State
	PSTN, 9600 Bps Internal modem; V.29, V.27	Usually via the personal computer's RS-232 serial port at rates up to 19.9 Kbps. 56 Kbps boards are also available.
Fast mode; 200 x 300 x 7 Picture mode; 296 x 440 x 7 Document mode; 592 x 440 x 4	Normal; 640 x 480 x 8-bits Fast; 320 x 240 x 8-bits Document; 1280 x 480 x 4-bits	Most common is 512 x 480, but lower resolution as well as up to 1280 x 1024 pel are available.
Estimate based on stated transmission time and resolution. Fast mode; 5.5 Picture mode; 4.7 to 6.3 Document mode; 2.7 to 7.3	Not specified	Available with PCM only, or occasionally with high speed Group 3 facsimile algorithm.
At 9600 bps Fast mode; < 8 sec. at 9600 bps Picture mode; 15 to 20 sec. Document mode; 15 to 40 sec.	At 9600 Bps Normal; progressive transmission First image, four seconds Typical completion, 80 seconds Fast; progressive transmission First image, two seconds Typical completion, 30 seconds Document; Typical completion, 16 seconds	Generally not stated.
Proprietary, with automatic error correction	Proprietary, including DISCON Ring communication protocol	Protocol is determined by the communication program and circuit board installed.

Video output format
Storage capability
Transmission capability
Resolution
Compression
Transmission time
Protocol
Image build-up

The information is taken from manufacturer's data sheets. In those cases where the information was not specifically provided, it was interpolated from other related data which was presented. All such cases are indicated.

3.0 DISCUSSION OF STANDARDIZATION ACTIVITIES

3.1 AREAS FOR STANDARDIZATION

Study of Table 2-1 and review of additional freeze frame system specification sheets shows the specifications for the following areas to vary substantially among the various manufacturers.

Protocol
Functional capabilities
Compression algorithm
Image file format
Image structure (including resolution and gray/color parameters)

In order to achieve interoperability and compatibility among terminals of various manufacturers, it is essential that each terminal have at least a subset of their protocol, functional capabilities, compression capability, image format, and image structure in common with all other terminals. The protocol must contain the ability to communicate and arbitrate with the called terminal down to this common set of parameters regardless of the terminal's more sophisticated capabilities.

The process of standardization must define this global set of capabilities and the format in which its commands and data are communicated among terminals. The standard must, in addition, allow freedom for the manufacturer to implement in his terminals, capabilities beyond the global set which will assure his terminal's competitiveness in the marketplace.

3.2 STANDARDIZATION ACTIVITIES

Several highly regarded national and international technical organizations have recognized the importance of standards for teleconferencing equipments. These standards are to various degrees applicable to freeze frame which is, of course, a teleconferencing technique. Some organizations have directed their attention primarily to the basic functions and the protocol; others, primarily to the compression technique. Although these efforts are relatively recent and, in some cases, are still in progress, a substantial amount of very useful results have been developed. The major efforts are described below.

3.2.1 CCITT

Several excellent standardization efforts regarding imagery transmission are underway and in various stages of development in the United States. These efforts can be related to freeze frame standards as discussed below. The efforts have already become or are directed toward becoming CCITT Recommendations. Among them are the following United States activities.

Graphic teleconferencing; EIA TR-29, Subcommittee for Audiographic Teleconferencing
Facsimile standards; EIA TR-29 Subcommittee for Group 3 Facsimile Standards
Facsimile standards; EIA TR-29 Subcommitee for Group 4 Facsimile Standards.

3.2.1.1 EIA TR-29 Audiographic Teleconferencing Subcommittee

This group has started developing a standard for audiographic teleconferencing equipments. Audiographic teleconferencing is an electronic conferencing technique for the digital transmission, storage, and display of graphic hardcopy material, which may be accompanied by multiplexed digital voice. It is presently in an infant state of development and is as yet inadequate to form a basis for a freeze frame standard considering other applicable field proven standards available. It is included here to show the processes and considerations similar to those which must be considered for the freeze frame standard.

The basic resolution for which the standard is being developed is 200 pels per inch over an 8 1/2 x 11 inch image in black-white (1700 x 2200), and 100 pels per inch over 8 1/2 x 11 inches in gray scale or color (850 x 1100). It is desireable that the standard be based on the ISO Open Systems Interconnect 7-level architecture. Its goal is to specify the communication

protocol, networking protocol, basic functions, basic compression algorithm, and error correction technique. The proposed protocol is to allow the equipments to negotiate a range of each parameter such as resolution and compression.

Equipments for which this standard is being developed may include the features shown in Table 3.2.1-1 as baseline parameters. The protocol may allow arbitration of each of these features.

The protocol is expected to make use of packet transmission within the HDLC framework. Based on early discussions within the EIA TR-29 Committee, five packet types appear likely:

Command
Image data
Network control
Downloading
Compression

Packet reception is to be acknowledged if received without error, otherwise packet retransmission is to occur.

The development of an audiographic standard indicates use of a form of the HDLC format. As such it may incorporate fields from the standard HDLC format which includes fields of the type shown below:

Flags
Station address
Control
Source address
Destination address
Length
Sequence number
Message; command, data, response, etc.
CRC

To provide the capability required for audiographic teleconferencing, the protocol must consider commands of the type listed in Table 3.2.1-2. An indication of the system capability required can be obtained by reviewing this list. While none of these may be used explicitly in the form listed, similar concepts may be included in the protocol.

The protocol development is expected to review previously defined applicable recommendations and standards such as follow.

ANSI (American National Standards Institute).
ASCII, American Standard Code for Information Exchange, American National Standard X3.4-1977, ANSI, 1977.

TABLE 3.2.1-1;

POSSIBLE BASELINE PARAMETERS OF THE FUTURE CCITT AUDIOGRAPHIC TELECONFERENCING STANDARD

OPERATING MODES

Point-to-point
Multipoint
Broadcast
Mixed multi-point and broadcast
Error detection and correction (block retransmission)
Download mode for low data rate circuits

IMAGE MODES

Black-white
Gray scale
Color
Interactive annotation

SCANNING RESOLUTION (On an 8.5 x 11 inch document)

Black-white mode;	200 dpi horizontally and vertically
Gray scale mode;	100 dpi horizontally and vertically
Color mode;	100 dpi horizontally and vertically
Annotation mode;	100 dpi horizontally and vertically

DISPLAY RESOLUTION *

Black-white mode;	1000 TV lines, 2-bits
Gray scale mode;	1000 TV lines, 4-bits
Color mode;	1000 TV lines, 4-bits per color
Annotation mode;	1000 TV lines

OTHER FEATURES

Image zoom
Image rotation
Computer video input
Disk storage
Laser printout
Compression (Group 3 and JPEG)

* Nominal Resolution: may be impacted by HDTV standards.

TABLE 3.2.1-2;

POSSIBLE BASELINE CONTROL AND COMMANDS OF THE FUTURE CCITT AUDIOGRAPHIC TELECONFERENCING STANDARD

Image control
Image request
Image transfer permission
Header for image data
Image transfer done
Disk image request
Image is a disk image
Dispaly original image
Rotate image
Zoom current image
Create white board
Rotate on the fly
Enter interactive mode
Acknowledge for image control
Line functions
Block functions
Pointer move
Pointer off
Clear system
Download
Download done
Download acknowledge
Arbitration information request
Compression arbitration
Function arbitration
Arbitration done
System identification information

CCITT Yellow Book, Volume VII - Fascicle VII.2, Telegraph and Telmatic Services Terminal Equipment, Recommendations of the S and T series, Geneva 1981.

CCITT Red Book, Volume VII - Fascicle VII.3, Terminal Equipment and Protocols for Telematic Services, Recommendations of the T series, Geneva, 1985.

CCITT Blue Book, Volume VII - Fascicles VII.3, VII.5, VII.6 and VII.7, Terminal Equipment and Protocols for Telematic Services, Recommendations of the T Series, Geneva, 1989.

Electronic Industries Association, EIA Standard RS-449, General Purpose 37-Position and 9-Position Interface for Data Terminal Equipment and Data Circuit Terminating Equipment Employing Serial Binary Data Interchange, February, 1980, Electronic Industries Association, Engineering Department, 1980.

International Organization for Standardization, ISO 3309, Data Communication - High-level Data Link Control Procedures -Frame Structure, Second edition - 1979-07-01, Technical Committee ISO/TC 97, ISO Council, 1979.

International Organization for Standardization, OSI Reference Model, Version 2, Technical Committee ISO/TC 97 16 N227, ISO Council, Circa 1979.

3.2.1.2 EIA, TR-29, Group 3 Facsimile Standards

One of the most successful standardization efforts is the CCITT Recommendations for Facsimile; namely, T.2, T.3, T.4, and T.30. The latter of this series of recommendations defines the protocol for the Group 1, Group 2, and Group 3 facsimile equipments. Their success is attested to by the phenomenal growth of the facsimile industry and the extremely reliable communication among these equipments.

Of particular interest is Recommendation T.30 "Procedures for Document Facsimile Transmission in the General Switched Telephone Network". This document describes the procedures and signals to be used where facsimile equipments are to be operated over the general switched telephone network. Five separate and consecutive phases are described.

Phase A	Call set-up
Phase B	Pre-message procedure for identifying and Selecting the required facilities
Phase C	Message transmission

Phase D Post-message procedure including end-of-message, confirmation, and multi-document procedures
Phase E Call release

Two signalling systems are described: tonal and binary coded. The binary coded signalling system is based on a high level data link control (HDLC) developed for data transmission procedures. The basic HDLC structure consists of a number of frames each of which is subdivided into a number of fields. It provides for frame labelling, commands, responses, data transmission, error checking, and confirmation of correctly received information. Frames can be extended for additional requirements.

One of the fields, non-standard facilities field, permits variations on the basic application of the recommendation. For example, presently under consideration is the addition of the capability for the transmission of conventional computer data files within the vehicle of the CCITT T.30 Recommendation. This capability is of interest because it could also provide a highly developed protocol for freeze frame transmission. Higher resolution and higher data rates are also being considered.

The entire recommendation is too lengthy and complex to describe within the confines of this report. The reader is referred to the CCITT Blue Book, Volume VII - Fascicle VII.3, "Procedures for Document Facsimile Transmission in the General Switched Telephone Network".

A very straightforward way of describing the binary coded signal functions and features provided by the T.30 protocol is to present a tabulation of the various commands as in Table 3.2.1-3. This tabulation of commands and responses, and the sequence in which they are used, will give the reader a general idea of the functionality of the T.30 Recommendation.

An HDLC frame structure is utilized for all binary coded facsimile control procedures. The HDLC structure consists of a number of frames each of which is subdivided into a number of fields. An example of the HDLC format is shown in Figure 3.2.1-1. It shows an initial identification sequence which would be modified for subsequent transmissions.

The binary coded signal functions, commands, and responses of the T.30 Recommendation and supported by the HDLC format are listed in Table 3.2.1-3. Standard commands are listed in Table 3.2.1-4.

TABLE 3.2.1-3;

TABULATION OF COMMANDS AND RESPONSES FOR RECOMMENDATION T.30 BY SIGNALLING FIELDS

This Table is designed to be used in conjunction with Figure 3.2.1-1.

PREAMBLE

For the Binary Coded Procedure at 2400 b/s the preamble is the long training sequence per Recommendation T.4.

FLAG SEQUENCE

Denotes the beginning and end of an HDLC frame.

ADDRESS FIELD

Provides ID of specific stations in a multi-point network.

CONTROL FIELD

Provides the ability of encoding commands and responses.

INFORMATION FIELD

Variable length field containing the specific information for control and message interchange. Consists of two parts;

FCF Facsimile control field
FIF Facsimile information field

FACSIMILE CONTROL FIELD

The first eight bits of the HDLC information field. Defines the type of information to be exchanged.

1) Initial Identification- From the called to the calling station.
a) DIS, Digital identification signal; characterizes the CCITT capabilities of the called station.
b) CSI, Called subscriber identification- Specific identity of called station by international phone number.
c) NSF, Non-standard facilities- Identifies user requirements not included in Series T Recommendations.

2) Command to send- From the calling station wishing to be a receiver to the called station.
a) DTC, Digital transmit command- Response to DIS.
b) CIG, Calling subscriber identification- Indicates FIF is identification of the calling station.

c) NSC, Non-standard facilities command- Response to information in an NSF signal.

3) Command to receive- From transmitter to receiver.
a) DCS, Digital command signal- Resonse to standard capabilities of DIS signal.
b) TSI, Transmiting subscriber identification- Indicates FIF is identification of the transmitting station.
c) NSS, Non-standard facilities set-up- Response to information in NSC or NSF signal.

4) Pre-message response signal- From the receiver to the transmitter.
a) CFR, Confirmation to receive- message transmission may commence.
b) FTT, Failure to train- rejects training signal, requests retrain.

5) In-messqage procedure- From transmitter to receiver.
a) EOM, End of message- Indicates end of page and return to beginning of Phase B.
b) MPS, Multi-page signal- Indicates end of paageand return to beginning of Phase C upon receipt of confirmation.
c) EOP, End of procedure- Indicates end of page, no further documents forthcoming, proceed to Phase E upon receipt of confirmation.
d) PRI-EOM, Procedure interrupt-End of message- Same as EOM but requests operator intervention.
e) PRI-MPS, Procedure interrupt-Multi-page signal- Same as MPS but requests operator intervention.
f) PRI-EOP, Procedure interrupt-End-off-procedure- Same as EOP but requests operator intervention.

6) Post message responses- From receiver to transmitter.
a) MCF, Message confirmation- indicates a complete message has been received, additional messages may follow positive response to MPS or EOM.
b) RTP, Retrain positive- complete message received, additional message may follow after retrain and CFR.
c) RTN, Retrain negative- previous message not satisfactorily received.
d) PIP, Procedural interrupt positive- message has been received, but further transmission requires operator intervention.
e) PIN, Procedural interrupt negative- message not satisfactorily received, and further transmission requires operator intervention.

(Page 3 of Table 3.2.1-3)

7) Other line control signals
a) DCN, Disconnect- Initiation of Phase E.
b) CRP, Command repepat- previous command received in error, repeat in its entirety.

FACSIMILE INFORMATION FIELD

Additional 8-bit octets following the control field to clarify the facsimile procedure; eg, definition of informaton in DIS,DCS, DTC, CSI, CIG, TSI, NSC, NSF, and NSS signals.

1) DIS standard capabilities- defines the standard Group 1, Group 2, and Group 3 facilities of the called station.
2) DCS standard commands- See Table 3.2.1-4.
3) DTC standard commands- See Table 3.2.1-4.
4) CSI coding formats- FIF contains the international telephone number, with area code, country code, and subscriber number of the called station.
5) CIG coding format, FIF contains the international telephone number, with area code, country code, and subscriber number of the calling station.
6) TSI coding format, FIF contains the international telephone number, with area code, country code, and subscriber number of the transmitting station.
7) Non-standard capabilities (NSF, NSC, NSS)-The first octet contains a CCITT country code. The succeeding information is not specified and can be used to describe non-standard facilities.
8) Frame checking sequence, FIF contains a 16-bit error checking code.

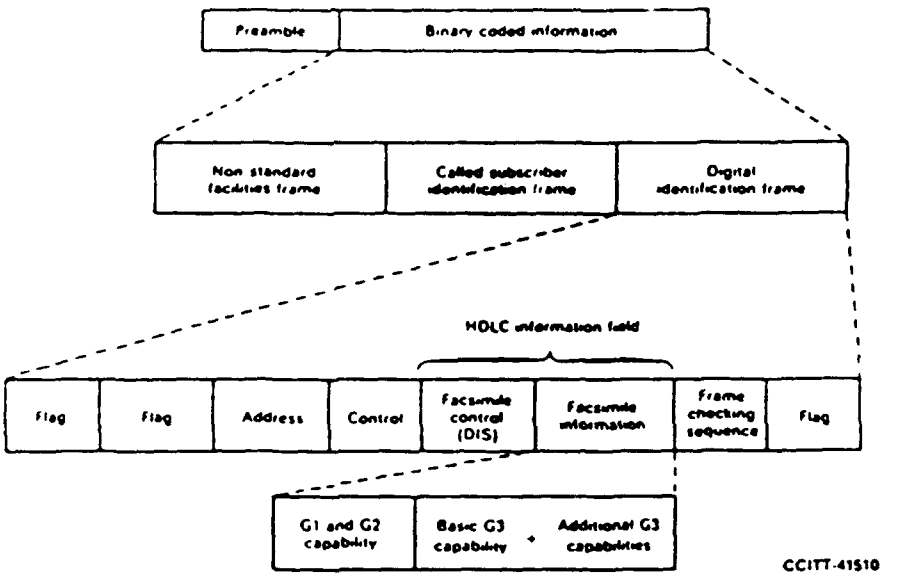


FIGURE 16/T.30

FIGURE 3.2.1-1, EXERPT FROM THE CCITT RECOMMENDATION SHOWING THE HDLC FRAME STRUCTURE

TABLE 3.2.1-4;

DCS AND DCT STANDARD COMMANDS

(Selected commands)

Transmitter- T.2 operaton
Receiver- T.2 operation
Transmitter- T.3 operation
Receiver- T.3 operation
Transmitter- T.4 operation
Receiver- T.4 operation
Data signalling rate
- V.27 ter fall back mode
- V.27 ter
- V.29
- V.27 ter and V.29

Vertical resolution = 7.7 line / mm
Two dimensional coding capability
Recording width capabilities
- 1728 picture elements along a scan line of 215 mm
- 1728 picture elements along a scan line of 215 mm and 2048 picture elements along a scan line of 255 mm and 2432 picture elements along a scan line of 303 mm
- 1728 picture elements a scan line of 215 mm and 2048 picture elements along a scan line of 255 mm

Maximum recording length capability
- A4 (297 mm)
- Unlimited
- A4 (297 mm) and B4 (364 mm)

Minimum scan line time capability at the receiver
- 20 ms at 3.85 l/mm: T(7.7) = T(3.85)
- 40 ms at 3.85 l/mm: T(7.7) = T(3.85)
- 10 ms at 3.85 l/mm: T(7.7) = T(3.85)
- 5 ms at 3.85 l/mm: T(7.7) = T(3.85)
- 10 ms at 3.85 l/mm: T(7.7) = 1/2 T(3.85)
- 20 ma at 3.85 l/mm: T(7.7) = 1/2 T(3.85)
- 40 ms at 3.85 l/mm: T(7.7) = 1/2 T(3.85)
- 0 ms at 3.85 l/mm: T(7.7) = T(3.85)

Extend field
2400 bit/s handshaking
Uncompressed mode

Note; Tranmitter and receiver operation includes compression schemes specified in the appropriate T Recommendations.

3.2.1.3 EIA, TR-29 Group 4 Facsimile Standards

Technology in the areas of digital communication circuits and scanners/printers has advanced substantially since the inception of the Group 3 facsimile standards. The advancement and new and more demanding requirements were of such magnitude that it was considered prudent to develop a new standard rather than to amend the Group 3 standard. The new standard, Group 4, provides for new features such as:

gray scale images,
color images,
digital transmission,
image storage and display as well as printout,
higher resolution images,
interactive operation,
higher data rates,
and mixed mode operation with other telematic services.

Group 4 performance is specified in a series of Recommendations adopted by the CCITT as shown in Table 3.2.1-5. Highlights of these recommendations as they could be applied to freeze frame standardization will be pointed out below.

Recommendation T.563, "Terminal Characteristics of Group 4 Facsimile Apparatus" specifies the basic capabilities of a Group 4 terminal. The Group 4 facsimile service was developed mainly for use on public data networks (PDN) including circuit-switched, packet-switched, and the integrated services digital network (ISDN). It may also be used on the public switched telephone network (PSTN), but it requires that data be received essentially without transmission errors. The redundant information in the facsimile signal is reduced prior to transmission. Although the basic image type of Group 4 systems is black and white, provision is made for transmission of gray scale and color images. The rules for Group 4 facsimile service are defined in Recommendation F.184. The coding schemes for black and white operation are defined in Recommendation T.6.

The basic characteristics of Group 4 facsimile service relevant to this discussion are tabulated below in a condensed form.

Direct document transmission from one subscriber to another.

All terminals must be compatible with each other at the basic level. Additional functions may be invoked.

A range of transmission data rates is provided.

The page is the basis for image formatting and transmission.

TABLE 3.2.1-5:

CCITT RECOMMENDATIONS SUPPORTING GROUP 4 FACSIMILE AND TELETEX

F.184	-	Defines the rules to be followed in the Group 4 facsimile service.
F.200	-	Specifies the Group 4 facsimile terminal identifier and the date-time coding.
T.6	-	Defines details of the Group 4 facsimile coding scheme.
T.60	-	Defines the network dependent communications procedures for Teletex.
T.62	-	Defines the end-to-end procedures to be used within Teletex and Group 4 facsimile service (network independent - session service).
T.70	-	Specifies network dependent procedures for forming a network independent transport service.
T.71	-	Specifies network dependent procedures for forming a network independent transport service (to the extent applicable).
T.400 Series	-	Defines the Open Document architecture and the DTAM services and protocol for the purpose of the document transfer and manipulation.
T.503	-	Document application profile for the interchange of Group 4 Facsimile documents.
T.521	-	Communication application profile BTO for Document bulk transfer based on the session service.
T.563	-	Terminal characteristics for Group 4 Facsimile Apparatus.

Although A4 and the North American page formats are basic, various size pages can be accommodated.

The content, layout and format of the output image must be identical to the input image.

The coding schemes defined in T.6 are standard, but provision is made for the use of other schemes. See Section 3.2.2 on the JPEG algorithm.

The basic functions of Group 4 service are tabulated below in condensed form.

The Group 4 terminal handles the end-to-end contol procedures of T.62, the document interchange protocol of T.503 and T.400 series, and the coding scheme and control functions of T.6.

Scanning, transmitting, receiving, and presenting hard and soft copy.

Basic page orientation is vertical, scanned and reproduced size is ISO A4 and North American format.

The image area is scanned so that picture elements are processed from left to right and subsequent scans from top to bottom at both the transmitter and the receiver.

The standard resolution specification and the number of pels per scan line and the number of scan lines per image height are shown in Figure 3.2.1-2 which is taken from Recommendation T.563.

The redundancy reducing coding schemes are defined in Recommendation T.6.

The recommendation further defines the possibility of using optional functions which can be negotiated during the handshaking control procedure of T.62. The "standard" optional functions include the following:

Different pel transmission densities
Optional coding schemes
Gray scale images
Color images
Mixed mode operation
Resolution conversion algorithm
Other image sizes
Escape to private and national options

Recommendation F.184, "Operational Provisions for the International Public Facsimile Service Between Subscriber

TABLE 2a/T.5

Number of pels and the scan line length for different paper sizes

		ISO A4	North American	ISO B4	ISO A3
Number of picture elements along a scan line	Resolution (pels/25.4 mm)				
	200	1728	1728	2048	2432
	240	2074	2074	2458	2918
	300	2592	2592	3072	3648
	400	3456	3456	4096	4864
Scan line length (mm) (P)		219.46	219.46	260.10	308.86
Paper width (mm) (Q)		210	215.9	250	297
P – Q		9.46	3.56	10.10	11.86

TABLE 2b/T.5

Nominal number of scan lines for various paper sizes

		ISO A4	North American	ISO B4	ISO A3
Nominal number of scan lines per page for each pel-transmission density	Resolution (pels/25.4 mm)				
	200	2339	2200	2780	3307
	240	2806	2640	3335	3969
	300	3508	3300	4169	4961
	400	4677	4400	5559	6614
Nominal paper length (mm)		297	279.4	353	420

FIGURE 3.2.1.-2: GROUP 4 STANDARD RESOLUTION SPECIFIED IN CCITT RECOMMENDATION T.5

Stations with Group 4 Facsimile Machines (Telefax 4)", defines the operation of Group 4 service. In particular, it calls out the appropriate CCITT Recommendations as described in this report to assure performance of the Group 4 functions and to insure compatibility between terminals. F.184 defines three phases of operation together with subphases:

Preparation of information to be transmitted.
Transmission
    Call establishment
    Pre-information phase
    Information transfer
    Post information phase
    Call clearing
Output; displaying the information

Recommendation T.62, "Control Procedures for Teletex and Group 4 Facsimile Services", forms the session layer protocol for Group 4 facsimile. It consists of a series of commands and responses, each with a number of parameters, and rules for their use by means of which control and information transfer is effected among terminals. An indication of the function and power of these commands can be obtained by reviewing Table 3.2.1-6. Only the command words are listed (without parameters) due to the length of the overall list. As can be seen these commands cover call establishment, information transfer, session management, document control, and error recovery. The commands and responses are transmitted in specific formats as is shown in Figure 3.2.1-3.

The rules by which these commands accomplish their intended purpose can best be shown in a simple state diagram as depicted in Figure 3.2.1-4. This is the basic state diagram and shows the process of advancing from function to function within the transmit terminal and the receive terminal in response to the commands received and the responses evoked. This is the most basic of many state digrams, each of which provides for a unique set of circumstances. It is the vehicle by means of which an image is transferred from the terminal which is serving as the transmitter to the receiving terminal.

The recommendation is far more sophisticated than the previous description may indicate, and therefore the reader is encouraged to review the recommendation itself since space does not permit further expansion here.

The T.400 series of Recommendations defines a document architecture and structuring for the interchange of documents. A set of image attributes is also defined: some applicable primarily to text, others developed primarily for 'photographic' images. It is the latter attributes that are of interest to freeze frame technology. These include the following:

TABLE 3.2.1-6;

COMMANDS AND RESPONSES TO IMPLEMENT GROUP 4 FACSIMILE CONTROL PROCEDURES

SESSION LEVEL COMMANDS AND RESPONSES

Session establishment and clearing

CSS - Command, session start
RSSP - Response, session start positive
RSSN - Response, session start negative
CSE - Command, session end
RSEP - Response, session end positive
CSA - Command, session abort
RSAP - Response, session abort positive

Information transfer

CSUI - Command, session user information
RSUI - Response, session user information

Session management

CSCC - Command, session change control
RSCCP - Response, session change control positive

DOCUMENT COMMANDS AND RESPONSES

Document control

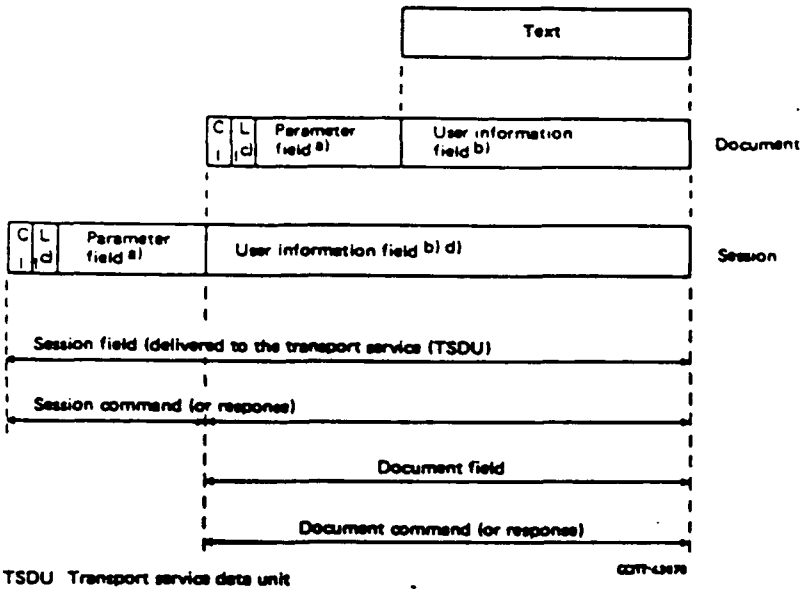
CDS - Command, document start
CDC - Command, document continue
CDCL - Command, document capability list
RDCLP - Response, document capability list positive
CDE - Command, document end
RCDE - Response, document end positive
CDD - Command, document discard
RDDP - Response, document discard positive
CDR - Command, document resynchronize
RCDR - Response, document resynchronize positive

Information transfer

CDUI - Command, document user information

Error recovery

RDGR - Response, document general reject
CDPB - Command, document page boundary
RDPBP - Response, document page boundary positive
RDPBN - Response, document page boundary negative



a) Present only if LI ≠ 0.

b) Present only after user information commands (or responses).

c) See § 5.2.5.

d) See § 1.2.1.

FIGURE 4/T.62

Illustration of the relationship between session and document commands/responses

FIGURE 3.2.1-3; COMMAND AND RESPONSE FORMATS FOR GROUP 4 FACSIMILE

(Taken from CCITT Recommendation T.62)

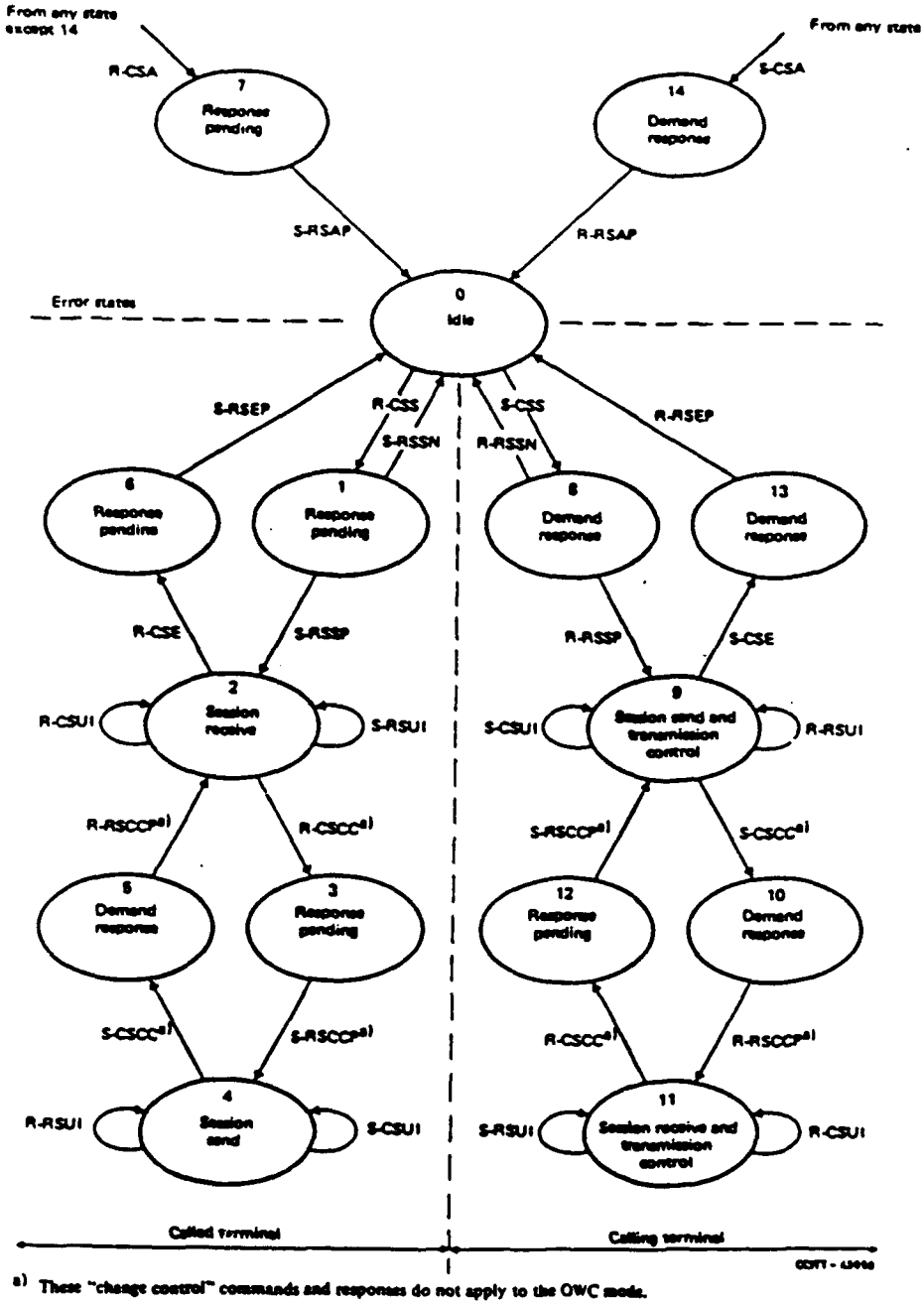
CI or RI - Command or Response Identifier. Identifies the command or response concerned.

LI - Length indicator. Represents the length in octets of an associated field or group of fields.

PI - Parameter identifier. Indicates the type of information contained in an associated field or group of fields.

PV - Parameter value. The information that represents the value of the parameter identified by PI.

Field - Either a group of bits within a single octet or a group of one or more octets, used to represent a particular set of information.



a) These "change control" commands and responses do not apply to the OWC mode.

FIGURE 1/T.62

State transition diagram for TWA and OWC session modes

FIGURE 3.2.1-4; BASIC STATE TRANSITION DIAGRAM FOR GROUP 4 FACSIMILE

(Two way alternate, TWA, and one way continuous,OWC, session modes. From CCITT Recommendation T.62)

Page coordinate system
Positioning of photographic elements
Dimensions in picture elements
Initial offset
Overlay
PEL path
Line progression
PEL transmission density
Type of coding (defined in Recommendation T.6)
Coding attributes
    Number of pels per line
    Number of discarded pels
    Number of lines
    Compression type, including uncompressed parts

The attributes used may be specified by invocation or by negotiation.

3.2.2 Joint Photographic Experts Group (JPEG)

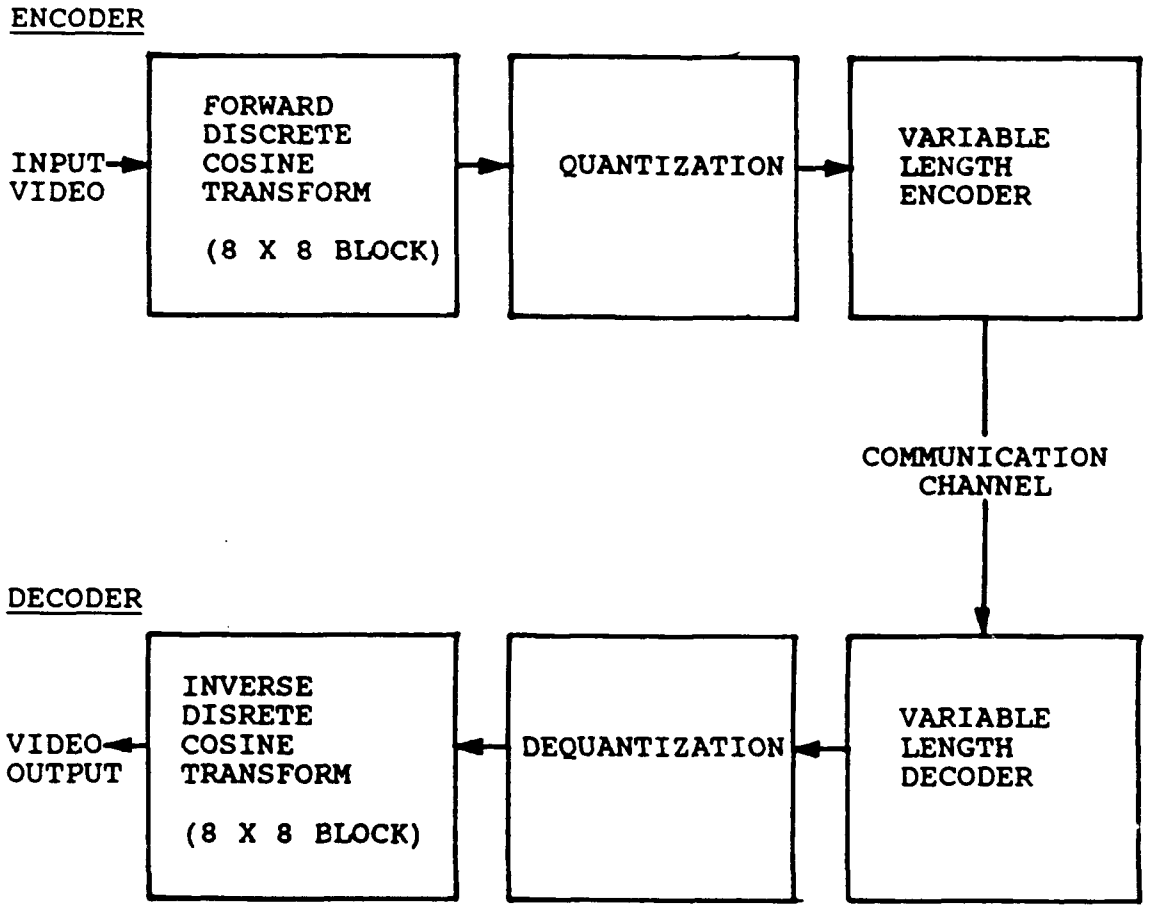
The JPEG committee is a joint working group of ISO/JTC1/SC2/WG8 (Picture Coding) and the CCITT SG VIII Subgroup on Common Components for Image Communication. The effort will produce a common standard for ISO and the CCITT. Its goal is to develop a practical algorithm optimized for the compression of gray scale and color still frame imagery. The algorithm is not constrained by image size or format and therefore is applicable to most imagery transmission applications such as freeze frame television, Group 4 facsimile, etc. The Group will release a draft proposal in early 1990.

The compression technique studied, evaluated, and finally selected as JPEG's candidate for the proposed compression standard is based on the Discrete Cosine Transform technique together with certain enhancements. The structure of the algorithm consists of a "Baseline System" and optional "Extended Features".

The Baseline system provides two-dimensional Discrete Cosine Transform compression for gray scale and color images. The Baseline System will form the default compression technique of every JPEG Encoder/Decoder thus assuring interoperability among standard systems. The two-dimensional Discrete Cosine Transform is performed on 8 x 8 blocks of pels of up to 8 dimensional bits per pel for each signal component; ie, luminance and color components. This is followed by coefficient quantization and Huffman coding. The compression efficiencies obtained in the JPEG evaluation tests have been excellent. Figure 3.2.2-1 is a block diagram of the JPEG coder system.

FIGURE 3.2.2-1

BLOCK DIAGRAM OF JPEG GRAY SCALE CODER
PROPOSED FOR GROUP 4 FACSIMILE



The Extended Features include functions which provide additional improvements in coding efficiency as optional (arbitrated) enhancements to the Baseline System. They include Arithmetic Coding, Progressive Transmission, and ability to accomodate input signals of greater than 8 bits per pel per component. The Extended Features also provide a lossless (reversible) mode of compression.

Table 3.2.2-1 lists the major features of the JPEG gray scale algorithm and compares the Baseline system with the Extended system.

The Baseline system transmits code and reproduces the picture elements sequentially along a scan line and builds the image by displaying scan lines squentially from top to bottom as they are reconstructed. The Extended system builds up the image by first presenting a course image of 'random' picture elements and then progressively enhancing the image up to a satisfactory level as more data is received. In the ultimate, a lossless image can be produced given adequate time and source data.

In the Baseline system, the reproduced image usually does contain some degree of loss of quality. This is due primarily to the quantization applied to the transform coefficients. However, the algorithm takes advantage of the relative visual impact of the various coefficients. The visibility matrix is shown in Table 3.2.2-2. The visual effect of each coefficient is inversely proportional to the magnitude of the entry in the corresponding position in the table. Other features of the algorithm which provide the excellent performance achieved are listed in Table 3.2.2-3. As mentioned above, The Extended system can be made lossless provided adequate data is transmitted. The remainder of the table is self explanatory. As shown under 'Application', the Baseline system is well suited to freeze frame transmission.

3.2.3 TTC Recommendation

3.2.3.1 Basic Recommendation

The TTC (Telecommunication Technology Committee of Japan) has published a recommendation for freeze frame video transmission entitled "Standard for Still-Video Communication Over an Analog Telephone Network". This recommendation was prepared by Mitsubishi Electric Corporation, Nippon Telegraph and Telephone Corporation, Sanyo Electric Company, Ltd., and Sony Corporation.

Since the Recommendation is not as readily available as the CCITT Recommendations, it is included as Appendix B. The

TABLE 3.2.2-1

JPEG GRAY SCALE ALGORITHM FEATURES

	BASELINE	EXTENDED
TRANSMISSION MODE	SEQUENTIAL	PROGRESSIVE
REVERSIBILITY	USUALLY LOSSY	CAN BE LOSSLESS
MAXIMUM INPUT/OUTPUT CODING PRECISION PER PICTURE ELEMENT	UP TO 8-BITS	UP TO 16-BITS
VARIABLE LENGTH CODING	HUFFMAN	ARITHMETIC
APPLICATIONS	GROUP 4 FAX VIDEOTEX FREEZE FRAME	REMOTE ACCESS TO DATA BASE

TABLE 3.2.2-2

JPEG ALGORITHM VISIBILITY MATRIX

16	11	10	16	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	57	69	56
14	17	22	29	51	87	80	62
18	22	37	56	68	109	103	77
24	35	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

The data in the table represents the relative visual impact of the various coefficients of the two dimensional cosine transform of an 8 x 8 block of picture elements. The entries are an inverse relationship to the relative impact. The entries are arranged in correspondence to the terms they represent: the 0 order (d.c.) term being in the upper left corner.

TABLE 3.2.2-3

JPEG ALGORITHM; METHOD OF CODING AC COEFFICIENTS

ZIG-ZAG SEQUENCE

ZERO ORDER (DC) COEFFICIENTS ARE DEFINED BY RUN LENGTH CODE

AC COEFFICIENTS ARE DEFINED BY VARIABLE LENGTH CODE

END OF BLOCK CODE

Recommendation defines a still frame video system providing analog transmission for video, and digital transmission for data using a unique modulation scheme on PSTN analog circuits.

The proposed recommendation defines procedures and conditions for the following five specific areas:

Physical Interface
Signal Structure
Signal Characteristics and Transmission Method
Communication Protocol
Screen Mode

3.2.3.2 Physical Interface

The physical interface to the telephone circuit is defined in terms of the Japan Ministry of Posts and Telecommunications, specifically, M.P.T Ordinance No. 31 of 1985, M.P.T., and Notice No. 399. These define connectors, signal levels, and operation with either power supply polarity. Receive signal level is -40 dBm or greater.

3.2.3.3 Signal Structure

The signal is stuctured into the following segments:

Dual tone; Initiates terminal changeover from voice to video mode.

Control Information; Consists of three parts- Block synchronization, signal which provides block, clock, and bit synchronization.

Amplitude calibration, which transmits a pattern of sixteen gray levels for receiver calibration.

ID, which identifies the transmitting terminal and its capabilities. It also defines the video mode used in the following transmission.

Picture data, which consists of the amplitude-phase modulated picture information.

3.2.3.4 Signal Characteristics and Transmission Method

The transmission is in amplitude-phase modulated format. Binary signals are transmitted at full amplitude. Each bit consists of three carrier cycles: "1" in phase one, and "0" in phase two. The picture information is quantized linearly into 16 levels. Each level is transmitted as a unique combination of

amplitude and phase according to the following tabulation.

PICTURE LUMINANCE LEVEL	(------CARRIER MODULATION------) RELATIVE AMPLITUDE	PHASE	NO. OF CYCLES
0 (Black)	8 (Max)	1	1
1	7	1	1
2	6	1	1
3	5	1	1
4	4	1	1
5	3	1	1
6	2	1	1
7	1	1	1
8	1	2	1
9	2	2	1
10	3	2	1
11	4	2	1
12	5	2	1
13	6	2	1
14	7	2	1
15 (White)	8	2	1

Note: The carrier frequency is 1747.82 Hz.

The following parameters are also defined under signal characterisitics and transmission method: amplitude and group delay characteristics, received signal frequency tolerance, scrambling, ID signal form, transmission sequence, guard cycle, and picture data transmission.

3.2.3.5 Communication Protocol

The communication protocol specifies communication procedures, speech/picture switching, and control information.

a) Communication Procedures; Two types of procedures are defined; the Basic Procedure and the Extended Pprocedure.

b) Basic Procedure; Transmits a picture without a handshake after the dual tone has been sent out.

c) Extended Procedure; allows picture transmisssion with handshaking in order to utilize a variety of functions such as those controlled by the information shown in the following tabulation:

Picture mode
- Mode A (160 x 100 pel)
- Mode B (96 x 100 pel)
- Color

Waiting time
Supplier code
Abnormal communication
Type of control
    Polling
    Extended option
    Response
    Character-data
    NAK control
Supplier data
Receive capability (to insure compatibility)
ID extension
Frame check sequence
Error handling

3.2.4 National Communications System (NCS) Letter

The National Communications System assists the President, the National Security Council, the Office of Science and Technology Policy, and the Office of Management and the Budget in planning for and provision of national security and emergency communications for the Federal Government. In support of the mission of the NCS is the Federal Telecommunication Standards Program (FTSP). The FTSP develops Federal standards to insure interoperability or achieve interface between functionally similar networks and equipments.

For this reason, the NCS is investigating the feasibility of developing a Federal standard for freeze frame video systems and has prepared and distributed a letter to manufacturers of freeze frame equipments. The purpose of the letter is to advise the manufacturers that the NCS is in the process of preparing a freeze frame standard and to solicit their input, assistance, and suggestions rgarding the standardization effort.

A copy of the letter is contained in Appendix A.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 REQUIREMENTS OF THE FREEZE FRAME STANDARD

Any standard has, as its principal requirement, the ability to support the function for which it is being developed. In this case it is to support a freeze frame system used for teleconferencing. The first step in developing a standard is to list the functions required in order to permit the system to perform its intended function; ie, teleconferencing.

There are two levels of functions to be supported; baseline and extended. The baseline functions constitute that minimal set of functions which are required for a teleconference to be conducted satisfactorily. The baseline functions are incorporated into all equipments. The extended functions include those functions which enhance the conduct of the teleconference by providing additional functions, unique functions, or a higher level of performance of the baseline functions. The extended functions are generally incorporated into higher level equipment models. Therefore, the baseline functions assure interoperability at a specific minimum level of performance while the extended functions provide a competitive edge to the manufacturer who incorporates them into his equipments.

The freeze frame standard must accommodate the baseline functions. It must have provision for accommodating the extended functions as they are required.

4.1.1 Baseline System

The baseline system functions are those required in order to accomplish a teleconference while maintaining at least a minimum degree of compatibility among all freeze frame terminals. The following discussion deals with functions rather than system components. A baseline system is shown in Figure 4.1.1-1 in a point-to-point configuration. It indicates a source of video which is typically a TV camera. The video output is typically applied to a television type display device. The interface with these devices is not a subject for standardization except that they must support the transmitted video format. The standard must define the parameters allowed for these functions as they are transmitted over the communication circuit, the rate and format in which they are transmitted, and the word structure for commands, responses, and data. The basic functions which are deemed necessary in order to conduct a conference (exclusive of audio) are tabulated below.

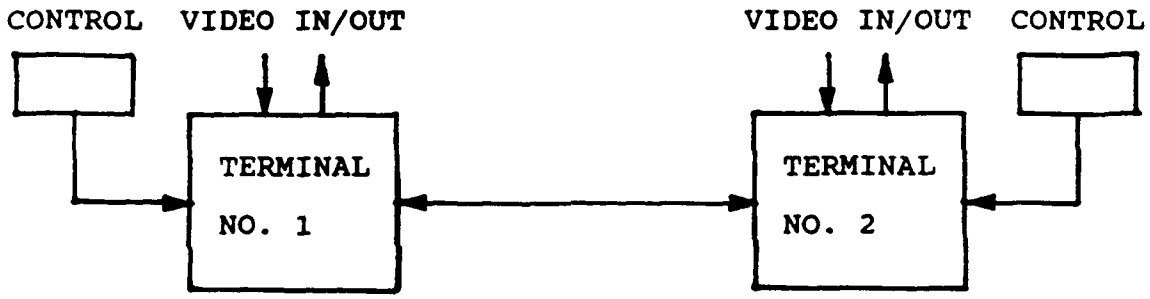
Video format for internal storage and transmission
- Resolution
- Image width in pels
- Image height in pels
- Number of gray levels
- Format

Compression algorithm
Transmission data rates
Transmission modes;
- Point-to-point

Error detection and correction technique
Communication protocol;
- Message header
- Command format

FIGURE 4.1.1-1

BASELINE FREEZE FRAME SYSTEM



Responses
Error detection and correction format
Call and network set-up
Pre-message procedure and addressing
Message transmission
Post-message procedure
Call and network release
Additional functions deemed essential

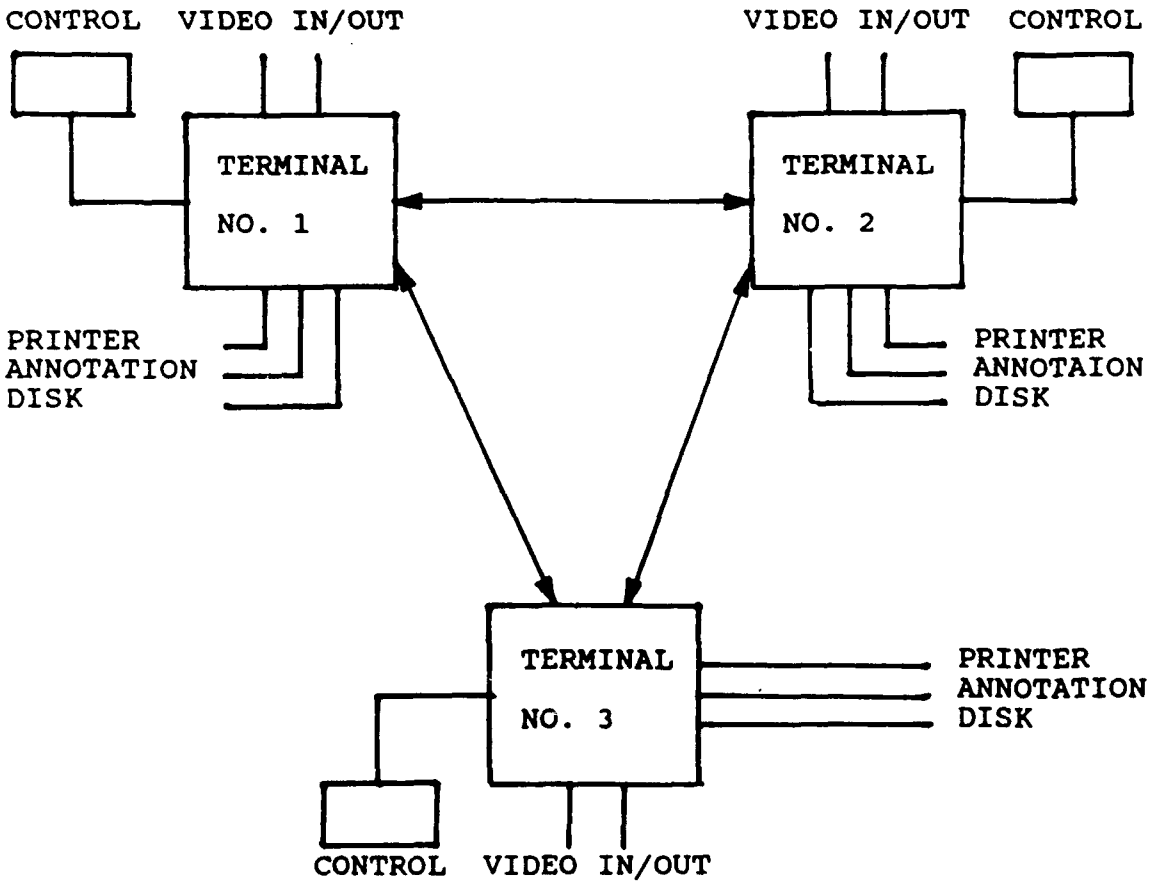
4.1.2 Extended System

The extended system includes all of the above functions plus a set of functions to enhance the conference which may be negotiated at the start of the conference. Figure 4.1.2-1 depicts an extended system concept in a three node multi-point network configuration. Along with additional features is the requirement to arbitrate among equipments connected in a teleconferencing network to provide the maximum capability set of common functions required for conduct of the teleconference. Only those functions which are desirable in freeze frame terminals and which are required, controlled, and utilized by other terminals in the network are subjects for the standard. The following is a tabulation of candidates for extended features.

Image zoom
Image rotate
Download to disk
Read from disk
Annotation
Black
White
Line
Block
Write
Erase
Color
Resolution (other than baseline)
Image width in pels
Image height in pels
Number of gray levels
Color
Format (RGB, palette, etc.)
Print
Broadcast mode, mixed mode, point-to-point, multi-point
Other data rates

FIGURE 4.1.2-1

EXAMPLE OF EXTENDED FREEZE FRAME SYSTEM



4.2 CONCLUSION

The standardization efforts described earlier, in particular the CCITT Recommendations, are all related to the transmission of imagery. They contain the type of format required in order to provide the basic imagery communication functions. Their structure establishes a basic definition of the service to be provided and then provides the performance specifications and the protocol to assure reliable, compatible, imagery communication. In general, they also provide the capability to negotiate enhanced functions.

It appears, therefore, that they are well suited as the basis from which to develop a freeze frame standard. In fact, with some modification the freeze frame requirements might be incorporated into an existing standard as one of its capabilities thereby serving as a freeze frame standard.

4.3 RECOMMENDATION

The recommended standard for Freeze Frame TV has three basic elements -- picture format, compression algorithm, and communication protocol. The proposed standard for each of these items is presented below.

4.3.1 Picture Format

Based upon the prior technical discussion in this report, the recommended picture format for monochrome operation is listed below.

- Pixels per line 512
- Lines per picture 480
- Number of gray levels 64 (6 bits per pel)

When operating in the color mode the recommended format of the two chroma signals (B-Y, R-Y) is listed below.

- Pixels per line 256
- Lines per picture 240
- Number of levels 64

4.3.2 Compression Algorithm

A major consideration in the selection of a compression algorithm for the standard is that images transmitted by freeze frame systems are predominantly gray scale or color images. Rarely are black-white images (1-bit images) involved. Even when

the subject matter for the TV camera generating the images is, for example, a black-white chart, the output of the camera is in reality a gray scale image.

The Group 3 and Group 4 facsimile standards presently incorporate a basic run length coding scheme in either one or two dimensions. These techniques provide adequate compression for black-white document transmission. The compression and restoration is lossless. However, the efficiency of this type of compression is rather low when applied to gray scale or color transmission and is one of the reasons for the interest in the newly developed JPEG algorithm. The JPEG algorithm was developed specifically for the transmission of gray scale and color images of all types such as freeze frame and is not limited to facsimile.

Since freeze frame images are either gray scale or color and rarely black-white, the JPEG algorithm is recommended as the compression algorithm to be incorporated into a freeze frame standard.

4.3.3 Communication Protocol

It is recommended that the T.30 Facsimile Standard be used as a framework for a freeze frame standard protocol. This recommendation is based on the fact that the primary orientation for Freeze Frame equipment is for transmission over the PSTN, and the T 30 standard already provides for excellent operation over the PSTN.

The Recommendations which support T.30 Facsimile have certainly proven their merit in providing an image transmission capability. The inherent ability to modify the parameters of the standards specifying the images to be transmitted from the fax requirements to the freeze frame requirements make them an excellent vehicle for freeze frame. Presently the T.30 standards do not provide for high data rate digital transmission, although T.30 operating at 64kbps on ISDN is being discussed by the CCITT; they do provide, however, a very detailed and extremely successful communication protocol for use on PSTN circuits.

The recommended JPEG compression algorithm requires an error free communication channel. Consequently, it will be important to employ the new error control procedure which has been recently added to the T.30 standard. Other enhancements to the G3 standard such as transmission at 14.4 Kbps will also benefit the freeze frame mode.

It is possible that the Group 4 facsimile standard will include a mode for PSTN operation in the future. It is more likely that Group 4 will be used on ISDN. In both cases, it may

be appropriate to consider expanding the Freeze Frame Standard in the future to include Group 4.

APPENDIX A

LETTER TO FREEZE FRAME
MANUFACTURERS

NATIONAL COMMUNICATIONS SYSTEM
OFFICE OF THE MANAGER
WASHINGTON, D.C. 20305 - 2010

IN REPLY
REFER TO

NCS-TS

Dear Sir:

The National Communications System (NCS) is a confederation in which Federal departments and agencies participate with their telecommunications assets to assist the President, the National Security Council, the Office of Science and Technology Policy, and the Office of Management and Budget in:

The exercise of their wartime and non-wartime emergency functions, and their planning and oversight responsibilities; and

Coordination of the planning for and provision of national security and emergency preparedness communications for the Federal Government under all circumstances, including crisis or emergency.

Executive Order 12472 assigns national security emergency preparedness telecommunications functions. Among the functions assigned by E.O. 12472 in support of the mission of the NCS is the Federal Telecommunication Standards Program (FTSP). The focus of the FTSP is to develop Federal standards which either contribute to the interoperability of functionally similar Federal telecommunications networks or to achieving a compatible, efficient, and economical interface between such networks and appended computer terminals. An area of major attention is teleconferencing.

Freeze frame video equipment has been used extensively throughout the government for many years, and it is likely that more units will be deployed in the future. These units are manufactured by several vendors, and of course, they are not compatible with each other. The NCS is investigating the feasibility of developing a Federal standard for freeze frame video systems, and I am writing to you because it is my understanding that your company manufactures freeze frame TV equipment.

Federal standards are frequently developed in conjunction with standards adopted by international standards organizations (e.g., the CCITT and ISO) and national standards organizations (e.g., EIA, ANSI). This is desirable because it usually achieves compatibility on a broad national and international basis and frequently results in reduced cost for government users. The CCITT and ISO recently established a joint committee known as JPEG (Joint Photographic Encoding Group). The purpose of this group was to choose a compression algorithm for single frame images which can be used for a wide range of

applications such as videotex, Group 4 facsimile, and freeze frame TV. The JPEG group recently completed a run-off competition between three coding techniques, and the winner was based on the Discrete Cosine Transform (DCT) algorithm. I am enclosing a description of the winning coding concept for your review.

The primary purpose of this letter is to advise you that the NCS is planning to develop a Federal standard for freeze frame video systems which is based upon the JPEG DCT algorithm. We are advising your company of this plan and project for two reasons:

To give you adequate time to develop a freeze frame system based upon the anticipated standard, if you choose.

To solicit your input, assistance, and suggestions regarding this standardization effort.

The NCS is being assisted on this project by Delta Information Systems. Should you have any questions or information regarding this effort, please contact either of the two parties listed below:

Richard A. Schaphorst
Delta Information Systems
(215) 657-5270

Gary Rekstad
National Communications System
Office of Technology & Standards
(202) 692-2124

We appreciate your assistance and cooperation.

Dennis Bodson

Dennis Bodson
Assistant Manager
Technology and Standards

APPENDIX B

The JJ-40.10 Standard for Still-Video Communications Over an Analog Telephone Network

Proposed by
The Japanese Telecommunications Technology Committee

JJ-40.10 Standard for still-video communication over an analog telephone network

General

This standard is concerned with the procedures and conditions necessary for communication between an apparatus transmitting and a device receiving still-video information over an analog telephone network.

Based on a study of several video communication systems, communication technology has been established that allows economical transmission and reception of still-video information.

The purpose of this standard is to insure still-video communication between any two apparatus and to promote their widespread use.

Standard for still-video communication over an analog telephone network

<Remarks>

1. Relation to international recommendations and standards

This standard is not related to any international standards.

NOTE :

The user's attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights.

By publication of this standard, no position is taken with respect to the validity of this claim or of any patent rights in connection therewith. The patent holders* have, however, filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license.

* Mitsubishi Electric Corporation

Nippon Telegraph and Telephone Corporation

Sanyo Electric Co., Ltd.

Sony Corporation

JT-G721 32 kbit/s Adaptive-Differential Pulse-Code Modulation (ADPCM)

1. Relations with international standards

This standard conforms to CCITT Recommendation G.721 (refer to the accelerated procedure of 1986).

1. Summary of departures from CCITT recommendations

(1) In this standard, the following items are deleted from the above recommendation:

(a) Items related to A-law

(b) Items related to international connections

Parts (a) and (b) are deleted because a μ-law has been adopted for pulse-code modulation in Japan and TTC standards provide for domestic inter-network interfaces only.

1. Introduction

This standard is concerned with the procedures and conditions necessary for communication between devices transmitting and receiving still-video information over an analog telephone network.

The procedures and conditions are stipulated under the following items.

(1) physical interface

(2) signal structure

(3) signal characteristics and transmission method

(4) communication protocol

(5) screen mode

With a physical interface, the electrical and other characteristics of the interconnections and interactions between the device and the telephone line are stipulated.

With a signal structure, a general structure of messages is stipulated containing information such as on the message type, screen mode, calibration, associated apparatus capabilities, and the picture itself. The changeover signal used to switch from speech communication to the picture communication state is also defined.

For signal characteristics and trasmission method, the frequency and duration of the changeover signal, and the carrier frequency, modulation, and other specifications related to the signal are stipulated. Amplitude-phase modulation is adopted to provide economical transmission of pictures with multiple gray levels.

Under communication protocol, two procedures are stipulated. The first basic procedure allows the transmission of still-video information, without negotiating or exchanging of control information between the two devices prior to picture-signal transmission. The second is an extended-option procedure that will greatly extend applications in the future through utilization of a handshaking or negotiating procedure.

Under the screen mode, two modes are stipulated as mandatory. One is suitable for general-purpose communications, that have the same screen-aspect ratio as a

to-face communication; pictures that have a shorter horizontal screen-aspect ratio and fewer picture elements.

2. Physical requirements for connecting to telephone lines

The physical requirements for connection to the analog telephone network comply with Regulations for Terminal Facilities, etc. together with the following. (M.P.T Ordinance No. 31 of 1985)

2.1 Connectors

Connectors to the telephone line should be consistent with M.P.T. Notice No. 399.

2.2 Electrical requirements for connecting to a telephone line

(1) Receiving and transmitting signal level

(a) The maximum transmitting level should match Article 13 of the Regulations for Terminal Facilities, etc. (M.P.T. Ordinance No. 31 of 1985).

(b) The receiving level for normal operation will be -40 dBm or greater.

(2) Relation with power supply polarity supplied from the network

Equipment should function properly, regardless of line polarity supplied from telephone network.

(Note) M. P. T : Ministry of Posts and Telecommunications

V. 3 Coding Method

Introduction

These TTC standards relate to high-efficiency pulse-code modulation and provide the technical specifications for voice-frequency coding methods other than PCM.

The TTC standards have been established, based on CCITT recommendations, with selection, addition and deletion of relevant items being based on the state of advancement in Japan.

In the present TTC standards (1988 version), only 32 kbit/s ADPCM is specified.

TTC STANDARDS (SUMMARY)

AUGUST, 1988 ¥10,000

Printed by HIFUMI SHOBO Co., Ltd.

Note: TTC has the full text of TTC Standards (Japanese)

THE TELECOMMUNICATION TECHNOLOGY COMMITTEE

NISHI-SHINBASHI ABE BUILDING TEL 432-1551

3-12-10 NISHI-SHINBASHI, MINATO-KU FAX 432-1553

TOKYO JAPAN 105

3. Signal characteristics and transmission method

The standard format for the signal is provided.

3.1 Signal structure

The general structure of the signal is shown in Figure 3-1/JJ-40.10.

Note that the dual tone and/or picture data are not included in the case of certrain communication mode.

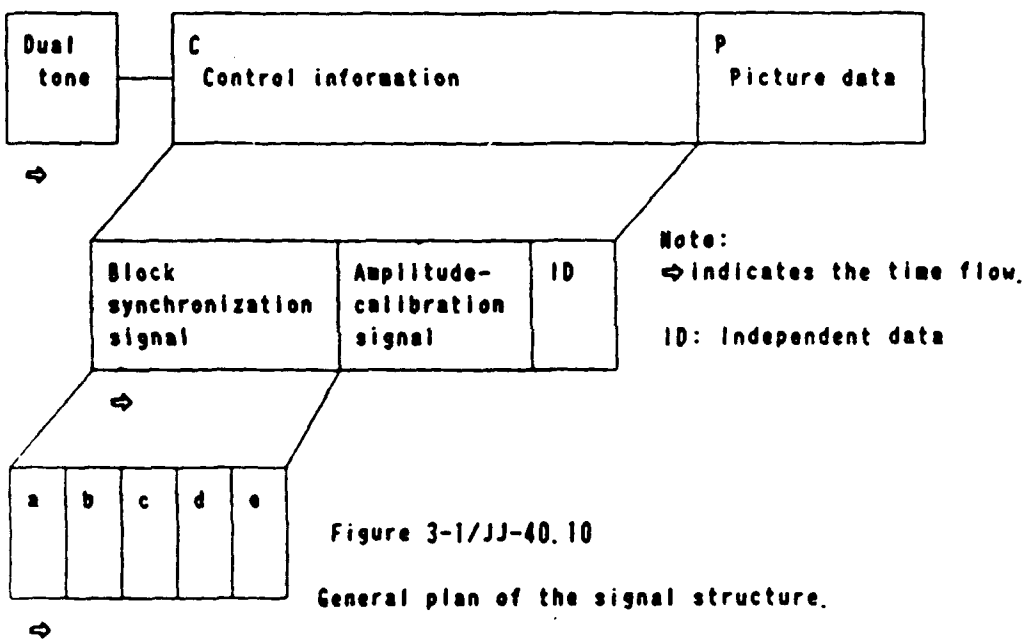


Figure 3-1/JJ-40.10

General plan of the signal structure.

(1) Transmission order of the signal components

The transmission order of the signal components should be as follows.

Dual tone ⇨ Control information ⇨ Picture data

3.2 The components of the signal

The signal is composed of the following elements.

(1) Dual tone

The dual-tone signal is followed by a blank period.

This signal switches the speech communication mode to the picture communication mode.

(2) Control information

The control signal carries information about the picture data. Then the receiving device decides upon the appropriate receiving mode and functions.

(3) Picture data

It is a modulated picture signal.

3.3 Control information

Control information includes all necessary controls required to transmit or receive picture data.

3.3.1 Block synchronization signal

The block synchronization signal consists of the following sections.

All the sections are transmitted at the maximum amplitude.

(Also refer to Chaper 4 for the definition of amplitude and phase.)

(1) Section-a

A signal of 16 cycles with Phase 1

(For synchronizing the receive-carrier frequency)

(2) Section-b

One cycle of the Phase 1 signal and one cycle of the Phase 2 signal are alternately repeated 20 times.

(For adjusting the frequency and phase of the receive-data clock)

(3) Section-c

A signal of 8 cycles with Phase 1

(For the re-adjustment of the receive-carrier frequency)

(4) Section-d

2nd phase: 4 cycles A signal of 4 cycles with Phase 2

1st phase: 2 cycles A signal of 2 cycles with Phase 1

2nd phase: 2 cycles A signal of 2 cycles with Phase 2

The above signal is repeated 4 times. (total of 48 cycles).

For the re-adjustment of receive data-clock phase and for gaining bit synchronization. If the signal cannot be detected, then return to the speech-communication mode.

(5) Section-e

⇨

S, S, S, P, P, P, S, S, S, P, P, P, S, P, P, P,

S, S, S, S, P, P, P, S, S, S, S, P, P, P, S, S,

P, P, P, P, S, P, P, P, S, S, P, P, S, S, S, S,

S, P, S, P, P, P, S, P, S, P, P, P, S, S, S, S,

Figure 3-2/JJ-40.10 Order of signal

Note:

⇨ indicates the time flow.

P: phase 1 S: phase 2

This signal pattern totals 64 symbols

For establishing data block synchronization and for avoiding any false starts. If these signals are detected with errors, then return to the speech-communication mode.

3.3.2 Amplitude-calibration signal

This signal is used for the automatic gain control for reception. It is a calibration signal that sets up each of the gray levels of a picture.

See Table 3-1/JJ-40.11 for the composition of the calibration signal.

Table 3-1/JJ-40.10 Calibration signal

NUMBER OF CYCLES	RELATIVE AMPLITUDE	PHASE
72	8 (maximum)	phase 1
3	8 (maximum)	"
3	7	"
3	6	"
3	5	"
3	4	"
3	3	"
3	2	"
3	1	"
3	1	phase 2
3	2	"
3	3	"
3	4	"
3	5	"
3	6	"
3	7	"
3	8 (maximum)	"
8	8 (maximum)	"

3.3.3 ID

Independent data is specified as follows. See Chapter 5 for details.

(1) The ID includes the following information.

- Screen mode
- Transmitting capability of the device
- Whether or not the ID format is extended
- Etc.

(2) Each device, by communicating the ID signal containing its capability and information about the transmitted signal, allows the receiver to perform necessary operations.

(3) Any control information signal has more than one ID.

(4) The length of the ID signal is a multiple of 64 cycles.

(See 4.2.2.)

4. Signal characteristics and transmission method

4.1 Dual tone

Specified below are the initially sent dual-tone signal to be sent initially, and a succeeding blank period; for a switchover to the picture-communication mode from the speech-communication mode.

4.1.1 Frequency

The two frequencies of the dual-tone signal should be 1633 Hz ±1.5% and 2006 Hz±1.5%.

4.1.2 Sending duration

The sending duration of the dual-tone signal should be 400±50 ms.

The duration of the blank period following the dual-tone signal should be 400 ±50 ms.

4.1.3 Power difference at the two frequencies

The power difference between the two frequency components of the dual-tone signal should be less than 3 dB.

4.2 Control information and picture data

4.2.1 Modulation

Described below is the modulation method employed to transmit control information and picture data following the dual tone signal and the blank period.

4.2.1.1 Carrier frequency

The carrier frequency is 1747.82 Hz ±0.01%. This 1747.82 Hz is fsc (=3.579545 MHz)/2048.

4.2.1.2 Modulation of picture data

In this paragraph, the modulation of picture data in the case of sixteen gray levels is specified

Each picture element is subject to linear quantization into sixteen gray levels and is sent out with a modulated carrier which is a combination of 8 levels (16 levels/2) and two phases. That is, the amplitude-phase modulation (AM-PM) method

is used.

The picture-element transmission rate is nominally 1747.82 picture elements/s. This transmission is accomplished by bringing each picture element into synchronization with one cycle of carrier.

The black picture element (the minimum luminance) is given the maximum amplitude carrier with Phase 1. The white picture element (the maximum luminance) is allocated the maximum amplitude carrier with Phase 2. The amplitude of each picture element gray level is quantized and allocated into one of the equally divided into eight (=16 levels/2) levels except the 0 amplitude. The details of this are shown in Table 4-1 /JJ-40.10 and Figure 4-1/JJ-40.10.

On the receiver, the luminance of picture elements and the receiving signal levels are calibrated with the calibration signals given in Table 3-1/JJ-40.10.

Note--Two phases are defined as below:

Phase 1

The phase whose phase difference with respect to the carrier phase locked by the block synchronization signal is 0 ±10°

Phase 2

The phase whose phase difference with respect to the carrier phase locked by the block synchronization signal is 180 ±10°

The same applies to the case of more than sixteen gray levels, by properly increasing the number of amplitude levels. The calibration signals given in Table 3-1/JJ-40.10 remain unchanged even if the number of gray levels is varied.

Table 4-1/JJ-40.10 Luminance of picture elements and corresponding carriers

Luminance of picture element	Modulation of carrier		
16 gray levels	Relative amplitude	phase	No. of cycles
0 (black)	8 (max.)	Phase 1	1
1	7	Phase 1	1
2	6	Phase 1	1
3	5	Phase 1	1
4	4	Phase 1	1
5	3	Phase 1	1
6	2	Phase 1	1
7	1	Phase 1	1
8	1	Phase 2	1
9	2	Phase 2	1
10	3	Phase 2	1
11	4	Phase 2	1
12	5	Phase 2	1
13	6	Phase 2	1
14	7	Phase 2	1
15 (white)	8 (max.)	Phase 2	1

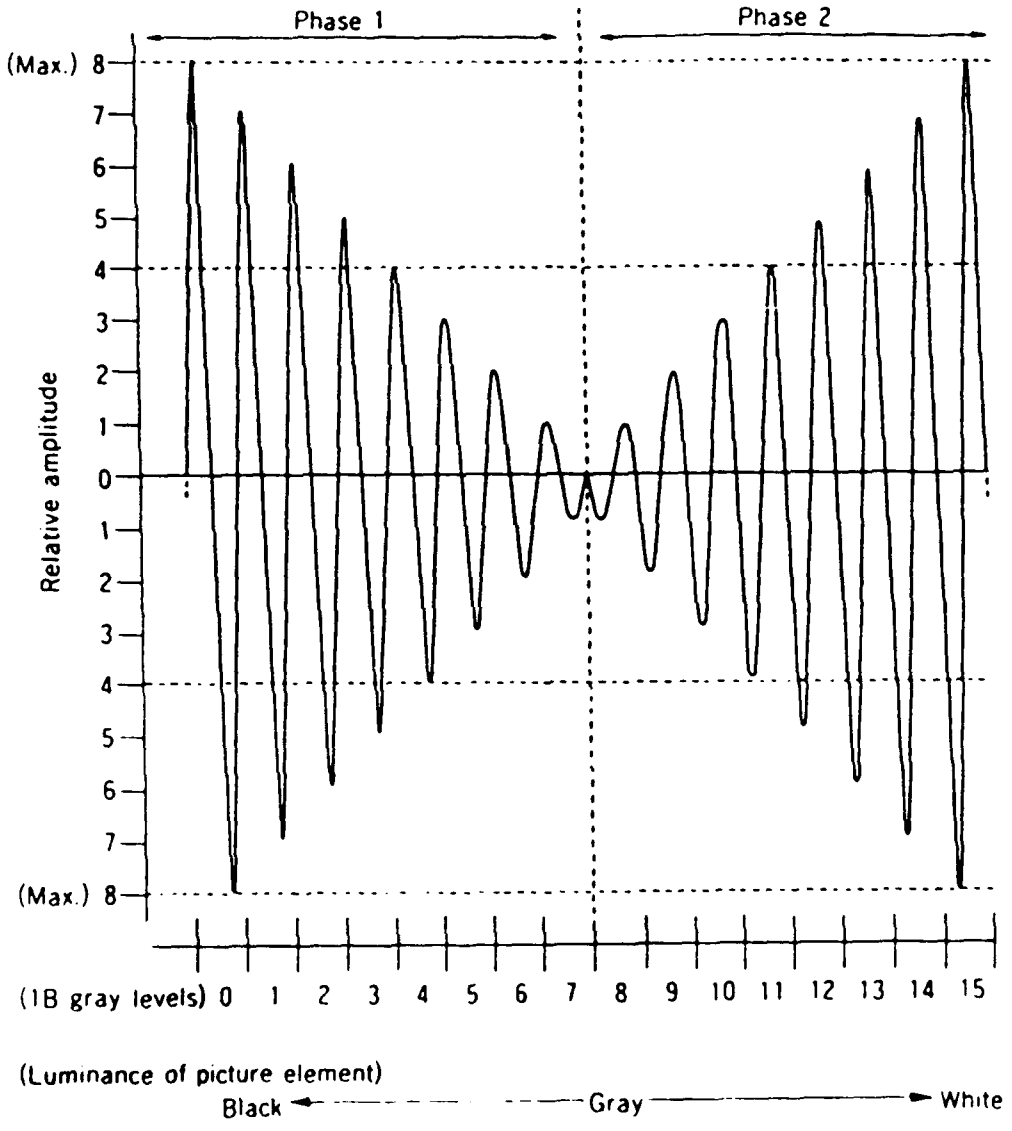


Figure 4-1/JJ-40.10 Carrier waveform corresponding to gray levels

4.2.1.3 Modulation of binary data

'1' and '0' of binary data (ID) are transmitted with the carrier modulated into two phases. That is, the phase modulation (PM) method is used.

The binary data transmission rate should nominally be 582.6 bit/s. Each bit is transmitted on three cycles of carrier.

'1' of binary data signals the 3-cycle carrier of maximum amplitude with Phase 1. '0' of binary data signals a 3-cycle carrier of maximum amplitude with Phase 2 for modulation as shown in Table 4-2 and Figure 4-2/JJ-40.10.

Table 4-2/JJ-40.10 Binary data and corresponding carriers

Binary data	Modulation of carrier		
	Relative amplitude	Phase	No. of cycles
1	Max.	Phase 1	3
0	Max.	Phase 2	3

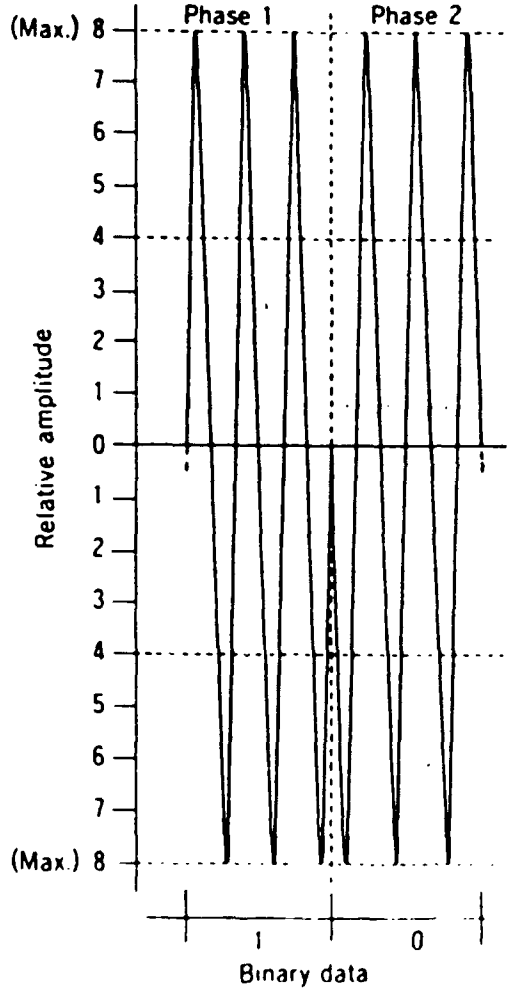


Figure 4-2/JJ-40.10 Carrier waveforms for binary data

4.2.1.4 Amplitude and group-delay characteristics

Compensation for required line characteristics should be effected at the receiver. The amplitude and group-delay of the transmitter output should be basically flat over the frequency range 300 Hz - 3400 Hz.

4.2.1.5 Received-signal frequency tolerance

A frequency deviation of at least ±7 Hz should be allowable at the receiver.

4.2.2. ID signal form (for the description of ID, refer to 5.3).

4.2.2.1 Scrambling

Each byte of ID should be transmitted after scrambling by an exclusive-OR with the 8-bit fixed pattern of '10101010' (hexadecimally AA).

The 7th, 6th and 5th bits (MSB 3 bits) of the 3rd byte should not be transmitted.

4.2.2.2 Transmission sequence

The transmission sequence begins with the 1st byte. Among bits of each byte, the 0th bit (LSB) is the first to be sent.

4.2.2.3 Guard cycle

The ID is created by adding one guard cycle of maximum amplitude of Phase 1 following the data section of 21 bits (=63 cycles).

4.2.3 Picture-data transmission

If the ID is followed by picture data, the first picture element is sent following the guard cycle of the ID.

5 Communication protocol

This protocol specifies communication procedures, speech/picture switching, and control information.

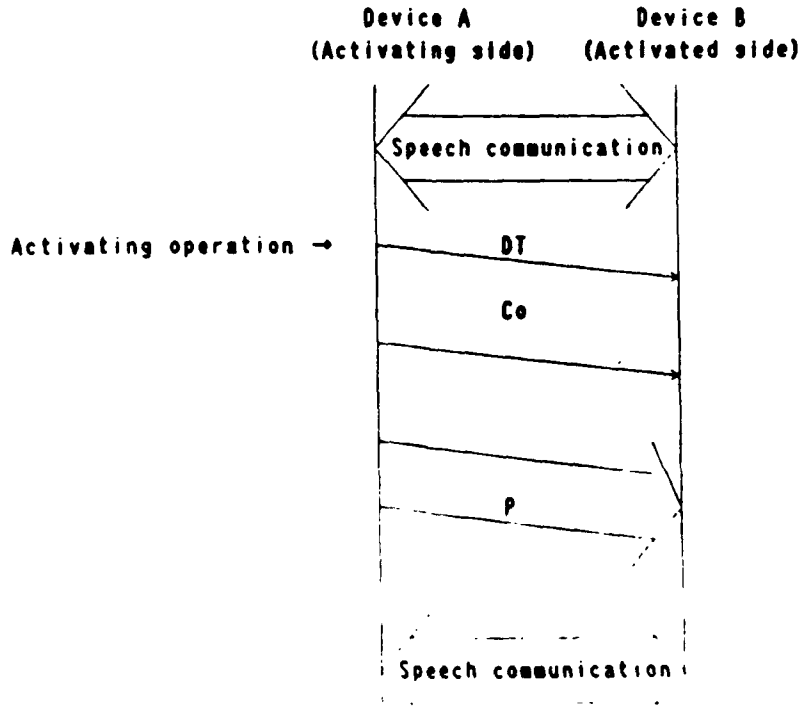
5.1 Communication procedures

The communication procedures specify the basic and extended procedures for picture transmission.

5.1.1 Basic procedure

The procedure transmits a picture without a handshake, after a dual tone has been sent out.

After the dual tone has been sent out, the activating side sends out picture-control information and picture data.



DT: Dual tone

Co: Picture-control information

P: Picture data

Figure 5-1/JJ-40.10 Basic procedure

5.1.2 Extended-option procedure

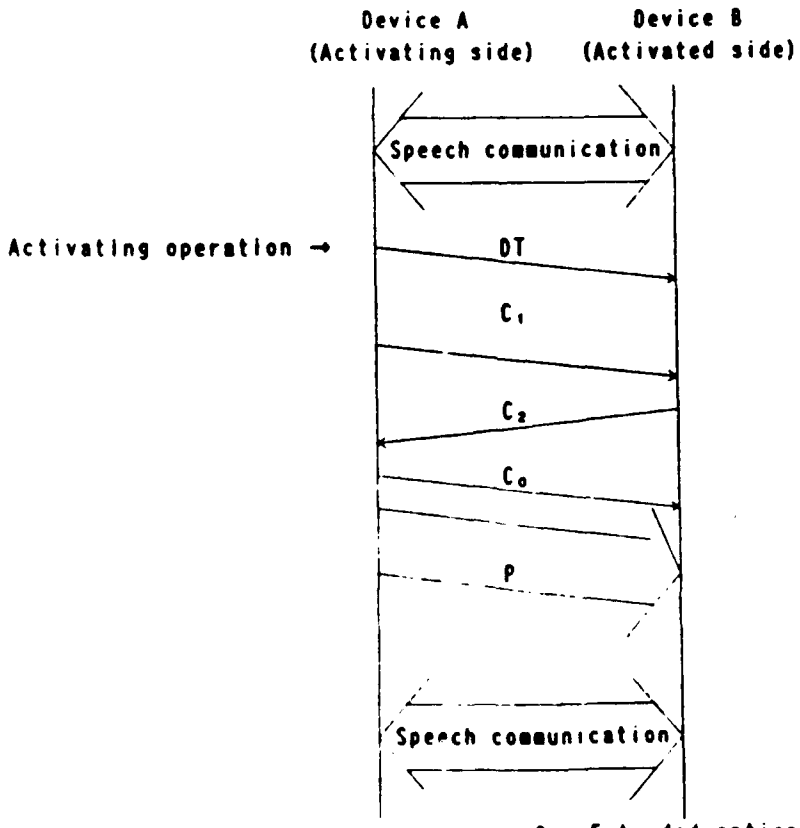
To utilize more functions, the procedure allows picture transmission with a handshake, after a dual tone has been sent.

After the dual tone has been sent out, the activating side sends out extended-option control information.

The activated apparatus, when it receives extended-option control information, sends out response-control information.

The activating side, when it receives the response-control information, sends out picture-control information and picture data.

The extended-option procedure is not an indispensable function, but the capability to return response-control information is indispensable (see 5.3.4).



C_1: Extended-option control information

C_2: Response-control information

Figure 5-2/JJ-40.10 Extended-option procedure

ed as a trigger for switch-

unication mode.

compatible between communi-

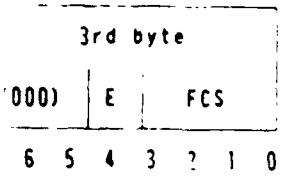
ch other's communication

ol information, extended-

on, polling-control infor-

l information, and color-

rmation are specified with



ment

e bytes. Note that 3 MSBs

(1) 1st byte

This field contains information on one of the following:

(a) Picture (L field)

(b) Waiting time (T field)

(c) Supplier code (SC field)

(d) Abnormal communication (N field)

The supplier code will be separately specified.

(2) Upper 4 bits of 2nd byte

This field contains one of the following:

(a) Indication of type of control information containing within this ID (F field)

(b) Data that is used by the supplier itself (S field)

Table 5-1/JJ-40.10 shows the relationship between the value of F field and type of control information.

(3) Lower 4 bits of 2nd byte

This field, called the M field, indicates the receiving capability, etc., of the device to transmitting the control information.

(4) Bit 4 of 3rd byte

This field, called the E field, indicates an ID extension. Setting this bit to "1" allows this ID to be followed immediately by an ID having the same composition (see Figure 5-4/JJ-40.10).

(Note:) Undefined fields in this standard are each filled with "0" during transmission, and ignored during receiving.

Table 5-1/JJ-40.10 Value of F field and type of control information

Value of F field	Type of control information
0000	Polling-control information
0001	Undefined
0010	Extended-option-control information Response-control information
0011	Undefined
0100	Mode B picture-control information (Note)
0101	Undefined
0110	Mode A picture-control information (Note)
0111	Undefined
1000	Color picture-control information
1001	Undefiend polling-control information
1010	
1011	
1100	
1101	Character-data-control information
1110	Undefined
1111	NAK-control information

(Note:) See Chapter 6 for mode A and B.

E Field	Extended or not
1	Yes
0	No

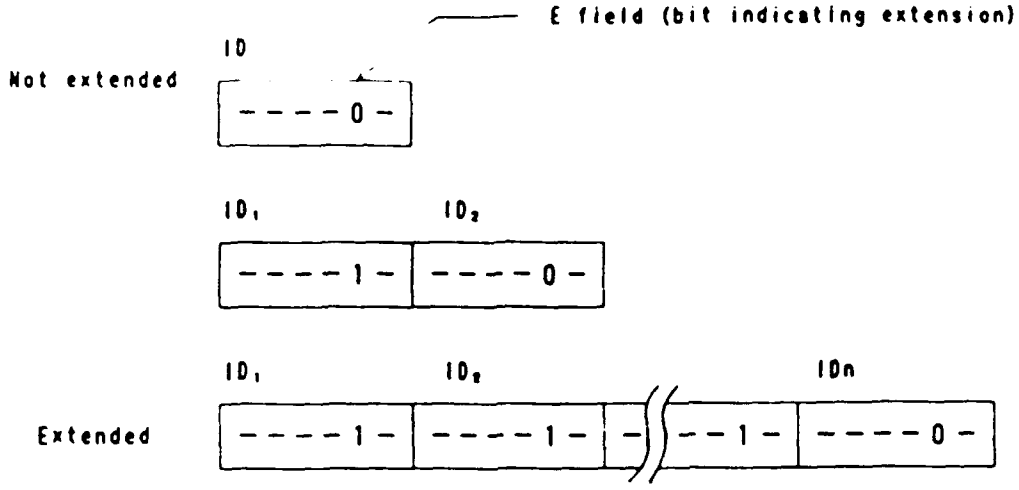


Figure 5-4/JJ-40.10 ID extension

(5) Lower 4 bits of 3rd byte

This field, called the FCS field, indicates the value of the check sum of IDs, which is set by the following formula:

FCS (4-bit length) = (1st byte, bit 7 to 4) ⊕ (1st byte, bit 3 to 0)
⊕ (2nd byte, bit 7 to 4) ⊕ (2nd byte, bit 3 to 0)
⊕ (3rd byte, bit 7 to 4)

Note 1: ⊕ indicates Exclusive OR.

2: 3rd byte, bit 7 to 5 are set as "000".

5.3.2 Picture-control information

(1) Picture-control information

Picture-control information is transmitted before sending picture data. That is, the picture data follows the pciture-control information.

(2) Picture-control-information ID format

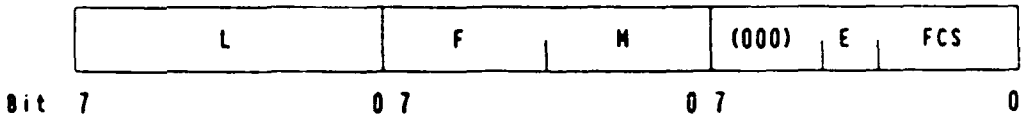


Figure 5-5/JJ-40.10 Picture-control-information ID format

(a) L: Fixed pattern of "01100100"

(b) F: Indicates screen mode (screen mode is specified in Section 6).

(i) mode A: F ="0110"

(ii) mode B: F ="0100"

(c) M: Undefined

(d) E: "0" at present (extension is a subject for further study).

5.3.3 Extended-option control information

(1) Extended-option control information

Extended-option control information is used to request a handshake, and is not an indispensable function.

(2) Extended-option-control-information ID, format

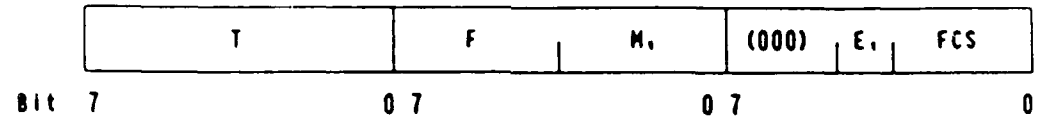
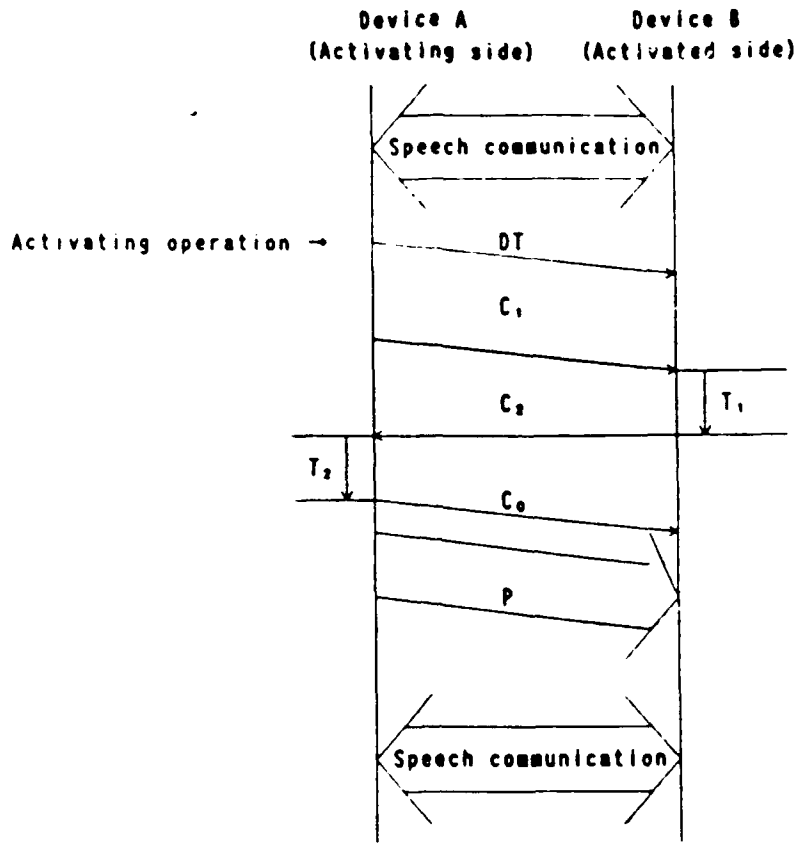


Figure 5-6/JJ-40.10 Extended-option-control-information ID, format

(a) The activated side, after receiving extended-option-control information, must pause for at least the waiting time shown in Figure 5-6/JJ-40.10. *before sending out response-control information.*

Table 5-2 Extended-option-control-information T field

Value of T field	Waiting time
00000000	Undefined
00000001	0 sec.
00000010	1.5 sec.
00000011	3 sec.
00000100	4.5 sec.
00000101	6 sec.
Others	Undefined



T_1: Waiting time

T_2: Waiting time

(See 5.3.4 Waiting time.)

Figure 5-7/JJ-40.10 Waiting time

(b) F: Fixed pattern of "0010"

(c) M_1: Undefined

(d) E_1: Indicates existence/non-existence of ID_2

(i) E_1 = "0": ID_2 does not exist

(ii) E_1 = "1": ID_2 exists

(3) Extended-option-control-information ID_2 format

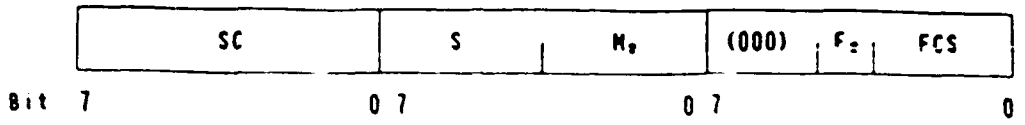


Figure 5-8/JJ-40.10 Extended-option-information ID_2 format

(a) SC: Supplier code. Undefined, however, if M_2 bit 0 = "0".

(b) S: Undefined if M_2 bit 0 = "0".

Can be used for supplier's own procedure when M_2 bit 0 = "1"

(c) M_2: As shown in Table 5-3/JJ-40.10

Table 5-3/JJ-40.10 Extension-option-control-information M_2 field

Bit	Value	Meaning
0	0	Requests communication according to this standard
	1	Requests communication according to the supplier's own procedure
1	—	Undefined
2	—	
3	—	

When M_2 field is all "0", ID_2 need not be transmitted.

(4) Extension after ID_2

Undefined

5.3.4 Response-control information

(1) Response-control information

Response-control information is used to respond to a handshake request. Every device, when it receives extended-option-control information (handshake request), must return the response-control information indicating its capabilities.

(2) Response-control-information ID, format.

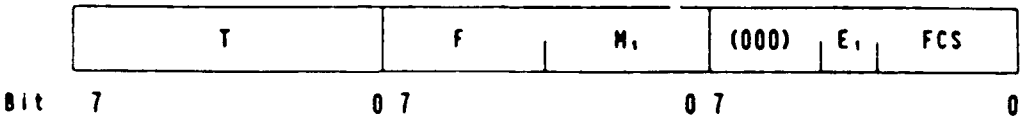


Figure 5-9/JJ-40.10 Response-control-information ID, format

(a) T: Indicates waiting time before picture-control information and others can be sent out (see Figure 5-7/JJ-40.10)

Table 5-4/JJ-40.10 Response-control-information T field

Value of T field	Waiting time
00000000	Undefined
00000001	0 sec.
00000010	1.5 sec.
00000011	3 sec.
00000100	4.5 sec.
00000101	6 sec.
Others	Undefined

(b) F: Fixed pattern of "0010"

(c) M_1: Indicates the receiving capability for screen modes.

M_1 = "0100" is used to indicate the capability to receive screen modes A and B.

Others are undefined.

(d) E_1: Indicates ID_2 existence/non-existence

(i) E_1 = "0": ID_2 does not exist

(ii) E_1 = "1": ID_2 exists

(3) Response-control-information ID_2 format

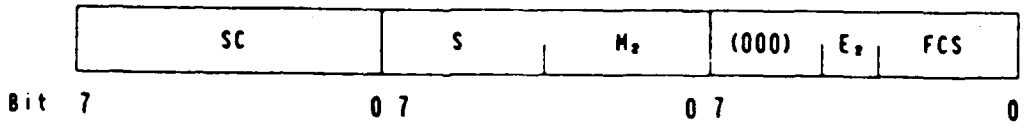


Figure 5-10/JJ-40.10 Response-control-information ID_2 format

(a) SC: Supplier code. Undefined, however, if M_2 bit 0 = "0".

(b) S: Undefined if M_2 bit 0 = "0".

Can be used for supplier's own procedure when M_2 bit 0 = "1".

(c) M_2: As shown in Table 5-5/JJ-40.10.

When M_2 field is all "0", ID_2 need not be transmitted.

Table 5-5/JJ-40.10 Response-control-information M_2 field

Bit	Value	Meaning
0	0	Indicates that the device has a supplier's own procedure.
	1	Indicates that the device does not have a supplier's own procedure.
1	0	Indicates that the device has polling capability.
	1	Indicates that the device does not have polling capability.
2	0	Indicates that the device has color-picture communication capability.
	1	Indicates that the device does not have color-picture communication capability.
3	0	Indicates that the device has character-data-receiving capability.
	1	Indicates that the device does not have character-data-receiving capability.

(4) Extension after ID_2

Undefined

5.3.5 Polling-control information

(1) Polling-control information

Polling-control information is used to request picture data, and is not an indispensable function.

F field for the polling-control information is defined as F = "0000".

Others are undefined.

5.3.6 Color-picture-control information

(1) Color-picture-control information

Color-picture-control information is transmitted before the color picture is transmitted.

It is not an indispensable function.

F field for the color-picture-control information ID is defined as F = "1000".

Others are undefined.

More code words for the F field may be needed for this control information.

This will be examined in the future.

5.3.7 Character-data-control information

(1) Character-data-control information

Character-data-control information is transmitted before character data is transmitted.

It is not an indispensable function.

Character data follows the character-control information.

F field for the character-control-information is defined as F = "1101".

Others are undefined.

5.3.8 NAK-control information

(1) NAK-control information

NAK-control information indicates abnormal communications.

It is not indispensable function.

(2) NAK-control information ID format

Figure 5-11/JJ-40.10 NAK-control-information ID, format

(a) M: "00000000" indicates that an FCS error has occurred when control information was received

(b) F: Fixed pattern of "1111"

(c) M: Undefined

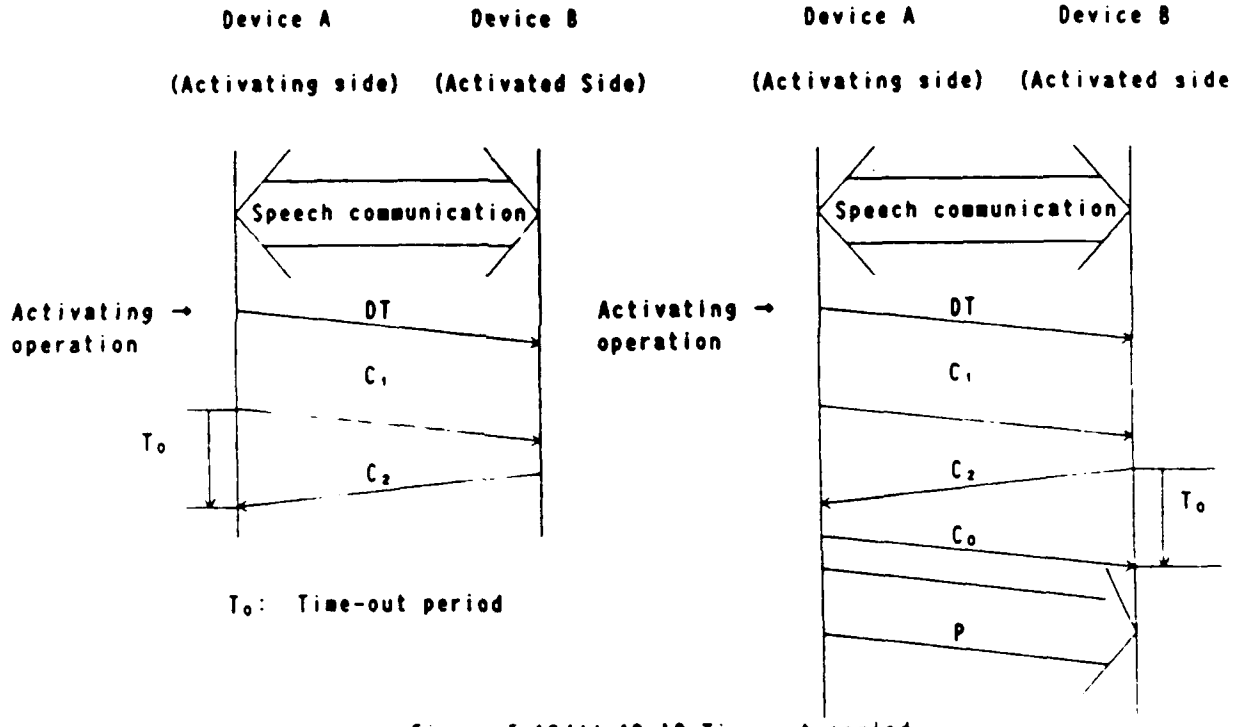
(3) Extension after ID,

Undefined

5.4 Error handling

The error-handling method is specified as follows:

(1) If a signal specified according to this protocol is not received within the time-out period, the device is switched back to the speech communication state. The time-out period must be considered in light of propagation delay in the transmission line.



To: Time-out period

Figure 5-12/JJ-40.10 Time-out period

(2) If control information is received with any of the following conditions (a), (b) and (c), by any device not having the functions to send and receive NAK-control information. Then the device transmits, instead of NAK-control information, response-control information not having ID_2 or IDs beyond it:

(a) The F field of the received control information is undefined.

(b) An FCS error has occured when the control information is received.

(c) The received number of extended control-information IDs exceeds the receiving capabilities.

(3) If an error occurred in any device having a function to send and receive NAK-control information, the device treats the error as follows:

(a) Device at activating side

(i) If NAK-control information is received, or an FCS error occurs when control information is received, or the F field of the received control information is undefined, then the last-sent control information is retransmitted.

(ii) If NAK-control information is received twice, or an FCS error occurs twice, or any control information with an undefined F field is received twice, then the state is switched to speech communication.

(iii) If response-control information not having ID_2 is received, or if the received number of extended control-information IDs exceeds the receiving capabilities, then a selection is made. It is decided whether the picture in picture mode A or B is sent out, or the state is switched to a speech communication.

(b) Device on activated side

(i) If an FCS error occurs when control information is received, then NAK-control information is sent out.

(ii) If the received number of extended control-information IDS exceeds the receiving capabilities or the F field of the received control information is undefined, then response-control information not having ID_2 or IDs beyond is sent out.

Table 5-6/JJ-40.10 Error-handling method of device with NAK-control information sent and receive capability

Control-information receiving state	Handling method	
	Activating side	Activated side
Occurrence of FCS error	Send the last control information again.	Send NAK-control information.
Second occurrence of FCS error.	Switch to speech-communication mode. (Note)	Send NAK-control information.
NAK-control information received.	Send the last control information again.	
Second NAK-control information received.	Switch to speech-communication state. (Note)	
Control information containing undefined F field received.	Send the last control information again.	Send response-control information (with only ID, held).
Second control information containing undefined F field received.	Switch to speech-communication state. (Note)	
Response-control information (with ID, only held)	Continue picture mode transmission or switch to speech-communication mode	
ID receiving capabilities exceeded.	Continue picture mode transmission or switch to speech-communication mode.	Send response control information (with ID, only held).

Note: The activated device is switched to the speech communication mode when the time-out is reached.

6. Screen mode

6.1 Screen mode

The following two modes are prescribed as the standard modes.

All of the devices must be able to receive both of these two modes.

(Refer to Figure 6-1/JJ-40.10.)

(1) Mode A

- Number of picture elements 100 x 160 (V x H)
- Screen-aspect ratio 3 : 4 (V : H)

(2) Mode B

- Number of picture elements 100 x 96 (V x H)
- Screen-aspect ratio 5 : 4 (V : H)

For both modes A and B, basically the picture element is an orthogonal pattern and its V:H ratio is 6:5.

[V: Screen vertical direction
H: Screen horizontal direction]

6.2 Order of picture-element transmission

(1) As shown in Figure 6-2/JJ-40.10, the picture elements are transmitted from the upper left to right starting at the top. When the right edge is reached for the first line, the second line is transmitted in the same way, from left to right.

The above is repeated until the picture element at the bottom right corner is sent and transmission ends.

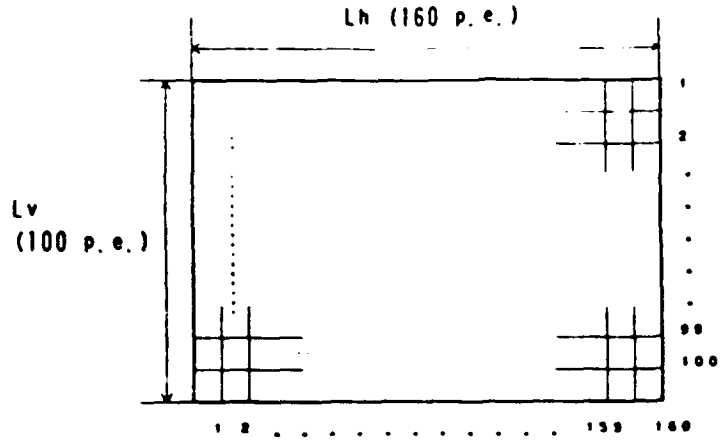
(2) The receiving side displays the picture-element data on the screen in the corresponding locations in the order sent by transmission (1) above.

(3) One picture should be sent by one transmission.

6.3 Quantization of picture

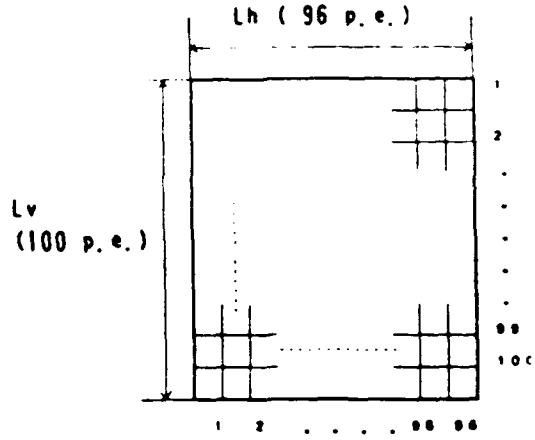
Picture elements should be obtained by sampling and linearly quantizing to more than 16 levels of the luminance signal as determined by Item 22, Article 2 of the 1983 Order by the Ministry of Post and Telecommunications.

Lv : Lh = 3 : 4



<mode A>

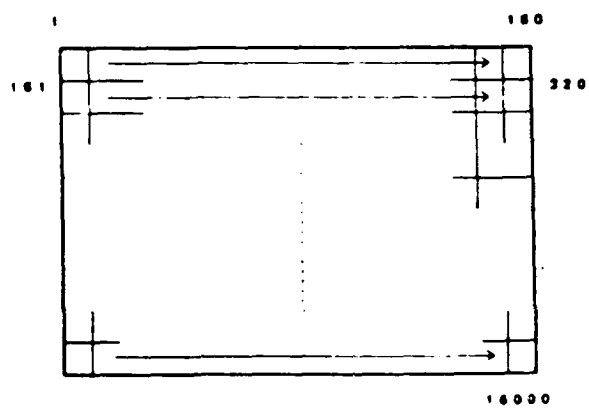
Lv : Lh = 5 : 4



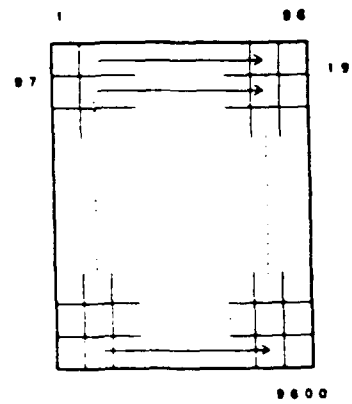
<mode B>

(p.e.: picture elements)

Figure 6-1/JJ-40.10 Number of picture elements and aspect ratio



<mode A>



<mode B>

(Numbers indicate order of transmission.)

Figure 6-2/JJ-40.10 Order of picture elements transmission