SMPTE RECOMMENDED PRACTICE

RP 113-1992
Revision of RP 113-1983

Supervisory Protocol for Digital Control Interface

1 General

1.1 Scope

This practice defines the supervisory protocol used within a general purpose communication channel of an interface system which transports data and digital control signals between equipment utilized in the production, post-production, and/or transmission of visual and aural information. It is intended that the supervisory protocol described in this practice be part of an overall system, allowing interconnection of programmable and nonprogrammable equipment as required to configure an operational system with a defined function, and to allow rapid reconfiguration of a system to provide more than one defined function utilizing a given group of equipment.

1.1.1 The primary intent of this practice is to establish supervisory procedures of the communication channel for the purpose of transmitting control messages to equipment by external means. (The contents of the messages are not defined.) This practice, or sections thereof, may be applied to the interconnection of elements within an item of equipment.

1.2 Definitions

(See figure 1.) For the purposes of this practice, the following definitions apply:

1.2.1 bus controller: Each system contains one bus controller which supervises all tributaries in the system. Supervision is exercised through the use of this supervisory protocol.

1.2.2 byte: A byte consists of eight bits of information. Bits used to effect transmission such as byte start, parity, or end are not part of the byte.

1.2.3 tributary: A tributary transfers messages to and from an operational device via the interface system. The tributary is distinct from the function of the operational device and exists to transfer control messages between the communication channel and the device.

1.2.4 word: A word consists of a byte and associated bits used to effect transmission such as start, parity, or end.

2 Message types

Two types of messages shall be transmitted on the channel:

Supervisory messages to supervise the channel and direct the flow of device messages.

Device messages to control operation of equipment functions. This type of message shall be transmitted only within standard message blocks or during device defined communications modes. Details of device messages are specified in RP 138-1992.

3 Tributary addresses

Tributary addresses shall consist of two bytes: the most significant byte, which is transmitted first, and the least significant byte. The most significant bit of both bytes shall be set to binary 1. This provides an address range starting at 8080_h. Each tributary shall be assigned two unique addresses, a SELECT address and a POLL address.

3.1 Select address

An address in which the least significant bit of the least significant byte equals binary 0 is a SELECT address.

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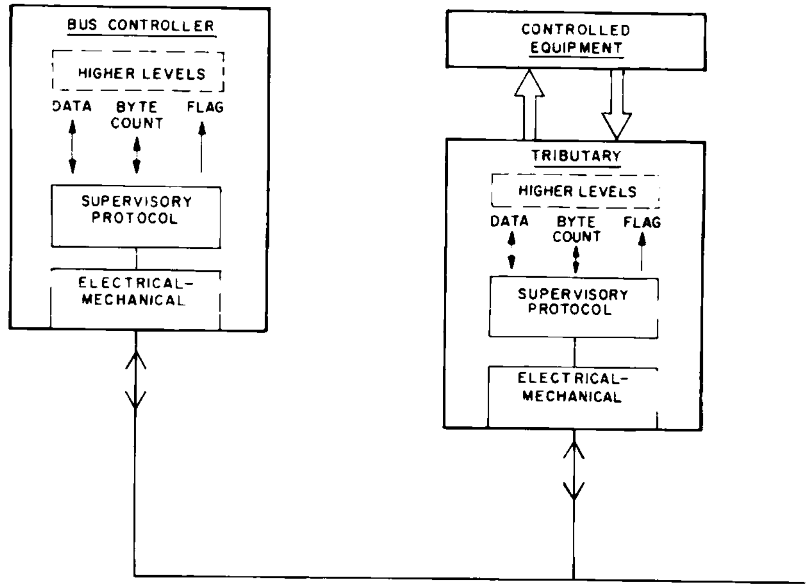


Figure 1 – System elements

3.2 Poll address

An address in which the least significant bit of the least significant byte equals binary 1 is a POLL address.

3.3 Group addresses

Address pairs $8080\text{-}8081_h$ and $8082\text{-}8083_h$ through $81FE\text{-}81FF_h$ are reserved as GROUP SELECT addresses. The addresses in which the least significant bit of the least significant byte equals binary 1 (POLL address) shall not be used but are retained in the address numbering scheme for software considerations.

3.4 Discrete addresses

Tributary addresses shall start at $8280\text{-}8281_h$. Precisely 8064 discrete tributary address pairs are available.

3.5 Address allocation table

$8080\text{–}8081_h$	Group select — all call
$8082\text{–}80FF_h$	Group select — groups 1-63
$8180\text{–}81FF_h$	Group select — groups 64-127
$8280\text{–}82FF_h$	64 tributaries
$8380\text{–}83FF_h$	64 tributaries
•	
•	
•	
$FF80\text{–}FFFF_h$	64 tributaries

4 Tributary operational states

A tributary shall be in one of five major operational states:

IDLE: The tributary shall not perform any communications. This state shall be exited only in response to BREAK.

ACTIVE: Prerequisite for transition to other operational states. The tributary shall enter this state whenever BREAK is received.

POLL: The tributary shall transmit a single status byte to the bus controller.

SELECT: A single tributary shall enter a communications mode with the bus controller.

GROUP SELECT: All tributaries or a selected group of tributaries shall enter a communications mode with the bus controller.

5 Supervisory messages

Tributaries shall be directed to operational states through various communications sequences by supervisory messages as shown in figure 2. Supervisory messages consist of the following elements:

BREAK: Shall drive all tributaries to the ACTIVE state. (See ANSI/SMPTE 207M-1992, for code.)

(ADDR-POLL): A tributary poll address (ADDR-POLL) shall drive the addressed tributary to the POLL state.

(ADDR-SELECT): A tributary select address (ADDR-SEL) shall drive the addressed tributary to the SELECT state.

(GROUP ADDR-SEL): A group select address shall drive a group of tributaries to the GROUP SELECT state.

Supervisory character: Identify communications sequences and provide status information. Supervisory characters are single bytes within the range 00_h-$7F_h$. Supervisory characters shall consist of:

01_h	(GRP)	Group assign
02	(STX)	Start of message
03	(ESC)	Escape
04	(ACK)	Acknowledge
05	(NAK)	Not acknowledge
06	(BSY)	Busy
07	(RST)	Reset
08	(SVC)	Service request from tributary
09	(TEN)	Transmit enable

All other supervisory characters are reserved. The use of other characters for tributary supervision is noncompliant with this specification.

6 Operational sequences (See figure 2)

6.1 Idle

Tributaries in the idle state shall not perform any communications sequences.

6.1.1 Idle shall be entered under the following conditions:

– Tributary power on or reset;

– Upon receipt of an (ADDR-SEL) not assigned to the tributary;

– Upon receipt of a GROUP (ADDR-SEL) not assigned to the tributary;

– When a specified time out of six words in duration occurs;

– On receipt of an undefined byte;

– On encountering a transmission error or ambiguous condition.

6.1.2 A tributary shall exit the IDLE state only on receipt of BREAK.

6.2 Active

A tributary in the ACTIVE state shall perform communications sequences as directed by the bus controller.

6.2.1 All tributaries shall enter the ACTIVE state whenever BREAK is received and on completion of a poll sequence.

6.2.2 A tributary shall exit the ACTIVE state on receipt of an address which directs it to the POLL, SELECT, or GROUP SELECT states. A time out between the two address bytes shall cause the tributary to enter the IDLE state.

6.3 Poll

The POLL state shall be used to determine the presence and status of a tributary.

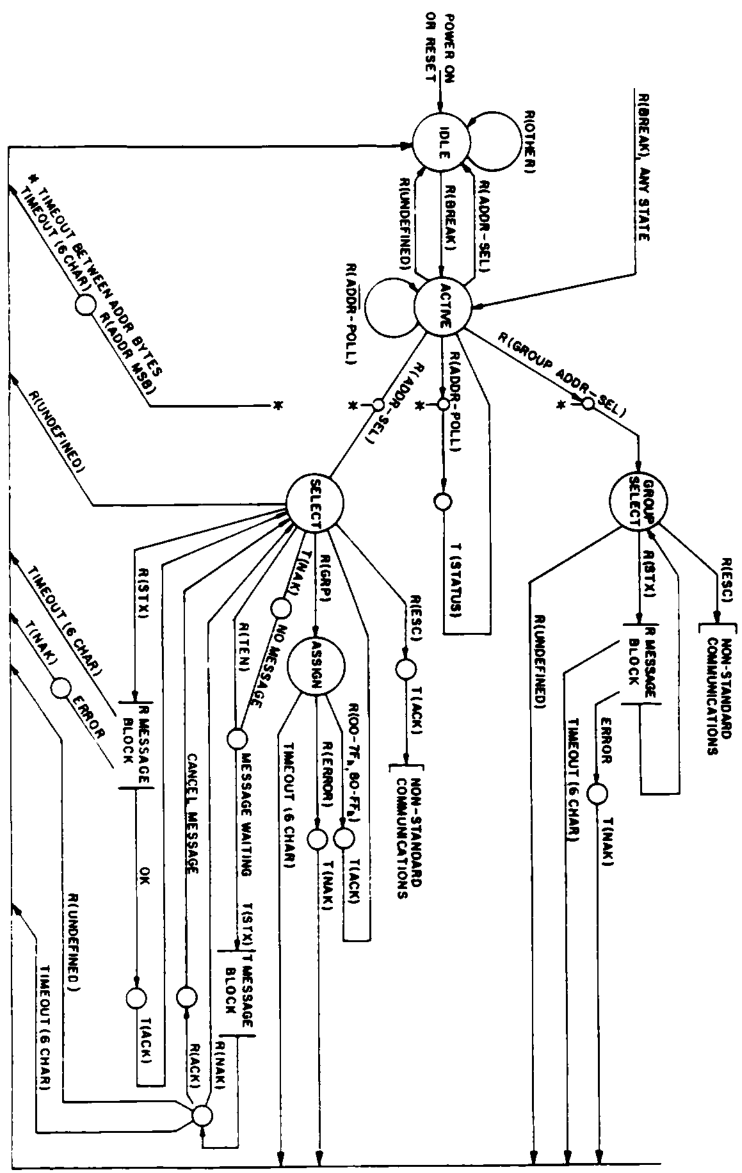


Figure 2 – Tributary supervisory protocol

6.3.1 A tributary shall enter the POLL state on receipt of its poll address (ADDR-POLL). The tributary shall transmit one supervisory character to indicate its status, then return to the ACTIVE state. Tributaries not addressed shall remain in the ACTIVE state. Supervisory characters transmitted shall be of the following:

RESET (07_h): Tributary has powered up or been reset since last poll.

NAK (05_h): An exception (time out, undefined byte, etc.) condition has occurred since last poll or select.

BSY (06_h): Tributary not available to receive messages.

SVC (08_h): Service request from tributary.

ACK (04_h): Tributary available to receive messages.

These characters rank in priority according to the order shown above.

6.4 Select

6.4.1 A single tributary shall enter the SELECT state on receipt of its select address (ADDR-SEL). All other tributaries shall transition to the IDLE state. A tributary in the SELECT state shall execute the communications sequences detailed in 6.4.1.1 through 6.4.1.4 as directed by the bus controller.

6.4.1.1 Receive message

Supervisory character STX (02_h) shall be followed by a message block containing the following characters:

- byte 1: byte count of bytes 2 through n (0 = 256 bytes).

- bytes 2 through n: (256 bytes maximum) — device defined message.

- byte n + 1: checksum = 2's complement of the least significant byte of the sum of bytes 1 through n.

The tributary shall indicate error-free reception by responding with ACK and shall return to the SELECT state.

On encountering an error during reception, the tributary shall respond with NAK, then transition to IDLE.

If transmission from the bus controller is interrupted for more than the time-out period, the tributary shall transition to IDLE.

The tributary shall transfer a complete message, the byte count specified above, and a "block ready" indication to the entities using the system for control.

6.4.1.2 Transmit message

A tributary shall notify the bus controller that a message is waiting by transmitting SVC (08_h) during POLL. Upon receipt of TEN (09_h) while in SELECT, the tributary shall transmit a standard message block as defined in 6.4.1.1.

6.4.1.3 Assign tributary to group

Supervisory character GRP (01_h) shall be followed by a single byte:

00_h deletes all previous group assignments.

If the most significant bit of the byte following GRP (01-$7F_h$) is a ZERO, the assignment of the tributary to the address represented by the following seven bits of that byte is deleted (1_h to 127_h).

80_h assigns the tributary to groups 1-127.

If the most significant bit of the byte following GRP (01_h) is a ONE, the tributary is assigned to the address represented by the following seven bits of that byte (1_h to 127_h).

A tributary may be removed from or assigned to more than one group by repeating the assignment sequence.

If transmission from the bus controller is interrupted for more than the time-out period between receipt of GRP and the group assignment byte, the tributary shall transition to IDLE.

All group addresses except "all call" (8080_h) shall be deleted at tributary power-up or reset

6.4.1.4 Nonstandard communications

Supervisory character ESC (03_h) shall release a tributary to nonstandard communications sequences. The tributary shall respond with ACK; it shall exit the ESC mode only in response to BREAK.

6.4.2 The tributary shall exit SELECT on receipt of BREAK or in response to the exceptional conditions noted in 6.4.1.1 through 6.4.1.3 above.

6.5 Group select

6.5.1 Groups of tributaries shall enter the GROUP SELECT state on receipt of their group select address (GROUP ADDR-SEL). All tributaries not assigned to the group shall transition to IDLE. Tributaries in the GROUP SELECT state shall execute the communications sequences detailed in 6.5.1.1 and 6.5.1.2 as directed by the bus controller.

6.5.1.1 Receive message

Supervisory character STX shall be followed by a message block as defined in 6.4.1.1.

Each tributary returns to GROUP SELECT state after error-free reception of the block; no response shall be transmitted.

On encountering an error during reception, a tributary shall respond with NAK, then transition to IDLE.

If transmission from the bus controller is interrupted for more than the time-out period, tributaries shall transition to IDLE.

6.5.1.2 Nonstandard communications

Supervisory character ESC shall release a group to nonstandard communications in accordance with 6.4.1.4. Tributaries shall exit this mode only in response to BREAK.

6.5.2 Tributaries shall exit GROUP SELECT on receipt of BREAK or in response to the exceptional conditions noted in 6.5.1.1.

7 Bus controller operation

7.1 System synchronization

The bus controller shall transmit BREAK when power is turned on and after being reset.

7.2 Tributary response time out

The bus controller shall transmit BREAK when a tributary fails to respond within the following time-out periods:

- In response to ADDR-POLL, GRP (#), ESC, TEN, END OF MSG BLOCK – 6 words.

8 Guidelines

8.1 Function of this practice

This practice specifies the supervisory protocol used within the communication channel. The protocol is the sequence of characters used to transfer messages between the bus controller and tributaries, provide recovery from error conditions, and generally supervise the usage of the communication channel. This practice is concerned only with channel supervision. Electrical/mechanical characteristics are specified in separate standards since many types of channels which can deliver eight-bit binary bytes and a unique BREAK condition can operate under supervision of the protocol. Message content is specified by standards which are independent of both electrical/mechanical and supervisory characteristics of the communication channel.

8.2 System configurations

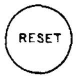
This supervisory protocol permits supervision of point-to-point and multipoint systems. A point-to-point configuration is one in which a communication channel is connected to only one tributary. The bus controller may be connected to more than one channel, each having one tributary. This configuration has the advantage of speed since the dedicated channels provide access to all tributaries simultaneously.

The multipoint bus configuration is one in which more than one tributary is connected to a channel. This configuration has the advantage of reduced cabling costs and complexity. The main disadvantage of multipoint is that messages to different tributaries must queue up and be sent serially on the bus. This configuration is therefore slower in response time than point-to-point systems.

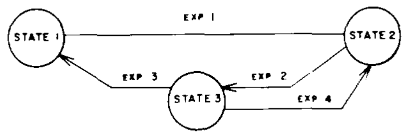
8.3 State diagrams

The supervisory procedures are described by means of state diagrams that show how the interfacing hardware and software in a tributary follow sequences of bytes as they are received from the communication channel.

8.3.1 Each state (condition) that a tributary can assume is represented graphically as a circle; major states are identified by an upper case label or mnemonic within the circle:

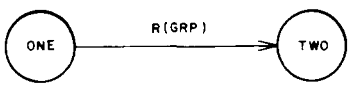


8.3.2 All possible transitions between states are represented by arrows between the states; each transition is qualified by an expression which will produce the transition.



8.3.3 Expressions can be messages received from or transmitted to the communication channel, or local messages generated within the tributary.

8.3.3.1 Messages received from the channel are represented by R followed by the received message *in parentheses:*



indicates transition from state ONE to state TWO on receipt of the message GRP.

8.3.3.2 Messages transmitted to the bus are represented by T followed by the transmitted message in parentheses:

indicates transition from state THREE to state FOUR after transmitting the message ACK.

8.3.3.3 Local messages are represented by lower case labels:

indicates transition from state FIVE to state SIX when reset occurs.

8.4 *Channel synchronization*

Data density is maximized by allowing the transmission of binary data in all device messages. This means that there must be no combination of transmitted bytes which can be interpreted as a channel synchronization command. The channel synchronization command is a unique transmission sequence called BREAK. This sequence cannot be accidentally generated by normal communications. Tributaries receiving BREAK are required to immediately transfer to the ACTIVE state regardless of what they are currently doing in relation to the communication channel. On power up, a tributary enters the IDLE state and ignores all bus transactions until it receives BREAK. Electrical specifications appropriate for use with this supervisory protocol assure that BREAK cannot be generated accidentally.

8.5 Supervisory message components

The protocol uses BREAK, tributary addresses, and a small number of predefined supervisory characters *to manage the communication channel.* Since the addresses and supervisory characters are eight-bit binary bytes, they must be recognized by being received immediately after BREAK. The only supervisory message that is unconditionally recognizable is the BREAK sequence.

8.5.1 Tributary addresses

Tributary addresses consist of two bytes. Up to 8064 tributaries can be addressed uniquely. A one-byte addressing scheme would serve most small system applications with a saving in channel overhead, but complex reassignment strategies would have to be employed in order to accommodate larger users.

The address bytes are characterized by a 1 in the most significant bit. Each tributary is assigned two addresses, a SELECT address and a POLL address. The least significant bit of the least significant byte is set to 0 for SELECT and 1 for POLL.

A unique two-byte address serves as an all-call SELECT address. When this address is transmitted, all tributaries in a multipoint system simultaneously receive and act on system messages.

Tributaries can be assigned to one or more of 127 group SELECT addresses. These addresses allow simultaneous operation with selected groups of tributaries in multipoint systems similar to all-call.

During all-call or group operation, transmission by the tributaries is allowed only when an error condition is encountered, since other transmission could cause channel errors as several tributaries attempt to transmit at the same time. When error conditions are encountered, tributaries transmit the supervisory character NAK; reception of the NAK, or an error indicating channel contention, alerts the bus controller *to an error condition in one or more tributaries.* The bus controller must assert BREAK and poll individual tributaries to determine which tributary(ies) has encountered an error and the nature of the error.

8.5.2 Supervisory characters

The only supervisory characters used are those given in clause 5. Supervisory characters are single eight-bit bytes in which the most significant bit is 0. Implementations of this protocol must not use any other supervisory characters for nonspecified functions as such use would render a tributary incompatible with other systems and could occasion serious operational *failures if other supervisory functions are added to this* practice in the future.

8.6 Poll sequence

The POLL sequence is used to verify tributary presence and status. In multipoint systems, the POLL sequence allows all tributaries to be scanned quickly to see if servicing or attention is required by any of them.

Status characters transmitted by a tributary inform the bus controller of the tributary's current condition. Characters associated with specific conditions are detailed in 6.3.1. *The tributary is required to send the* highest priority status character applicable to its condition if more than one applies. All status characters except service request (SVC) apply to conditions within the interface function. SVC is a pass-through condition which indicates a service need by the equipment controlled through the interface. Device messages are used to identify and provide the service required.

8.7 Message receive or transmit sequences

Device messages are received or transmitted by a tributary by means of the message receive or transmit sequence from the SELECT state. This sequence offers message lengths of 1 to 256 bytes with checksum protection. Groups of tributaries can receive messages from the GROUP SELECT state.

On receipt of a message, the bus controller will transmit an ACK or NAK. It then waits for six characters for any exceptional condition. (See figure 2.)

All equipment control and status information is exchanged by means of device messages.

8.8 Escape sequence

The escape sequence is provided for those users who wish to remain compatible with the electrical and supervisory protocol characteristics *of the interface* system but require nonstandard operational sequences or messages. Single tributaries or groups of tributaries may be placed outside the normal protocol limits using this sequence. The only protocol requirement which must be observed by devices while using this sequence is the requirement to enter the ACTIVE state whenever a BREAK is received from the communication channel.

8.9 System design considerations

This practice and associated standards specify characteristics for equipment compatible with the interface system. *System function and configuration is left to* the system designer. Certain cautions must be observed by the designer:

8.9.1 Device messages

Device messages are specified by other standards. Only device messages which conform to those standards should be transmitted via the standard message receive/transmit facilities. Nonstandard messages should be transmitted via the escape sequence.

8.9.2 Switched tributaries

This practice and associated standards consider operation of bus controllers and tributaries to be within one communication channel. If tributaries are transferred between channels, the system designer must provide means to place them in an appropriate state before connection to a new channel. It is recommended that the tributaries be forced to the IDLE state with all group address assignments cleared before connection. Procedures for notifying a bus controller of the attachment of a tributary will generally be required; these procedures are dependent on the nature of the system and are left to the designer's discretion.

Annex A (informative)
Bibliography

ANSI/SMPTE 207M-1992, Television — Digital Control Interface — Electrical and Mechanical Characteristics

RP 138-1992, Control Message Architecture

RP 138-1992
Revision of RP 138-1986

Control Message Architecture

1 General

1.1 Scope

This practice defines the architecture of the control message language used within a general-purpose communications channel of an interface system which transports data and control signals between equipment utilized in the production, post-production, and/or transmission of visual and aural information.

It is intended that the language described in this practice be utilized when constructing messages used as part of an overall system, allowing interconnection of programmable and nonprogrammable equipment as required to configure an operational system with a defined function, and to allow rapid reconfiguration of a system to provide more than one defined function utilizing a given group of equipment.

1.1.1 Control message language is composed of vocabulary, syntax, and semantics expressed in terms of tokens, rules, and actions, respectively.

1.1.2 The primary intent of this practice is to define the architecture of the messages to be transmitted within the supervisory protocol of the communications channel for the purpose of controlling equipment by external means. Syntax is the set of rules which shall be applied to the vocabulary (tokens) to construct control messages. (The content of the vocabulary and its semantics, being specific to the type of generic equipment, is defined elsewhere.) This practice, or sections thereof, may be applied to the interconnection of elements within an item of equipment.

1.2 Definitions

For the purpose of this practice, the following definitions shall apply:

virtual machine: A logical device consisting of a single device or a combination of devices that responds in essence or effect as a generic type of equipment; e.g., VTR, video switcher, telecine, etc.

virtual circuit: A transparent, logical communications connection between virtual machines. The communications path, in reality, passes through other levels and is propagated over a physical medium.

2 Message structure

2.1 Architecture

The message architecture described in this practice is prepared broadly on the principals of communications levels. This architecture follows a logical structure and is defined in terms of a virtual machine. Messages are of variable length according to function. Complex functions may be divided into basic functions, transmitted as a sequence of shorter messages for execution in the virtual machine.

2.2 Virtual machine

All messages pertaining to generic types of equipment shall be defined in terms of the virtual machine. Utilization of the virtual machine concept in defining messages provides a message architecture that is independent of machine-specific characteristics.

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3 Control message classification

3.1 Control messages

Control messages are classified in accordance with figure 1.

3.1.1 Virtual machine messages are used to pass commands and responses between virtual machines. Virtual machine messages are those initiated by a controlling device with responses originating in the controlled device. Receipt of a virtual machine message shall result in a defined action and/or response by the virtual machine.

Virtual machine messages may be subdivided into:

3.1.1.1 Common messages whose coding is reserved to provide for functions of general application; e.g., procedures, reference time functions, and reset.

3.1.1.2 Type-specific messages are applicable to specific generic categories of equipment.

3.1.1.3 User-defined messages implement special functions which are not included in the type-specific message set.

3.1.2 System-service messages are messages other than virtual machine messages.

3.2 Virtual machine message subsets

A separate and distinct subset of virtual machine messages shall be specified for each type of virtual machine (VTR, telecine, audio tape recorder, graphics generator, etc.). Said subset, termed a dialect, shall comprise common messages, type-specific messages, and, optionally, user-defined messages.

3.2.1 Common messages: Resident machine messages which are in all virtual machine dialects but not necessarily operative in all virtual machines, whose coding is reserved to provide for functions of general applications.

3.2.2 Type-specific messages: Virtual machine messages which are defined in virtual machine dialect recommended practices.

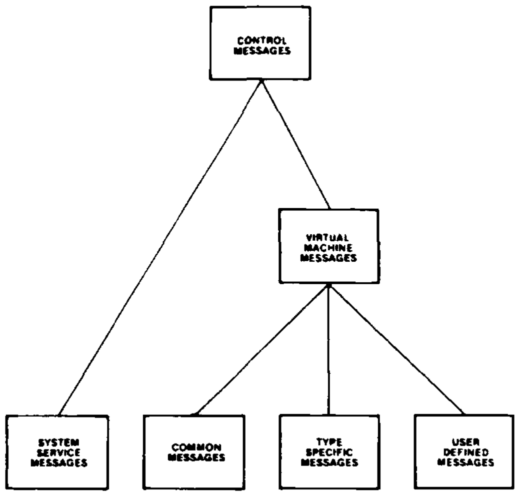


Figure 1 – Message Classification

3.2.3 User-defined messages: Virtual machine messages which are unique to the type (manufacturer, model, version, S/N, etc.) of the specific machine. Although the definition and/or documentation of user-defined messages is considered outside the scope of this practice, the structure of such messages shall conform to the message architecture as defined herein.

4 Control message construction

4.1 Syntax

System service and virtual machine messages are uniformly constructed with the following syntax:

MESSAGE = KEYWORD (+ ARGUMENT)

where the keyword characterizes the function to be performed and the argument contains the parameters, where necessary, to perform that function.

A parameter has the following syntax:

PARAMETER = (NAME +) VALUE(S)

The name may be implied with the use of specific keywords and, in such cases, is therefore not required. The length and format of the value (or values) are defined by the name (or implied name). No restriction is placed on the possible concatenation of parameter values.

4.2 Message formats

All control messages are formed as groups of integral bytes. The first byte of each message shall be the keyword. A keyword specification defines the format of its arguments; although no mathematical relationship is intended between the bit pattern of the keyword and the format. Messages are constructed in one of the following formats:

Format 1 Message	=	<Keyword>
Format 2 Message	=	<Keyword> <Parameter List>
where:		
<Parameter List>	=	<Parameter>
or:		
<Parameter List>	=	<Begin> <Parameter Group> <End>
where:		
<Parameter Group>	=	<Parameter>
or:		
<Parameter Group>	=	<Parameter Group> <Parameter>
where:		
<Parameter>	=	<Parameter Value> . . . <Parameter Value>
or:		
<Parameter>	=	<Parameter Name>
	=	<Parameter Value> . . . <Parameter Value>

The appropriate message format can be selected by means of the decision tree given in figure 2.

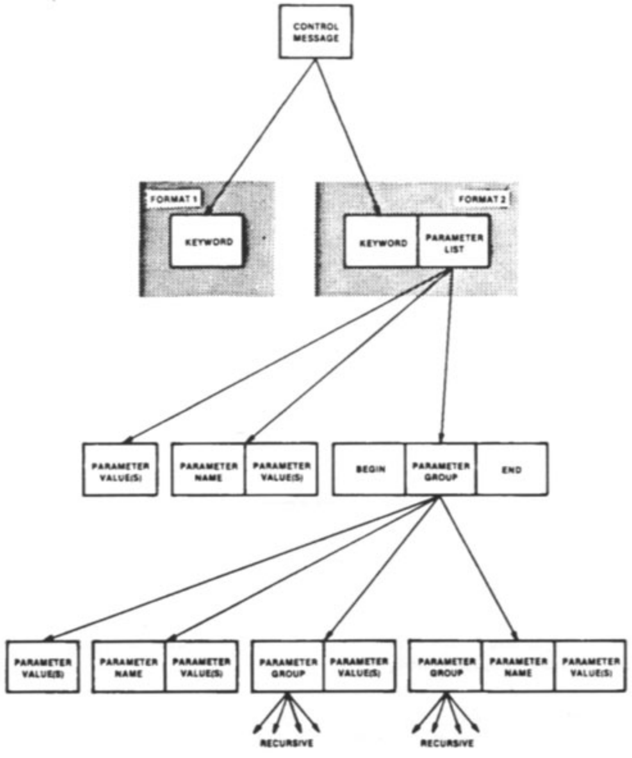


Figure 2 – Decision tree

5 Message coding

5.1 Identical or similar functions on equipment of differing generic types should be effected by the same keyword bit pattern.

5.2 Parameter values

Messages may contain parameters as an essential part. All parameters are classified as follows:

5.2.1 Logical parameter values

Parameters representing any abstract function(s) that may be expressed by a simple binary state of 1 (true) or 0 (false) such as tally on/off or yes/no.

The minimum code length for a single logical parameter is one byte. Individual logical parameters can be assembled, where applicable, into groups to form bit-specific bytes for transmission purposes.

5.2.2 Numerical parameter values

Parameters representing a numerical value and consisting of the following:

Unsigned number parameters:

Parameters representing any numerical value without polarity.

Signed number parameters:

Parameters representing any numerical value with polarity.

5.2.3 Time-code parameter values

Time is indicated as a four-byte quantity. Parameters representing hours, minutes, seconds,and frames are expressed in BCD in that order. (In BCD,the least significant bit is transmitted first.) The hex "40"-bit of the frame's byte will be set to one (1) in drop-frame compensated mode. In nondrop frame uncompensated mode and all other time code standards, this bit will be zero (0). In all standards, the hex "80"-bit of the second's byte will be set to zero (0) to indicate monochrome field 1 or color fields 1, 3, 5, or 7. This bit set to one (1) will indicate monochrome field 2 or color fields 2, 4, 6, or 8. Unused bits are reserved and are set to zero (0) until defined. (See figure 3.)

5.2.4 *High-resolution time code parameter values*

High-resolution time is indicated as a six-byte quantity. The first four bytes are exactly the same as time parameter values. The two remaining bytes express fractions of frames as a 16-bit binary unsigned number. (See figure 3.)

5.2.5 Literal parameters are parameters based, in general, on ASCII characters.

5.2.6 Raw data parameters are parameters based on a free-form data stream. Raw data parameters must provide for byte transparency to the lower layers. The first byte of a raw data parameter shall be a byte count.

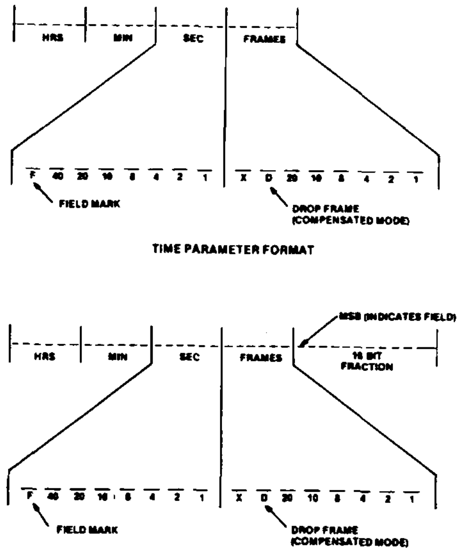


Figure 3 – High-resolution time parameter format

SMPTE RECOMMENDED PRACTICE

RP 139-1992
Revision of RP 139-1986

Tributary Interconnection

1 General

1.1 Scope

This practice describes the mechanism for the transfer of control messages between tributaries used within a general-purpose communications channel of an interface system which transports data and digital control signals between equipment utilized in the production, post-production, and/or transmission of visual and aural information.

It is intended that the mechanism described in this practice be utilized when transferring control messages between tributaries used as a part of an overall system. The tributaries may be located either within a local network or on separate local networks which are interconnected by means of gateways and an interconnection bus.

It is further intended that this mechanism, when used as part of an overall system, shall allow the interconnection of programmable and nonprogrammable equipment as required to configure an operational system with defined functions, and will allow rapid reconfiguration of a system to provide more than one defined function utilizing a given group of equipment.

1.1.1 The message transfer mechanism makes use of virtual circuits, linkage directories, and system service messages (defined below).

1.1.2 The primary intent of this practice is to define the mechanism enabling the transfer of messages between tributaries for the purpose of controlling equipment by external means.

1.2 Definitions

For the purposes of this practice, the following definitions shall apply:

1.2.1 virtual machine: A logical device consisting of a single device or a combination of devices that respond in essence or effect as a generic type of equipment; e.g., VTR, video switcher, telecine, etc.

1.2.2 virtual circuit: A transparent, unidirectional, logical communications connection between virtual machines. The communications path, in reality, passes through other levels and is propagated over a physical medium.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this practice. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this practice are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

ISO 3309:1984, Information Processing Systems — Data Communication — High-Level Data Link Control Procedures — Frame Structure

ISO 4335:1987, Information Processing Systems — Data Communication — High-Level Data Link Control Elements of Procedures

ISO 4903:1989, Information Technology — Data Communication — 15-pole DTE/DCE Interface Connector and Contact Number Assignments

Approved August 1, 1991

CCITT Recommendation X.21, Interface Between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) for Synchronous Operation on Public Data Networks

CCITT Recommendation X.24, List of Definitions for Interchange Circuits Between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) on Public Data Networks

CCITT Recommendation X.25, Interface Between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) for Terminals Operating in the Packet Mode and Connected to Public Data Networks by Dedicated Circuit

CCITT Recommendation X.27, Electrical Characteristics for Balanced Double-Current Interchange Circuits for General Use with Integrated Circuit Equipment in the Field of Data Communications

3 Interconnection within a local network

3.1 Message transfer

The mechanism for message transfer between tributaries is based broadly on the principles of communications layering and makes use of virtual circuits. This allows for the establishing of, and breaking down of, multiple links between the tributaries. System service messages perform this function.

A linkage directory is established within the bus controller for each working session. The directory is considered to be a system service feature and provides for the establishment of multiple virtual circuits through the network.

3.2 Linkage directory

The linkage directory shall establish a relationship between virtual machines; i.e., a virtual circuit. Establishment of the linkage directory shall be completed as the initial task in each working session. The linkage directory resident within the system service level of the bus controller binds message sources and destinations.

Linkage information may originate in any application level, and shall effect directory construction within the system service level of the bus controller. Linkage messages are reserved messages within the system service subset of all message dialects; they establish and disconnect virtual circuits within the network.

The bus controller, on receipt of a transmission request from the supervisory level of any tributary, will identify the destination tributary by reference to the linkage directory; acting as an intermediary, it will forward the message as directed.

3.3 Multiplexing within tributaries

Tributaries, in general, have a single supervisory level address, and a single physical connection end point to the bus. Alternative multiplexing mechanisms, as described below, enable multiple virtual circuits to pass through any single connection end point.

3.3.1 Multiple, logically independent virtual machines, each with a unique supervisory level address, may be attached to the communications channel through a common connection end point. Multiplexing is then performed by multiple polling of the addressing entity residing within the supervisory level. (See figure 1.)

NOTE - It may be noted that any individual tributary address may achieve a higher priority — and hence an improved response time at the expense of that of the remaining tributaries — by being allocated more than one poll within each poll sequence.

3.3.2 Alternatively, a single supervisory level address may be multiplexed to multiple logically independent virtual machines with selection being performed by a logical switch residing within the entity of the destination tributary system service level. (See figure 2.)

The required virtual machine is selected from those associated with the single supervisory level address, by means of a system service virtual-machine-select message. (See 4.4.) This is transmitted from the bus controller under the direction of the linkage directory held within its system service level, to the destination tributary system service level, immediately prior to the transmission of any control message, or sequence of control messages, destined for that specific virtual machine.

The selected routing will remain in existence until receipt, by the system service level, of a new virtual-machine-select message thereby minimizing the message traffic on the communications channel.

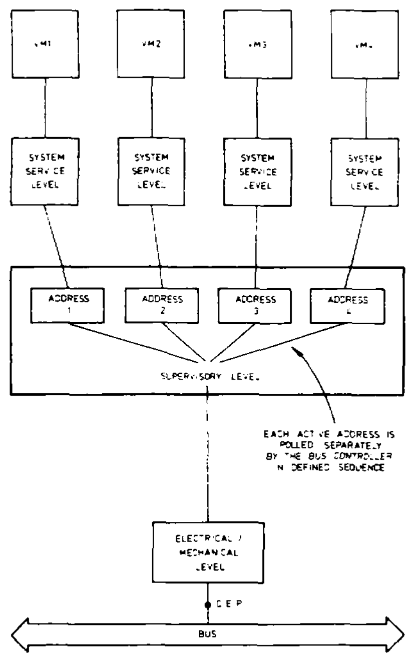


Figure 1 – Multiplexing within supervisory level

3.3.2.1 The reverse route of each virtual circuit, when required, will be selected similarly by the *logical switch resident* within the entity of the system service level of the multiplexed tributary. This selection is performed on receipt of a control or response message from any one of the virtual machines attached to the system service level of the tributary. The system service level will then instruct its supervisory level to transmit the appropriate virtual-machine-select message to the supervisory, and hence the system service, level of the bus controller.

3.3.2.2 System service level group assign and deassign commands shall be used to assemble/disassemble groups of virtual machines within the system service level, from those associated with a single supervisory level address, for simultaneous control purposes.

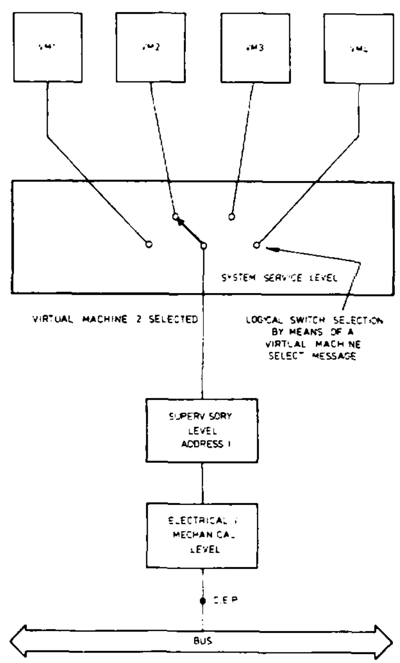


Figure 2 – Multiplexing within system service level

Virtual circuits employing virtual group identifiers shall be recorded as additional entries within the bus controller linkage table.

3.3.3 It should be noted that a bus overhead exists in each method of virtual circuit multiplexing. Where the multiplex is to take place within the supervisory level (3.3.1), the overhead will take the form of additional polls in each cycle.

System service level multiplexing (3.3.2) introduces an additional control message (the virtual-machine-select message) prior to each virtual machine message, or series of virtual machine messages, destined for an alternative virtual machine.

The choice of multiplexing mechanism, where used, rests with the system designer in recognition of specific design considerations.

3.4 Forbidden configurations

Some virtual circuit configurations may be forbidden due to the function of the particular tributary; i.e., the *functions of the tributaries are incompatible.* Checking mechanisms should be employed to ensure that illegal virtual circuits cannot be established. Most of the checking would be performed in the system service level according to predefined rules within the particular network. Some rules could be readily derived from the type of tributary (built in) while others may be imposed by the user or system designer.

4 System service messages

System service messages are messages contained in the *system service subset of all message dialects* and shall be used to command the performance of system functions. These functions include but are not limited to:

4.1 Segmentation and reassembly

These processes enable the transfer of messages which exceed the maximum supervisory level message block length (see figure 3a.) The parsing mechanism for segmentation and blocking is described by the state diagram given in figure 4.

4.1.1 A data segment shall take the following form (see figure 3b):

- 1st byte: Keyword SEGMENT.

- 2nd byte: Number of segments remaining; last segment is 0; segment count shall be sent in sequentially descending order.

- Remaining bytes: Segment data. No further message shall follow a data segment message within a single supervisory level block.

4.2 Blocking and deblocking

These processes enable the concatenation of messages within a single supervisory level message block.

4.2.1 A data block shall take the following form (see figure 3c):

- 1st byte: Keyword BLOCK.

- *2nd byte: Byte count* (N), *where* N is the number of bytes in the block data.

- Remaining bytes: Block data.

4.2.2 The supervisory level shall transfer the byte count to the system service level.

4.3 Establishment of virtual circuits

This process is effected through the management of the linkage directory contained within the bus controller.

4.4 Selection of a virtual machine

This process enables the selection of a virtual machine from those previously assigned to a tributary.

4.5 Tributary reset

This command returns the tributary to its power-up default state.

4.6 Group assign/deassign

These commands establish/break down system service level groups of virtual machines for joint control purposes.

4.7 Virtual group assign/deassign

These commands establish/break down supervisory *level groups of tributaries* for joint control purposes.

5 Interconnection of local networks

5.1 Interconnection bus

Interconnection of individual local networks shall be by means of an interconnection bus (see figure 5). *Linking of the local network to the interconnection bus* shall be by means of a GATEWAY.

ISO 3309 and 4335 (HDLC), in accordance with CCITT Recommendation X.25 — LAPB, shall be used for the data link layer protocol between the gateway and the interconnection bus coupler; the physical interface shall employ the connector and pin assignment as specified by CCITT Recommendation X.21 (ISO 4903); using balanced signalling as specified by CCITT Recommendation X.27; and with interface signals as specified by CCITT Recommendation X.24.

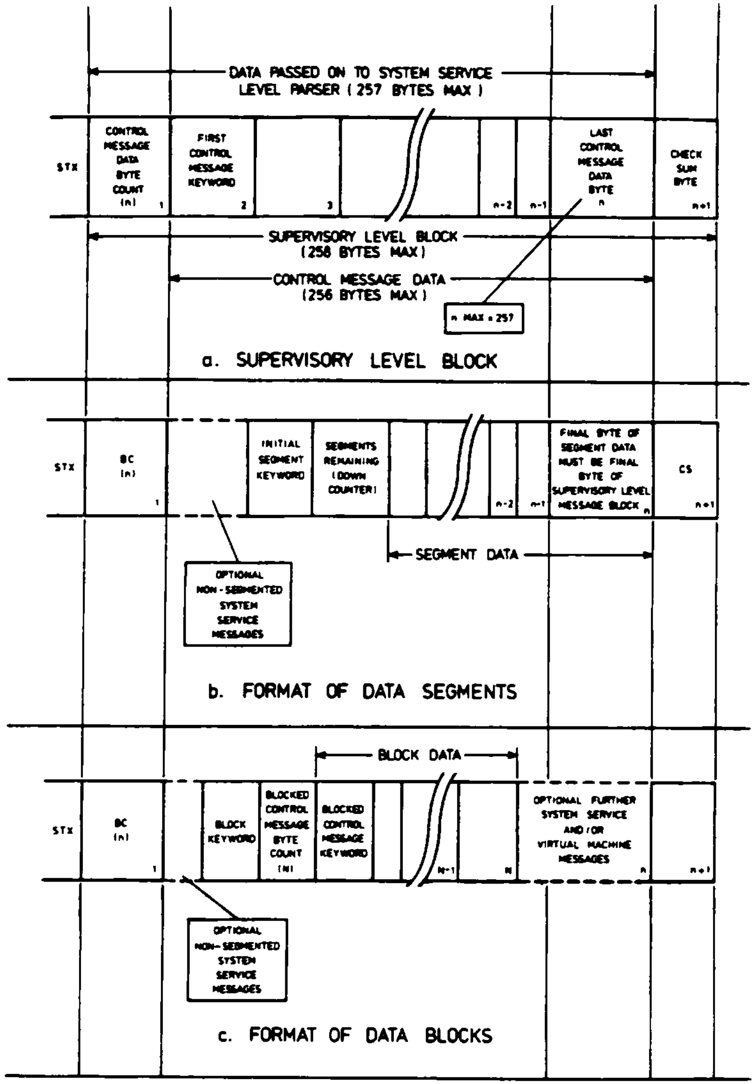


Figure 3 – Data segments and blocks

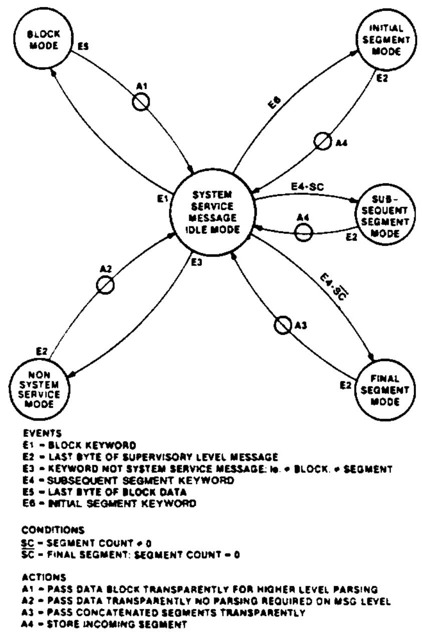


Figure 4 – Segmentation/blocking state diagram

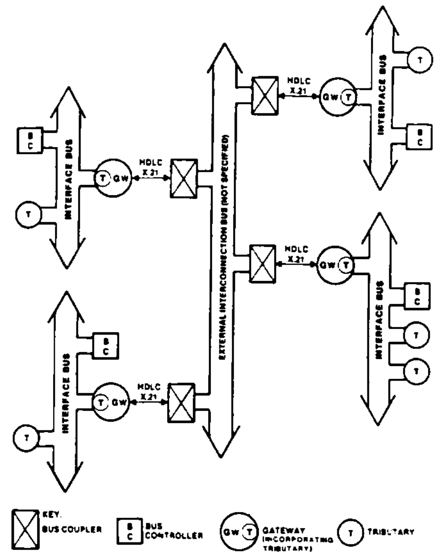


Figure 5 – Local network interconnection

5.2 Gateway

The gateway is a logical device whose task is to transfer messages between a local network and an external interconnection bus coupler. The gateway provides for the interchange of messages between multiple local networks.

The gateway will maintain a linkage directory in its system service level. The linkage table will allow the gateway to be seen by the bus controller as a set of virtual tributaries linked by virtual circuits.

The gateway will provide for all protocol conversions required to convert from the interface bus supervisory and electrical/mechanical level standards as specified in RP 113-1992 and ANSI/SMPTE 207M-1992, respectively, to the HDLC data link and X.21 physical link layers.

The gateway will provide decoding of group addresses provided for in the supervisory level (RP 113-1992) and will forward messages addressed to these groups over the interconnection bus as discrete individual select addresses. Where more than one external tributary is addressed by a group message, the individual messages to all such tributaries shall be dispatched sequentially as individual messages from the gateway. Translation takes place in the system service level of the gateway. The functional structure of the gateway is shown in figure 6.

6 Guidelines

This clause gives a typical example of virtual machine selection when using the multiplexing technique detailed in 3.3.2. It encompasses operations in both the system service and supervisory levels and thus includes features described in RP 113-1992.

In 6.1, the procedure is described in broad outline; in 6.2, the same example is dealt with in more rigorous detail.

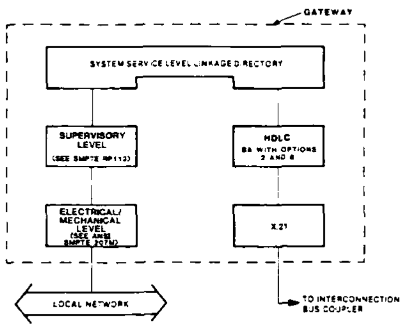


Figure 6 – Gatway functional structure

6.1 In this broad outline, the form of the messages is not defined precisely, but is given only as an illustration of the function to be performed.

(A) Assume that three control panels are linked to the local network through a single tributary address and connection end point as shown in figure 7.

During the assignment process, the control panels CP1, CP2, and CP3 have been associated with VTR, telecine, and still store, respectively, via virtual circuits (1), (2), and (3).

(B) Assume further that a VTR command has just been issued by CP1 and a telecine PLAY command is now required.

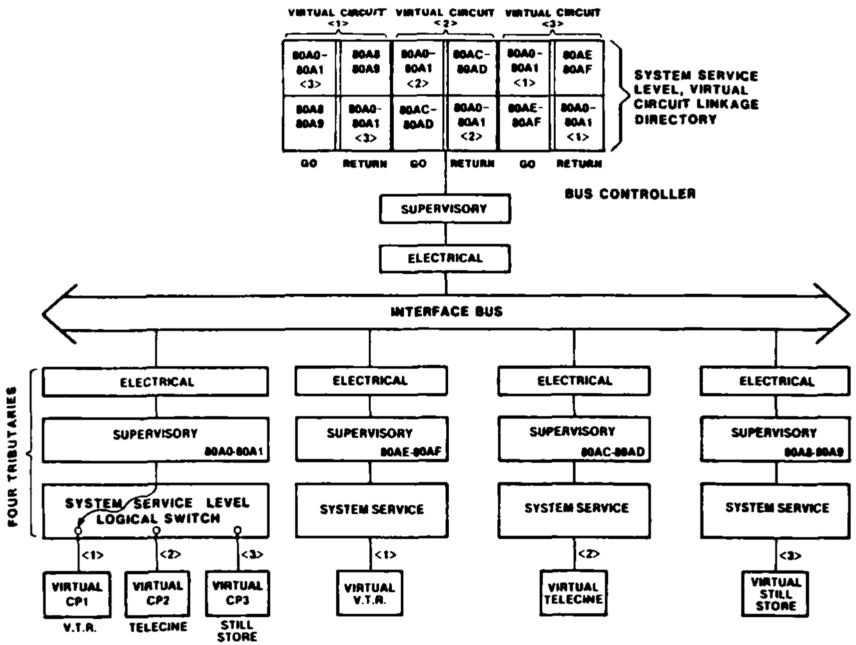


Figure 7 – Example of virtual circuit select mechanism

(C) The following linkage message must be issued by the system service level of the control panel tributary:

[Virtual-machine-select] [2]

This changes the virtual machine selection from virtual machine [1], (VTR), to virtual machine [2], (telecine).

(D) The control panel virtual machine then issues the control message:

[PLAY]

This causes the telecine virtual machine to change to the play state.

Any subsequent messages from the control panel to the telecine will be transferred without any further linkage; e.g., the control message [STOP].

A [NEXT SLIDE] command for the still store virtual machine would, however, require:

1. [Virtual-machine-select] [3] and
2. [NEXT SLIDE]

in order to reselect the virtual machine CP3.

6.2 In this more rigorous treatment of the example given in 6.1, it is assumed that the three control panel virtual machines, CP1, CP2, and CP3, are linked to the interface bus through the single tributary address [82A0/82A1] and connection end point.

6.2.1 A [START] command from the telecine control panel virtual machine CP2 attached to tributary 82A0/82A1 is to be sent by virtual circuit [2] to the telecine virtual machine connected to tributary 82AC/82AD. A possible message exchange might be:

(A) Telecine control panel virtual machine, (CP2), passes [START] command to system service level of tributary 82A0/82A1.

(B) 82A0/82A1 system service level instructs supervisory level to raise the service request flag (SVC).

(C) The bus controller, as part of its normal poll sequence, polls 82A1; and receives [SVC].

(D) The bus controller issues select address 82A0; it then sends [TEN] to 82A0/82A1 supervisory level.

(E) 82A0/82A1 supervisory level sends:

[STX] [byte count (BC)] [virtual-machine-select] [2] block check (B.CK)]

to the bus controller. (See note 1.)

(F) The bus controller responds with [ACK] and a further [TEN].

(Since the last message was a virtual-machine-select message, a further virtual machine control message is expected by the bus controller.) (See note 1.)

(G) The supervisory level of the tributary 82A0/82A1 sends:

[STX] [BG] [START] [B.CK]

to the bus controller. (See note 1.)

(H) The bus controller system service level identifies the destination of [82A0/82A1 — virtual-machine 2] from its linkage directory. The address is found to be 82AC/82AD.

(I) The bus controller issues [BREAK] followed by the select address 82AC.

(J) 82AC/82AD tributary supervisory level responds with [ACK].

(K) The bus controller then sends:

[STX] [BC] [START] [B.CK]

to tributary 82AC/82AD.

(L) The supervisory level of tributary 82AC/82AD responds with [ACK] and passes the control message to the system service level parser.

(M) The system service level parser passes the [START] command to the telecine virtual machine.

NOTE 1 - The messages in (E) and (G) might be concatenated into the single hybrid command:

[STX] [BC] [virtual-machine-select] [2] [BLOCK] [START] [B.CK]

in order to limit protocol overhead. In this case, the message contained in (F) would not be necessary.

6.2.2 A tally response [STARTED] from the telecine virtual machine tributary 82AC/82AD is to be sent to telecine control panel virtual machine CP2 attached to the interface bus through tributary 82A0/82A1.

(A) The telecine virtual machine passes the [STARTED] tally to the system service level of tributary 82AC/82AD.

(B) The system service level instructs the supervisory level of 82AC/82AD to raise the service request flag (SVC).

(C) The bus controller, as part of its normal poll sequence, polls 82AD and receives [SVC].

(D) The bus controller issues the select address 82AC, followed by [TEN] to the supervisory level of 82AC/82AD.

(E) The bus controller receives the tally:

[STX] [BC] [STARTED] [B.CK]

from 82AC/82AD.

(F) The bus controller system service level determines the destination (82A0/82A1 — virtual machine 2) from its system service level linkage directory.

(G) The bus controller issues [BREAK] and the select address 82A0.

(H) 82A0/82A1 supervisory level responds with [ACK].

(I) The bus controller sends:

[STX] [BC] [virtual-machine-select] [2] [B.CK]

to tributary 82A0/82A1 (see note 2).

(J) The tributary 82A0/82A1 responds with [ACK], and sets the logical switch in its system service level to select telecine control panel virtual machine CP2.

(K) The bus controller sends tally:

[STX] [BC] [STARTED] [B.CK]

to tributary 82A0/82A1 supervisory level (see note 2).

(L) The supervisory level of tributary 82A0/82A1 responds with [ACK] and passes the control message to the system service level parser.

(M) The system service level parser passes [STARTED] tally to the telecine control panel virtual machine CP2.

NOTE 2 - The messages in (I) and (K) might be concatenated into a single hybrid command thus:

[STX] [BC] [virtual-machine-select] [2] [BLOCK] [STARTED] [B.CK]

in order to limit protocol overhead.

6.2.3 It should be noted that further commands to the same virtual machine, and which follow immediately on the sequences detailed in 6.2.1, will omit steps (E) and (F) since no further changes are needed in the virtual machine selection.

Similarly, 6.2.2 steps (I) and (J) will be omitted under the same circumstances.

Annex A (informative)
Bibliography

ANSI/SMPTE 207M-1992, Television — Digital Control Interface — Electrical and Mechanical Characteristics

RP 113-1992, Supervisory Protocol for Digital Control Interface

PROPOSED

SMPTE RECOMMENDED PRACTICE
Critical Viewing Conditions for Evaluation of Color Television Pictures

1 Scope

1.1 This practice specifies the environmental and surround conditions that are required in television or video program review areas for the consistent and critical evaluation of 525-line, 59.94-field television signals and other video program material at different technical facilities on properly aligned color picture monitors.

1.2 This practice also is designed to provide for repeatable color grading or correction and the rendering of subjective assessments when used with RP 167.

2 Color monitor characteristics

Parameters for the monitor screen at reference white (100 IRE) are as follows:

- a chromaticity of illuminant D_{65};
- a screen aim luminance of 120 cd/m^2 (35 fL).

3 Observer viewing characteristics

3.1 The observer should have normal color perception.

3.2 Adequate time must be allowed for visual adaptation to the viewing environment.

3.3 The observer's distance from the monitor screen should be 4–6 picture heights.

3.4 The observer should view the monitor screen at a preferred angle in both the horizontal and vertical planes of 0° ± 5°, but no greater than ± 15°, from the perpendicular to the midpoint of the screen .

4 General conditions — Viewing area decor

4.1 The viewing area decor should have a generally neutral matte impression, without dominant colors (see A.4). It is most critical that areas in the field of view be devoid of vivid colors.

4.2 Surface reflectances should be nonspecular and should not exceed 10% of the peak luminance value of the monitor white. Surfaces which may be visible in the monitor screens, due to the mirror effect, should have a nonspecular surface reflectance of less than 15%.

4.3 Production desk and control console surfaces should have a generally neutral matte finish without dominant colors or specular features.

5 Surround characteristics

5.1 The surround wall should be either illuminated or reflective (see A.2 and A.3).

5.2 The reflective surround should be a visually neutral surface (preferable white or gray).

5.3 The reflective surround should be illuminated with a light quality closely matching illuminant D_{65}. Generally, the reflective surround receives its illumination from the controlled ambient lighting in the room (see clause 7).

5.4 The reflected light from the surround or background in the field of view should have a peak luminance of 12 cd/m^2 (3.5 fL) which is nominally 10% of the monitor screen(s) reference white (see A.2). Practice has shown that a uniform field is not optimum but that a gradation of intensity from top to bottom, or bottom to top, is more pleasing.

5.5 The surround should have an area, outside the monitor screen mask, of ideally at least eight times the monitor screen area (see figure 1).

5.6 If two monitor screens are mounted in one monitoring wall, then the total surround area should ideally be five times the total monitor screen area (see figure 2).

5.7 For monitors mounted in studio control room walls, see annex B.

6 Acceptable methods

6.1 A good practical approach is to have a monitor placed in a free-standing environment 2.5 to 5 screen heights in front of a wall providing the visual surround. The surround receives its illumination from directly controlled and ambient lighting in the room (see A.5).

6.2 Another approach is to mount the monitor in a wall with its face approximately flush with the surface of the wall.

7 Viewing room lighting characteristics (see annex C)

7.1 All light sources in use during picture assessment or adjustment should have a color quality closely matching the monitor screen at reference white; i.e., D_{65} (see A.5).

7.2 The ambient light reflected from the screen of a switched-off monitor should be the lowest possible level (see A.6).

7.3 Reflections on the monitor screen should not cause a perceptible impairment from the normal viewing position (see A.7).

7.4 The production desk and control consoles where a script is read should be illuminated to a light level of about 100 lx (10 fc). The illumination on the general working surfaces of the production desks and consoles should be 30–40 lx (3–4 fc) (see annexes A.8 and C).

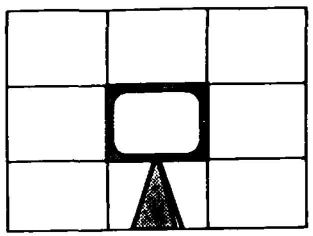


Figure 1 – Single monitor surround area

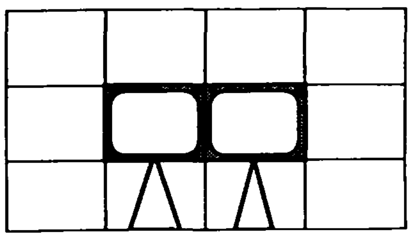


Figure 2 – Two-monitor surround area

Annex A (informative)
Additional data

A.1 Reference white

Reference white is obtained when a color video signal at a specified luminance level with zero color subcarrier is displayed on a properly aligned color picture monitor.

A.2 Surround

The surround is defined as the light, visible to the observer, from a plane or from behind a plane coincident with and surrounding but not including the viewing screen(s).

A.3 Characteristics of surrounds — Chromaticity and luminance

A surround, lit either from behind or from the front, makes picture matching easier to control. The surround, rather than the base luminance, becomes a fixed neutral visual reference. The surround will appear gray (neutral) compared to monitor screen(s) since it is about 10% of the light intensity of the monitor screen(s) reference white and the same color quality. The surround stabilizes the eye to achieve adaptation because it provides the observer(s) with a fixed neutral visual reference for color and brightness judgements, increases the apparent picture contrast, and provides for a more pleasant and less fatiguing work environment.

A.4 Decor

The viewing room should provide a pleasant environment. Areas in the field of view at normal operating positions should be a neutral surface color. For other areas, the use of pastel colors is preferred if a change from neutral is desired.

A.5 Viewing room light source

The preferred luminaires are daylight type fluorescent lights. Incandescent light sources filtered to daylight color temperature are also acceptable.

A.6 Impact of light

For a tutorial on the impact of light on the screen, see "Operations Adjustment of Picture Monitors in Television Studios," by C. A. Siocos, *J. SMPTE*, 74: 11-14, January 1965.

A.7 Veiling reflection

A veiling reflection is defined as a regular reflection which is superimposed upon diffuse reflections from an object and *which partially or totally obscures the details to be seen* (on the color monitor screen(s)) by reducing the contrast.

A.8 Illumination

A fluorescent script luminaire without a special louver, mounted about 122 cm (48 in) above a surface will create a light level of about 500 lx (50 fc) on the surface. When a special matte-black egg-crate louver is installed, the lighting level is reduced to 100 lx (10 fc) and the angle of light spread is less than 15°. It is normal to have the illuminated area cut off within 50 mm (2 in) at the edge of the work surface. For additional light intensity control, neutral density filter material can be installed on the upper surface of the special louver to achieve the correct illumination levels.

NOTES

1 A fluorescent compatible dimmer should be used to avoid flicker.

2 Fluorescent luminaires can provide no hard edge of light cut off; therefore, the control area should be configured within this constraint.

Annex B (informative)
Studio control room monitor walls

It is often necessary to have black-and-white monitors surrounding one or more color monitors in a studio control room environment. These black-and-white monitors should be the same color temperature as the properly adjusted color monitor(s), 6500 K.

Black-and-white monitors are normally equipped with P4 phosphors, about 9300 K. This cooler color temperature prevents the background surrounding the color monitors from remaining neutral, 6500 K. Monitors with CRTs containing P4 phosphors should have their CRTs changed to D_{65}. Most manufacturers provide a CRT with 6500 K phosphors as an option in black-and-white monitors. When used, the peak-light output of these black-and-white monitors should be lower in value than that of the color monitors, usually two-thirds of the color monitor peak white value.

It is often important that the color monitor(s) be the primary viewing object in a wall full of monitors. The light output intensity of surrounding black-and-white monitors can divert attention from the color monitor(s) if the black-and-white monitors are set equal to or above the color monitor(s) intensity.

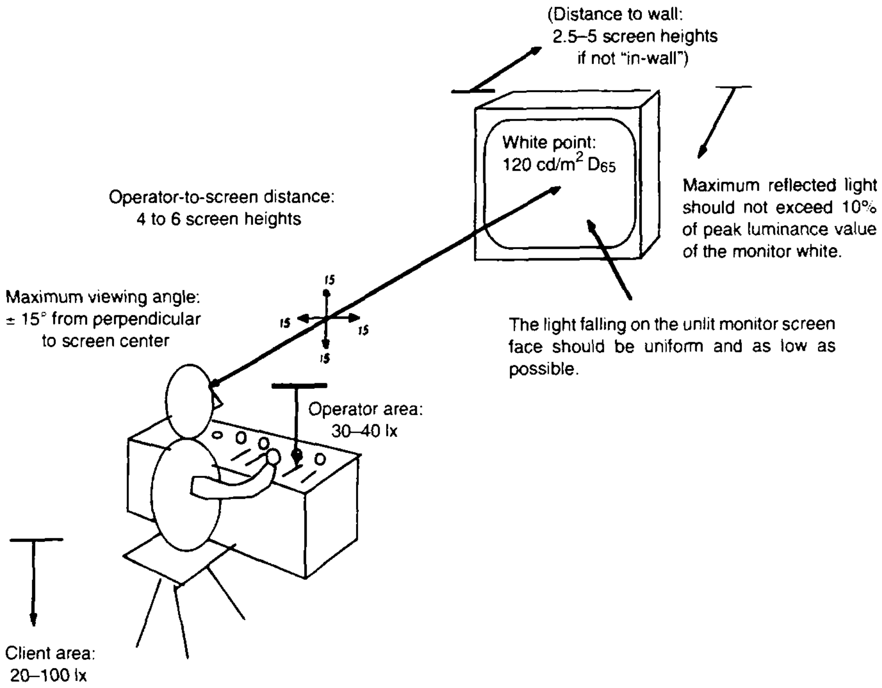
Annex C (informative)
Surround specifications

C.1 Background

The monitor is set in front of or into a wall. If in front of a wall, the tube face is typically 2.5 to 5 picture heights from the wall. The color of the monitor wall and the side walls within the field of view should be neutral.

C.2 Illuminant

The illuminant should approximate D_{65}.



Annex D (informative)
Bibliography

SMPTE RP 167, Alignment of Professional Television/Studio Color Picture Monitors

PROPOSED
SMPTE RECOMMENDED PRACTICE
Alignment of Professional Television Color Picture Monitors

1 Scope

1.1 This practice describes an alignment procedure for the consistent and repeatable alignment of television color picture monitors.

1.2 For critical evaluation of picture program material, the aligned monitor shall be used in an environment such as that described in SMPTE RP 166.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this practice. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this practice are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

SMPTE EG 1-1990, Alignment Color Bar Test Signal for Television Picture Monitors

SMPTE RP 166, Critical Viewing Conditions for Evaluation of Color Television Pictures

3 Test signals and equipment

A video test signal generator providing the following signals shall be available:

- SMPTE color bars with PLUGE (picture lineup generating equipment) signal (SMPTE EG 1-1990)
- Unmodulated gray-scale (50% APL)
- Window signal (100 IRE)
- Unmodulated variable level flat field
- Crosshatch
- Pulse and bar
- Multiburst
- Centrally placed PLUGE signal

Ideally, a spectroradiometer is the optimum instrument for setting color temperature. Operationally, a split-field optical comparator with a photometer and/or tristimulus (color analyzer) device is required.

4 Definition of terms

All color picture monitors are functionally similar, but the designation of the controls varies among models and manufacturers. (Refer to A.1 for a listing of controls that perform similar functions.)

5 Alignment

Although this practice specifies an operational alignment procedure for television color picture monitors, other alignment procedures are equally valid if they achieve the desired result. All the steps are not required every time the color picture monitor is to be aligned. If the desired results cannot be obtained, then the corrective procedures suggested by the manufacturer should be followed.

If the color picture monitors have an NTSC corrective matrix, the matrix should be switched off during alignment (see A.4). Alignment procedures should be followed in the sequence given below:

- Initial conditions (see 5.1)
- Initial screen adjustments (see 5.2)
- Display uniformity (see 5.3)
- Scan size (see 5.4)
- Geometry and aspect ratio (see 5.5)
- Focus (see 5.6)
- Convergence (see 5.7)
- Aperture correction (see 5.8)
- Chrominance amplitude and phase (see 5.9)
- Brightness, color temperature, and gray-scale tracking (see 5.10)
- Monitor matching (see 5.11)

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5.1 Initial conditions

The color picture monitor should be turned on and allowed to stabilize for 20–30 minutes. The room ambient lighting should be the same as it is when the monitor is in normal service. Several minutes must be allowed for visual adaptation. All the color picture monitor controls should be in their preset positions. It is important that the aim luminance value, 120 cd/m^2 (35 fL), be used for all the adjustments, except as noted. It is important that the comb filter and NTSC color matrix, if present, be defeated (see A.4).

5.2 Initial screen adjustments

Switch the monitor to the setup position. In this mode, only horizontal lines or bars appear on the monitor screen. Adjust the red, green, and blue screen controls individually so that red, green, and blue signals are barely visible. These adjustments are only preliminary and will be modified later to achieve correct gray-scale tracking (consult manufacturer's procedures).

5.3 Display uniformity

Good display uniformity is essential for color monitor matching. Perceptible variations in luminance levels or discolorations will make monitor matching difficult or impossible.

5.3.1 Purity

Purity is the ability of the gun to excite only its designated phosphor. It is checked by applying a low-level flat-field signal and activating only one of the three guns at a time. The display should have no noticeable discolorations. Purity can also be checked by turning the contrast control to minimum and increasing the brightness control until a medium bright red, green, or blue raster appears. If discolorations are perceptible, then appropriate corrective action should be taken; i.e., degaussing, movement of purity magnets, etc. (see A.5).

5.4 Scan size

The color picture monitor application establishes whether the overscan or underscan presentation of the display will be selected. An underscanned display is one in which the active video (picture) area, including the corners of the raster, is visible within the screen mask. Normal scan brings the edges of the picture

tangent to the mask position. Overscan should be no more than 5% (see A.6).

5.5 Geometry and aspect ratio

Geometry and aspect ratio of 4:3 are adjusted with the crosshatch signal by scanning the display device with the green beam only.

Correct geometry and linearity are obtained by adjusting the pin-cushion and scan-linearity controls so that the picture appears without evident distortions from the normal viewing distance.

The following options are available:

- place a linearity (ball chart) overlay onto the face of the CRT display;
- project a linearity slide onto the CRT display with a high-quality slide projector (a long focal length is required):
- use a transparent linearity tape with 2% tolerance markings.

5.6 Focus

An ideal focus target is not currently available on most test signal generators; however, multiburst, crosshatch, or white noise can be used as tools to optimize the focus of the displayed picture.

The focus control should be adjusted at the aim luminance level with all the beams on for optimum picture resolution in the central areas of the picture. (There should be no noticeable loss of definition in the corners.)

5.7 Convergence

Convergence is adjusted with a crosshatch signal. Convergence should be optimized for either normal scan or underscan, depending upon the application. The manufacturer generally provides an alignment sequence to ensure all scanning beams coincide.

5.8 Aperture correction

If aperture correction is used, the amount of aperture correction can be estimated visually by ensuring that the 2T sin^2 pulse has the same brightness as the luminance bar or the multiburst signal when the 3 MHz and 4.2 MHz bursts have the same sharpness and contrast. This adjustment should be verified under normal viewing conditions with picture material, not test signals (see A.7).

5.9 Chrominance amplitude and phase

The chrominance amplitude and phase are adjusted using the SMPTE color bar test signal and viewing only the blue channel. Switching off the comb filter, if present, provides a clear blue channel display. The chroma set signal in the SMPTE color bar signal consists of four blue patches, which are to be matched with the four blue bars vertically above them. These blue bars and patches should increase and decrease in brightness equally as the contrast control is varied over its normal range; i.e., they should track (see A.8). Periodically, the red channel should be checked in a similar manner to verify that the decoders are working properly.

5.9.1 Visual alignment procedure

A visual alignment procedure is given below:

The left blue bar (blue component of the gray bar) is the reference bar and its brightness is affected only by the contrast control. The phase control affects the brightness of the inner two bars and patches. The chroma control affects the brightness of the right outer bar and also the inner two bars. The adjustment sequence is to first adjust the chroma and then the phase so that all the bars and patches are of equal brightness and that black is interspersed between the blue bars. However, should the blue bars not track equally with a change in contrast, then the AFPC (automatic frequency and phase control) probably requires adjustment.

Reduce the contrast until the blue bars and patches are barely visible. (The left-hand bar is the reference bar.) Adjust the phase control so that the right-hand blue bar matches the blue component of the gray patch. Then adjust the AFPC until the two center bars and patches are of equal brightness; the AFPC reacts in the same manner as the phase control. Slight readjustment of the chroma control to achieve uniform blue bars and patches may be necessary. Increase the contrast over its normal range. If the blue bars and patches do not track, repeat the above procedure with slight adjustments of the phase and/or AFPC.

5.10 Brightness, color temperature, and gray-scale tracking

The 100-IRE window signal is used to supply the reference white. Because of typical luminance shading limitations, a centrally-placed PLUGE signal is recommended for setting the monitor brightness control. However, until a centrally-placed PLUGE signal is commonly available, the PLUGE or black set signal provided in the SMPTE color bars signal can also be used for setting the monitor brightness control. (Refer to S. F. Quinn and C. A. Siocos. Pluge method of adjusting picture monitors in television studios — a technical note. *J. SMPTE*, 76: 925, September 1967.)

5.10.1 Reference white

Using a split-field optical comparator, adjust the displayed reference white to the illuminant D_{65} and a luminance value of 120 cd/m^2 (35 fL) (see A.2). If the optical comparator has a variable luminance control, set the reference white on the monitor screen to the specified luminance value with a photometer and then adjust the comparator.

Brightness, color temperature, and gray-scale tracking controls are interactive. Achieving all the correct results simultaneously requires adjustments which reduce but do not completely correct the perceived error(s). The adjustment sequence must be performed several times, each time with smaller incremental adjustments.

5.10.2 Preferred method

An optical comparator is used to set the color temperature of the white point, using the monitor R,G,B gain controls. If the optical comparator does not have an output level equivalent to the reference luminance level, then it is necessary to adjust the contrast so that the white signal matches the brightness of the optical comparator.

Gray-scale tracking is most easily set using a color photometer, but it must have adequate low-light sensitivity. The procedure is as follows:

(1) Initialize the white point of the colorimeter using a 100-IRE window signal.

(2) Reduce the input signal to about 10-20 IRE.

(3) Adjust the monitor screen controls for matching RGB values as measured by the color photometer.

(4) Using the PLUGE signal, set the brightness control so that the darker patch of the PLUGE just merges with the reference black level, but the brighter patch is clearly distinguishable from where the monitor will be normally viewed (see A.10).

(5) Readjust the input to a 100-IRE window signal.

(6) Adjust RGB gain controls, as necessary, to obtain the reference white values.

(7) Repeat steps (1) through (6) until RGB measurements at both high- and low-luminance levels track closely.

Alternatively, an unmodulated 50% APL stairstep signal can be used to verify gray-scale tracking *throughout the displayed scale (see A.12).*

5.10.3 Alternate method

(1) Place the split-field optical comparator against the face of the monitor and over the center of the white area. Adjust the color picture monitor contrast control for a brightness match with the split-field optical comparator (see A.12). Adjust the red, green, and/or blue gain controls so that the monitor has a close match in color with the split-field optical comparator.

(2) Display a 50% APL unmodulated stairstep signal. Then adjust the red, green, and/or blue screen controls to produce visual neutrals in the darker picture areas.

(3) Using the PLUGE signal, set the brightness control so that the darker patch of the PLUGE just merges with the reference black level, but the brighter patch is clearly distinguishable from where the monitor will be normally viewed (see A.10).

(4) Repeat steps (1) to (3) for optimum results.

The gray-scale signal (50% APL unmodulated stairstep signal) should now be visually neutral (black to white) and the reference white should have the desired color temperature and luminance value.

5.11 Monitor matching

When color matching two or more color monitors, the same alignment steps should be performed on each monitor in turn (see A.3).

CAUTION – Monitors cannot be matched without the same phosphor sets, similar display uniformity characteristics, and similar sharpness, etc. (see A.14).

The most noticeable faults on color monitors are the lack of uniform color presentations and brightness shading. Color matching of monitors cannot be completely checked using a static test signal such as the SMPTE color bars. Monitors may match on static scenes, but may not match when scenes change.

There could be many reasons why the monitors do not match. Most often, the problems relate to incorrect adjustments, usually in this sequence: AFPC, color temperature and brightness of the reference white, and brightness control.

The most critical means of checking for color picture monitor matching in the studio is to use a color background generator where the luminance, saturation, and hue can be varied.

If a color background generator is unavailable, the SMPTE color bars can be used in monitor matching. When comparing the yellow-cyan bars, where the eye has good phase discrimination, any phase difference between the monitors may be compared; with the red-magenta bars, the chrominance level may be visually compared.

6 Noncomposite monitors

Similar adjustment procedures, with the exception of *chrominance amplitude* and phase, can be followed with noncomposite color monitors. It should be noted that the setting of the brightness control is performed visually using the appropriate PLUGE signal (see A.10).

Annex A (informative)
General information

A.1 Controls

The following controls perform similar functions:

- Screen, low-light, background, bias, cut-off, black balance, low level;
- Gain, highlight, white balance, drive;
- Chroma, saturation;
- Phase, hue;
- Color hold, AFPC, APC, oscillator lock;
- Black level, brightness;
- Contrast

A.2 Reference white

Reference white is obtained when a color video signal at a 100-IRE unit luminance level with zero color subcarrier is displayed on a properly aligned color picture monitor.

When a 100-IRE unit reference patch is used, it should be located in the center of the raster for consistency because of luminance shading artifacts

A.3 Photometric measurement devices

Adjustment of the television reference white to a specific value of color or luminance cannot be done reliably by eye from personal visual memory; *it requires a light-measuring* instrument. Various devices exist on the market.

Each monitor must first be aligned to the absolute color reference and brightness because color picture tubes vary from batch to batch and manufacturer to manufacturer. Therefore, the same meter indication may not be the same *for two or more monitors. This is usually done with a split-*field optical color comparator as an operational quality instrument. Spectroradiometers are preferred for laboratory and research facilities. After the color balance is established, the R,G,B data can be transferred, with a photometer or other light-measurement device calibrated from the reference monitor.

NOTE – Personnel using split-field optical color comparators must have normal color vision.

There are devices using light-measuring cells and meter indication that produce results in a very short time and can eliminate differences in visual perception among people who align monitors. It must be remembered, however, that these devices can only transfer standards and can supply no absolute reference.

A.4 NTSC corrective display matrix

The NTSC corrective matrix in a display device is intended to correct any colorimetric errors introduced by the difference between the camera primaries and the display tube phosphors.

NOTE – It must not be used during monitor alignment setup.

A.5 Purity and degaussing

A very critical evaluation of purity can be made by examining the red or green or blue beam landing with a magnifying glass.

Generally, the integral degaussing system does a better job of degaussing the internal shield and picture tube than an external hand-held coil. External degaussing is more effective for magnetized cabinet parts.

A.6 Scan size

The underscan position of the monitor allows viewing of the entire active image, allows studio technical personnel to be vigilant for video defects, and enables the producer/director to check the framing of the scene. Determination of whether the picture is within the safe action or safe title areas should be made by a special safe title/action generator which is keyed over the video signal or geometric overlays to conform to SMPTE RP 27.3-1989.

A.7 Aperture correction

Aperture correction is used to correct for the aperture distortion caused by the finite size of the picture tube scanning beams. The effect of this impairment is most noticeable as a loss of fine picture details. The aperture control is adjusted for a relatively flat modulation transfer function (MTF) on the picture monitor screen.

The amount of aperture correction is adjusted with a test signal giving amplitude/frequency characteristics. A 2T pulse and bar signal is recommended.

A.8 Chrominance amplitude and phase

The alignment accuracy of the chrominance amplitude and phase and subsequent tracking of the blue bars is greatly increased by using the SMPTE color bar signal. Visual adjustment of the four blue bars for equal brightness when spaced over the screen is difficult. The use of the SMPTE color bar signal increases the alignment accuracy by placing the blue signals to be matched directly adjacent to each other. The eye can then perceive brightness differences without the effects of purity or shading.

A.9 Chrominance dot crawl

A color monitor has basically two modes of operation: color and monochrome. In the monochrome mode, the monitor will display a color program in black and white by disabling the chrominance circuitry. Depending upon the type of monitor, the monochrome mode may have wide-band luminance information going to the picture tube and hence show the chrominance dot crawl, or a subcarrier trap (notch filter) will be switched into the circuit and thus limit the bandwidth of the luminance channel. If the dot crawl is present on the monitor screen in the monochrome mode, the brightness rendition is higher than it should be because of a phenomenon called subcarrier dot rectification.

A.10 Black level

Setting the black level control is extremely important as it affects the interpretation of scene contrast. With a reference black level signal applied at the input, the setting is correct when the active scanning lines are just at the point of visual extinction from normal viewing distance; generally 4 to 6 picture heights (see SMPTE RP 166). The PLUGE is a signal designed to simplify this adjustment.

The PLUGE is currently found in the lower right-hand corner of the black area of the SMPTE color bar signal. Studies have shown that because of luminance shading this geometric area can no longer be considered representative. It is recommended that the PLUGE signal be placed in the central 25% area of the screen for proper setup.

The PLUGE signal consists of two small vertical ribbons, one slightly above and the other slightly below the encoded reference black level of the source. When setting the black level, it is imperative that the ambient lighting and viewing conditions be the same as when the monitor is in service.

The black level should be adjusted to the point where the darker patch just merges with the reference black level, but the brighter patch is clearly distinguishable from where the monitor will be normally viewed.

A.11 Color temperature

The split-field optical comparator is placed over the center of the reference white area on the monitor face. The central area of the monitor screen must be used when adjusting reference white (100 IRE units) for the correct color temperature and brightness.

Reference white has the correct color temperature and luminance when there is a visual match between the reference area of the split-field optical comparator and the face of the monitor screen. In trying to obtain a perfect match, the eye will become tired and lose color discrimination. To avoid these effects, the eyes should occasionally be diverted to look elsewhere, preferably on a neutral area.

A.12 Gray scale

The color monitor must be capable of reproducing a neutral scale without perceptible color at any level between reference black and white.

In order to minimize the effect of color shading, it is best to evaluate gray-scale tracking using a variable level window or full-field signal. Alternatively, a 50% APL unmodulated stairstep test signal can be used.

The monitor gray scale can be evaluated with an unmodulated gray-scale test signal including burst and with all controls and switches set for the intended operating conditions.

A.13 Shading

Color shading is a variation in color temperature throughout the displayed picture area.

Luminance shading is a variation in light intensity throughout the displayed picture area.

These characteristics are inherent properties of the CRT and will affect color monitor matching.

A.14 Phosphor characteristics

The color display coordinates, expressed in terms of the CIE 1931 x,y chromaticity coordinate values, are:

	x	y
Red	0.630	0.340
Green	0.310	0.595
Blue	0.155	0.070

Tolerance for x and y is ± 0.005.

Annex B (informative)
Bibliography

SMPTE RP 27.3-1989, Specifications for Safe Action and Safe Title Areas Test Pattern for Television Systems