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Cable networks for television signals, sound signals and interactive services –

Part 7-2: Hybrid Fibre Coax Outside Plant Status Monitoring – Media access Control (MAC) Layer Specification

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CABLE NETWORKS FOR TELEVISION SIGNALS, SOUND SIGNALS AND INTERACTIVE SERVICES –

Part 7-2: Hybrid Fibre Coax Outside Plant status monitoring – Media Access Control (MAC) layer specification

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International Standard IEC 60728-7-2 has been prepared by technical area 5: Cable networks for television signals, sound signals and interactive services, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

This standard was submitted to the national committees for voting under the IEC Fast Track Procedure as the following documents:

CDV	Report on voting
100/577/CDV	100/684/RVC

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until 2006. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

The following differences exist in some countries:

The Japanese *de facto* standard (NCTEA S-006) concerning requirements for the HFC outside plant management, which was published in 1995, has already been available in Japan. The purpose of this standard is to support the design and implementation of interoperable management systems for HFC cable networks used in Japan.

INTRODUCTION

Standards of the IEC 60728 series deal with cable networks for television signals, sound signals and interactive services including equipment, systems and installations for

- head-end reception, processing and distribution of television and sound signals and their associated data signals, and
- processing, interfacing and transmitting all kinds of signals for interactive services

using all applicable transmission media.

All kinds of networks like

- CATV-networks,
- MATV-networks and SMATV-networks,
- individual receiving networks,

and all kinds of equipment, systems and installations installed in such networks, are within this scope.

The extent of this standardization work is from the antennas, special signal source inputs to the head-end or other interface points to the network up to the system outlet or the terminal input, where no system outlet exists.

The standardization of any user terminals (i.e. tuners, receivers, decoders, multimedia terminals, etc.) as well as any coaxial and optical cables and accessories therefore is excluded.

CABLE NETWORKS FOR TELEVISION SIGNALS, SOUND SIGNALS AND INTERACTIVE SERVICES –

Part 7-2: Hybrid Fibre Coax Outside Plant status monitoring – Media Access Control (MAC) layer specification

1 Scope

This part of IEC 60728 specifies requirements for The Hybrid Fibre Coax (HFC) Outside Plant (OSP) Media Access Control (MAC) Layer. This standard is part of the series developed to support the design and implementation of interoperable management systems for evolving HFC cable networks. The HMS Media Access Control (MAC) layer specification describes the messaging and protocols implemented at the Data Link Layer (DLL), layer 2 in the 7 layer ISO-OSI reference model, that support reliable and efficient communications between HMS compliant transponders interfacing to managed OSP network elements (NEs) and a centralized head-end element (HE).

This standard describes the MAC layer protocols that must be implemented between all *Type 2* and *Type 3* compliant OSP transponders on the HFC plant and the controlling equipment in the head-end to support bandwidth management and reliable communications. Any exceptions to compliance with this standard will be specifically noted herein as necessary. Refer to Table 1 for a full definition of the type classifications.

Transponder type classifications referenced within the HMS series of standards are defined in Table 1.

Table 1 – Transponder type classifications

Type	Description	Application
Type 0	Refers to legacy transponder equipment, which is incapable of supporting the specifications	This transponder interfaces with legacy network equipment through proprietary means. This transponder could be managed through the same management applications as the other types through proxies or other means at the head-end.
Type 1	Refers to stand-alone transponder equipment (legacy or new), which can be upgraded to support the specifications	This transponder interfaces with legacy network equipment through proprietary means. Type 1 is a standards-compliant transponder (either manufactured to the standard or upgraded) that connects to legacy network equipment via a proprietary interface.
Type 2	Refers to a stand-alone, compliant transponder	This transponder interfaces with network equipment designed to support the electrical and physical specifications defined in the standards. It can be factory or field-installed. Its RF connection is independent of the monitored NE.
Type 3	Refers to a stand-alone or embedded, compliant transponder.	This transponder interfaces with network equipment designed to support the electrical specifications defined in the standards. It may or may not support the physical specifications defined in the standards. It can be factory-installed. It may or may not be field-installed. Its RF connection is through the monitored NE.

2 Normative references

None.

3 Terms, definitions and abbreviations

For the purposes of this document, the following definitions apply.

3.1 Terms and definitions

3.2
data link layer (DLL)
layer 2 in the Open System Interconnection (OSI) architecture; the layer that provides services to transfer data over the physical transmission link between open systems

3.3
forward spectrum
pass band of frequencies in HFC cable systems with a lower edge of between 48 MHz and 87,5 MHz, depending on the particular geographical area, and an upper edge that is typically in the range of 300 MHz to 860 MHz depending on implementation

3.4
full spectrum
combined forward and return spectrums in HFC cable systems and excludes any guard band

3.5
guard band
unused frequency band between the upper edge of the usable return spectrum and the lower edge of the usable forward spectrum in HFC cable systems

3.6
network element (NE)
active element in the outside plant (OSP) that is capable of receiving commands from a head-end element (HE) in the head-end and, as necessary, providing status information and alarms back to the HE

3.7
open system interconnection (OSI)
a framework of the International Organization for Standardization (ISO) standards for communication between multi-vendor systems that organizes the communication process into seven different categories that are placed in a layered sequence based on the relationship to the user. Each layer uses the layer immediately below it and provides services to the layer above. Layers 7 through 4 deal with end-to-end communication between the message source and destination, and layers 3 through 1 deal with network functions

3.8
organizationally unique identifier (OUI)
a 3-octet IEEE assigned identifier that can be used to generate universal LAN MAC addresses and protocol identifiers per ANSI/IEEE standard 802 for use in local and metropolitan area network applications

3.9
physical (PHY) layer
layer 1 in the open system interconnection (OSI) architecture; the layer that provides services to transmit bits or groups of bits over a transmission link between open systems and which entails electrical, mechanical and handshaking procedures

3.10
return spectrum
pass band of frequencies in HFC cable systems with a lower edge of 5 MHz and an upper edge that is typically in the range of 42 MHz to 65 MHz depending on the particular geographical area

3.11
transponder
device that interfaces to outside plant (OSP) NEs and relays status and alarm information to the HE. It can interface with an active NE via an arrangement of parallel analogue, parallel digital and serial ports

3.12 Abbreviated terms

CCITT	Comité Consultatif International de Télégraphie et Téléphonie (ITU – International Telecommunication Union)
CRC	Cyclic Redundancy Code
DLL	Data Link Layer
EMS	Element Management System
FCS	Frame Check Sequence
HE	Head-end Element
HEX	Hexadecimal
HFC	Hybrid Fibre Coax
HMS	Hybrid Management Sub-Layer (defined in the standard)
I/G	Individual / group address bit
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
ISO	International Organization for Standardization
LSB	Least Significant Bit
MAC	Media Access Control
MIB	Management Information Base
MSB	Most Significant Bit
NE	Network Element
OSI	Open System Interconnection
OSP	Outside Plant
OUI	Organizationally Unique Identifier
PDU	Protocol Data Unit
PHY	Physical
POSIX	Portable Operating System Interface
RF	Radio Frequency
RFC	Request for Comment
RSVD	Reserved
SNMP	Simple Network Management Protocol
TOD	Time-of-Day
UART	Universal Asynchronous Receiver/Transmitter
UDP	User Data-gram Protocol

4 Reference architecture forward and return channel specifications

The reference architecture for the series of specifications is illustrated in Figure 1.

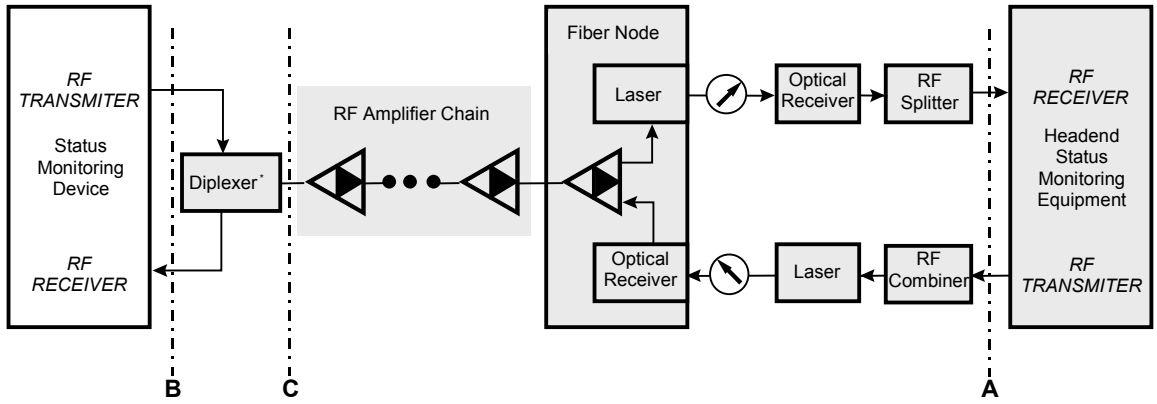


Figure 1 – Reference architecture diagram

All quantities relating to forward channel transmission or reverse channel reception are measured at point A in Figure 1. All quantities relating to forward channel reception or reverse channel transmission are measured at point B for two-port devices and point C for single-port devices as shown in Figure 1.

5 Media access control layer specification

5.1 Overview

This clause describes the MAC protocol. Some of the MAC protocol features include:

- support for transaction-based message exchange over the HFC forward and return RF channels. Transactions can be initiated by either the HE or the NE; support for transport of multiple network PDU types over the HFC forward and return RF channels including, but not limited to, IP over serial and SNMP over serial;
- extensions provided to support future transport of other network PDU types;
- efficient use of HFC forward and return RF spectrum through central HE management of NE transmission opportunities.

5.1.1 Definitions and conventions

5.1.1.1 Separate forward and return channels

The one-way communication channel from the HE to a managed OSP NE is referred to as the *forward* channel. The one-way communication channel from a managed OSP NE to the HE is referred to as the *return* channel. Both the forward and the return channels are placed on specific centre frequencies. The forward and return channels' centre frequencies are different. Since the NEs only listen to the forward channel, they cannot listen to return channel transmissions from other NEs. This channel separation is a result of the sub-band split between the forward and return portions of the typical HFC plant spectrum.

5.1.1.2 Single forward and return path channels per MAC layer domain

To keep management of carrier frequencies simple, each status monitoring system has a single forward channel and a single return channel. This does not preclude the use of multiple monitoring systems, each with its own individual forward and return RF channels.

A MAC layer domain consists of a single forward RF channel and a single return RF channel over which a single MAC layer bandwidth allocation and management protocol operates. It includes a centralized HE and multiple compliant transponders interfacing to managed OSP NEs. The centralized HE may support multiple HMS-based status monitoring systems, i.e. multiple MAC layer domains. Each OSP NE must only access a single forward channel and its associated single return channel, i.e. it must only operate within a single HMS MAC layer domain.

5.1.1.3 Network element (NE) term usage

The HMS MAC layer supports bandwidth management and reliable communications between a HE and multiple compliant transponders that interface to managed OSP NEs. Throughout this standard, the terms “compliant transponder”, “transponder”, and “NE” are used interchangeably when describing the MAC processes that support the exchange of data or other information between two or more entities at the DLL.

5.1.1.4 Packet

A packet is a unit of data exchanged between the HE and any of a number of managed OSP NEs at the DLL. Packets are strings of bytes that can be sent contiguously or be separated by periods of silence. Document *Outside Plant Status Monitoring – Physical (PHY) Layer Specification* describes specific byte transmission modes that must be implemented in both forward and return channels. A MAC packet consists of a MAC header, a variable-length payload, and a frame check sequence (see 5.3).

5.1.1.5 Most significant byte

Unless otherwise specified, it is assumed throughout this standard that the left-most entry in any numeric value is the most significant, i.e. for the address represented as 12-34-56-78-9A-BC the left-most entry ‘12’ is the most significant value.

5.1.1.6 Byte number representation

Throughout this standard, bits labelled ‘0’ are the least significant bits (LSBs) and bits labelled ‘7’ are the most significant bits (MSBs). The bits in a given byte will be described with bit 7 (MSB) at the left and bit 0 (LSB) at the right. This convention has been adopted for presentation purposes only and has no effect on the actual bit transmission order. Bit transmission order details are provided in 5.2 of this standard.

5.1.1.7 Reserved bits

A number of bits are indicated with the word “Reserved” or the abbreviation “RSVD” in the various MAC packets described in this standard. Any receiving NE must ignore these bits when implementing this version of the MAC protocol.

5.2 MAC packet transport

5.2.1 Byte transmission format

Bytes transmitted over both forward and return channels are ten bits in length. They contain one start bit, eight bits of data, and one stop bit. The start bit has the binary value ‘0’, and the stop bit has the binary value ‘1.’

5.2.2 Byte transmission order

Fields consisting of multiple bytes, i.e. a MAC address will have the most significant byte transmitted first. Any exceptions to this rule will be specifically noted in this standard as necessary.

5.2.3 Bit transmission order

The LSB of a single byte, bit 0, is always transmitted first following the start bit. The MSB of a single byte, bit 7, is always transmitted last followed by the stop bit. The transmission order is summarized in Figure 2.

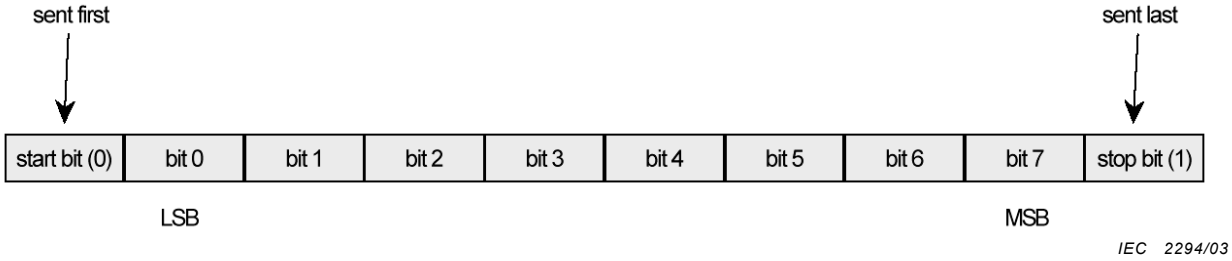


Figure 2 – Bit transmission order

NOTE In the NCTEA S-006, eleven bits data format is used as follows:
– start bit(0);
– LSB bit(0) ~ MSB bit(7);
– parity bit;
– stop bit(1).

5.2.4 Transmission timing

5.2.4.1 Forward channel packets

5.2.4.1.1 Timing

Forward channel packets shall be transmitted in such a manner that

a) no two bytes within a packet are separated by more than 3 ms, and

b) the entire packet must be transmitted within 120 % of the *shortest* time for that frame. The shortest time is defined as the time for transmission of the packet with no gaps between bytes.

5.2.4.2 Return channel packets

5.2.4.2.1 Front porch

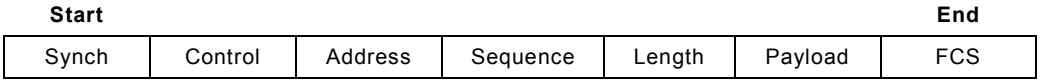
NE transmission of the first byte of a message shall begin within a window of two and five byte times after the transmitter power reaches 90 % of its final value. Until the first byte is transmitted, the frequency will rest on the ‘mark’ frequency. This is standard Universal Asynchronous Receiver/Transmitter (UART) transmission. The front porch ensures that the receiving UART can be cleared of all framing errors prior to the start of reception of valid data.

5.2.4.2.2 Timing

Return channel packets must be transmitted in such a manner that no two bytes within a packet are separated by more than 260 µs (1 byte time). All bits within a single byte shall be immediately contiguous; there shall be no gaps at bit boundaries within a byte.

5.3 MAC packet structure

MAC packets consist of a MAC header, a variable-length payload, and a two-byte frame check sequence. Packet structure and sizes are identical for both forward and return channel packets. MAC packet structure is illustrated in Figure 3.



IEC 2295/03

Figure 3 – MAC packet structure

All MAC packets must have the general format as described in Table 2.

Table 2 – Generic MAC packet structure

Field name	Length (bits)	Subclause
Synch	8	5.3.1
Control	8	5.3.2
Address	48	5.3.3
Sequence	8	5.3.4
Length	16	5.3.5
Payload	N	5.3.6
FCS	16	5.3.7

5.3.1 Synch

The synch field consists of a single byte and identifies the start of the MAC layer packet. It shall be set to 0xA5.

5.3.2 Control

The control field consists of a single byte and defines the type and format of the payload field. The bit definition of the control byte is shown in Figure 4. The control field also serves, in conjunction with the synch, length and FCS fields, as a packet delimiter as described in 5.4.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
RSVD3	RSVD2	RSVD1	RSVD0	Protocol			

IEC 2296/03

Figure 4 – MAC header control byte – bit definition

5.3.2.1 Protocol (bits 3:0)

The four-bit protocol field indicates the type of protocol to be used to interpret the payload field of the MAC layer packet. In addition, the protocol field allows the message service handler to pass messages with alternative protocol values to other upper layer processes without having to unravel the entire message. The value represented by the protocol field shall be as assigned in Table 3.