# SMPTE STANDARD

# Transport of High Bit Rate Media Signals over IP Networks (HBRMT)



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Approved
October 9, 2012

## Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices, and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in Part XIII of its Operations Manual.

SMPTE ST 2022-6 was prepared by Technology Committee 32NF.

## Intellectual Property

At the time of publication no notice had been received by SMPTE claiming patent rights essential to the implementation of this Standard. However, attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. SMPTE shall not be held responsible for identifying any or all such patent rights.

## Introduction

This section is entirely informative and does not form an integral part of this Engineering Document.

IP-based networks have become increasingly important for delivery of media content such as SMPTE ST 259, SMPTE ST 292-1 and SMPTE ST 424 streams. However, existing transport protocols do not fully meet the user requirements. This standard describes a transport protocol which can be used for the real time transport of video/audio over IP networks. In this standard, it is specified that the entire payload of the serial digital interface signal including all VANC and HANC is encapsulated as one stream. The payload packing into RTP datagrams is designed to allow implementers to conveniently employ error concealment in the case where no FEC is utilized, or in the case that errors extend beyond what the FEC is capable of correcting. The acronym HBRMT (High Bit Rate Media Transport) has developed a modicum of support in the industry in reference to the technique standardized in this document.

This standard is intended for real-time audio/video applications such as contribution, primary distribution, and digital cinema. This standard is designed to be applied to television transport for broadcast production and is not intended for emission purposes. Typically a connection will be set up and torn down as a managed configuration of transmitting and receiving equipment. A connection may be unicast or multicast. Support of RFC 4566 Session Description Protocol (SDP) or RFC 3550 Real Time Control Protocol (RTCP) are not required for equipment supporting this standard but could be utilized at the implementers discretion.

The method described herein has been in the process of standardization for several years. The informal name "High Bit-Rate Media Transport" and the acronym "HBRMT" have been associated with the work throughout that time. The mention of HBRMT in the title of this document references that heritage.

This standard makes provision for, and specifies relevant parameter limits of an optional FEC mechanism. Details of the FEC implementation are defined in a separate standard document.

## 1 Scope

This standard defines a unidirectional IP-based protocol for the transport of real-time video, audio, and ancillary signals. In particular this standard defines a method for the encapsulation of the payloads of a variety of existing SMPTE serial digital video standards.

The term High Bit Rate is used herein to distinguish from other Media-over-IP applications in which compressed signals are transported. The uncompressed signals in this document are at rates of 270 Mbits/sec and higher.

## 2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword “reserved” indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword “forbidden” indicates “reserved” and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; followed by formal languages; then figures; and then any other language forms.

## 3 Normative References

Note: All references in this document to other SMPTE documents use the current numbering style (e.g. SMPTE ST 259:2008) although, during a transitional phase, the document as published (printed or PDF) may bear an older designation (such as SMPTE 259M-2008). Documents with the same root number (e.g. 259) and publication year (e.g. 2008) are functionally identical.

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

IETF RFC 3550, RTP: A Transport Protocol for Real-Time Applications

Recommendation ITU-R BT.656-5, Interface for Digital Video Signals in 525-Line and 625-Line Television Systems Operating at the 4:2:2 Level of Recommendation ITU-R BT.601

SMPTE ST 259:2008, Television — SDTV Digital Signal/Data — Serial Digital Interface

SMPTE ST 292-1:2012, 1.5 Gb/s Signal/Data Serial Interface

SMPTE ST 425-1:2011, Source Image Format and Ancillary Data Mapping for the 3 Gb/s Serial Interface

SMPTE ST 2022-1:2007, Forward Error Correction for Real-Time Video/Audio Transport Over IP Networks

SMPTE ST 2022-5:2012, Forward Error Correction for High Bit Rate Media Transport Over IP Networks

## 4 Acronyms

**D:** Number of Rows in an FEC Matrix

**DiffServ:** Differentiated Services (see IETF RFC 2474)

**FEC:** Forward Error Correction

**HBRMT:** High Bit Rate Media Transport

**IP:** Internet Protocol (see IETF STD05)

**L:** (Length) Number of Columns in an FEC Matrix

**MTU:** Maximum Transmission Unit

**RSVP:** Resource Reservation Protocol (see IETF RFC 2205)

**RTP:** Real Time Protocol (see IETF RFC 3550)

**SDI:** Serial Digital Interface

**SSRC:** Synchronization Source List

**TOS:** Type Of Service

**TS:** Timestamp

**UDP:** User Datagram Protocol (see IETF STD06)

**UTC:** Coordinated Universal Time

**XOR:** Exclusive OR

## 5 Definitions

**Block Aligned FEC Operation:** Block Aligned FEC Operation is a correction scheme using a two dimensional matrix where the Media Datagrams are a contiguous group of L x D datagrams. The Media Datagrams are protected as follows. Level A protection is achieved by L FEC Datagrams derived from each column for the FEC Matrix. Optional level B protection is achieved by D FEC Datagrams derived from each row for the FEC Matrix. Level A FEC stream shall protect all media packets exactly once. Optional Level B FEC stream shall protect all media packets exactly once.

**FEC Datagram:** An FEC Datagram is an RTP Datagram consisting of an RTP Header and an FEC Payload. The FEC Payload is composed of an FEC Header and the FEC Payload. The FEC Datagrams are formatted according to the rules specified in SMPTE ST 2022-5.

**FEC Header:** The FEC Header is the header information contained in an FEC Datagram.

**FEC Matrix:** An FEC Matrix is a set of Media Datagrams ordered in a matrix with L columns and D rows. The datagrams are entered into the matrix to fill each row sequentially with incremented RTP sequence numbers.

**FEC Payload:** The FEC Payload is the payload of an FEC Datagram.

**High Bit Rate:** At the time of development of this Standard, High Bit Rate commonly refers to transmission rates higher than 270 Mb/s (SDI, HD SDI, 3G), although the techniques specified herein may have continued utility at higher rates (e.g. 40 Gb/s, 100 Gb/s) as technology allows.

**IP Stream:** An individual flow of media and / or FEC datagrams on an IP network which includes all necessary components of the video signal including video, embedded audio, and embedded ancillary data signals.

**Media Datagram:** A Media Datagram is an RTP Datagram consisting of an RTP header and the media data payload. The media data payload is composed of a Payload Header and a Media Payload.

**Media Payload:** The Media Payload is the raw data (including video, audio, and ancillary data) that are transmitted from the sender. The Payload Header and the Media Payload are placed inside of a Media Datagram.

**Non Block-Aligned FEC Operation:** A Non Block-Aligned FEC Operation is a correction scheme similar to a Block-Aligned FEC Operation, but performed over non-contiguous Media Datagrams. In a Non Block-aligned FEC Operation the FEC columns are offset from each other to facilitate Traffic Shaping and/or lower Latency. The FEC rows of a Non Block-Aligned FEC Operation cover contiguous Media Datagrams.

**Payload Header:** The Payload Header is the portion of the payload that precedes the Media Payload. The Payload Header is placed inside of a Media Datagram. The format and contents of the Payload Header is specified in Section 6.4.

**RTP Datagram:** RTP Datagrams are defined in IETF RFC 3550.

**Video Timestamp:** A 32-bit value formed of a sample from a 32-bit Time Clock at the sending device. See Section 6.5 for more information.

# 6 User Performance Requirements

## 6.1 Basic Network Requirements

In order for a system supporting this standard to function correctly, the bandwidth available in the network shall always meet or exceed that required by the IP Stream generated by the system.

Note: It is important to ensure that the network path is designed with adequate bandwidth and a low enough error rate such that end equipment can successfully decode the stream. An optional error correction scheme is defined in SMPTE ST 2022-5.

## 6.2 Media Datagram Description

The size of output Media Datagrams from a transmitting device shall be less than or equal to 1500 octets so that the Media Datagrams can pass through most networks without fragmentation.

The video luminance and color-difference values shall be encapsulated into 1376 octet media payloads. The last datagram of the video frame, being only partially filled with luminance and color-difference values, shall have additional null octets added to achieve a total length of 1376 octets. This is not considered padding at the RTP layer, therefore the padding bit in the RTP header shall be set to zero.

The IP ‘don’t fragment’ bit shall be set so that IP fragmentation does not occur at the output of the device. As end-point devices will typically be connected to Ethernet style networks, this limits the maximum transmission unit (MTU) to 1500 octets.

Note: The MTU on links between intermediate nodes in the network might be lower than 1500 octets, so care should be taken to ensure that IP datagrams are not lost due to the ‘don’t fragment’ requirement.

The Media Datagram structure is shown in Figure 1.

```
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     RTP Header (12 octets)                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       Payload Header (4, 8, 12 or greater if extended)        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Media Payload                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 1 – Media Datagram Format**

## 6.3 RTP/UDP/IP Header

The use of IP/UDP/RTP shall be required, as it provides a standard header for the media and FEC datagrams. For interoperability, equipment shall only depend on the main RTP communication between sending and receiving units, and shall not require any additional communication.

The UDP port number for the Media Datagrams shall be unique and different from the UDP port numbers of the datagrams used for Row FEC and Column FEC. If FEC is used, the UDP port number for the Column FEC Stream shall be a port number that is two greater than the UDP port number of the media stream. The UDP port number for the Row FEC Stream shall be a port number that is four greater than the UDP port number of the media stream.

The RFC 3550 RTP header shall be used.

Note: The Media Datagram rate for the 3 Gb/s television formats is close to 270,000 datagrams per second; therefore, a 90-kHz clock as utilized for MPEG-2 transport stream (Payload Type 33) will not be useful for receiver datagram management of this payload. A higher rate clock is specified instead, using the CF field in the payload header.

The RTP header has the following format as shown in Figure 2:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|V=2|P|X|  CC   |M|     PT      |       sequence number         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           timestamp                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           synchronization source (SSRC) identifier            |
+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+
```

**Figure 2 – RTP Header**

The following describes the specific fields and how they shall be used in this document:

Version (V): 2 bits

This field identifies the version of RTP. The version defined by this Standard shall be two (2).

Padding (P): 1 bit

Set to 0 no padding used

Set to 1 padding used

Usage: If the padding bit is set, the datagram shall contain one or more additional padding octets at the end, which are not part of the payload. The last octet of the padding contains a count of how many padding octets should be ignored, including itself.

Extension (X): 1 bit

Set to (0) no header extension

CSRC Count (CC): 4 bits

This field shall be set to 0.

Note: There are no CSRC lists present in the Media Datagrams.

Marker (M): 1 bit

The marker bit shall be set to 1 to denote the last Media Datagram of the video frame, and shall be set to zero for all other Media Datagrams (as defined in RFC 3497).

Payload Type (PT): 7 bits

This field identifies the format of the RTP payload and determines its interpretation by the application. A receiver shall ignore datagrams with payload types that it does not understand.

High bit rate Media Datagrams shall utilize a dynamically allocated payload type field to designate the clock frequency used to timestamp RTP packets. The payload type should be set to one of the values defined below. Alternatively, payload types may be set by other means in accordance with RFC 3550.

- PT = 98 – High bit rate media transport / 27-MHz Clock
- PT = 99 – High bit rate media transport FEC / 27-MHz Clock

Note: The list of RTP payload types above is constrained. The intention of the RTP payload type is to identify the frequency of the RTP clock and to allow the receiver to reject datagrams with payload types it is not prepared to accept. Indications of specific payload characteristics or parameters are covered in separate layers, i.e. payload header, and it is not the intention to mix functionality between layers.

Sequence number (low bits): 16 bits

The low order bits for RTP sequence counter. The sequence number shall increment by one for each RTP data datagram sent.

Timestamp: 32 bits

The timestamp reflects the sampling instant of the first octet in the RTP datagram. The transmission instant shall be derived from a clock that increments monotonically and linearly in time to allow synchronization and jitter calculations. The RTP timestamp assists with datagram buffer management at the receiver and optionally with identification of received datagrams for protection switching. Time stamp frequency per payload type description is indicated above under payload type.

Note: To identify Media Datagrams in case of rollover, the sequence number and timestamp value can both be utilized.

SSRC: 32 bits

The SSRC field identifies the synchronization source. This shall be set compliant to RFC 3550.

### 6.4 High Bit Rate Media Payload Header

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1

+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Ext    |F|VSID | FRCount       | R | S | FEC | CF    | RESERVE |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  MAP  |      FRAME      |      FRATE     |SAMPLE |  FMT-RESERVE  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   Video timestamp (only if CF>0)              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Header extension (0nly if Ext > 0)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 3 – Payload Header**

The following describes the specific fields and how they shall be used in this document:

Extension field: (Ext) 4 bits

“0000” = No extension

“0001–1111” = Payload header is extended by this number x 4 octets

Video source format flag: (F) 1 bit.

The F bit is set to

”0” = Video source format is not present

“1” = Video source format is present

For the method specified in this document, the F bit shall be set to 1, and the video source format shall be transmitted.

The F bit setting and the presence or absence of the video Source Format shall be constant for the duration of the session

Note: This F bit is not to be confused with the similarly-named bit referred to in Annex D of SMPTE ST 292-1 or similar. They are unrelated.

Video source ID (VSID) Protection profile: 3 bits

Set to 000 – primary stream
Set to 001 – protect stream
010-111 – reserved

Frame Count (FRCount): 8 bits

This field identifies a video frame counter value. The counter shall increment to a new value for the next RTP sequence numbered datagram immediately after the end of video frame M marker bit and shall roll over after 256 frames.

Reference for time stamp (R): 2 bit

Specific reference to the source of the time stamp
Set to 00 – not locked
Set to 01 – reserved
Set to 10 – locked to UTC time/frequency reference
Set to 11 – locked to a private time frequency reference

Video Payload Scrambling (S): 2 bits

Payload scrambling control. Setting this field to a value other than 00 is outside the scope of this standard.

Set to 00 – not scrambled
Set to 01 – reserved for future use
Set to 10 – reserved for future use
Set to 11 – reserved for future use

FEC usage (FEC): 3 bits

This field identifies whether or not FEC streams have been associated with the media stream at the sender.

000 = No FEC stream
001 = L (Column) FEC utilized
010 = L & D (Column & Row) FEC utilized
All other values – reserved

Clock Frequency (CF) 4 bits

Indicates the video word clock frequency of the payload video
0000 = No time stamp
0001 = 27 MHz
0010 = 148.5 MHz
0011 = 148.5 /1.001 MHz
0100 = 297 MHz
0101 = 297/1.001MHz
0110-1111 = Reserved

If the clock frequency field is set to non-zero by the sender, then the sender shall include the Video Timestamp. If this field is set to zero (0) by the sender, then the sender shall not include Video Timestamp octets in the payload header. The CF field may be set to zero by the sender, indicating that no timestamps are being transmitted. A compliant receiver shall handle both the CF=0000 and CF not 0000 cases.

Note: Video can be timed locally at the receiver via internal frame sync and local gunlock.

Reserved (RESERVE):

These fields are reserved for future use and shall be set to 0 by the sender.

Video Source Format fields:

The following five fields comprise the Video Source Format whose presence or absence is indicated by the “F” bit defined above.

MAP

This four-bit field shall indicate the top-level structure of the data stream.

| MAP code | Structure |
|---|---|
| 0x00 | Direct sample structure as per SMPTE ST 292-1, SMPTE ST 425-1 Level A, etc. |
| 0x01 | SMPTE ST 425-1 Level B-DL Mapping of ST 372 Dual-Link |
| 0x02 | SMPTE ST 425-1 Level B-DS Mapping of two ST 292-1 Streams |
| 0x03-0x0F | Reserved |

FRAME

This eight-bit field shall indicate the luminance active pixel structure of the payload as per the table below:

| FRAME code | Horizontal Active | Vertical Active | Vertical Total | Sampling Structure | Transport Structure |
|---|---|---|---|---|---|
| 0x00 | Unknown/Unspecified Frame Structure | | | | |
| 0x01-0x0F | Reserved | | | | |
| 0x10 | 720 | 486 | 525 | Interlace | Interlace |
| 0x11 | 720 | 576 | 625 | Interlace | Interlace |
| 0x12-0x1F | Reserved | | | | |
| 0x20 | 1920 | 1080 | 1125 | Interlace | Interlace |
| 0x21 | 1920 | 1080 | 1125 | Progressive | Progressive |
| 0x22 | 1920 | 1080 | 1125 | Progressive | Interlace (Segmented) |
| 0x23 | 2048 | 1080 | 1125 | Progressive | Progressive |
| 0x24 | 2048 | 1080 | 1125 | Progressive | Interlace (Segmented) |
| 0x25-0x2F | Reserved | | | | |
| 0x30 | 1280 | 720 | 750 | Progressive | Progressive |
| 0x31-0xFF | Reserved | | | | |

FRATE

This eight-bit field shall indicate the frame rate of the payload:

| FRATE code | Frame Rate (Hz) |
|---|---|
| 0x00 | Unknown/Unspecified frame rate 2.970 GHz signal |
| 0x01 | Unknown/Unspecified frame rate 2.970/1.001 GHz signal |
| 0x02 | Unknown/Unspecified frame rate 1.485 GHz signal |
| 0x03 | Unknown/Unspecified frame rate 1.485/1.001 GHz signal |
| 0x04 | Unknown/Unspecified frame rate 0.270 GHz signal |
| 0x04-0x0f | Reserved |
| 0x10 | 60 |
| 0x11 | 60/1.001 |
| 0x12 | 50 |
| 0x13 | Reserved |
| 0x14 | 48 |
| 0x15 | 48/1.001 |
| 0x16 | 30 |
| 0x17 | 30/1.001 |
| 0x18 | 25 |
| 0x19 | Reserved |
| 0x1A | 24 |
| 0x1B | 24/1.001 |
| 0x1C-0xFF | Reserved |

SAMPLE

This four-bit field shall indicate the component pixel sampling structure and bit depth of the payload as per the table below:

| SAMPLE code | Sampling Structure | Bit Depth |
|---|---|---|
| 0x00 | Unknown/Unspecified | |
| 0x01 | 4:2:2 | 10 bits |
| 0x02 | 4:4:4 | 10 bits |
| 0x03 | 4:4:4:4 | 10 bits |
| 0x04 | Reserved | |
| 0x05 | 4:2:2 | 12 bits |
| 0x06 | 4:4:4 | 12 bits |
| 0x07 | 4:4:4:4 | 12 bits |
| 0x08 | 4:2:2:4 | 12 bits |
| 0x09-0x0F | Reserved for future use | |

FMT-RESERVE

This 8-bit field is reserved for future use and shall be set to 0 by the sender.

Video Timestamp: 32 bits

The timestamp field (when present) shall contain the value of a free running counter that is synchronous with the interface word clock of the encapsulated video. The timestamp is fixed at the transmitter to the first information contained in the datagram. The timestamp shall indicate the time of the first pixel whose complete data word is contained in the current datagram. The frequency of the counter shall be set as indicated in the CF field. This allows for a unique timestamp for each pixel's data word. In cases where a pixel value is spread across two datagrams, the Video Timestamp shall apply to the first pixel that is completely contained in the current datagram.

Note: The counter value can be used at the receiver to recreate the transmitted video clock.

Header Extension : 1 to 15 times 32 bits

When present (Ext field set to a non-zero value), the Header Extension field shall contain TLV (Tag, Length, Value) information structured as follows:

T : Tag

field size : 1 byte

special value 0 : this is the PAD Tag. In this case, No L field follows. This special encoding of the PAD byte copes with padding an odd number of bytes.

values 1..FF : free to allocate

L : Length

field size : 1 byte

L gives the number of subsequent bytes that build up the V field

V : Value

field size : L bytes long

Note: The following informative example shows how the extension field is populated:

```
  0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    0x01       |     0x03      |---------3 octets value--------|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|---------------|     0x02      |      0x00     |     0x04      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     0x01      |-1 octet value-|   PAD (0x00)  |  PAD (0x00)   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

In this specific case this extension field carries the following values:

{0x01, value[0..2]} Tag # 0x01 with a 3-octets value

{0x02} Tag # 0x02 with a binary value

{0x04, value[0]} Tag # 0x04 with a 1-octet value

## 6.5 High Bit Rate Media Payload

```
                   Nominal Payload 1376 Octets
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Media Data 1376 Octets                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                   Last Payload of Media Frame
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Media data payload       |  Reserved         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 4 – High Bit Rate Media Payload**

The payload shall include 10 bit or 12 bit samples of the luminance and color difference values as defined by the FRAME, FRATE, and SAMPLE fields in the header. The sample words shall be carried in their original form and shall not include NRZI encoding/scrambling. All TRS, VANC, and HANC shall be included in the media data payload

The start of the digital frame is the EAV sequence immediately preceding the $0_H$ datum of the first line of the digital frame, which is line 1 in the HD formats and in 625 systems (Recommendation ITU-R BT.656-5), but line 4 in 525 systems.

Samples shall be placed into 1376 octet payloads in pixel order exactly following the values in each video frame. The first sample of each digital frame shall be encapsulated as the first octets in the datagram payload of the datagram immediately following the end-of-frame datagram. The eight most-significant-bits of the first sample shall be placed directly into the first octet. The remaining least-significant-bits shall be left justified in the next octets, followed by the most-significant-bits of the next video sample.

Reserved octets follow the media data in only the last datagram of the media frame.

Note: The following informative example shows the Payload Header and start of Media Payload for the first Media Datagram of a frame carrying SMPTE ST 259.

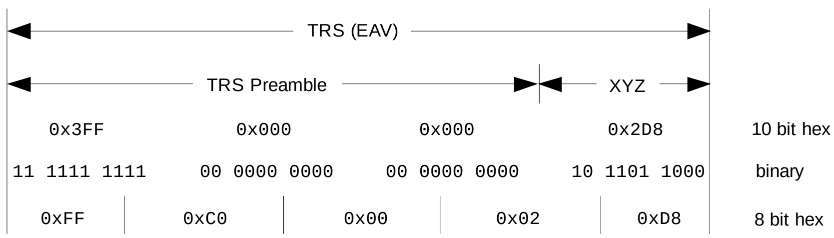


**Figure 5 – Bit Packing of SDI Video (Informative)**

```
 0                   1                   2                   3

 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Ext    |F|VSID | FRCount       | R | S | FEC | CF    | RESERVE |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  MAP  |     FRAME     |     FRATE     |SAMPLE |  FMT-RESERVE  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   Video Timestamp (only if CF>0)              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Header extension (0nly if Ext > 0)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     0xFF      |     0xC0      |     0x00      |     0x02      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     0xD8      |---------3 octets HANC data-------------------|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|-------------------------HANC data----------------------------|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 6 – Alignment of TRS within the first Media Datagram of a frame (Informative)**

The following equation shall be used to determine the exact number of video octets in the last payload of the video frame:

PL = pixels per line (Horizontal Total based on the FRAME and FRATE codes)
BS = bits per sample (Bit Depth from the SAMPLE definition table in section 6.4)
OL = octets per line

For 4:2:2 Video Formats:
*OL = PL x BS x 2/8*

For 4:4:4 or 4:4:4:4
*OL = PL x BS x 4/8*

*LF = lines per frame (Vertical Total from the FRAME definition table in Section 6.4)*
*OF = octets per video frame*
*OF = OL x LF*

*DPF = datagram payloads per frame*
*LPO = last payload media octets*

*DPF = Integer value of (OF/1376) +1*
*LPO = OF – (1376 x (DPF – 1))*

# 7 FEC Interoperability and Usage

## 7.1 FEC Interoperability

To promote interoperability and simplify implementation, limits shall be specified for matrix values of the L and D parameters as defined in SMPTE ST 2022-5. Devices shall support all combinations of values of L and D that comply with all limits. Devices may extend beyond these values if desired. The limits are:

Column Only FEC
$1 \le L \le 1020$
$4 \le D \le 255$

Column and Row FEC
$4 \le L \le 1020$
$4 \le D \le 255$

For Standard Definition (SD) signals (270 Mb/s) the product of L and D (L x D) shall be ≤ 1500.
For High Definition (HD) signals (1.485 Mb/s) the product of L and D (L x D) shall be ≤ 3000
For Three Gigabit (3G) signals (2.97 Gb/s) the product of L and D (L x D) shall be ≤ 6000 .
Block Aligned FEC Operation and Non Block Aligned FEC Operation interleaves shall be supported.

## 7.2 Network Consideration (Informative)

FEC can be used to correct for short duration outages and isolated random datagram loss, not to hide network protection switches. Maximum protection varies with data rate and is as follows:

270 Mb/s (SD-SDI) – maximum 33 ms protection

1.485 Gb/s (HD-SDI 1080i) – maximum 6 ms protection

2.97 Gb/s (3G-SDI 1080p) – maximum 3 ms protection

For outages beyond maximums above or when FEC is not utilized it is expected that other mechanisms will be utilized to conceal errors. These other mechanisms could include Media Datagram retransmission or repetition of single video frames. This standard includes the marking of the end of video frames so that frames can be easily repeated in the absence of expected datagrams.

FEC Maximums

This standard is designed with certain FEC maximum protection capabilities. This standard provides optional FEC protection for error events up to the point where a network protection switch would occur.

The following parameters are commonly used in telecommunications applications:

Signal degradation causing a switch to protect is between 10^-3 to 10^-5 BER

Soft failure detection is between 10^-5 to 10^-9 BER

Loss of signal (LOS) is detected in around 375 µs

The receiver has 625 µs to detect an out-of-frame (OOF) condition

Worse case loss of frame detection (LOF) of Frame is around 3 ms

A conservative number then for maximum loss protection would be 3 ms.

## Annex A Bibliography (Informative)

Note: All references in this document to other SMPTE documents use the current numbering style (e.g. SMPTE ST 2022-2:2007) although, during a transitional phase, the document as published (printed or PDF) may bear an older designation (such as SMPTE 2022-1-2007). Documents with the same root number (e.g. 2022-1) and publication year (e.g. 2007) are functionally identical.

IETF RFC 2205, Resource Reservation Protocol (RSVP)

IETF RFC 2474, Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers

IETF RFC 3376, Internet Group Management Protocol, Version 3

IETF RFC 3551, RTP Profile for Audio and Video Conferences with Minimal Control

IETF RFC 3497, RTP Payload Format for Society of Motion Picture and Television Engineers (SMPTE)

IETF RFC 4566, SDP: Session Description Protocol

IETF ST05, Internet Protocol

IETF ST06, User Datagram Protocol

SMPTE ST 372:2011, Dual Link 1/5 Gb/s Digital Interface for 1920 x 1080 and 2048 x 1080 Picture Formats

SMPTE ST 424:2012, 3 Gb/s Signal/Data Serial Interface

SMPTE ST 2022-2:2007, Unidirectional Transport of Constant Bit Rate MPEG-2 Transport Streams on IP Networks

EBU Tech 3292 Rev. 2, Technical Specification — Basic Interoperable Scrambling System with Encrypted Key