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# ITU-T

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# J.151

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SERIES J: TRANSMISSION OF TELEVISION, SOUND PROGRAMME AND OTHER MULTIMEDIA SIGNALS

Digital television distribution through local subscriber networks

## RF remodulator interface for digital television

ITU-T Recommendation J.151

(Formerly CCITT Recommendation)

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**ITU-T Recommendation J.151**

# RF remodulator interface for digital television


## Summary

With the advent of digital television (DTV) there is now a need for a simple and cost-effective interconnect between the various digital signal sources and the DTV receiver. Digital video and audio are now available from digital VCRs (DVCR), terrestrial broadcasts, digital video disks (DVD), cable TV, satellite systems and digital camcorders. The RF remodulator in this Recommendation is an economical and practical digital interconnect for the new consumer digital video devices. The RF remodulator, is a one way throughput device with a data rate of 19.3 Mbit/s, which is suitable for most connections. The interface transmits MPEG (Moving Picture Experts Group) data for compressed digital video and audio and an OSD (on-screen display) overlay. The RF remodulator uses a simple coaxial cable to interconnect devices in a way with which consumers are most familiar.



## Source

ITU-T Recommendation J.151 was prepared by ITU-T Study Group 9 (1997-2000) and approved by the World Telecommunication Standardization Assembly (Montreal, 27 September – 6 October 2000).

## FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

## NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

## INTELLECTUAL PROPERTY RIGHTS

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

## CONTENTS

**ITU-T Recommendation J.151**

# RF remodulator interface for digital television

## 1 Scope

This ITU-T Recommendation defines an RF remodulator interface for digital television with an advanced on-screen display (OSD) overlay capability. This Recommendation defines minimum specifications for a one-way data path utilizing an 8 VSB trellis (8T VSB) or a 16 VSB remodulator in compliance with Annex D/J.83 (System D) (ATSC Standard A/53, Annex D). The advanced overlay uses the same OSD syntax as ITU-T J.117 and allows signal service providers their incremental revenue from programme guides and supplemental services. The RF remodulator also facilitates conditional access required by service providers.

This Recommendation applies to any type of device used to connect to a J.83 System D compliant digital television receiver. Devices meeting this Recommendation should interoperate with any J.83 System D compliant receiver that also supports "monitor mode."

This Recommendation addresses RF output specifications, on-screen display (OSD) capabilities, and capability profiles for a DTV remodulator and recommendations concerning input to the remodulator.

This Recommendation is derived from several standards of the Electronic Industries Alliance (EIA).

## 2 Normative references

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is published regularly.

- ITU-R BT.601-5 (1995), *Studio encoding parameters of digital television for standard 4:3 and wide-screen 16:9 aspect ratios*.
- ITU-R BT.709-4 (2000), *Parameter values for the HDTV standards for production and international programme exchange*.
- ITU-T J.83 (1997), *Digital multi-programme systems for television, sound and data services for cable distribution, Annex D*.
- IEC 60169-24 (1991), *Radio-frequency connectors – Part 24: Radio-frequency coaxial connectors with screw coupling, typically for use in 75 ohm cable distribution systems (Type F)*.

## 3 Abbreviations

This Recommendation uses the following abbreviations:

ATSC Advanced Television Systems Committee

A/V Audio/Video

CEA Consumer Electronics Association

| | |
|---|---|
| CLUT | Colour Look-Up Table |
| CPU | Central Processing Unit |
| CVCT | Cable Virtual Channel Table |
| D/A | Digital-to-Analogue |
| DTV | Digital Television: ATSC compliant receiving device |
| DVCR | Digital Video Cassette Recorder |
| DVD | Digital Video Disk |
| EIA | Electronic Industries Alliance |
| EIT | Event Information Table |
| EVM | Error Vector Magnitude |
| HDTV | High Definition TeleVision |
| IEC | International Electrotechnical Commission |
| IEEE | Institute of Electrical and Electronics Engineers |
| IF | Intermediate Frequency |
| IRC | Interface Reference Clock |
| ITU | International Telecommunication Union |
| MPEG | Moving Picture Experts Group |
| NTSC | National Television Systems Committee |
| OSD | On-Screen Display |
| PAT | Program Association Table |
| PES | Program Elementary Stream |
| PID | Program Identifier |
| PMT | Program Map Table |
| PSIP | Program and System Information Protocol |
| RF | Radio Frequency |
| SDTV | Standard Definition Television |
| STB | Set-Top Box |
| TSID | Transport Stream Identification |
| TVCT | Terrestrial Virtual Channel Table |
| UHF | Ultra High Frequency |
| VCR | Video Cassette Recorder |
| VCT | Virtual Channel Table |
| VHF | Very High Frequency |
| VSB | Vestigial SideBand |

## 4 System overview

A typical NTSC analogue system with an RF remodulator appears in Figure 1. The figure shows a typical VCR block diagram but could be a cable set top box (STB) or satellite receiver. The consumer connects the RF signal from the antenna or cable feed to the VCR or STB. The VCR or other receiving device connects to the television receiver via the RF output jack. If the VCR or receiving device is not in use, it simply passes the entire RF spectrum through to the TV. If the VCR or receiving device is active in the play mode, it remodulates the video and audio signals to an unused RF channel for display by the television set. The VCR, STB or satellite receiver can overlay its own on-screen display for user control or added features. The connection is made with an inexpensive coaxial cable.

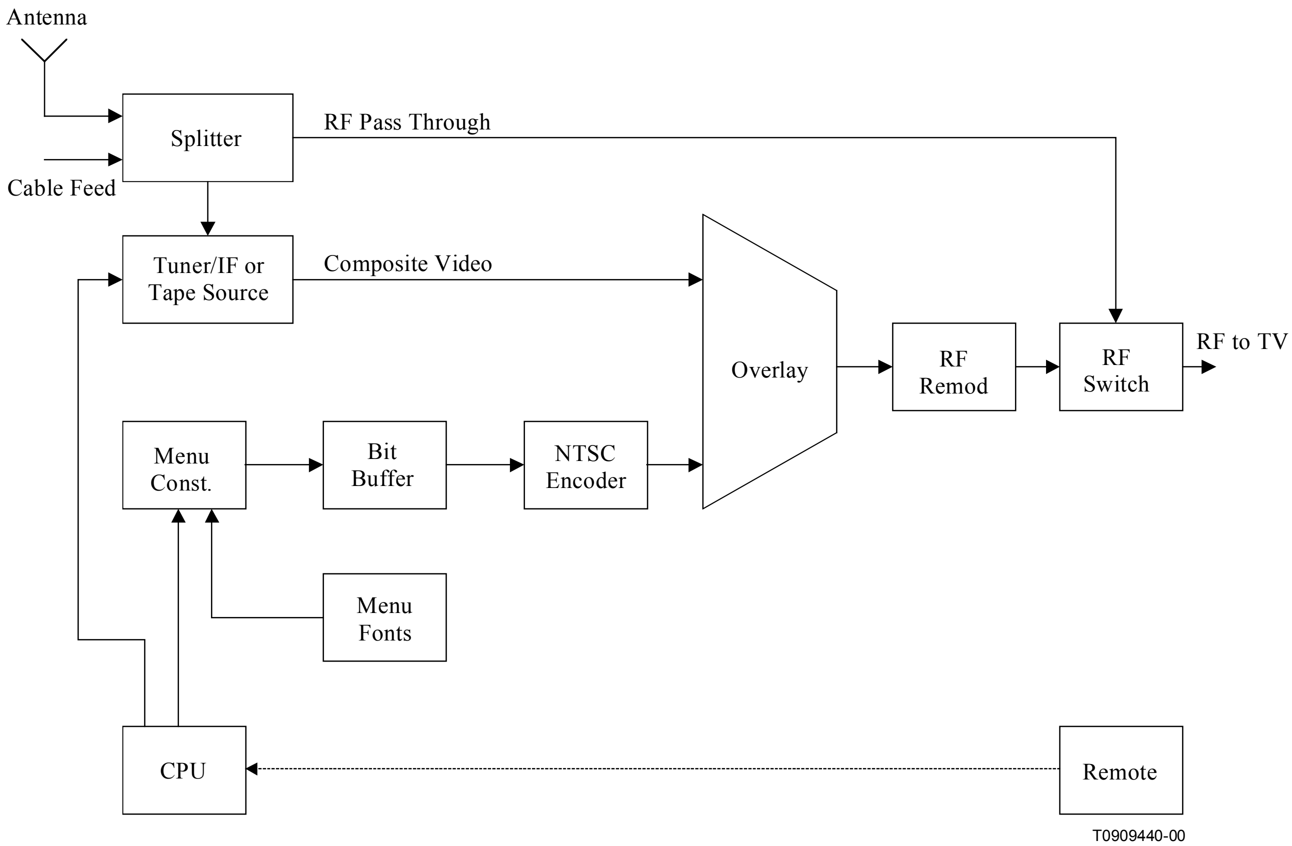


**Figure 1/J.151 – Typical NTSC system**

The system of Figure 1 can be extended to the digital receiving device and digital TV receiver (DTV) by using the RF Remodulator as depicted in Figure 2. This Recommendation defines a specification for an RF digital interface to a DTV receiver that provides a level of functionality that is similar to the analogue system. This solution is very practical, cost-effective, and introduces no picture or sound degradation. The RF Remodulator has the added advantage of no cable length limitation as do some baseband digital interfaces such as the type in ITU-T J.117.

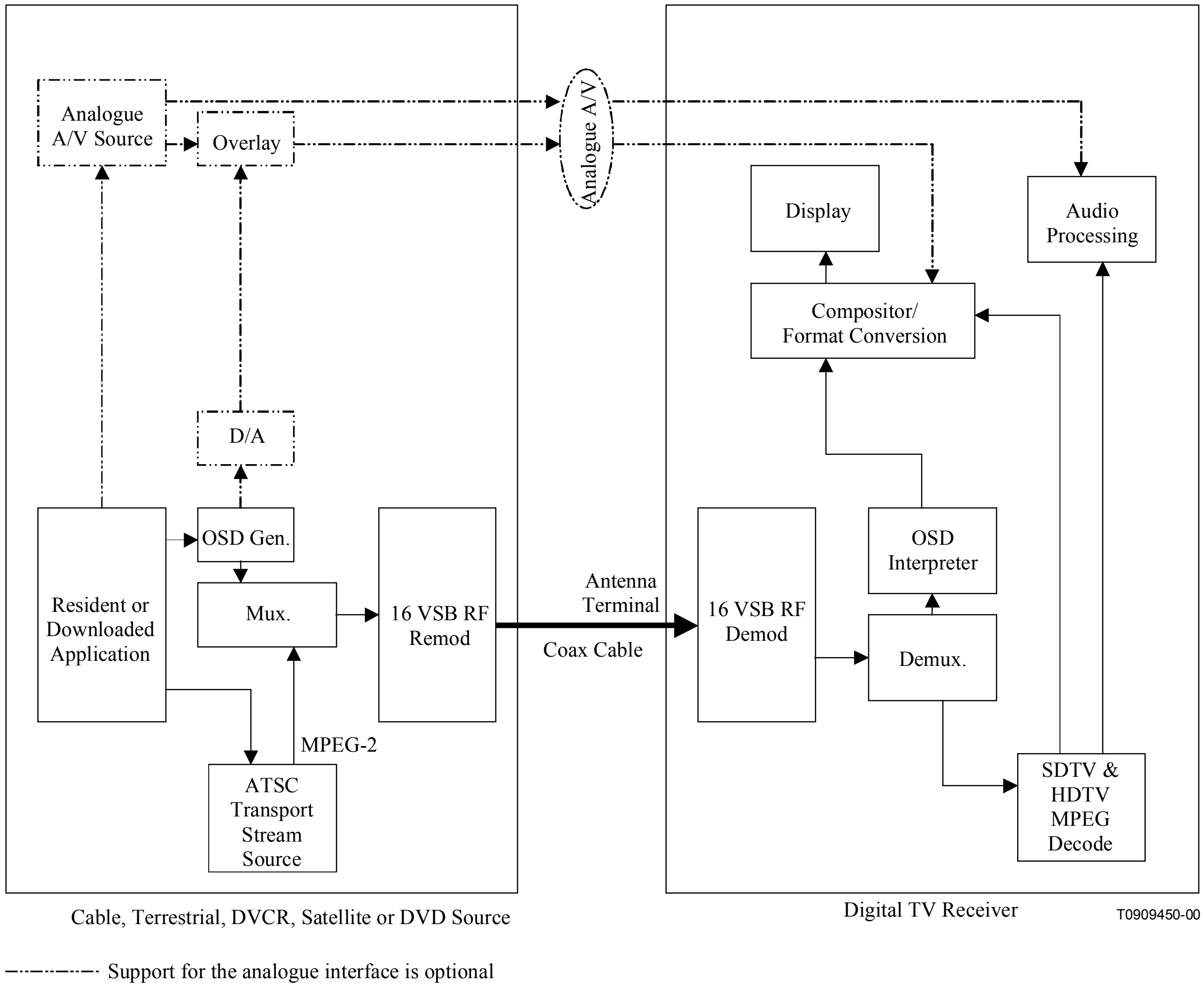


**Figure 2/J.151 – Equivalent DTV system**

Figure 2 depicts a digital audio/video receiving device connected to a DTV receiver with a 75-ohm coaxial cable. The figure also shows an optional analogue baseband connection. The OSD data is multiplexed with the source material before the remodulator. This allows for extended features like on-screen programming guides or on-screen display capability for operating the VCR, STB or other signal-receiving device. If no OSD information is required, this system can deliver two HD signals to the DTV receiver using the 16VSB mode.

Users of this Recommendation should note that future copy protection systems or standards will be implemented and content traversing this DTV RF interface will be required to comply with these future systems or standards.

## 5 DTV remodulator RF output specifications

The entire transport modulation system should be compliant with Annex D/J.83, System D.

### 5.1 Selectable output channel frequency

The channel output frequency is user selectable to one of two adjacent VHF or UHF channels. The system designer should choose output channels appropriate for the market or country where the product will be implemented. In addition, the channel frequency tolerance should be ±10 kHz. All devices equipped with RF modulators should be clearly marked indicating the available output channels.

### 5.2 Nominal RMS output level

The Nominal RMS Output level should be –3 dBmV (+6/–3 dB) at 75 ohms.

NOTE – Nominal output signal is based on a reduction of 3 to 6 dB from typical NTSC levels. The value of –3dBmV at 75 ohms is equivalent to –51.8 dBm in the entire VSB signal (which includes 0.3 dB for the pilot), or –119.4 dBm/Hz in the data portion of the spectrum.

### 5.3 Pilot phase noise

This clause addresses pilot phase noise for 8 VSB trellis and 16 VSB.

#### 5.3.1 Pilot phase noise – 8 VSB trellis

Pilot Phase Noise should be less than –90 dBc at 20 kHz for 8 VSB trellis.

NOTE – The specification is 12 dB better than the demonstrated threshold of –78 dBc at 20 kHz for 8 VSB (trellis coded) reception.

#### 5.3.2 Pilot phase noise – 16 VSB

Pilot Phase Noise should be less than –90 dBc at 20 kHz for 16 VSB.

NOTE – The specification is 7 dB better than the demonstrated threshold of –83 dBc at 20 kHz for 16 VSB reception.

### 5.4 Error vector magnitude (EVM)

#### 5.4.1 EVM – 8 VSB trellis

The EVM, in instances without equalization, should be at least 18 dB below the measured output power for 8 VSB trellis. The specification is set to allow simple filtering without phase correction in the remodulator, while leaving sufficient tolerance for additional linear distortion due to home wiring. The EVM, in instances with equalization, should be at least 24 dB below the measured output power. The specification effectively sets a limit on non-linear distortions in the remodulator.

#### 5.4.2 EVM – 16 VSB

The EVM, in instances without equalization, should be at least 18 dB below the measured output power for 16 VSB. The specification is set to allow simple filtering without phase correction in the remodulator, while leaving sufficient tolerance for additional linear distortion due to home wiring. The EVM, in instances with equalization, should be at least 34 dB below the measured output power for 16 VSB. The specification effectively sets a limit on non-linear distortions in the remodulator.

#### 5.4.3 EVM definition

EVM is a measure of performance of the received and demodulated 8 or 16 VSB constellation. EVM will quantify the in-band distortions.

$$\mathrm{EVM} = \sqrt{(\mathrm{Iref} - \mathrm{Imeas})^2 + (\mathrm{Qref} - \mathrm{Qmeas})^2} \tag{5.1}$$

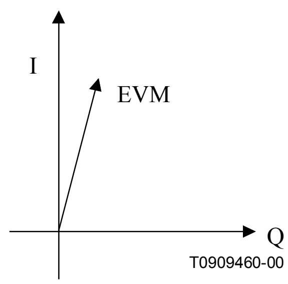


**Figure 3/J.151 – Error vector magnitude**

In theory the VSB signal has no Q component, Q reference = 0. However, non-linear effects can cause phase distortion which could transfer the vector into the Q domain.

$$\mathrm{EVM\,(dB)} = 10 \log \left[ \frac{\mathrm{Signal\,Energy}}{\sum_1^n \left[ \mathrm{EVM}_{(n)} / n \right]} \right] \tag{5.2}$$

## 5.5 Connector

The connector should be an F-type female connector per IEC 60169-24 (1991-11).

## 5.6 Side-band output

A double side-band output is acceptable.

## 5.7 Roll-off specification

All spurious signals that are greater than 12 MHz from the pilot of the desired channel's output signal should be more than 30 dB down from the actual signal level. See Figure 4.

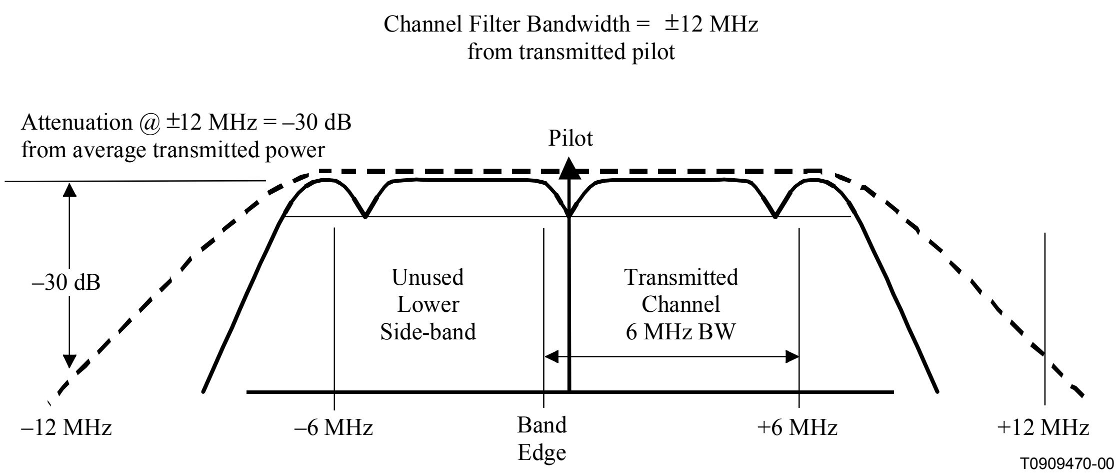


**Figure 4/J.151 – Roll-off**

## 5.8 Data and clock rates

Data and clock rates should be as indicated in Table 1.

**Table 1/J.151 – Data and clock rates**

| VSB Mode | IRC (Interface Reference Clock) | Input data rate bits per second (bit/s)[1] | Input data rate bytes per second (byte/s)[2] |
|---|---|---|---|
| 16 VSB | 5 381 118 | 38 785 317 | 4 848 164 |
| 8 VSB Trellis | 2 690 559 | 19 392 658 | 2 424 082 |

# 6 On-screen display (OSD) support

Figure 5 illustrates a typical OSD system.

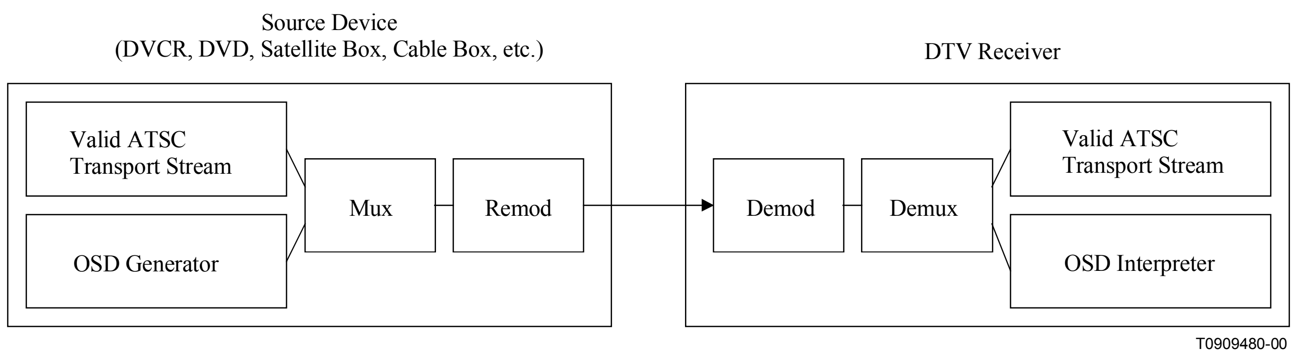


**Figure 5/J.151 – Typical OSD system illustration**

## 6.1 OSD encapsulation

OSD data should be encapsulated in PES packets, which are then converted to MPEG-2 transport stream packets. See Figure 6.

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[1] Includes MPEG2-TS packet sync byte (0 × 47). The effective bit rate, not including MPEG2-TS sync byte is 19 289 506 bit/s and 38 579 012 bit/s.

[2] The input data rate is not an integral number of byte/s. The actual byte/s is derived from the bit rate. The values in this table have been rounded.

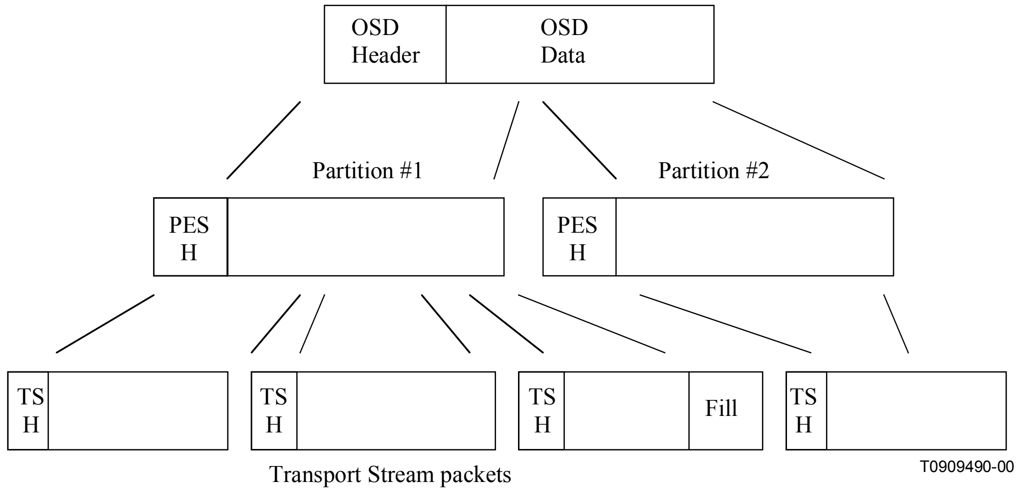


**Figure 6/J.151 – OSD data packet illustration**

### 6.1.1 PES encapsulation

The following restrictions should apply:

a) **stream_id** is defined as 0xBF to indicate that this stream should be of type private_stream_2.

b) OSD data should be carried as the payload of PES packets identified by PID 0x1ABC.

c) Each OSD subframe should start a new PES packet.

d) The OSD subframe may be transported in more than one PES packet.

In addition, the Transport Stream packets that result from PES segmentation should conform to the following constraints:

a) **transport_scrambling_control** bits should have the value '**00**'.

b) **adaptation_field_control** bits should have the value '**01**'.

For a detailed description of PES encapsulation, see ITU-T H.222.0 | ISO/IEC 13818-1, as constrained by Annex D/J.83.

### 6.1.2 Syntax and semantics for PES packets carrying OSD information

The syntax and semantics for a PES packet carrying OSD information should be as defined in Table 2.

**Table 2/J.151 – PES packet definition for carrying OSD information**

| | Bits | Format |
|---|---|---|
| **OSD_PES_packet( ) {** | | |
| **Start_code_prefix** | 24 | Bslbf |
| **stream_id** | 8 | 0xBF |
| **PES_packet_length** | 16 | Uimsbf |
| **Total_partitions** | 8 | Uimsbf |
| **partition_number** | 8 | Uimsbf |
| **version_control** | 5 | Uimsbf |
| **protocol_id** | 3 | Uimsbf |
| **additional_info_length** | 8 | Uimsbf |
| **additional_info( )** | var | |
| **OSD_data( )** | var | |
| **Reserved** | 32 | rpchof |
| **}** | | |

where:

**start_code_prefix**: is a 24-bit field that identifies the beginning of a packet. Its value should be set to 0x000001.

**stream_id**: is an 8-bit field that should be set to 0xBF (private_stream_2) to indicate that the format of the OSD PES packets follows a privately defined protocol.

**PES_packet_length**: is a 16-bit field specifying the number of bytes in the PES packet immediately following this field to the end of the PES packet. The value of this field should not exceed 65 529 (equivalently, the maximum size for an OSD PES packet is 65 535 bytes).

**total_partitions**: is an 8-bit field that specifies the total number of partitions required to carry the OSD datagram using fixed length PES packets. The range for this field should be between 1 and 255 (inclusive).

**partition_number**: is an 8-bit field that specifies the OSD partition carried in this PES packet. The range for this field should be between 1 and 255 (inclusive).

**version_control**: is a 5-bit field that identifies the version number of the transmitted OSD. Its value increases by one every time a new OSD subframe is generated and transmitted. If the same subframe is retransmitted, then this value is not incremented. Upon reaching the value 31, it wraps around to 0.

**protocol_id**: is a 3-bit field that is currently defined as '000'. All other values are reserved for future eventual additions and/or restructuring of the OSD protocol.

**additional_info_length**: is an 8-bit field the value of which corresponds to the length in bytes of the **additional_info** field.

**additional_info**: is a field designated to contain additional information that may be added eventually in the future. Currently, no additional information exists and therefore the value of the field **additional_info_length** is 0x00.

**OSD_data**: is a subframe header. It may contain data if necessary.

### 6.1.3 Maximum transmission rate for OSD data

The maximum transmission rate for OSD data should not exceed 19.29 Mbit/s[3] averaged over any 100 ms interval. This rate should be further constrained by the requirement that the solid colour fill region subframes should not be transmitted more frequently than fully expanded subframes. Further,

[3] This value does not include the MPEG2-TS packet sync byte (0 × 47). See ITU-T Annex D/J.83, System D.

the OSD source should pause between transmission of a solid colour fill region subframe and the next subframe to permit the subframe to be expanded. Even though the solid colour fill region subframe may be smaller in size than the fully expanded subframe, the processing time required in the OSD consumer is the same. The time in seconds ($T_S$) required to transmit the fully expanded subframe may be calculated as follows:

Step 1: Subframe Width × Subframe[4] Height × # bits/pixel = $T_b$

Step 2: $T_b$/19.29 Mbit/s = $T_s$

where:

$T_s$ = time in seconds

$T_b$ = total bits to be transmitted

Example calculations follow:

a) A 640 × 480, 4-bit solid colour fill region subframe

Step 1: 640 × 480 × 4 = 1.23 Mbit

Step 2: 1.23 Mbit/19.29 Mbit/s = 63.8 ms

Therefore the OSD source should pause 63.8 ms after the transmission of the first solid colour fill region subframe before another subframe is transmitted.

b) A 300 × 200, 16-bit solid colour fill region subframe

Step 1: 300 × 200 × 16 = 0.96 Mbit

Step 2: 0.96 Mbit/19.29 Mbit/s = 49.8 ms

Therefore the OSD source should pause 49.8 ms after the transmission of the first solid colour fill region subframe before another subframe is transmitted.

If the OSD producer is making use of the double buffering feature, then it should not assume a frame rate faster than 24 frames per second.

#### 6.1.4 OSD retransmission

The consumer device should retransmit the OSD within 1 second, if there has been no change to the OSD.

## 7 OSD data

### 7.1 Format of OSD data

In this clause the source of the OSD signal is called the OSD Producer and the DTV Display is called the OSD Consumer.

#### 7.1.1 Subframe types

The defined subframe types are:

**Set_OSD_pixel_format**: Establishes the format of the basic 16-bit pixels that make up the data definition to follow, and the size and colour depth of the OSD grid. For OSD grid formats with either 4- or 8-bit colour depths, the subframe should contain either a 4- or 8-bit Colour Look-up Table (CLUT).

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[4] All references in this Recommendation to resolutions, such as 640 × 480, are termed as width × height.

**4_bit_OSD_data**: Defines 4-bit pixels in a rectangular region. Each 4-bit pixel represents a colour/alpha blend value derived by indirection through the 4-bit CLUT.

**8_bit_OSD_data**: Defines 8-bit pixels in a rectangular region. Each 8-bit pixel represents a colour/alpha blend value derived by indirection through the 8-bit CLUT.

**Uncompressed_16_bit_data**: Defines raw uncompressed 16-bit OSD data in a rectangular region.

**Fill_region_with_constant**: Defines a rectangular region to fill with a 16-bit constant with a format defined by **pixel_format**.

**Clear_OSD**: Should load the complete OSD with a transparent value.

### 7.1.2 Subframe typeCode

The type of each subframe is identified by a **typeCode** field, as defined in Table 3. All subframes in this protocol, as well as ones defined in future extensions, are formatted with the 8-bit **typeCode** and 24-bit **dataLength** in the first quadlet. OSD Consumer equipment that encounters a subframe with an unknown **typeCode** should use the **dataLength** to skip that subframe.

**Table 3/J.151 – typeCode coding**

| typeCode | Meaning |
|---|---|
| 0 | Reserved |
| 1 | **Set_OSD_pixel_format** |
| 2 | **4_bit_OSD_data** |
| 3 | **8_bit_OSD_data** |
| 4 | **Uncompressed_16_bit_data** |
| 5 | **Fill_region_with_constant** |
| 6 | **Clear_OSD** |
| 7-255 | Reserved for future use |

### 7.1.3 Subframe processing

The DTV should process subframes in the order received. A DTV may not have buffer space sufficient to hold a complete frame of OSD data; if that is the case, processing of subframes as they arrive will be necessary. In any case, the DTV should process each subframe as it arrives.

### 7.1.4 Subframe syntax and definition

#### 7.1.4.1 Set OSD pixel format subframe

The OSD Producer device should use the **Set_OSD_pixel_format** subframe to set the pixel format, colour depth, and CLUT (if applicable) for subsequent delivery of OSD data.

The **Set_OSD_pixel_format** subframe should be formatted as shown in Figure 7 when **OSD_layout** specifies a 16-bit colour depth.

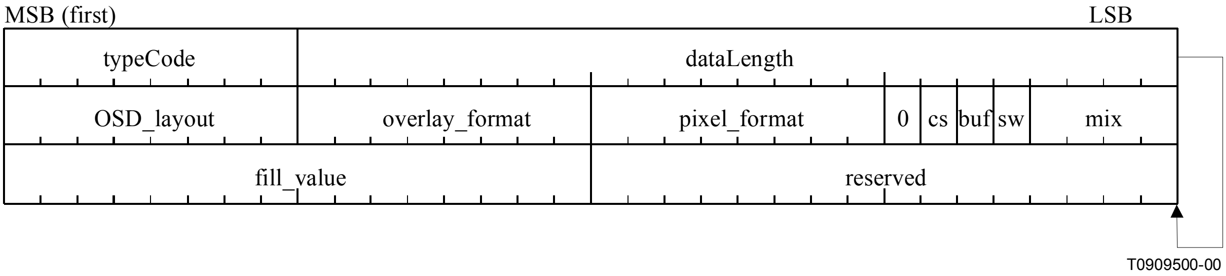


**Figure 7/J.151 – Set OSD pixel format subframe, 16-bit colour depth**

The **Set_OSD_pixel_format** subframe should be formatted as shown in Figure 8 when **OSD_layout** specifies a 4-bit colour depth.

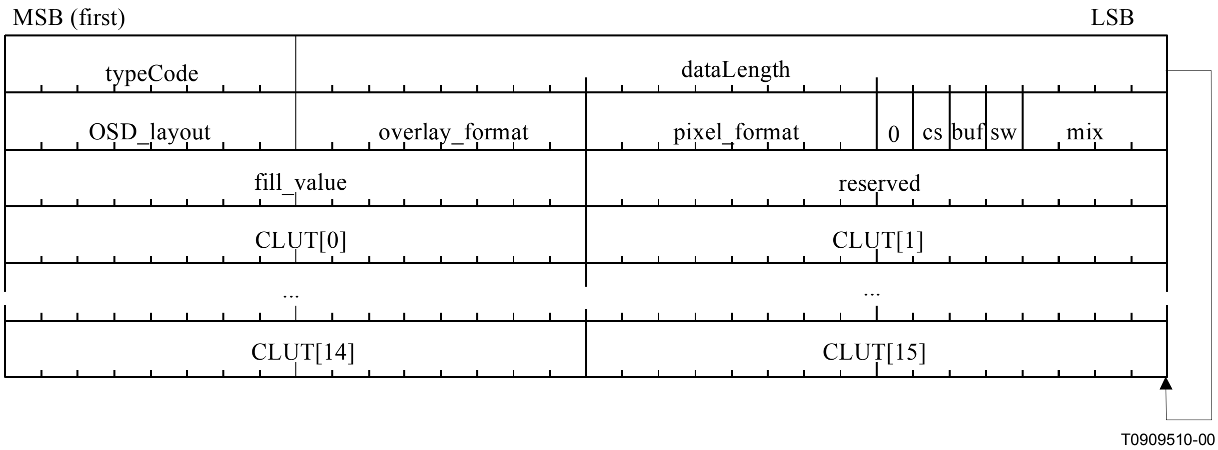


**Figure 8/J.151 – Set OSD pixel format subframe, 4-bit colour depth**

The **Set_OSD_pixel_format** subframe should be formatted as shown in Figure 9 when **OSD_layout** specifies an 8-bit colour depth.

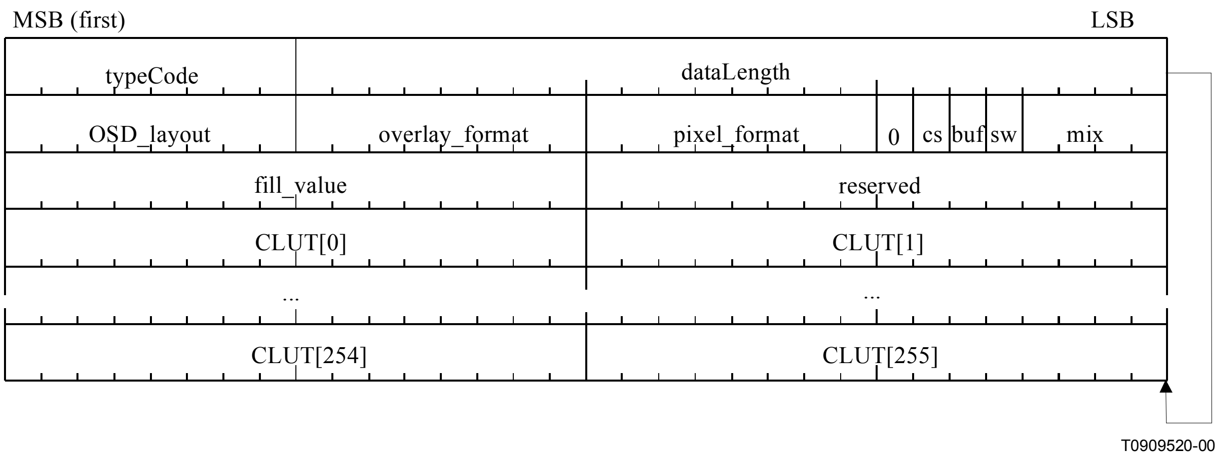


**Figure 9/J.151 – Set OSD pixel format subframe, 8-bit colour depth**

The source should send the **Set_OSD_pixel_format** subframe prior to the initial delivery of OSD data to establish the format for the data to follow. The subframe should also be sent prior to delivery of OSD data in a different pixel format. Note that it is not possible to define one OSD image as a mixture of different pixel formats (**pixel_format** 0 and 1, for example).

The **Set_OSD_pixel_format** subframe also selects one of possibly several OSD buffer formats offered by the OSD Consumer.

**typeCode** for the **Set_OSD_pixel_format** subframe is $01_{16}$.

**dataLength** should reflect the number of bytes in the subframe following the **dataLength** field itself, either 8, 40, or 520, depending upon the colour depth defined in **OSD_layout**.

**OSD_layout** specifies the OSD frame buffer dimensions and colour depth and should be as specified in Table 4.

**Table 4/J.151 – OSD layout coding**

| OSD_layout | Meaning |
|---|---|
| 0 | $640 \times 480 \times 4$ |
| 1 | $640 \times 480 \times 8$ |
| 2 | $640 \times 480 \times 16$ |
| 3-255 | Reserved for future use |

**overlay_format** specifies the way the OSD Consumer should overlay the selected grid format over decoded video. Table 5 defines coding for **overlay_format**. Support for formats 1 and 2 is optional. All devices should support format 0.

**Table 5/J.151 – Overlay format coding**

| overlay_format | Meaning |
|---|---|
| 0 | no stretch requested |
| 1 | Stretch horizontally to 14:9 |
| 2 | Stretch horizontally to 16:9 |
| 3-255 | Reserved for future use |

**pixel_format** should be as specified in Table 6. The format for the 16 bit pixel for each pixel format is as shown in Figure 10.

**Table 6/J.151 – Pixel format coding**

| pixel_format | Meaning |
|---|---|
| 0 | $Y:C_b:C_r = 6:5:5$ |
| 1 | $a:Y:C_b:C_r = 2:6:4:4$ |
| 2 | $a:Y:C_b:C_r = 4:6:3:3$ |
| 3-255 | Reserved for future use |

A zero value for Y indicates lowest luminance (most black). A maximum value for Y (all ones) indicates highest luminance level. Y is related to primary colour signals (R, G, B) in accordance with the colourimetry clauses of ITU-R BT.709-2, the standard for DTV, or ITU-R BT.601-4, the standard for NTSC. An OSD consumer may only support one of the standards; as the complexity of requiring support for both was deemed excessive for the improvement in quality that would result. $C_r$ and $C_b$ are chrominance vectors related to primary colour signals (R, G, B) in accordance with ITU-R BT.709-2 or ITU-R BT.601-4.

For **pixel_format** 0 only, any pixel with a Y value of zero should be transparent. Pixels with non-zero values of Y should be opaque.

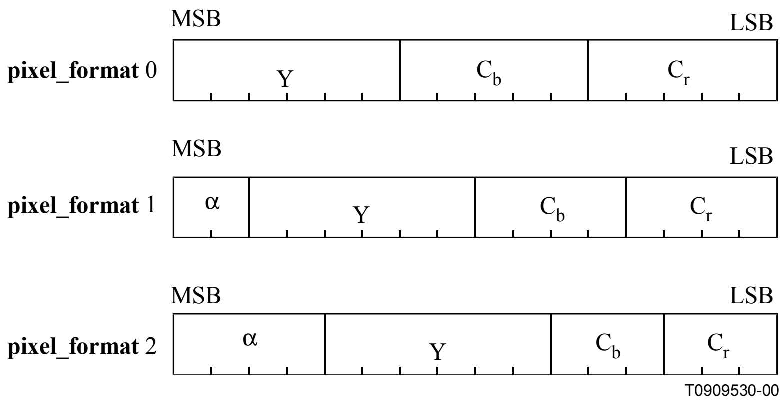


**Figure 10/J.151 – Pixel format bit fields**

**a** is an alpha level associated with pixels in **pixel_format** 1 or 2. **a** values for **pixel_format** 1 are defined in Table 7. For **pixel_format** 2, values in between 0 and all-ones indicate the mix weight between the OSD pixel and decoded video for each pixel. A zero value for a indicates transparent. The all-ones value indicates opaque. The interpolation between zero and all ones should be approximately linear.

The **mix** parameter in the **Set_OSD_pixel_format** subframe is used with **pixel_format** 1 to specify the alpha-blend value to use for pixels that are neither transparent nor opaque. Table 7 should define the interpretation of the 2-bit alpha field in pixels formatted as **pixel_format** 1. The **mix** parameter should be ignored in an OSD Consumer for pixel formats 0 and 2.

**Table 7/J.151 – A field interpretation for pixel_format 1**

| **pixel** a | **Meaning** |
|---|---|
| 0 | Opaque |
| 1 | Mix with video using **mix** parameter in the **Set_OSD_pixel_format** subframe |
| 2 | Transparent |
| 3 | Reserved for future use |

**cs** defines the chrominance standard used in the OSD Producer, and acts to notify the OSD Consumer that it should interpret Y-Cb-Cr data in accordance with the referenced standard, if possible. **cs** is defined in Table 8.

**Table 8/J.151 – Colourimetry standards**

| **cs** | **Colour Standard** |
|---|---|
| 0 | ITU-R BT.709-2 |
| 1 | ITU-R BT.601-4 |

**buf** indicates whether data is placed into the buffer currently being used for output (**buf** = 0) or into an a buffer that is not currently being used for output (**buf** = 1). The **buf** and **sw** bits together specify how the data update will take place as shown in Table 9.

When double buffering is not supported in the OSD consumer, **buf** = 1 has no meaning. In this case the OSD consumer may ignore subframes with **buf** = 1.

**Table 9/J.151 – buf/sw coding**

| **buf** | **sw** | **Rule** |
|---|---|---|
| 0 | 0 | Should put data into the active buffer immediately |
| 0 | 1 | Should start to put data into the active buffer synchronized with the start of the next vertical retrace |
| 1 | 0 | Should put data into an off-screen buffer |
| 1 | 1 | Should put data into an off-screen buffer and then swap with the active buffer, synchronized with the start of the next vertical retrace |

**sw** indicates when the data update will take place. The **buf** and **sw** bits together specify how the data update will take place as shown in Table 9.

**fill_value** is formatted according to **OSD_Layout** as shown in Table 10.

**Table 10/J.151 – fill_value coding**

| **OSD_layout** | **fill_value format** |
|---|---|
| 0 | 4 bits (right justified) |
| 1 | 8 bits (right justified) |
| 2 | as defined by **pixel_format** Coding |
| 3-255 | Reserved |

For Set_OSD_pixel_format purposes, Set OSD pixel format subframe, Item 1 below states "Processing the first **Set_OSD_pixel_format** subframe after establishing the OSD connection should have the effect of setting the OSD frame buffers to the fill pixel value provided in the command." For purposes of compliance with this Recommendation, the condition "…after establishing the OSD connection…", should mean "…after an OSD producer has been selected…".

Processing within the OSD Consumer of the **Set_OSD_pixel_format** subframe should conditionally cause the OSD frame buffers to be initialized to the **fill_value** value provided:

1) Processing the first **Set_OSD_pixel_format** subframe after establishing the OSD connection should have the effect of setting the OSD frame buffers to the fill pixel value provided in the command.

2) Processing a subsequent **Set_OSD_pixel_format** subframe that changes the **pixel_format** or **OSD_layout**, the DTV should initialize the OSD buffers to the fill pixel value provided.

Processing a subsequent **Set_OSD_pixel_format** subframe that changes only the **mix** field or CLUT data, previously defined pixel data values do not change.

**CLUT[N]** is a colour look-up table entry. CLUT entries are 16-bits, formatted according to the pixel format defined in **pixel_format**.

### 7.1.4.2 4-bit OSD data subframe

Figure 11 defines the format of the **4_bit_OSD_data** subframe, used to deliver 4-bit pixels from A/V Source to display.

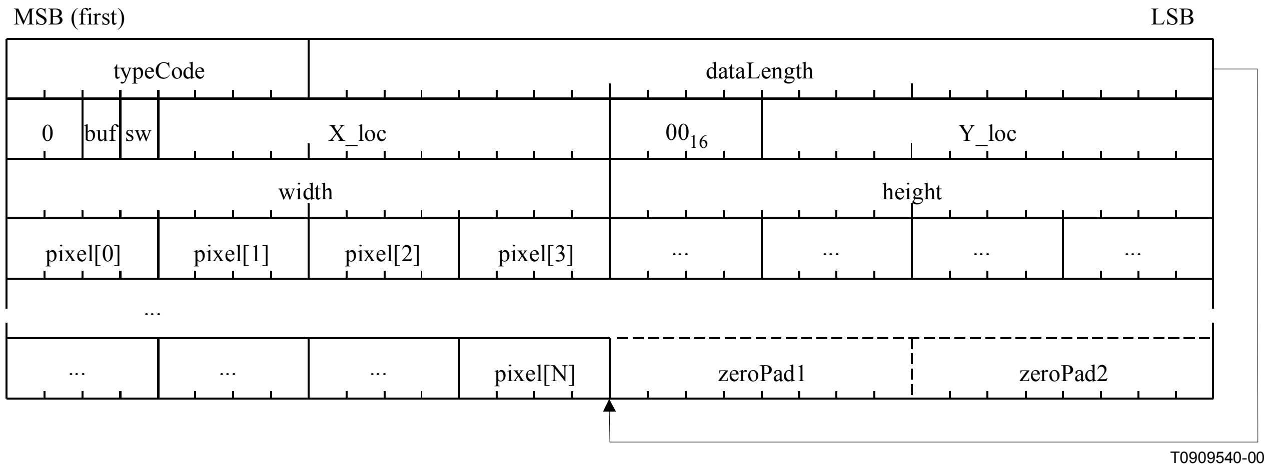


**Figure 11/J.151 – 4-bit OSD data subframe format**

**typeCode** should be set to value $02_{16}$, indicating the **4_bit_OSD_data** subframe format.

The 24-bit **dataLength** field should be set to indicate the number of data bytes in the remainder of the subframe. The subframe should be padded so that the next subframe address is quadlet aligned. Based on the height and width parameters (if both are odd numbers), the least significant 4 bits in the last data byte may be unused.

**X_loc** is the 12-bit X-coordinate (column number) within the image buffer in the buffer indicated by **buf**. The coordinate system is defined with 0,0 in the upper left corner.

**Y_loc** is the 12-bit Y-coordinate (row number) within the image buffer in the buffer indicated by **buf**.

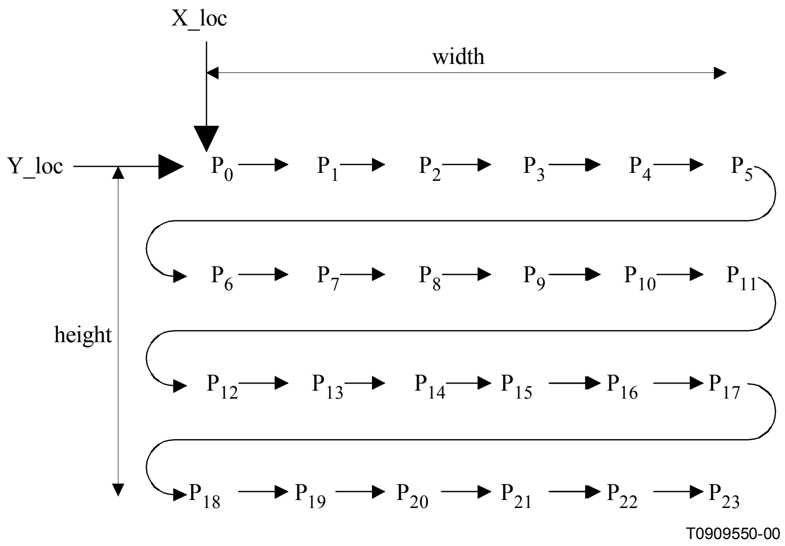


**Figure 12/J.151 – Pixel data display order**

**buf** and **sw** are the same as defined in 7.1.4.1, **Set_OSD_pixel_format** subframe.
**width** is a 16-bit unsigned integer number representing the width, in pixels, of the OSD region being defined. Value zero is undefined.

**height i**s a 16-bit unsigned integer number representing the height, in pixels, of the OSD region being defined. Value zero is undefined.

**pixel[0]** through **pixel[N]** are 4-bit pixel values. The pixels should be listed in a scan order that is left to right and top to bottom. An illustration of the order is shown in Figure 12. In this particular example **width** has a value of 6 and **height** has a value of 4. The display values for each should be expanded through the 4-bit to 16-bit CLUT defined in the most recently received **Set_OSD_pixel_format** subframe.

### 7.1.4.3 8-bit OSD data subframe

Figure 13 defines the format of the **8_bit_OSD_data** subframe, used to deliver 8-bit pixels from an OSD Producer to an OSD Consumer.

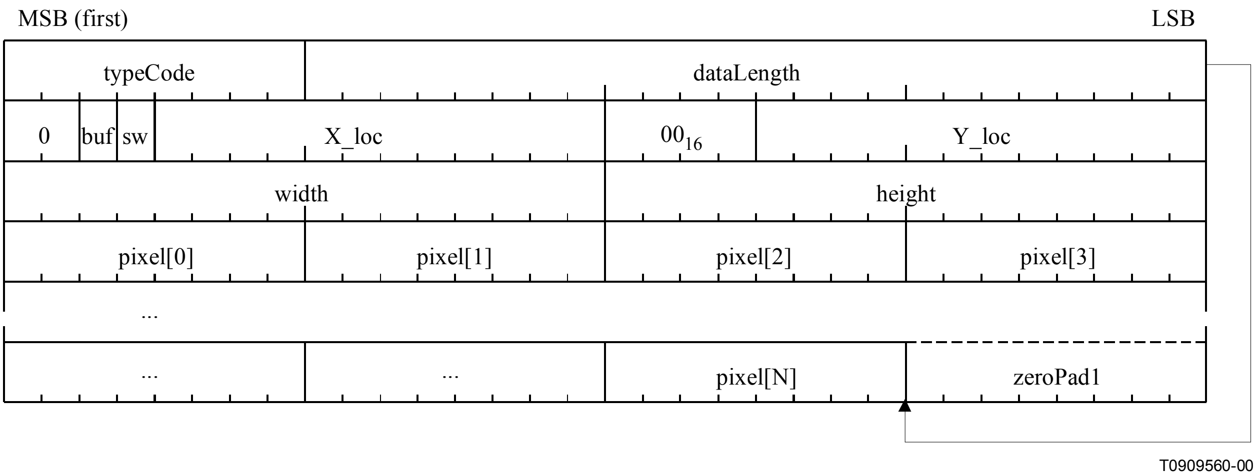


**Figure 13/J.151 – 8-bit OSD data subframe format**

**typeCode** should be set to value $03_{16}$, indicating the **8_bit_OSD_data** subframe format.
The definitions for **dataLength**, **X_loc**, **Y_loc**, width and **height** are the same as for the **4_bit_OSD_data** subframe.

The definitions for **buf** and **sw** are the same as defined in 7.1.4.1, **Set_OSD_pixel_format** subframe.

**pixel[0]** through **pixel[N]** are 8-bit pixel values. The display values for each should be derived by indirection through the 8-bit CLUT defined in the last received **Set_OSD_pixel_format** subframe. The pixels should be listed in a scan order as shown in Figure 12.

### 7.1.4.4 Uncompressed 16-bit data subframe

Figure 14 defines the format of the **Uncompressed_16_bit_data** subframe, used to deliver uncompressed 16-bit pixels from A/V Source to display.

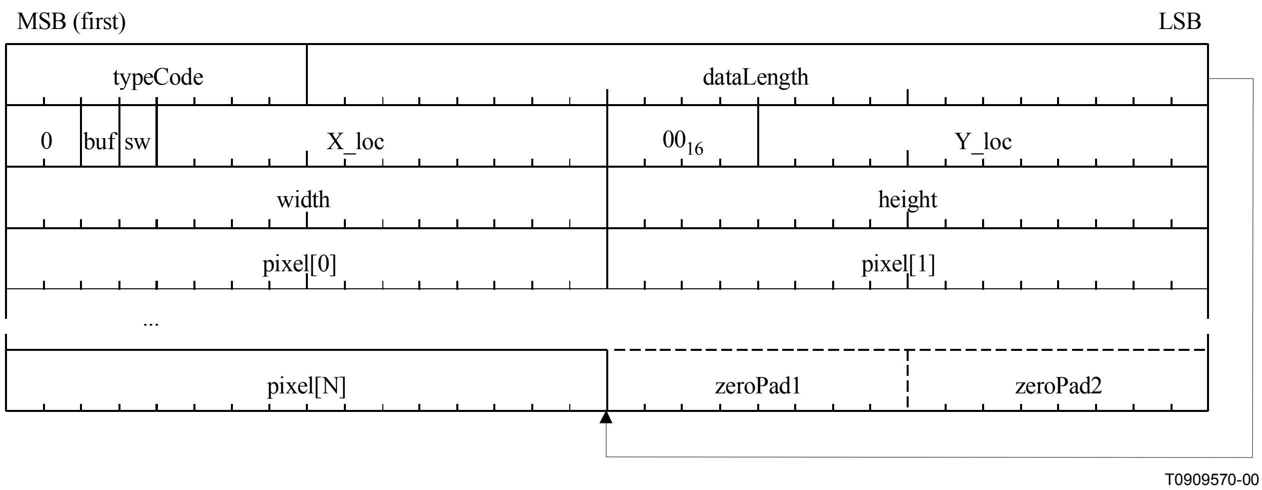


**Figure 14/J.151 – Uncompressed 16-bit data subframe format**

**typeCode** should be set to value $04_{16}$, indicating the **Uncompressed_16_bit_data** subframe format.

The definitions for **dataLength**, **X_loc**, **Y_loc**, **width** and **height** are the same as for the **4_bit_OSD_data** subframe.

The definitions for **buf** and **sw** are the same as defined in 7.1.4.1, **Set_OSD_pixel_format** subframe.

**pixel[0]** through **pixel[N]** are 16-bit pixel values. The format of each pixel (in terms of luminance, chrominance, and optional alpha level) are as defined by the **Set_OSD_pixel_format** subframe. The pixels should be listed in a scan order as shown in Figure 12.

### 7.1.4.5 Fill region with constant subframe

Figure 15 defines the format of the **Fill_region_with_constant** subframe, used to direct the display to fill a rectangular area in the display image buffer with a constant value.

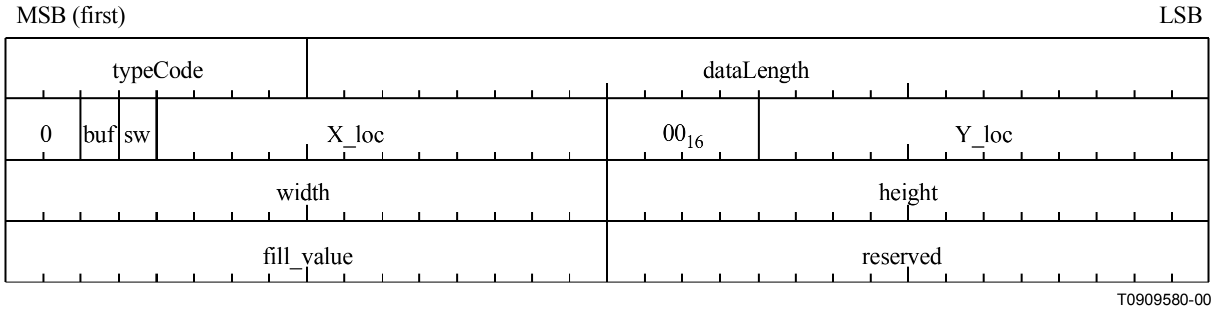


**Figure 15/J.151 – Fill region with constant subframe format**

**typeCode** should be set to value $05_{16}$, indicating the **Fill_region_with_constant** subframe format.

The 24-bit **dataLength** field should be set to 12 for this subframe type.

The definitions for **dataLength**, **X_loc**, **Y_loc**, **width** and **height** are the same as for the **4_bit_OSD_data** subframe.

The definitions for **buf** and **sw** are the same as defined in 7.1.4.1, **Set_OSD_pixel_format** subframe.

**Fill_Value** indicates the constant value to be filled. The format of **fill_value** should be as defined by Table 10.

Some implementations of DTVs may provide a feature that allows the colour of the area surrounding the defined OSD grid to be defined. The OSD Producer may specify the fill colour for the surrounding area by setting the **width** and **height** fields to $FF_{16}$.

### 7.1.4.6 Clear OSD subframe

Figure 16 defines the format of the **Clear_OSD** subframe, used to direct the display to fill the display image buffer with a zero (Transparent) value.

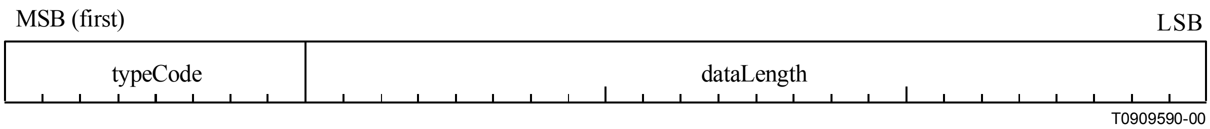


**Figure 16/J.151 – Clear_OSD subframe format**

**typeCode** should be set to value $06_{16}$, indicating the **Clear_OSD** subframe format.

The 24-bit **dataLength** field should be set to 0 for this subframe type.

## 7.2 Alignment of OSD with video

A Square pixel aspect ratio is desirable. The OSD consumer should align the 640 × 480 display grid with video according to the constraints:

a) The 640 × 480 grid should be centered horizontally within the visible display area.

b) The 640 × 480 grid should be centered vertically within the visible display area, or cover it completely.

## 8 Capability profiles

This clause defines the capability profiles for the RF DTV interface. At present, two profiles are defined. Future extensions to this protocol may define additional profiles.

All OSD consumers using OSDs should have the capabilities defined in Profile 1 of Table 11 and the OSD capabilities defined in Profile 1 of Table 12. Profile 1 is intended to define the capabilities for near-term designs. Profile 2 is intended to identify prospective capabilities for future designs.

**Table 11/J.151 – Capability profiles**

| Capability | Profile 1 | Profile 2 |
|---|---|---|
| RF Demodulator 8 VSB (trellis coded) | ✓ | ✓ |
| RF Demodulator 16 VSB | ✓ | ✓ |
| Decodes All Video Formats | ✓ | ✓ |
| Delivery Format Supports Region-Based Updating | ✓ | ✓ |
| Pixel transparency support (Transparent or Opaque Pixels) | ✓ | ✓ |
| Double Buffering | | ✓ |

**Table 12/J.151 – OSD capability profiles**

| Capability | Profile 1 | Profile 2 |
|---|---|---|
| 640 × 480 × 4 OSD grid, 4-bit to 16-bit CLUT format:<br>α, $YC_BC_R$, 2:6:4:4, transparent, opaque or per-screen alpha value<br>α, $YC_BC_R$, 4:6:3:3, transparent, opaque or alpha value per pixel | <br>✓<br> | <br>✓<br>✓ |
| 640 × 480 × 8 OSD grid, 8-bit to 16-bit CLUT format:<br>α, $YC_BC_R$, 2:6:4:4, transparent, opaque or per-screen alpha value<br>α, $YC_BC_R$, 4:6:3:3, transparent, opaque or alpha value per pixel<br>$YC_BC_R$ 6:5:5 | | <br>✓<br>✓<br>✓ |
| 640 × 480 × 16 OSD grid, pixel format:<br>α, $YC_BC_R$, 2:6:4:4, transparent, opaque or per-screen alpha value<br>α, $YC_BC_R$, 4:6:3:3, transparent, opaque or alpha value per pixel<br>$YC_BC_R$ 6:5:5 | | <br>✓<br>✓<br>✓ |

## 9 DTV RF remodulator input specifications

### 9.1 Input overview

An overview of input to the DTV remodulator is provided in Figure 17. If the device is partitioned as indicated in Figure 17, then it is expected (in general) that:

a) The remodulator should support transport streams for both the 16 VSB high data rate transmission mode and the 8 VSB (trellis coded) transmission mode.

b) The remodulator should support 3.3V Process TTL Logic Levels.

c) The f(sym) is equal to 10 762 238 Hz. (4.5E6 × 684/286) ± 10 ppm.

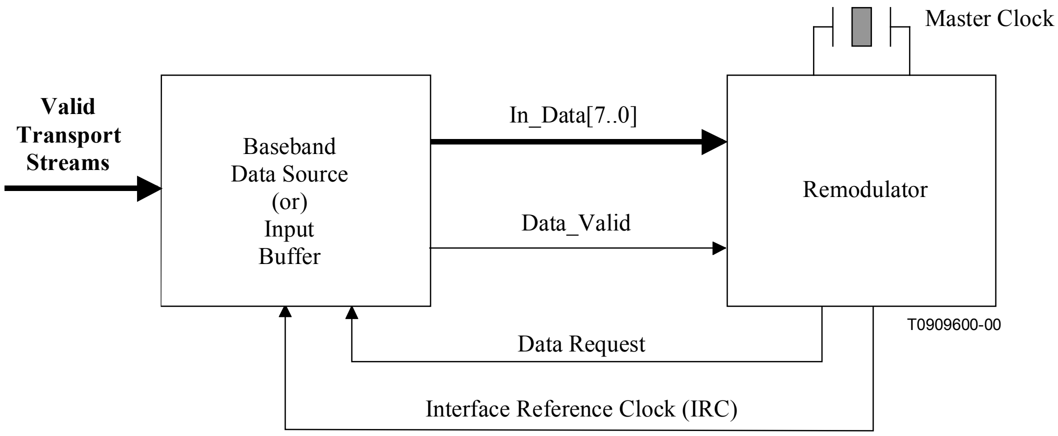


**Figure 17/J.151 – Remodulator system**

### 9.2 Input from remodulator to source

In general

a) The **IRC... (I**nterface **R**eference **C**lock) is generated from the Master Clock to provide the frequency reference.

b) The **Data_Request...** is generated to provide timing for the data pull from the source device. (Active High for 188 cycles).

c) The first byte of packet is the 0 × 47 MPEG Sync.

d) There are 313 packet cycles, 312 with Data_Request active and 1 with Data_Request inactive.

### 9.3 Input from source to remodulator

In general

a) The **In_Data...** is an 8 bit Parallel (Byte Wide) data bus.

b) The **Data_Valid...** is active high (for 188 cycles) starting at packet sync (0 × 47). See Figure 18.

c) There are 313 packet cycles, 312 with Data_Valid active and 1 with Data_Valid inactive.

Figure 18 provides a detailed illustration of the preceding three points.

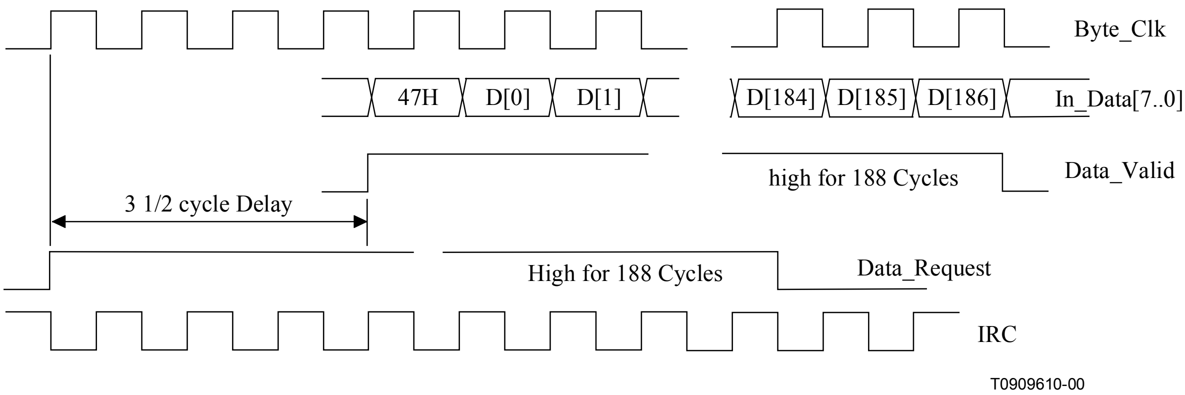


**Figure 18/J.151 – Data_Valid timing**

## 10 Monitor mode

### 10.1 Monitor mode overview

In this system, the DTV receiver tunes according to the PSIP tables present in the transport stream. The PSIP tables contain the virtual channel identification information (the major and minor channel number) and actual frequency on which the digital signal is transmitted, as well as other data such as time and programming information. In some situations, a "monitor" mode may be needed in DTV receivers.

In a remodulator system, a source unit produces a transport stream that is intended to be sent to the DTV receiver via an RF cable to the terrestrial RF input. The manufacturer may choose a separate RF input for the monitor mode, however the separate RF input should have the same characteristics as the terrestrial RF input to the DTV. Since the remodulator outputs on the frequency of the selected RF channel, any frequency related PSIP data, which is part of the transport stream, should be ignored, if present. A source unit may already be performing some modification of the transport stream prior to output, but a source unit such as a digital VCR (DVCR) may simply record the entire transport stream of a particular input program and replay it at a later time through the remodulator. The remodulator system should accommodate both types of source units. A remodulator system, permits proper display of a program without a specific change to the PSIP content of the transport stream, thus enabling an extremely simple and low complexity source unit using a remodulator to properly interface with a DTV.

### 10.2 Monitor mode conditions

The following conditions are applied concerning the "monitor mode":

- A unique[5] transport stream payload is serviced by the DTV receiver at a time. In principle, any RF channel can be monitored, and therefore this process is referred to as "***setting the DTV receiver to monitor mode N***" where *N* is the monitored RF channel number[6].
- A requirement to have a unique transport stream payload to carry a valid Program Association Table (PAT), Program Map Table (PMT), and PSIP information

[5] Unique means that there is no need to compose aggregated channel maps for devices connected to the DTV unit since each unit is serviced one at time.

[6] A statement such as "tune to channel 3 for VCR operation" is no longer valid in DTV. Instead, the concept of monitor mode *N* permits similar functionality. Future digital VCR manuals may carry a statement like "set your DTV to monitor mode 3 for VCR operation".

- The DTV receiver relies on PSIP data to identify the virtual channels present in the transport stream. The channel map in PSIP may be a Terrestrial Virtual Channel Table (TVCT) or a Cable Virtual Channel Table (CVCT) and receivers should be prepared to understand both[7].
- In monitor mode, there may be one or more virtual channels in the monitored transport stream and the DTV receiver may use software and on-screen menus to provide navigation and/or option selection for display or for other use.

## 10.3 Monitor mode practices

Based on the monitor mode conditions, the following practices are established to engineer DTV receivers capable of utilizing RF unidirectional interfacing:

- The channel mapping described by PSIP defines the use of virtual channels identified by their major and minor numbers. These numbers are, in general, independent of the actual RF channel that carries the data payload. For this reason, direct tuning to an RF channel in digital television is not recommended. Therefore, standard navigation and access devices (such as remote control units, on-screen menus, or buttons on the DTV receiver) for DTV receivers should be engineered with special controls to switch operation to **monitor mode *N***.
- In monitor mode, the channel mapping, via the Virtual Channel Table (VCT), and its parameters may change completely at a given time. For example, these changes will occur when a recorded segment in a digital VCR follows another segment with different channels and programs. Accordingly, the TSID of the monitored transport stream will also change with different recording segments. In normal DTV operation, the TSID for a given transport stream does not change, therefore DTV receivers should be engineered to operate under variable conditions for the monitoring mode.
- In the VCT, some fields are no longer relevant for the operation of a DTV receiver in monitor mode. The fields that should be ignored include, but are not limited to the following: the carrier frequency, the modulation mode, the path-select field, and the out-of-band field.
- In monitor mode, the major and minor numbers, as well as the short and extended channel names may be used to provide navigation for services carried within the monitored transport stream. In the case of digital VCRs, major and minor channel numbers also give reference to the original channels from which programs were recorded.
- All time of day clock references explicitly or implicitly[8] defined in PSIP tables obtained from monitored transport streams should be considered relative to decoded System Time Tables (STT) rather than the local clock of the DTV receiver.
- The set of tables identified as EIT-0 give necessary program guide information about services found in the monitored transport stream. Future Event Information Tables (EIT) (EIT-1 to EIT-127), although still valid and applicable, should be considered mostly in an informative sense since, according to the practice of bullet 2 described above, there is no guarantee of the constancy of the transport stream.

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[7] The most important difference is the location of audiovisual PIDs. For a TVCT, these are carried as part of the TVCT within the service_location_descriptor, while for a CVCT these are entries listed in the PMT.

[8] An explicit time reference in PSIP is, for example, the start time field for events in the EIT. An implicit time reference is the definition of the time segment for which an EIT is applicable.

- When navigating the transport stream in monitor mode, PSIP may identify programs that are not in the current transport stream. Accessing such channels is beyond the scope of this Recommendation. The transport stream ID (TSID) can be used to make this distinction. Virtual channels with channel_TSID values different than that indicated in the transport_stream_ID field of the virtual channel table (VCT) may be ignored.

## 11 Measurement

Measurement of the values specified herein should be with respect to an impedance of 75 ohms ±1%. This tolerance has no other applicability.

## Bibliography

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Geneva, 2001