BT.656 Video Interface for ICs

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Introduction

When ITU-R BT.601, formally CCIR-601, was developed (which defined the YCbCr color space, the 4:2:2 YCbCr sampling organization, and sampling resolutions), it was soon followed by ITU-R BT.656 (formally CCIR-656).

BT.656 defined the parallel and serial interfaces for transmitting 4:2:2 YCbCr digital video between equipment in studio and pro-video applications. Active video resolutions are either 720 x 486 (525/60 video systems) or 720 x 576 (625/50 video systems).

The BT.656 parallel interface uses 8 or 10 bits of multiplexed YCbCr data and a 27MHz clock (ECL levels are used for the data and clock signals). Instead of the conventional video timing signals (HSYNC, VSYNC, and BLANK) also being transmitted, BT.656 uses unique timing codes embedded within the video stream. This reduces the number of wires (and IC pins) required for a BT.656 video interface.

Ancillary digital information (such as audio, closed captioning, and teletext) may also be transmitted during the blanking intervals. This eliminates the need for a separate audio interface and additional control signals.

Because of its capabilities, a TTL compatible version of the parallel interface is now being used as a chip-to-chip interface for video ICs.

YCbCr Video Stream

The 4:2:2 YCbCr data is multiplexed into an 8-bit or 10-bit stream: $Cb_0Y_0Cr_0Y_1Cb_2Y_2Cr_2$, etc. Figures 1 and 2 illustrate the format for 525/60 and 625/50 video systems, respectively, using 8-bit YCbCr data.

After each SAV code, the stream of active data words always begins with a Cb sample. In the multiplexed sequence, the co-sited samples (those that correspond to the same point on the picture) are grouped as Cb, Y, Cr.

Each line of video is sampled at 13.5MHz, generating 720 active samples of 24-bit 4:4:4 YCbCr data, as shown in Figures 3 and 4. This is converted to 16-bit 4:2:2 YCbCr data, resulting in 720 active samples of Y per line, and 360 active samples each of Cb and Cr per line.

The Y data and the CbCr data are multiplexed, and the 13.5MHz sample clock rate is increased by two times to 27MHz.

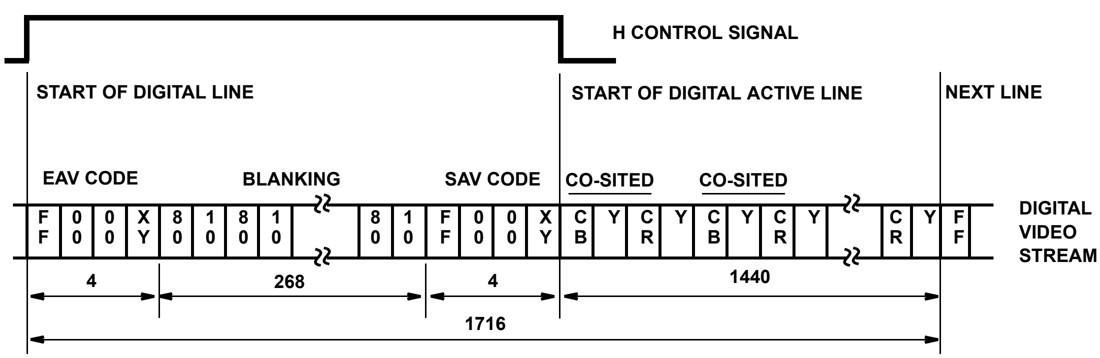


FIGURE 1. BT.656 8-BIT PARALLEL INTERFACE DATA FORMAT FOR 525/60 VIDEO SYSTEMS

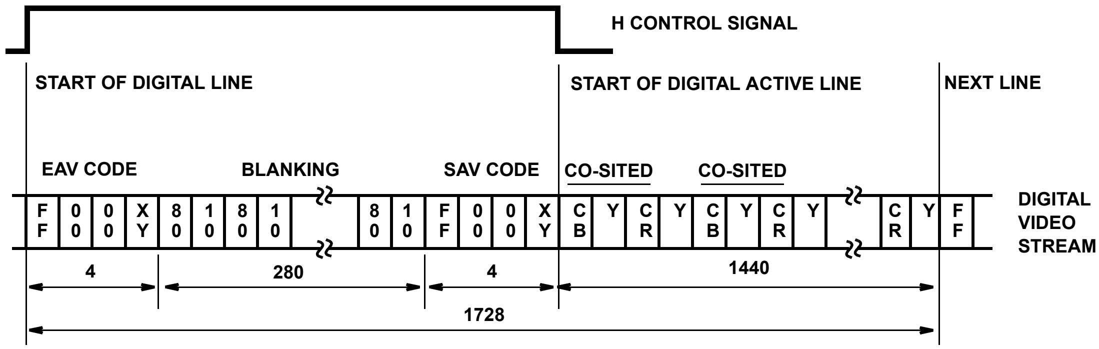


FIGURE 2. BT.656 8-BIT PARALLEL INTERFACE DATA FORMAT FOR 625/50 VIDEO SYSTEMS

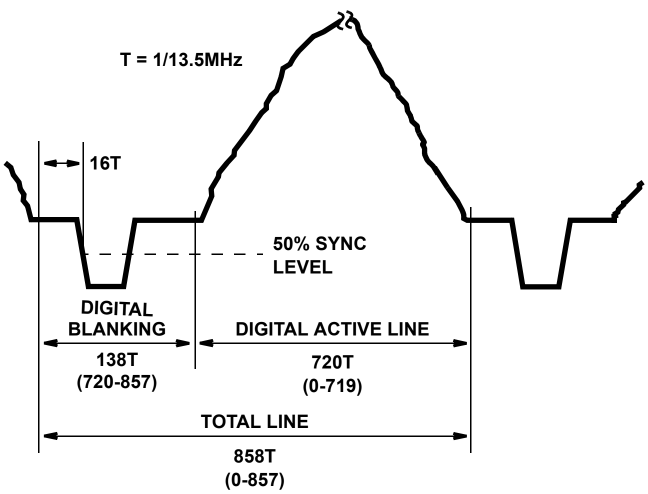


FIGURE 3. BT.656 HORIZONTAL TIMING RELATIONSHIP FOR 525/60 VIDEO SYSTEMS

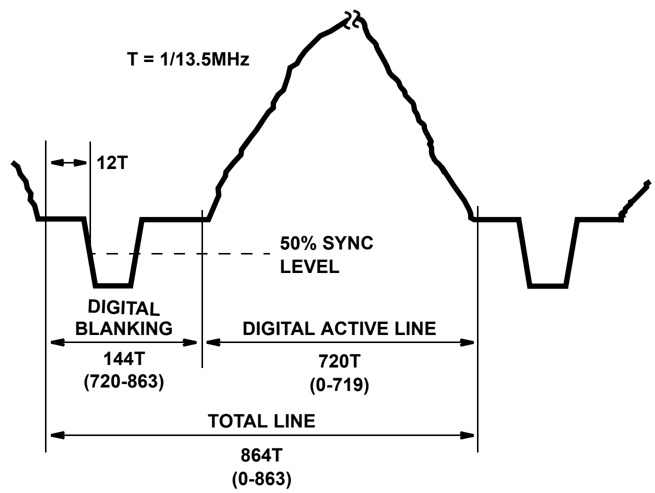


FIGURE 4. BT.656 HORIZONTAL TIMING RELATIONSHIP FOR 625/50 VIDEO SYSTEMS

SAV and EAV Timing Codes

SAV (start of active video) and EAV (end of active video) codes are embedded within the YCbCr video stream. They eliminate the need for the HSYNC, VSYNC, and BLANK timing signals normally used in a video system. The EAV and SAV sequences are shown in Table 1.

The XY status word, which also indicates whether it is an SAV or EAV sequence, is defined as:

F = 0 for field 1; F = 1 for field 2

V = 1 during vertical blanking

H = 0 at SAV, H = 1 at EAV

P3-P0 = protection bits

$P3 = V \oplus H$

$P2 = F \oplus H$

$P1 = F \oplus V$

$P0 = F \oplus V \oplus H$

where $\oplus$ represents the exclusive-OR function. These protection bits enable single-bit errors to be detected and corrected (and some multiple bit errors detected) at the receiver. Although they should always be generated in video IC interconnect applications, they are usually ignored by the receiving IC.

BT.656 uses the BT.601 - defined vertical blanking intervals, as shown in Figures 5 and 6. However, note that active resolutions other than 720 x 486 and 720 x 576 may be supported (effectively cropping the image) by adjusting where the EAV and SAV codes and vertical blanking intervals occur.

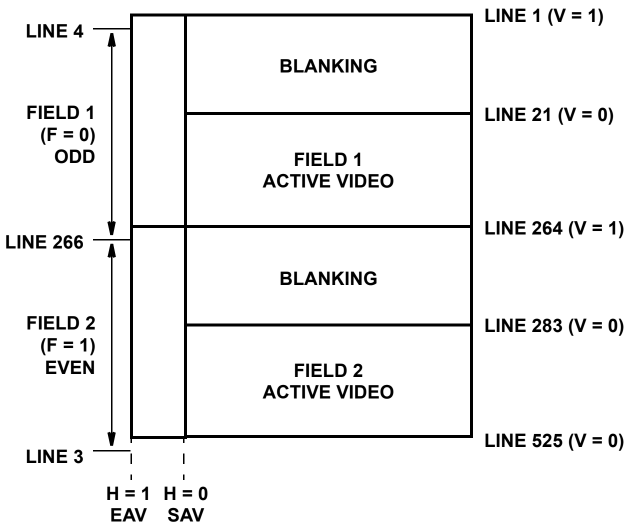
Square Pixel Variation

A variation using square pixels has been developed, although not endorsed by the BT.656 standard. Instead of a 27MHz clock, a 24.54MHz clock is used for 525/60 video systems (640 x 480 active resolution), and a 29.5MHz clock is used for 625/50 video systems (768 x 576 active resolution).

Figures 7 and 8 illustrate the data format, Figures 9 and 10 illustrate the horizontal timing relationships, and Figures 11 and 12 show the vertical blanking intervals.

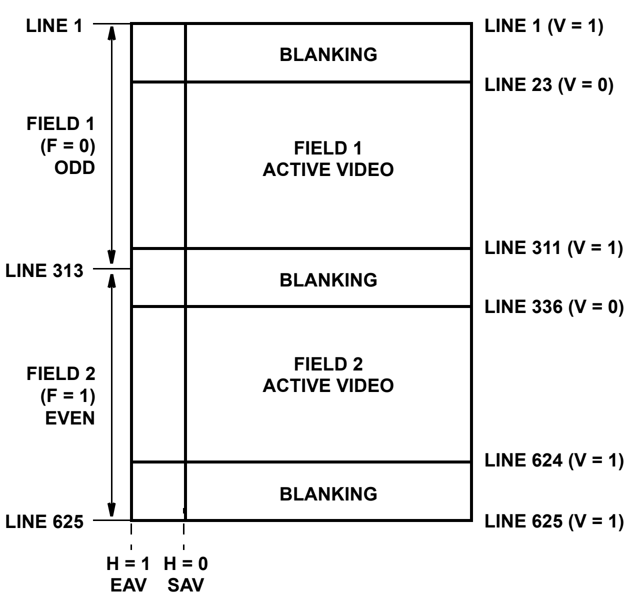
TABLE 1. BT.656 EAV AND SAV SEQUENCE

	8-BIT DATA								10-BIT DATA	
	D9 (MSB)	D8	D7	D6	D5	D4	D3	D2	D1	D0
Preamble	1	1	1	1	1	1	1	1	1	1
	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
Status Word	1	F	V	H	P3	P2	P1	P0	0	0



LINE NUMBER	F	V	H (EAV)	H (SAV)
1-3	1	1	1	0
4-20	0	1	1	0
21-263	0	0	1	0
264-265	0	1	1	0
266-282	1	1	1	0
283-525	1	0	1	0

FIGURE 5. TYPICAL BT.656 VERTICAL BLANKING INTERVALS FOR 525/60 VIDEO SYSTEMS



LINE NUMBER	F	V	H (EAV)	H (SAV)
1-22	0	1	1	0
23-310	0	0	1	0
311-312	0	1	1	0
313-335	1	1	1	0
336-623	1	0	1	0
624-625	1	1	1	0

FIGURE 6. TYPICAL BT.656 VERTICAL BLANKING INTERVALS FOR 625/50 VIDEO SYSTEMS

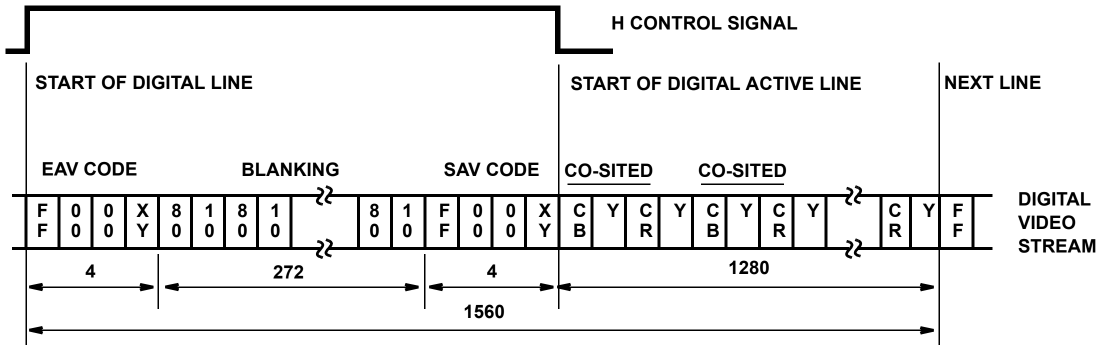


FIGURE 7. 8-BIT DATA FORMAT FOR SQUARE PIXEL 525/60 VIDEO SYSTEMS

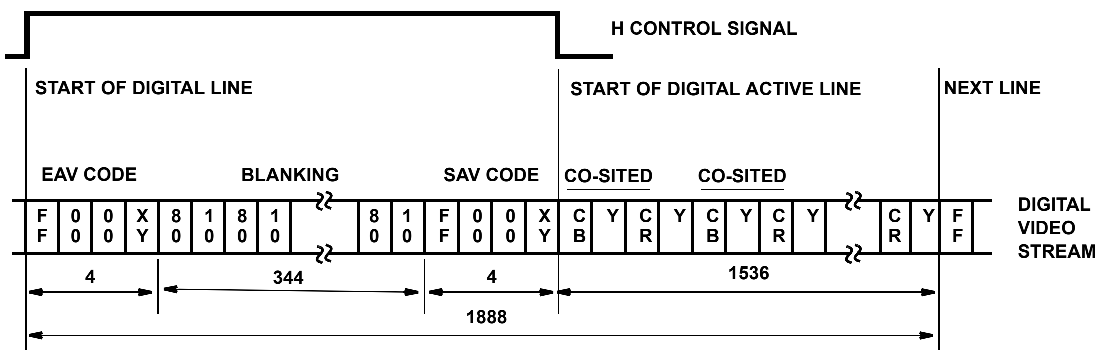


FIGURE 8. 8-BIT DATA FORMAT FOR SQUARE PIXEL 625/50 VIDEO SYSTEMS

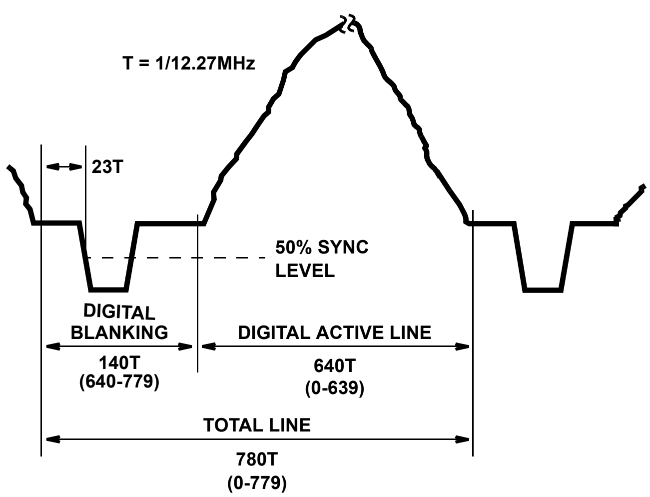


FIGURE 9. HORIZONTAL TIMING RELATIONSHIP FOR SQUARE PIXEL 525/60 VIDEO SYSTEMS

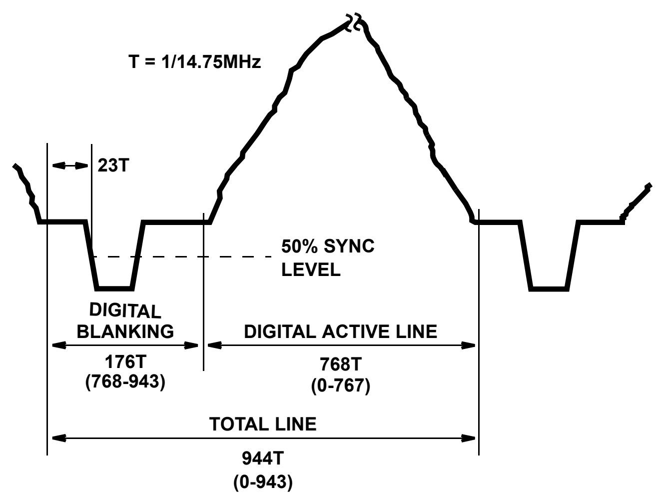
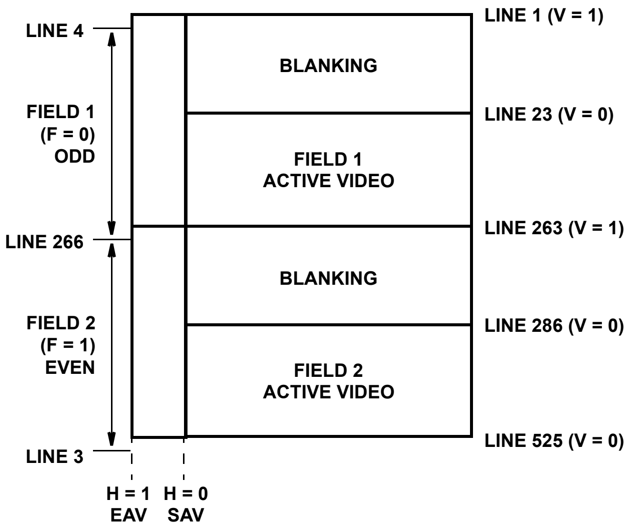
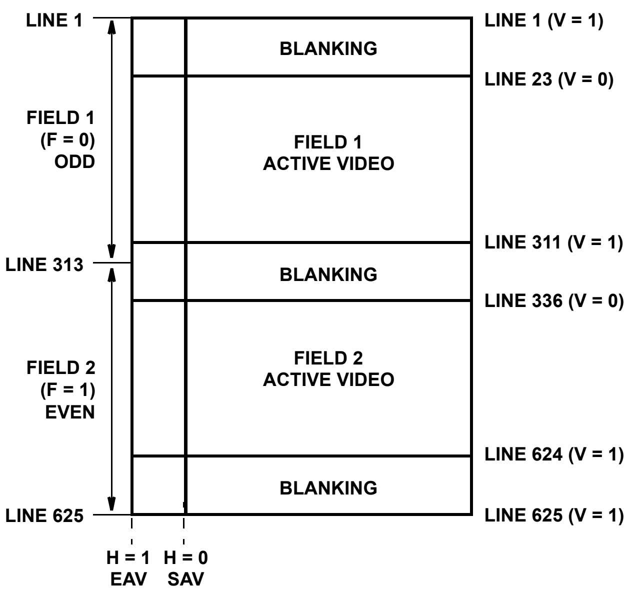


FIGURE 10. HORIZONTAL TIMING RELATIONSHIP FOR SQUARE PIXEL 625/50 VIDEO SYSTEMS



LINE NUMBER	F	V	H (EAV)	H (SAV)
1-3	1	1	1	0
4-22	0	1	1	0
23-262	0	0	1	0
263-265	0	1	1	0
266-285	1	1	1	0
286-525	1	0	1	0

FIGURE 11. TYPICAL VERTICAL BLANKING INTERVALS FOR SQUARE PIXEL 525/60 VIDEO SYSTEMS



LINE NUMBER	F	V	H (EAV)	H (SAV)
1-22	0	1	1	0
23-310	0	0	1	0
311-312	0	1	1	0
313-335	1	1	1	0
336-623	1	0	1	0
624-625	1	1	1	0

FIGURE 12. TYPICAL VERTICAL BLANKING INTERVALS FOR SQUARE PIXEL 625/50 VIDEO SYSTEMS

Ancillary Data

Ancillary data packets are used to transmit information such as digital audio, captioning information, and teletext data. BT.656 discusses ancillary data only in very general terms; the SMPTE 291M standard goes into much more detail.

On scan lines containing active video data, ancillary data may be transmitted in the time between the EAV sequence and SAV sequence (horizontal blanking). On blanked scan lines during the vertical blanking intervals, ancillary data may be transmitted at any time.

There are two types of ancillary data formats, as shown in Tables 2 and 3. In general, Type 1 (an older format) uses a single data ID word to indicate the type of ancillary data, Type 2 (a newer format) uses two words for the data ID.

Data ID (DID)

The Data ID word indicates the type of data being sent. The assignment of most of the Data ID values is controlled by the ITU and SMPTE to ensure equipment compatibility. A few ID values are available for user applications that don't require registration. Video ICs for the PC multimedia market use these user-application ID codes to avoid contention with professional video equipment.

TABLE 2. TYPE 1 ANCILLARY DATA PACKET FORMAT

	8-BIT DATA								**10-BIT DATA**	
	D9 (MSB)	**D8**	**D7**	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**
Preamble	0	0	0	0	0	0	0	0	0	0
	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1
Data ID	$\overline{PAR}$	PAR	Value of 0000 0000 to 1111 1111							
Data Block Number	$\overline{PAR}$	PAR	Value of 0000 0000 to 1111 1111							
Data Word Count	$\overline{PAR}$	PAR	Value of 0000 0000 to 1111 1111							
User Data Word 0	Value of 00 0000 0100 to 11 1111 1011									
:	:									
User Data Word N	Value of 00 0000 0100 to 11 1111 1011									
Check Sum	$\overline{PAR}$	Sum of D0–D8 of data ID through last user data word. Preset to all zeros; carry is ignored.								

NOTES:

1. PAR = even parity for D0–D7.
2. $\overline{D8}$ = inverted value of D8 bit.
3. 8-bit data is transferred using the D2–D9 bits

TABLE 3. TYPE 2 ANCILLARY DATA PACKET FORMAT

	8-BIT DATA								**10-BIT DATA**	
	D9 (MSB)	**D8**	**D7**	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**
Preamble	0	0	0	0	0	0	0	0	0	0
	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1
Data ID	$\overline{PAR}$	PAR	Value of 0000 0000 to 1111 1111							
Secondary ID	$\overline{PAR}$	PAR	Value of 0000 0000 to 1111 1111							
Data Word Count	$\overline{PAR}$	PAR	Value of 0000 0000 to 1111 1111							
User Data Word 0	Value of 00 0000 0100 to 11 1111 1011									
:	:									
User Data Word N	Value of 00 0000 0100 to 11 1111 1011									
Check Sum	$\overline{PAR}$	Sum of D0–D8 of data ID through last user data word. Preset to all zeros; carry is ignored.								

NOTES:

4. PAR = even parity for D0–D7.
5. 8-bit data is transferred using the D2–D9 bits.

Secondary ID (SDID): Type 2 Format Only

The Secondary Data ID word is also part of the data ID for Type 2 ancillary formats. The assignment of most of the Secondary Data ID values is also controlled by the ITU and SMPTE to ensure equipment compatibility. A few SDID values are available for user applications that don't require registration. Video ICs for the PC multimedia market use these user-application SDID codes to avoid contention with professional video equipment.

Data Block Number (DBN): Type 1 Format Only

The Data Block Number word is used to allow multiple ancillary packets (sharing the same data ID) to be put back together at the receiver. This is the case when there are more than 255 user data words required to be transmitted, thus requiring more than one ancillary packet to be used. The Data Block Number value increments by one for each consecutive ancillary packet.

Data Word Count (DC)

The Data Word Count word specifies the number of user data words in the packet.

User Data Words (UDW)

Up to 255 user data words may be present in the packet. 8-bit values of 00_H and FF_H are not allowed; 10-bit values of 000_H-003_H and $3FC_H$-$3FF_H$ are not allowed.

Data Limits

YCbCr and ancillary data may not use the 8-bit values of 00_H and FF_H since those values are used for timing information. For 10-bit systems, the 10-bit values 000_H-003_H and $3FC_H$-$3FF_H$ may not be used to avoid contention with 8-bit systems.

During blanking intervals, unless ancillary data is present, Y values must be set to 10_H (040_H if a 10-bit system) and CbCr values set to 80_H (200_H if a 10-bit system).

Implementation Considerations

Video IC Receivers

Only the EAV and SAV sequences should be used to recover the video timing. Assumptions should not be made about the number of clock cycles per line or horizontal blanking interval. Otherwise, the implementation may not work with real-world video signals and proposed variations such as scaled video.

Some older video sources also indicate sync timing by having Y data be a value of less than 16. However, new video ICs have the option of outputting digital data (such as closed captioning and teletext) during the blanking intervals. In addition, to allow real-world video and test signals to be passed through with minimum disruption, many also now allow the Y data to have a value less than 16 during active video. Thus, receiver designs assuming sync timing will be present on the Y channel will no longer work with these newer ICs.

For maximum compatibility when processing ancillary data, once the Data Word Count value (N) is read, it should disable the Preamble detection circuitry for N + 1 words. Some proposed variations allow the User Data to have the 8-bit values of 00_H and FF_H and 10-bit values of 000_H-003_H and $3FC_H$-$3FF_H$.

Video IC Sources

To ensure maximum compatibility, active video data should be transmitted as a contiguous stream of data, with a valid data word each clock cycle. If there are any variations in the line length, the horizontal digital blanking interval (the interval between the EAV and SAV sequences) should be shortened or lengthened to reflect the true line timing.

Summary

This Application Note presented some of the capabilities of the BT.656 interface as applied for ICs.

Using NTSC and PAL decoders (such as the HMP8116) and encoders (such as the HMP8171 and HMP8173) that support the BT.656 interface can simplify system design and lower cost, while allowing new capabilities.

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