



TDA19989AET

150 MHz pixel rate HDMI 1.4 transmitter with 3 × 8-bit video inputs, HDCP and CEC support

Rev. 02 — 18 May 2010

Product data sheet

HDMI

1. General description

TDA19989AET is a very low power and very small size High-Definition Multimedia Interface (HDMI) v. 1.4 transmitter. It is backward compatible DVI 1.0 and can be connected to any DVI 1.0 and HDMI sink.

This device is primarily intended for mobile applications like Digital Video Camera (DVC), Digital Still Camera (DSC), Portable Multimedia Player (PMP), Mobile Phone and Ultra-Mobile Personal Computer (UM PC) where size and very low power are mandatory for battery autonomy.

It allows mixing 3 × 8-bit RGB or YCbCr video stream with a pixel rate up to 150 MHz together with one S/PDIF or two I²S-bus audio streams with an audio sampling rate up to 192 kHz.

In order to be compatible with most applications, TDA19989AET integrates a full programmable input formatter and color space conversion block. The video input formats accepted are YCbCr 4 : 4 : 4 (up to 3 × 8-bit), YCbCr 4 : 2 : 2 semi-planar (up to 2 × 12-bit) and YCbCr 4 : 2 : 2 compliant with ITU656 (up to 1 × 12-bit). In case of ITU656-like format, the input pixel clock can be made active on one (SDR mode) or both edges (DDR mode).

TDA19989AET includes a HDCP 1.3 compliant cipher block. The HDCP keys are stored internally in a non-volatile OTP memory for maximum security.

This device provides additional embedded feature like CEC (Consumer Electronic Control). CEC is a single bidirectional wire that transmits CEC commands (like Standby from remote control) over the home appliance network connected through this wire. This eliminates the need of any additional device to handle this feature thus improving BOM (Bill Of Materials) of the whole system and enabling the connected devices (CEC enabled) to be controlled by only one remote control.

TDA19989AET supports xvYCC HDMI 1.4 feature.

It can be switched to very low power Standby or Sleep modes to save power when HDMI is not used.

TDA19989AET includes I²C-bus master interface for DDC-bus communication for EDID reading and HDCP purpose.

This device can be controlled or configured via I²C-bus interface.



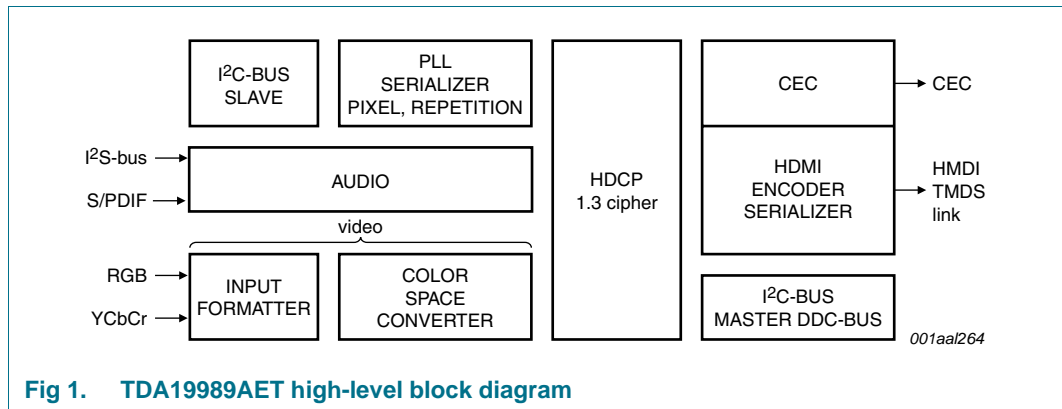


Fig 1. TDA19989AET high-level block diagram

2. Features and benefits

- Compliance:
 - ◆ DVI 1.0
 - ◆ HDMI 1.4
 - ◆ EIA/CEA-861B
 - ◆ CEC (HDMI 1.4)
 - ◆ SimplayHD
 - ◆ HDCP 1.3
- Video:
 - ◆ xvYCC HDMI 1.4 feature
 - ◆ Video formats with a pixel rate up to 150 MHz:
 - RGB 4 : 4 : 4
 - YCbCr 4 : 4 : 4
 - YCbCr 4 : 2 : 2 semi-planar
 - YCbCr 4 : 2 : 2 ITU656
 - ◆ Maximum resolution:
 - 1080p for TV
 - 1600 × 1200 at 60 Hz for PC (UXGA60)
 - 720p/1080i in ITU656
 - ◆ Programmable color space converter:
 - RGB to YCbCr
 - YCbCr to RGB
 - ◆ Programmable input formatter and upsampler/interpolator allows input of any of the 4 : 4 : 4, 4 : 2 : 2 semi-planar, 4 : 2 : 2 ITU656-like formats
 - ◆ Horizontal synchronization, vertical synchronization and Data Enable (DE) inputs or VREF, HREF and FREF could be used for input data synchronization
 - ◆ Pixel clock input can be made active on one or both edges (selectable by I²C-bus)
 - ◆ Repetition of video samples as required by HDMI specification
- Audio:
 - ◆ 2 × I²S-bus 2 channels or one S/PDIF; audio data rate up to 192 kHz
- Deals with multiple levels of HDCP receivers and repeaters
- Internal SHA-1 calculation

- System operation:
 - ◆ Master DDC-bus interface for EDID read
 - ◆ Controllable via I²C-bus
 - ◆ Downstream availability through the use of hot plug detect (HPD) and receiver detection (RxSense)
- Package:
 - ◆ TFBGA64
 - ◆ Size 4.5 × 4.5 × 0.95 mm
- Power management:
 - ◆ External voltage supplies 1.8 V
 - ◆ Low power
 - ◆ Flexible power modes
- Miscellaneous:
 - ◆ POR (Power-On Reset)
 - ◆ Audio and video inputs LV-CMOS 1.8 V compatible and LV-CMOS 3.3 V tolerant
 - ◆ 250 MHz to 1.5 GHz TMDS transmitter operation

3. Applications

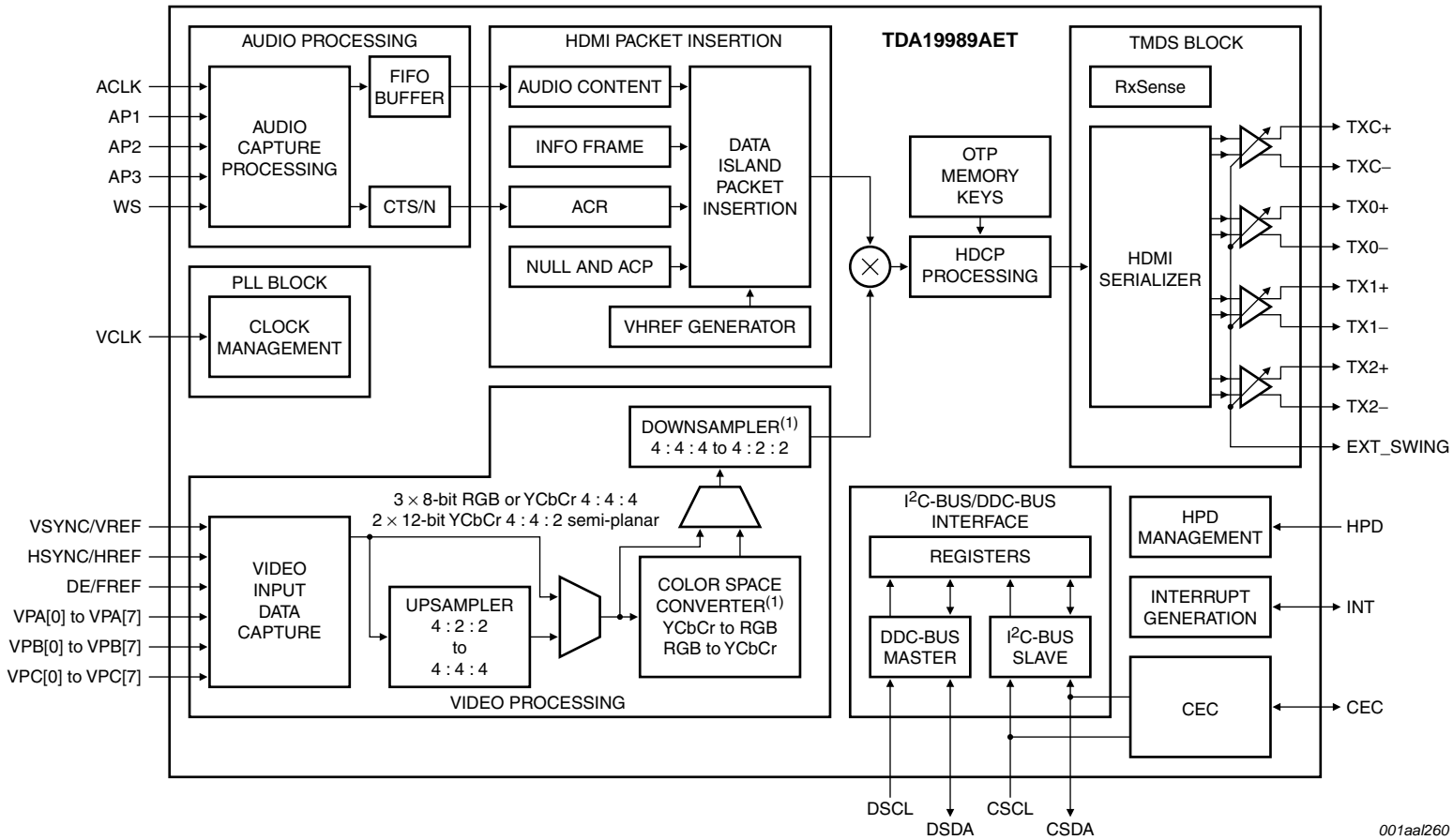
- Digital Video Camera (DVC)
- Digital Still Camera (DSC)
- Portable Multimedia Player (PMP)
- Mobile Phone
- Ultra-Mobile Personal Computer (UM PC)

4. Ordering information

Table 1. Ordering information

Type number	Package		
	Name	Description	Version
TDA19989AET	TFBGA64	plastic thin fine-pitch ball grid array package; 64 balls	SOT962-3

5. Block diagram



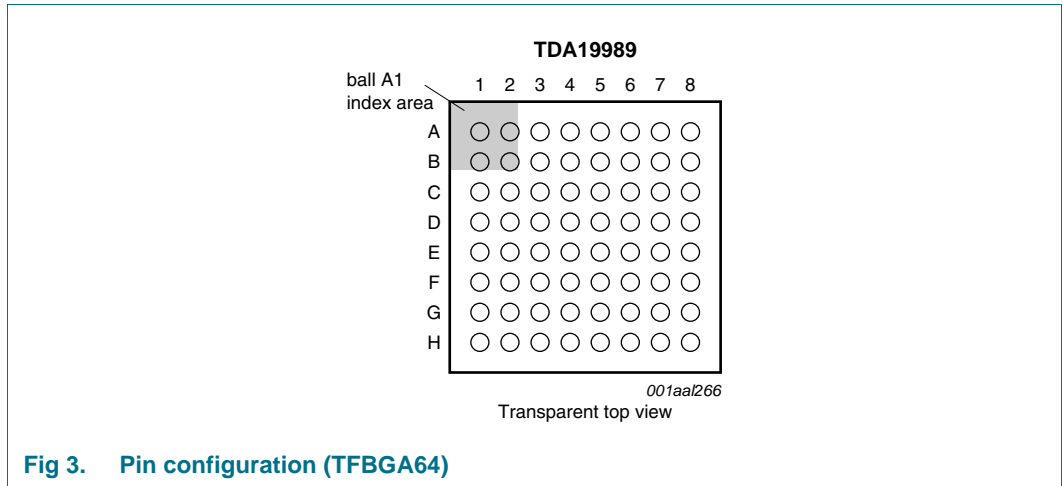
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(1) The color space converter can be bypassed.
The device can handle HDCP based on 1.3 features.

Fig 2. TDA19989AET Block diagram

6. Pinning information

6.1 Pinning



6.2 Pin description

Table 2. Pin description

Symbol	Pin	Type ^[1]	Description
ACLK	H5	I	audio clock input
AP0	G5	I	audio port 0 input
AP1	F5	I	audio port 1 input
AP2	G6	I	audio port 2 input
OSC_IN/AP3	H6	I	input connected to the external oscillator circuit or external clock source/audio port 3 input
HPD	E6	I	hot plug detect; 5 V tolerant
EXT_SWING	E7	O	TMDS output swing adjustment; place resistor ($R_{EXT_SWING} = 10\text{ k}\Omega \pm 1\%$) between this pin and analog ground.
DSDA	F6	I/O	DDC-bus data input/output; 5 V tolerant
DSCL	F7	I	DDC-bus clock input; 5 V tolerant
VCLK	D4	I	input video pixel clock
HSYNC/HREF	F4	I	input horizontal synchronization or reference input
VSYNC/VREF	G4	I	input vertical synchronization or reference input
DE/FREF	H4	I	data enable or field reference input
CSCL	B5	I	I ² C-bus clock input; 1.8 V to 3.3 V tolerant
CSDA	A5	I/O	I ² C-bus data input/output; 1.8 V to 3.3 V tolerant
INT	B6	I/O	interrupt HDMI output (open-drain); this pin is used as Dual function pin selectable through I ² C-bus. In calibration mode only this pin is used as input for $10\text{ ms} \pm 1\%$ calibration pulse. In operation mode this pin is used to warn the external microprocessor that a special event has occurred for HDMI or CEC

Table 2. Pin description ...continued

Symbol	Pin	Type ^[1]	Description
TX0-	E8	O	negative data channel 0 for TMDS output
TX0+	D8	O	positive data channel 0 for TMDS output
TX1-	C8	O	negative data channel 1 for TMDS output
TX1+	B8	O	positive data channel 1 for TMDS output
TX2-	A7	O	negative data channel 2 for TMDS output
TX2+	A6	O	positive data channel 2 for TMDS output
TXC-	G8	O	negative clock channel for TMDS output
TXC+	F8	O	positive clock channel for TMDS output
CEC	H7	I/O	CEC connection (open-drain) to HDMI connector
VPA[0]	C1	I	video port A input bit 0 (LSB)
VPA[1]	B1	I	video port A input bit 1
VPA[2]	B2	I	video port A input bit 2
VPA[3]	A2	I	video port A input bit 3
VPA[4]	B3	I	video port A input bit 4
VPA[5]	A3	I	video port A input bit 5
VPA[6]	B4	I	video port A input bit 6
VPA[7]	A4	I	video port A input bit 7 (MSB)
VPB[0]	E3	I	video port B input bit 0 (LSB)
VPB[1]	E2	I	video port B input bit 1
VPB[2]	E1	I	video port B input bit 2
VPB[3]	D1	I	video port B input bit 3
VPB[4]	D2	I	video port B input bit 4
VPB[5]	D3	I	video port B input bit 5
VPB[6]	C2	I	video port B input bit 6
VPB[7]	C3	I	video port B input bit 7 (MSB)
VPC[0]	H3	I	video port C input bit 0 (LSB)
VPC[1]	H2	I	video port C input bit 1
VPC[2]	G3	I	video port C input bit 2
VPC[3]	G2	I	video port C input bit 3
VPC[4]	G1	I	video port C input bit 4
VPC[5]	F1	I	video port C input bit 5
VPC[6]	F2	I	video port C input bit 6
VPC[7]	F3	I	video port C input bit 7 (MSB)
V _{DDA(TMDS)} (1V8)	A8, C7	P	TMDS analog supply voltage (1.8 V)
V _{DDD(IO)} (1V8)	E4	P	I/O digital supply voltage (1.8 V)
V _{DDA(PLL)} (1V8)	C6	P	PLL analog supply voltage (1.8 V), this PLL provides the clock for the serializer
V _{DDA} (1V8)	G7, H8	P	analog supply voltage (1.8 V), is used for parallel-to-serial shift register and miscellaneous blocks
V _{DDDC}	E5	P	core digital supply voltage (1.8 V)
V _{DDDC}	D5	P	core digital supply voltage (1.8 V)

Table 2. Pin description ...continued

Symbol	Pin	Type ^[1]	Description
V _{SSD}	B7, C4, C5, H1	G	digital ground supply voltage, is used for digital core; I/O
V _{SSA}	D6, D7	G	analog ground supply voltage, is used for PLL; serializer, transmitter, and parallel-to-serial shift register
n.c.	A1		not connected

[1] P = power supply, G = ground, I = input, O = output.

7. Functional description

TDA19989AET is designed to convert digital data (video and audio) provided by Set-Top Boxes (STB), Digital Video Camera (DVC), Digital Still Camera (DSC), Portable Multimedia Player (PMP) or DVD into an HDMI output, which can be used by a TV with either an HDMI or DVI input.

The video data input formats are:

- RGB 4 : 4 : 4
- YCbCr 4 : 4 : 4
- YCbCr 4 : 2 : 2 semi-planar
- YCbCr 4 : 2 : 2 ITU656-like

TDA19989AET is able to output HDMI with the formats:

- RGB 4 : 4 : 4
- YCbCr 4 : 4 : 4
- YCbCr 4 : 2 : 2

It can also handle audio formats:

- two I²S-bus channels
- one S/PDIF channel

TDA19989AET is also designed to support CEC protocol. For more details about CEC, refer to *HDMI 1.4 specification*.

7.1 System clock

The system clock section has a PLL serializer.

It is a system clock generator which enables the stream produced by the encoder to be transmitted on the HDMI data channel at ten times, or above, the sampling rate.

7.2 Video input formatter

7.2.1 Description

TDA19989AET has three video input ports VPA[0] to VPA[7], VPB[0] to VPB[7] and VPC[0] to VPC[7].

TDA19989AET can accept any of the following video input modes (see [Table 6](#)):

- RGB, with 8-bit for each component
- YCbCr 4 : 4 : 4, with 8-bit for each component
- YCbCr 4 : 2 : 2 semi-planar, with up to 12-bit for each component (YCbCr)
- YCbCr 4 : 2 : 2 ITU656, with up to 12-bit data depth

TDA19989AET can be set to latch data at either rising or falling edge, or both.

7.2.2 Internal assignment

The aim of the video input processor is to internally map the incoming data to the corresponding mode, which can be handled by the video processing. The internal signal named VP[23:0] is assigned depending on the input mode as defined below.

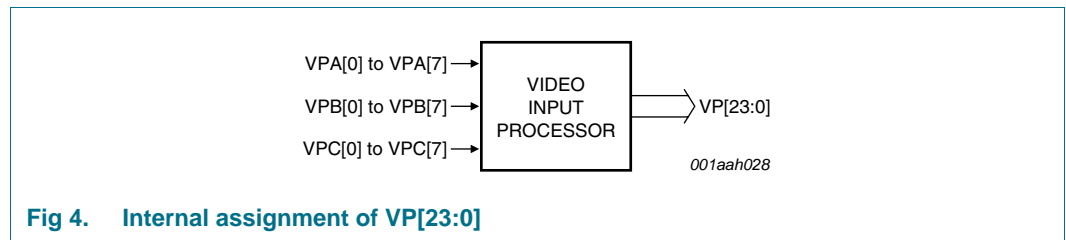


Fig 4. Internal assignment of VP[23:0]

Table 3. Internal assignment

Internal assignment				
Internal port	RGB	YCbCr 4 : 4 : 4	YCbCr 4 : 2 : 2 semi-planar	YCbCr 4 : 2 : 2 ITU656
VP[23]	G[7]	Y[7]	Y[11]	YCbCr[11]
VP[22]	G[6]	Y[6]	Y[10]	YCbCr[10]
VP[21]	G[5]	Y[5]	Y[9]	YCbCr[9]
VP[20]	G[4]	Y[4]	Y[8]	YCbCr[8]
VP[19]	G[3]	Y[3]	Y[7]	YCbCr[7]
VP[18]	G[2]	Y[2]	Y[6]	YCbCr[6]
VP[17]	G[1]	Y[1]	Y[5]	YCbCr[5]
VP[16]	G[0]	Y[0]	Y[4]	YCbCr[4]
VP[15]	B[7]	Cb[7]	Y[3]	YCbCr[3]
VP[14]	B[6]	Cb[6]	Y[2]	YCbCr[2]
VP[13]	B[5]	Cb[5]	Y[1]	YCbCr[1]
VP[12]	B[4]	Cb[4]	Y[0]	YCbCr[0]

Table 3. Internal assignment ...continued

Internal assignment				
Internal port	RGB	YCbCr 4 : 4 : 4	YCbCr 4 : 2 : 2 semi-planar	YCbCr 4 : 2 : 2 ITU656
VP[11]	B[3]	Cb[3]	CbCr[11]	
VP[10]	B[2]	Cb[2]	CbCr[10]	
VP[9]	B[1]	Cb[1]	CbCr[9]	
VP[8]	B[0]	Cb[0]	CbCr[8]	
VP[7]	R[7]	Cr[7]	CbCr[7]	
VP[6]	R[6]	Cr[6]	CbCr[6]	
VP[5]	R[5]	Cr[5]	CbCr[5]	
VP[4]	R[4]	Cr[4]	CbCr[4]	
VP[3]	R[3]	Cr[3]	CbCr[3]	
VP[2]	R[2]	Cr[2]	CbCr[2]	
VP[1]	R[1]	Cr[1]	CbCr[1]	
VP[0]	R[0]	Cr[0]	CbCr[0]	

The device can swap and invert, in the event of a little endian stream, the incoming video data using I²C-bus registers VIP_CNTRL_0, VIP_CNTRL_1 and VIP_CNTRL_2 (page 00h) to match the expectation of the video processing block. [Table 4](#) shows the behavior of SWAP_A[2:0] of VIP_CNTRL_0 register, whose function is to map the 4 MSBs VP[23:20] to the incoming video port.

Table 4. Video input swap to VP[23:20]

External assignment		SWAP_A[2:0] selector value	Internal assignment								
Pin number	Pin name		Internal port	RGB	YCbCr 4 : 4 : 4	YCbCr 4 : 2 : 2 semi-planar		YCbCr 4 : 2 : 2 ITU656			
F3	VPC[7]	000b	VP[23]	G[7]	Y[7]	Y ₀ [11]	Y ₁ [11]	Cb[11]	Y ₀ [11]	Cr[11]	Y ₁ [11]
F2	VPC[6]		VP[22]	G[6]	Y[6]	Y ₀ [10]	Y ₁ [10]	Cb[10]	Y ₀ [10]	Cr[10]	Y ₁ [10]
F1	VPC[5]		VP[21]	G[5]	Y[5]	Y ₀ [9]	Y ₁ [9]	Cb[9]	Y ₀ [9]	Cr[9]	Y ₁ [9]
G1	VPC[4]		VP[20]	G[4]	Y[4]	Y ₀ [8]	Y ₁ [8]	Cb[8]	Y ₀ [8]	Cr[8]	Y ₁ [8]
G2	VPC[3]	001b	VP[23]	G[7]	Y[7]	Y ₀ [11]	Y ₁ [11]	Cb[11]	Y ₀ [11]	Cr[11]	Y ₁ [11]
G3	VPC[2]		VP[22]	G[6]	Y[6]	Y ₀ [10]	Y ₁ [10]	Cb[10]	Y ₀ [10]	Cr[10]	Y ₁ [10]
H2	VPC[1]		VP[21]	G[5]	Y[5]	Y ₀ [9]	Y ₁ [9]	Cb[9]	Y ₀ [9]	Cr[9]	Y ₁ [9]
H3	VPC[0]		VP[20]	G[4]	Y[4]	Y ₀ [8]	Y ₁ [8]	Cb[8]	Y ₀ [8]	Cr[8]	Y ₁ [8]
C3	VPB[7]	010b	VP[23]	G[7]	Y[7]	Y ₀ [11]	Y ₁ [11]	Cb[11]	Y ₀ [11]	Cr[11]	Y ₁ [11]
C2	VPB[6]		VP[22]	G[6]	Y[6]	Y ₀ [10]	Y ₁ [10]	Cb[10]	Y ₀ [10]	Cr[10]	Y ₁ [10]
D3	VPB[5]		VP[21]	G[5]	Y[5]	Y ₀ [9]	Y ₁ [9]	Cb[9]	Y ₀ [9]	Cr[9]	Y ₁ [9]
D2	VPB[4]		VP[20]	G[4]	Y[4]	Y ₀ [8]	Y ₁ [8]	Cb[8]	Y ₀ [8]	Cr[8]	Y ₁ [8]
D1	VPB[3]	011b	VP[23]	G[7]	Y[7]	Y ₀ [11]	Y ₁ [11]	Cb[11]	Y ₀ [11]	Cr[11]	Y ₁ [11]
E1	VPB[2]		VP[22]	G[6]	Y[6]	Y ₀ [10]	Y ₁ [10]	Cb[10]	Y ₀ [10]	Cr[10]	Y ₁ [10]
E2	VPB[1]		VP[21]	G[5]	Y[5]	Y ₀ [9]	Y ₁ [9]	Cb[9]	Y ₀ [9]	Cr[9]	Y ₁ [9]
E3	VPB[0]		VP[20]	G[4]	Y[4]	Y ₀ [8]	Y ₁ [8]	Cb[8]	Y ₀ [8]	Cr[8]	Y ₁ [8]
A4	VPA[7]	100b	VP[23]	G[7]	Y[7]	Y ₀ [11]	Y ₁ [11]	Cb[11]	Y ₀ [11]	Cr[11]	Y ₁ [11]
B4	VPA[6]		VP[22]	G[6]	Y[6]	Y ₀ [10]	Y ₁ [10]	Cb[10]	Y ₀ [10]	Cr[10]	Y ₁ [10]
A3	VPA[5]		VP[21]	G[5]	Y[5]	Y ₀ [9]	Y ₁ [9]	Cb[9]	Y ₀ [9]	Cr[9]	Y ₁ [9]
B3	VPA[4]		VP[20]	G[4]	Y[4]	Y ₀ [8]	Y ₁ [8]	Cb[8]	Y ₀ [8]	Cr[8]	Y ₁ [8]
A2	VPA[3]	101b	VP[23]	G[7]	Y[7]	Y ₀ [11]	Y ₁ [11]	Cb[11]	Y ₀ [11]	Cr[11]	Y ₁ [11]
B2	VPA[2]		VP[22]	G[6]	Y[6]	Y ₀ [10]	Y ₁ [10]	Cb[10]	Y ₀ [10]	Cr[10]	Y ₁ [10]
B1	VPA[1]		VP[21]	G[5]	Y[5]	Y ₀ [9]	Y ₁ [9]	Cb[9]	Y ₀ [9]	Cr[9]	Y ₁ [9]
C1	VPA[0]		VP[20]	G[4]	Y[4]	Y ₀ [8]	Y ₁ [8]	Cb[8]	Y ₀ [8]	Cr[8]	Y ₁ [8]

In the same way:

- SWAP_B[2:0] is used to map incoming video port to the internal port VP[19:16].
- SWAP_C[2:0] is used to map incoming video port to the internal port VP[15:12].
- SWAP_D[2:0] is used to map incoming video port to the internal port VP[11:8].
- SWAP_E[2:0] is used to map incoming video port to the internal port VP[7:4].
- SWAP_F[2:0] is used to map incoming video port to the internal port VP[3:0].

The device expects to receive big endian incoming data. However, in cases where the input digital stream to the chip is little endian, the use of the mirror bit of the same register can help to re-order the input bits as described in [Table 5](#).

Table 5. TDA19989AET input/output capability

Bit setting	Internal port	To be mapped to
MIRR_A = 1 SWAP_A[2:0] = 1	VP[23]	VPC[0]
	VP[22]	VPC[1]
	VP[21]	VPC[2]
	VP[20]	VPC[3]
MIRR_B = 1 SWAP_B[2:0] = 0	VP[19]	VPC[4]
	VP[18]	VPC[5]
	VP[17]	VPC[6]
	VP[16]	VPC[7]
MIRR_C = 1 SWAP_C[2:0] = 3	VP[15]	VPB[0]
	VP[14]	VPB[1]
	VP[13]	VPB[2]
	VP[12]	VPB[3]
MIRR_D = 1 SWAP_D[2:0] = 2	VP[11]	VPB[4]
	VP[10]	VPB[5]
	VP[9]	VPB[6]
	VP[8]	VPB[7]
MIRR_E = 1 SWAP_E[2:0] = 5	VP[7]	VPA[4]
	VP[6]	VPA[5]
	VP[5]	VPA[6]
	VP[4]	VPA[7]
MIRR_F = 1 SWAP_F[2:0] = 4	VP[3]	VPA[0]
	VP[2]	VPA[1]
	VP[1]	VPA[2]
	VP[0]	VPA[3]

When input ports are not used, it is possible to deactivate them via the I²C-bus with the appropriate set of registers ENA_VP_0, ENA_VP_1 and ENA_VP_2 on page 00h.

7.2.3 Input format mappings

[Table 6](#) gives more information concerning input format supported.

Table 6. Inputs of video input formatter

Color space	Format	Channels	Sync type	Rising edge	Falling edge	Double edge	Transmission input format	Max. pixel clock (MHz)	Max. input format	Comments	Reference				
RGB	4 : 4 : 4	3 × 8-bit	external	X			-	150	-		Section 7.2.3.1				
					X		-	150	-						
			embedded	X			-	150	-						
					X		-	150	-						
YCbCr	4 : 4 : 4	3 × 8-bit	external	X			-	150	-		Section 7.2.3.2				
					X		-	150	-						
			embedded	X			-	150	-						
					X		-	150	-						
			YCbCr	4 : 2 : 2	up to 1 × 12-bit ITU656-like	external	X			ITU656-like		54.054	480p/576p		Section 7.2.3.3
								X		ITU656-like		54.054	480p/576p		
embedded	X						ITU656-like	54.054	480p/576p						
		X					ITU656-like	54.054	480p/576p						
external	X						ITU656-like	74.25	720p/1080i	double edge	Section 7.2.3.4				
		X					ITU656-like	74.25	720p/1080i	double edge	Section 7.2.3.6				
up to 2 × 8-bit semi-planar			external	X			SMPTE293M	148.5	1080p		Section 7.2.3.7				
					X		SMPTE293M	148.5	1080p						
			embedded	X			SMPTE293M	148.5	1080p		Section 7.2.3.8				
					X		SMPTE293M	148.5	1080p						

7.2.3.1 RGB 4 : 4 : 4 external synchronization (rising edge)

Table 7. RGB (3 × 8-bit) external synchronization input (rising edge) mapping

Register VIP_CNTRL_0 = 23h; VIP_CNTRL_1 = 45h; VIP_CNTRL_2 = 01h.

Video port A		Video port B		Video port C		Control	
Pin	RGB 4 : 4 : 4	Pin	RGB 4 : 4 : 4	Pin	RGB 4 : 4 : 4	Pin	RGB 4 : 4 : 4
VPA[0]	B[0]	VPB[0]	G[0]	VPC[0]	R[0]	HSYNC/HREF	used
VPA[1]	B[1]	VPB[1]	G[1]	VPC[1]	R[1]	VSYNC/VREF	used
VPA[2]	B[2]	VPB[2]	G[2]	VPC[2]	R[2]	DE/FREF	used
VPA[3]	B[3]	VPB[3]	G[3]	VPC[3]	R[3]		
VPA[4]	B[4]	VPB[4]	G[4]	VPC[4]	R[4]		
VPA[5]	B[5]	VPB[5]	G[5]	VPC[5]	R[5]		
VPA[6]	B[6]	VPB[6]	G[6]	VPC[6]	R[6]		
VPA[7]	B[7]	VPB[7]	G[7]	VPC[7]	R[7]		

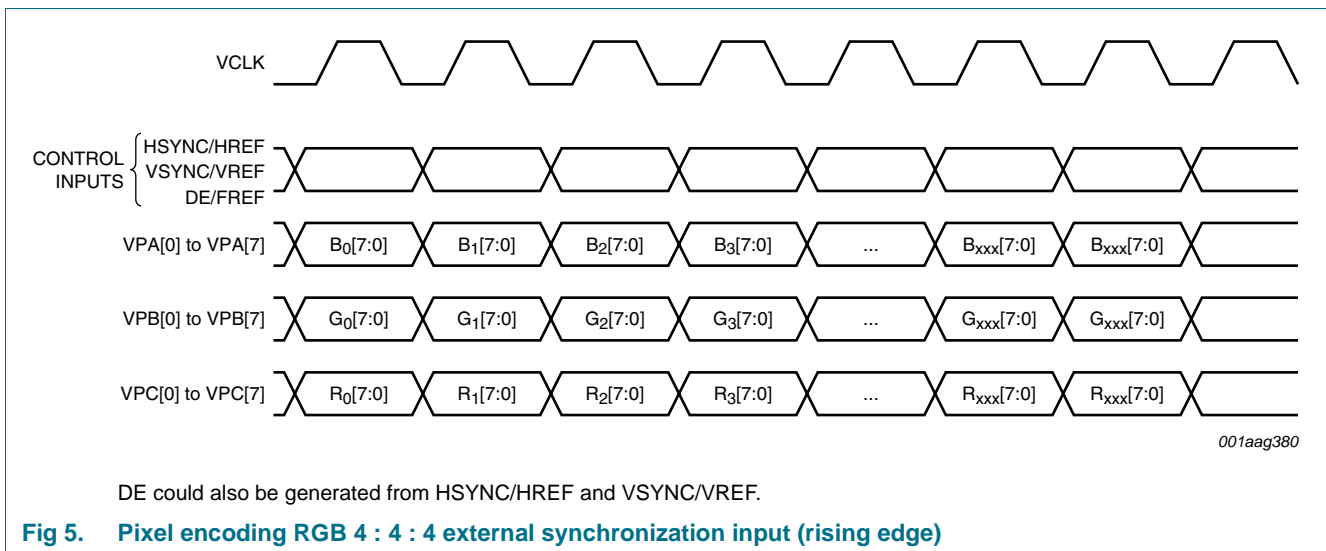


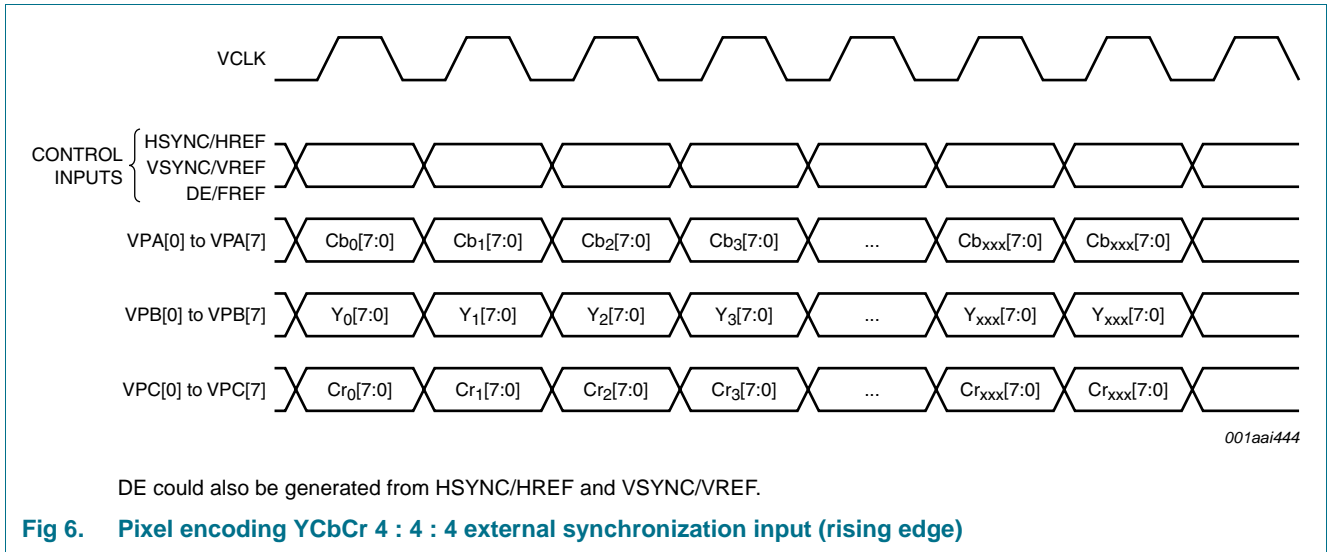
Fig 5. Pixel encoding RGB 4 : 4 : 4 external synchronization input (rising edge)

7.2.3.2 YCbCr 4 : 4 : 4 external synchronization (rising edge)

Table 8. YCbCr 4 : 4 : 4 (3 × 8-bit) external synchronization input (rising edge) mapping

Register VIP_CNTRL_0 = 23h; VIP_CNTRL_1 = 45h; VIP_CNTRL_2 = 01h.

Video port A		Video port B		Video port C		Control	
Pin	YCbCr 4 : 4 : 4	Pin	YCbCr 4 : 4 : 4	Pin	YCbCr 4 : 4 : 4	Pin	YCbCr 4 : 4 : 4
VPA[0]	Cb[0]	VPB[0]	Y[0]	VPC[0]	Cr[0]	HSYNC/HREF	used
VPA[1]	Cb[1]	VPB[1]	Y[1]	VPC[1]	Cr[1]	VSYNC/VREF	used
VPA[2]	Cb[2]	VPB[2]	Y[2]	VPC[2]	Cr[2]	DE/FREF	used
VPA[3]	Cb[3]	VPB[3]	Y[3]	VPC[3]	Cr[3]		
VPA[4]	Cb[4]	VPB[4]	Y[4]	VPC[4]	Cr[4]		
VPA[5]	Cb[5]	VPB[5]	Y[5]	VPC[5]	Cr[5]		
VPA[6]	Cb[6]	VPB[6]	Y[6]	VPC[6]	Cr[6]		
VPA[7]	Cb[7]	VPB[7]	Y[7]	VPC[7]	Cr[7]		

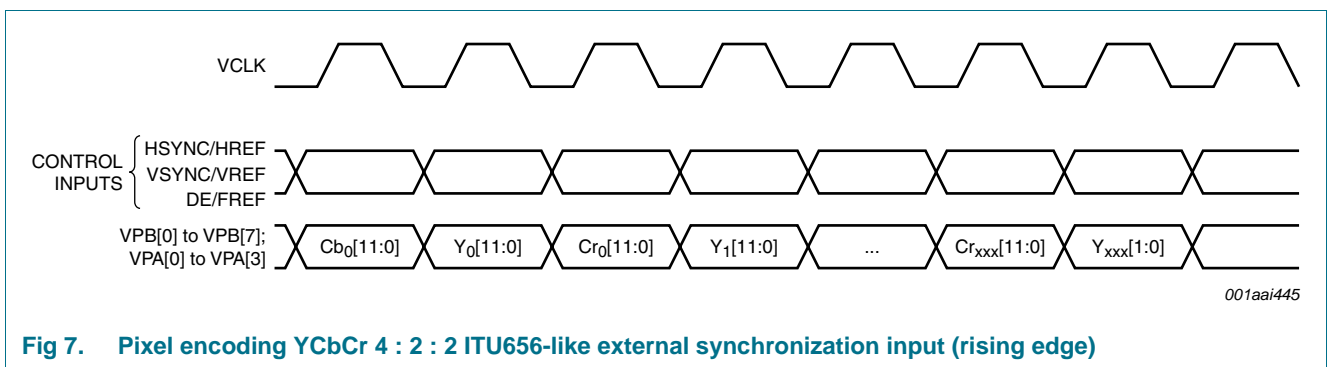


7.2.3.3 YCbCr 4 : 2 : 2 ITU656-like external synchronization (rising edge)

Table 9. YCbCr 4 : 2 : 2 ITU656-like external synchronization input (rising edge) mapping

Register *VIP_CNTRL_0* = 23h; *VIP_CNTRL_1* = 50h; *VIP_CNTRL_2* = 00h.

Video port A					Video port B					Control	
Pin	YCbCr 4 : 2 : 2 (ITU656-like)				Pin	YCbCr 4 : 2 : 2 (ITU656-like)				Pin	YCbCr 4 : 2 : 2
VPA[0]	Cb[0]	Y ₀ [0]	Cr[0]	Y ₁ [0]	VPB[0]	Cb[4]	Y ₀ [4]	Cr[4]	Y ₁ [4]	HSYNC/HREF	used
VPA[1]	Cb[1]	Y ₀ [1]	Cr[1]	Y ₁ [1]	VPB[1]	Cb[5]	Y ₀ [5]	Cr[5]	Y ₁ [5]	VSYNC/VREF	used
VPA[2]	Cb[2]	Y ₀ [2]	Cr[2]	Y ₁ [2]	VPB[2]	Cb[6]	Y ₀ [6]	Cr[6]	Y ₁ [6]	DE/FREF	used
VPA[3]	Cb[3]	Y ₀ [3]	Cr[3]	Y ₁ [3]	VPB[3]	Cb[7]	Y ₀ [7]	Cr[7]	Y ₁ [7]		
VPA[4]	-	-	-	-	VPB[4]	Cb[8]	Y ₀ [8]	Cr[8]	Y ₁ [8]		
VPA[5]	-	-	-	-	VPB[5]	Cb[9]	Y ₀ [9]	Cr[9]	Y ₁ [9]		
VPA[6]	-	-	-	-	VPB[6]	Cb[10]	Y ₀ [10]	Cr[10]	Y ₁ [10]		
VPA[7]	-	-	-	-	VPB[7]	Cb[11]	Y ₀ [11]	Cr[11]	Y ₁ [11]		

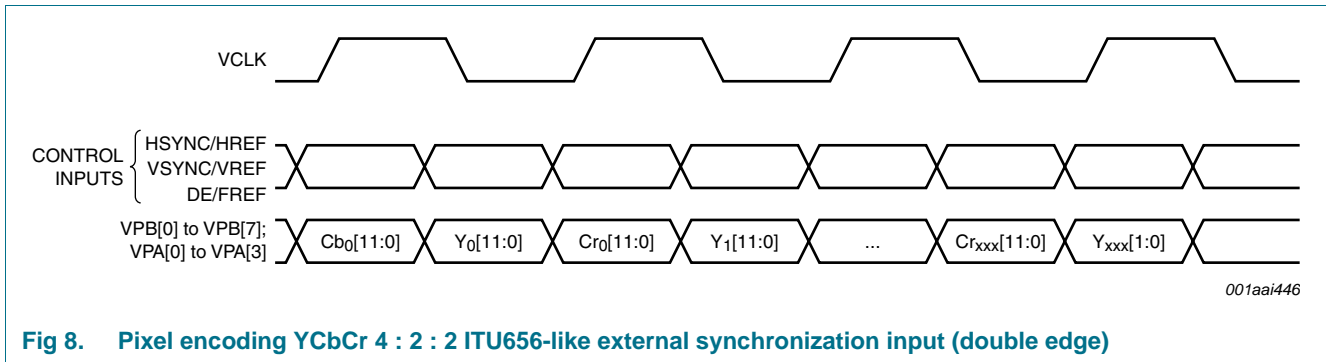


7.2.3.4 YCbCr 4 : 2 : 2 ITU656-like external synchronization (double edge)

Table 10. YCbCr 4 : 2 : 2 ITU656-like external synchronization input (double edge) mapping

Register VIP_CNTRL_0 = 23h; VIP_CNTRL_1 = 50h; VIP_CNTRL_2 = 00h.

Video port A					Video port B					Control	
Pin	YCbCr 4 : 2 : 2 (ITU656-like)				Pin	YCbCr 4 : 2 : 2 (ITU656-like)				Pin	YCbCr 4 : 2 : 2
VPA[0]	Cb[0]	Y ₀ [0]	Cr[0]	Y ₁ [0]	VPB[0]	Cb[4]	Y ₀ [4]	Cr[4]	Y ₁ [4]	HSYNC/HREF	used
VPA[1]	Cb[1]	Y ₀ [1]	Cr[1]	Y ₁ [1]	VPB[1]	Cb[5]	Y ₀ [5]	Cr[5]	Y ₁ [5]	VSYNC/VREF	used
VPA[2]	Cb[2]	Y ₀ [2]	Cr[2]	Y ₁ [2]	VPB[2]	Cb[6]	Y ₀ [6]	Cr[6]	Y ₁ [6]	DE/FREF	used
VPA[3]	Cb[3]	Y ₀ [3]	Cr[3]	Y ₁ [3]	VPB[3]	Cb[7]	Y ₀ [7]	Cr[7]	Y ₁ [7]		
VPA[4]	-	-	-	-	VPB[4]	Cb[8]	Y ₀ [8]	Cr[8]	Y ₁ [8]		
VPA[5]	-	-	-	-	VPB[5]	Cb[9]	Y ₀ [9]	Cr[9]	Y ₁ [9]		
VPA[6]	-	-	-	-	VPB[6]	Cb[10]	Y ₀ [10]	Cr[10]	Y ₁ [10]		
VPA[7]	-	-	-	-	VPB[7]	Cb[11]	Y ₀ [11]	Cr[11]	Y ₁ [11]		



7.2.3.5 YCbCr 4 : 2 : 2 ITU656-like embedded synchronization (rising edge)

Table 11. YCbCr 4 : 2 : 2 ITU656-like embedded synchronization input (rising edge) mappings

Register VIP_CNTRL_0 = 23h; VIP_CNTRL_1 = 50h; VIP_CNTRL_2 = 00h.

Video port A					Video port B					Control	
Pin	YCbCr 4 : 2 : 2 (ITU656-like)				Pin	YCbCr 4 : 2 : 2 (ITU656-like)				Pin	YCbCr 4 : 2 : 2
VPA[0]	Cb[0]	Y ₀ [0]	Cr[0]	Y ₁ [0]	VPB[0]	Cb[4]	Y ₀ [4]	Cr[4]	Y ₁ [4]	HSYNC/HREF	not used
VPA[1]	Cb[1]	Y ₀ [1]	Cr[1]	Y ₁ [1]	VPB[1]	Cb[5]	Y ₀ [5]	Cr[5]	Y ₁ [5]	VSYNC/VREF	not used
VPA[2]	Cb[2]	Y ₀ [2]	Cr[2]	Y ₁ [2]	VPB[2]	Cb[6]	Y ₀ [6]	Cr[6]	Y ₁ [6]	DE/FREF	not used
VPA[3]	Cb[3]	Y ₀ [3]	Cr[3]	Y ₁ [3]	VPB[3]	Cb[7]	Y ₀ [7]	Cr[7]	Y ₁ [7]		
VPA[4]	-	-	-	-	VPB[4]	Cb[8]	Y ₀ [8]	Cr[8]	Y ₁ [8]		
VPA[5]	-	-	-	-	VPB[5]	Cb[9]	Y ₀ [9]	Cr[9]	Y ₁ [9]		
VPA[6]	-	-	-	-	VPB[6]	Cb[10]	Y ₀ [10]	Cr[10]	Y ₁ [10]		
VPA[7]	-	-	-	-	VPB[7]	Cb[11]	Y ₀ [11]	Cr[11]	Y ₁ [11]		

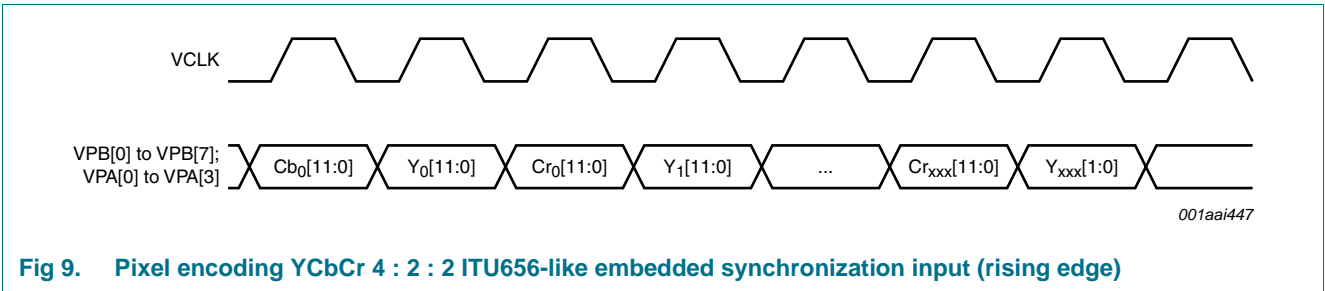


Fig 9. Pixel encoding YCbCr 4 : 2 : 2 ITU656-like embedded synchronization input (rising edge)

7.2.3.6 YCbCr 4 : 2 : 2 ITU656-like embedded synchronization (double edge)

Table 12. YCbCr 4 : 2 : 2 ITU656-like embedded synchronization input (double edge) mapping

Register VIP_CNTRL_0 = 23h; VIP_CNTRL_1 = 50h; VIP_CNTRL_2 = 00h.

Video port A					Video port B					Control	
Pin	YCbCr 4 : 2 : 2 (ITU656-like)				Pin	YCbCr 4 : 2 : 2 (ITU656-like)				Pin	YCbCr 4 : 2 : 2
VPA[0]	Cb[0]	Y ₀ [0]	Cr[0]	Y ₁ [0]	VPB[0]	Cb[4]	Y ₀ [4]	Cr[4]	Y ₁ [4]	HSYNC/HREF	not used
VPA[1]	Cb[1]	Y ₀ [1]	Cr[1]	Y ₁ [1]	VPB[1]	Cb[5]	Y ₀ [5]	Cr[5]	Y ₁ [5]	VSYNC/VREF	not used
VPA[2]	Cb[2]	Y ₀ [2]	Cr[2]	Y ₁ [2]	VPB[2]	Cb[6]	Y ₀ [6]	Cr[6]	Y ₁ [6]	DE/FREF	not used
VPA[3]	Cb[3]	Y ₀ [3]	Cr[3]	Y ₁ [3]	VPB[3]	Cb[7]	Y ₀ [7]	Cr[7]	Y ₁ [7]		
VPA[4]	-	-	-	-	VPB[4]	Cb[8]	Y ₀ [8]	Cr[8]	Y ₁ [8]		
VPA[5]	-	-	-	-	VPB[5]	Cb[9]	Y ₀ [9]	Cr[9]	Y ₁ [9]		
VPA[6]	-	-	-	-	VPB[6]	Cb[10]	Y ₀ [10]	Cr[10]	Y ₁ [10]		
VPA[7]	-	-	-	-	VPB[7]	Cb[11]	Y ₀ [11]	Cr[11]	Y ₁ [11]		

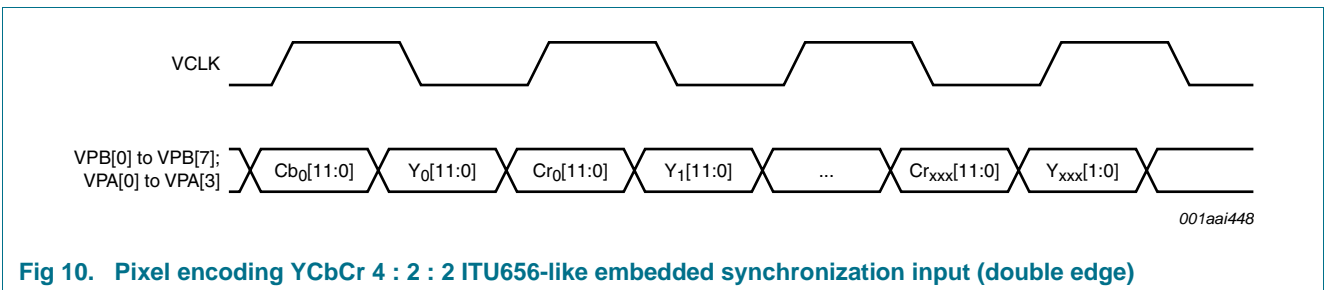


Fig 10. Pixel encoding YCbCr 4 : 2 : 2 ITU656-like embedded synchronization input (double edge)

7.2.3.7 YCbCr 4 : 2 : 2 semi-planar external synchronization (rising edge)

Table 13. YCbCr 4 : 2 : 2 semi-planar external synchronization input (rising edge) mapping

Register VIP_CNTRL_0 = 23h; VIP_CNTRL_1 = 50h; VIP_CNTRL_2 = 14h.

Video port A			Video port B			Video port C			Control	
Pin	YCbCr 4 : 2 : 2 semi-planar		Pin	YCbCr 4 : 2 : 2 semi-planar		Pin	YCbCr 4 : 2 : 2 semi-planar		Pin	YCbCr 4 : 2 : 2
VPA[0]	Y ₀ [0]	Y ₁ [0]	VPB[0]	Y ₀ [4]	Y ₁ [4]	VPC[0]	Cb[4]	Cr[4]	HSYNC/HREF	used
VPA[1]	Y ₀ [1]	Y ₁ [1]	VPB[1]	Y ₀ [5]	Y ₁ [5]	VPC[1]	Cb[5]	Cr[5]	VSYNC/VREF	used
VPA[2]	Y ₀ [2]	Y ₁ [2]	VPB[2]	Y ₀ [6]	Y ₁ [6]	VPC[2]	Cb[6]	Cr[6]	DE/FREF	used
VPA[3]	Y ₀ [3]	Y ₁ [3]	VPB[3]	Y ₀ [7]	Y ₁ [7]	VPC[3]	Cb[7]	Cr[7]		
VPA[4]	Cb[0]	Cr[0]	VPB[4]	Y ₀ [8]	Y ₁ [8]	VPC[4]	Cb[8]	Cr[8]		
VPA[5]	Cb[1]	Cr[1]	VPB[5]	Y ₀ [9]	Y ₁ [9]	VPC[5]	Cb[9]	Cr[9]		
VPA[6]	Cb[2]	Cr[2]	VPB[6]	Y ₀ [10]	Y ₁ [10]	VPC[6]	Cb[10]	Cr[10]		
VPA[7]	Cb[3]	Cr[3]	VPB[7]	Y ₀ [11]	Y ₁ [11]	VPC[7]	Cb[11]	Cr[11]		

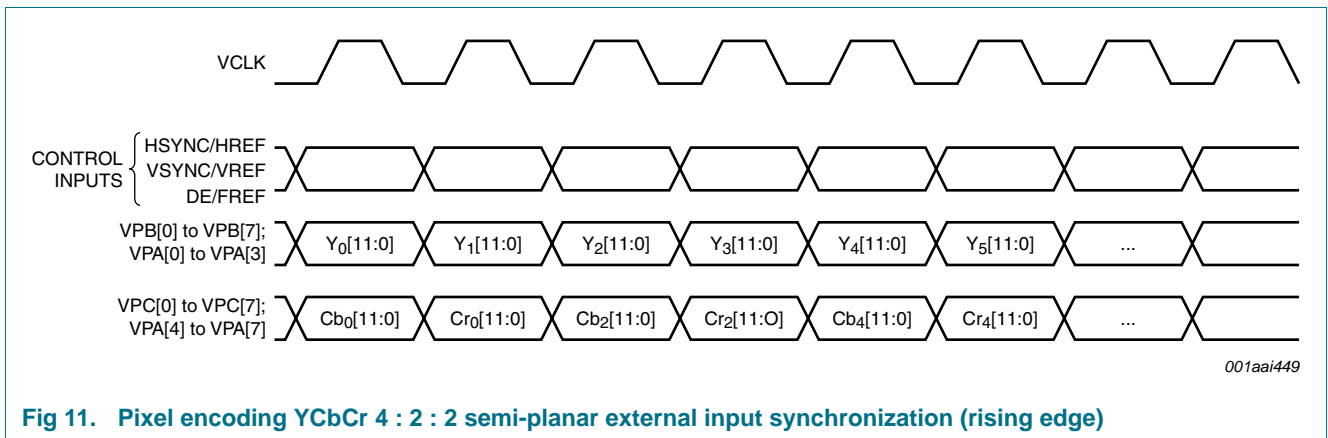


Fig 11. Pixel encoding YCbCr 4 : 2 : 2 semi-planar external input synchronization (rising edge)

7.2.3.8 YCbCr 4 : 2 : 2 semi-planar embedded synchronization (rising edge)

Table 14. YCbCr 4 : 2 : 2 semi-planar embedded synchronization input (rising edge) mapping

Register VIP_CNTRL_0 = 23h; VIP_CNTRL_1 = 50h; VIP_CNTRL_2 = 14h.

Video port A			Video port B			Video port C			Control	
Pin	YCbCr 4 : 2 : 2 semi-planar		Pin	YCbCr 4 : 2 : 2 semi-planar		Pin	YCbCr 4 : 2 : 2 semi-planar		Pin	YCbCr 4 : 2 : 2
VPA[0]	Y ₀ [0]	Y ₁ [0]	VPB[0]	Y ₀ [4]	Y ₁ [4]	VPC[0]	Cb[4]	Cr[4]	HSYNC/HREF	not used
VPA[1]	Y ₀ [1]	Y ₁ [1]	VPB[1]	Y ₀ [5]	Y ₁ [5]	VPC[1]	Cb[5]	Cr[5]	VSYNC/VREF	not used
VPA[2]	Y ₀ [2]	Y ₁ [2]	VPB[2]	Y ₀ [6]	Y ₁ [6]	VPC[2]	Cb[6]	Cr[6]	DE/FREF	not used
VPA[3]	Y ₀ [3]	Y ₁ [3]	VPB[3]	Y ₀ [7]	Y ₁ [7]	VPC[3]	Cb[7]	Cr[7]		
VPA[4]	Cb[0]	Cr[0]	VPB[4]	Y ₀ [8]	Y ₁ [8]	VPC[4]	Cb[8]	Cr[8]		
VPA[5]	Cb[1]	Cr[1]	VPB[5]	Y ₀ [9]	Y ₁ [9]	VPC[5]	Cb[9]	Cr[9]		
VPA[6]	Cb[2]	Cr[2]	VPB[6]	Y ₀ [10]	Y ₁ [10]	VPC[6]	Cb[10]	Cr[10]		
VPA[7]	Cb[3]	Cr[3]	VPB[7]	Y ₀ [11]	Y ₁ [11]	VPC[7]	Cb[11]	Cr[11]		

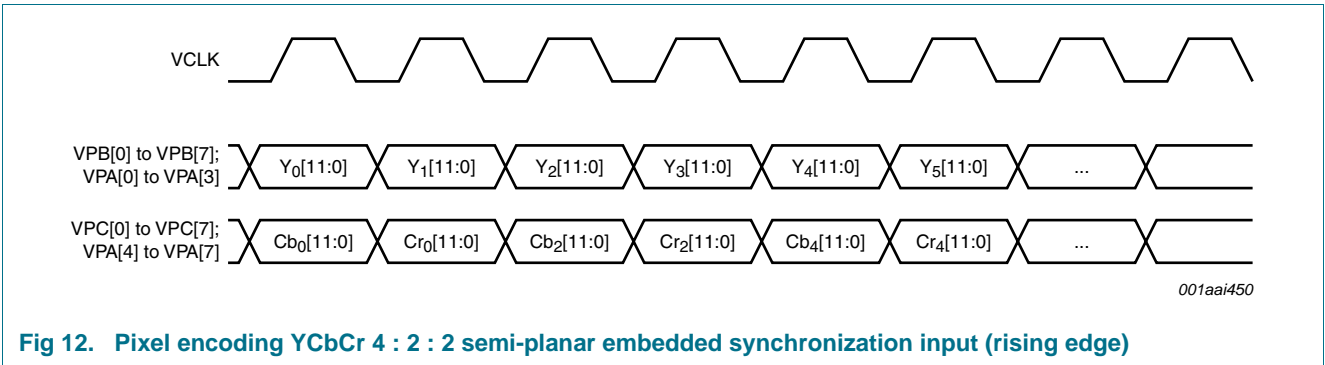


Fig 12. Pixel encoding YCbCr 4 : 2 : 2 semi-planar embedded synchronization input (rising edge)

7.2.4 Synchronization

TDA19989AET can be synchronized with extraction of the sync information from embedded sync (SAV/EAV) codes inside the video stream or with external HSYNC/VSYNC inputs.

7.2.4.1 Timing extraction generator

Synchronization signals can be extracted from Start Active Video (SAV) and End Active Video (EAV) in case of embedded synchronization in the data stream.

Synchronization signals can be embedded in YCbCr 4 : 2 : 2 ITU656 (up to 1 × 12-bit) and YCbCr 4 : 2 : 2 semi-planar (up to 2 × 12-bit).

7.2.4.2 Data enable generator

TDA19989AET contains a Data Enable (DE) generator; this can generate an internal DE signal for a system which does not provide one.

7.3 Input and output video format

Due to the flexible video input formatter, TDA19989AET can accept a large range of input formats. This flexibility allows TDA19989AET to be compatible with the maximum possible number of MPEG decoders. Moreover, these input formats may be changed in many ways (color space converter, upsampler, downsampler) before it is transmitted across the HDMI link. [Table 15](#) gives the possible inputs and outputs.

Table 15. Use of color space converter, upsampler and downsampler

Input			Output		
Color space	Format	Channels	Color space	Format	Channels
RGB	4 : 4 : 4	3 × 8-bit	RGB	4 : 4 : 4	3 × 8-bit
			YCbCr	4 : 4 : 4	3 × 8-bit
			YCbCr	4 : 2 : 2	2 × 12-bit
YCbCr	4 : 4 : 4	3 × 8-bit	RGB	4 : 4 : 4	3 × 8-bit
			YCbCr	4 : 4 : 4	3 × 8-bit
			YCbCr	4 : 2 : 2	2 × 12-bit
YCbCr	4 : 2 : 2	up to 1 × 12-bit semi-planar	RGB	4 : 4 : 4	3 × 8-bit
			YCbCr	4 : 4 : 4	3 × 8-bit
			YCbCr	4 : 2 : 2	2 × 12-bit

Table 15. Use of color space converter, upsampler and downsampler ...continued

Input			Output		
Color space	Format	Channels	Color space	Format	Channels
YCbCr	4 : 2 : 2	up to 2 × 12-bit semi-planar	RGB	4 : 4 : 4	3 × 8-bit
			YCbCr	4 : 4 : 4	3 × 8-bit
			YCbCr	4 : 2 : 2	2 × 12-bit

7.4 Upsampler

The incoming YCbCr 4 : 2 : 2 (2 × 12-bit) data stream format may be upsampled into YCbCr 4 : 4 : 4 (3 × 8-bit) data stream by repeating or linearly interpolating the chrominance pixels.

7.5 Color space converter

The color space converter is used to convert input video data from one type to another color space (e.g. RGB to YCbCr and YCbCr to RGB). This block can be bypassed and each coefficient is programmable via the I²C-bus register.

$$\begin{bmatrix} Y \\ Cr \\ Cb \end{bmatrix} = \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ C_{31} & C_{32} & C_{33} \end{bmatrix} \times \left(\begin{bmatrix} Y \\ R/Cr \\ B/Cb \end{bmatrix} + \begin{bmatrix} Oin_{G/Y} \\ Oin_{R/Cr} \\ Oin_{B/Cb} \end{bmatrix} \right) + \begin{bmatrix} Oout_{Y/G} \\ Oout_{Cr/R} \\ Oout_{Cb/B} \end{bmatrix} \tag{1}$$

7.6 Gamut-related metadata

Gamut-related metadata is an enhanced colorimetry beyond the default standard with higher definition colorimetries. Profile P0 is supported, which means that only one packet per video field is sent. Color gamut boundary data are defined the standards:

- xvYCC601 (IEC 61966-2-4 – SD) (using YCbCr)
- xvYCC709 (IEC 61966-2-4 – HD) (using YCbCr)
- AdobeYCC601 (IEC 61966-2-5) (using YCbCr)
- AdobeRGB (IEC 61966-2-5) (using RGB)

Remark: Gamut-related metadata is an HDMI 1.4 feature.

7.7 Downsampler

This block works only with YCbCr input format; the filters downsample the Cb and Cr signals by a factor of 2. A delay is added on the Y channel, which corresponds to the pipeline delay of the filters, to put the Y channel in phase with the Cb-Cr channel.

7.8 Audio input format

TDA19989AET is compatible with the following audio features described in the HDMI 1.4 specification:

- S/PDIF
- I²S-bus up to four channels

TDA19989AET can carry audio in I²S-bus format (one stereo to two stereo channels) or in S/PDIF format through one audio pin named AP1 or AP2. S/PDIF or I²S-bus format can be selected via the I²C-bus. Only one audio format can be used at a time: either S/PDIF or I²S-bus. [Table 16](#) shows the audio port allocation and [Section 7.8.3](#) gives more details.

Table 16. Audio port configuration

Audio port	Input configuration	
	S/PDIF	I ² S-bus
AP0	-	WS (word select)
AP1	S/PDIF input	I ² S-bus channel 0
AP2	S/PDIF input	I ² S-bus channel 1
AP3	MCLK	
ACLK	-	SCK (I ² S-bus clock)

All audio ports are LV-CMOS 1.8 V compatible and LV-CMOS 3.3 V tolerant. It is possible to deactivate unused ports via I²C-bus with ENA_AP register on page 00h for both audio and clock inputs.

7.8.1 S/PDIF

In this format TDA19989AET supports 2-channel uncompressed PCM data (IEC 60958) layout 0, or compressed bit stream (Dolby Digital, DTS, AC3 etc.) layout 1.

Only one S/PDIF input can be used at the same time. The selection is done by register.

TDA19989AET is able to recover the original clock from the S/PDIF signal (no need of external clock). In addition, it can also use an external clock to decode the S/PDIF signal.

7.8.2 I²S-bus

There are 2 × I²S-bus stereo input, which enables 4 PCM channels to be carried. The I²S-bus input interface receives an I²S-bus signal including serial data, word select and serial clock.

Typical waveforms for the I²S-bus signals at 64f_s are given by [Figure 13](#).

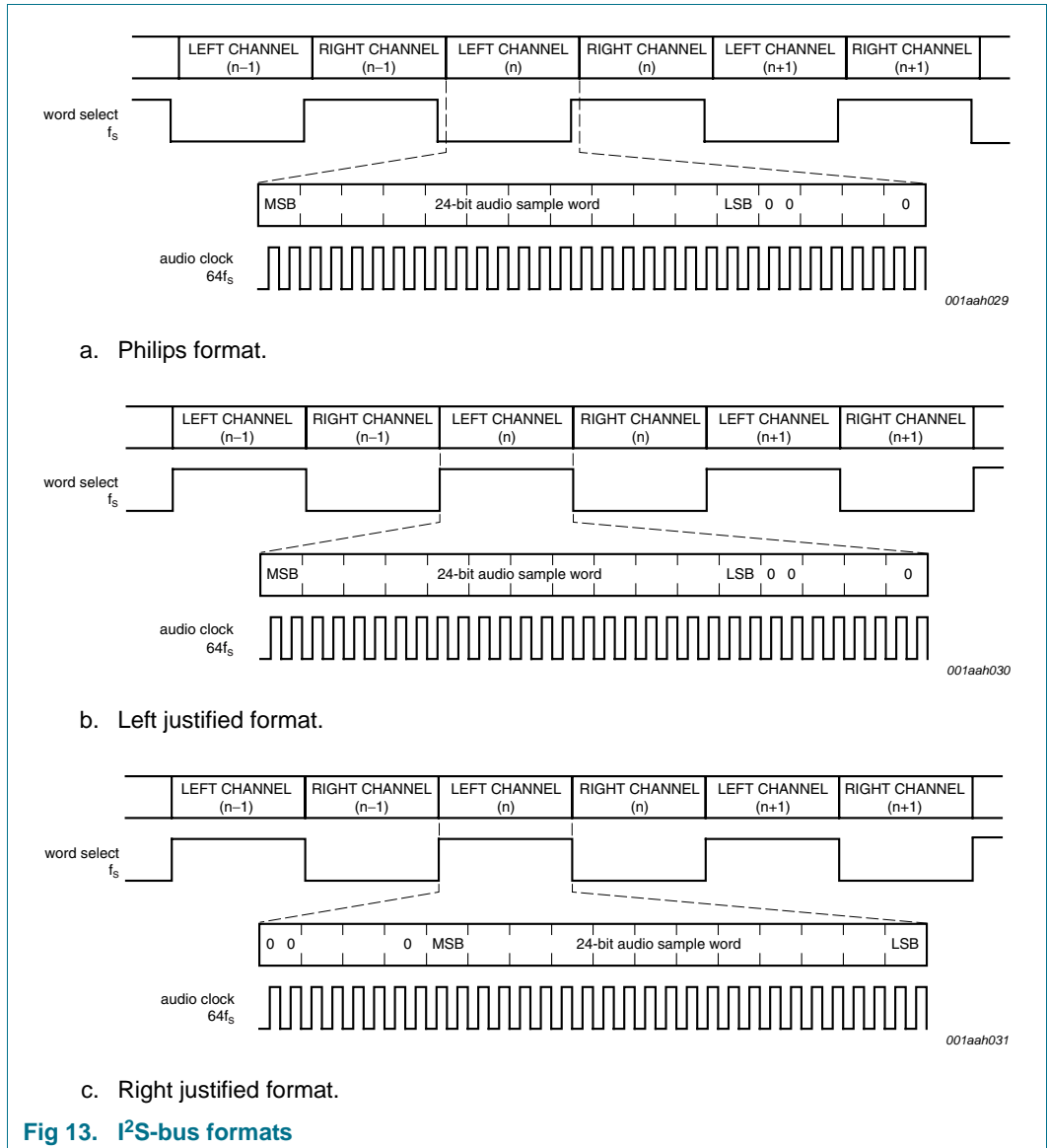


Fig 13. I²S-bus formats

The I²S-bus input interface can receive up to 24-bit wide audio samples via the serial data input with a clock frequency of at least 32 times the input sample frequency f_s .

Audio samples with a precision better than 24-bit are truncated to 24-bit. If the input clock has a frequency of $32f_s$, only 16-bit audio-samples can be received. In this case, the 8 LSBs will be set to 0. If the input clock has a frequency of $64f_s$ and is left justified or Philips, the audio word is truncated to 24-bit format and other bits padded with zeros. If the input clock has a frequency of $64f_s$ and is right justified, audio sample size has to be specified via software drivers.

The serial data signal carries the serial baseband audio data, sample by sample left/right interleaved.

The word select signal indicates whether left or right channel information is transferred over the serial data line.

7.8.3 Audio port internal assignment

The aim of the internal audio input assignment is to internally map any of the incoming data from the audio port AP1 or AP2 to I²S-bus channel 0 or S/PDIF internal ports by setting the appropriate I²C-bus register.

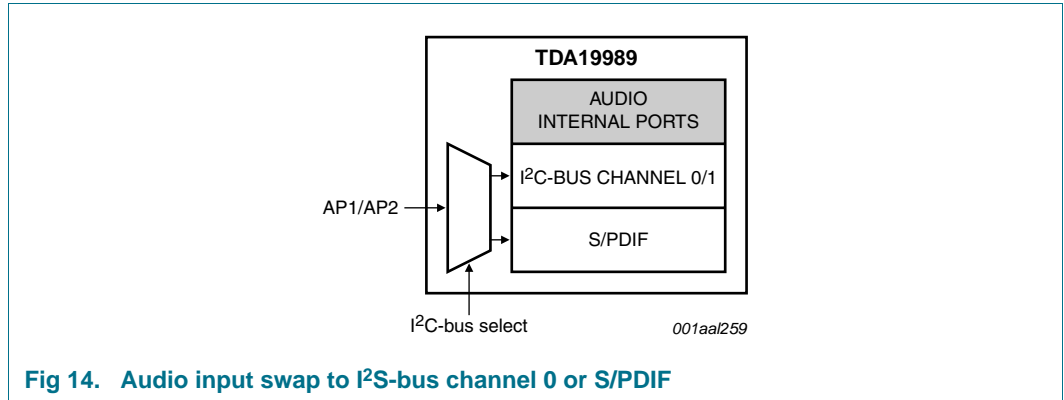


Fig 14. Audio input swap to I²S-bus channel 0 or S/PDIF

7.9 Power management

TDA19989AET HDMI and CEC cores can be independently powered down by the I²C-bus register. In Standby mode all activities are reduced by switching off all PLLs, HDMI and CEC cores and disconnecting the biasing structure of the output stage. TDA19989AET has a very low power consumption, which is suitable for portable applications.

Table 17 gives the typical power consumption of the device in different configurations.

Table 17. TDA19989AET typical power consumption in different configurations

Typical power	Configuration	Comment
400 μ W	Standby mode: <ul style="list-style-type: none"> I²C-bus ON 	default configuration: after power-up; PLLs HDMI and CEC cores are OFF; can be switched ON via I ² C-bus register
1.5 mW	Sleep mode without CEC: <ul style="list-style-type: none"> HDMI interruption (HPD, RxSense only) 	no sink connected; CEC is OFF
1.8 mW	Sleep mode with CEC: <ul style="list-style-type: none"> HDMI interruption (HPD, RxSense only) CEC interruption 	no sink connected; CEC is ON
90 mW	Low power 1080i mode: <ul style="list-style-type: none"> Video format 1080i Video input RGB 4 : 4 : 4 No CEC 	sink connected; CEC is OFF; 30 % activity on video input ports
140 mW	Full speed mode: <ul style="list-style-type: none"> Video format 1080p 	all blocks enabled and running; 30 % activity on video input ports

7.10 Interrupt controller

Pin INT is used to alert the system microcontroller that a critical event concerning the HDMI or CEC has occurred. The software provided with the device read a status register (I²C-bus) to determine which block between HDMI and CEC has caused the interruption before processing it. Some of these interrupts are maskable. The interrupt types are described in [Table 18](#).

Table 18. Interruptions

Interrupt domain	Interrupt name	Definition	Maskable feature
HDCP	r0	r0 = R'0 check done	maskable
	pj	pj = P'j check fails	
	sha-1	V = V' check success	
	bstatus	bstatus available	
	bcaps	bcaps available	
	t0	HDCP goes to initial state	
	security	HDCP encryption is off or blue screen removed	not maskable
HPD	hpd	transition on HPD input	maskable
RxSense	rx_sense	transition on RxSense	maskable
Interrupt	sw_intsoftware	test purpose (output an interrupt signal)	maskable
EDID	edid_block_rd	EDID block read finished	maskable
CEC	cec_int	CEC message received	not maskable

7.10.1 Hot plug/unplug detect

The hot plug detect (HPD) pin is 5 V input tolerant. The HPD signal, when asserted, tells the transmitter that the receiver is connected. When changing from LOW-to-HIGH, TDA19989AET has to read the EDID of the receiver in order to select the video format that the receiver can handle.

7.10.2 Receiver sensitivity

TDA19989AET has the capability to sense the receiver connectivity and working behavior. This feature (RxSense) detects the presence of the 50 Ω pull-up resistor R_T on the TMDS clock channel of the downstream side.

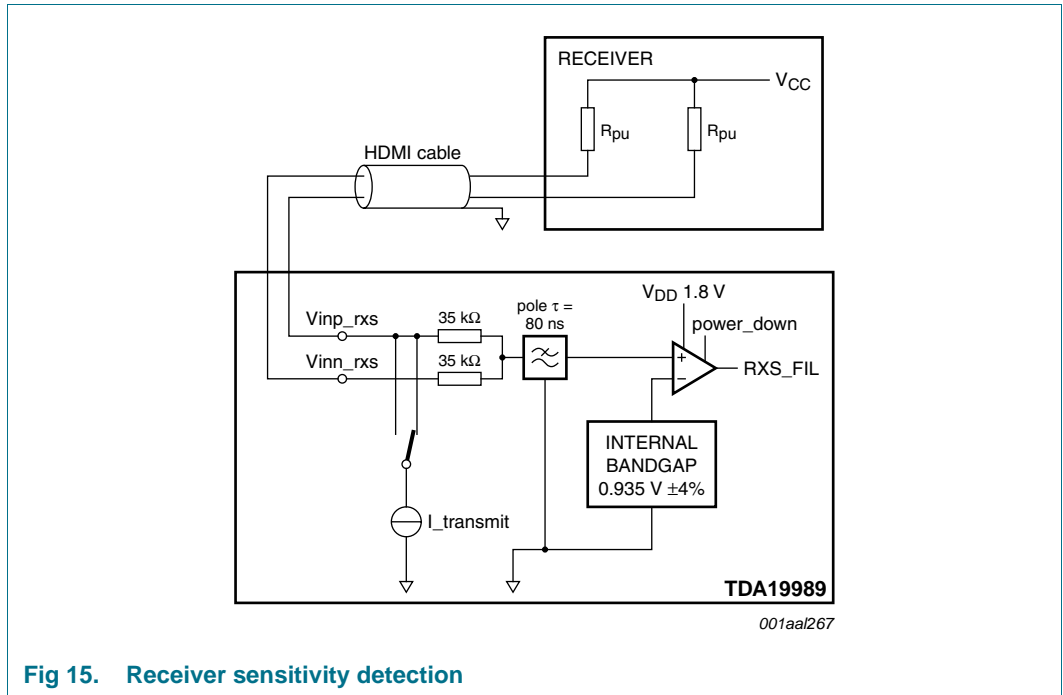


Fig 15. Receiver sensitivity detection

As long as the receiver is connected to the transmitter and powered-up, bit Rxs_FIL is set to logic 1.

As soon as the cable is unplugged or receiver side powered off (assuming in this case that V_{CC} is switched off), the RxSense generates an interrupt inside TDA19989AET, changing the value of bit Rxs_FIL to logic 0 (See Table 19). This allows the application to stop sending unnecessary video content.

This feature is very useful when the receiver recovers from an off-state and does not generate a HPD transition HIGH-to-LOW-to-HIGH. In this particular case, RxSense will generate an interrupt so that the chip restarts sending video.

Table 19. Receiver detection according to averaged terminal voltage

Average voltage (V _{inp_rxs} + V _{inn_rxs}) / 2	bit Rxs_FIL: receiver powered on	bit Rxs_FIL: receiver powered off
V ≥ 1.2 V	1	0
0.7 V < V < 1.2 V	undefined	0
V ≤ 0.7 V	0	0

Remark: According to the HDMI specification, only the HPD interrupt allows the application to read the EDID. The RxSense interrupt is not mandatory to initialize the EDID reading procedure.

7.11 HDCP processing

7.11.1 High-bandwidth digital content protection

TDA19989 contains an HDCP function, which encrypts the transmitted stream content (both video and audio). This function can be enabled and disabled via the I²C-bus.

The keys are stored internally in OTP non-volatile memory for maximum security.

7.11.1.1 Repeater function

TDA19989AET can be used in a repeater device according to the *HDCP specification, Rev 1.3*. TDA19989AET is able to store the KSV list of a maximum of 127 devices in a register memory.

7.11.1.2 SHA-1

To deal with repeater, a SHA-1 calculation is performed by the transmitter and by the downstream repeater. For security purposes and in order to relieve the microcontroller, the SHA-1 has been implemented within TDA19989AET.

This calculation is worked out after the transmitter has loaded the KSV list (see *HDCP specification, Rev 1.3*). If SHA-1 calculated by transmitter equals the SHA-1 calculated by repeater, then an interrupt is sent.

7.12 CEC

TDA19989AET with its embedded CEC block provides a complete solution to enable Consumer Electronic Control (CEC) in product (DSC, DVC, PMP, UM PC). This eliminates the need of any additional device to handle this feature thus improving BOM (Bill Of Materials). CEC capability allows AV products (CEC enable) to communicate together over the home appliance network which could be controlled using only one remote control.

The CEC block manages low level transactions (compliant to CEC timing specification) over the one bidirectional line. It translates CEC protocol in I²C-bus for the host processor and vice versa. It manages CEC message reception and transmission compliant to CEC protocol and provides the message to the system microcontroller (host processor).

For power consumption optimization purpose CEC could be enable or disable through I²C-bus register. The following sections describe CEC:

- Features
- Clocking scheme

7.12.1 Features

- Receive and transmit CEC messages to host processor
- Supports multiple CEC logical addresses
- Supports CEC messages up to 16 bytes long
- Programmable retry count
- Comprehensive arbitration and collision handling

7.12.2 Clock

CEC clock must be running in Sleep mode (with CEC) to wake up TDA19989AET using CEC specific message as described in “HDMI specification 1.4”.

CEC module can be clocked using:

- External clock:
 - 12 MHz crystal $\pm 1\%$.
- Internal clock:
 - FRO (Free Running Oscillator). FRO frequency varies and in the range from 12.64 MHz to 12.9 MHz. See [Figure 16](#).

CEC operates normally (i.e. matches the timing requested CEC specification) if and only if its clock frequency is set to 12 MHz.

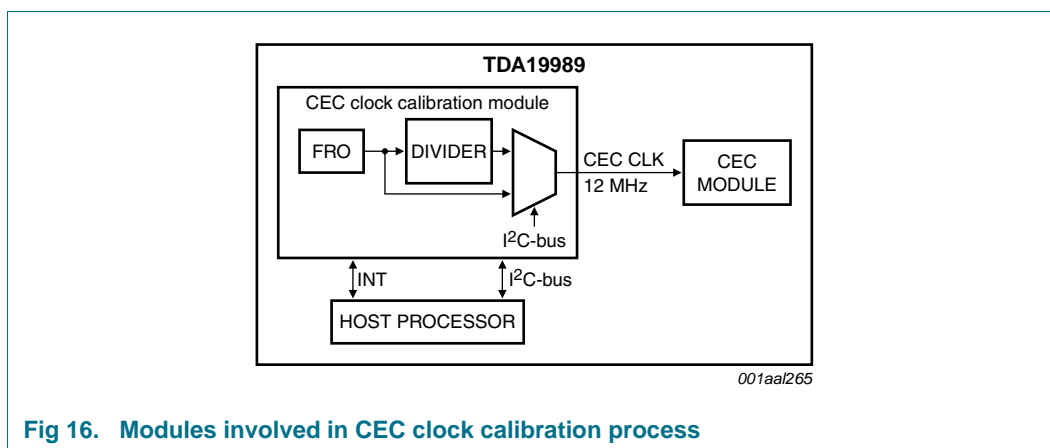


Fig 16. Modules involved in CEC clock calibration process

Calibration procedure is completely handled by the software delivered together with the device, it has the following steps:

- Host processor set TDA19989AET in calibration mode
- Host processor generates a negative pulse of 10 ms $\pm 1\%$ on INT pin
- Host processor deselects the calibration mode when it is completed, the chip is ready to operate

CEC clock calibration must be performed at each power-up and each time TDA19989AET moves from Standby or Sleep (without CEC) state to normal operating mode.

Non successful calibration will lead to CEC signal not matching timings specification; as a consequence, CEC will not be functional.

7.12.3 CEC interrupt

Pin INT is used by TDA19989AET to warn the host processor that HDMI or CEC events (CEC message is available to read) have occurred.

Software interrupt status register reads determine which block between HDMI or CEC has raised the interruption before processing it.

7.12.4 Power-On Reset (POR)

After power-up, TDA19989AET is activated by internal reset from POR module. This is used to set TDA19989AET to a known state.

7.12.5 Repeater function

TDA19989AET can be used in a repeater device according to HDMI 1.4.

7.13 HDMI core

7.13.1 Output TMDS buffers

7.13.1.1 Digitally controlled signal amplitude

The TMDS signal output peak-to-peak voltage (Vswing) is programmable by the software using I²C-bus register vswing_ctrl[3:0]. Vswing varies from 370 mV to 640 mV with $\pm 5\%$ accuracy in 18 mV steps according to the following formula:

$$V_{\text{swing}} = 370 \text{ mV} + 18 \text{ mV} \times \text{vswing_ctrl}[3:0]$$

An external resistor ($10 \text{ k}\Omega \pm 1\%$) must be connected between pin EXT_SWING and analog ground.

7.13.2 Pixel repetition

To transmit video formats with pixel rates below 25 megasamples per second or to increase the number of audio sample packets in each frame, TDA19989AET uses pixel repetition to increase the transmitted pixel clock (see [Table 20](#)).

Table 20. Pixel repetition

PR[3]	PR[2]	PR[1]	PR[0]	Pixel repetition factor
0	0	0	0	no repetition: pixel sent once
0	0	0	1	2 times: pixel repeated once
0	0	1	0	3 times
0	0	1	1	4 times
0	1	0	0	5 times
0	1	0	1	6 times
0	1	1	0	7 times
0	1	1	1	8 times
1	0	0	0	9 times
1	0	0	1	10 times
others				reserved

7.13.3 DDC-bus channel

The DDC-bus pins DSDA and DSCL are 5 V tolerant and can work at standard mode (100 kHz). The DDC-bus is used as a master interface when reading the EDID.

When the device is power-off, DSDA and DSCL ports:

- become in high-impedance
- can withstand 5 V from the sink

7.14 E-EDID

7.14.1 E-EDID reading

As a master interface for the EDID process, the DDC-bus is compliant with the I²C-bus specification and has the possibility of repeat/start condition to enable quick access to the EDID content, as well as the possibility of reading a large EDID (with the use of segment pointer).

TDA19989AET has a whole I²C-bus (page 09h) dedicated to the EDID where one block (128 bytes) can be stored. The block can be read by the system microcontroller to determine the supported video and audio format of the downstream site.

Remark: When the block is read by TDA19989AET, it generates an interrupt to warn the main processor that the chip is ready to transmit the content. Once the content is read out by the main processor, it can allow other blocks to be read if required.

7.14.2 HDMI and DVI receiver discrimination

This information is located in the E-EDID receiver part, in the 'vendor-specific data block' within the first CEA EDID timing extension.

If the 24-bit IEEE Registration Identifier contains the value 00 0C03h, then the receiver will support HDMI, otherwise the device will be treated as a DVI device.

However, even though TDA19989AET have directly access to that information, it is the task of the host processor to ask to switch from DVI to HDMI mode.

8. I²C-bus interface and register definitions

8.1 I²C-bus protocol

The I²C-bus pins CSDA and CSCL are 1.8 V and 3.3 V tolerant. Both Fast mode (400 kHz) and Standard mode (100 kHz) are supported.

The registers of TDA19989AET can be accessed via the I²C-bus. All registers are R/W except for those which are confidential.

HDMI and CEC cores I²C-bus addresses are given in [Table 21](#) and [Table 22](#).

Table 21. HDMI core I²C-bus address

HDMI core address							
A6	A5	A4	A3	A2	A1	A0	R/W
1	1	1	0	0	0	0	0/1

Table 22. CEC core I²C-bus address

CEC core address							
A6	A5	A4	A3	A2	A1	A0	R/W
0	1	1	0	1	0	0	0/1

For read access, the master writes the address of TDA19989AET HDMI or CEC core, and the subaddress to access the specific register and then the data.

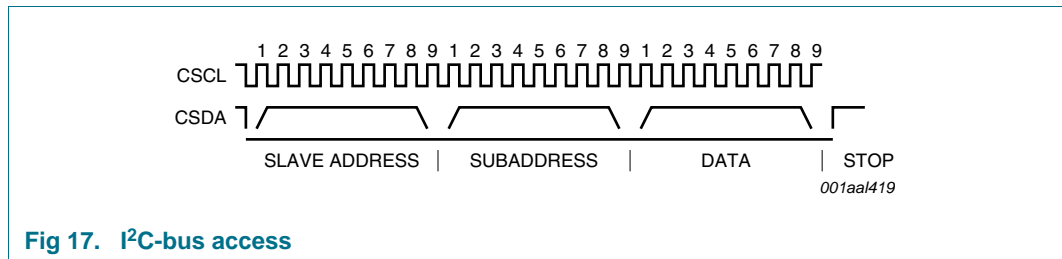


Fig 17. I²C-bus access

8.2 Memory page management

The I²C-bus memory is split into several pages for HDMI core only, and the selection between pages is made with common register CURPAGE_ADR. It is only necessary to write in this register once to change the current page. So multiple read or write operations in the same page need a write register CURPAGE_ADR once at the beginning.

The following memory pages are available for TDA19989AET:

- Page 00h: general control
- Page 02h: PLL settings
- Page 09h: EDID control page
- Page 10h: information frames and packets
- Page 11h: audio settings and content info packets
- Page 12h: HDCP and OTP
- Page 13h: gamut-related metadata packets

The CEC core does not need memory page mechanism due to its reduced number of registers.

8.3 ID version

The ID version readable via I²C-bus is defined by the concatenation of VERSION_MSB and VERSION registers. The ID version value is 212h.

8.4 Clock stretching

Clock stretching pauses a transaction by holding the CSCL line LOW. The transaction cannot continue until the line is released HIGH again.

For example: on the byte level, a device may be able to receive bytes of data at a fast rate, but needs more time to store a received byte or prepare another byte to be transmitted. Slaves can then hold the CSCL line LOW after reception and acknowledgment of a byte to force the master into a wait state until the slave is ready for the next byte transfer; see [Table 31](#).

Clock stretching must be supported by I²C-bus master especially when CEC feature of TDA19989AET is used. If CEC feature of TDA19989AET is not used, I²C-bus master does not need to support clock stretching.

9. Input format

In [Table 23](#) the port VPA has been mapped to C_b (YCbCr space)/B (RGB space), VPB has been mapped to Y (YCbCr space)/G (RGB space) and VPC has been mapped to Cr (YCbCr space)/R (RGB space).

Table 23. Input format

L: recommend tied to LOW voltage, e.g. ground

Input pins	Signal	RGB	YCbCr							
		4 : 4 : 4	4 : 4 : 4	4 : 2 : 2 (semi-planar)	4 : 2 : 2 (ITU 656-like)					
Video port A										
VPA[0]	Cb[0]/B[0]	B[0]	Cb[0]	Y ₀ [0]	Y ₁ [0]	Cb[0]	Y ₀ [0]	Cr[0]	Y ₁ [0]	
VPA[1]	Cb[1]/B[1]	B[1]	Cb[1]	Y ₀ [1]	Y ₁ [1]	Cb[1]	Y ₀ [1]	Cr[1]	Y ₁ [1]	
VPA[2]	Cb[2]/B[2]	B[2]	Cb[2]	Y ₀ [2]	Y ₁ [2]	Cb[2]	Y ₀ [2]	Cr[2]	Y ₁ [2]	
VPA[3]	Cb[3]/B[3]	B[3]	Cb[3]	Y ₀ [3]	Y ₁ [3]	Cb[3]	Y ₀ [3]	Cr[3]	Y ₁ [3]	
VPA[4]	Cb[4]/B[4]	B[4]	Cb[4]	Cb[0]	Cr[0]	L	L	L	L	
VPA[5]	Cb[5]/B[5]	B[5]	Cb[5]	Cb[1]	Cr[1]	L	L	L	L	
VPA[6]	Cb[6]/B[6]	B[6]	Cb[6]	Cb[2]	Cr[2]	L	L	L	L	
VPA[7]	Cb[7]/B[7]	B[7]	Cb[7]	Cb[3]	Cr[3]	L	L	L	L	
Video port B										
VPB[0]	Y[0]/G[0]	G[0]	Y[0]	Y ₀ [4]	Y ₁ [4]	Cb[4]	Y ₀ [4]	Cr[4]	Y ₁ [4]	
VPB[1]	Y[1]/G[1]	G[1]	Y[1]	Y ₀ [5]	Y ₁ [5]	Cb[5]	Y ₀ [5]	Cr[5]	Y ₁ [5]	
VPB[2]	Y[2]/G[2]	G[2]	Y[2]	Y ₀ [6]	Y ₁ [6]	Cb[6]	Y ₀ [6]	Cr[6]	Y ₁ [6]	
VPB[3]	Y[3]/G[3]	G[3]	Y[3]	Y ₀ [7]	Y ₁ [7]	Cb[7]	Y ₀ [7]	Cr[7]	Y ₁ [7]	
VPB[4]	Y[4]/G[4]	G[4]	Y[4]	Y ₀ [8]	Y ₁ [8]	Cb[8]	Y ₀ [8]	Cr[8]	Y ₁ [8]	
VPB[5]	Y[5]/G[5]	G[5]	Y[5]	Y ₀ [9]	Y ₁ [9]	Cb[9]	Y ₀ [9]	Cr[9]	Y ₁ [9]	

Table 23. Input format ...continued

L: recommend tied to LOW voltage, e.g. ground

Input pins	Signal	RGB	YCbCr						
		4 : 4 : 4	4 : 4 : 4	4 : 2 : 2 (semi-planar)		4 : 2 : 2 (ITU 656-like)			
VPB[6]	Y[6]/G[6]	G[6]	Y[6]	Y ₀ [10]	Y ₁ [10]	Cb[10]	Y ₀ [10]	Cr[10]	Y ₁ [10]
VPB[7]	Y[7]/G[7]	G[7]	Y[7]	Y ₀ [11]	Y ₁ [11]	Cb[11]	Y ₀ [11]	Cr[11]	Y ₁ [11]

Video port C

VPC[0]	Cr[0]/R[0]	R[0]	Cr[0]	Cb[4]	Cr[4]	L	L	L	L
VPC[1]	Cr[1]/R[1]	R[1]	Cr[1]	Cb[5]	Cr[5]	L	L	L	L
VPC[2]	Cr[2]/R[2]	R[2]	Cr[2]	Cb[6]	Cr[6]	L	L	L	L
VPC[3]	Cr[3]/R[3]	R[3]	Cr[3]	Cb[7]	Cr[7]	L	L	L	L
VPC[4]	Cr[4]/R[4]	R[4]	Cr[4]	Cb[8]	Cr[8]	L	L	L	L
VPC[5]	Cr[5]/R[5]	R[5]	Cr[5]	Cb[9]	Cr[9]	L	L	L	L
VPC[6]	Cr[6]/R[6]	R[6]	Cr[6]	Cb[10]	Cr[10]	L	L	L	L
VPC[7]	Cr[7]/R[7]	R[7]	Cr[7]	Cb[11]	Cr[11]	L	L	L	L

9.1 Timing parameters for video supported

TDA19989AET supports all EIA/CEA-861B standards and ATSC video input formats.

Table 24. Timing parameters for EIA/CEA-861B

EIA/CEA-861b Video code	Format	V frequency (Hz)	H total	V total	H frequency (kHz)	Pixel frequency (MHz)	Pixel repetition
59.94 Hz systems							
1 (VGA)	640 × 480p	59.9401	800	525	31.469	25.175	1
2, 3	720 × 480p	59.9401	858	525	31.469	27.000	1
4	1280 × 720p	59.9401	1650	750	44.955	74.175	1
5	1920 × 1080i	59.9401	2200	1125	33.716	74.175	1
6, 7 (NTSC)	1440 × 480i	59.9401	1716	525	15.734	27.000	2
8, 9	1440 × 240p	59.9401	1716	262	15.734	27.000	2
8, 9	1440 × 240p	59.9401	1716	263	15.734	27.000	2
10, 11	2880 × 480i	59.9401	3452	525	15.734	54.000	4 ^[1]
12, 13	2880 × 240p	59.9401	3452	262	15.734	54.000	4 ^[1]
12, 13	2880 × 240p	59.9401	3452	263	15.734	54.000	4 ^[1]
14, 15	1440 × 480p	59.9401	1716	525	31.469	54.000	2
16	1920 × 1080p	60.000	2200	1125	67.432	148.350	1
60 Hz systems							
1 (VGA)	640 × 480p	60.000	800	525	31.500	25.200	1
2, 3	720 × 480p	60.000	858	525	31.500	27.027	1
4	1280 × 720p	60.000	1650	750	45.000	74.250	1
5	1920 × 1080i	60.000	2200	1125	33.750	74.250	1
6, 7 (NTSC)	1440 × 480i	60.000	1716	525	15.750	27.027	2
8, 9	1440 × 240p	60.000	1716	262	15.750	27.027	2
8, 9	1440 × 240p	60.000	1716	263	15.750	27.027	2

Table 24. Timing parameters for EIA/CEA-861B ...continued

EIA/CEA-861b Video code	Format	V frequency (Hz)	H total	V total	H frequency (kHz)	Pixel frequency (MHz)	Pixel repetition
10, 11	2880 × 480i	60.000	3452	525	15.750	54.054	4 ^[1]
12, 13	2880 × 240p	60.000	3452	262	15.750	54.054	4 ^[1]
12, 13	2880 × 240p	60.000	3452	263	15.750	54.054	4 ^[1]
14, 15	1440 × 480p	60.000	1716	525	31.500	54.054	2
16	1920 × 1080p	60.000	2200	1125	67.500	148.50	1
50 Hz systems							
17, 18	720 × 576p	50.000	864	625	31.250	27.000	1
19	1280 × 720p	50.000	1980	750	37.500	74.250	1
20	1920 × 1080i	50.000	2640	1125	28.125	74.250	1
21, 22 (PAL)	1440 × 576i	50.000	1728	625	15.625	27.000	2
23, 24	1440 × 288p	50.000	1728	312	15.625	27.000	2
23, 24	1440 × 288p	50.000	1728	313	15.625	27.000	2
23, 24	1440 × 288p	50.000	1728	314	15.625	27.000	2
25, 26	2880 × 576i	50.000	3456	625	15.625	54.000	4 ^[1]
27, 28	2880 × 288p	50.000	3456	312	15.625	54.000	4 ^[1]
27, 28	2880 × 288p	50.000	3456	313	15.625	54.000	4 ^[1]
27, 28	720 × 288p	50.000	3456	314	15.625	54.000	4
29, 30	1440 × 576p	50.000	1728	625	31.250	54.000	2
31	1920 × 1080p	50.000	2640	1125	56.250	148.50	1
Various systems							
32	1920 × 1080p	23.976	2750	1125	26.973	74.175824	1
32	1920 × 1080p	24	2750	1125	27	74.25	1
33	1920 × 1080p	25	2640	1125	28.125	74.25	1
34	1920 × 1080p	29.97	2200	1125	33.716	74.175824	1
34	1920 × 1080p	30	2200	1125	33.75	74.25	1

[1] Format can also be defined with a repetition factor of up to 10.

Table 25. Timing parameters for ATSC DTV standards, which are not defined in EIA/CEA-861B

Standard	Format	V frequency (Hz)	H total	V total	H frequency (kHz)	Pixel frequency (MHz)	Pixel repetition
SMPTE-296M	1280 × 720p	30.000	3300	750	22.500	74.250	1
SMPTE-296M	1280 × 720p	29.970	3300	750	22.478	74.175	1
SMPTE-296M	1280 × 720p	25.000	3960	750	18.750	74.250	1
SMPTE-296M	1280 × 720p	23.976	4125	750	17.982	74.175	1

9.2 Timing parameters for PC standards supported

TDA19989AET can support all major PC Standards up to 150 MHz.

Table 26. Timing parameters for PC standards below 150 MHz

Standard	Format	V frequency (Hz)	H total	V total	H frequency (kHz)	Pixel frequency (MHz)	Pixel repetition
	640 × 350p	85.080	832	445	37.861	31.500	-
	640 × 400p	85.080	832	445	37.861	31.500	-
	720 × 400p	85.039	936	446	37.927	35.500	-
0.31M3 VGA	640 × 480p	59.940	800	525	31.469	25.175	-
	640 × 480p	72.809	832	520	37.861	31.500	-
	640 × 480p	75.000	840	500	37.500	31.500	-
	640 × 480p	85.008	832	509	43.269	36.000	-
0.48M3 SVGA	800 × 600p	56.250	1024	625	35.156	36.000	-
	800 × 600p	60.317	1056	628	37.879	40.000	-
	800 × 600p	72.188	1040	666	48.077	50.000	-
	800 × 600p	75.000	1056	625	46.875	49.500	-
	800 × 600p	85.061	1048	631	53.674	56.250	-
0.48M3-R	800 × 600p	119.972	960	636	76.302	73.250	-
0.41M9	848 × 480p	60.000	1088	517	31.020	33.750	-
0.79M3 XGA	1024 × 768p	60.004	1344	806	48.363	65.000	-
	1024 × 768p	70.069	1328	806	56.476	75.000	-
	1024 × 768p	75.029	1312	800	60.023	78.750	-
	1024 × 768p	84.997	1376	808	68.677	94.500	-
	1024 × 768i	86.957	1264	817	35.522	44.900	-
0.79M3-R XGA	1024 × 768p	119.989	1184	813	97.551	115.500	-
1.00M3	1152 × 864p	75.000	1600	900	67.500	108.000	-
0.98M9-R	1280 × 768p	59.995	1440	790	47.396	68.250	-
	1280 × 768p	119.798	1440	813	97.396	140.250	-
0.98M9	1280 × 768p	59.870	1664	798	47.776	79.500	-
	1280 × 768p	74.893	1696	805	60.289	102.250	-
	1280 × 768p	84.837	1712	809	68.633	117.500	-
1.02MA-R	1280 × 800p	59.910	1440	823	49.306	71.000	-
	1280 × 800p	119.909	1440	847	101.563	146.250	-
1.02MA	1280 × 800p	59.810	1680	831	49.702	83.500	-
	1280 × 800p	74.934	1696	838	62.795	106.500	-
	1280 × 800p	84.880	1712	843	71.554	122.500	-
1.23M3	1280 × 960p	60.000	1800	1000	60.000	108.000	-
	1280 × 960p	85.002	1728	1011	85.938	148.500	-
1.31M4 SXGA	1280 × 1024p	60.020	1688	1066	63.981	108.000	-
	1280 × 1024p	75.025	1688	1066	79.976	135.000	-
1.04M9	1360 × 768p	60.015	1792	795	47.712	85.500	-
1.04M9-R	1360 × 768p	119.967	1520	813	97.533	148.250	-

Table 26. Timing parameters for PC standards below 150 MHz ...continued

Standard	Format	V frequency (Hz)	H total	V total	H frequency (kHz)	Pixel frequency (MHz)	Pixel repetition
1.47M3-R	1400 × 1050p	59.948	1560	1080	64.744	101.000	-
1.47M3	1400 × 1050p	59.978	1864	1089	65.317	121.750	-
1.29MA-R	1440 × 900p	59.901	1600	926	55.469	88.750	-
1.29MA	1440 × 900p	59.887	1904	934	55.935	106.500	-
	1440 × 900p	74.984	1936	942	70.635	136.750	-
1.76MA-R	1680 × 1050p	59.883	1840	1080	64.674	119.000	-
1.76MA	1680 × 1050p	59.954	2240	1089	65.290	146.250	-

10. Limiting values

Table 27. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit	
V _{DDA(TMDS)(1V8)}	TMDS analog supply voltage (1.8 V)		-0.5	+2.5	V	
V _{DDA(PLL)(1V8)}	PLL analog supply voltage (1.8 V)		-0.5	+2.5	V	
V _{DDA(1V8)}	analog supply voltage (1.8 V)		-0.5	+2.5	V	
V _{DDD(IO)(1V8)}	I/O digital supply voltage (1.8V)		-0.5	+2.5	V	
V _{DDDC}	core digital supply voltage		-0.5	+2.5	V	
ΔV _{DD}	supply voltage difference		-2	+2	V	
V _{ESD}	electrostatic discharge voltage	EIA/JESD22-A114 (HBM)	[1]	-2500	+2500	V
		EIA/JESD22-C101-C (FCDM)	[2]	1000	-	V

[1] On TMDS outputs.

[2] It withstands class III of JEDEC classification.

11. Thermal characteristics

Table 28. Thermal characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
R _{th(j-a)}	thermal resistance from junction to ambient	in free air; JEDEC 4L board	-	56.9	-	K/W
R _{th(j-c)}	thermal resistance from junction to case		-	15.1	-	K/W
T _{stg}	storage temperature		-	-	+150	°C
T _{amb}	ambient temperature		-20	-	+85	°C
T _j	junction temperature		-	-	+125	°C

12. Static characteristics

Table 29. Supplies

$T_{amb} = -20\text{ °C to }+85\text{ °C}$; without HDCP; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{DDDC}	core digital supply voltage		[1] 1.7	1.8	1.9	V
$V_{DDA(TMDS)(1V8)}$	TMDS analog supply voltage (1.8 V)		1.7	1.8	1.9	V
$V_{DDA(PLL)(1V8)}$	PLL analog supply voltage (1.8 V)		1.7	1.8	1.9	V
$V_{DDA(1V8)}$	analog supply voltage (1.8 V)		1.7	1.8	1.9	V
$V_{DDD(IO)(1V8)}$	I/O digital supply voltage (1.8V)		1.7	1.8	1.9	V
$I_{DDA(sum)(1V8)}$	sum analog supply current (1.8 V)	$I_{DDA(sum)(1V8)} = I_{DDA(TMDS)(1V8)} + I_{DDA(1V8)}$	[2] 15	19	22	mA
$I_{DDA(PLL)(1V8)}$	PLL analog supply current (1.8 V)		[2] -	6	9	mA
$I_{DDD(IO)(1V8)}$	input/output digital supply current (1.8 V)		[2] -	40	60	μ A
$I_{DDDC(1V8)}$	core digital supply current (1.8 V)		[2] -	52	72	mA
			[3] -	32	40	mA
			[2] -	140	230	mW
P_{cons}	power consumption		[3] -	90	115	mW
		Sleep mode with CEC	-	1.8	4.5	mW
		Sleep mode without CEC	-	1.5	4	mW
		Standby mode	-	400	650	μ W
			[4] -	252	300	mW
P_{tot}	total power dissipation		[5] -	202	260	mW

[1] see [Table 6](#).

[2] Input format: 1080p, any color space; output format: 1080p any color space: 30 % activity on video input ports.

[3] Input format: 1080i YCbCr 4 : 2 : 2; output format: YCbCr 4 : 2 : 2; CEC feature disable: 30 % activity on video input ports.

[4] Same as [Table note \[2\]](#) with TMDS output current added.

[5] Same as [Table note \[3\]](#) with TMDS output current added.

Table 30. Digital inputs and outputs

$T_{amb} = -20\text{ °C to }+85\text{ °C}$; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Not 5 V tolerant CMOS 1.8 V and CMOS 3.3 V tolerant digital input pins HSYNC, VSYNC, APn, ACLK, VPA[n], VPB[n], VPC[n], VCLK, DE						
V_{IL}	LOW-level input voltage	-	0	-	0.75	V
V_{IH}	HIGH-level input voltage	-	1.4	-	-	V
I_{IL}	LOW-level input current	-	-2	-	+2	μA
I_{IH}	HIGH-level input current	-	-2	-	+2	μA
C_i	input capacitance	-	-	4.5	-	pF
5 V tolerant input pin HPD						
V_{IL}	LOW-level input voltage	-	0	-	0.8	V
V_{IH}	HIGH-level input voltage	-	2	-	-	V
C_i	input capacitance	-	-	4.5	-	pF
CMOS 1.8 V and CMOS 3.3 V tolerant digital input/output pin INT						
V_{IL}	LOW-level input voltage	-	0	-	0.85	V
V_{IH}	HIGH-level input voltage	-	1.4	-	-	V
V_{OL}	LOW-level output voltage	$C_L = 10\text{ pF}; I_{OL} = 2\text{ mA}$	0	-	0.4	V
5 V tolerant master bus: DDC-bus pins DSDA, DSCL^[1]						
V_{OL}	LOW-level output voltage	-	0	-	0.4	V
V_{IL}	LOW-level input voltage	-	0	-	0.6	V
V_{IH}	HIGH-level input voltage	-	1.4	-	5.5	V
1.8 V to 3.3 V tolerant slave bus: I²C-bus input/output pins CSCL, CSDA^[1]						
V_{OL}	LOW-level output voltage	-	0	-	0.4	V
V_{IL}	LOW-level input voltage	-	0	-	0.6	V
V_{IH}	HIGH-level input voltage	-	1.4	-	5.5	V
CEC input/output^[2] pin						
V_{OL}	LOW-level output voltage	-	0	-	0.4	V
V_{OH}	HIGH-level output voltage	-	2.5	-	3.6	V
V_{IL}	LOW-level input voltage	-	0	-	0.60	V
V_{IH}	HIGH-level input voltage	-	2.5	-	3.6	V
$V_{hys(i)}$	input hysteresis voltage	-	^[2] -	0.27	-	V
TMDS output pins: TX0-, TX0+, TX1-, TX1+, TX2-, TX2+, TXC- and TXC+						
$V_{O(dif)}$	differential output voltage	$R_{EXT_SWING} = 10\text{ k}\Omega \pm 1\%$	400	505	600	mV

[1] See [Section 7.1](#) and refer to the *I²C-bus specification version 2.1* (document order number 9398 393 40011).

[2] For information, input hysteresis is normally supplied by the microprocessor input circuit: in this circumstance, external hysteresis circuitry is not needed.

13. Dynamic characteristics

Table 31. Timing characteristics

$T_{amb} = -20\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Clock input: pin VCLK						
$f_{clk(max)}$	maximum clock frequency	-	-	-	148.5	MHz
$t_{su(D)}$	data input set-up time	see Figure 18 and 19	1.6	-	-	ns
$t_{h(D)}$	data input hold time	see Figure 18 and 19	1.2	-	-	ns
δ_{clk}	clock duty cycle		[1] 30	50	70	%
f_{clk}	clock frequency	CEC	-	12	-	MHz
DDC-bus: pins DSDA, DSCL (5 V tolerant) master bus[2]						
f_{SCL}	SCL frequency	Standard mode	-	-	100	kHz
C_i	capacitance for each I/O pin		-	7	-	pF
I²C-bus: pins CSCL, CSDA (5 V tolerant) slave bus[2]						
f_{SCL}	SCL frequency	Standard mode	-	-	100	kHz
		Fast mode	-	-	400	kHz
$t_{stretch}$	stretch time	CEC	-	80	-	μ s
CEC input/output[3]						
t_r	rise time	10 % to 90 %	-	-	50	μ s
t_f	fall time	10 % to 90 %	-	-	2	μ s
TMDS output pins: TXC- and TXC+						
$f_{clk(max)}$	maximum clock frequency	on the TMDS link	-	-	148.5	MHz
TMDS output pins: TX0-, TX0+, TX1-, TX1+, TX2- and TX2+						
$f_{clk(max)}$	maximum clock frequency		-	-	1.485	GHz

[1] $\delta_{clk} = t_{clk(H)} / (t_{clk(H)} + t_{clk(L)})$.

[2] See [Section 7.1](#) and refer to the *I²C-bus specification version 2.1* (document order number 9398 393 40011).

[3] For details about CEC electrical specification, see *HDMI 1.4 specification*.

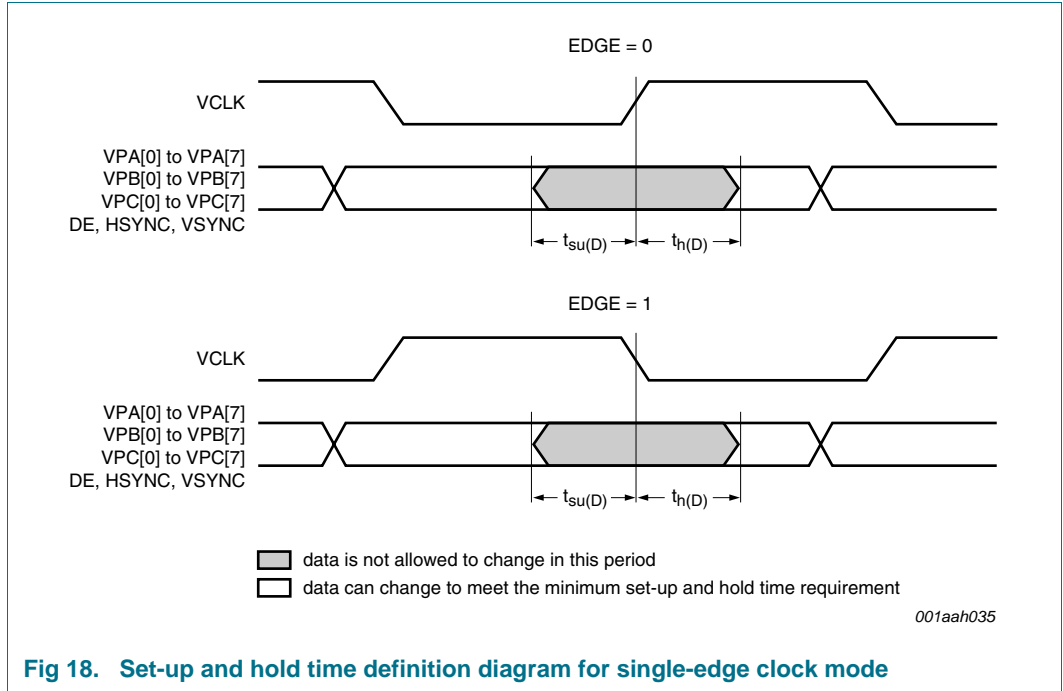


Fig 18. Set-up and hold time definition diagram for single-edge clock mode

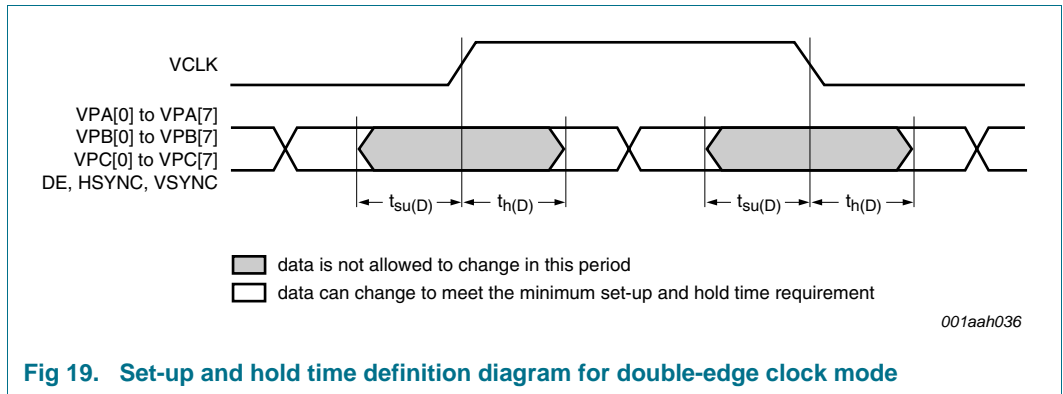


Fig 19. Set-up and hold time definition diagram for double-edge clock mode

14. Application information

14.1 Transmitter connection with external world

Figure 20 and Figure 21 refer to a simple receiver application. However, TDA19989AET can be part of a repeater application as described in "HDMI specification 1.4".

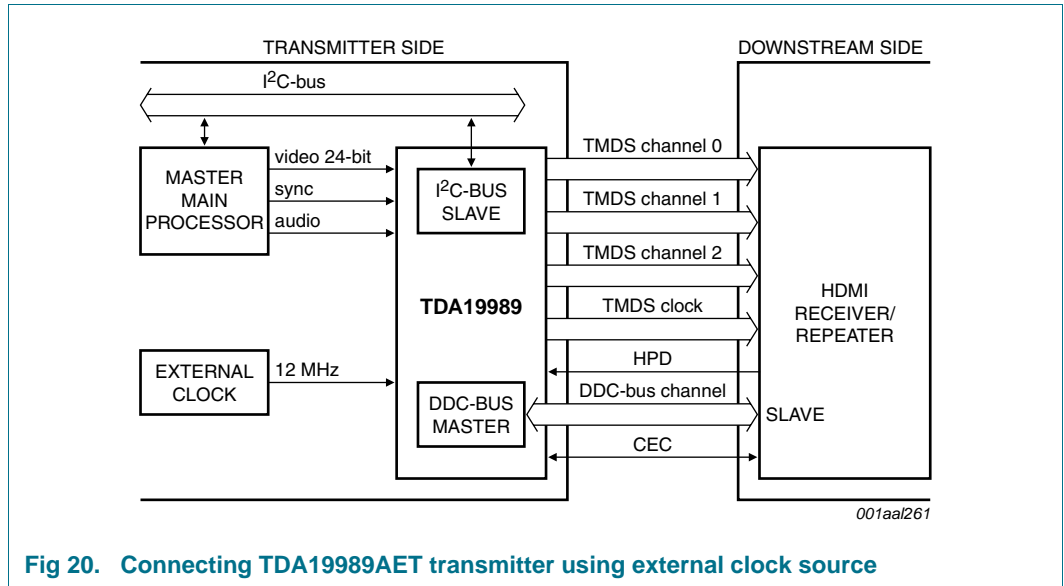


Fig 20. Connecting TDA19989AET transmitter using external clock source

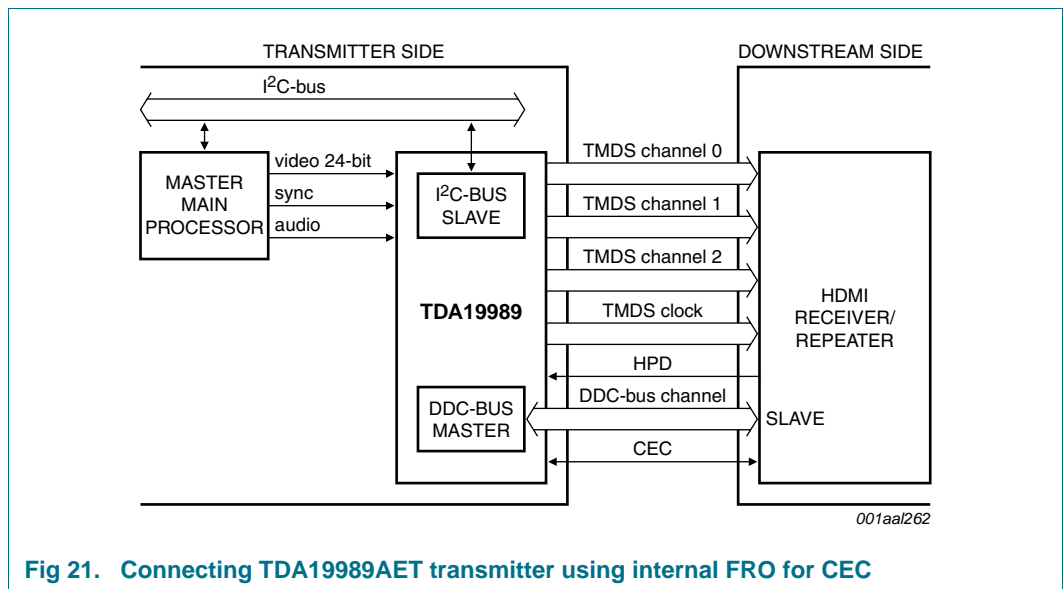


Fig 21. Connecting TDA19989AET transmitter using internal FRO for CEC

15. Package outline

TFBGA64: plastic thin fine-pitch ball grid array package; 64 balls

SOT962-3

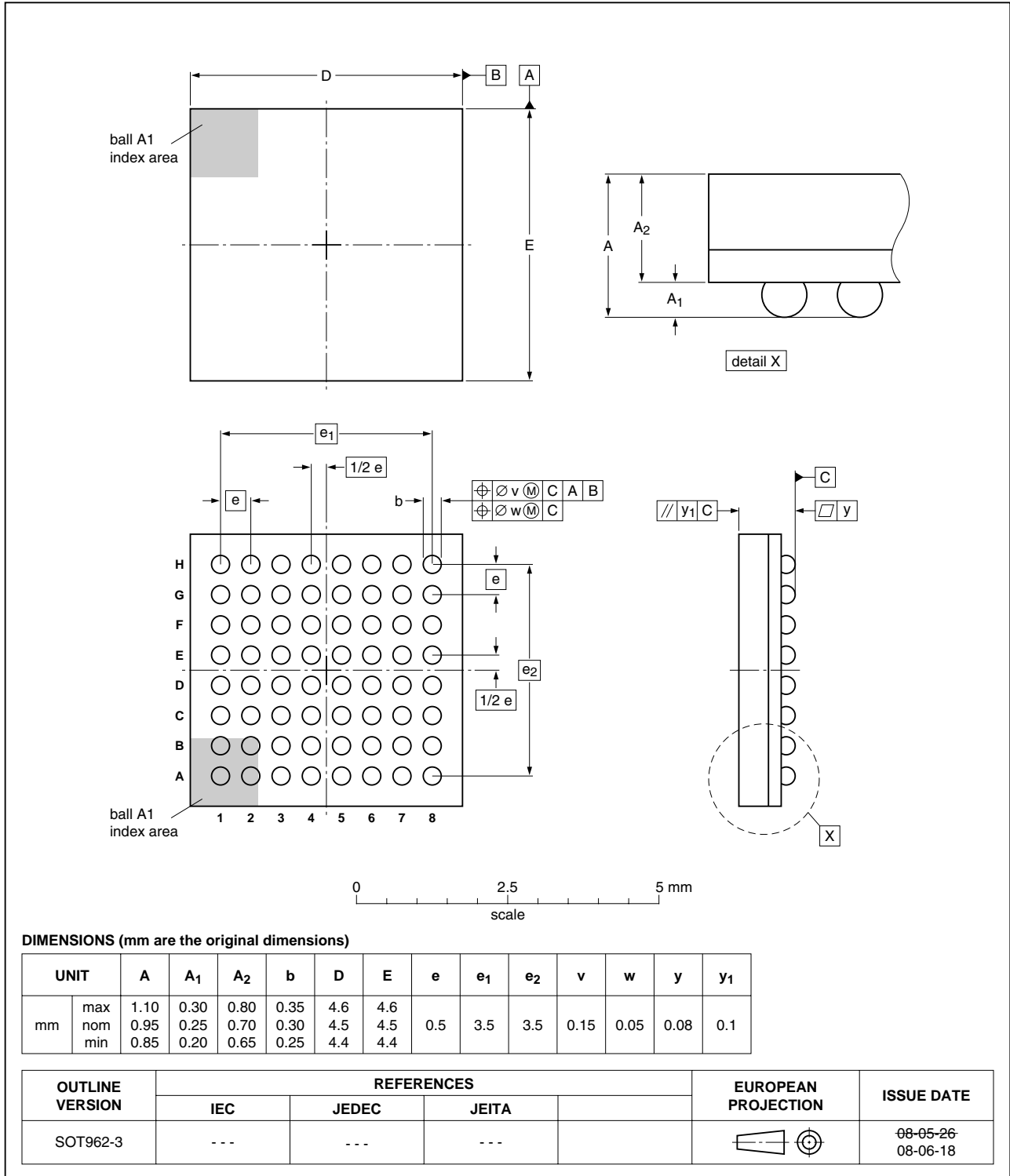


Fig 22. Package outline SOT962-3 (TFBGA64)

16. Abbreviations

Table 32. Abbreviations

Acronym	Description
AC3	Active Coding-3
ACP	Audio Content Protection
ACR	Audio Clock Recovery
ATSC	Advanced Television Systems Committee
AV	Audio Video
BOM	Bill Of Materials
CEA	Consumer Electronics Association
CEC	Consumer Electronics Control
CTS/N	Clock Time Stamp integer divider
DDC	Display Data Channel
DDR	Double Data Rate
DE	Data Enable
DSC	Digital Still Camera
DTS	Digital Transmission System
DTV	Desk Top Video
DVC	Digital Video Camera
DVD	Digital Versatile Disc
DVI	Digital Visual Interface
EAV	End Active Video
EDID	Extended Display Identification Data
E-EDID	Enhanced Extended Display Identification Data
EIA	Electronic Industries Alliance
FCDM	Field Charged Device Model
FIFO	First In, First Out
FREF	Field REFerence
FRO	Free Running Oscillator
HBM	Human Body Model
HDCP	High-bandwidth Digital Content Protection
HDMI	High-Definition Multimedia Interface
HPD	Hot Plug Detection
HREF	Horizontal REFerence
HSYNC	Horizontal SYNChronization
LSB	Least Significant Bit
LV-CMOS	Low Voltage Complementary Metal-Oxide Semiconductor
MPEG	Moving Picture Experts Group
MSB	Most Significant Bit
OTP	One Time Programming
PC	Personal Computer
PCB	Printed Circuit Board

Table 32. Abbreviations ...continued

Acronym	Description
PCM	Pulse Code Modulation
PLL	Phase-Locked Loop
PMP	Portable Multimedia Player
POR	Power-On Reset
RGB	R = red, G = green, B = blue
SAV	Start Active Video
SDR	Single Data Rate
SMPTE	Society of Motion Picture and Television Engineers
S/PDIF	Sony/Philips Digital Interface
STB	Set-Top Box
TMDS	Transition Minimized Differential Signalling
UM PC	Ultra-Mobile Personal Computer
UXGA60	Ultra Extended Graphics Array
VHREF	Vertical Horizontal REFerence
VREF	Vertical REFerence
VSYNC	Vertical SYNChronization
YCbCr	Y = luminance, Cb = Chroma component blue, Cr = Chroma component red
WS	Word Select

17. Revision history

Table 33. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
TDA19989AET_2	20100518	Product data sheet	-	TDA19989_1
Modifications:	<ul style="list-style-type: none"> • Renamed TDA19989 by TDA19989AET • All document: replaced HDMI 1.3 by HDMI 1.4 • Section 7.6: updated • Table 19: updated • Table 29: updated • Table 31: updated 			
TDA19989_1	20100215	Preliminary data sheet	-	-

18. Legal information

18.1 Data sheet status

Document status ^{[1][2]}	Product status ^[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL <http://www.nxp.com>.

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20. Tables

Table 1. Ordering information	3	downsampler	18
Table 2. Pin description	5	Table 16. Audio port configuration	20
Table 3. Internal assignment	8	Table 17. TDA19989AET typical power consumption in different configurations	22
Table 4. Video input swap to VP[23:20]	10	Table 18. Interruptions	23
Table 5. TDA19989AET input/output capability	11	Table 19. Receiver detection according to averaged terminal voltage	24
Table 6. Inputs of video input formatter	12	Table 20. Pixel repetition	27
Table 7. RGB (3 ´ 8-bit) external synchronization input (rising edge) mapping	13	Table 21. HDMI core I ² C-bus address	29
Table 8. YCbCr 4 : 4 : 4 (3 ´ 8-bit) external synchronization input (rising edge) mapping	13	Table 22. CEC core I ² C-bus address	29
Table 9. YCbCr 4 : 2 : 2 ITU656-like external synchronization input (rising edge) mapping	14	Table 23. Input format	30
Table 10. YCbCr 4 : 2 : 2 ITU656-like external synchronization input (double edge) mapping	15	Table 24. Timing parameters for EIA/CEA-861B	31
Table 11. YCbCr 4 : 2 : 2 ITU656-like embedded synchronization input (rising edge) mappings	15	Table 25. Timing parameters for ATSC DTV standards, which are not defined in EIA/CEA-861B	32
Table 12. YCbCr 4 : 2 : 2 ITU656-like embedded synchronization input (double edge) mapping	16	Table 26. Timing parameters for PC standards below 150 MHz	33
Table 13. YCbCr 4 : 2 : 2 semi-planar external synchronization input (rising edge) mapping	17	Table 27. Limiting values	34
Table 14. YCbCr 4 : 2 : 2 semi-planar embedded synchronization input (rising edge) mapping	17	Table 28. Thermal characteristics	34
Table 15. Use of color space converter, upsampler and downsampler	18	Table 29. Supplies	35
		Table 30. Digital inputs and outputs	36
		Table 31. Timing characteristics	37
		Table 32. Abbreviations	41
		Table 33. Revision history	42

21. Figures

Fig 1. TDA19989AET high-level block diagram	2	Fig 19. Set-up and hold time definition diagram for double-edge clock mode	38
Fig 2. TDA19989AET Block diagram	4	Fig 20. Connecting TDA19989AET transmitter using external clock source	39
Fig 3. Pin configuration (TFBGA64)	5	Fig 21. Connecting TDA19989AET transmitter using internal FRO for CEC	39
Fig 4. Internal assignment of VP[23:0]	8	Fig 22. Package outline SOT962-3 (TFBGA64)	40
Fig 5. Pixel encoding RGB 4 : 4 : 4 external synchronization input (rising edge)	13		
Fig 6. Pixel encoding YCbCr 4 : 4 : 4 external synchronization input (rising edge)	14		
Fig 7. Pixel encoding YCbCr 4 : 2 : 2 ITU656-like external synchronization input (rising edge)	14		
Fig 8. Pixel encoding YCbCr 4 : 2 : 2 ITU656-like external synchronization input (double edge)	15		
Fig 9. Pixel encoding YCbCr 4 : 2 : 2 ITU656-like embedded synchronization input (rising edge)	16		
Fig 10. Pixel encoding YCbCr 4 : 2 : 2 ITU656-like embedded synchronization input (double edge)	16		
Fig 11. Pixel encoding YCbCr 4 : 2 : 2 semi-planar external input synchronization (rising edge)	17		
Fig 12. Pixel encoding YCbCr 4 : 2 : 2 semi-planar embedded synchronization input (rising edge)	18		
Fig 13. I ² S-bus formats	21		
Fig 14. Audio input swap to I ² S-bus channel 0 or S/PDIF	22		
Fig 15. Receiver sensitivity detection	24		
Fig 16. Modules involved in CEC clock calibration process	26		
Fig 17. I ² C-bus access	29		
Fig 18. Set-up and hold time definition diagram for single-edge clock mode	38		

22. Contents

1	General description	1	7.11.1	High-bandwidth digital content protection	25
2	Features and benefits	2	7.11.1.1	Repeater function.	25
3	Applications	3	7.11.1.2	SHA-1	25
4	Ordering information	3	7.12	CEC	25
5	Block diagram	4	7.12.1	Features.	25
6	Pinning information	5	7.12.2	Clock	26
6.1	Pinning	5	7.12.3	CEC interrupt	26
6.2	Pin description	5	7.12.4	Power-On Reset (POR)	27
7	Functional description	7	7.12.5	Repeater function.	27
7.1	System clock	7	7.13	HDMI core	27
7.2	Video input formatter	8	7.13.1	Output TMDS buffers.	27
7.2.1	Description	8	7.13.1.1	Digitally controlled signal amplitude.	27
7.2.2	Internal assignment	8	7.13.2	Pixel repetition	27
7.2.3	Input format mappings	12	7.13.3	DDC-bus channel.	27
7.2.3.1	RGB 4 : 4 : 4 external synchronization (rising edge)	13	7.14	E-EDID	28
7.2.3.2	YCbCr 4 : 4 : 4 external synchronization (rising edge)	13	7.14.1	E-EDID reading	28
7.2.3.3	YCbCr 4 : 2 : 2 ITU656-like external synchronization (rising edge)	14	7.14.2	HDMI and DVI receiver discrimination	28
7.2.3.4	YCbCr 4 : 2 : 2 ITU656-like external synchronization (double edge)	15	8	I²C-bus interface and register definitions	29
7.2.3.5	YCbCr 4 : 2 : 2 ITU656-like embedded synchronization (rising edge)	15	8.1	I ² C-bus protocol	29
7.2.3.6	YCbCr 4 : 2 : 2 ITU656-like embedded synchronization (double edge)	16	8.2	Memory page management	29
7.2.3.7	YCbCr 4 : 2 : 2 semi-planar external synchronization (rising edge)	17	8.3	ID version.	30
7.2.3.8	YCbCr 4 : 2 : 2 semi-planar embedded synchronization (rising edge)	17	8.4	Clock stretching	30
7.2.4	Synchronization	18	9	Input format	30
7.2.4.1	Timing extraction generator	18	9.1	Timing parameters for video supported	31
7.2.4.2	Data enable generator	18	9.2	Timing parameters for PC standards supported	33
7.3	Input and output video format.	18	10	Limiting values	34
7.4	Upsampler	19	11	Thermal characteristics	34
7.5	Color space converter.	19	12	Static characteristics	35
7.6	Gamut-related metadata.	19	13	Dynamic characteristics	37
7.7	Downsampler	19	14	Application information	39
7.8	Audio input format	19	14.1	Transmitter connection with external world	39
7.8.1	S/PDIF	20	15	Package outline	40
7.8.2	I ² S-bus	20	16	Abbreviations	41
7.8.3	Audio port internal assignment.	22	17	Revision history	42
7.9	Power management	22	18	Legal information	43
7.10	Interrupt controller	23	18.1	Data sheet status	43
7.10.1	Hot plug/unplug detect	23	18.2	Definitions	43
7.10.2	Receiver sensitivity.	23	18.3	Disclaimers	43
7.11	HDCP processing	25	18.4	Licenses	44
			18.5	Trademarks	44
			19	Contact information	44
			20	Tables	45
			21	Figures	45
			22	Contents	46

Please be aware that important notices concerning this document and the product(s) described herein, have been included in section 'Legal information'.