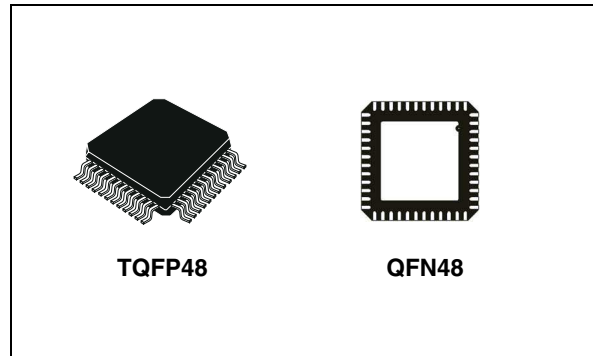


## Adaptive single 3.4 Gbps TMDS/HDMI signal equalizer

### Features

- Compatible with the high-definition multimedia interface (HDMI) v1.3 digital interface
- Conforms to the transition minimized differential signaling (TMDS) voltage standard on input and output channels
- 340 MHz maximum clock speed operation supports all video formats with deep color at maximum refresh rates
- 3.4 Gbps data rate per channel
- Fully automatic adaptive equalizer for cables lengths up to 25 m
- Single supply  $V_{CC}$ : 3.135 to 3.465 V
- ESD:  $> \pm 5$  KV HBM for all TMDS I/Os
- Integrated open-drain I<sup>2</sup>C buffer for display data channel (DDC)
- 5.3 V tolerant DDC and HPD I/Os
- Lock-up free operation of I<sup>2</sup>C bus
- 0 to 400 kHz clock frequency for I<sup>2</sup>C bus
- Low capacitance of all the channels
- Equalizer regenerates the incoming attenuated TMDS signal



- Buffer drives the TMDS outputs over long PCB track lengths
- Low output skew and jitter
- Tight input thresholds reduce bit error rates
- On-chip selectable 50  $\Omega$  input termination
- Low ground bounce
- Data and control inputs provide undershoot clamp diode
- Demonstration kit is available

**Table 1. Device summary**

Order code	Operating temperature	Package	Packaging
STDVE001ABTR	-40 °C to 85 °C	TQFP48	Tape and reel
STDVE001AQTR	-40 °C to 85 °C	QFN48	Tape and reel

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# 1 Description

The STDVE001A integrates a 4-channel 3.4 Gbps TMDS equalizer. High-speed data paths and flow-through pinout minimize the internal device jitter and simplify the board layout.

The equalizer overcomes the intersymbol interference (ISI) jitter effects from lossy cables. The buffer/driver on the output can drive the TMDS output signals over long distances. In addition to this, STDVE001A integrates the 50  $\Omega$  termination resistor on all the input channels to improve performance and reduce board space. The device can be placed in a low-power mode by disabling the output current drivers. The STDVE001A is ideal for advanced TV and STB applications supporting HDMI/DVI standard. The differential signal from the HDMI/DVI ports can be routed through the STDVE001A to guarantee good signal quality at the HDMI receiver. Designed for very low skew, jitter and low I/O capacitance, the switch preserves the signal integrity to pass the stringent HDMI compliance requirements.

## 2 Block diagram

Figure 1. STDVE001A block diagram

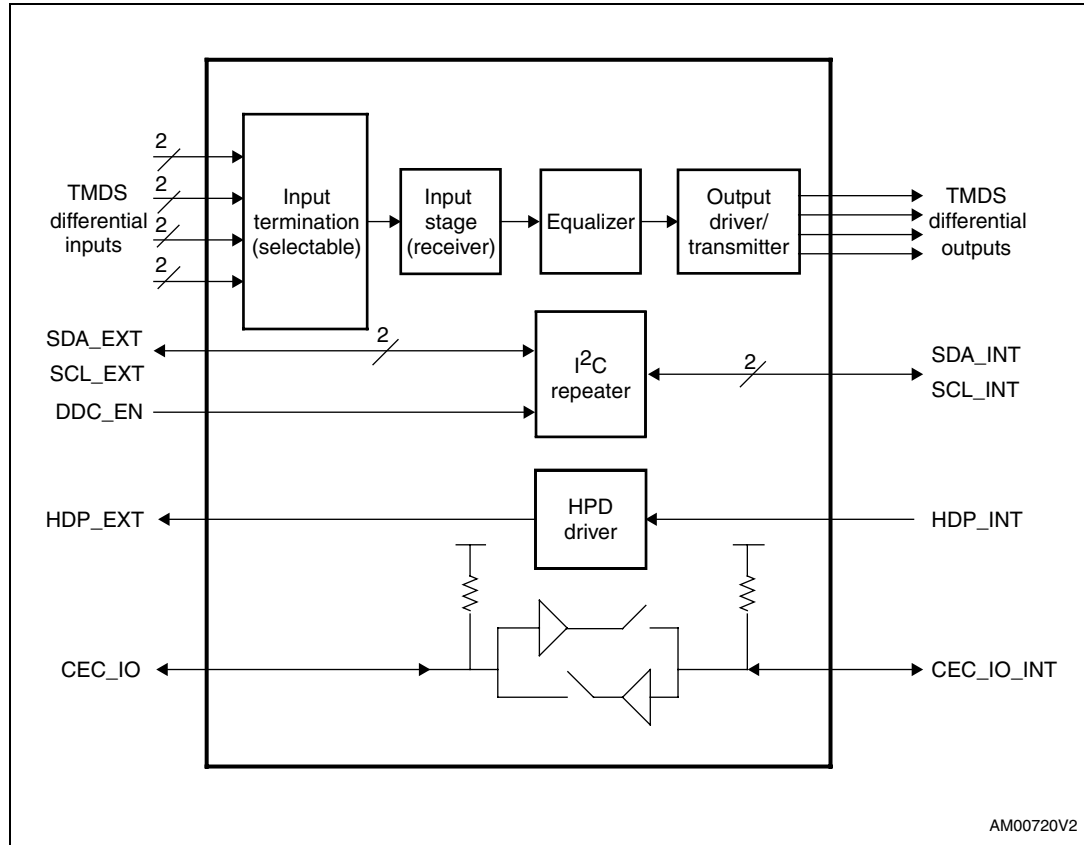


Figure 2. Equalizer functional diagram (one signal pair)

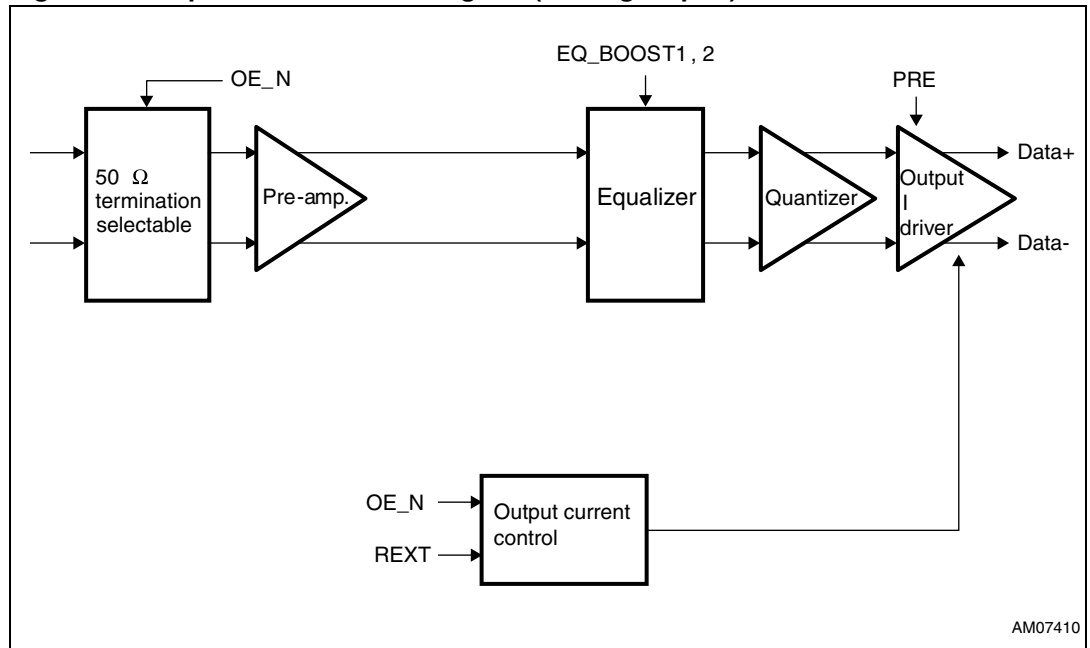
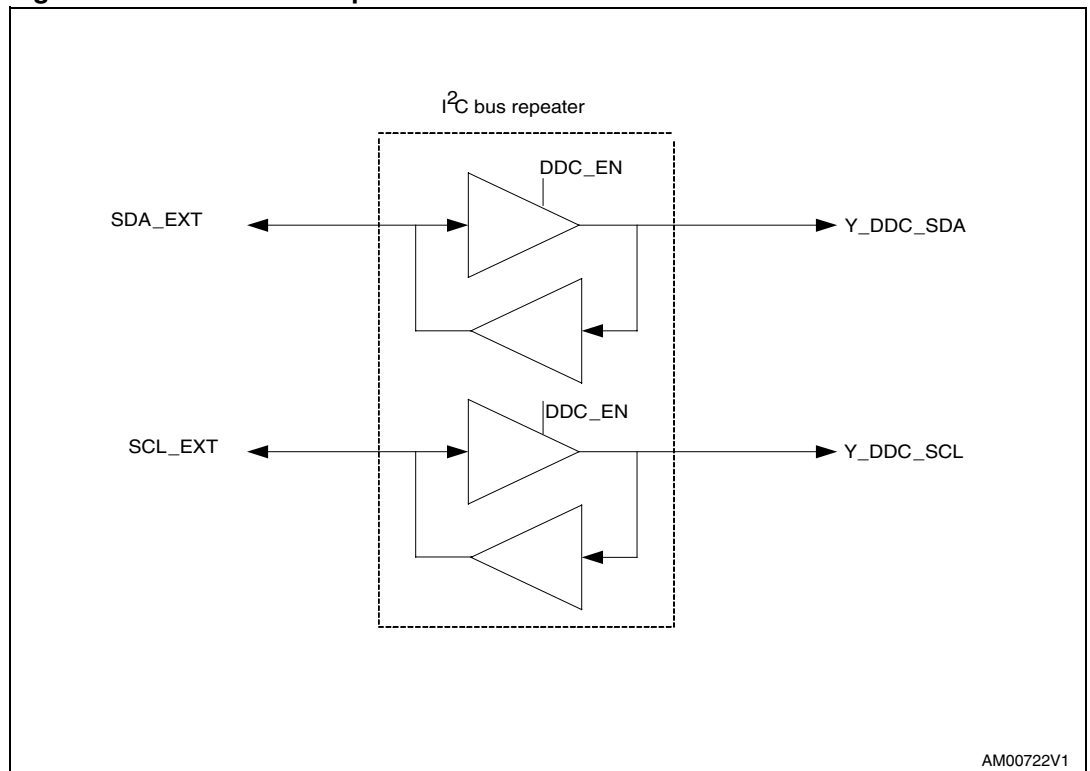
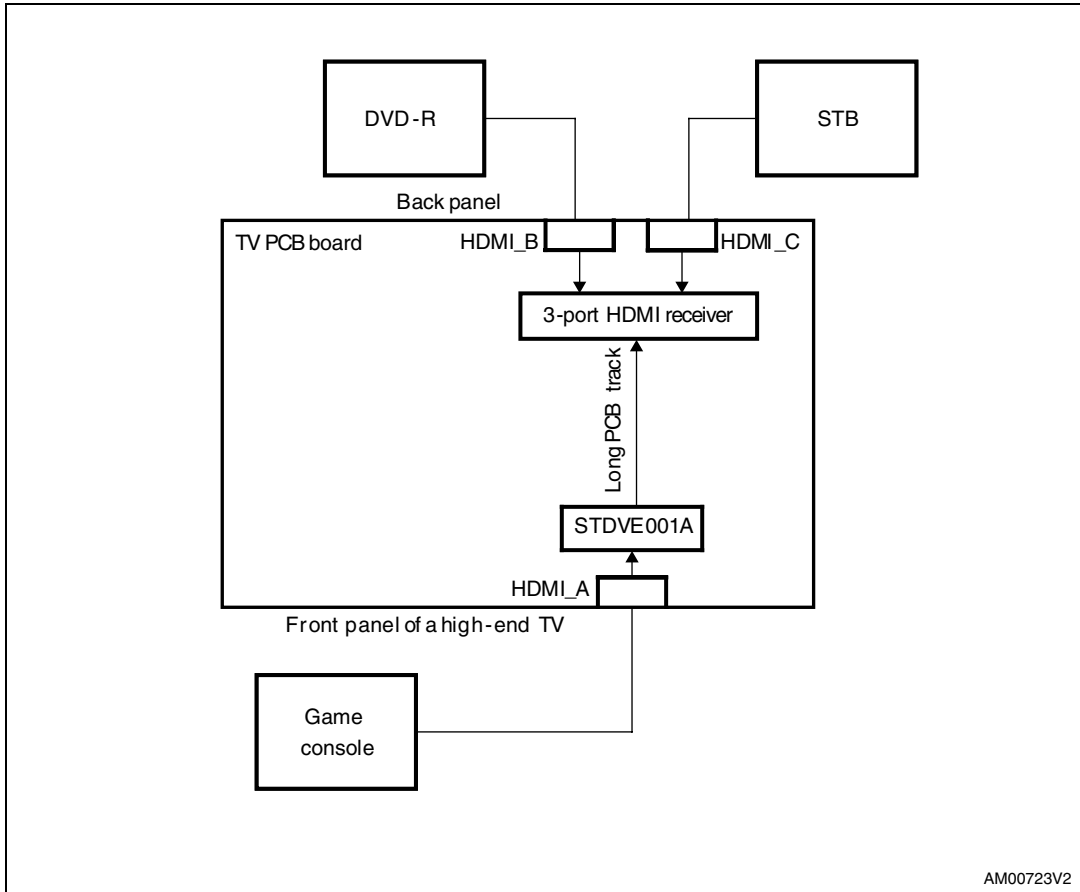


Figure 3. DDC I<sup>2</sup>C bus repeater



### 3 Application diagram

Figure 4. STDVE001A in a digital TV



# 4 Pin configuration

Figure 5. Pin configuration (TQFP48 package)

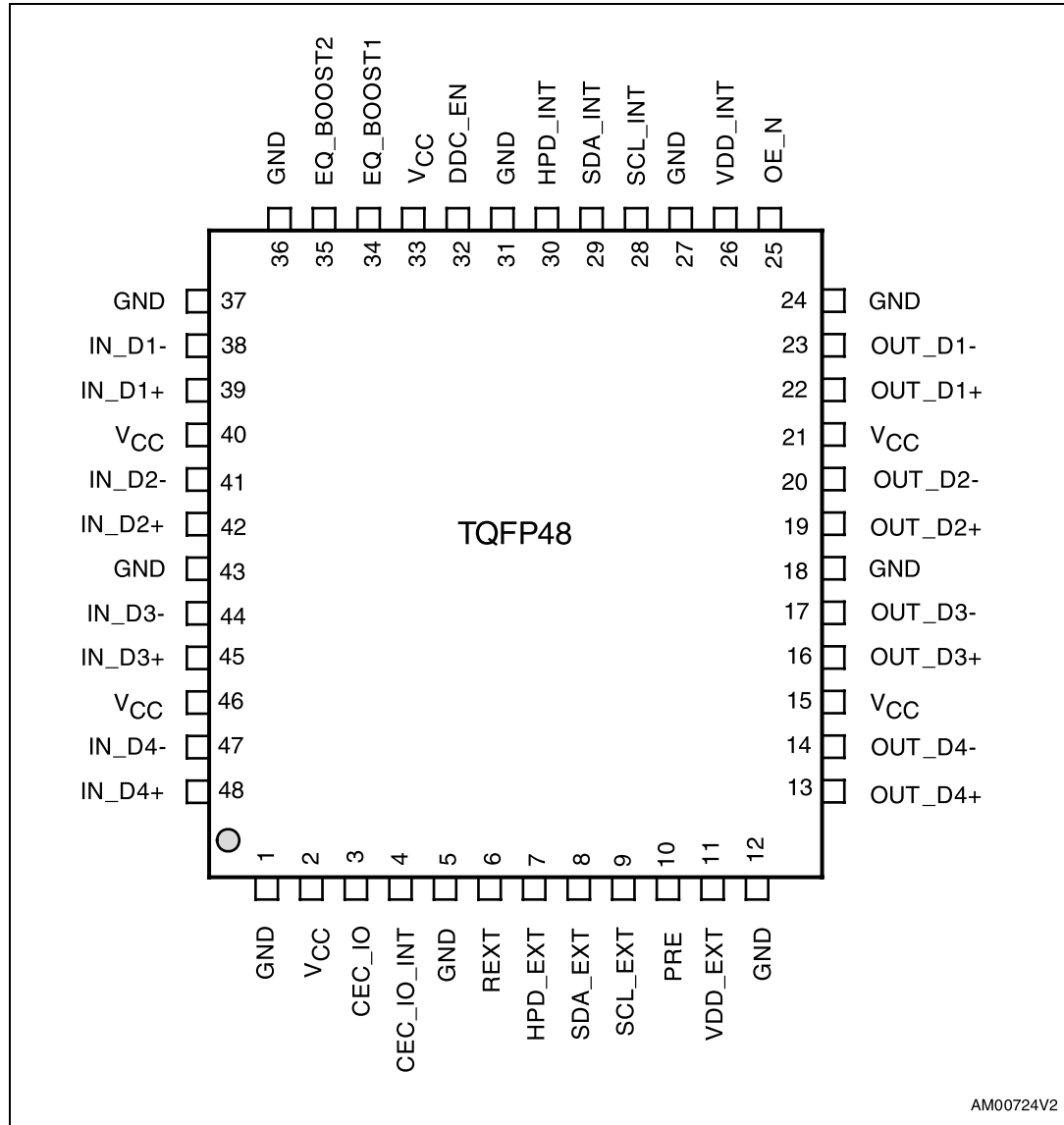
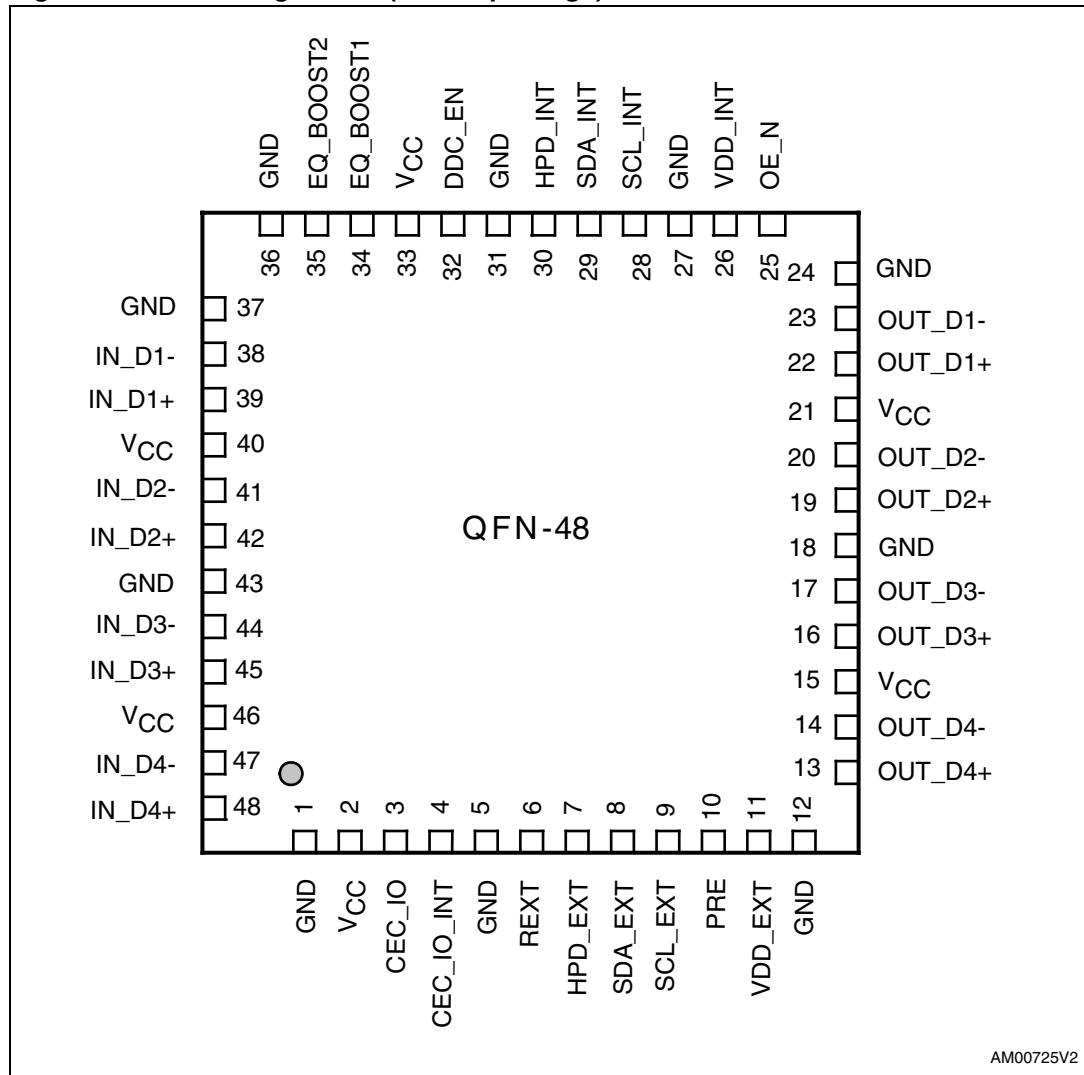


Figure 6. Pin configuration (QFN48 package)



**Table 2. Pin description**

Pin number	Pin name	Type	Function	
1	GND	Power	Ground	
2	VCC	Power	3.3 V ± 5% DC supply	
3	CEC_IO	I/O	CEC signal to/from the connector end	
4	CEC_IO_INT	I/O	CEC signal to/from TV end	
5	GND	Power	Ground	
6	REXT	Analog	Connect to GND through a 4.7 KΩ ± 1% precision reference resistor. Sets the output current to generate the output voltage compliant with TMDS.	
7	HPD_EXT	Output	0 to 5.0 V (nominal) output signal. Hot plug detector output. Open-drain output. Connect an external resistor according to the HDMI specification.	
8	SDA_EXT	I/O	DDC data I/O. Pulled-up by external termination to V <sub>CC</sub> .	
9	SCL_EXT	I/O	DDC clock I/O. Pulled-up by external termination to V <sub>CC</sub> .	
10	PRE	Input	TMDS output deemphasis adjustment	
			<b>PRE</b>	<b>Output deemphasis</b>
			0 V	0 dB
			3.3 V	3 dB
11	VDD_EXT	Power	DC supply for DDC, HPD and CEC (can be 5 V or 3.3 V or unconnected).	
12	GND	Power	Ground	
13	OUT_D4+	Output	HDMI 1.3 compliant TMDS output. OUT_D4+ makes a differential output signal with OUT_D4-.	
14	OUT_D4-	Output	HDMI 1.3 compliant TMDS output. OUT_D4- makes a differential output signal with OUT_D4+.	
15	VCC	Power	3.3 V ± 10% DC supply	
16	OUT_D3+	Output	HDMI 1.3 compliant TMDS output. OUT_D3+ makes a differential output signal with OUT_D3-.	
17	OUT_D3-	Output	HDMI 1.3 compliant TMDS output. OUT_D3- makes a differential output signal with OUT_D3+.	
18	GND	Power	Ground	
19	OUT_D2+	Output	HDMI 1.3 compliant TMDS output. OUT_D2+ makes a differential output signal with OUT_D2-.	
20	OUT_D2-	Output	HDMI 1.3 compliant TMDS output. OUT_D2- makes a differential output signal with OUT_D2+.	
21	VCC	Power	3.3 V ± 10% DC supply	
22	OUT_D1+	Output	HDMI 1.3 compliant TMDS output. OUT_D1+ makes a differential output signal with OUT_D1-.	
23	OUT_D1-	Output	HDMI 1.3 compliant TMDS output. OUT_D1- makes a differential output signal with OUT_D1+.	
24	GND	Power	Ground	

Table 2. Pin description (continued)

Pin number	Pin name	Type	Function		
25	OE_N	Input	Active low enable signal.		
			<b>OE_N</b>	<b>N_D termination</b>	<b>IOOUT_D outputs</b>
			1	High-Z	High-Z
			0	50 Ω	Active
26	VDD_INT	Power	DC supply for DDC, HPD and CEC (can be 5 V or 3.3 V or unconnected).		
27	GND	Power	Ground		
28	SCL_INT	I/O	DDC Clock I/O. Pulled-up by external termination to V <sub>CC</sub> .		
29	SDA_INT	I/O	DDC Data I/O. Pulled-up by external termination to V <sub>CC</sub> .		
30	HPD_INT	Input	Sink side, low-frequency, 0 V to 5 V (nominal) hot plug detector input signal. Voltage high indicates “plugged” state; voltage low indicates “unplugged” state. High: 5 V power signal asserted from source to sink and EDID is ready. Low: No 5 V power signal is asserted from source to sink or EDID is not ready.		
31	GND	Power	Ground		
32	DDC_EN	Input	I <sup>2</sup> C repeater enable signal		
			<b>DDC_EN</b>		<b>I<sup>2</sup>C repeater</b>
			0 V		Disabled, high-Z
			3.3 V		Enabled, active
33	VCC	Power	3.3 V ± 10% DC supply		
34-35	EQ_BOOST1, EQ_BOOST2	Input	TMDS input equalization selector (control pin).		
			<b>EQ_BOOST2</b>	<b>EQ_BOOST1</b>	<b>Setting at 825 MHz</b>
			0	0	11 dB
			0	1	9 dB
			1	0	4 dB
1	1	16 dB			
36	GND	Power	Ground		
37	GND	Power	Ground		
38	IN_D1-	Input	HDMI 1.3 compliant TMDS input. IN_D1- makes a differential pair with IN_D1+.		
39	IN_D1+	Input	HDMI 1.3 compliant TMDS input. IN_D1+ makes a differential pair with IN_D1-.		
40	VCC	Power	3.3 V ± 10% DC supply		
41	IN_D2-	Input	HDMI 1.3 compliant TMDS input. IN_D2- makes a differential pair with IN_D2+.		
42	IN_D2+	Input	HDMI 1.3 compliant TMDS input. IN_D2+ makes a differential pair with IN_D2-.		
43	GND	Power	Ground		
44	IN_D3-	Input	HDMI 1.3 compliant TMDS input. IN_D3- makes a differential pair with IN_D3+.		
45	IN_D3+	Input	HDMI 1.3 compliant TMDS input. IN_D3+ makes a differential pair with IN_D3-.		
46	VCC	Power	3.3 V ± 10% DC supply		
47	IN_D4-	Input	HDMI 1.3 compliant TMDS input. IN_D4- makes a differential pair with IN_D4+.		
48	IN_D4+	Input	HDMI 1.3 compliant TMDS input. IN_D4+ makes a differential pair with IN_D4-.		

## 5 Functional description

The STDVE001A routes physical layer signals for high bandwidth digital video and is compatible with low voltage differential signaling standard like TMDS. The device passes the differential inputs from a video source to a common display when it is in the active mode of operation. The device conforms to the TMDS standard on both inputs and outputs.

The low on-resistance and low I/O capacitance of the switch in STDVE001A result in a very small propagation delay. Additionally, it supports the DDC, HPD and CEC signaling.

The I<sup>2</sup>C interface of the enabled input port is linked to the I<sup>2</sup>C interface of the output port, and the hot plug detector (HPD) of the enabled input port is output to HPD\_EXT.

### 5.1 Adaptive equalizer

The equalizer dramatically reduces the intersymbol interference (ISI) jitter and attenuation from long or lossy transmission media. The inputs present high impedance when the device is not active or when V<sub>CC</sub> is absent or 0 V. In all other cases, the 50 Ω termination resistors on input channels are present.

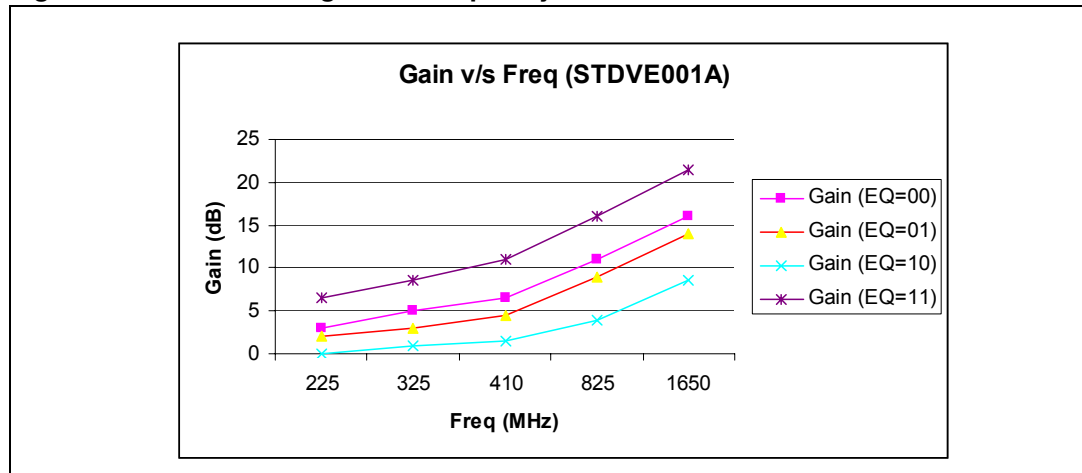
This circuit helps to improve the signal eye pattern significantly. Shaping is performed by the gain stage of the equalizer to compensate the signal degradation and then the signals are driven on to the output ports.

The equalizer is fully adaptive and automatic in function providing smaller gain at low frequencies and higher gain at high frequencies. The default setting of EQ = 00 is recommended on EQ pins for optimized operation.

**Table 3. Adaptive equalizer gain with frequency**

Freq (MHz)	Gain in dB (EQ = 00)	Gain in dB (EQ = 01)	Gain in dB (EQ = 10)	Gain in dB (EQ = 11)
225	3	2	0	6.5
325	5	3	1	8.5
410	6.5	4.5	1.5	11
825	11	9	4	16
1650	16	14	8.5	21.5

Figure 7. STDVE001A gain vs. frequency



The equalizer of STDVE001A is fully adaptive and automatic in function. The default setting of EQ = 00 is recommended for optimal operation. The equalizer performance is optimized for all frequencies over the cable lengths from 1 m to 25 m at EQ = 00. If cable lengths greater than 25 m are desired in application, then EQ = 11 setting is recommended. The other two EQ settings of 01 and 10 are provided simply for fine-tuning purposes and can be used for very short external cables or PCB traces only if deemed necessary.

### Input termination

The STDVE001A integrates precise  $50 \Omega \pm 5\%$  termination resistors, pulled up to  $V_{CC}$ , on all its differential input channels. External terminations are not required. This gives better performance and also minimizes the PCB board space. These on-chip termination resistors should match the differential characteristic impedance of the transmission line. Since the output driver consists of current steering devices, an output voltage is not generated without a termination resistor. Output voltage levels are dependent on the value of the total termination resistance. The STDVE001A produces TMDS output levels for point-to-point links that are doubly terminated ( $100 \Omega$  at each end). With the typical 10 mA output current, the STDVE001A produces an output voltage of  $3.3 - 0.5 V = 2.8 V$  when driving a termination line terminated at each end. The input terminations are selectable thus saving power for the unselected ports.

### Output buffers

Each differential output of the STDVE001A drives external  $50 \Omega$  load (pull-up resistor) and conforms to the TMDS voltage standard. The output drivers consist of 10 mA differential current-steering devices.

The driver outputs are short-circuit current limited and are high-impedance to ground when OE\_N = H or the device is not powered. The current steering architecture requires a resistive load to terminate the signal to complete the transmission loop from  $V_{CC}$  to GND through the termination resistor. Because the device switches the direction of the current flow and not voltage levels, the output voltage swing is determined by  $V_{CC}$  minus the voltage drop across the termination resistor. The output current drivers are controlled by the OE\_N pin and are turned off when OE\_N is a high. A stable 10 mA current is derived by accurate internal current mirrors of a stable reference current which is generated by bandgap voltage across the  $R_{EXT}$ . The differential output driver provides a typical 10 mA current sink capability, which provides a typical 500 mV voltage drop across a  $50 \Omega$  termination resistor.

### TMDS voltage levels

The TMDS interface standard is a signaling method intended for point-to-point communication over a tightly controlled impedance medium. The TMDS standard uses a lower voltage swing than other common communication standards, achieving higher data rates with reduced power consumption while reducing EMI emissions and system susceptibility to noise. The device is capable of detecting differential signals as low as 100 mV within the entire common mode voltage range.

## 5.2 Operating modes

Table 4. OE\_N operating modes

Input			Output		Function
OE_N	IN+	IN-	OUT+	OUT-	
L	H	L	H	L	Active mode
L	L	H	L	H	Active mode
H	X	X	Hi-Z	Hi-Z	Low power mode

The OE\_N input activates a hardware power down mode. When the power down mode is active (OE\_N = H), all input and output buffers and internal bias circuitry are powered-off and disabled.

Outputs are tri-stated in power-down mode. When exiting power-down mode, there is a delay associated with turning on band-references and input/output buffer circuits.

Note that the OE\_N pin is only used to disable the TMDS paths in the chip to same maximum amount of current. It does not affect the HPD, DDC and CEC portions. The DDC is controlled only by the DDC\_EN pin whereas the HPD and CEC are always active as long as the supply to the chip is present.

## 5.3 HPD pins

The input pin HPD\_INT is 5 V tolerant, allowing direct connection to 5 V signals. The output HPD pin has open-drain structure so that the disabled HPD output is driven to GND whereas the enabled HPD port has the same polarity as the HPD\_INT. Note that the HPD output should have an external pull-up resistor connected to +5 V from the HDMI source.

## 5.4 DDC channels

The DDC channels are designed together with a bi-directional buffer so as to ensure the voltage levels on the I<sup>2</sup>C lines are met even after long capacitive cables. This feature eliminates the errors during EDID and HDCP reading.

## 5.5 I<sup>2</sup>C DDC line repeater

The device contains two identical bi-directional open-drain, non-inverting buffer circuits that enable I<sup>2</sup>C DDC bus lines to be extended without degradation in system performance. The

STDVE001A buffers both the serial data (DDC SDA) and serial clock (DDC SCL) on the I<sup>2</sup>C bus, while retaining all the operating modes and features of the I<sup>2</sup>C system. This enables two buses of 400 pF bus capacitance to be connected in an I<sup>2</sup>C application. These buffers are operational from a supply V of 3.0 V to 3.6 V.

The I<sup>2</sup>C bus capacitance limit of 400 pF restricts the number of devices and bus length. The STDVE001A enables the system designer to isolate the two halves of a bus, accommodating more I<sup>2</sup>C devices or longer trace lengths. It can also be used to run two buses, one at 5 V and the other at 3.3 V or a 400 kHz and 100 kHz bus, where the 100 kHz bus is isolated when 400 kHz operation of the other bus is required. The STDVE001A can be used to run the I<sup>2</sup>C bus at both 5 V and 3.3 V interface levels.

The DDC\_EN acts as the enable for the DDC buffer. The DDC\_EN line should not change state during an I<sup>2</sup>C operation, because disabling during bus operation hangs the bus and enabling port may through a bus cycle could confuse the I<sup>2</sup>C ports being enabled. The DDC\_EN input should change state only when the global bus and repeater port are in idle state, to prevent system failures.

The output low levels for each internal buffer are approximately 0.5 V, but the input voltage of each internal buffer must be 70 mV or more below the output low level, when the output internally is driven low. This prevents a lock-up condition from occurring when the input low condition is released.

As with the standard I<sup>2</sup>C system, pull up resistors are required to provide the logic high levels on the buffered bus. The STDVE001A has standard open collector configuration of the I<sup>2</sup>C bus. The size of the pull up resistors depends on the system, but each side of the repeater must have a pull up resistor.

This part is designed to work with standard mode and fast mode I<sup>2</sup>C devices. Standard mode I<sup>2</sup>C devices only specify 3 mA output drive, this limits the termination current to 3 mA in a generic I<sup>2</sup>C system where standard mode devices and multiple masters are possible. Under certain conditions, higher termination currents can be used.

## 5.6 Power-down condition

The OE\_N pin can be used to disable the device. The OE\_N is used to disable most of the internal circuitry of STDVE001A that puts the device in a low power mode of operation.

## 5.7 Bias

The bandgap reference voltage over the external R<sub>EXT</sub> reference resistor sets the internal bias reference current. This current and its factors (achieved by employing highly accurate and well matched current mirror circuit topologies) are generated on-chip and used by several internal modules. The 10 mA current used by the transmitter block is also generated using this reference current. It is important to ensure that the R<sub>EXT</sub> value is within the ±1% tolerance range of its typical value.

**Table 5. Bias parameter**

Parameter	Min	Typ	Max	Unit
Bandgap voltage	–	1.2	–	V

The output voltage swing depends on 3 components: supply voltage ( $V_{\text{supply}}$ ), termination resistor ( $R_T$ ) and current drive ( $I_{\text{drive}}$ ). The supply voltage can vary from  $3.3 \text{ V} \pm 5\%$ , termination resistor can vary from  $50 \Omega \pm 10\%$ .

The voltage on the output is given by:

$$V_{\text{supply}} - I_{\text{drive}} \times R_T$$

The variation on  $I_{\text{drive}}$  must be controlled to ensure that the voltage on HDMI output is within the HDMI specification under all conditions.

This is achieved when:

$$400 \text{ mV} \leq I_{\text{drive}} \times R_T \leq 600 \text{ mV} \text{ with typical value centered at } 500 \text{ mV}.$$

## 5.8 Timing between HPD and DDC

It is important to ensure that the I<sup>2</sup>C DDC interface is ready by the time the HPD detection is complete.

As soon as the discovery is finished by the HPD detection, the configuration data is exchanged between a source and sink through the I<sup>2</sup>C DDC interface. The STDVE001A DDC interface is ready for communication as soon as the power supply to the chip is present and stable. When the desired port is enabled and the chip is out of shutdown mode, the I<sup>2</sup>C DDC lines can be used for communication.

Thus, as soon as the HPD detection sequence is complete, the DDC interface can be readily used. There is no delay between the HPD detection and I<sup>2</sup>C DDC interface to be ready.

## 5.9 CEC

The CEC channel is a dedicated single pin bus and electrically translates to a bi-directional buffer used to ensure that the electrical specs of the CEC are met even with high capacitance on the single CEC line. The pull-up resistor of 26 K $\Omega$  is integrated on either sides of the buffer. The CEC is used for AV control of the electronic devices connected in a HDMI cluster. The drive of the buffer is set to meet the requirements of the CEC. This is optionally used for higher-level user functions such as automatic set-up tasks or tasks typically associated with infrared remote control usage.

The CEC line is continuously monitored during the power-on state and is not monitored during powered-off state. In powered off state, the CEC line should not be pulled low and it should not affect the CEC communication between other devices. The maximum capacitance on the CEC lines can be 7.2 nF.

## 6 Maximum ratings

Stressing the device above the rating listed in [Table 6](#) may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the operating sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

**Table 6. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
V <sub>CC</sub>	Supply voltage to ground	-0.5 to +4.0	V
V <sub>I</sub>	DC input voltage (TMDS ports)	1.7 to +4.0	V
	OE_N, DDC_EN, PRE, EX_BOOST1, EX_BOOST2	-0.5 to +4.0	V
	SDA_INT, SCL_INT, SDA_EXT, SCL_EXT, HPD_INT, HPD_EXT	-0.5 to +6.0	V
I <sub>O</sub>	DC output current	120	mA
T <sub>STG</sub>	Storage temperature	-65 to +150	°C
T <sub>L</sub>	Lead temperature (10 sec.)	300	°C

**Table 7. Thermal data**

Symbol	Parameter	TQFP48 QFN48	Unit
θ <sub>JA</sub>	Thermal coefficient (junction-ambient)	48	°C/W

## 7 DC and AC characteristics

### 7.1 DC electrical characteristics<sup>(a)</sup>

$T_A = -40$  to  $+85$  °C,  $V_{CC} = 3.3$  V  $\pm$  5%.

**Table 8. Power supply characteristics**

Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
$V_{CC}$	Supply voltage		3.135	3.3	3.465	V
$I_{CC}$	Supply current	All inputs/outputs are enabled. Inputs are terminated with 50 $\Omega$ to $V_{CC}$ . $V_{CC} = 3.465$ V data rate = 3.4 Gbps	–	130	–	mA

**Table 9. DC specifications for TMD5 differential inputs**

Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
$V_{TH}$	Differential input high threshold (peak-to-peak)	$V_{CC} = 3.465$ V over the entire $V_{CMR}$	–	0	150	mV
$V_{TL}$	Differential input low threshold	$V_{CC} = 3.465$ V over the entire $V_{CMR}$	-150	0	–	mV
$V_{ID}$	Differential input voltage (peak-to-peak) <sup>(1)</sup>	$V_{CC} = 3.465$ V	150	–	1560	mV
$V_{CMR}$	Common mode voltage range		$V_{CC} - 0.3$	–	$V_{CC} - 0.04$	V
$C_{IN}$	Input capacitance	IN+ or IN- to GND F = 1 MHz	–	3.5	–	pF

1. Differential output voltage is defined as  $| (OUT+ - OUT-) |$ .  
Differential input voltage is defined as  $| (IN+ - IN-) |$ .

a. Typical parameters are measured at  $V_{CC} = 3.3$  V,  $T_A = +25$  °C.

Table 10. DC specifications for TMD5 differential outputs

Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
$V_{OH}$	Single-ended high level output voltage		$V_{CC}-10$	–	$V_{CC}+10$	mV
$V_{OL}$	Single-ended low level output voltage		$V_{CC}-600$	–	$V_{CC}-400$	mV
$V_{swing}$	Single ended output swing voltage	$V_{CC} = 3.3\text{ V}$ $R_{TERM} = 50\ \Omega$	400	500	600	mV
$V_{OD}$	Differential output voltage (peak-to-peak) <sup>(1)</sup>	$V_{CC} = 3.3\text{ V}$ $R_{TERM} = 50\ \Omega$	800	1000	1200	mV
$I_{OH}$	Differential output high level current		0	–	50	$\mu\text{A}$
$I_{OL}$	Differential output low level current		8	10	12	mA
$ I_{SC} $	Output driver short-circuit current (continuous)	$OUT_{\pm} = \text{GND}$ through a $50\ \Omega$ resistor. see <a href="#">Figure 12</a>	–	–	12	mA
$C_{OUT}$	Output capacitance	$OUT_{+}$ or $OUT_{-}$ to GND when tri-state $F = 1\text{ MHz}$	–	5.5	–	pF

1. Differential output voltage is defined as  $| (OUT_{+} - OUT_{-}) |$ . Differential input voltage is defined as  $| (IN_{+} - IN_{-}) |$ .

Table 11. DC specifications for OE\_N, EQ\_BOOST, EQ\_BOOST2, PRE, DDC\_EN inputs

Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
$V_{IH}$	HIGH level input voltage	High level guaranteed	2.0	–	–	V
$V_{IL}$	LOW level input voltage	Low level guaranteed	-0.5	–	0.8	V
$V_{IK}$	Clamp diode voltage	$V_{CC} = 3.465\text{ V}$ $I_{IN} = -18\text{ mA}$	-1.2	-0.8	–	V
$I_{IH}$	Input high current	$V_{CC} = 3.465\text{ V}$ $V_{IN} = V_{CC}$	-5	–	+5	$\mu\text{A}$
$I_{IL}$	Input low current	$V_{CC} = 3.465\text{ V}$ $V_{IN} = \text{GND}$	-5	–	+5	$\mu\text{A}$
$C_{IN}$	Input capacitance	Pin to GND $F = 1\text{ MHz}$	–	3.5	–	pF

Table 12. Input termination resistor

Symbol	Parameter	Test condition	Value			Unit
$R_{TERM}$	Differential input termination resistor on IN $\pm$ channels relative to $V_{CC}$	$I_{IN} = -10\text{ mA}$	45	50	55	$\Omega$

Table 13. External reference resistor

Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
$R_{EXT}$	Resistor for TMDS compliant voltage swing range	Tolerance for $R = \pm 1\%$	–	4.7	–	$\text{K}\Omega$

**Table 14. DDC I/O pins**

Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
$V_{I(DDC)}$	Input voltage		GND		5.3	V
$I_{I(leak)}$	Input leakage current	$V_{CC} = 3.465\text{ V}$ input port = 5.3 V output port = 0.0 V switch is isolated	–	–	6	$\mu\text{A}$
		$V_{CC} = 3.465\text{ V}$ input port = 3.3 V output port = 0.0 V switch is isolated	–	–	2	$\mu\text{A}$
$C_{I/O}$	Input/output capacitance	$V_I = 0\text{ V}$ $F = 1\text{ MHz}$ switch disabled	–	5	–	pF
		$V_I = 0\text{ V}$ $F = 1\text{ MHz}$ switch enabled	–	9	–	pF

**Table 15. Status pins (HPD\_INT)**

Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
$V_{IH}$	High level input voltage	$V_{CC} = 3.3\text{ V}$ high level guaranteed	2.0	–	5.3	V
$V_{IL}$	Low level input voltage	$V_{CC} = 3.3\text{ V}$ low level guaranteed	GND	–	0.8	V
$I_{I(leak)}$	Input leakage current	$V_{CC} = 3.465\text{ V}$ output = 5.3 V	–	–	4	$\mu\text{A}$
		$V_{CC} = 3.465\text{ V}$ output = 3.3 V	–	–	2	$\mu\text{A}$

Table 16. Status pins (HPD\_EXT)<sup>(1)</sup>

Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
V	Voltage		GND	–	5.3	V
C <sub>I/O</sub>	Input/output capacitance	V <sub>I</sub> = 0 V F = 1 MHz switch disabled	–	5	–	pF
		V <sub>I</sub> = 0 V F = 1 MHz switch enabled	–	9	–	pF
V <sub>OL</sub>	Output low voltage (open-drain I/Os)	V <sub>CC</sub> = 3.3 V I <sub>OL</sub> = 8 mA	–	–	0.4	V

1. Typical parameters are measured at V<sub>CC</sub> = 3.3 V, T<sub>A</sub> = +25 °C.

## 7.2 DC electrical characteristics (I<sup>2</sup>C repeater)

(T<sub>A</sub> = -40 to +85 °C, V<sub>CC</sub> = 3.3 V ± 5%, GND = 0 V; unless otherwise specified).

**Table 17. Supplies**

Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
V <sub>CC</sub>	DC supply voltage		3.135	3.3	3.465	V

**Table 18. Input/output SDA, SCL**

Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
V <sub>IH</sub>	High level input voltage		0.7 V <sub>CC</sub>	–	5.3	V
V <sub>IL</sub>	Low level input voltage <sup>(1)</sup>		-0.5	–	0.3 V <sub>CC</sub>	V
V <sub>ILc</sub>	Low level input voltage contention <sup>(1)</sup>		-0.5	–	0.4	V
V <sub>IK</sub>	Input clamp voltage	I <sub>I</sub> = -18 mA	–	–	-1.2	V
I <sub>IL</sub>	Input current low (SDA, SCL)	Input current low (SDA, SCL)	–	–	1	μA
I <sub>IH</sub>	Input current high (SDA, SCL)	V <sub>I</sub> = 3.465 V (SDA, SCL)	–	–	10	μA
		V <sub>I</sub> = 5.3 V (SDA, SCL)	–	–	10	μA
V <sub>OL</sub>	Low level output voltage	I <sub>OL</sub> = 3 mA			0.4	V
		I <sub>OL</sub> = 6 mA			0.65	V
I <sub>OH</sub>	Output high level leakage current	V <sub>O</sub> = 3.6 V; driver disabled	–	–	10	μA
		V <sub>O</sub> = 5.3 V; driver disabled	–	–	10	μA
C <sub>I</sub>	Input capacitance	V <sub>I</sub> = 3 V or 0 V	–	6	7 <sup>(2)</sup>	pF

- V<sub>IL</sub> specification is for the first low level seen by the SDA/SCL lines. V<sub>ILc</sub> is for the second and subsequent low levels seen by the SDA/SCL lines.
- The SCL/SDA C<sub>I</sub> is about 200 pF when V<sub>CC</sub> = 0 V. The STDVE001A should be used in applications where power is secured to the repeater but an active bus remains on either set of the SDA/SCL pins.

### 7.3 DC electrical characteristics (CEC)

( $T_A = -40$  to  $+85$  °C,  $V_{CC} = 3.3$  V  $\pm$  5%, GND = 0 V; unless otherwise specified).

**Table 19. DC electrical characteristics (CEC)**

Symbol	Parameter	Test condition	Value			
			Min	Typ	Max	Unit
$V_{CC}$	DC supply voltage		3.135	3.3	3.465	V
$V_{OL}$	Logic 0 output		0.0	–	0.6	V
$V_{OH}$	Logic 1 output		2.5	–	3.63	V
$V_{HL(th)}$	High to low input V threshold for logic '0'		–	$V_{CEC('0')} \leq 0.8$	–	V
$V_{LH(th)}$	Low to high input V threshold for logic '1'		–	$V_{CEC('1')} \geq 2.0$	–	V
$V_{hys}$	Typical input hysteresis <sup>(1)</sup>		–	0.4	–	V
$t_r$	Maximum rise time (10% to 90%)	$C_L = 7.2$ nF	–	–	250	$\mu$ s
$t_f$	Maximum fall time (90% to 10%)	$C_L = 7.2$ nF	–	–	50	$\mu$ s
$R_{PU}$	Internal pull-up resistor <sup>(2)</sup>		23.4	26	28.6	K $\Omega$
$I_{OFF}$	CEC IO current in unpowered state	$V_{CC} = 0.0$ V	–	–	1.8	$\mu$ A

1. Input hysteresis is normally supplied by the microprocessor input circuit. In this case, additional hysteresis circuitry is not needed.
2. The internal device pull-up should be disconnected from the line when the device is powered-off.

### 7.4 Dynamic switching characteristics<sup>(b)</sup>

( $T_A = -40$  to  $+85$  °C,  $V_{CC} = 3.3$  V  $\pm$  5%,  $R_{TERM} = 50$   $\Omega$   $\pm$  5%,  $C_L = 5$  pF).

Typical values are at  $T_A = +25$  °C and  $V_{CC} = 3.3$  V.

**Table 20. Clock and data rate**

Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
$f_{CK}$	Clock frequency (1/10 th of the differential data rate)		25	–	340	MHz
$D_{rate}$	Signaling rate		–	–	3.4	Gbps

**Table 21. Differential output timings**

Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
$t_r$	Differential data and clock output rise/fall times	20% to 80% of $V_{OD}$	75	150	240	ps
$t_f$		80% to 20% of $V_{OD}$	75	150	240	ps
$t_{PLH}$	Differential low to high propagation delay	Alternating 1 and 0 pattern at slow and fast data rates	250	–	800	ps
$t_{PHL}$	Differential high to low propagation delay	Measure at 50% $V_{OD}$ between input to output	250	–	800	ps

**Table 22. Skew times**

Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
$t_{SK(O)}$	Inter-pair channel-to-channel output skew		–	–	100	ps
$t_{SK(P)}$	Pulse skew	$ t_{PLH} - t_{PHL} $	–	25	80	ps
$t_{SK(D)}$	Intra-pair differential skew		–	–	44	ps
$t_{SK(CC)}$	Output channel to channel skew	Difference in propagation delay ( $t_{PLH}$ or $t_{PHL}$ ) among all output channels	–	50	125	ps

b. The timing values in this section are tested during characterization and are guaranteed by design and simulation. Not tested in production.

**Table 23. Turn-on and turn-off times**

Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
$t_{ON}$	TMDS output enable time	Time from OE_N to OUT $\pm$ change from tri-state to active	–	12	20	ns
$t_{OFF}$	TMDS output disable time	Time from OE_N to OUT $\pm$ change from active to tri-state	–	6	10	ns

**Table 24. Status pins (HPD\_INT, HPD\_EXT, OE\_N)**

Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
$t_{PD(HPD)}$	Propagation delay (from Y_HPDP to the active port of HPD)	$C_L = 10 \text{ pF}$ , $R_{PU} = 1 \text{ K}\Omega$	–	150	–	ns
$t_{ON/OFF}$	Switch time (from port select to the latest valid status of HPD)	$C_L = 10 \text{ pF}$	–	50	–	ns

**Table 25. Jitter**

Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
$t_{JIT}$	Total jitter <sup>(1)</sup>	PRBS pattern at 1.6 Gbps (800 MHz)	–	35	–	ps (p-p)

1. Total jitter is measured peak-to-peak with a histogram including 3500 window hits. Stimulus and fixture jitter has been subtracted. Input differential voltage =  $V_{ID} = 500 \text{ mV}$ , PRBS random pattern at 1.65 Gbps,  $t_r = t_f = 50 \text{ ps}$  (20% to 80%). Jitter parameter is not production-tested but guaranteed through characterization on a sample-to-sample basis.

## 7.5 Dynamic switching characteristics (I<sup>2</sup>C repeater)

(T<sub>A</sub> = -40 to +85 °C, V<sub>CC</sub> = 3.3 V ± 5%)

Typical values are at T<sub>A</sub> = +25 °C and V<sub>CC</sub> = 3.3 V.

Table 26. I<sup>2</sup>C repeater<sup>(1)</sup>

Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
f <sub>SCL</sub>	I <sup>2</sup> C clock frequency	Standard mode	–	–	100	kHz
		Fast mode	–	–	400	kHz
t <sub>LOW</sub>	Low duration on SCL pin	100 KHz see <a href="#">Figure 20</a> voltage on line = 5 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ Depends on input signal rise time. Includes the 20% time intervals on both transitions.	4.7	–	–	µs
		400 KHz see <a href="#">Figure 20</a> voltage on line = 5 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ Depends on input signal rise time. Includes the 20% time intervals on both transitions.	1.3	–	–	µs
t <sub>LOW</sub>	Low duration on SCL pin	100 KHz see <a href="#">Figure 20</a> voltage on line = 3.3 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ Depends on input signal rise time. Includes the 20% time intervals on both transitions.	4.7	–	–	µs
		400 KHz see <a href="#">Figure 20</a> voltage on line = 3.3 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ Depends on input signal rise time. Includes the 20% time intervals on both transitions.	1.3	–	–	µs
t <sub>HIGH</sub>	High duration on SCL pin	100 KHz see <a href="#">Figure 20</a> voltage on line = 5 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ Depends on input signal rise time. Includes the 20% time intervals on both transitions.	4.0	–	–	µs
		400 KHz see <a href="#">Figure 20</a> voltage on line = 5 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ Depends on input signal rise time. Includes the 20% time intervals on both transitions.	0.6	–	–	µs

Table 26. I<sup>2</sup>C repeater<sup>(1)</sup> (continued)

Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
t <sub>HIGH</sub>	High duration on SCL pin	100 KHz see <a href="#">Figure 20</a> voltage on line = 3.3 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ Depends on input signal rise time. Includes the 20% time intervals on both transitions.	4.0	–	–	μs
		400 KHz see <a href="#">Figure 20</a> voltage on line = 3.3 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ Depends on input signal rise time. Includes the 20% time intervals on both transitions.	0.6	–	–	μs
t <sub>PHL</sub>	Propagation delay	400 KHz waveform 1 ( <a href="#">Figure 18</a> ) voltage on line = 5 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ	–	–	250	μs
t <sub>PLH</sub>	Propagation delay	400 KHz waveform 1 ( <a href="#">Figure 18</a> ) voltage on line = 5 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ	–	–	300	μs
t <sub>PHL</sub>	Propagation delay	400 KHz waveform 1 ( <a href="#">Figure 18</a> ) voltage on line = 3.3 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ	–	–	250	ns
t <sub>PLH</sub>	Propagation delay	400 KHz waveform 1 ( <a href="#">Figure 18</a> ) voltage on line = 3.3 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ	–	–	450	ns
t <sub>PHL</sub>	Propagation delay	100 KHz waveform 1 ( <a href="#">Figure 18</a> ) voltage on line = 5 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ	–	–	250	ns
t <sub>PLH</sub>	Propagation delay	100 KHz waveform 1 ( <a href="#">Figure 18</a> ) voltage on line = 5 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ	–	–	300	ns
t <sub>PHL</sub>	Propagation delay	100 KHz waveform 1 ( <a href="#">Figure 18</a> ) voltage on line = 3.3 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ	–	–	250	ns
t <sub>PLH</sub>	Propagation delay	100 KHz waveform 1 ( <a href="#">Figure 18</a> ) voltage on line = 3.3 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ	–	–	450	ns

**Table 26. I<sup>2</sup>C repeater<sup>(1)</sup> (continued)**

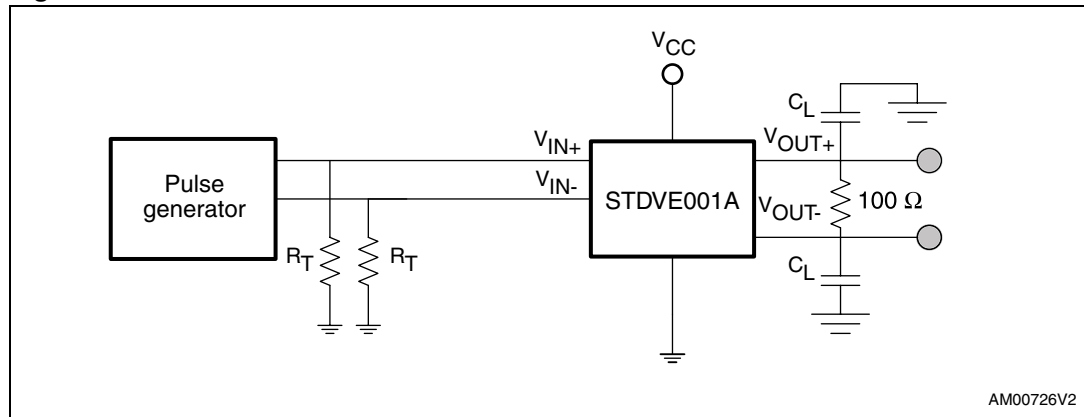
Symbol	Parameter	Test condition	Value			Unit
			Min	Typ	Max	
t <sub>f</sub>	Output fall time	400 KHz waveform 1 (Figure 18) <sup>(2)</sup> voltage on line = 5 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ	–	–	300	ns
		400 KHz waveform 1 <sup>(2)</sup> voltage on line = 3.3 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ	–	–	300	ns
t <sub>f</sub>	Output fall time	100 KHz waveform 1 (Figure 18) <sup>(2)</sup> voltage on line = 5 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ	–	–	300	ns
		100 KHz waveform 1 (Figure 18) <sup>(2)</sup> voltage on line = 3.3 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ	–	–	300	ns
t <sub>r</sub>	Output rise time	400 KHz waveform 1 (Figure 18) <sup>(2)</sup> , voltage on line = 5 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ	–	–	300	ns
		400 KHz waveform 1 (Figure 18) <sup>(2)</sup> , voltage on line = 3.3 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ	–	–	300	ns
t <sub>r</sub>	Output rise time	100 KHz waveform 1 <sup>(2)</sup> , voltage on line = 5 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ	–	–	1000	ns
		100 KHz waveform 1 (Figure 18) <sup>(2)</sup> , voltage on line = 3.3 V, C <sub>max</sub> = 400 pF, R <sub>max</sub> = 2 KΩ	–	–	1000	ns

1. All the timing values are tested during characterization and are guaranteed by design and simulation. Not tested in production.
2. The t<sub>r</sub> transition time is specified with maximum load of 2 kΩ pull-up resistance and 400 pF load capacitance. Different load resistance and capacitance will alter the RC time constant, thereby changing the propagation delay and transition times. Refer to Figure 10.

**Table 27. ESD performance**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
ESD	TMDS I/Os	Human body model	–	±5	–	kV
	Other I/Os	Human body model	–	±2	–	kV

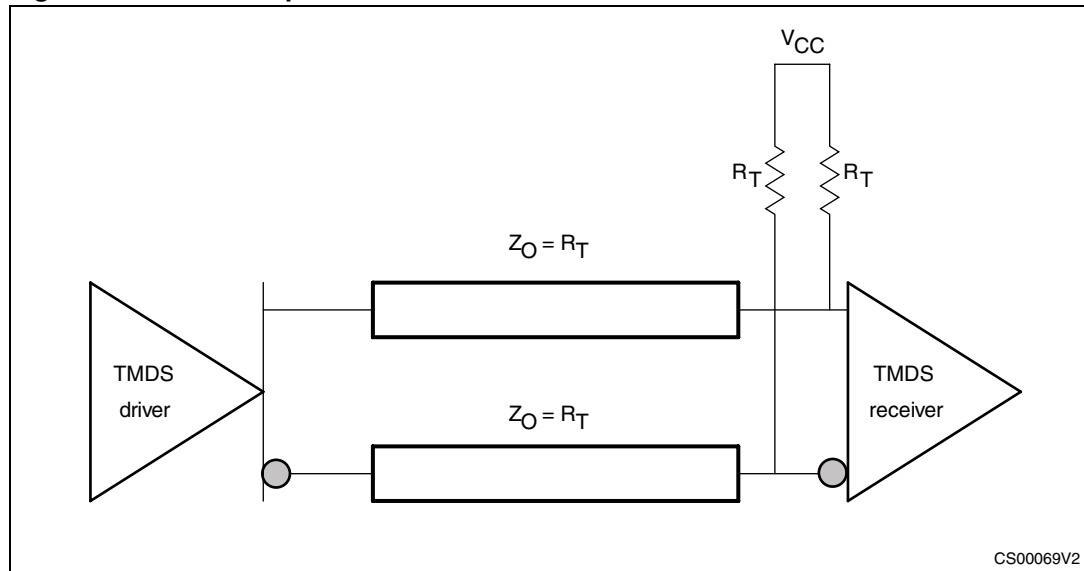
**Figure 8. Test circuit for electrical characteristics**



AM00726V2

1.  $C_L$  = load capacitance: include jig and probe capacitance.
2.  $R_T$  = termination resistance; should be equal to  $Z_{OUT}$  of the pulse generator.

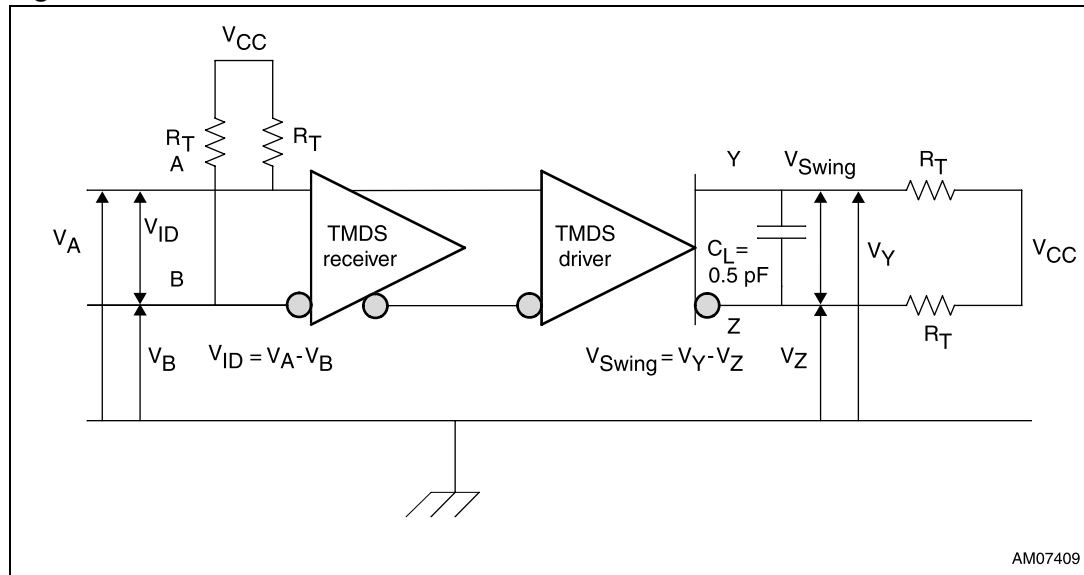
**Figure 9. TMD5 output driver**



CS00069V2

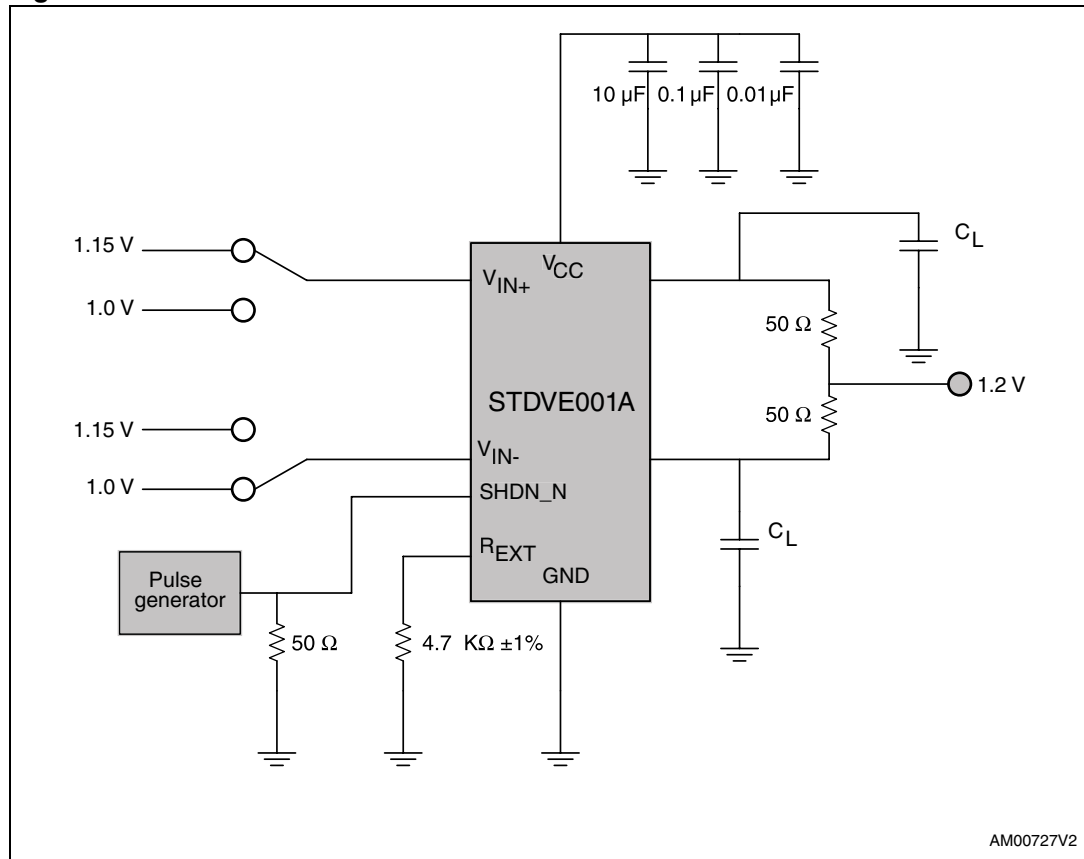
1.  $Z_O$  = characteristic impedance of the cable.
2.  $R_T$  = termination resistance: should be equal to  $Z_O$  of the cable. Both are equal to 50  $\Omega$ .

Figure 10. Test circuit for HDMI receiver and driver



1.  $R_T = 50 \Omega$

Figure 11. Test circuit for turn-on and turn-off times



1.  $C_L = 5 \text{ pF}$ .

Figure 12. Test circuit for short-circuit output current

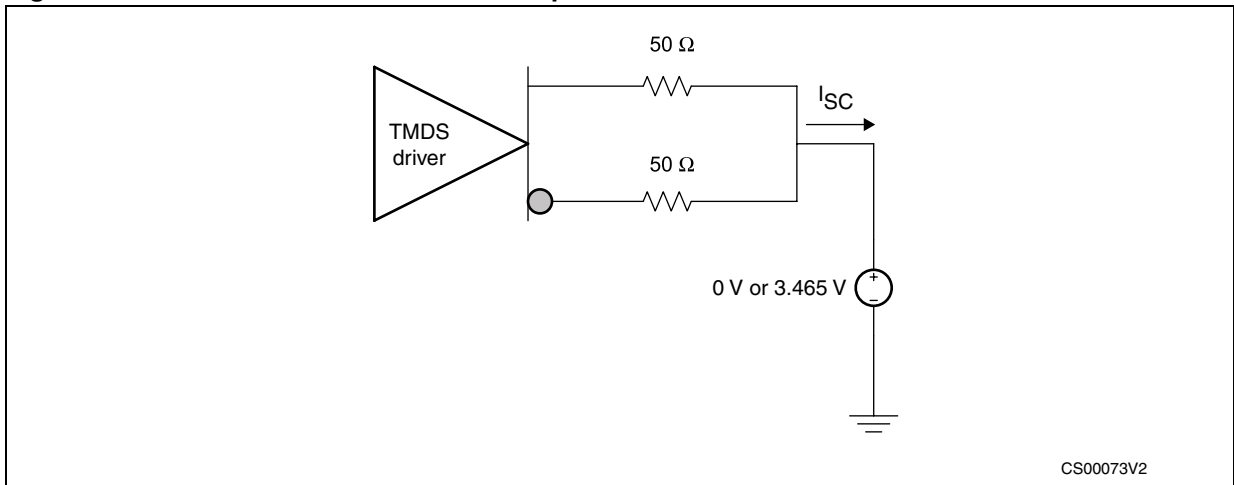


Figure 13. Propagation delays

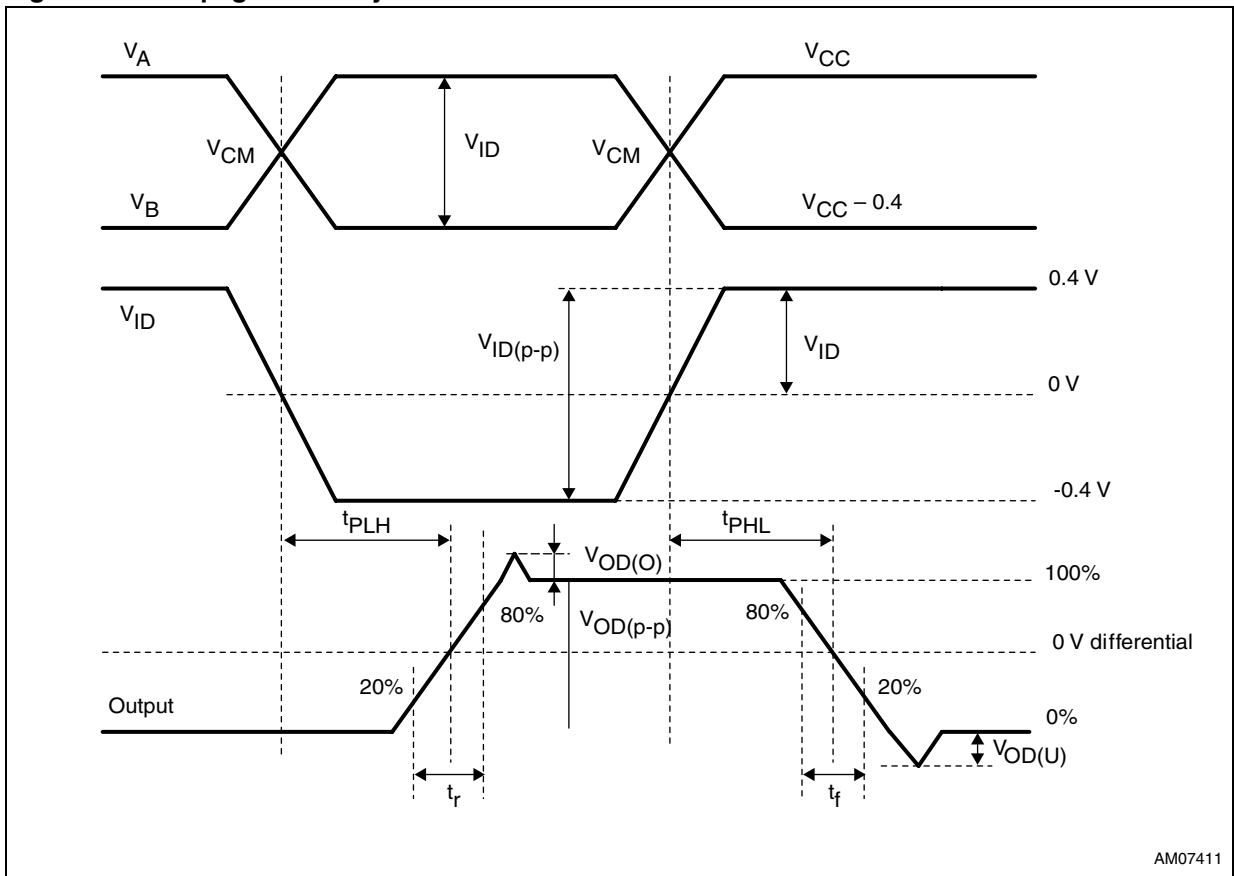


Figure 14. Turn-on and turn-off times

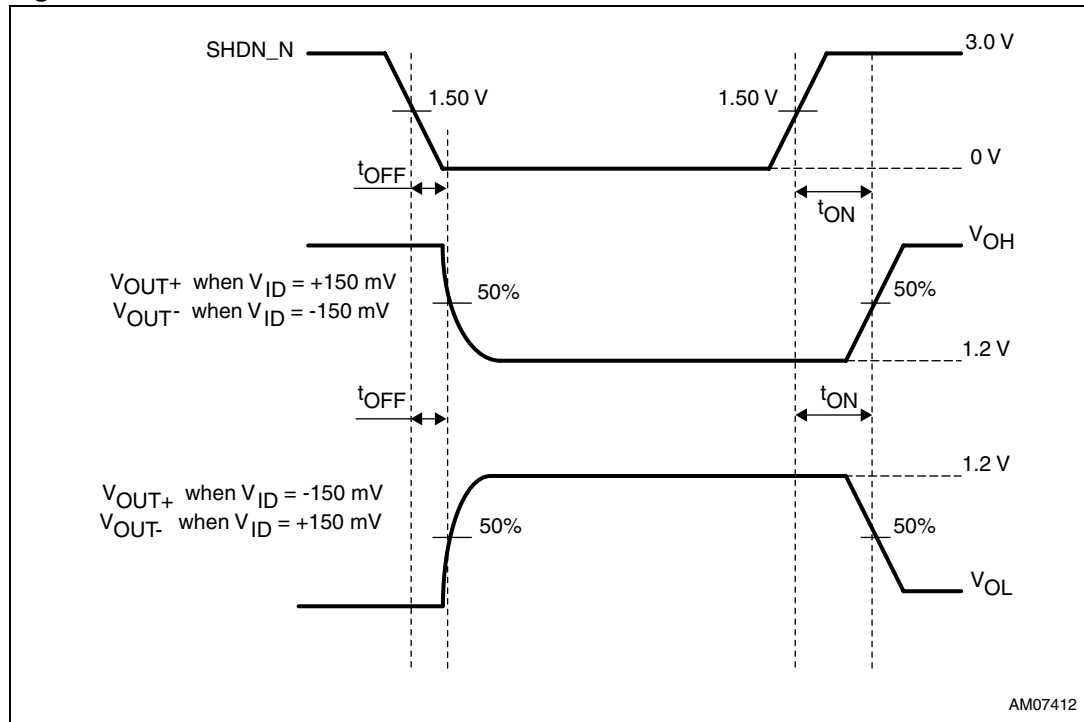


Figure 15.  $t_{SK(O)}$

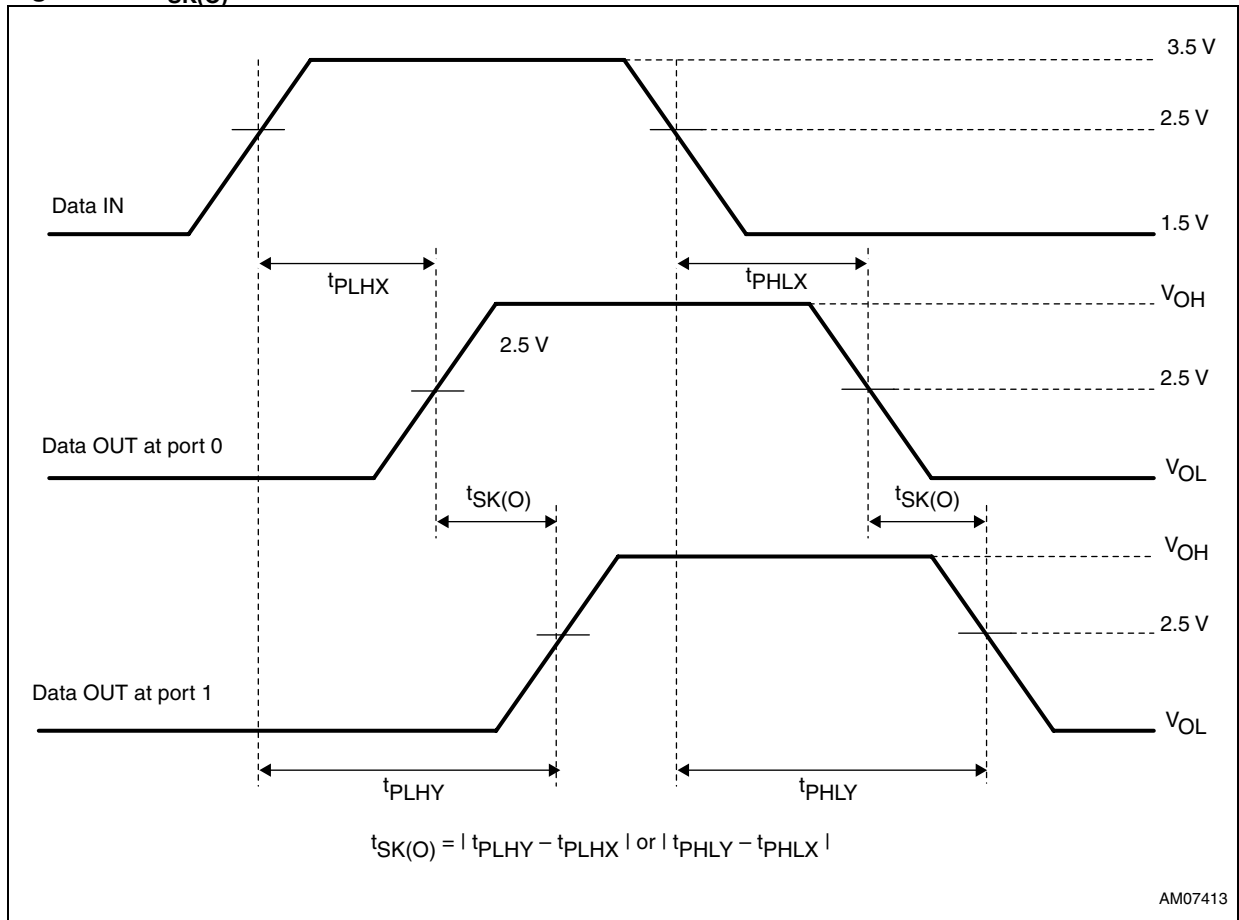


Figure 16.  $t_{SK(P)}$

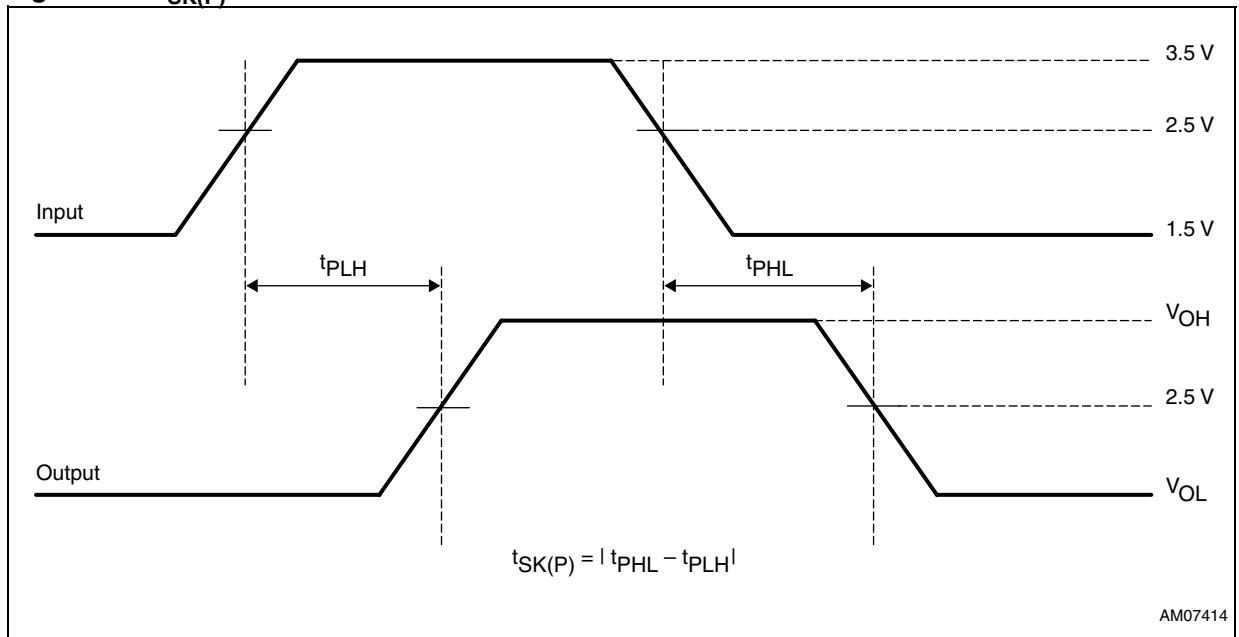
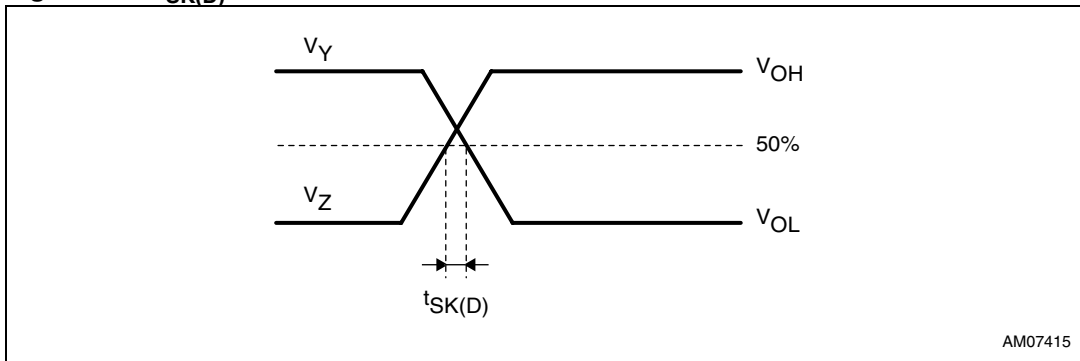
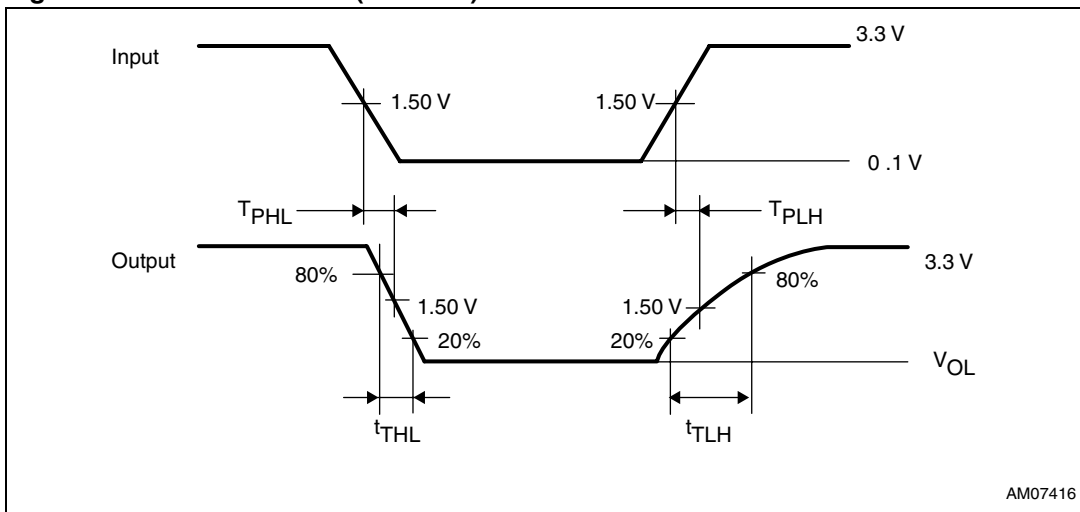


Figure 17.  $t_{SK(D)}$



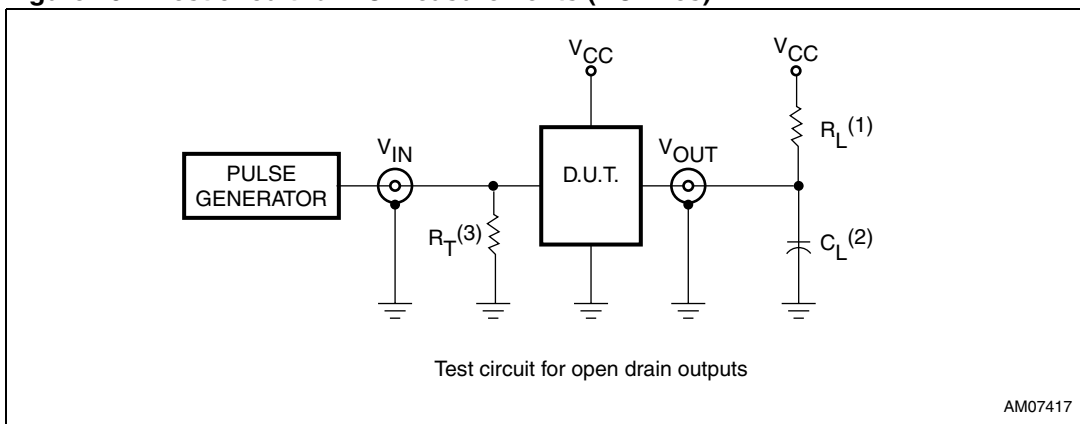
AM07415

Figure 18. AC waveform 1 (I<sup>2</sup>C lines)



AM07416

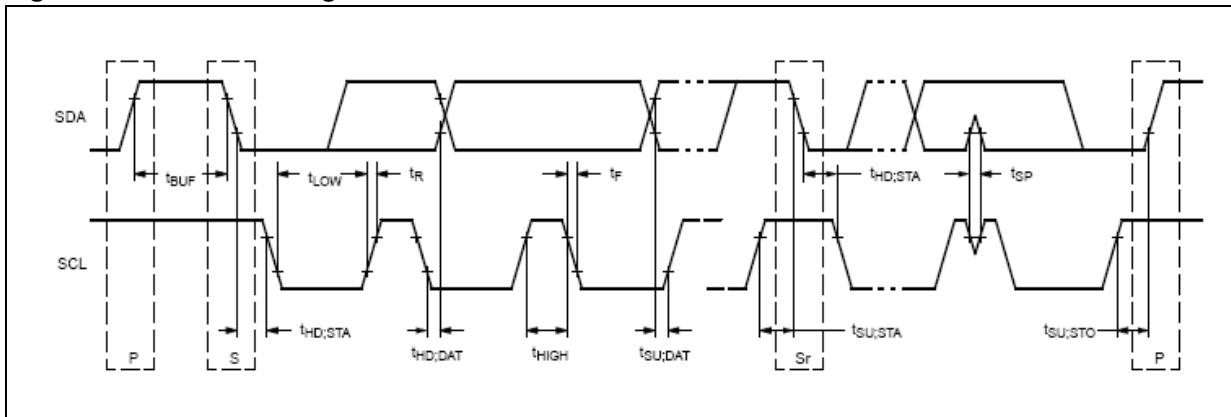
Figure 19. Test circuit for AC measurements (I<sup>2</sup>C lines)



AM07417

1.  $R_L$  = load resistor; 1.35 k $\Omega$
2.  $C_L$  = load capacitance includes jig and probe capacitance; 7 pF.
3.  $R_T$  = termination resistance should be equal to  $Z_{OUT}$  of pulse generator.

Figure 20. I<sup>2</sup>C bus timing



## 8 Application information

### 8.1 Power supply sequencing

Proper power-supply sequencing is advised for all CMOS devices. It is recommended to always apply  $V_{CC}$  before applying any signals to the input/output or control pins.

### 8.2 Power supply requirements

Bypass each of the  $V_{CC}$  pins with 0.1  $\mu\text{F}$  and 1 nF capacitors in parallel as close to the device as possible, with the smaller-valued capacitor as close to the  $V_{CC}$  pin of the device as possible.

All  $V_{CC}$  pins can be tied to a single 3.3 V power source. A 0.01  $\mu\text{F}$  capacitor is connected from each  $V_{CC}$  pin directly to ground to filter supply noise. The maximum power supply variation can only be  $\pm 5\%$  as per the HDMI specifications.

The maximum tolerable noise ripple on 3.3 V supply must be within a specified limit.

### 8.3 Differential traces

The high-speed TMDS inputs are the most critical parts for the device. There are several considerations to minimize discontinuities on these transmission lines between the connectors and the device.

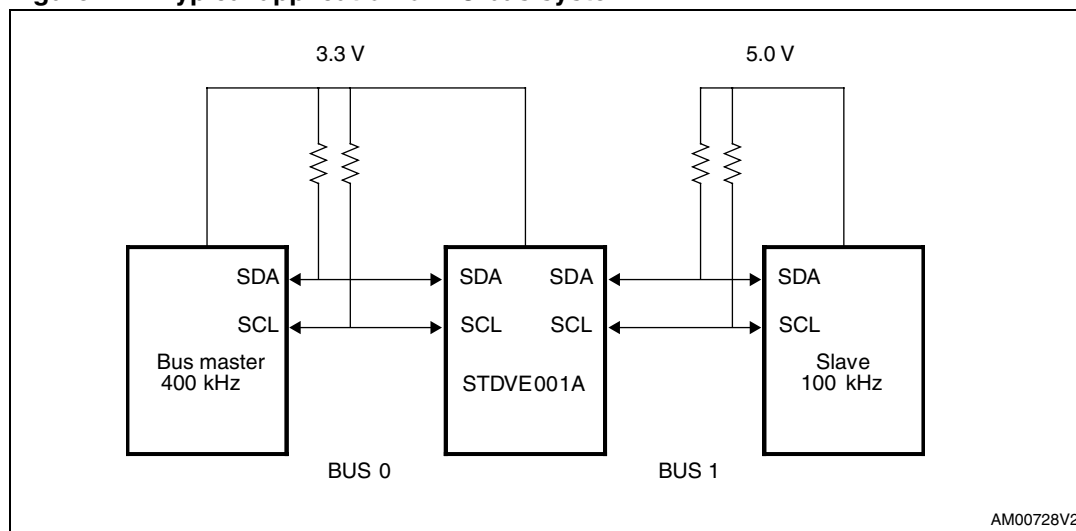
- a) Maintain 100- $\Omega$  differential transmission line impedance into and out of the STDVE001A.
- b) Keep an uninterrupted ground plane below the high-speed I/Os.
- c) Keep the ground-path vias to the device as close as possible to allow the shortest return current path.
- d) Layout of the TMDS differential inputs should be with the shortest stubs from the connectors.

Output trace characteristics affect the performance of the STDVE001A. Use controlled impedance traces to match trace impedance to both the transmission medium impedance and termination resistor. Run the differential traces close together to minimize the effects of the noise. Reduce skew by matching the electrical length of the traces. Avoid discontinuities in the differential trace layout. Avoid 90 degree turns and minimize the number of vias to further prevent impedance discontinuities.

### 8.4 I<sup>2</sup>C lines application information

A typical application is shown in the figure below. In the example, the system master is running on a 3.3 V I<sup>2</sup>C-bus while the slave is connected to a 5 V bus. Both buses run at 100 kHz unless the slave bus is isolated and then the master bus can run at 400 kHz. Master devices can be placed on either bus.

Figure 21. Typical application of I<sup>2</sup>C bus system



The STDVE001A DDC lines are 5 V tolerant; so it does not require any extra circuitry to translate between the different bus voltages.

## 9 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK® is an ST trademark.

Figure 22. TQFP48 (7 x 7 mm) package outline

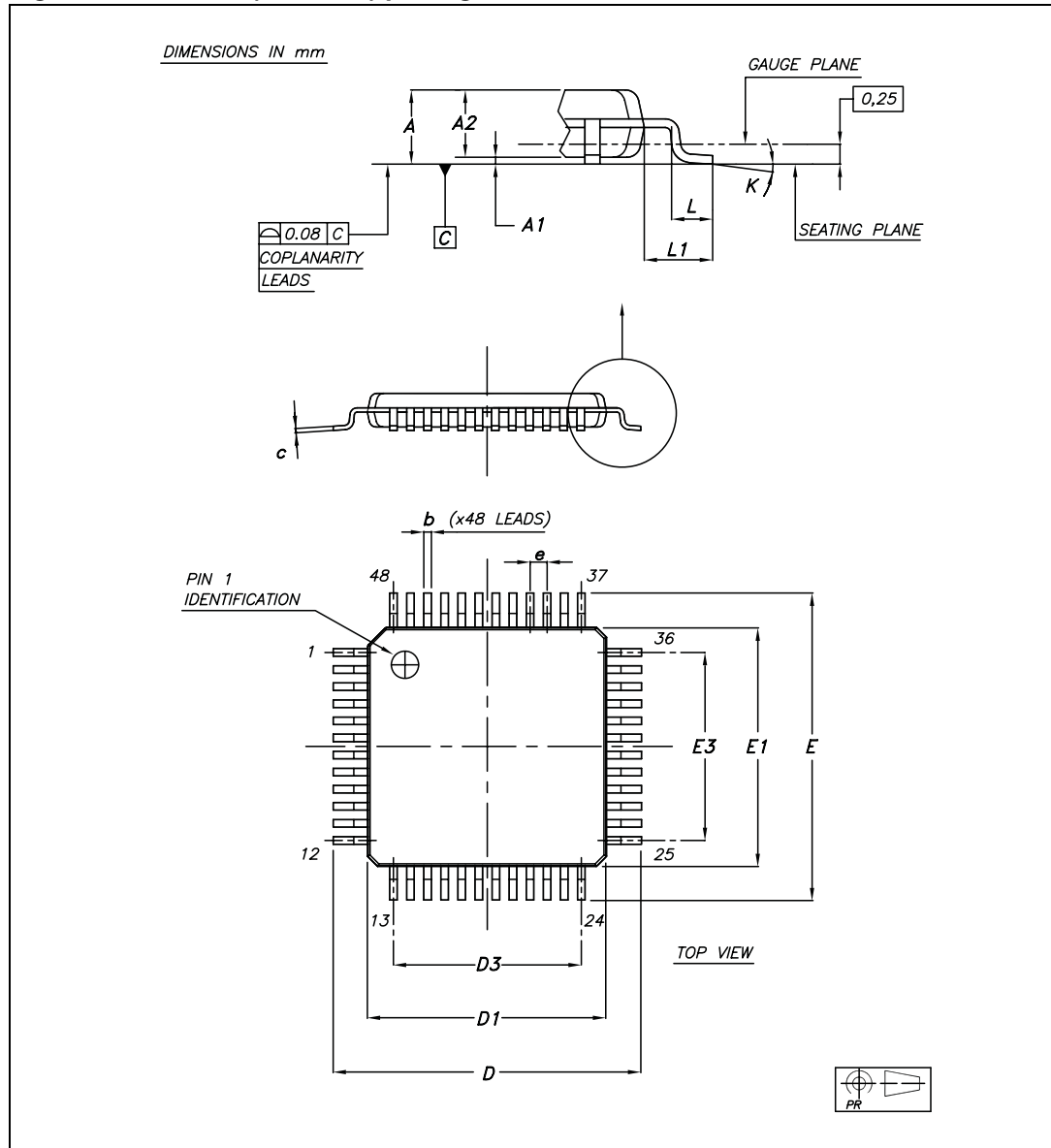


Table 28. TQFP48 (7 x 7 mm) mechanical data

Symbol	Millimeters		
	Min	Typ	Max
A	-	-	1.20
A1	0.05	0.10	0.15
A2	0.95	1.00	1.05
D	8.80	9.00	9.20
D1	6.90	7.00	7.10
E	8.80	9.00	9.20
E1	6.90	7.00	7.10
L	0.45	0.60	0.75
L1	–	1.00	–
T	0.70	0.15	0.20
T1	0.10	0.13	1.15
a	0°	–	7°
b	0.17	0.22	0.27
b1	0.17	0.20	0.23
e	–	0.500	–
ccc / ddd	–	0.08	–



Figure 24. TQFP48 (7 x 7 mm) tape and reel information

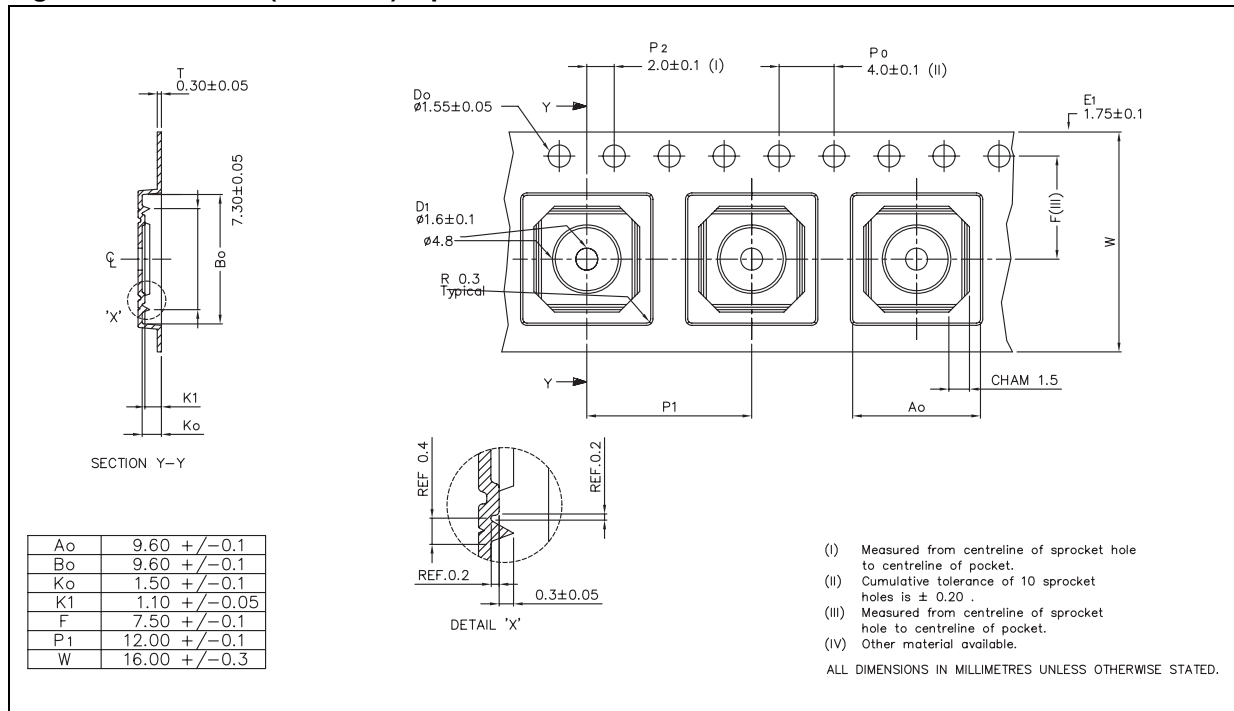


Figure 25. QFN48 (7 x 7 mm) package outline

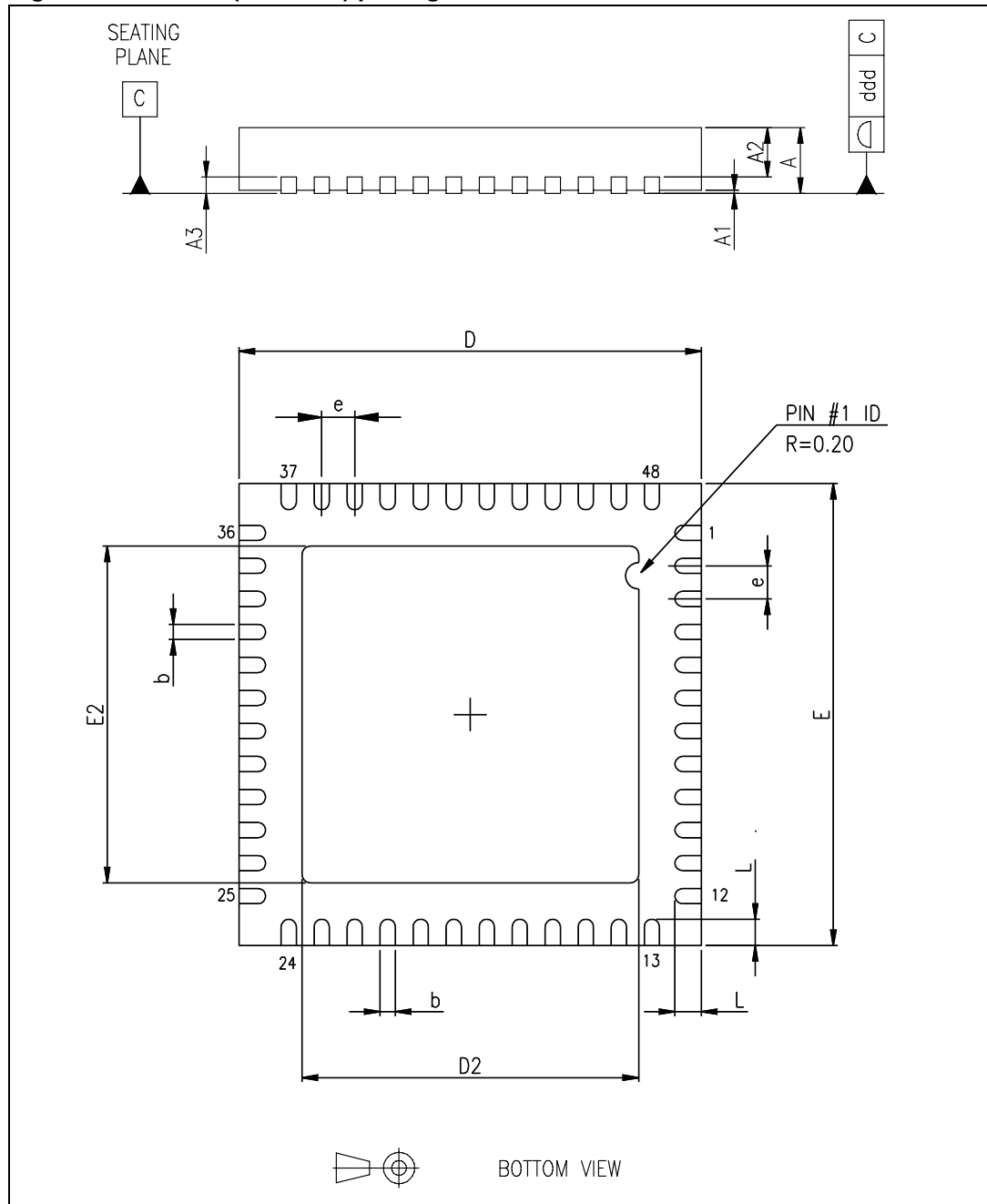


Table 29. QFN48 (7 x 7 mm) package mechanical data

Symbol	Millimeters		
	Min	Typ	Max
A	0.80	0.90	1.00
A1	—	0.02	0.05
A2	—	0.65	1.00
A3	—	0.25	—
b	0.18	0.23	0.30
D	6.85	7.00	7.15
D2	2.25	4.70	5.25
E	6.85	7.00	7.15
E2	2.25	4.70	5.25
e	0.45	0.50	0.55
L	0.30	0.40	0.50
ddd	—	—	0.08

## 10 Revision history

**Table 30. Document revision history**

Date	Revision	Changes
02-Jul-2008	1	Initial release.
21-Jul-2008	2	Modified: <a href="#">Figure 2</a> and <a href="#">Section 5: Functional description on page 14</a> Replaced 'equation' with 'equalizer' in the Features section.
28-Jul-2009	3	Document status promoted from preliminary data to datasheet. Updated: ESD values.
06-Dec-2010	4	Document reformatted, updated <a href="#">Features</a> , <a href="#">Section 5</a> , title of <a href="#">Figure 11</a> , replaced $V_{DD}$ by $V_{CC}$ in <a href="#">Table 2</a> , corrected typo in <a href="#">Table 1</a> , to <a href="#">Table 3</a> , <a href="#">Table 6</a> , <a href="#">Table 8</a> to <a href="#">Table 10</a> , <a href="#">Table 13</a> to <a href="#">Table 16</a> , <a href="#">Table 19</a> , <a href="#">Table 20</a> , <a href="#">Table 22</a> , <a href="#">Table 24</a> to <a href="#">Table 26</a> , <a href="#">Figure 1</a> , <a href="#">Figure 2</a> , <a href="#">Figure 4</a> to <a href="#">Figure 6</a> , <a href="#">Figure 8</a> to <a href="#">Figure 19</a> , <a href="#">Figure 21</a> , <a href="#">Section 4</a> , <a href="#">Section 5</a> , <a href="#">Section 6</a> , <a href="#">Section 8</a> , removed Table 24 - DDC I/O pins.
30-Aug-2011	5	Changed the maximum value of parameter A to 1.20 in <a href="#">Table 28</a> .

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