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Kind regards,

Team Nexperia



# IP4786CZ32

**DVI and HDMI interface ESD and overcurrent protection,  
DDC/CEC buffering, hot plug detect and backdrive protection**

Rev. 5 — 24 June 2014

Product data sheet

## 1. Product profile

### 1.1 General description

The IP4786CZ32 is designed to protect High-Definition Multimedia Interface (HDMI) transmitter host interfaces. It includes HDMI 5 V overcurrent / overvoltage protection, Display Data Channel (DDC) buffering and decoupling, hot plug detect, backdrive protection, Consumer Electronic Control (CEC) buffering and decoupling, and  $\pm 12$  kV contact ElectroStatic Discharge (ESD) protection for all I/Os, exceeding the IEC 61000-4-2 level 4 standard.

The IP4786CZ32 incorporates Transmission Line Clamping (TLC) technology on the high-speed Transition Minimized Differential Signaling (TMDS) lines to simplify routing and help reduce impedance discontinuities. All TMDS lines are protected by an impedance-matched diode configuration that minimizes impedance discontinuities caused by typical shunt diodes.

The enhanced 60 mA overcurrent / overvoltage linear regulator guarantees HDMI-compliant 5 V output voltage levels with up to 6.5 V inputs.

The DDC lines use a new buffering concept which decouples the internal capacitive load from the external capacitive load for use with standard Complementary Metal Oxide Semiconductor (CMOS) or Low Voltage Transistor-Transistor Logic (LVTTL) I/O cells down to 1.8 V. This buffering also redrives the DDC and CEC signals, allowing the use of longer or cheaper HDMI cables with a higher capacitance. The internal hot plug detect module simplifies the application of the HDMI transmitter to control the hot plug signal.

All lines provide appropriate integrated pull-ups and pull-downs for HDMI compliance and backdrive protection to guarantee that HDMI interface signals are not pulled down if the system is powered down or enters Standby mode. Only a single external capacitor is required for operation.

### 1.2 Features and benefits

- HDMI 2.0 and all backward compatible standards are supported
- 6.0 Gbps TMDS Bit Rate (600 Mcsc TMDS Character Rate) compatible
- Supports UHD 4k (2160p) 60 Hz display modes
- Impedance matched 100  $\Omega$  differential transmission line ESD protection for TMDS lines ( $\pm 10$   $\Omega$ ). No Printed-Circuit Board (PCB) pre-compensation required
- Simplified flow-through routing utilizing less overall PCB space
- DDC capacitive decoupling between system side and HDMI connector side and buffering to drive cable with high capacitive load ( $> 700$  pF/25 m)



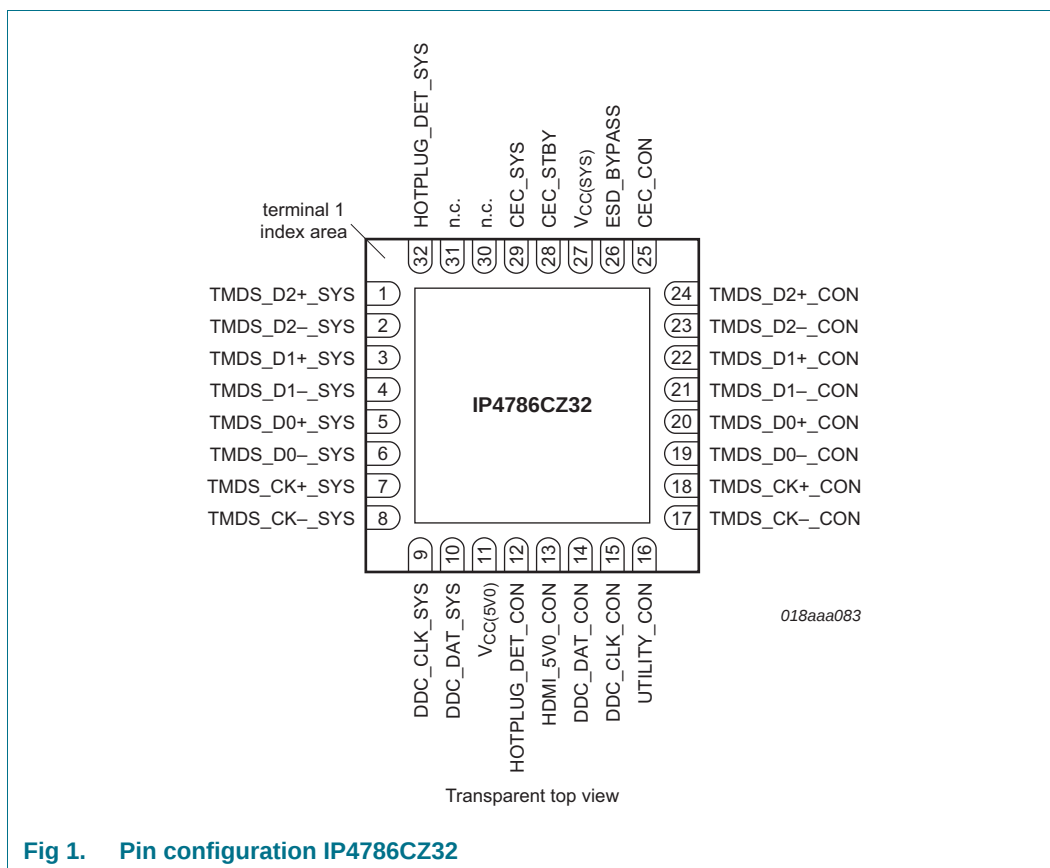
- All external I/O lines with ESD protection of at least  $\pm 12$  kV, exceeding the IEC 61000-4-2, level 4 standard
- Hot plug detect module
- CEC buffering and isolation, with integrated backdrive-protected 26 k $\Omega$  pull-up
- Robust ESD protection without degradation after repeated ESD strikes
- Highest integration in a small footprint, PCB level, optimized RF routing, 32-pin HVQFN leadless package

### 1.3 Applications

- The IP4786CZ32 can be used for a wide range of HDMI source devices, consumer and computing electronics:
  - ◆ Standard-Definition (SD) and High-Definition (HD) DVD player
  - ◆ Set-top box
  - ◆ PC graphic card
  - ◆ Game console
  - ◆ HDMI picture performance quality enhancer module
  - ◆ Digital Visual Interface (DVI)

## 2. Pinning information

### 2.1 Pinning



## 2.2 Pin description

Table 1. Pin description

| Pin        | Name                 | Description                                                    |
|------------|----------------------|----------------------------------------------------------------|
| 1          | TMDS_D2+_SYS         | TMDS to ASIC inside system                                     |
| 2          | TMDS_D2-_SYS         | TMDS to ASIC inside system                                     |
| 3          | TMDS_D1+_SYS         | TMDS to ASIC inside system                                     |
| 4          | TMDS_D1-_SYS         | TMDS to ASIC inside system                                     |
| 5          | TMDS_D0+_SYS         | TMDS to ASIC inside system                                     |
| 6          | TMDS_D0-_SYS         | TMDS to ASIC inside system                                     |
| 7          | TMDS_CK+_SYS         | TMDS to ASIC inside system                                     |
| 8          | TMDS_CK-_SYS         | TMDS to ASIC inside system                                     |
| 9          | DDC_CLK_SYS          | DDC clock system side                                          |
| 10         | DDC_DAT_SYS          | DDC data system side                                           |
| 11         | V <sub>CC(5V0)</sub> | 5 V supply input                                               |
| 12         | HOTPLUG_DET_CON      | hot plug detect connector side                                 |
| 13         | HDMI_5V0_CON         | 5 V overcurrent out to connector                               |
| 14         | DDC_DAT_CON          | DDC data connector side                                        |
| 15         | DDC_CLK_CON          | DDC clock connector side                                       |
| 16         | UTILITY_CON          | utility line ESD protection                                    |
| 17         | TMDS_CK-_CON         | TMDS ESD protection to connector                               |
| 18         | TMDS_CK+_CON         | TMDS ESD protection to connector                               |
| 19         | TMDS_D0-_CON         | TMDS ESD protection to connector                               |
| 20         | TMDS_D0+_CON         | TMDS ESD protection to connector                               |
| 21         | TMDS_D1-_CON         | TMDS ESD protection to connector                               |
| 22         | TMDS_D1+_CON         | TMDS ESD protection to connector                               |
| 23         | TMDS_D2-_CON         | TMDS ESD protection to connector                               |
| 24         | TMDS_D2+_CON         | TMDS ESD protection to connector                               |
| 25         | CEC_CON              | CEC signal connector side                                      |
| 26         | ESD_BYPASS           | ESD bias voltage                                               |
| 27         | V <sub>CC(SYS)</sub> | supply voltage for level shifting                              |
| 28         | CEC_STBY             | CEC Standby mode control (LOW for lowest power, CEC-only mode) |
| 29         | CEC_SYS              | CEC I/O signal system side                                     |
| 30         | n.c.                 | not connected                                                  |
| 31         | n.c.                 | not connected                                                  |
| 32         | HOTPLUG_DET_SYS      | hot plug detect system side                                    |
| ground pad | GND                  | ground                                                         |

### 3. Ordering information

Table 2. Ordering information

| Type number | Package |                                                                                                       |          |
|-------------|---------|-------------------------------------------------------------------------------------------------------|----------|
|             | Name    | Description                                                                                           | Version  |
| IP4786CZ32  | HVQFN32 | plastic thermal enhanced very thin quad flat package;<br>no leads; 32 terminals; body 5 × 5 × 0.85 mm | SOT617-3 |

4. Functional diagram

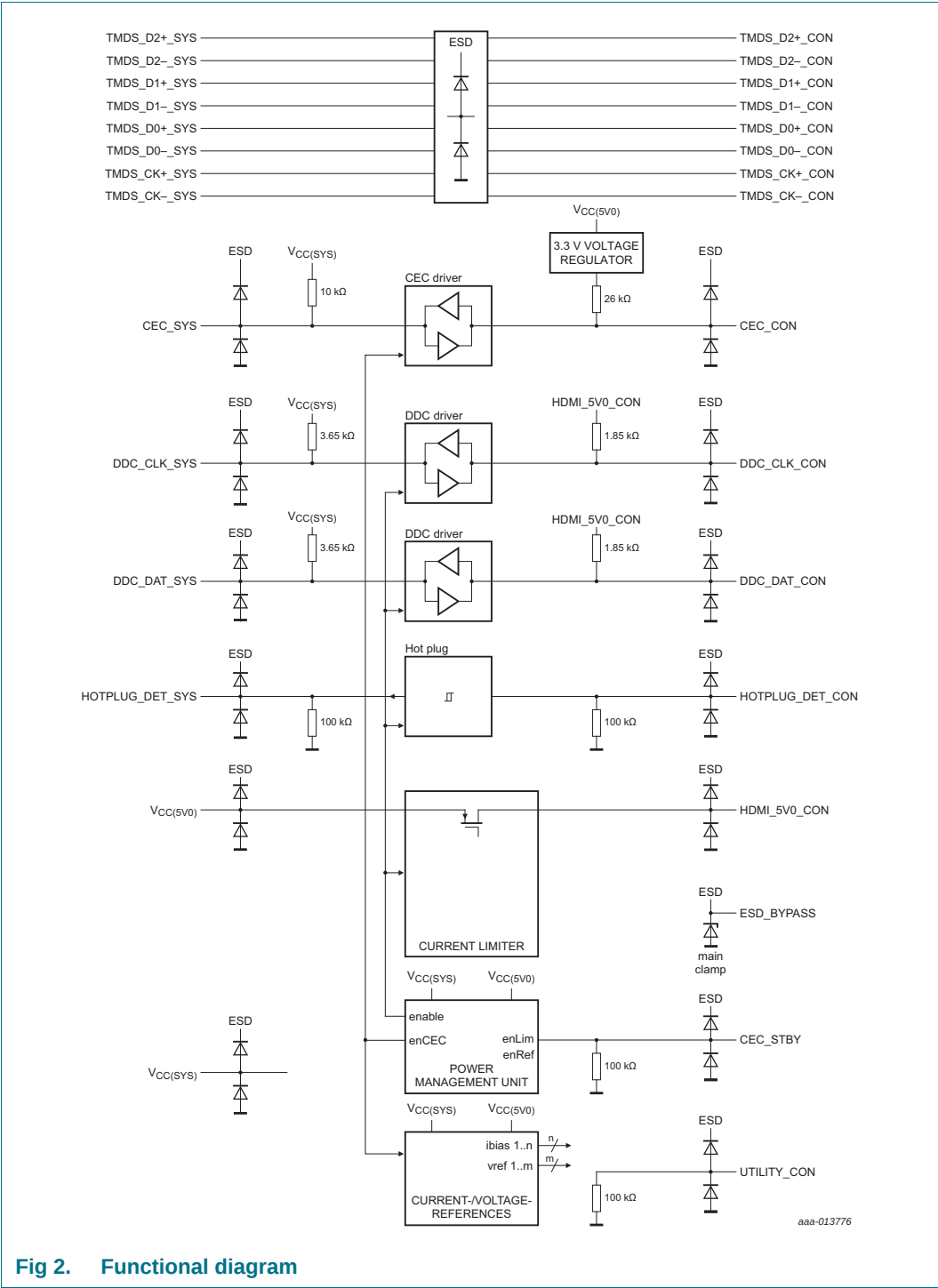


Fig 2. Functional diagram

## 5. Limiting values

**Table 3. Limiting values**

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

| Symbol               | Parameter                       | Conditions                                                                                                              | Min       | Max  | Unit |
|----------------------|---------------------------------|-------------------------------------------------------------------------------------------------------------------------|-----------|------|------|
| V <sub>CC(5V0)</sub> | supply voltage (5.0 V)          |                                                                                                                         | GND – 0.5 | 6.5  | V    |
| V <sub>I</sub>       | input voltage                   | I/O pins                                                                                                                | GND – 0.5 | 5.5  | V    |
| V <sub>ESD</sub>     | electrostatic discharge voltage | IEC 61000-4-2, level 4 (contact) <a href="#">[1]</a>                                                                    | -         | ±12  | kV   |
|                      |                                 | IEC 61000-4-2, level 1 (contact) <a href="#">[2]</a>                                                                    | -         | ±2   | kV   |
| P <sub>tot</sub>     | total power dissipation         | DDC operating at 100 kHz;<br>CEC operating at 1 kHz;<br>50 % duty cycle; CEC_STBY = HIGH;<br>no current at HDMI_5V0_CON | -         | 50   | mW   |
|                      |                                 | DDC and CEC bus in idle mode;<br>CEC_STBY = HIGH;<br>no current at HDMI_5V0_CON                                         | -         | 3.0  | mW   |
|                      |                                 | DDC and CEC bus in idle mode;<br>CEC_STBY = LOW                                                                         | -         | 1.0  | mW   |
| T <sub>amb</sub>     | ambient temperature             |                                                                                                                         | -25       | +85  | °C   |
| T <sub>stg</sub>     | storage temperature             |                                                                                                                         | -55       | +125 | °C   |

[1] Connector-side pins (typically denoted with “\_CON” suffix) to ground.

[2] System-side pins: CEC\_SYS, DDC\_DAT\_SYS, DDC\_CLK\_SYS, HOTPLUG\_DET\_SYS, CEC\_STBY, V<sub>CC(SYS)</sub> and V<sub>CC(5V0)</sub>.

## 6. Static characteristics

**Table 4. Supplies**

$T_{amb} = -25\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$  unless otherwise specified.

| Symbol        | Parameter              | Conditions | Min  | Typ | Max | Unit |
|---------------|------------------------|------------|------|-----|-----|------|
| $V_{CC(5V0)}$ | supply voltage (5.0 V) | [1]        | 4.5  | 5.0 | 6.5 | V    |
| $V_{CC(SYS)}$ | system supply voltage  |            | 1.62 | 3.3 | 5.5 | V    |

- [1] The IP4786CZ32 contains a 5 V voltage regulator function for higher input voltages. Any input voltage of  $4.925\text{ V} < V_{CC(5V0)} < 6.50\text{ V}$  will provide HDMI-compliant output levels of 4.8 V to 5.3 V on HDMI\_5V0\_CON.

**Table 5. TMDS protection circuit**

$T_{amb} = -25\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$  unless otherwise specified.

| Symbol                  | Parameter                                   | Conditions                                                          | Min    | Typ | Max | Unit          |
|-------------------------|---------------------------------------------|---------------------------------------------------------------------|--------|-----|-----|---------------|
| <b>TMDS channel</b>     |                                             |                                                                     |        |     |     |               |
| $Z_{i(dif)}$            | differential input impedance                | TDR measured;<br>$t_r = 200\text{ ps}$                              | 90     | 100 | 110 | $\Omega$      |
| $C_{eff}$               | effective capacitance                       | equivalent shunt capacitance for TDR minimum; $t_r = 200\text{ ps}$ | [1][2] | 0.6 | -   | pF            |
| <b>Protection diode</b> |                                             |                                                                     |        |     |     |               |
| $V_{BRzd}$              | Zener diode breakdown voltage               | $I = 1.0\text{ mA}$                                                 | 6.0    | -   | 9.0 | V             |
| $r_{dyn}$               | dynamic resistance                          | surge; $I = 1.0\text{ A}$ ;<br>IEC 61000-4-5/9                      |        |     |     |               |
|                         |                                             | positive transient                                                  | -      | 1.0 | -   | $\Omega$      |
|                         |                                             | negative transient                                                  | -      | 1.0 | -   | $\Omega$      |
|                         |                                             | TLP                                                                 |        |     |     |               |
|                         |                                             | positive transient [3]                                              | -      | 1.0 | -   | $\Omega$      |
|                         |                                             | negative transient [3]                                              | -      | 1.0 | -   | $\Omega$      |
| $I_{bck}$               | back current                                | $V_{CC(5V0)} < V_{ch(TMDS)}$ [4][5]                                 | -      | 0.1 | 1.0 | $\mu\text{A}$ |
| $I_{LR}$                | reverse leakage current                     | $V_I = 3.0\text{ V}$                                                | -      | 1.0 | -   | $\mu\text{A}$ |
| $V_F$                   | forward voltage                             |                                                                     | -      | 0.7 | -   | V             |
| $V_{CL(ch)trt(pos)}$    | positive transient channel clamping voltage | 100 ns TLP;<br>50 $\Omega$ pulser at 50 ns                          | -      | 8.0 | -   | V             |

- [1] This parameter is guaranteed by design.
- [2] Capacitive dip at HDMI Time Domain Reflectometer (TDR) measurement conditions.
- [3] ANSI-ESD5.1-2004, ESD sensitivity testing Transmission Line Pulse (TLP) component level method 50 TDR.
- [4] Signal pins:  
TMDS\_D0+\_CON, TMDS\_D0-\_CON, TMDS\_D1+\_CON, TMDS\_D1-\_CON, TMDS\_D2+\_CON, TMDS\_D2-\_CON, TMDS\_CK+\_CON, TMDS\_CK-\_CON,  
TMDS\_D0+\_SYS, TMDS\_D0-\_SYS, TMDS\_D1+\_SYS, TMDS\_D1-\_SYS, TMDS\_D2+\_SYS, TMDS\_D2-\_SYS, TMDS\_CK+\_SYS and TMDS\_CK-\_SYS.
- [5] Backdrive current from TMDS\_x\_SYS and TMDS\_x\_CON pins to local  $V_{CC(5V0)}$  bias rail at power-down. Device does not block backdrive current leakage through the device to/from ASIC I/O pins connected to TMDS\_x\_SYS pins.

**Table 6. HDMI\_5V0\_CON** $T_{amb} = -25\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$  unless otherwise specified.

| Symbol       | Parameter                    | Conditions                                                                                    | Min | Typ  | Max | Unit          |
|--------------|------------------------------|-----------------------------------------------------------------------------------------------|-----|------|-----|---------------|
| $r_{dyn}$    | dynamic resistance           | TLP                                                                                           |     |      |     |               |
|              |                              | positive transient [1]                                                                        | -   | 1.0  | -   | $\Omega$      |
|              |                              | negative transient [1]                                                                        | -   | 1.0  | -   | $\Omega$      |
| $V_{CL}$     | clamping voltage             | 100 ns TLP;<br>50 $\Omega$ pulser at 50 ns                                                    | -   | 8    | -   | V             |
| $I_{O(max)}$ | maximum output current       | $V_{(HDMI\_5V0\_CON)} = 4.8\text{ V}$                                                         | 55  | -    | -   | mA            |
| $I_{bck}$    | back current                 | $V_{CC(5V0)} < V_{(HDMI\_5V0\_CON)}$                                                          | -   | -    | 10  | $\mu\text{A}$ |
| $I_{O(sc)}$  | short-circuit output current | $V_{(HDMI\_5V0\_CON)} = 0\text{ V}$                                                           | -   | 125  | 175 | mA            |
| $V_{do}$     | dropout voltage              | $4.5\text{ V} < V_{CC(5V0)} < 4.925\text{ V}$ ;<br>DDC = LOW [2]                              |     |      |     |               |
|              |                              | $I_O = 10\text{ mA}$                                                                          | -   | 70   | -   | mV            |
|              |                              | $I_O = 55\text{ mA}$                                                                          | -   | -    | 125 | mV            |
| $V_{O(LDO)}$ | LDO output voltage           | $I_O \leq 55\text{ mA}$ ;<br>$4.925\text{ V} < V_{CC(5V0)} < 6.5\text{ V}$ ;<br>DDC = LOW [2] | 4.8 | 5.05 | 5.3 | V             |

[1] ANSI-ESD5.1-2004, ESD sensitivity testing TLP component level method 50 TDR.

[2] The IP4786CZ32 contains a 5 V voltage regulator function for higher input voltages.  
Any input voltage of  $4.925\text{ V} < V_{CC(5V0)} < 6.50\text{ V}$  will provide HDMI-compliant output levels of 4.8 V to 5.3 V on HDMI\_5V0\_CON.**Table 7. UTILITY\_CON** $T_{amb} = -25\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$  unless otherwise specified.

| Symbol                                                                      | Parameter            | Conditions                                                                                                                                              | Min | Typ | Max | Unit       |
|-----------------------------------------------------------------------------|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|------------|
| <b>Supplies: pins <math>V_{CC(5V0)}</math> and <math>V_{CC(SYS)}</math></b> |                      |                                                                                                                                                         |     |     |     |            |
| $r_{dyn}$                                                                   | dynamic resistance   | TLP                                                                                                                                                     |     |     |     |            |
|                                                                             |                      | positive transient [1]                                                                                                                                  | -   | 1.0 | -   | $\Omega$   |
|                                                                             |                      | negative transient [1]                                                                                                                                  | -   | 1.0 | -   | $\Omega$   |
| $V_{CL}$                                                                    | clamping voltage     | 100 ns TLP;<br>50 $\Omega$ pulser at 50 ns                                                                                                              | -   | 8.0 | -   | V          |
| $C_i$                                                                       | input capacitance    | $V_{CC(5V0)} = 0\text{ V}$ ;<br>$V_{CC(SYS)} = 0\text{ V}$ ; $V_{bias} = 2.5\text{ V}$ ;<br>AC input = $3.5\text{ V}_{(p-p)}$ ;<br>$f = 100\text{ kHz}$ | -   | 8.0 | 10  | pF         |
| $R_{pd}$                                                                    | pull-down resistance |                                                                                                                                                         | 60  | 100 | 140 | k $\Omega$ |

[1] ANSI-ESD5.1-2004, ESD sensitivity testing TLP component level method 50 TDR.

**Table 8. Static characteristics** $T_{amb} = -25\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$  unless otherwise specified.

| Symbol                                             | Parameter                 | Conditions                                                                                                                                                 | Min                               | Typ  | Max                               | Unit       |
|----------------------------------------------------|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|------|-----------------------------------|------------|
| <b>DDC buffer on connector side</b> <sup>[1]</sup> |                           |                                                                                                                                                            |                                   |      |                                   |            |
| $V_{IH}$                                           | HIGH-level input voltage  |                                                                                                                                                            | $0.5 \times V_{(HDMI\_5V0\_CON)}$ | -    | 6.5                               | V          |
| $V_{IL}$                                           | LOW-level input voltage   |                                                                                                                                                            | -0.5                              | -    | $0.3 \times V_{(HDMI\_5V0\_CON)}$ | V          |
| $V_{OH}$                                           | HIGH-level output voltage |                                                                                                                                                            | $V_{(HDMI\_5V0\_CON)} - 0.02$     | -    | $V_{(HDMI\_5V0\_CON)} + 0.02$     | V          |
| $V_{OL}$                                           | LOW-level output voltage  | internal pull-up and external sink                                                                                                                         | -                                 | 100  | 200                               | mV         |
| $V_{IK}$                                           | input clamping voltage    | $I_I = -18\text{ mA}$                                                                                                                                      | -                                 | -    | -1.0                              | V          |
| $C_{IO}$                                           | input/output capacitance  | $V_{CC(5V0)} = 5.0\text{ V}$ ;<br>$V_{CC(SYS)} = 3.3\text{ V}$ ;<br>CEC_STBY = HIGH                                                                        | -                                 | 8.0  | 10                                | pF         |
| $R_{pu}$                                           | pull-up resistance        |                                                                                                                                                            | 1.6                               | 1.8  | 2.0                               | k $\Omega$ |
| <b>DDC buffer on system side</b> <sup>[1][4]</sup> |                           |                                                                                                                                                            |                                   |      |                                   |            |
| $V_{IH}$                                           | HIGH-level input voltage  | $V_{CC(SYS)} = 1.8\text{ V}$                                                                                                                               | 450                               | -    | -                                 | mV         |
|                                                    |                           | $V_{CC(SYS)} = 2.5\text{ V}$                                                                                                                               | 620                               | -    | -                                 | mV         |
|                                                    |                           | $V_{CC(SYS)} = 3.3\text{ V}$                                                                                                                               | 760                               | -    | -                                 | mV         |
|                                                    |                           | $V_{CC(SYS)} = 5.0\text{ V}$                                                                                                                               | 800                               | -    | -                                 | mV         |
| $V_{IL}$                                           | LOW-level input voltage   | $V_{CC(SYS)} = 1.8\text{ V}$                                                                                                                               | -                                 | -    | 330                               | mV         |
|                                                    |                           | $V_{CC(SYS)} = 2.5\text{ V}$                                                                                                                               | -                                 | -    | 380                               | mV         |
|                                                    |                           | $V_{CC(SYS)} = 3.3\text{ V}$                                                                                                                               | -                                 | -    | 400                               | mV         |
|                                                    |                           | $V_{CC(SYS)} = 5.0\text{ V}$                                                                                                                               | -                                 | -    | 420                               | mV         |
| $V_{OH}$                                           | HIGH-level output voltage |                                                                                                                                                            | $V_{CC(SYS)} - 0.02$              | -    | $V_{CC(SYS)} + 0.02$              | V          |
| $V_{OL}$                                           | LOW-level output voltage  | $V_{CC(SYS)} = 1.8\text{ V}$                                                                                                                               | -                                 | 490  | 500                               | mV         |
|                                                    |                           | $V_{CC(SYS)} = 2.5\text{ V}$                                                                                                                               | -                                 | 640  | 690                               | mV         |
|                                                    |                           | $V_{CC(SYS)} = 3.3\text{ V}$                                                                                                                               | -                                 | 685  | 790                               | mV         |
|                                                    |                           | $V_{CC(SYS)} = 5.0\text{ V}$                                                                                                                               | -                                 | 720  | 820                               | mV         |
| $V_{IK}$                                           | input clamping voltage    | $I_I = -18\text{ mA}$                                                                                                                                      | -                                 | -    | -1.0                              | V          |
| $C_{IO}$                                           | input/output capacitance  | $V_{CC(5V0)} = 0\text{ V}$ ;<br>$V_{CC(SYS)} = 0\text{ V}$ ;<br>$V_{bias} = 2.5\text{ V}$ ;<br>AC input = $3.5\text{ V}_{(p-p)}$ ;<br>$f = 100\text{ kHz}$ | -                                 | 6.0  | 8.0                               | pF         |
| $R_{pu}$                                           | pull-up resistance        |                                                                                                                                                            | 3.2                               | 3.65 | 4.1                               | k $\Omega$ |

**Table 8.** Static characteristics ...continued $T_{amb} = -25\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$  unless otherwise specified.

| Symbol                                | Parameter                 | Conditions                                                                                                                                               | Min                  | Typ  | Max                  | Unit          |
|---------------------------------------|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|------|----------------------|---------------|
| <b>CEC_CON</b> <sup>[1]</sup>         |                           |                                                                                                                                                          |                      |      |                      |               |
| $V_{IH}$                              | HIGH-level input voltage  |                                                                                                                                                          | 2.0                  | -    | -                    | V             |
| $V_{IL}$                              | LOW-level input voltage   |                                                                                                                                                          | -                    | -    | 0.80                 | V             |
| $V_{OH}$                              | HIGH-level output voltage |                                                                                                                                                          | 2.88                 | 3.3  | 3.63                 | V             |
| $V_{OL}$                              | LOW-level output voltage  | $I_{OL} = 1.5\text{ mA}$                                                                                                                                 | -                    | 100  | 200                  | mV            |
| $C_{IO}$                              | input/output capacitance  | $V_{CC(5V0)} = 0\text{ V};$<br>$V_{CC(SYS)} = 0\text{ V};$<br>$V_{bias} = 1.65\text{ V};$<br>AC input = $2.5\text{ V}_{(p-p)}$ ;<br>$f = 100\text{ kHz}$ | <sup>[2]</sup> -     | 8.0  | 10                   | pF            |
| $R_{pu}$                              | pull-up resistance        |                                                                                                                                                          | 23.4                 | 26.0 | 28.6                 | k $\Omega$    |
| $I_{leak(CEC)}$                       | CEC leakage current       | $V_{CC(5V0)} = 0\text{ V};$<br>$V_{CC(SYS)} = 0\text{ V};$<br>CEC_CON connected<br>to 3.63 V via 27 k $\Omega$                                           | -                    | -    | 0.1                  | $\mu\text{A}$ |
| <b>CEC_SYS</b> <sup>[1][4]</sup>      |                           |                                                                                                                                                          |                      |      |                      |               |
| $V_{IH}$                              | HIGH-level input voltage  | $V_{CC(SYS)} = 1.8\text{ V}$                                                                                                                             | 450                  | -    | -                    | mV            |
|                                       |                           | $V_{CC(SYS)} = 2.5\text{ V}$                                                                                                                             | 620                  | -    | -                    | mV            |
|                                       |                           | $V_{CC(SYS)} = 3.3\text{ V}$                                                                                                                             | 760                  | -    | -                    | mV            |
|                                       |                           | $V_{CC(SYS)} = 5.0\text{ V}$                                                                                                                             | 800                  | -    | -                    | mV            |
| $V_{IL}$                              | LOW-level input voltage   | $V_{CC(SYS)} = 1.8\text{ V}$                                                                                                                             | -                    | -    | 330                  | mV            |
|                                       |                           | $V_{CC(SYS)} = 2.5\text{ V}$                                                                                                                             | -                    | -    | 380                  | mV            |
|                                       |                           | $V_{CC(SYS)} = 3.3\text{ V}$                                                                                                                             | -                    | -    | 400                  | mV            |
|                                       |                           | $V_{CC(SYS)} = 5.0\text{ V}$                                                                                                                             | -                    | -    | 420                  | mV            |
| $V_{OH}$                              | HIGH-level output voltage | <sup>[2]</sup>                                                                                                                                           | $V_{CC(SYS)} - 0.02$ | -    | $V_{CC(SYS)} + 0.02$ | V             |
| $V_{OL}$                              | LOW-level output voltage  | $V_{CC(SYS)} = 1.8\text{ V}$ <sup>[5]</sup>                                                                                                              | -                    | 490  | 500                  | mV            |
|                                       |                           | $V_{CC(SYS)} = 2.5\text{ V}$ <sup>[5]</sup>                                                                                                              | -                    | 640  | 690                  | mV            |
|                                       |                           | $V_{CC(SYS)} = 3.3\text{ V}$ <sup>[5]</sup>                                                                                                              | -                    | 675  | 770                  | mV            |
|                                       |                           | $V_{CC(SYS)} = 5.0\text{ V}$ <sup>[5]</sup>                                                                                                              | -                    | 710  | 800                  | mV            |
| $C_{IO}$                              | input/output capacitance  | $V_{CC(5V0)} = 0\text{ V};$<br>$V_{CC(SYS)} = 0\text{ V};$<br>$V_{bias} = 1.65\text{ V};$<br>AC input = $2.5\text{ V}_{(p-p)}$ ;<br>$f = 100\text{ kHz}$ | <sup>[2]</sup> -     | 6.0  | 7.0                  | pF            |
| $R_{pu}$                              | pull-up resistance        |                                                                                                                                                          | 8.5                  | 10   | 11.5                 | k $\Omega$    |
| <b>HOTPLUG_DET_CON</b> <sup>[1]</sup> |                           |                                                                                                                                                          |                      |      |                      |               |
| $V_{IH}$                              | HIGH-level input voltage  |                                                                                                                                                          | 2.0                  | -    | -                    | V             |
| $V_{IL}$                              | LOW-level input voltage   |                                                                                                                                                          | -                    | -    | 0.8                  | V             |
| $R_{pd}$                              | pull-down resistance      |                                                                                                                                                          | 60                   | 100  | 140                  | k $\Omega$    |
| $C_i$                                 | input capacitance         | $V_{CC(5V0)} = 0\text{ V};$<br>$V_{CC(SYS)} = 0\text{ V};$<br>$V_{bias} = 2.5\text{ V};$<br>AC input = $3.5\text{ V}_{(p-p)}$ ;<br>$f = 100\text{ kHz}$  | <sup>[2]</sup> -     | 8.0  | 10                   | pF            |

**Table 8.** Static characteristics ...continued $T_{amb} = -25\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$  unless otherwise specified.

| Symbol                               | Parameter                 | Conditions              | Min                      | Typ | Max | Unit       |
|--------------------------------------|---------------------------|-------------------------|--------------------------|-----|-----|------------|
| <b>HOTPLUG_DET_SYS<sup>[1]</sup></b> |                           |                         |                          |     |     |            |
| $V_{OH}$                             | HIGH-level output voltage | $I_{OL} = 1\text{ mA}$  | $0.7 \times V_{CC(SYS)}$ | -   | -   | V          |
| $V_{OL}$                             | LOW-level output voltage  | $I_{OL} = -1\text{ mA}$ | -                        | 200 | 300 | mV         |
| $R_{pd}$                             | pull-down resistance      |                         | 60                       | 100 | 140 | k $\Omega$ |

[1] The device is active if the input voltage at pin CEC\_STBY is above the HIGH level.

[2] This parameter is guaranteed by design.

[3] Capacitive load measured at power-on.

[4] No external pull-up resistor attached.

[5] Typical value at  $T_{amb} = +25\text{ }^{\circ}\text{C}$ .

**Table 9.** CEC\_STBY power management circuit $V_{CC(SYS)} = 1.62\text{ V}$  to  $5.5\text{ V}$ ;  $V_{CC(5V0)} = 4.5\text{ V}$  to  $6.5\text{ V}$ ;  $GND = 0\text{ V}$ ;  $T_{amb} = -25\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$  unless otherwise specified.

| Symbol                                              | Parameter                | Conditions                         | Min  | Typ | Max | Unit       |
|-----------------------------------------------------|--------------------------|------------------------------------|------|-----|-----|------------|
| <b>Board side: input pin CEC_STBY<sup>[1]</sup></b> |                          |                                    |      |     |     |            |
| $V_{IH}$                                            | HIGH-level input voltage | HIGH = active <sup>[2]</sup>       | 1.2  | -   | 6.5 | V          |
| $V_{IL}$                                            | LOW-level input voltage  | LOW = standby <sup>[3]</sup>       | -0.5 | -   | 0.8 | V          |
| $R_{pd}$                                            | pull-down resistance     |                                    | 60   | 100 | 140 | k $\Omega$ |
| $C_i$                                               | input capacitance        | $V_i = 3\text{ V}$ or $0\text{ V}$ | -    | 6   | 7   | pF         |

[1] The CEC\_STBY pin should be connected permanently to  $V_{CC(5V0)}$  or  $V_{CC(SYS)}$  if no enable control is needed.

[2] DDC buffers, Hot Plug Detect (HPD) buffer, and HDMI\_5V0\_CON out enabled; CEC buffer enabled.

[3] DDC buffers, HPD buffer, and HDMI\_5V0\_CON out disabled; CEC buffer enabled.

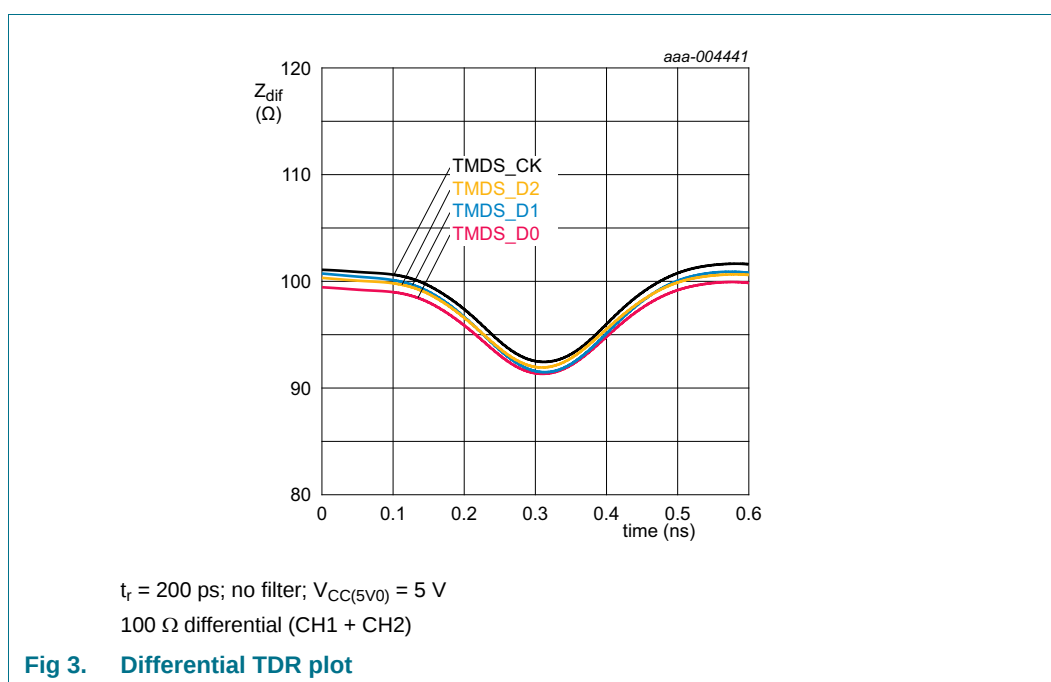
## 7. Dynamic characteristics

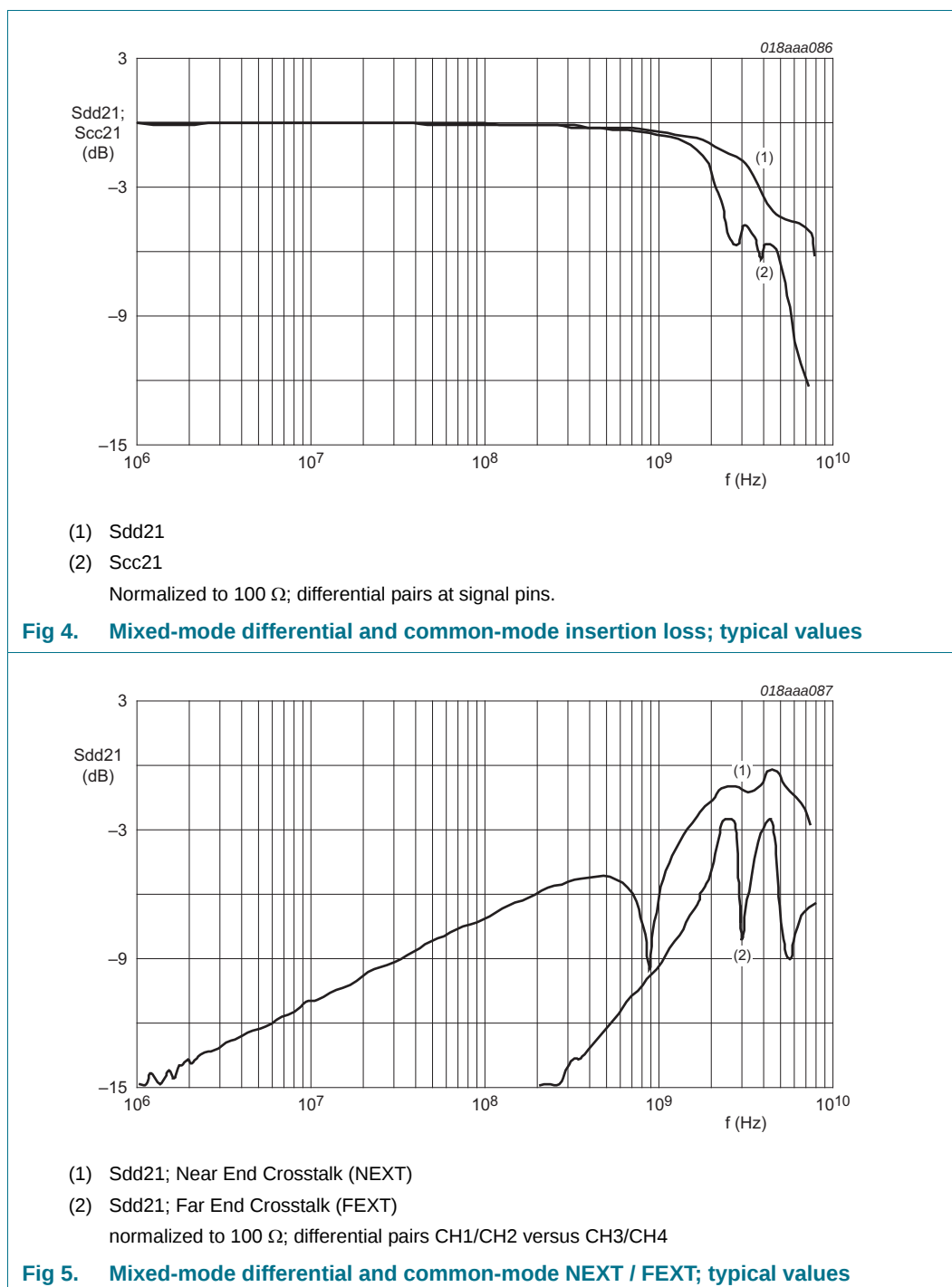
**Table 10. Dynamic characteristics**

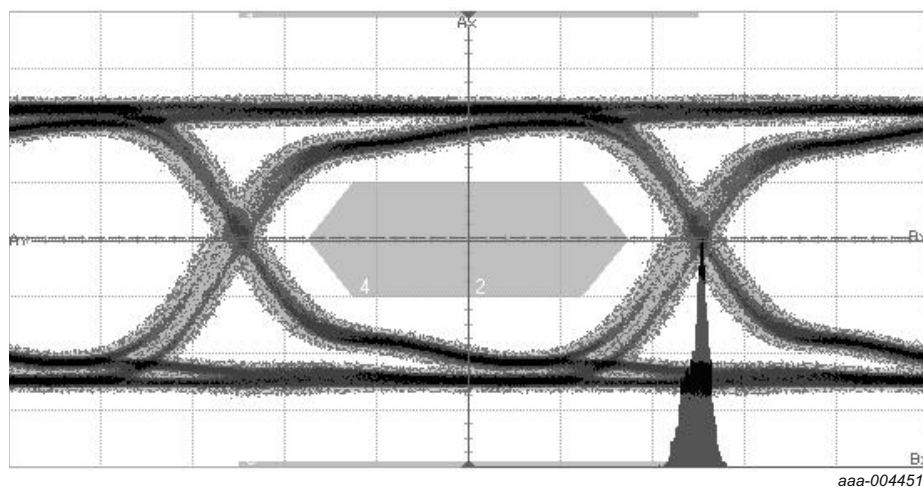
$V_{CC(5V0)} = 5.0\text{ V}$ ;  $V_{CC(SYS)} = 1.8\text{ V}$ ;  $GND = 0\text{ V}$ ;  $T_{amb} = -25\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$  unless otherwise specified.

| Symbol                                                                  | Parameter                     | Conditions                                              | Min | Typ | Max | Unit |
|-------------------------------------------------------------------------|-------------------------------|---------------------------------------------------------|-----|-----|-----|------|
| <b>DDC_DAT_SYS, DDC_CLK_SYS, DDC_DAT_CON, DDC_CLK_CON<sup>[1]</sup></b> |                               |                                                         |     |     |     |      |
| $t_{PLH}$                                                               | LOW to HIGH propagation delay | system side to connector side <a href="#">Figure 16</a> | -   | 80  | -   | ns   |
| $t_{PHL}$                                                               | HIGH to LOW propagation delay | system side to connector side <a href="#">Figure 16</a> | -   | 60  | -   | ns   |
| $t_{PLH}$                                                               | LOW to HIGH propagation delay | connector side to system side <a href="#">Figure 17</a> | -   | 120 | -   | ns   |
| $t_{PHL}$                                                               | HIGH to LOW propagation delay | connector side to system side <a href="#">Figure 17</a> | -   | 80  | -   | ns   |
| $t_{TLH}$                                                               | LOW to HIGH transition time   | connector side <a href="#">Figure 18</a>                | -   | 150 | -   | ns   |
| $t_{THL}$                                                               | HIGH to LOW transition time   | connector side <a href="#">Figure 18</a>                | -   | 100 | -   | ns   |
| $t_{TLH}$                                                               | LOW to HIGH transition time   | system side <a href="#">Figure 19</a>                   | -   | 250 | -   | ns   |
| $t_{THL}$                                                               | HIGH to LOW transition time   | system side <a href="#">Figure 19</a>                   | -   | 80  | -   | ns   |

[1] All dynamic measurements are done with a 75 pF load. Rise times are determined by internal pull-up resistors.

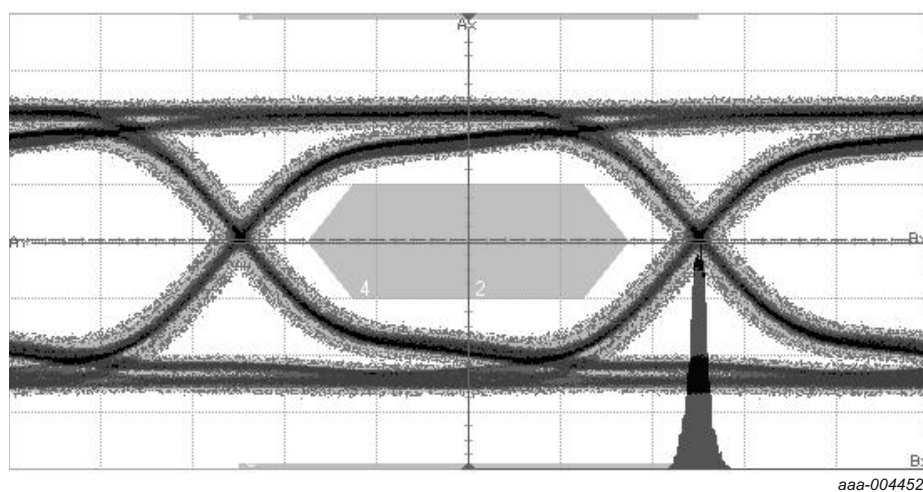






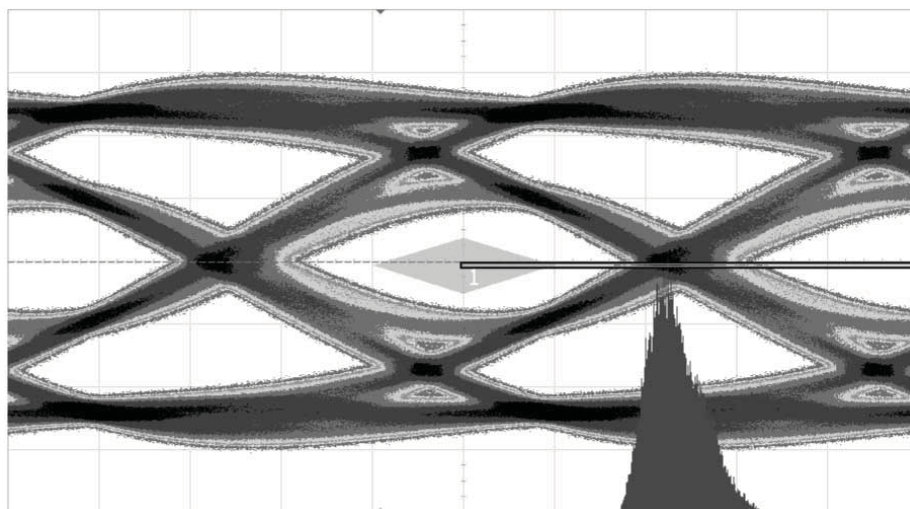
227 MHz pixel clock  
Horizontal scale: 90 ps/div  
Vertical scale: 200 mV/div  
Offset: 42.6 mV

**Fig 6. Eye diagram using IP4786CZ32 (1080p, 12 bit)**



297 MHz pixel clock  
Horizontal scale: 67.5 ps/div  
Vertical scale: 200 mV/div  
Offset: 42.6 mV

**Fig 7. Eye diagram using IP4786CZ32 (1080p, 16 bit)**



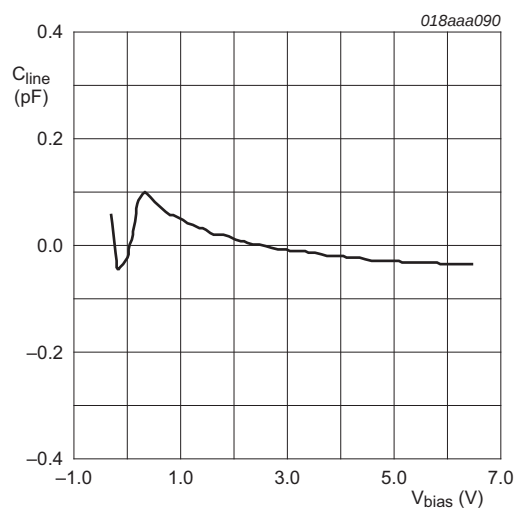
148.5 MHz test frequency

Horizontal scale: 53.8 ps/div

Vertical scale: 200 mV/div

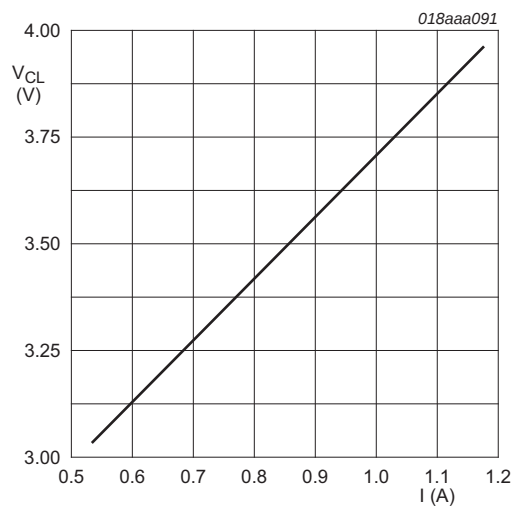
Measured at TP2 with worst cable emulator, reference cable equalizer and worst case negative skew

**Fig 8. Eye diagram using IP4786CZ32 (2160p, 60 Hz)**



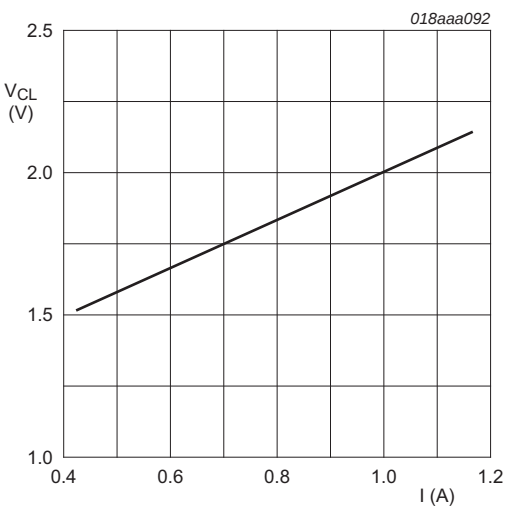
Deviation from typical capacitance normalized at  $V_{bias} = 2.5 \text{ V}$

**Fig 9. Line capacitance as a function of bias voltage; typical values**



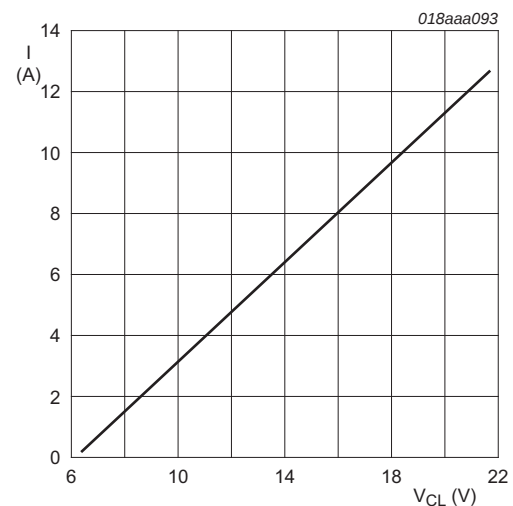
IEC 61000-4-5;  $t_p = 8/20 \mu s$ ; positive pulse

Fig 10. Dynamic resistance with positive clamping



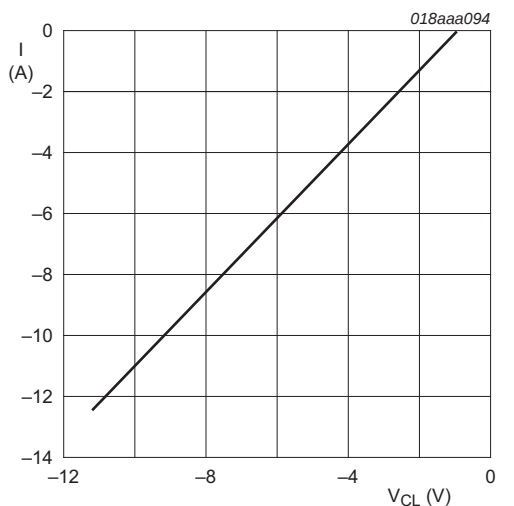
IEC 61000-4-5;  $t_p = 8/20 \mu s$ ; negative pulse

Fig 11. Dynamic resistance with negative clamping



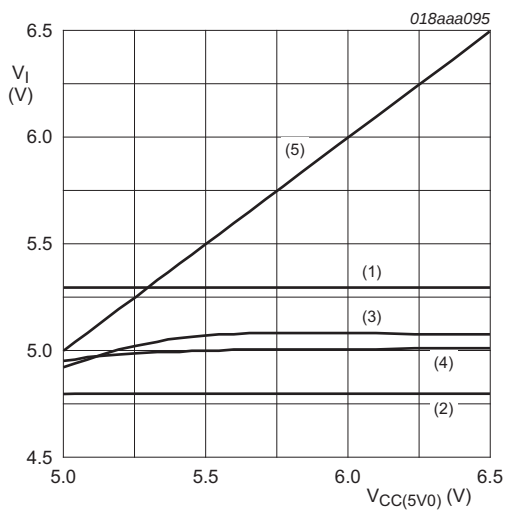
$t_p = 100 ns$ ; TLP; signal pins; typical values

Fig 12. Dynamic resistance with positive clamping



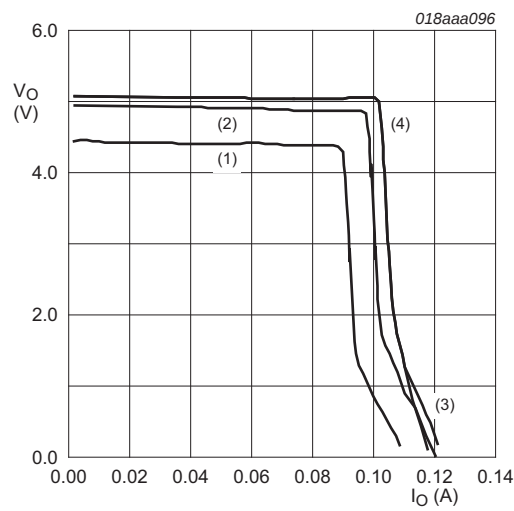
$t_p = 100 ns$ ; TLP; signal pins; typical values

Fig 13. Dynamic resistance with negative clamping



- (1) 5.3 V; maximum values; HDMI CTS TID 7-11
- (2) 4.8 V; minimum values; HDMI CTS TID 7-11
- (3)  $I = 0\text{ mA}$
- (4)  $I = 55\text{ mA}$
- (5)  $V_{CC(5V0)}$  supply input; 4.925 V to 6.5 V

Fig 14. Overvoltage limiter function (HDMI\_5V0\_CON)



- (1)  $V_{CC(5V0)} = 4.5\text{ V}$
- (2)  $V_{CC(5V0)} = 5.0\text{ V}$
- (3)  $V_{CC(5V0)} = 5.5\text{ V}$
- (4)  $V_{CC(5V0)} = 6.5\text{ V}$

Fig 15. Overcurrent limiter function (HDMI\_5V0\_CON)

8. AC waveforms

8.1 DDC propagation delay

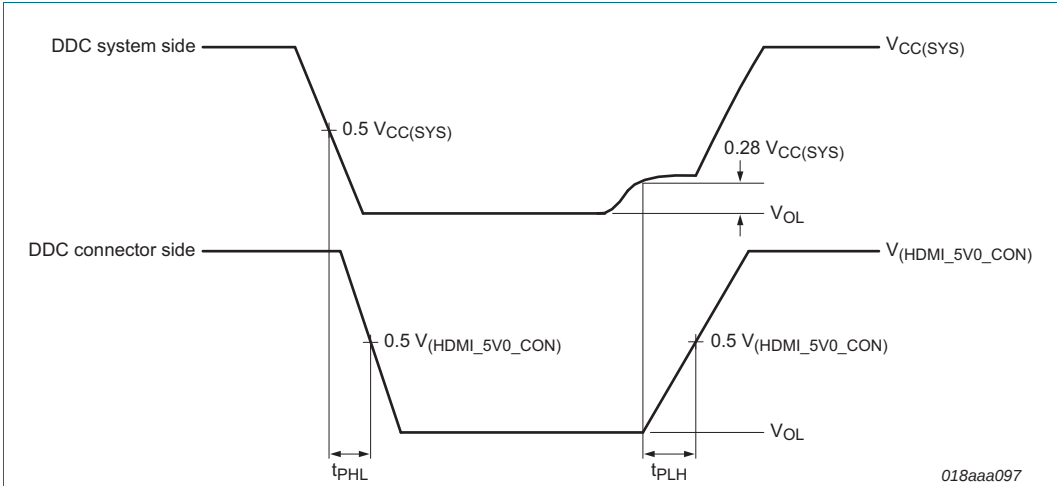


Fig 16. Propagation delay DDC, DDC system side to DDC connector side

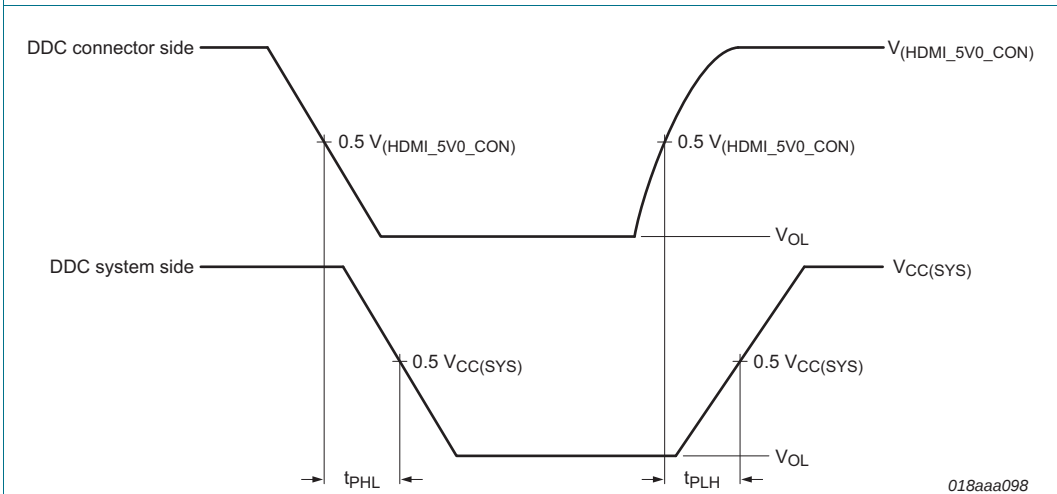


Fig 17. Propagation delay DDC, DDC connector side to DDC system side

8.2 DDC transition time

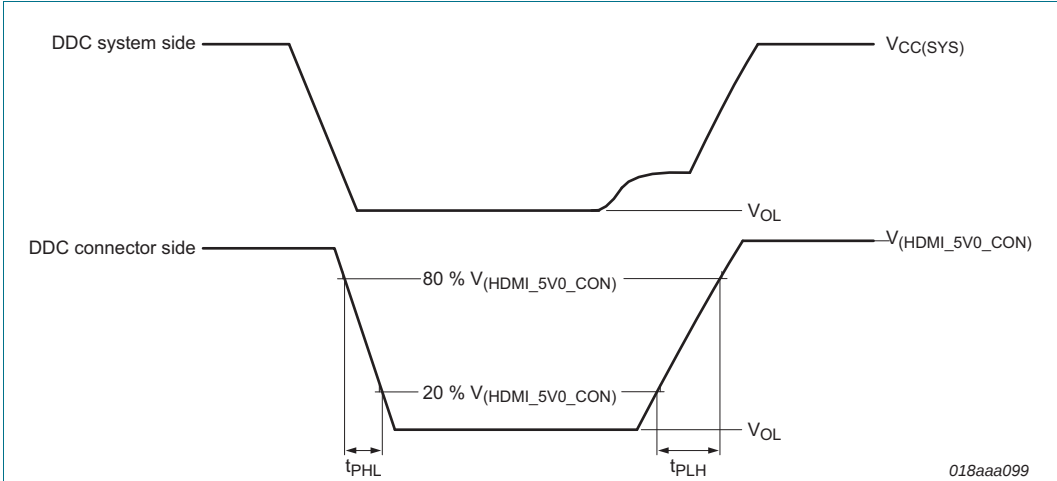


Fig 18. Transition time DDC connector side

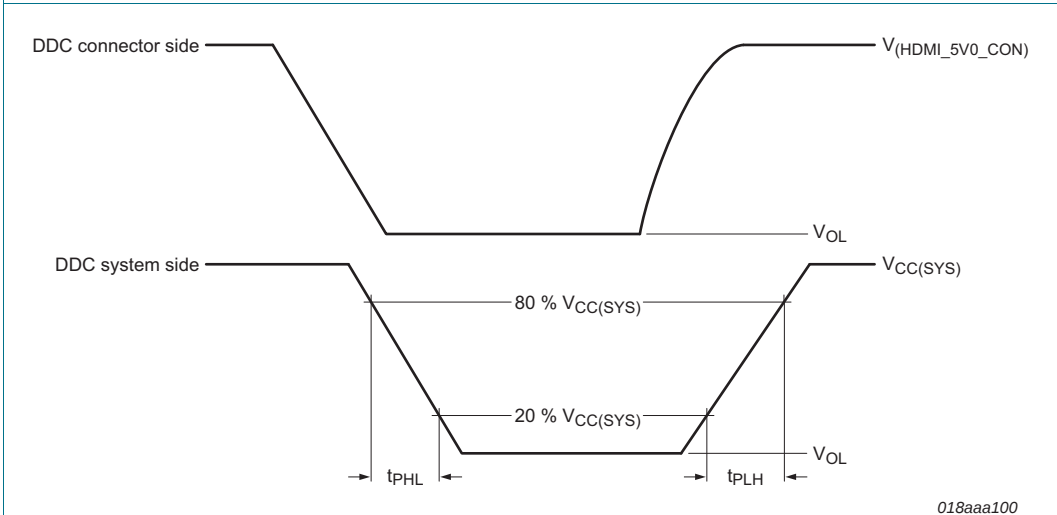


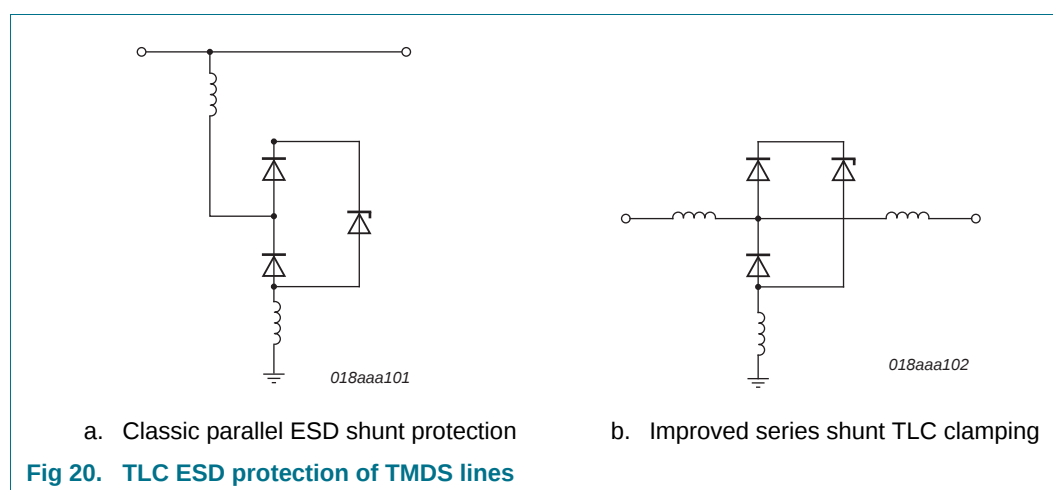
Fig 19. Transition time DDC system side

## 9. Application information

### 9.1 TMDS ESD

To protect the TMDS lines and also to comply with the impedance requirements of the HDMI specification, the IP4786CZ32 provides ESD protection with matched TLC ESD structures. Typical Dual Rail Clamp (DRC) or rail-to-rail shunt structures are common for low-capacitance ESD protection (as shown on the left side of [Figure 20](#)) where the dominant factor for the TMDS line impedance dip is determined by the capacitive load to ground. Parasitic lead inductances of the packaging in this case works against the ESD clamping performance by including the  $\Delta I/\Delta t$  reactance of the inductance into the path of the ESD shunt.

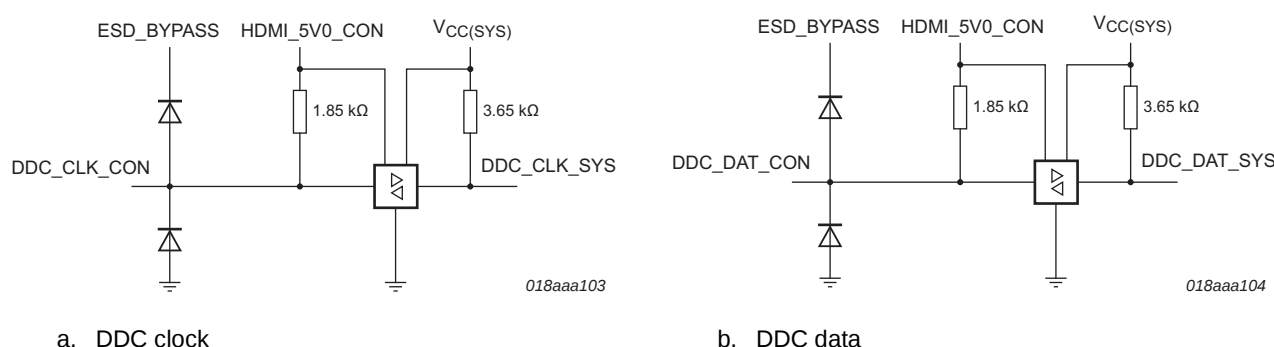
The IP4786CZ32 utilizes these inherent inductances in series with the transmission line in order to present an effective capacitive load of roughly only 0.7 pF. This TLC structure minimizes the capacitive dip, for ideal signal integrity ([Figure 20](#); right side) without complicated PCB pre-compensation. As a beneficial side effect, this enhances the ESD performance of the device as well, since the reactance of the series inductance attenuates the fast initial peak of the ESD pulse, for a lower residual pulse delivered to the Application Specific Integrated Circuit (ASIC).



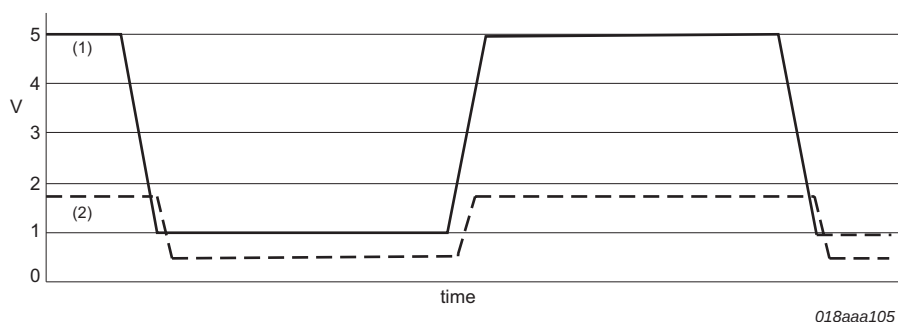
## 9.2 DDC circuit

The DDC bus circuit integrates all required pull-ups, and provides full capacitive decoupling between the HDMI connector and the DDC bus lines on the PCB. The capacitive decoupling ensures that the maximum capacitive load is well within the 50 pF maximum of the HDMI specification. No external pull-ups or pull-downs are required.

The bidirectional buffers support high-capacitive load on the HDMI cable-side. Various non-compliant but prevalent low-cost cables have been observed with a capacitive load of up to 6 nF on the DDC lines, far exceeding the 700 pF HDMI limit. The IP4786CZ32 can easily decouple this from the weaker ASIC I/O buffers, and drive the rogue cable successfully.



**Fig 21. DDC circuit**

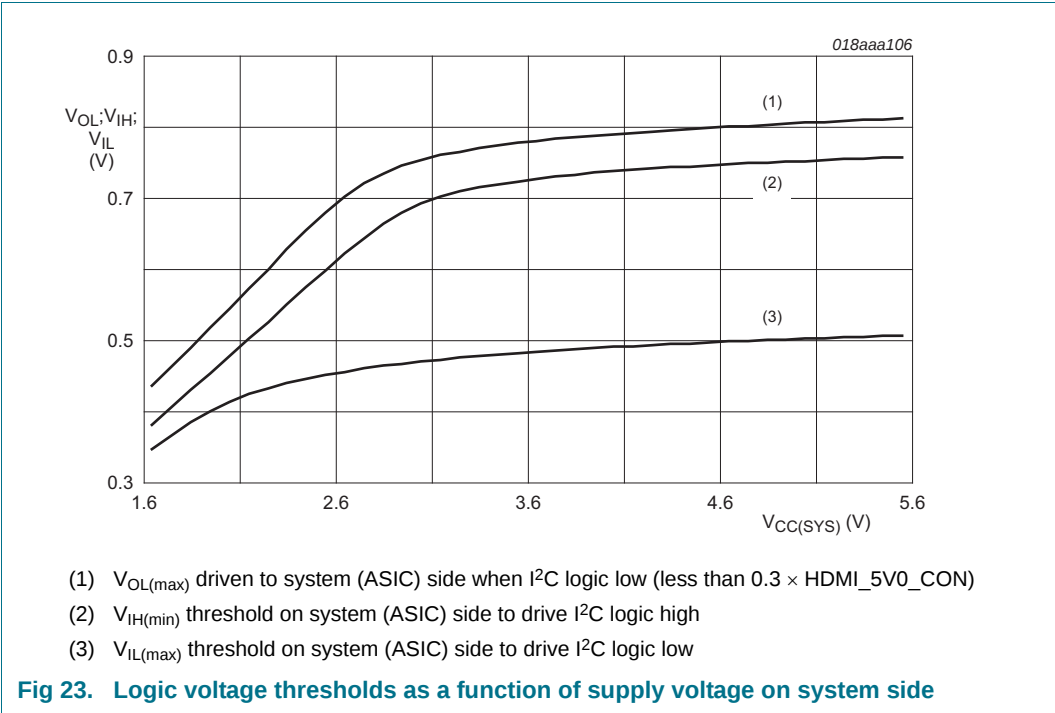


**Fig 22. DDC level shifting waveform example**

9.3 Logic low I<sup>2</sup>C voltage shifter

The DDC buffers provide an additional feature commonly required for high-integration HDMI ASICs which are limited to CMOS or LVTTTL LOW-level input voltage ( $V_{IL}$ ) on their available I/O buffer cells. These I/Os are not strictly compliant with the  $0.3 V_{DD}$  threshold voltage levels of I<sup>2</sup>C and may miss intended logic low levels on the cable between 0.8 V and 1.5 V (typical values).

This feature is also included in the CEC buffer, and thus allows standard I/O buffer cells to be used in ASICs and microcontrollers.



## 9.4 Hot plug detect circuit and HEAC support

The IP4786CZ32 includes a hot plug detect circuit that simplifies the hot plug application. The circuit generates a standard logic level from the hot plug signal.

The hot plug detect circuit is pulling down the signal to avoid any floating signal. The comparator guarantees a safe detection of the 2 V hot plug signal without any glitches or oscillation at the hot plug output.

The IP4786CZ32 also provides an additional ESD pin to protect the reserved / HEAC pin along with hot plug detect to 12 kV, exceeding IEC 61000-4-2 level 4.

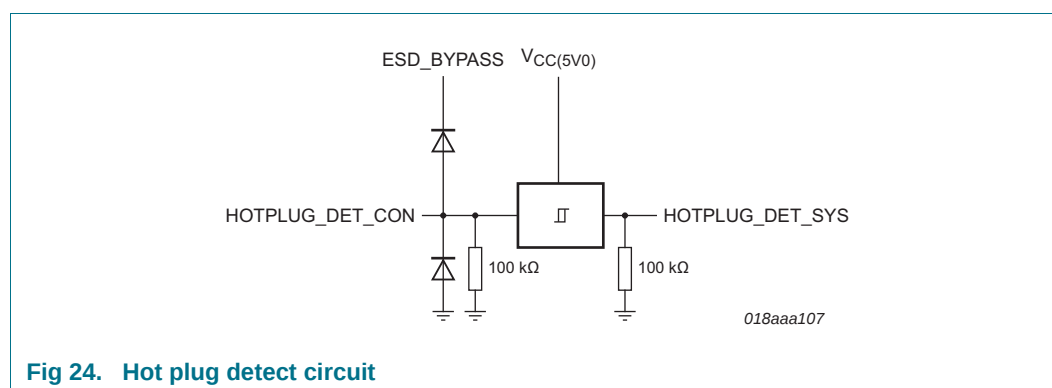


Fig 24. Hot plug detect circuit

## 9.5 CEC

The logical multidrop topology of the CEC bus can include complex physical stubs, loading cables, and interconnects that may deteriorate signal quality.

The IP4786CZ32 includes a full bidirectional buffer to drive the CEC bus and isolate the CEC microcontroller or ASIC General-Purpose Input/Output (GPIO).

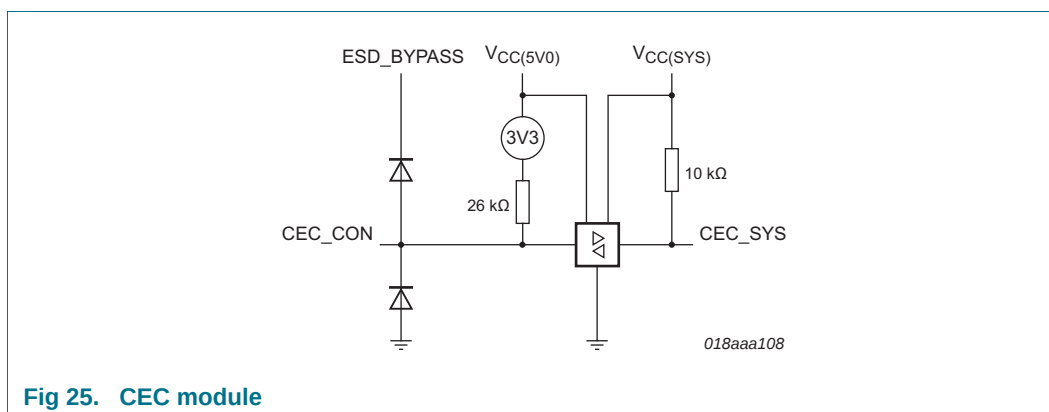
The CEC buffer derives power from an on-board 3.3 V regulator from the  $V_{CC(5V0)}$  domain (see [Figure 25](#)). This allows extensive system power management configurations and guarantees an HDMI-compliant  $V_{(CEC\_CON)}$  on the connector, as well as the backdrive-protected 125  $\mu$ A nominal CEC pull-up which does not degrade the bus when powered down.

By placing the CEC microcontroller and  $V_{CC(5V0)}$  input on a 5 V rail as shown in [Figure 28](#), the CEC microcontroller can communicate over CEC for power commands, and then enable the HDMI port via the CEC\_STBY pin, as well as the rest of the system as needed.

If IP4786CZ32 Standby modes are not required, or if the Power-down modes are not desired, the CEC\_STBY pin can be pulled HIGH to  $V_{CC(5V0)}$  or  $V_{CC(SYS)}$  for continuous HDMI and CEC operation.

Strapping the CEC\_STBY =  $V_{CC(SYS)}$  =  $V_{DD}$  of ASIC guarantees that all interface signals ending with the suffix “\_SYS” on the system side will be disabled when  $V_{CC(SYS)}$  goes low, protecting the ASIC I/O signals from exceeding its local  $V_{DD}$ . In this mode, even if  $V_{CC(5V0)}$  is powered, HDMI\_5V0\_CON go active and hot plug events can be detected only when the ASIC power supply rail is on.

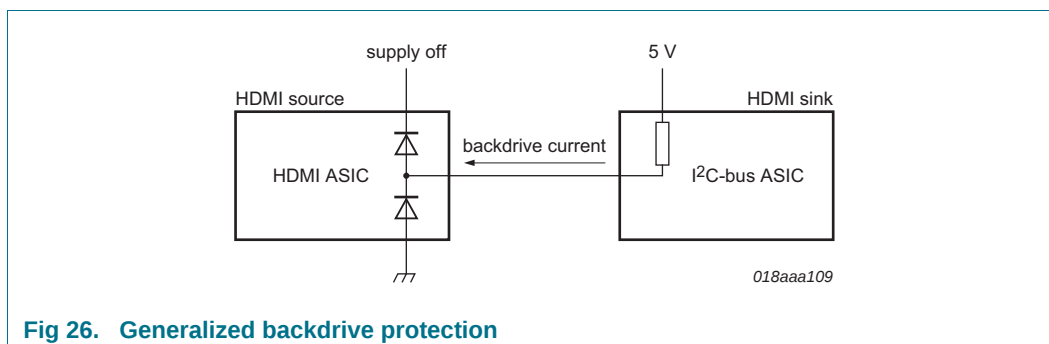
Strapping CEC\_STBY =  $V_{CC(5V0)}$  is the most basic configuration where the buffers are enabled whenever the local  $V_{CC(5V0)}$  and  $V_{CC(SYS)}$  supplies reach minimum operating levels.



## 9.6 Backdrive protection

The HDMI connector contains various signals which can partly supply current into an HDMI device that is powered down.

Typically, the DDC lines and the CEC signals can force significant current back into the powered-down rails as shown in [Figure 26](#), causing power-on reset problems with the system, and possible damage. The IP4786CZ32 prevents this backdrive condition whenever the I/O voltage is greater than the local supply.



### 9.7 55 mA overcurrent / overvoltage LDO function

The IP4786CZ32 integrates a complete linear output overcurrent protection to isolate faults from the source power supply, while still meeting HDMI output specifications.

The Low DropOut (LDO) design provides a low-cost solution requiring just a single output capacitor (1  $\mu$ F or higher, Equivalent Series Resistance (ESR) < 1  $\Omega$ ), eliminating start-up and ripple concerns (see [Figure 27](#)).

A typical 100 mV  $V_{do}$  overcurrent-only solution would require a  $5.1\text{ V} \pm 3\%$  input supply to guarantee 4.8 V to 5.3 V over 0 mA to 55 mA at the HDMI connector.

The overcurrent / overvoltage feature of the IP4786CZ32 allows the use of wider tolerance input supplies up to 6.5 V while still meeting the 4.8 V-to-5.3 V output limit required by HDMI. This means, for example, a cost-reduced  $5.2\text{ V} \pm 5\%$  or even a  $5.5\text{ V} \pm 10\%$  supply can be used with the IP4786CZ32.

As with all the I/O pins, this block is ESD-protected and also provides backdrive protection when a rogue HDMI sink powers the HDMI cable unexpectedly.

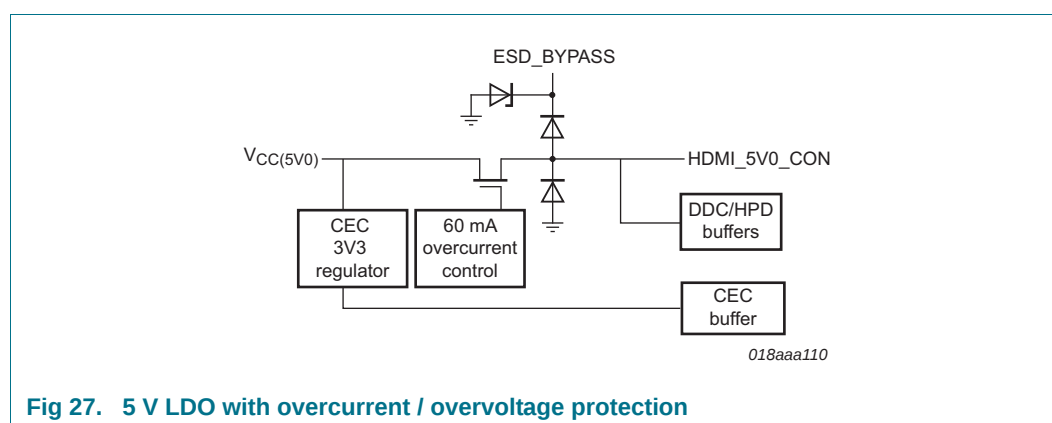


Fig 27. 5 V LDO with overcurrent / overvoltage protection

9.8 Schematic view of application

Only a single external component ( $C_O = 1\ \mu\text{F}$ ) is required to protect and interface the ASIC to a complete and compliant HDMI port. The 100 nF ESD bypass capacitor is optional.

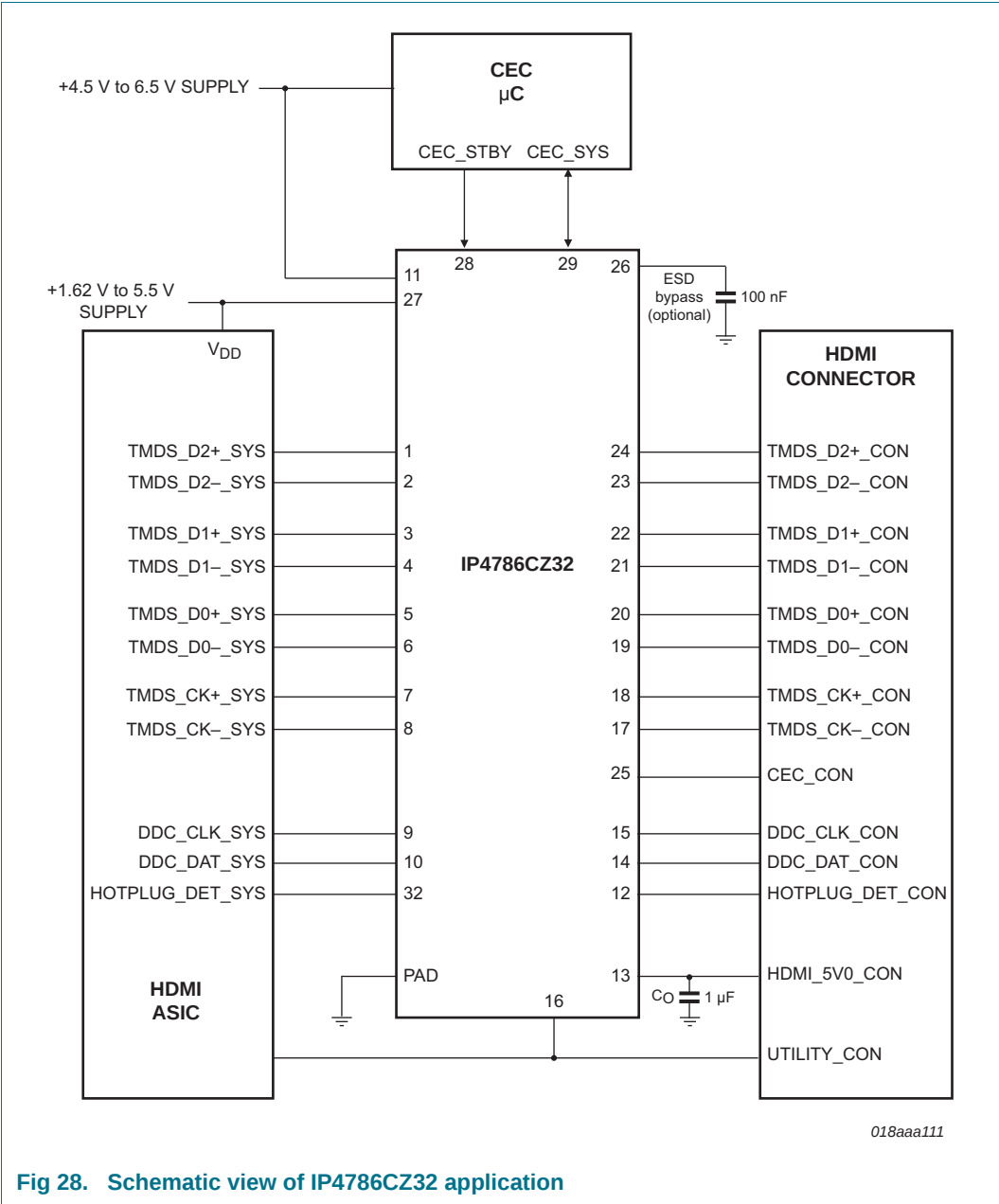


Fig 28. Schematic view of IP4786CZ32 application

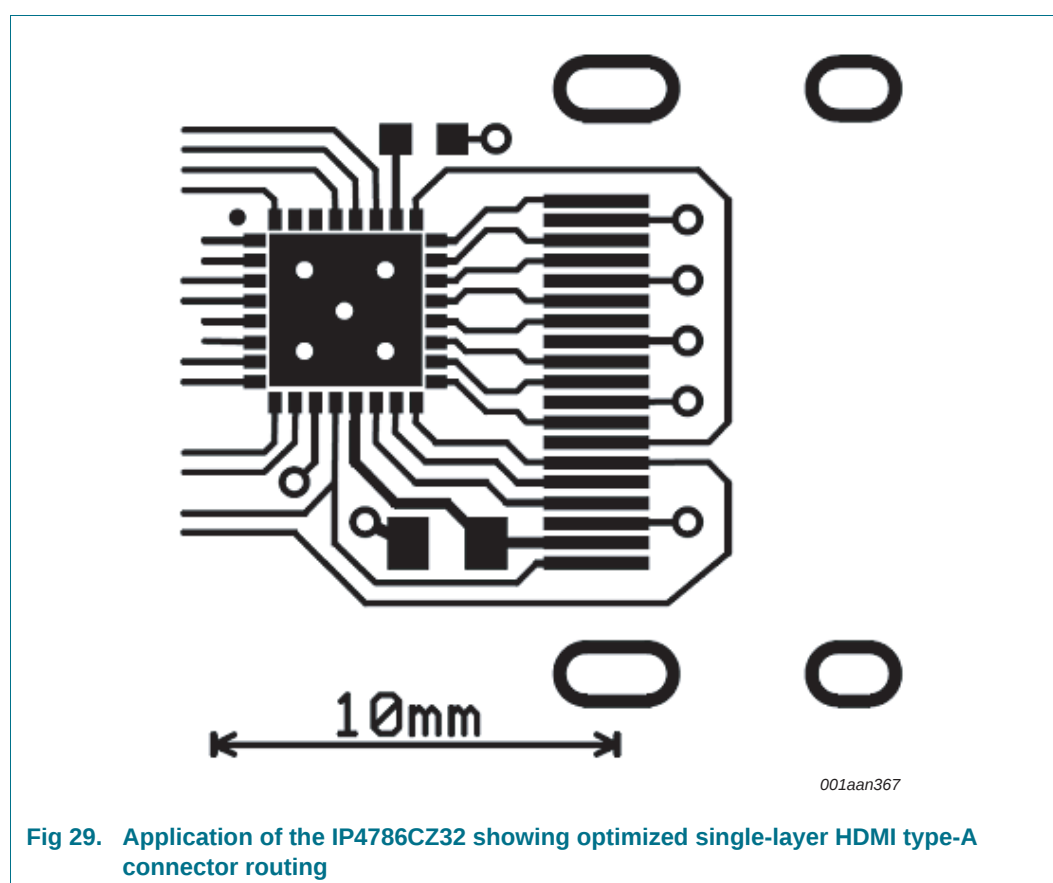
## 9.9 Typical application

The IP4786CZ32 is designed to simplify routing to the HDMI connector, and ease the incorporation of high-level ESD protection into delicately balanced high-speed TMDS lines. These lines rely on tightly controlled microstrip or stripline transmission lines with minimal impedance discontinuities, which can deteriorate return loss, increase deterministic jitter and generally erode overall link signal integrity.

Normally when designing the PCB with standard shunt ESD clamps, careful consideration must be given to manual pre-compensation of the additional load of the added ESD component. With the IP4786CZ32 TLCs, the ESD suppressor is designed to maintain the characteristic impedance of the PCB microstrip or stripline, and therefore the designer needs only be concerned with the standard-controlled impedance of the unloaded PCB lines. This simplifies the task of the PCB designer, and minimizes the tuning cycles, which are sometimes required when pre-compensation misses the mark. A basic application diagram for the ESD protection of an HDMI interface is shown in [Figure 29](#) and [Figure 30](#) for type-A and type-D HDMI connector versions.

The optimized HVQFN32 pinning simplifies the PCB design to keep the ESD protection close to the connector where it can minimize the coupling of the ESD pulse onto other lines in the system during a strike.

Due to the integrated pull-up and pull-down resistors, only two external capacitors are required to implement a fully compliant HDMI port.



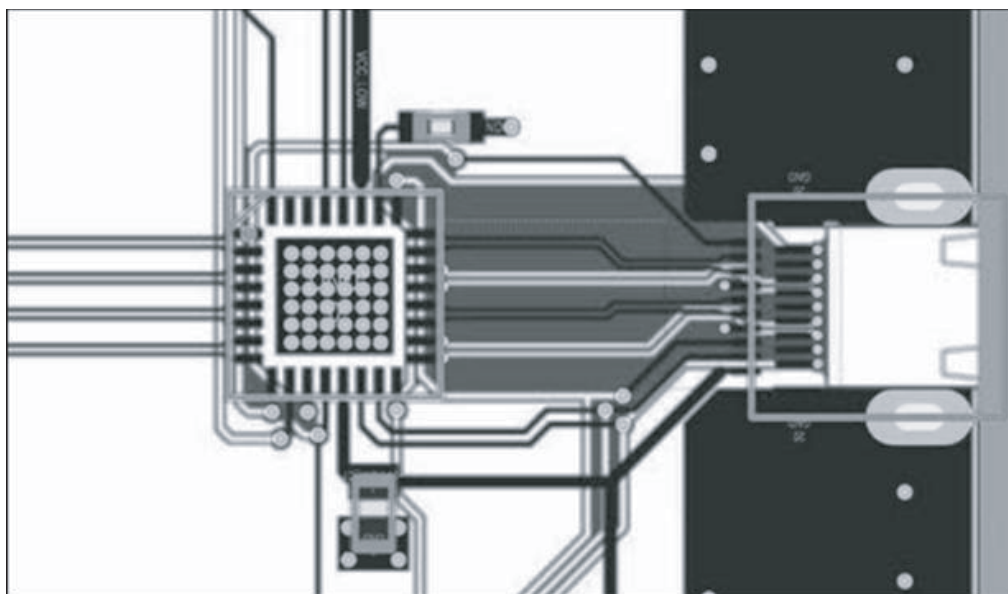
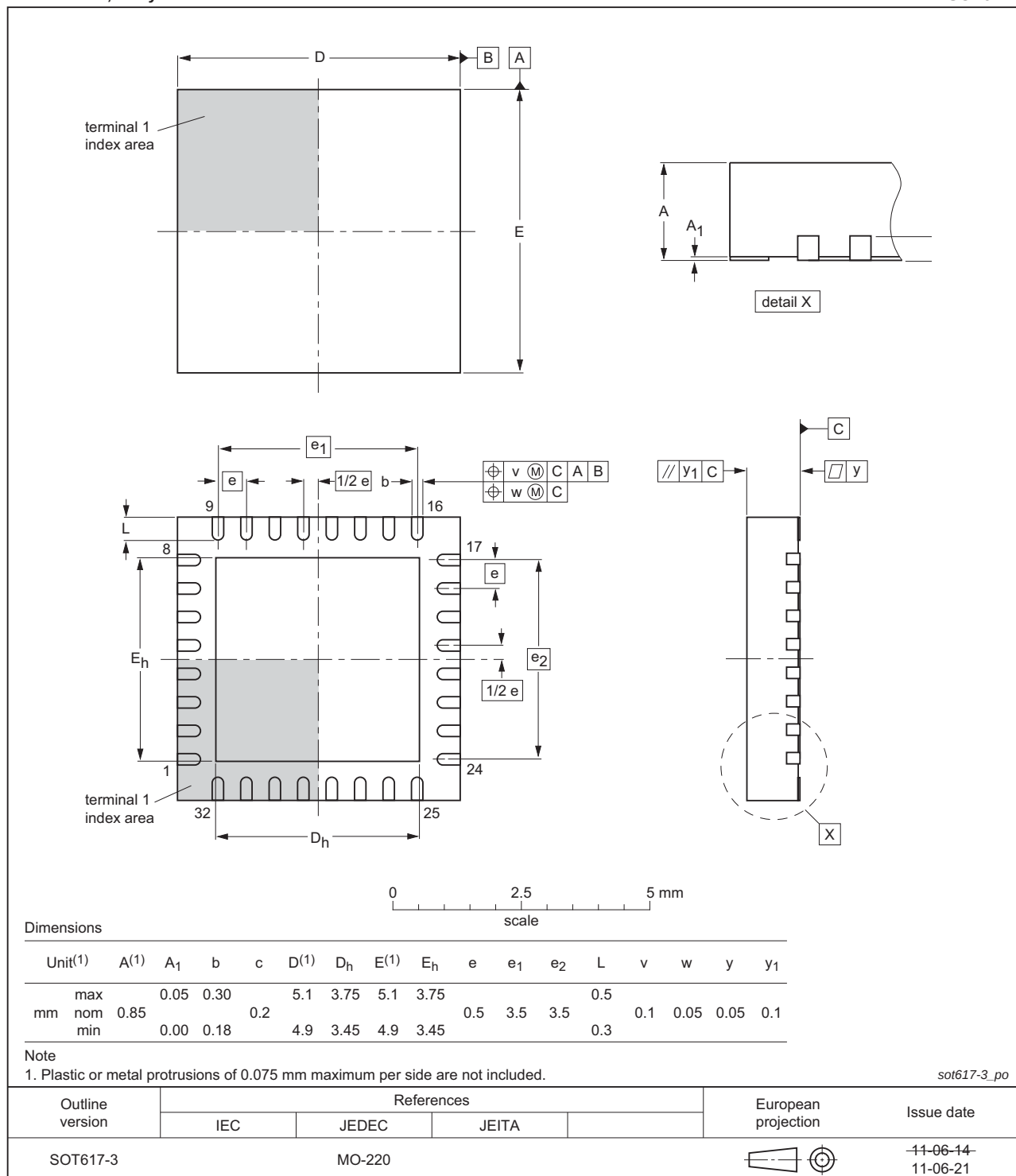


Fig 30. Application of the IP4786CZ32 showing optimized HDMI type-D connector routing

## 10. Package outline

**HVQFN32:** plastic thermal enhanced very thin quad flat package; no leads; 32 terminals; body 5 x 5 x 0.85 mm

**SOT617-3**



**Fig 31. Package outline SOT617-3 (HVQFN32)**

## 11. Soldering of SMD packages

This text provides a very brief insight into a complex technology. A more in-depth account of soldering ICs can be found in Application Note AN10365 “Surface mount reflow soldering description”.

### 11.1 Introduction to soldering

Soldering is one of the most common methods through which packages are attached to Printed Circuit Boards (PCBs), to form electrical circuits. The soldered joint provides both the mechanical and the electrical connection. There is no single soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and Surface Mount Devices (SMDs) are mixed on one printed wiring board; however, it is not suitable for fine pitch SMDs. Reflow soldering is ideal for the small pitches and high densities that come with increased miniaturization.

### 11.2 Wave and reflow soldering

Wave soldering is a joining technology in which the joints are made by solder coming from a standing wave of liquid solder. The wave soldering process is suitable for the following:

- Through-hole components
- Leadless or leadless SMDs, which are glued to the surface of the printed circuit board

Not all SMDs can be wave soldered. Packages with solder balls, and some leadless packages which have solder lands underneath the body, cannot be wave soldered. Also, leadless SMDs with leads having a pitch smaller than ~0.6 mm cannot be wave soldered, due to an increased probability of bridging.

The reflow soldering process involves applying solder paste to a board, followed by component placement and exposure to a temperature profile. Leadless packages, packages with solder balls, and leadless packages are all reflow solderable.

Key characteristics in both wave and reflow soldering are:

- Board specifications, including the board finish, solder masks and vias
- Package footprints, including solder thieves and orientation
- The moisture sensitivity level of the packages
- Package placement
- Inspection and repair
- Lead-free soldering versus SnPb soldering

### 11.3 Wave soldering

Key characteristics in wave soldering are:

- Process issues, such as application of adhesive and flux, clinching of leads, board transport, the solder wave parameters, and the time during which components are exposed to the wave
- Solder bath specifications, including temperature and impurities

## 11.4 Reflow soldering

Key characteristics in reflow soldering are:

- Lead-free versus SnPb soldering; note that a lead-free reflow process usually leads to higher minimum peak temperatures (see [Figure 32](#)) than a SnPb process, thus reducing the process window
- Solder paste printing issues including smearing, release, and adjusting the process window for a mix of large and small components on one board
- Reflow temperature profile; this profile includes preheat, reflow (in which the board is heated to the peak temperature) and cooling down. It is imperative that the peak temperature is high enough for the solder to make reliable solder joints (a solder paste characteristic). In addition, the peak temperature must be low enough that the packages and/or boards are not damaged. The peak temperature of the package depends on package thickness and volume and is classified in accordance with [Table 11](#) and [12](#)

**Table 11. SnPb eutectic process (from J-STD-020D)**

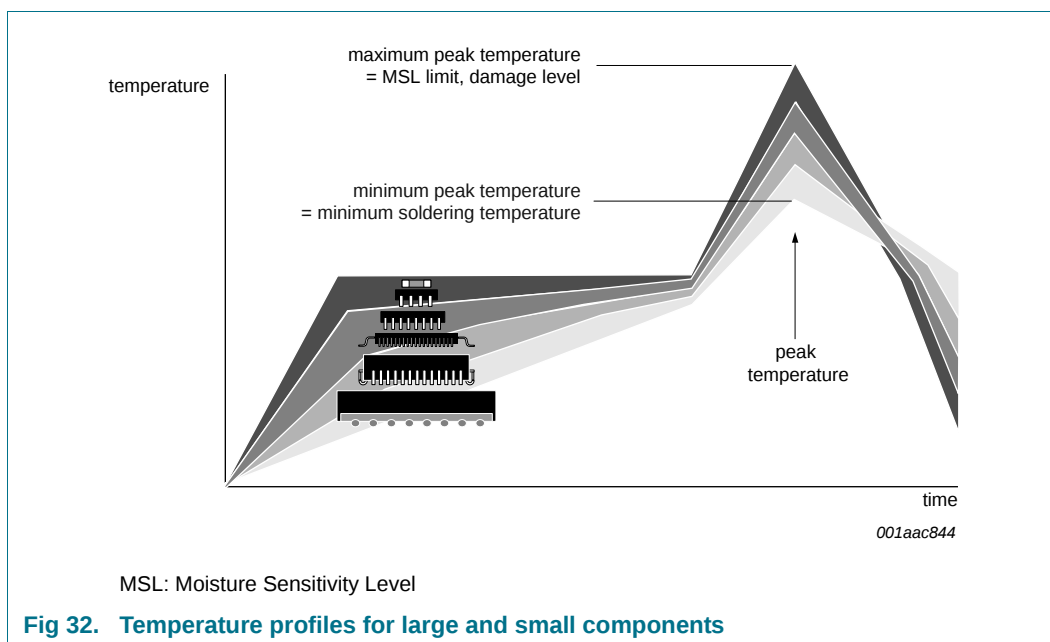
| Package thickness (mm) | Package reflow temperature (°C) |       |
|------------------------|---------------------------------|-------|
|                        | Volume (mm <sup>3</sup> )       |       |
|                        | < 350                           | ≥ 350 |
| < 2.5                  | 235                             | 220   |
| ≥ 2.5                  | 220                             | 220   |

**Table 12. Lead-free process (from J-STD-020D)**

| Package thickness (mm) | Package reflow temperature (°C) |             |        |
|------------------------|---------------------------------|-------------|--------|
|                        | Volume (mm <sup>3</sup> )       |             |        |
|                        | < 350                           | 350 to 2000 | > 2000 |
| < 1.6                  | 260                             | 260         | 260    |
| 1.6 to 2.5             | 260                             | 250         | 245    |
| > 2.5                  | 250                             | 245         | 245    |

Moisture sensitivity precautions, as indicated on the packing, must be respected at all times.

Studies have shown that small packages reach higher temperatures during reflow soldering, see [Figure 32](#).



For further information on temperature profiles, refer to Application Note AN10365 "Surface mount reflow soldering description".

## 12. Glossary

**HDMI sink** — Device which receives HDMI signals e.g. a TV set.

**HDMI source** — Device which transmit HDMI signal e.g. DVD player.

## 13. Revision history

**Table 13.** Revision history

| Document ID    | Release date                                                       | Data sheet status  | Change notice | Supersedes     |
|----------------|--------------------------------------------------------------------|--------------------|---------------|----------------|
| IP4786CZ32 v.5 | 20140624                                                           | Product data sheet | -             | IP4786CZ32 v.4 |
| Modifications: | • Added support for HDMI 2.0 display modes; updated ESD robustness |                    |               |                |
| IP4786CZ32 v.4 | 20120705                                                           | Product data sheet | -             | IP4786CZ32 v.3 |
| IP4786CZ32 v.3 | 20120608                                                           | Product data sheet | -             | IP4786CZ32 v.2 |
| IP4786CZ32 v.2 | 20120321                                                           | Product data sheet | -             | IP4786CZ32 v.1 |
| IP4786CZ32 v.1 | 20110415                                                           | Product data sheet | -             | -              |

## 14. Legal information

### 14.1 Data sheet status

| Document status <sup>[1][2]</sup> | Product status <sup>[3]</sup> | 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".

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