

# 带有升压直流/直流、 $I^2C$ 电平转换器和高速 ESD 钳位的 TPD12S015A HDMI 配套芯片

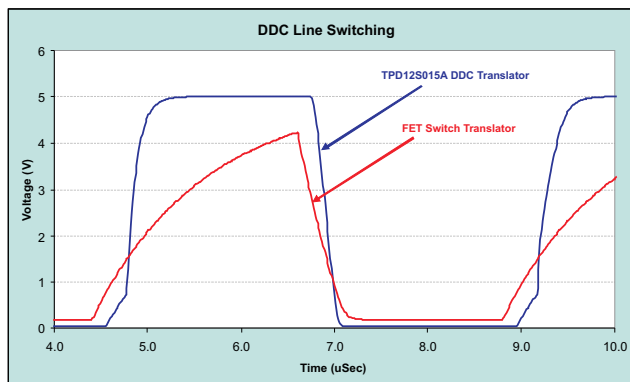
## 1 特性

- 符合 HDMI 合规性测试，无需任何外部组件
- 支持 HDMI 1.3 和 HDMI 1.4 数据速率
- 与 D 类和 C 类引脚映射相匹配
- 在各个差分信号对之间提供出色的匹配电容 (0.05pF)
- 内部升压转换器，可从 2.3V-5.5V 的电池电压生成 5V 电压
- 支持在 CEC、SDA 和 SCL 路径中进行自动方向感应和电平转换
- IEC 61000-4-2 (级别 4) 系统级 ESD 兼容
- 业界常用 TPD12S015A 的改良版简易替代器件
- 工业温度范围：-40°C 至 85°C

## 2 应用

- 智能电话
- 电子书
- 平板电脑
- 数码摄像机
- 便携式游戏机
- 数码相机

TPD12S015A 的 SCL\_B 或 SDA\_B 缓冲器可驱动较长的 HDMI 电缆 (750pF 负载)



## 3 说明

TPD12S015A 器件是一款集成式 HDMI 配套芯片解决方案。此器件提供了 8 个低电容 ESD 钳位，支持 HDMI 1.3/1.4 数据速率。0.4mm 间距 DSBGA 封装引脚映射与 HDMI D 型或 C 型连接器相匹配。采用单片硅技术的集成式 ESD 钳位能够在各个差分信号对之间实现良好的匹配。此钳位优于离散 ESD 钳位解决方案，后者在 ESD 钳位之间的差异会降低差分信号质量。

TPD12S015A 提供稳定的 5V 输出电压 (5VOUT)，用于为 HDMI 电源线路供电。5VOUT 引脚可在满足 HDMI 5VOUT 规格的条件下，为 HDMI 接收器提供最小 55mA 的电流。5VOUT 和热插拔检测 (HPD) 电路独立于 LS\_OE 控制信号，由 CT\_CP\_HPDP 引脚控制。此独立控制可在启用 HDMI 链接之前启用检测方案 (5VOUT + HPD)。HPD\_B 端口配有干扰滤波器，可在插入 HDMI 插座时避免由反跳引起的误检测。

有 3 个适用于 SDA、SCL 和 CEC 线路的同相双向转换电路；它们由 LS\_OE 控制信号控制。每个电路在 A 侧具有一个介于 1.1V 至 3.6V 之间的共同电源轨 (VCCA)。在 B 侧，SCL\_B 和 SDA\_B 各有一个连接至稳压 5V 电源轨 (5VOUT) 的内部 1.75kΩ 上拉电阻器。SCL 和 SDA 引脚符合  $I^2C$  规格，至少可驱动超出 HDMI 电缆规格的 750pF 负载。当 LS\_OE = H 且 CT\_CP\_HPDP = H 时，LDO 可为 CEC 电路生成 3.3V 的内部电源轨以供其正常工作。CEC\_B 引脚具有与此内部 3.3V 电源轨相连的 26kΩ 上拉电阻器。

TPD12S015A 提供 IEC61000-4-2 (级别 4) ESD 保护。此器件采用节省空间的 1.56mm × 2.76mm DSBGA 封装。

### 器件信息<sup>(1)</sup>

| 器件型号       | 封装         | 封装尺寸 (标称值)      |
|------------|------------|-----------------|
| TPD12S015A | DSBGA (28) | 1.56mm × 2.76mm |

(1) 要了解所有可用封装，请参阅数据表末尾的可订购产品附录。



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## 4 修订历史记录

注：之前版本的页码可能与当前版本有所不同。

### Changes from Revision C (March 2013) to Revision D

Page

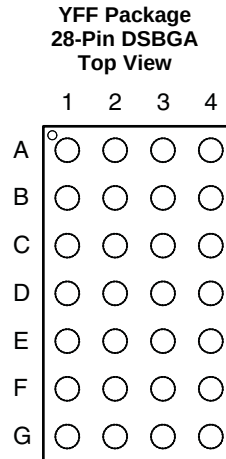
- 已添加 ESD 额定值表、热性能信息表、特性说明部分，器件功能模式，应用和实施部分，电源相关建议部分，布局部分，器件和文档支持部分以及机械、封装和可订购信息部分 1

### Changes from Revision B (April 2012) to Revision C

Page

- Added Power Derating Curve 14
- Changed Board Layout section 27

## 5 Pin Configuration and Functions



For package dimensions, see [机械、封装和可订购信息](#)

### Pin Functions

| PIN                                                                                                             |                              | TYPE          | DESCRIPTION                                                                                                                                                                                                |
|-----------------------------------------------------------------------------------------------------------------|------------------------------|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NAME                                                                                                            | NO.                          |               |                                                                                                                                                                                                            |
| 5VOUT                                                                                                           | F1                           | Power Out     | DC-DC output. The 5-V power pin can supply 55 mA of regulated current to the HDMI receiver. Separate DC-DC converter control pin CT_CP_HPDP disables the DC-DC converter when operating at low-power mode. |
| CEC_A                                                                                                           | B2                           | I/O           | System-side CEC bus I/O. This pin is bidirectional and referenced to V <sub>CCA</sub> .                                                                                                                    |
| CEC_B                                                                                                           | D3                           | I/O           | HDMI-side CEC bus I/O. This pin is bidirectional and referenced to the 3.3-V internal supply.                                                                                                              |
| CLK <sup>-</sup> , CLK <sup>+</sup>                                                                             | G4, F4                       | ESD           | High-speed ESD clamp: provides ESD protection to the high-speed HDMI differential data lines                                                                                                               |
| CT_CP_HPDP                                                                                                      | D1                           | Control       | DC-DC Enable. Enables the DC-DC converter and HPD circuitry when CT_CP_HPDP = H. The CT_CP_HPDP is referenced to V <sub>CCA</sub> .                                                                        |
| D0 <sup>-</sup> , D0 <sup>+</sup> ,<br>D1 <sup>-</sup> , D1 <sup>+</sup> ,<br>D2 <sup>-</sup> , D2 <sup>+</sup> | E4, D4,<br>C4, B4,<br>A4, A3 | ESD           | High-speed ESD clamp: provides ESD protection to the high-speed HDMI differential data lines                                                                                                               |
| FB                                                                                                              | E1                           | I             | Feedback input. This pin is a feedback control pin for the DC-DC converter. It must be connected to 5VOUT.                                                                                                 |
| GND                                                                                                             | B3, C3,<br>D2, E2            | Ground        | Device ground                                                                                                                                                                                              |
| HPD_A                                                                                                           | C2                           | O             | System-side output for the hot plug detect. This pin is unidirectional and is referenced to V <sub>CCA</sub> .                                                                                             |
| HPD_B                                                                                                           | G3                           | I             | HDMI-side input for the hot plug detect. This pin is unidirectional and is referenced to 5VOUT.                                                                                                            |
| LS_OE                                                                                                           | A1                           | Control       | Level shifter enable. This pin is referenced to V <sub>CCA</sub> . Enables SCL, SDA, CEC level shifters, and LDO when LS_OE = H.                                                                           |
| P <sub>GND</sub>                                                                                                | G1                           | Analog Ground | DC-DC converter ground. This pin must be tied externally to the system GND plane. See <a href="#">Layout Guidelines</a> .                                                                                  |
| SCL_A                                                                                                           | B1                           | I/O           | System-side input and output for I <sup>2</sup> C bus. This pin is bidirectional and referenced to V <sub>CCA</sub> .                                                                                      |
| SCL_B                                                                                                           | E3                           | I/O           | HDMI-side input and output for I <sup>2</sup> C bus. This pin is bidirectional and referenced to 5VOUT.                                                                                                    |
| SDA_A                                                                                                           | C1                           | I/O           | System-side input and output for I <sup>2</sup> C bus. This pin is bidirectional and referenced to V <sub>CCA</sub> .                                                                                      |
| SDA_B                                                                                                           | F3                           | I/O           | HDMI-side input and output for I <sup>2</sup> C bus. This pin is bidirectional and referenced to 5VOUT.                                                                                                    |
| SW                                                                                                              | F2                           | I             | Switch input. This pin is the inductor input for the DC-DC converter.                                                                                                                                      |
| V <sub>BAT</sub>                                                                                                | G2                           | Supply        | Battery supply. This voltage is typically 2.3 V to 5.5 V                                                                                                                                                   |
| V <sub>CCA</sub>                                                                                                | A2                           | Supply        | System-side supply. this voltage is typically 1.2 V to 3.3 V from the core microcontroller.                                                                                                                |

**TPD12S015A**

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**Table 1. YFF Package Pin Mapping**

|          | <b>1</b>         | <b>2</b>         | <b>3</b> | <b>4</b> |
|----------|------------------|------------------|----------|----------|
| <b>A</b> | LS_OE            | V <sub>CCA</sub> | D2+      | D2–      |
| <b>B</b> | SCL_A            | CEC_A            | GND      | D1+      |
| <b>C</b> | SDA_A            | HPD_A            | GND      | D1–      |
| <b>D</b> | CT_CP_HPDP       | GND              | CEC_B    | D0+      |
| <b>E</b> | FB               | GND              | SCL_B    | D0–      |
| <b>F</b> | 5VOUT            | SW               | SDA_B    | CLK+     |
| <b>G</b> | P <sub>GND</sub> | V <sub>BAT</sub> | HPD_B    | CLK–     |

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

|                     |                                                                                             |                            | MIN  | MAX                    | UNIT |
|---------------------|---------------------------------------------------------------------------------------------|----------------------------|------|------------------------|------|
| V <sub>CCA</sub>    | Supply voltage                                                                              |                            |      | 4                      | V    |
| V <sub>BAT</sub>    | Supply voltage                                                                              |                            | –0.3 | 6                      |      |
| V <sub>I</sub>      | Input voltage                                                                               | HPD_B, Dx, CLKx            | –0.3 | 6                      | V    |
|                     |                                                                                             | CT_CP_HPDP, LS_OE          | –0.3 | 4                      |      |
| V <sub>O</sub>      | Voltage range applied to any output in the high-impedance or power-off state <sup>(2)</sup> | SCL_A, SDA_A, CEC_A, HPD_A | –0.3 | 4                      | V    |
|                     |                                                                                             | SCL_B, SDA_B, CEC_B        | –0.3 | 6                      |      |
|                     | Voltage range applied to any output in the high or low state <sup>(3)</sup>                 | SCL_A, SDA_A, CEC_A, HPD_A | –0.3 | V <sub>CCA</sub> + 0.3 |      |
|                     |                                                                                             | SCL_B, SDA_B, CEC_B        | –0.3 | 6                      |      |
| I <sub>IK</sub>     | Input clamp current                                                                         | V <sub>I</sub> < 0         |      | –50                    | mA   |
| I <sub>OK</sub>     | Output clamp current                                                                        | V <sub>O</sub> < 0         |      | –50                    | mA   |
| I <sub>OUTMAX</sub> | Continuous current through 5VOUT or GND                                                     |                            |      | ±100                   | mA   |
| T <sub>stg</sub>    | Storage temperature                                                                         |                            | –65  | 150                    | °C   |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
- (3) The package thermal impedance is calculated in accordance with JESD 51-7.

### 6.2 ESD Ratings

|                    |                         |                                                                                | VALUE  | UNIT |
|--------------------|-------------------------|--------------------------------------------------------------------------------|--------|------|
| V <sub>(ESD)</sub> | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>              | ±2500  | V    |
|                    |                         | Pins E4, D4, B4, C4, D2+, D2-, F4, G4, E3, F3, D3, G3, F1, and E1              | ±15000 |      |
|                    |                         | Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup> | ±1000  |      |
|                    |                         | IEC 61000-4-2 contact discharge                                                | ±8000  |      |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 6.3 Recommended Operating Conditions

over recommended operating free-air temperature range (unless otherwise noted)

|                  |                          |                     | SUPPLY                            | MIN                                 | NOM | MAX                           | UNIT |
|------------------|--------------------------|---------------------|-----------------------------------|-------------------------------------|-----|-------------------------------|------|
| V <sub>CCA</sub> | Supply voltage           |                     |                                   | 1.1                                 |     | 3.6                           | V    |
| V <sub>BAT</sub> | Supply voltage           |                     |                                   | 2.3                                 |     | 5.5                           | V    |
| V <sub>IH</sub>  | High-level input voltage | SCL_A, SDA_A, CEC_A | V <sub>CCA</sub> = 1.1 V to 3.6 V | 0.7 × V <sub>CCA</sub>              |     | V <sub>CCA</sub>              | V    |
|                  |                          | CT_CP_HPDP, LS_OE   |                                   | 1                                   |     | 3.6                           |      |
|                  |                          | SCL_B, SDA_B        | 5VOUT = 5 V                       | 0.7 × 5VOUT                         |     | 5VOUT                         |      |
|                  |                          | CEC_B               |                                   | 0.7 × 3.3 (internal) <sup>(1)</sup> |     | 3.3 (internal) <sup>(1)</sup> |      |
|                  |                          | HPD_B               |                                   | 2                                   |     | 5VOUT                         |      |

- (1) '3.3V (internal)' is an internally generated voltage node for the CEC\_B output buffer supply reference. An LDO generates this 3.3 V from 5VOUT when LS\_OE = H & CT\_CP\_HPDP = H.

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### Recommended Operating Conditions (continued)

over recommended operating free-air temperature range (unless otherwise noted)

|                                    |                                                    | SUPPLY              | MIN                               | NOM | MAX                                  | UNIT |
|------------------------------------|----------------------------------------------------|---------------------|-----------------------------------|-----|--------------------------------------|------|
| V <sub>IL</sub>                    | Low-level input voltage                            | SCL_A, SDA_A, CEC_A | V <sub>CCA</sub> = 1.1 V to 3.6 V | 0   | 0.082 × V <sub>CCA</sub>             | V    |
|                                    |                                                    | CT_CP_HPD, LS_OE    |                                   | 0   | 0.4                                  |      |
|                                    |                                                    | SCL_B, SDA_B        | 5VOUT = 5 V                       | 0   | 0.3 × 5VOUT                          |      |
|                                    |                                                    | CEC_B               |                                   | 0   | 0.3 × 3.3V (internal) <sup>(1)</sup> |      |
|                                    |                                                    | HPD_B               |                                   | 0   | 0.8                                  |      |
| V <sub>ILC</sub>                   | Low-level input voltage (contention)               | SCL_A, SDA_A, CEC_A | V <sub>CCA</sub> = 1.1 V to 3.6 V | 0   | 0.065 × V <sub>CCA</sub>             | V    |
| V <sub>OL</sub> – V <sub>ILC</sub> | Delta between V <sub>OL</sub> and V <sub>ILC</sub> | SCL_A, SDA_A, CEC_A | V <sub>CCA</sub> = 1.1 V to 3.6 V |     | 0.1 × V <sub>CCA</sub>               | V    |
| T <sub>A</sub>                     | Operating free-air temperature                     |                     |                                   | –40 | 85                                   | °C   |

### 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | TPD12S015A  | UNIT |
|-------------------------------|----------------------------------------------|-------------|------|
|                               |                                              | YFF (DSBGA) |      |
|                               |                                              | 28 PINS     |      |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | 63          | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    | 0.4         | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         | 9.2         | °C/W |
| ψ <sub>JT</sub>               | Junction-to-top characterization parameter   | 1.6         | °C/W |
| ψ <sub>JB</sub>               | Junction-to-board characterization parameter | 9.1         | °C/W |
| R <sub>θJC(bot)</sub>         | Junction-to-case (bottom) thermal resistance | N/A         | °C/W |

(1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

### 6.5 Electrical Characteristics: I<sub>CC</sub>

| PARAMETER        |                             | PIN              | TEST CONDITIONS                      | MIN | TYP | MAX | UNIT |
|------------------|-----------------------------|------------------|--------------------------------------|-----|-----|-----|------|
| I <sub>CCA</sub> | Standby                     | V <sub>CCA</sub> | I/O = High                           |     |     | 2   | μA   |
|                  | Active                      |                  |                                      |     |     | 15  |      |
| I <sub>CCB</sub> | Standby                     | V <sub>BAT</sub> | CT_CP_HPD=L, LS_OE=L, HPD_B=L        |     | 2   |     | μA   |
|                  | DC-DC and HPD active        |                  | CT_CP_HPD=H, LS_OE=L, HPD_B=L        |     | 30  | 50  |      |
|                  | DC-DC, HPD, DDC, CEC active |                  | CT_CP_HPD=H LS_OE=H, HPD_B=L, I/O =H |     | 225 | 300 |      |

### 6.6 Electrical Characteristics: High-Speed ESD Lines: Dx, CLK

| PARAMETER        | TEST CONDITIONS                     |                                                        | MIN | TYP  | MAX | UNIT |
|------------------|-------------------------------------|--------------------------------------------------------|-----|------|-----|------|
| I <sub>OFF</sub> | Current from IO port to supply pins | V <sub>CC</sub> = 0 V, V <sub>IO</sub> = 3.3 V         |     | 0.01 | 0.5 | μA   |
| V <sub>DL</sub>  | Diode forward voltage               | I <sub>D</sub> = 8 mA, Lower clamp diode               |     | 0.85 | 1   | V    |
| R <sub>DYN</sub> | Dynamic resistance                  | I = 1 A, D, CLK                                        |     | 1    |     | Ω    |
| C <sub>IO</sub>  | IO capacitance                      | V <sub>CC</sub> = 5 V, V <sub>IO</sub> = 2.5 V, D, CLK |     | 1.3  |     | pF   |
| V <sub>BR</sub>  | Break-down voltage                  | I <sub>IO</sub> = 1 mA                                 | 9   |      | 12  | V    |

## 6.7 Electrical Characteristics: DC-DC Converter

| PARAMETER                     |                                                                        | TEST CONDITIONS                                                                                                              | MIN | TYP | MAX  | UNIT  |
|-------------------------------|------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|-----|-----|------|-------|
| V <sub>BAT</sub>              | Input voltage range                                                    |                                                                                                                              | 2.3 |     | 5.5  | V     |
| 5V <sub>OUT</sub>             | Total DC output voltage                                                | Includes voltage references, DC load / line regulations, process and temperature                                             | 4.9 | 5   | 5.13 | V     |
| TOVA                          | Total output voltage accuracy                                          | Includes voltage references, DC load / line regulations, transient load / line regulations, ripple, process, and temperature | 4.8 | 5   | 5.3  | V     |
| V <sub>O_Ripple</sub>         | Output voltage ripple, loaded                                          | I <sub>O</sub> = 65 mA                                                                                                       |     |     | 20   | mVp-p |
| F <sub>clk</sub>              | Internal operating frequency                                           | V <sub>BAT</sub> = 2.3 V to 5.5 V                                                                                            |     | 3.5 |      | MHz   |
| t <sub>start</sub>            | Start-up time                                                          | From CT_CP_HPDP input to 5-V power output 90% point                                                                          |     |     | 300  | μs    |
| I <sub>O</sub>                | Output current                                                         | V <sub>BAT</sub> = 2.3 V to 5.5 V                                                                                            | 55  |     |      | mA    |
|                               | Reverse leakage current V <sub>O</sub>                                 | CT_CP_HPDP = L, V <sub>O</sub> = 5.5 V                                                                                       |     |     | 2.5  | μA    |
|                               | Leakage current from battery to V <sub>O</sub>                         | CT_CP_HPDP = L                                                                                                               |     |     | 5    | μA    |
| V <sub>BATUVT</sub>           | Undervoltage lockout threshold                                         | Falling                                                                                                                      |     | 2   |      | V     |
|                               |                                                                        | Rising                                                                                                                       |     | 2.1 |      | V     |
| V <sub>BATOV</sub>            | Overvoltage lockout threshold                                          | Falling                                                                                                                      |     | 5.9 |      | V     |
|                               |                                                                        | Rising                                                                                                                       |     | 6   |      | V     |
|                               | Line transient response                                                | V <sub>BAT</sub> = 3.6 V, a pulse of 217-Hz 600 mVp-p square wave, I <sub>O</sub> = 20/65 mA                                 |     | ±25 | ±50  | mVpk  |
|                               | Load transient response                                                | V <sub>BAT</sub> = 3.6 V, I <sub>O</sub> = 5 to 65 mA, pulse of 10 μs, t <sub>r</sub> = t <sub>f</sub> = 0.1 μs              |     | 50  |      | mVpk  |
| I <sub>DD</sub> (idle)        | Power supply current from V <sub>BAT</sub> to DC-DC, enabled, unloaded | I <sub>O</sub> = 0 mA                                                                                                        |     | 30  | 50   | μA    |
| I <sub>DD</sub> (disabled)    | Power supply current from V <sub>BAT</sub> , DC-DC Disabled, Unloaded  | V <sub>BAT</sub> = 2.3 V to 5.5 V, I <sub>O</sub> = 0 mA, CT_CP_HPDP Low                                                     |     |     | 2    | μA    |
| I <sub>DD(system off)</sub>   | Power supply current from V <sub>BAT</sub> , V <sub>CCA</sub> = 0 V    | V <sub>CCA</sub> = 0 V                                                                                                       |     |     | 5    | μA    |
| I <sub>inrush (startup)</sub> | Inrush current, average over T <sub>startup</sub> time                 | V <sub>BAT</sub> = 2.3 V to 5.5 V, I <sub>O</sub> = 65 mA                                                                    |     | 100 |      | mA    |
| T <sub>SD</sub>               | Thermal shutdown                                                       | Increasing junction temperature                                                                                              |     | 140 |      | °C    |
| ΔT <sub>SD</sub>              | Thermal shutdown hysteresis                                            | Decreasing junction temperature                                                                                              |     | 20  |      | °C    |
| I <sub>SC</sub>               | Short-circuit current limit from output                                | 5-Ω short to GND                                                                                                             |     |     | 500  | mA    |

## 6.8 Electrical Characteristics: Passive Components

| PARAMETER         |                                   | TYP | UNIT |
|-------------------|-----------------------------------|-----|------|
| L <sub>IN</sub>   | External inductor, 0805 footprint | 1   | μH   |
| C <sub>IN</sub>   | Input capacitor, 0603 footprint   | 4.7 | μF   |
| C <sub>OUT</sub>  | Output capacitor, 0603 footprint  | 4.7 | μF   |
| C <sub>VCCA</sub> | Input capacitor, 0402 footprint   | 0.1 | μF   |

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**6.9 Electrical Characteristics: Voltage Level Shifter: SCL, SDA Lines (x\_A/x\_B Ports)**
 $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  unless otherwise specified

| PARAMETER                  |                                                          | TEST CONDITIONS                                                        |                                                    | V <sub>CCA</sub> | MIN                     | TYP | MAX | UNIT |
|----------------------------|----------------------------------------------------------|------------------------------------------------------------------------|----------------------------------------------------|------------------|-------------------------|-----|-----|------|
| V <sub>OHA</sub>           |                                                          | I <sub>OH</sub> = −10 μA, V <sub>I</sub> = V <sub>IH</sub>             |                                                    | 1.1 V to 3.6 V   | V <sub>CCA</sub> × 0.8  |     |     | V    |
| V <sub>OLA</sub>           |                                                          | I <sub>OL</sub> = 10 μA, V <sub>I</sub> = V <sub>IL</sub>              |                                                    | 1.1 V to 3.6 V   | V <sub>CCA</sub> × 0.17 |     |     | V    |
| V <sub>OHB</sub>           |                                                          | I <sub>OH</sub> = −10 μA, V <sub>I</sub> = V <sub>IH</sub>             |                                                    |                  | 5V <sub>OUT</sub> × 0.9 |     |     | V    |
| V <sub>OLB</sub>           |                                                          | I <sub>OL</sub> = 3 mA, V <sub>I</sub> = V <sub>IL</sub>               |                                                    |                  | 0.4                     |     |     | V    |
| ΔV <sub>T</sub> hysteresis | SDx_A (V <sub>T+</sub> − V <sub>T−</sub> )               |                                                                        |                                                    | 1.1 V to 3.6 V   | 40                      |     |     | mV   |
|                            | SDx_B (V <sub>T+</sub> − V <sub>T−</sub> )               |                                                                        |                                                    | 1.1 V to 3.6 V   | 400                     |     |     |      |
| R <sub>PU</sub>            | (Internal pullup)                                        | SCL_A, SDA_A,                                                          | Internal pullup connected to V <sub>CCA</sub> rail |                  | 10                      |     |     | kΩ   |
|                            |                                                          | SCL_B, SDA_B,                                                          | Internal pullup connected to 5-V rail              |                  | 1.75                    |     |     |      |
| I <sub>PULLUPAC</sub>      | Transient boosted pullup current (rise time accelerator) | SCL_B, SDA_B,                                                          | Internal pullup connected to 5-V rail              |                  | 15                      |     |     | mA   |
| I <sub>OFF</sub>           | A port                                                   | V <sub>CCA</sub> = 0 V, V <sub>I</sub> or V <sub>O</sub> = 0 to 3.6 V  |                                                    | 0 V              | ±5                      |     |     | μA   |
|                            | B port                                                   | 5V <sub>OUT</sub> = 0 V, V <sub>I</sub> or V <sub>O</sub> = 0 to 5.5 V |                                                    | 0 V to 3.6 V     | ±5                      |     |     |      |
| I <sub>OZ</sub>            | B port                                                   | V <sub>O</sub> = V <sub>CCO</sub> or GND                               |                                                    | 1.1 V to 3.6 V   | ±5                      |     |     | μA   |
|                            | A port                                                   | V <sub>I</sub> = V <sub>CCI</sub> or GND                               |                                                    | 1.1 V to 3.6 V   | ±5                      |     |     |      |

**6.10 Electrical Characteristics: Voltage Level Shifter: CEC Lines (x\_A/x\_B Ports)**
 $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  unless otherwise specified

| PARAMETER                  |                                            | TEST CONDITIONS                                                        | V <sub>CCA</sub> | MIN                                  | TYP | MAX | UNIT |
|----------------------------|--------------------------------------------|------------------------------------------------------------------------|------------------|--------------------------------------|-----|-----|------|
| V <sub>OHA</sub>           |                                            | I <sub>OH</sub> = −10 μA, V <sub>I</sub> = V <sub>IH</sub>             | 1.1 V to 3.6 V   | V <sub>CCA</sub> × 0.8               |     |     | V    |
| V <sub>OLA</sub>           |                                            | I <sub>OL</sub> = 10 μA, V <sub>I</sub> = V <sub>IL</sub>              | 1.1 V to 3.6 V   | V <sub>CCA</sub> × 0.17              |     |     | V    |
| V <sub>OHB</sub>           |                                            | I <sub>OH</sub> = −10 μA, V <sub>I</sub> = V <sub>IH</sub>             |                  | 3.3V (internal) × 0.9 <sup>(1)</sup> |     |     | V    |
| V <sub>OLB</sub>           |                                            | I <sub>OL</sub> = 3 mA, V <sub>I</sub> = V <sub>IL</sub>               |                  | 0.4                                  |     |     | V    |
| ΔV <sub>T</sub> hysteresis | CEC_A (V <sub>T+</sub> − V <sub>T−</sub> ) |                                                                        | 1.1 V to 3.6 V   | 40                                   |     |     | mV   |
|                            | CEC_B (V <sub>T+</sub> − V <sub>T−</sub> ) |                                                                        | 1.1 V to 3.6 V   | 300                                  |     |     |      |
| R <sub>PU</sub>            | (Internal pullup)                          | CEC_A Internal pullup connected to V <sub>CCA</sub> rail               |                  | 10                                   |     |     | kΩ   |
|                            |                                            | CEC_B Internal pullup connected to internal 3.3-V rail                 |                  | 26                                   |     |     |      |
| I <sub>OFF</sub>           | A port                                     | V <sub>CCA</sub> = 0 V, V <sub>I</sub> or V <sub>O</sub> = 0 to 3.6 V  | 0 V              | ±5                                   |     |     | μA   |
|                            | B port                                     | 5V <sub>OUT</sub> = 0 V, V <sub>I</sub> or V <sub>O</sub> = 0 to 5.5 V | 0 V to 3.6 V     | ±1.8                                 |     |     |      |
| I <sub>OZ</sub>            | B port                                     | V <sub>O</sub> = V <sub>CCO</sub> or GND                               | 1.1 V to 3.6 V   | ±5                                   |     |     | μA   |
|                            | A port                                     | V <sub>I</sub> = V <sub>CCI</sub> or GND                               | 1.1 V to 3.6 V   | ±5                                   |     |     |      |

(1) 3.3 V (internal) is an internally generated voltage node for the CEC\_B output buffer supply reference. An LDO generates this 3.3 V from 5VOUT when LS\_OE = H & CT\_CP\_HPD = H



### 6.11 Electrical Characteristics: Voltage Level Shifter: HPD Line (x\_A/x\_B Ports)

 $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  unless otherwise specified

| PARAMETER               |                             | TEST CONDITIONS                           | $V_{CCA}$      | MIN                  | TYP | MAX | UNIT          |
|-------------------------|-----------------------------|-------------------------------------------|----------------|----------------------|-----|-----|---------------|
| $V_{OHA}$               |                             | $I_{OH} = -3\text{ mA}$ , $V_I = V_{IH}$  | 1.1 V to 3.6 V | $V_{CCA} \times 0.7$ |     |     | V             |
| $V_{OLA}$               |                             | $I_{OL} = 3\text{ mA}$ , $V_I = V_{IL}$   | 1.1 V to 3.6 V | 0.4                  |     |     | V             |
| $\Delta V_T$ hysteresis | HPD_B ( $V_{T+} - V_{T-}$ ) |                                           | 1.1 V to 3.6 V | 200                  |     |     | mV            |
| $R_{PD}$                | (Internal pulldown)         | HPD_B, Internal pulldown connected to GND |                | 11                   |     |     | k $\Omega$    |
| $I_{OZ}$                | A port                      | $V_I = V_{CCI}$ or GND                    | 3.6 V          | $\pm 5$              |     |     | $\mu\text{A}$ |

### 6.12 Electrical Characteristics: LS\_OE, CT\_CP\_HPDP

 $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  unless otherwise specified

| PARAMETER | TEST CONDITIONS        | $V_{CCA}$      | MIN | TYP | MAX      | UNIT          |
|-----------|------------------------|----------------|-----|-----|----------|---------------|
| $I_I$     | $V_I = V_{CCA}$ or GND | 1.1 V to 3.6 V |     |     | $\pm 12$ | $\mu\text{A}$ |

### 6.13 Electrical Characteristics: I/O Capacitance

 $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  unless otherwise specified

| PARAMETER |                | TEST CONDITIONS                                                                                                       | $V_{CCA}$      | MIN | TYP | MAX | UNIT |
|-----------|----------------|-----------------------------------------------------------------------------------------------------------------------|----------------|-----|-----|-----|------|
| $C_I$     | Control inputs | $V_I = 1.89\text{ V}$ or GND, AC input = 30 mV(p-p); f = 10 MHz                                                       | 1.1 V to 3.6 V |     | 7.1 |     | pF   |
| $C_{IO}$  | A port         | $V_O = 1.89\text{ V}$ or GND, AC input = 30 mV(p-p); f = 10 MHz, CT_CP_HPDP = H, LS_OE = L                            | 1.1 V to 3.6 V |     | 8.3 |     | pF   |
|           | B port         | $V_O = 5\text{ V}$ or GND, AC input = 30 mV(p-p); f = 10 MHz, CT_CP_HPDP = H, LS_OE = L                               | 3.3 V          |     | 15  |     | pF   |
| $C_{IO}$  | SCL_B, SDA_B   | $V_{BAT} = 0\text{ V}$ , $V_{bias} = 2.5\text{ V}$ ; AC input = 3.5 V(p-p); f = 100 kHz                               | 0 V            |     | 20  |     | pF   |
|           | CEC_B          | $V_{BAT} = 0\text{ V}$ , $V_{bias} = 1.65\text{ V}$ ; AC input = 2.5 V(p-p); f = 100 kHz                              | 0 V            |     | 20  |     | pF   |
|           |                | $V_{BAT} = 3.3\text{ V}$ , $V_{bias} = 1.65\text{ V}$ ; AC input = 2.5 V(p-p); f = 100 kHz, CT_CP_HPDP = H, LS_OE = L | 3.3 V          |     | 20  |     | pF   |

### 6.14 Switching Characteristics

| PARAMETER |                               | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|-----------|-------------------------------|-----------------|-----|-----|-----|------|
| $C_L$     | Bus load capacitance (B side) |                 |     |     | 750 | pF   |
|           | Bus load capacitance (A side) |                 |     |     | 15  |      |

### 6.15 Switching Characteristics: Voltage Level Shifter: SCL, SDA Lines (x\_A & x\_B ports); $V_{CCA} = 1.2\text{ V}$

 $V_{CCA} = 1.2\text{ V}$ 

| PARAMETER |                             | PINS   | TEST CONDITIONS      | MIN | TYP | MAX | UNIT |
|-----------|-----------------------------|--------|----------------------|-----|-----|-----|------|
| $t_{PHL}$ | Propagation delay           | A to B | DDC Channels Enabled |     | 344 |     | ns   |
|           |                             | B to A |                      |     | 355 |     |      |
| $t_{PLH}$ | Propagation delay           | A to B | DDC Channels Enabled |     | 452 |     | ns   |
|           |                             | B to A |                      |     | 178 |     |      |
| $t_f$     | A port fall time            | A Port | DDC Channels Enabled |     | 138 |     | ns   |
|           | B port fall time            | B Port |                      |     | 83  |     |      |
| $t_r$     | A port rise time            | A Port | DDC Channels Enabled |     | 194 |     | ns   |
|           | B port rise time            | B Port |                      |     | 92  |     |      |
| $f_{MAX}$ | Maximum switching frequency |        | DDC Channels Enabled | 400 |     |     | kHz  |

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**6.16 Switching Characteristics: Voltage Level Shifter: CEC Line (x\_A & x\_B ports);  $V_{CCA} = 1.2\text{ V}$** 
 $V_{CCA} = 1.2\text{ V}$ 

| PARAMETER        |                   | PINS   | TEST CONDITIONS      | MIN | TYP   | MAX | UNIT |
|------------------|-------------------|--------|----------------------|-----|-------|-----|------|
| t <sub>PLH</sub> | Propagation delay | A to B | CEC Channels Enabled |     | 445   |     | ns   |
|                  |                   | B to A |                      |     | 337   |     |      |
| t <sub>PLH</sub> |                   | A to B |                      |     | 13    |     | μs   |
|                  |                   | B to A |                      |     | 0.266 |     |      |
| t <sub>f</sub>   | A port fall time  | A Port | CEC Channels Enabled |     | 140   |     | ns   |
|                  | B port fall time  | B Port |                      |     | 96    |     |      |
| t <sub>r</sub>   | A port rise time  | A Port | CEC Channels Enabled |     | 202   |     | ns   |
|                  | B port rise time  | B Port |                      |     | 15    |     | μs   |

**6.17 Switching Characteristics: Voltage Level Shifter: HPD Line (x\_A & x\_B ports);  $V_{CCA} = 1.2\text{ V}$** 
 $V_{CCA} = 1.2\text{ V}$ 

| PARAMETER |                   | PINS   | TEST CONDITIONS      | MIN | TYP  | MAX | UNIT          |
|-----------|-------------------|--------|----------------------|-----|------|-----|---------------|
| $t_{PLH}$ | Propagation delay | B to A | CEC Channels Enabled |     | 10   |     | $\mu\text{s}$ |
|           |                   | B to A |                      |     | 9    |     |               |
| $t_f$     | A port fall time  | A Port | CEC Channels Enabled |     | 0.67 |     | ns            |
| $t_r$     | A port rise time  | A Port | CEC Channels Enabled |     | 0.74 |     | ns            |

**6.18 Switching Characteristics: Voltage Level Shifter: SCL, SDA Lines (x\_A & x\_B ports);  $V_{CCA} = 1.5\text{ V}$** 
 $V_{CCA} = 1.5\text{ V}$ 

| PARAMETER        |                             | PINS   | TEST CONDITIONS      | MIN | TYP | MAX | UNIT |
|------------------|-----------------------------|--------|----------------------|-----|-----|-----|------|
| t <sub>PLH</sub> | Propagation delay           | A to B | DDC Channels Enabled | 335 |     | ns  |      |
|                  |                             | B to A |                      | 265 |     |     |      |
| t <sub>PLH</sub> |                             | A to B |                      | 438 |     |     |      |
|                  |                             | B to A |                      | 169 |     |     |      |
| t <sub>f</sub>   | A port fall time            | A Port | DDC Channels Enabled | 110 |     | ns  |      |
|                  | B port fall time            | B Port |                      | 83  |     |     |      |
| t <sub>r</sub>   | A port rise time            | A Port | DDC Channels Enabled | 190 |     | ns  |      |
|                  | B port rise time            | B Port |                      | 92  |     |     |      |
| f <sub>MAX</sub> | Maximum switching frequency |        | DDC Channels Enabled | 400 |     |     | kHz  |

**6.19 Switching Characteristics: Voltage Level Shifter: CEC Line (x\_A & x\_B ports);  $V_{CCA} = 1.5\text{ V}$** 
 $V_{CCA} = 1.5\text{ V}$ 

| PARAMETER        |                   | PINS   | TEST CONDITIONS      | MIN | TYP   | MAX | UNIT |
|------------------|-------------------|--------|----------------------|-----|-------|-----|------|
| t <sub>PLH</sub> | Propagation delay | A to B | CEC Channels Enabled |     | 437   |     | ns   |
|                  |                   | B to A |                      |     | 267   |     |      |
| t <sub>PLH</sub> |                   | A to B |                      |     | 13    |     | μs   |
|                  |                   | B to A |                      |     | 0.264 |     |      |
| t <sub>f</sub>   | A port fall time  | A Port | CEC Channels Enabled |     | 110   |     | ns   |
|                  | B port fall time  | B Port |                      |     | 96    |     |      |
| t <sub>r</sub>   | A port rise time  | A Port | CEC Channels Enabled |     | 202   |     | ns   |
|                  | B port rise time  | B Port |                      |     | 15    |     | μs   |

## 6.20 Switching Characteristics: Voltage Level Shifter: HPD Line (x\_A & x\_B ports); $V_{CCA} = 1.5\text{ V}$

 $V_{CCA} = 1.5\text{ V}$ 

| PARAMETER |                   | PINS   | TEST CONDITIONS      | MIN | TYP  | MAX | UNIT          |
|-----------|-------------------|--------|----------------------|-----|------|-----|---------------|
| $t_{PLH}$ | Propagation delay | B to A | CEC Channels Enabled |     | 10   |     | $\mu\text{s}$ |
| $t_{PLH}$ |                   | B to A |                      |     | 9    |     |               |
| $t_f$     | A port fall time  | A Port | CEC Channels Enabled |     | 0.47 |     | ns            |
| $t_r$     | A port rise time  | A Port | CEC Channels Enabled |     | 0.51 |     | ns            |

## 6.21 Switching Characteristics: Voltage Level Shifter: SCL, SDA Lines (x\_A & x\_B ports); $V_{CCA} = 1.8\text{ V}$

 $V_{CCA} = 1.8\text{ V}$ 

| PARAMETER |                             | PINS   | TEST CONDITIONS      | MIN | TYP | MAX | UNIT |
|-----------|-----------------------------|--------|----------------------|-----|-----|-----|------|
| $t_{PLH}$ | Propagation delay           | A to B | DDC Channels Enabled |     | 334 |     | ns   |
|           |                             | B to A |                      |     | 229 |     |      |
| $t_{PLH}$ |                             | A to B |                      |     | 431 |     |      |
|           |                             | B to A |                      |     | 169 |     |      |
| $t_f$     | A port fall time            | A Port | DDC Channels Enabled |     | 94  |     | ns   |
|           | B port fall time            | B Port |                      |     | 83  |     |      |
| $t_r$     | A port rise time            | A Port | DDC Channels Enabled |     | 191 |     | ns   |
|           | B port rise time            | B Port |                      |     | 92  |     |      |
| $f_{MAX}$ | Maximum switching frequency |        | DDC Channels Enabled | 400 |     |     | kHz  |

## 6.22 Switching Characteristics: Voltage Level Shifter: CEC Line (x\_A & x\_B ports); $V_{CCA} = 1.8\text{ V}$

 $V_{CCA} = 1.8\text{ V}$ 

| PARAMETER |                   | PINS   | TEST CONDITIONS      | MIN | TYP  | MAX | UNIT          |
|-----------|-------------------|--------|----------------------|-----|------|-----|---------------|
| $t_{PLH}$ | Propagation delay | A to B | CEC Channels Enabled |     | 441  |     | ns            |
|           |                   | B to A |                      |     | 231  |     |               |
| $t_{PLH}$ |                   | A to B |                      |     | 13   |     | $\mu\text{s}$ |
|           |                   | B to A |                      |     | 0.26 |     |               |
| $t_f$     | A port fall time  | A Port | CEC Channels Enabled |     | 94   |     | ns            |
|           | B port fall time  | B Port |                      |     | 96   |     |               |
| $t_r$     | A port rise time  | A Port | CEC Channels Enabled |     | 201  |     | ns            |
|           | B port rise time  | B Port |                      |     | 15   |     | $\mu\text{s}$ |

## 6.23 Switching Characteristics: Voltage Level Shifter: HPD Line (x\_A & x\_B ports); $V_{CCA} = 1.8\text{ V}$

 $V_{CCA} = 1.8\text{ V}$ 

| PARAMETER |                   | PINS   | TEST CONDITIONS      | MIN | TYP  | MAX | UNIT          |
|-----------|-------------------|--------|----------------------|-----|------|-----|---------------|
| $t_{PLH}$ | Propagation delay | B to A | CEC Channels Enabled |     | 10   |     | $\mu\text{s}$ |
| $t_{PLH}$ |                   | B to A |                      |     | 9    |     |               |
| $t_f$     | A port fall time  | A Port | CEC Channels Enabled |     | 0.41 |     | ns            |
| $t_r$     | A port rise time  | A Port | CEC Channels Enabled |     | 0.45 |     | ns            |

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**6.24 Switching Characteristics: Voltage Level Shifter: SCL, SDA Lines (x\_A & x\_B ports);  $V_{CCA} = 2.5\text{ V}$** 
 $V_{CCA} = 2.5\text{ V}$ 

| PARAMETER        |                             | PINS   | TEST CONDITIONS      | MIN | TYP | MAX | UNIT |
|------------------|-----------------------------|--------|----------------------|-----|-----|-----|------|
| t <sub>PLH</sub> | Propagation delay           | A to B | DDC Channels Enabled | 330 |     | ns  |      |
|                  |                             | B to A |                      | 182 |     |     |      |
| t <sub>PLH</sub> |                             | A to B |                      | 423 |     |     |      |
|                  |                             | B to A |                      | 166 |     |     |      |
| t <sub>f</sub>   | A port fall time            | A Port | DDC Channels Enabled | 79  |     | ns  |      |
|                  | B port fall time            | B Port |                      | 83  |     |     |      |
| t <sub>r</sub>   | A port rise time            | A Port | DDC Channels Enabled | 188 |     | ns  |      |
|                  | B port rise time            | B Port |                      | 92  |     |     |      |
| f <sub>MAX</sub> | Maximum switching frequency |        | DDC Channels Enabled | 400 |     |     | kHz  |

**6.25 Switching Characteristics: Voltage Level Shifter: CEC Line (x\_A & x\_B ports);  $V_{CCA} = 2.5\text{ V}$** 
 $V_{CCA} = 2.5\text{ V}$ 

| PARAMETER        |                   | PINS   | TEST CONDITIONS      | MIN | TYP   | MAX | UNIT |
|------------------|-------------------|--------|----------------------|-----|-------|-----|------|
| t <sub>PLH</sub> | Propagation delay | A to B | CEC Channels Enabled |     | 454   |     | ns   |
|                  |                   | B to A |                      |     | 184   |     |      |
| t <sub>PLH</sub> |                   | A to B |                      |     | 13    |     | μs   |
|                  |                   | B to A |                      |     | 0.255 |     |      |
| t <sub>f</sub>   | A port fall time  | A Port | CEC Channels Enabled |     | 79    |     | ns   |
|                  | B port fall time  | B Port |                      |     | 96    |     |      |
| t <sub>r</sub>   | A port rise time  | A Port | CEC Channels Enabled |     | 194   |     | ns   |
|                  | B port rise time  | B Port |                      |     | 15    |     | μs   |

**6.26 Switching Characteristics: Voltage Level Shifter: HPD Line (x\_A & x\_B ports);  $V_{CCA} = 2.5\text{ V}$** 
 $V_{CCA} = 2.5\text{ V}$ 

| PARAMETER |                   | PINS   | TEST CONDITIONS      | MIN | TYP  | MAX | UNIT          |
|-----------|-------------------|--------|----------------------|-----|------|-----|---------------|
| $t_{PLH}$ | Propagation delay | B to A | CEC Channels Enabled |     | 10   |     | $\mu\text{s}$ |
|           |                   | B to A |                      |     | 9    |     |               |
| $t_f$     | A port fall time  | A Port | CEC Channels Enabled |     | 0.37 |     | ns            |
| $t_r$     | A port rise time  | A Port | CEC Channels Enabled |     | 0.39 |     | ns            |

**6.27 Switching Characteristics: Voltage Level Shifter: SCL, SDA Lines (x\_A & x\_B ports);  $V_{CCA} = 3.3\text{ V}$** 
 $V_{CCA} = 3.3\text{ V}$ 

| PARAMETER        |                             | PINS   | TEST CONDITIONS      | MIN | TYP | MAX | UNIT |
|------------------|-----------------------------|--------|----------------------|-----|-----|-----|------|
| t <sub>PLH</sub> | Propagation delay           | A to B | DDC channels enabled |     | 323 |     | ns   |
|                  |                             | B to A |                      |     | 158 |     |      |
| t <sub>PLH</sub> |                             | A to B |                      |     | 421 |     |      |
|                  |                             | B to A |                      |     | 162 |     |      |
| t <sub>f</sub>   | A port fall time            | A Port | DDC channels enabled |     | 71  |     | ns   |
|                  | B port fall time            | B Port |                      |     | 84  |     |      |
| t <sub>r</sub>   | A port rise time            | A Port | DDC channels enabled |     | 188 |     | ns   |
|                  | B port rise time            | B Port |                      |     | 92  |     |      |
| f <sub>MAX</sub> | Maximum switching frequency |        | DDC channels enabled | 400 |     |     | kHz  |

## 6.28 Switching Characteristics: Voltage Level Shifter: CEC Line (x\_A & x\_B ports); $V_{CCA} = 3.3\text{ V}$

 $V_{CCA} = 3.3\text{ V}$ 

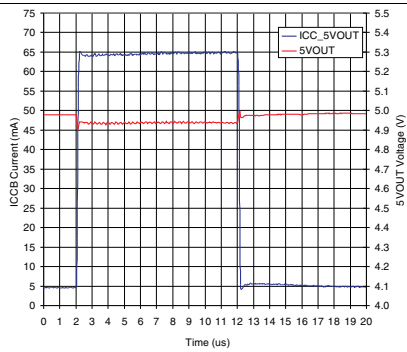
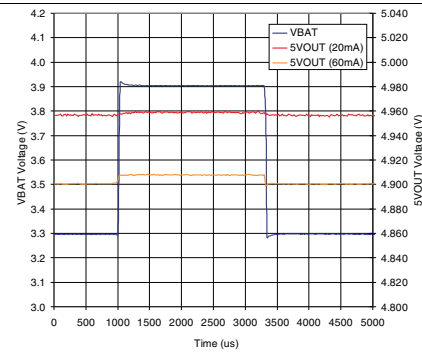
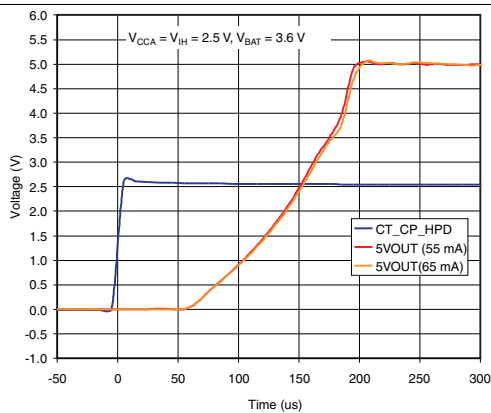
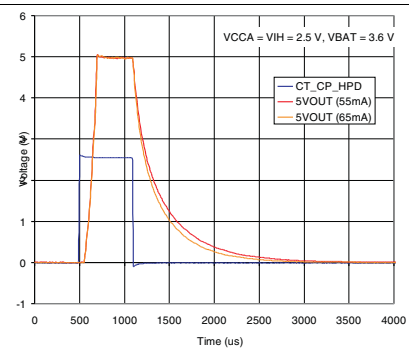
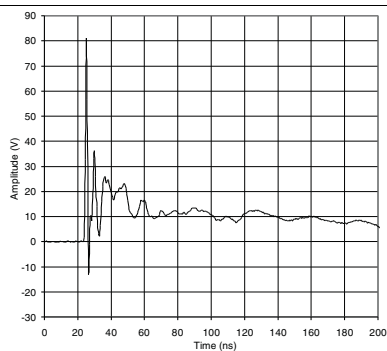
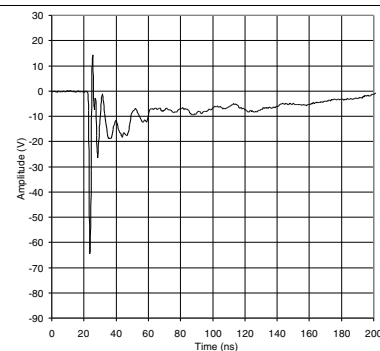
| PARAMETER        |                   | PINS   | TEST CONDITIONS      | MIN | TYP   | MAX | UNIT |
|------------------|-------------------|--------|----------------------|-----|-------|-----|------|
| t <sub>PLH</sub> | Propagation delay | A to B | CEC channels enabled |     | 450   |     | ns   |
|                  |                   | B to A |                      |     | 160   |     |      |
| t <sub>PLH</sub> |                   | A to B |                      |     | 13    |     | μs   |
|                  |                   | B to A |                      |     | 0.251 |     |      |
| t <sub>f</sub>   | A port fall time  | A Port | CEC channels enabled |     | 71    |     | ns   |
|                  | B port fall time  | B Port |                      |     | 96    |     |      |
| t <sub>r</sub>   | A port rise time  | A Port | CEC channels enabled |     | 194   |     | ns   |
|                  | B port rise time  | B Port |                      |     | 15    |     | μs   |

## 6.29 Switching Characteristics: Voltage Level Shifter: HPD Line (x\_A & x\_B ports); $V_{CCA} = 3.3\text{ V}$

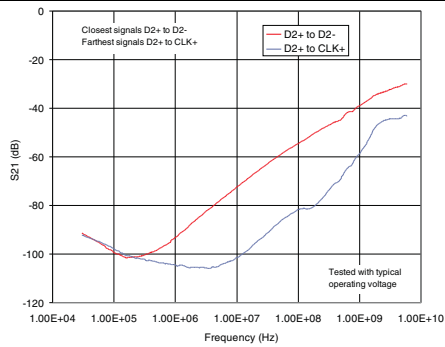
 $V_{CCA} = 3.3\text{ V}$ 

| PARAMETER |                   | PINS   | TEST CONDITIONS      | MIN | TYP  | MAX | UNIT          |
|-----------|-------------------|--------|----------------------|-----|------|-----|---------------|
| $t_{PLH}$ | Propagation delay | B to A | CEC channels enabled |     | 10   |     | $\mu\text{s}$ |
|           |                   | B to A |                      |     | 9    |     |               |
| $t_f$     | A port fall time  | A Port | CEC channels enabled |     | 0.35 |     | ns            |
| $t_r$     | A port rise time  | A Port | CEC channels enabled |     | 0.37 |     | ns            |

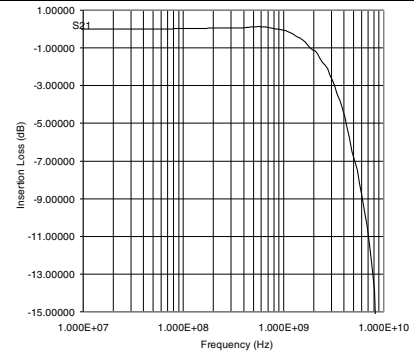
## 6.30 Typical Characteristics


**Figure 1. Load Transient Response**

**Figure 2. Line Transient Response**

**Figure 3.  $t_{START}$** 

**Figure 4. DC-DC Start-Up and Shutdown**

**Figure 5. IEC Clamping Waveforms 8-kV Contact (IEC ESD Pins)**

**Figure 6. IEC Clamping Waveforms -8 kV Contact (IEC ESD Pins)**

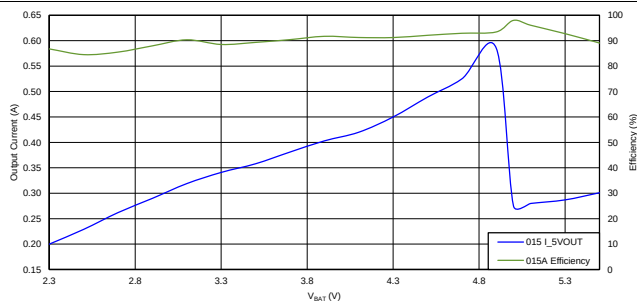
## Typical Characteristics (continued)



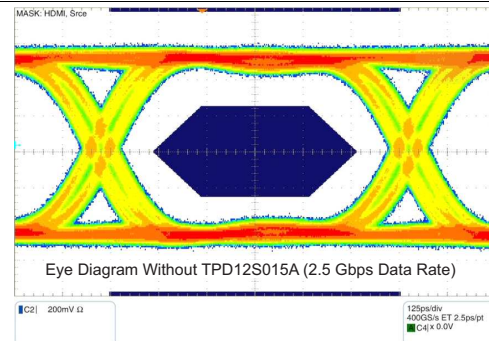
**Figure 7. Channel-to-Channel Crosstalk**



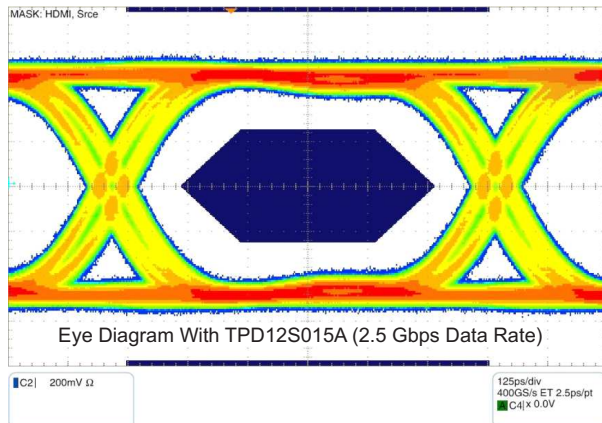
**Figure 8. Insertion Loss Data Line to GND**



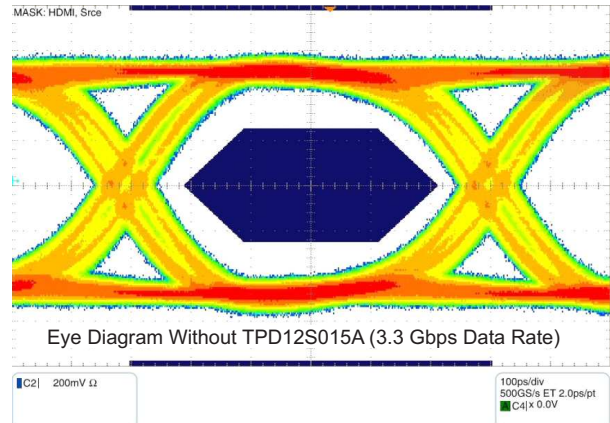
**Figure 9. Power Derating Curve**



**Figure 10. Eye Diagram Performance on a Test Board for the D+, D- Lines at 2.5 Gbps**



**Figure 11. Eye Diagram Performance on a Test Board for the D+, D- Lines at 2.5 Gbps**



**Figure 12. Eye Diagram Performance on a Test Board for the D+, D- Lines at 3.3 Gbps**

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### Typical Characteristics (continued)

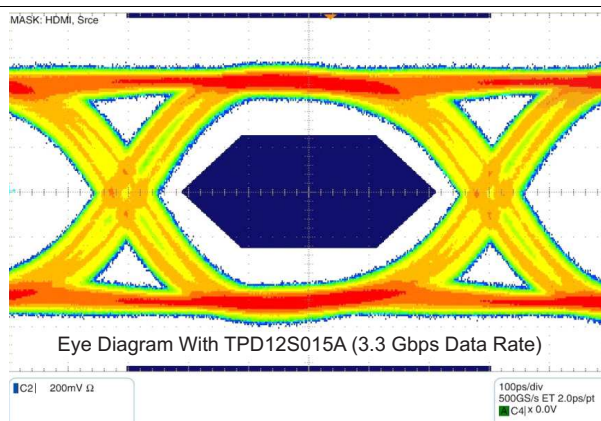
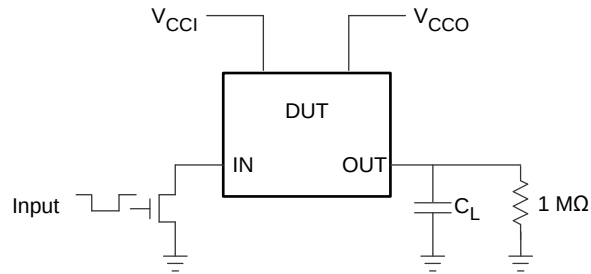


Figure 13. Eye Diagram Performance on a Test Board for the D+, D- Lines at 3.3 Gbps

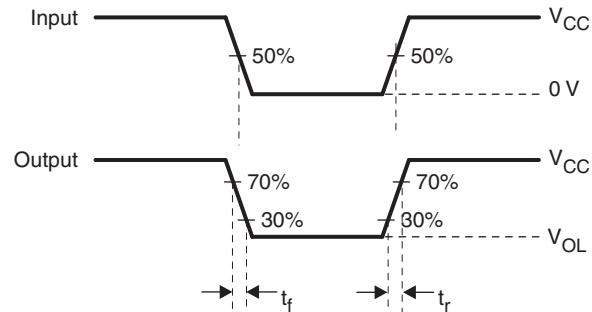


## 7 Parameter Measurement Information



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| PIN                    | $C_L$  |
|------------------------|--------|
| DDC, CEC (A side)      | 750 pF |
| DDC, CEC, HPD (B side) | 15 pF  |



- A.  $R_T$  termination resistance must be equal to  $Z_{OUT}$  of pulse generators.
- B.  $C_L$  includes probe and jig capacitance.
- C. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 10$  MHz,  $Z_O = 50 \Omega$ , slew rate  $\geq 1$  V/ns.
- D. The outputs are measured one at a time, with one transition per measurement.
- E.  $t_{PLH}$  and  $t_{PHL}$  are the same as  $t_{pd}$ .

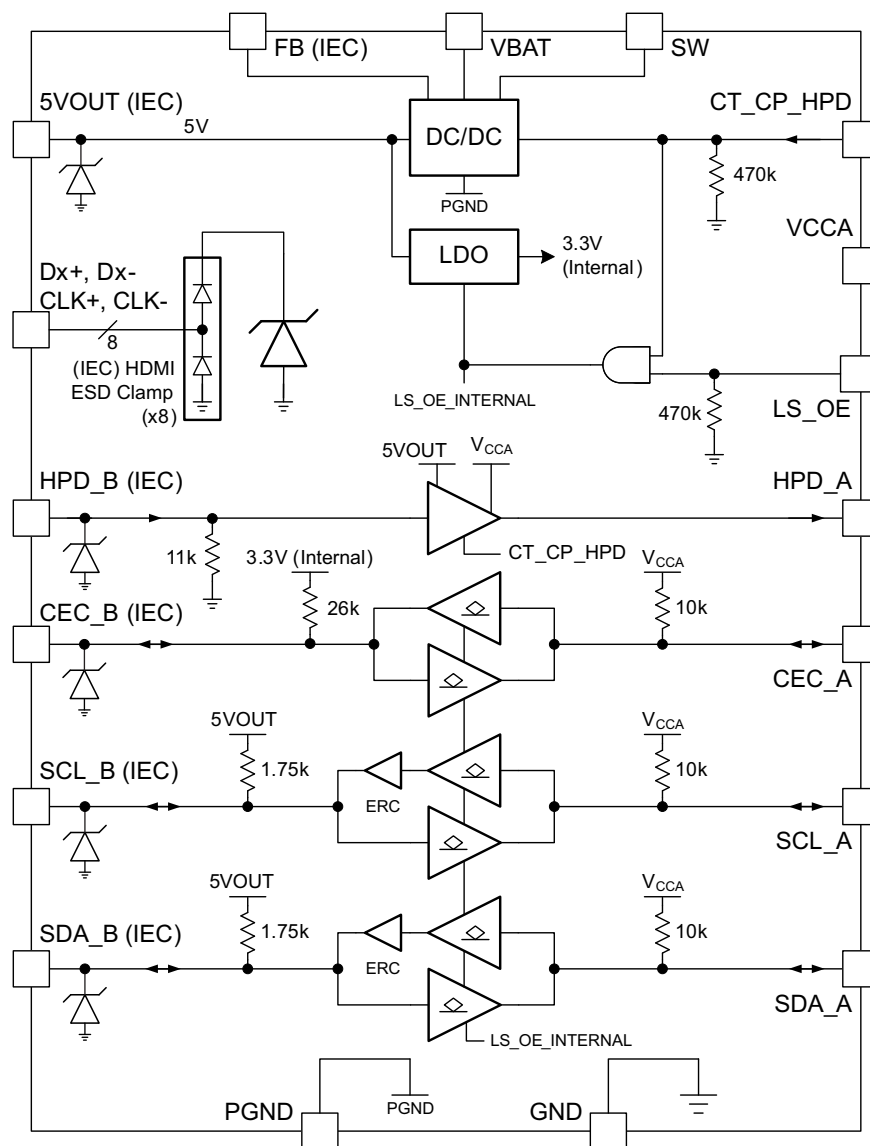
**Figure 14. Test Circuit and Voltage Waveforms**

## 8 Detailed Description

### 8.1 Overview

The TPD12S015A is an integrated interface solution for HDMI 1.3/1.4 interfaces, for both portable and non-portable electronics applications. It has a boost DC-DC converter that uses the 2.3-V to 5.5-V internal power supply and outputs regulated 5-V standard compliant power supply to the cable. This power supply output has current limit and short-circuit protection function. There are bidirectional level shifting and signal conditioning circuits on CEC, SCL, SDA with pullup resistors integrated to minimize the external passive discrete component use. There is also a unidirectional level shifter for HPD signal that translates the 5-V HPD down to  $V_{CCA}$  level. The HPD\_B port has a glitch filter to avoid false detection due to the bouncing while inserting the HDMI plug. For the eight TMDS lines, there are high-speed ESD diodes on each line to make sure that the system pass 8-kV contact ESD.

### 8.2 Functional Block Diagram



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3.3 V (Internal) is an internally generated voltage node for the CEC\_B output buffer supply reference. An LDO generates this 3.3 V from 5VOUT when LS\_OE = H & CT\_CP\_HPDP = H.

## 8.3 Feature Description

### 8.3.1 Rise-Time Accelerators

The HDMI cable side of the DDC lines incorporates rise-time accelerators to support the high capacitive load on the HDMI cable side. The rise time accelerator boosts the cable side DDC signal independent of which side of the bus is releasing the signal.

### 8.3.2 Internal Pullup Resistor

The TPD12S015A has incorporated all the required pullup and pulldown resistors at the interface pins. The system is designed to work properly with no external pullup resistors on the DDC, CEC, and HPD lines. For proper system operation, no external resistors must be placed at the A and B ports. If there is internal pullups at the host processor, they must be disabled.

### 8.3.3 Undervoltage Lockout

The undervoltage lockout circuit prevents the DC-DC converter from malfunctioning at low input voltages and from excessive discharge of the battery. It disables the output stage of the converter once the falling  $V_{IN}$  trips the undervoltage lockout threshold  $V_{BATUV}$ . The undervoltage lockout threshold  $V_{BATUV}$  for falling  $V_{IN}$  is typically 2 V. The device starts operation once the rising  $V_{IN}$  trips undervoltage lockout threshold  $V_{BATUV}$  again at typical 2.1 V.

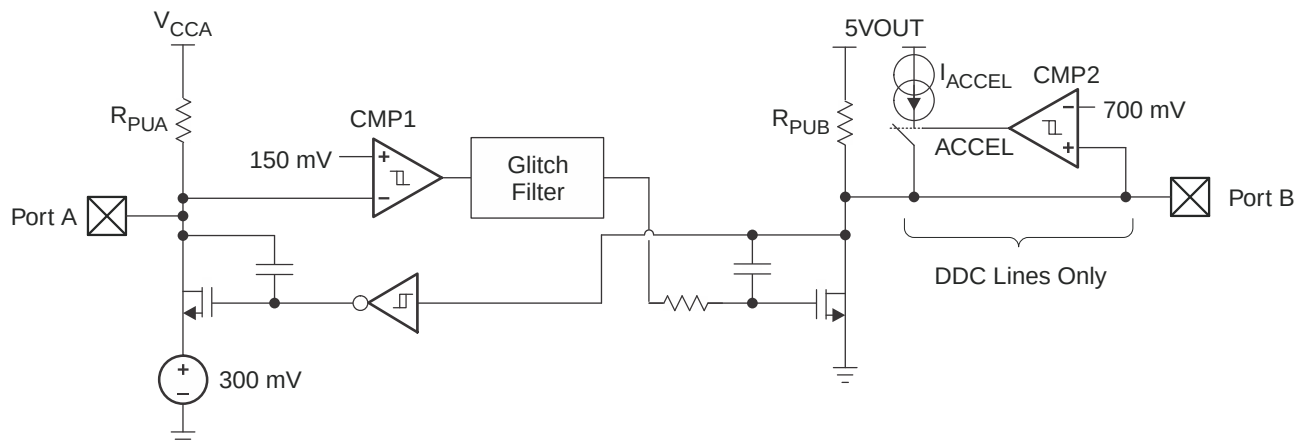
### 8.3.4 Soft Start

The DC-DC converter has an internal soft-start circuit that controls the ramp-up of the output voltage. The output voltage reaches its nominal value within  $t_{Start}$  of typically 250  $\mu$ s after CT\_CP\_HPDP pin has been pulled to high level. The output voltage ramps up from 5% to its nominal value within  $t_{Ramp}$  of 300  $\mu$ s. This limits the inrush current in the converter during start-up, and prevents possible input voltage drops when a battery or high impedance power source is used. During soft start, the switch current limit is reduced to 300 mA until the output voltage reaches  $V_{IN}$ . Once the output voltage trips this threshold, the device operates with its nominal current limit ILIMF.

### 8.3.5 DDC/CEC Level Shifting Function

The TPD12S015A enables DDC translation from  $V_{CCA}$  (system side) voltage levels to 5-V (HDMI cable side) voltage levels without degradation of system performance. The TPD12S015A contains two bidirectional open-drain buffers specifically designed to support up-translation and down-translation between the low voltage,  $V_{CCA}$  side DDC-bus and the 5-V DDC-bus. The port B I/Os are overvoltage tolerant to 5.5 V even when the device is unpowered. After power up and with the LS\_OE and CT\_CP\_HPDP pins high, a low level on port A (below approximately  $V_{ILC} = 0.08 \times V_{CCA}$  V) turns the corresponding port B driver (either SDA or SCL) on and drives port B down to  $V_{OLB}$  V. When port A rises above approximately  $0.10 \times V_{CCA}$  V, the port B pulldown driver is turned off, and the internal pullup resistor pulls the pin high. When port B falls first and goes below  $0.3 \times 5V_{OUT}$ , a CMOS hysteresis input buffer detects the falling edge, turns on the port A driver, and pulls port A down to approximately  $V_{OLA} = 0.16 \times V_{CCA}$  V. The port B pulldown is not enabled unless the port A voltage goes below  $V_{ILC}$ . If the port A low voltage goes below  $V_{ILC}$ , the port B pulldown driver is enabled until port A rises above  $(V_{ILC} + \Delta V_{T-HYSTA})$ ; then port B, if not externally driven LOW, continues to rise being pulled up by the internal pullup resistor.

## Feature Description (continued)

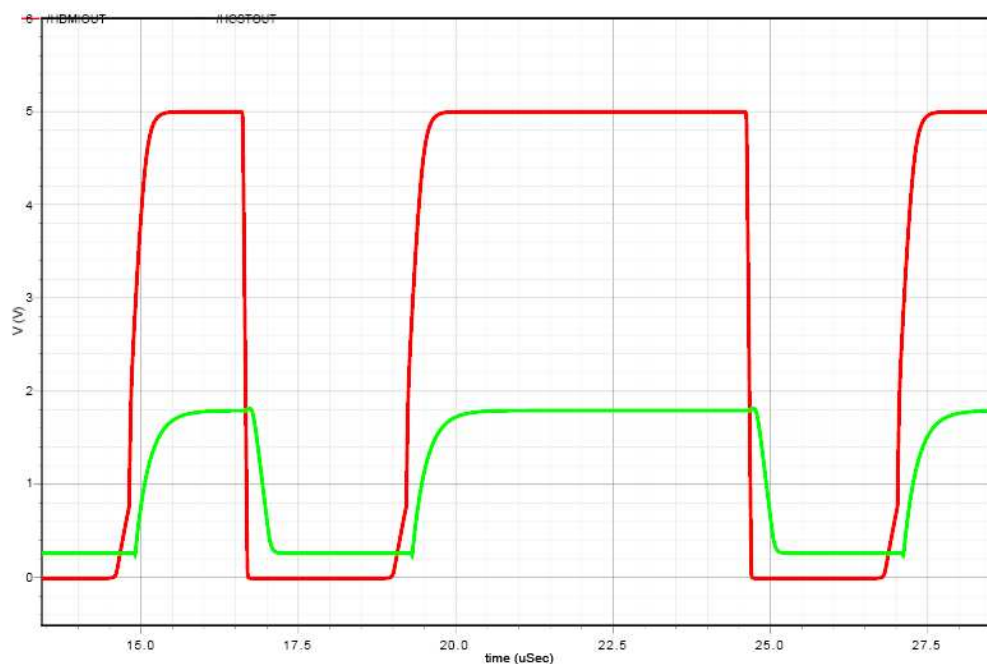


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**Figure 15. DDC/CEC Level Shifter Block Diagram**

### 8.3.6 DDC/CEC Level Shifting Function When $V_{CCA} = 1.8\text{ V}$

- The threshold of CMP1 is approximately  $150\text{ mV} \pm$  the  $40\text{ mV}$  of total hysteresis.
- The comparator trips for a falling waveform at approximately  $130\text{ mV}$
- The comparator trips for a rising waveform at approximately  $170\text{ mV}$
- To be recognized as a zero, the level at Port A must first go below  $130\text{ mV}$  (VILC in spec) and then stay below  $170\text{ mV}$  (VILA in spec)
- To be recognized as a one, the level at A must first go above  $170\text{ mV}$  and then stay above  $130\text{ mV}$
- VILC is set to  $110\text{ mV}$  to give some margin to the  $130\text{ mV}$
- VILA is set to  $140\text{ mV}$  to give some margin to the  $170\text{ mV}$
- VIHA is set to  $70\%$  of  $V_{CCA}$  to be consistent with standard CMOS levels



**Figure 16. DDC/CEC Level Shifter Operation (B to A Direction)**

## Feature Description (continued)

### 8.3.7 CEC Level Shifting Function

The CEC level shift function operates in the same manner as the DDC lines except that the CEC line does not need the rise time accelerator function.

## 8.4 Device Functional Modes

### 8.4.1 Enable

The DC-DC converter is enabled when the CT\_CP\_HPDP is set to high. At first, the internal reference is activated and the internal analog circuits are settled. Afterwards, the soft start is activated and the output voltage is ramped up. The output voltage reaches its nominal value in typically 250  $\mu$ s after the device has been enabled. The CT\_CP\_HPDP input can be used to control power sequencing in a system with various DC-DC converters. The CT\_CP\_HPDP pin can be connected to the output of another converter, to drive the EN pin high and getting a sequencing of supply rails. With CT\_CP\_HPDP = GND, the DC-DC enters shutdown mode.

### 8.4.2 Power Save Mode

The TPD12S015A integrates a power save mode to improve efficiency at light load. In power save mode the converter only operates when the output voltage trips below a set threshold voltage. It ramps up the output voltage with several pulses and goes into power save mode once the output voltage exceeds the set threshold voltage. The PFM mode is left and PWM mode entered in case the output current can not longer be supported in PFM mode.

**Table 2. System Block Diagram Function Table**

| LS_OE | CT_CP_HPDP | V <sub>CCA</sub> | VBAT  | 5VOUT | A-SIDE  | DDC, B-SIDE | CEC, B-SIDE | CEC LDO | DC-DC & HPDP | DDC/CEC | ICC V <sub>CCA</sub> | ICC VBAT    | COMMENT         |
|-------|------------|------------------|-------|-------|---------|-------------|-------------|---------|--------------|---------|----------------------|-------------|-----------------|
|       |            |                  |       |       | PULLUPS | PULLUPS     | PULLUPS     |         |              | VLTs    | TYP                  | TYP         |                 |
| L     | L          | 1.8 V            | 3.3 V | Off   | Off     | Off         | Off         | Off     | Off          | Off     | 1 $\mu$ A            | 1 $\mu$ A   | Fully Disabled  |
| L     | H          | 1.8 V            | 3.3 V | On    | On      | On          | Off         | Off     | On           | Off     | 1 $\mu$ A            | 30 $\mu$ A  | DC-DC on        |
| H     | L          | 1.8 V            | 3.3 V | Off   | Off     | Off         | Off         | Off     | Off          | Off     | 1 $\mu$ A            | 1 $\mu$ A   | Not Valid State |
| H     | H          | 1.8 V            | 3.3 V | On    | On      | On          | On          | On      | On           | On      | 13 $\mu$ A           | 255 $\mu$ A | Fully On        |
| X     | X          | 0 V              | 0 V   | Off   | High-Z  | High-Z      | High-Z      | Off     | Off          | Off     | 0                    | 0           | Power Down      |
| X     | X          | 1.8 V            | 0 V   | Off   | Low     | High-Z      | High-Z      | Off     | Off          | Off     | 0                    | 0           | Power Down      |
| X     | X          | 0 V              | 3.3 V | Off   | High-Z  | High-Z      | High-Z      | Off     | Off          | Off     | 0                    | 0           | Power Down      |

## 9 Application and Implementation

### NOTE

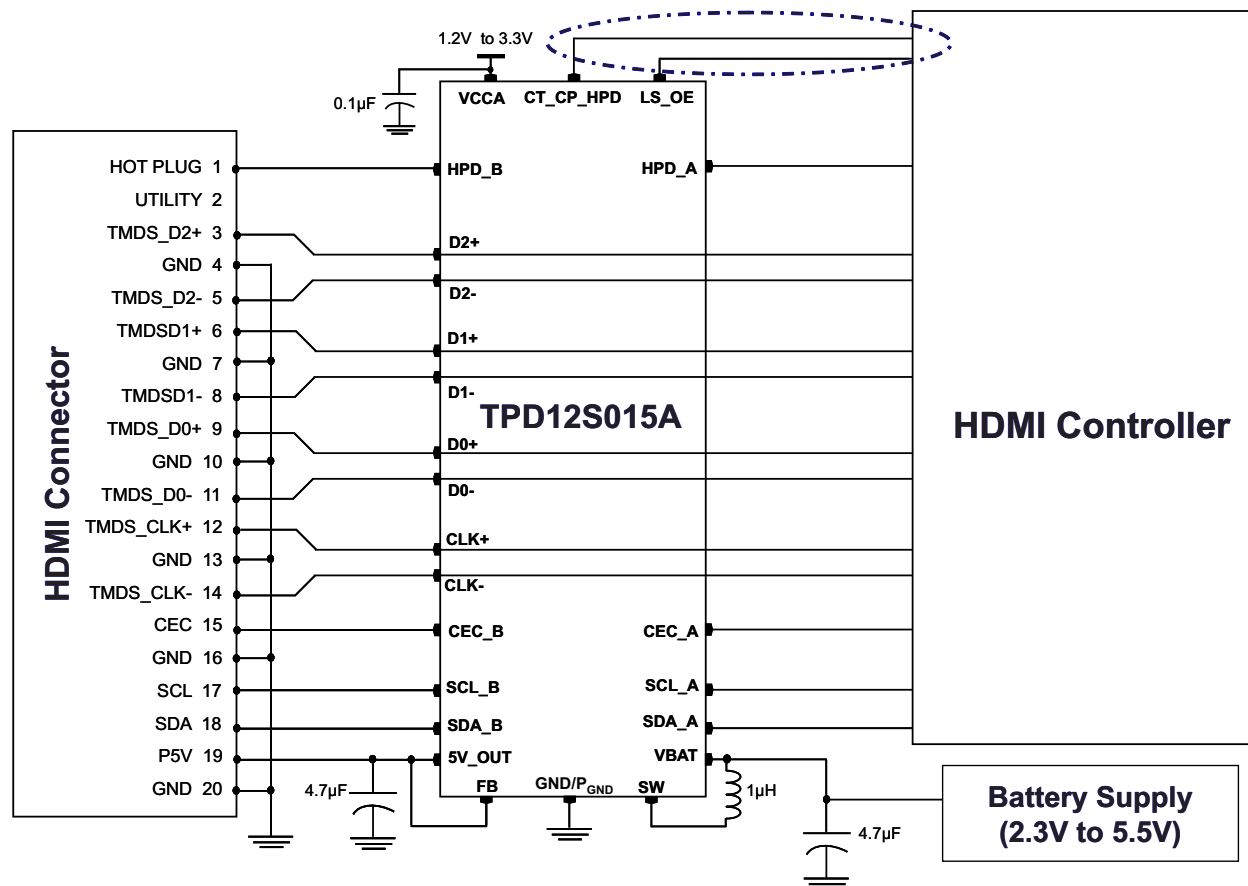
Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers must validate and test their design implementation to confirm system functionality.

### 9.1 Application Information

The TPD12S015A is an integrated solution for HDMI 1.3/1.4 interface. The device has a boost converter on the power supply, signal conditioning circuits on CEC, SCL, SDA, HPD lines, and ESD protection on the TMDS lines. To get the best performance, see [Design Requirements](#), [Detailed Design Procedure](#), and [Application Curves](#).

### 9.2 Typical Applications

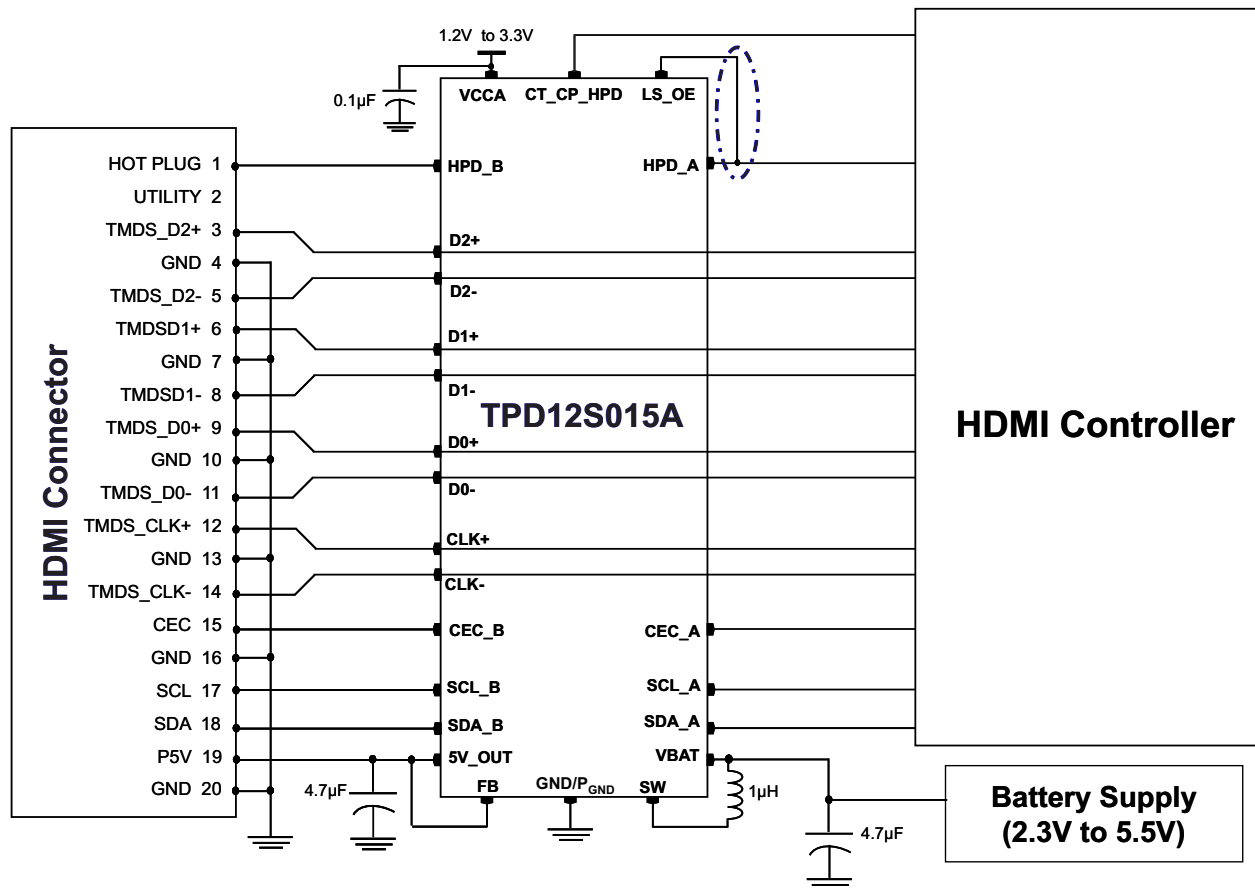
Some HDMI controller chips may have two GPIOs to control the HDMI interface chip. [Figure 17](#) shows how TPD12S015A is used in this situation. Whereas some HDMI driver chips may have only one GPIO(CT\_CP\_HPDP) available. In this situation, LE\_OE pin is tied to HPD\_A instead. [Figure 18](#) shows how TPD12S015A is used in this situation.



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**Figure 17. Application Schematics for HDMI Controllers With Two GPIOs for HDMI Interface Control**

## Typical Applications (continued)



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Figure 18. Application Schematics for HDMI Controllers With One GPIO for HDMI Interface Control

### 9.2.1 Design Requirements

Table 3 lists the known system parameters for an HDMI 1.3/1.4 application.

Table 3. Design Parameters

| DESIGN PARAMETER                         | VALUE            |
|------------------------------------------|------------------|
| 5V_OUT DC current                        | 55 mA            |
| CEC_A, HPD_A, SCL_A, SDA_A voltage level | V <sub>CCA</sub> |
| HDMI data rate per TMDS signal pair      | 3.4 Gbps         |
| Required IEC 61000-4-2 ESD Protection    | ±8-kV Contact    |

### 9.2.2 Detailed Design Procedure

#### 9.2.2.1 Inductor Selection

To make sure that the TPD12S015A devices can operate, an inductor must be connected between pin V<sub>BAT</sub> and pin SW. A boost converter normally requires two main passive components for storing energy during the conversion. A boost inductor and a storage capacitor at the output are required. To select the boost inductor, TI recommends keeping the possible peak inductor current below the current limit threshold of the power switch in the chosen configuration. The highest peak current through the inductor and the switch depends on the output load, the input (V<sub>BAT</sub>), and the output voltage (5V<sub>OUT</sub>). Use Equation 1 to estimate the maximum average inductor current.

$$I_{L\_MAX} \approx I_{OUT} \times \frac{V_{OUT}}{\eta \times V_{IN}} \quad (1)$$

For example, for an output current of 55 mA at 5V<sub>OUT</sub>, approximately 150 mA of average current flows through the inductor at a minimum input voltage of 2.3 V.

The second parameter for choosing the inductor is the desired current ripple in the inductor. Normally, it is advisable to work with a ripple of less than 20% of the average inductor current. A smaller ripple reduces the magnetic hysteresis losses in the inductor, as well as output voltage ripple and EMI. However, in the same way, regulation time at load changes rises. In addition, a larger inductor increases the total system size and cost. With these parameters, it is possible to calculate the value of the minimum inductance by using [Equation 2](#).

$$L_{MIN} \approx \frac{V_{IN} \times (V_{OUT} - V_{IN})}{\Delta I_L \times f \times V_{OUT}}$$

where

- $f$  is the switching frequency
  - $\Delta I_L$  is the ripple current in the inductor, that is,  $20\% \times I_L$
- (2)

With this calculated value and the calculated currents, it is possible to choose a suitable inductor. In typical applications, TI recommends 1-μH inductance. The device has been optimized to operate with inductance values between 1 μH and 1.3 μH. TI recommends using at least 1-μH inductance, even if [Equation 2](#) yields something lower. Take care so that load transients and losses in the circuit can lead to higher currents as estimated in [Equation 3](#). Also, the losses in the inductor caused by magnetic hysteresis losses and copper losses are a major parameter for total circuit efficiency.

With the chosen inductance value, the peak current for the inductor in steady state operation can be calculated. [Equation 3](#) shows how to calculate the peak current  $I$ .

$$I_{L(peak)} = \frac{V_{IN} \times D}{2 \times f \times L} + \frac{I_{OUT}}{(1-D) \times \eta}$$

$$D = \frac{V_{OUT} - V_{IN}}{V_{OUT}} \quad (3)$$

This would be the critical value for the current rating for selecting the inductor. It also must be considered that load transients and error conditions may cause higher inductor currents.

### 9.2.2.2 Input Capacitor

Because of the nature of the boost converter having a pulsating input current, a low ESR input capacitor is required to prevent large voltage transients that can cause misbehavior of the device or interferences with other circuits in the system. TI recommends at least a 1.2-μF input capacitor to improve transient behavior of the regulator and EMI behavior of the total power supply circuit. TI recommends placing a ceramic capacitor as close as possible to the V<sub>IN</sub> and GND pins; to improve the input noise filter, it is better to use a 4.7-μF capacitor.

### 9.2.2.3 Output Capacitor

For the output capacitor, TI recommends using small ceramic capacitors placed as close as possible to the V<sub>OUT</sub> and GND pins of the IC. If, for any reason, the application requires the use of large capacitors, which cannot be placed close to the IC, TI recommends using a smaller ceramic capacitor in parallel to the large one. This small capacitor must be placed as close as possible to the V<sub>OUT</sub> and GND pins of the IC. To get an estimate of the recommended minimum output capacitance, use [Equation 4](#).

$$C_{min} = \frac{I_{OUT} \times (V_{OUT} - V_{IN})}{f \times \Delta V \times V_{OUT}}$$

where

- $f$  is the switching frequency
  - $\Delta V$  is the maximum allowed ripple
- (4)



With a chosen ripple voltage of 10 mV, a minimum effective capacitance of 2.7  $\mu\text{F}$  is needed. The total ripple is larger due to the ESR of the output capacitor. This additional component of the ripple can be calculated using [Equation 5](#).

$$\Delta V_{\text{ESR}} = I_{\text{OUT}} \times R_{\text{ESR}} \quad (5)$$

A capacitor with a value in the range of the calculated minimum must be used. This is required to maintain control loop stability. There are no additional requirements regarding minimum ESR. There is no upper limit for the output capacitance value. Larger capacitors cause lower output voltage ripple as well as lower output voltage drop during load transients.

Note that ceramic capacitors have a DC Bias effect, which will have a strong influence on the final effective capacitance needed. Therefore, the right capacitor value must be chosen very carefully. Package size and voltage rating in combination with material are responsible for differences between the rated capacitor value and the effective capacitance. The minimum effective capacitance value must be 1.2  $\mu\text{F}$ , but the preferred value is about 4.7  $\mu\text{F}$ .

**Table 4. Passive Components: Recommended Minimum Effective Values**

| COMPONENT        | MIN | TARGET | MAX | UNIT          |
|------------------|-----|--------|-----|---------------|
| C <sub>IN</sub>  | 1.2 | 4.7    | 6.5 | $\mu\text{F}$ |
| C <sub>OUT</sub> | 1.2 | 4.7    | 10  | $\mu\text{F}$ |
| L <sub>IN</sub>  | 0.7 | 1      | 1.3 | $\mu\text{H}$ |

#### 9.2.2.4 CEC, HPD, SCL, SDA Level Shifting Function

To accommodate for the lower logic levels of some processors' control lines, level shifters are needed to translate the interface voltage down to  $V_{\text{CCA}}$ , the voltage level used by the processor. The TPD12S015A has bidirectional level shifters on CEC, SCL, SDA lines to support the two-way communication. The pullup resistors are integrated to minimize the number of external components. For HPD line, only one way of hot-plug indication is needed, the level shifter is unidirectional. There is a built-in HPD\_B pulldown resistor to keep the voltage level low on the connector side when nothing is attached. Apart from the signal level translation, the rise-time accelerators on the connector side increases the load driving capability.

#### 9.2.2.5 ESD

To get the best ESD performance on the interface side pins, high performance ESD diodes are needed. The TPD12S015A's ESD diodes on D0+, D0-, D1+, D1-, D2+, D2-, CLK+, CLK-, SCL\_B, SDA\_B, CEC\_B, HPD\_B, 5VOUT, FB ensure passing 8-kV contact IEC, the highest level ESD. Signal integrity on TMDS lines is also a design concern that needs to be evaluated to meet the HDMI 1.3/1.4 data rate. With the typical I/O capacitance of 1.3 pF and a bandwidth above 3 GHz, [Figure 12](#) shows that TPD12S015A's ESD structure has enough margin to meet the data rate requirement of HDMI 1.3/1.4.

#### 9.2.2.6 Ground Offset Consideration

Ground offset between the TPD12S015A ground and the ground of devices on port A of the TPD12S015A must be avoided. The reason for this cautionary remark is that a CMOS/NMOS open-drain capable of sinking 3 mA of current at 0.4 V has an output resistance of 133  $\Omega$  or less. Such a driver shares enough current with the port A output pulldown of the TPD12S015A to be seen as a LOW as long as the ground offset is zero. If the ground offset is greater than 0 V, then the driver resistance must be less. Because VILC can be as low as 90 mV at cold temperatures and the low end of the current distribution, the maximum ground offset must not exceed 50 mV. Bus repeaters that use an output offset are not interoperable with the port A of the TPD12S015A as their output LOW levels are not recognized by the TPD12S015A as a LOW. If the TPD12S015A is placed in an application where the VIL of port A of the TPD12S015A does not go below its VILC, it pulls port B LOW initially when port A input transitions LOW but the port B returns HIGH, so it does not reproduce the port A input on port B. Such applications must be avoided. Port B is interoperable with all I<sup>2</sup>C bus slaves, masters, and repeaters.

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### 9.2.3 Application Curves

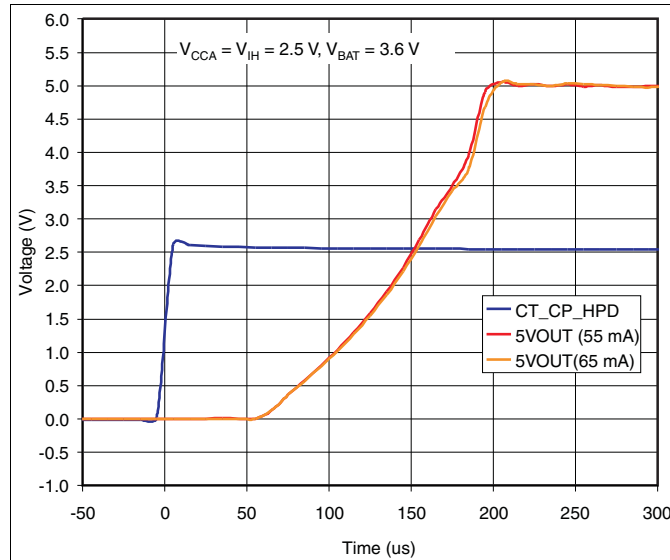


Figure 19.  $t_{START}$

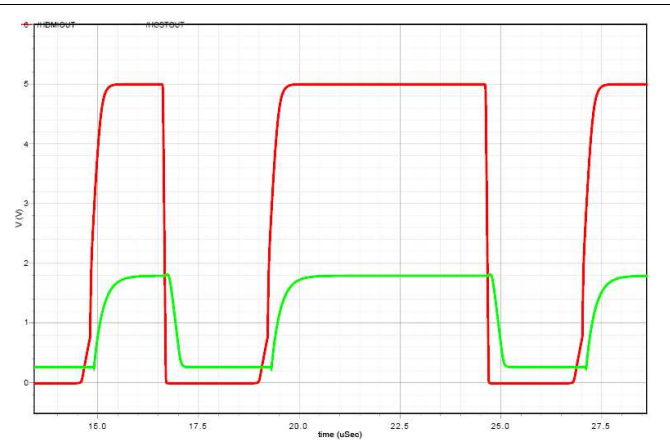


Figure 20. DDC/CEC Level Shifting Operation (B to A Direction)

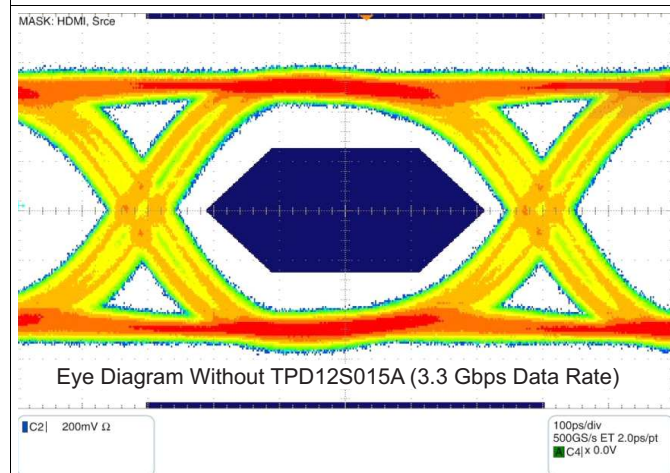


Figure 21. Eye Diagram Performance on a Test Board for the D+, D- Lines at 3.3 Gbps

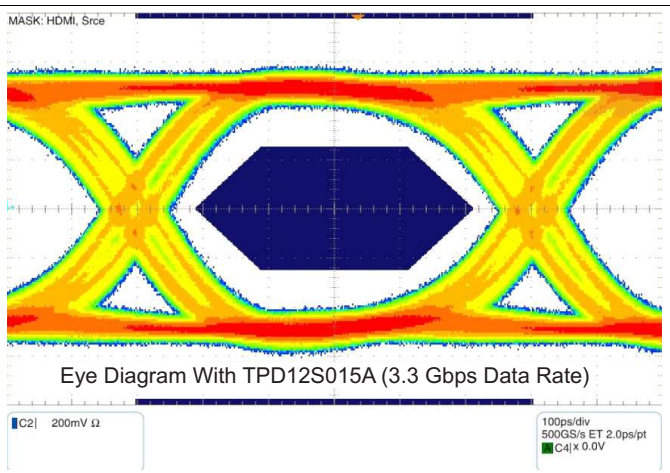


Figure 22. Eye Diagram Performance on a Test Board for the D+, D- Lines at 3.3 Gbps

## 10 Power Supply Recommendations

See [Detailed Design Procedure](#) for detailed power supply recommendations.

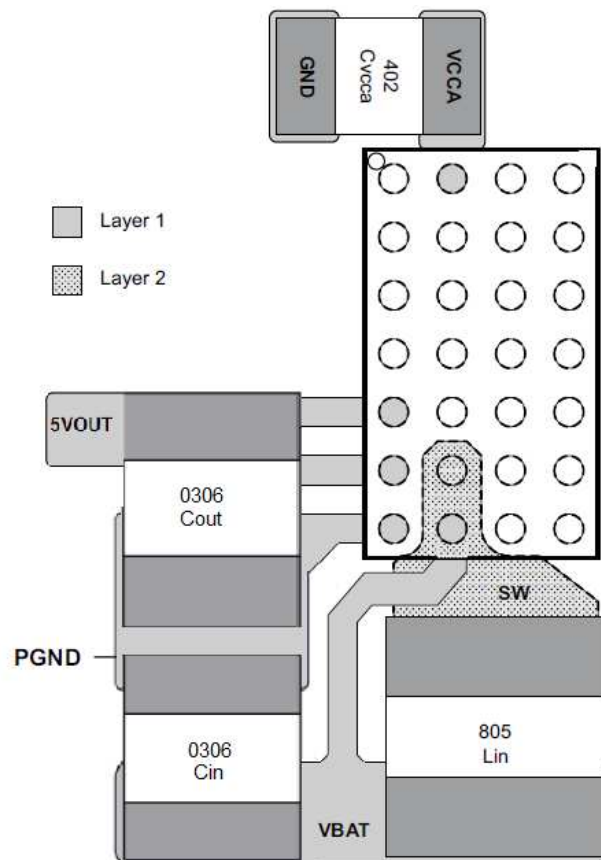
## 11 Layout

### 11.1 Layout Guidelines

For proper operation, follow these layout and design guidelines.

- Place the TPD12S015A as close to the connector as possible. This allows it to remove the energy associated with ESD strike before it reaches the internal circuitry of the system board.
- Place power line capacitors and inductors close to the pins with wide traces to allow enough current to flow through with less trace parasitics.
- Ensure that there is enough metallization for the GND pad. A sufficient current path enables safe discharge of all the energy associated with the ESD strike.
- The critical routing paths for HDMI interface are the high-speed TMDS lines. Make sure to match the lengths of the differential pair. Maintain constant trace width after to avoid impedance mismatches in the transmission lines. Maximize differential pair-to-pair spacing when possible.

### 11.2 Layout Example



**Figure 23. Board Layout (DC-DC Components) (Top View)**

List of components:

- $L_{IN}$  = MURATA LQM21PN1R0MC0 (1  $\mu$ H, 800 mA, 0805, Shielded)
- $C_{IN} = C_{OUT}$  = MURATA LLL31MR70J475MA01 (4.7  $\mu$ F, Low ESL type, 6.3 V, 0306, X7R)
- $C_{VCCA}$  = MURATA GRM155R60J475ME87D (0.1  $\mu$ F, 6.3 V, 0402, X5R)

## 12 器件和文档支持

### 12.1 文档支持

#### 12.1.1 相关文档

请参阅如下相关文档：

[TPD12S015A EVM 用户指南](#) (SLVU485)

### 12.2 接收文档更新通知

要接收文档更新通知，请导航至 [TI.com](#) 上的器件产品文件夹。请单击右上角的通知我进行注册，即可收到所有的产品更改信息每周摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

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ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

### 12.6 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

## 13 机械、封装和可订购信息

以下页面包含机械、封装和可订购信息。这些信息是指定器件的最新可用数据。这些数据如有变更，恕不另行通知和修订此文档。如欲获取此数据表的浏览器版本，请参阅左侧的导航。

## PACKAGING INFORMATION

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2) | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| TPD12S015AYFFR   | ACTIVE        | DSBGA        | YFF                | 28   | 3000           | RoHS & Green    | SNAGCU                               | Level-1-260C-UNLIM   | -40 to 85    | PN015A                  | <a href="#">Samples</a> |

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSELETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

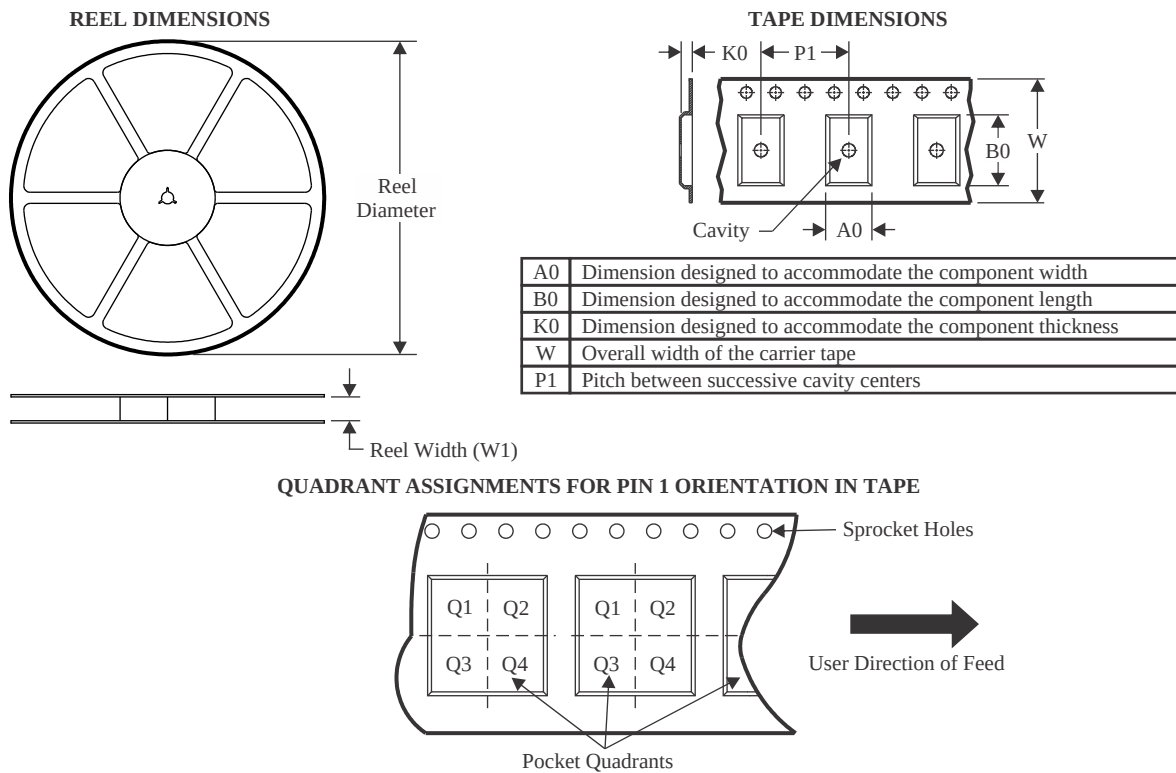
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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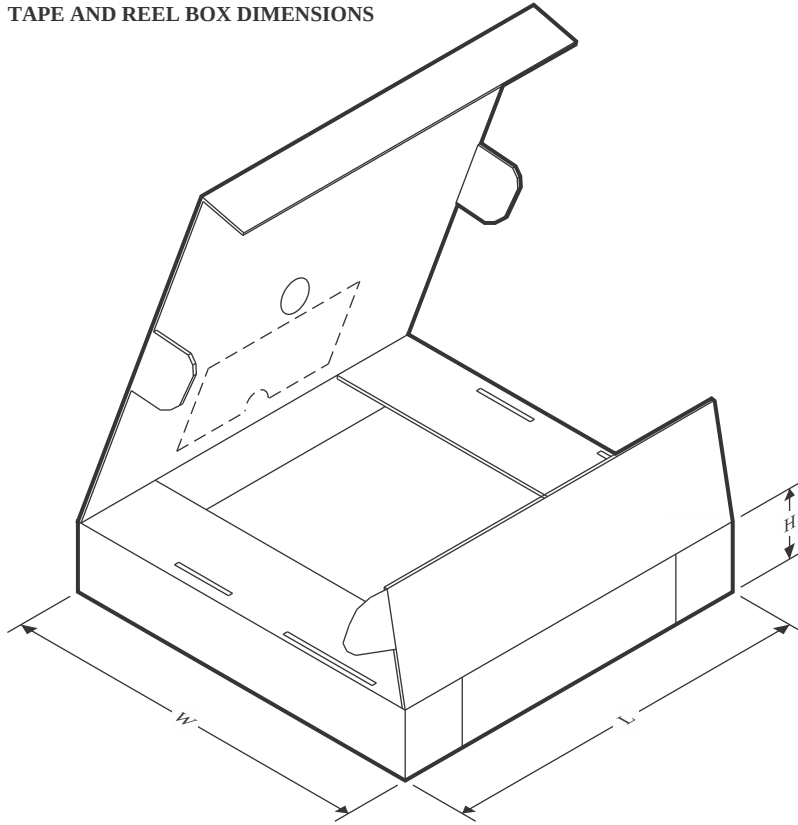
## TAPE AND REEL INFORMATION



\*All dimensions are nominal

| Device         | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TPD12S015AYFFR | DSBGA        | YFF             | 28   | 3000 | 180.0              | 8.4                | 1.73    | 2.93    | 0.81    | 4.0     | 8.0    | Q1            |

## TAPE AND REEL BOX DIMENSIONS

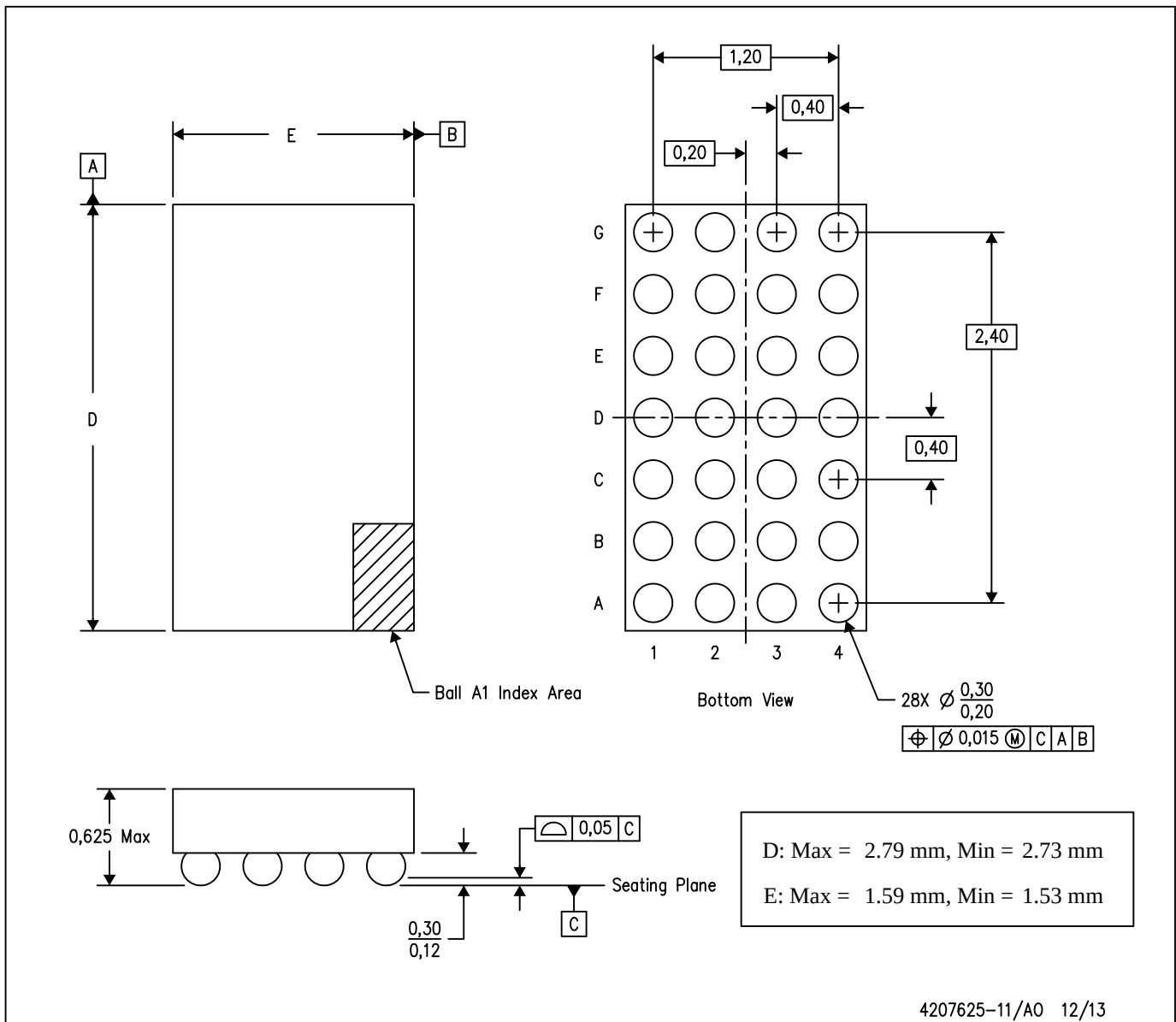


\*All dimensions are nominal

| Device         | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TPD12S015AYFFR | DSBGA        | YFF             | 28   | 3000 | 182.0       | 182.0      | 20.0        |

YFF (R-XBGA-N28)

DIE-SIZE BALL GRID ARRAY



- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. NanoFree™ package configuration.

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