

## 2.3 Analog video output

- VSIS 1.2 compliance ([Ref. 3](#)) for all supported video output modes
- Analog RGB current-source outputs
- VSYNC and HSYNC outputs
- Pixel clock up to 240 MHz
- Triple 8-bit Digital-to-Analog Converter (DAC)
- Direct drive of double terminated 75  $\Omega$  load with standard 700 mV (peak-to-peak) signals

## 2.4 General features

- Supports 'Flash-over-AUX' field upgradability
- Monitor presence detection. Connection/disconnection reported via HPD IRQ and DPCD update.
- All display resolutions from VGA to WUXGA are supported<sup>1</sup>, including e.g.:
  - ◆ WUXGA: 6 bits, 1920 × 1200, 60 Hz, 193 MHz pixel clock rate
  - ◆ WUXGA: 1920 × 1200, 60 Hz, reduced blanking, 154 MHz pixel clock rate
  - ◆ UXGA: 1600 × 1200, 60 Hz, 162 MHz pixel clock rate
  - ◆ SXGA: 1280 × 1024, 60 Hz, 108 MHz pixel clock rate
  - ◆ XGA: 1024 × 768, 60 Hz, 65 MHz pixel clock rate
  - ◆ SVGA: 800 × 600, 60 Hz, 40 MHz pixel clock rate
  - ◆ VGA: 640 × 480, 60 Hz, 25 MHz pixel clock rate
  - ◆ Any resolution and refresh rates are supported up to 8 bit color
- Bits per color (bpc) supported<sup>1</sup>
  - ◆ 6, 8 bits supported
  - ◆ 10, 12, 16 bits supported by truncation to 8 MSBs
- All VGA colorimetry formats (RGB) supported
- Power modes
  - ◆ Active-mode power consumption:
    - ~600 mW at UXGA / 162 MHz pixel clock
    - ~500 mW at SXGA / 108 MHz pixel clock
  - ◆ ~40 mW at Low-power mode or before link training started
- On-board crystal oscillator for use with external 27 MHz crystal
- ESD protection: 7 kV ESD HBM JEDEC
- 3.3 V  $\pm$  10 % power supply
- Commercial temperature range: 0 °C to 85 °C
- 40-pin HVQFN, 6 mm × 6 mm × 0.85 mm (nominal); 0.5 mm pitch; lead-free package

1. Except for color depth beyond 8 bits, display resolutions and refresh rates are only limited to those which a standard 2-lane DisplayPort configuration is able to support.

### 3. Applications

- Dongle PC accessory
  - ◆ Dongle connected to PC DisplayPort output and connected to RGB monitor via VGA cable
  - ◆ PTN3393 is powered by the DP\_PWR pin on the DisplayPort connector
- Desktop and notebook computers
- Notebook docking stations

### 4. Ordering information

**Table 1. Ordering information**

| Type number                 | Topside mark | Package |                                                                                               |          |
|-----------------------------|--------------|---------|-----------------------------------------------------------------------------------------------|----------|
|                             |              | Name    | Description                                                                                   | Version  |
| PTN3393BS <sup>[1]</sup>    | PTN3393      | HVQFN40 | plastic thermal enhanced very thin quad flat package; no leads; 40 terminals; 6 × 6 × 0.85 mm | SOT618-6 |
| PTN3393BS/FX <sup>[2]</sup> | PTN3393      | HVQFN40 | plastic thermal enhanced very thin quad flat package; no leads; 40 terminals; 6 × 6 × 0.85 mm | SOT618-6 |

[1] PTN3393BS uses latest firmware version.

[2] PTN3393BS/FX uses specific firmware version ('X' = 1, 2, 3, etc., and changes according to firmware version).

#### 4.1 Ordering options

**Table 2. Ordering options**

| Type number                 | Orderable part number | Package | Packing method                                | Minimum order quantity | Temperature                       |
|-----------------------------|-----------------------|---------|-----------------------------------------------|------------------------|-----------------------------------|
| PTN3393BS <sup>[1]</sup>    | PTN3393BSY            | HVQFN40 | Reel 13" Q1/T1<br>*Standard mark SMD dry pack | 4000                   | T <sub>amb</sub> = 0 °C to +85 °C |
| PTN3393BS/FX <sup>[2]</sup> | PTN3393BS/FXY         | HVQFN40 | Reel 13" Q1/T1<br>*Standard mark SMD dry pack | 4000                   | T <sub>amb</sub> = 0 °C to +85 °C |

[1] PTN3393BS uses latest firmware version.

[2] PTN3393BS/FX uses specific firmware version ('X' = 1, 2, 3, etc., and changes according to firmware version).

5. Functional diagram

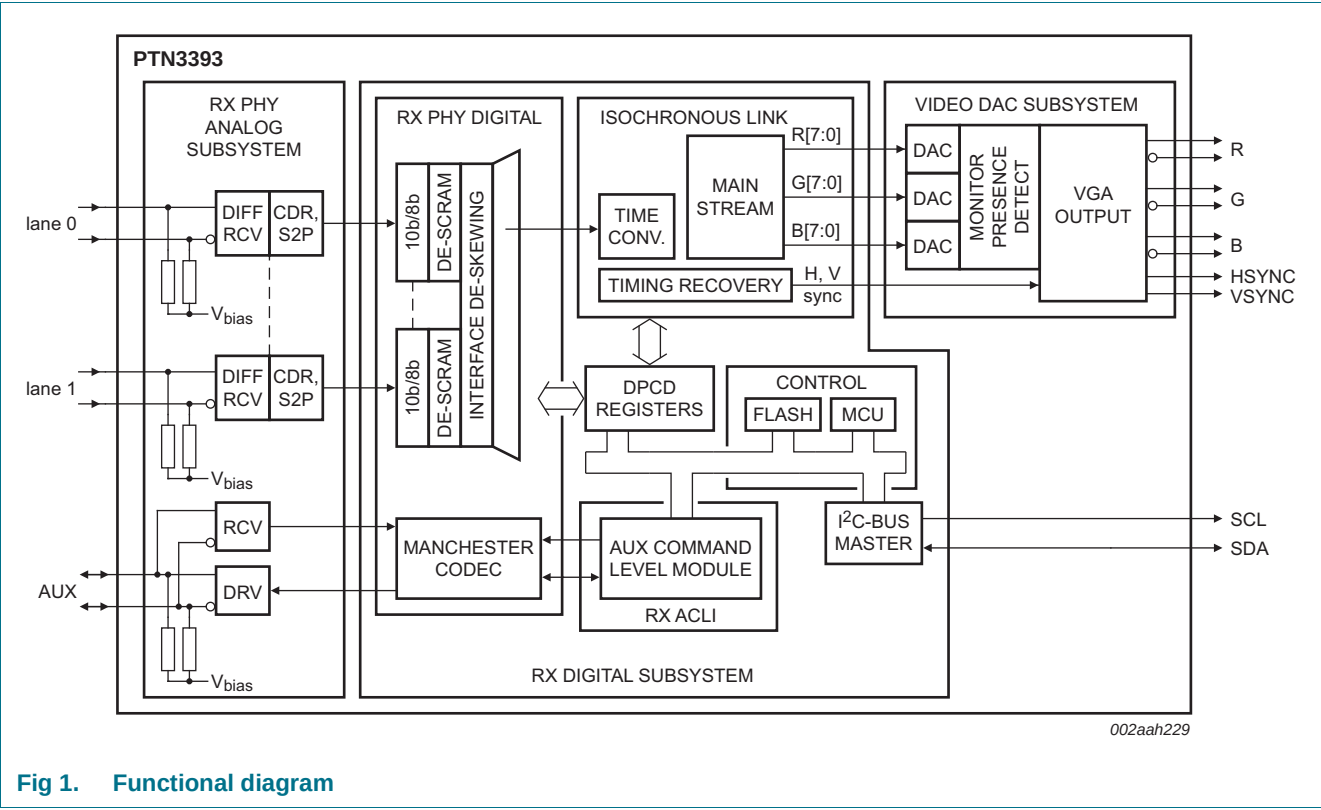


Fig 1. Functional diagram

6. Pinning information

6.1 Pinning

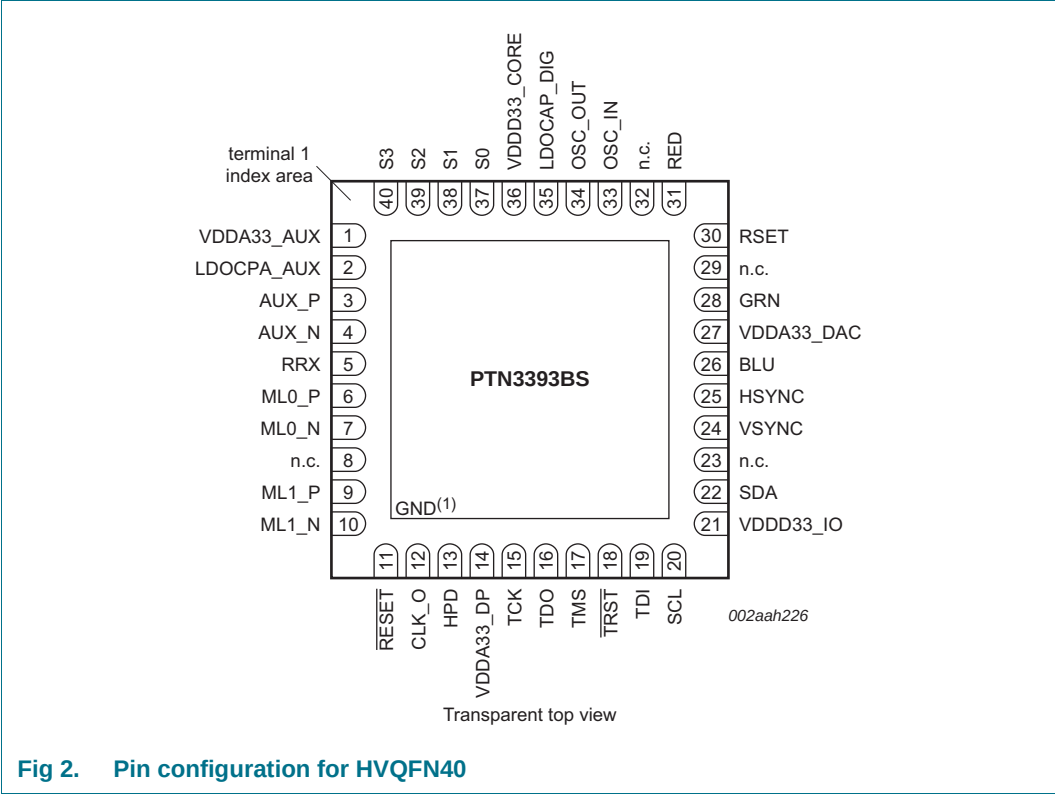


Fig 2. Pin configuration for HVQFN40

## 6.2 Pin description

Table 3. Pin description

| Symbol                   | Pin | Type                                   | Description                                                                                                    |
|--------------------------|-----|----------------------------------------|----------------------------------------------------------------------------------------------------------------|
| <b>Power</b>             |     |                                        |                                                                                                                |
| VDDD33_CORE              | 36  | power                                  | Digital core 3.3 V supply voltage                                                                              |
| VDDA33_AUX               | 1   | power                                  | Analog AUX, bias and PLL 3.3 V supply voltage                                                                  |
| VDDA33_DP                | 14  | power                                  | Analog 3.3 V supply for DisplayPort receiver module                                                            |
| VDDD33_IO                | 21  | power                                  | I/O 3.3 V supply voltage                                                                                       |
| VDDA33_DAC               | 27  | power                                  | Analog 3.3 V supply for DAC                                                                                    |
| LDOCAP_AUX               | 2   | power                                  | 1.8 V AUX supply decoupling                                                                                    |
| LDOCAP_DIG               | 35  | power                                  | 1.8 V digital core supply decoupling                                                                           |
| <b>DisplayPort</b>       |     |                                        |                                                                                                                |
| ML0_P                    | 6   | self-biasing differential input        | DisplayPort main lane signal lane 0, positive                                                                  |
| ML0_N                    | 7   | self-biasing differential input        | DisplayPort main lane signal lane 0, negative                                                                  |
| ML1_P                    | 9   | self-biasing differential input        | DisplayPort main lane signal lane 1, positive                                                                  |
| ML1_N                    | 10  | self-biasing differential input        | DisplayPort main lane signal lane 1, negative                                                                  |
| AUX_P                    | 3   | self-biasing differential input/output | DisplayPort auxiliary channel signal, positive                                                                 |
| AUX_N                    | 4   | self-biasing differential input/output | DisplayPort auxiliary channel signal, negative                                                                 |
| HPD                      | 13  | 3.3 V TTL single-ended output          | Hot Plug Detect                                                                                                |
| <b>RGB DAC outputs</b>   |     |                                        |                                                                                                                |
| BLU                      | 26  | analog output                          | 'blue' current analog output                                                                                   |
| GRN                      | 28  | analog output                          | 'green' current analog output                                                                                  |
| RED                      | 31  | analog output                          | 'red' current analog output                                                                                    |
| RSET                     | 30  | analog input/output                    | DAC full-scale current control resistor. Pull down to ground by an external 1.2 k $\Omega$ $\pm$ 1 % resistor. |
| <b>DDC</b>               |     |                                        |                                                                                                                |
| SCL                      | 20  | single-ended 5 V open-drain DDC I/O    | 5 V sink-side DDC clock I/O. Pulled up by external resistor to 5 V.                                            |
| SDA                      | 22  | single-ended 5 V open-drain DDC I/O    | 5 V sink-side DDC data I/O. Pulled up by external resistor to 5 V.                                             |
| <b>Monitor-side sync</b> |     |                                        |                                                                                                                |
| HSYNC                    | 25  | single-ended 3.3 V TTL output          | horizontal sync signal to monitor                                                                              |
| VSNC                     | 24  | single-ended 3.3 V TTL output          | vertical sync signal to monitor                                                                                |

Table 3. Pin description ...continued

| Symbol               | Pin           | Type   | Description                                                                                                                                                                                                                                                                                                                                                                                                     |
|----------------------|---------------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>JTAG</b>          |               |        |                                                                                                                                                                                                                                                                                                                                                                                                                 |
| TCK                  | 15            | input  | JTAG clock input                                                                                                                                                                                                                                                                                                                                                                                                |
| TDO                  | 16            | output | JTAG data output                                                                                                                                                                                                                                                                                                                                                                                                |
| TMS                  | 17            | input  | JTAG mode select input                                                                                                                                                                                                                                                                                                                                                                                          |
| TRST                 | 18            | input  | JTAG reset (active LOW) input                                                                                                                                                                                                                                                                                                                                                                                   |
| TDI                  | 19            | input  | JTAG data input                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Miscellaneous</b> |               |        |                                                                                                                                                                                                                                                                                                                                                                                                                 |
| S0                   | 37            | input  | Open (internal pull-down) = logic 0<br>Implement VGA-side monitor detect according to <i>VESA DisplayPort Standard v1.1a</i> , sections 7 and 8.<br>HIGH (external pull-up) = logic 1<br>Set HPD HIGH upon VGA monitor detection; set HPD LOW upon VGA monitor detachment.                                                                                                                                      |
| S1                   | 38            | input  | reserved; leave open-circuit (default internal pull-down)                                                                                                                                                                                                                                                                                                                                                       |
| S2                   | 39            | input  | Open (internal pull-down) = logic 0 to set default I <sup>2</sup> C-bus speed to 50 kbit/s.<br>HIGH (external pull-up) = logic 1, to set default I <sup>2</sup> C-bus speed to 10 kbit/s.<br>This pin may be left open-circuit (internal pull-down) or tied to V <sub>DD</sub> according to the desired default I <sup>2</sup> C-bus speed. See more explanation about S2 pin setting and DPCD register 00109h. |
| S3                   | 40            | input  | reserved; leave open-circuit (default internal pull-down)                                                                                                                                                                                                                                                                                                                                                       |
| RESET                | 11            | input  | Hardware reset input (active LOW); internal pull-up. A capacitor must be connected between this pin and ground. A 1 µF capacitor is recommended.                                                                                                                                                                                                                                                                |
| CLK_O                | 12            | output | DisplayPort receiver test clock output                                                                                                                                                                                                                                                                                                                                                                          |
| OSC_IN               | 33            | input  | crystal oscillator input                                                                                                                                                                                                                                                                                                                                                                                        |
| OSC_OUT              | 34            | output | crystal oscillator output                                                                                                                                                                                                                                                                                                                                                                                       |
| RRX                  | 5             | input  | Receiver termination resistance control. A 12 kΩ resistor must be connected between this pin and LDOCAP_AUX (pin 2).                                                                                                                                                                                                                                                                                            |
| n.c.                 | 8, 23, 29, 32 | -      | not connected                                                                                                                                                                                                                                                                                                                                                                                                   |
| GND <sup>[1]</sup>   | -             | power  | central supply ground connection (exposed die pad)                                                                                                                                                                                                                                                                                                                                                              |

- [1] HVQFN40 package die supply ground is connected to exposed center pad. Exposed center pad must be connected to supply ground for proper device operation. For enhanced thermal, electrical, and board level performance, the exposed pad must be soldered to the board using a corresponding thermal pad on the board and for proper heat conduction through the board, thermal vias must be incorporated in the PCB in the thermal pad region.

## 7. Functional description

Referring to [Figure 1 “Functional diagram”](#), the PTN3393 converts the DisplayPort AC-coupled high-speed differential signaling protocol into a VESA VSIS 1.2 compliant analog VGA signaling. The PTN3393 integrates a DisplayPort receiver (according to *VESA DisplayPort v1.1a specification*, [Ref. 1](#)) and a high-speed triple 8-bit video digital-to-analog converter that supports display resolution from VGA to WUXGA (see [Table 5 “Display resolution and pixel clock rate\[1\]”](#)), up to a pixel clock rate of 240 MHz. The PTN3393 supports one or two DisplayPort v1.1a Main Link lanes operating at either in 2.7 Gbit/s or 1.62 Gbit/s per lane. The PTN3393 can drive up to 100 feet of analog video cable.

The DisplayPort receiver comprises the following functional blocks:

- Main Link
- AUX CH (Auxiliary Channel)
- DPCD (DisplayPort Configuration Data)
- Monitor detection
- EDID handling
- Video DAC

The RGB video data with corresponding synchronization references is extracted from the main stream video data. Main stream video attribute information is also extracted. This information is inserted once per video frame during the vertical blanking period by the DisplayPort source. The attributes describe the main video stream format in terms of geometry, timing, and color format. The original clock and video stream are derived from these main link data.

The PTN3393 internal DPCD registers can be accessed by the source via the auxiliary channel. The monitor's DDC control bus may also be controlled via the auxiliary channel. A bridging conversion block translates the input DisplayPort auxiliary channel signals from the source side to the DDC signals on the sink side. The PTN3393 passes through sink-side status change (for example, hot-plug events) to the source side, through HPD interrupts and DPCD registers.

### 7.1 DisplayPort Main Link

The DisplayPort main link consists of doubly terminated, AC-coupled differential pair. The 50  $\Omega$  internally calibrated termination resistors are integrated inside PTN3393.

The PTN3393 supports HBR at 2.7 Gbit/s and RBR at 1.62 Gbit/s per lane.

### 7.2 DisplayPort auxiliary channel

The AUX CH is a half-duplex, bidirectional channel between DisplayPort transmitter and receiver. It consists of one differential pair transporting self-clocked data at 1 Mbit/s. The PTN3393 integrates the AUX CH replier (or slave), and responds to transactions initiated by the DisplayPort source AUX CH requester (or master).

The AUX CH uses the Manchester-II code for the self-clocked transmission of signals; every 'zero' is represented by LOW-to-HIGH transition, and 'one' represented by HIGH-to-LOW transition, in the middle of the bit time.

### 7.3 DPCD registers

DPCD registers that are part of the VESA DisplayPort v1.1a are described in detail in [Ref. 1](#). The following paragraphs only describe the specific implementation by PTN3393.

The PTN3393 DisplayPort receiver capability and status information about the link are reported by DisplayPort Configuration Data (DPCD) registers, when a DisplayPort source issues a read command on the AUX CH. The DisplayPort source device can also write to the link configuration field of DPCD to configure and initialize the link. The DPCD is DisplayPort v1.1a compliant.

It is the responsibility of the host to only issue commands within the capability of the PTN3393 as defined in the 'Receiver Capability Field' in order to prevent undefined behavior. PTN3393 specific DPCD registers are listed in [Table 4](#).



### 7.3.1 PTN3393 specific DPCD register settings

Table 4. PTN3393 specific DPCD registers

| DPCD register <sup>[1]</sup>                 | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Power-on Reset value | Read/write over AUX CH |
|----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|------------------------|
| <b>Receiver Capability Field</b>             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                      |                        |
| 0000Bh                                       | RECEIVE_PORT1_CAP_1. ReceiverPort1 Capability_1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 00h                  | read only              |
| 0000Ch                                       | I <sup>2</sup> C-bus speed control capabilities bit map. The bit values in this register are assigned to I <sup>2</sup> C-bus speeds as follows:<br>Bits 7:0<br>0000 0001b = 1 kbit/s; supported by PTN3393<br>0000 0010b = 3 kbit/s; supported by PTN3393<br>0000 0100b = 10 kbit/s; supported by PTN3393<br>0000 1000b = 100 kbit/s; supported by PTN3393<br>0001 0000b = 400 kbit/s; not supported by PTN3393<br>0010 0000b = 1 Mbit/s; not supported by PTN3393<br>0100 0000b = reserved<br>1000 0000b = 50 kbit/s; supported by PTN3393BS/F3<br>1000 0000b = reserved in PTN3393BS/F1, PTN3393BS/F2 | 8Fh                  | read only              |
| <b>Automated testing subfield (optional)</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                      |                        |
| 00218h to 0027Fh                             | Not supported.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                      |                        |
| <b>Branch device-specific field</b>          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                      |                        |
| 00500h                                       | BRANCH_IEEE_OUI 7:0<br>Branch vendor 24-bit IEEE OUI.<br>NXP OUI = 00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 00h                  | read only              |
| 00501h                                       | BRANCH_IEEE_OUI 15:8<br>NXP OUI = 60                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 60h                  | read only              |
| 00502h                                       | BRANCH_IEEE_OUI 23:16<br>NXP OUI = 37                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 37h                  | read only              |
| 00503h                                       | ID string = 3392N2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 33h                  | read only              |
| 00504h                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 33h                  | read only              |
| 00505h                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 39h                  | read only              |
| 00506h                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 32h                  | read only              |
| 00507h                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 4Eh                  | read only              |
| 00508h                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 32h                  | read only              |
| 00509h                                       | Hardware revision level v1.2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 12h                  | read only              |
| 0050Ah, 0050Bh                               | Major revision level (example: v <b>1.38</b> ),<br>Minor revision level (example: v1. <b>38</b> )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 01h, 26h             | read only              |
| 0050Ch to 005FFh                             | RESERVED                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                      | read only              |

[1] Byte fields that are not explicitly listed are by definition reserved ('RES') and their default value is 0h.

## 7.3.2 I<sup>2</sup>C over AUX CH registers

### 7.3.2.1 I<sup>2</sup>C-bus speed control register (read only, 0000Ch)

Bit or bits are set to indicate I<sup>2</sup>C-bus speed control capabilities.

DisplayPort source reads register 0000Ch and sets the I<sup>2</sup>C-bus speed according to the DPCD register 00109h setting. The PTN3393 then adapts its I<sup>2</sup>C-bus bit rate to the speed set by the DisplayPort source.

### 7.3.2.2 I<sup>2</sup>C-bus speed control/status register (read/write, 00109h)

Bit values in this register are assigned to I<sup>2</sup>C-bus speeds.

Prior to software writing to this register, PTN3393 defaults to the I<sup>2</sup>C-bus speed (either 50 kbit/s or 10 kbit/s) selected by the S2 pin ([Table 3](#)).

On read, the PTN3393 returns a value set to indicate the speed currently in use.

On write, software provides a mask to limit the speeds to be enabled:

- The PTN3393 uses the slowest speed enabled by the mask and the PTN3393 speed capabilities.
- If the result of the mask with the speed capabilities is 0000 0000b, then the PTN3393 keeps the S2 setting I<sup>2</sup>C-bus speed that it is using before the software write (that is, no change).

Some specific examples are listed below for clarification purposes:

- If the source writes 1111 1111b, the PTN3393 uses the lowest speed of 1 kbit/s.
- If the source writes 0000 1100b, the PTN3393 uses the lower of 10 kbit/s and 100 kbit/s, that is, 10 kbit/s.
- If the source writes 0011 0000b, the PTN3393 would stay using the same I<sup>2</sup>C-bus speed that it is using before the software write (that is, no change).

For DDC communication, the PTN3393 generates defer responses to the source while the I<sup>2</sup>C-bus transfer is taking place as specified in the *DisplayPort standard v1.1a*. Note that when the I<sup>2</sup>C-bus bit rate is set to 1 kbit/s, each bit takes 1 ms. One byte including I2C\_ACK takes 9 ms. Given this, the DisplayPort source should expect over 20 I2C\_DEFER's when requesting to read a byte over I<sup>2</sup>C-bus at the slowest rate.

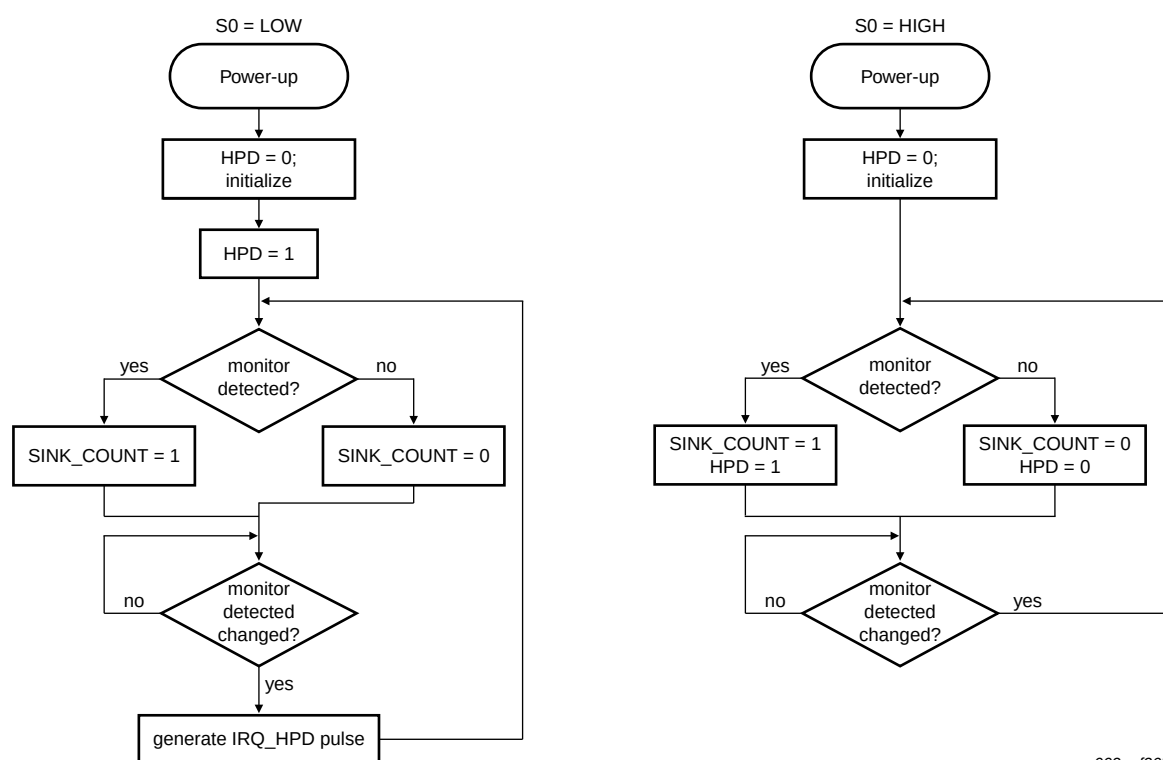
## 7.4 Monitor detection

The PTN3393 assumes 75  $\Omega$  double termination, as shown in [Figure 6](#). The load sensing circuit of the PTN3393 senses a 37.5  $\Omega$  or 75  $\Omega$  termination respectively, when the monitor is connected or disconnected. The load-sensing circuit is active during the vertical blanking period (never during the horizontal retrace period), so that there is no disturbance to the screen image caused by the load-sensing circuit.

Upon detection of an RGB monitor being connected, the PTN3393 dynamically updates DPCD register 00200h and 00204h, to indicate the presence of a sink device being connected (see [Section 7.3](#)). After updating the DPCD register 00200h, the PTN3393 generates an IRQ request on HPD.

The PTN3393 implements two different ways to handle the HPD signal. The HPD behavior is governed by the S0 pin's value after the reset and initialization sequence is completed (see [Figure 3](#)).

- If S0 is tied LOW, HPD is driven HIGH irrespective of whether a VGA monitor is detected.
- If S0 pin is tied HIGH, HPD is only driven HIGH when a monitor is detected.



002aaf365

Fig 3. Pin S0 behavior

### 7.4.1 S0 = logic 0

If S0 is left open-circuit (internal pull-down) (DisplayPort v1.1a compliant behavior), PTN3393 behaves as stated in *VESA DisplayPort v1.1a*, sections 7 and 8. PTN3393 will keep HPD LOW during its internal initialization sequence after power-up. It then updates DPCD register SINK\_COUNT to the expected value, depending if a VGA monitor is detected or not, and then asserts HPD HIGH whatever is the value of SINK\_COUNT register. Each time PTN3393 detects a change in the VGA monitor connection status, it updates the SINK\_COUNT register accordingly, sets DOWNSTREAM\_PORT\_STATUS\_CHANGED register bit to 1 and generates IRQ\_HPDP pulse to signal the source about the status change. Refer to [Figure 3](#), S0 = LOW flowchart.

### 7.4.2 S0 = logic 1

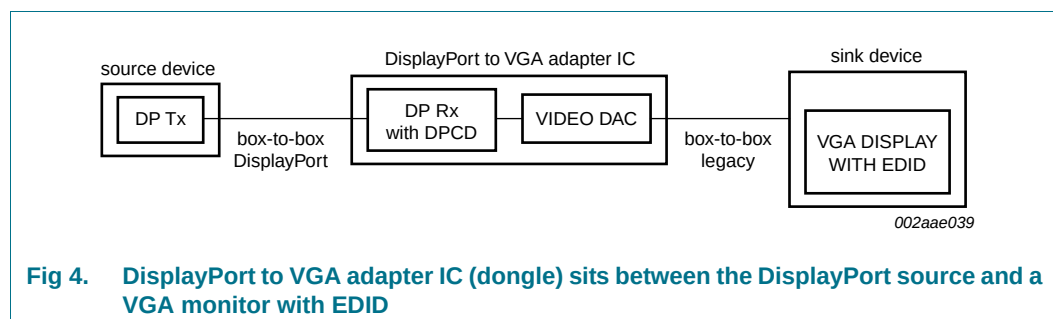
If S1 is tied to HIGH with external pull-up (best interoperability behavior), the PTN3393 will keep HPD LOW during its internal initialization sequence after power-up. It then waits for a VGA monitor to be connected downstream before asserting HPD HIGH to force source waiting for a VGA monitor before starting protocol negotiations. If a VGA monitor is disconnected during normal operations, PTN3393 asserts HPD LOW so that the source considers that no sink device is connected anymore. Refer to [Figure 3](#), S0 = HIGH flowchart.

## 7.5 EDID handling

[Figure 4](#) shows a DisplayPort-to-analog video converter (or dongle) situated between the DisplayPort source and a VGA monitor. The PTN3393 converts a DP I<sup>2</sup>C Over AUX request to I<sup>2</sup>C on the monitor's DDC bus. The monitor's EDID read data is then returned to the DP source via an I<sup>2</sup>C Over AUX response issued by the PTN3393.

It is the responsibility of the source to choose only video modes which are declared in the EDID and to adjust the DisplayPort link capabilities (link rate and lane count) to provide the necessary video bandwidth. The PTN3393 does not cache or modify the EDID to match the capabilities of the DisplayPort link data.

If the DisplayPort source drives display modes that are not specified in the EDID mode list, the PTN3393 does not detect such conditions, and displays at its output what it is presented by the DisplayPort source.



## 7.6 Triple 8-bit video DACs and VGA outputs

The triple 8-bit video DACs output a 700 mV (peak-to-peak) analog video output signal into  $37.5\ \Omega$  load, as is the case of a doubly terminated  $75\ \Omega$  cable. The DAC is capable of supporting the maximum pixel rate supported by a two-lane DP link (240 MHz).

The PTN3393 generates the RGB video timing and synchronization signals, RGB signals are then sent to the DACs for conversion to analog signals.

### 7.6.1 DAC reference resistor

An external reference resistor must be connected between pin RSET and analog ground. This resistor sets the reference current which determines the analog output level, and is specified as  $1.2\ \text{k}\Omega$  with a 1 % tolerance. This value allows a 0.7 V (peak-to-peak) output into a  $37.5\ \Omega$  load, such as a double-terminated  $75\ \Omega$  coaxial cable.

## 8. Power-up and reset

PTN3393 has built-in power-on reset circuitry which automatically sequences the part through reset and initialization.

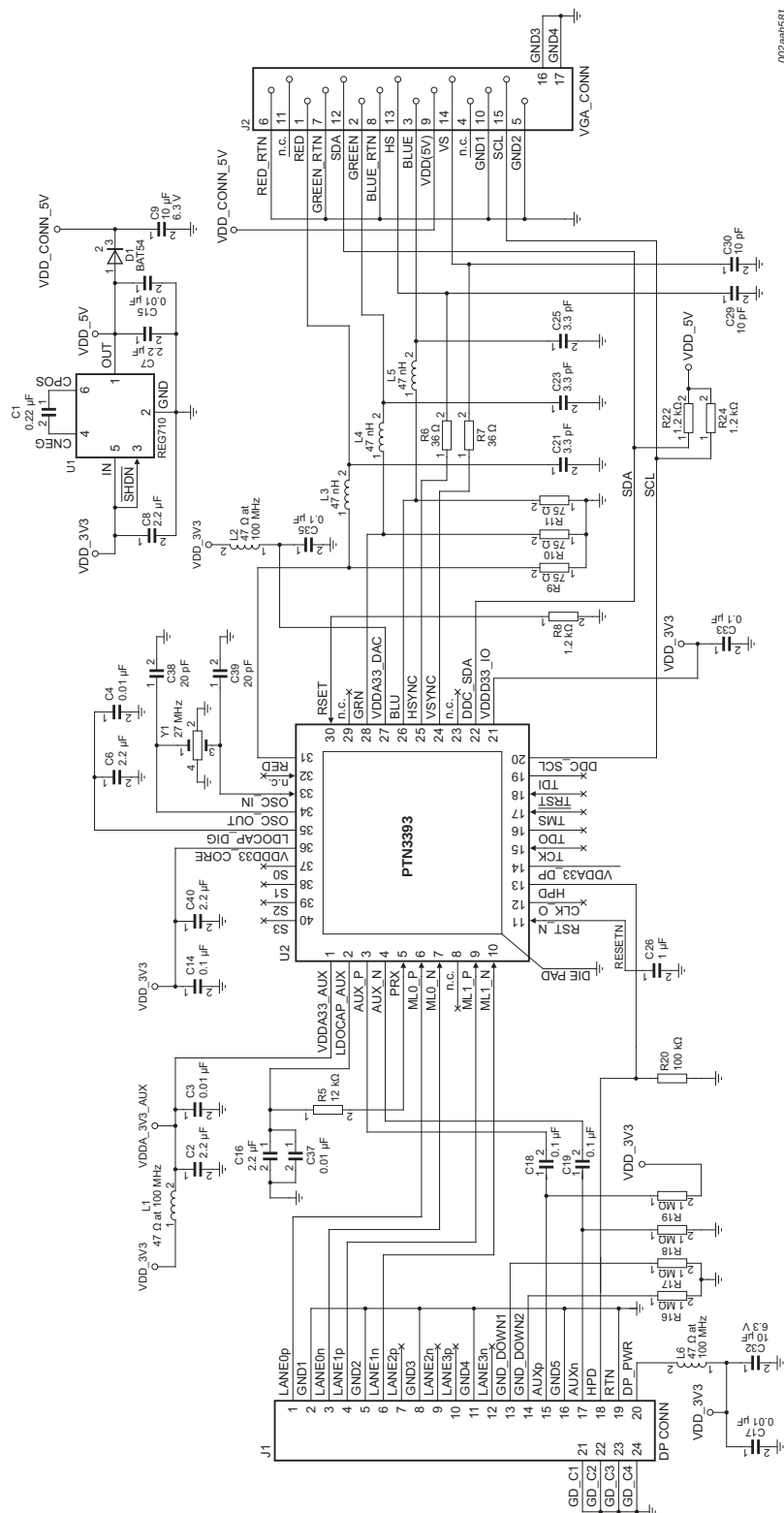
For proper behavior, a capacitor should be connected from the RESET\_N pin to ground to slow down the internal reset pulse;  $1\ \mu\text{F}$  capacitance is recommended.

Before link is established, the PTN3393 holds VSYNC and HSYNC signals LOW and blanks the RGB signals.

While the PTN3393 performs initialization,

- The HPD signal is driven LOW, to indicate to the DisplayPort source that the PTN3393 is not ready for link communication
- The RED, GRN, BLU and complementary outputs (RED\_N, GRN\_N, BLU\_N) are disabled
- The VSYNC and HSYNC outputs are driven LOW

## 9. Application design-in information



**Fig 5. Application diagram**

## 9.1 Display resolution

[Table 5](#) lists some example display resolutions and clock rates that PTN3393 supports. (Refer to [Footnote 1 on page 2.](#))

**Table 5.** Display resolution and pixel clock rate<sup>[1]</sup>

| Display type | Active video |          | Total frame              |                       | Bits per pixel | Vertical frequency (Hz) | Pixel clock (MHz) | Data rate (Gbit/s) | Standard type     |
|--------------|--------------|----------|--------------------------|-----------------------|----------------|-------------------------|-------------------|--------------------|-------------------|
|              | Horizontal   | Vertical | Horizontal total (pixel) | Vertical total (line) |                |                         |                   |                    |                   |
| VGA          | 640          | 480      | 800                      | 525                   | 24             | 59.94                   | 25.175            | 0.76               | Industry standard |
| SVGA         | 800          | 600      | 1056                     | 628                   | 24             | 60.317                  | 40.000            | 1.20               | VESA guidelines   |
| XGA          | 1024         | 768      | 1344                     | 806                   | 24             | 60.004                  | 65.000            | 1.95               | VESA guidelines   |
| XGA+         | 1152         | 864      | 1600                     | 900                   | 24             | 75                      | 108.000           | 3.24               | VESA standard     |
| HD           | 1360         | 768      | 1792                     | 795                   | 24             | 60.015                  | 85.500            | 2.56               | VESA standard     |
| HD/WXGA      | 1366         | 768      | 1792                     | 798                   | 24             | 59.79                   | 85.501            | 2.57               | VESA standard     |
| HD/WXGA      | 1280         | 720      | 1650                     | 750                   | 24             | 60                      | 74.250            | 2.23               | CEA standard      |
| WXGA         | 1280         | 800      | 1680                     | 831                   | 24             | 59.81                   | 83.500            | 2.50               | CVT               |
| WXGA         | 1280         | 800      | 1696                     | 838                   | 24             | 74.934                  | 106.500           | 3.19               | CVT               |
| WXGA         | 1280         | 800      | 1712                     | 843                   | 24             | 84.88                   | 122.500           | 3.68               | CVT               |
| SXGA–        | 1280         | 960      | 1800                     | 1000                  | 24             | 60                      | 108.000           | 3.24               | VESA standard     |
| SXGA         | 1280         | 1024     | 1688                     | 1066                  | 24             | 60.02                   | 108.000           | 3.24               | VESA standard     |
| SXGA         | 1280         | 1024     | 1688                     | 1066                  | 24             | 75.025                  | 135.001           | 4.05               | VESA standard     |
| SXGA         | 1280         | 1024     | 1728                     | 1072                  | 24             | 85.024                  | 157.500           | 4.72               | VESA standard     |
| SXGA+        | 1400         | 1050     | 1864                     | 1089                  | 24             | 59.978                  | 121.749           | 3.65               | CVT               |
| WXGA+        | 1440         | 900      | 1904                     | 934                   | 24             | 59.887                  | 106.499           | 3.19               | CVT               |
| HD+          | 1600         | 900      | 1800                     | 1000                  | 24             | 60                      | 108.000           | 3.24               | VESA standard     |
| UXGA         | 1600         | 1200     | 2160                     | 1250                  | 24             | 60                      | 162.000           | 4.86               | VESA standard     |
| UXGA         | 1600         | 1200     | 2160                     | 1250                  | 24             | 65                      | 175.500           | 5.27               | VESA standard     |
| WSXGA+       | 1680         | 1050     | 2240                     | 1089                  | 24             | 59.954                  | 146.249           | 4.39               | CVT               |
| FHD          | 1920         | 1080     | 2200                     | 1125                  | 24             | 60                      | 148.500           | 4.46               | CEA standard      |
| WUXGA        | 1920         | 1200     | 2592                     | 1245                  | 18             | 59.885                  | 193.251           | 4.35               | CVT               |
| WUXGA        | 1920         | 1200     | 2080                     | 1235                  | 24             | 59.95                   | 154.000           | 4.62               | CVT RB            |
|              | 1920         | 1440     | 2600                     | 1500                  | 18             | 60                      | 234.000           | 5.27               | CVT RB            |
| QWXGA        | 2048         | 1152     | 2250                     | 1200                  | 24             | 60                      | 162.000           | 4.86               | VESA standard     |
| QXGA         | 2048         | 1536     | 2144                     | 1555                  | 24             | 49.266                  | 164.249           | 4.93               | CVT               |

[1] Contact NXP team for other monitor timings not listed in this table.

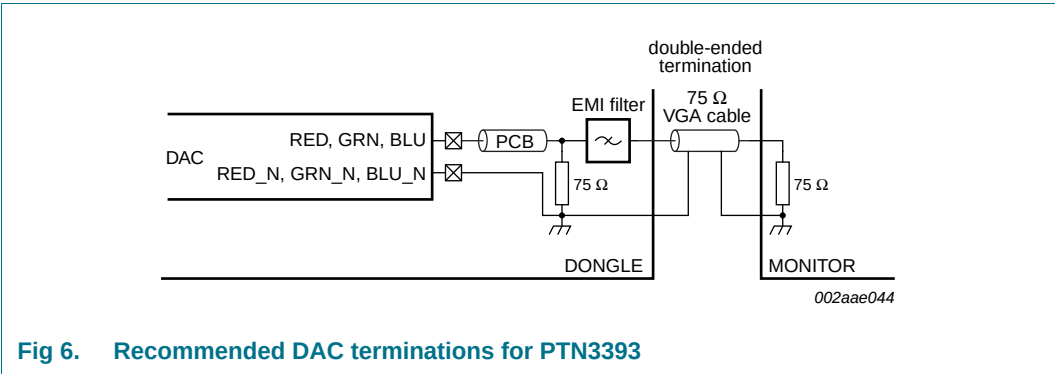
The available bandwidth over a 2-lane HBR DisplayPort v1.1a link limits pixel clock rate support to:

- 240 MHz at 6 bpc
- 180 MHz at 8 bpc

9.2 Power supply filter

All supply pins can be tied to a single 3.3 V power source. Sufficient decoupling capacitance to ground should be connected from each  $V_{DD}$  pin directly to ground to filter supply noise. (Refer to [Figure 5 “Application diagram”](#).)

9.3 DAC terminations



We recommend the DAC outputs to use 75  $\Omega$  double termination. [Figure 6](#) shows an example of VGA dongle application. A 75  $\Omega$  termination is used to terminate inside the dongle, and another 75  $\Omega$  termination is typically used inside the RGB monitor. The load sensing mechanism assumes this double termination.

10. Limiting values

Table 6. Limiting values  
In accordance with the Absolute Maximum Rating System (IEC 60134).

| Symbol    | Parameter                       | Conditions        | Min  | Max            | Unit |
|-----------|---------------------------------|-------------------|------|----------------|------|
| $V_{DDA}$ | analog supply voltage           |                   | −0.3 | +3.8           | V    |
| $V_{DDD}$ | digital supply voltage          |                   | −0.3 | +4.6           | V    |
| $V_I$     | input voltage                   | 3.3 V CMOS inputs | −0.3 | $V_{DD} + 0.5$ | V    |
| $T_{stg}$ | storage temperature             |                   | −65  | +150           | °C   |
| $V_{ESD}$ | electrostatic discharge voltage | HBM               | [1]  | 7000           | V    |
|           |                                 | CDM               | [2]  | 1000           | V    |

- [1] Human Body Model: ANSI/ESDA/JEDEC JDS-001-2012 (Revision of ANSI/ESDA/JEDEC JS-001-2011), ESDA/JEDEC Joint standard for ESD sensitivity testing, Human Body Model - Component level; Electrostatic Discharge Association, Rome, NY, USA; JEDEC Solid State Technology Association, Arlington, VA, USA.
- [2] Charged Device Model: JESD22-C101E December 2009 (Revision of JESD22-C101D, October 2008), standard for ESD sensitivity testing, Charged Device Model - Component level; JEDEC Solid State Technology Association, Arlington, VA, USA.



## 11. Recommended operating conditions

**Table 7. Operating conditions**

| Symbol                 | Parameter                       | Conditions                                                                                              | Min | Typ       | Max | Unit |
|------------------------|---------------------------------|---------------------------------------------------------------------------------------------------------|-----|-----------|-----|------|
| V <sub>DDA</sub>       | analog supply voltage           |                                                                                                         | 3.0 | 3.3       | 3.6 | V    |
| V <sub>DDD</sub>       | digital supply voltage          |                                                                                                         | 3.0 | 3.3       | 3.6 | V    |
| V <sub>I</sub>         | input voltage                   | 3.3 V CMOS inputs                                                                                       | 0   | 3.3       | 3.6 | V    |
|                        |                                 | SDA and SCL inputs with respect to ground                                                               | 0   | 5         | 5.5 | V    |
| V <sub>I(AV)</sub>     | average input voltage           | DC value at<br>ML_LANE0+, ML_LANE0-,<br>ML_LANE1+, ML_LANE1-,<br>AUX_CH+, AUX_CH- inputs <sup>[1]</sup> | -   | 0         | -   | V    |
| R <sub>ext(RSET)</sub> | external resistance on pin RSET | between RSET (pin 22) and GND                                                                           | -   | 1.2 ± 1 % | -   | kΩ   |
| T <sub>amb</sub>       | ambient temperature             | commercial grade                                                                                        | 0   | -         | 85  | °C   |

[1] Input signals to these pins must be AC-coupled.

## 12. Characteristics

### 12.1 Current consumption, power dissipation and thermal characteristics

**Table 8. Current consumption, power dissipation and thermal characteristics**

| Symbol               | Parameter                                   | Conditions                                            | Min | Typ | Max | Unit |
|----------------------|---------------------------------------------|-------------------------------------------------------|-----|-----|-----|------|
| I <sub>DD</sub>      | supply current                              | normal operation,<br>UXGA / 162 MHz pixel clock       | -   | 180 | -   | mA   |
| I <sub>DD(stb)</sub> | standby supply current                      | Standby mode                                          | -   | 12  | -   | mA   |
| P                    | power dissipation                           | normal operation,<br>UXGA / 162 MHz pixel clock       | -   | 600 | -   | mW   |
| R <sub>th(j-a)</sub> | thermal resistance from junction to ambient | in free air for SOT619-1                              | -   | 35  | -   | K/W  |
| R <sub>PU</sub>      | pull-up resistance                          | RESET_N pin; 0 V ≤ V <sub>I</sub> ≤ V <sub>DD</sub>   | 44  | 66  | 95  | kΩ   |
| R <sub>pd</sub>      | pull-down resistance                        | S0 to S3 pins; 0 V ≤ V <sub>I</sub> ≤ V <sub>DD</sub> | 44  | 66  | 95  | kΩ   |

## 12.2 DisplayPort receiver main link

**Table 9.** DisplayPort receiver main link characteristics

| Symbol                           | Parameter                                                              | Conditions                                                           | Min  | Typ | Max   | Unit |
|----------------------------------|------------------------------------------------------------------------|----------------------------------------------------------------------|------|-----|-------|------|
| UI                               | unit interval                                                          | for high bit rate (2.7 Gbit/s per lane) <a href="#">[1]</a>          | -    | 370 | -     | ps   |
|                                  |                                                                        | for low bit rate (1.62 Gbit/s per lane) <a href="#">[1]</a>          | -    | 617 | -     | ps   |
| $\Delta f_{\text{DOWN\_SPREAD}}$ | link clock down spreading                                              | <a href="#">[2]</a>                                                  | 0.0  | -   | 0.5   | %    |
| $V_{\text{RX\_DIFFp-p}}$         | differential input peak-to-peak voltage                                | at RX package pins                                                   |      |     |       |      |
|                                  |                                                                        | for high bit rate <a href="#">[3]</a>                                | 120  | -   | -     | mV   |
|                                  |                                                                        | for reduced bit rate <a href="#">[3]</a>                             | 40   | -   | -     | mV   |
| $t_{\text{RX\_EYE\_CONN}}$       | receiver eye time at RX-side connector pins                            | for high bit rate <a href="#">[4]</a>                                | 0.51 | -   | -     | UI   |
|                                  |                                                                        | for reduced bit rate <a href="#">[4][5]</a>                          | 0.25 | -   | -     | UI   |
| $t_{\text{RX\_EYE\_CHIP}}$       | receiver eye time at RX package pins                                   | for high bit rate <a href="#">[4]</a>                                | 0.47 | -   | -     | UI   |
|                                  |                                                                        | for reduced bit rate <a href="#">[4][5]</a>                          | 0.22 | -   | -     | UI   |
| $t_{\text{RX\_EYE\_m-mJT\_CHP}}$ | time between jitter median and maximum median deviation (package pins) | for high bit rate <a href="#">[4]</a>                                | -    | -   | 0.265 | UI   |
|                                  |                                                                        | for reduced bit rate <a href="#">[4][5]</a>                          | -    | -   | 0.39  | UI   |
| $V_{\text{RX\_DC\_CM}}$          | RX DC common mode voltage                                              | <a href="#">[6]</a>                                                  | 0    | -   | 2.0   | V    |
| $I_{\text{RX\_SHORT}}$           | RX short-circuit current limit                                         | <a href="#">[7]</a>                                                  | -    | -   | 50    | mA   |
| $t_{\text{sk(dif)}}$             | differential skew time                                                 | inter-pair; lane-to-lane skew at RX package pins <a href="#">[8]</a> | -    | -   | 5200  | ps   |
|                                  |                                                                        | lane intra-pair skew at RX package pins;                             |      |     |       |      |
|                                  |                                                                        | for high bit rate <a href="#">[9]</a>                                | -    | -   | 100   | ps   |
|                                  |                                                                        | for reduced bit rate <a href="#">[9]</a>                             | -    | -   | 300   | ps   |
| $f_{\text{RX\_TRACKING\_BW}}$    | jitter tracking bandwidth                                              | <a href="#">[10]</a>                                                 | 20   | -   | -     | MHz  |

[1] Range is nominal  $\pm 350$  ppm. DisplayPort link RX does not require local crystal for link clock generation.

[2] Up to 0.5 % down spread is supported. Modulation frequency range of 30 kHz to 33 kHz must be supported.

[3] Informative; refer to [Figure 7](#) for definition of differential voltage.

[4]  $t_{\text{RX\_EYE\_m-mJT\_CHP}}$  specifies the total allowable Deterministic Jitter (DJ).

[5]  $1 - t_{\text{RX\_EYE\_CONN}}$  specifies the allowable Total Jitter (TJ).

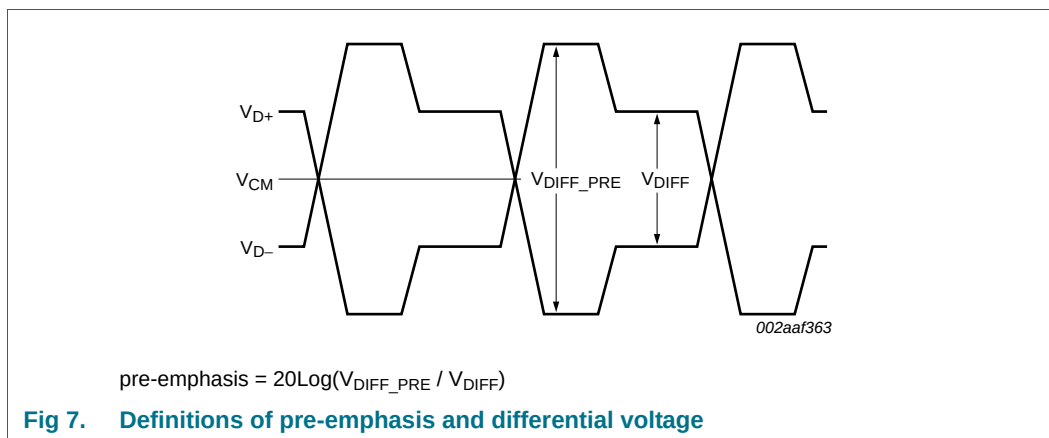
[6] Common mode voltage is equal to  $V_{\text{bias\_RX}}$  voltage.

[7] Total drive current of the input bias circuit when it is shorted to its ground.

[8] Maximum skew limit between different RX lanes of a DisplayPort link.

[9] Maximum skew limit between D+ and D- of the same lane.

[10] Minimum CDR tracking bandwidth at the receiver when the input is repetition of D10.2 symbols without scrambling.



## 12.3 DisplayPort receiver AUX CH

**Table 10. DisplayPort receiver AUX CH characteristics**

| Symbol                        | Parameter                             | Conditions              | Min  | Typ | Max  | Unit |
|-------------------------------|---------------------------------------|-------------------------|------|-----|------|------|
| UI                            | unit interval                         | AUX [1]                 | 0.4  | 0.5 | 0.6  | μs   |
| N <sub>PRECHARGE_PULSES</sub> | number of precharge pulses            | [2]                     | 10   | -   | 16   |      |
| t <sub>AUX_BUS_PARK</sub>     | AUX CH bus park time                  | [3]                     | 10   | -   | -    | ns   |
| t <sub>jitter(cc)</sub>       | cycle-to-cycle jitter time            | transmitting device [4] | -    | -   | 0.04 | UI   |
|                               |                                       | receiving device [5]    | -    | -   | 0.05 | UI   |
| V <sub>AUX_DIFFp-p</sub>      | AUX differential peak-to-peak voltage | transmitting device [6] | 0.39 | -   | 1.38 | V    |
|                               |                                       | receiving device [6]    | 0.32 | -   | 1.36 | V    |
| R <sub>AUX_TERM(DC)</sub>     | AUX CH termination DC resistance      | informative             | -    | 100 | -    | Ω    |
| V <sub>AUX_DC_CM</sub>        | AUX DC common-mode voltage            | [7]                     | 0    | -   | 2.0  | V    |
| V <sub>AUX_TURN_CM</sub>      | AUX turnaround common-mode voltage    | [8]                     | -    | -   | 0.4  | V    |
| I <sub>AUX_SHORT</sub>        | AUX short-circuit current limit       | [9]                     | -    | -   | 90   | mA   |
| C <sub>AUX</sub>              | AUX AC coupling capacitor             | [10]                    | 75   | -   | 200  | nF   |

[1] Results in the bit rate of 1 Mbit/s including the overhead of Manchester II coding.

[2] Each pulse is a '0' in Manchester II code.

[3] Period after the AUX CH STOP condition for which the bus is parked.

[4] Maximum allowable UI variation within a single transaction at connector pins of a transmitting device. Equal to 24 ns maximum. The transmitting device is a source device for a request transaction and a sink device for a reply transaction.

[5] Maximum allowable UI variation within a single transaction at connector pins of a receiving device. Equal to 30 ns maximum. The transmitting device is a source device for a request transaction and a sink device for a reply transaction.

[6]  $V_{\text{AUX\_DIFFp-p}} = 2 \times |V_{\text{AUX+}} - V_{\text{AUX-}}|$ .

[7] Common-mode voltage is equal to V<sub>bias\_TX</sub> (or V<sub>bias\_RX</sub>) voltage.

[8] Steady-state common-mode voltage shift between transmit and receive modes of operation.

[9] Total drive current of the transmitter when it is shorted to its ground.

[10] The AUX CH AC coupling capacitor placed both on the DisplayPort source and sink devices.

## 12.4 HPD characteristics

**Table 11. HPD characteristics**

| Symbol                        | Parameter                               | Conditions                               | Min | Typ | Max | Unit |
|-------------------------------|-----------------------------------------|------------------------------------------|-----|-----|-----|------|
| <b>Output characteristics</b> |                                         |                                          |     |     |     |      |
| $V_{OH}$                      | HIGH-level output voltage               | $I_{OH} = 2\text{ mA}$                   | 2   | -   | -   | V    |
| $V_{OL}$                      | LOW-level output voltage                | $I_{OL} = -2\text{ mA}$                  | -   | -   | 0.8 | V    |
| $I_{OSH}$                     | HIGH-level short-circuit output current | drive HIGH;<br>cell connected to ground  | -   | -   | 129 | mA   |
| $I_{OSL}$                     | LOW-level short-circuit output current  | drive LOW;<br>cell connected to $V_{DD}$ | -   | -   | 126 | mA   |

## 12.5 DDC characteristics

**Table 12. DDC characteristics**

$V_{CC} = 4.5\text{ V to }5.5\text{ V}$  [1]

| Symbol                        | Parameter                    | Conditions                                              | Min                 | Typ | Max     | Unit          |
|-------------------------------|------------------------------|---------------------------------------------------------|---------------------|-----|---------|---------------|
| <b>Input characteristics</b>  |                              |                                                         |                     |     |         |               |
| $V_{IH}$                      | HIGH-level input voltage     |                                                         | 2                   | -   | 5.5     | V             |
| $V_{IL}$                      | LOW-level input voltage      |                                                         | -0.5                | -   | +0.8    | V             |
| $V_{I(hys)}$                  | hysteresis of input voltage  |                                                         | $0.1 \times V_{DD}$ | -   | -       | V             |
| $I_{LI}$                      | input leakage current        | $V_I = 5.5\text{ V}$                                    | -                   | -   | $\pm 1$ | $\mu\text{A}$ |
| <b>Output characteristics</b> |                              |                                                         |                     |     |         |               |
| $I_{OL}$                      | LOW-level output current     | $V_{OL} = 0.4\text{ V}$                                 | 3.0                 | -   | -       | mA            |
| $I_{O(sc)}$                   | short-circuit output current | drive LOW;<br>cell connected to $V_{DD}$                | -                   | -   | 40.0    | mA            |
| $C_{io}$                      | input/output capacitance     | $V_I = 3\text{ V or }0\text{ V}; V_{DD} = 3.3\text{ V}$ | -                   | 6   | 7       | pF            |
|                               |                              | $V_I = 3\text{ V or }0\text{ V}; V_{DD} = 0\text{ V}$   | -                   | 6   | 7       | pF            |

[1]  $V_{CC}$  is the pull-up voltage for DDC.

## 12.6 DAC

**Table 13. DAC characteristics**

| Symbol              | Parameter                    | Conditions          | Min | Typ       | Max  | Unit |
|---------------------|------------------------------|---------------------|-----|-----------|------|------|
| $N_{res(DAC)}$      | DAC resolution               |                     | -   | -         | 8    | bit  |
| $f_{clk}$           | clock frequency              |                     | -   | -         | 240  | MHz  |
| $\Delta I_{O(DAC)}$ | DAC output current variation | DAC-to-DAC          | -   | -         | 4    | %    |
| INL                 | integral non-linearity       |                     | -1  | $\pm 0.5$ | +1   | LSB  |
| DNL                 | differential non-linearity   |                     | -1  | -         | +1   | LSB  |
| $V_{O(DAC)}$        | DAC output voltage           |                     | 0   | -         | 1.25 | V    |
| $C_{O(DAC)}$        | DAC output capacitance       |                     | -   | 3.5       | -    | pF   |
| $\alpha_{ct(DAC)}$  | DAC crosstalk                | between DAC outputs | -   | -54       | -    | dB   |

## 12.7 HSYNC, VSYNC characteristics

Table 14. HSYNC and VSYNC characteristics

| Symbol                        | Parameter                               | Conditions                                                       | Min | Typ | Max   | Unit |
|-------------------------------|-----------------------------------------|------------------------------------------------------------------|-----|-----|-------|------|
| <b>Output characteristics</b> |                                         |                                                                  |     |     |       |      |
| V <sub>OH</sub>               | HIGH-level output voltage               | I <sub>OH</sub> = 8 mA                                           | 2   | -   | -     | V    |
| V <sub>OL</sub>               | LOW-level output voltage                | I <sub>OL</sub> = -8 mA                                          | -   | -   | 0.8   | V    |
| I <sub>OSH</sub>              | HIGH-level short-circuit output current | drive HIGH; cell connected to ground <a href="#">[1]</a>         | -   | -   | 129.0 | mA   |
| I <sub>OSL</sub>              | LOW-level short-circuit output current  | drive LOW; cell connected to V <sub>DD</sub> <a href="#">[1]</a> | -   | -   | 126.0 | mA   |

[1] The parameter values specified are simulated and absolute values.

## 12.8 Strap pins S[3:0]

Table 15. Strap pins S[3:0] characteristics

| Symbol                                | Parameter                | Conditions                       | Min                   | Typ  | Max                   | Unit |
|---------------------------------------|--------------------------|----------------------------------|-----------------------|------|-----------------------|------|
| <b>Input characteristics</b>          |                          |                                  |                       |      |                       |      |
| V <sub>IH</sub>                       | HIGH-level input voltage |                                  | 0.7 × V <sub>DD</sub> | -    | -                     | V    |
| V <sub>IL</sub>                       | LOW-level input voltage  |                                  |                       |      | 0.3 × V <sub>DD</sub> | V    |
| <b>Weak pull-down characteristics</b> |                          |                                  |                       |      |                       |      |
| I <sub>pd</sub>                       | pull-down current        | V <sub>I</sub> = V <sub>DD</sub> | 25.0                  | 50.0 | 95.0                  | μA   |

## 12.9 JTAG and RESET\_N

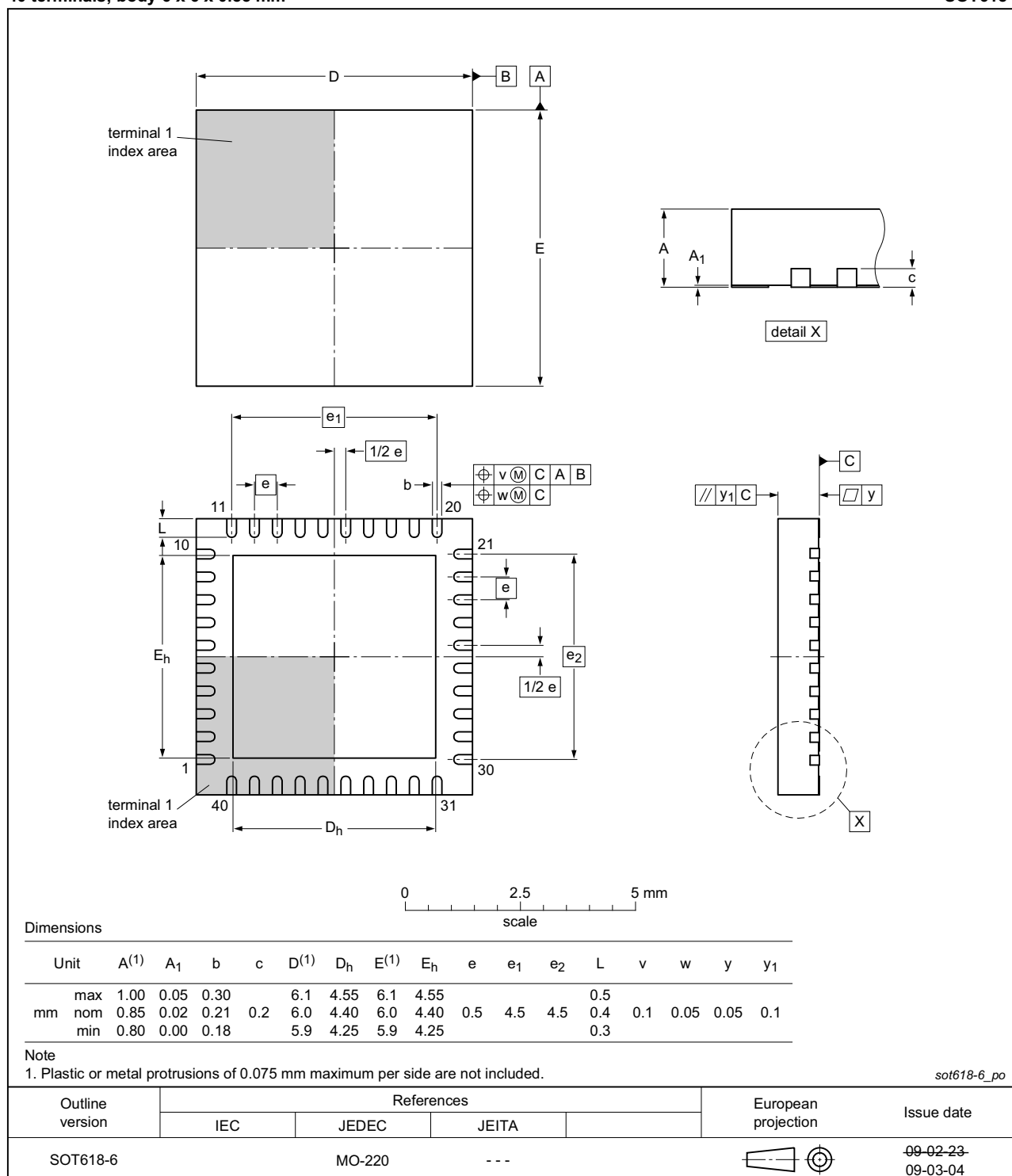
Table 16. JTAG and RESET\_N characteristics

| Symbol                        | Parameter                 | Conditions                       | Min                   | Typ | Max                   | Unit |
|-------------------------------|---------------------------|----------------------------------|-----------------------|-----|-----------------------|------|
| <b>Input characteristics</b>  |                           |                                  |                       |     |                       |      |
| V <sub>IH</sub>               | HIGH-level input voltage  |                                  | 0.7 × V <sub>DD</sub> | -   | -                     | V    |
| V <sub>IL</sub>               | LOW-level input voltage   |                                  |                       |     | 0.3 × V <sub>DD</sub> | V    |
| <b>Output characteristics</b> |                           |                                  |                       |     |                       |      |
| V <sub>OH</sub>               | HIGH-level output voltage | RESET_N; I <sub>OH</sub> = 4 mA  | 2                     | -   | -                     | V    |
|                               |                           | JTAG; I <sub>OH</sub> = 2 mA     | 2                     | -   | -                     | V    |
| V <sub>OL</sub>               | LOW-level output voltage  | RESET_N; I <sub>OL</sub> = -4 mA | -                     | -   | 0.8                   | V    |
|                               |                           | JTAG; I <sub>OL</sub> = -2 mA    | -                     | -   | 0.8                   | V    |

## 13. Package outline

**HVQFN40:** plastic thermal enhanced very thin quad flat package; no leads; 40 terminals; body 6 x 6 x 0.85 mm

**SOT618-6**



**Fig 8. Package outline SOT618-6 (HVQFN40)**

## 14. 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*”.

### 14.1 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.

### 14.2 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

### 14.3 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

## 14.4 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 9](#)) 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 17](#) and [18](#)

**Table 17. 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   |

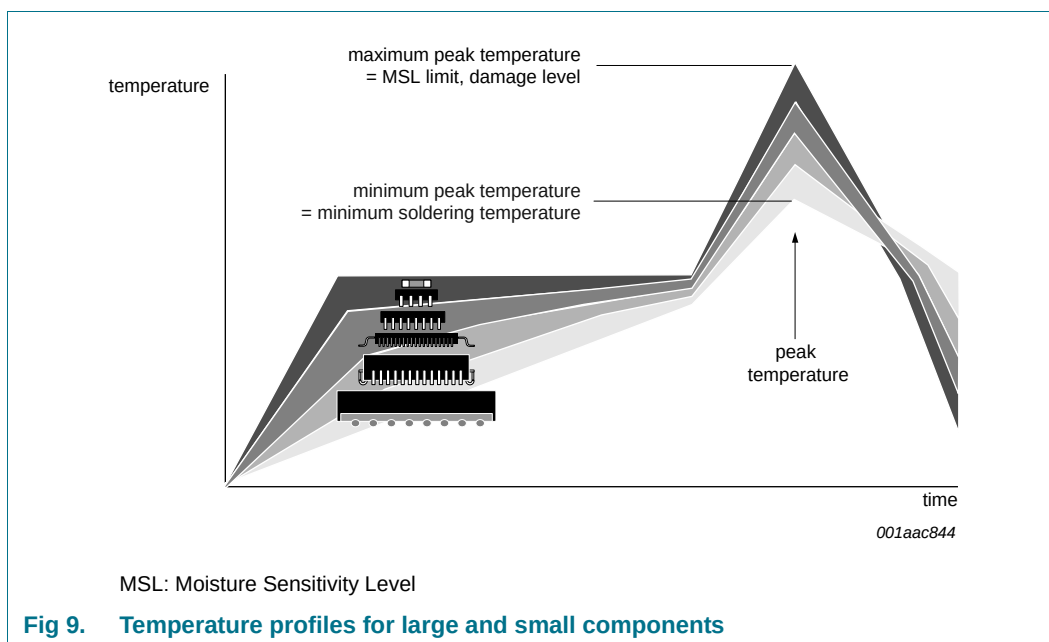
**Table 18. Lead-free process (from J-STD-020D)**

| 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 9](#).





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

## 15. Abbreviations

**Table 19. Abbreviations**

| Acronym | Description                               |
|---------|-------------------------------------------|
| AUX CH  | Auxiliary Channel                         |
| BER     | Bit Error Rate                            |
| bpc     | bits per color                            |
| CDM     | Charged-Device Model                      |
| CMOS    | Complementary Metal-Oxide Semiconductor   |
| CVT     | Coordinated Video Timings                 |
| CVT RB  | CVT Reduced Blanking                      |
| DAC     | Digital-to-Analog Converter               |
| DDC     | Data Display Channel                      |
| DJ      | Deterministic Jitter                      |
| DP      | DisplayPort (VESA)                        |
| DPCD    | DisplayPort Configuration Data            |
| ECC     | Error Correction Code                     |
| EDID    | Extended Display Identification Data      |
| ESD     | ElectroStatic Discharge                   |
| HBM     | Human Body Model                          |
| HBR     | High Bit Rate                             |
| HDCP    | High-bandwidth Digital Content Protection |
| HPD     | Hot Plug Detect                           |

Table 19. Abbreviations ...continued

| Acronym              | Description                               |
|----------------------|-------------------------------------------|
| I <sup>2</sup> C-bus | Inter-Integrated Circuit bus              |
| IEC                  | International Electrotechnical Commission |
| I/O                  | Input/Output                              |
| LSB                  | Least Significant Bit                     |
| MCCS                 | Monitor Control Command Set (VESA)        |
| MSB                  | Most Significant Bit                      |
| QXGA                 | Quad eXtended Graphics Array              |
| RBR                  | Reduced Bit Rate                          |
| RGB                  | Red/Green/Blue                            |
| SSC                  | Spread Spectrum Clocking                  |
| SVGA                 | Super Video Graphics Array                |
| SXGA                 | Super eXtended Graphics Array             |
| TJ                   | Total Jitter                              |
| UI                   | Unit Interval                             |
| UXGA                 | Ultra eXtended Graphics Array             |
| VESA                 | Video Electronics Standards Association   |
| VGA                  | Video Graphics Array                      |
| VSIS                 | Video Signal Interface Standard           |
| WUXGA                | Wide Ultra eXtended Graphics Array        |
| XGA                  | eXtended Graphics Array                   |

## 16. References

- [1] **VESA DisplayPort Standard** — Version 1, Revision 1a; January 11, 2008
- [2] **Display Data Channel Command Interface Standard** — Version 1.1; October 29, 2004
- [3] **Video Signal Standard (VSIS)** — Version 1, Rev. 2; December 12, 2002

## 17. Revision history

Table 20. Revision history

| Document ID    | Release date                                                                                                                                                                                                                                                                                                                                                                                              | Data sheet status  | Change notice | Supersedes  |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|---------------|-------------|
| PTN3393 v.4    | 20140610                                                                                                                                                                                                                                                                                                                                                                                                  | Product data sheet | -             | PTN3393 v.3 |
| Modifications: | <ul style="list-style-type: none"> <li>• <a href="#">Table 5 “Display resolution and pixel clock rate<sup>[1]</sup>”</a> updated</li> <li>• <a href="#">Table 6 “Limiting values”</a>: <ul style="list-style-type: none"> <li>– <a href="#">Table note [1]</a> updated to new ESD testing standards</li> <li>– <a href="#">Table note [2]</a> updated to new ESD testing standards</li> </ul> </li> </ul> |                    |               |             |
| PTN3393 v.3    | 20130808                                                                                                                                                                                                                                                                                                                                                                                                  | Product data sheet | -             | PTN3393 v.2 |
| PTN3393 v.2    | 20130422                                                                                                                                                                                                                                                                                                                                                                                                  | Product data sheet | -             | PTN3393 v.1 |
| PTN3393 v.1    | 20130404                                                                                                                                                                                                                                                                                                                                                                                                  | Product data sheet | -             | -           |

## 18. Legal information

### 18.1 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".

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

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