

DisplayPort 1:1 Dual-Mode Repeater

Check for Samples: [SN75DP120](#)

FEATURES

- DP Signal Repeater Supporting Dual-Mode DisplayPort DP1.1a (DP++) Signaling
- Supports Data Rates up to 2.7Gbps
- Participates in DP Link Training to set Output Voltage and Pre-Emphasis Levels
- Automatic Selectable Equalization for Improved Signal Integrity
- Integrated HPD Inversion and Level Translation Required on Some Source Platforms

- Enhanced ESD: 11 kV HBM on All Pins
- Enhanced Commercial Temperature Range: 0°C to 85°C
- 36 Pin 6 × 6 QFN Package

APPLICATIONS

- Personal Computer Market
 - Desktop PC
 - Notebook PC
 - PC Docking Station
 - PC Standalone Video Card

DESCRIPTION

The SN75DP120 is a single port Dual-Mode DisplayPort (DP++) repeater that regenerates the DP high speed digital link.

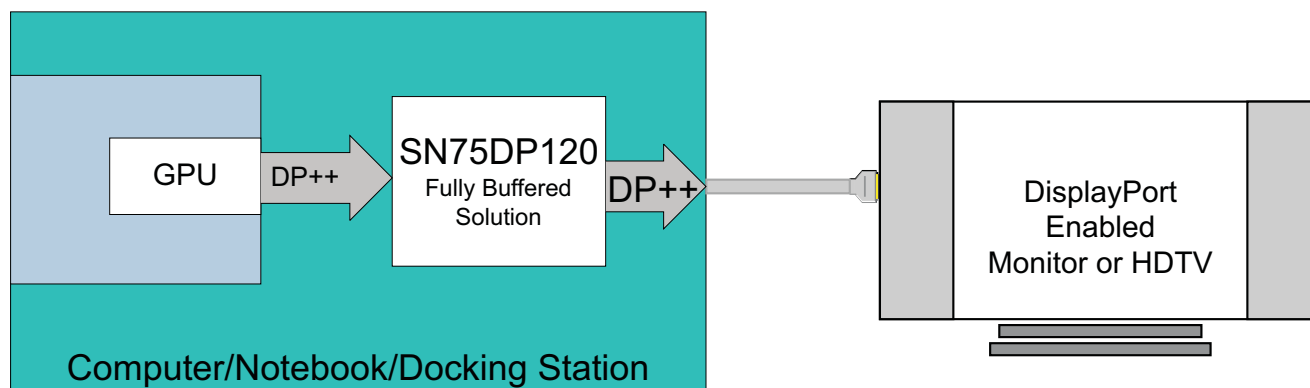
Four levels of differential output voltage swing (VOD) and four levels of pre-emphasis are supported in accordance with the DisplayPort specification version 1.1a. The device monitors the AUX channel and automatically adjusts the output signaling levels in response to link training commands. The SN75DP120 also supports multiple selectable levels of equalization to provide improved signal integrity in cases where the input link has a high level of loss. The equalization level will be automatically selected based on link training. The equalization in the DP120 is optimized to compensate losses of up to 6dB for frequencies up to 1.35GHz. This corresponds to approximately 18–24 inches of FR4 trace with 4–6mil width.

A built in level translator for the hot plug detect (HPD) line and level translator / inverter for the cable adapter detect line (CAD) allow for a reduction of the overall circuitry needed for a DisplayPort source system.

When not in use, the SN75DP120 device supports an ultra low power shutdown mode. In this mode the main link outputs are disabled and pulled to GND, and the device draws less than 40 μ W of power.

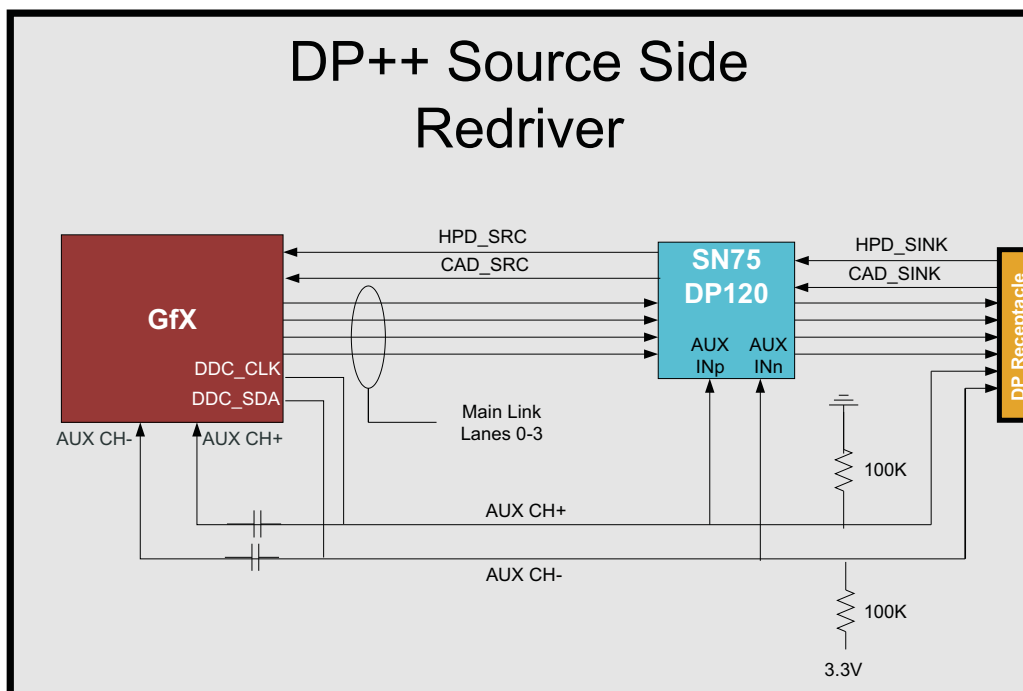
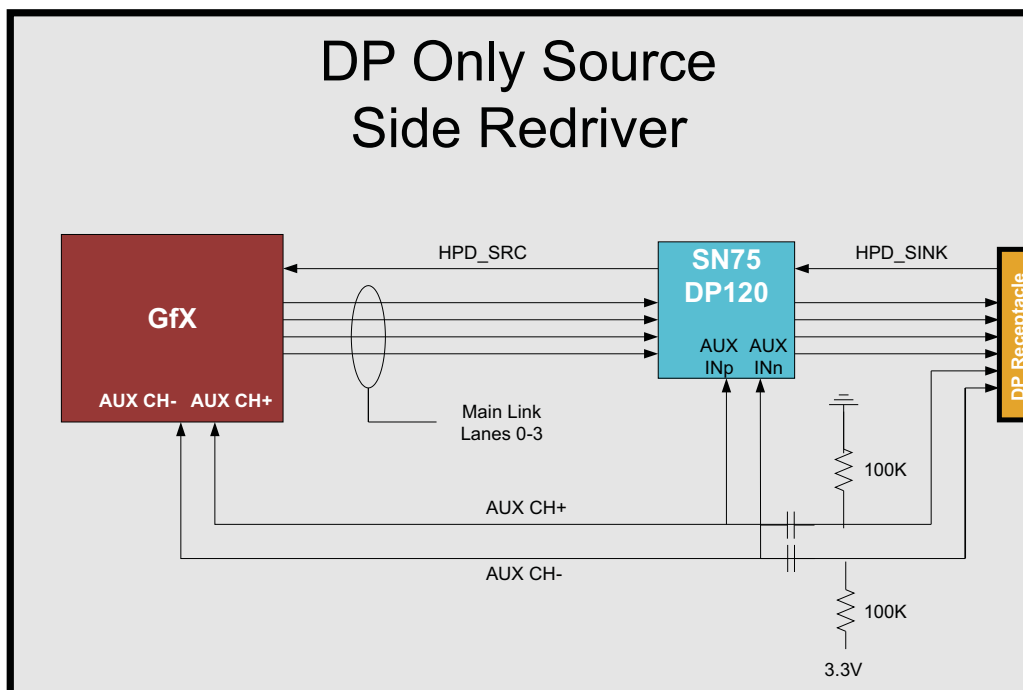
The device is characterized for an extended operational temperature range from 0°C to 85°C.

TYPICAL APPLICATION

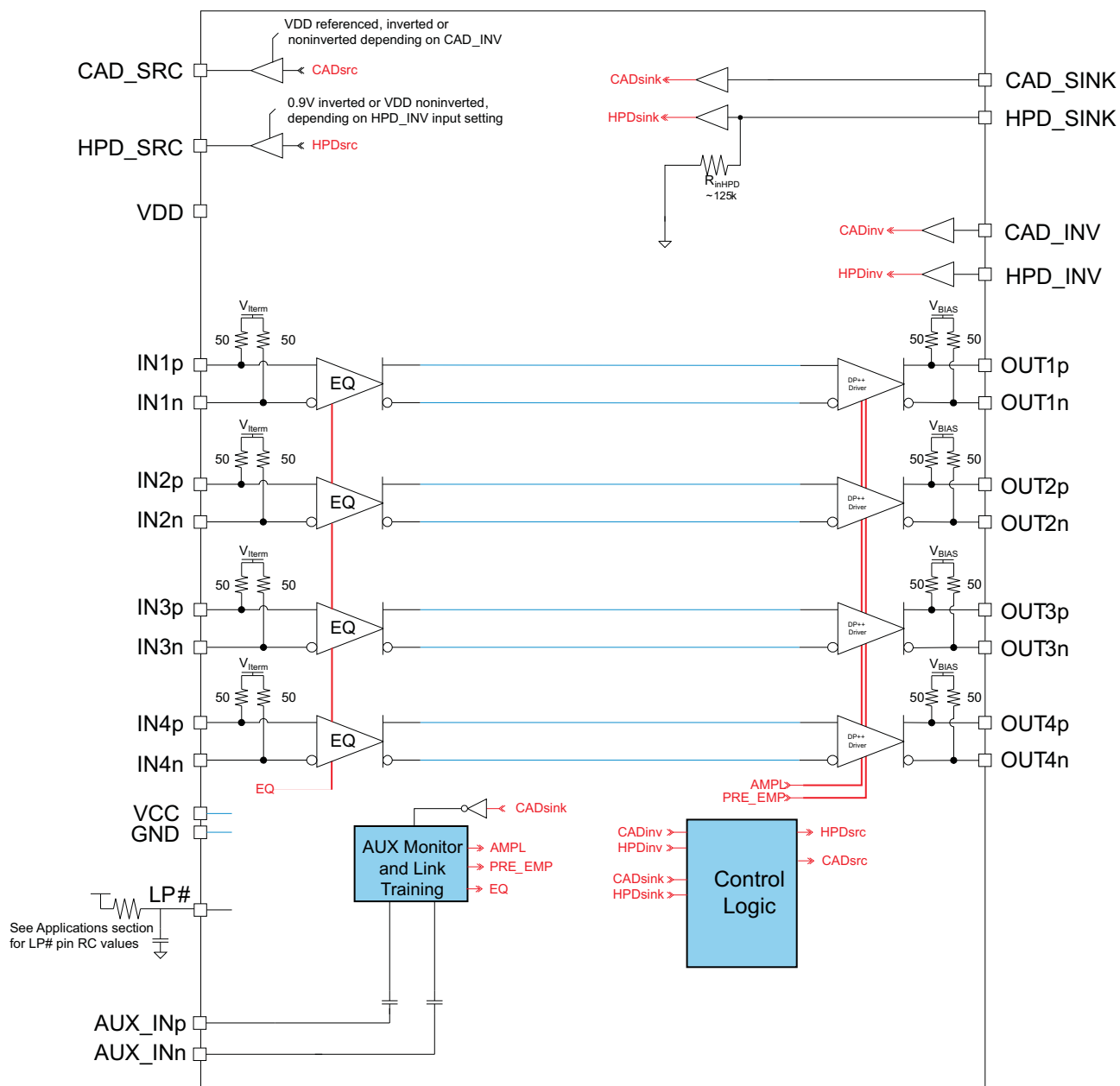


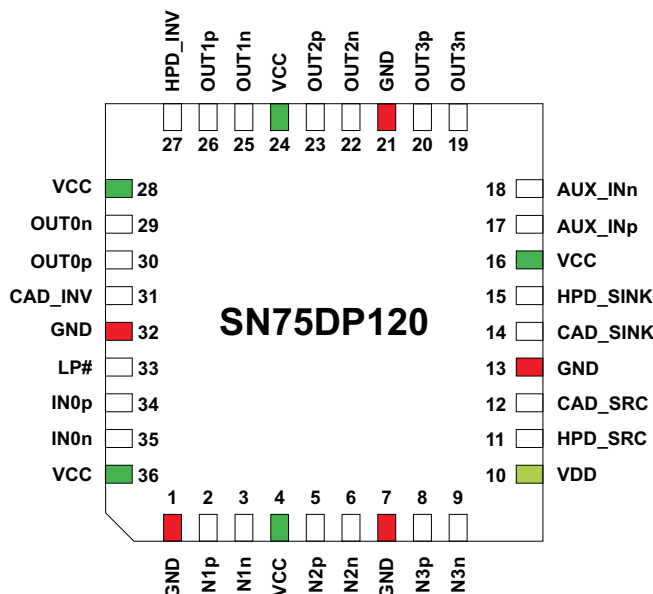
Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

TYPICAL IMPLEMENTATION



DATA FLOW BLOCK DIAGRAM



RHH PACKAGE (TOP VIEW)**PIN FUNCTIONS**

| PIN | | I/O | DESCRIPTION |
|-----------------------------|--------|------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SIGNAL | NO. | | |
| MAIN LINK INPUT PINS | | | |
| IN0p/n | 34, 35 | $I_{[100\Omega \text{ diff}]}$ | DisplayPort Main Link Channel 0 Differential Input |
| IN1p/n | 2, 3 | | DisplayPort Main Link Channel 1 Differential Input |
| IN2p/n | 5, 6 | | DisplayPort Main Link Channel 2 Differential Input |
| IN3p/n | 8, 9 | | DisplayPort Main Link Channel 3 Differential Input |
| MAIN LINK OUTPUT PINS | | | |
| OUT0p/n | 30, 29 | $O_{[100\Omega \text{ diff}]}$ | DisplayPort Main Link Channel 0 Differential Output |
| OUT1p/n | 26, 25 | | DisplayPort Main Link Channel 1 Differential Output |
| OUT2p/n | 23, 22 | | DisplayPort Main Link Channel 2 Differential Output |
| OUT3p/n | 20, 19 | | DisplayPort Main Link Channel 3 Differential Output |
| HOT PLUG DETECT PINS | | | |
| HPD_SRC | 11 | $O_{[3.3V/0.9V \text{ SE}]}$ | Hot Plug Detect Output to the DisplayPort Source The polarity and output level of HPD_SRC is set by the HPD_INV pin |
| HPD_SINK | 15 | $I_{[CMOS] \text{ w/ } 125k\Omega \text{ pulldown}}$ | Hot Plug Detect Input from DisplayPort Sink |
| AUXILIARY DATA PINS | | | |
| AUX_INp/n | 17, 18 | I/O | Bidirectional DisplayPort Auxiliary Data Line |
| CABLE ADAPTER DETECT PINS | | | |
| CAD_SRC | 12 | $O_{[CMOS]}$ | Cable Adapter Detect Output to the DisplayPort Source The polarity of CAD_SRC is set by the CAD_INV pin. |
| CAD_SINK | 14 | $I_{[CMOS]}$ | DisplayPort Cable Adapter Detect Input; No pulldown resistor on this pin. |
| CONTROL PINS ⁽¹⁾ | | | |
| LP# | 33 | $I_{[CMOS]}$ | Low Power Shutdown Mode When LP# = H; Device in Active Mode When LP# = L; Device in Shutdown mode. All main link outputs are disabled and pulled to GND; Inputs ignored. HPD_SRC follows HPD_SINK. An external capacitor may be required on this pin if it is connected to VCC by a pullup resistor. See Application Information section. |

(1) (H) Logic High; (L) Logic Low

PIN FUNCTIONS (continued)

| PIN | | I/O | DESCRIPTION |
|-------------------------------|-------------------|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SIGNAL | NO. | | |
| CAD_INV | 31 | I [CMOS] w/ weak pulldown | CAD output polarity Inversion When CAD_INV = H; CAD_SRC is INVERSE logic of CAD_SINK When CAD_INV = L; CAD_SRC is NON-INVERSE logic of CAD_SINK |
| HPD_INV | 27 | I [CMOS] w/ weak pulldown | HPD output polarity Inversion When HPD_INV = H; HPD_SRC is set to INVERSE logic of HPD_SINK, and HPD_SRC VOH is fixed at 0.8V to 1.1V, i.e. not referenced to VDD When HPD_INV = L; HPD_SRC is set to NON-INVERSE logic of HPD_SINK, and HPD_SRC VOH is referenced to VDD |
| SUPPLY AND GROUND PINS | | | |
| VDD | 10 | | HPD_SRC (when HPD_INV = H) and CAD_SRC Supply |
| VCC | 4, 16, 24, 28, 36 | | 3.3V Supply |
| GND | 1, 7, 13, 21, 32 | | Ground |

STATUS DETECT AND OPERATING MODES FLOW DIAGRAM

The SN75DP120 switches between power saving and active modes in the following way:

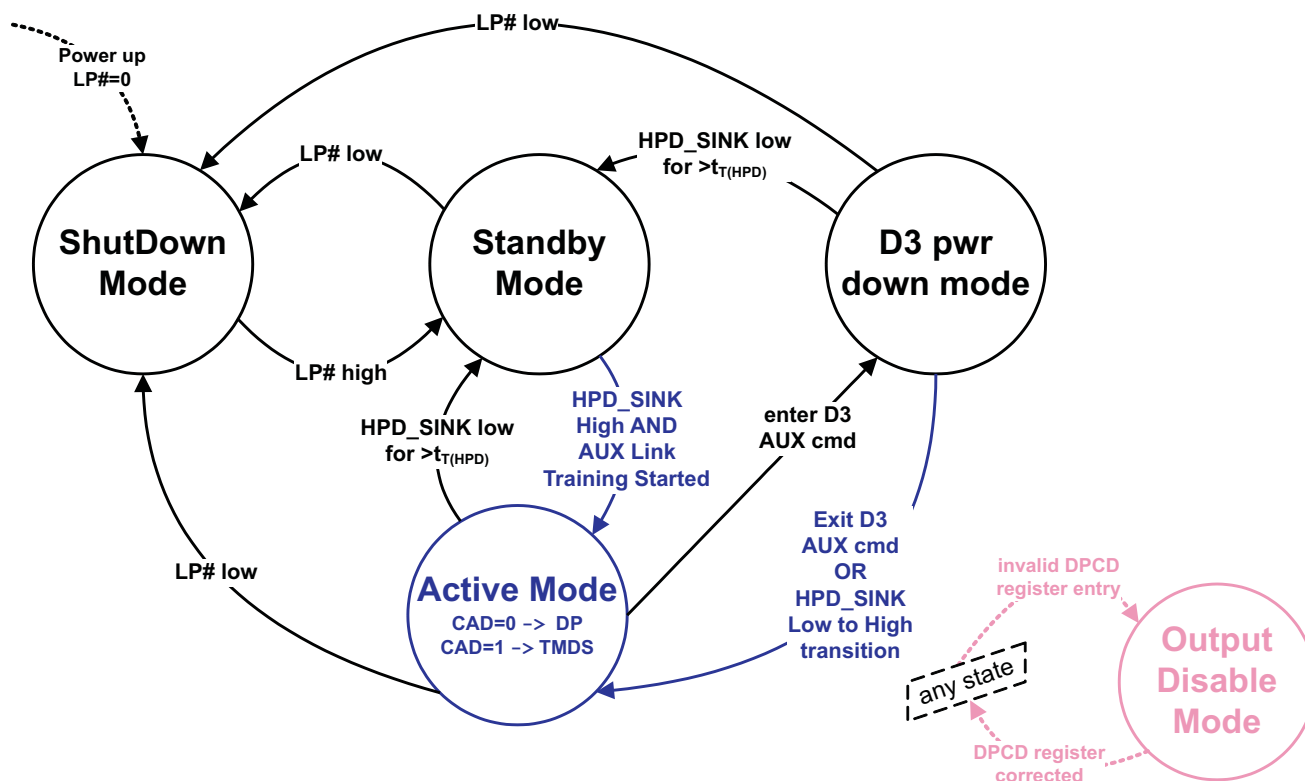


Figure 1. SN75DP120 Operational Modes Flow Chart

Table 1. Description of SN75DP120 Modes

| MODE | CHARACTERISTICS | CONDITIONS |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ShutDown Mode | Least amount of power consumption (most circuitry turned off); HPD_SRC reflects HPD_SINK state, all other outputs are high impedance and all other inputs are ignored. DPCD registers and logic are held reset to default values | LP# is low |
| Standby Mode | Low power consumption; main link inputs and outputs are disabled, AUX monitoring is enabled | LP# is high; HPD_SINK low for longer than $t_{T(HPD)}$ |
| D3 Power Down Mode | Low power consumption; main link inputs and outputs disabled, AUX monitoring is enabled | LP# is high; AUX command requested DP sink to enter D3 power saving mode |
| Active Mode | Data transfer (normal operation); The device is either in TMDS mode (CAD_SINK=high) or DP mode (CAD_SINK=low); In DP mode, the AUX monitor is actively monitoring for link training, and the output signal swing, input equalization level and lane count depend on the link training. At power-up all main link outputs are disabled by default. AUX Link training is necessary to overwrite the DPCD registers to enable main link outputs. In TMDS mode, the output signal swing will be 600mVp-p, and transactions on the AUX lines will be ignored. | LP# is high; HPD_SINK is high HPD_SINK can also be low for less than $t_{T(HPD)}$ (e.g. sink interrupt request to source) Link Training has begun or completed |
| Output Disable Mode | DPCD write commands on the AUX bus detected by the SN75DP120 will also write to the local DP120 DPCD register. The local DPCD registers should always be written with valid entries. If register 101h or 103h is written with an invalid value, the SN75DP120 disables the OUTx main link output signals, forcing the DP sink to issue an interrupt. The DP source can now re-train the link using valid DPCD register values. As soon as all DPCD registers contain a valid entry, the SN75DP120 switches back into the appropriate mode of operation. For a list of valid and invalid DPCD register entries refer to Table 3 and the DP1.1a specification Table 2-52 and Table 3-12. | EN is high DPCD register 101h or 103h entry is invalid |

Table 2. Transition Between Operational Modes

| MODE TRANSITION | USE CASE | TRANSITION SPECIFICS |
|---------------------------------|-----------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Shutdown → Standby | Activate DP120 | <ol style="list-style-type: none"> 1. LP# transitions from low to high 2. Receiver enters Standby mode 3. AUX listener turns on and begins to monitor the AUX lines |
| Standby → Active | Turn on main link (monitor plugged in) | <ol style="list-style-type: none"> 1. HPD_SINK input asserts high 2. Main link outputs turn on |
| Active → D3 | DP source requests temporary power down for power savings | <ol style="list-style-type: none"> 1. Receive D3 entry command on AUX 2. Main link inputs and outputs are disabled 3. AUX monitor remains active |
| D3 → Active | Exit temporary power down | <ol style="list-style-type: none"> 1. AUX channel receives D3 exit command or HPD_SINK transitions from low to high 2. Enable main link |
| D3 → Standby | Exit temporary power down | <ol style="list-style-type: none"> 1. HPD_SINK de-asserted to low for longer than $t_{T(HPD)}$ |
| Active → Standby | turn off main link (monitor unplugged) | <ol style="list-style-type: none"> 1. HPD_SINK de-asserted for longer than $t_{T(HPD)}$ 2. Main link inputs and outputs are disabled |
| Active/Standby → Shutdown | Turn off DP120 | <ol style="list-style-type: none"> 1. LP# pulled low 2. AUX, Main link inputs and outputs are disabled 3. Most IC circuitry is shut down for ultra low power consumption 4. HPD_SRC reflects HPD_SINK |
| Any State → Output Disable Mode | Invalid DPCD write value to register 101h or 103h | <ol style="list-style-type: none"> 1. OUTx becomes disabled |

Table 2. Transition Between Operational Modes (continued)

| MODE TRANSITION | USE CASE | TRANSITION SPECIFICS |
|------------------------------------|--------------------------------------------------------|-----------------------------------|
| Output Disable Mode → Any State | DPCD register values correct to a valid register entry | 1. Appropriate mode is re-entered |

ORDERING INFORMATION⁽¹⁾

| PART NUMBER | PART MARKING | PACKAGE |
|---------------|--------------|-------------------------|
| SN75DP120RHHR | DP120 | 36-pin QFN reel (large) |
| SN75DP120RHHT | DP120 | 36-pin QFN reel (small) |

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.

ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range (unless otherwise noted)⁽¹⁾

| | | VALUE / UNIT |
|-------------------------------------|------------------------------------------------|------------------------------|
| Supply voltage range ⁽²⁾ | VDD | –0.3 V to 4.0 V |
| Supply voltage range | VCC | –0.3 V to 4.0 V |
| Voltage range | Main Link I/O (INx, OUTx) | –0.3 V to VCC + 0.3 V |
| | Main Link I/O (INx, OUTx) differential voltage | 1.5V |
| | HPD_SINK and CAD_SINK | –0.3 V to 5.5 V |
| | HPD_SRC and CAD_SRC | –0.3 V to VCC + 0.3 V |
| | Auxiliary (AUX_IN) | –0.3 V to 5.5 V |
| | Control pins | –0.3 V to 4.0 V |
| Electrostatic discharge | Human body model ⁽³⁾ | 11 kV |
| | Charged-device model ⁽⁴⁾ | ±1500 V |
| | Machine model ⁽⁵⁾ | ±200 V |
| Continuous power dissipation | | See Dissipation Rating Table |

(1) Stresses beyond those listed under *absolute maximum ratings* may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any conditions beyond those indicated under *recommended operating conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) All voltage values, except differential voltages, are with respect to network ground terminal.

(3) Tested in accordance with JEDEC Standard 22, Test Method A114-E

(4) Tested in accordance with JEDEC Standard 22, Test Method C101-D

(5) Tested in accordance with JEDEC Standard 22, Test Method A115-A

DISSIPATION RATINGS

| PACKAGE | PCB JEDEC STANDARD | T _A ≤ 25°C | DERATING FACTOR ⁽¹⁾ ABOVE T _A = 25°C | T _A = 85°C POWER RATING |
|------------------|--------------------|-----------------------|---------------------------------------------------------------|---------------------------------------|
| 36-pin QFN (RHH) | Low-K | 1250 mW | 12.5 mW/°C | 500 mW |
| | High-K | 3095 mW | 30.95 mW/°C | 1238 mW |

(1) This is the inverse of the junction-to-ambient thermal resistance when board-mounted and with no air flow.

THERMAL CHARACTERISTICS

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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX ⁽¹⁾ | UNIT |
|-------------------|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|------|--------------------|------|
| R _{θJB} | Junction-to-board thermal resistance | 4x4 Thermal vias under PowerPAD | | 4.35 | | °C/W |
| R _{θJC} | Junction-to-case thermal resistance | | | 20.3 | | °C/W |
| P _N | Device power in Active Mode | LP# = VCC, ML: VOD = 1200mVp-p, 2.7Gbps PRBS; AUX: VID = 1000mVp-p, 1Mbps PRBS; VDD= 3.6V, VCC=3.6V Highest power level. All lanes running at largest VOD swing. | | | 720 | mW |
| P _{PDWN} | Device Power under D3 Power Down Mode or Standby | LP# = VCC, ML: VID = 0mVp-p, AUX: VID = 0mVp-p; VDD= 3.6V, VCC=3.6V | | | 44 | mW |
| P _{LP} | Device power dissipation in Shutdown mode | LP# = 0V, VDD= 3.6V, VCC=3.6V, HPD_INV = NC, 0V | | | 40 | μW |
| | | LP# = 0V, VDD= 3.6V, VCC=3.6, HPD_INV=VCC | | | 2.5 | mW |

(1) The maximum rating is simulated under VDD, VCC = 3.6V.

RECOMMENDED OPERATING CONDITIONS

| | | MIN | NOM | MAX | UNIT |
|------------------------------------------------|-----------------------------------------------------------------------------------|------|-----|------|------|
| V _{DD} | HPD_SRC and CAD_SRC reference voltage; HPD_SRC Ref voltage only when HPD_INV = 0V | 1.62 | | 3.6 | V |
| V _{CC} | Supply voltage | 3 | 3.3 | 3.6 | V |
| T _A | Operating free-air temperature | 0 | | 85 | °C |
| MAIN LINK DIFFERENTIAL PINS (INX, OUTX) | | | | | |
| V _{ID} | Peak-to-peak input differential voltage | 0.20 | | 1.40 | Vp-p |
| d _R | Data rate | | | 2.7 | Gbps |
| R _t | Termination resistance | 40 | 50 | 60 | Ω |
| V _{CM} | Output common mode voltage | 0 | | 2 | V |
| AUXILIARY PINS (AUX_IN) | | | | | |
| V _I | Input voltage | 0 | | 5.25 | V |
| d _{R(AUX)} | Auxiliary data rate | | | 1 | Mbps |
| HPD_SINK AND CAD_SINK | | | | | |
| V _{IH} | High-level input voltage | 1.9 | | 3.6 | V |
| V _{IL} | Low-level input voltage | 0 | | 0.8 | V |
| CONTROL PINS (LP#, HPD_INV, CAD_INV) | | | | | |
| V _{IH} | High-level input voltage | 1.9 | | 3.6 | V |
| V _{IL} | Low-level input voltage | 0 | | 0.8 | V |

DEVICE POWER

The SN75DP120 main and AUX link is designed to run from a single supply voltage of 3.3V. However since the device has a built in level shifter, another supply voltage (VDD) is needed to set the voltage level of HPD_SRC and CAD_SRC pins.

NOTE

An external capacitor may be required on LP# pin if that pin is tied to the supply through a pullup resistor. The capacitor specifies a proper power on reset for the device. See Applications section for recommended resistor and capacitor values.

ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|-----|-----|-----|---------|
| I_{CC} Supply current under active operating mode | LP# = VCC, ML: VOD = 1200mVp-p, 2.7Gbps PRBS; AUX: VID = 1000mVp-p, 1Mbps PRBS; VDD= 3.6V, VCC=3.6V | | 165 | 200 | mA |
| I_{PDWN} Device power under power down mode (D3) or standby main link disabled | LP# = VCC, ML: VID = 0mVp-p, AUX: VID = 0mVp-p; VDD= 3.6V, VCC=3.6V | | 8 | 12 | mA |
| I_{LP} Low power current | LP# = 0V, VDD= 3.6V, VCC=3.6V HPD_INV, CAD_INV = NC, 0V | | 1 | 10 | μ A |
| | LP# = 0V, VDD= 3.6V, VCC=3.6V HPD_INV=VCC | | 400 | 640 | |
| I_{DD} Supply current | VDD = 3.6V, HPD_INV = VDD | | | 4 | mA |
| t_{PWDNEX} D3 Powerdown or standby mode exit time | Total time for the device to exit from D3 or standby state to active mode | | 1.2 | 1.8 | μ s |

HOT PLUG AND CABLE ADAPTER DETECT

The SN75DP120 has an integrated 125K Ω pull down on the HPD_SINK input pin. The HPD and CAD timing diagrams in this section are for the non-inverting case. The same timing diagrams apply for the inverting case except the output is inverted. The VOH level of CAD_SRC follows that of VDD irrespective of CAD_INV setting. However VOH for HPD_SRC depends on HPD_INV setting. When HPD_INV is low or left floating, HPD_SRC VOH follows that of VDD. When HPD_INV = H then HPD_SRC VOH is set to 0.8V – 1.1V irrespective of VDD.

Explanation of HPD power management and interrupt behavior of the SN75DP120 is located in the Application Information section at the end of the datasheet.

ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--------------------------------------------------------------------------|--------------------------------------------------------------------------|------|-----|-----|------------|
| HPD_INV, CAD_INV = L | | | | | |
| $V_{OH3.3}$ High-level output voltage (CAD_SRC and HPD_SRC) | VDD = 3.3 V, I_{OH} = –100 μ A, CAD_SINK, HPD_SINK = H | 3 | | | V |
| $V_{OH2.5}$ High-level output voltage (CAD_SRC and HPD_SRC) | VDD = 2.5 V, I_{OH} = –100 μ A, CAD_SINK, HPD_SINK = H | 2.25 | | | V |
| $V_{OH1.8}$ High-level output voltage (CAD_SRC and HPD_SRC) | VDD = 1.8 V, I_{OH} = –100 μ A, CAD_SINK, HPD_SINK = H | 1.62 | | 1.8 | V |
| $V_{OL3.3}$ High-level output voltage (CAD_SRC and HPD_SRC) | VDD = 3.3 V, I_{OL} = 100 μ A, CAD_SINK, HPD_SINK = L | | | 0.1 | V |
| $V_{OL2.5}$ Low-level output voltage (CAD_SRC and HPD_SRC) | VDD = 2.5 V, I_{OL} = 100 μ A, CAD_SINK, HPD_SINK = L | | | 0.1 | V |
| $V_{OL1.8}$ Low-level output voltage (CAD_SRC and HPD_SRC) | VDD = 1.8 V, I_{OL} = 100 μ A, CAD_SINK, HPD_SINK = L | | | 0.1 | V |
| HPD_INV = H | | | | | |
| $V_{OH1.1}$ High-level output voltage (HPD_SRC) | I_{OH} = –100 μ A, HPD_SINK = L | 0.8 | 0.9 | 1.1 | V |
| $V_{OL1.1}$ Low-level output voltage (HPD_SRC) | I_{OH} = 100 μ A, HPD_SINK = H | | | 0.1 | V |
| I_{IH} High-level input current (HPD_SINK, CAD_SINK, HPD_INV, CAD_INV) | V_{IH} = 2.0 V, V_{DD} = 3.6 V (Leakage includes pull down resistor) | –5 | | 35 | μ A |
| I_L Low-level input current (HPD_SINK, CAD_SINK, HPD_INV, CAD_INV) | V_{IL} = 0.8 V, V_{DD} = 3.6 V (Leakage includes pull down resistor) | –5 | | 35 | μ A |
| R_{HPDIN} Weak pull down resistor on HPD_SINK | | 100 | 125 | 150 | k Ω |

SWITCHING CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---------------|----------------------------------------------------------------------------|-----|-----|-----|------|
| $t_{PD(CAD)}$ | Propagation delay VDD = 3.3 V, See Figure 2 and Figure 5 | | 6.4 | 22 | ns |
| $t_{PD(HPD)}$ | Propagation delay VDD = 3.3 V, See Figure 2 and Figure 3, $C_L = 20$ pF | | 6.4 | 22 | ns |
| $t_T(HPD)$ | HPD logic shut off time VDD = 3.3 V, See Figure 4 | 250 | | 550 | ms |

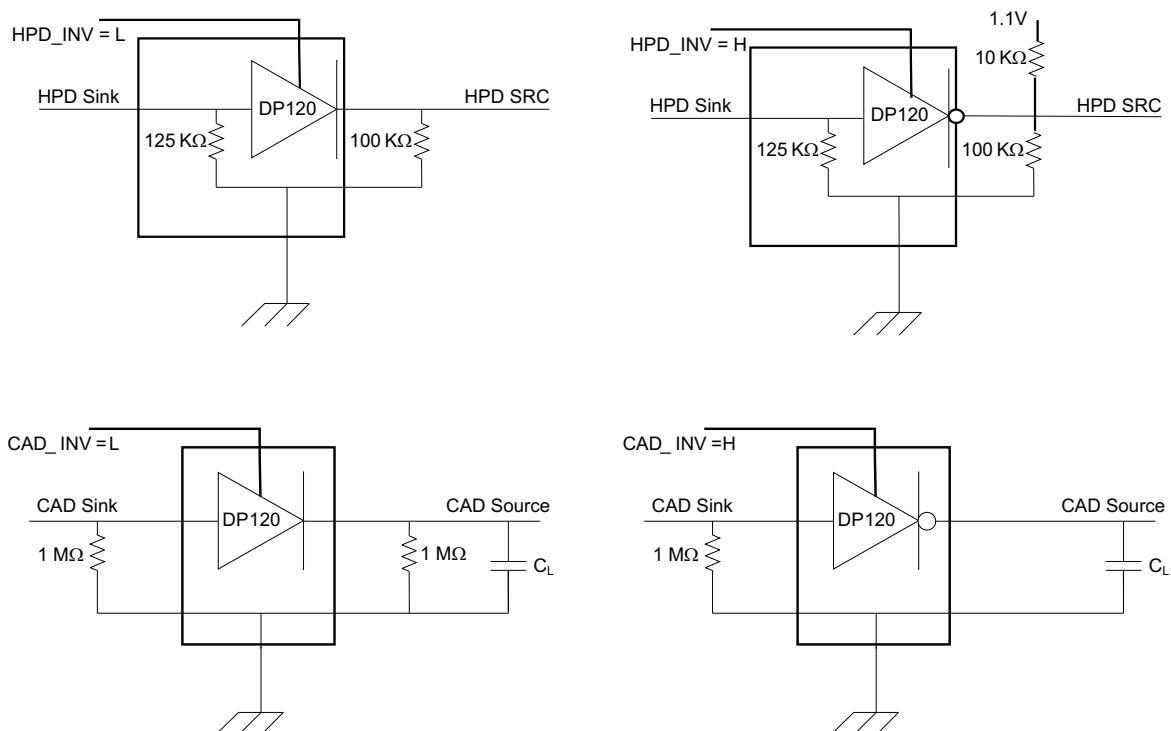


Figure 2. HPD and CAD Test Circuits

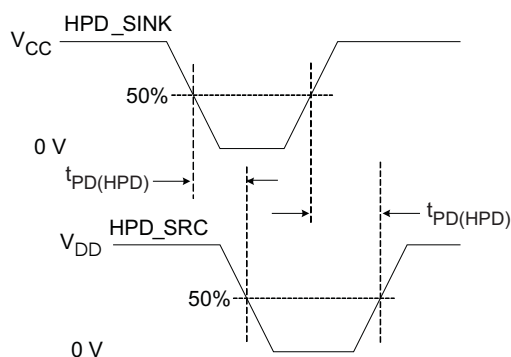


Figure 3. HPD Timing Diagram #1 (HPD_INV = L)

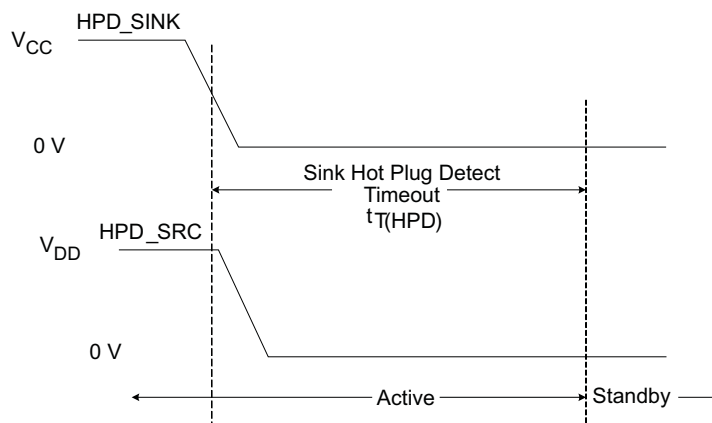


Figure 4. HPD Timing Diagram #2 (HPD_INV = L)

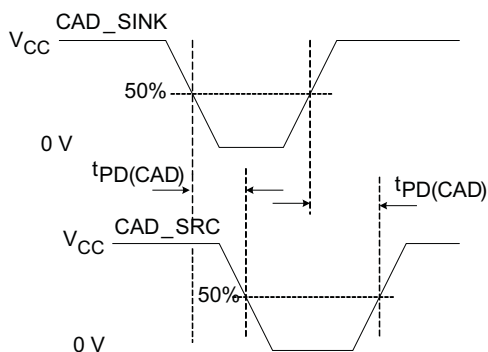


Figure 5. CAD Timing Diagram

DisplayPort Auxiliary Pins

The SN75DP120 is designed to monitor the bidirectional auxiliary signals in DP mode and participates in link training. The SN75DP120 adjusts the output swing, output pre-emphasis, and the EQ setting of every main link port. The SN75DP120 AUX monitor configures the output based on the DPCD addresses below.

The AUX channel is monitored for the Display Port D3 standby command. Upon detecting the D3 command, the SN75DP120 will go into a low power standby state with the AUX activity monitor remaining active.

Table 3. DPCD Lookup Table

| ADDRESS | NAME | DESCRIPTION |
|---------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 00100h | LINK_BW_SET | <p>Main Link Bandwidth Setting</p> <p>Bits 7:0 = link bandwidth setting</p> <ul style="list-style-type: none"> • 06h = 1.62Gbps per lane (default) • 0Ah = 2.7Gbps per lane <p><i>Note: Setting the register value in register 0100h to anything else but 0Ah puts the device into 1.62Gbps mode.</i></p> |
| 00101h | LANE_COUNT_SET | <p>Determines the number of lanes to be enabled</p> <p>Bits 4:0 = lane count</p> <ul style="list-style-type: none"> • 1h = one lane • 2h = two lanes • 4h = four lanes <p><i>Note: Any other register value in register 0101h bit 4:0 is invalid and disables all OUTx lanes until the register value is changed back to a valid entry. Default all lanes are disabled.</i></p> |

Table 3. DPCD Lookup Table (continued)

| ADDRESS | NAME | DESCRIPTION |
|---------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 00103h | TRAINING_LANE0_SET | <p>Sets the VOD and pre-emphasis levels for lane 0</p> <p>Bits 1:0 = voltage swing</p> <ul style="list-style-type: none"> • 00 = voltage swing level 0 (default) • 01 = voltage swing level 1 • 10 = voltage swing level 2 • 11 = voltage swing level 3 <p>Bits 4:3 = pre-emphasis level</p> <ul style="list-style-type: none"> • 00 = pre-emphasis level 0 (default) • 01 = pre-emphasis level 1 • 10 = pre-emphasis level 2 • 11 = pre-emphasis level 3 <p><i>Note: The following combinations of output swing and pre-emphasis are not allowed for register 103h bits [1:0]/[4:3]: 01/11, 10/10, 10/11, 11/01, 11/10, 11/11; setting the DPCD register to any of these invalid combinations disables all OUTx lanes until the register value is changed back to a valid entry.</i></p> |
| 00104h | TRAINING_LANE1_SET | Sets the VOD and pre-emphasis levels for lane 1, Same definition as lane 0 |
| 00105h | TRAINING_LANE2_SET | Sets the VOD and pre-emphasis levels for lane 2, Same definition as lane 0 |
| 00106h | TRAINING_LANE3_SET | Sets the VOD and pre-emphasis levels for lane 3, Same definition as lane 0 |
| 00600h | SET_POWER | <p>Sets the power mode of the device</p> <p>Bits 1:0 = Power mode</p> <ul style="list-style-type: none"> • 01 = Normal mode (default) • 10 = Power down mode (D3 or Standby Mode) <p>When power down mode is selected, the main link and all analog circuits are shut down to minimize power consumption. The AUX channel is still monitored. Upon detecting a D3 exit command or if CAD_SNK goes high, the device exits the power down mode. The device will also exit D3 if HPD_SNK goes low for longer than $t_{T(HPD)}$, which indicates that the DP sink was disconnected.</p> <p><i>Note: Setting the register to the invalid combination 0600h[1:0]=00 or 11 is ignored by the device and the device remains in normal mode.</i></p> |

ELECTRICAL CHARACTERISTICS

over recommended operating (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|----------------------------------------------------------------------|-----------------|------|-----|-----|---------|
| V_{ID} Differential input voltage | | 0.25 | | 1.6 | Vp-p |
| $V_{ID(HYS)}$ Differential input hysteresis | | | 50 | | mV |
| I_H High-level input current | | -1 | | 1 | μA |
| I_L Low-level input current | | -1 | | 1 | μA |
| T_{jit} Maximum allowable UI variation within a single transaction | | | | 0.1 | UI |

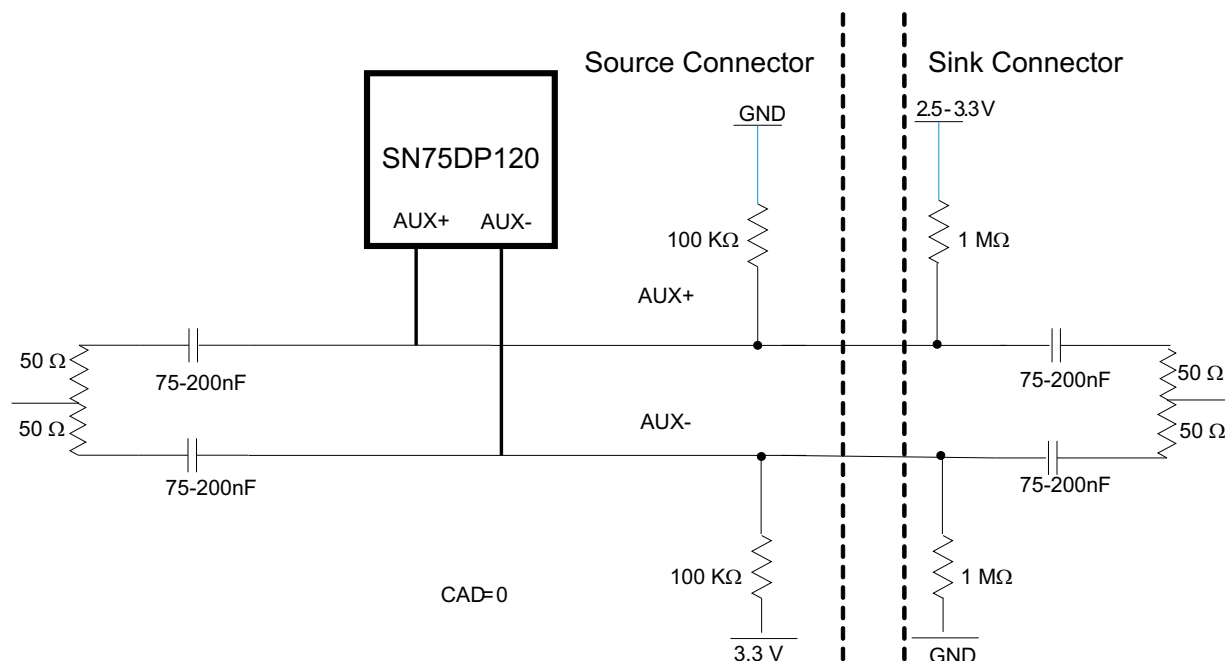


Figure 6. Auxiliary Channel Measurement

DisplayPort Main Link Pins

The SN75DP120 is designed to support DisplayPort's high speed differential main link with four levels of output voltage swing and four levels of pre-emphasis. The main link I/Os of the SN75DP120 are designed to be compliant to the DisplayPort 1.1a specification.

ELECTRICAL CHARACTERISTICS

over recommended operating (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---------------------------|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|-----------|------|-----|-----|-------|
| OUTx (Mainlink Outputs) | | | | | | | |
| V _{ODpp(1)} | Output differential peak-to-peak voltage Level 1 | PRBS7 pattern at 1.67 Gbps and 2.7 Gbps, Measured at TP1 in Figure 8 | | 400 | | | mVp-p |
| V _{ODpp(2)} | Output differential peak-to-peak voltage Level 2 | | | 600 | | | mVp-p |
| V _{ODpp(3)} | Output differential peak-to-peak voltage Level 3 | | | 800 | | | mVp-p |
| V _{ODpp(4)} | Output differential peak-to-peak voltage Level 4 | | | 1200 | | | mVp-p |
| V _{ODpp(5)} | Output differential peak-to-peak voltage TMDS mode | CAD_SINK = 3.6V | | 600 | | | mVp-p |
| V _{ODpp(CTS1.1)} | Output differential peak-to-peak voltage for DP Compliance v1.1 | Level 3 (800mVpp), Pattern used is PRBS7, Measured at TP2 in Figure 8 , Per Eye Mask Test in CTS1.1 | 1.67 Gbps | 400 | | | mVp-p |
| | | | 2.7 Gbps | 350 | | | |
| ΔV _{ODpp1} | Output differential peak-to-peak voltage increase from Level 1 to Level 2 | Measured at TP2, ΔV _{ODppn} = 20*log(V _{ODpp2(n+1)} / V _{ODpp2(n)}), Refer to Section 3.2 in DP CTS1.1 | | 1.8 | 3.3 | 5.0 | dB |
| ΔV _{ODpp2} | Output differential peak-to-peak voltage increase from Level 2 to Level 3 | | | 1.1 | 2.7 | 4.1 | dB |
| ΔV _{ODpp3} | Output differential peak-to-peak voltage increase from Level 3 to Level 4 | | | 1.8 | 3.4 | 5.0 | dB |

ELECTRICAL CHARACTERISTICS (continued)

over recommended operating (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|-------------------|--------------------------------------------------------|--------------------------------------------------------------------------------------------------------|------------------------------------|-----|-----|-----|----------|
| $V_{PRE(0)}$ | Driver output pre-emphasis 0 dB Level | See Figure 3-3 in DP CTS1.1, PRBS7 pattern at 1.67 Gbps and 2.7 Gbps, Measured at TP1 | All VOD levels | | | 0 | dB |
| $V_{PRE(1)}$ | Driver output pre-emphasis 3.5 dB Level | | VOD = VODpp(1), VODpp(2), VODpp(3) | | 3.5 | | dB |
| $V_{PRE(2)}$ | Driver output pre-emphasis 6 dB level | | VOD = VODpp(1), VODpp(2) | | 6.0 | | dB |
| $V_{PRE(3)}$ | Driver output pre-emphasis 9.5 dB level | | VOD = VODpp(1) | | 9.5 | | dB |
| $V_{PRE2(0)}$ | Driver output pre-emphasis 0dB level | Measured at TP2 | | | | 0 | dB |
| ΔV_{PRE1} | Pre-emphasis delta | Measured at TP2, At each supported pre-emphasis level: $\Delta V_{PREn} = V_{PRE2(n+1)} - V_{PRE2(n)}$ | | 2.5 | | | dB |
| ΔV_{PRE2} | | | | 1.9 | | | dB |
| ΔV_{PRE3} | | | | 1.9 | | | dB |
| V_{PRE_NPP} | Pre-emphasis non-transition peak-to-peak voltage range | All supported pre-emphasis levels, Measured at TP2 | | | | 40 | mV-pp |
| R_{OUT2} | Driver output impedance | | | 40 | 50 | 60 | Ω |
| R_{INT} | Input termination impedance | | | 40 | 50 | 60 | Ω |
| V_{Iterm} | Input termination voltage | | | 0 | | 2 | V |
| V_{Oterm} | Output common mode voltage | | | 0 | | 2 | V |
| V_{TXACCM} | Output AC common mode voltage | Measured at 1.62Gbps and 2.7Gbps (All output and pre-emphasis levels), Measured at TP2 | | | | 20 | mVrms |
| $I_{TXSHORT}$ | Output short circuit current limit | OUT pins shorted to GND | | | | 50 | mA |
| $I_{RXSHORT}$ | Input short circuit current limit | IN pins shorted to GND | | | | 50 | mA |

SWITCHING CHARACTERISTICS

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

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|--------------------|-------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|-------------------|-----|-----|------|------|
| $t_{R/F(DP)}$ | Differential Output edge rate (20%–80%) | No pre-emphasis, 800mV differential swing, Measured at TP1, PRBS7 | | 60 | | 150 | ps |
| $t_{PD(ML)}$ | Propagation delay time | $d_R = 2.7$ Gbps, No pre-emphasis, 800 mV differential voltage swing, See Figure 9 | | | | 450 | ps |
| $t_{SK(1)}$ | Output Intra-pair skew | $d_R = 2.7$ Gbps, No pre-emphasis, 800 mV differential voltage swing, PRBS7, See Figure 10 | | | | 15 | ps |
| $t_{SK(2)}$ | Output Inter-pair skew ⁽¹⁾ | $d_R = 2.7$ Gbps, No pre-emphasis, 800 mV differential voltage swing, PRBS7 | | | | 40 | ps |
| $t_{DPJIT1(PP)}$ | Peak-to-peak output residual jitter at Pkg Pins | No pre-emphasis, All levels differential voltage swing, PRBS7. Vid = 400 mVpp TTP3-TTP2 in Figure 11 | $d_R = 2.7$ Gbps | | | 10 | ps |
| | | | $d_R = 1.62$ Gbps | | | 10 | |
| $t_{DPJIT2(PP)}$ | Peak-to-peak output residual jitter | No pre-emphasis, All levels differential voltage swing, PRBS7. Vid = 400 mVpp, TTP4-TTP1 in Figure 11 | $d_R = 2.7$ Gbps | | | 0.08 | UI |
| | | | $d_R = 1.62$ Gbps | | | 0.06 | |
| $t_{SK(in)}$ | Intra-pair skew at the input package pins | $d_R = 2.7$ Gbps | | | | 100 | ps |
| | | $d_R = 1.62$ Gbps | | | | 300 | |
| $T_{TMDSJIT1(PP)}$ | Peak-to-peak output residual jitter at Pkg Pins | $d_R = 2.25$ Gbps, CAD_SINK = H, Input Vid = 600 mVp-p, No pre-emphasis, See Figure 12 | | | | 10 | ps |
| $T_{TMDSJIT2(PP)}$ | Peak-to-peak output residual jitter | $d_R = 2.25$ Gbps CAD_SINK = H, Input Vid = 600 mVp-p, No pre-emphasis, See Figure 12 | | | | 0.1 | UI |

(1) $t_{SK(2)}$ is the magnitude of the time difference between $t_{PD(ML)}$ of any two mainlink outputs on a single device.

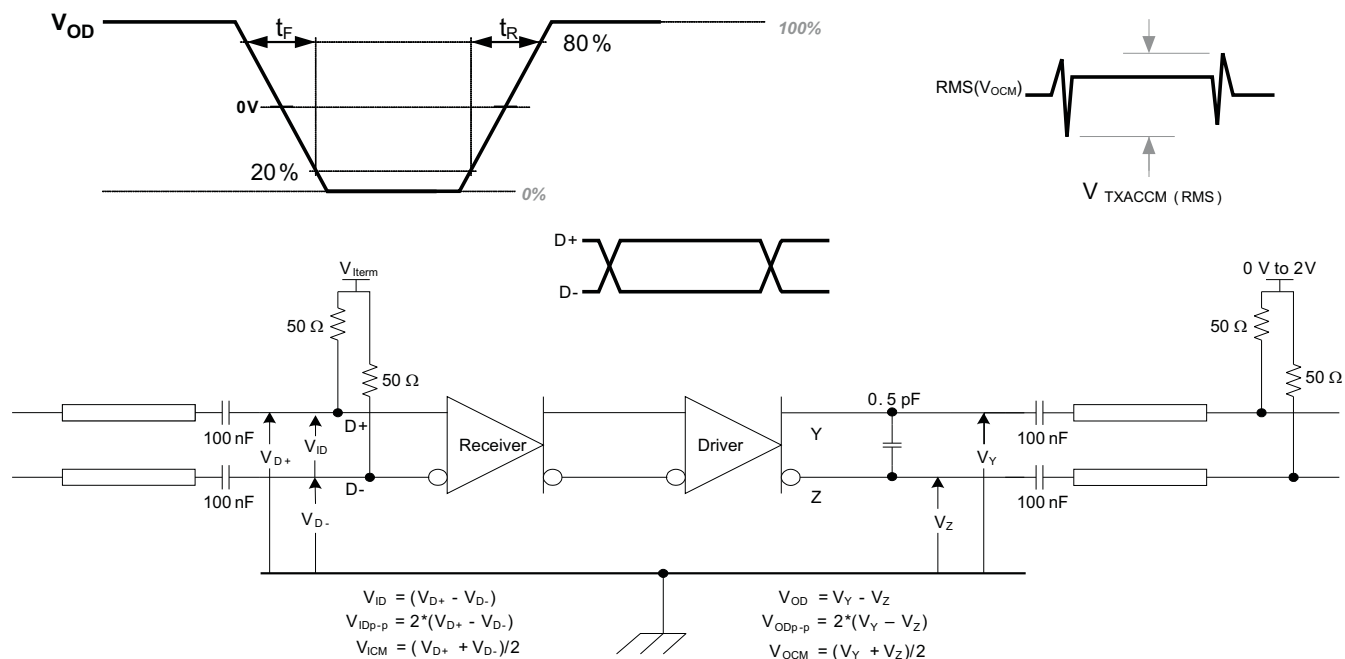


Figure 7. Main Link Test Circuit and Definitions

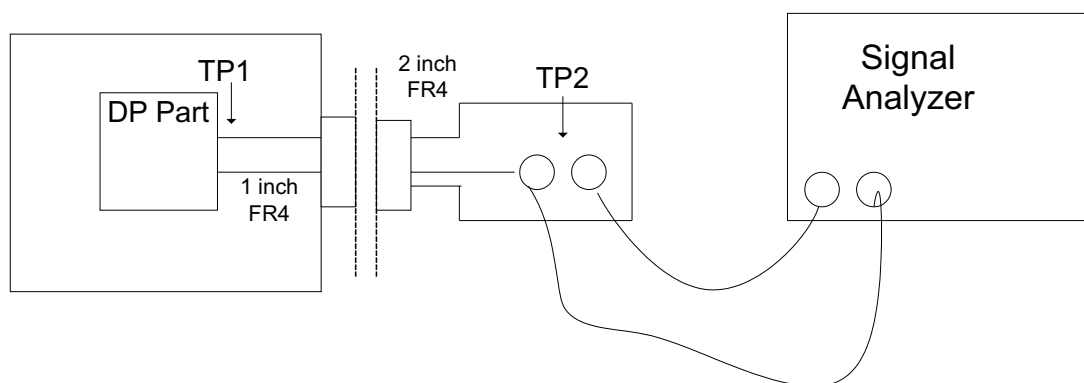


Figure 8. Display Port Compliance Setup

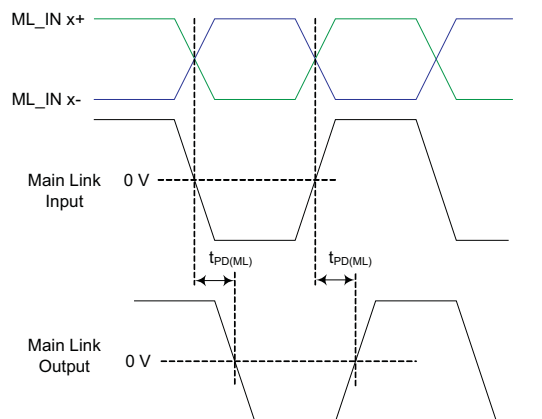
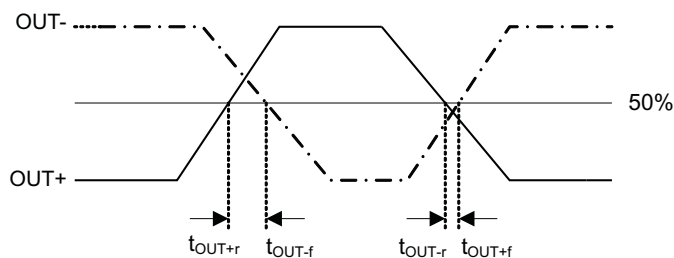
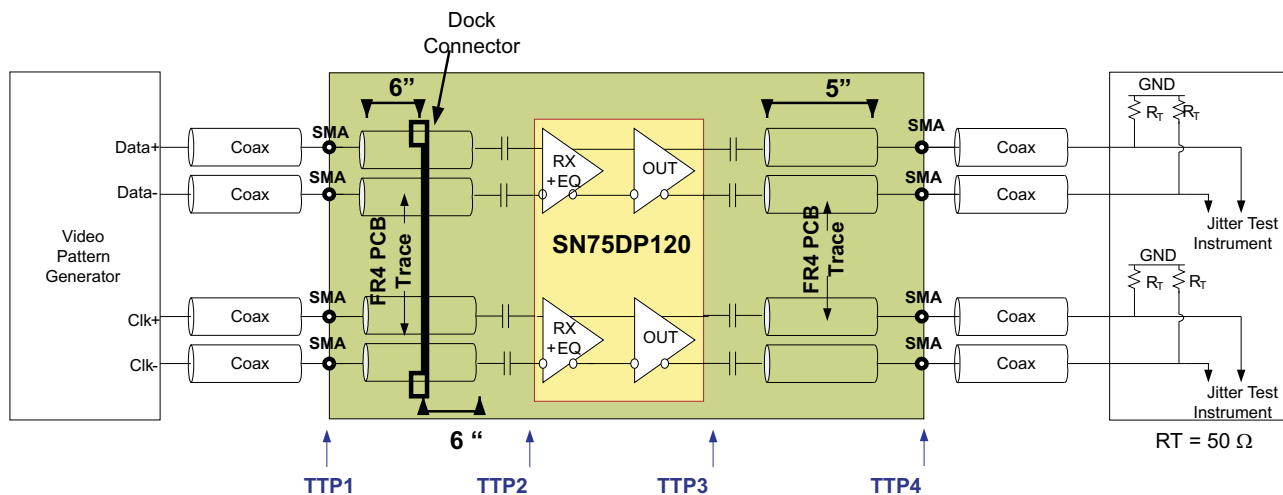


Figure 9. Main Link Delay Measurement



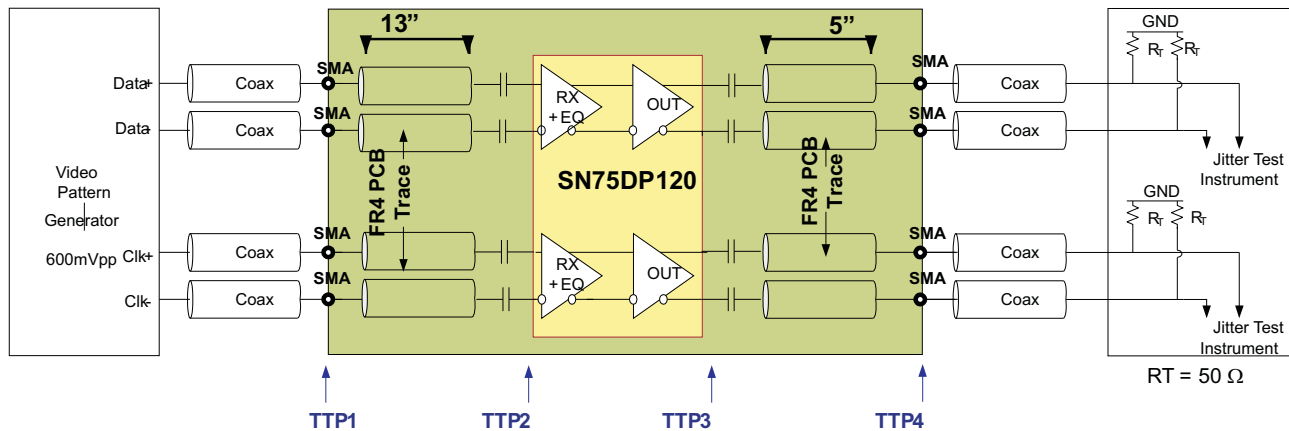
$$t_{sk(1)} = 0.5 * | (t_{OUT+r} - t_{OUT-f}) + (t_{OUT+f} - t_{OUT-r}) |$$

Figure 10. Intra-Pair Skew Measurement



- (1) All jitter measured at BER of 10-e9.
- (2) Residual jitter reflects the total jitter measured at TTP4 minus the jitter at TTP1.
- (3) 5 inches on the output represents 2 inches of trace, plus connector, plus 2 more inches of trace.

Figure 11. Jitter Measurement Setup – DP Mode



- (1) All jitter measured at BER of 10-e9.
- (2) Residual jitter reflects the total jitter measured at TTP4 minus the jitter at TTP1.
- (3) Input trace of 13 inches represents 6 inches trace, connector, and additional 6 inches of trace.
- (4) Output trace of 5 inches represents 2 inches of trace, connector, and 2 inches of trace.
- (5) Input edge rate from Video Pattern Generator is 50ps (20%–80%) with output level 600mVpp.
- (6) CAD_SINK is H and DP120 output levels are set to 600mVp-p level.

Figure 12. Jitter Measurement Setup – TMD5 Mode

TYPICAL CHARACTERISTICS

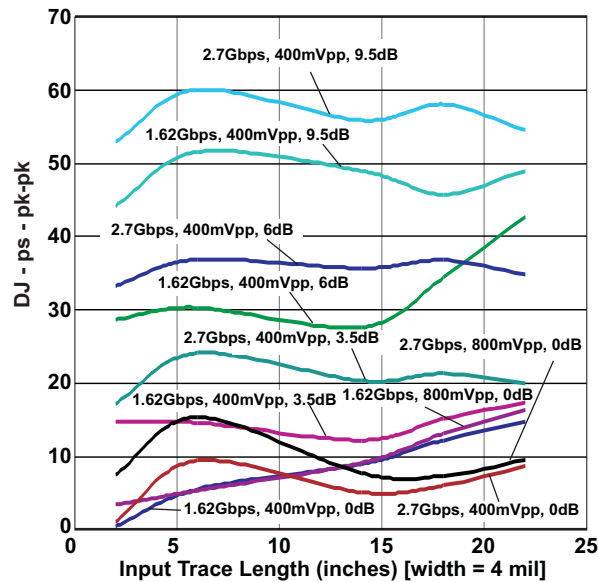


Figure 13. Output Jitter vs Input Trace Length

TYPICAL CHARACTERISTICS (continued)

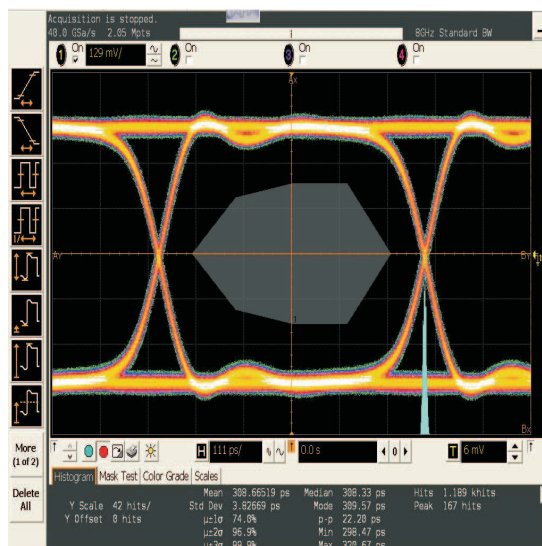


Figure 14. Eye Diagram at TP2 with 22 Inch FR4 Input Trace
Output Set at 800mV_{pp}, 0dB at RBR (1.62 Gbps), with DP Source Compliance Eyemask

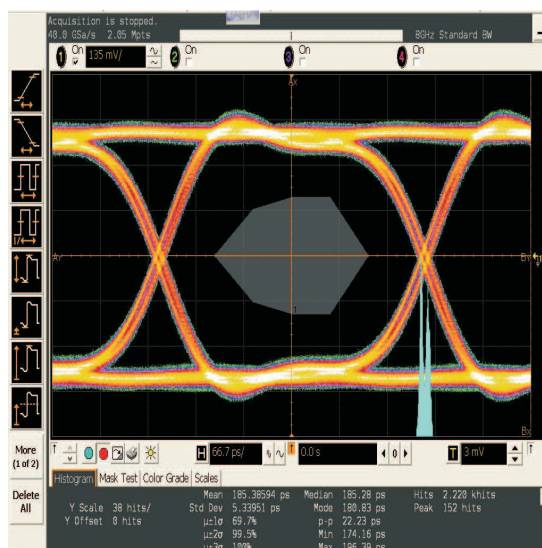


Figure 15. Eye Diagram at TP2 with 22 Inch FR4 Input Trace
Output Set at 800mV_{pp}, 0dB at HBR (2.7 Gbps), with DP Source Compliance Eyemask

APPLICATION INFORMATION

POWER ON RESET

On power up, the interaction of the LP# pin and power on ramp could result in digital circuits not being set correctly. The device should not be enabled until the power on ramp has settled to 3V or higher to guarantee a correct power on reset of the digital circuitry. If LP# cannot be held low by microcontroller or other circuitry until the power on ramp has settled, then a pullup resistor and external capacitor are required to hold the device in the low power reset state.

To use LP# as a reset pin, the pullup resistor should be connected from VCC to LP# and the capacitor from LP# pin to GND. The RC time constant should be larger than 5 times of the power on ramp time (0 to VCC). The pullup resistor should be less than 100KΩ. The following table shows example of power on ramp time and R and C values.

Table 4. Recommended LP# RC Values

| POWER ON RAMP | R | C |
|---------------|--------|--------|
| 100 μs | 6 kΩ | 0.1 μF |
| 0.5 ms | 40 kΩ | 0.1 μF |
| 1 ms | 100 kΩ | 0.1 μF |
| 5 ms | 100 kΩ | 0.5 μF |
| 10 ms | 100 kΩ | 1 μF |

HPD POWER MANAGEMENT AND INTERRUPT BEHAVIOR

The power management of the SN75DP120 is controlled by the state of the HPD_SINK pin as well as the low power (LP#) pin. When HPD_SINK is LOW for $t_{T(HPD)}$ the SN75DP120 will enter a standby state. In this state main link outputs will be high impedance and shutdown to conserve power. When HPD_SINK goes high the device will enter the normal operational state.

The LP# pin puts the SN75DP120 in its lowest power mode, shutdown, when LP# is low. In this state, almost all circuitry is shutdown with inputs and outputs at high impedance. HPD is still active, however, and HPD_SRC will follow HPD_SINK.

1. HPD and Main Link behavior

- **Case one:** In this case HPD_SINK is initially LOW and the low power pin is also LOW. In this initial state the device is in a low power mode. Once the HPD input goes to a HIGH state the device will remain in the low power mode with both the main link and auxiliary I/O in a high impedance state. Refer [Figure 16](#). However the HPD_SRC signal is not gated by the LP# pin. HPD_SRC will follow HPD_SINK after the propagation delay $t_{PD(HPD)}$.
- **Case two:** In this case HPD_SINK is initially LOW and the low power pin is HIGH. In this initial state the device is in a standby mode. Once the HPD input goes to a HIGH state the device will come out of the standby mode and will enter active mode enabling the main link. The HPD output to the source will follow the logic state of the input HPD. See [Figure 17](#), where $HPD_INV = L$.

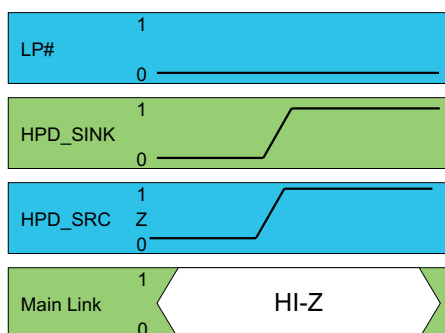


Figure 16.

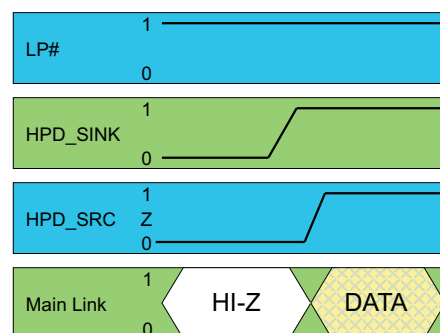


Figure 17.

2. HPD Interrupt and Time Out

- In this case the HPD_SINK input is initially HIGH. The HPD_SRC output logic state will follow the state of the HPD_SINK input (when HPD_INV = L). If the HPD_SINK input pulses LOW, as may be the case if the Sink device is requesting an interrupt, the HPD_SRC output to the source will also pulse Low for the same duration of time with a slight delay (see Figure 18). The delay of this signal through the SN75DP120 is specified as $t_{PD(HPD)}$. If the duration of the LOW pulse exceeds $t_{T(HPD)}$ the device will assume that an unplug event has occurred and enter the low power state (see Figure 19). Once the HPD_SINK input goes high again the device will return to the active state as indicated in Figure 17.

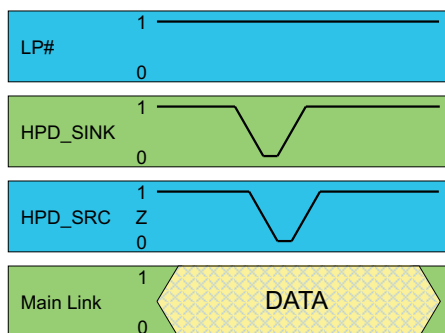


Figure 18.

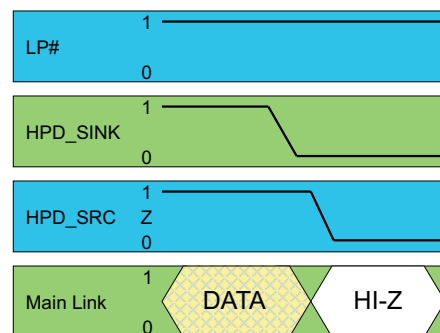


Figure 19.

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) | Op Temp (°C) | Top-Side Markings (4) | Samples |
|------------------|---------------|--------------|--------------------|------|-------------|----------------------------|------------------|----------------------|--------------|--------------------------|-------------------------|
| SN75DP120RHHR | ACTIVE | VQFN | RHH | 36 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR | 0 to 85 | DP120 | Samples |
| SN75DP120RHHT | ACTIVE | VQFN | RHH | 36 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR | 0 to 85 | DP120 | Samples |

(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.

OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

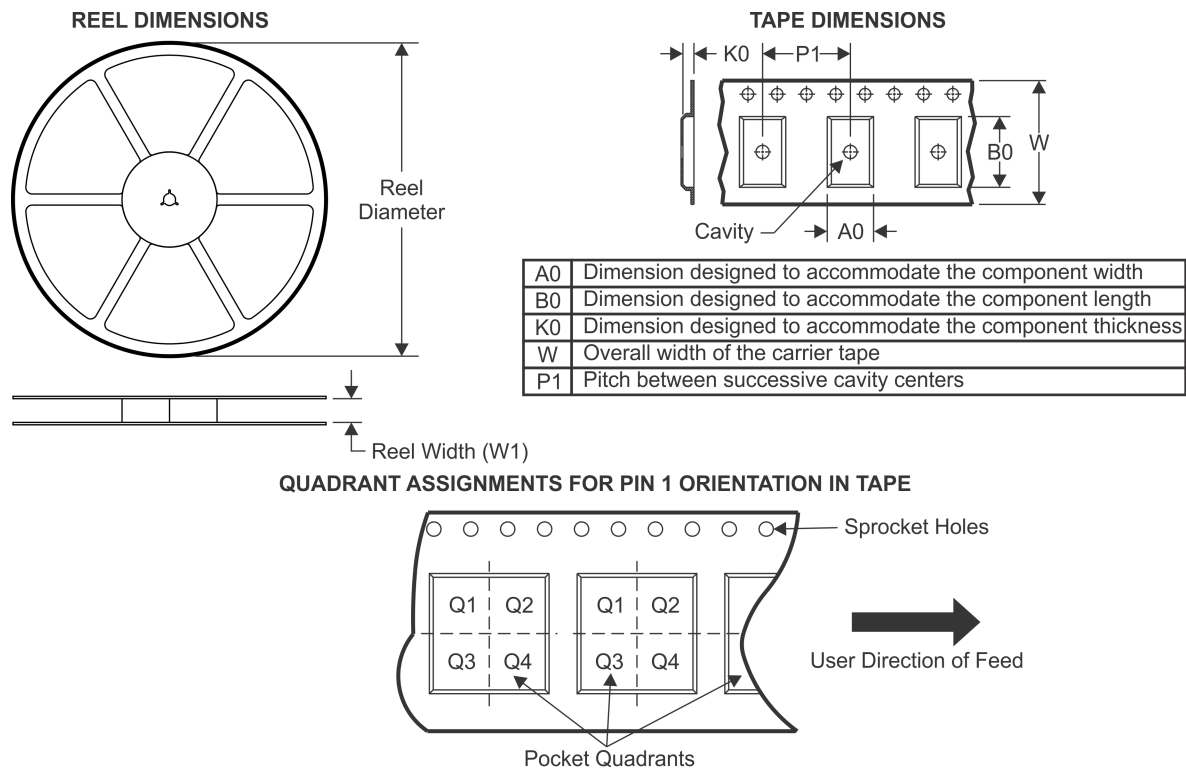
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

(4) Only one of markings shown within the brackets will appear on the physical device.

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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 |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| SN75DP120RHHR | VQFN | RHH | 36 | 2500 | 330.0 | 16.4 | 6.3 | 6.3 | 1.1 | 12.0 | 16.0 | Q2 |
| SN75DP120RHHT | VQFN | RHH | 36 | 250 | 180.0 | 16.4 | 6.3 | 6.3 | 1.1 | 12.0 | 16.0 | Q2 |

TAPE AND REEL BOX DIMENSIONS

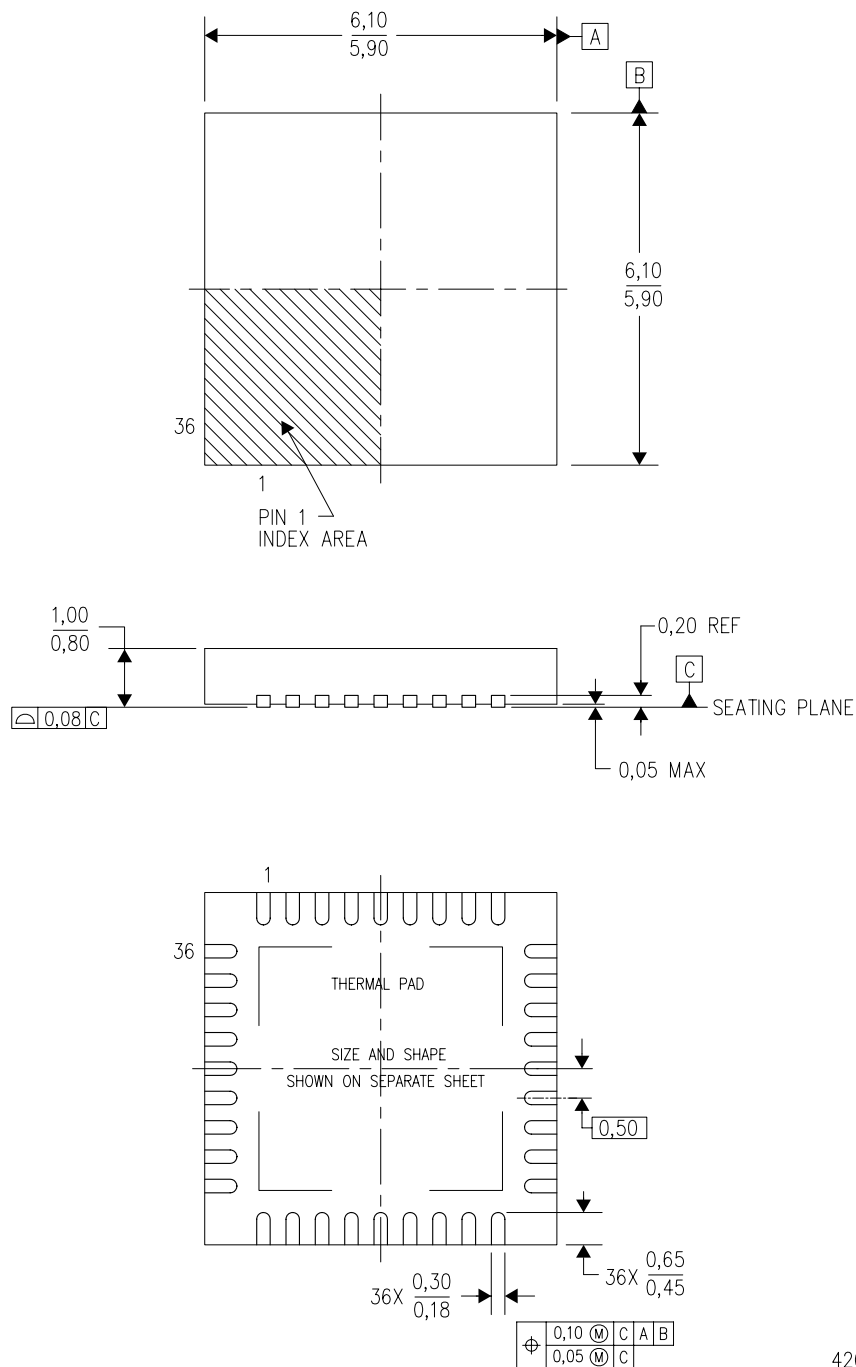


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| SN75DP120RHHR | VQFN | RHH | 36 | 2500 | 367.0 | 367.0 | 38.0 |
| SN75DP120RHHT | VQFN | RHH | 36 | 250 | 210.0 | 185.0 | 35.0 |

RHH (S-PVQFN-N36)

PLASTIC QUAD FLATPACK NO-LEAD



4205094/E 06/11

- 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. QFN (Quad Flatpack No-Lead) Package configuration.
 - D. The package thermal pad must be soldered to the board for thermal and mechanical performance.
 - E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
 - F. Falls within JEDEC MO-220.

RHH (S-PVQFN-N36)

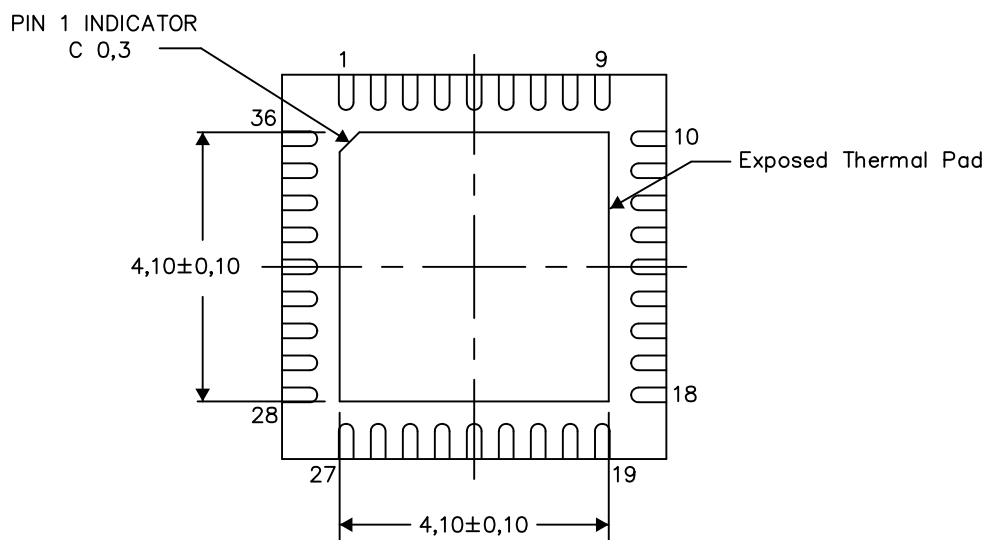
PLASTIC QUAD FLATPACK NO-LEAD

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.



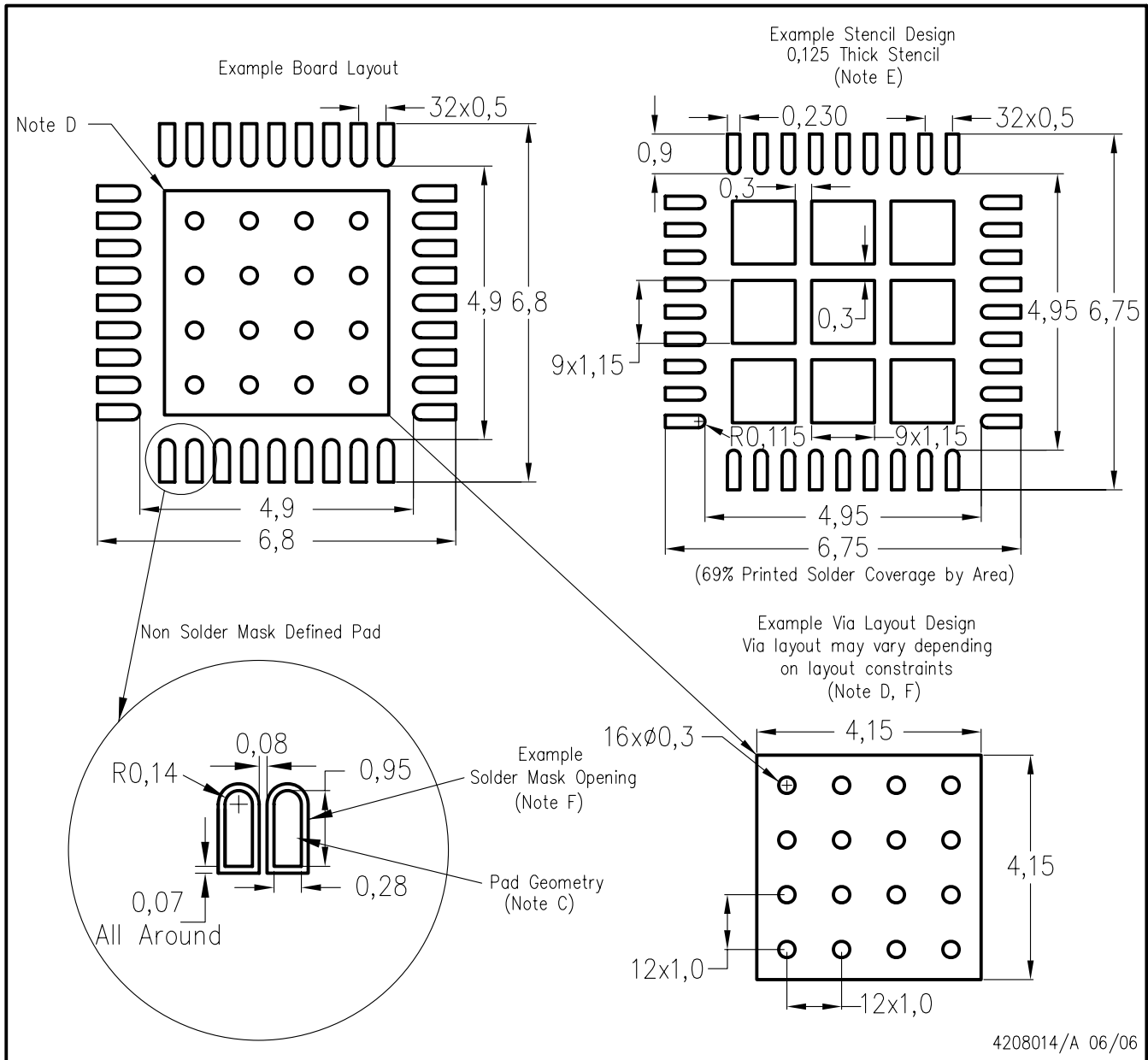
Bottom View

Exposed Thermal Pad Dimensions

4206362-3/L 10/12

NOTE: All linear dimensions are in millimeters

RHH (S-PQFP-N36)



4208014/A 06/06

- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Publication IPC-7351 is recommended for alternate designs.
 - D. This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat-Pack Packages, Texas Instruments Literature No. SCBA017, SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <<http://www.ti.com>>.
 - E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
 - F. Customers should contact their board fabrication site for recommended solder mask tolerances and via tenting recommendations for vias placed in the thermal pad.

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