

## DockPort Controller

Check for Samples: [HD3SS2521](#)

### FEATURES

- **Ideal for DockPort Applications**
  - Bi-Directional 2:1 Switch for USB 2.0 (HS/FS/LS) and HPD Signals
  - Bi-Directional 2:1 Switch for SuperSpeed USB and DisplayPort Signals
  - Integrated DockPort Controller Manages DockPort Detection, Signal Switching and Power Switching
- Supports Host-and Dock-side Applications
- VCC Operating Range 3.3V ± 10%
- SuperSpeed USB I/O Supports Common Mode Voltage from 0V to 2.2V
- USB 2.0 I/O Supports Signal Up to 3.6V
- Wide –3dB Differential BW on High-bandwidth Path of over 6 GHz
- Excellent High-bandwidth Path Dynamic Characteristics on (at 2.5GHz)
  - Crosstalk = –39dB
  - Isolation = –22dB
  - Insertion Loss = –1.2dB
  - Return Loss = 12 dB
  - Max Bit-Bit Skew = 8 ps
- 5mm x11mm, 56-Pin WQFN Package (RHU)

- **ESD**
  - HBM: 2000V
  - CDM: 500V

### APPLICATIONS

- Desktop PCs
- Notebook PCs
- Tablets
- Docking Station

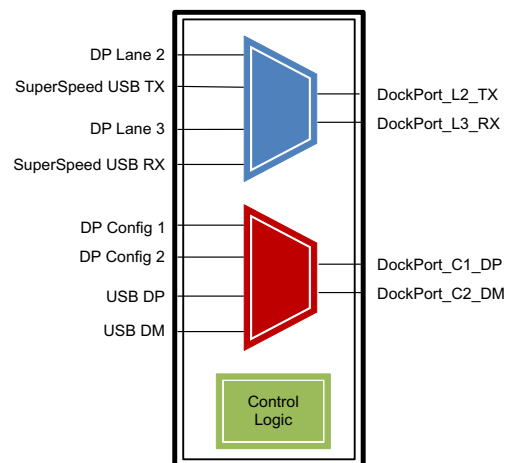


Figure 1. DockPort Functional Diagram

### DESCRIPTION

The HD3SS2521 is an integrated DockPort switch solution. It provides independent 2:1 passive switching for the SuperSpeed USB and Display Port signals as well as for the USB 2.0 (HS/FS/LS) and I2C necessary to support DockPort applications. In addition, a firmware upgradable integrated DockPort controller is provided to manage host and dock side DockPort detection, signal switch and power configuration.

The HD3SS2521 is offered in 56-pin WQFN package and is specified to operate from a single supply voltage of 3.3V over the temperature range of 0°C to 70°C .

**PRODUCT PREVIEW**


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.

PRODUCT PREVIEW information concerns products in the formative or design phase of development. Characteristic data and other specifications are design goals. Texas Instruments reserves the right to change or discontinue these products without notice.

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# HD3SS2521

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This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

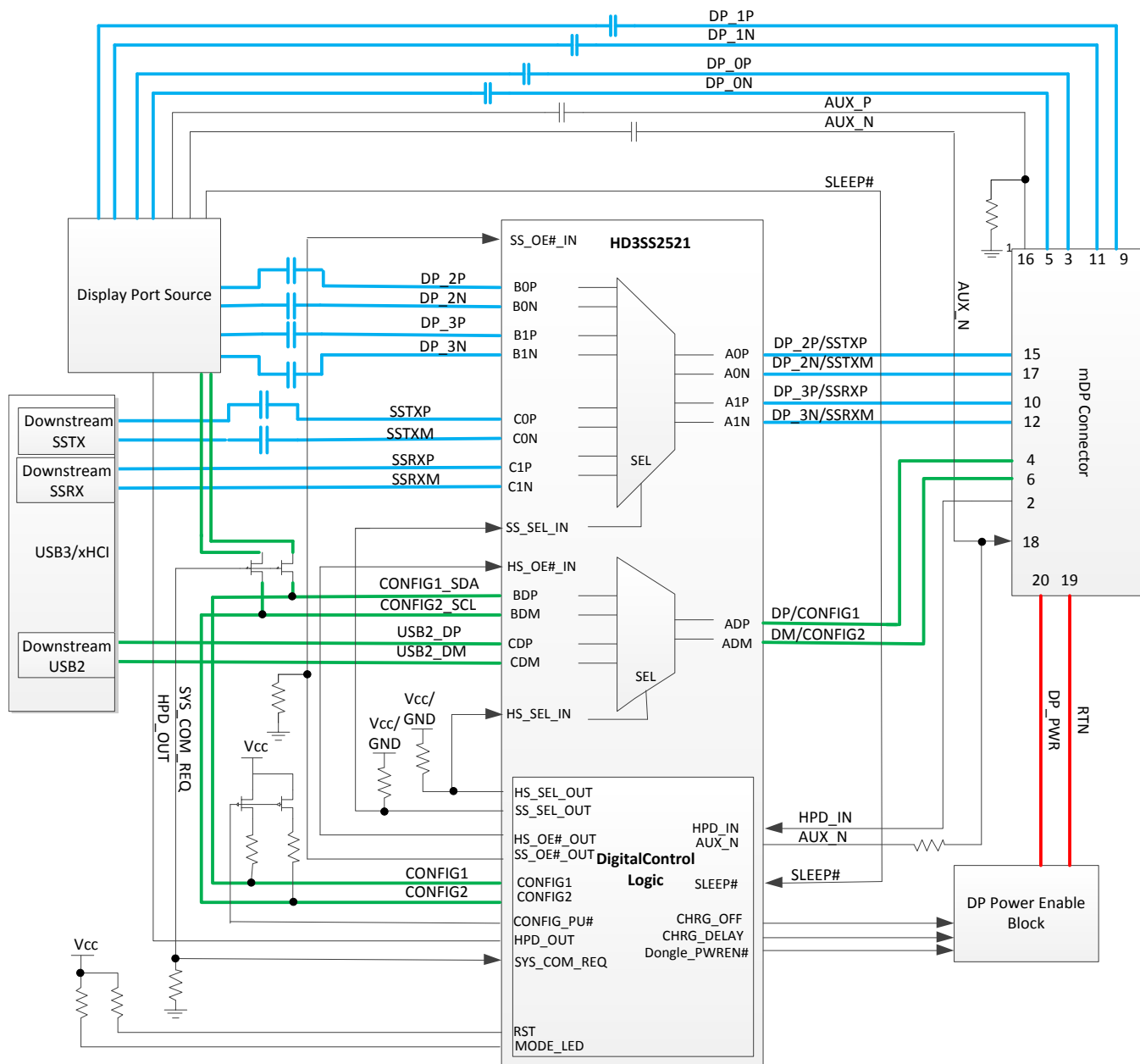
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## ORDERING INFORMATION

| PART NUMBER   | PART MARKING | PACKAGE                  |
|---------------|--------------|--------------------------|
| HD3SS2521RHUR | HD3S2521     | 56-Pin WQFN (Reel Large) |
| HD3SS2521RHUT | HD3S2521     | 56-Pin WQFN (Reel Small) |

PRODUCT PREVIEW

## TYPICAL APPLICATION



NOTE: Refer to the implementation guide for details on design considerations and configuration options

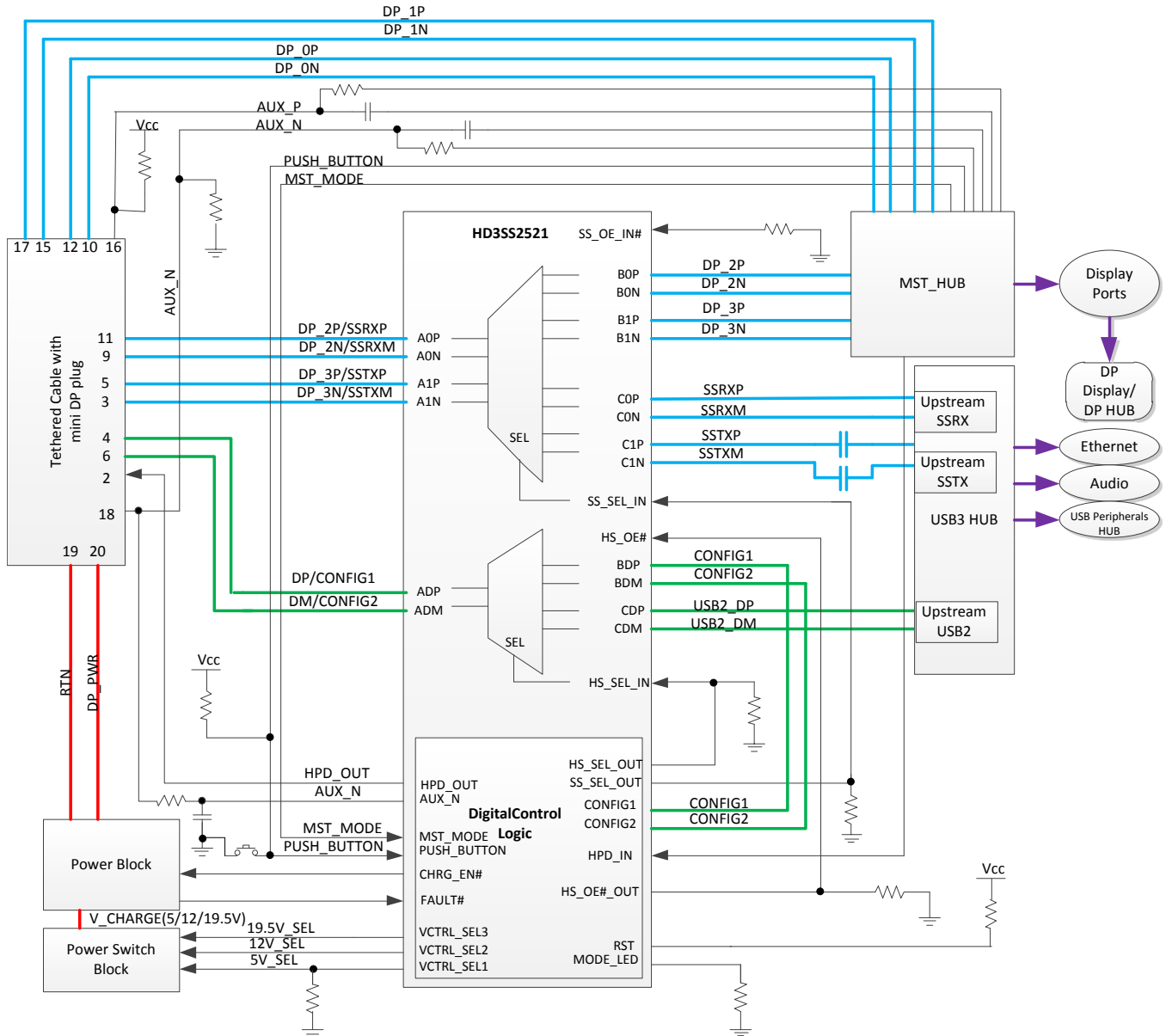
Figure 2. DockPort Host Implementation

PRODUCT PREVIEW

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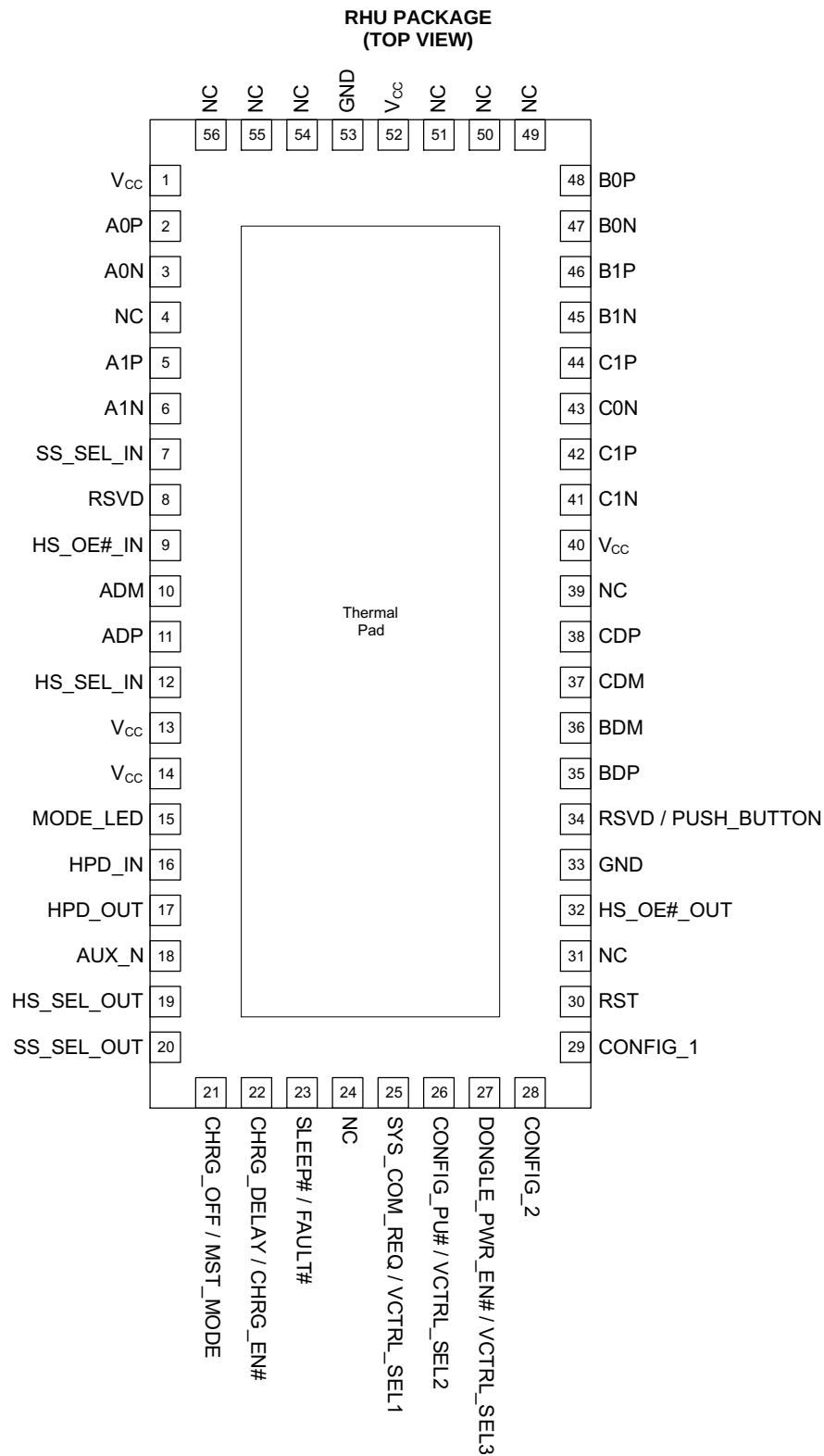
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NOTE: Refer to the implementation guide for details on design considerations and configuration options

**Figure 3. DockPort Hub Implementation**



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## PIN FUNCTIONS

| PIN | I/O | PIN NAME            | DockPort HOST<br>(SIGNAL MUX)                                                                                            | DockPort DEVICE<br>(SIGNAL DE-MUX) | SIGNAL<br>SPEED<br>(MAX)                                                                                                   |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
|-----|-----|---------------------|--------------------------------------------------------------------------------------------------------------------------|------------------------------------|----------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2   | I/O | A0P                 | DockPort Lane 2, Positive Signal<br>(DockPort cable between DockPort host and DockPort device)                           |                                    | Fast Lane<br>(Up to<br>5.4Gbps)                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
| 3   | I/O | A0N                 |                                                                                                                          |                                    |                                                                                                                            | DockPort Lane 2, Negative Signal<br>(DockPort cable between DockPort host and DockPort device) |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
| 5   | I/O | A1P                 |                                                                                                                          |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  | DockPort Lane 3, Positive Signal (DockPort cable between DockPort host and DockPort device) |                                                                                                                                                                                                 |
| 6   | I/O | A1N                 |                                                                                                                          |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
| 48  | I/O | B0P                 | DisplayPort Lane 2, Positive Signal                                                                                      |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
| 47  | I/O | B0N                 |                                                                                                                          |                                    | DisplayPort Lane 2, Negative Signal                                                                                        |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
| 46  | I/O | B1P                 |                                                                                                                          |                                    |                                                                                                                            |                                                                                                | DisplayPort Lane 3, Positive Signal                                                                                                                                              |                                                                                             |                                                                                                                                                                                                 |
| 45  | I/O | B1N                 |                                                                                                                          |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             | DisplayPort Lane 3, Negative Signal                                                                                                                                                             |
| 44  | I/O | C0P                 | SuperSpeed USB TX, Positive Signal                                                                                       |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
| 43  | I/O | C0N                 |                                                                                                                          |                                    | SuperSpeed USB RX, Positive Signal                                                                                         |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
| 42  | I/O | C1P                 |                                                                                                                          |                                    |                                                                                                                            |                                                                                                | SuperSpeed USB TX, Negative Signal                                                                                                                                               |                                                                                             |                                                                                                                                                                                                 |
| 41  | I/O | C1N                 |                                                                                                                          |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             | SuperSpeed USB RX, Negative Signal                                                                                                                                                              |
| 11  | I/O | ADP                 | DockPort Config1 (DockPort cable between DockPort host and DockPort device)                                              |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
| 10  | I/O | ADM                 |                                                                                                                          |                                    | DockPort Config2 (DockPort cable between DockPort host and DockPort device)                                                |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
| 35  | I/O | BDP                 |                                                                                                                          |                                    |                                                                                                                            |                                                                                                | CONFIG 1                                                                                                                                                                         |                                                                                             |                                                                                                                                                                                                 |
| 36  | I/O | BDM                 |                                                                                                                          |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             | CONFIG 2                                                                                                                                                                                        |
| 37  | I/O | CDP                 | High-speed USB D+                                                                                                        |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
| 38  | I/O | CDM                 |                                                                                                                          |                                    | High-speed USB D-                                                                                                          |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
| 7   | I   | SS_SEL_IN           |                                                                                                                          |                                    |                                                                                                                            |                                                                                                | DisplayPort / SuperSpeed USB Mux Select (Connect to SS_SEL_OUT - Pin 20)                                                                                                         |                                                                                             |                                                                                                                                                                                                 |
| 12  | I   | HS_SEL_IN           |                                                                                                                          |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             | DisplayPort / HighSpeed USB Mux Select (Connect to HS_SEL_OUT - Pin 19)                                                                                                                         |
| 8   | I   | RSVD<br>(SS_OE#_IN) | N/C<br>For future compatibility (Connect to<br>RSVD [SS_OE#_OUT] signal - Pin 34)                                        |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
| 9   | I   | HS_OE#_IN           |                                                                                                                          |                                    | N/C<br>Requires external 10 kΩ Pull-down.                                                                                  |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
| 15  | I/O | MODE_LED            |                                                                                                                          |                                    |                                                                                                                            |                                                                                                | This signal is sampled at power on or<br>reset to determine the mode of operation:<br>Pulled High for DockPort host operation.<br>(Optionally through LED for debug<br>purposes) |                                                                                             |                                                                                                                                                                                                 |
| 16  | I   | HPD_IN              |                                                                                                                          |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             | This signal is sampled at power on or<br>reset to determine the mode of<br>operation:<br>Pulled Low for DockPort hub<br>(dock/dongle) operation. (Optionally<br>through LED for debug purposes) |
| 17  | O   | HPD_OUT             | Hot Plug Detect from DockPort device                                                                                     |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
| 18  | I/O | AUX_N               |                                                                                                                          |                                    | Hot Plug Detect from MST Hub/DP<br>Device                                                                                  |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
|     |     |                     |                                                                                                                          |                                    |                                                                                                                            |                                                                                                | Hot Plug Detect to System Graphics                                                                                                                                               |                                                                                             |                                                                                                                                                                                                 |
|     |     |                     |                                                                                                                          |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             | Hot Plug Detect to DockPort host.                                                                                                                                                               |
|     |     |                     | AUX Negative Pull-Up to DockPort<br>device (Output)<br>This signal indicates a connection event<br>to a DockPort device. |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
|     |     |                     |                                                                                                                          |                                    | AUX Negative from DockPort host<br>(Input)<br>This signal is used to detect a<br>connection event from a DockPort<br>host. |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
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|     |     |                     |                                                                                                                          |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
|     |     |                     |                                                                                                                          |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
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|     |     |                     |                                                                                                                          |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
|     |     |                     |                                                                                                                          |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
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|     |     |                     |                                                                                                                          |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
|     |     |                     |                                                                                                                          |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
|     |     |                     |                                                                                                                          |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
|     |     |                     |                                                                                                                          |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
|     |     |                     |                                                                                                                          |                                    |                                                                                                                            |                                                                                                |                                                                                                                                                                                  |                                                                                             |                                                                                                                                                                                                 |
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**PIN FUNCTIONS (continued)**

| PIN | I/O | PIN NAME    | DockPort HOST<br>(SIGNAL MUX)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | DockPort DEVICE<br>(SIGNAL DE-MUX)                                                                                                                                                                                                 | SIGNAL<br>SPEED<br>(MAX) |
|-----|-----|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| 19  | O   | HS_SEL_OUT  | DisplayPort / High-speed USB Mux Select (Connect to HS_SEL_IN - Pin 12)<br>This signal in conjunction with SS_SEL_OUT is sampled at power-on or reset to determine the voltage level supplied to a DockPort host and must be strapped to correct logic level for the corresponding voltage level: 5 V, 12 V or 19 V.<br>Refer to the Power Delivery Voltage Selection table for strapping options.<br>After power-on/reset, this signal is driven by DockPort host to select the device operation between DisplayPort and High-speed USB.<br>0 = DisplayPort<br>1 = High-speed USB      |                                                                                                                                                                                                                                    |                          |
| 20  | O   | SS_SEL_OUT  | DisplayPort / SuperSpeed USB Mux Select (Connect to SS_SEL_IN - Pin 7)<br>This signal in conjunction with HS_SEL_OUT is sampled at power-on or reset to determine the voltage level to be supplied to a DockPort host and must be strapped to correct logic level for the corresponding voltage level: 5 V, 12 V or 19 V.<br>Refer to the Power Delivery Voltage Selection table for strapping options.<br>After power-on/reset, this signal is driven by DockPort host to select the device operation between DisplayPort and SuperSpeed USB.<br>0 = DisplayPort<br>1 = SuperSpeed USB |                                                                                                                                                                                                                                    |                          |
| 28  | I/O | CONFIG_2    | DisplayPort CONFIG2/CEC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                    |                          |
| 29  | I/O | CONFIG_1    | DisplayPort CONFIG1/CAD                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                    |                          |
| 21  | O   | CHRG_OFF    | This signal controls the power delivery circuit.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | —                                                                                                                                                                                                                                  |                          |
|     |     | MST_MODE    | —                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | MST Mode Input from MST HUB which indicates 2/4 DisplayPort lane switch.<br>0 = 2-lane (external 10 kΩ Pull-down)<br>1 = 4-lane (external 10 kΩ Pull-up)                                                                           |                          |
| 22  | O   | CHRG_DELAY  | This signal controls the power delivery circuit.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | —                                                                                                                                                                                                                                  |                          |
|     |     | CHRG_EN#    | —                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | This signal is the power delivery enable for a DockPort hub.                                                                                                                                                                       |                          |
| 23  | I   | SLEEP#      | Connect to the DockPort host sleep state signal.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | —                                                                                                                                                                                                                                  |                          |
|     |     | FAULT#      | —                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Connect to the fault indicator of the power management circuit                                                                                                                                                                     |                          |
| 25  | I   | SYS_COM_REQ | External 100K Pull-down required. This signal is a sampled at power on or reset to determine if the system is in a FW update mode.<br>After power on reset, the signal is used for communication request via a GPIO in a DockPort host for communication request                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                    |                          |
|     | O   | VCTRL_SEL1  | —                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Power enable for 5 V power delivery<br>In addition, this signal is sampled at power on or reset to determine the mode of operation:<br>0 = DockPort hub (external 10 kΩ Pull-down)<br>1 = DockPort dongle (external 10 kΩ Pull-up) |                          |

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## PIN FUNCTIONS (continued)

| PIN                                          | I/O    | PIN NAME             | DockPort HOST<br>(SIGNAL MUX)                                                                                                 | DockPort DEVICE<br>(SIGNAL DE-MUX)                                                                          | SIGNAL<br>SPEED<br>(MAX) |
|----------------------------------------------|--------|----------------------|-------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|--------------------------|
| 26                                           | O      | CONFIG_PU#           | Connect to FET switch to control pull-up option on DisplayPort CONFIG1/CONFIG2 for DockPort communication.                    | —                                                                                                           |                          |
|                                              |        | VCTRL_SEL2           | —                                                                                                                             | Power enable for 12 V power delivery                                                                        |                          |
| 27                                           | O      | Dongle_PWREN#        | Power enable for 5 V DockPort dongle power circuitry                                                                          | —                                                                                                           |                          |
|                                              |        | VCTRL_SEL3           | —                                                                                                                             | Power enable for 19 V power delivery                                                                        |                          |
| 34                                           | O      | RSVD<br>(SS_OE#_OUT) | N/C<br>For future compatibility (Connect to RSVD [SS_OE#_IN] signal - Pin 8)                                                  | —                                                                                                           |                          |
|                                              | I      | PUSH_BUTTON          | —                                                                                                                             | External 5.6 kΩ Pull-up required. Push button input to DockPort hub and MST HUB for 2-lane/4-lane switching |                          |
| 32                                           | O      | HS_OE#_OUT           | DisplayPort / High-speed USB Mux Enable. (Connect to HS_OE#_IN - Pin 9)<br>An external 10 kΩ Pull-down to ground is required. |                                                                                                             |                          |
| 30                                           | I/O    | RST                  | Reset                                                                                                                         |                                                                                                             |                          |
| 33<br>39<br>53                               | GND    | GND                  | Connect to Supply Ground                                                                                                      |                                                                                                             |                          |
| 24<br>31<br>49<br>50<br>51<br>54<br>55<br>56 | NC     | NC                   | No Connect                                                                                                                    |                                                                                                             |                          |
| 1<br>4<br>13<br>14<br>40<br>52               | Supply | VCC                  | 3.3V Positive power supply voltage                                                                                            |                                                                                                             |                          |

PRODUCT PREVIEW

**Table 1. Power Delivery Voltage Selection**

| VOLTAGE | HS_SEL_OUT | SS_SEL_OUT |
|---------|------------|------------|
| 0 V     | 0          | 0          |
| 12 V    | 0          | 1          |
| 19 V    | 1          | 0          |
| 5 V     | 1          | 1          |

**ABSOLUTE MAXIMUM RATINGS<sup>(1) (2)</sup>**

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

|                                     |                                                                    | MIN               | MAX            | UNIT |
|-------------------------------------|--------------------------------------------------------------------|-------------------|----------------|------|
| Supply Voltage Range <sup>(2)</sup> | VCC                                                                | –0.3              | 4              | V    |
| Voltage Range                       | Differential I/O (High bandwidth signal path, AxP/N, BxP/N, CxP/N) | –0.5              | 4              | V    |
|                                     | Differential I/O (Low bandwidth signal path, ADP/M, BDP/M, CDP/M)  | –0.5              | 7              | V    |
|                                     | Control Pin and Single Ended I/O                                   | –0.3              | $V_{CC} + 0.3$ | V    |
| Electrostatic discharge             | Human body model <sup>(3)</sup>                                    |                   | ±2000          | V    |
|                                     | Charged-device model <sup>(4)</sup>                                |                   | ±500           | V    |
| Continuous power dissipation        |                                                                    | See Thermal 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-B
- (4) Tested in accordance with JEDEC Standard 22, Test Method C101-A

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## THERMAL INFORMATION

| THERMAL METRIC <sup>(1)</sup> |                                              | HD3SS2521    | UNITS |
|-------------------------------|----------------------------------------------|--------------|-------|
|                               |                                              | RHU (56 PIN) |       |
| $\theta_{JA}$                 | Junction-to-ambient thermal resistance       | 31.6         | °C/W  |
| $\theta_{JCTop}$              | Junction-to-case (top) thermal resistance    | 15.9         |       |
| $\theta_{JB}$                 | Junction-to-board thermal resistance         | 8.5          |       |
| $\Psi_{JT}$                   | Junction-to-top characterization parameter   | 0.5          |       |
| $\Psi_{JB}$                   | Junction-to-board characterization parameter | 8.5          |       |

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, [SPRA953](#).

## RECOMMENDED OPERATING CONDITIONS

(Typical values for all parameters are at  $V_{CC} = 3.3V$  and  $T_A = 25^{\circ}C$ . All temperature limits are specified by design)

|                 |                                |                                                                          | MIN  | TYP | MAX      | UNITS           |
|-----------------|--------------------------------|--------------------------------------------------------------------------|------|-----|----------|-----------------|
| $V_{CC}$        | Supply voltage                 |                                                                          | 3    | 3.3 | 3.6      | V               |
| $V_{IH}$        | Input high voltage             | Control/Status Pins                                                      | 2    |     | $V_{CC}$ | V               |
| $V_{IL}$        | Input low voltage              | Control/Status Pins                                                      | -0.1 |     | 0.8      | V               |
| $V_{I/O\_Diff}$ | Differential voltage           | Switch I/O diff voltage (High-bandwidth path AxP/N, BxP/N, CxP/N)        | 0    |     | 1.8      | V <sub>pp</sub> |
| $V_{I/O\_CM}$   | Common voltage                 | Switch I/O common mode voltage (High-bandwidth path AxP/N, BxP/N, CxP/N) | 0    |     | 2        | V               |
| $V_{I/O}$       | Input/output voltage           | Data input/output voltage (Low-bandwidth path ADP/M, BDP/M, CDP/M)       | 0    |     | 5.5      | V               |
| $T_A$           | Operating free-air temperature |                                                                          | 0    |     | 70       | °C              |

## ELECTRICAL CHARACTERISTICS – DEVICE PARAMETERS

(under recommended operating conditions)

| PARAMETER                                                                                                                                                                                           |                                                                 | CONDITIONS                                                                                               | MIN                  | TYP                   | MAX | UNITS |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|----------------------|-----------------------|-----|-------|
| I <sub>CC</sub>                                                                                                                                                                                     | Supply Current                                                  | V <sub>CC</sub> = 3.6V, HS_SEL_IN/SS_SEL_IN = V <sub>CC</sub> /GND;<br>HS_OE#_IN = GND; Outputs Floating |                      | 4.5                   |     | mA    |
| AUX_N, CONFIG_1, CONFIG_2, FAULT#, HPD_IN, MODE_LED, PUSH_BUTTON, RST, SLEEP#, SYS_COM_REQ, TEST                                                                                                    |                                                                 |                                                                                                          |                      |                       |     |       |
| V <sub>IT+</sub>                                                                                                                                                                                    | Positive-going input threshold voltage                          |                                                                                                          | 0.45 V <sub>CC</sub> | 0.75 V <sub>CC</sub>  |     | V     |
| V <sub>IT-</sub>                                                                                                                                                                                    | Negative-going input threshold voltage                          |                                                                                                          | 0.25 V <sub>CC</sub> | 0.55 V <sub>CC</sub>  |     | V     |
| V <sub>hys</sub>                                                                                                                                                                                    | Input voltage hysteresis (V <sub>IT+</sub> – V <sub>IT-</sub> ) | V <sub>CC</sub> = 3V                                                                                     | 0.3                  |                       | 1   | V     |
| R <sub>PULL</sub>                                                                                                                                                                                   | Pullup/pulldown resistor                                        | Pullup: V <sub>IN</sub> = GND,<br>Pulldown: V <sub>IN</sub> = V <sub>CC</sub> , V <sub>CC</sub> = 3V     | 20                   | 35                    | 50  | kΩ    |
| C <sub>I</sub>                                                                                                                                                                                      | Input capacitance                                               | V <sub>IN</sub> = GND or V <sub>CC</sub>                                                                 |                      | 5                     |     | pF    |
| I <sub>LK</sub>                                                                                                                                                                                     | High-impedance leakage current                                  | V <sub>IN</sub> = GND or V <sub>CC</sub> , V <sub>CC</sub> = 3V, Pullup/Pulldown disabled                |                      |                       | ±50 | nA    |
| AUX_N, CHRG_DELAY, CHRG_EN, CHRG_OFF, CONFIG_1, CONFIG_2, CONFIG_PU#, Dongle_PWREN#, HPD_OUT, HS_OE#_OUT, HS_SEL_OUT, MODE_LED, MST_MODE, SS_SEL_OUT, RST, TEST, VCTRL_SEL1, VCTRL_SEL2, VCTRL_SEL3 |                                                                 |                                                                                                          |                      |                       |     |       |
| V <sub>OH</sub>                                                                                                                                                                                     | High-level outptut voltage                                      | I <sub>OHmax</sub> = –6 mA <sup>(1)</sup>                                                                |                      | V <sub>CC</sub> – 0.3 |     | V     |
| V <sub>OL</sub>                                                                                                                                                                                     | Low-level outptut voltage                                       | I <sub>OLmax</sub> = 6 mA <sup>(1)</sup>                                                                 |                      | GND + 0.3             |     | V     |
| SS_SEL_IN                                                                                                                                                                                           |                                                                 |                                                                                                          |                      |                       |     |       |
| I <sub>IH</sub>                                                                                                                                                                                     | Input High Current                                              | V <sub>CC</sub> = 3.6V, V <sub>IN</sub> = V <sub>CC</sub>                                                |                      |                       | 95  | μA    |
| I <sub>IL</sub>                                                                                                                                                                                     | Input Low Current                                               | V <sub>CC</sub> = 3.6V, V <sub>IN</sub> = GND                                                            |                      |                       | 1   |       |

(1) The maximum total current,  $I_{OHmax}$  and  $I_{OLmax}$ , for all outputs combined should not exceed  $\pm 48\text{ mA}$  to hold the maximum voltage drop specified.

## ELECTRICAL CHARACTERISTICS – DEVICE PARAMETERS (continued)

(under recommended operating conditions)

| PARAMETER              |                                | CONDITIONS                                                                                                            | MIN | TYP | MAX | UNITS |
|------------------------|--------------------------------|-----------------------------------------------------------------------------------------------------------------------|-----|-----|-----|-------|
| HS_OE#_IN , HS_SEL_IN  |                                |                                                                                                                       |     |     |     |       |
| I <sub>IH</sub>        | Input High Current             | V <sub>CC</sub> = 3.6V, V <sub>IN</sub> = V <sub>CC</sub>                                                             |     |     | 1   | μA    |
| I <sub>IL</sub>        | Input Low Current              | V <sub>CC</sub> = 3.6V, V <sub>IN</sub> = GND                                                                         |     |     | 1   | μA    |
| AxP/N, BxP/N, CxP/N    |                                |                                                                                                                       |     |     |     |       |
| I <sub>LK</sub>        | High-impedance leakage current | V <sub>CC</sub> = 3.6V, V <sub>IN</sub> = 0V, V <sub>OUT</sub> = 2V<br>(I <sub>LK</sub> on open outputs Port B and C) |     |     | 130 | μA    |
|                        |                                | V <sub>CC</sub> = 3.6V, V <sub>IN</sub> = 0V, V <sub>OUT</sub> = 2V<br>(I <sub>LK</sub> on open outputs Port A)       |     |     | 4   |       |
| ADP/DM, BDP/DM, CDP/DM |                                |                                                                                                                       |     |     |     |       |
| I <sub>LK</sub>        | High-impedance leakage current | V <sub>CC</sub> = 3.6V, V <sub>IN</sub> = 0V, V <sub>OUT</sub> = 0V to 4V,<br>HS_OE#_IN = GND                         |     |     | 1   | μA    |

## ELECTRICAL CHARACTERISTICS – SIGNAL SWITCH PARAMETERS

(under recommended operating conditions; R<sub>L</sub>, R<sub>sc</sub> = 50Ω, C<sub>L</sub> = 10pF unless otherwise noted)

| PARAMETER                                                |                                                                       | CONDITIONS                                                                         | MIN | TYP  | MAX  | UNITS |
|----------------------------------------------------------|-----------------------------------------------------------------------|------------------------------------------------------------------------------------|-----|------|------|-------|
| <b>AxP/IN, BxP/IN, CxP/IN HIGH-BANDWIDTH SIGNAL PATH</b> |                                                                       |                                                                                    |     |      |      |       |
| t <sub>PD</sub>                                          | Switch Propagation Delay                                              | R <sub>sc</sub> and R <sub>L</sub> = 50 Ω, See <a href="#">Figure 5</a>            |     |      | 85   | ps    |
| T <sub>on</sub>                                          | SS_SEL_IN -to-Switch T <sub>on</sub>                                  | R <sub>sc</sub> and R <sub>L</sub> = 50 Ω, See <a href="#">Figure 4</a>            |     | 70   | 250  | ns    |
| T <sub>off</sub>                                         | SS_SEL_IN -to-Switch T <sub>off</sub>                                 |                                                                                    |     | 70   | 250  |       |
| T <sub>SK(O)</sub>                                       | Inter-Pair Output Skew (CH-CH)                                        | R <sub>sc</sub> and R <sub>L</sub> = 50 Ω, See <a href="#">Figure 5</a>            |     |      | 20   | ps    |
| T <sub>SK(b-b)</sub>                                     | Intra-Pair Output Skew (bit-bit)                                      |                                                                                    |     |      | 8    | ps    |
| C <sub>ON</sub>                                          | Outputs ON Capacitance                                                | V <sub>IN</sub> = 0V, Outputs Open, Switch ON                                      |     | 1.5  |      | pF    |
| C <sub>OFF</sub>                                         | Outputs OFF Capacitance                                               | V <sub>IN</sub> = 0V, Outputs Open, Switch OFF                                     |     | 1    |      | pF    |
| R <sub>ON</sub>                                          | Output ON resistance                                                  | V <sub>CC</sub> = 3.3V, V <sub>CM</sub> = 0.5V – 1.5V,<br>I <sub>O</sub> = –8 mA   |     | 5    | 8    | Ω     |
| ΔR <sub>ON</sub>                                         | On resistance match between channels                                  | V <sub>CC</sub> = 3.3V; –0.35V ≤ V <sub>IN</sub> ≤ 1.2V;<br>I <sub>O</sub> = –8 mA |     |      | 2    | Ω     |
|                                                          | On resistance match between pairs of the same channel                 |                                                                                    |     |      | 0.7  |       |
| R <sub>FLAT_ON</sub>                                     | On resistance flatness [R <sub>ON(MAX)</sub> – R <sub>ON(MIN)</sub> ] | V <sub>CC</sub> = 3.3V; –0.35V ≤ V <sub>IN</sub> ≤ 1.2V                            |     |      | 1.15 | Ω     |
| R <sub>L</sub>                                           | Differential Return Loss (V <sub>CM</sub> = 0V)                       | f = 2.5 GHz                                                                        |     | –12  |      | dB    |
|                                                          |                                                                       | f = 4.0 GHz                                                                        |     | –11  |      |       |
| X <sub>TALK</sub>                                        | Differential Crosstalk (V <sub>CM</sub> = 0V)                         | f = 2.5 GHz                                                                        |     | –39  |      | dB    |
|                                                          |                                                                       | f = 4.0 GHz                                                                        |     | –35  |      |       |
| O <sub>IRR</sub>                                         | Differential Off-Isolation (V <sub>CM</sub> = 0V)                     | f = 2.5 GHz                                                                        |     | –22  |      | dB    |
|                                                          |                                                                       | f = 4.0 GHz                                                                        |     | –19  |      |       |
| I <sub>L</sub>                                           | Differential Insertion Loss (V <sub>CM</sub> = 0V)                    | f = 2.5 GHz                                                                        |     | –1.1 |      | dB    |
|                                                          |                                                                       | f = 4.0 GHz                                                                        |     | –1.5 |      |       |
| BW                                                       | Bandwidth                                                             | At –3 dB                                                                           |     | 6    |      | GHz   |
| <b>ADP/DM, BDP/DM, CDP/DM SIGNAL PATH</b>                |                                                                       |                                                                                    |     |      |      |       |
| t <sub>PD</sub>                                          | Switch Propagation Delay                                              | R <sub>sc</sub> and R <sub>L</sub> = 50 Ω, See <a href="#">Figure 5</a>            |     | 250  |      | ps    |
| T <sub>on</sub>                                          | HS_SEL_IN -to-Switch T <sub>on</sub>                                  | R <sub>sc</sub> and R <sub>L</sub> = 50 Ω, See <a href="#">Figure 4</a>            |     |      | 30   |       |
|                                                          | HS_OE#_IN -to-Switch T <sub>on</sub>                                  |                                                                                    |     |      | 17   | ns    |
| T <sub>off</sub>                                         | HS_SEL_IN Toff                                                        | R <sub>sc</sub> and R <sub>L</sub> = 50 Ω, See <a href="#">Figure 4</a>            |     |      | 12   |       |
|                                                          | HS_OE#_IN -to-Switch Toff                                             |                                                                                    |     |      | 10   |       |
| T <sub>SK(O)</sub>                                       | Inter-Pair Output Skew (CH-CH)                                        | R <sub>sc</sub> and R <sub>L</sub> = 50 Ω, See <a href="#">Figure 5</a>            |     | 10   | 20   | ps    |
| T <sub>SK(b-b)</sub>                                     | Intra-Pair Output Skew (bit-bit)                                      |                                                                                    |     | 10   | 20   | ps    |
| C <sub>ON</sub>                                          | Outputs ON Capacitance                                                | V <sub>IN</sub> = V <sub>CC</sub> or 0V, Outputs Open,<br>Switch ON                |     | 6    | 7.5  | pF    |

## HD3SS2521

SLAS941A –APRIL 2013–REVISED MAY 2013

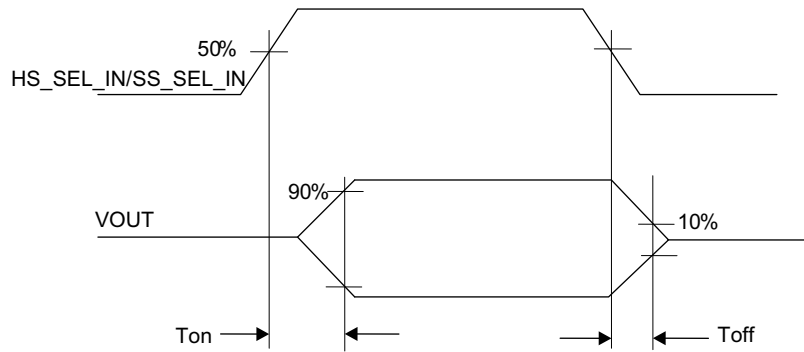
[www.ti.com](http://www.ti.com)

### ELECTRICAL CHARACTERISTICS – SIGNAL SWITCH PARAMETERS (continued)

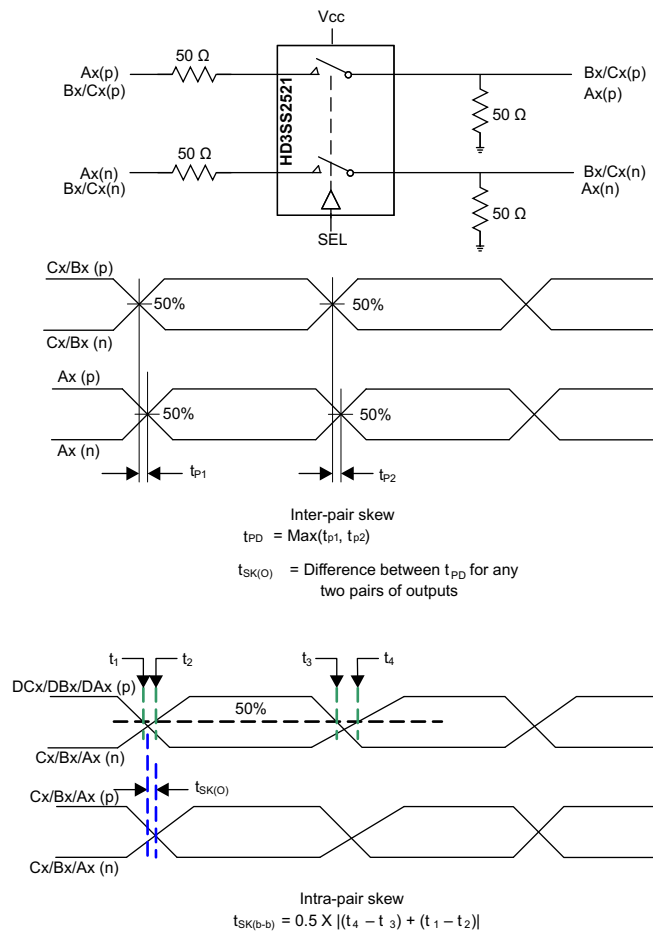
(under recommended operating conditions;  $R_L$ ,  $R_{sc} = 50\Omega$ ,  $C_L = 10\text{pF}$  unless otherwise noted)

| PARAMETER       |                                                           | CONDITIONS                                              | MIN | TYP | MAX | UNITS    |
|-----------------|-----------------------------------------------------------|---------------------------------------------------------|-----|-----|-----|----------|
| $C_{OFF}$       | Outputs OFF Capacitance                                   | $V_{IN} = V_{CC}$ or $0V$ , Outputs Open, Switch OFF    |     | 3.5 | 6   | pF       |
| $R_{ON}$        | Output ON resistance                                      | $V_{CC} = 3V$ , $V_{IN} = 0V$ , $I_O = 30\text{ mA}$    |     | 3   | 6   | $\Omega$ |
|                 |                                                           | $V_{CC} = 3V$ , $V_{IN} = 2.4V$ , $I_O = -15\text{ mA}$ |     | 3.4 | 6   |          |
| $\Delta R_{ON}$ | On resistance match                                       | $V_{CC} = 3V$ , $V_{IN} = 0V$ , $I_O = 30\text{ mA}$    |     | 0.2 |     | $\Omega$ |
|                 |                                                           | $V_{CC} = 3V$ , $V_{IN} = 1.7V$ , $I_O = -15\text{ mA}$ |     | 0.2 |     |          |
| $R_{FLAT\_ON}$  | On resistance flatness<br>[ $R_{ON(MAX)} - R_{ON(MIN)}$ ] | $V_{CC} = 3V$ , $V_{IN} = 0V$ , $I_O = 30\text{ mA}$    |     | 1   |     | W        |
|                 |                                                           | $V_{CC} = 3V$ , $V_{IN} = 1.7V$ , $I_O = -15\text{ mA}$ |     | 1   |     |          |
| $X_{TALK}$      | Differential Crosstalk ( $V_{CM} = 0V$ )                  | $R_L = 50\text{ W}$ , $f = 250\text{ MHz}$              |     | -40 |     | dB       |
| $O_{IRR}$       | Differential Off-Isolation ( $V_{CM} = 0V$ )              | $R_L = 50\text{ W}$ , $f = 250\text{ MHz}$              |     | -41 |     | dB       |
| BW              | Bandwidth                                                 | $R_L = 50\text{ W}$                                     |     | 0.9 |     | GHz      |

## TEST TIMING DIAGRAMS



**Figure 4. Select to Switch  $T_{on}$  and  $T_{off}$**



**NOTES:**

1. Measurements based on an ideal input with zero intra-pair skew on the input, i.e. the input at A to B/C or the input at B/C to A
2. Inter-pair skew is measured from lane to lane on the same channel, e.g. C0 to C1
3. Intra-pair skew is defined as the relative difference from the p and n signals of a single lane

**Figure 5. Propagation Delay and Skew**

## PACKAGING INFORMATION

| Orderable part number         | Status<br>(1) | Material type<br>(2) | Package   Pins  | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|-------------------------------|---------------|----------------------|-----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">HD3SS2521RHUR</a> | Active        | Production           | WQFN (RHU)   56 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-3-260C-168 HR               | 0 to 70      | HD3S2521            |
| HD3SS2521RHUR.A               | Active        | Production           | WQFN (RHU)   56 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-3-260C-168 HR               | 0 to 70      | HD3S2521            |
| HD3SS2521RHUR.B               | Active        | Production           | WQFN (RHU)   56 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-3-260C-168 HR               | 0 to 70      | HD3S2521            |
| HD3SS2521RHUT                 | Preview       | Production           | WQFN (RHU)   56 | 250   null            | -           | Call TI                              | Call TI                           | 0 to 70      |                     |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

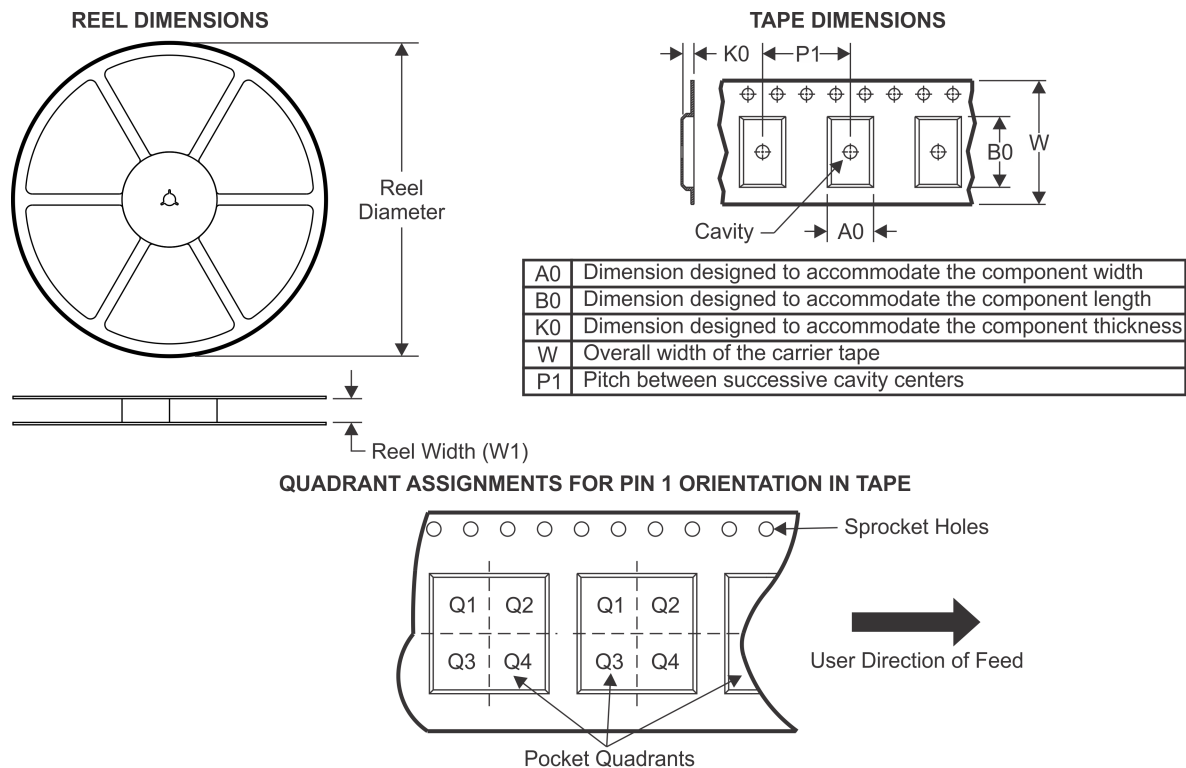
<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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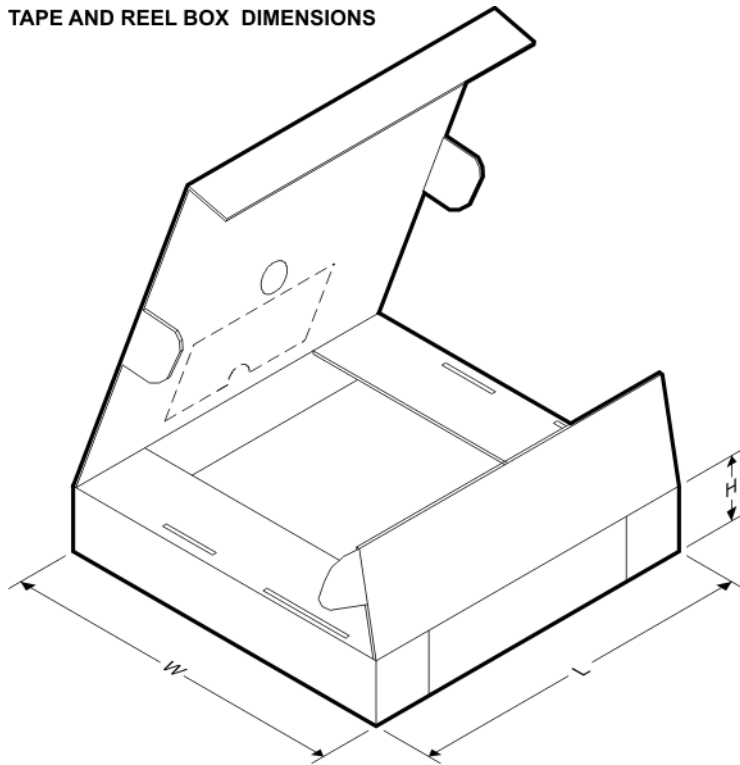
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**TAPE AND REEL INFORMATION**


\*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 |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| HD3SS2521RHUR | WQFN         | RHU             | 56   | 2000 | 330.0              | 24.4               | 5.3     | 11.3    | 1.0     | 8.0     | 24.0   | Q1            |

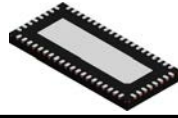
## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device        | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| HD3SS2521RHUR | WQFN         | RHU             | 56   | 2000 | 367.0       | 367.0      | 45.0        |

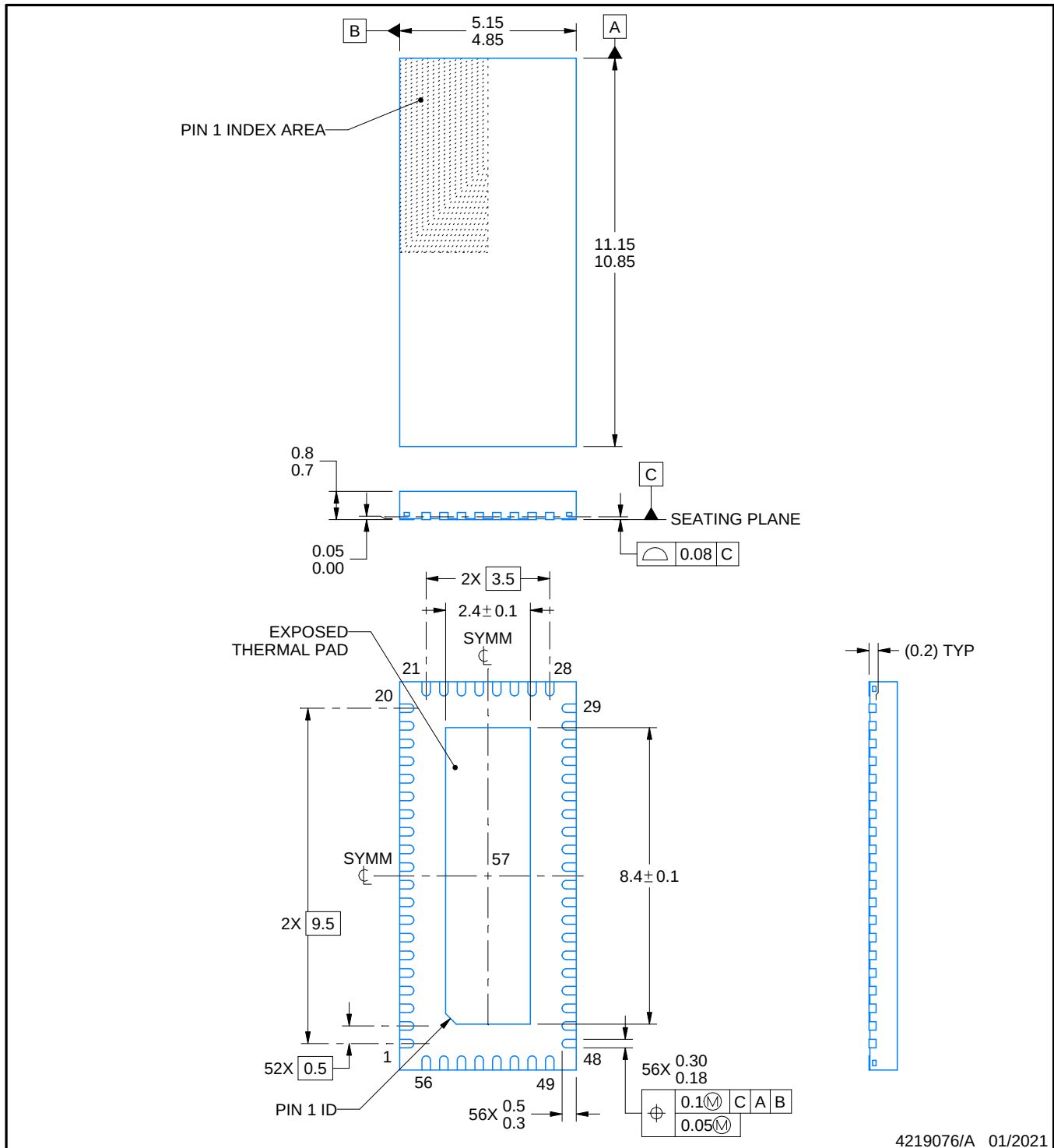
RHU0056A



# PACKAGE OUTLINE

## WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



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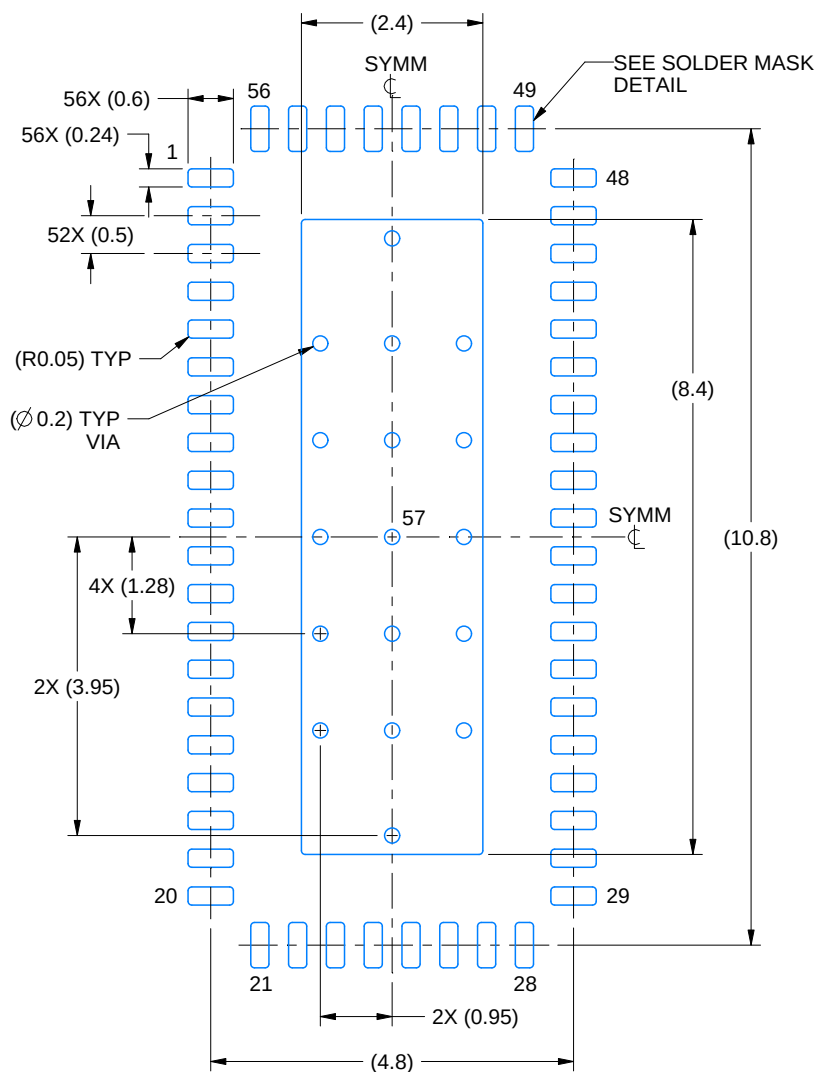
### NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

**RHU0056A**

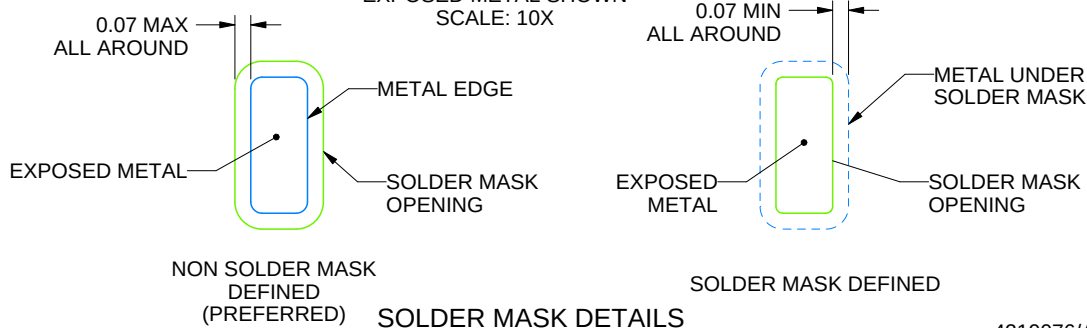
**WQFN - 0.8 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD



## LAND PATTERN EXAMPLE

EXPOSED METAL SHOWN  
SCALE: 10X



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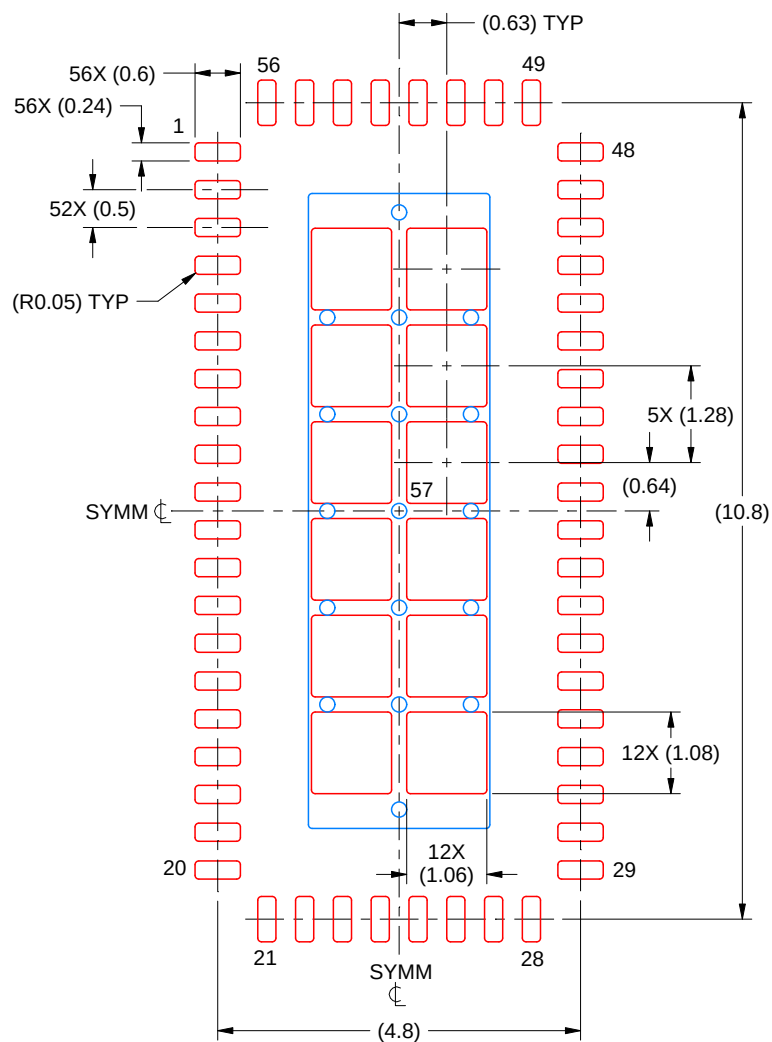
NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/slua271](http://www.ti.com/lit/slua271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

**RHU0056A**

**WQFN - 0.8 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD



SOLDER PASTE EXAMPLE  
BASED ON 0.125 MM THICK STENCIL  
SCALE: 10X

EXPOSED PAD 57  
68% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE

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NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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