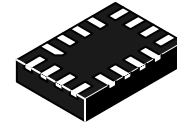


# Type-C CC with High Speed Digital (HSD) Port Protection Switch

## FUSB252



UQFN16 1.8 x 2.6, 0.4P  
CASE 523BF

### Description

The FUSB252 is an integrated port protection switch for USB Type-C<sup>®</sup> applications. This product will protect HSD+/- and CCx pins when stressed with voltages up to 20 V. Over-Voltage Protection (OVP) at 5.8 V typical will protect the system for Electrical Overstress (EOS) damage. With a fully integrated USB 2.0 switch for HSD+/-, this product can be easily integrated into existing solutions. The HSD switches can pass USB 2.0 signals with bandwidth 1 GHz to maintain signal integrity and eye compliance.

The CC switches have very low RON of 0.3 Ω to minimize signal attenuation. The FUSB252 also provides Dead Battery support per the Type-C specification. Additional features include Under-Voltage Lockout (UVLO) and thermal shutdown.

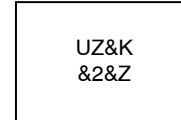
### Features

- Fully Type-C Port Protection
- Supports USB Type-C Specification 1.2
- V<sub>CC</sub> 0 V – 5.5 V
- 20 V DC Protection on V<sub>CC</sub>
- 16 V DC Protection on HSD Port
- V<sub>DD</sub> Operating Range, 2.7 V – 5.5 V
- Current Capability: 1 A
- CC R<sub>ON</sub>: 0.3 Ω Typical
- HSD R<sub>ON</sub>: 5 Ω Typical
- Wide -3 db Bandwidth: 1 GHz
- Low Power Operation: I<sub>CC</sub> = 9 μA Typical
- Dead Battery Support (UFP Support when No Power Applied)
- CC Over-Voltage Protection: Typical = 5.6 V
- This is a Pb-Free Device

### Applications

- Smartphones
- Tablets
- Laptops

### MARKING DIAGRAM



- UZ = Device Code
- &K = 2-Digit Lot Run Traceability Code
- &2 = 2-Digit Date Code
- &Z = Assembly Location

### ORDERING INFORMATION

See detailed ordering and shipping information on page 2 of this data sheet.

# FUSB252

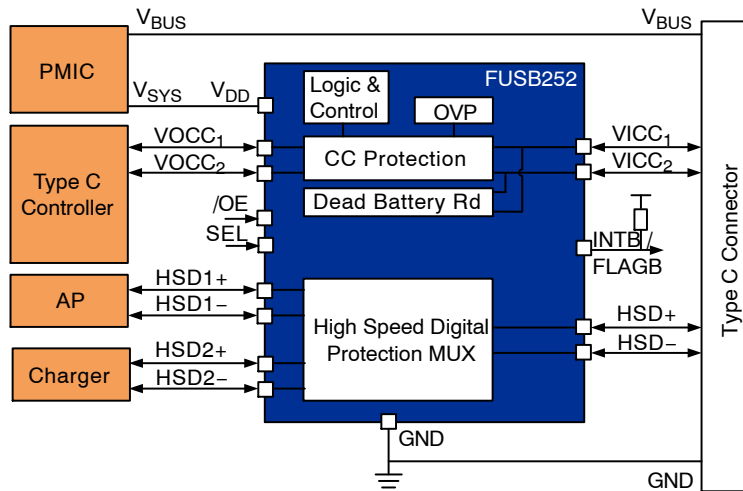


Figure 1. Typical Application

## ORDERING INFORMATION

| Part Number | Operating Temperature Range | Package   | Top Mark | Shipping†            |
|-------------|-----------------------------|---|----------|----------------------|
| FUSB252UMX  | -40 to 85°C                 | 16-Lead Ultrathin Molded Leadless Package (UMLP) 1.8 x 2.6 mm | UZ       | 5000 / Tape and Reel |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

# FUSB252

## BLOCK DIAGRAM

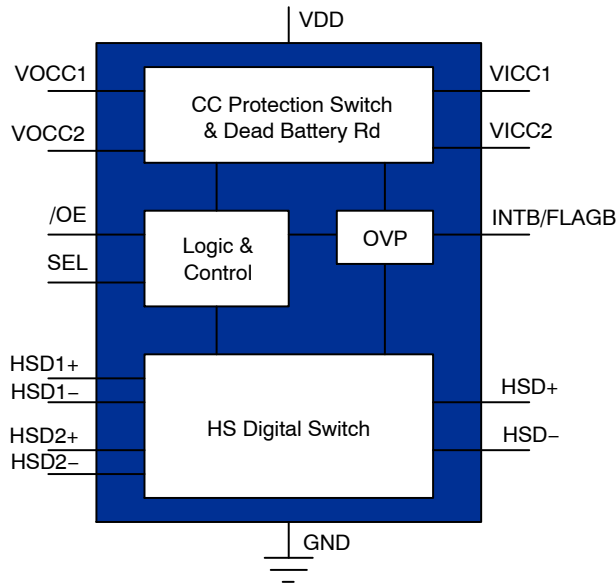


Figure 2. Block Diagram

## REFERENCE SCHEMATIC

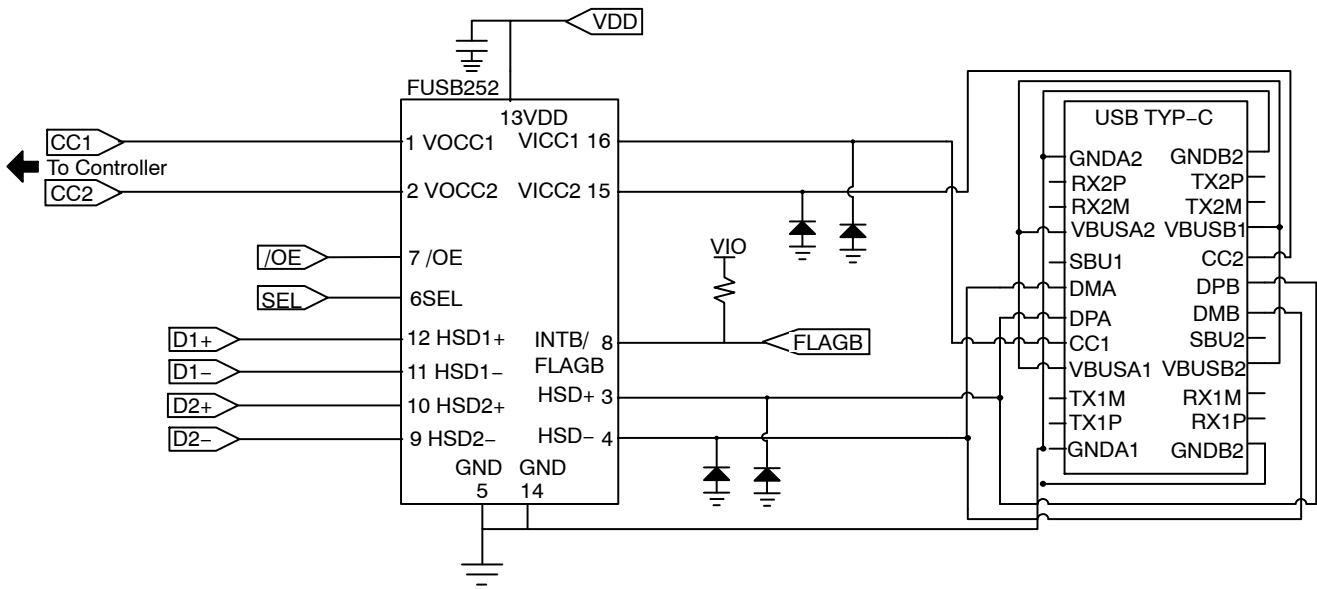


Figure 3. Reference Schematic

# FUSB252

## PIN CONFIGURATIONS

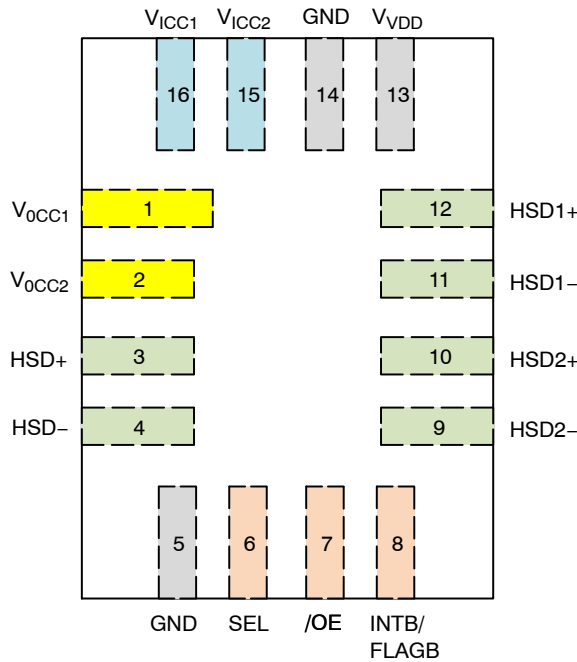


Figure 4. Pin Assignment (Top Through View)

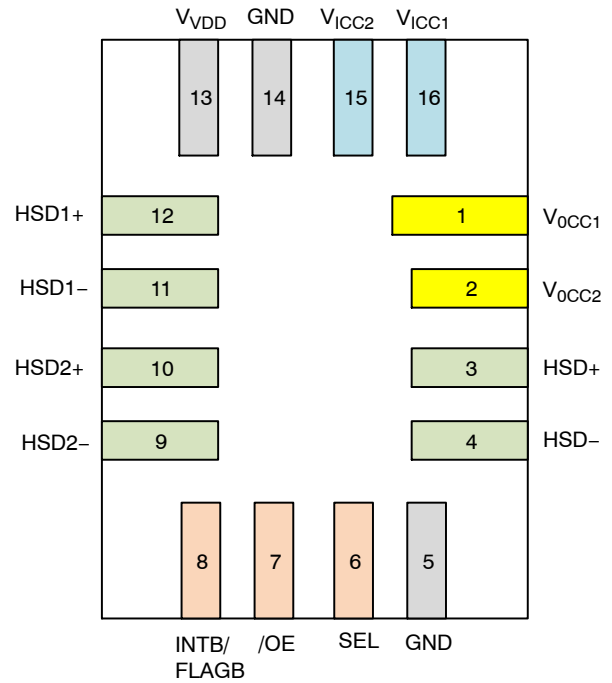


Figure 5. Pin Assignment (Bottom View)

### PIN DESCRIPTION

| Bump   | Name       | Type   | Description  |
|--|------------|--------|--|
| <b>POWER INTERFACE</b>                       |            |        |  |
| 13   | VDD        | Power  | Power  |
| 5, 14  | GND        | Ground | Ground   |
| <b>USB TYPE-C CONNECTOR INTERFACE INPUT</b>  |            |        |  |
| 15, 16                                       | VICC1, 2   | Input  | Type C CC Interface OVP protection input, Connect to connector |
| <b>USB TYPE-C CONNECTOR INTERFACE OUTPUT</b> |            |        |  |
| 1, 2   | VOCC1, 2   | Output | Type C CC Interface output. Connect to controller              |
| <b>USB HIGH SPEED DATA INTERFACE</b>         |            |        |  |
| 3  | HSD+       | I/O    | Common High Speed Digital / USB Data Bus                       |
| 4  | HSD-       | I/O    | Common High Speed Digital / USB Data Bus                       |
| 12   | HSD1+      | I/O    | Multiplexed Source Input 1                                     |
| 11   | HSD1-      | I/O    | Multiplexed Source Input 1                                     |
| 10   | HSD2+      | I/O    | Multiplexed Source Input 2                                     |
| 9  | HSD2-      | I/O    | Multiplexed Source Input 2                                     |
| <b>SIGNAL INTERFACE</b>                      |            |        |  |
| 7  | /OE        | I/O    | Switch Enable  |
| 6  | SEL        | I/O    | Switch Select  |
| 8  | INTB/FLAGB | Output | OVP Interrupt Flag   |

# FUSB252

**Table 1. CC SWITCH TRUTH TABLE CONFIGURATION**

| V <sub>DD</sub>        | V <sub>ICC</sub> Voltage | CC Switch Configuration      |
|------------------------|--------------------------|------------------------------|
| 0 V – UVLO (Not Valid) | 0 V – 5.8 V              | OFF Dead Battery Rd Inserted |
|                        | 5.8 V to 20 V            | OFF Dead Battery Rd Inserted |
| 2.7 V – 5.5 V (Valid)  | 0 V – 5.8 V              | On                           |
|                        | 5.8 V to 20 V            | OFF (OVP)                    |

**Table 2. CC SWITCH TRUTH TABLE CONFIGURATION**

| /OE | SEL | VDD       | HSD+ / HSD-     | CC           |
|-----|-----|-----------|-----------------|--------------|
| 1   | 0   | Not Valid | X (Open/High-Z) | Dead Battery |
| 0   | 0   | Not Valid | X (Open/High-Z) | Dead Battery |
| 1   | X   | Valid     | X (Open/High-Z) | On           |
| 0   | 0   | Valid     | HSD1+ / HSD1-   | On           |
| 0   | 1   | Valid     | HSD2+ / HSD2-   | On           |

# FUSB252

## ABSOLUTE MAXIMUM RATINGS

| Symbol                                     | Parameter                                     |  | Min     | Max              | Unit |    |
|--|---|--|---------|------------------|------|----|
| V <sub>VDD</sub>                           | Supply Voltage from V <sub>DD</sub>           |  | -0.5    | 12.0             | V    |    |
| V <sub>VICC</sub>                          | V <sub>ICCx</sub> , to GND                    |  | -0.5    | 24               | V    |    |
| V <sub>SW</sub>                            | V <sub>HSD±</sub> , to GND                    |  | -5      | 16               | V    |    |
| V <sub>OCC</sub> , V <sub>SW</sub>         | V <sub>OCCx</sub> , V <sub>HSDx±</sub> to GND |  | -0.5    | 6                | V    |    |
| V <sub>CONTROL</sub>                       | DC Input Voltage (S, /OE)                     |  | -0.5    | V <sub>VDD</sub> | V    |    |
| I <sub>CCSW</sub>                          | DC CC Switch Current                          |  |         | 1.25             | A    |    |
| I <sub>USBSW</sub>                         | DC Output Current                             |  |         | 100              | mA   |    |
| I <sub>IK</sub>                            | DC Input Diode Current                        |  | -50     |                  | mA   |    |
| T <sub>STORAGE</sub>                       | Storage Temperature Range                     |  | -65     | +150             | °C   |    |
| T <sub>J</sub>                             | Maximum Junction Temperature                  |  |         | +150             | °C   |    |
| T <sub>L</sub>                             | Lead Temperature (Soldering, 10 seconds)      |  |         | +260             | °C   |    |
| ESD  | IEC 61000-4-2 System ESD                      | Connector Pins<br>(V <sub>VDD±</sub> , V <sub>ICCx</sub> , V <sub>HSD±</sub> ) | Air Gap | 15               |      | kV |
|  |   |  | Contact | 8                |      |    |
|  | IEC 61000-4-5 Surge ESD                       | V <sub>ICCx</sub> to GND   |         | -24              | 24   | V  |
|  |   | V <sub>HSD±</sub> to GND   |         | -16              | 16   | V  |
|  | Human Body Model, JEDEC<br>JESD22-A114        | Power to GND   |         | 4                |      | kV |
|  |   | External Pins to GND<br>(V <sub>HSD±</sub> , V <sub>ICCx</sub> )               |         |                  |      |    |
|  |   | System Side Pin<br>(V <sub>HSDx±</sub> , V <sub>OCCx</sub> , S, /OE, FLAGB)    |         | 2                |      |    |
| Charged Device Model,<br>JEDEC LESD22-C101 | All Pins                                      |  | 1       |                  |      |    |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

## RECOMMENDED OPERATING CONDITIONS

| Symbol            | Parameter                        | Min  | Typ | Max              | Unit |
|-------------------|----------------------------------|------|-----|------------------|------|
| V <sub>VDD</sub>  | Supply Voltage                   | 2.7  | 4.2 | 5.5              | V    |
| V <sub>VICC</sub> | Type C Input Voltage             | 0    |     | 5.5              | V    |
| V <sub>OCC</sub>  | Type C Output Voltage            | 0    |     | 5.5              | V    |
| I <sub>CCSW</sub> | Maximum CC Switch Current        |      |     | 1                | A    |
| V <sub>CTRL</sub> | Control Input Voltage (SEL, /OE) | -0.5 |     | V <sub>VDD</sub> | V    |
| V <sub>SW</sub>   | HSD/USB Switch I/O Voltage       | -0.5 |     | 4.5              | V    |
| T <sub>A</sub>    | Operating Temperature            | -40  |     | +85              | °C   |

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

# FUSB252

**DC CHARACTERISTICS** (Unless otherwise specified: Recommended  $T_A$  and  $T_J$  temperature ranges. All typical values are at  $T_A = 25^\circ\text{C}$  and  $V_{DD} = 4.2\text{ V}$  unless otherwise specified.)

| Symbol | Characteristic | $V_{DD}$ (V) | Conditions | $T_A = -40^\circ\text{C to } +85^\circ\text{C}$<br>$T_J = -40^\circ\text{C to } +125^\circ\text{C}$ |     |     | Unit |
|--------|----------------|--------------|------------|---|-----|-----|------|
|        |                |              |            | Min   | Typ | Max |      |

## BASIC OPERATION DEVICE

|           |                           |            |                        |  |   |  |               |
|-----------|---------------------------|------------|------------------------|--|---|--|---------------|
| $I_{CC}$  | Quiescent Supply Current  | 2.7 to 5.5 | /OE = L, $I_{OUT} = 0$ |  | 9 |  | $\mu\text{A}$ |
|           |                           |            | /OE = H, $I_{OUT} = 0$ |  | 9 |  |               |
| $I_{OFF}$ | Power-Off Leakage Current | 0          |                        |  | 3 |  | $\mu\text{A}$ |

## BASIC OPERATION CC SWITCH

|                |                                   |            |                                   |      |      |      |                  |
|----------------|-----------------------------------|------------|-----------------------------------|------|------|------|------------------|
| $I_{SD(DB)}$   | Dead Battery Supply Current       | 0 to UVLO  | Dead Battery State Supply Current |      | 15   |      | $\mu\text{A}$    |
| $R_{ON}$       | CC Path On Resistance             | 2.7 to 5.5 | $I_{OUT} = 200\text{ mA}$         |      | 350  | 480  | $\text{m}\Omega$ |
| $V_{OV\_TRIP}$ | Input OVP Lockout                 | 2.7 to 5.5 | $V_{ICC}$ Rising                  |      | 5.65 | 6.20 | V                |
|                |                                   |            | $V_{ICC}$ Falling                 |      | 5.3  |      |                  |
| $V_{OV\_HYS}$  | Input OVP Hysteresis              | 2.7 to 5.5 |                                   |      | 0.35 |      | V                |
| $V_{UVLO}$     | Under-Voltage Lockout             | 2.7 to 5.5 | $V_{DD}$ Rising                   |      | 2.55 | 2.70 | V                |
|                |                                   |            | $V_{DD}$ Falling                  |      | 2.5  |      |                  |
| TSD            | Thermal Shutdown (Note 1)         |            | Shutdown Threshold                |      | 150  |      | $^\circ\text{C}$ |
|                |                                   |            | Return from Shutdown              |      | 130  |      |                  |
|                |                                   |            | Hysteresis                        |      | 20   |      |                  |
| $R_d$          | Dead Battery Pull-Down Resistance | 0 to UVLO  | Dead Battery Resistance           | 4.08 | 5.10 | 6.12 | $\text{k}\Omega$ |
|                |                                   |            | Voltage on Pin                    | 0.25 |      | 2.6  |                  |

## BASIC OPERATION HSD SWITCH

|                 |                             |            |   |     |      |     |               |
|-----------------|-----------------------------|------------|---|-----|------|-----|---------------|
| $V_{OV\_TRIP}$  | Input OVP Lockout           | 2.7 to 5.5 | $V_{HSD\pm}$ Rising   |     | 4.4  | 5.0 | V             |
|                 |                             |            | $V_{HSD\pm}$ Falling  |     | 4.1  |     |               |
| $V_{OV\_HYS}$   | Input OVP Hysteresis        | 2.7 to 5.5 |   |     | 0.3  |     | V             |
| $V_{UV\_TRIP}$  | Input Under-Voltage Lockout | 2.7 to 5.5 |   |     | -1.2 |     | V             |
| $V_{IH}$        | Input Voltage High          | 2.7 to 5.5 |   | 1.3 |      |     | V             |
| $V_{IL}$        | Input Voltage Low           | 2.7 to 5.5 |   |     |      | 0.5 | V             |
| $I_{IN}$        | Control Input Leakage       | 2.7 to 5.5 | $V_{SW} = 0$ to $V_{DD}$  |     | 0.1  |     | $\mu\text{A}$ |
| $I_{OZ}$        | Off State Leakage           | 4.2        | $0 \leq \text{HSDn} \leq 3.6\text{ V}$                            |     | 2    |     | $\mu\text{A}$ |
|                 |                             | 4.2        | $0 \leq \text{HSD1n}_{\pm}, \text{HSD2n}_{\pm} \leq 3.6\text{ V}$ |     | 100  |     | nA            |
| $R_{ON}$        | HS Switch On Resistance     | 4.2        | $V_{SW} = 0.4\text{ V}, I_{ON} = -8\text{ mA}$                    |     | 5    |     | $\Omega$      |
| $\Delta R_{ON}$ | HS Delta $R_{ON}$           | 4.2        | $V_{SW} = 0.4\text{ V}, I_{ON} = -8\text{ mA}$                    |     | 0.1  |     | $\Omega$      |

1. Guaranteed by characterization, not production tested.

# FUSB252

**AC CHARACTERISTICS** (Unless otherwise specified: Recommended  $T_A$  and  $T_J$  temperature ranges. All typical values are at  $T_A = 25^\circ\text{C}$  and  $V_{DD} = 3.8\text{ V}$  unless otherwise specified.)

| Symbol | Characteristic | $V_{DD}$ (V) | Conditions | $T_A = -40^\circ\text{C to } +85^\circ\text{C}$<br>$T_J = -40^\circ\text{C to } +125^\circ\text{C}$ |     |     | Unit |
|--------|----------------|--------------|------------|---|-----|-----|------|
|        |                |              |            | Min   | Typ | Max |      |

## CC SWITCH TIMING PARAMETER

|           |                        |            |  |  |     |     |               |
|-----------|------------------------|------------|--|--|-----|-----|---------------|
| $t_{OVP}$ | Response Time (Note 2) | 2.7 to 5.5 | $I_{OUT} = 0.2\text{ A}$ , $C_L = 200\text{ pF}$ ,<br>$V_{ICCX} = 5\text{ V to } 6\text{ V}$ |  | 0.5 | 1.0 | $\mu\text{s}$ |
| $t_{ON}$  | Turn-On Time           |            | $V_{DD}$ Rising 2 V to 3 V   |  | 25  |     | ms            |
| $T_{MBS}$ | Make-Before-Break      | 2.7 to 5.5 | $V_{DD}$ Rising 2 V to 3 V   |  | 600 |     | ns            |

## CC SWITCH CAPACITANCE

|          |                                     |            |  |  |     |  |               |
|----------|-------------------------------------|------------|--|--|-----|--|---------------|
| $C_{ON}$ | Switch Path On Capacitance (Note 2) | 2.7 to 5.5 |  |  | 100 |  | $\mu\text{F}$ |
|----------|-------------------------------------|------------|--|--|-----|--|---------------|

## CC SWITCH BANDWIDTH

|    |                               |            |  |  |    |  |     |
|----|-------------------------------|------------|--|--|----|--|-----|
| BW | PD Traffic Bandwidth (Note 2) | 2.7 to 5.5 | $R_L = 50\ \Omega$ , $C_L = 200\text{ pF}$ |  | 25 |  | MHz |
|----|-------------------------------|------------|--|--|----|--|-----|

## HSD SWITCH TIMING PARAMETER

|           |                                       |            |  |  |      |     |               |
|-----------|---------------------------------------|------------|--|--|------|-----|---------------|
| $t_{OVP}$ | Response Time (Note 2)                | 2.7 to 5.5 | $I_{OUT} = 0.2\text{ A}$ , $V_{D\pm} = 4\text{ V to } 5\text{ V}$                                |  | 0.5  | 1.0 | $\mu\text{s}$ |
| $t_{ON}$  | Turn-On Time, /OE to Output (Note 2)  | 2.7 to 5.5 | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ ,<br>$V_{SW} = 0.8\text{ V}$                            |  | 25   |     | ms            |
| $t_{OFF}$ | Turn-Off Time, /OE to Output (Note 2) | 2.7 to 5.5 | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ ,<br>$V_{SW} = 0.8\text{ V}$                            |  | 100  | 400 | ns            |
| $t_{PD}$  | Propagation Delay (Note 2)            | 2.7 to 5.5 | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$   |  | 0.25 |     | ns            |
| $T_{BBS}$ | Break-Before-Make (Note 2)            | 2.7 to 5.5 | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ ,<br>$V_{SWx} = 0.8\text{ V SEL} = H \leftrightarrow L$ |  | 100  |     | $\mu\text{s}$ |
| $O_{IRR}$ | Off Isolation                         | 2.7 to 5.5 | $R_L = 50\ \Omega$ , $f = 240\text{ MHz}$  |  | -25  |     | dB            |
| Xtalk     | Non-Adjacent Channel Crosstalk        | 2.7 to 5.5 | $R_L = 50\ \Omega$ , $f = 240\text{ MHz}$  |  | -40  |     | dB            |

## HSD SWITCH CAPACITANCE

|           |  |            |                               |  |     |  |               |
|-----------|--|------------|-------------------------------|--|-----|--|---------------|
| $C_{IN}$  | Control Pin Input Capacitance (Note 2) | 0          |                               |  | 1.5 |  | $\mu\text{F}$ |
| $C_{ON}$  | HSD+ / HSD- On Capacitance (Note 2)    | 2.7 to 5.5 | /OE = L, $f = 240\text{ MHz}$ |  | 4   |  | $\mu\text{F}$ |
| $C_{OFF}$ | HSD1x / HSD2x Off Capacitance (Note 2) | 2.7 to 5.5 | /OE = H                       |  | 2.5 |  | $\mu\text{F}$ |

## USB SWITCH BANDWIDTH

|    |                          |            |  |  |      |  |     |
|----|--------------------------|------------|--|--|------|--|-----|
| BW | -3 db Bandwidth (Note 2) | 2.7 to 5.5 | $R_L = 50\ \Omega$ , $C_L = 0\text{ pF}$ |  | 1400 |  | MHz |
|    |                          | 2.7 to 5.5 | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ |  | 560  |  |     |

## USB HIGH-SPEED-RELATED

|             |  |  |  |  |     |  |    |
|-------------|--|--|--|--|-----|--|----|
| $t_{SK(P)}$ | Skew of Opposite Transitions of the Same Output (Note 2) |  | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$   |  | 25  |  | ps |
| $t_J$       | Total Jitter (Note 2)                                    |  | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ ,<br>$t_R = t_F = 500\text{ ps}$ (10-90%) at<br>480 Mbps (PRBS = $2^{15} - 1$ ) |  | 200 |  | ps |

2. Guaranteed by characterization, not production tested.



# FUSB252

## OPERATION AND APPLICATION DESCRIPTION

### Out of Spec Surge/Spike Voltage due to Hot Plug

The FUSB252 protects end systems against 20 V DC on the CC pin, in cases where the FUSB252 is tested to mimic a hot plug event, a fully charged cable connected to a power supply set to 20 V is used to zap the VICC pins of the device. In these cases, the inductance of the cable causes voltage spikes that are higher than the absolute maximum ratings of the of the VICC pins. These voltages can cause damage to the VOCC pins. This scenario does not occur in normal usage. The Type-C specification prevents the plug from having 20 V on VBUS from a PD source prior to a PD contract being completed. When the 20 V potential is on VBUS and shorted to the CC pin, it causes a detach and the voltage spikes are less likely to occur. The following reference circuit is required when the application calls for additional protection to protect against such event as hot plug.

### Application Specific Schematic

- Place a 5 V to 6 V rated Zener TVS diode such as (CZRF52C5V6 or CD1005-Z5V1) on the VOCC pin, and a 5  $\Omega$  resistor to device ground to prevent the FUSB252 from being damaged during these tests. With this additional protection if is also important to select the right external VICC IEC TVS for the best overall performance.
- Without the additional protection the device by itself can withstand up to 9 V under the same hot plug condition.

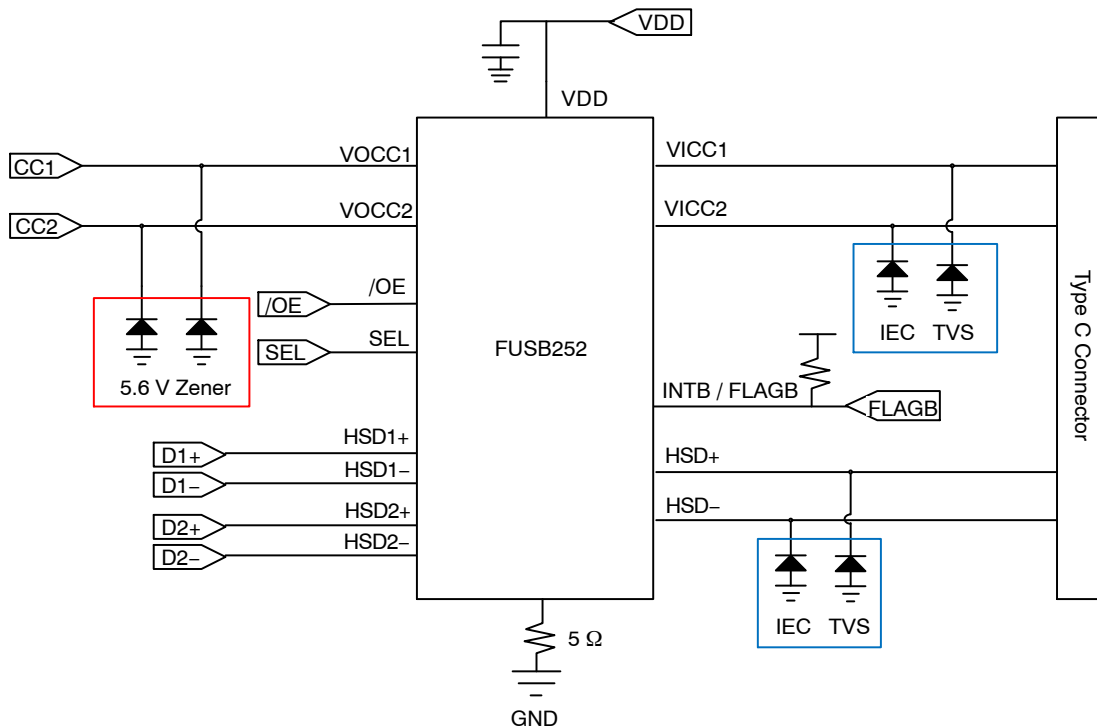


Figure 6. Reference Schematic

### Over-Voltage Protection

When over-voltage event is detected, device will activate OVP to shutdown the switch within  $t_{OVB}$  as well as signal the FLAGB to indicate there is OV event to the system.

### Fault Reporting

Upon the detection of an over-voltage event, the INTB/FLAGB signals the fault by activating LOW.

# FUSB252

## Type-C Solution Reference

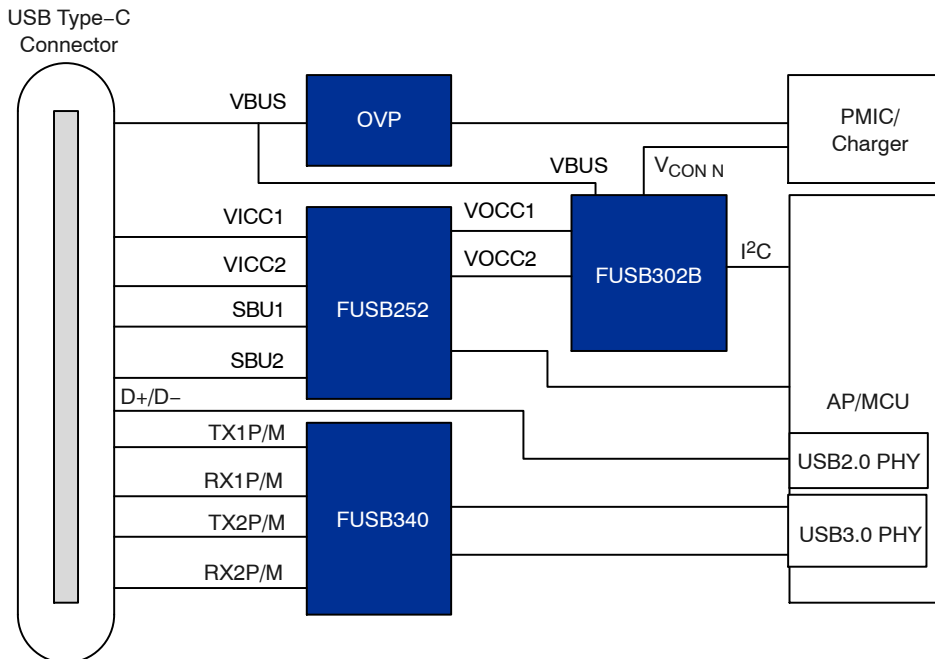


Figure 7. Example of Type-C Solution Reference (SBU)

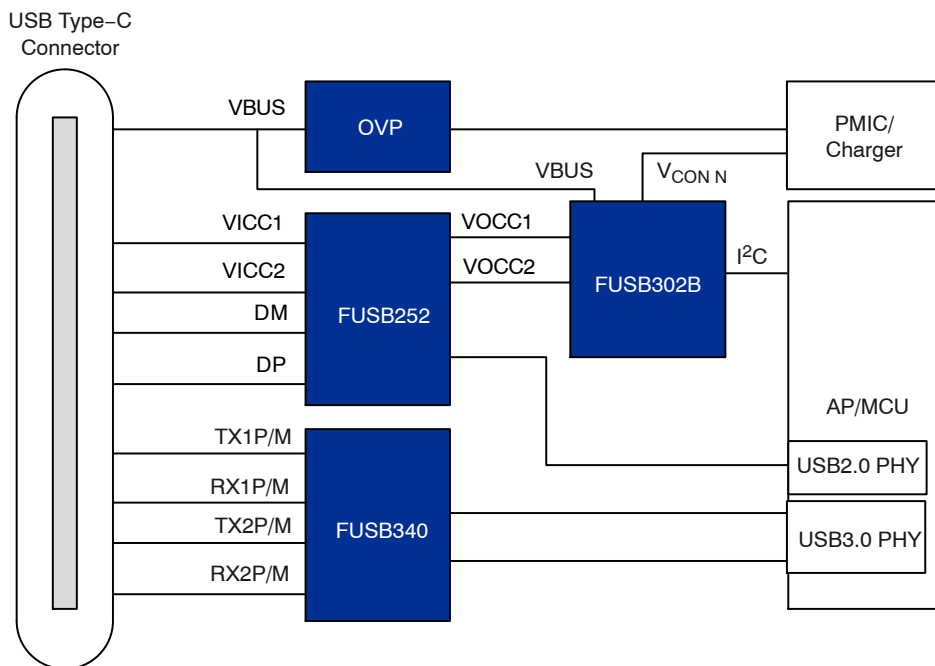


Figure 8. Example of Type-C Solution Reference (USB)

TEST DIAGRAMS

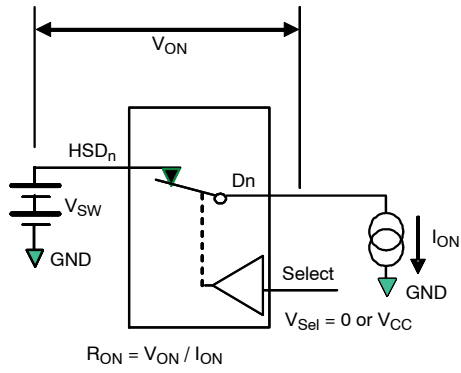
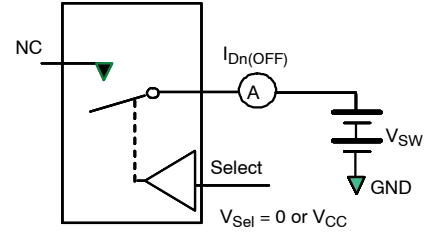
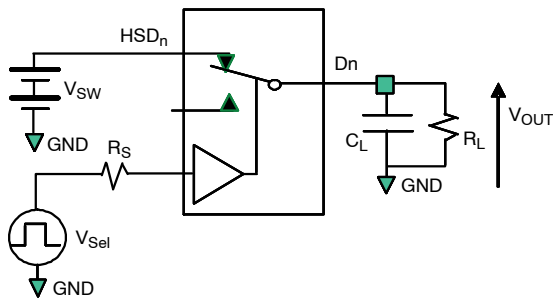


Figure 9. On Resistance



NOTE: Each switch port is tested separately.

Figure 10. Off Leakage



NOTE:  $R_L$ ,  $R_S$ , and  $C_L$  are functions of the application environment (see AC Tables for specific values)  $C_L$  includes test fixture and stray capacitance.

Figure 11. AC Test Circuit Load

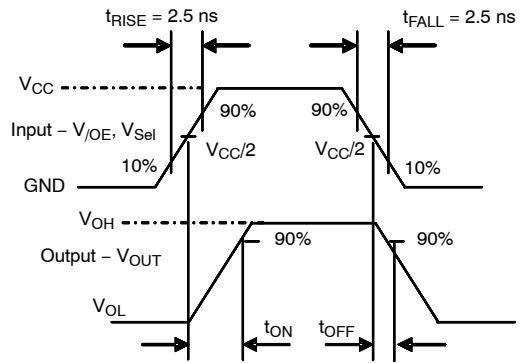


Figure 12. Turn-On / Turn-Off Waveforms

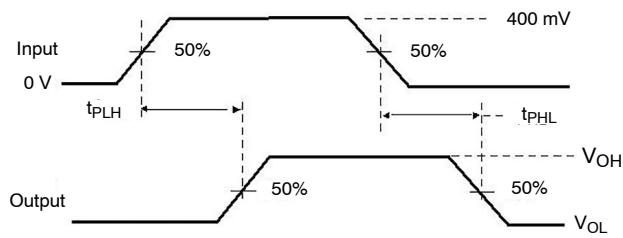


Figure 13. Propagation Delay ( $t_{RtF} = 500$  ps)

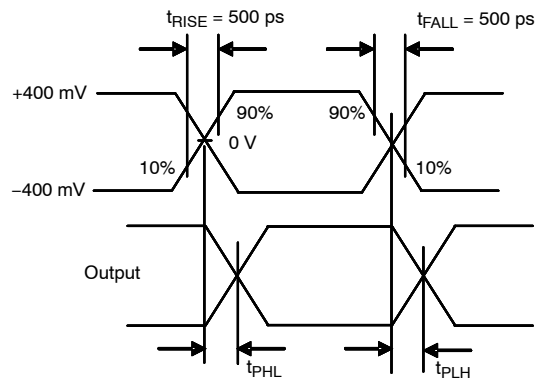


Figure 14. Intra-Pair Skew Test  $t_{SK(P)}$

TEST DIAGRAMS (continued)

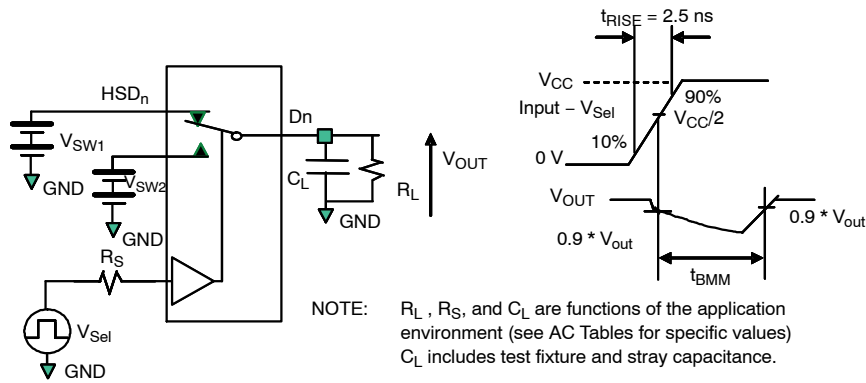


Figure 15. Break-Before-Make Interval Timing

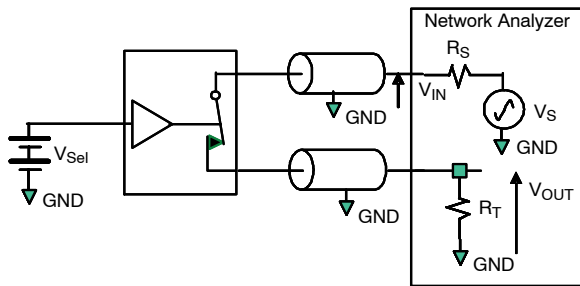
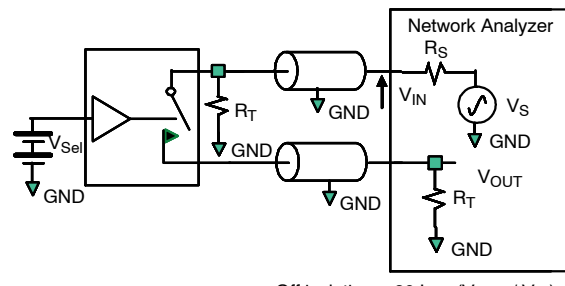
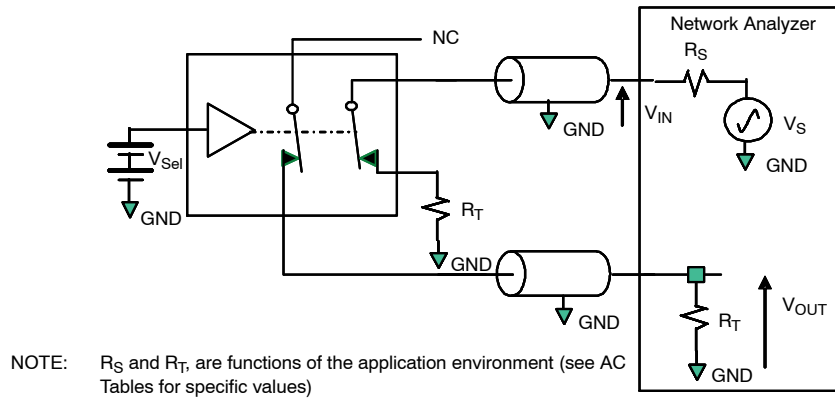


Figure 16. Bandwidth



Off isolation =  $20 \text{ Log} (V_{OUT} / V_{IN})$

Figure 17. Channel Off Isolation



Crosstalk =  $20 \text{ Log} (V_{OUT} / V_{IN})$

Figure 18. Non-Adjacent Channel-to-Channel Crosstalk

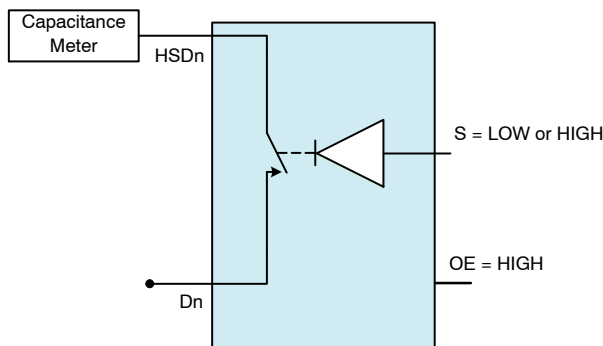


Figure 19. Channel Off Capacitance

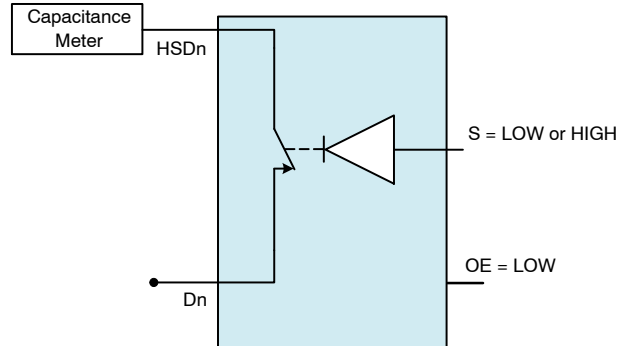


Figure 20. Channel On Capacitance

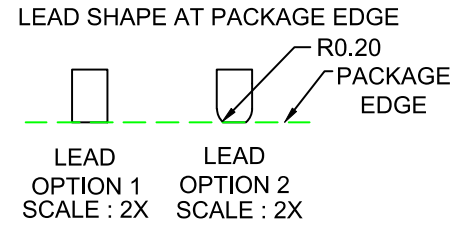
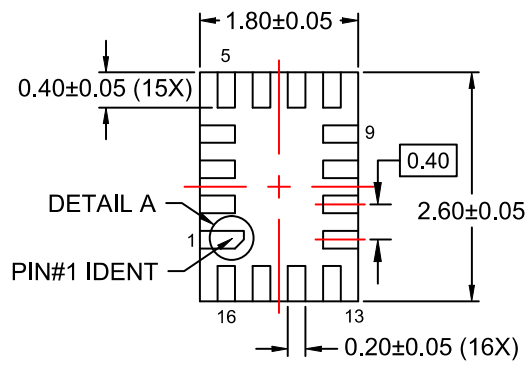
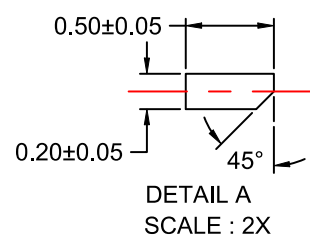
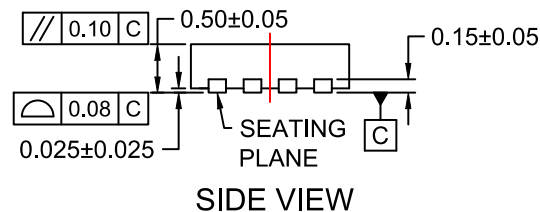
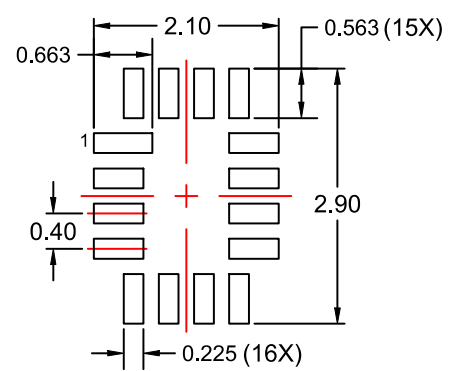
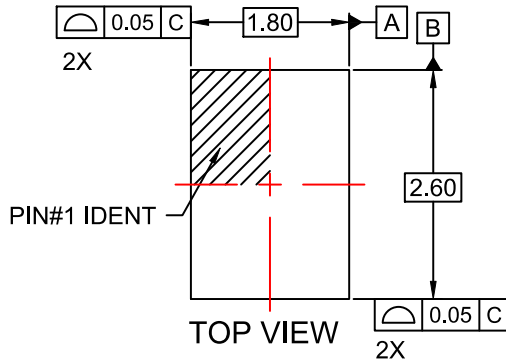
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**UQFN16 1.8x2.6, 0.4P**  
CASE 523BF  
ISSUE O

DATE 31 OCT 2016



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  - D. LAND PATTERN RECOMMENDATION IS EXISTING INDUSTRY LAND PATTERN.
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