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# FSUSB43 — Low-Power, Two-Port, High-Speed, USB2.0 (480Mbps) Switch

## Features

- Over-Voltage Tolerance (OVT) on all USB Ports up to 5.25V without External Components
- Low On Capacitance: 3.7pF Typical
- Low On Resistance: 3.9Ω Typical
- Low Power Consumption: 1μA Maximum
  - 20μA Maximum $I_{CCT}$ over an Expanded Voltage Range ($V_{IN}$=1.8V, $V_{CC}$=4.3V)
- Wide -3db Bandwidth: > 720MHz
- Packaged in 10-Lead MicroPak™ (1.6 x 2.1mm)
- 8kV ESD Rating, >16kV Power/GND ESD Rating
- Power-Off Protection on All Ports when $V_{CC}$=0V
  - D+/D- Pins Tolerate up to 5.25V

## Applications

- Cell phone, PDA, Digital Camera, and Notebook
- LCD Monitor, TV, and Set-Top Box

## Description

The FSUSB43 is a bi-directional, low-power, two-port, high-speed, USB2.0 switch. Configured as a double-pole, double-throw (DPDT) switch, it is optimized for switching between two high-speed (480Mbps) sources or a high-speed and full-speed (12Mbps) source.

The FSUSB43 is compatible with the requirements of USB2.0 and features an extremely low on capacitance ($C_{ON}$) of 3.7pF. The wide bandwidth of this device (720MHz) exceeds the bandwidth needed to pass the third harmonic, resulting in signals with minimum edge and phase distortion. Superior channel-to-channel crosstalk also minimizes interference.

The FSUSB43 contains special circuitry on the switch I/O pins for applications where the $V_{CC}$ supply is powered-off ($V_{CC}$=0), which allows the device to withstand an over-voltage condition. This minimizes current consumption even when the control voltage applied to the SEL pin is lower than the supply voltage ($V_{CC}$). This feature is especially valuable to mobile applications, such as cell phones, allowing for direct interface with the general-purpose I/Os of the baseband processor. Other applications include switching and connector sharing in portable cell phones, PDAs, digital cameras, printers, and notebook computers.

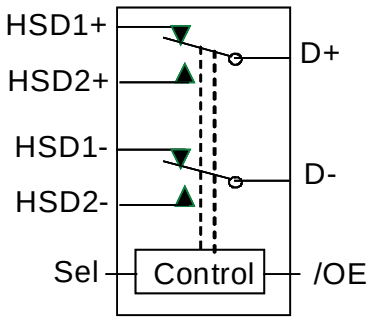



**Figure 1. Analog Symbol**

## Ordering Information

| Part Number | Top Mark | Operating Temperature Range | Eco Status | Package |
|---|---|---|---|---|
| FSUSB43L10X | JH | -40 to +85°C | Green | 10-Lead MicroPak™ 1.6 x 2.1mm, JEDEC MO-255B |

MicroPak™ is a trademark of Semiconductor Components Industries, LLC.


September-2017, Rev. 2

Publication Order Number:
FSUSB43/D

## Pin Configuration

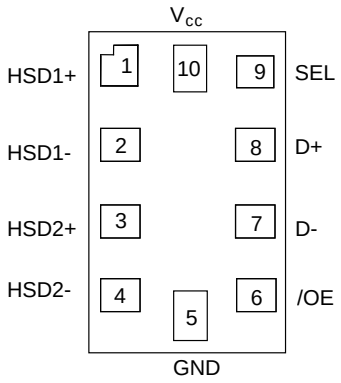



**Figure 2. Pin Assignment (Top Through View)**

## Pin Definitions

| Pin # | Name | Description |
|---|---|---|
| 1 | HSD1+ | Multiplexed Source Inputs |
| 2 | HSD1- | Multiplexed Source Inputs |
| 3 | HSD2+ | Multiplexed Source Inputs |
| 4 | HSD2- | Multiplexed Source Inputs |
| 5 | GND | Ground |
| 6 | /OE | Switch Enable |
| 7 | D- | USB Data Bus |
| 8 | D+ | USB Data Bus |
| 9 | SEL | Switch Select |
| 10 | $V_{CC}$ | Supply Voltage |

## Truth Table

| SEL | /OE | Function |
|---|---|---|
| X | HIGH | Disconnect |
| LOW | LOW | D+, D-=HSD1+, HSD1- |
| HIGH | LOW | D+, D-=HSD2+, HSD2- |

## Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

| Symbol | Parameter | | Min. | Max. | Unit |
|---|---|---|---|---|---|
| $V_{CC}$ | Supply Voltage | | -0.5 | +5.5 | V |
| $V_{CNTRL}$ | DC Input Voltage (Sel, /OE)(1) | | -0.5 | $V_{CC}$ | V |
| $V_{SW}$ | ALL PINS for $V_{CC}$ 0 to 5.5V | | -0.5 | 5.5 | V |
| $I_{IK}$ | DC Input Diode Current | | -50 | | mA |
| $I_{OUT}$ | DC Output Current | | | 100 | mA |
| $T_{STG}$ | Storage Temperature | | -65 | +150 | °C |
| ESD | Human Body Model: JEDEC JESD22-A114 | All Pins | | 8 | kV |
| | | I/O to GND | | 9 | |
| | | Power to GND | | 16 | |
| | Charged Device Model: JEDEC JESD22-C101 | | | 2 | |

**Note:**

1. The input and output negative ratings may be exceeded if the input and output diode current ratings are observed.

## Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. ON Semiconductor does not recommend exceeding them or designing to Absolute Maximum Ratings.

| Symbol | Parameter | Min. | Max. | Unit |
|---|---|---|---|---|
| $V_{CC}$ | Supply Voltage | 2.4 | 4.4 | V |
| $V_{CNTRL}$ | Control Input Voltage(2) (Sel, /OE) | 0 | $V_{CC}$ | V |
| $V_{SW}$ | Switch I/O Voltage | -0.5 | 4.5 | V |
| $T_A$ | Operating Temperature | -40 | +85 | °C |

**Note:**

2. The control input must be held HIGH or LOW; it must not float.

## DC Electrical Characteristics

All typical values are at 25°C unless otherwise specified.

| Symbol | Parameter | Conditions | $V_{CC}$ (V) | $T_A$=- 40ºC to +85ºC | | | Units |
|---|---|---|---|---|---|---|---|
| | | | | Min. | Typ. | Max. | |
| $V_{IK}$ | Clamp Diode Voltage | $I_{IN}$=-18mA | 3.0 | | | -1.2 | V |
| $V_{IH}$ | Input Voltage High | | 2.4 to 3.6 | 1.3 | | | V |
| | | | 4.3 | 1.7 | | | V |
| $V_{IL}$ | Input Voltage Low | | 2.4 to 3.6 | | | 0.5 | V |
| | | | 4.3 | | | 0.7 | V |
| $I_{IN}$ | Control Input Leakage | $V_{SW}$=0 to $V_{CC}$ | 4.3 | -1.0 | | 1.0 | µA |
| $I_{OZ}$ | Off State Leakage | 0 ≤ Dn, HSD1n, HSD2n ≤ 3.6V | 4.3 | -2.0 | | 2.0 | µA |
| $I_{OFF}$ | Power-Off Leakage Current (All I/O Ports) | $V_{SW}$=0V to 4.3V, $V_{CC}$=0V Figure 4 | 0 | -2 | | 2 | µA |
| $R_{ON}$ | HS Switch On Resistance(3) | $V_{SW}$=0.4V, $I_{ON}$=-8mA Figure 3 | 2.4 | | 4.5 | 7.5 | Ω |
| | | | 3.0 | | 3.9 | 6.5 | |
| $\Delta R_{ON}$ | HS Delta $R_{ON}$(4) | $V_{SW}$=0.4V, $I_{ON}$=-8mA | 3.0 | | 0.65 | | Ω |
| $I_Q$ | Quiescent Supply Current | $V_{CNTRL}$=0 or $V_{CC}$, $I_{OUT}$=0 | 4.3 | | | 1.0 | µA |
| $I_{CCT}$ | Increase in $I_Q$ Current per Control Voltage and $V_{CC}$ | $V_{CNTRL}$=2.6V, $V_{CC}$=4.3V | 4.3 | | | 10.0 | µA |
| | | $V_{CNTRL}$=1.8V, $V_{CC}$=4.3V | 4.3 | | | 20.0 | µA |

**Notes:**

3. Measured by the voltage drop between HSDn and Dn pins at the indicated current through the switch. On resistance is determined by the lower of the voltage on the two (HSDn or Dn ports).
4. Guaranteed by characterization.

## AC Electrical Characteristics

All typical values are for $V_{CC}$=3.3V at 25°C unless otherwise specified.

| Symbol | Parameter | Conditions | $V_{CC}$ (V) | $T_A$=- 40ºC to +85ºC | | | Units |
|---|---|---|---|---|---|---|---|
| | | | | Min. | Typ. | Max. | |
| $t_{ON}$ | Turn-On Time SEL, /OE to Output | $R_L$=50Ω, $C_L$=5pF, $V_{SW}$=0.8V Figure 5, Figure 6 | 2.4 | | 24 | 40 | ns |
| | | | 3.0 to 3.6 | | 13 | 30 | |
| $t_{OFF}$ | Turn-Off Time SEL, /OE to Output | $R_L$=50Ω, $C_L$=5pF, $V_{SW}$=0.8V Figure 5, Figure 6 | 2.4 | | 15 | 35 | ns |
| | | | 3.0 to 3.6 | | 12 | 25 | |
| $t_{PD}$ | Propagation Delay(5) | $R_L$=50Ω, $C_L$=5 pF Figure 5, Figure 7 | 3.3 | | 0.25 | | ns |
| $t_{BBM}$ | Break-Before-Make Time(5) | $R_L$=50Ω, $C_L$=5pF $V_{SW1}$=$V_{SW2}$=0.8V Figure 9 | 2.4 | 2.0 | | 10 | ns |
| | | | 3.0 to 3.6 | 2.0 | | 6.5 | |
| OIRR | Off Isolation(5) | $R_L$=50Ω, f=240MHz Figure 11 | 3.0 to 3.6 | | -30 | | dB |
| Xtalk | Non-Adjacent Channel Crosstalk(5) | $R_L$=50Ω, f=240MHz Figure 12 | 3.0 to 3.6 | | -45 | | dB |
| BW | -3db Bandwidth(5) | $R_L$=50Ω, $C_L$=0pF Figure 10 | 3.0 to 3.6 | | 720 | | MHz |
| | | $R_L$=50Ω, $C_L$=5pF Figure 10 | | | 550 | | MHz |

**Note:**

5. Guaranteed by characterization.

## USB High-Speed-Related AC Electrical Characteristics

| Symbol | Parameter | Conditions | $V_{CC}$ (V) | $T_A$=- 40ºC to +85ºC | | | Units |
|---|---|---|---|---|---|---|---|
| | | | | Min. | Typ. | Max. | |
| $t_{SK(P)}$ | Skew of Opposite Transitions of the Same Output(6) | $R_L$=50Ω, $C_L$=5pF Figure 8 | 3.0 to 3.6 | | 20 | | ps |
| $t_J$ | Total Jitter(6) | $R_L$=50Ω, $C_L$=5pf, $t_r$=$t_f$=500ps (10-90%) at 480Mbps, (PRBS=$2^{15}$ – 1) | 3.0 to 3.6 | | 200 | | ps |

**Note:**

6. Guaranteed by characterization.

## Capacitance

| Symbol | Parameter | Conditions | $T_A$=- 40ºC to +85ºC | | | Units |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| $C_{IN}$ | Control Pin Input Capacitance(7) | $V_{CC}$=0V | | 1.5 | | pF |
| $C_{ON}$ | D+/D- On Capacitance(7) | $V_{CC}$=3.3V, /OE=0V, f=240MHz Figure 14 | | 3.7 | | |
| $C_{OFF}$ | D1n, D2n Off Capacitance(7) | $V_{CC}$ and /OE=3.3V Figure 13 | | 2.0 | | |

**Note:**

7. Guaranteed by characterization.

## Test Diagrams

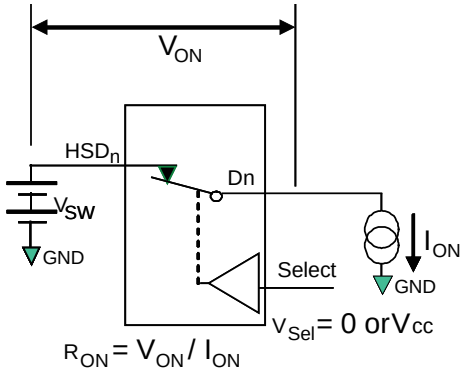
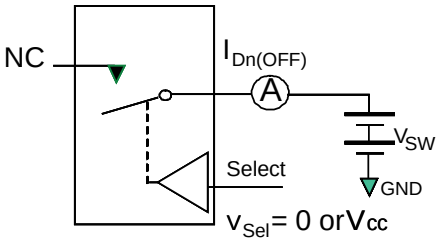
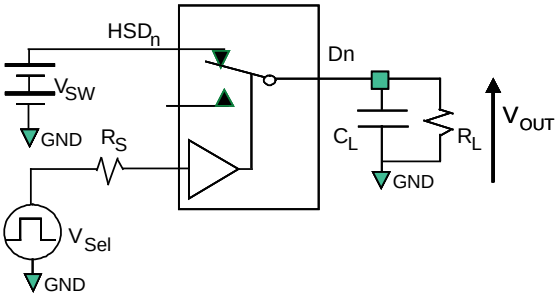



**Figure 3. On Resistance**




**Each switch port is tested separately

**Figure 4. Off Leakage**




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

**Figure 5. AC Test Circuit Load**

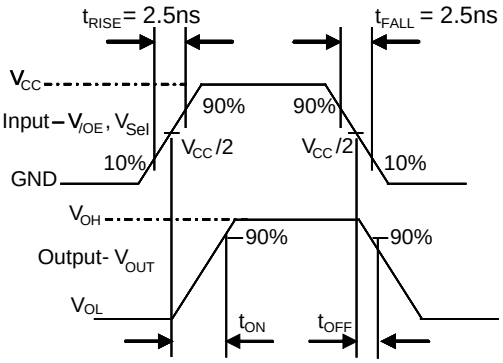



**Figure 6. Turn-On / Turn-Off Waveforms**

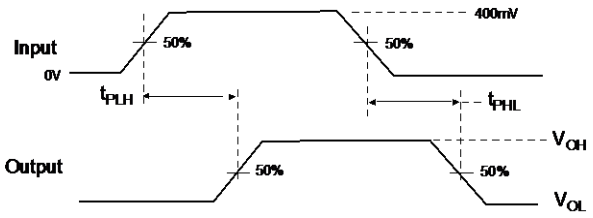



**Figure 7. Propagation Delay ($t_r$/$t_f$ – 500ps)**

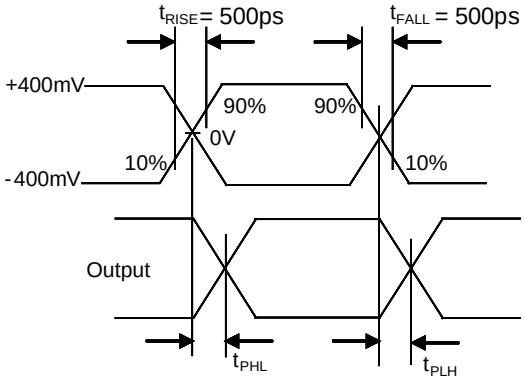
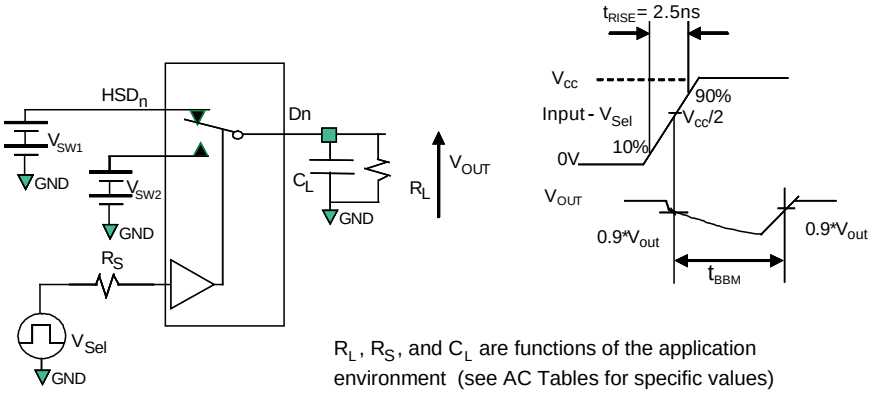


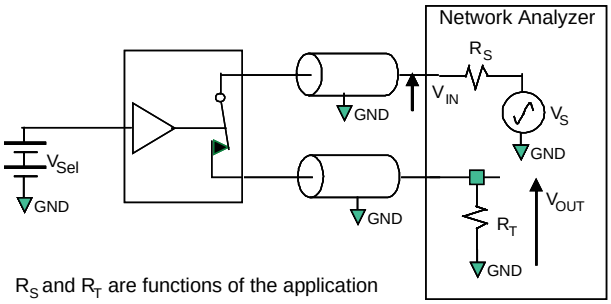

**Figure 8. Intra-Pair Skew Test $t_{SK(P)}$**

## Test Diagrams (Continued)



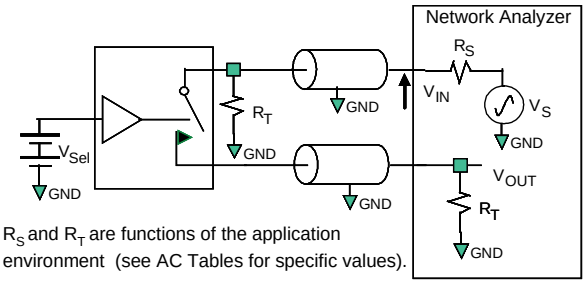

$R_L$, $R_S$, and $C_L$ are functions of the application environment (see AC Tables for specific values)
$C_L$ includes test fixture and stray capacitance.

**Figure 9. Break-Before-Make Interval Timing**




$R_S$ and $R_T$ are functions of the application environment (see AC Tables for specific values).

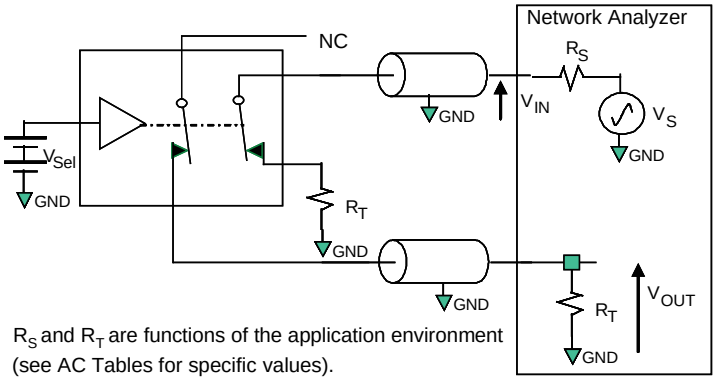
**Figure 10. Bandwidth**




$R_S$ and $R_T$ are functions of the application environment (see AC Tables for specific values).

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

**Figure 11. Channel Off Isolation**




$R_S$ and $R_T$ are functions of the application environment (see AC Tables for specific values).

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

**Figure 12. Non-Adjacent Channel-to-Channel Crosstalk**

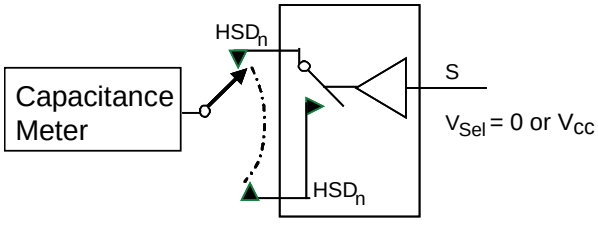



**Figure 13. Channel Off Capacitance**

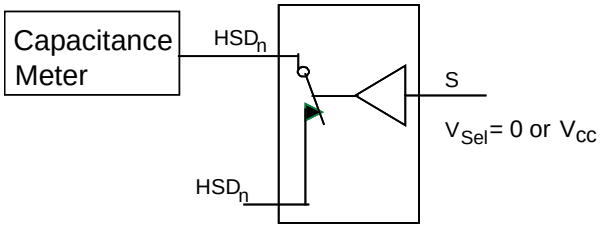



**Figure 14. Channel On Capacitance**