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ON Semiconductor®

# FSUSB104 — Low-Power, Two-Port, Hi-Speed, USB2.0 (480 Mbps) Switch

## Features

- Low On Capacitance: 3.7 pF Typical
- Low On Resistance: 3.9 Ω Typical
- Low Power Consumption: 1 μA Maximum
  - 15 μA Maximum I<sub>CC</sub>T over an Expanded Voltage Range (V<sub>IN</sub>=1.8 V, V<sub>CC</sub>=4.3 V)
- Wide -3 db Bandwidth: > 720 MHz
- Packaged in Pb-free 10-Lead UMLP (1.4 x 1.8 mm)
- 8 kV ESD Rating, >16 kV Power/GND ESD Rating
- Power-Off Protection on All Ports When V<sub>CC</sub>=0 V
  - D+/D- Pins Tolerate up to 5.25 V

## Applications

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

## Description

The FSUSB104 is a bi-directional, low-power, two-port, Hi-Speed, USB2.0 switch. Configured as a double-pole, double-throw switch (DPDT) switch, it is optimized for switching between two Hi-Speed (480 Mbps) sources or a Hi-Speed and Full-Speed (12 Mbps) source.

The FSUSB104 is compatible with the requirements of USB2.0 and features an extremely low on capacitance (C<sub>ON</sub>) of 3.7 pF. The wide bandwidth of this device (720 MHz) 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 FSUSB104 contains special circuitry on the switch I/O pins for applications where the V<sub>CC</sub> supply is powered-off (V<sub>CC</sub>=0), which allows the device to withstand an over-voltage condition. This device is designed to minimize current consumption even when the control voltage applied to the SEL pin is lower than the supply voltage (V<sub>CC</sub>). This feature is especially valuable to ultra-portable 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.

## Ordering Information

Part Number	Top Mark	Operating Temperature Range	Package
FSUSB104UMX	JF	-40 to +85°C	10-Lead, Quad, Ultrathin Molded Leadless Package (UMLP), 1.4 x 1.8 mm

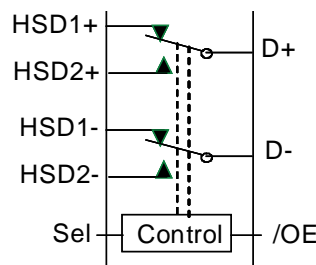


Figure 1. Analog Symbol

## Pin Assignments

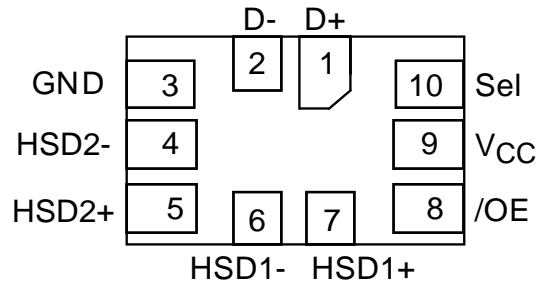


Figure 2. Pin Assignment (Top Through View)

## Pin Definitions

Pin #	Name	Description
1	D+	USB Data Bus
2	D-	USB Data Bus
3	GND	Ground
4	HSD2-	Multiplexed Source Inputs
5	HSD2+	Multiplexed Source Inputs
6	HSD1-	Multiplexed Source Inputs
7	HSD1+	Multiplexed Source Inputs
8	/OE	Switch Enable
9	V <sub>CC</sub>	Supply Voltage
10	Sel	Switch Select

## 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 <sub>CC</sub>	Supply Voltage	-0.5	5.6	V	
V <sub>CNTRL</sub>	DC Input Voltage (S, /OE) <sup>(1)</sup>	-0.5	V <sub>CC</sub>	V	
V <sub>SW</sub>	DC Switch I/O Voltage <sup>(1)</sup>	-0.5	5.25	V	
I <sub>IK</sub>	DC Input Diode Current	-50		mA	
I <sub>OUT</sub>	DC Output Current		50	mA	
T <sub>STG</sub>	Storage Temperature	-65	+150	°C	
ESD	Human Body Model, JEDEC: JESD22-A114	All Pins		7	kV
		I/O to GND		8	
		Power to GND		16	
	Charged Device Model, JEDEC: JESD22-C101			2	

**Note:**

- 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 <sub>CC</sub>	Supply Voltage	3.0	4.4	V
V <sub>CNTRL</sub>	Control Input Voltage (S, /OE) <sup>(2)</sup>	0	V <sub>CC</sub>	V
V <sub>SW</sub>	Switch I/O Voltage	-0.5	4.5	V
T <sub>A</sub>	Operating Temperature	-40	+85	°C

**Note:**

- The control input must be held HIGH or LOW and it must not float.

## DC Electrical Characteristics

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

Symbol	Parameter	Conditions	V <sub>CC</sub> (V)	T <sub>A</sub> =- 40°C to +85°C			Units
				Min.	Typ.	Max.	
V <sub>IK</sub>	Clamp Diode Voltage	I <sub>IN</sub> =-18 mA	3.0			-1.2	V
V <sub>IH</sub>	Input Voltage High		3.0 to 3.6	1.3			V
			4.3	1.7			V
V <sub>IL</sub>	Input Voltage Low		3.0 to 3.6			0.5	V
			4.3			0.7	V
I <sub>IN</sub>	Control Input Leakage	V <sub>SW</sub> =0 to V <sub>CC</sub>	4.3	-1		1	μA
I <sub>OZ</sub>	Off State Leakage	0 ≤ D <sub>n</sub> , HSD1 <sub>n</sub> , HSD2 <sub>n</sub> ≤ 3.6V	4.3	-2		2	μA
I <sub>OFF</sub>	Power-Off Leakage Current (All I/O Ports)	V <sub>SW</sub> =0 V to 4.3 V, V <sub>CC</sub> =0 V Figure 4	0	-2		2	μA
R <sub>ON</sub>	HS Switch On Resistance <sup>(3)</sup>	V <sub>SW</sub> =0.4 V, I <sub>ON</sub> =-8 mA Figure 3,	3.0		3.9	6.5	Ω
ΔR <sub>ON</sub>	HS Delta Ron <sup>(4)</sup>	V <sub>SW</sub> =0.4 V, I <sub>ON</sub> =-8 mA	3.0		0.65		Ω
I <sub>CC</sub>	Quiescent Supply Current	V <sub>CNTRL</sub> =0 or V <sub>CC</sub> , I <sub>OUT</sub> =0	4.3			1.0	μA
I <sub>CC</sub> T	Increase in I <sub>CC</sub> Current per Control Voltage and V <sub>CC</sub>	V <sub>CNTRL</sub> =2.6 V, V <sub>CC</sub> =4.3 V	4.3			10.0	μA
		V <sub>CNTRL</sub> =1.8 V, V <sub>CC</sub> =4.3 V	4.3			15.0	μA

### Notes:

- Measured by the voltage drop between HSD<sub>n</sub> and D<sub>n</sub> pins at the indicated current through the switch. On resistance is determined by the lower of the voltage on the two (HSD<sub>n</sub> or D<sub>n</sub> ports).
- Guaranteed by characterization. Not tested in production.

## AC Electrical Characteristics

All typical value are for  $V_{CC}=3.3\text{ V}$  at  $25^{\circ}\text{C}$  unless otherw ise specified.

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

**Note:**

5. Guaranteed by characterization. Not tested in production.

## USB Hi-Speed-Related AC Electrical Characteristics

Symbol	Parameter	Conditions	$V_{CC}$ (V)	$T_A=-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$			Units
				Min.	Typ.	Max.	
$t_{SK(P)}$	Skew of Opposite Transitions of the Same Output <sup>(6)</sup>	$C_L=5\ \text{pF}$ , $R_L=50\ \Omega$ Figure 8	3.0 to 3.6		20		ps
$t_J$	Total Jitter <sup>(6)</sup>	$R_L=50\ \Omega$ , $C_L=5\ \text{pF}$ , $t_R=t_F=500\text{ps}$ (10-90%) at 480 Mbps (PRBS= $2^{15}-1$ )	3.0 to 3.6		200		ps

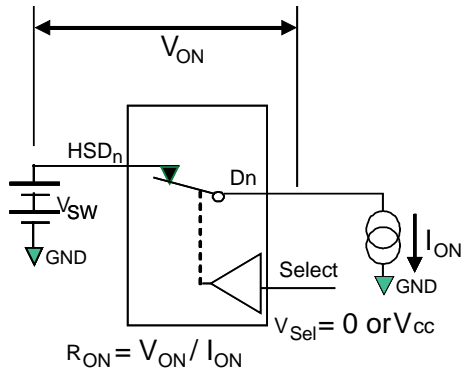
**Note:**

6. Guaranteed by characterization. Not tested in production.

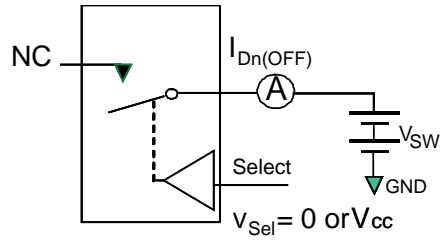
## Capacitance

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

### Test Diagrams

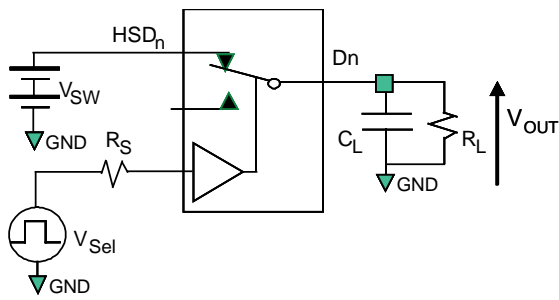


**Figure 3. On Resistance**



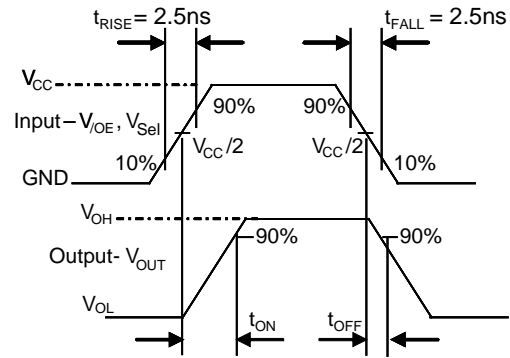
\*\*Each switch port is tested separately

**Figure 4. Off Leakage**

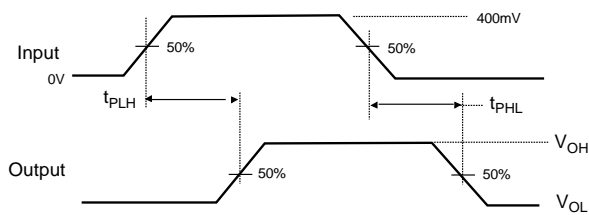


$R_L$ ,  $R_S$ , and  $C_L$  are functions of the application environment (see AC Tables for specific values)  
 $C_L$  includes test fixture and stray capacitance.

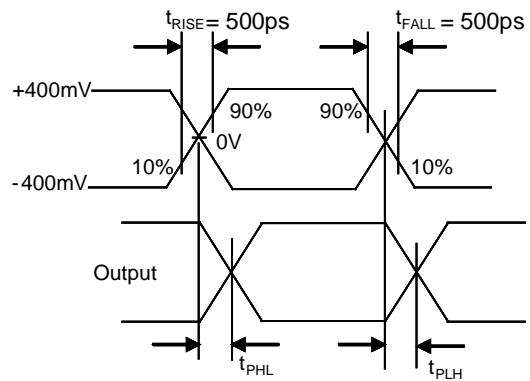
**Figure 5. AC Test Circuit Load**



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

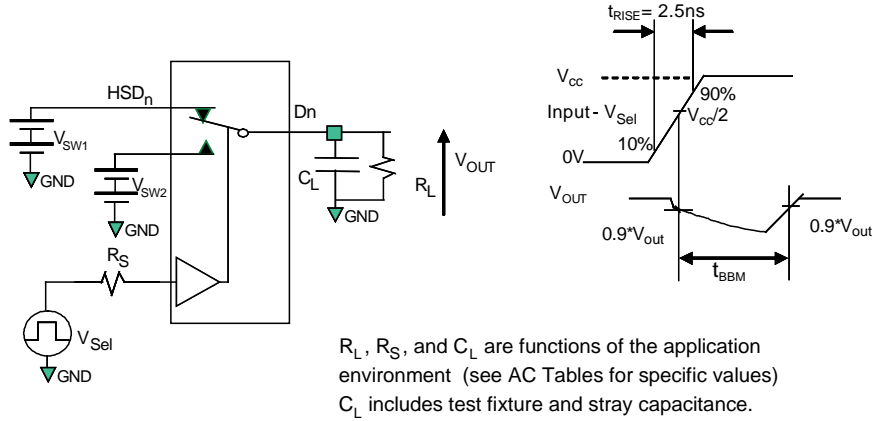


**Figure 7. Propagation Delay ( $t_{rTf} = 500 \text{ ps}$ )**

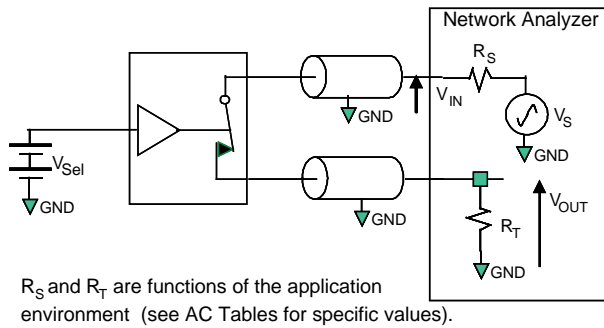


**Figure 8. Intra-Pair Skew Test  $t_{sk(P)}$**

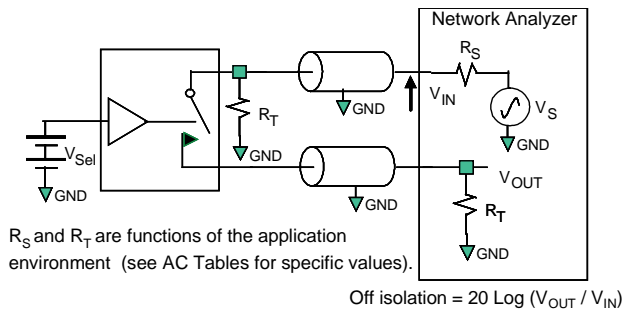
**Test Diagrams** (Continued)



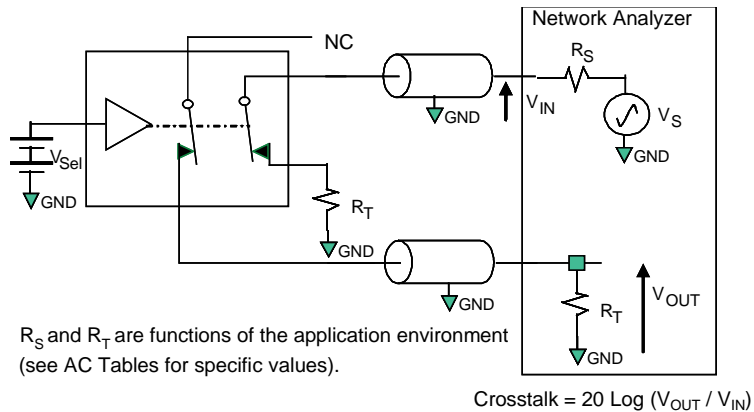
**Figure 9. Break-Before-Make Interval Timing**



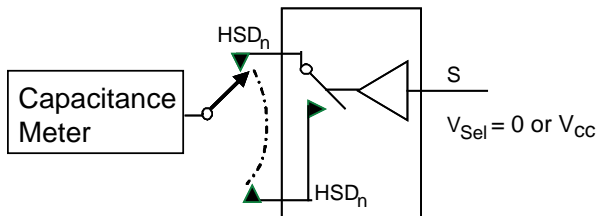
**Figure 10. Bandwidth**



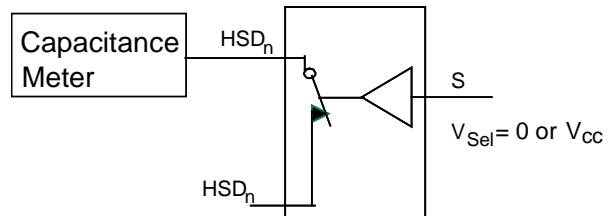
**Figure 11. Channel Off Isolation**



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



**Figure 13. Channel Off Capacitance**



**Figure 14. Channel On Capacitance**



## Physical Dimensions

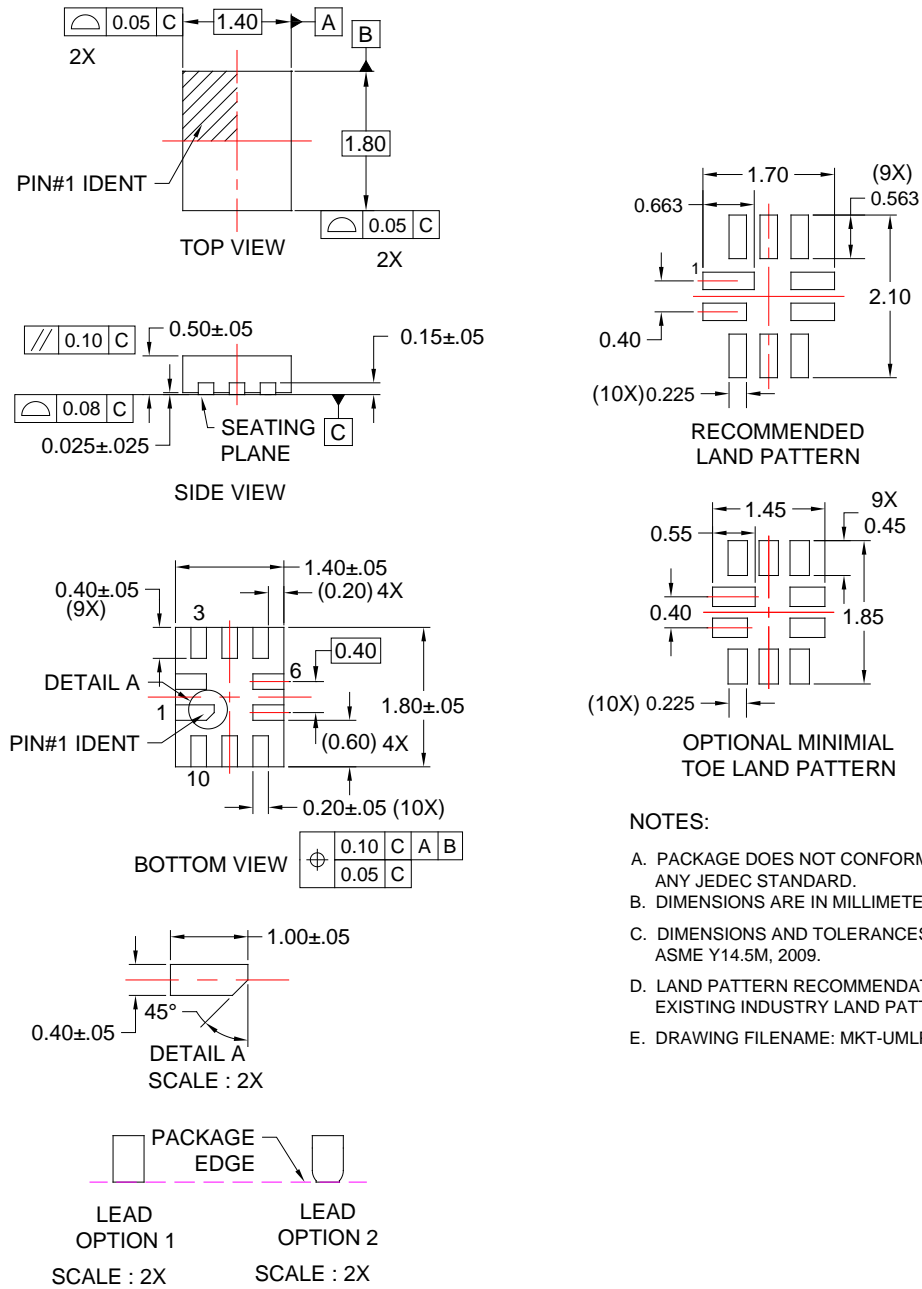


Figure 15. 10-Lead, Ultrathin Molded Leadless Package (UMLP)

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