FAIRCHILD SEMICONDUCTOR®

February 2009

FSUSB31
Low-Power, Single-Port, High-Speed USB 2.0 (480Mbps) Switch

Features

- Low On Capacitance: 3.7pF (Typical)
- Low On Resistance: 6.5Ω (Typical)
- Low Power Consumption: 1µA (Maximum)
  - 10µA Maximum I_{CCT} Over an Expanded Control Voltage Range: V_{IN} = 2.6V, V_{CC} = 4.3V
- Wide -3dB Bandwidth: > 720MHz
- 8kV I/O to GND ESD Protection
- Power-off Protection When V_{CC} = 0V, D+ / D- Pins Can Tolerate up to 5.5V
- Packaged in:
  - 8-lead MicroPak™ (1.6 x 1.6mm)
  - 8-lead US8
  - 8-lead Ultrathin MLP (1.2 x 1.4mm)

Applications

- Cell Phone, PDA, Digital Camera, and Notebook
- LCD Monitor, TV, and Set-top Box

Related Resources

- *AN-6022 Using the FSUSB30/31 to Comply with USB 2.0 Fault Condition Requirements*

Description

The FSUSB31 is a low-power, single-port, high-speed USB 2.0 switch. This part is configured as a double-pole, single-throw switch and is optimized for switching or isolating a high-speed (480Mbps) source or a high-speed and full-speed (12Mbps) source. The FSUSB31 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 minimizes interference.

The FSUSB31 contains special circuitry on the D+ / D- pins that allows the device to withstand an over-voltage condition. This device is also designed to minimize current consumption even when the control voltage applied to the $\overline{OE}$ pin is lower than the supply voltage (V_{CC}). This feature is especially valuable for mobile applications, such as cell phones, allowing direct interface with the general-purpose I/Os of the baseband processor. Other applications include port isolation and switching in portable cell phones, PDAs, digital cameras, printers, and notebook computers.

Ordering Information

Part Number	Package	Eco Status	Package Description
FSUSB31K8X	MAB08A	Green	8-Lead US8, JEDEC MO-187, Variation CA 3.1mm Wide
FSUSB31L8X	MAC08A	RoHS	8-Lead MicroPak, 1.6mm Wide
FSUSB31UMX	UMLP08A	Green	8-Lead, Ultrathin Molded Leadless Package (UMLP), 1.2 x 1.4mm

For Fairchild's definition of "green" Eco Status, please visit: http://www.fairchildsemi.com/company/green/rohs_green.html.

Application Diagram

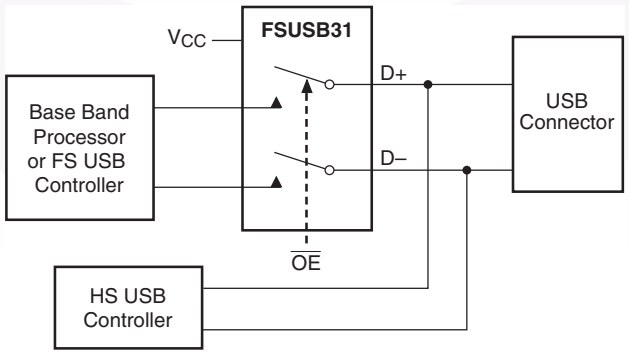


Figure 1. Typical Application Diagram

MicroPak™ is a trademark of Fairchild Semiconductor Corporation.

Analog Symbol

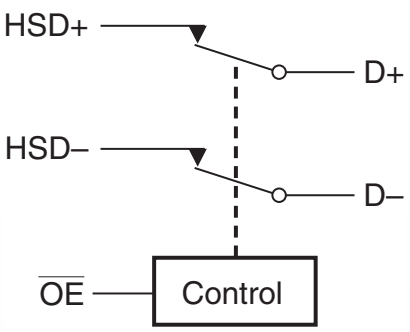


Figure 2. Analog Symbol

Pin Descriptions

Pin Name	Description
$\overline{OE}$	Bus Switch Enable
D+, D–, HSD+, HSD–	Data Ports
NC	No Connect

Truth Table

$\overline{OE}$	Function
HIGH	Disconnect
LOW	D+, D– = HSD+, HSD-

Connection Diagrams

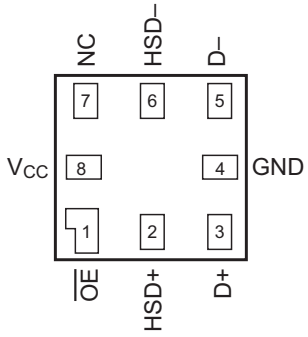


Figure 3. Pin Assignments for MicroPak

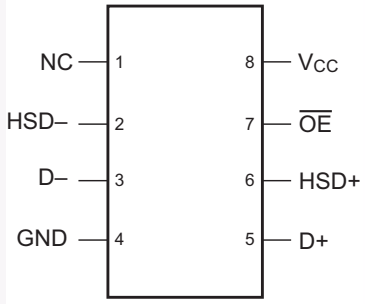


Figure 4. Pin Assignments for US8

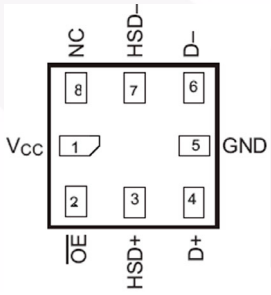


Figure 5. Pin Assignments for UMLP

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		Minimum	Maximum	Unit
V_{CC}	Supply Voltage		-0.5	5.5	V
V_S	DC Input Voltage(1)		-0.5	V_{CC}	V
V_{IN}	DC Switch Voltage(1)	HSD	-0.5	V_{CC}	V
		D+, D–	-0.5	V_{CC}	V
I_{IK}	DC Input Diode Current		-50		mA
I_{OUT}	DC Output Current			50	mA
T_{STG}	Storage Temperature		-65	+150	°C
ESD	Human Body Model: JESD22-A114	All Pins		7.5	kV
		I/O to GND		8	kV

Note:

1.The input and output negative voltage 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. Fairchild does not recommend exceeding them or designing to absolute maximum ratings.

Symbol	Parameter	Minimum	Maximum	Unit
V_{CC}	Supply Voltage	3.0	4.3	V
V_{IN}	Control Input Voltage(2)	0	V_{CC}	V
	Switch Input Voltage	0	V_{CC}	V
T_A	Operating Temperature	-40	+85	°C

Note:

2. 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_{CC} (V)	T_A = –40°C to +85°C			Unit
				Min.	Typ.	Max.	
V_{IK}	Clamp Diode Voltage	I_{IN} = –18mA	3.0			-1.2	V
V_{IH}	Input Voltage HIGH		3.0 to 3.6	1.3			V
			4.3	1.7			
V_{IL}	Input Voltage LOW		3.0 to 3.6			0.5	V
			4.3			0.7	
I_{IN}	Control Input Leakage	V_{IN} = 0V to V_{CC}	0 to V_{CC}	-1.0		1.0	µA
I_{OZ}	OFF State Leakage	0 ≤ HSD ≤ V_{CC}	4.3	-2.0		2.0	µA
I_{OFF}	Power OFF Leakage Current (D+, D–)	V_{IN} = 0.0V to 4.3V, V_{CC} = 0V	0	-2.0		2.0	µA
R_{ON}	Switch On Resistance[3]	V_{IN} = 0.4V, I_{ON} = –8mA	3.0		6.5	10.0	Ω
ΔR_{ON}	Delta R_{ON}[4]	V_{IN} = 0.4V, I_{ON} = –8mA	3.0		0.35		Ω
R_{ON} Flatness	R_{ON} Flatness[3]	V_{IN} = 0.0V –1.0V, I_{ON} = –8mA	3.0		2.0		Ω
I_{CC}	Quiescent Supply Current	V_{IN} = 0.0V or V_{CC}, I_{OUT} = 0	4.3			1.0	µA
I_{CCT}	Increase in I_{CC} Current per Control Voltage and V_{CC} Levels	V_{IN} = 2.6V, V_{CC} = 4.3V	4.3			10.0	µA

Notes:

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

AC Electrical Characteristics

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

Symbol	Parameter	Conditions	V_{CC} (V)	T_A = –40°C to +85°C			Unit	Figure Number
				Min.	Typ.	Max.		
t_{ON}	Turn-On Time, $\overline{OE}$ to Output	V_{IN} = 0.8V, R_L = 50Ω, C_L = 5pF	3.0 to 3.6		15.0	30.0	ns	Figure 13
t_{OFF}	Turn-Off Time, $\overline{OE}$ to Output	V_{IN} = 0.8V, R_L = 50Ω, C_L = 5pF	3.0 to 3.6		12.0	25.0	ns	Figure 13
t_{PD}	Propagation Delay[5]	R_L = 50Ω, C_L = 5pF	3.3		0.25		ns	Figure 11 Figure 12
t_{BBM}	Break-Before-Make	R_L = 50Ω, C_L = 5pF, V_{IN} = 0.8V	3.0 to 3.6	2.0		6.5	ns	Figure 14
O_{IRR}	Off Isolation (Non-Adjacent)	R_T = 50Ω, f = 240MHz	3.0 to 3.6		-35.0		dB	Figure 17
Xtalk	Non-Adjacent Channel Crosstalk	R_T = 50Ω, f = 240MHz	3.0 to 3.6		-55.0		dB	Figure 18
BW	-3dB Bandwidth	R_T = 50Ω, C_L = 0pF	3.0 to 3.6		720		MHz	Figure 16
		R_T = 50Ω, C_L = 5pF			550			

Note:

5. Guaranteed by characterization.

USB Hi-Speed Related AC Electrical Characteristics

Symbol	Parameter	Conditions	V_{CC} (V)	T_A = –40°C to +85°C			Unit	Figure Number
				Min.	Typ.	Max.		
$t_{SK(O)}$	Channel-to-Channel Skew(6)	C_L = 5pF	3.0 to 3.6		50.0		ps	Figure 11 Figure 15
$t_{SK(P)}$	Skew of Opposite Transitions of the Same Output(6)	C_L = 5pF	3.0 to 3.6		20.0		ps	Figure 11 Figure 15
t_J	Total Jitter(6)	R_L = 50Ω, C_L = 5pF, $t_R = t_F$ = 500ps at 480 Mbps (PRBS = $2^{15} - 1$)	3.0 to 3.6		200		ps	

Note:

6. Guaranteed by design.

Capacitance

Symbol	Parameter	Conditions	T_A = –40°C to +85°C			Unit	Figure Number
			Min.	Typ.	Max.		
C_{IN}	Control Pin Input Capacitance	V_{CC} = 0V		1.0		pF	Figure 20
C_{ON}	On Capacitance	V_{CC} = 3.3V, $\overline{OE}$ = 0V		3.7		pF	Figure 19
C_{OFF}	Off Capacitance	V_{CC} and $\overline{OE}$ = 3.3V		1.7		pF	Figure 20

Typical Characteristics

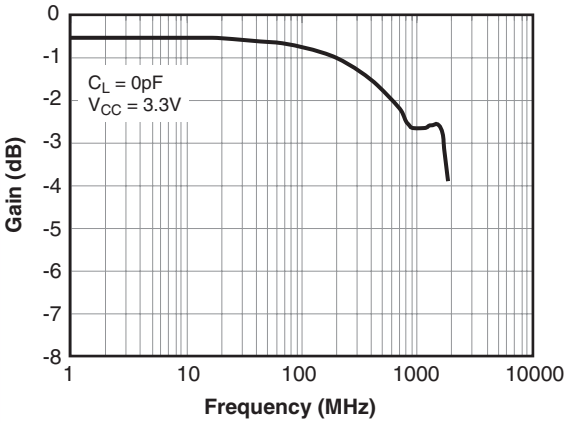


Figure 6. Gain vs. Frequency

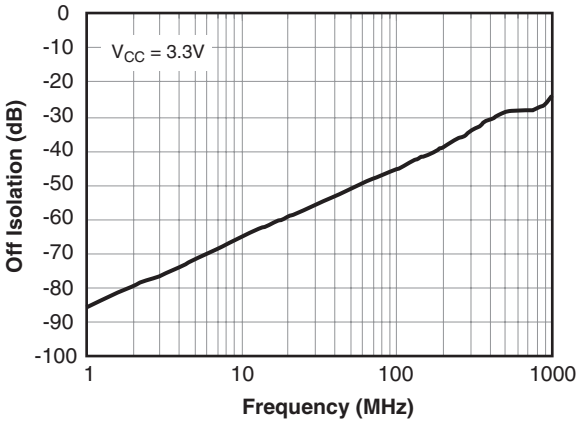


Figure 7. Off Isolation

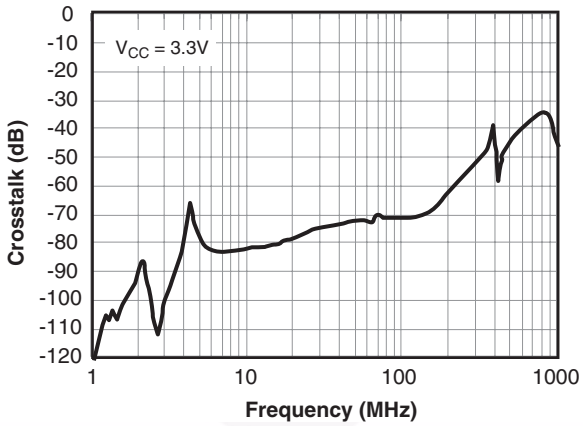


Figure 8. Crosstalk

Test Diagrams

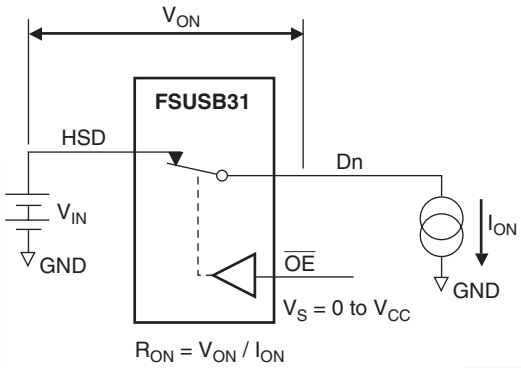
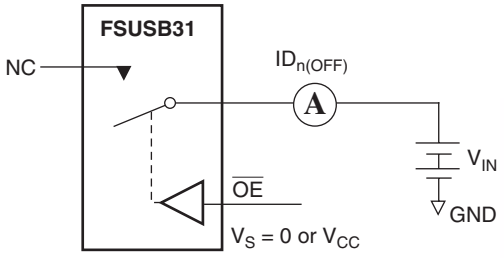
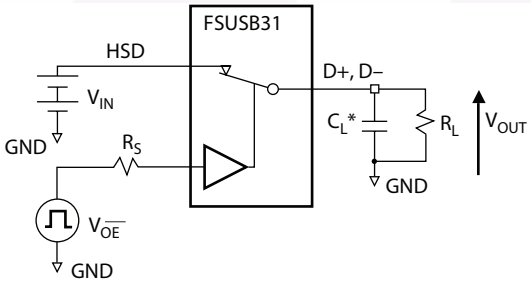


Figure 9. On Resistance



Each switch port is tested separately.

Figure 10. Off Leakage



R_L, R_S, and C_L are functions of the application environment (see AC Electrical tables for specific values).

*C_L includes test fixture and stray capacitance.

Figure 11. AC Test Circuit Load

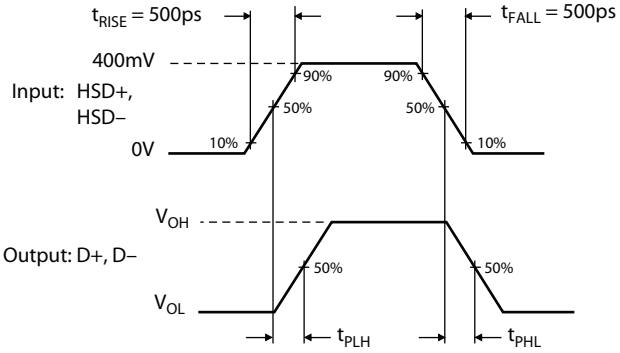


Figure 12. Switch Propagation Delay Waveforms (t_{PD})

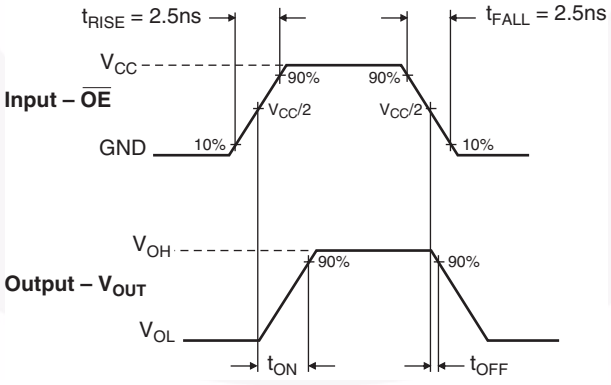


Figure 13. Turn On / Turn Off Waveform (t_{ON} / t_{OFF})

Test Diagrams (Continued)

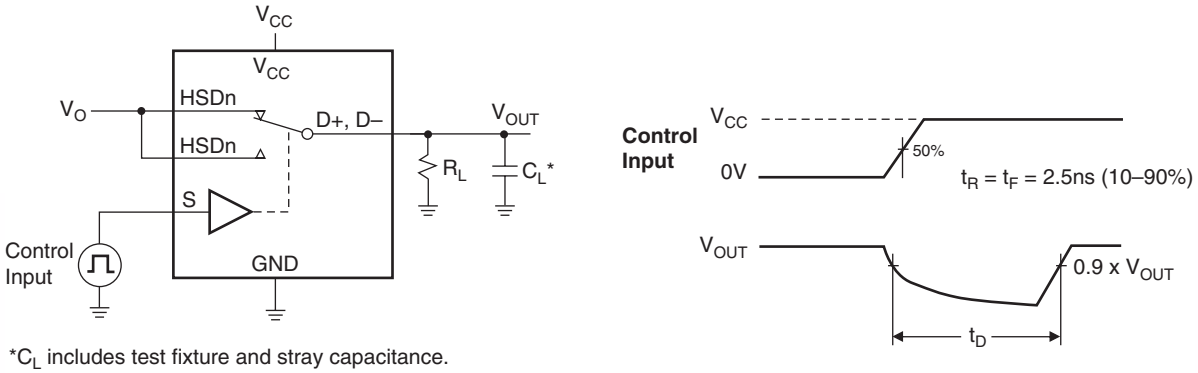


Figure 14. Break-Before-Make (t_{BBM})

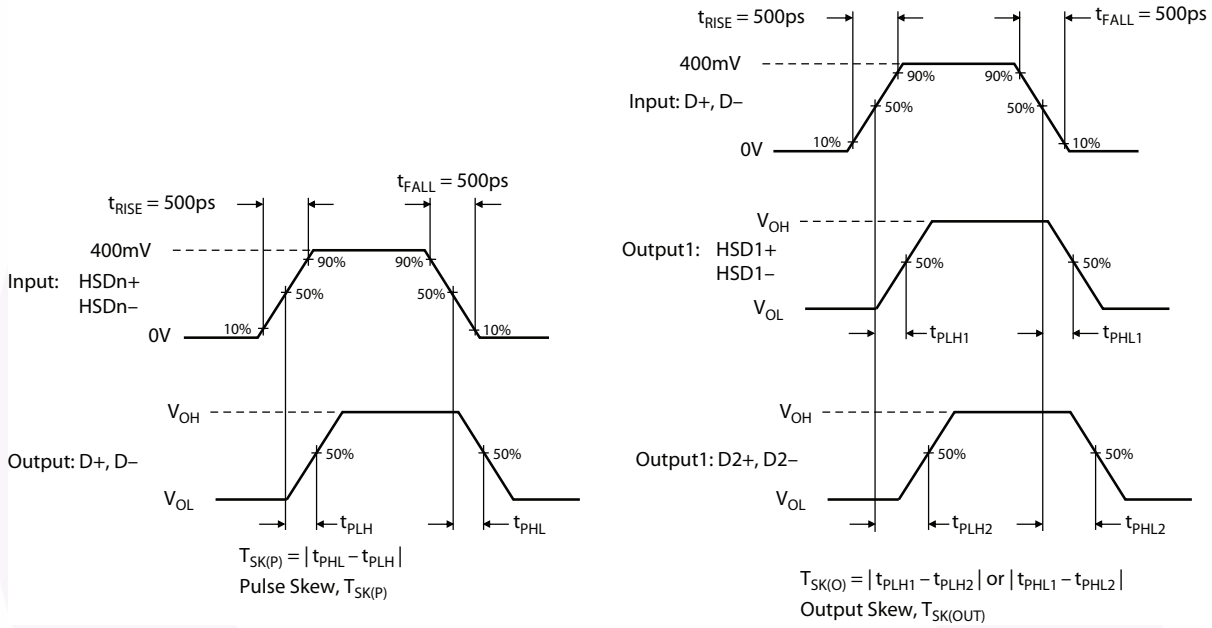


Figure 15. Switch Skew Tests

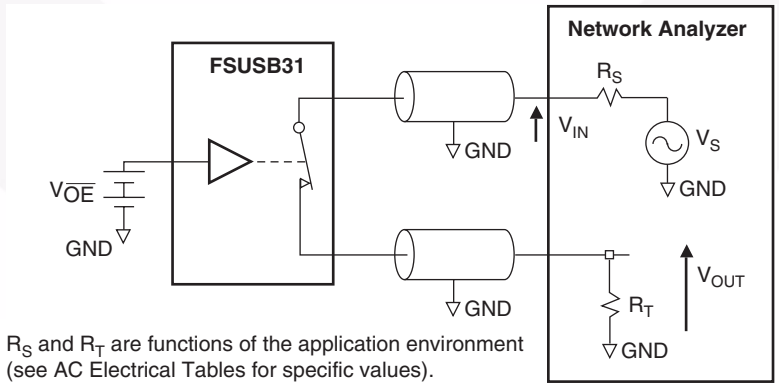


Figure 16. Bandwidth

Test Diagrams (Continued)

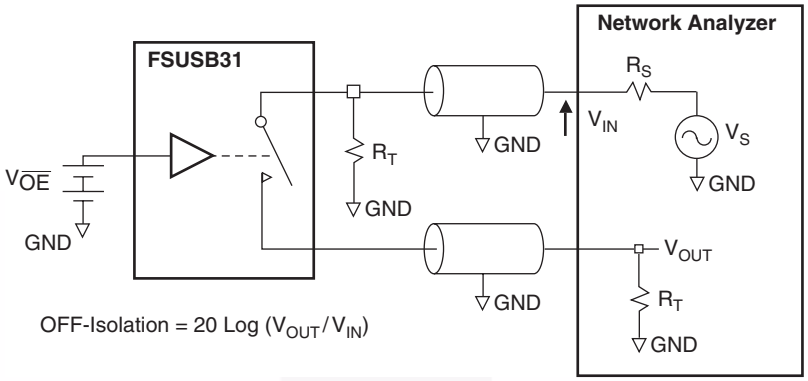


Figure 17. Channel Off Isolation

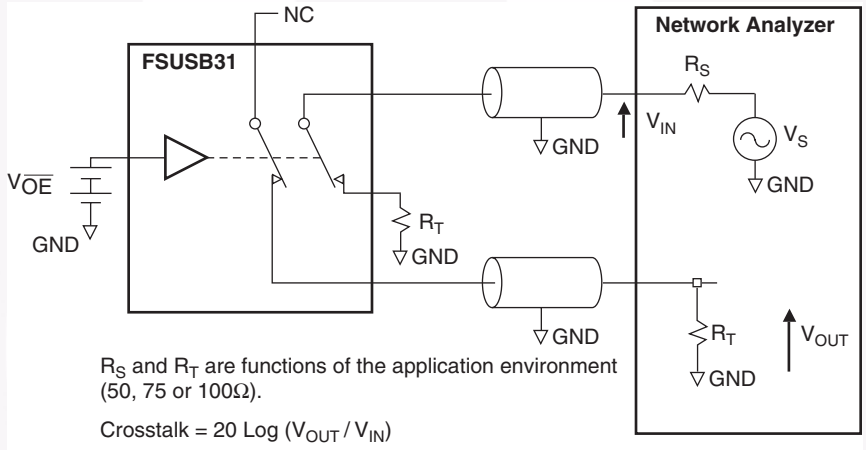


Figure 18. Non-Adjacent Channel-to-Channel Crosstalk

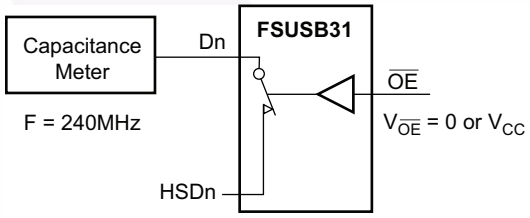


Figure 19. Channel On Capacitance

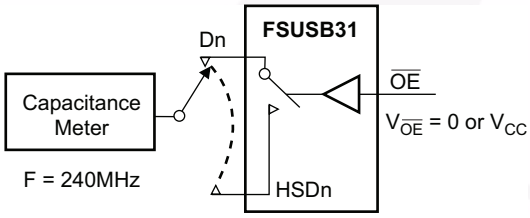


Figure 20. Channel Off Capacitance

Application Guidance: Meeting USB 2.0 Vbus Short Requirements

In section 7.1.1 of the USB 2.0 specification, it notes that USB devices must be able to withstand a Vbus short to D+ or D- when the USB devices is either powered off or powered on. The FSUSB31 can be successfully configured to meet both these requirements.

Power-Off Protection

For a Vbus short circuit, the switch is expected to withstand such a condition for at least 24 hours. The FSUSB31 has specially designed circuitry which prevents unintended signal bleed through as well as guaranteed system reliability during a power-down, over-voltage condition. The protection has been added to the common pins (D+, D-).

Power-On Protection

The USB 2.0 specification also notes that the USB device should be capable of withstanding a Vbus short during transmission of data. Fairchild recommends adding a 100Ω series resister between the switch VCC pin and supply rail to protect against this case. This modification works by limiting current flow back into the VCC rail during the over-voltage event so current remains within the safe operating range. In this application, the switch passes the full 5.25V input signal through to the selected output, while maintaining specified off isolation on the un-selected pins.

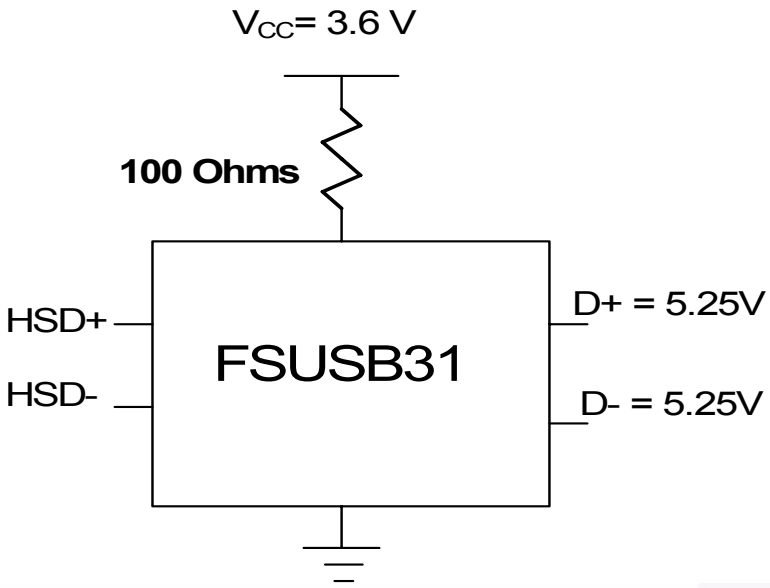
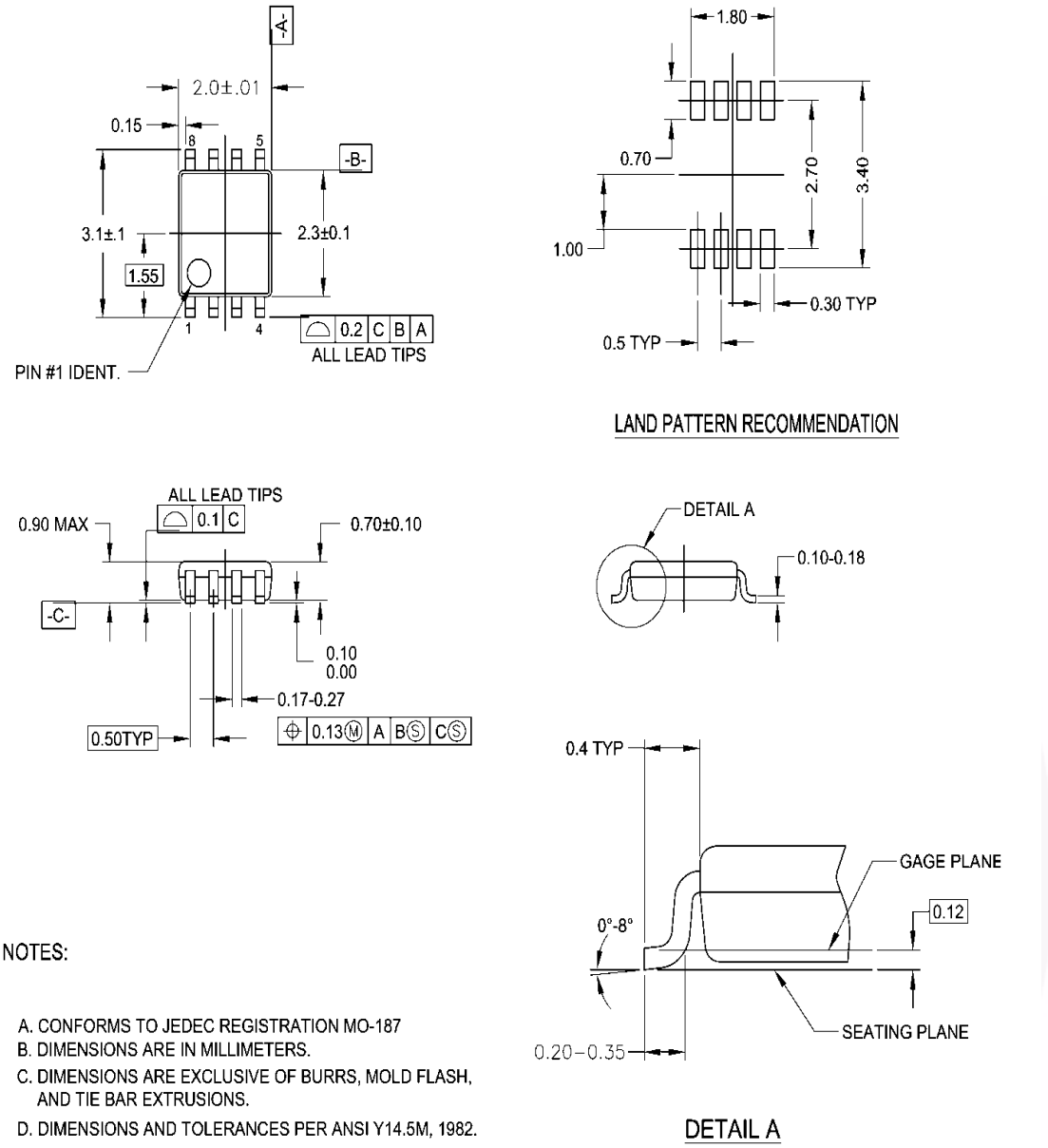


Figure 21. A 100Ω resistor in series with the V_{CC} supply allows the FSUSB31 to withstand a Vbus short when powered up

For more information, see Applications Note AN-6022 — Using the FSUSB30/FSUSB31 to Comply with USB 2.0 Fault Condition Requirements at www.fairchildsemi.com.

Physical Dimensions



NOTES:

A. CONFORMS TO JEDEC REGISTRATION MO-187
B. DIMENSIONS ARE IN MILLIMETERS.
C. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.
D. DIMENSIONS AND TOLERANCES PER ANSI Y14.5M, 1982.

MAB08AREVC

Figure 22. 8-Lead US8, JEDEC MO-187, Variation CA 3.1mm Wide

For MicroPak™ tape and reel specifications, please visit Fairchild's website: http://www.fairchildsemi.com/ms/MS/MS-522.pdf.

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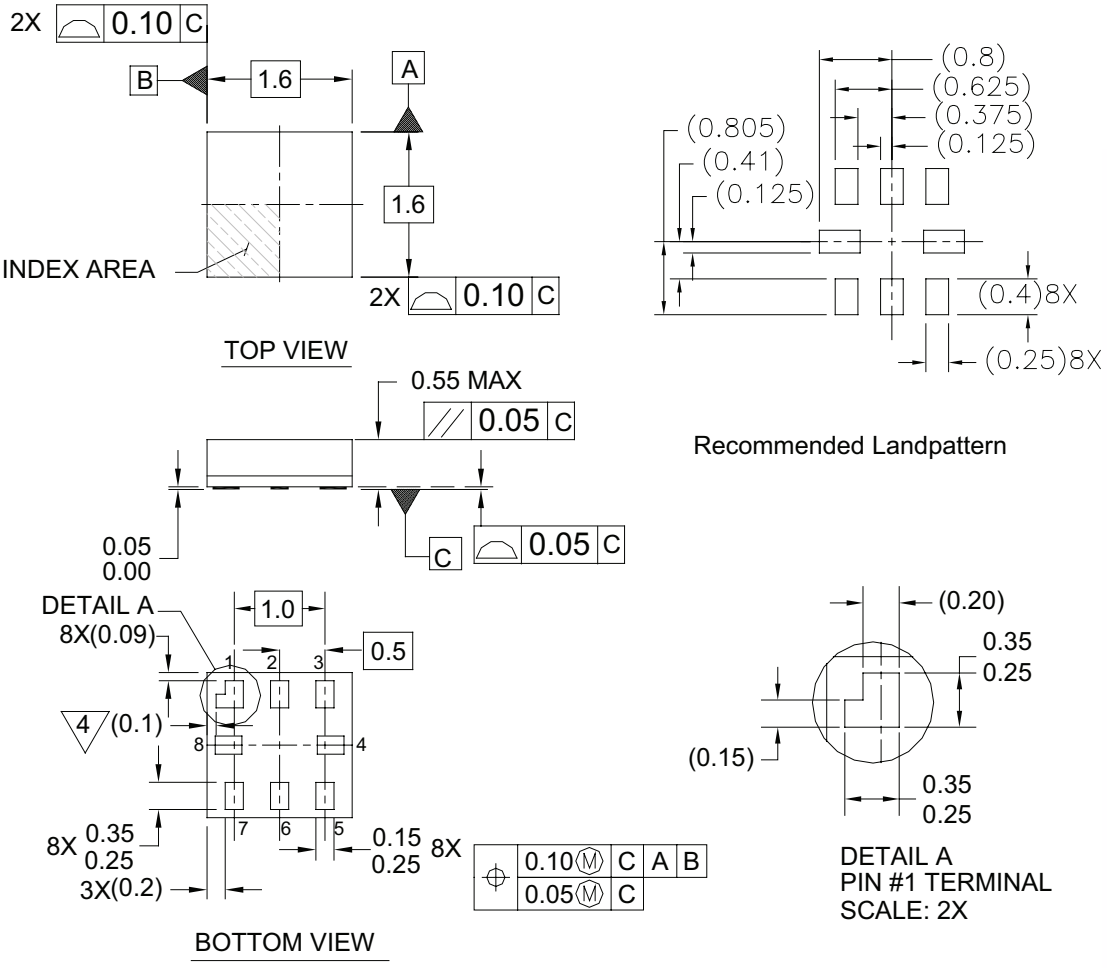
Physical Dimensions (Continued)



Notes:

1. PACKAGE CONFORMS TO JEDEC MO-255 VARIATION UAAD
2. DIMENSIONS ARE IN MILLIMETERS
3. DRAWING CONFORMS TO ASME Y.14M-1994
4. PIN 1 FLAG, END OF PACKAGE OFFSET
5. DRAWING FILE NAME: MKT-MAC08AREV4

MAC08AREV4

Figure 23. 8-Lead MicroPak, 1.6mm Wide

For MicroPak™ tape and reel specifications, please visit Fairchild's website:
http://www.fairchildsemi.com/products/logic/pdf/micropak_tr.pdf.

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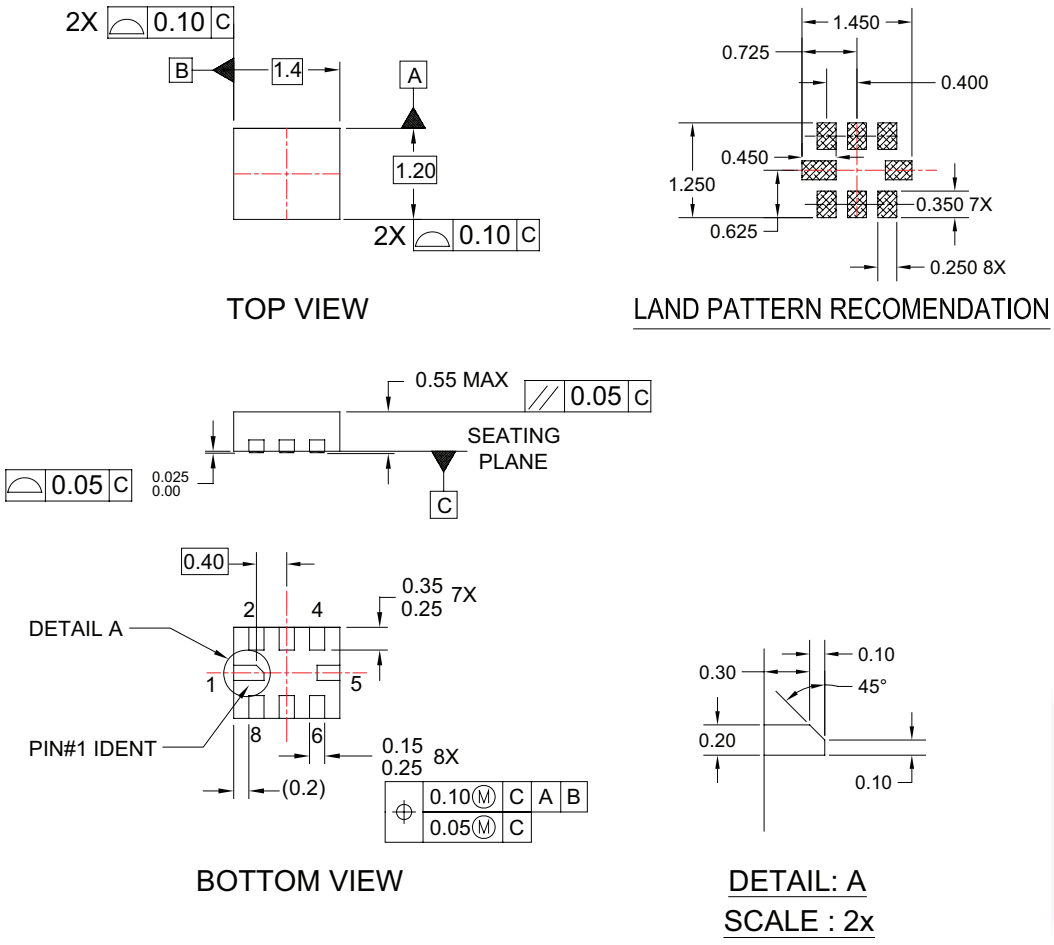
Physical Dimensions (Continued)



NOTES:

A. DOES NOT CONFORMS TO JEDEC STANDARD.

B. DIMENSIONS ARE IN MILLIMETERS.

C. DIMENSIONS AND TOLERANCES CONFORMS TO ASME Y14.5M, 1994.

D. DRAWING FILE NAME : UMLP08Arev1

Figure 24. 8-Lead, Ultrathin Molded Leadless Package (UMLP), 1.2 x 1.4mm

For MicroPak™ tape and reel specifications, please visit Fairchild's website:
http://www.fairchildsemi.com/products/logic/pdf/micropak_tr.pdf.

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FACT®
FAST®
FastvCore™
FlashWriter®*
FPS™
F-PFS™
FRFET®
Global Power Resource℠
Green FPS™
Green FPS™ e-Series™
GTO™
IntelliMAX™
ISOPLANAR™
MegaBuck™
MICROCOUPLER™
MicroFET™
MicroPak™
MillerDrive™
MotionMax™
Motion-SPM™
OPTOLOGIC®
OPTOPLANAR®
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PDP SPM™
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PowerTrench®
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SuperSOT™-6
SuperSOT™-8
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SyncFET™
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the power franchise
TinyBoost™
TinyBuck™
TinyLogic®
TINYOPTO™
TinyPower™
TinyPWM™
TinyWire™
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