

## FSA3000 — Two-Port, High-Speed, MHL™ Switch

### Features

- Low On Capacitance: 2.7 pF/4.1 pF MHL/USB (Typical)
- Low Power Consumption: 30  $\mu$ A Maximum
- MHL Data Rate: 4.92 Gbps ( $f_{3dB} = 2.46$  GHz)
- Packaged in 10-Lead MicroPak™
- Over-Voltage Tolerance (OVT) on all USB and MHL Ports; Up to 5.25 V without External Components

### Applications

- Cell Phones and Digital Cameras

### Description

The FSA3000 is a bi-directional, low-power, two-port, high-speed, USB2.0 and video data switch that supports the Mobile High-Definition Link (MHL) Specification Rev. 2.0. Configured as a double-pole, double-throw (DPDT) switch for data, FSA3000 is optimized for USB2.0 and MHL data sources.

The FSA3000 contains circuitry on the switch I/O pins that allows the device to withstand an over-voltage condition in applications where the  $V_{CC}$  supply is powered off ( $V_{CC}=0$ ). The FSA3000 minimizes current consumption even when the voltage applied to the control pins is lower than the supply voltage ( $V_{CC}$ ). This feature is especially valuable in mobile applications, such as cell phones; allowing direct interface with the general-purpose I/Os of the baseband processor. Other applications include switching and connector sharing in portable cell phones, digital cameras, and notebook computers.

### Ordering Information

Part Number	Top Mark	Operating Temperature Range	Package
FSA3000L10X	LK	-40 to +85°C	10-Lead, MicroPak™ 1.6 x 2.1 mm JEDEC MO255B

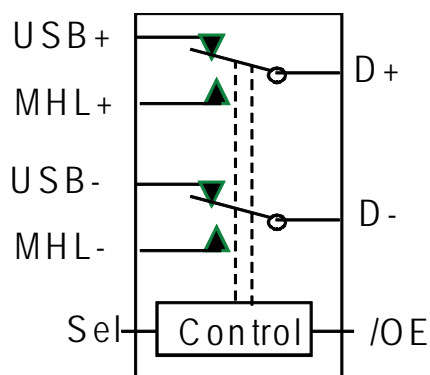


Figure 1. Analog Symbol

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### Data Switch Select Truth Table

SEL <sup>(1)</sup>	/OE <sup>(1)</sup>	Function
X	HIGH	USB and MHL paths both high impedance
LOW	LOW	D+/D- connected to USB+/USB-
HIGH	LOW	D+/D- connected to MHL+/MHL-

**Note:**

- Control inputs should never be left floating or unconnected.

### Pin Configurations

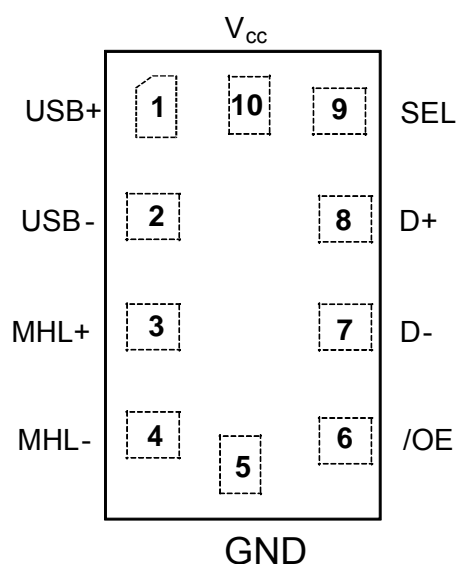


Figure 2. Pin Assignments (Top-Through View)

### Pin Definitions

Pin#	Name	Description
1	USB+	USB Differential Data (Positive)
2	USB-	USB Differential Data (Negative)
3	MHL+	MHL Differential Data (Positive)
4	MHL-	MHL Differential Data (Negative)
5	GND	Ground
6	/OE	Output Enable (Active LOW)
7	D-	Data Switch Output (Negative)
8	D+	Data Switch Output (Positive)
9	SEL	Data Switch Select
10	V <sub>cc</sub>	Supply

## 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	5.5	V
V <sub>CNTRL</sub>	DC Input Voltage (SEL, /OE) <sup>(2)</sup>		-0.5	V <sub>CC</sub>	V
V <sub>SW</sub>	DC Switch I/O Voltage <sup>(2,3)</sup>		-0.50	5.25	V
I <sub>IK</sub>	DC Input Diode Current		-50		mA
I <sub>OUT</sub>	DC Output Current			100	mA
T <sub>STG</sub>	Storage Temperature		-65	+150	°C
MSL	Moisture Sensitivity Level (JEDEC J-STD-020A)			1	
ESD	Human Body Model, JEDEC: JESD22-A114	All Pins		3.5	kV
	IEC 61000-4-2, Level 4, for D+/D- and V <sub>CC</sub> Pins <sup>(4)</sup>	Contact		8	
	IEC 61000-4-2, Level 4, for D+/D- and V <sub>CC</sub> Pins <sup>(4)</sup>	Air		15	
	Charged Device Model, JESD22-C101			2	

### Notes:

- The input and output negative ratings may be exceeded if the input and output diode current ratings are observed.
- V<sub>SW</sub> refers to analog data switch paths (USB and MHL).
- Testing performed in a system environment using TVS diodes.

## 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	Min.	Max.	Unit
V <sub>CC</sub>	Supply Voltage	2.7	4.3	V
t <sub>RAMP(VCC)</sub>	Power Supply Slew Rate	100	1000	µs/V
V <sub>CNTRL</sub>	Control Input Voltage (SEL, /OE) <sup>(5)</sup>	0	4.3	V
θ <sub>JA</sub>	Thermal Resistance		313	C°/W
V <sub>SW(USB)</sub>	Switch I/O Voltage (USB Switch Path)	-0.5	3.6	V
V <sub>SW(MHL)</sub>	Switch I/O Voltage (MHL Switch Path)	1.65	3.45	V
T <sub>A</sub>	Operating Temperature	-40	+85	°C

### Note:

- The control inputs must be held HIGH or LOW; they must not float.

## DC Electrical Characteristics

All typical value are at  $T_A=25^\circ\text{C}$  unless otherwise specified.

Symbol	Parameter	Condition	$V_{CC}$ (V)	$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			Unit
				Min.	Typ.	Max.	
$V_{IK}$	Clamp Diode Voltage	$I_{IN} = -18\text{ mA}$	2.7			-1.2	V
$V_{IH}$	Control Input Voltage High	SEL, /OE	2.7 to 4.3	1.25			V
$V_{IL}$	Control Input Voltage Low	SEL, /OE	2.7 to 4.3			0.6	V
$I_{IN}$	Control Input Leakage	$V_{SW}=0$ to 3.6 V, $V_{CNTRL}=0$ to $V_{CC}$	4.3	-500		500	nA
$I_{OZ(MHL)}$	Off-State Leakage for Open MHLn Data Paths	$V_{SW}=1.65 \leq \text{MHL} \leq 3.45\text{ V}$	4.3	-500		500	nA
$I_{OZ(USB)}$	Off-State Leakage for Open USBn Data Paths	$V_{SW}=0 \leq \text{USB} \leq 3.6\text{ V}$	4.3	-500		500	nA
$I_{CL(MHL)}$	On-State Leakage for Closed MHLn Data Paths <sup>(6)</sup>	$V_{SW}=1.65 \leq \text{MHL} \leq 3.45\text{ V}$	4.3	-500		500	nA
$I_{CL(USB)}$	On-State Leakage for Closed USBn Data Paths <sup>(6)</sup>	$V_{SW}=0 \leq \text{USB} \leq 3.6\text{ V}$	4.3	-500		500	nA
$I_{OFF}$	Power-Off Leakage Current (All I/O Ports)	$V_{SW}=0\text{ V}$ or 3.6 V, Figure 4	0	-500		500	nA
$R_{ON(USB)}$	HS Switch On Resistance (USB to Dn Path)	$V_{SW}=0.4\text{ V}$ , $I_{ON}=-8\text{ mA}$ , Figure 3	2.7		3.5	4.8	$\Omega$
$R_{ON(MHL)}$	HS Switch On Resistance (MHL to Dn Path)	$V_{SW}=V_{CC}-1050\text{ mV}$ , $I_{ON}=-8\text{ mA}$ , Figure 3	2.7		4.7	6.0	$\Omega$
$\Delta R_{ON(MHL)}$	Difference in $R_{ON}$ Between MHL Positive-Negative	$V_{SW}=V_{CC}-1050\text{ mV}$ , $I_{ON}=-8\text{ mA}$ , Figure 3,	2.7		0.03		$\Omega$
$\Delta R_{ON(USB)}$	Difference in $R_{ON}$ Between USB Positive-Negative	$V_{SW}=0.4\text{ V}$ , $I_{ON}=-8\text{ mA}$ , Figure 3	2.7		0.18		$\Omega$
$R_{ONF(MHL)}$	Flatness for $R_{ON}$ MHL Path	$V_{SW}=1.65$ to 3.45 V, $I_{ON}=-8\text{ mA}$ , Figure 3	2.7		0.9		$\Omega$
$I_{CC}$	Quiescent Supply Current	$V_{IOE}=0$ , $V_{SEL}=0$ or $V_{CC}$ , $I_{OUT}=0$	4.3			30	$\mu\text{A}$
$I_{CCZ}$	Quiescent Supply Current (High Impedance)	$V_{SEL}=X$ , $V_{IOE}=V_{CC}$ , $I_{OUT}=0$	4.3			1	$\mu\text{A}$
$I_{CCT}$	Increase in Quiescent Supply Current	$V_{SEL}=X$ , $V_{IOE}=1.65\text{ V}$	4.3		5	10	$\mu\text{A}$

**Note:**

6. For this test, the data switch is closed with the respective switch pin floating.

## AC Electrical Characteristics

All typical value are for  $V_{CC}=3.3\text{ V}$  and  $T_A=25^\circ\text{C}$  unless otherwise specified.

Symbol	Parameter	Condition	$V_{CC}$ (V)	$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			Unit
				Min.	Typ.	Max.	
$t_{ON}$	MHL Turn-On Time, SEL to Output	$R_L=50\ \Omega$ , $C_L=5\ \text{pF}$ , $V_{SW(USB)}=0.8\ \text{V}$ , $V_{SW(MHL)}=3.3\ \text{V}$ , Figure 5, Figure 6	2.7 to 3.6 V		350	600	ns
$t_{OFF}$	MHL Turn-Off Time, SEL to Output	$R_L=50\ \Omega$ , $C_L=5\ \text{pF}$ , $V_{SW(USB)}=0.8\ \text{V}$ , $V_{SW(MHL)}=3.3\ \text{V}$ , Figure 5, Figure 6	2.7 to 3.6 V		125	300	ns
$t_{ZHM,ZLM}$	MHL Enable Time, /OE to Output	$R_L=50\ \Omega$ , $C_L=5\ \text{pF}$ , $V_{SW(MHL)}=3.3\ \text{V}$ , Figure 5, Figure 6	2.7 to 3.6 V		60	150	$\mu\text{s}$
$t_{ZHU,ZLU}$	USB Enable Time, /OE to Output	$R_L=50\ \Omega$ , $C_L=5\ \text{pF}$ , $V_{SW(USB)}=0.8\ \text{V}$ , Figure 5, Figure 6	2.7 to 3.6 V		100	300	ns
$t_{LZM,HZM}$	MHL Disable Time, /OE to Output	$R_L=50\ \Omega$ , $C_L=5\ \text{pF}$ , $V_{SW(MHL)}=3.3\ \text{V}$ , Figure 5, Figure 6	2.7 to 3.6 V		35	100	ns
$t_{LZU,HZU}$	USB Disable Time, /OE to Output	$R_L=50\ \Omega$ , $C_L=5\ \text{pF}$ , $V_{SW(USB)}=0.8\ \text{V}$ , Figure 5, Figure 6	2.7 to 3.6 V		35	100	ns
$t_{PD}$	Propagation Delay <sup>(7)</sup>	$C_L=5\ \text{pF}$ , $R_L=50\ \Omega$ , Figure 5, Figure 7	2.7 to 3.6 V		0.25		ns
$t_{BBM}$	Break-Before-Make <sup>(7)</sup>	$R_L=50\ \Omega$ , $C_L=5\ \text{pF}$ , $V_{ID}=V_{MHL}=3.3\ \text{V}$ , $V_{USB}=0.8\ \text{V}$ , Figure 9	2.7 to 3.6 V	2		13	ns
$O_{IRR(MHL)}$	Off Isolation <sup>(7)</sup>	$V_S=1\ \text{V}_{pk-pk}$ , $R_L=50\ \Omega$ , $f=240\ \text{MHz}$ , Figure 11	2.7 to 3.6 V		-55		dB
$O_{IRR(USB)}$		$V_S=400\ \text{mV}_{pk-pk}$ , $R_L=50\ \Omega$ , $f=240\ \text{MHz}$ , Figure 11	2.7 to 3.6 V		-45		dB
$Xtalk_{MHL}$	Non-Adjacent Channel <sup>(7)</sup> Crosstalk	$V_S=1\ \text{V}_{pk-pk}$ , $R=50\ \Omega$ , $f=240\ \text{MHz}$ , Figure 12	2.7 to 3.6 V		-47		dB
$Xtalk_{USB}$		$V_S=400\ \text{mV}_{pk-pk}$ , $R_L=50\ \Omega$ , $f=240\ \text{MHz}$ , Figure 12	2.7 to 3.6 V		-45		dB
BW (Insertion Loss)	Differential -3db Bandwidth <sup>(7)</sup>	$V_{IN}=1\ \text{V}_{pk-pk}$ , MHL Path, $R_L=50\ \Omega$ , $C_L=0\ \text{pF}$ , Figure 10, Figure 15	2.7 to 3.6 V		2.46		GHz
		$V_{IN}=400\ \text{mV}_{pk-pk}$ , USB Path, $R_L=50\ \Omega$ , $C_L=0\ \text{pF}$ , Figure 10, Figure 16			1.22		

**Note:**

7. Guaranteed by characterization.

## USB High-Speed AC Electrical Characteristics

Typical values are for  $V_{CC}=3.3$  V and  $T_A=25^\circ\text{C}$  unless otherwise specified.

Symbol	Parameter	Condition	$V_{CC}$ (V)	Typ.	Unit
$t_{SK(P)}$	Skew of Opposite Transitions of the Same Output <sup>(8)</sup>	$C_L=5$ pF, $R_L=50$ $\Omega$ , Figure 8	3.0 to 3.6	6	ps
$t_J$	Total Jitter <sup>(8)</sup>	$R_L=50$ $\Omega$ , $C_L=5$ pf, $t_R=t_F=500$ ps (10-90%) at 480 Mbps, PN7	3.0 to 3.6	15	ps

**Note:**

8. Guaranteed by characterization.

## MHL AC Electrical Characteristics

Typical values are for  $V_{CC}=3.3$  V and  $T_A=25^\circ\text{C}$  unless otherwise specified.

Symbol	Parameter	Condition	$V_{CC}$ (V)	Typ.	Unit
$t_{SK(P)}$	Skew of Opposite Transitions of the Same Output <sup>(9)</sup>	$R_{PU}=50$ $\Omega$ to $V_{CC}$ , $C_L=0$ pF	3.0 to 3.6 V	6	ps
$t_J$	Total Jitter <sup>(9)</sup>	$f=2.25$ Gbps, PN7, $R_{PU}=50$ $\Omega$ to $V_{CC}$ , $C_L=0$ pF	3.0 to 3.6 V	15	ps

**Note:**

9. Guaranteed by characterization.

## Capacitance

Typical values are for  $V_{CC}=3.3$  V and  $T_A=25^\circ\text{C}$  unless otherwise specified.

Symbol	Parameter	Condition	Typ.	Max.	Unit
$C_{IN}$	Control Pin Input Capacitance <sup>(10)</sup>	$V_{CC}=0$ V, $f=1$ MHz	2.1		pF
$C_{ON(USB)}$	USB Path On Capacitance <sup>(10)</sup>	$V_{CC}=3.3$ V, $f=240$ MHz, Figure 14	4.1	5.0	pF
$C_{OFF(USB)}$	USB Path Off Capacitance <sup>(10)</sup>	$V_{CC}=3.3$ V, $f=240$ MHz, Figure 13	2.8	3.2	pF
$C_{ON(MHL)}$	MHL Path On Capacitance <sup>(10)</sup>	$V_{CC}=3.3$ V, $f=240$ MHz, Figure 14	2.7	3.0	pF
$C_{OFF(MHL)}$	MHL Path Off Capacitance <sup>(10)</sup>	$V_{CC}=3.3$ V, $f=240$ MHz, Figure 13	1.1	1.5	pF

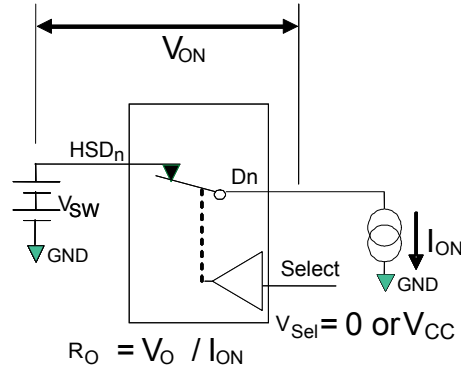
**Note:**

10. Guaranteed by characterization, not production tested.

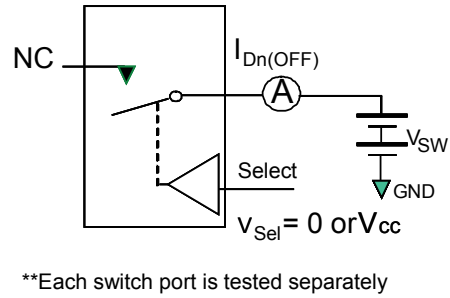
## Test Diagrams

**Note:**

11. HSD refers to the high-speed data on USB or MHL paths.

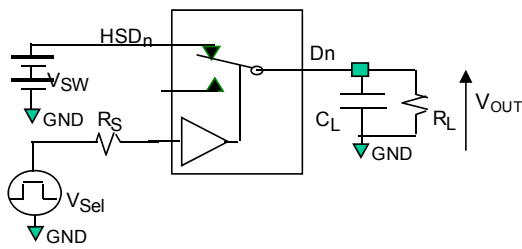


**Figure 3. On Resistance**



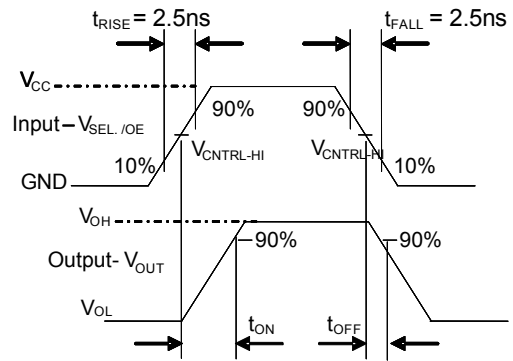
\*\*Each switch port is tested separately

**Figure 4. Off Leakage**

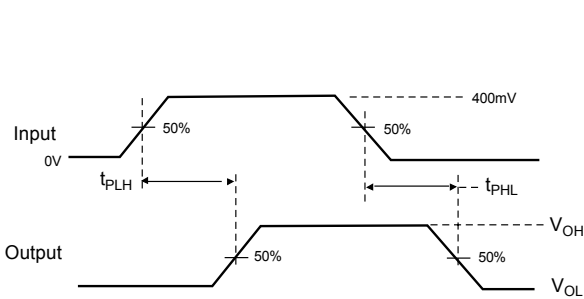


$R_L$ ,  $R_S$  and  $C_L$  are function of application environment (see AC Tables for specific values)  
 $C_L$  includes test fixture and stray capacitance

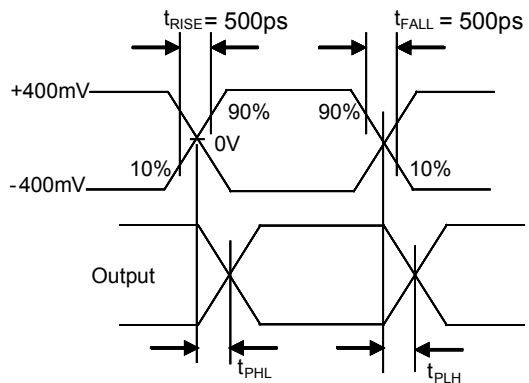
**Figure 5. AC Test Circuit Load**



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

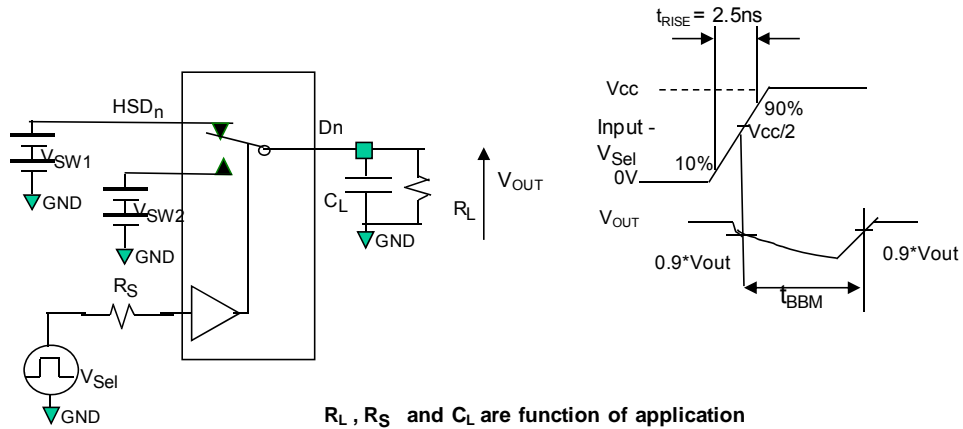


**Figure 7. Propagation Delay ( $t_{RtF} = 500$  ps)**



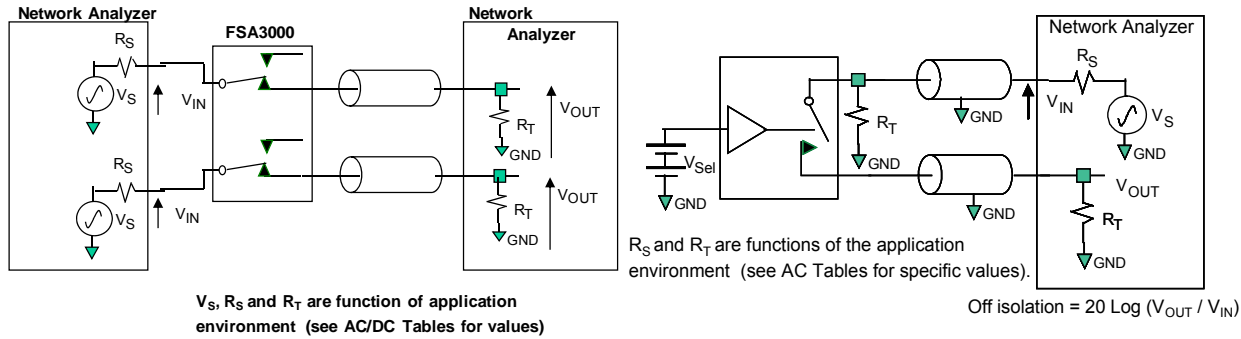
**Figure 8. Intra-Pair Skew Test  $t_{SK(P)}$**

**Test Diagrams** (Continued)



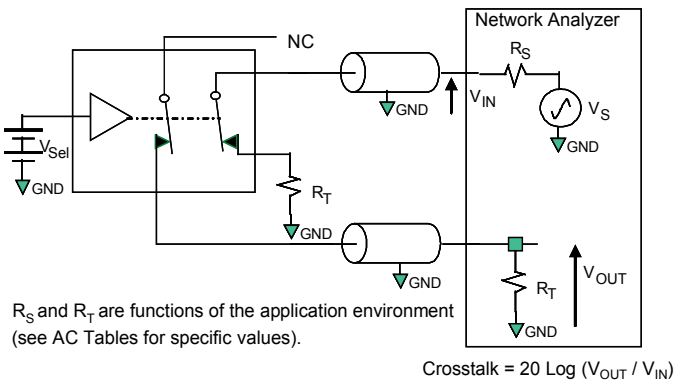
$R_L$ ,  $R_S$  and  $C_L$  are function of application environment (see AC Tables for specific values)  
 $C_L$  includes test fixture and stray capacitance

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

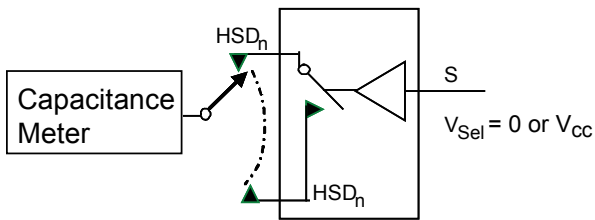


**Figure 10. Insertion Loss**

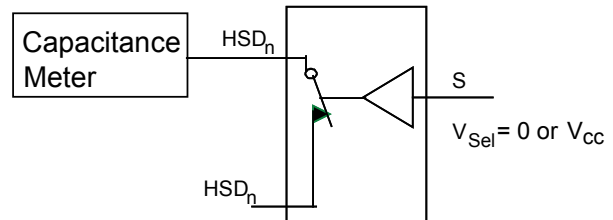
**Figure 11. Channel Off Isolation**



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



**Figure 13. Channel Off Capacitance**



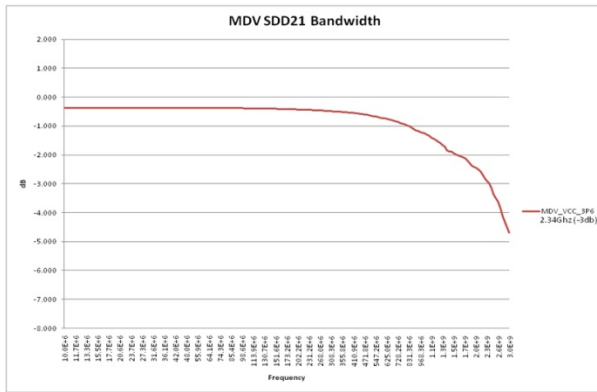
**Figure 14. Channel On Capacitance**



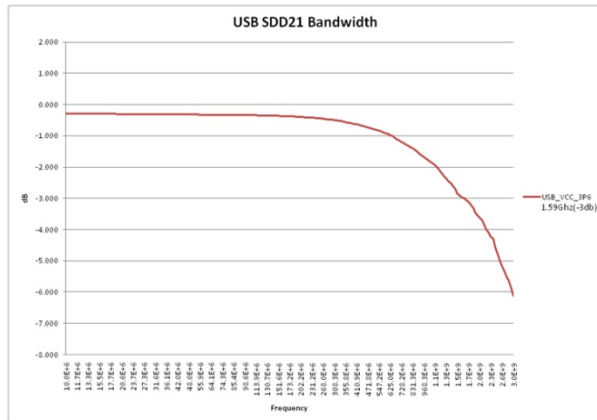
## Insertion Loss

One of the key factors for the FSA3000 in mobile digital video applications is the small amount of insertion loss in the received signal as it passes through the switch. This results in minimal degradation of the received eye. One of the ways to measure the quality of the high data rate channels is using balanced ports and 4-port differential S-parameter analysis, particularly SDD21.

Bandwidth is measured using the S-parameter SDD21 methodology. Figure 15 shows the bandwidth (GHz) for the MHL path and Figure 16 shows the bandwidth curve for the USB path.



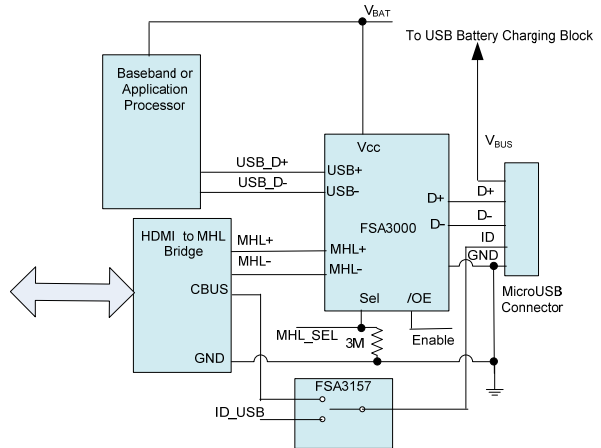
**Figure 15. MHL (MDV) Path SDD21 Insertion Loss Curve**



**Figure 16. USB Path SDD21 Insertion Loss Curve**

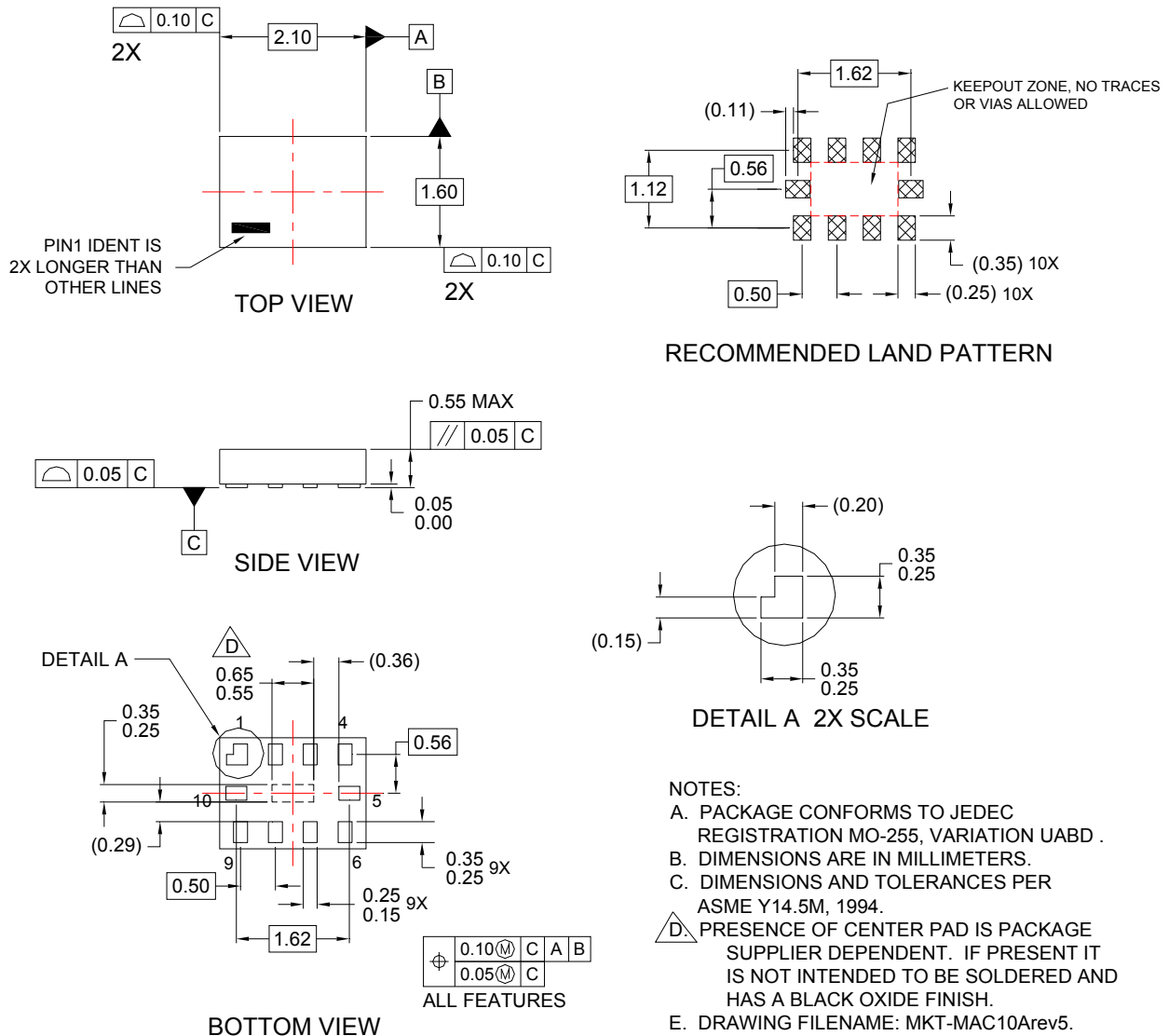
## Typical Application

Figure 17 shows a typical mobile application using the FSA3000 for MHL switching. The FSA3157 is used for OTG dual-role device implementations where the CBUS of MHL and the ID pin for USB needs to be switched. The 3M resistor for MHL\_SEL is optional to ensure that on power up the USB switch path is selected as default.



**Figure 17. Typical Mobile MHL Application**

## Physical Dimensions



**Figure 18. 10-Lead, MicroPak™ 1.6 x 2.1 mm JEDEC MO255B**

Package drawings are provided as a service to customers considering Fairchild components. Drawings may change in any manner without notice. Please note the revision and/or date on the drawing and contact a Fairchild Semiconductor representative to verify or obtain the most recent revision. Package specifications do not expand the terms of Fairchild's worldwide terms and conditions, specifically the warranty therein, which covers Fairchild products.

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| Build it Now™  | Green FPS™  | QS™  | TinyCalc™   |
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| CROSSVOLT™   | GTO™  |  ™                | TinyPower™  |
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| FastvCore™   | OPTOLOGIC®  | SyncFET™   | VoltagePlus™  |
| FETBench™  | OPTOPLANAR®   | Sync-Lock™   | XS™   |
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**ANTI-COUNTERFEITING POLICY**

Fairchild Semiconductor Corporation's Anti-Counterfeiting Policy. Fairchild's Anti-Counterfeiting Policy is also stated on our external website, [www.fairchildsemi.com](http://www.fairchildsemi.com), under Sales Support.

Counterfeiting of semiconductor parts is a growing problem in the industry. All manufacturers of semiconductor products are experiencing counterfeiting of their parts. Customers who inadvertently purchase counterfeit parts experience many problems such as loss of brand reputation, substandard performance, failed applications, and increased cost of production and manufacturing delays. Fairchild is taking strong measures to protect ourselves and our customers from the proliferation of counterfeit parts. Fairchild strongly encourages customers to purchase Fairchild parts either directly from Fairchild or from Authorized Fairchild Distributors who are listed by country on our web page cited above. Products customers buy either from Fairchild directly or from Authorized Fairchild Distributors are genuine parts, have full traceability, meet Fairchild's quality standards for handling and storage and provide access to Fairchild's full range of up-to-date technical and product information. Fairchild and our Authorized Distributors will stand behind all warranties and will appropriately address any warranty issues that may arise. Fairchild will not provide any warranty coverage or other assistance for parts bought from Unauthorized Sources. Fairchild is committed to combat this global problem and encourage our customers to do their part in stopping this practice by buying direct or from authorized distributors.

**PRODUCT STATUS DEFINITIONS**

**Definition of Terms**

Datasheet Identification	Product Status	Definition
Advance Information	Formative / In Design	Datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	Datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
No Identification Needed	Full Production	Datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve the design.
Obsolete	Not In Production	Datasheet contains specifications on a product that is discontinued by Fairchild Semiconductor. The datasheet is for reference information only.

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