

# FSA223 — USB2.0 High-Speed (480Mbps) and Audio Switches with Negative Signal Capability

## Features

- HS-USB: 4 Ω Typical On Resistance
- HS-USB: 4.5 pF Typical On Capacitance
- Audio: 3 Ω Typical On Resistance
- -3 db Bandwidth: > 720 MHz
- Low Power Consumption
- Power-off Protection on Common D+/R, D-/L Ports
- Automatically Detects  $V_{CC}$  for Switch Path Selection

## Applications

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

## Related Resources

- Please refer to tape and reel specifications on [www.fairchildsemi.com](http://www.fairchildsemi.com); <http://www.fairchildsemi.com/packaging>.

## Description

The FSA223 is a Double-Pole, Double Throw (DPDT) multiplexer that combines a low-distortion audio and a USB2.0 High-Speed (HS) switch path. This configuration enables audio and USB data to share a common connector port. The architecture is designed to allow both audio and USB signals to swing below ground. This means a common USB and headphone jack can be used for personal media players and portable peripheral devices.

Since USB2.0 is an industry standard for shared data-path in portable devices, the FSA223 also incorporates a  $V_{CC}$  detection capability. The FSA223 includes a power-off feature to minimize current consumption when  $V_{CC}$  is not present. This power-off circuitry is available for the common D+/R, D-/L ports only. Typical applications involve switching in portables and consumer applications, such as cell phones, digital cameras, and notebooks with hubs or controllers.

## IMPORTANT NOTE:

For additional performance information, please contact [analogswitch@fairchildsemi.com](mailto:analogswitch@fairchildsemi.com).

## Ordering Information

Part Number	Package Number	Top Mark	Package Description
FSA223L10X	MAC010A	GN	10-Lead MicroPak™, JEDEC MO-255, 1.6 x 2.1 mm
FSA223MUX	MUA010A	FSA223	10-Lead MSOP, JEDEC MO-187, 3.0 mm Wide
FSA223UMX	MLP010A	GP	10-Lead Quad, Ultrathin MLP, 1.4 x 1.8 mm

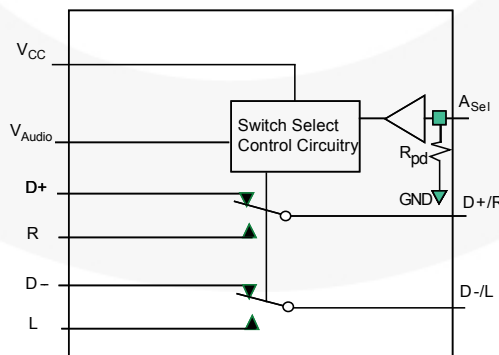


Figure 1. FSA223 Analog Symbol

## Pin Configuration

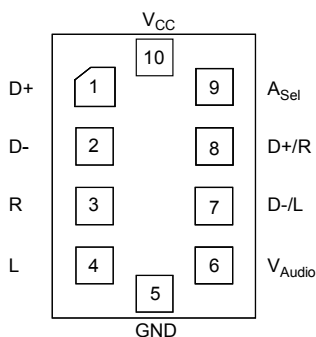


Figure 2. 10-Pin MicroPak™

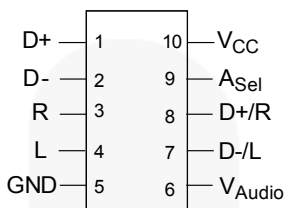


Figure 3. 10-Pin MSOP

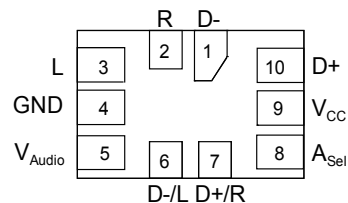


Figure 4. 10-Pin UMLP

## Pin Definitions

Name	Description
$V_{\text{audio}}$	Power supply (audio)
$V_{\text{CC}}$	Power supply (USB) and auto USB switch-path select
$A_{\text{Sel}}$	Audio select to override auto USB detect when $V_{\text{AUDIO}}$ supply is present
D+, D-	USB data bus input sources
R, L	Audio right and left input sources
D+/R, D-/L	USB and audio common connector ports

## Truth Table

$A_{\text{Sel}}^{(1)}$	$V_{\text{audio}}$	$V_{\text{CC}}$	L, R	D+, D-
— <sup>(2)</sup>	—	LOW	OFF	OFF
—	LOW	HIGH	OFF	ON
LOW	HIGH	HIGH	OFF	ON
HIGH	HIGH	HIGH	ON	OFF

### Note:

- $A_{\text{Sel}}$  - Internal resistor to GND provides auto- $V_{\text{CC}}$  detect if there is no external connection. Forcing  $A_{\text{Sel}}$  HIGH when  $V_{\text{AUDIO}}$  is present overrides the USB path.
- The dash (—) indicates “Don’t Care” state.

### Functional Description

The FSA223 is a combined USB and audio switch that enables sharing the D+/D- lines of a USB connector with stereo audio CODEC outputs. The switch is optimized for high-speed USB signals and includes an automatic  $V_{CC}$ -detection circuit. The FSA223 detects the presence of  $V_{CC}$  and defaults to USB mode. Both the USB and audio switch paths

also handle negative signals, which eliminates the need for large coupling capacitors.

The  $A_{Sel}$  pin is internally terminated by a resistor to GND (typical value: 3 M $\Omega$ ) and results in a default USB connection. For optimal performance,  $V_{CC}$  should be connected directly to the device battery.

### Application Diagram

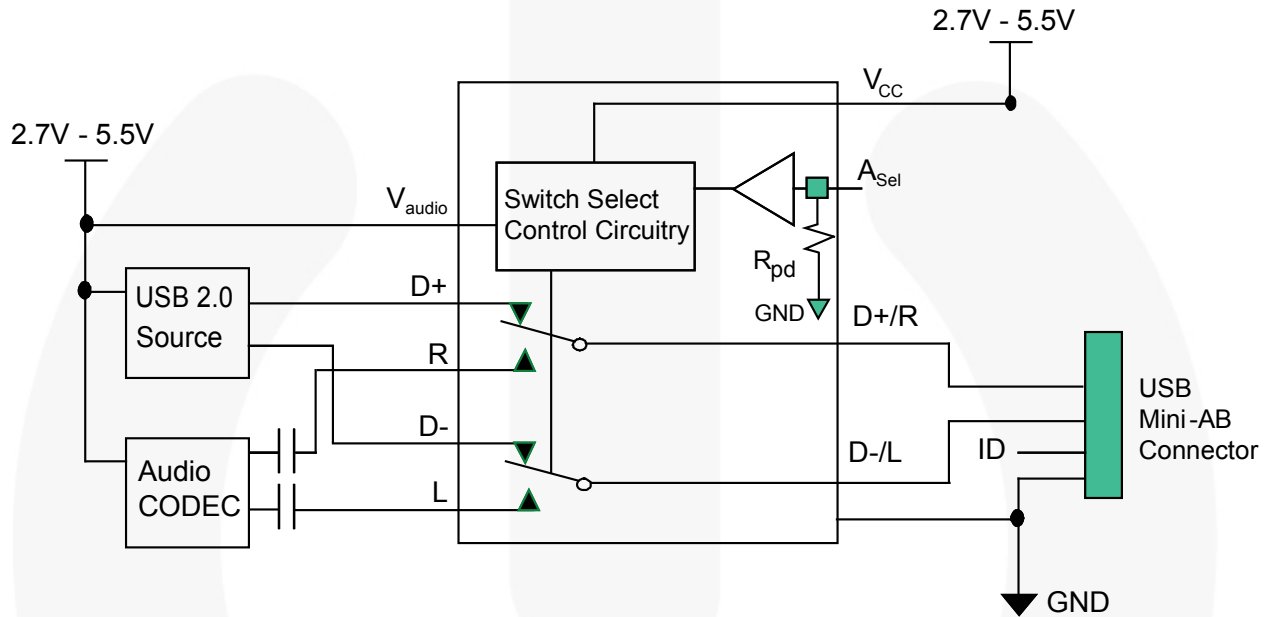


Figure 5. Typical Application

## 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
$V_{\text{Audio}}$	Supply Voltage		-0.5	6.0	V
$V_{\text{CC}}$	Supply Voltage		-0.5	6.0	V
$V_{\text{SW}}$	Switch I/O Voltage <sup>(3,4)</sup>	R, L Pins	$V_{\text{audio}} - 7.0\text{V}$	$V_{\text{audio}} + 0.3\text{V}$	V
		D+, D-, D+/R, D-/L Pins	$V_{\text{CC}} - 7.0\text{V}$	$V_{\text{CC}} + 0.3\text{V}$	V
$A_{\text{Sel}}$	Control Input Voltage <sup>(3)</sup>		-0.5	6.0	V
$I_{\text{IK}}$	Input Clamp Diode Current			-50	mA
$I_{\text{SW}}$	Switch I/O Current (Continuous)	USB		50	mA
		Audio		50	mA
$I_{\text{SWPEAK}}$	Peak Switch Current (Pulsed at 1ms Duration, <10% Duty Cycle)	USB		100	mA
		Audio		100	mA
$T_{\text{STG}}$	Storage Temperature Range		-65	+150	°C
$T_{\text{J}}$	Maximum Junction Temperature			+150	°C
$T_{\text{L}}$	Lead Temperature (Soldering, 10 seconds)			+260	°C
ESD	Human Body Model, JESD22-A114	I/O to GND		7.5	kV
		All Other Pins		3.0	
		$V_{\text{Audio}}$ $V_{\text{CC}}$ to GND		12.0	
	Charged Device Model, JESD22-C101				2.0

### Notes:

- The input and output negative ratings may be exceeded if the input and output diode current ratings are observed.
- $V_{\text{SW}}$  maximum values can be exceeded ONLY if  $I_{\text{SW}}$  maximum values are observed. For example,  $V_{\text{SW}} = V_{\text{CC}} + 0.6\text{V}$  is acceptable if  $I_{\text{SW}}$  is limited externally to  $\leq 50\text{mA}$ .

## 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.	Units
$V_{\text{Audio}}$	Supply Voltage		2.7	5.5	V
$V_{\text{CC}}$	Supply Voltage		2.7	5.5	V
$A_{\text{Sel}}$	Control Input Voltage		0	$V_{\text{CC}}$	V
$V_{\text{SW}}$	Switch I/O Voltage	$V_{\text{Audio}} - 6.5\text{V}$	$V_{\text{Audio}} - 0.3\text{V}$	V	
		$V_{\text{CC}} - 6.5\text{V}$	$V_{\text{CC}}$	V	
$T_{\text{A}}$	Operating Temperature		-40	+85	°C
$\theta_{\text{JA}}$	Thermal Resistance (free air)	MicroPak™		330 (estimated)	°C/W

## DC Electrical Characteristics

V<sub>Audio</sub> supply=2.7 V and typical values are at 25°C unless otherwise specified.

Symbol	Parameter	V <sub>CC</sub> (V)	Condition	T <sub>A</sub> =- 40°C to +85°C			Unit
				Min.	Typ.	Max.	
<b>Common Pins</b>							
V <sub>IK</sub>	Clamp Diode Voltage	3.0	I <sub>IK</sub> =-18 mA			-1.2	V
V <sub>IH</sub>	Control Input Voltage HIGH	3.0 to 4.3 <sup>(5)</sup>		1.2			
V <sub>IL</sub>	Control Input Voltage LOW	3.0 to 4.3 <sup>(5)</sup>				0.5	
I <sub>IN</sub>	A <sub>SEL</sub> Input HIGH Current	V <sub>audio</sub> =4.3 V V <sub>CC</sub> =3.0 V	V <sub>IN</sub> =3.6 V	-1		10	μA
			V <sub>IN</sub> =0 V	-1		1	
I <sub>OFF</sub>	Power Off Leakage Current (Common Port Only D+/R, D-/L)	V <sub>audio</sub> =V <sub>CC</sub> =0 V	Common Port (D+/R, D-/L) V <sub>SW</sub> =0V, 5.5 V			10	μA
I <sub>NO(OFF)</sub>	Off-Leakage Current of Port D+, D-, R, L	3.6	D+/R, D-/L=0.3 V, V <sub>CC</sub> - 0.3 V D+, D-, R, L=0.3 V, V <sub>CC</sub> - 0.3 V or Floating	-50	1	50	nA
I <sub>NC(ON)</sub>	On-Leakage Current of Port D+/R or D-/L	3.6	D+/R, D-/L=0.3 V, V <sub>CC</sub> - 0.3 V D+, D-, R, L=Floating	-50	1	50	nA
R <sub>PD</sub>	A <sub>SEL</sub> Internal Pull-Down Resistor				3		MΩ
<b>USB Switch Path</b>							
	USB Analog Signal Range			0		3.6	V
R <sub>ONUSB</sub>	HS Switch On Resistance <sup>(6)</sup>	3.0	V <sub>D+/D-</sub> =0 V, 0.4 V, I <sub>ON</sub> =-8 mA		4	6	Ω
Δ R <sub>ONUSB</sub>	HS Delta R <sub>ON</sub> <sup>(7,8)</sup>	3.0	V <sub>D+/D-</sub> =0V, I <sub>ON</sub> =-8 mA		0.4		Ω
<b>Audio Switch Path</b>							
	Audio Analog Signal Range			V <sub>audio</sub> - 5.5		V <sub>audio</sub>	V
R <sub>ONAudio</sub>	Audio Switch On Resistance <sup>(6)</sup>	3.0 to 4.3 <sup>(5)</sup>	V <sub>L/R</sub> =-2V, 0V, 0.7V, 2.0V; I <sub>ON</sub> =-26 mA		3	6	Ω
Δ R <sub>ONAudio</sub>	Audio Delta R <sub>ON</sub> <sup>(7)</sup>	3.0 to 4.3 <sup>(5)</sup>	V <sub>L/R</sub> =0.7V I <sub>ON</sub> =-26 mA		0.4		Ω
R <sub>FLAT(Audio)</sub>	Audio R <sub>ON</sub> Flatness <sup>(9)</sup>	3.0 to 4.3 <sup>(5)</sup>	V <sub>L/R</sub> =-2 V, 0 V, 0.7 V, 2.0 V; I <sub>ON</sub> =-26 mA		1.5	2.5	Ω
<b>Power Supply</b>							
I <sub>CC(Audio)</sub>	Quiescent Supply Current (Audio)	V <sub>audio</sub> =5.5 V	V <sub>ASEL</sub> =0 and V <sub>CC</sub> , I <sub>OUT</sub> =0		4	10	μA
I <sub>CC(VCC)</sub>	Quiescent Supply Current (V <sub>CC</sub> )	V <sub>CC</sub> =5.5 V	I <sub>OUT</sub> =0, V <sub>audio</sub> =0		12	20	μA
I <sub>CCT</sub>	Increase in I <sub>CC</sub> Current per Control Voltage and V <sub>CC</sub>	V <sub>audio</sub> =3.6 V, 4.3 V <sup>(5)</sup>	V <sub>ASEL</sub> =2.6 V, V <sub>CC</sub> =Floating		10	15	μA
			V <sub>ASEL</sub> =1.8 V, V <sub>CC</sub> =Floating		14	18	

### Notes:

- 4.3 V is guaranteed by characterization, not production tested.
- On resistance is determined by the voltage drop between the A and B pins at the indicated current through the switch.
- Δ R<sub>ON</sub>=R<sub>ON</sub> max - R<sub>ON</sub> min measured at identical V<sub>CC</sub>, temperature, and voltage. Worst-case signal path, audio or USB channel, is characterized.
- Guaranteed by characterization, not production tested.
- Flatness is defined as the difference between the maximum and minimum values of on resistance over the specified range of conditions.

## AC Electrical Characteristics

V<sub>Audio</sub> supply=2.7 V unless otherwise specified.

Symbol	Parameter	V <sub>CC</sub> (V)	Conditions	T <sub>A</sub> =- 40°C to +85°C			Unit
				Min.	Typ.	Max.	
t <sub>ONAUDIO2</sub>	Turn-On Time A <sub>SEL</sub> to Output	3.0 to 4.3 <sup>(10)</sup>	V <sub>D+/R, D-/L</sub> =1.0 V; R <sub>L</sub> =50 Ω; C <sub>L</sub> =50pF, Figure 14, Figure 15			2	μs
t <sub>OFFAUDIO2</sub>	Turn-Off Time A <sub>SEL</sub> to Output	3.0 to 4.3 <sup>(10)</sup>	V <sub>D+/R, D-/L</sub> =1.0 V; R <sub>L</sub> =50 Ω; C <sub>L</sub> =50pF, Figure 14, Figure 15			2	μs
t <sub>PDUSB</sub>	USB Switch Propagation Delay <sup>(10)</sup>	3.6	R <sub>L</sub> =50 Ω; C <sub>L</sub> =0 pF Figure 17		0.25		ns
Xtalk <sub>A</sub>	Non-Adjacent Channel Crosstalk - Audio	3.0 to 4.3 <sup>(10)</sup>	f=20 kHz; R <sub>T</sub> =32 Ω; C <sub>L</sub> =0 pF Figure 22		-110		dB
BW	-3db Bandwidth - USB	3.0 to 4.3 <sup>(10)</sup>	R <sub>T</sub> =50 Ω, C <sub>L</sub> =0 pF, Signal 0 dBm Figure 20		720		MHz
THD	Total Harmonic Distortion	3.0 to 4.3 <sup>(10)</sup>	f=20 Hz to 20 kHz; R <sub>L</sub> =32 Ω, V <sub>IN</sub> =2 V <sub>pp</sub> , Figure 25		0.1		%

### Note:

10. Guaranteed by characterization, not production tested.

## USB High-Speed-Related AC Electrical Characteristics

V<sub>Audio</sub> supply=2.7 V unless otherwise specified.

Symbol	Parameter	V <sub>CC</sub> (V)	Conditions	T <sub>A</sub> =- 40°C to +85°C			Unit
				Min.	Typ.	Max.	
t <sub>SK(O)</sub>	Channel-to-Channel Skew <sup>(11)</sup>	3.0 to 4.3 <sup>(11)</sup>	t <sub>R</sub> =t <sub>F</sub> =750 ps (10-90%) at 240 MHz C <sub>L</sub> =0 pF, R <sub>L</sub> =50 Ω Figure 18, Figure 19		35		ps
t <sub>SK(P)</sub>	Skew of Opposite Transitions of the Same Output <sup>(11)</sup>	3.0 to 4.3 <sup>(11)</sup>	t <sub>R</sub> =t <sub>F</sub> =750 ps (10-90%) at 240 MHz C <sub>L</sub> =0 pF, R <sub>L</sub> =50 Ω Figure 18, Figure 19		35		
t <sub>J</sub>	Total Jitter <sup>(11)</sup>	3.0 to 4.3 <sup>(11)</sup>	R <sub>L</sub> =50 Ω, C <sub>L</sub> =50 pF, t <sub>R</sub> =t <sub>F</sub> =500 ps (10-90%) at 480 Mbps (PRBS=2 <sup>15</sup> - 1)		130		ps

### Note:

11. Guaranteed by characterization, not production tested.

## Capacitance<sup>(12)</sup>

V<sub>Audio</sub> supply=3.0V unless otherwise specified.

Symbol	Parameter	V <sub>CC</sub> (V)	Condition	T <sub>A</sub> =- 40°C to +85°C			Unit
				Min.	Typ.	Max.	
C <sub>IN (A<sub>SEL</sub>)</sub>	Control Pin Input Capacitance (A <sub>SEL</sub> )	V <sub>CC</sub> =3.0 V, 4.3 V	V <sub>Bias</sub> =0.05 V		2.0		pF
C <sub>ON(D+/R, D-/L)</sub>	D+/R, D-/L (Source Port) On Capacitance	V <sub>CC</sub> =3.0 V, 4.3 V A <sub>SEL</sub> =0V (C <sub>ONUSB</sub> )	V <sub>Bias</sub> =0.2 V; f=240 MHz Figure 24		4.5	6.0	pF
		V <sub>CC</sub> =3.0 V, 4.3 V A <sub>SEL</sub> =3.0 V (C <sub>ONAudio</sub> )	V <sub>Bias</sub> =0.2 V; f=1 MHz Figure 24		9.0		
C <sub>OFF(D+, D-)</sub>	USB Input Source Off Capacitance	V <sub>CC</sub> =3.0 V, 4.3 V A <sub>SEL</sub> =3.0 V	f=1 MHz Figure 23		1.5		pF
C <sub>OFF(R/L)</sub>	Audio Input Source Off Capacitance	V <sub>CC</sub> =3.0 V, 4.3 V A <sub>SEL</sub> =0 V	f=1MHz Figure 23		3.0		pF

### Note:

12. Guaranteed by characterization, not production tested.

## Applications Information

In applications where  $V_{sw}$  could exceed the absolute maximum rating of  $V_{CC}+0.3V$ , the following recommendations help maintain low power consumption and protect the part.

The addition of the series diode in the  $V_{CC}$  supply line blocks any current that might leak back into  $V_{CC}$  for over-voltage input cases.

Because the deselected channel may no longer provide guaranteed off isolation, consider the following:

- During USB transfer, the audio amplifier should be powered down.
- During audio transfer, the USB pull-up resistor supply must be removed (as specified on page 141 of the USB 2.0 specification).

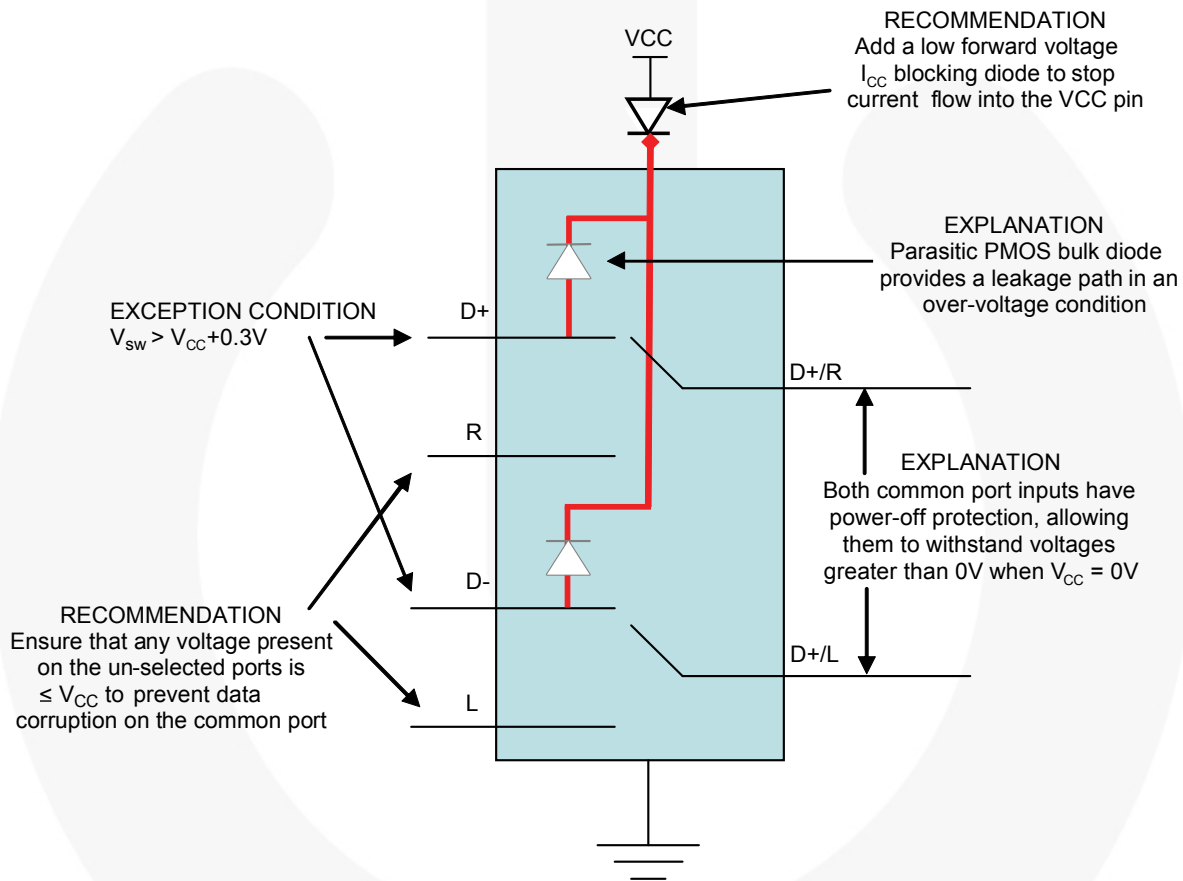


Figure 6. Application Suggestions

Typical Performance Characteristics

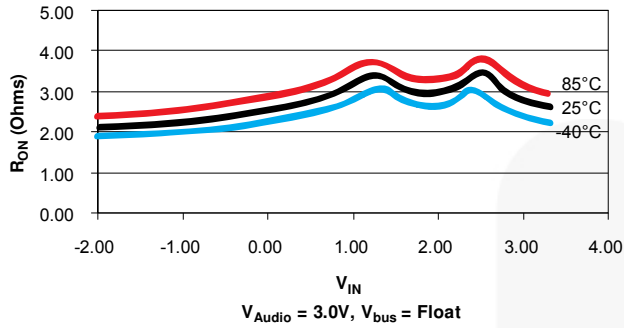


Figure 7.  $R_{ON}$  Audio,  $V_{Audio}=3.0 V$

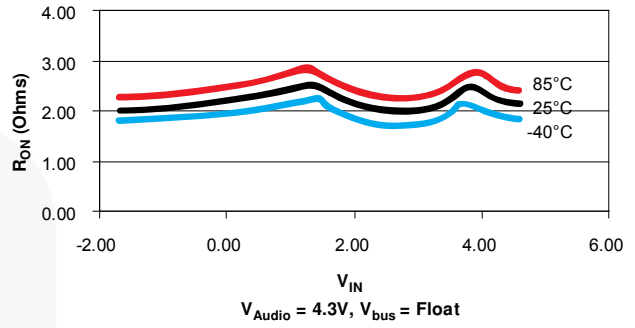


Figure 8.  $R_{ON}$  Audio,  $V_{Audio}=4.3 V$

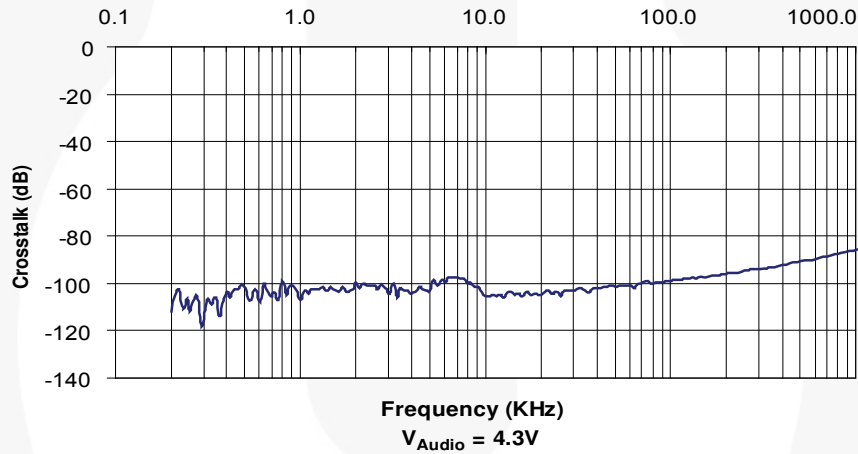


Figure 9. Crosstalk

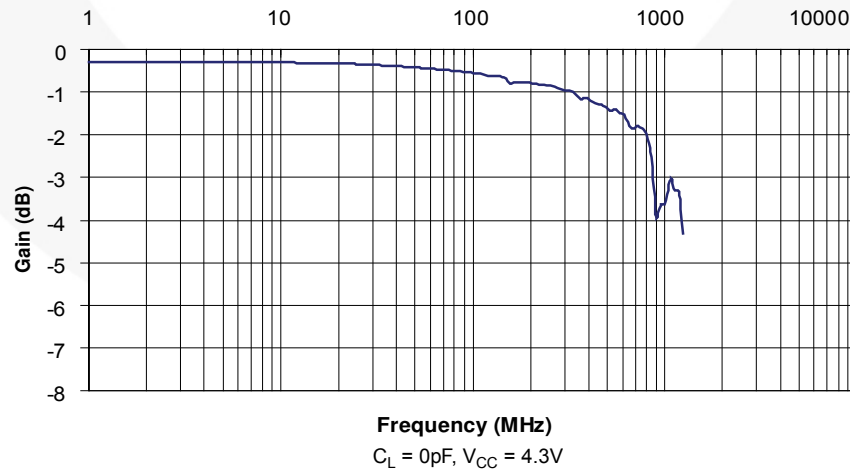
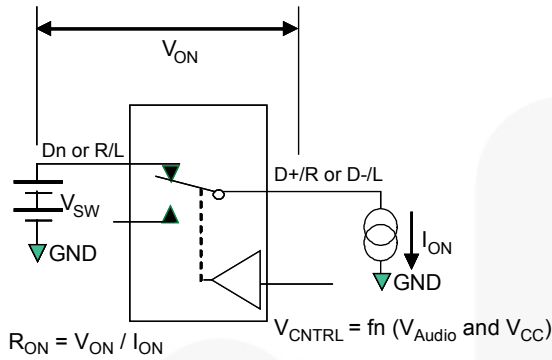


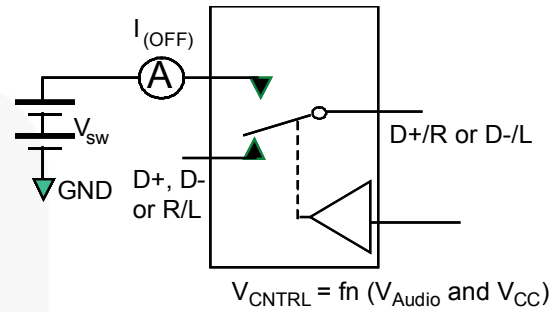
Figure 10. USB Bandwidth



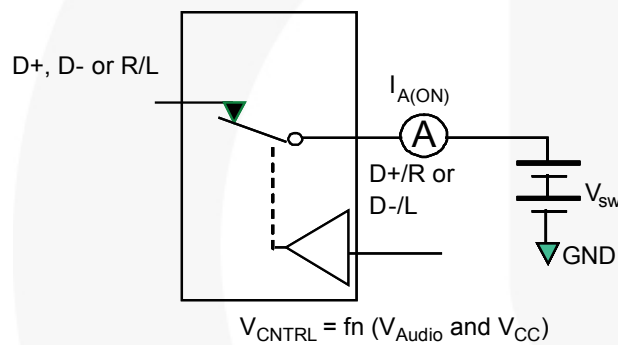
## Test Diagrams



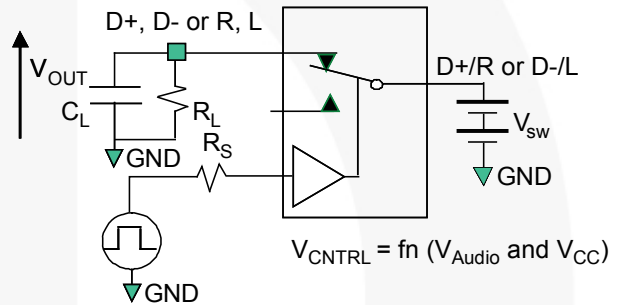
**Figure 11. On Resistance**



**Figure 12. Off Leakage**

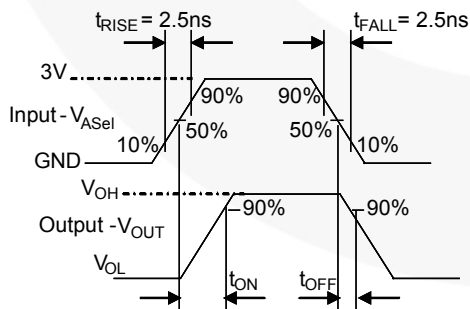


**Figure 13. On Leakage**

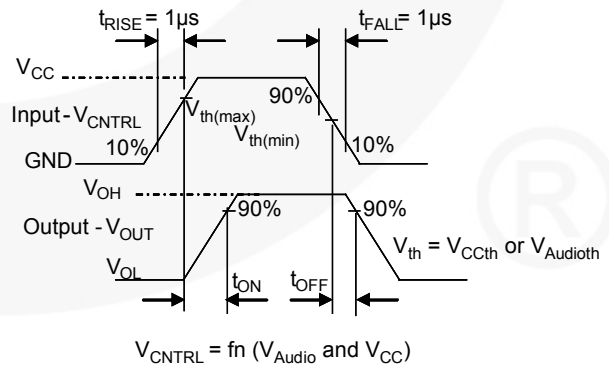


$R_L$ ,  $R_S$ , and  $C_L$  are functions of the application environment (see AC tables for specific values).  $C_L$  includes test fixture and stray capacitance.

**Figure 14. AC Test Circuit Load**



**Figure 15. Turn-On / Turn-Off Waveforms ( $A_{Sel}$ )**



**Figure 16. Turn-On / Turn-Off Waveforms (USB/Audio)**

Test Diagrams (Continued)

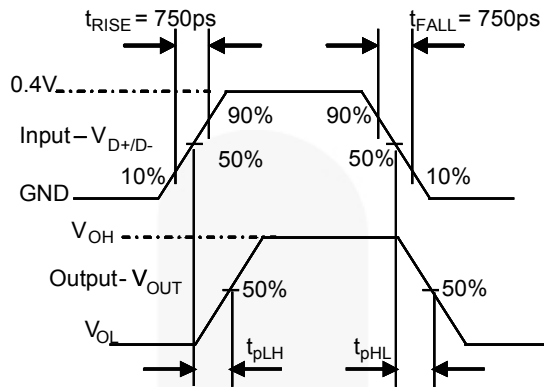


Figure 17. USB Switch Propagation Delay Waveforms

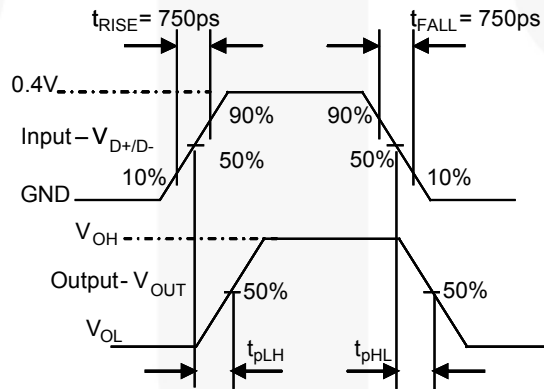


Figure 18. Pulse Skew:  $t_{SK(P)} = | t_{pHL} - t_{pLH} |$

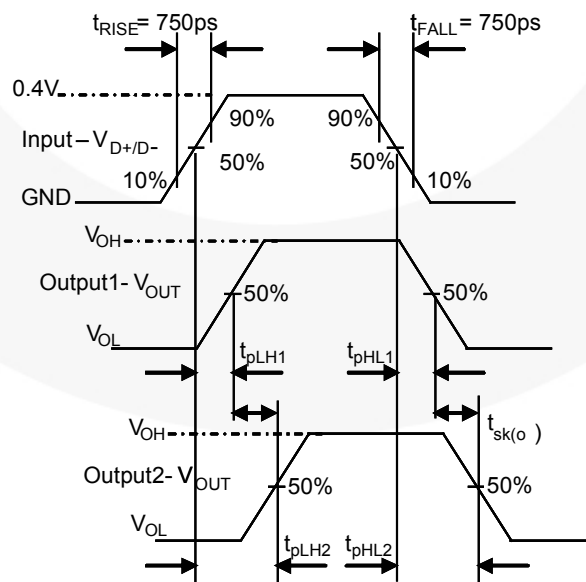


Figure 19. Output Skew:  $t_{SK(O)} = | t_{pLH1} - t_{pLH2} |$  OR  $| t_{pHL1} - t_{pHL2} |$

Test Diagrams (Continued)

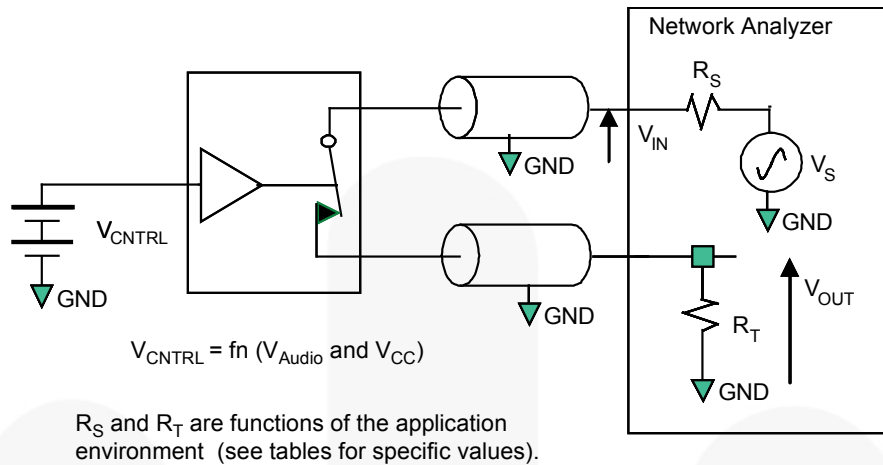


Figure 20. USB Bandwidth

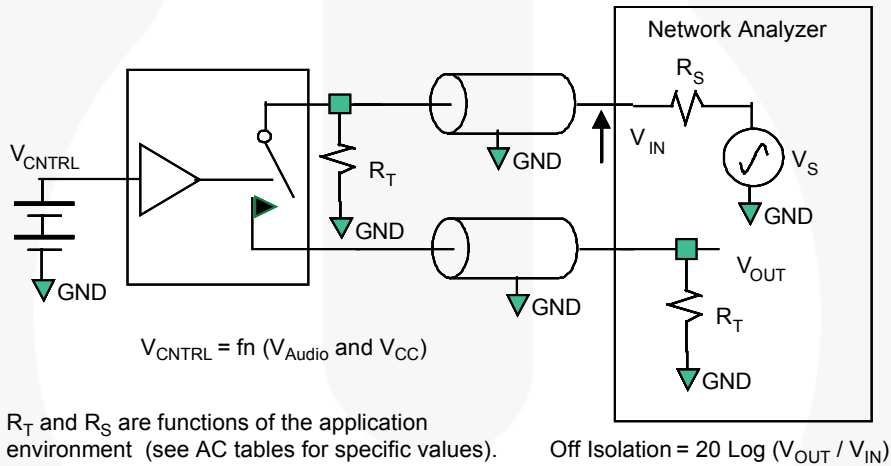


Figure 21. Channel Off Isolation

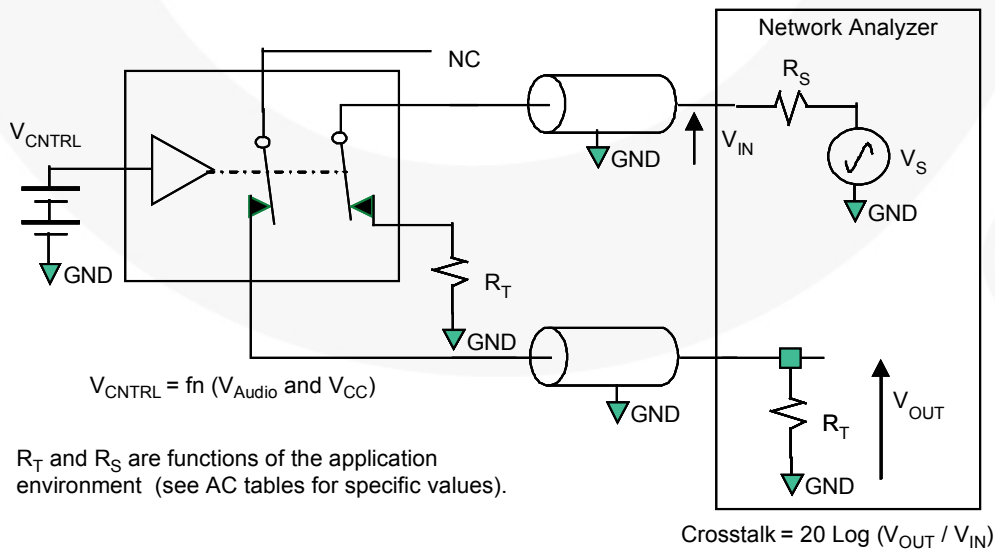
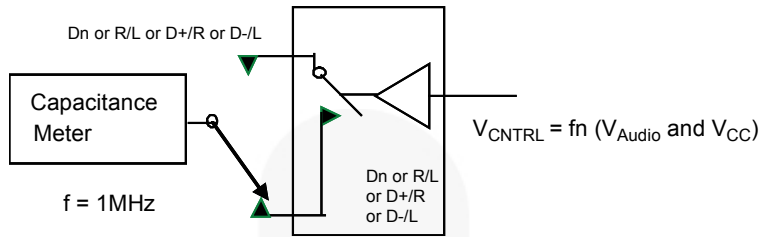
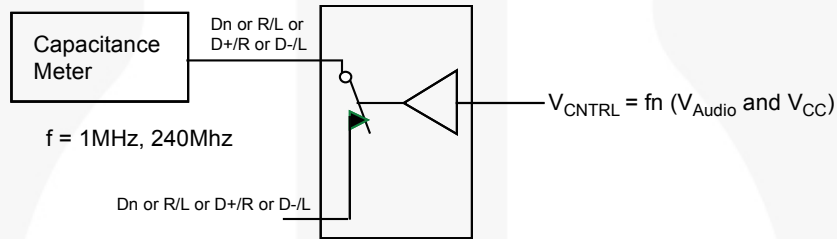


Figure 22. Non-Adjacent Channel-to-Channel Crosstalk

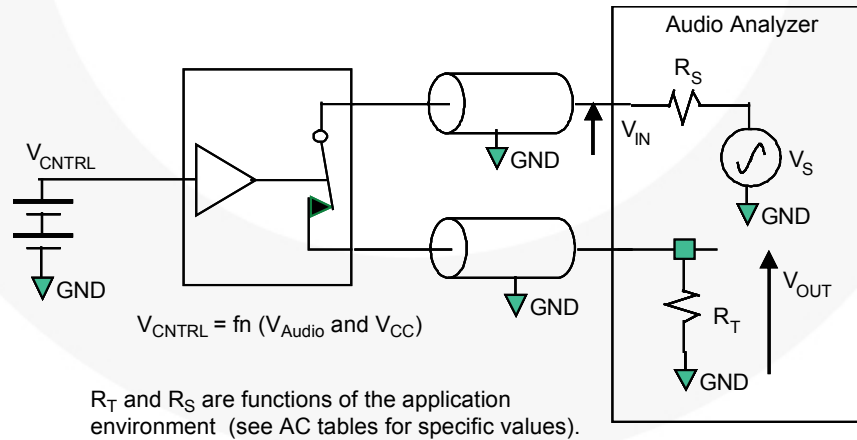
**Test Diagrams** (Continued)



**Figure 23. Channel Off Capacitance**

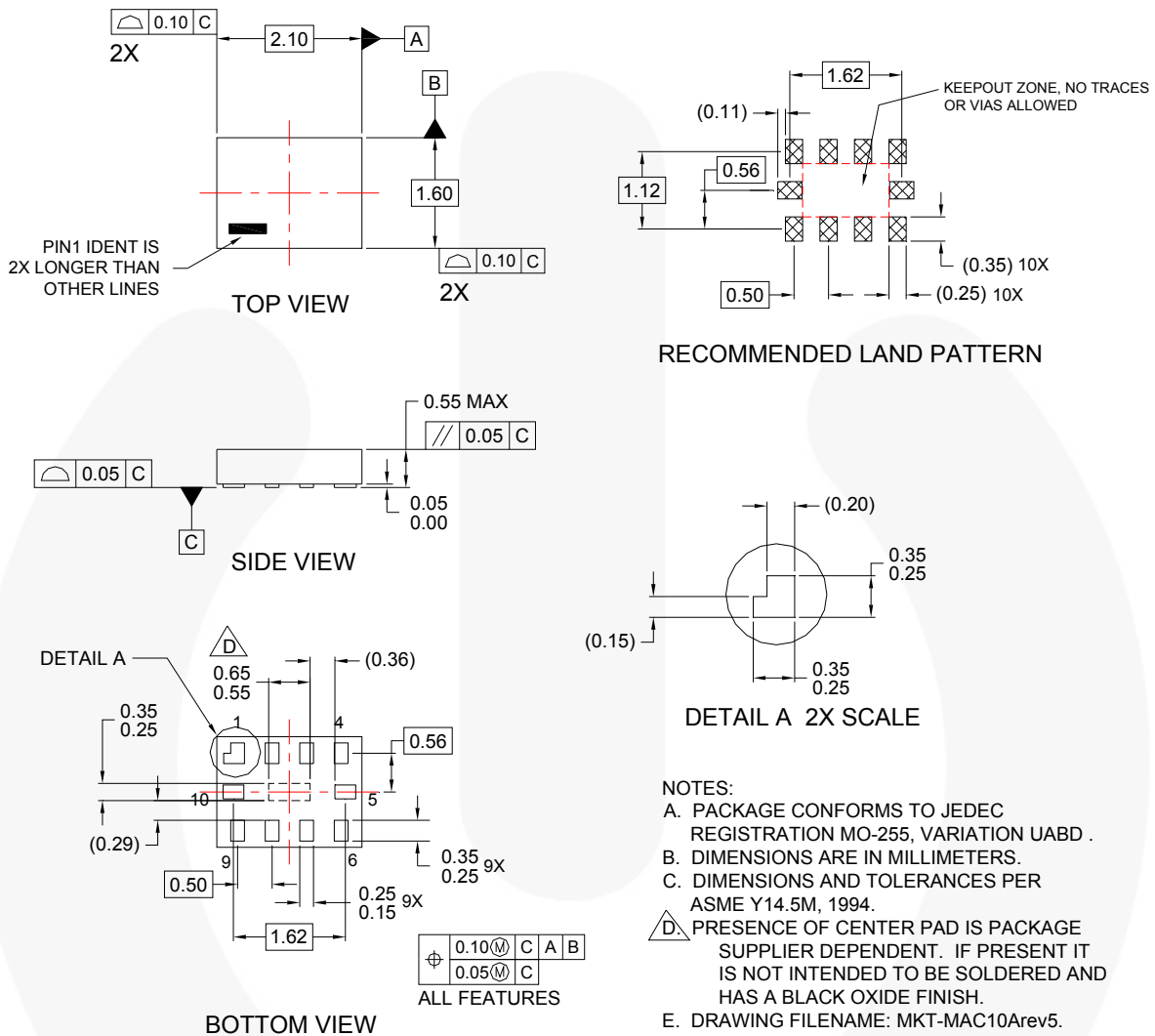


**Figure 24. Channel On Capacitance**



**Figure 25. Total Harmonic Distortion**

## Physical Dimensions



**Figure 26. 10-Lead MicroPak™**

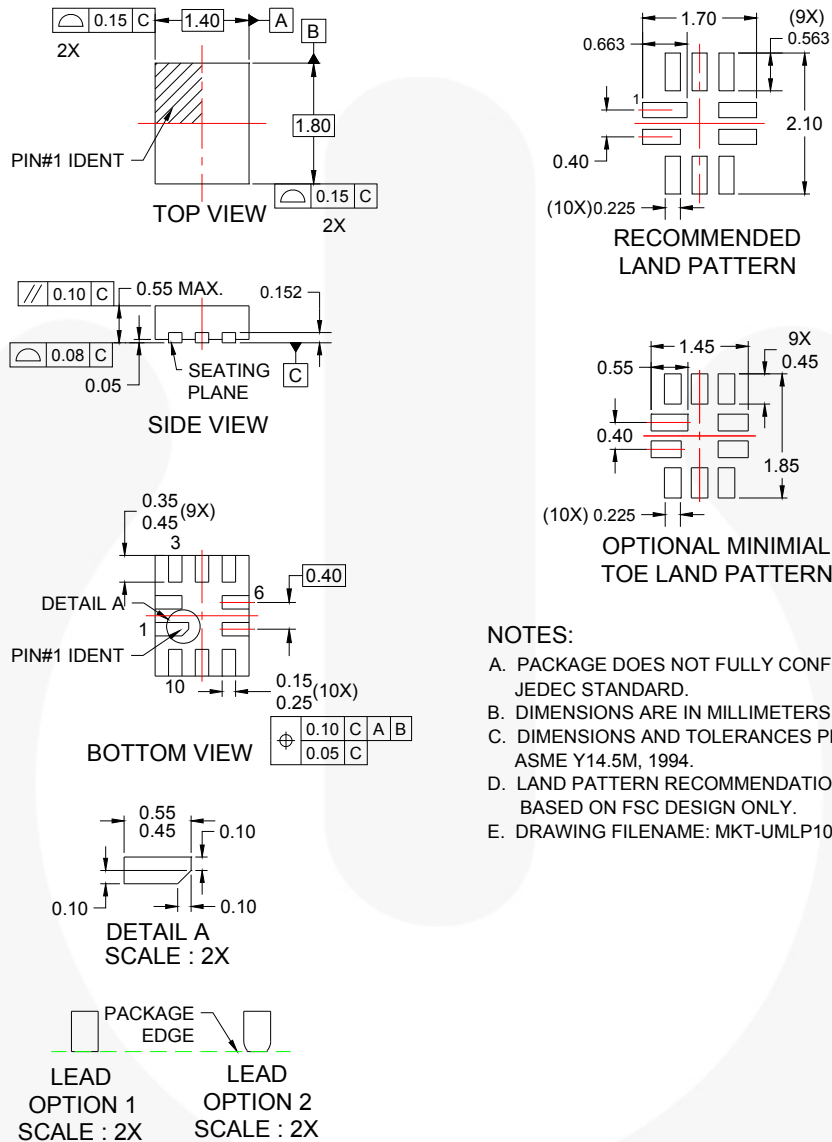
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**Physical Dimensions** (Continued)



**Figure 28. 10-Lead Quad Ultrathin MLP**

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