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# FSA221 — USB2.0 High-Speed (480Mbps) and Audio Switches with Negative Signal Capability

## Features

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

## Applications

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

## Description

The FSA221 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 audio 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 FSA221 also incorporates a  $V_{bus}$  detection capability. The FSA221 includes a power-off feature to minimize current consumption when  $V_{bus}$  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.

## Ordering Information

Part Number	Package Number	Top Mark	Package Description
FSA221L10X	MAC10A	GK	10-Lead MicroPak™, JEDEC MO-255, 1.6 x 2.1mm
FSA221MUX	MUA10A	FSA221	10-Lead MSOP JEDEC MO-187, 3.0 mm Wide
FSA221UMX	UMLP10A	GL	10-Lead Quad, Ultrathin MLP, 1.4 x 1.8mm

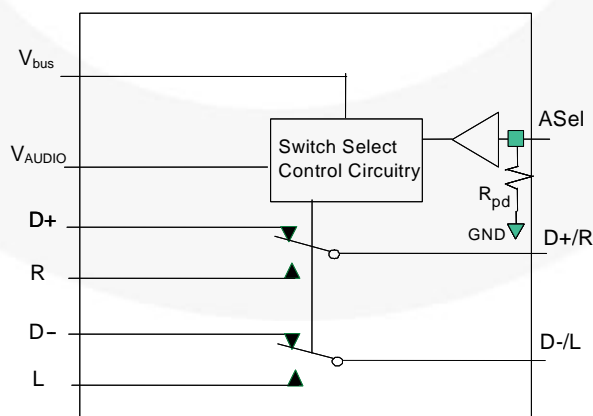


Figure 1. Analog Symbol

## Pin Assignments

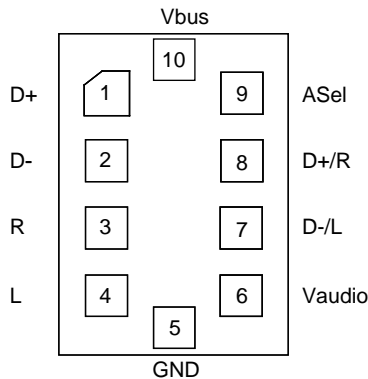


Figure 2. 10-Lead MicroPak™

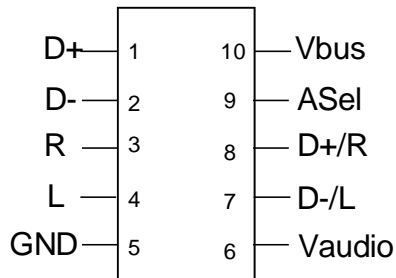


Figure 3. 10-Lead MSOP

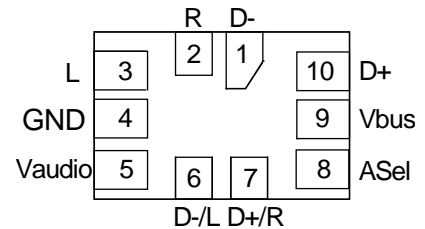


Figure 4. 10-Lead UMLP

## Pin Descriptions

Name	Description
$V_{audio}$	Power supply (Audio)
$V_{bus}$	Power supply (USB) and auto USB switch-path select
$A_{Sel}$	Audio select to override auto USB detect when $V_{AUDIO}$ 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

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

### Notes:

1.  $A_{Sel}$  - Internal resistor to GND provides auto- $V_{bus}$  detect if there is no external connection. Forcing  $A_{Sel}$  HIGH when  $V_{AUDIO}$  is present overrides the USB path even if  $V_{bus}$  is present.
2. HIGH - Value is the threshold as defined to meet USB2.0  $V_{bus}$  requirements and audio supply threshold in a system (see DC Tables).

## Functional Description

The FSA221 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  $V_{bus}$ -detection circuit. When a USB connector, rather than a headphone, is connected to the ultra-portable device the switch is automatically configured for high-speed USB data transfer. If no  $V_{bus}$  is detected, and yet  $V_{AUDIO}$  is present, the switch is configured for the low-distortion audio switch path. The audio switch path also handles negative signals (down to -2V), which eliminates the need for large coupling capacitors.

For those applications where the  $V_{bus}$  is generated as a self-powered device or where  $V_{bus}$  is not removed, the  $A_{Sel}$  pin provides the ability to switch, under software

control, to the audio path. The  $A_{Sel}$  pin is internally terminated by a resistor to GND (typical value  $3M\Omega$ ) and requires no connection for the standard ultra-portable (cell-phone, MP3, or portable media player). In an application where the supply to the FSA221  $V_{bus}$  pin is not guaranteed to be removed, a GPIO pin can be used to switch out of high-speed USB mode into audio mode, using the  $A_{Sel}$  pin.

The FSA221  $V_{bus}$  pin must be connected directly to  $V_{bus}$  or a supply > 3.8V, not an LDO regulated down to 3.6V or a  $V_{bat}$ -generated supply that may fall below 3.8V in normal operation.

## Application Diagram

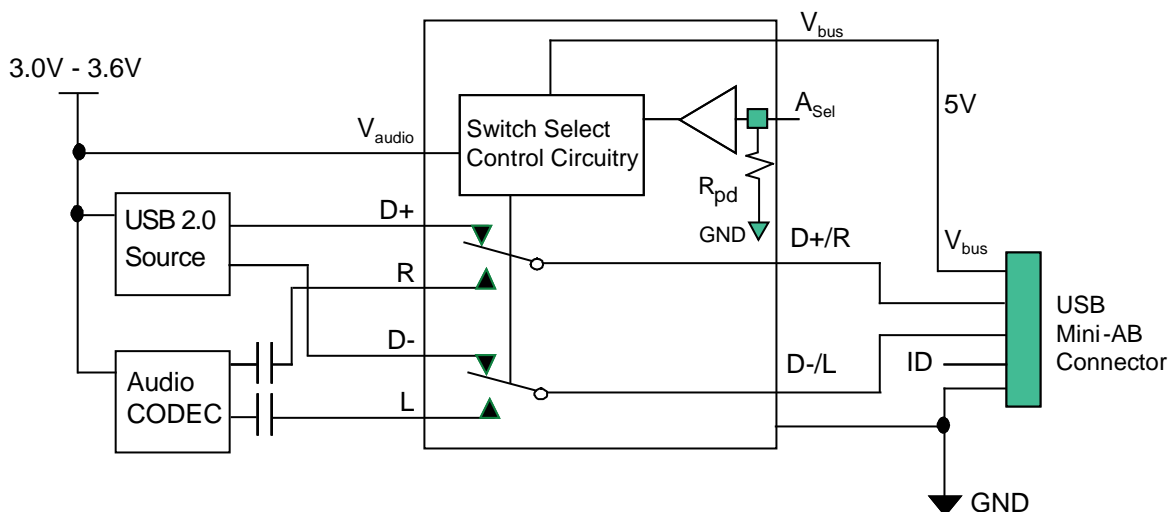


Figure 5. Typical Application

## 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
$V_{\text{AUDIO}}/V_{\text{BUS}}$	Supply Voltage		-0.5	6.0	V
$V_{\text{SW}}$	Switch I/O Voltage <sup>(3)</sup>	D+, D-, D+/R, D-/L Pins	$V_{\text{BUS}} - 7.0$	$V_{\text{BUS}} + 0.3$	V
		R, L, Pins	$V_{\text{AUDIO}} - 7.0$	$V_{\text{AUDIO}} - 0.3$	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	
$I_{\text{SWPEAK}}$	Peak Switch Current (Pulsed at 1ms Duration, <10% Duty Cycle)	USB		100	mA
		Audio		100	
$T_{\text{STG}}$	Storage Temperature Range		-65	+150	°C
$T_{\text{J}}$	Maximum Junction Temperature			+150	°C
$T_{\text{L}}$	Lead Temperature (Soldering, 10 seconds)			+260	°C
MSL	Moisture Sensitivity Level (JEDEC J-STD-020A)		Level 1		
ESD	Human Body Model (JEDEC: JESD22-A114)	I/O to GND		7500	V
		All Other Pins		7500	
		$V_{\text{AUDIO}} V_{\text{BUS}}$ to GND		12000	
	Charged Device Model (JEDEC: JESD22-C101)			2000	

### Note:

3. 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. Fairchild does not recommend exceeding them or designing to Absolute Maximum Ratings.

Symbol	Parameter		Minimum	Maximum
$V_{\text{AUDIO}}$	Supply Voltage		3.0V	4.2V
$V_{\text{BUS}}$	Supply Voltage		4.25V	5.50V
$A_{\text{Sel}}$	Control Input Voltage		0V	$V_{\text{AUDIO}}$
$V_{\text{SW}}$	Switch I/O Voltage		$V_{\text{AUDIO}} - 6.5\text{V}$	$V_{\text{AUDIO}} - 0.3\text{V}$
			$V_{\text{BUS}} - 6.5\text{V}$	$V_{\text{BUS}}$
$T_{\text{A}}$	Operating Temperature		-40°C	85°C
$\theta_{\text{JA}}$	Thermal Resistance (Free Air)	MicroPak™		330°C / W (Estimated)

## DC Electrical Characteristics

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

Symbol	Parameter	V <sub>AUDIO</sub> (V)	Condition	T <sub>A</sub> =- 40°C to +85°C			Unit
				Min.	Typ.	Max.	
Common Pins							
V <sub>IK</sub>	Clamp Diode Voltage	3.0	I <sub>IK</sub> =-18mA			-1.2	V
V <sub>IH</sub>	Control Input Voltage HIGH	3.0 to 3.6		1.2			
V <sub>IL</sub>	Control Input Voltage LOW	3.0 to 3.6				0.5	
I <sub>IN</sub>	A <sub>SeI</sub> Input HIGH Current	3.6	V <sub>IN</sub> =3.6V	-1		10	μA
			V <sub>IN</sub> =0V	-1		1	
I <sub>OFF</sub>	Power-Off Leakage Current (Common Port Only D+/R, D-/L)	V <sub>AUDIO</sub> = V <sub>BUS</sub> =0V	Common Port (D+/R, D-/L), V <sub>SW</sub> =0V to 5.5V			10	μA
I <sub>NO(OFF)</sub>	Off-Leakage Current of Port D+, D-, R, L	4.2	V <sub>BUS</sub> =0V, 5. 5V, D+/R, D-/L=0.3V, V <sub>AUDIO</sub> – 0.3V, D+, D-, R, L=0.3V, V <sub>AUDIO</sub> –0.3V or Floating, Figure 11	-50	1	50	nA
I <sub>NC(ON)</sub>	On-Leakage Current of Port D+/R or D-/L	4.2	V <sub>bus</sub> =0V, 5.5V, D+/R, D-/L=0.3V, V <sub>AUDIO</sub> – 0.3V, D+, D-, R, L=Floating, Figure 12	-50	1	50	nA
R <sub>PD</sub>	A <sub>SeI</sub> Internal Pull-Down Resistor				3		MΩ
USB Switch Path		V <sub>BUS</sub> (V)					
	USB Analog Signal Range			0		3.6	V
R <sub>ONUSB</sub>	HS Switch On Resistance <sup>(4)</sup>	4.25	V <sub>D+/D-</sub> =0V, 0.4V, I <sub>ON</sub> =-8mA, V <sub>AUDIO</sub> =3V		4	6	Ω
ΔR <sub>ONUSB</sub>	HS Delta R <sub>ON</sub> <sup>(5,6)</sup>	4.25	V <sub>D+/D-</sub> =0V, I <sub>ON</sub> =-8mA, V <sub>AUDIO</sub> =3V		0.4		Ω
Audio Switch Path		V <sub>AUDIO</sub> (V)					
	Audio Analog Signal Range			V <sub>AUDIO</sub> – 5.5		V <sub>AUDIO</sub>	V
R <sub>ONAudio</sub>	Audio Switch On Resistance <sup>(4)</sup>	3.0	V <sub>L/R</sub> =-2V, 0V, 0.7V, V <sub>BUS</sub> =0V, V <sub>AUDIO</sub> -0.7V, V <sub>AUDIO</sub> , I <sub>ON</sub> =-26mA		3	5	Ω
ΔR <sub>ONAudio</sub>	Audio Delta R <sub>ON</sub> <sup>(5)</sup>	3.0	V <sub>L/R</sub> =0.7V I <sub>ON</sub> =-26mA		0.4		Ω
R <sub>FLAT(Audio)</sub>	Audio R <sub>ON</sub> Flatness <sup>(7)</sup>	3.0	I <sub>ON</sub> =-26mA		1.5	2.5	Ω
Power Supply							
V <sub>busth</sub>	V <sub>BUS</sub> Threshold Voltage			3.2		3.8	V
V <sub>audieth</sub>	V <sub>AUDIO</sub> Threshold			0.5		1.5	V
I <sub>CC(Audio)</sub>	Quiescent Supply Current (Audio)	4.2	V <sub>ASeI</sub> =0 to V <sub>AUDIO</sub> , I <sub>OUT</sub> =0		6	10	μA
I <sub>CC(Vbus)</sub>	Quiescent Supply Current (V <sub>BUS</sub> )		V <sub>ASeI</sub> =0 to V <sub>AUDIO</sub> , I <sub>OUT</sub> =0, V <sub>BUS</sub> =5.5V		12	20	μA
I <sub>CCCT</sub>	Increase in I <sub>CC</sub> Current per Control Voltage and V <sub>CC</sub>	4.2	V <sub>ASeI</sub> =2.6V, V <sub>BUS</sub> =Floating		10	15	μA
			V <sub>ASeI</sub> =1.8V, V <sub>BUS</sub> =Floating		14	18	

### Notes:

- On resistance is determined by the voltage drop between the A and B pins at the indicated current through the switch.
- $\Delta R_{\text{ON}}=R_{\text{ON max}} - R_{\text{ON min}}$  measured at identical  $V_{\text{CC}}$ , 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

All typical value are for  $V_{\text{AUDIO}}=3.3\text{V}$  and  $V_{\text{BUS}}=5.0$  at  $T_A=25^\circ\text{C}$  unless otherwise specified.

Symbol	Parameter	$V_{\text{AUDIO}} / V_{\text{BUS}}$ (V)	Condition	$T_A = -40^\circ\text{C to } +85^\circ\text{C}$			Unit
				Min.	Typ.	Max.	
$t_{\text{ONAUDIO1}}$	Turn-On Time $V_{\text{AUDIO}} \uparrow$ to Output	$V_{\text{BUS}}=0\text{V}$	$V_{\text{D+R}}, V_{\text{D-/L}}=1.0\text{V}$ , $R_L=50\Omega$ , $C_L=50\text{pF}$ Figure 13, Figure 15			10	$\mu\text{s}$
$t_{\text{OFFAUDIO1}}$	Turn-Off Time $V_{\text{BUS}} \uparrow$ to Output	$V_{\text{AUDIO}}=3.0$ for $V_{\text{BUS}} \uparrow$	$V_{\text{D+R}}, V_{\text{D-/L}}=1.0\text{V}$ , $R_L=50\Omega$ , $C_L=50\text{pF}$ Figure 13, Figure 15			10	$\mu\text{s}$
$t_{\text{ONAUDIO2}}$	Turn-On Time $A_{\text{Sel}}$ to Output	$V_{\text{BUS}}=4.25\text{V}$ $V_{\text{AUDIO}}=3.0$	$V_{\text{D+R}}, V_{\text{D-/L}}=1.0\text{V}$ , $R_L=50\Omega$ , $C_L=50\text{pF}$ Figure 13, Figure 14			2	$\mu\text{s}$
$t_{\text{OFFAUDIO2}}$	Turn-Off Time $A_{\text{Sel}}$ to Output	$V_{\text{BUS}}=4.25\text{V}$ $V_{\text{AUDIO}}=3.0$	$V_{\text{D+R}}, V_{\text{D-/L}}=1.0\text{V}$ , $R_L=50\Omega$ , $C_L=50\text{pF}$ Figure 13, Figure 14			2	$\mu\text{s}$
$t_{\text{ONAUDIO3}}$	Turn-On Time $V_{\text{BUS}} \downarrow$ to Output	$V_{\text{AUDIO}}=3.0$	$V_{\text{D+R}}, V_{\text{D-/L}}=1.0\text{V}$ , $R_L=50\Omega$ , $C_L=50\text{pF}$ Figure 13, Figure 15			10	$\mu\text{s}$
$t_{\text{ONUSB}}$	Turn-On Time $V_{\text{USB}} \uparrow$ to Output	$V_{\text{AUDIO}}=3.0$	$V_{\text{D+R}}, V_{\text{D-/L}}=1.0\text{V}$ , $R_L=50\Omega$ , $C_L=0\text{pF}$ Figure 13, Figure 15			10	$\mu\text{s}$
$t_{\text{OFFUSB}}$	Turn-Off Time $V_{\text{USB}} \downarrow$ to Output	$V_{\text{AUDIO}}=3.0$	$V_{\text{D+R}}, V_{\text{D-/L}}=1.0\text{V}$ , $R_L=50\Omega$ , $C_L=0\text{pF}$ Figure 13, Figure 15			10	$\mu\text{s}$
$t_{\text{PDUSB}}$	USB Switch Propagation Delay <sup>(8)</sup>	$V_{\text{AUDIO}}=3.0$ $V_{\text{BUS}}=4.25\text{V}$	$R_L=50\Omega$ , $C_L=0\text{pF}$ , Figure 16		0.25		ns
$X_{\text{talk}_A}$	Non-Adjacent Channel Crosstalk - Audio	$V_{\text{AUDIO}}=3.0$ $V_{\text{BUS}}=4.25\text{V}$	$f=20\text{kHz}$ , $R_T=32\Omega$ , $C_L=0\text{pF}$ Figure 7, Figure 21		-110		dB
BW	-3db Bandwidth - USB	$V_{\text{AUDIO}}=3.0$ $V_{\text{BUS}}=4.25\text{V}$	$R_T=50\Omega$ , $C_L=0\text{pF}$ , Signal 0dBm Figure 9, Figure 19		720		MHz
THD	Total Harmonic Distortion	$V_{\text{AUDIO}}=3.0$ $V_{\text{BUS}}=0\text{V}$	$f=20\text{Hz to } 20\text{kHz}$ , $R_L=32\Omega$ , $V_{\text{IN}}=2V_{\text{pp}}$ Figure 24		0.05		%

**Note:**

8. Guaranteed by characterization, not production tested.

## USB High-Speed-Related AC Electrical Characteristics

$T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ .

Symbol	Parameter	$V_{\text{AUDIO}} / V_{\text{BUS}}(\text{V})$	Conditions	Typ.	Unit
$t_{\text{SK(o)}}$	Channel-to-Channel Skew <sup>(9)</sup>	$V_{\text{AUDIO}}=3.0\text{V}$ $V_{\text{BUS}}=4.25\text{V}$	$t_R=t_F=750\text{ps}$ (10-90%) at 240MHz $C_L=0\text{pF}$ , $R_L=50\Omega$ Figure 17, Figure 18	35	ps
$t_{\text{SK(P)}}$	Skew of Opposite Transitions of the Same Output <sup>(9)</sup>	$V_{\text{AUDIO}}=3.0\text{V}$ $V_{\text{BUS}}=4.25\text{V}$	$t_R=t_F=750\text{ps}$ (10-90%) at 240MHz $C_L=0\text{pF}$ , $R_L=50\Omega$ Figure 17, Figure 18	35	
$t_J$	Total Jitter <sup>(9)</sup>	$V_{\text{AUDIO}}=3.0\text{V}$ $V_{\text{BUS}}=4.25\text{V}$	$R_L=50\Omega$ , $C_L=50\text{pF}$ , $t_R=t_F=500\text{ps}$ (10-90%) at 480Mbps (PRBS= $2^{15}-1$ )	130	ps

### Note:

9. Guaranteed by characterization, not production tested.

## Capacitance

$T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ .

Symbol	Parameter	$V_{\text{AUDIO}} / V_{\text{BUS}}(\text{V})$	Condition	Typ.	Unit
$C_{\text{IN (ASel)}}$	Control Pin Input Capacitance ( $A_{\text{Sel}}$ )	$V_{\text{AUDIO}}=3.0\text{V}$ , $V_{\text{BUS}}=4.25\text{V}$	$V_{\text{Bias}}=0.2\text{V}$	2.0	pF
$C_{\text{ON(D+/R, D-/L)}}$	D+/R, D-/L (Source Port) On Capacitance	$V_{\text{AUDIO}}=3.0\text{V}$ , $V_{\text{BUS}}=4.25\text{V}$ , $A_{\text{Sel}}=0\text{V}$ ( $C_{\text{ONUSB}}$ )	$V_{\text{Bias}}=0.2\text{V}$ , $f=240\text{MHz}$ , Figure 23	4.5	pF
		$V_{\text{AUDIO}}=3.0\text{V}$ , $V_{\text{BUS}}=4.25\text{V}$ , $A_{\text{Sel}}=3.0\text{V}$ ( $C_{\text{ONAudio}}$ )	$V_{\text{Bias}}=0.2\text{V}$ , $f=1\text{MHz}$ , Figure 23	9.0	
$C_{\text{OFF(D+, D-)}}$	USB Input Source Off Capacitance	$V_{\text{AUDIO}}=3.0\text{V}$ , $V_{\text{BUS}}=4.25\text{V}$ , $A_{\text{Sel}}=3.0\text{V}$	$f=1\text{MHz}$ , Figure 22	1.5	pF
$C_{\text{OFF(R/L)}}$	Audio Input Source Off Capacitance	$V_{\text{AUDIO}}=3.0\text{V}$ , $V_{\text{BUS}}=4.25\text{V}$ , $A_{\text{Sel}}=0\text{V}$	$f=1\text{MHz}$ , Figure 22	3.0	pF

## Typical Characteristics

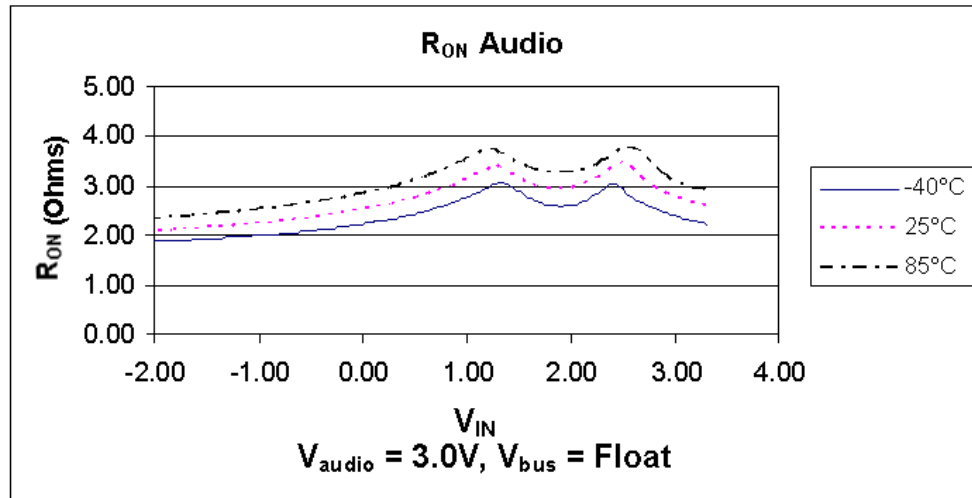


Figure 6. R<sub>ON</sub> Audio, V<sub>Audio</sub>=3.0V, V<sub>BUS</sub>=Float

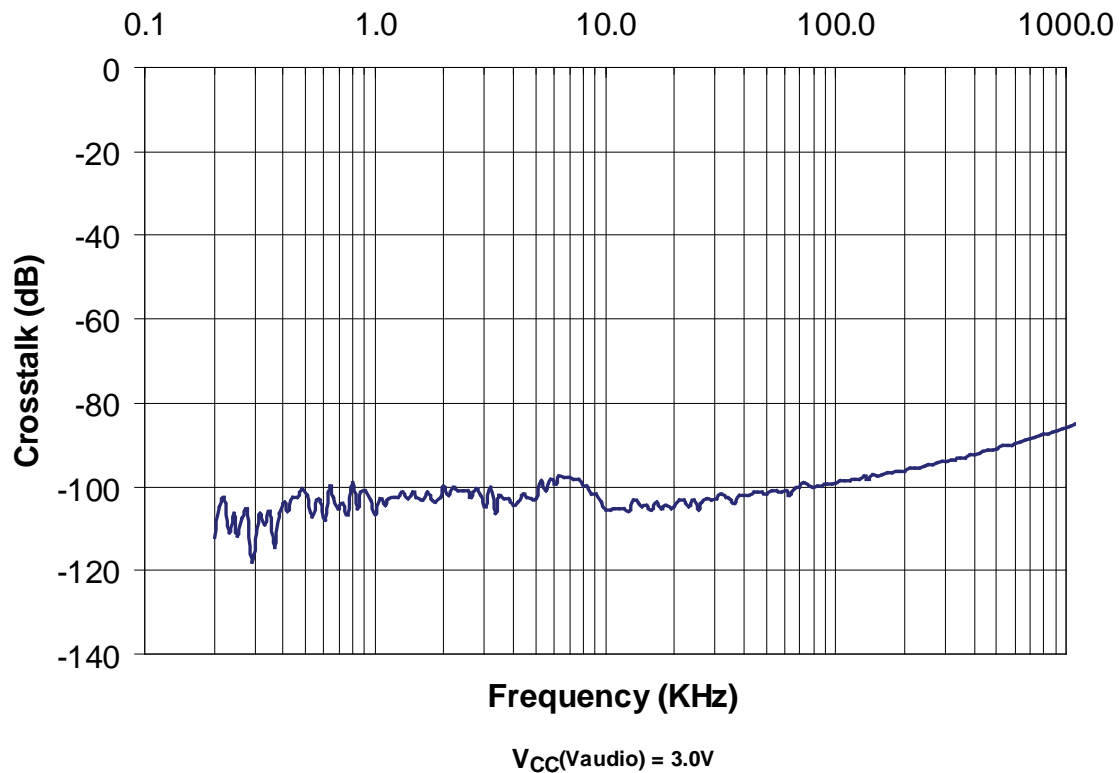


Figure 7. Non-Adjacent Channel Crosstalk – Audio

# Typical Characteristics (Continued)

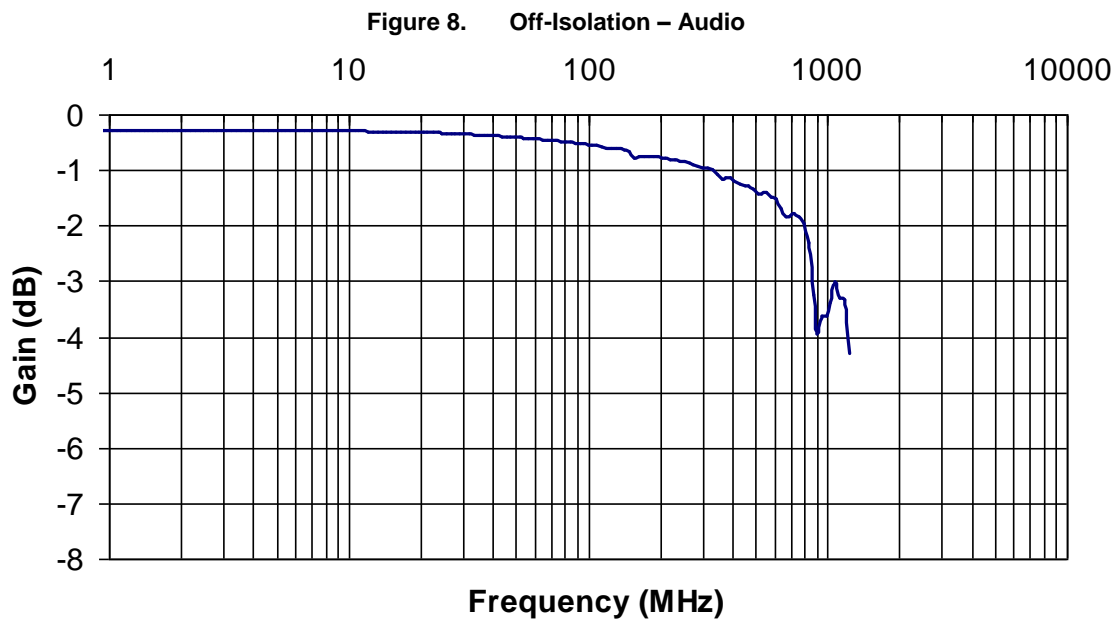
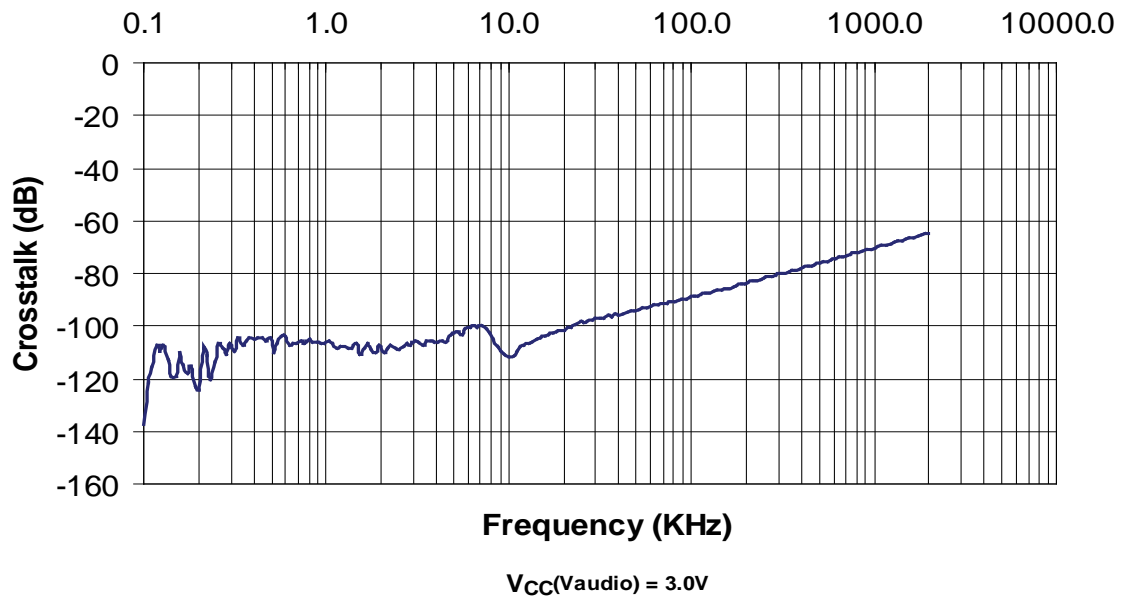


Figure #. Bandwidth Characterization, Frequency Response at  $CL = 0pF, V_{CC}(V_{bus}) = 4.25V$

## Test Diagrams

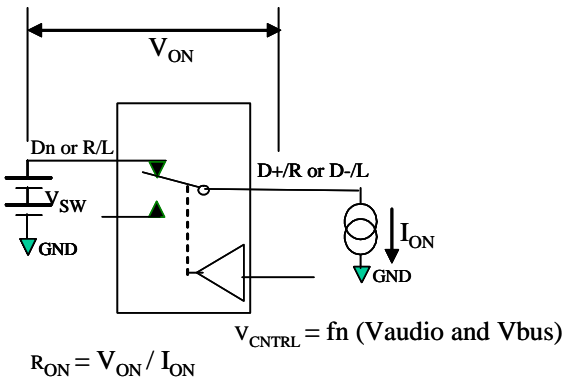


Figure 10. On Resistance

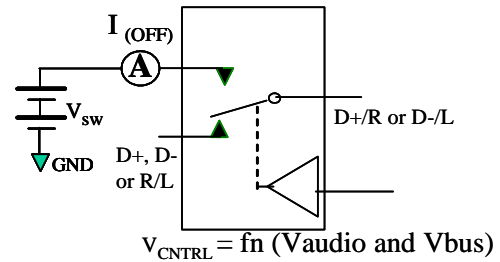


Figure 11. Off Leakage

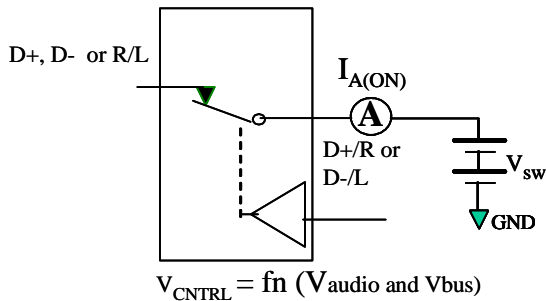


Figure 12. On Leakage

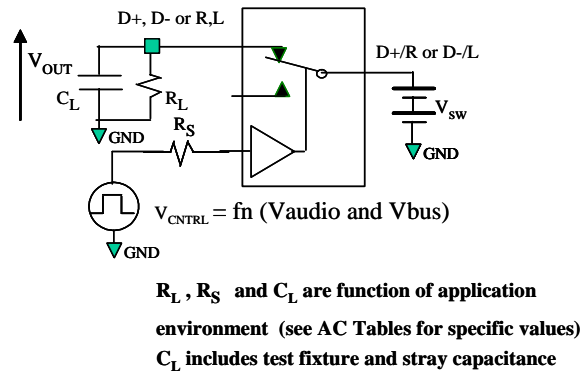


Figure 13. AC Test Circuit Load

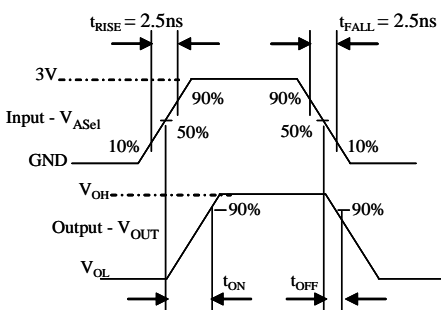


Figure 14. Turn-On / Turn-Off Waveforms ( $A_{\text{Sel}}$ )

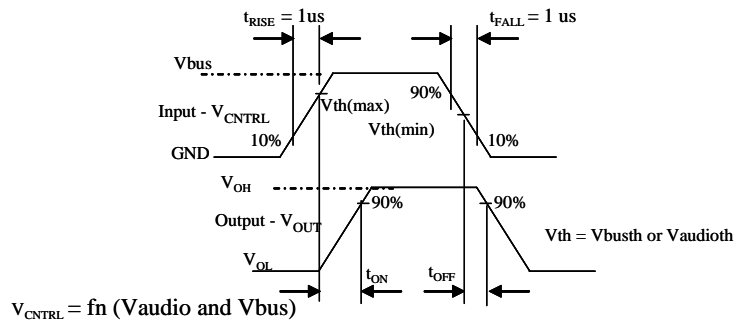


Figure 15. Turn-On / Turn-Off Waveforms (USB/Audio)

# Test Diagrams (Continued)

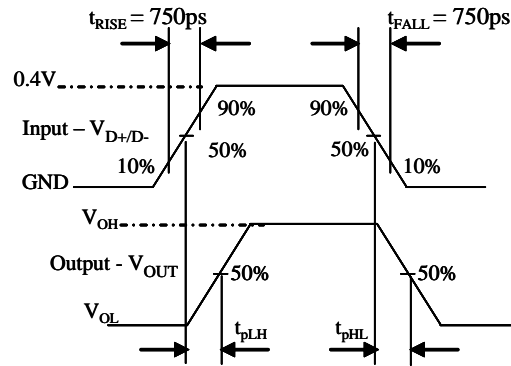


Figure 16. USB Switch Propagation Delay Waveforms

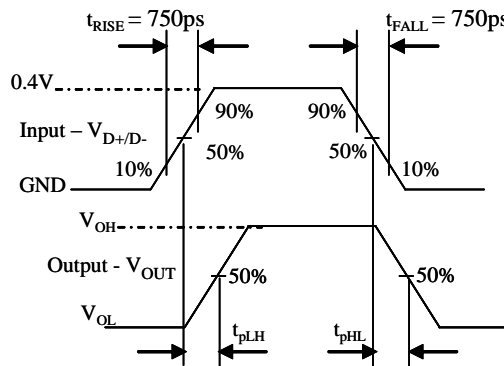


Figure 17. Pulse Skew:  $t_{SK(P)} = |t_{pHL} - t_{pLH}|$

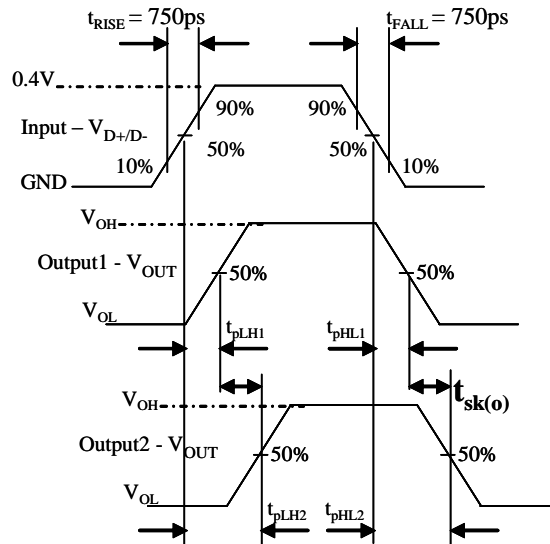


Figure 18. Output Skew:  $t_{SK(O)} = |t_{pLH1} - t_{pLH2}|$  or  $|t_{pHL1} - t_{pHL2}|$

# Test Diagrams (Continued)

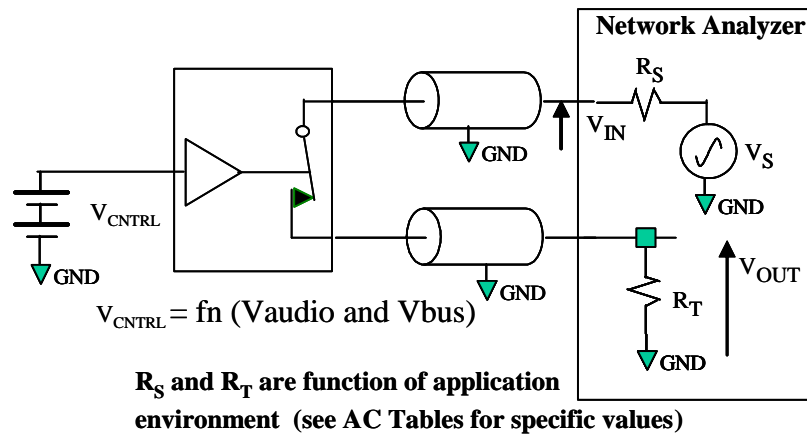


Figure 19. USB Bandwidth

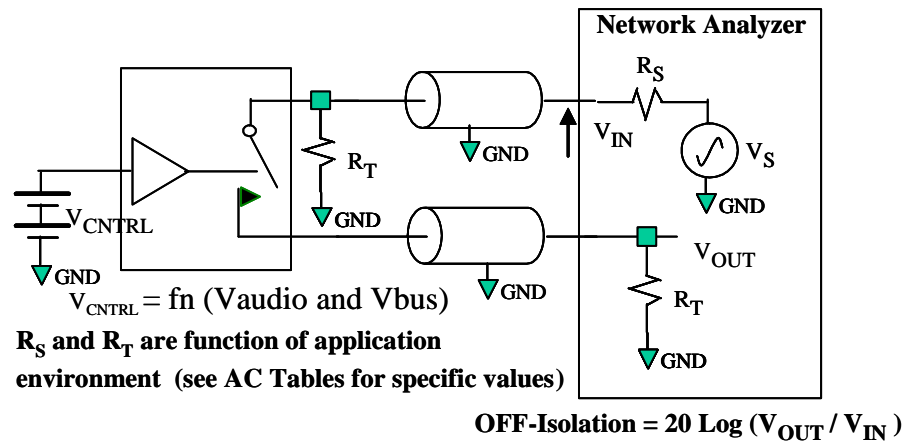


Figure 20. Channel Off Isolation

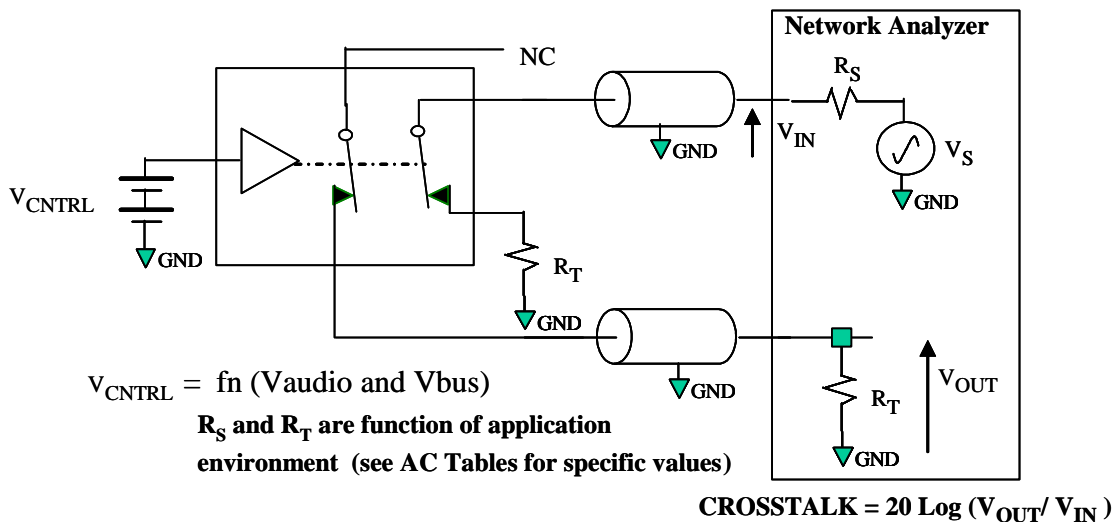


Figure 21. Non-Adjacent Channel-to-Channel Crosstalk

# Test Diagrams (Continued)

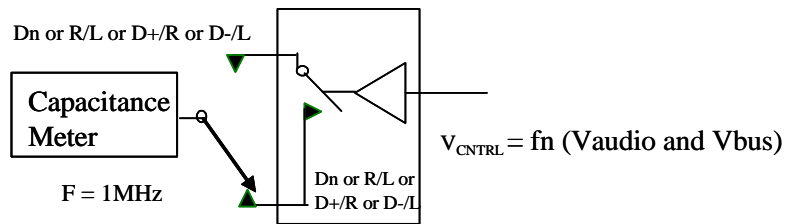


Figure 22. Channel Off Capacitance

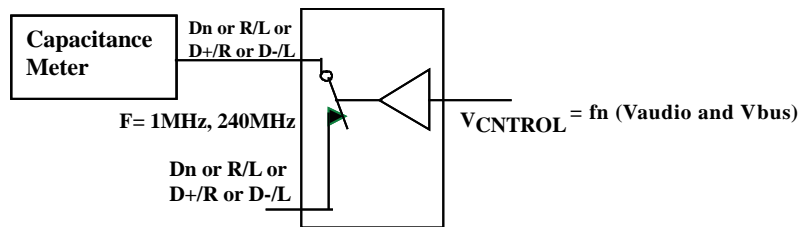


Figure 23. Channel On Capacitance

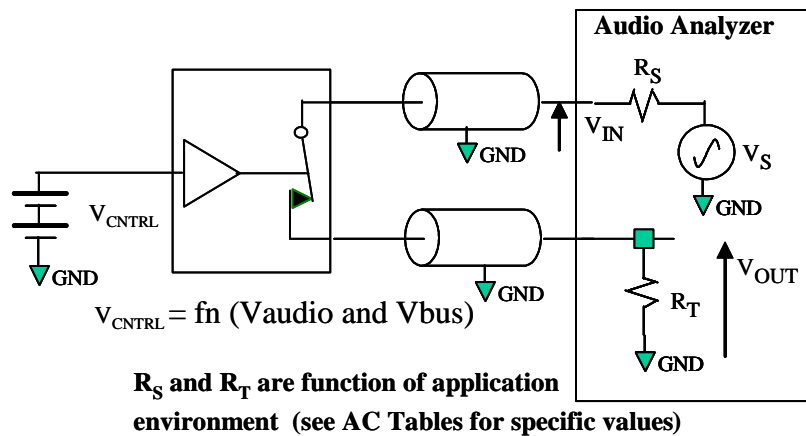


Figure 24. Total Harmonic Distortion

## Physical Dimensions

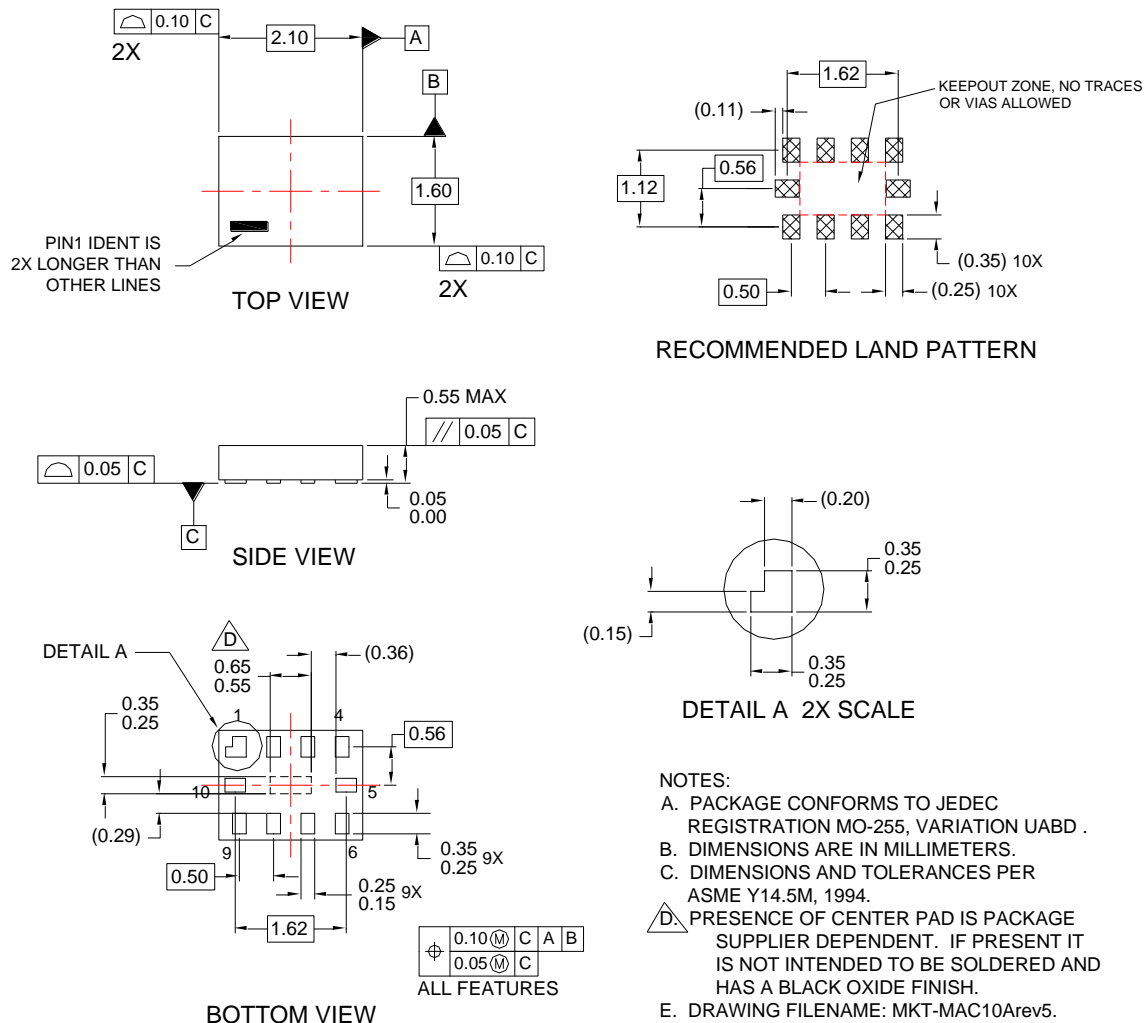


Figure 25. 10-Lead MicroPak™

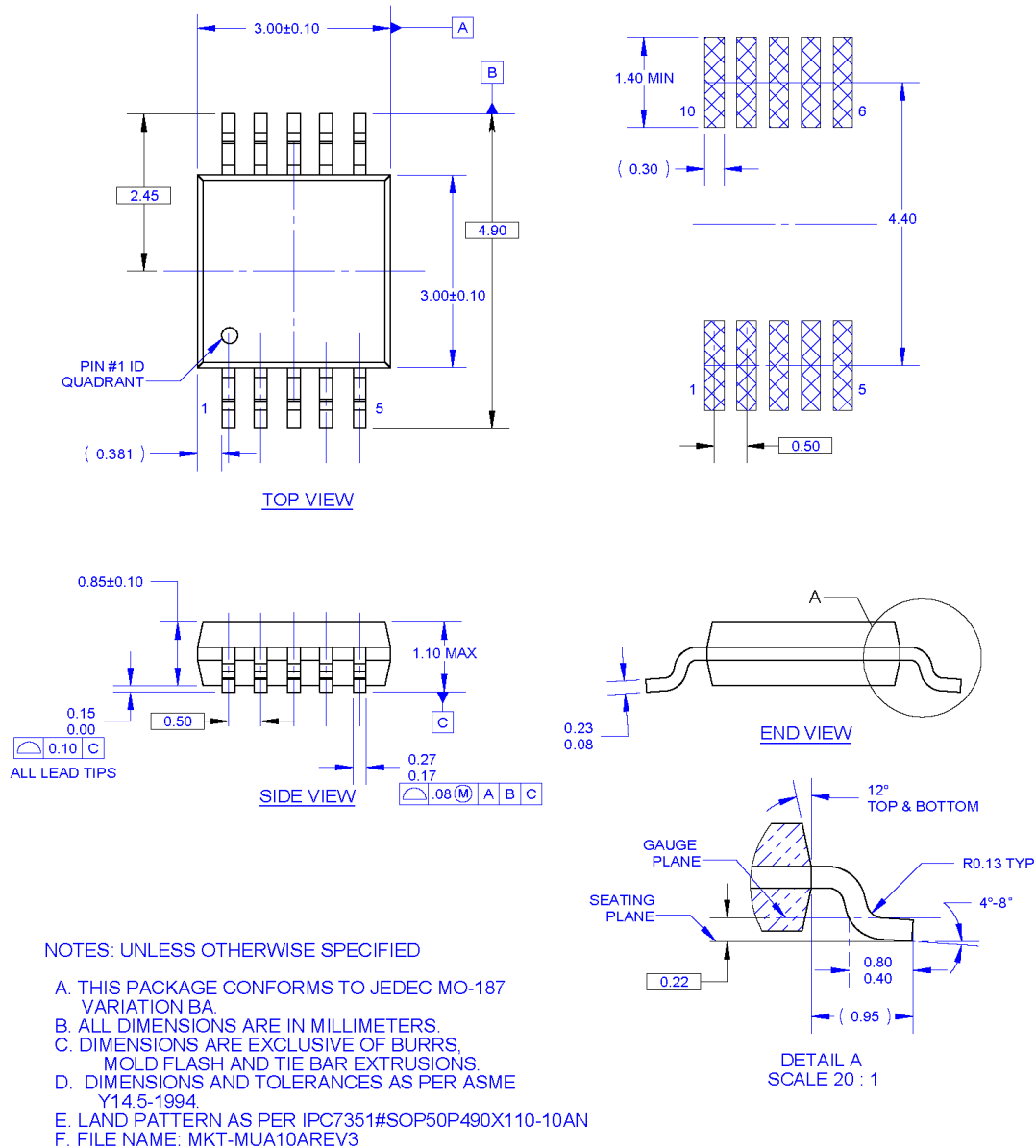
Package Designator	Tape Section	Number Cavity	Cavity Status	Cover Tape Status
L10X	Leader (Start End)	125 (Typical)	Empty	Sealed
	Carrier	5000	Filled	Sealed
	Trailer (Hub End)	75 (Typical)	Empty	Sealed

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[http://www.fairchildsemi.com/products/logic/pdf/micropak\\_tr.pdf](http://www.fairchildsemi.com/products/logic/pdf/micropak_tr.pdf).

# Physical Dimensions



**Figure 26. 10-Lead Molded Small Outline Package (MSOP)**

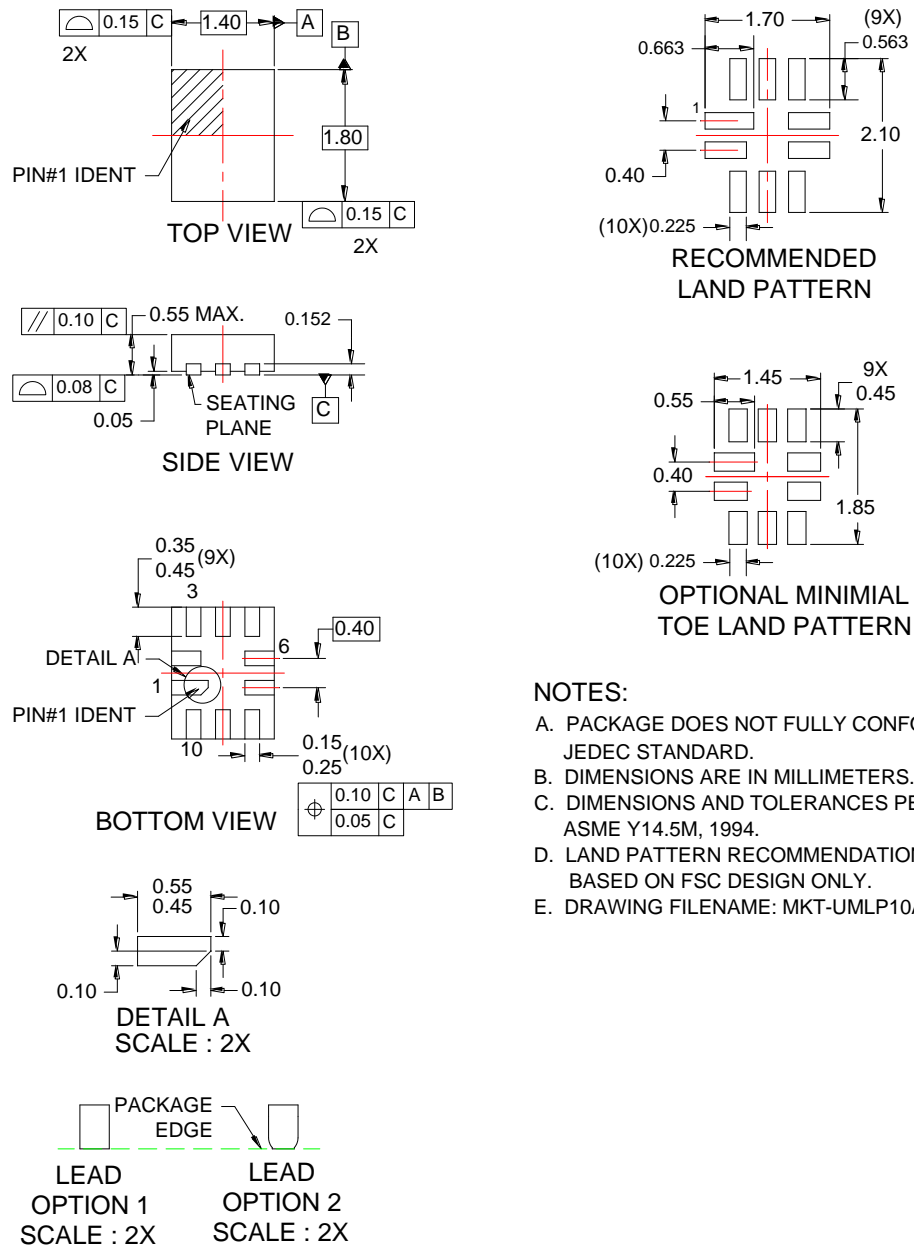
Tape Size	A	B	C	D	N	W1	W2	W3
	13	0.059	0.512	0.795	7.008	0.448	0.724	0.486-0.606
(12mm)	(330)	(1.5)	(13)	(20.2)	(178)	(12.4)	(18.4)	(11.9-15.4)

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## Physical Dimensions



**Figure 27. 10-Lead Quad, Ultrathin MLP, 1.4 x 1.8mm**

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