FAIRCHILD SEMICONDUCTOR®

November 2012

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/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.

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

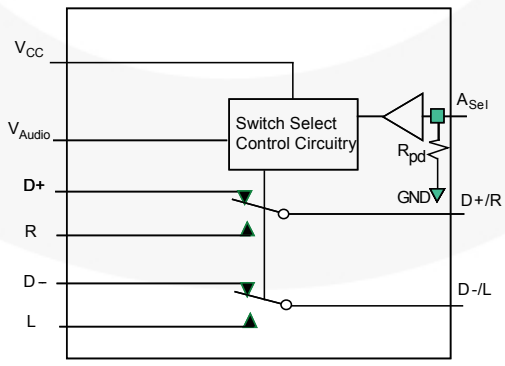


Figure 1. FSA223 Analog Symbol

Pin Configuration

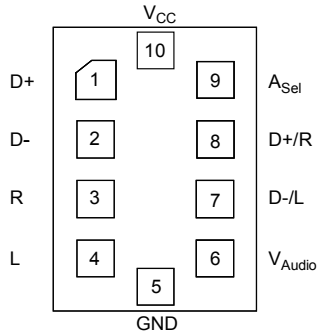


Figure 2. 10-Pin MicroPak™

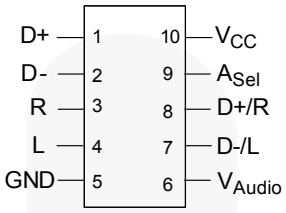


Figure 3. 10-Pin MSOP

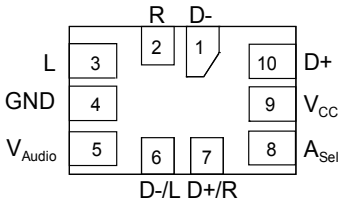


Figure 4. 10-Pin UMLP

Pin Definitions

Name	Description
V_{audio}	Power supply (audio)
V_{CC}	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_{CC}	L, R	D+, D-
—(2)	—	LOW	OFF	OFF
—	LOW	HIGH	OFF	ON
LOW	HIGH	HIGH	OFF	ON
HIGH	HIGH	HIGH	ON	OFF

Note:

1. A_{Sel} - Internal resistor to GND provides auto-V_{CC} detect if there is no external connection. Forcing A_{Sel} HIGH when V_{AUDIO} is present overrides the USB path.
2. 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 MΩ) and results in a default USB connection. For optimal performance, V_{CC} should be connected directly to the device battery.

Application Diagram

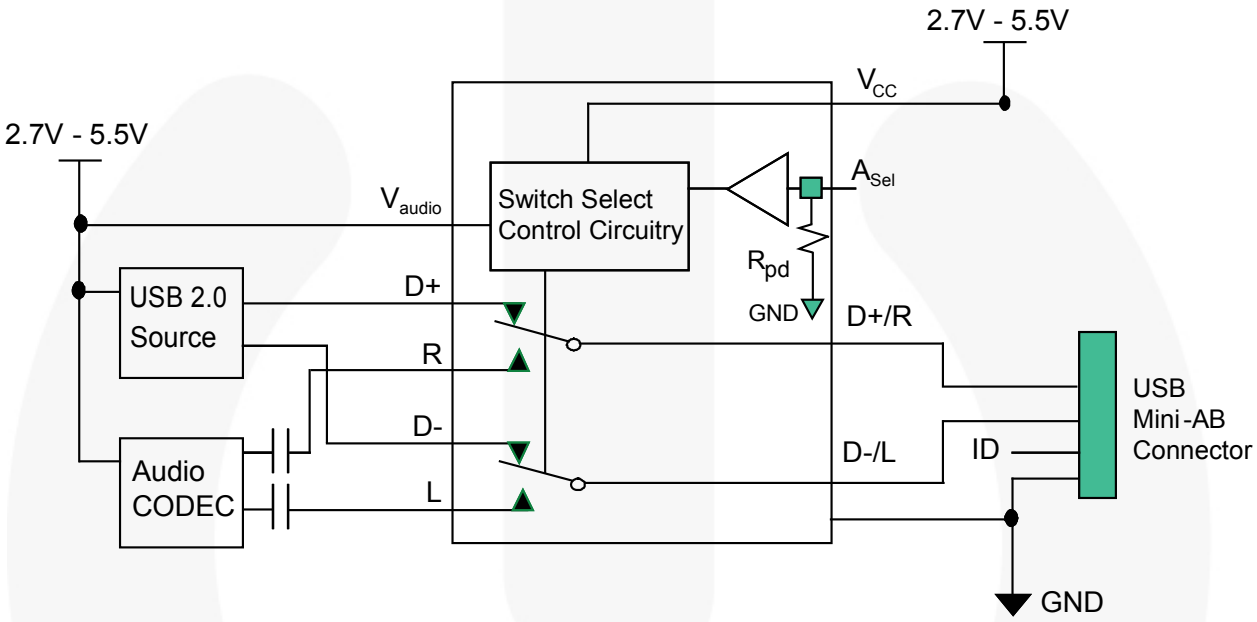


Figure 5. Typical Application

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_{Audio}	Supply Voltage		-0.5	6.0	V
V_{CC}	Supply Voltage		-0.5	6.0	V
V_{SW}	Switch I/O Voltage[3,4]	R, L Pins	V_{audio}- 7.0V	V_{audio} + 0.3V	V
		D+, D-, D+/R, D-/L Pins	V_{CC}- 7.0V	V_{CC} + 0.3V	V
A_{Sel}	Control Input Voltage[3]		-0.5	6.0	V
I_{IK}	Input Clamp Diode Current			-50	mA
I_{SW}	Switch I/O Current (Continuous)	USB		50	mA
		Audio		50	mA
I_{SWPEAK}	Peak Switch Current (Pulsed at 1ms Duration, <10% Duty Cycle)	USB		100	mA
		Audio		100	mA
T_{STG}	Storage Temperature Range		-65	+150	°C
T_J	Maximum Junction Temperature			+150	°C
T_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_{Audio} V_{CC} to GND		12.0	
	Charged Device Model, JESD22-C101			2.0	

Notes:

3. The input and output negative ratings may be exceeded if the input and output diode current ratings are observed.
4. V_{SW} maximum values can be exceeded ONLY if I_{SW} maximum values are observed. For example, V_{SW}=V_{CC} + 0.6 V is acceptable if I_{SW} is limited externally to ≤ 50 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_{Audio}	Supply Voltage		2.7	5.5	V
V_{CC}	Supply Voltage		2.7	5.5	V
A_{Sel}	Control Input Voltage		0	V_{CC}	V
V_{SW}	Switch I/O Voltage		V_{Audio} – 6.5 V	V_{Audio} – 0.3 V	V
			V_{CC} – 6.5 V	V_{CC}	V
T_A	Operating Temperature		-40	+85	°C
θ_{JA}	Thermal Resistance (free air)	MicroPak™		330 (estimated)	°C/W

DC Electrical Characteristics

V_{Audio} supply=2.7 V and typical values are at 25ºC unless otherwise specified.

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

Notes:

5. 4.3 V is guaranteed by characterization, not production tested.
6. On resistance is determined by the voltage drop between the A and B pins at the indicated current through the switch.
7. Δ R_{ON}=R_{ON} max – R_{ON} min measured at identical V_{CC}, temperature, and voltage. Worst-case signal path, audio or USB channel, is characterized.
8. Guaranteed by characterization, not production tested.
9. 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_{Audio} supply=2.7 V unless otherwise specified.

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

Note:

10. Guaranteed by characterization, not production tested.

USB High-Speed-Related AC Electrical Characteristics

V_{Audio} supply=2.7 V unless otherwise specified.

Symbol	Parameter	V_{CC} (V)	Conditions	T_A=- 40°C to +85°C			Unit
				Min.	Typ.	Max.	
$t_{SK(o)}$	Channel-to-Channel Skew(11)	3.0 to 4.3(11)	t_R=t_F=750 ps (10-90%) at 240 MHz C_L=0 pF, R_L=50 Ω Figure 18, Figure 19		35		ps
$t_{SK(P)}$	Skew of Opposite Transitions of the Same Output(11)	3.0 to 4.3(11)	t_R=t_F=750 ps (10-90%) at 240 MHz C_L=0 pF, R_L=50 Ω Figure 18, Figure 19		35		
t_J	Total Jitter(11)	3.0 to 4.3(11)	R_L=50 Ω, C_L=50 pF, t_R=t_F=500 ps (10-90%) at 480 Mbps (PRBS=2^{15} – 1)		130		ps

Note:

11. Guaranteed by characterization, not production tested.

Capacitance(12)

V_{Audio} supply=3.0V unless otherwise specified.

Symbol	Parameter	V_{CC} (V)	Condition	T_A=- 40°C to +85°C			Unit
				Min.	Typ.	Max.	
$C_{IN\ (ASel)}$	Control Pin Input Capacitance (A_{Sel})	V_{CC}=3.0 V, 4.3 V	V_{Bias}=0.05 V		2.0		pF
$C_{ON(D+/R, D-/L)}$	D+/R, D-/L (Source Port) On Capacitance	V_{CC}=3.0 V, 4.3 V A_{Sel}=0V (C_{ONUSB})	V_{Bias}=0.2 V; f=240 MHz Figure 24		4.5	6.0	pF
		V_{CC}=3.0 V, 4.3 V A_{Sel}=3.0 V ($C_{ONAudio}$)	V_{Bias}=0.2 V; f=1 MHz Figure 24		9.0		
$C_{OFF(D+, D-)}$	USB Input Source Off Capacitance	V_{CC}=3.0 V, 4.3 V A_{Sel}=3.0 V	f=1 MHz Figure 23		1.5		pF
$C_{OFF(R/L)}$	Audio Input Source Off Capacitance	V_{CC}=3.0 V, 4.3 V A_{Sel}=0 V	f=1MHz Figure 23		3.0		pF

Note:

12. Guaranteed by characterization, not production tested.

Applications Information

In applications where Vsw could exceed the absolute maximum rating of V_{CC}+0.3 V, 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)*.

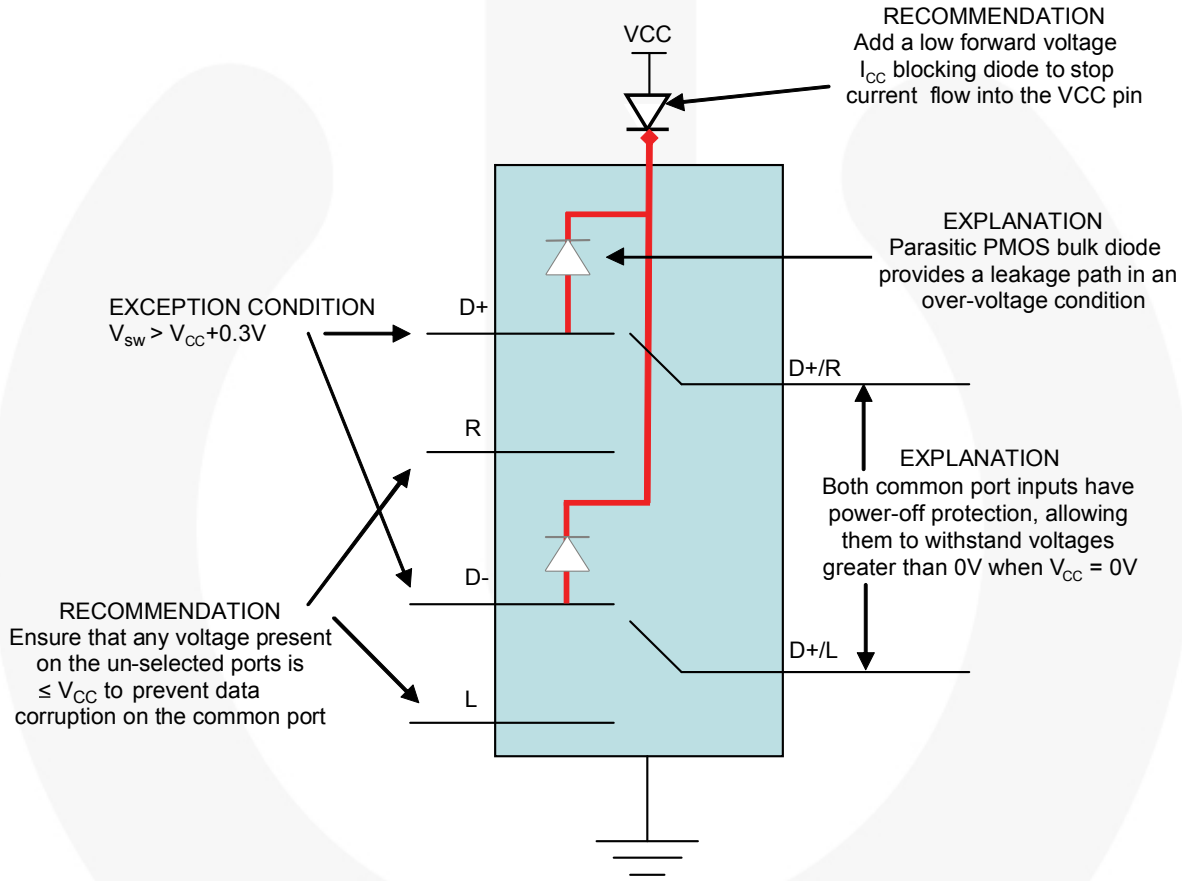


Figure 6. Application Suggestions

Typical Performance Characteristics

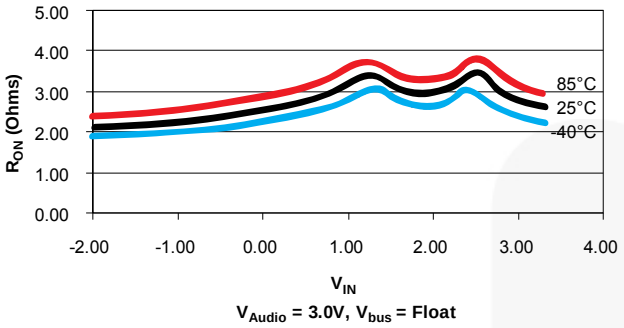


Figure 7. R_{ON} Audio, V_{Audio}=3.0 V

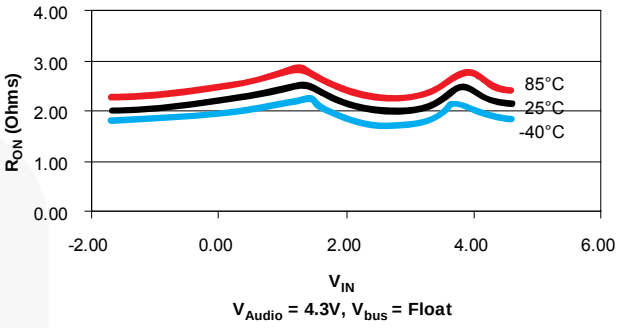


Figure 8. R_{ON} Audio, V_{Audio}=4.3 V

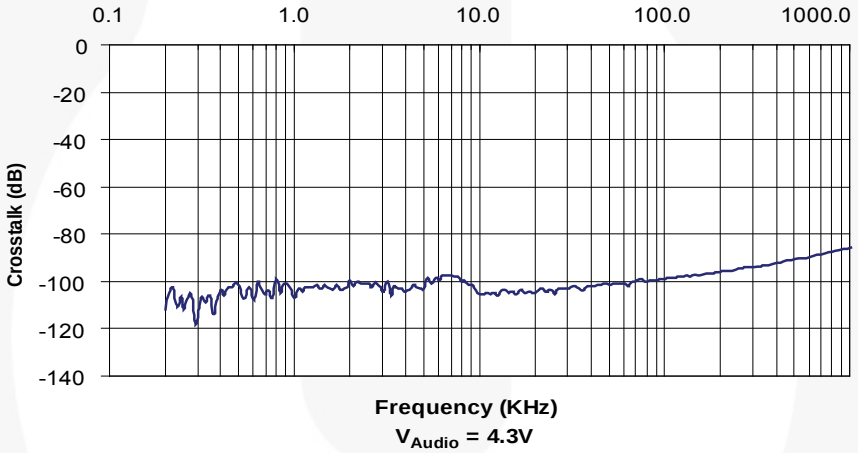


Figure 9. Crosstalk

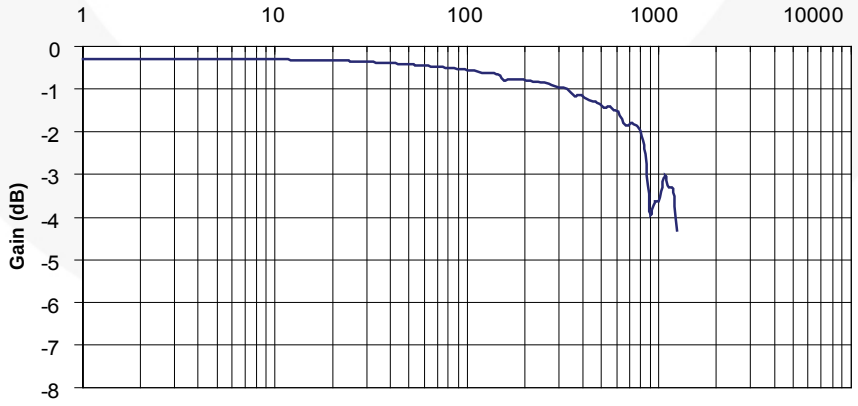


Figure 10. USB Bandwidth

Test Diagrams

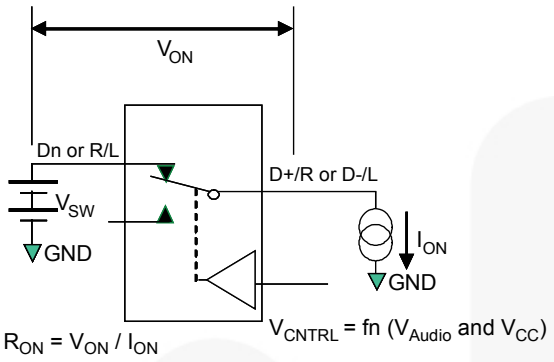


Figure 11. On Resistance

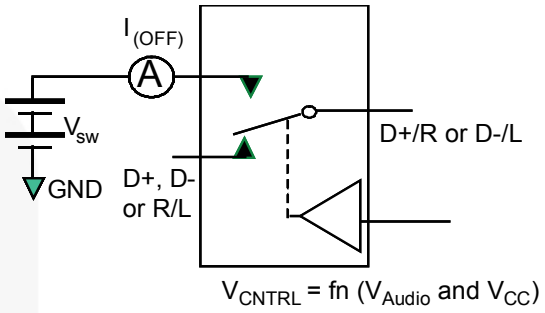


Figure 12. Off Leakage

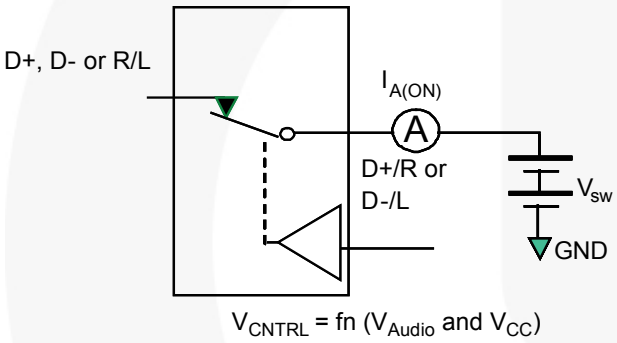
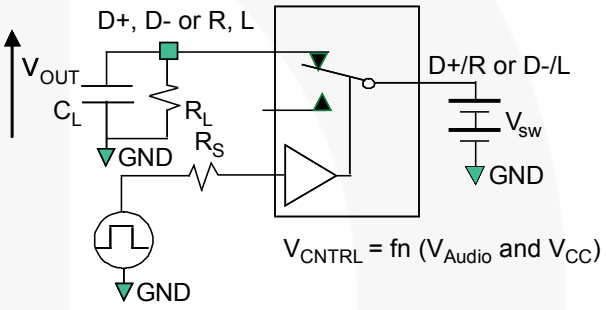


Figure 13. On Leakage



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

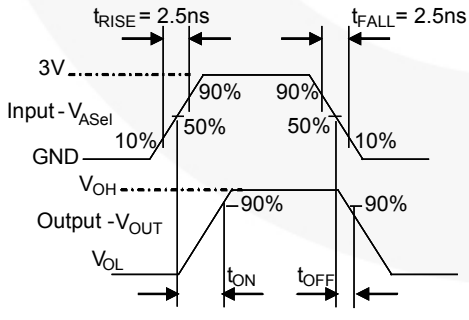


Figure 15. Turn-On / Turn-Off Waveforms (A_{Sel})

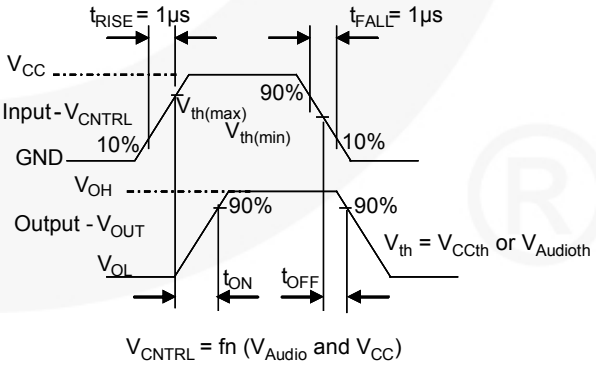


Figure 16. Turn-On / Turn-Off Waveforms (USB/Audio)

Test Diagrams (Continued)

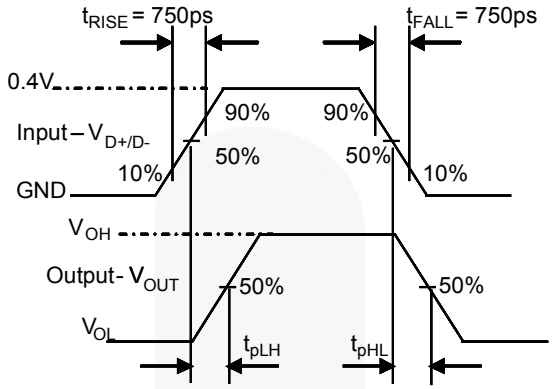


Figure 17. USB Switch Propagation Delay Waveforms

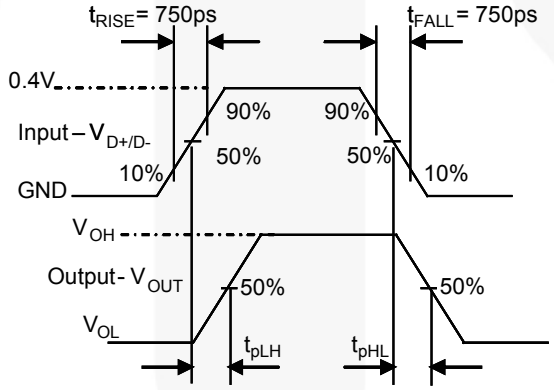


Figure 18. Pulse Skew: $t_{SK(P)}$=| t_{PHL} – t_{PLH} |

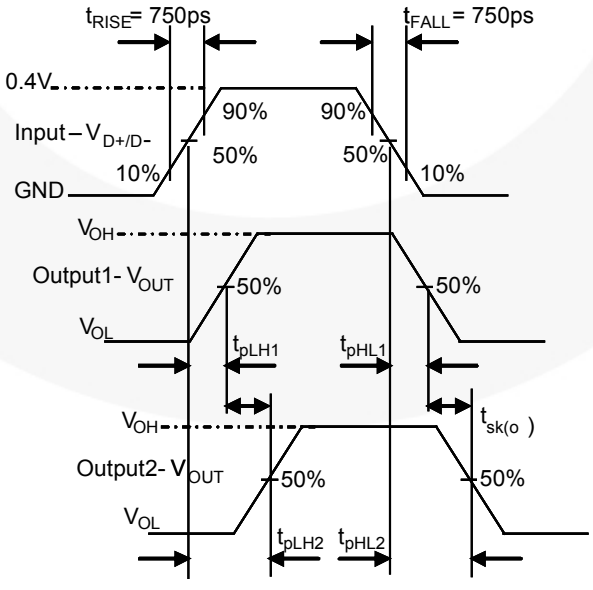
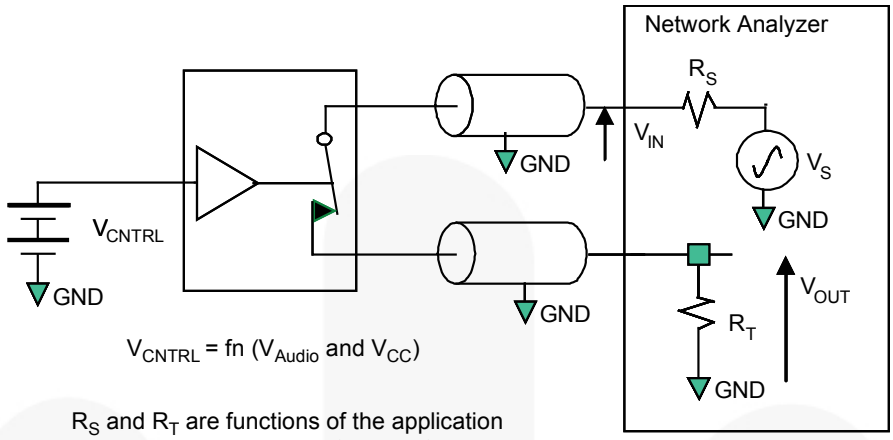


Figure 19. Output Skew: $t_{SK(O)}$=| t_{PLH1} – t_{PLH2} | or | t_{PHL1} – t_{PHL2} |

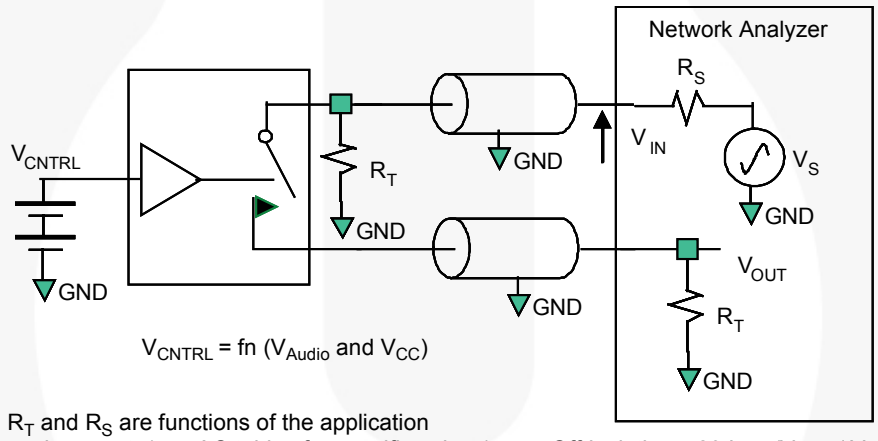
Test Diagrams (Continued)



V_{CNTRL} = fn (V_{Audio} and V_{CC})

R_S and R_T are functions of the application environment (see tables for specific values).

Figure 20. USB Bandwidth

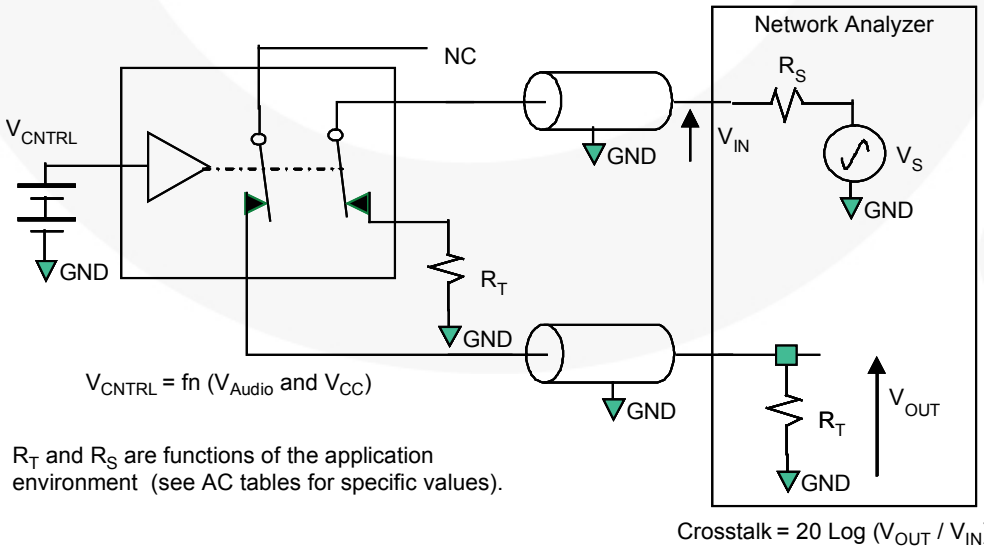


V_{CNTRL} = fn (V_{Audio} and V_{CC})

R_T and R_S are functions of the application environment (see AC tables for specific values).

Off Isolation = 20 Log (V_{OUT} / V_{IN})

Figure 21. Channel Off Isolation



V_{CNTRL} = fn (V_{Audio} and V_{CC})

R_T and R_S are functions of the application environment (see AC tables for specific values).

Crosstalk = 20 Log (V_{OUT} / V_{IN})

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

Test Diagrams (Continued)

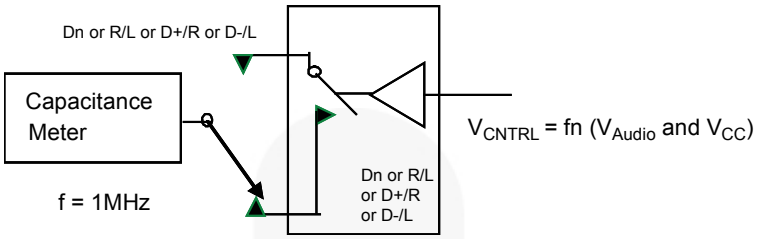


Figure 23. Channel Off Capacitance

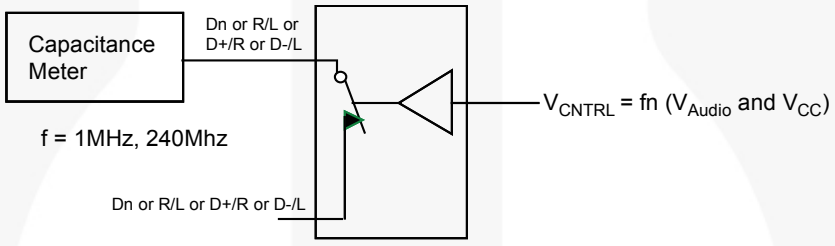
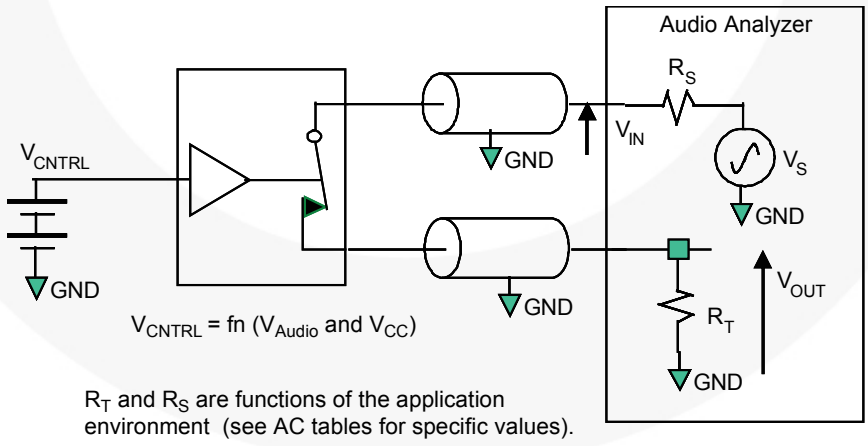


Figure 24. Channel On Capacitance



R_T and R_S are functions of the application environment (see AC tables for specific values).

Figure 25. Total Harmonic Distortion

Physical Dimensions

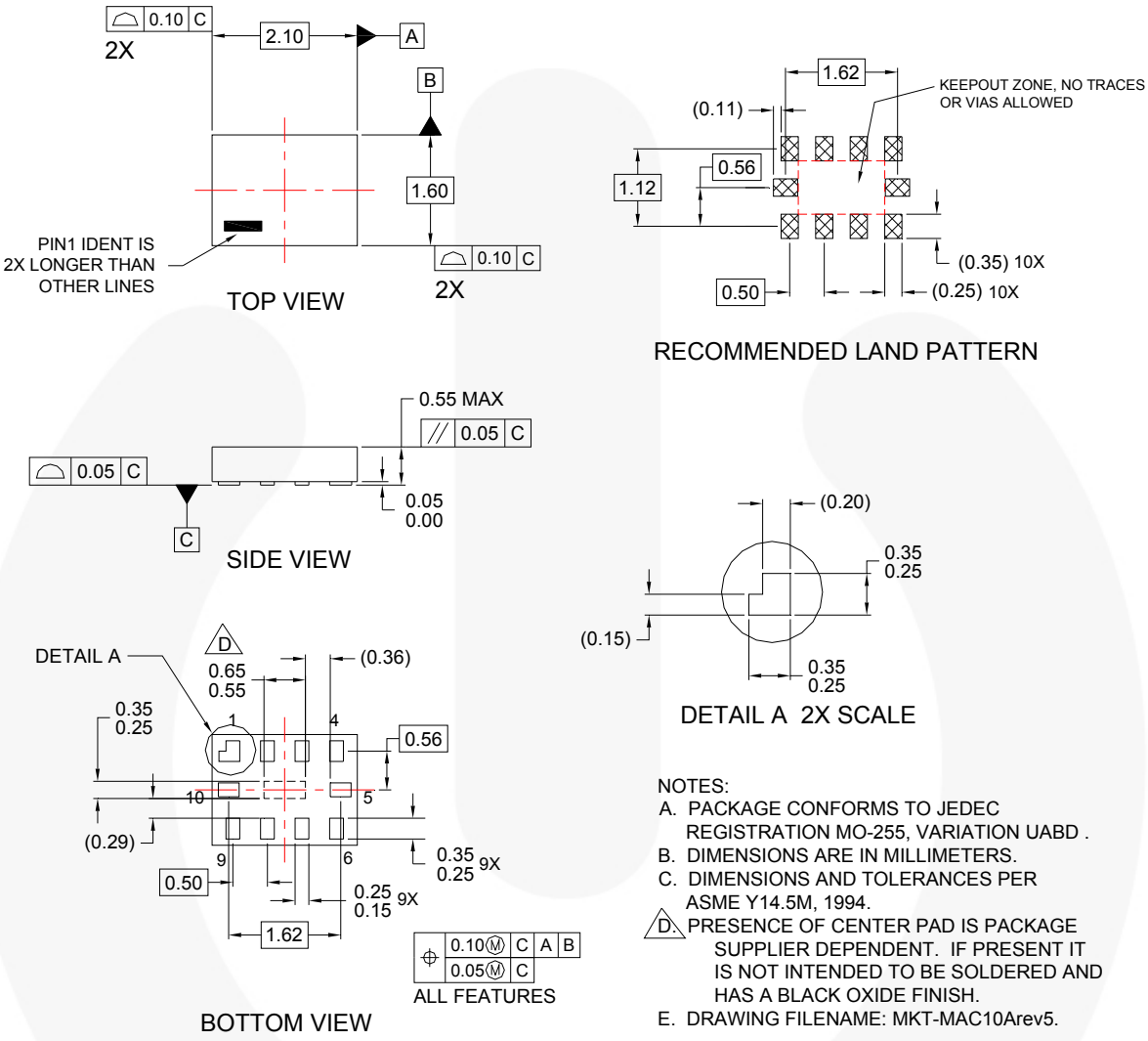


Figure 26. 10-Lead MicroPak™

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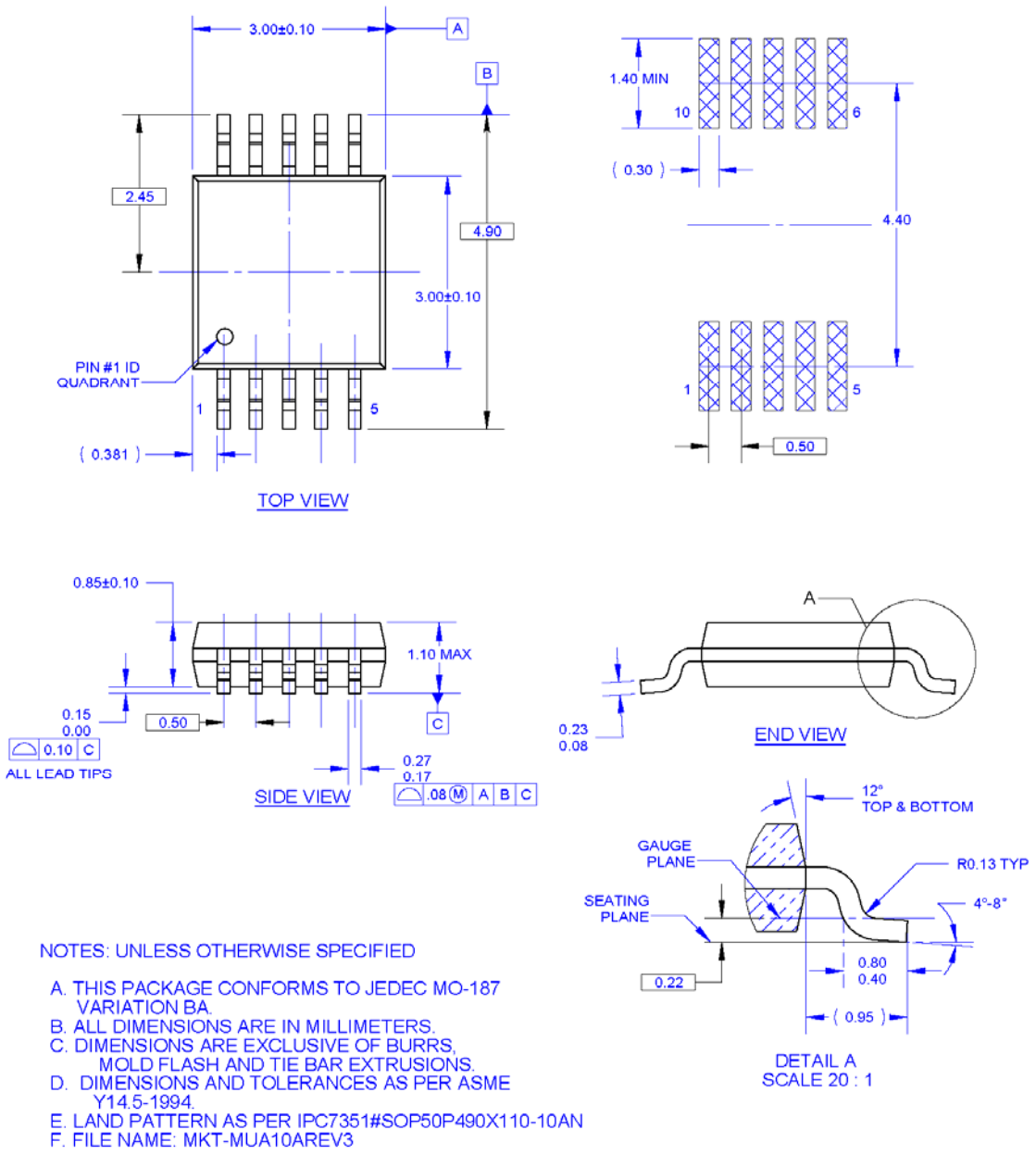
For tape & reel specifications, please visit, http://www.fairchildsemi.com/products/logic/pdf/micropak_tr.pdf.

Physical Dimensions (Continued)



NOTES: UNLESS OTHERWISE SPECIFIED

A. THIS PACKAGE CONFORMS TO JEDEC MO-187 VARIATION BA.
B. ALL DIMENSIONS ARE IN MILLIMETERS.
C. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH AND TIE BAR EXTRUSIONS.
D. DIMENSIONS AND TOLERANCES AS PER ASME Y14.5-1994.
E. LAND PATTERN AS PER IPC7351#SOP50P490X110-10AN
F. FILE NAME: MKT-MUA10AREV3

Figure 27. 10-Lead Molded Small Outline Package (MSOP)

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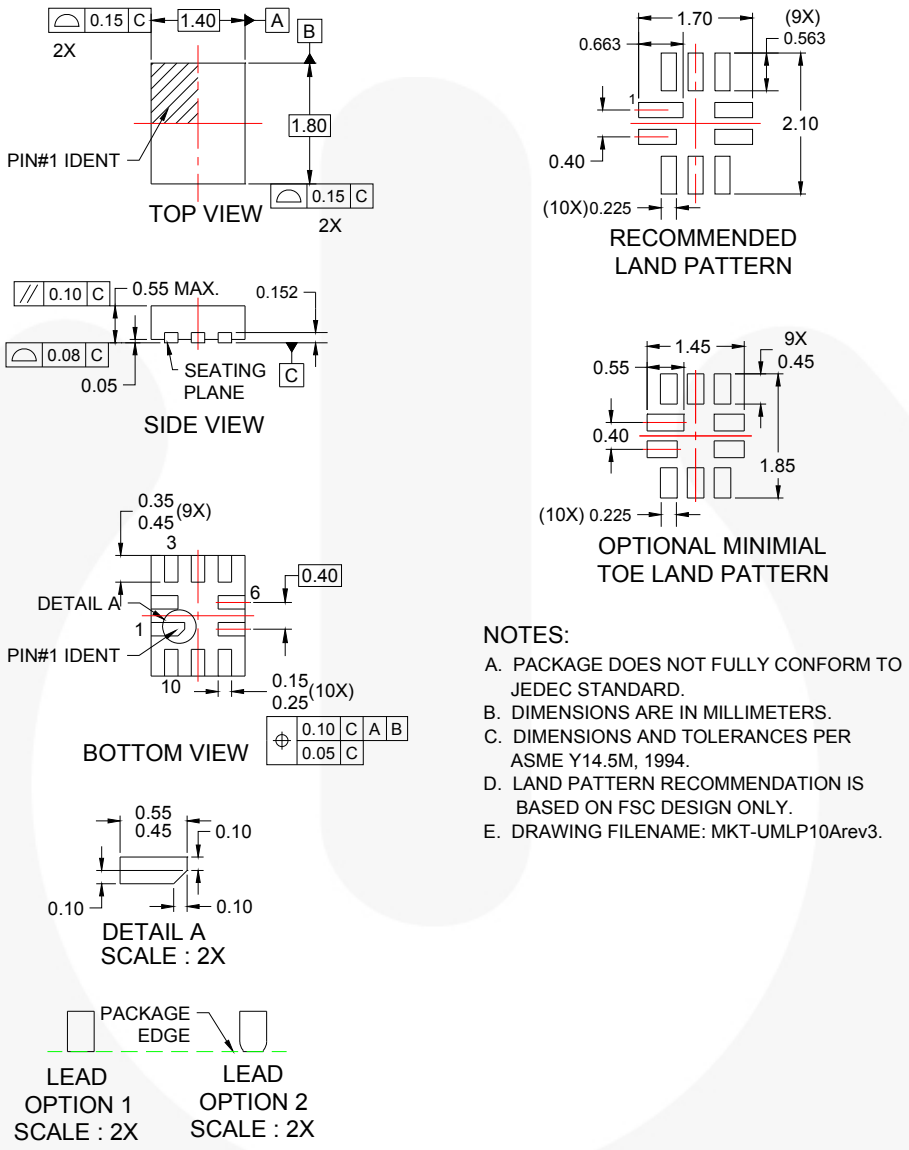
Physical Dimensions (Continued)



NOTES:

A. PACKAGE DOES NOT FULLY CONFORM TO JEDEC STANDARD.
B. DIMENSIONS ARE IN MILLIMETERS.
C. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994.
D. LAND PATTERN RECOMMENDATION IS BASED ON FSC DESIGN ONLY.
E. DRAWING FILENAME: MKT-UMLP10Arev3.

Figure 28. 10-Lead Quad Ultrathin MLP

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