FAIRCHILD SEMICONDUCTOR®

November 2006

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

Features

- HS-USB: 4Ω Typical On Resistance
- Audio: 3Ω Typical On Resistance
- -3db Bandwidth: > 720MHz
- Low Power Consumption
- Packaged in Pb-free 10-Lead MicroPak™ (1.6 x 2.1mm), 10-pin MSOP (Preliminary)
- Power-off Protection on Common D+/R, D-/L Ports
- Automatically Detects V_{bus} for Switch Path Selection
- D+/R, D-/L Ports: 8pf Typical On Capacitance

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 similar 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	Pb-Free	Package Description
FSA221L10X	MAC010A	GK	Yes	10-Lead MicroPak, JEDEC MO-255, 1.6 x 2.1mm
FSA221MUX (Preliminary)	MUA10A	FSA221	Yes	10-Lead MSOP JEDEC MO-187, 3.0 mm Wide
FSA221UMX (Preliminary)	MLP010A	GL	Yes	10-Lead Quad, Ultrathin MLP, 1.4 x 1.8mm

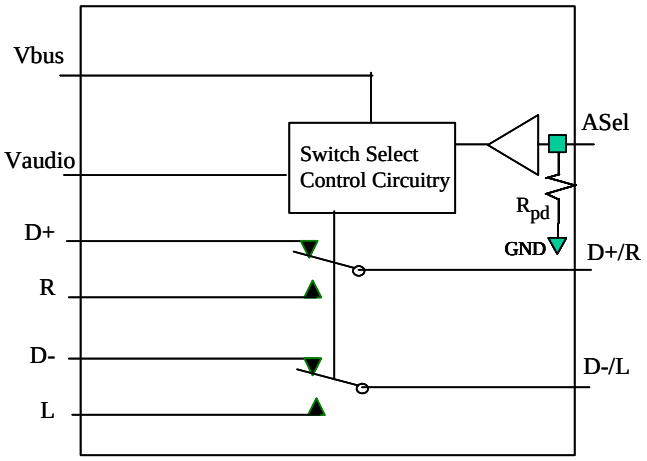

Figure 1. FSA221 Analog Symbol

Pin Assignments

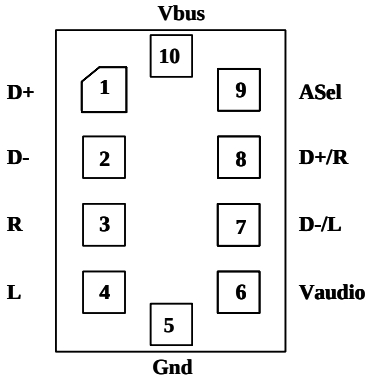

Figure 2. 10-Pin MicroPak

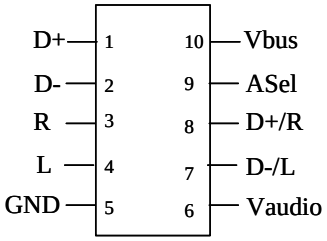

Figure 3. 10-Pin MSOP

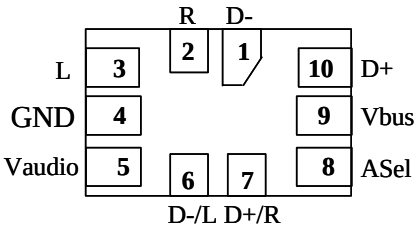

Figure 4. 10-Pin µMLP

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-
L	L	L	OFF	OFF
L	L	H (2)	OFF	ON
L	H (2)	L	ON	OFF
L	H (2)	H (2)	OFF	ON
H	L	L	OFF	OFF
H	L	H (2)	OFF	ON
H	H (2)	L	ON	OFF
H	H (2)	H (2)	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. H - 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 3MΩ) 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

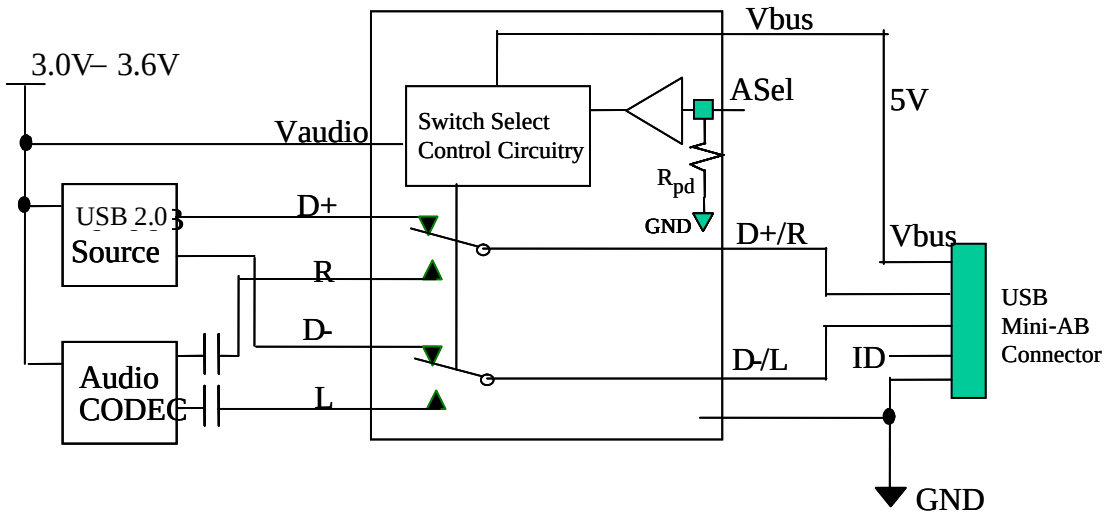

Figure 5. FSA221 Typical Application Diagram

Absolute Maximum Ratings

The "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the Electrical Characteristics tables are not guaranteed at the absolute maximum ratings. The "Recommended Operating Conditions" table defines the conditions for actual device operation.

Symbol	Parameter		Conditions
V_{Audio}	Supply Voltage		-0.5V to 6.0V
V_{bus}	Supply Voltage		-0.5V to 6.0V
V_{SW}	Switch I/O Voltage[3]	R, L Pins	(V_{audio}- 7.0V) to (V_{audio}+ 0.3V)
		D+, D-, D+/R, D-/L Pins	(V_{bus}- 7.0V) to (V_{bus}+ 0.3V)
A_{Sel}	Control Input Voltage[3]		-0.5V to + 6.0V
I_{IK}	Input Clamp Diode Current		- 50mA
I_{SW}	Switch I/O Current (Continuous)	USB	50mA
		Audio	50mA
I_{SWPEAK}	Peak Switch Current (Pulsed at 1ms Duration, <10% Duty Cycle)	USB	100mA
		Audio	100mA
T_{STG}	Storage Temperature Range		-65°C to +150°C
T_J	Maximum Junction Temperature		+150°C
T_L	Lead Temperature (Soldering, 10 seconds)		+260°C
ESD	Human Body Model (JEDEC: JESD22-A114)	I/O to GND	7000
		All Other Pins	7000
		V_{Audio} V_{bus} to GND	12000
	Charge Discharge Model (JEDEC-JESD-C101)		2000

Notes:

3. The input and output negative ratings may be exceeded if the input and output diode current ratings are observed.

Recommended Operating Conditions

Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fairchild does not recommend exceeding or designing to Absolute Maximum Ratings.

Symbol	Parameter		Minimum	Maximum
V_{Audio}	Supply Voltage		3.0V	3.6V
V_{bus}	Supply Voltage		4.25V	5.5V
A_{Sel}	Control Input Voltage		0V	V_{Audio}
V_{SW}	Switch I/O Voltage		V_{Audio} - 6.5V	V_{Audio} – 0.3V
			V_{bus} - 6.5V	V_{bus}
T_A	Operating Temperature		-40ºC	85ºC
θ_{JA}	Thermal Resistance (free air)	MicroPak 10L package		330ºC / W (estimated)

DC Electrical Characteristics

All typical values are at 25ºC unless otherwise specified.

Symbol	Parameter	V_{Audio} (V)	Conditions	T_A = - 40°C to +85°C			Unit
				Min.	Typ.	Max.	
Common Pins		V_{Audio} (V)					
V_{IK}	Clamp Diode Voltage	3.0	I_{IK} = -18mA			-1.2	V
V_{IH}	Control Input Voltage HIGH	3.0 to 3.6		1.2			
V_{IL}	Control Input Voltage LOW	3.0 to 3.6				0.5	
I_{IN}	A_{Sel} Input HIGH Current	3.6	V_{IN} = 3.6V	-1		10	µA
			V_{IN} = 0V	-1		1	
I_{OFF}	Power Off Leakage Current (Common Port Only D+/R, D-/L)	V_{audio} = V_{bus} = 0V	Common Port (D+/R, D-/L) V_{SW} = 0V to 5.5V			10	µA
$I_{NO(0FF)}$	Off-Leakage Current of Port D+, D-, R, L	3.6	V_{bus} = 0V, 5. 5V D+/R, D-/L = 0.3V, V_{AUDIO} – 0.3V D+, D-, R, L = 0.3V, V_{AUDIO} –0.3V or Floating See Figure 11	-50	1	50	nA
$I_{NC(0N)}$	On-Leakage Current of Port D+/R or D-/L	3.6	V_{bus} = 0V, 5.5V D+/R, D-/L = 0.3V, V_{AUDIO} – 0.3V D+, D-, R, L = Floating See Figure 12	-50	1	50	nA
R_{PD}	A_{Sel} Internal Pull-Down Resistor				3		MΩ
USB Switch Path		V_{bus} (V)					
	USB Analog Signal Range			0		3.6	V
R_{ONUSB}	HS Switch On Resistance(4)	4.25	$V_{D+/D-}$ = 0V, 0.4V, I_{ON} = -8mA, V_{AUDIO} = 3V		4	6	Ω
Δ R_{ONUSB}	HS Delta R_{ON}(5,6)	4.25	$V_{D+/D-}$ = 0V, I_{ON} = -8mA, V_{AUDIO} = 3V		0.4		Ω
Audio Switch Path		V_{Audio} (V)					
	Audio Analog Signal Range			V_{audio} – 5.5		V_{audio}	V
$R_{ONAudio}$	Audio Switch On Resistance(4)	3.0	$V_{L/R}$ = -2V, 0V, 0.7V, V_{bus} = 0V V_{AUDIO}-0.7V, V_{AUDIO} I_{ON} = -26mA		3	5	Ω
Δ $R_{ONAudio}$	Audio Delta R_{ON}(5)	3.0	$V_{L/R}$ = 0.7V I_{ON} = -26mA		0.4		Ω
$R_{FLAT(Audio)}$	Audio R_{ON} Flatness(7)	3.0	I_{ON} = -26mA		1.5	2.5	Ω

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DC Electrical Characteristics (Continued)

All typical values are at 25ºC unless otherwise specified.

Symbol	Parameter	V_{Audio} (V)	Conditions	T_A = - 40°C to +85°C			Unit
				Min.	Typ.	Max.	
Power Supply							
V_{busth}	V_{bus} Threshold Voltage			3.2		3.8	V
$V_{audioth}$	V_{audio} Threshold			0.5		1.5	V
$I_{CC(Audio)}$	Quiescent Supply Current (Audio)	3.6	V_{ASel} = 0 to V_{audio}, I_{OUT} = 0		6	10	µA
$I_{CC(Vbus)}$	Quiescent Supply Current (V_{bus})		V_{ASel} = 0 to V_{audio}, I_{OUT} = 0 V_{bus} = 5.5V		12	20	µA
I_{CCT}	Increase in I_{CC} current per control voltage and V_{CC}	3.6	V_{ASel} = 2.6V, V_{bus} = floating		10	15	µA
			V_{ASel} =1.8V, V_{bus} = floating		14	18	

Notes:

4. On resistance is determined by the voltage drop between the A and B pins at the indicated current through the switch.
5. $\Delta R_{ON} = R_{ON\ max} - R_{ON\ min}$ measured at identical V_{CC}, temperature, and voltage. Worst-case signal path, audio or USB channel, is characterized.
6. Guaranteed by characterization, not production tested.
7. 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_{AUDIO} = 3.3V and V_{bus} = 5.0 at 25ºC unless otherwise specified.

Symbol	Parameter	V_{audio}/V_{bus} (V)	Conditions	T_A = - 40°C to +85°C			Unit
				Min.	Typ.	Max.	
$t_{ONAUDIO1}$	Turn-On Time V_{AUDIO}↑ to Output	V_{bus} = 0V	$V_{D+/R, D-/L}$ = 1.0V R_L = 50Ω, C_L = 50pF Figure 13, Figure 15			10	µs
$t_{OFFAUDIO1}$	Turn-Off Time V_{Bus}↑ to Output	V_{AUDIO} = 3.0 for V_{bus} ↑	$V_{D+/R, D-/L}$ = 1.0V R_L = 50Ω, C_L = 50pF Figure 13, Figure 15			10	µs
$t_{ONAUDIO2}$	Turn-On Time A_{Sel} to Output	V_{bus} = 4.25V V_{AUDIO} = 3.0	$V_{D+/R, D-/L}$ = 1.0V R_L = 50Ω, C_L = 50pF Figure 13, Figure 14			2	µs
$t_{OFFAUDIO2}$	Turn-Off Time A_{Sel} to Output	V_{bus} = 4.25V V_{AUDIO} = 3.0	$V_{D+/R, D-/L}$ = 1.0V R_L = 50Ω, C_L = 50pF Figure 13, Figure 14			2	µs
$t_{ONAUDIO3}$	Turn-On Time V_{Bus}↓ to Output	V_{AUDIO} = 3.0	$V_{D+/R, D-/L}$ = 1.0V R_L = 50Ω, C_L = 50pF Figure 13, Figure 15			10	µs
t_{ONUSB}	Turn-On Time V_{USB}↑ to Output	V_{AUDIO} = 3.0	$V_{D+/R, D-/L}$ = 1.0V R_L = 50Ω, C_L = 0pF Figure 13, Figure 15			10	µs
t_{OFFUSB}	Turn-Off Time V_{USB}↓ to Output	V_{AUDIO} = 3.0	$V_{D+/R, D-/L}$ = 1.0V R_L = 50Ω, C_L = 0pF Figure 13, Figure 15			10	µs
t_{PDUSB}	USB Switch Propagation Delay[8]	V_{AUDIO} = 3.0 V_{bus} = 4.25V	R_L = 50Ω, C_L = 0pF Figure 16		0.25		ns
$Xtalk_A$	Non-Adjacent Channel Crosstalk - Audio	V_{AUDIO} = 3.0 V_{bus} = 4.25V	f = 20kHz, R_T = 32Ω, C_L = 0pF Figure 7, Figure 21		-110		dB
BW	-3db Bandwidth - USB	V_{AUDIO} = 3.0 V_{bus} = 4.25V	R_T = 50Ω, C_L = 0pF, Signal 0dBm Figure 9, Figure 19		720		MHz
THD	Total Harmonic Distortion	V_{AUDIO} = 3.0 V_{bus} = 0V	f = 20Hz to 20 kHz R_L = 32Ω, V_{IN} = $2V_{pp}$ Figure 24		0.05		%

Notes:

8. Guaranteed by characterization, not production tested.

USB High-Speed-Related AC Electrical Characteristics

Symbol	Parameter	V_{AUDIO}/ V_{bus}(V)	Conditions	T_A = - 40°C to +85°C			Unit
				Min.	Typ.	Max.	
$t_{SK(o)}$	Channel-to-Channel Skew[9]	V_{AUDIO} = 3.0V V_{bus} = 4.25V	$t_R = t_F$ = 750ps (10-90%) at 240MHz C_L = 0pF, R_L = 50Ω Figure 17, Figure 18		35		ps
$t_{SK(P)}$	Skew of Opposite Transitions of the Same Output[9]	V_{AUDIO} = 3.0V V_{bus} = 4.25V	$t_R = t_F$ = 750ps (10-90%) at 240MHz C_L = 0pF, R_L = 50Ω Figure 17, Figure 18		35		
t_J	Total Jitter[9]	V_{AUDIO} = 3.0V V_{bus} = 4.25V	R_L = 50Ω, C_L = 50pF, $t_R = t_F$ = 500ps (10-90%) at 480Mbps (PRBS = 2^{15} – 1)		130		ps

Notes:
9. Guaranteed by characterization, not production tested.

Capacitance

Symbol	Parameter	V_{AUDIO}/ V_{bus}(V)	Conditions	T_A = - 40°C to +85°C			Unit
				Min.	Typ.	Max.	
$C_{IN\ (ASel)}$	Control Pin Input Capacitance (A_{Sel})	V_{AUDIO} = 3.0V V_{bus} = 4.25V	V_{Bias} = 0.2V		2.0		pF
$C_{ON(D+/R,\ D-/L)}$	D+/R, D-/L (Source Port) On Capacitance	V_{AUDIO} = 3.0V V_{bus} = 4.25V A_{Sel} = 0V (C_{ONUSB})	V_{Bias} = 0.2V f = 1MHz Figure 23		9.0		pF
		V_{AUDIO} = 3.0V V_{bus} = 4.25V A_{Sel} = 3.0V ($C_{ONAudio}$)	V_{Bias} = 0.2V f = 1MHz Figure 23		10.0		
$C_{OFF(D+,\ D-)}$	USB Input Source Off Capacitance	V_{AUDIO} = 3.0V V_{bus} = 4.25V A_{Sel} = 3.0V	f = 1MHz Figure 22		1.5		pF
$C_{OFF(R/L)}$	Audio Input Source Off Capacitance	V_{AUDIO} = 3.0V V_{bus} = 4.25V A_{Sel} =0V	f = 1MHz Figure 22		3.0		pF

Typical Characteristics

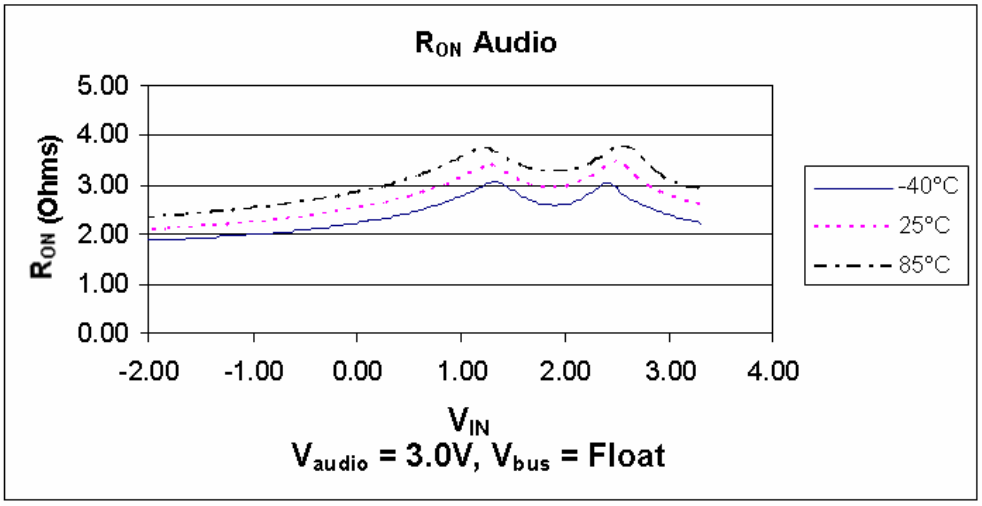


Figure 6. R_{ON} Audio, V_{Audio} = 3.0V, V_{BUS} = Float

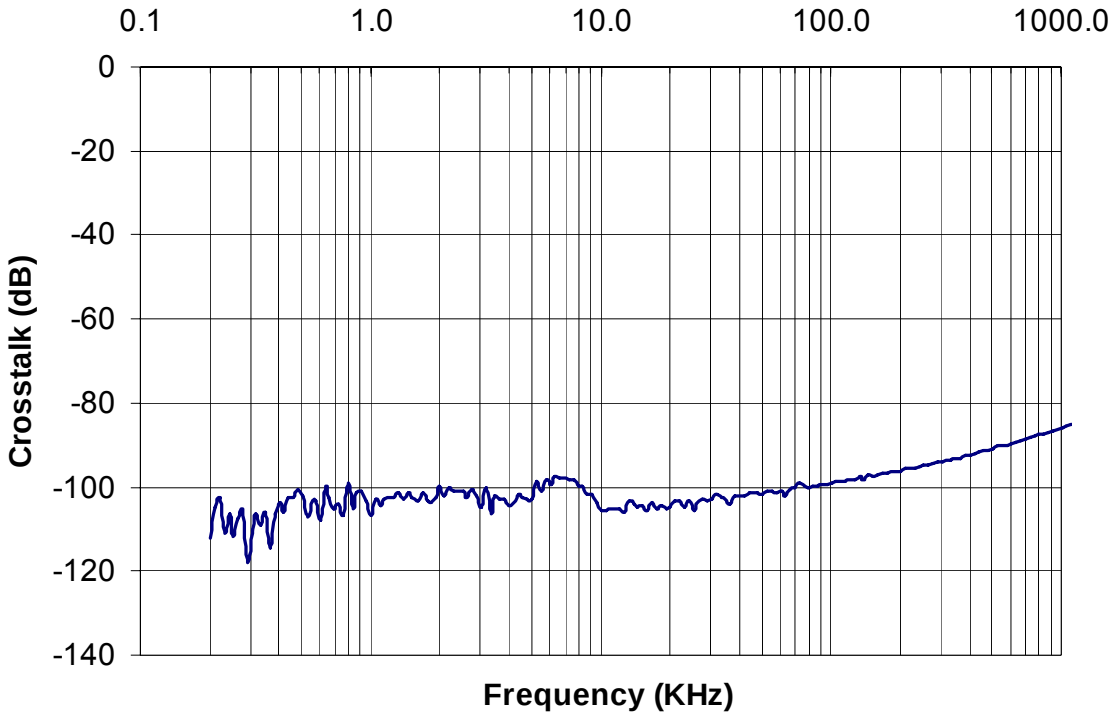
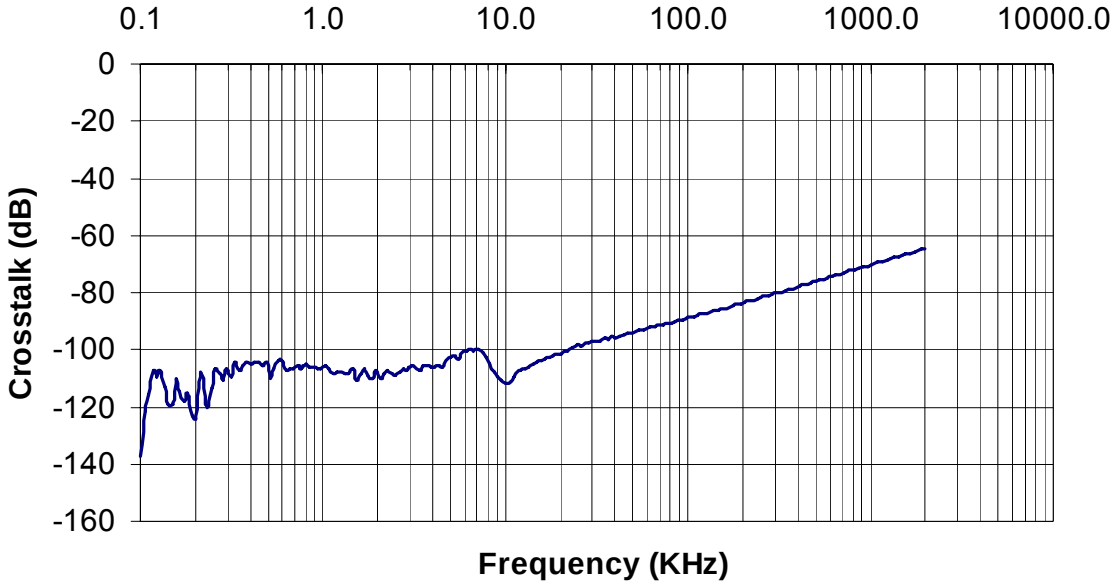


Figure 7. Non-Adjacent Channel Crosstalk – Audio

Typical Characteristics (Continued)



VCC(Vaudio) = 3.0V

Figure 8. Off-Isolation – Audio

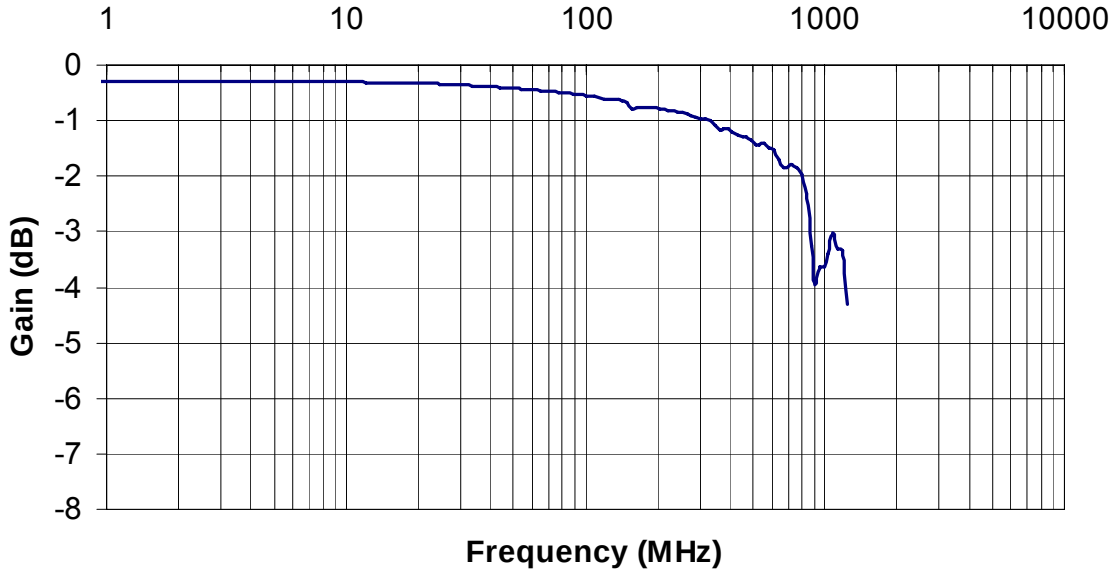


Figure #. Bandwidth Characterization, Frequency Response at CL= 0pF,VCC (Vbus) = 4.25V

Figure 9. Bandwidth, Gain vs. Frequency – USB

Test Diagrams

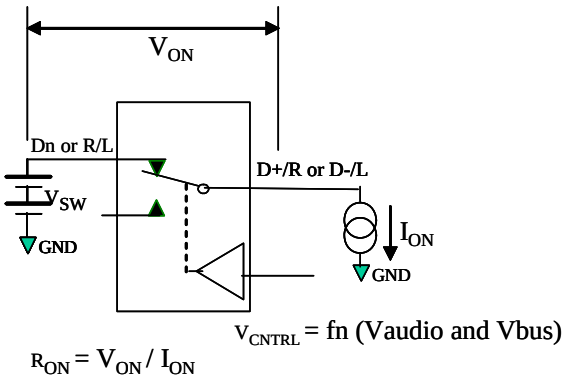


Figure 10. On Resistance

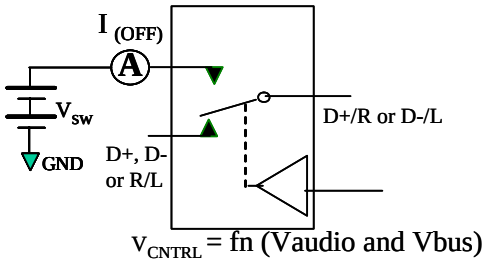


Figure 11. Off Leakage

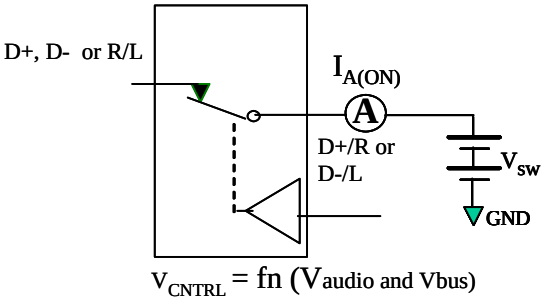
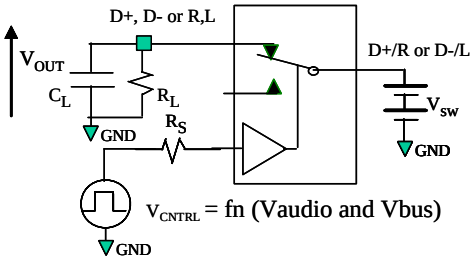


Figure 12. On Leakage



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 13. AC Test Circuit Load

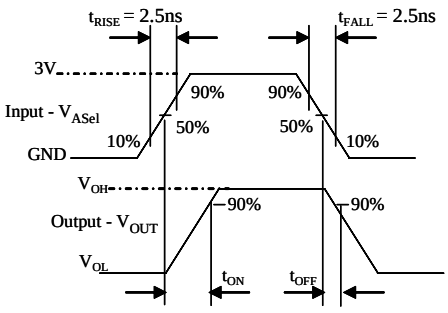


Figure 14. Turn-On / Turn-Off Waveforms (A_{Sel})

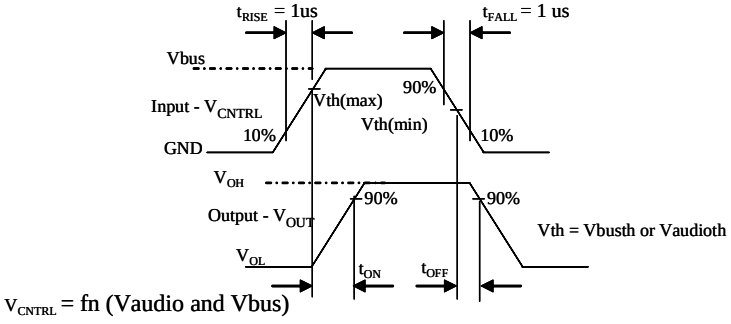


Figure 15. Turn-On / Turn-Off Waveforms (USB/Audio)

Test Diagrams (Continued)

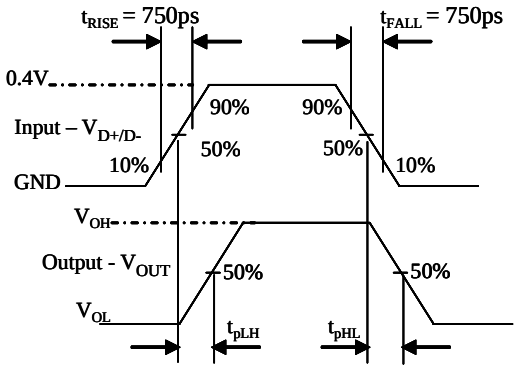


Figure 16. USB Switch Propagation Delay Waveforms

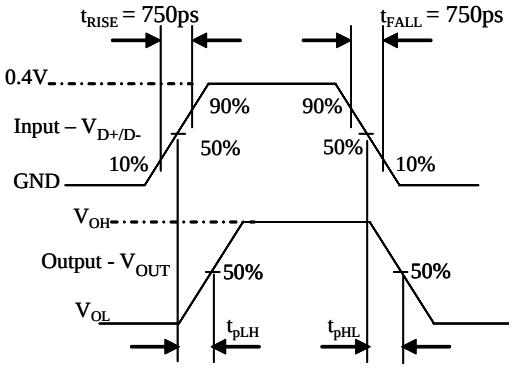


Figure 17. Pulse Skew: $t_{SK(P)} = | t_{PHL} - t_{PLH} |$

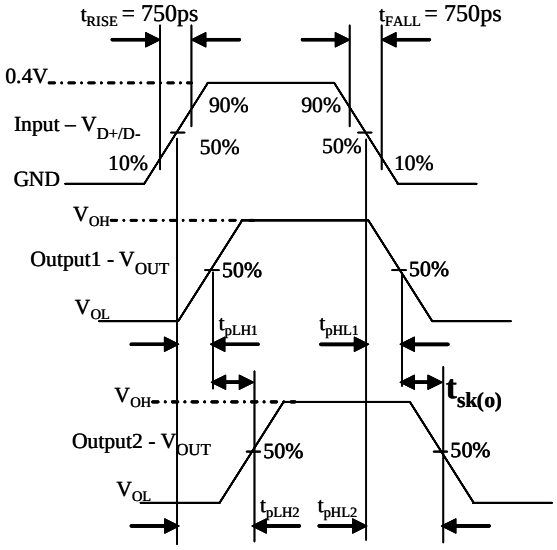


Figure 18. Output Skew: $t_{SK(O)} = | t_{PLH1} - t_{PLH2} |$ or $| t_{PHL1} - t_{PHL2} |$

Test Diagrams (Continued)

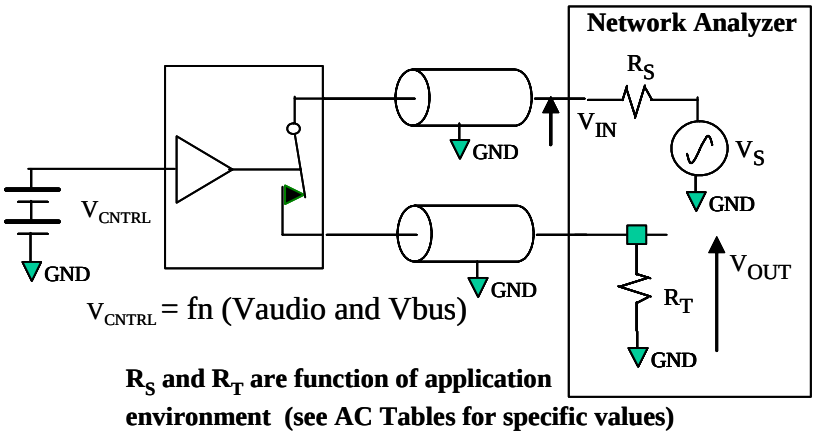


Figure 19. USB Bandwidth

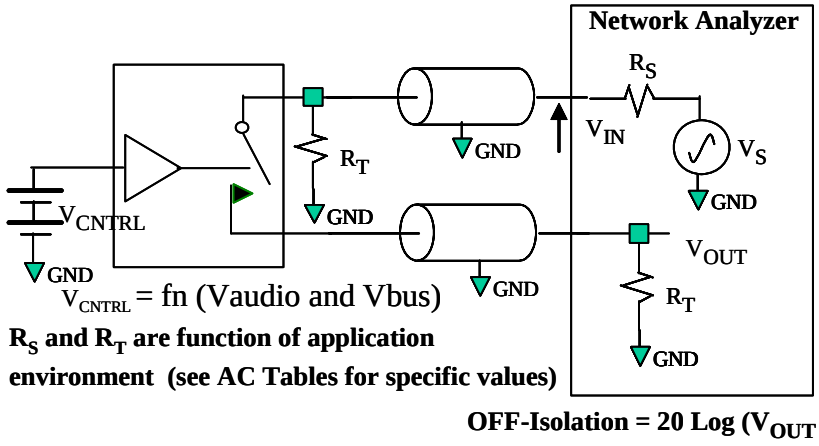


Figure 20. Channel OFF Isolation

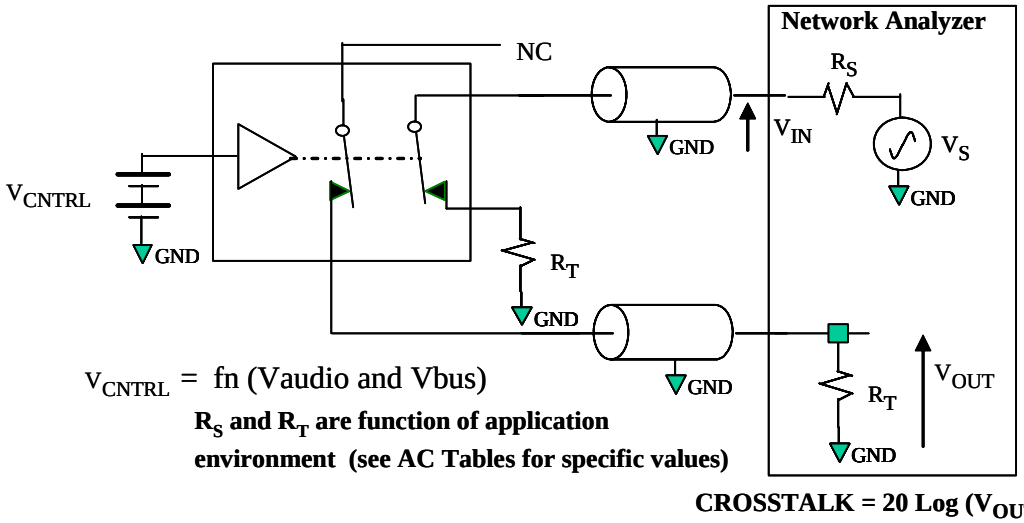


Figure 21. Non-Adjacent Channel-to-Channel Crosstalk

Test Diagrams (Continued)

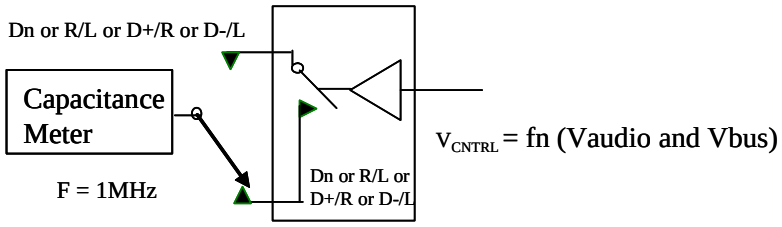


Figure 22. Channel OFF Capacitance

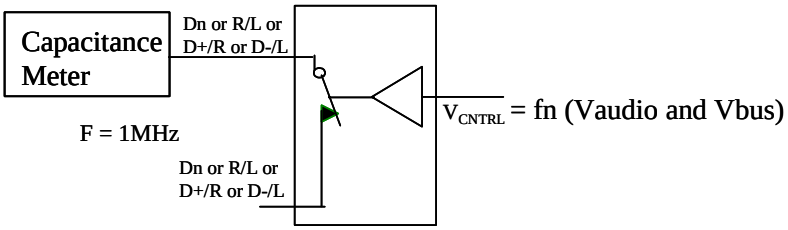
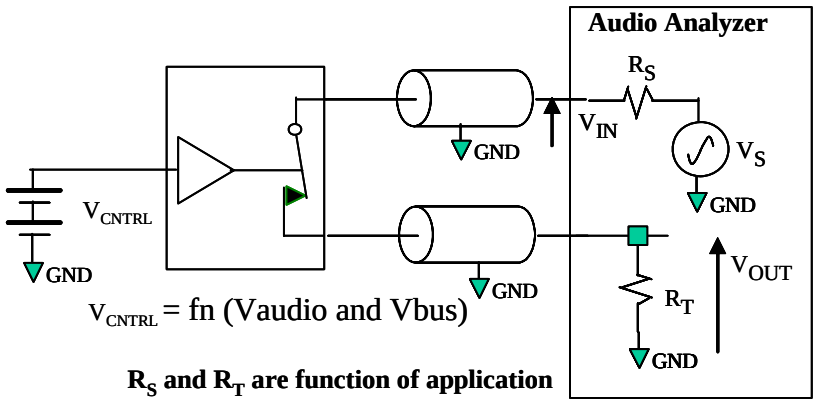


Figure 23. Channel ON Capacitance

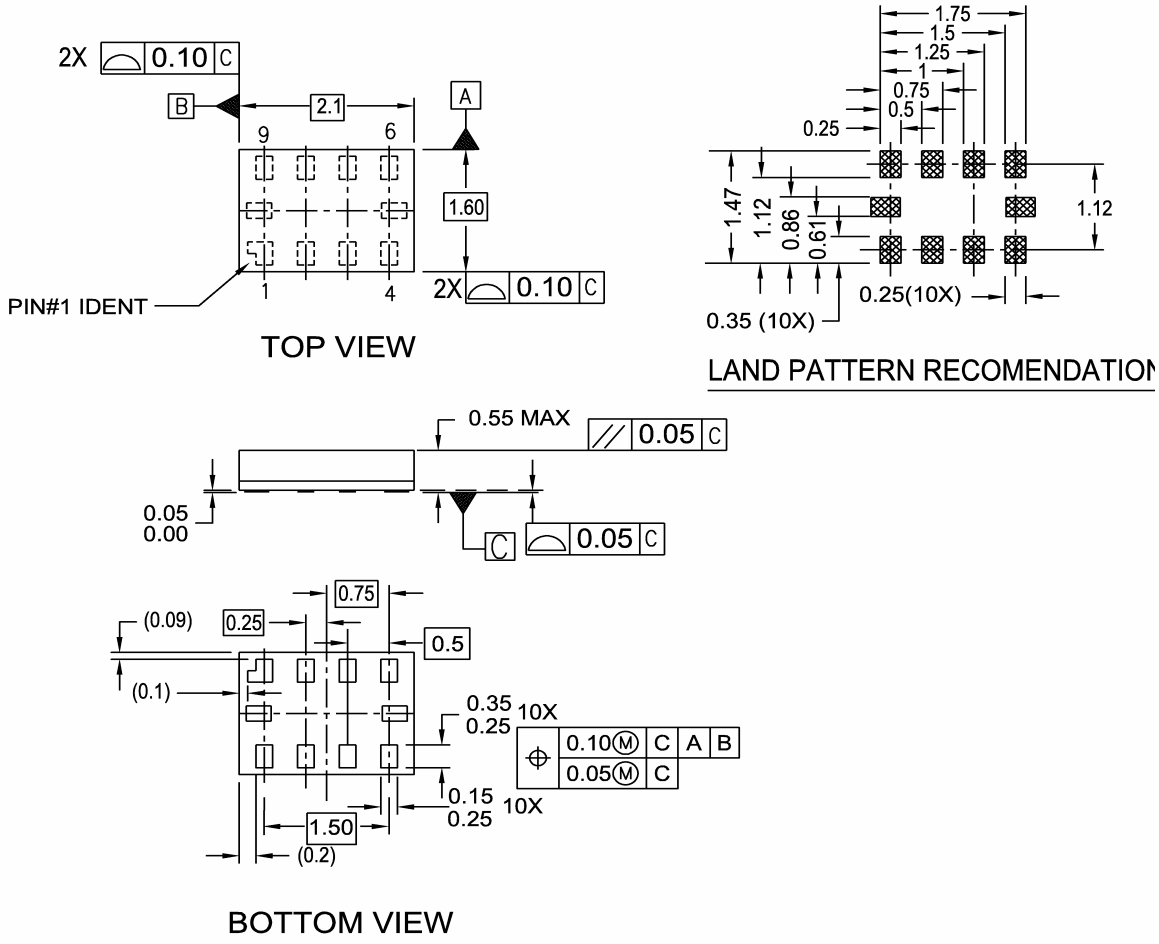


R_S and R_T are function of application environment (see AC Tables for specific values)

Figure 24. Total Harmonic Distortion

Physical Dimensions

Dimensions are in millimeters unless otherwise noted.



NOTES:

A. PACKAGE CONFORMS TO JEDEC MO255, VARIATION UABD

B. DIMENSIONS ARE IN MILLIMETERS.

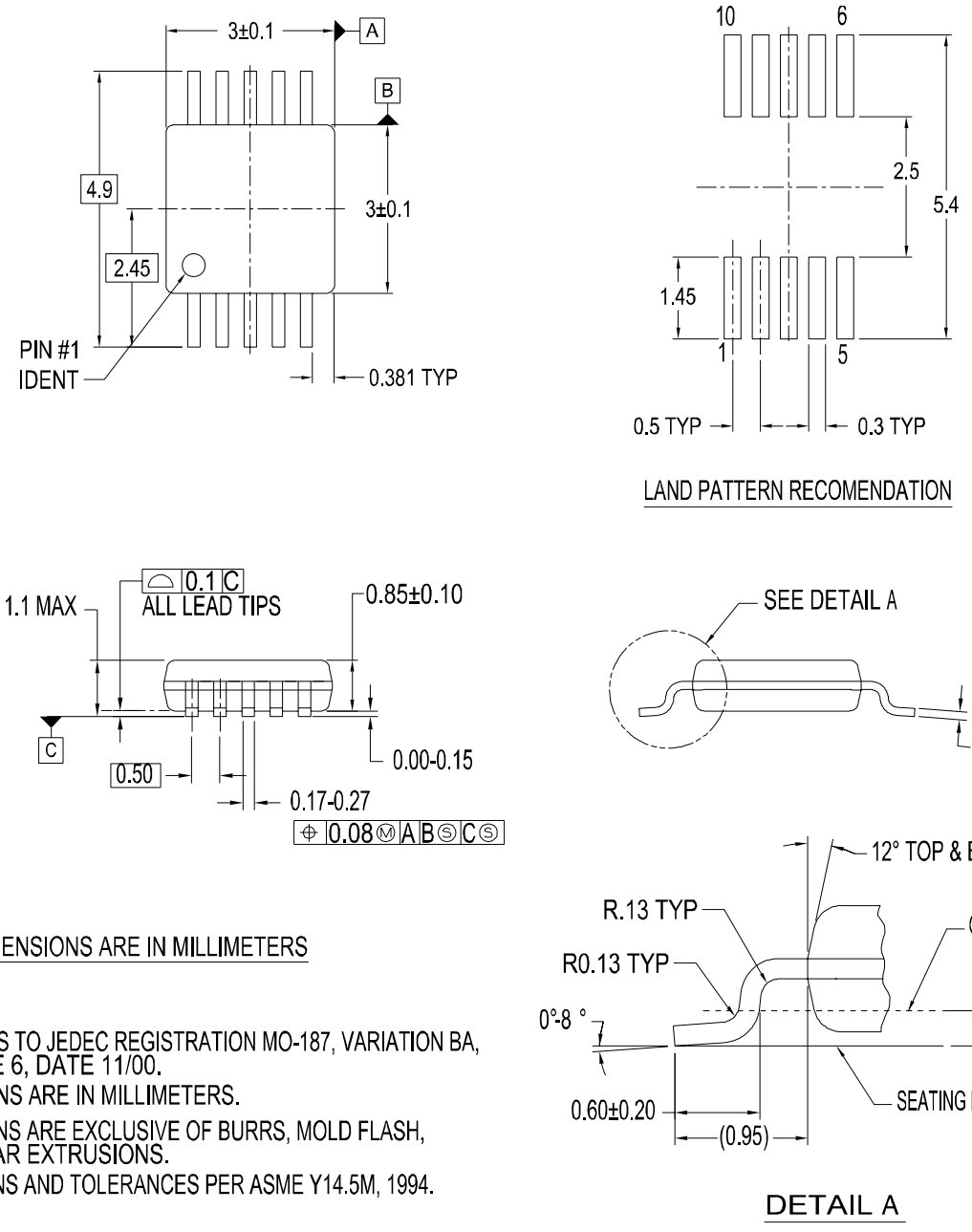
C. DIMENSIONS AND TOLERANCES CONFORMS TO ASME Y14.5M, 1994.

MAC010ARevB

Figure 25. 10-Lead MicroPak FSA221

Physical Dimensions

Dimensions are in millimeters unless otherwise noted.



DIMENSIONS ARE IN MILLIMETERS

NOTES:

A. CONFORMS TO JEDEC REGISTRATION MO-187, VARIATION BA, REF NOTE 6, DATE 11/00.

B. DIMENSIONS ARE IN MILLIMETERS.

C. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.

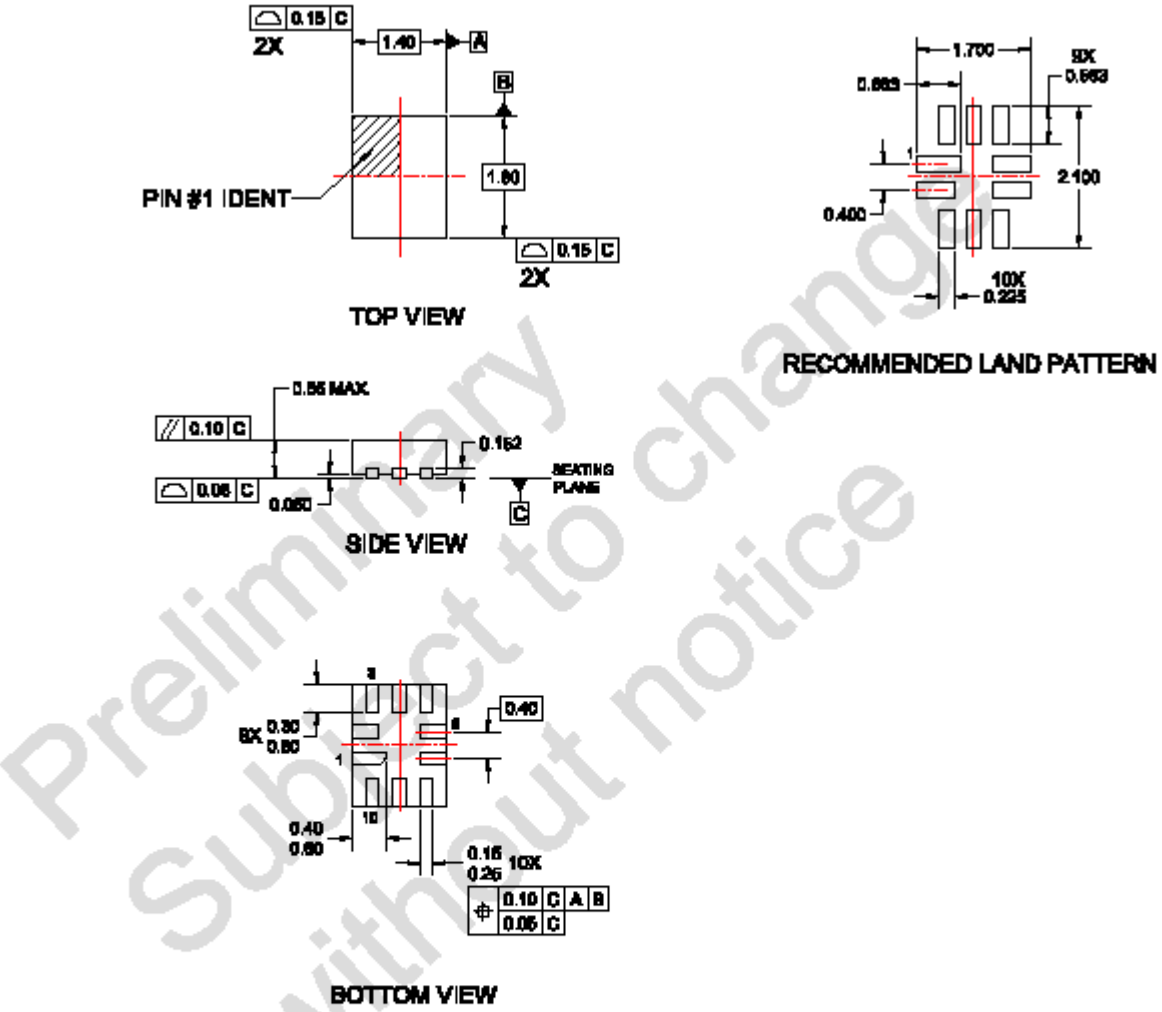
D. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994.

MUA10AREVA

Figure 26. 10-Lead MSOP FSA221 (Preliminary)

Physical Dimensions

Dimensions are in millimeters unless otherwise noted.



NOTES:

A. DIMENSIONS ARE IN MILLIMETERS.

B. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994

MLP10 XXXX

Figure 27. 10-Lead Quad Ultrathin FSA221 (Preliminary)

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EnSigna™	MICROCOUPLER™	QFET®	SyncFET™	VCX™
FACT®	MicroFET™	QS™	TCM™	Wire™
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FAST®	MICROWIRE™	Quiet Series™		
FASTr™	MSX™	RapidConfigure™	Across the board. Around the world.™	
FPS™	MSXPro™	RapidConnect™	Programmable Active Droop™	
FRFET™	OCX™	ScalarPump™	The Power Franchise®	

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Rev. I21