



# FSA2000

## Auto-Selecting HS-USB Switch with Cap-Free Headphone Audio Amplifier

### Features

Switch Type	USB + Headphone Amplifier
Switch Mechanism	Auto (USB with $V_{BUS}$ )
USB Detection	YES
USB	USB 2.0 High Speed & Full-Speed Compliant
Audio Amplifier	Class AB
Amplifier Output Power	40mW <sub>RMS</sub> (32Ω)
Amplifier Gain	0dB
THD+N	0.1%
SNR	-90dB
PSRR	-95dB
$V_{CC}$	2.7 to 4.3V
$I_{CC}$ (Audio)	3mA
$I_{CC}$ (USB)	6μA
Package	16- Lead UMLP 1.80 x 2.60 x 0.55mm, 0.40mm pitch
Ordering Information	FSA2000UMX

### Description

The FSA2000 is a low-cost integrated HS-USB and audio switch that incorporates an audio headphone amplifier. This solution eliminates many of the discrete parts currently used in stereo headset applications. It provides stereo headphone drivers designed to operate with a ground-centered output signal. This allows for the removal of large and expensive DC blocking capacitors. The headphone drivers are capable of driving up to 40mW<sub>RMS</sub> per channel.

### Related Resources

- [FSA2000 Demonstration Board](#)
- [FSA2000 Evaluation Board](#)
- [FDB323 — FSA2000 Demonstration Board User Guide](#)
- [FEB322 — FSA2000 Evaluation Board User Guide](#)
- [AN-8032 — Demonstration Board Quick-Start Guide](#)
- [AN-8031 — Utilizing the FSA2000 MUTE Function to Reduce Audio “Click” and “Pop”](#)
- For samples, questions, or board requests; please contact: [Analog.Switch@fairchildsemi.com](mailto:Analog.Switch@fairchildsemi.com).

### Applications

- MP3 Portable Media Players
- Cellular Phones, Smartphones

### Typical Application

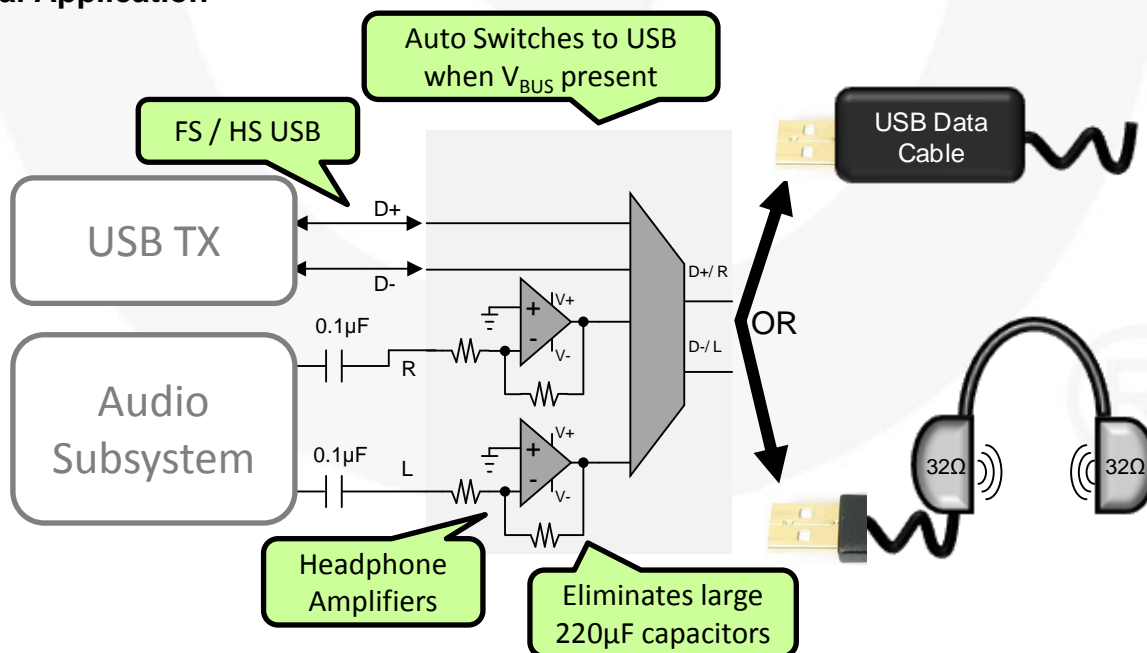


Figure 1. Mobile Phone Example

## Pin Descriptions

Pin #	Name	Type	Description
1	D+	I/O	USB D+ port from processor or transceiver
2	D-	I/O	USB D- port from processor or transceiver
3	R	Input	Right audio channel input
4	L	Input	Left audio channel input
5	V <sub>CC</sub>	Audio Supply	Supply voltage for audio amplifiers, charge pump, and audio control; not required for USB path
6	MUTE	Input	Control pin intended to be used temporarily to quiet transients on the audio path upon transition of /SHDN. Ground if not being used.
7	/SHDN	Input	Shutdown Enable (Requires V <sub>CC</sub> only)
8	GND	GND	IC ground
9	D-/L	I/O	Common USB/Audio Port; USB D- data to connector or left audio channel output
10	D+/R	I/O	Common USB/Audio Port; USB D+ data to connector or right audio channel output
11	V <sub>BUS</sub>	Input/Supply	USB input select pin and USB supply
12	V+	Node	Node for filtering internal positive amplifier rail; suggest 1μF to GND
13	V-	Input	Negative amplifier rail input; suggest 1μF to GND. Requires connection to CPO.
14	CPO	Output	Charge pump output used to drive V-, suggest 2.2 μF to GND for filtering.
15	CM	I/O	Charge pump negative flying capacitor pin; connect to CP via storage capacitor, typically 1μF.
16	CP	I/O	Charge pump positive flying capacitor pin; connect to CM via storage capacitor, typically 1μF.

## Pin Configuration

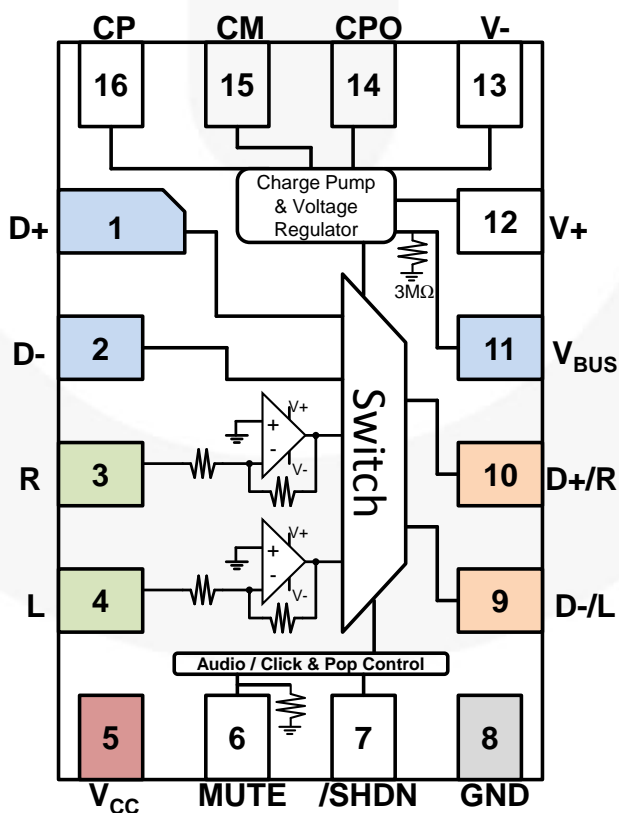


Figure 2. FSA2000UMX (Top View)

## Functional Diagram

Functional Mode	Power Down	Audio Power Down	Transient Suppression	Audio Mode	USB Mode
$V_{BUS}$	LOW	LOW	LOW	LOW	HIGH
$V_{CC}$	LOW	HIGH	HIGH	HIGH	X <sup>(1)</sup>
/SHDN	X <sup>(1)</sup>	LOW	HIGH	HIGH	X <sup>(1)</sup>
MUTE	X <sup>(1)</sup>	X <sup>(1)</sup>	HIGH	LOW	X <sup>(1)</sup>
Charge Pump	OFF	OFF	ON	ON	OFF
R/L Amplifiers	OFF	OFF	OFF	ON	OFF
D+/R, D-/L	HI-Z	HI-Z	D+/R, D-/L=0V	R/L	D+/D-
Figure 3 Label	A	B	C	D	E

### Notes:

- The (X) indicates "Don't Care" state.

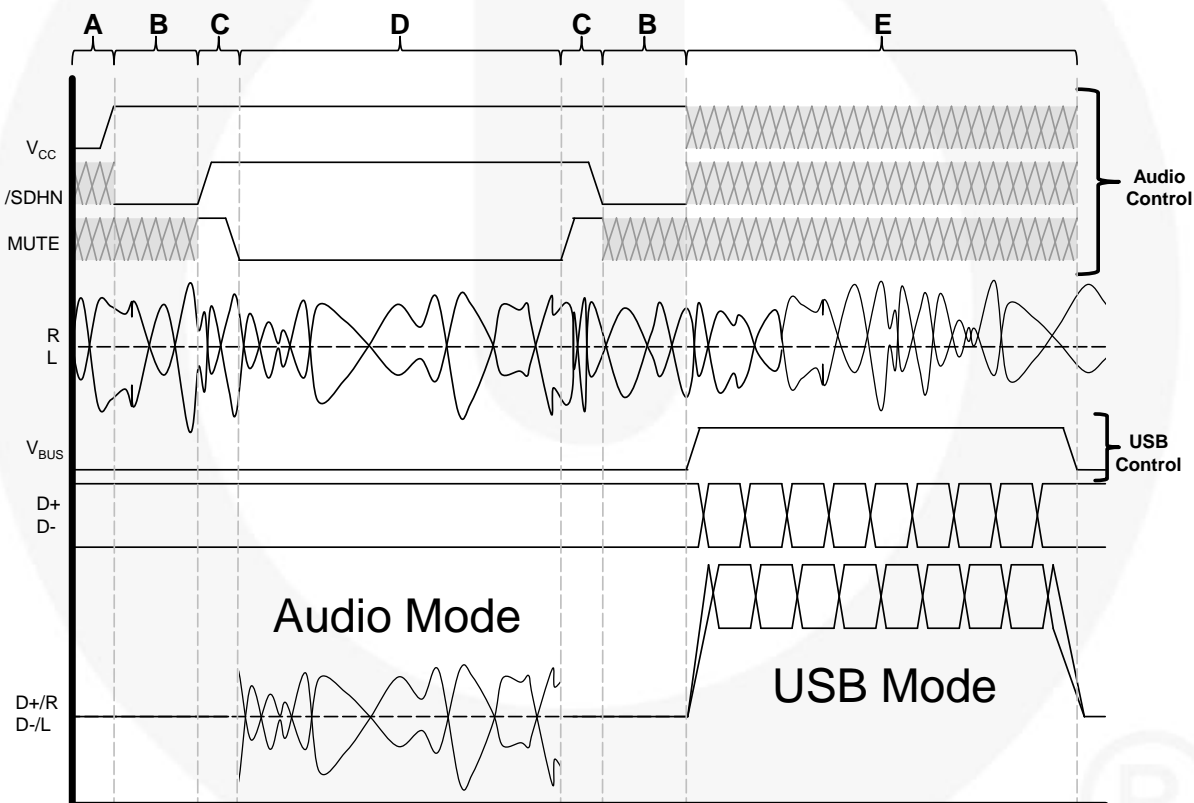


Figure 3. Functional Diagram

- Audio Power Down** – An active-LOW shutdown pin (/SHDN) allows the amplifiers to be placed in low-power (or shutdown) mode to conserve battery power. While the FSA2000 is in shutdown mode, USB data transfers are allowed whenever a USB cable is connected to a host ( $V_{BUS}$  is HIGH). The audio amplifiers are enabled and connected to the common port when /SHDN is HIGH and  $V_{BUS}$  is LOW.
- Transient Suppression** – The FSA2000 audio amplifier has a soft turn-on feature that suppresses click and pop on the audio path when the path is selected. In addition to the soft turn-on feature of the amplifier, the MUTE pin mutes the audio path when asserted HIGH. The mute functionality also has an internal pull-down that disables mute if the MUTE pin is floated. The MUTE pin allows control of the mute functionality by the application. Please refer to application note AN-8031, describing the recommended timing and control of MUTE for optimal performance.

## Functional Description

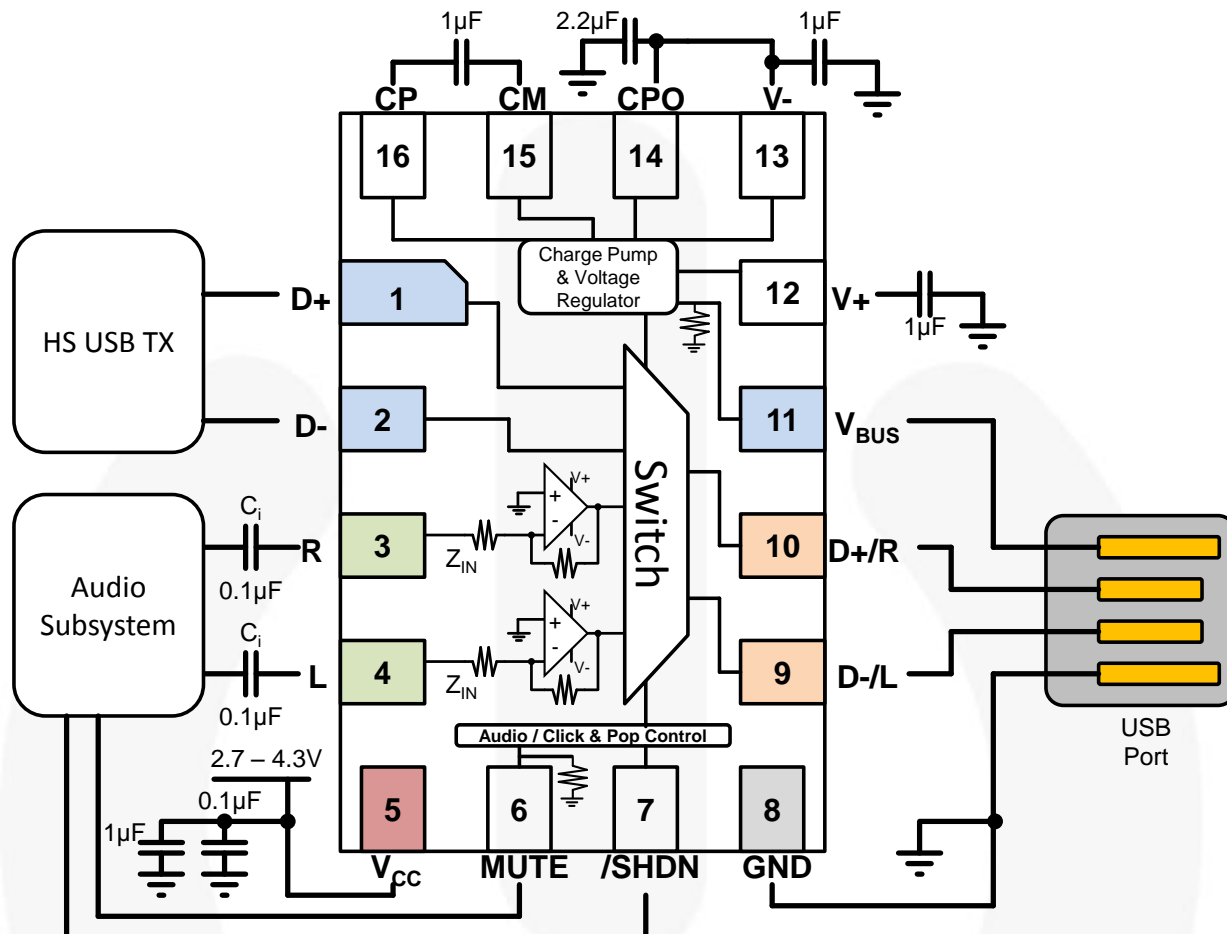


Figure 4. Micro-USB Application

## Application Guidelines

- **Device Placement** – Minimize to USB port & USB TX.
- **PIN 1, 2, 9, 10** – Minimize and match trace lengths for USB compliance.
- **PIN 3, 4** – Suggest 0.1µF capacitor as close to the device as possible for DC-blocking and setting low-frequency response of audio amplifier. The input capacitors combine with the input impedance of the amplifiers to form a high-pass filter. Equation 1 can be used to calculate the -3dB cut-off frequency of the high-pass filter for the given input capacitor value and the FSA2000 input impedance.

$$f_{-3dB} = \frac{1}{2\pi \cdot Z_{IN} C_i} \quad (1)$$

$$17.7Hz = \frac{1}{2\pi(90k\Omega)(0.1\mu F)} \quad (2)$$

- It is desirable to be below the 20Hz audio range. Users have flexibility to adjust capacitor for audio

performance in the system design. Equation 2 shows the cut-off frequency of the recommended guidelines.

- **PIN 5** – Use standard decoupling devices, 0.1µF & 1µF capacitors; as close to the device as possible.
- **PIN 8** – Minimize ground trace length between headphone connector and device; minimize ground path resistance.
- **PIN 12** – Suggested 0.1µF capacitor to GND for filtering; as close to the device as possible.
- **PIN 13, 14** – Use low-ESR (equivalent series resistance) ceramic capacitors for lowest charge pump impedance, which provides maximum output power of the audio amplifiers. Recommended to place the components as close as possible to the device.
- **PIN 15, 16** - The charge pump has been optimized for low-ESR ceramic capacitors for the flying capacitor between CP and CM, along with the output capacitors on V+, CPO, and V-. Optimized values for these capacitors are in Figure 4.

## Detailed Description

### USB Compliance

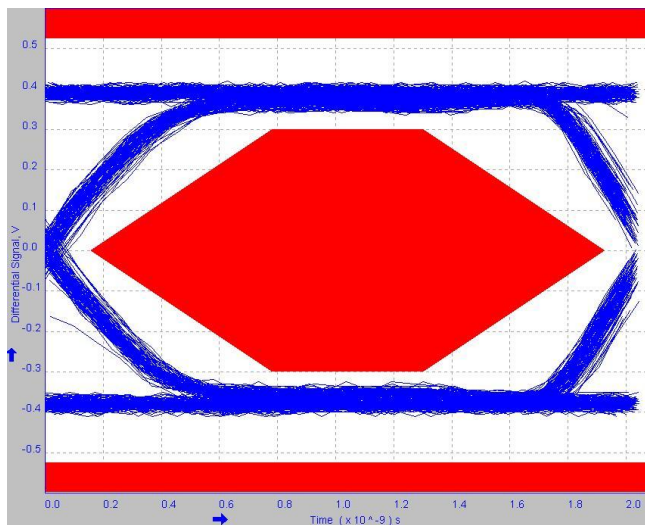


Figure 5. High-Speed USB 2.0 Eye Compliance (5.5V)

### Transient Suppression

A common issue with headphone amplifiers is audible noises through the headset when the amplifier is powering up or down. Sharp transients often occur on the audio outputs during this transition that cause audible “click and pop.” The FSA2000 prevents these transients during power-up by muting the outputs until the internal charge pumps are stable. This ensures that any transients caused by the charge pump are not propagated to the outputs. In cases where the application needs a longer startup time for mute, the FSA2000 has a MUTE pin that allows application control

over the behavior of the amplifier during startup and power down. The MUTE pin forces the audio outputs into a known and controlled state so that any transients of the amplifier are not propagated to the headphones as clicks and pops. Figure 6 shows the correct timing of the MUTE pin in relation to the /SHDN pin for optimal click and pop performance.

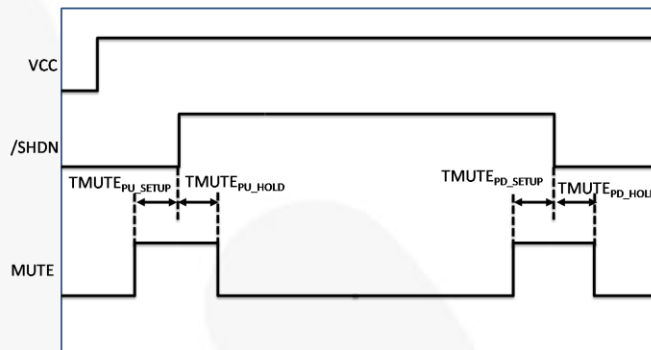


Figure 6. Power-Up and Power-Down Timing

Table 1. Recommended MUTE Timing

Parameter	Description	Suggested Timing
TMUTE <sub>PU_SETUP</sub>	MUTE setup time to /SHDN rising edge	≥500ns
TMUTE <sub>PU_HOLD</sub>	MUTE hold time to /SHDN rising edge	~500ns
TMUTE <sub>PD_SETUP</sub>	MUTE setup time to /SHDN falling edge	≥500ns
TMUTE <sub>PD_HOLD</sub>	MUTE hold time to /SHDN falling edge	~500ns

## 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
$V_{CC}$	Supply Voltage	Audio Mode		-0.3	+4.5	V
		USB Mode		-0.3	+6.0	
$V_{BUS}$	Supply Voltage			-0.3	+6.0	V
$V_{CNTRL}$	Control Pin Voltage - /SHDN, MUTE			-0.3	+6.0	V
$V_{SWUSB}$	USB I/O			$V_{BUS} - 6.0$	$V_{BUS} + 0.3$	V
$V_{SWAUDIO}$	Audio I/O			$V_{CC} - 6.0$	$V_{CC} + 0.3$	V
$I_{SW}$	Switch I/O Current (Continuous)				30	mA
$I_{PEAK}$	Peak Switch I/O Current (Pulsed, 1ms Duration, <10% Duty Cycle)				50	mA
$T_J$	Junction Temperature				+150	°C
$T_{STG}$	Storage Temperature Range			-65	+150	°C
$T_L$	Lead Temperature (Soldering, 10 seconds)				+240	°C
ESD	IEC 61000-4-2 System	USB Connector pins (D+/R, D-/L, $V_{BUS}$ )	Air Gap	15		kV
	JEDEC JESD22-A114, Human Body Model		D+/R, D-/L	4		
			All Other Pins	2		
			$V_{BUS}$	1		
	JEDEC JESD22-C101, Charged Device Model		All Pins	2		

## 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 these ratings or designing to Absolute Maximum Ratings.

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{BUS}$	USB Supply Voltage	4.0	5.0	5.5	V
$V_{CC}$	Supply Voltage	2.7	3.3	4.5	V
$V_{CNTRL}$	Control Voltage - /SHDN, MUTE	0		$V_{CC}$	V
$V_{SWUSB}$	D+/L, D-/R, D+, D- Input Range	0		$V_{BUS}$	V
$V_{SWAUDIO}$	L,R Audio Input Range	-2.5		$V_{CC}$	V
$V_{SWING}$	L,R Audio Input Amplitude			5	$V_{P-P}$
$T_A$	Temperature Range	-40	+25	+85	°C
$Z_{LOAD}$	Headset Load Impedance	16	32		$\Omega$
$\Theta_{JA}$	Package Thermal Resistance, JEDEC Standard Multi-Layer Boards, Still Air		40		°C/W

## DC Electrical Characteristics

$T_A = 25^\circ\text{C}$ ,  $V_{CC} = 3.0\text{V}$ , audio inputs at  $-6\text{dBV}$  and AC coupled with  $0.1\mu\text{F}$ , audio outputs DC coupled into  $32\Omega$  loads referenced to  $1\text{kHz}$ , unless otherwise noted.

Symbol	Parameter	$V_{CC}$ (V)	Conditions	$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			Unit
				Min.	Typ.	Max.	
<b>Common Pins</b>							
$V_{IH}$	/SHDN, MUTE, Control Input Voltage HIGH	2.7 to 4.5		1.65			V
$V_{IL}$	Control Input Voltage LOW	2.7 to 4.5				0.5	
$I_{IN}$	/SHDN, MUTE, Input HIGH Current	4.5	$V_{CNTRL} = 3.6\text{V}$	-1		10	$\mu\text{A}$
			$V_{CNTRL} = 0\text{V}$	-1		1	
$I_{OFF}$	Power Off Leakage Current	$V_{CC} = V_{BUS} = 0$	Common Port (D+/R, D-/L) $V_{SW} = 0\text{V}, 5.5\text{V}$			10	$\mu\text{A}$
$I_{NO(OFF)}$	Off-Leakage Current of Port D+, D-	3.6	D+/R, D-/L = $0.3\text{V}$ , $V_{CC} - 0.3\text{V}$ , D+, D- = $0.3\text{V}$ , $V_{CC} - 0.3\text{V}$ or Floating, /SHDN=0V, $V_{BUS}=0\text{V}$ , MUTE=0V, R/L=0V	-50	1	50	nA
$I_{NC(ON)}$	On-Leakage Current of Port D+/R or D-/L	3.6	D+/R, D-/L = $0.3\text{V}$ , $V_{CC} - 0.3\text{V}$ D+, D- = Floating $V_{BUS}=5.5\text{V}$ , /SHDN=0V, MUTE=0V, R/L=0V	-50	1	50	nA
$R_{PD}$	$V_{BUS}$ , MUTE, Internal Pull-Down Resistor				3.5		$\text{M}\Omega$
<b>USB Switch Path</b>							
	USB Analog Signal Range			0		3.6	V
$R_{ONUSB}$	HS Switch On Resistance <sup>(2)</sup>	$V_{BUS}=5$	$V_{D+/D-} = 0\text{V}, 0.4\text{V}$ , $I_{ON} = -8\text{mA}$		4.0	6.5	$\Omega$
$\Delta R_{ONUSB}$	HS Delta $R_{ON}$ <sup>(2,3)</sup>	$V_{BUS}=5$	$V_{D+/D-} = 0\text{V}$ , $I_{ON} = -8\text{mA}$		0.4		$\Omega$
<b>Audio Amplifier Path</b>							
$Z_{IN}$	Audio Amp Input Impedance <sup>(4)</sup>	3.0 to 4.5			90		k $\Omega$
<b>Power Supply</b>							
$I_{CC(Audio)}$	Quiescent Supply Current (Audio Mode)	4.5	$I_{OUT} = 0$ , /SHDN = $V_{CC}$ , MUTE=0V, D+/D-=0V		3	5	mA
$I_{CC(SHDN)}$	Quiescent Supply Current ( $V_{CC}$ ) in Shutdown Mode	4.5	$I_{OUT} = 0$ , /SHDN = 0V, MUTE=0V, D+/D-=0V		1	5	$\mu\text{A}$
$I_{CC(USB)}$	Quiescent Supply Current (USB Mode)	$V_{BUS}=5.5$	$I_{OUT}=0$ , MUTE=0V, /SHDN= $V_{BUS}$ , L/R=0V		6	10	$\mu\text{A}$

### Notes:

- On resistance is determined by the voltage drop between the D+/D- and D+/R,D-/L pins at the indicated current through the switch.
- $\Delta R_{ON} = R_{ON\_max} - R_{ON\_min}$  measured at identical  $V_{CC}$ , temperature, and voltage.
- Guaranteed by characterization, but not production tested.

## AC Electrical Characteristics

$T_A = 25^\circ\text{C}$ ,  $V_{CC} = 3.0\text{V}$ , audio inputs at  $-6\text{dBV}$  and AC coupled with  $0.1\mu\text{F}$ , audio outputs DC coupled into  $32\Omega$  loads referenced to  $1\text{kHz}$ , unless otherwise noted.

Symbol	Parameter	$V_{CC}$ (V)	Conditions	$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			Unit
				Min.	Typ.	Max.	
<b>Audio Amplifier Path</b>							
$t_{ONAUDIO}$	Turn-On Time /SHDN to Output	3.0 to 4.5	$V_{D+R, D-L} = 1.0\text{V}$ ; $C_L = 0\text{pF}$ ,			1	ms
$t_{OFFAUDIO}$	Turn-Off Time /SHDN to Output	3.0 to 4.5	$V_{D+R, D-L} = 1.0\text{V}$ ; $C_L = 0\text{pF}$			100	$\mu\text{s}$
$t_{MUTE\_ON}$	MUTE Turn-On Time	3.0 to 4.5			1		$\mu\text{s}$
$t_{MUTE\_OFF}$	MUTE Turn-Off Time	3.0 to 4.5			1		$\mu\text{s}$
$P_{out}$	Output Power <sup>(5)</sup>	2.7	THD <sub>N</sub> =1%, $V_{L,R}$ In Phase, $R_{LOAD}=32\Omega$ , 1KHz		25		$\text{mW}_{rms}$
		3.3			35		
		4.5			40		
$V_{OS}$	Output Offset Voltage		Inputs Grounded		5		mV
$A_V$	Amplifier Gain		Input = $-26\text{dBV}$ at $1\text{kHz}$ , $R_L=16\Omega$		0		dB
$A_{MATCH}$	Gain Matching of L & R Channels <sup>(5)</sup>		Input = $-26\text{dBV}$ , 20Hz to 20kHz			0.5	dB
$f_R$	Frequency Response <sup>(5)</sup>		20Hz to 20kHz referenced to $1\text{kHz}$	-1.5		1.5	dB
THD+N	Distortion <sup>(5)</sup>		$f=1\text{kHz}$ , $V_{sw}=50\text{mV}_{rms}$ , $R_L=64\Omega$		0.1		%
SNR	Signal to Noise Ratio <sup>(5)</sup>		A Weighted		-90		dB
$XTLK_{SPKR}$	Crosstalk between L & R Channel <sup>(5)</sup>		Input= $-26\text{dBV}$		-60		dB
<b>USB Switch Path</b>							
$t_{PDUSB}$	USB Switch Propagation Delay <sup>(5)</sup>	4.0 to 5.5	$R_L = 50\Omega$ ; $C_L = 0\text{pF}$		0.25		ns
$t_{ONUSB}$	Turn-On Time $V_{BUS}$ to Output	4.0 to 5.5	$V_{D+R, D-L} = 1.0\text{V}$ ; $R_L = 32\Omega$ ; $C_L = 0\text{pF}$ , /SHDN, $V_{CC}=0$			5.5	$\mu\text{s}$
$t_{OFFUSB}$	Turn-Off Time $V_{BUS}$ to Output	4.0 to 5.5	$V_{D+R, D-L} = 1.0\text{V}$ ; $R_L = 32\Omega$ ; $C_L = 0\text{pF}$ , /SHDN, $V_{CC}=0$			2	$\mu\text{s}$
BW	-3db Bandwidth – USB	4.0 to 5.5	$R_L=50\Omega$ , $C_L=0\text{pF}$ , Signal 0dBm		720		MHz
<b>Power Supply</b>							
$t_{SUPPLY}$	Power-Up Stabilization Time		$V+$ , $V-$ within 90% of Final Value			1	ms
$PSRR_{SPKR}$	Power Supply Noise Rejection at Common Output <sup>(5)</sup>		217Hz 12% Duty Cycle Square Wave 2.7V to 3.2V at $V_{CC}$ Output (D+/R) in $V_{rms}$ as Single Wideband Noise Measurement within 20Hz – 20kHz, A Weighted		-95		dB

### Note:

5. Guaranteed by characterization; not production tested.



## USB High-Speed-Related AC Electrical Characteristics

$T_A = 25^\circ\text{C}$  unless otherwise noted.

Symbol	Parameter	$V_{BUS}$ (V)	Conditions	$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			Unit
				Min.	Typ.	Max.	
$t_{SK(P)}$	Skew of Opposite Transitions of the Same Output <sup>(6)</sup>	4.0 to 5.5	$t_R = t_F = 750\text{ps}$ (10-90%) at 240MHz $C_L = 0\text{pF}$ , $R_L = 50\Omega$		35		ps
$t_J$	Total Jitter <sup>(6)</sup>	4.0 to 5.5	$R_L = 50\Omega$ , $C_L = 50\text{pF}$ , $t_R = t_F = 500\text{ps}$ (10-90%) at 480Mbps (PRBS = $2^{15} - 1$ )		130		ps

### Note:

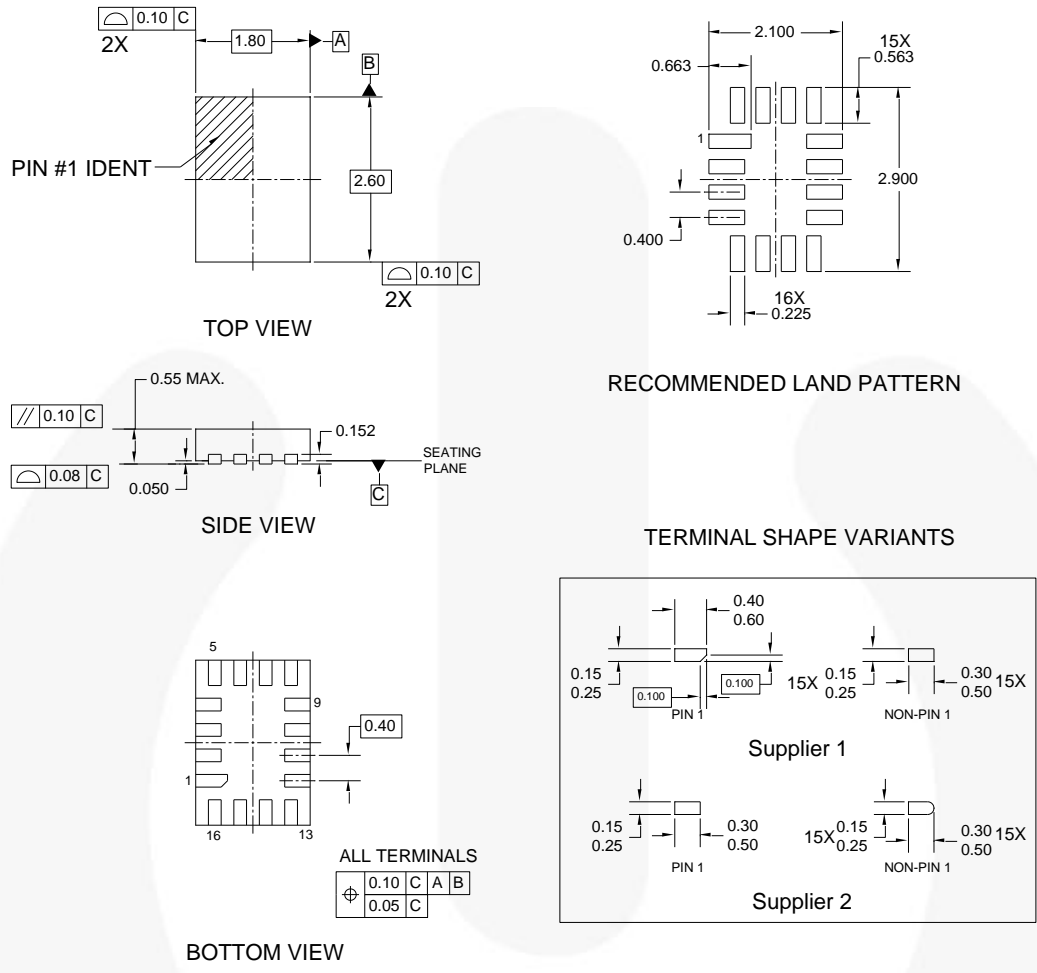
6. Guaranteed by characterization; not production tested.

## Capacitance

$T_A = 25^\circ\text{C}$  unless otherwise noted.

Symbol	Parameter	$V_{CC}$ / $V_{BUS}$ (V)	Conditions	$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			Unit
				Min.	Typ.	Max.	
$C_{IN}$	Control Pin Input Capacitance (/SHDN, MUTE)	$V_{CC} = 3.0, 4.5$	$V_{Bias} = 0.05\text{V}$		2.8		pF
$C_{ON\_USB}$	D+, D- (Source Port) On Capacitance	$V_{BUS} = 5.0$	$V_{Bias} = 0.2\text{V}$ , $f = 1\text{MHz}$ , $f = 240\text{MHz}$		8.8		pF
$C_{OFF\_USB}$	D+, D- (Source Port) Off Capacitance	$V_{BUS} = 5.0$	$f = 1\text{MHz}$		2.8		pF

### Physical Dimensions



- NOTES:**
- A. THIS PACKAGE IS NOT CURRENTLY REGISTERED WITH ANY STANDARDS COMMITTEE
  - B. DIMENSIONS ARE IN MILLIMETERS.
  - C. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994
  - D. TERMINAL SHAPE MAY VARY ACCORDING TO PACKAGE SUPPLIER, SEE TERMINAL SHAPE VARIANTS
  - E. LAND PATTERN IS A MINIMAL TOE DESIGN
  - F. DRAWING FILE NAME : UMLP16AREV3

**Figure 7. 16-Pin Ultrathin Molded Leadless Package (UMLP)**

Order Number	Operating Temperature Range	Package Description	Packing Method
FSA2000UMX	-40 to 85°C	16-Terminal Ultrathin Molded Leadless Package (UMLP)	Tape & Reel


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 SmartMax™  
 SMART START™  
 SPM®  
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 SuperFET™  
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 SuperSOT™-6  
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2. A critical component in any component of a life support, device, or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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**Definition of Terms**

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