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July 12, 2006 FN6240.3

Low Voltage, Dual SPDT, USB/Audio Switches with Negative Signal Capability

The Intersil ISL54400, ISL54401, ISL54402 dual SPDT (Single Pole/Double Throw) switches combine low distortion audio and accurate USB 2.0 full speed data signal switching in the same low voltage device. When operated with a 2.5V to 3.6V single supply these analog switches allow audio signal swings below-ground, allowing the use of a common USB and audio headphone connector in Personal Media Players and other portable battery powered devices.

The ISL54400 and ISL54401 incorporate circuitry for detection of the USB V_{BUS} voltage, which is used to switch between the audio and USB signal source in the portable device. In addition, the ISL54400 includes circuitry for generation of a V_{TERM} voltage of 3.3V for use with USB speed setting pull-up resistor.

The ISL54400, ISL54401, ISL54402 are available in 10 Ld 3mm x 3mm TDFN and 10 Ld tiny 2.1mm x 1.6mm ultra-thin μTQFN packages. They operate over a temperature range of -40 to +85°C.

Related Literature

- Application Note AN1255 “ISL5440XEVAL1Z Evaluation Board User’s Manual”
- Technical Brief TB363 “Guidelines for Handling and Processing Moisture Sensitive Surface Mount Devices (SMDs)”
- Application Note AN557 “Recommended Test Procedures for Analog Switches”

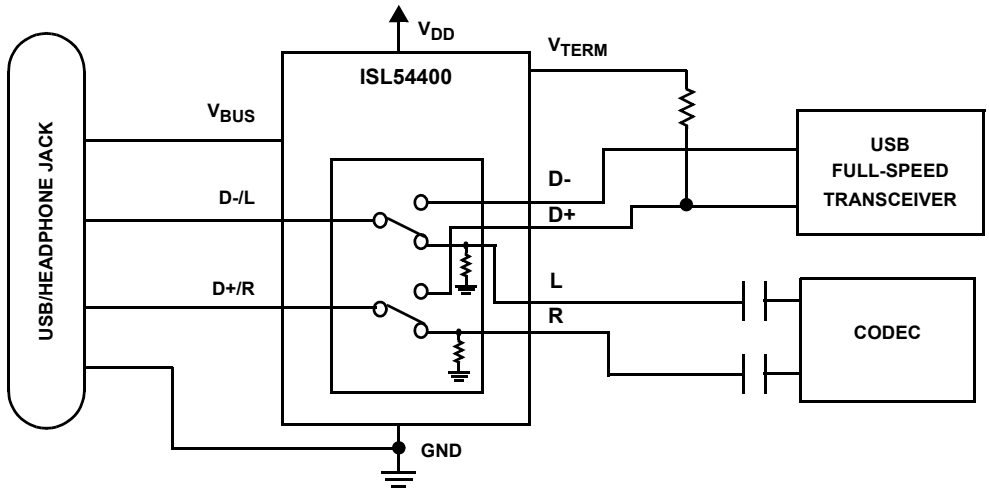
Features

- Low Distortion Negative Signal Capability
- Detection of V_{BUS} Voltage on USB Cable (ISL54400 and ISL54401)
- Generation of V_{TERM} Voltage for USB D+/D- Pull-up Resistor (ISL54400)
- Low Distortion Headphone Audio Signals
  - THD+N at 12mW into 32Ω Load . . . . . <0.007%
- Cross-talk (20Hz to 20kHz) . . . . . -110dB
- 1.8V Logic Compatible (ISL54402)
- Single Supply Operation (V_{DD})
  - ISL54400 and ISL54401 . . . . . 2.5V to 3.6V
  - ISL54402 . . . . . 1.8V to 5.5V
- Available in Ultra-thin μQFN and TDFN Packages
- Pb-Free Plus Anneal Available (RoHS Compliant)

Applications

- MP3 and other Personal Media Players
- Cellular/Mobile Phones
- PDA’s
- USB Switching
- Audio/USB Switching

Application Block Diagram



CAUTION: These devices are sensitive to electrostatic discharge; follow proper IC Handling Procedures.
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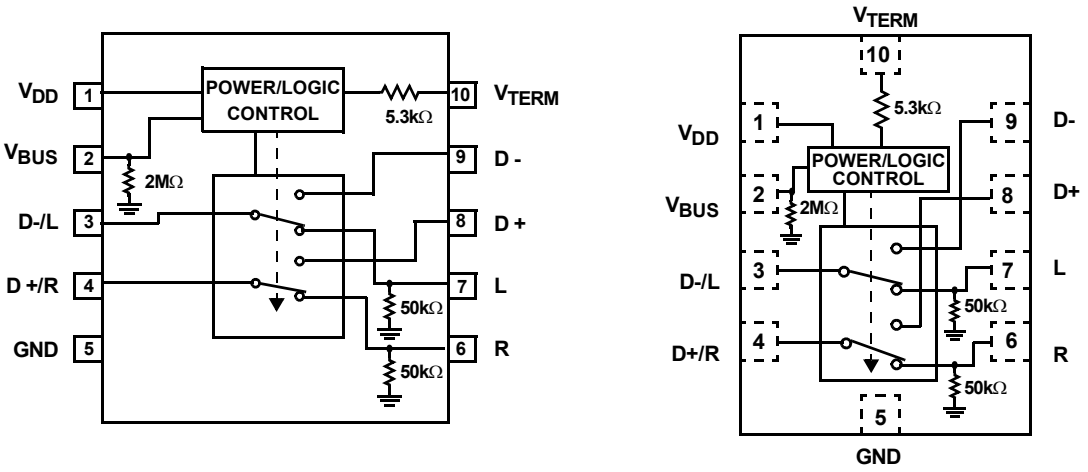
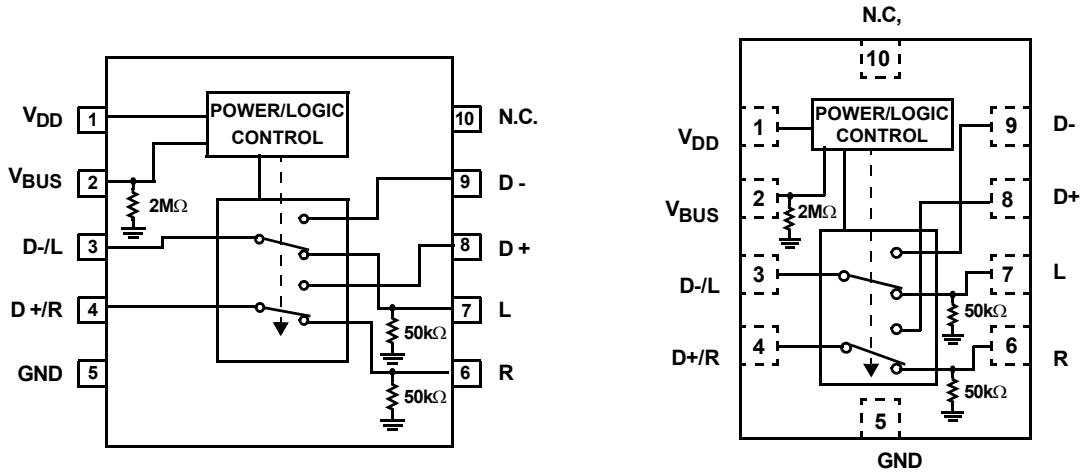
Pinouts (Note 1)

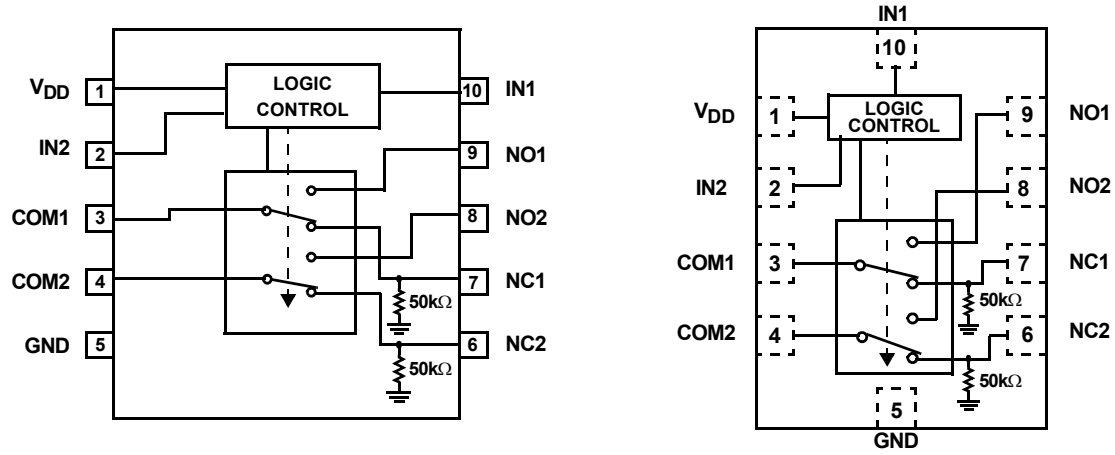
ISL54400 (TDFN, μTQFN)
TOP VIEW



ISL54401 (TDFN, μTQFN)
TOP VIEW



ISL54402 (TDFN, μTQFN)
TOP VIEW



NOTE:

1. ISL54400, ISL54401 Switches Shown for V_{BUS} not present (or idle). ISL54402 Switches Shown for Logic “0” Inputs.

Truth Table

ISL54401		
V_{BUS}	L, R	D+, D-
0	ON	OFF
1	OFF	ON

Logic “0” when ≤ V_{DD} + 0.2V, Logic “1” when ≥ V_{DD} + 0.8V

Truth Table

ISL54400				
V_{DD}	V_{BUS}	L, R	D+, D-	V_{TERM}
0	0	ON	OFF	Open
0	1	OFF	ON	Open
1	0	ON	OFF	Open
1	1	OFF	ON	3.3V to 4.0V

V_{DD}: Logic “0” when < 2.4V, Logic “1” when ≥ 2.5V
V_{BUS}: Logic “0” when ≤ V_{DD} + 0.2V, Logic “1” when ≥ V_{DD} + 0.8V

Truth Table

ISL54402		
IN	NCx	NOx
0	ON	OFF
1	OFF	ON

Logic “0” ≤ 0.5V. Logic “1” ≥ 1.4V, with V_{DD} between 2.7V and 3.6V

Pin Descriptions

	ISL54400		ISL54401		ISL54402	
NO.	NAME	FUNCTION	NAME	FUNCTION	NAME	FUNCTION
1	V_{DD}	Power Supply (Audio Switches) Control Input for V_{TERM}	V_{DD}	Power Supply (Audio Switches)	V_{DD}	System Power Supply Input
2	V_{BUS}	Digital Control Input Power Supply (USB Switches)	V_{BUS}	Digital Control Input Power Supply (USB Switches)	IN2	Digital Control Input
3	D-/L	Voice and Data Common Pin	D-/L	Voice and Data Common Pin	COM1	Common Pin
4	D+/R	Voice and Data Common Pin	D+/R	Voice and Data Common Pin	COM2	Common Pin
5	GND	Ground Connection	GND	Ground Connection	GND	Ground Connection
6	R	Audio Right Input	R	Audio Right Input	NC2	Normally Closed Pin
7	L	Audio Left Input	L	Audio Left Input	NC1	Normallly Closed Pin
8	D+	USB Differential Input	D+	USB Differential Input	NO2	Normally Open Pin
9	D-	USB Differential Input	D-	USB Differential Input	NO1	Normallly Open Pin
10	V_{TERM}	USB V_{TERM} Voltage, Outputs 3.3V to 4.0V when V_{BUS} = 4.4V to 5.25V and V_{DD} = logic “1” and connected to Upstream USB Termination.	N.C.	No Connect	IN1	Digital Control Input

Ordering Information

PART NUMBER (Note)	BRAND	TEMP. RANGE (°C)	PACKAGE (Pb-Free)	PKG. DWG. #
ISL54400IRZ	400Z	-40 to 85	10 Ld 3x3 Thin DFN	L10.3x3A
ISL54401IRZ	401Z	-40 to 85	10 Ld 3x3 Thin DFN	L10.3x3A
ISL54402IRZ	402Z	-40 to 85	10 Ld 3x3 Thin DFN	L10.3x3A
ISL54400IRZ-T	400Z	-40 to 85	10 Ld 3x3 Thin DFN Tape and Reel	L10.3x3A
ISL54401IRZ-T	401Z	-40 to 85	10 Ld 3x3 Thin DFN Tape and Reel	L10.3x3A
ISL54402IRZ-T	402Z	-40 to 85	10 Ld 3x3 Thin DFN Tape and Reel	L10.3x3A
ISL54400IRUZ-T	FA	-40 to 85	10 Ld 2.1 x 1.6mm μTQFN Tape and Reel	L10.2.1x1.6A
ISL54401IRUZ-T	FB	-40 to 85	10 Ld 2.1 x 1.6mm μTQFN Tape and Reel	L10.2.1x1.6A
ISL54402IRUZ-T	FC	-40 to 85	10 Ld 2.1 x 1.6mm μTQFN Tape and Reel	L10.2.1x1.6A
ISL54400EVAL1Z	-	-40 to 85	ISL54400 Evaluation Kit	-
ISL54401EVAL1Z	-	-40 to 85	ISL54401 Evaluation Kit	-
ISL54402EVAL1Z	-	-40 to 85	ISL54402 Evaluation Kit	-

NOTE: Intersil Pb-free plus anneal products employ special Pb-free material sets; molding compounds/die attach materials and 100% matte tin plate or NiPdAu termination finish, which are RoHS compliant and compatible with both SnPb and Pb-free soldering operations. Intersil Pb-free products are MSL classified at Pb-free peak reflow temperatures that meet or exceed the Pb-free requirements of IPC/JEDEC J STD-020.

Absolute Maximum Ratings

V_{DD} to GND . . . . . -0.3 to 6.0V
V_{BUS} to GND . . . . . -0.3 to 6.0V
Input Voltages
NOx, NCx, L, R (Note 2) . . . . . - 2V to ((V_{DD}) + 0.3V)
D+, D- (Note 2) . . . . . -2V to ((V_{BUS}) + 0.3V)
INx (Note 2) . . . . . -0.3 to ((V_{DD}) + 0.3V)
Output Voltages (ISL54400 and ISL54401)
D-/L, D+/R (Note 2) Audio Mode . . . . . -2V to ((V_{DD}) + 0.3V)
D-/L, D+/R (Note 2) USB Mode . . . . . -2V to ((V_{BUS}) + 0.3V)
Output Voltages (ISL54402)
COMx (Note 2) . . . . . -2V to ((V_{DD}) + 0.3V)
Continuous Current (L, R, NCx, or COMx) . . . . . ±300mA
Peak Current (L, R, NCx, or COMx)
(Pulsed 1ms, 10% Duty Cycle, Max) . . . . . ±500mA
Continuous Current (D+, D-, NOx) . . . . . ±40mA
Peak Current (D+, D-, NOx)
(Pulsed 1ms, 10% Duty Cycle, Max) . . . . . ±100mA
ESD Rating:
HBM COMx, D-/L, D+/R, V_{BUS} . . . . . >4kV
HBM All Other Pins . . . . . >4kV
MM COMx, D-/L, D+/R, V_{BUS} . . . . . >500V
MM All Other Pins . . . . . >300V
CDM (TDFN) . . . . . >1kV

Thermal Information

Thermal Resistance (Typical, Note 3)	θ_{JA} (°C/W)
10 Ld 3x3 TDFN Package	80
10 Ld μQFN Package	96

Maximum Junction Temperature (Plastic Package) . . . . . 150°C
Maximum Storage Temperature Range . . . . . -65°C to 150°C

Operating Conditions

Temperature Range
ISL5440XIR and ISL5440XIRU . . . . . -40°C to 85°C

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTES:

2. Signals on D+, D-, L, R, D-/L, D+/R, V_{BUS}, NOx, NCx, COMx, INx, exceeding V_{DD} or GND by specified amount are clamped. Limit forward current through clamp to maximum current ratings.
3. θ_{JA} is measured with the component mounted on a high effective thermal conductivity test board in free air. See Tech Brief TB379 for details.

Electrical Specifications - 2.7V to 5.5V Supply

Test Conditions: V_{DD} = +3.0V, GND = 0V, V_{BUSH} = 3.8V, V_{BUSL} = 3.2V, V_{INH} = 1.4V, V_{INL} = 0.5V (Notes 4, 6), Unless Otherwise Specified

PARAMETER	TEST CONDITIONS	TEMP (°C)	(NOTE 5) MIN	TYP	(NOTE 5) MAX	UNITS
ANALOG SWITCH CHARACTERISTICS						
Audio Switches (L, R, NC1, NC2)						
Analog Signal Range, V_{ANALOG}		Full	-1.5	-	1.5	V
R_{ON} Matching Between Channels, ΔR_{ON}	V_{DD} = 3.0V, V_{BUS} = 3.2V or V_{IN} = 0.5V, I_{COM} = 40mA, V_L or V_R or V_{NCx} = Voltage at max R_{ON} over signal range of -0.85V to 0.85V, (Note 9)	25	-	0.02	0.12	Ω
		Full	-	-	0.15	Ω
R_{ON} Flatness, $R_{FLAT(ON)}$	V_{DD} = 3.0V, V_{BUS} = 3.2V or V_{IN} = 0.5V, I_{COM} = 40mA, V_L or V_R or V_{NCx} = -0.85V to 0.85V, (Note 7)	25	-	0.002	0.08	Ω
		Full	-	-	0.09	Ω
Discharge Pull-down Resistance, R_L, R_R	V_{DD} = 3.6V, V_{BUS} = 0V or V_{IN} = 0.5V, $V_{D-/L}$ or $V_{D+/R}$ or V_{COM} = -0.85V, 0.85V, V_L or V_R or V_{NCx} = -0.85V, 0.85V, V_{D+} and V_{D-} = floating, Measure current through the discharge pull-down resistor and calculate resistance value.	25	30	50	70	kΩ
USB Switches (D+, D-, NO1, NO2)						
Analog Signal Range, V_{ANALOG}		Full	-1.5	-	V_{BUS}	V
ON Resistance, R_{ON} , (ISL54400 and ISL54401 Only)	V_{DD} = 3.6V, V_{BUS} = 4.4V, I_{COM} = 40mA, V_{D+} or V_{D-} = 0V to V_{BUS}, (See Figure 3)	25	-	5	6	Ω
		Full	-	-	6.5	Ω
R_{ON} Matching Between Channels, ΔR_{ON} , (ISL54400 and ISL54401 Only)	V_{DD} = 3.6V, V_{BUS} = 4.4V, I_{COM} = 40mA, V_{D+} or V_{D-} = Voltage at max R_{ON}, (Note 9)	25	-	0.2	0.4	Ω
		Full	-	-	0.45	Ω

Electrical Specifications - 2.7V to 5.5V Supply Test Conditions: V_{DD} = +3.0V, GND = 0V, V_{BUSH} = 3.8V, V_{BUSL} = 3.2V, V_{INH} = 1.4V, V_{INL} = 0.5V (Notes 4, 6), Unless Otherwise Specified **(Continued)**

PARAMETER	TEST CONDITIONS	TEMP (°C)	(NOTE 5) MIN	TYP	(NOTE 5) MAX	UNITS
R_{ON} Flatness, $R_{FLAT(ON)}$, (ISL54400 and ISL54401 Only)	V_{DD} = 3.6V, V_{BUS} = 4.4V, I_{COM} = 40mA, V_{D+} or V_{D-} = 0V to V_{BUS}, (Note 7)	25	-	0.8	1.9	Ω
		Full	-	-	2.5	Ω
ON Resistance, R_{ON} (ISL54402 Only)	V_{DD} = 3.0V, V_{INx} = 1.4V, I_{COM} = 40mA, V_{NOx} = 0V to 3.0V, (See Figure 3)	25	-	7.5	9	Ω
		Full	-	-	9.5	Ω
R_{ON} Matching Between Channels, ΔR_{ON} (ISL54402 Only)	V_{DD} = 3.0V, V_{INx} = 1.4V, I_{COM} = 40mA, V_{NOx} = Voltage at max R_{ON}, (Note 9)	25	-	0.2	0.4	Ω
		Full	-	-	0.45	Ω
R_{ON} Flatness, $R_{FLAT(ON)}$ (ISL54402 Only)	V_{DD} = 3.0V, V_{IN} = 1.4V, I_{COM} = 40mA, V_{NOx} = 0V to 3.0V, (Note 7)	25	-	0.8	1.9	Ω
		Full	-	-	2.5	Ω
OFF Leakage Current, $I_{D+(OFF)}$ or $I_{D-(OFF)}$, $I_{NOx(OFF)}$	V_{DD} = 3.6V, V_{BUS} = 0V or V_{IN} = 0.5V, $V_{D-/L}$ or $V_{D+/R}$ or V_{COM} = 0.5V, 0V, V_{D+} or V_{D-} or V_{NOx} = 0V, 0.5V, V_L and V_R = floating	25	-5	1.5	5	µA
		Full	-15	-	15	µA
ON Leakage Current, I_{ON}	V_{DD} = 3.6V, V_{BUS} = 5.25V or V_{IN} = 1.4V, $V_{D-/L}$ or $V_{D+/R}$ or V_{COM} = 0.3V, 3.6V, V_{D+} or V_{D-} or V_{NOx} = 0.3V, 3.6V, V_L and V_R = floating	25	-30	5	30	µA
		Full	-35	-	35	µA
DYNAMIC CHARACTERISTICS						
Turn-ON Time, t_{ON} (ISL54402 Only)	V_{DD} = 2.7V, V_{NO} or V_{NC} = 1.5V, R_L = 300Ω, C_L = 35pF, (See Figure 1)	25	-	40	-	ns
		Full	-	60	-	ns
Turn-OFF Time, t_{OFF} (ISL54402 Only)	V_{DD} = 2.7V, V_{NO} or V_{NC} = 1.5V, R_L = 300Ω, C_L = 35pF, (See Figure 1)	25	-	20	-	ns
		Full	-	40	-	ns
Break-Before-Make Time Delay, t_D (ISL54402 Only)	V_{DD} = 3.3V, V_{NO} or V_{NC} = 1.5V, R_L = 300Ω, C_L = 35pF, (See Figure 2)	Full	-	8	-	ns
Skew, t_{SKEW}	V_{DD} = 3.0V, V_{BUS} = 3.8V, R_L = 39Ω, C_L = 50pF, t_R = t_F = 12ns at 12Mbps, (Duty Cycle = 50%) (See Figure 7)	25	-	0.15	-	ns
Rise/Fall Time Mismatch, t_M	V_{DD} = 3.0V, V_{BUS} = 3.8V, R_L = 39Ω, C_L = 50pF, t_R = t_F = 12ns at 12Mbps, (Duty Cycle = 50%), (See Figure 6)	25	-	10	-	%
Total Jitter, t_J	V_{DD} = 3.0V, V_{BUS} = 3.8V, R_L = 39Ω, C_L = 50pF, t_R = t_F = 12ns at 12Mbps	25	-	1.6	-	ns
Propagation Delay, t_{PD}	V_{DD} = 3.0V, V_{BUS} = 3.8V, R_L = 39Ω, C_L = 50pF, (See Figure 7)	25	-	0.9	-	ns
Crosstalk (Channel-to-Channel), R to D-/L, L to D+/R, NC2 to COM1, NC1 to COM2	R_L = 32Ω, f = 20Hz to 20kHz, V_R or V_L = 1.75V_{P-P}, (See Figure 4)	25	-	-110	-	dB
Total Harmonic Distortion	f = 20Hz to 20kHz, V_{DD} = 3.0V, V_{BUS} = 3.2V or V_{IN} = 0.5V, V_L or V_R or V_{NCx} = 0.60V_{RMS}, R_L = 32Ω	25	-	0.007	-	%
Audio (NC) Switch -3dB Bandwidth	Signal = 8dBm, R_L = 50Ω, C_L = 5pF	25	-	394	-	MHz
USB (NO) Switch -3dB Bandwidth	Signal = 18dBm, 1VDC offset, R_L = 50Ω, C_L = 5pF	25	-	239	-	MHz
D+/D- OFF Capacitance, C_{D+OFF}, C_{D-OFF}, C_{NOxOFF}	f = 1MHz, V_{DD} = 3.0V, V_{BUS} = 3.2V or V_{IN} = 0.5V, V_{NO} or V_{NC} = V_{COM} = 0V, (See Figure 5)	25	-	10	-	pF
L/R OFF Capacitance, C_{LOFF}, C_{ROFF}, C_{NCxOFF}	f = 1MHz, V_{DD} = 3.0V, V_{BUS} = 3.8V or V_{IN} = 1.4V, V_{NO} or V_{NC} = V_{COM} = 0V, (See Figure 5)	25	-	13	-	pF
COM ON Capacitance, $C_{D-/L(ON)}$, $C_{D+/R(ON)}$, $C_{COMx(ON)}$	f = 1MHz, V_{DD} = 3.0V, V_{BUS} = 3.8V or V_{IN} = 1.4V, V_{NO} or V_{NC} = V_{COM} = 0V, (See Figure 5)	25	-	46	-	pF

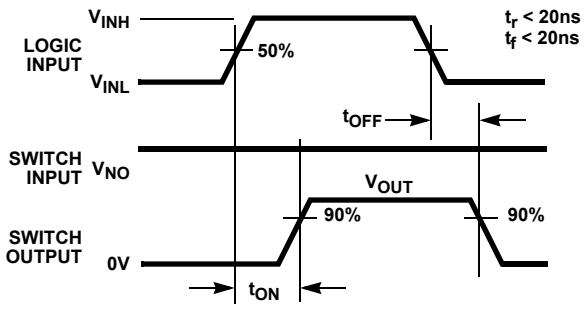
Electrical Specifications - 2.7V to 5.5V Supply Test Conditions: V_{DD} = +3.0V, GND = 0V, V_{BUSH} = 3.8V, V_{BUSL} = 3.2V, V_{INH} = 1.4V, V_{INL} = 0.5V (Notes 4, 6), Unless Otherwise Specified **(Continued)**

PARAMETER	TEST CONDITIONS	TEMP (°C)	(NOTE 5) MIN	TYP	(NOTE 5) MAX	UNITS
POWER SUPPLY CHARACTERISTICS						
Power Supply Range, V_{DD} (ISL54400 and ISL54401 only)		Full	2.5	-	3.6	V
Power Supply Range, V_{DD} (ISL54402 Only)		Full	1.8	-	5.5	V
Positive Supply Current, I_{DD} Audio Mode (ISL54400 and ISL54401 only)	V_{DD} = 3.6V, V_{BUS} = Float	25	-	4.5	8	µA
		Full	-	-	10	µA
Positive Supply Current, I_{BUS} USB Mode (ISL54400 and ISL54401 only)	V_{DD} = 3.6V, V_{BUS} = 5.25V	25	-	3.5	8	µA
		Full	-	-	25	µA
Positive Supply Current, I_{DD} (ISL54402 Only)	V_{DD} = 5.5V, V_{IN} = 0V	25	-	8	11	µA
		Full	-	-	15	µA
Positive Supply Current, I_{DD} (ISL54402 Only)	V_{DD} = 5.5V, V_{IN} = 5.5V	25	-	0.06	0.5	µA
		Full	-	-	1	µA
Positive Supply Current, I_{DD} (ISL54402 Only)	V_{DD} = 5.5V, V_{IN} = 2.85V	25	-	5.5	8	µA
		Full	-	-	10	µA
V_{TERM} Voltage, V_{VTERM} (ISL54400 Only)	V_{DD} = 2.5V, V_{BUS} = 4.4V, R_{TERM} = 16.5kΩ to Ground	25	3.0V	-	3.6V	V
V_{TERM} Voltage, V_{VTERM} (ISL54400 Only)	V_{DD} = 2.0V, V_{BUS} = 4.4V	25	-1.4	-	0.5	V
DIGITAL INPUT CHARACTERISTICS						
V_{BUS} Voltage Low, V_{BUSL} (ISL54400 and ISL54401 Only)		Full	-	-	V_{DD} + 0.2	V
V_{BUS} Voltage High, V_{BUSH} (ISL54400 and ISL54401 Only)		Full	V_{DD} + 0.8	-	-	V
Input Voltage Low, V_{INL} (ISL54402 Only)	V_{DD} = 2.7V to 3.6V	Full	-	-	0.5	V
Input Voltage High, V_{INH} (ISL54402 Only)	V_{DD} = 2.7V to 3.6V	Full	1.4	-	-	V
Input Voltage Low, V_{INL} (ISL54402 Only)	V_{DD} = 5.0V	Full	-	-	0.8	V
Input Voltage High, V_{INH} (ISL54402 Only)	V_{DD} = 5.0V	Full	2.3	-	-	V
Input Current, I_{INH}, I_{INL} (ISL54402 Only)	V_{DD} = 5.5V, V_{IN} = 0V or V_{DD}	Full	-	0.1	-	µA

NOTES:

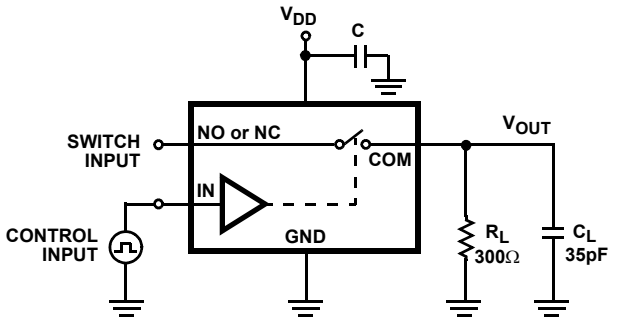
4. V_{IN} = input voltage to perform proper function.
5. The algebraic convention, whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
6. Parts are 100% tested at +25°C**.** Limits across the full temperature range are guaranteed by design and correlation.
7. Flatness is defined as the difference between maximum and minimum value of on-resistance over the specified analog signal range.
8. Guaranteed by design.
9. R_{ON} matching between channels is calculated by subtracting the channel with the highest max R_{ON} value from the channel with lowest max R_{ON} value, between L and R, between NC1 and NC2 or between D+ and D-, or between NO1 and NO2.

Test Circuits and Waveforms



Logic input waveform is inverted for switches that have the opposite logic sense.

FIGURE 1A. MEASUREMENT POINTS



Repeat test for all switches. C_L includes fixture and stray capacitance.

$$V_{OUT} = V_{(NO\ or\ NC)} \frac{R_L}{R_L + R_{(ON)}}$$

FIGURE 1B. TEST CIRCUIT

FIGURE 1. SWITCHING TIMES (ISL54402 ONLY)

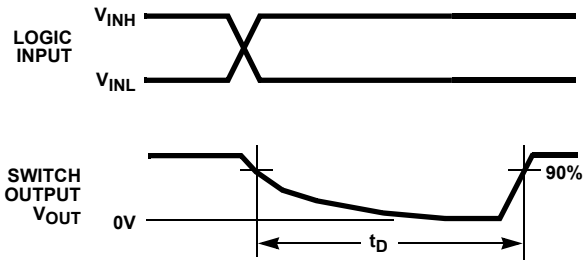
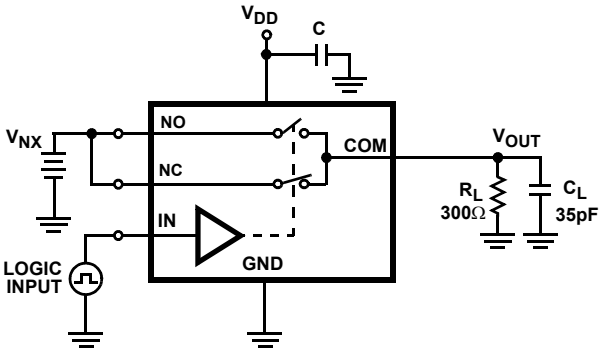


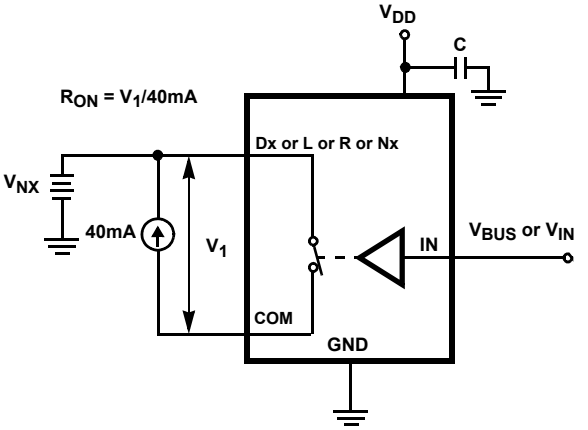
FIGURE 2A. MEASUREMENT POINTS



Repeat test for all switches. C_L includes fixture and stray capacitance.

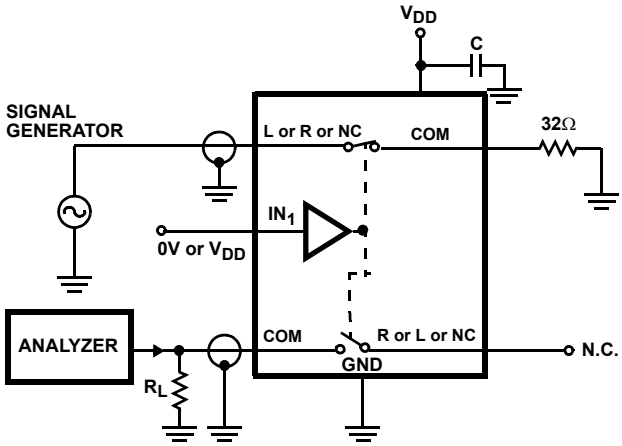
FIGURE 2B. TEST CIRCUIT

FIGURE 2. BREAK-BEFORE-MAKE TIME (ISL54402 ONLY)



Repeat test for all switches. Note: COM designation in diagram refers to: D-/L, D+/R, COM1, and COM2.

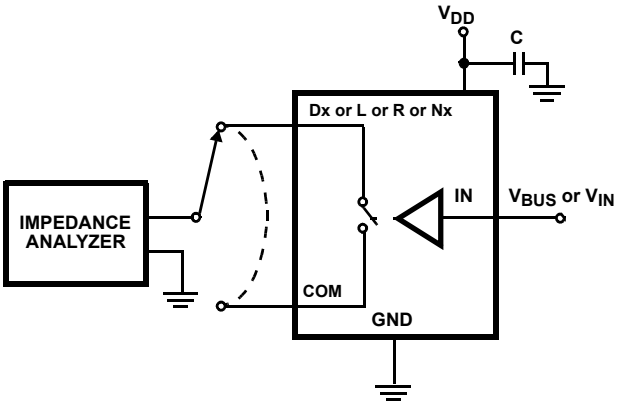
FIGURE 3. R_{ON} TEST CIRCUIT



Signal direction through switch is reversed, worst case values are recorded. Repeat test for all switches. COM designation in diagram refers to: D-/L, D+/R, COM1, and COM2.

FIGURE 4. AUDIO CROSSTALK TEST CIRCUIT

Test Circuits and Waveforms (Continued)



Repeat test for all witches. COM designation in diagram refers to: D-/L, D+/R, COM1, and COM2.

FIGURE 5. CAPACITANCE TEST CIRCUIT

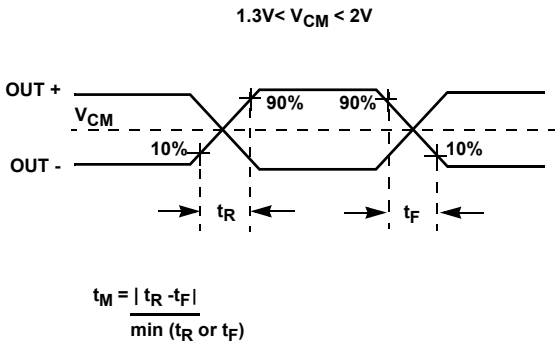


FIGURE 6. RISE/FALL TIME MISMATCH TEST

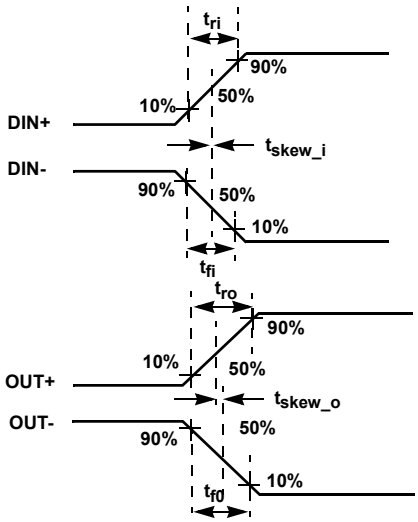
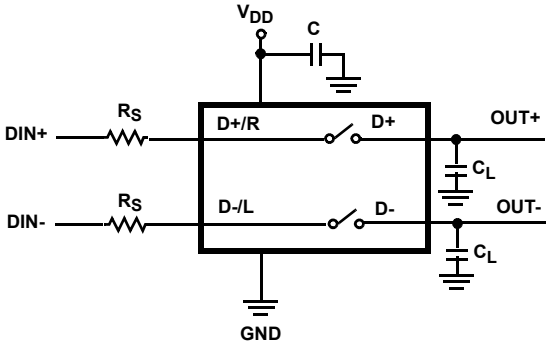


FIGURE 7A. MEASUREMENT POINTS



|tro - tri| Delay Due to Switch for Rising Input and Rising Output Signals.

|tfo - tfi| Delay Due to Switch for Falling Input and Falling Output Signals.

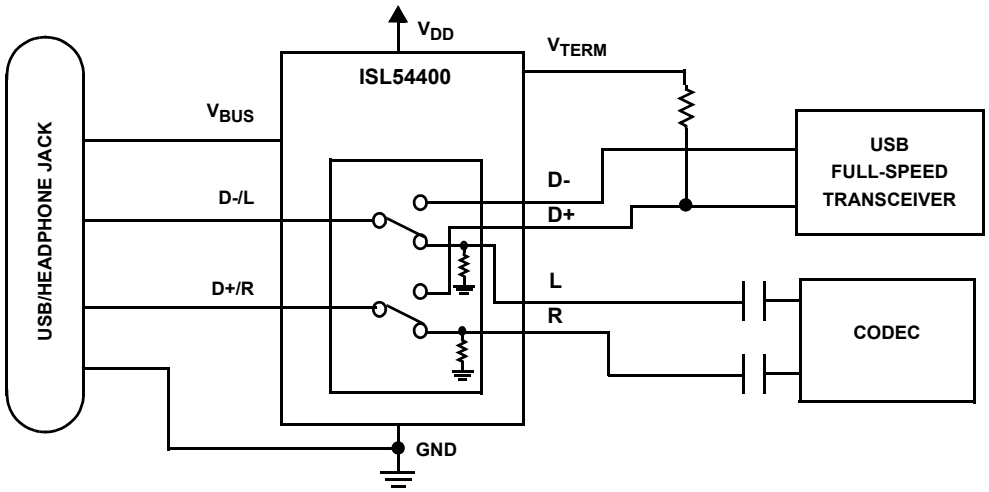
|tskew_0| Change in Skew through the Switch for Output Signals.

|tskew_i| Change in Skew through the Switch for Input Signals.

FIGURE 7B. TEST CIRCUIT

FIGURE 7. SKEW TEST

Application Block Diagram



Detailed Description

The ISL5440X family of devices are dual single pole/double throw (SPDT) analog switches that operate from a single power supply. They were designed to function as dual 2 to 1 multiplexers to select between USB differential data signals and audio L and R stereo signals. They come in tiny µTQFN and TDFN packages for use in MP3 players, PDAs, cellphones, and other personal media players.

All devices in this family consist of two 1Ω normally closed (NC) audio switches and two 5Ω normally open (NO) USB switches. The audio switches can accept signals that swing below ground. They were designed to pass audio left and right stereo signals, that are ground referenced, with minimal distortion. The USB switches were designed to pass full-speed USB differential data signals with minimal edge and phase distortion.

The ISL54400 and ISL54401 were specifically designed for MP3 players, personal media players and cellphone applications that need to combine the audio headphone jack and the USB data connector into a single shared connector, thereby saving space and component cost. A typical application block diagram of this functionality is shown above. The ISL54400 and ISL54401 incorporate circuitry for the detection of the USB V_{BUS} voltage, which is used to switch between the audio CODEC drivers and USB transceiver of the MP3 player or cellphone. The ISL54400 contains additional circuitry to generate the required USB V_{TERM} of 3.3V for use with the USB speed setting pull-up resistor.

The ISL54402 is an audio/data switch and its functionality is typical of a standard dual SPDT device.

A detailed description of the two types of switches and of each part type in the ISL5440x family are provided in the sections below. The USB transmission and audio playback are intended to be mutually exclusive operations.

Audio Switches

The two NC (normally closed) audio switches (L, R, NCx) are 1Ω switches that can pass signals that swing below ground. Crosstalk between the audio switches is < -110dB and has a -3dB bandwidth of 394MHz.

The recommended maximum signal range is from -1.5V to 1.5V. You can apply positive signals greater than 1.5V but the R_{ON} resistance of the switch increases rapidly above 1.5V. The audio signal should not be allowed to exceed the V_{DD} rail or swing more negative than -1.5V.

Over a signal range of ±1V these switches have an extremely low R_{ON} flatness. They can pass ground referenced audio signals with very low distortion (<0.01% THD+N) when delivering 12mW into a 32Ω headphone speaker load. See Figures 8 and 9 THD+N performance curves.

These switches are uni-directional switches. The audio sources should be connected at the NC side of the switch (pins 7 and 8) and the speaker loads should be connected at the COM side of the switch (pins 3 and 4).

For the ISL54400 and ISL54401 parts the audio switches are active (turned ON) whenever the V_{BUS} voltage is ≤ to V_{DD} + 0.2V. The V_{BUS} pin is internally pulled low through a pulldown resistor allowing the V_{BUS} pin to float. When the V_{BUS} pin is floating the audio switches are ON.

Note: Whenever the audio switches are ON the USB transceivers connected at D- and D+ (pins 8 and 9) need to be in the high impedance state or static high or low state to keep from interfering with the audio transmission.

For the ISL54402 part the NC1 audio switch is active (turned ON) whenever logic pin IN1 (pin 10) is LOW. The NC2 audio switch is active (turned ON) whenever the logic pin IN2 (pin 2) is LOW. Unlike the ISL54400 and ISL54401 parts

where the two SPDT switches work in tandem, the ISL54402 gives you independent control over each SPDT switch.

USB Switches

The two NO (normally open) USB switches (D+, D-, NOx) are 5Ω bidirectional switches that are designed to pass low speed and full-speed USB differential signals typically in the range of 0V to 3.6V. The switches have low capacitance and high bandwidth to pass USB full-speed signals (12Mbps) with minimum edge and phase distortion to meet USB 2.0 signal quality specifications. See eye diagram Figure 11 on page 13.

For the ISL54400 and ISL54401 parts, the maximum signal range for the USB switches is from -1.5V to V_{BUS}. The signal voltage should not be allowed to exceed the V_{BUS} voltage rail or go below ground by more than -1.5V.

For the ISL54402 part, the maximum signal range is from -1.5V to V_{DD}. The signal voltage should not be allowed to exceed the V_{DD} voltage rail or go below ground by more than -1.5V.

When using the ISL54400 and ISL54401 parts, the USB switches are active (turned ON) whenever the V_{BUS} voltage is ≥ to V_{DD} + 0.8V. V_{BUS} is internally pulled low, so when V_{BUS} is floating the USB switches are OFF.

Note: Whenever the USB switches are ON the audio drivers of the CODEC, connected at R and L (pins 6 and 7), need to be at AC or DC ground or floating to keep from interfering with the data transmission.

When using the ISL54402 part, the NO1 USB switch is active (turned ON) whenever logic pin IN1 (pin 10) is HIGH. The NO2 USB switch is active (turned ON) whenever the logic pin IN2 (pin 2) is HIGH. Unlike the ISL54400 and ISL54401 parts where the two SPDT switches work in tandem, the ISL54402 gives you independent control over each SPDT switch.

ISL54400 and ISL54401 Operation

The ISL54400 and ISL54401 function the same except the ISL54401 does not have the V_{TERM} feature. The discussion that follows pertains to both devices and will discuss using the parts in the typical application shown in the block diagram on page 10.

LOGIC CONTROL

The state of the ISL54400 and ISL54401 devices are determined by the voltage at the V_{BUS} pin (pin 2). The V_{BUS} pin is internally pulled low and can be left floating.

If V_{BUS} (pin 2) is floating or the V_{BUS} voltage ≤ V_{DD} + 0.2V the part will be in the Audio mode. In Audio mode the L (left) and R (right) 1Ω audio switches are ON and the D- and D+ 5Ω switches are OFF (high impedance). In this state, power to the part will be provided by the DC voltage connected at the V_{DD} pin (pin 1). In a typical application V_{DD} will be in the range of 2.5V to 3.6V and will be connected to the battery or LDO of the MP3 player or cellphone. When a headphone is plugged into the common connector, nothing gets connected at the V_{BUS} pin (it's floating) and the ISL54400 and ISL54401 parts remain in the audio mode and the MP3 player or cellphone audio drivers can drive the headphones and play music.

If V_{BUS} (pin 2) voltage is greater than V_{DD} by 0.8V the part will go into USB mode. In USB mode the D- and D+ 5Ω switches are ON and the L and R 1Ω audio switches are OFF (high impedance). In this state the part will be powered by the voltage connected at the V_{BUS} pin (pin 2). When a USB cable from a computer or USB hub is connected at the common connector the V_{BUS} voltage is driven to between 4.4V and 5.25V. The ISL54400 and ISL54401 parts will go into the USB mode. In USB mode the computer or USB hub transceiver and the MP3 player or cellphone USB transceiver are connected and digital data will be able to be transmitted back and forth.

When the USB cable is disconnected the switch automatically turns the D+ and D- switches OFF and turns the L and R audio switches ON.

POWER

In audio mode the power supply connected at V_{DD} (pin 1) provides power to the ISL54400 and ISL54401 parts. Its voltage should be kept in the range of 2.5V to 3.6V when used in a USB/Audio application to ensure you get proper switching when the V_{BUS} voltage is at its lower limit of 4.4V.

In USB mode power for the ISL54400 and ISL54401 parts is provided from the V_{BUS} line from the host USB controller of the computer or USB hub. Its voltage will be between 4.4V and 5.25V.

V_{TERM} OPERATION (ISL54400 ONLY)

When a USB cable from a computer is connected to a USB device a V_{TERM} voltage must be applied to a speed indicating pull-up resistor to properly terminate the bus and identify whether the USB device is a full-speed or low-speed device to facilitate proper digital transmission. When the cable is removed from the device this V_{TERM} voltage must be disconnected from the speed indicating pull-up resistor. The ISL54400 device can perform this operation.

When V_{DD} ≥ 2.5V and V_{BUS} ≥ V_{DD} + 0.8V, the V_{TERM} pin (pin 10) outputs an open circuit voltage equal to the voltage at the V_{BUS} pin. Otherwise the V_{TERM} pin will be in a HI-Z state.

The ISL54400 V_{TERM} circuitry has an internal series resistor approximately equal to 5.3kΩ. For a full speed USB application, it is recommended you use a 3kΩ ±5% speed indicating pull-up resistor. When the USB bus is in the idle state, a 3kΩ ±5% resistor will put the D+ line voltage in the range of 2.7V to 3.6V as required by the USB specification. For low-speed USB application, it is recommended you use

a 2kΩ ±5% pull-up resistor at the D- line in order to meet the USB connect and disconnect timing requirements.

ISL54402 Operation

The ISL54402 is an audio/data switch. Its logic control is typical of a standard dual SPDT switch.

The digital control for the ISL54402 are the IN pins (pin 2 and pin 10). These pins are 1.8V logic compatible when operated with a 3.0V supply. The device has been designed to have low I_{DD} current even when the logic voltage is not at the rail. With V_{DD} = 5.5V and VIN = 2.85V the ISL54402 draws only 8µA current.

When logic pin IN1 (pin 10) is LOW the NC1 audio switch is ON and the NO1 USB data switch is OFF. When logic pin IN1 (pin 10) is HIGH the NC1 audio switch is OFF and the NO1 USB data switch is ON.

When logic pin IN2 (pin 2) is LOW the NC2 audio switch is ON and the NO2 USB data switch is OFF. When logic pin IN2 (pin 2) is HIGH the NC2 audio switch is OFF and the NO2 USB data switch is ON.

Power for the ISL54402 device is always provided by the DC voltage source connected at the V_{DD} pin (pin 1). The V_{DD} power supply voltage range is from 1.8V to 5.5V.

Typical Performance Curves T_A = 25°C, Unless Otherwise Specified

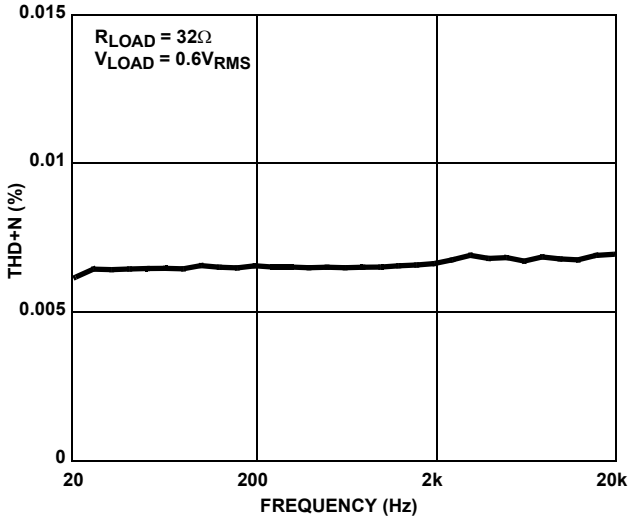


FIGURE 8. THD+N vs FREQUENCY

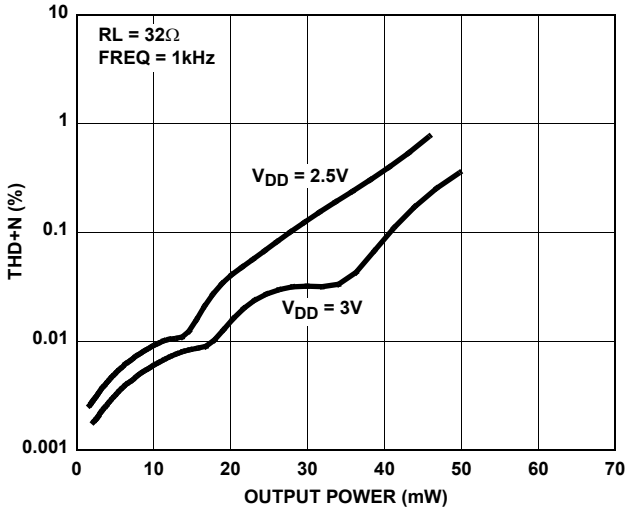


FIGURE 9. THD+N vs POWER

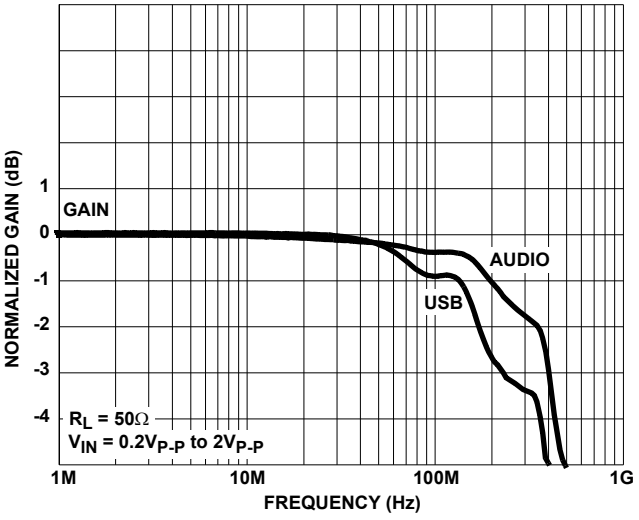


FIGURE 10. FREQUENCY RESPONSE

Die Characteristics

SUBSTRATE POTENTIAL (POWERED UP):

GND (TDFN Paddle Connection: Tie to GND or Float)

TRANSISTOR COUNT:

98

PROCESS:

Submicron CMOS

Typical Performance Curves T_A = 25°C, Unless Otherwise Specified **(Continued)**

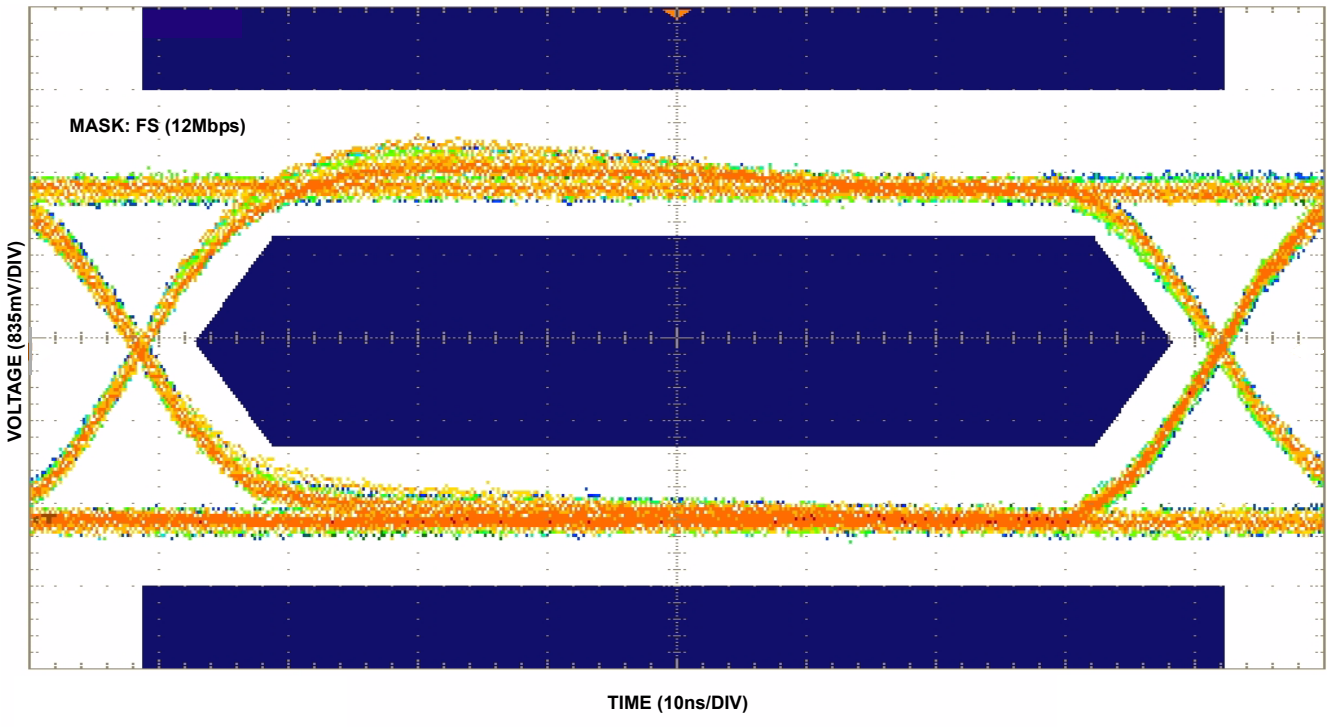
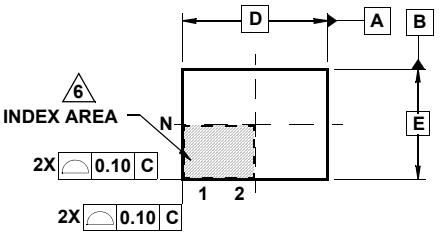
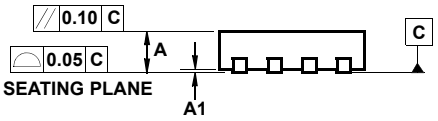


FIGURE 11. EYE PATTERN: 12Mbps

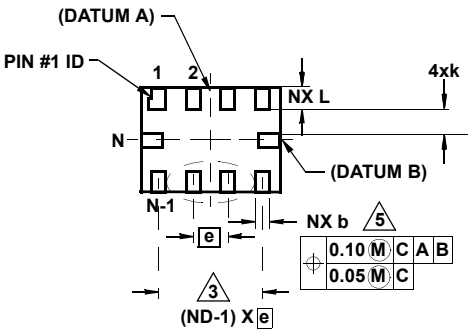
Ultra Thin Quad Flat No-Lead Plastic Package (UTQFN)



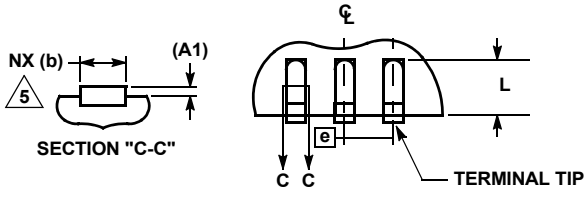
TOP VIEW



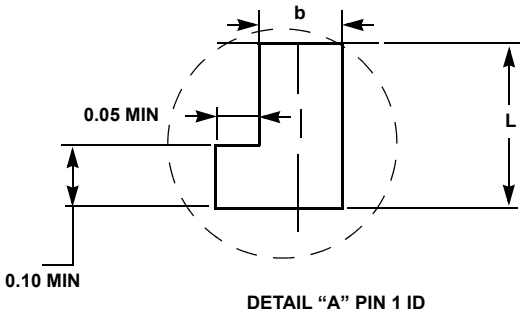
SIDE VIEW



BOTTOM VIEW



FOR ODD TERMINAL/SIDE



DETAIL “A” PIN 1 ID

L10.2.1x1.6A

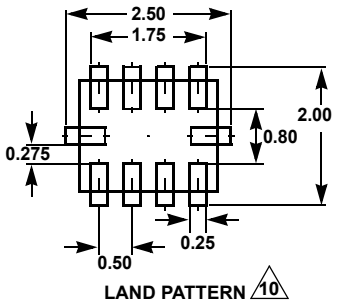
10 LEAD ULTRA THIN QUAD FLAT NO-LEAD PLASTIC PACKAGE

SYMBOL	MILLIMETERS			NOTES
	MIN	NOMINAL	MAX	
A	0.45	0.50	0.55	-
A1	-	-	0.05	-
A3		0.127 REF		-
b	0.15	0.20	0.25	5
D	2.05	2.10	2.15	-
E	1.55	1.60	1.65	-
e		0.50 BSC		-
k	0.20	-	-	-
L	0.35	0.40	0.45	-
N		10		2
Nd		4		3
Ne		1		3
θ	0	-	12	4

Rev. 3 6/06

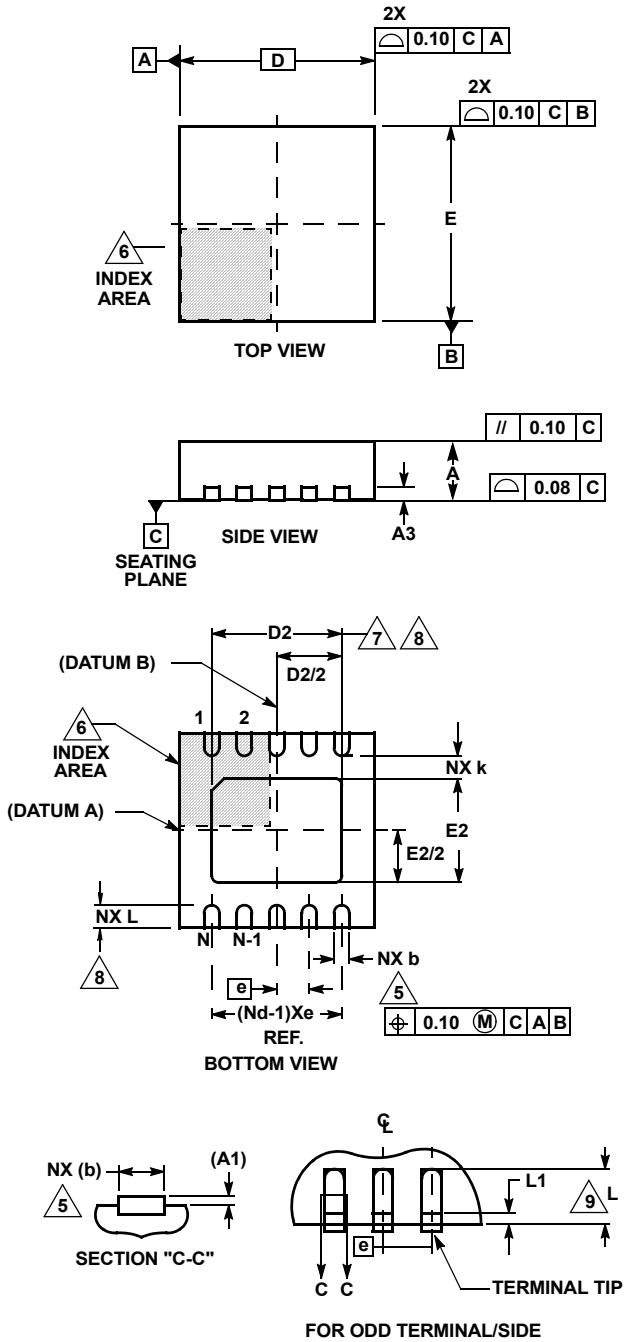
NOTES:

1. Dimensioning and tolerancing conform to ASME Y14.5-1994.
2. N is the number of terminals.
3. Nd and Ne refer to the number of terminals on D and E side, respectively.
4. All dimensions are in millimeters. Angles are in degrees.
5. Dimension b applies to the metallized terminal and is measured between 0.15mm and 0.30mm from the terminal tip.
6. The configuration of the pin #1 identifier is optional, but must be located within the zone indicated. The pin #1 identifier may be either a mold or mark feature.
7. Maximum package warpage is 0.05mm.
8. Maximum allowable burrs is 0.076mm in all directions.
9. Same as JEDEC MO-255UABD except:
   No lead-pull-back, "A" MIN dimension = 0.45 not 0.50mm
   "L" MAX dimension = 0.45 not 0.42mm.
10. For additional information, to assist with the PCB Land Pattern Design effort, see Intersil Technical Brief TB389.



LAND PATTERN 10

Thin Dual Flat No-Lead Plastic Package (TDFN)



L10.3x3A

10 LEAD THIN DUAL FLAT NO-LEAD PLASTIC PACKAGE

SYMBOL	MILLIMETERS			NOTES
	MIN	NOMINAL	MAX	
A	0.70	0.75	0.80	-
A1	-	-	0.05	-
A3		0.20 REF		-
b	0.20	0.25	0.30	5, 8
D	2.95	3.0	3.05	-
D2	2.25	2.30	2.35	7, 8
E	2.95	3.0	3.05	-
E2	1.45	1.50	1.55	7, 8
e		0.50 BSC		-
k	0.25	-	-	-
L	0.25	0.30	0.35	8
N		10		2
Nd		5		3

Rev. 3 3/06

NOTES:

1. Dimensioning and tolerancing conform to ASME Y14.5-1994.
2. N is the number of terminals.
3. Nd refers to the number of terminals on D.
4. All dimensions are in millimeters. Angles are in degrees.
5. Dimension b applies to the metallized terminal and is measured between 0.15mm and 0.30mm from the terminal tip.
6. The configuration of the pin #1 identifier is optional, but must be located within the zone indicated. The pin #1 identifier may be either a mold or mark feature.
7. Dimensions D2 and E2 are for the exposed pads which provide improved electrical and thermal performance.
8. Nominal dimensions are provided to assist with PCB Land Pattern Design efforts, see Intersil Technical Brief TB389.
9. Compliant to JEDEC MO-229-WEED-3 except for D2 dimensions.

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Intersil Corporation's quality certifications can be viewed at www.intersil.com/design/quality

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