ISL54415, ISL54416, ISL54417

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

The Intersil ISL54415, ISL54416, ISL54417 dual SPDT (Single Pole/Double Throw) switches combine low distortion audio/video 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/video signal swings below-ground, allowing the use of a common USB and audio/video connector in digital cameras, camcorders and other portable battery powered Personal Media Player devices.

The ISL54415 and ISL54416 incorporate circuitry for detection of the USB V_{BUS} voltage, which is used to switch between the audio/video and USB signal source in the portable device. In addition, the ISL54415 includes circuitry for generation of a V_{TERM} voltage of 3.3V for use with USB speed setting pull-up resistor.

The ISL54415, ISL54416, ISL54417 are available in a tiny 10Ld 2.1mm x 1.6mm ultra-thin µTQFN package. They operate over a temperature range of -40 to +85°C.

Related Literature

- 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 (ISL54415 and ISL54416)

- Generation of V_{TERM} Voltage for USB D+/D- Pull-up Resistor (ISL54415)

- Low Distortion Mono Audio Signal
  - THD+N at 12mW into 32Ω Load . . . . <0.007%

- Low Distortion Color Video Signal
  - Differential Gain 0.04%
  - Differential Phase . . . . 0.03°

- Cross-talk (4MHz) . . . . -60dB

- 1.8V Logic Compatible (ISL54417)

- Single Supply Operation (V_{DD})
  - ISL54415 and ISL54416 . . . . 2.5V to 3.6V
  - ISL54417 . . . . 1.8V to 5.5V

- Available in Ultra-thin µTQFN Package

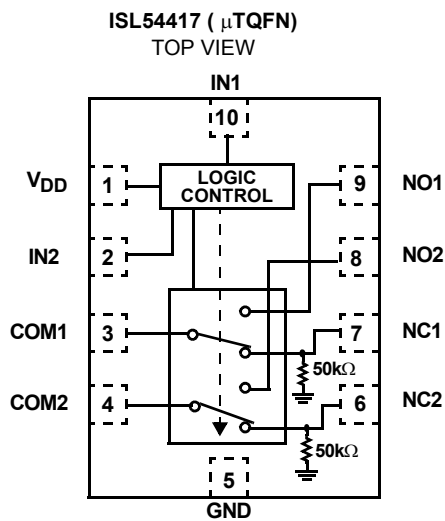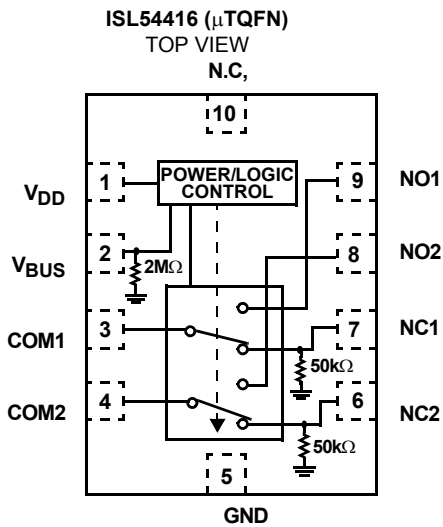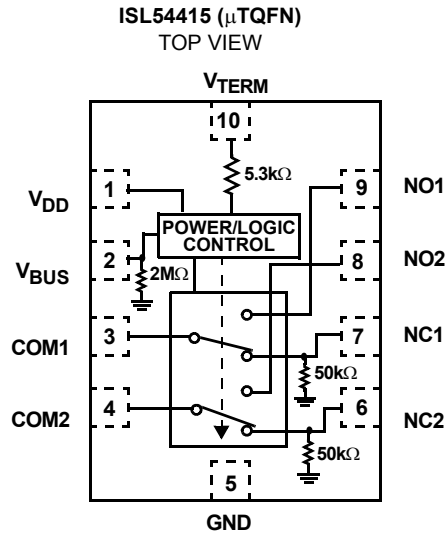- Pb-Free Plus Anneal Available (RoHS Compliant)

Applications

- Digital Camera and Camcorders

- Video MP3 and other Personal Media Players

- Cellular/Mobile Phones

- PDA's

- Audio/Video/USB Switching

Application Block Diagram

Pinouts (Note 1)

ISL54415 (μTQFN)
TOP VIEW

ISL54416 (μTQFN)
TOP VIEW

ISL54417 (μTQFN)
TOP VIEW
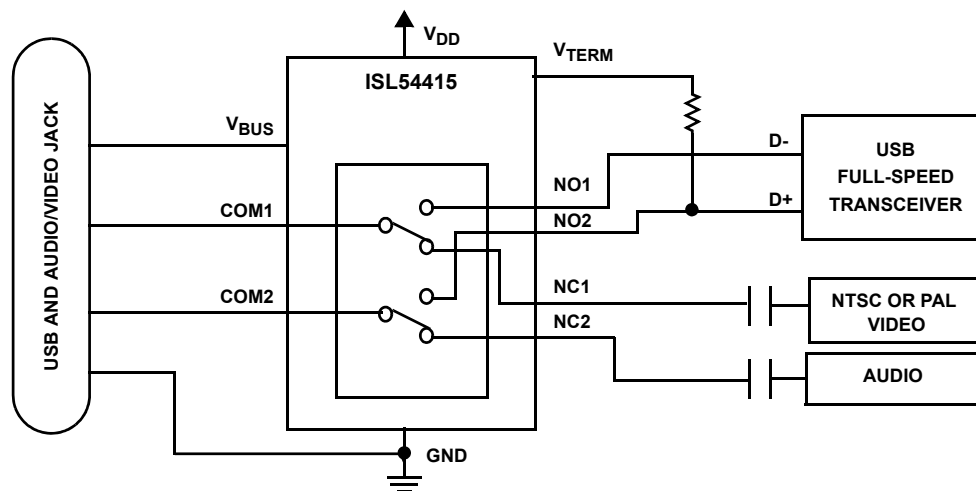
NOTE:

1. ISL54415, ISL54416 Switches Shown for V_{BUS} not present (or idle). ISL54417 Switches Shown for Logic "0" Input.

Truth Table

ISL54417		
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

Truth Table

ISL54416		
V_{BUS}	NCx	NOx
0	ON	OFF
1	OFF	ON

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

Truth Table

ISL54415				
V_{DD}	V_{BUS}	NCx	NOx	V_{TERM}
0	0	ON	OFF	Open
0	1	OFF	ON	Open
1	0	ON	OFF	Open
1	1	OFF	ON	3.0V 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

Pin Descriptions

		ISL54415		ISL54416		ISL54417
NO.	NAME	FUNCTION	NAME	FUNCTION	NAME	FUNCTION
1	V_{DD}	Power Supply (Audio/Video Switches) Control Input for V_{TERM}	V_{DD}	Power Supply (Audio/Video 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	COM1	Voice/Video and USB Common Pin	COM1	Voice/Video and USB Common Pin	COM1	Voice/Video and Data Common Pin
4	COM2	Voice/Video and USB Common Pin	COM2	Voice/Video and USB Common Pin	COM2	Voice/Video and Data Common Pin
5	GND	Ground Connection	GND	Ground Connection	GND	Ground Connection
6	NC2	Audio or Video Input	NC2	Audio or Video Input	NC2	Audio or Video Input
7	NC1	Audio or Video Input	NC1	Audio or Video Input	NC1	Audio or Video Input
8	NO2	USB Differential Input	NO2	USB Differential Input	NO2	Data Differential Input
9	NO1	USB Differential Input	NO1	USB Differential Input	NO1	Data Differential Input
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)	PART MARKING	TEMP. RANGE (°C)	PACKAGE (Pb-Free)	PKG. DWG. #
ISL54415IRUZ-T	FD	-40 to 85	10 Ld 2.1 x 1.6mm μTQFN Tape and Reel	L10.2.1x1.6A
ISL54416IRUZ-T	FE	-40 to 85	10 Ld 2.1 x 1.6mm μTQFN Tape and Reel	L10.2.1x1.6A
ISL54417IRUZ-T	FF	-40 to 85	10 Ld 2.1 x 1.6mm μTQFN Tape and Reel	L10.2.1x1.6A

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 Voltage (ISL54415 and ISL54416)
  NCx (Note 2) . . . . - 2V to ((V_{DD}) + 0.3V)
  NOx (Note 2) . . . . -2V to ((V_{BUS}) + 0.3V)
Input Voltage (ISL54417)
  NOx, NCx (Note 2). . . . . - 2V to ((V_{DD}) + 0.3V)
  IN (Note 2) . . . . -0.3 to ((V_{DD}) + 0.3V)
Output Voltage (ISL54415 and ISL54416)
  COMx (Note 2) Audio/Video Mode. . . . . . . -2V to ((V_{DD}) + 0.3V)
  COMx (Note 2) USB Mode. . . . . -2V to ((V_{BUS}) + 0.3V)
Output Voltage (ISL54417)
  COMx (Note 2). . . . . -2V to ((V_{DD}) + 0.3V)
Continuous Current (NCx, or COMx). . . . . ±300mA
Peak Current (NCx, or COMx)
  (Pulsed 1ms, 10% Duty Cycle, Max) . . . . ±500mA
Continuous Current (NOx). . . . . ±40mA
Peak Current (NOx)
  (Pulsed 1ms, 10% Duty Cycle, Max) . . . . ±100mA
ESD Rating:
  HBM COMx, V_{BUS}. . . . .>4kV
  HBM All Other Pins . . . .>4kV
  MM COMx, V_{BUS}. . . . .>500V
  MM All Other Pins . . . .>300V
  CDM . . . .>1kV

Thermal Information

Thermal Resistance (Typical, Note 3) θ_{JA} (°C/W)
  10 Ld μTQFN Package 96
Maximum Junction Temperature (Plastic Package). . . . . 150°C
Maximum Storage Temperature Range . . . . -65°C to 150°C

Operating Conditions

Temperature Range
ISL5441XIRUZ. . . . . -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 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/Video Switches (NC1, NC2)						
Analog Signal Range, V_{ANALOG}		Full	-1.5	-	1.5	V
ON Resistance, R_{ON}	V_{DD} = 3.0V, V_{BUS} = 3.2V or V_{IN} = 0.5V, I_{COM} = 40mA, V_{NCx} = -0.85V to 0.85V, (Figure 3)	25	-	1	-	Ω
R_{ON} Matching Between Channels, ΔR_{ON}	V_{DD} = 3.0V, V_{BUS} = 3.2V or V_{IN} = 0.5V, I_{COM} = 40mA, 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_{NCx} = -0.85V to 0.85V, (Note 7)	25	-	0.002	0.080	Ω
		Full	-	-	0.095	Ω
Discharge Pull-down Resistance, R_{NC1}, R_{NC2}	V_{DD} = 3.6V, V_{BUS} = 0V or V_{IN} = 0.5V, V_{COMx} = -0.85V, 0.85V, V_{NCx} = -0.85V, 0.85V, V_{NOx} = floating, measure current through the discharge pull-down resistor and calculate resistance value.	25	30	50	70	kΩ
USB Switches (NO1, NO2)						
Analog Signal Range, V_{ANALOG}		Full	-1.5	-	V_{BUS}	V
ON Resistance, R_{ON} (ISL54415 and ISL54416 Only)	V_{DD} = 3.6V, V_{BUS} = 4.4V, I_{COM} = 40mA, V_{NOx} = 0V to V_{BUS}, (See Figure 3)	25	-	5	6	Ω
		Full	-	-	6.5	Ω
R_{ON} Matching Between Channels, ΔR_{ON} (ISL54415 and ISL54416 Only)	V_{DD} = 3.6V, V_{BUS} = 4.4V, I_{COM} = 40mA, V_{NOx} = Voltage at max R_{ON}, (Note 9)	25	-	0.2	0.4	Ω
		Full	-	-	0.45	Ω

RENESAS

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, $R_{FLAT(ON)}$ (ISL54415 and ISL54416 Only)	V_{DD} = 3.6V, V_{BUS} = 4.4V, I_{COM} = 40mA, V_{NOx} = 0V to V_{BUS}, (Note 7)	25	-	0.8	1.9	Ω
		Full	-	-	2.5	Ω
ON Resistance, R_{ON} (ISL54417 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} (ISL54417 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, $R_{FLAT(ON)}$ (ISL54417 Only)	V_{DD} = 3.0V, V_{IN} = 1.4V, I_{COM} = 40mA, V_{NOx} = 0V to 3.0V, (Note 7)	25	-	1.0	1.9	Ω
		Full	-	-	2.5	Ω
OFF Leakage Current, $I_{NOx(OFF)}$	V_{DD} = 3.6V, V_{BUS} = 0V or V_{IN} = 0.5V, V_{COMx} = 0.5V, 0V, V_{NOx} = 0V, 0.5V, V_{NCx} = floating	25	-5	1.5	5	µA
		Full	-15	-	15	µA
ON Leakage Current, $I_{NOx(ON)}$	V_{DD} = 3.6V, V_{BUS} = 5.25V or V_{IN} = 1.4V, V_{COMx} = 0.3V, 3.6V, V_{NOx} = 0.3V, 3.6V, V_{NCx} = floating	25	-30	5	30	µA
		Full	-35	-	35	µA
DYNAMIC CHARACTERISTICS						
Turn-ON Time, t_{ON} (ISL54417 Only)	V_{DD} = 2.7V, V_{NOx} or V_{NCx} = 1.5V, R_L = 300Ω, C_L = 35pF, (See Figure 1)	25	-	40	-	ns
		Full	-	60	-	ns
Turn-OFF Time, t_{OFF} (ISL54417 Only)	V_{DD} = 2.7V, V_{NOx} or V_{NCx} = 1.5V, R_L = 300Ω, C_L = 35pF, (See Figure 1)	25	-	20	-	ns
		Full	-	40	-	ns
Break-Before-Make Time Delay, t_D (ISL54417 Only)	V_{DD} = 3.3V, V_{NOx} or V_{NCx} = 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), NC2 to COM1, NC1 to COM2	R_L = 75Ω, f = 4MHz, V_{NCx} = 300mV_{P-P}, (See Figure 4 and Figure 17)	25	-	-60	-	dB
Differential Gain	V_{IN} = 300mV_{P-P}, V_{OFFSET} = 0V to 0.7V, f = 3.58MHz and 4.43MHz, R_L = 50, See Figure 15 and Figure 16)	25	-	0.04	-	%
Differential Phase	V_{IN} = 300mV_{P-P}, V_{OFFSET} = 0V to 0.7V, f = 3.58MHz and 4.43MHz, R_L = 50, See Figure 15 and Figure 16)	25	-	0.03	-	°
Total Harmonic Distortion	f = 20Hz to 20kHz, V_{DD} = 3.0V, V_{BUS} = 3.2V or V_{IN} = 0.5V, V_{NCx} = 0.60V_{RMS}, R_L = 32Ω, (See Figure 10)	25	-	0.007	-	%
NCx (Audio/Video) Switch -3dB Bandwidth	Signal = 8dBm, R_L = 50Ω, C_L = 5pF, (See Figure 13)	25	-	394	-	MHz
NCx (Audio/Video) Switch -3dB Bandwidth	Signal = 8dBm, R_L = 75Ω, C_L = 5pF, (See Figure 14)	25	-	264	-	MHz
NOx (USB) Switch -3dB Bandwidth	Signal = 18dBm, 1Vdc offset, R_L = 50Ω, C_L = 5pF, (See Figure 13)	25	-	239	-	MHz
NOx OFF Capacitance, $C_{NOx(OFF)}$	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
NCx OFF Capacitance, $C_{NCx(OFF)}$	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
COMx ON Capacitance, $C_{COMx(ON)}$	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} (ISL54415 and ISL54416 Only)		Full	2.5	-	3.6	V
Power Supply Range, V_{DD} (ISL54417 Only)		Full	1.8	-	5.5	V
Positive Supply Current, I_{DD} Audio/Video Mode (ISL54415 and ISL54416 Only)	V_{DD} = 3.6V, V_{BUS} = Float	25	-	4.5	8	µA
		Full	-	-	10	µA
Positive Supply Current, I_{BUS} USB Mode (ISL54415 and ISL54416 Only)	V_{DD} = 3.6V, V_{BUS} = 5.25V	25	-	3.5	8	µA
		Full	-	-	25	µA
Positive Supply Current, I_{DD} (ISL54417 Only)	V_{DD} = 5.5V, V_{IN} = 0V	25	-	8	11	µA
		Full	-	-	15	µA
Positive Supply Current, I_{DD} (ISL54417 Only)	V_{DD} = 5.5V, V_{IN} = 5.5V	25	-	0.06	0.5	µA
		Full	-	-	1	µA
Positive Supply Current, I_{DD} (ISL54417 Only)	V_{DD} = 5.5V, V_{IN} = 2.85V	25	-	5.5	8	µA
		Full	-	-	10	µA
V_{TERM} Voltage, V_{VTERM} (ISL54415 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} (ISL54415 Only)	V_{DD} = 2.0V, V_{BUS} = 4.4V	25	0V	-	0.5V	V
DIGITAL INPUT CHARACTERISTICS						
V_{BUS} Voltage Low, V_{BUSL} (ISL54415 and ISL54416 Only)		Full	-	-	V_{DD} + 0.2	V
V_{BUS} Voltage High, V_{BUSH} (ISL54415 and ISL54416 Only)		Full	V_{DD} + 0.8	-	-	V
Input Voltage Low, V_{INL} (ISL54417 Only)	V_{DD} = 2.7V to 3.6V	Full	-	-	0.5	V
Input Voltage High, V_{INH} (ISL54417 Only)	V_{DD} = 2.7V to 3.6V	Full	1.4	-	-	V
Input Voltage Low, V_{INL} (ISL54417 Only)	V_{DD} = 5.0V	Full	-	-	0.8	V
Input Voltage High, V_{INH} (ISL54417 Only)	V_{DD} = 5.0V	Full	2.3	-	-	V
Input Current, I_{INH}, I_{INL} (ISL54417 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 Ron value from the channel with lowest max R_{ON} value between NC1 and NC2 or between NO1 and NO2.

Test Circuits and Waveforms
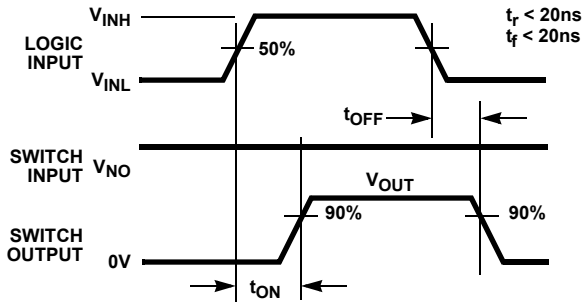
Logic input waveform is inverted for switches that have the opposite logic sense.

FIGURE 1A. MEASUREMENT POINTS

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

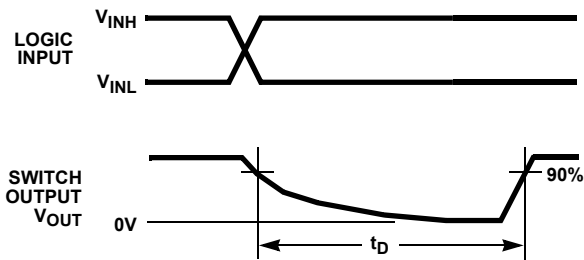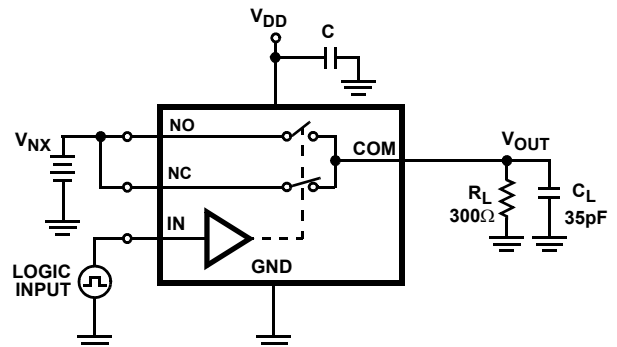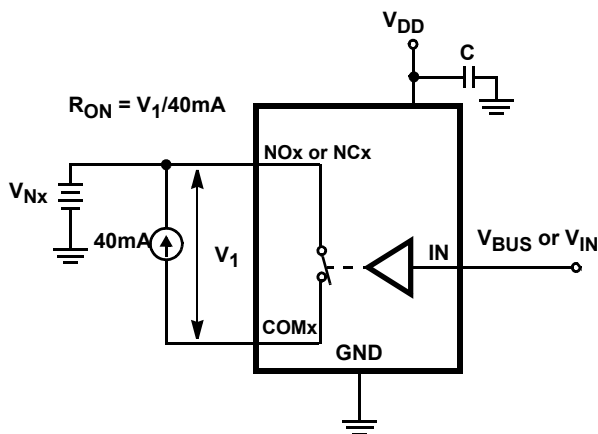$$V_{OUT} = V_{(NO\ or\ NC)} \frac{R_L}{R_L + R_{(ON)}}$$

FIGURE 1B. TEST CIRCUIT

FIGURE 1. SWITCHING TIMES (ISL54417 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 (ISL54417 ONLY)

$R_{ON} = V_1/40mA$

Repeat test for all switches.

FIGURE 3. R_{ON} TEST CIRCUIT
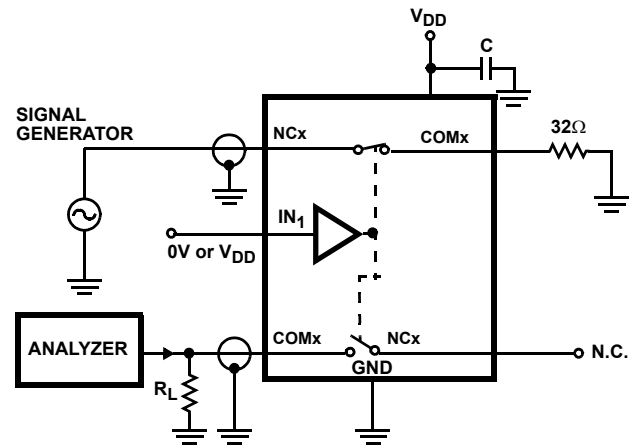
Signal direction through switch is reversed, worst case values are recorded. Repeat test for all switches.

FIGURE 4. CROSSTALK TEST CIRCUIT

Test Circuits and Waveforms (Continued)
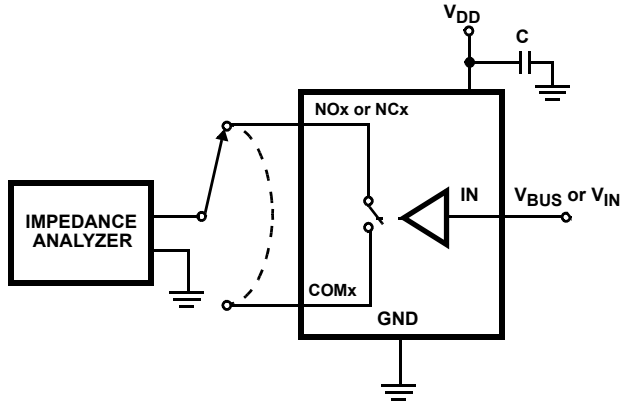
Repeat test for all switches.

FIGURE 5. CAPACITANCE TEST CIRCUIT

$1.3V < V_{CM} < 2V$

$$t_M = \frac{|t_R - t_F|}{min\ (t_R\ or\ t_F)}$$
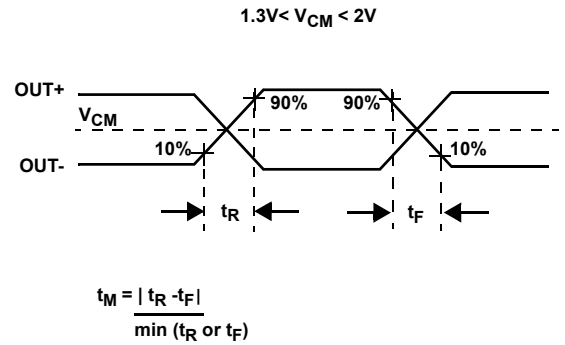
FIGURE 6. RISE/FALL TIME MISMATCH TEST
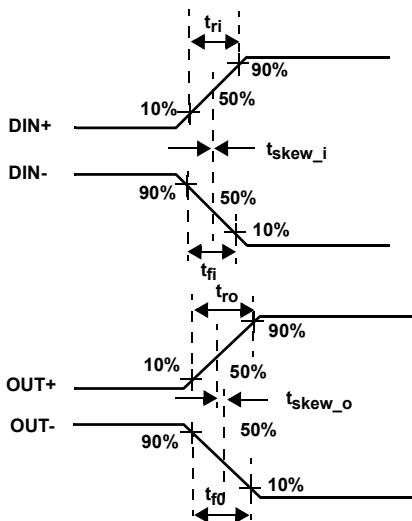
FIGURE 7A. MEASUREMENT POINTS
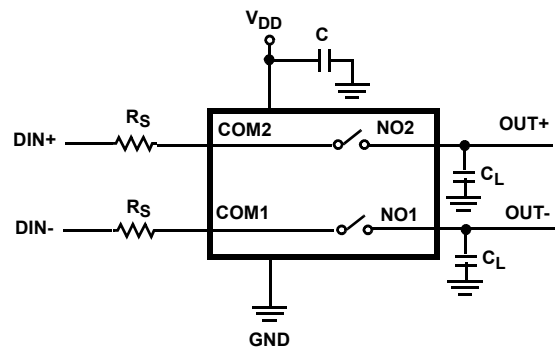
$|t_{ro} - t_{ri}|$ Delay Due to Switch for Rising Input and Rising Output Signals.

$|t_{fo} - t_{fi}|$ Delay Due to Switch for Falling Input and Falling Output Signals.

$|t_{skew\_0}|$ Change in Skew through the Switch for Output Signals.

$|t_{skew\_i}|$ Change in Skew through the Switch for Input Signals.

FIGURE 7B. TEST CIRCUIT

FIGURE 7. SKEW TEST

RENESAS

Application Block Diagram
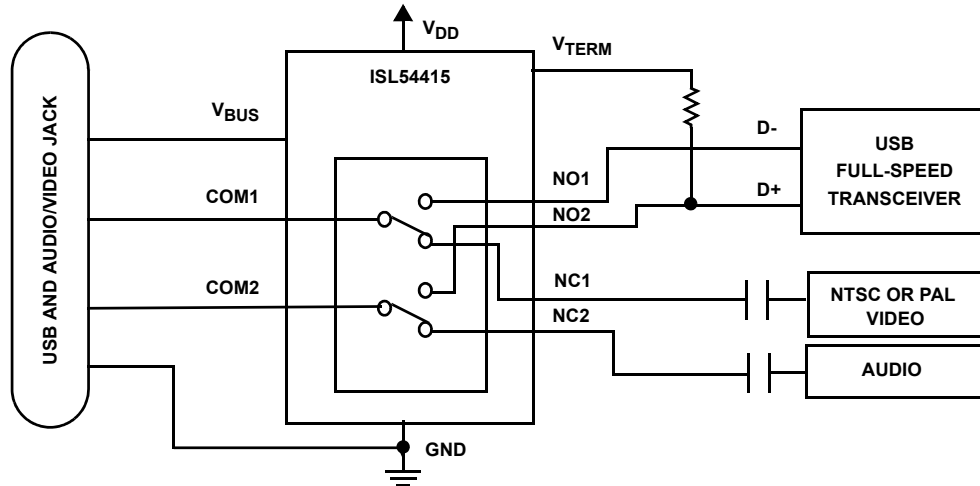
Detailed Description

The ISL5441X 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 mono Audio/Composite Video Broadcast System (CVBS). They come in tiny µTQFN package for use in digital cameras, camcorders, video MP3 players, PDAs, cellphones, and other personal media players.

All devices in this family consist of two 1Ω normally closed (NC) Audio/Video switches and two 5Ω normally open (NO) USB switches. The audio/video switches can accept signals that swing below ground. They were designed to pass ground reference audio or DC-restored with synch composite video signals with minimal distortion. The USB switches were designed to pass full-speed USB differential data signals with minimal edge and phase distortion.

The ISL54415 and ISL54416 were specifically designed for digital cameras, camcorders, MP3 players, cellphones and other personal media player applications that need to combine the audio/video jacks 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 ISL54415 and ISL54416 incorporate circuitry for the detection of the USB V_{BUS} voltage, which is used to switch between the audio/video drivers and USB transceiver of media player. The ISL54415 contains additional circuitry to generate the required USB V_{TERM} of 3.3V for use with the USB speed setting pull-up resistor.

The ISL54417 is an audio/video and data switch who's logic control is typical of a standard dual SPDT device.

A detailed description of the two types of switches and of each part type in the ISL5441X family are provided in the following sections. The digital data transmission (USB, etc.)

and audio/video playback are intended to be mutually exclusive operations.

NC1 and NC2 Audio/Video Switches

The two NC (normally closed) audio/video switches (NC1, NC2) are 1Ω high bandwidth switches that can pass signals that swing below ground by as much as 1.5V. They were design to pass ground reference audio signals and DC-restored Composite Video Broadcast System (CVBS) including negative synchronizing pulse with minimal insertion loss and very low distortion and degradation.

The -3dB bandwidth into 50Ω is 394MHz and into 75Ω is 264MHz. Crosstalk between NC1 and NC2 @ 4MHz is -60dB which allows composite video to be routed through one switch and mono-audio through the other switch with little interference.

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 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 a ground referenced audio signal with very low distortion (<0.007% THD+N) when delivering 12mW into a 32Ω headphone speaker load. See Figures 10 and 11 THD+N performance curves.

Figures 8 and 9 show the vector scope plots of a standard NTSC color bar signal at both the input (Figure 8) and output (Figure 9) of the ISL54415. The plots show that except for a little attenuation, due to switch R_{ON} and test fixture cabling, there is virtually no degradation of the video waveform through the switch.
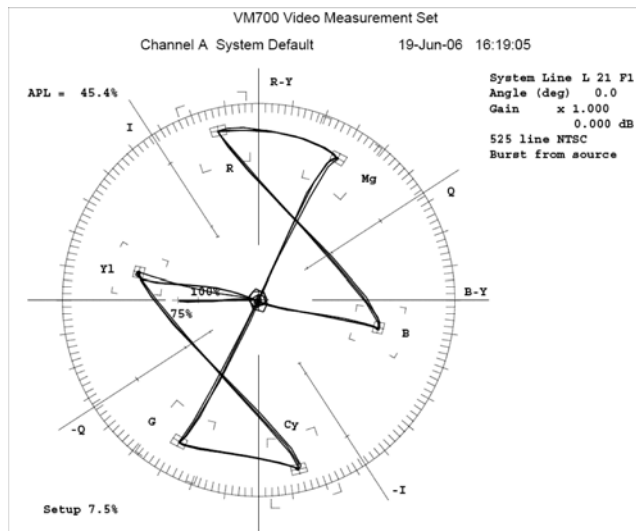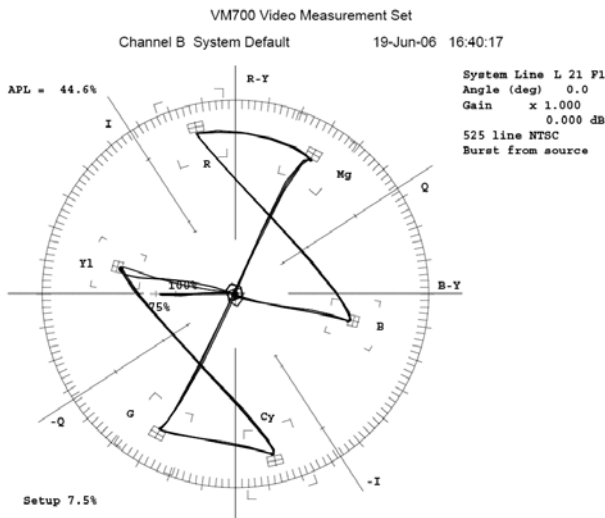
FIGURE 8. VECTOR-SCOPE PLOT BEFORE SWITCH

FIGURE 9. VECTOR-SCOPE PLOT AFTER SWITCH

Figure 15 shows the measured gain and phase of a 3.58MHz, 300MV$_{P-P}$ signal at the output of the switch relative to the signal at the input of the switch as you vary the DC offset of the signal from 0V to 1V using a network analyzer. The data from the sweep was used to calculated the differential gain (DG) and differential phase (DP). Over luminance range of 0V to 1V: DG = 0.03% and DP = 0.05°. Over luminanace range of 0V to 0.7V: DG = 0.03% and DP = 0.03°. DG and DP plot using an actual NTSC video signal is shown in Figure 16. DG = 0.05% and DP = 0.02°.

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

For the ISL54415 and ISL54416 parts the NC audio/video switches are active (turned ON) whenever the V$_{BUS}$ voltage is ≤ V$_{DD}$ + 0.2V. The V$_{BUS}$ pin is internally pulled low through a pull-down resistor allowing the V$_{BUS}$ pin to float. When the V$_{BUS}$ pin is floating the NC audio/video switches are ON.

Note: Whenever the audio/video switches are ON the USB transceivers need to be in the high impedance state or static high or low state to keep from interfering with the audio/video transmission.

For the ISL54417 part the NC1 audio/video switch is active (turned ON) whenever logic pin IN1 (pin 10) is LOW. The NC2 audio/video switch is active (turned ON) whenever the logic pin IN2 (pin 2) is LOW. Unlike the ISL54415 and ISL54416 parts were the two SPDT switches work in tandem, the ISL54417 gives you independent control over each SPDT switch.

NO1 and NO2 USB Switches

The two NO (normally open) USB switches (NO1, NO2) are 5Ω bidirectional switches that were 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 (0.47pF) and high bandwidth (239MHz) to pass USB full-speed signals (12Mbps) with minimum edge and phase distortion to meet USB 2.0 signal quality specifications. See Figure 12 for full-speed USB eye diagram.

For the ISL54415 and ISL54416 parts the maximum signal range for the USB switches is from -1.5V to V$_{BUS}$. The signal voltage should not be allow to exceed the V$_{BUS}$ voltage rail or go below ground by more than -1.5V.

For the ISL54417 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 ISL54415 and ISL54416 parts the USB switches are active (turned ON) whenever the V$_{BUS}$ voltage is ≥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 and video drivers need to be at AC or DC ground or floating to keep from interfering with the data transmission.

When using the ISL54417 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 ISL54415 and ISL54416 parts were the two SPDT switches work in tandem, the ISL54417 gives you independent control over each SPDT switch.

ISL54415 and ISL54416 Operation

The ISL54415 and ISL54416 function the same except the ISL54416 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 ISL54415 and ISL54416 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 $\leq V_{DD}$ + 0.2V the part will be in the audio/video mode. In Audio/Video mode the NC1 and NC2 1Ω audio/video switches are ON and the NO1 and NO2 5Ω USB switches are OFF (high impedance). In this state power to the part is 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 media player. When a headphone/video receiver is plugged into the common connector, nothing gets connected at the V_{BUS} pin (its floating) and the ISL54415 and ISL54416 parts remains in the audio/video mode and the media player audio and video drivers can drive the headphones and video display.

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 NO1 and NO2 5Ω USB switches are ON and the NC1 and NC2 1Ω audio/video 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 ISL54415 and ISL54416 parts will go into the USB mode. In USB mode the computer or USB hub transceiver and the media player USB transceiver are connected and digital data will be able to be transmit back and forth.

When the USB cable is disconnected the switch automatically turns the NO1 and NO2 switches OFF and turns the NC1 and NC2 audio/video switches ON.

POWER

In audio/video mode the power supply connected at V_{DD} (pin 1) provides power to the ISL54415 and ISL54416 parts. Its voltage should be kept in the range of 2.5V to 3.6V when used in a USB 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 ISL54415 and ISL54416 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 (ISL54415 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 pullup resistor. The ISL54415 device can perform this operation.

When $V_{DD} \geq 2.5V$ and $V_{BUS} \geq V_{DD}$ + 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 ISL54415 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 recommend you use a 2kΩ ±5% pull-up resistor at the D- line in order to meet the USB connect and disconnect timing requirements.

ISL54417 Operation

The ISL54417 is an audio/video and data switch. Its logic control is typical of a standard dual SPDT switch.

The digital control for the ISL54417 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 V_{IN} = 2.85V the ISL54417 draws only 8µA current.

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

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

Power for the ISL54417 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.

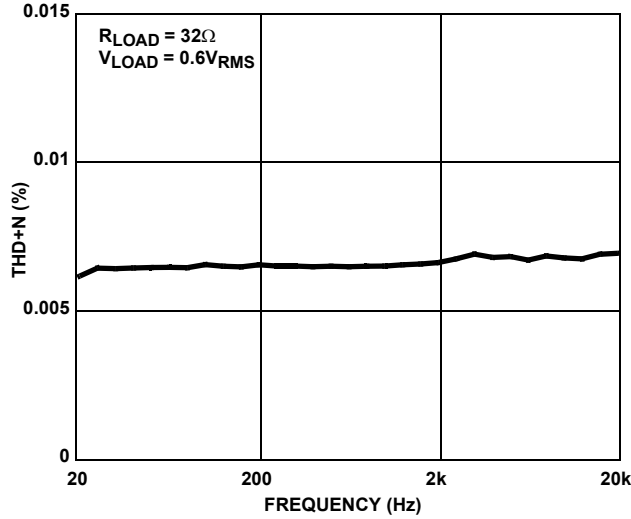# Typical Performance Curves T_A = 25°C, Unless Otherwise Specified
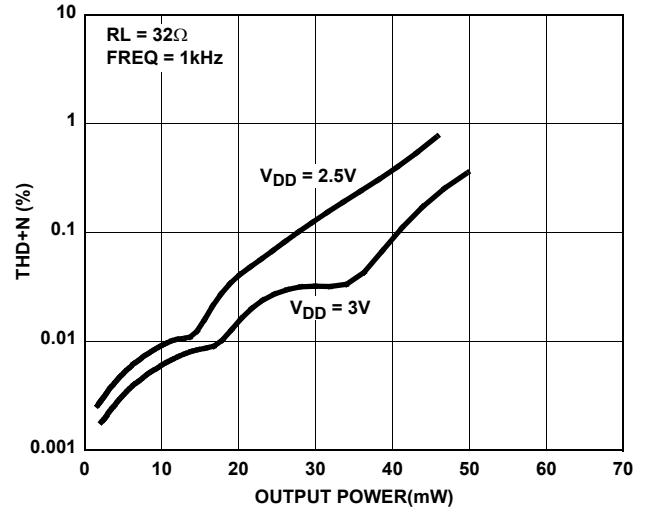

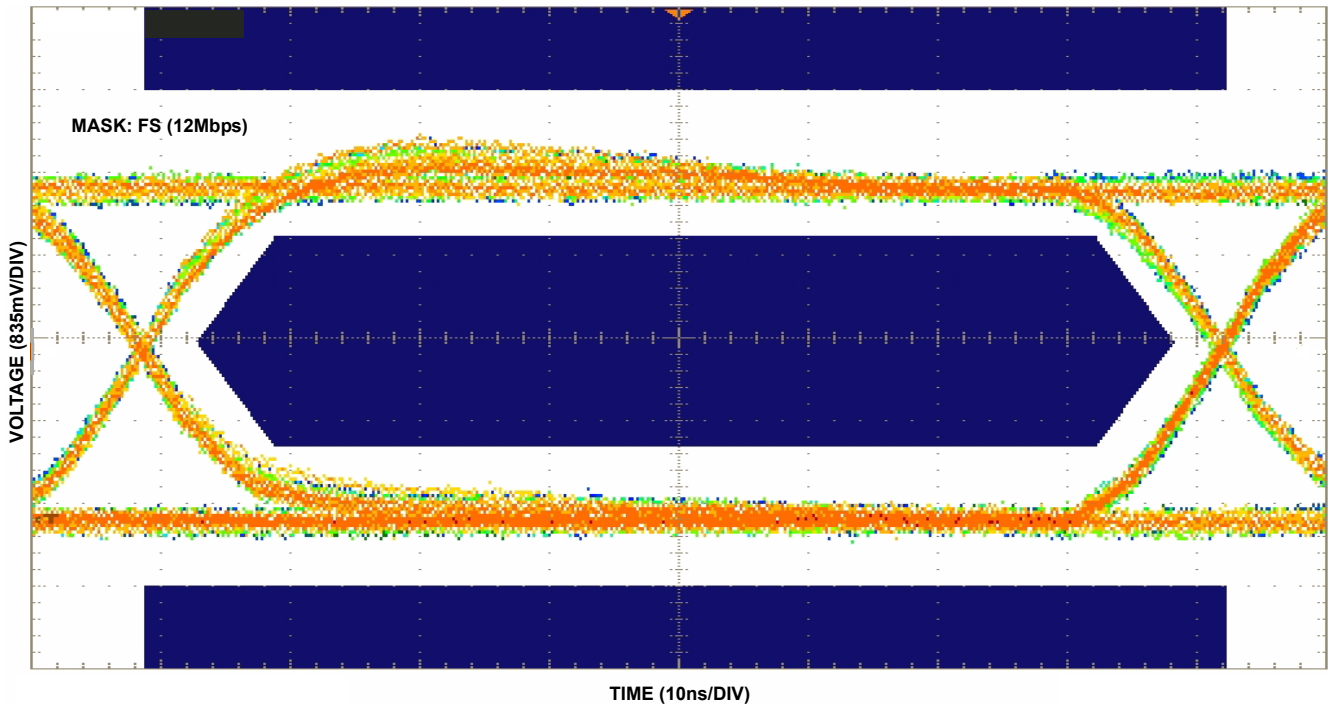FIGURE 10. THD+N vs FREQUENCY

FIGURE 11. THD+N vs POWER

FIGURE 12. EYE PATTEREN: 12Mbps

For additional products, see www.intersil.com/en/products.html

For information regarding Intersil Corporation and its products, see www.intersil.com

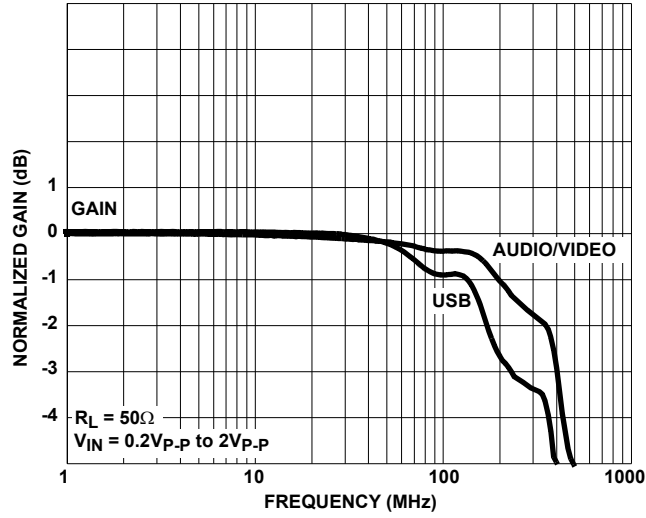## *Typical Performance Curves* T_A = 25°C, Unless Otherwise Specified **(Continued)**
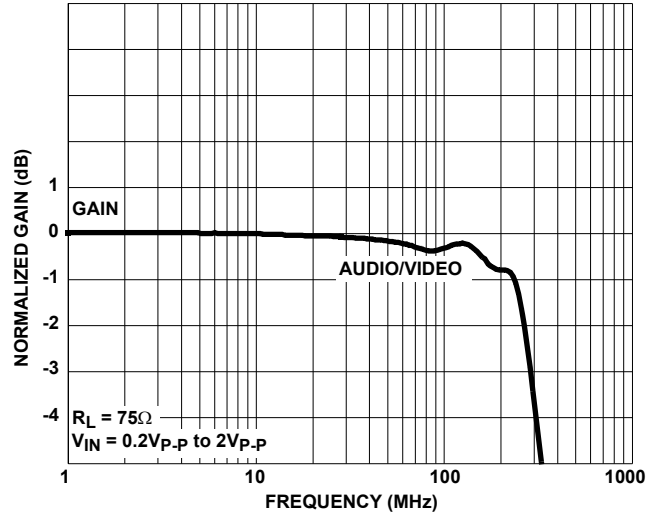

FIGURE 13. FREQUENCY RESPONSE

FIGURE 14. FREQUENCY RESPONSE
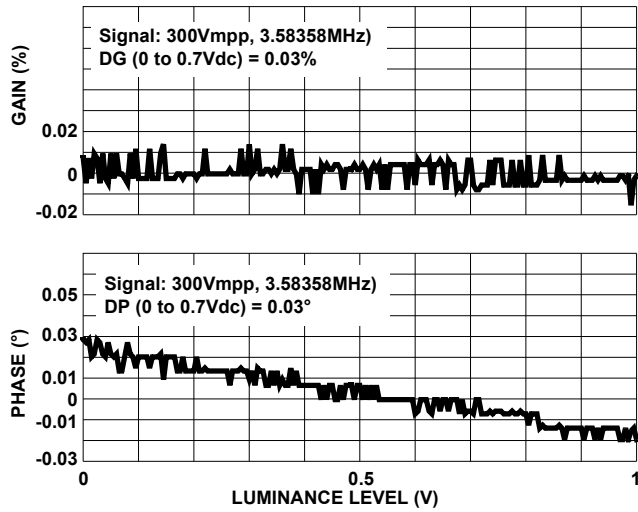
FIGURE 15.
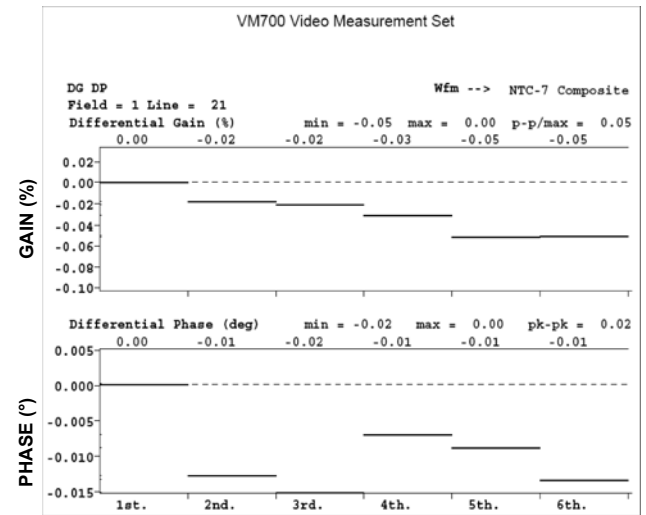
FIGURE 16.
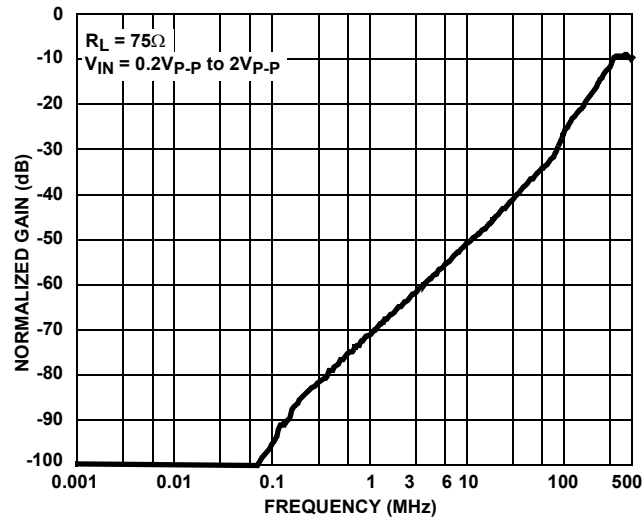
FIGURE 17. VIDEO TO AUDIO CROSSTALK

Die Characteristics
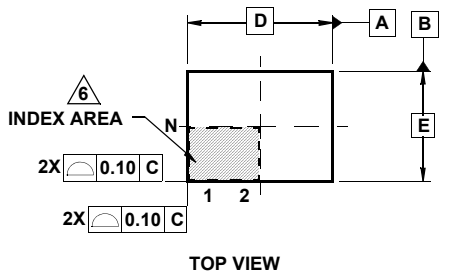
SUBSTRATE POTENTIAL (POWERED UP):

GND

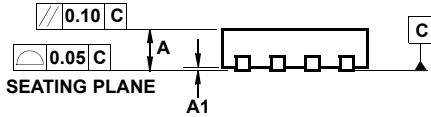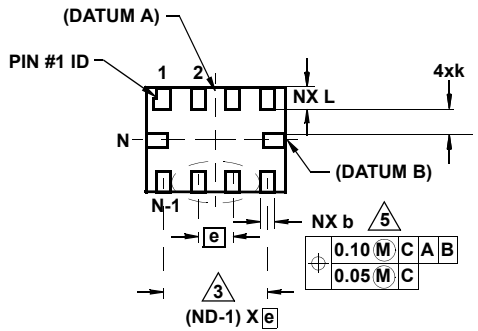**TRANSISTOR COUNT:**

98

PROCESS:

Submicron CMOS

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

TOP VIEW
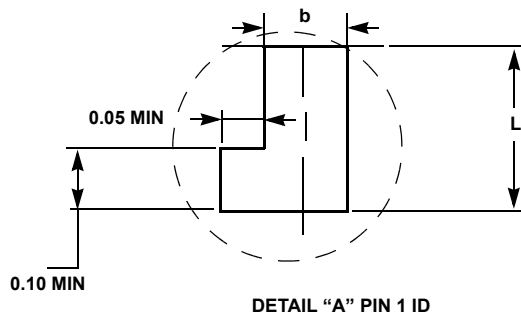
SIDE VIEW

BOTTOM VIEW

SECTION "C-C"
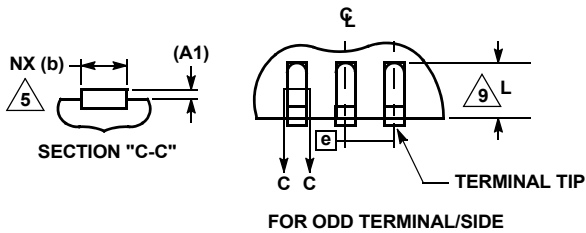
FOR ODD TERMINAL/SIDE

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, 9
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	9
N	10			2
Nd	4			3
Ne	1			3
θ	0	-	12	4

Rev. 2 4/06

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. Nominal dimensions are provided to assist with PCB Land Pattern Design efforts, see Intersil Technical Brief TB389.

10. 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