Data Sheet | December 18, 2006 | FN6410.0

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

The Intersil ISL54208 dual SPDT (Single Pole/Double Throw) switches combine low distortion audio/video and accurate USB 2.0 high speed (480Mbps) data signal switching in the same low voltage device. When operated with a 2.7V 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 ISL54208 logic control pins are 1.8V logic compatible which allows control via a standard µcontroller. With a VDD voltage in the range of 2.7V to 3.6V the IN pin voltage can exceed the VDD rail allowing for the USB 5V VBUS voltage from a computer to directly drive the IN pin to switch between the audio/video and USB signal sources in the portable device. The part has an enable control pin to open all the switches and put the part in a low power state.

The ISL54208 is available in a small 10 Ld 2.1mmx1.6mm ultra-thin µTQFN package and a 10 Ld 3mmx3mm TDFN package. It operates 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”

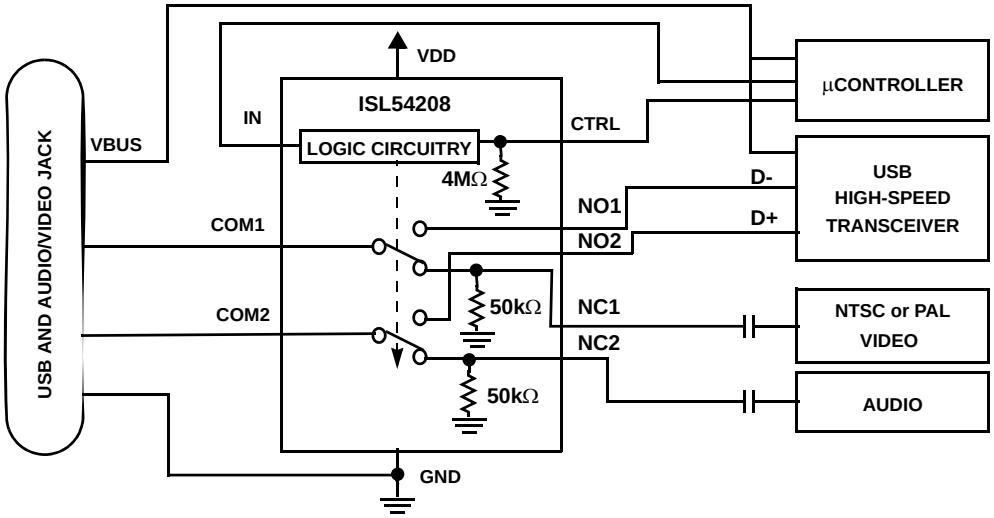
## Features

- High Speed (480Mbps) Signaling Capability per USB 2.0
- Low Distortion Negative Signal Capability
- Control Pin to Open all Switches and Enter Low Power State
- Low Distortion Mono Audio Signal
  - THD+N at 20mW into 32Ω Load . . . . . <0.1%
- Low Distortion Color Video Signal
  - Differential Gain . . . . . 0.28%
  - Differential Phase . . . . . 0.04°
- Cross-talk NCx Channels (4MHz) . . . . . -78dB
- Single Supply Operation ($V_{DD}$) . . . . . 1.8V to 5.5V
- -3dB Bandwidth USB NOx Switches . . . . . 630MHz
- Available in µTQFN and TDFN Packages
- Pb-Free Plus Anneal (RoHS Compliant)
- Compliant with USB 2.0 Short Circuit Requirements Without Additional External Components

## Applications

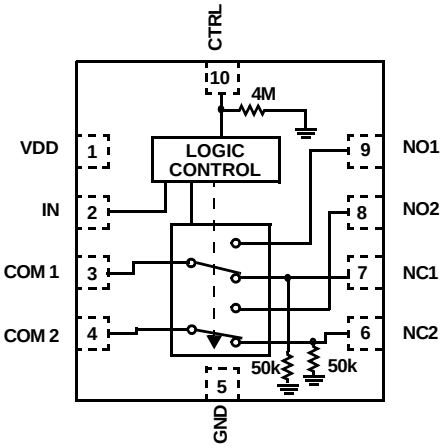
- Digital Camera and Camcorders
- Video MP3 and other Personal Media Players
- Cellular/Mobile Phones
- PDA’s
- Audio/Video/USB Switching

## Application Block Diagram

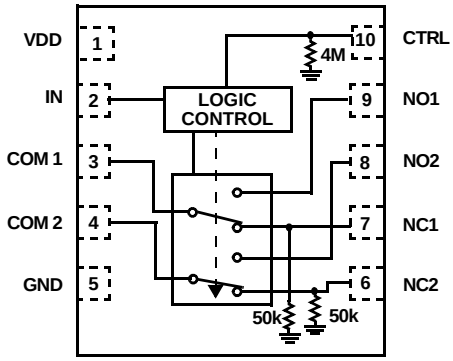


## Pinouts (Note 1)

**ISL54208**
**(10 LD μTQFN)**
TOP VIEW




**ISL54208**
**(10 LD TDFN)**
TOP VIEW




NOTE:

1. ISL54208 Switches shown for IN = Logic “0” and CTRL = Logic “1”.

## Truth Table

| ISL54208 | | | |
|---|---|---|---|
| **IN** | **CTRL** | **NC1, NC2** | **NO1, NO2** |
| 0 | 0 | OFF | OFF |
| 0 | 1 | ON | OFF |
| 1 | X | OFF | ON |

IN: Logic “0” when ≤ 0.5V, Logic “1” when ≥1.4V with 2.7V to 3.6V supply.
CTRL: Logic “0” when ≤ 0.5V or Floating, Logic “1” when ≥1.4V with 2.7V to 3.6V supply.

## Pin Descriptions

| ISL54208 | | |
|---|---|---|
| **PIN NO.** | **NAME** | **FUNCTION** |
| 1 | VDD | Power Supply |
| 2 | IN | Digital Control Input |
| 3 | COM1 | Voice/Video and USB Common Pin |
| 4 | COM2 | Voice/Video and USB Common Pin |
| 5 | GND | Ground Connection |
| 6 | NC2 | Audio or Video Input |
| 7 | NC1 | Audio or Video Input |
| 8 | NO2 | USB Differential Input |
| 9 | NO1 | USB Differential Input |
| 10 | CTRL | Digital Control Input (Audio/Vidio Enable) |

## Ordering Information

| PART NUMBER (Note) | PART MARKING | TEMP. RANGE (°C) | PACKAGE (Pb-Free) | PKG. DWG. # |
|---|---|---|---|---|
| ISL54208IRUZ-T | FR | -40 to +85 | 10 Ld 2.1x1.6mm μTQFN Tape and Reel | L10.2.1x1.6A |
| ISL54208IRZ-T | 4208 | -40 to +85 | 10 Ld 3mmx3mm TDFN Tape and Reel | L10.3x3A |
| ISL54208IRZ | 4208 | -40 to +85 | 10 Ld 3mmx3mm TDFN | L10.3x3A |

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

VDD to GND . . . . . -0.3 to 6.0V
Input Voltages
NCx, NOx(Note 2) . . . . . -2V to (($V_{DD}$) + 0.3V)
IN (Note 2) . . . . . -2V to 5.5V
CTRL (Note 2) . . . . . -0.3 to (($V_{DD}$) + 0.3V)
Output Voltages
COMx (Note 2) . . . . . -2V to (($V_{DD}$) + 0.3V)
Continuous Current (NCx, COMx) . . . . . ±150mA
Peak Current (NCx, COMx)
(Pulsed 1ms, 10% Duty Cycle, Max) . . . . . ±300mA
Continuous Current (NOx) . . . . . ±40mA
Peak Current (NOx)
(Pulsed 1ms, 10% Duty Cycle, Max) . . . . . ±100mA
ESD Rating:
HBM . . . . . >7kV
MM . . . . . >400V
CDM . . . . . >1.4kV

## Thermal Information

| Thermal Resistance (Typical, Note 3) | $\theta_{JA}$ (°C/W) |
|---|---|
| 10 Ld μTQFN Package | 130 |
| 10 Ld 3x3 TDFN Package | 110 |

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

## Operating Conditions

Temperature Range ISL54208IRUZ and
ISL54208IRZ. . . . . -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 NOx, NCx, COMx, CTRL, IN exceeding $V_{DD}$ or GND by specified amount are clamped. Limit current to maximum current ratings.
3. $\theta_{JA}$ 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 3.6V Supply

Test Conditions: $V_{DD}$ = +3.3V, GND = 0V, $V_{INH}$ = 1.4V, $V_{INL}$ = 0.5V, $V_{CTRLH}$ = 1.4V, $V_{CTRLL}$ = 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, $V_{ANALOG}$ | $V_{DD}$ = 3.0V, IN = 0.5V, CTRL = 1.4V | Full | -1.5 | - | 1.5 | V |
| ON Resistance, $R_{ON}$ | $V_{DD}$ = 3.0V, IN = 0.5V, CTRL = 1.4V, $I_{COMx}$ = 100mA, $V_{NCx}$ = -0.85V to 0.85V, (See Figure 3) | 25 | - | 2.65 | 4 | Ω |
| | | Full | - | - | 5.5 | Ω |
| $R_{ON}$ Matching Between Channels, $\Delta R_{ON}$ | $V_{DD}$ = 3.0V, IN = 0.5V, CTRL = 1.4V, $I_{COMx}$ = 100mA, $V_{NCx}$ = Voltage at max $R_{ON}$ over signal range of -0.85V to 0.85V, (Note 8) | 25 | - | 0.02 | 0.13 | Ω |
| | | Full | - | - | 0.16 | Ω |
| $R_{ON}$ Flatness, $R_{FLAT(ON)}$ | $V_{DD}$ = 3.0V, IN = 0.5V, CTRL = 1.4V, $I_{COMx}$ = 100mA, $V_{NCx}$ = -0.85V to 0.85V, (Note 7) | 25 | - | 0.03 | 0.05 | Ω |
| | | Full | - | - | 0.07 | Ω |
| Discharge Pull-Down Resistance, $R_{NC1}$, $R_{NC2}$ | $V_{DD}$ = 3.6V, IN = 0V, CTRL = 3.6V, $V_{COM-}$ or $V_{COM+}$ = -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 | - | 50 | - | kΩ |
| **USB Switches (NO1, NO2)** | | | | | | |
| Analog Signal Range, $V_{ANALOG}$ | $V_{DD}$ = 3.6V, IN = 1.4V, CTRL = 1.4V | Full | 0 | - | $V_{DD}$ | V |
| ON Resistance, $R_{ON}$ | $V_{DD}$ = 3.6V, IN = 1.4V, CTRL = 1.4V, $I_{COMx}$ = 40mA, $V_{NOx}$ = 0V to 400mV (See Figure 4) | 25 | - | 4.6 | 5 | Ω |
| | | Full | - | - | 6.5 | Ω |
| $R_{ON}$ Matching Between Channels, $\Delta R_{ON}$ | $V_{DD}$ = 3.6V, IN = 1.4V, CTRL = 1.4V, $I_{COMx}$ = 40mA, $V_{NOx}$ = Voltage at max $R_{ON}$, (Note 8) | 25 | - | 0.06 | 0.5 | Ω |
| | | Full | - | - | 0.55 | Ω |
| $R_{ON}$ Flatness, $R_{FLAT(ON)}$ | $V_{DD}$ = 3.6V, IN = 1.4V, CTRL = 1.4V, $I_{COMx}$ = 40mA, $V_{NOx}$ = 0V to 400mV, (Note 7) | 25 | - | 0.4 | 0.6 | Ω |
| | | Full | - | - | 1.0 | Ω |

**Electrical Specifications - 2.7V to 3.6V Supply** Test Conditions: $V_{DD}$ = +3.3V, GND = 0V, $V_{INH}$ = 1.4V, $V_{INL}$ = 0.5V, $V_{CTRLH}$ = 1.4V, $V_{CTRLL}$ = 0.5V, (Notes 4, 6), unless otherwise specified. **(Continued)**

| PARAMETER | TEST CONDITIONS | TEMP (°C) | (NOTE 5) MIN | TYP | (NOTE 5) MAX | UNITS |
|---|---|---|---|---|---|---|
| OFF Leakage Current, $I_{NOx(OFF)}$ | $V_{DD}$ = 3.6V, IN = 0V, CTRL = 3.6V, $V_{COMx}$ = 0.5V, 0V, $V_{NOx}$ = 0V, 0.5V, $V_{NCx}$ = float | 25 | -10 | - | 10 | nA |
| | | Full | -70 | - | 70 | nA |
| ON Leakage Current, $I_{NOx}$ | $V_{DD}$ = 3.3V, IN = 3.3V, CTRL = 0V or 3.3V, $V_{NOx}$ = 2.0V, $V_{COMx}$ , $V_{NCx}$ = float | 25 | -10 | 2 | 10 | nA |
| | | Full | -75 | - | 75 | nA |
| **DYNAMIC CHARACTERISTICS** | | | | | | |
| Turn-ON Time, $t_{ON}$ | $V_{DD}$ = 2.7V, $R_L$ = 50Ω, $C_L$ = 10pF, (See Figure 1) | 25 | - | 67 | - | ns |
| Turn-OFF Time, $t_{OFF}$ | $V_{DD}$ = 2.7V, $R_L$ = 50Ω, $C_L$ = 10pF, (See Figure 1) | 25 | - | 48 | - | ns |
| Break-Before-Make Time Delay, $t_D$ | $V_{DD}$ = 2.7V, $R_L$ = 50Ω, $C_L$ = 10pF, (See Figure 2) | 25 | - | 18 | - | ns |
| Skew, $t_{SKEW}$ | $V_{DD}$ = 3.3V, IN = 3.3V, CTRL = 3.3V, $R_L$ = 45Ω, $C_L$ = 10pF, $t_R$ = $t_F$ = 750ps at 480Mbps, (Duty Cycle = 50%) (See Figure 7) | 25 | - | 50 | - | ps |
| Total Jitter, $t_J$ | $V_{DD}$ = 3.3V, IN = 3.3V, CTRL = 3.3V, $R_L$ = 45Ω, $C_L$ = 10pF, $t_R$ = $t_F$ = 750ps at 480Mbps | 25 | - | 210 | - | ps |
| Propagation Delay, $t_{PD}$ | $V_{DD}$ = 3.3V, IN = 3.3V, CTRL = 3.3V, $R_L$ = 45Ω, $C_L$ = 10pF, (See Figure 7) | 25 | - | 250 | - | ps |
| Crosstalk (Channel-to-Channel), NC2 to COM1, NC1 to COM2 | $V_{DD}$ = 3.3V, IN = 0V, CTRL = 3.3V, $R_L$ = 75Ω, f = 4MHz, $V_{NCx}$ = 300m$V_{P-P}$, (See Figure 6) | 25 | - | -78 | - | dB |
| Differential Gain | $V_{SIGNAL}$ = 300mVp-p, $V_{OFFSET}$ = 0V to 0.7V, f = 3.58MHz, $R_L$ = 75 | 25 | - | 0.28 | - | % |
| Differential Phase | $V_{SIGNAL}$ = 300mVp-p, $V_{OFFSET}$ = 0V to 0.7V, f = 3.58MHz, $R_L$ = 75 | 25 | - | 0.04 | - | deg |
| Total Harmonic Distortion | f = 20Hz to 20kHz, $V_{DD}$ = 3.0V, IN = 0V, CTRL = 3.0V, $V_{NCx}$ = 0.707$V_{RMS}$ (2$V_{P-P}$), $R_L$ = 32Ω | 25 | - | 0.06 | - | % |
| NCx (Audio/Video) Switch -3dB Bandwidth | Signal = 8dBm, $R_L$ = 75Ω, $C_L$ = 5pF, (See Figure 14) | 25 | - | 338 | - | MHz |
| NOx (USB) Switch -3dB Bandwidth | Signal = 0dBm, 0.2$V_{DC}$ offset, $R_L$ = 50Ω, $C_L$ = 5pF | 25 | - | 630 | - | MHz |
| NOx OFF Capacitance, $C_{NOx(OFF)}$ | f = 1MHz, $V_{DD}$ = 3.0V, IN = 0V, CTRL = 3.0V, $V_{NOx}$ = $V_{COMx}$ = 0V, (See Figure 5) | 25 | - | 6 | - | pF |
| NCx OFF Capacitance, $C_{NCx(OFF)}$ | f = 1MHz, $V_{DD}$ = 3.0V, IN = 3.0V, CTRL = 3.0V, $V_{NCx}$ = $V_{COMx}$ = 0V, (See Figure 5) | 25 | - | 9 | - | pF |
| COMx ON Capacitance, $C_{COMx(ON)}$ | f = 1MHz, $V_{DD}$ = 3.0V, IN = 3.0V, CTRL = 3.0V, $V_{NOx}$ = $V_{COMx}$ = 0V, (See Figure 5) | 25 | - | 10 | - | pF |
| **POWER SUPPLY CHARACTERISTICS** | | | | | | |
| Power Supply Range, $V_{DD}$ | | Full | 1.8 | | 5.5 | V |
| Positive Supply Current, $I_{DD}$ | $V_{DD}$ = 3.6V, IN = 0V or 3.6V, CTRL = 3.6V | 25 | - | 6 | 8 | µA |
| | | Full | - | - | 10 | µA |
| Positive Supply Current, $I_{DD}$ (Low Power State) | $V_{DD}$ = 3.6V, IN = 0V, CTRL = 0V or float | 25 | - | 1 | 7 | nA |
| | | Full | - | - | 140 | nA |
| **DIGITAL INPUT CHARACTERISTICS** | | | | | | |
| Voltage Low, $V_{INL}$, $V_{CTRLL}$ | $V_{DD}$ = 2.7V to 3.6V | Full | - | - | 0.5 | V |
| Voltage High, $V_{INH}$ , $V_{CTRLH}$ | $V_{DD}$ = 2.7V to 3.6V | Full | 1.4 | - | - | V |
| Input Current, $I_{INL}$, $I_{CTRLL}$ | $V_{DD}$ = 3.6V, IN = 0V, CTRL = 0V | Full | -50 | 20 | 50 | nA |
| Input Current, $I_{INH}$ | $V_{DD}$ = 3.6V, IN = 3.6V, CTRL = 0V | Full | -50 | 20 | 50 | nA |

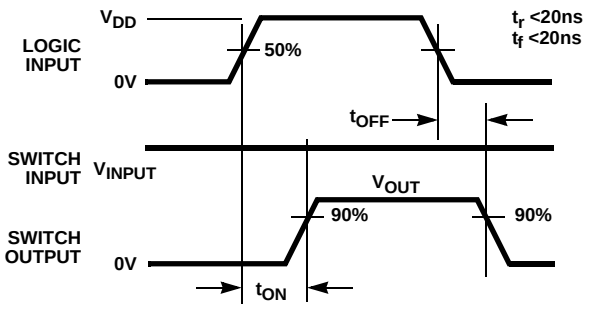
**Electrical Specifications - 2.7V to 3.6V Supply** Test Conditions: $V_{DD}$ = +3.3V, GND = 0V, $V_{INH}$ = 1.4V, $V_{INL}$ = 0.5V, $V_{CTRLH}$ = 1.4V, $V_{CTRLL}$ = 0.5V, (Notes 4, 6), unless otherwise specified. **(Continued)**

| PARAMETER | TEST CONDITIONS | TEMP (°C) | (NOTE 5) MIN | TYP | (NOTE 5) MAX | UNITS |
|---|---|---|---|---|---|---|
| Input Current, $I_{CTRLH}$ | $V_{DD}$ = 3.6V, IN = 0V, CTRL = 3.6V | Full | -2 | 1.1 | 2 | µA |
| CTRL Pull-Down Resistor, $R_{CTRL}$ | $V_{DD}$ = 3.6V, IN = 0V, CTRL = 3.6V | Full | - | 4 | - | MΩ |

NOTES:

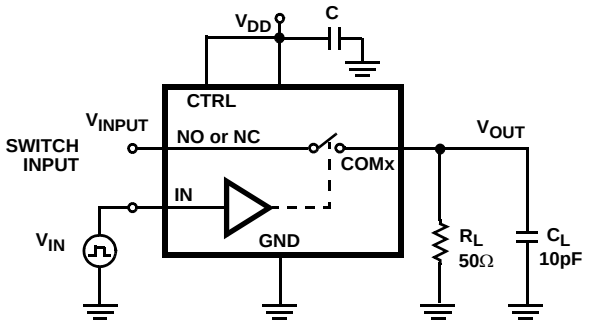
4. $V_{LOGIC}$ = Input voltage to perform proper function.
5. The algebraic convention, whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
6. Parameters with limits are 100% tested at +25°C**.** Limits across the full temperature range are guaranteed 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. $R_{ON}$ 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 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.

$$V_{OUT} = V_{(INPUT)} \frac{R_L}{R_L + R_{(ON)}}$$

**FIGURE 1B. TEST CIRCUIT**

**FIGURE 1. SWITCHING TIMES**

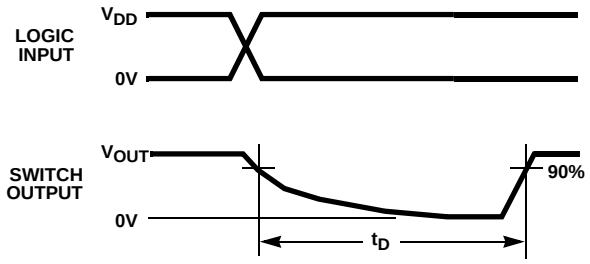
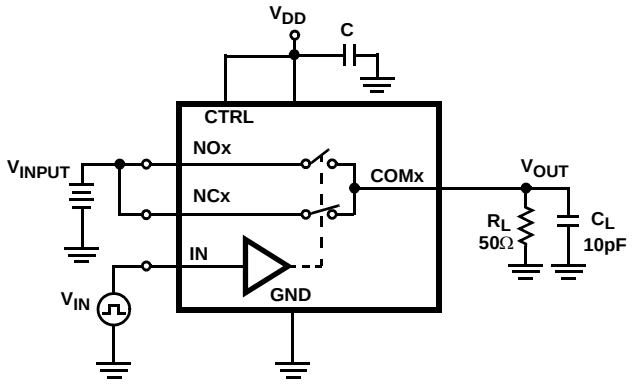



**FIGURE 2A. MEASUREMENT POINTS**

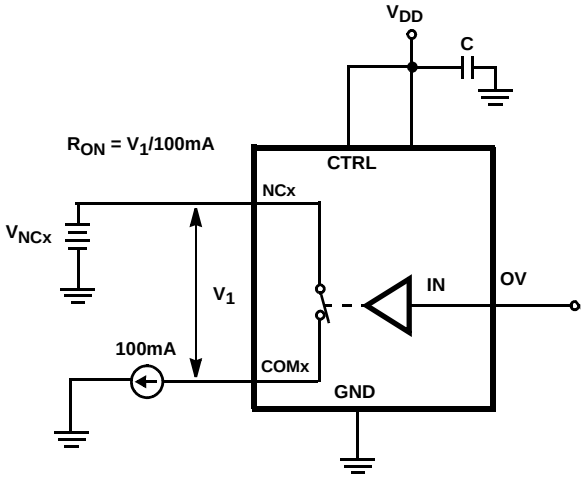



Repeat test for all switches. $C_L$ includes fixture and stray capacitance.

**FIGURE 2B. TEST CIRCUIT**

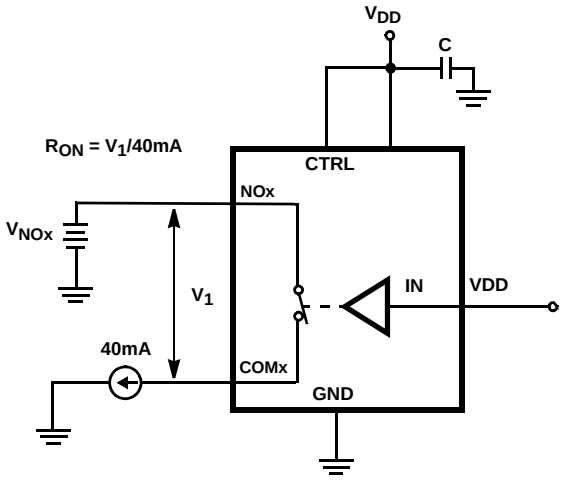
**FIGURE 2. BREAK-BEFORE-MAKE TIME**

## Test Circuits and Waveforms (Continued)



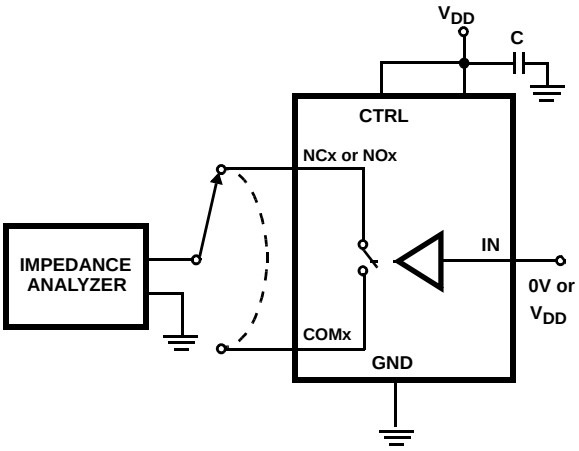

Repeat test for all switches.

**FIGURE 3. AUDIO/VIDEO $R_{ON}$ TEST CIRCUIT**



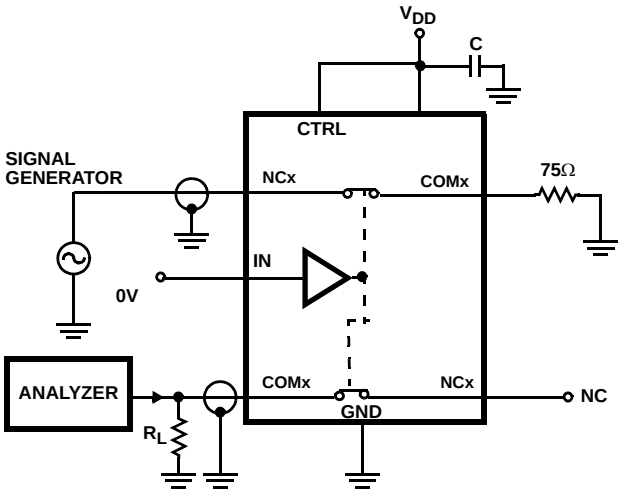

Repeat test for all switches.

**FIGURE 4. USB $R_{ON}$ TEST CIRCUIT**




Repeat test for all switches.

**FIGURE 5. CAPACITANCE TEST CIRCUIT**




Signal direction through switch is reversed, worst case values are recorded. Repeat test for all switches.

**FIGURE 6. NCx CROSSTALK TEST CIRCUIT**

## Test Circuits and Waveforms (Continued)

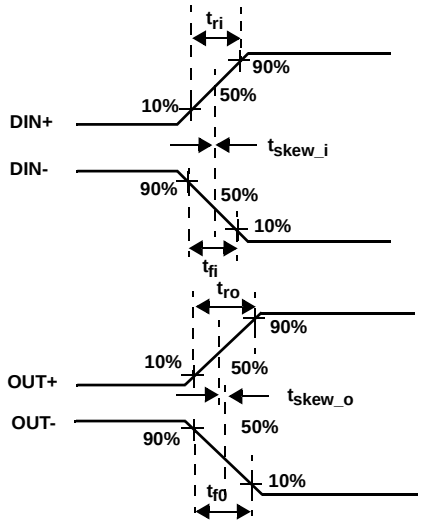
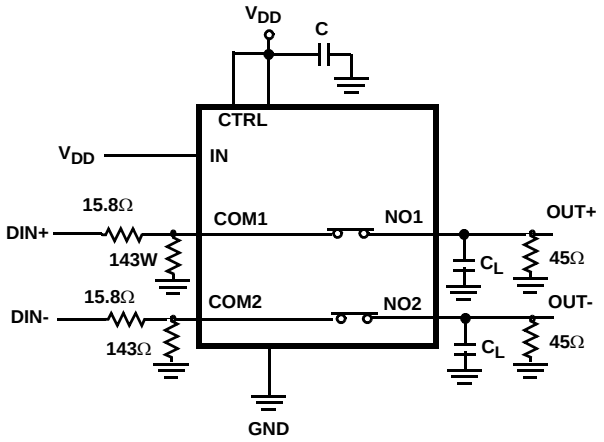



FIGURE 7A. MEASUREMENT POINTS

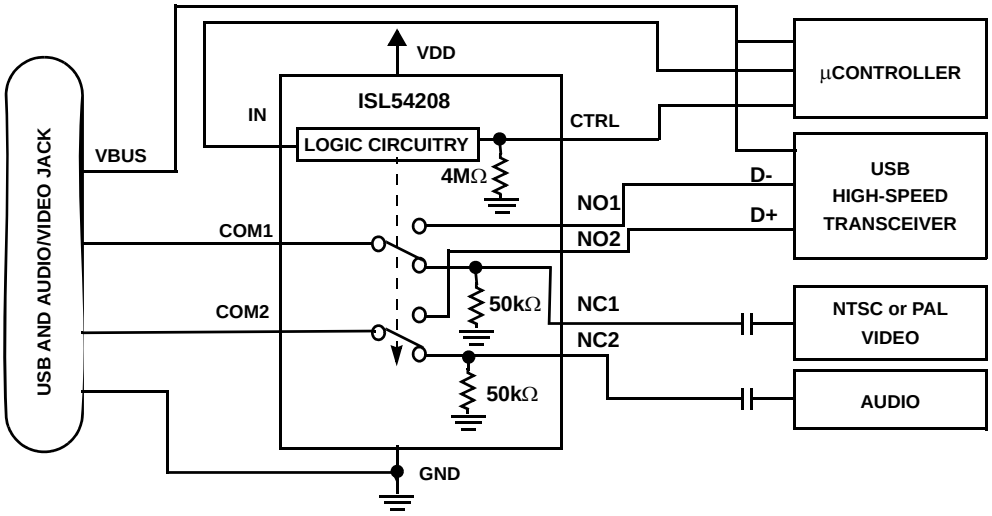



|tro - tri| Delay Due to Switch for Rising Input and Rising Output Signals.
|tfo - tfi| Delay Due to Switch for Falling Input and Falling Output Signals.
|tskew_0| Change in Skew through the Switch for Output Signals.
|tskew_i| Change in Skew through the Switch for Input Signals.

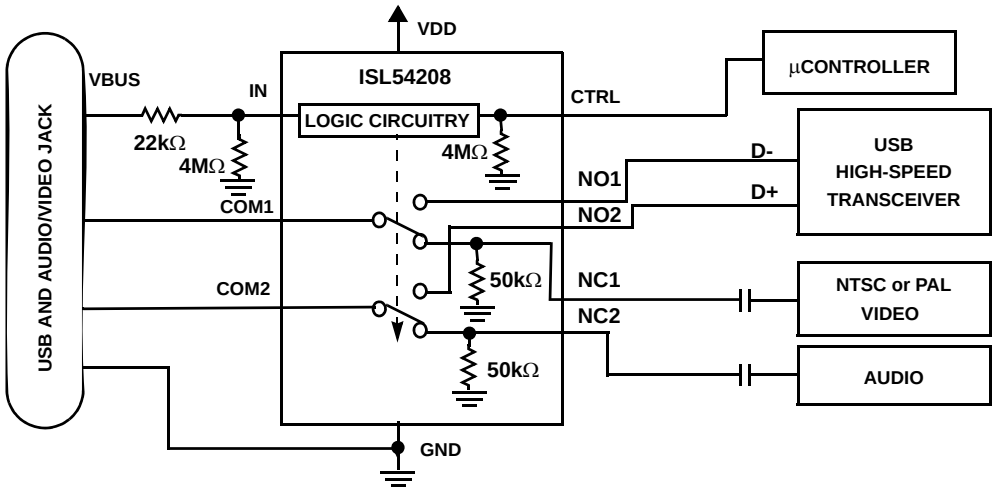
FIGURE 7B. TEST CIRCUIT

FIGURE 7. SKEW TEST

## Application Block Diagrams




LOGIC CONTROL VIA MICRO-PROCESSOR




LOGIC CONTROL VIA VBUS VOLTAGE FROM COMPUTER OR USB HUB

## Detailed Description

The ISL54208 device is a dual single pole/double throw (SPDT) analog switch device that can operate from a single dc power supply in the range of 1.8V to 5.5V. It was designed to function as a dual 2 to 1 multiplexer to select between USB differential data signals and mono audio/composite video baseband signals (CVBS). It comes in tiny μTQFN and TDFN packages for use in cameras, camcorders, video MP3 players, PDAs, cell phones, and other personal media players.

The part consists of two 3Ω audio/video switches and two 5Ω 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 high-speed USB differential data signals with minimal edge and phase distortion.

The ISL54208 was specifically designed for digital cameras, camcorders, MP3 players, cell phones 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. Typical application block diagrams of this functionality is shown above.

The ISL54208 logic control pins are 1.8V logic compatible and can be driven by a standard μcontroller. It has a single logic control pin (IN) that selects between the audio/video switches and the USB switches. The ISL54208 also contains a logic control pin (CTRL) that when driven Low while IN is Low, opens all switches and puts the part into a low power state, drawing typically 1nA of $I_{DD}$ current.

A detailed description of the two types of switches is provided in the sections below. The USB transmission 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 3Ω switches that can pass signals that swing below ground by as much as 1.5V. They were designed to pass ground reference audio signals and dc restored composite base-band signals (CVBS) including negative synchronizing pulse with minimal insertion loss and very low distortion and degradation.

The -3dB bandwidth into 75Ω is 338MHz (Figure 17). Crosstalk between NC1 and NC2 @ 4MHz is -78dB (Figure 16) 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 (0.707Vrms) with $V_{DD}$ >2.7V, these switches have an extremely low $r_{ON}$ resistance variation. They can pass a ground referenced audio signal with very low distortion (<0.06% THD+N) when delivering 15.6mW into a 32Ω headphone speaker load. See Figures 10, 11, 12, and 13 THD+N performance curves.

Figures 8 and 9 shows the vector scope plots of a standard NTSC color bar signal at both the input (Figure 8) and output (Figure 9) of the ISL54208. The plots show that except for a little attentuation, due to switch $R_{ON}$ and test fixture cabling, there is virtually no degradation of the video waveform through the switch.

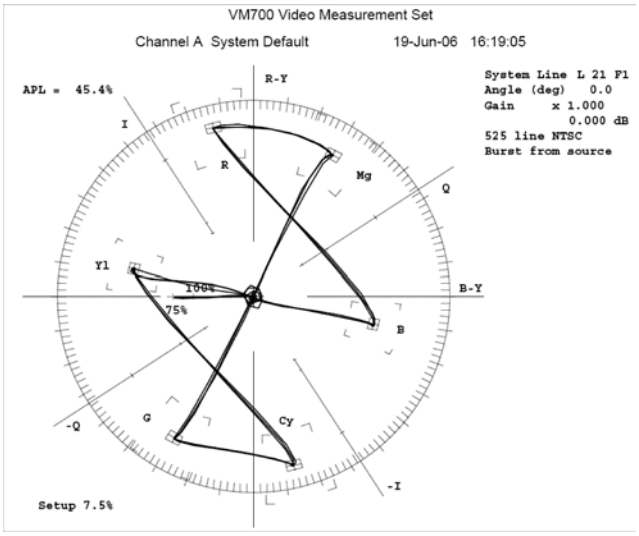



**FIGURE 8. VECTOR-SCOPE PLOT BEFORE SWITCH**

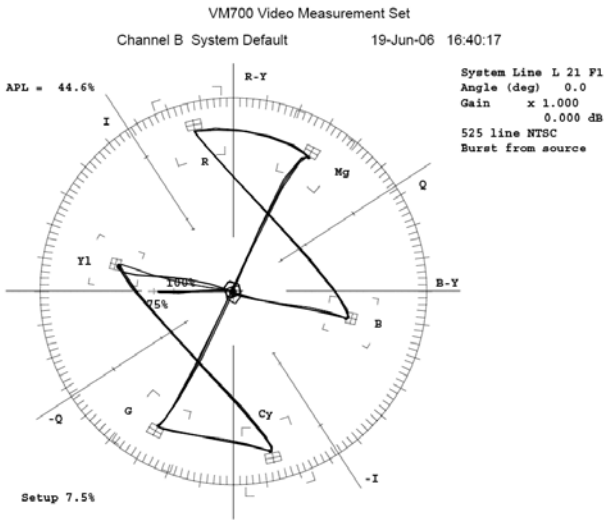



**FIGURE 9. VECTOR-SCOPE PLOT AFTER SWITCH**

Figure 18 shows the differential gain (DG) and differential phase (DP) plots at the output of the switch using an actual NTSC composite video signal and a VM700A Video Measurement Test Set. DG = 0.28% and DP = 0.04deg.

The 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).

The NC switches are active (turned ON) whenever the IN voltage is ≤ to 0.5V and the CTRL voltage to ≥1.4V.

Note: Whenever the NC switches are ON the USB transceiver drivers need to be in the high impedance state or static high or low state.

### NO1 and NO2 USB Switches

The two NO (normally open) USB switches (NO1, NO2) are 5Ω bidirectional switches that were designed to pass high-speed USB differential signals in the range of ±0V to 400mV. These switches have low capacitance and high bandwidth to pass USB high-speed signals (480Mbps) with minimum edge and phase distortion to meet high-speed USB 2.0 high-speed signal quality specifications. See Figure 14 for High-speed Eye Pattern taken with switch in the signal path.

The maximum signal range for the USB switches is from -1.5V to $V_{DD}$. The signal voltage at NO1 and NO2 should not be allow to exceed the $V_{DD}$ voltage rail or go below ground by more than -1.5V.

The NO switches are active (turned ON) whenever the IN voltage is to ≥1.4V.

Note: Whenever the NO 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.

## ISL54208 Operation

The discussion that follows will discuss using the ISL54208 in the typical application shown in the block diagrams on page 8.

### VDD SUPPLY

The dc power supply connected at VDD (pin 1) provides the required bias voltage for proper switch operation. The part can operate with a supply voltage in the range of 1.8V to 5.5V.

In a typical USB/Audio/Video application for portable battery powered devices the $V_{DD}$ voltage will come from a battery or an LDO and be in the range of 2.7V to 3.6V. For best possible USB full-speed operation (12Mbps) it is recommended that the VDD voltage be ≥3.3V in order to get a USB data signal level above 2.5V.

### LOGIC CONTROL

The state of the ISL54208 device is determined by the voltage at the IN pin (pin 2) and the CTRL pin (pin 10). Refer to truth-table on page 2 of data sheet. These logic pins are 1.8V compatible with $V_{DD}$ in the range of 2.7V to 3.6V and can be controlled by a standard µprocessor.

The CTRL pin is internally pulled low through a 4MΩ resistors to ground and can be left floating or tri-stated by the µprocessor. The CTRL control pin is only active when IN is logic “0”.

The IN pin does not have an internal pull-down resistor and must not be allowed to float. It must be driven High or Low.

The voltage at the IN pin can exceed the $V_{DD}$ voltage by as much as 2.55V. This allows the VBUS voltage from a computer or USB hub (4.4V to 5.25V) to drive the IN pin while the $V_{DD}$ voltage is in the range of 2.7V to 3.6V. An external pull-down resistor is required from the IN pin to ground when directly driving the IN pin with the computer VBUS voltage. See the section titled “USING THE COMPUTER VBUS VOLTAGE TO DRIVE THE “IN’ PIN”.

**Logic control voltage levels:**

IN = Logic “0” (Low) when ≤0.5V
IN = Logic “1” (High) when IN ≥1.4V
CTRL = Logic “0” (Low) when ≤0.5V or floating.
CTRL = Logic “1” (High) when ≥1.4V

**Audio/Video Mode**

If the IN pin = Logic “0” and CTRL pin = Logic “1,” the part will be in the Audio/Video mode. In Audio/Video mode the NC1 and NC2 3Ω audio/video switches are ON and the NO1 and NO2 5Ω USB switches are OFF (high impedance).

When nothing is plugged into the common connector or a audio/video jack is plugged into the common connector, the µprocessor will sense that there is no voltage at the VBUS pin of the connector and will drive and hold the IN control pin of the ISL54208 low. As long as the CTRL = Logic “1,” the ISL54208 part will be in the audio/video mode and the media player audio and video drivers can drive the speaker and video display.

**USB Mode**

If the IN pin = Logic “1” and CTRL pin = Logic “0” or Logic “1” the part will go into USB mode. In USB mode, the NO1 and NO2 5Ω switches are ON and the NC1 and NC2 3Ω audio/video switches are OFF (high impedance).

When a USB cable from a computer or USB hub is connected at the common connector, the µprocessor will sense the present of the 5V VBUS and drive the IN pin voltage high. The ISL54208 part 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 transmitted back and forth.

When the USB cable is disconnected, the µprocessor will sense that the 5V VBUS voltage is no longer connected and will drive the IN pin low and put the part back into the Audio/Video or Low Power Mode.

**Low Power Mode**

If the IN pin = Logic “0” and CTRL pin = Logic “0,” the part will be in the Low Power mode. In the Low Power mode, the NCx switches and the NOx switches are OFF (high impedance). In this state, the device draws typically 1nA of current.

### USING THE COMPUTER VBUS VOLTAGE TO DRIVE THE “IN” PIN

**External IN Pull-Down Resistor**

Rather than using a micro-processor to control the IN logic pin you can directly drive the IN pin using the VBUS voltage from the computer or USB hub. In order to do this you must connected an external pull-down resistor from the IN pin to ground.

When an audio/video jack or nothing is connected at the common connector the external pull-down resistor will pull the IN pin low putting the ISL54208 in the Audio/Video Mode or Low Power Mode depending on the condition of the CTRL pin.

When a USB cable is connected at the common connector the voltage at the IN pin will be driven to 5V and the part will automatically go into the USB mode.

When the USB cable is disconnected from the common connector the voltage at the IN pin will be pulled low by the pull-down resistor and return to the Audio/Video Mode or Low Power Mode depending on the condition of the CTRL pin.

Note: The voltage at the IN pin can exceed the VDD voltage by as much as 2.55V. This allows the VBUS voltage from a computer or USB hub (4.4V to 5.25V) to drive the IN pin while the $V_{DD}$ voltage is in the range of 2.7V to 3.6V.

### EXTERNAL SERIES RESISTOR AT IN LOGIC CONTROL PIN

The ISL54208 contains a clamp circuit between IN and VDD. Whenever the IN voltage is greater than the $V_{DD}$ voltage by more than 2.55V, current will flow through this clamp circuitry into the $V_{DD}$ power supply bus.

During normal USB operation, $V_{DD}$ is in the range of 2.7V to 3.6V and IN ($V_{BUS}$ voltage from computer or USB hub) is in the range of 4.4V to 5.25V, the clamp circuit is not active and no current will flow through the clamp into the $V_{DD}$ supply.

In a USB application, the situation can exist where the $V_{BUS}$ voltage from the computer could be applied at the IN pin before the $V_{DD}$ voltage is up to its normal operating voltage range and current will flow through the clamp into the $V_{DD}$ power supply bus. This current could be quite high when $V_{DD}$ is OFF or at 0V and could potentially damage other components connected in the circuit. In the application circuit, a 22kΩ resistor has been put in series with the IN pin to limit the current to a safe level during this situation.

It is recommended that a current limiting resistor in the range of 10kΩ to 50kΩ be connected in series with the IN pin. It will have minimal impact on the logic level at the IN pin during normal USB operation and protect the circuit during the time $V_{BUS}$ is present before $V_{DD}$ is up to its normal operating voltage.

Note: No external resistor is required in applications where IN pin voltage will not exceed $V_{DD}$ by more than 2.55V.

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

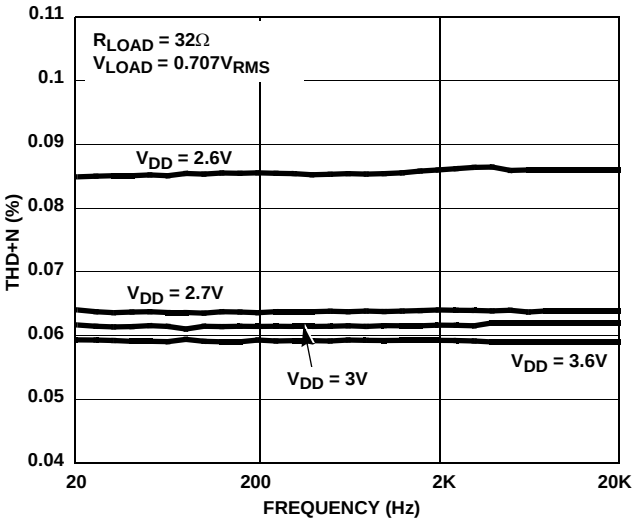



**FIGURE 10. THD+N vs SUPPLY VOLTAGE vs FREQUENCY**

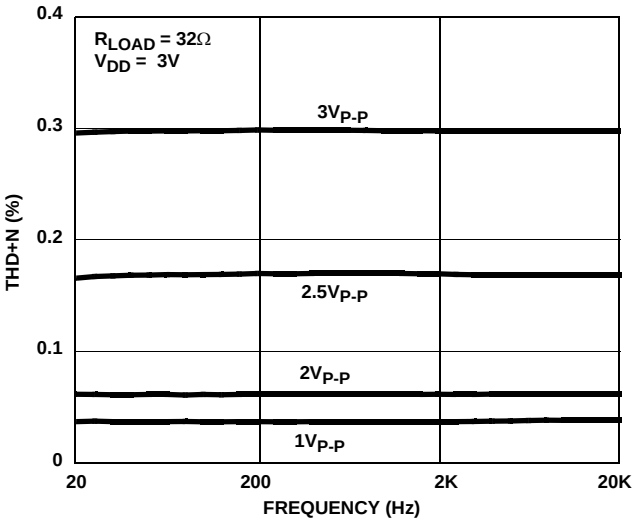



**FIGURE 11. THD+N vs SIGNAL LEVELS vs FREQUENCY**

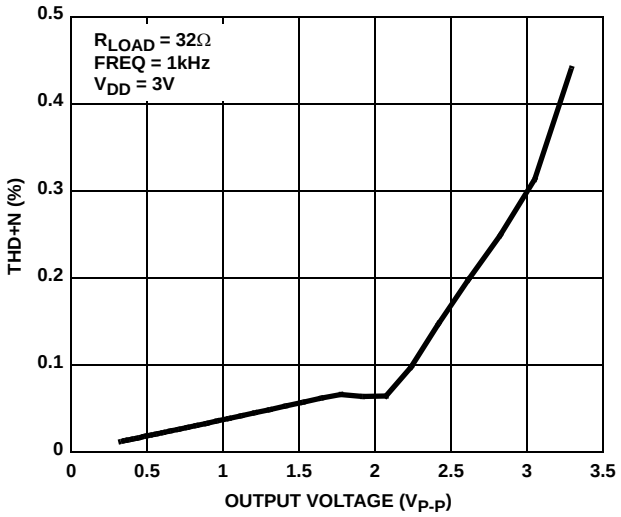



**FIGURE 12. THD+N vs OUTPUT VOLTAGE**

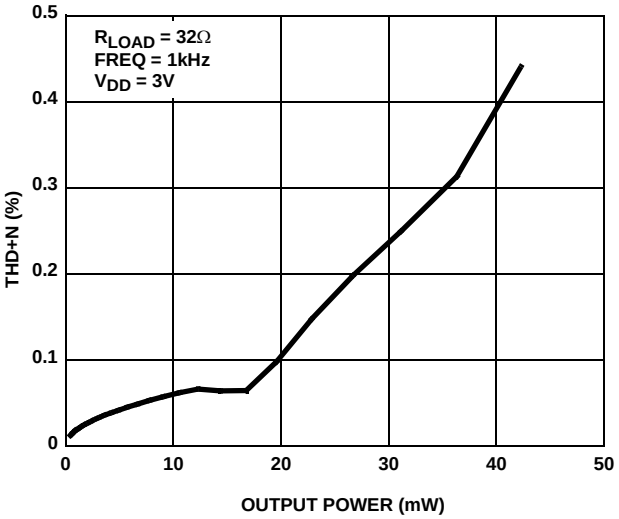



**FIGURE 13. THD+N vs OUTPUT POWER**

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

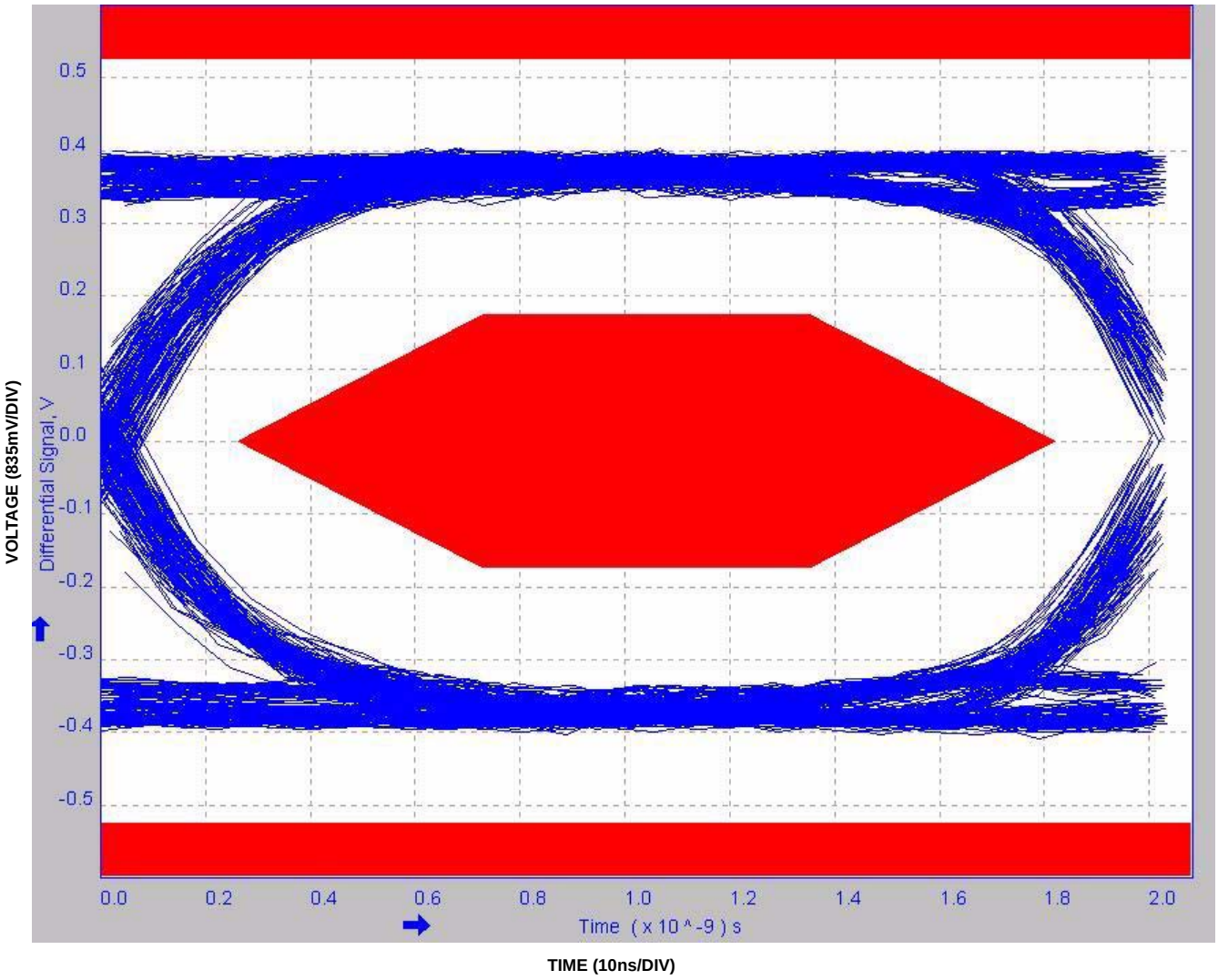



**FIGURE 14. EYE PATTERN: 480Mbps WITH NOx SWITCHES IN THE SIGNAL PATH**

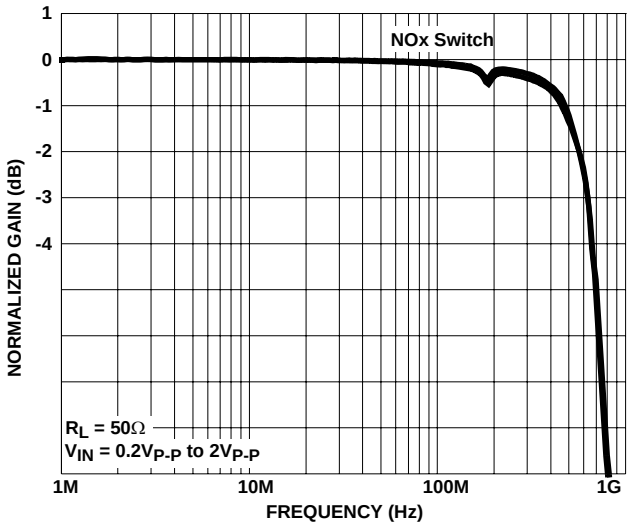



**FIGURE 15. FREQUENCY RESPONSE**

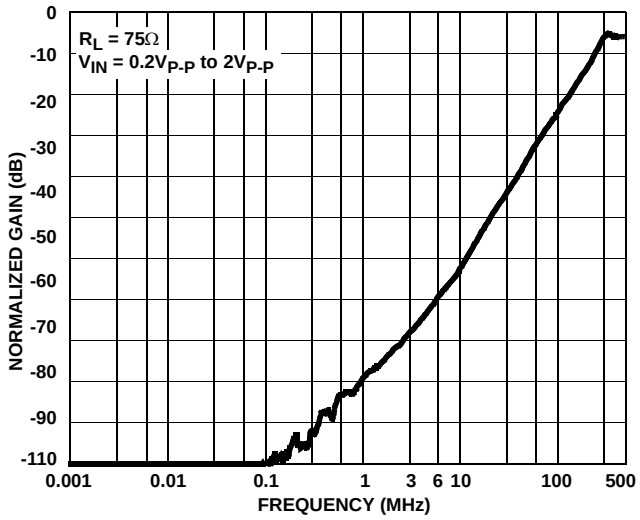



**FIGURE 16. VIDEO TO AUDIO CROSSTALK**

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

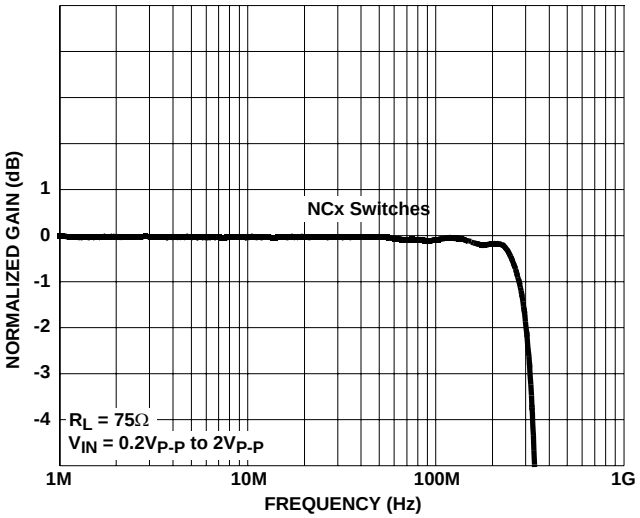



**FIGURE 17.**

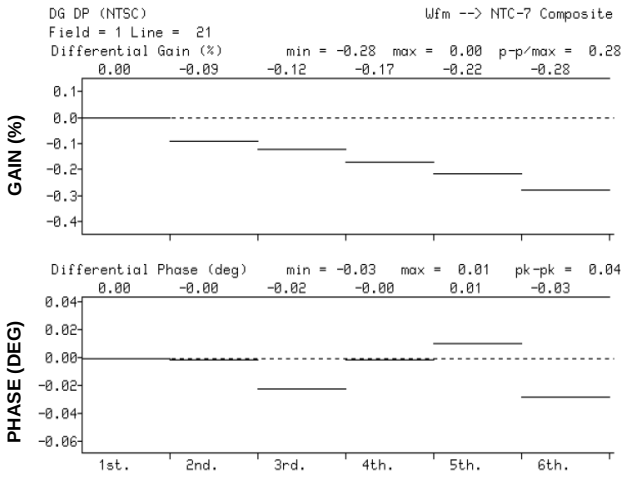



**FIGURE 18.**

## Die Characteristics

**SUBSTRATE POTENTIAL (POWERED UP):**

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

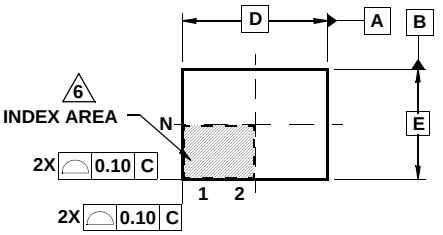
**TRANSISTOR COUNT:**

98

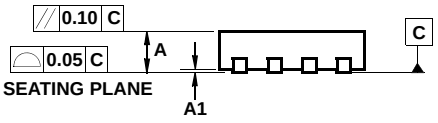
**PROCESS:**

Submicron CMOS

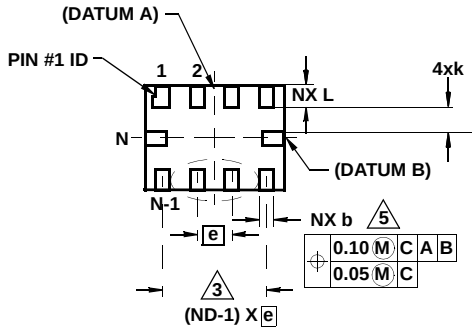
## Ultra Thin Quad Flat No-Lead Plastic Package (UTQFN)



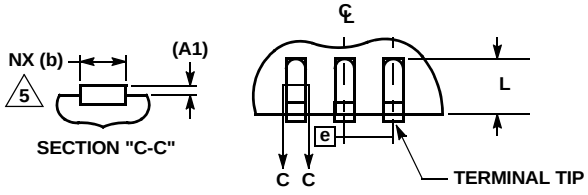

TOP VIEW



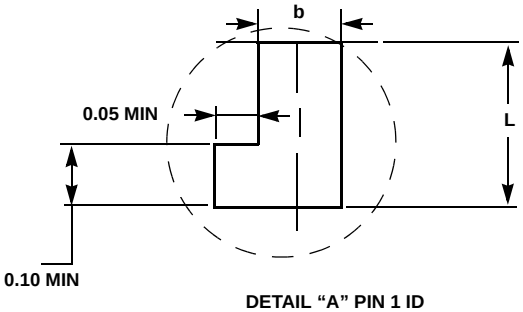

SIDE VIEW




BOTTOM VIEW




FOR ODD TERMINAL/SIDE




DETAIL “A” PIN 1 ID

### L10.2.1x1.6A

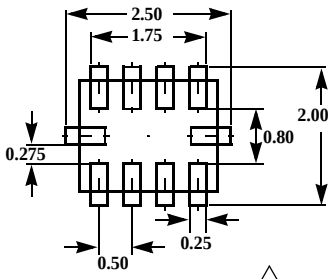
**10 LEAD ULTRA THIN QUAD FLAT NO-LEAD PLASTIC PACKAGE**

| 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

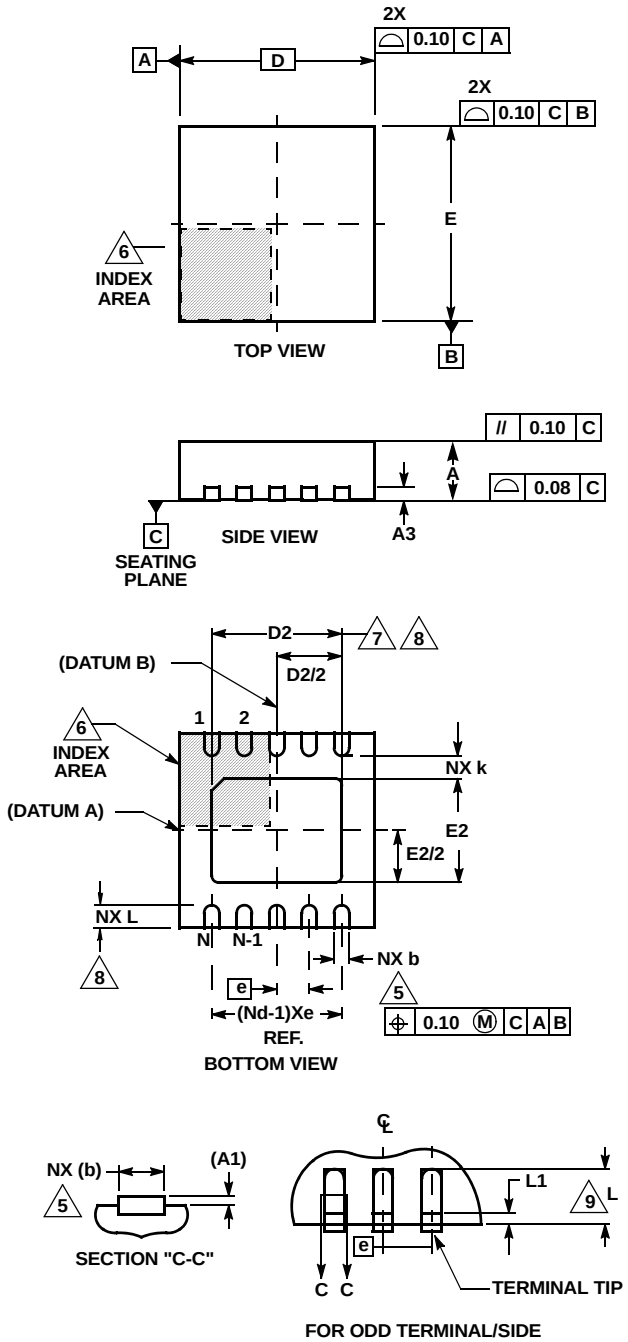
NOTES:

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.