

# ISL54227

High-Speed USB 2.0 (480Mbps) DPST Switch with Overvoltage Protection (OVP) and Dedicated Charger Port Detection

FN7593  
Rev 1.00  
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The Intersil ISL54227 is a single supply, dual SPST (Single Pole/Single Throw) switch that is configured as a DPST. It can operate from a single 2.7V to 5.25V supply. The part was designed for switching or isolating a USB high-speed source or a USB high-speed and full-speed source in portable battery powered products.

The 3.5Ω SPST switches were specifically designed to pass USB full speed and USB high speed data signals. They have high bandwidth and low capacitance to pass USB high speed data signals with minimal distortion. The device has two logic control input pins (OE and LP) to control the SPST switches.

The ISL54227 has OVP detection circuitry on the COM pins to open the SPST switches when the voltage at these pins exceeds 3.8V or goes negative by -0.45V. It isolates fault voltages up to +5.25V or down to -5V from getting passed to the other side of the switch, thereby protecting the USB downstream transceiver. It has an alarm indicator output pin (ALM) to indicate when the part is in the overvoltage condition.

The part has an interrupt ( $\overline{\text{INT}}$ ) output pin to indicate a 1-to-1 (high/high) state on the COM lines to inform the  $\mu$ processor when entering a dedicated charging port mode of operation.

The ISL54227 is available in 10 Ld 1.8mmx1.4mm  $\mu$ TQFN and 10 Ld 3mmx3mm TDFN packages. It operates over a temperature range of -40°C to +85°C.

## Features

- High-speed (480Mbps) and full-speed (12Mbps) signaling capability per USB 2.0
- 1.8V logic compatible (2.7V to +3.6V supply)
- Alarm overvoltage indicator output
- Charger interrupt indicator output
- Low power state
- Power OFF protection
- COM pins overvoltage detection and protection for +5.25V and -5V fault voltages
- -3dB Frequency. . . . . 790MHz
- Low ON capacitance @ 240MHz. . . . . 2pF
- Low ON-resistance . . . . . 3.5Ω
- Single supply operation ( $V_{DD}$ ). . . . . 2.7V to 5.25V
- Available in  $\mu$ TQFN and TDFN packages
- Pb-Free (RoHS compliant)
- Compliant with USB 2.0 short circuit and overvoltage requirements without additional external components

## Applications

- MP3 and other Personal Media Players
- Cellular/Mobile Phones, PDA's
- Digital Cameras and Camcorders
- USB Switching

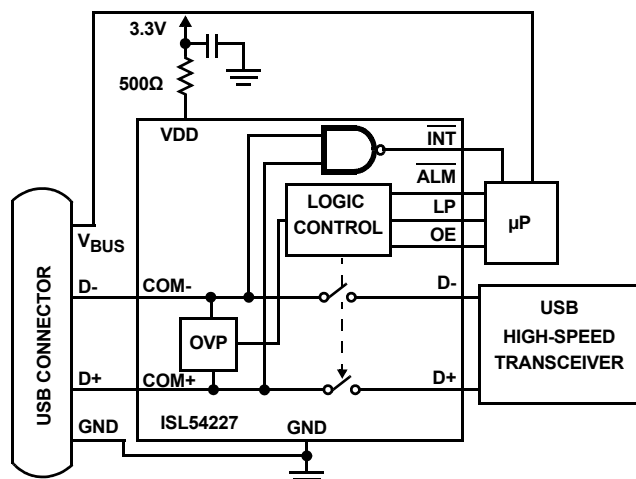


FIGURE 1. TYPICAL APPLICATION

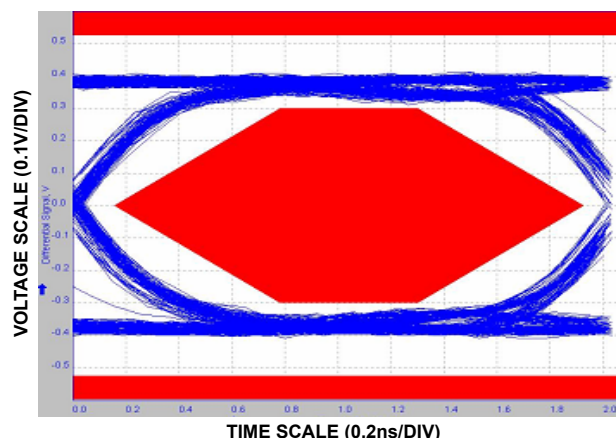
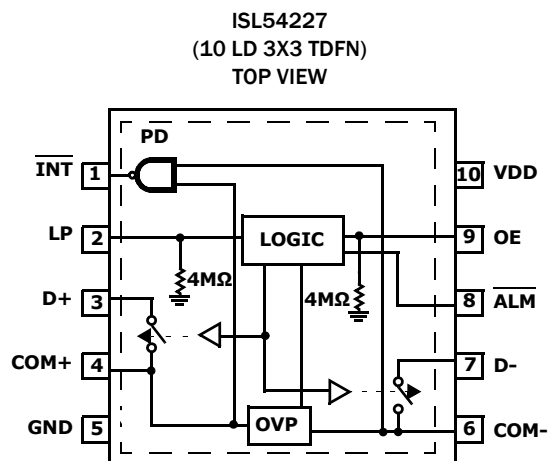
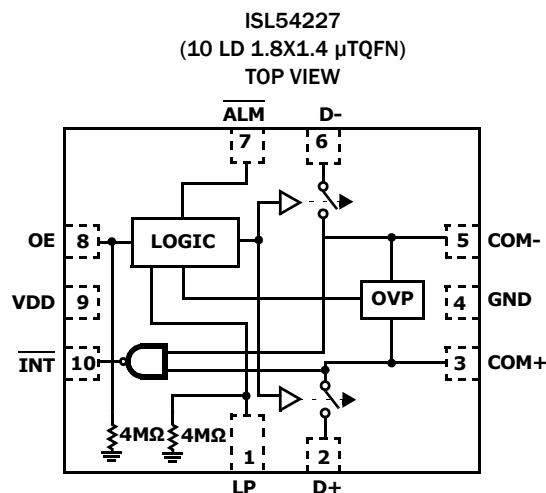


FIGURE 2. USB 2.0 HS EYE PATTERN WITH SWITCHES IN THE SIGNAL PATH

## Pin Configurations



NOTE:

1. Switches Shown for OE = "0".

## Pin Descriptions

| $\mu$ TQFN | TDFN | PIN NAME | DESCRIPTION                         |
|------------|------|----------|-------------------------------------|
| 1          | 2    | LP       | Low Power Input                     |
| 2          | 3    | D+       | USB Data Port                       |
| 3          | 4    | COM+     | USB Data Port                       |
| 4          | 5    | GND      | Ground Connection                   |
| 5          | 6    | COM-     | USB Data Port                       |
| 6          | 7    | D-       | USB Data Port                       |
| 7          | 8    | ALM      | OVP ALARM Interrupt Output          |
| 8          | 9    | OE       | Switch Enable                       |
| 9          | 10   | VDD      | Power Supply                        |
| 10         | 1    | INT      | Charger Mode Interrupt Output       |
| -          | PD   | PD       | Thermal Pad. Tie to Ground or Float |

## Truth Table

| INPUT                                                |    |    | OUTPUT |      |      |                          |
|------------------------------------------------------|----|----|--------|------|------|--------------------------|
| SIGNAL AT COM PINS                                   | LP | OE | D-, D+ | INT  | ALM  | STATE                    |
| 0V to 3.6V                                           | 0  | 0  | OFF    | High | High | Normal                   |
| 0V to 3.6V                                           | 0  | 1  | ON     | High | High | Normal                   |
| 0V to 3.6V                                           | 1  | 0  | OFF    | High | High | Low Power                |
| Overvoltage Range<br>3.65V to 5.25V<br>-0.29V to -5V | 0  | 1  | OFF    | High | Low  | OVP                      |
| COM Pins Tied Together                               | 0  | 0  | OFF    | Low  | High | Charger Port (CP)        |
| COM Pins Tied Together                               | 1  | 0  | OFF    | Low  | High | Charger Port (Low Power) |

Logic "0" when  $\leq 0.5V$ , Logic "1" when  $\geq 1.4V$  with a 2.7V to 3.6V Supply.

TABLE 1. OVP TRIP POINT VOLTAGE

| SYSTEM VOLTAGE CONDITIONS |                            |                 |           | TRIP POINT |        |
|---------------------------|----------------------------|-----------------|-----------|------------|--------|
| CODEC SUPPLY              | SWITCH SUPPLY ( $V_{DD}$ ) | COMs SHORTED TO | PROTECTED | MIN        | MAX    |
| 2.7V to 3.3V              | 2.7V to 5.25V              | VBUS            | Yes       | 3.62V      | 3.95V  |
| 2.7V to 3.3V              | 2.7V to 5.25V              | -5V             | Yes       | -0.6V      | -0.29V |

## Ordering Information

| PART NUMBER<br>(Note 5)       | PART<br>MARKING  | TEMP. RANGE<br>(°C) | PACKAGE<br>(Pb-Free)                         | PKG.<br>DWG. # |
|-------------------------------|------------------|---------------------|----------------------------------------------|----------------|
| ISL54227IRUZ-T (Notes 2, 4)   | U1               | -40 to +85          | 10 Ld 1.8 x 1.4mm $\mu$ TQFN (Tape and Reel) | L10.1.8x1.4A   |
| ISL54227IRUZ-T7A (Notes 2, 4) | U1               | -40 to +85          | 10 Ld 1.8 x 1.4mm $\mu$ TQFN (Tape and Reel) | L10.1.8x1.4A   |
| ISL54227IRTZ (Note 3)         | 4227             | -40 to +85          | 10 Ld 3x3 TDFN                               | L10.3x3A       |
| ISL54227IRTZ-T (Notes 2, 3)   | 4227             | -40 to +85          | 10 Ld 3x3 TDFN (Tape and Reel)               | L10.3x3A       |
| ISL54227IRTZEVAL1Z            | Evaluation Board |                     |                                              |                |

### NOTES:

2. Please refer to [TB347](#) for details on reel specifications.
3. These Intersil Pb-free plastic packaged products employ special Pb-free material sets, molding compounds/die attach materials, and 100% matte tin plate plus anneal (e3 termination finish, which is 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.
4. These Intersil Pb-free plastic packaged products employ special Pb-free material sets; molding compounds/die attach materials and NiPdAu plate - e4 termination finish, which is 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.
5. For Moisture Sensitivity Level (MSL), please see device information page for [ISL54227](#). For more information on MSL please see techbrief [TB363](#).

## Absolute Maximum Ratings

|                                                 |               |
|-------------------------------------------------|---------------|
| VDD to GND                                      | -0.3 to 6.5V  |
| VDD to COMx                                     | 10.5V         |
| COMx to Dx                                      | 8.6V          |
| Input Voltages                                  |               |
| D+, D-                                          | -0.3V to 6.5V |
| COM+, COM-                                      | -5V to 6.5V   |
| OE, LP                                          | -0.3 to 6.5V  |
| Continuous Current (COM-/D-, COM+/D+)           | ±40mA         |
| Peak Current (COM-/D-, COM+/D+)                 |               |
| (Pulsed 1ms, 10% Duty Cycle, Max)               | ±100mA        |
| ESD Rating:                                     |               |
| Human Body Model (Tested per JESD22-A114-F)     | >5.5kV        |
| Machine Model (Tested per JESD22-A115-A)        | >250V         |
| Charged Device Model (Tested per JESD22-C101-D) | >2kV          |
| Latch-up (Tested per JEDEC; Class II Level A)   | at +85°C      |

## Thermal Information

|                                                |                                                                                                                 |                      |
|------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|----------------------|
| Thermal Resistance (Typical)                   | $\theta_{JA}$ (°C/W)                                                                                            | $\theta_{JC}$ (°C/W) |
| 10 Ld $\mu$ TQFN Package (Note 6, 9)           | 210                                                                                                             | 165                  |
| 10 Ld TDFN Package (Notes 7, 8)                | 58                                                                                                              | 22                   |
| Maximum Junction Temperature (Plastic Package) | +150°C                                                                                                          |                      |
| Maximum Storage Temperature Range              | -65°C to +150°C                                                                                                 |                      |
| Pb-Free Reflow Profile                         | see link below                                                                                                  |                      |
|                                                | <a href="http://www.intersil.com/pbfree/Pb-FreeReflow.asp">http://www.intersil.com/pbfree/Pb-FreeReflow.asp</a> |                      |

## Normal Operating Conditions

|                                          |                |
|------------------------------------------|----------------|
| Temperature Range                        | -40°C to +85°C |
| VDD Supply Voltage Range                 | 2.7V to 5.25V  |
| Logic Control Input Voltage              | 0V to 5.25V    |
| Analog Signal Range, VDD = 2.7V to 5.25V | 0V to 3.6V     |

**CAUTION:** Do not operate at or near the maximum ratings listed for extended periods of time. Exposure to such conditions may adversely impact product reliability and result in failures not covered by warranty.

### NOTES:

- $\theta_{JA}$  is measured with the component mounted on a high effective thermal conductivity test board in free air. See Tech Brief [TB379](#) for details.
- $\theta_{JA}$  is measured in free air with the component mounted on a high effective thermal conductivity test board with “direct attach” features. See Tech Brief [TB379](#).
- For  $\theta_{JC}$ , the “case temp” location is the center of the exposed metal pad on the package underside.
- For  $\theta_{JC}$ , the “case temp” location is taken at the package top center.

**Electrical Specifications - 2.7V to 5.25V Supply** Test Conditions: VDD = +3.3V, GND = 0V, VLP = GND, VOEH = 1.4V, VOEL = 0.5V, (Note 10), Unless Otherwise Specified. **Boldface limits apply over the operating temperature range, -40°C to +85°C.**

| PARAMETER                                                        | TEST CONDITIONS                                                                              | TEMP (°C) | MIN (Notes 11, 12) | TYP   | MAX (Notes 11, 12) | UNITS    |
|------------------------------------------------------------------|----------------------------------------------------------------------------------------------|-----------|--------------------|-------|--------------------|----------|
| <b>ANALOG SWITCH CHARACTERISTICS</b>                             |                                                                                              |           |                    |       |                    |          |
| ON-Resistance, $r_{ON}$ (High-Speed)                             | VDD = 2.7V, OE = 1.4V, IDX = 17mA, VCOM+ or VCOM- = 0V to 400mV (see Figure 4, Note 15)      | 25        | -                  | 3.5   | 5                  | $\Omega$ |
|                                                                  |                                                                                              | Full      | -                  | -     | <b>7</b>           | $\Omega$ |
| $r_{ON}$ Matching Between Channels, $\Delta r_{ON}$ (High-Speed) | VDD = 2.7V, OE = 1.4V, IDX = 17mA, VCOM+ or VCOM- = Voltage at max $r_{ON}$ , (Notes 14, 15) | 25        | -                  | 0.2   | 0.45               | $\Omega$ |
|                                                                  |                                                                                              | Full      | -                  | -     | <b>0.55</b>        | $\Omega$ |
| $r_{ON}$ Flatness, $R_{FLAT(ON)}$ (High-Speed)                   | VDD = 2.7V, OE = 1.4V, IDX = 17mA, VCOM+ or VCOM- = 0V to 400mV, (Notes 13, 15)              | 25        | -                  | 0.26  | 1                  | $\Omega$ |
|                                                                  |                                                                                              | Full      | -                  | -     | <b>1.2</b>         | $\Omega$ |
| ON-Resistance, $r_{ON}$                                          | VDD = 3.3V, OE = 1.4V, ICOMX = 17mA, VCOM+ or VCOM- = 3.3V (see Figure 4, Note 15)           | +25       | -                  | 6.8   | 17                 | $\Omega$ |
|                                                                  |                                                                                              | Full      | -                  | -     | <b>22</b>          | $\Omega$ |
| OFF Leakage Current, IDX(OFF)                                    | VDD = 5.25V, OE = 0V, VDX = 0.3V, 3.3V, VCOMX = 3.3V, 0.3V                                   | 25        | -20                | 1     | 20                 | nA       |
|                                                                  |                                                                                              | Full      | -                  | 30    | -                  | nA       |
| ON Leakage Current, IDX(ON)                                      | VDD = 5.25V, OE = 5.25V, VDX = 0.3V, 3.3V, VCOMX = 0.3V, 3.3V                                | 25        | -9                 | -     | 9                  | $\mu$ A  |
|                                                                  |                                                                                              | Full      | <b>-12</b>         | -     | <b>12</b>          | $\mu$ A  |
| Power OFF Leakage Current, ICOM+, ICOM-                          | VDD = 0V, VCOM+ = 5.25V, VCOM- = 5.25V, OE = 0V                                              | 25        | -                  | -     | 11                 | $\mu$ A  |
| Power OFF Logic Current, IOE                                     | VDD = 0V, OE = 5.25V                                                                         | 25        | -                  | -     | 22                 | $\mu$ A  |
| Power OFF D+/D- Current, ID+, ID-                                | VDD = 0V, OE = VDD, VDD+ = VDD- = 5.25V                                                      | 25        | -                  | -     | 1                  | $\mu$ A  |
| <b>Overvoltage Protection Detection</b>                          |                                                                                              |           |                    |       |                    |          |
| Positive Fault-Protection Trip Threshold, VPPF                   | VDD = 2.7V to 5.25V, OE = VDD (See Table 1 on page 2)                                        | 25        | 3.62               | 3.8   | 3.95               | V        |
| Negative Fault-Protection Trip Threshold, VNFP                   | VDD = 2.7V to 5.25V, OE = VDD (See Table 1 on page 2)                                        | 25        | -0.6               | -0.45 | -0.29              | V        |

**Electrical Specifications - 2.7V to 5.25V Supply** Test Conditions:  $V_{DD} = +3.3V$ ,  $GND = 0V$ ,  $V_{LP} = GND$ ,  $V_{OE} = 1.4V$ ,  $V_{OEL} = 0.5V$ , (Note 10), Unless Otherwise Specified. **Boldface limits apply over the operating temperature range, -40°C to +85°C. (Continued)**

| PARAMETER                                                     | TEST CONDITIONS                                                                                                                                                       | TEMP<br>(°C) | MIN<br>(Notes 11, 12) | TYP | MAX<br>(Notes 11, 12) | UNITS |
|---------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-----------------------|-----|-----------------------|-------|
| OFF Persistence Time<br>Fault Protection Response Time        | Negative OVP Response: V <sub>DD</sub> = 2.7V, SEL = 0V or V <sub>DD</sub> , OE/ALM = V <sub>DD</sub> , V <sub>Dx</sub> = 0V to -5V, RL = 1.5kΩ                       | 25           | -                     | 102 |                       | ns    |
|                                                               | Positive OVP Response: V <sub>DD</sub> = 2.7V, SEL = 0V or V <sub>DD</sub> , OE/ALM = V <sub>DD</sub> , V <sub>Dx</sub> = 0V to 5.25V, RL = 1.5kΩ                     | 25           | -                     | 2   |                       | μs    |
| ON Persistence Time<br>Fault Protection Recovery Time         | V <sub>DD</sub> = 2.7V, OE = V <sub>DD</sub> , V <sub>Dx</sub> = 0V to 5.25V or 0V to -5V, RL = 1.5kΩ                                                                 | 25           | -                     | 45  |                       | μs    |
| DYNAMIC CHARACTERISTICS                                       |                                                                                                                                                                       |              |                       |     |                       |       |
| Turn-ON Time, t <sub>ON</sub>                                 | V <sub>DD</sub> = 3.3V, V <sub>INPUT</sub> = 3V, R <sub>L</sub> = 50Ω, C <sub>L</sub> = 50pF (see Figure 3)                                                           | 25           | -                     | 160 | -                     | ns    |
| Turn-OFF Time, t <sub>OFF</sub>                               | V <sub>DD</sub> = 3.3V, V <sub>INPUT</sub> = 3V, R <sub>L</sub> = 50Ω, C <sub>L</sub> = 50pF (see Figure 3)                                                           | 25           | -                     | 60  | -                     | ns    |
| Skew, (t <sub>SKEWOUT</sub> - t <sub>SKEWIN</sub> )           | V <sub>DD</sub> = 3.3V, OE = 3.3V, R <sub>L</sub> = 45Ω, C <sub>L</sub> = 10pF, t <sub>R</sub> = t <sub>F</sub> = 500ps at 480Mbps, (Duty Cycle = 50%) (see Figure 7) | 25           | -                     | 50  | -                     | ps    |
| Rise/Fall Degradation (Propagation Delay), t <sub>PD</sub>    | V <sub>DD</sub> = 3.3V, OE = 3.3V, R <sub>L</sub> = 45Ω, C <sub>L</sub> = 10pF, (see Figure 7)                                                                        | 25           | -                     | 250 | -                     | ps    |
| Crosstalk                                                     | V <sub>DD</sub> = 3.3V, R <sub>L</sub> = 50Ω, f = 240MHz (see Figure 6)                                                                                               | 25           | -                     | -39 | -                     | dB    |
| OFF-Isolation                                                 | V <sub>DD</sub> = 3.3V, OE = 0V, R <sub>L</sub> = 50Ω, f = 240MHz                                                                                                     | 25           | -                     | -23 | -                     | dB    |
| -3dB Bandwidth                                                | Signal = 0dBm, 0.86VDC offset, R <sub>L</sub> = 50Ω                                                                                                                   | 25           | -                     | 790 | -                     | MHz   |
| OFF Capacitance, C <sub>OFF</sub>                             | f = 1MHz, V <sub>DD</sub> = 3.3V, LP = 0V, OE = 0V (see Figure 5)                                                                                                     | 25           | -                     | 2.5 | -                     | pF    |
| COM ON Capacitance, C <sub>(ON)</sub>                         | f = 1MHz, V <sub>DD</sub> = 3.3V, LP = 0V, OE = 3.3V, (see Figure 5)                                                                                                  | 25           | -                     | 4   | -                     | pF    |
| COM ON Capacitance, C <sub>(ON)</sub>                         | f = 240MHz, V <sub>DD</sub> = 3.3V, LP = 0V, OE = 3.3V                                                                                                                | 25           | -                     | 2   | -                     | pF    |
| POWER SUPPLY CHARACTERISTICS                                  |                                                                                                                                                                       |              |                       |     |                       |       |
| Power Supply Range, V <sub>DD</sub>                           |                                                                                                                                                                       | Full         | 2.7                   |     | 5.25                  | V     |
| Positive Supply Current, I <sub>DD</sub>                      | V <sub>DD</sub> = 5.25V, OE = 5.25V, LP = GND                                                                                                                         | 25           | -                     | 45  | 56                    | μA    |
|                                                               |                                                                                                                                                                       | Full         | -                     | -   | 59                    | μA    |
| Positive Supply Current, I <sub>DD</sub>                      | V <sub>DD</sub> = 3.6V, OE = 3.6V, LP = GND                                                                                                                           | 25           | -                     | 23  | 30                    | μA    |
|                                                               |                                                                                                                                                                       | Full         | -                     | -   | 34                    | μA    |
| Positive Supply Current, I <sub>DD</sub><br>(Low Power State) | V <sub>DD</sub> = 3.6V, OE = 0V, LP = V <sub>DD</sub>                                                                                                                 | 25           | -                     | 5   | 6                     | μA    |
|                                                               |                                                                                                                                                                       | Full         | -                     | -   | 10                    | μA    |
| Positive Supply Current, I <sub>DD</sub>                      | V <sub>DD</sub> = 4.3V, OE = 2.6V, LP = GND                                                                                                                           | 25           | -                     | 35  | 45                    | μA    |
|                                                               |                                                                                                                                                                       | Full         | -                     | -   | 50                    | μA    |
| Positive Supply Current, I <sub>DD</sub>                      | V <sub>DD</sub> = 3.6V, OE = 1.4V, LP = GND                                                                                                                           | 25           | -                     | 25  | 32                    | μA    |
|                                                               |                                                                                                                                                                       | Full         | -                     | -   | 38                    | μA    |
| DIGITAL INPUT CHARACTERISTICS                                 |                                                                                                                                                                       |              |                       |     |                       |       |
| Input Voltage Low, V <sub>OEL</sub> , V <sub>LPL</sub>        | V <sub>DD</sub> = 2.7V to 3.6V                                                                                                                                        | Full         | -                     | -   | 0.5                   | V     |
| Input Voltage High, V <sub>OE</sub> H, V <sub>LPH</sub>       | V <sub>DD</sub> = 2.7V to 3.6V                                                                                                                                        | Full         | 1.4                   | -   | -                     | V     |
| Input Voltage Low, V <sub>OEL</sub> , V <sub>LPL</sub>        | V <sub>DD</sub> = 3.7V to 4.2V                                                                                                                                        | Full         | -                     | -   | 0.7                   | V     |
| Input Voltage High, V <sub>OE</sub> H, V <sub>LPH</sub>       | V <sub>DD</sub> = 3.7V to 4.2                                                                                                                                         | Full         | 1.7                   | -   | -                     | V     |
| Input Voltage Low, V <sub>OEL</sub> , V <sub>LPL</sub>        | V <sub>DD</sub> = 4.3V to 5.25V                                                                                                                                       | Full         | -                     | -   | 0.8                   | V     |

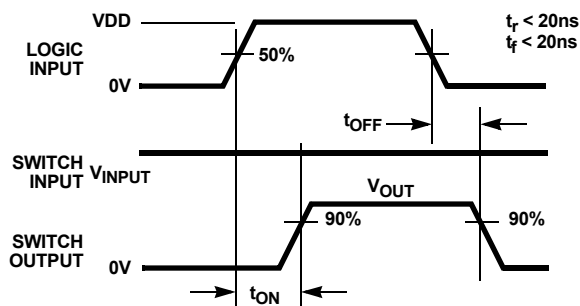
**Electrical Specifications - 2.7V to 5.25V Supply** Test Conditions:  $V_{DD} = +3.3V$ ,  $GND = 0V$ ,  $V_{LP} = GND$ ,  $V_{OE\overline{H}} = 1.4V$ ,  $V_{OE\overline{L}} = 0.5V$ , (Note 10), Unless Otherwise Specified. **Boldface limits apply over the operating temperature range, -40°C to +85°C. (Continued)**

| PARAMETER                                            | TEST CONDITIONS                                                          | TEMP<br>(°C) | MIN<br>(Notes 11, 12) | TYP  | MAX<br>(Notes 11, 12) | UNITS   |
|------------------------------------------------------|--------------------------------------------------------------------------|--------------|-----------------------|------|-----------------------|---------|
| Input Voltage High, $V_{OE\overline{H}}$ , $V_{LPH}$ | $V_{DD} = 4.3V$ to $5.25V$                                               | Full         | <b>2.0</b>            | -    | -                     | V       |
| Input Current, $I_{OE\overline{L}}$ , $I_{LPL}$      | $V_{DD} = 5.25V$ , $OE = 0V$ , $LP = 0V$                                 | Full         | -                     | -8.2 | -                     | nA      |
| Input Current, $I_{OE\overline{H}}$ , $I_{LPH}$      | $V_{DD} = 5.25V$ , $OE = 5.25V$ , $LP = 5.25V$ , $4M\Omega$<br>Pull-down | Full         | -                     | 1.4  | -                     | $\mu A$ |

## NOTES:

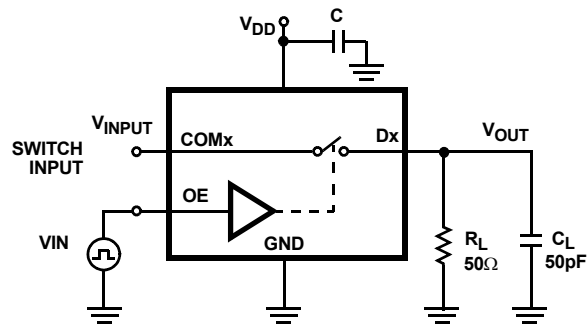
10.  $V_{LOGIC}$  = Input voltage to perform proper function.
11. The algebraic convention, whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
12. Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified. Temperature limits established by characterization and are not production tested.
13. Flatness is defined as the difference between maximum and minimum value of ON-resistance over the specified analog signal range.
14.  $r_{ON}$  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.
15. Limits established by characterization and are not production tested.

## Test Circuits and Waveforms



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

FIGURE 3A. MEASUREMENT POINTS

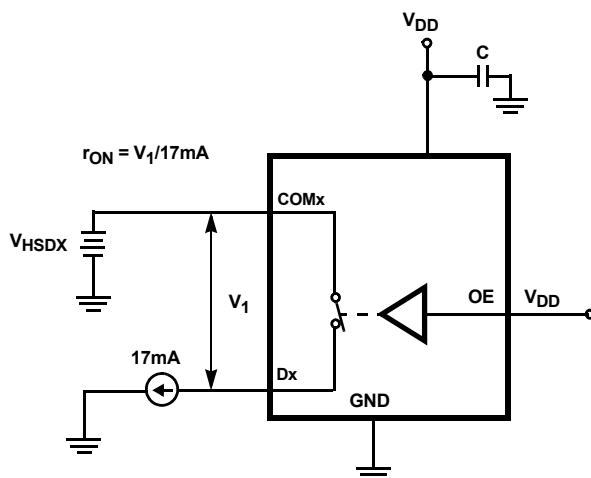


Repeat test for all switches.  $C_L$  includes fixture and stray capacitance.

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

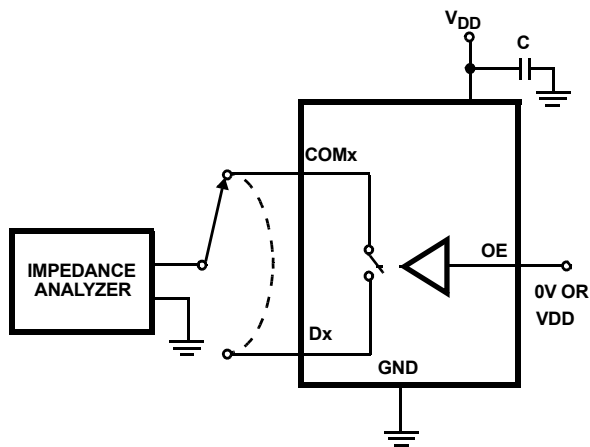
FIGURE 3B. TEST CIRCUIT

FIGURE 3. SWITCHING TIMES



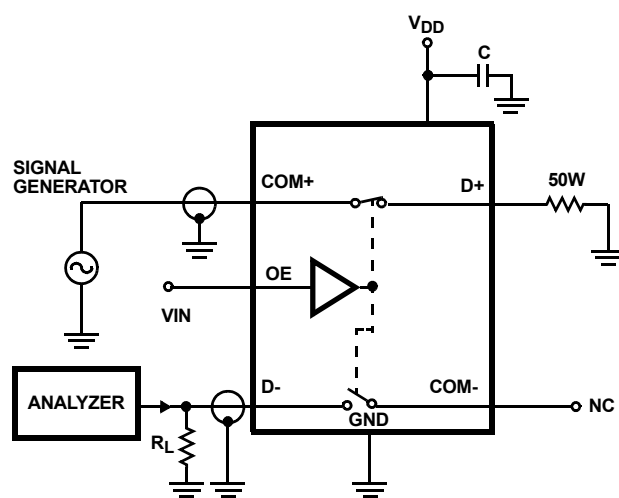
Repeat test for all switches.

FIGURE 4.  $r_{ON}$  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. CROSSTALK TEST CIRCUIT

## Test Circuits and Waveforms (Continued)

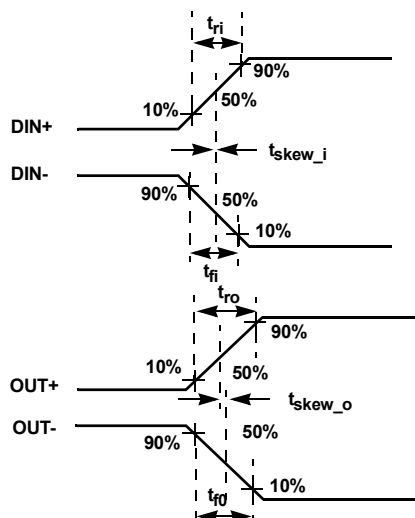
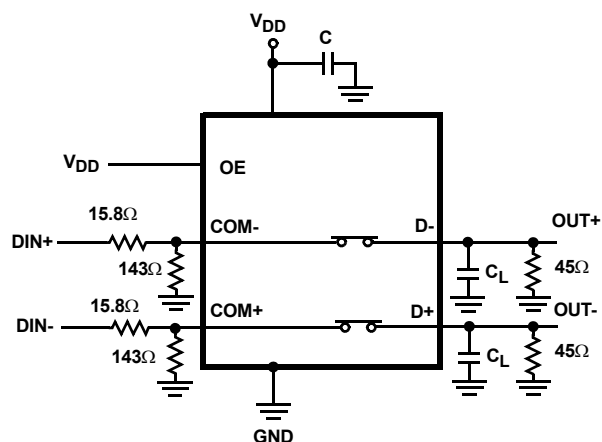


FIGURE 7A. MEASUREMENT POINTS



$|t_{ro} - t_{ri}|$  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.

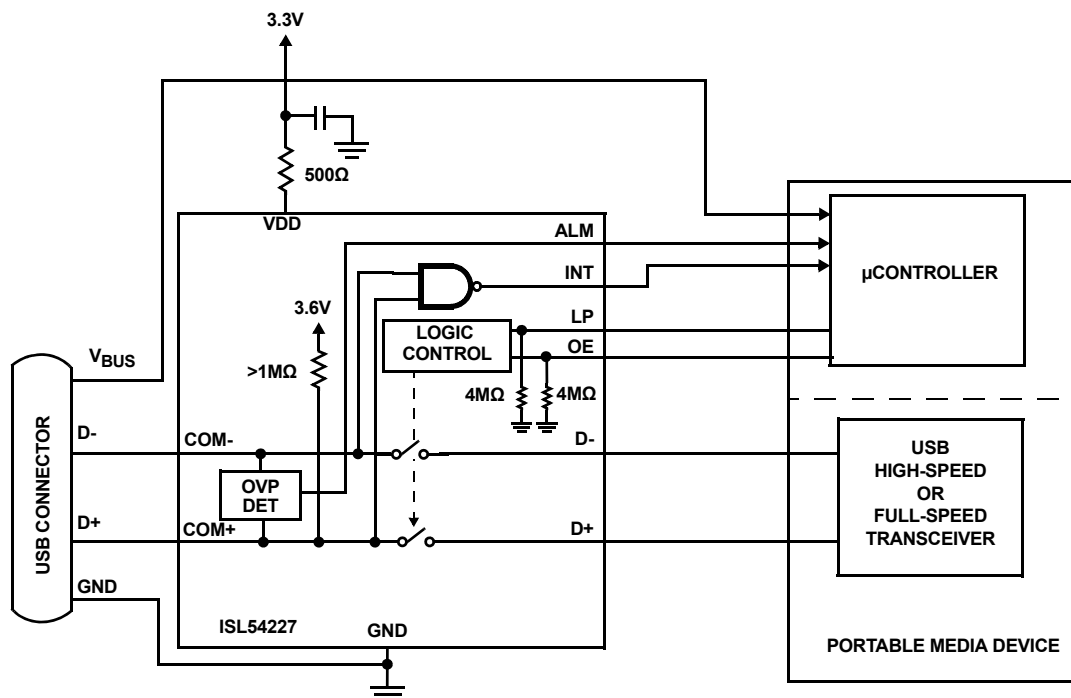
$|t_{skew_o}|$  Change in Skew through the Switch for Output Signals.

$|t_{skew_i}|$  Change in Skew through the Switch for Input Signals.

FIGURE 7B. TEST CIRCUIT

FIGURE 7. SKEW TEST

## Application Block Diagram



## Detailed Description

The ISL54227 device is a dual single pole/single throw (SPST) analog switch configured as a DPST that operates from a single DC power supply in the range of 2.7V to 5.25V.

It was designed for switching a USB high-speed or full-speed source in portable battery powered products. It is offered in small  $\mu$ TQFN and TDFN packages for use in MP3 players, cameras, PDAs, cellphones, and other personal media players.

The part consists of two  $3.5\Omega$  high-speed SPST switches. These switches have high bandwidth and low capacitance to pass USB high-speed (480Mbps) differential data signals with minimal edge and phase distortion. They can also swing from 0V to 3.6V to pass USB full speed (12Mbps) differential data signals with minimal distortion.

The device has a single logic control pin (OE) to open and close the two SPST switches. The part has an LP control pin to put the part in a low power state.

The part contains special over voltage protection (OVP) circuitry on the COM+ and COM- pins. This circuitry acts to open the SPST switches when the part senses a voltage on the COM pins that is  $>3.8V$  (typ) or  $<-0.45V$  (typ). It isolates voltages up to 5.25V and down to -5V from getting through to the other side of the switches (D-, D+) to protect the USB down-stream transceiver connected at the D+ and D- pins. It has an alarm ( $\overline{ALM}$ ) interrupt output to indicate when the device has detected and entered the OVP state. This output can be monitored by a  $\mu$ Controller to indicate a fault condition to the system.

The part has charger port interrupt detection circuitry (CP) on the COM pins that outputs a Low on the  $\overline{INT}$  pin to inform the  $\mu$ Controller or power management circuitry when entering a dedicated charging port mode of operation. The charger mode operation is initiated by driving the OE pin Low and externally connecting the COM pins together which pulls the COM lines High, triggering the INT pin to go Low and the SPST switches to open.

The ISL54227 was designed for MP3 players, cameras, cellphones, and other personal media player applications that need to switch a high-speed or full-speed transceiver source. See this functionality in the "Application Block Diagram" on page 8.

A detailed description of the SPST switches is provided in the following section.

### High-Speed (Dx) SPST Switches

The Dx switches are bi-directional switches that can pass USB high-speed and USB full-speed signals when VDD is in the range of 2.7V to 5.25V.

When powered with a 2.7V supply, these switches have a nominal  $r_{ON}$  of  $3.5\Omega$  over the signal range of 0V to 400mV with a  $r_{ON}$  flatness of  $0.26\Omega$ . The  $r_{ON}$  matching between the switches over this signal range is only  $0.2\Omega$ , ensuring minimal impact by the switches to USB high speed signal transitions. As the signal level increases, the  $r_{ON}$  switch resistance increases. At signal level of 3.3V, the switch resistance is nominally  $6.8\Omega$ . See Figures 11, 12, 13, 14, 15, 16 in the "Typical Performance Curves" beginning on page 11.

The Dx switches were specifically designed to pass USB 2.0 high-speed (480Mbps) differential signals in the range of 0V to 400mV. They have low capacitance and high bandwidth to pass the USB high-speed signals with minimum edge and phase distortion to meet USB 2.0 high speed signal quality specifications. See Figure 17 in the "Typical Performance Curves" on page 13 for USB High-speed Eye Pattern taken with switch in the signal path.

The Dx switches can also pass USB full-speed signals (12Mbps) in the range of 0V to 3.6V with minimal distortion and meet all the USB requirements for USB 2.0 full-speed signaling. See Figure 18 in the "Typical Performance Curves" on page 14 for USB Full-speed Eye Pattern taken with switch in the signal path.

The switches are active (turned ON) whenever the OE voltage is logic "1" (High) and the LP voltage is logic "0" (Low) and OFF when the OE voltage is logic "0" (Low) and the LP voltage is logic "0" (Low) or logic "1" (High).

### OVERVOLTAGE PROTECTION (OVP)

The maximum normal operating signal range for the Dx switches is from 0V to 3.6V. For normal operation the signal voltage should not be allowed to exceed these voltage levels or go below ground by more than -0.3V.

However, in the event that a positive voltage  $>3.8V$  (typ) to 5.25V, such as the USB 5V  $V_{BUS}$  voltage, gets shorted to one or both of the COM+ and COM- pins or a negative voltage  $<-0.45V$  (typ) to -5V gets shorted to one or both of the COM pins, the ISL54227 has OVP circuitry to detect the over voltage condition and open the SPST switches to prevent damage to the USB down-stream transceiver connected at the signal pins (D-, D+).

The OVP and power-off protection circuitry allows the COM pins (COM-, COM+) to be driven up to 5.25V while the  $V_{DD}$  supply voltage is in the range of 0V to 5.25V. In this condition, the part draws  $<100\mu A$  of  $I_{COMx}$  and  $I_{DD}$  current and causes no stress to the IC. In addition the SPST switches are OFF and the fault voltage is isolated from the other side of the switch.

The part has an alarm ( $\overline{ALM}$ ) interrupt output to indicate when the device has detected and entered the OVP state. This output can be monitored by a  $\mu$ Controller to indicate a fault condition to the system.

### External $V_{DD}$ Series Resistor to Limit $I_{DD}$ Current during Negative OVP Condition

A  $100\Omega$  to  $1k\Omega$  resistor in series with the VDD pin (see Figure 8) is required to limit the  $I_{DD}$  current draw from the system power supply rail during a negative OVP fault event.

With a negative -5V fault voltage at both com pins, the graph in Figure 9 shows the  $I_{DD}$  current draw for different external resistor values for supply voltages of 2.7V, 3.6V, and 5.25V. Note: With a  $500\Omega$  resistor the current draw is limited to around 5mA. When the negative fault voltage is removed the  $I_{DD}$  current will return to its normal operation current of 25 $\mu A$  to 45 $\mu A$ .

The series resistor also provides improved ESD and latch-up immunity. During an overvoltage transient event (such as occurs during system level IEC 61000 ESD testing), substrate currents can be generated in the IC that can trigger parasitic SCR structures to turn ON, creating a low impedance path from the

VDD power supply to ground. This will result in a significant amount of current flow in the IC, which can potentially create a latch-up state or permanently damage the IC. The external VDD resistor limits the current during this overstress situation and has been found to prevent latch-up or destructive damage for many overvoltage transient events.

Under normal operation, the low microamp  $I_{DD}$  current of the IC produces an insignificant voltage drop across the series resistor resulting in no impact to switch operation or performance.

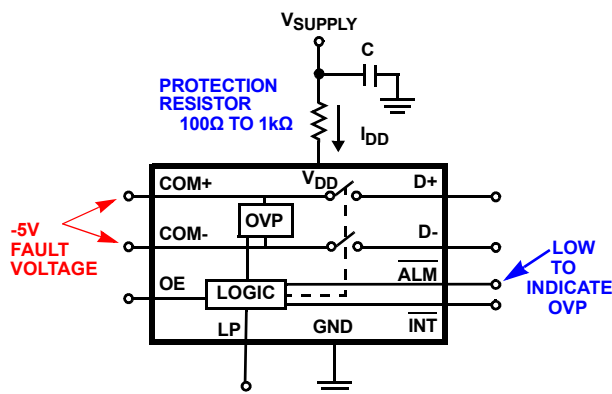


FIGURE 8.  $V_{DD}$  SERIES RESISTOR TO LIMIT  $I_{DD}$  CURRENT DURING NEGATIVE OVP AND FOR ENHANCED ESD AND LATCH-UP IMMUNITY

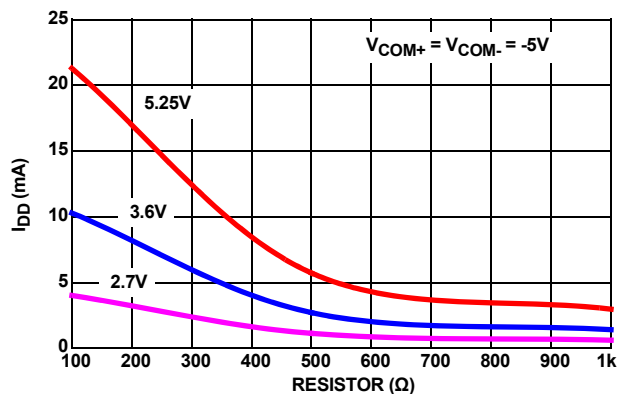


FIGURE 9. NEGATIVE OVP  $I_{DD}$  CURRENT vs RESISTOR VALUE vs  $V_{SUPPLY}$

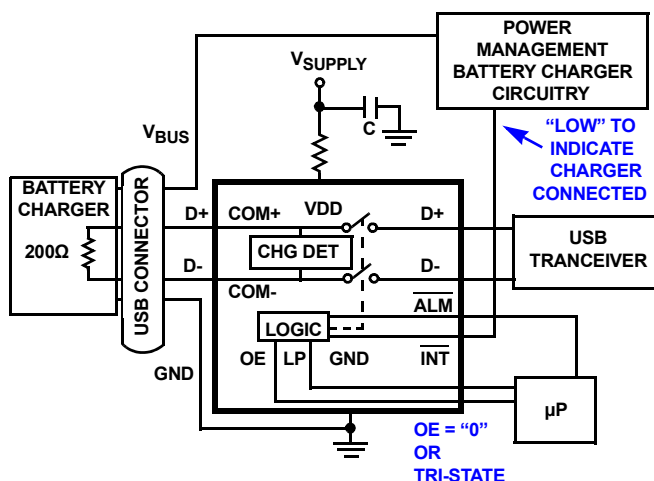


FIGURE 10. CHARGER PORT DETECTION

The ISL54227 has special charger port detection circuitry that monitors the voltage at the com pins to detect when a battery charger has been connected into the USB port (see Figure 10).

When the battery charger is connected into the USB connector, it shorts the COM+ and COM- pins together. The shorting of the pins is sensed by the ISL54227 IC and it pulls the COM+ and COM- lines high and as long as the OE = "0" or is tri-stated by the  $\mu P$ , it will drive its INT logic output "Low" to tell the power management circuitry that a battery charger is connected at the port and not a USB host transceiver. The power management circuitry will then use the USB connector  $V_{BUS}$  line to charge the battery.

## ISL54227 Operation

The following will discuss using the ISL54227 shown in the "Application Block Diagram" on page 8.

### POWER

The power supply connected at the VDD pin provides the DC bias voltage required by the ISL54227 part for proper operation. The ISL54227 can be operated with a  $V_{DD}$  voltage in the range of 2.7V to 5.25V.

For lowest power consumption you should use the lowest  $V_{DD}$  supply.

A 0.01 $\mu F$  or 0.1 $\mu F$  decoupling capacitor should be connected from the VDD pin to ground to filter out any power supply noise from entering the part. The capacitor should be located as close to the VDD pin as possible.

In a typical application,  $V_{DD}$  will be in the range of 2.8V to 4.3V and will be connected to the battery or LDO of the portable media device.

### LOGIC CONTROL

The state of the ISL54227 device is determined by the voltage at the OE pin, LP pin, and the signal voltage at the COM pins. Refer to "Truth Table" on page 2.

The OE and LP pins are internally pulled low through a 4M $\Omega$  resistor to ground and can be tri-stated or left floating.

The ISL54227 is designed to minimize  $I_{DD}$  current consumption when the logic control voltage is lower than the  $V_{DD}$  supply voltage. With  $V_{DD} = 3.6V$  and the OE logic pin is at 1.4V the part typically draws only 25 $\mu A$ . With  $V_{DD} = 4.3V$  and the OE logic pin is at 2.6V the part typically draws only 35 $\mu A$ . Driving the logic pin to the  $V_{DD}$  supply rail minimizes power consumption.

The OE and LP pin can be driven with a voltage higher than the  $V_{DD}$  supply voltage. It can be driven up to 5.25V with a  $V_{DD}$  supply in the range of 2.7V to 5.25V.

TABLE 2. LOGIC CONTROL VOLTAGE LEVELS

| $V_{DD}$ SUPPLY RANGE | LOGIC = "0" (LOW)             |                               | LOGIC = "1" (HIGH) |             |
|-----------------------|-------------------------------|-------------------------------|--------------------|-------------|
|                       | OE                            | LP                            | OE                 | LP          |
| 2.7V to 3.6V          | $\leq 0.5V$<br>or<br>floating | $\leq 0.5V$<br>or<br>floating | $\geq 1.4V$        | $\geq 1.4V$ |
| 3.7V to 4.2V          | $\leq 0.7V$<br>or<br>floating | $\leq 0.7V$<br>or<br>floating | $\geq 1.7V$        | $\geq 1.7V$ |
| 4.3V to 5.25V         | $\leq 0.8V$<br>or<br>floating | $\leq 0.8V$<br>or<br>floating | $\geq 2.0V$        | $\geq 2.0V$ |

#### Low Power Mode

If the OE pin = Logic "0", and the LP pin = Logic "1" the switches will turn OFF (high impedance) and the part will be put in a low

power mode. In this mode the part draws only 10 $\mu A$  (max) of current across the operating temperature range.

#### Normal Operation Mode

With a signal level in the range of 0V to 3.6V and with the LP pin = Logic "0" the switches will be ON when the OE pin = Logic "1" and will be OFF (high impedance) when the OE pin = Logic "0".

#### USB 2.0 $V_{BUS}$ Short Requirements

The USB specification in section 7.1.1 states a USB device must be able to withstand a  $V_{BUS}$  short (4.4V to 5.25V) or a -1V short to the D+ or D- signal lines when the device is either powered off or powered on for at least 24 hours.

The ISL54227 part has special power-off protection and OVP detection circuitry to meet these short circuit requirements. This circuitry allows the ISL54227 to provide protection to the USB down-stream transceiver connected at its signal pins (D-, D+) to meet the USB specification short circuit requirements.

The power-off protection and OVP circuitry allows the COM pins (COM-, COM+) to be driven up to 5.25V or down to -5V while the  $V_{DD}$  supply voltage is in the range of 0V to 5.25V. In these overvoltage conditions with a 500 $\Omega$  external  $V_{DD}$  resistor the part draws <55 $\mu A$  of current into the COM pins and causes no stress/damage to the IC. In addition all switches are OFF and the shorted  $V_{BUS}$  voltage will be isolated from getting through to the other side of the switch channels, thereby protecting the USB transceiver.

### Typical Performance Curves $T_A = +25^\circ C$ , Unless Otherwise Specified

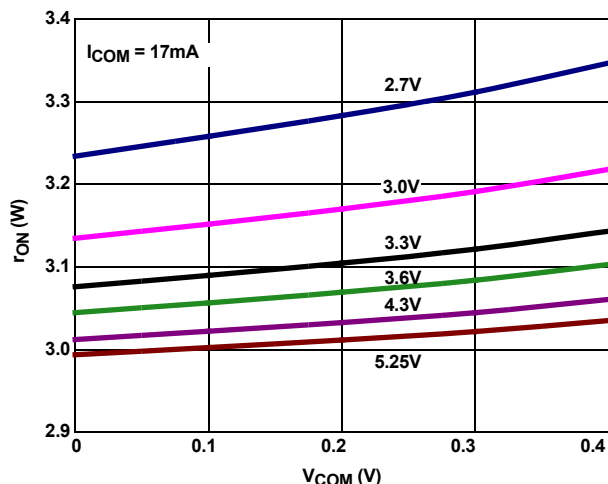


FIGURE 11. ON-RESISTANCE vs SUPPLY VOLTAGE vs SWITCH VOLTAGE

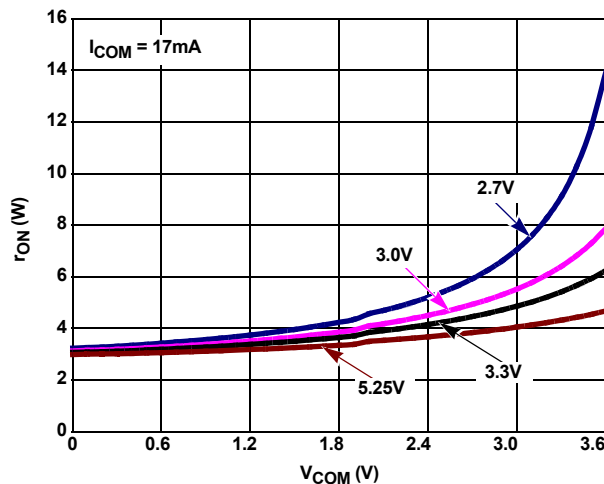


FIGURE 12. ON-RESISTANCE vs SUPPLY VOLTAGE vs SWITCH VOLTAGE

## Typical Performance Curves $T_A = +25^\circ\text{C}$ , Unless Otherwise Specified (Continued)

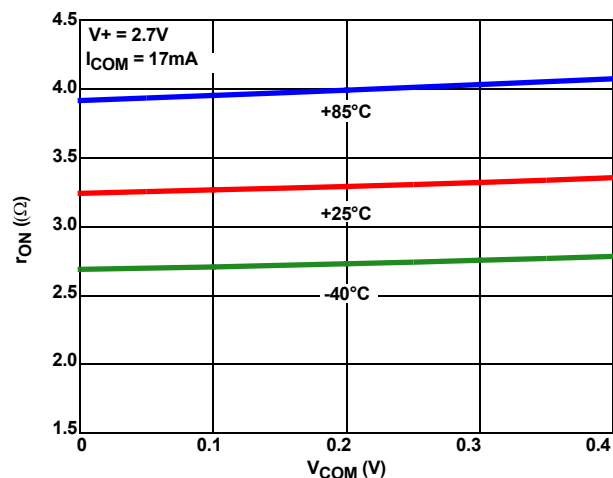


FIGURE 13. ON-RESISTANCE vs SWITCH VOLTAGE

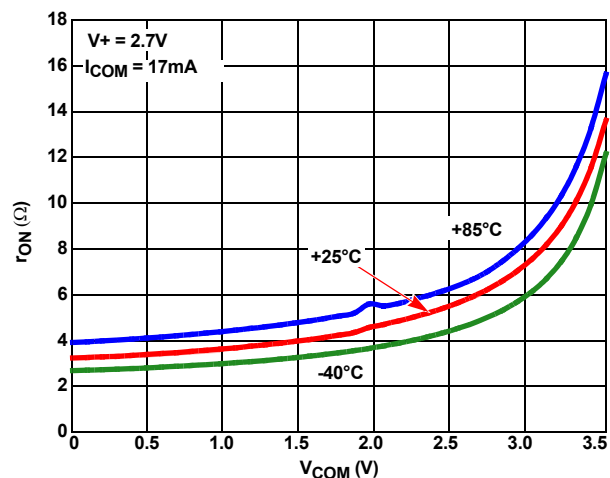


FIGURE 14. ON-RESISTANCE vs SWITCH VOLTAGE

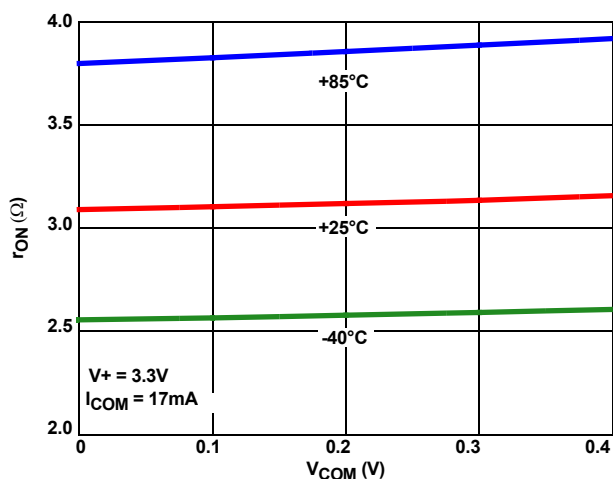


FIGURE 15. ON-RESISTANCE vs SWITCH VOLTAGE

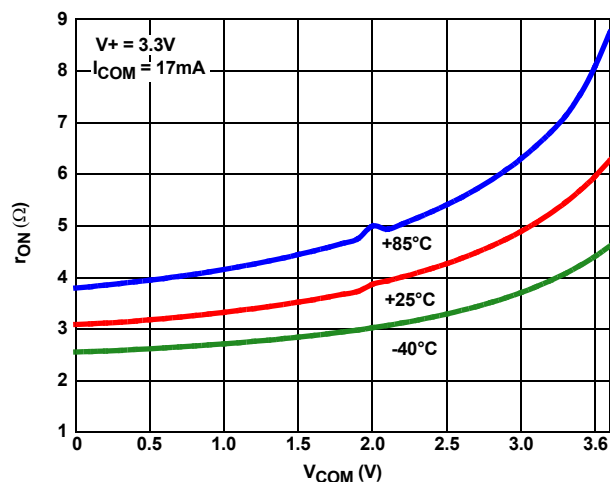
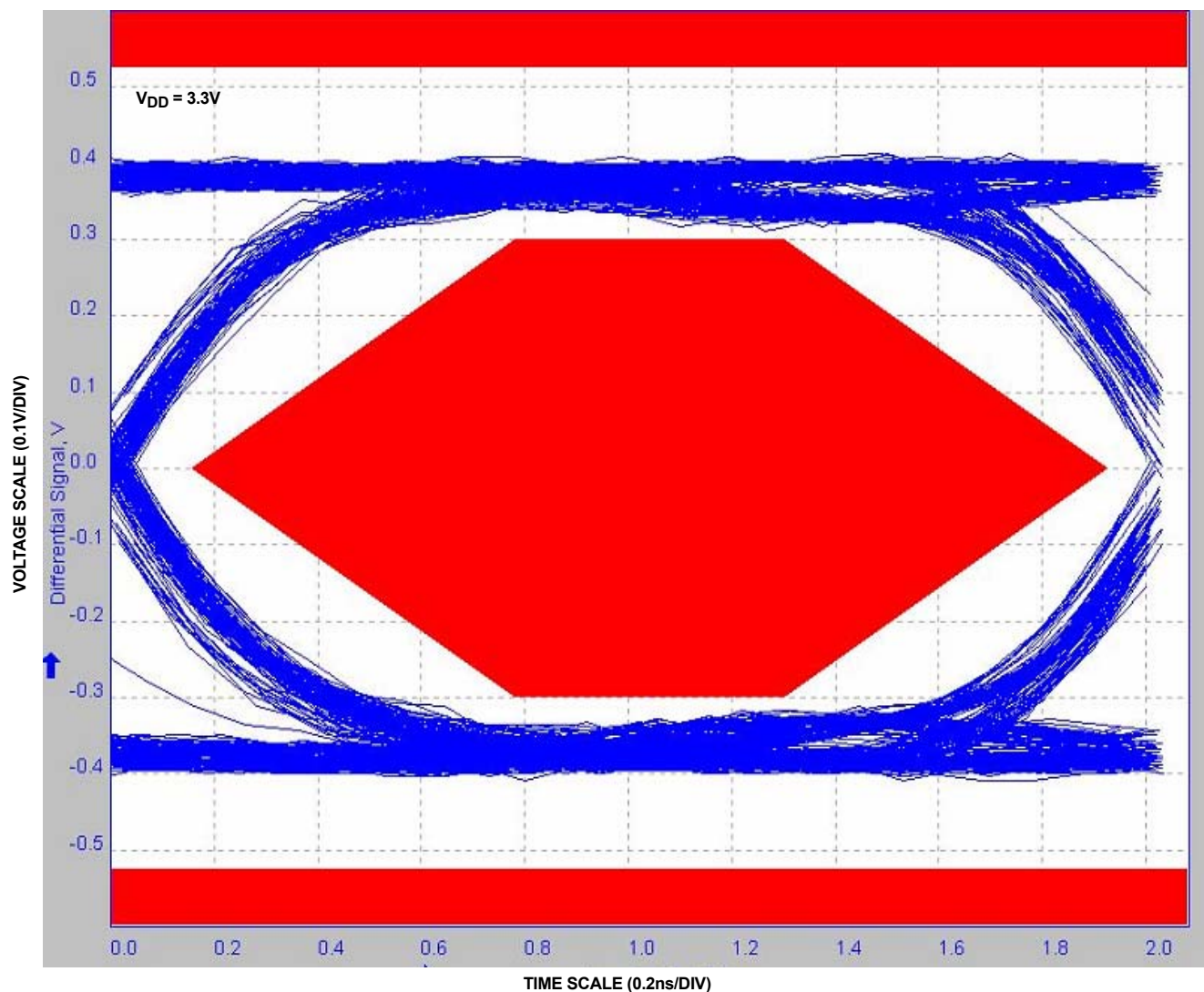


FIGURE 16. ON-RESISTANCE vs SWITCH VOLTAGE

**Typical Performance Curves**  $T_A = +25^\circ\text{C}$ , Unless Otherwise Specified **(Continued)****FIGURE 17. EYE PATTERN: 480Mbps WITH USB SWITCHES IN THE SIGNAL PATH**

## Typical Performance Curves $T_A = +25^\circ\text{C}$ , Unless Otherwise Specified (Continued)

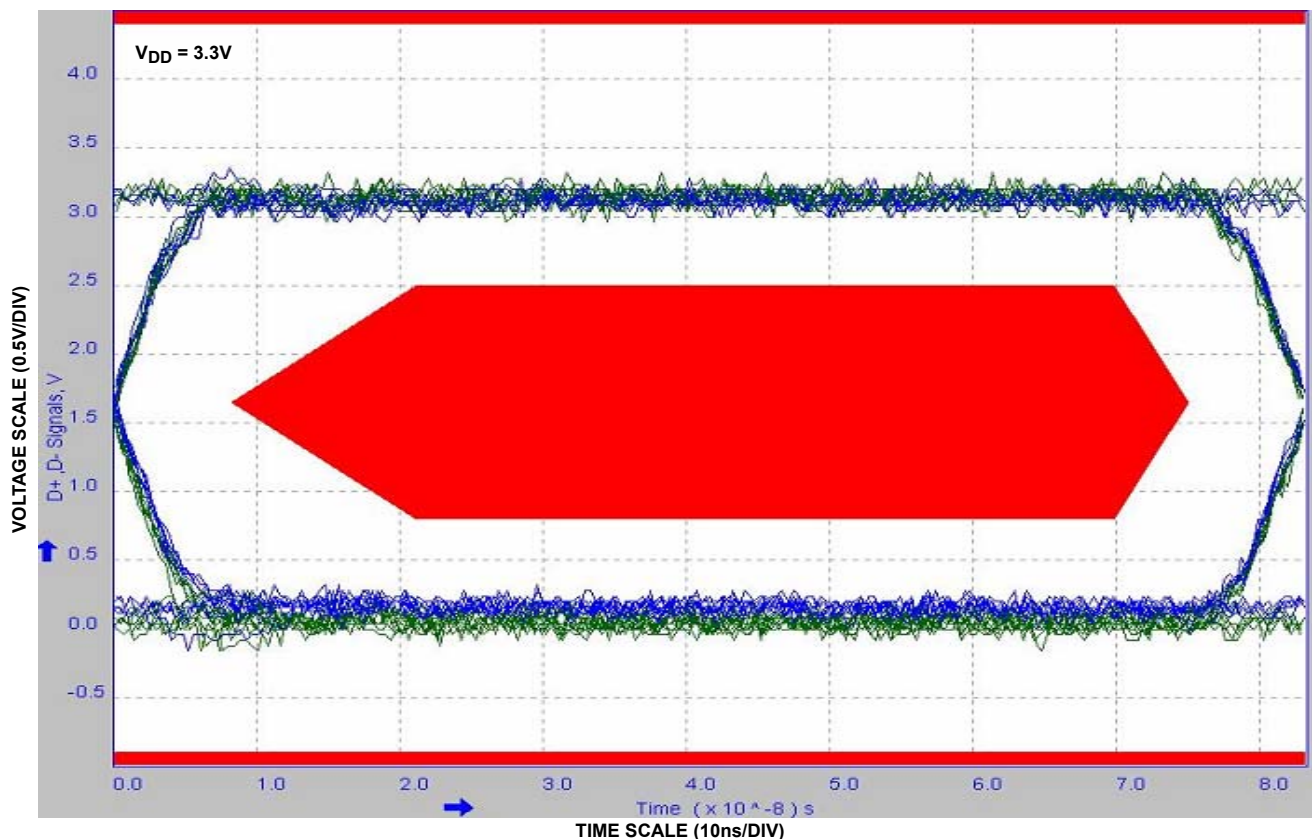


FIGURE 18. EYE PATTERN: 12Mbps WITH USB SWITCHES IN THE SIGNAL PATH

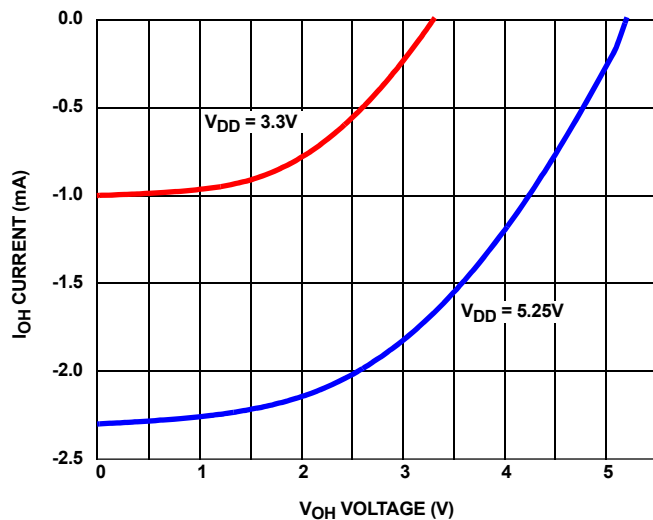


FIGURE 19.  $I_{OH}$  vs  $V_{OH}$  vs  $V_{DD}$  for  $\overline{INT}$  and  $\overline{ALM}$

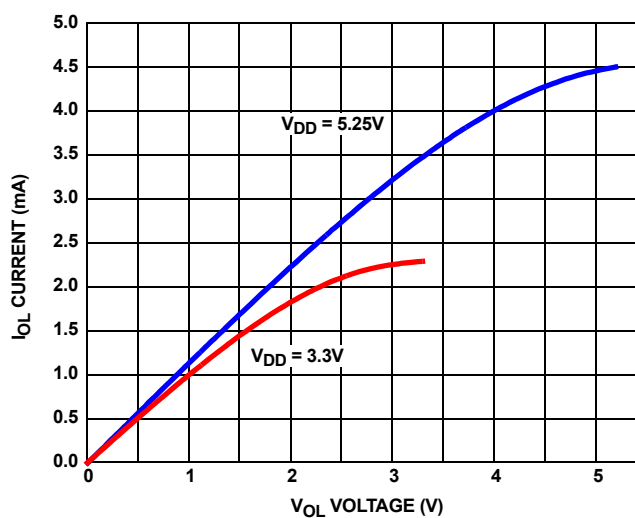


FIGURE 20.  $I_{OL}$  vs  $V_{OL}$  vs  $V_{DD}$  for  $\overline{INT}$  and  $\overline{ALM}$

## Typical Performance Curves $T_A = +25^\circ\text{C}$ , Unless Otherwise Specified (Continued)

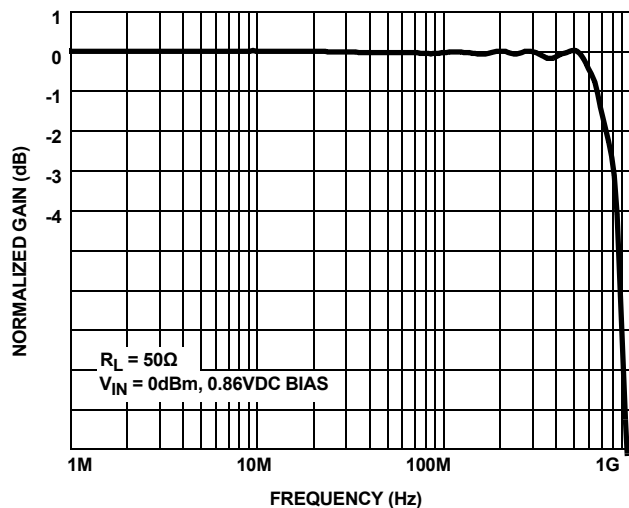


FIGURE 21. FREQUENCY RESPONSE

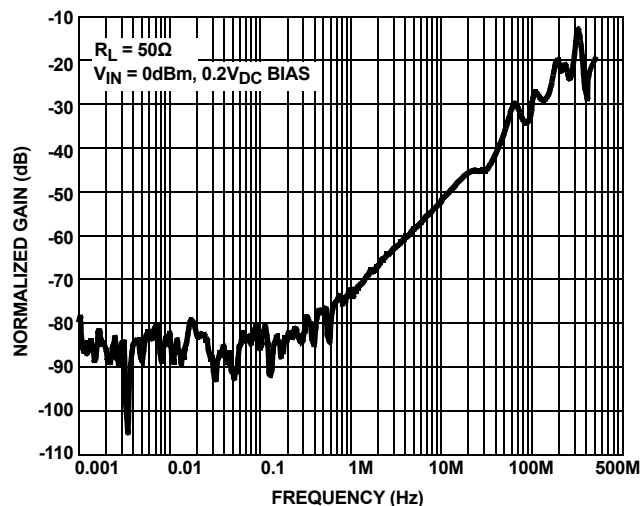


FIGURE 22. OFF-ISOLATION

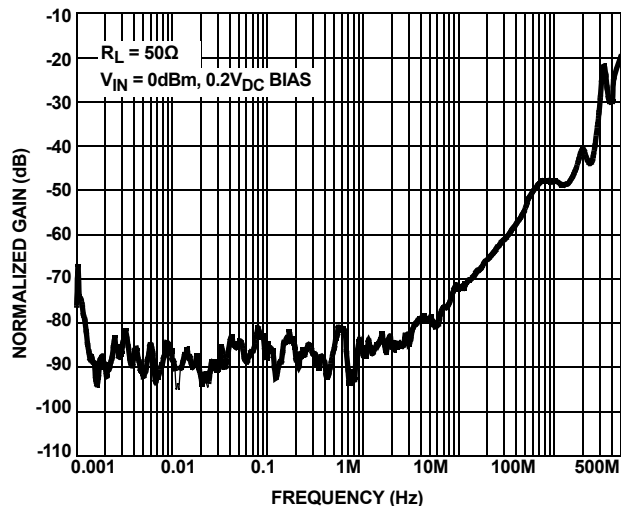


FIGURE 23. CROSSTALK

## Die Characteristics

### Substrate and TDFN Thermal Pad Potential (Powered Up):

GND

### Transistor Count:

1297

### Process:

Submicron CMOS

## Revision History

The revision history provided is for informational purposes only and is believed to be accurate, but not warranted. Please go to web to make sure you have the latest Rev.

| DATE              | REVISION | CHANGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-------------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| September 5, 2013 | FN7593.1 | <p>"Pin Descriptions" on page 2 table row 8, column 4 changed from: "OTV ALARM Interrupt Output", to: "OVP ALARM Interrupt Output"</p> <p>"Absolute Maximum Ratings" on page 4 changed ESD Ratings</p> <p>From:</p> <p>ESD Rating:</p> <p>Human Body Model (Tested per JESD22-A114-F) ..... &gt;2kV</p> <p>Machine Model (Tested per JESD22-A115-A) ..... &gt;150V</p> <p>Charged Device Model (Tested per JESD22-C101-D) ..... &gt;2kV</p> <p>To:</p> <p>ESD Rating:</p> <p>Human Body Model (Tested per JESD22-A114-F) ..... &gt;5.5kV</p> <p>Machine Model (Tested per JESD22-A115-A) ..... &gt;250V</p> <p>Charged Device Model (Tested per JESD22-C101-D) ..... &gt;2kV</p> <p>"Detailed Description" on page 9 paragraph 5 changed 2nd to last sentence from ".....and entered the OTV state.", to: ".....and entered the OVP state.".</p> <p>"OVervoltage protection (ovp)" on page 9 paragraph 4 changed the 1st sentence from: .....and entered the OTV state.", to: .....and entered the OVP state.".</p> |
| July 2, 2010      | FN7593.0 | Initial Release.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

## About Intersil

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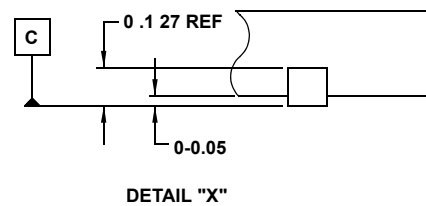
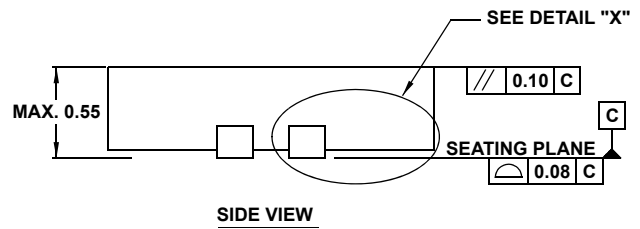
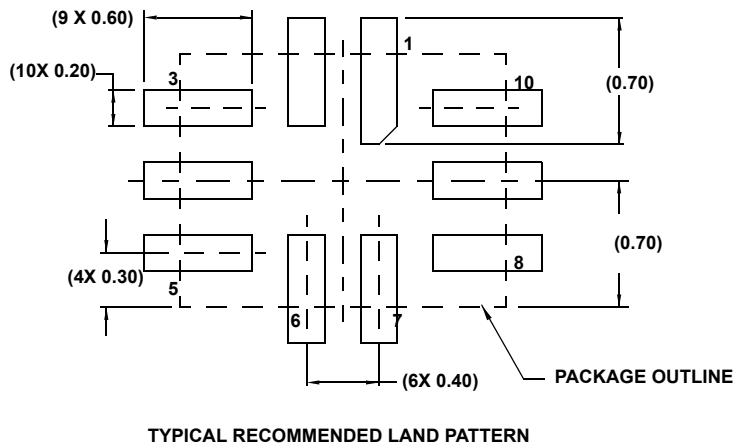
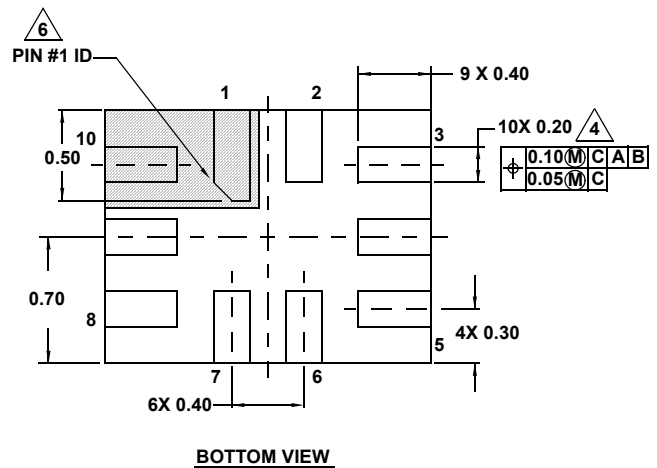
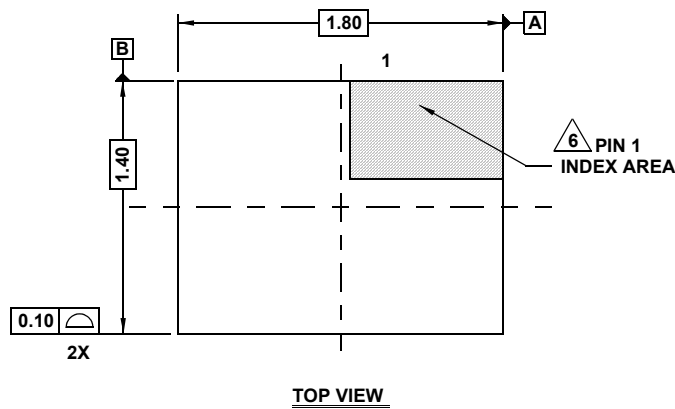
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## Package Outline Drawing

### L10.1.8x1.4A

10 LEAD ULTRA THIN QUAD FLAT NO-LEAD PLASTIC PACKAGE

Rev 5, 3/10



#### NOTES:

1. Dimensions are in millimeters.  
Dimensions in ( ) for Reference Only.
2. Dimensioning and tolerancing conform to ASME Y14.5m-1994.
3. Unless otherwise specified, tolerance : Decimal  $\pm 0.05$
4. Dimension applies to the metallized terminal and is measured between 0.15mm and 0.30mm from the terminal tip.
5. JEDEC reference MO-255.
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.

