

# USB 2.0 High/Full Speed Multiplexer

## ISL54200

The Intersil ISL54200 dual 2:1 multiplexer IC is a single supply part that can operate from a single 2.7V to 5.5V supply. It contains two SPDT (Single Pole/Double Throw) switches configured as a DPDT. The part was designed for switching between USB High-Speed and USB Full-Speed sources in portable battery powered products.

The 7Ω normally-closed (NC) FSx switches can swing rail-to-rail and were specifically designed to pass USB full speed data signals (12Mbps) that range from 0V to 3.6V. The 4.5Ω normally-open (NO) HSx switches have high bandwidth and low capacitance and were specifically designed to pass USB high speed data signals (480Mbps) with minimal distortion.

The part can be used in Personal Media Players and other portable battery powered devices that need to switch between a high-speed transceiver and a full-speed transceiver while connected to a single USB host (computer).

The digital logic inputs are 1.8V logic compatible when operated with a 2.7V to 3.6V supply. The part has an enable pin to open all switches. It can be used to facilitate proper bus disconnect and connection when switching between the USB sources.

The ISL54200 is available in a 10 Ld 3mmx3mm TDFN and a small 10 Ld 2.1mmx1.6mm μTQFN package. 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)
- Enable Pin to Open all Switches
- -3dB Frequency
  - HSx Switches . . . . .880MHz
  - FSx Switches . . . . .550MHz
- Crosstalk @ 1MHz . . . . . -70dB
- Off Isolation @ 100kHz . . . . . -98dB
- Single Supply Operation (V<sub>DD</sub>) . . . . . 2.7V to 5.5V
- Available in Ultra-thin μTQFN and TDFN Packages
- Pb-Free (RoHS Compliant)

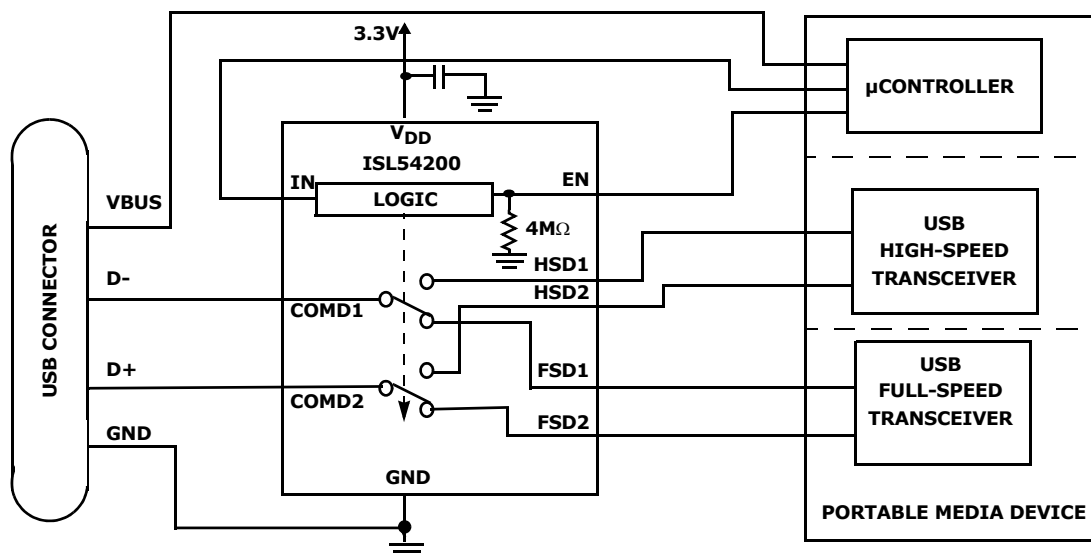
## Applications\* (see page 16)

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

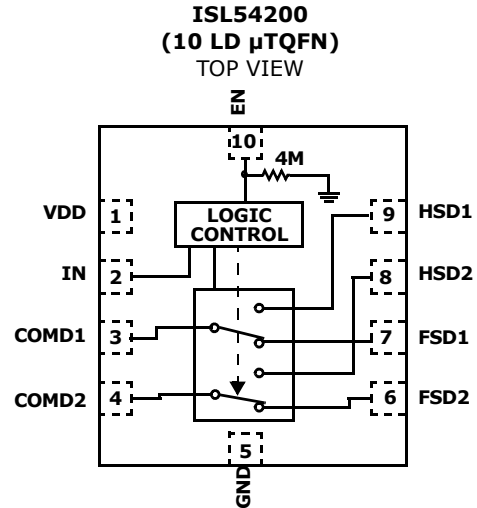
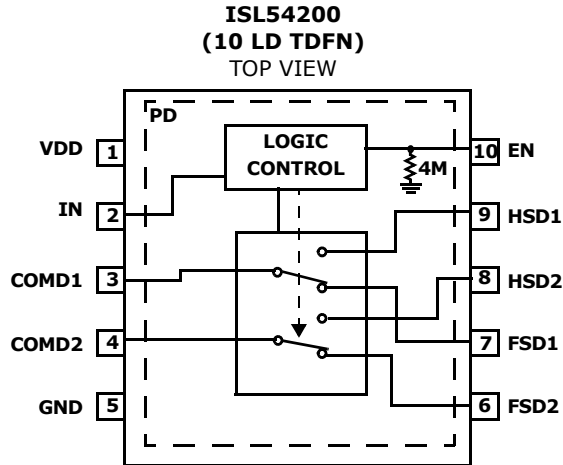
## Related Literature\* (see page 16)

- Technical Brief [TB363](#) "Guidelines for Handling and Processing Moisture Sensitive Surface Mount Devices (SMDs)".
- Application Note [AN1330](#) "ISL54200EVAL1Z Evaluation Board User's Manual"

## Application Block Diagram



## Pin Configurations



NOTE:

1. ISL54200 Switches Shown for IN = Logic "0" and EN = Logic "1".

## Ordering Information

| PART NUMBER<br>(Note 5)    | PART MARKING     | TEMP. RANGE<br>(°C) | PACKAGE<br>(Pb-Free)                       | PKG.<br>DWG. # |
|----------------------------|------------------|---------------------|--|----------------|
| ISL54200IRZ (Note 3)       | 200Z             | -40 to +85          | 10 Ld 3x3 TDFN                             | L10.3x3A       |
| ISL54200IRZ-T (Note 2, 3)  | 200Z             | -40 to +85          | 10 Ld 3x3 TDFN Tape and Reel               | L10.3x3A       |
| ISL54200IRUZ-T (Note 2, 4) | FM               | -40 to +85          | 10 Ld 2.1mmx1.6mm $\mu$ TQFN Tape and Reel | L10.2.1x1.6A   |
| ISL54200EVAL1Z             | 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 [ISL54200](#). For more information on MSL please see techbrief [TB363](#).

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## Truth Table

| ISL54200 |    |            |            |
|----------|----|------------|------------|
| EN       | IN | FSD1, FSD2 | HSD1, HSD2 |
| 1        | 0  | ON         | OFF        |
| 1        | 1  | OFF        | ON         |
| 0        | X  | OFF        | OFF        |

Logic "0" when  $\leq 0.5V$ , Logic "1" when  $\geq 1.4V$  with a 2.7V to 3.6V Supply. X = Don't Care

## Pin Descriptions

| ISL54200 |       |   |
|----------|-------|---|
| PIN NO.  | NAME  | FUNCTION  |
| 1        | VDD   | Power Supply  |
| 2        | IN    | Select Logic Control Input                              |
| 3        | COMD1 | USB Common Port   |
| 4        | COMD2 | USB Common Port   |
| 5        | GND   | Ground Connection                                       |
| 6        | FSD2  | Full Speed USB Differential Port                        |
| 7        | FSD1  | Full Speed USB Differential Port                        |
| 8        | HSD2  | High Speed USB Differential Port                        |
| 9        | HSD1  | High Speed USB Differential Port                        |
| 10       | EN    | Bus Switch Enable                                       |
| -        | PD    | Thermal Pad. Tie to Ground or Float (TDFN package only) |

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## Absolute Maximum Ratings

|   |                        |
|---|------------------------|
| VDD to GND                                  | -0.3V to 6.0V          |
| Input Voltages                              |                        |
| FSD2, FSD1, HSD2, HSD1 (Note 6)             | -1V to ((VDD) +0.3V)   |
| IN, EN (Note 6)                             | -0.3V to ((VDD) +0.3V) |
| Output Voltages                             |                        |
| COMD1, COMD2 (Note 6)                       | -1V to 5V              |
| Continuous Current (HSD2, HSD1, FSD2, FSD1) | ±40mA                  |
| Peak Current (HSD2, HSD1, FSD2, FSD1)       |                        |
| (Pulsed 1ms, 10% Duty Cycle, Max)           | ±100mA                 |
| ESD Rating:                                 |                        |
| HBM   | >7kV                   |
| MM  | >400V                  |
| CDM   | >1.4kV                 |
| 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 (Notes 7, 8)                  | 145   | 90                   |
| 10 Ld TDFN (Notes 9, 10)                       | 55  | 16.5                 |
| 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> |                      |

## Operating Conditions

|                          |                |
|--------------------------|----------------|
| Temperature Range        | -40°C to +85°C |
| VDD Supply Voltage Range | 2.7V to 5.5V   |

**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:

- Signals on FSD1, FSD2, HSD1, HSD2, COMD1, COMD2, EN, IN exceeding VDD or GND by specified amount are clamped. Limit current to maximum current ratings.
- $\theta_{JA}$  is measured with the component mounted on a high effective thermal conductivity test board in free air. See Tech Brief TB379 for details.
- For  $\theta_{JC}$ , the "case temp" location is taken at the package top center.
- $\theta_{JA}$  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.

**Electrical Specifications - 2.7V to 3.6V Supply** Test Conditions: VDD = +3.3V, GND = 0V, VINH = 1.4V, VINL = 0.5V, VENH = 1.4V, VENL = 0.5V, (Note 11), Unless Otherwise Specified. **Bold-face limits apply over the operating temperature range, -40°C to +85°C.**

| PARAMETER                                      | TEST CONDITIONS  | TEMP (°C) | MIN (Notes 12, 13) | TYP | MAX (Notes 12, 13) | UNITS    |
|--|--|-----------|--------------------|-----|--------------------|----------|
| <b>ANALOG SWITCH CHARACTERISTICS</b>           |  |           |                    |     |                    |          |
| <b>NC Switches (FSD1, FSD2)</b>                |  |           |                    |     |                    |          |
| Analog Signal Range, VANALOG                   | VDD = 3.3V, IN = 0V, EN = 3.3V   | Full      | <b>0</b>           | -   | <b>VDD</b>         | V        |
| ON-Resistance, rON                             | VDD = 3.3V, IN = 0.5V, EN = 1.4V, ICOMx = 40mA, VFSD1 or VFSD2 = 0V to 3.3V, (See Figure 4)                                    | +25       | -                  | 7   | 10                 | $\Omega$ |
|  |  | Full      | -                  | -   | <b>15</b>          | $\Omega$ |
| rON Matching Between Channels, $\Delta r_{ON}$ | VDD = 3.3V, IN = 0.5V, EN = 1.4V, ICOMx = 40mA, VFSD1 or VFSD2 = Voltage at max rON over signal range of 0V to 3.3V, (Note 15) | +25       | -                  | 0.1 | 0.35               | $\Omega$ |
|  |  | Full      | -                  | -   | <b>0.4</b>         | $\Omega$ |
| rON Flatness, rFLAT(ON)                        | VDD = 3.3V, IN = 0.5V, EN = 1.4V, ICOMx = 40mA, VFSD1 or VFSD2 = 0V to 3.3V, (Note 14)   | +25       | -                  | 4   | 6                  | $\Omega$ |
|  |  | Full      | -                  | -   | <b>8</b>           | $\Omega$ |
| OFF Leakage Current, IFsx(OFF)                 | V+ = 3.6V, IN = 3.6V, EN = 0V and 3.6V, VCOMx = 0.3V, 3V, VFsx = 3V, 0.3V  | +25       | -20                | 2   | 20                 | nA       |
|  |  | Full      | <b>-70</b>         | -   | <b>70</b>          | nA       |
| ON Leakage Current, IFsx(ON)                   | V+ = 3.6V, IN = 0V, EN = 3.6V, VCOMx = 0.3V, 3V, VFsx = 0.3V, 3V   | +25       | -20                | 2   | 20                 | nA       |
|  |  | Full      | <b>-70</b>         | -   | <b>70</b>          | nA       |
| <b>NO Switches (HSD1, HSD2)</b>                |  |           |                    |     |                    |          |
| Analog Signal Range, VANALOG                   | VDD = 3.3V, IN = 3.3V, EN = 3.3V   | Full      | <b>0</b>           | -   | <b>VDD</b>         | V        |

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**Electrical Specifications - 2.7V to 3.6V Supply** Test Conditions:  $V_{DD} = +3.3V$ ,  $GND = 0V$ ,  $V_{INH} = 1.4V$ ,  $V_{INL} = 0.5V$ ,  $V_{ENH} = 1.4V$ ,  $V_{ENL} = 0.5V$ , (Note 11), Unless Otherwise Specified. **Bold-face limits apply over the operating temperature range, -40°C to +85°C. (Continued)**

| PARAMETER   | TEST CONDITIONS   | TEMP (°C) | MIN (Notes 12, 13) | TYP  | MAX (Notes 12, 13) | UNITS    |
|---|---|-----------|--------------------|------|--------------------|----------|
| ON-Resistance, $r_{ON}$                                 | $V_{DD} = 3.3V$ , $I_N = 1.4V$ , $E_N = 1.4V$ , $I_{COMX} = 1mA$ , $V_{HSD2}$ or $V_{HSD1} = 3.3V$ (See Figure 3)   | +25       | -                  | 20   | 30                 | $\Omega$ |
|   |   | Full      | -                  | -    | <b>35</b>          | $\Omega$ |
| ON-Resistance, $r_{ON}$                                 | $V_{DD} = 3.3V$ , $I_N = 1.4V$ , $E_N = 1.4V$ , $I_{COMX} = 40mA$ , $V_{HSD2}$ or $V_{HSD1} = 0V$ to $400mV$ (See Figure 3)   | +25       | -                  | 4.5  | 6                  | $\Omega$ |
|   |   | Full      | -                  | -    | <b>8</b>           | $\Omega$ |
| $r_{ON}$ Matching Between Channels, $\Delta r_{ON}$     | $V_{DD} = 3.3V$ , $I_N = 1.4V$ , $E_N = 1.4V$ , $I_{COMX} = 40mA$ , $V_{HSD2}$ or $V_{HSD1} =$ Voltage at max $r_{ON}$ , Voltage at max $r_{ON}$ over signal range of $0V$ to $400mV$ (Note 15) | +25       | -                  | 0.01 | 0.1                | $\Omega$ |
|   |   | Full      | -                  | -    | <b>0.5</b>         | $\Omega$ |
| $r_{ON}$ Flatness, $r_{FLAT(ON)}$                       | $V_{DD} = 3.3V$ , $I_N = 1.4V$ , $E_N = 1.4V$ , $I_{COMX} = 40mA$ , $V_{HSD2}$ or $V_{HSD1} = 0V$ to $400mV$ , (Note 14)  | +25       | -                  | 0.4  | 1                  | $\Omega$ |
|   |   | Full      | -                  | -    | <b>1.5</b>         | $\Omega$ |
| OFF Leakage Current, $I_{HSD2(OFF)}$ or $I_{HSD1(OFF)}$ | $V_{DD} = 3.6V$ , $I_N = 0V$ , $E_N = 0$ and $3.6V$ , $V_{COMD1}$ or $V_{COMD2} = 3V$ , $0.3V$ , $V_{HSD2}$ or $V_{HSD1} = 0.3V$ , $3V$   | +25       | -20                | 2    | 20                 | nA       |
|   |   | Full      | <b>-70</b>         | -    | <b>70</b>          | nA       |
| ON Leakage Current, $I_{HSD2(ON)}$ or $I_{HSD1(ON)}$    | $V_{DD} = 3.6V$ , $I_N = 3.6V$ , $E_N = 3.6V$ , $V_{COMD1}$ or $V_{COMD2} = 0.3V$ , $3.0V$ , $V_{HSD2}$ or $V_{HSD1} = 0.3V$ , $3.0V$   | +25       | -20                | 2    | 20                 | nA       |
|   |   | Full      | <b>-70</b>         | -    | <b>70</b>          | nA       |
| <b>DYNAMIC CHARACTERISTICS</b>                          |   |           |                    |      |                    |          |
| Turn-ON Time, $t_{ON}$                                  | $V_{DD} = 3.3V$ , $R_L = 45\Omega$ , $C_L = 10pF$ , (See Figure 1)  | +25       | -                  | 25   | -                  | ns       |
| Turn-OFF Time, $t_{OFF}$                                | $V_{DD} = 3.3V$ , $R_L = 45\Omega$ , $C_L = 10pF$ , (See Figure 1)  | +25       | -                  | 15   | -                  | ns       |
| Break-Before-Make Time Delay, $t_D$                     | $V_{DD} = 3.3V$ , $R_L = 45\Omega$ , $C_L = 10pF$ , (See Figure 2)  | +25       | -                  | 7    | -                  | ns       |
| Skew, $t_{SKEW}$ (HSx Switch)                           | $V_{DD} = 3.3V$ , $I_N = 3.3V$ , $E_N = 3.3V$ , $R_L = 45\Omega$ , $C_L = 10pF$ , $t_R = t_F = 720ps$ at $480Mbps$ , (Duty Cycle = 50%) (See Figure 7)  | +25       | -                  | 50   | -                  | ps       |
| Total Jitter, $t_j$ (HSx Switch)                        | $V_{DD} = 3.3V$ , $I_N = 3.3V$ , $E_N = 3.3V$ , $R_L = 45\Omega$ , $C_L = 10pF$ , $t_R = t_F = 720ps$ at $480Mbps$  | +25       | -                  | 210  | -                  | ps       |
| Propagation Delay, $t_{PD}$ (HSx Switch)                | $V_{DD} = 3.3V$ , $I_N = 3.3V$ , $E_N = 3.3V$ , $R_L = 45\Omega$ , $C_L = 10pF$ , (See Figure 7)  | +25       | -                  | 250  | -                  | ps       |
| Skew, $t_{SKEW}$ (FSx Switch)                           | $V_{DD} = 3.3V$ , $I_N = 0V$ , $E_N = 3.3V$ , $R_L = 39\Omega$ , $C_L = 50pF$ , $t_R = t_F = 12ns$ at $12Mbps$ , (Duty Cycle = 50%) (See Figure 7)  | +25       | -                  | 0.15 | -                  | ns       |
| Rise/Fall Time Mismatch, $t_M$ (FSx Switch)             | $V_{DD} = 3.3V$ , $I_N = 0V$ , $E_N = 3.3V$ , $R_L = 39\Omega$ , $C_L = 50pF$ , $t_R = t_F = 12ns$ at $12Mbps$ , (Duty Cycle = 50%)   | +25       | -                  | 10   | -                  | %        |
| Total Jitter, $t_j$ (FSx Switch)                        | $V_{DD} = 3.3V$ , $I_N = 0V$ , $E_N = 3.3V$ , $R_L = 39\Omega$ , $C_L = 50pF$ , $t_R = t_F = 12ns$ at $12Mbps$  | +25       | -                  | 1.6  | -                  | ns       |
| Propagation Delay, $t_{PD}$ (FSx Switch)                | $V_{DD} = 3.3V$ , $I_N = 0V$ , $E_N = 3.3V$ , $R_L = 39\Omega$ , $C_L = 50pF$ , (See Figure 7)  | +25       | -                  | 0.9  | -                  | ns       |
| Crosstalk   | $V_{DD} = 3.3V$ , $R_L = 45\Omega$ , $f = 1MHz$ (See Figure 6)  | +25       | -                  | -70  | -                  | dB       |
| Off Isolation   | $V_{DD} = 3.3V$ , $R_L = 45\Omega$ , $f = 100kHz$   | +25       | -                  | -98  | -                  | dB       |
| FSx Switch -3dB Bandwidth                               | Signal = -10dBm, 1.0VDC offset, $R_L = 45\Omega$ , $C_L = 5pF$  | +25       | -                  | 550  | -                  | MHz      |
| HSx Switch -3dB Bandwidth                               | Signal = -10dBm, 0.2VDC offset, $R_L = 45\Omega$ , $C_L = 5pF$  | +25       | -                  | 880  | -                  | MHz      |
| HSx OFF Capacitance, $C_{HSXOFF}$                       | $f = 1MHz$ , $V_{DD} = 3.3V$ , $I_N = 0V$ , $E_N = 3.3V$ , $V_{HSD1}$ or $V_{HSD2} = V_{COMX} = 0V$ , (See Figure 5)  | +25       | -                  | 6    | -                  | pF       |

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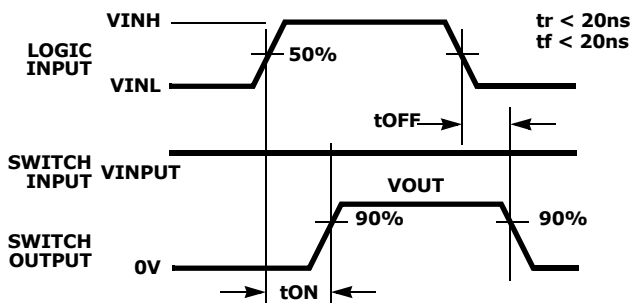
**Electrical Specifications - 2.7V to 3.6V Supply** Test Conditions:  $V_{DD} = +3.3V$ ,  $GND = 0V$ ,  $V_{INH} = 1.4V$ ,  $V_{INL} = 0.5V$ ,  $V_{ENH} = 1.4V$ ,  $V_{ENL} = 0.5V$ , (Note 11), Unless Otherwise Specified. **Bold-face limits apply over the operating temperature range, -40°C to +85°C. (Continued)**

| PARAMETER                                 | TEST CONDITIONS  | TEMP (°C) | MIN (Notes 12, 13) | TYP | MAX (Notes 12, 13) | UNITS   |
|---|--|-----------|--------------------|-----|--------------------|---------|
| FSx OFF Capacitance, $C_{FSxOFF}$         | $f = 1MHz$ , $V_{DD} = 3.3V$ , $IN = 3.3V$ , $EN = 3.3V$ , $V_{FSD1}$ or $V_{FSD2} = V_{COMx} = 0V$ , (See Figure 5) | +25       | -                  | 9   | -                  | pF      |
| COM ON Capacitance, $C_{COMX(ON)}$        | $f = 1MHz$ , $V_{DD} = 3.3V$ , $IN = 3.3V$ , $EN = 3.3V$ , $V_{HSD1}$ or $V_{HSD2} = V_{COMx} = 0V$ , (See Figure 5) | +25       | -                  | 12  | -                  | pF      |
| COM ON Capacitance, $C_{COMX(ON)}$        | $f = 1MHz$ , $V_{DD} = 3.3V$ , $IN = 0V$ , $EN = 3.3V$ , $V_{FSD1}$ or $V_{FSD2} = V_{COMx} = 0V$ , (See Figure 5)   | +25       | -                  | 15  | -                  | pF      |
| <b>POWER SUPPLY CHARACTERISTICS</b>       |  |           |                    |     |                    |         |
| Power Supply Range, $V_{DD}$              |  | Full      | <b>2.7</b>         | -   | <b>5.5</b>         | V       |
| Positive Supply Current, $I_{DD}$         | $V_{DD} = 3.6V$ , $IN = 0V$ or $3.6V$ , $EN = 0V$ or $3.6V$  | +25       | -                  | 20  | 60                 | nA      |
|   |  | Full      | -                  | -   | <b>500</b>         | nA      |
| <b>DIGITAL INPUT CHARACTERISTICS</b>      |  |           |                    |     |                    |         |
| Input Voltage Low, $V_{INL}$ , $V_{ENL}$  | $V_{DD} = 2.7V$ to $3.6V$  | Full      | -                  | -   | <b>0.5</b>         | V       |
| Input Voltage High, $V_{INH}$ , $V_{ENH}$ | $V_{DD} = 2.7V$ to $3.6V$  | Full      | <b>1.4</b>         | -   | -                  | V       |
| Input Current, $I_{INL}$ , $I_{ENL}$      | $V_{DD} = 3.6V$ , $IN = 0V$ , $EN = 0V$  | Full      | -                  | 10  | -                  | nA      |
| Input Current, $I_{INH}$                  | $V_{DD} = 3.6V$ , $IN = 3.6$   | Full      | -                  | 10  | -                  | nA      |
| Input Current, $I_{ENH}$                  | $V_{DD} = 3.6V$ , $EN = 3.6$   | Full      | -                  | 1   | -                  | $\mu A$ |

**NOTES:**

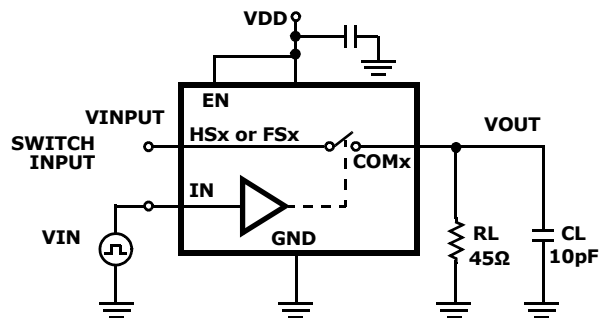
- $V_{LOGIC}$  = Input voltage to perform proper function.
- The algebraic convention, whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
- Parts are 100% tested at +25°C. Over temperature limits established by characterization and are not production tested.
- Flatness is defined as the difference between maximum and minimum value of on-resistance over the specified analog signal range.
- $r_{ON}$  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 HSD2 and HSD1 or between FSD2 and FSD1.

## 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**

Test Circuits and Waveforms (Continued)

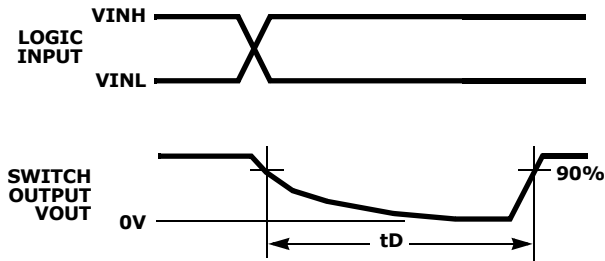
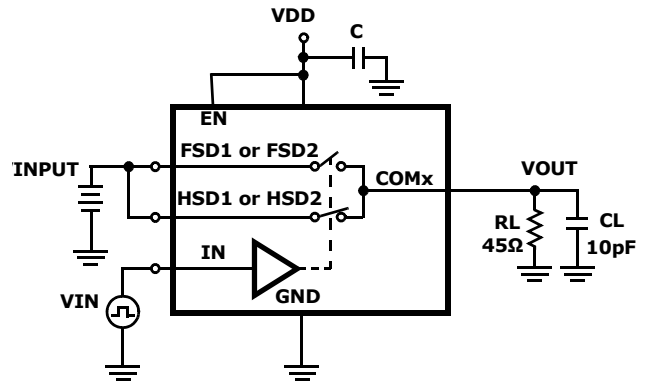


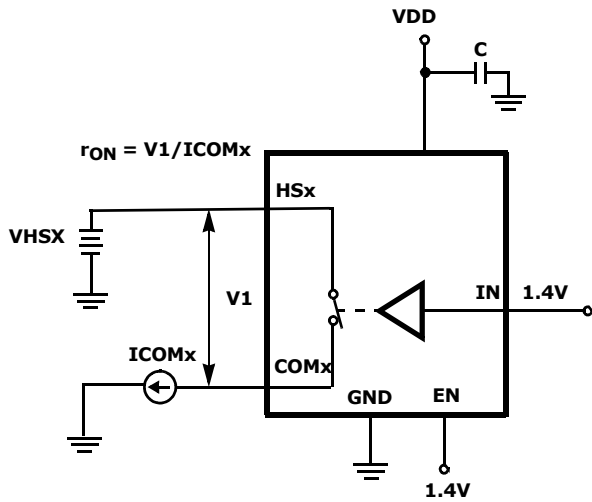
FIGURE 2A. MEASUREMENT POINTS



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

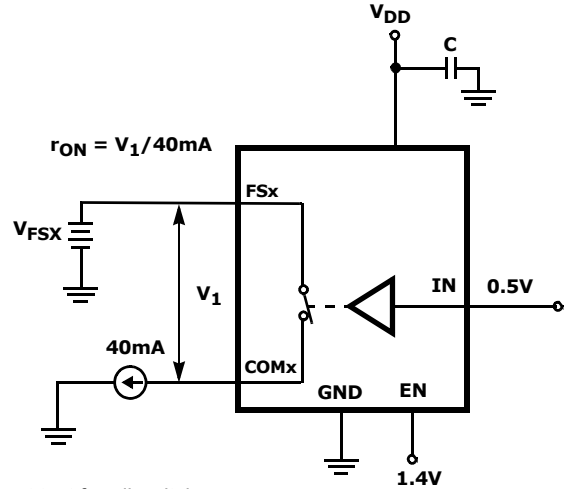
FIGURE 2B. TEST CIRCUIT

FIGURE 2. BREAK-BEFORE-MAKE TIME



Repeat test for all switches.

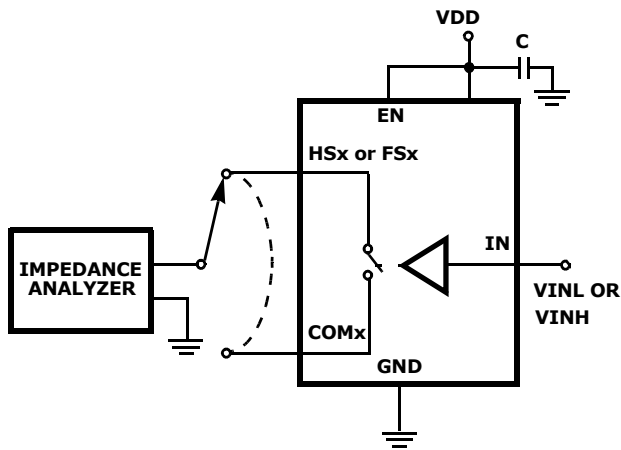
FIGURE 3. HSx SWITCH  $r_{ON}$  TEST CIRCUIT



Repeat test for all switches.

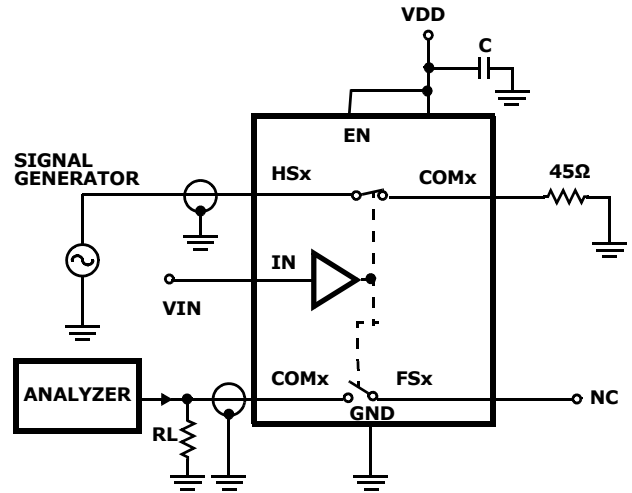
FIGURE 4. FSx SWITCH  $r_{ON}$  TEST CIRCUIT

Test Circuits and Waveforms (Continued)



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

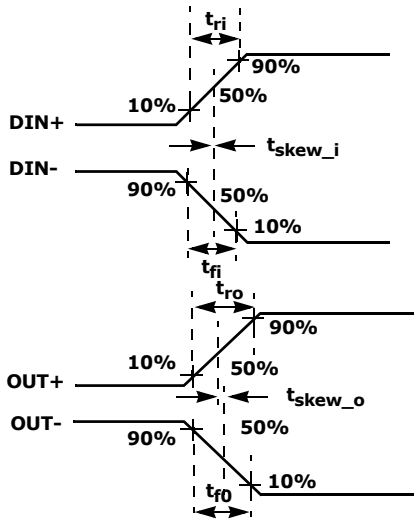
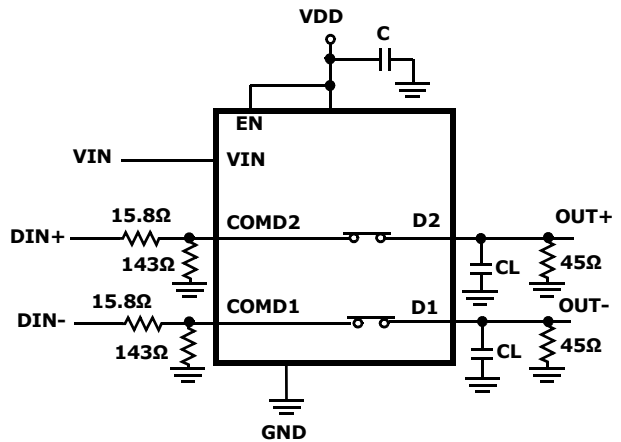


FIGURE 7A. MEASUREMENT POINTS



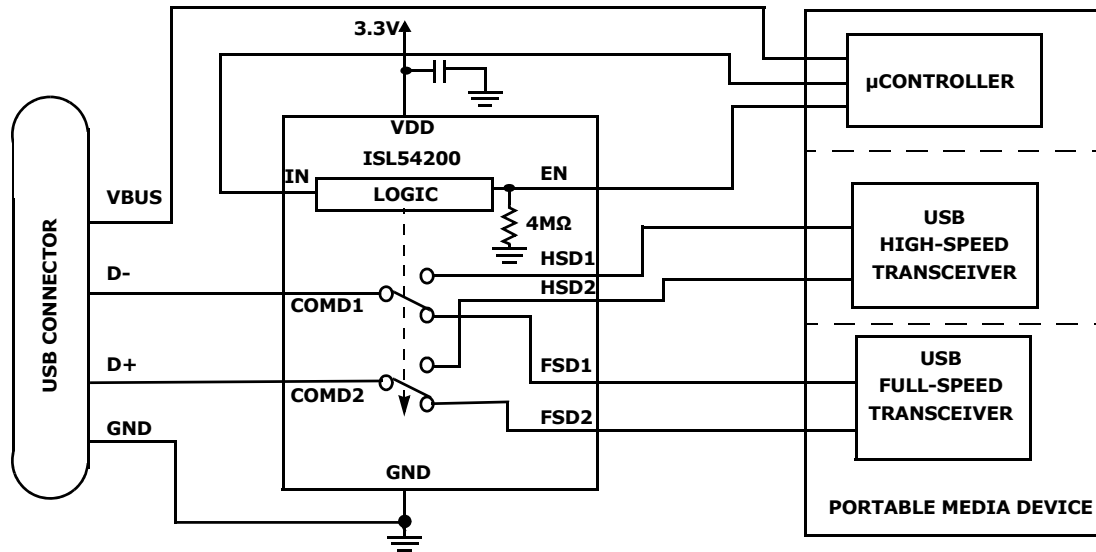
$|t_{ro}-t_{ri}|$  Delay Due to Switch for Rising Input and Rising Output Signals.  
 $|t_{fo}-t_{fi}|$  Delay Due to Switch for Falling Input and Falling Output Signals.  
 $|t_{skew_o}|$  Change in Skew through the Switch for Output Signals.  
 $|t_{skew_i}|$  Change in Skew through the Switch for Input Signals.

FIGURE 7B. TEST CIRCUIT

FIGURE 7. SKEW TEST



## Application Block Diagram



## Detailed Description

The ISL54200 device is a dual single pole/double throw (SPDT) analog switch that operates from a single DC power supply in the range of 2.7V to 5.5V. It was designed to function as a dual 2-to-1 multiplexer to select between a USB high-speed transceiver and a USB full-speed transceiver in portable battery powered products. It is offered in a TDFN package and a small  $\mu$ TQFN package for use in MP3 players, cameras, PDAs, cellphones, and other personal media players. The device has an enable pin to open all switches.

The part consists of two  $7\Omega$  full speed (FSx) switches and two  $4.5\Omega$  high speed (HSx) switches. The FSx switches can swing from 0V to  $V_{DD}$ . They were designed to pass USB full speed (12Mbps) differential data signals with minimal distortion. The HSx switches have high bandwidth and low capacitance to pass USB high-speed (480Mbps) differential data signals with minimal edge and phase distortion.

The ISL54200 was designed for MP3 players, cameras, cellphones, and other personal media player applications that have both high-speed and full-speed transceivers and need to multiplex between these USB sources to a single USB host (computer). A typical application block diagram of this functionality is shown on page 9.

A detailed description of the two types of switches are provided in the following sections.

### FSx Switches (FSD1, FSD2)

The two FSx switches (FSD1, FSD2) are bidirectional switches that can pass rail-to-rail signals. When powered with a 3.3V supply, these switches have a nominal  $r_{ON}$  resistance of  $7\Omega$  over the signal range of 0V to 3.3V. They were specifically designed to pass USB full-speed

(12Mbps) differential signals and meet the USB 2.0 full-speed signal quality specifications. See Figure 8.

The FSx switches can also pass USB high speed signals (480Mbps) but do not quite meet the USB 2.0 high speed signal quality eye diagram compliance requirement.

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

When operated with a 2.7V to 3.6V supply, the FSx switches are active (turned ON) whenever the IN logic control voltage is  $\leq 0.5V$  and the EN logic voltage  $\geq 1.4V$ .

### HSx Switches (HSD1, HSD2)

The two HSx switches (HSD2, HSD1) are bi-directional switches that can pass rail-to-rail signals. When powered with a 3.3V supply, these switches have a nominal  $r_{ON}$  of  $4.5\Omega$  over the signal range of 0V to 400mV with a  $r_{ON}$  flatness of  $0.4\Omega$ . The  $r_{ON}$  matching between the HSD1 and HSD2 switches over this signal range is only  $0.01\Omega$ , 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  $20\Omega$ .

The HSx switches were specifically designed to pass USB 2.0 high-speed (480Mbps) differential signals typically 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 Figures 9 and 10.

The HSx switches can also pass USB full-speed signals (12Mbps) with minimal distortion and meet all the USB

requirements for USB 2.0 full-speed signaling. See Figure 11.

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

The HSx switches are active (turned ON) whenever the IN voltage is  $\geq 1.4V$  and the EN logic voltage  $\geq 1.4V$  when operated with a 2.7V to 3.6V supply.

## ISL54200 Operation

The discussion that follows will discuss using the ISL54200 in the typical application shown in the "Application Block Diagram" on page 9.

### POWER

The power supply connected at the VDD (pin 1) provides the DC bias voltage required by the ISL54200 part for proper operation. The ISL54200 can be operated with a VDD voltage in the range of 2.7V to 5.5V. When used in a USB application, the VDD voltage should be kept in the range of 3.0V to 5.5V to ensure you get the proper signal levels for good signal quality.

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.

### LOGIC CONTROL

The state of the ISL54200 device is determined by the voltage at the IN pin (pin 2) and the EN pin (pin 10). IN is only active when the EN pin is logic "1" (High). Refer to the "Truth Table" on page 3.

The EN pin is internally pulled low through a 4M $\Omega$  resistor to ground. For logic "0" (Low) it can be driven low or allowed to Float. The IN pin must be driven low or high and cannot be left floating.

#### Logic Control Voltage Levels:

EN = Logic "0" (Low) when  $V_{EN} \leq 0.5V$  or Floating.

EN = Logic "1" (High) when  $V_{EN} \geq 1.4V$

IN = Logic "0" (Low) when  $V_{IN} \leq 0.5V$ .

IN = Logic "1" (High) when  $V_{IN} \geq 1.4V$

### Full-speed Mode

If the IN pin = Logic "0" and the EN pin = Logic "1", the part will be in the full-speed mode. In this mode, the FSD1 and FSD2 switches are ON and the HSD1 and HSD2 switches are OFF (high impedance). In a typical application,  $V_{DD}$  will be in the range of 2.8V to 3.6V and will be connected to the battery or LDO of the portable media device. When a computer or USB hub is plugged into the common USB connector and the part is in the full-speed mode, a link will be established between the full-speed driver section of the media player and the computer. The device will be able to transmit and receive data from the computer at a data rate of 12Mbps.

### High-speed Mode

If the IN pin = Logic "1" and the EN pin = Logic "1", the part will go into high-speed mode. In high-speed mode, the HSD1 and HSD2 switches are ON and the FSD1 and FSD2 switches are OFF (high impedance). When a USB cable from a computer or USB hub is connected at the common USB connector and the part is in the high-speed mode, a link will be established between the high-speed driver section of the media player and the computer. The device will be able to transmit and receive data from the computer at a data rate of 480Mbps.

### All Switches OFF Mode

If the IN pin = Logic "0" or Logic "1" and the EN pin = Logic "0", all of the switches will turn OFF (high impedance).

The all OFF state can be used to switch between the two USB sections of the media player. When disconnecting from one USB device to the other USB device, you can momentarily put the ISL54200 switch in the "all off" state in order to get the computer to disconnect from the one device so it can properly connect to the other USB device when that channel is turned ON.

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

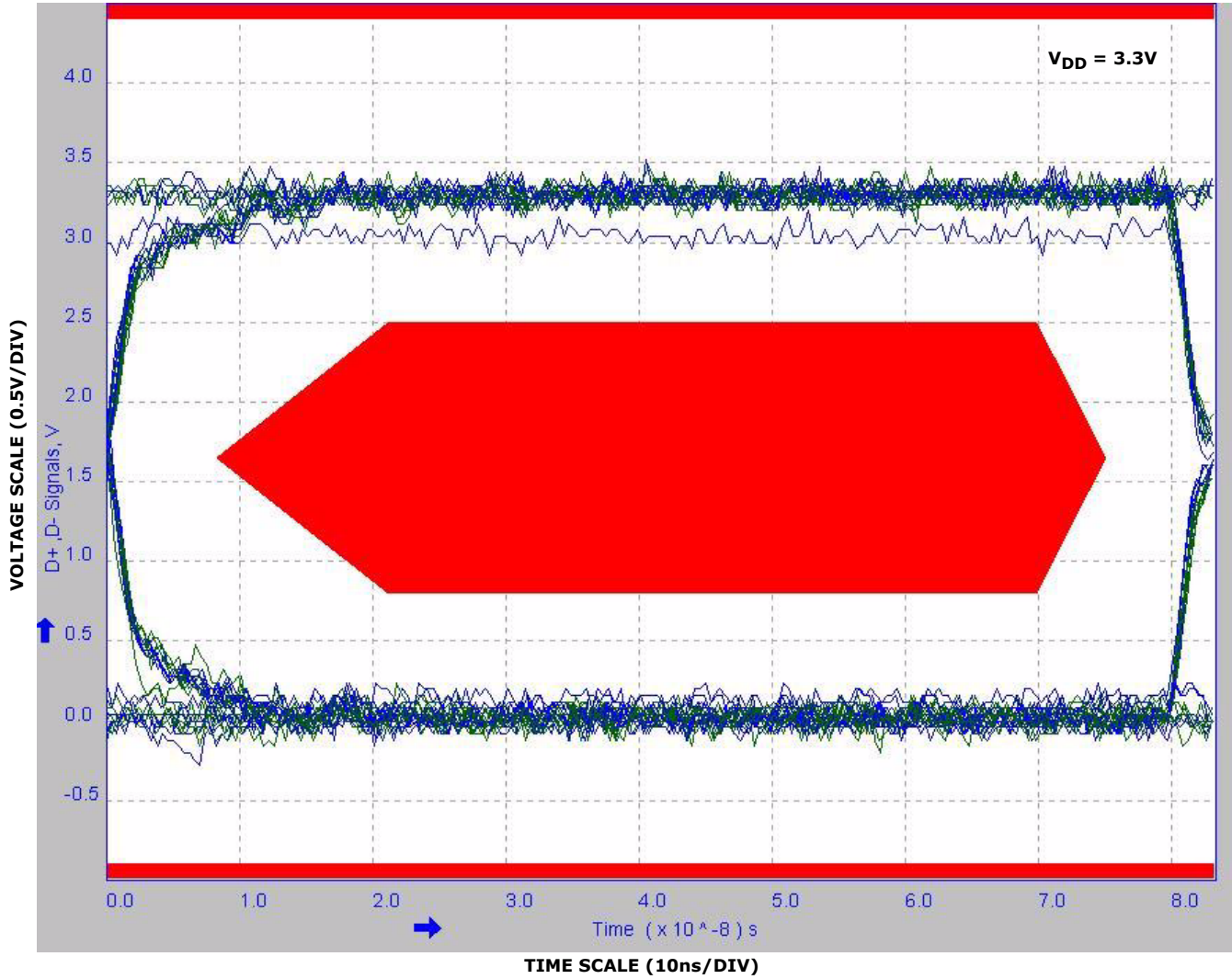


FIGURE 8. EYE PATTERN: 12MBPS USB SIGNAL WITH FSx SWITCHES IN THE SIGNAL PATH

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

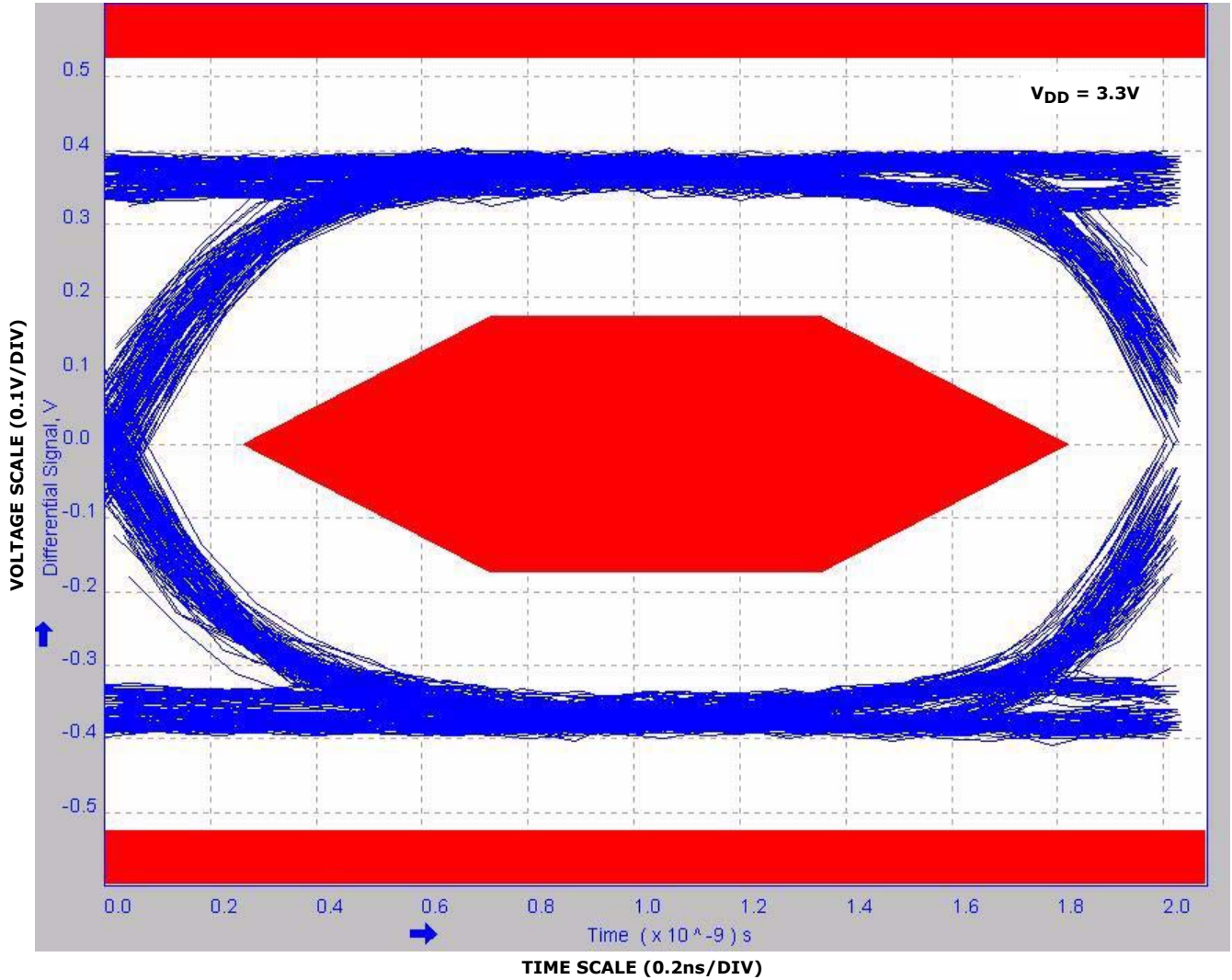


FIGURE 9. EYE PATTERN WITH FAR END MASK: 480MBPS USB SIGNAL WITH HSx SWITCHES IN THE SIGNAL PATH

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

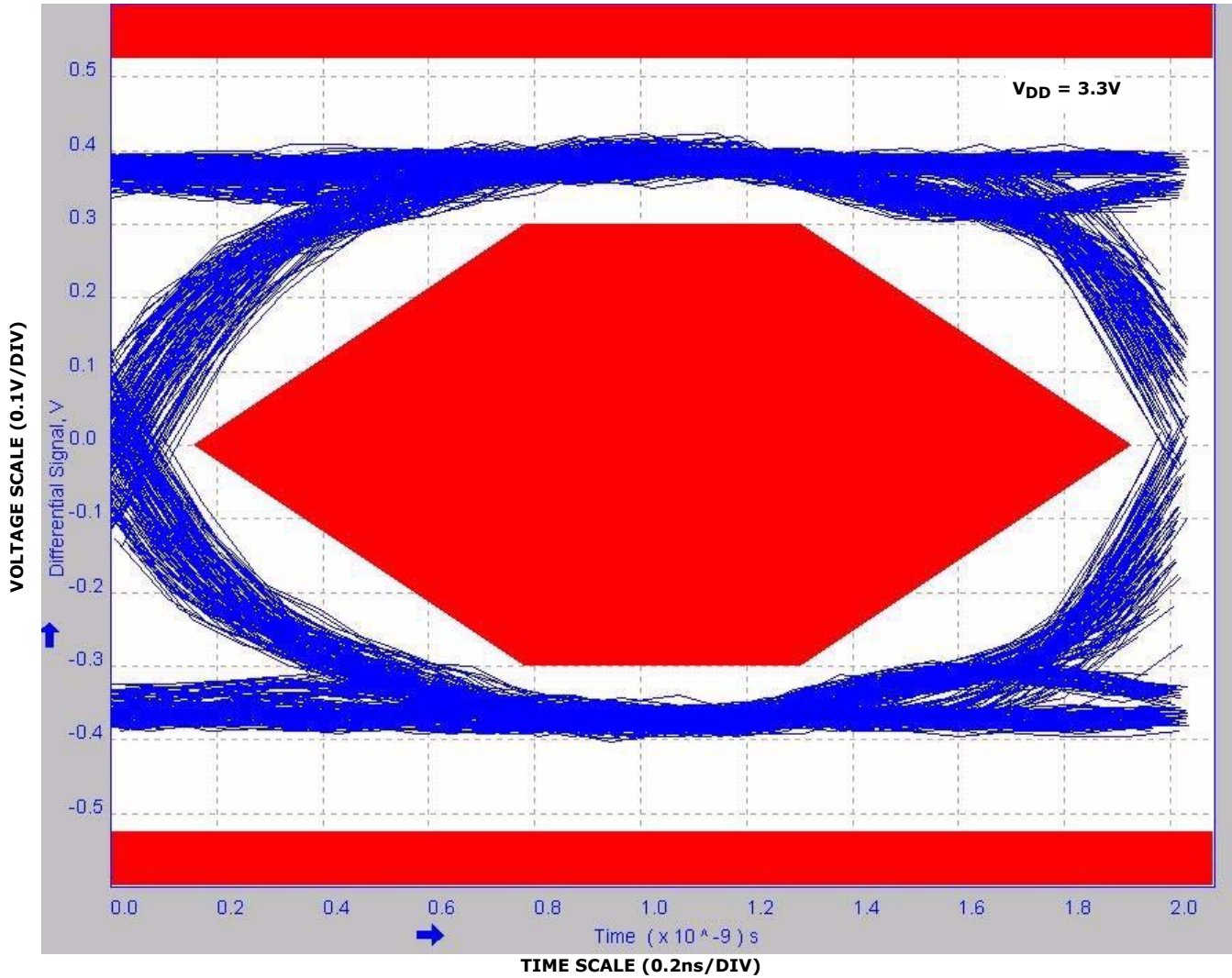


FIGURE 10. EYE PATTERN WITH NEAR END MASK: 480MBPS USB SIGNAL WITH HSx SWITCHES IN THE SIGNAL PATH

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

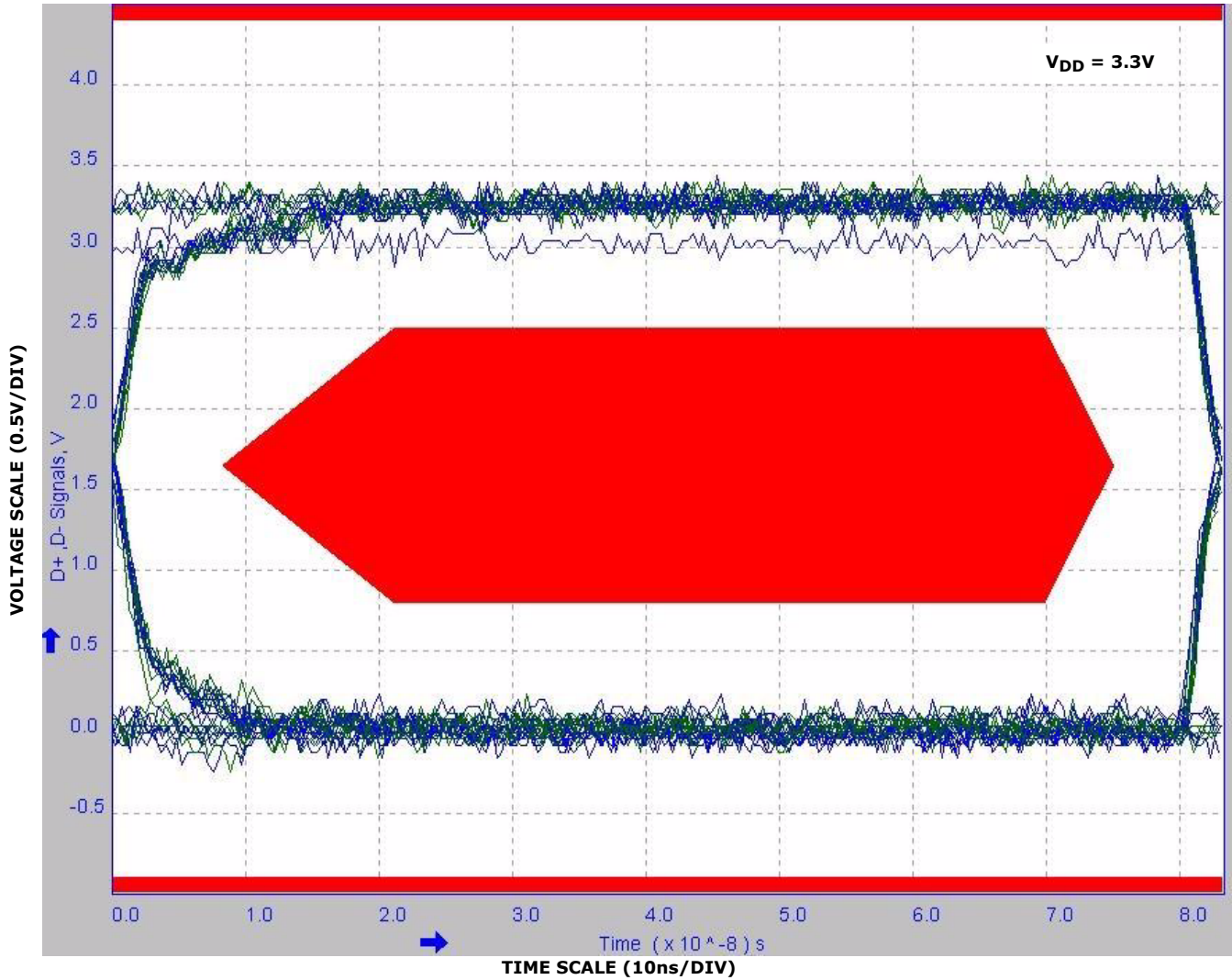


FIGURE 11. EYE PATTERN: 12MBPS USB SIGNAL WITH HSx SWITCHES IN THE SIGNAL PATH

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

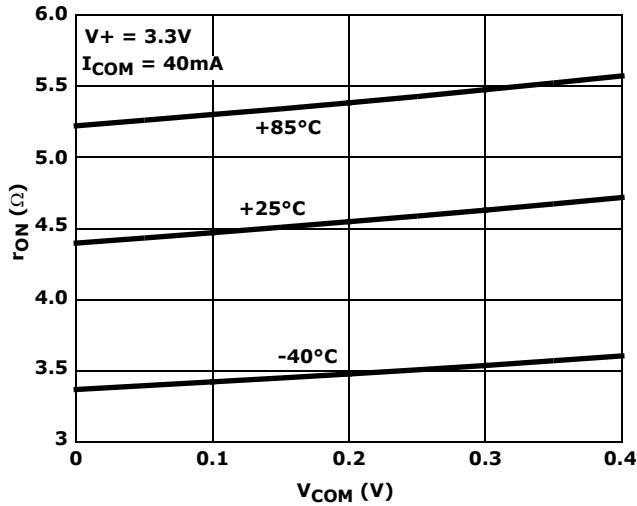


FIGURE 12. HSx SWITCH ON-RESISTANCE vs SWITCH VOLTAGE

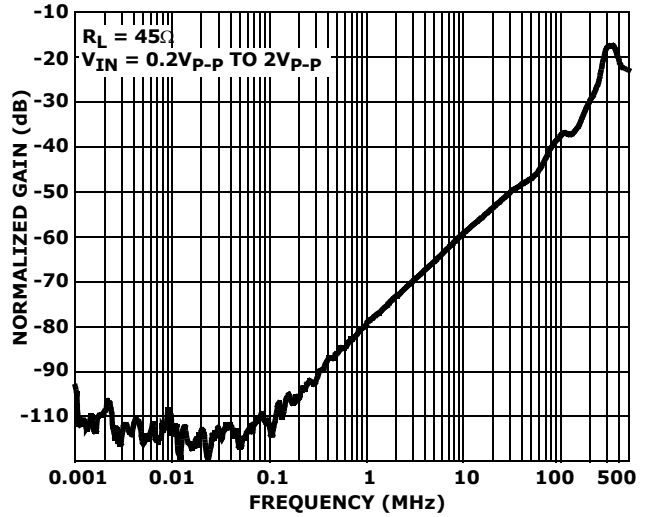


FIGURE 13. OFF-ISOLATION

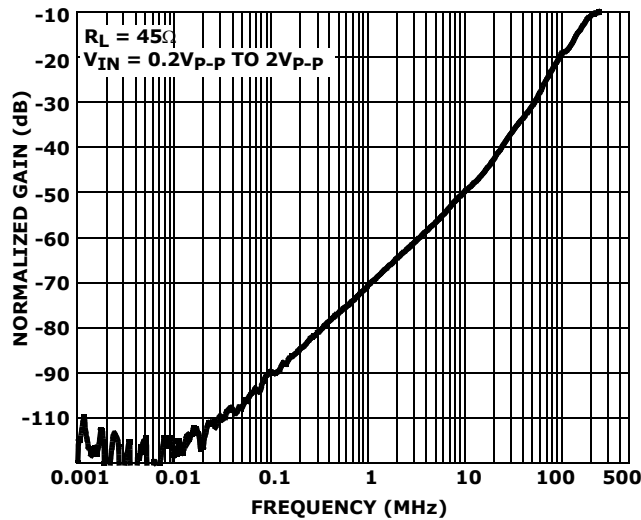


FIGURE 14. CROSSTALK

**Die Characteristics**

**SUBSTRATE AND TDFN THERMAL PAD POTENTIAL (POWERED UP):**

GND

**TRANSISTOR COUNT:**

98

**PROCESS:**

Submicron CMOS

## Revision History

| DATE    | REVISION | CHANGE   |
|---------|----------|--|
| 5/17/10 | FN6408.2 | <p>Updated Pb-free bullet in "Features" on page 1 and Pb-free notes 3 and 4 in "Ordering Information" on page 2 per Mark Kwoka's new verbiage based on lead finish. Added TB347 link note 2 to "Ordering Information" on page 2 for reel specifications.</p> <p>In "Thermal Information" on page 4, added <math>\theta_{JC}</math> for both TDFN and uTQFN packages. Updated <math>\theta_{JA}</math> for <math>\mu</math>TQFN from 140 to 145. Added applicable <math>\theta_{JA}/\theta_{JC}</math> notes 7 through 10.</p> <p>Changed "Positive Supply Current, IDD" on page 6 for full temp from: 80nA to 500nA Limit changes required to improve yield (PCN required)</p> <p>Changes to "L10.2.1x1.6A" on page 17 as follows:<br/>           Converted to new POD format (Moved dimensions from table onto drawing)<br/>           Corrected leadframe thickness in Detail x from 0.2 REF to 0.125 REF<br/>           Corrected Note 4 to read "...between 0.15mm and 0.30mm...", it previously read "...between .015mm and 0.30mm..."<br/>           Corrected the word "indentifier" in Note 8 to read "identifier".</p> <p>Changes to "L10.3x3A" on page 18 as follows:<br/>           Added Typical Recommended Land Pattern</p> <p>Put into new data sheet format. Changes include:<br/>           Add "Related Literature*(see page 16)" on page 1<br/>           Added MSL note 5 to "Ordering Information" on page 2<br/>           Added "Boldface limits apply over the operating temperature range, -40°C to +85°C." to common conditions of "Electrical Specifications" table beginning on page 4. Bolded applicable specs.<br/>           Added "Products" on page 16<br/>           Added "Revision History" on page 16<br/>           Updated the "Pin Descriptions" on page 3 to show the thermal pad.<br/>           Added latch-up level to "Absolute Maximum Ratings" on page 4.</p> |
| 7/11/07 | FN6408.1 | <p>Made changes to "Pin Descriptions" on page 3<br/>           Made changes to Bandwidth in "DYNAMIC CHARACTERISTICS" on page 5<br/>           On page 11 to page 14, made changes to eye diagram axis labels</p>  |

## Products

Intersil Corporation is a leader in the design and manufacture of high-performance analog semiconductors. The Company's products address some of the industry's fastest growing markets, such as, flat panel displays, cell phones, handheld products, and notebooks. Intersil's product families address power management and analog signal processing functions. Go to [www.intersil.com/products](http://www.intersil.com/products) for a complete list of Intersil product families.

\*For a complete listing of Applications, Related Documentation and Related Parts, please see the respective device information page on intersil.com: [ISL54200](http://www.intersil.com/ISL54200)

To report errors or suggestions for this datasheet, please go to [www.intersil.com/askourstaff](http://www.intersil.com/askourstaff)

FITs are available from our website at <http://rel.intersil.com/reports/search.php>

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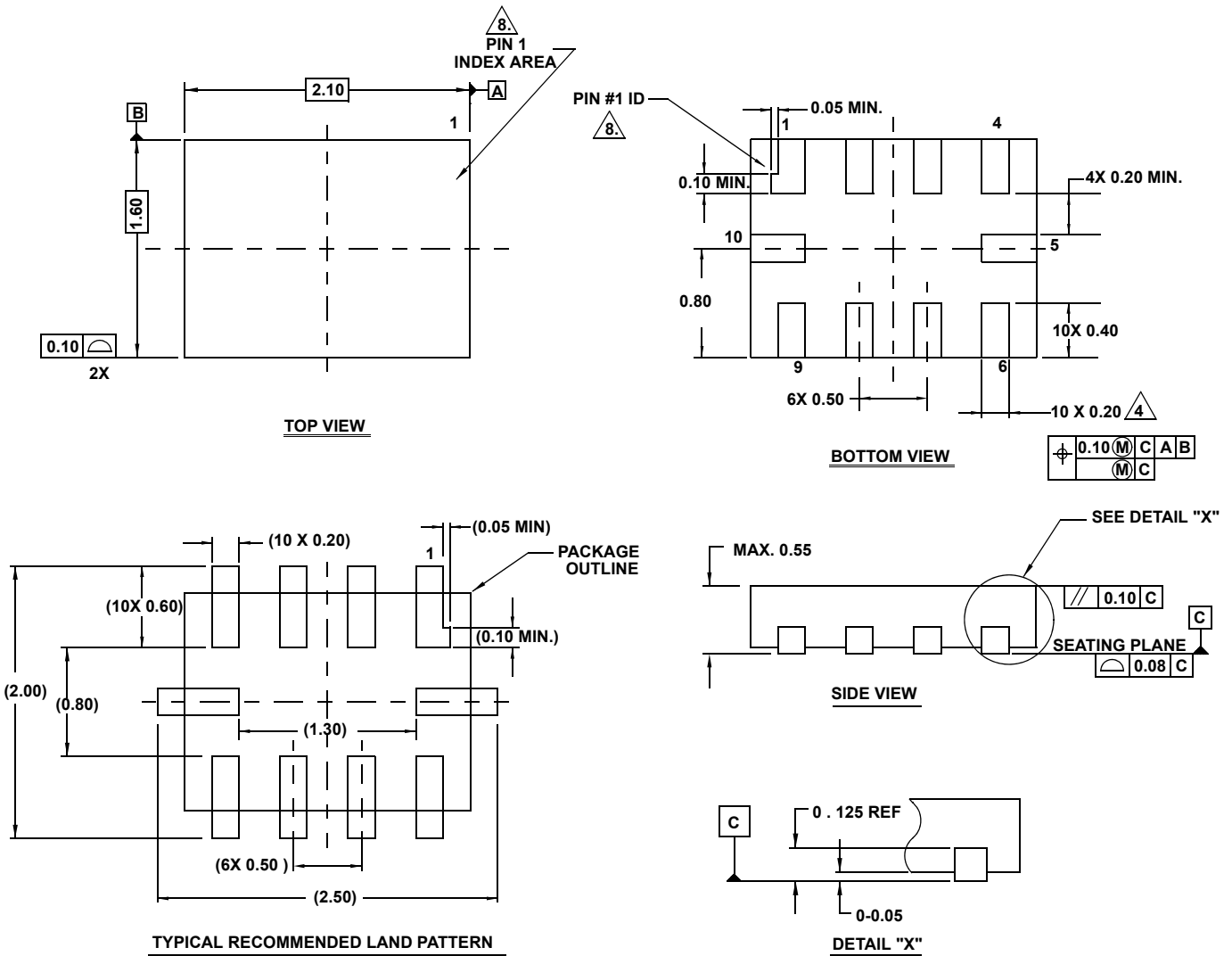


Package Outline Drawing

L10.2.1x1.6A

10 LEAD ULTRA THIN QUAD FLAT NO-LEAD PLASTIC PACKAGE

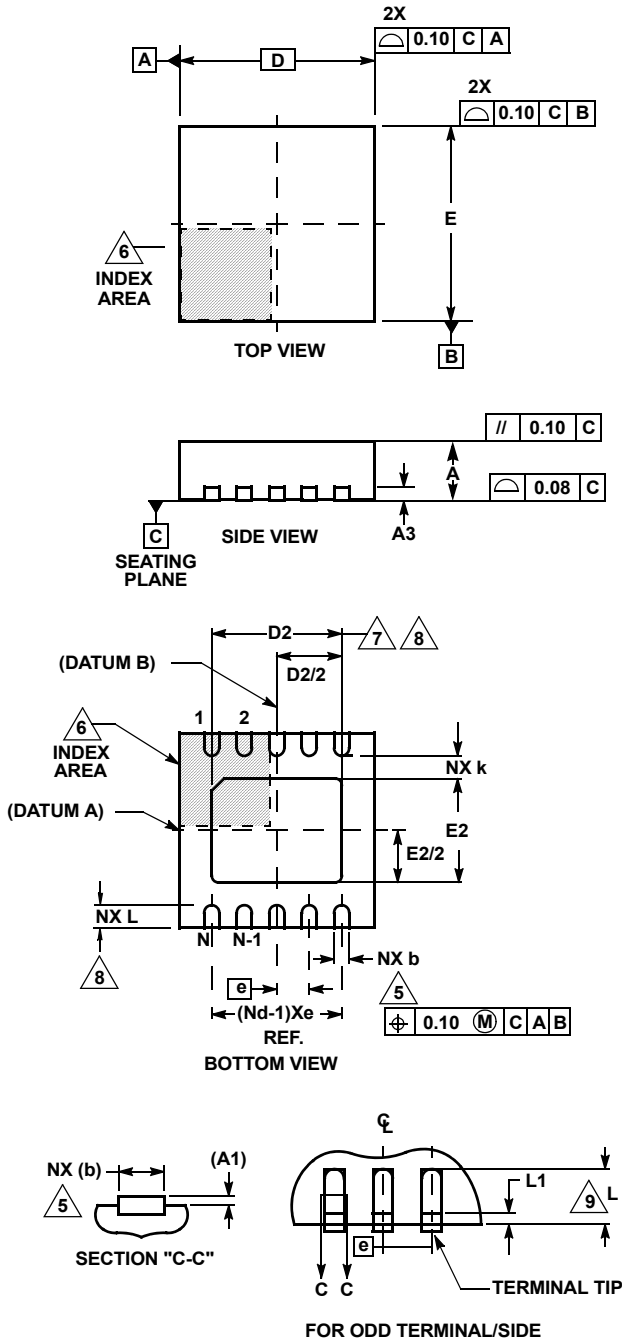
Rev 5, 3/10



NOTES:

1. Dimensioning and tolerancing conform to ASME Y14.5M-1994.
2. All Dimensions are in millimeters. Angles are in degrees. Dimensions in ( ) for Reference Only.
3. Unless otherwise specified, tolerance : Decimal  $\pm 0.05$
4. Lead width dimension applies to the metallized terminal and is measured between 0.15mm and 0.30mm from the terminal tip.
5. Maximum package warpage is 0.05mm.
6. Maximum allowable burrs is 0.076mm in all directions.
7. Same as JEDEC MO-255UABD except:  
No lead-pull-back, MIN. Package thickness = 0.45 not 0.50mm  
Lead Length dim. = 0.45mm max. not 0.42mm.
8. 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.

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. 4 8/09

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.

