



# 3-Wire Interface Full-Speed USB Transceivers With/Without Internal Series Resistors

## General Description

The MAX13342E/MAX13345E USB-compliant transceivers are designed to minimize the area and external components required to interface low-voltage ASICs to USB. The devices comply with USB 2.0 specification for full-speed-only (12Mbps) operation. The transceivers include an internal 3.3V regulator, an internal 1.5k $\Omega$  D+ pullup resistor, and built-in  $\pm 15$ kV ESD protection circuitry to protect the USB I/O ports (D+, D-). The MAX13345E also has internal series resistors, allowing it to be wired directly to a USB connector.

These devices operate with logic-supply voltages as low as +2.3V, ensuring compatibility with low-voltage ASICs. A low-power mode reduces current consumption to less than 45 $\mu$ A. An enumerate function controls the D+ pullup resistor, allowing devices to logically disconnect while remaining plugged in.

The MAX13342E has controlled output impedance of 2 $\Omega$  (max) on D+/D-, allowing the use of external switches to multiplex two different USB devices onto a single USB connector. The MAX13345E has 43.5 $\Omega$  (max) internal resistors on D+/D- for direct connection to the USB connector.

The MAX13342E/MAX13345E are equipped with DAT and SE0 interface signals. These transceivers provide a USB detection function that monitors the presence of USB V<sub>BUS</sub> and signals the event.

These devices operate over the extended -40°C to +85°C temperature range and are available in UCSP™ 2.0mm x 1.5mm and 14-pin TDFN (3mm x 3mm) packages.

UCSP™ is a trademark of Maxim Integrated Products, Inc.

## Applications

PDA's  
PC Peripherals  
Cellular Telephones  
Data Cradles  
MP3 Players

**Pin Configurations and Selector Guide appear at end of data sheet.**

## Features

- ◆ USB 2.0 (Full-Speed, 12Mbps)-Compliant Transceiver
- ◆ Internal Pullup
- ◆ V<sub>BUS</sub> Detection
- ◆ Internal Series Resistors (MAX13345E)
- ◆  $\pm 15$ kV (HBM) ESD Protection on D+, D-, and V<sub>BUS</sub>
- ◆ Enumeration Input Controls D+ Pullup Resistor
- ◆ Supports 3-Wire DAT/SE0 Interface
- ◆ +2.3V to +3.6V Interface Voltage (V<sub>L</sub>)
- ◆ No Power-Supply Sequencing Required
- ◆ Low USB Output Impedance (MAX13342E)

## Ordering Information

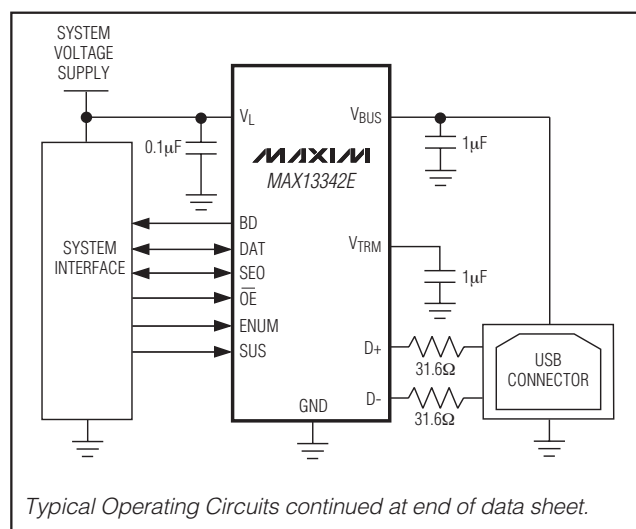
| PART           | PIN-PACKAGE                | TOP MARK | PKG CODE |
|----------------|----------------------------|----------|----------|
| MAX13342EETD+  | 14 TDFN-EP<br>(3mm x 3mm)  | ACZ      | T1433-2  |
| MAX13342EEBC+* | 12 UCSP<br>(2.0mm x 1.5mm) | ACU      | B12-3    |
| MAX13345EETD+  | 14 TDFN-EP<br>(3mm x 3mm)  | ADA      | T1433-2  |
| MAX13345EEBC+* | 12 UCSP<br>(2.0mm x 1.5mm) | ACX      | B12-3    |

\*Future product—contact factory for availability.

+Denotes lead-free package.

EP = Exposed pad.

## Typical Operating Circuits



# 3-Wire Interface Full-Speed USB Transceivers With/Without Internal Series Resistors

## ABSOLUTE MAXIMUM RATINGS

(All voltages refer to GND unless otherwise noted.)

Supply Voltage ( $V_{BUS}$ ) .....-0.3V to +6V  
 System Supply Voltage ( $V_L$ ) .....-0.3V to +6V  
 Output of Internal Regulator ( $V_{TRM}$ ) .....-0.3V to ( $V_{BUS} + 0.3V$ )  
 Input Voltage (D+, D-) .....-0.3V to +6V  
 SUS, BD .....-0.3V to ( $V_L + 0.3V$ )  
 ENUM, SE0, DAT .....-0.3V to ( $V_L + 0.3V$ )  
 Short-Circuit Current to  $V_{BUS}$  or GND (D+, D-) .....±150mA  
 Maximum Continuous Current (all other pins) .....±15mA

Continuous Power Dissipation ( $T_A = +70^\circ\text{C}$ )

14-Pin TDFN (derate 18.5mW/ $^\circ\text{C}$  above  $+70^\circ\text{C}$ ) .....1482mW  
 4mm x 3mm UCSP

(derate 6.5mW/ $^\circ\text{C}$  above  $+70^\circ\text{C}$ ) .....518mW

Operating Temperature Range .....-40 $^\circ\text{C}$  to +85 $^\circ\text{C}$

Junction Temperature .....+150 $^\circ\text{C}$

Storage Temperature Range .....-65 $^\circ\text{C}$  to +150 $^\circ\text{C}$

Bump Soldering .....+235 $^\circ\text{C}$

Lead Soldering (10s) ..... +300 $^\circ\text{C}$

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

( $V_{BUS} = +4.0V$  to  $+5.5V$ ,  $V_L = +2.3V$  to  $+3.6V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $V_{BUS} = +5.0V$ ,  $V_L = +2.5V$ ,  $T_A = +25^\circ\text{C}$ .) (Note 1)

| PARAMETER                                                                           | SYMBOL            | CONDITIONS                                                                                            | MIN | TYP | MAX | UNITS         |
|-------------------------------------------------------------------------------------|-------------------|-------------------------------------------------------------------------------------------------------|-----|-----|-----|---------------|
| <b>SUPPLY INPUTS (<math>V_{BUS}</math>, <math>V_{TRM}</math>, <math>V_L</math>)</b> |                   |                                                                                                       |     |     |     |               |
| $V_{BUS}$ Input Range                                                               | $V_{BUS}$         |                                                                                                       | 4.0 |     | 5.5 | V             |
| $V_L$ Input Range                                                                   | $V_L$             |                                                                                                       | 2.3 |     | 3.6 | V             |
| Regulated Supply-Voltage Output                                                     | $V_{TRM}$         |                                                                                                       | 3.0 | 3.3 | 3.6 | V             |
| Operating $V_{BUS}$ Supply Current                                                  | $I_{VBUS}$        | Full-speed transmitting/receiving at 12Mbps, $C_L = 50\text{pF}$ on D+ and D-                         |     |     | 10  | mA            |
| Operating $V_L$ Supply Current                                                      | $I_{VL}$          | Full-speed transmitting/receiving at 12Mbps, $C_L = 15\text{pF}$ receiver outputs, $V_L = 2.5V$       |     | 1.5 |     | mA            |
| Full-Speed Idle and SE0 Supply Current                                              | $I_{VBUS(IDLE)}$  | Full-speed idle, $V_{D+} > 2.7V$ , $V_{D-} < 0.3V$                                                    |     |     | 500 | $\mu\text{A}$ |
|                                                                                     |                   | SE0: $V_{D-} < 0.3V$ , $V_{D+} < 0.3$                                                                 |     |     | 500 |               |
| Static $V_L$ Supply Current                                                         | $I_{VL(STATIC)}$  | Full-speed idle, SE0 or suspend mode                                                                  |     |     | 10  | $\mu\text{A}$ |
| Suspend Supply Current                                                              | $I_{VBUS(SUSP)}$  | SE0 = DAT = open;<br>SUS = $\overline{OE}$ = high                                                     |     | 30  | 45  | $\mu\text{A}$ |
| Disable-Mode Supply Current                                                         | $I_{VBUS(DIS)}$   | $V_L = \text{GND}$ or open                                                                            |     |     | 25  | $\mu\text{A}$ |
| Sharing-Mode $V_L$ Supply Current                                                   | $I_{VL(SHARING)}$ | $V_{BUS} = \text{GND}$ or open, $\overline{OE} = \text{low}$ ,<br>SE0 = DAT = low or high, SUS = high |     |     | 5   | $\mu\text{A}$ |
| D+/D- Supply Current                                                                | $I_{D+/D-}$       | $V_{BUS} = \text{GND}$ or open                                                                        |     |     | 20  | $\mu\text{A}$ |
| $V_{BUS}$ Power-Supply Detection Threshold                                          | $V_{TH\_VBUS}$    | $V_L > 2.3V$                                                                                          | 0.8 |     | 3.6 | V             |
| $V_{BUS}$ Power-Supply Detection Hysteresis                                         | $V_{VBUSHYS}$     |                                                                                                       |     | 100 |     | mV            |
| $V_L$ Power-Supply Threshold                                                        | $V_{TH\_VL}$      |                                                                                                       |     | 850 |     | mV            |

# 3-Wire Interface Full-Speed USB Transceivers With/Without Internal Series Resistors

## ELECTRICAL CHARACTERISTICS (continued)

(V<sub>BUS</sub> = +4.0V to +5.5V, V<sub>L</sub> = +2.3V to +3.6V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at V<sub>BUS</sub> = +5.0V, V<sub>L</sub> = +2.5V, T<sub>A</sub> = +25°C.) (Note 1)

| PARAMETER                                                                               | SYMBOL            | CONDITIONS                                                                              | MIN                  | TYP                  | MAX   | UNITS |
|-----------------------------------------------------------------------------------------|-------------------|-----------------------------------------------------------------------------------------|----------------------|----------------------|-------|-------|
| <b>DIGITAL INPUTS AND OUTPUTS (DAT, SE0, <math>\overline{OE}</math>, ENUM, SUS, BD)</b> |                   |                                                                                         |                      |                      |       |       |
| Input-High Voltage                                                                      | V <sub>IH</sub>   |                                                                                         | 0.7 × V <sub>L</sub> |                      |       | V     |
| Input-Low Voltage                                                                       | V <sub>IL</sub>   |                                                                                         |                      | 0.3 × V <sub>L</sub> |       | V     |
| Output-Voltage High                                                                     | V <sub>OH</sub>   | I <sub>SOURCE</sub> = 2mA                                                               | V <sub>L</sub> - 0.4 |                      |       | V     |
| Output-Voltage Low                                                                      | V <sub>OL</sub>   | I <sub>SINK</sub> = 2mA                                                                 |                      | 0.4                  |       | V     |
| Input Leakage Current                                                                   | I <sub>LKG</sub>  |                                                                                         | -1                   |                      | +1    | μA    |
| Input Capacitance                                                                       |                   | Measured from input to GND                                                              |                      | 10                   |       | pF    |
| <b>ANALOG INPUTS AND OUTPUTS (D+/D-)</b>                                                |                   |                                                                                         |                      |                      |       |       |
| Differential Input Sensitivity                                                          | V <sub>ID</sub>   | V <sub>D+</sub> - V <sub>D-</sub>                                                       | 200                  |                      |       | mV    |
| Differential Common-Mode Voltage Range                                                  | V <sub>CM</sub>   | Includes V <sub>ID</sub> range                                                          | 0.8                  |                      | 2.5   | V     |
| Single-Ended Input Voltage High                                                         | V <sub>IHSE</sub> |                                                                                         | 2.0                  |                      |       | V     |
| Single-Ended Input Voltage Low                                                          | V <sub>ILSE</sub> |                                                                                         |                      | 0.8                  |       | V     |
| Receiver Single-Ended Hysteresis                                                        | V <sub>HYS</sub>  |                                                                                         |                      | 200                  |       | mV    |
| Output-Voltage Low                                                                      | V <sub>OLD</sub>  | R <sub>L</sub> = 1.5kΩ from D+ or D- to 3.6V                                            |                      |                      | 0.3   | V     |
| Output-Voltage High                                                                     | V <sub>OHD</sub>  | R <sub>L</sub> = 15kΩ from D+ or D- to GND                                              | 2.8                  |                      | 3.6   | V     |
| Off-State Leakage Current                                                               |                   | Tri-state driver                                                                        | -1                   |                      | +1    | μA    |
| Transceiver Capacitance                                                                 | C <sub>IND</sub>  | Measured from D+ or D- to GND                                                           |                      | 20                   |       | pF    |
| Driver Output Impedance                                                                 | R <sub>OUT</sub>  | MAX13342E                                                                               | 4                    |                      | 14    | Ω     |
|                                                                                         |                   | MAX13345E                                                                               | 28                   |                      | 43    |       |
| Internal Pullup Resistor                                                                | R <sub>PU</sub>   |                                                                                         | 1.425                | 1.500                | 1.575 | kΩ    |
| Input Impedance                                                                         | Z <sub>IN</sub>   | Drivers off, tri-state driver, ENUM = 0, V <sub>D+</sub> , V <sub>D-</sub> = 0 OR +3.6V | 1                    |                      |       | MΩ    |
| <b>LINEAR REGULATOR</b>                                                                 |                   |                                                                                         |                      |                      |       |       |
| External Capacitor                                                                      | C <sub>OUT</sub>  | Compensation of linear regulator                                                        | 1                    |                      |       | μF    |
| <b>ESD PROTECTION (D+, D-)</b>                                                          |                   |                                                                                         |                      |                      |       |       |
| Human Body Model                                                                        |                   |                                                                                         |                      | ±15                  |       | kV    |
| IEC 61000-4-2 Air-Gap Discharge                                                         |                   |                                                                                         |                      | ±8                   |       | kV    |
| IEC 61000-4-2 Contact Discharge                                                         |                   |                                                                                         |                      | ±8                   |       | kV    |

MAX13342E/MAX13345E

# 3-Wire Interface Full-Speed USB Transceivers With/Without Internal Series Resistors

## TIMING CHARACTERISTICS

( $V_{BUS} = +4V$  to  $+5.5V$ ,  $V_L = +2.3V$  to  $+3.6V$ ,  $EN_{UM} = V_L$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $V_{BUS} = +5V$ ,  $V_L = +2.5V$ ,  $T_A = +25^\circ C$ .) (Note 1)

| PARAMETER                               | SYMBOL                                     | CONDITIONS                                                                                                           |                       | MIN | TYP | MAX | UNITS |
|-----------------------------------------|--------------------------------------------|----------------------------------------------------------------------------------------------------------------------|-----------------------|-----|-----|-----|-------|
| TRANSMITTER ( C <sub>L</sub> = 50pF)    |                                            |                                                                                                                      |                       |     |     |     |       |
| Rise Time                               | t <sub>FR</sub>                            | 10% to 90% of  V <sub>OHD</sub> -V <sub>OLD</sub>   with an external 31.6Ω series resistor (MAX13342E), Figures 3, 8 |                       | 4   |     | 20  | ns    |
| Fall Time                               | t <sub>FF</sub>                            | 10% to 90% of  V <sub>OHD</sub> -V <sub>OLD</sub>   with an external 31.6Ω series resistor (MAX13342E), Figures 3, 8 |                       | 4   |     | 20  | ns    |
| Rise-and-Fall Time Matching (Note 1)    | t <sub>LR</sub> /t <sub>LF</sub>           | Figures 3, 8                                                                                                         |                       | 90  |     | 110 | %     |
| Output Signal Crossover (Note 2)        | V <sub>CRS_L</sub> ,<br>V <sub>CRS_F</sub> | Figure 4                                                                                                             |                       | 1.3 |     | 2   | V     |
| Driver Propagation Delay                | t <sub>PLH_DRV</sub>                       | Low-to-high transition, Figures 4, 8                                                                                 | V <sub>L</sub> > 2.3V |     |     | 20  | ns    |
|                                         | t <sub>PHL_DRV</sub>                       | High-to-low transition, Figures 4, 8                                                                                 | V <sub>L</sub> > 2.3V |     |     | 20  |       |
| Driver-Enabled Delay Time               | t <sub>PZH_DRV</sub>                       | Off-to-high transition, Figures 5, 8                                                                                 | V <sub>L</sub> > 2.3V |     |     | 18  | ns    |
|                                         | t <sub>PZL_DRV</sub>                       | Off-to-low transition, Figures 5, 8                                                                                  | V <sub>L</sub> > 2.3V |     |     | 18  |       |
| Driver Disable Delay                    | t <sub>PHZ_DRV</sub>                       | High-to-off transition, Figure 5, 9                                                                                  | V <sub>L</sub> > 2.3V |     |     | 18  | ns    |
|                                         | t <sub>PLZ_DRV</sub>                       | Low-to-off transition, Figures 5, 9                                                                                  | V <sub>L</sub> > 2.3V |     |     | 18  |       |
| RECEIVER (C <sub>L</sub> = 15pF)        |                                            |                                                                                                                      |                       |     |     |     |       |
| Differential Receiver Propagation Delay | t <sub>PLH_RCV</sub>                       | Low-to-high transition, Figures 6,10                                                                                 | V <sub>L</sub> > 2.3V |     |     | 20  | ns    |
|                                         | t <sub>PHL_RCV</sub>                       | High-to-low transition, Figures 6,10                                                                                 | V <sub>L</sub> > 2.3V |     |     | 20  |       |
| Single-Ended Receiver Propagation Delay | t <sub>PLH_SE</sub>                        | Low-to-high transition, Figures 6,10                                                                                 |                       |     |     | 18  | ns    |
|                                         | t <sub>PHL_SE</sub>                        | High-to-low transition, Figures 6,10                                                                                 |                       |     |     | 18  |       |
| Single-Ended Receiver Disable Delay     | t <sub>PHZ_SE</sub>                        | High-to-off transition, Figure 7                                                                                     | V <sub>L</sub> > 2.3V |     |     | 20  | ns    |
|                                         | t <sub>PLZ_SE</sub>                        | Low-to-off transition, Figure 7                                                                                      | V <sub>L</sub> > 2.3V |     |     | 20  |       |
| Single-Ended Receiver Enable Delay      | t <sub>PZH_SE</sub>                        | Off-to-high transition, Figure 7                                                                                     | V <sub>L</sub> > 2.3V |     |     | 22  | ns    |
|                                         | t <sub>PZL_SE</sub>                        | Off-to-low transition, Figure 7                                                                                      | V <sub>L</sub> > 2.3V |     |     | 22  |       |

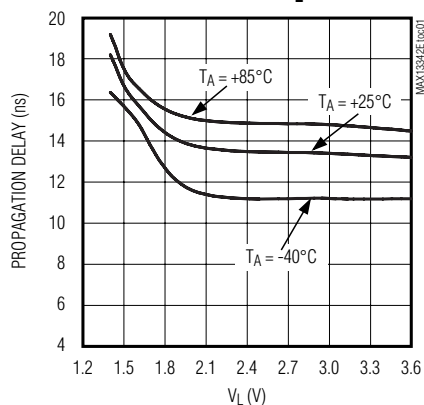
**Note 1:** Parameters are 100% production tested at  $+25^\circ C$ , unless otherwise noted. Limits over temperature are guaranteed by design.

# 3-Wire Interface Full-Speed USB Transceivers With/Without Internal Series Resistors

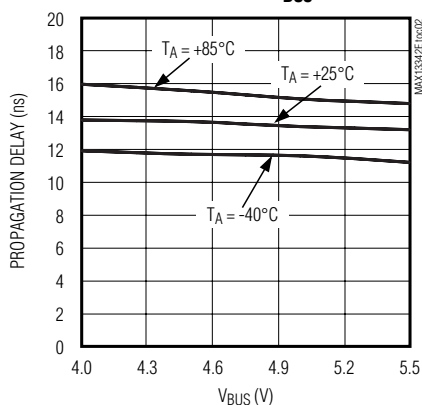
## Typical Operating Characteristics

( $V_{BUS} = +5V$ ,  $V_L = +3.3V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

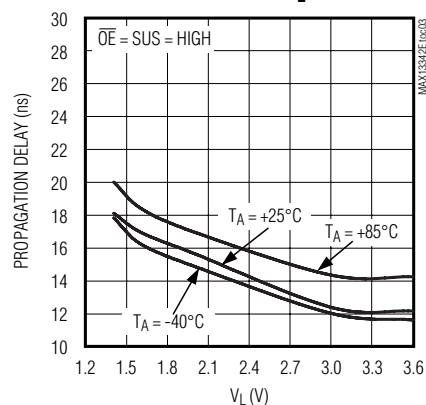
**DIFFERENTIAL RECEIVER PROPAGATION  
DELAY vs.  $V_L$**



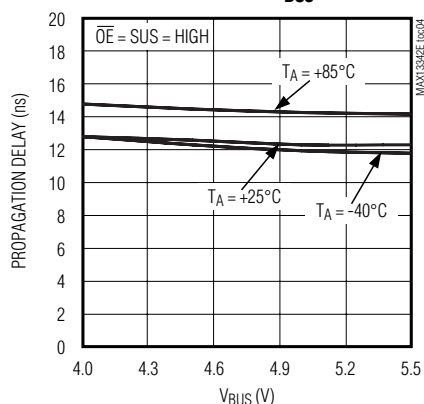
**DIFFERENTIAL RECEIVER PROPAGATION  
DELAY vs.  $V_{BUS}$**



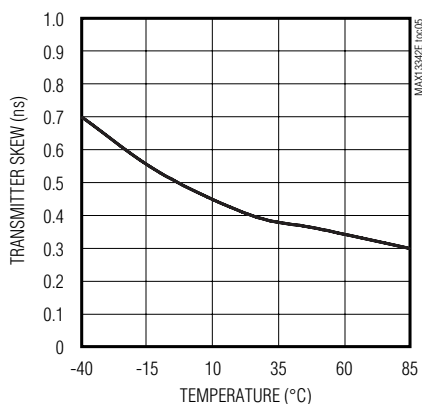
**SINGLE-ENDED RECEIVER PROPAGATION  
DELAY vs.  $V_L$**



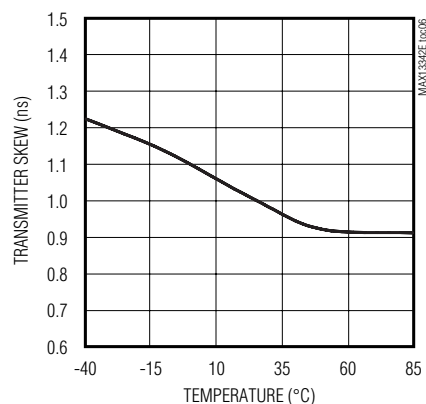
**SINGLE-ENDED RECEIVER PROPAGATION  
DELAY vs.  $V_{BUS}$**



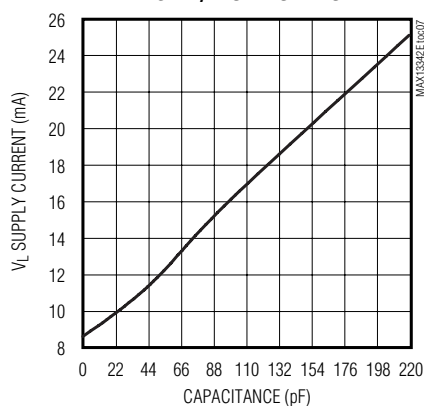
**TRANSMITTER SKEW  
vs. TEMPERATURE**



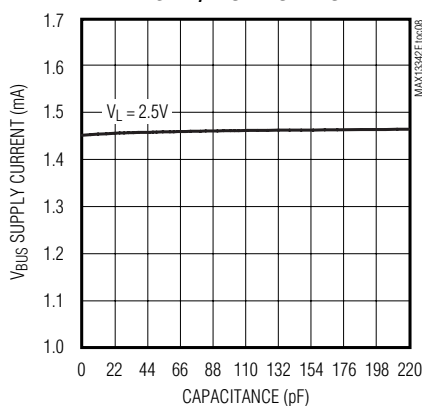
**RECEIVER SKEW  
vs. TEMPERATURE**



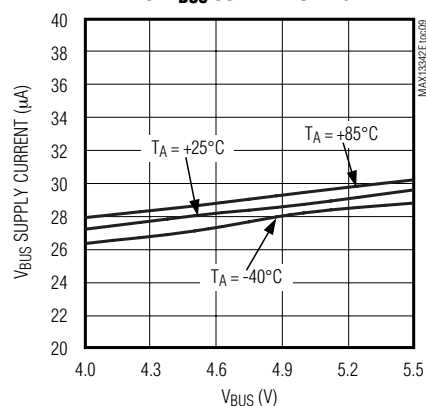
**$V_L$  SUPPLY CURRENT  
vs. D+/D- CAPACITANCE**



**$V_{BUS}$  SUPPLY CURRENT  
vs. D+/D- CAPACITANCE**



**$V_{BUS}$  SUSPEND CURRENT  
vs.  $V_{BUS}$  SUPPLY VOLTAGE**



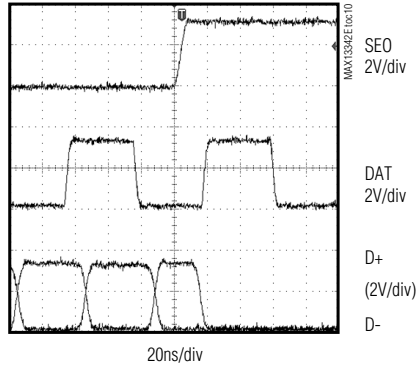
MAX13342E/MAX13345E

# 3-Wire Interface Full-Speed USB Transceivers With/Without Internal Series Resistors

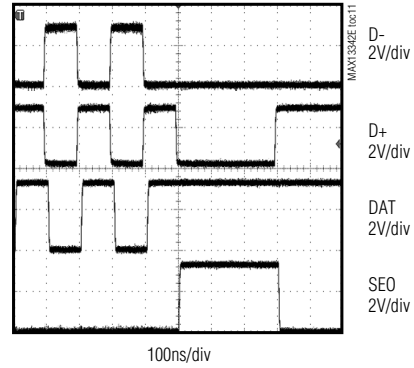
## Typical Operating Characteristics (continued)

(V<sub>BUS</sub> = +5V, V<sub>L</sub> = +3.3V, T<sub>A</sub> = +25°C, unless otherwise noted.)

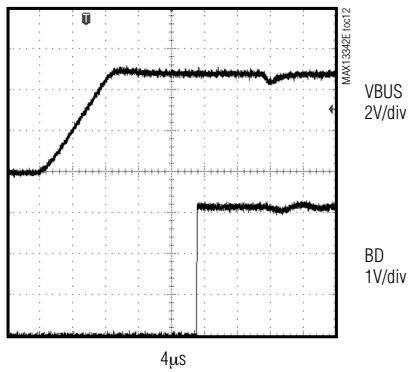
**MAX13342E/MAX13345E  
TRANSMITTING**



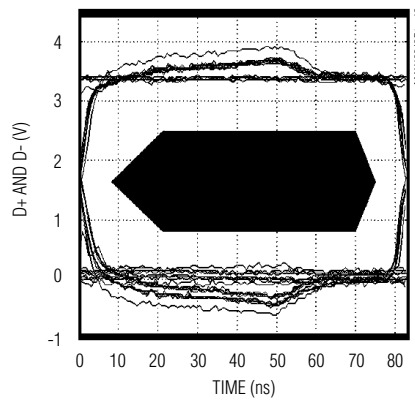
**MAX13342E/MAX13345E  
RECEIVING**



**MAX13342E/MAX13345E  
BUS DETECTION**



**EYE DIAGRAM**



# 3-Wire Interface Full-Speed USB Transceivers With/Without Internal Series Resistors

## Pin Description

| PIN   |      | NAME             | FUNCTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|-------|------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TDFN  | UCSP |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 1     | B1   | V <sub>TRM</sub> | Regulated Output Voltage. V <sub>TRM</sub> provides a 3.3V output derived from V <sub>BUS</sub> . Bypass V <sub>TRM</sub> to GND with a 1μF (min) low-ESR capacitor, such as ceramic or plastic film types. V <sub>TRM</sub> provides power to internal circuitry and the internal D+ pullup resistor. Do not use V <sub>TRM</sub> to power external circuitry. These USB transceivers can also be powered by an externally regulated 3.3V supply connected to both V <sub>BUS</sub> and V <sub>TRM</sub> . |
| 2     | A1   | V <sub>L</sub>   | System-Side Power-Supply Input. Connect V <sub>L</sub> to the systems logic-level power supply. Bypass V <sub>L</sub> to GND with a 0.1μF (min) low-ESR ceramic capacitor.                                                                                                                                                                                                                                                                                                                                  |
| 3     | A2   | SE0              | Logic-Side Data Input/Output. SE0 operates as an input when $\overline{OE}$ is low and as an output when $\overline{OE}$ is high. As an input, when SE0 is active high, D+ and D- are both driven low. As an output, SE0 goes active high when both D+ and D- are low. (See Tables 3 and 4.)                                                                                                                                                                                                                |
| 4     | A3   | DAT              | Logic-Side Data Input/Output. DAT operates as an input for data on D+/D- when $\overline{OE}$ is low. DAT operates as the output of the differential receiver on D+/D- when $\overline{OE}$ is high. (See Tables 3 and 4.)                                                                                                                                                                                                                                                                                  |
| 5, 12 | —    | N.C.             | No Connection. Leave N.C. unconnected. N.C. is not internally connected.                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 6     | B3   | SUS              | Suspend Input. Drive SUS low for normal transceiver operation. Drive SUS high for low-power state.                                                                                                                                                                                                                                                                                                                                                                                                          |
| 7     | A4   | BD               | USB Detector Output. A high on BD indicates that V <sub>BUS</sub> is present.                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 8     | B4   | $\overline{OE}$  | Output Enable. $\overline{OE}$ controls the USB transmitter outputs (D+/D-) and the interface signals (DAT, SE0) when in USB mode. Drive $\overline{OE}$ high to operate D+/D- as inputs and to operate the logic interface signals as outputs. Drive $\overline{OE}$ low to operate D+/D- as outputs and to operate the logic interface signals as inputs.                                                                                                                                                 |
| 9     | C4   | GND              | Ground                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 10    | C3   | D-               | Negative USB Differential Data Input/Output. D- is wired to the USB connector directly (MAX13345E) or through a series resistor (MAX13342E). D- operates as an input when $\overline{OE}$ is high and as an output when $\overline{OE}$ is low.                                                                                                                                                                                                                                                             |
| 11    | C2   | D+               | Positive USB Differential Data Input/Output. D+ is wired to the USB connector directly (MAX13345E) or through a series resistor (MAX13342E). D+ operates as an input when $\overline{OE}$ is high and as an output when $\overline{OE}$ is low.                                                                                                                                                                                                                                                             |
| 13    | B2   | ENUM             | Enumerate. Drive ENUM high to connect the internal 1.5kΩ resistor from D+ to V <sub>TRM</sub> . Drive ENUM low to disconnect the internal 1.5kΩ resistor.                                                                                                                                                                                                                                                                                                                                                   |
| 14    | C1   | V <sub>BUS</sub> | USB-Side Power-Supply Input. Connect V <sub>BUS</sub> to the incoming USB power supply. Bypass V <sub>BUS</sub> to GND with a 1μF ceramic capacitor.                                                                                                                                                                                                                                                                                                                                                        |
| EP    | —    | EP               | Exposed Paddle. Connect EP to GND.                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

MAX13342E/MAX13345E

## 3-Wire Interface Full-Speed USB Transceivers With/Without Internal Series Resistors

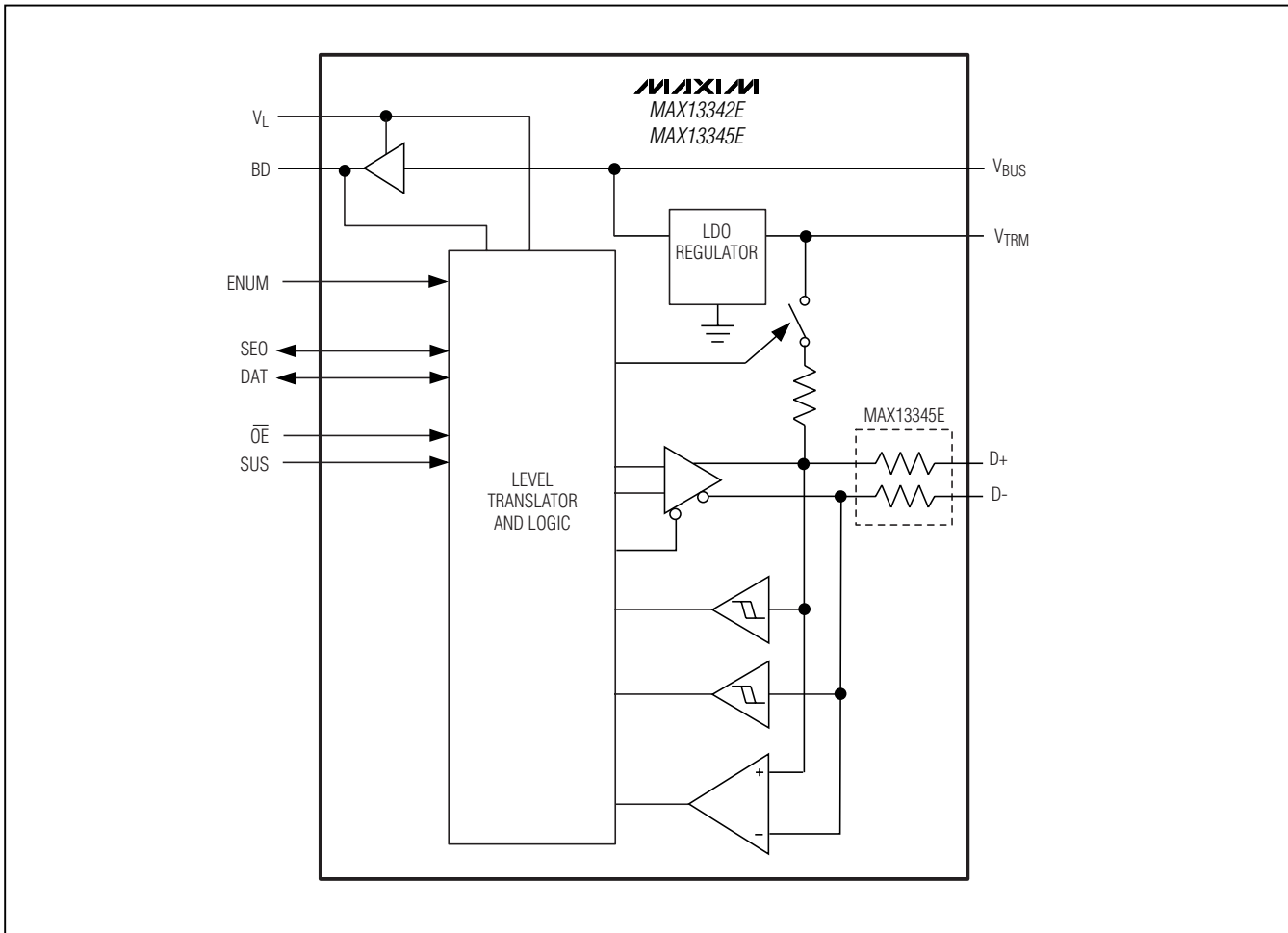


Figure 1. MAX13342E/MAX13345E Functional Diagram

### Detailed Description

The MAX13342E/MAX13345E USB-compliant transceivers are designed to minimize the area and external components required to interface low-voltage ASICs to USB. The devices comply with the USB 2.0 specification for full-speed (12Mbps) operation. The transceivers include an internal 3.3V regulator, an internal 1.5k $\Omega$  D+ pullup resistor, and built-in  $\pm 15$ kV (HBM) ESD protection circuitry to protect D+, D-. Figure 1 is the MAX13342E/MAX13345E functional diagram.

The MAX13342E has controlled output impedance of 12 $\Omega$  (max) on D+/D-, allowing the use of external switches to multiplex two different USB devices onto a single USB connector.

The MAX13345E uses internal series resistors on D+/D- to allow direct interface to the USB connector. A low-power mode reduces current consumption to less than 45 $\mu$ A. An enumerate function controls connection of the internal D+ pullup resistor.

The MAX13342E/MAX13345E are equipped with DAT and SEO interface signals and support the 3-wire USB transceiver interface. Although the 3-wire interface is commonly associated with USB On-the-Go transceivers, the MAX13342E/MAX13345E support USB peripherals only. These transceivers provide a USB V<sub>BUS</sub> detection function that monitors the presence of USB V<sub>BUS</sub> and signals the event.

## 3-Wire Interface Full-Speed USB Transceivers With/Without Internal Series Resistors

### Interface

The MAX13342E/MAX13345E control signals are used to control the USB D+/D- lines.  $V_L$  powers the logic-side interface and sets the input and output thresholds of these signals. The control signals for the MAX13342E and MAX13345E are DAT, SE0, and  $\overline{OE}$ .

### Power-Supply Configuration

#### Normal Operating Mode

See Table 1 for various power-supply configurations.

$V_{BUS}$  supplies power to the USB transceivers. Connect  $V_{BUS}$  to a +4V to +5.5V supply. Connect  $V_L$  to a +2.3V to +3.6V supply.  $V_{BUS}$  is typically connected directly to the USB connector. An internal regulator provides 3.3V to internal circuitry, and a regulated 3.3V output at  $V_{TRM}$ , in addition to powering the internal D+ pullup resistor. The MAX13342E and MAX13345E can be powered by connecting both  $V_{BUS}$  and  $V_{TRM}$  to a 3.3V external regulator.

#### Low-Power Mode

Operate the transceivers in low-power mode by asserting SUS high. In low-power mode, the USB differential receiver is turned off and  $V_{BUS}$  consumes less than

45 $\mu$ A of supply current. The single-ended D+ and D- receivers are still active when driving SUS high.

#### Sharing Mode

Connect  $V_L$  to a system power supply and leave  $V_{BUS}$  (or  $V_{BUS}$  and  $V_{TRM}$ ) unconnected or connected to GND. D+ and D- are tri-stated, allowing other circuitry to share the USB D+ and D- line.  $V_L$  consumes less than 5 $\mu$ A of supply current. When operating the transceivers in sharing mode, the SUS input is ignored, and the interface signals (SE0, DAT) are high impedance.

#### Disable Mode

Connect  $V_{BUS}$  to a system power supply and leave  $V_L$  unconnected or connect to ground. In disable mode, D+ and D- are tri-stated, and  $V_{BUS}$  and/or  $V_{TRM}$  (or  $V_{BUS}$  and  $V_{TRM}$ ) consume less than 25 $\mu$ A. When operating the transceivers in disable mode,  $\overline{OE}$ , SUS, and inputs to the interface control signals are ignored. (See Table 2.)

**Table 1. Power-Supply Configuration**

| $V_{BUS}$ (V)   | $V_{TRM}$ (V)       | $V_L$ (V)       | CONFIGURATION | NOTES   |
|-----------------|---------------------|-----------------|---------------|---------|
| +4.0 to +5.5    | +3.0 to +3.6 output | +2.3 to +3.6    | Normal mode   | —       |
| +4.0 to +5.5    | +3.0 to +3.6 output | GND or floating | Disable mode  | Table 2 |
| GND or Floating | High Z              | +2.3 to +3.6    | Sharing mode  | Table 2 |

**Table 2. Disable-Mode and Sharing-Mode Connection**

| INPUTS/OUTPUTS        | DISABLE MODE                 | SHARING MODE                 |
|-----------------------|------------------------------|------------------------------|
| $V_{BUS}$ / $V_{TRM}$ | 4V to 5.5V                   | Floating or connected to GND |
| $V_L$                 | Floating or connected to GND | 2.3V to 3.6V input           |
| D+ and D-             | High impedance               | High impedance               |
| DAT, SE0              | High impedance               | High impedance               |
| SUS                   | High impedance               | High impedance               |
| BD                    | Low                          | Low                          |

## 3-Wire Interface Full-Speed USB Transceivers With/Without Internal Series Resistors

### 3-Wire DAT/SE0 Interface

The MAX13342E/MAX13345E use DAT and SE0 to drive data or a single-ended zero onto the D+/D- lines. When  $\overline{OE}$  is low, SE0 is an input and functions as a single-ended zero driver. When SE0 is high, both D+ and D- are driven low. When SE0 is driven low, the D+/D- outputs are controlled by DAT.

DAT is used to send data on D+/D- when both  $\overline{OE}$  and SE0 are low. When DAT is high, D+ is driven high and D- is driven low. When DAT is low, D+ is driven low and D- is driven high.

In receive mode ( $\overline{OE}$  = high), DAT is the output of the differential receiver connected to D+ and D-. SE0 only goes active high when both D+ and D- are low.

### Control Signals

#### USB Detection

The MAX13342E/MAX13345E USB detection function indicates that V<sub>BUS</sub> is present. The MAX13342E/MAX13345E push-pull bus detection output (BD) monitors V<sub>BUS</sub>, and asserts high when V<sub>BUS</sub> and V<sub>L</sub> are present. BD asserts low if V<sub>BUS</sub> is less than +3.6V and enters sharing mode.

#### $\overline{OE}$

$\overline{OE}$  controls the direction of communication when V<sub>L</sub> and V<sub>BUS</sub> are both present. When  $\overline{OE}$  is low, DAT and SE0 operate as logic inputs and D+/D- are outputs. When  $\overline{OE}$  is high, DAT and SE0 operate as logic outputs and D+/D- are inputs.

#### SUS

SUS determines whether the MAX13342E/MAX13345E operate in normal mode or in suspend mode. Drive SUS low for normal operation. Drive SUS high to enable suspend mode. In suspend mode, the single-ended receivers (D+/D-) are active to detect a wake-up event. Supply current decreases to less than 45μA in suspend mode.

The MAX13342E/MAX13345E can transmit data on D+ and D- while in suspend mode. This function is used to signal a remote wake-up event.

#### ENUM

A 1.5kΩ pullup resistor on D+ is used to indicate full-speed (12Mbps) operation. Drive ENUM high to connect the internal pullup resistor from D+ to V<sub>TRM</sub>. Drive ENUM low to disconnect the internal pullup resistor from D+ to V<sub>TRM</sub>.

#### D+ and D-

D+ and D- are bidirectional signals and are ESD protected to ±15kV (HBM).  $\overline{OE}$  controls the direction of D+ and D- when in USB normal mode (Tables 3 and 4).

#### V<sub>TRM</sub>

An internal linear regulator generates the V<sub>TRM</sub> voltage (+3.3V typ). V<sub>TRM</sub> derives power from V<sub>BUS</sub> (see the *Power-Supply Configuration* section). V<sub>TRM</sub> powers the internal USB circuitry and provides the pullup voltage for the internal 1.5kΩ resistor. Bypass V<sub>TRM</sub> to GND with a 1μF ceramic capacitor as close to the device as possible. Do not use V<sub>TRM</sub> to provide power to external circuitry.

## 3-Wire Interface Full-Speed USB Transceivers With/Without Internal Series Resistors

**Table 3. Transmit Truth Table**

| $(\overline{OE} = 0, SUS = 0)$ |     |         |    |
|--------------------------------|-----|---------|----|
| INPUTS                         |     | OUTPUTS |    |
| DAT                            | SE0 | D+      | D- |
| 0                              | 0   | 0       | 1  |
| 0                              | 1   | 0       | 0  |
| 1                              | 0   | 1       | 0  |
| 1                              | 1   | 0       | 0  |

### Applications Information

#### USB Data Transfer

##### Transmitting Data

The MAX13342E/MAX13345E transmit USB data to the USB differentially on D+ and D- when  $\overline{OE}$  is low. The D+ and D- outputs are determined by SE0 and DAT (see Table 3).

##### Receiving Data

Drive  $\overline{OE}$  high and SUS low to receive data on D+/D-. Differential data received on D+ and D- appear at DAT. SE0 goes high only when both D+ and D- are low (Table 4).

#### External Resistors (MAX13342E)

The MAX13342E provides low internal resistance on D+/D-. Two external series resistors for impedance matching are required for USB. Place the resistors in between the MAX13342E and the USB connector (see Figure 2).

**Table 4. Receive Truth Table**

| $(\overline{OE} = 1, SUS = 0)$ |    |         |     |
|--------------------------------|----|---------|-----|
| INPUTS                         |    | OUTPUTS |     |
| D+                             | D- | DAT     | SE0 |
| 0                              | 0  | *DAT    | 1   |
| 0                              | 1  | **0     | 0   |
| 1                              | 0  | **1     | 0   |
| 1                              | 1  | X       | 0   |

\*Last state

\*\*D+/D- differential receiver output

X = Undefined

#### External Capacitors

Use three external capacitors for proper operation. Bypass  $V_L$  to GND with a 0.1 $\mu$ F ceramic capacitor. Bypass  $V_{BUS}$  to GND with a 1 $\mu$ F ceramic capacitor. Bypass  $V_{TRM}$  to GND with a 1 $\mu$ F (min) ceramic or plastic capacitor. Place all capacitors as close to the device as possible.

#### UCSP Application Information

For the latest application details on UCSP construction, dimensions, tape carrier information, printed circuit board (PCB) techniques, bump-pad layout, and recommended reflow temperature profile, as well as the latest information on reliability testing results, refer to Application Note 1891: *UCSP—A Wafer-Level Chip-Scale Package* available on Maxim's website at [www.maxim-ic.com/ucsp](http://www.maxim-ic.com/ucsp).

# 3-Wire Interface Full-Speed USB Transceivers With/Without Internal Series Resistors

## ESD Protection

The MAX13342E/MAX13345E feature  $\pm 15\text{kV}$  (HBM) ESD protection on D+ and D-. The ESD structures withstand high ESD in all states: normal operation, suspend, and powered down. For the  $\pm 15\text{kV}$  ESD structures to work correctly, a  $1\mu\text{F}$  or greater capacitor must be connected from VTRM to GND. VBUS and D+/D- are characterized for protection to the following limits:

- $\pm 15\text{kV}$  using the Human Body Model
- $\pm 8\text{kV}$  using the IEC 61000-4-2 Contact Discharge Method
- $\pm 8\text{kV}$  using the IEC 61000-4-2 Air-Gap Method

## ESD Test Conditions

ESD performance depends on a variety of conditions. Contact Maxim for a reliability report that documents test setup, test methodology, and test results.

## Human Body Model

Figure 11 shows the Human Body Model, and Figure 12 shows the current waveform it generates when discharged into a low impedance. This model consists of

a  $100\text{pF}$  capacitor charged to the ESD voltage of interest, which is then discharged into the test device through a  $1.5\text{k}\Omega$  resistor.

## IEC 61000-4-2

The IEC 61000-4-2 standard covers ESD testing and performance of finished equipment; it does not specifically refer to integrated circuits. The MAX13342E/MAX13345E help the user design equipment that meets level 4 of IEC 61000-4-2, without the need for additional ESD-protection components. The major difference between tests done using the Human Body Model and IEC 61000-4-2 is a higher peak current in IEC 61000-4-2 because series resistance is lower in the IEC 61000-4-2 model. Hence, the ESD withstand voltage measured to IEC 61000-4-2 is generally lower than that measured using the Human Body Model. Figure 13 shows the IEC 61000-4-2 model. The Air-Gap Discharge Method involves approaching the device with a charged probe. The Contact Discharge Method connects the probe to the device before the probe is energized.

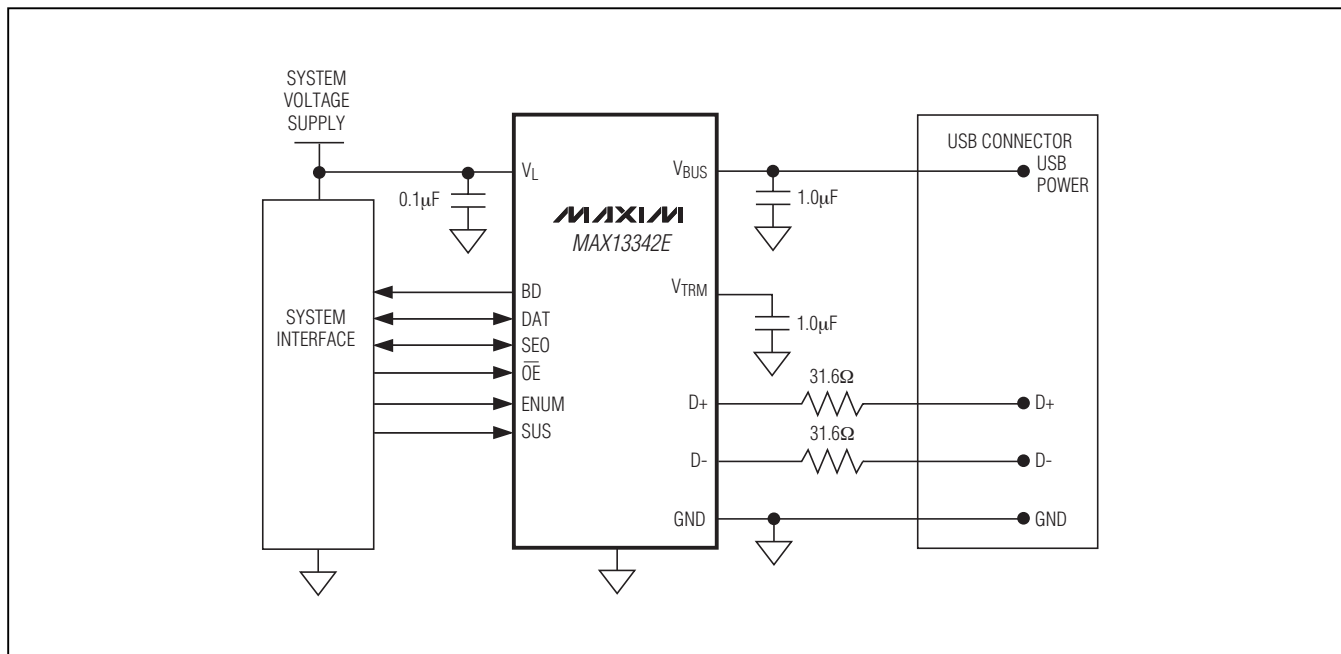


Figure 2. Adding External Resistors to the USB Connector for the MAX13342E

# 3-Wire Interface Full-Speed USB Transceivers With/Without Internal Series Resistors

## Timing Diagrams/Test Circuits

MAX13342E/MAX13345E

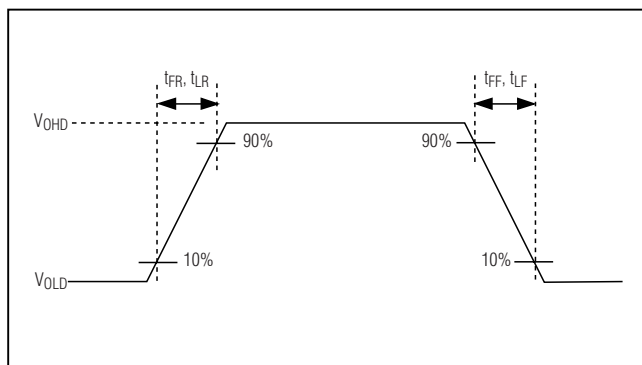


Figure 3. Rise and Fall Times

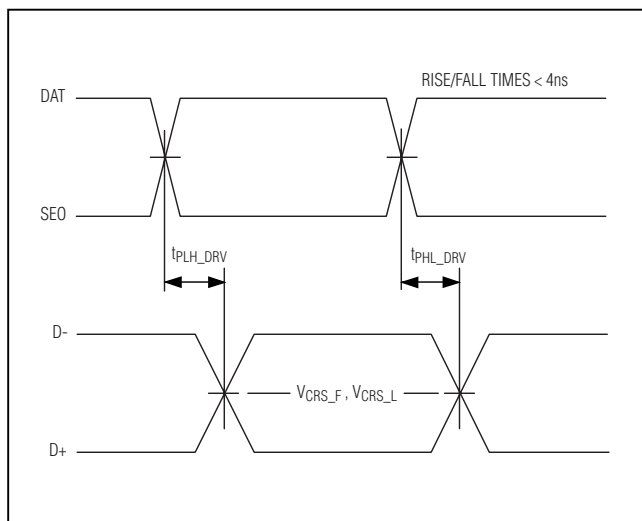


Figure 4. Timing of DAT, SE0 to D+ and D-

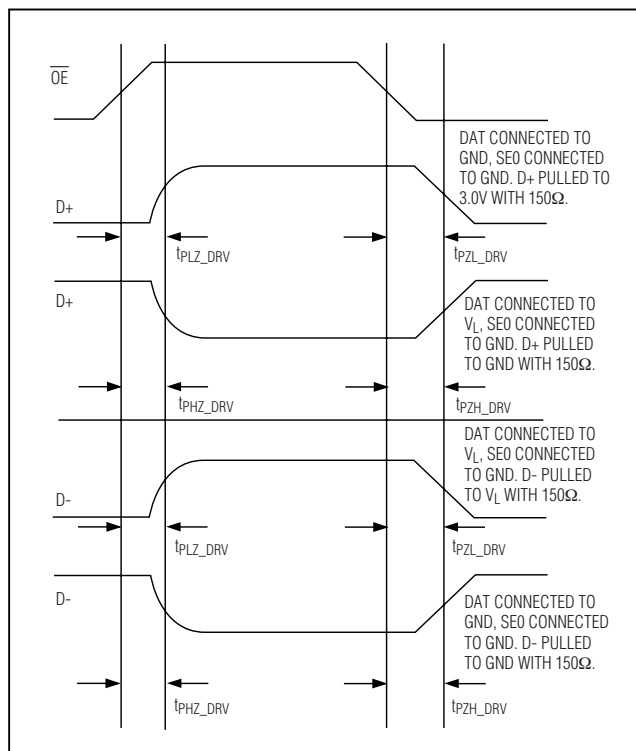


Figure 5. Enable and Disable Timing, Transmitter

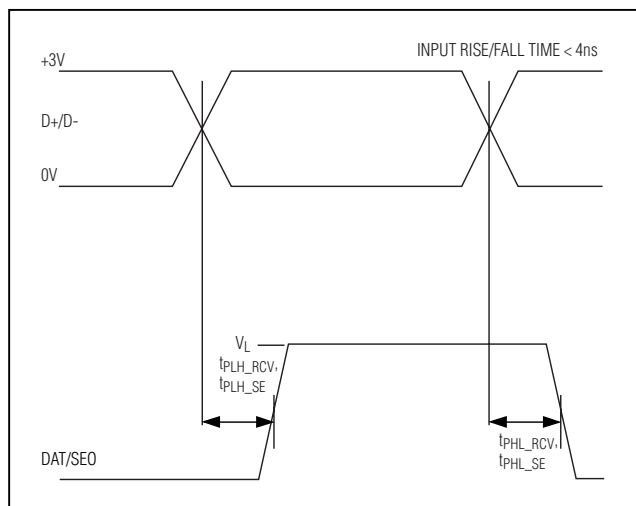


Figure 6. D+/D- to DAT, SE0 Propagation Delays

# 3-Wire Interface Full-Speed USB Transceivers With/Without Internal Series Resistors

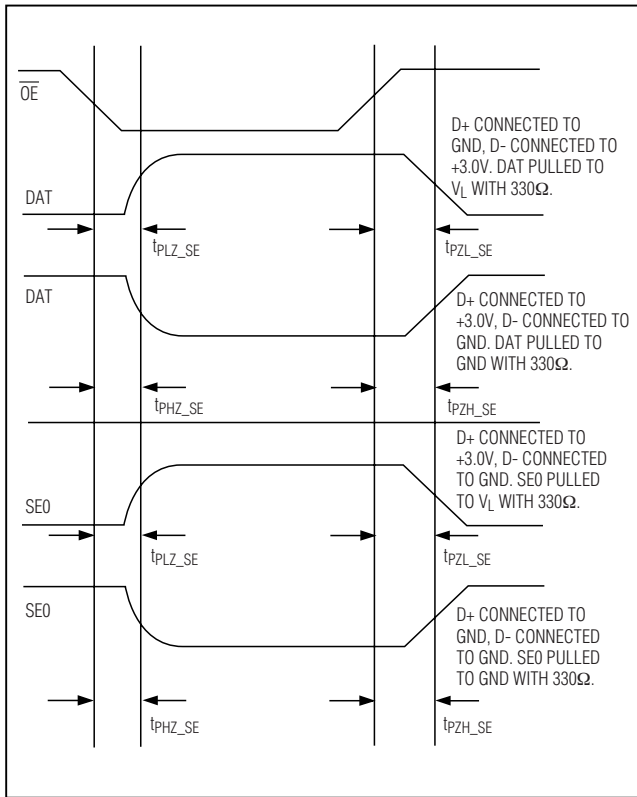


Figure 7. Receiver Enable and Disable Timing

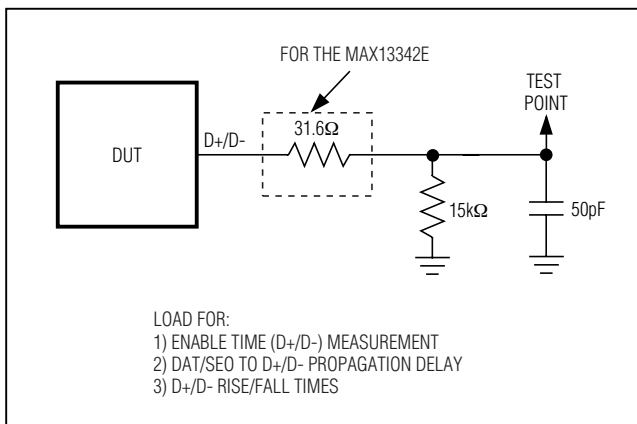


Figure 8. Load for Transmitter Propagation Delay, Enable Time, Transmitter Rise/Fall Times

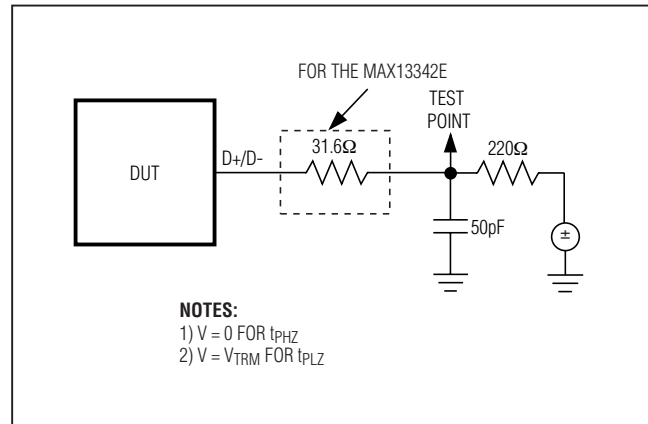


Figure 9. Load for Disable Time Measurements

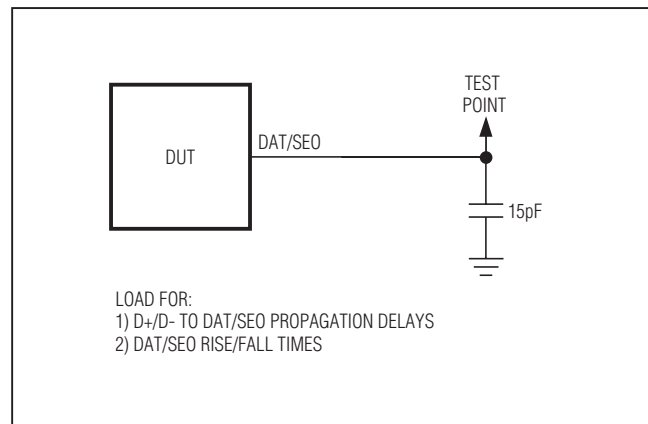


Figure 10. Load for Receiver Propagation Delay and Receiver Rise/Fall Times

# 3-Wire Interface Full-Speed USB Transceivers With/Without Internal Series Resistors

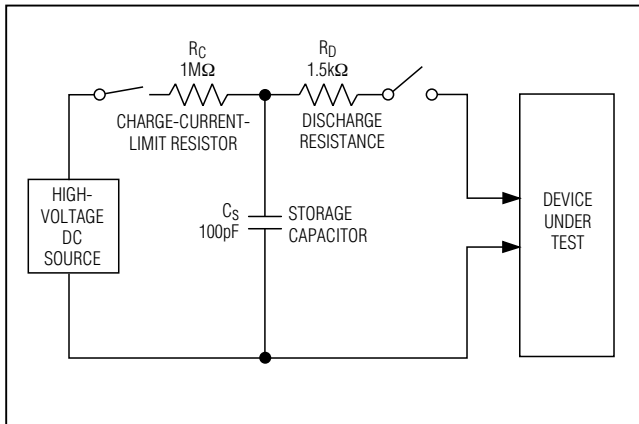


Figure 11. Human Body ESD Test Model

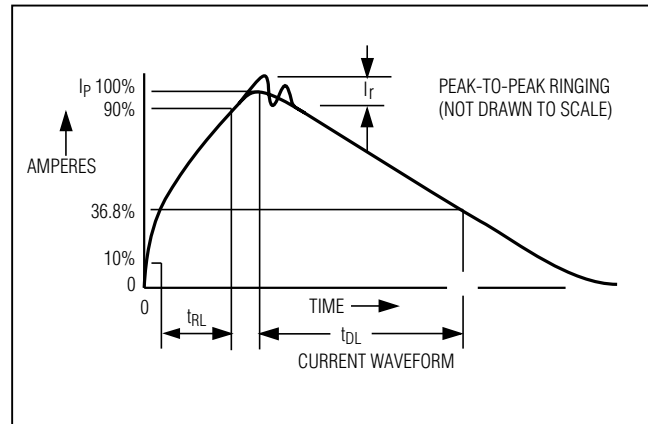


Figure 12. Human Body Model Current Waveform

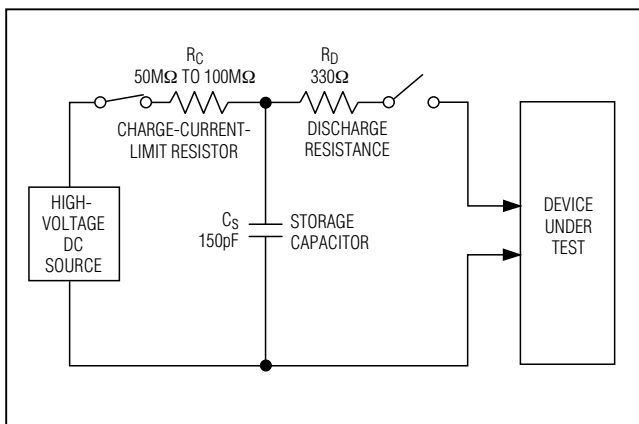
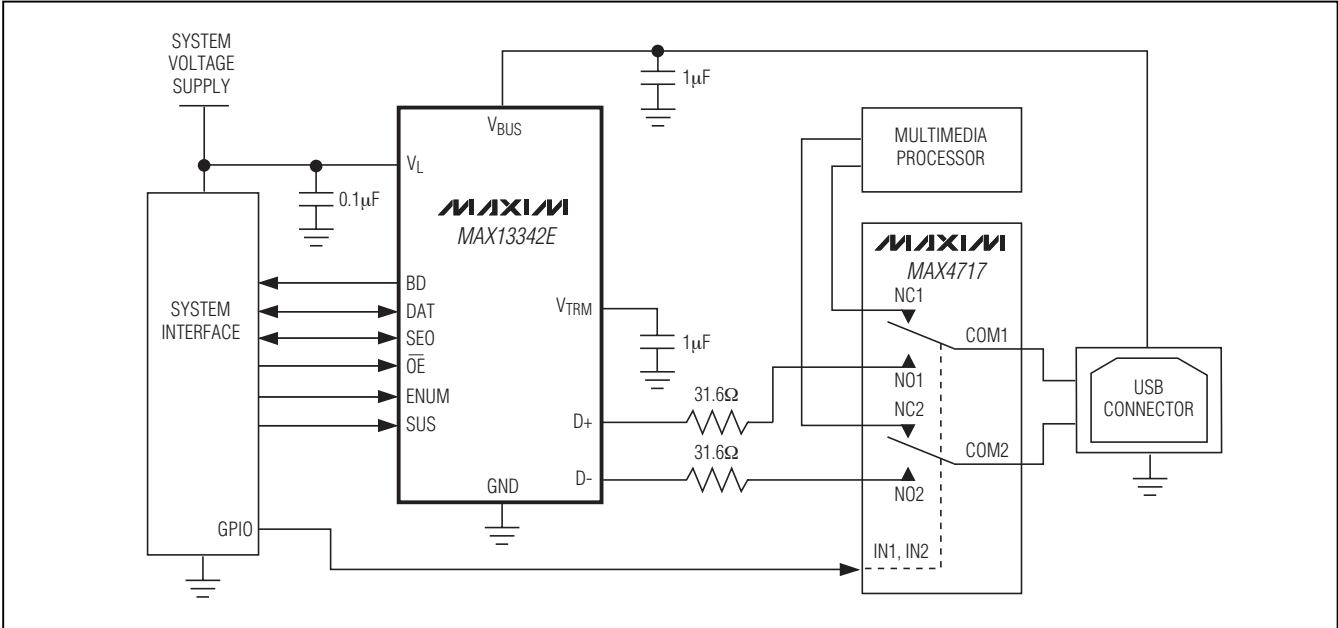


Figure 13. IEC 61000-4-2 ESD Test Model

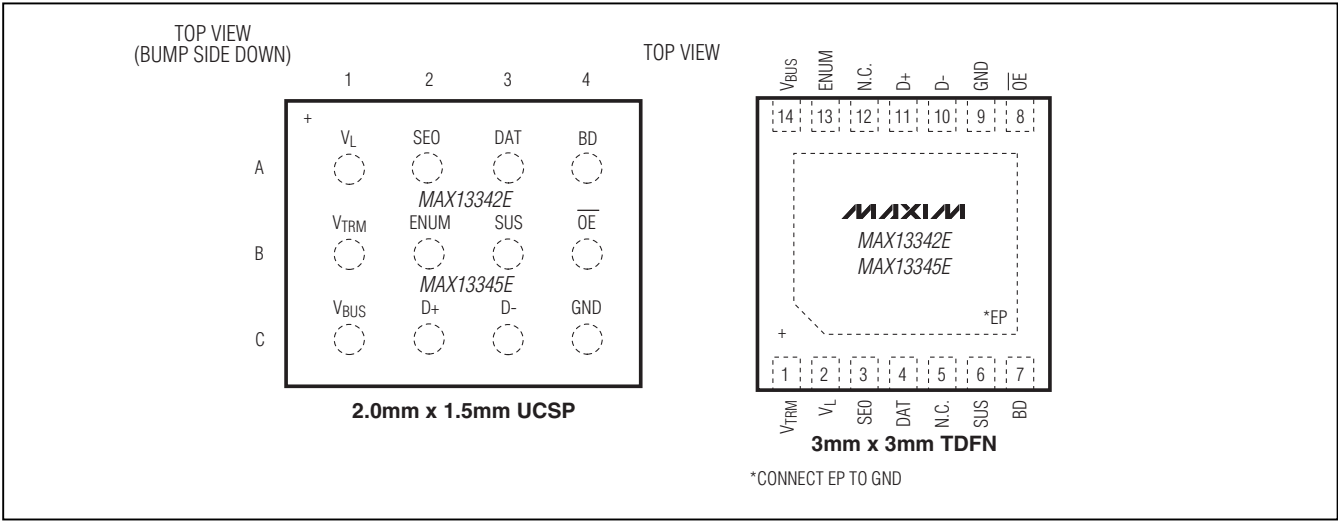
MAX13342E/MAX13345E

# 3-Wire Interface Full-Speed USB Transceivers With/Without Internal Series Resistors

Typical Application Circuit



Pin Configurations



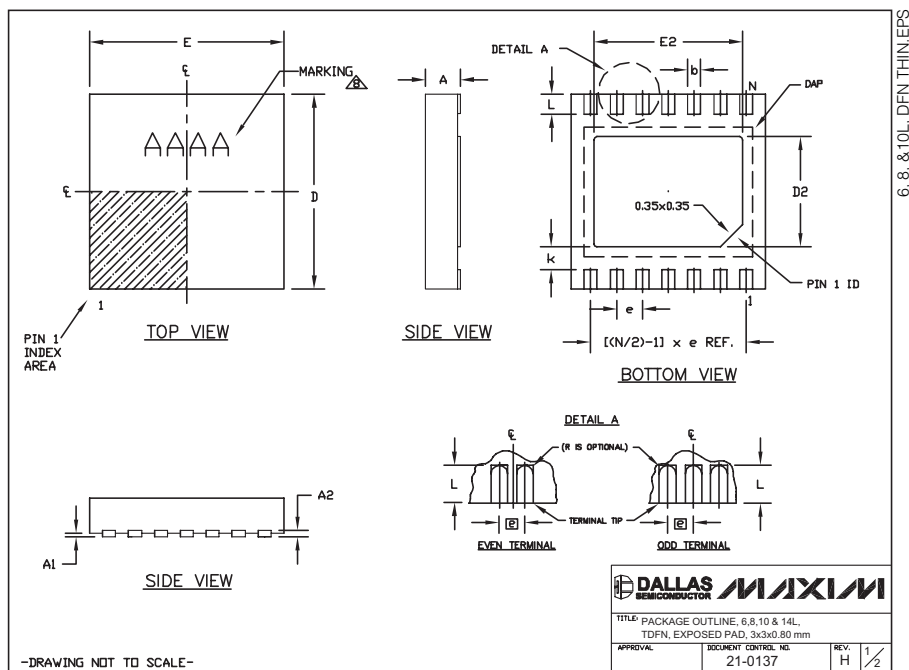
Chip Information

PROCESS: BICMOS

# 3-Wire Interface Full-Speed USB Transceivers With/Without Internal Series Resistors

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



| COMMON DIMENSIONS |           |      |
|-------------------|-----------|------|
| SYMBOL            | MIN.      | MAX. |
| A                 | 0.70      | 0.80 |
| D                 | 2.90      | 3.10 |
| E                 | 2.90      | 3.10 |
| A1                | 0.00      | 0.05 |
| L                 | 0.20      | 0.40 |
| k                 | 0.25 MIN. |      |
| A2                | 0.20 REF. |      |

| PACKAGE VARIATIONS |    |           |           |          |                |           |               |  |
|--------------------|----|-----------|-----------|----------|----------------|-----------|---------------|--|
| PKG. CODE          | N  | D2        | E2        | e        | JEDEC SPEC     | b         | [(N/2)-1] x e |  |
| T633-1             | 6  | 1.50-0.10 | 2.30-0.10 | 0.95 BSC | MO229 / WEEA   | 0.40-0.05 | 1.90 REF      |  |
| T633-2             | 6  | 1.50-0.10 | 2.30-0.10 | 0.95 BSC | MO229 / WEEA   | 0.40-0.05 | 1.90 REF      |  |
| T833-1             | 8  | 1.50-0.10 | 2.30-0.10 | 0.65 BSC | MO229 / WEEC   | 0.30-0.05 | 1.95 REF      |  |
| T833-2             | 8  | 1.50-0.10 | 2.30-0.10 | 0.65 BSC | MO229 / WEEC   | 0.30-0.05 | 1.95 REF      |  |
| T833-3             | 8  | 1.50-0.10 | 2.30-0.10 | 0.65 BSC | MO229 / WEEC   | 0.30-0.05 | 1.95 REF      |  |
| T1033-1            | 10 | 1.50-0.10 | 2.30-0.10 | 0.50 BSC | MO229 / WEED-3 | 0.25-0.05 | 2.00 REF      |  |
| T1033-2            | 10 | 1.50-0.10 | 2.30-0.10 | 0.50 BSC | MO229 / WEED-3 | 0.25-0.05 | 2.00 REF      |  |
| T1433-1            | 14 | 1.70-0.10 | 2.30-0.10 | 0.40 BSC | ----           | 0.20-0.05 | 2.40 REF      |  |
| T1433-2            | 14 | 1.70-0.10 | 2.30-0.10 | 0.40 BSC | ----           | 0.20-0.05 | 2.40 REF      |  |

- NOTES:
1. ALL DIMENSIONS ARE IN mm. ANGLES IN DEGREES.
  2. COPLANARITY SHALL NOT EXCEED 0.08 mm.
  3. WARPAGE SHALL NOT EXCEED 0.10 mm.
  4. PACKAGE LENGTH/PACKAGE WIDTH ARE CONSIDERED AS SPECIAL CHARACTERISTIC(S).
  5. DRAWING CONFORMS TO JEDEC MO229, EXCEPT DIMENSIONS "D2" AND "E2", AND T1433-1 & T1433-2.
  6. "N" IS THE TOTAL NUMBER OF LEADS.
  7. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.
- MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.

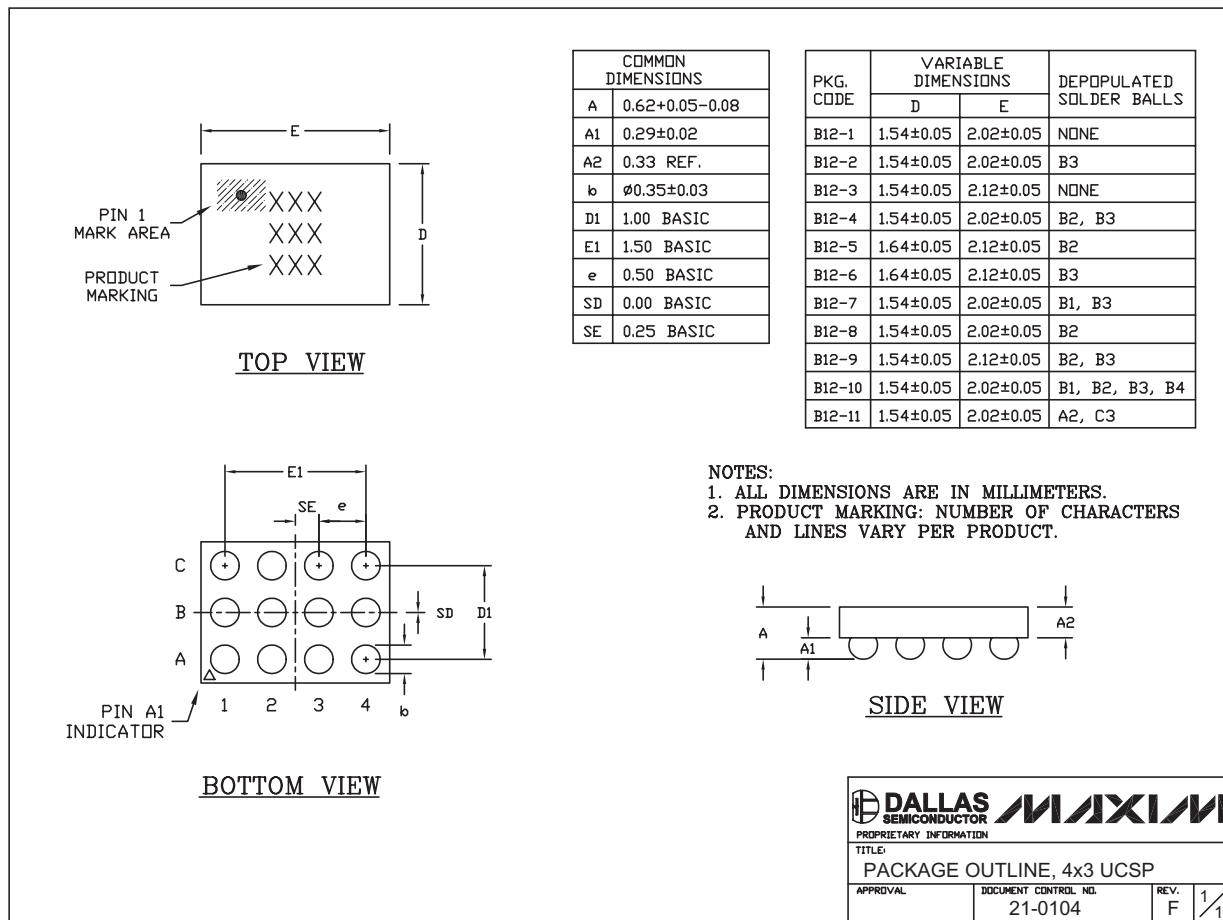
| DALLAS SEMICONDUCTOR MAXIM                                            |                              |            |
|-----------------------------------------------------------------------|------------------------------|------------|
| TITLE: PACKAGE OUTLINE, 6, 8, 10 & 14L, DFN, EXPOSED PAD, 3x3x0.80 mm |                              |            |
| APPROVAL:                                                             | DOCUMENT CONTROL NO. 21-0137 | REV. H 2/2 |

-DRAWING NOT TO SCALE-

# 3-Wire Interface Full-Speed USB Transceivers With/Without Internal Series Resistors

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



12L UCSP 4x3.EPS

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