19-3171; Rev 0; 2/04

MAXIM

±15kV ESD-Protected USB Transceivers in UCSP with USB Detect

General Description

The MAX3344E/MAX3345E USB transceivers convert logic-level signals to USB signals, and USB signals to logic-level signals. An internal 1.5kΩ USB pullup resistor supports full-speed (12Mbps) USB operation. The MAX3344E/MAX3345E provide built-in ±15kV ESD-protection circuitry on the USB I/O pins, D+ and D-, and V_{CC}.

The MAX3344E/MAX3345E operate with logic supply voltages as low as 1.65V, ensuring compatibility with low-voltage ASICs. The suspend mode lowers supply current to less than 40µA. An enumerate function allows devices to logically disconnect while plugged in. The MAX3344E/MAX3345E are fully compliant with USB specification 1.1, and full-speed operation under USB specification 2.0.

The MAX3344E/MAX3345E have a USB detect that monitors the USB bus for insertion and signals this event. The MAX3344E USB_DET threshold is between 3.6V (min) and 4V (max), while the MAX3345E USB_DET threshold is between 1V (min) and 2.8V (max).

The MAX3344E/MAX3345E are available in the miniature 4 × 4 UCSP™, as well as the small 16-pin TSSOP, and are specified over the extended temperature range, -40°C to +85°C.

Applications

Cell Phones
PC Peripherals
Information Appliances
Data Cradles
PDAs
MP3 Players
Digital Cameras

Features

- ±15kV ESD Protection On D+ and D-
- Comply with USB Specification 1.1 (Full Speed 2.0)
- Separate VP and VM Inputs/Outputs
- V_L Down to 1.65V Allows Connection with Low-Voltage ASICs
- Enumerate Input—Allows USB Connection through Software
- USB Detect Function
  - 3.6V (min) to 4V (max)—MAX3344E
  - 1V (min) to 2.8V (max)—MAX3345E
- Allow Single-Ended or Differential Logic I/O
- Internal Linear Regulator Allows Direct Powering from the USB
- Internal Pullup Resistor for Full-Speed Operation
- Three-State Outputs
- No Power-Supply Sequencing Required
- Driver Active in Suspend Mode
- Available in Miniature Chip-Scale Package

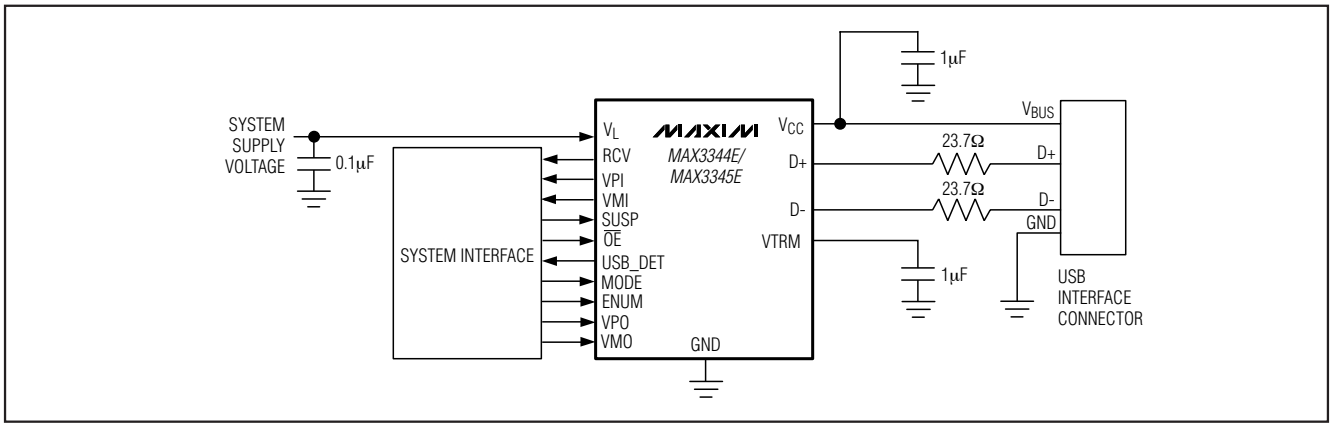
Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX3344EEUE	-40°C to +85°C	16 TSSOP
MAX3344EEBE-T	-40°C to +85°C	4 x 4 UCSP
MAX3345EEUE	-40°C to +85°C	16 TSSOP
MAX3345EEBE-T	-40°C to +85°C	4 x 4 UCSP

Pin Configurations appear at end of data sheet.

UCSP is a trademark of Maxim Integrated Products, Inc.

Typical Operating Circuit



±15kV ESD-Protected USB Transceivers in UCSP with USB Detect

ABSOLUTE MAXIMUM RATINGS

(All voltages refer to GND, unless otherwise noted.)
Supply Voltage (V_{CC}) .....-0.3V to +6V
Output of Internal Regulator (VTRM).....-0.3V to (V_{CC} + 0.3V)
Input Voltage (D+, D-) .....-0.3V to +6V
System Supply Voltage (V_L) .....-0.3V to +6V
RCV, SUSP, VMO, MODE, VPO, $\overline{OE}$, VMI, VPI, USB_DET, ENUM.....-0.3V to (V_L + 0.3V)
Short-Circuit Current (D+, D-) to V_{CC} or GND (Note 1) .....Continuous
Maximum Continuous Current (all other pins).....±15mA
Continuous Power Dissipation (T_A = +70°C)
16-Pin TSSOP (derate 9.4mW/°C above +70°C)...754mW (U16-2)
4 × 4 UCSP (derate 8.2mW/°C above +70°C)...659mW (B16-1)
Operating Temperature Range .....-40°C to +85°C
Junction Temperature.....+150°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10s).....+300°C
Bump Temperature (soldering) Reflow.....+235°C

Note 1: External 23.7Ω resistors connected to D+ and D-.

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_{CC} = 4V to 5.5V bypassed with 1µF to GND, GND = 0, V_L = 1.65V to 3.6V, ENUM = V_L, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at V_{CC} = 5V, V_L = 2.5V, T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SUPPLY INPUTS (VCC, VTRM, VL)						
Regulated Supply Voltage Output	V_{VTRM}	Internal regulator	3.0	3.3	3.6	V
V_{CC} Input Range	V_{CC}		4.0		5.5	V
V_L Input Range	V_L		1.65		3.60	V
Operating V_{CC} Supply Current	I_{VCC}	Full-speed transmitting/receiving at 12Mbps, C_L = 50pF on D+ and D-			10	mA
Operating V_L Supply Current	I_{VL}	Full-speed transmitting/receiving at 12Mbps			8	mA
Full-Speed Idle and SE0 Supply Current	$I_{VCC(IDLE)}$	Full-speed idle: V_{D+} > 2.7V, V_{D-} < 0.3V		340	450	µA
		SE0: V_{D+} < 0.3V, V_{D-} < 0.3V		390	500	
Static V_L Supply Current	$I_{VL(STATIC)}$	Full-speed idle, SE0, or suspend mode			12.5	µA
Suspend Supply Current	$I_{VCC(SUSP)}$	SUSP = $\overline{OE}$ = high			40	µA
Disable-Mode Supply Current	$I_{VCC(DIS)}$	V_L = GND or open			20	µA
D+/D- Disable-Mode Load Current	$I_{D\_(DIS)}$	V_L = GND or open, $V_{D\_}$ = 0 or +5.5V			5	µA
Sharing-Mode V_L Supply Current	$I_{VL(SHARING)}$	V_{CC} = GND or open, $\overline{OE}$ = low, SUSP = high			20	µA
D+/D- Sharing-Mode Load Current	$I_{D\_(SHARING)}$	V_{CC} = GND or open, $V_{D\_}$ = 0 or +5.5V			20	µA
LOGIC-SIDE I/O						
Input High Voltage	V_{IH}	SUSP, MODE, ENUM, $\overline{OE}$, VMO, VPO	2/3 x V_L			V
Input Low Voltage	V_{IL}	SUSP, MODE, ENUM, $\overline{OE}$, VMO, VPO			0.4	V
Output-Voltage High	V_{OH}	VPI, VMI, RCV, USB_DET; I_{SOURCE} = 2mA	V_L - 0.4			V
Output-Voltage Low	V_{OL}	VPI, VMI, RCV, USB_DET; I_{SINK} = -2mA			0.4	V

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = 4V to 5.5V bypassed with 1µF to GND, GND = 0, V_L = 1.65V to 3.6V, ENUM = V_L, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at V_{CC} = 5V, V_L = 2.5V, T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Leakage Current		SUSP, MODE, ENUM, $\overline{OE}$, VMO, VPO = 0 or V_L			±1	µA
USB-SIDE I/O						
Output-Voltage Low	V_{OL}	R_L = 1.5kΩ from D+ or D- to 3.6V			0.3	V
Output-Voltage High	V_{OH}	R_L = 15kΩ from D+ and D- to GND	2.8		3.6	V
Input Impedance	Z_{IN}	Three-state driver, ENUM = 0, $V_{D\_}$ = 0 or +3.6V	1			MΩ
Single-Ended Input-Voltage High	V_{IH}		2.0			V
Single-Ended Input-Voltage Low	V_{IL}				0.8	V
Receiver Single-Ended Hysteresis	V_{HYS}			200		mV
Differential Input Sensitivity	V_{DIFF}		200			mV
Input Common-Mode Voltage Range	V_{CM}		0.8		2.5	V
Driver Output Impedance	R_{OUT}		4.6		16.0	Ω
Internal Pullup Resistor	R_{PU}		1.410	1.500	1.540	kΩ
USB_DET Threshold	V_{USBLH1}	MAX3344E			4.0	V
	V_{USBHL1}	MAX3344E	3.6			
	V_{USBLH2}	MAX3345E			2.8	
	V_{USBHL2}	MAX3345E	1			
USB_DET Hysteresis	V_{USBHYS}	MAX3344E		25		mV
LINEAR REGULATOR						
External Capacitor	C_{OUT}	Compensation of linear regulator	1			µF
ESD PROTECTION (V_{CC}, D+, D-)						
Human Body Model				±15		kV
IEC1000-4-2 Air-Gap Discharge				±10		kV
IEC1000-4-2 Contact Discharge				±8		kV

TIMING CHARACTERISTICS

(V_{CC} = 4V to 5.5V, GND = 0, V_L = 1.65V to 3.6V, ENUM = V_L, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at V_{CC} = 5V, V_L = 2.5V, T_A = +25°C.) (Figures 2–6) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
TRANSMITTER						
$\overline{OE}$ to Transmit Delay Enable Time	t_{PZD}	Figures 2 and 6c			20	ns
$\overline{OE}$ to Driver Three-State Delay Driver Disable Time	t_{PDZ}	Figures 2 and 6c			20	ns
VPO/VMO to D+/D- Propagation Delay	$t_{PLH1(drv)}$	MODE = high, Figures 4 and 6b		10	18	ns
	$t_{PHL1(drv)}$	MODE = high, Figures 4 and 6b		10	18	
VPO/VMO D+/D- Propagation Delay	$t_{PLH0(drv)}$	MODE = low, Figures 3 and 6c		11	20	ns
	$t_{PHL0(drv)}$	MODE = low, Figures 3 and 6c		11	20	

TIMING CHARACTERISTICS (continued)

(V_{CC} = 4V to 5.5V, GND = 0, V_L = 1.65V to 3.6V, ENUM = V_L, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at V_{CC} = 5V, V_L = 2.5V, T_A = +25°C.) (Figures 2–6) (Note 2)

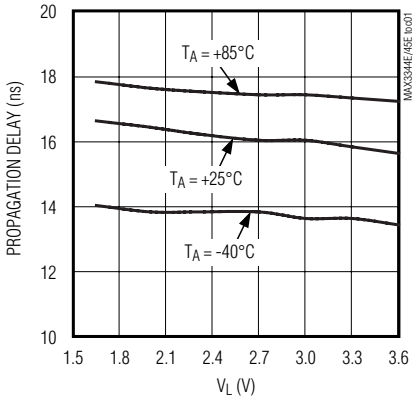
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Rise Time D+/D-	t_{R1}	C_L = 50pF, 10% to 90% of $\lvert V_{OH} - V_{OL} \rvert$	4		20	ns
Fall Time D+/D-	t_{F1}	C_L = 50pF, 90% to 10% of $\lvert V_{OH} - V_{OL} \rvert$	4		20	ns
Rise- and Fall-Time Matching	t_{R1}/t_{F1}	(Note 3)	90		111	%
Output Signal Crossover	V_{CRS}	(Note 3)	1.3		2.0	V
DIFFERENTIAL RECEIVER (Figures 5 and 6a)						
D+/D- to RCV Propagation Delay	$t_{PLH(RCV)}$				18	ns
	$t_{PHL(RCV)}$				18	ns
SINGLE-ENDED RECEIVERS (Figures 5 and 6a)						
D+/D- to VPI or VMI Propagation Delay	$t_{PLH(SE)}$				18	ns
	$t_{PHL(SE)}$				18	ns

Note 2: Parameters are 100% production tested at 25°C, limits over temperature are guaranteed by design.
Note 3: Guaranteed by design, not production tested.

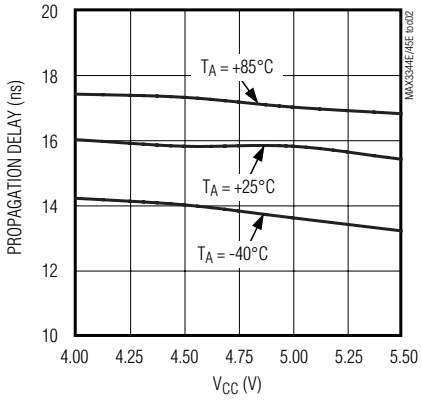
Typical Operating Characteristics

(V_{CC} = 5V, V_L = 3.3V, T_A = +25°C, unless otherwise noted.)

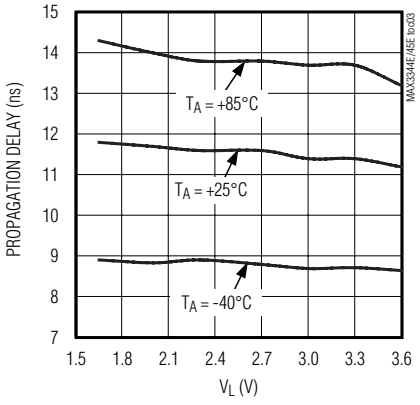
DIFFERENTIAL RECEIVER PROPAGATION DELAY vs. V_L



DIFFERENTIAL RECEIVER PROPAGATION DELAY vs. V_{CC}



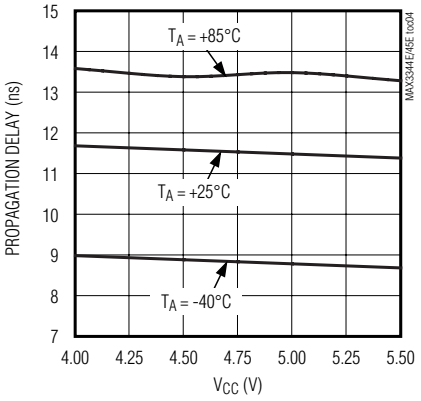
SINGLE-ENDED RECEIVER PROPAGATION DELAY vs. V_L



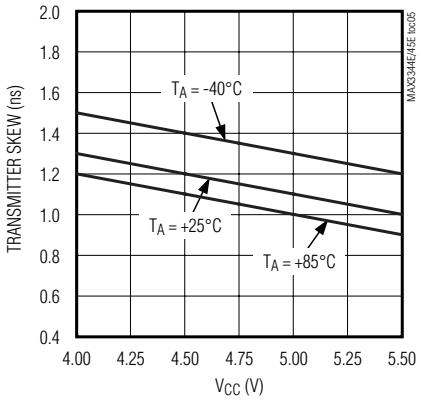
Typical Operating Characteristics (continued)

(V_{CC} = 5V, V_L = 3.3V, T_A = +25°C, unless otherwise noted.)

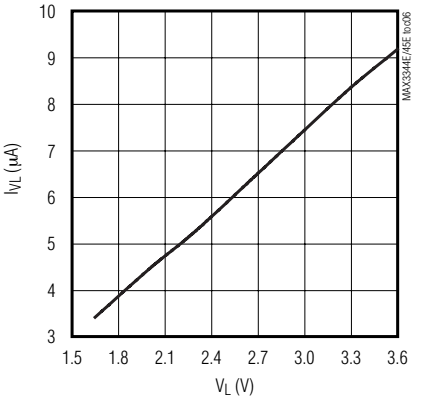
SINGLE-ENDED RECEIVER PROPAGATION DELAY vs. V_{CC}



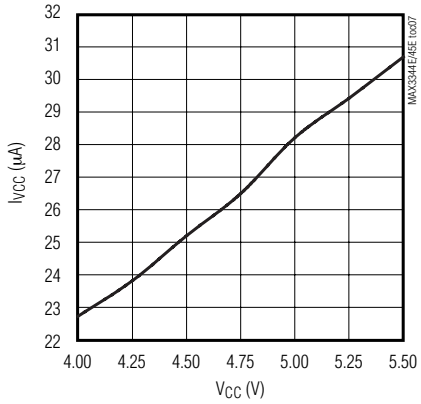
TRANSMITTER SKEW vs. V_{CC}



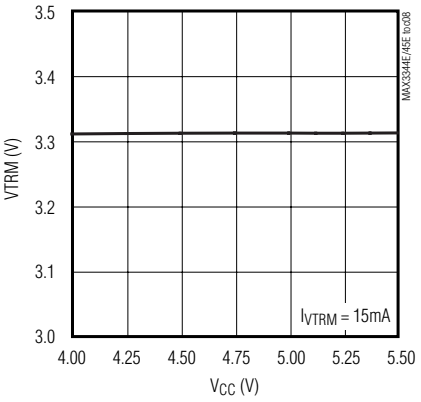
LOGIC CURRENT CONSUMPTION IN SUSPEND MODE



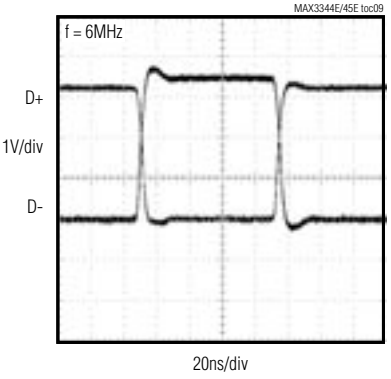
V_{CC} CURRENT CONSUMPTION IN SUSPEND MODE



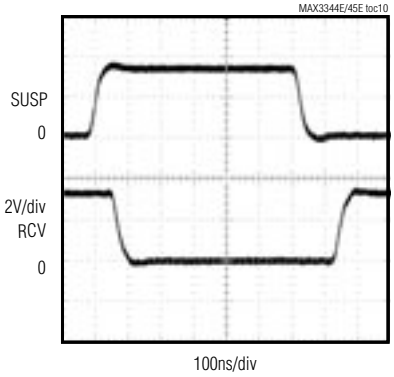
VTRM vs. V_{CC}



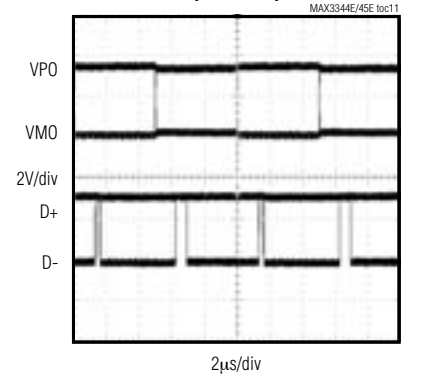
RISE- AND FALL-TIME MATCHING



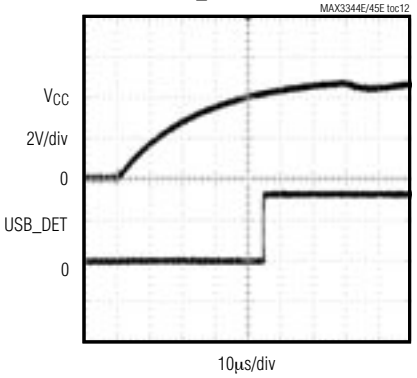
SUSPEND RESPONSE



TRANSMISSION IN SUSPEND MODE (SUSP = 1)



USB_DET RESPONSE



±15kV ESD-Protected USB Transceivers in UCSP with USB Detect

Pin Description

PIN		NAME	INPUT/ OUTPUT	FUNCTION
TSSOP	UCSP			
1	D2	RCV	Output	Receiver Output. Single-ended CMOS output. RCV responds to the differential input on D+ and D-.
2	D1	VPO	Input	Logic-Level Data Input. VPO is level translated to D+.
3	C2	MODE	Input	Mode-Control Input. Selects differential (mode 1) or single-ended (mode 0) input for the system side when converting logic-level signals to USB level signals. Force MODE high to select mode 1. Force MODE low to select mode 0.
4	C1	VMO	Input	Logic-Level Data Input. VMO is level translated to D-.
5	B1	$\overline{OE}$	Input	Output Enable. Drive $\overline{OE}$ low to enable data transmission on D+ and D-. Drive $\overline{OE}$ high to disable data transmission or to receive data.
6	B2	SUSP	Input	Suspend Input. Drive SUSP low for normal operation. Drive SUSP high for low-power state. In low-power state, RCV is low and VPI/VMI are active.
7	A1	VPI	Output	Logic-Level Data Output. VPI is the level-translated value of D+.
8	A2	VMI	Output	Logic-Level Data Output. VMI is the level-translated value of D-.
9	B3	ENUM	Input	Enumerate. Drive ENUM high to connect the internal 1.5kΩ resistor from D+ to 3.3V. Drive ENUM low to disconnect the internal 1.5kΩ resistor.
10	A3	V_{CC}	Power	USB-Side Power-Supply Input. Connect V_{CC} to the incoming USB power supply. Bypass V_{CC} to GND with a 1µF ceramic capacitor.
11	A4	GND	Power	Ground
12	B4	D-	Input/ Output	Negative USB Differential Data Input/Output. Connect to the USB's D- signal through a 23.7Ω ±1% resistor.
13	C4	D+	Input/ Output	Positive USB Differential Data Input/Output. Connect to the USB's D+ signal through a 23.7Ω ±1% resistor.
14	D4	VTRM	Power	Regulated Output Voltage. VTRM provides a 3.3V output derived from V_{CC}. Bypass VTRM to GND with a 1µF (min) low-ESR capacitor, such as ceramic or plastic film types.
15	D3	V_L	Power	System-Side Power-Supply Input. Connect to the system's logic-level power supply, 1.65V to 3.6V.
16	C3	USB_DET	Output	USB Detector Output. A high at USB_DET signals to the ASIC that V_{CC} is present. A low at USB_DET indicates that V_{CC} is not present. The MAX3344E USB_DET threshold is between 3.6V (min) and 4V (max), while the MAX3345E USB_DET threshold is between 1V (min) and 2.8V (max).

Detailed Description

The MAX3344E/MAX3345E are bidirectional transceivers that convert single-ended or differential logic-level signals to differential USB signals, and convert differential USB signals to single-ended or differential logic-level signals. The MAX3344E/MAX3345E are operational from V_{CC} = 5.5V to V_{CC} = 3V (electrical specifications are not guaranteed for V_{CC} < 4V). Both devices include an internal 1.5kΩ pullup resistor that connects and disconnects D+ to VTRM (see the *Functional Diagram*).

The MAX3344E/MAX3345E are tolerant to power sequencing with either V_{CC} > V_L or V_L > V_{CC}. Additionally, the USB I/O, D+ and D-, and V_{CC} are ESD protected to ±15kV. The MAX3344E/MAX3345E can receive USB power (V_{CC}) directly from the USB connection and operate with logic supplies (V_L) down to 1.65V, while still meeting the USB physical layer specifications. The MAX3344E/MAX3345E support full-speed (12Mbps) USB specification 2.0 operation.

The MAX3344E/MAX3345E have an enumerate feature that functions when power is applied. Driving ENUM low disconnects the internal 1.5kΩ pullup resistor from D+ enumerating the USB. This is useful if changes in communication protocol are required while power is applied, and while the USB cable is connected.

Power-Supply Configurations

Normal Operating Mode

Connect V_L and V_{CC} to system power supplies (Table 1). Connect V_L to a +1.65V to +3.6V supply. Connect V_{CC} to a +4.0V to +5.5V supply. Alternatively, the MAX3344E/MAX3345E can derive power from a single Li+ battery. Connect the battery to V_{CC}. V_{VTRM} remains above +3.0V for V_{CC} as low as +3.1V.

Additionally, the MAX3344E/MAX3345E can derive power from a 3.3V ±10% voltage regulator. Connect V_{CC} and VTRM to an external +3.3V voltage regulator.

Disable Mode

Connect V_{CC} to a system power supply and leave V_L unconnected or connect to GND. D+ and D- enter a tri-state mode and V_{CC} consumes less than 20µA of supply current. D+ and D- withstand external signals up to +5.5V in disable mode (Table 2).

Sharing Mode

Connect V_L to a system power supply and leave V_{CC} (or V_{CC} and VTRM) unconnected or connect to GND. D+ and D- enter a tri-state mode, allowing other circuitry to share the USB D+ and D- lines, and V_L consumes less than 20µA of supply current. D+ and D- withstand external signals up to +5.5V in sharing mode (Table 2).

Device Control

D+ and D-

D+ and D- are the USB-side transmitter I/O connections, and are ESD protected to ±15kV using the Human Body Model, ±10kV using IEC 1000-4-2 Air-Gap Discharge, and ±8kV using IEC 1000-4-2 Contact Discharge, making the MAX3344E/MAX3345E ideal for applications where a robust transmitter is required. A 23.7Ω resistor is required on D+ and D- for normal operation (see the *External Resistors* section).

ENUM

USB specification 2.0 requires a 1.5kΩ pullup resistor on D+ for full-speed (12Mbps) operation. Controlled by enumerate (ENUM), the MAX3344E/MAX3345E provide this internal 1.5kΩ resistor. Drive ENUM high to connect the pullup resistor from D+ to VTRM. Drive ENUM low to disconnect the pullup resistor from D+ to VTRM.

VPO/VMO, VPI/VMI, and $\overline{OE}$

The MAX3344E/MAX3345E system-side inputs are VPO and VMO. Data comes into the MAX3344E/MAX3345E through VPO and VMO. VPO and VMO operate either differentially with VPO as the positive terminal and VMO as the negative terminal, or single ended with VPO as the data input (see the *MODE* section).

Table 1. Power-Supply Configurations

V_{CC} (V)	VTRM (V)	V_L (V)	CONFIGURATION	NOTES
+4.0 to +5.5	+3.3 Output	+1.65 to +3.6	Normal mode	—
+3.1 to +4.5	+3.3 Output	+1.65 to +3.6	Battery supply	—
+3.0 to +3.6	+3.0 to +3.6 Input	+1.65 to +3.6	Voltage regulator supply	—
GND or floating	Output	+1.65 to +3.6	Sharing mode	Table 2
+3.0 to +5.5	Output	GND or floating	Disable mode	Table 2

Table 2. Disable-Mode and Sharing-Mode Configurations

INPUTS/OUTPUTS	DISABLE MODE	SHARING MODE
V_{CC}/VTRM	• +5V input/+3.3V output • +3.3V input/+3.3V input • +3.7V input/+3.3V output	• Floating or connected to GND • < +3.6V (MAX3344E) • < +1.0V (MAX3345E)
V_L	Floating or connected to GND	+1.65V to +3.6V input
D+ and D-	High impedance	High impedance
VPI and VMI	Invalid*	High impedance for $\overline{OE}$ = Low
		High for $\overline{OE}$ = High
RCV	Invalid*	Undefined**
SPEED, SUSP, $\overline{OE}$, ENUM	High impedance	High impedance

**High Impedance or low.*

***High or low.*

±15kV ESD-Protected USB Transceivers in UCSP with USB Detect

The MAX3344E/MAX3345E system-side outputs are VPI, VMI, and RCV. The MAX3344E/MAX3345E send data through VPI, VMI, and RCV. VPI and VMI are outputs to the single-ended receivers and RCV is the output of the differential receiver.

Output enable ($\overline{OE}$) controls data transmission. Drive $\overline{OE}$ low to enable data transmission on D+ and D-. Drive $\overline{OE}$ high to disable data transmission or receive data.

MODE

MODE is a control input that selects whether differential or single-ended logic signals are recognized by the system side of the MAX3344E/MAX3345E. Drive MODE high to select differential mode with VPO as the positive terminal and VMO as the negative terminal. Drive MODE low to select single-ended mode with VPO as the data input (Table 3).

VTRM

VTRM is the 3.3V output of the internal linear voltage regulator. VTRM powers the internal circuitry of the USB side of the MAX3344E/MAX3345E. Connect a 1µF (min) low-ESR ceramic or plastic capacitor from VTRM to GND, as close to VTRM as possible. Do not use VTRM to power external circuitry.

VCC

Bypass V_{CC} to GND with a 1µF ceramic capacitor as close to the device as possible. If V_{CC} drops below the USB detect threshold, supply current drops below 20µA avoiding excessive V_{CC} current consumption, and D+/D- enter a high-impedance state allowing other devices to drive the lines.

USB Detect

USB detect output (USB_DET) signals that V_{CC} is present. A high at USB_DET indicates that V_{CC} is present, while a low at USB_DET indicates that V_{CC} is not present. The MAX3344E USB_DET threshold is between 3.6V (min) and 4V (max), while the MAX3345E USB_DET threshold is between 1V (min) and 2.8V (max).

SUSP

Suspend (SUSP) is a control input. Force SUSP high to place the MAX3344E/MAX3345E in a low-power state. In this state, the quiescent supply current into V_{CC} is less than 40µA and RCV goes low.

In suspend mode, VPI and VMI remain active as receive outputs and VTRM stays on. The MAX3344E/MAX3345E continue to receive data from the USB, allowing the µP to sense activity on the D+/D- lines and wake up the MAX3344E/MAX3345E.

The MAX3344E/MAX3345E can also transmit data to D+ and D- while in suspend mode. This function is used to signal a remote wake-up by driving a signal on D+ and D- for a period of 1ms to 15ms. In suspend mode, data can only be transmitted with full-speed slope control.

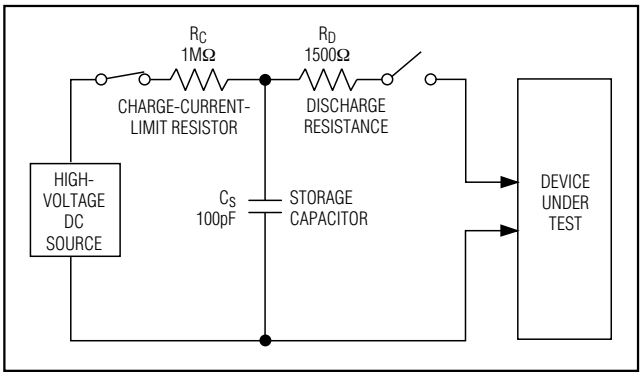


Figure 1a. Human Body ESD Test Models

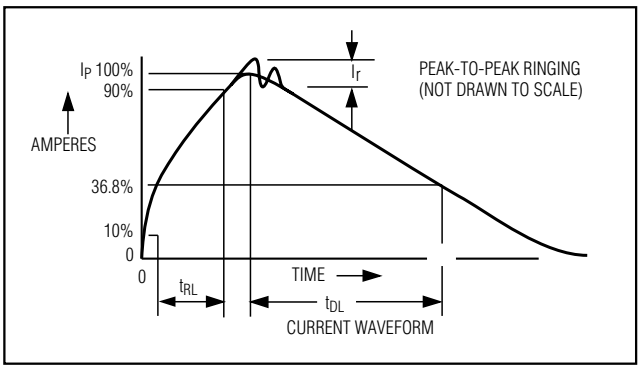


Figure 1b. Human Body Model Current Waveform

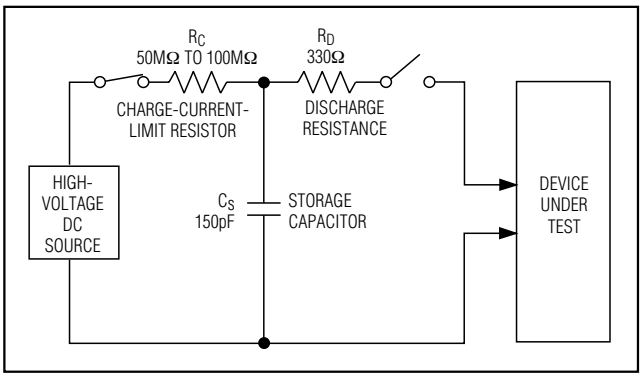


Figure 1c. IEC 1000-4-2 ESD Test Model

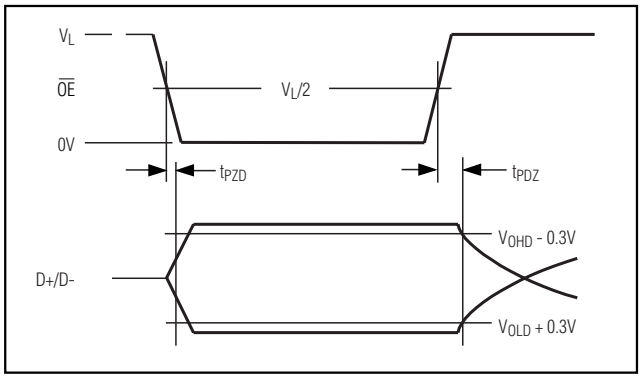


Figure 2. Enable and Disable Timing, Transmitter

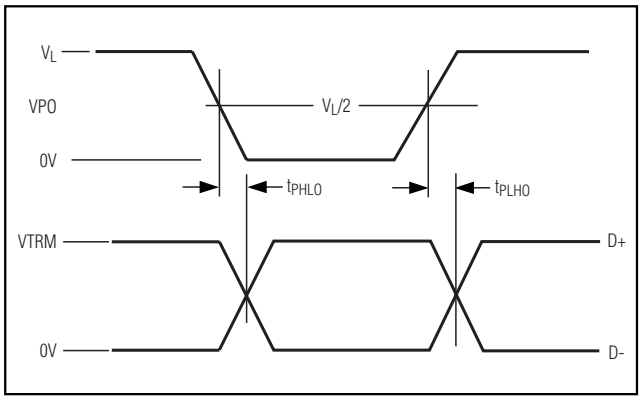


Figure 3. Mode 0 Timing

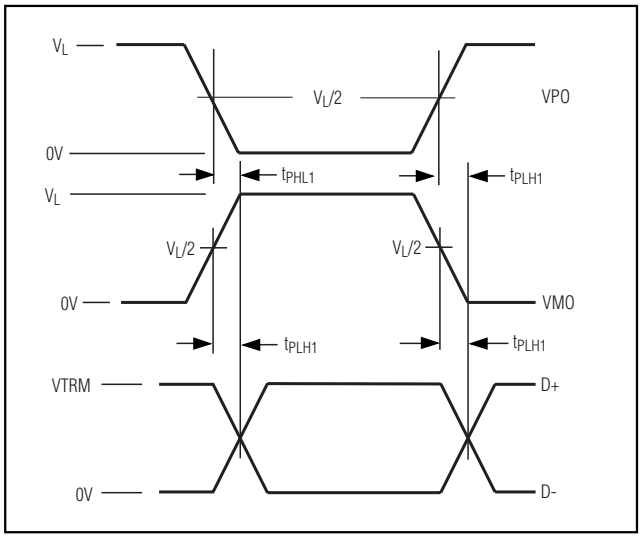


Figure 4. Mode 1 Timing

Data Transfer

Receiving Data from the USB

Data received from the USB are output to VPI/VMI in either of two ways, differentially or single ended. To receive data from the USB, force $\overline{OE}$ high and SUSP low. Differential data arriving at D+/D- appear as differential logic signals at VPI/VMI, and as a single-ended logic signal at RCV. If both D+ and D- are low, then VPI and VMI are low, signaling a single-ended zero condition on the bus; RCV remains in the last known state (Table 3).

Transmitting Data to the USB

The MAX3344E/MAX3345E output data to the USB differentially on D+ and D-. The logic driving signals can be either differential or single ended. For sending differential logic, force MODE high, force $\overline{OE}$ and SUSP low, and apply data to VPO and VMO. D+ then follows VPO, and D- follows VMO. To send single-ended logic signals, force MODE, SUSP, and $\overline{OE}$ low, and apply data to VPO/VMO.

ESD Protection

To protect the MAX3344E/MAX3345E against ESD, D+ and D- have extra protection against static electricity to protect the device up to ±15kV. The ESD structures withstand high ESD in all states—normal operation, suspend, and powered down. For the 15kV ESD structures to work correctly, a 1µF or greater capacitor must be connected from VTRM to GND.

ESD protection can be tested in various ways; the D+ and D- input/output pins are characterized for protection to the following limits:

1) ±15kV using the Human Body Model
2) ±8kV using the IEC 1000-4-2 Contact Discharge Method
3) ±10kV using the IEC 1000-4-2 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 1a shows the Human Body Model, and Figure 1b shows the current waveform it generates when discharged into a low impedance. This model consists of a 100pF capacitor charged to the ESD voltage of interest, which is then discharged into the test device through a 1.5kΩ resistor.

Table 3a. Truth Table Transmit (SUSP = 0, $\overline{OE}$ = 0, ENUM = X)

INPUT			OUTPUT					
MODE	VPO	VMO	D+	D-	RCV	VPI	VMI	RESULT
0	0	0	0	1	0	0	1	LOGIC 0
0	0	1	0	0	RCV*	0	0	SE0
0	1	0	1	0	1	1	0	LOGIC 1
0	1	1	0	0	RCV*	0	0	SE0
1	0	0	0	0	RCV*	0	0	SE0
1	0	1	0	1	0	0	1	LOGIC 0
1	1	0	1	0	1	1	0	LOGIC 1
1	1	1	1	1	X	1	1	UNDEFINED

**RCV denotes the signal level on output RCV just before SE0 state occurs. This level is stable during the SE0 period.*

Table 3b. Truth Table Receive (SUSP = 0, OE = 1, ENUM = X)

INPUT		OUTPUT			
D+	D-	RCV	VPI	VMI	RESULT
0	0	RCV*	0	0	SE0
0	1	0	0	1	LOGIC 0
1	0	1	1	0	LOGIC 1
1	1	X	1	1	UNDEFINED

**RCV denotes the signal level on output RCV just before SE0 state occurs. This level is stable during the SE0 period.*

Table 3c. Truth Table Transmit in Suspend* (SUSP = 1, $\overline{OE}$ = 0, ENUM = X)

INPUT			OUTPUT					
MODE	VPO	VMO	D+	D-	RCV	VPI	VMI	RESULT
0	0	0	0	1	0	0	1	LOGIC 0
0	0	1	0	0	0	0	0	SE0
0	1	0	1	0	0	1	0	LOGIC 1
0	1	1	0	0	0	0	0	SE0
1	0	0	0	0	0	0	0	SE0
1	0	1	0	1	0	0	1	LOGIC 0
1	1	0	1	0	0	1	0	LOGIC 1
1	1	1	1	1	0	1	1	UNDEFINED

**Timing specifications are not guaranteed for D+ and D-.*

Table 3d. Truth Table Receive in Suspend* (SUSP = 1, $\overline{OE}$ = 1, MODE = X, VPO/VMO = X, ENUM = X)

INPUT		OUTPUT			
D+	D-	RCV	VPI	VMI	RESULT
0	0	0	0	0	VPI/VMI ACTIVE
0	1	0	0	1	VPI/VMI ACTIVE
1	0	0	1	0	VPI/VMI ACTIVE
1	1	0	1	1	VPI/VMI ACTIVE

**Timing specifications are not guaranteed for D+ and D-.*

IEC 1000-4-2

The IEC 1000-4-2 standard covers ESD testing and performance of finished equipment; it does not specifically refer to integrated circuits. The MAX3344E/MAX3345E help the user design equipment that meets level 4 of IEC 1000-4-2, without the need for additional ESD-protection components.

The major difference between tests done using the Human Body Model and IEC 1000-4-2 is a higher peak current in IEC 1000-4-2, because series resistance is lower in the IEC 1000-4-2 model. Hence, the ESD withstand voltage measured to IEC 1000-4-2 is generally lower than that measured using the Human Body Model. Figure 1c shows the IEC 1000-4-2 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.

Machine Model

The Machine Model for ESD tests all pins using a 200pF storage capacitor and zero discharge resistance. Its objective is to emulate the stress caused by contact that occurs with handling and assembly during manufacturing. All pins require this protection during manufacturing. Therefore, after PC board assembly, the Machine Model is less relevant to I/O ports.

Applications Information

External Components

External Resistors

Two external 23.7Ω ±1% to 27.4Ω ±1%, 1/2W resistors are required for USB connection. Place the resistors in between the MAX3344E/MAX3345E and the USB connector on the D+ and D- lines (see the *Typical Operating Circuit*).

External Capacitors

Use three external capacitors for proper operation. Use a 0.1µF ceramic for decoupling V_L, a 1µF ceramic for decoupling V_{CC}, and a 1.0µF (min) ceramic or plastic filter capacitor on VTRM. Return all capacitors to GND.

UCSP Applications Information

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

Chip Information

TRANSISTOR COUNT: 2162

PROCESS: BiCMOS

±15kV ESD-Protected USB Transceivers in UCSP with USB Detect

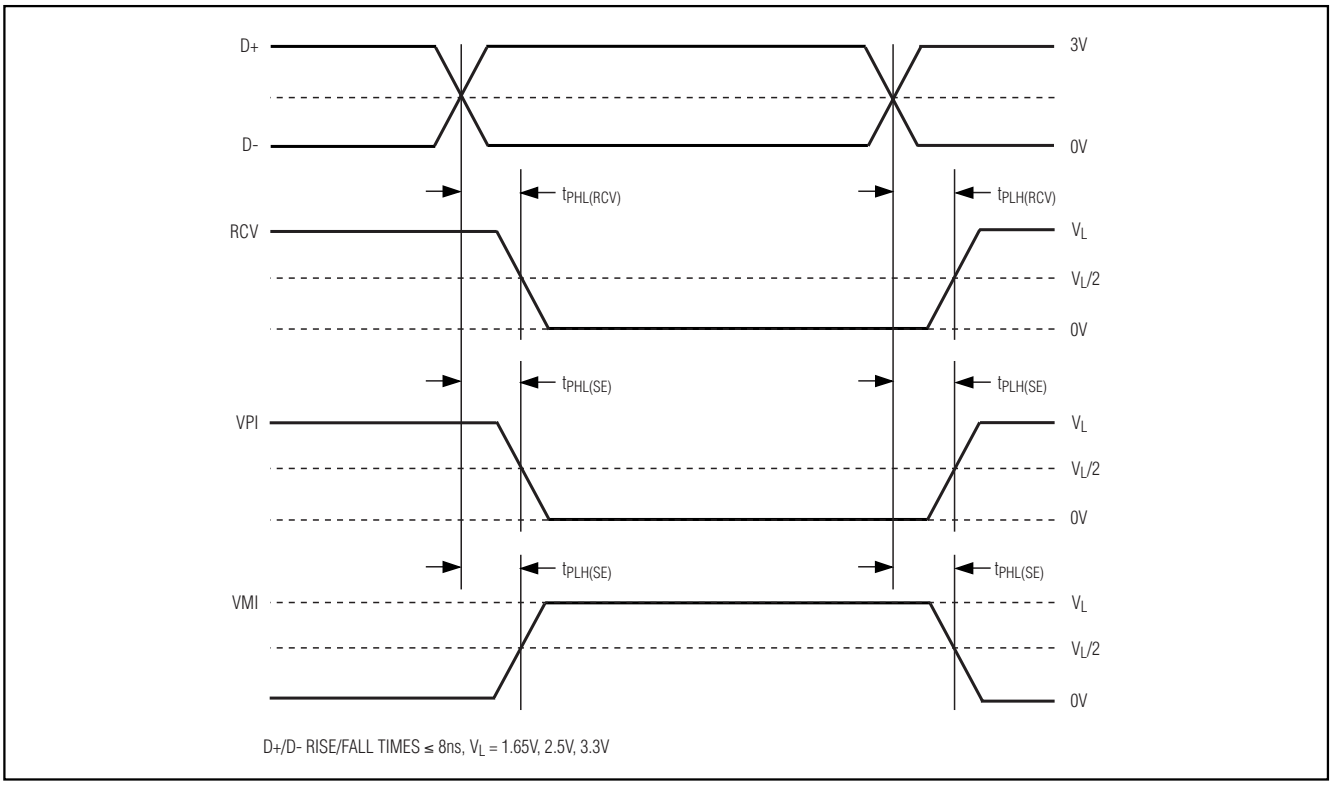


Figure 5. D+/D- to RCV, VPI, VMI Propagation Delays

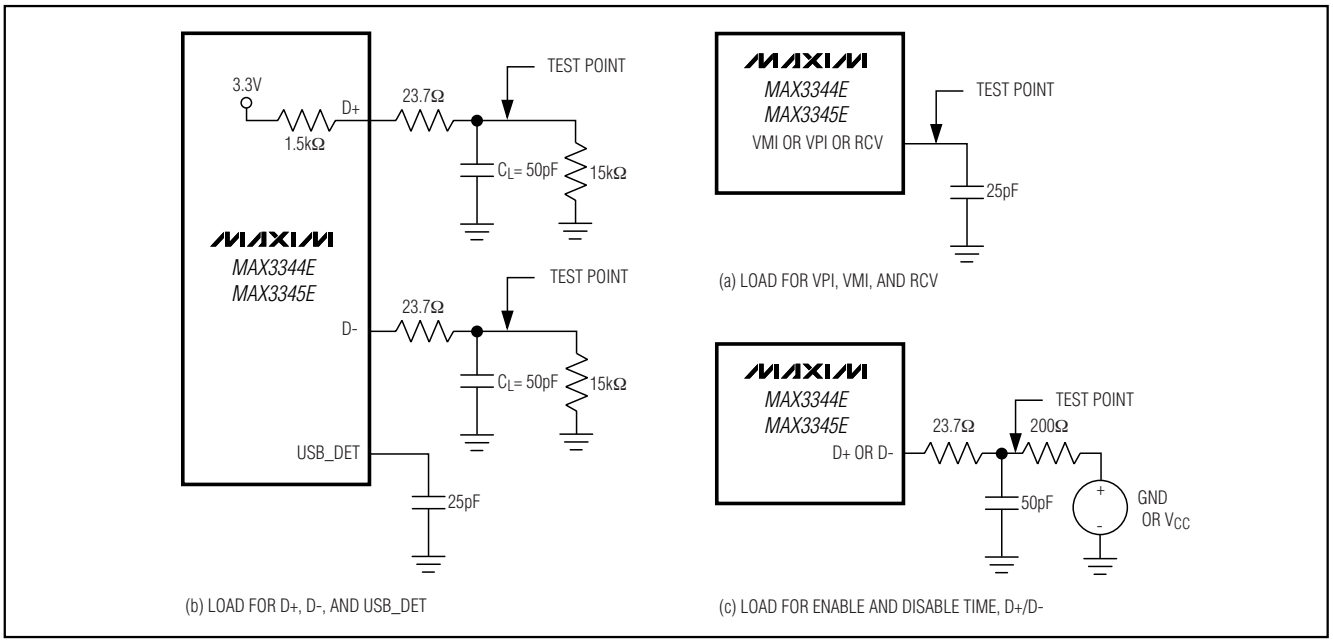
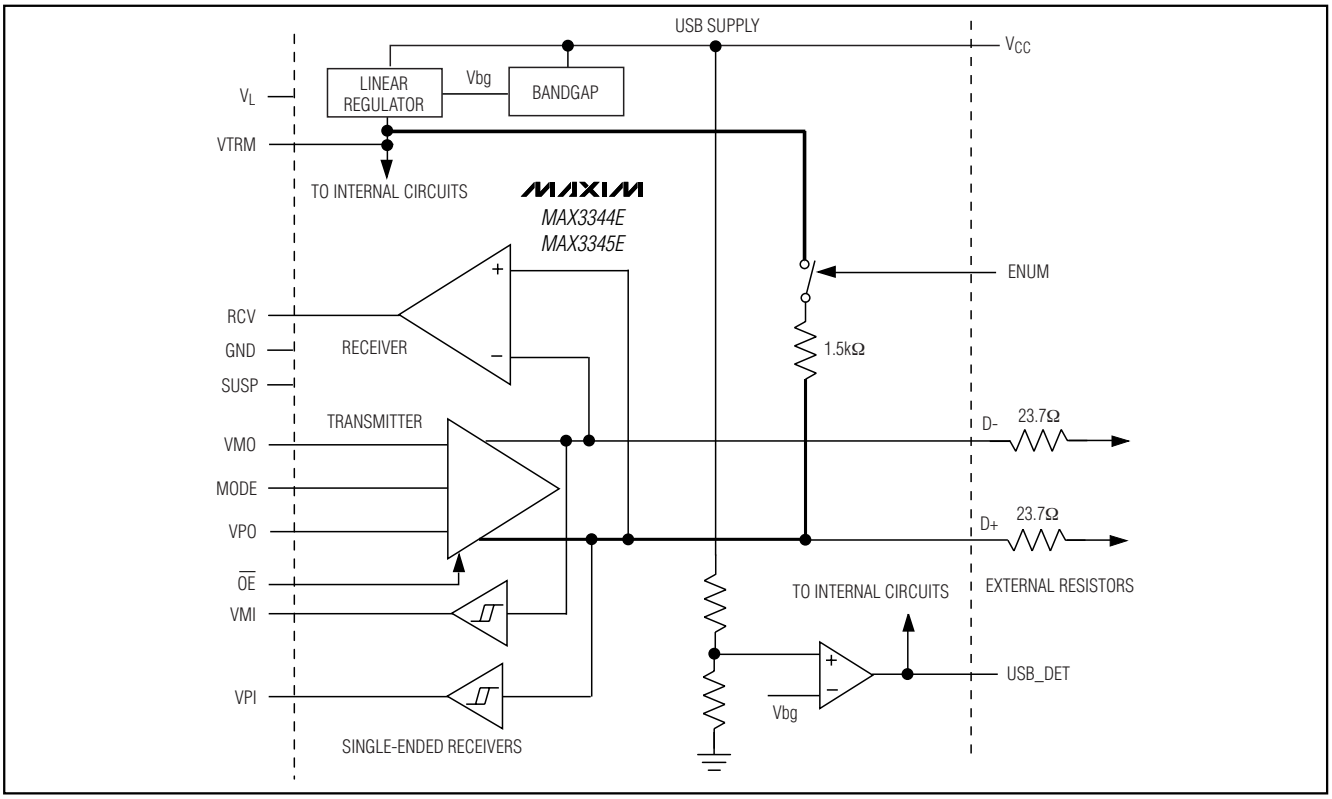
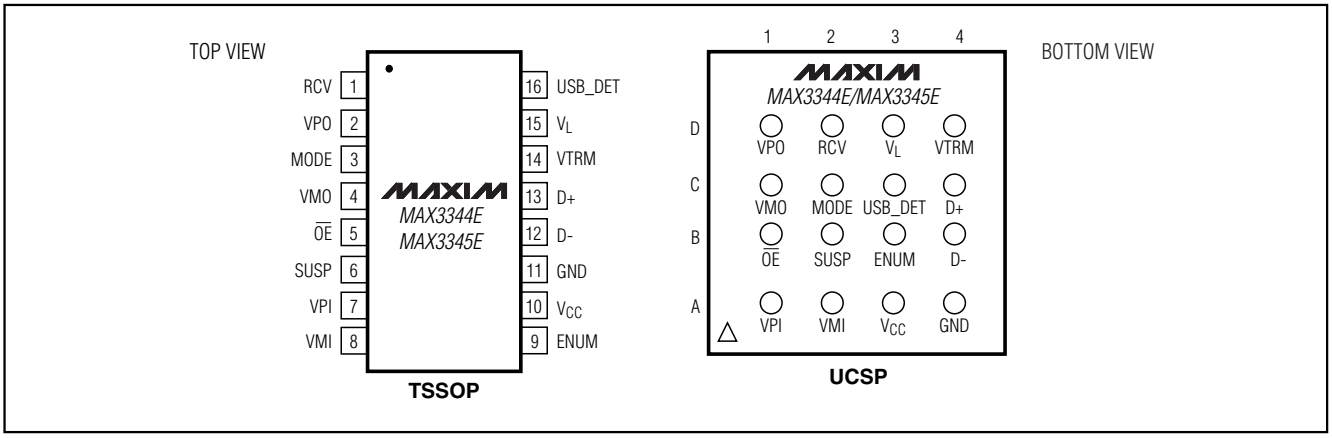


Figure 6. Test Circuits

Functional Diagram



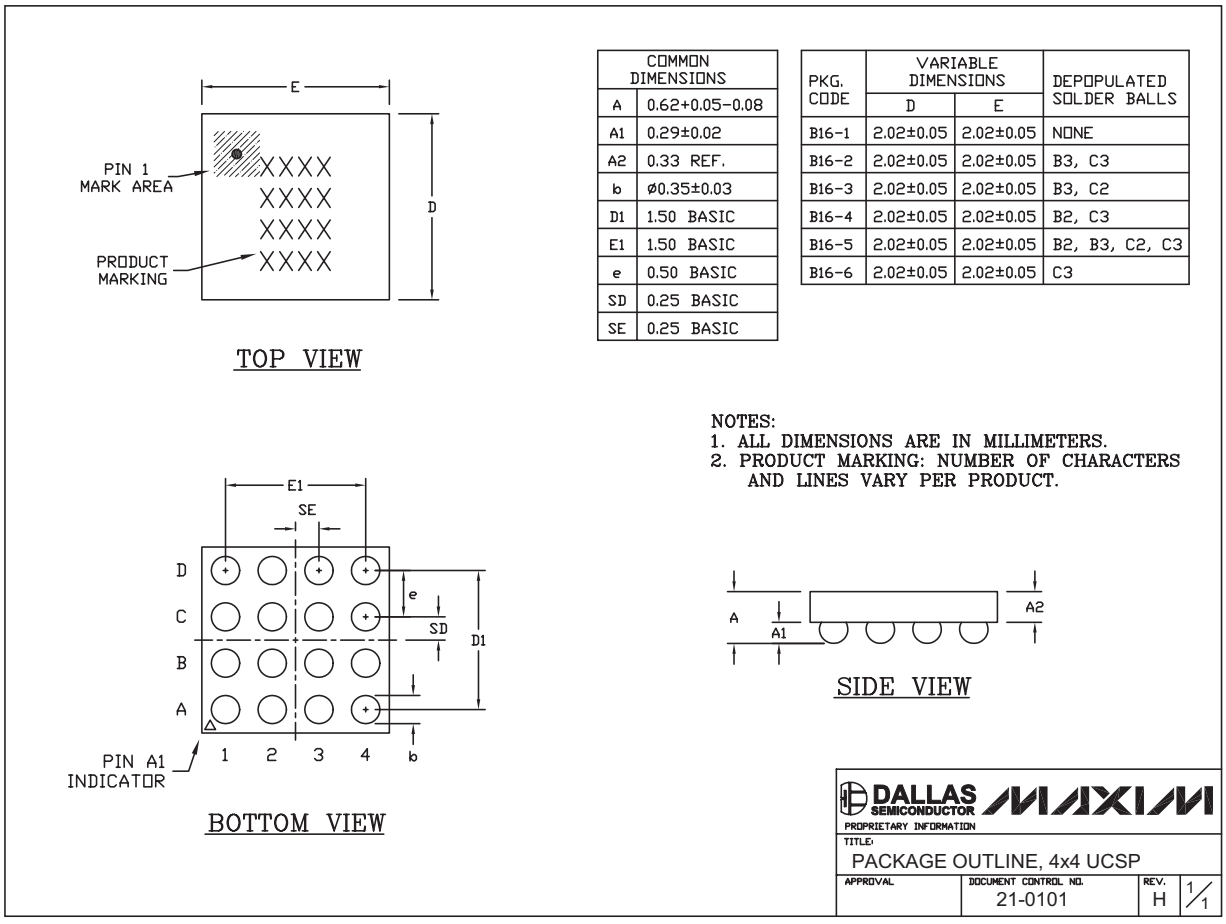
Pin Configurations



±15kV ESD-Protected USB Transceivers in UCSP with USB Detect

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**.)



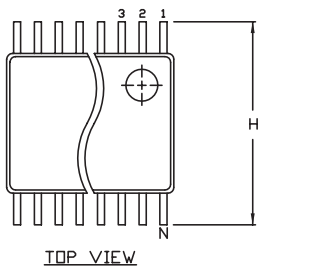
COMMON DIMENSIONS	
A	0.62+0.05-0.08
A1	0.29±0.02
A2	0.33 REF.
b	ø0.35±0.03
D1	1.50 BASIC
E1	1.50 BASIC
e	0.50 BASIC
SD	0.25 BASIC
SE	0.25 BASIC

PKG. CODE	VARIABLE DIMENSIONS		DEPOPULATED SOLDER BALLS
	D	E	
B16-1	2.02±0.05	2.02±0.05	NONE
B16-2	2.02±0.05	2.02±0.05	B3, C3
B16-3	2.02±0.05	2.02±0.05	B3, C2
B16-4	2.02±0.05	2.02±0.05	B2, C3
B16-5	2.02±0.05	2.02±0.05	B2, B3, C2, C3
B16-6	2.02±0.05	2.02±0.05	C3

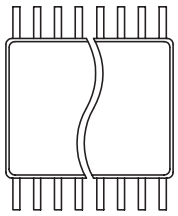
Package Information (continued)

(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**.)

TSSOP4.40mm.EPS

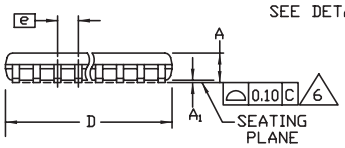


TOP VIEW

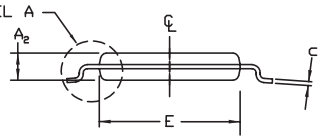


BOTTOM VIEW

SYMBOL	COMMON DIMENSIONS			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	——	1.10		.043
A_1	0.05	0.15	.002	.006
A_2	0.85	0.95	.033	.037
b	0.19	0.30	.007	.012
b_1	0.19	0.25	.007	.010
c	0.09	0.20	.004	.008
c_1	0.09	0.14	.004	.006
D	SEE VARIATIONS		SEE VARIATIONS	
E	4.30	4.50	.169	.177
e	0.65 BSC		.026 BSC	
H	6.25	6.55	.246	.258
L	0.50	0.70	.020	.028
N	SEE VARIATIONS		SEE VARIATIONS	
α	0°	8°	0°	8°

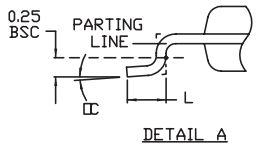


SIDE VIEW

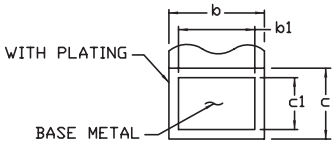


END VIEW

JEDEC			VARIATIONS			
MO-153	N		MILLIMETERS		INCHES	
			MIN.	MAX.	MIN.	MAX.
AB-1	14	D	4.90	5.10	.193	.201
AB	16	D	4.90	5.10	.193	.201
AC	20	D	6.40	6.60	.252	.260
AD	24	D	7.70	7.90	.303	.311
AE	28	D	9.60	9.80	.378	.386



DETAIL A



LEAD TIP DETAIL

NOTES:
1. DIMENSIONS D AND E DO NOT INCLUDE FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm PER SIDE
3. CONTROLLING DIMENSION: MILLIMETER
4. MEETS JEDEC OUTLINE MO-153. SEE JEDEC VARIATIONS TABLE
5. "N" REFERS TO NUMBER OF LEADS
6. THE LEAD TIPS MUST LIE WITHIN A SPECIFIED ZONE. THIS TOLERANCE ZONE IS DEFINED BY TWO PARALLEL PLANES. ONE PLANE IS THE SEATING PLANE, DATUM [-C-]; THE OTHER PLANE IS AT THE SPECIFIED DISTANCE FROM [-C-] IN THE DIRECTION INDICATED

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, TSSOP 4.40mm BODY

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0066	F	1/1

Mouser Electronics

Authorized Distributor

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