19-6390; Rev 0; 6/12

MAX14581/MAX14582

Industry's Smallest and Lowest (V_L) Full-Speed USB Transceivers, with Low VIO 3/5-Wire Interface

General Description

The MAX14581/MAX14582 USB-compliant transceivers are designed to minimize the area and external components required to interface low-voltage ASICs to USB. These devices comply with USB 2.0 specification for full-speed-only (12Mbps) operation. The transceivers include an internal 3.3V regulator, an internal 1.5kΩ D+ pullup resistor, and built-in ±15kV ESD HBM protection circuitry to protect the USB I/O ports (D+, D-). The MAX14581/MAX14582 also have internal series resistors, allowing the devices to be wired directly to a USB connector.

These devices operate with logic-supply voltages as low as +1.2V, ensuring compatibility with low-voltage ASICs. A low-power disable mode reduces current consumption to typically less than 13µA (typ) from V_{BUS}. An enumerate function controls the D+ pullup resistor, allowing devices to logically disconnect while remaining plugged in.

The devices have 36Ω (typ) internal series resistors on D+/D- for direct connection to the USB connector. These devices can be used as either peripheral or host (FS) USB transceivers. As a host USB transceiver, the MAX14581/MAX14582 require external 15kΩ pulldown resistors and driving ENUM logic-low.

The MAX14581 (3-wire) is equipped with DAT and SE0 interface signals. The transceiver provides a USB detection function that monitors the presence of USB V_{BUS} and signals the event by means of a BD pin.

The MAX14582 (5-wire) is equipped with VP, VM, and RCV interface signals. The detection of V_{BUS} in the MAX14582 is encoded as VP = VM = logic-high.

These devices operate over the extended -40°C to +85°C temperature range and are available in 12-bump WLP packages.

Applications

Smart Phones

Tablets

Portable Media Players

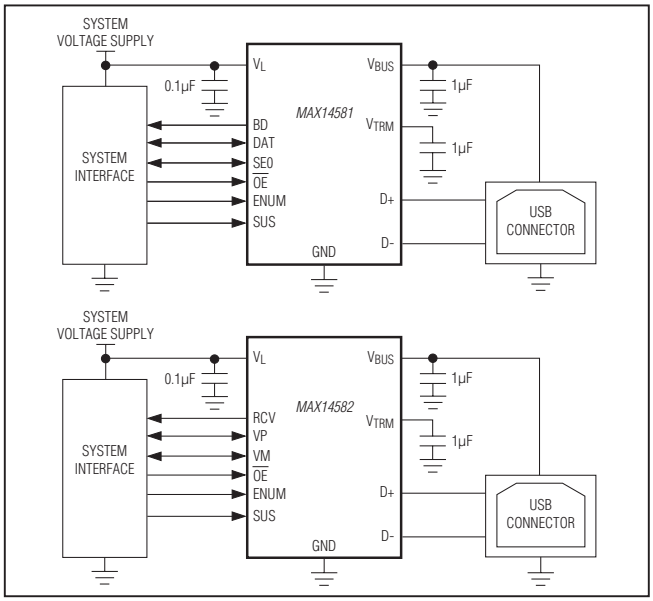
ebook Readers

Ordering Information and USB Inter-Chip Typical Application Circuits appear at end of data sheet.

Benefits and Features

- **Provide Flexible USB Transceiver Design**
  - **Supports 3-Wire Interface (MAX14581)**
  - **Supports 5-Wire Interface (MAX14582)**
  - **USB 2.0 (Full-Speed, 12Mbps)-Compliant Transceiver**
  - **+1.2V to +3.6V Interface Voltage (VL)**
  - **Enumeration Input Controls D+ Pullup Resistor**
  - **13µA (typ) Current in Disable Mode**
- **Minimize PCB Area**
  - **Internal Pullup Resistor on D+**
  - **Internal Series Resistors**
- **Additional Protection Features Increase System Reliability**
  - **Low Output Capacitance for Easy Connection to an External USB HS Transceiver in Parallel**
  - **No Power-Supply Sequencing Required**
  - **Ability to Accept D+/D- Voltages Up to 3.6V with V_{BUS} = 0V**
  - **28V-Tolerant V_{BUS} Pin**
  - **Bus Detect (BD) Pin for the V_{BUS} Detection (MAX14581 Only)**
  - **High-ESD Protection on D+/D- and V_{BUS} ±15kV HBM**

Typical Application Circuits



For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

ABSOLUTE MAXIMUM RATINGS

(All Voltages Referenced to GND, unless otherwise noted.)
Supply Voltage (V_{BUS}) ..... -0.3V to +30V
Supply Voltage (V_L) ..... -0.3V to +6V
V_{TRM} ..... -0.3V to min(+6V, V_{BUS} + 0.3V)
D+, D- ..... -0.3V to 6V
VP, VM, SUS, BD, ENUM,
RCV, $\overline{OE}$, DAT, SE0 ..... -0.3V to (V_L +0.3V)
Short-Circuit Current (D+ and D-) to V_{BUS} or GND ... Continuous
Maximum Continuous Current (all other pins) ..... ±15mA
Continuous Power Dissipation (T_A = +70°C)
WLP (derate 13.7mW/°C above +70°C) 500mW
Operating Temperature Range ..... -40°C to +85°C
Junction Temperature ..... +150°C
Storage Temperature Range ..... -65°C to +150°C
Soldering Temperature (reflow) ..... +260°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.

PACKAGE THERMAL CHARACTERISTICS (Note 1)

WLP
Junction-to-Ambient Thermal Resistance (θ_{JA}) ..... 73°C/W

Note 1: Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to **www.maxim-ic.com/thermal-tutorial**.

ELECTRICAL CHARACTERISTICS

(V_{BUS} = +3.0V to +5.5V, V_L = +1.20V to +3.6V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at V_{BUS} = +3.6V, V_L = +2.5V, and T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage Range	V_{BUS}		3		5.5	V
	V_L		1.2		3.6	
Regulated Supply Voltage Output	V_{TRM}	V_{BUS} > 3.6V	3	3.3	3.6	V
		3.0V < V_{BUS} < 3.6V	2.8		3.6	
Operating V_{BUS} Supply Current	I_{VBUS}	Full-speed transmitting/receiving at 12Mbps, C_L = 50pF on D+ and D-			8	mA
Operating V_L Supply Current	I_L	Full-speed transmitting/receiving at 12Mbps, C_L = 15pF on receiver outputs, V_L = 2.5V		1	2	mA
Full-Speed Idle and SE0 Supply Current	$I_{VBUS\ (IDLE)}$	Full-speed idle: V_{D+} > 2.7V, V_{D-} < 0.3V, $\overline{OE}$ = high or low		300	500	µA
		SE0: V_{D+} < 0.3V, V_{D-} < 0.3V, $\overline{OE}$ = high or low		140	250	
Static V_L Supply Current	$I_{VL(STATIC)}$	Full-speed idle, SE0, or suspend mode; $\overline{OE}$ = high or low		1	4	µA
Suspend V_{BUS} Supply Current	$I_{VBUS(SUSP)}$	DAT = SE0 = open, SUS = $\overline{OE}$ = high (MAX14581)			33	µA
		VM = VP = open, SUS = $\overline{OE}$ = high (MAX14582)			33	
Disable-Mode V_{BUS} Supply Current	$I_{VBUS\ (DIS)}$	V_L = GND or open, V_{BUS} up to 5V		13	23	µA

ELECTRICAL CHARACTERISTICS (continued)

(V_{BUS} = +3.0V to +5.5V, V_L = +1.20V to +3.6V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at V_{BUS} = +3.6V, V_L = +2.5V, and T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Sharing-Mode V_L Supply Current	$I_{VL(SHARING)}$	V_{BUS} = GND or open, $\overline{OE}$ = low, DAT = SE0 = high or high-Z, SUS = high, MAX14581			0.1	1	µA
		V_{BUS} = GND or open, $\overline{OE}$ = low, VP = VM = high or high-Z, SUS = high, MAX14582			0.1	1	
D+/D- Sharing-Mode Load Current	$I_{D(SHARING)}$	V_{BUS} = GND or open, $V_{D_}$ = 0V or +5.5V, $\overline{OE}$ = high or low			0.1	1	µA
V_{BUS} Power-Supply Detection Threshold	V_{TH_VBUS}	V_L = 1.2V		2.0	2.4	2.7	V
V_{BUS} Power-Supply Detection Hysteresis	V_{HYST_VBUS}				100		mV
V_L Power-Supply Detection Threshold	V_{TH_VL}	(Note 3)			0.85		V
DIGITAL INPUTS AND OUTPUTS (VP, VM, DAT, SE0, RCV, $\overline{OE}$, ENUM, SUS, BD)							
Input-Voltage Low	V_{IL}					0.3 x V_L	V
Input-Voltage High	V_{IH}			0.7 x V_L			V
Output-Voltage Low	V_{OL}	I_{OL} = 2mA	V_L > 1.65V			0.4	V
			1.2V < V_L < 1.65V			0.55	
Output-Voltage High	V_{OH}	I_{OH} = -2mA	V_L > 1.65V	V_L - 0.4			V
			1.2V < V_L < 1.65V	V_L - 0.55			
Input Leakage Current	I_{LKG}			-1		+1	µA
ANALOG INPUTS AND OUTPUTS (D+, D-)							
Differential Input Sensitivity	V_{ID}	$\lvert V_{D+} - V_{D-} \rvert$		0.2			V
Differential Common-Mode Voltage	V_{CM}	Includes V_{ID} range		0.8		2.5	V
Single-Ended Input Low Voltage	V_{ILSE}					0.8	V
Single-Ended Input High Voltage	V_{IHSE}			2.0			V
USB Output-Voltage Low	V_{USB_OLD}	R_L = 1.5kΩ resistor connected to +3.6V				0.3	V
USB Output-Voltage High	V_{USB_OHD}	R_L = 15kΩ resistor connected to GND		2.8		3.6	V
Internal Pullup Resistance	R_{PULLUP}			1425		1575	Ω
Driver Output Impedance	Z_{DRV}	Steady-state drive		28	36	44	Ω
Input Impedance	Z_{IN}	Driver off		10			MΩ
D+/D- Off Capacitance	C_{USB}	Driver off (Note 3)			8		pF

ELECTRICAL CHARACTERISTICS (continued)

(V_{BUS} = +3.0V to +5.5V, V_L = +1.20V to +3.6V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at V_{BUS} = +3.6V, V_L = +2.5V, and T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
DRIVER CHARACTERISTICS (C_L = 50pF)							
Rise Time	t_{FR}	10% to 90% of $\lvert V_{OHD} - V_{OLD}\rvert$; Figures 1, 6		4		20	ns
Fall Time	t_{FF}	90% to 10% of $\lvert V_{OHD} - V_{OLD}\rvert$; Figures 1, 6		4		20	ns
Rise/Fall Time Matching	t_{FR}/t_{FF}	Excluding the first transition from idle state; Figures 1, 6 (Note 3, inferred from drive output impedance)		90		110	%
Output Signal Crossover Voltage	V_{CRS_F}	Excluding the first transition from idle state, Figure 2 (Note 3)		1.3		2.0	V
Driver-Propagation Delay	t_{PLH_DRV}	Low-to-high transition; Figures 2, 6	V_L > 1.65V			15	ns
			1.2V < V_L < 1.65V			20	
	t_{PHL_DRV}	High-to-low transition; Figures 2, 6	V_L > 1.65V			15	
			1.2V < V_L < 1.65V			20	
Driver-Disable Delay	t_{PHZ_DRV}	High-to-off transition; Figures 3, 6	V_L > 1.65V			15	ns
			1.2V < V_L < 1.65V			20	
	t_{PLZ_DRV}	Low-to-off transition; Figures 3, 6	V_L > 1.65V			15	
			1.2V < V_L < 1.65V			20	
Driver-Enable Delay	t_{PZH_DRV}	Off-to-high transition; Figures 3, 6	V_L > 1.65V			15	ns
			1.2V < V_L < 1.65V			20	
	t_{PZL_DRV}	Off-to-low transition; Figures 3, 6	V_L > 1.65V			15	
			1.2V < V_L < 1.65V			20	
RECEIVER (C_L = 15pF)							
Differential Receiver Propagation Delay	t_{PLH_RCV}	Low-to-high transition; Figures 4, 7	V_L > 1.65V			15	ns
			1.2V < V_L < 1.65V			20	
	t_{PHL_RCV}	High-to-low transition; Figures 4, 7	V_L > 1.65V			15	
			1.2V < V_L < 1.65V			20	
Single-Ended Receiver Propagation Delay	t_{PLH_SE}	Low-to-high transition; Figures 4, 7	V_L > 1.65V			15	ns
			1.2V < V_L < 1.65V			20	
	t_{PHL_SE}	High-to-low transition; Figures 4, 7	V_L > 1.65V			15	
			1.2V < V_L < 1.65V			20	
Single-Ended Receiver Disable Delay	t_{PHZ_SE}	High-to-off transition, Figure 5	V_L > 1.65V			15	ns
			1.2V < V_L < 1.65V			20	
	t_{PLZ_SE}	Low-to-off transition, Figure 5	V_L > 1.65V			15	
			1.2V < V_L < 1.65V			20	

ELECTRICAL CHARACTERISTICS (continued)

(V_{BUS} = +3.0V to +5.5V, V_L = +1.20V to +3.6V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at V_{BUS} = +3.6V, V_L = +2.5V, and T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Single-Ended Receiver Enable Delay	t_{PZH_SE}	Off-to-high transition, Figure 5	V_L > 1.65V			15	ns
			1.2V < V_L < 1.65V			20	
	t_{PZL_SE}	Off-to-low transition, Figure 5	V_L > 1.65V			15	
			1.2V < V_L < 1.65V			20	
ESD PROTECTION							
V_{BUS}		1µF external ceramic capacitor, HBM			±15		kV
D+, D-					±15		kV

Note 2: All specifications are 100% production tested at T_A = +25°C, unless otherwise noted. Specifications are over -40°C to +85°C and are guaranteed by design.

Note 3: Guaranteed by design, not production tested.

Industry's Smallest and Lowest (V_L) Full-Speed USB Transceivers, with Low VIO 3/5-Wire Interface

Timing Diagrams

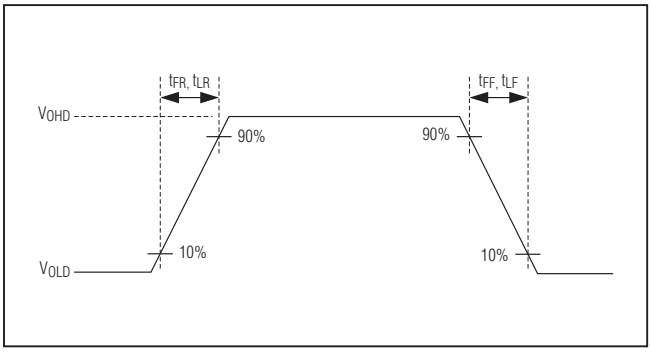


Figure 1. Rise and Fall Times

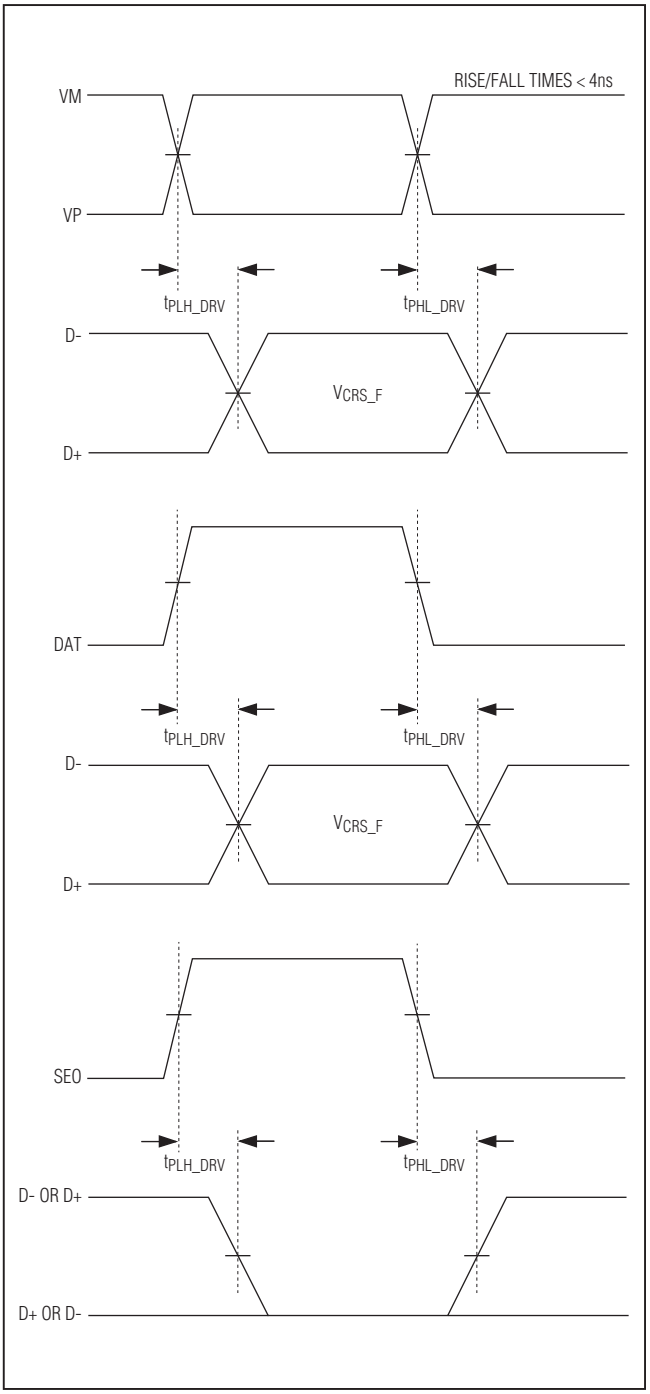


Figure 2. Timing of (DAT and SE0) and (VP and VM) to D+ and D-

Industry's Smallest and Lowest (V_L) Full-Speed USB Transceivers, with Low VIO 3/5-Wire Interface

Timing Diagrams (continued)

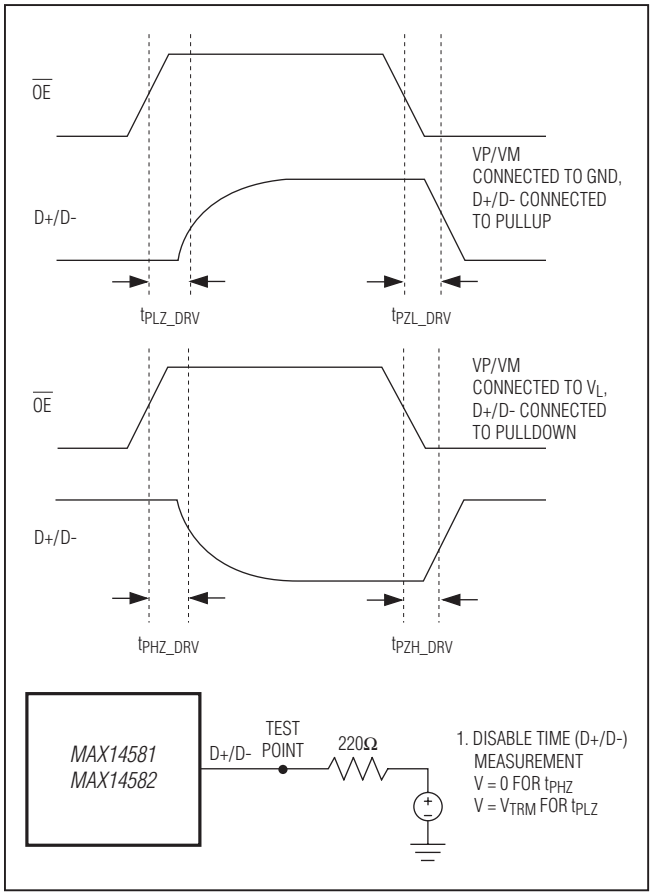


Figure 3. Driver Enable and Disable Timing

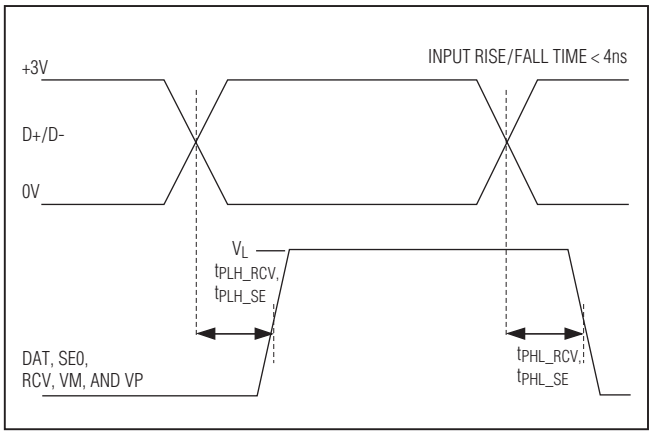


Figure 4. D+/D- Timing to VP, VM, and RCV

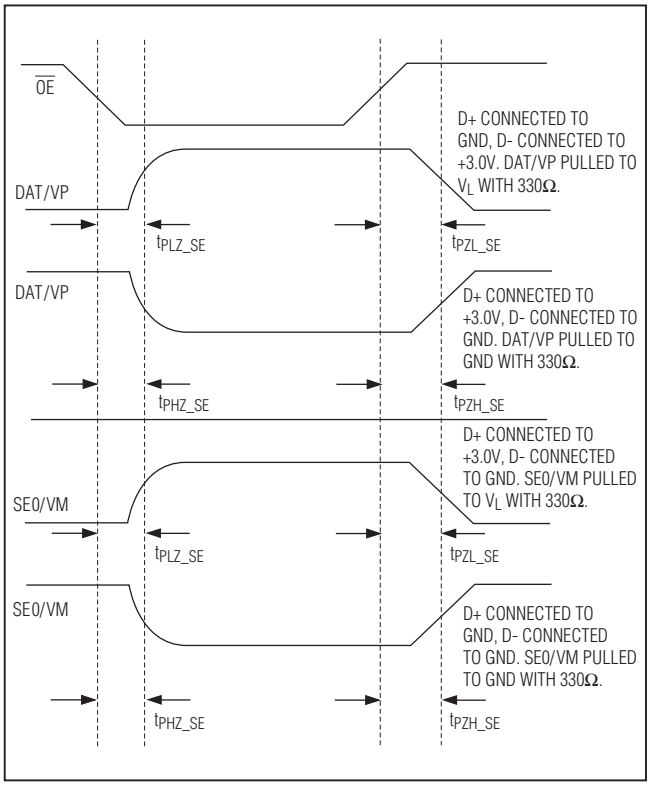


Figure 5. Receiver Enable and Disable Timing

Industry's Smallest and Lowest (V_L) Full-Speed USB Transceivers, with Low VIO 3/5-Wire Interface

Timing Diagrams (continued)

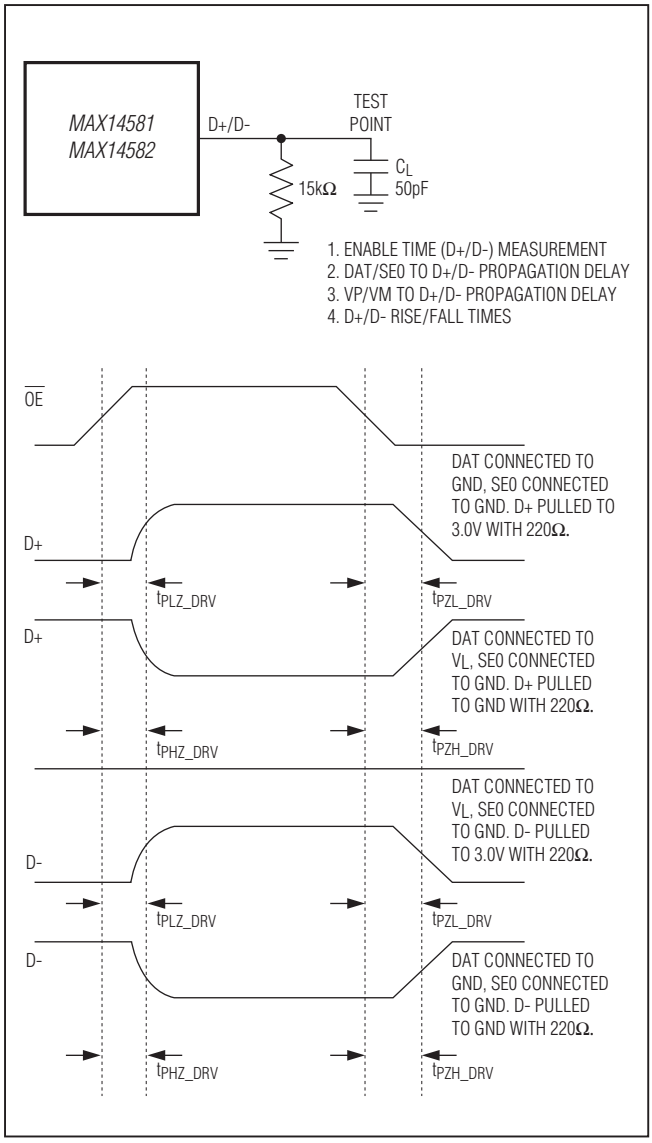


Figure 6. Test Circuit for Enable Time, Disable Time, Transmitter Propagation Delay, and Transmitter Rise/Fall Time

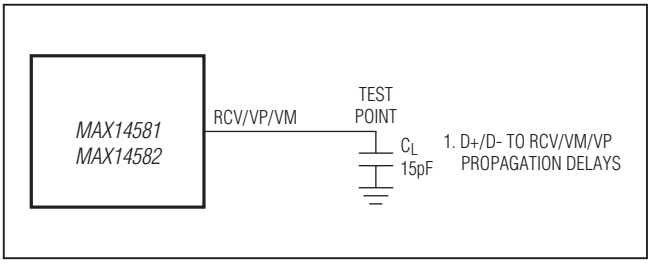


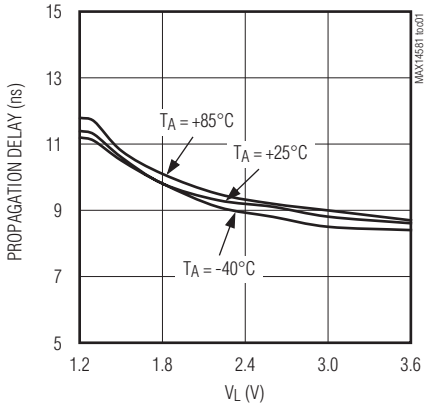
Figure 7. Test Circuit for Receiver Propagation Delay

Industry's Smallest and Lowest (V_L) Full-Speed USB Transceivers, with Low VIO 3/5-Wire Interface

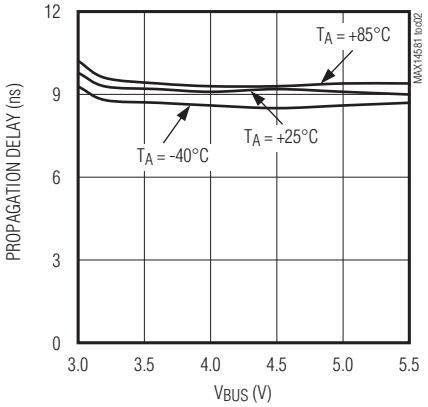
Typical Operating Characteristics

(V_{BUS} = +3.6V, V_L = +2.5V, T_A = +25°C, unless otherwise noted.)

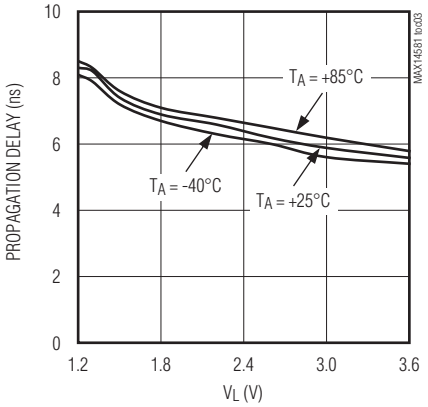
DIFFERENTIAL RECEIVER PROPAGATION DELAY vs. V_L



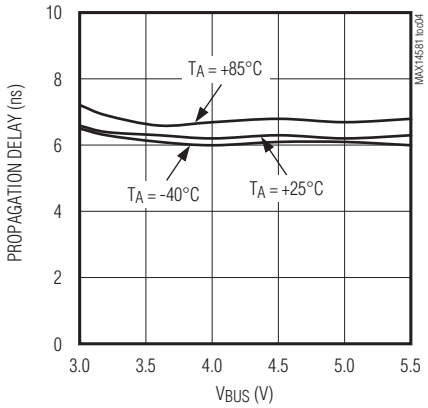
DIFFERENTIAL RECEIVER PROPAGATION DELAY vs. V_{BUS}



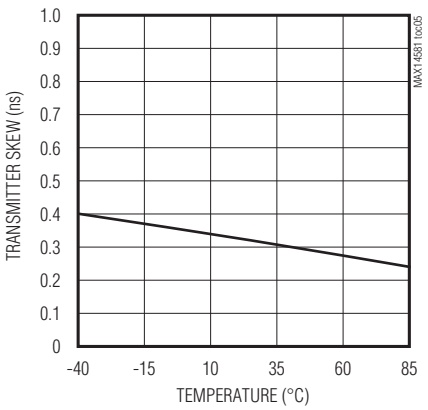
SINGLE-ENDED RECEIVER PROPAGATION DELAY vs. V_L



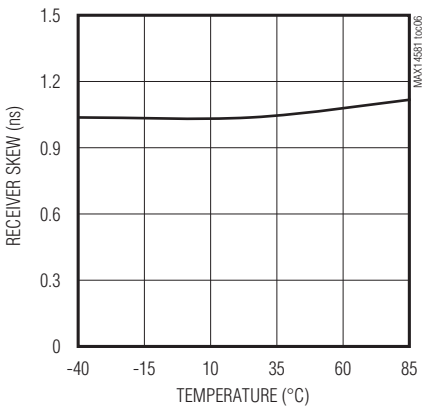
SINGLE-ENDED RECEIVER PROPAGATION DELAY vs. V_{BUS}



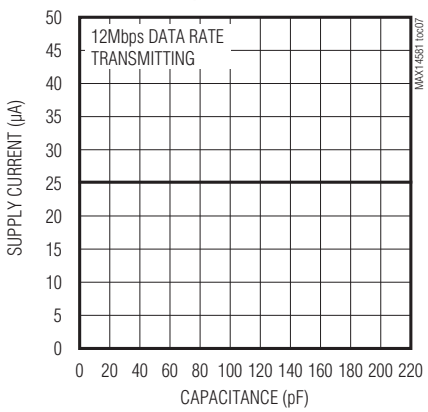
TRANSMITTER SKEW vs. TEMPERATURE



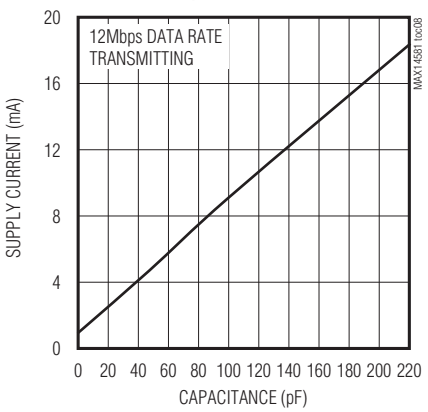
RECEIVER SKEW vs. TEMPERATURE



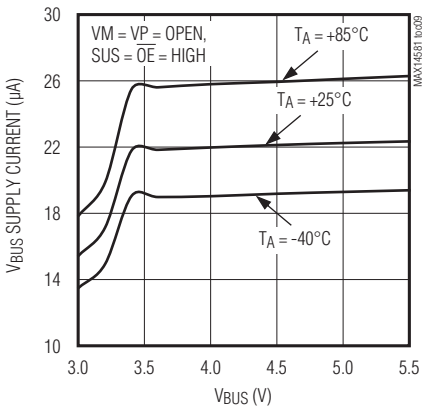
V_L SUPPLY CURRENT vs. D+/D- CAPACITANCE



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



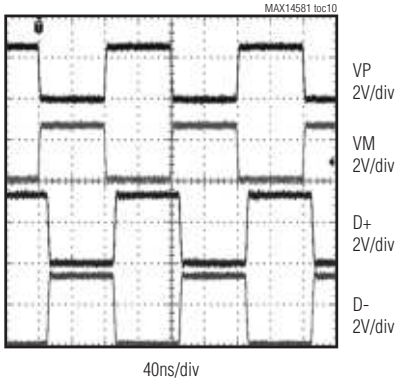
V_{BUS} SUSPEND CURRENT vs. V_{BUS} SUPPLY VOLTAGE



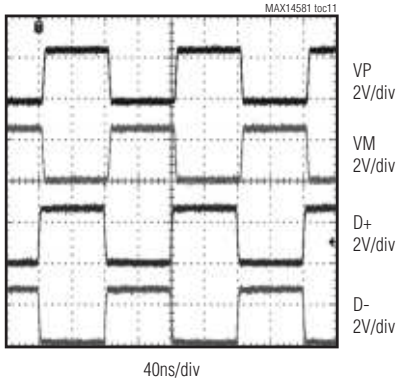
Typical Operating Characteristics (continued)

(V_{BUS} = +3.6V, V_L = +2.5V, T_A = +25°C, unless otherwise noted.)

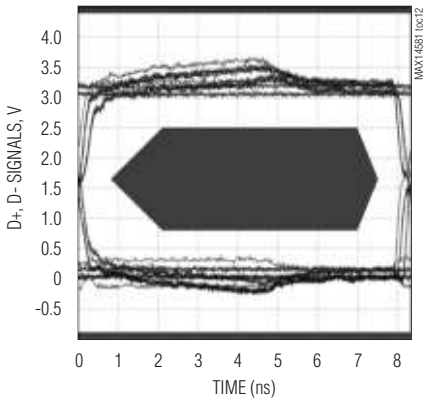
MAX14582 TRANSMITTTING



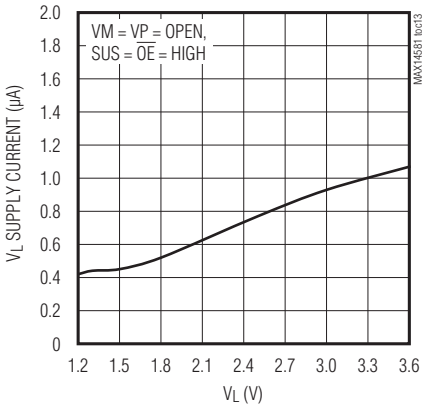
MAX14582 RECEIVING



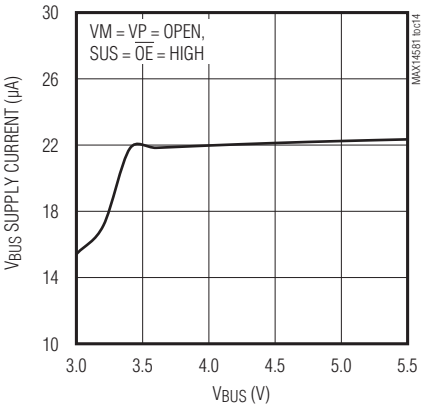
EYE DIAGRAM



LOGIC CURRENT CONSUMPTION IN SUSUPEND MODE

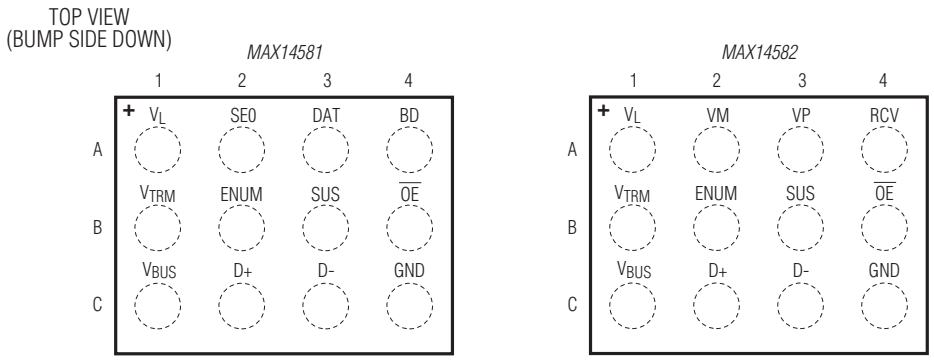


V_{BUS} CURRENT CONSUMPTION IN SUSUPEND MODE



Industry's Smallest and Lowest (V_L) Full-Speed USB Transceivers, with Low VIO 3/5-Wire Interface

Bump Configurations



Bump Description

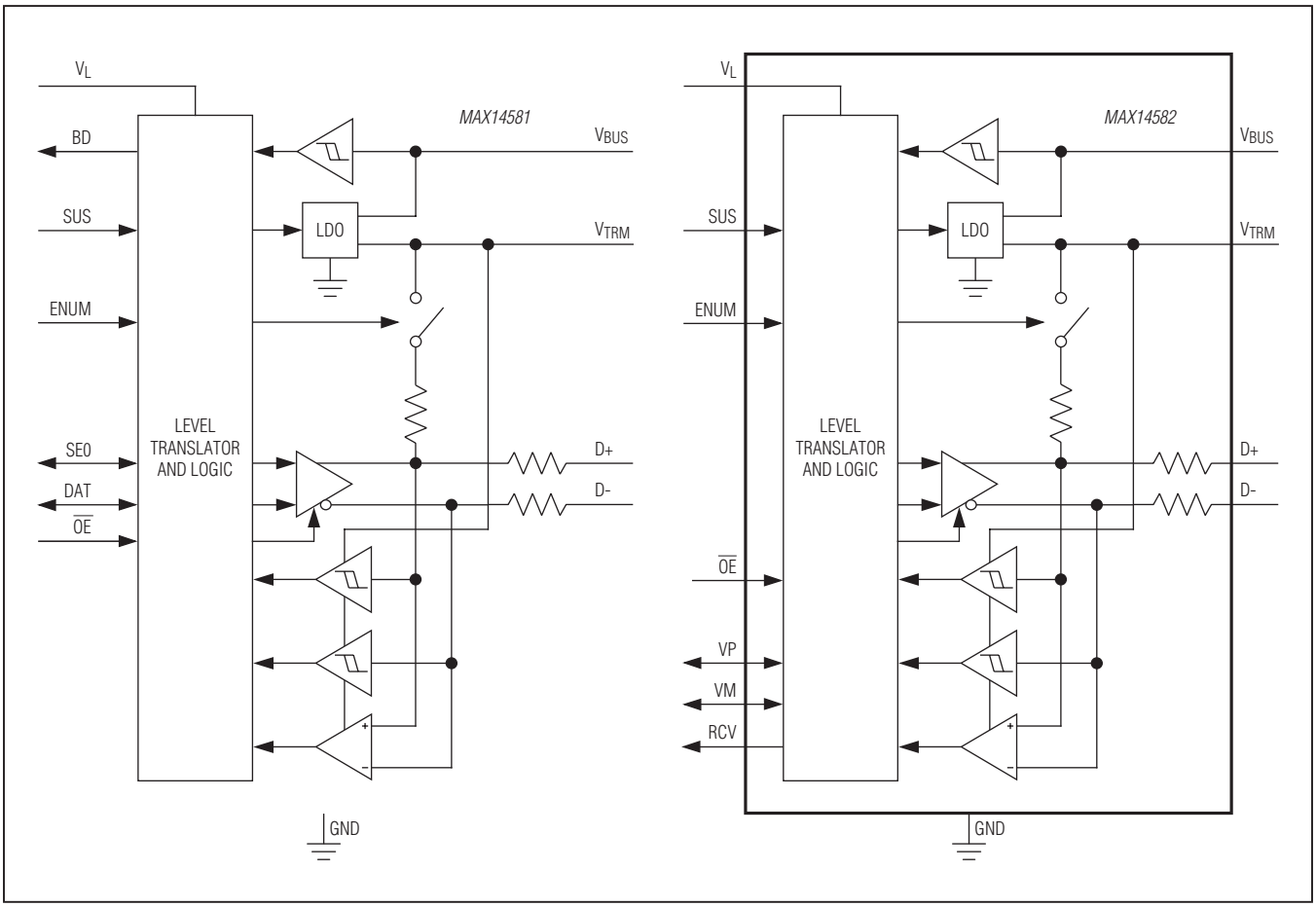
BUMP	NAME		FUNCTION
	MAX14581	MAX14582	
A1	V_L	V_L	Digital I/O Connections Logic Supply. V_L sets the logic level for the interface signal. A +1.2V to +3.6V supply is connected to V_L. Bypass V_L to GND with a 0.1µF ceramic capacitor.
A2	SE0	—	Logic Side Data Input/Output. This pin is an input when $\overline{OE}$ is low and an output when $\overline{OE}$ is high. As an input, SE0 is used to output a single-ended zero (SE0) on D+/D- (when active-high). D+ and D- are both driven low. As an output, SE0 goes active-high when both D+ and D- are low regardless of the status of SUS. (See Tables 3, 4a, and 4b.)
A3	DAT	—	Logic Side Data Input/Output. This pin is an input when $\overline{OE}$ is low and an output when $\overline{OE}$ is high. As an input, DAT acts as the data for the D+ and D- outputs. As an output DAT is the output of the differential receiver on D+/D- (SUS = 0) or the output of the D+ single-ended comparator if SUS = $\overline{OE}$ = V_L. (See Tables 3, 4a, and 4b.)
A4	BD	—	V_{BUS} Detect. This output goes active-high when V_{BUS} is present.
B1	V_{TRM}	V_{TRM}	Internal Regulator Output. V_{TRM} provides a regulated +3.3V output. Bypass V_{TRM} to GND with a 1µF (min) ceramic capacitor as close as possible to the device. V_{TRM} normally derives power from V_{BUS}. Alternatively, both V_{BUS} and V_{TRM} can be driven directly with the same +3.3V ±10% voltage supply. **Note:** In this case V_{BUS} and V_{TRM} must be connected to the same supply. V_{TRM} provides power to internal circuitry only. It can also be used to power an external pullup resistor, if the application calls for the internal pullup to be disabled. It should not be used to power external circuitry.
B2	ENUM	ENUM	Enumerate. ENUM controls the connection of the D+ pullup resistor. When ENUM is low, the pullup is disconnected. When ENUM is high, the pullup is connected to D+.

Bump Description (continued)

BUMP	NAME		FUNCTION
	MAX14581	MAX14582	
B3	SUS	SUS	Suspend. When SUS is low, the transceiver operates normally. When SUS is active-high, the transceiver enters a low-power state. The differential receiver on D+/D- is powered down, and RCV outputs low.
B4	$\overline{OE}$	$\overline{OE}$	Output Enable. $\overline{OE}$ controls the USB transmitter outputs (D+, D-) and the interface signals VP/VM or DAT/SE0. When $\overline{OE}$ is high, the interface signals are outputs and D+/D- are inputs. When $\overline{OE}$ is low, the interface signals are inputs and D+/D- are outputs.
C1	V_{BUS}	V_{BUS}	USB Power-Supply Input. V_{BUS} is typically sourced from the USB connector or to the battery for USB inter-chip applications. V_{BUS} should be a supply in the +3.0V to +5.5V range. V_{BUS} provides power to the internal linear regulator. Bypass V_{BUS} to GND with a 1µF ceramic capacitor as close as possible to the device.
C2	D+	D+	USB Input/Output. When $\overline{OE}$ is low, D+ functions as a USB output. When $\overline{OE}$ is high, D+ functions as a USB input. A 1.5kΩ resistor is connected between D+ and V_{TRM} to indicate full-speed (12Mbps) operation when ENUM is high.
C3	D-	D-	USB Input/Output. When $\overline{OE}$ is low, D- functions as a USB output. When $\overline{OE}$ is high, D- functions as a USB input.
C4	GND	GND	Ground
A2	—	VM	Logic Side Data Input/Output. This pin is an input when $\overline{OE}$ is low and an output when $\overline{OE}$ is high. As an input, VM controls the D- output. As an output, VM is the output of the single-ended receiver on D-. VM is output high when V_{BUS} is not present. (See Tables 5 and 6.)
A3	—	VP	Logic Side Data Input/Output. This pin is an input when $\overline{OE}$ is low and an output when $\overline{OE}$ is high. As an input, VP controls the D+ output. As an output, VP is the output of the single-ended receiver on D+. VP is output high when V_{BUS} is not present. (See Tables 5 and 6.)
A4	—	RCV	Differential Receiver Output. RCV responds to the differential input on D+ and D-. (See Table 6.) RCV asserts low if SUS = V_L.

Industry's Smallest and Lowest (V_L) Full-Speed USB Transceivers, with Low VIO 3/5-Wire Interface

Functional Diagrams



Detailed Description

The MAX14581/MAX14582 USB-compliant transceivers are designed to minimize the area and external components required to interface low-voltage ASICs to USB. These devices comply with USB 2.0 specifications for full-speed-only (12Mbps) operation. The transceivers include an internal 3.3V regulator, an internal 1.5kΩ D+ pullup resistor, and built-in ±15kV ESD protection circuitry to protect the USB I/O ports (D+, D-). The MAX14581/MAX14582 also have internal series resistors, allowing these devices to be wired directly to a USB connector.

These devices operate with logic-supply voltages as low as +1.2V, ensuring compatibility with low-voltage ASICs. A low-power disable mode reduces current consumption to less than 13µA (typ). An enumerate function controls the D+ pullup resistor, allowing devices to logically disconnect while remaining plugged in.

The ICs have 36Ω (typ) internal resistors on D+/D- for direct connection to the USB connector.

The MAX14581 is equipped with DAT and SE0 interface signals and supports 3-wire USB transceiver interface. Although the 3-wire interface is commonly associated with USB on-the-go transceivers, the MAX14581 supports USB peripherals only. These transceivers provide a USB V_{BUS} detection function that monitors the presence of USB V_{BUS} and signals the event.

Interface

The MAX14581/MAX14582 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 MAX14581 are DAT, SE0, and $\overline{OE}$. The control signals for the MAX14582 are VP, VM, RCV, 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 +3.0V to +5.5V supply. Connect V_L to a +1.2V 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 ICs can be powered by connecting both V_{BUS} and V_{TRM} to the same 3.3V external regulator.

V_{BUS} can also be connected directly to a Li+ battery for inter-chip communications, when the transceiver is used for example as the USB analog front-end (AFE) of the 3G modem, used to communicate with the system-on-chip (SOC).

Suspend Mode

Operate the transceivers in low-power mode by asserting SUS high. In suspend mode, the USB differential receiver is turned off and V_{BUS} consumes less than 18µA 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 three-stated, allowing other circuitry to share the USB D+ and D- line. V_L consumes less than 1µA of supply current. When operating the transceivers in sharing mode, the SUS and $\overline{OE}$ inputs are ignored, and the interface signals (SE0, DAT, or RCV) 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 three-stated, and V_{BUS} and/or V_{TRM} (or V_{BUS} and V_{TRM}) consume less than 13µA (typ). When operating the transceivers in disable mode, OE, SUS, and inputs to the interface control signals are according to Table 2a and Table 2b.

Table 1. Power-Supply Configuration

V_{BUS} (V)	V_{TRM} (V)	V_L (V)	CONFIGURATION	NOTES
+3.0V to +5.5	+3.0 to +3.6 output	+1.2 to +3.6V	Normal mode	—
+3.0V to +5.5	+3.0 to +3.6 output	GND or unconnected	Disable mode	Tables 2a, 2b
GND or unconnected	High impedance	+1.2 to +3.6V	Sharing mode	Tables 2a, 2b

Table 2a. Disable Mode and Sharing Mode Connection, 3-Wire Interface

INPUTS/OUTPUTS	DISABLE MODE	SHARING MODE
V_{BUS}	3.0V to 5.5V	Unconnected or connected to GND
V_L	Unconnected or connected to GND	1.2V to 3.6V input
D+ and D-	High impedance	High impedance
DAT, SE0	High impedance	5kΩ pullup resistor to V_L
SUS	Unconnected or connected to GND	High or low
$\overline{OE}$	Unconnected or connected to GND	High or low
BD	Low	Low

Table 2b. Disable Mode and Sharing Mode Connection, 5-Wire Interface

INPUTS/OUTPUTS	DISABLE MODE	SHARING MODE
V_{BUS}	3.0V to 5.5V	Unconnected or connected to GND
V_L	Unconnected or connected to GND	1.2V to 3.6V input
D+ and D-	High impedance	High impedance
SUS	Unconnected or connected to GND	High or low
$\overline{OE}$	Unconnected or connected to GND	High or low
VM, VP	High impedance	5kΩ pullup resistor to V_L
RCV	Low	Low

3-Wire Interface

The MAX14581 uses 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- if SUS = 0 or the putput of the D+ single-ended comparator if SUS = $\overline{OE}$ = V_L. SE0 only goes active-high when both D+ and D- are low.

5-Wire Interface

In USB mode, the MAX14582 implements a full-speed (12Mbps) USB interface on D+ and D-, with enumerate and suspend functions. A differential USB receiver presents the USB state as a logic-level output RCV (Table 6). VP/VM are outputs of single-ended USB receivers when $\overline{OE}$ is high, allowing detection of single-ended zero (SE0) events. When $\overline{OE}$ is low, VP and VM serve as inputs to the USB transmitter. Drive suspend input SUS logic-high to force the MAX14581/MAX14582 into a suspend mode and disable the differential USB receiver (Table 6).

Control Signals

USB Detection (MAX14581)

The MAX14581 USB detection function indicates that V_{BUS} is present. The MAX14581 push-pull bus detection output (BD) monitors V_{BUS}, and asserts high when V_{BUS} and V_L are present. BD asserts low if V_{BUS} is less than V_{TH_VBUS} and enters sharing mode.

$\overline{OE}$

$\overline{OE}$ controls the direction of communication when V_L and V_{BUS} are both present.

For the MAX14581 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.

For the MAX14582 when $\overline{OE}$ is logic-low, VP and VM operate as logic inputs, and D+/D- are outputs. When $\overline{OE}$ is logic-high, VP and VM operate as logic outputs, and D+/D are inputs. RCV is the output of the differential USB receiver connected to D+/D-, and is not affected by the $\overline{OE}$ logic level.

SUS

SUS determines whether the MAX14581/MAX14582 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 18µA (typ) from V_{BUS} in suspend mode.

The devices 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_{TRM}. Drive ENUM low to disconnect the internal pullup resistor from D+ to V_{TRM}.

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.

V_{TRM}

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

RCV (MAX14582)

RCV is the output of the differential USB receiver. RCV is a logic-high for D+ high and D- low. RCV is a logic-low for D+ low and D- high. RCV retains the last valid logic state when D+ and D- are both low (SE0). RCV is driven logic-low when SUS is high. See Table 3, Table 4a, and Table 4b.

BD (MAX14581)

The V_{BUS} detect (BD) output is asserted high when a voltage greater than V_{TH-BUS} is presented on V_{BUS}. This is typically the case when the MAX14581 is connected to a powered USB. BD is low when V_{BUS} is unconnected.

The MAX14582 doesn't have the BD pin. Nevertheless, the status of V_{BUS} is provided by encoding VP and VM as follows: VP = VM = high.

Applications Information

External Capacitors

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

USB Data Transfer

Transmitting Data, 3 Wires (MAX14581)

The MAX14581 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, 3 Wires (MAX14581)

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

Table 3. Transmit Truth Table, 3 Wires

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

Table 4a. Receive Truth Table, 3 Wires, SUS = 0

($\overline{OE}$ = 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

Table 4b. Receive Truth Table, 3 Wires, SUS = 1

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

**D+ single-ended receiver output.*

Transmitting Data, 5 Wires

To transmit data to the USB, operate the MAX14582 in USB mode (see the *Power-Supply Configuration* section) and drive $\overline{OE}$ low. The MAX14582 transmits data to the USB differentially on D+ and D-. VP and VM serve as differential input signals to the driver. When VP and VM are both driven low, a single-ended zero (SE0) is output on D+/D-.

Receiving Data, 5 Wires

To receive data from the USB, operate the MAX14582 in USB mode (see the *Power-Supply Configuration* section). Drive $\overline{OE}$ high and SUS low. Differential data received at D+/D- appears as a logic signal at RCV. VP and VM are the outputs of single-ended receivers on D+ and D-.

Host Usage

As a host USB transceiver, the MAX14581/MAX14582 require external 15kΩ pulldown resistors and connecting ENUM = low.

ESD Protection

The MAX14581/MAX14582 feature ±15kV (HBM) ESD protection on D+ and D-. The ESD structures withstand high ESD in all states: normal operation, suspend, sharing mode, disable mode, and powered down. V_{BUS} (with a 1µF ceramic capacitor) and D+/D- are characterized for protection to the following limits:

- ±15kV using the Human Body Model

Table 5. Transmit Truth Table, 5 Wires

($\overline{OE}$ = 0)			
INPUTS		OUTPUTS	
VP	VM	D+	D-
0	0	0	0
0	1	0	1
1	0	1	0
1	1	1	1

Table 6. Receive Truth Table, 5 Wires

($\overline{OE}$ = 1)					
INPUTS		OUTPUTS			
D+	D-	VP	VM	RCV (SUS = 0)	RCV (SUS = 1)
0	0	0	0	*RCV	0
0	1	0	1	0	0
1	0	1	0	1	0
1	1	1	1	X	0

Note: *The SE1 condition (D+ = D- = 1) is a forbidden condition in the USB protocol.*
**Last state.*
X = Undefined.

Industry's Smallest and Lowest (V_L) Full-Speed USB Transceivers, with Low VIO 3/5-Wire Interface

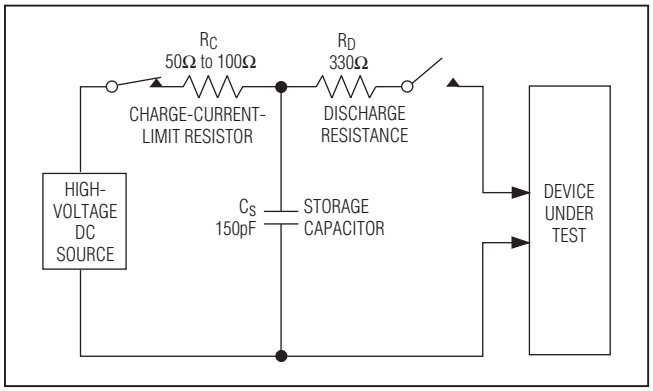


Figure 8. Human Body ESD Test Model

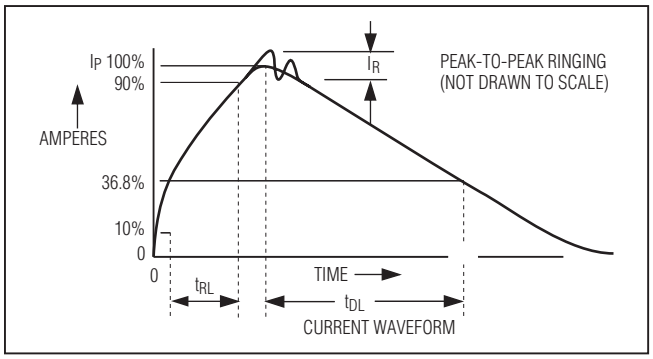


Figure 9. Human Body Model Current Waveform

ESD Test Conditions

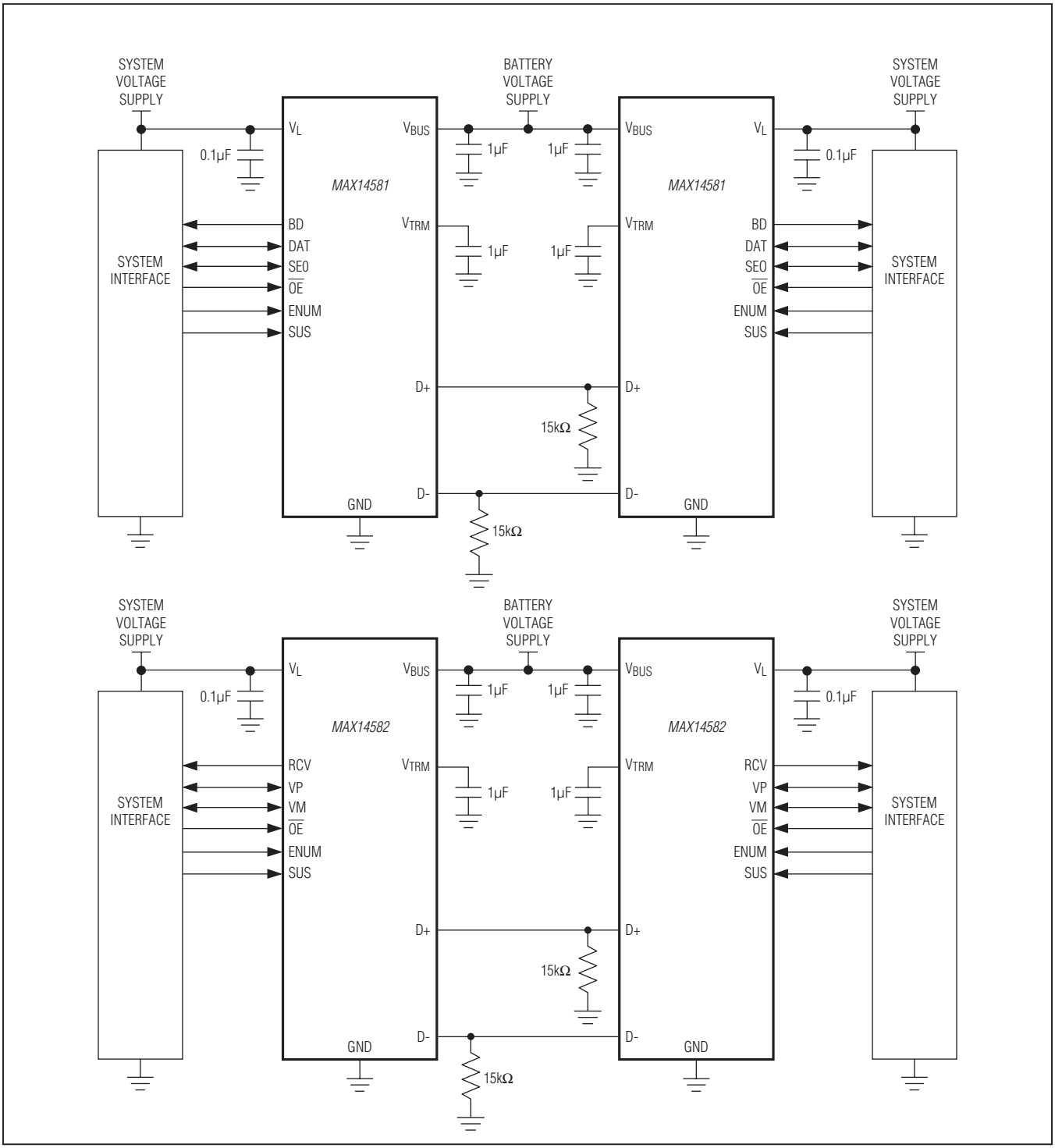
ESD performance depends on a variety of conditions. Contact Maxim for a reliability report that documents test setup, test methodology, and test results.

HBM ESD Protection

Figure 8 shows the Human Body Model, and Figure 9 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.

Industry's Smallest and Lowest (V_L) Full-Speed USB Transceivers, with Low VIO 3/5-Wire Interface

USB Inter-Chip Typical Application Circuits



Industry's Smallest and Lowest (V_L) Full-Speed USB Transceivers, with Low VIO 3/5-Wire Interface

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX14581EWC+T	-40°C to +85°C	12 WLP	ACF
MAX14582EWC+T	-40°C to +85°C	12 WLP	ACD

+Denotes a lead(Pb)-free/RoHS-compliant package.
T = Tape and reel.

Chip Information

PROCESS: BiCMOS

Package Information

For the latest package outline information and land patterns (footprints), go to **www.maxim-ic.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

PACKAGE TYPE	PACKAGE CODE	OUTLINE NO.	LAND PATTERN NO.
12 WLP	W121A1+1	**21-0449**	Refer to **Application Note 1891**

Industry's Smallest and Lowest (V_L) Full-Speed USB Transceivers, with Low VIO 3/5-Wire Interface

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	6/12	Initial release	—

Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time. The parametric values (min and max limits) shown in the Electrical Characteristics table are guaranteed. Other parametric values quoted in this data sheet are provided for guidance.

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