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MAX14550E

USB Host Charger Identification Analog Switch

General Description

The MAX14550E is a USB Hi-Speed analog switch with a USB host charger (dedicated charger) identification circuit. The MAX14550E supports both the USB Battery Charging Specification Revision 1.0 and a set resistor bias for Apple®-compliant devices.

The MAX14550E features a high-performance Hi-Speed USB switch with low 4pF (typ) on-capacitance and low 4Ω (typ) on-resistance. In addition, the MAX14550E features two digital inputs (CB0 and CB1) to switch between pass-through and charger modes. The USB host charger identification circuit allows a host USB port to support USB chargers with shorted D+/D- detection and to provide support for Apple-compliant devices using a resistor bias. When an Apple-compliant device is attached to the port, the MAX14550E provides the voltage from the resistor-divider. The MAX14550E uses the internal or external resistor based on the voltage at RDP. If a USB Revision 1.0-compliant device is attached, the MAX14550E connects a short across DP and DM to allow correct charger detection. The MAX14550E auto-detection circuit can be disabled and either a DP/DM short or resistor network is chosen as the default.

The MAX14550E has enhanced high electrostatic discharge (ESD) protection on the DP and DM inputs up to ±15kV Human Body Model (HBM).

The MAX14550E is available in a 10-pin (3mm x 3mm) TDFN package and is specified over the -40°C to +85°C extended temperature range.

Features

- ◆ USB 2.0 Hi-Speed Switching
- ◆ Low 4.0pF On-Capacitance
- ◆ Low 4.0Ω On-Resistance
- ◆ Ultra-Low 0.1Ω On-Resistance Flatness
- ◆ +2.8V to +5.5V Supply Range
- ◆ Ultra-Low 7μA Supply Current
- ◆ Automatic USB Charger Identification Circuit
- ◆ Optional External Resistor-Divider with Auto Selection
- ◆ ±15kV High ESD HBM Protection on DP/DM
- ◆ 3mm x 3mm, 10-Pin TDFN Package

Applications

Laptops
Netbooks
Cell Phones

Ordering Information

| PART | TEMP RANGE | PIN-PACKAGE | TOP MARK |
|---------------|----------------|-------------|----------|
| MAX14550EETB+ | -40°C to +85°C | 10 TDFN-EP* | AWG |

+Denotes a lead(Pb)-free/RoHS-compliant package.

*EP = Exposed pad.

Typical Operating Circuit appears at end of data sheet.

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Maxim Integrated Products 1

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.

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MAX14550E

ABSOLUTE MAXIMUM RATINGS

| | | | |
|--|--------------|--------------------------------------|-----------------|
| V _{CC} , DP, DM, TDP, TDM, RDP, RDM, CB ₋ to GND | -0.3V to +6V | Operating Temperature Range | -40°C to +85°C |
| Continuous Current Into Any Terminal | ±30mA | Maximum Junction Temperature..... | +150°C |
| Continuous Power Dissipation (T _A = +70°C) 10-Pin TDFN (derate 24.4mW/°C above +70°C)..... | 1951mW | Storage Temperature Range..... | -65°C to +150°C |
| Thermal Resistance (Note 1) Junction-to-Ambient Thermal Resistance (θ _{JA})..... | 41°C/W | Soldering Temperature (Reflow) | 260°C |
| Junction-to-Case Thermal Resistance (θ _{JC})..... | 9°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.

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} = +2.8V to +5.5V, T_A = T_J = -40°C to +85°C, unless otherwise noted. Typical values are at V_{CC} = +3.3V, T_A = +25°C, unless otherwise noted.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|-----------------------------------|---|---|-----|-----------------|-------|
| Power-Supply Voltage | V _{CC} | | 2.8 | | 5.5 | V |
| Supply Current | I _{CC} | V _{CC} = 3.3V | VCB ₀ = V _{CB} = V _{CC} | 0.7 | 2 | μA |
| | | | VCB ₀ = 0V, V _{CB} = V _{CC} | 6.5 | 10 | |
| | | | External resistors used, VCB ₀ = V _{CB} = 0V or VCB ₀ = V _{CC} , V _{CB} = 0V | 7 | 12 | |
| | | | Internal resistors used, VCB ₀ = V _{CB} = 0V or VCB ₀ = V _{CC} , V _{CB} = 0V | 76 | 120 | |
| | | V _{CC} = 5.5V | VCB ₀ = V _{CB} = V _{CC} | 2.5 | 7 | |
| | | | VCB ₀ = 0V, V _{CB} = V _{CC} | 8.5 | 15 | |
| | | | External resistors used, VCB ₀ = V _{CB} = 0V or VCB ₀ = V _{CC} , V _{CB} = 0V | 9 | 16 | |
| | | | Internal resistors used, VCB ₀ = V _{CB} = 0V or VCB ₀ = V _{CC} , V _{CB} = 0V | 125 | 180 | |
| Supply Current Increase | ΔI _{CC} | 0V ≤ V _{CB₋} ≤ V _{IL} or V _{IH} ≤ V _{CB₋} ≤ V _{CC} | | | 2 | μA |
| Analog Signal Range | V _{DP} , V _{DM} | | 0 | | V _{CC} | V |
| ANALOG SWITCH | | | | | | |
| On-Resistance TDP/TDM Switch | R _{ONT} | 0V ≤ V _{DP/DM} ≤ V _{CC} , I _{DP} or I _{DM} = 10mA | | 4 | 6.5 | Ω |
| On-Resistance Match Between Channels TDP/TDM Switch | ΔR _{ONT} | V _{DP} = V _{DM} = 400mV, I _{DP} or I _{DM} = 10mA | | 0.1 | | Ω |

USB Host Charger Identification Analog Switch

ELECTRICAL CHARACTERISTICS (continued)

(VCC = +2.8V to +5.5V, TA = TJ = -40°C to +85°C, unless otherwise noted. Typical values are at VCC = +3.3V, TA = +25°C, unless otherwise noted.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|-------|-------|--------|-------|
| On-Resistance Flatness TDP/TDM Switch | R _{FLATT} | V _{DP} = V _{DM} , 0V ≤ V _{DP} ≤ V _{CC} , I _{DP} = I _{DM} = 10mA | | 0.1 | | Ω |
| On-Resistance RDP/RDM Switch | R _{ONR} | 0.4V ≤ V _{RDP/RDM} ≤ V _{CC} , I _{RDP} = I _{RDM} = 10mA | | 4 | 7.5 | Ω |
| On-Resistance Flatness RDP/RDM Switch | R _{FLATR} | V _{RDP} = V _{RDM} , 0.4V ≤ V _{RDP} ≤ V _{CC} , I _{RDP} = I _{RDM} = 10mA | | 0.1 | | Ω |
| On-Resistance of DP/DM Short | R _{SHORT} | V _{CB0} = 0V, V _{CB} = V _{CC} , V _{DP} = V _{DM} , 0V ≤ V _{DP} ≤ V _{CC} , I _{DP} = I _{DM} = 1mA | | 50 | 70 | Ω |
| TDP/TDM Off-Leakage Current | I _{TDPOFF} , I _{TDMOFF} | V _{CC} = 5.5V, V _{CB0} = V _{CC} , V _{CB} = 0V, V _{DP} = V _{DM} = 5.5V to 0V, V _{TDP} = V _{TDM} = 0V to 5.5V | -250 | | +250 | nA |
| DP/DM On-Leakage Current | I _{DPON} , I _{DMON} | V _{CC} = 5.5V, V _{CB0} = V _{CB} = V _{CC} , V _{DP} = V _{DM} = 5.5V to 0V | -250 | | +250 | nA |
| DYNAMIC PERFORMANCE | | | | | | |
| Turn-On Time | t _{ON} | V _{TDP} or V _{TDM} = 1.5V, R _L = 300Ω, C _L = 35pF, V _{IH} = V _{CC} , V _{IL} = 0V, Figure 1 | | 20 | 100 | μs |
| Turn-Off Time | t _{OFF} | V _{TDP} or V _{TDM} = 1.5V, R _L = 300Ω, C _L = 35pF, V _{IH} = V _{CC} , V _{IL} = 0V, Figure 1 | | 2.5 | 5 | μs |
| TDP/TDM Switch Propagation Delay | t _{PLH} , t _{PHL} | R _L = R _S = 50Ω | | 60 | | ps |
| Output Skew Between Switches | t _{SK(O)} | Skew between DP and DM when connected to TDP and TDM, R _L = R _S = 50Ω, Figure 2 | | 40 | | ps |
| TDP/TDM Off-Capacitance | C _{OFF} | f = 1MHz, V _{BIAS} = 0V, V _{SIGNAL} = 500mV _{P-P} (Note 3) | | 2.0 | | pF |
| DP/DM On-Capacitance (Connected to TD_) | C _{ON} | f = 240MHz, V _{BIAS} = 0V, V _{SIGNAL} = 500mV _{P-P} | | 4.0 | 5.5 | pF |
| -3dB Bandwidth | BW | R _L = R _S = 50Ω | | 1000 | | MHz |
| Off-Isolation | V _{ISO} | V _{TDP} , V _{DP} = 0dBm, R _L = R _S = 50Ω, f = 250MHz, Figure 3 | | -20 | | dB |
| Crosstalk | V _{CT} | V _{TDP} , V _{DP} = 0dBm, R _L = R _S = 50Ω, f = 250MHz, Figure 3 | | -25 | | dB |
| INTERNAL RESISTORS | | | | | | |
| DP/DM Short Pulldown | R _{PD} | | 350 | 500 | 700 | kΩ |
| RP1/RP2 Ratio | R _{TRP} | | 1.485 | 1.5 | 1.515 | Ratio |
| RP1 + RP2 Resistance | R _{RP} | | 93.75 | 125 | 156.25 | kΩ |
| RM1/RM2 Ratio | R _{TRM} | | 0.854 | 0.863 | 0.872 | Ratio |
| RM1 + RM2 Resistance | R _{RM} | | 69.75 | 93 | 116.25 | kΩ |

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ELECTRICAL CHARACTERISTICS (continued)

(VCC = +2.8V to +5.5V, TA = TJ = -40°C to +85°C, unless otherwise noted. Typical values are at VCC = +3.3V, TA = +25°C, unless otherwise noted.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---------------------------------------|-------------------|---|------|------|------|--------|
| COMPARATORS | | | | | | |
| DM Comparator Threshold | VDMF | VRDP > 0.4V, DM falling | 1.9 | 2.1 | 2.3 | V |
| | | VRDP < 0.3V, DM falling | 44 | 45 | 46 | %VCC |
| DP and RDP Comparator Threshold | V DPR | DP or RDP falling | 0.3 | 0.35 | 0.4 | V |
| DM Comparator Hysteresis | | | | 1 | | %VDMF |
| DP and RDP Comparator Hysteresis | | | | 1 | | %V DPR |
| DM Comparator Debounce Time | tDM | VDM from 2.8V to 1.5V | 30 | 100 | 200 | µs |
| DP Comparator Debounce Time | tDP | VDP from 0.7V to 0V | 30 | 100 | 200 | µs |
| DIGITAL I/O (CB0, CB1) | | | | | | |
| Input Logic Voltage High | V _{IH} | | 1.4 | | | V |
| Input Logic Voltage Low | V _{IL} | | | | 0.4 | V |
| Input Logic Hysteresis | V _{HYST} | | | 100 | | mV |
| Input Leakage Current | I _{IN} | VCC = 5.5V, 0V ≤ VCB ₋ ≤ V _{IL} or V _{IH} ≤ VCB ₋ ≤ VCC | -250 | | +250 | nA |
| ESD PROTECTION | | | | | | |
| All Pins | | Human Body Model | | ±2 | | kV |
| ESD Protection Level (DP and DM Only) | | Human Body Model | | ±15 | | kV |

Note 2: All devices are 100% production tested at TA = +25°C. Specifications over temperature are guaranteed by design.

Note 3: Guaranteed by design.

Test Circuits/Timing Diagrams

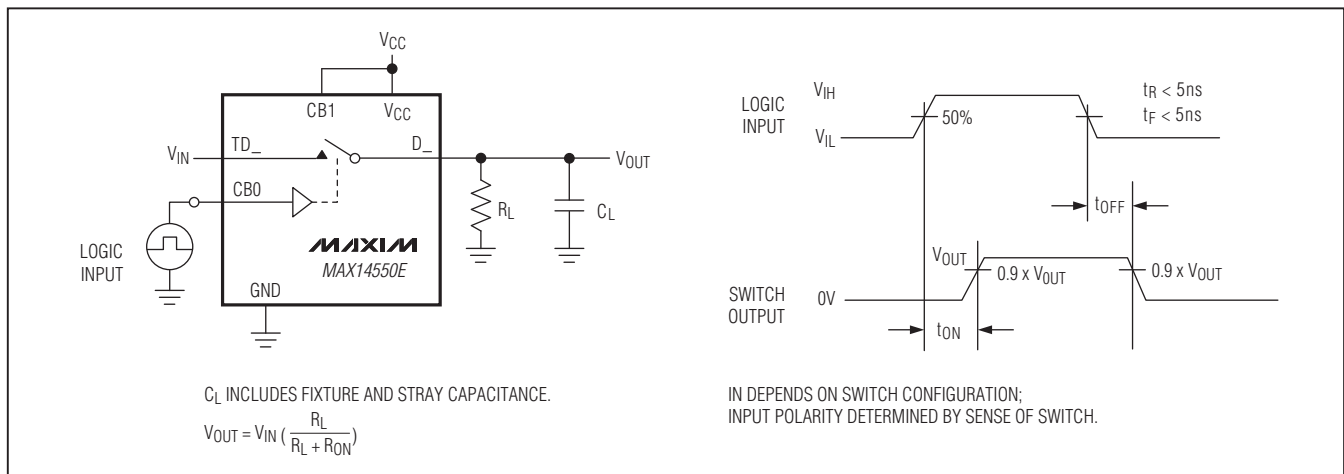


Figure 1. Switching Time

USB Host Charger Identification Analog Switch

Test Circuits/Timing Diagrams (continued)

MAX14550E

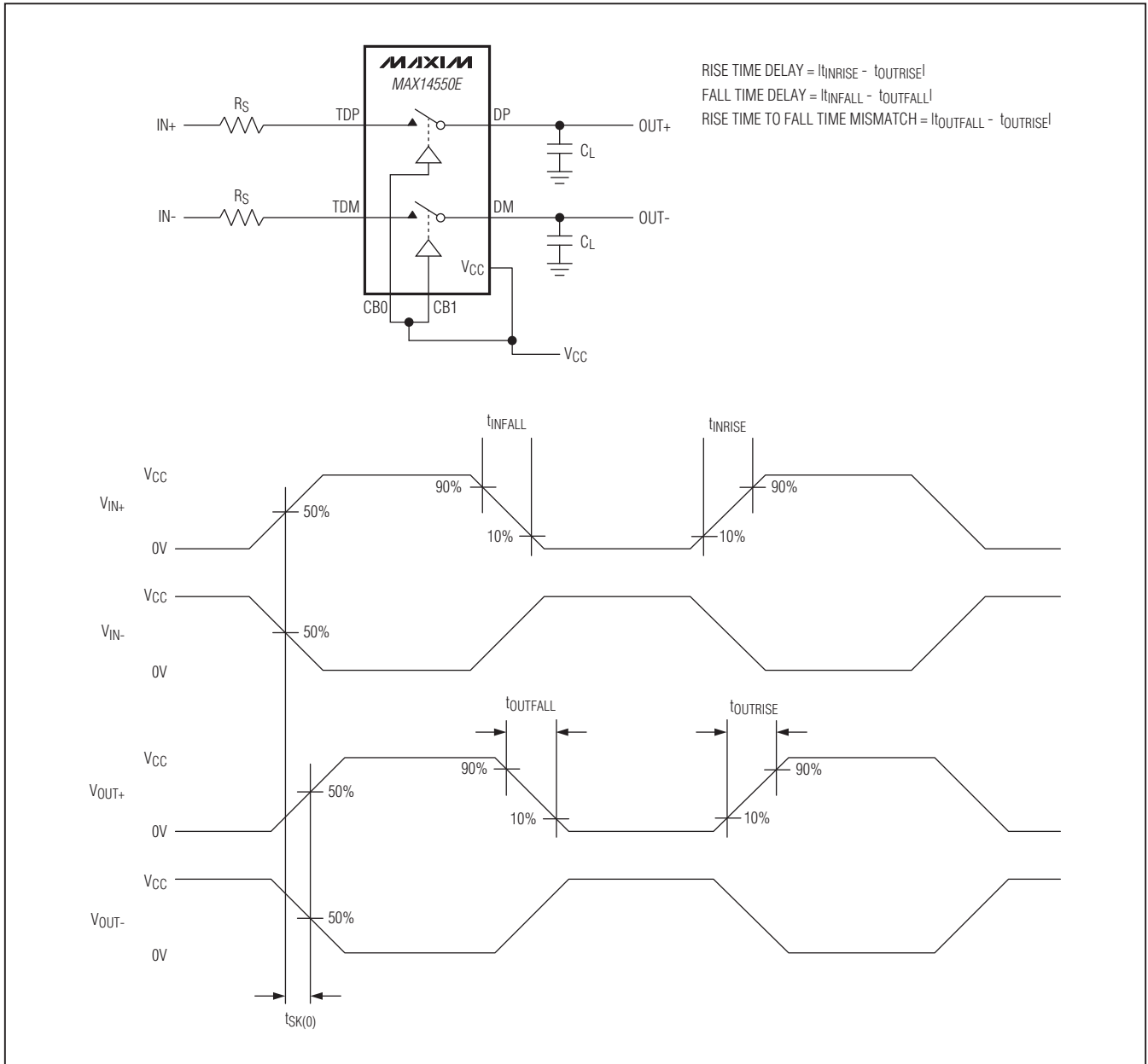


Figure 2. Output Signal Skew

USB Host Charger Identification Analog Switch

Test Circuits/Timing Diagrams (continued)

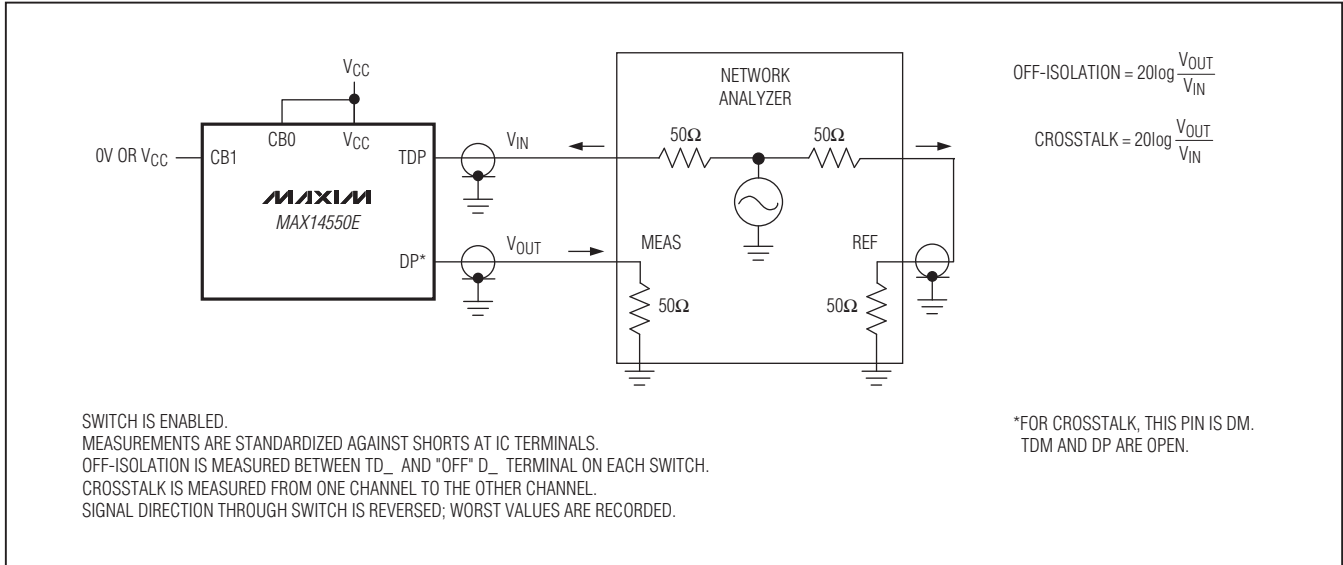
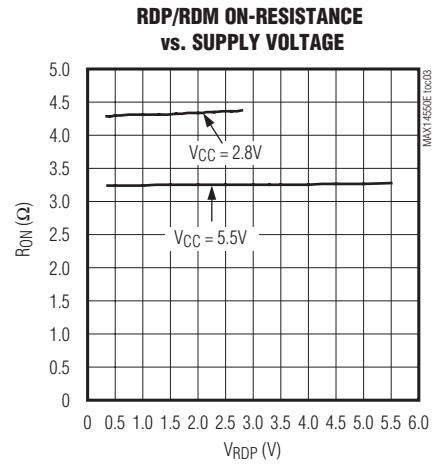
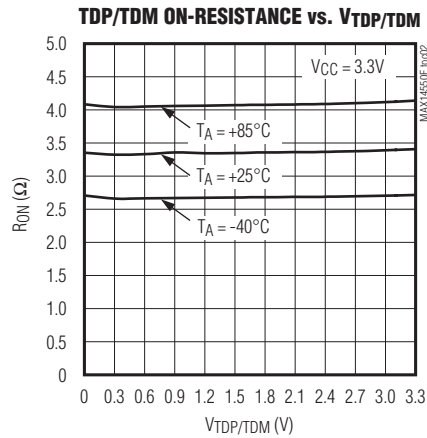
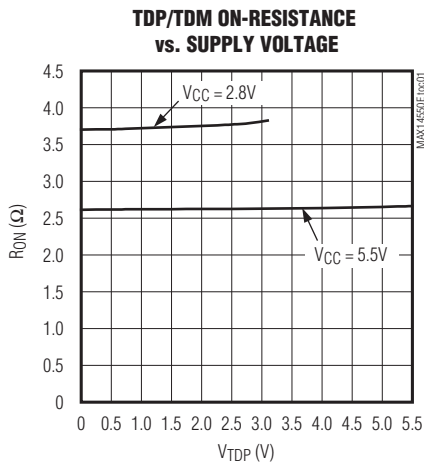


Figure 3. Off-Isolation and Crosstalk

Typical Operating Characteristics

(T_A = +25°C, unless otherwise noted.)

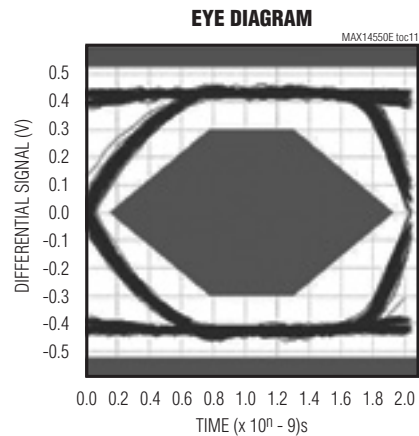
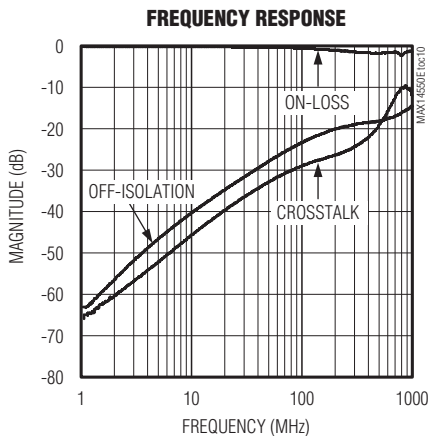
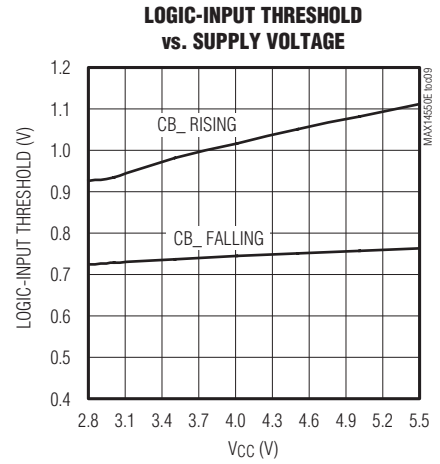
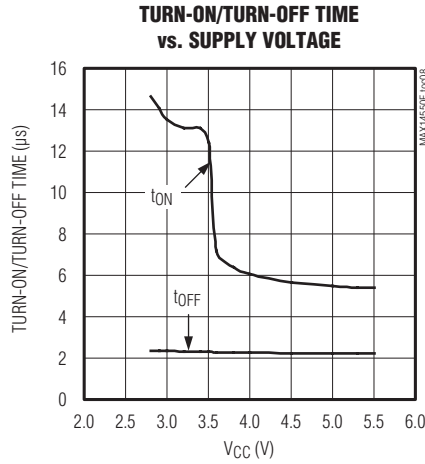
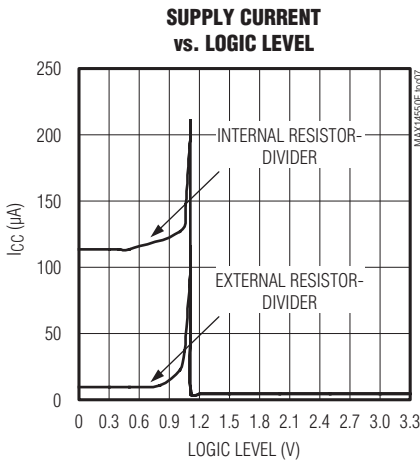
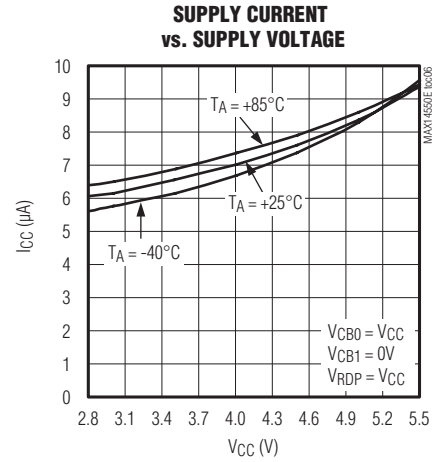
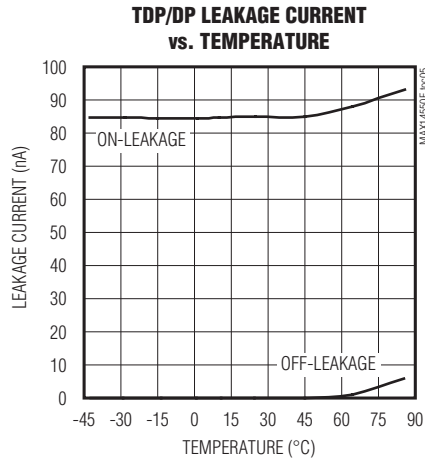
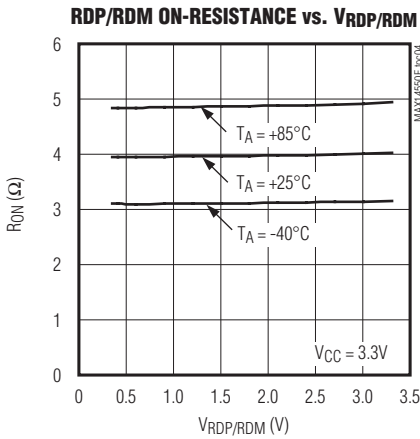


USB Host Charger Identification Analog Switch

Typical Operating Characteristics (continued)

($T_A = +25^\circ\text{C}$, unless otherwise noted.)

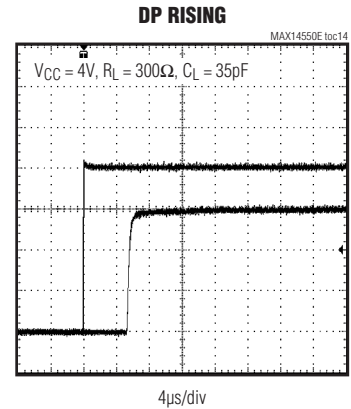
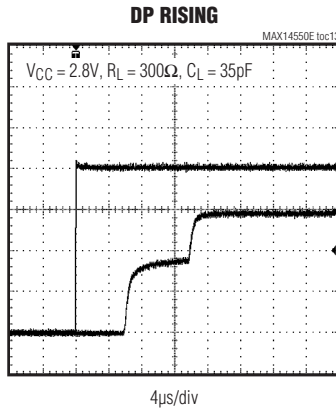
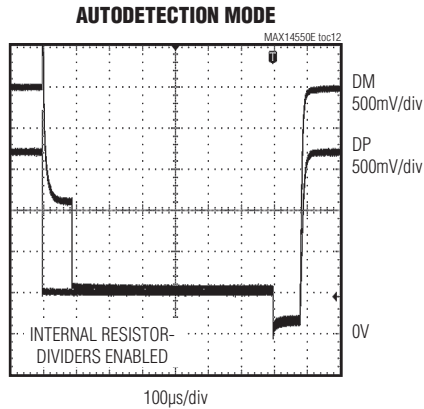
MAX14550E



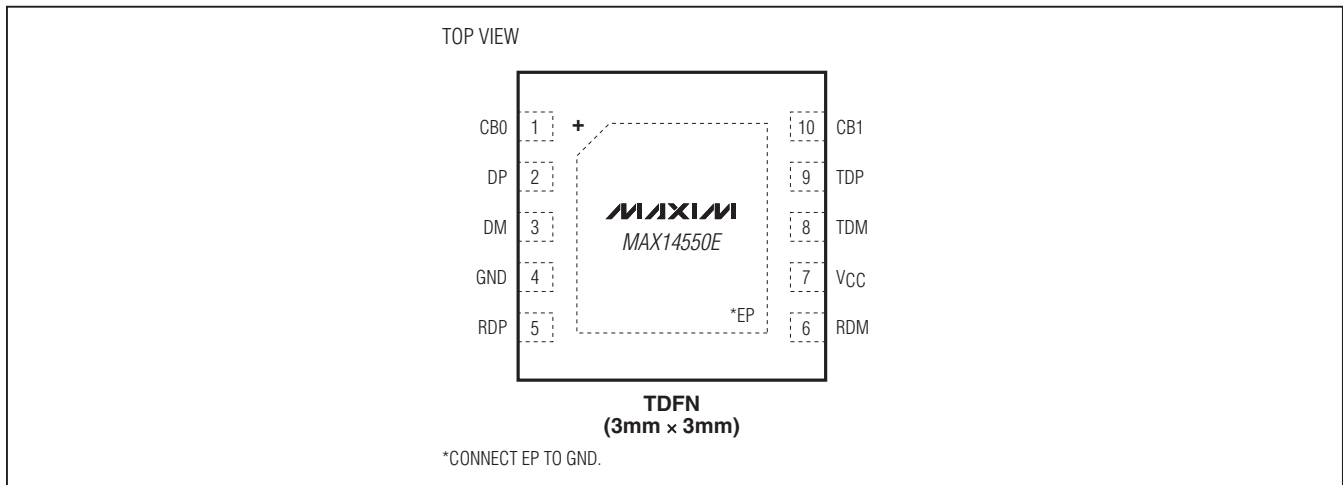
USB Host Charger Identification Analog Switch

Typical Operating Characteristics (continued)

(T_A = +25°C, unless otherwise noted.)



Pin Configuration



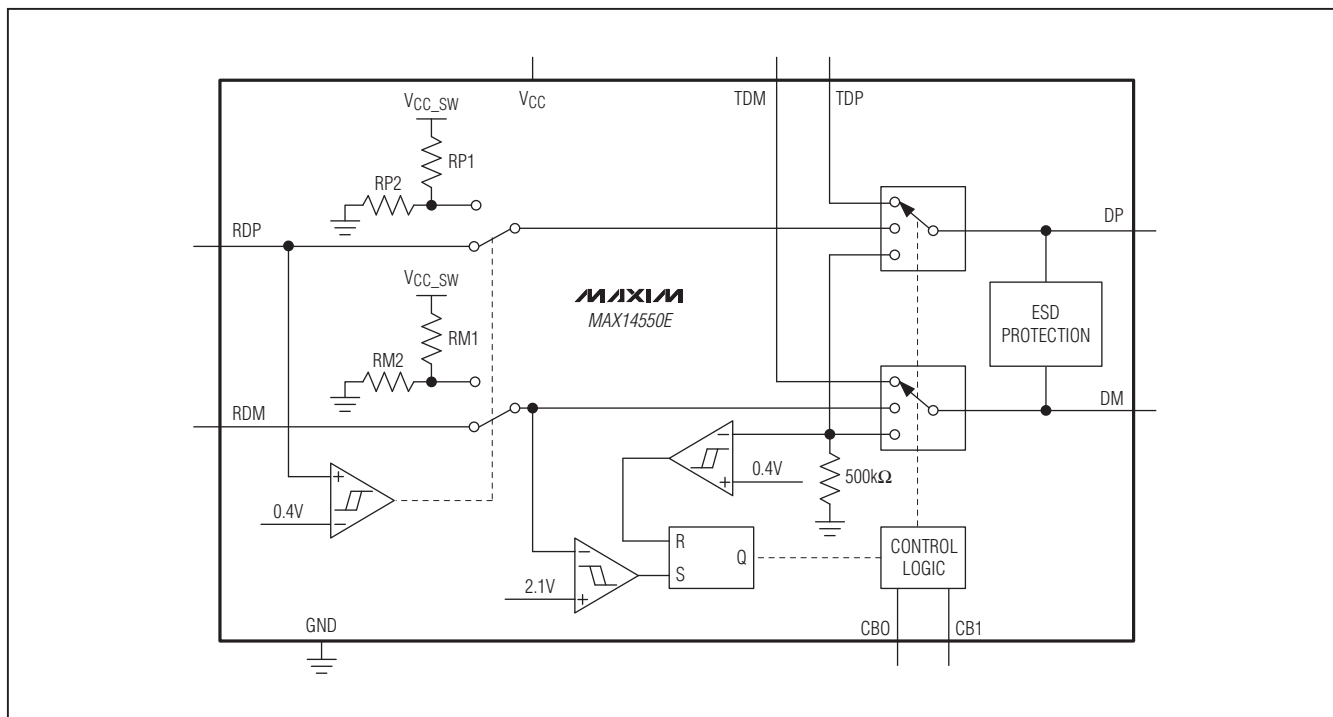
Pin Description

| PIN | NAME | FUNCTION |
|-----|------|--|
| 1 | CB0 | Switch Control Bit 0. See the <i>Switch Control</i> section. |
| 2 | DP | USB Connector D+ Connection |
| 3 | DM | USB Connector D- Connection |
| 4 | GND | Ground |
| 5 | RDP | External Resistor Bias Input for D+ and Selection for External Resistors in RDP and RDM |
| 6 | RDM | External Resistor Bias Input for D- |
| 7 | VCC | Power Supply. Bypass VCC to GND through a 0.1µF capacitor. Place the capacitor as close as possible to the device. |
| 8 | TDM | USB Transceiver D- Connection |
| 9 | TDP | USB Transceiver D+ Connection |
| 10 | CB1 | Switch Control Bit 1. See the <i>Switch Control</i> section. |
| — | EP | Exposed Pad. Connect EP to GND. Do not use EP as the main ground connection. |

USB Host Charger Identification Analog Switch

Functional Diagram

MAX14550E



Detailed Description

The MAX14550E is a combination of a Hi-Speed USB analog switch and a charger host identification detection analog switch, which allows USB hosts to identify the USB port as a charger port when the USB host is in a low-power mode and cannot enumerate USB devices. The MAX14550E features a high-performance, Hi-Speed USB switch with low 4pF on-capacitance and low 4Ω on-resistance. DP and DM can survive signals between 0V and 6V with any supply voltage.

Resistor-Dividers

The MAX14550E features an internal resistor-divider for biasing or can operate with external resistors. Connect RDP to ground to use the internal resistor-divider (see the *Typical Operating Circuit*). The user must provide 5V supply voltage to VCC when the internal resistor-divider is used. When the MAX14550E is not operated with the internal resistor-dividers, the device disconnects the internal resistor-dividers' pullup voltage (VCC_SW) to minimize supply current requirements.

Connect RDP to a voltage above 0.4V (max) to use external resistors (Figure 4). Internal resistor-dividers are always disconnected from the supply voltage when external resistor-dividers are detected at RDP (VRDP > 0.4V).

Switch Control

The MAX14550E features two digital inputs, CB0 and CB1, for mode selection (Table 1). Connect CB0 and CB1 to a logic-level low voltage for autodetection mode (see the *Autodetection* section).

Connect CB0 and CB1 to a logic-level high voltage for normal Hi-Speed USB bypass functionality.

Connect CB0 to a logic-level low and CB1 to a logic-level high voltage to select charger mode. Optionally, CB0 and CB1 can be forced to set the detection to a particular state. The USB Implementers Forum (USB-IF) has defined that dedicated chargers have D+ and D- shorted together. In USB charger mode, DP and DM are shorted together for dedicated charging functionality. Connect CB0 to a logic-level high and CB1 to a logic-level low voltage to force the resistor network to be connected to DP and DM.

USB Host Charger Identification Analog Switch

MAX14550E

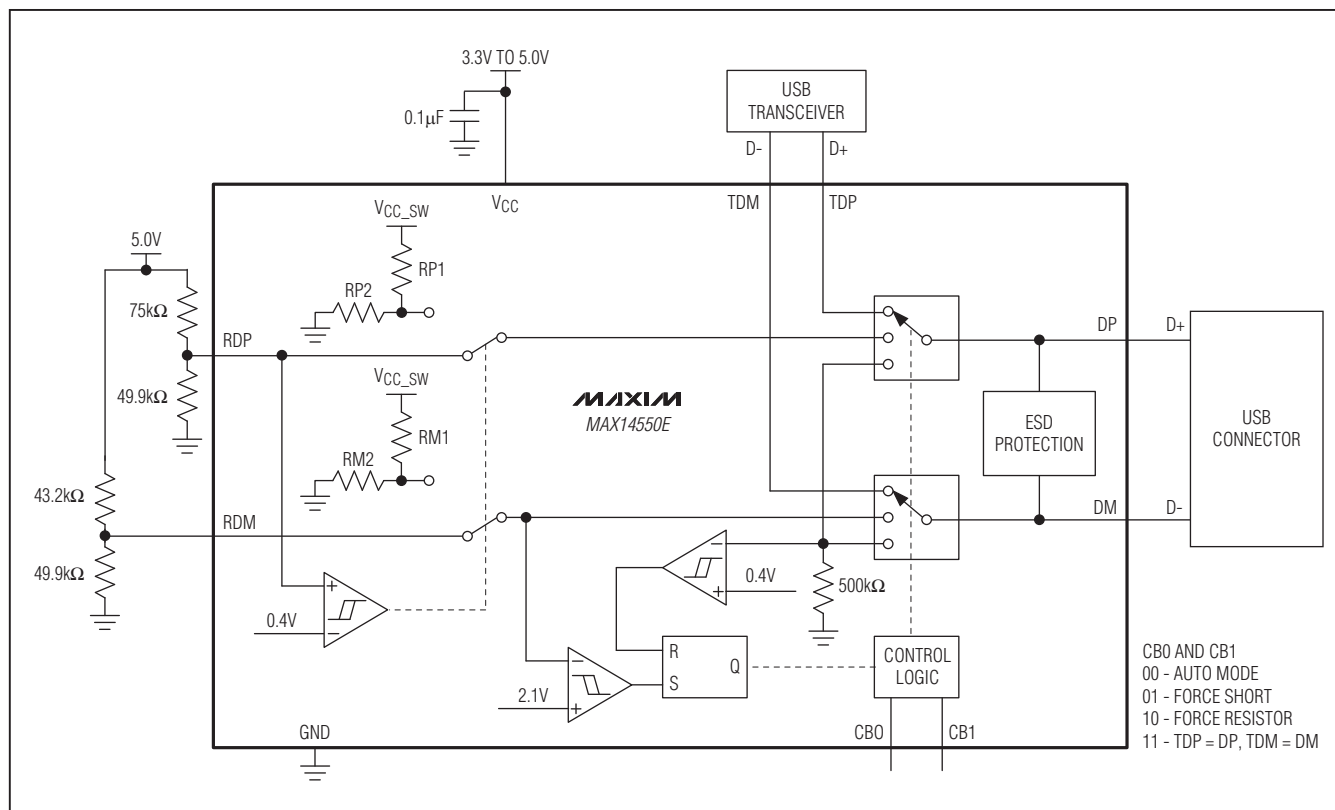


Figure 4. Operation with External Resistors

Autodetection

The MAX14550E features autodetection mode for dedicated chargers and USB masters. CB0 and CB1 must both be set low to activate autodetection mode.

In autodetection mode, the MAX14550E initially connects the resistor network to DP and DM. The MAX14550E monitors the voltage at DM to determine the type of device attached. If the voltage at DM is 2.1V (typ) or higher, the voltage stays as is.

If the voltage at DM is below the 2.1V (typ) threshold, the internal switch disconnects DP from the resistor network and DM. DP and DM are shorted together. The MAX14550E then monitors the voltage at DM to determine when to reconnect the resistor network. If the volt-

age at DM > 0.35V (typ), the short remains connected. If the voltage at DM drops below 0.35V (typ), the short is removed and the resistor network is reconnected to DP and DM.

DP and DM feature a 100 μ s (typ) debounce time to reject transients.

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.

The Air-Gap test involves approaching the device with a charged probe. The Contact-Discharge method connects the probe to the device before the probe is energized.

USB Host Charger Identification Analog Switch

MAX14550E

Table 1. Digital Input States

| V _{CC} (V) | RDP < 0.4V = INTERNAL RESISTOR > 0.4V = EXTERNAL RESISTOR | CB0 | CB1 | DP/DM POSITION | INTERNAL OR EXTERNAL RESISTOR CONNECTED TO DP/DM | COMMENT |
|------------------------|---|-----|-----|----------------------------------|--|-----------------------|
| 3.3 | RDP < 0.4V | X | X | — | — | Not recommended |
| 3.3 | RDP > 0.4V | 0 | 0 | Autodetection circuit active | External resistor | Auto mode |
| | | 0 | 1 | Shorted | Not connected | Auto mode disabled |
| | | 1 | 0 | Connected to resistor-divider | External resistor | Auto mode disabled |
| | | 1 | 1 | Connected to TDP/TDM | Not connected | USB traffic active |
| 5.0 | RDP < 0.4V | 0 | 0 | Autodetection circuit active | Internal resistor | Auto mode |
| | | 0 | 1 | Shorted | Not connected | Auto mode disabled |
| | | 1 | 0 | Connected to resistor-divider | Internal resistor | Auto mode disabled |
| | | 1 | 1 | Connected to TDP/TDM | Not connected | USB traffic active |
| | RDP > 0.4V | 0 | 0 | Autodetection circuit active | External resistor | Auto mode |
| | | 0 | 1 | Shorted | Not connected | Auto mode disabled |
| | | 1 | 0 | Connected to resistor-divider | External resistor | Auto mode disabled |
| | | 1 | 1 | Connected to TDP/TDM | Not connected | USB traffic active |

USB Host Charger Identification Analog Switch

Extended ESD Protection (Human Body Model)

ESD-protection structures are incorporated on all pins to protect against electrostatic discharges up to $\pm 2\text{kV}$ (Human Body Model) encountered during handling and assembly. DP and DM are further protected against ESD

up to $\pm 15\text{kV}$ (Human Body Model) without damage. The ESD structures withstand high ESD both in normal operation and when the device is powered down. After an ESD event, the device continues to function without latchup (Figures 5a and 5b).

Table 2. Tested Portable Device

| MANUFACTURER/ SPECIFICATION | DEVICE | IDENTIFICATION | DETECTION METHOD/COMMENTS | MAX14550E SUPPORT |
|--------------------------------|---------------------------|------------------------------------|---|---|
| Apple | iPod® and some iPhones® | None | Immediately draws 500mA when 5V is attached to VBUS | iPhone 2G, 3G, and 3GS; iPod classic®; iPod video; iPod touch (1st and 2nd generations); iPod nano® (3rd, 4th, 5th generation); and iPod mini |
| | iPod touch® and iPhone 3G | Resistor-divider on D+ and D- | USB FS/HS configuration: draws < 500mA D+/D- voltage detection: <1A | |
| Motorola | All phones with mini-USB | Resistor to GND on ID line | USB FS/HS configuration: draws < 500mA. Follows CEA-936-A specification, which is the only known company to use this specification. | Depends on model |
| RIM | BlackBerry® | Some models look for shorted D+/D- | USB FS/HS configuration: draws < 500mA. Some models look for shorted D+/D- with a pullup to 2.7V for dedicated charger. | Depends on model |
| HTC | QUALCOMM®-based phones | None | Immediately draws 500mA when 5V is attached to VBUS | Full support |
| USB-IF Standard | — | Shorted D+/D- | Device uses a specific method (voltages and timing well defined) | 2009 and newer LG and Samsung models with micro-USB connector |
| China Standard | — | Shorted D+/D- | Method not defined | Depends on model |

iPod, iPhone, iPod touch, iPod classic, and iPod nano are registered trademarks of Apple, Inc.

BlackBerry is a registered trademark/servicemark of Research In Motion Limited.

QUALCOMM is a registered trademark of QUALCOMM Incorporated.

USB Host Charger Identification Analog Switch

MAX14550E

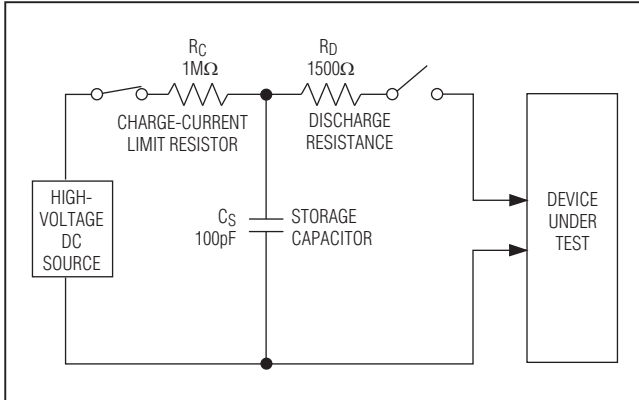


Figure 5a. Human Body ESD Test Model

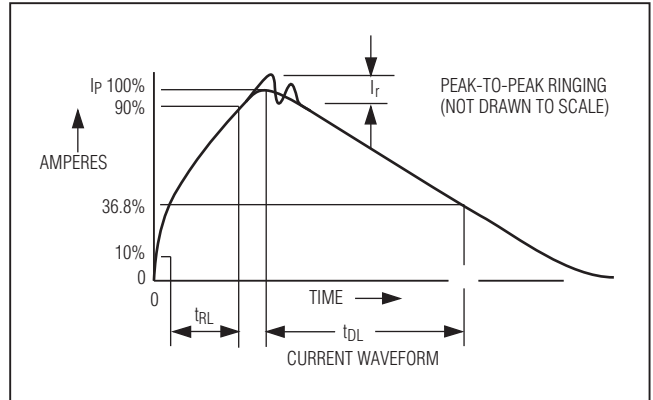
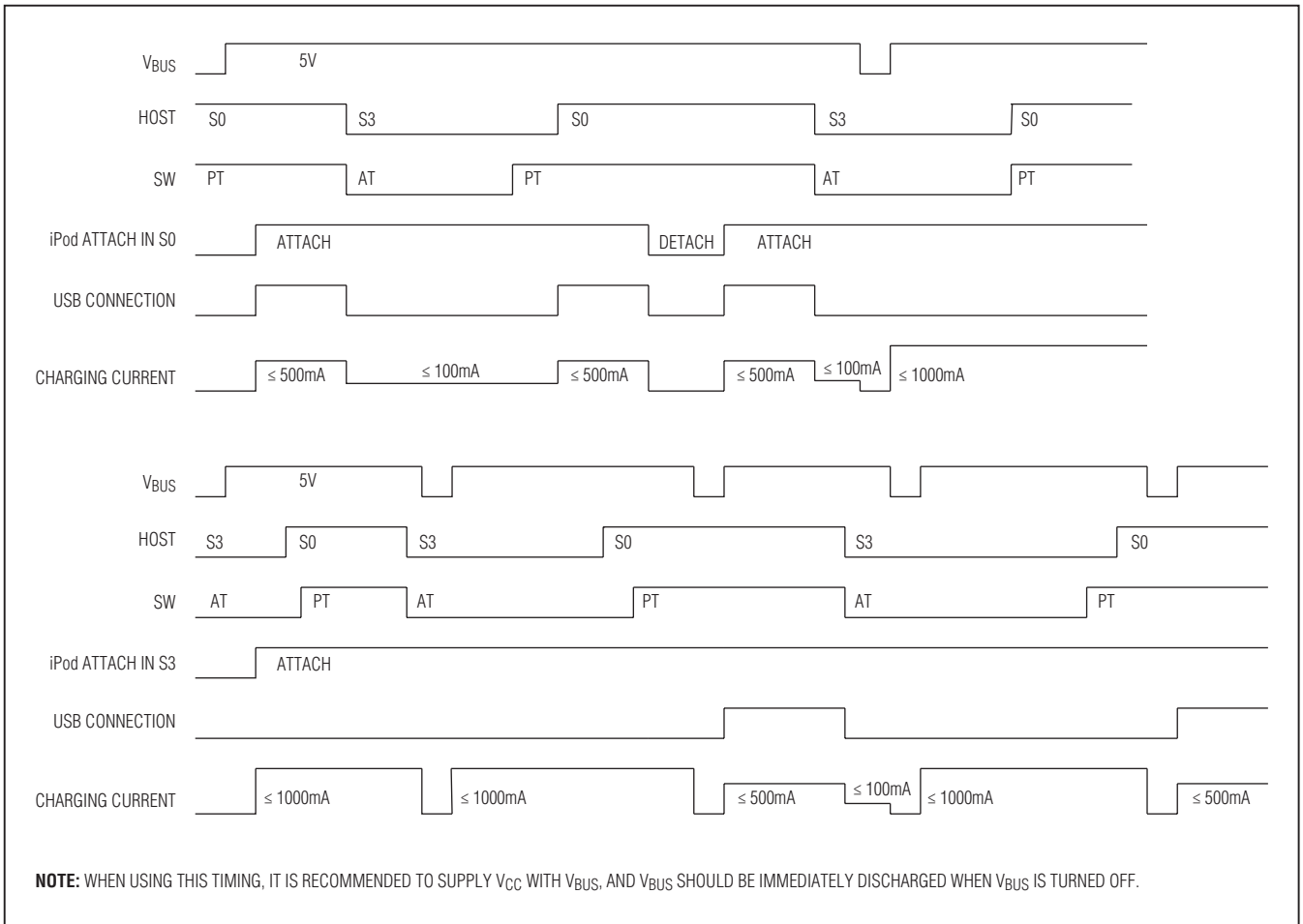


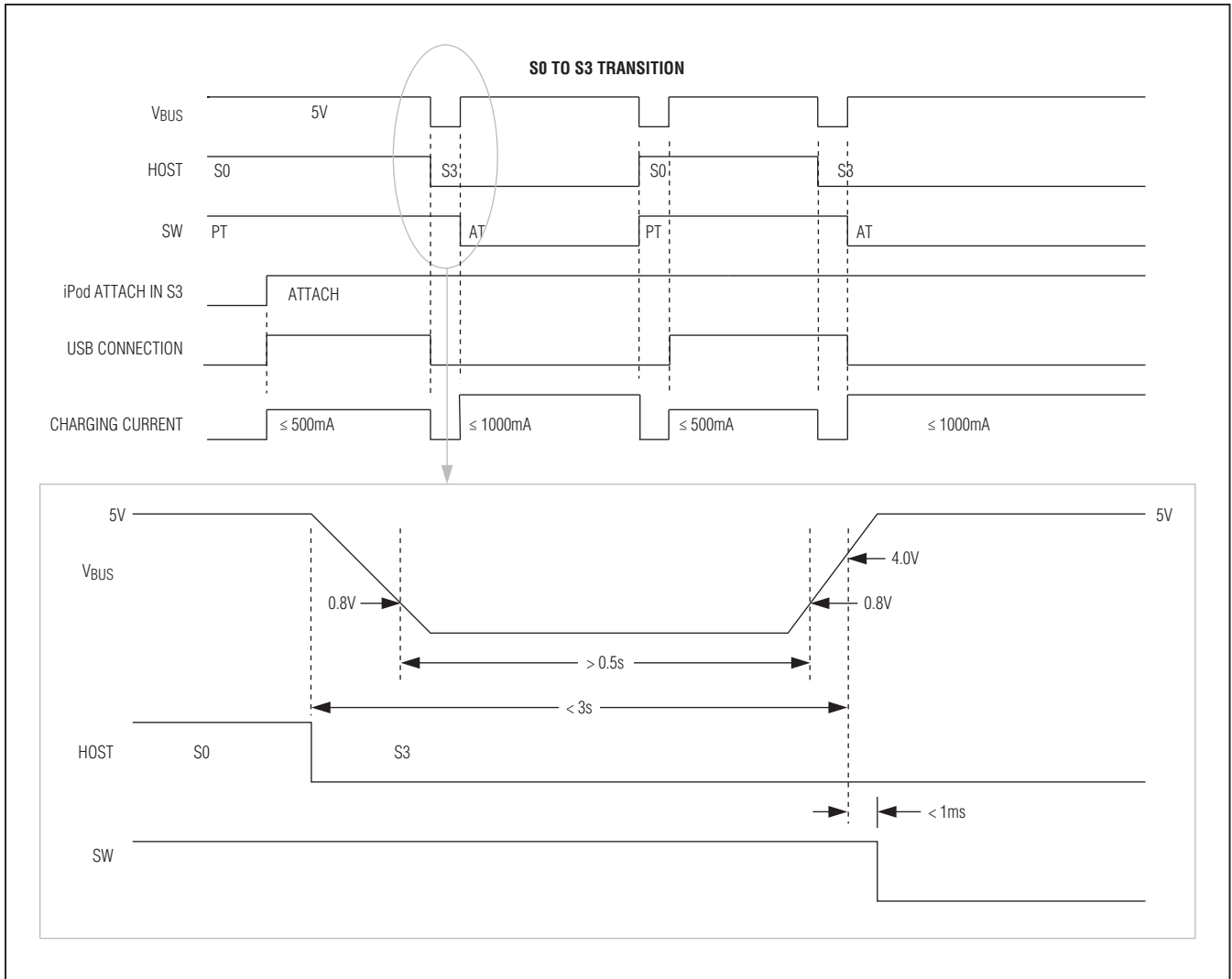
Figure 5b. Human Body Current Waveform

Timing Charts



USB Host Charger Identification Analog Switch

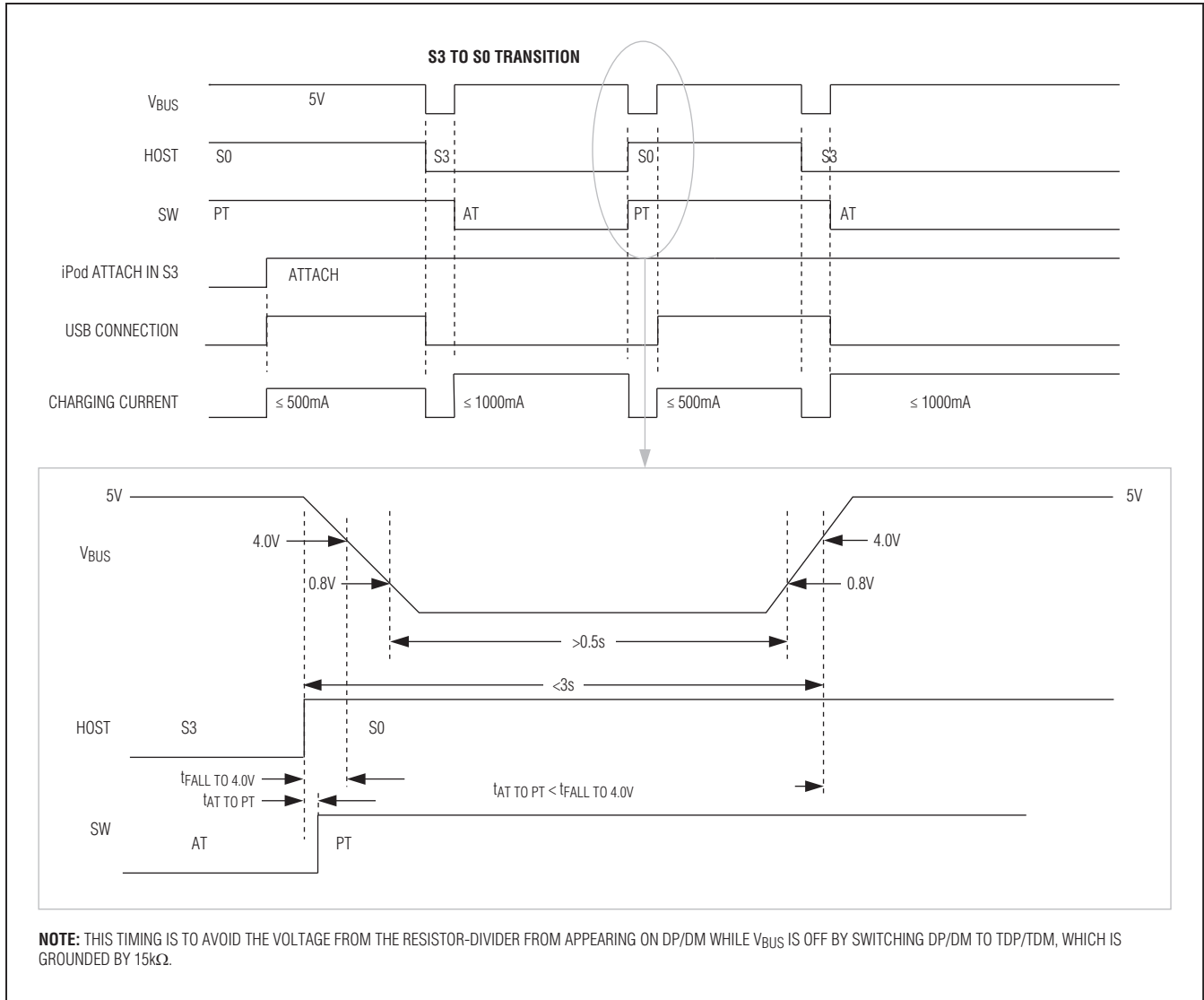
Timing Charts (continued)



USB Host Charger Identification Analog Switch

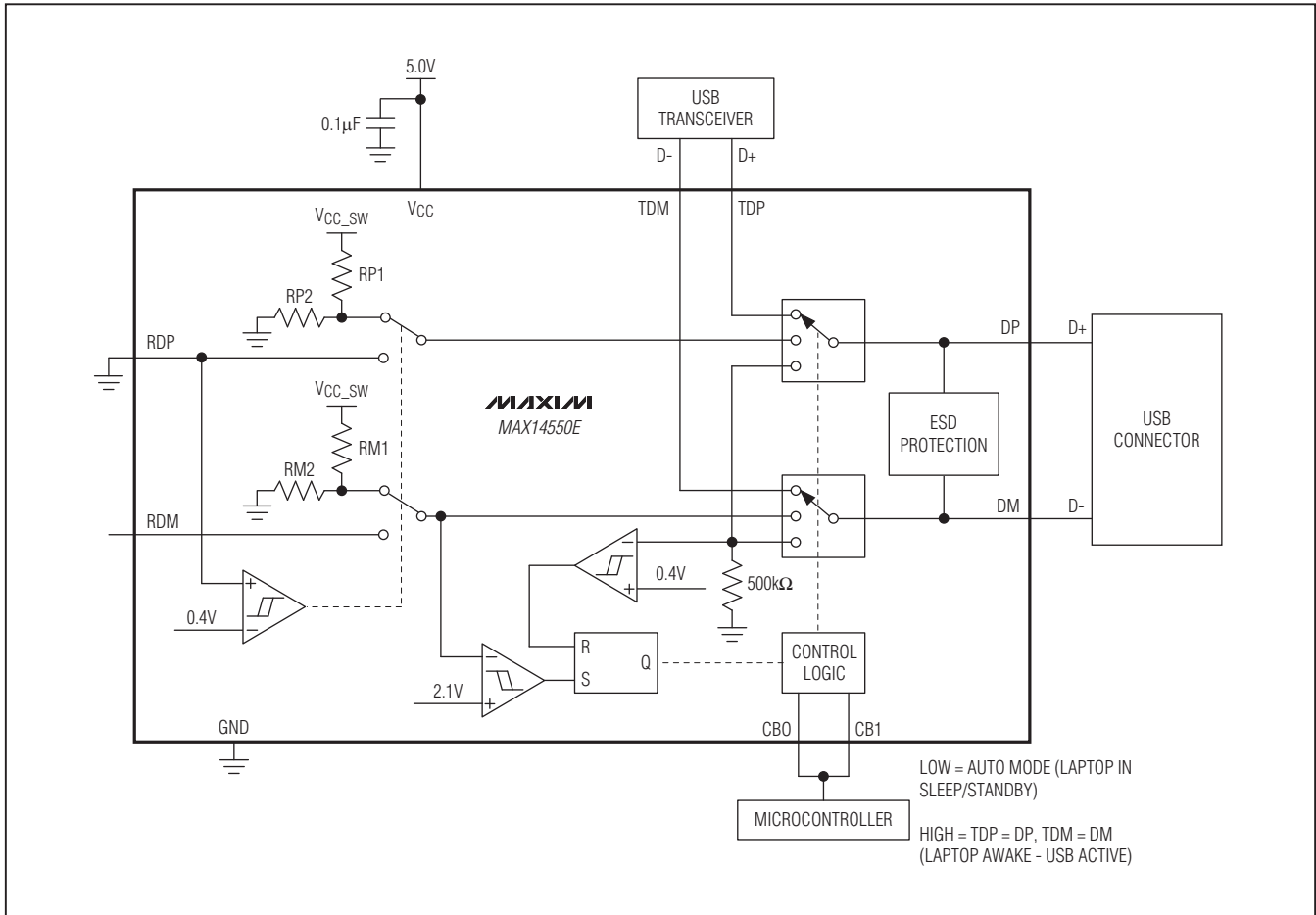
Timing Charts (continued)

MAX14550E



USB Host Charger Identification Analog Switch

Typical Operating Circuit



Chip Information

PROCESS: BiCMOS

Package Information

For the latest package outline information and land patterns, 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 | DOCUMENT NO. |
|--------------|--------------|-------------------------|
| 10 TDFN-EP | T1033+1 | 21-0137 |

USB Host Charger Identification Analog Switch

Revision History

MAX14550E

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|-----------------|---------------|--|---------------------|
| 0 | 8/09 | Initial release. | — |
| 1 | 11/09 | <ul style="list-style-type: none">• Replaced the Lead Temperature with Soldering Temperature in the <i>Absolute Maximum Ratings</i> section.• Changed the "DP/DM On-Capacitance" specification in the <i>Electrical Characteristics</i> table conditions from f = 1MHz to f = 240MHz and 6.0pF (max) to 5.5pF (max).• Replaced TOC11 (Eye Diagram) in the <i>Typical Operating Characteristics</i> section.• Replaced Table 1 and added Table 2.• Added the <i>Timing Chart</i>. | 2, 3, 7, 11, 12, 13 |
| 2 | 1/10 | Replaced the timing diagrams in <i>Timing Charts</i> . | 13, 14,15 |

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