

## MAX14984

# Enhanced VGA Port Protector with Monitor Detection and Dual USB Power Switches

### General Description

The MAX14984 is a complete VGA port protector with dual USB power switches. The device features all the circuitry required to detect the insertion and removal of a monitor and automatically connect the graphics controller when a monitor is detected. A switched 5V output provides up to 55mA to the VGA port in addition to normal VGA signals.

The MAX14984 features a single active-low enable input to control two 5V USB switches. Each switch supplies 500mA of current with less than 250mV drop from  $V_{CC}$ , and is protected against short-circuit faults. Two active-low fault outputs indicate when a fault condition is detected on either output.

High-bandwidth analog switches exceed VESA rise/fall time requirements for the RGB channels. The horizontal and vertical synchronization (H/V) buffers shift logic levels to support +2.5V to +5.0V CMOS or TTL-compatible graphics controllers while meeting the VESA drive capability requirement of  $\pm 8\text{mA}$ . An internal 2.5V regulator and pullup resistors on the monitor side translate the DDC voltage levels to be compatible with low-voltage graphics controllers.

The MAX14984 features high-ESD protection of  $\pm 8\text{kV}$  Human Body Model (HBM) on all VGA and USB outputs. The device is available in a 24-pin (4mm x 4mm) TQFN package and is specified over the  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  extended temperature range.

### Applications

Servers  
Workstations  
Desktop PCs

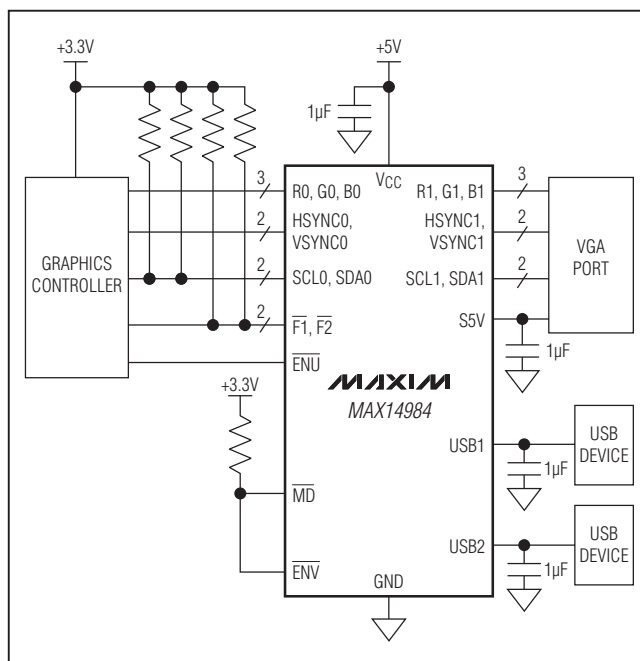
**Ordering Information** appears at end of data sheet.

For related parts and recommended products to use with this part, refer to [www.maxim-ic.com/MAX14984.related](http://www.maxim-ic.com/MAX14984.related).

### Benefits and Features

- ◆ **Design Flexibility**
  - ◇ Graphics Controller Port Is Protected when  $V_{CC} = 0\text{V}$
  - ◇ External Pullup Resistors Match DDC Channel to Graphics Controller Supply
  - ◇ Up to Two USB Ports Supported
- ◆ **High Level of Integration for Performance**
  - ◇ S5V Provides +5V at 55mA to VGA Port
  - ◇ Internal Pullup Resistors on DDC Outputs to S5V
  - ◇ Low 6pF (typ) RGB Capacitance
  - ◇ 2.1ns (typ)  $t_R/t_F$  with 10pF, 2.2k $\Omega$  Load on Monitor-Side SYNC Signals
  - ◇ Source and Sink 8mA While Meeting Speed Requirements
  - ◇ High-ESD Protection on VGA and USB Outputs  $\pm 8\text{kV}$  Human Body Model (HBM)
- ◆ **Saves Space on Board**
  - ◇ Internal USB Switches
    - Pass +5V at 500mA with 250mV (max) IR Drop
    - Current Limited/Thermal Protection
  - ◇ 4mm x 4mm, 24-Pin TQFN Package

### Typical Operating Circuit



# Enhanced VGA Port Protector with Monitor Detection and Dual USB Power Switches

## ABSOLUTE MAXIMUM RATINGS

(All voltages referenced to GND.)

$V_{CC}$ , S5V, H0, V0, SDA0, SCL0,  $\overline{EN\overline{U}}$ ,  $\overline{ENV}$ , SDA1, SCL1, USB1, USB2,  $\overline{MD}$ ,  $\overline{F1}$ ,  $\overline{F2}$  (Note 1) ..... -0.3V to +6V  
 R0, G0, B0, R1, G1, B1, H1, V1 ..... -0.3V to  $V_{CC} + 0.3V$   
 Continuous Current Out of USB1, USB2 ..... 500mA  
 Continuous Current Out of S5V ..... 60mA  
 Continuous Current Through all I/O Pins .....  $\pm 50mA$   
 Peak Current Through RGB, DDC Switches (1ms Pulse, 10% Duty Cycle) .....  $\pm 100mA$

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

TQFN (derate 27.8mW/ $^\circ C$  above  $+70^\circ C$ ) ..... 2222.2mW  
 Operating Temperature Range .....  $-40^\circ C$  to  $+85^\circ C$   
 Junction Temperature .....  $+150^\circ C$   
 Storage Temperature Range .....  $-65^\circ C$  to  $+150^\circ C$   
 Lead Temperature (soldering, 10s) .....  $+300^\circ C$   
 Soldering Temperature (reflow) .....  $+260^\circ C$

## PACKAGE THERMAL CHARACTERISTICS (Note 2)

TQFN

Junction-to-Ambient Thermal Resistance ( $\theta_{JA}$ ) .....  $36^\circ C/W$  Junction-to-Case Resistance ( $\theta_{JC}$ ) .....  $3^\circ C/W$

**Note 1:** When  $\overline{F1}$  and  $\overline{F2}$  are connected to a voltage higher than  $V_{CC}$ , some current will be sunk (see the [Detailed Description](#)).

**Note 2:** 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](http://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

( $V_{CC} = 5.0V \pm 5\%$ ,  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise noted. Typical values are at  $V_{CC} = 5.0V$  and  $T_A = +25^\circ C$ .) (Note 3)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
<b>POWER SUPPLY</b>						
Supply Voltage	$V_{CC}$		4.75		5.25	V
Supply Current	$I_{CC}$	$V_{CC} = +5.25V$ , $V_{ENV} = V_{EN\overline{U}} = 0V$ , SCL0 and SDA0 not connected		2.3	5	mA
		$V_{CC} = +5.25V$ , $V_{ENV} = V_{EN\overline{U}} = 0V$ , $V_{SCL0} = V_{SDA0} = 0V$		6.6	10	
Shutdown Supply Current	$I_{SHDN}$	$V_{CC} = +5.25V$ , $V_{ENV} = V_{EN\overline{U}} = V_{CC}$		29	100	$\mu A$
<b>5-VOLT SWITCH (S5V)</b>						
Voltage Drop	$V_{S5V}$	$I_{OUT} = 55mA$		135	300	mV
Reverse Leakage Current	$I_L$	$V_{S5V} = +5.25V$ , $V_{CC} = 0V$ , $V_{ENV} = 0V$			10	$\mu A$
Current Limit	$I_{LIM}$		55	305	500	mA
<b>USB SWITCHES (USB1, USB2)</b>						
Voltage Drop	$V_{USB}$	$I_{OUT} = 500mA$			250	mV
Continuous Load Current	$I_{LOAD}$		500			mA
Current-Limit Threshold	$I_{LIM}$		0.5		1.0	A
Current-Limit Blanking Period	$t_{BLANK}$	(Note 4)	7.5		50	ms
Output Rise Time	$t_R$	$R_L = 10\Omega$ , $C_L = 1\mu F$ , 10%–90%, Figure 1		11.6		$\mu s$
Output Fall Time	$t_F$	$R_L = 10\Omega$ , $C_L = 1\mu F$ , 90%–10%, Figure 1		25.2		$\mu s$
Turn-On Delay	$t_{ON}$	$R_L = 10\Omega$ , $C_L = 1\mu F$ , to 10% of $V_{OUT}$ , Figure 1			100	$\mu s$
Turn-Off Delay	$t_{OFF}$	$R_L = 10\Omega$ , $C_L = 1\mu F$ , to 90% of $V_{OUT}$ , Figure 1			100	$\mu s$
Reverse Leakage Current	$I_{LUSB}$	$V_{USB} = 5.25V$ , $V_{CC} = 0V$ , $V_{EN\overline{U}} = 0V$			10	$\mu A$
Pulldown Resistance					1200	$\Omega$

## Enhanced VGA Port Protector with Monitor Detection and Dual USB Power Switches

### ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = 5.0V \pm 5\%$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ , unless otherwise noted. Typical values are at  $V_{CC} = 5.0V$  and  $T_A = +25^{\circ}C$ .) (Note 3)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
<b>DDC SWITCHES (SDA0, SCL0, SDA1, SCL1)</b>						
SDA1/SCL1 Off-Leakage Current	$I_{OFF}$	$\overline{V_{ENV}} = V_{CC}$ , $V_{SDA1} = V_{SCL1} = 0V$ or $5.25V$	-1		+1	$\mu A$
SDA0/SCL0 Off-Leakage Current	$I_{LDDC}$	$V_{CC} = 0V$ , $3.3k\Omega$ pullup to $+3.3V$ on SDA0 and SCL0			10	$\mu A$
On-Resistance	$R_{ONDDC}$	$V_{IN} = +0.8V$ , $I_{IN} = \pm 10mA$		7		$\Omega$
<b>LOGIC INPUTS (H0, V0, <math>\overline{ENV}</math>, <math>\overline{ENU}</math>)</b>						
Input Logic-Low	$V_{IL}$		0.8			V
Input Logic-High	$V_{IH}$				2.0	V
Input Leakage Current	$I_L$	$V_{IN} = 0V$ or $5.25V$	-1		+1	$\mu A$
Input Hysteresis (H0, V0)	$V_{HYST}$			100		mV
<b>PUSH-PULL LOGIC OUTPUTS (H1, V1)</b>						
Output Logic-Low	$V_{OL}$	$I_{SINK} = 8mA$ , $V_{CC} = +4.75V$			0.5	V
Output Logic-High	$V_{OH}$	$I_{SOURCE} = 8mA$ , $V_{CC} = +4.75V$	2.4			V
Rise/Fall Time	$t_R$ , $t_F$	10% to 90%, $R_L = 2.2k\Omega$ , $C_L = 10pF$		2.1		ns
<b>OPEN-DRAIN LOGIC OUTPUTS (<math>\overline{F1}</math>, <math>\overline{F2}</math>, <math>\overline{MD}</math>)</b>						
Output Leakage Current	$I_{LKG}$	Output not asserted, $V_{IN} = 5.25V$			1	$\mu A$
Output Logic-Low	$V_{OL}$	$I_{SINK} = 1mA$			0.3	V
<b>RGB ANALOG SWITCHES (R0, G0, B0, R1, G1, B1)</b>						
Bandwidth	$f_{MAX}$	$R_S = R_L = 50\Omega$		1000		MHz
On-Loss	$I_{LOSS}$	$f = 50MHz$ , $R_S = R_L = 50\Omega$ , $0V \leq V_{IN} \leq +0.7V$ , Figure 2		0.4		dB
On-Resistance	$R_{ON}$	$V_{IN} = +0.7V$ , $I_{IN} = \pm 10mA$		5	8	$\Omega$
On-Resistance Matching	$\Delta R_{ON}$	$0V \leq V_{IN} \leq +0.7V$ , $I_{IN} = \pm 10mA$ , same device			1	$\Omega$
On-Resistance Flatness	$R_{FLAT(ON)}$	$0V \leq V_{IN} \leq +0.7V$ , $I_{IN} = \pm 10mA$		0.25	1	$\Omega$
On-Capacitance	$C_{ON}$	$f = 1MHz$ , switches enabled		6		pF
Off-Capacitance	$C_{OFF}$	$f = 1MHz$ , switches disabled		2		pF
<b>PROTECTION SPECIFICATIONS</b>						
High-ESD Pins ESD Protection		Human Body Model (Note 5)		$\pm 8$		kV
All Other Pins ESD Protection		Human Body Model (Note 6)		$\pm 2$		kV
Thermal-Shutdown Threshold	$T_{SHDN}$			+155		$^{\circ}C$
Thermal-Shutdown Hysteresis	$T_{SHDN\_HYS}$			25		$^{\circ}C$

**Note 3:** All units are production tested at  $T_A = +25^{\circ}C$ . Specifications over temperature are guaranteed by design.

**Note 4:**  $t_{BLANK}$  is the period between detecting an overcurrent condition and the fault output asserting.

**Note 5:** See the [Pin Description](#) section for the ESD status of each pin.

**Note 6:** Terminal tested vs. GND. Apply  $1\mu F$ -bypass capacitors on  $V_{CC}$ , USB1, USB2, and S5V.

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## Enhanced VGA Port Protector with Monitor Detection and Dual USB Power Switches

### Test Circuits/Timing Diagrams

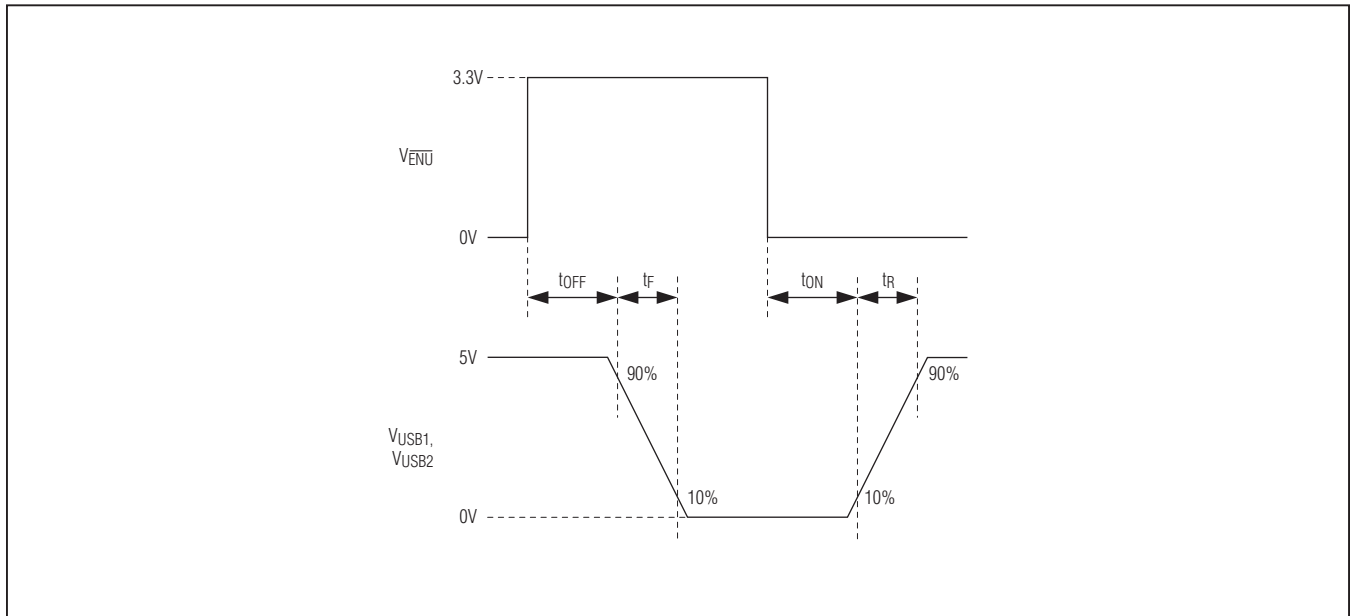


Figure 1. Timing Diagram for USB Switch Parameters

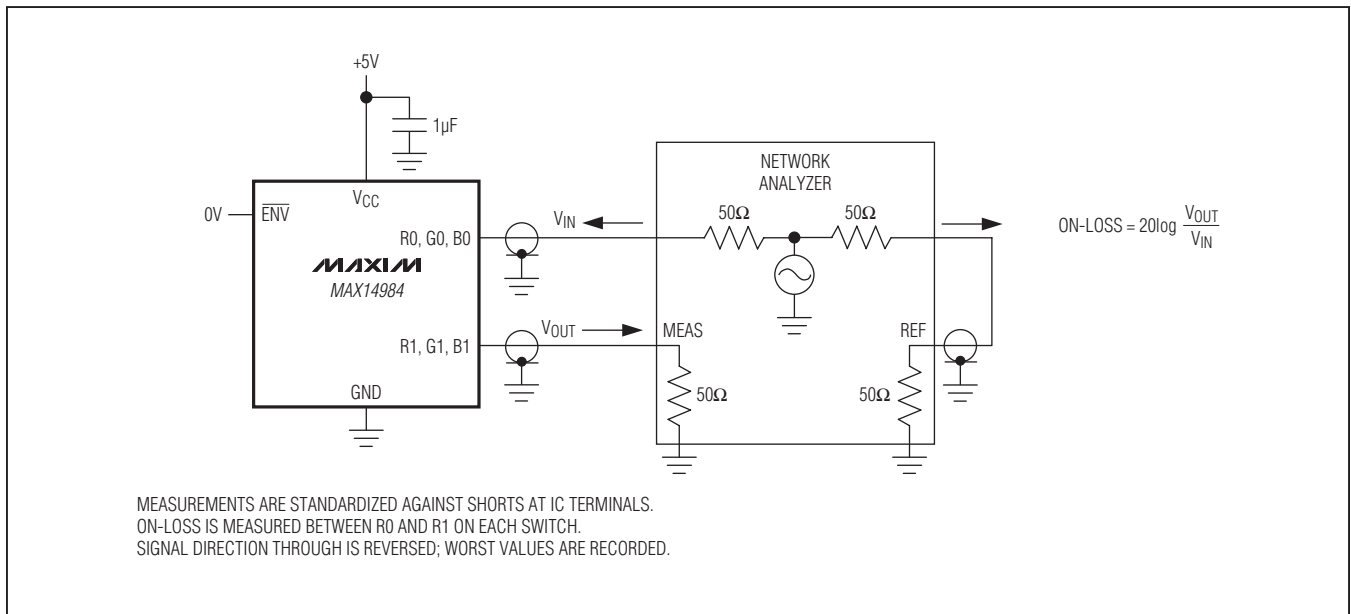
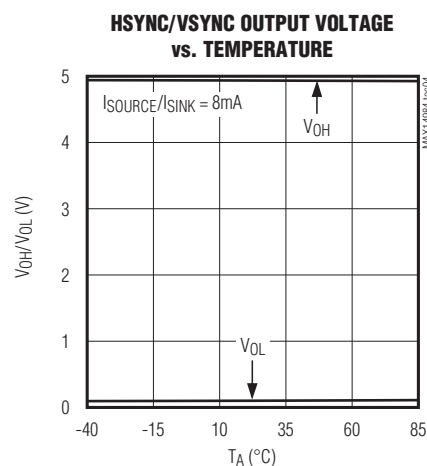
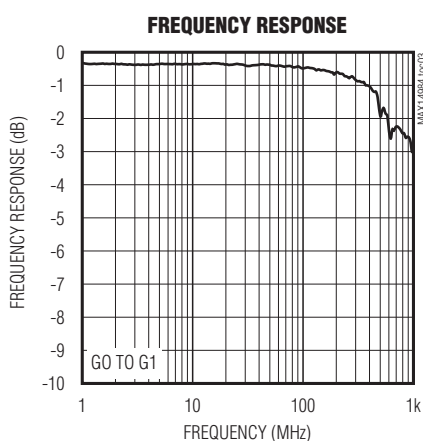
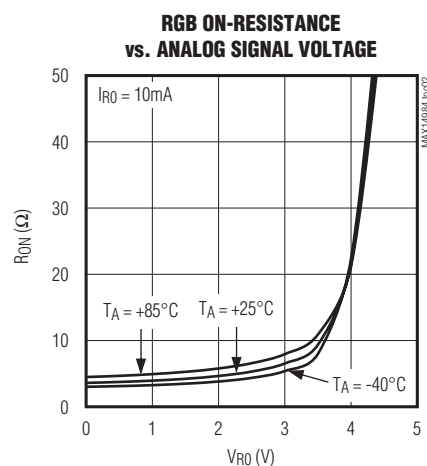
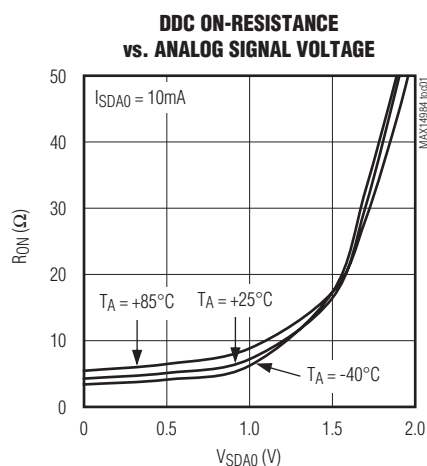


Figure 2. On-Loss

## Enhanced VGA Port Protector with Monitor Detection and Dual USB Power Switches

### Typical Operating Characteristics

( $V_{CC} = +5.0V$ ,  $T_A = +25^\circ C$ , unless otherwise noted)

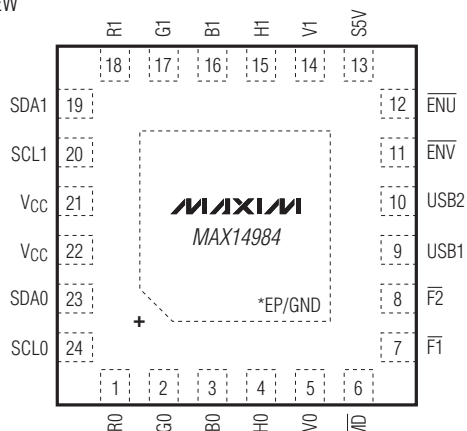


# MAX14984

## Enhanced VGA Port Protector with Monitor Detection and Dual USB Power Switches

### Pin Configuration

TOP VIEW



**TQFN**  
(4mm x 4mm)

\*CONNECT THE EXPOSED PAD (EP/GND) TO THE GROUND PLANE.

### Pin Description

PIN	NAME	FUNCTION	ESD
1	R0	RGB Analog Input	Standard
2	G0	RGB Analog Input	Standard
3	B0	RGB Analog Input	Standard
4	H0	Horizontal Sync Input	Standard
5	V0	Vertical Sync Input	Standard
6	$\overline{\text{MD}}$	Monitor Detect Output. $\overline{\text{MD}}$ is an active-low, open-drain output.	Standard
7	$\overline{\text{F1}}$	Fault Output 1. $\overline{\text{F1}}$ is an active-low, open-drain output that asserts when a fault condition is detected on USB1.	Standard
8	$\overline{\text{F2}}$	Fault Output 2. $\overline{\text{F2}}$ is an active-low, open-drain output that asserts when a fault condition is detected on USB2.	Standard
9	USB1	5V USB Power Output 1. USB1 is internally pulled down when not enabled.	High
10	USB2	5V USB Power Output 2. USB2 is internally pulled down when not enabled.	High
11	$\overline{\text{ENV}}$	Video Enable Input. Drive $\overline{\text{ENV}}$ low to connect the VGA signals to the VGA port.	High
12	$\overline{\text{ENU}}$	USB Enable Input. Drive $\overline{\text{ENU}}$ low to enable the USB power-supply outputs.	High

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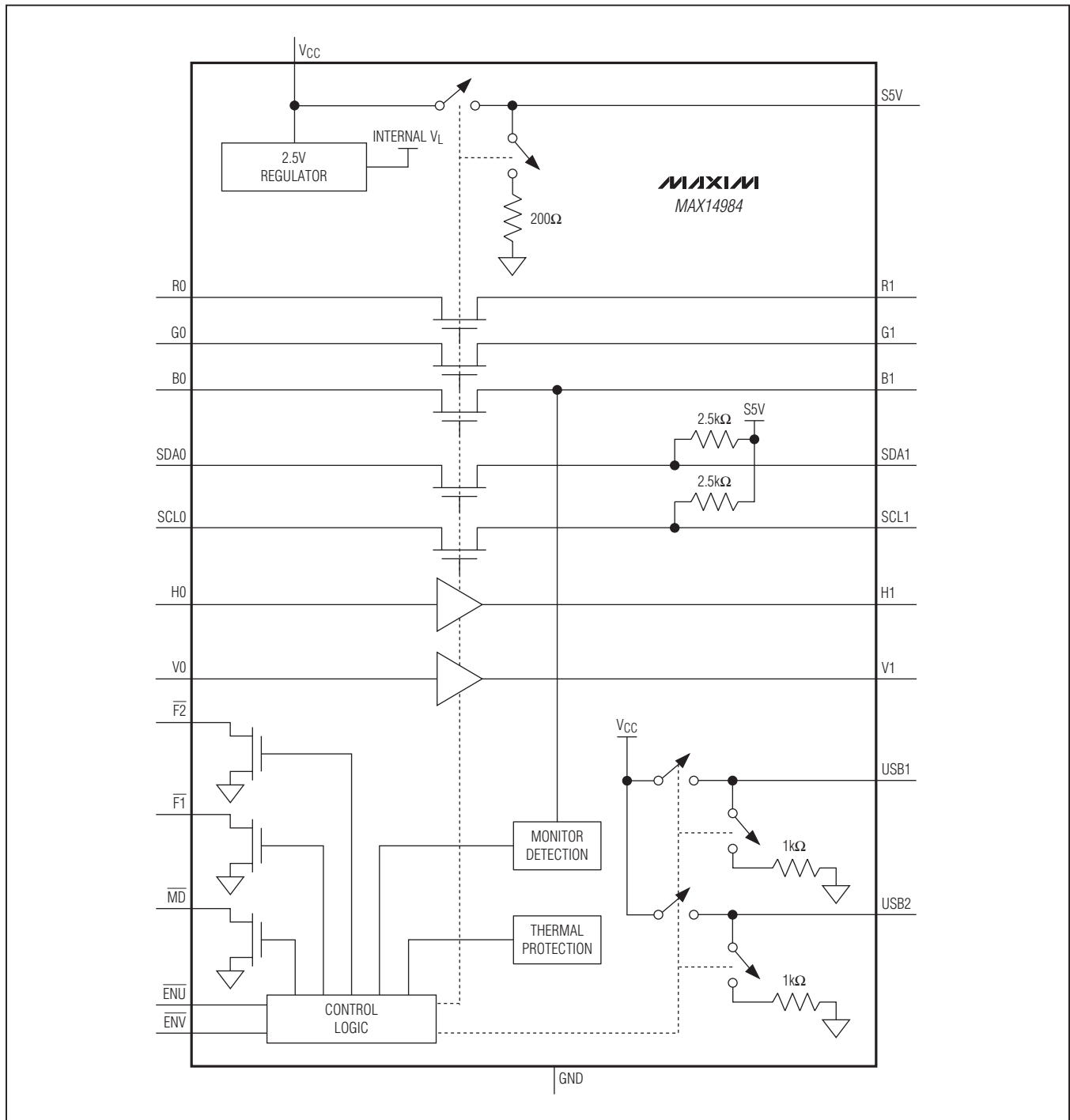
### Pin Description (continued)

PIN	NAME	FUNCTION	ESD
13	S5V	Switched 5V Output. S5V is connected when $\overline{\text{ENV}}$ is low and is internally pulled down when not connected.	High
14	V1	Vertical Sync Output	High
15	H1	Horizontal Sync Output	High
16	B1	RGB Analog Output	High
17	G1	RGB Analog Output	High
18	R1	RGB Analog Output	High
19	SDA1	DDC Input/Output. SDA1 has an internal $2.5\text{k}\Omega$ pullup resistor to S5V	High
20	SCL1	DDC Input/Output. SCL1 has an internal $2.5\text{k}\Omega$ pullup resistor to S5V	High
21, 22	V <sub>CC</sub>	Supply Voltage. V <sub>CC</sub> = 5.0V $\pm$ 5%. Bypass V <sub>CC</sub> to GND with a 1 $\mu$ F or larger ceramic capacitor as close as possible to V <sub>CC</sub> .	Standard
23	SDA0	DDC Input/Output	Standard
24	SCL0	DDC Input/Output	Standard
—	EP/GND	Exposed Pad. The exposed pad is the ground connection for the device. Connect EP/GND to the ground plane.	—

# MAX14984

## Enhanced VGA Port Protector with Monitor Detection and Dual USB Power Switches

### Functional Diagram





## Enhanced VGA Port Protector with Monitor Detection and Dual USB Power Switches

### Detailed Description

The MAX14984 integrates high-bandwidth analog switches and level-translating buffers with current-limited power switches to implement a VGA port protector. The device provides switching for red-green-blue (RGB) signals, horizontal and vertical synchronization (H/V) pulses, display data channel (DDC) signals, and 5V power supplies. The power switches provide +5V power with current limiting and reverse voltage protection to the VGA port and up to two USB ports.

The device uses a simplified power-supply interface that operates from a single +5V supply. An internal 2.5V regulator limits the voltage passed by the DDC switches to provide compatibility with low-voltage graphics controllers.

The device features two enable inputs, a monitor detection output, and two fault outputs.  $\overline{\text{ENV}}$  can be connected to  $\overline{\text{MD}}$  to automatically connect the graphics signal when a monitor is inserted. The fault outputs signal when a fault condition is detected on either of the USB power outputs and they are enabled by  $\overline{\text{ENU}}$ .

### 5V Power Switch (S5V)

The MAX14984 provides a switched +5V output in addition to the regular VGA signals (S5V). This output can supply 55mA with less than 300mV drop from  $V_{CC}$ . The S5V output tolerates +5V while turned off or when  $V_{CC}$  is not present.

The power switches are protected against overcurrent and overtemperature faults. The device limits current supplied to the monitor side to 300mA (typ). Thermal protection circuitry shuts off the switch when the temperature exceeds +155°C. The device is re-enabled once the temperature has fallen to below +130°C.

S5V is connected whenever  $\overline{\text{ENV}}$  is low and has a 200 $\Omega$  (typ) pulldown resistor to discharge filter capacitors when the switch is off.

### USB Switches and $\overline{\text{F1}}/\overline{\text{F2}}$ Outputs

The MAX14984 features two switches that provide power for up to two USB connectors. One enable input,  $\overline{\text{ENU}}$ , controls both switches simultaneously. Each switch can provide up to 500mA while only dropping 250mV from  $V_{CC}$ .

Two active-low fault outputs,  $\overline{\text{F1}}$  and  $\overline{\text{F2}}$ , assert when a fault is detected on USB1 or USB2, respectively. Two fault conditions can be detected: short circuit to GND and overcurrent draw from the USB port. The switches are protected against reverse current into  $V_{CC}$  while  $\overline{\text{ENU}}$  is high, but this condition is not detected by  $\overline{\text{F1}}$  and  $\overline{\text{F2}}$ . Current-limiting and thermal-shutdown circuitry protects the device in the presence of any fault.

A blanking period is built in to  $\overline{\text{F1}}$  and  $\overline{\text{F2}}$  that delays assertion until the current limit has been reached for at least  $t_{\text{BLANK}}$ . In addition, an internal 1k $\Omega$  pulldown resistor is connected on each USB output when it is disabled.

The  $\overline{\text{F1}}$  and  $\overline{\text{F2}}$  outputs are tolerant to external voltages of up to 6V. The MAX14984 limits the current into them to 600 $\mu$ A.

### RGB Switches

The MAX14984 provides three single-pole/single-throw (SPST) high-bandwidth switches to connect the standard VGA R, G, and B signals from the graphics controller to the VGA port. The R, G, B analog switches are identical, and any of the three switches can be used to route red, green, or blue video signals.

The RGB switches are connected when  $\overline{\text{ENV}}$  is low.

### Horizontal/Vertical Sync Buffer

The H/V signals are buffered to provide level shifting and drive capability to meet the VESA specification.

H1 and V1 are enabled when  $\overline{\text{ENV}}$  is low and high impedance when  $\overline{\text{ENV}}$  is high. The H and V channels are not interchangeable.

### Display Data Channel Switches (SDA\_, SCL\_)

The MAX14984 provides two voltage-limited SPST switches to connect DDC signals (SDA\_, SCL\_). These switches limit the voltage that can be passed through to the graphics controller to less than 2.5V. Internal pullup resistors on the monitor side of the switches translate the graphics controller signals to 5V compatible logic. Connect pullup resistors on SCL0 and SDA0 to define the logic level of the graphics controller.

The SDA\_ and SCL\_ switches are connected when  $\overline{\text{ENV}}$  is low and are identical; either switch can be used to route SDA or SCL I<sup>2</sup>C signals.

## Enhanced VGA Port Protector with Monitor Detection and Dual USB Power Switches

### Monitor Detection and Automatic Switching

The MAX14984 detects monitor insertion/removal events by measuring the voltage on B1. The monitor detection circuitry always correctly indicates the presence of a monitor as long as V0 is not high impedance. The voltage measurement is only sampled between synchronization pulses on V0 from the controller when a monitor is inserted to ensure that the video signal is not interrupted while promptly detecting a removal.

The device automatically connects the graphics controller to the monitor when it is plugged in if configured in automatic mode. To configure automatic mode, connect MD to ENV and add a pullup resistor.

### Applications Information

#### Compatibility with Low-Voltage Graphics Controllers

The MAX14984 provides the level shifting necessary to drive a standard VGA port using any graphics controller. Internal buffers drive the H and V signals to VGA standard TTL levels. The DDC switches provide level shifting by limiting signal levels that can be passed through the DDC switches to less than 2.5V. Add pullup resistors from the DDC lines to the graphics controller supply to set the logic level on the SDA0/SCL0 side.

#### Power-Supply Decoupling

Bypass  $V_{CC}$  to ground with a  $1\mu\text{F}$  or larger ceramic capacitor as close to the device as possible.

### PC Board Layout

High-speed switches such as the MAX14984 require proper PCB layout for optimum performance. Ensure that impedance-controlled PCB traces for high-speed signals are matched in length and as short as possible. Connect the exposed pad to a solid ground plane.

### High ESD Protection

Electrostatic Discharge (ESD) protection structures are incorporated on all pins to protect against electrostatic discharges up to  $\pm 2\text{kV}$  Human Body Model (HBM) encountered during handling and assembly. All VGA and USB outputs are further protected against ESD up to  $\pm 8\text{kV}$  (HBM) without damage (see the [Pin Description](#)). The ESD structures withstand high ESD both in normal operation and when the device is powered down. After an ESD event, the MAX14984 continues to function without latchup.

### 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 3 shows the Human Body Model. Figure 4 shows the current waveform it generates when discharged into a low impedance. This model consists of a  $100\text{pF}$  capacitor charged to the ESD voltage of interest that is then discharged into the device through a  $1.5\text{k}\Omega$  resistor.

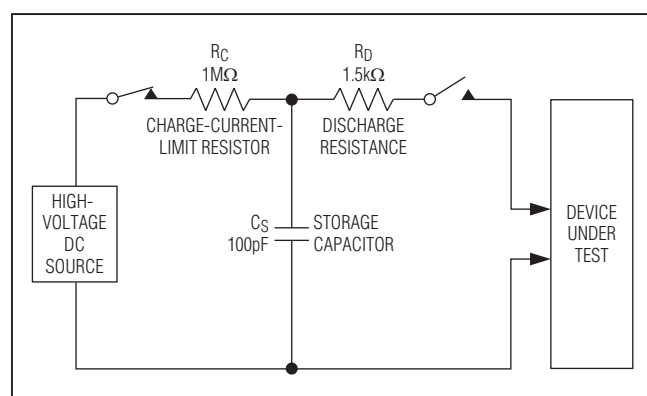


Figure 3. Human Body ESD Test Model

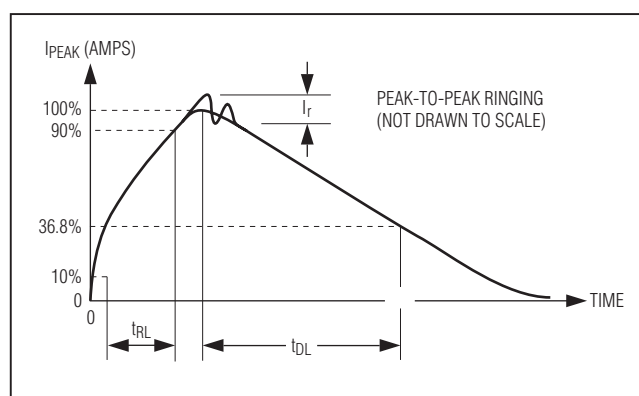


Figure 4. Human Body Current Waveform

# MAX14984

## Enhanced VGA Port Protector with Monitor Detection and Dual USB Power Switches

### Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX14984ETG+	-40°C to +85°C	24 TQFN-EP*

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

\*EP = Exposed paddle.

### Chip Information

PROCESS: BiCMOS

### Package Information

For the latest package outline information and land patterns (footprints), go to [www.maxim-ic.com/packages](http://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.
24 TQFN-EP	T2444+3	<a href="#">21-0139</a>	<a href="#">90-0021</a>

**MAX14984**

# Enhanced VGA Port Protector with Monitor Detection and Dual USB Power Switches

## Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	3/12	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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