General Description

The MAX8904 evaluation kit (EV kit) is a fully assembled and tested PCB that evaluates the MAX8904 power-management IC. The MAX8904 EV kit operates from an input supply range of 3.4V to 13.2V and is controlled by an I2C interface. The MAX8904 includes five step-down converters (1V2, 1V8, 3V3, 5V0, and ADJ), a WLED step-up converter (BST), a current-limited switch (CLS), a current-sense amplifier (CSA) with differential inputs, an active-low open-drain comparator (CMP), and an 8-bit GPIO port. The MAX8904 also controls an external n-MOSFET for input overvoltage protection (13.5V, typ) and an external p-MOSFET for reverse-polarity protection (up to -28V) of downstream circuits. The I2C interface supports output-voltage setting of the ADJ power rail and BST regulator (voltage-source mode), WLED current setting for the BST regulator (WLED current regulator mode), GPIO control, and enable/disable of ADJ, 5V0, BST, CSA, CMP, and CLS blocks.

The MAX8904 EV kit also includes Windows® 2000-, Windows XP®-, and Windows Vista®-compatible software that provides a simple graphical user interface (GUI) for exercising the features of the MAX8904. To evaluate the MAX8904, order the MINIQUSB+ command module along with the MAX8904 EV kit.

Windows, Windows XP, and Windows Vista are registered trademarks of Microsoft Corp.

Features

♦ **Input-Voltage Range of 3.4V to 13.2V**

♦ **1MHz, Up to 90% Efficient, Synchronous DC-DC Step-Down Converters**

♦ **Power Converters 1V2, 1V8, and ADJ Operated Out-of-Phase with Respect to 3V3 and 5V0**

♦ **667kHz Step-Up Converter Provides Up to 32V Output for Driving Up to Eight WLEDs**

♦ **Internal Compensation on All Power Converters**

♦ **Fast Line- and Load-Transient Responses**

♦ **Internal Soft-Start and Short-Circuit Protection on All Power Converter Outputs**

♦ **Input Overvoltage and Reverse-Polarity Protection**

♦ **250ms Fault Timer-Based Protection for Overload and Short Circuit**

♦ **I2C Serial Interface for On/Off Control, Output Voltage, WLED Current, GPIO Setting, and Fault Monitoring**

♦ **< 10µA Standby Current**

♦ **Compact, 56-Pin 7mm x 7mm TQFN Package**

♦ **Fully Assembled and Tested**

Ordering Information

PART	TYPE
MAX8904EVKIT+	EV Kit

+Denotes lead(Pb)-free and RoHS compliant.

Component List

DESIGNATION	QTY	DESCRIPTION
C1	1	0.22µF ±10%, 16V X7R ceramic capacitor (0603) Murata GRM188R71C224KA01D
C2, C10	2	1µF ±10%, 6.3V X5R ceramic capacitors (0603) Murata GRM188R60J105KA01D
C3	1	1µF ±10%, 6.3V X5R ceramic capacitor (0402) Murata GRM155R60J105K
C4	1	1µF ±10%, 16V X7R ceramic capacitor (0805) Taiyo Yuden EMK212BJ105KG

DESIGNATION	QTY	DESCRIPTION
C5	1	2.2µF ±10%, 16V X7R ceramic capacitor (0805) Taiyo Yuden EMK212BJ225KG
C6	1	1µF ±10%, 50V X7R ceramic capacitor (1206) Taiyo Yuden UMK316B7105KL
C7, C15, C18, C21, C24	5	4.7µF ±10%, 25V X7R ceramic capacitors (0805) Taiyo Yuden TMK212BJ475KG
C8_1, C8_2	2	22µF ±20%, 4V X5R ceramic capacitors (0603) Taiyo Yuden AMK107BJ226MA

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

19-5160; Rev 0; 2/10

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DESIGNATION	QTY	DESCRIPTION
C9, C12, C13, C16, C19, C22	6	0.1µF ±10%, 16V X7R ceramic capacitors (0402) Taiyo Yuden EMK105BJ104KV
C11	1	680µF ±20%, 16V aluminum electrolytic capacitor SANYO 16CE680AX
C14_1, C14_2, C17, C20_1, C20_2, C23	6	22µF ±10%, 6.3V X5R ceramic capacitors (1206) Taiyo Yuden JMK316BJ226ML
C25	0	Not installed, ceramic capacitor (0603)
C26	1	0.022µF ±10%, 25V X7R ceramic capacitor (0402) Taiyo Yuden TMK105BJ223KV
C27	1	0.01µF ±10%, 16V X7R ceramic capacitor (0402) Murata GRM155R71C104K
C28	1	220pF ±10%, 50V X5R ceramic capacitor (0402) Taiyo Yuden UMK105BJ221KV
D1, D2	2	40V, 0.5A Schottky diodes (SOD123) ON Semi MBR0540T1G
D3–D10, D11	9	Surface-mount LEDs, blue (0603) Kingbright APT1608PBCA
D12	1	Surface-mount LED, green (0603) Kingbright APT1608CGCK
D13	1	Surface-mount LED, yellow (0603) Kingbright APT1608SYCK
D14	1	Surface-mount LED, red (0603) Kingbright APT1608SRCP
J1	1	2 x 8 vertical male header
J2	1	1 x 8 single-row female receptacle Samtec SSW-108-01-T-S
JU1, JU2.0–JU2.7, JU3	10	2-pin headers, 0.1in Sullins PEC36SAAN or equivalent

DESIGNATION	QTY	DESCRIPTION
L1	1	10µH, 1.2A, 145mΩ DCR inductor TOKO DE3518 Series 1127AS-100M
L2, L4	2	4.7µH, 1.75A, 60mΩ DCR inductors TOKO DE3518 Series 1127AS-4R7M
L3, L5	2	4.3µH, 2.65A, 70mΩ DCR inductors TOKO DE4518 Series 1124BS-4R3M
L6	1	10µH, 1.75A, 120mΩ DCR inductor TOKO DE4518 Series 1124BS-100M
Q1	1	30V dual n-/p-MOSFET (8 SO) Fairchild FDS8958B
R1, R3	2	10Ω, 1/16W ±1% resistors (0402)
R2	1	0.015Ω, 1/4W ±1% resistor (1206) Vishay WSL1206R0150FEA
R4	1	0Ω ±1% resistor (0805)
R5, R6, R29, R30–R33	7	0Ω ±1% resistors (0402)
R7, R25, R26, R27	0	Not installed, resistors (0402)
R8–R11	4	100Ω ±1% resistors (0402)
R12–R19	8	100kΩ ±1% resistors (0402)
R20–R24	5	10kΩ ±1% resistors (0402)
R28	1	24.9kΩ ±1% resistor (0402)
U1	1	Power-management IC (56 TQFN-EP*) Maxim MAX8904ETN+
—	9	Shunts, 2 positions Sullins STC02SYAN or equivalent
—	1	PCB: MAX8904 EVALUATION KIT+

*EP = Exposed pad.

Component Suppliers

SUPPLIER	PHONE	WEBSITE
Fairchild Semiconductor	888-522-5372	www.fairchildsemi.com
Kingbright Corporation	909-468-0500	www.kingbrightusa.com
Murata Electronics North America, Inc.	770-436-1300	www.murata-northamerica.com
Samtec, Inc.	800-726-8329	www.samtec.com
SANYO Electric Co., Ltd.	619-661-6835	www.sanyodevice.com
Sullins Electronics Corp.	760-744-0125	www.sullinselecstronics.com
Taiyo Yuden	847-925-0888	www.yuden.co.jp
TOKO	847-297-0070	www.toko.com
ON Semiconductor	888-743-7826	www.onsemi.com
Vishay	402-563-6866	www.vishay.com

Note: *Indicate that you are using the MAX8904 when contacting these component suppliers*

MAX8904 EV Kit Files

FILES	DESCRIPTION
INSTALL.EXE	Installs the EV kit files on your computer
MAX8904.EXE	Application program
UNINST.INI	Uninstalls the EV kit software
TROUBLESHOOTING_USB.PDF	USB driver installation help file

Quick Start

Recommended Equipment

- Variable 14V power supply capable of supplying 5A of output current
- Voltmeter
- User-supplied Windows 2000, Windows XP, or Windows Vista PC with a spare USB port

Note: In the following sections, software-related items are identified by bolding. Text in **bold** refers to items directly from the EV kit software. Text in **bold and underlined** refers to items from the Windows operating system.

Procedure

The MAX8904 EV kit is a fully assembled and tested surface-mount board. Follow the steps below to verify board operation. **Caution: Do not turn on the power supply until all connections are completed.**

1) Visit **www.maximintegrated.com/evkitsoftware** to download the latest version of the EV kit software, 8904Rxx.ZIP. Save the EV kit software to a temporary folder and uncompress the ZIP file.

2) Install the EV kit software on your computer by running the INSTALL.EXE program inside the tempo-rary folder. The program files are copied and icons are created in the Windows **Start | Programs** menu.

3) Carefully connect the MINIQUSB+ command module with the MAX8904 EV kit by aligning the 16-pin connector J1 and 8-pin receptacle J2 of the MAX8904 EV kit with the 16-pin receptacle J3 and 8-pin header J4 of the MINIQUSB+ interface board, respectively.

4) Connect the USB cable from the PC to the MINIQUSB+ command module. A **Building Driver Database** window pops up in addition to a **New Hardware Found** message if this is the first time the EV kit board is connected to the PC. If a window is not seen that is similar to the one described above after 30s, remove the USB cable from the board and reconnect it. Administrator privileges are required to install the USB device driver on Windows. Refer to the TROUBLESHOOTING_USB.PDF document included with the software if you have any problems during this step.

5) Follow the directions of the **Add New Hardware Wizard** to install the USB device driver. Choose the **Search for the best driver for your device** option. Specify the location of the device driver to be

C:\Program Files\MAX8904 (default installation directory) using the **Browse** button.

6) Preset the power supply to 7.2V. Turn off the power supply.

7) Connect the positive lead of the 7.2V power supply to the VIN pad. Connect the negative lead of the 7.2V power supply to the GND pad.

8) Turn on the power supply.

9) Start the MAX8904 program by opening its icon in the **Start | Programs** menu. The EV kit software main window appears, as shown in Figure 1.

10) Normal device operation is verified when **Command Module Connected, Device Connected** is displayed at the top-left side of the MAX8904 EV kit main window (Figure 1).

11) Verify that the voltage is 1.2V at the 1V2 pad.

12) Verify that the voltage is 1.8V at the 1V8 pad.

13) Verify that the voltage is 3.3V at the 3V3 pad.

14) Verify that the voltage is 5V at the 5V0 pad.

15) Choose 4.000 from the **VADJSP (V)** group box to set the ADJ output voltage to 4V and check the **VADJEN** checkbox and press the **Write** button in the **ENABLE/SHUTDOWN** group box to turn on the ADJ step-down converter.

16) Verify that the voltage is 4V at the ADJ pad.

17) Verify that the jumper JU1 shunt is installed.

18) Choose 10 from the **BSTCSP (mA)** group box to set the LED current to 10mA. Choose **32** from the **BSTVSP (V)-current mode** group box to set the overvoltage threshold for BST current-mode operation to 32V. Check the **BSTEN** checkbox and press the **Write** button in the **ENABLE/SHUTDOWN** group box to turn on the BST step-up converter.

19) Verify that blue LEDs D3–D10 turn on.

20) Switch to the **GPIO Configuration** tab, as shown in Figure 2. Choose **Open-Drain/HiZ** from the **GPIO Config** drop-down list for GPIO4–GPIO7.

21) Verify that LEDs D11–D14 turn on.

__Detailed Description of Software

User-Interface Panel

The MAX8904 EV kit uses the MINIQUSB+ command module for an I^{2}C interface to control the MAX8904 configurations. The EV kit software displays two tabs to set the MAX8904 configurations, **Power Controller, Status**

and **GPIO Configuration**. Changes to the controls followed by a **Write/Write All** update the appropriate registers of the MAX8904. After any write or read operation, the related command and data sent are shown in the top-middle box.

Power Controller, Status Tab

The MAX8904 includes five step-down converters (1V2, 1V8, 3V3, 5V0, and ADJ), a WLED step-up converter (BST), a current-limited switch (CLS), a current-sense amplifier (CSA) with differential inputs, and an active-low open-drain comparator (CMP). Their configuration can be set by using the EV kit software. The **MODE** group box provides control of CSA gain, ADJ, and BST operating mode, CSA overcurrent-fault detection, and overvoltage protection. The output voltage of the ADJ and BST regulator (voltage-source mode), and WLED current for the BST regulator (current-regulator mode), are set through the **VADJSP(V)**, **BSTCSP(mA)**, and **BSTVSP(V)** group boxes.

ENABLE(Checked) allows the host processor to enable/disable the individual block when needed. **SHUTDOWN(Unchecked)** works in conjunction with the MAX8904 $\overline{SHDN}$ pin to program which function block is turned off in the event of a power failure.

The **Fault Status**, **Overload Fault Status**, and **VOK Fault Register** read-only registers monitor the MAX8904 operating state and fault status. They indicate any overload, short circuit, power-ok, input overvoltage fault, input overcurrent fault, or overtemperature. The **STATUS** indicators require a **Read** if a fault or event has occurred, in which case the corresponding indicator flag turns red. Press the **CLRFLTS** button to clear the status bit and pull $\overline{FLT}$ back to high if the fault or event is no longer present. Press the **REARM** button to rearm fault detections.

GPIO Configuration Tab

The **GPIO Configuration** tab sheet allows the MAX8904 to configure the GPIO0–GPIO7 to the following modes:

- Schmitt-trigger input with an internal 1MΩ pullup resistor to GPIOPWR

- Open-drain output, with an internal 10kΩ pullup resistor off-state, capable of sinking up to 20mA current

- Open-drain output with high-impedance state, capable of sinking up to 20mA current

- High-impedance output

The status of eight GPIO bits can be read/written by the **GPIO Data** register. The GPIOs can also perform LED dimming, which is achieved by setting **PWM**, **PWM Bank**, and **GPIO PWM Control** boxes.
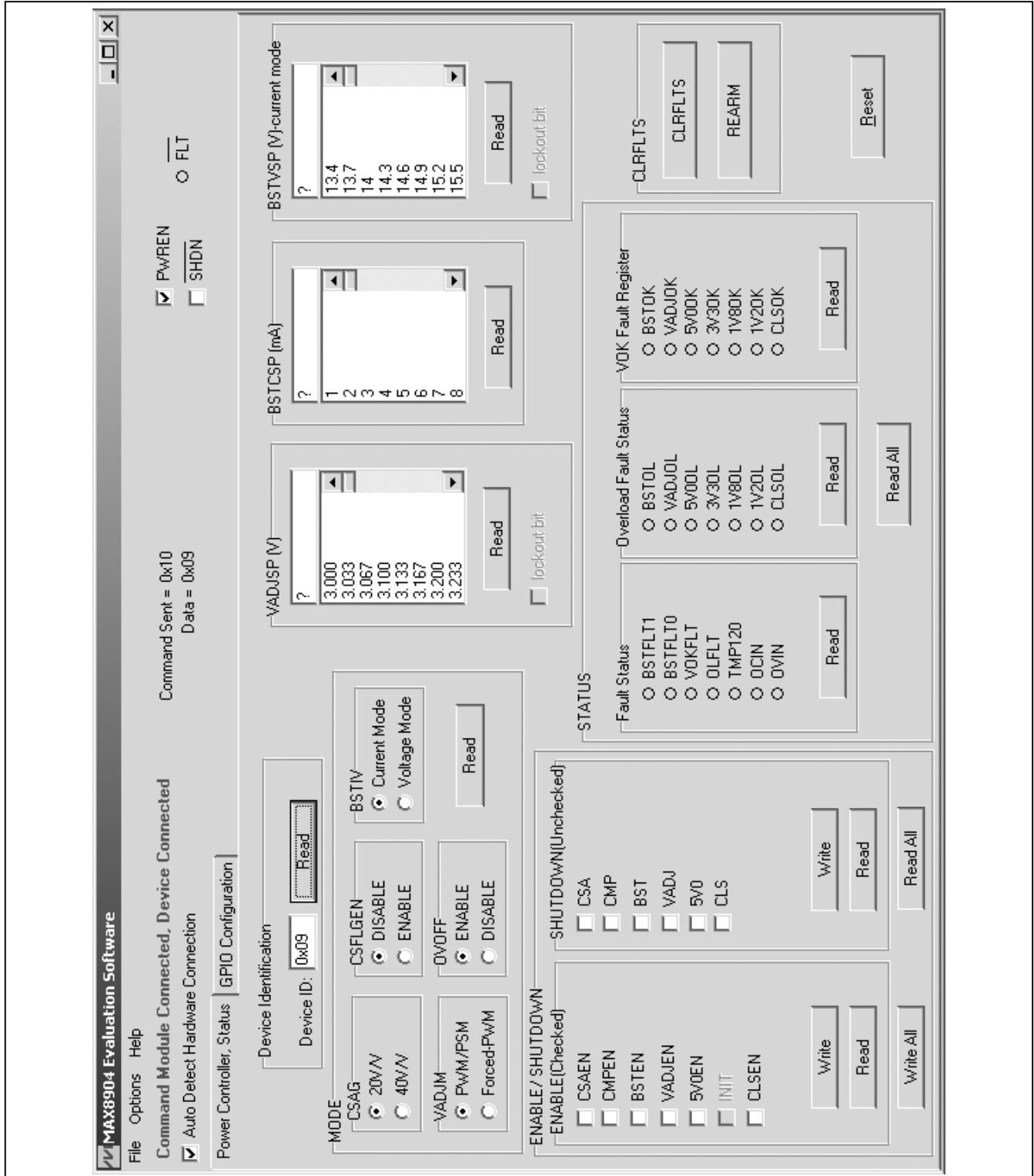
Figure 1. MAX8904 EV Kit Software (Power Controller, Status Tab)

MAX8904 Evaluation Kit
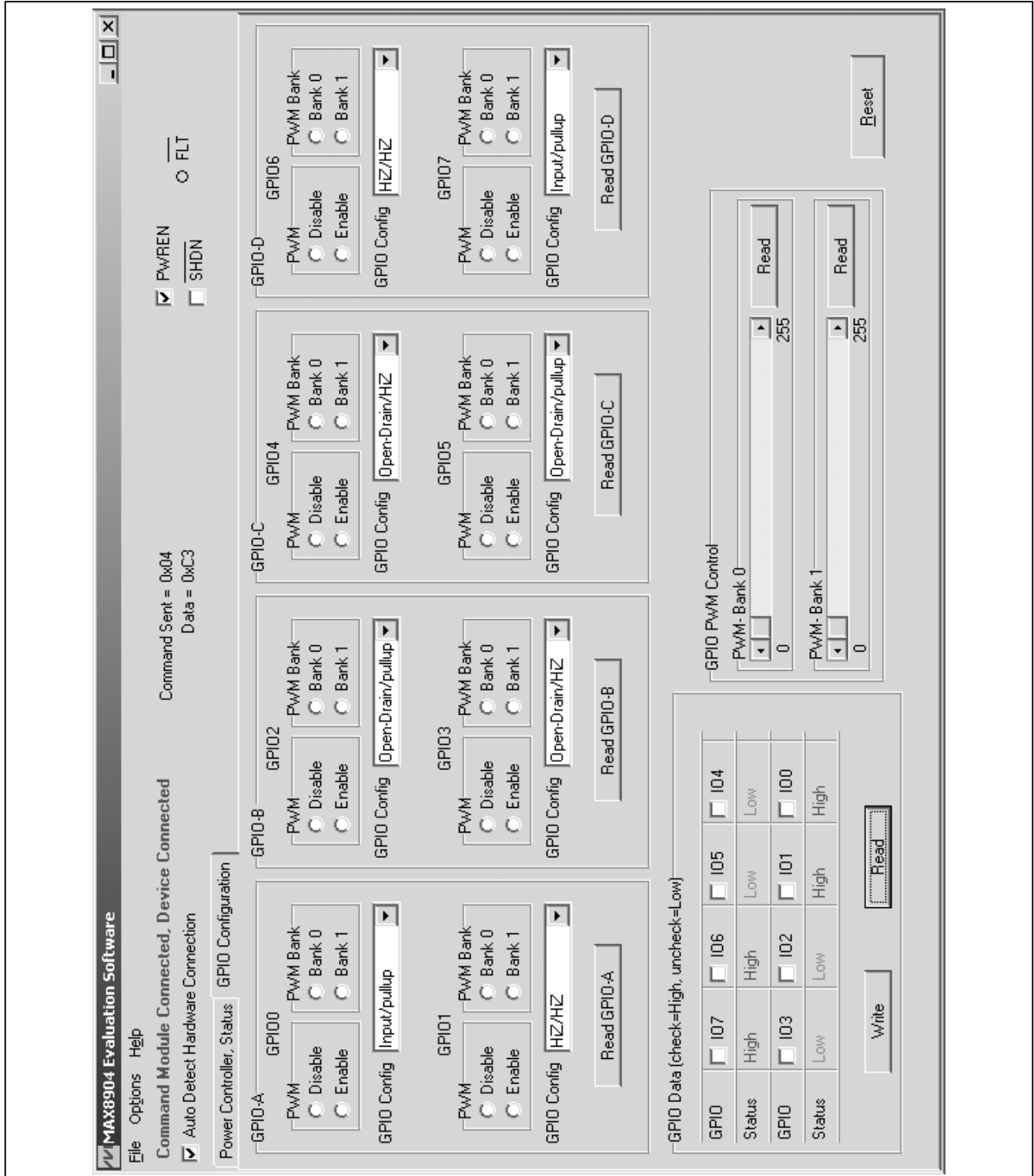
Evaluates: MAX8904

Figure 2. GPIO Configuration Tab

Simple I²C/SMBus Commands

There are two methods for communicating with the MAX8904, through the normal user-interface panel (Figure 1), or through the SMBus commands available by choosing the **Options | 2-wire Interface** menu item from the menu bar. The I²C/SMBus commands allow low-level I²C commands to be sent and are typically used for debugging purposes. The **Maxim Command Module Interface (CmodGUIForm)** window (Figure 3) pops up and includes a **2-wire interface** tab that allows for execution of the simple I²C commands.

It is necessary to first properly identify the slave address of the MAX8904. This is done by pressing the **Hunt for active listeners** button. The PWREN pin must be driven high prior to searching for the active listeners, since PWREN enables the 3.3V step-down converter, which powers the I²C pullup resistors and the internal I²C circuitry.

The WriteByte and ReadByte protocols can be used to send and receive 8-bit commands directly to the MAX8904 registers. Refer to the MAX8904 IC data sheet for command-byte format. For the Write Byte protocol, the register address is entered in the **Command Byte** combo box, and the 8-bit data contents are entered in the **Data Out** combo box. For the Read Byte protocol, the register address is entered in the **Command Byte** combo box, and the register contents are read back into the **Data In** edit box. Pressing the **Execute** button sends the command. The **PASS/FAIL** indicator flag indicates a successful transaction by turning green.

The **SMBus dialog** boxes accept numeric data in binary, decimal, or hexadecimal. Hexadecimal numbers should be prefixed by $ or 0x. Binary numbers must be exactly eight digits. See Figure 3 for an illustration of this tool.
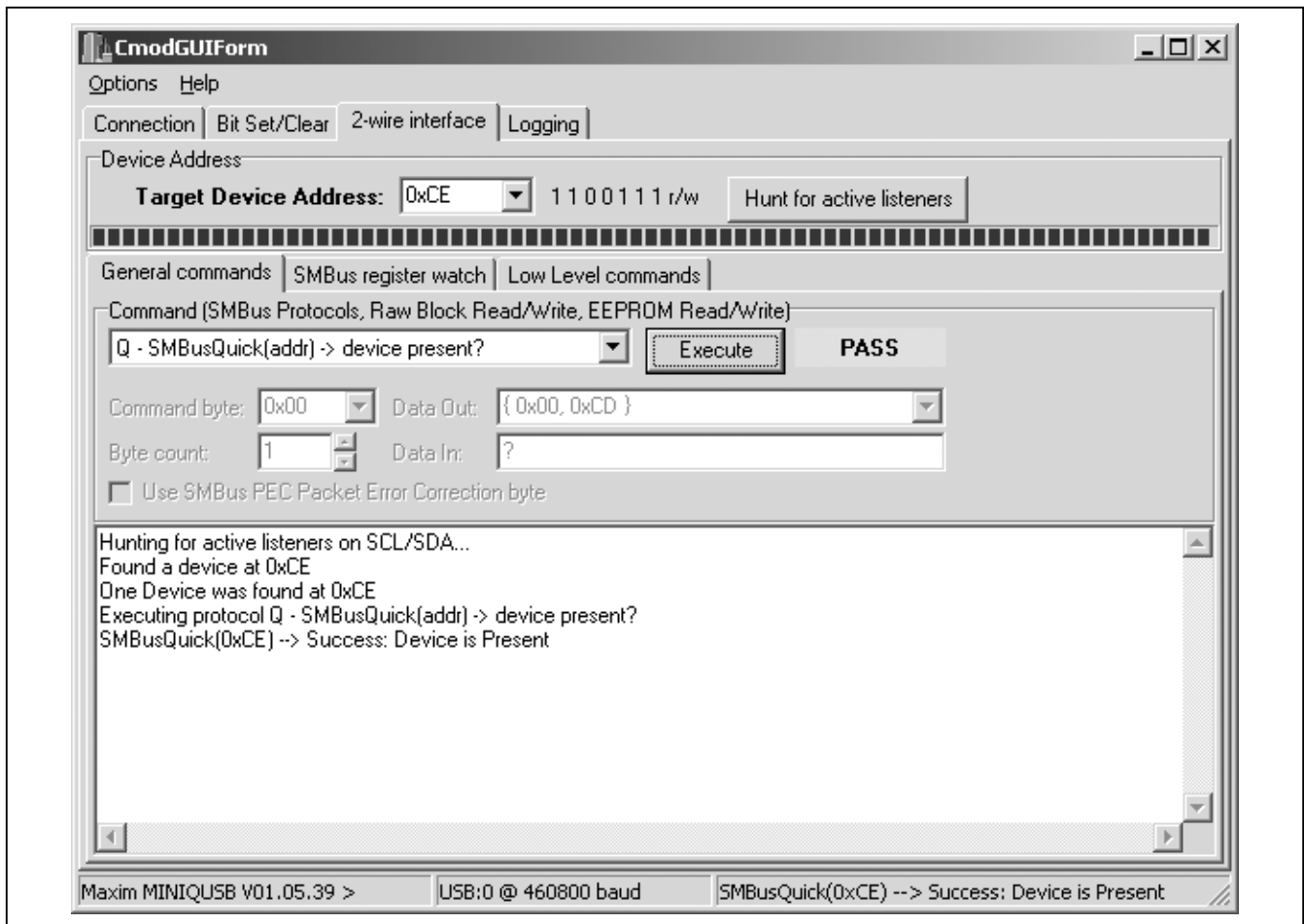

Figure 3. Maxim Command Module Interface (CmodGUIForm) Window

MAX8904 Evaluation Kit

Evaluates: MAX8904

Detailed Description of Hardware

Step-Down Converters

The MAX8904 has four fixed-voltage step-down converters (1V2, 1V8, 3V3, and 5V0) and an adjustable voltage step-down converter ADJ. Table 1 lists the output voltages and currents for each converter. The ADJ converter output voltage can be programmed from 3V to 5.067V in 33.3mV increments using the MAX8904 EV kit software. The PWREN logic-high input turns on the 1V2, 1V8, 3V3, and 5V0 power converters. Once the 5V0 converter is in regulation, it can be disabled by the **5V0EN** bit in the **Enable** register. The ADJ converter can be enabled by checking the **ADJEN** bit in the **Enable** register.

BST Step-Up Converters

The MAX8904 EV kit contains a BST step-up converter that can operate in either current mode or voltage mode. When the **Current Mode** radio button in the **BSTIV** group box is selected, select the value from 1mA to 63mA from the **BSTCSP(mA)** group box to set the current flowing through D3–D10. Select a value from the **BSTVSP(V)-current mode** group box to set the overvoltage threshold for WLED protection.

Click on the **Voltage Mode** radio button to operate the BST converter in voltage mode. The BST output voltage can be programmed by the **BSTVSP(V)** from 12.5V to 18.7V with 100mV increments. In voltage mode, the BST converter can provide up to 63mA output current. Ensure that the jumper JU1 shunt is not installed and the jumper JU3 shunt is installed to short PCS to GND in voltage mode.

Current-Limit Switch

The current-limited switch (CLS) allows the MAX8904 to control the amount of current that an external device draws from the input-voltage source. The CLS is connected between the input-voltage source and the target peripheral device. It provides at least 450mA current and is protected under short-circuit conditions. A short-circuit condition that lasts greater than 250ms latches the CLS

Table 1. Step-Down Converter Output Voltage and Output Current

OUTPUT	VOLTAGE (V)	CURRENT (mA)
1V2	1.2	600
1V8	1.8	975
3V3	3.3	1250
5V0	5	800
ADJ	3 to 5.067	1500

off. The CLS can be enabled/disabled by checking/unchecking the **CLSEN** bit in the **Enable** register.

Current-Sense Amplifier

The current-sense amplifier (CSA) measures the MAX8904 input current and provides an analog voltage output. The CSOUT voltage is given by the following equation:

$$V_{CSOUT} = A_V \times R2 \times I_{IN}$$

where A_V = 20V/V or 40V/V (programmed by the **CSAG** bit in the **Mode** register), R2 = 0.015Ω, and I_{IN} = input current. The CSA allows full-scale (1.2V) output for 4A (20V/V) and 2A (40V/V) currents.

The **CSFLGEN** bit is used to enable/disable the CSA input overcurrent-fault-detection feature. If **CSFLGEN** is set to **Enable**, the MAX8904 sets the **OCIN** bit in the **Fault Status** register and pulls $\overline{FLT}$ to low when an input overcurrent is sensed at CSOUT. The input overcurrent-fault detection is disabled if **CSFLGEN** is set to **Disable**.

The CSA can be enabled or disabled by checking/unchecking the **CSAEN** bit in the **Enable** register.

Open-Drain Comparator

The open-drain comparator (CMP) is an uncommitted, 14V, open-drain output comparator with 20mA of sinking capability. The CMP can be enabled or disabled by checking/unchecking the **CMPEN** bit in the **Enable** register.

Overvoltage and Reverse-Polarity Protection

The MAX8904 supports input overvoltage protection (OVP) at 13.5V (typ) by controlling an external n-MOSFET and reverse-polarity protection (down to -28V) of downstream circuits by controlling an external p-MOSFET.

As the V_{IN} voltage rises above 4V, the overvoltage charge-pump gate drive is powered up and OVGATE turns on the Q1 n-MOSFET. Once V_{IN} approaches 13.5V, OVGATE is discharged, turning off the Q1 n-MOSFET and disconnecting the downstream circuit from the high input. When the input voltage goes negative, the MAX8904 pulls RPGATE to OVPWR voltage to turn off the external p-MOSFET. When the input voltage rises in the positive direction to a maximum of 30V, RPGATE pulls low and turns on the Q1 p-MOSFET.

GPIO Port

The MAX8904 EV kit features an 8-bit GPIO port controller with PWM capability. The GPIO0–GPIO7 can be configured by using the MAX8904 EV kit software as:

- Schmitt-trigger input with an internal 1MΩ pullup resistor to GPIOPWR

- Open-drain output, with an internal 10kΩ pullup resistor off-state, capable of sinking up to 20mA current

- Open-drain output with high-impedance state, capable of sinking up to 20mA current

- High-impedance output

The D11–D14 LEDs are controlled by GPIO4–GPIO7 on the MAX8904 EV kit. Their brightness can be controlled by selecting **PWM Enable** and setting the PWM duty cycle through **PWM Bank Control**. Each LED can also be switched between two intensities by toggling its **PWM Bank** assignment between **Bank 0** and **Bank 1**.

Power Enable Input (PWREN)

Driving PWREN logic input high turns on 1V2, 1V8, 3V3, and 5V0 default power rails. The 5V0 converter can also be turned on/off through the **Enable** register once it is in 5V regulation. The 1V2, 1V8, and 3V3 power rails can only be turned off by driving PWREN logic input low.

Shutdown Input ($\overline{\text{SHDN}}$)

The MAX8904 features an emergency shutdown input ($\overline{\text{SHDN}}$) to turn off the function blocks preselected by the **Shutdown** register under power-fail conditions. When an active-low $\overline{\text{SHDN}}$ is asserted, the function blocks whose corresponding bits are programmed to 0 in the **Shutdown** register are immediately turned off, and the blocks whose bits in the **Shutdown** register are programmed to 1 remain enabled. The function blocks include CSA, CMP, BST, ADJ, 5V0, and CLS.

Fault Handling

The MAX8904 EV kit software provides all the fault information in the **STATUS** group box. The three read-only registers, **Fault Status**, **Overload Fault Status**, and **VOK Fault Register** monitor the MAX8904 fault status. They indicate any VOK, overload, or system fault. The **STATUS** indicators require a **Read** if a fault has occurred, in which case the corresponding indicator flag turns red. A second **Read** clears the status bit if the fault is no longer present.

A VOK fault occurs either when an output voltage fails to soft-start or due to overload/short-circuit conditions under normal operation, causing the output voltage to fall below its VOK threshold. When a VOK fault occurs on a particular converter or CLS, press the **Read** button in the **VOK Fault Register** box to see the corresponding **_OK** indicator flag turns red.

The **Overload** register indicates if any overload occurs on the power converters or CLS. The corresponding **_OL** indicator flag turns red after pressing **Read** in the **Overload Fault Status** group box.

The **Fault Status** register reports all the system faults (fault on BST, VOK, overload, overtemperature, input overcurrent, or input overvoltage). Refer to the MAX8904 IC data sheet for more information. The $\overline{\text{FLT}}$ output goes low immediately after any fault detection.

Press the **Read All** button to update all the fault information in the **Status** registers.

User-Supplied I2C Interface

To use the MAX8904 EV kit with a user-supplied I2C interface, connect the SDA, SCL, and GND lines from the user-supplied I2C interface to the SDA, SCL, and GND pads on the EV kit. Remove pullup resistors R21 and R22 and install resistors R26 and R27 for the user-supplied I2C interface. For resistors R26 and R27, 2.2kΩ is recommended.
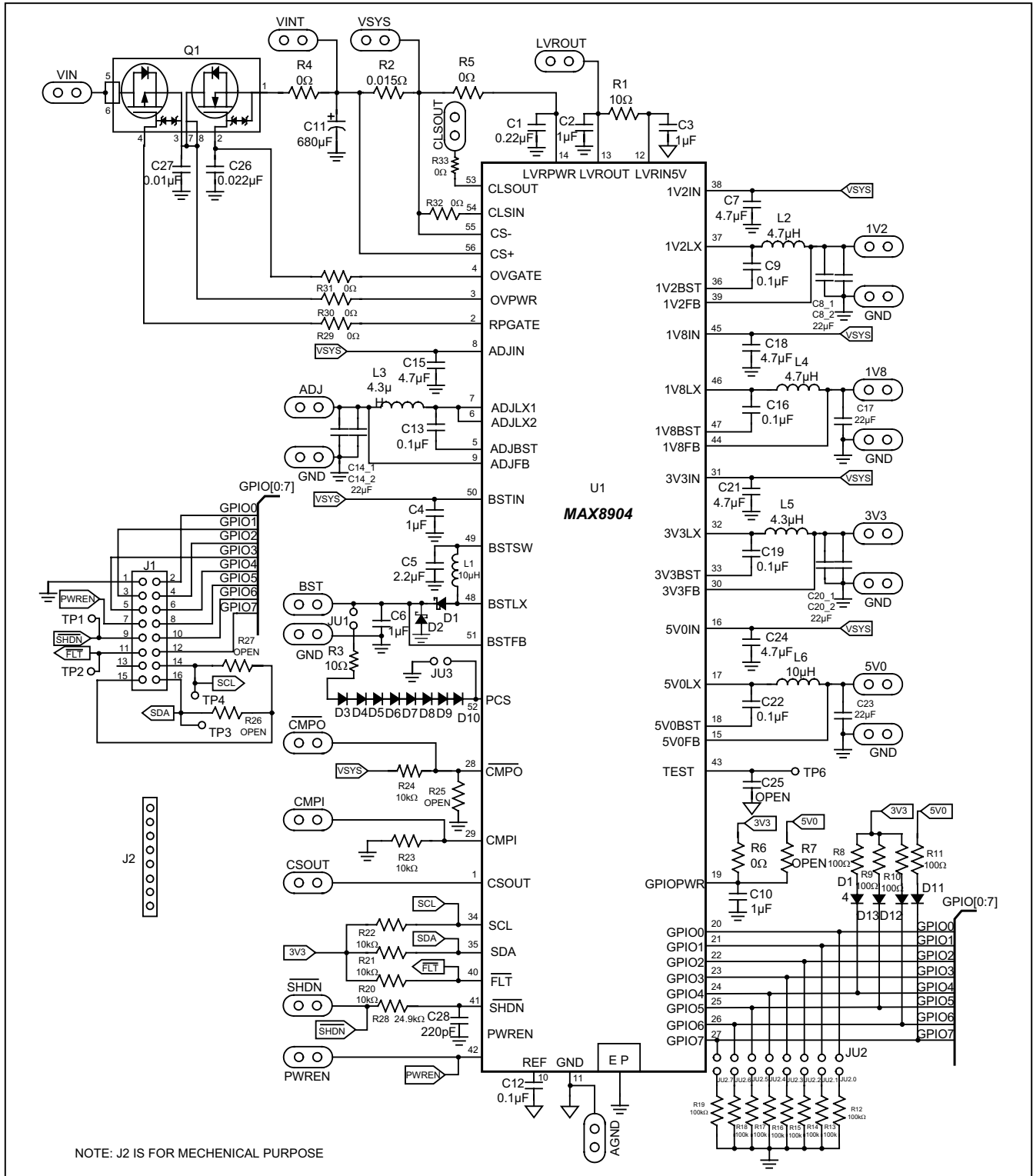
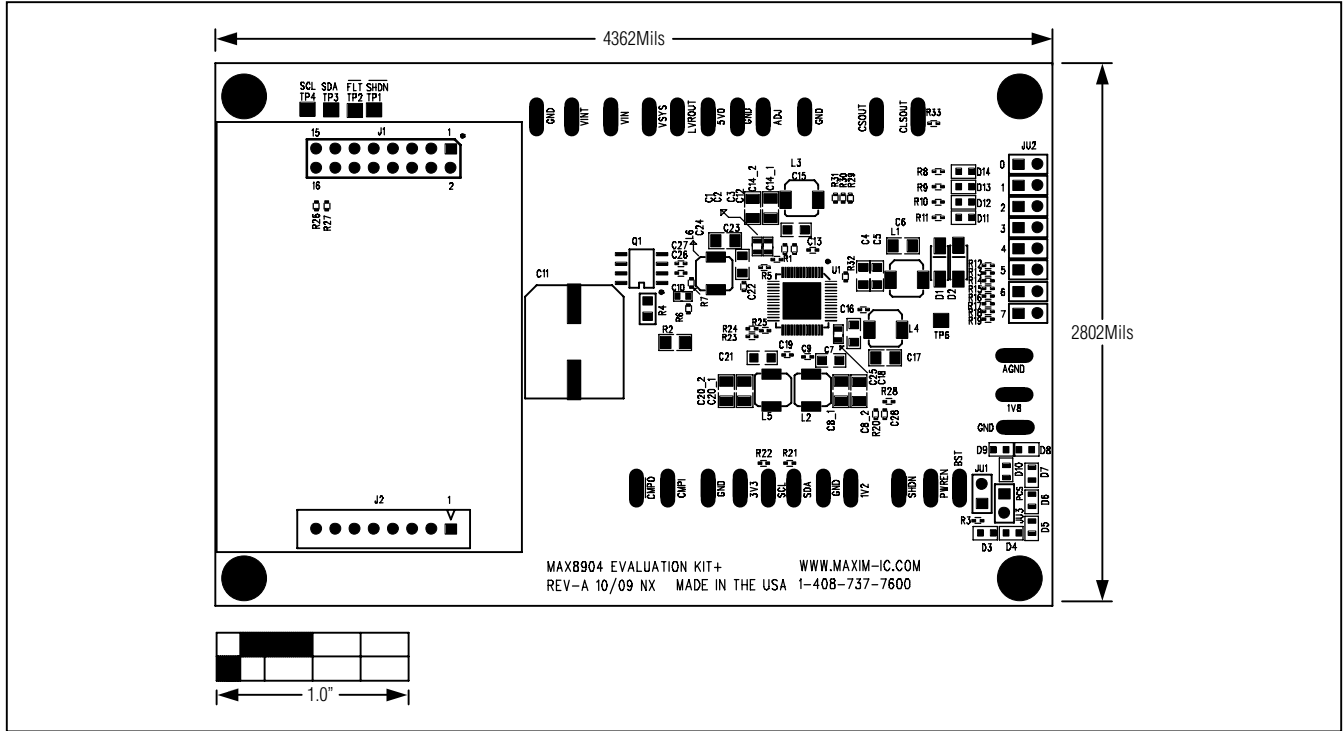Figure 4. MAX8904 EV Kit Schematic

Figure 5. MAX8904 EV Kit Component Placement
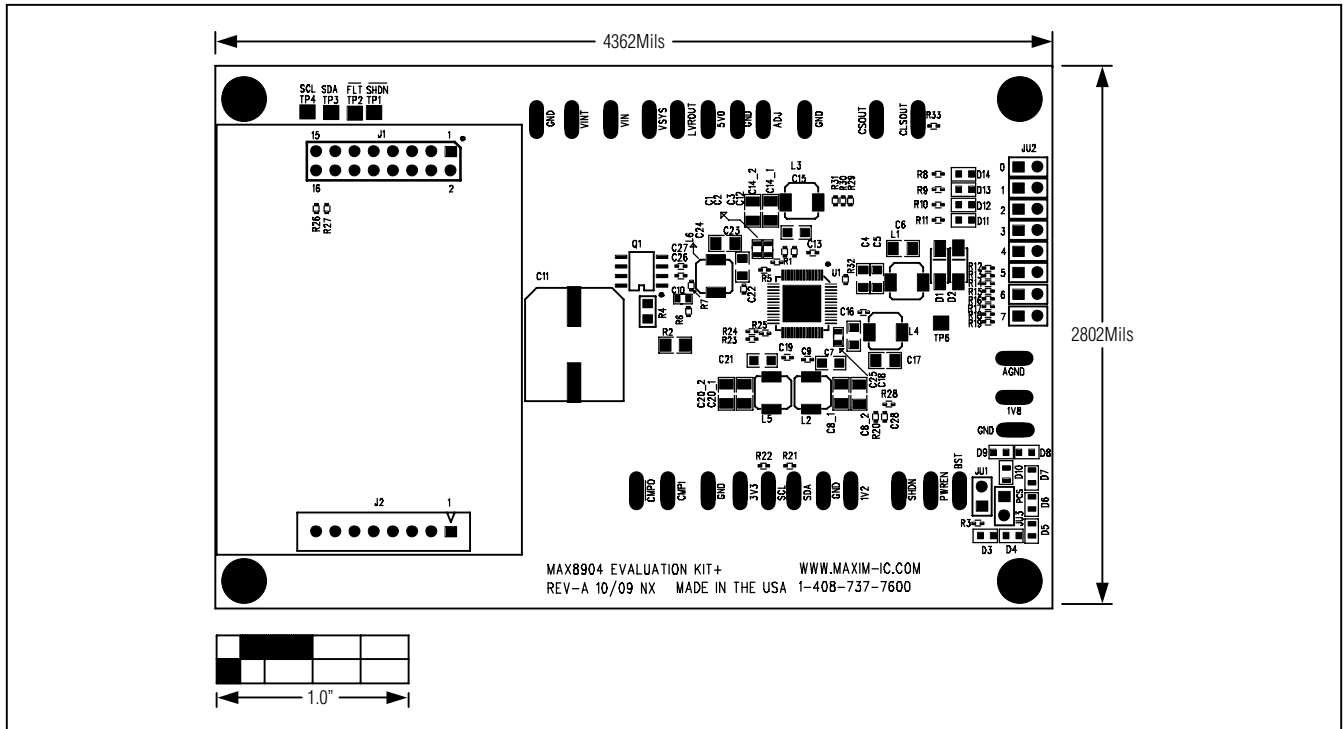

Figure 6. MAX8904 EV Kit PCB Layout—Top Layer 1
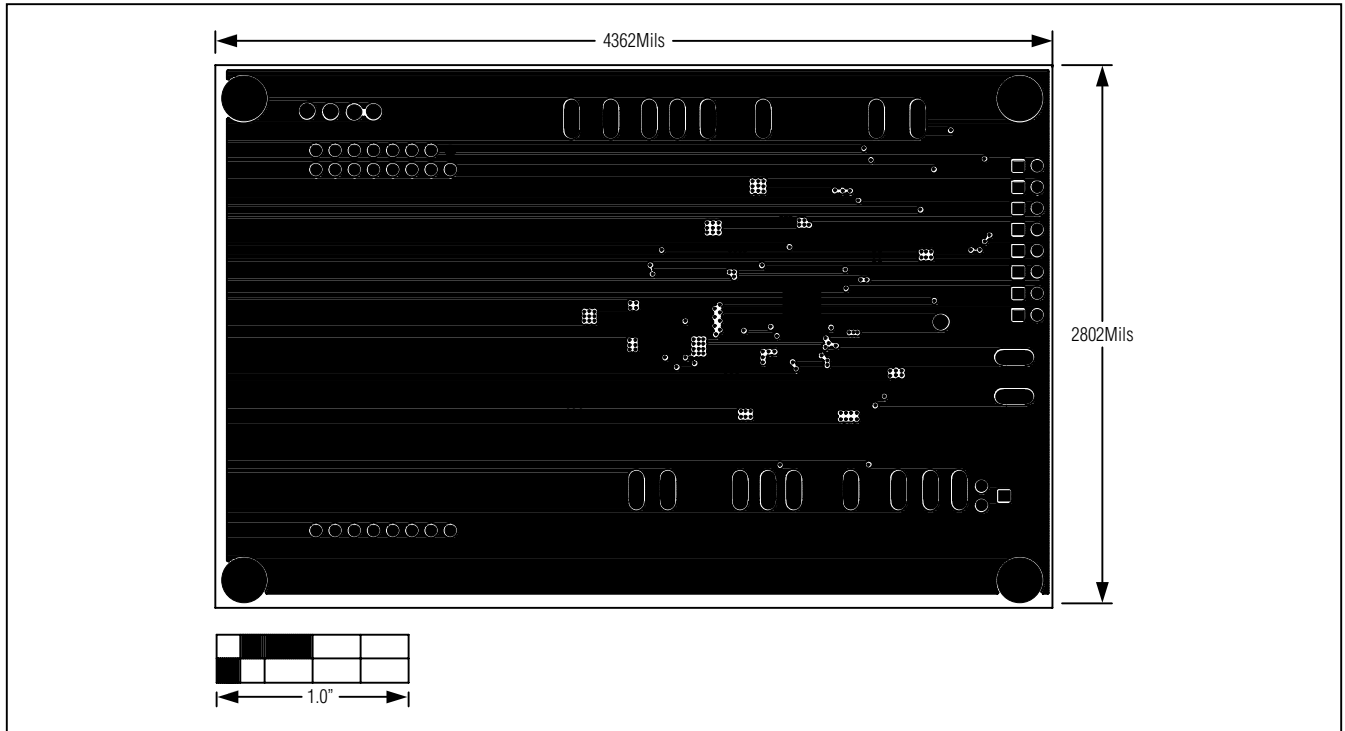
MAX8904 Evaluation Kit

Evaluates: MAX8904

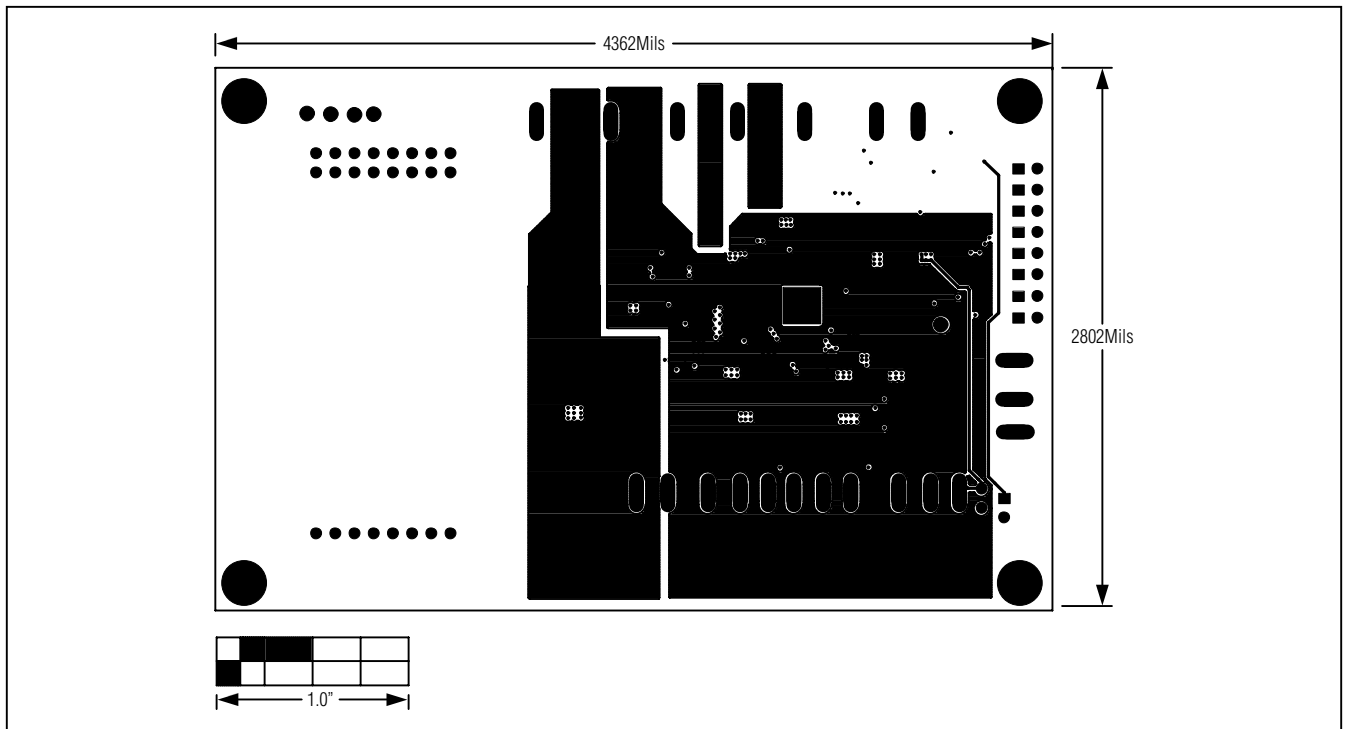Figure 7. MAX8904 EV Kit PCB Layout—PGND Layer 2

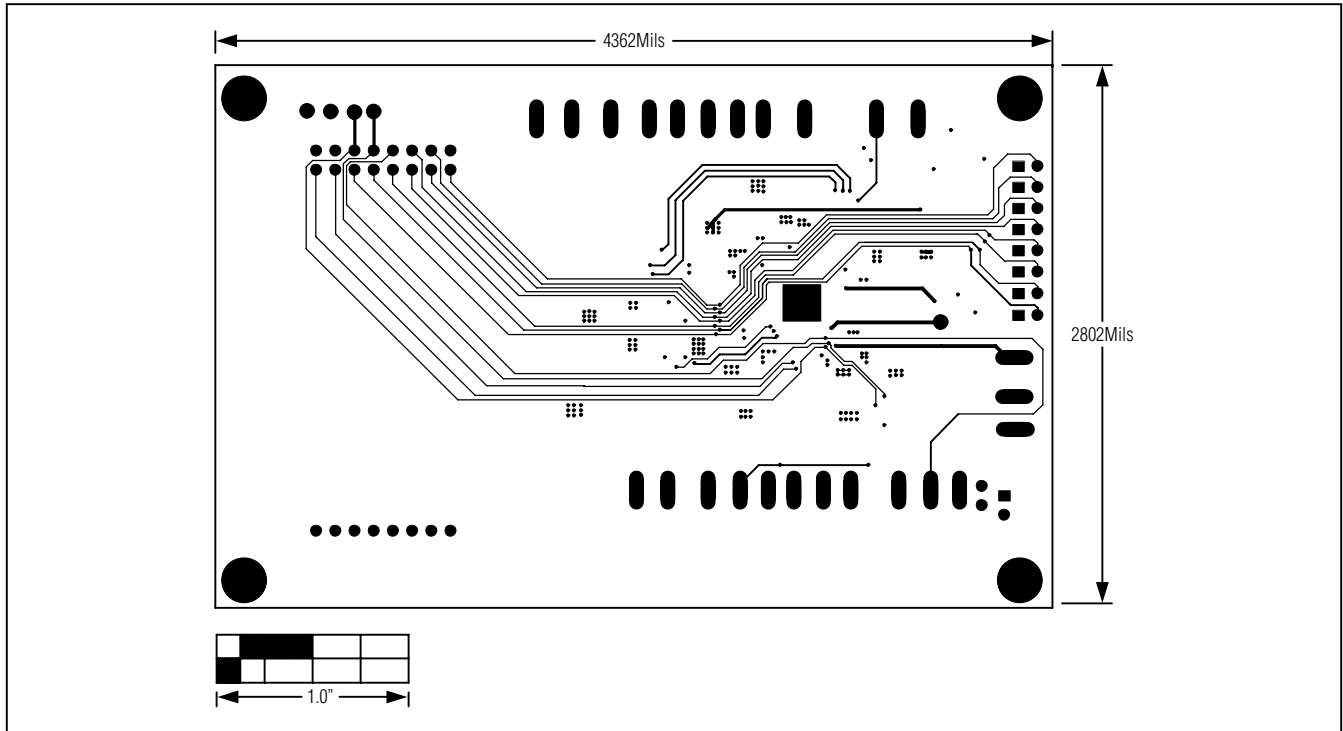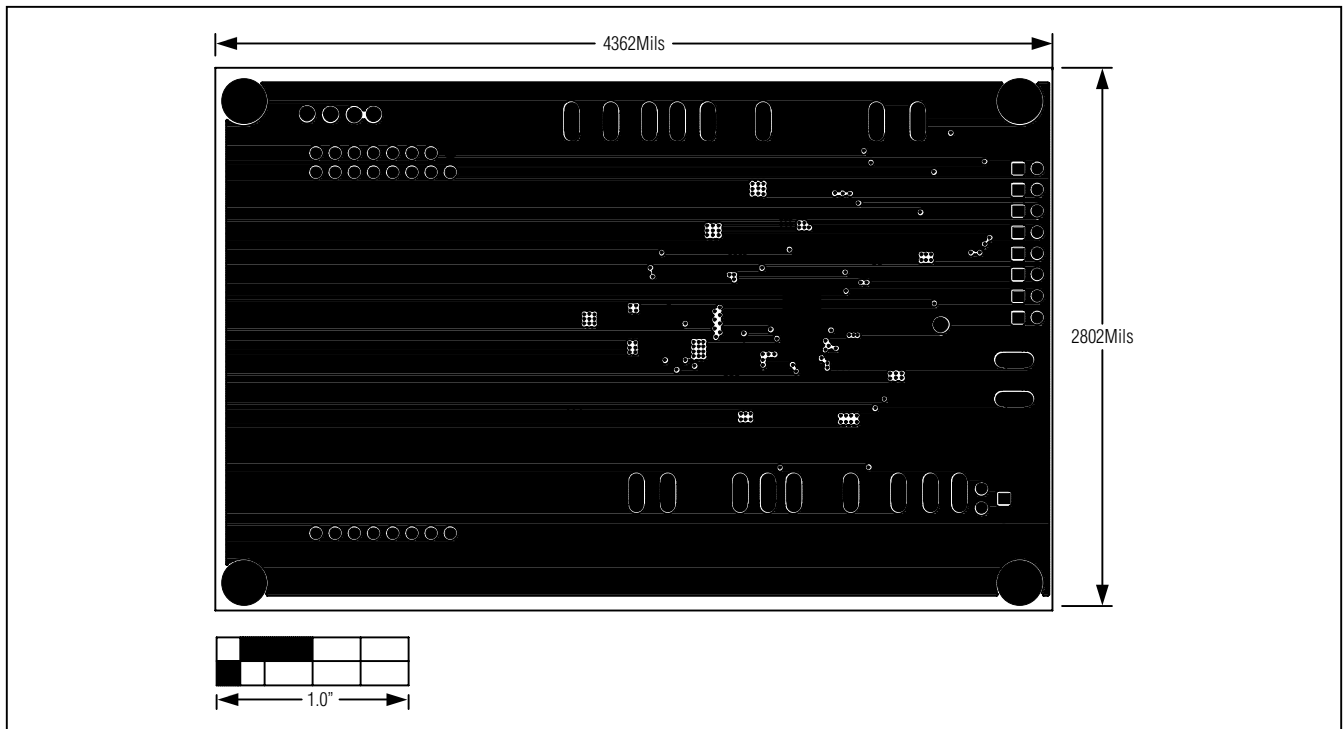Figure 8. MAX8904 EV Kit PCB Layout—Power Layer 3

Maxim Integrated

Figure 9. MAX8904 EV Kit PCB Layout—Routing Layer 4

Figure 10. MAX8904 EV Kit PCB Layout—GND Layer 5
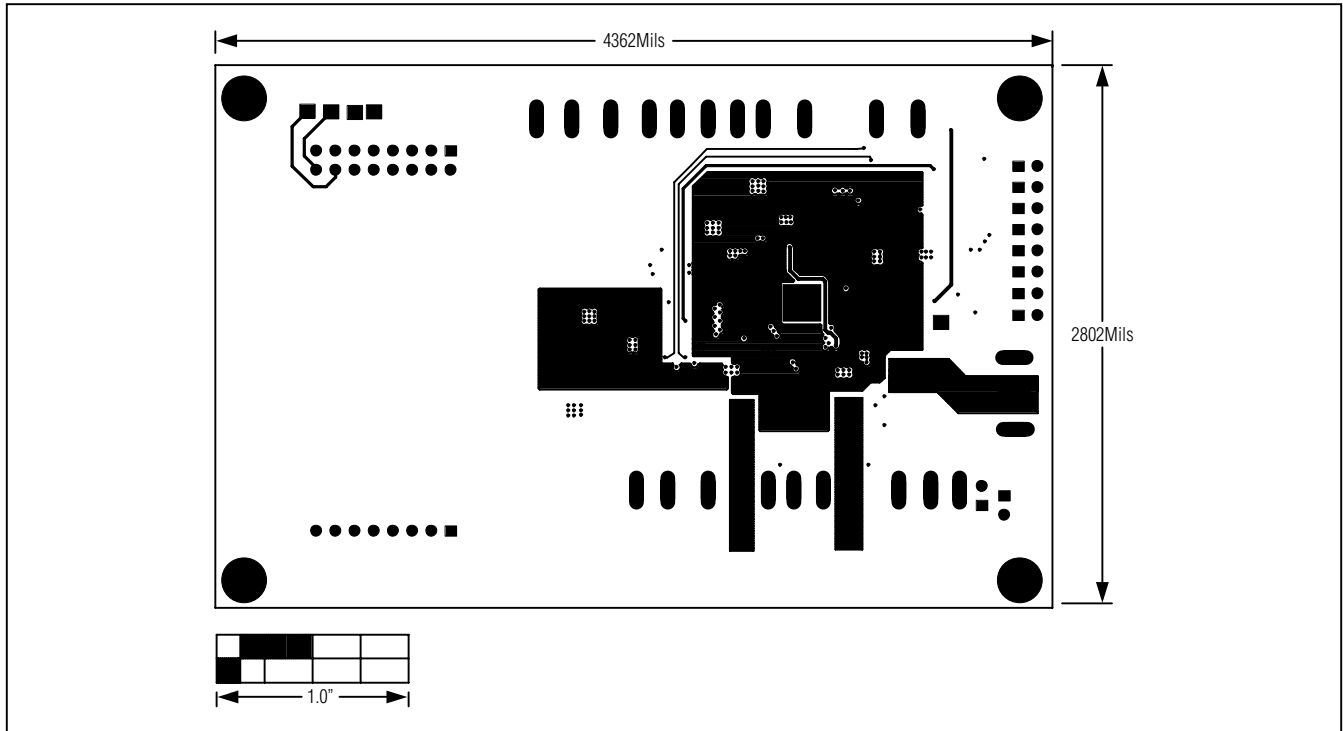
Figure 11. MAX8904 EV Kit PCB Layout—Bottom Layer 6

Maxim Integrated 160 Rio Robles, San Jose, CA 95134 USA 1-408-601-1000