19-4313; Rev 0; 10/08

MAX9694 Evaluation Kit

Evaluates: MAX9694

General Description

The MAX9694 evaluation kit (EV kit) demonstrates the MAX9694 reference voltage generator for gamma correction in TFT-LCD panels, such as those found in high-resolution TVs, high-end monitors, or for general industrial reference voltage generation. The MAX9694 EV kit provides 14 programmable reference voltage outputs (DAC outputs), four static buffered reference voltage outputs (reference outputs), and a 7-bit digital variable reference (DVR) for V_{COM} voltage calibration. The EV kit can use a 9V to 20V DC power supply for powering the application circuit.

The EV kit features a USB-to-I^2C interface circuit. Windows® 2000/XP- and Windows Vista®-compatible software, with a graphical user interface (GUI), is available for exercising the MAX9694 features. The EV kit can also connect to a user-supplied I^2C interface circuit for stand-alone MAX9694 operation.

Ordering Information

PART	TYPE
MAX9694EVKIT+	EV Kit

+Denotes lead-free and RoHS compliant.

Features

- **14 8-Bit Programmable Reference Voltages (DAC Outputs)**
- **Four Static Buffered Reference Voltages (Reference Outputs)**
- **Programmable V_{COM} Voltage Calibration**
- **400mA Peak Current on Reference Outputs and DAC Outputs 1, 7, 8, and 14**
- **200mA Peak Current on DAC Outputs 2–6 and 9–13**
- **Peak Output Currents**
  - **400mA: 4 DAC Outputs and 4 DAC Reference Outputs**
  - **200mA: 10 DAC Outputs**
- **9V to 20V DC Power-Supply Operation**
- **USB-Powered USB-to-I^2C Interface Circuit**
- **Windows 2000/XP/Vista (32-Bit)-Compatible Software**
- **Lead-Free and RoHS Compliant**
- **Proven PCB Layout**
- **Fully Assembled and Tested**

Component List

DESIGNATION	QTY	DESCRIPTION
C1–C18	0	Not installed, ceramic capacitors (0603)
C19, C21, C23, C25, C27–C34, C40, C41, C42	15	0.1µF ±10%, 25V X7R ceramic capacitors (0603) Murata GRM188R71E104K or TDK C1608X7R1E104K
C20, C26, C45, C47	4	10µF ±10%, 10V X7R ceramic capacitors (0805) Murata GRM21BR71A106K
C22, C24	2	10µF ±10%, 25V X5R ceramic capacitors (1206) Murata GRM31CR61E106K
C35, C36	2	10pF ±5%, 50V C0G ceramic capacitors (0603) Murata GRM1885C1H100J or TDK C1608C0G1H100J

DESIGNATION	QTY	DESCRIPTION
C37	1	3300pF ±10%, 50V X7R ceramic capacitor (0603) Murata GRM188R71H332K or TDK C1608X7R1H332K
C38, C39	2	22pF ±5%, 50V C0G ceramic capacitors (0603) Murata GRM1885C1H220J or TDK C1608C0G1H220J
C43, C44, C46	3	1µF ±10%, 10V X5R ceramic capacitors (0603) Murata GRM188R61A105K or TDK C1608X5R1A105K
D1	1	Green LED (0603) Panasonic LNJ314G8TRA
FB1	0	Not installed, ferrite-bead inductor (0603)

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Component List (continued)

DESIGNATION	QTY	DESCRIPTION
J1	0	Not installed, dual-row (2 x 20) 40-pin header
J2	0	Not installed, dual-row (2 x 2) 4-pin header
JU1	1	3-pin header
JU2	1	5-pin header
OUT_1–OUT_14, OUTREFUH, OUTREFUL, OUTREFLH, OUTREFLL	0	Not installed, small PCB test points
R1–R20, R29–R46, R58	0	Not installed, resistors (0603) R1–R20, R58 are open; R29–R46 are short
R21, R25	2	100Ω ±1% resistors (0603)
R22, R24	2	4.32kΩ ±1% resistors (0603)
R23	1	1.21kΩ ±1% resistor (0603)
R26, R27, R50, R54, R55	5	2.2kΩ ±5% resistors (0603)
R28	1	3.3kΩ ±1% resistor (0603)
R47, R48	2	27Ω ±5% resistors (0603)
R49	1	1.5kΩ ±5% resistor (0603)
R51	1	10kΩ ±5% resistor (0603)
R52	1	220Ω ±5% resistor (0603)
R53	0	Not installed, resistor (0402)
R59	1	0Ω ±5% resistor (0603)

DESIGNATION	QTY	DESCRIPTION
U1	1	Reference voltage generator (32 TQFN-EP*) Maxim MAX9694ETJ+
U2	1	Low-power 16-bit microcontroller (68 QFN-EP*) Maxim MAXQ2000-RAX+
U3	1	93C46 3-wire 16-bit EEPROM (8 SO)
U4	1	UART-to-USB converter (32 TQFP)
U5	1	3.3V regulator (5 SC70) Maxim MAX8511EXK33+T (Top Mark: AEI)
U6	1	2.5V regulator (5 SC70) Maxim MAX8511EXK25+T (Top Mark: ADV)
U7	1	Dual bidirectional level translators (8 TDFN-EP*) Maxim MAX3394EETA+T (Top Mark: APE)
USB	1	USB type-B right-angle female receptacle
Y1	1	16MHz crystal
Y2	1	6MHz crystal
—	2	Shunts (JU1, JU2)
—	1	PCB: MAX9694 Evaluation Kit+

**EP = Exposed pad.*

Component Suppliers

SUPPLIER	PHONE	WEBSITE
Murata Electronics North America, Inc.	770-436-1300	www.murata-northamerica.com
Panasonic Corp.	800-344-2112	www.panasonic.com
TDK Corp.	847-803-6100	www.component.tdk.com

Note: *Indicate that you are using the MAX9694 when contacting these component suppliers.*

MAX9694 EV Kit Files

FILES	DESCRIPTION
INSTALL.EXE	Installs the EV kit files on your computer
MAX9694.EXE	Application program
REF.INI	Software Initialization File
FTD2XX.INF	USB device driver file
UNINST.INI	Uninstalls the EV kit software
USB_Driver_Help.PDF	USB driver installation help file

Quick Start

Required Equipment

Before beginning, the following equipment is needed:

- MAX9694 EV kit (USB cable included)
- A user-supplied Windows 2000/XP- or Windows Vista-compatible PC with a spare USB port
- 9V to 20V DC power supply @ 500mA
- One digital voltmeter (DVM)

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 MAX9694 EV kit is fully assembled and tested. Follow the steps below to verify board operation:

1) Visit **www.maxim-ic.com/evkitsoftware** to download the latest version of the EV kit software, 9694Rxx.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 temporary folder. The program files are copied and icons are created in the Windows **Start | Programs** menu.
3) Connect the USB cable from the PC to the EV kit board. A **New Hardware Found** window pops up when installing the USB driver for the first time. If you do not see a window that is similar to the one described above after 30 seconds, remove the USB cable from the board and reconnect it. Administrator privileges are required to install the USB device driver on Windows.
4) 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\MAX9694** (default installation directory) using the **Browse** button. During device driver installation, Windows may show a warning message indicating that the device driver Maxim uses does not contain a digital signature. This is not an error condition and it is safe to proceed with installation. Refer to the USB_Driver_Help.PDF document included with the software for additional information.
5) Once the software and hardware installation is complete, disconnect the USB cable from the EV kit.
6) Verify that shunts are installed as follows:

   JU1: Pins 1-2 (on-board 3.3V digital power supply)

   JU2: Pins 1-2 (MAX9694 write address = 0xE8)
7) Connect the USB cable to the EV kit.
8) Connect the DVM negative terminal to the AGND PCB pad next to the VREFL_L PCB pad.
9) Connect a voltage probe to the DVM positive terminal for later use.
10) Set the power supply to 15V and disable the power-supply output.
11) Connect the power-supply positive terminal to the AVDD PCB pad (center of board) and the negative terminal to the nearby AGND PCB pad.
12) Enable the power-supply output.
13) Start the MAX9694 EV kit software by opening its icon in the **Start | Programs** menu. The EV kit software main window appears, as shown in Figure 1.
14) Use the DVM voltage probe to measure the reference input voltages on the VREFU_H, VREFU_L, VREFL_H, and VREFL_L PCB pads, and type those values into the corresponding edit boxes of the **Reference Voltages (V)** group box in the software.

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15) Press the **Quick Start** button.

16) Use the DVM voltage probe to verify that the DAC output voltages are close to the voltages shown in the **Output (V)** edit boxes for the respective channel.

Detailed Description of Software

The MAX9694 evaluation software main window is shown in Figure 1. The GUI software automatically detects the MAX9694 device address and displays it in the **I2C Address Setting** drop-down list and in the software status bar. The DAC output voltages in the **Upper DAC Channels** and **Lower DAC Channels** group boxes are calculated using the upper and lower reference input voltages on PCB pads VREFU_H, VREFU_L, VREFL_H, and VREFL_L. The reference input voltages MUST be measured at the appropriate PCB pads and the values entered in the respective **Reference Voltages (V)** edit boxes for the DAC output calculations to be correct.

Upon IC startup, the DAC outputs wake up in high-impedance mode. To exit high-impedance mode, press the **Quick Start** button or perform the following steps:

1) Modify any of the DAC channel's register values. Register values are modified using the edit boxes and scrollbars of the **Register Settings** tab. See the *Output Register Values* section for more information.

2) Press the **Load All Values To Registers** button.

The **Quick Start** button loads all registers with the values shown in Figure 1.

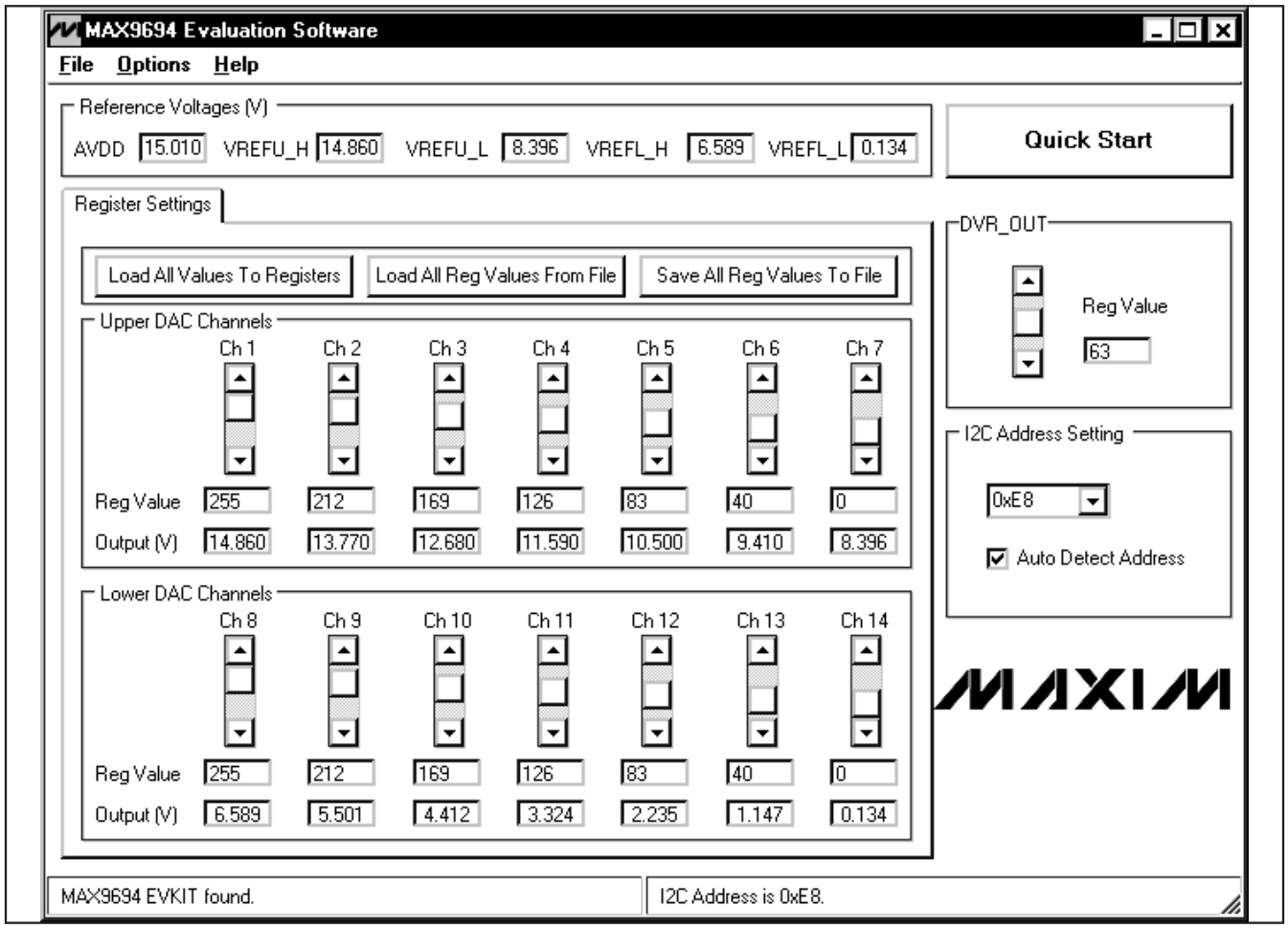

Figure 1. MAX9694 Evaluation Software Main Window

I²C Address Setting

The MAX9694's I²C slave address is displayed in the **I2C Address Setting** drop-down list and in the bottom status bar of the software window. If an address is manually selected in the drop-down list, the software verifies the address and changes the address displayed appropriately. If no acknowledge is received from the EV kit, a pop-up window opens, directing the user to properly set jumper JU2 on the EV kit. If the **Auto Detect Address** checkbox is checked, the software automatically detects the I²C address of the MAX9694.

Upper and Lower DAC Output Voltages

The upper and lower DAC output voltages are generated using an on-board resistor-divider network. The user can also apply external references to the VREFU_H, VREFU_L, VREFL_H, and VREFL_L and AGND PCB pads. The voltages on these four pads MUST be captured and typed into the appropriate edit boxes in the **Reference Voltages (V)** group box for the calculated DAC output voltages shown in the **Upper DAC Channels** and **Lower DAC Channels** group boxes to be correct.

The transfer function for the upper DAC channels is:

$$V_{OUT} = VREFU\_L + \frac{D}{256} \times (VREFU\_H - VREFU\_L)$$

The transfer function for the lower DAC channels is:

$$V_{OUT} = VREFL\_L + \frac{D}{256} \times (VREFL\_H - VREFL\_L)$$

In both equations, D is the register's decimal value. Refer to the MAX9694 IC data sheet for more details.

When the evaluation software is run for the first time, the reference input-voltage values in the **Reference Voltages (V)** group box are loaded from an initialization file (REF.INI). When the program is closed, the current values are logged into the initialization file. The next time the program is run, the latest values are loaded automatically.

Output Register Values

Each DAC channel's register value can be set in three ways within the **Upper DAC Channels** and **Lower DAC Channels** group boxes by:

- Moving the channel's scrollbar.
- Typing register values directly into the channel's **Reg Value** edit box (decimal 8-bit equivalent).
- Typing the expected output voltage in the channel's **Output (V)** edit box. The software uses a register value that generates a voltage closest to the desired voltage value.

When a register value is changed, the corresponding field changes its color to red. A user should synchronize the GUI fields and actual device registers by pressing the **Load All Values To Registers** button.

The **Load All Reg Values From File** button is used to load all the register values and reference voltages from a user-selected text file. The **Save All Reg Values To File** button is used to save all the register values and reference voltages on the current GUI to a user-named text file.

V_{COM} Calibration

V_{COM} calibration is controlled using the scrollbar and edit box of the **DVR_OUT** group box (see the *Hardware Configuration for V_{COM} Calibration* section to make use of this feature). The register value for the 7-bit DAC controls the DVR_OUT sink current adjusting the voltage at the DVR_OUT pin as follows:

$$V_{DVR} = \left(\frac{R20}{R19 + R20}\right) \times \left(1 - \left(\frac{D+1}{128}\right) \times \left(\frac{R19}{20 \times R28}\right)\right) \times AVDD$$

where D is the DVR_OUT 7-bit register value and AVDD is the voltage at the AVDD PCB pad.

Advanced User Interface

A serial interface can be used by advanced users by clicking **Options | Interface (Advanced Users)** from the menu bar.

Click on the **2-wire interface** tab shown in Figure 2. Press the **Hunt for active listeners** button to obtain the current MAX9694 slave address in the **Target Device Address:** combo box. In the **General commands** tab select **1 – SMBusWriteByte(addr,cmd,data8)** in the **Command (SMBus Protocols, Raw Block Read/Write, EEPROM Read/Write)** drop-down list. Enter the desired values into the **Command byte:** and **Data Out:** combo boxes and then press the **Execute** button.

Detailed Description of Hardware

The MAX9694 EV kit demonstrates the MAX9694 reference voltage generator in a 32-pin TQFN surface-mount package with an exposed pad. EV kit applications include gamma correction in TFT-LCD panels, such as those found in high-resolution TVs, high-end monitors, or for general industrial reference voltage generation. Using four input reference voltages (DAC reference inputs), the MAX9694 EV kit provides 14 programmable reference voltage outputs (DAC out-

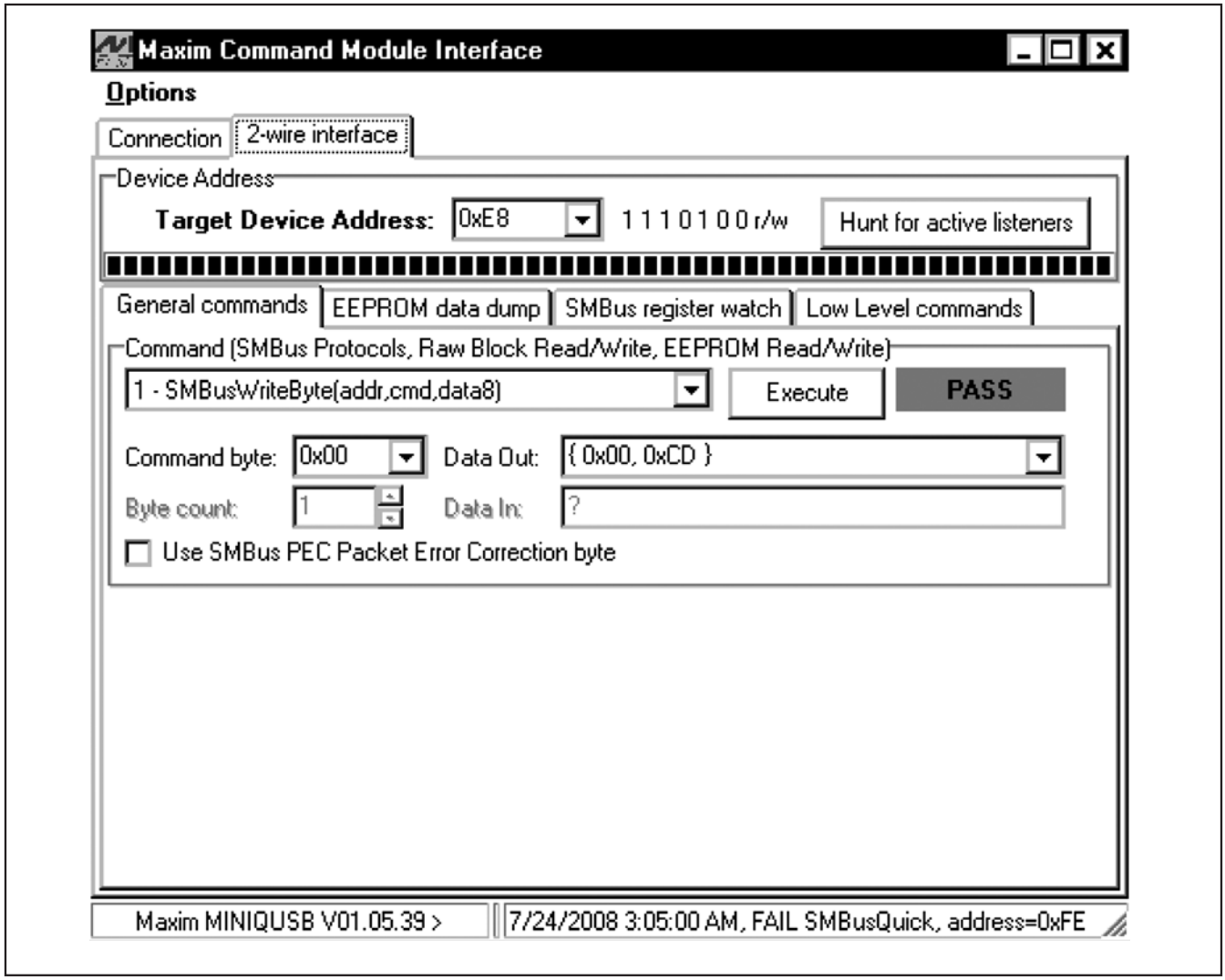

Figure 2. Advanced I²C User Interface Window (2-Wire Interface Tab)

puts), four static buffered reference voltage outputs (reference outputs), and a 7-bit DVR output for calibrating a V_{COM} voltage.

To monitor the MAX9694 EV kit's 14 DAC outputs (OUT1–OUT14), and four reference outputs (OUT_REFU_H, OUT_REFU_L, OUT_REFL_H, and OUT_REFL_L), use header J1 or the labeled test points. Reference outputs OUT_REFU_H, OUT_REFU_L, OUT_REFL_H, OUT_REFL_L and DAC outputs OUT1, OUT7, OUT8, and OUT14 provide 400mA of peak current. DAC outputs OUT2–OUT6 and OUT9–OUT13 provide 200mA of peak current. Please stay within the MAX9694 IC's power rating. Refer to the MAX9694 IC data sheet for more information.

The on-board resistor-divider network (R21–R25) generates the reference inputs (REFU_H, REFU_L, REFL_H, and REFL_L). The user can also apply external reference voltages to the VREFU_H, VREFU_L, VREFL_H, and VREFL_L PCB pads after removing resistors R21–R25.

The EV kit uses a 9V to 20V DC power supply, connected across the AVDD and AGND PCB pads, for powering the EV kit application circuit. The EV kit may require up to 500mA of supply current depending on output loading.

The USB-to-I²C interface circuit is powered by 2.5V and 3.3V Maxim MAX8511 voltage regulators. The application circuit's digital supply (DVDD) can operate from the on-board 3.3V supply or from a 2.7V to 3.6V user supply. A Maxim MAX3394E dual, bidirectional level translator provides logic-level translation between the MAXQ2000 low-power 16-bit microcontroller and the featured MAX9694 reference voltage generator.

Hardware Configuration for V_{COM} Calibration

To make use of the MAX9694 V_{COM} calibration feature, connect the DVR_OUT PCB pad to a V_{COM} amplifier or install appropriate values for resistors R19 and R20. By default, the EV kit comes with 3.3kΩ installed at set resistor R28. Refer to the *Digital Variable Reference (DVR)* section of the MAX9694 IC data sheet for more information.

Digital Supply Configuration

The MAX9694 EV kit provides two options to power the MAX9694 DVDD, digital supply input. DVDD can operate from the 3.3V supply generated by the USB-to-I²C interface circuit or from a user-supplied 2.7V to 5.5V DC power supply connected across the DIN and DGND PCB pads. The user supply must provide a minimum of 100mA. See Table 1 to configure DVDD using jumper JU1.

Caution: Always ensure that DVDD is powered before AVDD.

MAX9694 Slave Address Description

The MAX9694 I²C slave address can be set by jumper JU2. The slave address can be set to one of four different addresses. See Table 2 for slave address configuration.

Stand-Alone User-Supplied I²C Communication

The MAX9694 EV kit can be used in stand-alone operation to interface with a user's I²C system without using a PC. To use the MAX9694 EV kit with a user-supplied I²C interface, perform the following steps:

1) Disconnect the USB cable from the EV kit.
2) Cut open the shorting traces of jumper J2 on the top layer.
3) Move the jumper JU1 shunt to pins 2-3.
4) Connect the positive terminal of a user-supplied 2.7V to 5.5V DC power supply to the DIN PCB pad and the negative terminal to the nearby DGND PCB pad.
5) If the user-supplied I²C interface circuit includes pullup resistors for SDA and SCL, remove resistors R26 and R27. Resistors R26 and R27 are pulled up to DVDD.
6) Connect the user-supplied I²C interface signals and signal ground return to the EV kit PCB pads, as shown in Table 3.

Table 1. Digital Supply Configuration (Jumper JU1)

SHUNT POSITION	DVDD PIN CONNECTION	DVDD POWER	I²C COMMUNICATION
1-2*	3.3V	On-board	On-board
2-3	DVDD PCB pad	User-supplied DVDD range: 3.3V to 5.5V**	On-board
2-3	DVDD PCB pad	User-supplied DVDD range: 2.7V to 5.5V	User-supplied

**Default position.*

***Minimum DVDD is limited to 3.3V by the USB-to-I²C interface circuit 3.3V logic level.*

Table 2. Slave Address Configuration (Jumper JU2)

SHUNT POSITION	A0 PIN CONNECTION	MAX9694 ADDRESS (hex)	
		WRITE	READ
1-2*	DGND	0xE8	0xE9
1-3	DIN	0xEA	0xEB
1-4	SCL	0xEC	0xED
1-5	SDA	0xEE	0xEF

**Default position.*

Table 3. User-Supplied I²C Interface

USER-SUPPLIED SIGNAL	SIGNAL	EV KIT PCB PAD
SDA	I²C data	SDA
SCL	I²C clock	SCL
GND	Signal ground return	DGND

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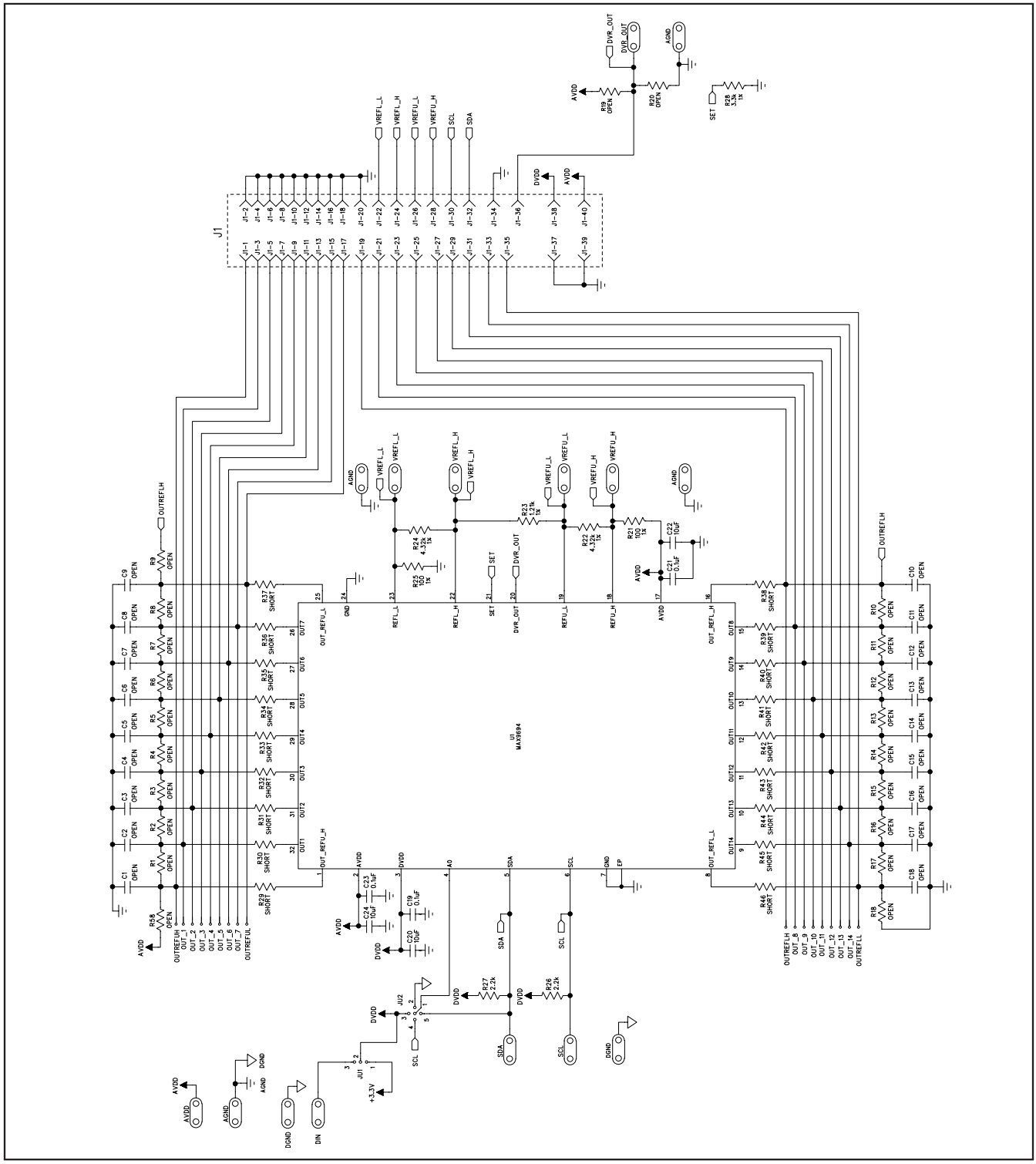

Figure 3. MAX9694 EV Kit Schematic—Application Circuit

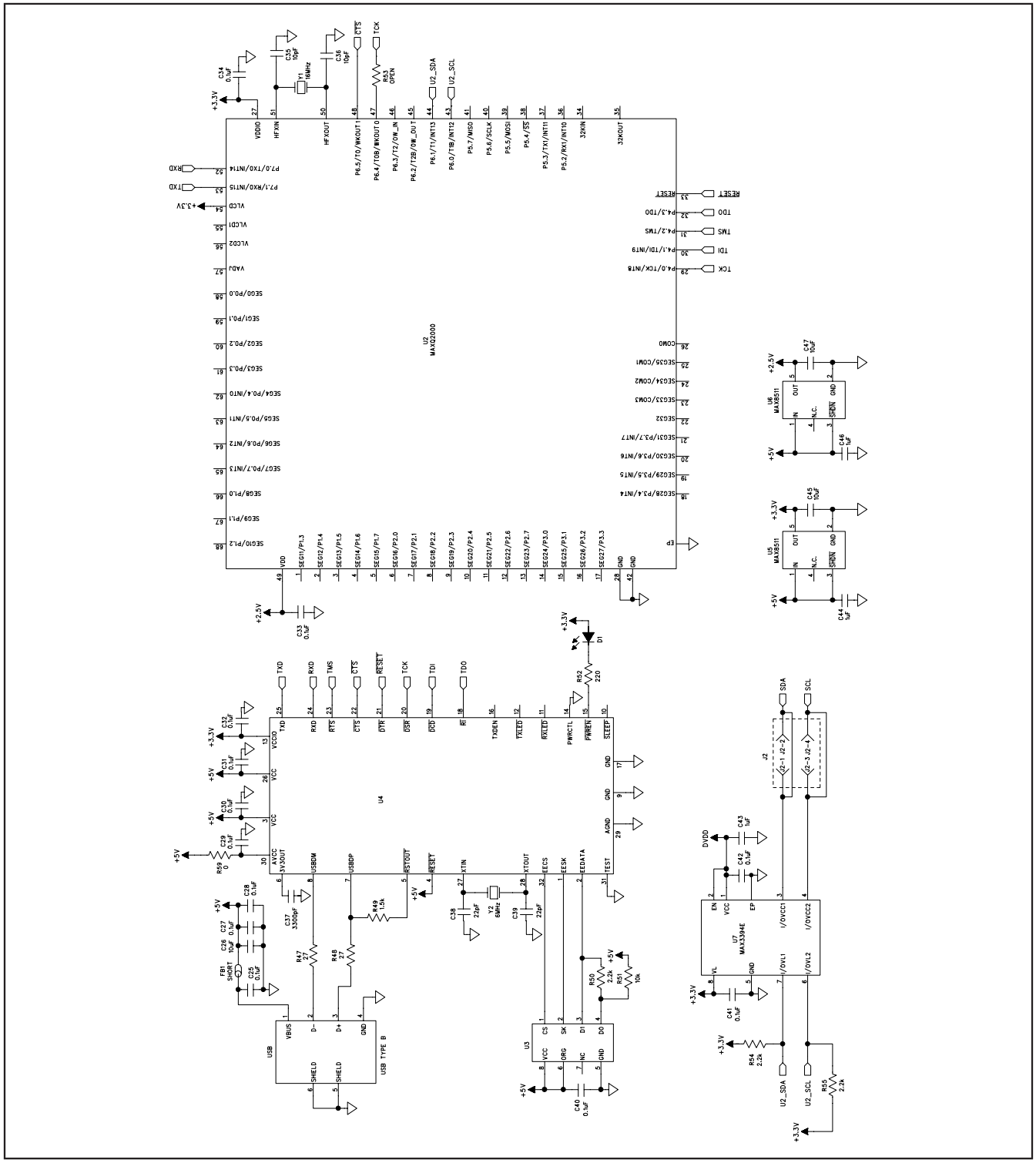

Figure 4. MAX9694 EV Kit Schematic—USB-to-I²C Circuit

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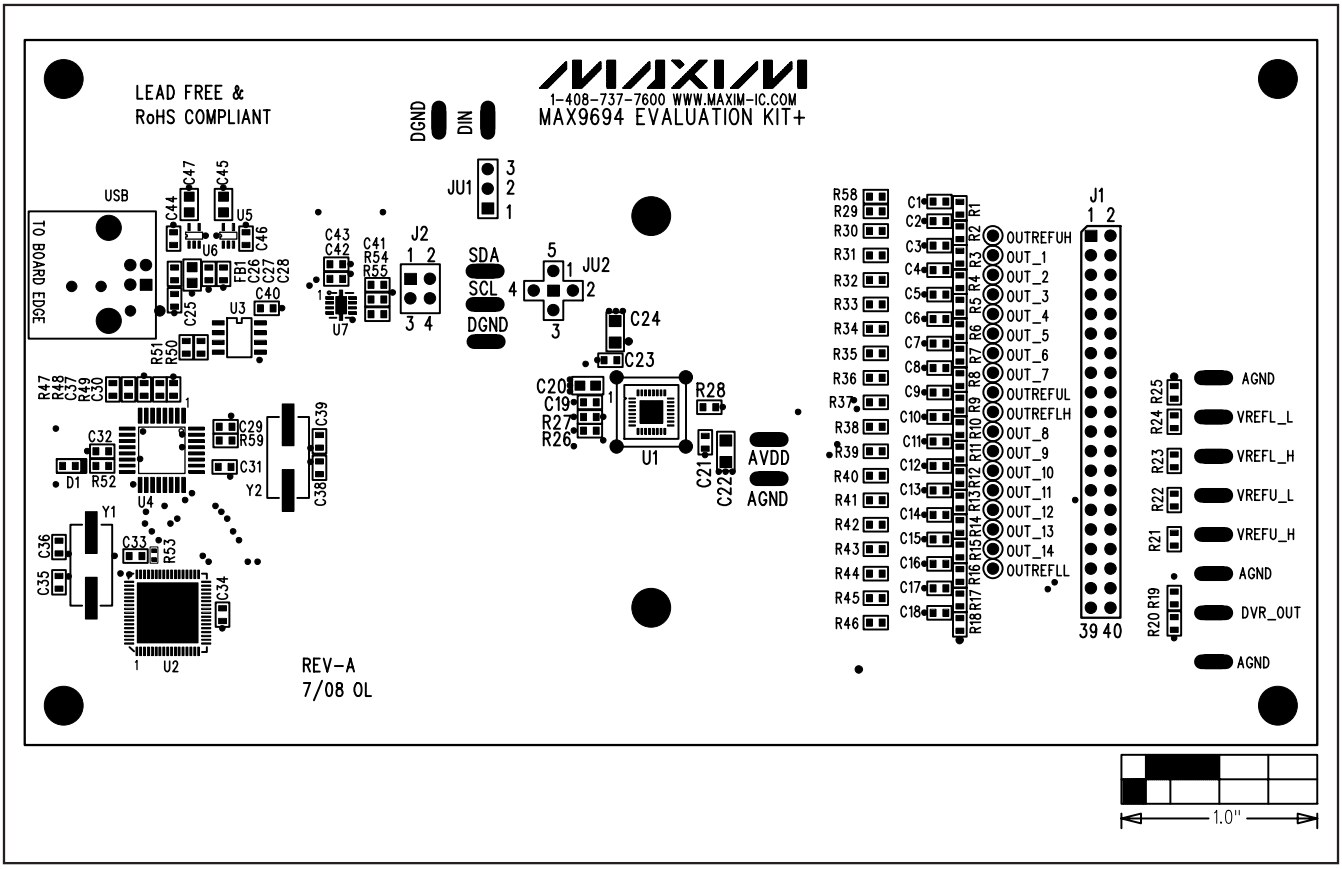

Figure 5. MAX9694 EV Kit Component Placement Guide—Component Side

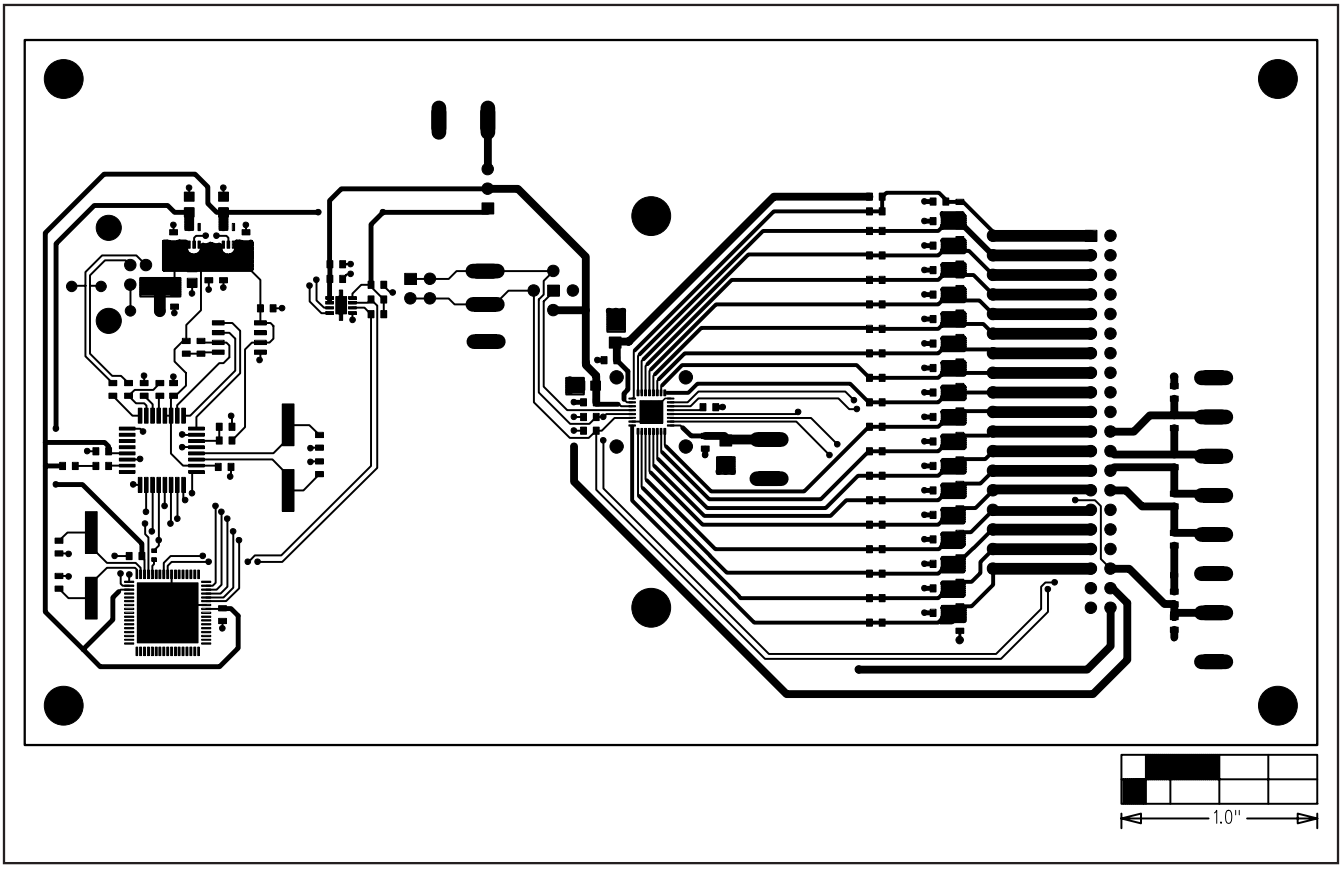

Figure 6. MAX9694 EV Kit PCB Layout—Component Side

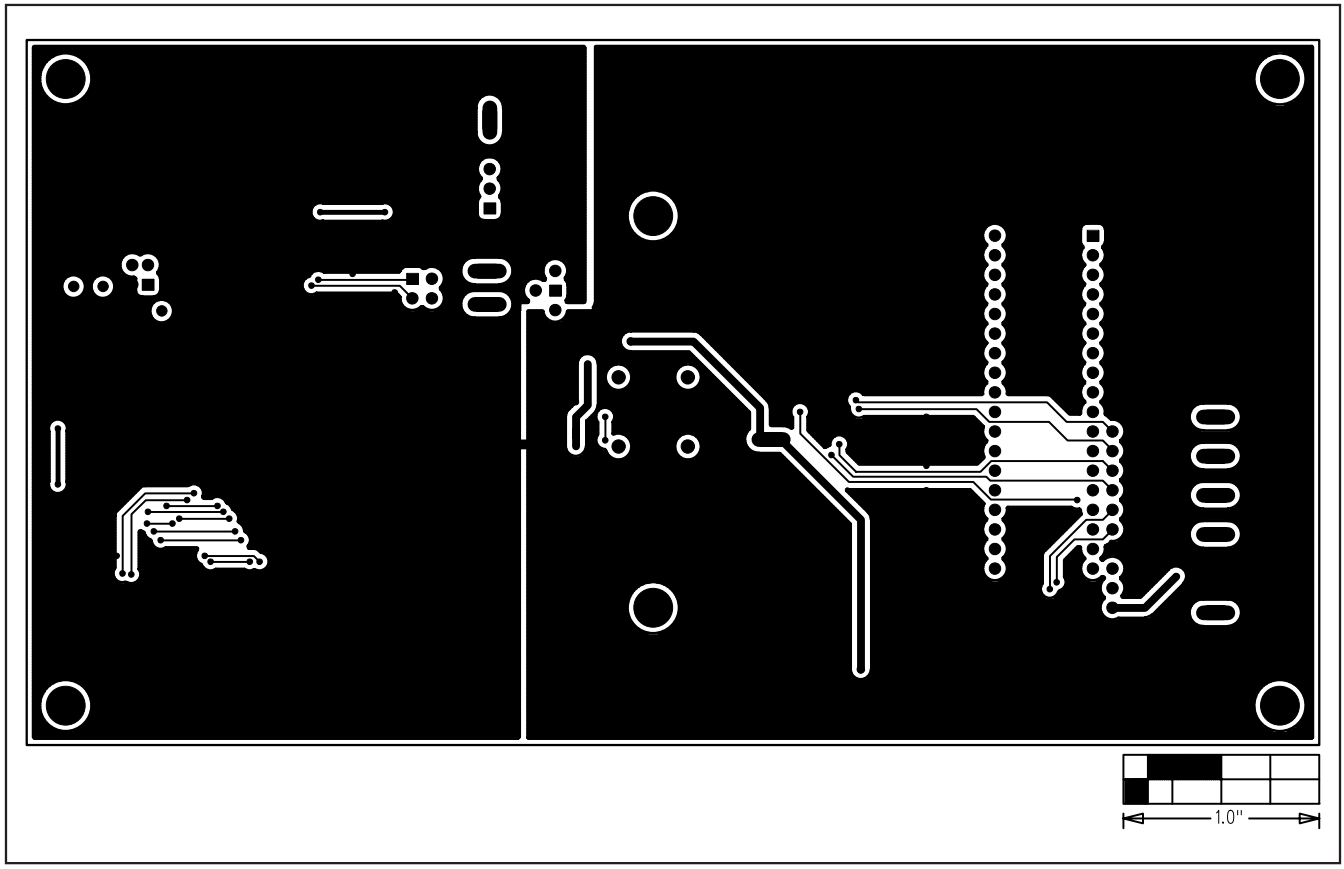

Figure 7. MAX9694 EV Kit PCB Layout—Solder Side