19-4248; Rev 0; 8/08

MAX5961 Evaluation Kit

Evaluates: MAX5961

General Description

The MAX5961 evaluation kit (EV kit) circuit demonstrates the MAX5961 quad-channel hot-swap controller that provides voltage and current monitoring. The EV kit circuitry features several jumpers to configure the MAX5961 initial settings. The input voltage range, output voltage limit(s), output current limit(s), and fault-management features are all software programmable. Each channel's undervoltage lockout threshold is also configurable by installing external components. FAULT_, PG_, and ALERT output signals are provided for circuit monitoring during evaluation.

The EV kit includes Windows® 2000/XP/Vista® (32-bit)-compatible software that provides a simple graphical user interface (GUI) for exercising the MAX5961 features.

Features

- **Safely Hot Swaps Four Independent 0V to 16V Power Supplies After Power-Up**
- **4-Layer, 2oz Copper PCB Designed for 20A Loads**
- **Multiple Output Signals with LEDs for Visual Monitoring**
- **Configurable Hot-Swap Channel Undervoltage Lockout Thresholds**
- **On-Board I²C Communication Interface Circuitry and USB Interface**
- **Windows 2000/XP/Vista (32-Bit)-Compatible Evaluation Software**
- **Fully Assembled and Tested**

Ordering Information

PART	TYPE
MAX5961EVKIT+	EV Kit

+Denotes lead-free and RoHS compliant.

Component List

DESIGNATION	QTY	DESCRIPTION
C1, C3–C10, C17, C21, C39	12	0.1µF ±10%, 16V X7R ceramic capacitors (0603) TDK C1608X7R1C104K
C2, C13, C15	3	10µF ±20%, 6.3V X5R ceramic capacitors (0805) TDK C2012X5R0J106M
C11, C12	2	10pF ±5%, 50V C0G ceramic capacitors (0603) TDK C1608C0G1H100J
C14, C16, C38, C40, C41	5	1µF ±10%, 25V X5R ceramic capacitors (0603) Murata GRM188R61E105K
C18, C19	2	22pF ±5%, 50V C0G ceramic capacitors (0603) TDK C1608C0G1H220J
C20	1	3300pF ±10%, 50V X7R ceramic capacitor (0603) TDK C1608X7R1H332K
C22, C24, C26, C28, C30, C32, C34, C36	8	10µF ±10%, 25V X5R ceramic capacitors (1206) Murata GRM31CR61E106K
C23, C27, C31, C35	4	4700pF ±10%, 50V X7R ceramic capacitors (0603) TDK C1608X7R1H472K or Murata GRM188R71H472K
C25, C29, C33, C37, C42–C45	0	Not installed, electrolytic capacitors
D1	1	200mA, 20V Schottky diode array (6 SOT363) Diodes Inc. BAT54CDW (Top Mark: KL7)
D2, D3	2	200mA, 25V Schottky diodes (3 SOT23) Fairchild BAT54 (Top Mark: L4P) Diodes Inc. BAT54 (Top Mark: KL1)

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MAX5961 Evaluation Kit

Component List (continued)

DESIGNATION	QTY	DESCRIPTION
D4–D8	5	Green LEDs (0603) Panasonic LNJ308G8TRA
D9–D13	5	Red LEDs (0603) Panasonic LNJ208R8ARA
D14–D17	4	4.7V zener diodes (SOD523) Diodes Inc. BZT52C4V7T (Top Mark: W7)
GND	1	Multipurpose PC test point, black
JU1–JU9	9	3-pin headers
JU10–JU16	7	2-pin headers
N1, N3, N5, N7	4	30V, 16A n-channel MOSFETs (8 SO) International Rectifier IRF7805Z
N2, N4, N6, N8	4	60V, 115mA n-channel MOSFETs (3 SOT23) Diodes Inc. 2N7002-7-F (Top Mark: K72)
P1–P5	5	-50V, 130mA p-channel MOSFETs (3 SOT23) Diodes Inc. BSS84 (Top Mark: K84)
R1, R8, R11, R21, R23, R25, R27, R55, R56, R57, R62, R63	0	Not installed, resistors (0603) R1, R8, R11, R55, R56, R62 shorted with PCB trace
R2	1	220Ω ±5% resistor (0603)
R3	1	10kΩ ±5% resistor (0603)
R4	1	2.2kΩ ±5% resistor (0603)
R5	1	1.5kΩ ±5% resistor (0603)
R6, R7	2	27Ω ±5% resistors (0603
R9, R10	2	4.7kΩ ±5% resistors (0603)
R12–R15	4	1kΩ ±1% resistors (0603)
R16–R19	4	0.005Ω ±1%, 2W sense resistors (2512) IRC LRC-LRF-2512LF-01-R005-F
R20, R22, R24, R26	4	100kΩ ±1% resistors (0603)
R28, R31, R34, R37, R40–R43, R48, R49, R50	11	1kΩ ±5% resistors (0603)
R44, R51–R54, R58–R61, R64–R67	13	100kΩ ±5% resistors (0603)
R29, R30, R32, R33, R35, R36, R38, R39, R46	9	150Ω ±5% resistors (0603)
R45, R47	2	10Ω ±5% resistors (0603)
TP1–TP27	27	Mini test points, red
TP28, TP29,	0	Not installed test points
U1	1	Quad, hot-swap controller (48 TQFN-EP) Maxim MAX5961ETM+
U2	1	Microcontroller (68 QFN-EP) Maxim MAXQ2000-RAX+
U3	1	93C46 type 3-wire EEPROM (8 SO)
U4	1	UART-to-USB converter (32 TQFP)
U5	1	3.3V regulator (5 SOT23) Maxim MAX8888EZK33+T (Top Mark: ADQC)
U6	1	2.5V regulator (5 SC70) Maxim MAX8511EXK25+T (Top Mark: ADV)
U7	1	16-port I/O expander (24 TQFN-EP) Maxim MAX7313ATG+
USB	1	USB series B right-angle PC mount receptacle
VIN	1	Multipurpose PC test point, red
VS1, VO1, VS2, VO2, VS3, VO3, VS4, VO4, GND (8x)	16	Noninsulated banana jack connectors
Y1	1	16MHz crystal
Y2	1	6MHz crystal
—	16	Shunts
—	1	PCB: MAX5691 Evaluation Kit+

Component Suppliers

SUPPLIER	PHONE	WEBSITE
Diodes Inc.	805-446-4800	www.diodes.com
Fairchild Semiconductor	888-522-5372	www.fairchildsemi.com
IRC, Inc.	361-992-7900	www.irctt.com
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
Vishay	402-563-6866	www.vishay.com

Note: *Indicate that you are using the MAX5961 when contacting these component suppliers.*

MAX5961 EV Kit Software Files

FILE	DESCRIPTION
INSTALL.EXE	Installs the EV kit files on your computer
MAX5961.EXE	Application program
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.

- MAX5961 EV kit (USB cable included)
- A user-supplied Windows 2000/XP/Vista PC with a spare USB port
- Four 16V DC power supplies
- Four voltmeters

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 MAX5961 EV kit is a fully assembled and tested surface-mount board. Follow the steps below for simple board operation. Do not turn on the power supplies until all connections are completed.

1) Visit **www.maxim-ic.com/evkitsoftware** to download the latest version of the EV kit software, 5961Rxx.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) Adjust the four power supplies to 5V and then disable the outputs.
4) Verify that shunts are installed across pins 2-3 of jumpers JU1–JU4 (maximum fast-trip voltage limit set to 25mV).
5) Verify that a shunt is installed across pins 2-3 of jumper JU5 (independent channel control).
6) Verify that a shunt is installed across pins 1-2 of jumper JU6 ($\overline{ALERT}$ output asserted and PG_ output deasserted upon critical UV/OV fault).
7) Verify that shunts are installed across pins 2-3 of jumpers JU7 and JU8 (MAX5961 I^2C address = 0x74).
8) Verify that a shunt is installed across pins 2-3 of jumper JU9 (+3.3V powers U1).
9) Verify that shunts are not installed across jumpers JU10, JU11, JU13, and JU14 (undervoltage lockout threshold for each input channel set to 0.6V).
10) Verify that a shunt is installed on jumper JU12 (latch-off mode).
11) Verify that a shunt is not installed on jumper JU15 (hardware enable, EN2 bit set to 1).
12) Verify that a shunt is not installed on jumper JU16 (PG_ output signal polarity set to active-high).

13) Connect the positive terminal of the 1st power supply to the VS1 banana jack connector and the negative terminal to the GND banana jack connector.
14) Connect the positive terminal of the 2nd power supply to the VS2 banana jack connector and the negative terminal to the GND banana jack connector.
15) Connect the positive terminal of the 3rd power supply to the VS3 banana jack connector and the negative terminal to the GND banana jack connector.
16) Connect the positive terminal of the 4th power supply to the VS4 banana jack connector and the negative terminal to the GND banana jack connector.
17) Connect the positive terminal of the 1st voltmeter to the VO1 PC pad and the negative terminal to the GND PC pad.
18) Connect the positive terminal of the 2nd voltmeter to the VO2 PC pad and the negative terminal to the GND PC pad.
19) Connect the positive terminal of the 3rd voltmeter to the VO3 PC pad and the negative terminal to the GND PC pad.
20) Connect the positive terminal of the 4th voltmeter to the VO4 PC pad and the negative terminal to the GND PC pad.
21) 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 30s, remove the USB cable from the board and reconnect it. Administrator privileges are required to install the USB device driver on Windows.
22) 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\MAX5961** (default installation directory) using the **Browse** button. During device driver installation, Windows might 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 for additional information.
23) Start the MAX5961 EV kit software by opening its icon in the **Start | Programs** menu. The EV kit software main window appears as shown in Figure 1.
24) Enable the four power-supply outputs.
25) Verify that the PG_ green LEDs (D5–D8) are on.
26) Verify that the $\overline{\text{FAULT\_}}$ and $\overline{\text{ALERT}}$ red LEDs (D9–D13) are off.
27) Verify that the four voltmeters measure 5V.
28) The EV kit is ready for further testing.

Detailed Description of Software

The MAX5961 EV kit GUI software provides a user interface (Figure 1) to control the programmable features of the MAX5961 IC. To start the MAX5961 EV kit software, double click the MAX5961 EV kit icon created during installation. The user has to wait approximately 2s while the software detects and configures the MAX5961 EV kit.

Note: In the following sections, words in **boldface** are user-selectable features in the software.

Graphical User Interface

The user interface (shown in Figure 1) is easy to operate. Use the mouse, or press the Tab key to navigate through the GUI controls. The software divides the EV kit functions into logical blocks. At the top, the Interface box contains system functions and each tab groups functions for each channel. The correct I^2C read or write operation is generated to access the internal memory registers of the MAX5961 when any of these controls are used.

Use the **Device Address** combo box to select the MAX5961 I^2C address. The **Silence I2C Activity** checkbox enables the software to continually read the MAX5961 IC's status and data registers and check that all the devices on the bus are working properly. These functions create activity on the I^2C bus. Check the **Silence I2C Activity** checkbox to reduce I^2C bus activity and enable easy triggering of an oscilloscope. Use the **Read All Registers** button to perform a read of all the MAX5961 IC registers and update the GUI with each register's data. The status bar located at the bottom of the GUI displays the status of the I/O expander, the registers accessed, and the data received or sent.

Software Startup

During startup, the MAX5961 EV kit software automatically searches first for the Maxim microcontroller (U2), which is used for I^2C communication, the MAX7313 I/O expander (U7), and then for the MAX5961. The status LED D4 indicates if the microcontroller is operational. If the microcontroller is not found, verify that the USB cable is connected properly, power is applied to the EV kit, and then click the YES button on the retry-connec-

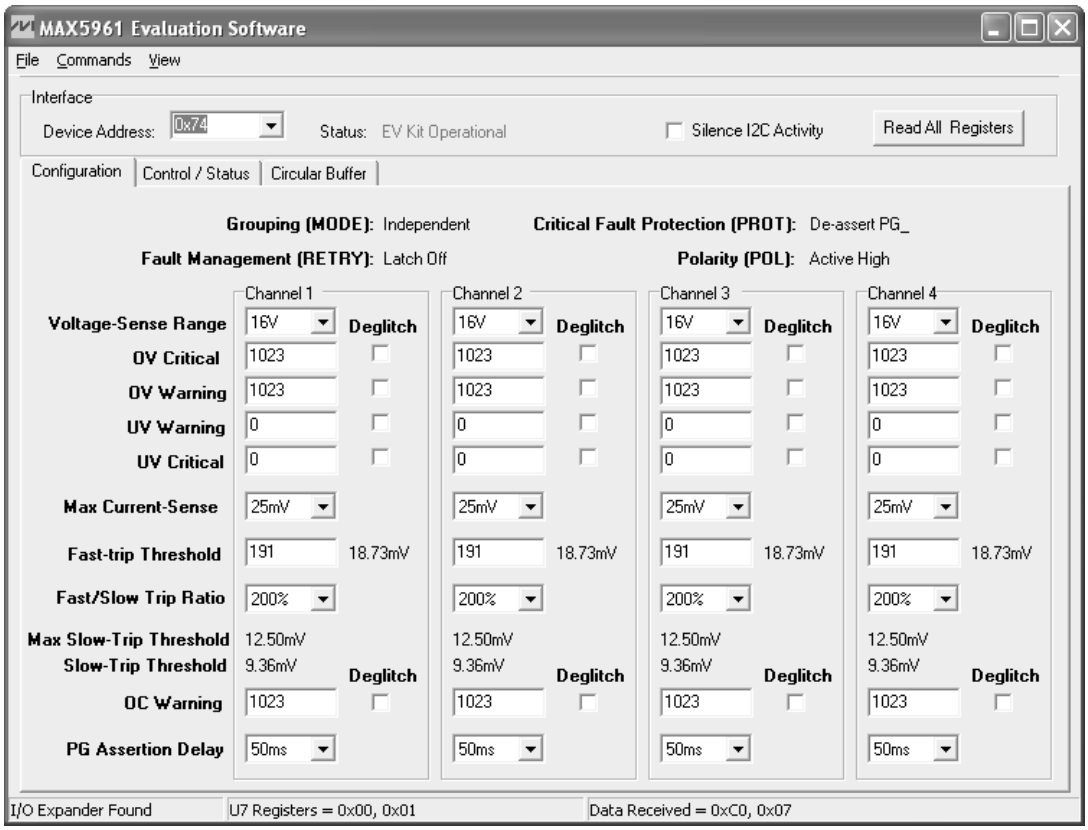

Figure 1. MAX5961 EV Kit Software Main Window

tion message box. Upon power-up, the software reads the data from all the registers and displays the data in their corresponding GUI fields.

The nonfunctional GUI can be viewed by clicking the NO button on the retry-connection message box when attempting to start the software without connecting to the EV kit. Restart the software with the EV kit properly connected for normal operation.

Configuration

The EV kit software **Configuration** tab (Figure 1) displays the MODE, PROT, RETRY, and POL general settings at the top, while grouping channel-specific settings below. See Table 1 for GUI control details for each channel. Check the **Deglitch** checkboxes located to the right of the **OV Critical**, **OV Warning**, **UV Warning**, **UV Critical**, and **OC Warning** input controls to enable the deglitch feature for those settings.

Control and Status

The EV kit software **Control/Status** tab (Figure 2) displays the status of each channel, including the voltage and current measurements in decimal format. Each channel can be enabled, regardless of the input voltage, by configuring the software's **EN1_** and **EN2_** combo boxes or enabling the **Force-ON Keys Enable** and **Force-ON** checkboxes. Check the corresponding **Reset** or **Hold** checkbox to reset or hold the maximum and minimum voltage measurements and the maximum and minimum current measurements. Click the **Clear Alert** button to clear the alert bit and output signal.

Circular Buffer

The EV kit software **Circular Buffer** tab (Figure 3) allows the user to control and configure the voltage and current circular buffers for each channel. Each circular buffer always contains a record of the 50 most-recent digital measurements. The resolution of these measure-

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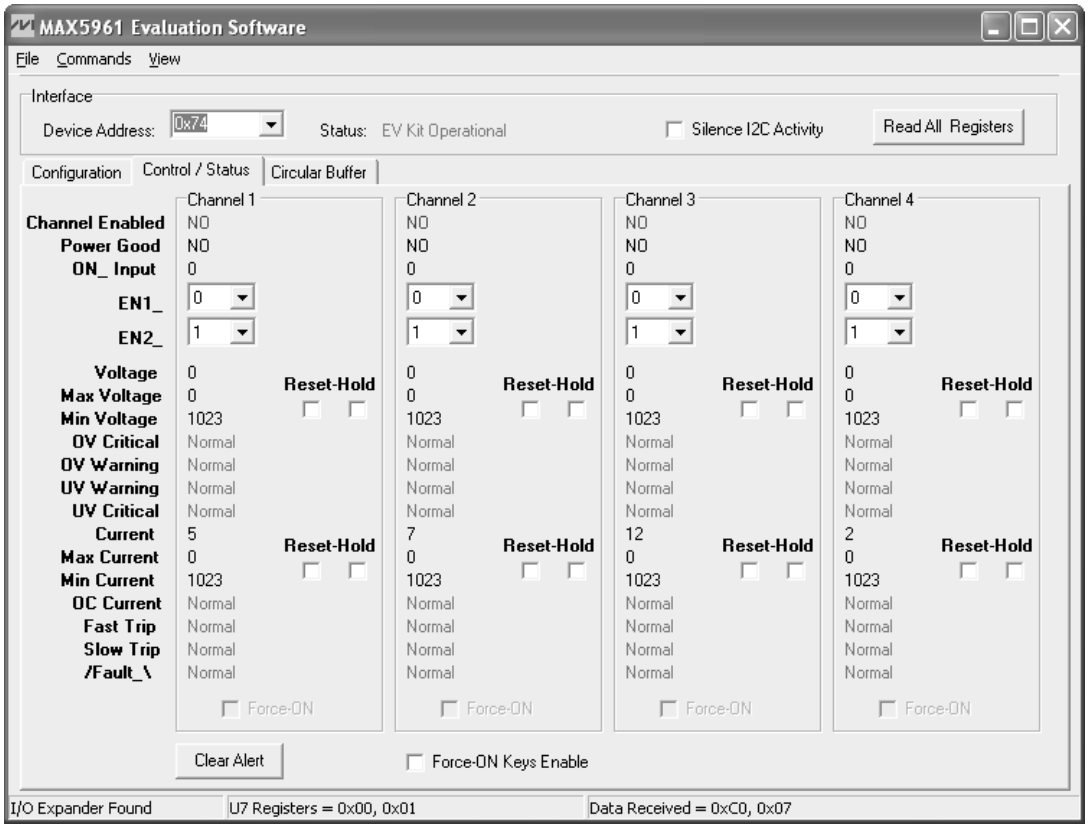

Figure 2. MAX5961 EV Kit Software GUI—Control/Status Tab

ments can be set to **8-Bit** or **10-Bit**. This measurement record includes the number of postshutdown event measurements set by the **Stop-Delay Buffer** setting, if the corresponding buffer (**Voltage Buffer** or **Current Buffer**) is set to Run. The corresponding circular buffer stops recording new data if it is set to Stop. The 50 measurements contained in the particular buffer are read and displayed when clicking on the **Read Voltage Buffer** or **Read Current Buffer** buttons.

Advanced User Interface

An I²C serial interface can be used by advanced users by clicking **View | 2-Wire Interface Diagnostic**.

A window is displayed (Figure 4) that allows I²C operations, such as Read and Write, for troubleshooting. Stop normal MAX5961 software I²C activity by checking the **Silence I2C Activity** checkbox in the MAX5961 main program when using this feature.

Click on the **2-wire interface** tab shown in Figure 4. Go to the **Target Device Address:** combo box to select the correct MAX5961 slave I²C address (port expander U7's fixed I²C address is 0x40). In the **General commands** tab, from the **Command** drop-down list, select 1-SMBusWriteByte(addr,cmd,data8), for a write operation, or 4-SMBusReadByte(addr,cmd)-> data8, for a read operation. Enter the register address into the **Command byte:** combo box, the 8-bit data into the **Data Out:** combo box, and press the **Execute** button for write operation. Enter the register address into the **Command byte:** combo box and press the **Execute** button for read operation. The data retrieved is displayed in the **Data In:** combo box. The I²C 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 of 0s and 1s.

Table 1. MAX5961 EV Kit Software GUI Controls

GUI CONTROL	FUNCTION
Voltage-Sense Range	Sets the maximum output voltage range to 2V, 4V, 8V, or 16V.
OV Critical	Sets the overvoltage critical limit. Enter a decimal value between 0 and 1023 (10-bit binary value).
OV Warning	Sets the overvoltage warning limit. Enter a decimal value between 0 and 1023 (10-bit binary value).
UV Warning	Sets the undervoltage warning limit. Enter a decimal value between 0 and 1023 (10-bit binary value).
UV Critical	Sets the undervoltage critical limit. Enter a decimal value between 0 and 1023 (10-bit binary value).
Max Current Sense	Sets the maximum current-sense range to 25mV, 50mV, or 100mV across the current-sense resistor.
Fast-Trip Threshold	Sets the fast-trip voltage threshold across the current-sense resistor between 40% and 100% of the **Max Current-Sense** setting. Enter a decimal value between 102 and 255 (8-bit binary value).
Fast/Slow Trip Ratio	Sets the fast-to-slow trip voltage ratio to 125%, 150%, 175%, or 200% across the current-sense resistor.
OC Warning	Sets the overcurrent warning limit. Enter a decimal value between 0 and 1023 (10-bit binary value).
PG Assertion Delay	Sets PG_ output signal assertion time delay to 50ms, 100ms, 200ms, or 400ms.
Deglitch	Enables deglitching function—two consecutive faults must be detected before the corresponding fault is asserted.
EN1_	Sets EN1 bit to 0 or 1.
EN2_	Sets EN2 bit to 0 or 1.
Reset	Resets the maximum and minimum voltage or current detection registers of the corresponding channel.
Hold	Locks the maximum and minimum voltage or current detection registers of the corresponding channel.
Force-ON Keys Enable	Enables the Force-ON control register.
Force-ON	Enables the channel regardless of any fault condition. **Warning:** When the force-on function is enabled, the device does not protect against any fault conditions. Since the device does not protect against overcurrent and short-circuit conditions, the MOSFET(s) might be damaged.
Clear Alert	Clears the Alert bit/deasserts the $\overline{\text{ALERT}}$ output.
Stop-Delay Buffer	Sets the number of samples that are recorded to a buffer after a shutdown event. Enter a number between 0 and 50.
Voltage Buffer	Enables the voltage buffer.
V Read Mode, 8-Bit	Sets the circular buffer resolution to 8 bits.
V Read Mode, 10-Bit	Sets the circular buffer resolution to 10 bits.
Current Buffer	Enables the current buffer.
C Read Mode, 8-Bit	Sets the circular buffer resolution to 8 bits.
C Read Mode, 10-Bit	Sets the circular buffer resolution to 10 bits.
Read Voltage Buffer	Reads and displays the voltage buffer data.
Read Current Buffer	Reads and displays the current buffer data.

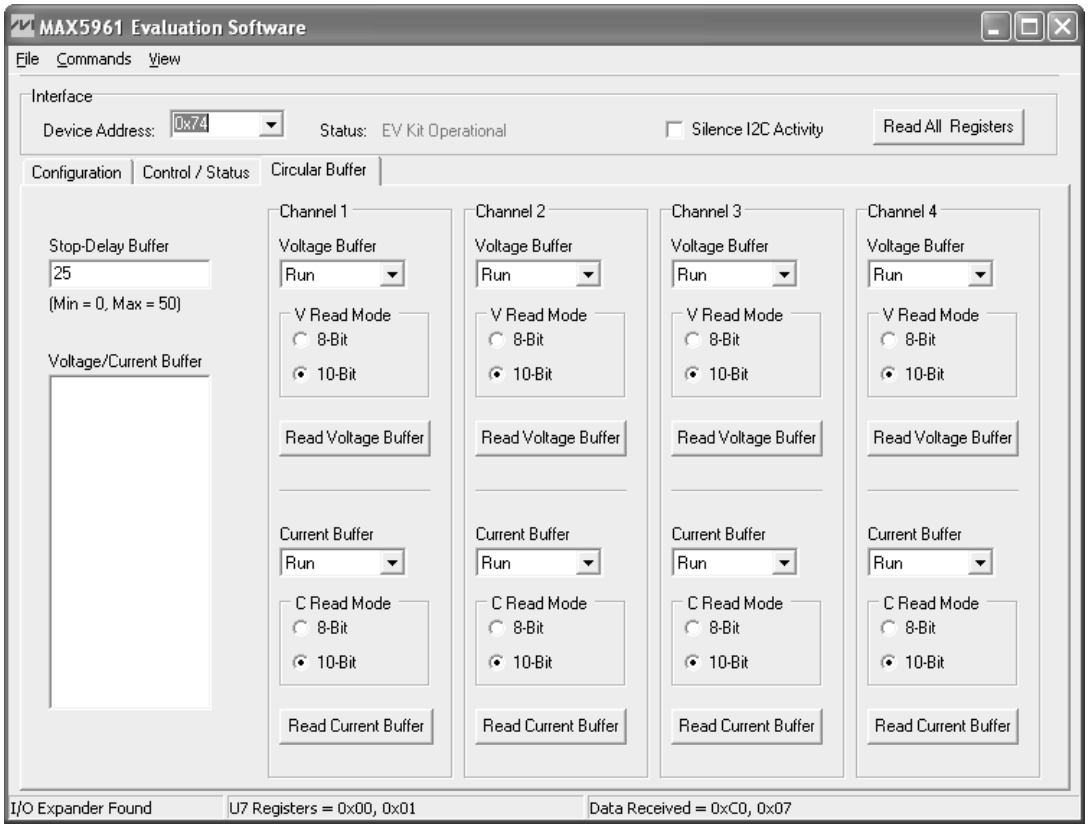

Figure 3. MAX5961 EV Kit Software GUI—Circular Buffer Tab

Detailed Description of Hardware

The MAX5961 EV kit circuit demonstrates the MAX5961 quad-channel hot-swap controller that continually monitors the output current and voltage with an internal 10-bit ADC. The MAX5961 IC controls each channel's n-channel MOSFET while monitoring the respective current across the sense resistor and the output voltage. The MAX5961 EV kit controller requires 3V (2.7V + Schottky diode drop) to 16V DC for normal operation. Each hot-swap channel is configured to operate with an input voltage as low as 0V.

During a startup cycle, the EV kit's four channels are off until the MAX5961 IN pin voltage exceeds 2.7V (typ). Once the MAX5961 powers up, it loads the initial operational settings to the internal registers. If any of the input channel's voltage is above the 0.6V undervoltage threshold, the respective MOSFET is turned on and the MAX5961 controller monitors the corresponding channel output current and voltage.

The MAX5961 EV kit features several jumpers to program the initial operational settings. These settings are: maximum current-sense range for each channel, fault protection behavior, power-good output signal polarity, hardware enable, fault-management mode, and I^2C address for the controller.

Input Power Sources

The MAX5961 EV kit requires a 3V (2.7V + Schottky diode drop) to 16V input DC source for normal EV kit operation. The EV kit circuit features jumper JU9 that

Table 2. Input Source Configuration (JU9)

SHUNT POSITION	MAX5961 IC INPUT POWER SOURCE
1-2	VS1, VS2, VS3, VS4, or VIN input
2-3	+3.3V or VIN input
Not installed	VIN input

Table 3. HWEN Configuration (JU15)

SHUNT POSITION	HWEN PIN	EN2 BIT
Not installed	Connected to DREG through resistor R48	Set to 1 during startup
Installed	Connected to GND	Set to 0 during startup

Table 4. ON_ Configuration (JU10, JU11, JU13, JU14)

SHUNT POSITION	ON_ PIN	ON_ BIT SETTING
Not installed	Connected to VS_ through resistor R20, R22, R24, or R26	Set to 1 when ON_ pin is above 0.6V. Channel_ enabled if EN1 or EN2 bits are set to 1.
Installed	Connected to GND	Set to 0. Channel_ disabled if EN1 and EN2 bits are set to 0.

allows the user to select one of three methods to provide power to the MAX5961 IC (U1). If the shunt is connected across pins 1 and 2 of jumper JU9, the highest voltage source connected to the VS1, VS2, VS3, VS4, or VIN inputs supplies power to the IC. If the shunt is connected across pins 2 and 3, the highest voltage between the +3.3V source (derived from the USB 5V supply) and the VIN input supplies power to the IC. If the shunt is removed, the VIN input supplies power to U1. Connect a 3V to 16V power source across VIN and GND PC pads when using this option. See Table 2 for jumper JU9 configuration. The communication circuitry and port expander (U7) are powered with the USB 5V supply.

Hot-Swap Channel Enable

During startup, each hot-swap channel is enabled if the respective EN2 bit is set to 1 and the ON_ input is high. The EN2 bit is dependent on the state of the HWEN pin. If the HWEN pin is pulled to DREG during startup, the EN2 bit for all four channels is set to 1. The EV kit circuit provides jumper JU15 to configure the HWEN pin. See Table 3 for jumper JU15 configuration. Connecting HWEN pin to ground GND after startup does not change the EN2 bit state to 0. However, after startup, the EN2 bit state for each channel can be changed using the EV kit GUI software.

Whenever the ON_ pin voltage exceeds the input voltage threshold of 0.6V (typ), the ON_ bit is set to 1; otherwise, it is set to 0. The EV kit circuit is configured to pull up the ON_ pins to the respective VS_ channel inputs through resistors R20, R22, R24, or R26. The VS_ input undervoltage threshold can be modified by completing the resistive divider at each ON_ pin. Use the following equation to select the value for each ON_ resistor:

$$R = \frac{100k\Omega}{\left(\frac{VS\_UVLO}{0.6V} - 1\right)}$$

where VS_{UVLO} is the desired VS1, VS2, VS3, or VS4 undervoltage input and R is the resistor value in ohms for R21, R23, R25, or R27, respectively.

The EV kit circuit also provides jumpers JU10, JU11, JU13, and JU14 to connect the respective ON_ pins to ground, thus setting the ON_ bit to 0. See Table 4 for jumper configuration.

Refer to the *Hot-Swap Channel On-Off Control* section in the MAX5961 IC data sheet for detailed information on enabling and disabling each hot-swap channel.

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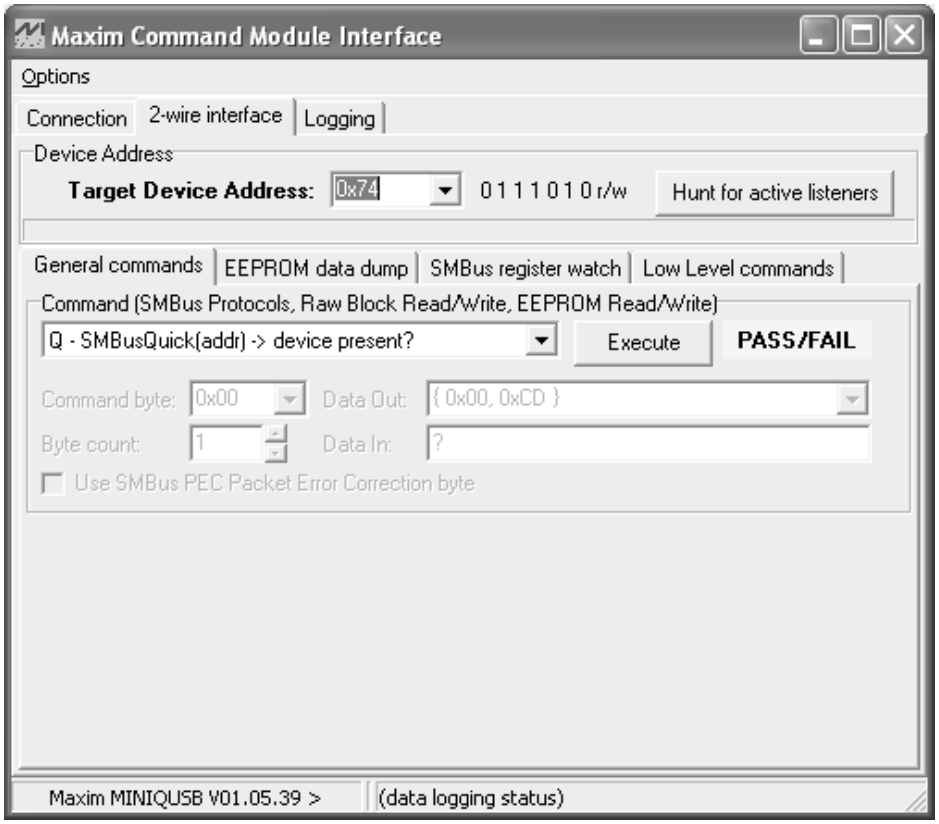

Figure 4. Advanced I²C User Interface Windowl2-Wire Interface Tab

Table 5. Grouping Configuration (JU5)

SHUNT POSITION	MODE PIN	GROUPING FUNCTION
1-2	Connected to DREG through resistor R40	Paired—Channel 1 and Channel 3 operate together. Channel 2 and Channel 4 operate together.
2-3	Connected to GND	Independent—Each channel operates as an independent hot-swap controller.
Not installed	Not connected	Grouped—All 4 channels operate as a group.

Grouping Hot-Swap Channels

Depending on the state of the MODE input pin during startup, the MAX5961 IC can operate as four independent hot-swap controllers, two pairs of controllers, or with all four controllers grouped together operating as a single controller. The MAX5961 EV kit circuit provides jumper JU5 to configure the MODE pin. See Table 5 for jumper JU5 configuration. Reconfiguring jumper JU5 after startup does not change the initial setting.

PROT, $\overline{ALERT}$

The MAX5961 IC fault protection mode is programmed during startup depending on the PROT pin configuration. The PROT pin configuration determines whether

Table 6. PROT Configuration (JU6)

SHUNT POSITION	PROT PIN	EV KIT FUNCTION
1-2	Connected to DREG through resistor R41	$\overline{ALERT}$ output asserted and respective PG_ output deasserted upon critical UV/OV fault.
2-3	Connected to GND	$\overline{ALERT}$ output asserted, PG_ output deasserted, and shutdown respective channel upon critical UV/OV fault.
Not installed	Not connected	$\overline{ALERT}$ output asserted upon critical UV/OV fault.

Table 7. POL Configuration (JU16)

SHUNT POSITION	POL PIN	PG_ OUTPUT POLARITY
Not installed	Connected to DREG through resistor R49	Active-high PG_ outputs
Installed	Connected to GND	Active-low PG_ outputs

Table 8. RETRY Configuration (JU12)

SHUNT POSITION	RETRY PIN	MAX5961 RETRY SETTING
Not installed	Connected to DREG through resistor R50	Autoretry operation
Installed	Connected to GND	Latch-off operation

the PG_ output signal for the channel(s) is cleared or the PG_ output is cleared and the channel(s) is shut down. The MAX5961 EV kit circuit provides jumper JU6 to configure the PROT pin. See Table 6 for jumper JU6 configuration. Reconfiguring jumper JU6 after startup does not change the initial setting. Once a PG_ output is asserted, the $\overline{ALERT}$ output signal (red LED D13/test point TP25) is always asserted low if any of the channels' output voltage is outside the warning or critical limits, or an overcurrent limit fault is detected.

Power-Good Outputs

The MAX5961 IC power-good (PG_) output signals are asserted when the output voltage is inside the warning undervoltage and overvoltage programmed limits. The PG_ output signal polarity is programmed depending on the POL pin configuration. If the signal polarity is set for active-high outputs, the respective channel LEDs (D5, D6, D7, and D8) are turned on when PG_ is asserted. If the signal polarity is set for active-low outputs, the respective channel's LED is turned off when PG_ is asserted. The PG_ output signals can also be accessed at test points TP17, TP18, TP19, and TP20. The MAX5961 EV kit circuit provides jumper JU16 to configure the POL pin. See Table 7 for jumper JU16 configuration.

$\overline{FAULT}$_ Outputs

The MAX5961 IC $\overline{FAULT}$_ output signal is asserted low whenever a circuit breaker channel shutdown event occurs. A circuit breaker shutdown event occurs whenever a fast-trip or slow-trip overcurrent fault event is detected. The respective channel LED (D9, D10, D11, or D12) is turned on when the $\overline{FAULT}$_ output is asserted. The $\overline{FAULT}$_ output signals can also be accessed at test points TP21, TP22, TP23, and TP24. See the *RETRY Configuration* section for instructions to clear the $\overline{FAULT}$_ outputs.

RETRY Configuration

The MAX5961 IC can be programmed to autoretry or latch-off mode during startup depending on the RETRY pin configuration. In autoretry mode, after a shutdown event, the $\overline{FAULT}$_ is cleared and the MAX5961 controller automatically attempts to restart the corresponding channel after 200ms. In latch-off mode, the channel is in shutdown. The power at the IN pin must be cycled or the affected channel's ON_ pin, EN1 bit, or EN2 bits must be toggled to restart the latched off channel and clear the $\overline{FAULT}$_. The MAX5961 EV kit circuit provides jumper JU12 to configure the RETRY pin. See Table 8 for jumper JU12 configuration. Reconfiguring jumper JU12 after startup does not change the initial RETRY

Table 9. ILIM_ Configuration (JU1, JU2, JU3, JU4)

SHUNT POSITION	ILIM_ PIN	MAXIMUM CURRENT-SENSE RANGE (mV)	MAXIMUM OUTPUT CURRENT (A)
2-3	Connected to GND	25	5
1-2	Connected to DREG through resistor R28, R31, R34, or R37	50	10
Not installed	Not connected	100	20

setting. Refer to the *Autoretry or Latched-Off Fault Management* section in the IC data sheet when operating in autoretry mode.

Current Limiting

The MAX5961 EV kit circuit limits the load current at the four hot-swap channels (VS1, VS2, VS3, and VS4) by monitoring the voltage across current-sense resistors R16, R17, R18, and R19 (5mΩ), respectively. When the load current is less than the programmed slow-trip and fast-trip current limits, the respective channel GATE_ output remains high to fully enhance the associated power MOSFET (N1, N2, N3, and N4). When the load current output (VO1, VO2, VO3, or VO4) exceeds the slow-trip or fast-trip current limits, the MOSFET(s) is turned off.

During startup, the ILIM_ pin setting determines the maximum current-sense range. Also at startup, by default, the fast-trip current limit is set to 75% of the current-sense range, and the fast-trip to slow-trip current-limit ratio is set to 200%. The EV kit circuit provides jumpers JU1, JU2, JU3, and JU4 to configure the ILIM_ pin for channels 1, 2, 3, and 4, respectively. See Table 9 for jumper configuration. After startup, the maximum current-sense range, the fast-trip current limit, and the fast-trip to slow-trip current-limit ratios can be changed using the EV kit GUI software. Refer to the *Circuit-Breaker Protection* and *Setting Circuit-Breaker Thresholds* sections in the MAX5961 IC data sheet for more details.

Replacing current-sense resistors R16, R17, R18, and R19 can reconfigure the maximum output current limits at the four channels. Use the following equation to select a new resistor value:

$$R_S = \frac{V_{TH}}{I_{MAX}}$$

where V_{TH} is the maximum current-sense range voltage, I_{MAX} is the new maximum output current limit, and R_S is the sense resistor value for R16, R17, R18, or R19. Choose a sense resistor that is rated for the new maximum power dissipation level. Verify that the power rating for the respective channel MOSFET meets the new operating conditions.

MAX5961 I²C Address Selection

The MAX5961 IC's slave I²C address is configured through the A0 and A1 pins. The EV kit features jumpers JU7 and JU8 to configure these pins. See Table 10 to configure jumpers JU7 and JU8 and select the I²C address. Verify that the new I²C address matches the address shown in the software's **Device Address** combo box.

Table 10. Device Address Configuration (Jumpers JU7, JU8)

JUMPER JU8 SHUNT POSITION (A1)	JUMPER JU7 SHUNT POSITION (A0)	MAX5961 ADDRESS	
		BINARY	HEXADECIMAL (WRITE)
2-3	2-3	0111 010Y	0x74
2-3	1-2	0111 001Y	0x72
2-3	Not installed	0111 000Y	0x70
1-2	2-3	0110 110Y	0x6C
1-2	1-2	0110 101Y	0x6A
1-2	Not installed	0110 100Y	0x68
Not installed	2-3	0110 010Y	0x64
Not installed	1-2	0110 001Y	0x62
Not installed	Not Installed	0110 000Y	0x60

Note: The first 7 bits shown are the address. The Y bit in Table 10 is the I²C read/write bit. The I²C protocol specifies that this bit is set to 1 for a read or to 0 for a write operation.

EV Kit I²C Signals

The MAX5961 EV kit's I²C signals can be monitored at the SCL and SDA PC pads. The signals' logic-high voltage level of 3.3V is generated by voltage regulator U5 that uses the USB 5V source. User-supplied I²C signals can be connected to the SCL and SDA pads after disconnecting the USB cable from the USB connector. Install 4.7kΩ resistors at R62 and R63 if the user supplies open-collector signals. Port expander U7 is disabled if the EV kit's USB is disconnected.

I/O Port Expander

The MAX5961 EV kit circuit includes an I/O port expander (MAX7313, U7) to detect the state of the four $\overline{\text{FAULT}}$_ output logic signals. The port expander is also used to detect the logic state of the four ON_ inputs and the four PG_ output signals. The MAX7313 IC slave I²C address is fixed to 0x40.

MAX5961 Evaluation Kit

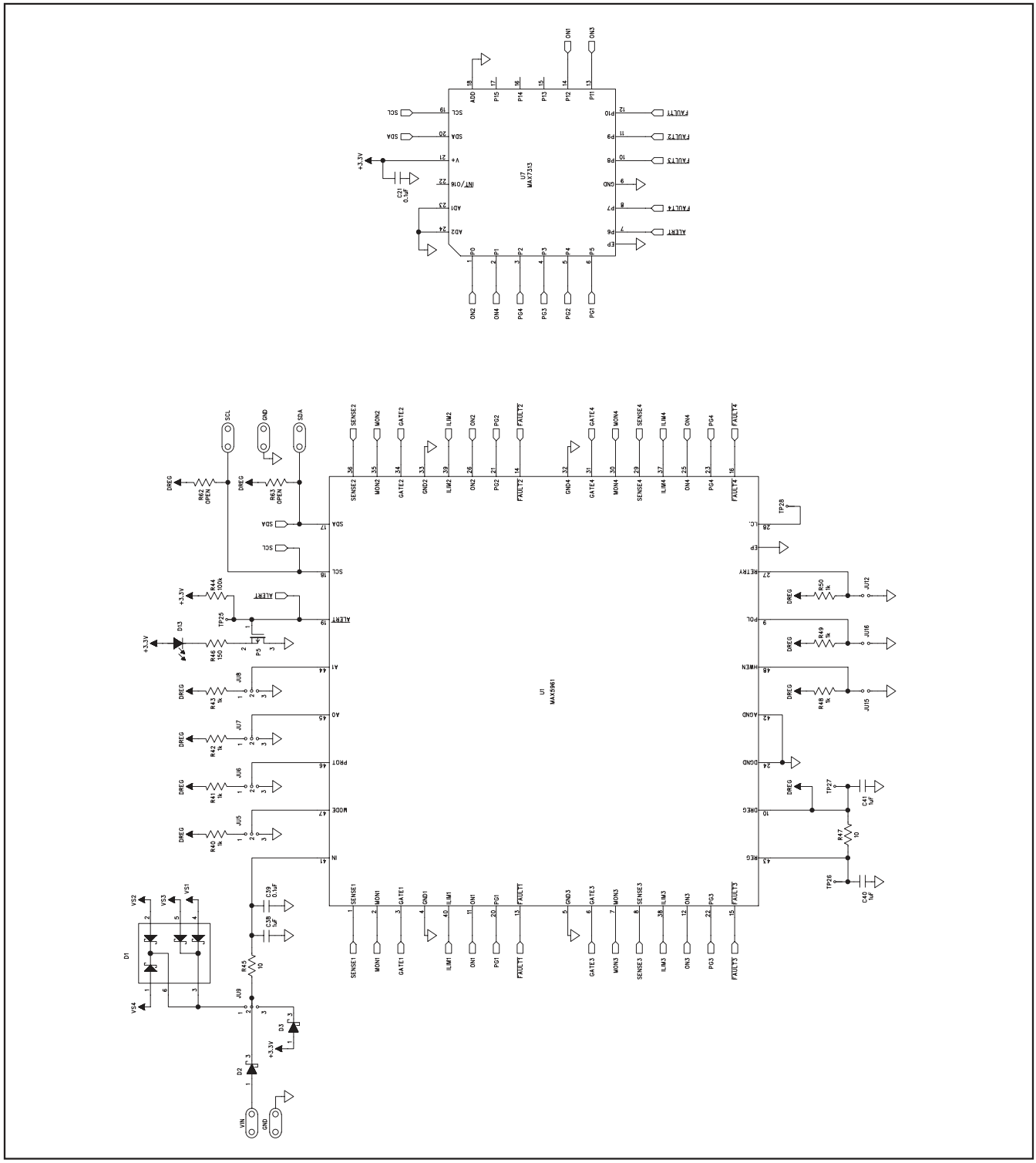

Figure 5a. MAX5961 EV Kit Schematic (Sheet 1 of 3)

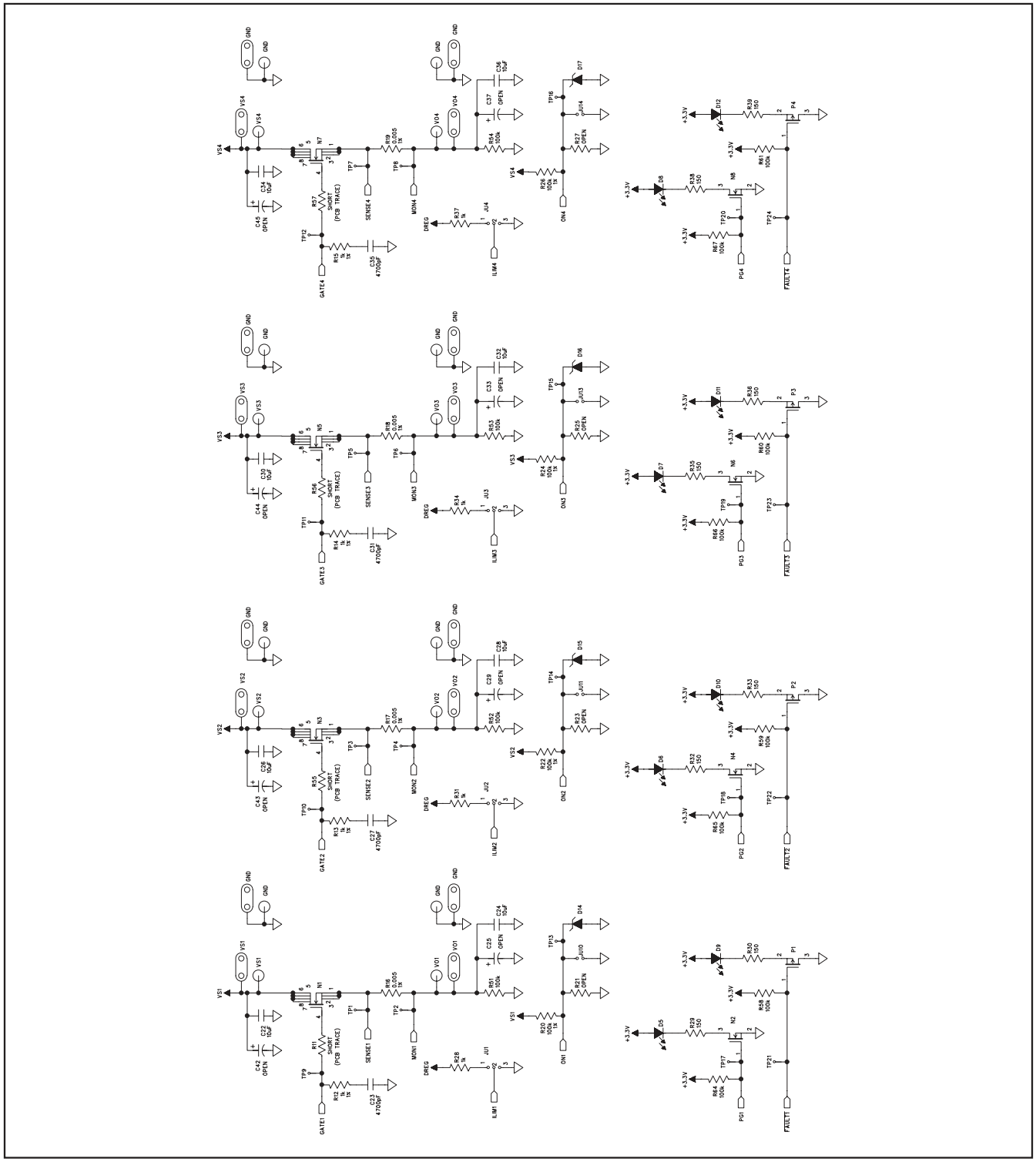

Figure 5b. MAX5961 EV Kit Schematic (Sheet 2 of 3)

MAX5961 Evaluation Kit

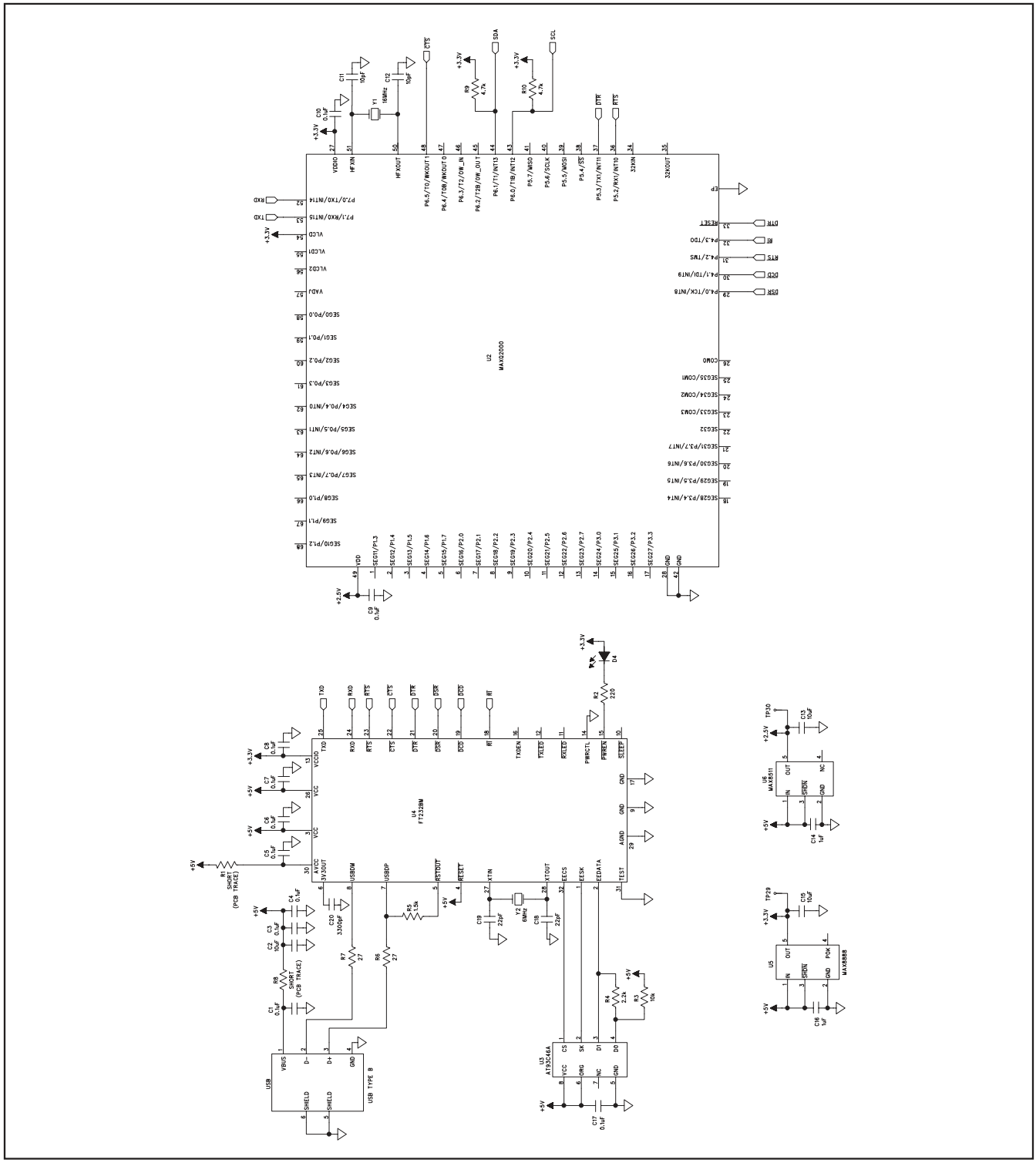

Figure 5c. MAX5961 EV Kit Schematic (Sheet 3 of 3)

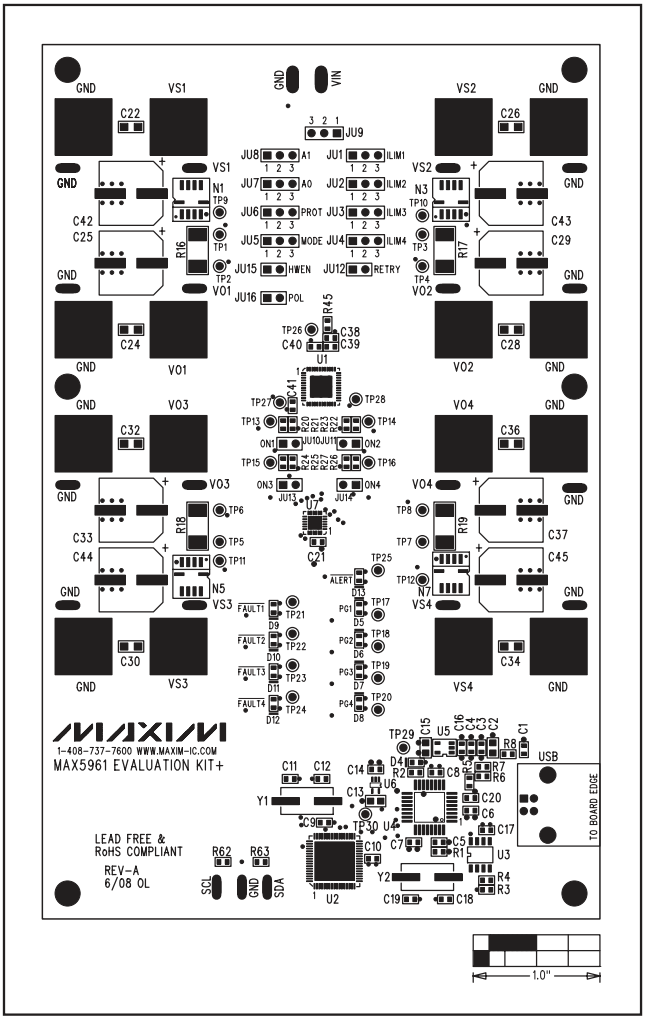

Figure 6. MAX5961 EV Kit Component Placement Guide—Component Side

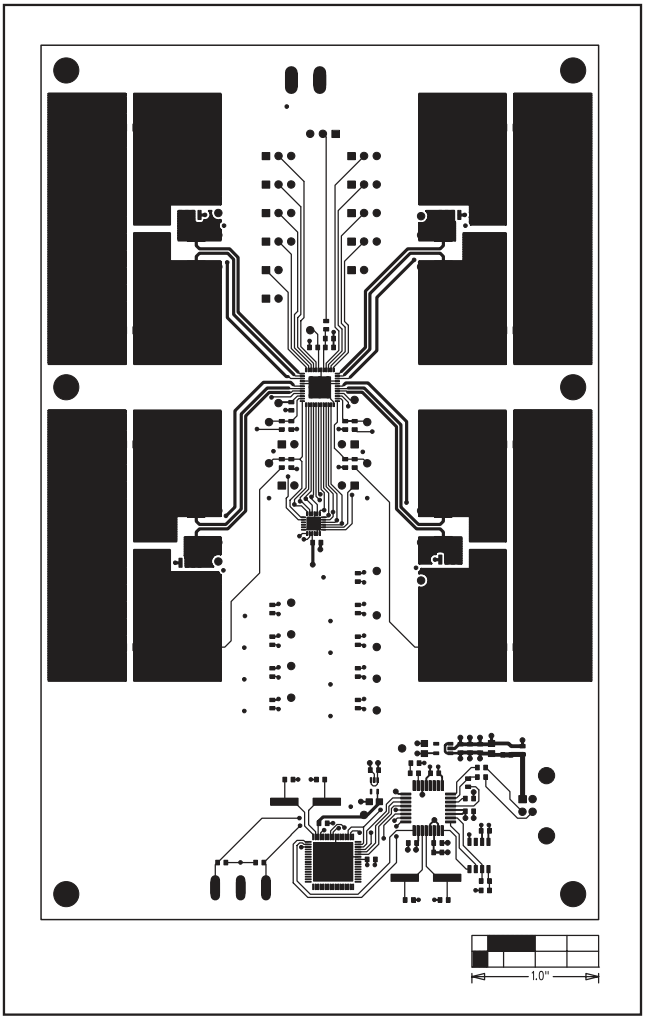

Figure 7. MAX5961 EV Kit PCB Layout—Component Side

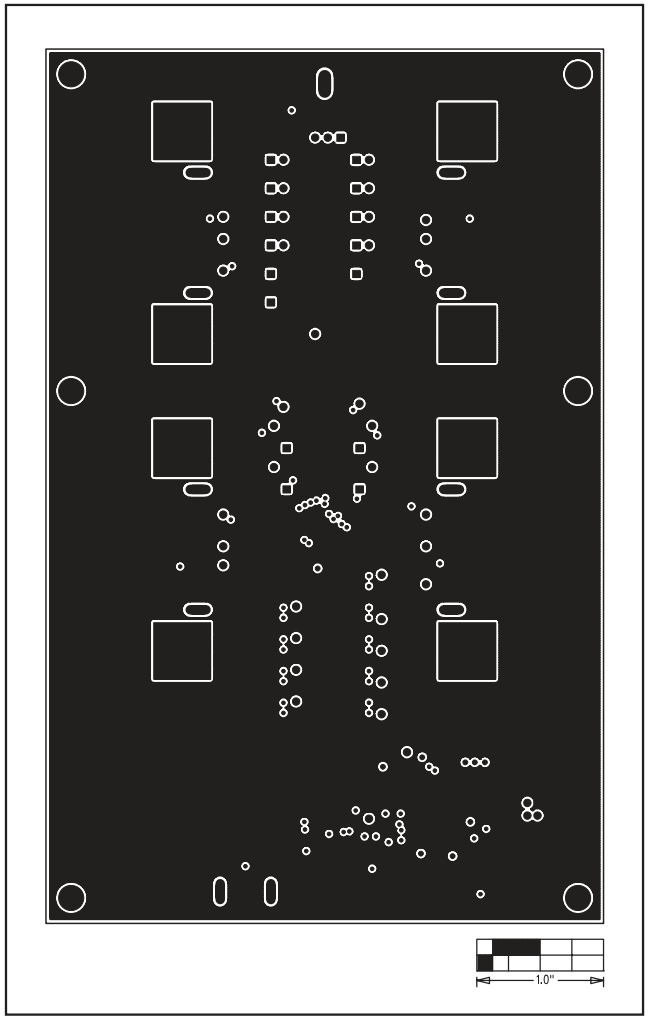

Figure 8. MAX5961 EV Kit PCB Layout—Ground Planes (Layer 2)

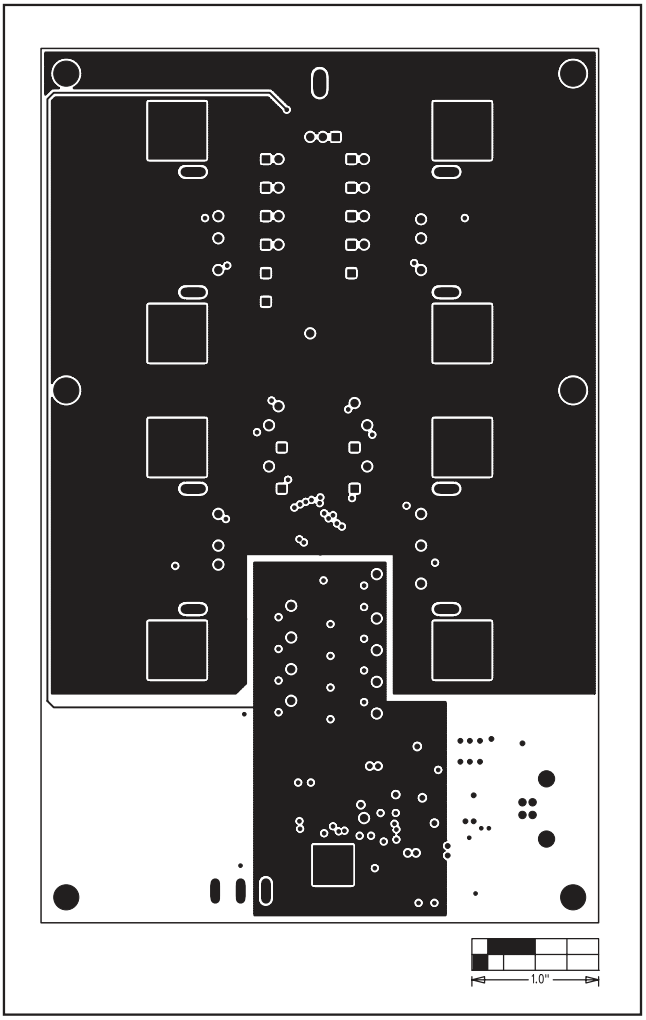

Figure 9. MAX5961 EV Kit PCB Layout—Power Planes (Layer 3)

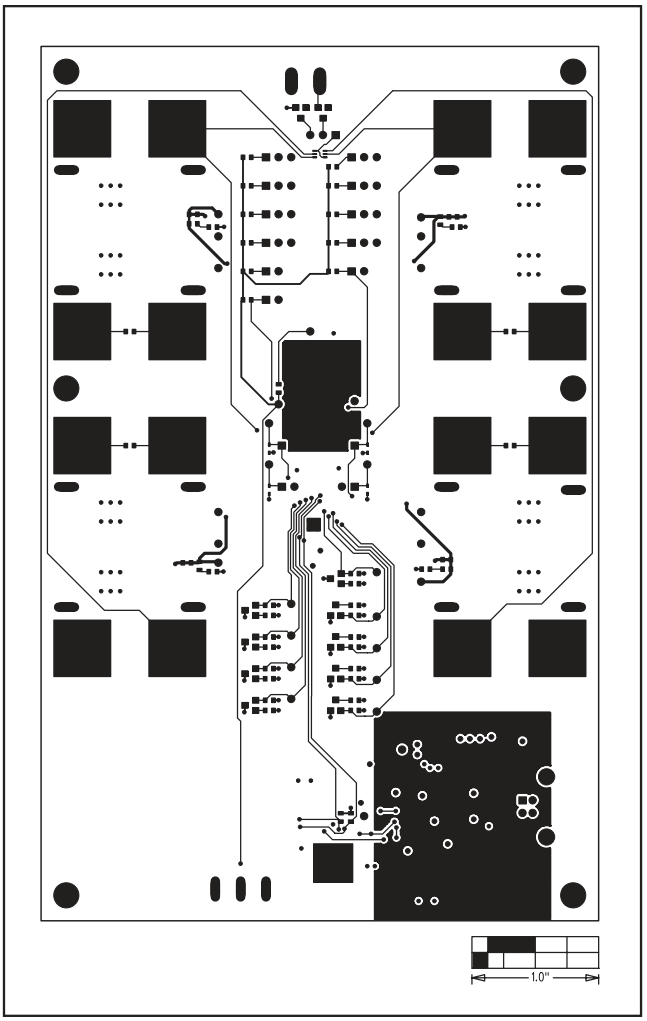

Figure 10. MAX5961 EV Kit PCB Layout—Solder Side

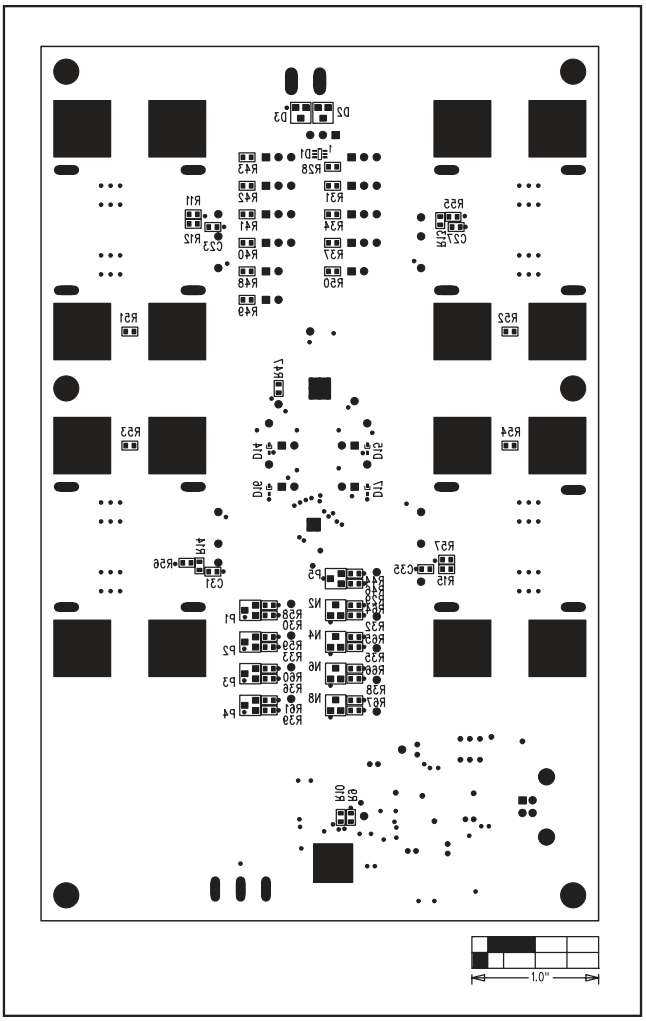

Figure 11. MAX5961 EV Kit Component Placement Guide—Solder Side