

# MAXIM

## MAX3509 Evaluation Kit

### General Description

The MAX3509 evaluation kit (EV kit) simplifies evaluation of the MAX3509 CATV upstream amplifier. The kit includes a serial data interface, which can be programmed through the parallel port of a standard PC. Software (Windows® 95/98 and DOS®) is included to facilitate this function. This software allows the user to program both the gain and transmit modes through a simple user interface.

Access to the device input and output is provided through 50Ω SMA connectors. The input is matched to 50Ω, while the output circuit includes a minimum-loss pad that increases the load on the output transformer to 75Ω nominal when using 50Ω test equipment.

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**Component Suppliers table appears at end of EV Kit Manual.**

### Features

- ◆ Single-Supply Operation
- ◆ Output Level Range from < 12dBmV to 67dBmV (QPSK)
- ◆ Gain Programmable in 1dB Steps via Software
- ◆ Transmit-Disable Mode
- ◆ Shutdown Mode
- ◆ Control Software Included
- ◆ Fully Assembled and Tested Surface-Mount Board

### Ordering Information

PART	TEMP. RANGE	IC PACKAGE
MAX3509EVKIT	-40°C to +85°C	20 TSSOP-EP*

\*Exposed paddle

### Component List

DESIGNATION	QTY	DESCRIPTION
B1–B4	4	Ferrite beads (0603) Murata BLM21P300SPT
C1, C4, C5, C8, C9, C11, C19	7	0.1μF ±10% ceramic capacitors (0805) Murata GRM40X7R104K016A
C2, C3	2	1000pF ±10% ceramic capacitors (0603) Murata GRM39X7R102K050A
C6	1	10μF ±10%, 16V min tantalum capacitor AVX TAJC106K016
C7	1	4.7μF ±10%, 10V min tantalum capacitor AVX TAJC475K020
C10, C18, C21–C24	6	100pF ±5% ceramic capacitors (0603) GRM40COG101J050A
C12, C20	2	4700pF ±10%, 25V min ceramic capacitors (0805) Murata GRM40X7R472K016A
C13–C17	0	Not installed
R1	1	49.9Ω ±1% resistor (0805)
R2, R5, R6, R7, R9, R13, R14, R18, R30, R32, R34, R35, 36	0	Not installed
R3, R37	2	86.6Ω ±1% resistors (0805)
R4, R33	2	100kΩ ±5% resistors (0805)

DESIGNATION	QTY	DESCRIPTION
R8, R10, R11, R15, R16, R19, R24, R26–R29	11	100Ω ±5% resistors (0805)
R12, R38	2	174Ω ±1% resistors (0805)
R22, R23	2	0Ω resistors (0805)
R25, R31	2	100Ω ±5% resistors (0805)
T1	1	Transformer 1:1 M/A-COM ETC1-1T or Minicircuits TC4-1W
T2	1	Transformer 1:1 Coilcraft TTWB1A
U1	1	MAX3509EUP 20-pin TSSOP
U2	1	SN74LVTH244ADBR 20-pin SSOP
U3	1	MAX1615EUK-T, 5-pin SOT23-5
IN1, IN2 (two each)	4	1-pin headers
JU1–JU7, J10	8	3-pin headers
J1, J2	2	SMA edge-mount connectors
J3	1	DB25 connector (right angle, female)
None	1	MAX3509 software disk
None	1	MAX3509 evaluation kit
None	1	MAX3509 data sheet
None	1	MAX3509 EV kit data sheet
None	1	MAX3509 errata



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**Table 1. Jumper Setting Functions**

JUMPER	FUNCTION	SHORT PIN 1 TO PIN 2	SHORT PIN 2 TO PIN 3
JU1	Sets the manual control state of TXEN	Logic 1 state (VCC3)	Logic 0 state (GND)
JU2	Sets the manual control state of $\overline{\text{SHDN}}$	Logic 1 state (VCC3)	Logic 0 state (GND)
JU3	Sets the method of control for TXEN	PC port control	Manual control through JU1
JU4	Sets the method of control for $\overline{\text{SHDN}}$	PC port control	Manual control through JU2
JU5	SCLK input	PC port control	N/A
JU6	SDA input	PC port control	N/A
JU7	$\overline{\text{CS}}$ input	PC port control	N/A
JU10	74LVTH244A buffer enable	Disable buffer	Enable buffer

## Quick Start

The MAX3509 EV kit is fully assembled and factory tested. Follow the instructions in the *Connections and Setup* section.

**Note:** The output circuit includes a minimum-loss pad that is used to bring the load impedance up to 75 $\Omega$ . This must be accounted for in all measurements (see *Output Circuit* section).

**Note:** The input transformer is supplied to allow differential input drive from a single-ended source. A transformer is not required in the application.

## Test Equipment Required

- DC supply capable of delivering 10V and 500mA of continuous current
- HP 8648 or equivalent signal source capable of generating 40dBmV up to 200MHz
- HP 8561E or equivalent spectrum analyzer with a minimum 200MHz frequency range
- Digital multimeter (DMM) to monitor VCC and ICC, if desired
- Lowpass filters to attenuate harmonic output of signal sources, if harmonic measurements are desired.
- Network analyzer, such as the HP 8753D. (May be used to measure gain and harmonic levels if configured with this option; contact test equipment manufacturer.)
- IBM PC or compatible
- Male-to-male 25-pin parallel cable, straight through

- 0V to 5V pulse generator (transient measurement)
- Low-noise amplifier with 40dB gain from 5MHz to 100MHz (noise measurement)
- Oscilloscope with 200MHz bandwidth

## Connections and Setup

- 1) Set the power supply to +9V, and connect it to the pins labeled +9V and GND on the circuit board. Connect a 50 $\Omega$  signal source to INPUT, and terminate OUTPUT with a spectrum analyzer or network analyzer having a 50 $\Omega$  input impedance. If using a signal source with a source impedance other than 50 $\Omega$ , or if a different input impedance is required, be sure to replace resistor R1 with the appropriate-value resistor.
- 2) Connect a 25-pin male-to-male cable between the parallel (printer) port of the PC and the 25-pin female connector on the EV kit board.
- 3) See Table 1 for board jumper settings.
- 4) Turn on the power supply. Turn on the PC and the test equipment. Set the signal source for -13dBm (34dBmV across a 50 $\Omega$  load).
- 5) Run the software program.

## Detailed Description

### Using the Software

The MAX3509 uses a serial data interface (SDI) to set gain. Some means of communicating with the SDI is required to use the MAX3509 EV kit. A microprocessor, pattern generator, or PC can be used for this function.

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**Table 2. MAX3509 EV Kit Software**

DIRECTORY	FILENAME	DESCRIPTION
DOS	MAX3509.BAS	QuickBASIC® Source Code
DOS	READ3509.TXT	"Read Me" Text File
Windows	MAX3509.EXE	Windows Executable
Windows	MAX3509.DLL	DLL File for Printer Port Control
Windows	READWIN3509.TXT	"Read Me" Text File

Software is included in this EV kit to facilitate the use of a PC.

The disk included with the MAX3509 EV kit contains five files. Table 2 shows these files and their appropriate usage.

If your PC has Windows 95/98 installed, read the file READWIN3509.TXT for instructions on operation of the MAX3509.EXE file. If your PC does not have Windows 95/98 installed, use the program MAX3509.BAS. Instructions for the QuickBASIC program are found in READ3509.TXT.

## Input Buffer

The input buffer (U2) is a 3.3V 74LVTH244 octal buffer. It provides protection for the PC's parallel port against potential +9V supply coupling. The buffer can be disabled by moving the shunt to the VCC position (pin 1 and pin 2). This will put the 74LVTH244 output into a high-impedance state.

## Gain Adjustment

The valid gain control word ranges from 0 to 63 (decimal). The nominal change in gain is 1dB per gain state. Gain states are set exclusively by programming the SDI. Refer to the MAX3509 data sheet for details.

## Shutdown and Transmit Enable

Jumpers JU1 through JU4 determine how the shutdown and transmit-enable features are controlled. Pin 2 of each of these jumpers is connected directly to the device. If an external source (such as a modulator chip or microprocessor) is used to control these features, make the connection to pin 2 of the appropriate jumper. Pads are provided on the bottom side of the board (R9 and R14, respectively) for placement of termination resistors, if needed.

If manual control of shutdown and transmit enable is desired, shunt pins 2 and 3 of jumper JU4 and pins 2 and 3 of jumper JU3. This will allow SHDN and TXEN to be controlled by JU2 and JU1, respectively. JU2 and JU1

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are used to place either +3.3V or ground at SHDN or TXEN. Pin 3 of these jumpers is ground, and pin 1 is +3.3V.

## Manual Control of Serial Data Interface

If using a source other than a PC to drive the serial data interface of the MAX3509 EV kit (such as a digital pattern generator or microprocessor), remove the shunts on jumpers JU5, JU6, and JU7. Access to the serial data interface is available through these jumpers. Termination pads are provided (R2, R5, R6). Solder an appropriate resistor to these pads, if desired. Refer to the MAX3509 data sheet for a description of the serial data interface.

## Input Circuit

The input circuit of the MAX3509 EV kit is configured with a 1:1 transformer (T1) and a 49.9Ω input resistor. This allows the input to be driven with single-ended 50Ω test equipment. The transformer (T1) is used to generate a differential signal, as rated performance is specified with a differential input drive (typically from a differential low-pass filter). Pads are provided for a pair of termination resistors, if needed (R13, R18).

If the MAX3509 is to be driven single ended, the input transformer (T1) must be removed and the undriven input connected to ground through a 0.1μF blocking capacitor.

## Output Circuit

The MAX3509 output has two current-feedback amplifiers configured as an instrumentation amplifier. This architecture aids in suppressing second-order distortion (harmonics). To convert to a single-ended output, a 1:1 transformer (T2) is used.

Since most test equipment is supplied with a 50Ω termination impedance, a minimum-loss pad is provided on the output of the transformer to increase the load impedance to a nominal 75Ω. This places the proper load on the device, **but will also reduce the measured output voltage level by 7.5dB**. It is essential to consider this when making any measurements with the EV kit; 7.5dB must be added to all measurements of voltage gain and output voltage level (including noise) to arrive at the correct value for a 75Ω system.

Use 75Ω test equipment, if available, and take the following steps:

- 1) Remove the 50Ω output SMA connector and replace it with a 75Ω connector.
- 2) Remove R3 and R37 and replace them with a 0Ω resistor or some other type of shunt.
- 3) Remove R12 and R38.
- 4) Be sure to use a 75Ω cable.

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## Analysis

### Harmonic Distortion

A filter will be needed to reject the harmonics generated by the signal source. For this example, a lowpass filter with approximately a 25MHz to 35MHz cutoff frequency will be required. This filter will need to reject at least 20dB of signal at 40MHz. Set the 50 $\Omega$  signal source for 20MHz and -13dBm. Adjust the amplitude to account for the insertion loss in the filter. Verify with the spectrum analyzer that the second and third harmonics generated by the source are suppressed by at least 70dBc. Connect the filter between INPUT of the EV kit and the output of the signal source, making sure the proper terminations are being used for this particular filter.

Connect a spectrum analyzer to OUTPUT. Set the center frequency for 40MHz and the span for 50MHz or more. Adjust the reference level so that the fundamental (20MHz tone) is within 10dB to 20dB of the reference level. If the fundamental is less than 10dB below the reference level, the harmonic distortion of the spectrum analyzer may prevent accurate measurement of the distortion.

Set the gain state to 50 (approximately 24dB of gain).

Measure the level of the fundamental, second, and third harmonics on the spectrum analyzer. These readings have units of dBm. To convert from dBm to dBmV in a 50 $\Omega$  system, use the following equation:

$$X(\text{dBmV}) = Y(\text{dBm}) + 47\text{dB (50}\Omega\text{ system)}$$

Add 7.5dB to this value to account for the attenuation of the minimum-loss pad, in dBmV, for a 75 $\Omega$  load. The gain can now be calculated in dB, and the harmonic distortion can be calculated in dBc.

### Switching Transients

To measure the transmit-enable and transmit-disable transients, the TXEN pin will be driven from an external source. No input signal is applied, and the output is viewed on an oscilloscope.

Connect OUTPUT to the oscilloscope's 50 $\Omega$  input. Set the scope's time base to 5 $\mu$ s/div and the vertical scale to 5mV/division.

Set the pulse generator as follows:

Amplitude	5V
Duty Cycle	50%
Rise/Fall Time	100ns
Pulse Width	25 $\mu$ s
Offset	2.5V

Take care not to drive the MAX3509 TXEN pin below 0V or above +5V. Turn on the power supply. Remove the shunt from jumper JU3 (TXEN), and connect the output of the pulse generator to pin 2 of this jumper. Trigger the oscilloscope from the pulse generator using a convenient method.

Set the gain control word to 57.

A rising- and falling-edge transient should appear on the scope's CRT. The amplitude of this transient should be less than 100mVp-p. Multiply the value of the measured transient by 2.37 to account for the presence of the minimum-loss pad. The gain may now be changed to show the output transient's dependence on gain.

### Output Noise

To measure output noise, a spectrum analyzer is used. A postamplifier with less than 10dB noise figure and greater than 40dB gain within the band of interest is needed.

With the power supply off, place a 50 $\Omega$  termination on the input of the EV kit.

Turn on the power supply to the MAX3509 EV kit. Using the software, set the device to transmit mode with a gain control word of 50 (approximately 24dB of gain).

Connect the output of the postamplifier to the spectrum analyzer and the input to OUTPUT on the EV kit. Set the spectrum analyzer as follows:

Center Frequency	35MHz
Span	60MHz
Reference	-50dBm
Scale	10dB/div
IF Bandwidth	1kHz

Power up the postamplifier.

If the spectrum analyzer being used has a noise marker function, enable it. The output noise can now be read directly from the spectrum analyzer. Move this marker to 42MHz. Read the value of the noise density from the spectrum analyzer.

This noise value is a combination of the output noise of the MAX3509, the gain of the postamp, and the noise figure of the postamp. With the specified noise figure of 10dB, the noise contribution of the postamp may be ignored. The minimum-loss pad reduces the actual measured value by 7.5dB. Use the following equation to arrive at the MAX3509's output noise:

$$V_{\text{NOISE}} = P_{\text{NOISE}} + 47\text{dB} + 7.5\text{dB} + 10 \times \log(160,000) - G_{\text{AMP}}$$

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where:

$V_{NOISE}$  = MAX3509 output noise in dBmV measured in a 160kHz bandwidth

$P_{NOISE}$  = Noise density in dBm/Hz read from the spectrum analyzer

GAMP = Gain of the postamplifier in dB

If the spectrum analyzer being used does not have a noise marker function, corrections must be made to account for the IF bandwidth used to make the measurement. Consult the user's manual for your spectrum analyzer for details. Once the correction is made, the value read from the spectrum analyzer can be converted to a noise density (dBm/Hz), and the above formula can be used.

Noise can now be measured at various gains. Output noise in transmit-disable mode is insignificant.

## Layout Considerations

The MAX3509 evaluation board can serve as a guide for your board layout. Particular attention should be paid to thermal design and to the output network.

The MAX3509 package exposed paddle (EP), labeled GND2, conducts heat out of the part and also provides a low-impedance electrical connection. The EP must be attached to the PC board ground plane with a low thermal and electrical impedance contact. Ideally, this would be provided by soldering the backside package contact directly to a top metal ground plane on the PC board. Alternatively, the EP could be connected to a ground plane using an array of plated vias directly below EP. The EV kit incorporates both of these methods.

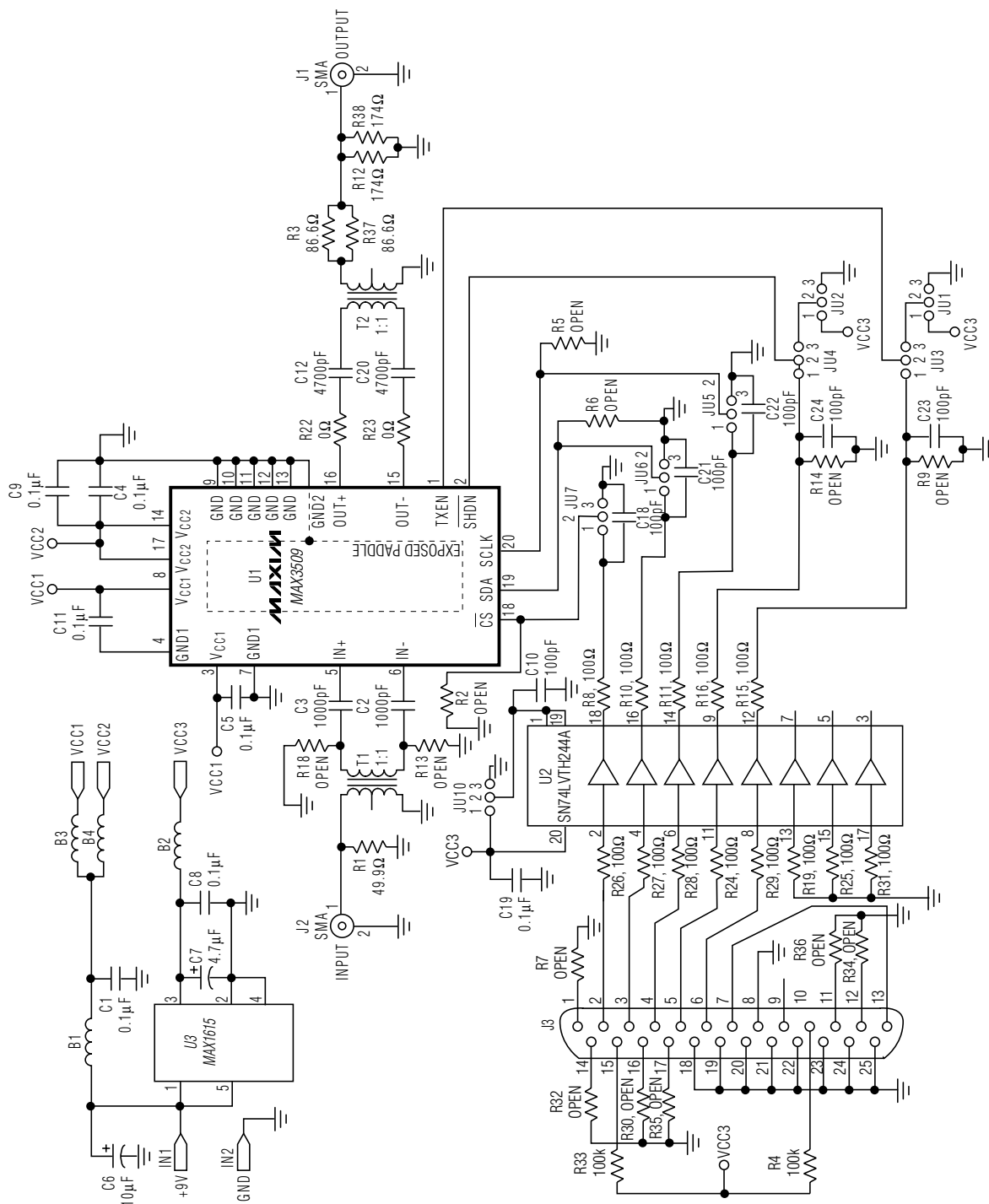
The output circuit that connects OUT+ and OUT- (pins 16 and 17) to the output transformer (T2) should be as symmetrical as possible to reduce second-order distortion. In addition, the inductance of this path should be kept low to minimize gain rolloff at high frequencies.

## Component Suppliers

SUPPLIER	PHONE	FAX
AVX	803-946-0690	803-626-3123
Coilcraft	847-639-6400	847-639-1469
M/A-COM	978-442-5000	978-442-4178
Murata	814-237-1431	814-238-0490

**Note:** Please indicate that you are using the MAX3509 when contacting these suppliers.

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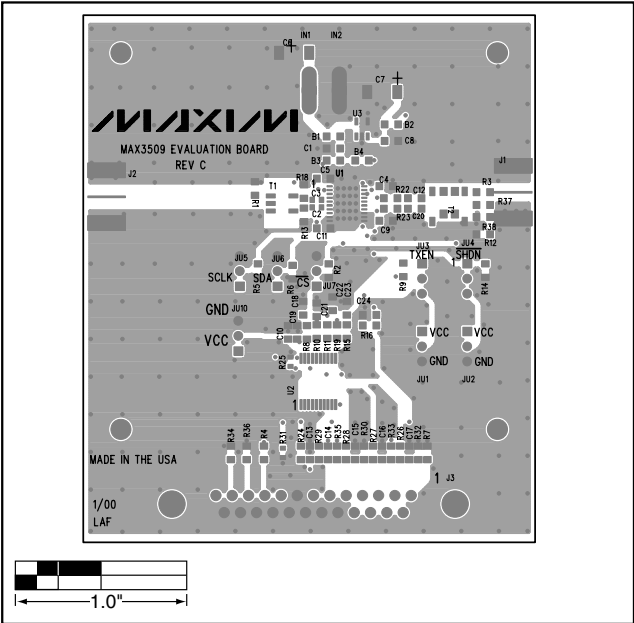


Figure 2. MAX3509 EV Kit Component Placement Guide—Component Side

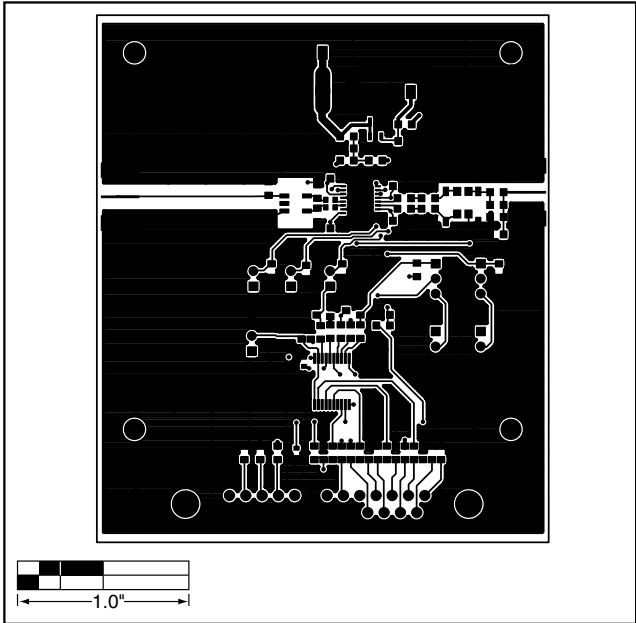


Figure 3. MAX3509 EV Kit PC Board Layout—Component Side

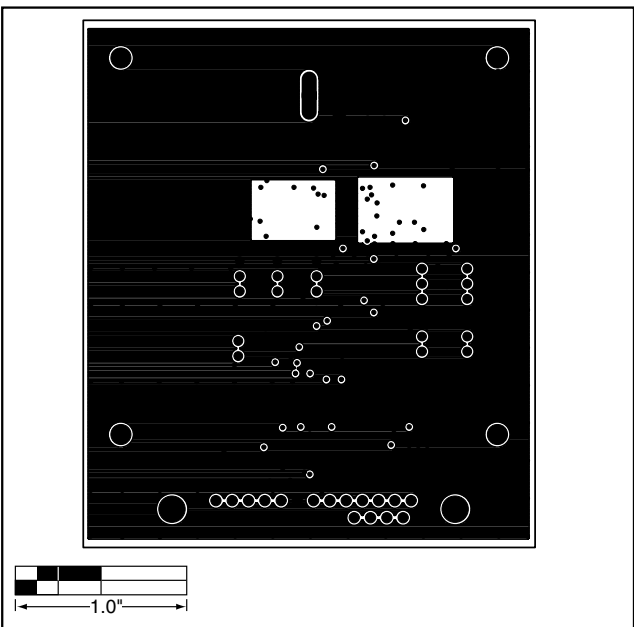


Figure 4. MAX3509 EV Kit PC Board Layout—GND Plane

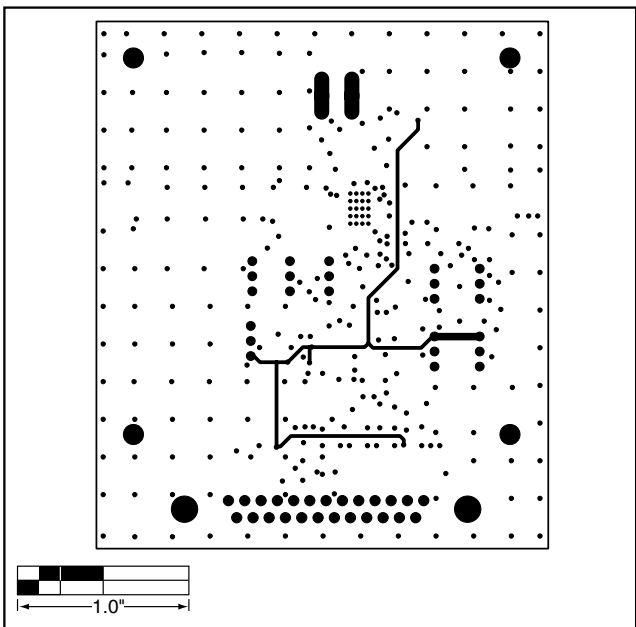


Figure 5. MAX3509 EV Kit PC Board Layout—Power Plane



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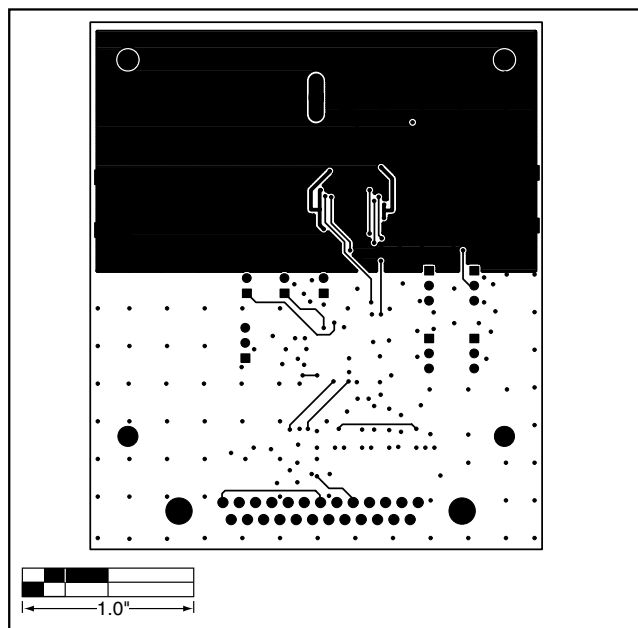


Figure 6. MAX3509 EV Kit PC Board Layout—Solder Side

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