19-2193; Rev 0; 10/01

MAXIM

MAX2216 Evaluation Kit

General Description

The MAX2216 evaluation kit (EV kit) simplifies the evaluation of the MAX2216 GSM/DCS/PCS tri-band power amplifiers. The MAX2216 EV kit enables testing of the devices' performance and require no additional support circuitry. All inputs and outputs use SMA connectors to facilitate easy connection of RF test equipment.

Features

- ♦ **Easy Evaluation of MAX2216**
- ♦ **All Peripheral Components Included**
- ♦ **Tuned for European GSM and DCS Bands**
- ♦ **Fully Assembled and Tested**

Ordering Information

PART	TEMP RANGE	IC PACKAGE
MAX2216EVKIT	-40°C TO +85°C	5 × 6 UCSP

Component List

DESIGNATION	QTY	DESCRIPTION
C1, C3, C4, C6, C8, C10, C21, C33, C37	9	100pF ±5% ceramic capacitors (0402) Murata GRM36COG101J050A
C2, C7, C12, C14, C15, C16, C18, C20, C26, C31	10	0.01µF ±10% ceramic capacitors (0402) Murata GRM36X7R103K016A
C5, C28	2	7.0pF ±0.1pF ceramic capacitors (0402) Murata GRM36COG070B050A
C9, C11	2	Open
C13, C35, C39	3	6.8pF ±0.1pF ceramic capacitors (0402) Murata GRM36COG6R8B050A
C17	1	10pF ±0.1pF ceramic capacitor (0402) Murata GRM36COG100B050A
C19	1	47pF ±5% ceramic capacitor (0402) Murata GRM36COG470J050A
C22	1	4.3pF ±0.1pF ceramic microwave chip capacitor (0603) Murata GRM706COG4R3C
C23	1	5.0pF ±0.1pF ceramic capacitor (0402) Murata GRM36COG050B050A
C24, C32	2	2.0pF ±0.1pF ceramic capacitors (0402) Murata GRM36COG020B050A
C25	1	5.6pF ±0.1pF ceramic microwave chip capacitor (0603) Murata GRM706COG5R6C
C27	1	18pF ±5% ceramic capacitor (0402) Murata GRM36COG180K050A
C29	1	4.0pF ±0.1pF ceramic capacitor (0402) Murata GRM36COG040B050A
C34, C38	2	33pF ±5% ceramic capacitors (0402) Murata GRM36COG330J050A
C40	1	33µF tantalum capacitor, 'C' case AVX TAJC336K010
J1–J4	4	SMA connectors, edge mount EFJohnson 142-0701-801 or Digi-Key J502-ND **Note:** Cut center pin to approximately 1/16in length.
J5, J6	2	Test points, Digi-Key 5000K-ND
L1, L2	2	5.45nH micro spring inductors Coilcraft 0906-5
R1	1	1.8kΩ resistor (0402)
R2	1	1.0kΩ resistor (0402)
TP1–TP4	4	1 × 4-pin headers (0.1in centers) Digi-Key S1012-36-ND
U1	1	MAX2216EBV chip-scale package, 5 × 6
None	1	MAX2216-2 evaluation circuit board, Rev A
None	1	MAX2216 EV kit data sheet
None	1	MAX2216 data sheet

Component Suppliers

SUPPLIER	PHONE	FAX	WEBSITE
AVX	843-448-9411	—	www.avxcorp.com
Coilcraft	847-639-1469	847-639-6400	www.coilcraft.com
EFJohnson	402-474-4800	402-474-4858	www.efjohnson.com
Murata	770-436-1300	770-436-3030	www.murata.com

Quick Start

The MAX2216 EV kit is fully assembled and factory tested. Follow the instructions in the *Connections and Setup* section for proper device evaluation.

Test Equipment Required

This section lists the test equipment recommended to verify the operation of the MAX2216. It is intended as a guide only, and some substitutions are possible.

- One DC power supply capable of supplying a minimum of 3A at +2.5V to +5.5V. Avoid force/sense types, as they can add noise to the output spectrum. This corrupts a noise power measurement. An on-board ammeter is nice for sanity checking, but is not required.
- One benchtop or handheld ammeter. It should have ranges to measure about 1A when the PA is on, and 5µA when the PA is off.
- One reservoir capacitor, at least 10,000µF (10mF). See *Connections and Setup,* step 7, for an explanation of why such a large reservoir capacitor is required.
- One RF spectrum analyzer capable of making measurements over the bandwidth of the MAX2216 as well as a few harmonics, such as the 6GHz HP8561E.
- One RF signal generator capable of delivering +12dBm output power at frequencies up to 1900MHz, such as the HP8648C signal generator. If noise power measurements are needed (not covered in this procedure), chose a signal generator with low output noise.
- High-power (5W min) 20dB SMA attenuator
- Power meter, with power detector rated to at least +20dBm
- Function/pulse generator
- Two-channel oscilloscope. A digital sampling oscilloscope that can measure duty cycle and peak voltage is ideal.
- Two 50Ω SMA cables
- One BNC tee
- Three BNC cables
- One BNC 50Ω inline termination
- One BNC-to-grabber

Keep in mind that GSM power amplifiers operate in a burst-transmit mode. At full power, supply current ramps from nearly 0A to as much as 3A for the duration of the transmit burst. The series resistance introduced by most ammeters is enough to cause a 1V drop across their internal current-sense circuitry. This means that the PA's supply is not at 3.2V during the pulse, but closer to 2.2V. Gain, efficiency, and noise power appear much worse than they would actually be at 3.2V. To mimic the behavior of a typical cell-phone battery, keep the series resistance from (and including) the supply to the EV kit below 200mΩ. Use the oscilloscope to watch the voltage at the EV kit during the transmit burst.

Note that if noise power measurements are required, special care must be taken in filtering the noise contributed by the signal source at the input, and notching out the output tone to limit the dynamic range at the output. Accurate measurements require higher performance RF test equipment than listed above.

Warning: Operating at 100% duty cycle can exceed the absolute maximum power dissipation for the device. A typical GSM application bursts the PA at 12.5% to 25% duty cycle with a 4.616ms period.

Connections and Setup

1) Calibrate the power meter for 900MHz. Dial in the losses in the 20dB attenuator and the output SMA cable as an offset in the power meter, so that it reads the output power at the EV kit SMA connector.
2) Connect the 20dB power attenuator to the GSM output of the kit. Connect one SMA cable from the 20dB pad to the spectrum analyzer. Configure the spectrum analyzer to display frequencies from 800MHz to 3GHz. Gate the sweep of the spectrum analyzer with the waveform generated by the function generator, so that the spectrum analyzer only samples during the transmit burst. See the operating manual for the particular spectrum analyzer for instructions on how to do this.

3) Configure the RF signal generator to deliver a +8dBm CW signal at 900MHz. Verify that the RF signal generator is disabled, and connect it to the GSM input of the EV kit.
4) Configure the function generator to deliver a GSM power-control waveform:

   Period = 4.616ms

   t_{ON} = 577µs; this is 12.5% duty cycle

   V_{LOW} = 0V

   V_{HI} = 1.0V

   Square wave output (add slew-rate limiting to rise/fall if so desired)

5) Connect a BNC tee to the output of the generator; then connect one output to the GATE/TRIGGER input of the spectrum analyzer, and the other output to the GSMGC input. Terminate this connection with a 50Ω BNC-series termination. Keep the output disabled until the kit is powered up.
6) Connect one scope probe to the EV kit's V_{CC}, and the other scope probe to the gain control input (GSMGC). Use the scope to keep track of what V_{CC} and V_{GSMGC} are doing; do not rely on the power supply and function generator displays. Set the scope up to measure peak voltage and duty cycle, if possible.
7) Measuring burst current to the PA is not a trivial task; discussion follows to help clarify the issues, and to offer a reliable setup to make accurate measurements:

   In making an efficiency measurement, one of two things can be done. The first is to measure the burst output power, the burst current, and the average supply voltage during the burst (it might be drooping). This requires the power meter to be gated (many older power meters cannot do this), and it requires the engineer to make an accurate burst-current measurement. The second method is to measure average output power, average current, and the average supply voltage during the burst. This removes the gated power measurement requirement for the power meter, as well as the requirement to measure current only during the burst.

   The burst power and current are exactly eight times the average, ONLY if the duty cycle is exactly 12.5%. Even with an oscilloscope that can measure the duty cycle of the power control waveform, it is unlikely that the duty cycle could be trimmed to be exactly 12.5%. The resulting calculation for efficiency will be in error by at least the percentage error of the duty cycle assumption: assuming a 12.5% duty cycle when it is in fact 12.0% is a 4% error, not 0.5%.

   The duty cycle unknown is nullified by making average measurements. The efficiency of the PA is the average output power divided by the average input power, regardless of duty cycle. Moreover, it is much easier to make average output power and average supply current measurements. The test setup and measurement procedures in this document are written to support making average current and power measurements, and to keep track of supply voltage during the burst on the oscilloscope.

   To make an efficiency measurement accurate to within ±0.5%, the average current must be known to within ±1.5mA (assuming 50% efficiency, +36dBm burst output, 12.5% duty cycle, and no voltage error). It is unlikely that any on-board ammeter offers this, and even if it did, it would only read the burst current one sample out of eight (because of the duty cycling of the PA) and would not provide the average current supplied to the PA.

   This is where the reservoir capacitor comes into play; it is connected between the ammeter and the PA. This way, the PA is drawing its 2A to 3A burst current directly from the capacitor, while the ammeter is measuring the average current delivered to the reservoir capacitor. The power supply is no longer required to support large current pulses, and the ammeter is not required to measure them.

   The size of the reservoir capacitor determines the supply droop during the burst. With a 10,000µF capacitor, the supply droops about 100mV during a 25% duty cycle (2 GSM time slots) full-power burst from the GSM PA. It should be half of this for a 12.5% duty-cycle measurement. The droop is very linear in this short duration, and neither the efficiency nor output power is much affected by the ±100mV change in supply voltage. Therefore, it is fair to control the power supply so that the voltage half-way through the burst is exactly 3.20V, and then say that the voltage during the whole burst was 3.20V.

   The size of the reservoir capacitor also determines the current ripple seen by the ammeter. With a 0µF capacitor, the ammeter sees the full-burst ripple, and with an infinitely large capacitor, it sees no ripple at all. The value required to keep the voltage droop during the burst below 100mV also provides enough filtering to keep the ripple seen by the ammeter less than 10mA. Even without an averaging function by the ammeter, the average supply current can be estimated to within ±2mA, very close to the goal of ±1.5mA from above.

Because of the losses in the ammeter and the ESR of the reservoir capacitor, the supply voltage at the IC can rise to 4.0V or 4.5V when the PA is not active. As long as this voltage remains below the 6.0V absolute maximum rating, this is just fine.

In summary, here's the setup for the supply:

- Ammeter connected between DC supply and 10,000µF reservoir capacitor, using averaging if possible.
- EV kit supply terminals connected directly to reservoir capacitor. If desired, solder banana jacks to EV kit supply terminals, and use short cables to accommodate the high burst currents with less voltage drop.
- Scope probes connected to EV kit supply terminals, and the oscilloscope is displaying both the power control waveform as well as the supply voltage at the EV kit.

8) If desired, use a directional coupler to measure the output spectrum and output power simultaneously. Recalibrate the setup as required. Adjust the analysis procedure to suit.

Analysis

This analysis procedure verifies the following for the GSM PA: shutdown supply current, off-isolation, output harmonics, +35dBm output drive capability, and efficiency.

1) With the function generator and RF generator disabled, verify that the shutdown supply current is less than 5µA.
2) Enable the function generator. At a peak voltage of 1.0V, the PA does not produce much output power. Slowly increase V_{HI} of the rectangle wave until the output power reaches about 35dBm (remember the spectrum analyzer is not very accurate when measuring absolute power). Do a sanity check here, and be sure the gating function on the spectrum analyzer is working as expected. Adjust the DC supply so the PA's supply voltage is 3.20V during the burst.
3) Disconnect the spectrum analyzer and connect the power meter, leaving the 20dB power pad connected at the EV kit output. Fine-tune V_{HI} of the power control waveform to deliver exactly +35dBm burst power (+26dBm average at exactly 12.5% duty cycle). Note the average supply current, and calculate efficiency:

$$\eta \approx \frac{P_{OUT}}{V_{CC} \times I_{CC}} = \frac{10^{\frac{P_{OUT}(dBm)}{10}}}{\left(V_{CC}(V)\right)\left(I_{CC}(mA)\right)}$$

4) Reconnect the spectrum analyzer, and use the peak-search function to measure the second and third harmonics in dBm. The second harmonic should be less than -6dBm, and the third harmonic should be less than -11dBm.
5) Disable the power control signal, but leave the RF input on. Now read the output power; this is the off-isolation, and should be below -30dBm.

Detailed Description

This section describes the circuitry surrounding the IC in the MAX2216 EV kit. For more detailed information covering device operation, please consult the MAX2216 data sheet.

The schematic for the MAX2216 EV kit appears in Figure 1. Looking at input, capacitors C3 and C4 are 100pF DC-blocking capacitors; this value contributes minimal reactance to the signal paths, down to 500MHz. Capacitors C12, C14, C16, C18, C33 through C39, and C40 form the V_{CC} decoupling network. Note the location of each component; a relatively large 33µF tantalum capacitor, C40, is located near the V_{CC} connector. Placed near the device, substantially smaller 0.01µF and 100pF decoupling capacitors reduce any high-frequency interference. The EV kit includes input-tuning circuits for both GSM and DCS bands. Resistors R1 and R2 maintain proper gain-control slope for the DCS amplifier; they do not affect the tuning circuits. Capacitors C13, C15, C17, and C19 are used for inter-stage tuning.

The MAX2216 EV kit ships with bias and tuning networks for the amplifier outputs. Capacitors C33 through C39 form an output-bias supply decoupling network. The inductors L1 and L2 act as RF chokes, and work in conjunction with C32, C23, C27, C28, C22, C24, and C25 to form narrow-band matching networks. This EV kit ships with the GSM output matched for 880MHz to 915MHz operation, and the DCS output tuned for 1710MHz to 1785MHz. Contact the factory regarding US PCS applications.

Refer to the applications note, *"Wafer Level Chip-Scale Package"* on Maxim's website (www.maxim-ic.com) for practical information about working with UCSP devices.

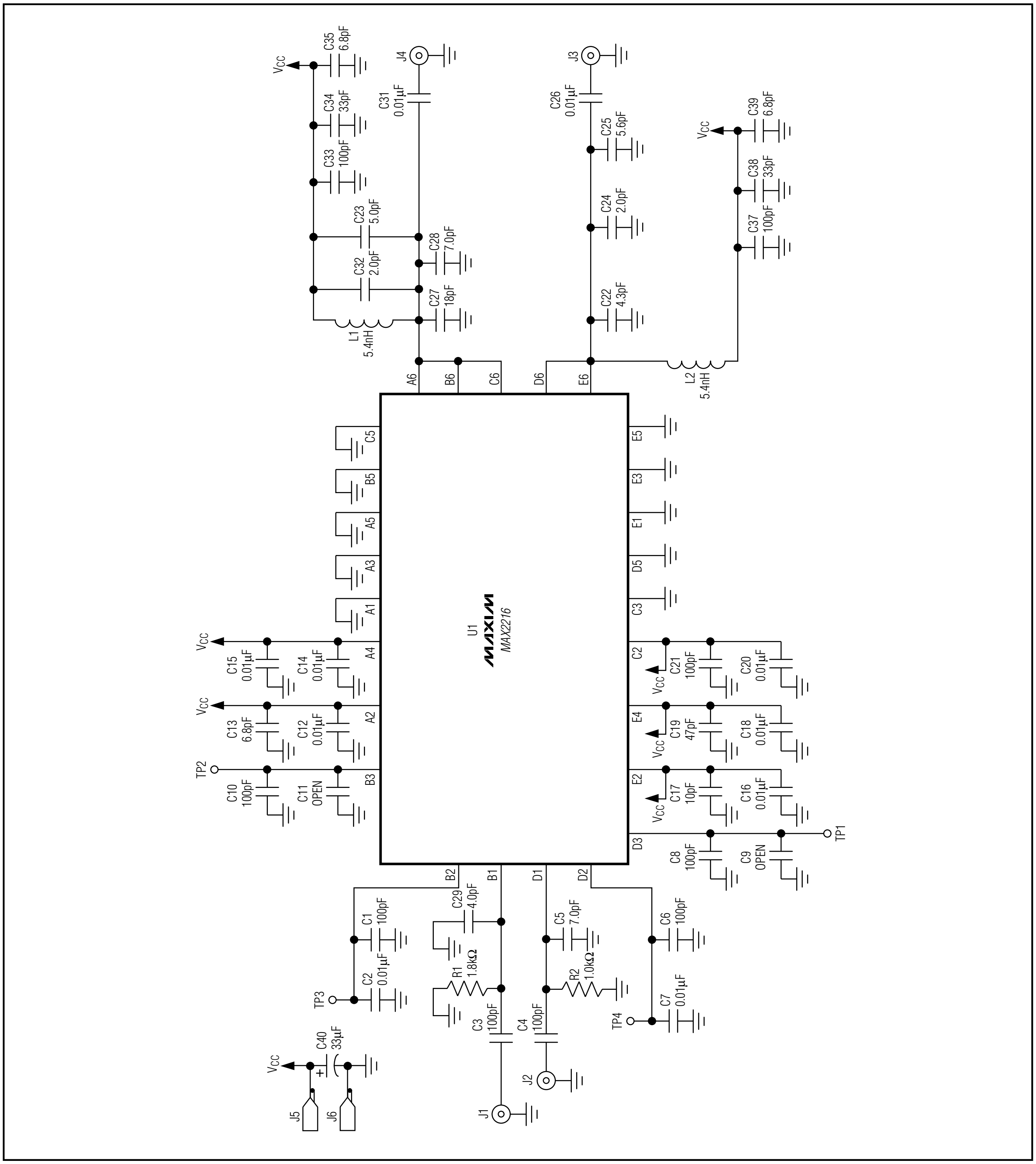

Figure 1. MAX2216 EV Kit Schematic

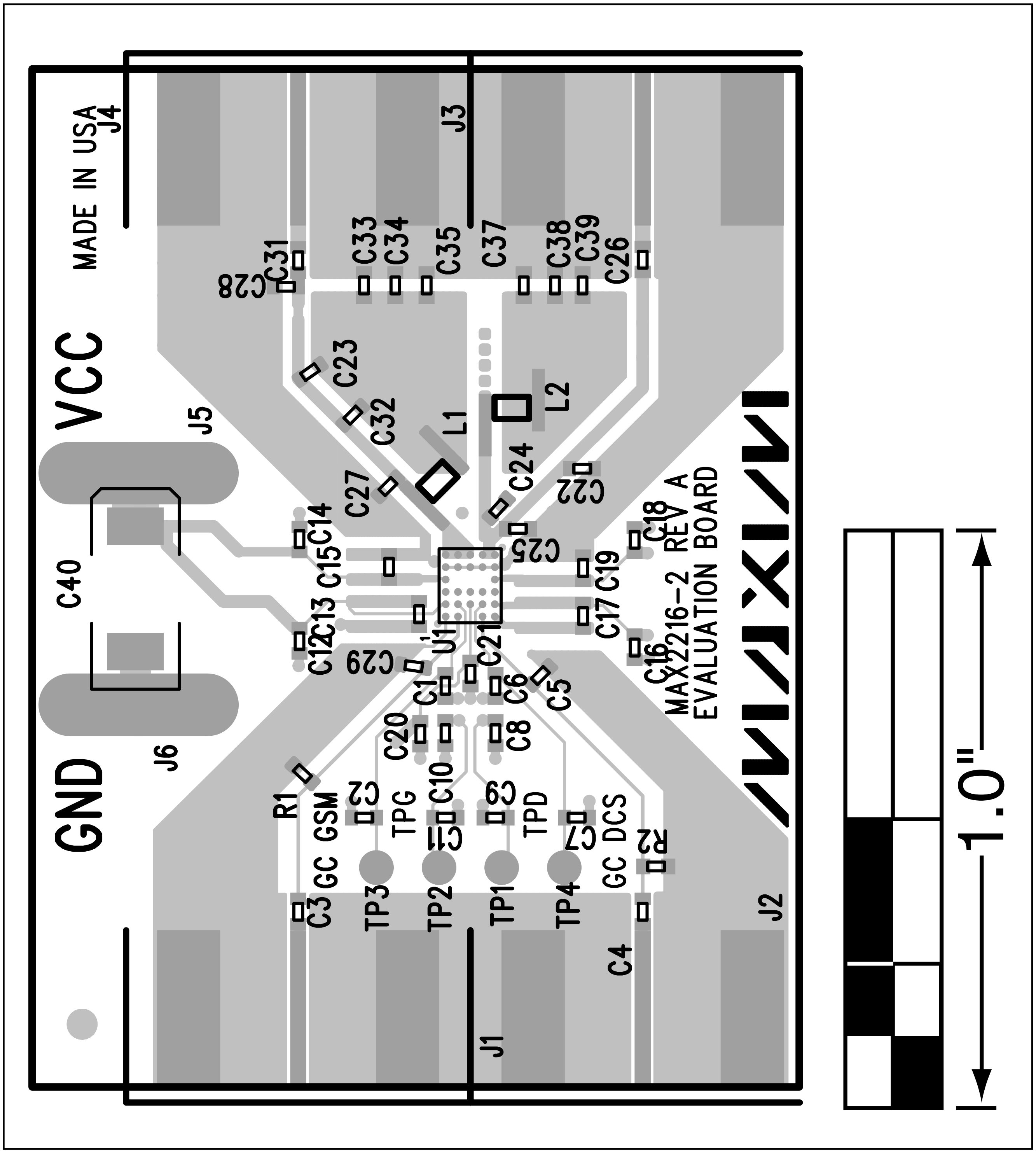

Figure 2. MAX2216 EV Kit PC Board Layout—Component Placement Guide

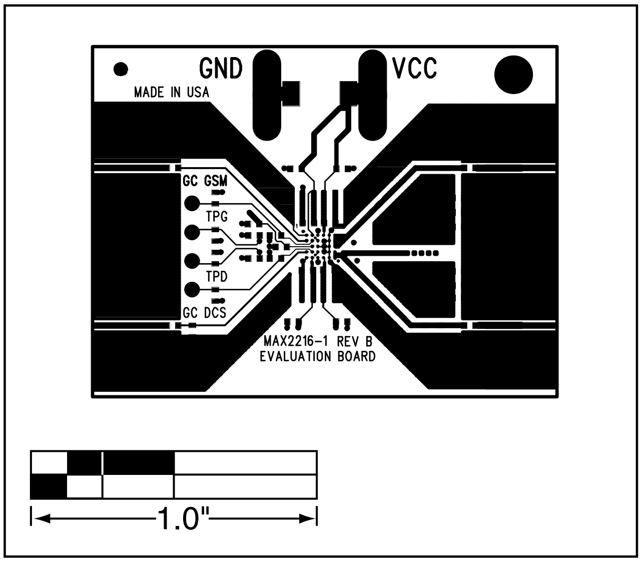

Figure 3. MAX2216 EV Kit PC Board Layout—Component Side

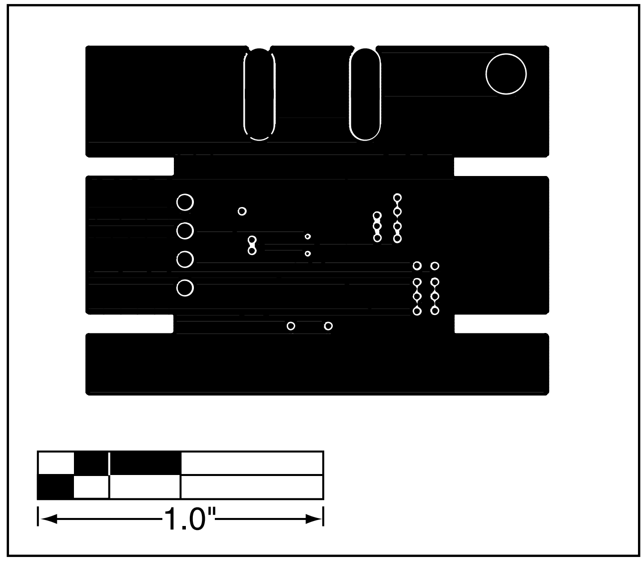

Figure 4. MAX2216 EV Kit PC Board Layout—Ground Plane

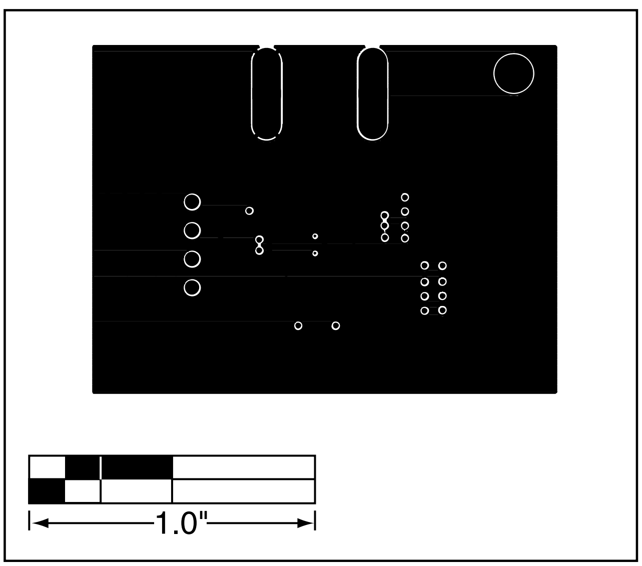

Figure 5. MAX2216 EV Kit PC Board Layout—Power Plane

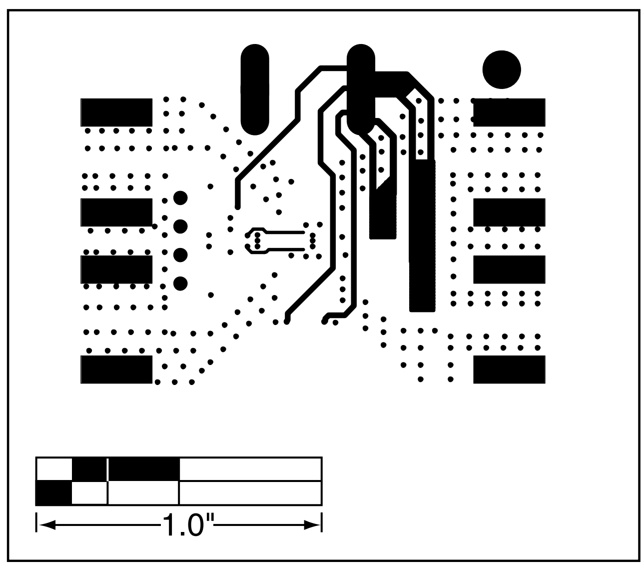

Figure 6. MAX2216 EV Kit PC Board Layout—Solder Side