



# MAX2391/MAX2392/MAX2393 Evaluation Kits

## General Description

The MAX2391/MAX2392/MAX2393 evaluation kits (EV kits) simplify the evaluation of the MAX2391/MAX2392/MAX2393 WCDMA/TD-SCDMA/3GPP-TDD direct-downconversion receive ICs. They are fully assembled and tested at the factory. Standard 50Ω SMA and BNC connectors are included on the EV kits to allow quick and easy evaluation on the test bench.

This document provides a list of equipment required to evaluate the device, a straightforward test procedure to verify functionality, a circuit schematic for each of the kits, a bill of materials (BOM) for each of the kits, and artwork for each layer of the PC board).

## Component Suppliers

SUPPLIER	PHONE	WEBSITE
CoilCraft	800-322-2645	www.coilcraft.com
DigiKey	800-344-4539	www.digikey.com
Johnson	507-833-8822	www.johnsoncomponents.com
MiniCircuits	718-934-4500	www.minicircuits.com
Murata	770-436-1300	www.murata.com

**Note:** When contacting these suppliers, please specify that you are using the MAX2391/MAX2392/MAX2393.

## Features

- ◆ EV Kits are Fully Assembled and Tested
- ◆ Fully Monolithic Direct-Conversion Receiver Includes: Fully Integrated On-Chip RF VCO and PLL Synthesizer  
Eliminates: IF SAW + IF AGC + I/Q Demodulator
- ◆ Meet All 3GPP Receiver's Standard Requirements with at Least 3dB Margin on  $E_b/N_0$
- ◆ Operate from a Single +2.7V to +3.3V Supply
- ◆ Over 90dB of Gain-Control Range
- ◆ Channel Selectivity Fully On-Chip, with Superior ACS (>39dB)
- ◆ SPI/QSPI/MICROWIRE™-Compatible 3-Wire Serial Interface
- ◆ Receiver Current Consumption  $\approx$  32mA
- ◆ Automatic Fast DC Offset Cancellation Scheme
- ◆ Compatible with Various CMOS Logic Levels
- ◆ Small 28-Pin QFN Leadless Package

## Ordering Information

PART*	TEMP RANGE	IC PACKAGE	APPLICATION
MAX2391EVKIT	-40°C to +85°C	28 QFN	IMT2000/UMTS
MAX2392EVKIT	-40°C to +85°C	28 QFN	TD-SCDMA
MAX2393EVKIT	-40°C to +85°C	28 QFN	WCDMA TDD

\*Contact factory for pricing and availability.

## Component List (MAX2391)

DESIGNATION	QTY	DESCRIPTION
C1, C7, C14, C16, C17	5	100pF capacitors (0402) Murata GRP1555C1H101J
C2, C32	2	10nF capacitors (0402) Murata GRP155R71C103K
C3, C18, C21, C22	4	1000pF capacitors (0402) Murata GRP155R71H102K
C4, C5	2	0Ω resistors (0402)
C6, C8, C27, C28, C33-C38, C40, C44, C45, C48	14	100nF capacitors (0402) Murata GRP155R61A104K
C9, C10-C13, C15, C20, C23, C31	9	Open capacitors (0402) (not installed)

DESIGNATION	QTY	DESCRIPTION
C19	1	220pF capacitor (0402) Murata GRP1555C1H221J
C25	1	1.0pF capacitor (0402) Murata GRP1555C1H1R0B
C39, C43, C46, C47	4	10μF tantalum capacitors (2012) (R code/case 0805-compatible) AVX TAJR106K006
C89	1	0.1μF capacitor (0805) Murata GRM21BR71E104K
C90	1	1.0μF capacitor (1206) Murata GRM31MR71C105K
C91	1	1.3pF capacitor (0402) Murata GRP1555C1H1R3B
C101	1	10μF capacitor (0805) Murata GRM216R71H103K

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Evaluate: MAX2391/2/3



# MAX2391/MAX2392/MAX2393 Evaluation Kit

**Evaluate: MAX2391/2/3**

## Component List (MAX2391) (continued)

DESIGNATION	QTY	DESCRIPTION
R1	1	100k $\Omega$ resistor (0402)
R2, R3, R4, R10, R11, R16, R17	7	0 $\Omega$ resistors (0402)
R5	1	27.4k $\Omega$ resistor (0402)
R6	1	6.8k $\Omega$ resistor (0402)
R7	1	Open resistor (0402)
R8	1	100 $\Omega$ resistor (0402)
R9, R18	2	10k $\Omega$ resistors (0402)
R12, R15	2	49.9 $\Omega$ resistors (0402)
R13, R14	2	2.0pF capacitors (0402) Murata GRP1555C1H2R0B
R19	1	1k $\Omega$ resistor (0402)
RBIAS	1	12k $\Omega$ $\pm$ 1% resistor (0402)
L1	1	3.3nH inductor (0402) Coilcraft 0402CS_3N3X
L2	1	Open inductor (0402) (not installed)
L4	1	1.8nH inductor (0402) Toko LL1005-FH1N8S
AGC, TCXO	2	10k $\Omega$ variable resistors (potentiometers)
FL1	1	2140MHz saw filter (2140MHz) Murata SAFSD2G14FA0T00R00
Y1	1	19.2MHz voltage-controlled TCXO (19.2MHz) Kinseki VC-TCXO-208C3-19.2
U1	1	MAX2391EGI WCDMA receiver
U2	1	Open RF balun (not installed)
U3, U4	2	MAX4444 low-distortion, differential- to-single-ended line driver

DESIGNATION	QTY	DESCRIPTION
U9	1	MAX8867EUK28 linear regulator
I, Q	2	BNC (50 $\Omega$ ) PC board receptacles (jacks) Amphenol 31-5239-52RFX
LNA_IN, LNA_OUT, LO_TEST, MXR_IN, REF_IN	5	SMA end launch jack receptacles 0.031in Johnson Components 142-0701-881
J9	1	—
GND, GND2, GND3, JU37, JU38, VCC_EXT, VCC_IC	7	—
G_LNA, G_MXR, SHDNB	3	Open
LD	1	—
JU20, JVCO, VCC_BB, VCC_CP, VCC_DIG, VCC_LNA, VCC _LOGIC, VCC_MXR, VCC_REF, VCC_TCXO, VCC_VCO	11	Open
BG, CSB, I+, I-, LOCK, Q+, Q-, TAGC, TUNE	9	Digi-Key 5000K-ND

# MAX2391/MAX2392/MAX2393 Evaluation Kit

## Component List (MAX2392)

DESIGNATION	QTY	DESCRIPTION
C1, C7, C14, C16, C17, C19	6	100pF capacitors (0402) Murata GRP1555C1H101J
C2, C32	2	10nF capacitors (0402) Murata GRP155R71C103K
C3, C18, C21, C22	4	1000pF capacitors (0402) Murata GRP155R71H102K
C4, C5, C10–C13	6	0 $\Omega$ resistors (0402)
C6, C8, C27, C28, C33–C38, C40, C44, C45, C48	14	100nF capacitors (0402) Murata GRP155R61A104K
C9, C15, C20, C23, C31	5	Open capacitors (0402) (not installed)
C25	1	1.0pF capacitor (0402) Murata GRP1555C1H1R0B
C39, C43, C46, C47	4	10 $\mu$ F tantalum capacitors (2012) (R code/case 0805-compatible) AVX TAJR106K006
C89	1	0.1 $\mu$ F capacitor (0805) Murata GRM21BR71E104K
C90	1	1.0 $\mu$ F capacitor (1206) Murata GRM31MR71C105MA01L
C91	1	1.3pF capacitor (0402) Murata GRP1555C1H1R3B
C101	1	0.01 $\mu$ F capacitor (0805) Murata GRM216R71H103K
R1	1	100k $\Omega$ resistor (0402)
R2, R3, R4, R10, R11, R16, R17	7	0 $\Omega$ resistors (0402)
R5	1	27.4k $\Omega$ resistor (0402)
R6	1	15k $\Omega$ resistor (0402)
R7	1	Open resistor (0402) (not installed)
R8	1	100 $\Omega$ resistor (0402)
R9, R18	2	10k $\Omega$ resistors (0402)
R12, R15	2	49.9 $\Omega$ resistors (0402)
R13, R14	2	2.0pF capacitors (0402) Murata GRP1555C1H2R0B

DESIGNATION	QTY	DESCRIPTION
R19	1	1k $\Omega$ resistor (0402)
RBIAS	1	12k $\Omega$ $\pm$ 1% resistor (0402)
L1	1	3.9nH inductor (0402) Coilcraft 0402CS_3N9X
L2	1	Open inductor (0402) (not installed)
L4	1	1.8nH inductor (0402) Toko LL1005-FH1N8S
AGC, TCXO	2	10k $\Omega$ variable resistors (potentiometers)
FL1	1	Open saw filter (2020MHz) (not installed)
Y1	1	19.2MHz voltage-controlled TCXO (19.2MHz) Kinseki VC-TCXO-208C3-19.2
U1	1	MAX2392EGI TD-SCDMA receiver
U2	1	Open RF balun (not installed)
U3, U4	2	MAX4444 low-distortion, differential-to-single-ended line driver
U9	1	MAX8867EUK28 linear regulator
I Q	2	BNC (50 $\Omega$ ) PC board receptacles (jacks) Amphenol 31-5239-52RFX
LNA_IN, LNA_OUT, LO_TEST, MXR_IN, REF_IN	5	SMA end launch jack receptacles 0.031in Johnson Components 142-0701-881
J9	1	—
GND, GND2, GND3, JU37, JU38, VCC_EXT, VCC_IC	7	—
G_LNA, G_MXR, SHDNB	3	Open
LD	1	—

Evaluate: MAX2391/2/3

# MAX2391/MAX2392/MAX2393 Evaluation Kit

## Component List (MAX2392) (continued)

DESIGNATION	QTY	DESCRIPTION
JU20, JVCO, VCC_BB, VCC_CP, VCC_DIG, VCC_LNA,VCC _LOGIC, VCC_MXR, VCC_REF, VCC_TCXO, VCC_VCO	11	Open
BG, CSB, I+, I- LOCK, Q+, Q- TAGC, TUNE	9	Digi-Key 5000K-ND

## Component List (MAX2393)

DESIGNATION	QTY	DESCRIPTION
C1, C7, C14, C16, C17, C19	6	100pF capacitors (0402) Murata GRP1555C1H101J
C2, C32	2	10nF capacitors (0402) Murata GRP155R71C103K
C3, C18, C21, C22	4	1000pF capacitors (0402) Murata GRP155R71H102K
C4, C5, C10-C13	6	0Ω resistors (0402)
C6, C8, C27, C28, C33-C38, C40, C44, C45, C48	14	100nF capacitors (0402) Murata GRP155R61A104K
C9, C15, C20, C23, C31	5	Open capacitors (0402) (not installed)
C25	1	1.0pF capacitor (0402) Murata GRP1555C1H1R0B
C39, C43, C46, C47	4	10μF tantalum capacitors (2012) (R code/case 0805-compatible) AVX TAJR106K006
C89	1	0.1μF capacitor (0805) Murata GRM21BR71E104K
C90	1	1.0μF capacitor (1206) Murata GRM31MR71C105MA01L
C91	1	1.3pF capacitor (0402) Murata GRP1555C1H1R3B
C101	1	0.01μF capacitor (0805) Murata GRM216R71H103K

DESIGNATION	QTY	DESCRIPTION
R1	1	100kΩ resistor (0402)
R2, R3, R4, R10, R11, R16, R17	7	0Ω resistors (0402)
R5	1	27.4kΩ resistor (0402)
R6	1	15kΩ resistor (0402)
R7	1	Open resistor (0402) (not installed)
R8	1	100Ω resistor (0402)
R9, R18	2	10kΩ resistors (0402)
R12, R15	2	49.9Ω resistors (0402)
R13, R14	2	2.0pF capacitors (0402) Murata GRP1555C1H2R0B
R19	1	1kΩ resistor (0402)
RBIAS	1	12kΩ ±1% resistor (0402)
L1	1	3.9nH inductor (0402) Coilcraft 0402CS_3N9X
L2	1	Open inductor (0402) (not installed)
L4	1	2.2nH inductor (0402) Toko LL1005-FH2N2S
AGC, TCXO	2	10kΩ variable resistors (potentiometers)
FL1	1	Open saw filter (1910MHz) (not installed)

# MAX2391/MAX2392/MAX2393 Evaluation Kit

## Component List (MAX2393) (continued)

DESIGNATION	QTY	DESCRIPTION
Y1	1	19.2MHz volt control TCXO (19.2MHz) Kinseki VC-TCXO-208C3-19.2
U1	1	MAX2393EGI TDD SCDMA receiver
U2	1	Open RF balun (not installed)
U3, U4	2	MAX4444 low-distortion, differential- to-single-ended line amplifier
U9	1	MAX8867EUK28 linear regulator
I Q	2	BNC (50Ω) PC board receptacles (jacks) Amphenol 31-5239-52RFX
LNA_IN, LNA_OUT, LO_TEST, MXR_IN, REF_IN	5	SMA end launch jack receptacles 0.031in Johnson Components 142-0701-881
J9	1	—
GND, GND2, GND3, JU37, JU38, VCC_EXT, VCC_IC	7	—
G_LNA, G_MXR, SHDNB	3	Open
LD	1	—
JU20, JVCO, VCC_BB, VCC_CP, VCC_DIG, VCC_LNA, VCC _LOGIC, VCC_MXR, VCC_REF, VCC_TCXO, VCC_VCO	11	Open
BG, CSB, I+, I- LOCK, Q+, Q- TAGC, TUNE	9	Digi-Key 5000K-ND

## Quick Start

The MAX2391/MAX2392/MAX2393 EV kits are 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 recommended test equipment to verify the operation of the MAX2391/MAX2392/MAX2393 EV kits. It is intended as a guide only, and some substitutions are possible.

- DC supply capable of delivering 200mA continuous current at +5.0V
- DC supply capable of delivering 200mA continuous current at -5.0V
- DC supply capable of delivering 50mA continuous current at +2.8V
- HP 34401 or equivalent DMM, to measure IC supply current
- HP8648C or equivalent signal source capable of generating -30dBm up to 2.2GHz
- HP8561E or equivalent RF spectrum analyzer (base-band spectrum only)
- TDS3012 or equivalent digitizing oscilloscope
- Windows® 95/98/2000 PC with an available parallel port

### Connections and Setup

This section provides a step-by-step guide to testing the basic functionality of the EV kits.

This procedure is specific to the MAX2391 in the UMTS band (reverse channel: 2110MHz to 2170MHz). Adapt the procedure for the MAX2392 or MAX2393 by changing the RF frequency of the test tone to suit the band of interest. The test tone at a 180kHz offset works well for all three parts.

- 1) Install the MAX2391/MAX2392/MAX2393 control software on PC. This software uses a 3rd-party DLL to allow communication through the parallel port: "DriverLINX" by Scientific Software Tools ([www.sst-net.com](http://www.sst-net.com)). The Maxim installer will install this DLL for you automatically.
- 2) Connect the interface board and cable from the PC parallel port to the EV kit header. Pin 1 on the ribbon cable is indicated with a stripe, and pin 1 on the header is nearest to the corner of the board. The interface board is just populated with logic buffers to protect the parallel port against accidental shorts, but be careful with these connections.

Windows is a registered trademark of Microsoft.

Evaluate: MAX2391/2/3

# MAX2391/MAX2392/MAX2393 Evaluation Kit

- 3) Calibrate the power meter, with the low-power head, at 2140MHz. A rough interpolation of the cal factor does not introduce noticeable error, if reading the cal factor from a table.
- 4) Set the signal generator for a 2140.18MHz CW (unmodulated) output at -27dBm, and connect a 3dB pad to the DUT side of the SMA cable. Use the power meter to set the input power to the DUT at -30dBm. Use measured attenuators and/or the signal generator's internal step attenuators (-40dB) to reduce the signal to -90dBm.
- 5) Connect the RF source's SMA cable and attenuators to the EV kit's LNAIN SMA input.
- 6) Connect the BNC cable from either I or Q to the spectrum analyzer. Connect the other output into the oscilloscope—be sure to set the oscilloscope's inputs to 50 $\Omega$ , and not 1M $\Omega$ . Cable loss at 180kHz is negligible; as long as cables are about the same length, no calibration is required at the output to observe proper signal level as well as proper I/Q gain-and-phase balance.
- 7) Set one of the DC supplies to 2.8V and set a current limit of 100mA (if available). Connect this supply through the ammeter to "VCC\_IC", and readjust the supply if necessary to get 2.8V at the IC when powered up. This supply connection only powers the IC on the EV kit – read the ammeter to watch IC supply current for the receiver. Connect another line directly from the 2.8V supply to "VCC\_EXT" to supply the external logic on the kit. Not having the voltage drop of the ammeter inline means the voltage is slightly higher than VCC\_IC, but this does not cause a problem.
- 8) Set the other supplies for  $\pm 5.0V$  with a current limit of about 100mA. Connect these supplies to the +5V, GND, and -5V on the opposite side of the kit. These are the bipolar supplies for the MAX4444 differential line drivers that buffer the I/Q outputs. Note that all GND test points are connected to the same ground plane—it is only necessary to use one of them.
- 8) Set the spectrum analyzer to span from DC (minimum sweep) to 2MHz. Set the reference level to +10dBm.
- 9) Set the oscilloscope for a sweep rate of about 1 $\mu s/div$ , DC coupling, with an amplitude scale of about 100mV/div.

## Testing the WCDMA Receiver

The power-up default state of the MAX2391 receiver is for:

- LO midband (2140MHz)
  - LNA high gain
  - Mixer high gain, normal linearity
  - Powered on (out of shutdown)
- 1) Verify that the IC itself is drawing about 32mA (from VCC\_IC). The two MAX4444 differential line drivers at the baseband outputs should draw about 80mA from each of their supplies.
  - 2) Use the AGC adjust potentiometer on the board to set VAGC at +2.2V (maximum gain).
  - 3) Spot-check the VCO tuning voltage (TUNE) to see that the synthesizer is locked. The voltage should be about mid-supply with the RFLO running at its power-up default of 2140MHz. Disconnect any leads from this before continuing, as the noise pick-up onto the tuning line directly frequency-modulates the VCO, and degrades LO phase noise.
  - 4) Observe the 180kHz tone on the spectrum analyzer. Adjust AGC to to achieve a -3.5dBm output level.
  - 5) The on-board TCXO has a fine-tuning control—the other potentiometer on the EV kit allows for external temperature compensation of the TCXO to further decrease frequency error. Adjust the TCXO potentiometer if desired to bring the output tone exactly to 180kHz.
  - 6) Observe the other output on the oscilloscope. At these input power levels, the SNR is typically much too low to see the output tone through the noise. If available, use the internal low pass filter option (often 20MHz) and lots of averaging.
  - 7) To make a gain/phase error measurement, connect both outputs to the scope. Increase the input power to about -50dBm, and back off the AGC until the outputs are swinging about 0.42V<sub>p-p</sub>. Again, use digital averaging to get both I and Q sinusoids visible on the scope. If automated measurements for phase and amplitude are not available, use the cursors to make the measurement. Calculate phase error in degrees, and gain error in dB, and verify that the results are better than 2 degrees and 0.6dB, respectively.

# MAX2391/MAX2392/MAX2393 Evaluation Kit

Evaluate: MAX2391/2/3

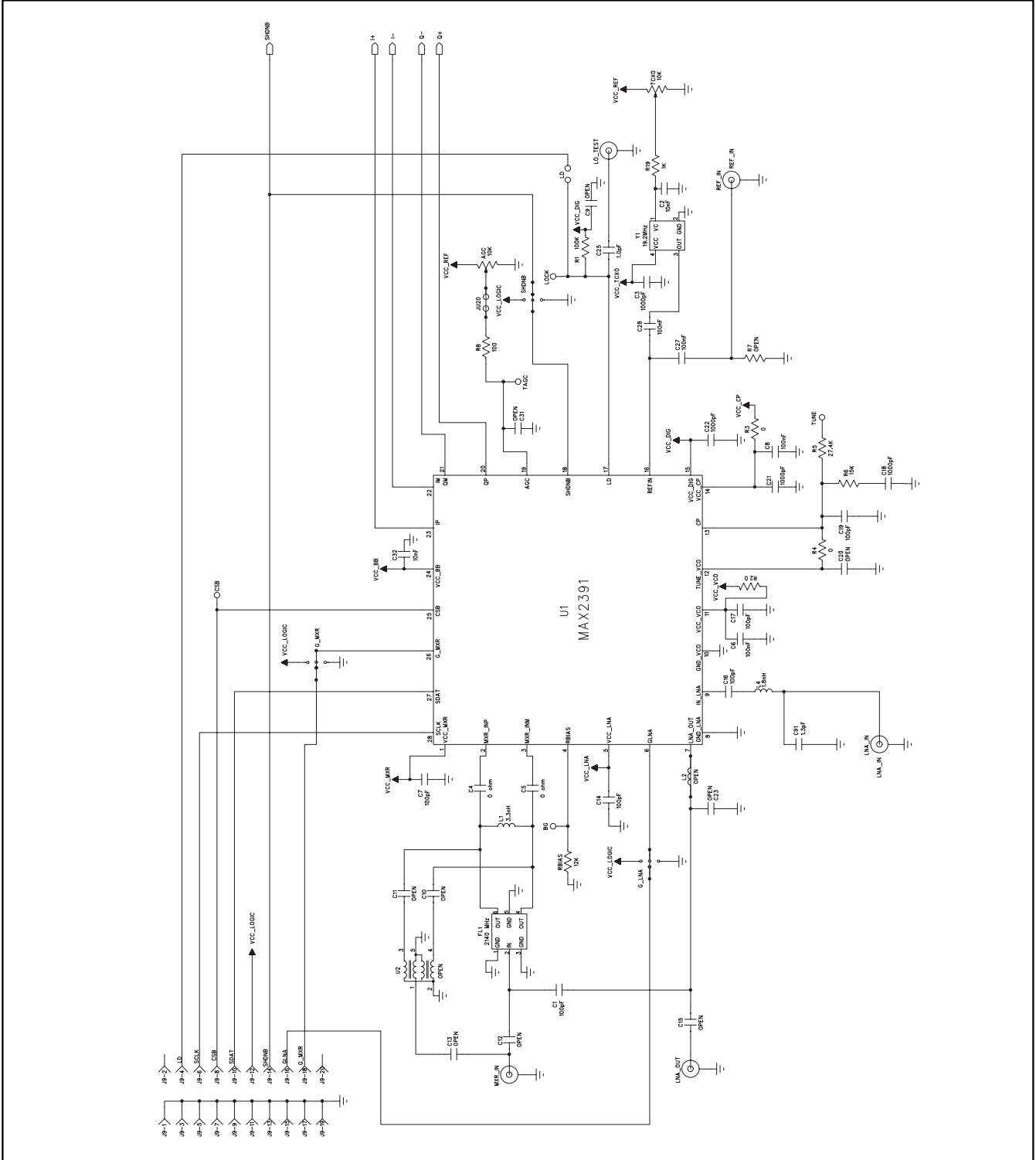


Figure 1a. EV Kit Schematic—Main Circuit (MAX2391)

# MAX2391/MAX2392/MAX2393 Evaluation Kit

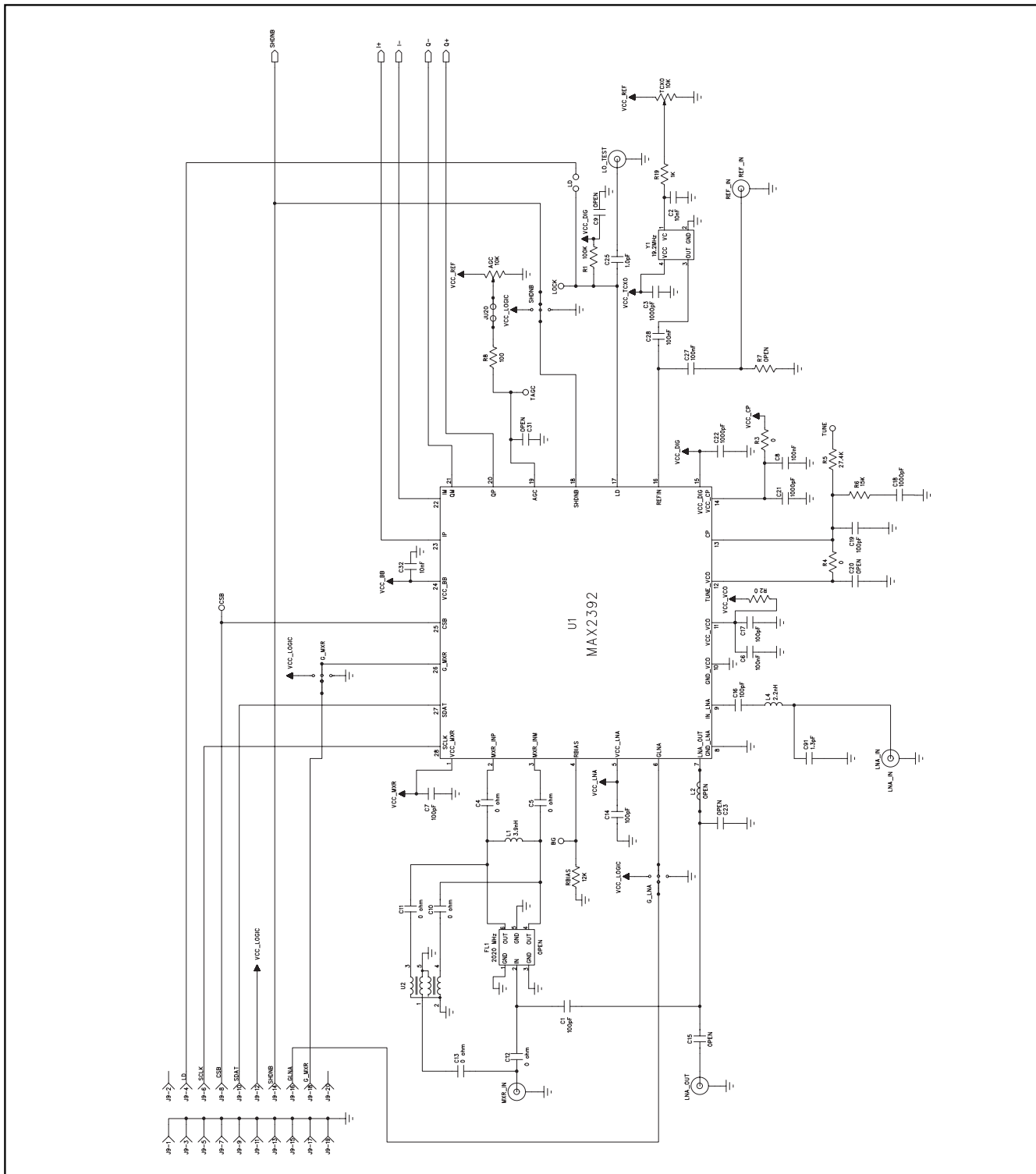


Figure 1b. EV Kit Schematic—Main Circuit (MAX2392)





# MAX2391/MAX2392/MAX2393 Evaluation Kit

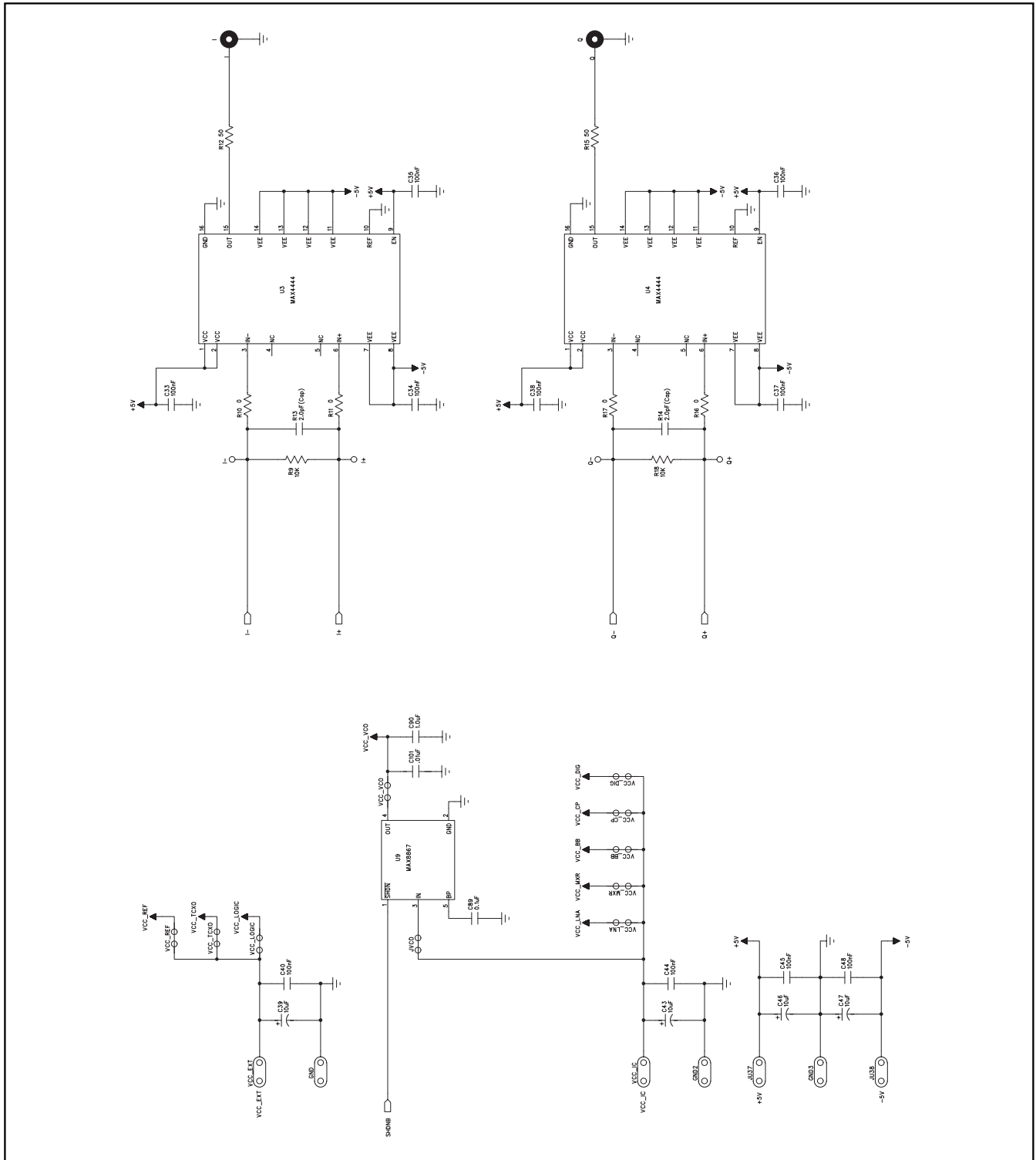


Figure 1d. EV Kit Schematic—Differential Line Driver and VCL LDO (MAX2391/MAX2392/MAX2393)

# MAX2391/MAX2392/MAX2393 Evaluation Kit

## PC Board Artwork—MAX2391/MAX2392/MAX2393

Evaluate: MAX2391/2/3

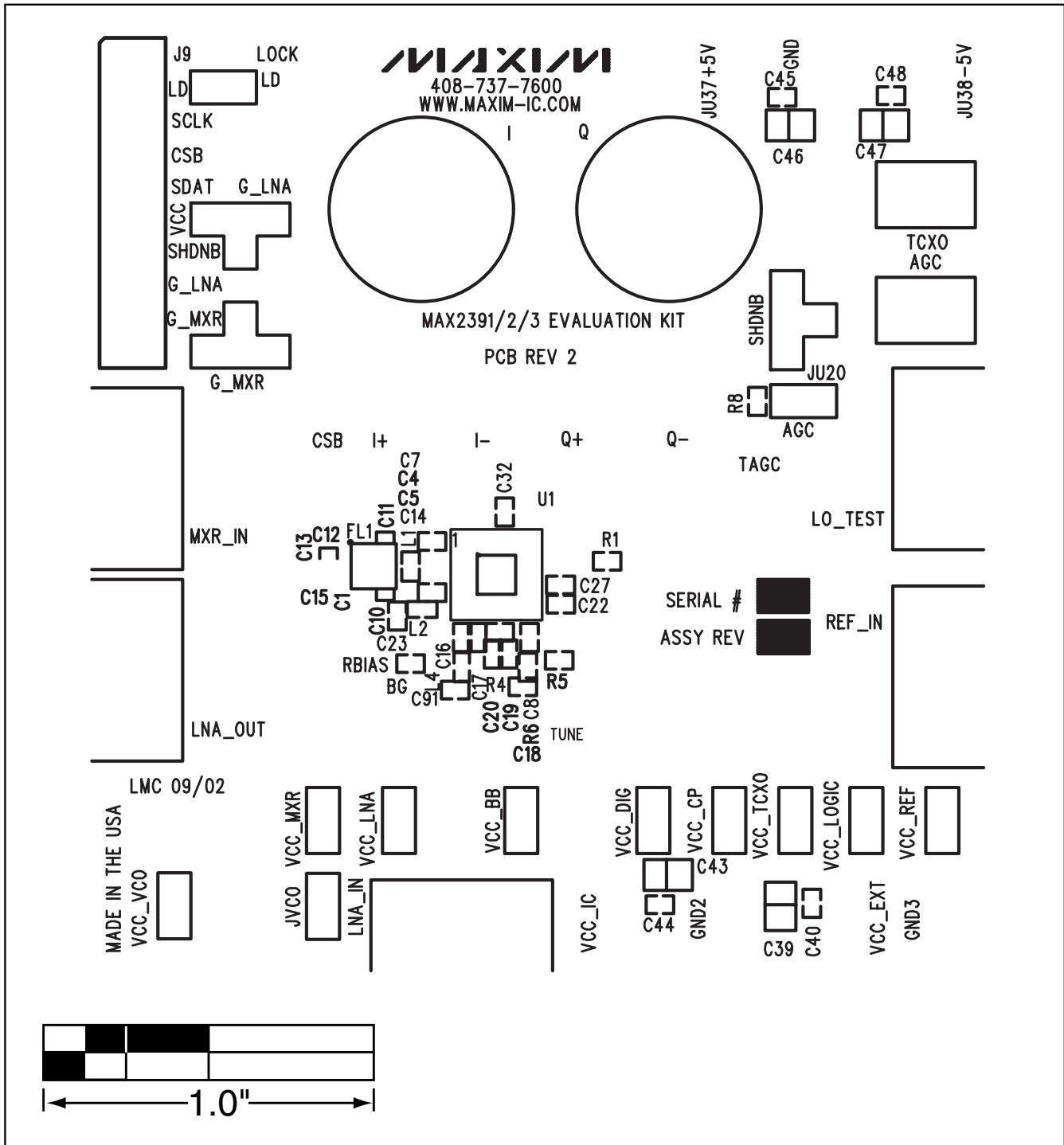


Figure 2. Top Silkscreen

# MAX2391/MAX2392/MAX2393 Evaluation Kit

PC Board Artwork—MAX2391/MAX2392/MAX2393 (continued)

Evaluate: MAX2391/2/3

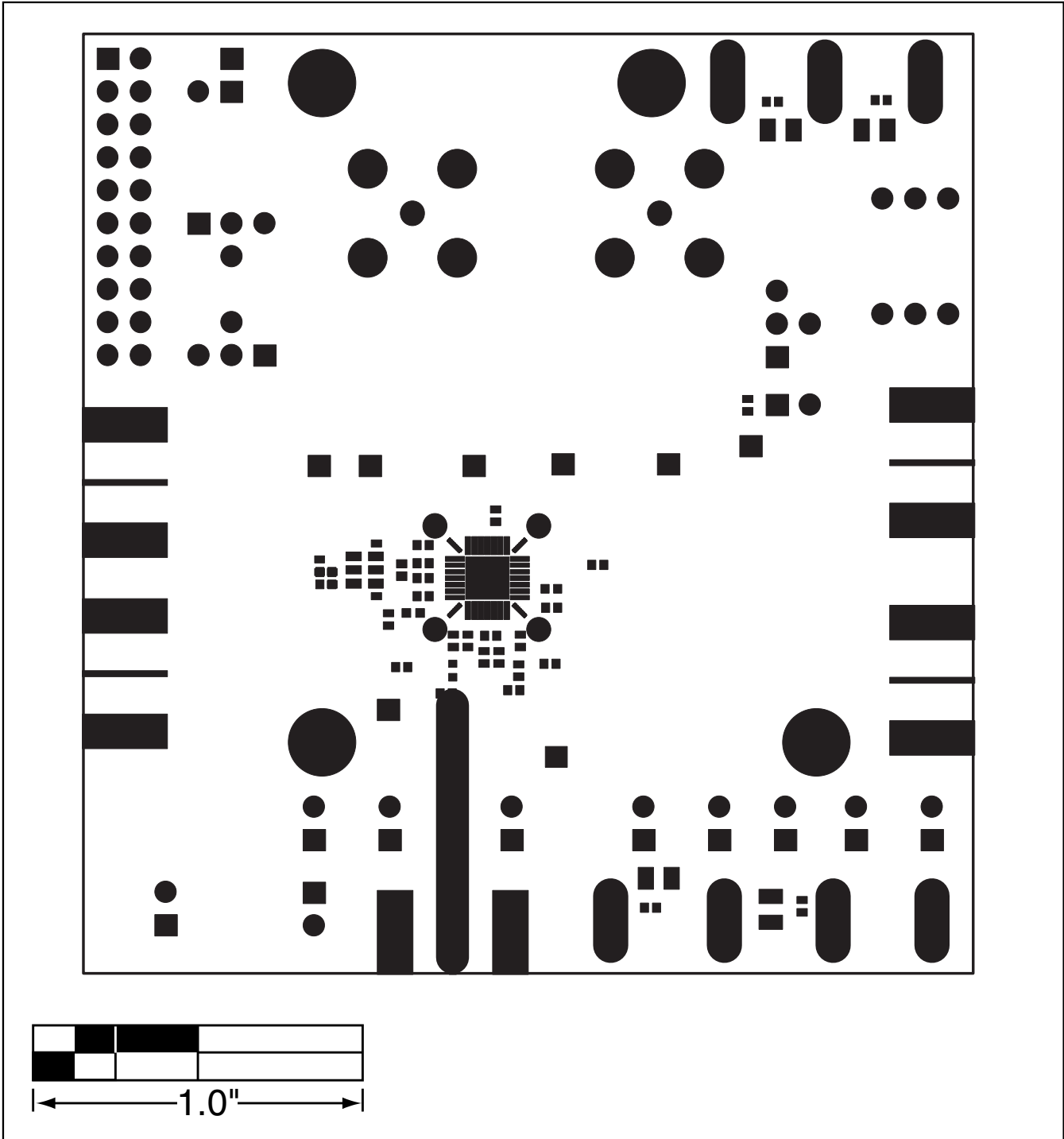


Figure 3. Top Solder Mask

# MAX2391/MAX2392/MAX2393 Evaluation Kit

PC Board Artwork—MAX2391/MAX2392/MAX2393 (continued)

Evaluate: MAX2391/2/3

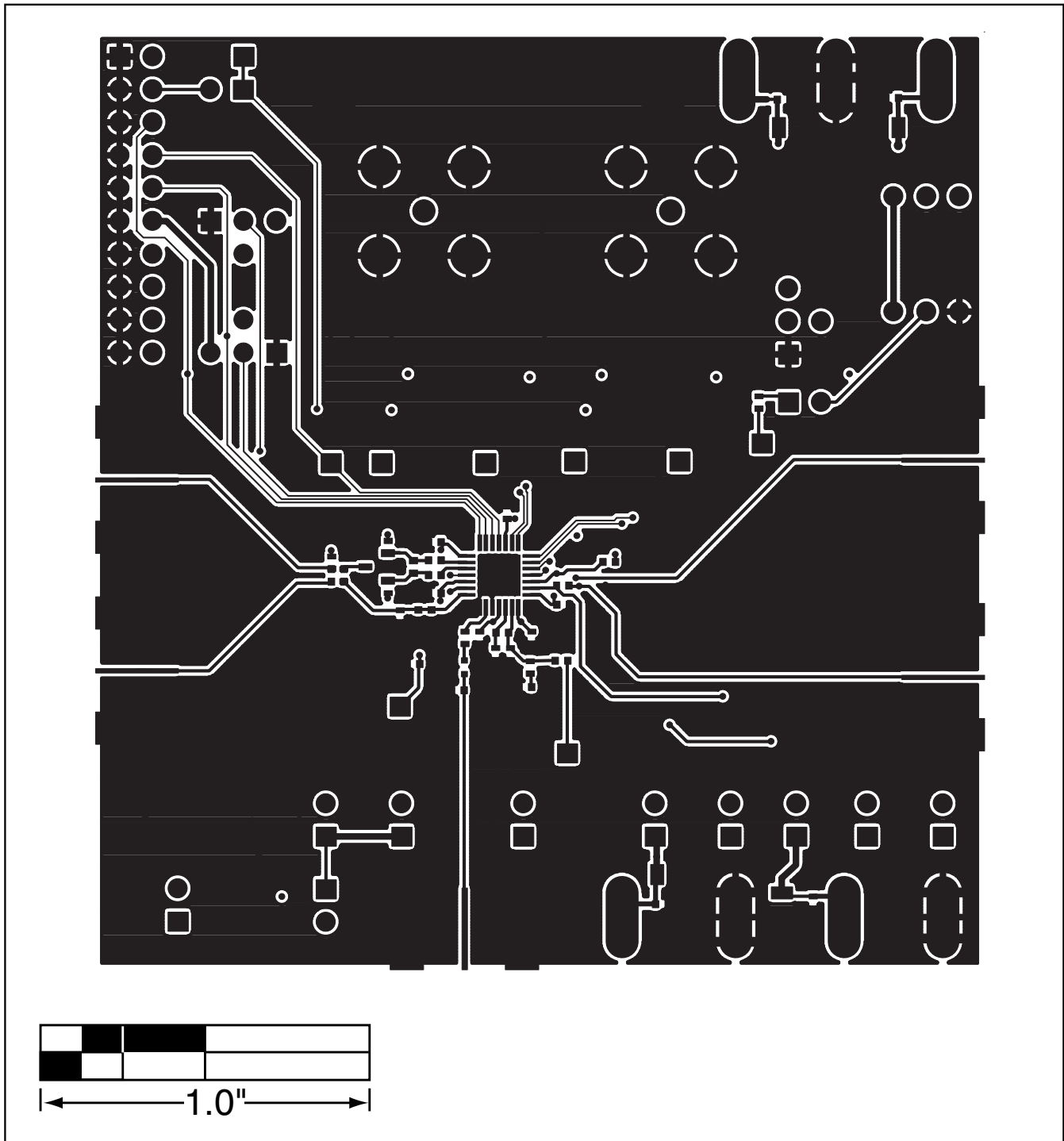


Figure 4. Top Layer Metal

# MAX2391/MAX2392/MAX2393 Evaluation Kit

## PC Board Artwork—MAX2391/MAX2392/MAX2393 (continued)

Evaluate: MAX2391/2/3

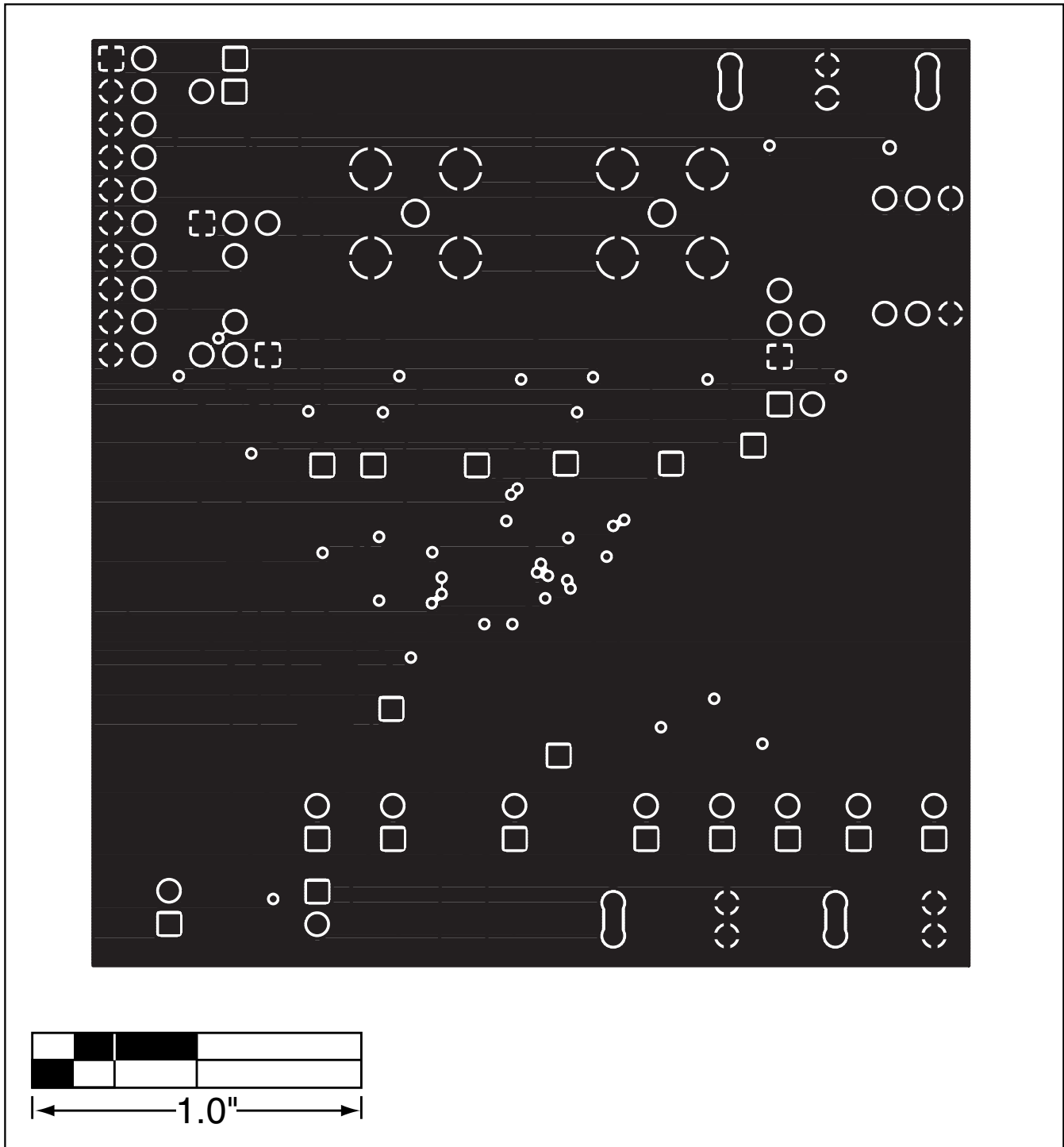
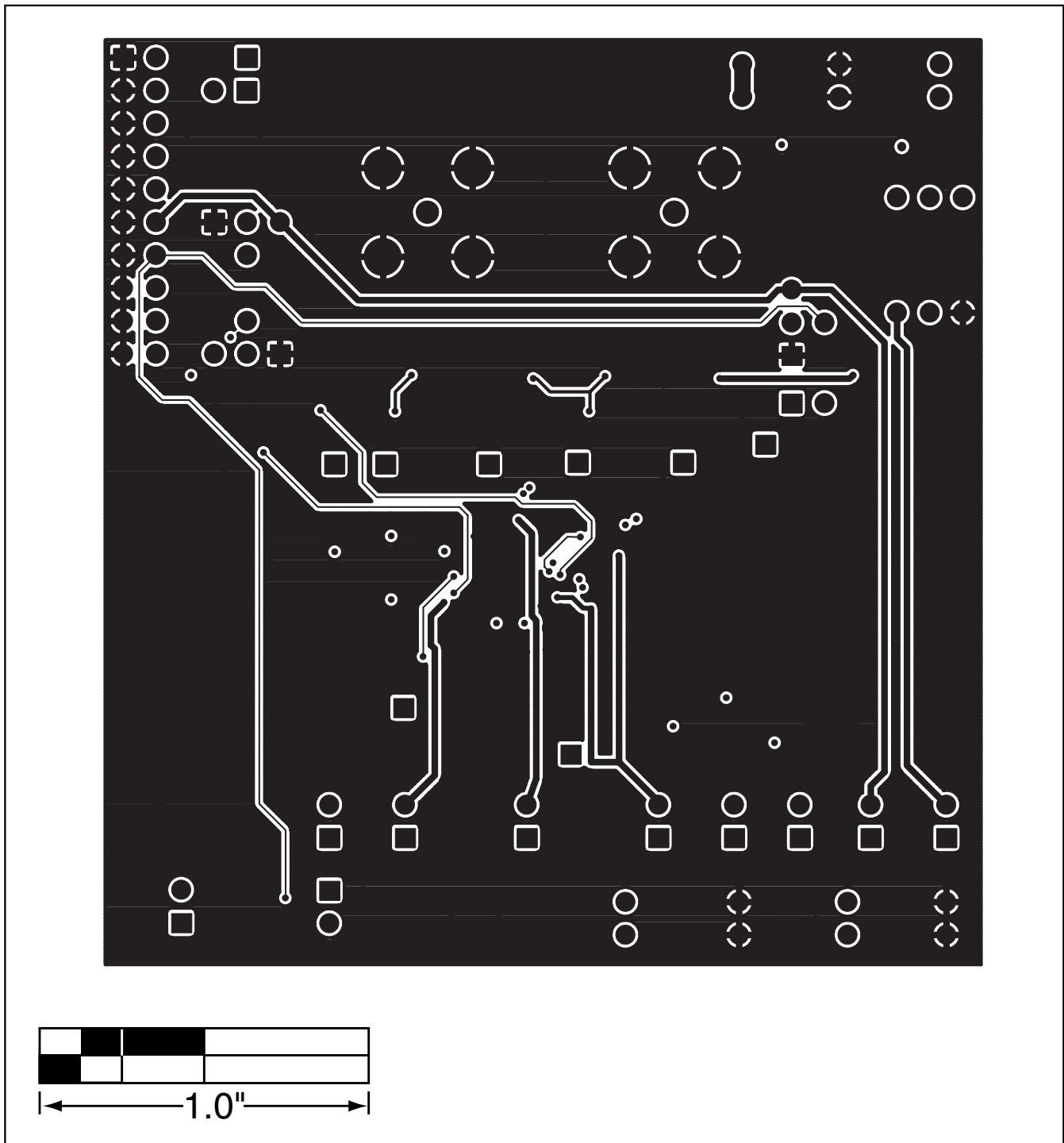


Figure 5. Metal Layer 2—Ground Plane

# MAX2391/MAX2392/MAX2393 Evaluation Kit

## PC Board Artwork—MAX2391/MAX2392/MAX2393 (continued)

Evaluate: MAX2391/2/3



# MAX2391/MAX2392/MAX2393 Evaluation Kit

PC Board Artwork—MAX2391/MAX2392/MAX2393 (continued)

Evaluate: MAX2391/2/3

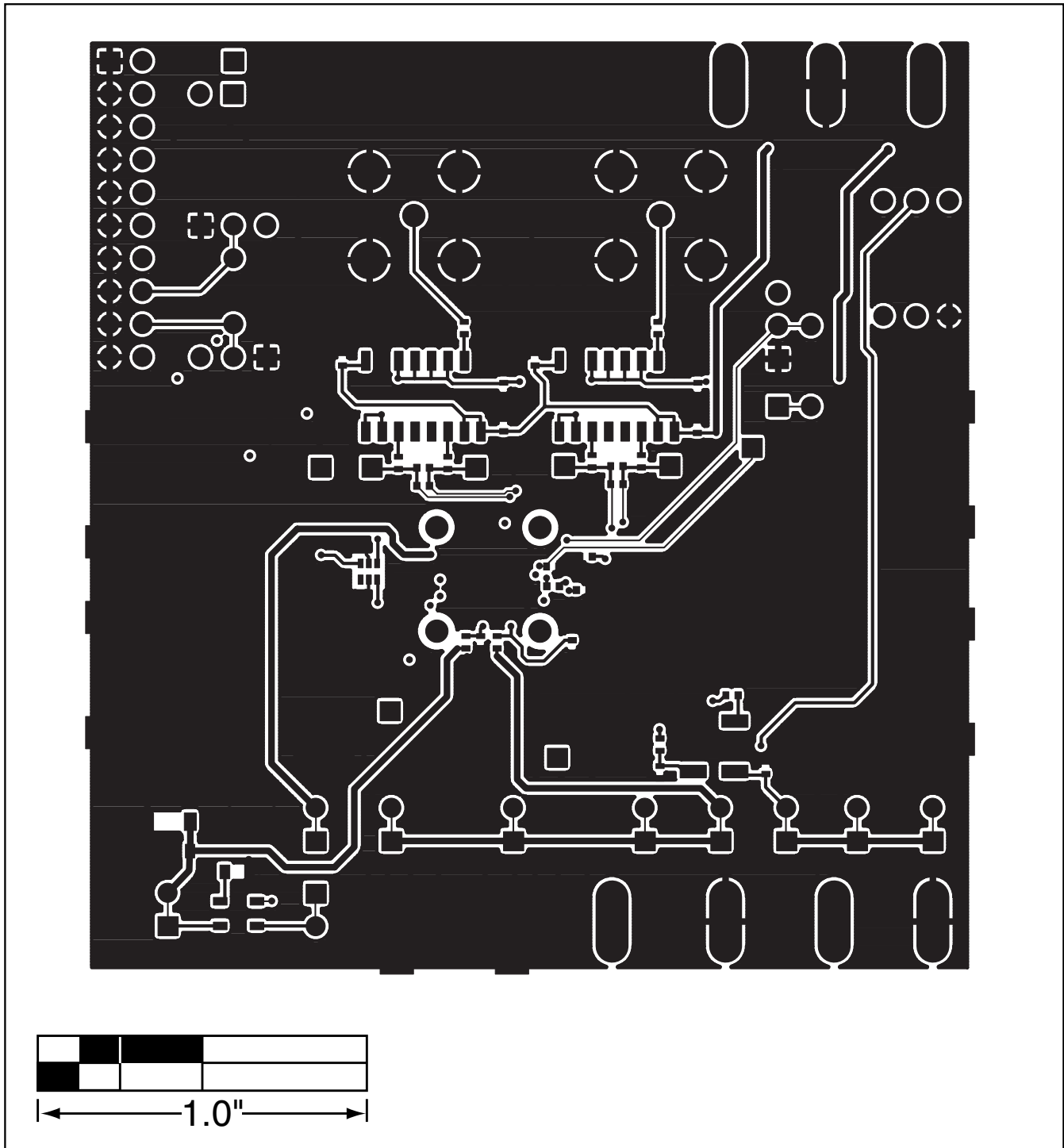


Figure 7. Bottom Layer Metal



# MAX2391/MAX2392/MAX2393 Evaluation Kit

PC Board Artwork—MAX2391/MAX2392/MAX2393 (continued)

Evaluate: MAX2391/2/3

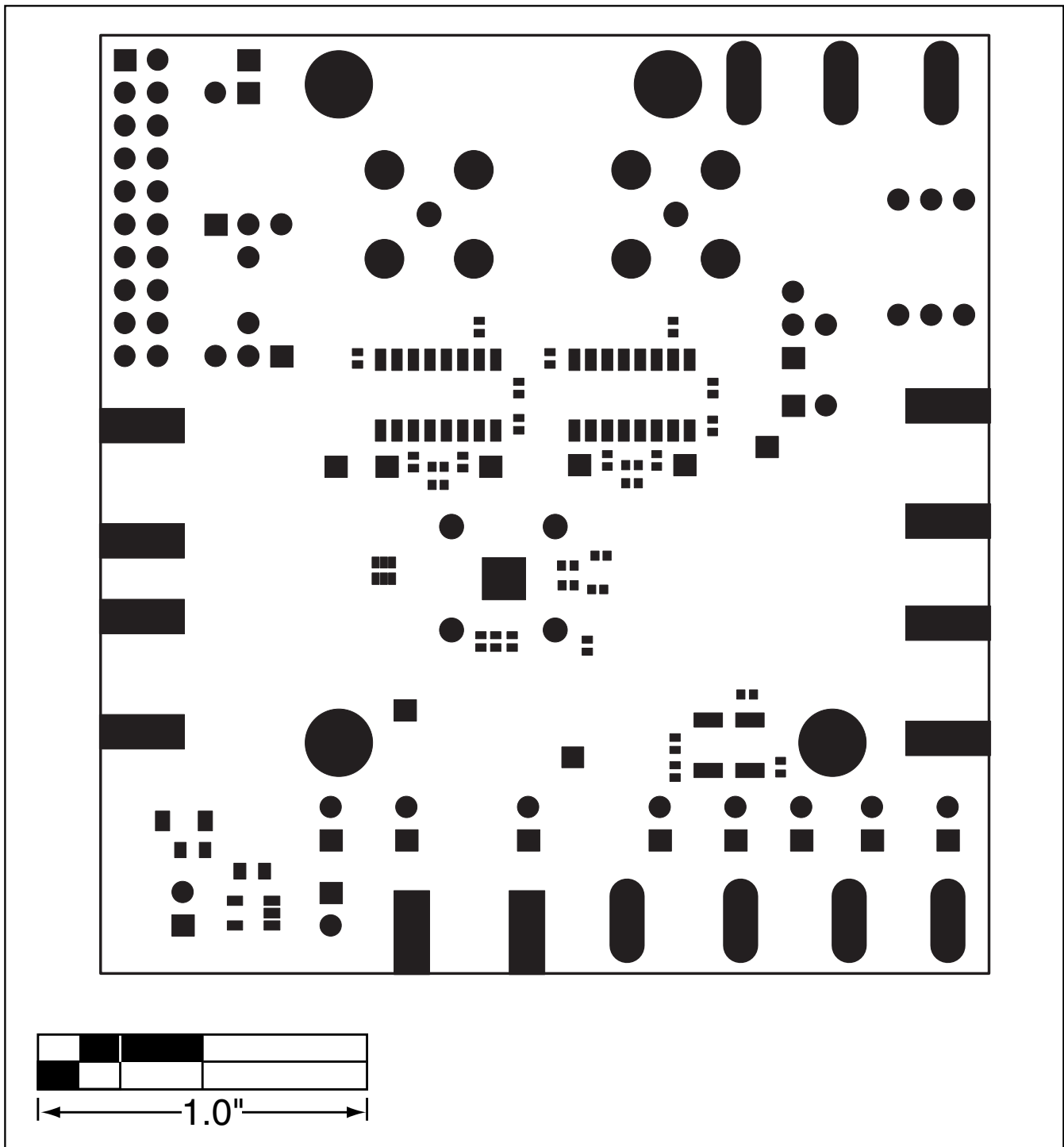


Figure 8. Bottom Solder Mask

# MAX2391/MAX2392/MAX2393 Evaluation Kit

## PC Board Artwork—MAX2391/MAX2392/MAX2393 (continued)

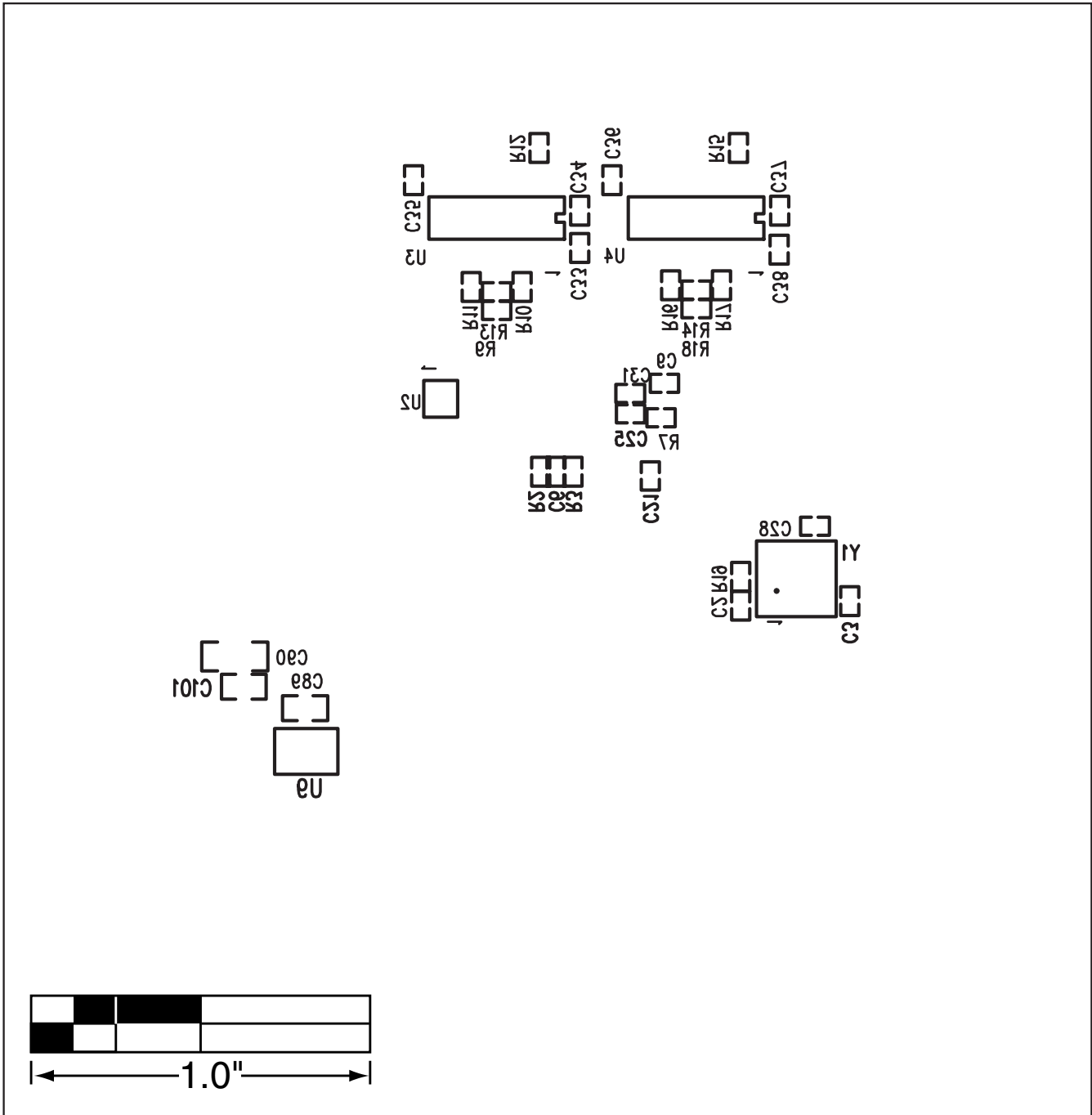


Figure 9. Bottom Silkscreen

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