*Click **here** for production status of specific part numbers.*

MAX15162ATG Evaluation Kit

Evaluates: MAX15162ATG+/ MAX15162AATG+

General Description

The MAX15162ATG evaluation kit (EV kit) is a fully assembled and tested surface-mount circuit board that contains all components necessary to evaluate the MAX15162ATG+/MAX15162AATG+ dual-channel circuit breaker IC for power amplifier system. The IC is in compact 24-pin, 4mm x 4mm TQFN package. The EV kit is powered from an 8V to 60V DC supply and can be configured as two independent single-channels or one parallel dual-channel circuit breaker. The EV kit provides multilevel overcurrent-limit protection and pin-strap programmable current-limit level up to 1.5A for each channel.

The EV kit demonstrates the full functionality of the MAX15162ATG+/MAX15162AATG+, such as IN-OUT short protection during startup, inrush current control, input undervoltage-lockout (UVLO), programmable overcurrent shutdown delay time and fast large overcurrent protection. The EV kit also features current monitoring/reporting with ±3% accuracy (0.8~1.5A) on individual channel and overcurrent/overtemperature fault status indication.

***Warning:** The EV kit is designed to operate with high voltages. Dangerous voltages are present on this EV kit and on equipment connected to it. Users who power up this EV kit or power the sources connected to it must be careful to follow safety procedures appropriately to work with high-voltage electrical equipment.*

Under severe fault or failure conditions, this EV kit may dissipate large amounts of power, which could result in the mechanical ejection of a component or of component debris at high velocity. Operate this kit with care to avoid possible personal injury.

Features

- 8V to 60V Wide Input Voltage Range
- Integrated Dual-Power MOSFET with Turn-on Resistance 200mΩ
- Dual-Channel Independent or Parallel Mode Configuration
- Undervoltage Lockout
- Enable Input for Individual Channel
- Constant Power Control at Startup
- Startup Watchdog Timer
- Startup IN-to-OUT Short Protection
- Over-current and Overtemperature Fault Status Indication on Individual Channel
- ±3% Accuracy Current Reporting on Individual Channel
- Multi-Level Overcurrent Limit Protection
- Programmable Current Limit Level
- Programmable Overcurrent Shutdown Delay Time
- Latch in a Fault Event (MAX15162ATG+)
- Auto-Retry in a Fault Event with Programmable Auto-Retry Time (MAX15162AATG+)
- Built-In Thermal Shutdown Protection
- Proven PCB Layout
- Fully Assembled and Tested

***Ordering Information** appears at end of data sheet.*

319-100478; Rev 0; 1/20

maxim integrated™

Quick Start

Required Equipment

- MAX15162ATG EV kit
- 8V to 60V, 5A capable DC power supply
- Two loads capable of supporting 60V and sinking 3A
- Digital voltmeters
- 100MHz dual-trace oscilloscope

Procedure

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

Caution: Do not turn on the power supply until all connections are completed.

1) Configure IMONx and ENx pins with power supply off (x = 1, 2):
   a) **Independent Mode:** Leave jumper J9 open (to disconnect IMON1 and IMON2), install a shunt across any one of four pin-straps of J11 and J12 individually (configure OC limit of channel 1 and channel 2 individually). Leave jumper J8 open (to disconnect EN1 and EN2) and shunt pins 2-3 of J4 and J6 respectively. Switch SW1 and SW2 to their pin-1.
   b) **Parallel Mode:** Install a shunt at jumper J9 (to tie IMON1 and IMON2 together), install a shunt across any one of four pin-straps of J11 (J12) and leave J12 (J11) open. Install a shunt at jumper J8 (to tie EN1 and EN2 together) and shunt pins 2-3 of J4 or J6. Switch SW1 and SW2 to their pin-1.
2) Connect electronic loads to the output:
   a) **Independent Mode:** Connect two 1A electronic loads to OUT1+/OUT1- and OUT2+/OUT2- banana jack connectors individually. Disable the load.
   b) **Parallel Mode:** Solder R33 (0Ω) to connect OUT1+ and OUT2+. Connect one 2A electronic load to OUT1+ and OUT1- banana jack connectors and disable the load.
3) Connect the external DC power supply to VIN and GND banana jack connectors. Turn on VIN at 0V and ramp it up to 8V or higher.
4) Using voltmeters, verify that the EV kit provides EN = 3.3V and $V_{OUT} = V_{IN}$ ($V_{IN} - V_{OUT} < 700mV$) across the OUT1+ (OUT2+) and OUT1- (OUT2-).

Detailed Description of Hardware

The MAX15162ATG EV kit is a fully assembled and tested board to evaluate the performance of the MAX15162ATG+/MAX15162AATG+ integrated dual-channel circuit breaker. With the wide range of input voltage (from 8V to 60V), inrush current control and programmable overcurrent protection limit level, the MAX15162ATG+/MAX15162AATG+ is well suited for telecommunication Power Amplifier systems. The EV kit features components and circuits that demonstrate the full functionality of the MAX15162ATG+/MAX15162AATG+ in both independent mode and parallel mode.

Mode Configuration

The MAX15162ATG+/MAX15162AATG+ device detects IMONx (x = 1, 2) pins connection during initialization process and determines the operation mode. To configure the device in independent mode on the EV kit, leave J9 open and connect J11 to any resistor from R16 to R19 and connect J12 to any resistor from R20 to R23. To configure the device in parallel mode, install a shunt at J9 to tie IMONx together besides configuring J11 and J12. In addition, J8 must also be shunted to tie EN1 and EN2 together. See Table 1 for operating mode settings.

Enable Input (ENx)

The dual channels of the MAX15162ATG+/MAX15162AATG+ can be individually enabled or disabled through the ENx (x=1, 2) by driving it above or below the Enable threshold voltage. The EV kit allows ENx pins to be pulled up with VIN rising edge by shunting 1-2 pins of J4 and J6. ENx pins can also be pulled high by 3.3V generated by external linear regulator MAX6765 by shunting 2-3 pins of J4 and J6. See Table 2 for EN jumpers' settings.

Current Limit Thresholds and Current Monitor (IMONx)

The EV kit configures overcurrent limit threshold through IMONx pins for each channel. Connect a resistor between IMONx and GND to program the overcurrent limit threshold in the device. In independent mode, connect J11 and J12 to the current-limit setting resistors individually. The following equation is used to calculate current-limit setting resistor:

$$R_{IMON}\ (\Omega) = 1.125 \times C_{IRATIO}/ILIM\ (A)$$

In parallel mode, connect IMON1 and IMON2 pins together with one resistor to GND by installing a shunt at J9, use below equation for calculate current-limit setting resistor:

$$R_{IMON}\ (\Omega) = 1.125 \times C_{IRATIO}/ILIM\ (A)/2$$

Where ILIM is the desired current limit, and C_{IRATIO} is the ratio of current mirror. See Table 3 and Table 4 for current-limit resistor settings in independent mode and parallel mode.

At the same time, the voltage on the IMONx pin monitors the OUT current in each channel with the following relationship:

$$I_{OUT}\ (A) = V_{IMON}\ (V) \times C_{IRATIO}/R_{IMON}\ (\Omega)$$

In independent mode, I_{OUT} in above equation represents the current from individual channel. In parallel mode, while connecting IMON1 and IMON2 pins together, I_{OUT} represents the sum of current of two channels.

Table 1. Operating Mode Setting

JUMPER	SHUNT POSITION	FUNCTION
J8	1-2	Parallel mode: tie EN1 and EN2
	Open	Independent mode
J9	1-2	Parallel mode: tie IMON1 and IMON2
	Open	Independent mode

Table 2. Enable Jumpers Selection

JUMPER / SWITCH	SHUNT POSITION	FUNCTION
SW1	2-3	Channel1 is disabled
SW1, J4	SW1 1-2, J4 1-2	Independent Mode: Channel1 is enabled by V_{IN} rising
	SW1 1-2, J4 2-3	Independent Mode: Channel1 is enabled by external 3.3V
SW2	2-3	Channel2 is disabled
SW2, J6	SW2 1-2, J6 1-2	Independent Mode: Channel2 is enabled by V_{IN} rising
	SW2 1-2, J6 2-3	Independent Mode: Channel2 is enabled by external 3.3V
SW1, J4, SW2, J6	SW1 1-2, J4 1-2, SW2 1-2, J6 open	Parallel Mode: IC is enabled by V_{IN} rising
SW1, J4, SW2, J6	SW1 1-2, J4 2-3, SW2 1-2, J6 open	Parallel Mode: IC is enabled by external 3.3V

Table 3. Overcurrent Limit Resistor Selection in Independent Mode

JUMPER/SHUNT POSITION	RESISTOR VALUE (kΩ)	OVERCURRENT LIMIT/ CHANNEL (A)	FAST OCP LIMIT/ CHANNEL (A)
J11, J12 / 1-2	9.09	0.50	0.66
J11, J12 / 3-4	6.04	0.75	0.99
J11, J12 / 5-6	4.53	0.99	1.32
J11, J12 / 7-8	3.01	1.50	1.99

Overcurrent Protection Delay (RDLY)

The EV kit configures the overcurrent protection response delay time by connecting DLY pin and GND through a resistor RDLY, as shown in Table 5. When the current through the device reaches the overcurrent limit threshold, the internal delay timer begins to count up. If the current drops back below the overcurrent limit within the delay time T_{DLY}, the MOSFET remains on. If the current stays higher than the overcurrent limit, the MOSFET turns off after T_{DLY} elapses.

Fault Status Indication ($\overline{ALRTx}$)

The EV kit indicates fault status through red LED connected $\overline{ALRT}$ pin in each channel. The LED turns on when the following faults occur:

- MOSFET is not turned on.
- Input voltage drops to UVLO level.
- Overcurrent limit is triggered.
- Overtemperature level is reached.
- Startup watchdog times out.
- IMONx pin are open.

Table 4. Overcurrent Limit Resistor Selection in Parallel Mode

JUMPER/SHUNT POSITION	RESISTOR VALUE (kΩ)	OVERCURRENT LIMIT/ CHANNEL (A)	FAST OCP LIMIT / CHANNEL (A)
J11, J12 / 1-2	4.53	0.50	0.66
J11, J12 / 3-4	3.01	0.75	1.00
J11, J12 / 5-6	2.26	0.99	1.33
J11, J12 / 7-8	1.50	1.50	2.00

Table 5. DLY Pin-Strap Configuration

RDLY (kΩ)	DELAY TIME	AUTORETRY TIME
0	12µs	0.6ms
27	100µs	6ms
47	1ms	60ms
68	10ms	600ms

Component Suppliers

SUPPLIER	WEBSITE
CoilCraft	www.coilcraft.com
Comchip	www.comchiptech.com
Diodes Incorporated	www. diodes.com
Emerson Network Power	www.vertivco.com
Fairchild Semiconductor	www.onsemi.com
Kemet	www.ir.kemet.com
Keystone	www.keyelco.com
Lite-On Electronics	www. us.liteon.com
Maxim Integrated	www.maximintegrated.com
Murata	www.murata .com
On Semiconductor	www.onsemi.com
Panasonic	www.panasonic.com
Pulse Electronics	www.pulseelectronics.com
Renesas Technology Group	www.renesas.com
Samsung Electronics	www.samsung.com
Stackpole Electronics	www.seielect.com
Sumida	www.sumida.com
Taiyo Yuden	www.yuden.co.jp
TDK	www.us.tdk.com
TE Connectivity	www.te.com
Texas Instruments	www.ti.com
Vishay Dale	www.vishay.com
Wurth Elektronik	www.we-online.com

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

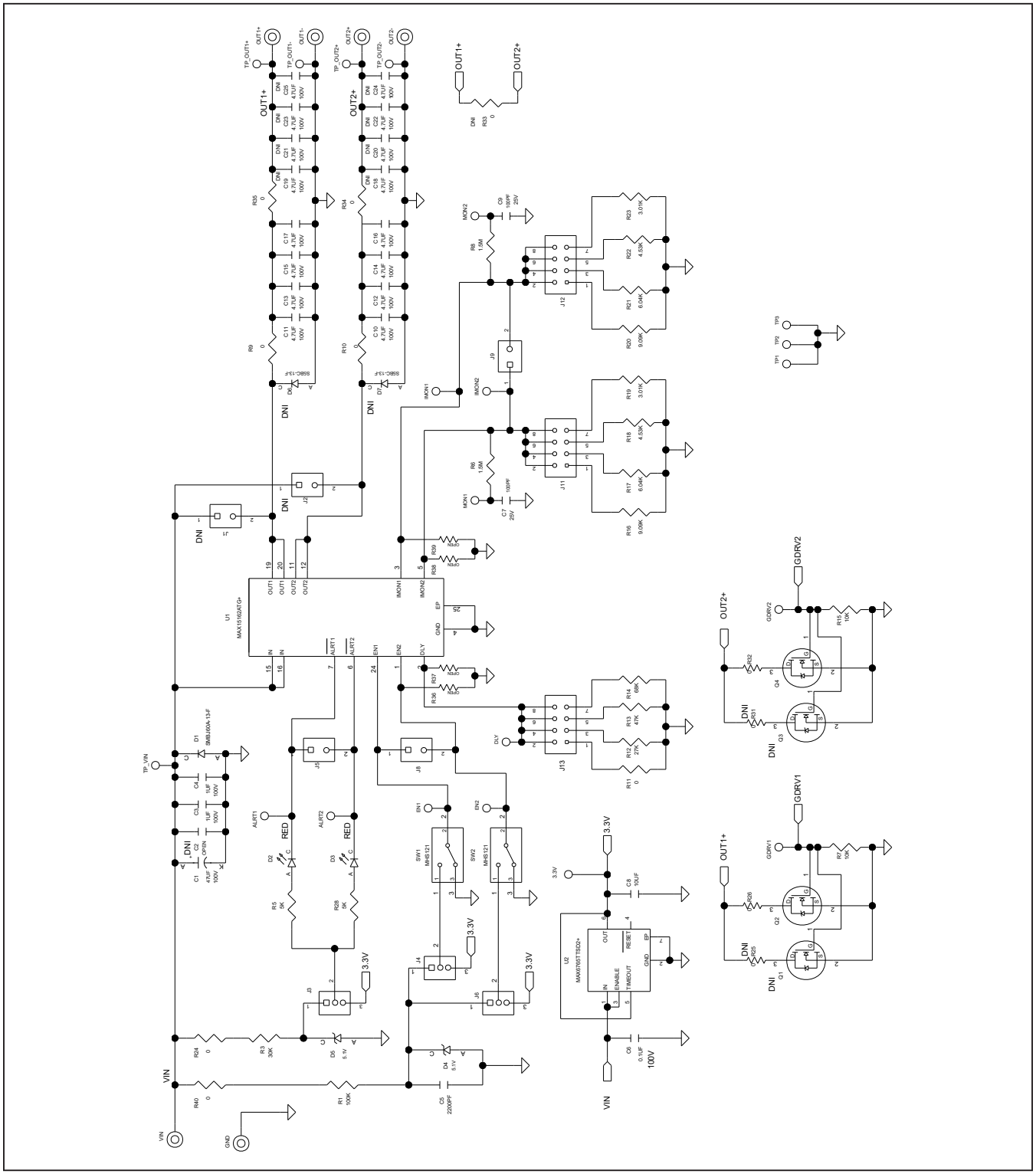
Ordering Information

PART	TYPE
MAX15162TAEVKIT#	MAX15162 TQFN (Autoretry)
MAX15162TLEVKIT#	MAX15162 TQFN (Latched off)

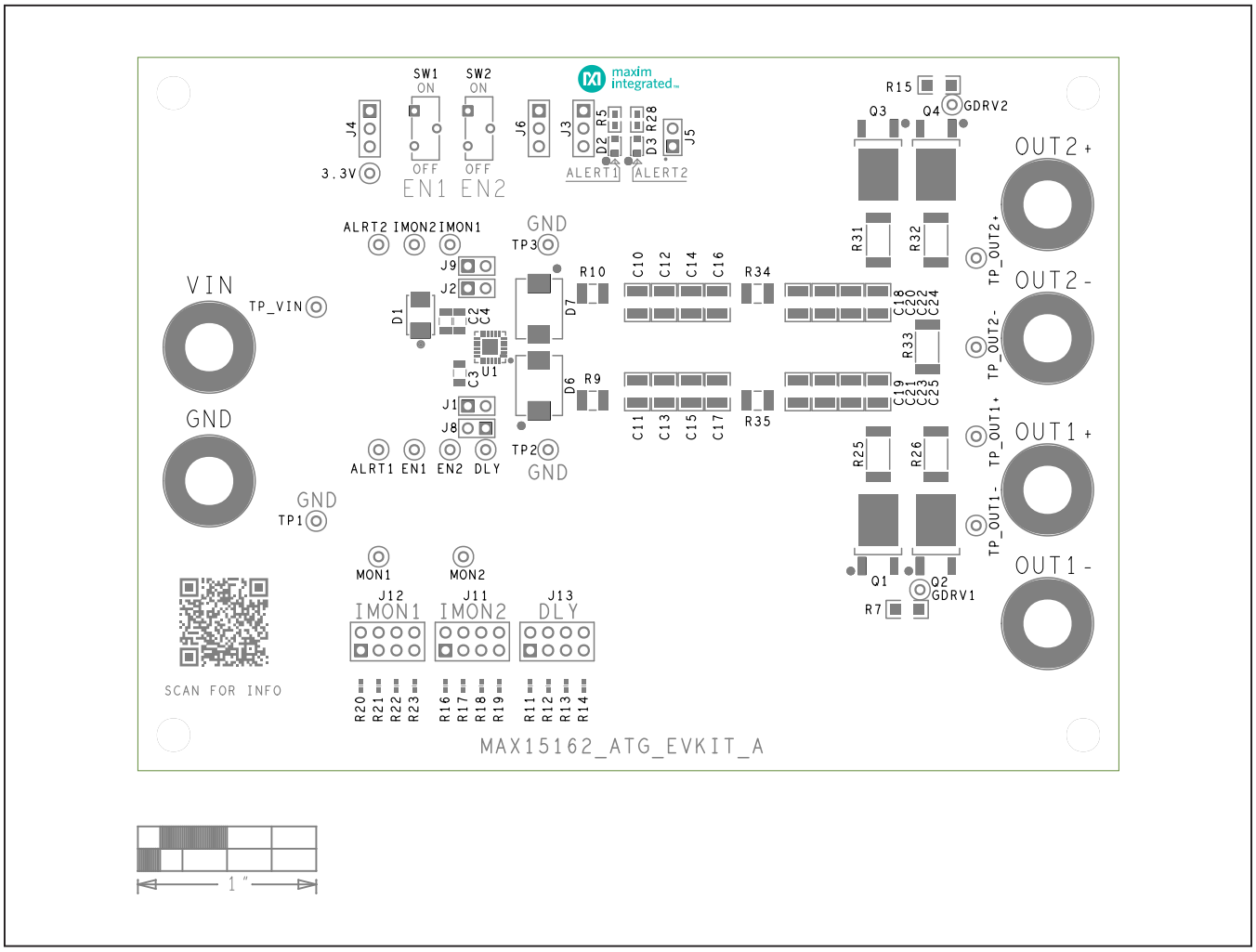
MAX15162ATG EV Kit Bill of Materials

PART	QTY	DESCRIPTION
C1	1	47µF ±20%, 100V; aluminum electrolytic capacitor (Case H13) Panasonic EEE-FK2A470AQ
C3, C4	2	1µF ±10%, 100V X7R ceramic capacitor (1206) Murata GRM31CR72A105KA01
C5	1	2200pF ±1%, 16V C0G ceramic capacitor (0402) Kemet C0402C222F4GAC7867
C6	1	0.1µF ±10%, 100V X7R ceramic capacitor (0603) Murata GRM188R72A104KA35
C7, C9	2	0.001µF ±20%, 25V X7R ceramic capacitor (0603) Kemet C0603C102M3GAC
C8	1	10µF ±10%, 25V X7R ceramic capacitor (1210) Murata GCJ32ER71E106KA18K
C10-C17	8	4.7µF ±10%, 100V X7R ceramic capacitor (1210) Murata GRM32ER72A475KE14
D1	1	TVS Diode, 60V, 6.2A, SMB Diodes Incorporated SMBJ60A-13-F
D2, D3	2	LED Diode, Red, SMT; Vf=2.1V; If=0.02A, VISHAY VLMS2100-GS08
D4, D5	2	Zener Diode, 5.1V, 0.005A, SOD-323 ON SEMICONDUCTOR MM3Z5V1T1
D6, D7	2	Rectifier Diode, 100V, 5A, SMC Diodes Incorporated S5BC-13-F
GND, OUT1+, OUT1-, OUT2+, OUT2-, VIN	6	Soft Drawn Bus TYPE-S, 20AWG, Weico Wire, 9020 BUSS
J3, J4	2	Breakaway Connector, Male, Through Hole, 3 Pins, Sullins, PBC03SAAN
J5, J8, J9	3	Breakaway Connector, Male, Through Hole, 2 Pins, Sullins, PEC02SAAN
J11-J13	3	Breakaway Connector, Male, Through Hole, 8 Pins, Sullins, PBC04DAAN
Q1-Q4	4	MOSFET N-channel, 80V, 100A, DPAK-3 ON Semiconductor FDD86367
R1	1	100kΩ +/-0.1% Resistor (0603) Panasonic ERA-3AEB104
R25, R26, R31, R32	4	0Ω +/-0% Resistor (2512) Vishay CRCW25120000Z0EGHP
R3	1	30kΩ +/-0.1% Resistor (0603) Koa Speer Electronics RN732BTTD3002B25
R5, R28	2	5kΩ +/-0.1% Resistor (0603) Vishay PNM0603E5001BS
R6, R8	2	1MΩ +/-0.1% Resistor (0402) Panasonic ERA-3AEB164
R7, R15	2	49.9Ω +/-1% Resistor (1206) Vishay CRCW120649R9FK
R9, R10, R24, R34, R35, R40	6	0Ω +/-0% Resistor (1210) Vishay CRCW12100000Z0
R11	1	0Ω +/-0% Resistor (0402) Vishay CRCW04020000Z0EDHP
R12	1	27kΩ +/-1% Resistor (0402) Vishay CRCW040227K0FK
R13	1	47kΩ +/-1% Resistor (0402) Vishay CRCW040247K0FK
R14	1	68kΩ +/-1% Resistor (0402) Vishay CRCW040268K0FK
R16, R20	2	9.09kΩ +/-1% Resistor (0402) Panasonic ERJ-2RKF9091
R17, R21	2	6.04kΩ +/-1% Resistor (0402) Panasonic ERJ-2RKF6041
R18, R22	2	4.53kΩ +/-1% Resistor (0402) Vishay CRCW04024K53FK
R19, R23	2	3.01kΩ +/-1% Resistor (0402) Vishay CRCW04023K01FK
SW1, SW2	2	Switch, 12V, 0.2A, Through hole Copal Electronics Inc. MHS121
U1	1	Integrated Dual-Channel Circuit Breaker, WLP-16, MAX15162/MAX15162AAWE+
U2	1	Micropower Linear Regulator, TDFN6-EP, MAX6765TTSD2+
PCB	1	PCB:MAX15162AWE+/MAX15162AAWE+
C2	0	1uF +/- 10%, 100V X7R ceramic capacitor (1206) Murata GRM31CR72A105KA01
C18-C25	0	4.7uF +/- 10%, 100V X7R ceramic capacitor (1210) Murata GRM32ER72A475KE14
J1-J2	0	Breakaway Connector, Male, Through Hole, 2 Pins, Sullins, PEC02SAAN
R33	0	0Ω +/-0% Resistor (2512) Vishay CRCW25120000Z0EGHP
R36-R39	0	DNP

MAX15162ATG EV Kit Schematic

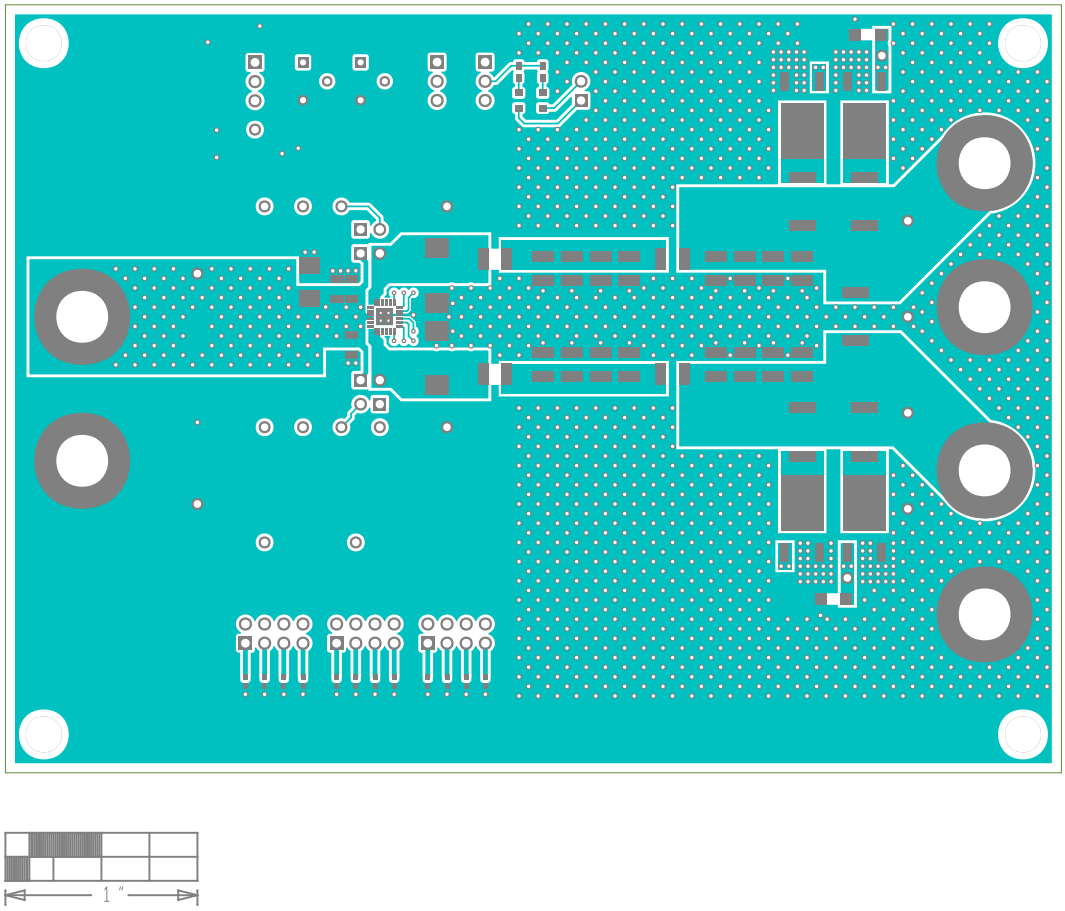


MAX15162ATG EV Kit PCB Layout Diagrams



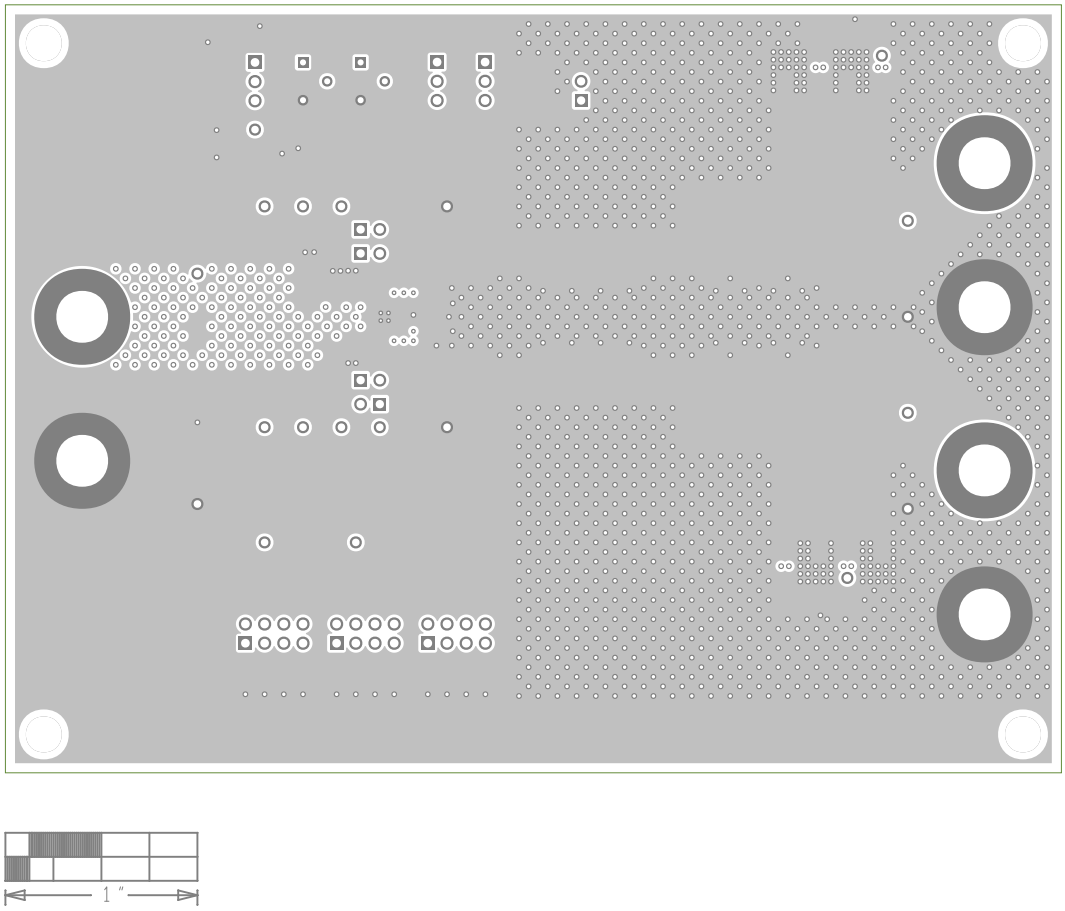
MAX15162ATG EV Kit PCB — Silkscreen Top Side

MAX15162ATG EV Kit PCB Layout Diagrams (continued)



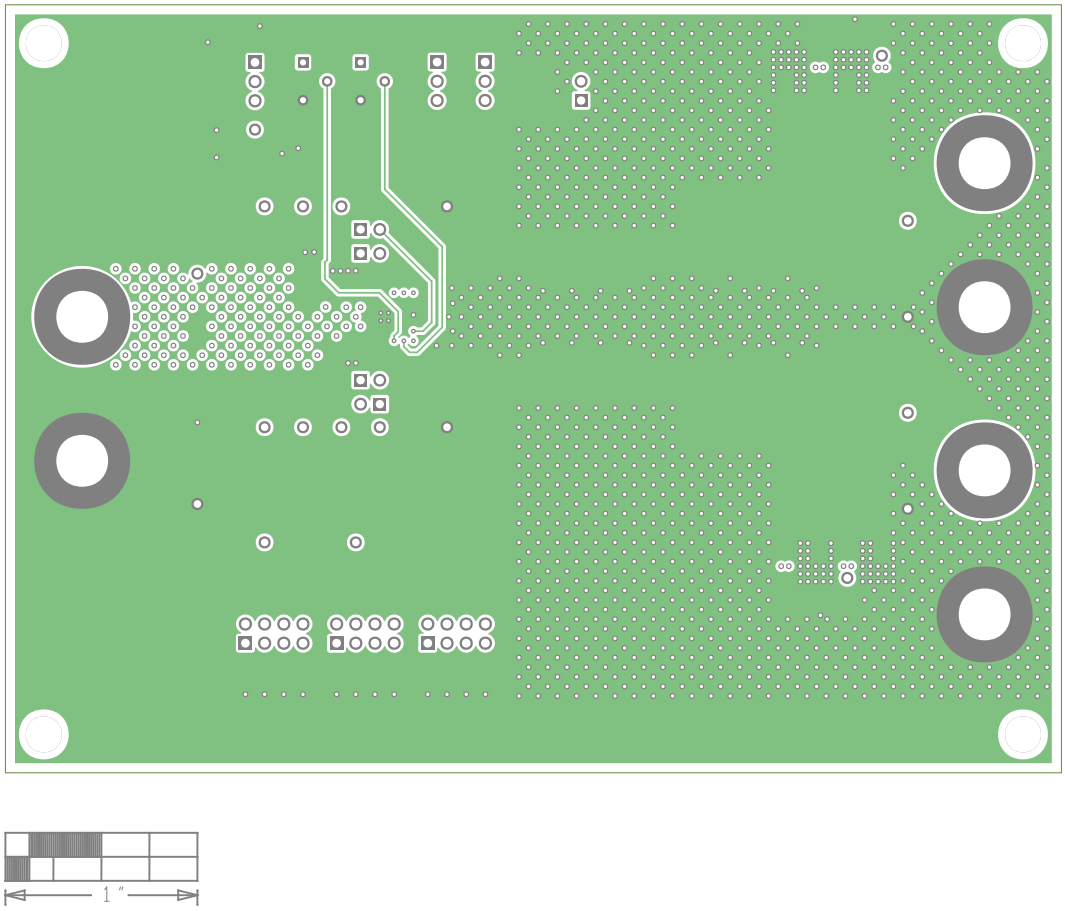
MAX15162ATG EV Kit PCB — Silkscreen Top Side

MAX15162ATG EV Kit PCB Layout Diagrams (continued)



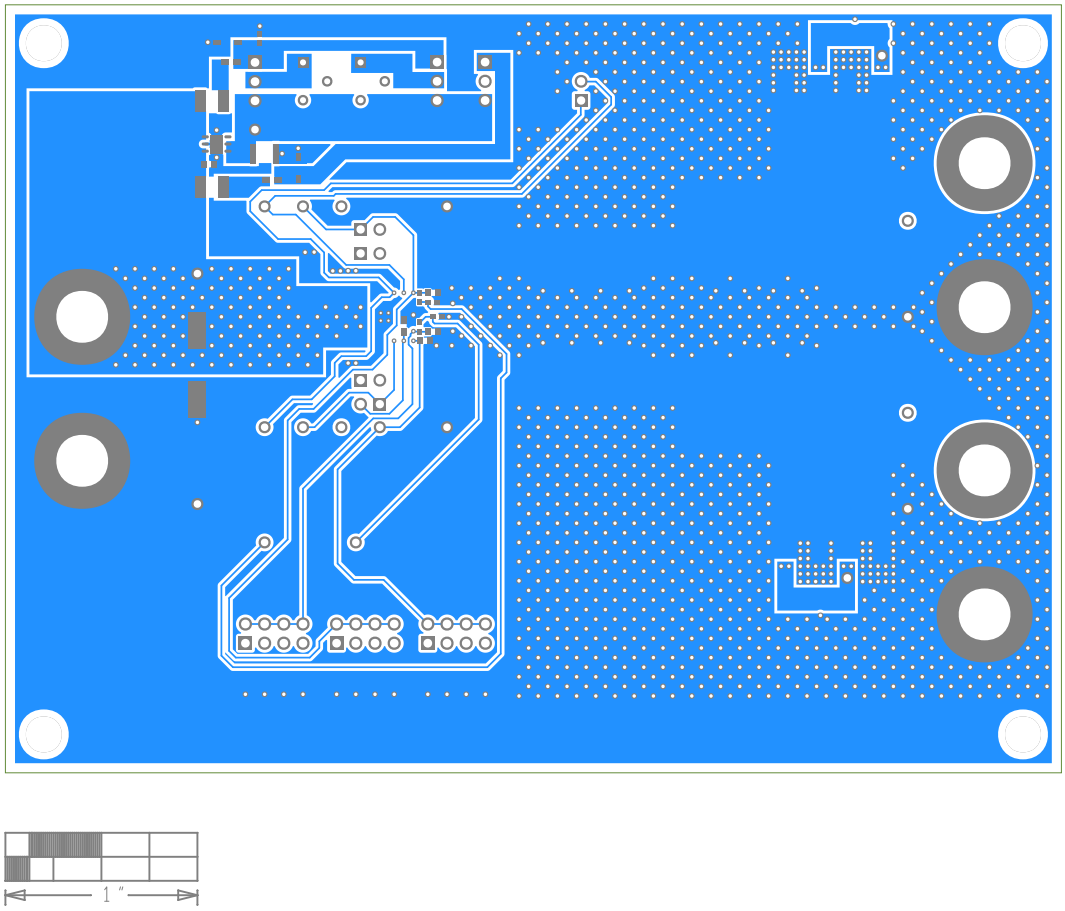
MAX15162ATG EV Kit PCB — Internal Layer 2

MAX15162ATG EV Kit PCB Layout Diagrams (continued)



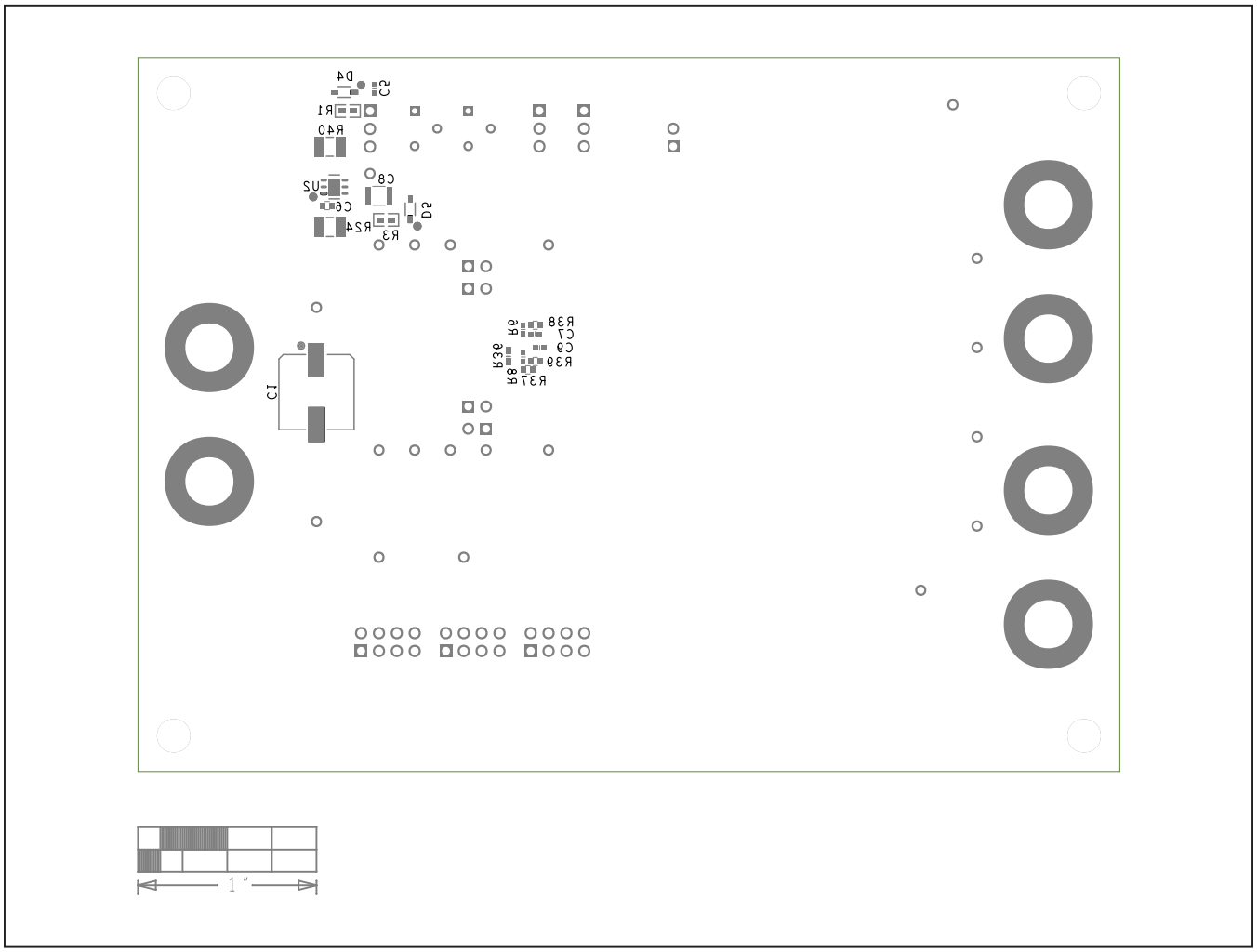
MAX15162ATG EV Kit PCB — Internal Layer 3

MAX15162ATG EV Kit PCB Layout Diagrams (continued)



MAX15162ATG EV Kit PCB — Bottom Side

MAX15162ATG EV Kit PCB Layout Diagrams (continued)



MAX15162ATG EV Kit PCB — Silkscreen Bottom Side

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	1/20	Initial release	—

For pricing, delivery, and ordering information, please visit Maxim Integrated's online storefront at https://www.maximintegrated.com/en/storefront/storefront.html.

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