# MAXM17536 5V Output Evaluation Kit

# Evaluates: MAXM17536 5V Output

## General Description

The *Himalaya* series of voltage regulator ICs and power modules enable cooler, smaller, and simpler power-supply solutions. The MAXM17536EVKIT# 5V-output evaluation kit (EV kit) is a demonstration circuit of the MAXM17536 60V, 4A high-efficiency, current-mode, synchronous step-down DC-DC switching power module. The EV kit operates over a wide input-voltage of 7V to 60V and provides up to 4A load current with a 5V-output voltage. The EV kit is programmed to switch at a frequency of 450kHz. The module is simple to use and easily configurable with minimal external components. It features cycle-by-cycle peak current-limit protection, undervoltage lockout (EN/UVLO), and thermal shutdown.

The EV kit comes with the compact 29-pin 15mm x 9mm x 4.32mm SiP package MAXM17536 module installed and is rated to operate over the full industrial -40°C to +125°C temperature range.

The MAXM17536 module data sheet provides a complete description of the part that should be read in conjunction with this data sheet prior to operating the EV kit. For full module features, benefits and parameters, refer to the MAXM17536 data sheet.

## Features

- Wide 7V to 60V Input Range
- Highly Integrated Solution with Built-In Shielded Inductor
- Programmed 5V Output, Up To 4A Output Current
- 450kHz Switching frequency
- MAXM17536 Offers High 92.1% Efficiency ($V_{IN}$ = 24V, $V_{OUT}$ = 5V, $I_{OUT}$ = 2.5A)
- All Ceramic Capacitors and Ultra-Compact Solution
- Selectable PWM, DCM, and PFM Modes
- Programmable 4ms Soft-Start Time and Prebias Startup
- Open-Drain RESET Output Pulled Up To 5V $V_{CC}$
- Programmable EN/UVLO Threshold
- Provision for External Frequency Synchronization
- Hiccup Overcurrent Protection (OCP)
- Overtemperature Protection (OTP)
- -40°C to +125°C Industrial Temperature Range
- Complies with CISPR22 (EN55022) Class B Conducted and Radiated Emissions

## Quick Start

### Recommended Equipment

- MAXM17536EVKIT# evaluation kit
- 7V to 60V DC, 4A power supply
- Dummy load capable of sinking 4A
- Digital voltmeter (DVM)
- 100MHz dual-trace oscilloscope

### Equipment Setup and Test Procedure

The MAXM17536EVKIT# 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) Set the power supply at a voltage between 7V and 60V. Disable the power supply.
2) Connect the positive and negative terminals of the power supply to VIN and GND PCB pads, respectively.
3) Connect the positive and negative terminals of the 4A load to VOUT and GND PCB pads, respectively. Set the load to 0A.
4) Connect the DVM across the VOUT PCB pad and the GND PCB pad.
5) Verify that shunts are not installed on jumper J1 (see Table 1 for details).
6) Select the shunt position on jumper J2 according to the intended mode of operation (see Table 2 for details).
7) Enable the input power supply.
8) Verify that the DVM displays 5V.
9) Increase the load up to 4A to verify the output voltage is 5V using DVM.

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

*319-100437; Rev 0; 9/19*

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## Detailed Description of Hardware

The MAXM17536EVKIT# is a proven circuit to demonstrate the high-voltage, high-efficiency, and compact solution size of the MAXM17536 synchronous step-down DC-DC power module. The output voltage is preset to 5V to operate from 7V to 60V input and provides up to 4A load current. The optimal frequency is set at 450kHz to maximize efficiency and minimize component size. The EV kit includes test points, for monitoring the $\overline{RESET}$, LX voltage, DL voltage, BST, and $V_{CC}$ voltage.

### Soft-Start Input (SS)

The MAXM17536 module implements adjustable soft-start operation to reduce inrush current. A capacitor connected from the SS pin to SGND programs the soft-start time. The selected output capacitance ($C_{SEL}$) and the output voltage ($V_{OUT}$) determine the minimum required soft-start capacitor as follows:

$$C_{SS} \geq 28 \times 10^{-6} \times C_{SEL} \times V_{OUT}$$

The soft-start time ($t_{SS}$) is related to the capacitor connected at SS ($C_{SS}$) by the following equation:

$$t_{SS} = C_{SS}/(5.55)$$

where $t_{SS}$ is in ms and $C_{SS}$ is in nF. For example, to program a 4ms soft-start time, a 22nF capacitor should be connected from the SS pin to SGND.

### Regulator Enable/Undervoltage-Lockout Level (EN/UVLO)

The EV kit offers an adjustable input undervoltage-lockout level by resistor-dividers connecting between the IN, EN/UVLO, and GND pins. For normal operation, a shunt should not be installed across pins 1-2 on J1 to enable the output through an internal pullup 3.32MΩ resistor from the EN/UVLO pin to the IN pin. To disable the output, install the shunt across pins 1-2 on J1 to pull the EN/UVLO pin to GND. See Table 1 for J1 setting details. The EV kit also provides an R3 resistor to program a UVLO threshold voltage at which an input-voltage level device turns on. The R3 resistor can be calculated by the following equation:

$$R3 = 3320 \times 1.215/(V_{INU} - 1.215)$$

where $V_{INU}$ is the input voltage at which the device is required to turn on, and R3 is in kΩ.

### MODE/SYNC Selection (MODE)

The device's MODE pin can be used to select among the PWM, PFM, or DCM modes of operation. The logic state of the MODE pin is latched when the $V_{CC}$ and EN/UVLO voltages exceed the respective UVLO rising thresholds and all internal voltages are ready to allow LX switching. State changes on the MODE pin are ignored during normal operation. Refer to the MAXM17536 module data sheet for more information on the PWM, PFM, and DCM modes of operation.

Table 2 lists J2 jumper settings that can be used to configure the desired mode of operation. The internal oscillator of the device can be synchronized to an external clock signal on the SYNC pin. The external synchronization clock frequency must be between 1.1 x $f_{SW}$ and 1.4 x $f_{SW}$, where $f_{SW}$ is the frequency of operation set by R4. The minimum external clock high pulse width should be greater than 50ns, while the minimum external clock low pulse width should be greater than 160ns.

## Table 1. EN/UVLO Enable/Disable Configuration (J1)

| SHUNT POSITION | EN PIN | MAXM17536_OUTPUT |
|---|---|---|
| 1-2 | Connected to GND | Disabled |
| Not installed* | Connected to the center node of resistor-divider 3.32MΩ and R3 | Enabled, UVLO level set through the 3.32MΩ and R3 resistors |

**Default position*

## Table 2. MODE Description (J2)

| SHUNT POSITION | MODE PIN | MAXM17536_MODE |
|---|---|---|
| Not installed | Unconnected | PFM mode of operation |
| 1-2 | Connected to $V_{CC}$ | DCM mode of operation |
| 2-3* | Connected to GND | PWM mode of operation |

**Default position*



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### EXTVCC Linear Regulator

Powering $V_{CC}$ of the IC from EXTVCC increases the efficiency of the power converter at higher input voltages. If the applied EXTVCC voltage is greater than 4.7V (typ), $V_{CC}$ is powered from EXTVCC. If EXTVCC is lower than 4.7V (typ), $V_{CC}$ is powered from $V_{IN}$. Refer to the MAXM17536 module data sheet for further information. To connect EXTVCC to $V_{OUT}$ place the shunt across pins 2-3 of jumper J3. Refer to Table 3 for summary of EXTVCC jumper configurations.

### Electro-Magnetic Interference (EMI)

Compliance to conducted emissions (CE) standards requires an EMI filter at the input of a switching power converter. The EMI filter attenuates high-frequency cur¬rents drawn by the switching power converter, and limits the noise injected back into the input power source.

Use of EMI filter components, as shown in the EV kit schematic, results in lower conducted emissions below CISPR22 Class B limits. The MAXM17536EVKIT# PCB layout is also designed to limit radiated emissions from switching nodes of the power converter resulting in radiated emissions below CISPR22 Class B limits. Further, capacitors 150pF/100V and 0.1µF/100V placed near the input of the board helps in attenuating high-frequency noise.

### Hot-Plug-In and Long Input Cables

The MAXM17536EVKIT# PCB provides an electrolytic capacitor (C24, 47µF/80V) to dampen input voltage peaks and oscillations that can arise during hot-plug-in and/or due to long input cables. This capacitor limits the peak voltage at the input of the MAXM17536 power module, when the EV kit is powered directly from a precharged capacitive source or an industrial backplane PCB. Long input cables, between input power source and the EV kit circuit can cause input-voltage oscillations due to the inductance of the cables. The equivalent series resistance (ESR) of the electrolytic capacitor helps damp out the oscillations caused by long input cables.

## Table 3. EXTVCC Configuration (J3)

| SHUNT POSITION | EXTVCC PIN | EXTVCC FUNCTION |
|---|---|---|
| Not installed | Unconnected | $V_{CC}$ Powered by $V_{IN}$ |
| 1-2 | Connected to GND | $V_{CC}$ Powered by $V_{IN}$ |
| 2-3* | Connected to $V_{OUT}$ | $V_{CC}$ Powered by $V_{OUT}$ |

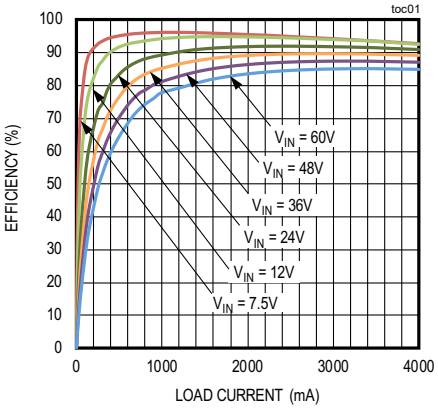
**Default position*



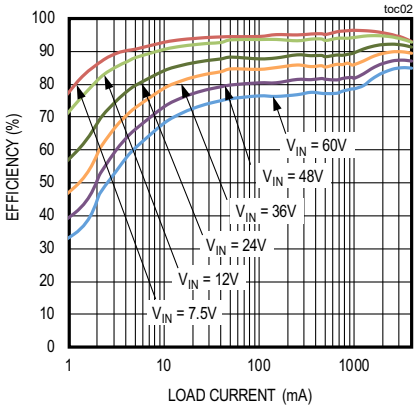
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## MAXM17536EVKIT# Performance Report

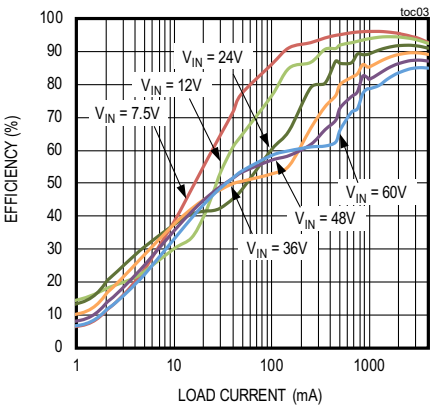
**EFFICIENCY vs. LOAD CURRENT (5V OUTPUT, PWM MODE, $f_{SW}$ = 450kHz)**



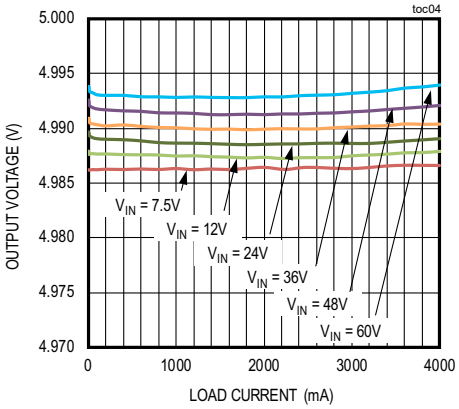

**EFFICIENCY vs. LOAD CURRENT (5V OUTPUT, PFM MODE, $f_{SW}$ = 450kHz)**



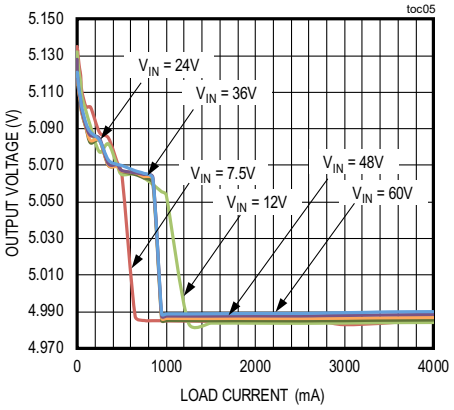

**EFFICIENCY vs. LOAD CURRENT (5V OUTPUT, DCM MODE, $f_{SW}$ = 450kHz)**



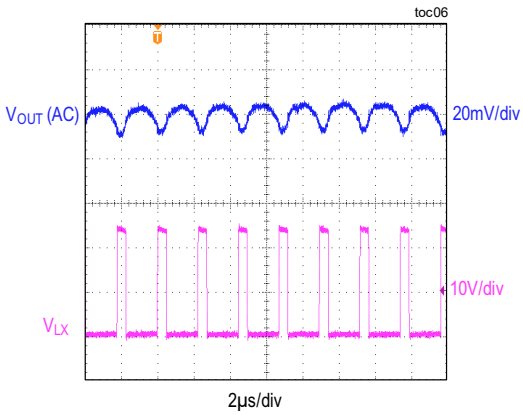

**OUTPUT VOLTAGE vs. LOAD CURRENT (5V OUTPUT, PWM MODE, $f_{SW}$ = 450kHz)**



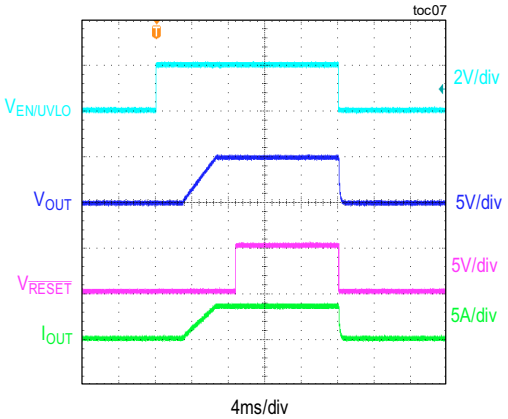

**OUTPUT VOLTAGE vs. LOAD CURRENT (5V OUTPUT, PFM MODE, $f_{SW}$ = 450kHz)**




**STEADY-STATE SWITCHING WAVEFORMS ($V_{IN}$ = 24V, $V_{OUT}$ = 5V, $I_{OUT}$ = 4A, PWM MODE)**




**POWER-UP AND DOWN THROUGH EN/UVLO ($V_{IN}$ = 24V, $V_{OUT}$ = 5V, $I_{OUT}$ = 4A, PWM MODE)**

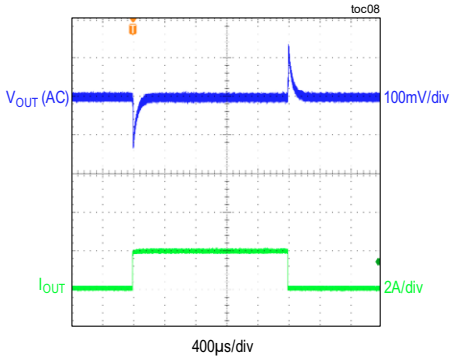




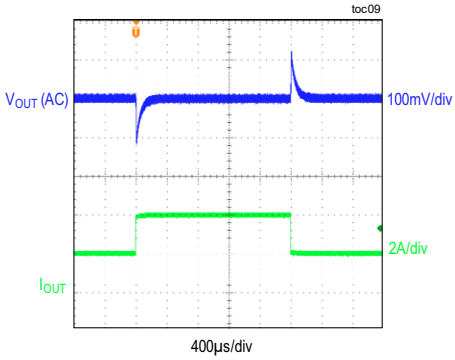

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## MAXM17536EVKIT# Performance Report (continued)

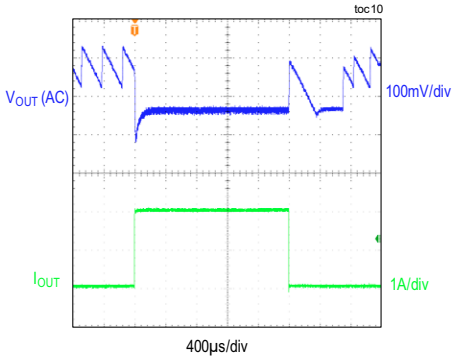
**LOAD TRANSIENT**
**($V_{IN}$ = 24V, $V_{OUT}$ = 5V, $I_{OUT}$ = 0A TO 2A, PWM MODE)**



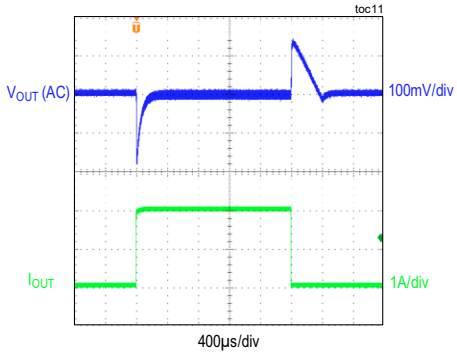

**LOAD TRANSIENT**
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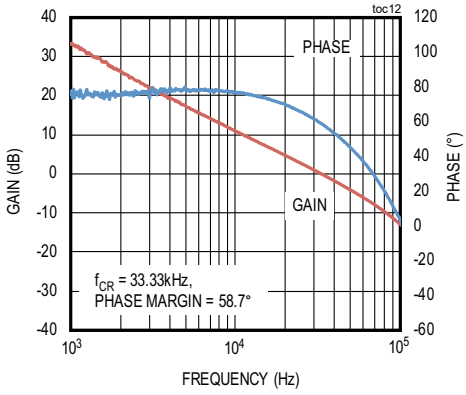

**LOAD TRANSIENT**
**($V_{IN}$ = 24V, $V_{OUT}$ = 5V, $I_{OUT}$ = 25mA TO 2A, PFM MODE)**



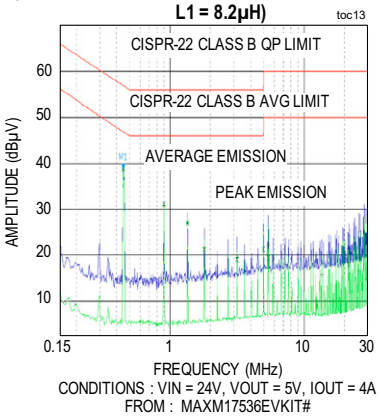

**LOAD TRANSIENT**
**($V_{IN}$ = 24V, $V_{OUT}$ = 5V, $I_{OUT}$ = 25mA TO 2A, DCM MODE)**



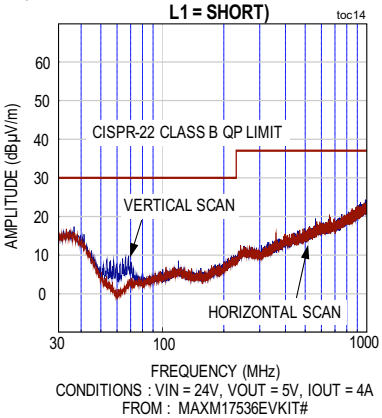

**BODE PLOT**
**($V_{IN}$ = 24V, $V_{OUT}$ = 5V, $I_{OUT}$ = 4A)**




**CONDUCTED EMISSION PLOT**
**(WITH FILTER, C18 = C19 = C20 = C21 = C22 = 4.7µF, L1 = 8.2µH)**




**RADIATED EMISSION PLOT**
**(NO FILTER, C18 = C19 = C20 = C21 = C22 = OPEN, L1 = SHORT)**






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## Ordering Information

| PART | TYPE |
|---|---|
| MAXM17536EVKIT# | EV Kit |

*#Denotes RoHS compliant.*

## Component Suppliers

| SUPPLIER | WEBSITE |
|---|---|
| TDK Corp. | www.tdk.com |
| Murata Americas | www.murata.com |
| Panasonic Corp. | www.panasonic.com |
| Vishay | www.vishay.com |

***Note:*** *Indicate that you are using the MAXM17536 when contacting these component suppliers.*



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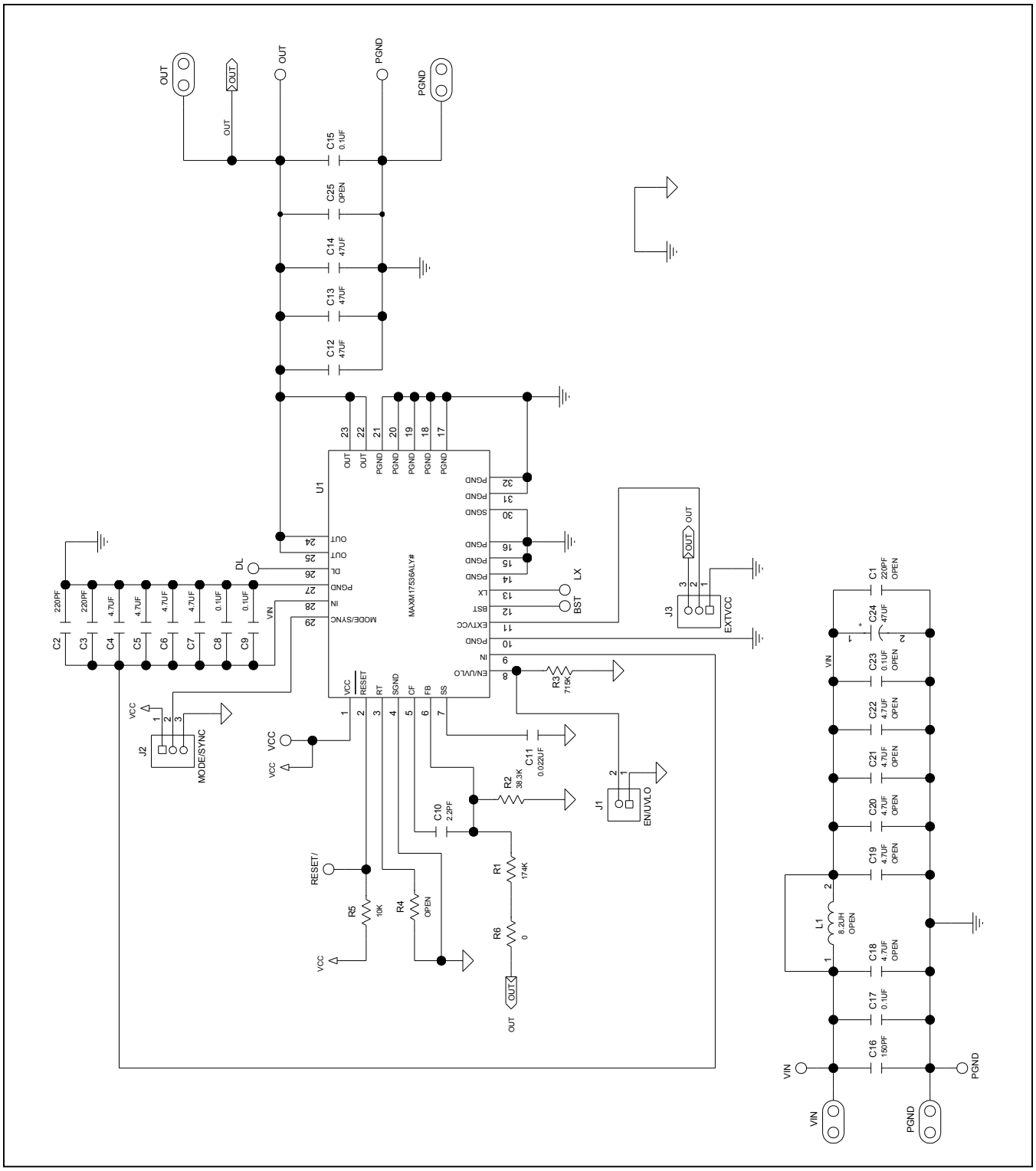
## MAXM17536EVKIT# Bill of Materials

| ITEM | QTY | REF DES | MFG PART # | DESCRIPTION |
|---|---|---|---|---|
| 1 | 2 | C2, C3 | TDK C1608C0G2A221J080AA | 220pF ± 5%, 100V, Ceramic Cap, C0G, NP0 (0603) |
| 2 | 4 | C4-C7 | MURATA GRM31CZ72A475KE11 | 4.7µF ± 10%, 100V, X7R, CAP (1206) |
| 3 | 4 | C8, C9, C15, C17 | MURATA GCJ188R72A104KA01D | 0.1µF ± 10%, 100V, Ceramic Cap, X7R (0603) |
| 4 | 1 | C10 | MURATA GRM1885C1H2R2CA01D | 2.2pF ± 0.1pF, 50V, Ceramic CAP (0603) |
| 5 | 1 | C11 | MURATA GCJ188R71H223KA01D | 0.022µF ± 10%, 50V, Ceramic Cap, X7R (0603) |
| 6 | 3 | C12-C14 | MURATA GRM32ER71A476KE15 | 47µF ± 10%, 10V, Ceramic Cap, X7R (1210) |
| 7 | 1 | C16 | TDK C1005C0G2A151J050BA | 150pF ± 5%, 100V, Ceramic Cap, C0G, NP0 (0402) |
| 8 | 1 | C24 | PANASONIC EEE-FK1K470P | 47µF ± 20%, 80V, Aluminium Electrolytic |
| 9 | 1 | R1 | PANASONIC ERJ-3EKF1743 | 174 kΩ ± 1%, 0.1W, Resistor (0603) |
| 10 | 1 | R2 | PANASONIC ERJ-3EKF3832 | 38.3 kΩ ± 1%, 0.1W, Resistor (0603) |
| 11 | 1 | R3 | VISHAY DALE CRCW0603715KFK | 715 kΩ ± 1%, 0.1W, Resistor (0603) |
| 12 | 1 | R5 | VISHAY DALE CRCW060310K0FK | 10 kΩ ± 1%, 0.1W, Resistor (0603) |
| 13 | 1 | R6 | VISHAY DALE CRCW06030000ZS | 0 Ω ± 1%, 0.1W, Resistor (0603) |
| 14 | 1 | U1 | MAXM17536ALY# | MAXM17536 DC-DC Module |
| 15 | 1 | C1 | TDK C1608C0G2A221J080AA | OPTIONAL : 220pF ± 5% 100V, Ceramic Cap, C0G, NP0 (0603) |
| 16 | 5 | C18-C22 | MURATA GRM31CZ72A475KE11 | OPTIONAL : 4.7µF ± 10%, 100V, X7R ceramic cap (1206) |
| 17 | 1 | C23 | MURATA GCJ188R72A104KA01 | OPTIONAL : 0.1µF ± 10%, 100V, X7R ceramic cap (0603) |
| 18 | 1 | L1 | COILCRAFT XAL5050-822ME | OPTIONAL : 8.2µH ± 20%, Inductor |
| 19 | 1 | R4 | | OPTIONAL : OPEN (0603) |
| 20 | 1 | C25 | | OPTIONAL : OPEN (1210) |



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## MAXM17536EVKIT# Schematic






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## MAXM17536EVKIT# PCB Layout Diagrams

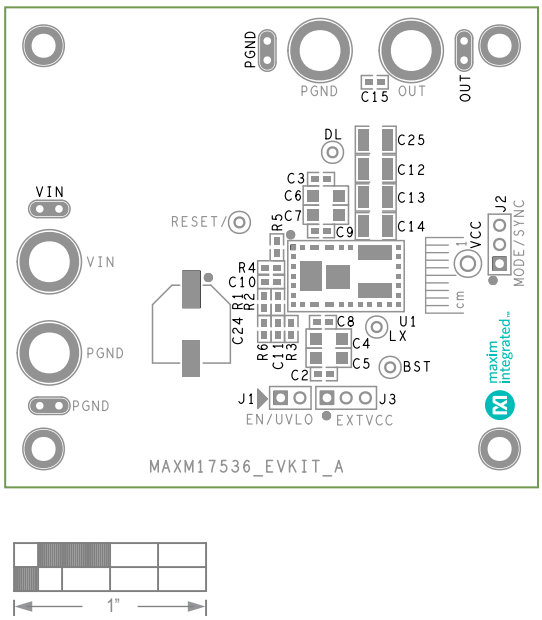



*Figure 1. MAXM17536 5V Output EV Kit PCB Layout—Top Silkscreen*

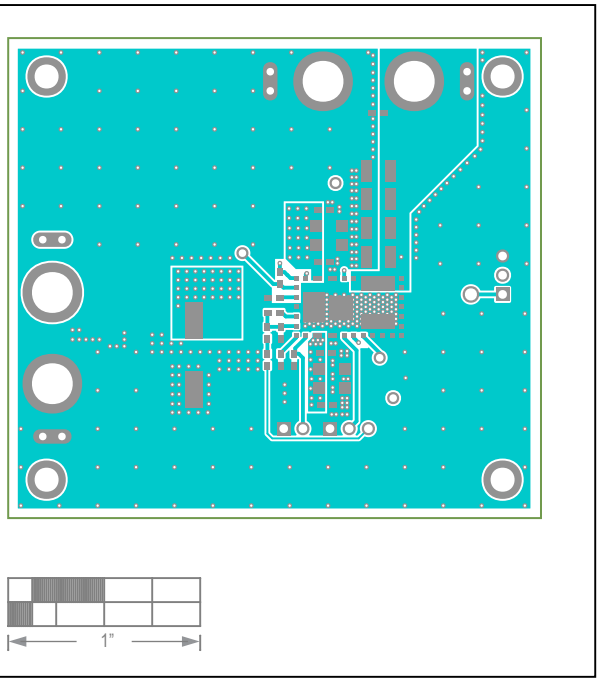



*Figure 2. MAXM17536 5V Output EV Kit PCB Layout—Top Layer*

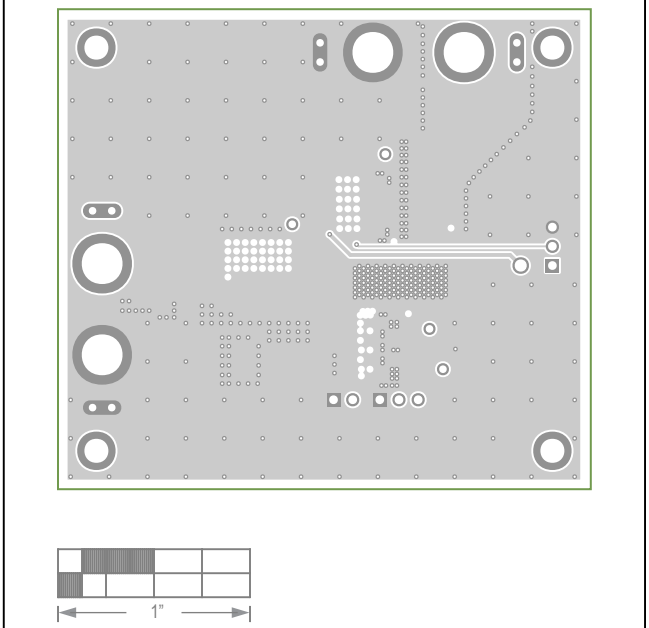



*Figure 3. MAXM17536 5V Output EV Kit PCB Layout—Layer 2*

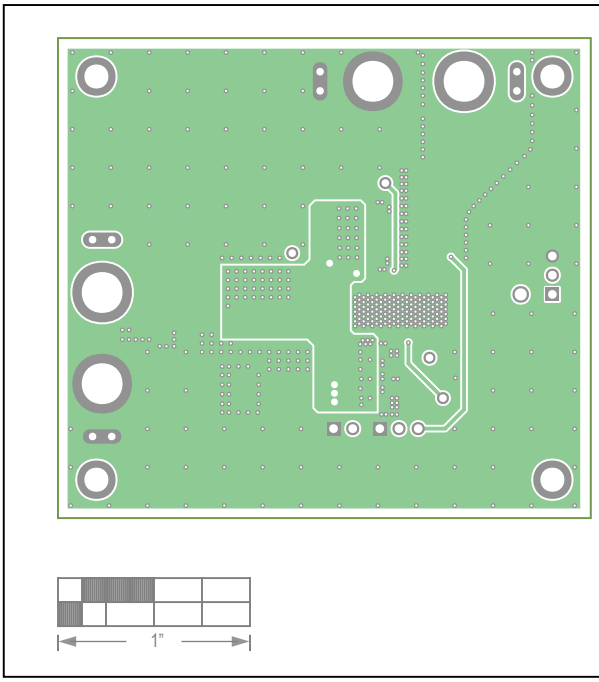



*Figure 4. MAXM17536 5V Output EV Kit PCB Layout—Layer 3*



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## MAXM17536EVKIT# PCB Layout Diagrams (continued)

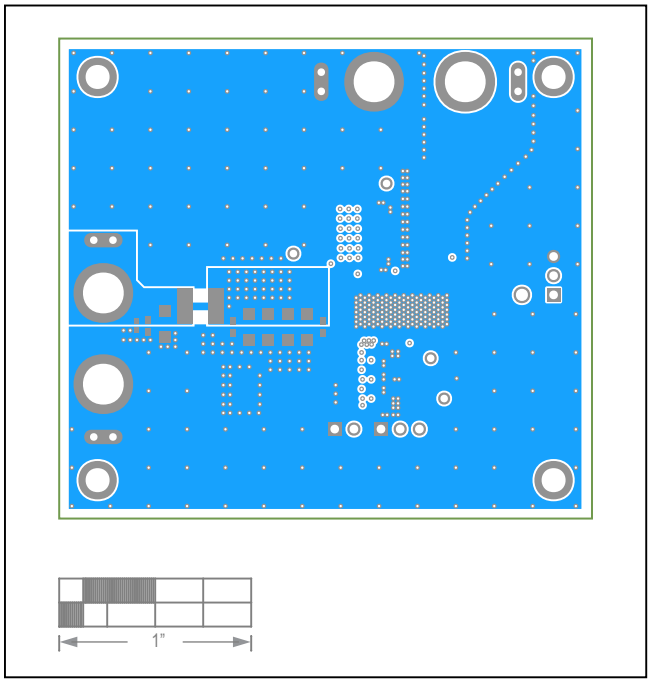


*Figure 5. MAXM17536 5V Output EV Kit PCB Layout—Layer 4*

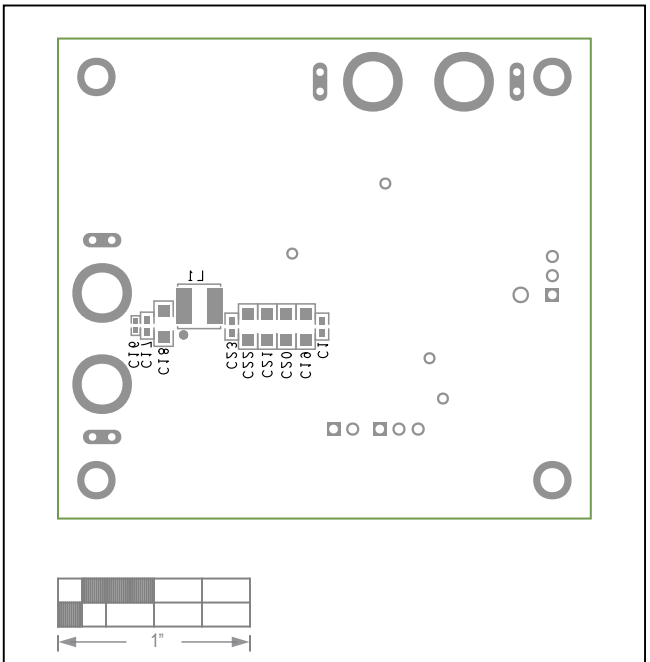


*Figure 6. MAXM17536 5V Output EV Kit PCB Layout—Bottom Silkscreen*



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## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|---|---|---|---|
| 0 | 9/19 | 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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