# EVQ4232-VE-00A

## 6A Buck-Boost Converter with Four Integrated MOSFETs and I²C Interface Evaluation Board, AEC-Q100 Qualified

## DESCRIPTION

The EVQ4232-VE-00A is an evaluation board designed to demonstrate the capabilities of the MPQ4232, a synchronous, four-switch, buck-boost converter with integrated MOSFETs. The device can deliver up to 6A of output current ($I_{OUT}$) and achieve excellent efficiency across a certain input supply range.

The MPQ4232 is designed for USB power delivery (PD) and wireless charging applications. It can work well with an external PD controller or wireless charging controller through the I²C interface.

The MPQ4232 is available in a small QFN-19 (4mmx5mm) package with wettable flanks. It is recommended to read the MPQ4232 datasheet prior to making any changes to the EVQ4232-VE-00A.

## PERFORMANCE SUMMARY

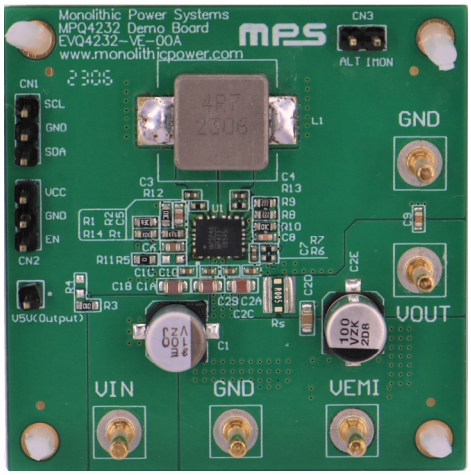
Specifications are at $T_A$ = 25°C, unless otherwise noted.

| Parameters | Conditions | Value |
|---|---|---|
| Input voltage ($V_{IN}$) range | | 4.3V to 22V, 36V tolerant |
| Output voltage ($V_{OUT}$) (1) | $V_{IN}$ = 4.3V to 22V, $I_{OUT}$ = 0A to 5A | $V_{OUT}$ = 5V |
| Maximum output current ($I_{OUT}$) | $V_{IN}$ = 4.3V to 22V | 6A |
| Typical efficiency | $V_{IN}$ = 12V, $V_{OUT}$ = 5V, $I_{OUT}$ = 3A | 95.58% |
| Peak efficiency | $V_{IN}$ = 12V, $V_{OUT}$ = 15V, $I_{OUT}$ = 1.5A | 98.28% |
| Switching frequency ($f_{SW}$) | | 420kHz |

**Note:**

1) $V_{OUT}$ can be adjusted via the I²C or feedback resistance.

## EVQ4232-VE-00A EVALUATION BOARD




**LxWxH (50mmx50mmx16mm)**
**4 Layers (2oz, 1oz, 1oz, and 2oz)**

| Board Number | MPS IC Number |
|---|---|
| EVQ4232-VE-00A | MPQ4232GVE-0000-AEC1 |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## QUICK START GUIDE

1. Preset the power supply ($V_{IN}$) to 12V, then turn the power supply off.
2. Connect the power supply terminals to:
   a. Positive (+): VIN
   b. Negative (-): GND
3. Connect the electronic load to:
   a. Positive (+): VOUT
   b. Negative (-): GND
4. After making the connections, turn the power supply on.
5. Once the power supply is on, the output voltage ($V_{OUT}$) should start up automatically.
6. To modify the MPQ4232's register setting, connect the EVQ4232-VE-00A to the USB-to-I²C communication kit (EVKT-USBI2C-02). Use Virtual Bench Pro 4.0 to read and write the I²C registers.
7. If the MPQ4232's silicon die temperature exceeds 165°C, over-temperature protection (OTP) is triggered and the entire chip shuts down. Once the temperature drops to below 145°C, the chip is enabled again and resumes normal operation.
8. Figure 1 shows the measurement equipment set-up.

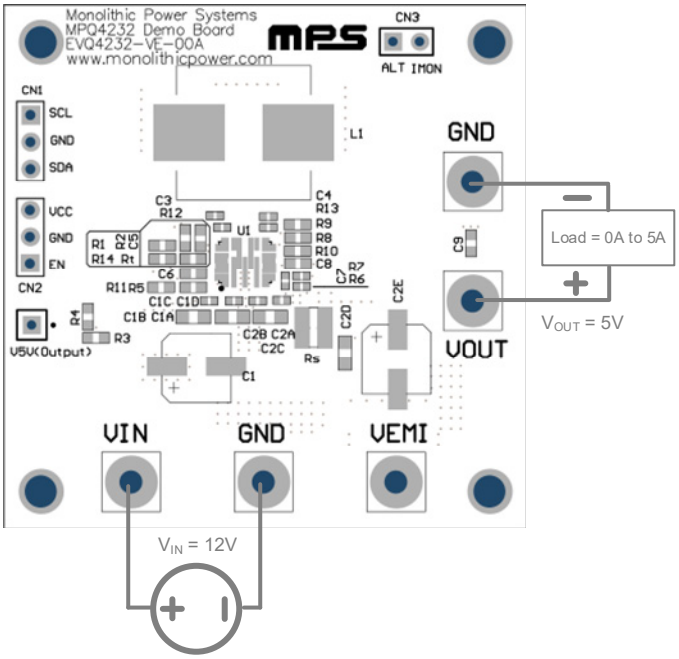


**Figure 1: Measurement Equipment Set-Up**


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## MPQ4232GVE-0000-AEC1 CONFIGURATIONS

| OTP Items | Description | Value |
|---|---|---|
| OPERATION | The MPQ4232 is on or off by default | 0: Off (2) (default) |
| VOUT_COMMAND | $V_{OUT}$, voltage reference ($V_{REF}$) = 0.5V | 5V (default) |
| DITHER_ENABLE | Enables frequency spread spectrum (FSS) | 1: Enabled |
| FREQ | Sets the switching frequency ($f_{SW}$) | 01: 420kHz (default) |
| PFM/PWM_MODE | Selects automatic pulse-frequency modulation (PFM) or pulse-width modulation (PWM) mode or forced PWM mode | 01: Forced PWM mode (default) |
| OUTPUT_OVP_EN | Output OVP enable or disable | 1: Enabled (default) |
| OUTPUT_DISCHARGE_EN | Enables output discharge function during the $V_{IN}$, I²C, or EN disabled period | 1: Enabled (default) |
| RSENS | Selects $R_{SENS}$ | 0: 5mΩ (default) |
| LDC_DISABLE | Enables line drop compensation | 0: Enables line drop compensation (default) |
| CONSTANT_CURRENT_LIMIT | Sets the output current ($I_{OUT}$) limit | 5.4 (default) |
| LINE_DROP_COMPENSATION | Sets $V_{OUT}$ compensation vs. $I_{OUT}$ | 00: No compensation (default) |
| SWITCHING_CURRENT_LIMIT | Sets the switch B (SWB) valley current limit and switch C (SWC) peak current limit | 01: SWC peak 13.2A, SWB valley 9A |
| CC_ADJ | Adjusts the CC limit vs. $V_{OUT}$ gain | 0: Does not add 50mA to the CC limit (default) |
| SLEW_RATE_RISE | Sets the $V_{REF}$ adjusted rising slew rate. The $V_{OUT}$ slew rate can be calculated with the following equation:<br>$V_{OUT}$ Slew Rate = $V_{REF}$ Slew Rate x Feedback Ratio<br>Where the feedback ratio is 10. | 01: 0.16mV/μs (default) |
| SLEW_RATE_FALL | Sets the $V_{REF}$ adjusted falling slew rate. The $V_{OUT}$ slew rate can be calculated with the following equation:<br>$V_{OUT}$ Slew Rate = $V_{REF}$ Slew Rate x Feedback Ratio<br>Where the feedback ratio is 10. | 10: 0.1mV/μs (default) |
| FREQ_MODE | Sets the frequency mode under buck-boost conditions | 1: Maintains the same frequency as buck and boost mode |
| CC_BLANK_TIMER | Sets the blank time before the MPQ4232 enters CC mode | 01: 2ms (default) |
| HICCUP_EN | Enables hiccup mode during the current limit | 1: Enabled |
| OT_WARNING | Enables the over-temperature (OT) warning | 135°C (default) |
| I2C_ADDRESS | Sets the I²C slave address | 00111: 07h |
| VOUT_MSK | Masks ALT pin indication | 1: Masked |
| IOUT/POUT_MSK | | 0: Not masked |
| VIN_MSK | | 1: Masked |
| TEMP_MSK | | 1: Masked |
| PG_MSK | | 11: The ALT pin does not indicate any PG edge changes |
| RESERVED | | 0: Not masked |
| UNKNOWN_MSK | | 1: Masked |

**Note:**

2) Pull the ADDR pin to exceed $V_{CC}$ by 57% to enable $V_{OUT}$.


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# EVALUATION BOARD SCHEMATIC

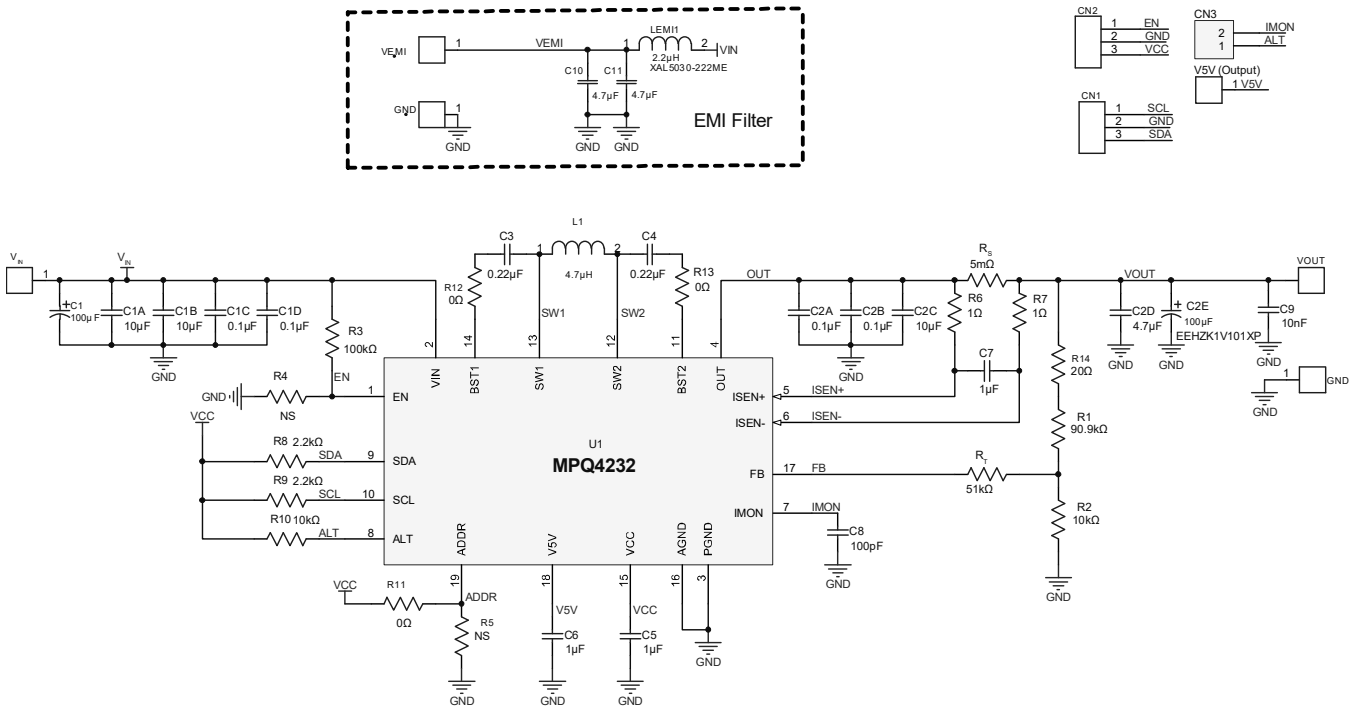


**Figure 2: Evaluation Board Schematic ($V_{IN}$ = 5V to 20V, default $f_{SW}$ = 420kHz, $V_{OUT}$ = 5V default)** (3) (4)

**Notes:**

3) ADDR sets the I²C address and I2C_EN status. I2C_EN is the logic or result of the OPERATION bit and ADDR status. When ADDR is connected to $V_{CC}$, I2C_EN is on. $V_{OUT}$ automatically starts up when $V_{IN}$ and $V_{EN}$ exceed their respective UVLO thresholds. When ADDR is connected to GND, I2C_EN is off. Once $V_{IN}$ and $V_{EN}$ exceed their respective UVLO thresholds, $V_{OUT}$ does not start up until 1 is written to the OPERATION bit.

4) The V5V pin outputs 5V and can supply the external MCU with a 60mA capability.


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## EVQ4232-VE-00A BILL OF MATERIALS

| Qty | Ref | Value | Description | Package | Manufacturer | Manufacturer PN |
|---|---|---|---|---|---|---|
| 1 | C1 | 100µF | Aluminum electrolytic capacitor, 35V | SMD | Nippon Chemic-Con | EMZJ350ADA101MF80G |
| 2 | C1A, C1B | 10µF | Ceramic capacitor, 50V, X5R | 0805 | Murata | GRM21BR61H106KE43L |
| 4 | C1C, C1D, C2A, C2B | 0.1µF | Ceramic capacitor, 50V, X7R | 0402 | Murata | GRM155R71H104ME14D |
| 1 | C2C | 10µF | Ceramic capacitor, 25V, X7S | 0805 | Murata | GRM21BC71E106KE11L |
| 1 | C2D | 4.7µF | Ceramic capacitor, 25V, X7R | 0805 | Murata | GRM21BC71E475KE11L |
| 1 | C2E | 100µF | Aluminum capacitor, 35V, ±20%, ESR = 35mΩ | SMD | Panasonic | EEHZK1V101XP |
| 2 | C3, C4 | 220nF | Ceramic capacitor, 16V, X7R | 0402 | Murata | GRM155R71C224KA12D |
| 2 | C5, C6 | 1µF | Ceramic capacitor, 16V, X5R | 0603 | Murata | GRM185R61C105KE44D |
| 1 | C7 | 1µF | Ceramic capacitor, 10V, X5R | 0402 | Wurth | 885012105012 |
| 1 | C8 | 100pF | Ceramic capacitor, 50V, X7R | 0603 | Wurth | 885012206077 |
| 1 | C9 | 10nF | Ceramic capacitor, 50V, X7R | 0603 | Wurth | 885012206089 |
| 2 | C10, C11 | 4.7µF | Ceramic capacitor, 50V, X7R | 0805 | TDK | CGA4J1X7R1H475K |
| 1 | R1 | 90.9kΩ | Film resistor, 1% | 0603 | Yageo | RC0603FR-0790K9L |
| 2 | R2, R10 | 10kΩ | Film resistor, 1% | 0603 | Yageo | RC0603FR-0710KL |
| 1 | RT | 51kΩ | Film resistor, 1% | 0603 | Yageo | RC0603FR-0751KL |
| 1 | R3 | 100kΩ | Film resistor, 1% | 0603 | Yageo | RC0603FR-07100KL |
| 0 | R4, R5 | NS | | | | |
| 2 | R6, R7 | 1Ω | Film resistor, 1% | 0402 | Yageo | RC0402FR-071RL |
| 2 | R8, R9 | 2.2kΩ | Film resistor, 1% | 0603 | Yageo | RC0603FR-072K2L |
| 1 | R11 | 0Ω | Film resistor, 1% | 0603 | Yageo | RC0603FR-070RL |
| 2 | R12, R13 | 0Ω | Film resistor, 1% | 0402 | Yageo | RC0402FR-070RL |
| 1 | R14 | 20Ω | Film resistor, 1% | 0603 | Yageo | RC0603FR-0720RL |
| 1 | Rs | 5mΩ | Current-sensing resistor, long side, 1%, 1W | L1508 | Susumu | RL3720WT-R005-F |
| 1 | L1 | 4.7µH | Inductor, $R_{DC}$ = 8mΩ, $I_{SAT}$ = 13A | SMD | Superworld | PIAQ1005S4R7MN |
| 1 | LEMI1 | 2.2µH | Inductor, $R_{DC}$ = 14.5mΩ, $I_{SAT}$ = 9.2A | 5030 | Coilcraft | XAL5030-222ME |
| 2 | CN1, CN2 | 2.54mm | Through-hole connector header, 1 x 3-pin, straight | DIP | Wurth | 61300311121 |


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## EVQ4232-VE-00A BILL OF MATERIALS *(continued)*

| Qty | Ref | Value | Description | Package | Manufacturer | Manufacturer PN |
|---|---|---|---|---|---|---|
| 1 | CN3 | 2.54mm | Through-hole connector header, 1 x 2-pin, straight | DIP | Wurth | 61300211121 |
| 1 | V5V | 2.54mm | Through-hole connector header, 1 x 1-pin, straight | DIP | Wurth | 61300111121 |
| 5 | GND x 2, VIN, VEMI, VOUT | 2mm | Copper pin, 1-pin | DIP | Any | |
| 1 | U1 | MPQ4232 | 6A buck-boost converter with four integrated MOSFETs and I²C interface, AEC-Q100 qualified | QFN-19 (4mmx 5mm) | MPS | MPQ4232GVE-0000-AEC1 |


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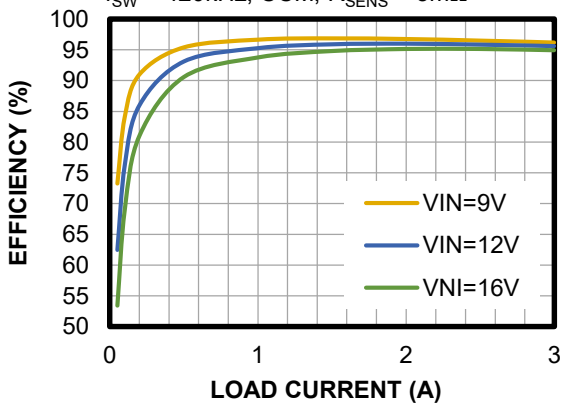
# EVB TEST RESULTS

**$V_{IN}$ = 12V, $V_{OUT}$ = 5V, L = 4.7µH, $T_A$ = 25°C, unless otherwise noted.**

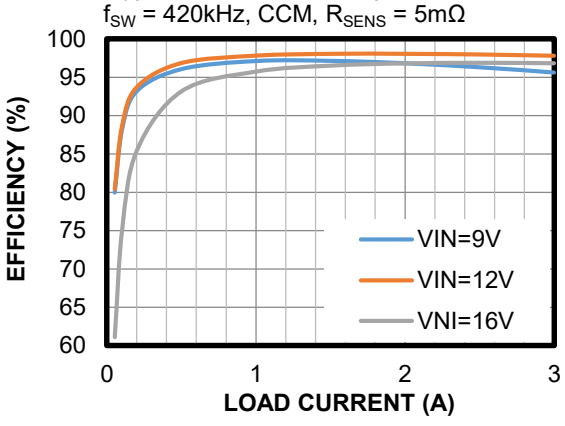
### Efficiency vs. Load Current

$V_{OUT}$ = 5V, L = 4.7µH, $R_{DC}$ = 8mΩ, $f_{SW}$ = 420kHz, CCM, $R_{SENS}$ = 5mΩ



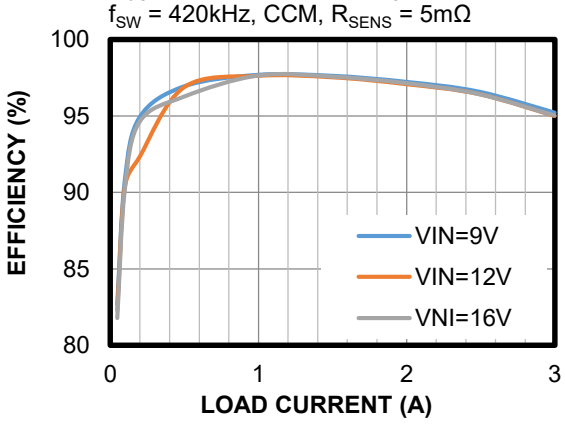

### Efficiency vs. Load Current

$V_{OUT}$ = 9V, L = 4.7µH, $R_{DC}$ = 8mΩ, $f_{SW}$ = 420kHz, CCM, $R_{SENS}$ = 5mΩ



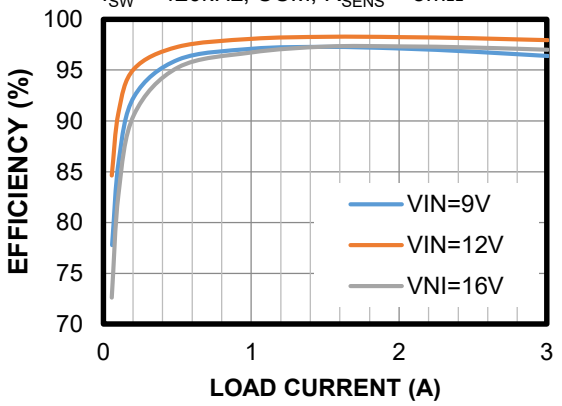

### Efficiency vs. Load Current

$V_{OUT}$ = 12V, L = 4.7µH, $R_{DC}$ = 8mΩ, $f_{SW}$ = 420kHz, CCM, $R_{SENS}$ = 5mΩ



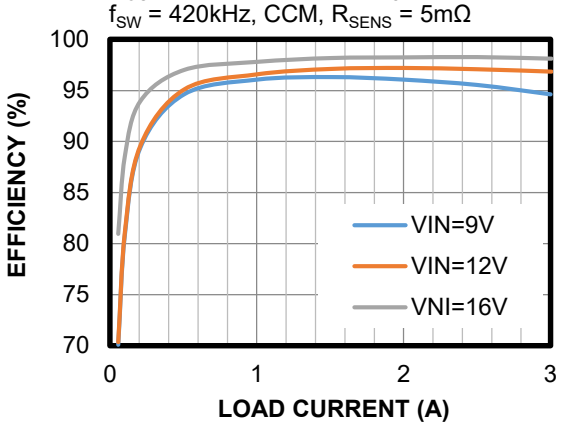

### Efficiency vs. Load Current

$V_{OUT}$ = 15V, L = 4.7µH, $R_{DC}$ = 8mΩ, $f_{SW}$ = 420kHz, CCM, $R_{SENS}$ = 5mΩ



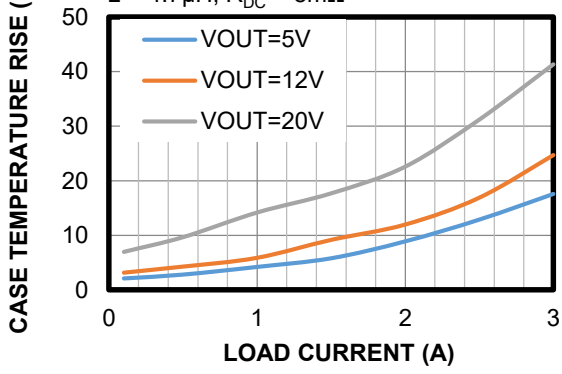

### Efficiency vs. Load Current

$V_{OUT}$ = 20V, L = 4.7µH, $R_{DC}$ = 8mΩ, $f_{SW}$ = 420kHz, CCM, $R_{SENS}$ = 5mΩ




### Case Temperature Rise vs. Load Current

$V_{IN}$ = 12V, $V_{OUT}$ = 5V/12V/20V, $f_{SW}$ = 420kHz, based on 5cmx5cm board, L = 4.7µH, $R_{DC}$ = 8mΩ





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# PCB LAYOUT

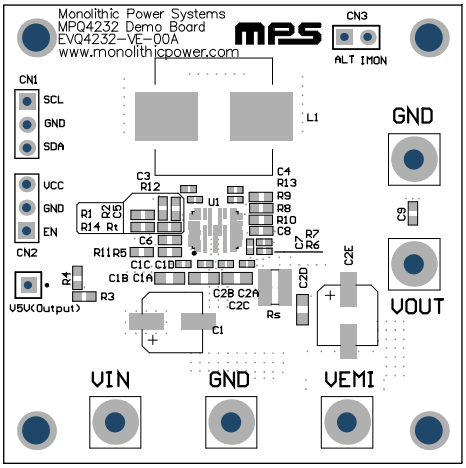


Figure 3: Top Silk

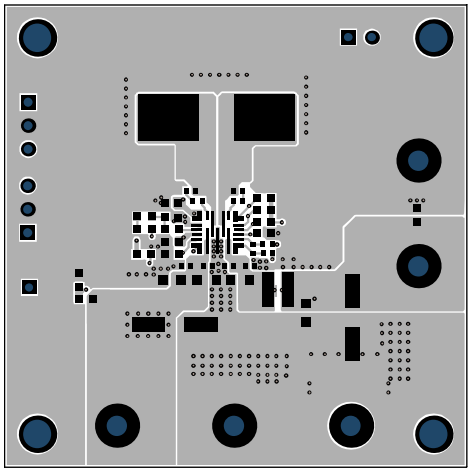

Figure 4: Top Layer

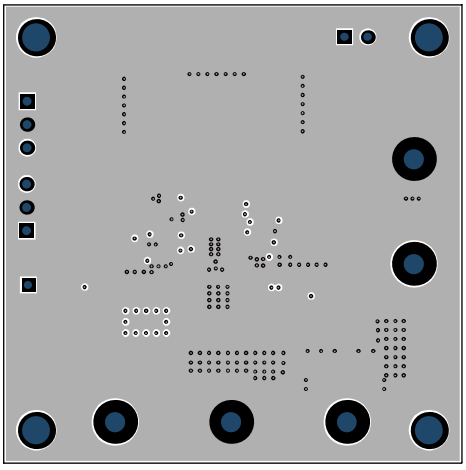

Figure 5: Mid-Layer 1

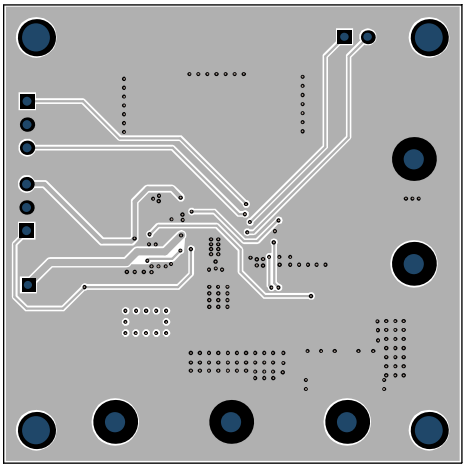

Figure 6: Mid-Layer 2

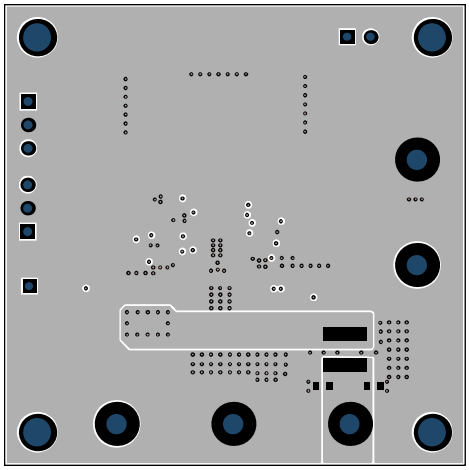

Figure 7: Bottom Layer

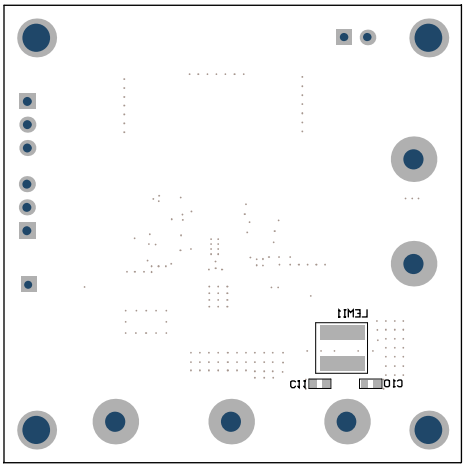

Figure 8: Bottom Silk


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## REVISION HISTORY

| Revision # | Revision Date | Description | Pages Updated |
|---|---|---|---|
| 1.0 | 7/5/2024 | Initial Release | - |

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