

ISL70002SEHEVAL1Z

Evaluation Board

AN1732  
Rev.1.00  
December 6, 2016

**Circuit Comments**

The ISL70002SEHEVAL1Z evaluation board is designed to demonstrate the features of the [ISL70002SEH](#), a TID and SEE hardened 12A synchronous buck regulator IC with integrated MOSFETs intended for space applications. For more detailed information about the ISL70002SEH, refer to the [ISL70002SEH](#) datasheet.

The ISL70002SEHEVAL1Z evaluation board accepts a nominal 3V to 5.5V input voltage and provides a regulated output voltage ranging from 0.8V to 85% of the input voltage at output currents ranging from 0A to 12A. The output can be quickly set to a preset voltage of 1.0V, or adjusted to an alternate voltage using the onboard potentiometer. A Power-Good (PGOOD) signal goes high and lights a red LED to indicate that the output voltage is within a  $\pm 11\%$  typical regulation window. A toggle switch is provided to conveniently enable or disable the output voltage.

The ISL70002SEHEVAL1Z evaluation board can be set to run from the nominal 500kHz or 1MHz internal oscillator of the ISL70002SEH or synchronized to a 500kHz to 1MHz  $\pm 20\%$  external clock. Two ISL70002SEH ICs can be synchronized to each other in a master/slave configuration, providing nearly twice the output current while switching 180° out-of-phase with respect to each other. See [AN1953](#), "Dual Phase Current Share Evaluation Board User Guide".

**Related Literature**

- For a full list of related documents, visit our website
- [ISL70002SEH](#) product page

**Schematic and BOM**

A photograph, schematic, and BOM of the ISL70002SEHEVAL1Z evaluation board are shown in [Figure 1](#), [Figure 20 on page 6](#), and [Table 1 on page 7](#), respectively. The schematic indicates the test points, which allow many nodes of the evaluation circuit to be monitored directly. The BOM shows components that are representative of the types needed for a design, but these components are not space-qualified. Equivalent space-qualified components would be required for flight applications. A 1 $\mu$ H inductor is recommended for 500kHz and a 500 $\mu$ H inductor is recommended for 1MHz.

**Recommended Test Equipment**

- A 0V to 6V power supply with at least 20A current capability
- An electronic load capable of sinking current up to 12A
- Two Digital Multimeters (DMMs)
- A 500MHz dual-trace oscilloscope

**Ordering Information**

| PART NUMBER       | DESCRIPTION                        |
|-------------------|------------------------------------|
| ISL70002SEHEVAL1Z | ISL70002SEHEVAL1Z Evaluation Board |

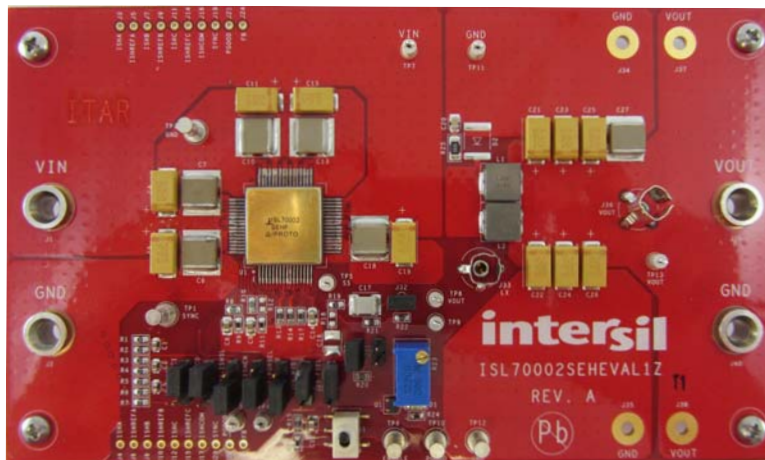


FIGURE 1. ISL70002SEHEVAL1Z TOP VIEW

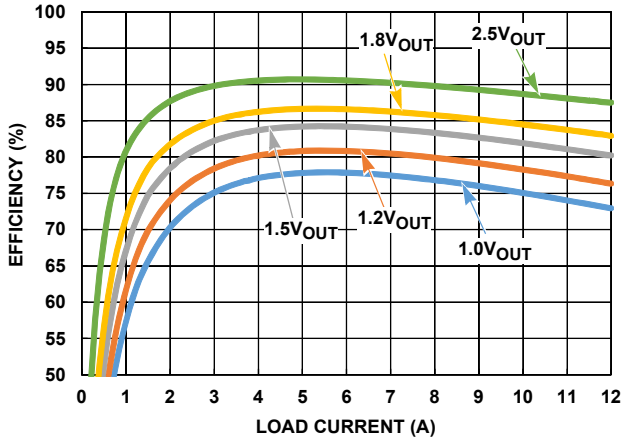
## Quick Start

1. Toggle S1 to the down (OFF) position.
2. Turn on the power supply. Set the output voltage to 3.3V and set the output current limit to 20A. Turn off the power supply.
3. Connect the positive lead of the power supply to J1 and the negative lead of the power supply to J2.
4. Turn on the electronic load and set the output current to 6A.
5. Connect the positive lead of the electronic load to J39 and connect the negative lead of the electronic load to J40.
6. Configure one DMM to monitor the input voltage from TP7 to TP11.
7. Configure another DMM to monitor the output voltage from TP13 to TP11.
8. Connect Channel 1 of the oscilloscope to J6 (or from TP33 to TP28) to monitor the rectangular waveform on the LXx pins.
9. Connect Channel 2 of the oscilloscope to J14 (or from TP36 to TP37) to monitor the output voltage. Ripple voltage is customarily measured with 20MHz bandwidth limiting.
10. Toggle S1 to the up (ON) position.
11. Verify the output voltage is  $1.0V \pm 3\%$  and the frequency of the LXx waveform is  $1MHz \pm 10\%$ .

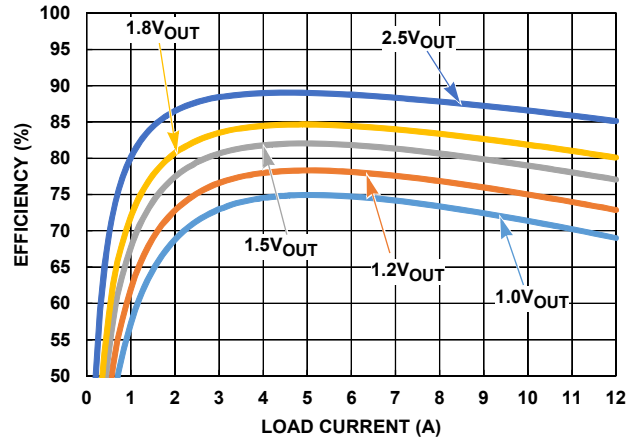
## Layout Guidelines

1. Use an eight-layer PCB with 2 ounce (70 $\mu$ m) copper or equivalent in thinner layers.
2. Two layers should be dedicated for ground plane.
3. Top and bottom layers should be used primarily for signals, but can also be used to increase the VIN, VOUT, and ground planes as required.
4. Connect all AGND, DGND, and PGNDx pins directly to the ground plane. Connect all PVINx pins directly to the VIN portion of the power plane.
5. Locate ceramic bypass capacitors as close as possible to U1. Prioritize the placement of the bypass capacitors on the pins of U1 in the order shown: PVINx, REF, AVDD, DVDD, SS, EN, PGOOD.
6. Locate the output voltage resistive divider as close as possible to the FB pin of the IC. The top leg of the divider should connect directly to the load and the bottom leg of the resistive divider should connect directly to AGND. The junction of the resistive divider should connect directly to the FB pin.
7. Use a small island of copper to connect the LXx pins of U1 to the inductor(s), L1 and L2, to minimize the routing capacitance that degrades efficiency. Separate the island from ground and power planes as much as possible.
8. Keep all signal traces as short as possible.
9. A small series snubber (R<sub>25</sub> and C<sub>20</sub>) connected from the LXx pins to the PGNDx pins may be used to dampen ringing on the LXx pins if desired.
10. For optimum thermal performance, place a pattern of vias on the top layer of the PCB directly underneath U1. Connect the vias to the ground planes, which serve as a heatsink. Thermal interface material such as a Sil-Pad should be used to fill the gap between the vias and the bottom of U1 to ensure good thermal contact. Using a Sil-Pad has the added benefit of raising the bottom of U1 from the PCB surface so that a slight bend can be added to the leads for strain relief.

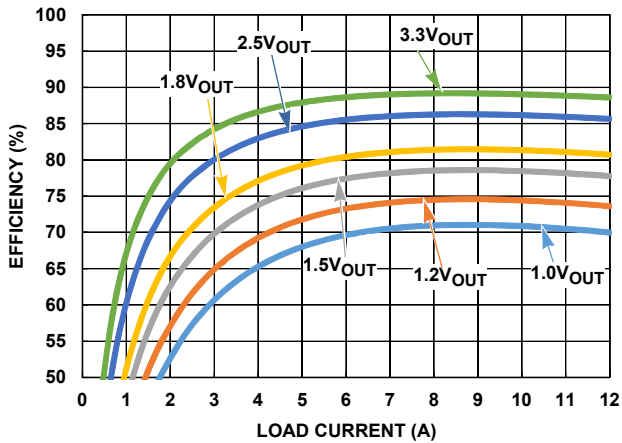
**ISL70002SEHEVAL1Z Efficiency Curves** The efficiency data presented in Figures 2 through 17 was taken with the ISL70002SEHEVAL1Z immersed in a temperature-calibrated liquid bath to ensure the notated IC case temperature.



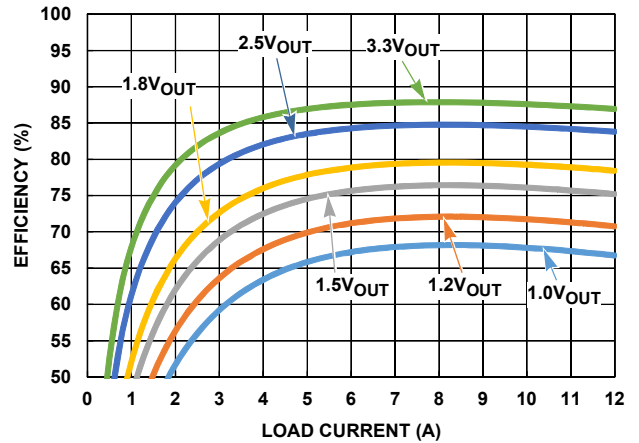
**FIGURE 2. EFFICIENCY vs LOAD vs OUTPUT VOLTAGE**  
 $V_{IN} = 3.3V, f_{SW} = 500kHz, -55^{\circ}C$  CASE TEMPERATURE



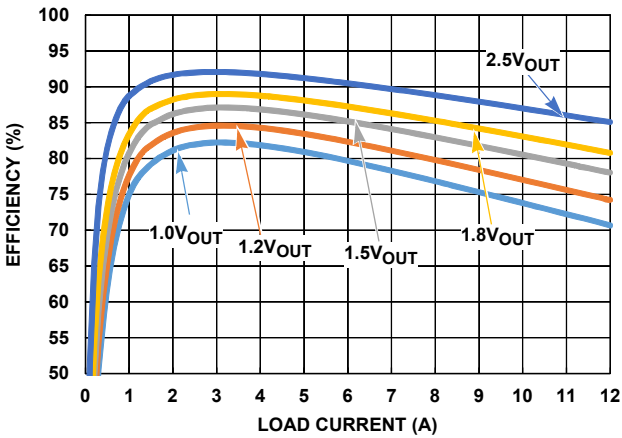
**FIGURE 3. EFFICIENCY vs LOAD vs OUTPUT VOLTAGE**  
 $V_{IN} = 3.3V, f_{SW} = 1MHz, -55^{\circ}C$  CASE TEMPERATURE



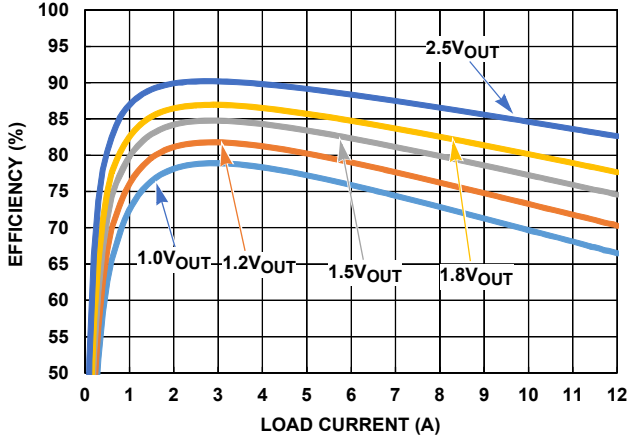
**FIGURE 4. EFFICIENCY vs LOAD vs OUTPUT VOLTAGE**  
 $V_{IN} = 5V, f_{SW} = 500kHz, -55^{\circ}C$  CASE TEMPERATURE



**FIGURE 5. EFFICIENCY vs LOAD vs OUTPUT VOLTAGE**  
 $V_{IN} = 5V, f_{SW} = 1MHz, -55^{\circ}C$  CASE TEMPERATURE

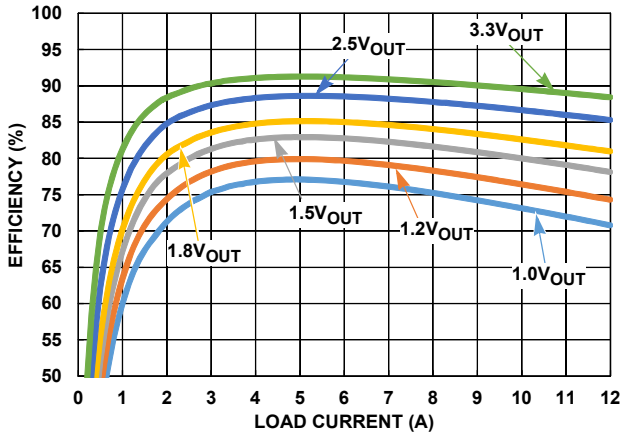


**FIGURE 6. EFFICIENCY vs LOAD vs OUTPUT VOLTAGE**  
 $V_{IN} = 3.3V, f_{SW} = 500kHz, +25^{\circ}C$  CASE TEMPERATURE

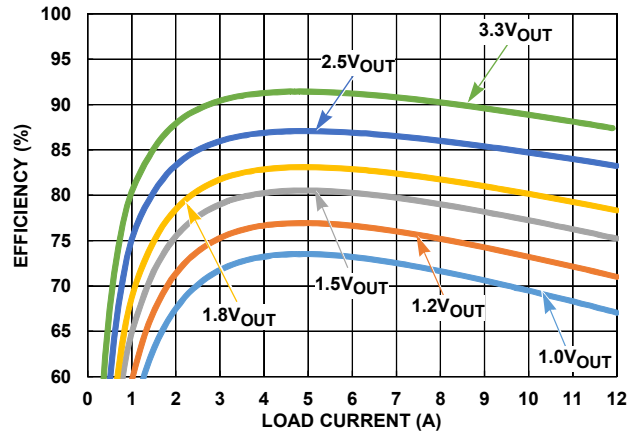


**FIGURE 7. EFFICIENCY vs LOAD vs OUTPUT VOLTAGE**  
 $V_{IN} = 3.3V, f_{SW} = 1MHz, +25^{\circ}C$  CASE TEMPERATURE

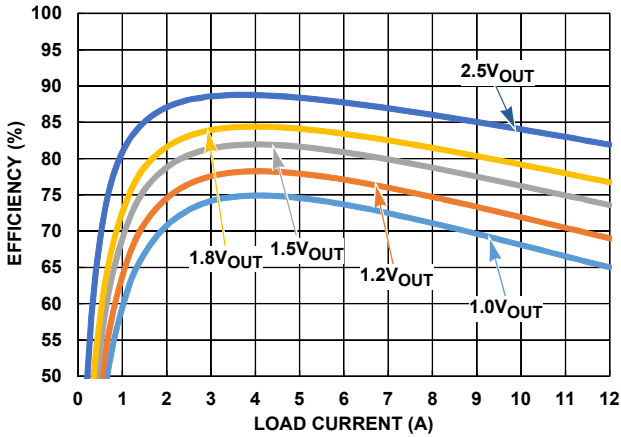
**ISL70002SEHEVAL1Z Efficiency Curves** The efficiency data presented in Figures 2 through 17 was taken with the ISL70002SEHEVAL1Z immersed in a temperature-calibrated liquid bath to ensure the notated IC case temperature. (Continued)



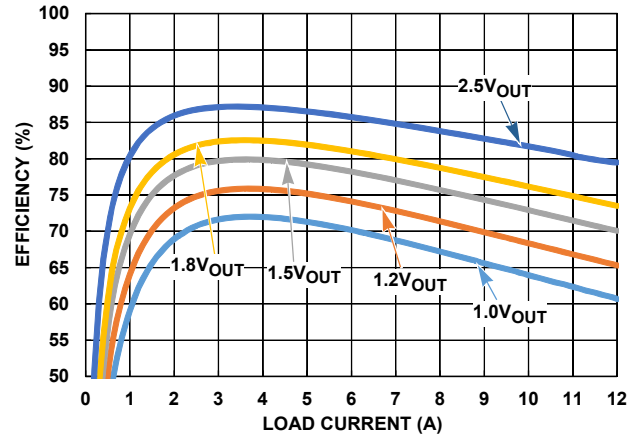
**FIGURE 8. EFFICIENCY vs LOAD vs OUTPUT VOLTAGE**  
 $V_{IN} = 5V, f_{SW} = 500kHz, +25^{\circ}C$  CASE TEMPERATURE



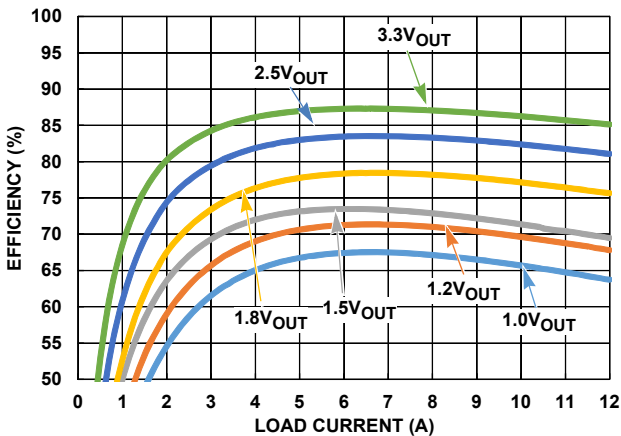
**FIGURE 9. EFFICIENCY vs LOAD vs OUTPUT VOLTAGE**  
 $V_{IN} = 5V, f_{SW} = 1MHz, +25^{\circ}C$  CASE TEMPERATURE



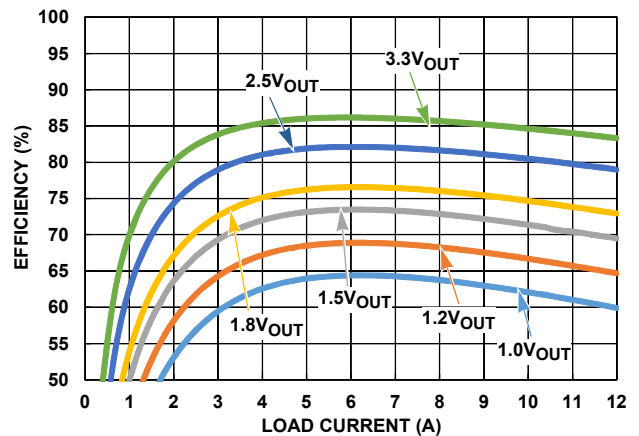
**FIGURE 10. EFFICIENCY vs LOAD vs OUTPUT VOLTAGE**  
 $V_{IN} = 3.3V, f_{SW} = 500kHz, +85^{\circ}C$  CASE TEMPERATURE



**FIGURE 11. EFFICIENCY vs LOAD vs OUTPUT VOLTAGE**  
 $V_{IN} = 3.3V, f_{SW} = 1MHz, +85^{\circ}C$  CASE TEMPERATURE



**FIGURE 12. EFFICIENCY vs LOAD vs OUTPUT VOLTAGE**  
 $V_{IN} = 5V, f_{SW} = 500kHz, +85^{\circ}C$  CASE TEMPERATURE



**FIGURE 13. EFFICIENCY vs LOAD vs OUTPUT VOLTAGE**  
 $V_{IN} = 5V, f_{SW} = 1MHz, +85^{\circ}C$  CASE TEMPERATURE

**ISL70002SEHEVAL1Z Efficiency Curves** The efficiency data presented in Figures 2 through 17 was taken with the ISL70002SEHEVAL1Z immersed in a temperature-calibrated liquid bath to ensure the notated IC case temperature. (Continued)

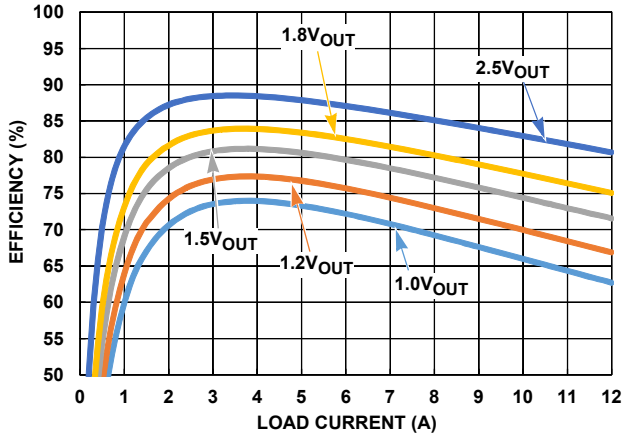


FIGURE 14. EFFICIENCY vs LOAD vs OUTPUT VOLTAGE,  $V_{IN} = 3.3V$ ,  $f_{SW} = 500kHz$ ,  $+125^{\circ}C$  CASE TEMPERATURE

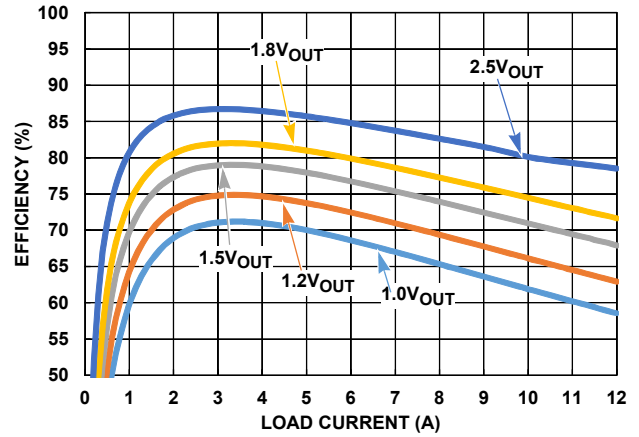


FIGURE 15. EFFICIENCY vs LOAD vs OUTPUT VOLTAGE  $V_{IN} = 3.3V$ ,  $f_{SW} = 1MHz$ ,  $+125^{\circ}C$  CASE TEMPERATURE

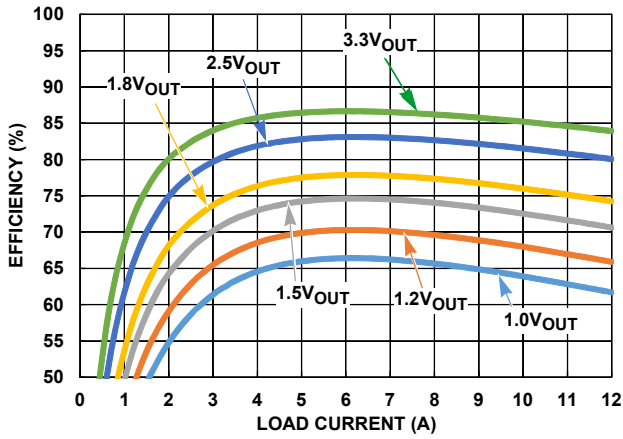


FIGURE 16. EFFICIENCY vs LOAD vs OUTPUT VOLTAGE  $V_{IN} = 5V$ ,  $f_{SW} = 500kHz$ ,  $+125^{\circ}C$  CASE TEMPERATURE

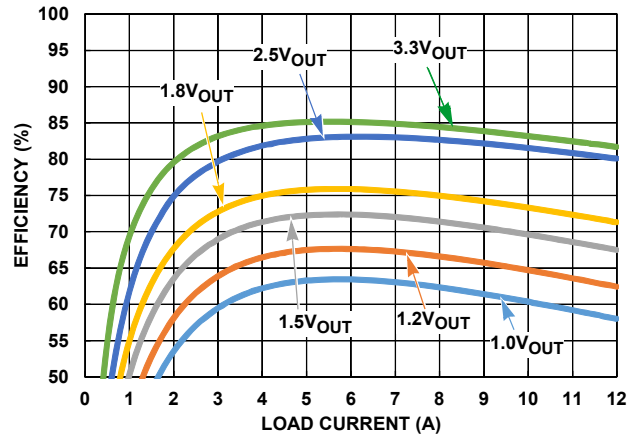


FIGURE 17. EFFICIENCY vs LOAD vs OUTPUT VOLTAGE  $V_{IN} = 5V$ ,  $f_{SW} = 1MHz$ ,  $+125^{\circ}C$  CASE TEMPERATURE

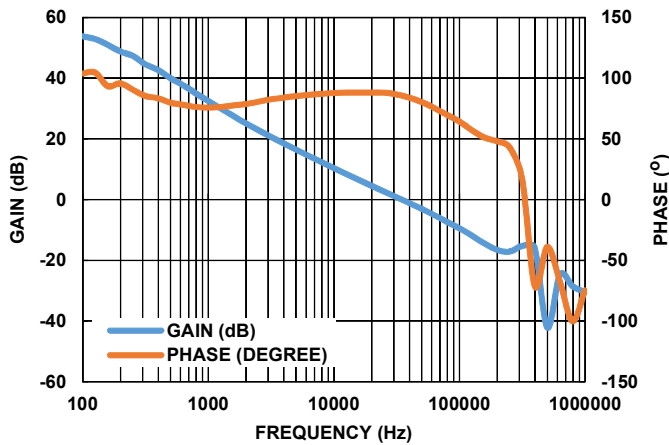


FIGURE 18. GAIN/PHASE PLOT,  $V_{IN} = 5V$ ,  $f_{SW} = 500kHz$ ,  $+25^{\circ}C$  AMBIENT TEMPERATURE

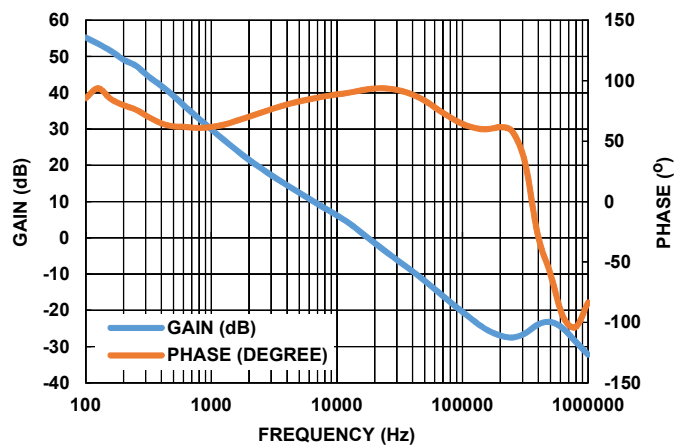


FIGURE 19. GAIN/PHASE PLOT,  $V_{IN} = 5V$ ,  $f_{SW} = 1MHz$ ,  $+25^{\circ}C$  AMBIENT TEMPERATURE

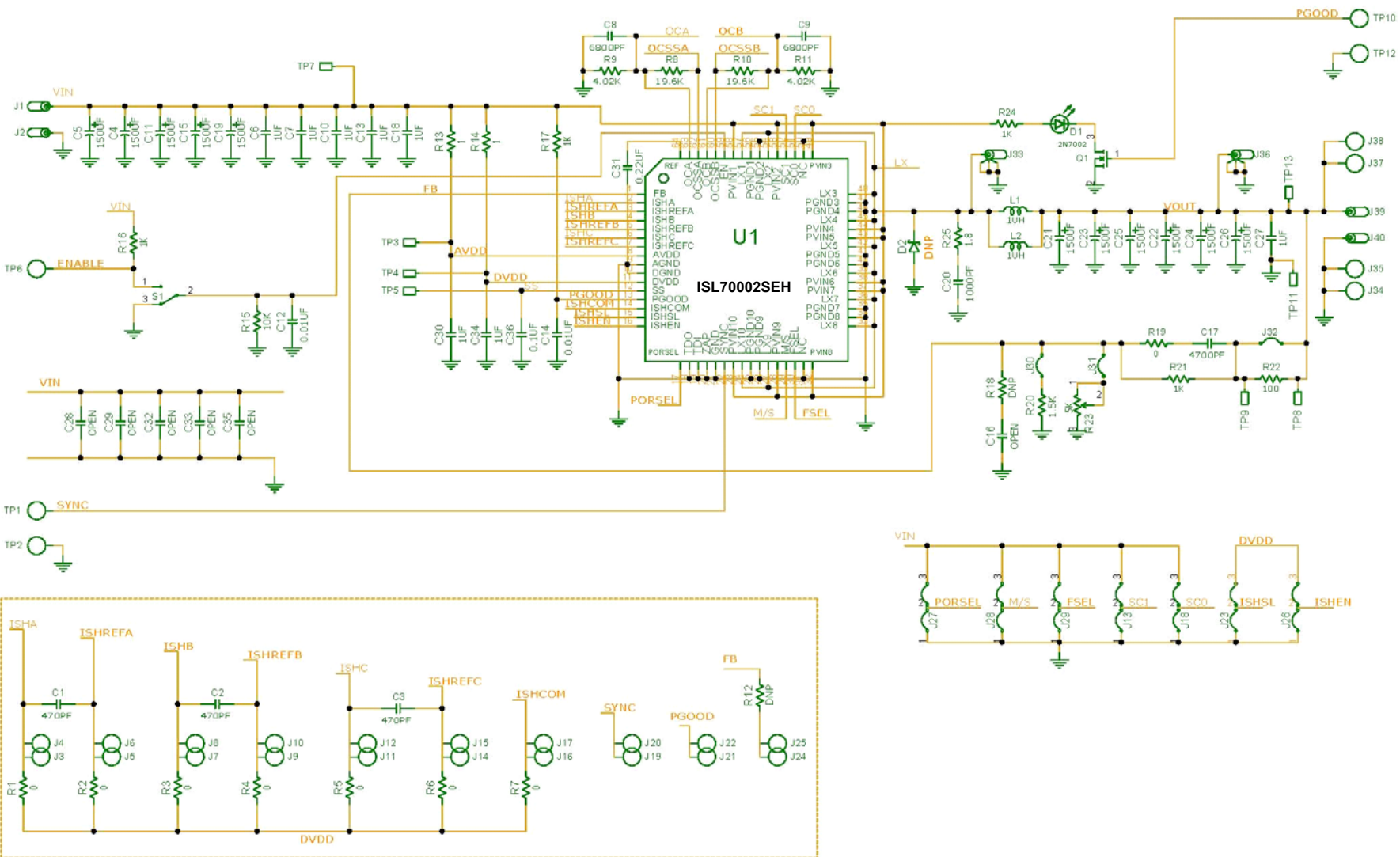


FIGURE 20. ISL70002SEHEVAL1Z BOARD SCHEMATIC

TABLE 1. ISL70002SEHEVAL1Z BILL OF MATERIALS

| PART NUMBER             | REF DES                                 | QTY | VALUE  | TOL   | VOLTAGE | POWER | PACKAGE TYPE | JEDEC TYPE         | MANUFACTURER     | DESCRIPTION   |
|-------------------------|---|-----|--------|-------|---------|-------|--------------|--------------------|------------------|---|
| C0805C103K2RAC          | C12, C14                                | 2   | 0.01µF | 10%   | 200V    |       | 805          | CAP_0805           | KEMET            | Ceramic Chip Cap                                      |
| H1082-OPEN              | C16                                     | 1   | OPEN   | 10%   | OPEN    |       | 1210         | CAP_1210           | GENERIC          | Ceramic Chip Cap                                      |
| C1812C472F2GAC          | C17                                     | 1   | 4700pF | 1%    | 200V    |       | 1812         | CAP_1812           | KEMET            | Multilayer Cap  |
| H1045-00471-25V20       | C1-C3                                   | 3   | 470pF  | 20%   | 25V     |       | 603          | CAP_0603           | GENERIC          | Multilayer Cap  |
| C0805C102K2RAC          | C20                                     | 1   | 1000pF | 10%   | 200V    |       | 805          | CAP_0805           | KEMET            | Ceramic Chip Cap                                      |
| H1045-OPEN              | C28, C29, C32,<br>C33, C35              | 5   | OPEN   | 5%    | OPEN    |       | 603          | CAP_0603           | GENERIC          | Multilayer Cap  |
| C1825C224K2RAC          | C31                                     | 1   | 0.22µF | 10%   | 200V    |       | 1825         | CAP_1825           | KEMET            | Ceramic Chip Cap                                      |
| C1210C104K2RAC          | C36                                     | 1   | 0.1µF  | 10%   | 200V    |       | 1210         | CAP_1210           | KEMET            | Ceramic Chip Cap                                      |
| T530D157M010AHE006      | C4, C5, C11, C1,<br>C19, C21-C26        | 11  | 150µF  | 20%   | 10V     |       | SMD          | CAP_7343_31        | KEMET            | High Capacitance Ultra-Low ESR<br>Tantalum SMD Cap    |
| C2225C105K2RAC          | C6, C7, C10, C13,<br>C18, C27, C30, C34 | 8   | 1µF    | 10%   | 200V    |       | 2225         | CAP_2225           | KEMET            | Multilayer Cap  |
| C0805C682K2RAC          | C8, C9                                  | 2   | 6800pF | 10%   | 200V    |       | 805          | CAP_0805           | KEMET            | Multilayer Cap  |
| LTST-C170CKT            | D1                                      | 1   |        |       |         |       | SMD          | LTST_C170CKT       | LITEON           | AlGaAs on GaAs Red LED                                |
| 1N5822US                | D2                                      | 0   |        |       |         |       | SMD2         | DIO_CASE_D-5B      | MICROSEMI        | 3A 40V SCHOTTKY<br>BARRIER RECTIFIER                  |
| 575-4                   | J1, J2, J39, J40                        | 4   |        |       |         |       | CONN         | CON_BAN_575        | KEYSTONE         | SOLDER MOUNT<br>BANANA PLUG                           |
| JUMPER-3-100            | J13, J18, J23,<br>J26-J29               | 7   |        |       |         |       | THOLE        | JUMPER-3           | GENERIC          | Three Pin Jumper                                      |
| JUMPER2_100             | J30-J32                                 | 3   |        |       |         |       | THOLE        | JUMPER-1           | GENERIC          | Two Pin Jumper  |
| 131-4353-00             | J33, J36                                | 2   |        |       |         |       | CONN         | TEK131-4353-00     | TEKTRONIX        | Scope Probe Test<br>Point PCB Mount                   |
| IHLP-2525CZ-ER-1R0-M-01 | L1, L2                                  | 2   | 1µH    | 20%   |         | 11A   | SMD          | IND_IHLP-2525CZ-01 | VISHAY           | LOW PROFILE HIGH CURRENT<br>INDUCTOR (RoHS COMPLIANT) |
| 2N7002-7-F              | Q1                                      | 1   |        |       |         |       | SOT23        | SOT23              | FAIRCHILD        | N-Channel EMF Effect<br>Transistor (Pb-Free)          |
| H2505-DNP-DNP-1         | R12, R18                                | 2   | DNP    | 1%    |         | DNP   | 603          | RES_0603           | GENERIC          | Metal Film Chip Resistor<br>(Do Not Populate)         |
| S0603CPZ1R00F10         | R13, R14                                | 2   | 1      | 1%    |         | 1/10W | 603          | RES_0603           | State of the Art | 100ppm Thick Film Chip Resistor                       |
| S0603CA1002BEZ          | R15                                     | 1   | 10k    | 0.10% |         | 1/10W | 603          | RES_0603           | State of the Art | 25ppm Thin Film Chip Resistor                         |
| MCR03EZPFX1001          | R16                                     | 1   | 1k     | 1%    |         | 1/10W | 603          | RES_0603           | ROHM             | Metal Film Chip Resistor                              |
| S0603CPZ1001F10         | R17                                     | 1   | 1k     | 1%    |         | 1/10W | 603          | RES_0603           | State of the Art | 100ppm Thick Film Chip Resistor                       |

TABLE 1. ISL70002SEHEVAL1Z BILL OF MATERIALS (Continued)

| PART NUMBER          | REF DES                      | QTY | VALUE | TOL   | VOLTAGE | POWER | PACKAGE TYPE | JEDEC TYPE         | MANUFACTURER     | DESCRIPTION   |
|----------------------|------------------------------|-----|-------|-------|---------|-------|--------------|--------------------|------------------|---|
| H2511-00R00-1/16W1   | R19                          | 1   | 0     | 1%    |         | 1/16W | 603          | RES_0603           | GENERIC          | Thick Film Chip Resistor  |
| ERJ3GEY0R00V         | R1-R7                        | 7   | 0     | 0%    |         | 1/10W | 603          | RES_0603           | PANASONIC        | Thick Film Chip Resistor  |
| S0603CA1501BEZ       | R20                          | 1   | 1.5k  | 0.10% |         | 1/10W | 603          | RES_0603           | State of the Art | 25ppm Thin Film Chip Resistor   |
| S0603CA1001BEZ       | R21                          | 1   | 1k    | 0.10% |         | 1/10W | 603          | RES_0603           | State of the Art | 25ppm Thin Film Chip Resistor   |
| S0603CPZ1000F10      | R22                          | 1   | 100   | 1%    |         | 1/10W | 603          | RES_0603           | State of the Art | 100ppm Thick Film Chip Resistor   |
| 3299W-1-502-LF       | R23                          | 1   | 5k    | 10%   |         | 1/2W  | RADIAL       | RES_POT_3299W      | BOURNS           | TRIMMER POTENTIOMETER (RoHS COMPLIANT)  |
| H2511-01001-1/16W1   | R24                          | 1   | 1k    | 1%    |         | 1/16W | 603          | RES_0603           | GENERIC          | Thick Film Chip Resistor  |
| H2513-001R8-1/8W1    | R25                          | 1   | 1.8   | 1%    |         | 1/8W  | 1206         | RES_1206           | GENERIC          | Thick Film Chip Resistor  |
| S0603CA1962BEZ       | R8, R10                      | 2   | 19.6k | 0.10% |         | 1/10W | 603          | RES_0603           | State of the Art | 25ppm Thin Film Chip Resistor   |
| S0603CA4021BEZ       | R9, R11                      | 2   | 4.02k | 0.10% |         | 1/10W | 603          | RES_0603           | State of the Art | 25ppm Thin Film Chip Resistor   |
| GT11MSCBE-T          | S1                           | 1   |       |       |         |       | SMT          | GT13MSCKE          | C&K              | SPDT On-None-On SMT Ultraminiature Toggle Switch (RoHS compliant)   |
| 1514-2               | TP1, TP2, TP6, TP10, TP12    | 5   |       |       |         |       | THOLE        | TP-150C100P        | KEYSTONE         | Test Point Turret 0.150 Pad 0.100 Thole   |
| 5002                 | TP3-TP5, TP7-TP9, TP11, TP13 | 8   |       |       |         |       | THOLE        | MTP500X            | KEYSTONE         | Miniature White Test Point 0.100 Pad 0.040 Thole  |
| ISL70002SEHVF        | U1                           | 1   |       |       |         |       | CQFP         | CQFP64_555X555_635 | INTERSIL         | 12A SYNCHRONOUS BUCK REGULATOR W/MOSFET   |
| SP2000-0.020-AC-1212 |                              | 1   |       |       |         |       |              |                    | Bergquist        | Thermal Interface Material, Sil-Pad, 12inx12inx0.020in, with adhesive, cut to 0.4inx0.4in and placed on underside of U1 |



# Board Layout

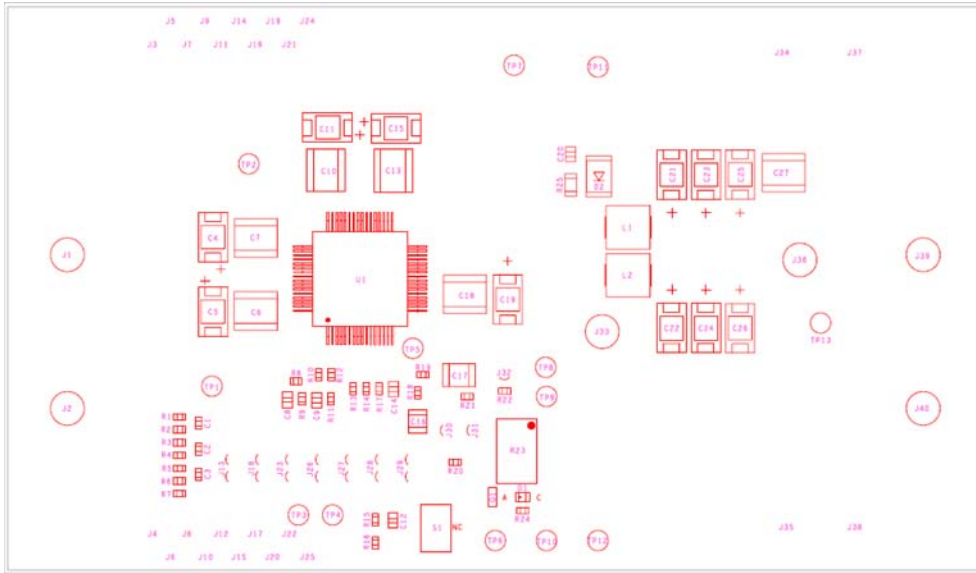


FIGURE 21. TOP SIDE ASSEMBLY DRAWING

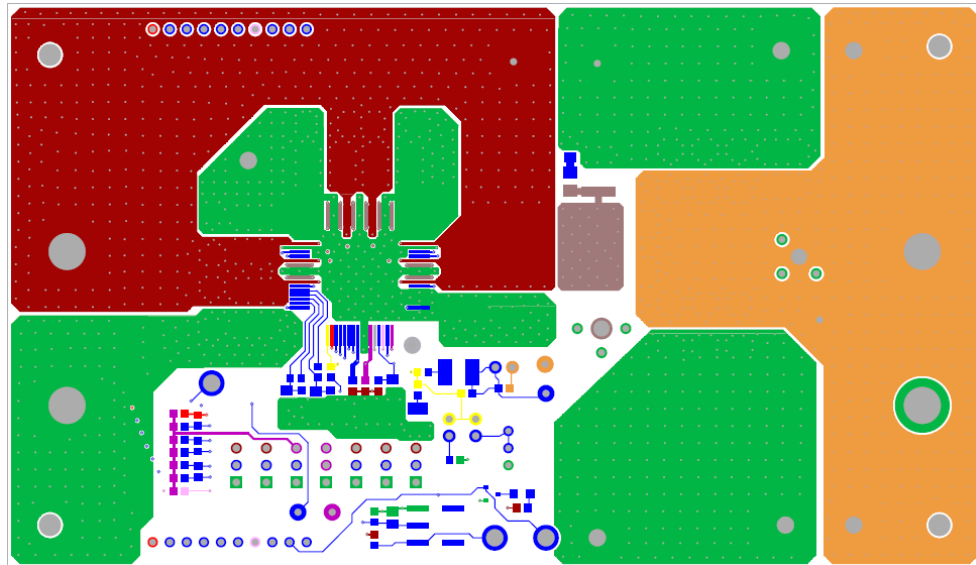


FIGURE 22. TOP LAYER

## Board Layout (Continued)

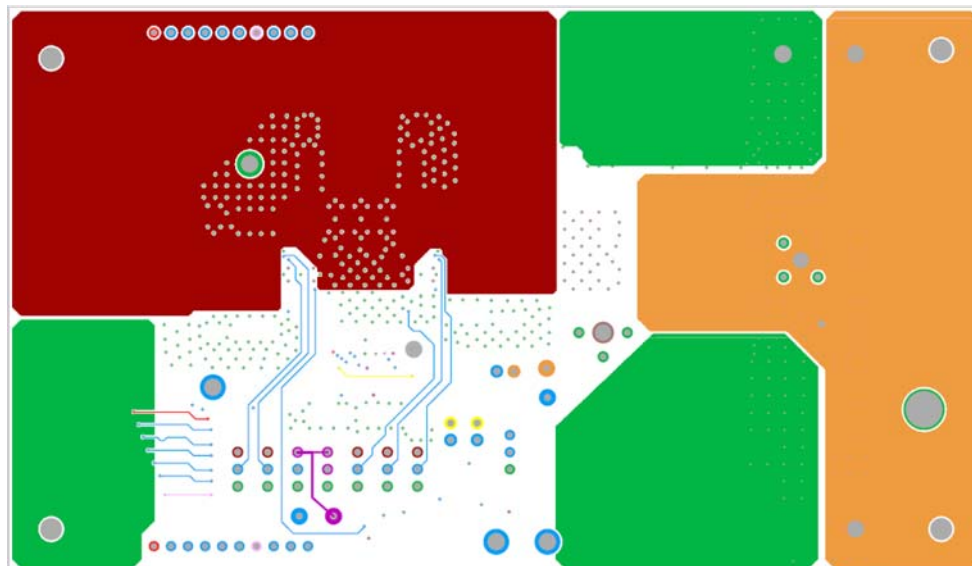


FIGURE 23. LAYER 2

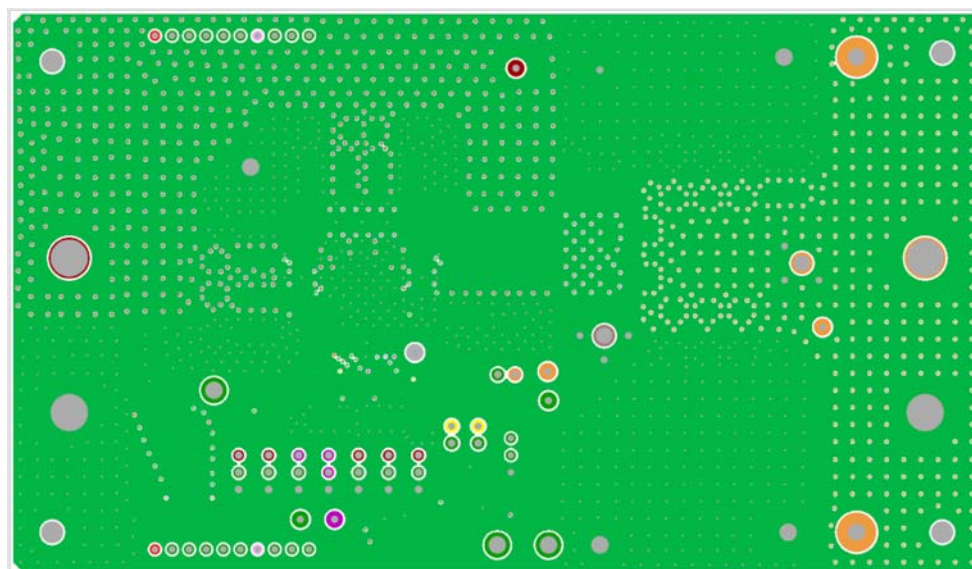


FIGURE 24. LAYER 3

## Board Layout (Continued)

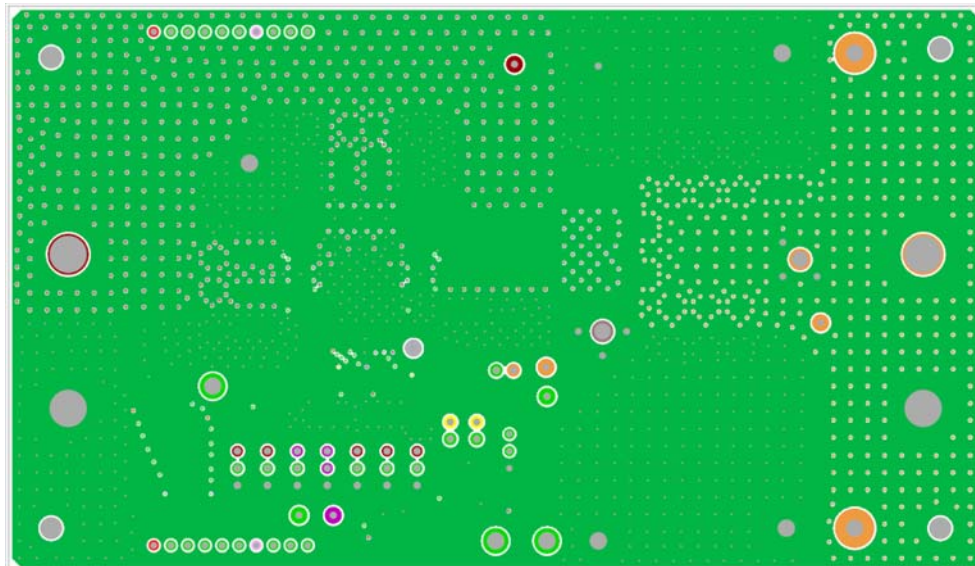


FIGURE 25. LAYER 4

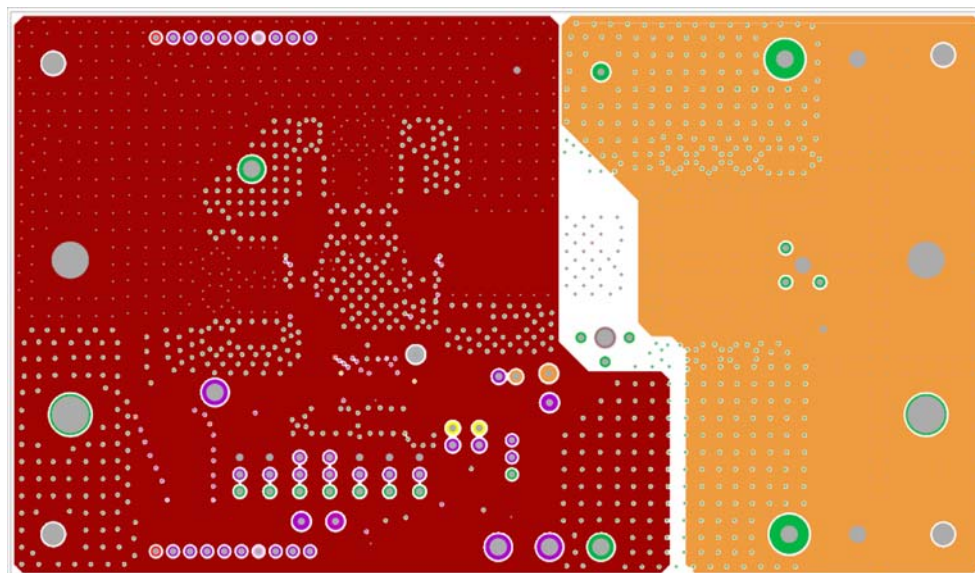


FIGURE 26. LAYER 5

## Board Layout (Continued)

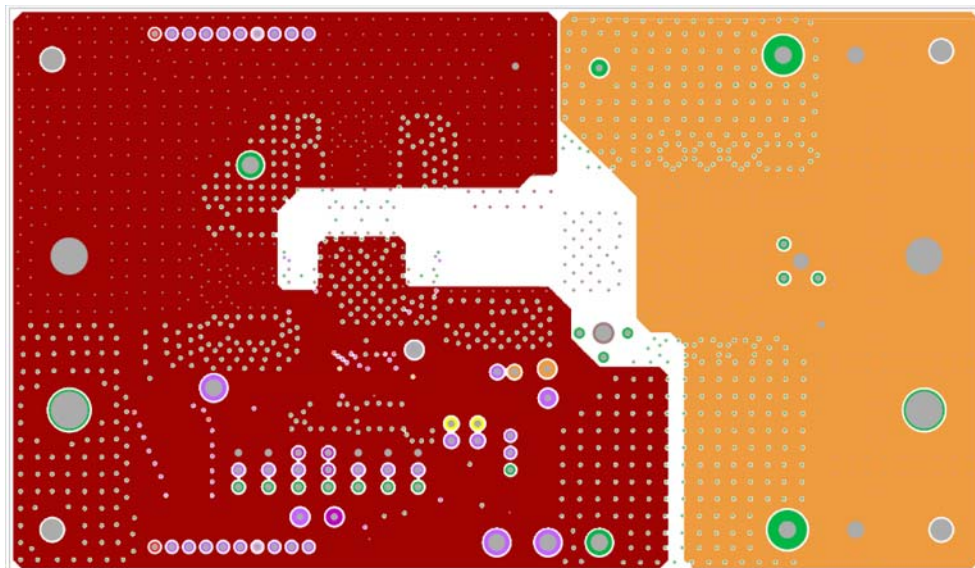


FIGURE 27. LAYER 6

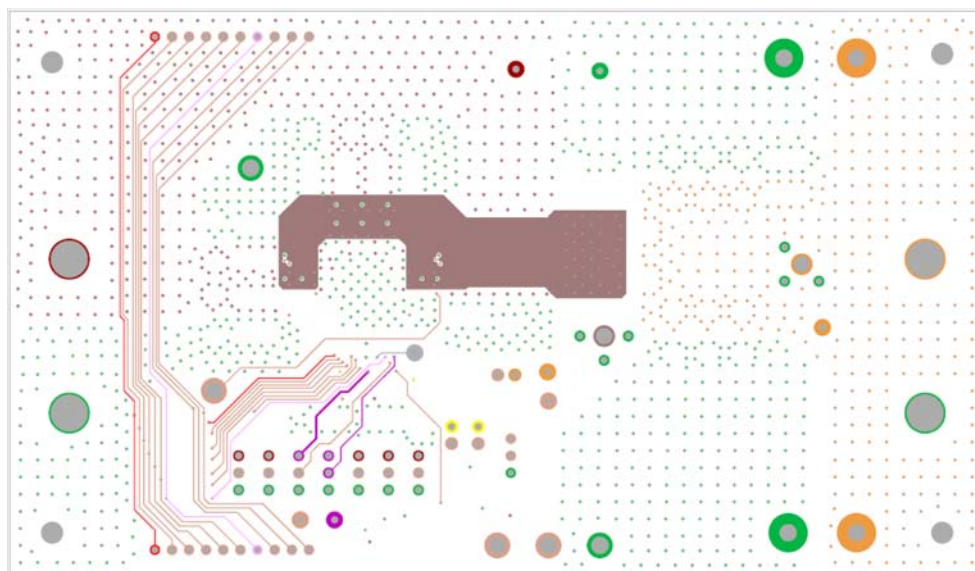


FIGURE 28. LAYER 7

# Board Layout (Continued)

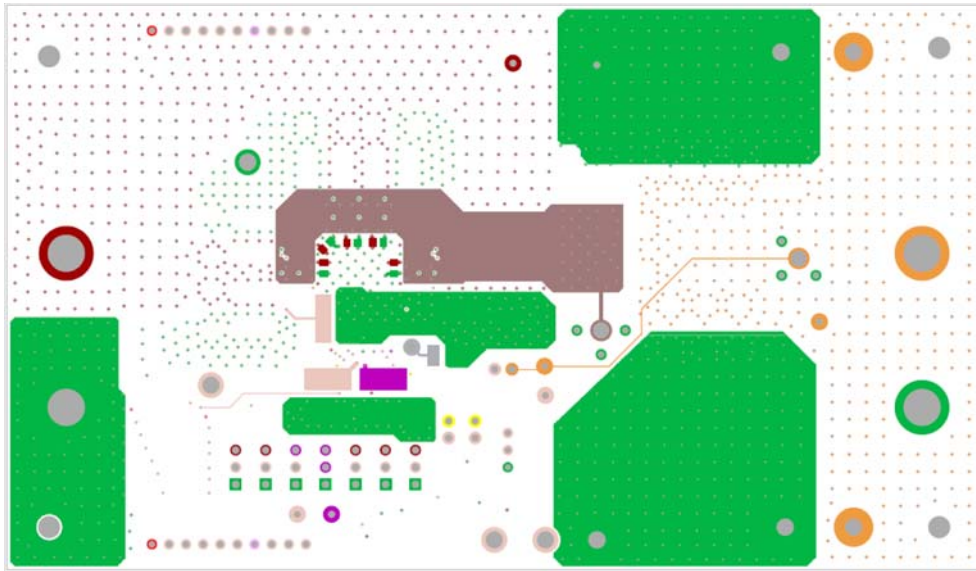


FIGURE 29. BOTTOM LAYER

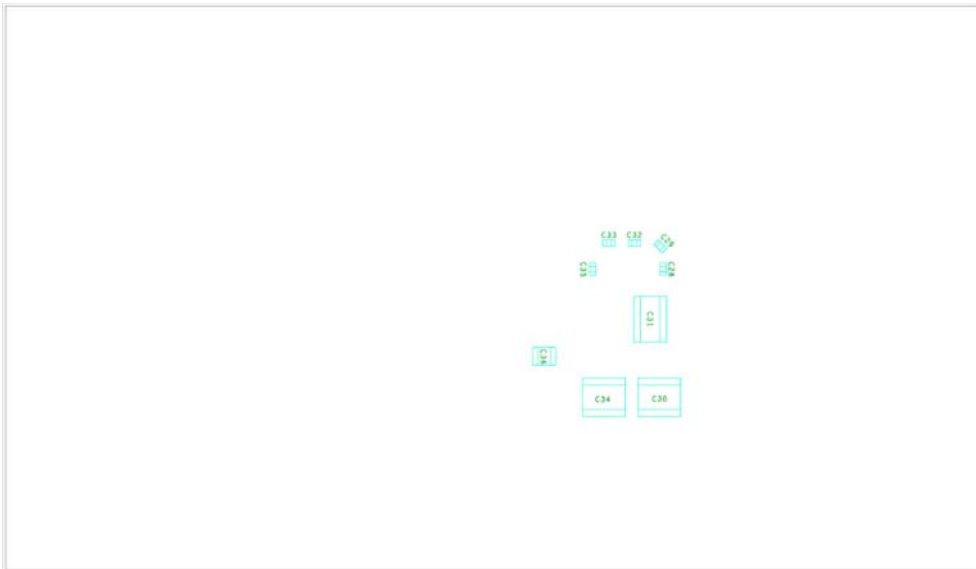


FIGURE 30. BOTTOM SIDE ASSEMBLY DRAWING

## Notice

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