AN-2205 LM25118 Evaluation Board

1 Introduction

The LM25118 Evaluation Board is designed to provide the design engineer with a fully functional, Emulated Current Mode Control, buck-boost power converter to evaluate the LM25118 controller IC. The evaluation board provides a 12V output with 3A of output current capability. The evaluation board's wide input voltage range is from 42V to 5V, with operation down to 3V with some component changes. The evaluation board operates at 300 kHz, a good compromise between conversion efficiency, tradeoffs between buck and buck-boost mode requirements, and converter size. The printed circuit board consists of 4 layers with 2 ounce copper top and bottom, and 1 ounce copper on internal layers. The board is constructed with FR4 material. This user' guide contains the evaluation board schematic, bill-of-materials (BOM) and a quick setup procedure. For more complete circuit and design information, see the *LM25118/LM25118Q Wide Voltage Range Buck-Boost Controller* (SNVS726) data sheet and quick start.

2 IC Features

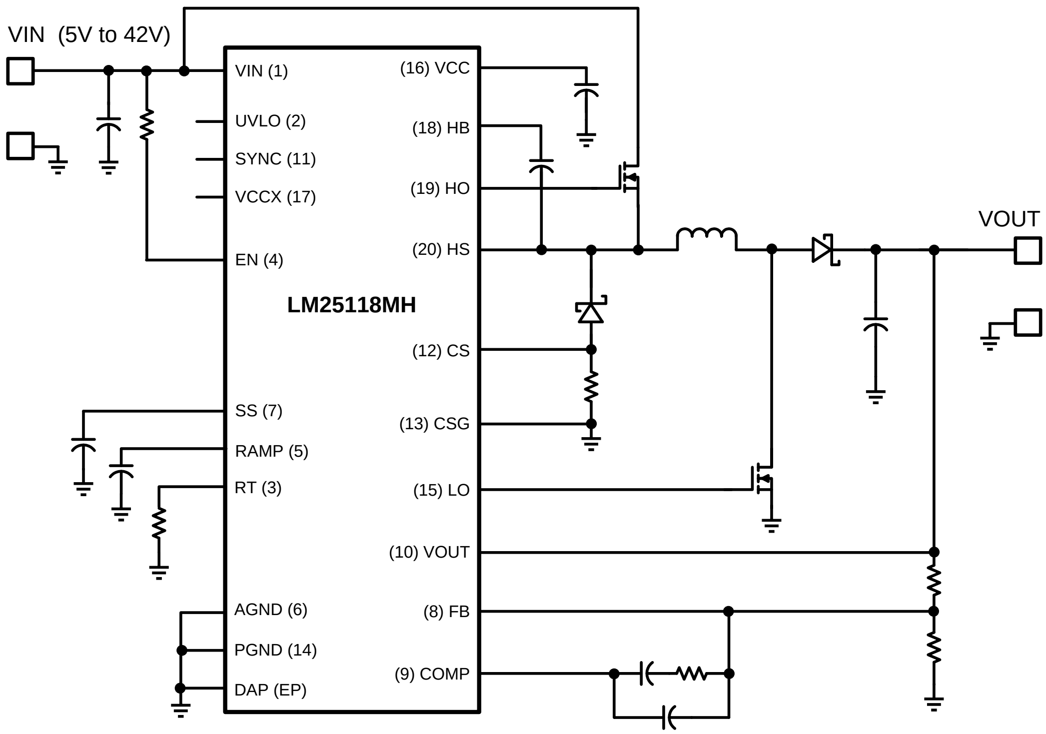
- Integrated High and Low Side Driver
- Internal High Voltage Bias Regulator
- Wide Input Voltage Range: 5V to 42V
- Emulated Current Mode Control
- Single Inductor Architecture
- VOUT Operation below and above VIN
- Single Resistor Sets Oscillator Frequency
- Oscillator Synchronization Capability
- Programmable Soft-Start
- Ultra Low (<10 µA) Shutdown Current
- Enable Input
- Wide Bandwidth Error Amplifier
- Adjustable Output Voltage 1.23V-38V
- 1.5% Feedback Reference Accuracy
- Thermal Shutdown
- No VIN to VOUT Connection during Fault Protection

3 Package

HTSSOP-20EP (Exposed Pad)

4 Application Circuit

See the detailed LM25118EVAL schematic at Figure 9.



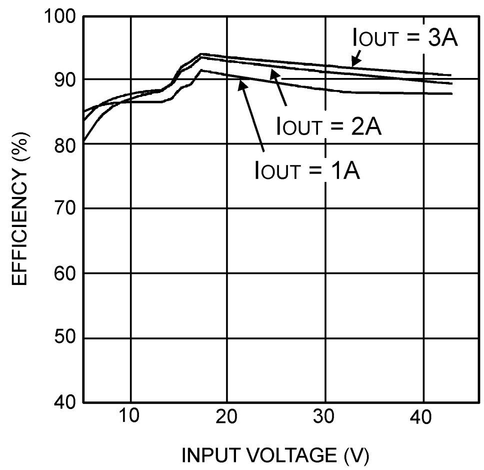


Figure 1. Efficiency

Figure 1 illustrates the efficiency of the converter vs. input voltage and output current. These curves highlight the high efficiency of the converter, especially considering the simplicity of design offered by a non synchronous implementation. Note the discontinuity in the curves at approximately 17V and 13V which represent mode transition boundaries. The lower efficiencies in the buck-boost region reflect additional losses at higher input and inductor currents. The decrease in efficiency at higher input voltages represents higher switching losses.

The performance of the evaluation board is as follows:

- Input Range: 42V to less than 5V at Full Current
- Operation to 3V at Reduced Current and Appropriate Adjustments*
- Output Voltage: 12V
- Output Current: 0 to 3A
- Frequency of Operation: 300 kHz
- Board Size: 3.45 X 2.65 inches
- Load Regulation: 1%
- Line Regulation: 0.1%
- Over-Current Limiting
- Operation with VIN Greater or Less than Vout

*Operation at full current to around 3V is possible with current limit sense resistor, UVLO threshold, and corresponding C_{ramp} adjustment. Additional input capacitance may be required. For more details, see the L*M25118/LM25118Q Wide Voltage Range Buck-Boost Controller* (SNVS726) data sheet.

5 Air Flow

Prolonged operation without airflow at low input voltage and at at full power will cause the MOSFET's and Diodes to overheat. A fan with a minimum of 200 LFM should always be provided. Figure 2 illustrates the temperature rise of various components with no airflow. The ambient was 25°C, and VIN was 8V.

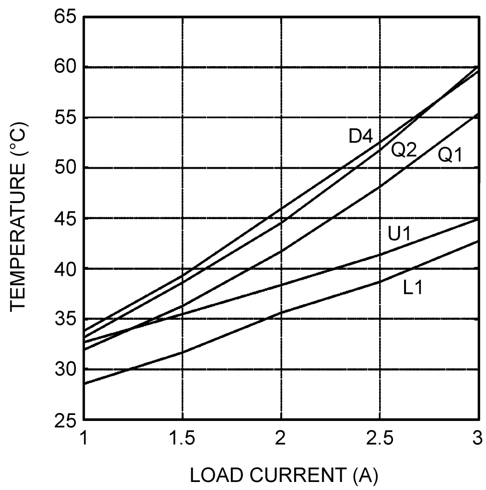


Figure 2. Temperature vs Load Current With No Airflow – 25°C Ambient

6 Powering Up

Connecting the IC's enable pin to ground will allow powering up the source supply with a minimal output load. Set the current limit of the source supply to provide about 1.5 times the anticipated wattage of the load. Note that input currents become very high at low input voltages, which requires an appropriate input supply. As you remove the connection from the enable pin to ground, immediately check for 12 volts at the output.

A quick efficiency check is the best way to confirm that everything is operating properly. If something is amiss, you can be reasonable sure that it will affect the efficiency adversely. Few parameters can be incorrect in a switching power supply without creating losses and potentially damaging heat.

7 Over Current Protection

The evaluation board is configured with over-current protection. The output current is limited to approximately 4.5 amps in the buck-boost mode The 4.5A value allows for component tolerances to specify a 3A output current. Note this current will be almost double, or about 7 amps in buck mode (Vin greater than 17 volts) due to the difference in peak inductor currents in the two different modes. However, a hard short will trigger the hiccup mode of current limit as illustrated in Figure 3. In this mode, the average output current will be less than .2 amps.

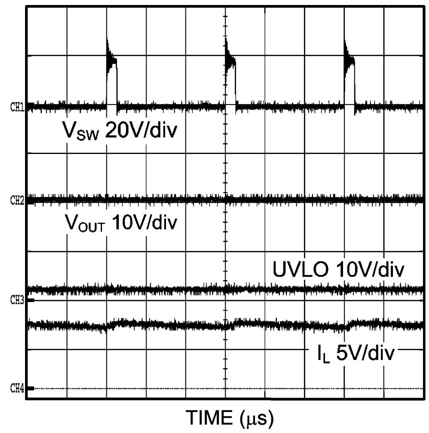


Figure 3. Short Circuit Current

8 VCCX

A place for a jumper between VOUT and VCCX is provided on the PC board. If operation below about 6 volts is required, connect the jumper to allow VCCX to power the converter (the exact voltage depends on the gate drive requirements of the switching FETs). The converter does require a minimum VIN of 5V to initially start. When running, the input voltage can decrease to below 5V at reduced current with VCCX connected to VOUT. Note that this design uses a current limit value to specify a full 3A of output current at a minimum VIN of 5V. For operation lower than 5V, the current limit resistor, UVLO threshold, and ramp capacitor must be re-calculated. Caution: make sure the input supply can source the required input current. Operation at low VIN at full power may overheat and damage the MOSFET’s and Diodes supplied on the board. Note there is a limit of 14 volts applied to VCCX. Never exceed this value if operating VCCX from an external source, or operating the board with Vout greater than 12 volts. To prevent oscillation, connect and additional 100uF or greater electrolytic capacitor across Vin for input voltages less than 5 volts.

9 Mode Transition

With Vout set at 12 volts, the LM25118 applications board will operate in the buck mode with VIN greater than about17 volts. As VIN is reduced below 17 volts, the converter begins to operate in a soft buck-boost mode. As VIN is decreased below 14 volts, the converter smoothly transitions to a pure buck-boost mode. This method of mode transition insures a smooth, glitch free operation as VIN is varied over the transition region.

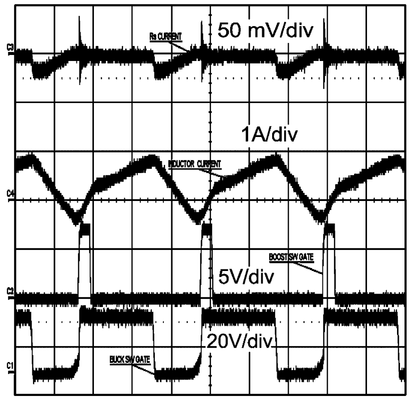
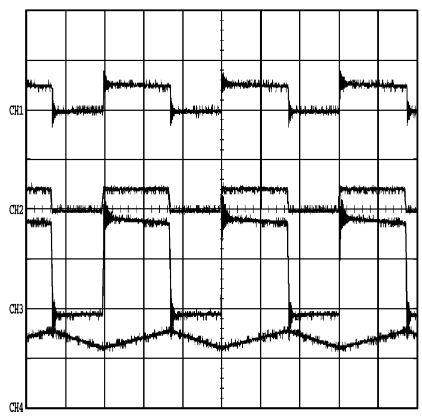


Figure 4. Mode Transition

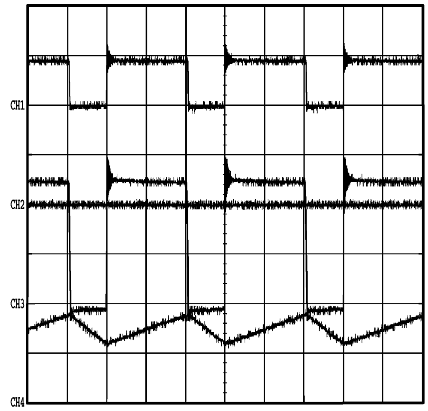
Figure 4 illustrates soft mode transition. The boost switch pulse-width is relatively narrow compared to the buck switch waveform. The boost switch pulse-width will gradually increase as VIN decreases, and will eventually match and lock to the buck switch waveform. At this point, the converter enters full buck-boost operation.

10 Typical Waveforms



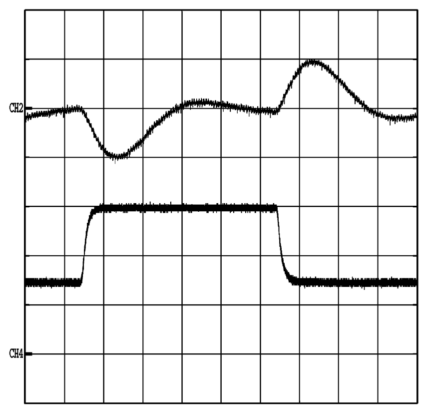
CH1: V_{SW} = 20V/div
CH2: Q1 = 20V/div
CH3: Q2 = 10V/div
CH4: I_L = 5A/div

Figure 5. Vin = 10V, Iout = 1A, illustrating Buck-Boost Operation



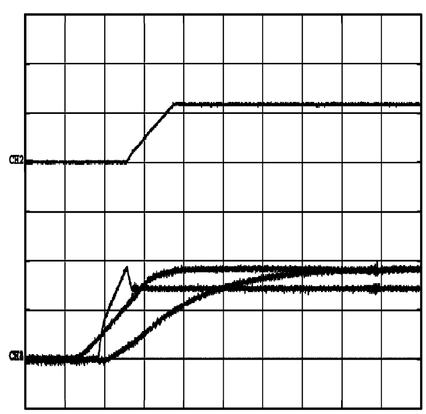
CH1: V_{SW} = 20V/div
CH2: Q1 = 20V/div
CH3: Q2 = 10V/div
CH4: I_L = 2A/div

Figure 6. Vin = 18V, Iout = 3A Illustrating Buck Operation



CH2: V_{OUT} = 0.1V/div
CH4: I_{OUT} = 1A/div

Figure 7. Transient Response



CH1: V_{IN} = 10V/div
CH2: V_{OUT} = 10V/div
CH3: VCC = 5V/div
CH4: UVLO = 5V/div

Figure 8. Start-Up Waveforms

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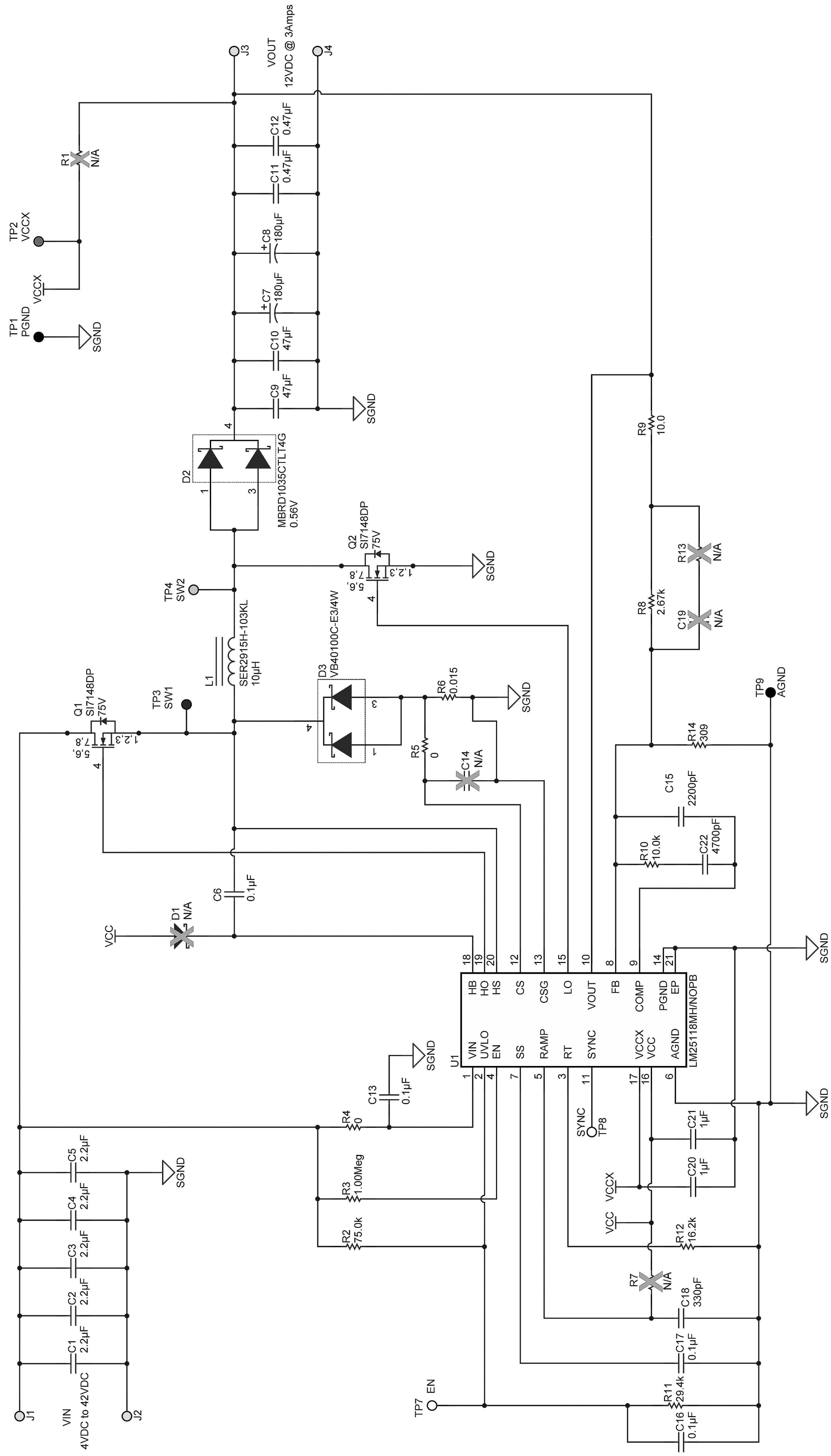


Figure 9. Evaluation Board Schematic

Table 1. Bill of Materials

ID	Description	Mfgr Part Number	Manufacturer
C1, C2, C3, C4, C5	Capacitor, MLCC, 2.2µF, 100V, ±20%, X7R, 1812	C4532X7R2A225M	TDK
C6, C16, C17	Capacitor, MLCC, 0.1µF, 100V, ±10%, X7R, 0603	GRM188R72A104KA35D	Murata Electronics North America
C7, C8	Capacitor, Polymer Aluminum, 180µF, 16V, ±20%, SMD	APXH160ARA181MJ80G	United Chemi-Con
C9, C10	Capacitor, MLCC, 47µF, 16V, ±10%, X5R, 1210	GRM32ER61C476KE15L	Murata Electronics North America
C11, C12	Capacitor, MLCC, 0.47µF, 25V, ±10%, X7R, 1206	12063C474KAT2A	AVX Corporation
C13	Capacitor, MLCC, 0.1µF, 100V, ±10%, X7R, 0805	C0805C104K1RACTU	Kemet
C14	Not Installed	N/A	N/A
C15	Capacitor, MLCC, 2200pF, 100V, ±10%, X7R, 0603	GRM188R72A222KA01D	Murata Electronics North America
C18	Capacitor, MLCC, 330pF, 100V, ±5%, NP0, 0603	GRM1885C2A331JA01D	Murata Electronics North America
C19	Not Installed	N/A	N/A
C20, C21	Capacitor, MLCC, 1µF, 25V, ±10%, X7R, 0805	GRM219R71E105KA88D	Murata Electronics North America
D1	Not Installed	N/A	N/A
D2	Diode, Schottky, 35V, 5A, DPAK	MBRD1035CTLT4G	ON Semiconductor
D3	Diode, Schottky, 100V, 20A, TO-263AB	VB40100C-E3/4W	Vishay/General Semiconductor
J1, J2,J3, J4	Terminal, Turret, Double, .109"L Brass	1503-2K	Keystone Electronics
L1	Inductor, Shielded E Core, Ferrite, 10µH, 18A, 1.86mΩ, SMD	SER2915H-103KL	Coilcraft
Q1, Q2	MOSFET N-Channel, 75V, 28A, PPAK, SOIC-8	SI7148DP	Vishay/Siliconix
R1	Not Installed	N/A	N/A
R2	Resistor, 75.0kΩ, 0.125W, ±1% Thick Film, 0805	CRCW080575K0FKEA	Vishay/Dale
R3	Resistor, 1.00MΩ, 0.125W, ±1% Thick Film, 0805	CRCW08051M00FKEA	Vishay/Dale
R4	Resistor, 0.0Ω, 0.25W, Thick Film, 1206	CRCW12060000Z0EA	Vishay/Dale
R5	Resistor, 0.0Ω, 0.10W, Thick Film, 0603	CRCW06030000Z0EA	Vishay/Dale
R6	Resistor, 15mΩ, 2W, ±2%,Thin Film, 3008	RL7520WT-R015-G	Susumu-USA
R7	Not Installed	N/A	N/A
R8	Resistor 2.67kΩ, 0.10W, ±1%, Thick Film, 0603	CRCW06032K67FKEA	Vishay/Dale
R9	Resistor, 10.0Ω, 0.10W, ±1%,Thick Film, 0603	CRCW060310R0FKEA	Vishay/Dale
R10	Resistor, 10.0kΩ, 0.10W, ±1%, Thick Film, 0603	CRCW060310K0FKEA	Vishay/Dale
R11	Resistor, 29.4kΩ, 0.10W, ±0.1%, Thin Film, 0603	RT0603BRD0729K4L	Yageo
R12	Resistor, 16.2kΩ, 0.10W, ±1%, Thick Film, 0603	CRCW060316K2FKEA	Vishay/Dale
R13	Not Installed	N/A	N/A
R14	Resistor, 309Ω,0.10W, ±1%, Thick Film, 0603	CRCW0603309RFKEA	Vishay/Dale
TP1, TP9	Test Point, PC Multi- Purpose, Black	5011K	Keystone Electronics
TP2	Test Point, PC Multi- Purpose, Red	5010K	Keystone Electronics

Table 1. Bill of Materials (continued)

ID	Description	Mfgr Part Number	Manufacturer
TP3,TP4, TP7, TP8	Test Point, PC Multi- Purpose, White	5012K	Keystone Electronics
U1	IC, PWM, HTSSOP 20	LM25118	Texas Instruments

12 Printed Circuit Board Layout

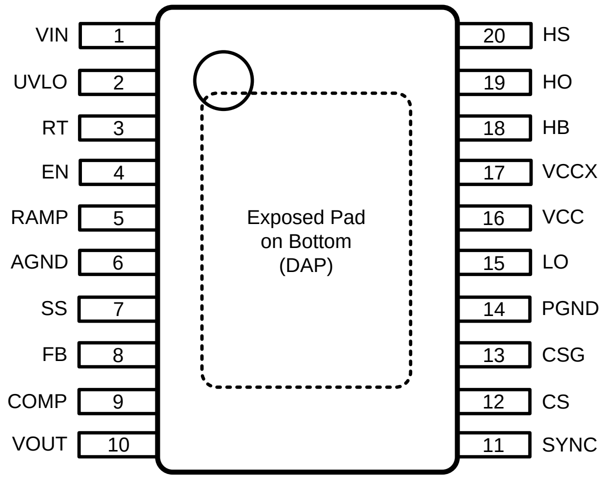


Figure 10. LM25118MH Connection Diagram

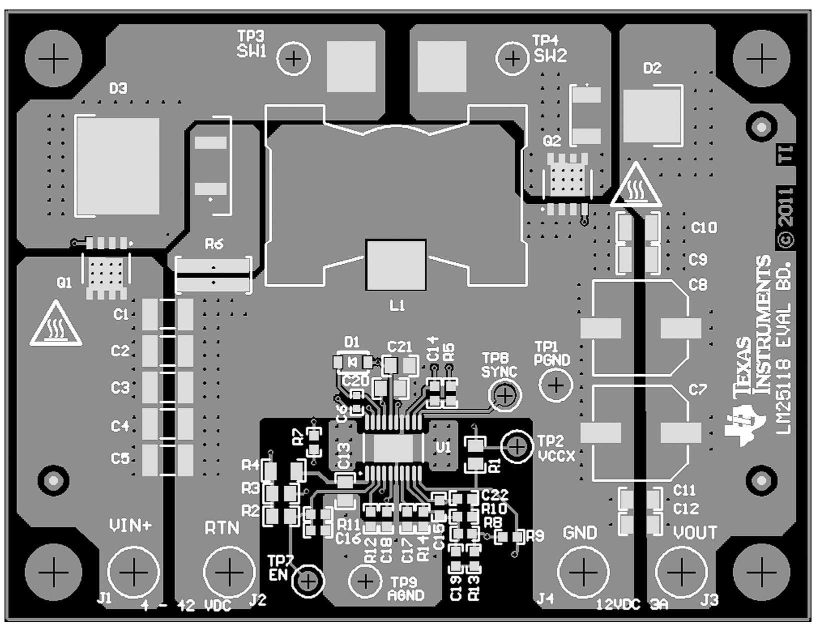


Figure 11. Top Layer as Viewed from Top

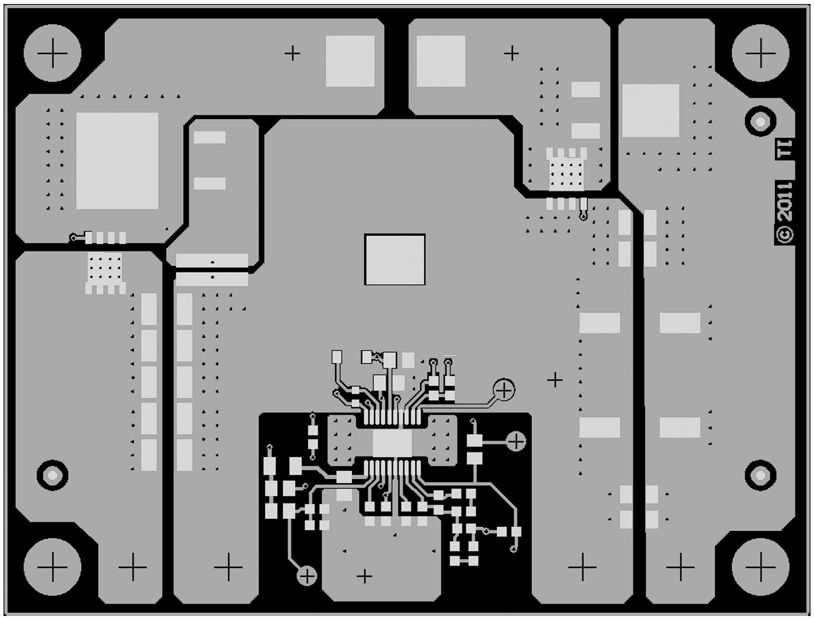


Figure 12. Copper Layer 1 (Top) as Viewed from Top

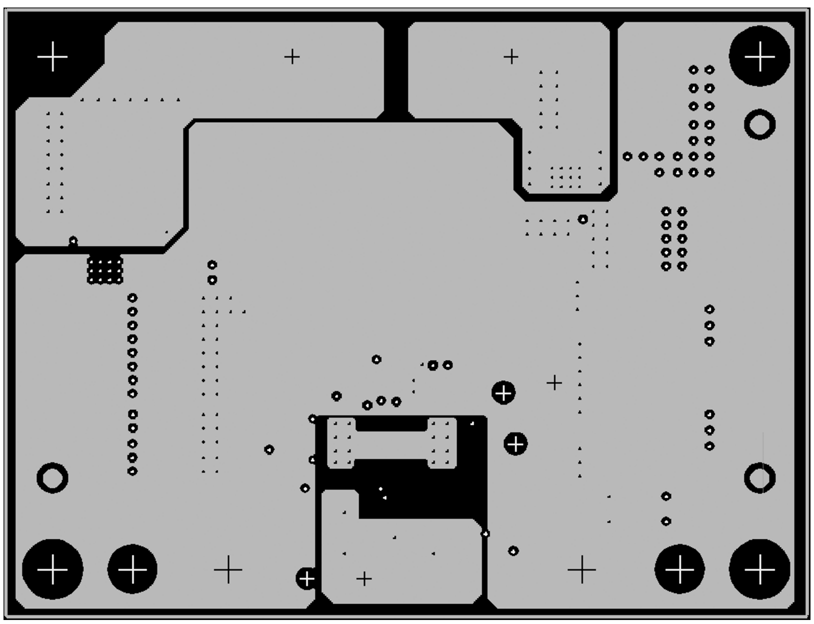


Figure 13. Copper Layer 2 (Mid-Layer 1) as Viewed from Top

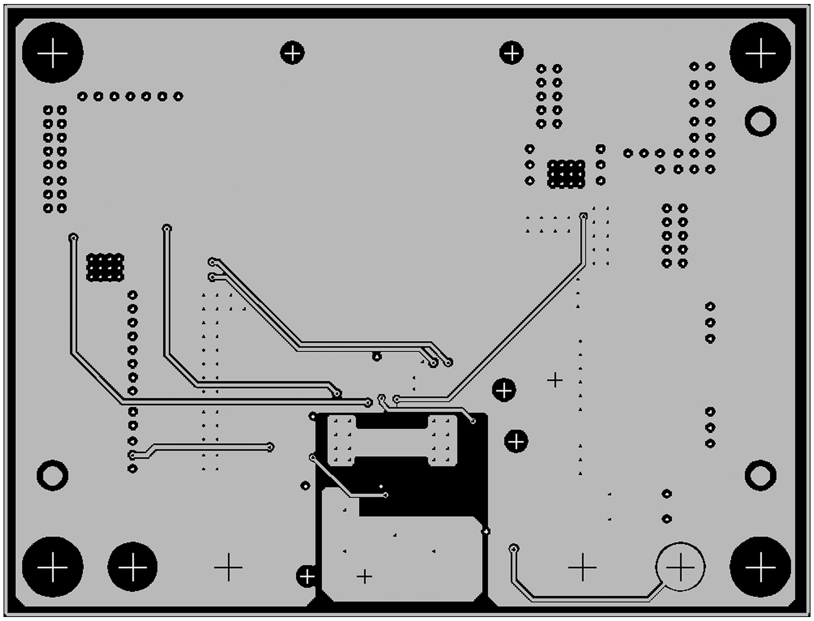


Figure 14. Copper Layer 3 (Mid-Layer 2) as Viewed from Top

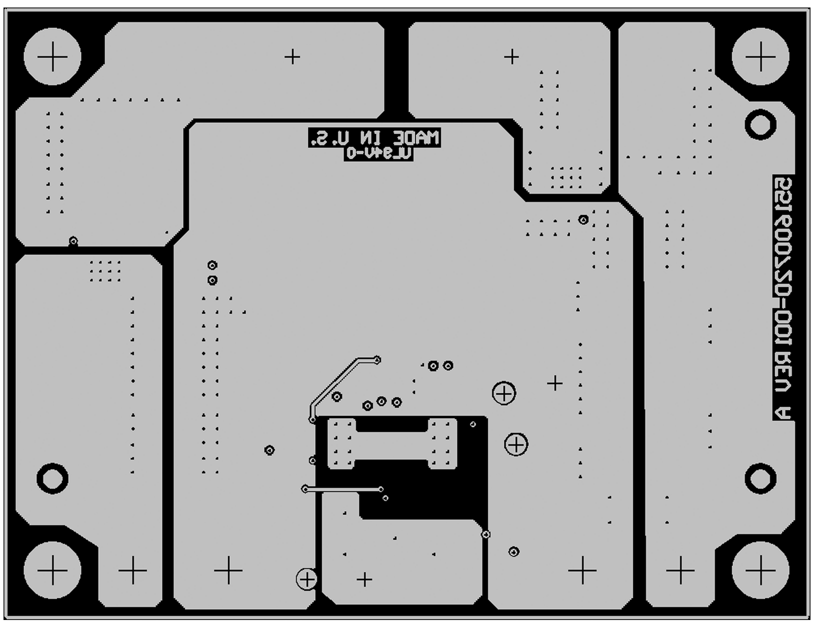


Figure 15. Copper Layer4 (Bottom) as Viewed from Top

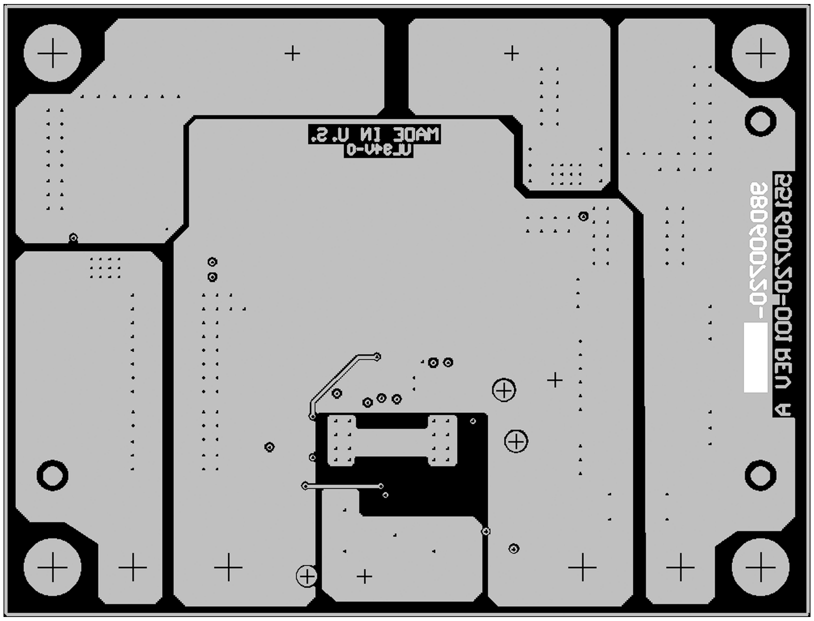
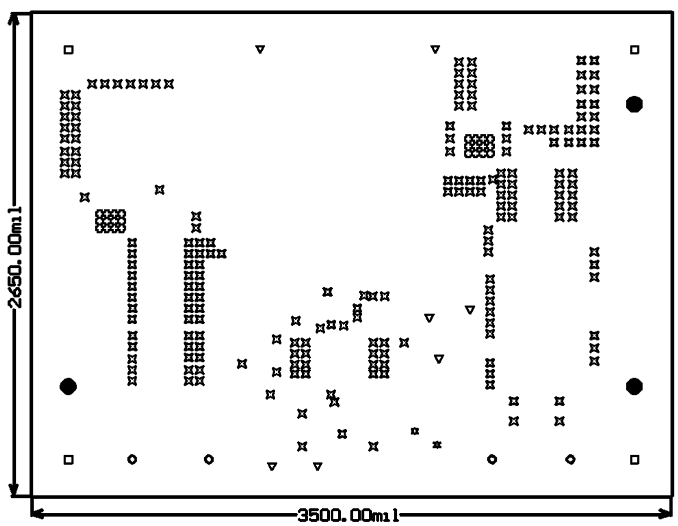


Figure 16. Bottom Layer as Viewed from Top



Symbol	Hit Count	Finished Hole Size	Plated	Hole Type
○	24	8mil (0.2032mm)	PTH	Round
⌑	193	10mil (0.254mm)	PTH	Round
☆	2	14mil (0.3556mm)	PTH	Round
▽	7	63mil (1.6002mm)	PTH	Round
○	4	122.047mil (3.1mm)	PTH	Round
□	4	125.984mil (3.2mm)	PTH	Round
	234 Total			

Drill Table

Figure 17. Drill Guide and Board Dimensions as Viewed from Top