AN-1819 LM5118 Evaluation Board

1 Introduction

The LM5118 evaluation board is designed to provide the design engineer with a fully functional, Emulated Current Mode Control, buck-boost power converter to evaluate the LM5118 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 75V 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 board is constructed with FR4 material. This user's guide contains the evaluation board schematic and Bill-of-Materials (BOM).

Refer to the LM5118 quick start (SNVU065) and for more complete circuit and design information, see *Wide Voltage Range Buck-Boost Controller* (SNVS566).

The performance of the evaluation board is:

- Input Range: 75V to less than 5V at full current
- Operation to 3V at reduced current and appropriate adjustments. 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. See the LM5118 datasheet (SNVS566) and quick start (SNVU065) for more details.
- Output Voltage: 12V
- Output Current: 0 to 3A
- Frequency of Operation: 300 kHz
- Board Size: 3.45 × 2.65 inches
- Load Regulation: 1%
- Line Regulation: .1%
- Over-Current Limiting
- Operation with VIN greater or less than Vout

2 Features

- Integrated high and low side driver
- Internal high voltage bias regulator
- Ultra-wide input voltage range: 5V to 75V
- 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 to 75V

- 1.5% feedback reference accuracy
- Thermal Shutdown
- No VIN to VOUT connection during fault protection

3 Package

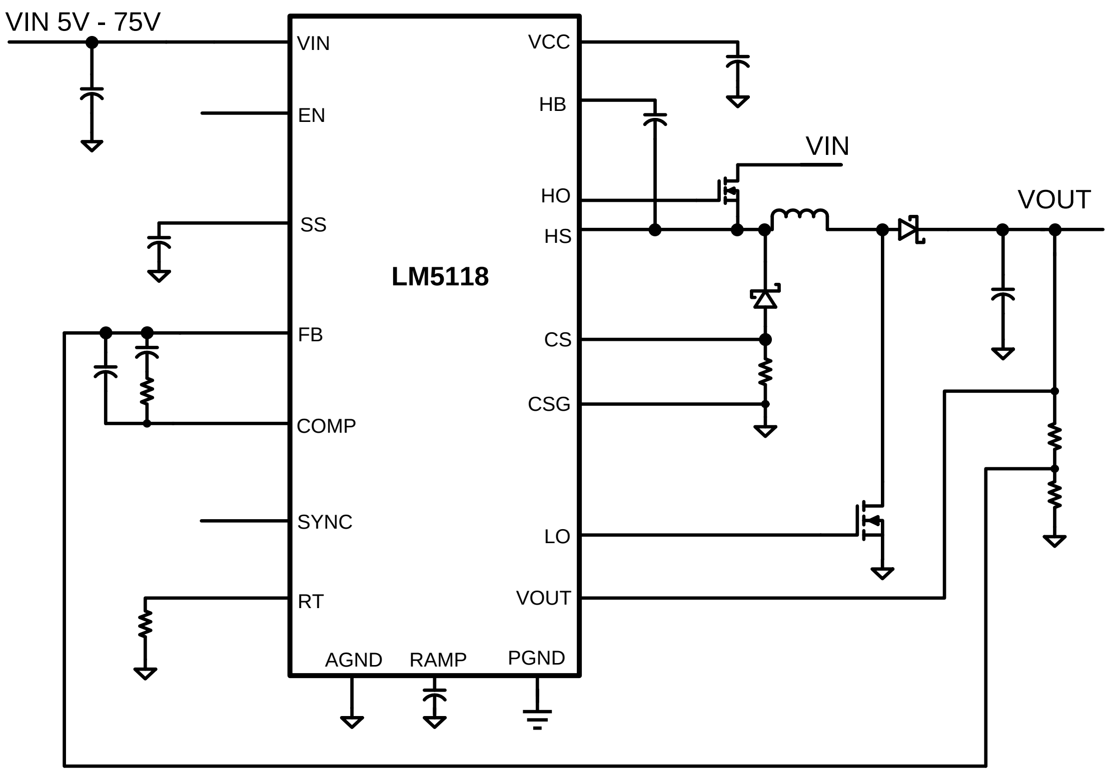


Figure 1. HTSSOP-20

Figure 2 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.

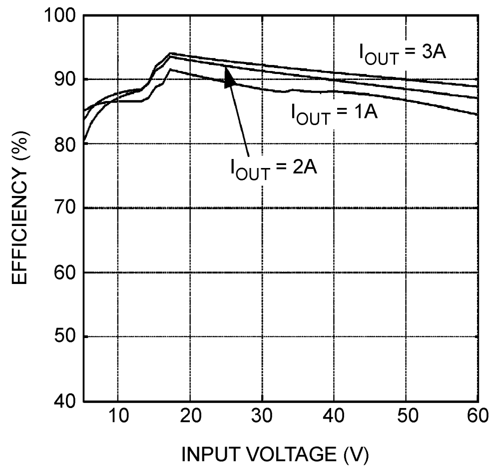


Figure 2. Efficiency

4 Air Flow

Prolonged operation without airflow at low input voltage and at full power will cause the MOSFETs and diodes to overheat. A fan with a minimum of 200 LFM should always be provided. Figure 3 illustrates the temperature rise of various components with no airflow. The ambient was 25°C, and VIN was 8V.

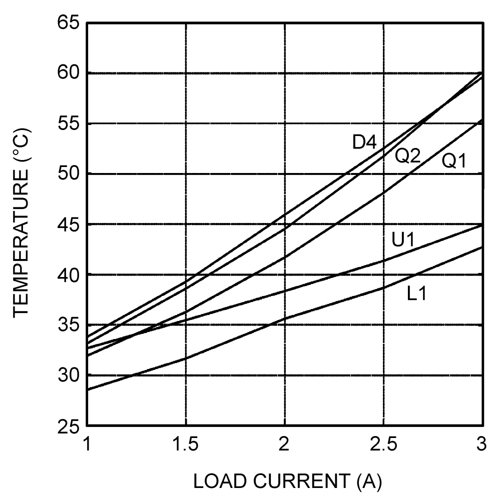


Figure 3. Temperature vs Load Current with No Airflow – 25°C Ambient

5 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.

6 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 guarantee 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 4. In this mode, the average output current will be less than .2 amps.

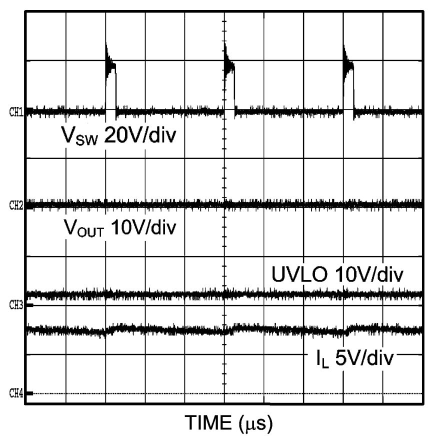


Figure 4. Short Circuit Current

7 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 guarantee 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 MOSFETs 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.

8 Mode Transition

With Vout set at 12 volts, the LM5118 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 5 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.

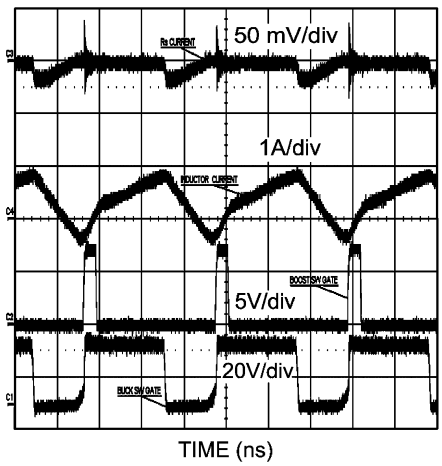
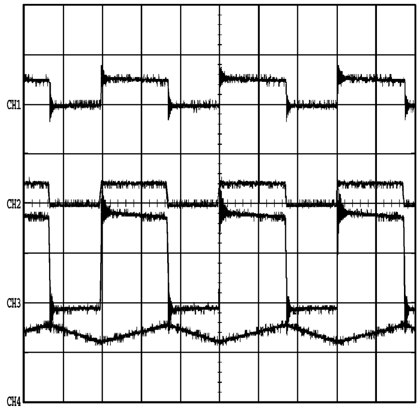


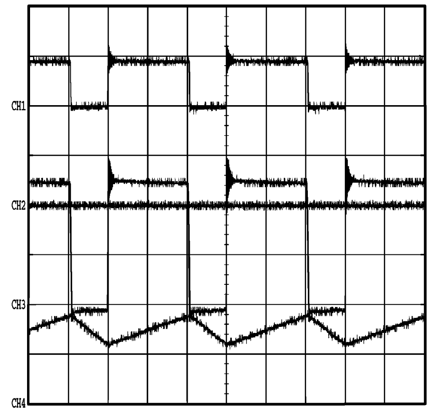
Figure 5. Mode Transition

9 Typical Waveforms



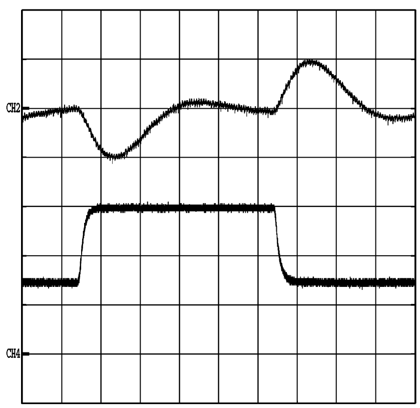
CH1: VSW = 20V/div; CH2: Q1 = 20V/div;
CH3: Q2 = 10V/div; CH4: IL = 5A/div

Figure 6. Illustrating Buck-Boost Operation Vin = 10V, Iout = 1A,



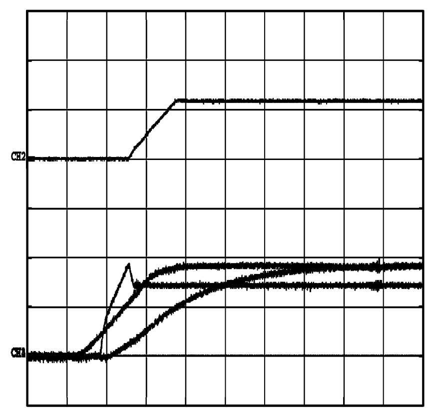
CH1: VSW = 20V/div; CH2: Q1 = 20V/div;
CH3: Q2 = 10V/div; CH4: IL = 2A/div

Figure 7. Illustrating Buck Operation Vin = 18V, Iout = 3A



CH2: VOUT = 0.1V/div ; CH4: IOUT = 1A/div

Figure 8. Transient Response



CH1: VIN = 10V/div; CH2: VOUT = 10V/div;
CH3: VCC = 5V/div; CH4: UVLO = 5V/div

Figure 9. Start-Up Waveforms

10 Bill of Materials

Qty	Reference	Value	Device	Part Number	Manufacturer
2	C1, C2	2.2 µF, 100V, X7R	SMD 1812	C4532X7R2A225KT	
3	C3, C4, C5	2.2 µF, 100V, X7R	SMD 1812	C4532X7R2A225KT	TDK
2	C6, C8	0.1 µF, 100V, X7R	SMD 0805	GCM21BR72A104KA37L	MURATA
2	C7, C20	1 µf, 25V, X7R	SMD 0805	GCM21BR71E105KA56L	MURATA
2	C9, C10	47 µF, 16V, X5R	SMD 1210	ECJ-4YB1C476M	PANASONIC
2	C11, C12	0.47 µF, 25V, X7R	SMD 0805	GRM21BR71E474KC01L	MURATA
2	C13, C14	180 µF, 16V	CAP, ELECTR POLY, SMD	PXA160ARA181MJ80G	NIPPON CHEMICON
1	C15	330 pF, 100V, COG	CAP_SMDC0603	GRM1885C2A331JA01D	MURATA
1	C16	0.1 µF, 100V, X7R	CAP_SMDC0603	GCM188R72A104KA37D	MURATA
1	C17	2200 pf, 100V, COG	CAP_SMDC0603	GRM1885C1H222JA01D	MURATA
1	C18	4700 pF	CAP_SMDC0603	C1608X7R2A472M	TDK
2	C19, C22	N/A	CAP_SMDC0603		
1	C21	0.1 µF	CAP_SMDC0603	GRM188R72A104KA35D	MURATA
1	D1	SCHOTTKY 10A 35V	DPAK TO-252	MBRD1035CTLT4G	ON-SEMI
1	D4	SCHOTTKY 40A 100V	D2PAK TO-263AB	VB40100C-E3/4W	VISHAY
1	D5	N/A	SOT-23		
1	J1, J2	INPUT	TERMINAL_TURRET	1503-2	KEYSTONE
1	J3, J4	OUTPUT	TERMINAL15A	7693	KEYSTONE
1	L1	10 µH	IND_SER2800	SER2814H-103	COILCRAFT
1	L1A	N/A			
2	Q1, Q2	NFET	PPAK_SO8	SI7148DP-T1-E3	VISHAY
1	R1	75.0K, 1%	SMD 0603	ERJ-3EKF7502V	PANASONIC
1	R2	1M, 1%	SMD 0603	ERJ-S03F1004V	PANASONIC
1	R3	29.4K, 1%	SMD 0603	ERJ-3EKF2942V	PANASONIC
1	R4	10K, 1%	SMD 0603	ERJ-3EKF1002V	PANASONIC
1	R5	N/A	SMD 0603		
1	R6	OMIT			
1	R7	16.2K, 1%	SMD 0603	ERJ-3EKF1622V	PANASONIC
1	R8	2.67K, 1%	SMD 0603	ERJ-3EKF2671V	PANASONIC
1	R9	309, 1%	SMD 0603	ERJ-3EKF3090V	PANASONIC
1	R10	0Ω, 1%	SMD 1206	ERJ-8GEY0R00V	PANASONIC
1	R11	0Ω, 1%	SMD 0603	ERJ-3GEY0R00V	PANASONIC
1	R12	10Ω, 1%	SMD 0603	ERJ-3EKF10R0V	PANASONIC
1	R13	0.015Ω, 2W, 2%	SMD 7520	RL7520WT-R015-F	SUSUMU
1	TP1, TP2, TP3, TP4, TP5, TP6	TEST	TEST_POINT2	5012	KEYSTONE
1	U1	IC, PWM	HTSSOP 20	LM5118	TEXAS INSTRUMENTS

11 Layout

The printed circuit board consists of 4 layers with 2 ounce copper top and bottom, and 1 ounce copper on internal layers.

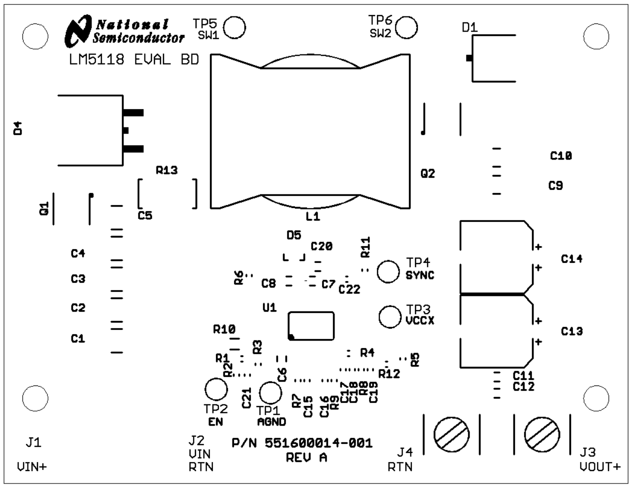


Figure 10. Top Silkscreen Layer as Viewed from Top

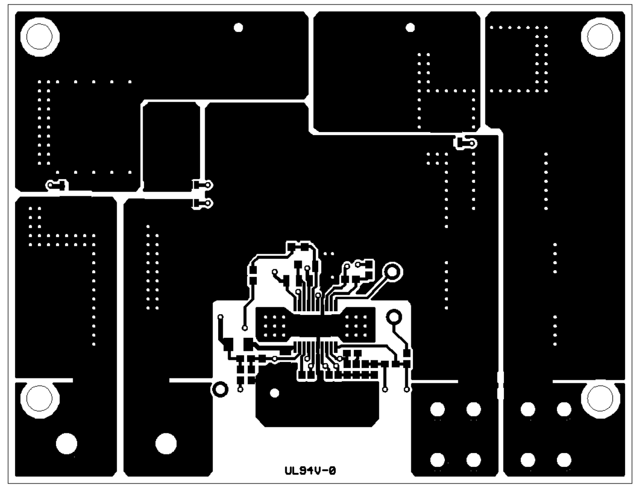


Figure 11. Top Layer as Viewed from Top

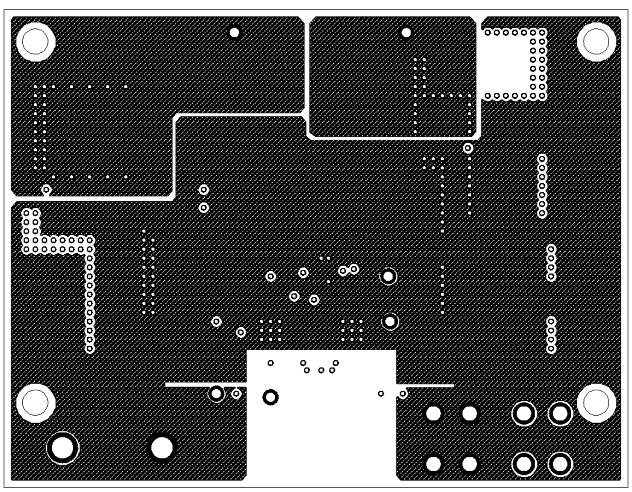


Figure 12. Layer 2 as Viewed from Top

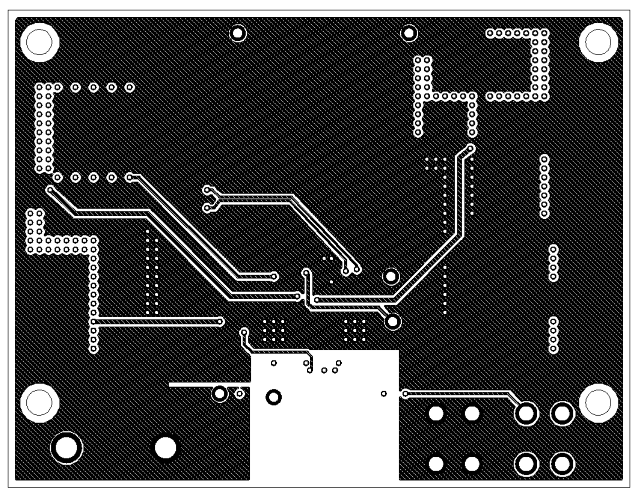


Figure 13. Layer 3 as Viewed from Top

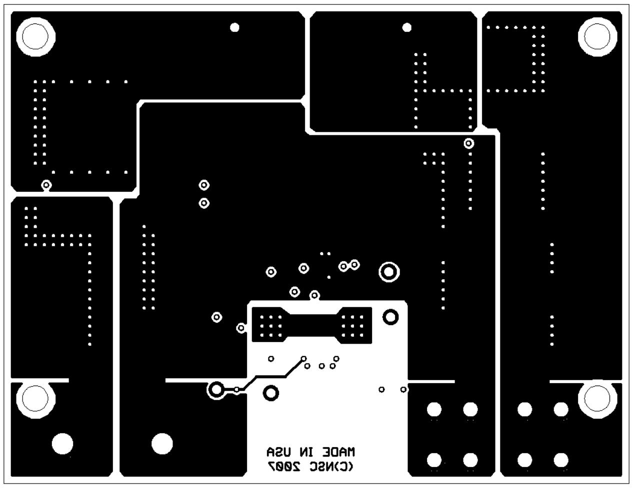
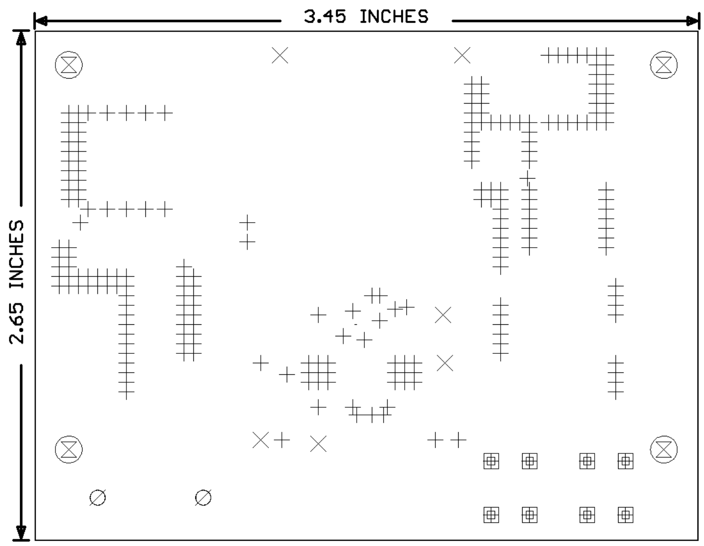


Figure 14. Bottom Layer as Viewed from Top

Figure 15. Bottom Silkscreen Layer as Viewed from Top



DRILL GUIDE	
+	0.014, +0.002, −0.002 INCHES
×	0.047, +0.005, −0.003 INCHES
□	0.076, +0.005, −0.005 INCHES
◇	0.115, +0.005, −0.005 INCHES
⧖	0.140, +0.008, −0.008 INCHES (NON-PLATED)

Figure 16. Drills and Dimensions as Viewed from Top

12 Evaluation Board Schematic

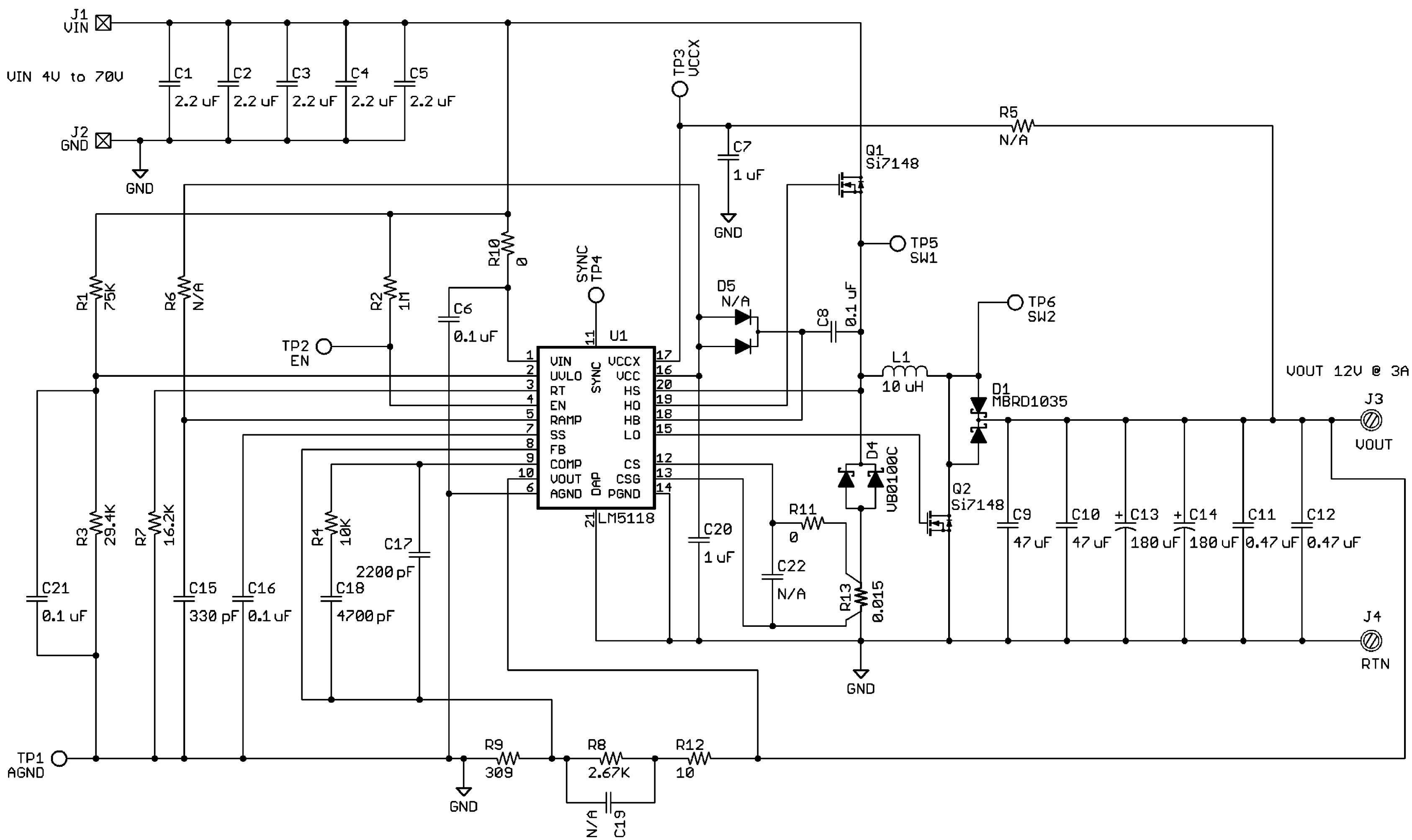


Figure 17. Evaluation Board Schematic

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