

AN-2237 LM5018 Buck Evaluation Board

1 Introduction

The LM5018 evaluation board, [Figure 1](#), provides the design engineer with a fully functional buck regulator, employing the constant on-time (COT) operating principle. This evaluation board provides a 10V output over an input range of 12.5V to 100V.

The board's specifications are:

- Input Range: 12.5V to 95V, transients up to 100V (absolute maximum)
- Output Voltage: 10V
- Output Current: 300 mA
- Nominal Switching Frequency ~ 440 kHz
- Measured Efficiency: 88.4% at 300mA and VIN = 24V
- Board size: 5.5 cm × 4.5 cm

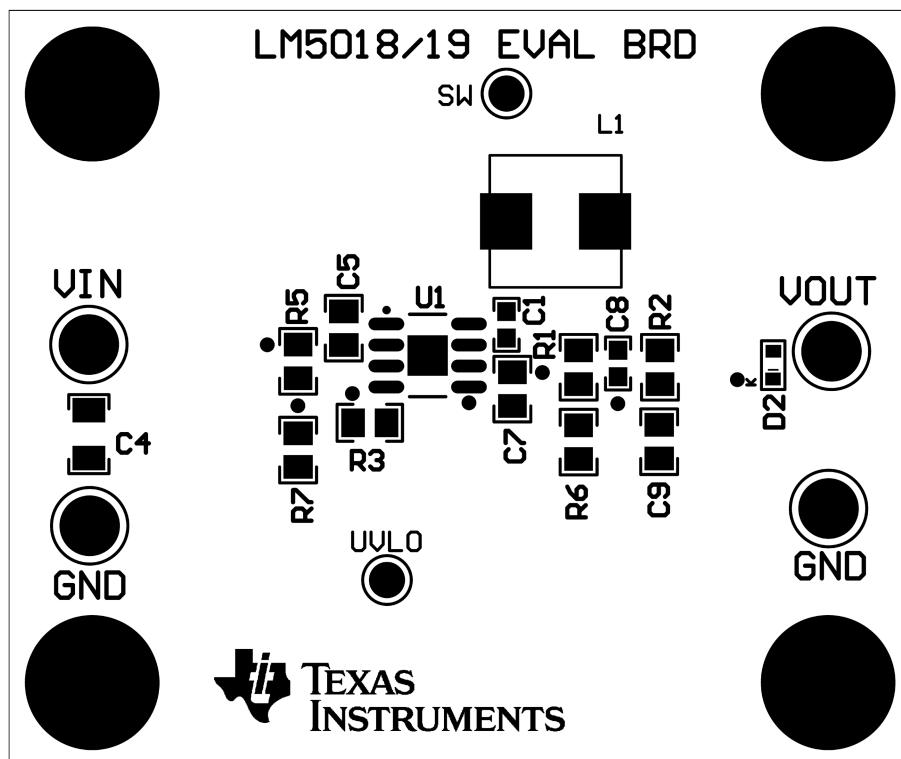


Figure 1. Evaluation Board (Top View)

2 Theory of Operation

Refer to the evaluation board schematic in [Figure 2](#). When the circuit is in regulation, the buck switch is turned on each cycle for a time determined by R3 and VIN according to the equation:

$$T_{ON} = \frac{10^{-10} \times R3}{V_{IN}} \quad (1)$$

The on-time of this evaluation board ranges from 5.56μs at VIN = 12V to 702ns at VIN = 95V. The on-time varies inversely with input voltage. At the end of each on-time the buck switch is off for at least 144ns. In normal operation, the off-time is much longer. During the off-time, the load current is supplied by the output capacitor (C9). When the output voltage falls sufficiently that the voltage at FB is below 1.225V, the regulation comparator initiates a new on-time period. For stable, fixed frequency operation, a minimum of 25mV of ripple is required at FB to switch the regulation comparator. For a more detailed block diagram and a complete description of the various functional blocks, see *LM5018 100V, 300mA Constant On-Time Synchronous Buck Regulator* ([SNVS787](#)).

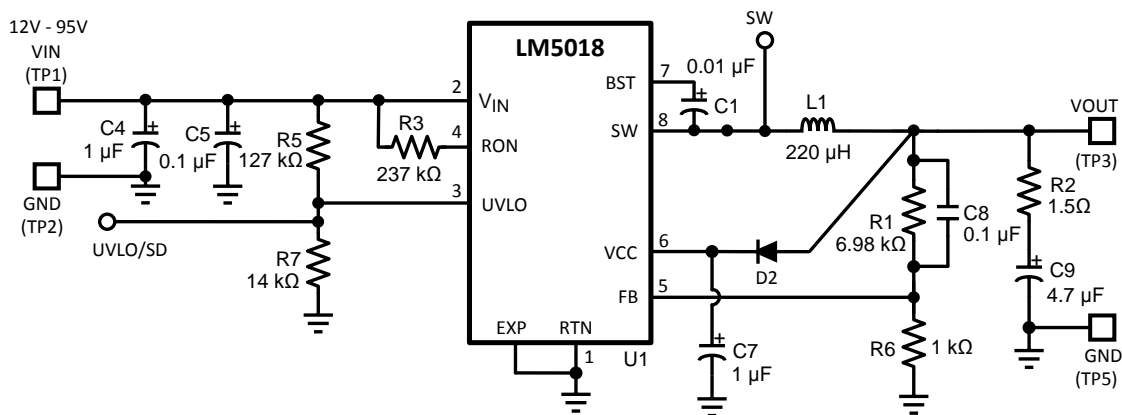


Figure 2. Complete Evaluation Board Schematic for LM5018 Based Buck Converter

3 UVLO

The UVLO resistors (R5, R7) are selected using the following two equations:

$$V_{IN(HYS)} = I_{HYS}R_5 \quad (2)$$

and

$$V_{IN (UVLO, rising)} = 1.225V \times \left(\frac{R_5}{R_7} + 1 \right) \quad (3)$$

On this evaluation board R5=127kΩ and R7=14.0kΩ, resulting in UVLO rising threshold at VIN=12V and a hysteresis of 2.5V.

4 Board Connection and Start-up

The input connections are made to the TP1 (VIN) and TP2 (GND) terminals. The load is connected to the TP3 (VOUT) AND TP5 (GND) terminals. Ensure the wires are adequately sized for the intended load current. Before start-up a voltmeter should be connected to the input terminals, and to the output terminals. The load current should be monitored with an ammeter or a current probe. It is recommended that the input voltage be increased gradually to 12V, at which time the output voltage should be 10V. If the output voltage is correct, then increase the input voltage as desired and proceed with evaluating the circuit. **DO NOT EXCEED 100V AT VIN. Caution: Do not leave EVM powered when unattended.**

5 Bill of Materials

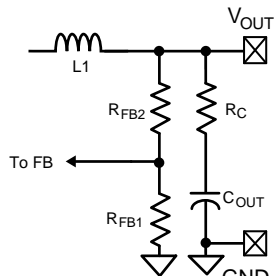
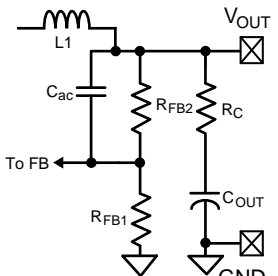
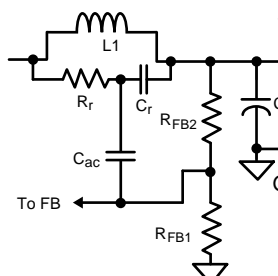
| Item | Description | Mfg., Part Number | Package | Value |
|------|--------------------------|-------------------------------|---------------|-----------------------|
| C5 | Ceramic Capacitor | Kemet, C0805C104K1RACTU | 0805 | 0.1uF, 100V, X7R |
| C7 | Ceramic Capacitor | TDK, C2012X7R1C105K | 0805 | 1uF, 16V, X7R |
| C8 | Ceramic Capacitor | Murata, GRM188R71E104KA01D | 0603 | 0.1uF, 25V, X7R, 0603 |
| C9 | Ceramic Capacitor | Murata, GRM21BR61E475KA12L | 0805 | 4.7uF, 25V, X5R |
| D2 | Diode | Diodes, Inc., SDM10U45-7-F | SOD-523 | Schottky, 45V, 0.1A |
| L1 | Inductor | Cooper Bussman, DR74-221-R | 7.6mm x 7.6mm | 220uH, 0.66A |
| | Alternate Inductor | Würth, 744777222 | 7.3mm x 4.5mm | 220uH, 0.54A |
| R1 | Resistor | Vishay-Dale, CRCW08056K98FKEA | 0805 | 220uH, 0.6A |
| R2 | Resistor | Vishay-Dale, CRCW08051R50FKEA | 0805 | 1.50 ohm, 1%, 0.125W |
| R3 | Resistor | Vishay-Dale, CRCW0805237KFKEA | 0805 | 237k ohm, 1%, 0.125W |
| R5 | Resistor | Vishay-Dale, CRCW0805127KFKEA | 0805 | 127k ohm, 1%, 0.125W |
| R6 | Resistor | Vishay-Dale, CRCW08051K00FKEA | 0805 | 1.00k ohm, 1%, 0.125W |
| R7 | Resistor | Vishay-Dale, CRCW080514K0FKEA | 0805 | 14.0k ohm, 1%, 0.125W |
| U1 | Sync Switching Regulator | Texas Instruments, LM5018 | SO PowerPAD-8 | 100V, 0.3A |

6 Ripple Configuration

The LM5018 is a constant-on-time (COT) buck, and requires adequate ripple at feedback (FB) node. Three commonly used ripple generation methods are shown in Table 1.

The LM5018 evaluation board has been supplied with reduced ripple configuration (Type 2). For more information on ripple configuration, see *LM5018 100V, 300mA Constant On-Time Synchronous Buck Regulator* (SNVS787).

Table 1. Ripple Configurations

| Type 1: Lowest Cost Configuration | Type 2: Reduced Ripple Configuration | Type 3: Minimum Ripple Configuration |
|--|--|---|
|  |  |  |
| C8 open. Select R2: $R2 \geq \frac{40 \text{ mV}}{\Delta I_L(\text{MIN})} \times \frac{V_{\text{OUT}}}{V_{\text{REF}}} \quad (4)$ | Select R2 and C8: $C8 \geq \frac{5}{f_{\text{SW}}(R_1 \parallel R_6)}$ $R2 \geq \frac{40 \text{ mV}}{\Delta I_L} \quad (5)$ | (Not on Board) $C_r = 3300 \text{ pF}$ $C_{ac} = 100 \text{ nF}$ $R_r \times C_r \leq \frac{(V_{\text{IN}(\text{MIN})} - V_{\text{OUT}})T_{\text{ON}}}{40 \text{ mV}} \quad (6)$ |

7 Performance Curves

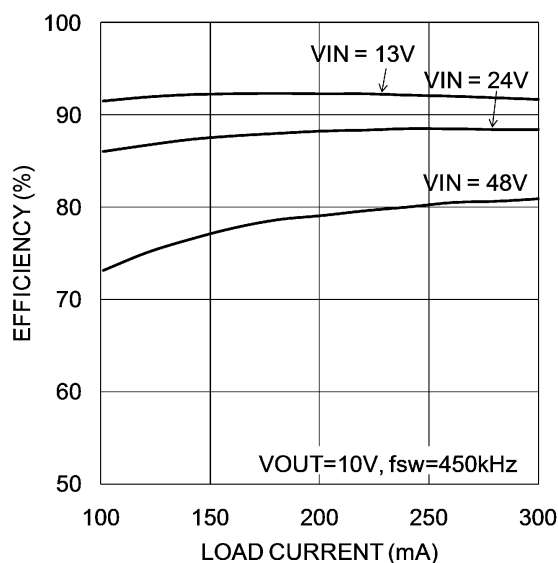


Figure 3. Efficiency vs Load Current

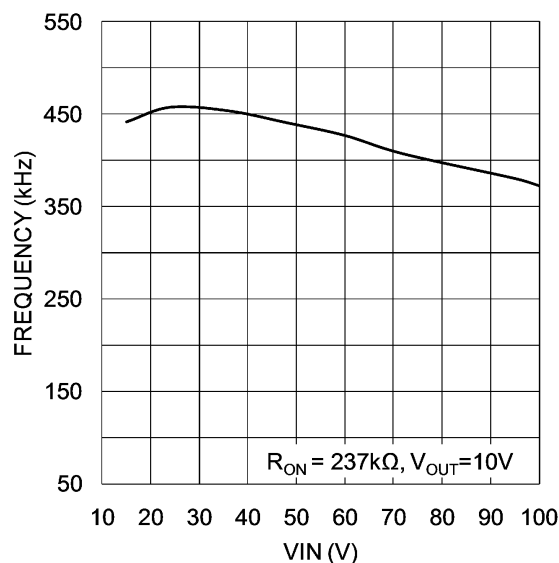


Figure 4. Frequency vs Input Voltage

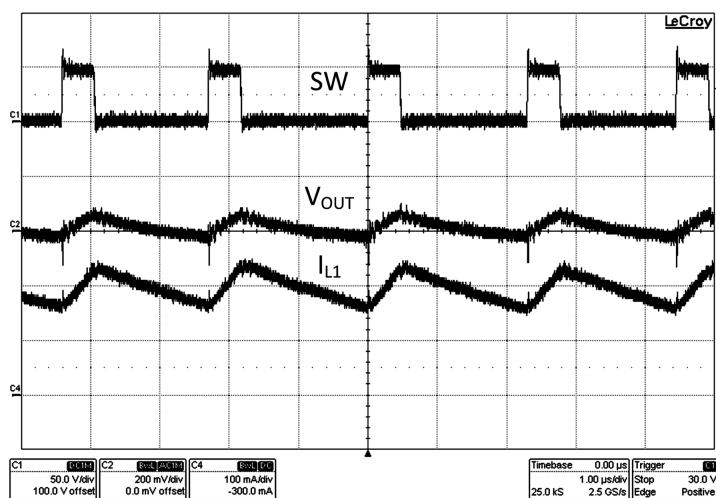


Figure 5. Typical Switching Waveform
($V_{IN} = 48V$, $I_{out} = 200mA$)

8 PC Board Layout

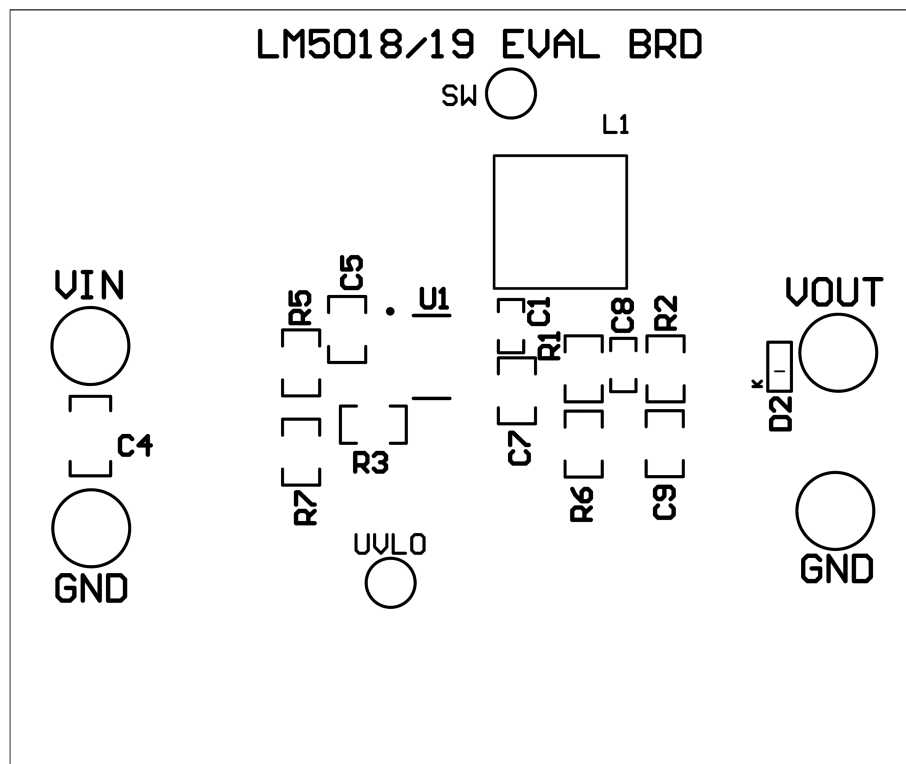


Figure 6. Board Silkscreen

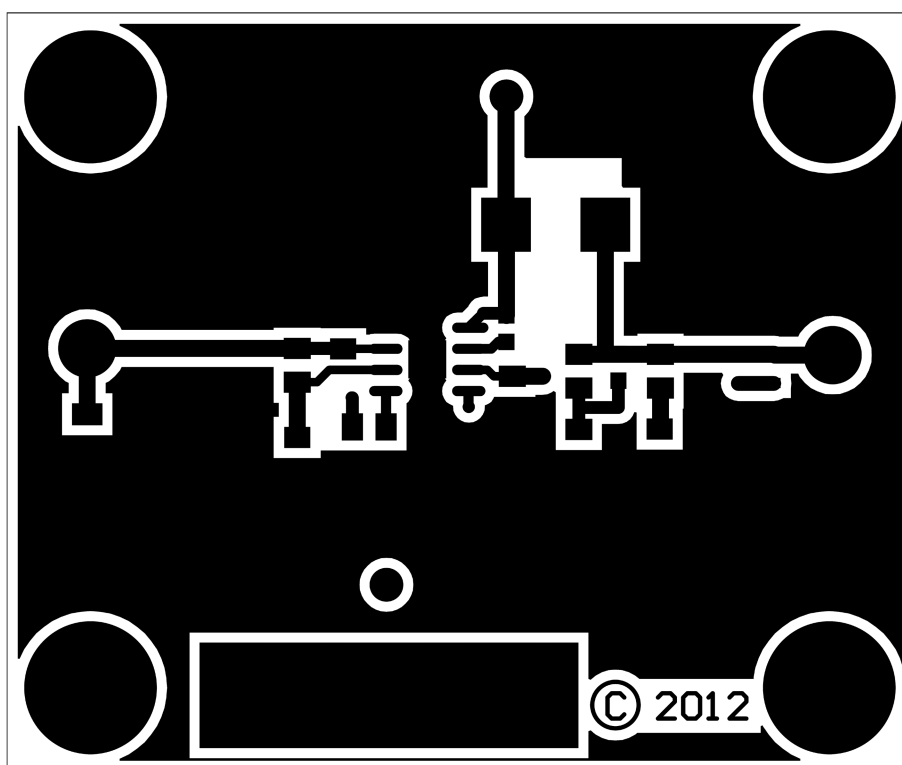


Figure 7. Board Top Layer

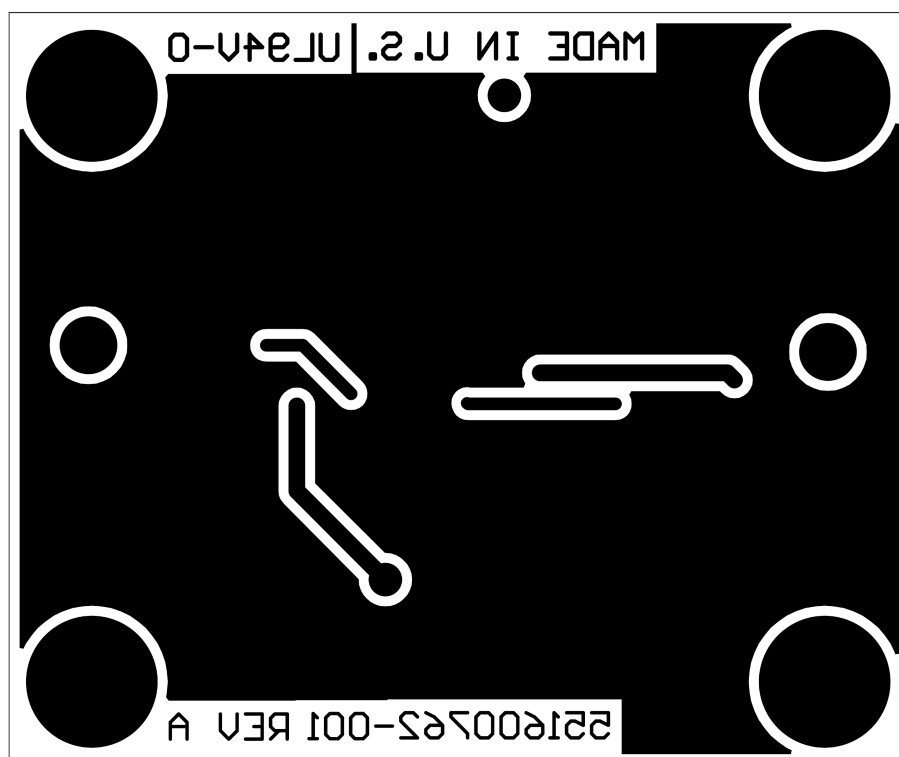


Figure 8. Board Bottom Layer

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- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
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