AN-2238 LM5019 Buck Evaluation Board

1 Introduction

The LM5019 evaluation board 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: 100mA
- Nominal Switching Frequency ~ 440kHz
- Measured Efficiency: 85% at 100mA and VIN = 24V
- Board size: 5.5 cm x 4.5 cm

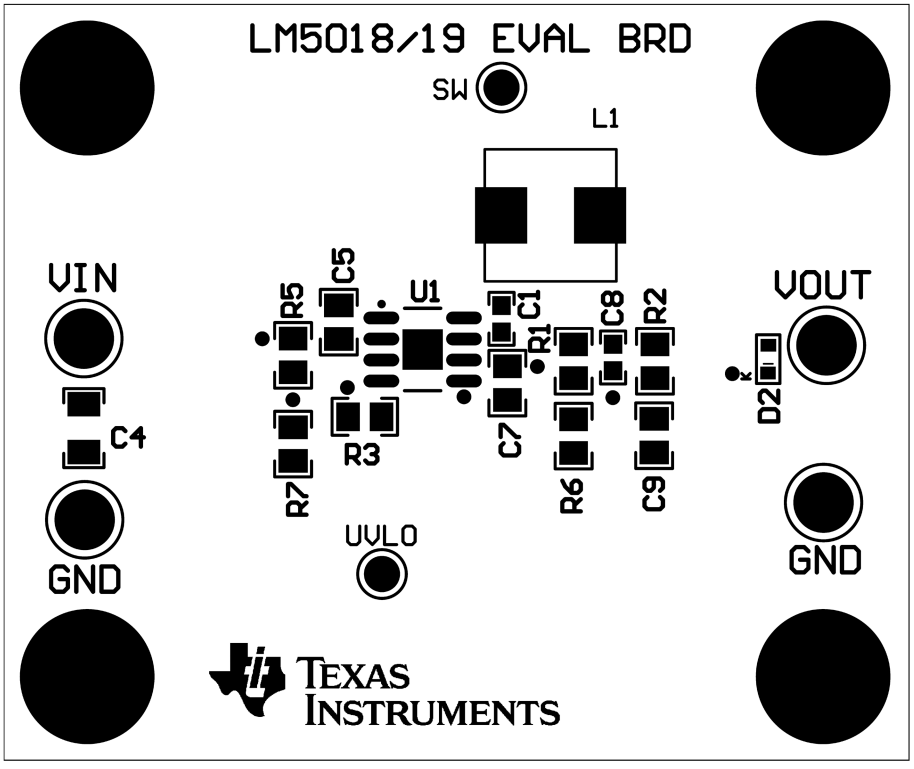


Figure 1. Evaluation Board (Top View)

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. Refer to the *LM5019 100V, 100mA Constant On-Time Synchronous Buck Regulator* (SNVS788) data sheet for a more detailed block diagram, and a complete description of the various functional blocks.

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.

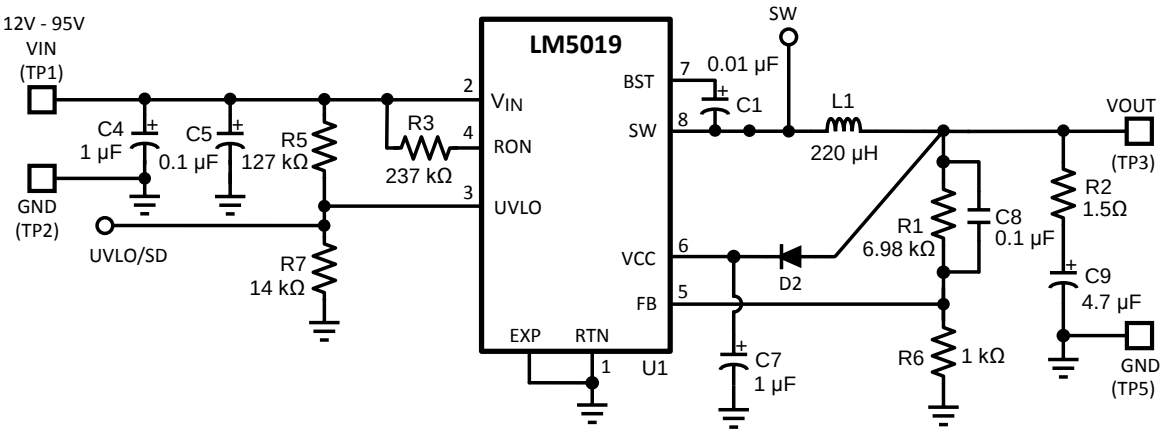


Figure 2. Complete Evaluation Board Schematic for LM5019 Based Buck Converter

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.**

Table 1. Bill of Materials

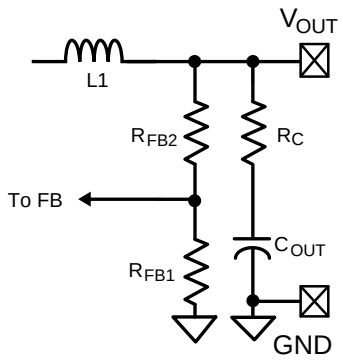
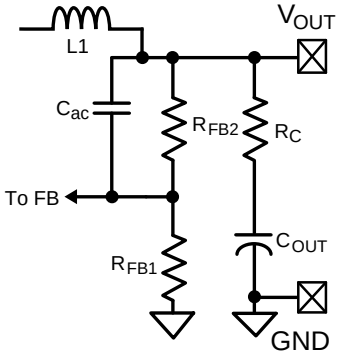
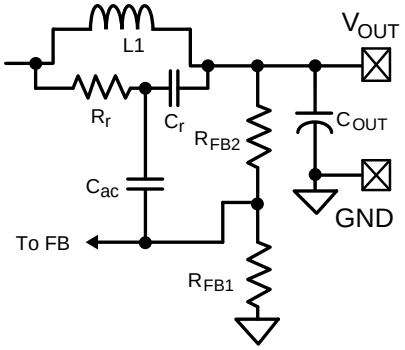
Item	Description	Mfg., Part Number	Package	Value
C5	Ceramic Capacitor	Kemet, C0805C104K1RACTU	0805	0.1uF, 100V, X7R
C7	Ceramic Capacitor	TDK, C2012X7R1C105K	0805	1uF, 16V, X7R
C8	Ceramic Capacitor	Murata, GRM188R71E104KA01D	0603	0.1uF, 25V, X7R, 0603
C9	Ceramic Capacitor	Murata, GRM21BR61E475KA12L	0805	4.7uF, 25V, X5R
D2	Diode	Diodes, Inc., SDM10U45–7–F	SOD-523	Schottky, 45V, 0.1A
L1	Inductor	Bourns, SRR0603–221kL	6.5mm x 6.5mm	220uH, 0.310A
	Alternate Inductor	Wurth, 744053221	5.8mm x 5.8mm	220uH, 0.290A
	Alternate Inductor	Coilcraft, LPS5030–224	5mm x 5mm	220uH, 0.245A
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, LM5019	SO PowerPAD-8	100V, 100 mA

5 Ripple Configuration

The LM5019 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 2.

The LM5019 evaluation board has been supplied with reduced ripple configuration (Type 2). For more information on ripple configuration, refer to LM5019 datasheet.

Table 2. Ripple Configuration

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

6 Performance Curves

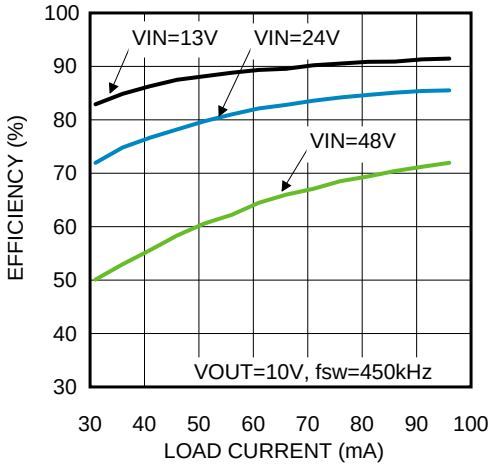


Figure 3. Efficiency vs Load Current

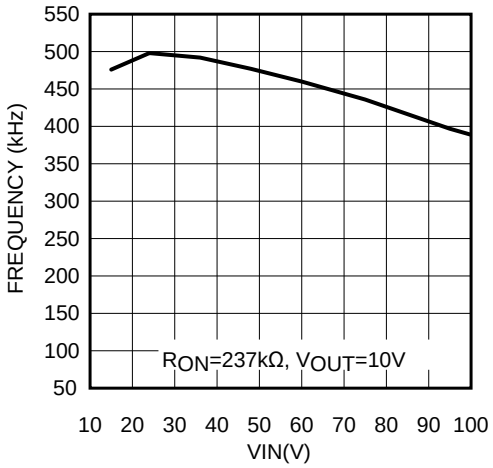


Figure 4. Frequency vs Input Voltage

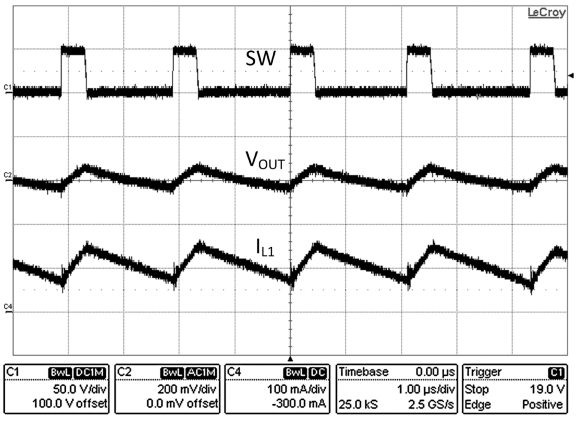


Figure 5. Typical Switching Waveform (VIN=48V, Iout=100mA)

7 PC Board Layout

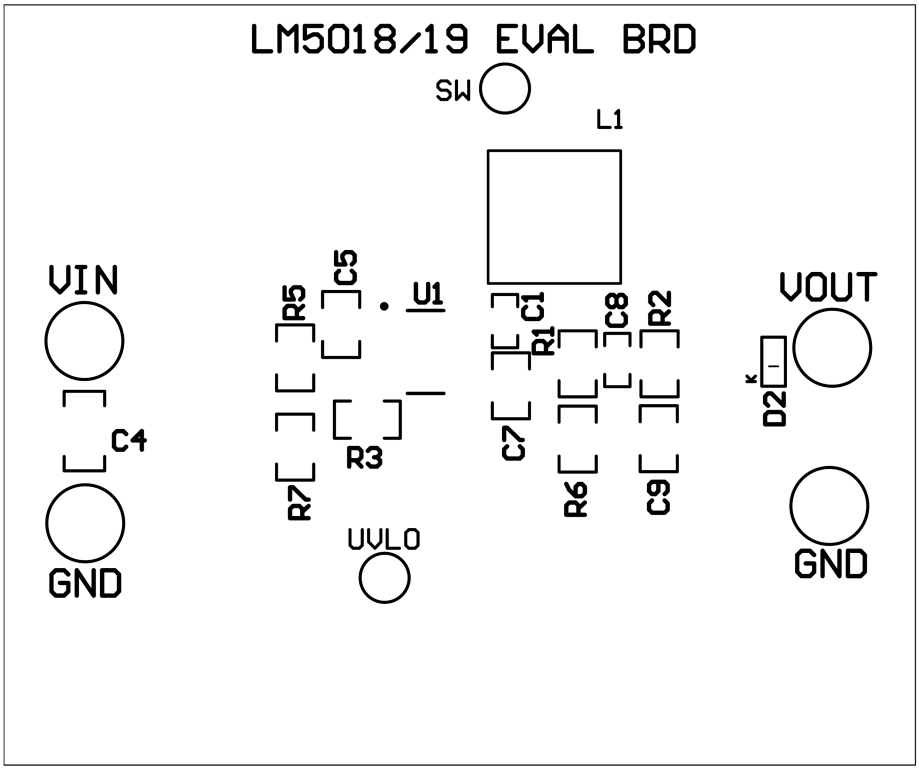


Figure 6. Board Silkscreen

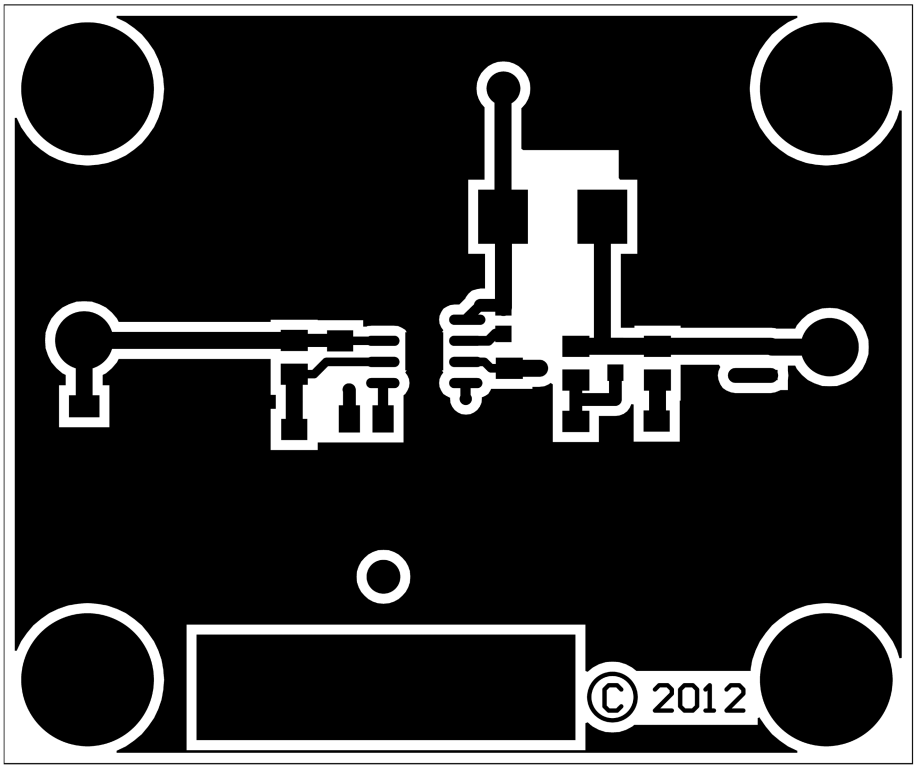


Figure 7. Board Top Layer

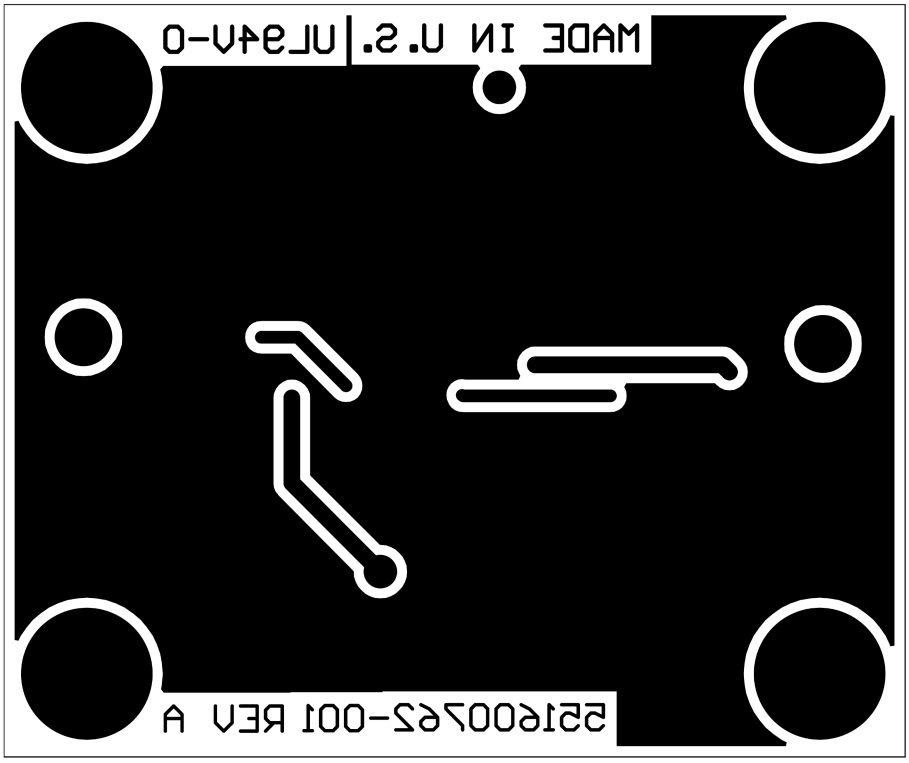


Figure 8. Board Bottom Layer

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