

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 $V_{IN} = 24V$
- Board size: 5.5 cm x 4.5 cm

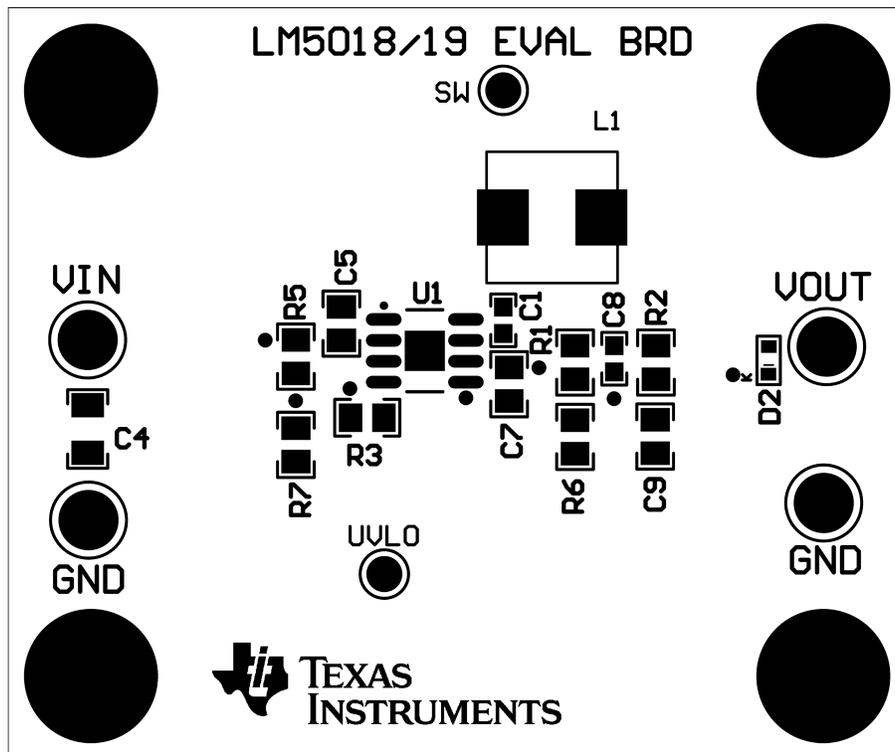


Figure 1. Evaluation Board (Top View)

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. 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](#)).

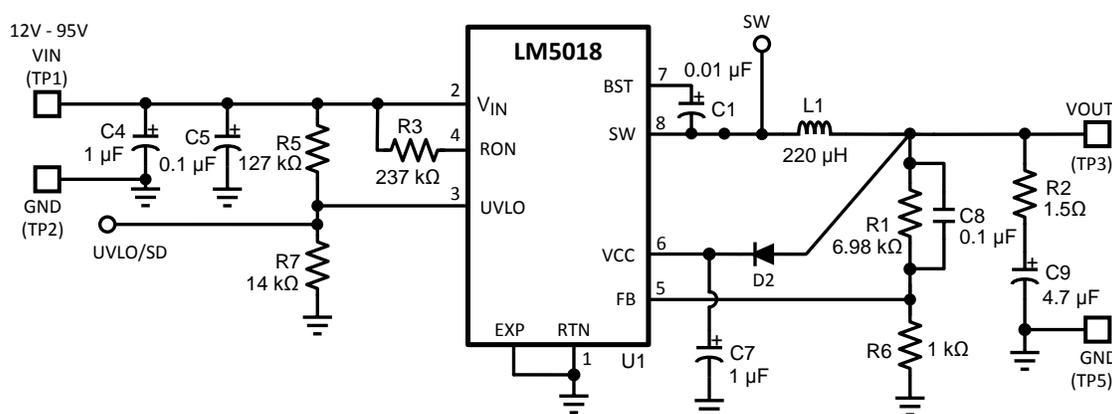


Figure 2. Complete Evaluation Board Schematic for LM5018 Based Buck Converter

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

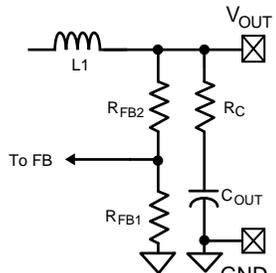
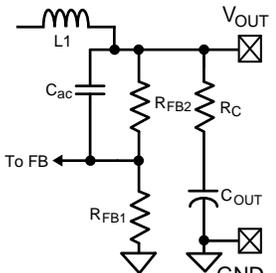
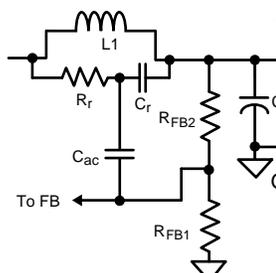
Item	Description	Mfg., Part Number	Package	Value
C5	Ceramic Capacitor	Kemet, C0805C104K1RACTU	0805	0.1uF, 100V, X7R
C7	Ceramic Capacitor	TDK, C2012X7R1C105K	0805	1uF, 16V, X7R
C8	Ceramic Capacitor	Murata, GRM188R71E104KA01D	0603	0.1uF, 25V, X7R, 0603
C9	Ceramic Capacitor	Murata, GRM21BR61E475KA12L	0805	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: $C8 \geq \frac{5}{f_{\text{SW}}(R1 \parallel R6)}$ $R2 \geq \frac{40 \text{ mV}}{\Delta I_L} \quad (5)$	(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

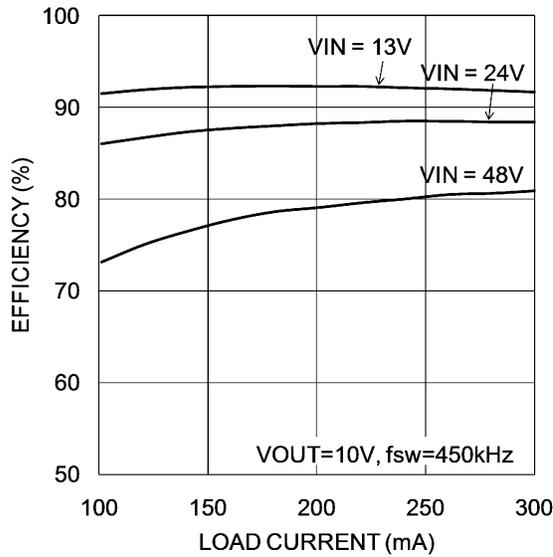


Figure 3. Efficiency vs Load Current

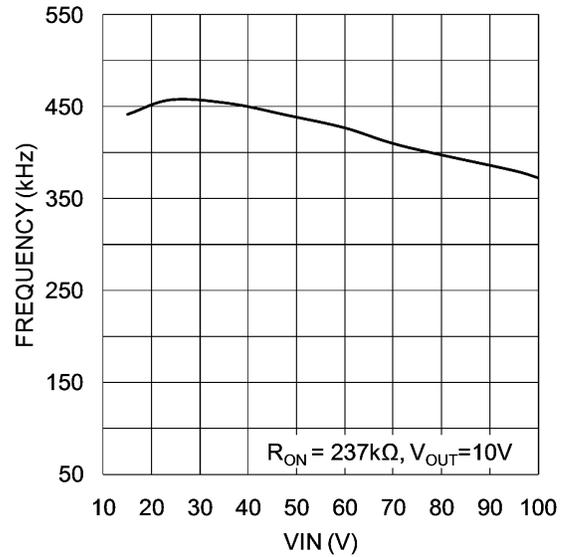


Figure 4. Frequency vs Input Voltage

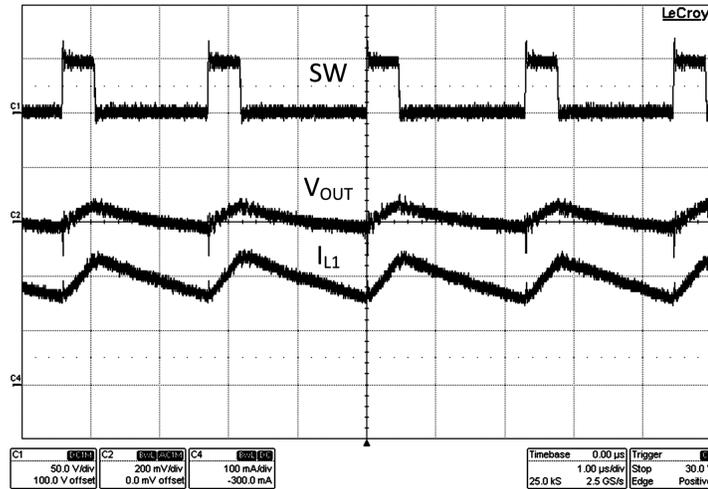


Figure 5. Typical Switching Waveform
(VIN = 48V, Iout = 200mA)

8 PC Board Layout

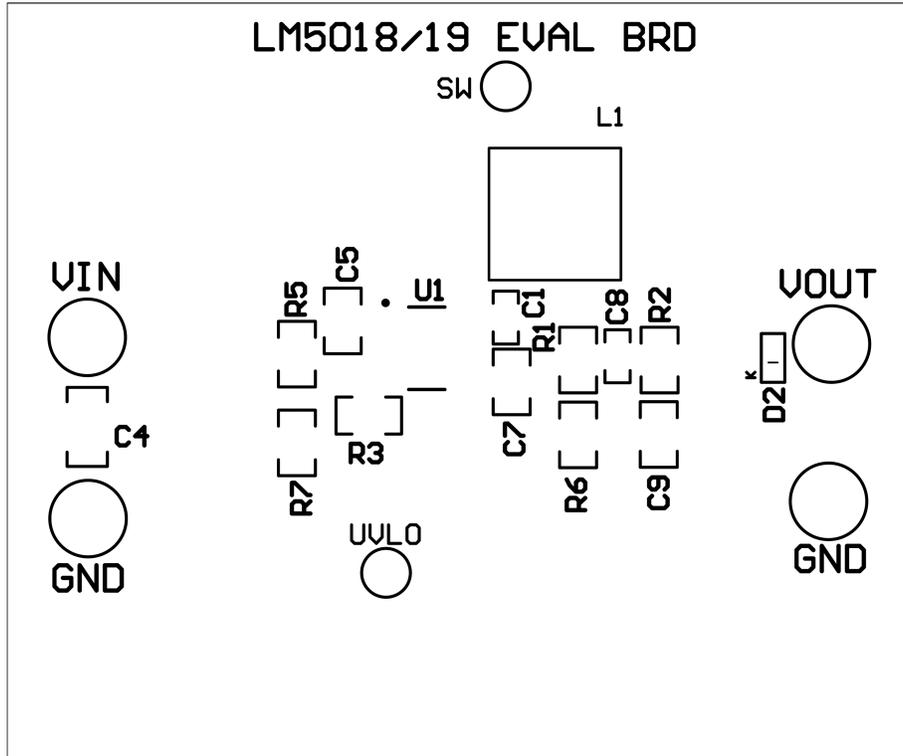


Figure 6. Board Silkscreen

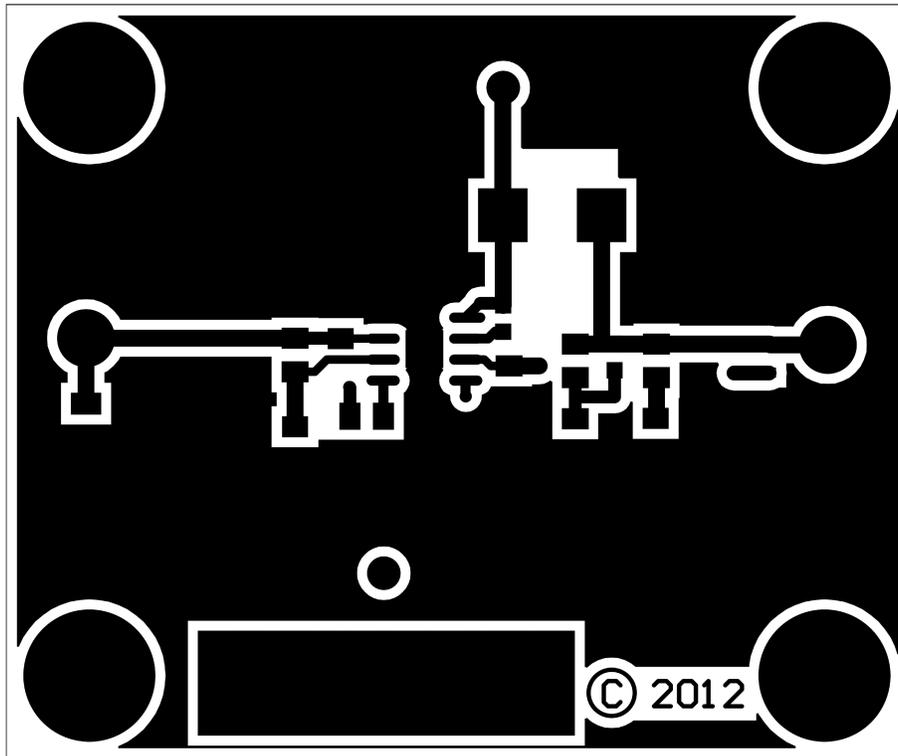


Figure 7. Board Top Layer

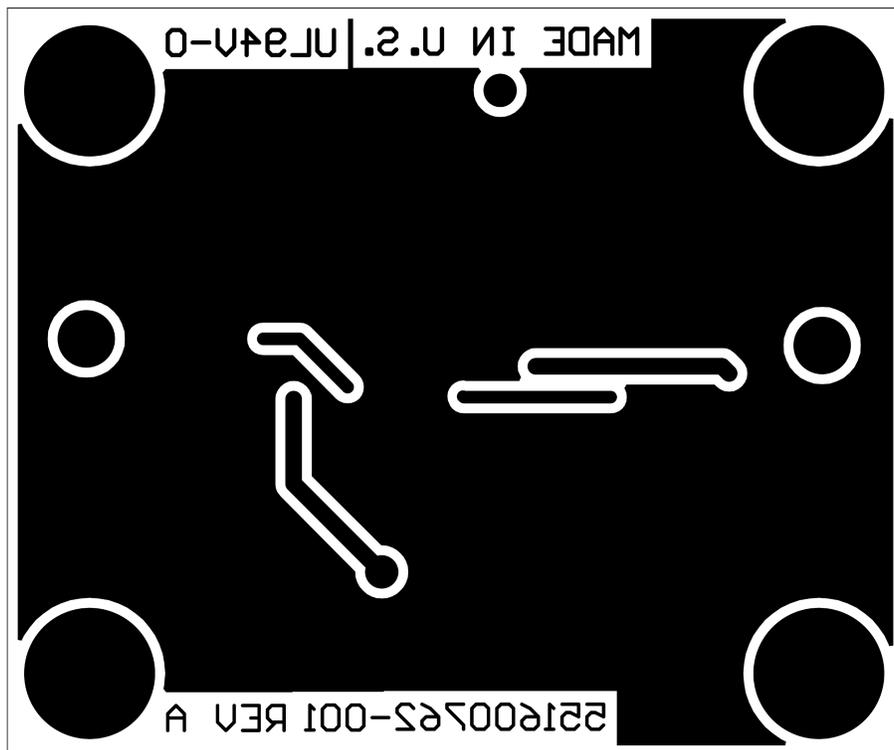


Figure 8. Board Bottom Layer

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com