LM34919C-Q1 Evaluation Board User's Guide

User's Guide

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LM34919C-Q1 Evaluation Board

The LM34919CQSDEVM 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 3.3 V output over an input range of 4.5 V to 24 V. The circuit delivers load current to 600 mA, with current limit set at a nominal 640 mA (valley current limit). The board is populated with all components except R7, C6, and C7. These components provide options for managing the output ripple as described later in this document.

1 INTRODUCTION

The LM34919CQSDEVM 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 3.3 V output over an input range of 4.5 V to 24 V. The circuit delivers load currents to 600 mA, with valley current limit set at 640 mA. The board is populated with all components except R7, C6 and C7. These components provide options for managing the output ripple as described later in this document.

The board's specification are:

- Input Voltage: 4.5 V to 24 V
- Output Voltage: 3.3 V
- Maximum load current: 600 mA
- Minimum load current: 0 A
- Current Limit: 768 mA to 812 mA
- Measured Efficiency: 87% (V_{IN} = 6 V, I_{OUT} = 300 mA)
- Nominal Switching Frequency: 1.5 MHz
- Size: 1.4 inches x 2.3 inches

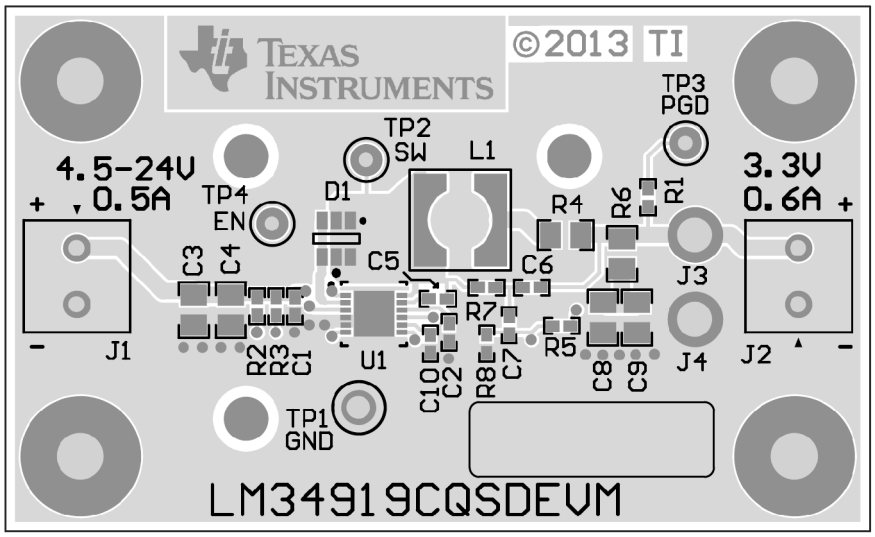


Figure 1. Evaluation Board - Top Side

2 THEORY OF OPERATION

Refer to the evaluation board topside view in Figure 1. At nominal input voltage, V_{IN} = 12 V, the switching frequency can be determined by R_2 (R_{ON} resistor) and output voltage V_O, according to Equation 1:

$$F_{SW} = \frac{V_{OUT}}{35.5 \times 10^{-12} \times R_2} \text{ Hz} \quad (1)$$

In LM34919C, like other constant on-time regulators, the on-time varies inversely with VIN to maintain a nearly constant switching frequency. For stable, fixed frequency operation, a minimum of 25 mV of ripple is required at FB to switch the regulation comparator. The average load current limit threshold is ≅768 mA at Vin = 4.5 V, and ≅812 mA at Vin = 24 V. The variation is due to the change in ripple current amplitude as Vin varies. Refer to the LM34919C data sheet for a more detailed block diagram, and a complete description of the various functional blocks.

3 BOARD LAYOUT AND PROBING

The picture in Figure 1 also shows the placement of the circuit components. The following should be kept in mind when the board is powered:

1) The LM34919C, and diode D1 may be hot to touch when operating at high input voltage and high load current.

2) Use CAUTION when probing the circuit at high input voltages to prevent injury, as well as possible damage to the circuit.

3) At maximum load current (0.6 A), the wire size and length used to connect the load becomes important. Ensure there is not a significant drop in the wires between this evaluation board and the load.

4 BOARD CONNECTION/START-UP

The input connections are made to the J1 connector. The load is connected to the J3 (OUT) and J4 (GND) connectors. 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 4.5 V and load current be set at 0 A, at which time the output voltage should be ≅3.3 V. If the output voltage is correct, then increase the input voltage as desired and proceed loading the evaluation board as shown in Figure 8. DO NOT EXCEED 40 V AT VIN.

5 OUTPUT RIPPLE CONTROL

The LM34919C requires a minimum of 25 mVp-p ripple at the FB pin, in phase with the switching waveform at the SW pin, for proper operation. The required ripple can be supplied from ripple at V_{OUT}, through the feedback resistors as described in Options A and B below, or the ripple can be generated separately (using R7, C6, and C7) in order to keep the ripple at V_{OUT} at a minimum (Option C).

Option A) Lowest Cost Configuration: This evaluation board is supplied with R6 installed in series with the output capacitance (C8, C9). R6 is chosen to generate ≥25 mVp-p at V_{OUT}. Using 0.47 Ω for R6, the ripple at V_{OUT} ranges from ≅38 mVp-p to ≅158 mVp-p over the input voltage range. If the application can accept this ripple level, this is the most economical solution. The circuit is shown in Figure 2.

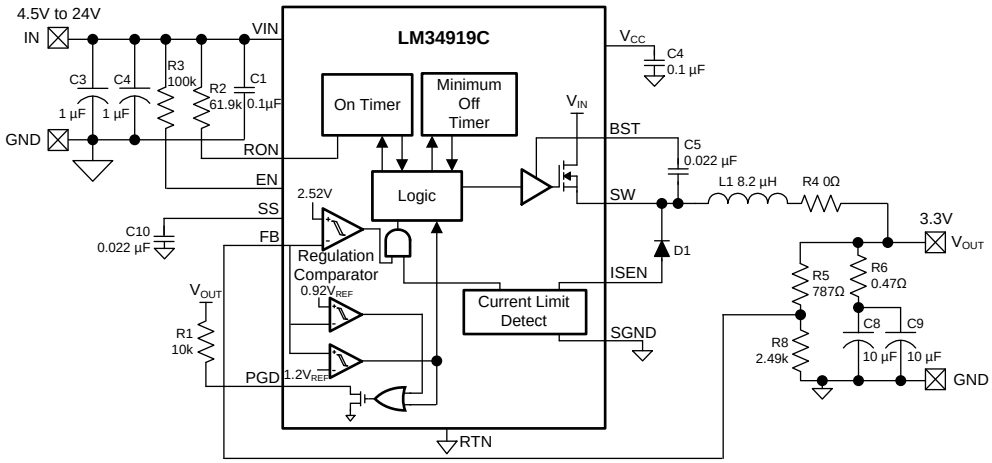


Figure 2. Lowest Cost Configuration

Option B) Intermediate Ripple Configuration: This configuration generates less ripple at V_{OUT} than option A above by the addition of one capacitor (Cff) across R5, as shown in Figure 3.

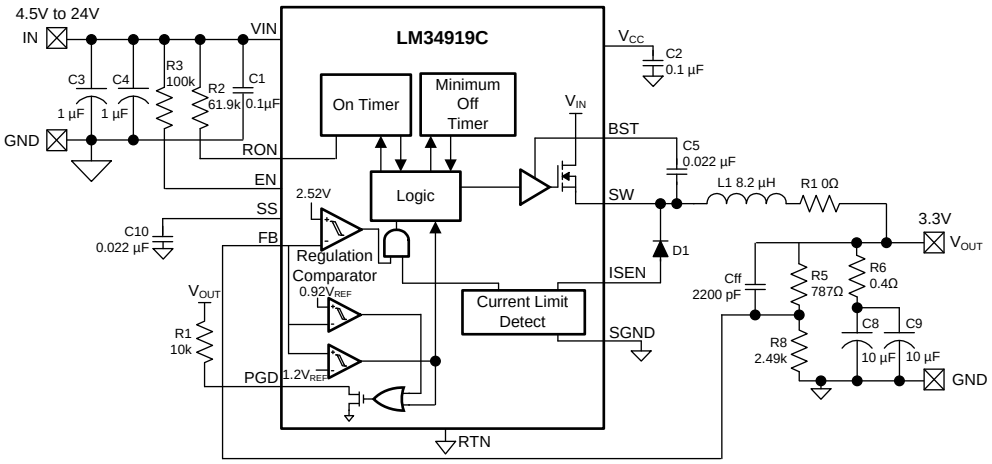


Figure 3. Intermediate Ripple Configuration

Since the output ripple is passed by Cff to the FB pin with little or no attenuation, R6 can be reduced so the minimum ripple at V_{OUT} is ≅25 mVp-p. The minimum value for Cff is calculated from:

$$Cff \geq \frac{t_{ON\ (max)} \times 3}{(R5//R8)} \tag{2}$$

where $t_{ON(max)}$ is the maximum on-time (at minimum V_{IN}), and R5//R8 is the parallel equivalent of the feedback resistors. See Figure 3.

Option C) Minimum Ripple Configuration: To obtain minimum ripple at V_{OUT}, R6 is set to 0Ω, and R7, C6, and C7 are added to generate the required ripple for the FB pin. In this configuration, the output ripple is determined primarily by the ESR of the output capacitance and the inductor's ripple current.

The ripple voltage required by the FB pin is generated by R7, C6, and C7 since the SW pin switches from –1 V to V_{IN}, and the right end of C6 is a virtual ground. The values for R7 and C6 are chosen to generate a 50-100 mVp-p triangle waveform at their junction. That triangle wave is then coupled to the FB pin through C7. The following procedure is used to calculate values for R7, C6 and C7:

1) Calculate the voltage V_A:

$$V_A = V_{OUT} - (V_{SW} \times (1 - (V_{OUT}/V_{IN}))) \tag{3}$$

where V_{SW} is the absolute value of the voltage at the SW pin during the off-time (typically 1 V), and V_{IN} is the minimum input voltage. For this circuit, V_A calculates to 3.03 V. This is the approximate DC voltage at the R7/C6 junction, and is used in the next equation.

2) Calculate the R7 x C6 product:

$$R7 \times C6 = \frac{(V_{IN} - V_A) \times t_{ON}}{\Delta V} \tag{4}$$

where t_{ON} is the maximum on-time, V_{IN} is the minimum input voltage, and ΔV is the desired ripple amplitude at the R7/C6 junction, 50 mVp-p for this example.

R7 and C6 are then chosen from standard value components to satisfy the above product. Typically C6 is 3000 to 5000 pF, and R7 chosen close to 10 kΩ. C7 is chosen large compared to C6, typically 0.1 µF. See Figure 4.

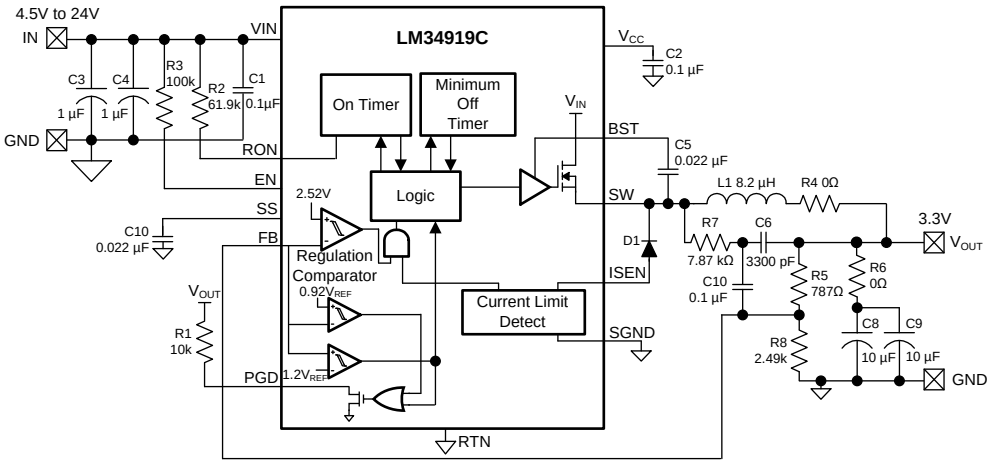


Figure 4. Minimum Output Ripple Configuration

6 MONITOR THE INDUCTOR CURRENT

The inductor's current can be monitored or viewed on a scope with a current probe. Remove R4, and install an appropriate current loop across the two large pads where R4 was located. In this way the inductor's ripple current and peak current can be accurately determined.

7 MINIMUM LOAD CURRENT

The LM34919C requires a minimum load current of ≅1 mA to ensure the boost capacitor (C5) is recharged sufficiently during each off-time. In this evaluation board, the minimum load current is provided by the feedback resistors allowing the board's minimum load current at V_{OUT} to be specified at zero.

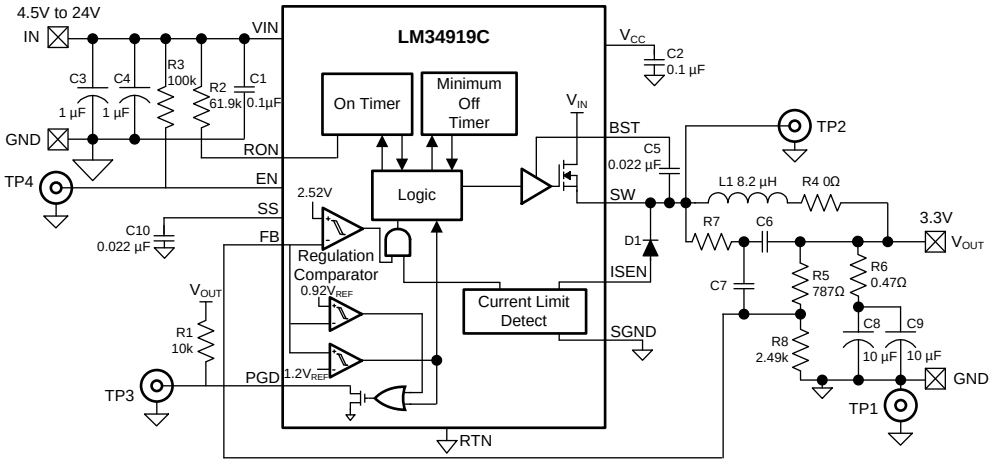


Figure 5. Complete Evaluation Board Schematic

Table 1. Bill of Materials

ITEM	DESCRIPTION	MFG. PART NUMBER	PACKAGE	VALUE
C1,C2	Ceramic Capacitor	TDK C1005X7R1H104K050BB	0402	0.1 µF,50 V
C3,C4	Ceramic Capacitor	Murata GRM21BR71H105KA12L	0805	1 µF,50 V
C5,C10	Ceramic Capacitor	Murata GRM155R71H223KA12D	0402	0.022 µF,50 V
C6	Ceramic Capacitor	Unpopulated	0402	
C7	Ceramic Capacitor	Unpopulated	0402	

Table 1. Bill of Materials (continued)

ITEM	DESCRIPTION	MFG. PART NUMBER	PACKAGE	VALUE
C8,C9	Ceramic Capacitor	Murata GRM21BR71A106KE51L	0805	10 µF,10 V
D1	Schottky Diode	Zetex ZLLS2000TA	SOT-23-6	40 V, 2.2 A
L1	Power Inductor	Wurth Elektronik 744053008	5.8mm x 5.8mm	8.2 µH, 2.1 A
R1	Resistor	Vishay-Dale CRCW040210K0FKED	0402	10 kΩ
R2	Resistor	Vishay-Dale CRCW040261K9FKED	0402	61.9 kΩ
R3	Resistor	Vishay-Dale CRCW0402100KFKED	0402	100 kΩ
R4	Resistor	Vishay-Dale CRCW08050000Z0EA	0805	0 Ω Jumper
R5	Resistor	Vishay-Dale CRCW0402787RFKED	0402	787 Ω
R6	Resistor	Vishay-Dale RCWE0805R470FKEA	0805	0.47 Ω
R7	Resistor	Unpopulated	0402	
R8	Resistor	Vishay-Dale CRCW04022K49FKED	0402	2.49 kΩ
U1	Switching Regulator	Texas Instruments LM34919CQSD	12 Pin WSON	

8 CIRCUIT PERFORMANCE

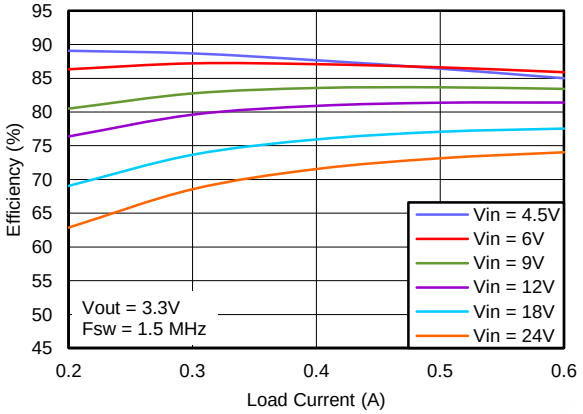


Figure 6. Efficiency vs Load Current

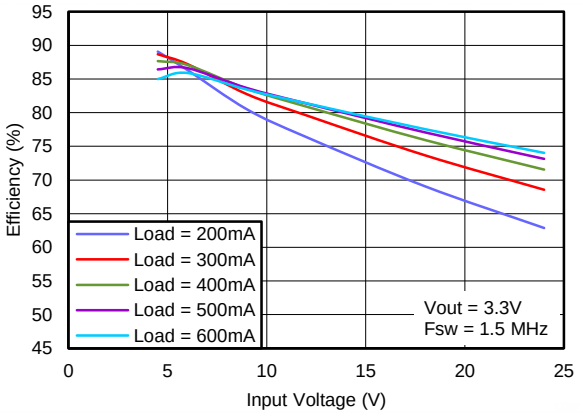


Figure 7. Efficiency vs Input Voltage

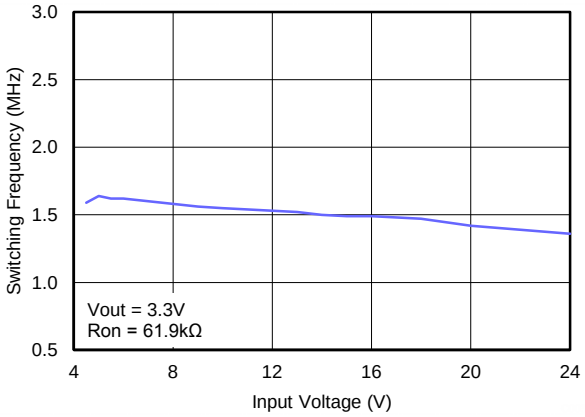


Figure 8. Switching Frequency vs. Input Voltage

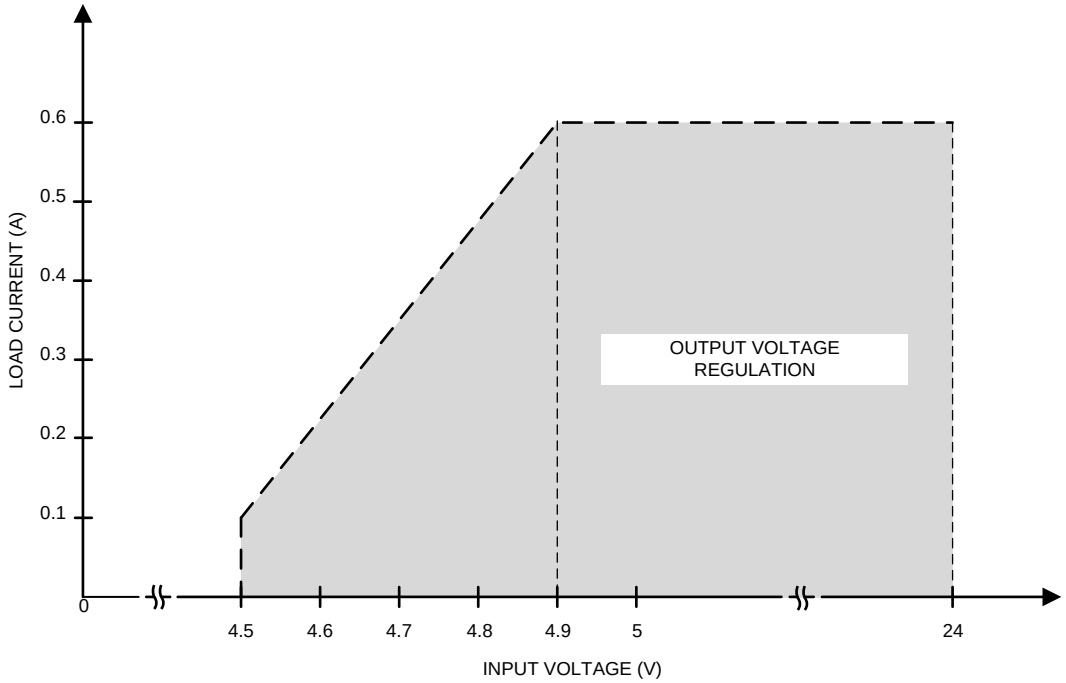
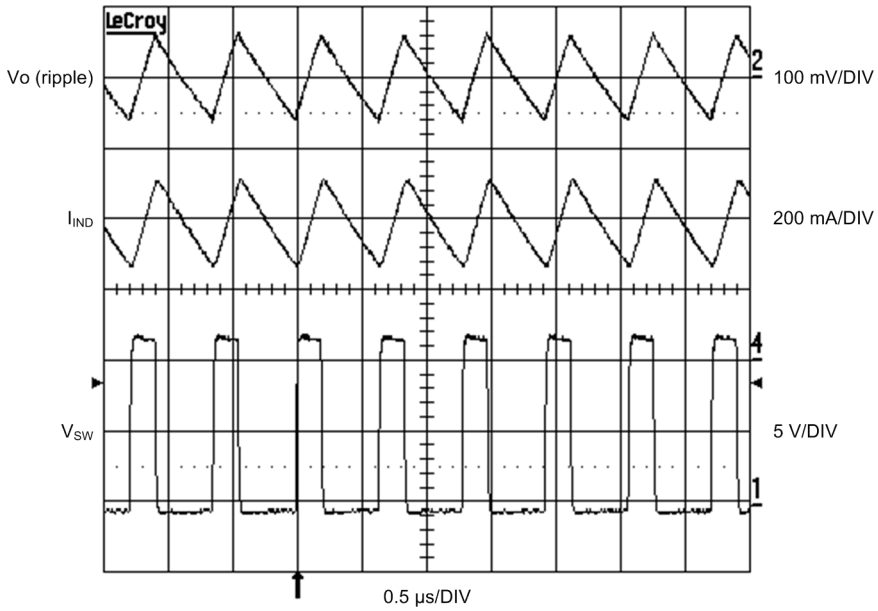


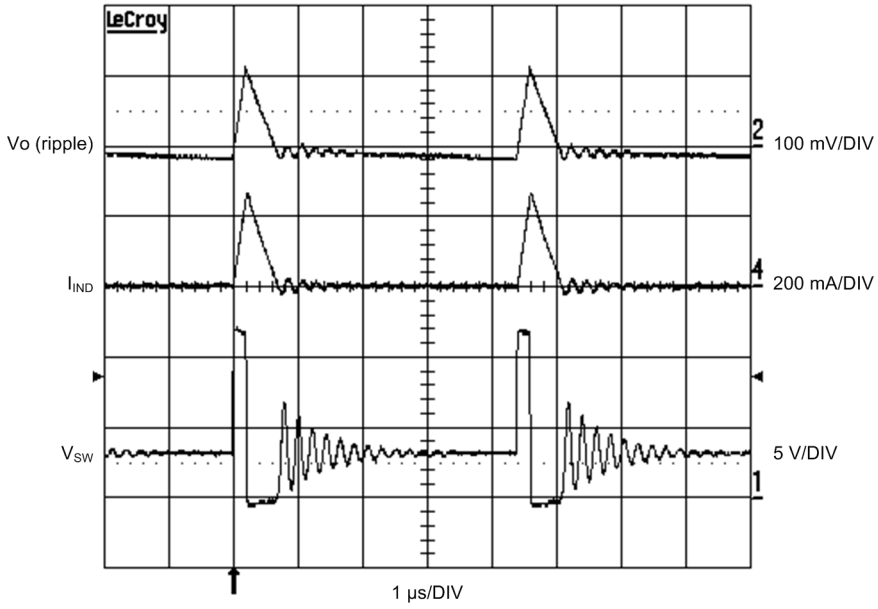
Figure 9. Load Derating Curve

9 TYPICAL WAVEFORMS



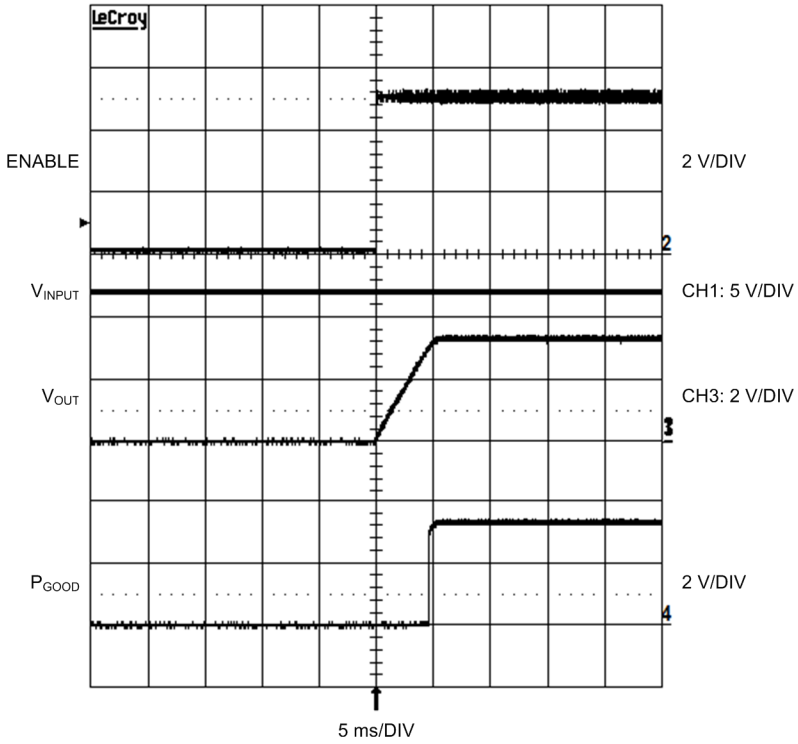
Trace 2 = V_{OUT} ripple (ac coupled)
Trace 4 = inductor Current
Trace 1 = SW Pin
Vin = 12 V, I_{OUT} = 400 mA

Figure 10. Continuous Conduction Mode



Trace 2 = V_{OUT} ripple (ac coupled)
Trace 4 = inductor Current
Trace 1 = SW Pin
Vin = 12 V, I_{OUT} = 20 mA

Figure 11. Discontinuous Conduction Mode



Trace 3 = V_{OUT}
Trace 2 = EN
Trace 4 = Power Good
Trace 1 = V_{IN} = 12 V
I_{OUT} = 300 mA

Figure 12. Enable, Output Voltage, and PGD at Startup

10 PC BOARD LAYOUT

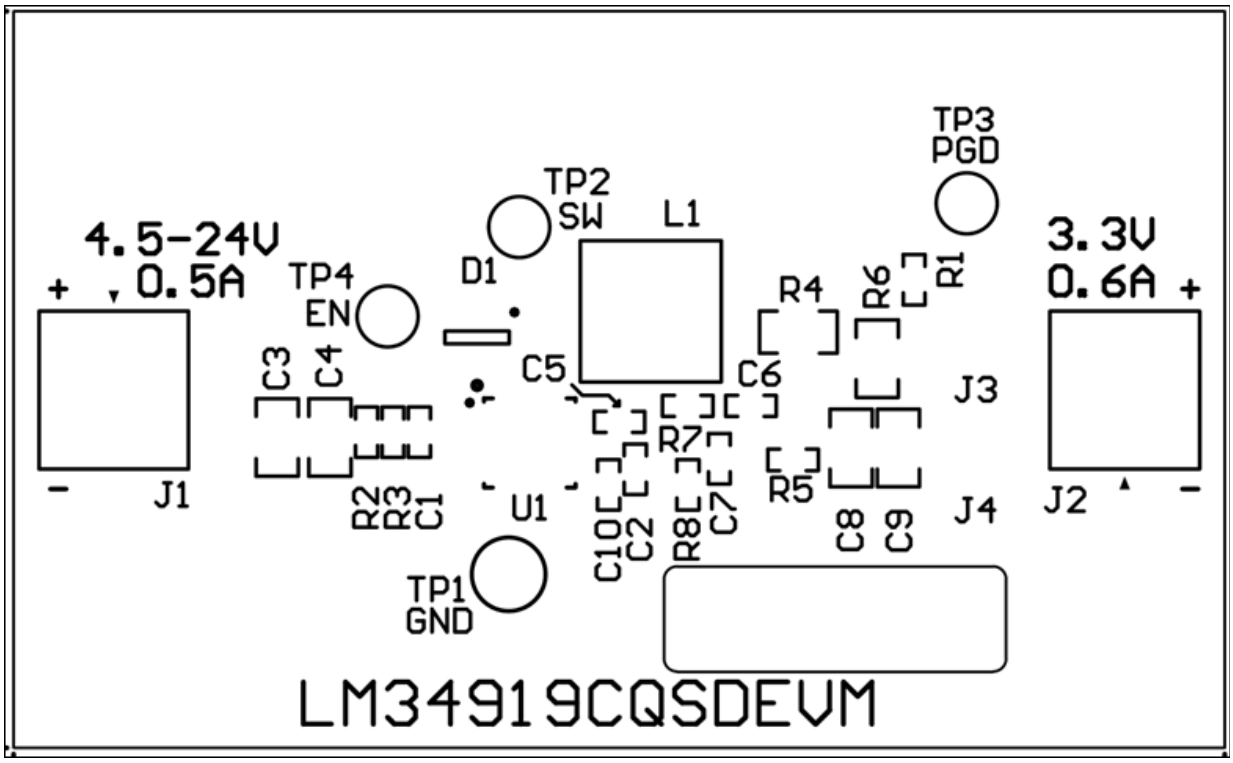


Figure 13. Board Silkscreen

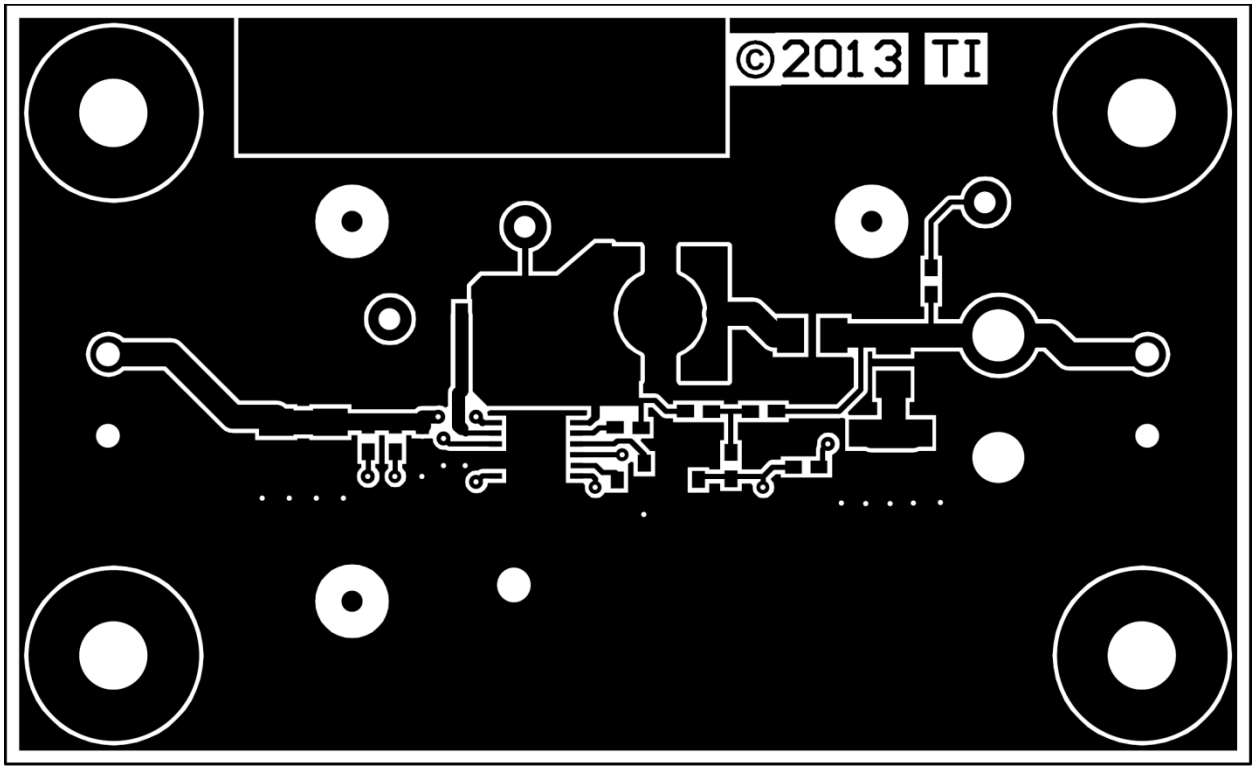


Figure 14. Board Top Layer

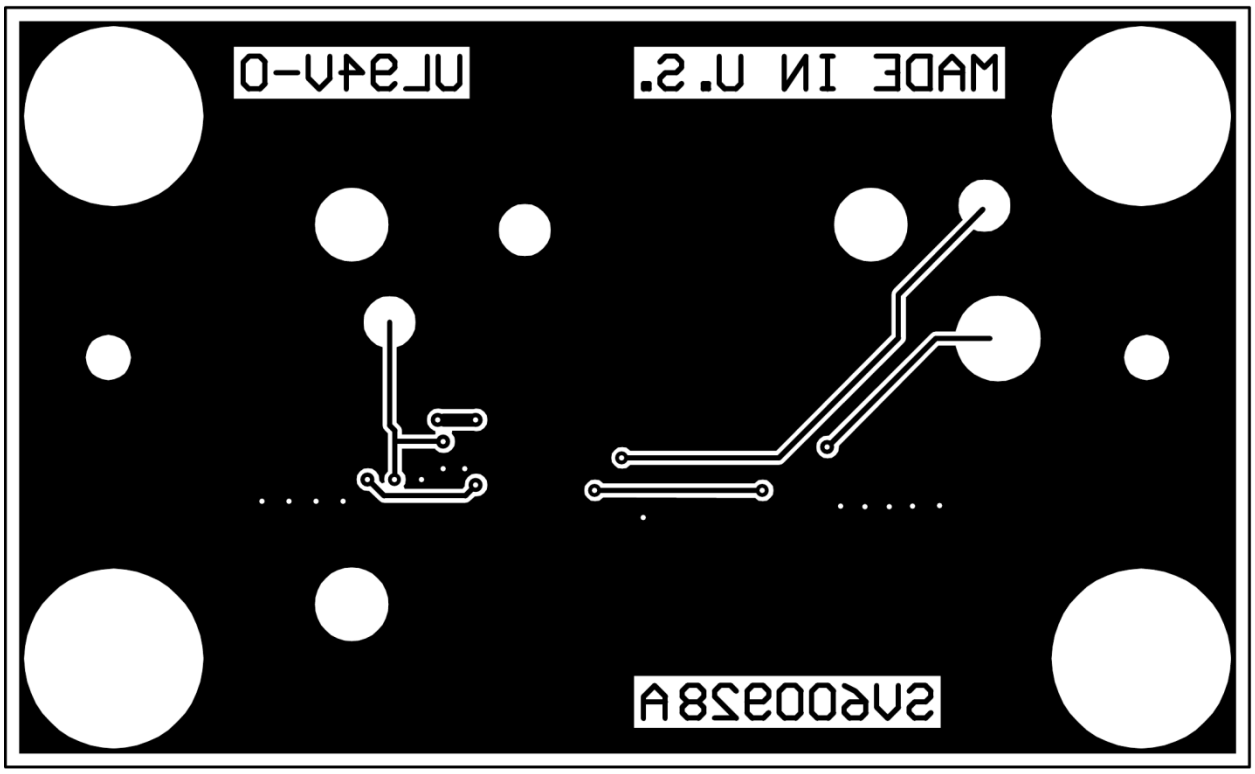


Figure 15. Board Bottom Layer (Viewed from Top)

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User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant

Caution

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- 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.
- Consult the dealer or an experienced radio/TV technician for help.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concerning EVMs including detachable antennas

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

Concernant les EVMs avec appareils radio

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

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This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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3. Since the EVM is not a completed product, it may not meet all applicable regulatory and safety compliance standards (such as UL, CSA, VDE, CE, RoHS and WEEE) which may normally be associated with similar items. You assume full responsibility to determine and/or assure compliance with any such standards and related certifications as may be applicable. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM’s electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI’s recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to defend, indemnify and hold TI, its licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, "Claims") arising out of or in connection with any use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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