

# LM74670-SQEVM

## User's Guide



Literature Number: SNVU494  
October 2015

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## 1 Introduction

The Texas Instruments LM74670-Q1-SQ Evaluation Module helps designers evaluate the operation and performance of the LM74670-Q1 Reverse Polarity Protection Smart Diode Controller. This EVM demonstrates how an N-Channel power MOSFET can emulate a very low forward voltage diode with zero  $I_q$  and low leakage current flowing through the IC. In this design scheme the LM74670-Q1 is combined with a MOSFET and used in series with battery as a replacement for schottky diode and PFET in reverse polarity protection circuitry as shown in [Figure 1](#). For more information on the LM74670-Q1 functional and electrical characteristics, see the LM74670-Q1 Reverse Polarity Protection Smart Diode Controller Data Sheet ([LM74670-Q1](#)).

**Table 1. Device and Package Configurations**

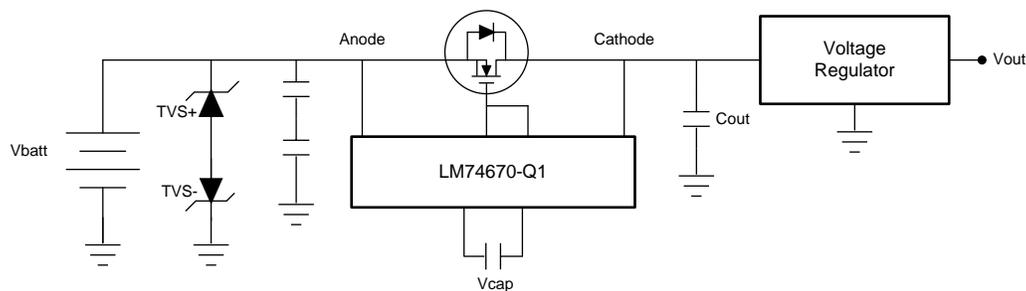
CONVERTER	IC	PACKAGE
U1	LM74670-Q1	VSSOP-8

## 2 Setup

This section describes the jumpers and connectors on the EVM as well and how to properly connect, set up and use the LM74670-Q1-SQEVM. Ensure the power supply is turned off while making connections on the board.

### 2.1 Input/Output Connector Description

- **VBAT\_1**: Power input connector to the positive rail of the input power supply.
- **GND**: Battery ground connector.
- **VOUT**: is the power output connector to the positive side of the load.
- **TEST POINTS**: are also available at **VBAT\_1**, **GND**, **VOUT**, **DRV\_1** (MOSFET Gate Voltage), and **VCAP\_1** (Charge pump capacitor).



**Figure 1. LM74670-Q1 Typical Application Circuit**

## 2.2 Board Setup

Before applying power to the LM74670-Q1EVM, all external connections should be verified. External power supplies should be turned off and connected with proper polarity to the VBAT\_1 and GND connectors. **An electronic or resistive load must be connected at the output.** The LM74670-Q1 will not initiate the charge pump operation if a closed loop system is in standby mode or the drain current is smaller than 1mA (typical). The tests outlined in this document have 3A constant load current and 12V input voltage supply (VBAT\_1). Make sure that the external power supply source for the input voltage is capable of providing enough current to the output load so that the output voltage can be obtained.

Once all connections to the LM74670-Q1-SQEVM are verified, power can be applied to VBAT\_1. The EVM will then begin to operate.

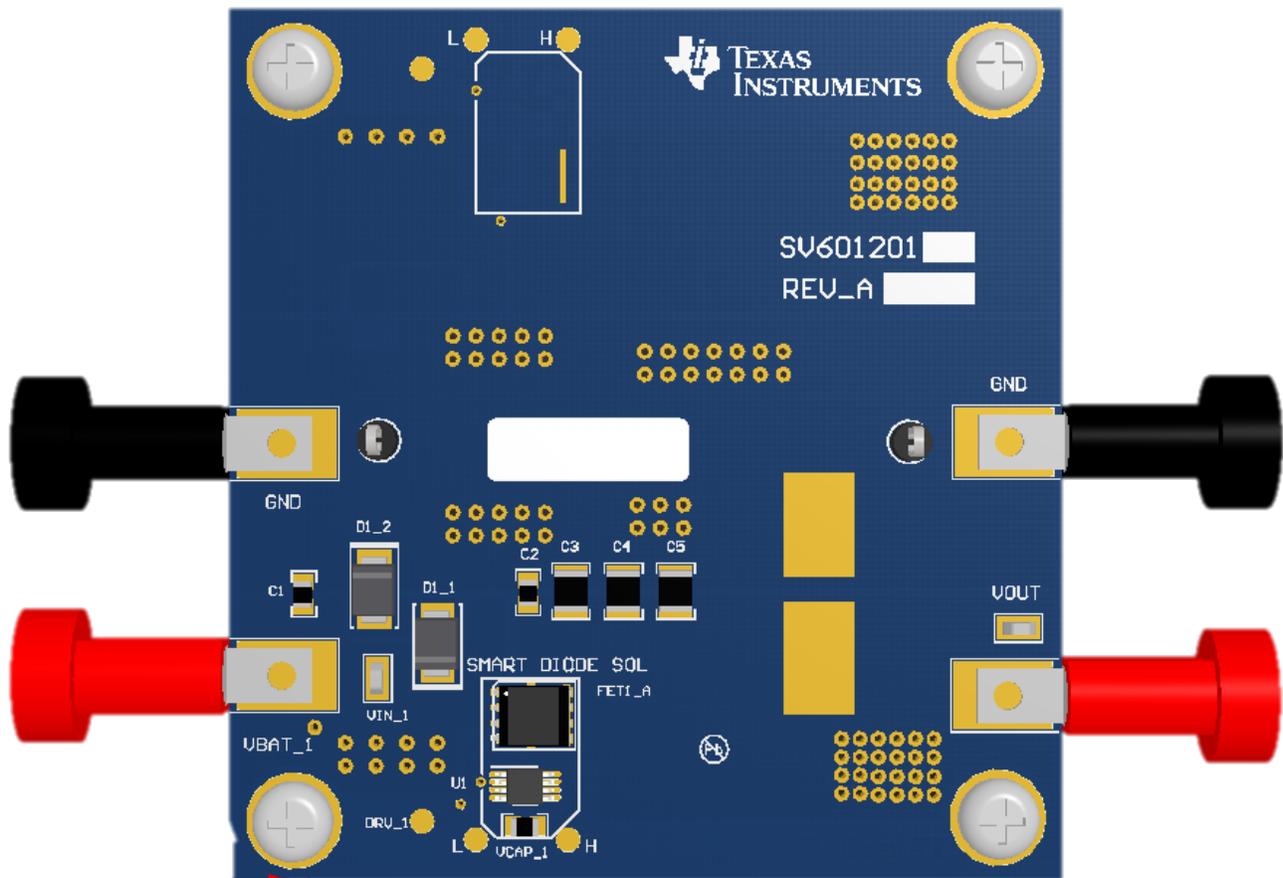
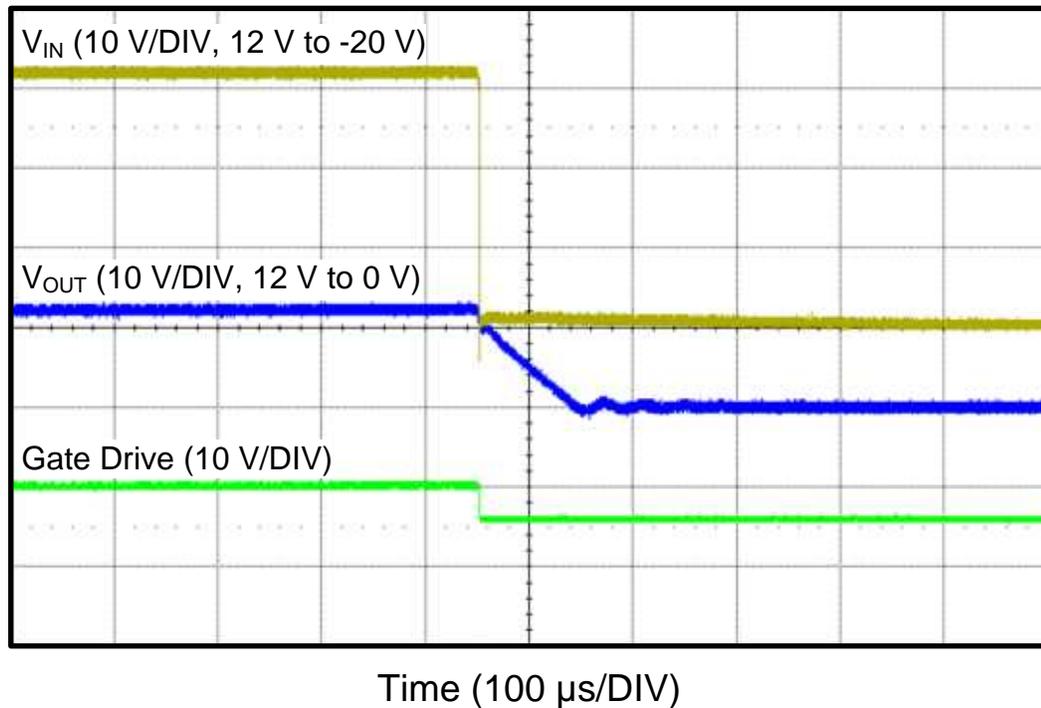


Figure 2. LM74670-Q1-SQ EVM

### 3 Operation

#### 3.1 Reverse Polarity Protection

A dynamic voltage pulse from +12V to -20V is applied at the VBAT\_1 input of the LM74670-Q1-SQEVM. [Figure 3](#) shows when the input voltage (yellow) drops down to -20V, the output voltage (blue) does not go negative, and therefore, the load is protected from dynamic reverse pulses at the input. The LM74670-Q1 reacts the negative voltage surge within 2 $\mu$ sec and shuts down the MOSFET by pulling the gate voltage to zero (green). The output slowly decays due to the large output capacitors and increased time constant.



**Figure 3. Response to Reverse Polarity 12V to -20V**

A -12V source is connected to the VBAT\_1 input of the LM74670-Q1-SQEVm. Figure 4 shows that the Output voltage will stay at a constant 0V in this situation. This test simulates the event of connecting a 12V battery in the reverse direction, and therefore, protects the load from negative voltages.

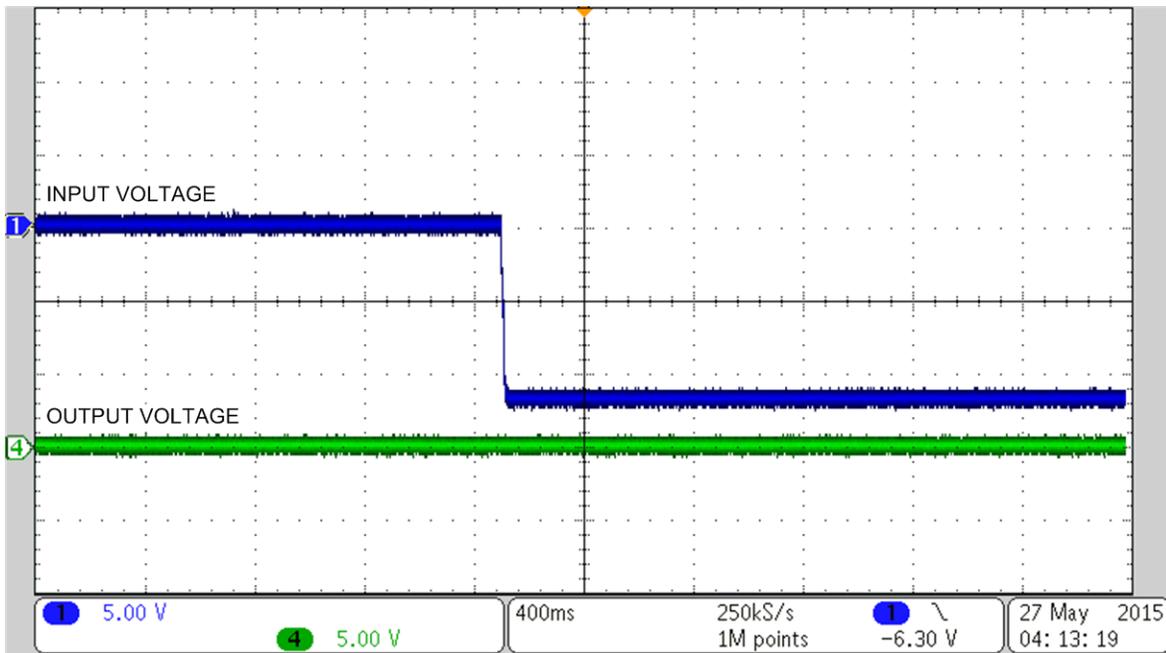
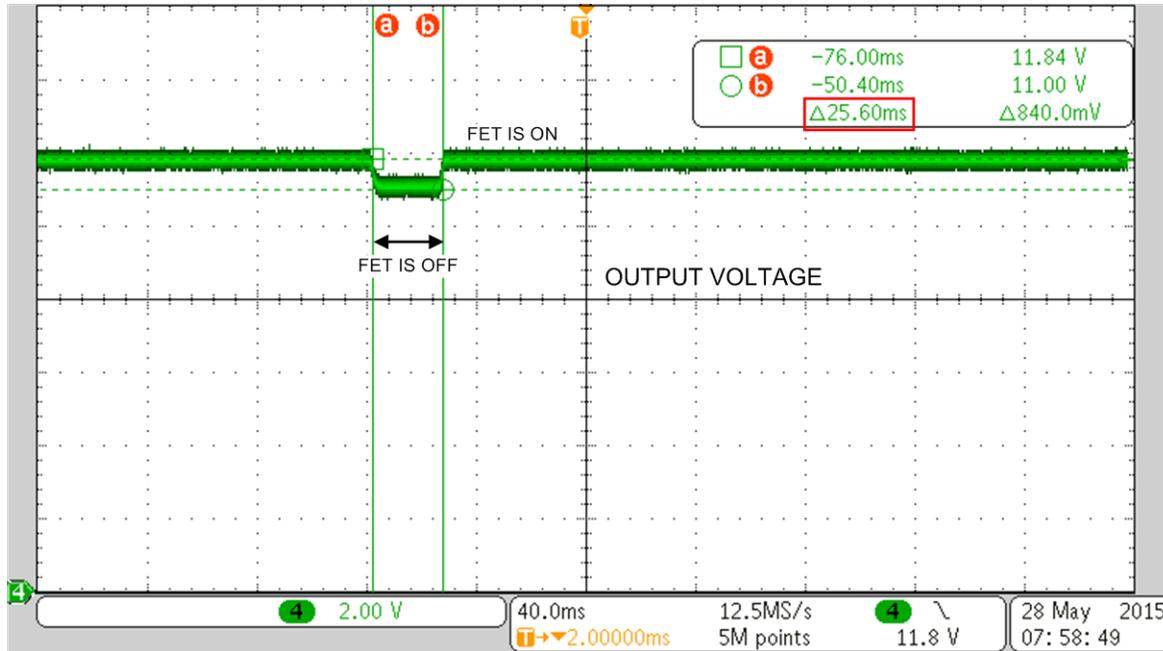


Figure 4. Response to Start Up Reverse Polarity

**Note:** Please note that the leakage current is 60uA (typ). This means that if you apply a voltage on the output you will see some voltage on input and this voltage will collapse if you draw more current than the leakage current. The same applies for a reverse voltage applied on the input.

### 3.2 Output Voltage

When power is initially applied, the load current ( $I_b$ ) will flow through the body diode of the MOSFET. This current will produce a forward voltage drop ( $V_f$ ) across the MOSFET body diode. This voltage is used to charge up the charge pump capacitor  $V_{cap}$ . This periodic voltage drop will be equal to the MOSFET body diode forward voltage drop and occurs for about 25.6msec as shown in Figure 5.



**Figure 5. Periodic body diode voltage drop at the output**

During the rest of the period of conduction, the LM74670-Q1 will drive the gate of the MOSFET. When the MOSFET is ON, it provides a low resistive path for the drain current to flow and minimizes the power dissipation associated with forward conduction. The power losses during the MOSFET ON state depend primarily on the  $R_{DS(ON)}$  of the selected MOSFET and load current. The LM74670-Q1 operation keeps the MOSFET ON at approximately 98% as shown in Figure 6, leading to very little overall power dissipation when compared to a typical diode.

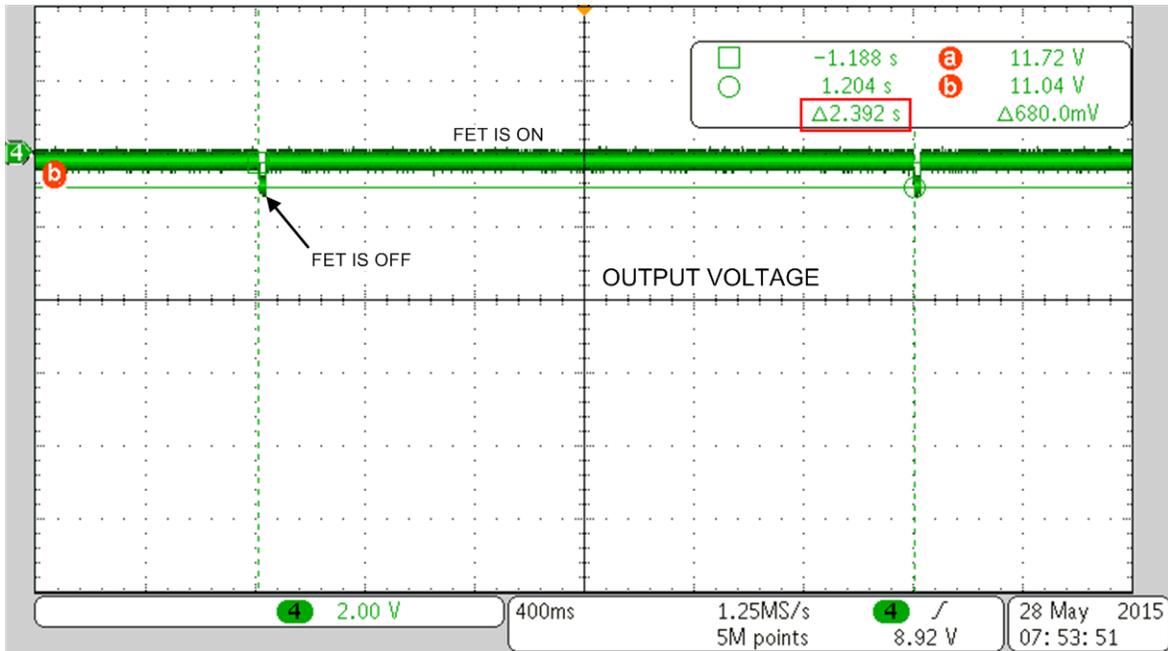


Figure 6. The LM74670-Q1-SQEVN Output voltage waveform

4 Board Layout

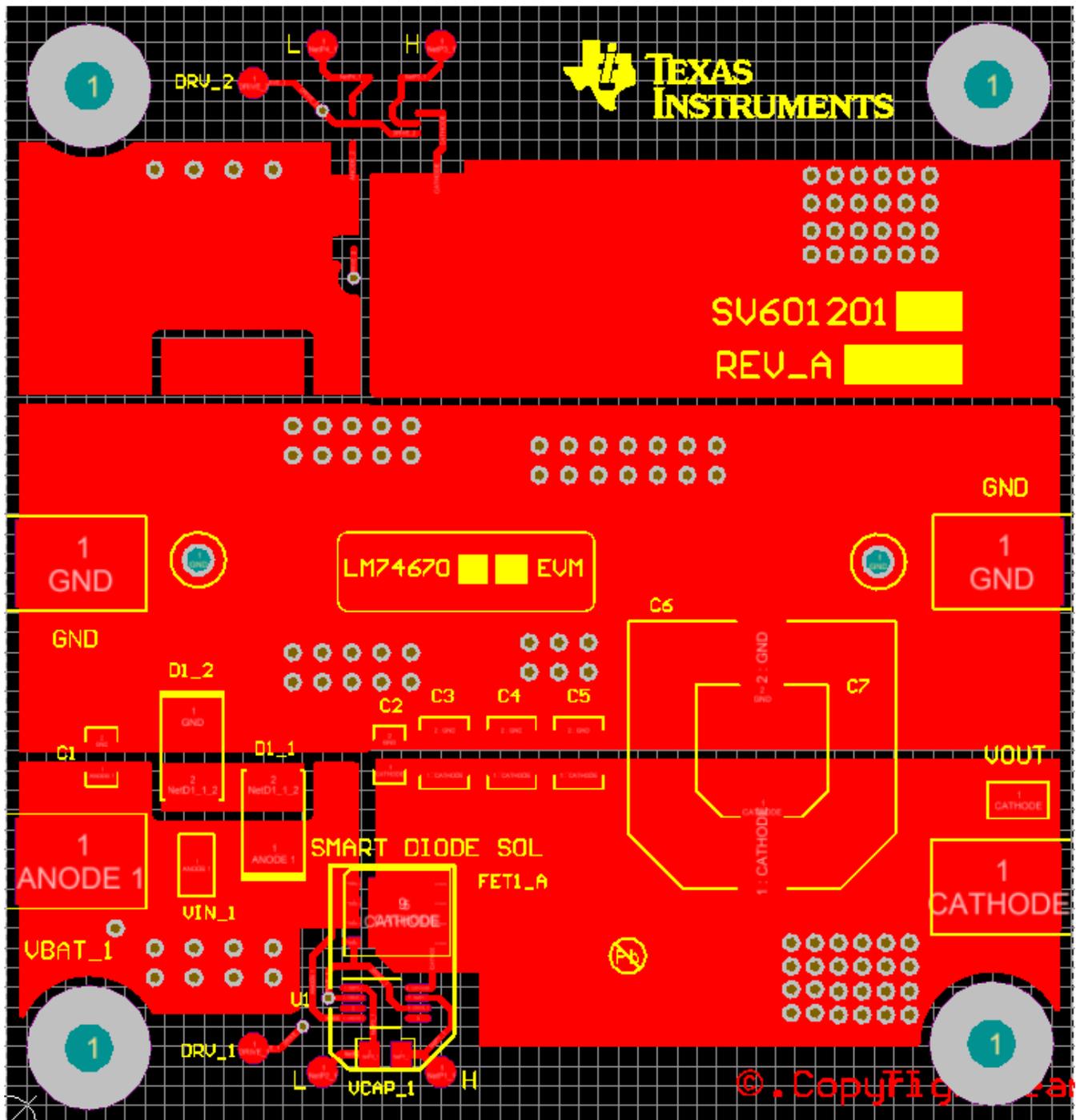


Figure 7. Top Assembly Layer

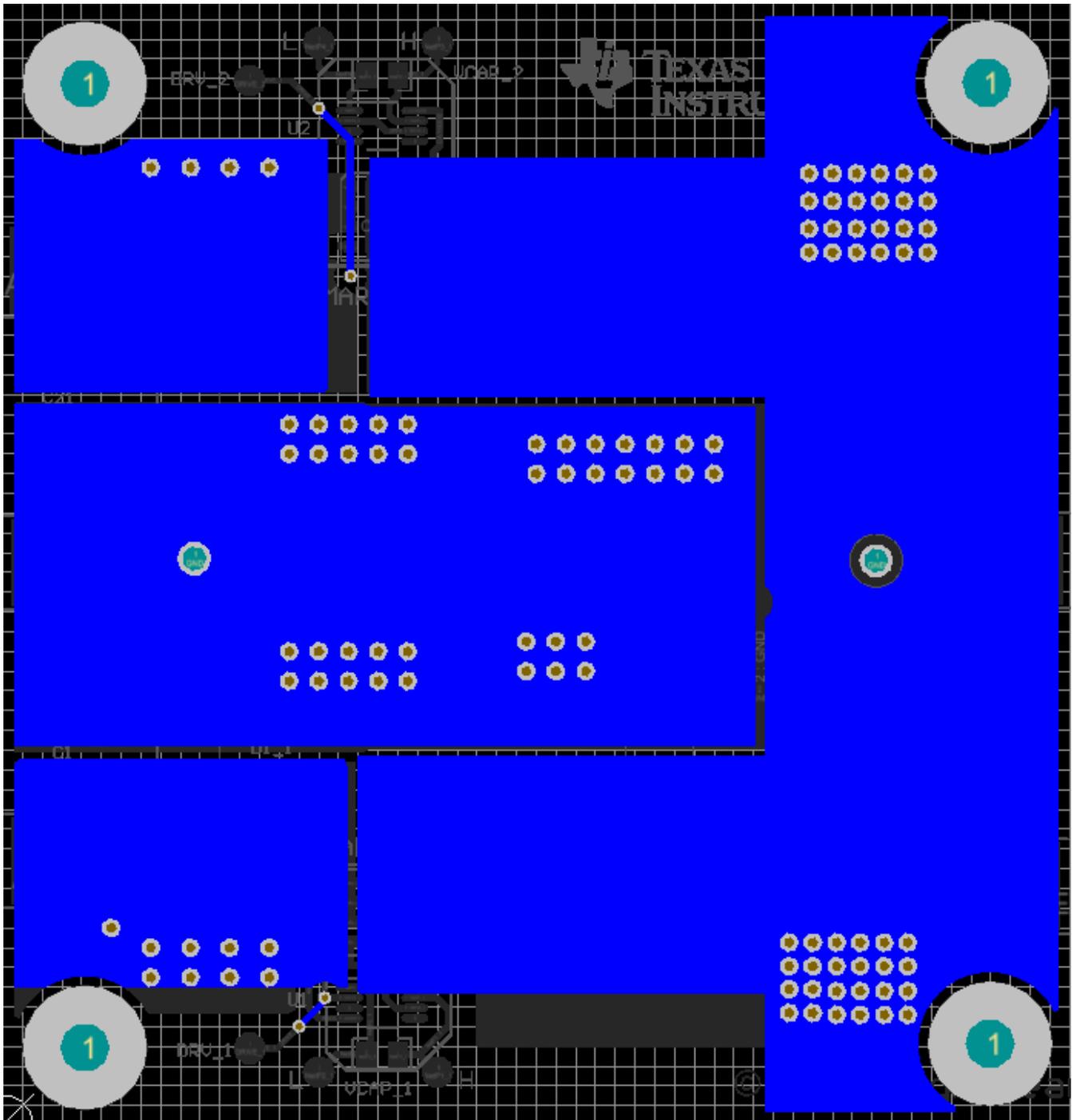


Figure 8. Bottom Layer

## 5 Schematic

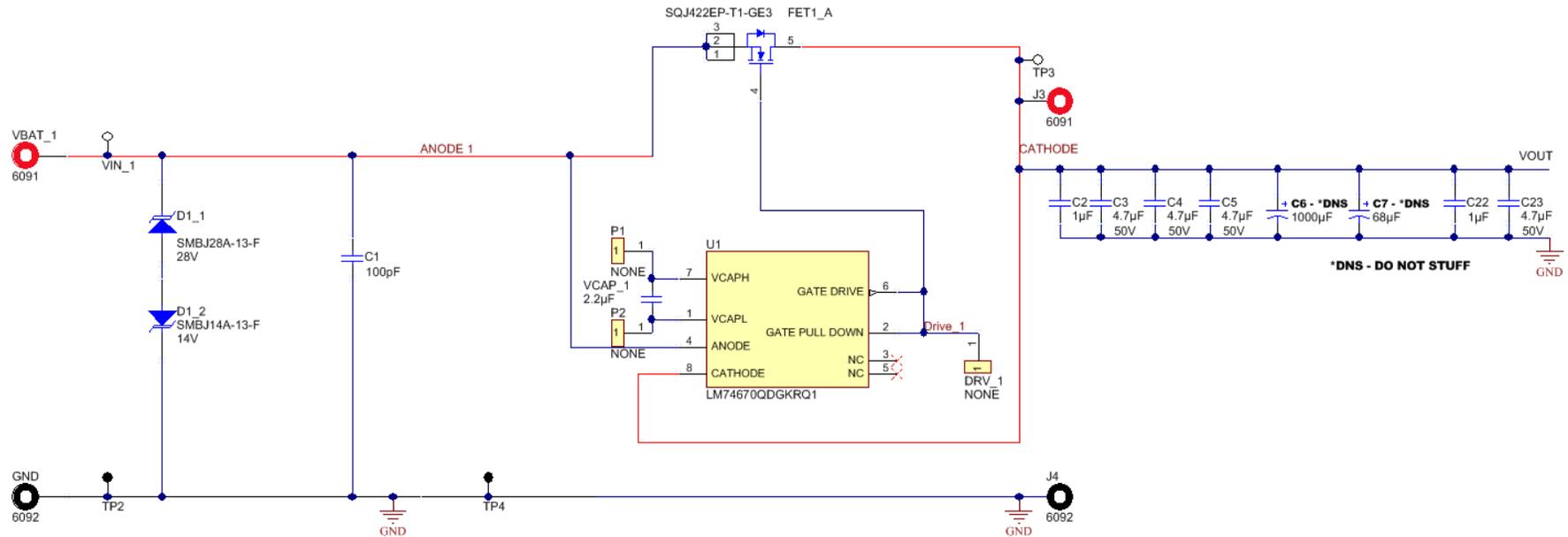


Figure 9. LM74670-Q1-SQEV Schematic

**Note:** The TVS+ and TVS- are not required for the LM74670-Q1. However, they are typically used to clamp the positive and negative voltage surges respectively. The output capacitors are recommended to protect the immediate output voltage collapse as a result of line disturbance.

## 6 Bill of Materials

**Table 2. LM74670-Q1-SQ EVM Bill of Materials for Configuration**

COUNT	REF DES	DESCRIPTION	MFR	PART NUMBER
1	C1	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0805	AVX	08055A101JAT2A
2	C2, C22	CAP, CERM, 1 $\mu$ F, 50 V, +/- 10%, X7R, 0805	TDK	C2012X7R1H105K125AB
4	C3, C4, C5, C23	CAP, CERM, 4.7 $\mu$ F, 50 V, +/- 10%, X7R, 1210	MuRata	GRM32ER71H475KA88L
DNS	C6	CAP, AL, 1000 $\mu$ F, 50 V, +/- 20%, 0.073 ohm, SMD	Panasonic	EEV-FK1H102M
DNS	C7	CAP, AL, 68 $\mu$ F, 50 V, +/- 20%, 0.6 ohm, SMD	Nippon Chemi-Con	EMVY500ADA680MHA0G
1	D1_1	Diode, TVS, Uni, 28 V, 600 W, SMB	Diodes Inc.	SMBJ28A-13-F
1	D1_2	Diode, TVS, Uni, 14 V, 600 W, SMB	Diodes Inc.	SMBJ14A-13-F
3	DRV_1, P1, P2		NONE	NONE
1	FET1_A	MOSFET, N-CH, 40 V, 75 A, PowerPAK_SO-8L	Vishay- Siliconix	SQJ422EP-T1-GE3
2	GND, J4	Standard Banana Jack, Insulated, Black	Keystone	6092
2	J3, VBAT_1	Standard Banana Jack, Insulated, Red	Keystone	6091
2	TP2, TP4	Test Point, Multipurpose, Black, TH	Keystone	5011
2	TP3, VIN_1	Test Point, Miniature, SMT	Keystone	5015
1	U1	Smart Diode Controller, DGK0008A	Texas Instruments	LM74670-Q1QDGKRQ1
1	VCAP_1	CAP, CERM, 2.2 $\mu$ F, 50 V, +/- 10%, X5R, 0805	TDK	C2012X5R1H225K125AB

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- 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.

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#### 3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210

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##### **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.

##### **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.

##### **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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3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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