

# LM74722-Q1 車載用低 IQ 理想ダイオード・コントローラ、200kHz アクティブ整流およびロード・ダンプ保護機能搭載

## 1 特長

- 下記内容で AEC-Q100 認定済み
  - デバイス温度グレード 1:
    - 40°C~+125°Cの動作時周囲温度範囲
  - デバイス HBM ESD 分類レベル 2
  - デバイス CDM ESD 分類レベル C4B
- 3V~65V の入力範囲
- 最低 -65V までの逆入力保護
- 動作時の低い静止電流: 35µA (最大値)
- 低いシャットダウン電流 (EN = LOW): 3.3µA
- アノードからカソードへ 13mV の順方向電圧降下レギュレーションを行う理想ダイオード動作
- 外部のバック・ツー・バック N チャネル MOSFET を駆動
- 30mA の昇圧レギュレータを内蔵
- 最大 200 kHz のアクティブ整流
- 逆電流阻止の高速応答: 0.5µs
- 高速な順方向 GATE ターンオン遅延: 0.72µs
- 調整可能な過電圧保護機能
- 適切な TVS ダイオードにより車載用 ISO7637 過渡要件に適合
- 省スペースの 12 ピン WSON パッケージで供給

## 2 アプリケーション

- 車載用バッテリー保護
  - ADAS ドメイン・コントローラ
  - プレミアム・オーディオ・アンプ
  - ヘッド・ユニット

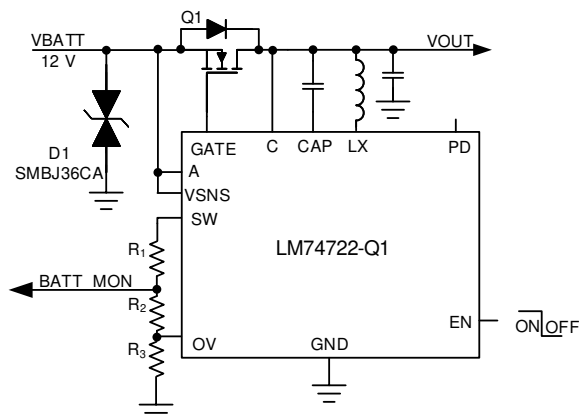
## 3 概要

LM74722-Q1 理想ダイオード・コントローラは外付けのバック・ツー・バック N チャネル MOSFET を駆動および制御して、電力バスの ON / OFF 制御と過電圧保護を備えた理想ダイオード整流器をエミュレートします。入力電源電圧範囲が 3V~65V と広いため、12V および 24V 車載用バッテリー駆動 ECU を保護および制御できます。このデバイスは最低 -65V の負の電源電圧に耐え、この電圧から負荷を保護できます。内蔵の理想ダイオード・コントローラ (GATE) は第 1 の MOSFET を駆動し、逆入力保護および出力電圧保持用のショットキー・ダイオードを置き換えることができます。高速ターンオン / オフ・コンパレータを搭載した強力な昇圧レギュレータは、たとえば、ECU が入力の瞬断にさらされたり、入力信号に最大 200kHz の周波数で AC が重畳されたりする、ISO16750 または LV124 などの車載テスト時に、堅牢で効率的な MOSFET スwitching 性能を確実に発揮します。動作中の静止電流が 35µA (最大値) と低いので、常時オンのシステム設計が可能になります。電力バスに第 2 の MOSFET を使えば、EN ピンを使用した負荷切断制御が可能になります。EN が LOW のとき、静止電流は 3.3µA (最大値) まで減少します。このデバイスは、OV ピンを使用して調整可能な過電圧カットオフまたは過電圧クランプ保護機能を備えています。

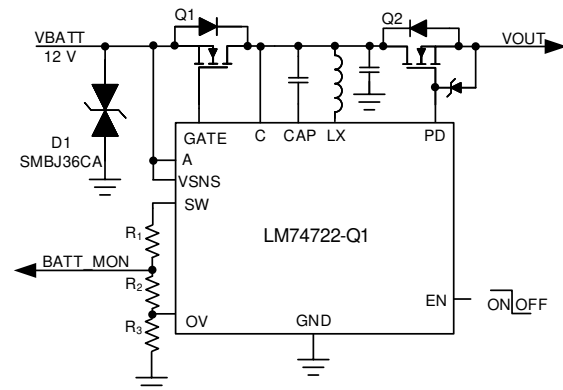
### 製品情報

部品番号	パッケージ <sup>(1)</sup>	本体サイズ (公称)
LM74722-Q1	WSON (12)	3.00mm × 3.00mm

(1) 利用可能なパッケージについては、このデータシートの末尾にある注文情報を参照してください。



低 IQ の理想ダイオード



スイッチ出力を備えた低 IQ の理想ダイオード



## Table of Contents

<b>1 特長</b> .....	1	9.1 Application Information.....	14
<b>2 アプリケーション</b> .....	1	9.2 Typical 12-V Reverse Battery Protection Application.....	14
<b>3 概要</b> .....	1	9.3 What to Do and What Not to Do.....	22
<b>4 Revision History</b> .....	2	<b>10 Power Supply Recommendations</b> .....	23
<b>5 Pin Configuration and Functions</b> .....	3	10.1 Transient Protection.....	23
<b>6 Specifications</b> .....	4	10.2 TVS Selection for 12-V Battery Systems.....	24
6.1 Absolute Maximum Ratings.....	4	10.3 TVS Selection for 24-V Battery Systems.....	24
6.2 ESD Ratings.....	4	<b>11 Layout</b> .....	25
6.3 Recommended Operating Conditions.....	4	11.1 Layout Guidelines.....	25
6.4 Thermal Information.....	5	11.2 Layout Example.....	25
6.5 Electrical Characteristics.....	5	<b>12 Device and Documentation Support</b> .....	26
6.6 Switching Characteristics.....	6	12.1 Receiving Notification of Documentation Updates..	26
6.7 Typical Characteristics.....	7	12.2 サポート・リソース.....	26
<b>7 Parameter Measurement Information</b> .....	9	12.3 Trademarks.....	26
<b>8 Detailed Description</b> .....	10	12.4 Electrostatic Discharge Caution.....	26
8.1 Overview.....	10	12.5 Glossary.....	26
8.2 Functional Block Diagram.....	10	<b>13 Mechanical, Packaging, and Orderable Information</b> .....	26
8.3 Feature Description.....	11		
8.4 Device Functional Modes.....	13		
<b>9 Application and Implementation</b> .....	14		

## 4 Revision History

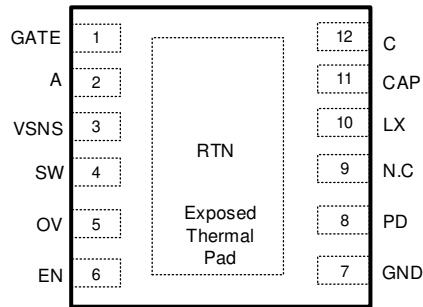
資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

Changes from Revision A (February 2022) to Revision B (August 2022)	Page
• ステータスを「事前情報」から「量産データ」に変更.....	1

---

Changes from Revision * (September 2021) to Revision A (February 2022)	Page
• データシートのタイトルを更新.....	1
• Updated the <i>Load Disconnect Switch Control (PD)</i> description.....	11

## 5 Pin Configuration and Functions



5-1. WSON 12-Pin DRR Transparent Top View

表 5-1. Pin Functions

PIN		TYPE	DESCRIPTION
NAME	LM74722-Q1 DRR-12 (WSON)		
GATE	1	O	Diode controller gate drive output. Connect to the GATE of the external MOSFET.
A	2	I	Anode of the ideal diode. Connect to the source of the external MOSFET.
VSNS	3	I	Voltage sensing input
SW	4	I	Voltage sensing disconnect switch terminal. VSNS and SW connect internally through a switch. Use SW as the top connection of the battery sensing or OV resistor ladder network. When EN is pulled low, the switch is OFF disconnecting the resistor ladder from the battery line, thereby cutting off the leakage current. If the internal disconnect switch between VSNS and SW is not used, then short them together and connect to C pin.
OV	5	I	Adjustable overvoltage threshold input. Connect a resistor ladder across SW to OV terminal. When the voltage at OV exceeds the over voltage cut-off threshold, then the PD is pulled low turning OFF the HSFET. PD is driven high when the sense voltage goes below the OV falling threshold.
EN	6	I	EN input. Connect to A or C pin for always ON operation. In this mode, the device consumes an IQ of 35 $\mu$ A (maximum) that can be driven externally from a micro controller I/O. Pulling this pin low below 0.3 V enters the device in low Iq shutdown mode.
GND	7	G	Connect to the system ground plane.
PD	8	O	Pull down connection for the external HSFET. Connect to the GATE of the external FET. Keep PD pin floating when not used.
N.C	9	I	No connect
LX	10	I	Switch node of the internal boost regulator. This node must be kept small on the PCB for good performance and low EMI. Connect the boost inductor between this pin and the DRAIN connection of the external FET.
CAP	11	O	Boost regulator output. This pin is used to provide a drive voltage to the gate driver of the ideal diode stage as well as drive supply for the HSFET. Connect a 1- $\mu$ F capacitor between this pin and the DRAIN connection of the external FET.
C	12	I	Cathode of the ideal diode and supply voltage pin. Connect to the DRAIN of the external MOSFET. The voltage sensed at this pin is used to control the external MOSFET GATE. This pin must be locally bypassed with at least 1 $\mu$ F.
RTN	Thermal Pad	—	Leave exposed pad floating. Do not connect to GND plane.

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

		MIN	MAX	UNIT
Input Pins	A to GND	-65	70	V
Input Pins	C to GND	-0.3	70	V
Input Pins	VSNS, SW, EN, OV to GND, $V_{(A)} > 0$ V	-0.3	70	V
Input Pins	VSNS, SW, EN, OV to GND, $V_{(A)} \leq 0$ V	$V_{(A)}$	$(70 + V_{(A)})$	V
Input Pins	RTN to GND	-65	0.3	V
Input Pins	$I_{VSNS}$ , $I_{SW}$	-1	10	mA
Input Pins	$I_{EN}$ , $I_{OV}$ , $V_{(A)} > 0$ V	-1		mA
Input Pins	$I_{EN}$ , $I_{OV}$ , $V_{(A)} \leq 0$ V	Internally limited		
Output Pins	CAP to C	-0.3	15.9	V
Output Pins	CAP to A	-0.3	85	V
Output Pins	GATE to A	-0.3	15	V
Output Pins	LX, CAP, PD to GND	-0.3	85	V
Output to Input Pins	C to A	-5	85	V
Operating junction temperature, $T_J$ <sup>(2)</sup>		-40	150	°C
Storage temperature, $T_{stg}$		-40	150	°C

- Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime
- High junction temperatures degrade operating lifetimes. Operating lifetime is de-rated for junction temperatures greater than 125°C.

### 6.2 ESD Ratings

			VALUE	UNIT	
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per AEC Q100-002 <sup>(1)</sup>	±2000	V	
		Charged device model (CDM), per AEC Q100-011	Corner pins (GATE, EN, GND, C)		±750
			Other pins		±500

- AEC-Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specifications.

### 6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

		MIN	NOM	MAX	UNIT
Input Pins	A to GND	-60		65	V
	C to GND			65	
	EN to GND	-60		65	
External capacitance	A	0.1			µF
	VS, C, CAP to C	1			µF
External Inductor	LX	100			µH
External MOSFET max $V_{GS}$ rating	GATE to A	15			V
$T_J$	Operating junction temperature range <sup>(2)</sup>	-40		150	°C

- Recommended Operating Conditions are conditions under which the device is intended to be functional. For specifications and test conditions, see [Electrical Characteristics](#).

(2) High junction temperatures degrade operating lifetimes. Operating lifetime is de-rated for junction temperatures greater than 125°C.

## 6.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>		LM74722-Q1	UNIT
		DRR (WSON)	
		12 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	61.6	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	50	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	32.7	°C/W
$\Psi_{JT}$	Junction-to-top characterization parameter	1.4	°C/W
$\Psi_{JB}$	Junction-to-board characterization parameter	32.7	°C/W
$R_{\theta JC}$	Junction-to-case (bottom) thermal resistance	6.9	°C/W

(1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report, SPRA953.

## 6.5 Electrical Characteristics

$T_J = -40^\circ\text{C}$  to  $+125^\circ\text{C}$ ; typical values at  $T_J = 25^\circ\text{C}$ ,  $V_{(A)} = V_{(C)} = 12\text{ V}$ ,  $C_{(CAP)} = 1\ \mu\text{F}$ ,  $V_{(EN)} = 2\text{ V}$ , over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>V<sub>A</sub> SUPPLY VOLTAGE</b>						
$V_{(A\ POR)}$	VA POR Rising threshold		3.1	3.4	3.85	V
	VA POR Falling threshold		2.2	2.6	2.9	
$V_{(C)}$	Minimum voltage at C				3	
$I_{(SHDN)}$	Shutdown Supply Current	$V_{(EN)} = 0\text{ V}$		1.5	3.3	$\mu\text{A}$
$I_{(Q)}$	Total System Quiescent Current	$V_{(EN)} = 2\text{ V}$ , Active Rectifier Controller In Regulation, $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$		27	32	
		$V_{(EN)} = 2\text{ V}$ , Active Rectifier Controller In Regulation, $-40^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$		27	35	
<b>ENABLE INPUT</b>						
$V_{(EN\_IH)}$	Enable input high threshold				2	V
$V_{(EN\_IL)}$	Enable input low threshold		0.5	0.85	1.2	
$V_{(EN\_Hys)}$	Enable Hysteresis			485		mV
$I_{(EN)}$	Enable sink current	$V_{(EN)} = 12\text{ V}$		55	155	nA
<b>V<sub>ANODE</sub> to V<sub>CATHODE</sub></b>						
$V_{(AC\ REG)}$	Regulated Forward $V_{(AC)}$ Threshold		7.5	12.8	18.7	mV
$V_{(AC\_FWD)}$	$V_{(AC)}$ threshold from RCB to oFCB		75	105	140	
$V_{(AC\_REV)}$	$V_{(AC)}$ threshold for reverse current blocking		-12	-5.6	-1.3	
<b>GATE DRIVE</b>						
$V_{(GATE)} - V_{(A)}$		$3\text{ V} < V_{(C)} < 65\text{ V}$	9.5		13	V
$I_{(GATE)}$	Regulation max sink current	$V_{(A)} - V_{(C)} = 0\text{ V}$ , $V_{(GATE)} - V_{(A)} = 5\text{ V}$	8.5	22	39	$\mu\text{A}$
	Peak Pull down current	$V_{(A)} - V_{(C)} = -20\text{ mV}$		2.5		A
$R_{GATE}$	GATE pull down resistance	$V_{(A)} - V_{(C)} = -20\text{ mV}$ , $V_{(GATE)} - V_{(A)} = 100\text{ mV}$		1.2		$\Omega$
<b>BOOST REGULATOR CHARGE PUMP</b>						
$V_{(CAP)} - V_{(C)}$	Boost output rising threshold			13	15.5	V
	Hysteresis			1.1		

## 6.5 Electrical Characteristics (continued)

$T_J = -40^\circ\text{C}$  to  $+125^\circ\text{C}$ ; typical values at  $T_J = 25^\circ\text{C}$ ,  $V_{(A)} = V_{(C)} = 12\text{ V}$ ,  $C_{(CAP)} = 1\ \mu\text{F}$ ,  $V_{(EN)} = 2\text{ V}$ , over operating free-air temperature range (unless otherwise noted)

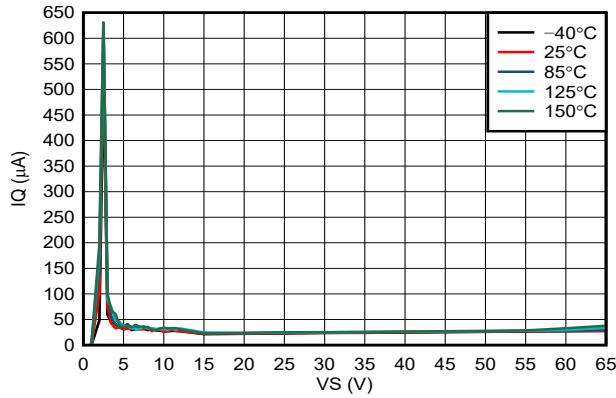
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$I_{(CAP)}$	Boost load capacity	$V_{(CAP)} - V_{(C)} = 7.5\text{ V}$		29		mA
$I_{(LX)}$	Peak Inductor current limit	$V_{(C)} = 12\text{ V}$	110	140	175	
		$V_{(C)} = 3\text{ V}$			210	
$R_{(LX)}$	Low side switch on-resistance		1.3	2.7	5.1	$\Omega$
<b>BATTERY SENSING (VSNS, SW) AND OVER VOLTAGE DETECTION (OVP, PD)</b>						
$R_{(SW)}$	Battery sensing disconnect switch resistance		104	226	430	$\Omega$
$V_{(OVR)}$	Overvoltage threshold input, rising		1.13	1.231	1.33	V
$V_{(OVF)}$	Overvoltage threshold input, falling		1.03	1.125	1.215	V
$V_{(OV\_Hys)}$	OV Hysteresis			110		mV
$I_{(OV)}$	OV Input leakage current	$0\text{ V} < V_{(OV)} < 5\text{ V}$		50	110	nA
$I_{(PD\_SRC)}$	Pull up current	$3\text{ V} < V_{(C)} < 65\text{ V}$	43	50	60	$\mu\text{A}$
$I_{(PD\_SINK,PK)}$	Peak Pull down current	$V_{(OV)} > V_{(OVR)}$	55	88	117	mA
$I_{(PD\_SINK,DC)}$	DC Pull down current		7	10	14	mA
<b>CATHODE</b>						
$V_{(C)}$	C POR Rising		2.58	2.8	2.95	V
	C POR Falling		2.35	2.6	2.85	
$I_{(C)}$	C sink current	$V_{(A)} = 12\text{ V}$ , $V_{(A)} - V_{(C)} = -100\text{ mV}$		8.5	15	$\mu\text{A}$
		$V_{(A)} = -14\text{ V}$ , $V_{(C)} = 14\text{ V}$		12.8	18	

## 6.6 Switching Characteristics

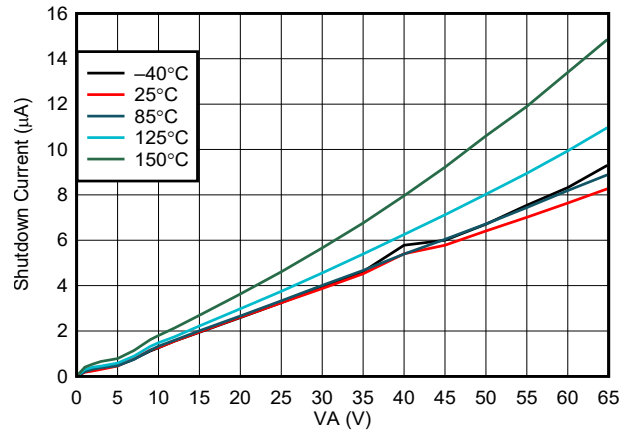
$T_J = -40^\circ\text{C}$  to  $+125^\circ\text{C}$ ; typical values at  $T_J = 25^\circ\text{C}$ ,  $V_{(A)} = V_{(C)} = 12\text{ V}$ ,  $C_{(CAP)} = 1\ \mu\text{F}$ ,  $V_{(EN)} = 2\text{ V}$ , over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{A\_POR(DLY)}$	A (low to high) to GATE turn-on delay	$V_{(A)} \uparrow V_{(A\text{ POR})}$ to $V_{(GATE-A)} > 5\text{ V}$ , $C_{((GATE-A))} = 10\text{ nF}$			200	$\mu\text{s}$
$t_{GATE\_ON(DLY)}$	Forward voltage detection to GATE turn-on delay	$V_{(A)} - V_{(C)} = -100\text{ mV}$ to $700\text{ mV}$ , $V_{(GATE-A)} > 5\text{ V}$ , $C_{((GATE-A))} = 10\text{ nF}$		0.72	1.25	$\mu\text{s}$
		$V_{(A)} - V_{(C)} = -100\text{ mV}$ to $700\text{ mV}$ , $V_{(GATE-A)} > 5\text{ V}$ , $C_{((GATE-A))} = 30\text{ nF}$		1.02	1.9	$\mu\text{s}$
$t_{GATE\_OFF(DLY)}$	Reverse voltage detection to GATE turn-off delay	$V_{(A)} - V_{(C)} = +30\text{ mV}$ to $-100\text{ mV}$ , $V_{(GATE-A)} < 1\text{ V}$ , $C_{((GATE-A))} = 10\text{ nF}$		0.46	0.65	$\mu\text{s}$
$t_{EN\_OFF(DLY)PD}$	EN to PD Delay	EN $\downarrow$ to PD $\downarrow$		6.5	12	$\mu\text{s}$
$t_{OV\_OFF(DLY)PD}$	OV to PD Deglitch	OV $\uparrow$ to PD $\downarrow$		0.9	1.5	$\mu\text{s}$
$t_{PD\_PK}$	Peak Pull Down duration	$I_{(PD\_SINK,PK)} \uparrow$ to $I_{(PD\_SINK,DC)} \downarrow$	11	38	65	$\mu\text{s}$

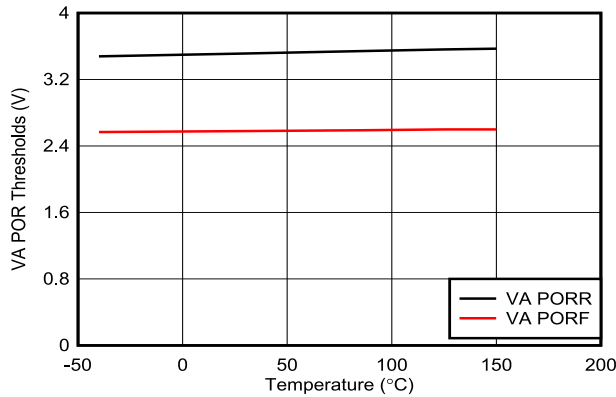
## 6.7 Typical Characteristics



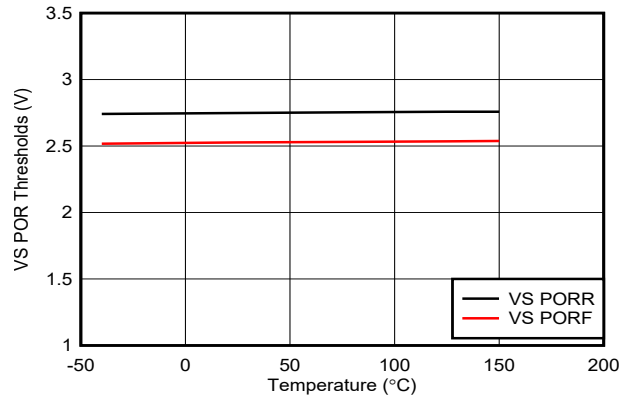
6-1. Operating Quiescent Current vs Supply Voltage



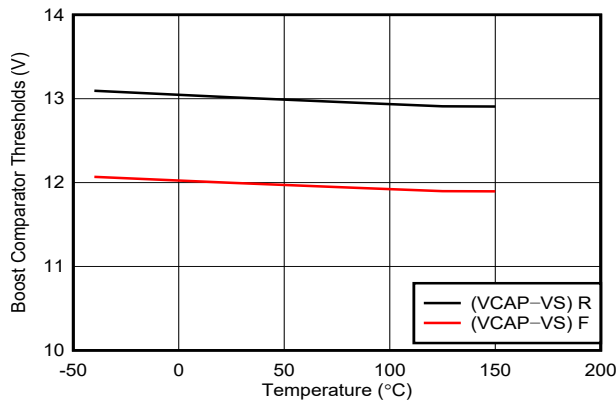
6-2. Shutdown Supply Current vs Supply Voltage



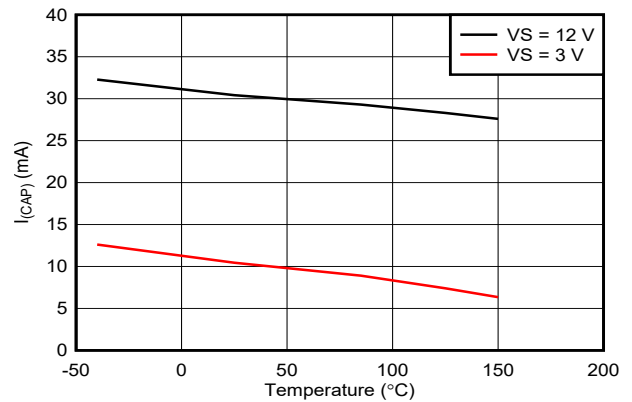
6-3. VA POR Threshold vs Temperature



6-4. VS POR Threshold vs Temperature

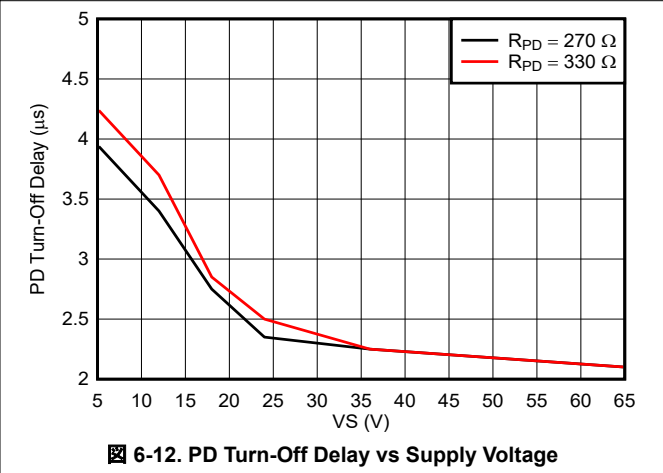
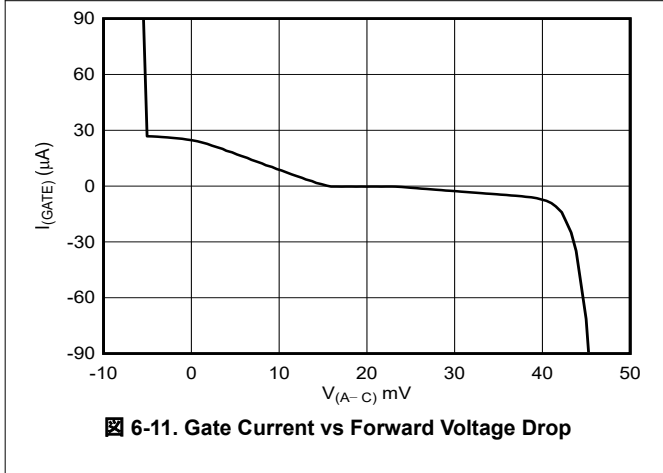
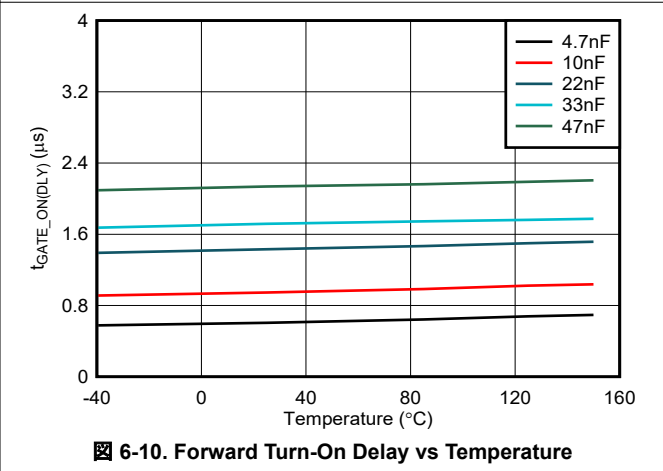
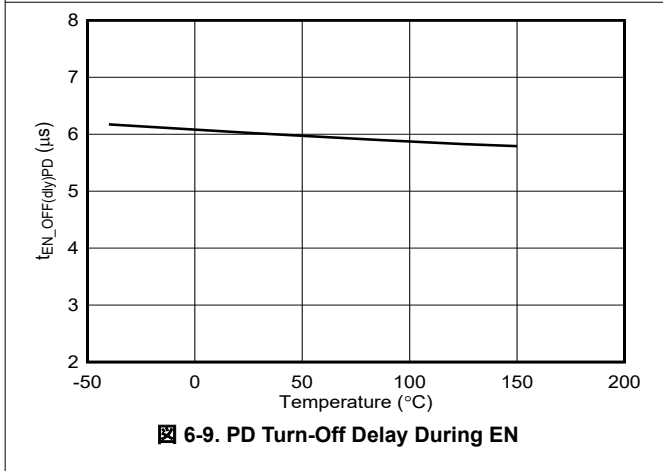
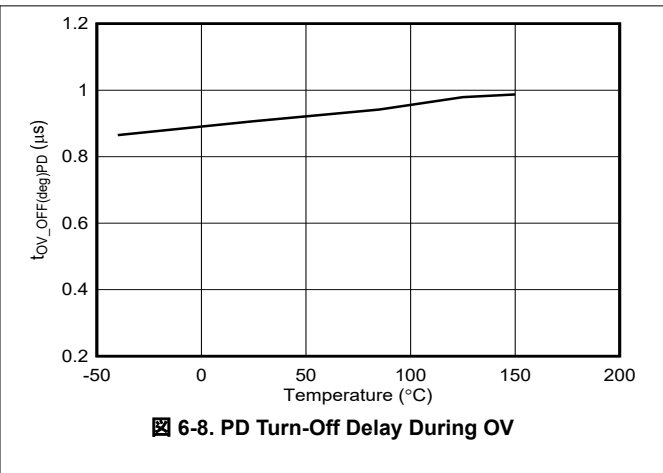
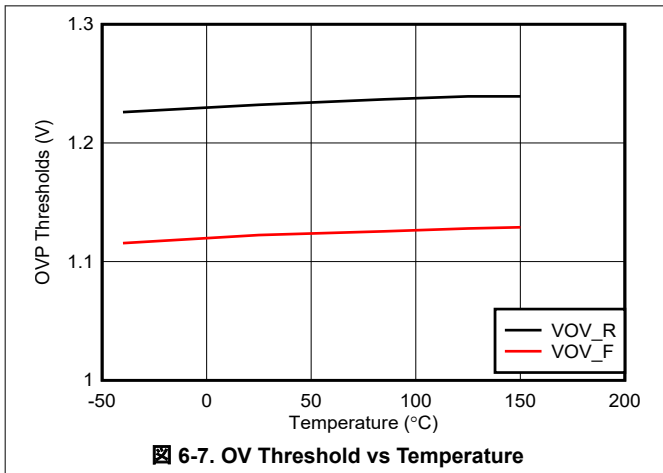


6-5. Boost Comparator Threshold vs Temperature



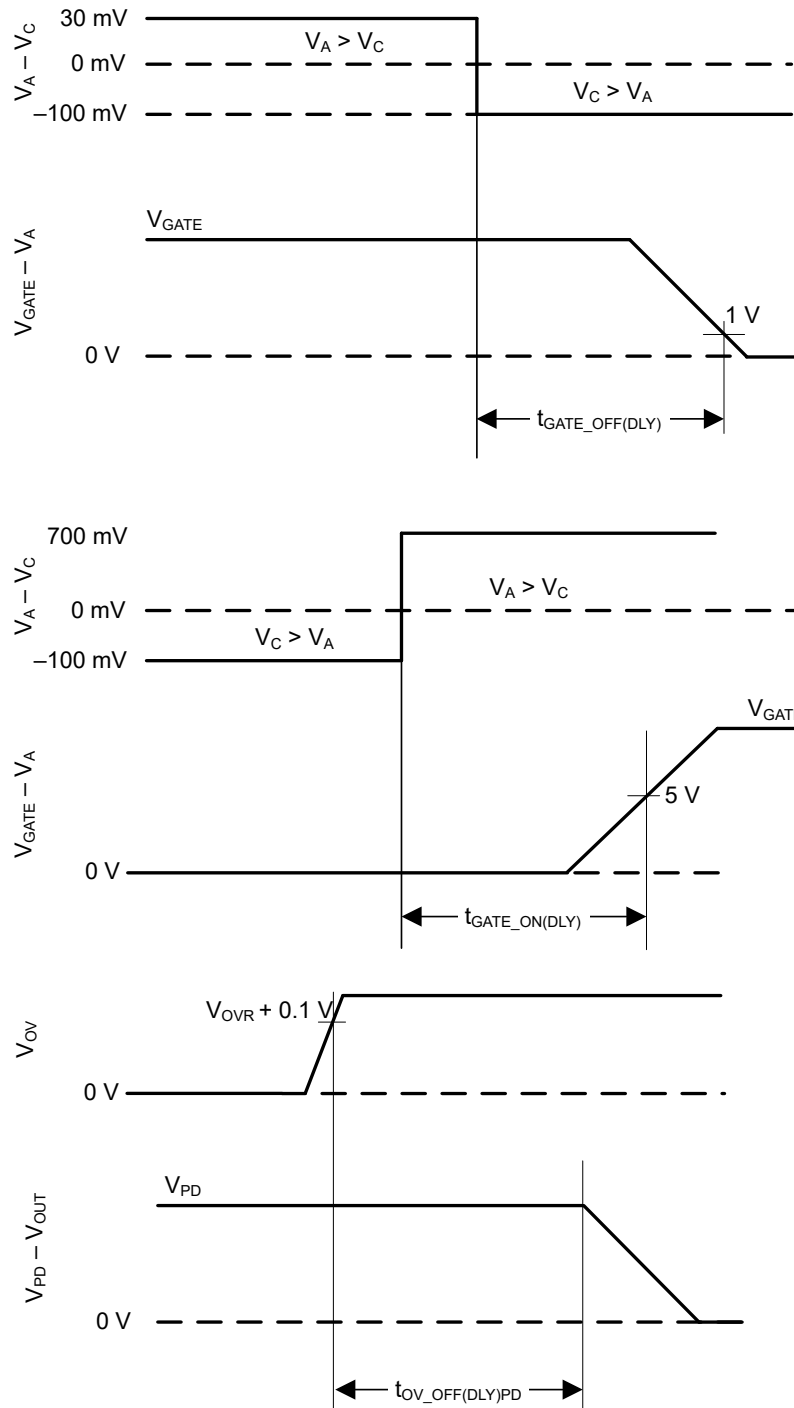
6-6. Boost Loading Capacity vs Temperature

### 6.7 Typical Characteristics (continued)





## 7 Parameter Measurement Information




**7-1. Timing Waveforms**

## 8 Detailed Description

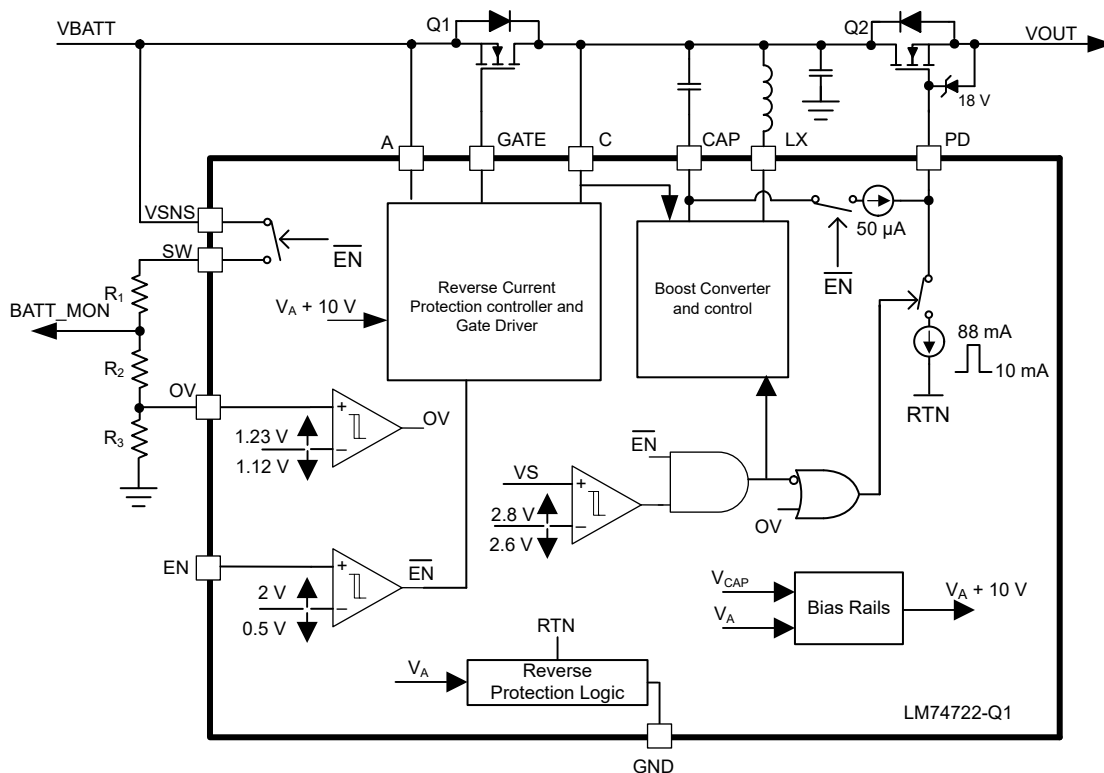
### 8.1 Overview

The LM74722-Q1 ideal diode controller drives and controls external back-to-back N-Channel MOSFETs to emulate an ideal diode rectifier with power path ON and OFF control and overvoltage protection. The wide input supply of 3 V to 65 V allows protection and control of 12-V and 24-V automotive battery powered ECUs. IQ during operation (EN = High) is <math>< 35 \mu\text{A}</math> and <math>< 3.3 \mu\text{A}</math> during shutdown mode (EN = Low). The device can withstand and protect the loads from negative supply voltages down to  $-65\text{ V}$ . An integrated ideal diode controller (GATE) drives the first MOSFET to replace a Schottky diode for reverse input protection and output voltage holdup. A strong 30-mA boost regulator and short turn-ON and turn-OFF delay times of comparators ensures fast transient response ensuring robust and efficient MOSFET switching performance during automotive testing, such as ISO16750 or LV124, where an ECU is subjected to input short interruptions and AC superimpose input signals up to 200-kHz frequency. The device features an adjustable overvoltage cutoff protection feature for load dump protection.

The LM74722-Q1 controls the GATE of the MOSFET Q1 to regulate the forward voltage drop at 13 mV. The linear regulation scheme in these devices enables graceful control of the GATE voltage and turns off of the MOSFET during a reverse current event and ensures zero DC reverse current flow.

LM74722-Q1 PD gate drive can be used to drive load disconnect MOSFET (Q2). The back to back connected MOSFET configuration can be used when system requires overvoltage protection, inrush current protection or output load disconnect function.

### 8.2 Functional Block Diagram



## 8.3 Feature Description

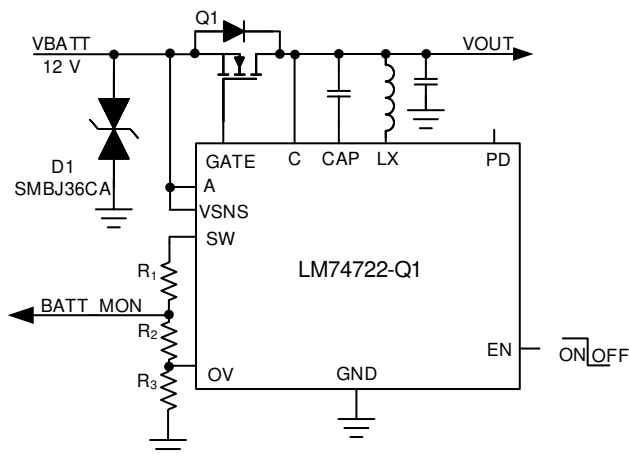
### 8.3.1 Dual Gate Control (GATE, PD)

The LM74722-Q1 features two separate gate control and driver outputs. That is, GATE and PD to drive back-to-back N-channel MOSFETs.

#### 8.3.1.1 Reverse Battery Protection (A, C, GATE)

A, C, GATE comprises of the ideal diode stage. Connect the source of the external MOSFET to A, drain to C and gate to GATE pin. The LM74722-Q1 has integrated reverse input protection down to  $-65$  V.

In LM74722-Q1, the voltage drop across the MOSFET is continuously monitored between the A and C pins. The GATE to A voltage is adjusted as needed to regulate the forward voltage drop at 13 mV (typical). This closed loop regulation scheme enables graceful turn-off of the MOSFET during a reverse current event and ensures zero DC reverse current flow. This scheme ensures robust performance during slow input voltage ramp down tests. Along with the linear regulation amplifier scheme, the LM74722-Q1 also integrates a fast reverse voltage comparator. When the voltage drop across A and C reaches  $V_{(AC\_REV)}$  threshold, then the GATE goes low within 0.5  $\mu$ s (typical). This fast reverse voltage comparator scheme ensures robust performance during fast input voltage ramp down tests such as input micro-shorts. The external MOSFET is turned ON back when the voltage across A and C hits the  $V_{(AC\_FWD)}$  threshold within 0.72  $\mu$ s (typical). As shown in [Figure 8-1](#), for ideal diode only designs, connect LM74722-Q1.

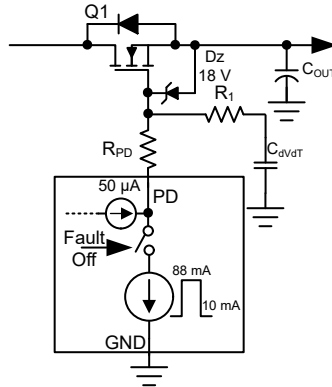


**Figure 8-1. Configuring LM74722-Q1 for Ideal Diode Only**

#### 8.3.1.2 Load Disconnect Switch Control (PD)

The PD pin provides a 50- $\mu$ A drive and 88-mA peak pulldown strength for the load disconnect switch stage. Connect the Gate of the FET to PD pin. Place a 18-V Zener (Dz) across the FET gate and source.

For inrush current limiting, connect  $C_{dVdT}$  capacitor and  $R_1$  as shown in [Figure 8-2](#).



**8-2. Inrush Current Limiting**

The  $C_{dVdT}$  capacitor is required for slowing down the PD voltage ramp during power up for inrush current limiting. Use [式 1](#) to calculate  $C_{dVdT}$  capacitance value.

$$C_{dVdT} = \frac{I_{PD\_DRV} \times C_{OUT}}{I_{INRUSH}} \quad (1)$$

where  $I_{PD\_DRV}$  is 50  $\mu\text{A}$  (typical),  $I_{INRUSH}$  is the inrush current, and  $C_{OUT}$  is the output load capacitance. An extra resistor,  $R_1$ , in series with the  $C_{dVdT}$  capacitor improves the turn-off time.

PD is pulled low during the following conditions:

- During an OV event with the OV pin voltage rising above the  $V_{(OVR)}$  threshold
- When the EN pin is pulled low with  $V_{(EN)}$  driven lower than  $V_{(EN\_IL)}$  level
- When the voltage at VS pin drops below the  $V_{(VS\_POR)}$  falling threshold

During these conditions, the FET Q1 turns OFF with its GATE connected to its SOURCE terminal through the external Zener (Dz).

Use [式 2](#) to the peak power dissipated in the LM74722-Q1 at the instance of PD pulldown.

$$P_{PD\_peak} = V_{OUT} \times I_{PD\_SINK} \quad (2)$$

where

- $I_{PDSINK\_peak}$  is the peak sink current of 88 mA (typical)

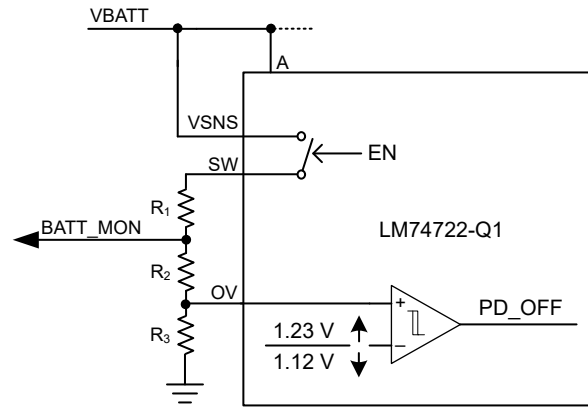
In the system designs with input voltage above 48 V, TI recommends to place a resistor,  $R_{PD}$ , in series with the PD pin as shown in [8-2](#). The peak power dissipation during the pulldown events gets distributed in  $R_{PD}$  and the internal PD switch. A resistor value in the range of 270  $\Omega$  to 330  $\Omega$  can be selected to limit the device power dissipation within the safe limits.

### 8.3.1.3 Overvoltage Protection and Battery Voltage Sensing (VSNS, SW, OV)

A disconnect switch is integrated between VSNS and SW pins. When the device is enabled, this internal switch allows input voltage monitoring by connecting a resistor divider from SW pin to GND. This switch is turned OFF when EN pin is pulled low. This action helps to reduce the leakage current through the resistor divider network during system shutdown state (IGN\_OFF state).

LM74722-Q1 has an OV pin which can be used to design overvoltage cutoff (OV setpoint referred to input side, VIN) or overvoltage clamp functionality (OV setpoint referred to output side, VOUT).

[8-3](#) shows a typical resistor ladder connection for battery voltage sensing and overvoltage threshold programming.



**8-3. Programming Overvoltage Threshold and Battery Voltage Sensing**

### 8.3.2 Boost Regulator

The LM74722-Q1 integrates a boost converter to provide voltage necessary to drive the external N-channel MOSFETs for the ideal diode and the load disconnect stages. Place a 1- $\mu$ F capacitor across drain of the FET to GND and across the CAP pin to drain of the FET. Use a 100- $\mu$ H inductor with saturation current rating > 175 mA. For the boost converter to be enabled, the EN pin voltage must be above the specified input high threshold,  $V_{(ENR)}$ . The boost converter has a maximum output load capacity of 30-mA typical. If EN pin is pulled low, then the boost converter remains disabled.

## 8.4 Device Functional Modes

### Shutdown Mode

The LM74722-Q1 enters shutdown mode when the EN pin voltage is below the specified input low threshold,  $V_{(EN\_IL)}$ . Both the gate drivers (GATE and PD) and the boost regulator are disabled in shutdown mode. During shutdown mode, the LM74722-Q1 enters low IQ operation with a total input quiescent consumption of 1.5  $\mu$ A (typical).

## 9 Application and Implementation

### 注

以下のアプリケーション情報は、TI の製品仕様に含まれるものではなく、TI ではその正確性または完全性を保証いたしません。個々の目的に対する製品の適合性については、お客様の責任で判断していただくこととなります。お客様は自身の設計実装を検証しテストすることで、システムの機能を確認する必要があります。

### 9.1 Application Information

LM74722-Q1 controls two N-channel power MOSFETs with GATE used to control diode MOSFET to emulate an ideal diode and PD controlling second MOSFET for power path cutoff when disabled or during an overvoltage protection and provide inrush current limiting. IQ during operation (EN = High) is < 38  $\mu$ A and < 3.5  $\mu$ A during shutdown mode (EN = Low). LM74722-Q1 can be placed into low quiescent current mode using EN = low, where both GATE and PD are turned OFF.

### 9.2 Typical 12-V Reverse Battery Protection Application

図 9-1 shows a typical application circuit of LM74722-Q1 configured to provide reverse battery protection with overvoltage protection and inrush current limiting.

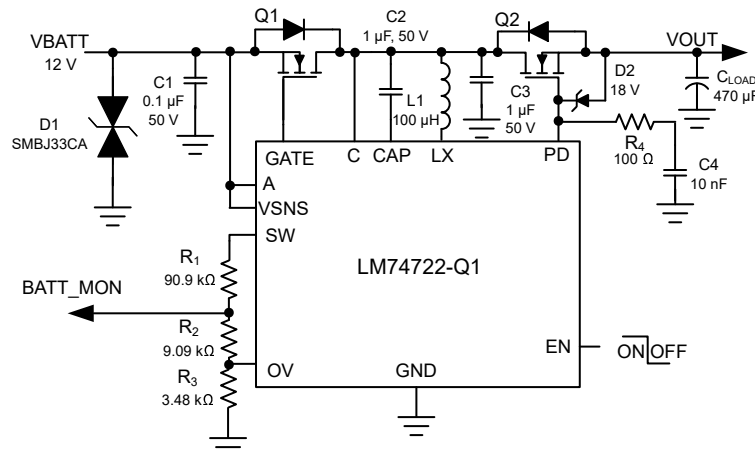


図 9-1. Typical Application Circuit – 12-V Reverse Battery Protection and Overvoltage Protection

#### 9.2.1 Design Requirements for 12-V Battery Protection

表 9-1 lists the system design requirements.

表 9-1. Design Parameters - 12-V Reverse Battery Protection and Overvoltage Protection

DESIGN PARAMETER	EXAMPLE VALUE
Operating input voltage range	12-V battery, 12-V nominal with 3.2-V cold crank and 35-V load dump
Output power	50 W
Output current range	4-A nominal, 5-A maximum
Input capacitance	0.1- $\mu$ F minimum
Output capacitance	0.1- $\mu$ F minimum, (optional 220 $\mu$ F for E-10 functional class A performance)
Overvoltage cutoff	37 V, output cutoff > 37 V
AC super imposed test	2-V peak-peak 100 kHz
Automotive transient immunity compliance	ISO 7637-2, ISO 16750-2 and LV124
Battery monitor ratio	8:1

### 9.2.1.1 Automotive Reverse Battery Protection

#### 9.2.1.1.1 Input Transient Protection: ISO 7637-2 Pulse 1

ISO 7637-2 pulse 1 specifies negative transient immunity of electronic modules connected in parallel with an inductive load when the battery is disconnected. A typical pulse 1 specified in ISO 7637-2 starts with battery disconnection where supply voltage collapses to 0 V followed by  $-150\text{ V}$  2 ms applied with a source impedance of  $10\ \Omega$  at a slew rate of  $1\ \mu\text{s}$  on the supply input. LM74722-Q1 blocks reverse current and prevents the output voltage from swinging negative, protecting the rest of the electronic circuits from damage due to negative transient voltage. MOSFET Q1 is quickly turned off within  $0.5\ \mu\text{s}$  by fast reverse comparator of LM74722-Q1. A single bidirectional TVS is required at the input to clamp the negative transient pulse within the operating maximum voltage across cathode to anode of  $85\text{ V}$  and does not violate the MOSFET Q1 drain-source breakdown voltage rating.

Figure 9-2 shows ISO 7637-2 pulse 1 performance of LM74722-Q1.

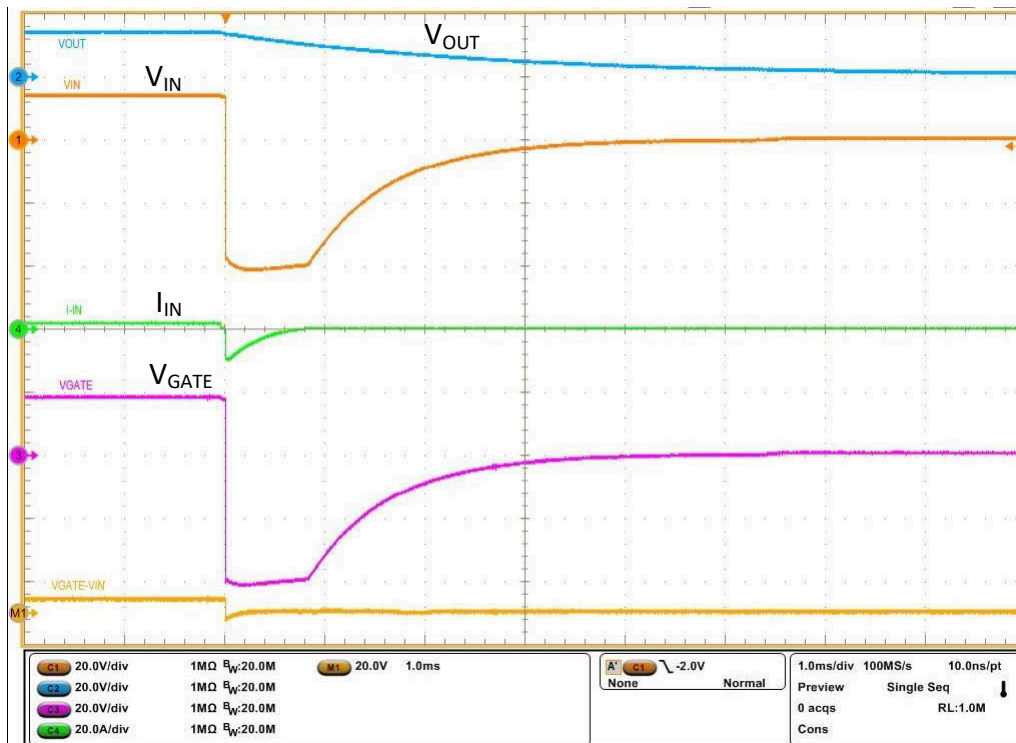


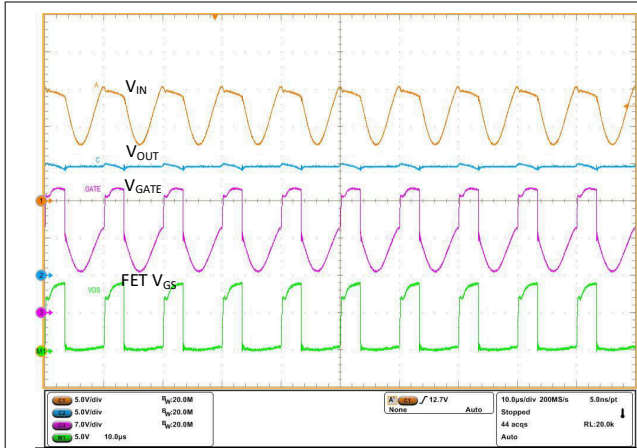
Figure 9-2. Performance During ISO 7637-2 Pulse 1 Test

#### 9.2.1.1.2 AC Super Imposed Input Rectification: ISO 16750-2 and LV124 E-06

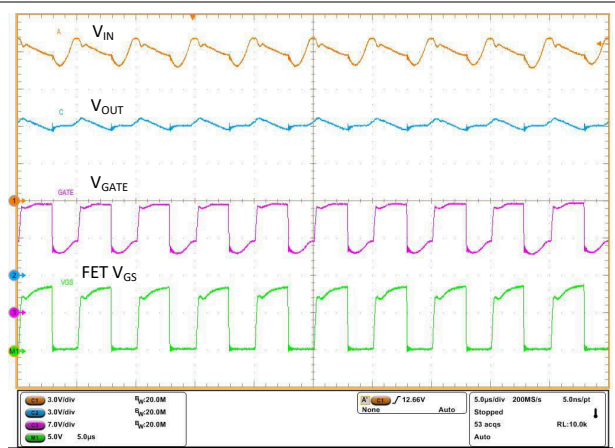
Alternators are used to power the automotive electrical system and charge the battery during normal run time of the vehicle. Rectified alternator output contains residual AC ripple voltage superimposed on the DC battery voltage due to various reasons. These reasons include engine speed variation, regulator duty cycle with field switching ON and OFF, and electrical load variations. On a 12-V battery supply, alternator output voltage is regulated by a voltage regulator between  $14.5\text{ V}$  to  $12.5\text{ V}$  by controlling the field current of alternator rotor. All electronic modules are tested for proper operation with superimposed AC ripple on the DC battery voltage. AC super imposed test specified in ISO 16750-2 and LV124 E-06 requires AC ripple of 2-V peak-peak on a 13.5-V DC battery voltage, swept from 15 Hz to 30 kHz. LM74722-Q1 rectifies the AC superimposed voltage by turning the MOSFET Q1 OFF quickly to cut off reverse current and turning the MOSFET Q1 ON quickly during forward conduction. Figure 9-3 shows active rectification of 6-V peak-peak 100-kHz AC input by LM74722-Q1. Fast turn-off and quick turn-on of the MOSFET reduces power dissipation in the MOSFET Q1, and active rectification reduces power dissipation in the output hold-up capacitor ESR by half. Figure 9-4 shows active rectification of 2-V peak-peak 200-kHz AC input.

**LM74722-Q1**

JAJSJ94B – SEPTEMBER 2021 – REVISED AUGUST 2022



**9-3. AC Super Imposed Test - 6-V Peak-Peak 100 kHz**

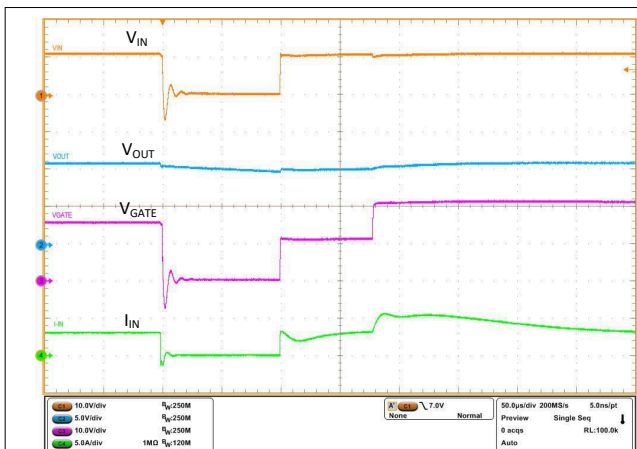


**9-4. AC Super Imposed Test - 2-V Peak-Peak 200 kHz**

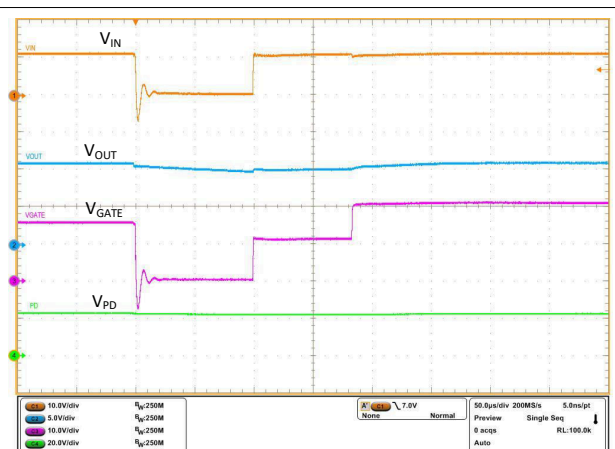
**9.2.1.1.3 Input Micro-Short Protection: LV124 E-10**

E-10 test specified in LV124 standard checks for immunity of electronic modules to short interruptions in power supply input due to contact issues or relay bounce. During this test (case 2), micro-short is applied on the input for a duration as low as 10  $\mu$ s to several ms. For a functional pass status A, electronic modules are required to run uninterrupted during the E-10 test (case 2) with 100- $\mu$ s duration. When input micro-short is applied for 100  $\mu$ s, LM74722-Q1 quickly turns off MOSFET Q1 by shorting GATE to ANODE (source of MOSFET) within 0.5  $\mu$ s to prevent the output from discharging and the PD remains ON keeping MOSFET Q2 ON, enabling fast recovery after the input short is removed.

9-5 shows performance of LM74722-Q1 during E10 input power supply interruption test case 2. After the input short is removed, input voltage recovers and MOSFET Q1 is turned back ON within 200  $\mu$ s. Note that dual-gate drive topology allows MOSFET Q2 to remain ON during the test and helps in restoring the input power faster. Output voltage remains unperturbed during the entire duration, achieving functional status A.



**9-5. Input Micro-Short – LV124 E10 TC 2 100  $\mu$ s**



**9-6. Input Micro-Short – LV124 E10 TC 2 100  $\mu$ s With PD**



## 9.2.2 Detailed Design Procedure

### 9.2.2.1 Design Considerations

表 9-1 summarizes the design parameters that must be known for designing an automotive reverse battery protection circuit with overvoltage cutoff. During power up, inrush current through MOSFET Q2 must be limited so that the MOSFET operates well within its SOA. Maximum load current, maximum ambient temperature, and thermal properties of the PCB determine the  $R_{DS(ON)}$  of the MOSFET Q2, and maximum operating voltage determines the voltage rating of the MOSFET Q2. Selection of MOSFET Q2 is determined mainly by the maximum operating load current, maximum ambient temperature, maximum frequency of AC super imposed voltage ripple, and ISO 7637-2 pulse 1 requirements. Overvoltage threshold is decided based on the rating of downstream DC/DC converter or other components after the reverse battery protection circuit. A single bi-directional TVS or two back-to-back uni-directional TVS are required to clamp input transients to a safe operating level for the MOSFETs Q1, Q2, and LM74722-Q1.

### 9.2.2.2 Boost Converter Components (C2, C3, L1)

Place a minimum of a 1- $\mu$ F capacitor across CAP pin to C pin (C2) and across C pin to GND (C3) of LM74722-Q1. Use a 100- $\mu$ H inductor (L1) with saturation current rating > 175 mA. Example: XPL2010-104ML from coil craft.

### 9.2.2.3 Input and Output Capacitance

TI recommends a minimum input capacitance C1 of 0.1  $\mu$ F and output capacitance  $C_{OUT}$  of 0.1  $\mu$ F.

### 9.2.2.4 Hold-Up Capacitance

Usually, bulk capacitors are placed on the output due to various reasons, such as uninterrupted operation during power interruption or micro-short at the input, holdup requirements for doing a memory dump before turning of the module, and filtering requirements as well. This design considers minimum bulk capacitors requirements for meeting functional status A during LV124 E10 test case 2 100- $\mu$ s input interruption. To achieve functional pass status A, acceptable voltage drop in the output of LM74722-Q1 is based on the UVLO settings of downstream DC/DC converters. For this design, 2.5-V drop in output voltage for 100  $\mu$ s is considered and the minimum holdup capacitance required is calculated by

$$C_{(HOLD\_UP\_MIN)} = \frac{I_{LOAD\_MAX} \times 100 \mu s}{\Delta V_{OUT}} \quad (3)$$

Minimum holdup capacitance required for 1-V drop in 100  $\mu$ s is 470  $\mu$ F.

### 9.2.2.5 Overvoltage Protection and Battery Monitor

Resistors  $R_1$ ,  $R_2$  and  $R_3$  connected in series are used to program the overvoltage threshold and battery monitor ratio. The resistor values required for setting the overvoltage threshold,  $V_{OV}$ , to 37 V and battery monitor ratio  $V_{BATT\_MON}:V_{BATT}$  to 1:8 are calculated by solving 式 4 and 式 5.

$$V_{OVR} = \frac{R_3 \times V_{OV}}{R_1 + R_2 + R_3} \quad (4)$$

$$V_{BATT\_MON} = \frac{(R_2 + R_3) \times V_{OV}}{R_1 + R_2 + R_3} \quad (5)$$

For minimizing the input current drawn from the battery through resistors  $R_1$ ,  $R_2$  and  $R_3$ , TI recommends to use higher value of resistance. Using high value resistors adds error in the calculations because the current through the resistors at higher value becomes comparable to the leakage current into the OV pin. Maximum leakage current into the OV pin is 1  $\mu$ A and choosing  $(R_1 + R_2 + R_3) < 120$  k $\Omega$  ensures current through resistors is 100 times greater than leakage through OV pin.

Based on the device electrical characteristics,  $V_{OVR}$  is 1.23 V and battery monitor ratio ( $V_{BATT\_MON} / V_{BATT}$ ) is designed for a ratio of 1:8. To limit  $(R_1 + R_2 + R_3) < 120 \text{ k}\Omega$ , select  $(R_1 + R_2) = 100 \text{ k}\Omega$ . Solving Equation 4 gives  $R_3 = 3.45 \text{ k}\Omega$ . Solving Equation 5 for  $R_2$  using  $(R_1 + R_2) = 100 \text{ k}\Omega$  and  $R_3 = 3.45 \text{ k}\Omega$ , gives  $R_2 = 9.48 \text{ k}\Omega$  and  $R_1 = 90.52 \text{ k}\Omega$ .

Standard 1% resistor values closest to the calculated resistor values are  $R_1 = 90.9 \text{ k}\Omega$ ,  $R_2 = 9.09 \text{ k}\Omega$ , and  $R_3 = 3.48 \text{ k}\Omega$ .

### 9.2.2.6 MOSFET Selection: Blocking MOSFET Q1

For selecting the blocking MOSFET Q1, important electrical parameters are the maximum continuous drain current  $I_D$ , the maximum drain-to-source voltage  $V_{DS(MAX)}$ , the maximum drain-to-source voltage  $V_{GS(MAX)}$ , and the maximum source current through body diode and the drain-to-source ON resistance  $R_{DS(ON)}$ .

The maximum continuous drain current,  $I_D$ , rating must exceed the maximum continuous load current.

The maximum drain-to-source voltage,  $V_{DS(MAX)}$ , must be high enough to withstand the highest differential voltage seen in the application. This includes all the automotive transient events and any anticipated fault conditions. TI recommends to use MOSFETs with  $V_{DS}$  voltage rating of 60 V along with a single bidirectional TVS or a  $V_{DS}$  rating 40-V maximum rating along with two unidirectional TVS connected back-to-back at the input.

The maximum  $V_{GS}$  LM74722-Q1 can drive is 14 V, so a MOSFET with 15-V minimum  $V_{GS}$  rating must be selected. If a MOSFET with  $< 15\text{-V } V_{GS}$  rating is selected, a Zener diode can be used to clamp  $V_{GS}$  to safe level, but this results in increased  $I_Q$  current.

To reduce the MOSFET conduction losses, lowest possible  $R_{DS(ON)}$  is preferred, but selecting a MOSFET based on low  $R_{DS(ON)}$  cannot always be beneficial. Higher  $R_{DS(ON)}$  provides increased voltage information to the LM74722-Q1 reverse comparator at a lower reverse current. Reverse current detection is better with increased  $R_{DS(ON)}$ . Choosing a MOSFET with  $< 50\text{-mV}$  forward voltage drop at maximum current is a good starting point. Based on the design requirements, BUK7Y4R8-60E MOSFET is selected

### 9.2.2.7 MOSFET Selection: Load Disconnect MOSFET Q2

The  $V_{DS}$  rating of the MOSFET Q2 must be sufficient to handle the maximum system voltage along with the input transient voltage. For this 12-V design, transient overvoltage events are during suppressed load dump 35 V 400 ms and ISO 7637-2 pulse 2 A 50 V for 50  $\mu\text{s}$ . Further, ISO 7637-2 pulse 3B is a very fast repetitive pulse of 100 V 100 ns that is usually absorbed by the input and output ceramic capacitors. The maximum voltage on the 12-V battery can be limited to  $< 40 \text{ V}$  the minimum recommended input capacitance of 0.1  $\mu\text{F}$ . The 50-V SO 7637-2 pulse 2 A can also be absorbed by input and output capacitors and its amplitude can be reduced to 40-V peak by placing sufficient amount of capacitance at input and output. Choose a MOSFET with  $\geq 40\text{-V } V_{DS}$  rating.

The  $V_{GS}$  rating of the MOSFET Q2 must be higher than that maximum boost drive output of 15.5 V. FET with  $V_{GS}$  absolute maximum rating of  $\pm 20 \text{ V}$  is selected.

Inrush current through the MOSFET during input hot-plug into the 12-V battery is determined by output capacitance. External capacitor on HGATE,  $C_{DVDT}$ , is used to limit the inrush current during input hot-plug or start-up. The value of inrush current determined by 式 1 must be selected to ensure that the MOSFET Q2 is operating well within its safe operating area (SOA). To limit inrush current to 250 mA, value of  $C_{DVDT}$  is 10.43 nF. The closest standard value of 10.0 nF is chosen.

Duration of inrush current is calculated by 式 6

$$T_{INRUSH} = \frac{12 \times C_{OUT}}{I_{INRUSH}} \quad (6)$$

Calculated inrush current duration is 2.36 ms with 250-mA inrush current.

MOSFET BUK7Y4R8-60E having 60-V  $V_{DS}$  and  $\pm 20\text{-V } V_{GS}$  rating is selected for Q2. Power dissipation during inrush is well within the MOSFET safe operating area (SOA).

### **9.2.2.8 TVS Selection**

TI recommends a 600-W SMBJ TVS such as SMBJ33CA for input transient clamping and protection. For detailed explanation on TVS selection for 12-V battery systems, refer to [TVS Selection for 12-V Battery Systems](#).

### 9.2.3 Application Curves

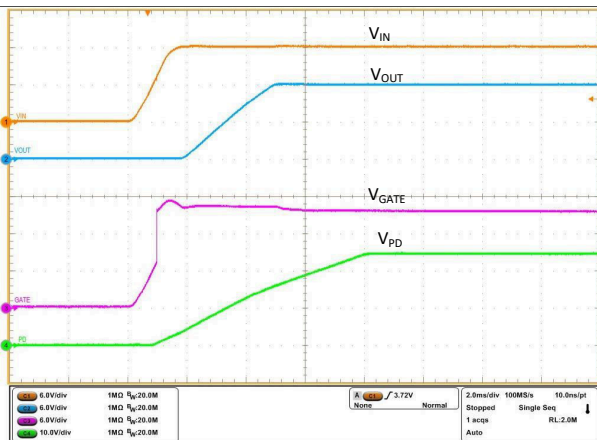


Figure 9-7. Start-Up 12 V with EN Pulled to VIN

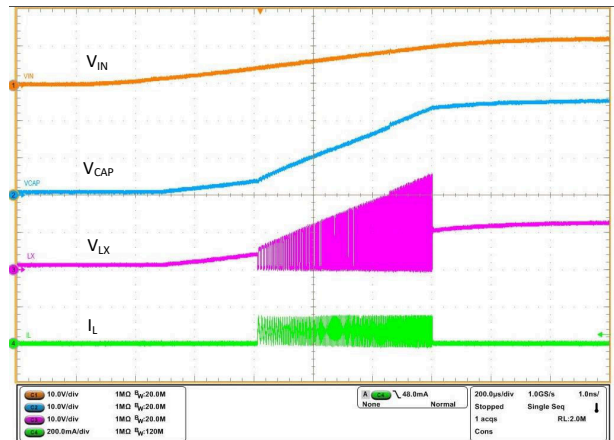


Figure 9-8. Start-Up 12 V Showing Boost Output ( $V_{CAP}$ ) and Switching ( $V_{LX}$ )

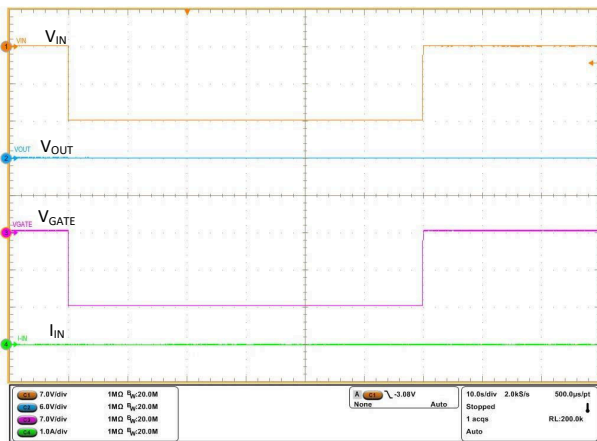


Figure 9-9. Reverse Input Voltage -14 V for 60 s

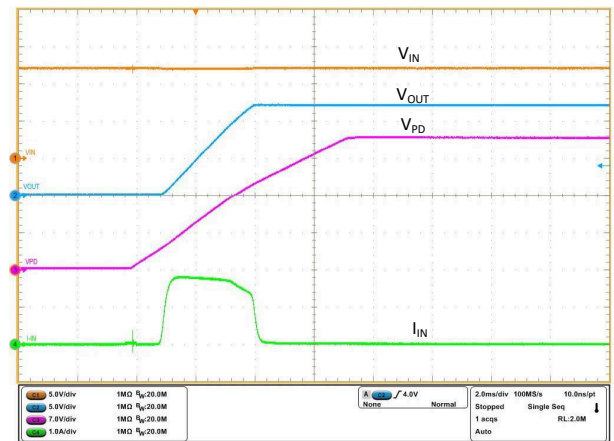


Figure 9-10. Inrush Current with No Load at Output

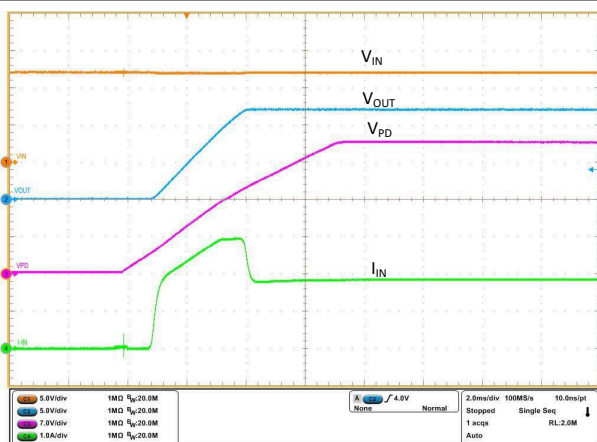


Figure 9-11. Inrush Current with 60- $\Omega$  Load

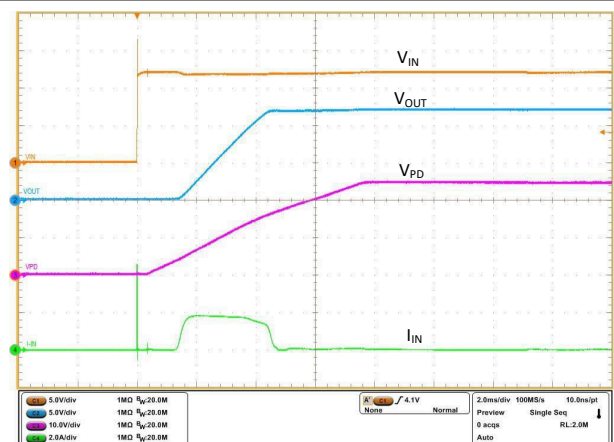
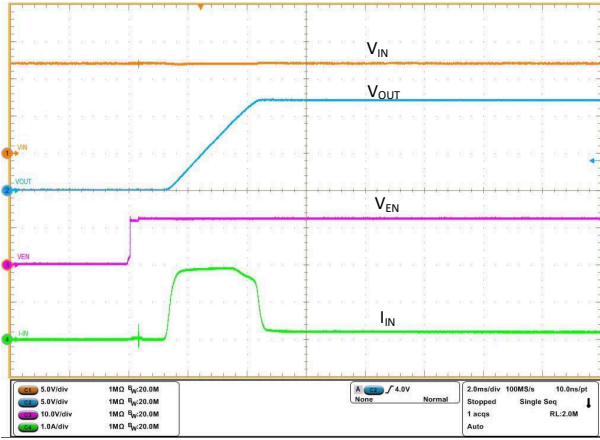
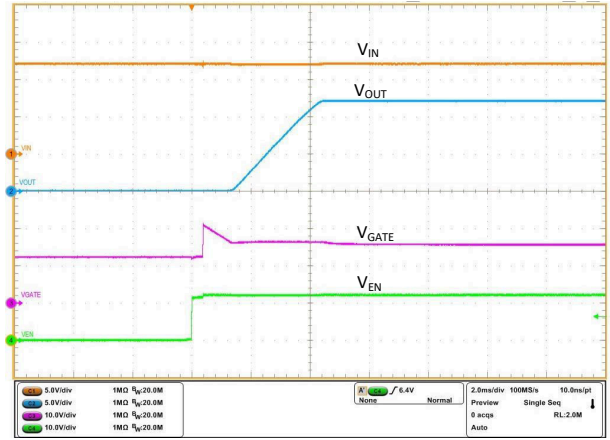


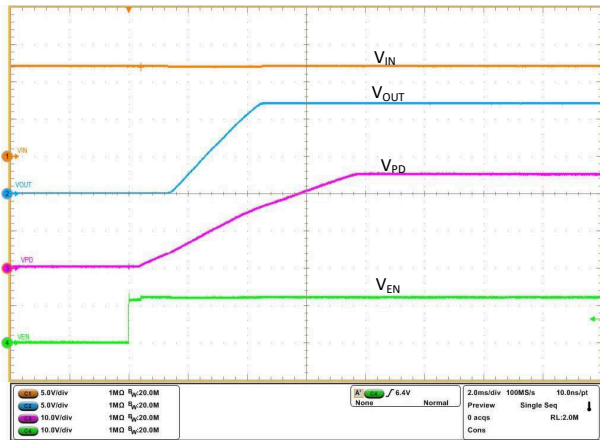
Figure 9-12. Hot-Plug into 12 V



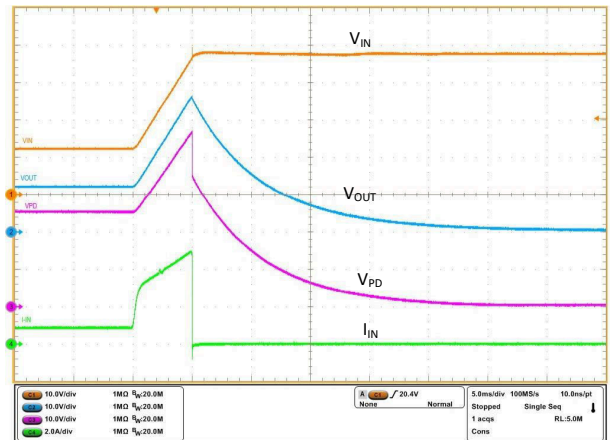
9-13. Output Turn-On with Enable



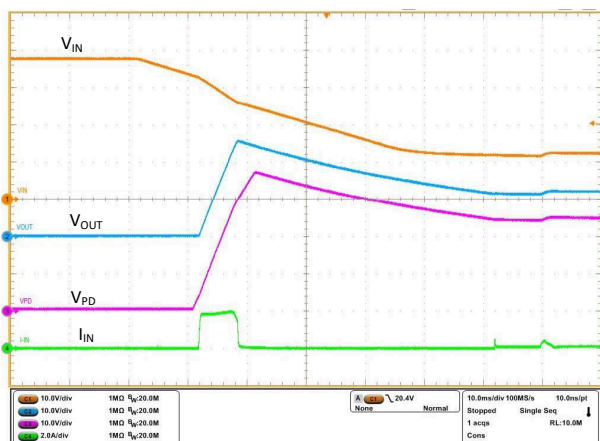
9-14. GATE Turn-On with Enable



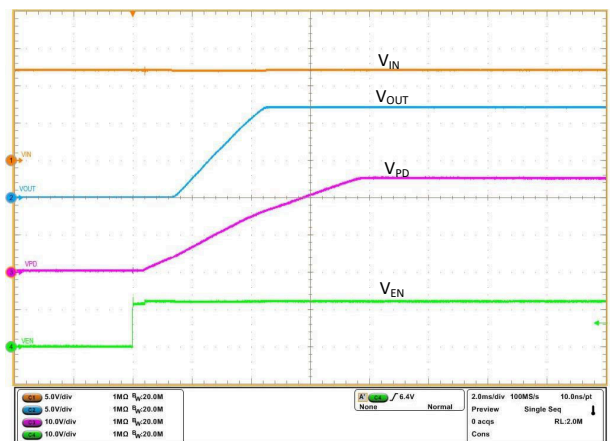
9-15. PD Turn-On with Enable



9-16. Overvoltage Protection



9-17. Overvoltage Recovery



9-18. Turn-On Delay – PD

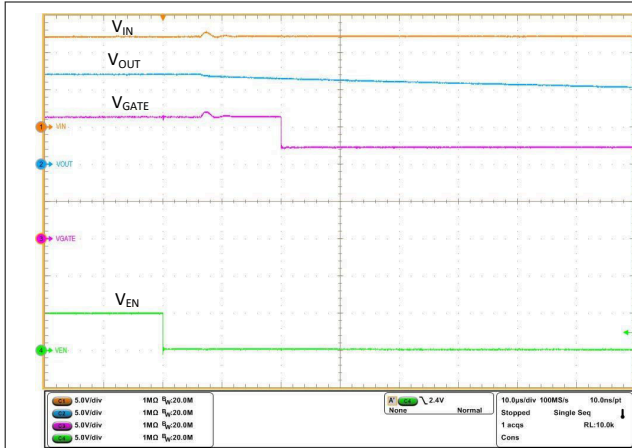


图 9-19. Turn-Off Delay – GATE

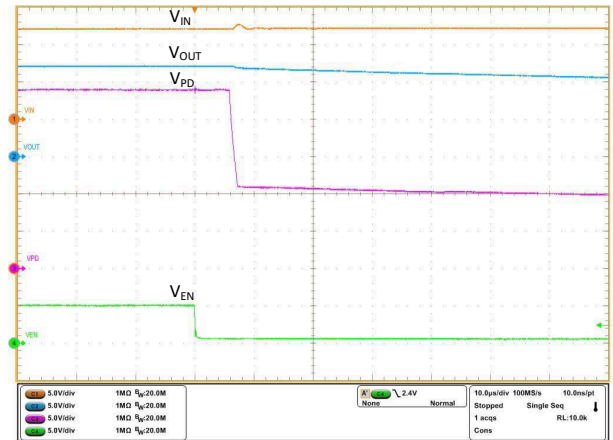


图 9-20. Turn-Off Delay – PD

### 9.3 What to Do and What Not to Do

Leave the exposed pad (RTN) of the IC floating. Do not connect the exposed pad (RTN) to the GND plane. Connecting the RTN to the GND disables the reverse polarity protection feature.



## 10 Power Supply Recommendations

### 10.1 Transient Protection

When the external MOSFETs turn OFF during the conditions such as overvoltage cutoff, reverse current blocking, and EN causing an interruption of the current flow, the input line inductance generates a positive voltage spike on the input and output inductance generates a negative voltage spike on the output. The peak amplitude of voltage spikes (transients) depends on the value of inductance in series to the input or output of the device. These transients can exceed the *Absolute Maximum Ratings* of the device if steps are not taken to address the issue.

Typical methods for addressing transients include:

- Minimizing lead length and inductance into and out of the device
- Using large PCB GND plane
- Use of a Schottky diode across the output and GND to absorb negative spikes
- A low value ceramic capacitor ( $C_{(IN)}$ ) to approximately 0.1  $\mu\text{F}$ ) to absorb the energy and dampen the transients

Equation 8 can estimate the approximate value of input capacitance.

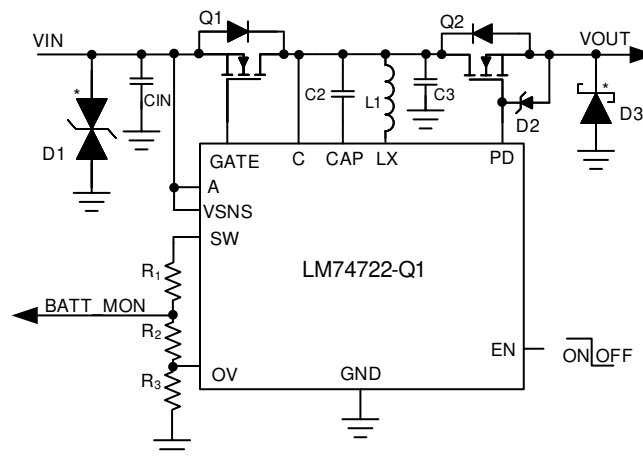
$$V_{\text{spike(Absolute)}} = V_{(IN)} + I_{(Load)} \times \sqrt{\frac{L_{(IN)}}{C_{(IN)}}} \quad (7)$$

where

- $V_{(IN)}$  is the nominal supply voltage
- $I_{(LOAD)}$  is the load current
- $L_{(IN)}$  equals the effective inductance seen looking into the source
- $C_{(IN)}$  is the capacitance present at the input

Some applications can require additional Transient Voltage Suppressor (TVS) to prevent transients from exceeding the *Absolute Maximum Ratings* of the device. These transients can occur during EMC testing, such as automotive ISO7637 pulses.

Figure 10-1 shows the circuit implementation with optional protection components (a ceramic capacitor, TVS, and Schottky diode).



\* Optional components needed for suppression of transients.

Figure 10-1. Circuit Implementation With Optional Protection Components for LM74722-Q1

## 10.2 TVS Selection for 12-V Battery Systems

In selecting the TVS, important specifications are breakdown voltage and clamping voltage. The breakdown voltage of the TVS+ must be higher than 24-V jump start voltage and 35-V suppressed load dump voltage and less than the maximum ratings of LM74722-Q1 (65 V). The breakdown voltage of TVS– must be beyond the maximum reverse battery voltage –16 V, so that the TVS– is not damaged due to long time exposure to reverse connected battery.

Clamping voltage is the voltage the TVS diode clamps in high current pulse situations and this voltage is much higher than the breakdown voltage. In the case of an ISO 7637-2 pulse 1, the input voltage goes up to –150 V with a generator impedance of 10  $\Omega$ . This translates to 15 A flowing through the TVS– and the voltage across the TVS is close to its clamping voltage.

The next criterion is that the absolute maximum rating of cathode to anode voltage of the LM74722-Q1 (85 V) and the maximum  $V_{DS}$  rating MOSFET are not exceeded. In the design example, 60-V rated MOSFET is chosen and maximum limit on the cathode to anode voltage is 60 V.

During ISO 7637-2 pulse 1, the anode of LM74722-Q1 is pulled down by the ISO pulse, clamped by TVS–, and the MOSFET Q1 is turned off quickly to prevent reverse current from discharging the bulk output capacitors. When the MOSFET turns off, the cathode to anode voltage seen is equal to (TVS clamping voltage + output capacitor voltage). If the maximum voltage on output capacitor is 16 V (maximum battery voltage), then the clamping voltage of the TVS– must not exceed  $(60\text{ V} - 16)\text{ V} = -44\text{ V}$ .

The SMBJ33CA TVS diode can be used for 12-V battery protection application. The breakdown voltage of 36.7 V meets the jump start, load dump requirements on the positive side and 16-V reverse battery connection on the negative side. During ISO 7637-2 pulse 1 test, the SMBJ33CA clamps at –44 V with 12 A of peak surge current and it meets the clamping voltage  $\leq 44\text{ V}$ .

SMBJ series of TVS are rated up to 600-W peak pulse power levels and are sufficient for ISO 7637-2 pulses.

If 40-V rated MOSFET is chosen then maximum voltage across C (Drain of the MOSFET) and A (Source of the MOSFET) must not exceed 40-V. For 40-V MOSFET selection, two back-to-back connected uni-directional TVS diodes are required to protect against input transient events. On the positive side, the SMBJ33A TVS diode can be used for 12-V battery protection application. However on the negative side, TVS has to withstand 16-V reverse battery connection and clamping voltage has to be  $-(40\text{ V} - 16\text{ V}) = -24\text{ V}$ . SMBJ16A can be used.

## 10.3 TVS Selection for 24-V Battery Systems

For 24-V battery protection application, the TVS and MOSFET in [Figure 9-1](#) must be changed to suit 24-V battery requirements.

The breakdown voltage of the TVS+ must be higher than 48-V jump start voltage, less than the absolute maximum ratings of anode and enable pin of LM74722-Q1 (70 V), and must withstand 65-V suppressed load dump. The breakdown voltage of TVS– must be lower than maximum reverse battery voltage –32 V, so that the TVS– does not damage due to long time exposure to reverse connected battery.

During ISO 7637-2 pulse 1, the input voltage goes up to –600 V with a generator impedance of 50  $\Omega$ . This translates to 12 A flowing through the TVS–. The clamping voltage of the TVS– cannot be the same as that of 12-V battery protection circuit. Because during the ISO 7637-2 pulse, the anode to cathode voltage seen is equal to  $(-TVS\text{ Clamping voltage} + \text{Output capacitor voltage})$ . For 24-V battery application, the maximum battery voltage is 32 V, then the clamping voltage of the TVS– must not exceed,  $85\text{ V} - 32\text{ V} = 53\text{ V}$ .

Single bi-directional TVS cannot be used for 24-V battery protection because breakdown voltage for TVS+  $\geq 65\text{ V}$ , maximum clamping voltage is  $\leq 53\text{ V}$  and the clamping voltage cannot be less than the breakdown voltage. Two un-directional TVS connected back-to-back must be used at the input. For positive side TVS+, TI recommends SMBJ58A with the breakdown voltage of 64.4 V (minimum), 67.8 (typical). For the negative side TVS–, TI recommends SMBJ28A with breakdown voltage close to 32 V (to withstand maximum reverse battery voltage –32 V) and maximum clamping voltage of 42.1 V.

For 24-V battery protection, TI recommends that a 75-V rated MOSFET be used along with SMBJ28A and SMBJ58A connected back-to-back at the input.

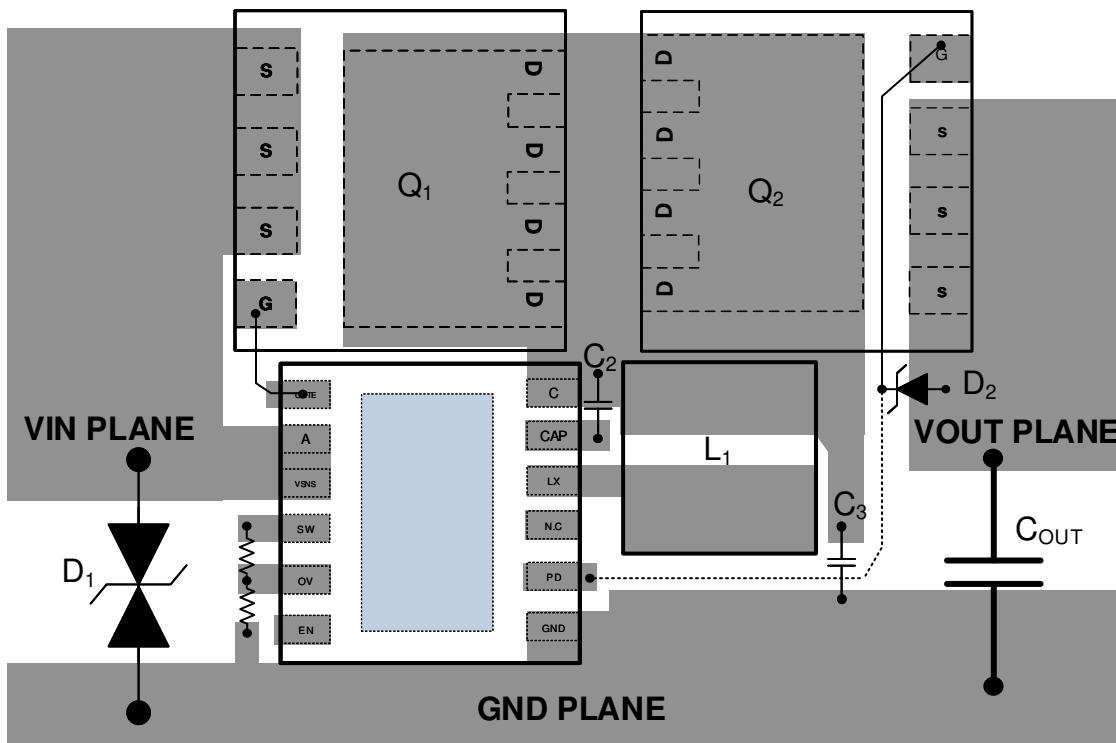


## 11 Layout

### 11.1 Layout Guidelines

- Connect A, GATE, and C pins of LM74722-Q1 close to the MOSFET SOURCE, GATE and DRAIN pins for the ideal diode stage.
- Use thick and short traces for source and drain of the MOSFET to minimize resistive losses because the high current path of for this solution is through the MOSFET.
- Connect the GATE pin of the LM74722-Q1 to the MOSFET GATE with short trace.
- Minimize the loops formed by capacitor across CAP pin and DRAIN of the FET and C3 to GND by placing these capacitors as close as possible. Keep the GND side of the C3 capacitor close to GND pin of LM74722-Q1. Boost converter switching currents flow into LX, CAP, GND pins and C3 (across DRAIN of the FET to GND).
- Place transient suppression components, like input TVS and output Schottky, close to LM74722-Q1.

### 11.2 Layout Example



11-1. LM74722-Q1 Layout Example

## 12 Device and Documentation Support

### 12.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](https://www.ti.com). Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 12.2 サポート・リソース

TI E2E™ サポート・フォーラムは、エンジニアが検証済みの回答と設計に関するヒントをエキスパートから迅速かつ直接得ることができる場所です。既存の回答を検索したり、独自の質問をしたりすることで、設計に必要な支援を迅速に得ることができます。

リンクされているコンテンツは、該当する貢献者により、現状のまま提供されるものです。これらは TI の仕様を構成するものではなく、必ずしも TI の見解を反映したものではありません。TI の[使用条件](#)を参照してください。

### 12.3 Trademarks

TI E2E™ is a trademark of Texas Instruments.

すべての商標は、それぞれの所有者に帰属します。

### 12.4 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 12.5 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM74722QDRRRQ1	ACTIVE	WSON	DRR	12	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	L74722	Samples

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM74722QDRRRQ1	WSO	DRR	12	3000	330.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM74722QDRRRQ1	WSON	DRR	12	3000	367.0	367.0	35.0

## GENERIC PACKAGE VIEW

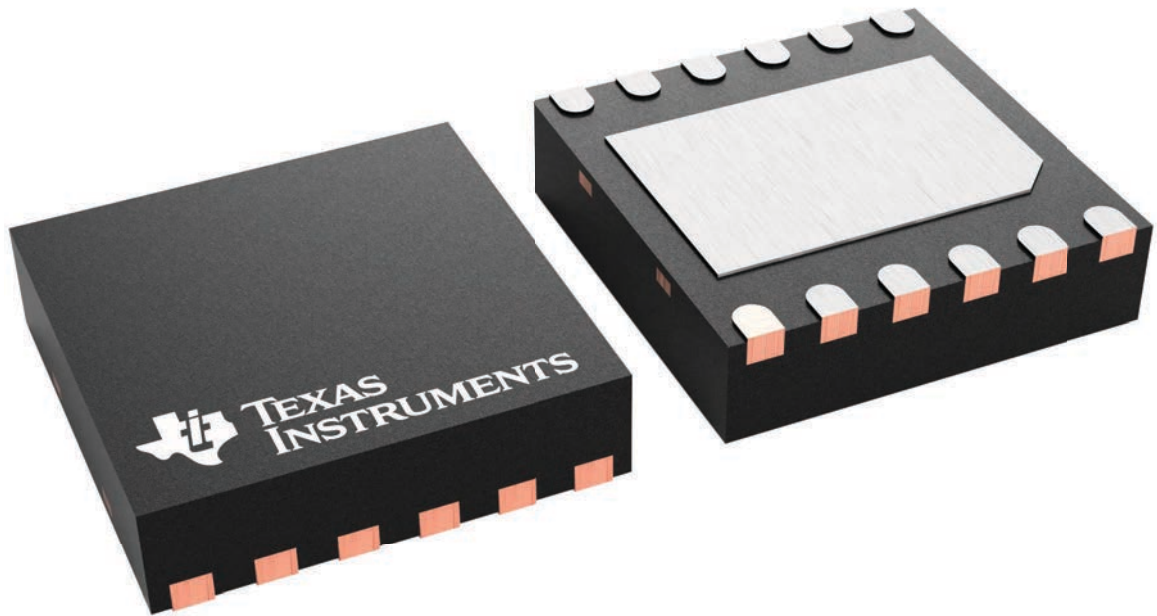
**DRR 12**

**WSON - 0.8 mm max height**

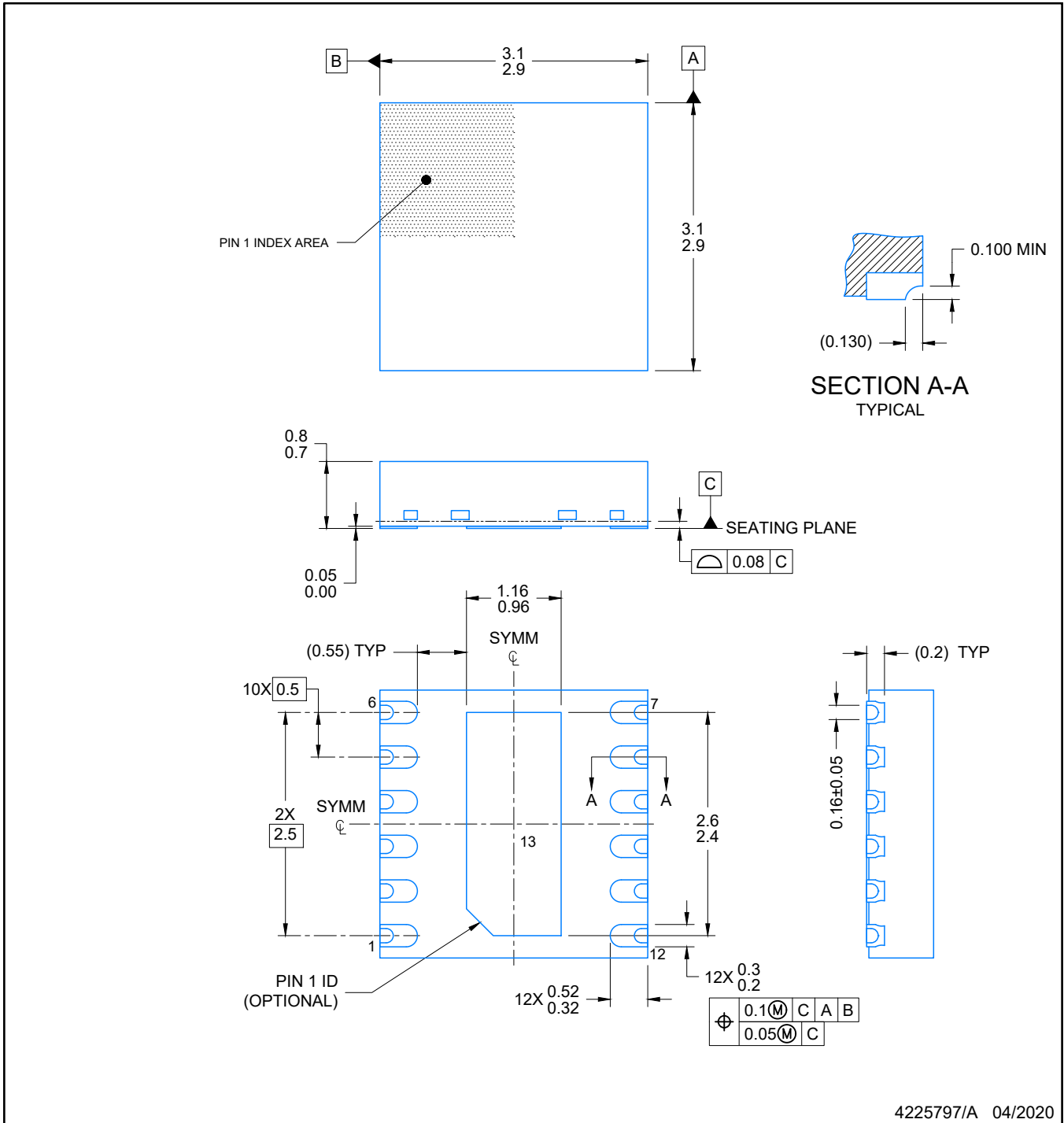
3 x 3, 0.5 mm pitch

PLASTIC SMALL OUTLINE - NO LEAD

This image is a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.



4223490/B



4225797/A 04/2020

NOTES:

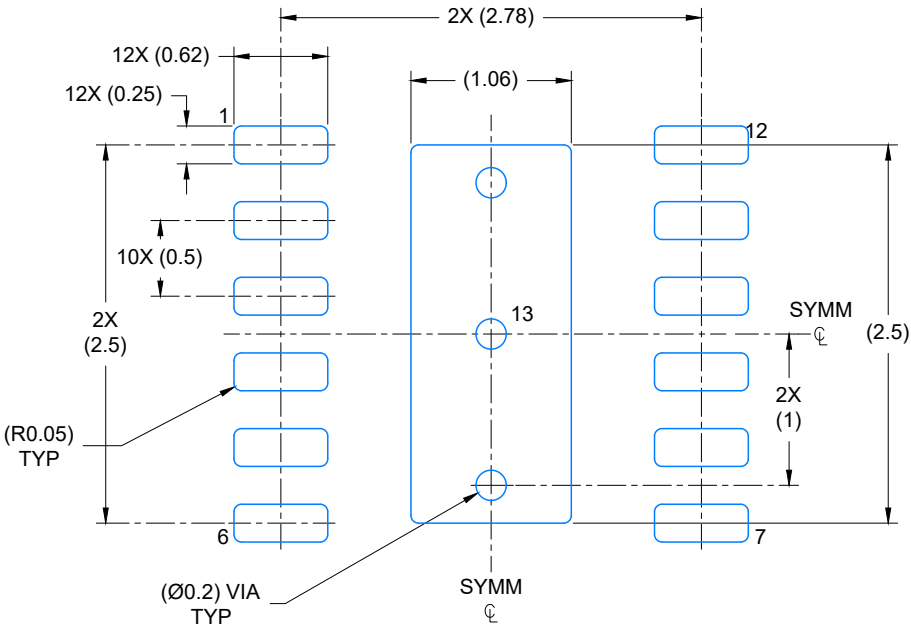
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for optimal thermal and mechanical performance.

# EXAMPLE BOARD LAYOUT

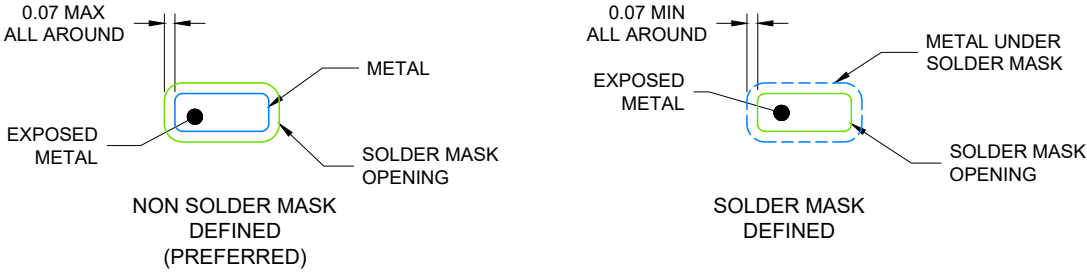
## WSON - 0.8 mm max height

DRR0012F

PLASTIC QUAD FLAT PACK- NO LEAD



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 20X



SOLDER MASK DETAILS

4225797/A 04/2020

NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/slua271](http://www.ti.com/lit/slua271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

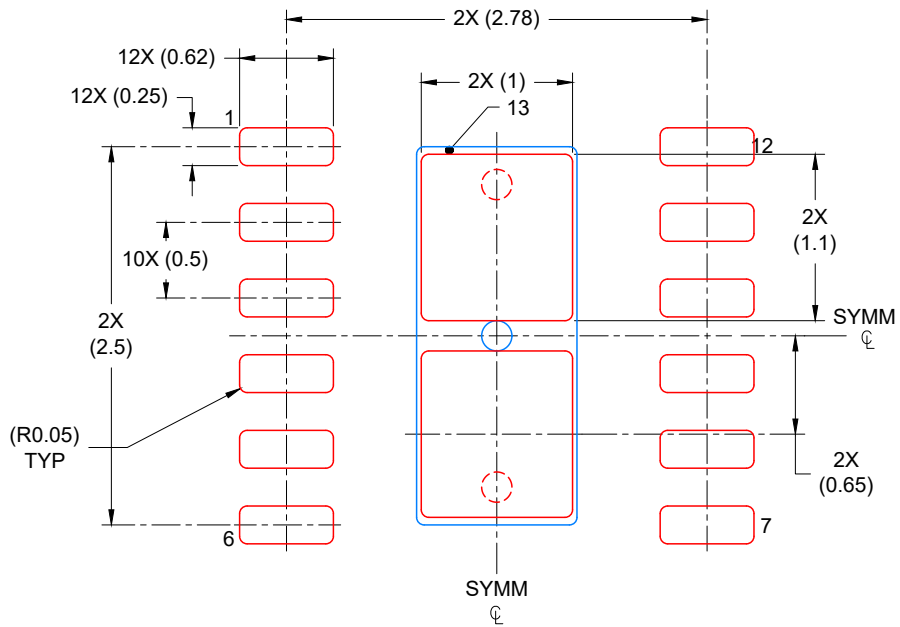


# EXAMPLE STENCIL DESIGN

WSON - 0.8 mm max height

DRR0012F

PLASTIC QUAD FLAT PACK- NO LEAD



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD  
83% PRINTED COVERAGE BY AREA  
SCALE: 20X

4225797/A 04/2020

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

## 重要なお知らせと免責事項

TI は、技術データと信頼性データ(データシートを含みます)、設計リソース(リファレンス・デザインを含みます)、アプリケーションや設計に関する各種アドバイス、Web ツール、安全性情報、その他のリソースを、欠陥が存在する可能性のある「現状のまま」提供しており、商品性および特定目的に対する適合性の黙示保証、第三者の知的財産権の非侵害保証を含むいかなる保証も、明示的または黙示的にかかわらず拒否します。

これらのリソースは、TI 製品を使用する設計の経験を積んだ開発者への提供を意図したものです。(1) お客様のアプリケーションに適した TI 製品の選定、(2) お客様のアプリケーションの設計、検証、試験、(3) お客様のアプリケーションに該当する各種規格や、その他のあらゆる安全性、セキュリティ、規制、または他の要件への確実な適合に関する責任を、お客様のみが単独で負うものとし、

上記の各種リソースは、予告なく変更される可能性があります。これらのリソースは、リソースで説明されている TI 製品を使用するアプリケーションの開発の目的でのみ、TI はその使用をお客様に許諾します。これらのリソースに関して、他の目的で複製することや掲載することは禁止されています。TI や第三者の知的財産権のライセンスが付与されている訳ではありません。お客様は、これらのリソースを自身で使用した結果発生するあらゆる申し立て、損害、費用、損失、責任について、TI およびその代理人を完全に補償するものとし、TI は一切の責任を拒否します。

TI の製品は、[TI の販売条件](#)、または [ti.com](#) やかかる TI 製品の関連資料などのいずれかを通じて提供する適用可能な条項の下で提供されています。TI がこれらのリソースを提供することは、適用される TI の保証または他の保証の放棄の拡大や変更を意味するものではありません。

お客様がいかなる追加条項または代替条項を提案した場合でも、TI はそれらに異議を唱え、拒否します。

郵送先住所 : Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2024, Texas Instruments Incorporated