







LM66100-Q1

JAJSM18A - NOVEMBER 2021 - REVISED MARCH 2022

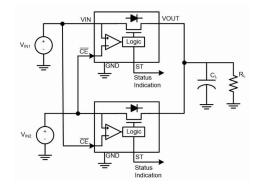
# LM66100-Q1 5.5V、1.5A、79mΩ、車載用、低静止電流 (IQ) の理想ダイオード、 入力極性保護付き

## 1 特長

- 車載アプリケーション用に AEC-Q100 認定済み:
  - デバイス温度グレード 1:-40℃~125℃の動作時 周囲温度範囲
- 広い動作電圧範囲:1.5V~5.5V
- VIN の逆電圧スタンドオフ:
  - -6V (絶対最大値)
- 最大連続電流 (I<sub>MAX</sub>):1.5A
- オン抵抗 (R<sub>ON</sub>):
  - 5V V<sub>IN</sub>:79mΩ (標準値)
  - 3.6V V<sub>IN</sub>:91mΩ (標準値)
  - 1.8V V<sub>IN</sub>: 141mΩ (標準値)
- コンパレータのチップ・イネーブル (CE)
- チャネルのステータス表示 (ST)
- 低消費電流:
  - 3.6V V<sub>IN</sub> 時のシャットダウン電流 (I<sub>SD,VIN</sub>):120nA
  - 3.6V V<sub>IN</sub> 時の静止電流 (I<sub>O, VIN</sub>):150nA (標準値)

## 2 アプリケーション

- インフォテインメントおよびクラスタ・ヘッド・ユニット
- 車載対応、クラスタ・ディスプレイ
- ADAS サラウンド・ビュー・システムの ECU
- ボディ・コントロール・モジュールおよびゲートウェイ



代表的なアプリケーション

#### 3 概要

LM66100-Q1 は、各種アプリケーションに適した単一入 力、単一出力 (SISO) の集積化理想ダイオードです。この デバイスは、1.5V~5.5V の入力電圧範囲で動作でき、最 大 1.5A の連続電流をサポートできる P チャネル MOSFET を内蔵しています。

チップ・イネーブルは、CE ピンの電圧を入力電圧と比較 することで動作します。 CE ピンの電圧が VIN より高い場 合、デバイスはディセーブルで、MOSFET はオフです。 CE ピンの電圧の方が低い場合、MOSFET はオンです。 LM66100-Q1 には逆極性保護 (RPP) 機能もあり、バッテ リの逆接続など入力の誤配線からデバイスを保護します。

デュアル・ダイオードの OR 実装のように、2 つの LM66100-Q1 デバイスを OR 構成で使用することもでき ます。この構成では、極めて高い入力電圧を出力に伝達 しながら、逆電流が入力電源に流れ込むのを阻止できま す。これらのデバイスは内部電圧コンパレータで入力と出 力の電圧を比較し、逆電流がブロックされるようにします。

LM66100-Q1 は標準の SC-70 パッケージで供給され、-40℃~150℃の接合部温度範囲で仕様が規定されてい ます。

#### 製品情報(1)

部品番号	パッケージ	本体サイズ (公称)
LM66100-Q1	SC-70 (6)	2.1mm × 2.0mm

利用可能なすべての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。



## **Table of Contents**

1 特長	1	8.3 Feature Description	11
2 アプリケーション		8.4 Device Functional Modes	
-		9 Application and Implementation	12
4 Revision History		9.1 Application Information	12
5 Pin Configuration and Functions		9.2 Typical Applications	12
6 Specifications		10 Power Supply Recommendations	
6.1 Absolute Maximum Ratings		11 Layout	16
6.2 ESD Ratings		11.1 Layout Guidelines	16
6.3 Recommended Operating Conditions		11.2 Layout Example	16
6.4 Thermal Information		12 Device and Documentation Support	17
6.5 Electrical Characteristics		12.1 Receiving Notification of Documentation Upd	ates17
6.6 Switching Characteristics		12.2 サポート・リソース	17
6.7 Typical Characteristics		12.3 Trademarks	
7 Parameter Measurement Information		12.4 Electrostatic Discharge Caution	17
8 Detailed Description		12.5 Glossary	17
8.1 Overview		13 Mechanical, Packaging, and Orderable	
8.2 Functional Block Diagram		Information	17
3			

## **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。

С	hanges from Revision * (November 2021) to Revision A (March 2022)	Page
•	データシートのステータスを「事前情報」から「量産データ」に変更	1



## **5 Pin Configuration and Functions**

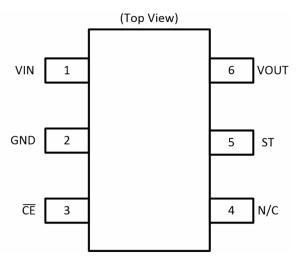


図 5-1. DCK Package 6-Pin SC-70 Top View

表 5-1. Pin Functions

PIN		I/O	DESCRIPTION		
NO.	NAME	1/0	DESCRIP HON		
1	VIN	I	Device input		
2	GND	_	Device ground		
3	CE	ı	Active-low chip enable. Can be connected to VOUT for reverse current protection. Do not leave floating.		
4	N/C	_	Not internally connected, can be tied to GND or left floating.		
5	ST	0	Active-low open-drain output, pulled low when the chip is disabled. Hi-Z when the chip is enabled. Connect to GND if not required.		
6	VOUT	0	Device output		



## **6 Specifications**

## **6.1 Absolute Maximum Ratings**

over operating free-air temperature range (unless otherwise noted) (1)

		MIN	MAX	UNIT
V <sub>IN</sub>	Maximum Input Voltage Range	-6	6	V
V <sub>OUT</sub>	Maximum Output Voltage Range	-0.3	6	V
V <sub>CE</sub>	Maximum CE Pin Voltage	-0.3	6	V
V <sub>ST</sub>	Maximum ST Pin Voltage	-0.3	6	V
I <sub>SW, MAX</sub>	Maximum Continuous Switch Current		1.5	Α
I <sub>SW, PLS</sub>	Maximum Pulsed Switch Current (≤120 ms, 2% Duty Cycle)		2.5	Α
I <sub>D, PLS</sub>	Maximum Pulsed Body Diode Current (≤0.1 ms, 0.2% Duty Cycle)		2.5	Α
I <sub>CE</sub>	Maximum CE Pin Current	-1		mA
I <sub>ST</sub>	Maximum ST Pin Current	-1		mA
T <sub>J</sub>	Junction temperature	-40	150	°C
T <sub>STG</sub>	Storage temperature	-65	150	°C
T <sub>LEAD</sub>	Maximum Lead Temperature (10 s soldering time)		300	°C

<sup>(1)</sup> 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.

## 6.2 ESD Ratings

			VALUE	UNIT
V	Electrostatic discharge	Human body model (HBM), per AEC Q100- 002 <sup>(1)</sup> HBM ESD classification level 2	±2000	V
V <sub>(ESD)</sub>	Electrostatic discharge	Charged device model (CDM), per AEC Q100- 011 CDM ESD classification level C4A	±500	V

<sup>(1)</sup> AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

## **6.3 Recommended Operating Conditions**

over operating free-air temperature range (unless otherwise noted)

		MIN	TYP MAX	UNIT
V <sub>IN</sub>	Input Voltage Range	1.5	5.5	V
V <sub>OUT</sub>	Output Voltage Range	1	5.5	V
V <sub>CE</sub>	CE Pin Voltage Range	0	5.5	V
V <sub>ST</sub>	ST Pin Voltage Range	0	5.5	V

#### 6.4 Thermal Information

		LM66100	
	THERMAL METRIC(1)	DCK (SC-70)	UNIT
		6 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	192	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	124	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	52	°C/W
$\Psi_{JT}$	Junction-to-top characterization parameter	34	°C/W

Product Folder Links: LM66100-Q1



		LM66100	
	THERMAL METRIC(1)	DCK (SC-70)	UNIT
		6 PINS	
$\Psi_{JB}$	Junction-to-board characterization parameter	52	°C/W

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

#### 6.5 Electrical Characteristics

Typical values are at 25°C with an input voltage of 3.6V. Maximum and minimum values are across the entire operating voltage range, from 1.5V to 5.5V. (unless otherwise noted)

	PARAMETER		TEST CONDITIONS	3	MIN TYP	MAX	UNI T
Input Sup	ply (VIN)						
I <sub>SD,VIN</sub>	VIN Shutdown Current	VOUT = VIN VCE > VIN + 80 mV I <sub>OUT</sub> = 0 A (VOUT = op	oen)	25°C -40°C to 125°C	0.12	0.3	·
		VOUT = VIN	Jen)	25°C	0.15	0.3	μA
$I_{Q,VIN}$	VIN Quiescent Current	VCE < VIN - 250 mV I <sub>OUT</sub> = 0 A (VOUT = op	pen)	-40°C to 125°C	0.13	0.3	<u> </u>
				25°C	0.2	0.5	μΑ
		VOUT – VIN ≤ 5.5 V VCE > VIN + 80 mV		-40°C to 85°C		2.7	μA
		VCL > VIIV + OO IIIV		-40°C to 125°C		8	μΑ
I <sub>OUT, OFF</sub>	OUT to IN Leakage Current (Current out of VIN)	VOUT – VIN ≤ 4.5 V		-40°C to 85°C		1.7	μΑ
	(Ourient out or viiv)	VCE > VIN + 80 mV		-40°C to 125°C		5.1	μA
		VOUT – VIN ≤ 1.0 V		-40°C to 85°C		0.7	μΑ
		VCE > VIN + 80 mV		-40°C to 125°C		2.1	μA
ON-Resist	ance (RON)						
				25°C	79	95	
R <sub>ON</sub>	ON-State Resistance	I <sub>OUT</sub> = -200 mA	VIN = 5 V	-40°C to 85°C		110	mΩ
				-40°C to 125°C		120	
				25°C	91	110	
R <sub>ON</sub>	ON-State Resistance	I <sub>OUT</sub> = -200 mA	VIN = 3.6 V	-40°C to 85°C		125	mΩ
				-40°C to 125°C		140	
				25°C	141	180	
R <sub>ON</sub>	ON-State Resistance	I <sub>OUT</sub> = -200 mA	VIN = 1.8 V	-40°C to 85°C		210	mΩ
				-40°C to 125°C		230	
Comparat	or Chip Enable (CE)			·			
V <sub>ON</sub>	Turn ON Threshold	VCE – VIN		-40°C to 125°C	-250 -150	-80	mV
V <sub>OFF</sub>	Turn OFF Threshold	VCE – VIN		-40°C to 125°C	0 35	80	mV
I <sub>CE</sub>	CE Pin Leakage Current	VCE < VIN - 250 mV		-40°C to 125°C	0 160	300	nA
I <sub>CE</sub>	CE Pin Leakage Current	VCE > VIN + 80 mV		-40°C to 125°C	0 400	610	nA
Reverse C	Surrent Blocking (RCB) and Bo	dy Diode Characteristi	cs				
I <sub>RCB</sub>	Reverse Activation Current	VCE = VOUT		-40°C to 125°C	0.5	1	Α
$V_{FWD}$	Body Diode Forward Voltage	I <sub>OUT</sub> = 10 mA VCE > VIN + 80 mV		-40°C to 125°C	0.1 0.5	1.1	V
Status Ind	lication (ST)						
V <sub>OL, ST</sub>	Output Low Voltage	IST = 1 mA		-40°C to 125°C		0.1	V
t <sub>ST</sub>	Status Delay Time	VCE transitions from le	ow to high	-40°C to 125°C	1		μs
	-					-	



#### **6.5 Electrical Characteristics (continued)**

Typical values are at 25°C with an input voltage of 3.6V. Maximum and minimum values are across the entire operating voltage range, from 1.5V to 5.5V. (unless otherwise noted)

	PARAMETER	TEST CONDITIONS		MIN	TYP MAX	UNI T
I <sub>ST</sub>	ST Pin Leakage Current	VCE < VIN – 250 mV	–40°C to 125°C	-20	20	nA

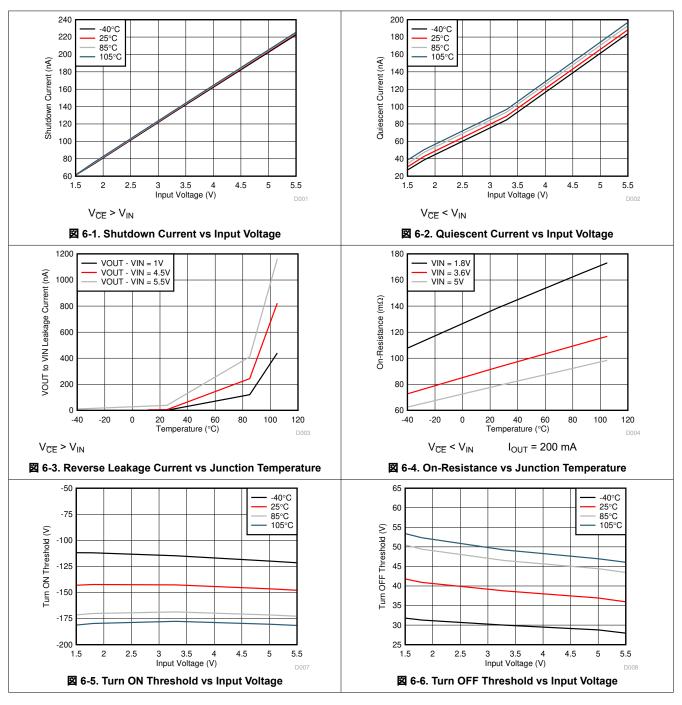
## **6.6 Switching Characteristics**

Unless otherwise noted, the typical characteristics in the following table applies over the entire recommended operating voltage at an ambient temperature of 25°C and a load of  $C_{\rm I}$  = 100 nF and  $R_{\rm I}$  = 1 k $\Omega$ 

	PARAMETER	TEST CONDITIONS	MIN TYP	MAX	UNIT
		VIN = 1.8 V	90		μs
t <sub>ON</sub>	Turn ON Time	VIN = 3.6 V	40		μs
		VIN = 5 V	27		μs
		VIN = 1.8 V	2		μs
t <sub>OFF</sub>	Turn OFF Time	VIN = 3.6 V	2		μs
		VIN = 5 V	2		μs
		VIN = 1.8 V	20		μs
t <sub>FALL</sub>	Output Fall Time	VIN = 3.6 V	10		μs
		VIN = 5 V	7.5		μs

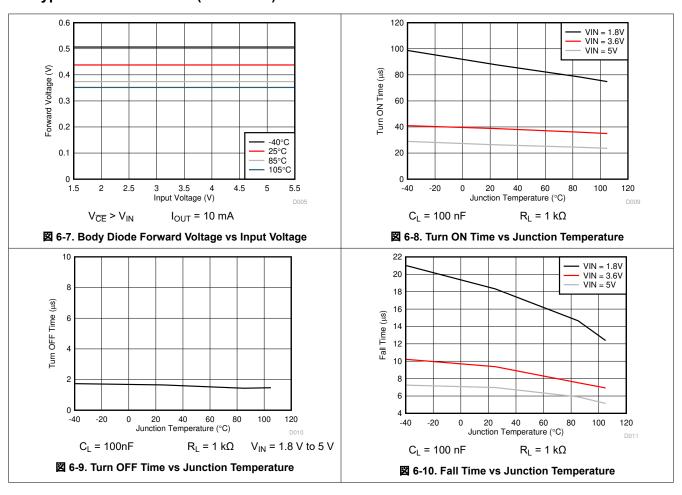
Product Folder Links: LM66100-Q1

## 6.7 Typical Characteristics





## **6.7 Typical Characteristics (continued)**





## 7 Parameter Measurement Information

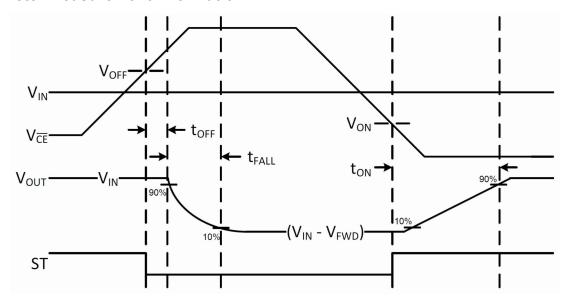


図 7-1. Timing Diagram

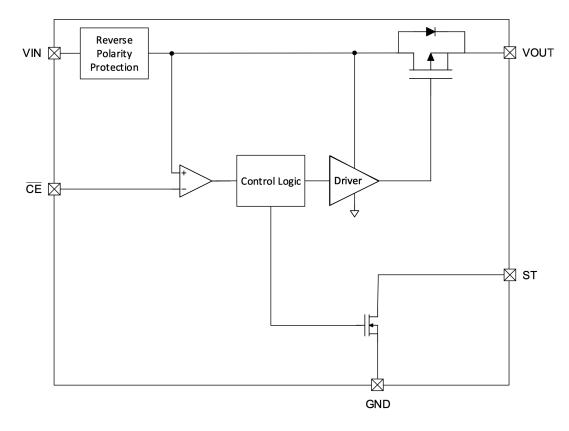
## **8 Detailed Description**

## 8.1 Overview

The LM66100-Q1 is a Single-Input, Single-Output (SISO) integrated ideal diode that contains a P-channel MOSFET to minimize the voltage drop from input to output. The LM66100-Q1 can operate over an input voltage range of 1.5 V to 5.5 V and support a maximum continuous current of 1.5 A.

The chip enable works by comparing the  $\overline{\text{CE}}$  pin voltage to the input voltage. When the  $\overline{\text{CE}}$  pin voltage is higher than VIN by 80 mV, the device is disabled and the MOSFET is off. When the  $\overline{\text{CE}}$  pin voltage is lower than V<sub>IN</sub> by 250 mV, the MOSFET is on. The LM66100-Q1 also comes with reverse polarity protection (RPP) that protects against events where the VIN and GND terminals are swapped.

## 8.2 Functional Block Diagram



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## **8.3 Feature Description**

## 8.3.1 Reverse Polarity Protection (RPP)

In the event a negative input voltage is applied, the ideal diode stays off and prevent current flow to protect the system load. For a stand-alone, always on application,  $\overline{CE}$  can be tied to GND so it does not go negative with respect to GND. See  $\boxtimes$  8-1.

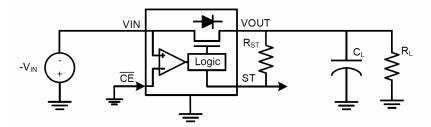


図 8-1. RPP Protection Circuit

#### 8.3.2 Always-ON Reverse Current Blocking (RCB)

By connecting the  $\overline{\text{CE}}$  pin to VOUT, this allows the comparator to detect reverse current flow through the switch. If the output is forced above the selected input by  $V_{\text{OFF}}$ , the channel switches off to stop the reverse current  $I_{\text{RCB}}$  within  $t_{\text{OFF}}$ . Once the output falls below  $V_{\text{IN}}$  by  $V_{\text{ON}}$ , the device turns back on.

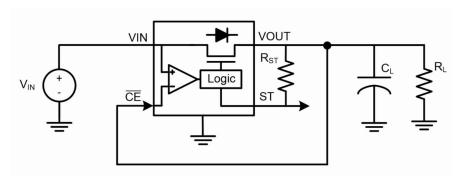


図 8-2. RCB Circuit

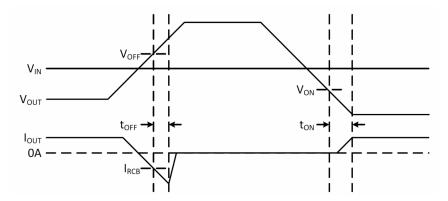


図 8-3. RCB Waveforms



#### 8.4 Device Functional Modes

表 8-1 summarizes the Device Functional Modes:

表 8-1. Device Functional Modes

State	IN-to-OUT	Power Dissipation	ST State
OFF	Diode	I <sub>OUT</sub> × V <sub>FWD</sub>	L
ON	Switch	I <sub>OUT</sub> <sup>2</sup> × R <sub>ON</sub>	Н

## 9 Application and Implementation

#### Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

#### 9.1 Application Information

The LM66100-Q1 Ideal Diode can be used in a variety of stand-alone and multi-channel applications.

#### 9.2 Typical Applications

#### 9.2.1 Dual Ideal Diode ORing

Two LM66100-Q1 Ideal Diodes can be used together for ORing between two power supplies.

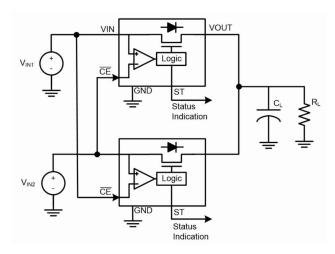


図 9-1. Dual Ideal Diode ORing

#### 9.2.1.1 Design Requirements

Design a circuit that allows the highest input voltage to power a downstream system while providing reverse current protection.

#### 9.2.1.2 Detailed Design Procedure

This circuit ties the  $\overline{\text{CE}}$  of each device to the opposite power source. In this configuration, the highest supply is always selected using a make-before-break logic. This selection prevents any reverse current flow between the supplies and avoids the need of a dedicated reverse current blocking comparator. For ORing applications that need RPP, TI recommends to use a series resistor ( $R_{\overline{\text{CE}}}$ ) to limit the current into the  $\overline{\text{CE}}$  pin during a negative voltage event.

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#### 9.2.1.3 Application Curves

The below scope shot shows the output voltage (VOUT) being initially powered by VIN1. When VIN2 is applied, it powers VOUT because it is a higher voltage. When VIN2 is removed, VOUT is once again powered by VIN1.

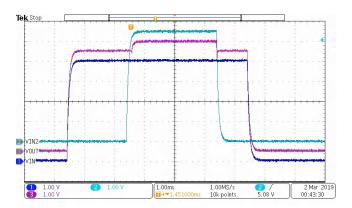


図 9-2. Dual Ideal Diode ORing Behavior

## 9.2.2 Dual Ideal Diode ORing for Continuous Output Power

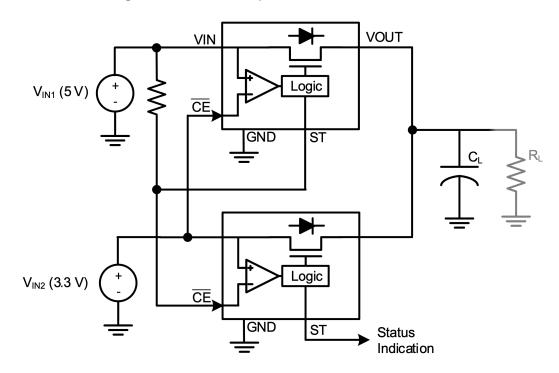


図 9-3. Dual Ideal Diode ORing for Continuous Output Power

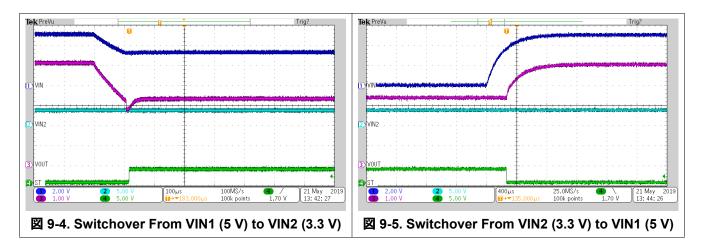
#### 9.2.2.1 Design Requirements

The shortcoming of the previous implementation happens when both input voltages are the same for a long period of time. Then, both devices completely turn off, powering down the output load. To avoid this case, use the status output from the priority supply and a pullup resistor, causing both devices to switchover at the same time. For ORing applications that need RPP, TI recommends to use a series resistor ( $R_{\overline{CE}}$ ) to limit the current into the  $\overline{CE}$  pin during a negative voltage event.



#### 9.2.2.2 Application Curves

The figures below show the switchover performance between VIN1 and VIN2.



#### 9.2.3 ORing with Discrete MOSFET

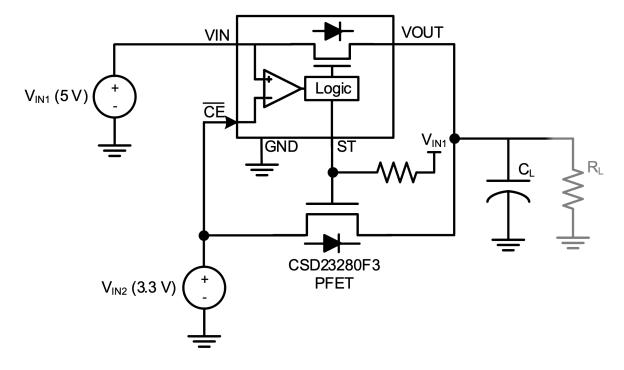


図 9-6. ORing with a Discrete MOSFET

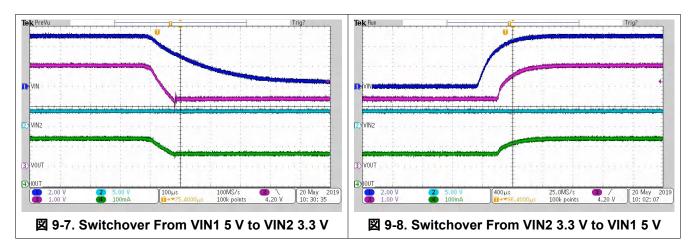
#### 9.2.3.1 Design Requirements

Similar to the Dual Ideal Diode circuit, the Status Output can also be used to control a discrete P-Channel MOSFET. This action can be useful in applications that want to minimize the leakage current on the secondary supply, such as battery backup systems. This configuration can also be used on systems that require a lower RON on the secondary rail, useful for higher current applications.

When the Ideal Diode path is enabled, the status is Hi-Z and pulls up the gate of the external PFET to keep it off. When the main supply (VIN1) drops such that backup supply (VIN2) is higher than VIN1, the ideal diode is disabled and pulls the ST pin and the PFET gate low to turn on the discrete MOSFET path.

## 9.2.3.2 Application Curves

The figures below show the switchover performance between VIN1 and VIN2.



## 10 Power Supply Recommendations

The device is designed to operate with a VIN range of 1.5 V to 5.5 V. The VIN power supply must be well regulated and placed as close to the device terminal as possible. The power supply must be able to withstand all transient load current steps. In most situations, using an input capacitance (CIN) of 1  $\mu$ F is sufficient to prevent the supply voltage from dipping when the switch is turned on. In cases where the power supply is slow to respond to a large transient current or large load current step, additional bulk capacitance can be required on the input.



## 11 Layout

## 11.1 Layout Guidelines

For best performance, all traces must be as short as possible. To be most effective, place the input and output capacitors close to the device to minimize the effects that parasitic trace inductances can have on normal operation. Using wide traces for VIN, VOUT, and GND helps minimize the parasitic electrical effects.

## 11.2 Layout Example

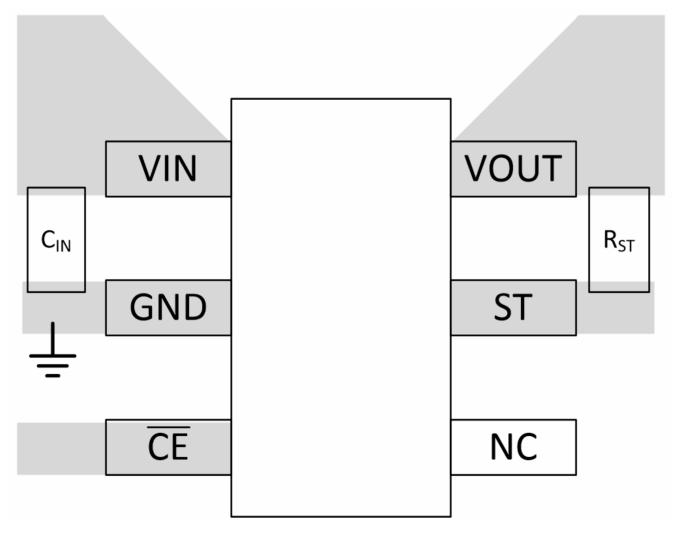


図 11-1. LM66100-Q1 Layout Example

## 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. In the upper right corner, click on *Alert me* 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<sup>™</sup> 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、設計で必要な支援を迅速に得ることができます。

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#### 12.3 Trademarks

TI E2E<sup>™</sup> 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.



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#### PACKAGING INFORMATION

Orderable Device	Status	Package Type	Package Drawing	Pins	Package Qty	Eco Plan	Lead finish/ Ball material	MSL Peak Temp	Op Temp (°C)	Device Marking (4/5)	Samples
LM66100QDCKRQ1	ACTIVE	SC70	DCK	6	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1IW	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 (CI) 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.

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#### OTHER QUALIFIED VERSIONS OF LM66100-Q1:

## **PACKAGE OPTION ADDENDUM**

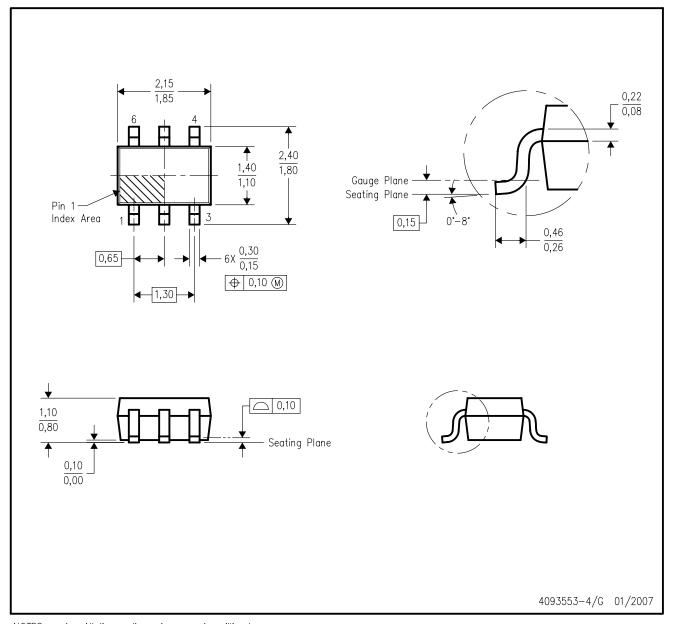
www.ti.com 26-Oct-2023

NOTE: Qualified Version Definitions:

• Catalog - TI's standard catalog product

# DCK (R-PDSO-G6)

## PLASTIC SMALL-OUTLINE PACKAGE



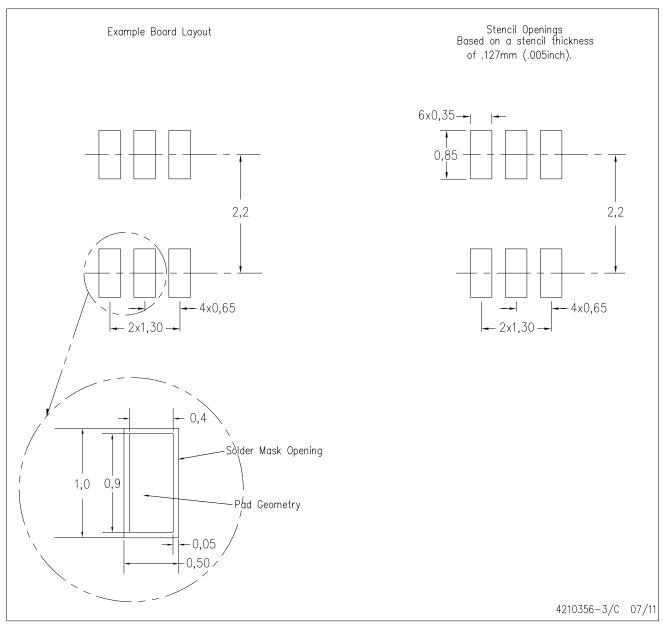
NOTES: A. All linear dimensions are in millimeters.

- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
- D. Falls within JEDEC MO-203 variation AB.



# DCK (R-PDSO-G6)

## PLASTIC SMALL OUTLINE



NOTES:

- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
- D. Publication IPC-7351 is recommended for alternate designs.
- E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.



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