

### General Description

The SQ24201E is an ultra-low  $R_{DS(ON)}$  power distribution switch with current limit to protect the power source from over current and short circuit conditions. It incorporates over temperature protection and reverse blocking function.

The SQ24201E is available in either DFN2x2-6 or SOT23-6 packages.

### Applications

- USB 3.1 Application
- USB 3G Data Card
- USB Dongle
- Mini PCI Accessories
- USB Charger
- Public Place Multi-USB Charger
- PC Card Hot Swap Applications

### Features

- Input Voltage: 2.5V to 5.5V
- Extremely Low Power Path Resistance: 65m $\Omega$  (Typ.)
- Adjustable Current Limit up to 2A
- Reverse Blocking (No Body Diode)
- Fast Reverse Recovery
- Fault Flag (OCB) Output for Over Current and Fault Conditions
- At Shutdown, OUT Can Be Forced Higher than IN
- Built-in Soft-start
- RoHS Compliant and Halogen Free
- Compact Package Minimizes the Board Space: DFN2x2-6/ SOT23-6
- UL Certificate Number: UL-US-2435031-0

### Typical Application

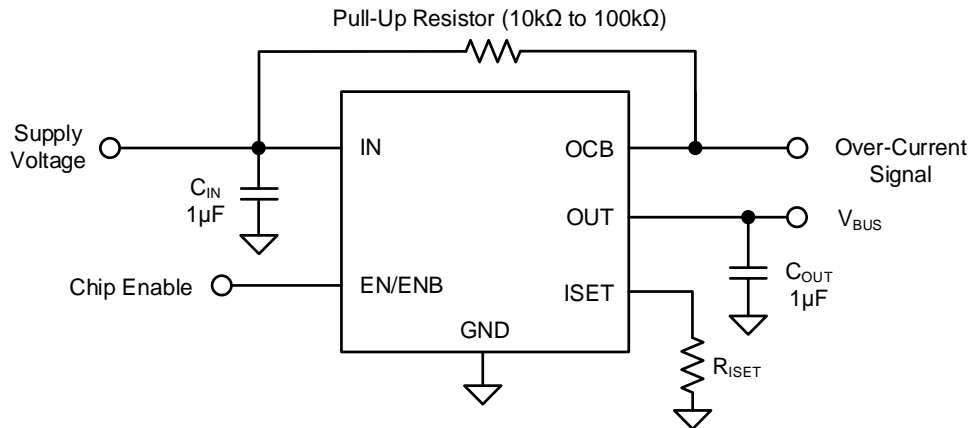
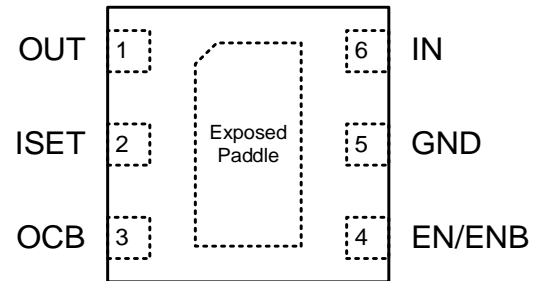


Figure 1. Schematic Diagram

## Ordering Information

Ordering Part Number	Details
SQ24201EDED	Active High Pin 4 -EN
SQ24201EABT	Active High Pin 4 -EN
SQ24201E2DED	Active Low Pin 4 -ENB

## Pinout (top view)\*

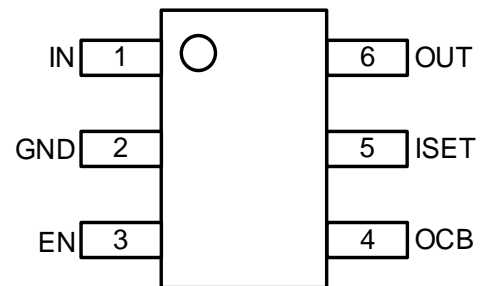


(DFN2x2-6)

\*Pin 4 is EN for SQ24201EDED, ENB for SQ24201E2DED

## Package Information

Ordering Part Number	Package Type	Top Mark
SQ24201EDED	DFN2x2-6 RoHS Compliant and Halogen Free	3gxyz
SQ24201EABT	SOT23-6 RoHS Compliant and Halogen Free	HJPxyz
SQ24201E2DED	DFN2x2-6 RoHS Compliant and Halogen Free	KCExyz



(SOT23-6)

*x = year code, y = week code, z = lot number code*

## Pin Description

Pin Name	Pin Number		Pin Description
	DFN2x2-6	SOT23-6	
OUT	1	6	Output pin, decoupled with a 1 $\mu$ F capacitor from the IN to the GND as close to the IC as possible.
ISET	2	5	Current limit programming pin. Connect a resistor R <sub>ISET</sub> from this pin to ground to program the current limit. Recommended 13k $\Omega$ $\leq$ R <sub>ISET</sub> $\leq$ 232 k $\Omega$
OCB	3	4	Active low, open-drain fault flag. Asserted during over current or over temperature.
EN/ENB	4	3	ON/OFF control. Do not leave it floating. EN: Active high; ENB: Active low.
GND	5, Exposed Paddle	2	Ground pin.
IN	6	1	Input pin, decoupled with a 1 $\mu$ F capacitor from the IN to the GND as close to the IC as possible.

## Block Diagram

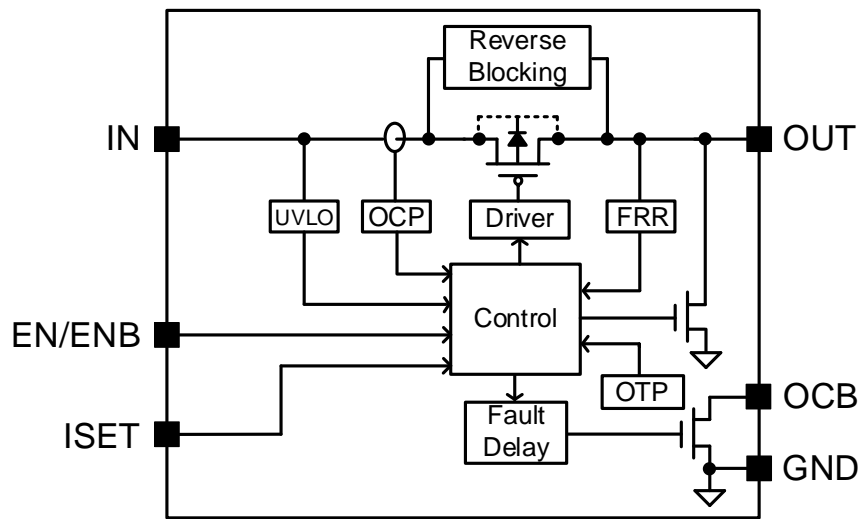


Figure2. Block Diagram

## Absolute Maximum Ratings

Parameter (Note1)	Min	Max	Unit
IN, OUT, ISET, OCB, EN/ENB	-0.3	6	V
Lead Temperature (Soldering, 10 sec.)		260	°C
Junction Temperature, Operating	-40	150	
Storage Temperature	-65	150	

## Thermal Information

Parameter (Note2)	Typ	Unit
$\theta_{JA}$ Junction-to-ambient Thermal Resistance (DFN2x2-6/ SOT23-6)	51.5 / 89.8	°C/W
$\theta_{JC}$ Junction-to-case Thermal Resistance (DFN2x2-6/ SOT23-6)	8.6 / 9.9	
$P_D$ Power Dissipation $T_A = 25^\circ\text{C}$ (DFN2x2-6/ SOT23-6)	1.9 / 1.1	W

## Recommended Operating Conditions

Parameter (Note 3)	Min	Max	Unit
IN, OUT	2.5	5.5	V
ISET, OCB, EN/ENB	0	5.5	
Junction Temperature, Operating	-40	125	°C
Ambient Temperature	-40	85	

## Electrical Characteristics

( $V_{IN} = 5V$ ,  $C_{OUT} = 10\mu F$ ,  $T_J = -40^\circ C$  to  $125^\circ C$ , typical values are at  $T_J = 25^\circ C$  unless otherwise specified. (Note 4).)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range	$V_{IN}$		2.5		5.5	V
IN UVLO Threshold	$V_{IN,UVLO}$				2.45	V
IN UVLO Hysteresis	$V_{IN,HYS}$	$T_J = 25^\circ C$		0.14		V
Shutdown Input Current	$I_{SHDN}$	Open load, switch off $-40^\circ C \leq T_J \leq 85^\circ C$		0.1	5	$\mu A$
		Output grounded, switch off $-40^\circ C \leq T_J \leq 85^\circ C$		0.1	5	$\mu A$
Reverse Leakage Current		IN tie to GND, $V_{OUT} = 5V$ $-40^\circ C \leq T_J \leq 85^\circ C$		0.1	5	$\mu A$
Reverse Blocking Threshold	$V_{RBT}$	IN tied to GND, $V_{OUT} = 5V$		100		mV
Reverse Blocking Recovery Threshold	$V_{RBT\_REC}$	$V_{OUT} - V_{IN}$		-30		mV
Quiescent Supply Current	$I_Q$	Open load, switch on		45	100	$\mu A$
FET $R_{DS(ON)}$	$R_{DS(ON)}$	$V_{IN} = 5V$ , $I_{OUT} = 0.5A$		65	100	m $\Omega$
Current Limit Threshold	$I_{LIM}$	$R_{ISET} = 15k\Omega$	1600	1740	1880	mA
		$R_{ISET} = 49.9k\Omega$	490	540	590	
		$R_{ISET} = 210k\Omega$	130	150	170	
		ISET shorted to IN	65	90	115	
EN Input Low Voltage/ ENB Input High Voltage	$V_{IL}$				0.4	V
EN Input High Voltage/ ENB Input Low Voltage	$V_{IH}$		1.0			V
EN/ENB Input Capacitor	$C_{EN}$	(Note 5)		1		pF
EN/ENB Leakage Current	$I_{ENLK}$				1	$\mu A$
Output Turn On Rise Time	$t_R$	$R_L = 100\Omega$ , $C_L = 1\mu F$ . Measure from $V_{OUT} = 10\%$ of $V_{IN}$ to $90\%$ of $V_{IN}$	1.9	2.7	3.7	ms
Output Turn Off Fall Time	$t_F$	$R_L = 100\Omega$ , $C_L = 1\mu F$ . Measure from $V_{OUT} = 90\%$ of $V_{IN}$ to $10\%$ of $V_{IN}$		126		$\mu s$
OCB Low Resistance	$R_{OCB}$	$V_{IN} = 5V$ , $I_L = 10\mu A$		9		$\Omega$
		$V_{IN} = 3.3V$ , $I_L = 10\mu A$		12		
OUT Shutdown Discharge Resistance	$R_{DSG}$	EN=0V, $V_{OUT} = 0.1V$ (SQ24201E) ENB=3.3V, $V_{OUT} = 0.1V$ (SQ24201E2)	75	100	145	$\Omega$
OCB Leakage Current	$I_{LKG\_OCB}$	$V_{OCB} = 5V$		0.01	1	$\mu A$
Fast Reverse Recovery Time	$t_{FRR}$	$V_{IN} = 3.3V$ , $V_{OUT} = 3.5V$ , $C_L = 1\mu F$ , OUT= $100\Omega$ to GND. Remove 3.5V from OUT. Measure time from $V_{OUT}$ thru 2.9V to $V_{OUT} = 3.2V$ (Note 5)			50	$\mu s$
Current-limit Response Time	$t_{OC\_res}$	$I_{LOAD} = 1.2I_{LIM}$ (Note 5)		15		$\mu s$
Over Current Flag Response Time	$t_{OCB}$	$I_{LOAD} = 1.2I_{LIM}$		10		ms
Short Circuit Response Time	$t_{OC}$	$I_{LOAD} = 1.5I_{LIM}$ (Note 5)		2		$\mu s$

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Reverse Blocking Response Time	t <sub>RBT</sub>	(Note 5)		800		ns
Thermal Shutdown Temperature	T <sub>SD</sub>	(Note 5)		150		°C
Thermal Shutdown Hysteresis	T <sub>HYS</sub>	(Note 5)		20		°C

**Note 1:** Stresses beyond the “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

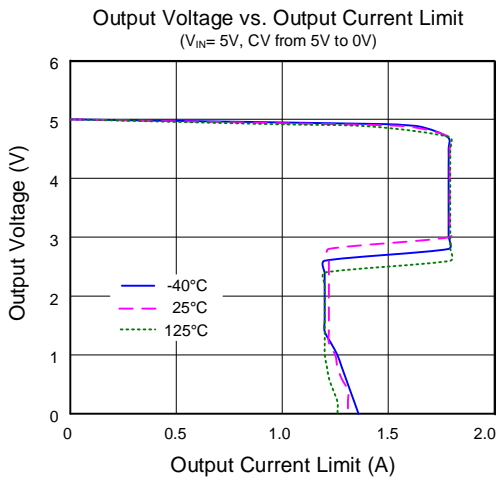
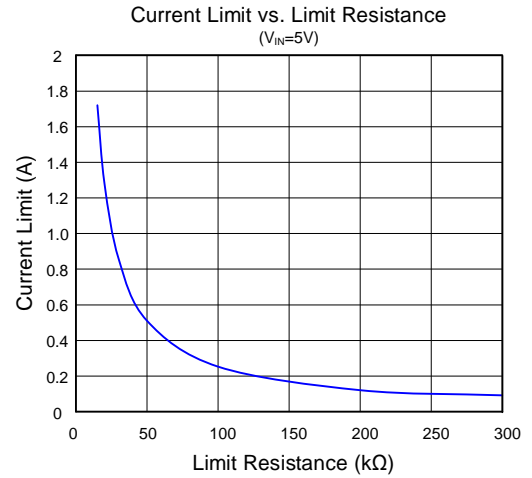
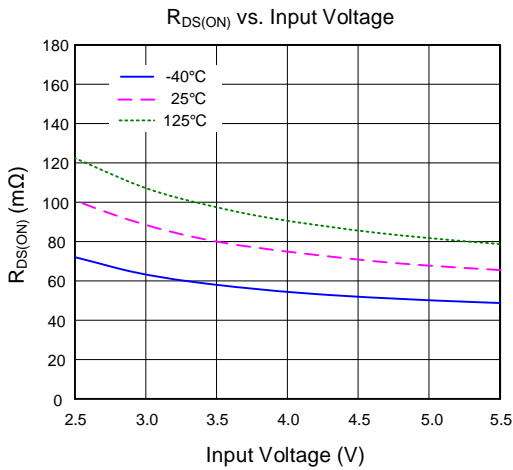
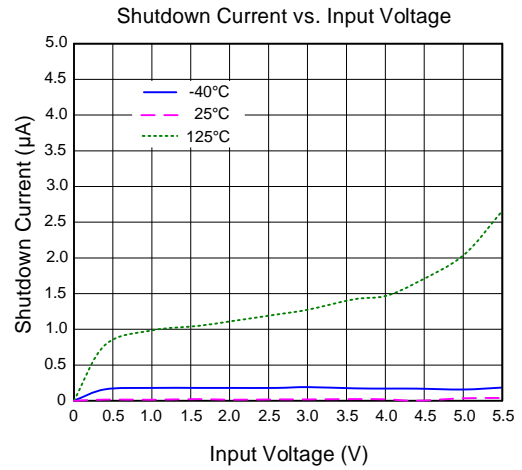
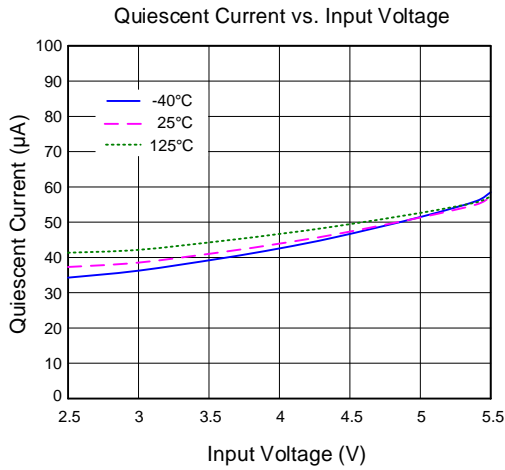
**Note 2:**  $\theta_{JA}$  is measured in the natural convection at  $T_A = 25^\circ\text{C}$  on a Silergy’s test board.

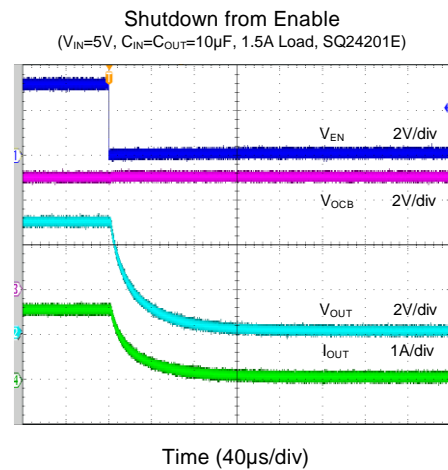
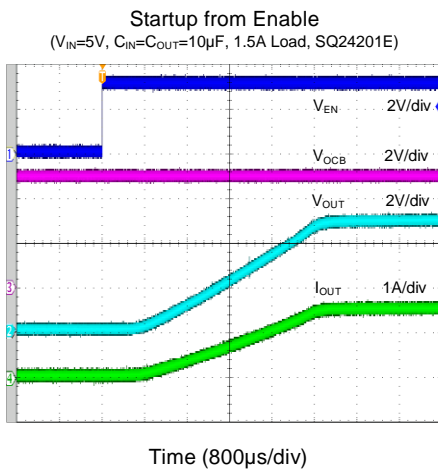
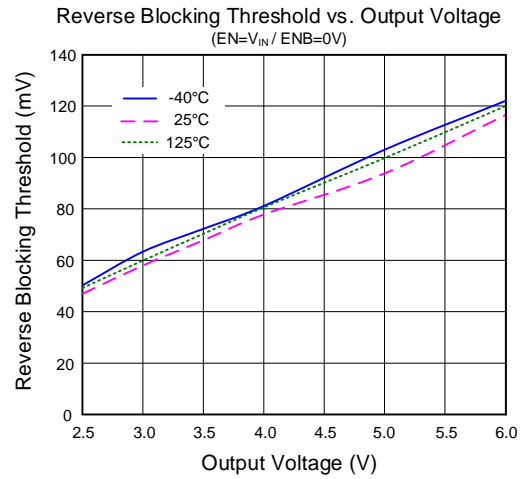
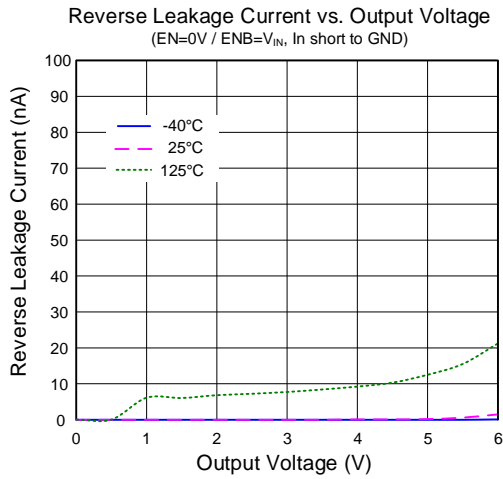
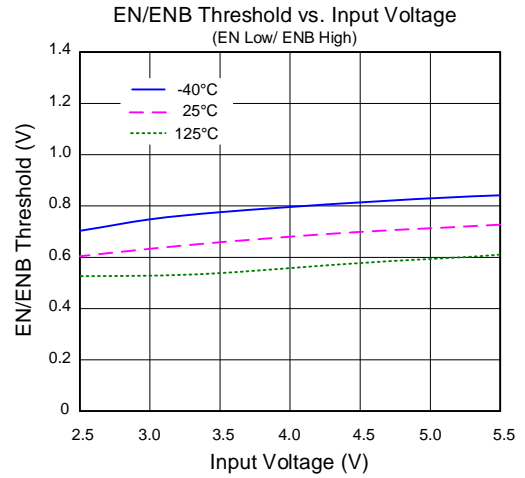
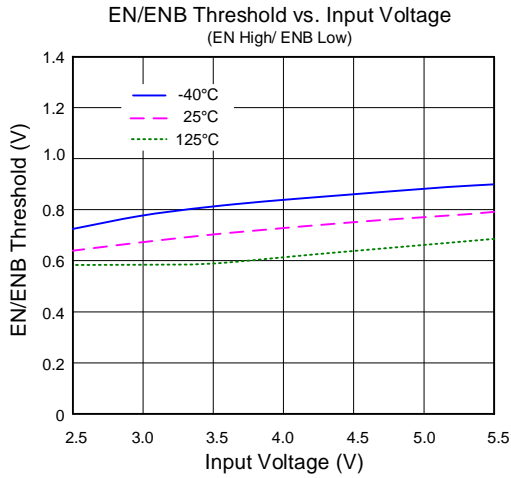
**Note 3:** The device is not guaranteed to function outside its operating conditions.

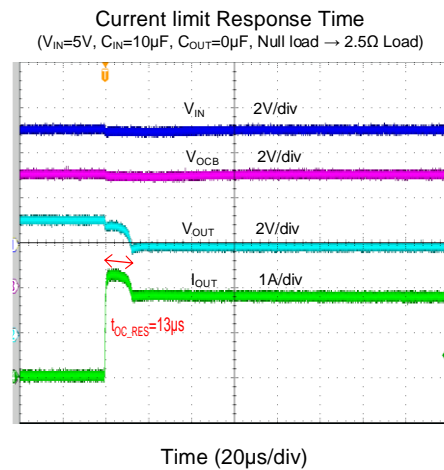
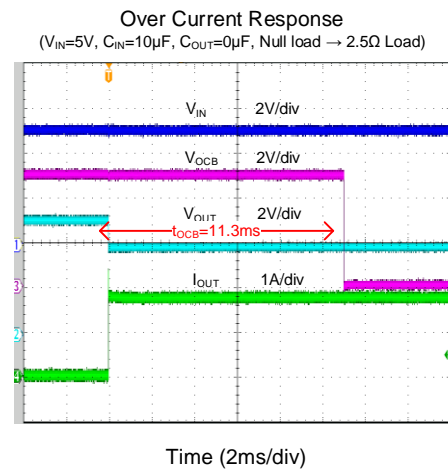
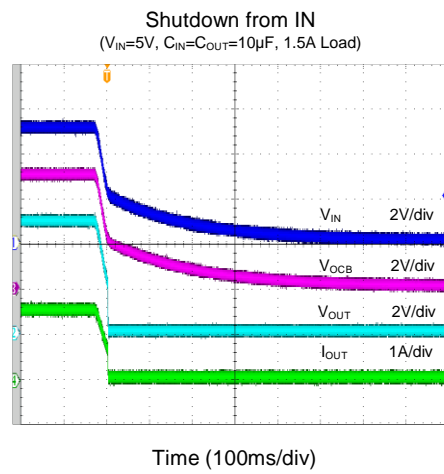
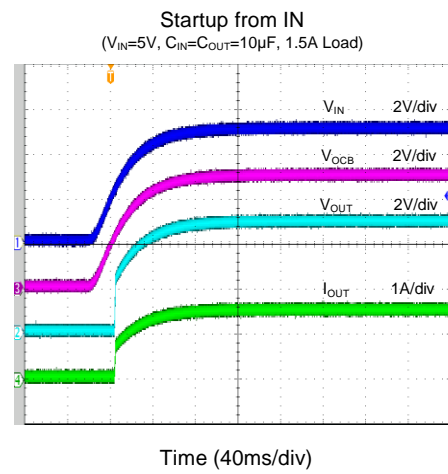
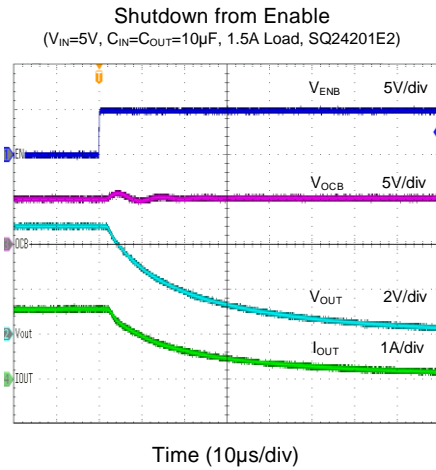
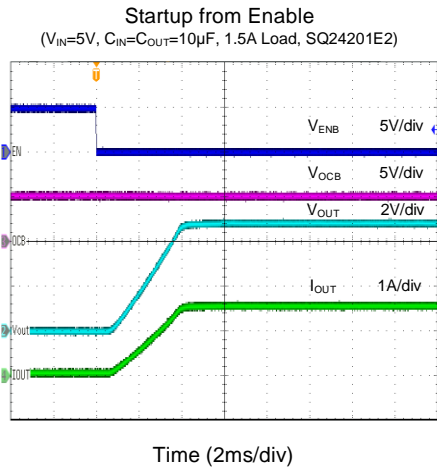
**Note 4:** Unless otherwise stated, limits are 100% production tested under pulsed load conditions such that  $T_A \cong T_J = 25^\circ\text{C}$ . Limits over the operating temperature range (See recommended operating conditions) and relevant voltage range(s) are guaranteed by design, test, or statistical correlation.

**Note 5:** Guaranteed by design but not production tested.

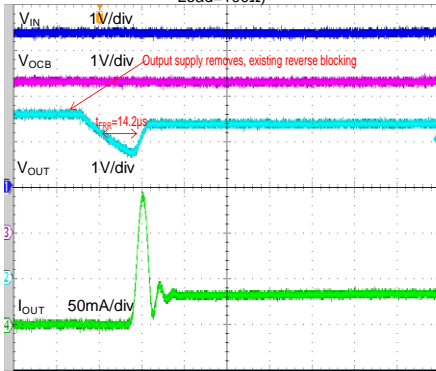
## Typical Performance Characteristics





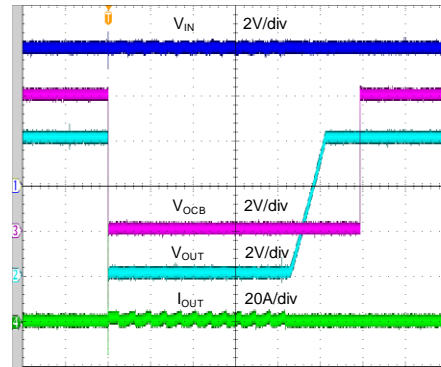


**Fast Reverse Blocking Recovery Response**  
 ( $V_{IN}=3.3V$ ,  $V_{OUT}=3.5V$  removes,  $C_{IN}=1nF$ ,  $C_{OUT}=1\mu F$ ,  
 Load= $100\Omega$ )



Time (20 $\mu s$ /div)

**Short Circuit**  
 ( $V_{IN}=6V$ ,  $R_{SET}=15k\Omega$  (1.7A))



Time (4ms/div)

## Operation

The SQ24201E is a current limited power switch designed for USB load-switching or hot plug applications. It incorporates the over temperature protection and reverse blocking function, so the IC prevents current flow from OUT to IN when out being externally forced to a higher voltage than IN.

### Over Current Protection

The SQ24201E supports Current Limit programming. Connect a resistor  $R_{ISET}$  from the ISET pin to ground to program the current limit:

$$I_{LIM(MAX)}(mA) = \frac{27633V}{R_{ISET}(k\Omega)} + 37mA$$

$$I_{LIM(MEAN)}(mA) = \frac{25697V}{R_{ISET}(k\Omega)} + 27mA$$

$$I_{LIM(MIN)}(mA) = \frac{23760V}{R_{ISET}(k\Omega)} + 16mA$$

where

$$13\text{ k}\Omega \leq R_{ISET} \leq 232\text{ k}\Omega$$

While the maximum recommended value of  $R_{ISET}$  is 232 k $\Omega$ , there is one additional configuration that allows for a lower current-limit threshold. The ISET pin may be connected directly to IN to provide a 90 mA (typical) current limit threshold. Additional low-ESR ceramic capacitance may be necessary from IN to GND in this configuration to prevent unwanted noise from coupling into the sensitive ISET circuitry.

The current limit of device will be folded back at about  $60\% \times I_{LIM}$  to decrease power dissipation when  $V_{OUT} < 60\% \times V_{IN}$ .

When the over current condition is sensed, the gate of the pass switch is modulated to achieve constant output current. If the over current condition persists for a long time, the junction temperature may exceed 150°C, and over-temperature protection will shut down the part. Once the chip temperature drops below 130°C, the part will restart.

### Fault Flag(OCB)

The OCB output is asserted (active low) when thermal shutdown protection is triggered or over current condition persists for 10ms. The output remains asserted until fault condition is removed. Connecting a heavy capacitance load to an enabled device can cause a momentary over current condition;

### Supply Filter Capacitor

In order to prevent the input voltage spike which could destroy the internal circuitry when the input transient exceeds the absolute maximum supply voltage during output short or other load transient situation, a 1 $\mu$ F ceramic capacitors from VIN to GND is strongly recommended. Higher capacitor values could reduce the voltage spike on the input further.

### Output Filter Capacitor

A 1 $\mu$ F output ceramic capacitor is recommended to be placed close to the IC and output connector to reduce voltage drop during load transient. Higher values of output capacitor can be used to further reduce the drop during high current application.

### Reverse Block Function

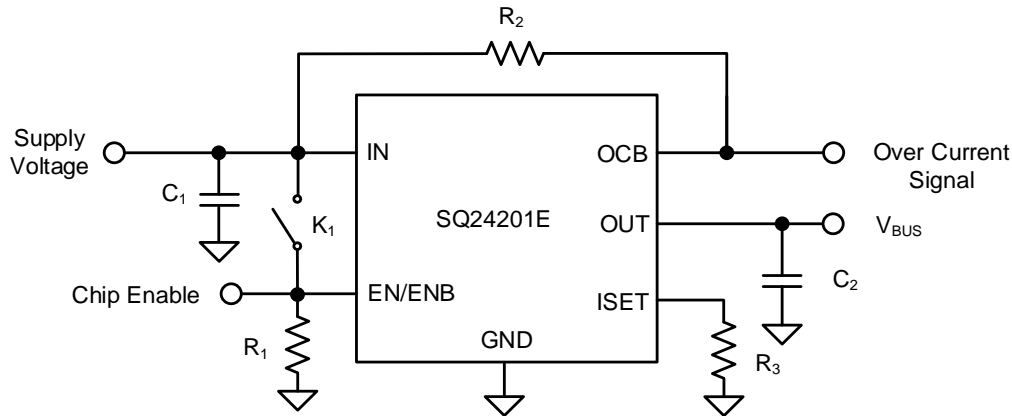
The SQ24201E integrates reverse blocking function. Once the deviation voltage of OUT-IN exceeds 100mV, the reverse block function is triggered. The power FET will be shut down within 800ns block the reverse current flow from OUT to IN.

The SQ24201E integrates the fast reverse blocking recovery function, which makes  $V_{OUT}$  recovery to 3.2V within 50 $\mu$ s once  $V_{OUT}$  drops 30mV lower than  $V_{IN}$  after the device is already work at reverse block mode.

### Short Circuit Protection

When detecting a critical overcurrent situation, the device initiates a rapid response to turn off the power FET within 2 $\mu$ s. The built-in fast trip comparator uses an adjustable threshold ( $I_{sc}$ ) set to  $1.5 \times I_{LIM}$ . This feature allows the user to customize the fast trip threshold, providing the flexibility that a fixed threshold might not offer.

## Schematic



## BOM List

Reference Designator	Description	Part Number	Manufacturer
C <sub>1</sub>	1 $\mu$ F/25V, 0603	GRM21BR71E105K	Murata
C <sub>2</sub>	1 $\mu$ F/25V, 0603	GRM21BR71E105K	Murata
R <sub>1</sub>	1M $\Omega$ , 0603	RC0603FR-071ML	YAGEO
R <sub>2</sub>	100K $\Omega$ , 0603	RC0603FR-07100KL	YAGEO
R <sub>3</sub>	15K $\Omega$ , 0603	RC0603FR-0715KL	YAGEO

## PCB Layout Guide

For best performance of the SQ24201E, the following guidelines must be strictly followed:

- 1) Keep all VBUS traces as short and wide as possible and use at least 2 ounce copper for all VBUS traces.
- 2) Locate the output capacitor as close to the connectors as possible to lower impedance (mainly inductance) between the port and the capacitor and improve transient performance.
- 3) Input and output capacitors should be placed closed to the IC and connected to ground plane to reduce noise coupling.

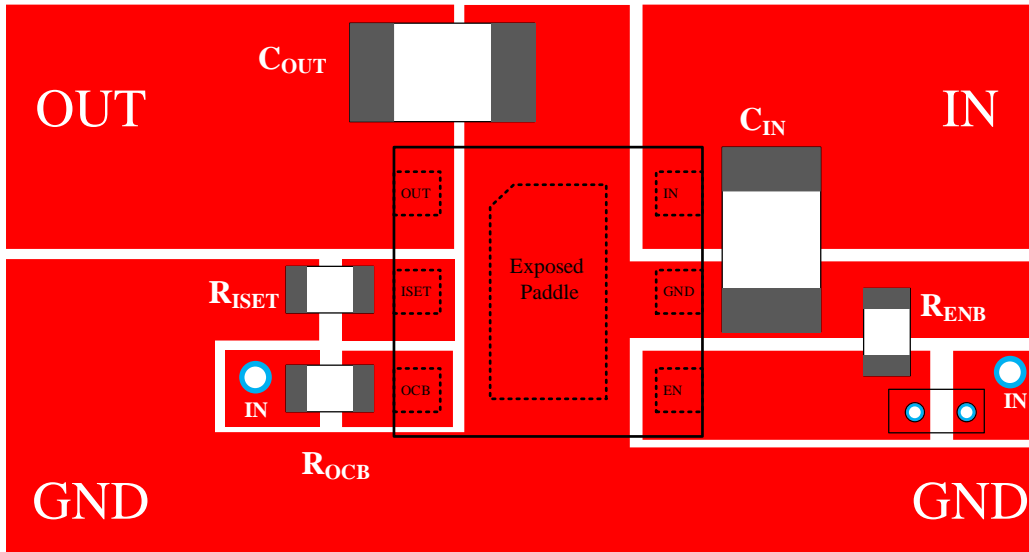


Figure3 (a). PCB Layout Suggestion (SQ24201EDED/SQ24201E2DED)

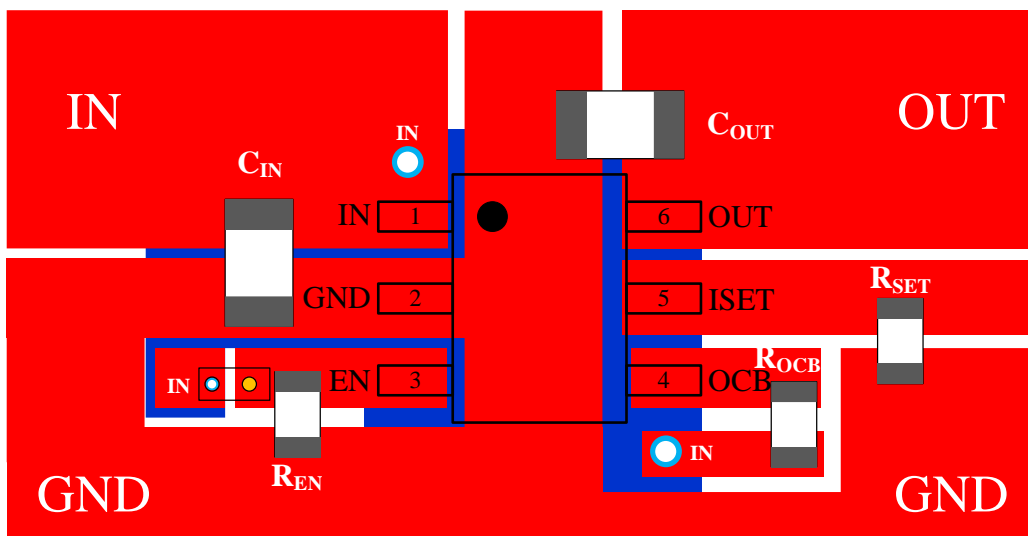
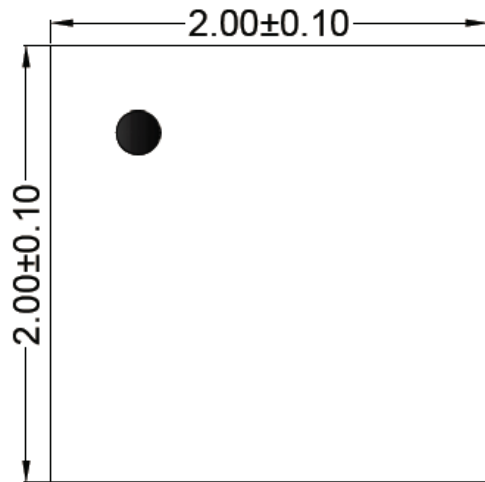
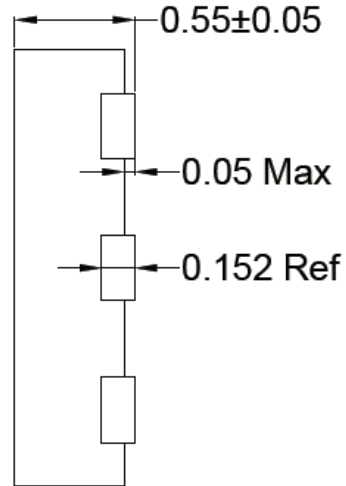


Figure3 (b). PCB Layout Suggestion (SQ24201EABT)

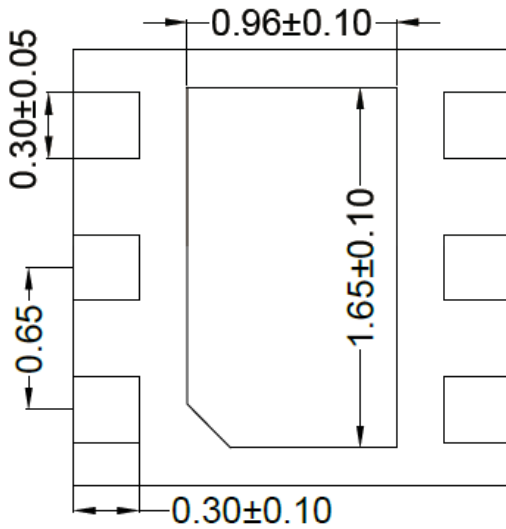
### DFN2x2-6 Package Outline



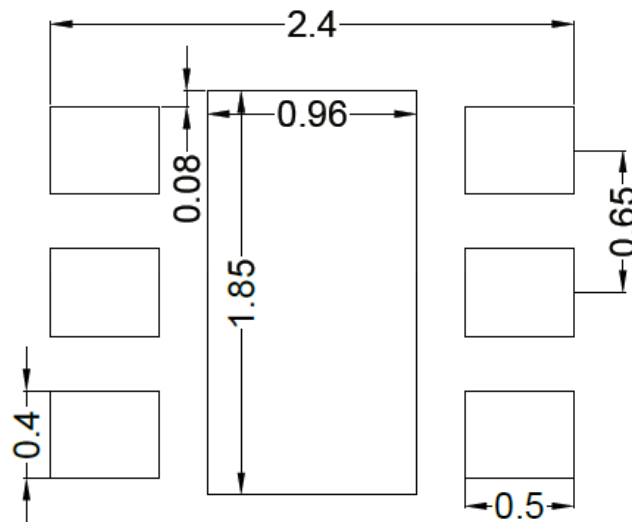
Top View



Side View



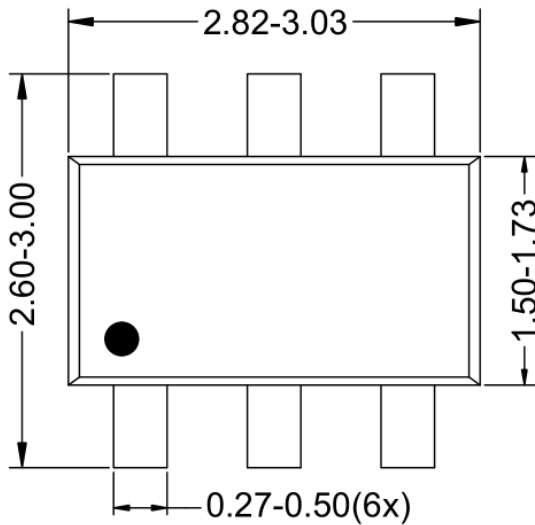
Bottom View



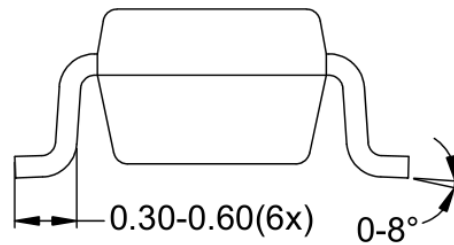
Recommended PCB layout

Notes: All dimension in millimeter and exclude mold flash & metal burr

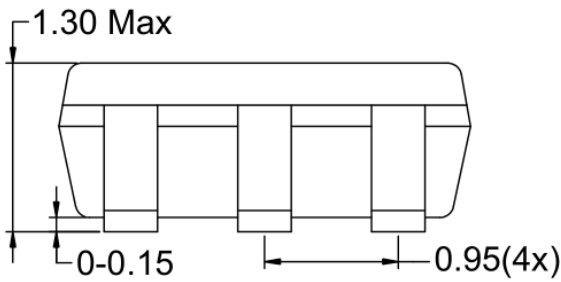
**SOT23-6 Package Outline & PCB layout**



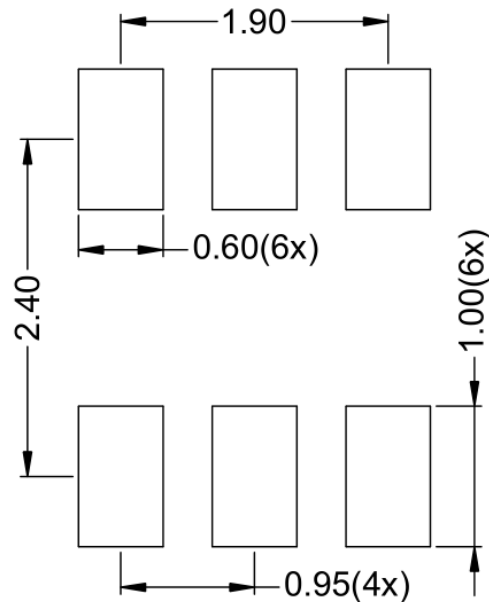
**Top View**



**Side View**



**Side View**



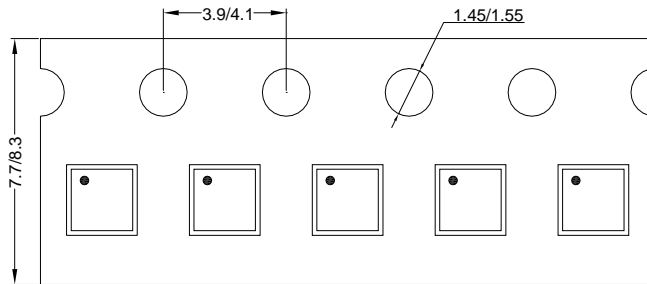
**Recommended PCB Layout**

*Notes: All dimension in millimeter and exclude mold flash & metal burr.*

## Tape and Reel Information

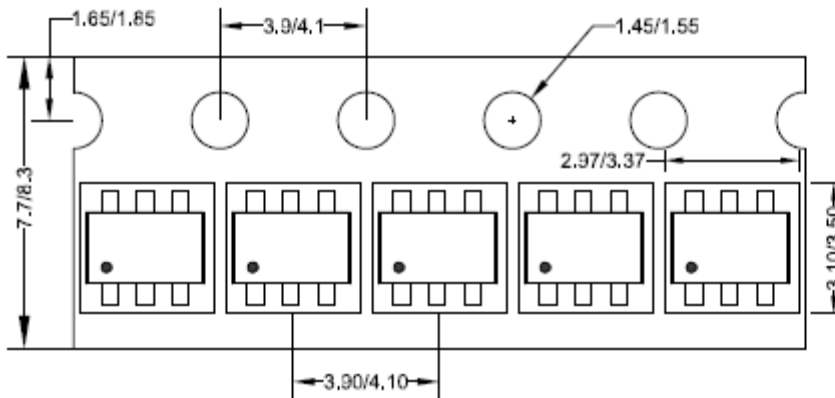
### 1. Tape Dimensions and Pin1 Orientation

DFN2x2



Direction of Feed →

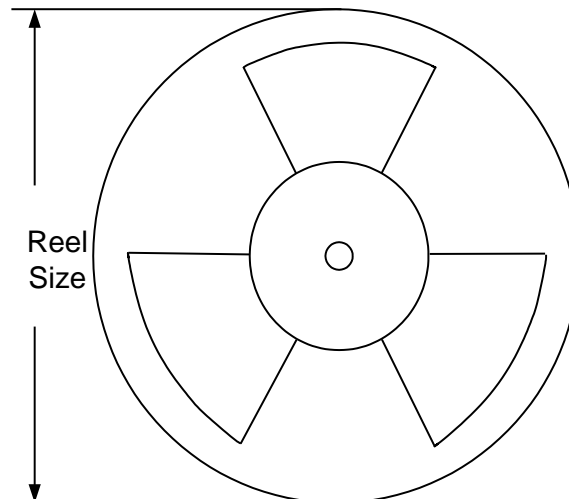
SOT23-6



Direction of Feed →



### 2. Reel Dimensions



Package types	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer length(mm)	Leader length (mm)	Qty per reel
DFN2x2	8	4	7"	400	160	3000
SOT23-6	8	4	7"	280	160	3000

## Revision History

The revision history provided is for informational purpose only and is believed to be accurate, however, not warranted. Please make sure that you have the latest revision.

Date	Revision	Change
Nov.19, 2024	Revision 1.0C	Add SQ24201E2DED
Oct. 11, 2024	Revision 1.0B	Add UL Certificate Number in Features (page 1)
July 08, 2024	Revision 1.0A	Update the Current Limit Curve (page 6)
Dec.18, 2023	Revision 1.0	Initial Release

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