SY86201E

Low Loss Power Distribution Switch with Programmable Current limit

General Description

The SY86201E 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 overtemperature protection and a reverse blocking function.

The SY86201E is available in either DFN2×2-6 or SOT23-6 package.

Applications

- USB 3.1 Applications
- USB 3G Data Cards
- USB Dongles
- Mini PCI Accessories
- USB Chargers
- Multi-USB Chargers
- PC Card Hot-Swap Applications

Features

- Input Voltage: 2.5V to 5.5V
- Extremely Low Power Path Resistance: 65mΩ (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
- During Shutdown, OUT Can Be Forced Higher than IN
- Built-In Soft-Start
- MSL1
- RoHS Compliant and Halogen Free
- Compact Package Minimizes Board Space: DFN2×2-6/ SOT23-6

Typical Application

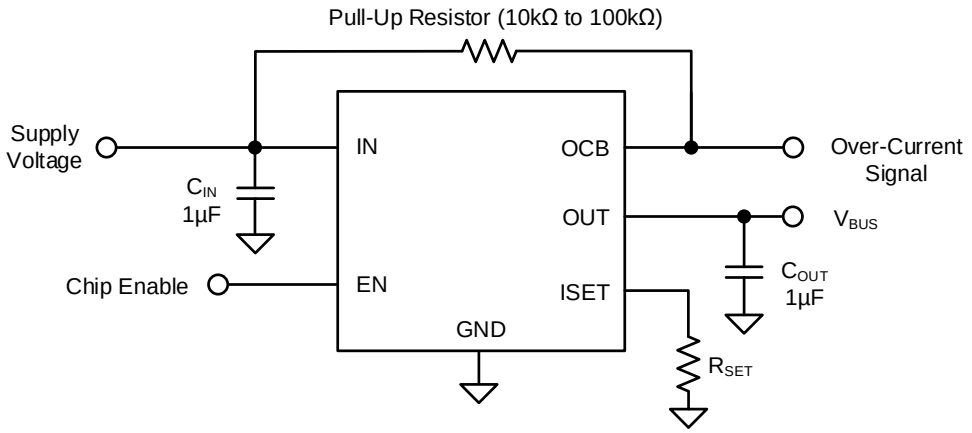


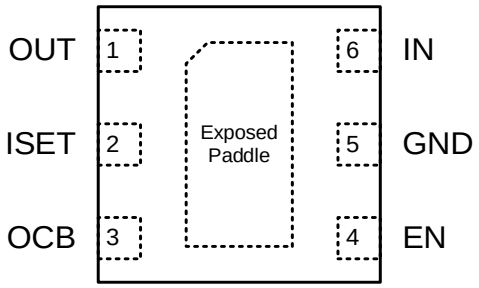
Figure1. Schematic Diagram

Ordering Information

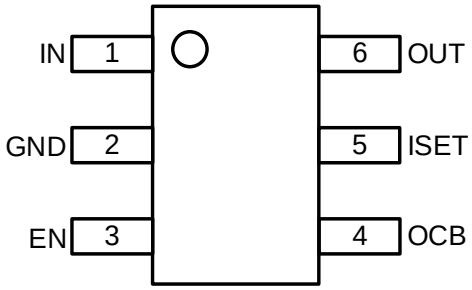
Ordering Part Number	Package Type	Top Mark
SY86201EDED	DFN2×2-6 RoHS Compliant and Halogen Free	**KBB*xyz***
SY86201EABT	SOT23-6 RoHS Compliant and Halogen Free	**HJRxyz**

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

Pinout (Top View)



(DFN2×2-6)



(SOT23-6)

Pin Description

Pin Name	Pin Number		Pin Description
	DFN2×2-6	SOT23-6	
OUT	1	6	Output pin, decoupled with a 1μF 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_{ISET} from this pin to ground to program the current limit. Recommended 13kΩ ≤R_{ISET}≤232 kΩ
OCB	3	4	Active low, open-drain fault flag. Asserted during over current or over temperature.
EN	4	3	ON/OFF control. Do not leave floating. A logic high turns on the power switch.
GND	5, Exposed Paddle	2	Ground pin.
IN	6	1	Input pin, decoupled with a 1μF capacitor from the IN to the GND, as close to the IC as possible.

Block Diagram

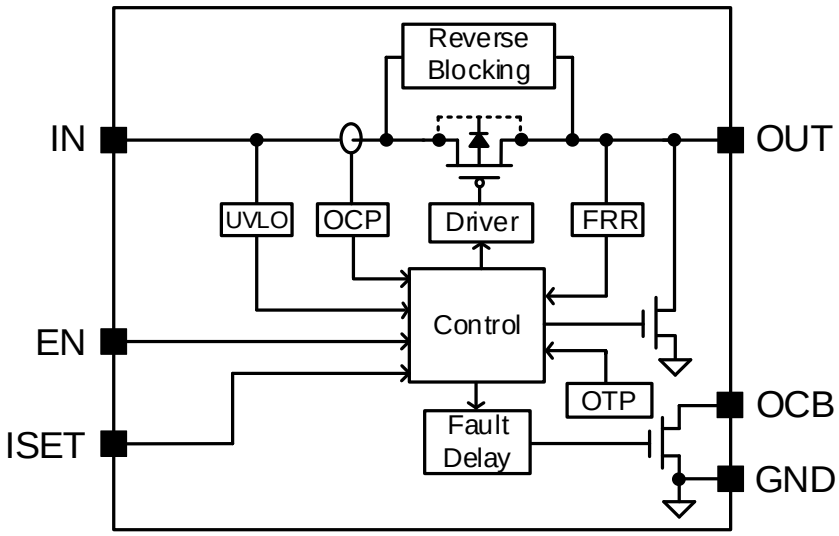


Figure2. Block Diagram

Absolute Maximum Ratings

Parameter (Note1)	Min	Max	Unit
IN, OUT, ISET, OCB, EN	-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
θ_{JA} Junction-to-ambient Thermal Resistance (DFN2×2-6/ SOT23-6)	51.5 / 89.8	°C/W
θ_{JC} Junction-to-case Thermal Resistance (DFN2×2-6/ SOT23-6)	8.6 /9.9	
P_D Power Dissipation T_A = 25°C (DFN2×2-6/ 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	0	5.5	
Junction Temperature, Operating	-40	125	°C
Ambient Temperature	-40	85	

Electrical Characteristics

(V_{IN} = 5V, C_{OUT} = 10μF, T_J = -40°C to 125°C, typical values are at T_J=25°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°C		0.14		V
Shutdown Input Current		I_{SHDN}	Open load, switch off -40°C ≤T_J ≤ 85°C		0.1	5	μA
			Output grounded, switch off -40°C ≤T_J ≤ 85°C		0.1	5	μA
Reverse Leakage Current			IN tie to GND, V_{OUT}=5V -40°C ≤T_J ≤ 85°C		0.1	5	μA
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	μA
FET $R_{DS(ON)}$		$R_{DS(ON)}$	V_{IN}=5V, I_{OUT}=0.5A		65	100	mΩ
Current Limit Threshold		I_{LIM4}	R_{SET}=15kΩ	1600	1740	1880	mA
			R_{SET}=49.9kΩ	490	540	590	
			R_{SET}=210kΩ	130	150	170	
			ISET shorted to IN	65	90	115	
EN/ENB Threshold	Logic-Low Voltage	V_{IL}				0.4	V
	Logic-High Voltage	V_{IH}		1.0			V
EN Input Capacitor		C_{EN}	(Note 5)		1		pF
EN Leakage Current		I_{ENLK}				1	μA
Output Turn On Rise Time		t_R	R_L=100Ω, C_L=1μF. 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=100Ω, C_L=1μF. Measure from V_{OUT}=90% of V_{IN} to 10% of V_{IN}		126		μs
OCB Low Resistance		R_{OCB}	V_{IN}=5V, I_L=10μA		9		Ω
			V_{IN}=3.3V, I_L=10μA		12		
OUT Shutdown Discharge Resistance		R_{DSG}	EN=0V, V_{OUT}=0.1V	75	100	145	Ω
OCB Leakage Current		I_{LKG_OCB}	V_{OCB}=5V		0.01	1	μA
Fast Reverse Recovery Time		t_{FRR}	V_{IN}=3.3V, V_{OUT}=3.5V, C_L=1μF, OUT= 100Ω to GND. Remove 3.5V from OUT. Measure time from V_{OUT} thru 2.9V to V_{OUT}=3.2V (Note 5)			50	us
Current-limit Response Time		t_{OC_res}	I_{LOAD}=1.2I_{LIMIT} (Note 5)		15		μs
Over Current Flag Response Time		t_{OCB}	I_{LOAD}=1.2I_{LIMIT}		10		ms

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Short Circuit Response Time	t_{OC}	I_{LOAD}=1.5I_{LIMIT} (Note 5)		2		μs
Reverse Blocking Response Time	t_{RBT}	(Note 5)		800		ns
Thermal Shutdown Temperature	T_{SD}	(Note 5)		150		°C
Thermal Shutdown Hysteresis	T_{HYS}	(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: θ_{JA} is measured in the natural convection at T_A = 25°C on a Silergy’s test board.

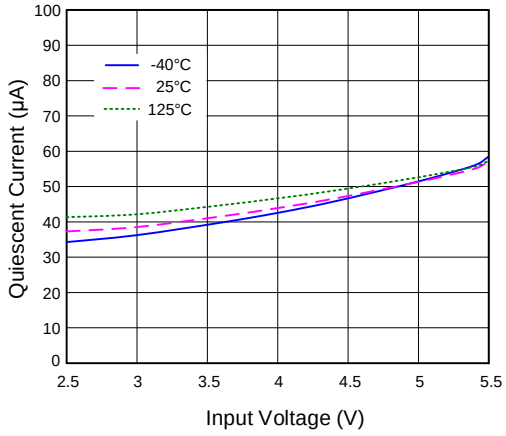
Note 3: The device is not guaranteed to function outside its operating conditions.

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

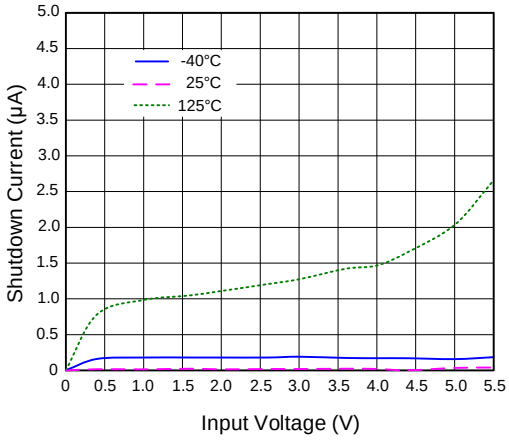
Note5: Guaranteed by design but not production tested.

Typical Performance Characteristics

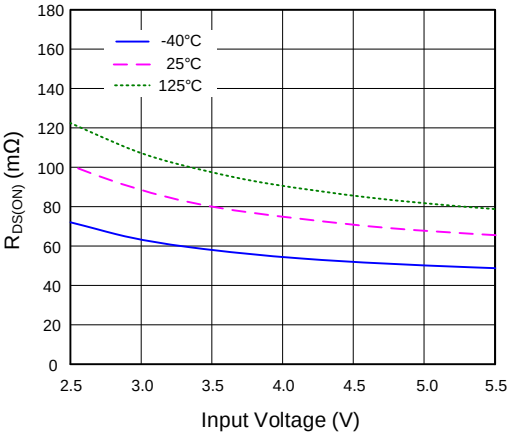
Quiescent Current vs. Input Voltage



Shutdown Current vs. Input Voltage

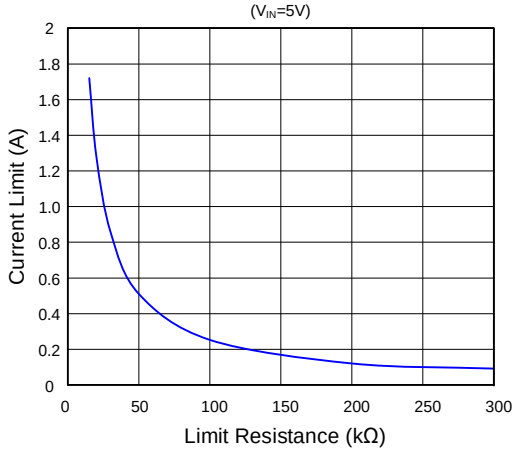


$R_{DS(ON)}$ vs. Input Voltage



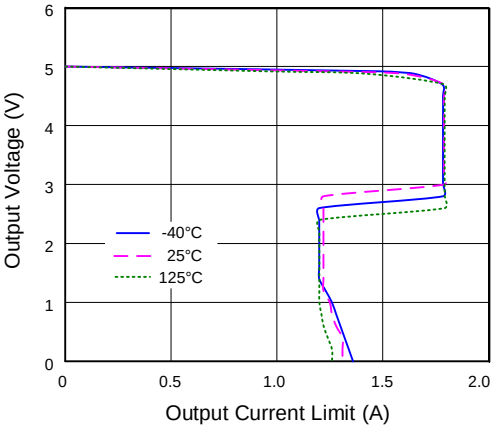
Current Limit vs. Limit Resistance

(V_{IN}=5V)

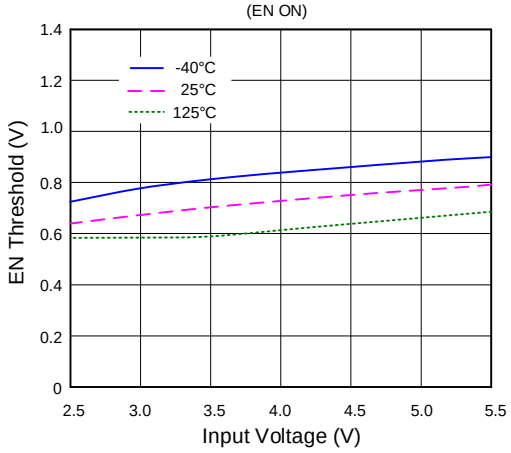


Output Voltage vs. Output Current Limit

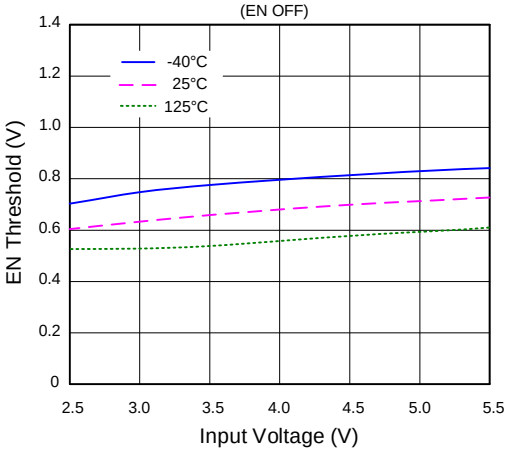
(V_{IN}=EN=5V, CV from 5V to 0V)



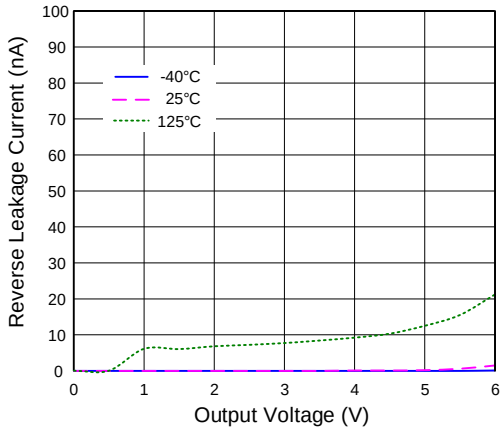
EN Threshold vs. Input Voltage
(EN ON)



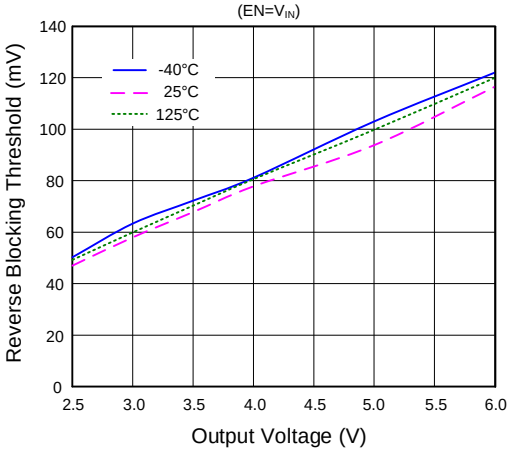
EN Threshold vs. Input Voltage
(EN OFF)



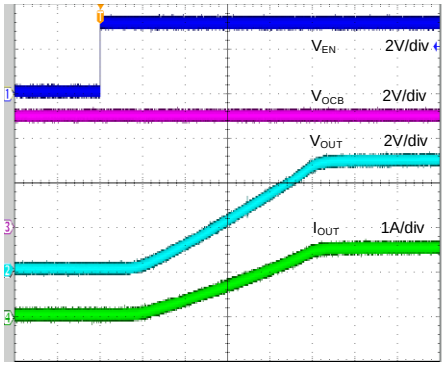
Reverse Leakage Current vs. Output Voltage
(EN=0V, In short to GND)



Reverse Blocking Threshold vs. Output Voltage
(EN=V_{IN})

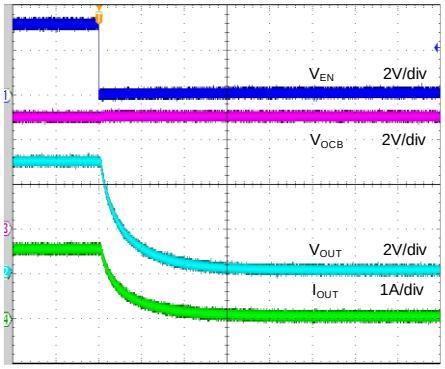


Startup from Enable
(V_{IN}=5V, C_{IN}=C_{OUT}=10μF, 1.5A Load)



Time (800μs/div)

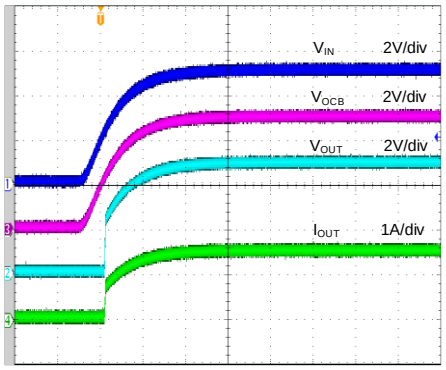
Shutdown from Enable
(V_{IN}=5V, C_{IN}=C_{OUT}=10μF, 1.5A Load)



Time (40μs/div)

Startup from IN

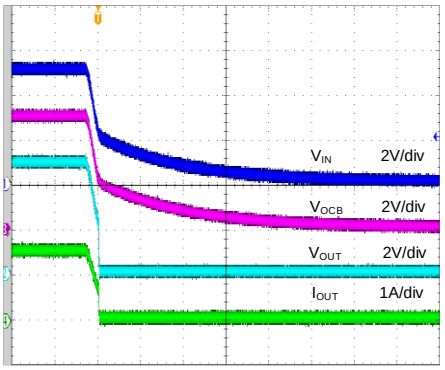
(V_{IN}=5V, C_{IN}=C_{OUT}=10μF, 1.5A Load)



Time (40ms/div)

Shutdown from IN

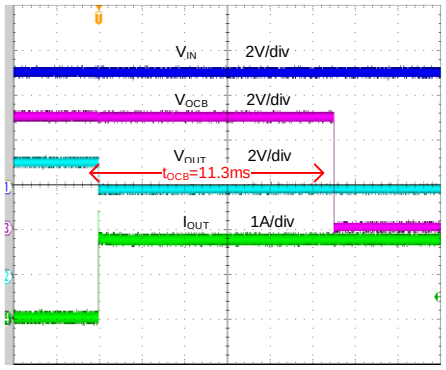
(V_{IN}=5V, C_{IN}=C_{OUT}=10μF, 1.5A Load)



Time (100ms/div)

Over Current Response

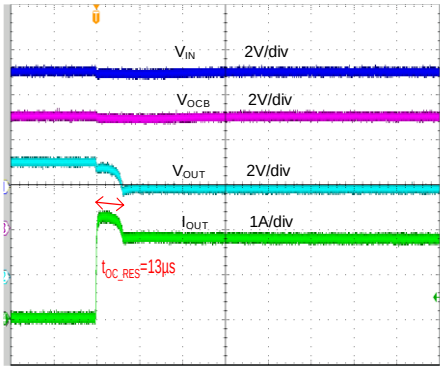
(V_{IN}=5V, C_{IN}=10μF, C_{OUT}=0μF, Null load → 2.5Ω Load)



Time (2ms/div)

Current limit Response Time

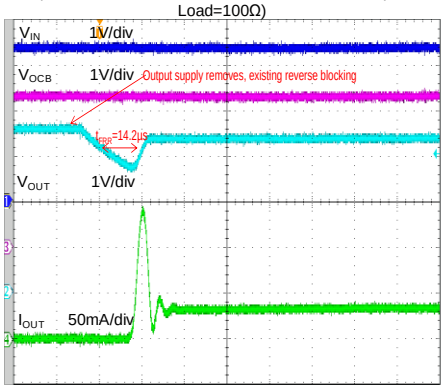
(V_{IN}=5V, C_{IN}=10μF, C_{OUT}=0μF, Null load → 2.5Ω Load)



Time (20μs/div)

Fast Reverse Blocking Recovery Response

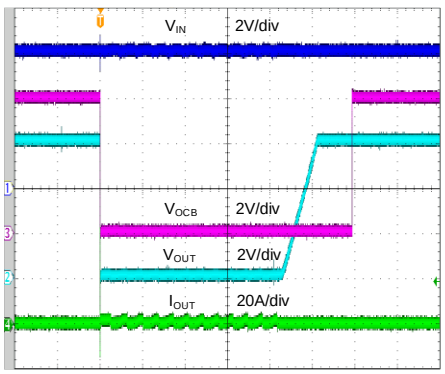
(V_{IN}=3.3V, V_{OUT}=3.5V removes, C_{IN}=1nF, C_{OUT}=1μF, Load=100Ω)



Time (20μs/div)

Short Circuit

(V_{IN}=EN=6V, R_{SET}=15kΩ (1.7A))



Time (4ms/div)

Operation

The SY86201E is a current limited power switch designed for USB load-switching or hot-plug applications. It incorporates overtemperature protection and reverse blocking function, to prevent current flow from OUT to IN when OUT is externally forced to a higher voltage than IN.

Over Current Protection

The SY86201E 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 kΩ ≤ R_{ISET} ≤ 232 kΩ

While the maximum recommended value of R_{ISET} is 232 kΩ, 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%×I_{LIMIT} to decrease power dissipation when V_{OUT} < 60%×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.

Short Circuit Protection

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

Fault Flag(OCB)

The OCB output is asserted (active low) when thermal shutdown protection is triggered or an overcurrent condition persists for more than 10ms. The output remains asserted until the 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 1μF ceramic capacitors from VIN to GND is strongly recommended. Higher capacitor values could reduce the voltage spike on the input further.

Output Filter Capacitor

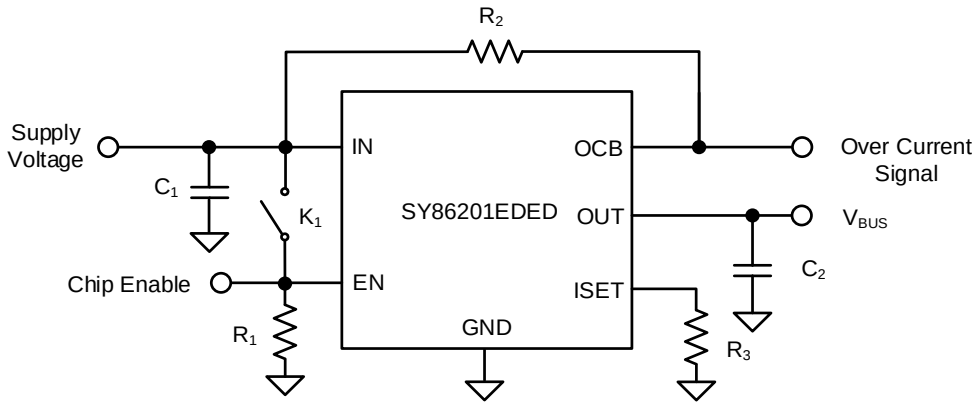
A 1μF output ceramic capacitor should be placed close to the device and output connector to reduce voltage drop during load transient. Higher values of output capacitor can be used to further reduce the droop in high current applications.

Reverse Blocking Function

The SY86201E integrates a reverse blocking function. When the voltage at the OUT pin exceeds the voltage at the IN pin by 100mV, the reverse block function is triggered. The power MOSFET will shut down within 1.3μs block the reverse current flow from OUT to IN.

The SY86201E integrates a fast reverse blocking recovery function, which enables V_{OUT} recovery to 3.2V within 50μs once V_{OUT} drops 30mV lower than V_{IN} after the device is already operating in reverse blocking mode.

Schematic



BOM List

Reference Designator	Description	Part Number	Manufacturer
C_1	1μF/25V, 0603	GRM21BR71E105K	Murata
C_2	1μF/25V, 0603	GRM21BR71E105K	Murata
R_1	1MΩ, 0603	RC0603FR-071ML	YAGEO
R_2	100KΩ, 0603	RC0603FR-07100KL	YAGEO
R_3	15KΩ, 0603	RC0603FR-0715KL	YAGEO

PCB Layout Guide

For optimal performance of the SY86201E, the following guidelines must be adhered to:

1) Keep all VBUS traces as short and wide as possible and use 2 ounce copper traces.

2) Place 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.

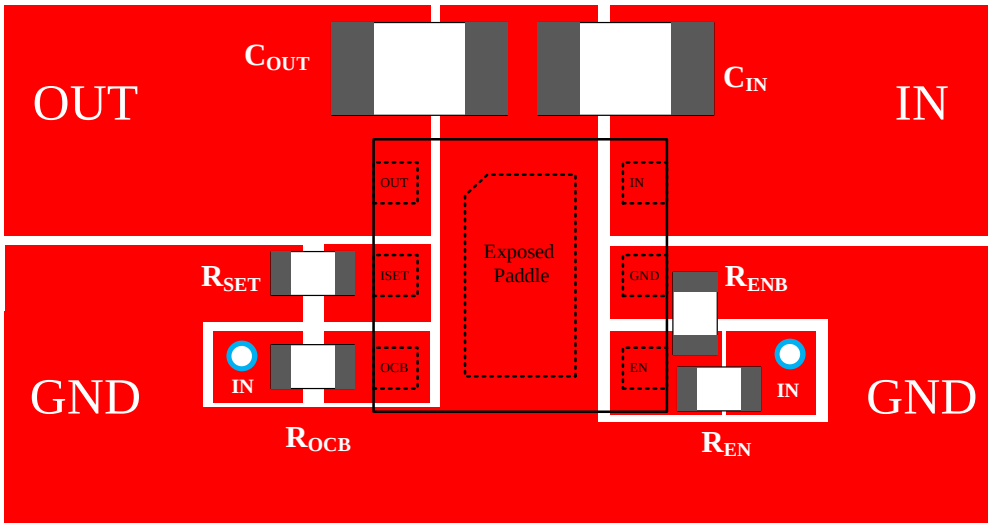
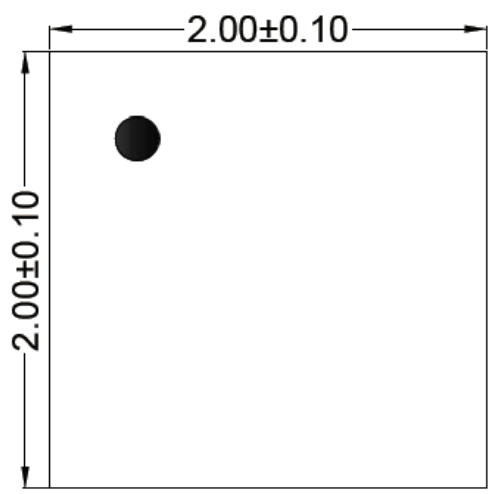
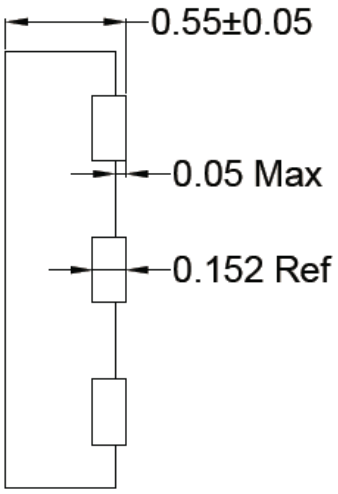


Figure3. PCB Layout Suggestion (SY86201EDED)

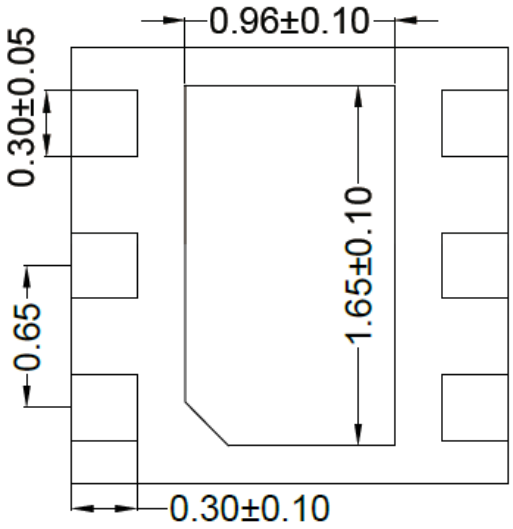
DFN2×2-6 Package Outline



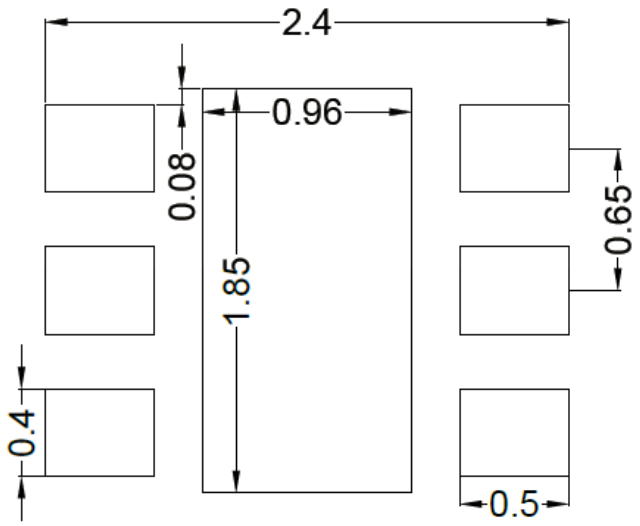
Top View



Side View



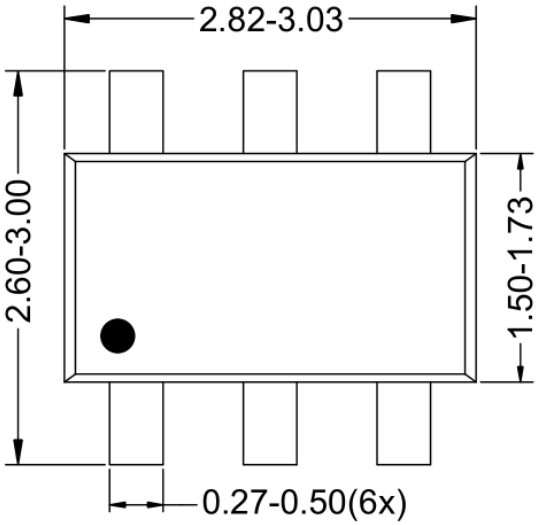
Bottom View



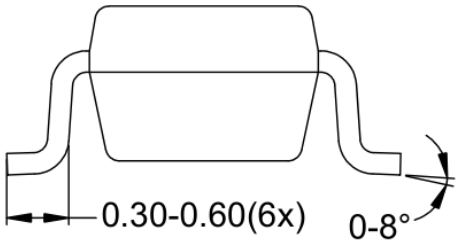
Recommended PCB layout

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

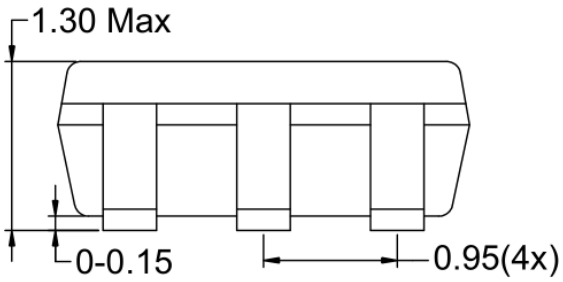
SOT23-6 Package Outline & PCB Layout



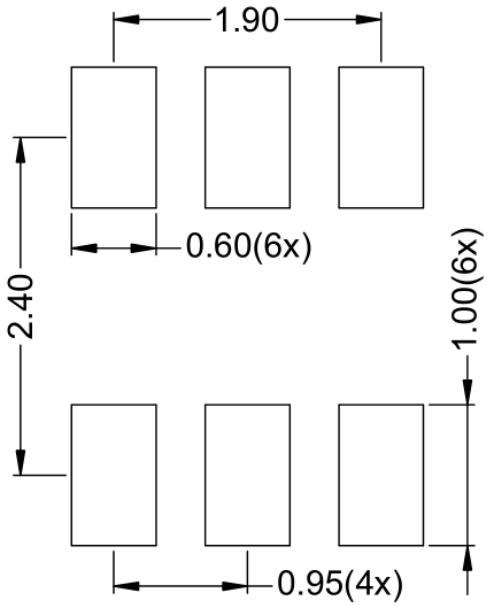
Top View



Side View



Side View



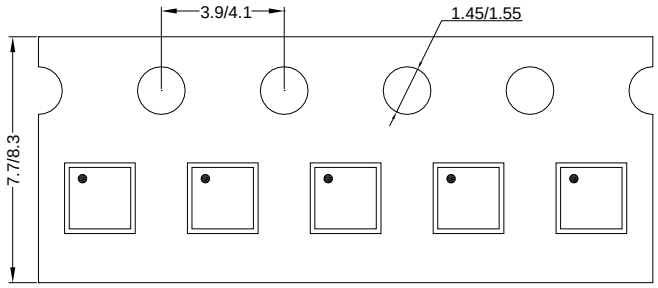
Recommended PCB Layout

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

Tape and Reel Information

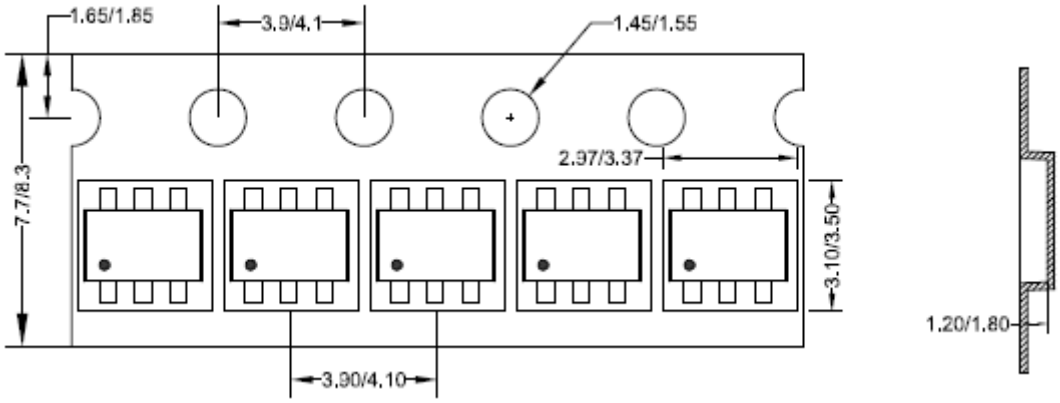
1. Tape dimensions and pin 1 orientation

DFN2×2



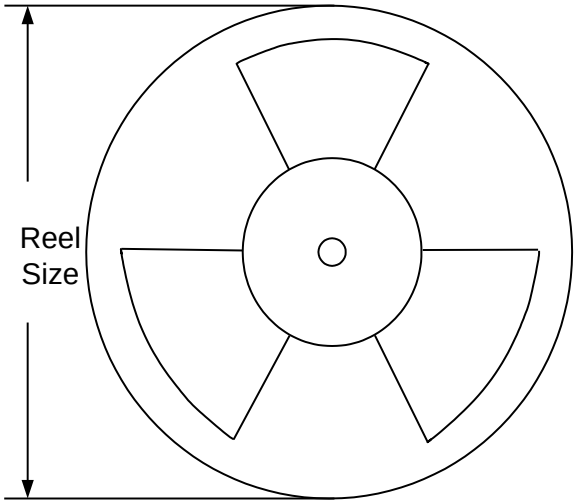
Feed Direction →

SOT23-6



Feed Direction →

2. Reel dimensions



Package types	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer length(mm)	Leader length (mm)	Qty per reel
DFN2×2	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
Feb. 28, 2025	Revision 1.0	Initial Release

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