SY28481

Advanced Load Management Controlled Load Switch with Low R_{ON}

General Description

The SY28481 load switch is an ultra-low on-resistance, compact device with inrush current limit via programmable soft−start. The device provides power good signaling for system status monitoring and downstream load control. With soft-start capability to reduce inrush current and low power consumption in a small footprint, the SY28481 is ideal for power management and hot-swap applications.

Under voltage lockout, short circuit protection and overternperature shutdown features are provided for reliable operation.

The SY28481 is available in a compact DFN3×3-12 package.

Features

- Integrated N-Channel MOSFET with Ultra Low R_{ON}
- Input Voltage Range 0.5 V to 13.5 V
- Soft-start via Controlled Slew Rate
- Power Good Signal
- Thermal Shutdown
- Under Voltage Lockout
- Short Circuit Protection
- Extremely Low Standby Current
- Load Bleed (Quick Discharge)

Applications

- Portable Electronics and Systems
- Notebook and Tablet Computers
- Telecom, Networking, Medical, and Industrial Equipment
- Set Top Boxes, Servers, and Gateways
- Hot Swap Devices and Peripheral Ports

Typical Application

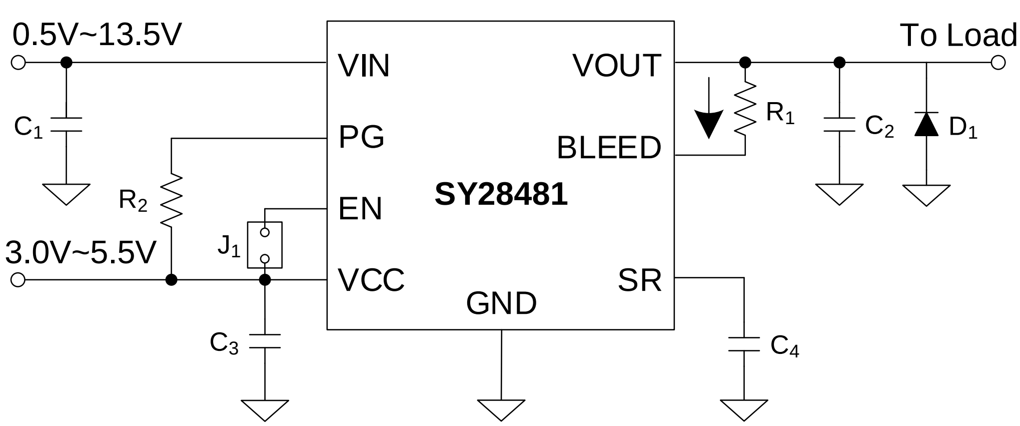


Figure1. Schematic Diagram

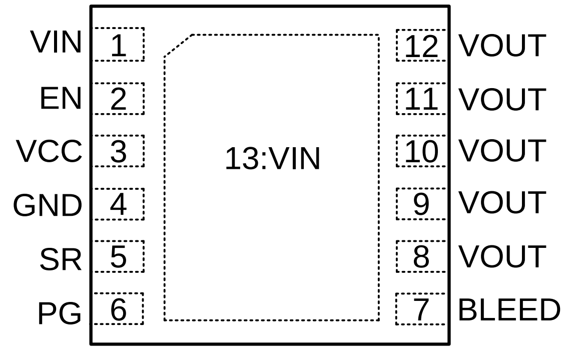
Ordering Information

Ordering Part Number	Package Type	Top Mark
SY28481DCD	**DFN3×3-12** RoHS Compliant and Halogen Free	**DQFxyz**

Device code: DQF

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

Pinout (top view)



Pin Name	Pin Number	Pin Description
VIN	1, 13	MOSFET Drain (0.5 V – 13.5 V). Pin 1 must be connected to Pin 13.
EN	2	SY28481-Active−high digital input, used to turn on the MOSFET. The pin has an internal pull-down resistor to GND.
VCC	3	Supply voltage
GND	4	Ground.
SR	5	Slew rate adjustment. Leave floating if not used.
PG	6	Active−high, open−drain output that indicates when the gate of the MOSFET is fully charged, external pull up resistor≥1 kΩ to an external voltage source required; tie to GND if not used.
BLEED	7	Load bleed connection, must be tied to V_{OUT} either directly or through a resistor ≤1 kΩ
VOUT	8-12	MOSFET source, Connected to load.

Block Diagram

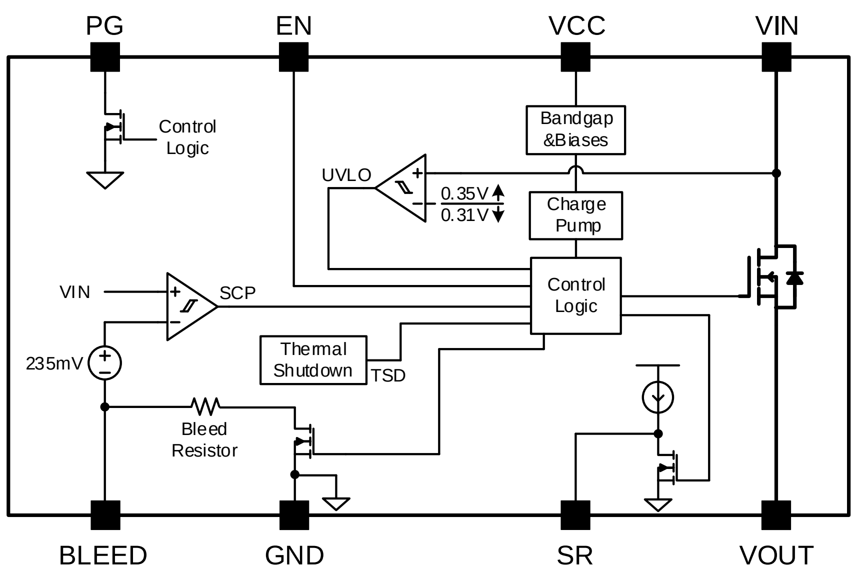


Figure 2 Block Diagram

Absolute Maximum Ratings

Parameter (Note 1)	Min	Max	Unit
VCC, VIN, VOUT	-0.3	18	V
EN	-0.3	VCC+0.3	
PG	-0.3	6	
I_{MAX} (Note 2)	0	24	A
Lead Temperature (Soldering, 10sec.)		260	°C
Junction Temperature, Operating	-40	150	
Storage Temperature	-65	150	

Thermal Information

Parameter (Note 3)	Typ	Unit
θ_{JA} Junction-to-Ambient Thermal Resistance	35	°C/W
θ_{JC} Junction-to-Case Thermal Resistance	1.7	
P_D Power Dissipation T_A = 25°C	2.86	W

Recommended Operating Conditions

Parameter (Note 4)	Min	Max	Unit
VCC	3	5.5	V
VIN, VOUT	0.5	13.5	
EN, PG	0	5.5	
Junction Temperature, Operating	-40	125	°C
Ambient Temperature	-40	85	

Electrical Characteristics

(R_{PG} = 100kΩ; R_L=10Ω, C_L=0.1µF, T_J=-40°C to 125°C, typical values are T_J=25°C, unless otherwise specified. The values are guaranteed by test, design or statistical correlation.)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
MOSFET						
On-Resistance	R_{ON}			4.1	6.8	mΩ
Leakage Current	I_{LEAK}	V_{EN} = 0 V; V_{IN} = 13.5 V		0.1	10	µA
Controller						
Supply Standby Current	I_{STBY}	V_{EN} = 0 V; V_{CC} = 3 V		6	13	µA
		V_{EN} = 0 V; V_{CC} = 5.5 V		7	14	
Supply Dynamic Current	I_{DYN}	V_{EN} = V_{CC} = 3 V; V_{IN} = 12 V		80	100	µA
		V_{EN} = V_{CC} = 5.5 V; V_{IN} = 1.8 V		230	300	
Bleed Resistance	R_{BLEED}	V_{EN} = 0 V; V_{CC} = 3 V	60	90	160	Ω
		V_{EN} = 0 V; V_{CC} = 5.5 V	60	90	160	
Bleed Pin Leakage Current	I_{BLEED}	V_{EN} = V_{CC} = 3 V, V_{IN} = 1.8 V		2.5	7	µA
		V_{EN} = V_{CC} = 3 V, V_{IN} = 12 V		5.5	11	
EN Input High Voltage	V_{IH}	V_{CC} = 3 V − 5.5 V	2.0			V
EN Input Low Voltage	V_{IL}	V_{CC} = 3 V − 5.5 V			0.8	V
EN Input Leakage Current	I_{IL}	V_{EN} = 0 V		90	500	nA
EN Pull Down Resistance	R_{PD}		76	100	130	kΩ
PG Output Low Voltage	V_{OL}	V_{CC} = 3 V; I_{SINK} = 5 mA			0.25	V
PG Output Leakage Current	I_{OH}	V_{CC} = 3 V; V_{TERM} = 3.3 V		5.0	100	nA
Slew Rate Control Constant	K_{SR}	V_{CC} = 3 V	21	31	44	µA
Fault Protections						
Thermal Shutdown Threshold	T_{SDT}	V_{CC} = 3 V − 5.5 V		145		℃
Thermal Shutdown Hysteresis	T_{HYS}	V_{CC} = 3 V − 5.5 V		20		℃
VIN Undervoltage Lockout Threshold	V_{UVLO}	V_{CC} = 3 V	0.25	0.35	0.45	V
VIN Undervoltage Lockout Hysteresis	V_{HYS}	V_{CC} = 3 V	25	40	60	mV
Short−Circuit Protection Threshold	V_{SC}	V_{CC} = 3 V; V_{IN} = 0.5 V	160	230	300	mV
		V_{CC} = 3 V; V_{IN} = 13.5 V	160	235	310	

Switching Characteristics

(R_{PG} = 100kΩ; R_L=10Ω, C_L=0.1µF, T_J=-40°C to 125°C, typical values are T_J=25°C, unless otherwise specified. The values are guaranteed by test, design or statistical correlation.)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Slew Rate	SR	V_{CC} = 3.3 V; V_{IN} = 1.8 V		8.8		kV/s
		V_{CC} = 5.0 V; V_{IN} = 1.8 V		8.9		
		V_{CC} = 3.3 V; V_{IN} = 12 V		11		
		V_{CC} = 5.0 V; V_{IN} = 12 V		11		
Output Turn−on Delay	t_{ON}	V_{CC} = 3.3 V; V_{IN} = 1.8 V		360		µs
		V_{CC} = 5.0 V; V_{IN} = 1.8 V		360		
		V_{CC} = 3.3 V; V_{IN} = 12 V		440		
		V_{CC} = 5.0 V; V_{IN} = 12 V		440		
Output Turn−off Delay	t_{OFF}	V_{CC} = 3.3 V; V_{IN} = 1.8 V		7.8		µs
		V_{CC} = 5.0 V; V_{IN} = 1.8 V		7.2		
		V_{CC} = 3.3 V; V_{IN} = 12 V		7.6		
		V_{CC} = 5.0 V; V_{IN} = 12 V		7.6		
Power Good Turn−on Time	$t_{PG,ON}$	V_{CC} = 3.3 V; V_{IN} = 1.8 V		0.71		ms
		V_{CC} = 5.0 V; V_{IN} = 1.8 V		0.75		
		V_{CC} = 3.3 V; V_{IN} = 12 V		1.66		
		V_{CC} = 5.0 V; V_{IN} = 12 V		1.66		
Power Good Turn−off Time	$t_{PG,OFF}$	V_{CC} = 3.3 V; V_{IN} = 1.8 V		4.5		µs
		V_{CC} = 5.0 V; V_{IN} = 1.8 V		4.5		
		V_{CC} = 3.3 V; V_{IN} = 12 V		4.5		
		V_{CC} = 5.0 V; V_{IN} = 12 V		4.5		

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: Ensure that the expected operating MOSFET current will not cause the Short−Circuit Protection to turn the MOSFET off undesirably.

Note 3: θ_{JA} is measured in the natural convection at T_A = 25℃ on a EVB test board.

Note 4: The device is not guaranteed to function outside its operating conditions.

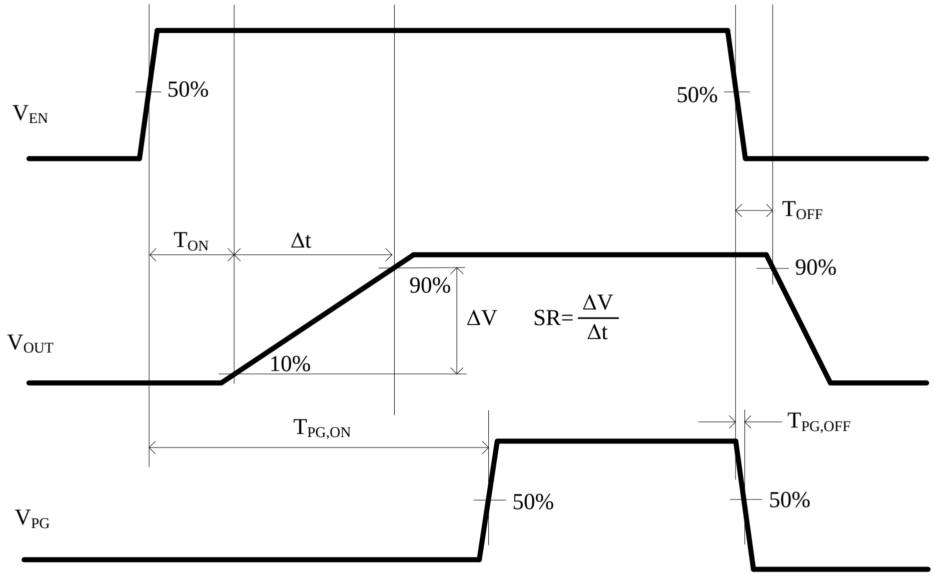


Figure3. Switching Time Waveform

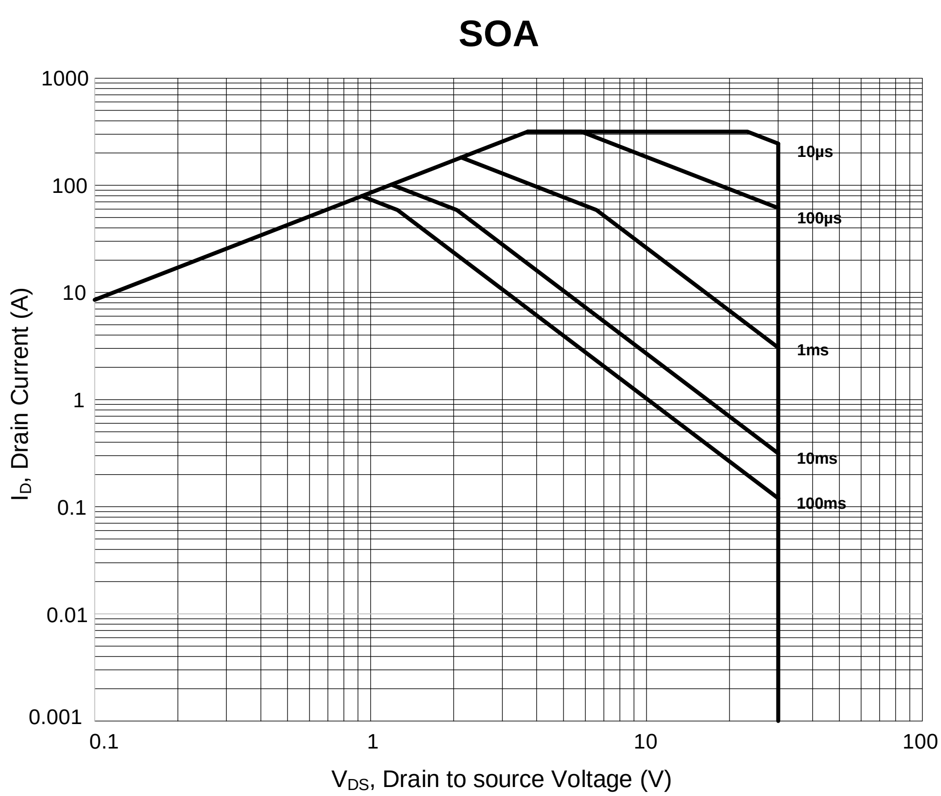
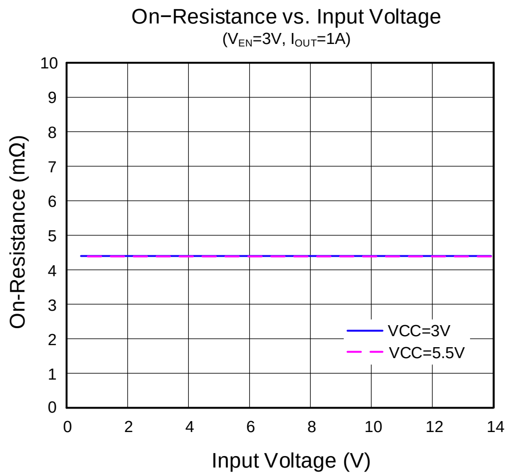
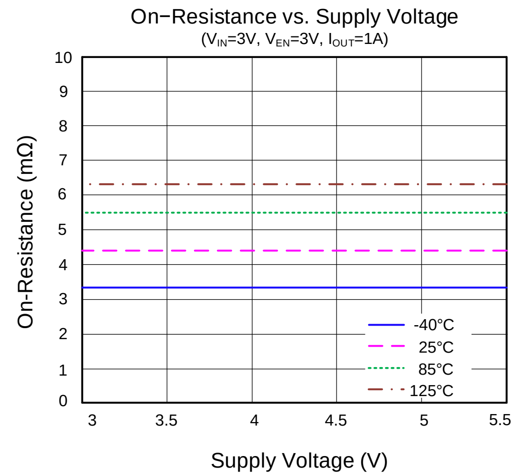
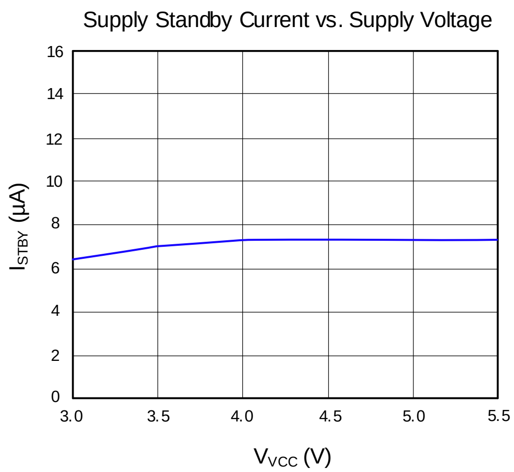


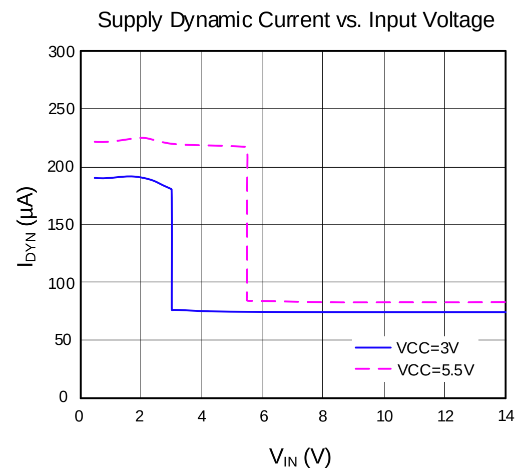
Figure 4. Safe Operating Area

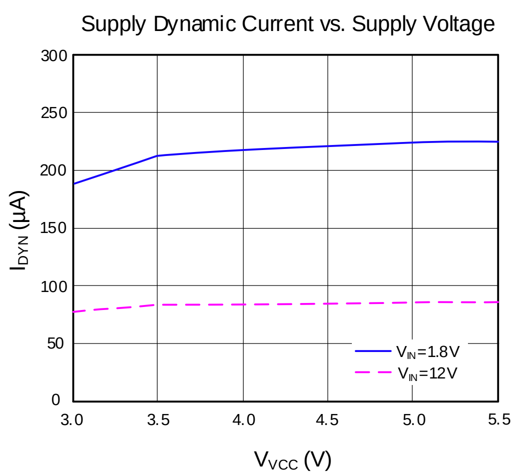
Typical Performance Characteristics

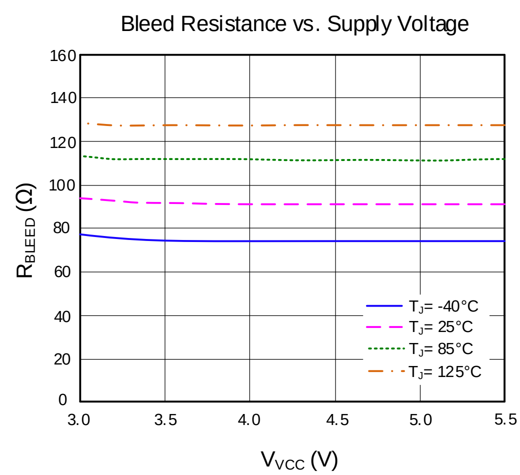


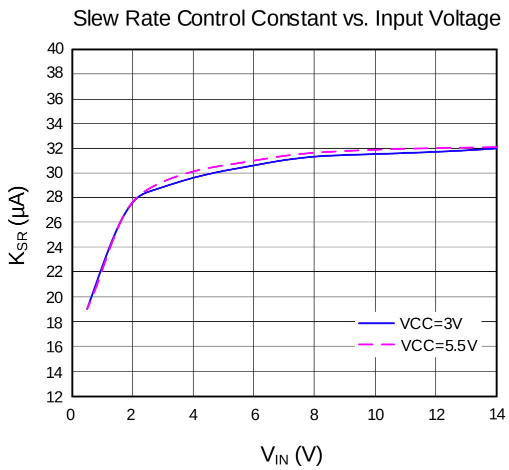


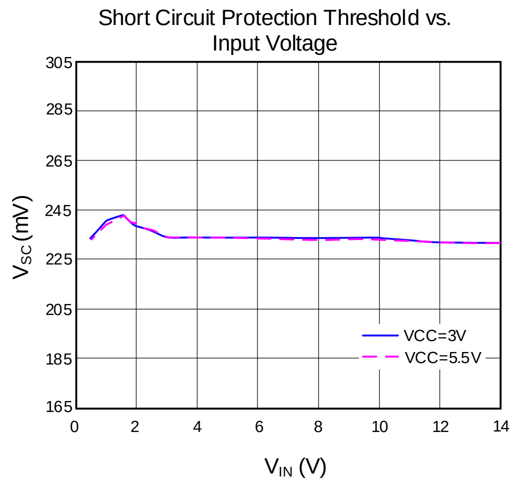


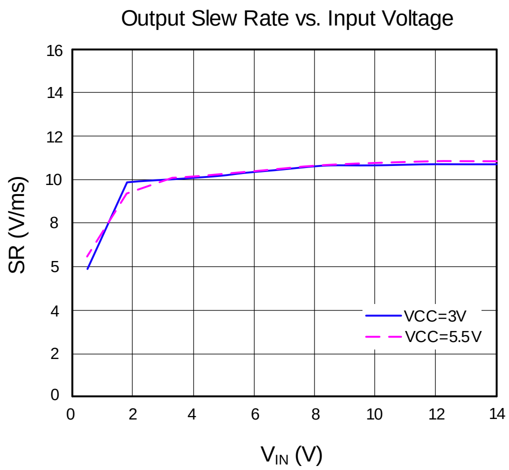


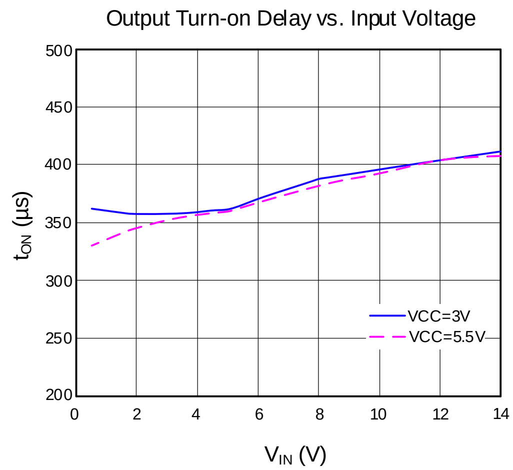


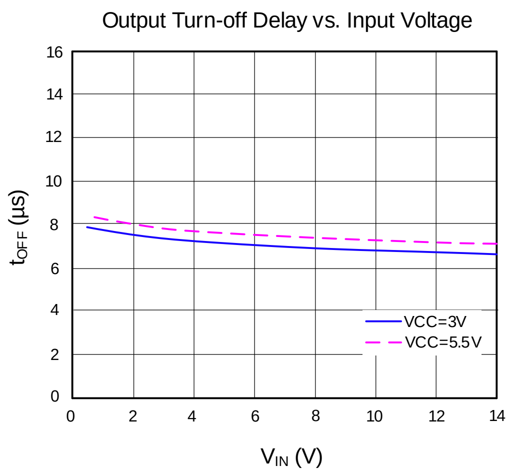


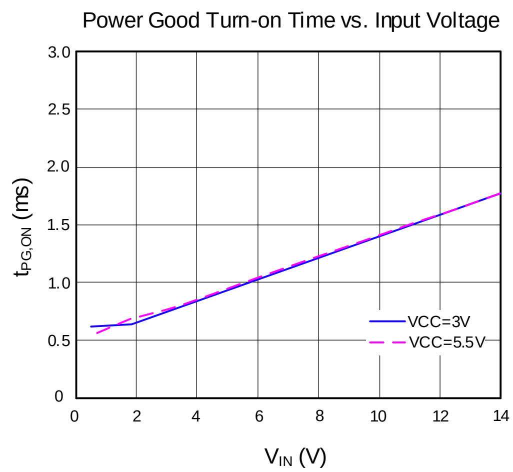

Slew Rate Control Constant vs. Input Voltage
K_SR (µA)
V_IN (V)
VCC=3V
VCC=5.5V


Short Circuit Protection Threshold vs. Input Voltage
V_SC (mV)
V_IN (V)
VCC=3V
VCC=5.5V

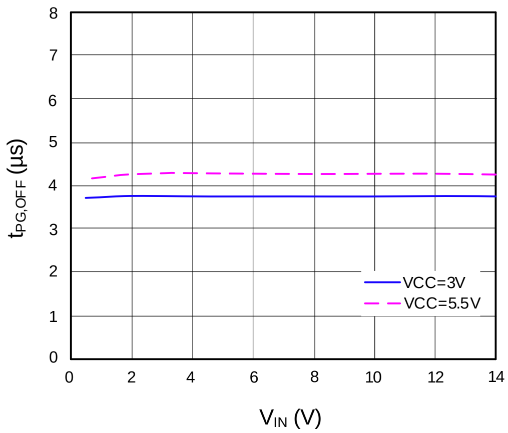

Output Slew Rate vs. Input Voltage
SR (V/ms)
V_IN (V)
VCC=3V
VCC=5.5V


Output Turn-on Delay vs. Input Voltage
t_ON (µs)
V_IN (V)
VCC=3V
VCC=5.5V


Output Turn-off Delay vs. Input Voltage
t_OFF (µs)
V_IN (V)
VCC=3V
VCC=5.5V

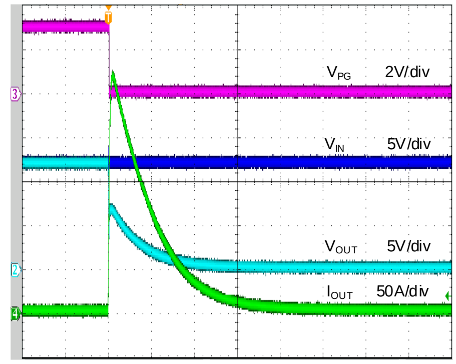

Power Good Turn-on Time vs. Input Voltage
t_PG,ON (ms)
V_IN (V)
VCC=3V
VCC=5.5V

Power Good Turn-off Time vs. Input Voltage



Hard Short

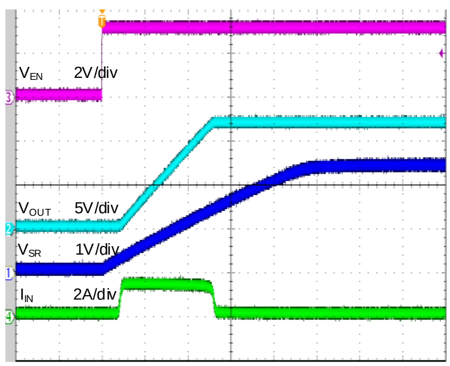
(V_{IN}=12V, V_{CC}=3V, R_{PG}=100kΩ, C_{SR}=100nF, C_{OUT}=100nF, 5mF Load, Short OUT)



Time (200µs/div)

Turn ON with Enable

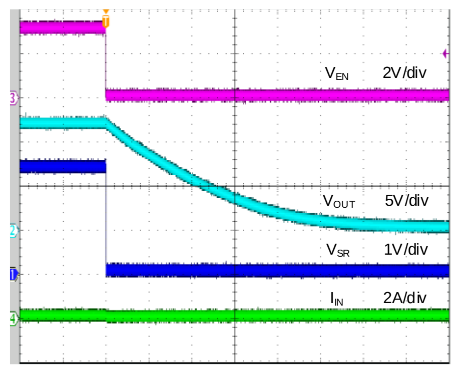
(V_{IN}=12V, V_{CC}=3V, C_{SR}=100nF, C_{OUT}=100nF, 5mF Load)



Time (20ms/div)

Turn OFF with Enable

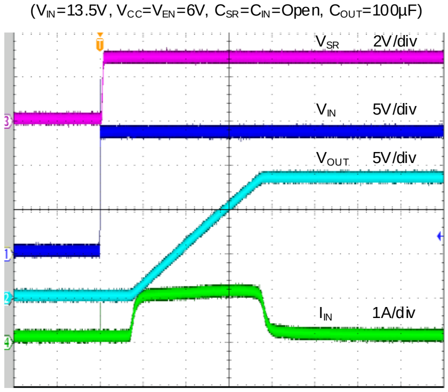
(V_{IN}=12V, V_{CC}=3V, C_{SR}=100nF, C_{OUT}=100nF, 5mF Load)



Time (400ms/div)

Hot Plug (V_{IN})

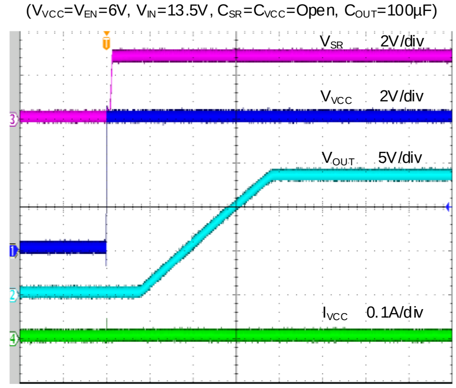
(V_{IN}=13.5V, V_{CC}=V_{EN}=6V, C_{SR}=C_{IN}=Open, C_{OUT}=100µF)



Time (400µs/div)

Hot Plug (V_{VCC})

(V_{VCC}=V_{EN}=6V, V_{IN}=13.5V, C_{SR}=C_{VCC}=Open, C_{OUT}=100µF)



Time (400µs/div)

Applications Information

Enable Control

EN is used to control the SY28481DCD ON and OFF. When VCC and VIN are in their operating voltage ranges, setting EN to a logic high level, the power MOSFET is turned on with soft start. When setting EN to a logic low level, the Power MOSFET is turn off immediately. Set EN to low, then back to high, can reset the SY28481DCD that has latched off due to SCP or OCP protection.

Power Sequencing

The SY28481DCD will function with any power sequence, but the output turn−on delay performance may vary depending on the sequence. To achieve the specified performance, there are two recommended power sequences:

1. $V_{CC} \rightarrow V_{IN} \rightarrow V_{EN}$
2. $V_{IN} \rightarrow V_{CC} \rightarrow V_{EN}$

Load Bleed (Quick Discharge)

To quick discharge output capacitor, the SY28481DCD integrates an internal bleed resistor (R_{BLEED}). The resistor is switched on when EN is inactive (logic low). Connect the BLEED pin either directly (as shown in Figure 6) or through an external resistor, R_{EXT} (<1kΩ, as shown in Figure 5). The maximum continuous power dissipation for the internal bleed resistor is 0.4W. Ensure that the maximum power dissipation is not exceeded.

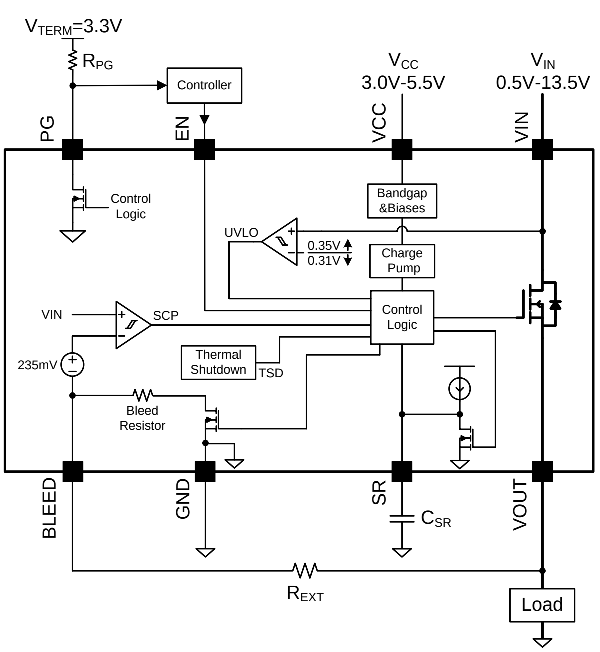


Figure5. Typical Application Diagram − Load Switch

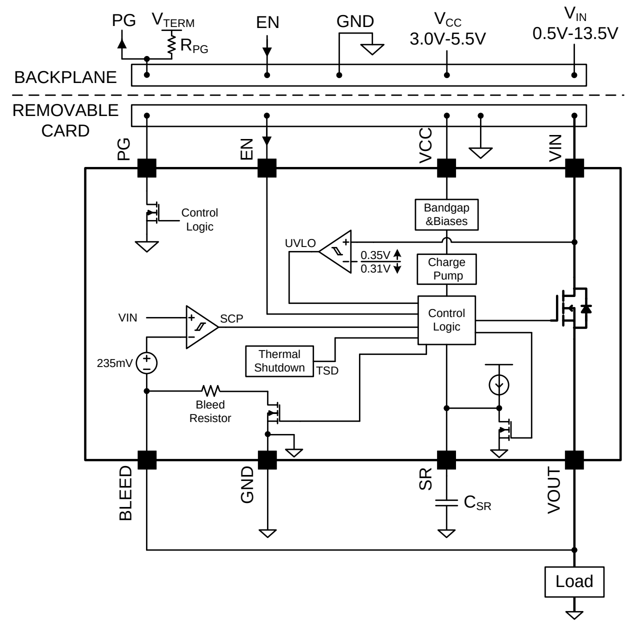


Figure 6. Typical Application Diagram − Hot Swap

Power Good

The SY28481DCD integrates a power good indicator (PG). The PG pin is an active high, open drain output. An external resistor with a value of 1kΩ or larger, connected to a voltage source is requied when this pin is used (as shown in Figures 5 and 6). When the MOSFET is turned ON, the PG pin is high impedance, and the voltage at the pin is is determined by the external voltage source that the external resistor is connected to.

The PG pin can be used for power sequencing in larger systems. Avoid draw large current before the switch is fully turned ON, to prevent system power up failures.

Slew Rate Control

The SY28481DCD features programmable output slew rate control to reduce the inrush current during start up with large output capacitance. Connect a C_{SR} from the SR pin to GND to program the slew rate (as shown in Figures 5 and 6). The slew rate can be calculated using the following equation:

$$\text{Slew Rate} = \frac{K_{SR}}{C_{SR}}(V/s)$$

Where K_{SR} is the specified slew rate control constant, found in EC table.

Short Circuit Protection

The SY28481DCD is equipped with a short-circuit protection against output hard short to GND events.

When VOUT is shorted to GND, a large current can draw VOUT low. The SY28481DCD monitors the voltage difference between VIN and VOUT through the BLEED pin, and once the voltage exceeds the short circuit threshold, the power FET will be shut down immediately to cut off the load and prevent the current from increasing further. The device will stay in the OFF state until EN is cycled or an UVLO event is detected at the VCC pin.
The short circuit protection is active after PG is set high.

Thermal Shutdown

The SY28481DCD thermal shutdown protects the part from internally or externally generated excessive temperature. When the junction temperature is higher than T_{SDT} threshold, the SY28481DCD the power MOSFET is disabled. After the junction temperature drops below T_{SDT}-T_{HYS} and if EN is still at a logic high level, the device will restart with a soft-start sequence.

Under-voltage Lockout

The SY28481DCD integrates UVLO protection. If VIN rises above the UVLO threshold and EN is set to high, the power MOSFET will be enbled with soft start. If VIN falls below V_{UVLO} -V_{HYS}, the device will be shut down.

PCB Layout Guide

1. For all applications, a 10μF or greater ceramic decoupling capacitor is recommended between IN terminal and GND. For hot-plug applications, where input power path inductance is negligible, this capacitor can be eliminated, or its value reduced.

2. The optimum placement of the decoupling capacitor is close to the IN and GND pins. Minimize the loop area formed by the bypass capacitor and the IN GND pins.

3. Place the following components C_{VCC}, C_{SR} and R_{EXT} close to their connection pin. Connect the other end of the components to GND with a short trace.

4. Protection devices such as TVS, snubbers, capacitors, or diodes should be placed physically close to the device they are intended to protect, and routed with short traces to reduce parasitic inductance. For example, a protection Schottky diode is recommended to address negative transients due to switching of inductive loads, and it should be physically close to the OUT pins.

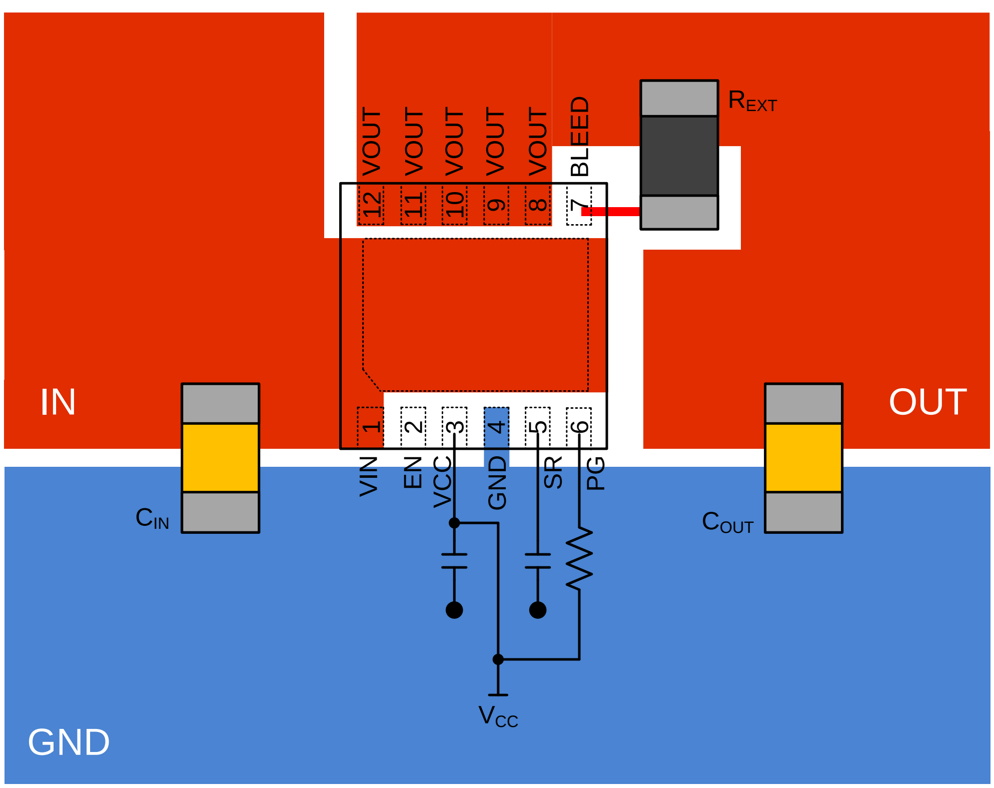
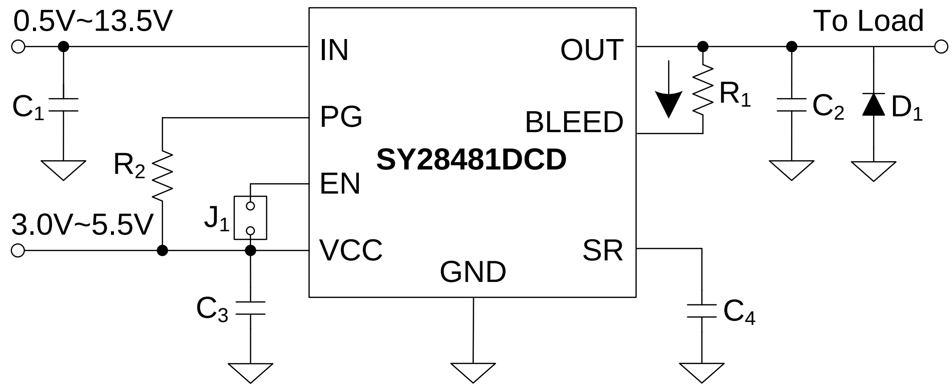


Figure7.PCB Layout Suggestion

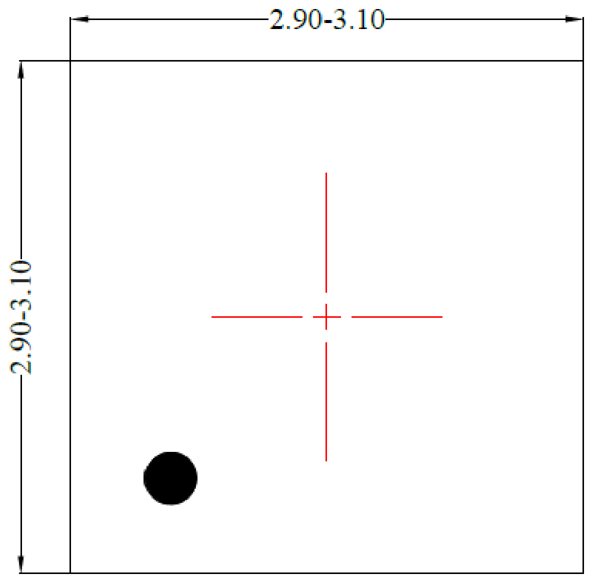
Schematic



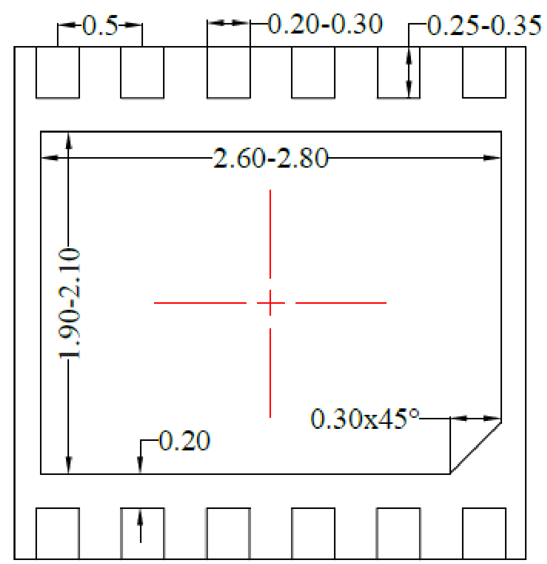
BOM List

Reference Designator	Description	Part Number	Manufacturer
C_1	10μF/50V, ±10%, X5R, 1206	C3216X5R1H106KT00N	TDK
C_2	10μF/50V, ±10%, X5R, 1206	C3216X5R1H106KT00N	TDK
C_3	1μF/50V, ±10%, X5R, 0603	GRM188R61H105KAALD	Muruta
C_4	100nF/50V, ±10%, X7R, 0603	GRM188R71H104KA93D	Muruta
R_1	0Ω, 1%, 0.1W, 0603	RC0603FR-070RL	YAGEO
R_2	100kΩ, 1%, 0.1W, 0603	RC0603FR-07100KL	YAGEO
D1	Schoottky	SS54	Any

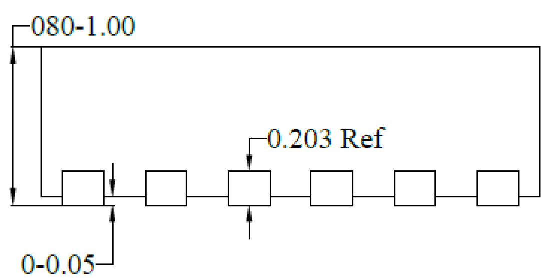
DFN3×3-12 Package Outline



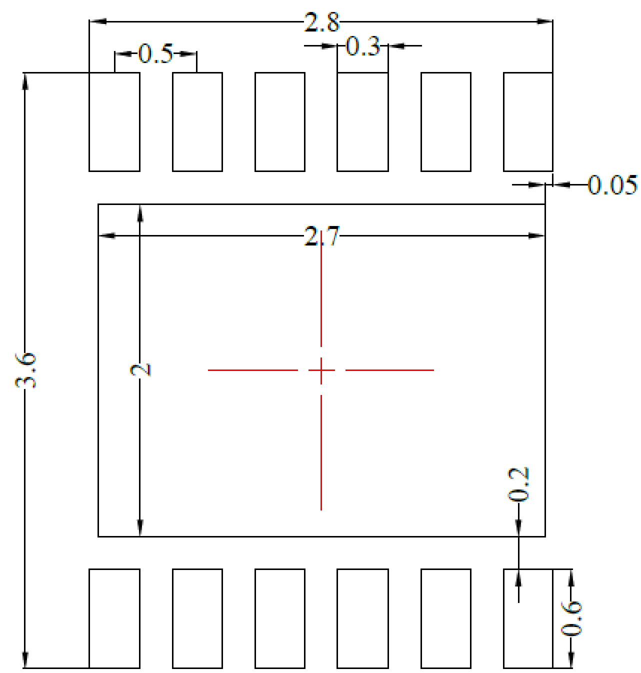
Top View



Bottom View



Front View

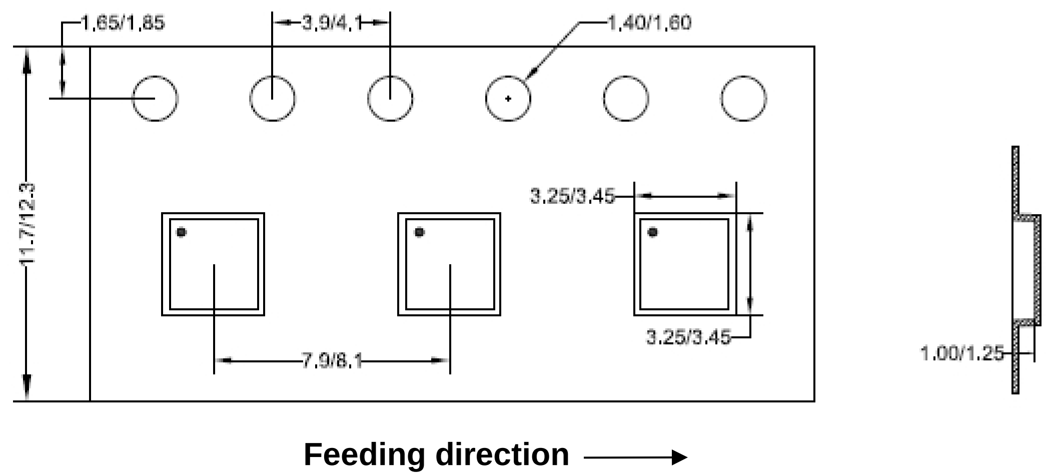


Recommended PCB layout (Only for reference)

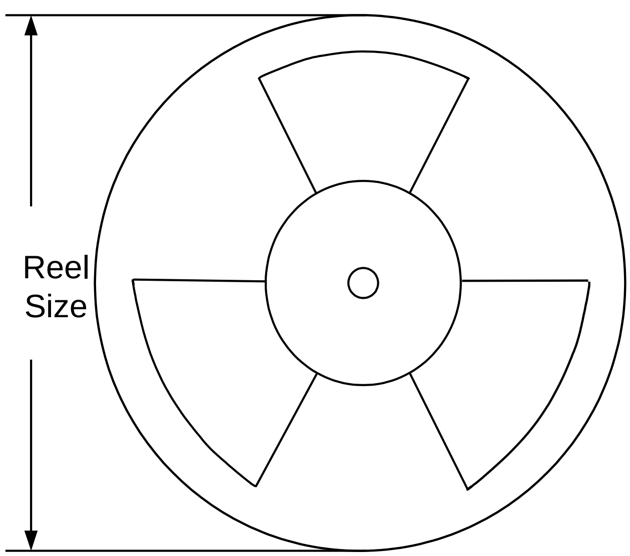
Notes: All dimension in millimeter and exclude mold flash & metal burr.

Taping & Reel Specification

1. DFN3×3 taping orientation



2. Carrier Tape & Reel specification for packages



Package type	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer length(mm)	Leader length (mm)	Qty per reel
DFN3×3	12	8	13"	400	400	5000

3. Others: NA

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
Jan.29, 2024	Revision 1.0	Language improvements for clarity.
Apr.19, 2023	Revision 0.9B	1. Change the typical value of On-Resistance from 3.7 mΩ to 4.1 mΩ; 2. Update the On-Resistance Curves (Page 7)
Oct.21, 2022	Revision 0.9A	Pin1 is changed from upper right to upper left in the taping orientation.
May.27, 2022	Revision 0.9	Initial Release

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