SQ24801

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

General Description

The SQ24801 load switch is an ultra-low on resistance, compact device with inrush current limit via soft−start. For system status monitoring and downstream load control, the device provides power good signaling. With soft-start capabilities to reduce inrush current and low power consumption in a small footprint, the SQ24801 is ideal for power management and hot-swap applications.

Ordering Information

SQ24801 □(□□□)

- Package Code
- Optional Spec Code

Ordering Number	Package type	Note
SQ24801DCD	DFN3×3-12	----

Features

- Advanced Controller with Charge Pump
- 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
- Adjustable Slew Rate Control
- Power Good Signal
- Thermal Shutdown
- Under Voltage Lockout
- Short Circuit Protection
- Extremely Low Standby Current
- Load Bleed (Quick Discharge)
- Pb-Free

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

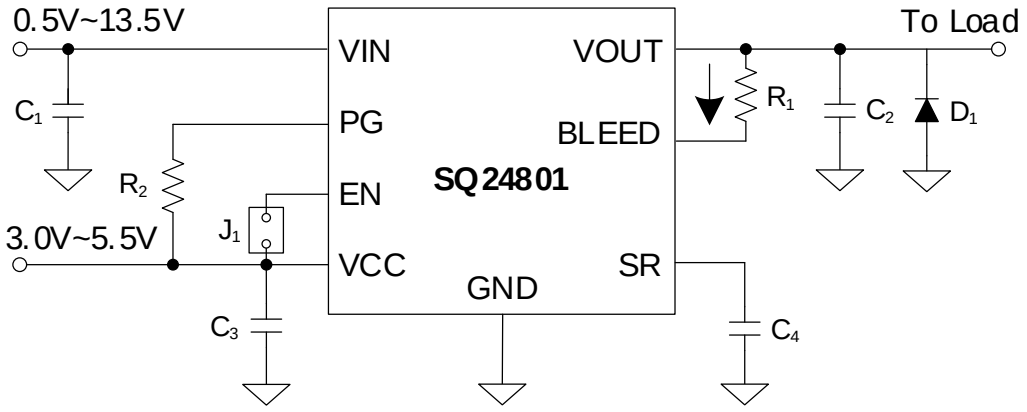
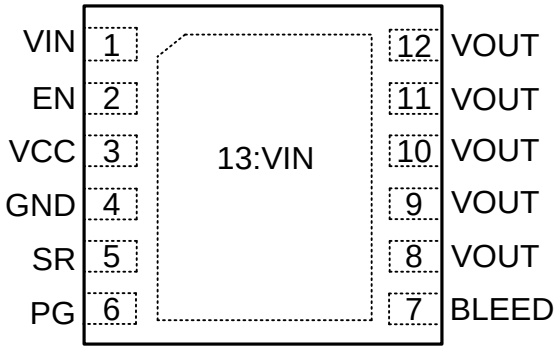


Figure1. Schematic Diagram

Pinout (top view)



(DFN3×3-12)

Top Mark: DQFxyz for SQ24801DCD (Device code: DQF; ***x=year code, y=week code, z= lot number code***)

Pin Name	Pin number	Pin Description
VIN	1, 13	Drain of MOSFET (0.5 V – 13.5 V), Pin 1 must be connected to Pin 13
EN	2	SQ24801-Active−high digital input used to turn on the MOSFET, pin has an internal pull-down resistor to GND
VCC	3	Supply voltage to controller (3.0 V − 5.5 V)
GND	4	Controller ground.
SR	5	Slew rate adjustment; Leave it 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	Source of MOSFET connected to load.

Block Diagram

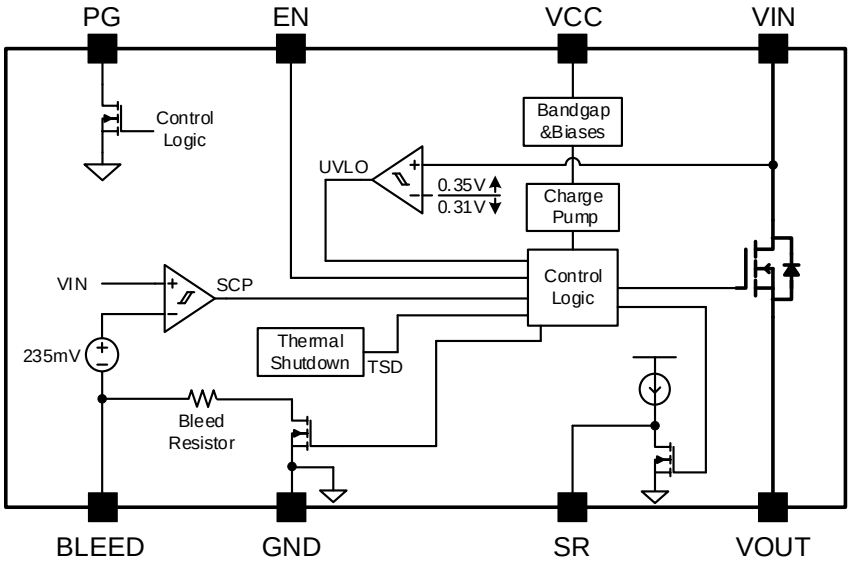


Figure 2 Block Diagram

Absolute Maximum Ratings (Note 1)

VCC ---------- -0.3V to 18V
VIN ---------- -0.3V to 18V
VOUT ---------- -0.3V to 18V
EN ---------- -0.3V to VCC+0.3V
PG ---------- -0.3V to 6V
I_{MAX} (Note 2)---------- 0A to 24A
Power Dissipation, P_D ---------- 2.86W
Package Thermal Resistance (Note 3)
θ_{JA} ---------- 35°C /W
θ_{JC} ---------- 1.7°C /W
Junction Temperature---------- 150°C
Lead Temperature (Soldering, 10 sec.) ---------- 260°C
Storage Temperature Range ---------- -65°C to 150°C

Recommended Operating Conditions (Note 4)

VCC ---------- 3V to 5.5V
VIN ---------- 0.5V to 13.5V
VOUT ---------- 0.5V to 13.5V
EN ---------- 0V to 5.5V
PG ---------- 0V to 5.5V
Junction Temperature Range ---------- -40°C to 125°C
Ambient Temperature Range ---------- -40°C to 85°C

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.

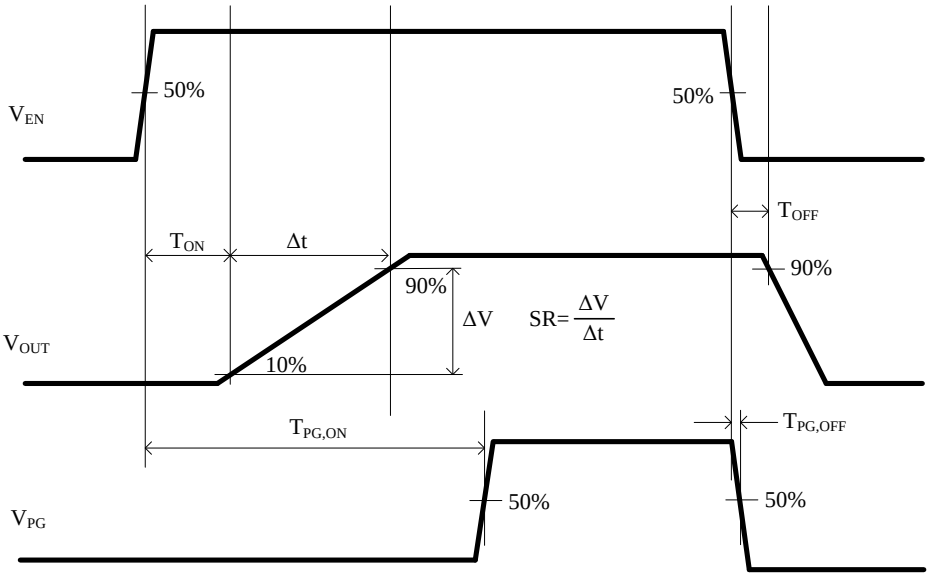


Figure3. Switching Time Waveform

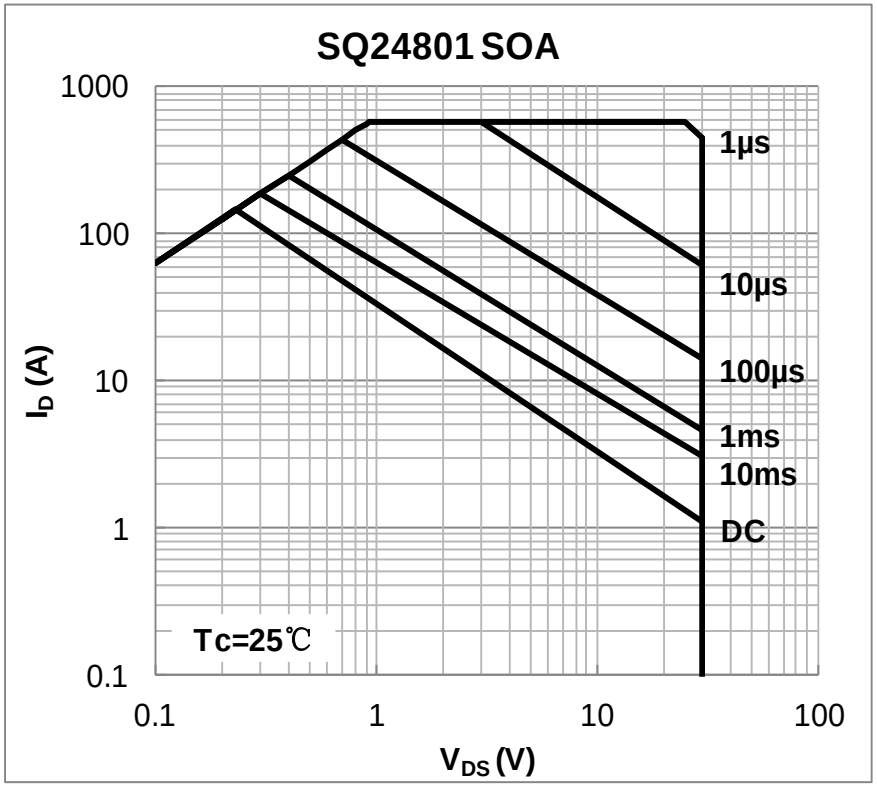
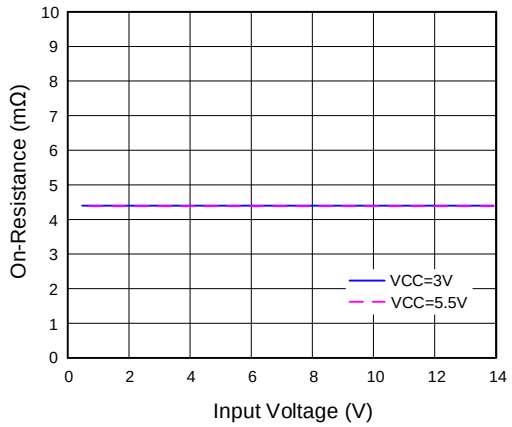


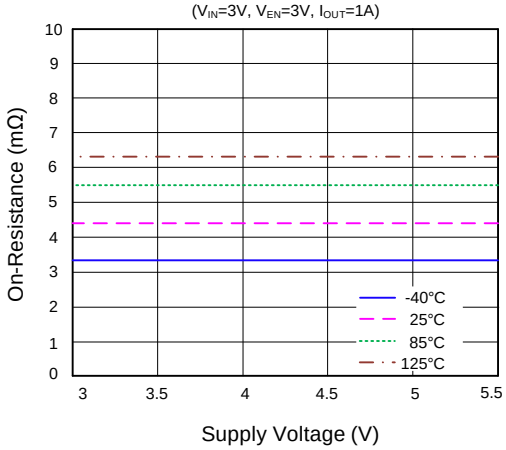
Figure 4. Safe Operating Area

Typical Performance Characteristics

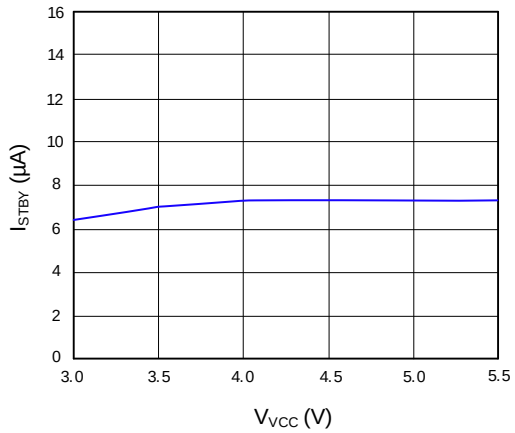
On−Resistance vs. Input Voltage
(V_{EN}=3V, I_{OUT}=1A)



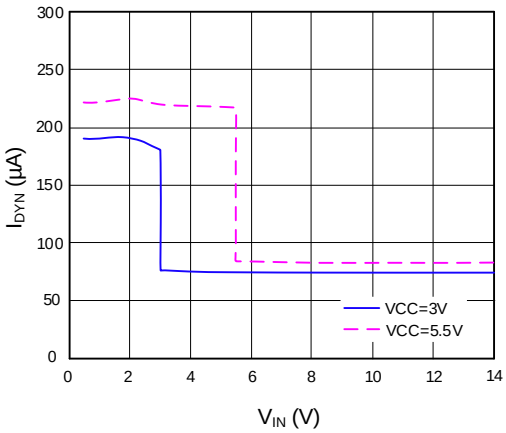
On−Resistance vs. Supply Voltage
(V_{IN}=3V, V_{EN}=3V, I_{OUT}=1A)



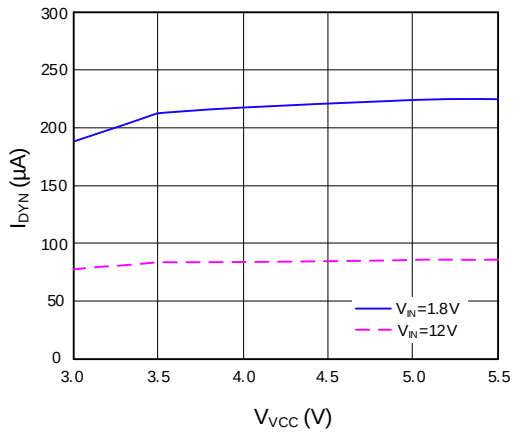
Supply Standby Current vs. Supply Voltage



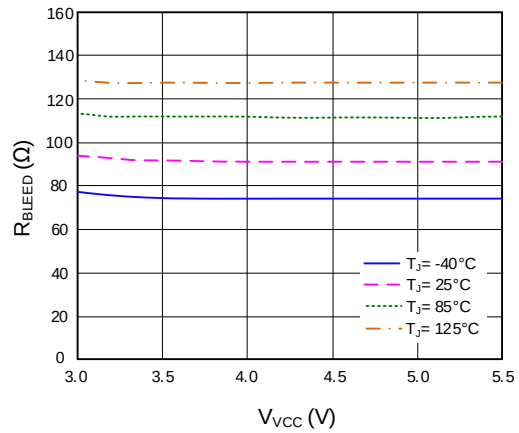
Supply Dynamic Current vs. Input Voltage



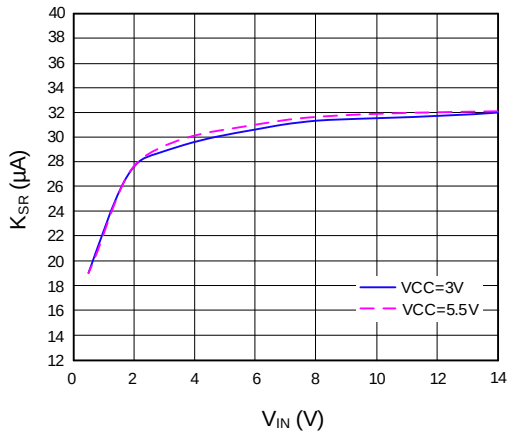
Supply Dynamic Current vs. Supply Voltage



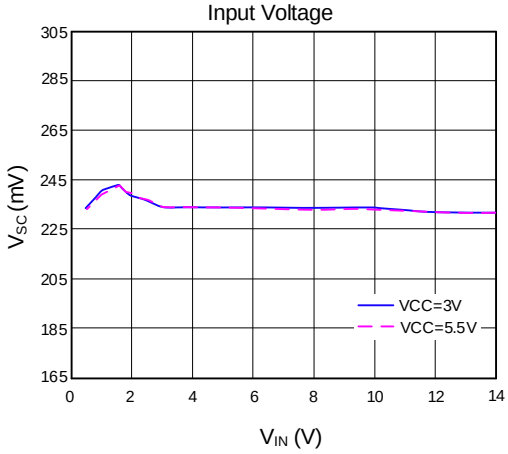
Bleed Resistance vs. Supply Voltage



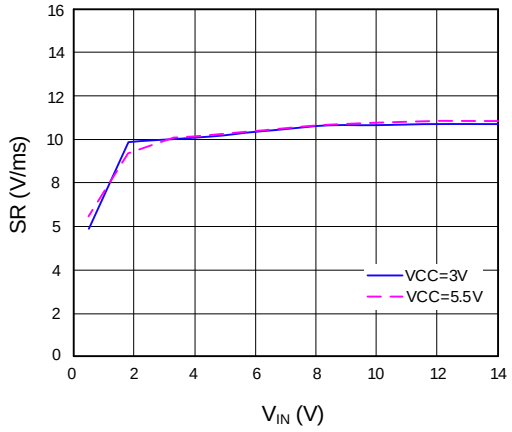
Slew Rate Control Constant vs. Input Voltage



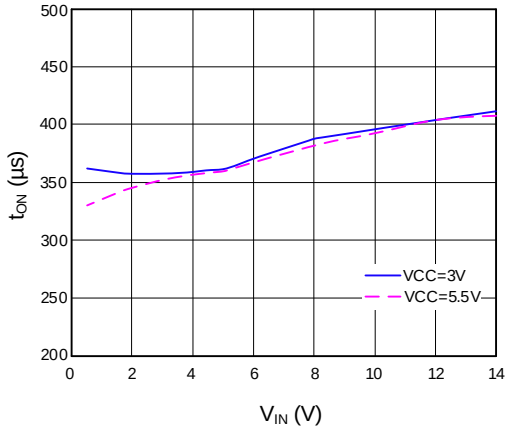
Short Circuit Protection Threshold vs. Input Voltage



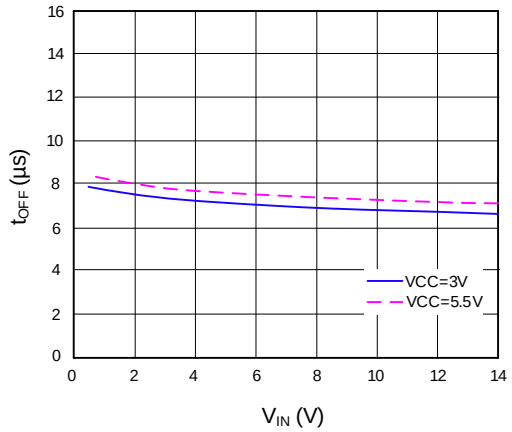
Output Slew Rate vs. Input Voltage



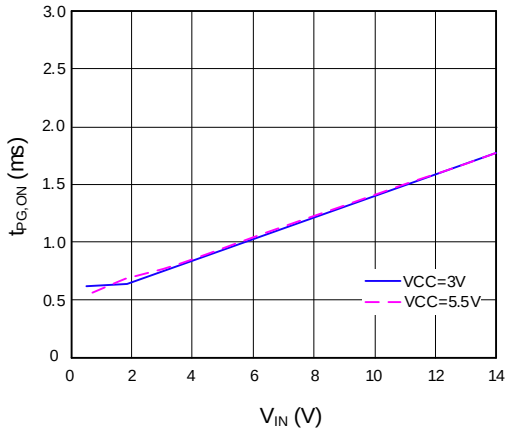
Output Turn-on Delay vs. Input Voltage



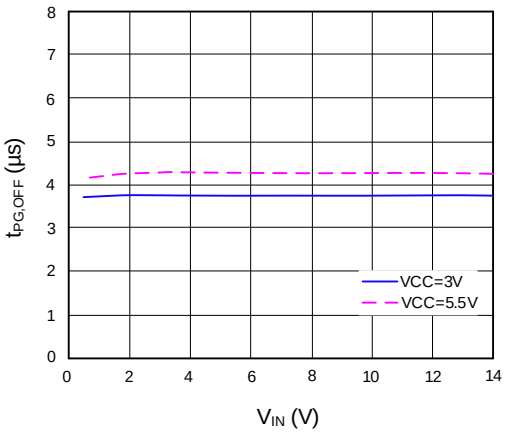
Output Turn-off Delay vs. Input Voltage



Power Good Turn-on Time vs. Input Voltage

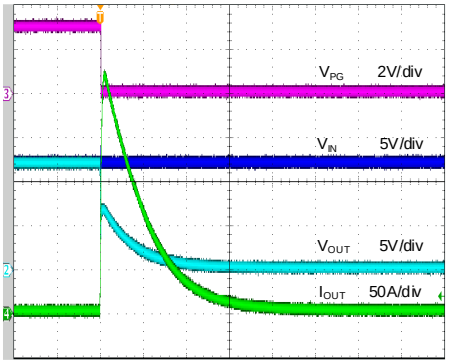


Power Good Turn-off Time vs. Input Voltage



Hard Short

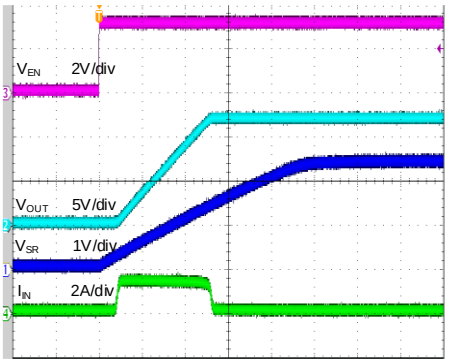
(V_{IN}=12V, V_{CC}=3V, R_{PG}=100kΩ, C_{SR}=100nF, C_{OUT}=100nF, 5mF Load, Short OUT)



Time (200μs/div)

Turn ON with Enable

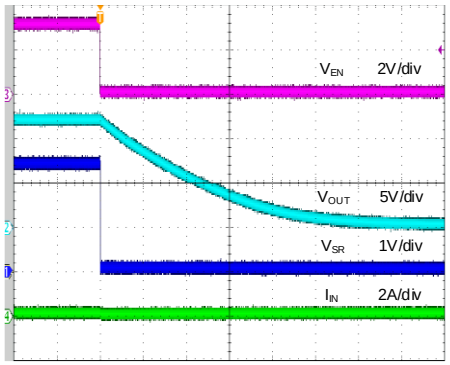
(V_{IN}=12V, V_{CC}=3V, C_{SR}=100nF, C_{OUT}=100nF, 5mF Load)



Time (20ms/div)

Turn OFF with Enable

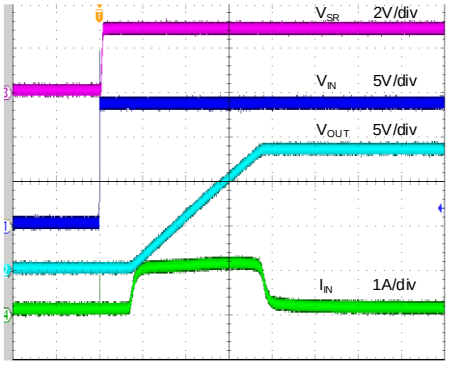
(V_{IN}=12V, V_{CC}=3V, C_{SR}=100nF, C_{OUT}=100nF, 5mF Load)



Time (400ms/div)

Hot Plug (V_{IN})

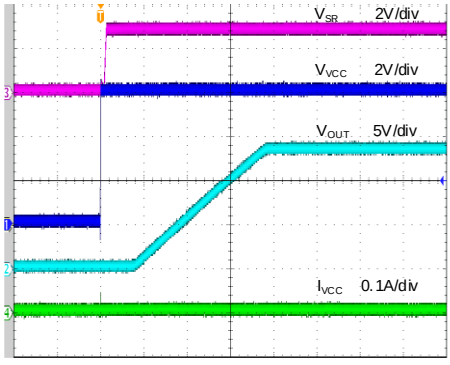
(V_{IN}=13.5V, V_{CC}=V_{EN}=6V, C_{SR}=C_{IN}=Open, C_{OUT}=100μF)



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

The SQ24801DCD allows for enabling the MOSFET in an active−high configuration. When the VCC supply pin has an adequate voltage applied and the EN pin is at a logic high level, the MOSFET will be enabled. Similarly, when the EN pin is at a logic low level, the MOSFET will be disabled. An internal pull down resistor to ground on the EN pin ensures that the MOSFET will be disabled when not being driven.

Power Sequencing

The SQ24801DCD will function with any power sequence, but the output turn−on delay performance may vary from what is specified. 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)

The SQ24801DCD has an internal bleed resistor, R_{BLEED}, which is used to bleed the charge off of the load to ground after the MOSFET has been disabled. In series with the bleed resistor is a bleed switch that is enabled whenever the MOSFET is disabled. The MOSFET and the bleed switch are never concurrently active. It is required that the BLEED pin be connected to V_{OUT} either directly (as shown in Figure 6) or through an external resistor, R_{EXT} (as shown in Figure 5). R_{EXT} should not exceed 1 kΩ and can be used to increase the total bleed resistance. Care must be taken to ensure that the power dissipated across R_{BLEED} is kept at a safe level. The maximum continuous power that can be dissipated across R_{BLEED} is 0.4 W. R_{EXT} can be used to decrease the amount of power dissipated across R_{BLEED}.

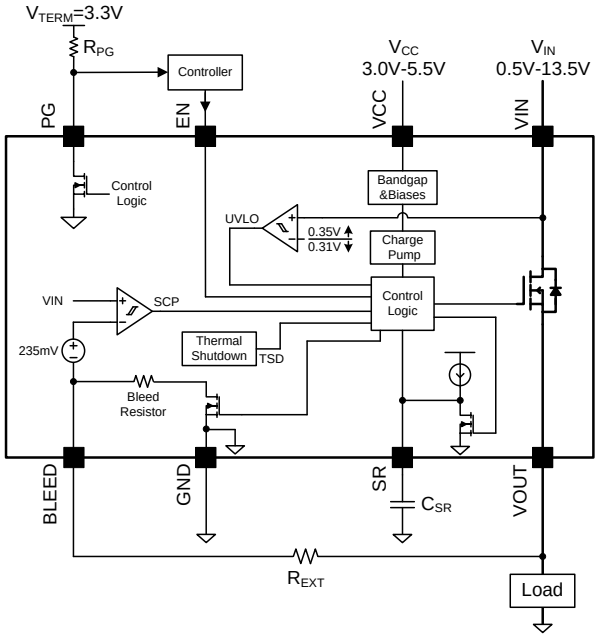


Figure5. Typical Application Diagram − Load Switch

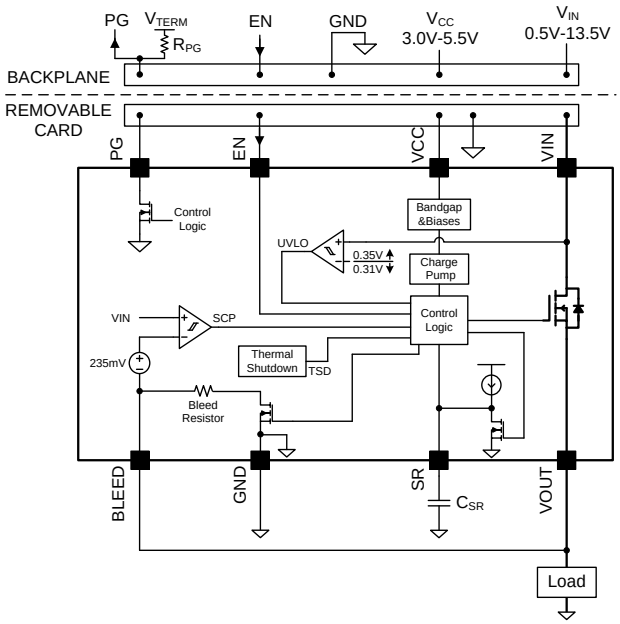


Figure 6. Typical Application Diagram − Hot Swap

Power Good

The SQ24801DCD has a power good output (PG) that can be used for indicating when the gate of the MOSFET is fully charged. The PG pin is an active−high, open−drain output that requires an external pull up resistor, R_{PG}, greater than or equal to 1kΩ to an external voltage source, V_{TERM}, compatible with input levels of other devices connected to this pin (as shown in Figures 5 and 6). If the power good feature is not used in the application, the PG pin should be tied to GND.

Slew Rate Control

The SQ24801DCD is equipped with controlled output slew rate which provides soft start functionality. This limits the inrush current caused by capacitor charging and enables these devices to be used in hot swap applications. The slew rate can be decreased with an external capacitor added between the SR pin and ground (as shown in Figures 5 and 6). With an external capacitor present, the slew rate can be determined by the following equation:

$$\text{Slew Rate} = \frac{K_{SR}}{C_{SR}}[\text{V/s}]$$

where K_{SR} is the specified slew rate control constant, found in EC Table, and C_{SR} is the slew rate control capacitor added between the SR pin and ground. The slew rate of the device will always be the lower of the default slew rate and the adjusted slew rate. Therefore, if the C_{SR} is not large enough to decrease the slew rate more than the specified default value, the slew rate of the device will be the default value. The SR pin can be left floating if the slew rate does not need to be decreased.

Short Circuit Protection

The SQ24801DCD is equipped with short circuit protection that is used to help protect the part and the system from a sudden high−current event, such as the output, V_{OUT}, being shorted to ground. This circuitry is only active when the gate of the MOSFET is fully charged.

Once active, the circuitry monitors the difference in the voltage on the V_{IN} pin and the voltage on the BLEED pin. In order for the V_{OUT} voltage to be monitored through the BLEED pin, it is required that the BLEED pin be connected to V_{OUT} either directly (as shown in Figure 6) or through a resistor, R_{EXT} (as shown in Figure 5), which should not exceed 1kΩ. With the BLEED pin connected to V_{OUT}, the short circuit protection is able to monitor the voltage drop across the MOSFET.

If the voltage drop across the MOSFET is greater than or equal to the short circuit protection threshold voltage, the MOSFET is immediately turned off and the load bleed is activated. The part remains latched in this off state until EN is toggled or V_{CC} supply voltage is cycled, at which point the MOSFET will be turned on in a controlled fashion with the normal output turn−on delay and slew rate. The current through the MOSFET that will cause a short circuit event can be calculated by dividing the short circuit protection threshold by the expected on−resistance of the MOSFET.

Thermal Shutdown

The thermal shutdown of the SQ24801DCD protects the part from internally or externally generated excessive temperatures. This circuitry is disabled when EN is not active to reduce standby current. When an over−temperature condition is detected, the MOSFET is immediately turned off and the load bleed is activated.

The part comes out of thermal shutdown when the junction temperature decreases to a safe operating temperature as dictated by the thermal hysteresis. Upon exiting a thermal shutdown state, and if EN remains active, the MOSFET will be turned on in a controlled fashion with the normal output turn−on delay and slew rate.

Under-voltage Lockout

The under-voltage lockout of the SQ24801DCD turns the MOSFET off and activates the load bleed when the input voltage, VIN, is less than or equal to the under-voltage lockout threshold. This circuitry is disabled when EN is not active to reduce standby current. If the VIN voltage rises above the under-voltage lockout threshold, and EN remains active, the MOSFET will be turned on in a controlled fashion with the normal output turn−on delay and slew rate.

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/minimized.

2. The optimum placement of decoupling capacitor is closest to the IN and GND terminals of the device. Care must be taken to minimize the loop area formed by the bypass-capacitor connection, the IN terminal, and the GND terminal of the IC.

3. Locate support components CVCC, CSR and REXT close to their connection pin. Connect the other end of the component to the GND with shortest trace length.

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 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.

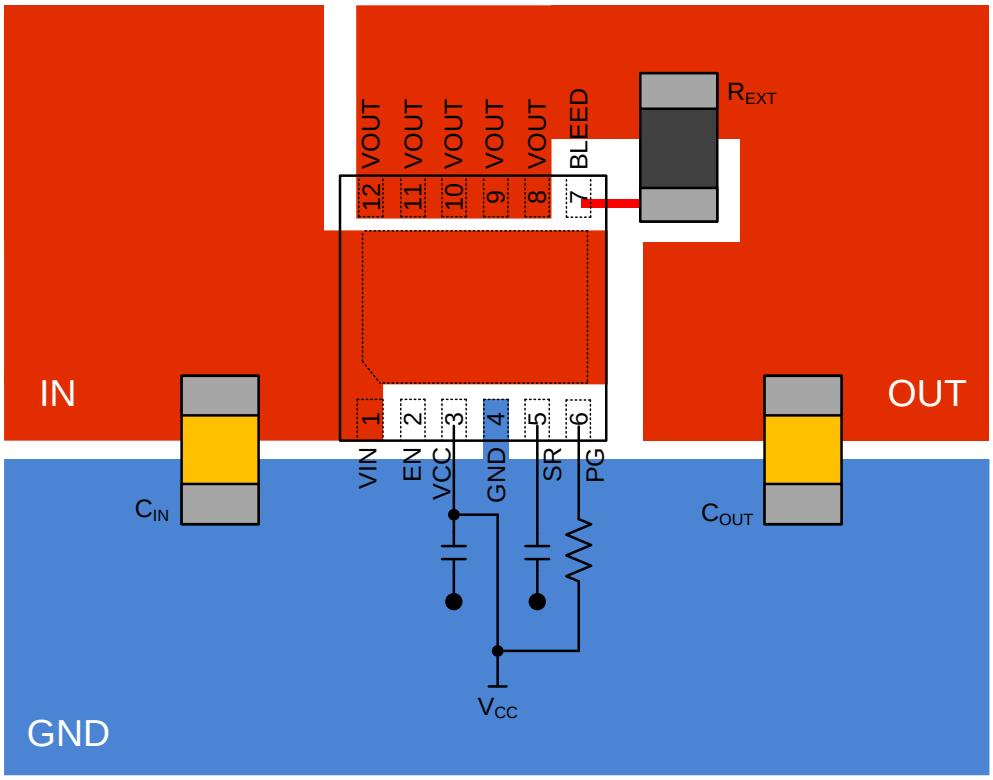
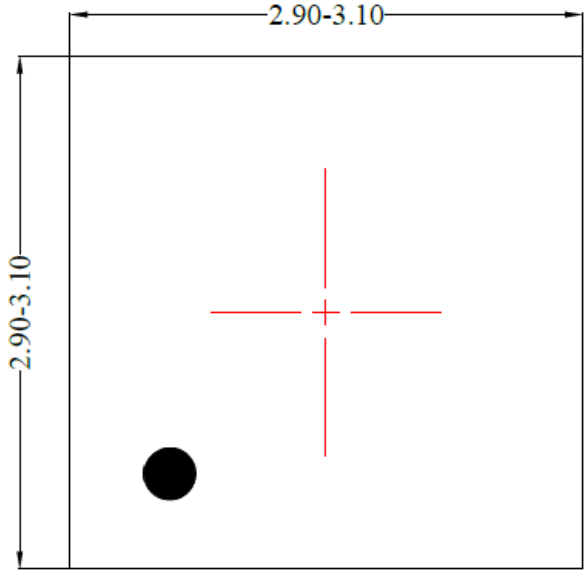
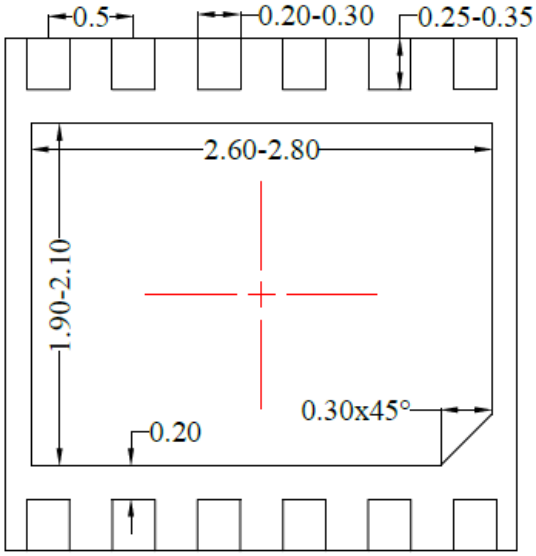


Figure7.PCB Layout Suggestion

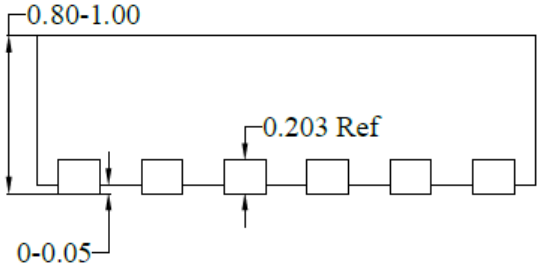
DFN3×3-12 Package outline



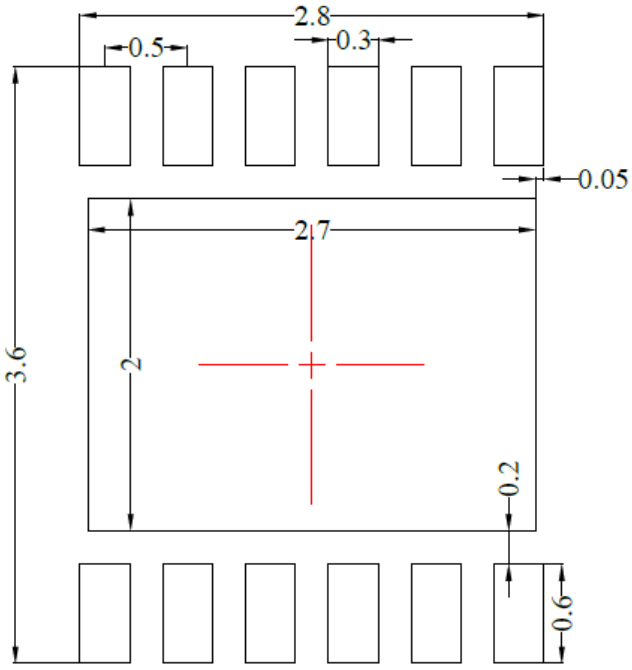
Top View



Bottom view



Front View

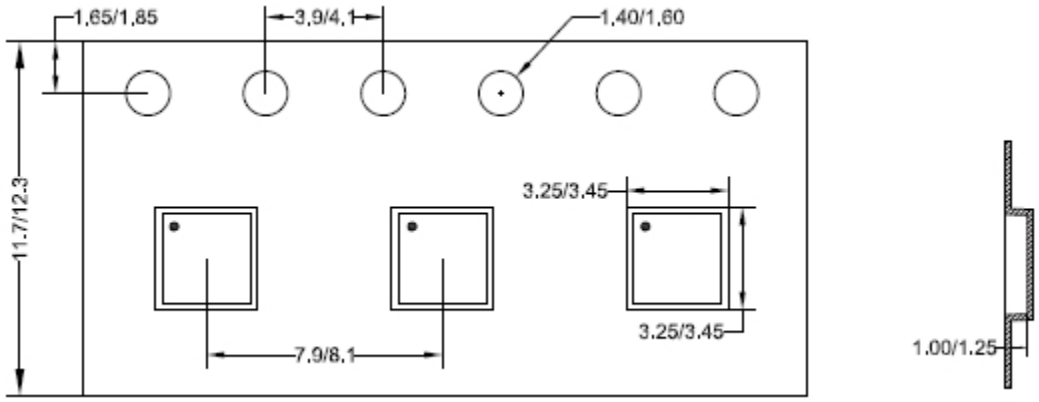


Recommended PCB layout
(only for reference)

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

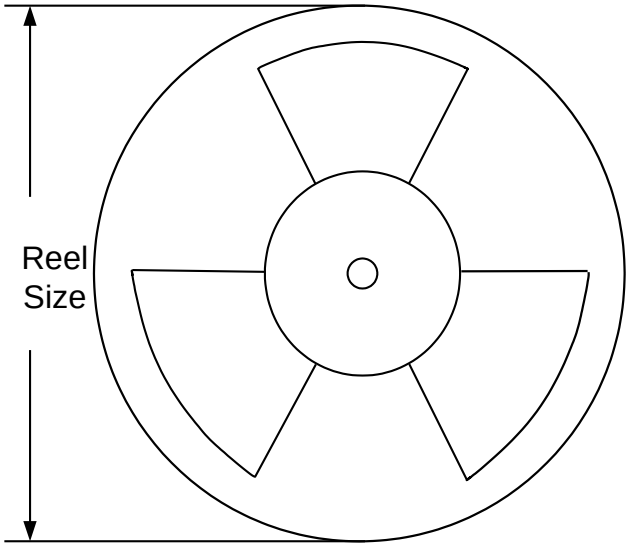
Taping & Reel Specification

1. DFN3×3 taping orientation



Feeding direction ⟶

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
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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