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

General Description

The SQ24801B 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 capabilities to reduce inrush current and low power consumption in a small footprint, the SQ24801B is ideal for power management and hot-swap applications.

The SQ24801B is available in a compact DFN3×3-12 package.

Features

- Integrated N-Channel MOSFET with Ultra Low R_{ON}
- Input Voltage Range 3 V to 24 V
- 3V to 5.5V Input Voltage Range for VCC
- Programmable Soft Start time
- Fault Detection with Power Good Output
- Thermal Shutdown Protection
- Short Circuit and Adjustable Over-Current Protection and latch off
- Output capacitor discharge during EN OFF
- Extremely Low Standby Current

Applications

- USB Type C Power Delivery
- 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

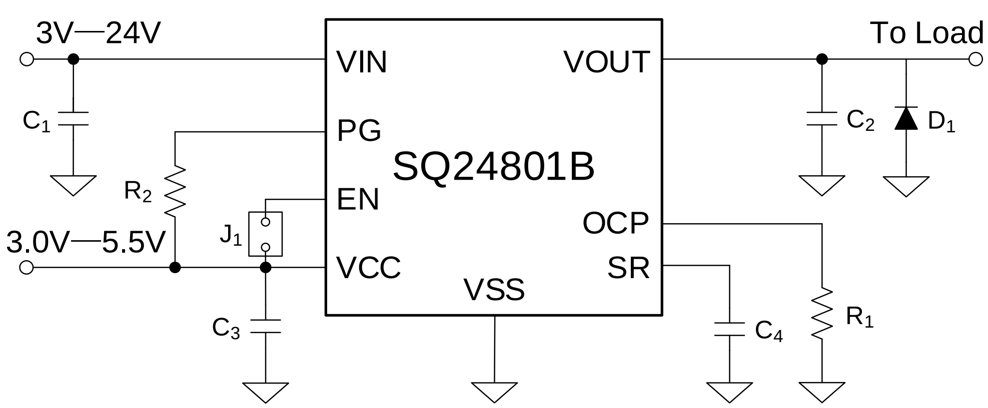

Figure1. Schematic Diagram

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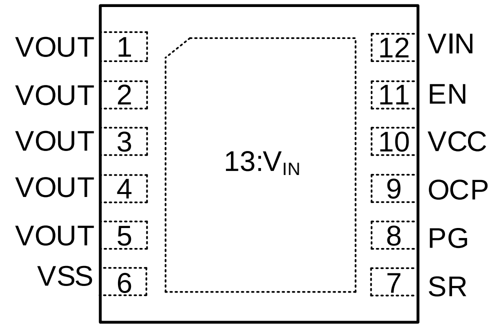
Ordering Information

Ordering Part Number	Package Type	Top Mark
SQ24801BDCD	**DFN3×3-12** RoHS Compliant and Halogen Free	**EHQxyz**

Device code: EHQ

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

Pinout (top view)



Pin Description

Pin Name	Pin number	Pin Description
VOUT	1, 2, 3, 4, 5	Source of MOSFET connected to load. Includes an internal bleed resistor to GND. All pins must be connected to provide correct R_{ON}, OCP, and current capability.
VSS	6	Driver ground
SR	7	Slew Rate control pin. Slew rate adjustment made with an external capacitor to GND. Leave it floating if not used.
PG	8	Active−high, open−drain output that indicates when the gate of the MOSFET is fully charged, external pull up resistor ≥ 1kΩ to an external voltage source required; tie to GND if not used.
OCP	9	Over−current protection trip point adjustment made with a resistor to ground; short to ground if over−current protection is not needed.
VCC	10	Driver supply voltage (3.0 V − 5.5 V)
EN	11	Active−high digital input used to turn on the MOSFET driver, pin has an internal pull-down resistor to GND.
VIN	12, 13	Input voltage (3 V − 24 V) – Pin 13 should be used for high current (>0.5 A)

Block Diagram

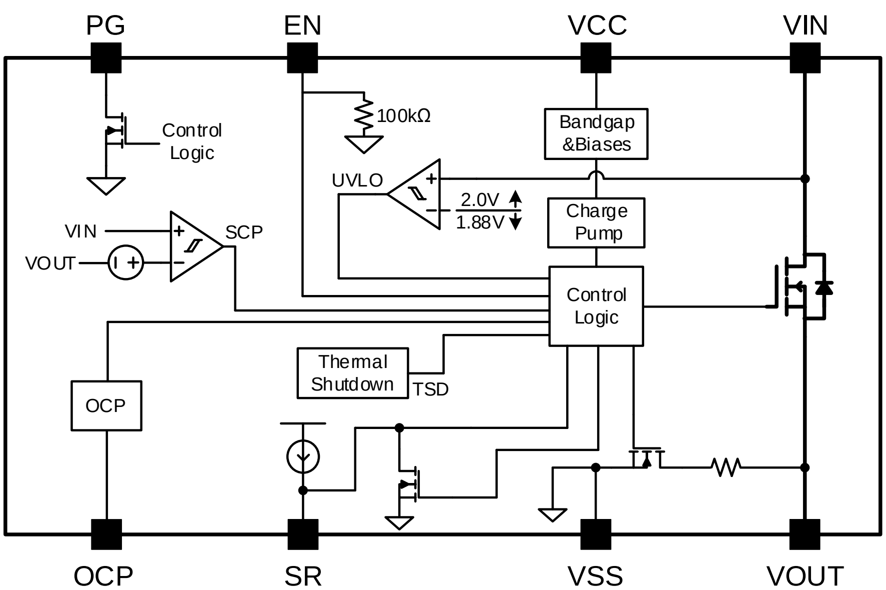


Figure 2 Block Diagram

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Absolute Maximum Ratings

Parameter (Note 1)	Min	Max	Unit
VCC, EN, PG, OCP	-0.3	6	V
VIN, VOUT	-0.3	30	
I_{MAX} (Note 2)		10	A
Lead Temperature (Soldering, 10s)		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	3	24	
EN, PG	0	5.5	
OCP External Resistor to VSS	short	open	
Junction Temperature, Operating	-40	125	°C
Ambient Temperature	-40	85	

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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}	V_{CC} = 3.3 V; V_{IN} = 24 V		5.2	9	mΩ
Leakage Current	I_{LEAK}	V_{EN} = 0 V; V_{IN} = 24 V		0.1	10	μA
CONTROLLER						
V_{IN} Control Current − V_{IN} to V_{SS}	I_{INCTL}	V_{EN} = 0 V; V_{IN} = 24 V; V_{CC} = 3.3 V			30	μA
V_{IN} Control Current − V_{IN} to V_{SS}	I_{INCTL_EN}	V_{EN} = V_{CC} = 3.3 V; V_{IN} = 24 V			260	μA
Supply Standby Current	I_{STBY}	V_{EN} = 0 V; V_{IN} = 24 V; V_{CC} = 3.3 V		2.0	8.0	μA
Supply Dynamic Current	I_{DYN}	V_{EN} = V_{CC} = 3.3 V; V_{IN} = 24 V			0.11	mA
Bleed Resistance	R_{BLEED}		40	95	150	kΩ
EN Input High Voltage	V_{IH}		2.0			V
EN Input Low Voltage	V_{IL}				0.8	V
EN Input Leakage Current	I_{IL}	V_{EN} = 0 V	-1.0		1.0	μA
EN Pull Down Resistance	R_{PD}		75	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_{PG} = 3.3 V		3.3	100	nA
Slew Rate Control Constant	K_{SR}	SR pin floating (default)	60	95	130	μA
FAULT PROTECTIONS						
Thermal Shutdown Threshold (Note 5)	T_{TSD}			145		°C
Thermal Shutdown Hysteresis (Note 5)	T_{HYS}			20		°C
VIN Undervoltage Lockout Threshold	V_{UVLO}	V_{IN} rising		2.0	2.1	V
VIN Undervoltage Lockout Hysteresis	V_{HYS}	V_{CC} = 3 V		220	300	mV
Over−Current Protection Trip	I_{TRIP}	R_{OCP} = open	0.85	1.2	1.45	A
		R_{OCP} = 32 kΩ		7.5		
		R_{OCP} = short to GND		12		
Over−Current Protection Blanking Time	t_{OCP}			2.25		ms
Short−Circuit Protection Trip Current (Note 5)	I_{SC}	Soft Short & Hard Short		20		A

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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} = 4.5 V; V_{IN} = 3 V	7	15	25	kV/s
		V_{CC} = 5.0 V; V_{IN} = 3 V	7	15	25	
		V_{CC} = 3.3 V; V_{IN} = 24 V	10	20	26	
		V_{CC} = 5.0 V; V_{IN} = 24 V	10	20	26	
Output Turn−on Delay	t_{ON}	V_{CC} = 4.5 V; V_{IN} = 3 V	100	330	700	µs
		V_{CC} = 5.0 V; V_{IN} = 3 V	100	330	700	
		V_{CC} = 3.3 V; V_{IN} = 24 V	100	410	700	
		V_{CC} = 5.0 V; V_{IN} = 24 V	100	410	700	
Output Turn−off Delay	t_{OFF}	V_{CC} = 4.5 V; V_{IN} = 3 V		48		µs
		V_{CC} = 5.0 V; V_{IN} = 3 V		48		
		V_{CC} = 3.3 V; V_{IN} = 24 V		48		
		V_{CC} = 5.0 V; V_{IN} = 24 V		48		
Power Good Turn−on Time	$t_{PG,ON}$	V_{CC} = 4.5 V; V_{IN} = 3 V	0.25	0.68	2.5	ms
		V_{CC} = 5.0 V; V_{IN} = 3 V	0.25	0.72	2.5	
		V_{CC} = 3.3 V; V_{IN} = 24 V	0.25	1.4	2.5	
		V_{CC} = 5.0 V; V_{IN} = 24 V	0.25	1.4	2.5	
Power Good Turn−off Time	$t_{PG,OFF}$	V_{CC} = 4.5 V; V_{IN} = 3 V		4.5		µs
		V_{CC} = 5.0 V; V_{IN} = 3 V		4.5		
		V_{CC} = 3.3 V; V_{IN} = 24 V		4.5		
		V_{CC} = 5.0 V; V_{IN} = 24 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°C on a Silergy EVB test board.

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

Note 5: Guaranteed by design, not production test.

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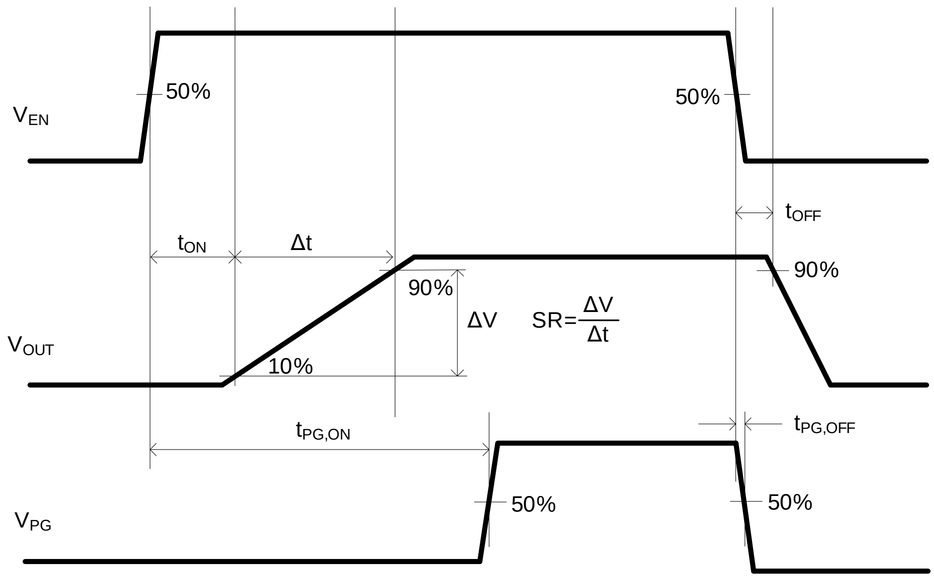

Figure3. Switching Time Waveform

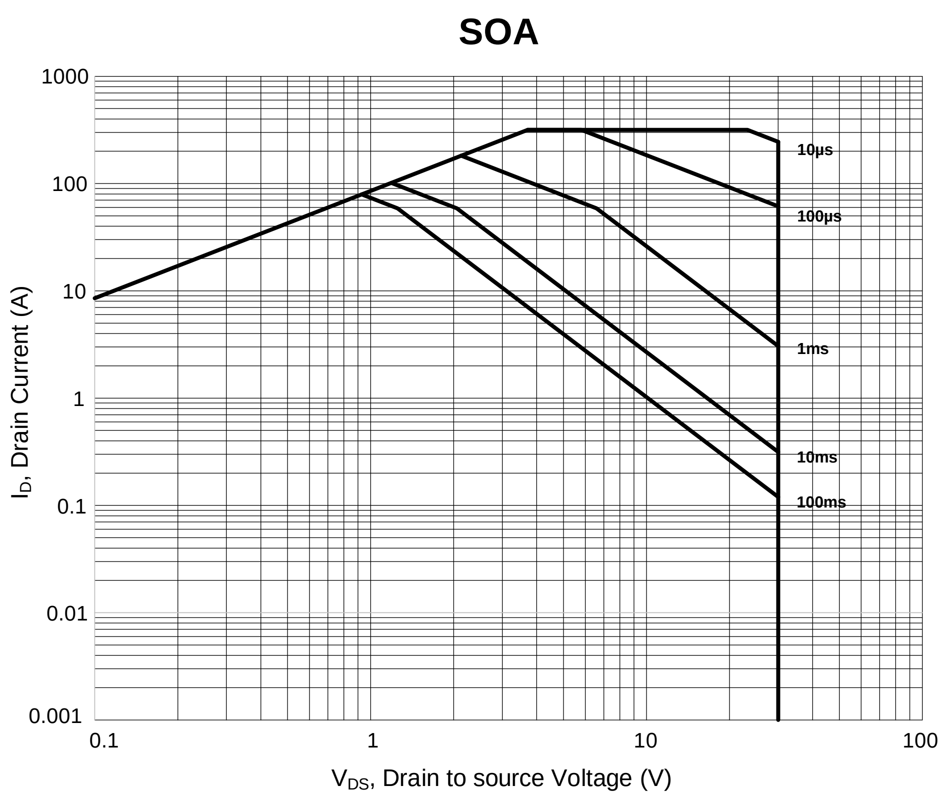

Figure 4. Safe Operating Area

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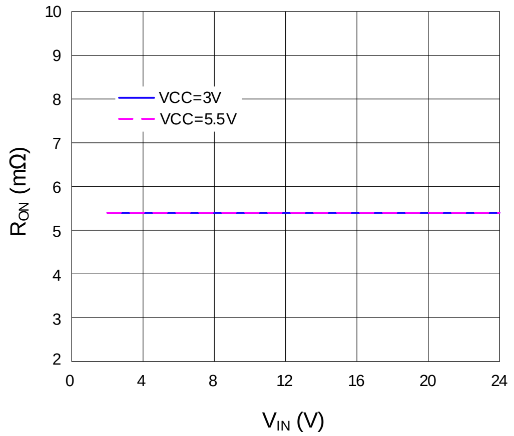
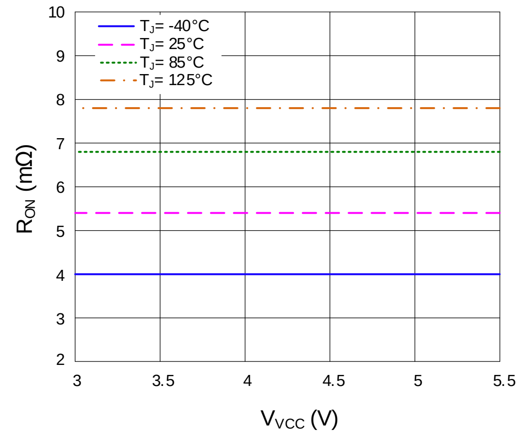
Typical Performance Characteristics

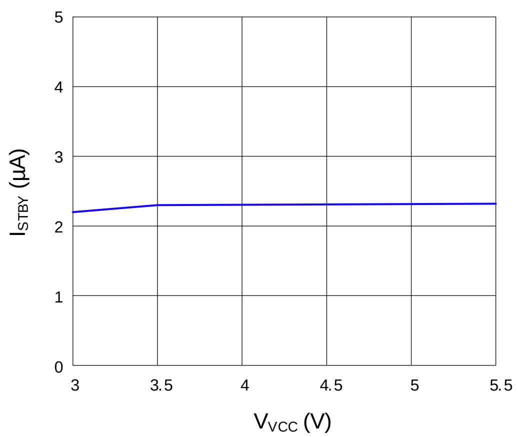
On−Resistance vs. Input Voltage



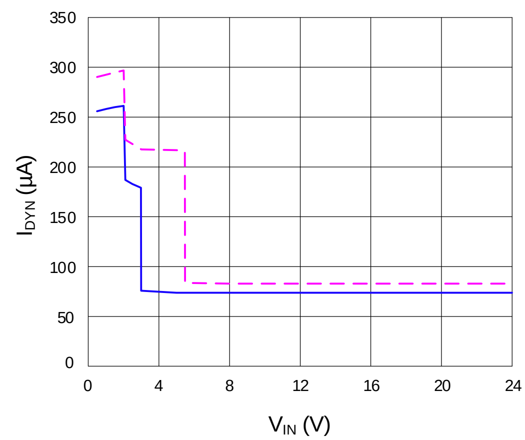
On−Resistance vs. Supply Voltage



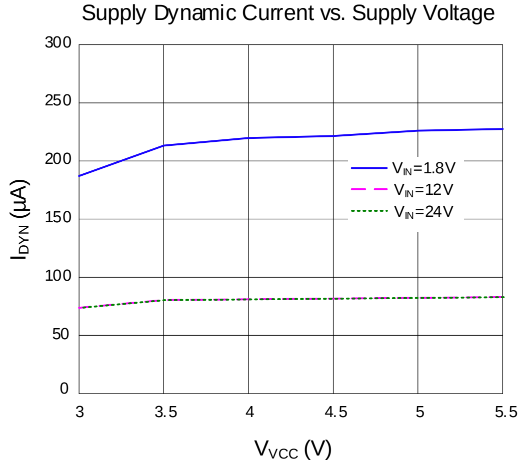
Supply Standby Current vs. Supply Voltage



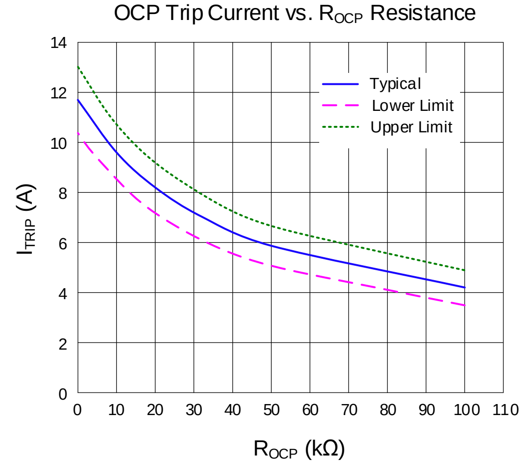
Supply Dynamic Current vs. Input Voltage



Supply Dynamic Current vs. Supply Voltage



OCP Trip Current vs. R_{OCP} Resistance



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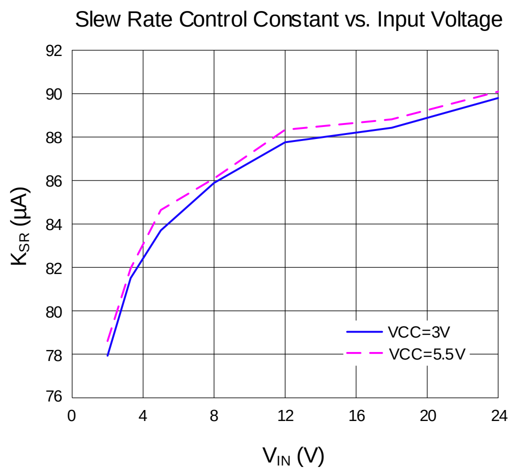

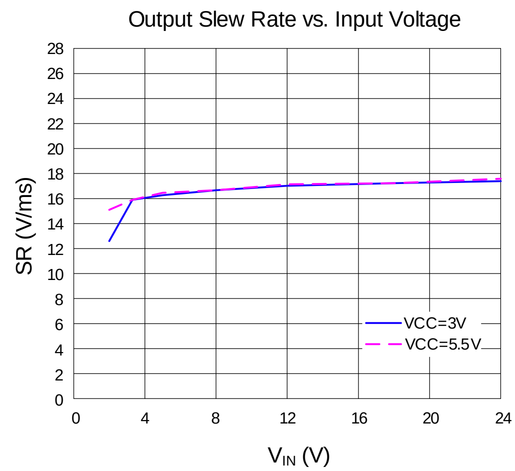

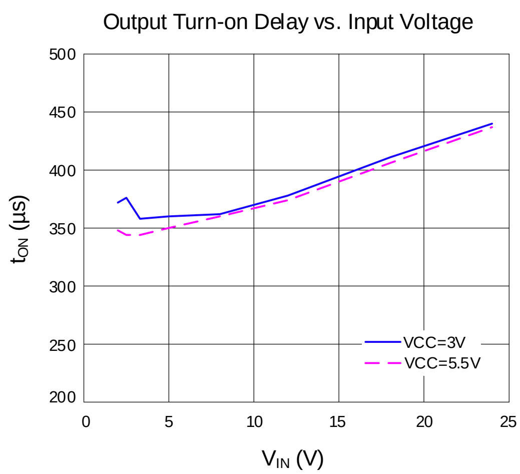

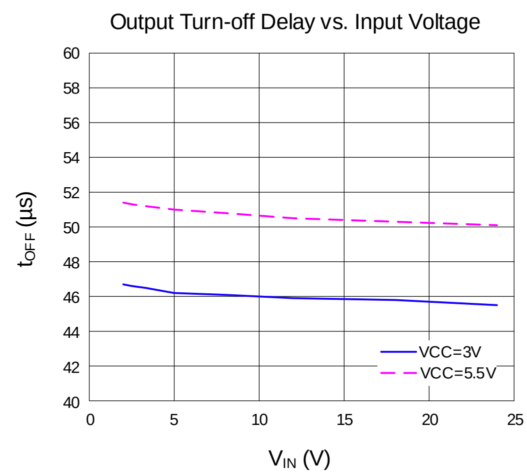

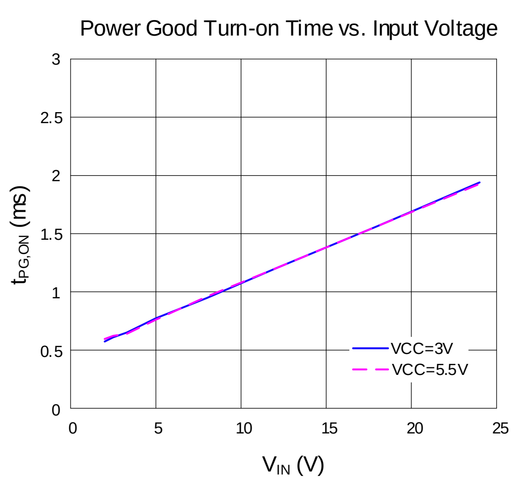

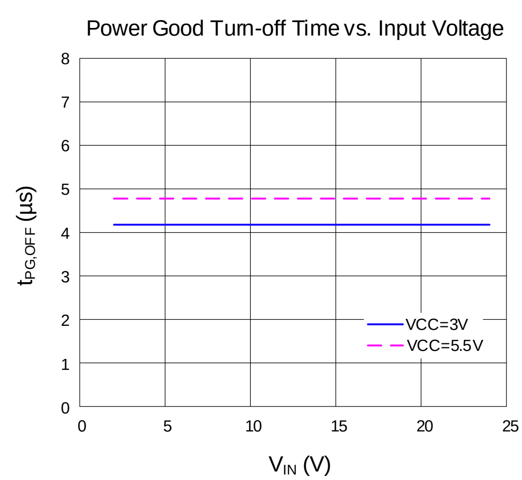

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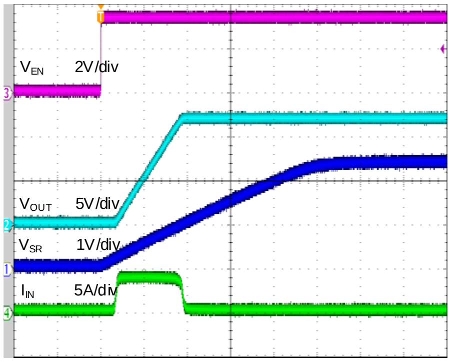
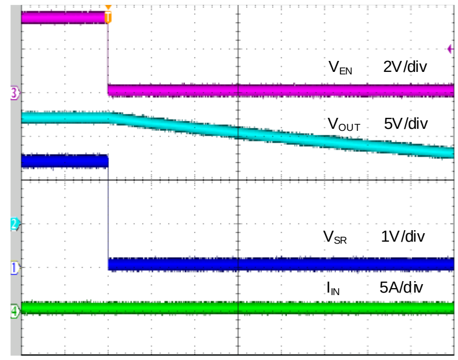
Turn ON with Enable
(V_{IN}=12V, V_{VCC}=3V, C_{SR}=100nF, C_{OUT}=100nF, 5mF Load)



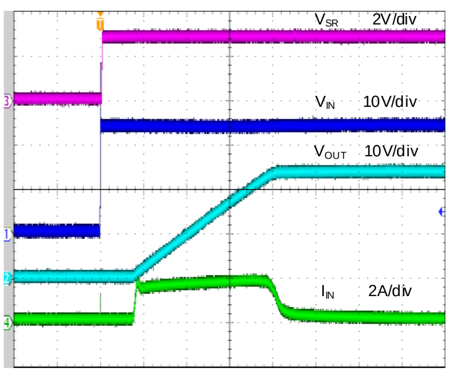
Time (10ms/div)

Turn OFF with Enable
(V_{IN}=12V, V_{VCC}=3V, C_{SR}=100nF, C_{OUT}=100nF, 5mF Load)



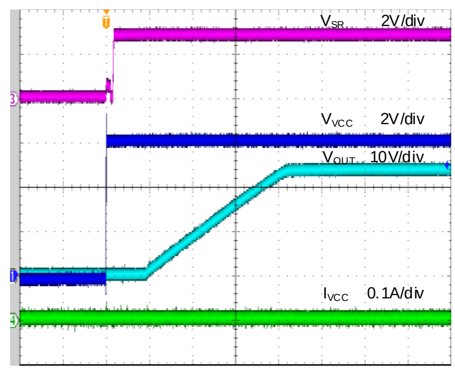
Time (1s/div)

Hot Plug (V_{IN})
(V_{IN}=24V, V_{VCC}=V_{EN}=6V, C_{SR}=C_{IN}=Open, C_{OUT}=100µF)



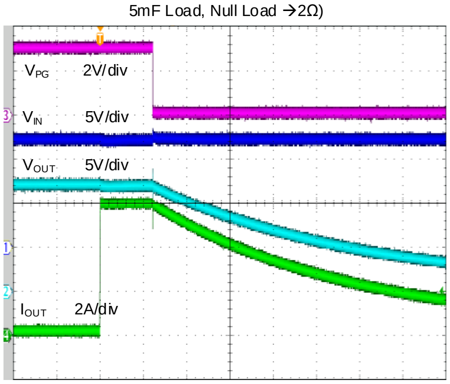
Time (400µs/div)

Hot Plug (V_{VCC})
(V_{VCC}=V_{EN}=6V, V_{IN}=24V, C_{SR}=C_{VCC}=Open, C_{OUT}=100µF)



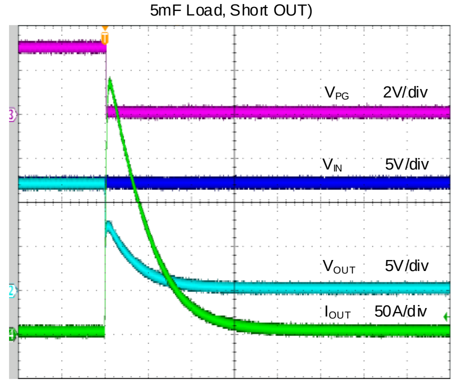
Time (400µs/div)

Over Current Protection
(V_{IN}=12V, V_{VCC}=3V, R_{OCP}=100kΩ, C_{SR}=100nF, C_{OUT}=100nF, 5mF Load, Null Load →2Ω)



Time (2ms/div)

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



Time (200µs/div)

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Applications Information

The SQ24801B 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 capabilities to reduce inrush current and low power consumption in a small footprint, the SQ24801B is ideal for power management and hot-swap applications.

Under voltage Lockout

The SQ24801B integrates UVLO protection. If VIN rise above UVLO threshold and EN is set to high, the power FET will controlled to turn on with soft start. If VIN fall below UVLO threshold-hysteresis, the device is shutdown.

Enable Control

EN is used to control the SQ24801BDCD ON and OFF. When VCC and VIN is in operation voltage range, setting EN to a logic high level, the power FET is turned on with soft start and setting EN to a logic low level, the Power FET is turn off immediately. Set EN to low, then back to high, can reset the SQ24801BDCD that has latched off due to SCP or OCP protection. The SQ24801BDCD internal integrated a 100kΩ resistor to keep the device off when EN pin is not driven.

Power Sequencing

The SQ24801BDCD must consider the power on timing specification for $V_{CC} \geqslant 3V$ before EN is enabled ($V_{EN} \leqslant 1.1V$ within the full temperature range) in design. To achieve the specified performance, there are two recommended power sequences:

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

Power Good

The SQ24801BDCD integrates a power good indicator, PG pin. The PG pin is an active high, open drain output. This pin shall connect an external pull high resistor, to an external voltage source. 1kΩ or larger is recommended. When the MOSFET is fully enhanced. The PG pin is high impedance, the voltage on PG pin is pulled high by external resistor.

The PG pin can be used to power up sequence design. Avoid draw large current before the switch is fully enhanced which may lead to system power up fail.

Slew Rate Control

The SQ24801B integrates programmable output slew rate control to reduce the inrush current during start up with large output cap. Connect a C_{SR} from SR pin to GND to program the slew rate. The slew rate can be calculated as following equation:

$$\text{Slew Rate} = \frac{K_{SR}}{C_{SR}} \quad (V/s) \qquad (1)$$

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

To make the power FET work within SOA limits in output short circuit condition, the capacitance value of C_{SR} should not exceed 22nF.

Short−Circuit Protection

The SQ24801B devices are equipped with a short-circuit protection which against output hard short to GND event.

Once VOUT is shorted to GND, large current draw VOUT low. The SQ24801BDCD monitor the voltage difference between VIN and VOUT, once the voltage exceeds short circuit threshold, the power FET is shut down immediately to cut off load and prevent current increasing. The device will keep in off status until EN off/on toggle or VCC UVLO event.

The short circuit protection is active after PG is settle high.

Over−Current Protection

The device is equipped with an over−current protection (OCP) that helps protect the part and the system from a high current event which exceeds the expected operational current (e.g., a soft short).

Once the load current exceeds programmed over current threshold, an internal timer will count a 2.25ms, t_{OCP} blanking time. If over current lasts longer than TOCP, Power FET is shut down and kept off status as SCP event. If load drop back to normal range t_{OCP}, the timer is reset and power FET maintain on state.

The over-current threshold is programmed by connect a resistor from OCP pin to GND, and can be calculated by following equation:

$$I_{TRIP} = \frac{420}{R_{OCP} + 40} + 1.2$$

• I_{TRIP} is OCP trip current in Ampere
• R_{OCP} is the programmable resistor in kΩ

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Thermal Shutdown

The thermal shutdown of the SQ24801BDCD devices protects the part from internally or externally generated excessive temperatures. When the junction temperature is higher than TSD threshold, T_{TSD}, the SQ24801BDCD will shut down the power FET. After junction temperature drop below the T_{TSD}-hys and EN is still keeps high, SQ24801BDCD will restart with slew rate control

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 C_{VCC}, C_{SR} and R_{OCP} 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.

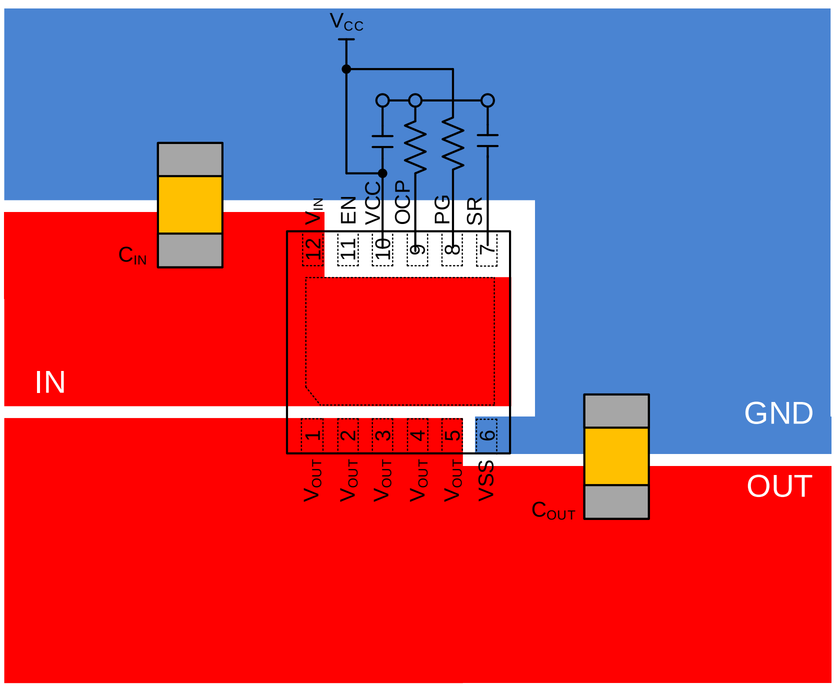

Figure5. PCB Layout Suggestion

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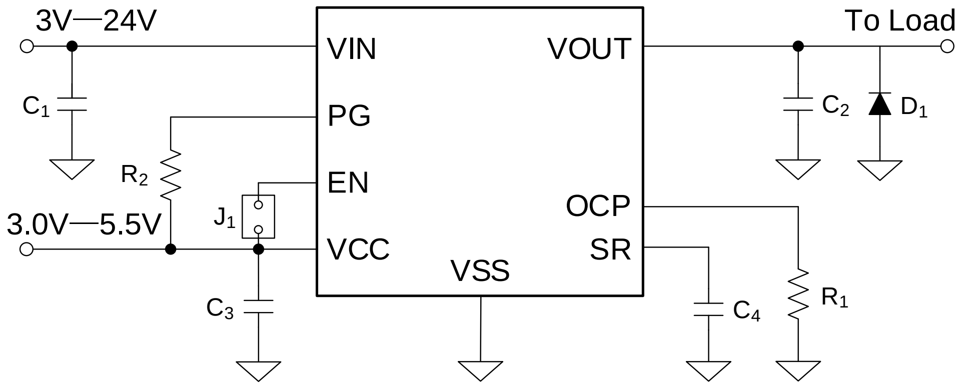
Schematic



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	10nF/50V, ±10%, X7R, 0603	GRM188R72A103KA01D	Muruta
R_1	0Ω, 1%, 0.1W, 0603	RC0603FR-070RL	YAGEO
R_2	100kΩ, 1%, 0.1W, 0603	RC0603FR-07100KL	YAGEO
D_1	Schottky	SS54	Any
J_1	Jumper, 2×1, Gold		Any

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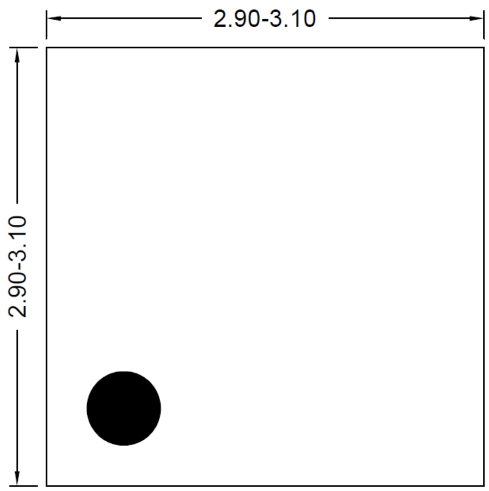
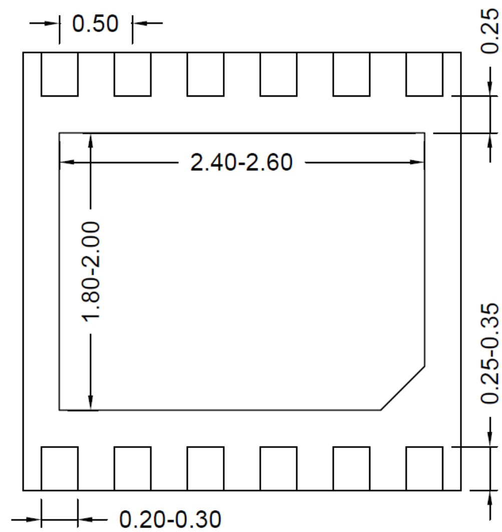
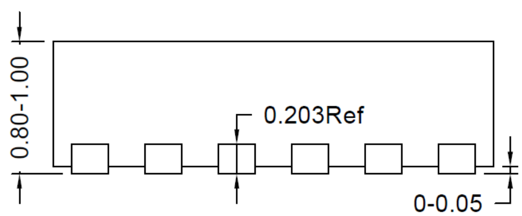
DFN3×3-12 Package outline



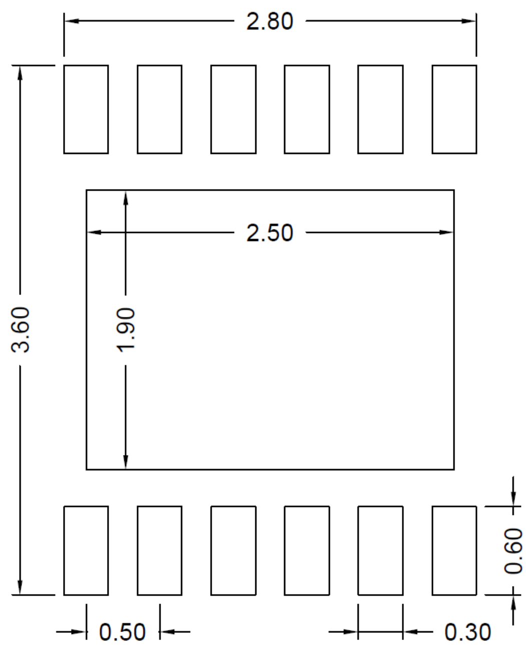
Top View



Bottom view



Front View



Recommended PCB layout
(only for reference)

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

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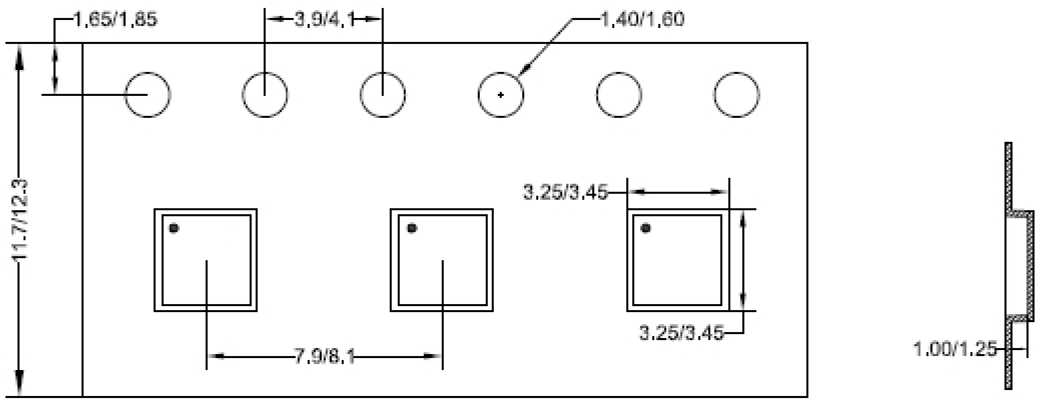
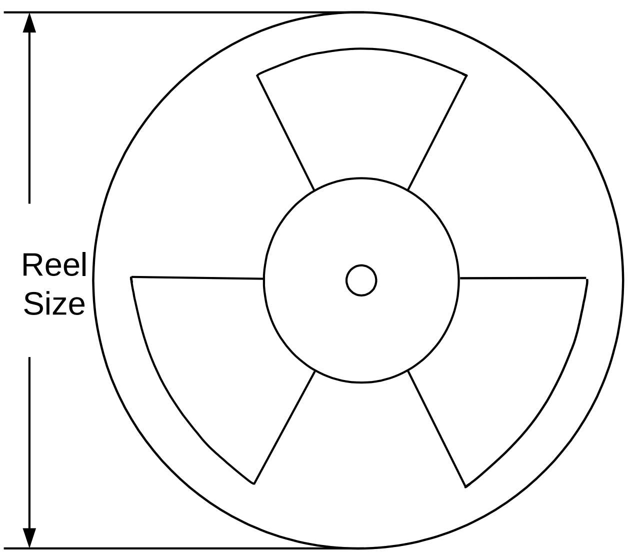
Tape and Reel Information

1. Tape dimensions and Pin1 orientation



Direction of Feed

2. Reel dimensions



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

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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
Oct. 08, 2024	Revision 1.0B	1. Update the Description of Slew Rate Control (page 10) 2. C4 changed from 100nF to 10nF in BOM list (page 12)
May 20, 2024	Revision 1.0A	3. Add Note 5 (Guaranteed by design, not production test.) for Thermal Shutdown Threshold/ Thermal Shutdown Hysteresis/ Short-Circuit Protection Trip Current (Page 4); 4. Update the description of Power Sequencing (page 10)； 5. Update the package outline (page13)
Jan.05, 2024	Revision 1.0	Initial Release

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