Lead-free Green

SINGLE CHANNEL SMART LOAD SWITCH

NEW PRODUCT

Description and Applications

The DML3009LDC load switch provides a component and area-reducing solution for efficient power domain switching with inrush current limit via soft-start. In addition to integrated control functionality with ultra-low on-resistance, this device offers system safeguards and monitoring via fault protection and power good signaling. This cost-effective solution is ideal for power management and hot-swap applications requiring low power consumption in a small footprint.

Applications

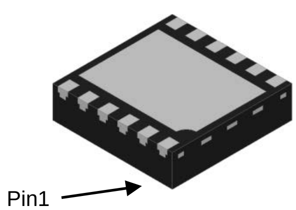
- Portable Electronics and Systems
- Notebook and Tablet Computers
- Telecom, Networking, Medical, and Industrial Equipment
- Set-Top Boxes, Servers, and Gateways
- Hot-Swap Devices and Peripheral Ports

Features and Benefits

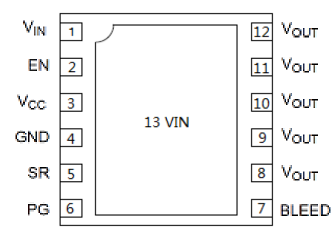
- Advanced Controller with Charge Pump
- Integrated N-Channel MOSFET with Ultra-Low R_{ON}
- Input Voltage Range 0.5V to 13.5V
- Soft-Start via Controlled Slew Rate
- Adjustable Slew Rate Control
- Power Good Signal
- Thermal Shutdown
- V_{IN} Undervoltage Lockout
- Short-Circuit Protection
- Extremely Low Standby Current
- Load Bleed (Quick Discharge)
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. “Green” Device (Note 3)**

V-DFN3030-12 (Type B)

Top View



Bottom View



Top View

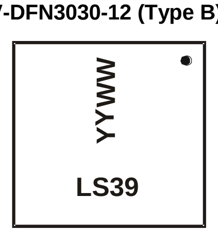
Ordering Information (Note 4)

Part Number	Case	Packaging
DML3009LDC-7	V-DFN3030-12 (Type B)	3000/Tape & Reel

Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated’s definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green” products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.
4. For packaging details, go to our website at https://www.diodes.com/design/support/packaging/diodes-packaging/.

Marking Information

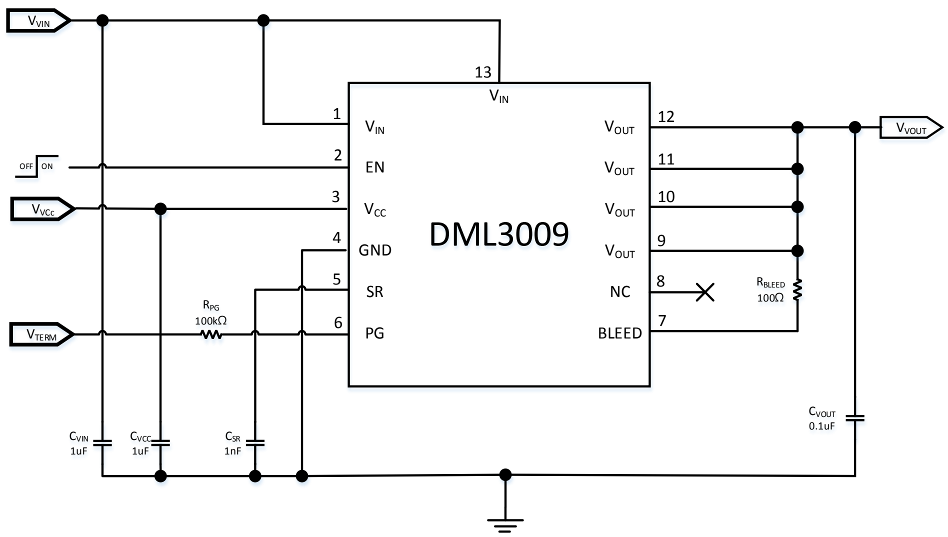
V-DFN3030-12 (Type B)



LS39 = Product Type Marking Code
YYWW = Date Code Marking
YY = Last Two Digits of Year (ex: 18 = 2018)
WW = Week Code (01 to 53)

NEW PRODUCT

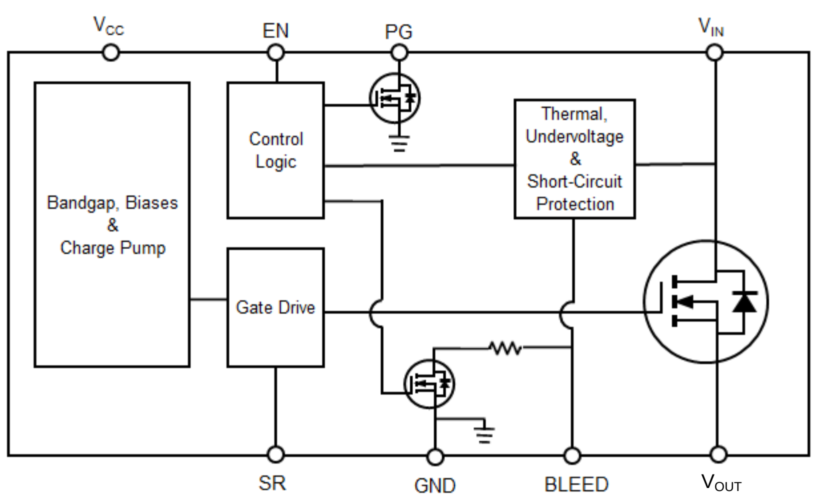
Typical Application Circuit



Pin Description

Pin Number	Pin Name	Pin Function
1, 13	V_{IN}	Drain of MOSFET (0.5V to 13.5V). Pin 1 must be connected to Pin 13.
2	EN	Active−high digital input used to turn on the MOSFET, pin has an internal pull down resistor to GND
3	V_{CC}	Supply voltage to controller (3.0V to 5.5V).
4	GND	Controller ground.
5	SR	Slew rate adjustment; Please refer C_{SR} vs. V_{OUT} rising time table.
6	PG	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.
7	BLEED	Load bleed connection, must be tied to V_{OUT} either directly or through a resistor ≤ 1kΩ.
8 to 12	V_{OUT}	Source of MOSFET connected to load.

Function Block Diagram



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Absolute Maximum Rating

Parameter	Rating
V_{IN}, BLEED, V_{OUT} to GND	-0.3V to 18V
EN, V_{CC}, SR, PG to GND	-0.3V to 6V
I_{MAX}	20A
Junction Temperature (T_J)	+150°C
Storage Temperature (T_S)	-65°C to +150°C

Recommended Operating Ranges

Parameter	Rating
Supply Voltage (V_{VCC})	3V to 5.5V
Input Voltage (V_{VIN})	0.5V to 13.5V
Ambient Temperature (T_A)	-40°C to +85°C
Package Thermal Resistance (Θ_{JC})	3.5°C/W
Package Thermal Resistance (Θ_{JA})	30°C/W

Electrical Characteristics

(T_A = +25°C, V_{VCC}=3.3V, V_{VIN}=5V=V_{TERM}, C_{VIN}=1µF, C_{VOUT}=0.1µF, C_{VCC}=1µF, C_{SR}=1nF, unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{VIN}	Input Voltage	—	0.5	—	13.5	V
V_{VCC}	Supply Voltage	—	3.0	—	5.5	V
I_{DYN}	V_{CC} Dynamic Supply Current	V_{EN} =V_{VCC}= 3V, V_{VIN} = 12V	—	310	400	µA
		V_{EN} =V_{VCC}= 5.5V, V_{VIN} = 1.8V	—	510	750	µA
I_{STBY}	V_{CC} Shutdown Supply Current	V_{VCC} = 3V, V_{EN} = 0V	—	0.1	1	µA
		V_{VCC} = 5.5V, V_{EN} = 0V	—	0.1	2	µA
V_{ENH}	EN High Level Voltage	V_{VCC} = 3V to 5.5V	2.0	—	—	V
V_{ENL}	EN Low Level Voltage	V_{VCC} = 3V to 5.5V	—	—	0.8	V
R_{BLEED}	Bleed Resistance	V_{VCC} = 3V, V_{EN} = 0V	86	108	130	Ω
		V_{VCC} = 5.5V, V_{EN} = 0V	64	80	100	Ω
I_{BLEED}	Bleed Pin Leakage Current	V_{VCC} = V_{EN} = 3V, V_{VIN} = 1.8V	—	20	45	µA
		V_{VCC} = V_{EN} = 3V, V_{VIN} = 12V	—	50	70	µA
V_{PGL}	PG Output Low Voltage	V_{VCC} = 3V; I_{SINK} = 5mA	—	—	0.2	V
I_{PG}	PG Output Leakage Current	V_{VCC} = 3V; V_{TERM} = 3.3V	—	—	100	nA
Switching Device						
R_{ON}	Switch On-State Resistance	V_{VCC} = 3.3V, V_{VIN} = 1.8V	—	6.1	9	mΩ
		V_{VCC} = 3.3V, V_{VIN} = 5V	—	5.9	8	mΩ
		V_{VCC} = 3.3V, V_{VIN} = 12V	—	5.8	8	mΩ
		V_{VCC} = 5V, V_{VIN} = 1.8V	—	4.8	7	mΩ
		V_{VCC} = 5V, V_{VIN} = 5V	—	4.8	7	mΩ
		V_{VCC} = 5V, V_{VIN} = 12V	—	4.8	7	mΩ
I_{LEAK}	Input Shutdown Supply Current	V_{EN} = 0V, V_{VIN} = 13.5V	—	—	1	µA
R_{PDEN}	EN Pull Down Resistance	—	76	100	124	kΩ
Fault Protection						
OTP	Thermal Shutdown Threshold	V_{VCC} = 3V to 5.5V	—	145	—	°C
OTP_{HYS}	Thermal Shutdown Hysteresis	V_{VCC} = 3V to 5.5V	—	20	—	°C
UVLO	V_{IN} Lockout Threshold	V_{VCC} = 3V	0.25	0.35	0.45	V
$UVLO_{HYS}$	V_{IN} Lockout Hysteresis	V_{VCC} = 3V	20	40	70	mV
SCP	Short−Circuit Protection Threshold	V_{VCC} = 3.3V; V_{VIN} = 0.5V	180	265	350	mV
		V_{VCC} = 3.3V; V_{VIN} = 13.5V	100	285	500	mV

Switching Characteristics (T_A = +25°C, V_{TERM} = V_{VCC} = 5V, R_{PG} = 100kΩ, R_{VOUT} = 10Ω, C_{VIN} = 1µF, C_{VOUT} = 0.1µF, C_{VCC} = 1µF, C_{SR} = 1nF, unless otherwise specified.)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
V_{VIN} = 1.8V						
t_{ON}	Output Turn-On Delay Time	V_{VCC} = 3.3V	—	375	—	µs
		V_{VCC} = 5V	—	370	—	
t_{OFF}	Output Turn-Off Delay Time	V_{VCC} = 3.3V	—	0.5	—	
		V_{VCC} = 5V	—	0.5	—	
t_{PGON}	Power Good Turn-on Time	V_{VCC} = 3.3V	—	1.4	—	ms
		V_{VCC} = 5V	—	1.3	—	
t_{PGOFF}	Power Good Turn-off Time	V_{VCC} = 3.3V	—	10	—	ns
		V_{VCC} = 5V	—	6	—	
SR	Output Slew Rate	V_{VCC} = 3.3V	—	9	—	kV/s
		V_{VCC} = 5V	—	9	—	
V_{VIN} = 12V						
t_{ON}	Output Turn-On Delay Time	V_{VCC} = 3.3V	—	340	—	µs
		V_{VCC} = 5V	—	330	—	
t_{OFF}	Output Turn-Off Delay Time	V_{VCC} = 3.3V	—	0.5	—	
		V_{VCC} = 5V	—	0.4	—	
t_{PGON}	Power Good Turn-on Time	V_{VCC} = 3.3V	—	1.6	—	ms
		V_{VCC} = 5V	—	1.5	—	
t_{PGOFF}	Power Good Turn-off Time	V_{VCC} = 3.3V	—	10	—	ns
		V_{VCC} = 5V	—	8	—	
SR	Output Slew Rate	V_{VCC} = 3.3V	—	30	—	kV/s
		V_{VCC} = 5V	—	31	—	

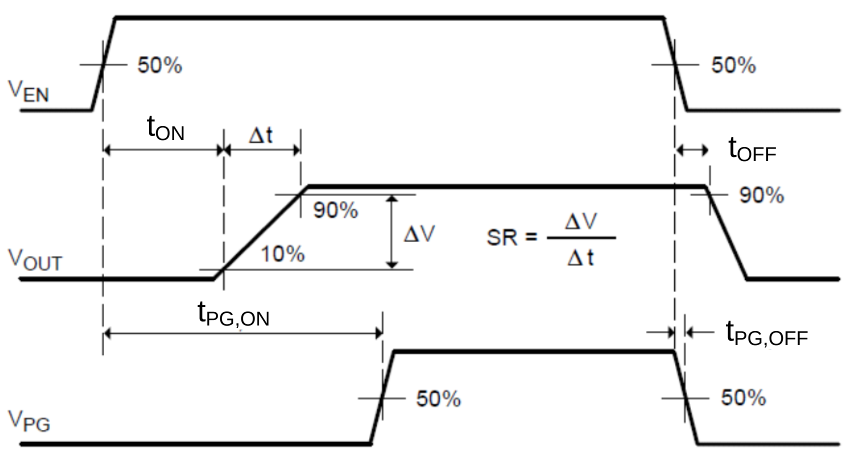
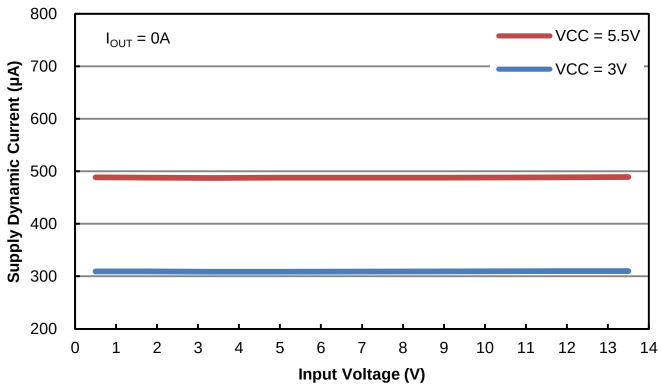


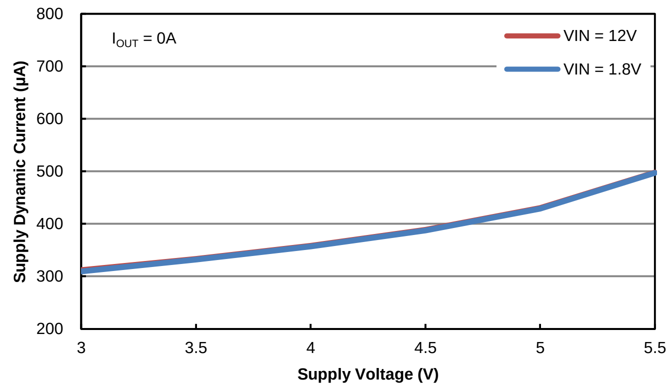
Figure 1 Timing Diagram

Performance Characteristics (@T_A = +25°C, unless otherwise specified.)

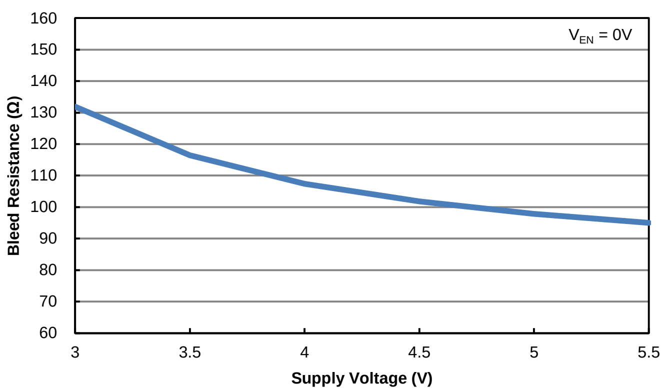
Supply Dynamic Current vs. Input Voltage



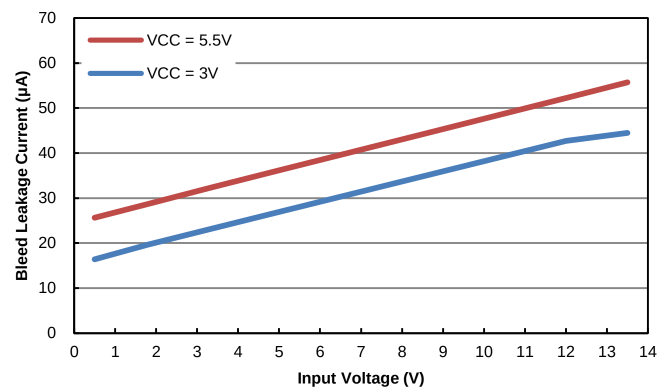
Supply Dynamic Current vs. Supply Voltage



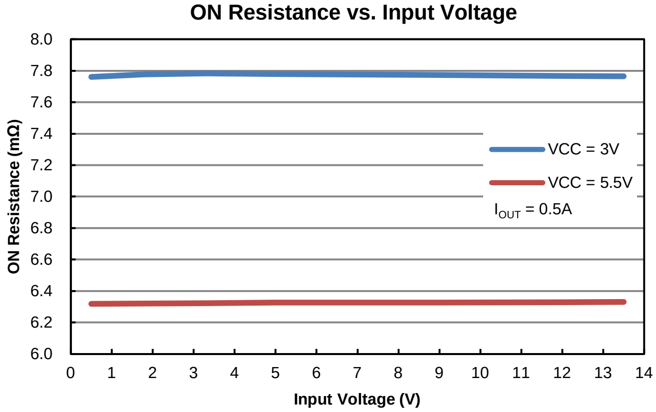
Bleed Resistance vs. Supply Voltage



Bleed Leakage Current vs. Input Voltage



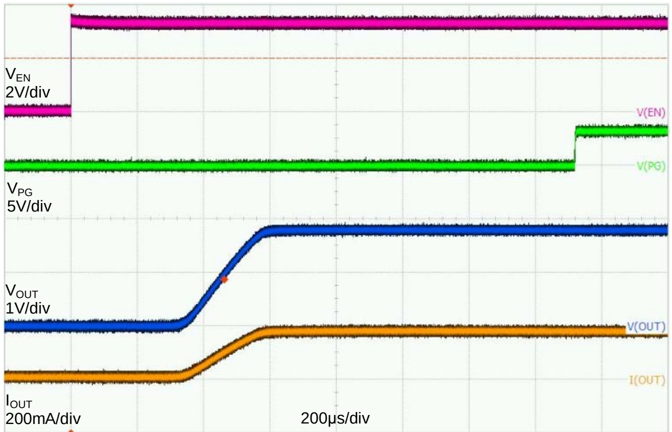
ON Resistance vs. Input Voltage



Performance Characteristics (@T_A = +25°C, unless otherwise specified. cont.)

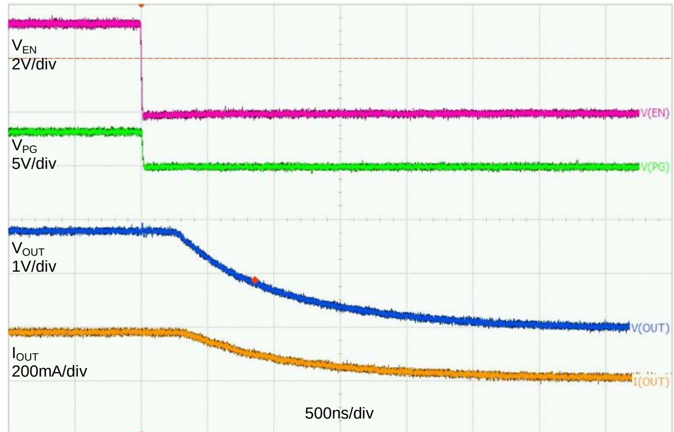
Turn ON Response

V_{VIN} = 1.8V, V_{VCC} = 3.3V, V_{EN} = 0V to 3.3V, R_L = 10Ω



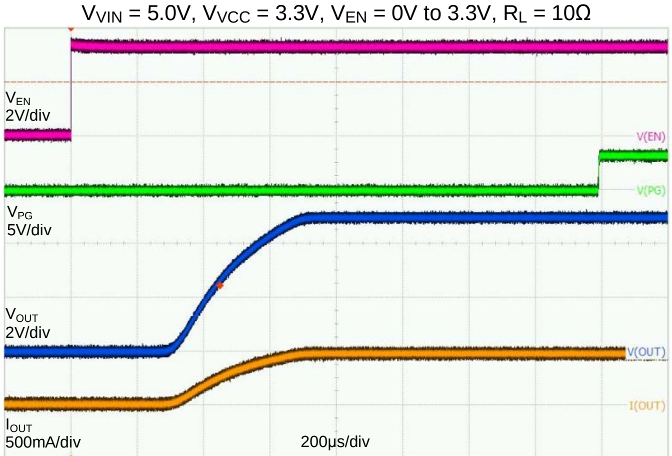
Turn OFF Response

V_{VIN} = 1.8V, V_{VCC} = 3.3V, V_{EN} = 3.3V to 0V, R_L = 10Ω



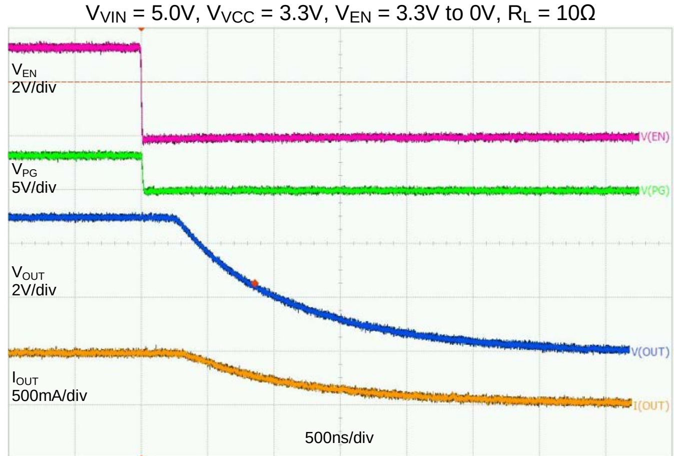
Turn ON Response

V_{VIN} = 5.0V, V_{VCC} = 3.3V, V_{EN} = 0V to 3.3V, R_L = 10Ω



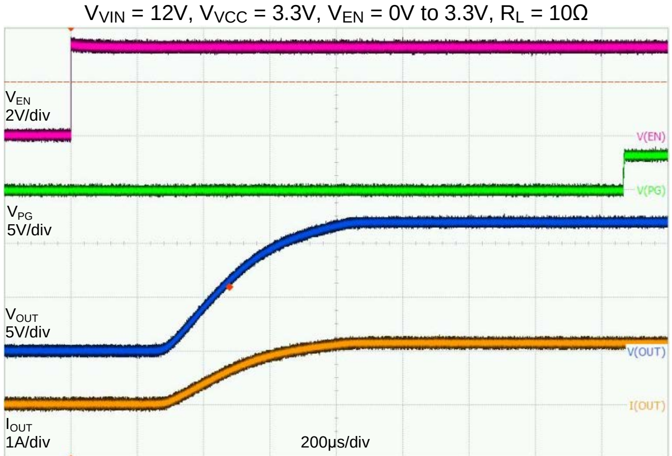
Turn OFF Response

V_{VIN} = 5.0V, V_{VCC} = 3.3V, V_{EN} = 3.3V to 0V, R_L = 10Ω



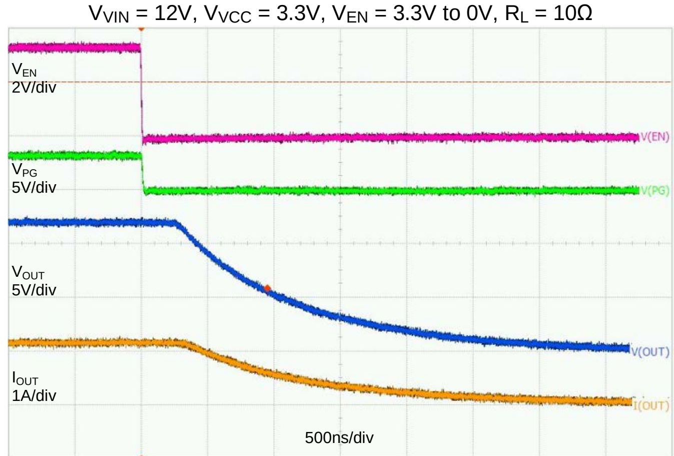
Turn ON Response

V_{VIN} = 12V, V_{VCC} = 3.3V, V_{EN} = 0V to 3.3V, R_L = 10Ω



Turn OFF Response

V_{VIN} = 12V, V_{VCC} = 3.3V, V_{EN} = 3.3V to 0V, R_L = 10Ω

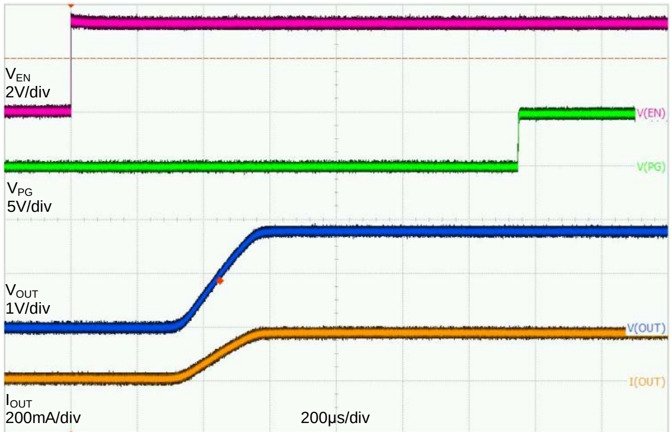


NEW PRODUCT

Performance Characteristics (@T_A = +25°C, unless otherwise specified. cont.)

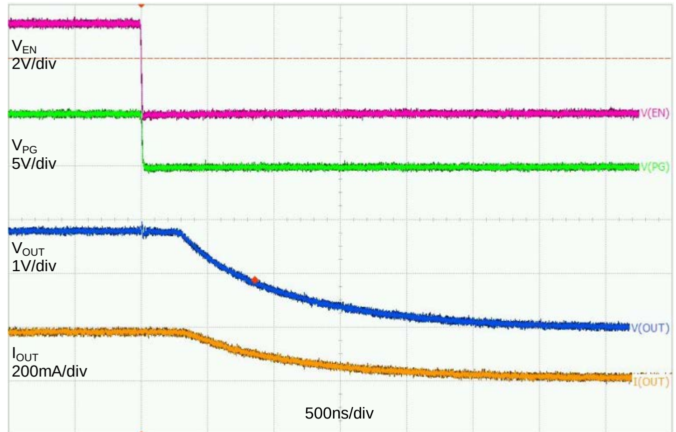
Turn ON Response

V_{VIN} = 1.8V, V_{VCC} = 5.0V, V_{EN} = 0V to 3.3V, R_L = 10Ω



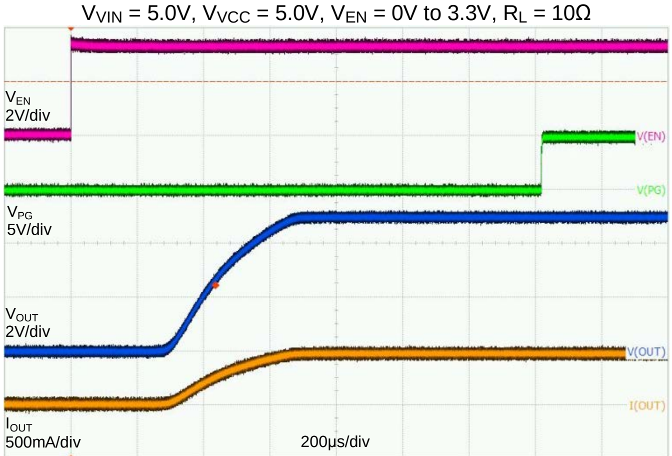
Turn OFF Response

V_{VIN} = 1.8V, V_{VCC} = 5.0V, V_{EN} = 3.3V to 0V, R_L = 10Ω



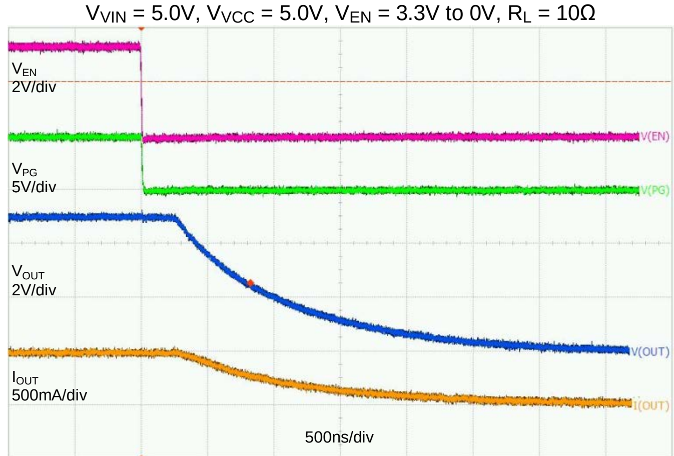
Turn ON Response

V_{VIN} = 5.0V, V_{VCC} = 5.0V, V_{EN} = 0V to 3.3V, R_L = 10Ω



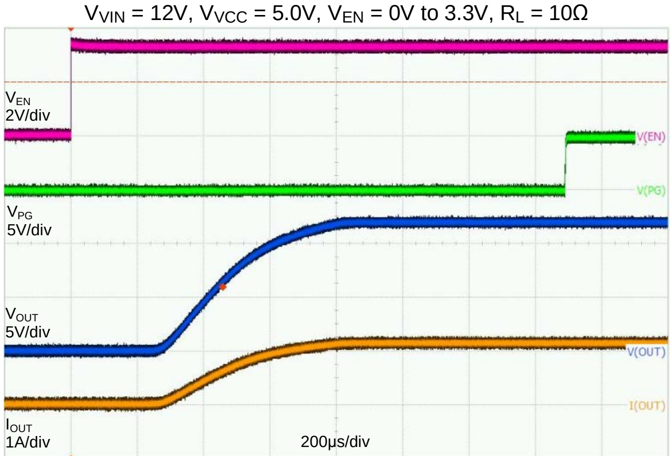
Turn OFF Response

V_{VIN} = 5.0V, V_{VCC} = 5.0V, V_{EN} = 3.3V to 0V, R_L = 10Ω



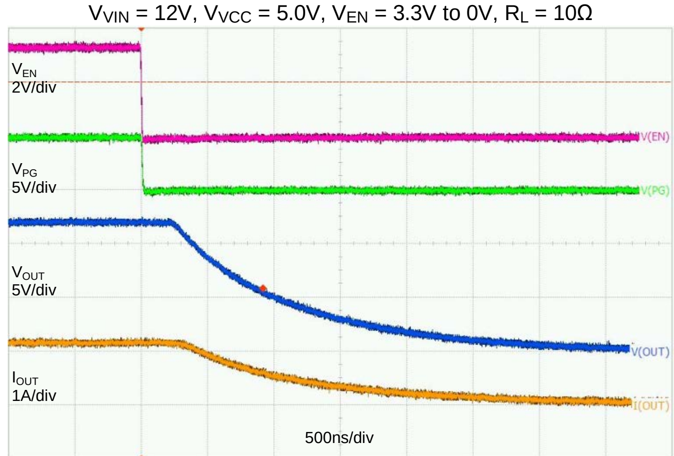
Turn ON Response

V_{VIN} = 12V, V_{VCC} = 5.0V, V_{EN} = 0V to 3.3V, R_L = 10Ω



Turn OFF Response

V_{VIN} = 12V, V_{VCC} = 5.0V, V_{EN} = 3.3V to 0V, R_L = 10Ω



NEW PRODUCT

Application Information

General Description

The DML3009LDC is a single-channel load switch with a controlled adjustable turn-on and integrated PG indicator in a 12-pin DFN30x30 package. The device contains an N-channel MOSFET that can operate over an input voltage range of 0.5V to 12V and can support a maximum continuous current of 10A. The wide-input voltage range and high-current capability enable the device to be used across multiple designs and end equipment. 6mΩ on-resistance minimizes the voltage drop across the load switch and power loss from the load switch.

The controlled rise time for the device greatly reduces inrush current by large bulk load capacitances thereby reducing or eliminating power supply droop. The adjustable slew rate through SR provides the design flexibility to trade off the inrush current and power up timing requirements. Integrated PG indicator notifies the system about the status of the load switch to facilitate seamless power sequencing. During shutdown, the device has very low leakage current thereby reducing unnecessary leakages for downstream modules during standby. The DML3009LDC also has an embedded 100Ω on-chip resistor on BLEED pin for quick discharge of the output when switch is disabled.

Enable Control

The DML3009LDC device 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 logic high level, the MOSFET is enabled. Similarly, when the EN pin is at logic low level, the MOSFET is disabled. An internal pull-down resistor to ground on the EN pin ensures that the MOSFET disables when not being driven.

Power Sequencing

The DML3009LDC device functions with any power sequence, but the output turn-on delay performance can vary from what is specified. To archive the specified performance, there are two recommended power sequences:

1.) $V_{VCC} \rightarrow V_{VIN} \rightarrow V_{EN}$
2.) $V_{VIN} \rightarrow V_{VCC} \rightarrow V_{EN}$

Load Bleed (Quick Discharge)

The DML3009LDC device has an internal bleed discharge device, which is used to bleed the charge off of the load to ground after the MOSFET is disabled. The bleed discharge device is enabled whenever the MOSFET is disabled. The MOSFET and the bleed device are never concurrently active.

The BLEED pin must be connected to V_{OUT} either directly or through an external resistor, R_{EXT}. R_{EXT} must not exceed 1KΩ 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 safe level. The maximum continuous power that dissipates across R_{BLEED} is 0.4W. R_{EXT} can be used to decrease the amount of power dissipated across R_{BLEED}.

Adjustable Rise Time (Slew Rate Control)

The DML3009LDC device has controlled rise time for inrush current control. A capacitor to ground on the SR pin adjusts the rise time. Without a capacitor on SR, the rise time is at its minimum for fastest timing. Equation 1 approximately shows the relationship between C_{SR}, V_{IN}, and rise time, t_R.

$$t_R = K2 C_{SR}\sqrt{V_{IN}} + K3\sqrt{2 + V_{IN}} + K4\sqrt{C_{SR}} - K5$$

Where t_R is the rise time (µs)

- V_{IN} is the input voltage (V)
- K2, K3, K4, and K5 is constant where K2 = 0.067, K3 = 137, K4 = 6.7, K5 = 67
- C_{SR} is the capacitance value on the SR pin (pF)

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Application Information (continued)

Table 1 contains rise time values measured on a typical device. Rise times shown below are only valid for the power-up sequence 1.

Table1. Rise Times vs SR Capacitor

C_{SR}	Rise Time V_{CC} = 5V, C_L = 0.1µF, R_L = 10Ω, 25°C; Measure V_{OUT} rising time from 10% to 90% V_{VIN}			
	V_{VIN} = 13.5V	V_{VIN} = 12V	V_{VIN} = 5V	V_{VIN} = 1.8V
0 (floating)	371µs	346µs	233µs	142µs
0.22nF	448µs	430µs	318µs	232µs
0.47nF	646µs	615µs	452µs	262µs
1nF	902µs	880µs	750µs	393µs
2.2nF	1408µs	1370µs	1028µs	585µs
4.7nF	2040µs	1935µs	1466µs	958µs

Note: An SR Capacitor less than 4.7nF for system success startup is recommended.

Power Good

The DML3009LDC device has a power good output (PG) that can be used to indicate when the gate of the MOSFET is driven high and the switch is on with the on-resistance close to its final value (full load ready). 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 those devices connected to this pin. Equation 2 approximately shows the relationship between C_{SR}, V_{IN}, and PG turn-on time, t_{PG_ON}.

$$t_{PG\_ON} = t_R + K1$$

Where

- t_{PG_ON} is the PG turn-on time (µs)
- K1 is constant, which is K1 = 800

Table 2 contains PG turn-on time values measured on a typical device. PG turn-on times shown below are valid for the power-up sequence 1.

Table 2. PG Turn-On Times vs SR Capacitor

C_{SR}	PG turn-on time V_{CC} = 5V, C_L = 0.1µF, R_L = 10Ω, R_{PG} = 10KΩ, 25°C			
	V_{VIN} = 13.5V	V_{VIN} = 12V	V_{VIN} = 5V	V_{VIN} = 1.8V
0 (floating)	1171µs	1098µs	863µs	935µs
0.22nF	1338µs	1260µs	1148µs	982µs
0.47nF	1464µs	1455µs	1292µs	1102µs
1nF	1702µs	1630µs	1530µs	1293µs
2.2nF	2248µs	2210µs	1868µs	1425µs
4.7nF	2840µs	2685µs	2467us	1758µs

The power good output can be used as the enable signal for other active-high devices in the system. This allows for guaranteed by design power sequencing and reduces the number of enable signals required from the system controller. If the power good feature is not used in the application, the PG pin must be tied to GND.

Short-Circuit Protection

The DML3009LDC device 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 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 BLEED pin be connected to V_{OUT} either directly or through a resistor, R_{EXT}, which should not exceed 1KΩ. With the BLEED pin connected to VOUT, 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 VCC supply voltage is cycled at which point the MOSFET turns on delay and slew rate. The current through the MOSFET that causes a short-circuit event can be calculated by dividing the short-circuit protection threshold by expected on-resistance of the MOSFET

Application Information (continued)

Thermal Shutdown

The DML3009LDC device has equipped thermal shutdown protection for internally or externally generated excessive temperatures. This circuitry is disabled when EN is not active to reduce standby current. When an overtemperature condition is detected, the MOSFET immediately turns off, and the load bleed is active.

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 turns on in a controlled fashion with the normal output turn-on delay and slew rate.

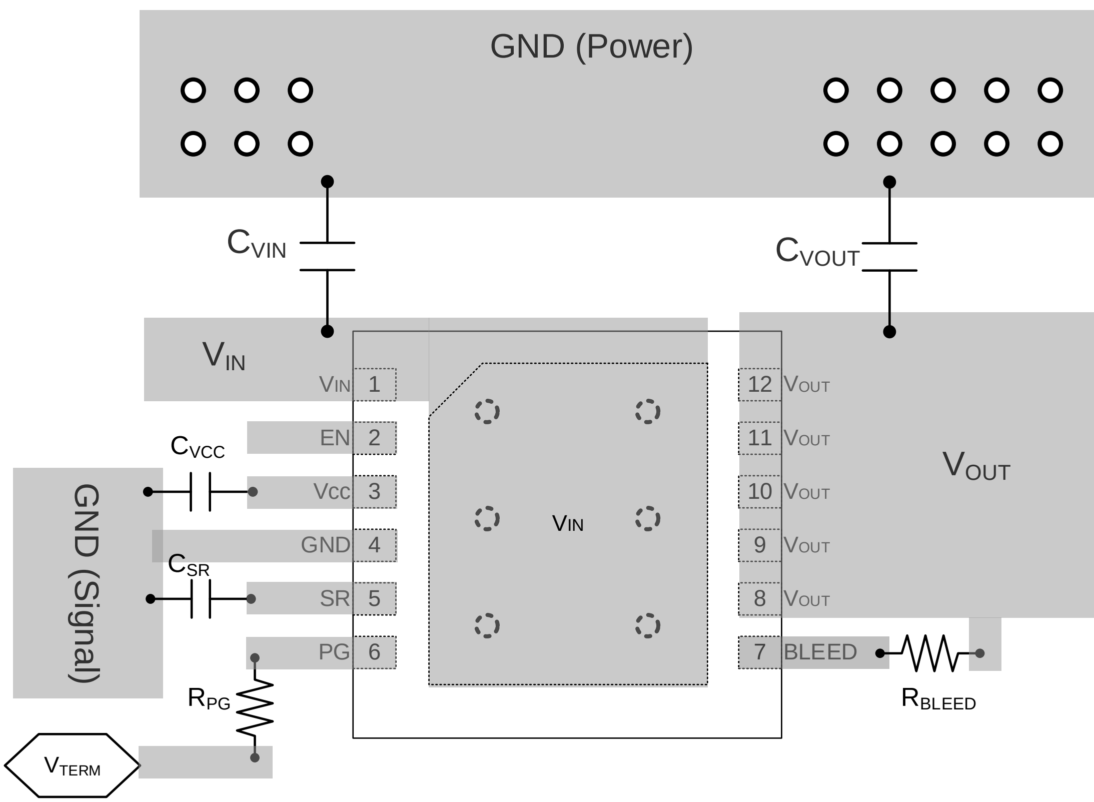
Undervoltage Lockout

The DML3009LDC device has equipped undervoltage lockout protection. DML3009LDC turns the MOSFET off and activates the load bleed when the input voltage. V_{IN}, is less than or equal to the undervoltage lockout threshold. This circuitry is disabled when EN is not active to reduce standby current.

If the VIN voltage rise above the undervoltage lockout threshold and EN remains active, the MOSFET turns on in a controlled fashion with the normal output turn-on delay and slew rate.

PCB Layout Consideration

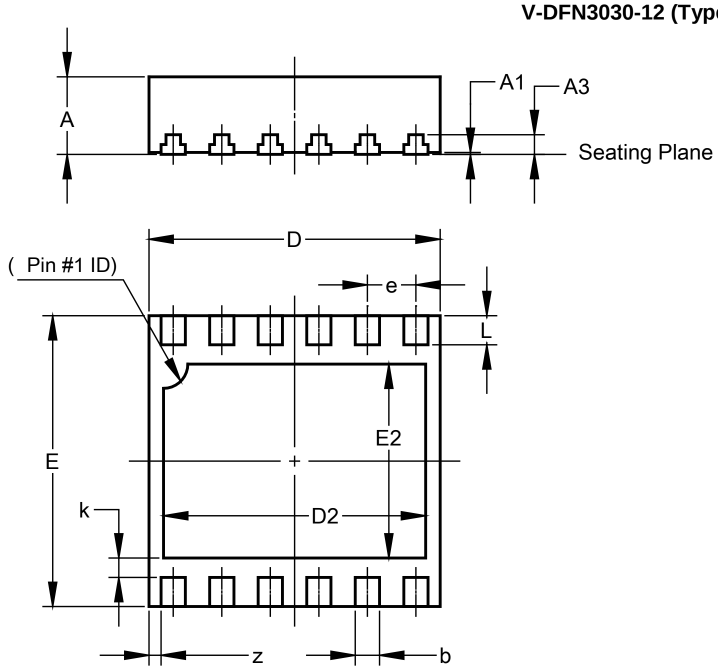
1. Place the input/output capacitors C_{VIN} and C_{VOUT} as close as possible to the V_{IN} and V_{OUT} pins.
2. The power traces, which are V_{IN} trace, V_{OUT} trace, and GND trace, should be short, wide, and direct for minimize parasitic inductance.
3. Place feedback resistance R_{BLEED} as close as possible to BLEED pin.
4. The SR trace must be as short as possible to reduce parasitic capacitance.
5. Place C_{VCC} capacitor near the device pin.
6. Connect the signal ground to the GND pin, and keep a single connection from GND pin to the power ground behind the input or output capacitors.
7. For better power dissipation, via holes are recommended to connect the exposed pad's landing area to a large copper polygon on the other side of the PCB. The copper polygons and exposed pad shall connect to V_{IN} pin on the printed circuit board.



Package Outline Dimensions

Please see http://www.diodes.com/package-outlines.html for the latest version.

V-DFN3030-12 (Type B)

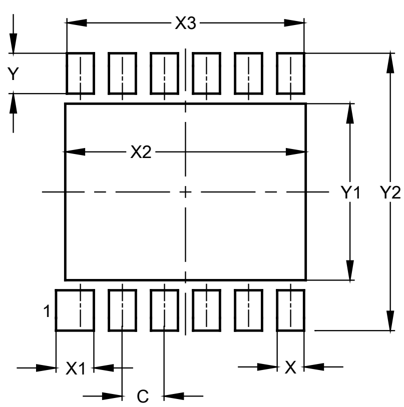


V-DFN3030-12 Type B			
Dim	**Min**	**Max**	**Typ**
A	0.77	0.85	0.80
A1	0.00	0.05	0.02
A3	--	--	0.203
b	0.20	0.30	0.25
D	2.95	3.05	3.00
D2	2.60	2.80	2.70
E	2.95	3.05	3.00
E2	1.90	2.10	2.00
e	0.50BSC		
k	--	--	0.20
L	0.25	0.35	0.30
z	--	--	0.125
All Dimensions in mm			

Suggested Pad Layout

Please see http://www.diodes.com/package-outlines.html for the latest version.

V-DFN3030-12 (Type B)



Dimensions	Value (in mm)
C	0.50
X	0.32
X1	0.45
X2	2.86
X3	2.82
Y	0.48
Y1	2.10
Y2	3.30

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