

# N **\$**4045

The NCV84045 is a fully protected single channel high side driver that can be used to switch a wide variety of loads, such as bulbs, solenoids, and other actuators. The device incorporates advanced protection features such as active inrush current management, over-temperature shutdown with automatic restart and an overvoltage active clamp. A dedicated Current Sense pin provides precision analog current monitoring of the output as well as fault indication of short to V<sub>D</sub>, short circuit to ground and OFF state open load detection. An active high Current Sense Enable pin allows all diagnostic and current sense features to be enabled.

#### Features

- Short Circuit Protection with Inrush Current Management
- CMOS (3 V / 5 V) Compatible Control Input
- Very Low Standby Current
- Very Low Current Sense Leakage
- Proportional Load Current Sense
- Current Sense Enable
- Off State Open Load Detection
- Output Short to V<sub>D</sub> Detection
- Overload and Short to Ground Indication
- Thermal Shutdown with Automatic Restart
- Undervoltage Shutdown
- Integrated Clamp for Inductive Switching
- Loss of Ground and Loss of V<sub>D</sub> Protection
- ESD Protection
- Reverse Battery Protection with External Components
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC–Q100 Grade 1 Qualified and PPAP Capable
- This is a Pb-Free Device

#### **Typical Applications**

- Switch a Variety of Resistive, Inductive and Capacitive Loads
- Can Replace Electromechanical Relays and Discrete Circuits
- Automotive / Industrial

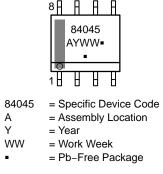
#### FEATURE SUMMARY

$R_{DSon}$ (typical) $T_J = 25^{\circ}C$	R <sub>ON</sub>	50	mΩ
Output Current Limit (typical)	I <sub>lim</sub>	32	А
OFF-state Supply Current (max)	I <sub>D(off)</sub>	0.5	μΑ

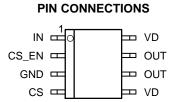


SOIC 8 CASE 751 07 STYLE 11

#### MARKING DIAGRAM



(Note: Microdot may be in either location)



(Top View)

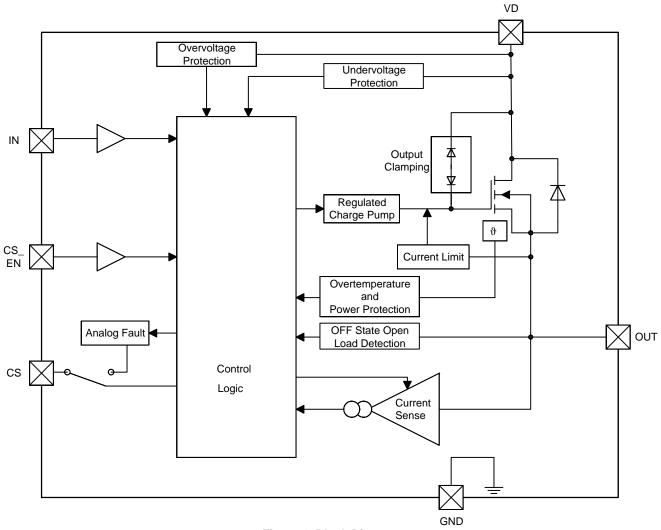
#### **ORDERING INFORMATION**

Device	Package	Shipping <sup>†</sup>
NCV84045DR2G	SOIC-8 (Pb-Free)	2500 / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

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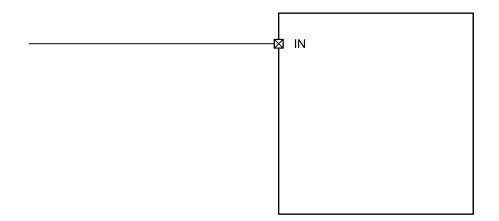
### **BLOCK DIAGRAM & PIN CONFIGURATION**





#### Table 1. SO8 PACKAGE PIN DESCRIPTION

Pin #	Symbol	Description		
1	IN	Logic Level Input		
2	CS_EN	Current Sense Enable		
3	GND	Ground		
4	CS	Analog Current Sense Output		
5	VD	Supply Voltage		
6	OUT	Output		
7	OUT	Output		
8	VD	Supply Voltage		



# **ELECTRICAL CHARACTERISTICS** (7 V $\leq$ V<sub>D</sub> $\leq$ 28 V; -40°C < T<sub>J</sub> < 150°C unless otherwise specified)

#### Table 5. POWER

				Value		
Rating	Symbol	Conditions	Min Typ		Max	Unit
Operating Supply Voltage	VD		4	-	28	V
Undervoltage Shutdown	V <sub>UV</sub>		-	3.5	4	V
Undervoltage Shutdown Hysteresis	V <sub>UV_hyst</sub>		-	0.4	-	V
On Resistance	R <sub>ON</sub>	$I_{OUT} = 3.5 \text{ A}, \text{ T}_{J} = 25^{\circ}\text{C}$	-	50	-	mΩ
		I <sub>OUT</sub> = 3.5 A, T <sub>J</sub> = 150°C	-	-	110	
		$I_{OUT} = 3.5 \text{ A}, V_D = 4.5 \text{ V}, T_J = 25^{\circ}\text{C}$	-	-	105	
Supply Current (Note 7)	Ι <sub>D</sub>	OFF-state: $V_D = 13 V$ , $V_{IN} = V_{OUT} = 0 V$ , $T_J = 25^{\circ}C$	-	0.2	0.5	μΑ
		OFF-state: $V_D = 13 V$ , $V_{IN} = V_{OUT} = 0 V$ , $T_J = 85^{\circ}C$ (Note 8)	-	0.2	0.5	μΑ
		OFF-state: $V_D = 13 V$ , $V_{IN} = V_{OUT} = 0 V$ , $T_J = 125^{\circ}C$	-	-	3	μΑ
		ON-state: $V_D = 13 V$ , $V_{IN} = 5 V$ , $I_{OUT} = 0 A$	-	1.9	3.5	mA
On State Ground Current	I <sub>GND(ON)</sub>	$V_D$ = 13 V, $V_{CS\_EN}$ = 5 V $V_{IN}$ = 5 V, $I_{OUT}$ = 1 A	-	-	6	mA
Output Leakage Current	١L	$V_{IN} = V_{OUT} = 0 V, V_D = 13 V, T_J = 25^{\circ}C$	-	-	0.5	μΑ
		V <sub>IN</sub> = V <sub>OUT</sub> = 0 V, V <sub>D</sub> = 13 V, T <sub>J</sub> = 125°C	-	-	3	1

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.
7. Includes PowerMOS leakage current.
8. Not subjected to production testing.

# Table 6. LOGIC INPUTS (V\_D = 13.5 V; -40°C < T\_J < 150°C)

				Value		
Rating	Symbol	Conditions	Min	Min Typ		Unit
Input Voltage – Low	V <sub>in_low</sub>		_	-	0.9	V
Input Current – Low	I <sub>in_low</sub>	V <sub>IN</sub> = 0.9 V	1	-	-	μΑ
Input Voltage – High	V <sub>in_high</sub>		2.1	-	-	V
Input Current – High	I <sub>in_high</sub>	V <sub>IN</sub> = 2.1 V	_	-	10	μΑ
Input Hysteresis Voltage	V <sub>in_hyst</sub>		_	0.2	-	V
Input Clamp Voltage	V <sub>in_cl</sub>	I <sub>IN</sub> = 1 mA	12	13	14	V
		I <sub>IN</sub> = -1 mA	-14	-13	-12	
CS_EN Voltage – Low	V <sub>CSE-low</sub>		-	-	0.9	V
CS_EN Current – Low	I <sub>CSE_low</sub>	$V_{CS\_EN} = 0.9 V$	1	-	-	μΑ
CS_EN Voltage – High	V <sub>CSE_high</sub>		2.1	-	-	V
CS_EN Current – High	I <sub>CSE_high</sub>	V <sub>CS_EN</sub> = 2.1 V	-	-	10	μΑ
CS_EN Hysteresis Voltage	V <sub>CSE_hyst</sub>		-	0.2	-	V
CS_EN Clamp Voltage	V <sub>CSE-cl</sub>	I <sub>CS_EN</sub> = 1 mA	12	13	14	V
		I <sub>CS_EN</sub>			•	

# Table 7. SWITCHING CHARACTERISTICS (V\_D = 13 V, -40°C < T\_J < 150°C)

			Value			
Rating	Symbol	Conditions	Min	Тур	Max	Unit
Turn-On Delay Time	t <sub>d_on</sub>	$V_{IN}$ high to 20% $V_{OUT}\!,R_L$ = 6.5 $\Omega\!,T_J$ = 25°C	5	60	120	μs
Turn-Off Delay Time	t <sub>d_off</sub>	$V_{IN}$ low to 80% $V_{OUT},R_L$ = 6.5 $\Omega,T_J$ = 25°C	5	40	100	μs
Slew Rate On	dV <sub>out</sub> /dt <sub>on</sub>	20% to 80% V <sub>OUT</sub> , R <sub>L</sub> = 6.5 $\Omega$ , T <sub>J</sub> = 25°C	0.1	0.27	0.7	V / μs
Slew Rate Off	dV <sub>out</sub> /dt <sub>off</sub>	80% to 20% V <sub>OUT</sub> , R <sub>L</sub> = 6.5 $\Omega$ , T <sub>J</sub> = 25°C	0.1	0.35	0.7	V / μs
Turn–On Switching Loss (Note 9)	E <sub>on</sub>	R <sub>L</sub> = 6.5 Ω	-	0.15	0.33	mJ
Turn–Off Switching Loss (Note 9)	E <sub>off</sub>	R <sub>L</sub> = 6.5 Ω	-	0.1	0.33	mJ
Differential Pulse Skew, $(t_{(OFF)} - t_{(ON)})$ see Figure 4 (Switching Characteristics)	t <sub>skew</sub>	R <sub>L</sub> = 6.5 Ω	-50	-	50	μs

9. Not subjected to production testing.

### Table 8. OUTPUT DIODE CHARACTERISTICS

			Value			
Rating	Symbol	Conditions	Min	Тур	Max	Unit
Forward Voltage	V <sub>F</sub>	$I_{OUT}$ = -2 A, $T_J$ = 150°C, $V_F$ = $V_{OUT}$ - $V_D$	-	Ι	0.7	V

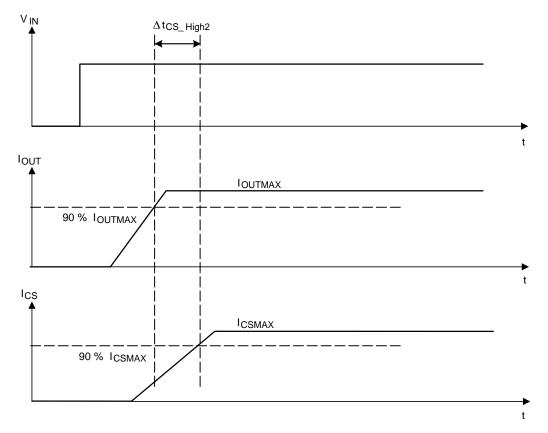
# Table 9. PROTECTION FUNCTIONS (Note 10) (7 V $\leq$ V<sub>D</sub> $\leq$ 18 V, -40°C < T<sub>J</sub> < 150°C)

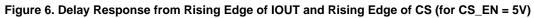
			Value			
Rating	Symbol	Conditions	Min	Тур	Max	Unit
Temperature Shutdown (Note 11)	T <sub>SD</sub>		150	175	200	°C
Temperature Shutdown Hysteresis (T <sub>SD</sub> – T <sub>R</sub> ) (Note 11)	T <sub>SD_hyst</sub>		-	7	-	°C
Reset Temperature (Note 11)	Τ <sub>R</sub>		T <sub>RS</sub> +1	T <sub>RS</sub> +7	-	°C
Thermal Reset of Status (Note 11)	T <sub>RS</sub>		135	-	-	°C
Delta T Temperature Limit (Note 11)	T <sub>DELTA</sub>	$T_J = -40^\circ C$ , $V_D = 13 V$	-	60	-	°C
DC Output Current Limit	I <sub>limH</sub>	V <sub>D</sub> = 13 V	22	32	46	А
		4 V < V <sub>D</sub> < 18 V	-	-	46	А
Short Circuit Current Limit during Thermal Cycling (Note 11)	I <sub>limTCycling</sub>	$V_D = 13 V$ $T_R < T_J < T_{TSD}$	-	11	-	A
Switch Off Output Clamp Voltage	V <sub>out_clamp</sub>	$I_{OUT} = 0.5 \text{ A}, V_{IN} = 0 \text{ V}, L = 20 \text{ mH}$	V <sub>D</sub> – 41	V <sub>D</sub> – 46	V <sub>D</sub> – 52	V
Overvoltage Protection	V <sub>OV</sub>	$V_{IN} = 0 V, I_D = 20 mA$	41	46	52	V
Output Voltage Drop Limitation	V <sub>DS_ON</sub>	I <sub>OUT</sub> = 0.2 A	-	20	-	mV

10. To ensure long term reliability during overload or short circuit conditions, protection and related diagnostic signals must be used together

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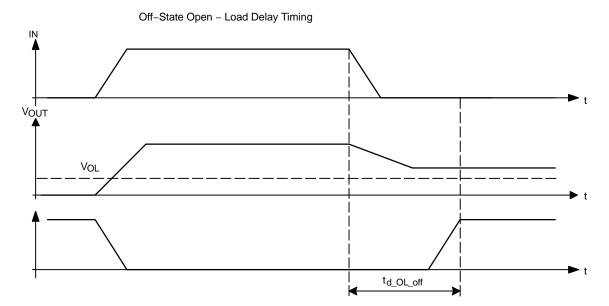
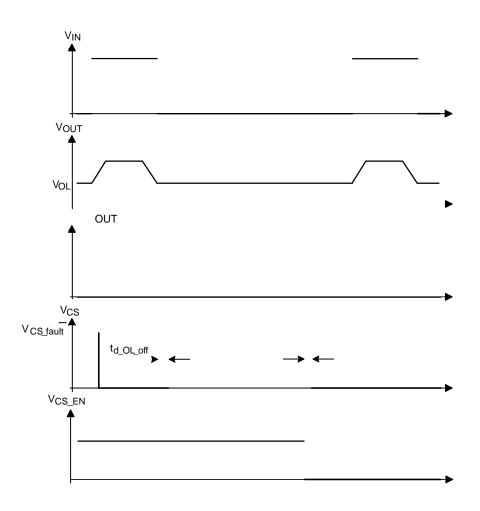
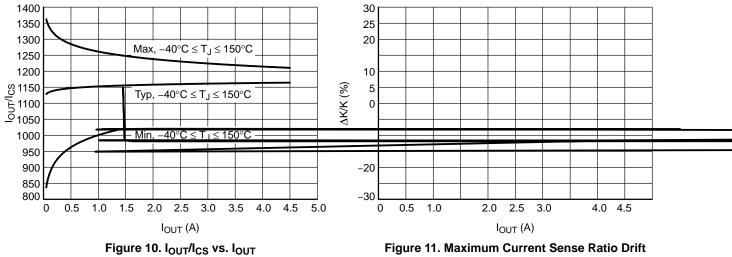


Figure 7. OFF State Open Load Flag Delay Timing





vs. Load Current

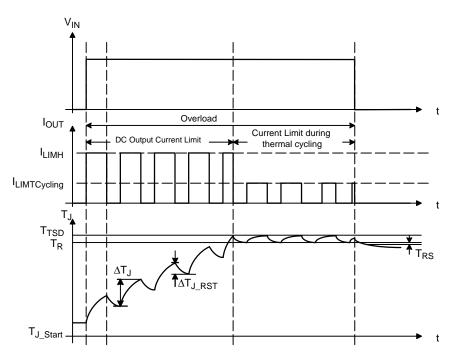
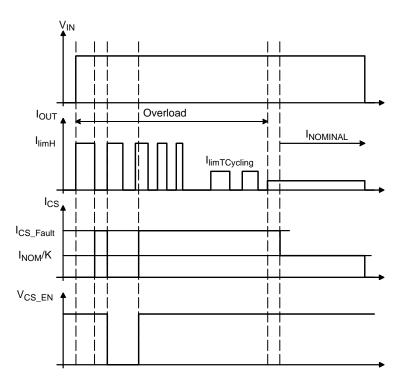
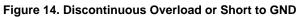
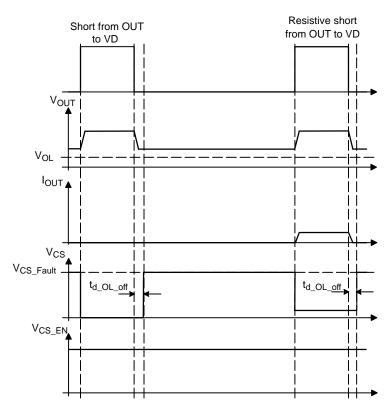


Figure 13. How  $T_{\rm J}$  progresses During Short to GND or Overload

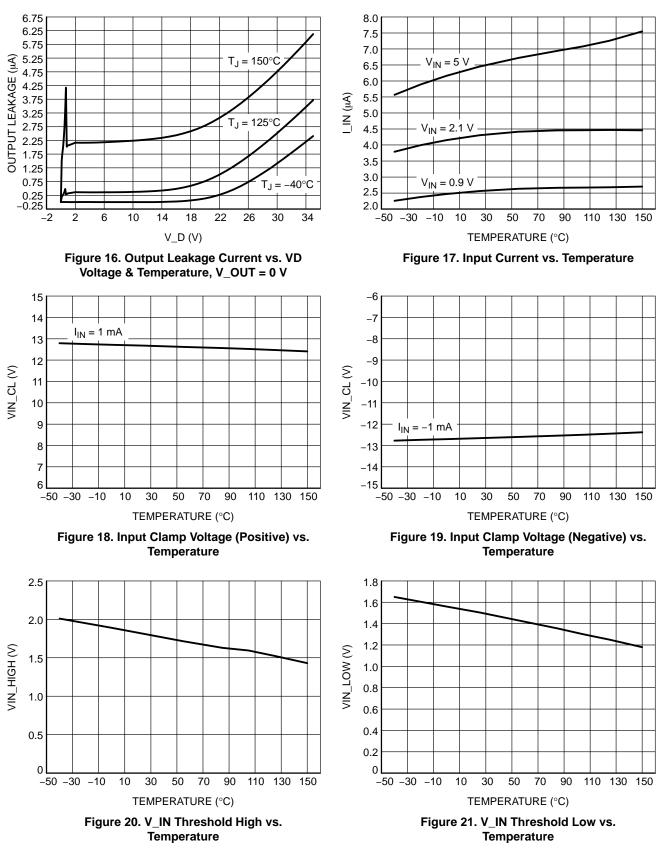




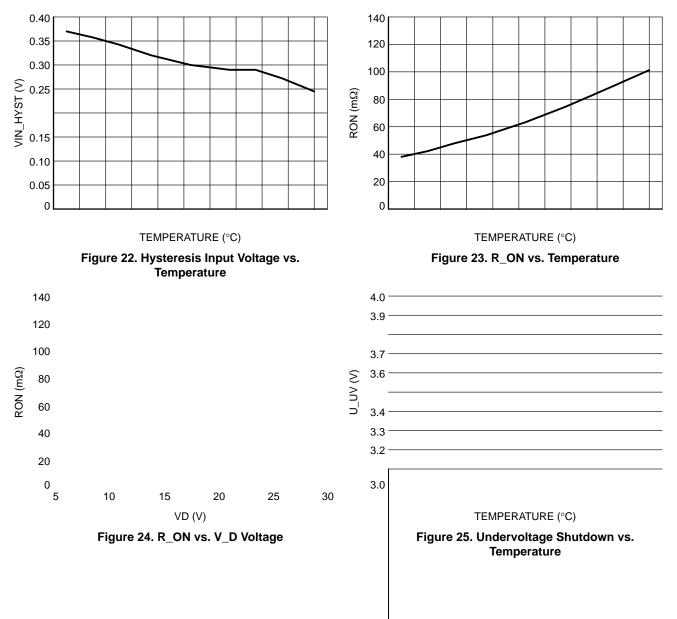




### **TYPICAL CHARACTERISTICS**



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Figure 28. Current Limit vs. Temperature

Figure 29. CS\_EN Threshold High vs. Temperature

ISO 7637 2:2011(E)	Test Se	everity Levels, 12 V System		Delays and	# of Pulses	Pulse / Burst
Test Pulse	1711	ш	IV	Impedance	or Test Time	Rep. Time
1	-75	-112	-150	2 ms, 10 Ω	500 pulses	0.5 s
2a	+37	+55	+112			

### Table 13. ISO 7637 2: 2011(E) PULSE TEST RESULTS

### **APPLICATION INFORMATION**

Figure 33. Application Schematic

### LOSS OF GROUND PROTECTION

When device or ECU ground connection is lost and load is still connected to ground, the device will turn the output OFF. In loss of ground state, the output stage is held OFF independent of the state of the input. Input resistors are recommended between the device and microcontroller.

### UNDERVOLTAGE PROTECTION

The device has two under–voltage threshold levels,  $V_{D\_MIN}$  and  $V_{UV}$ . Switching function (ON/OFF) requires supply voltage to be at least  $V_{D\_MIN}$ . The device features a lower supply threshold  $V_{UV}$ , above which the output can

remain in ON state. While all protection functions are guaranteed when the switch is ON, diagnostic functions are operational only within nominal supply voltage range  $V_{D.}$ 

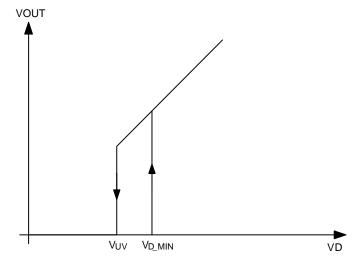


Figure 35. Undervoltage Behavior

**Overvoltage Protection** 

#### **Output Clamping with Inductive Load Switch Off**

The output voltage Vout drops below GND potential when switching off inductive loads. This is because the inductance develops a negative voltage across the load in response to a decaying current. The integrated clamp of the device clamps the negative output voltage to a certain level relative to the supply voltage V<sub>BAT</sub>. During output clamping with inductive load switch off, the energy stored in the inductance is rapidly dissipated in the device resulting in high power dissipation. This is a stressful condition for the device and the maximum energy allowed for a given load inductance should not be exceeded in any application.

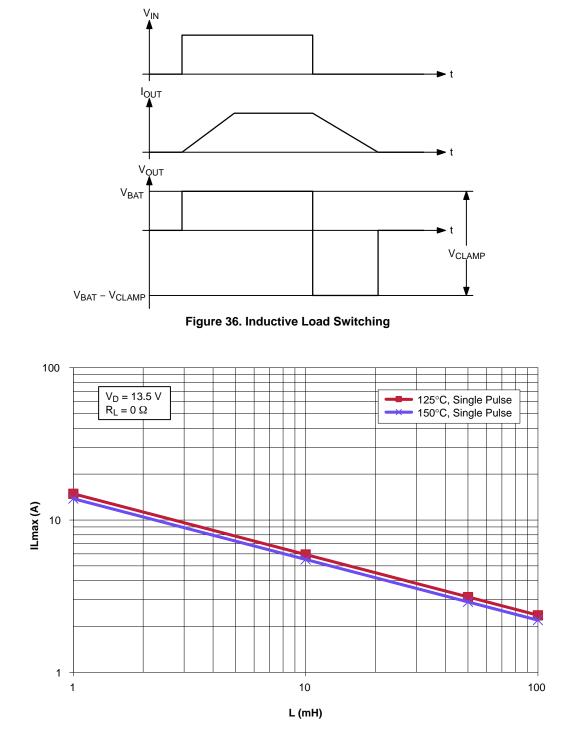


Figure 37. Maximum Switch Off Current vs. Load Inductance, V<sub>D</sub> = 13.5 V, R<sub>L</sub> = 0  $\Omega$ 

### **OPEN LOAD DETECTION IN OFF STATE**

Open load diagnosis in OFF state can be performed by activating an external resistive pull-up path ( $R_{PU}$ ) to  $V_{BAT}$ . To calculate the pull-up resistance, external leakage

currents (designed pull-down resistance, humidity-induced leakage etc) as well as the open load threshold voltage  $V_{OL}$  have to be taken into account.

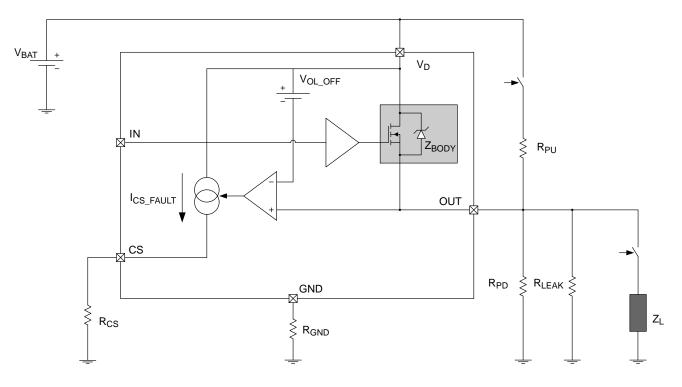


Figure 38. Open Load Detection in Off State

### **CURRENT SENSE IN PWM MODE**

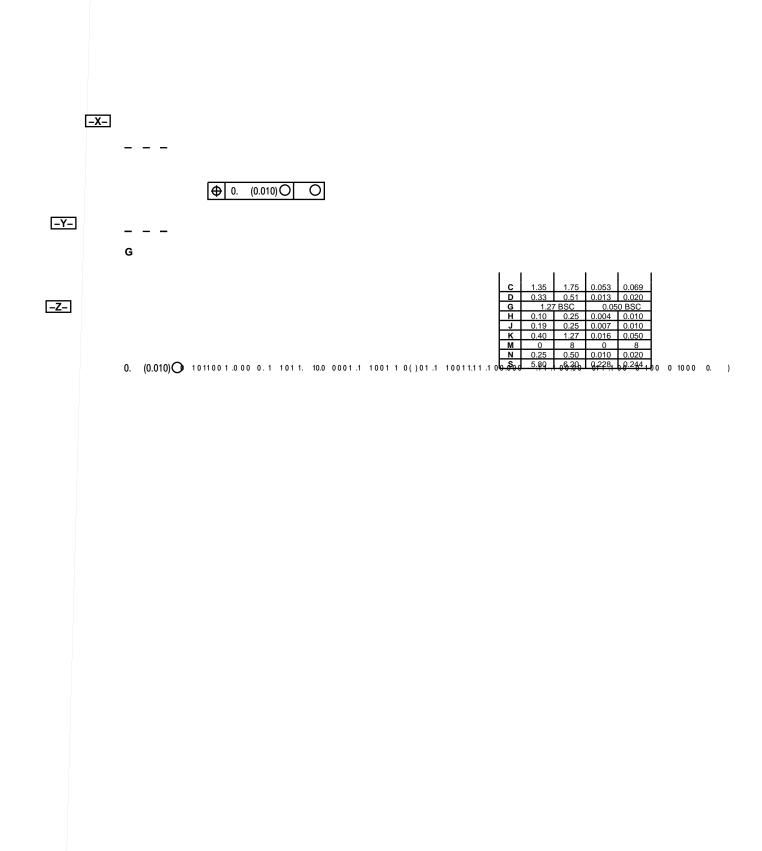
When operating in PWM mode, the current sense functionality can be used, but the timing of the input signal and the response time of the current sense need to be considered. When operating in PWM mode, the following performance is to be expected. The CS\_EN pin should be held high to eliminate any unnecessary delay time to the circuit. When V<sub>IN</sub> switches from low to high, there will be a typical delay (t<sub>CS\_High2</sub>) before the current sense responds. Once this timing delay has passed, the rise time of the current sense output ( $\Delta$ t<sub>CS\_High2</sub>) also needs to be considered. When V<sub>IN</sub> switches from high to low a delay time (t<sub>CS\_Low1</sub>) needs to be considered. As long as these timing delays are allowed, the current sense pin can be operated in PWM mode.

### HINTS

This device is not targeting safety critical applications as it does not contain specific safety mechanisms. In case a customer would like to use the device for safety critical applications then he would need to use decomposition at system level to use the device. This is possible and quite common practice and will be clearly indicated in the datasheet. In this condition the development would be done as QM without any ASIL level assigned.

### **EMC Performance**

If better EMC performance is needed, connect a C1 = 100 nF, C2 = C3 = 10 nF ceramic capacitors to the pins as close to the device as possible according to Figure 39.



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