Description

The ZXMS82045S14PQ is a dual-channel, high-side power switch in a SO-14EP exposed heatsink package incorporating protective and diagnostic functions.

The device comprises a monolithic n-channel vertical power MOSFET with integrated temperature and current sensors with a charge-pumped gate supply and has a low quiescent current in OFF state.

The device is enabled by active high 3.3V and 5V logic-level drive to the inputs. The device includes a diagnostic current-sense output proportional to load current and a defined diagnostic fault signal in case of overload operation, overtemperature, short-circuit or open-load conditions.

Features

Protection Functions

- Reverse-Battery Protection Using External Components
- Voltage Dependent Current Limiting
- Overtemperature Protection with Auto-Restart
- Overvoltage Protection Including Load Dump
- Stable Undervoltage Protection
- ESD Protection
- Loss of Ground Protection with External Components
- Enhanced Short-Circuit Protection

Diagnostic Functions

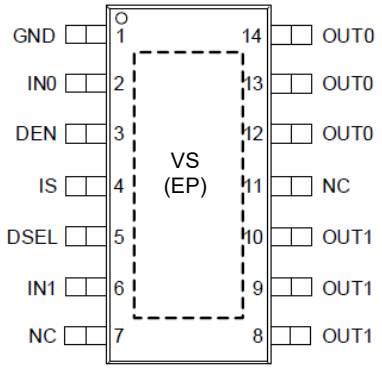
- Proportional Load Current-Sense Output
  - Linear Voltage Drop Regulation to Maintain Sense Accuracy Even at Very Low Load Currents
  - Enabled by Logic Input
  - Output Channel Selected by Logic Input
  - Defined Temperature and Current Dependency
- Open-Load Detection
  - Using Load Current-Sense in ON State
  - Using Output Voltage Detection in OFF State
- Defined Fault Signal in Case of Overload Operation, Overtemperature, or Short-Circuit and Open-Load in OFF State

Miscellaneous

- **Lead-Free Finish; RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **The ZXMS82045S14PQ is suitable for automotive applications requiring specific change control; this part is AEC-Q100 qualified, PPAP capable, and manufactured in IATF16949 certified facilities.**
  https://www.diodes.com/quality/product-definitions/

Pin Assignment

(Top View)



SO-14EP

Applications

- High-side switching with diagnostic feedback for:
  - 12V grounded loads
  - Resistive, inductive and capacitive loads
- Suitable for high inrush current loads
  - Incandescent lamps (P27W/P21W), motors, LEDs, etc.
- Compact low power replacement for:
  - Relays, fuses and discrete circuits

Summary Specifications

Parameter	Symbol	Rating
Operating Voltage	V_S	5V to 28V
Maximum Supply Voltage	$V_{S(LD)}$	41V
Maximum ON Resistance, T_J = 150°C	$R_{DS(ON)}$	90mΩ
Nominal Load Current	$I_{L(NOM)}$	4.5A
Typical Current Sense Ratio, I_L = 0.5A	K_{ILIS}	1500
Minimum Current Limitation	$I_{L5(SC)}$	25A
Maximum Standby Current, T_J = 25°C	$I_{S(OFF)}$	0.5µA

Notes:
1. EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant. All applicable RoHS exemptions applied.
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.

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Typical Applications Circuit

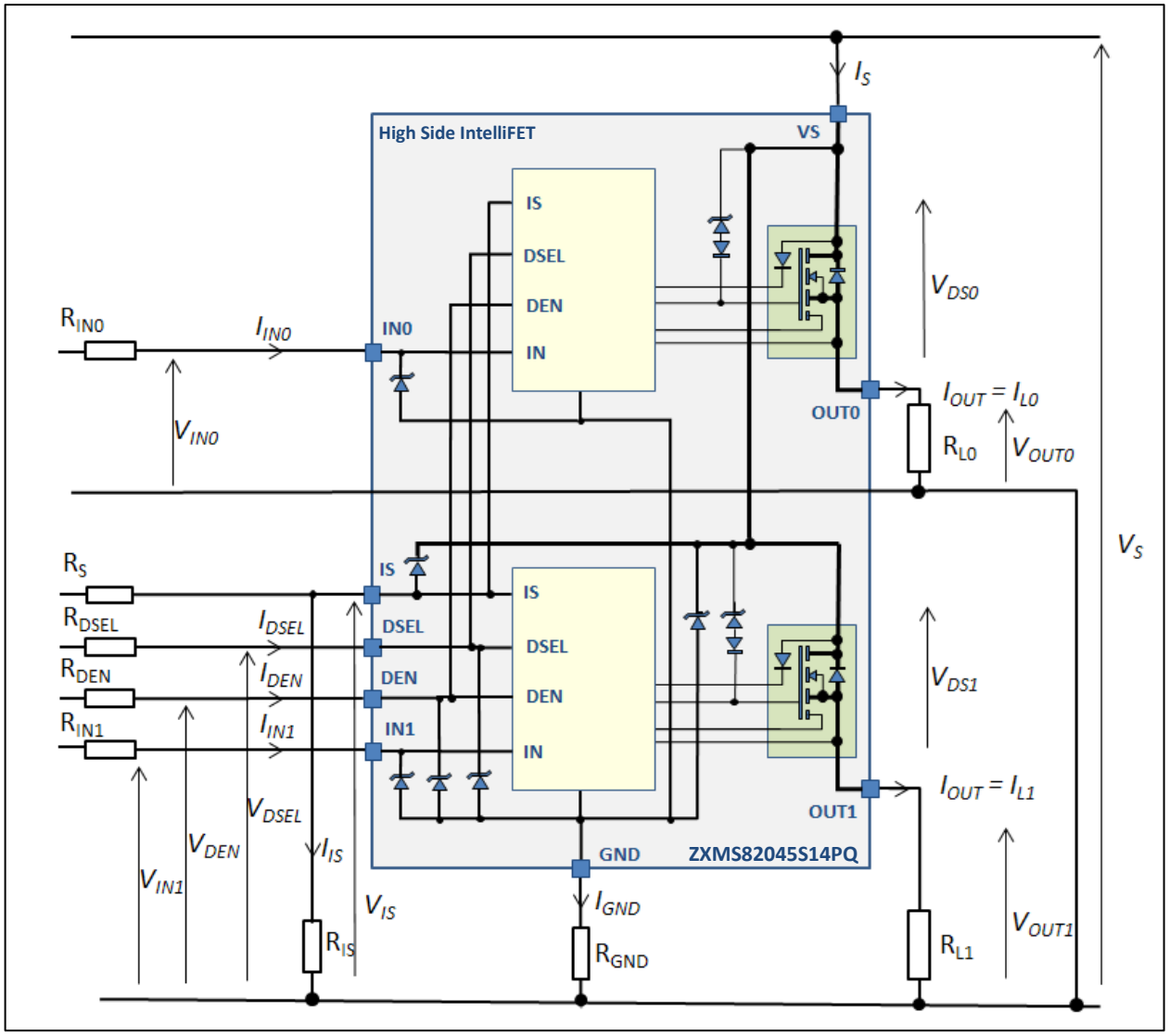


Figure 1. Typical Application Configuration

R_{GND}, R_{INx}, R_{DEN}, R_{DSEL} and R_S are optional. They may be replaced by shorts depending on the application. Non-zero resistors may be used to:

- Reduce peak currents during supply voltage transients that exceed the $\pm V_S$ internal clamp voltages
  - Typically, transients exceeding 41V or may activate the internal clamps
- Protect the customer's application from high currents during transients exceeding 41V
- Keep within rated current during reverse battery, recommended is $R_S = R_{DEN} = R_{INx} = R_{DSEL} = 4.7k\Omega$, $R_{GND} = 150\Omega$
- Ensure that the device is off when there is loss of ground connection to the device or module

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Pin Description

Pin Number	Pin Name	Function and Description
1	GND	Ground or negative supply
2	IN0	Input channel 0, activates output channel 0
3	DEN	Diagnostic enable, allows common connection of the IS pin with multiple devices
4	IS	Diagnostic output, provides an analog sense current proportional to the load current under normal operation, or a defined current under overload or shutdown conditions
5	DSEL	Input to select which channel to be diagnosed
6	IN1	Input channel 1, activates output channel 1
7, 11	NC	Not connected
8, 9, 10	OUT1	Output 1 to the load, must be connected together
12, 13, 14	OUT0	Output 0 to the load, must be connected together
EP	VS	Voltage supply or battery positive

Table 1. Pin Description

Functional Block Diagram

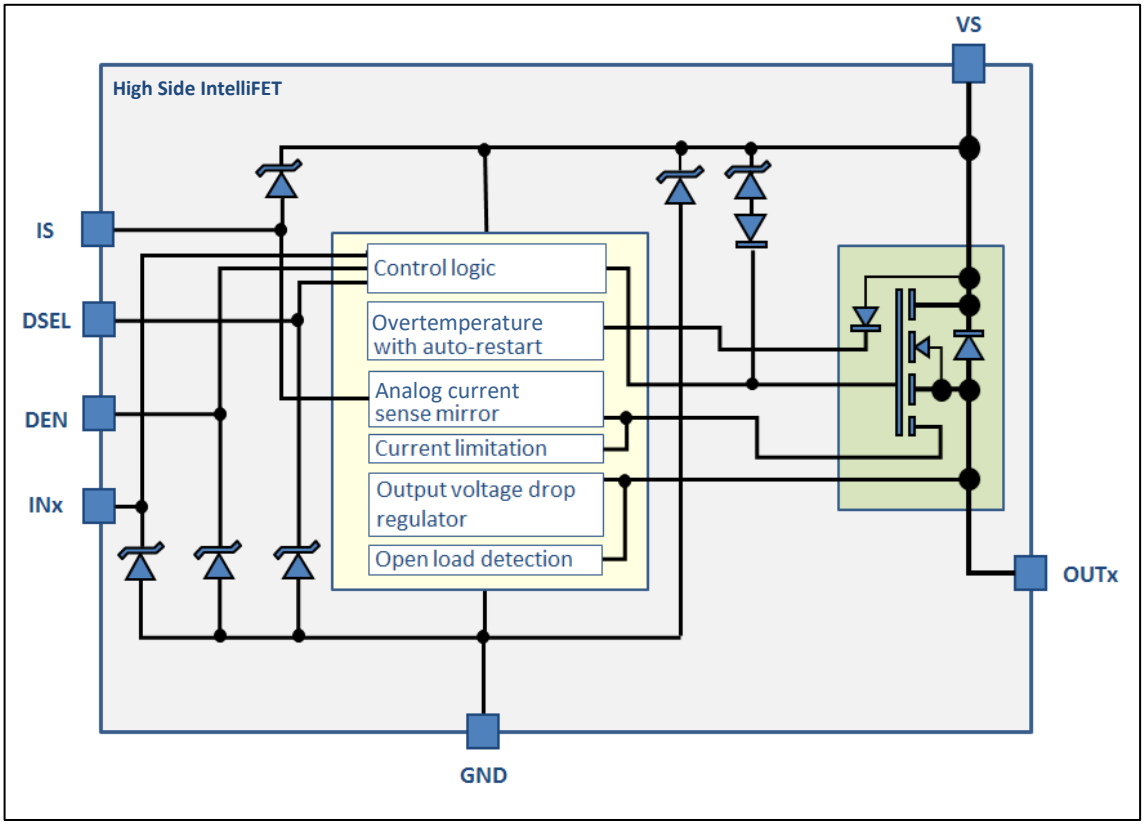


Figure 2. Functional Block Diagram of ZXMS82045S14PQ

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Absolute Maximum Ratings (Notes 4, 5) (@T_J = +25°C, unless otherwise specified.)

Symbol	Parameter	Ratings		Unit	Conditions
		Min	Max		
Supply Voltage					
V_S	Supply Voltage	-0.3	28	V	—
$V_{S(REV)}$	Reverse Supply Voltage	0	16	V	$R_L \geq 6\Omega$, $R_{GND} = 150\Omega$ T_{amb} = 25°C, t < 2 mins
$V_{S(SC)}$	Supply Voltage for Short-Circuit Protection (Note 6)	0	24	V	—
$V_{S(LD)}$	Supply Voltage for Load-Dump Protection (ISO 7637)	—	41	V	$R_{IN} = 2\Omega$, $R_L = 6\Omega$
Interface Pins					
V_{IN}	IN Pins Voltage	-0.3	6	V	—
		—	7	V	t < 2 mins
I_{IN}	Current in IN Pins	-2	2	mA	—
V_{DEN}	DEN Pin Voltage	-0.3	6	V	—
		—	7	V	t < 2 mins
I_{DEN}	Current in DEN Pin	-2	2	mA	—
V_{DSEL}	DSEL Pin Voltage	-0.3	6	V	—
		—	7	V	t < 2 mins
I_{DSEL}	Current in DSEL Pin	-25	50	mA	—
V_{IS}	IS Pin Voltage	-0.3	V_S	V	—
I_{IS}	Current in IS Pin	-25	50	mA	—
Output Stage					
I_L	Load Current (Note 7)	—	Self-limited	A	—
P_{TOT}	Power Dissipation	—	2	W	T_{amb} = 85°C, T_J < 150°C
E_{AS}	Energy Dissipation (Single Pulse, One Channel)	—	35	mJ	V_S = 13.5V, I_L = 4A T_J = 150°C
V_{DS}	VS to OUT Pin Voltage	—	41	V	—
N_{RSC}	Repetitive Short-Circuit Capability (Note 8)	—	100	kcyc	t_{ON} = 300ms
Current					
I_{GND}	Current in GND Pin	-10	10	mA	—
		-150	20	mA	t < 2 mins
Temperature					
T_J	Junction Temperature	-40	150	°C	—
T_{STG}	Storage Temperature	-55	150	°C	—
Electrostatic Discharge					
$V_{ESD(HBM)}$	ESD Capability HBM (All Pins)	-2	2	kV	EIA/JESD 22-A 114B
	ESD Capability HBM OUT to GND and V_S Shorted	-4	4	kV	
$V_{ESD(CDM)}$	ESD Capability CDM	-0.75	0.75	kV	AEC-Q100-011

Notes:
4. Stresses greater than those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to *Absolute Maximum Ratings* for extended periods can affect device reliability.
5. Not subject to production test, guaranteed by design.
6. Short-circuit protection is outside normal operation and is limited to single pulse and allowed combinations of resistance and inductance.
7. Current limit is a protection feature and operation in current limitation, e.g. with short-circuit loads, is outside the normal operation range.
8. Repetitive short-circuit protection characterisation also carried out according to AEC-Q100-012 at 14V.

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Package Thermal Data

Symbol	Parameter	Min	Typ	Max	Unit
$R_{\theta JS}$	Thermal Resistance, Junction-to-Soldering Point (Note 5)	—	4	—	°C//W
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient Mounted on PCB Both Channels Active (Notes 5, 9)	—	46	—	°C//W

Note: 9. Device mounted on vertical PCB, 2” x 2” x 1.6mm, FR4 with 2oz copper for all connections.

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
$V_{S(NOM)}$	Normal Operating Voltage (Note 10)	8	18	V
$V_{S(OP)}$	Extended Operating Voltage (Note 11)	5	28	V

Notes: 10. For normal operation and protection features.
11. Operation across an extended range is possible but is load dependant – device may have reduced protection against faulty (overload or short-circuit) loads.

Operational Electrical Characteristics

(Unless otherwise specified: -40°C < T_J < +150°C; typical values based on T_J = +25°C)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
General						
$V_{S(OP)}$	Extended Operating Voltage	V_{IN} = 4.5V, V_{DS} < 0.5V	5	13.5	28	V
$V_{S(OP_MIN)}$	Undervoltage Restart	V_{IN} = 4.5V, R_L = 6Ω	3.8	4.2	5	V
$V_{S(UV)}$	Undervoltage Shutdown	V_{IN} = 4.5V, V_{DEN} = 0V R_L = 6Ω	3	3.3	4.1	V
$V_{S(UV_HYS)}$	Undervoltage Hysteresis	—	—	0.85	—	V
I_{GND}	Operating Current One Channel Active	V_{IN} = V_{DEN} = 5.5V, V_S =18V Device in $R_{DS(ON)}$	—	2.5	6	mA
	Operating Current Both Channels Active		—	3.5	8	mA
$I_{S(OFF)}$	Standby Current	V_{IN} and V_{DEN} floating V_{OUT} = 0V, V_S = 18V T_J ≤ 85°C	—	0.1	0.5	µA
		V_{IN} and V_{DEN} floating V_{OUT} = 0V, V_S = 18V T_J = 150°C	—	3	20	µA
$I_{S(OFF_DEN)}$	Standby Current with Diagnostic Pin Active	V_{IN} floating, V_{OUT} = 0V V_S = 18V, V_{DEN} = 5.5V	—	1	—	mA

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Output ON-State Characteristics

The ON-state resistance $R_{DS(ON)}$ depends on the supply voltage V_S and junction temperature T_J.

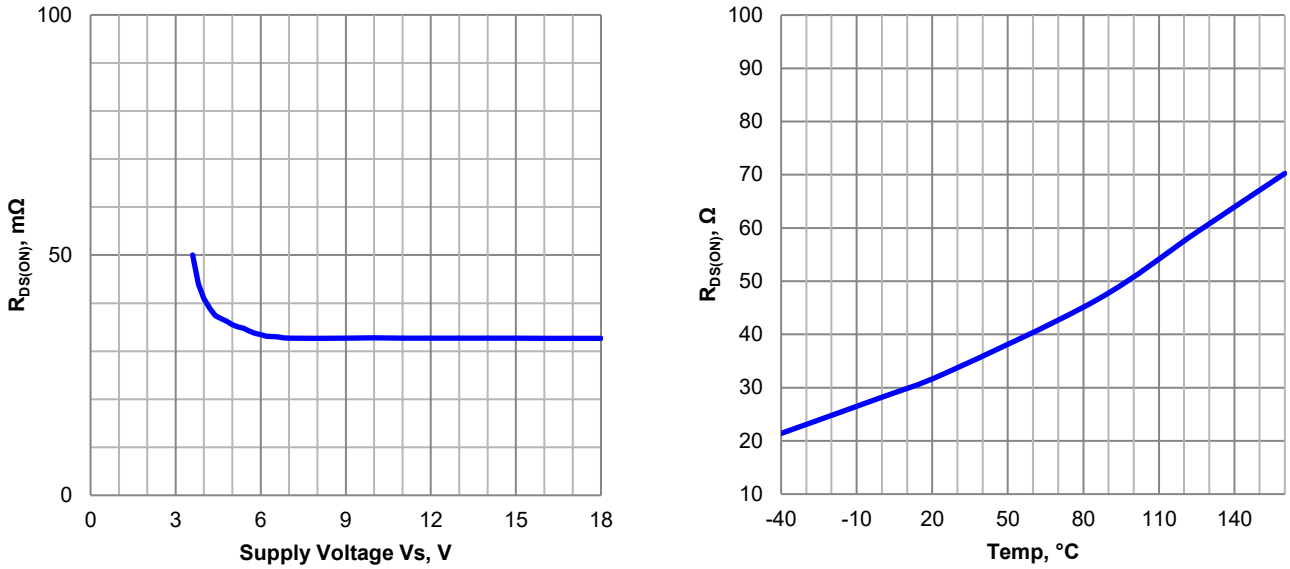


Figure 3. Typical R_{DS} ON-State Resistance

At low load current I_L, the MOSFET gate drive is reduced to maintain a near constant output voltage drop $V_{DS(NL)}$. This limits the effect of internal op-amp offset voltage, to maintain useful $K_{IL/IS}$ ratio accuracy even at very low I_L.

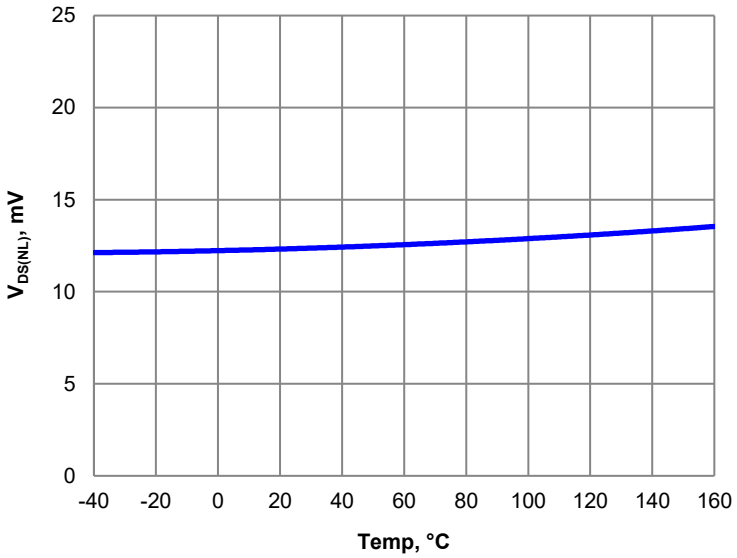


Figure 4. Output Voltage Drop Regulation, I_{OUT} = 50mA

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Resistive Load Switching

The power MOSFET turn-ON and turn-OFF processes are determined by the device itself, with rates suitable for EMC compatibility.

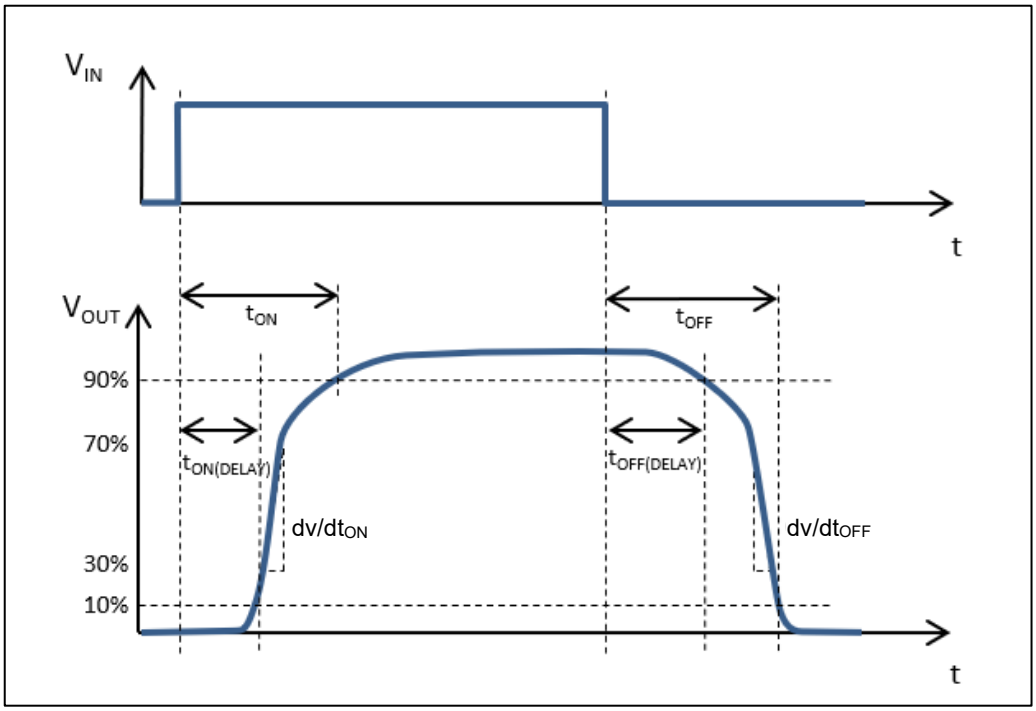


Figure 5. Switching a Resistive Load

Output Inductive Load Clamp

To de-energise inductive loads the OUT terminal must be allowed to swing below ground (V_{OUT} rings negative) during the OFF-state.

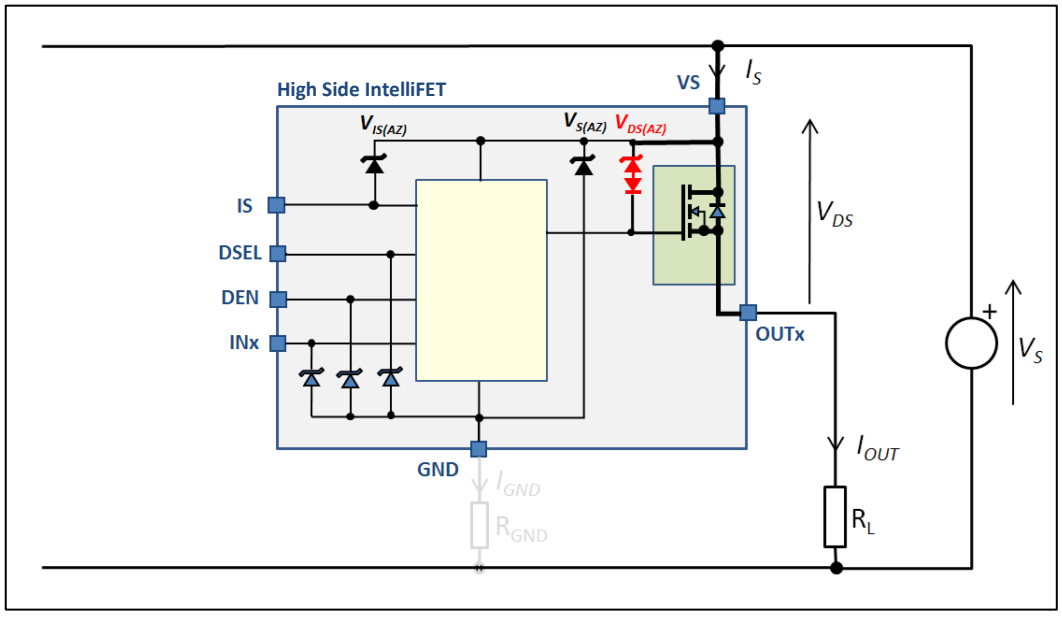


Figure 6. Output Clamp

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Output Inductive Load Clamp (continued)

A low-impedance active voltage clamp uses the MOSFET channel to limit the maximum voltage across the MOSFET drain-source terminals, limiting the swing of OUT below V_S to safe $V_{DS(AZ)}$. This prevents avalanche of the MOSFET or associated circuitry.

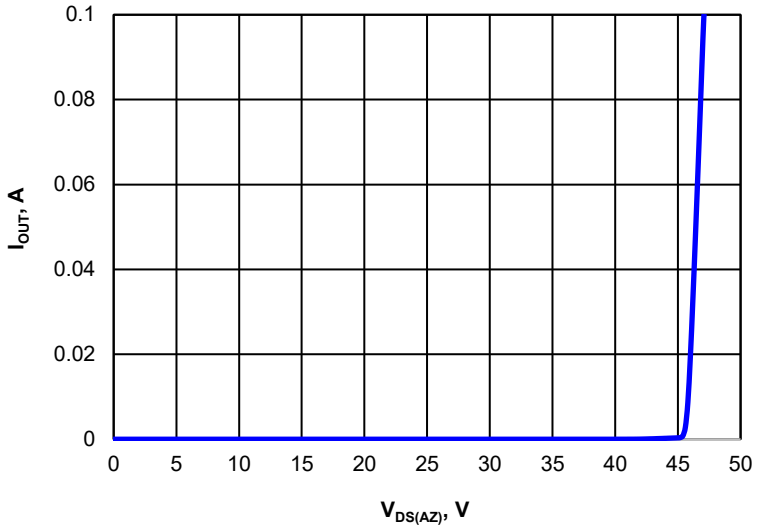


Figure 7. Typical Output Clamp Characteristic

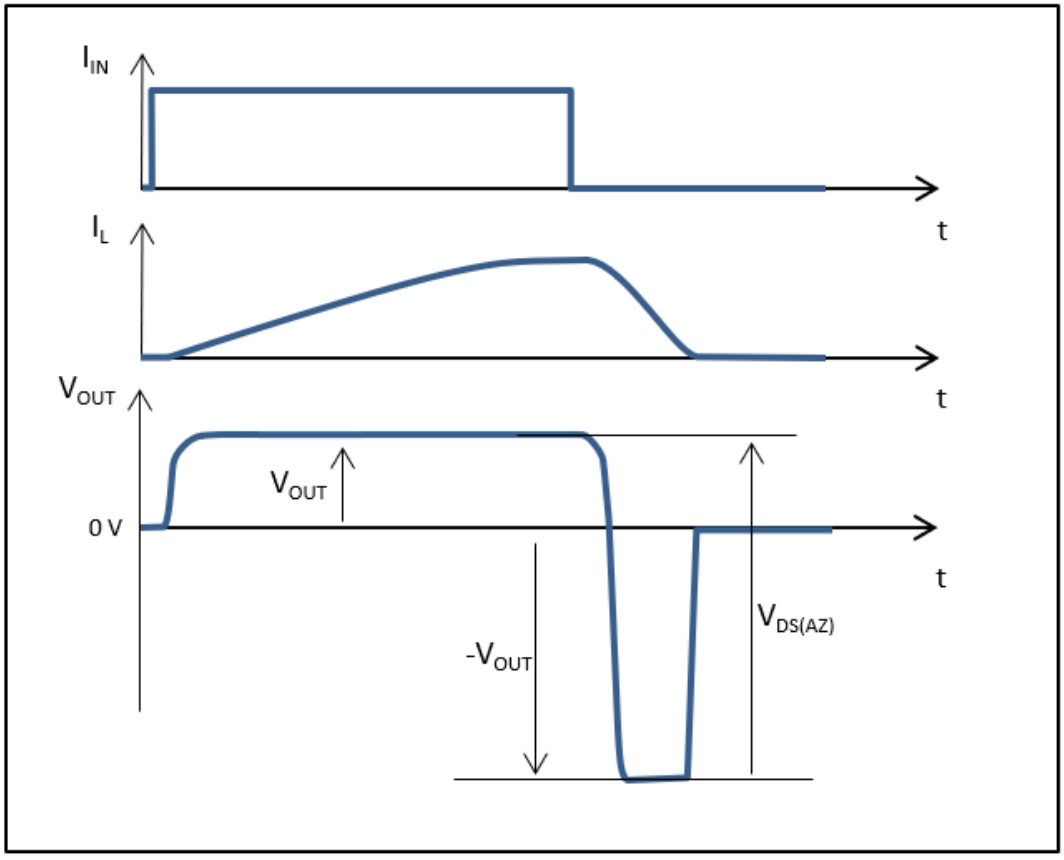


Figure 8. Switching an Inductive Load

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Maximum Load Inductance

Stored inductive load ring-OFF energy is dissipated in the MOSFET during switching and load ring-off clamping. Additional energy is also supplied to the system by the V_S supply until the load current I_L reaches zero. This causes a temporary rise in MOSFET temperature after turn-OFF begins. The temperature reached depends on the starting temperature, thermal environment, load current I_L, load inductance L_L, load resistance R_L and supply voltage V_S.

Inverse Current Capability

In the ON-state the device will remain on if the output current becomes inverse until or unless the inverse current becomes high enough to create a $-V_{DS}$ approaching body diode conduction. During inverse current conduction, $I_{L(INV)}$, the IS sense output will be zero. If body diode conduction occurs all functions are disabled or unspecified until the inverse current becomes very small.

If inverse current is present in the OFF-state body diode conduction occurs and all functions are disabled or unspecified. When inverse current is removed or becomes very small then turn-ON and normal function become possible.

Power Electrical Characteristics

(Unless otherwise specified: 8V < V_S < 18V, -40°C < T_J < +150°C; typical values based on V_S = 13.5V, T_J = +25°C)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Output Characteristics						
$R_{DS(ON)}$	ON-State Resistance per Channel	V_{IN} = 4.5V, I_L = 4A T_J = 150°C	—	78	90	mΩ
		V_{IN} = 4.5V, I_L = 4A T_J = 25°C	—	37	—	mΩ
$I_{L(NOM)}$	Nominal Load Current One Channel Active (Notes 12)	T_{amb} = 85°C, T_J < 150°C	—	4.5	—	A
	Nominal Load Current Both Channels Active (Notes 12)		—	3	—	A
$V_{DS(NL)}$	Voltage Drop Regulation at Low I_L	I_L = 50mA	—	12	25	mV
$V_{DS(AZ)}$	Output Clamp Voltage	I_L = 20mA	41	47	53	V
$I_{L(OFF)}$	Output Leakage Current per Channel	V_{IN} floating, V_{OUT} = 0V T_J ≤ 85°C	—	0.1	0.5	μA
		V_{IN} floating, V_{OUT} = 0V T_J = 150°C	—	1.5	10	μA
$I_{L(INV)}$	Inverse Output Current (Note 13)	V_S < V_{OUT}	—	3	—	A
Timings						
dv/dt_{ON}	Slew Rate ON, 30% to 70% V_S	R_L = 6Ω, V_S = 13.5V	0.1	0.25	0.5	V/μs
dv/dt_{OFF}	Slew Rate OFF, 70% to 30% V_S		0.1	0.25	0.5	V/μs
t_{ON}	Turn-ON Time to 90% V_S		30	100	230	μs
t_{OFF}	Turn-OFF Time to 10% V_S		30	100	230	μs
$t_{ON(DELAY)}$	Turn-ON Delay to 10% V_S		10	35	100	μs
$t_{OFF(DELAY)}$	Turn-OFF Delay to 90% V_S		10	95	150	μs
E_{ON}	Switch ON Energy	R_L = 6Ω, V_S = 18V V_{OUT} = 90% V_S	—	0.8	—	mJ
E_{OFF}	Switch OFF Energy	R_L = 6Ω, V_S = 18V V_{OUT} = 10% V_S	—	0.7	—	mJ

Notes: 12. Device mounted on vertical 50mm x 50mm x 1.5mm FR4 single-sided PCB with 6cm² 2oz copper in free air.
13. ON-state reverse conduction, functional test only.

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Protection Features

Loss of Ground Protection

The device will turn off in the case that the ground pin connection is lost and the load remains connected. It is recommended to use high ohmic input resistors in the interface pins to ensure that the device is turned off by limiting the current in the paths from the ground pin, through the input and diagnostic enable ESD diodes, to the external driving circuits.

Undervoltage Protection

The device will not turn on if the V_S supply voltage is below the minimum operating voltage $V_{S(OP_MIN)}$ where protection functions may not be operational. If the device is already on then the supply voltage has to drop to below the undervoltage threshold $V_{S(UV)}$ to turn the output off. Figure 9 shows the undervoltage mechanism.

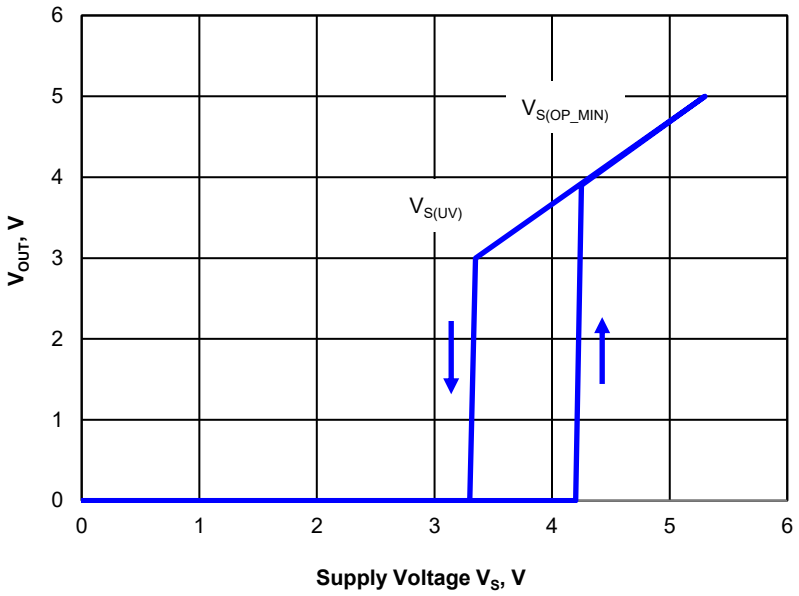


Figure 9. Undervoltage Behavior

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Protection Features (continued)

Overvoltage Protection

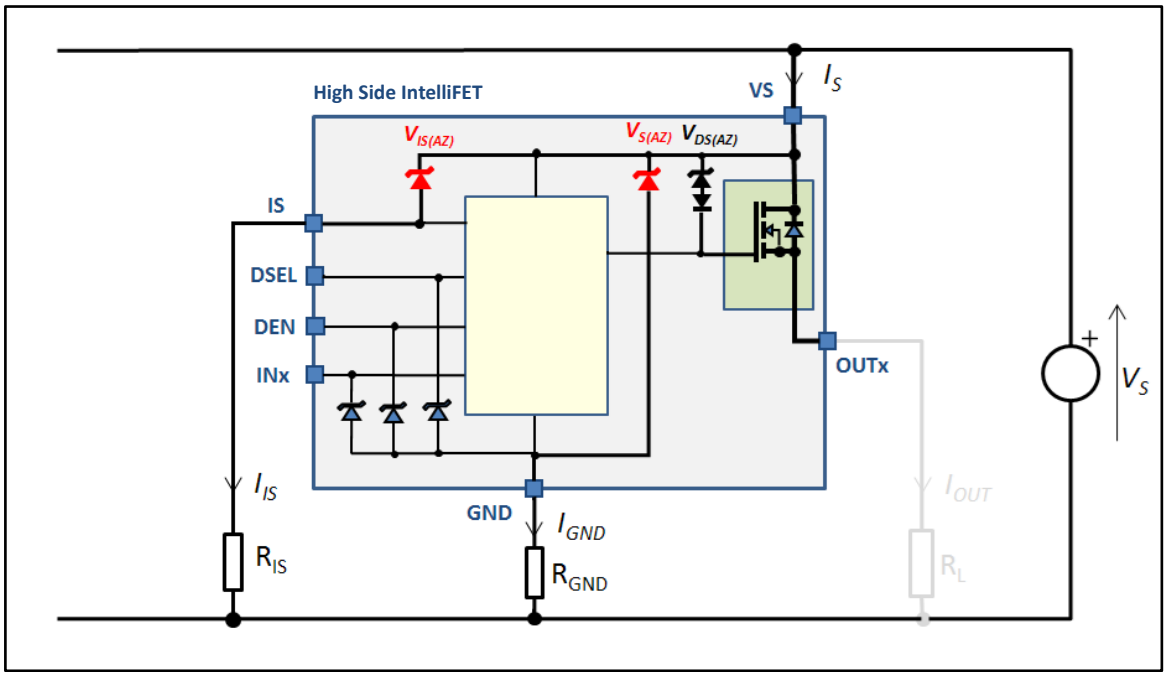


Figure 10. Overvoltage Clamping Circuit

The GND pin has an active protection clamp, operating much as a low noise high voltage Zener device, to protect it from overvoltage for high V_S transients. During V_S transient overvoltage the voltage is clamped and the excess voltage, V_S-$V_{S(AZ)}$, is applied across the ground resistor R_{GND} raising the potential on the ground pin. Additional high ohmic series resistors may be needed to prevent high V_{IN} and V_{DEN} being applied directly to the driving circuits.

The IS pin also has an active protection clamp and during V_S transient overvoltage the voltage is clamped and excess voltage, V_S-$V_{IS(AZ)}$, is applied across the sense resistor R_{IS}. An additional high ohmic series resistor may be needed in the application to prevent high V_{IS} being applied directly to the application monitoring circuit.

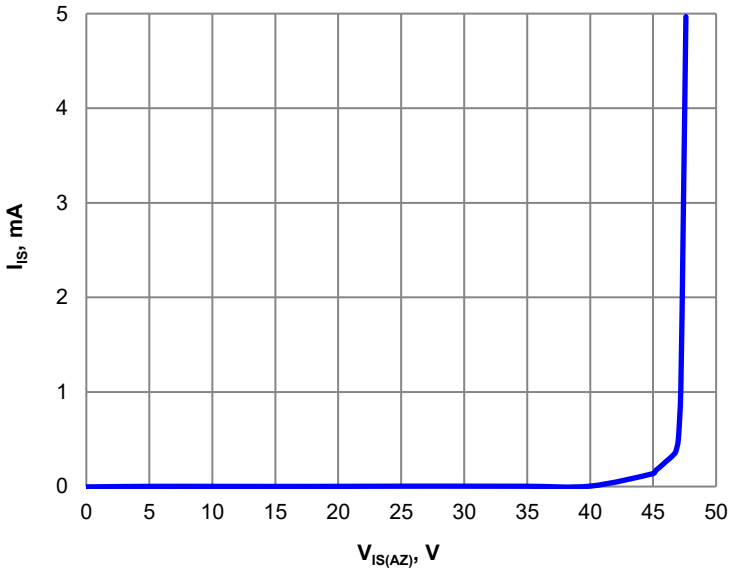


Figure 11. Typical I_{IS} Overvoltage Clamp Characteristic

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Protection Features (continued)

Also during V_S overvoltage transient the voltage V_S-OUT is clamped and the excess voltage, V_S-$V_{DS(AZ)}$, is applied across the load R_L. V_S-OUT is the same clamp described under the earlier section *Output Inductive Load Clamp*.

Reverse-Battery Protection

During reverse battery the output body diode is conducting current limited by the load itself resulting in power dissipation and the current in the ground and logic inputs has to be limited by external resistor components. No operating functions are available in this condition.

Overload Protection

During overload the output current is limited to a value depending on the V_{DS} voltage resulting in high dissipation in the output power stage. Sustained operation in this mode will raise the internal junction temperature until dynamic or absolute overtemperature protection cycling begins. There is a dynamic ($\Delta T_{J(SW)}$) and an absolute ($T_{J(SC)}$) temperature sensor. Figure 12 gives a sketch of overload protection.

If the temperature rise of the power stage versus the cooler control area exceeds $\Delta T_{J(SW)}$ then the device will be turned off until the rise falls to a reset level. Each cycle causes the absolute temperature to increase a little.

If the absolute temperature reaches $T_{J(SC)}$ then the device will be turned off until the absolute temperature falls by $\Delta T_{J(SC)}$. The device will continue to cycle to $T_{J(SC)}$ as long as the fault condition remains.

The IS pin outputs $I_{IS(FAULT)}$ during load current limitation. during dynamic overtemperature cycling, and absolute overtemperature cycling.

Both channels are independently overload protected and if both are in overtemperature shutdown, there is no restart synchronization. Only one channel can be monitored on the IS pin. It is not recommended to use both channels connected in parallel.

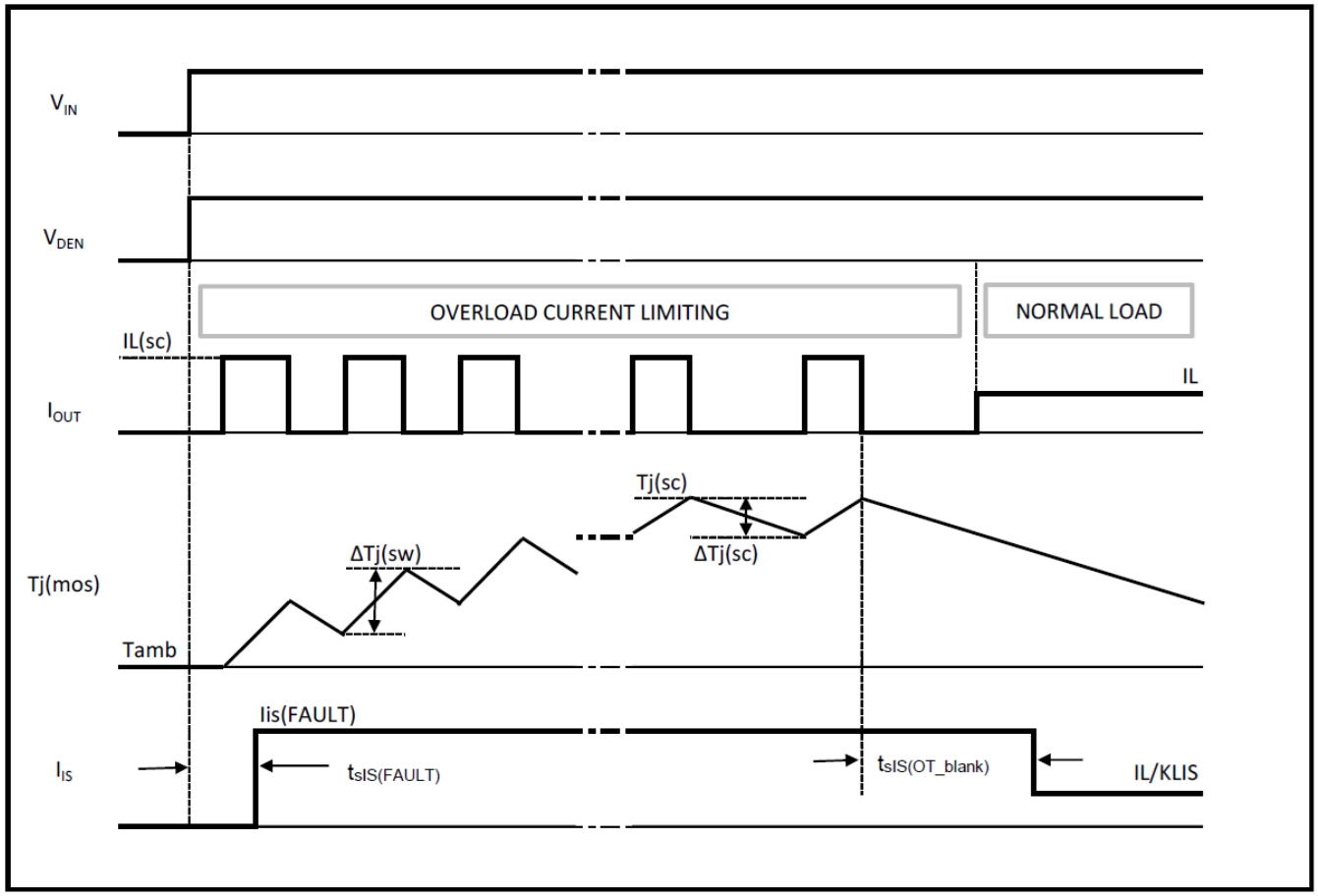


Figure 12. Overload Protection Diagram

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Protection Electrical Characteristics

(Unless otherwise specified: 8V < V_S < 18V, -40°C < T_J < +150°C; typical values based on V_S = 13.5V, T_J = +25°C)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Loss of Ground Protection						
$I_{OUT(GND)}$	Output Leakage Current (Note 14)	V_S = 28V GND disconnected	—	0.1	—	mA
Reverse-Battery Protection						
$V_{DS(REV)}$	Reverse Output Voltage (Note 15)	I_L = -2A, T_J = 150°C	0.2	0.65	0.7	V
Overvoltage Protection						
$V_{S(AZ)}$	V_S to GND Clamping	I_S = 5mA	41	47	53	V
Overload Protection						
$I_{L5(SC)}$	Load Current Limit	V_{DS} = 5V	25	32	40	A
$I_{L28(SC)}$	Load Current Limit (Note 14)	V_{DS} = 28V	—	16	—	A
$I_{L(RMS)}$	Load Current During Overtemperature Cycling (Note 14)	R_{SHORT} = 0.1Ω L_{SHORT} = 5µH	—	3	—	A
$\Delta T_{J(SW)}$	Dynamic Temperature Rise During Cycling (Note 16)	—	—	80	—	K
$T_{J(SC)}$	Thermal Shutdown Temperature (Note 17)	—	150	170	200	°C
$\Delta T_{J(SC)}$	Thermal Hysteresis (Notes 16, 17)	—	—	20	—	K

Notes: 14. Not subject to production test, guaranteed by design.
15. During reverse battery the body diode will conduct with a voltage drop $V_{DS(REV)}$.
16. Functional test only.
17. Test only at T_J = +150°C.

Diagnostic Functionality – Detailed Description

In normal operation the IS pin outputs a small analog sense current proportional to the main OUT current flowing in the power MOSFET depending upon which channel is selected by the DSEL pin. In the case where it is disabled by the DEN pin it becomes high impedance.

V_{DEN}	V_{DSEL}	IS Output
L	X	Z
H	L	Channel 0 diagnostics
H	H	Channel 1 diagnostics

Table 2. Diagnostic Truth Table

During overload/current limit operation/overtemperature/high temperature gradient or open load in the OFF-state, the IS pin outputs a defined current $I_{IS(FAULT)}$ greater than normal sense currents for normal loads.

During ON-state operation with open load, normal OFF-state, or OFF-state with inductive load ring-off current still flowing, the IS current is approximately zero.

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Diagnostic Functionality – Detailed Description (continued)

Operating Condition	V_{INx}	V_{DEN}	V_{OUTx}	IS Output Current, I_{IS} (Note 18)
Normal Operation	L H	H H	Z H	Z = I_L / K_{ILIS}
Current Limiting	H	H	H	$I_{IS(FAULT)}$
Short Circuit OUT To GND	L H	H H	L L	Z $I_{IS(FAULT)}$
Overtemperature	L H	H H	Z Z	Z $I_{IS(FAULT)}$
Short-Circuit OUT To V_S	L H	H H	H H	$I_{IS(FAULT)}$ < I_L / K_{ILIS} (Note 19)
Open Load	L L H	H H H	< $V_{OL(OFF)}$ > $V_{OL(OFF)}$ H	Z $I_{IS(FAULT)}$ (Note 20) < $I_{IS(OL)}$
Inverse Load Current	L H	H H	H H	$I_{IS(FAULT)}$ $I_{IS(OL)}$
All	X	L	X	Z

Table 3. Operational Truth Table (Note 21)

Notes:
18. The appropriate channel is selected by the DSEL pin.
19. A low resistance short between OUT and V_S will reduce the output current, I_L and therefore reduce the analog sense current, I_{IS}.
20. With external pullup resistor.
21. H = high level; L = low level; Z = high impedance, voltage depends on external circuit; X = don't care.

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Diagnostic Diagrams

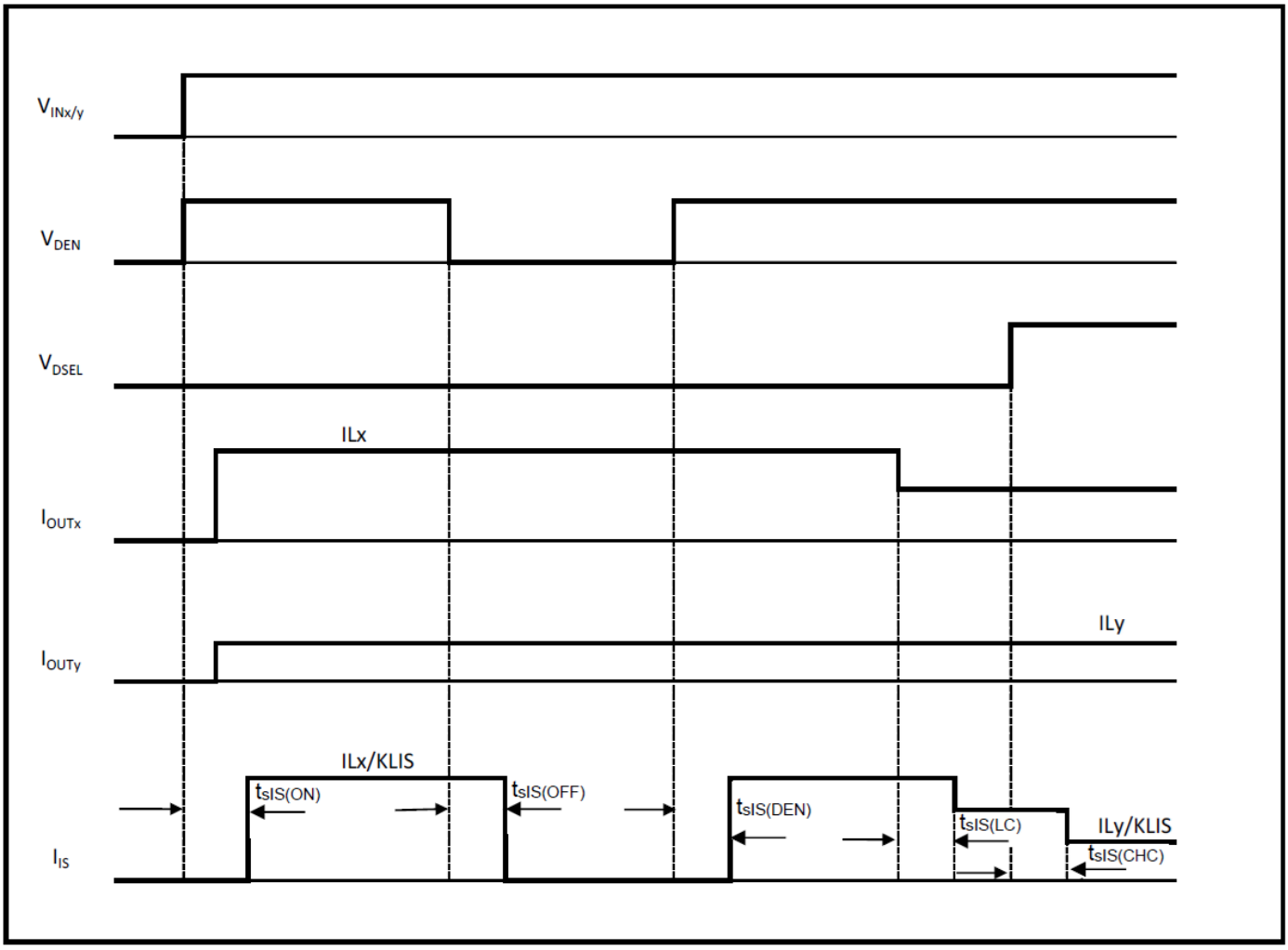


Figure 13. IS Signal Timing Diagram

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Diagnostic Diagrams (continued)

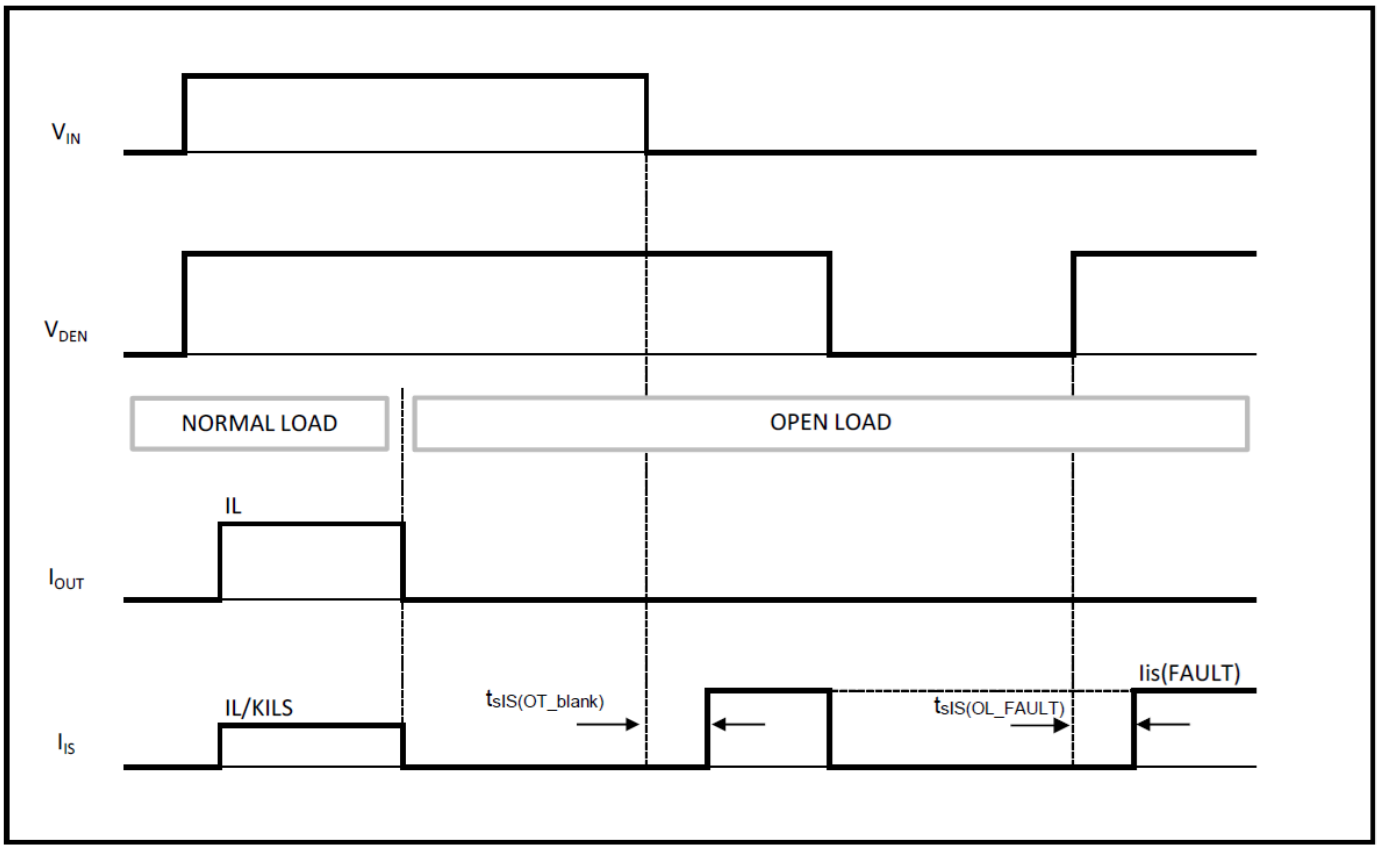


Figure 14. Open-Load Timing Diagram

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Diagnostic Electrical Characteristics

(Unless otherwise specified: 8V < V_S < 18V, -40°C < T_J < +150°C; typical values based on V_S = 13.5V, T_J = +25°C)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Open-Load Detection						
$V_{DS(OL)}$	Open-Load OFF State Detection Voltage	V_{IN} = 0V, V_{DEN} = 4.5V	4	4.9	6	V
$I_{L(OL)}$	Open-Load ON State Detection Current	V_{IN} = V_{DEN} = 4.5V $I_{IS(OL)}$ = 8µA	5	—	30	mA
Current Sense Pin						
$I_{IS(DIS)}$	Current Sense Leakage Current	V_{IN} = 4.5V, V_{DEN} = 0V I_L = 4A	—	—	1	µA
$V_{IS(SAT)}$	VS to IS Saturation Voltage	V_{IN} = 0V, V_{DEN} = 4.5V I_{IS} = 6mA, V_{OUT} = V_S > 10V	—	—	3	V
$I_{IS(FAULT)}$	Current Sense Under Fault Conditions	V_{IN} = V_{IS} = 0V, V_{DEN} = 4.5V V_{OUT} = V_S > 10V	6	15	35	mA
$V_{IS(AZ)}$	VS to IS Clamp Voltage	I_{IS} = 5mA	41	47	53	V
Load Current Sense						
K_{ILIS0}	Sense Current Ratio I_L = 50mA	V_{IN} = V_{DEN} = 4.5V	-30%	1650	+30%	—
K_{ILIS1}	Sense Current Ratio I_L = 0.5A		-20%	1630	+20%	—
K_{ILIS2}	Sense Current Ratio I_L = 1A		-10%	1540	+10%	—
K_{ILIS3}	Sense Current Ratio I_L = 2A		-7%	14980	+7%	—
K_{ILIS4}	Sense Current Ratio I_L = 4A		-5%	1470	+5%	—
ΔK_{ILIS}	Sense Current Ratio Variation I_L = 2A vs. I_L = 1A		-9%	-4%	+1%	—
Diagnostic Timings						
$t_{sIS(ON)}$	Current Sense Settling Time to 90% I_{IS} after IN and DEN High	V_S = 13.5V I_L = 2A, R_{IS} = 1.2kΩ	—	—	250	µs
$t_{sIS(DEN)}$	Current Sense Settling Time to 90% I_{IS} after DEN High	V_S = 13.5V, V_{IN} = 4.5V I_L = 2A, R_{IS} = 1.2kΩ	—	—	20	µs
$t_{sIS(LC)}$	Current Sense Settling Time to 90% I_{IS} after Load Current Change	V_S = 13.5V, V_{IN} = V_{DEN} = 4.5V I_L = 1A to 2A, R_{IS} = 1.2kΩ	—	—	20	µs
$t_{sIS(OL_FAULT)}$	Diagnostic fault Current Settling Time to 90% $I_{IS(FAULT)}$ after DEN High with OFF State Open-Load Condition	V_{IN} = 0V, V_{OUT} = V_S = 13.5V R_{IS} = 1.2kΩ	—	—	150	µs
$t_{sIS(FAULT)}$	Diagnostic Fault Current Settling Time to 90% $I_{IS(FAULT)}$ after IN and DEN High with Overload Condition	V_{DS} = 5V, R_{IS} = 1.2kΩ	—	—	250	µs
$t_{sIS(OT_blank)}$	Diagnostic Fault Current Off Delay Time to 90% $I_{IS(FAULT)}$ after Overtemperature Condition Returning to Normal Operation (Note 22)	V_{IN} = V_{DEN} = 4.5V R_{IS} = 1.2kΩ	—	150	—	µs
$t_{sIS(OFF)}$	Current Sense Fall Time to < 50% I_{IS} after DEN Low	V_{IN} = 4.5V, I_L = 2A R_{IS} = 1.2kΩ	—	—	30	µs
$t_{sIS(CHC)}$	Current Sense Settling Time to 90% I_{IS} after DSEL High	V_S = 13.5V, V_{IN0} = V_{IN1} = 4.5V V_{DEN} = 4.5V I_{L0} = 2A, I_{L1} = 1A R_{IS} = 1.2kΩ	—	—	20	µs

Note: 22. Not subject to production test, guaranteed by design.

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Input Pins

The input circuit is compatible with 3.3V and 5V logic levels. The input diode provides ESD protection. If the pin is left open the internal tie down resistor will keep the output off. A Schmitt trigger provides switching hysteresis to avoid an undefined state if there is a slowly rising or falling voltage on the IN pin. Figure 15 shows the electrical equivalent circuit.

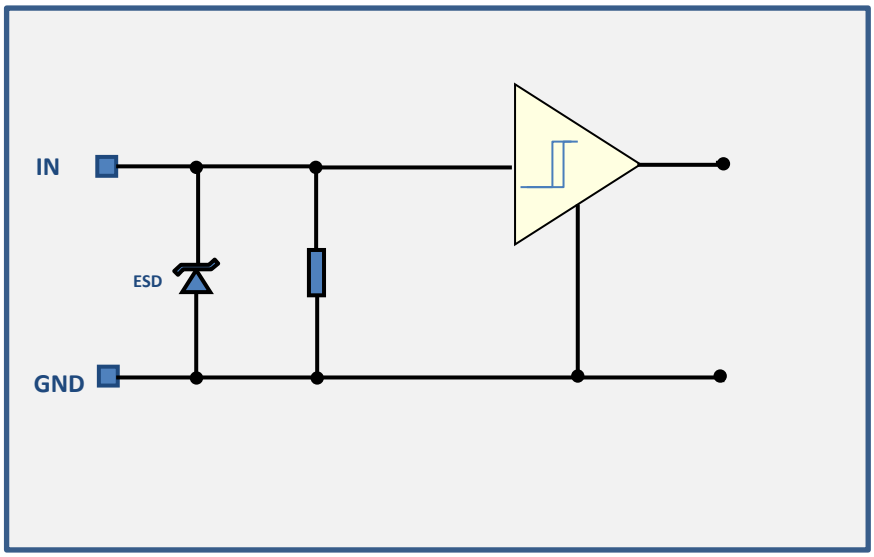


Figure 15. Input Pin Circuitry

The DEN and DSEL pins have the same circuitry as the IN pin.

Input Electrical Characteristics

(Unless otherwise specified: 8V < V_S < 18V, -40°C < T_J < +150°C; typical values based on V_S = 13.5V, T_J = +25°C)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
INx Pin						
$V_{IN(L)}$	Low-Level Input Voltage	—	-0.3	—	0.8	V
$V_{IN(H)}$	High-Level Input Voltage	—	2	—	6	V
$V_{IN(HYS)}$	Input Voltage Hysteresis	—	—	0.25	—	V
$I_{IN(L)}$	Low-Level Input Current	V_{IN} = 0.8V	1	3	25	µA
$I_{IN(H)}$	High-Level Input Current	V_{IN} = 5.5V	2	8	25	µA
DEN Pin						
$V_{DEN(L)}$	Low-Level Input Voltage	—	-0.3	—	0.8	V
$V_{DEN(H)}$	High-Level Input Voltage	—	2	—	6	V
$V_{DEN(HYS)}$	Input Voltage Hysteresis	—	—	0.25	—	V
$I_{DEN(L)}$	Low-Level Input Current	V_{DEN} = 0.8V	1	3	25	µA
$I_{DEN(H)}$	High-Level Input Current	V_{DEN} = 5.5V	2	8	25	µA
DSEL Pin						
$V_{DSEL(L)}$	Low-Level Input Voltage	—	-0.3	—	0.8	V
$V_{DSEL(H)}$	High-Level Input Voltage	—	2	—	6	V
$V_{DSEL(HYS)}$	Input Voltage Hysteresis	—	—	0.25	—	V
$I_{DSEL(L)}$	Low-Level Input Current	V_{DSEL} = 0.8V	1	3	25	µA
$I_{DSEL(H)}$	High-Level Input Current	V_{DSEL} = 5.5V	2	8	25	µA

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Characterisation – General Product

Minimum Functional Supply Voltage

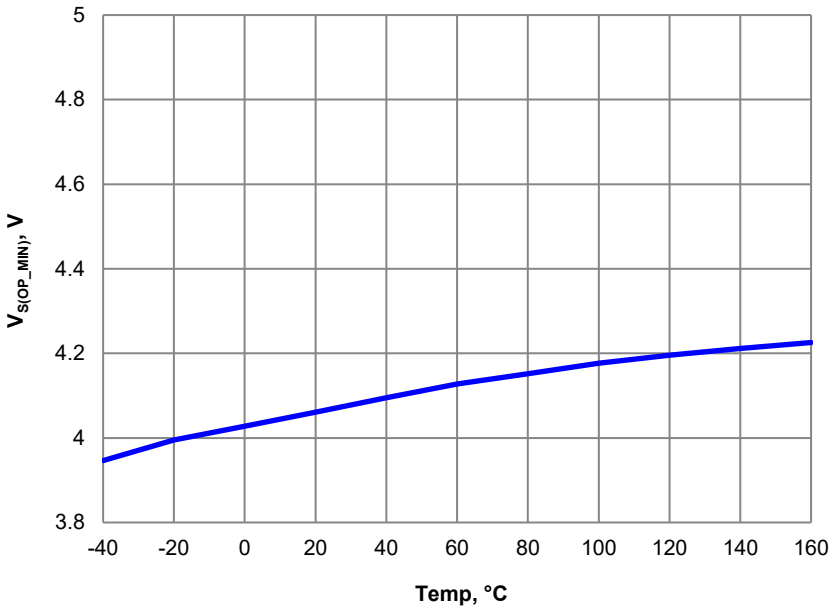


Figure 16. Minimum Functional Supply Voltage $V_{S(OP_MIN)} = f(T_J)$

Undervoltage Shutdown

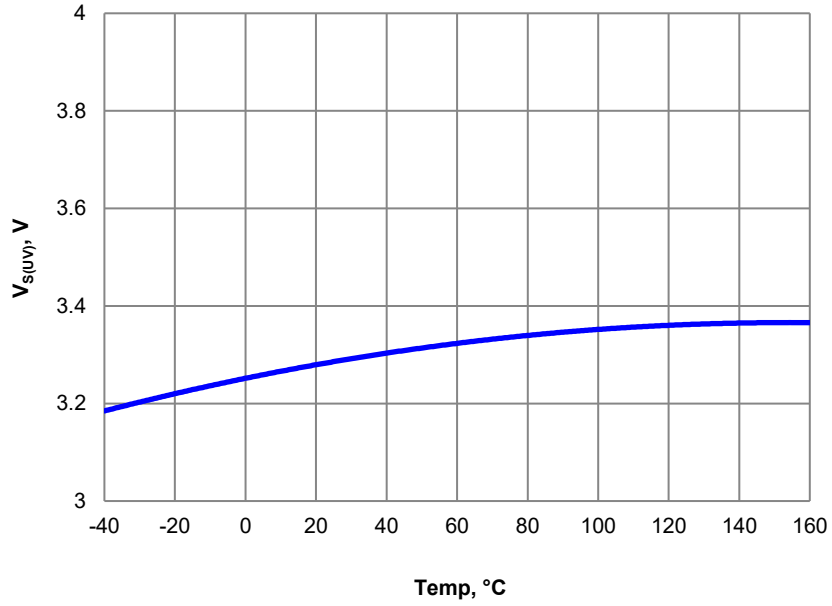


Figure 17. Undervoltage Shutdown $V_{S(UV)} = f(T_J)$

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Characterisation – General Product (continued)

Current Consumption One Channel Active

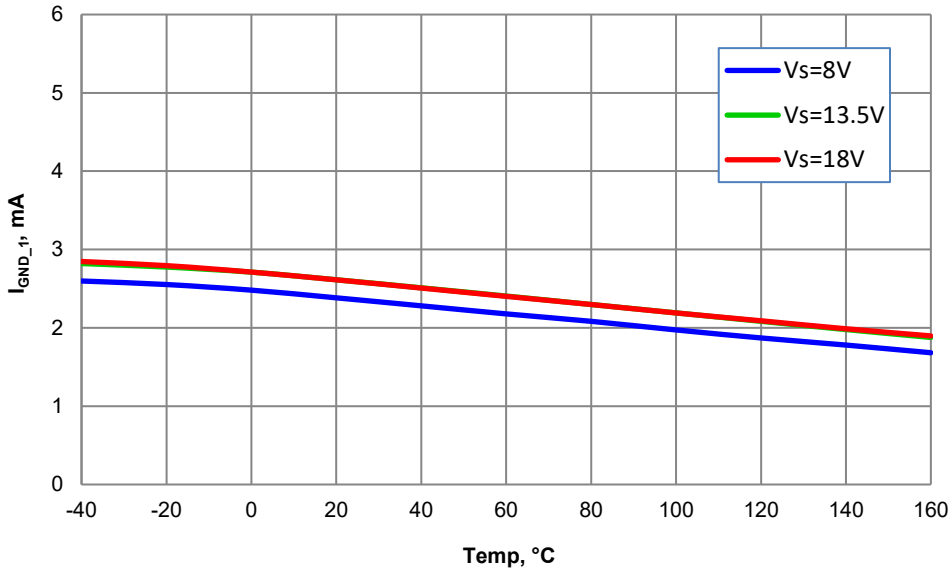


Figure 18. Current Consumption for Whole Device with Load, Channel Active I_{GND} = f(T_J;V_S)

Current Consumption Two Channels Active

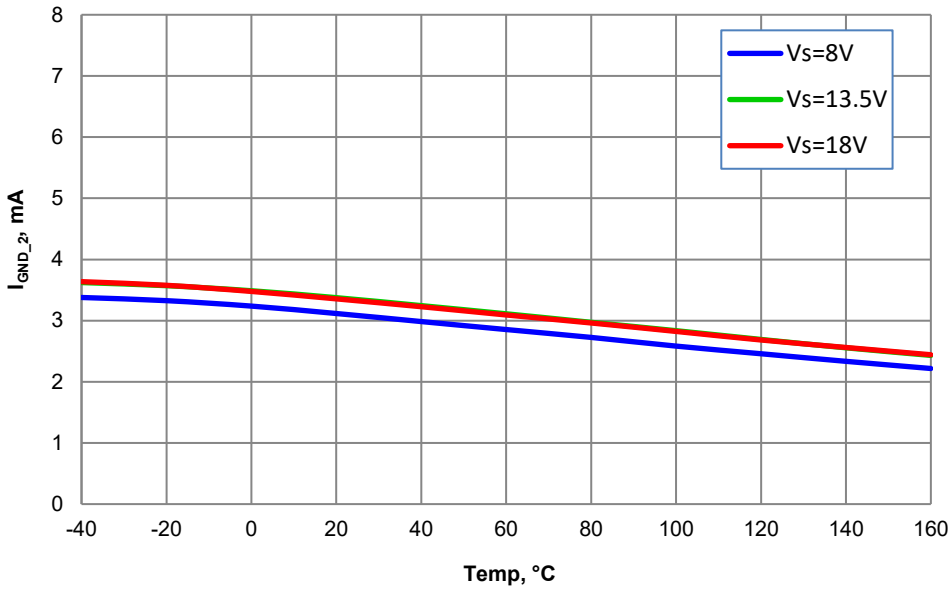


Figure 19. Current Consumption for Whole Device with Load, Channel Active I_{GND} = f(T_J;V_S)

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Characterisation – General Product (continued)

Standby Current for Whole Device with Load

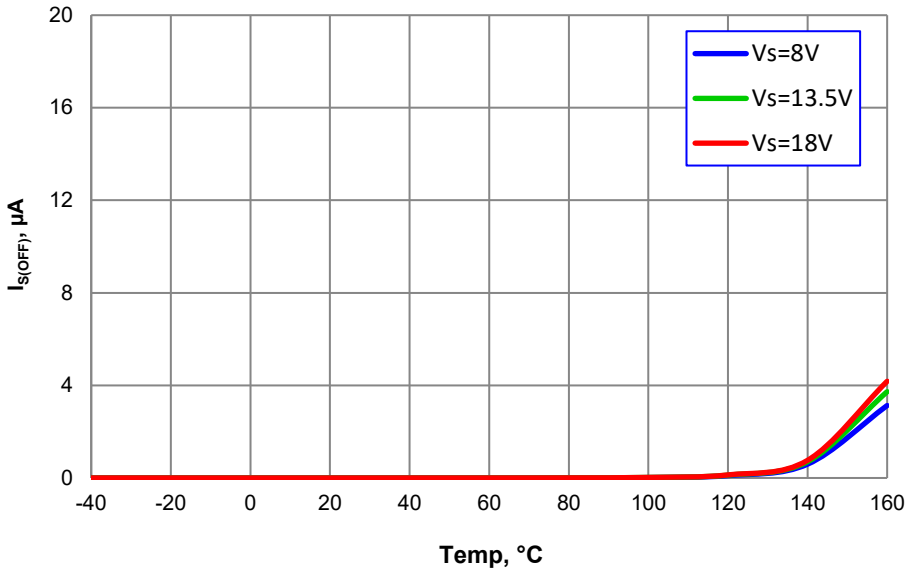


Figure 20. Standby Current for Whole Device with Load, $I_{S(OFF)} = f(T_J;V_S)$

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Characterisation – Power Stage

Output Voltage Drop Limitation at Low Load Current

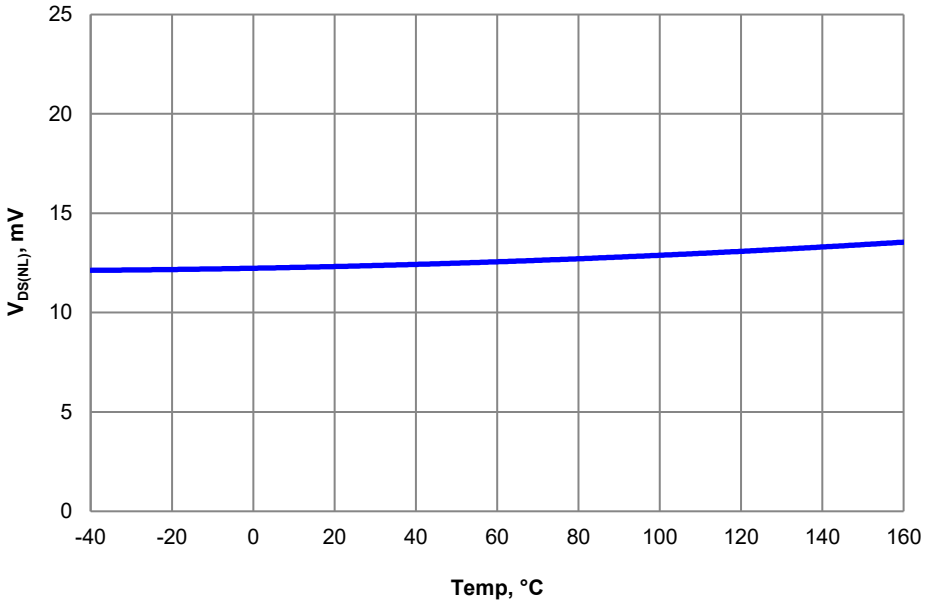


Figure 21. Output Voltage Drop Limitation at Low Load Current $V_{DS(NL)} = f(T_J)$, I_{Load} = 50mA

Drain to Source Clamp Voltage

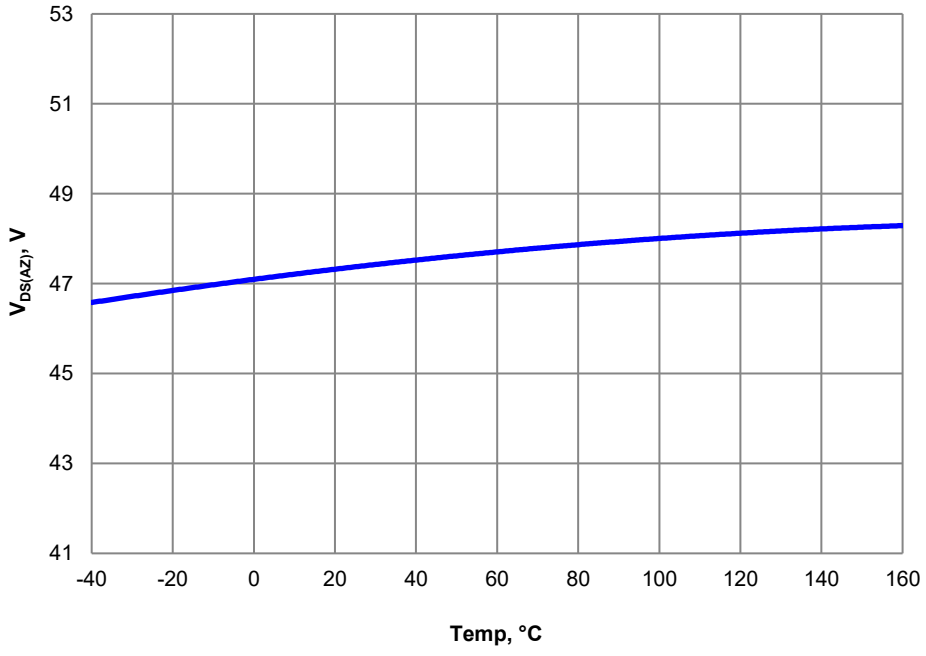


Figure 22. Drain to Source Clamp Voltage $V_{DS(AZ)} = f(T_J)$

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Characterisation – Power Stage (continued)

Slew Rate at Turn ON

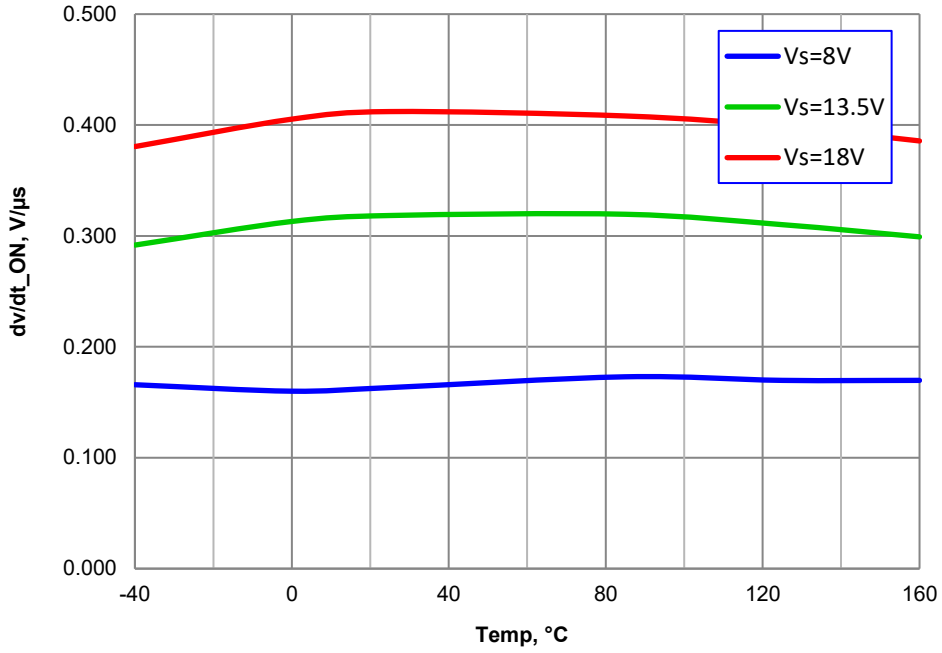


Figure 23. Slew Rate at Turn ON $dv/dt_{ON} = f(T_J;V_S)$, $R_L = 6\Omega$

Slew Rate at Turn OFF

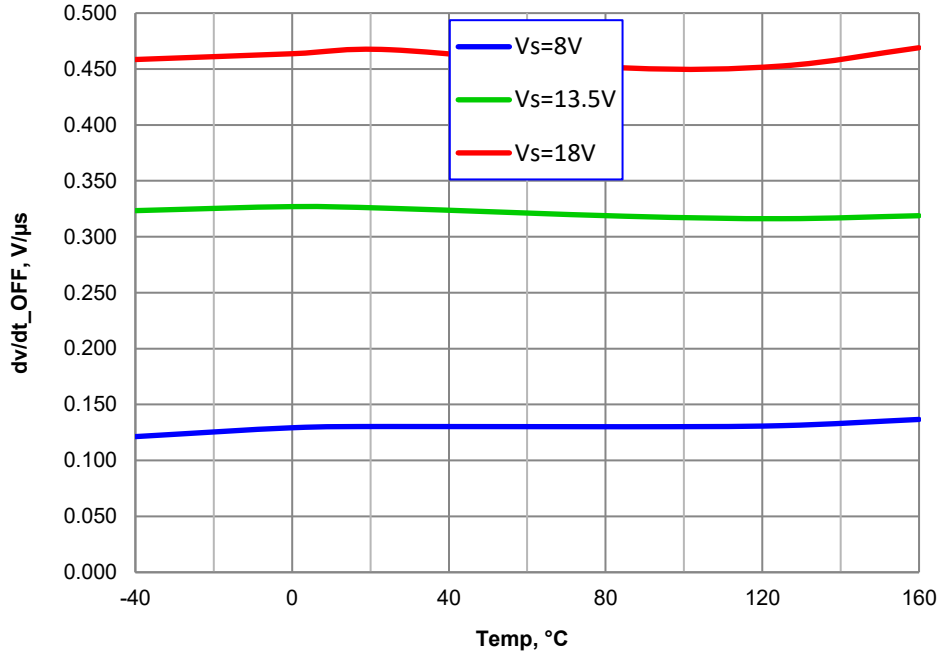


Figure 24. Slew Rate at Turn OFF $dv/dt_{OFF} = f(T_J;V_S)$, $R_L = 6\Omega$

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Characterisation – Power Stage (continued)

Turn ON Time

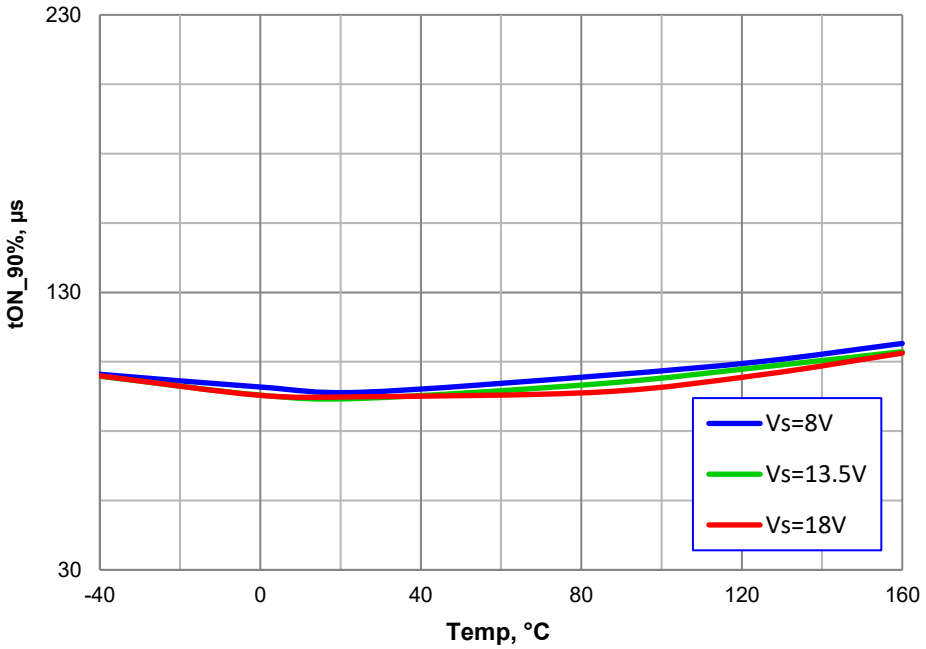


Figure 25. Turn ON $t_{ON} = f(T_J;V_S)$, $R_L = 6\Omega$

Turn OFF Time

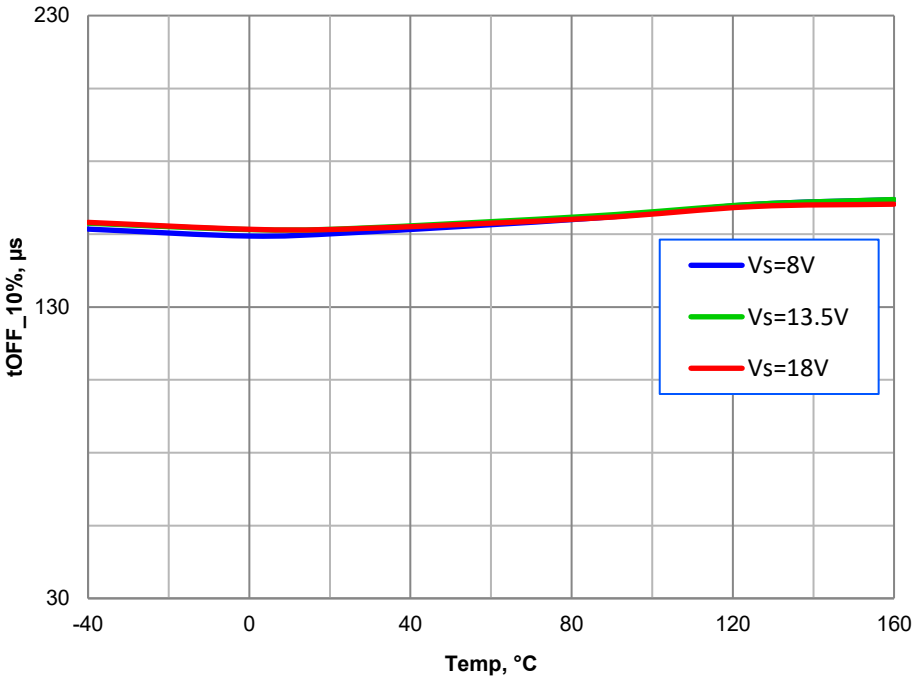


Figure 26. Turn OFF $t_{OFF} = f(T_J;V_S)$, $R_L = 6\Omega$

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Characterisation – Power Stage (continued)

Switch ON Energy

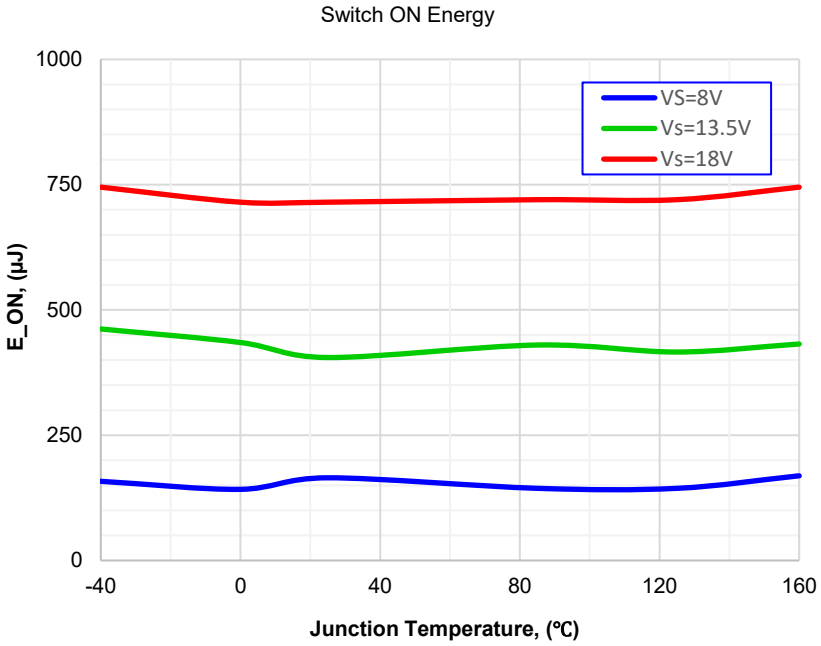


Figure 27. Switch ON Energy E_{ON} = f(T_J;V_S), R_L = 6Ω

Switch OFF Energy

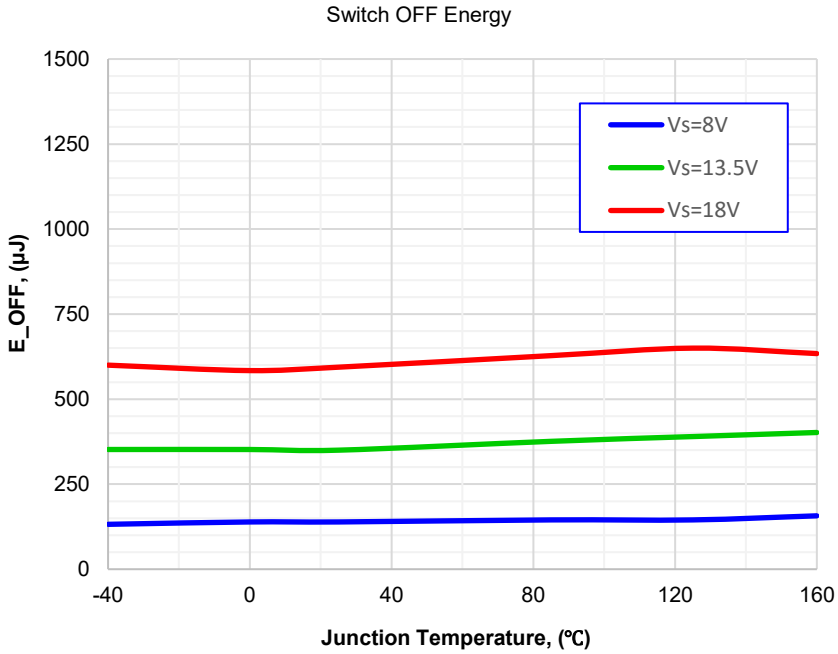


Figure 28. Switch OFF Energy E_{OFF} = f(T_J;V_S), R_L = 6Ω

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Characterisation – Protection

Overload Condition with Low Output Voltage Drop

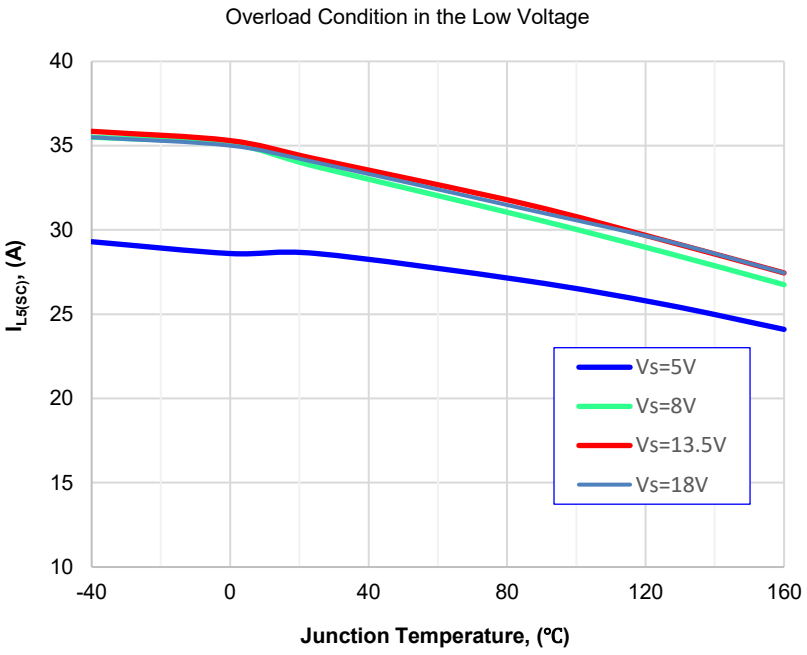


Figure 29. Overload Condition with Low Output Voltage Drop $I_{L5(SC)} = f(T_J)$

Overload Condition with High Output Voltage Drop

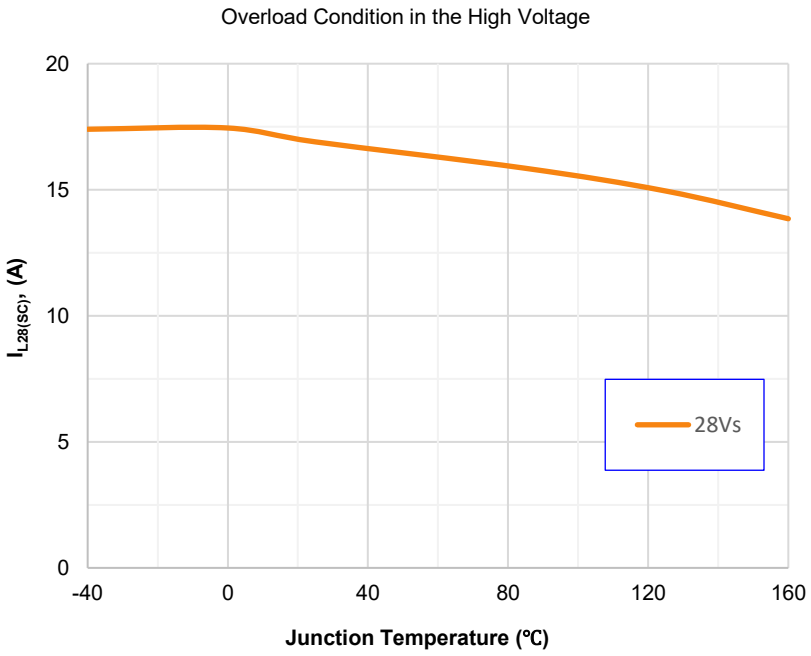


Figure 30. Overload Condition with High Output Voltage Drop $I_{L28(SC)} = f(T_J)$

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Characterisation – Diagnostic Mechanism

Current Sense at No Load

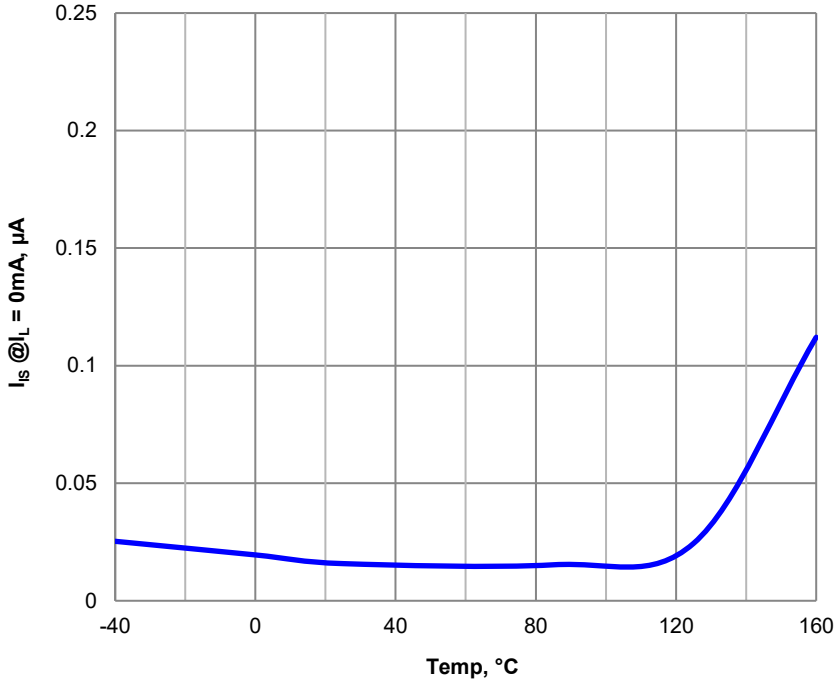


Figure 31. Current Sense at No Load $I_{IS} = f(T_J)$

Open-Load Detection Threshold in ON State

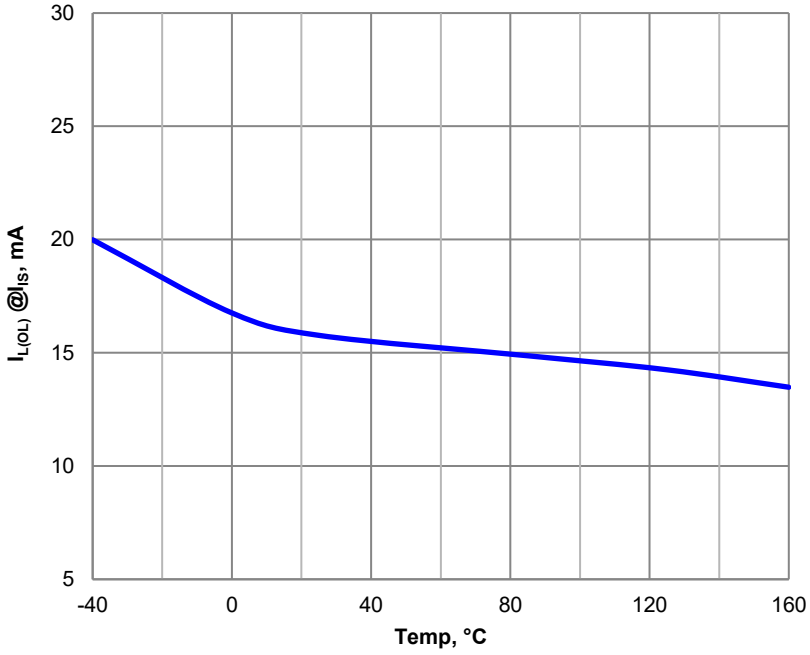


Figure 32. Open-Load Detection ON-State Threshold $I_{L(OL)} = f(T_J)$

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Characterisation – Diagnostic Mechanism (continued)

Sense Signal Maximum Voltage

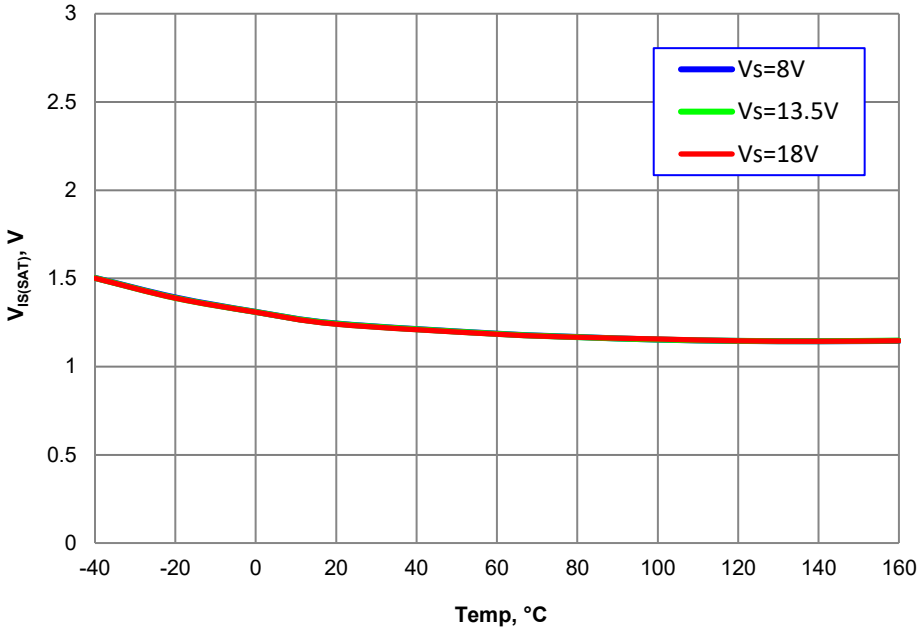


Figure 33. Sense Signal Maximum Voltage $V_{IS(SAT)} = f(T_J;V_S)$

Sense Signal Maximum Current

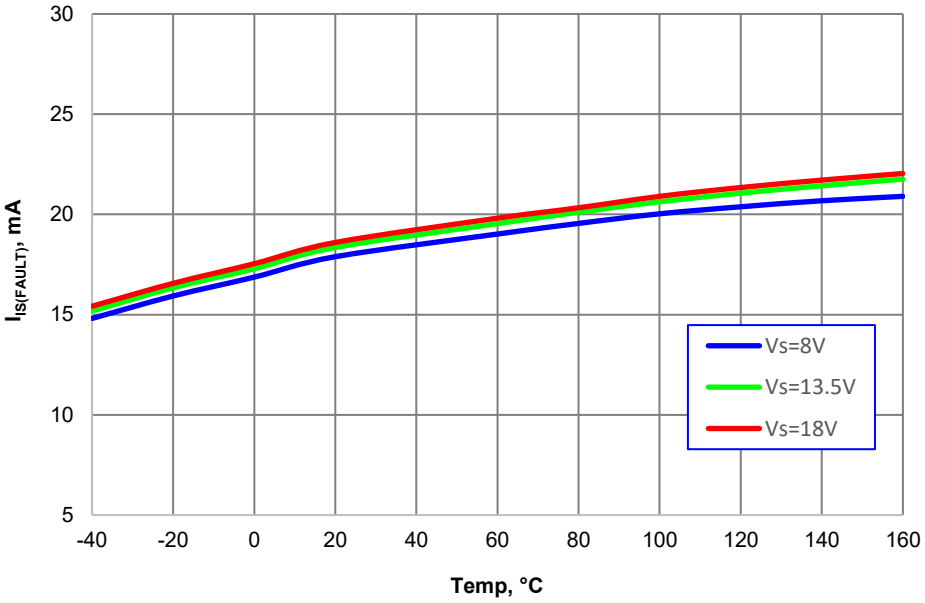


Figure 34. Sense Signal Maximum Current in Fault Condition $I_{IS(FAULT)} = f(T_J;V_S)$

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Characterisation – Input Pins

Input Voltage Threshold ON to OFF

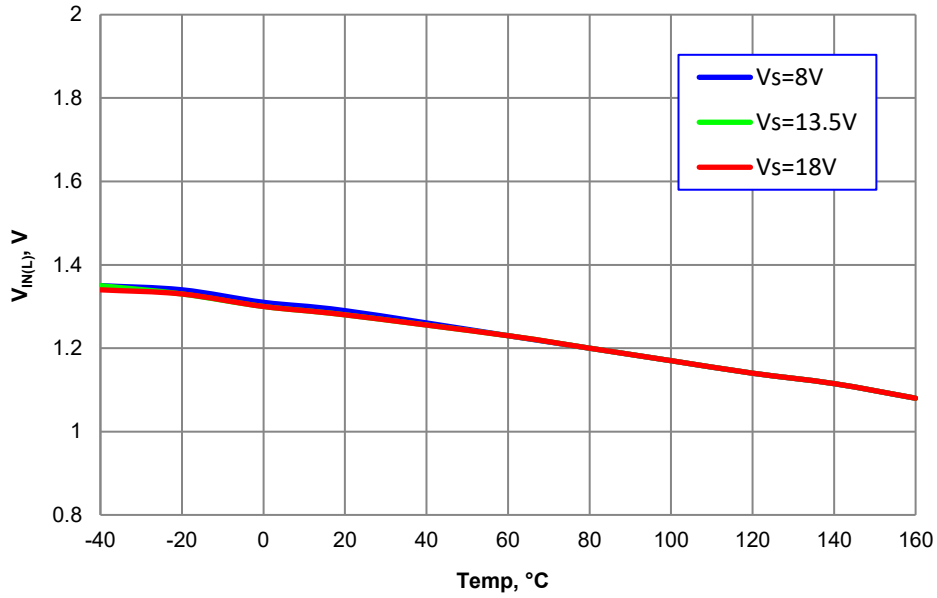


Figure 35. Input Voltage Threshold $V_{IN(L)} = f(T_J;V_S)$

Input Voltage Threshold OFF to ON

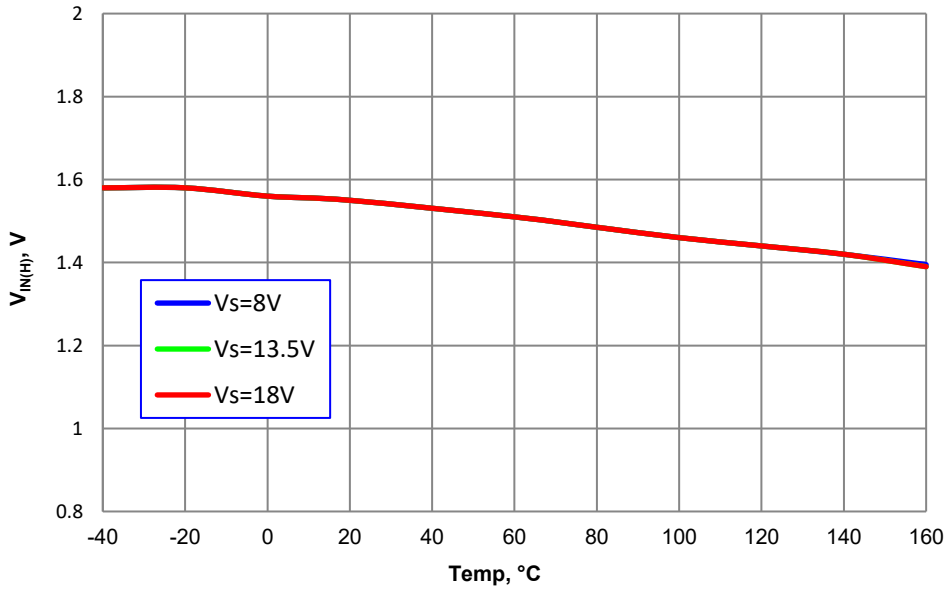


Figure 36. Input Voltage Threshold $V_{IN(H)} = f(T_J;V_S)$

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Characterisation – Input Pins (continued)

Input Voltage Hysteresis

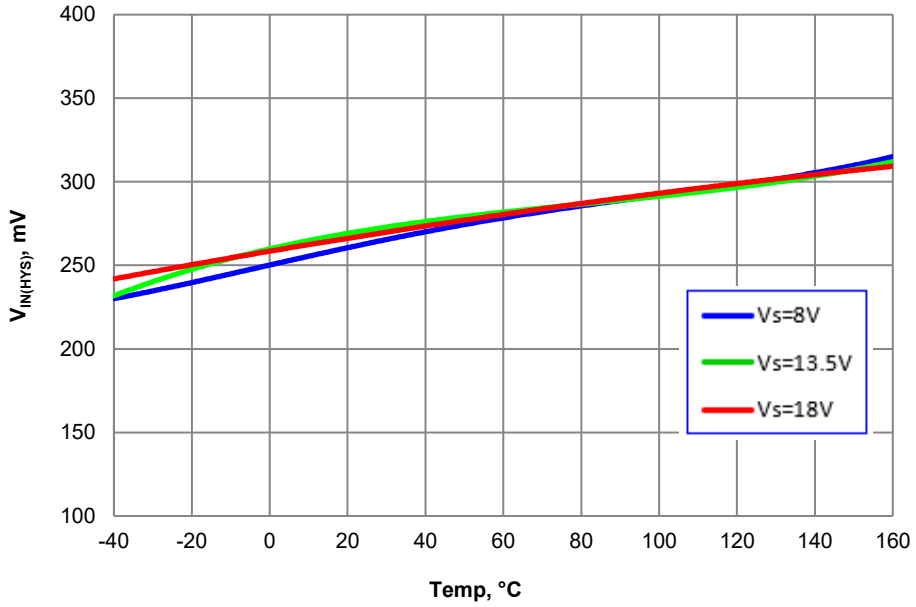


Figure 37. Input Voltage Hysteresis $V_{IN(HYS)} = f(T_J;V_S)$

Input Current High Level

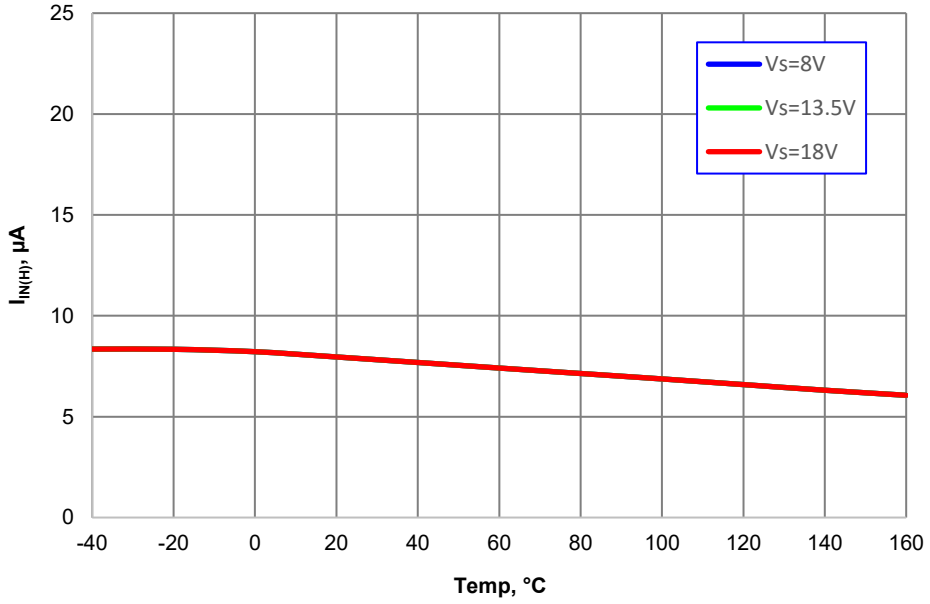


Figure 38. Input Current High Level $I_{IN(H)} = f(T_J;V_S)$

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Application Information (Note 23)

Note: The following information is given as a hint for the implementation of the device only and shall not be regarded as a description or warranty of a certain functionality, condition or quality of the device.

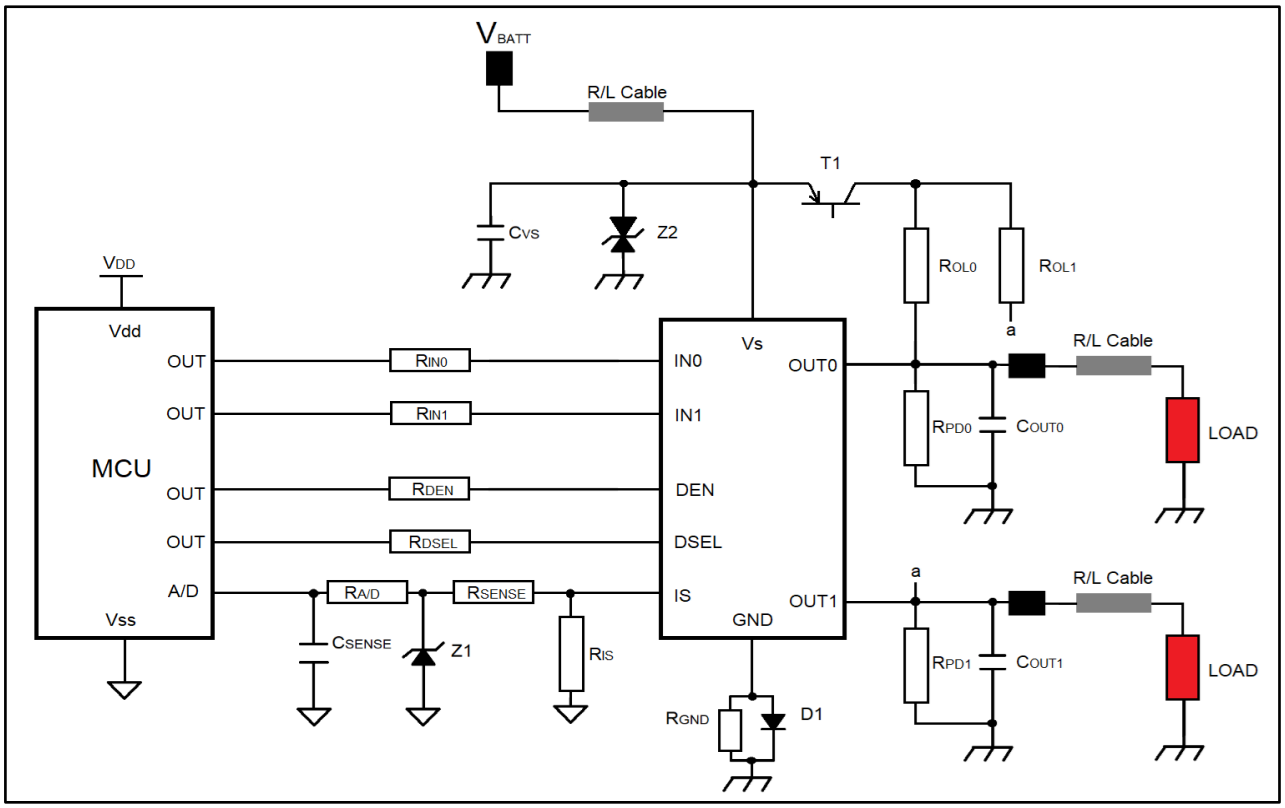


Figure 39. Application Circuit Diagram

Note: 23. This is a simplified example of an application circuit. The function must be verified in the real application.

Reference	Value	Purpose
R_{INx}	4.7kΩ	Connect to the micro controller for overvoltage, reverse-polarity protections
R_{DEN}	4.7kΩ	Connect to the micro controller for overvoltage, reverse-polarity protections
R_{PDx}	47kΩ	Improve immunity to electromagnetic noise
R_{IS}	1.2kΩ	Sense resistor
R_{SENSE}	4.7kΩ	Overvoltage, reverse polarity, loss of ground. Value to be tuned with micro controller specification
R_{OLx}	1.5kΩ	For open load in OFF diagnostic
$R_{A/D}$	4.7kΩ	Protection for the micro controller during overvoltage, reverse polarity
R_{GND}	1kΩ	To keep the device GND at a stable potential during clamping
D1	BAS21	Protection of the device during reverse polarity
Z1	7V Zener diode	Protection of the micro controller during overvoltage
Z2	36V Zener diode	Protection of the device during overvoltage
T1	BC 807	Switch the battery voltage for open load in OFF diagnostic
C_{SENSE}	100pF	Sense signal filtering
C_{VS}	100nF	Filtering of the voltage spikes on the battery line
C_{OUTx}	4.7nF	Protection of the device during ESD and BCI

Table 4. Bill of Materials

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Ordering Information (Note 24)

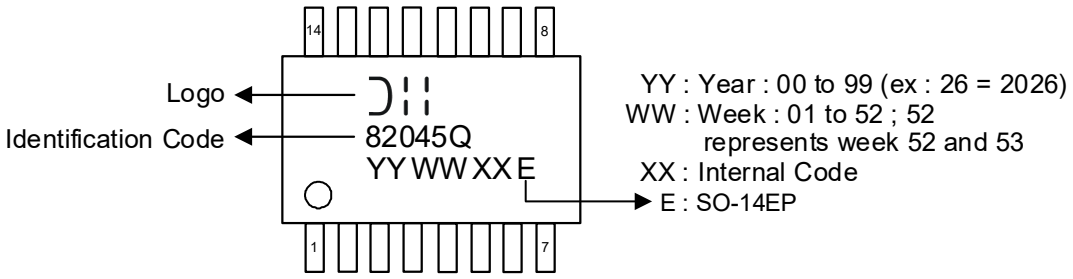
Orderable Part Number	Package	Identification Code	Reel Size (inches)	Tape Width (mm)	Packing	
					Qty.	Carrier
ZXMS82045S14PQ-13	SO-14EP	82045Q	13	16	2500	Reel

Note: 24. For packaging details, go to our website at https://www.diodes.com/design/support/packaging/diodes-packaging/.

Marking Information

SO-14EP

(Top View)



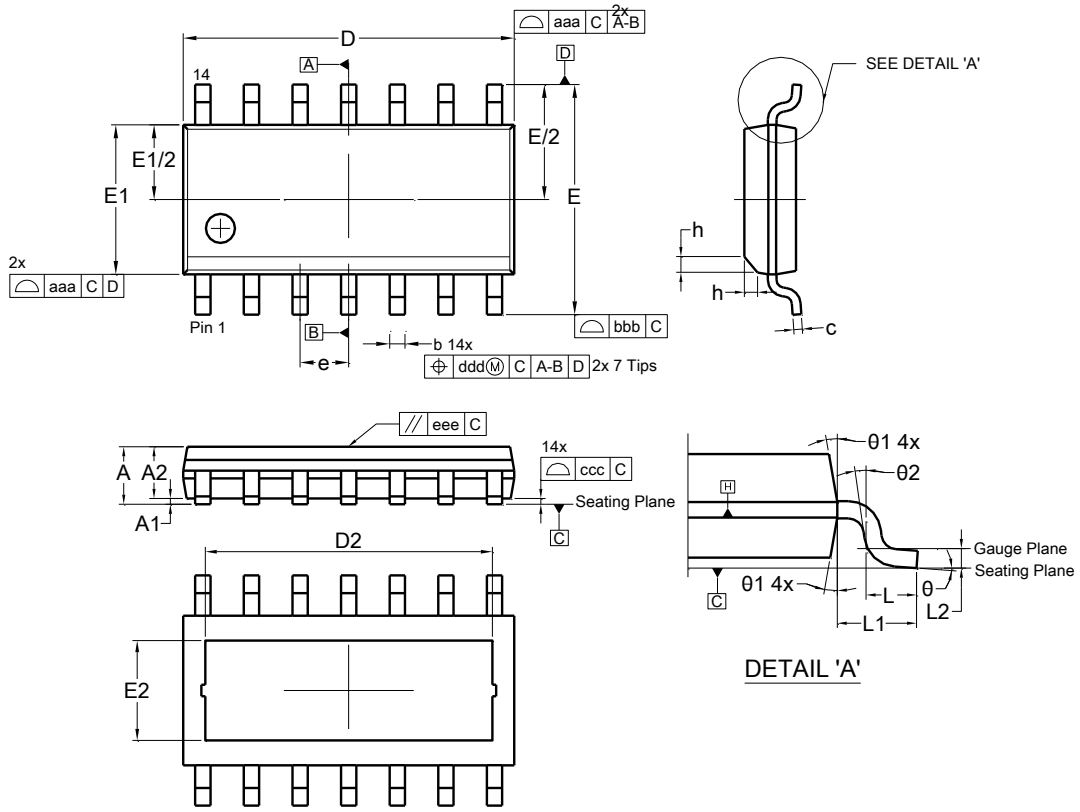
Orderable Part Number	Package	Identification Code
ZXMS82045S14PQ-13	SO-14EP	82045Q

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Package Outline Dimensions

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

SO-14EP

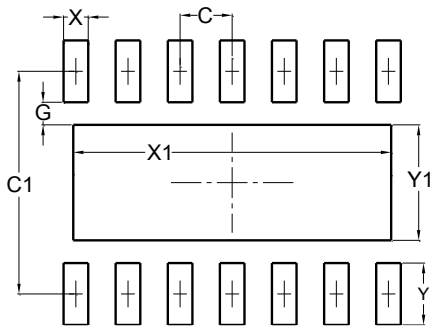


SO-14EP			
Dim	**Min**	**Max**	**Typ**
A	--	1.75	--
A1	0.00	0.10	--
A2	1.25	1.55	--
b	0.31	0.51	--
c	0.10	0.25	--
D	8.55	8.75	--
D2	7.40	7.60	7.50
E	5.80	6.20	--
E1	3.80	4.00	--
E2	2.50	2.70	2.60
e	1.27 BSC		
h	0.25	0.50	--
L	0.40	1.27	--
L1	1.04 REF		
L2	0.25 BSC		
θ	0°	8°	--
θ1	5°	15°	--
θ2	0°	--	--
aaa	0.10		
bbb	0.20		
ccc	0.10		
ddd	0.25		
eee	0.10		
All Dimensions in mm			

Suggested Pad Layout

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

SO-14EP



Dimensions	Value (in mm)
C	1.270
C1	5.400
G	0.550
X	0.600
X1	7.750
Y	1.500
Y1	2.800

Mechanical Data

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish – Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208 e3
- Weight: 0.15 grams (Approximate)

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