Description

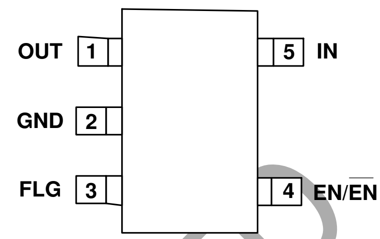
The DIODES™ AP22811 is a single channel current-limited integrated high-side power switch optimized for Universal Serial Bus (USB) and other hot-swap applications. The family of devices complies with USB standards and is available with both polarities of Enable input.

The device has fast short-circuit response time for improved overall system robustness, and has an integrated output discharge function to ensure completely controlled discharging of the output voltage capacitor. They provide a complete protection solution for applications subject to heavy capacitive loads and the prospect of short circuit, and offer reverse current blocking, over-current, over-temperature and short-circuit protection, as well as controlled rise time and under-voltage lockout functionality. A 6ms deglitch capability on the open-drain Flag output prevents false over-current reporting and does not require any external components.

The AP22811 is available in standard Green SOT25 and MSOP-8 packages with RoHS compliance.

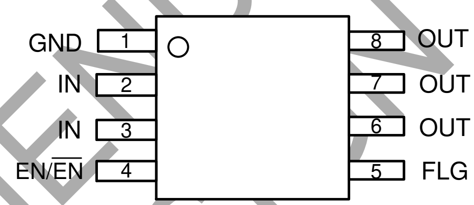
Pin Assignments

SOT25



Top View

MSOP-8



Top View

Features

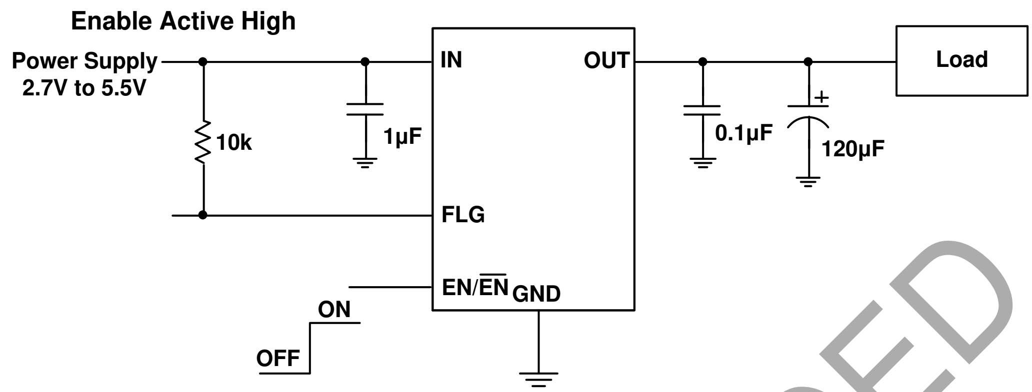
- Input Voltage Range: 2.7V to 5.5V
- 50mΩ On-Resistance
- Built-in Soft-Start with 0.6ms Typical Rise Time
- Fault Report (FLG) with Blanking Time (6ms Typ.)
- ESD Protection: 2kV HBM, 200V MM
- Active Low (B) or Active High (A) Enable
- Protection
  - Over Current with Auto Recovery
  - Short Circuit with Auto Recovery
  - Over Temperature with Auto Recovery
- Output Reverse Current/Voltage Protection
- Thermally Efficient Low Profile Package
- UL Recognized, File Number E322375
- IEC60950-1 CB Scheme Certified
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/104/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative. https://www.diodes.com/quality/product-definitions/**

Applications

- Integrated load switches in Ultrabook PC's
- Power up/down sequencing in Ultrabook PC's
- Notebooks
- Netbooks
- Set-top boxes
- SSD (solid state drives)
- Consumer electronics
- Tablet PC
- Telecom systems

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.

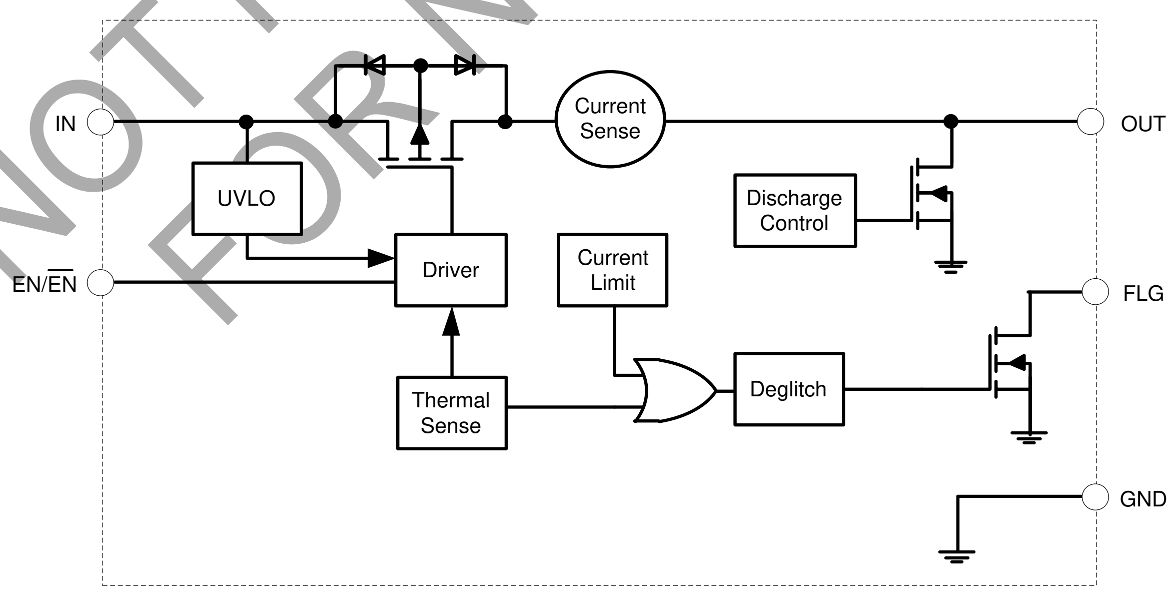
Typical Applications Circuit



Pin Descriptions

Pin Number		Pin Name	Function
SOT25	MSOP-8		
1	6, 7, 8	OUT	Voltage Output Pin, connect a 0.1µF bypass capacitor and a high-value capacitor to GND, close to IC. (At least 10µF in USB application.)
2	1	GND	Ground Pin of the Circuitry
3	5	FLG	Over Current and Over Temperature fault report; Open-Drain flag is active low when triggered.
4	4	EN/$\overline{EN}$	Enable Input
			AP22811A: Active High
			AP22811B: Active Low
5	2, 3	IN	Voltage Input Pin, connect a 1µF low ESR capacitor to GND, close to IC.

Functional Block Diagram



Absolute Maximum Ratings (@ T_A = +25°C, unless otherwise specified.) (Note 4)

Symbol	Parameter		Ratings	Unit
ESD HBM	Human Body ESD Protection		2000	V
ESD MM	Machine Model ESD Protection		200	V
V_{IN}	Input Voltage		-0.3 to 6.0	V
V_{OUT}	Output Voltage		-0.3 to (V_{IN} +0.3)	V
$V_{EN/\overline{EN}}$	Enable Voltage		-0.3 to (V_{IN} +0.3)	V
I_L	Load Current		Internal Limited	A
$T_{J(max)}$	Maximum Junction Temperature		+150	°C
T_{ST}	Storage Temperature		-65 to +150	°C
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	SOT25 (Note 6)	123	°C/W
		MSOP-8 (Note 5)	165	°C/W
$R_{\theta JC}$	Thermal Resistance, Junction to Case	SOT25 (Note 6)	33	°C/W
		MSOP-8 (Note 5)	33	°C/W

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. Test condition for MSOP-8: Device mounted on 1" x 1"/2" x 2" FR-4 substrate PC board, 2oz copper with minimum recommended pad layout.

6. $R_{\theta JA}$ and $R_{\theta JC}$ are measured at T_A = +25°C on a high effective thermal conductivity four-layer test board per JEDEC 51-7.

Recommended Operating Conditions (Note 7)

Symbol	Parameter	Min	Max	Unit
V_{IN}	Input Voltage	2.7	5.5	V
I_{OUT}	Output Current	0	2	A
V_{IL}	EN/$\overline{EN}$ Input Logic Low Voltage	0	0.5	V
V_{IH}	EN/$\overline{EN}$ Input Logic High Voltage	1.5	V_{IN}	V
T_A	Operating Ambient Temperature	-40	+85	°C

Note: 7. Refer to the typical application circuit.

Electrical Characteristics (V_{IN} = 5V @ T_A = +25°C, C_{IN} = 1µF, C_L = 100nF, unless otherwise specified.)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{UVLO}	Input UVLO	V_{IN} Rising	1.6	2.0	2.4	V
ΔV_{UVLO}	Input UVLO Hysteresis	V_{IN} Decreasing	—	180	—	mV
I_{SHDN}	Input Shutdown Current	Disabled, OUT = Open	—	0.1	1	µA
I_Q	Input Quiescent Current	Enabled, OUT = Open	—	80	—	µA
I_{LEAK}	Input Leakage Current	Disabled, OUT Grounded	—	0.1	1	µA
I_{REV}	Reverse Leakage Current	Disabled, V_{IN} = 0V, V_{OUT} = 5V, I_{REV} at V_{IN}	—	0.01	1	µA
$R_{DS(ON)}$	Switch On-Resistance	V_{IN} = 5V, I_{OUT} = 1A, T_A = +25°C	—	50	65	mΩ
		V_{IN} = 3.3V, I_{OUT} = 1A, T_A = +25°C	—	60	90	
I_{LIMIT}	Over Load Current Limit	V_{IN} = 5V, V_{OUT} = 4.5V	2.2	2.7	3.2	A
I_{SHORT}	Short-Circuit Current Limit	Enabled, Output short to ground	—	0.3	—	A
V_{IL}	EN/$\overline{EN}$ Input Logic Low Voltage	V_{IN} = 2.7V to 5.5V	—	—	0.5	V
V_{IH}	EN/$\overline{EN}$ Input Logic High Voltage	V_{IN} = 2.7V to 5.5V	1.5	—	—	V
$I_{LEAK-EN/\overline{EN}}$	EN/$\overline{EN}$ Input Leakage	V_{IN} = 5V, $V_{EN/\overline{EN}}$ = 0V and 5.5V	—	0.01	1	µA
I_{LEAK-O}	Output Leakage Current	Disabled, V_{OUT} = 0V	—	0.5	1	µA
$t_{D(ON)}$	Output Turn-On Delay Time	C_L = 4.7µF, R_{LOAD} = 10Ω @ V_{IN} = 3.3V Figure 1	—	1.7	—	ms
t_R	Output Turn-On Rise Time	C_L = 4.7µF, R_{LOAD} = 10Ω @ V_{IN} = 3.3V Figure 1	1.0	2.1	3.5	ms
$t_{D(OFF)}$	Output Turn-Off Delay Time	C_L = 4.7µF, R_{LOAD} = 10Ω @ V_{IN} = 3.3V Figure 1	—	20	—	µs
t_F	Output Turn-Off Fall Time	C_L = 4.7µF, R_{LOAD} = 100Ω @ V_{IN} = 3.3V Figure 1	—	0.65	—	ms
R_{FLG}	FLG Output FET On-Resistance	I_{FLG} = 10mA	—	40	60	Ω
I_{FOH}	FLG Off Current	V_{FLG} = 5V	—	0.01	1	µA
t_{BLANK}	FLG Blanking Time	Assertion or deassertion due to overcurrent and over-temperature condition	2	6	13	ms
t_{DIS}	Discharge Time	C_L = 1µF, V_{IN} = 5V, disabled to V_{OUT} < 0.5V	—	0.4	—	ms
R_{DIS}	Discharge Resistance	V_{IN} = 5V, Disabled, I_{OUT} = 1mA	—	90	130	Ω
T_{SHDN}	Thermal Shutdown Threshold	Enabled	—	+140	—	°C
T_{HYS}	Thermal Shutdown Hysteresis	—	—	+35	—	°C
V_{RVP}	Reverse-Voltage Comparator Trip Point	V_{OUT} - V_{IN}	25	50	75	mV
I_{ROCP}	Reverse Current Limit	V_{OUT} - V_{IN} = 100mV	—	400	—	mA
t_{TRIG}	Time from Reverse-Voltage Condition to MOSFET Turn off	V_{IN}	2	6	13	ms

Performance Characteristics

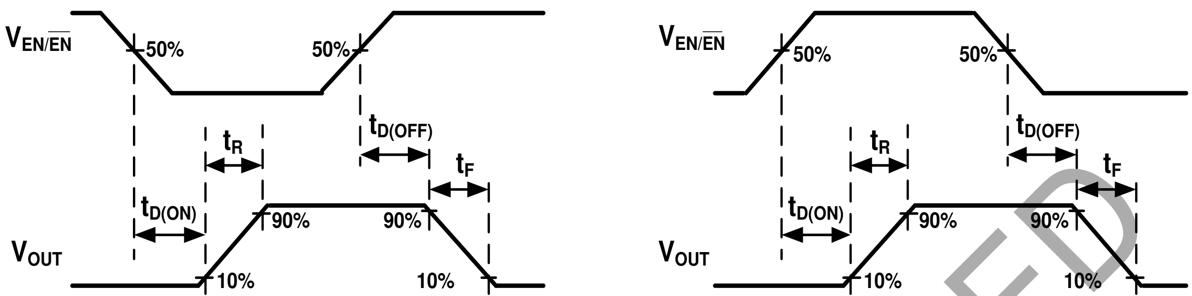
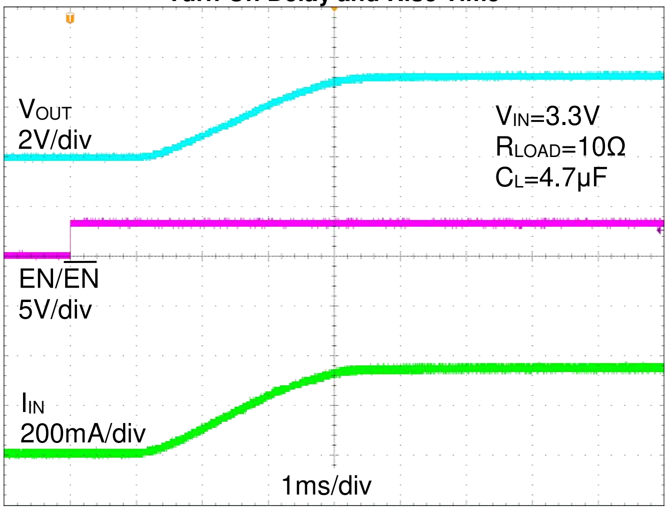


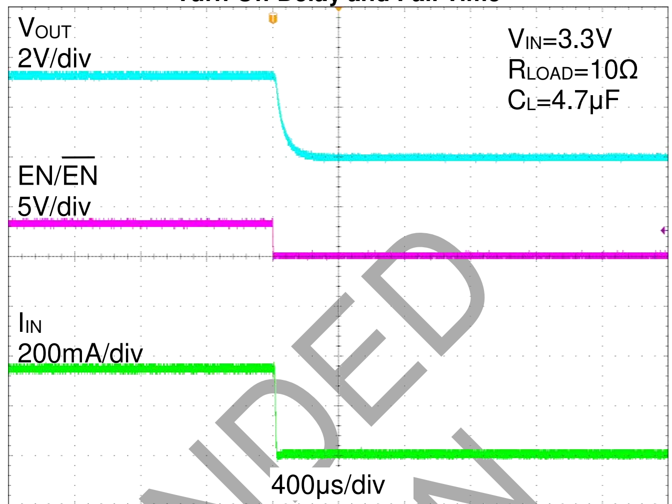
Figure 1. Voltage Waveforms: AP22811B (Active Low, Left), AP22811A (Active High, Right)

Performance Characteristics (continued) (T_A = +25°C, V_{IN} = 5V, C_{IN} = 1µF, C_L = 0.1µF, unless otherwise specified.)

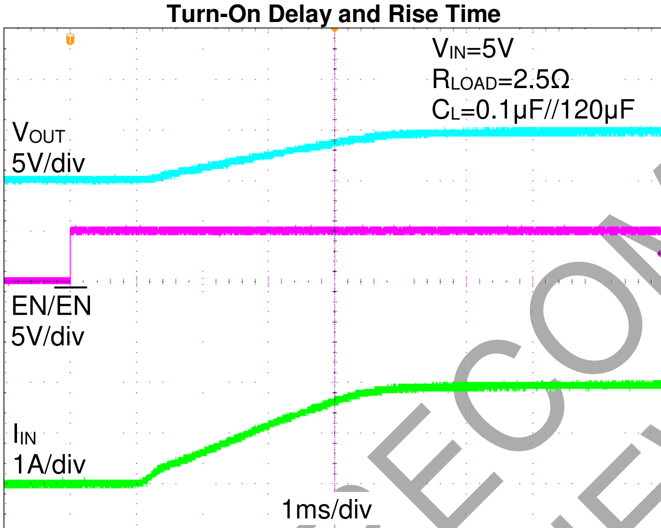
Turn On Delay and Rise Time



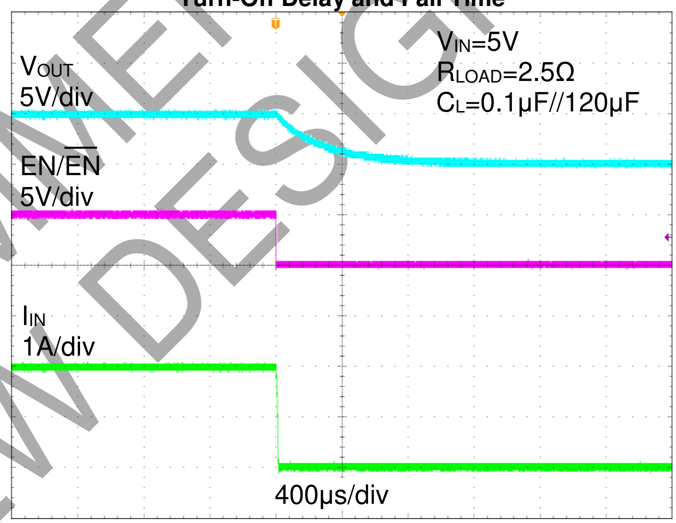
Turn Off Delay and Fall Time



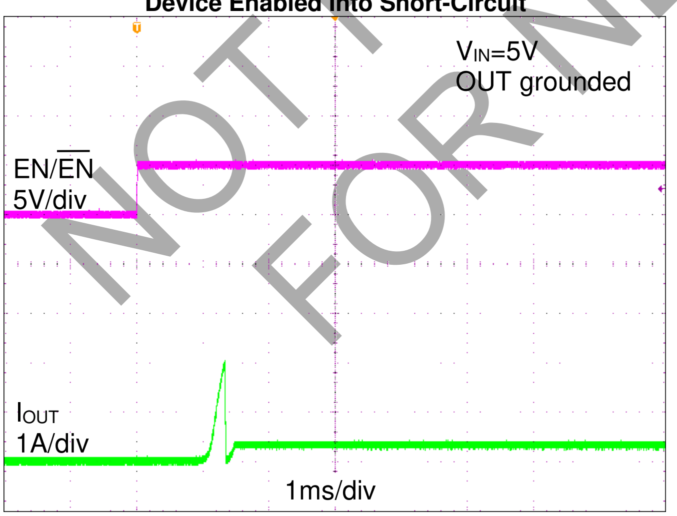
Turn-On Delay and Rise Time



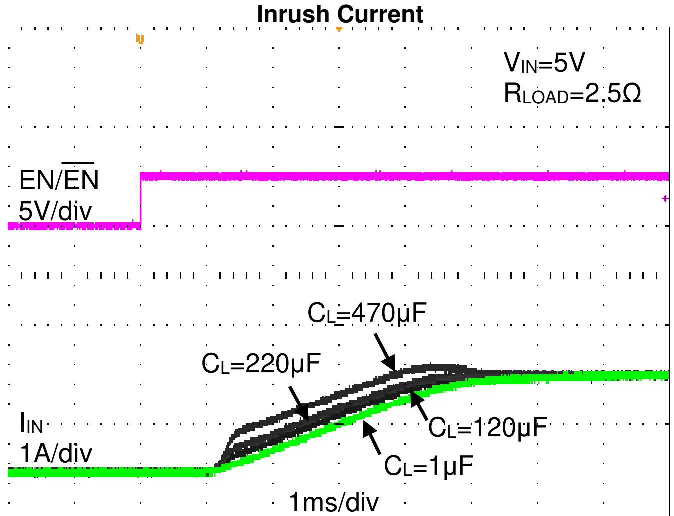
Turn-Off Delay and Fall Time



Device Enabled Into Short-Circuit

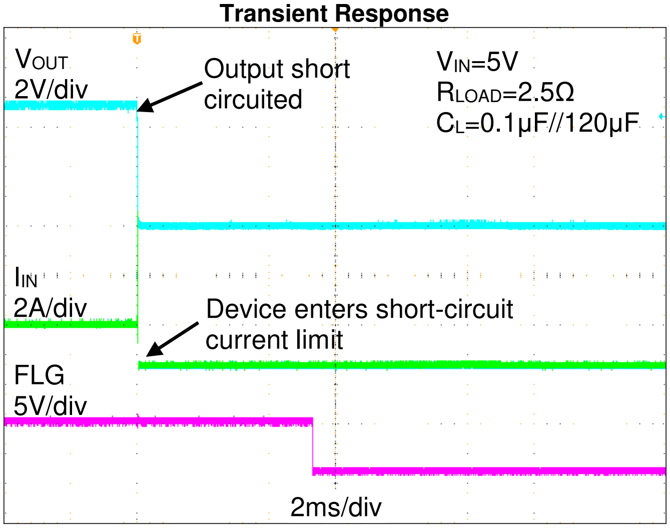


Inrush Current

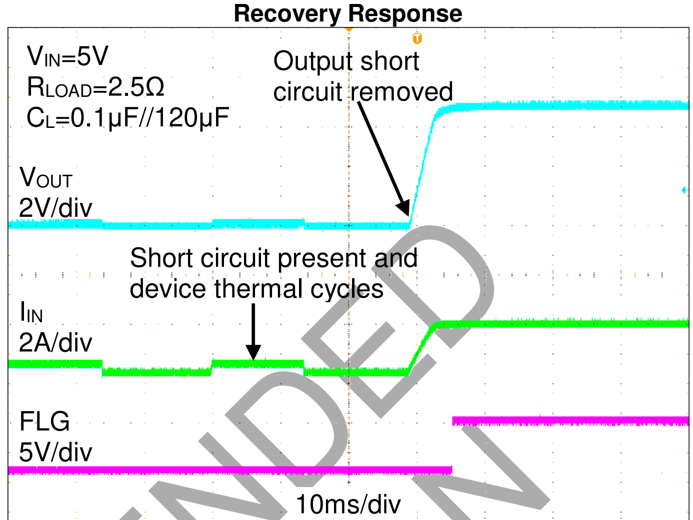


Performance Characteristics (continued) (T_A = +25°C, V_{IN} = 5V, C_{IN} = 1µF, C_L = 0.1µF, unless otherwise specified.)

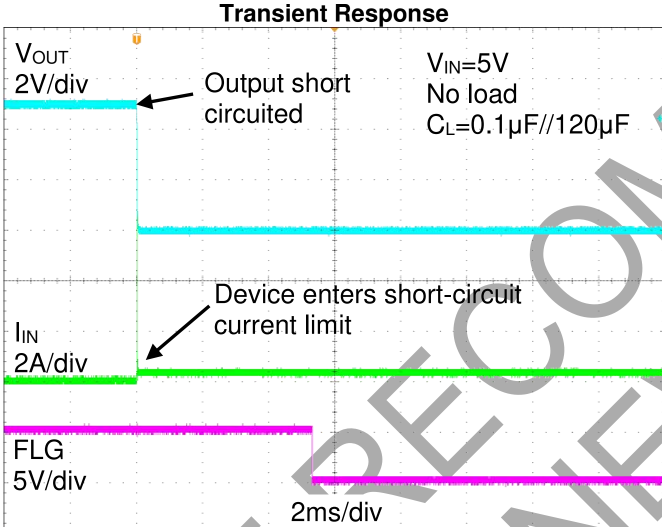
Full-Load to Short-Circuit Transient Response



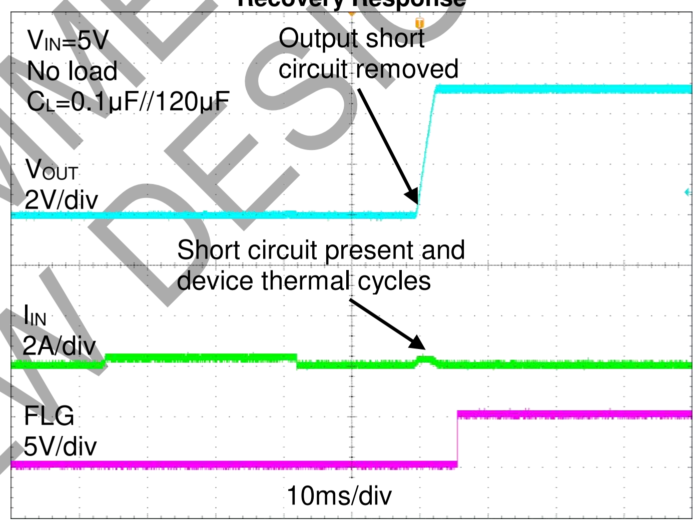
Short-Circuit to Full-Load Recovery Response



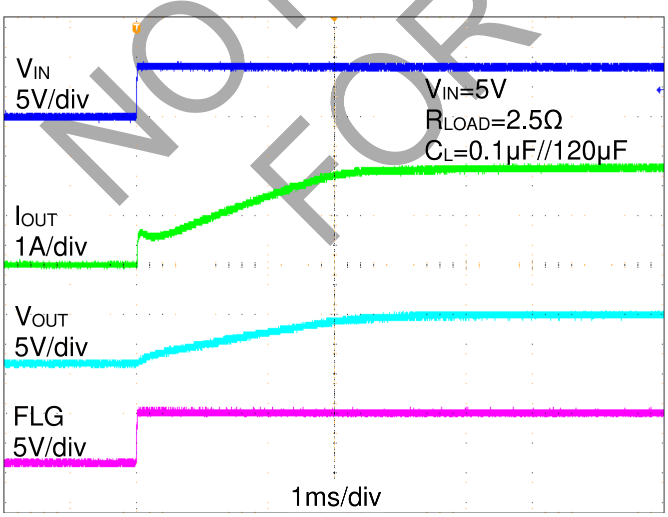
No-Load to Short-Circuit Transient Response



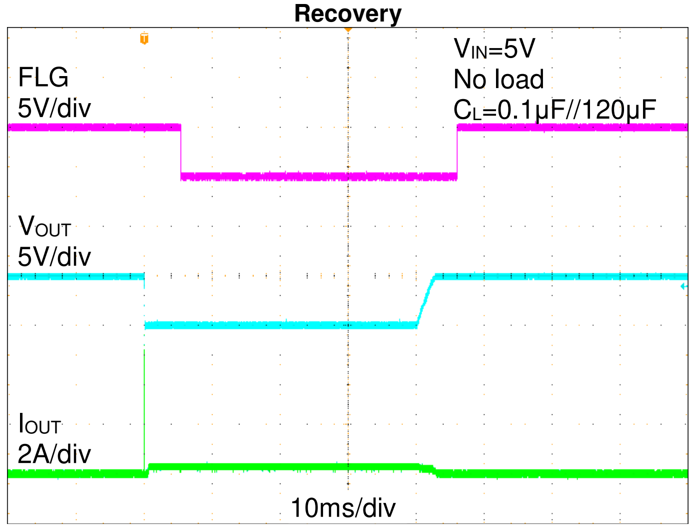
Short-Circuit to No-Load Recovery Response



Power ON

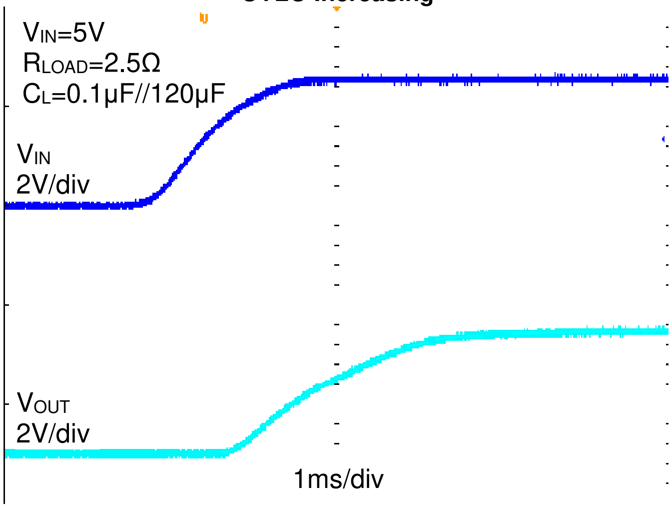


Short-Circuit with Blanking Time and Recovery

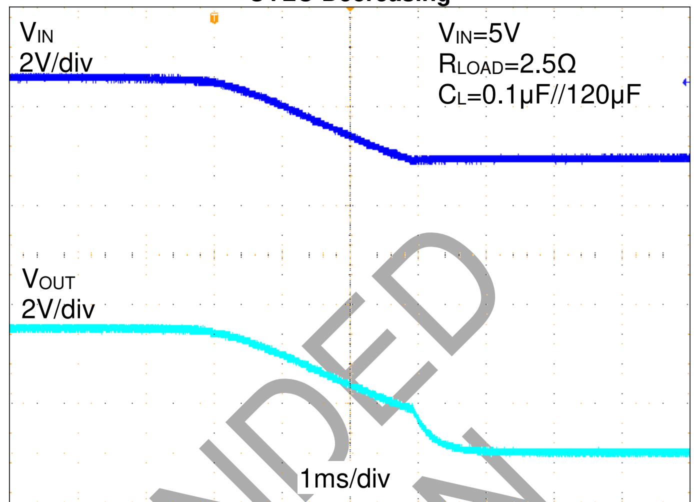


Performance Characteristics (continued) (T_A = +25°C, V_{IN} = 5V, C_{IN} = 1μF, C_L = 0.1μF, unless otherwise specified.)

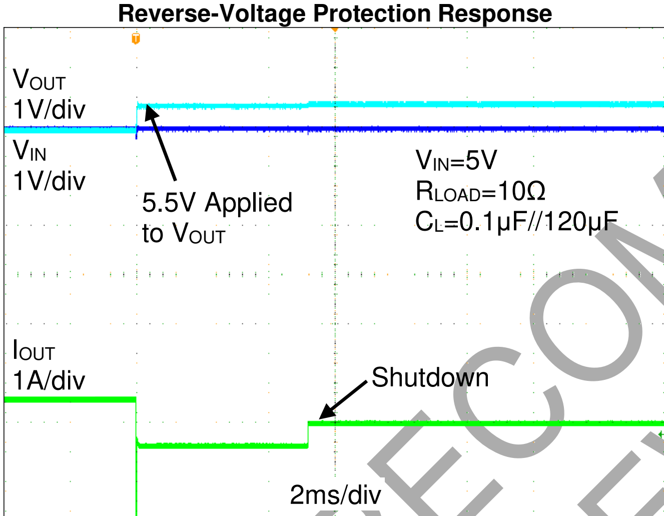
UVLO Increasing



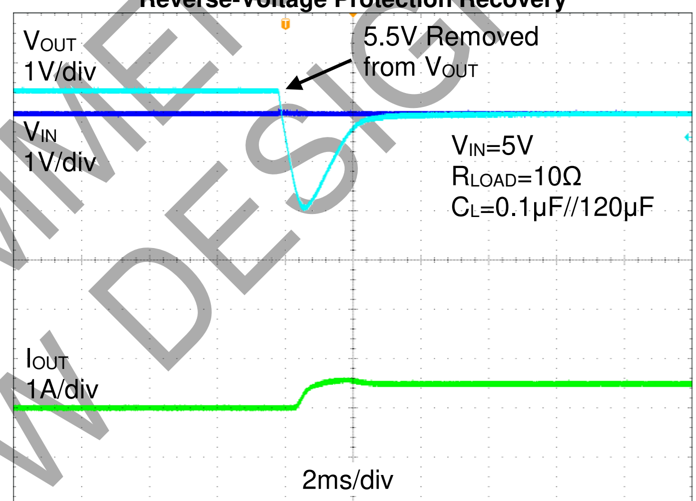
UVLO Decreasing



Reverse-Voltage Protection Response

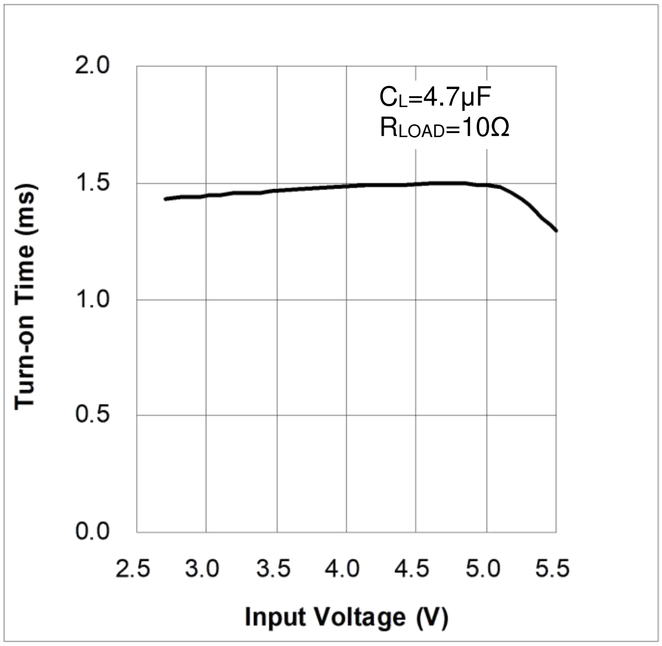


Reverse-Voltage Protection Recovery

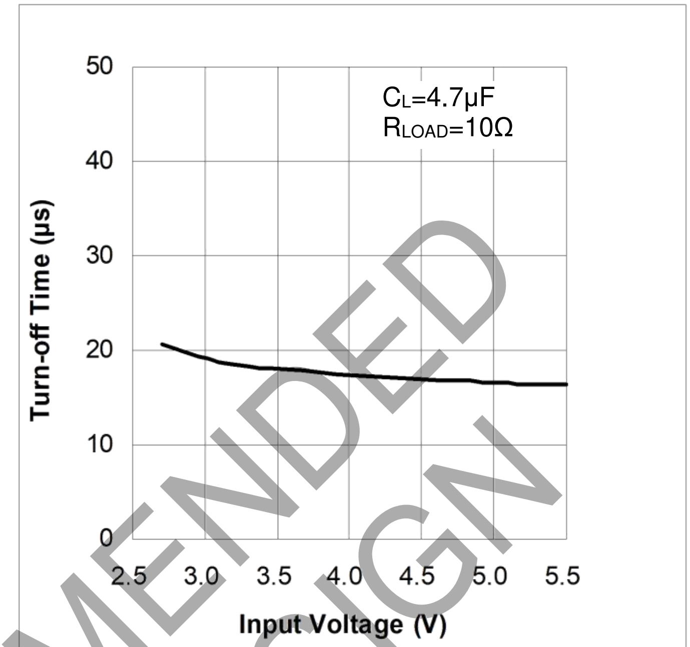


Performance Characteristics (continued) (T_A = +25°C, V_{IN} = 5V, C_{IN} = 1µF, C_L = 0.1µF, unless otherwise specified.)

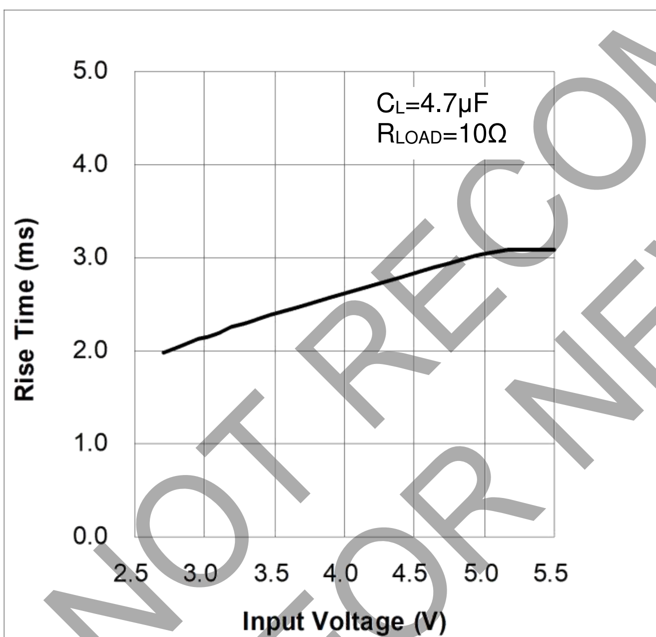
Turn-on Time vs. Input Voltage



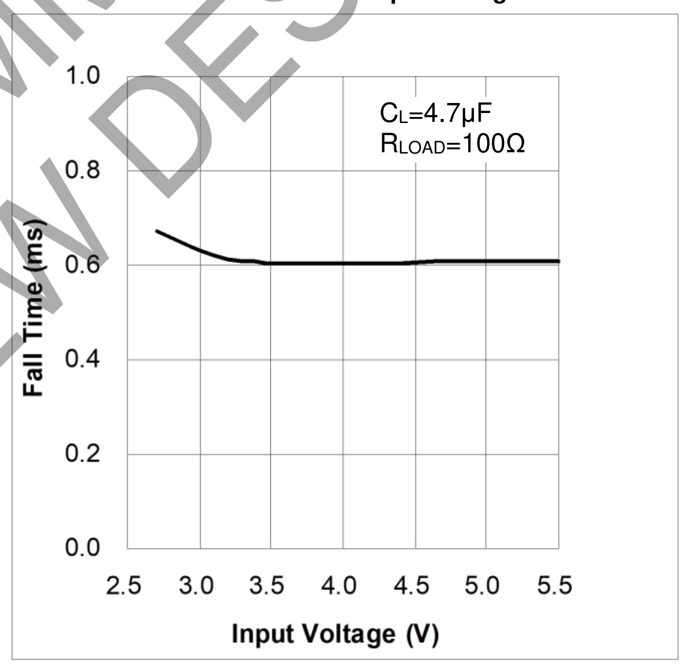
Turn-off Time vs. Input Voltage



Rise Time vs. Input Voltage

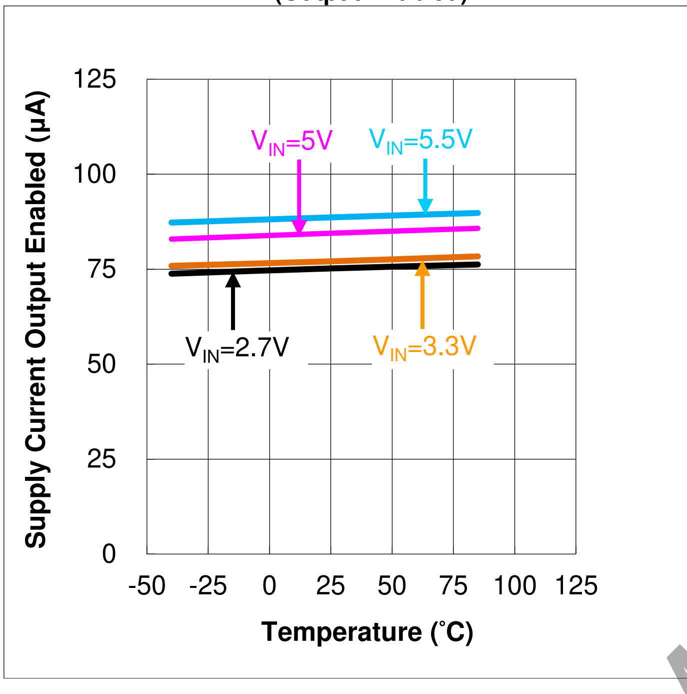


Fall Time vs. Input Voltage

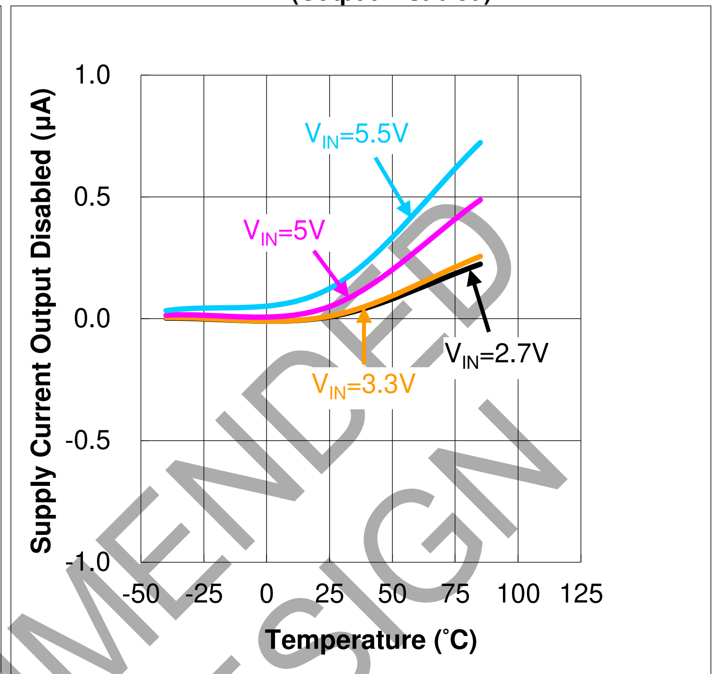


Performance Characteristics (continued) (T_A = +25°C, V_{IN} = 5V, C_{IN} = 1µF, C_L = 0.1µF, unless otherwise specified.)

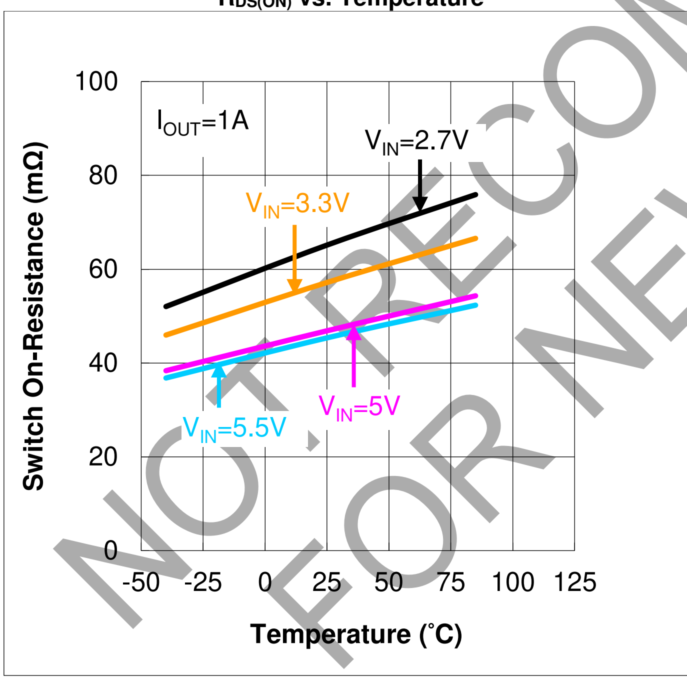
Supply Current vs. Temperature (Output Enabled)



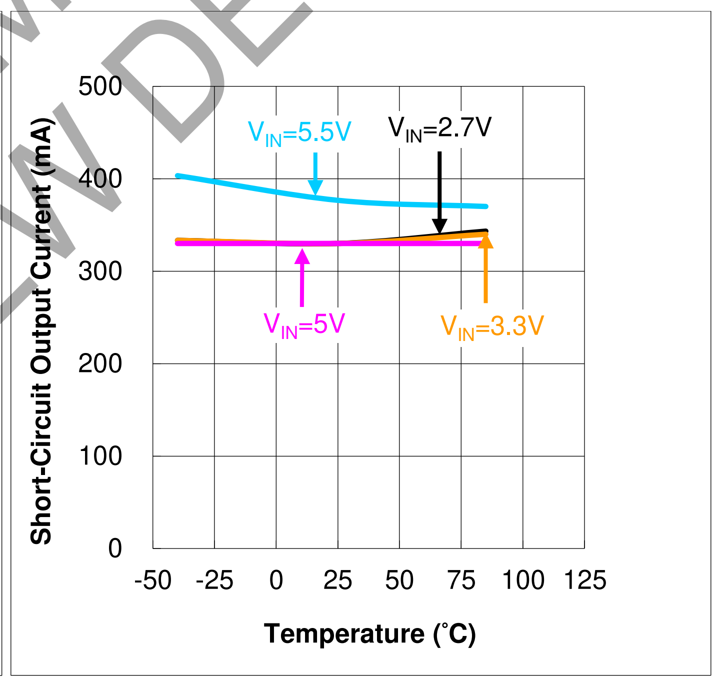
Supply Current vs. Temperature (Output Disabled)



$R_{DS(ON)}$ vs. Temperature

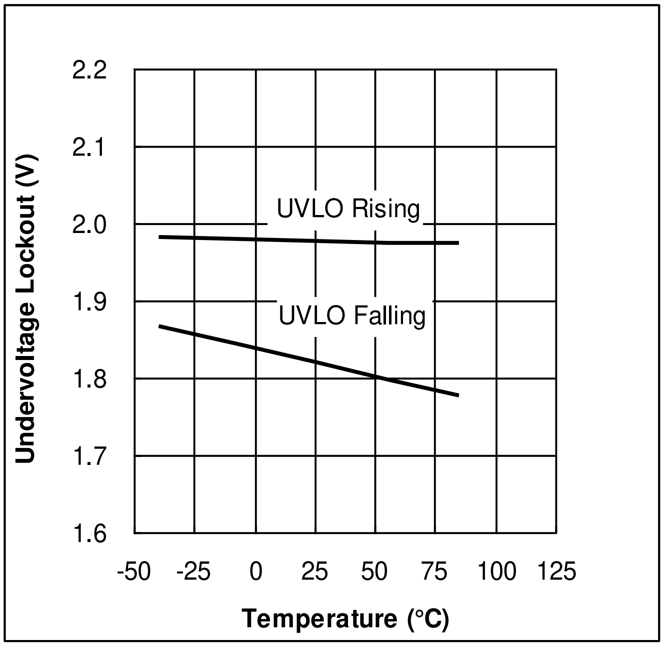


Short-Circuit Output Current vs. Temperature

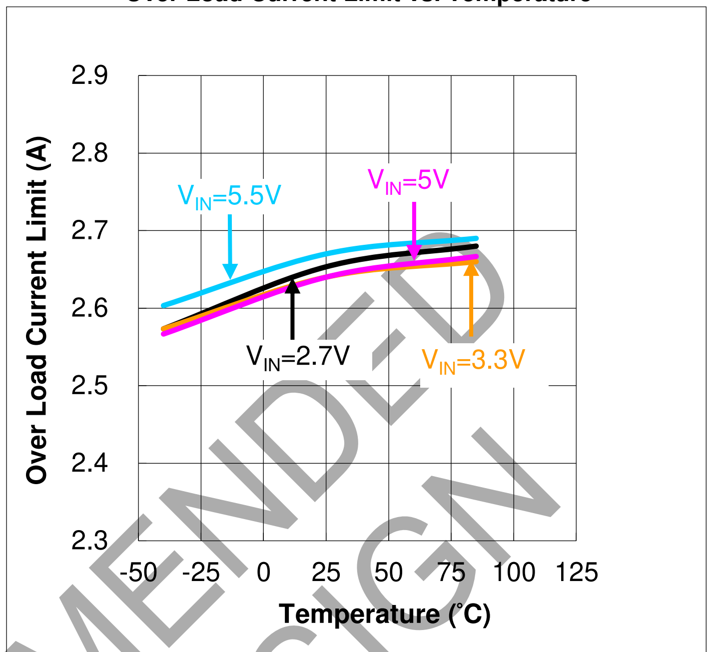


Performance Characteristics (continued) (T_A = +25°C, V_{IN} = 5V, C_{IN} = 1μF, C_L = 0.1μF, unless otherwise specified.)

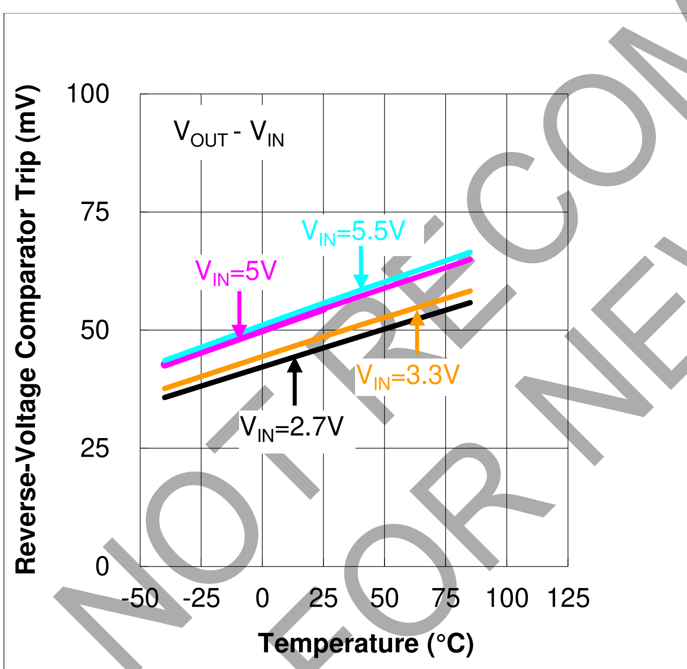
Under Voltage Lockout vs. Temperature



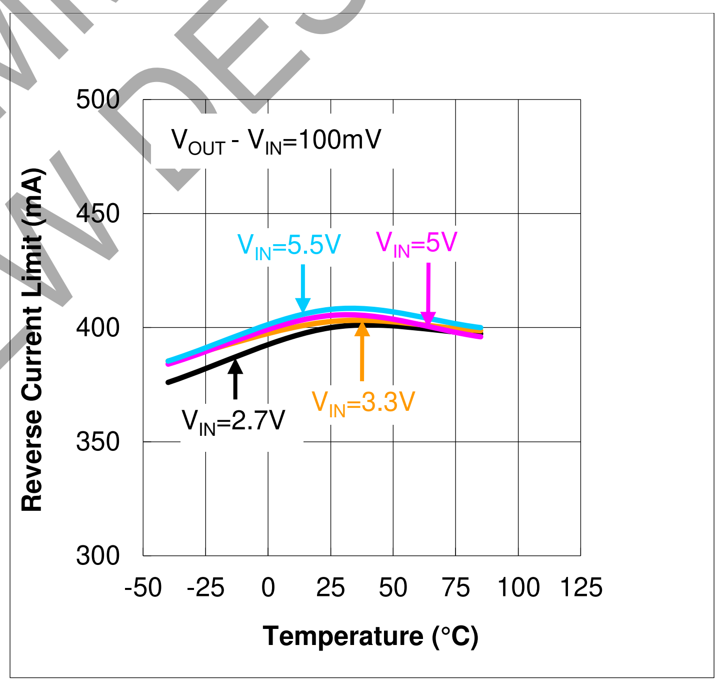
Over Load Current Limit vs. Temperature



Reverse-Voltage Comparator Trip vs. Temperature



Reverse Current Limit vs. Temperature



Application Information

Input and Output Capacitors

It is needed to place a 1μF X7R or X5R ceramic bypass capacitor between IN and GND, close to the device. Placing a high-value capacitor (10μF or 47μF) close to input pin is also recommended when the output transient load is heavy. This precaution reduces power-supply transients that may cause ringing on the input.

Connect a minimum 100μF low ESR electrolytic or tantalum capacitor (or 10μF MLCC) between OUT and GND is also needed for hot-plug applications. It's a must to bypass the output with a 0.1μF ceramic capacitor which improves the immunity of the device to short-circuit transients. The Bulky 100μF or larger capacitors help to reduce output droop voltage when a device is plugged in. When abnormal short-circuit condition happens, these capacitors can also reduce output negative voltage due to parasitic inductive effect and avoid device damage.

Please note without the bypass capacitors, an output short may cause ringing on the input; if the voltage is over the maximum voltage rating, it will destroy the internal control circuitry even the duration is short.

FLG Response

When an over-current or over-temperature shutdown condition is encountered, the FLG open-drain output goes active low after a nominal 6ms deglitch timeout. The FLG output remains low until both over-current and over-temperature conditions are removed. Connecting a heavy capacitive load to the output of the device can cause a momentary over-current condition, which does not trigger the FLG due to the 6ms deglitch timeout. The AP22811 is designed to eliminate false over-current reporting without the need of external components to remove unwanted pulses.

However, it is to be noted that, when the FLG pin is not supplied via the same V_{IN} voltage source of the AP22811 but other external power source, it is strongly required that the AP22811 must be sure to reach a stable operating voltage condition before the other power source applied to FLG pin.

Over-Current and Short Circuit Protection

An internal sensing FET is employed to check for over-current conditions. Unlike current-sense resistors, sense FETs do not increase the series resistance of the current path. When an overcurrent condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Complete shutdown occurs only if the fault stays long enough to activate thermal limiting.

Three possible overload conditions can occur. In the first condition, the output has been shorted to GND before the device is enabled or before V_{IN} has been applied. The AP22811 senses the short circuit and immediately clamps output current to a certain safe level.

In the second condition, an output short or an overload occurs while the device is enabled. At the instance the overload occurs, higher current may flow for a very short period of time before the current limit function can react. After the current limit function has tripped, the device switches into current limiting mode and the current is clamped at I_{LIMIT}, or I_{SHORT}.

In the third condition, the load has been gradually increased beyond the recommended operating current. The current is permitted to rise until the current-limit threshold (I_{TRIG}) is reached or until the thermal limit of the device is exceeded. The AP22811 is capable of delivering current up to the current-limit threshold without damaging the device. Once the threshold has been reached, the device switches into its current limiting mode and is set at I_{LIMIT}.

Thermal Protection

Thermal protection prevents the IC from damage when heavy-overload or short-circuit faults are present for extended periods of time. The AP22811 implements a thermal sensing to monitor the operating junction temperature of the power distribution switch. Once the die temperature rises to approximately +140°C due to excessive power dissipation in an over-current or short-circuit condition, the internal thermal sense circuitry turns the power switch off, thus preventing the power switch from damage. Hysteresis is built into the thermal sense circuit, allowing the device to cool down approximately +35°C before the switch turns back on. The switch continues to cycle in this manner until the load fault or input power is removed. The FLG open-drain output is asserted when an over-temperature shutdown or over-current occurs with 6ms deglitch.

ON/OFF Input Operator

The EN/$\overline{EN}$ input allows the output current to be switched on and off using a GPIO compatible input. The high signal (switch on) should be at least 1.5V, and the low signal (switch off) no higher than 0.65V. This pin should NOT be left floating. It is advisable to hold the EN/$\overline{EN}$ signal low when applying or removing power.

Application Information (continued)

Under-Voltage Lockout (UVLO)

Under-voltage lockout function (UVLO) keeps the internal power switch from being turned on until the power supply has reached at least 2V, even if the switch is enabled. Whenever the input voltage falls below approximately 2V, the power switch is quickly turned off. This facilitates the design of hot-insertion systems where it is not possible to turn off the power switch before input power is removed.

Discharge Function

The discharge function of the device is active when enable is disabled or de-asserted. The discharge function with the N-MOS power switch implementation is activated and offers a resistive discharge path for the external storage capacitor. This is designed for discharging any residue of the output voltage when either no external output resistance or load resistance is present at the output.

Output Reverse-Voltage/Current Protection

The output reverse-voltage protection turns off the MOSFET switch whenever the output voltage is higher than the input voltage by 50mV for 6ms, and the MOSFET switch will turn on when output reverse-voltage/current conditions are removed.

Power Dissipation and Junction Temperature

The low on-resistance of the internal MOSFET allows the small surface-mount packages to pass large current. Using the maximum operating ambient temperature (T_A) and $R_{DS(ON)}$, the power dissipation can be calculated by:

$P_D = R_{DS(ON)} \times I^2$

Finally, calculate the junction temperature:

$T_J = P_D \times R_{\theta JA} + T_A$

Where:

T_A = Ambient temperature °C

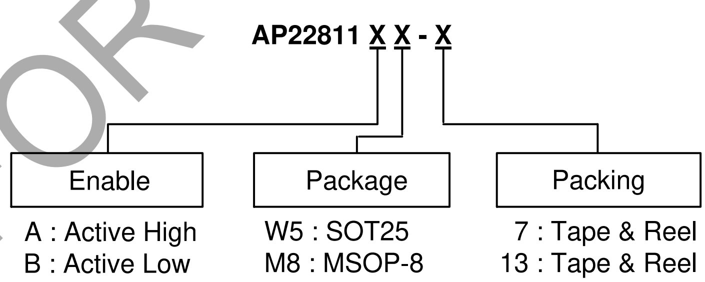
$R_{\theta JA}$ = Thermal resistance

P_D = Total power dissipation

Board Layout Instruction

Placing input and output capacitors, 1µF and 0.1µF+100µF respectively, close and next to the device pins must be implemented to minimize the effects of parasitic inductance. For best performance, all trace lengths should be kept as short as possible. The input and output PCB traces should be as wide as possible. Use a ground plane to enhance the power dissipation capability of the device.

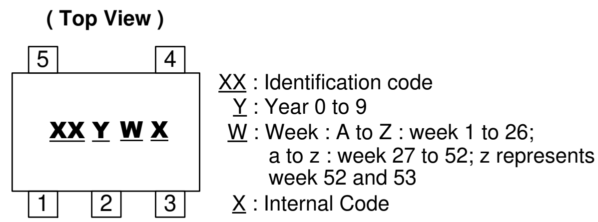
Ordering Information



Part Number	Part Number Suffix	Package Code	Package	Packing	
				Qty.	Carrier
AP22811AW5-7	-7	W5	SOT25	3000	7" Tape & Reel
AP22811BW5-7	-7	W5	SOT25	3000	7" Tape & Reel
AP22811AM8-13	-13	M8	MSOP-8	2500	13" Tape & Reel
AP22811BM8-13	-13	M8	MSOP-8	2500	13" Tape & Reel

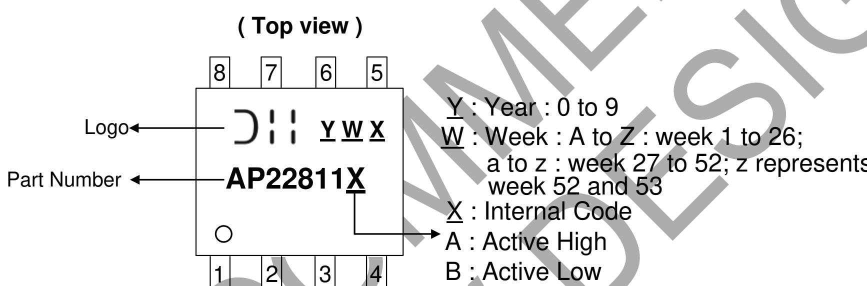
Marking Information

(1) SOT25



Part Number	Package	Identification Code
AP22811AW5-7	SOT25	5Y
AP22811BW5-7	SOT25	5Z

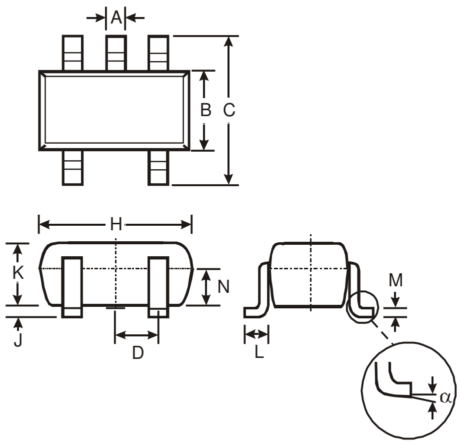
(2) MSOP-8



Package Outline Dimensions

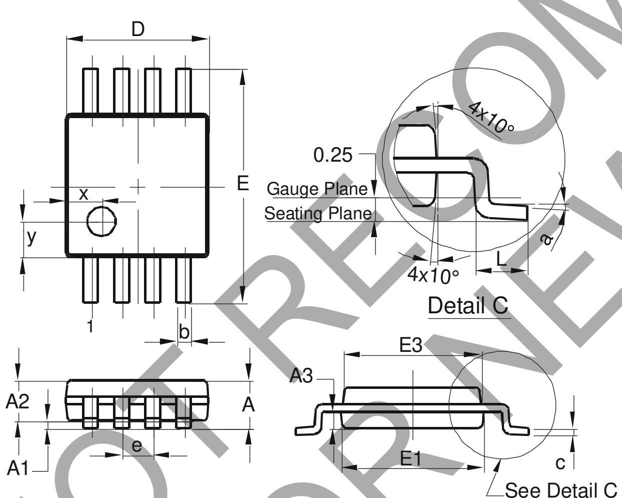
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) SOT25



SOT25			
Dim	**Min**	**Max**	**Typ**
A	0.35	0.50	0.38
B	1.50	1.70	1.60
C	2.70	3.00	2.80
D	—	—	0.95
H	2.90	3.10	3.00
J	0.013	0.10	0.05
K	1.00	1.30	1.10
L	0.35	0.55	0.40
M	0.10	0.20	0.15
N	0.70	0.80	0.75
α	0°	8°	—
All Dimensions in mm			

(2) MSOP-8

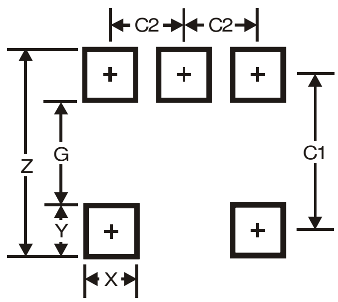


MSOP-8			
Dim	**Min**	**Max**	**Typ**
A	-	1.10	-
A1	0.05	0.15	0.10
A2	0.75	0.95	0.86
A3	0.29	0.49	0.39
b	0.22	0.38	0.30
c	0.08	0.23	0.15
D	2.90	3.10	3.00
E	4.70	5.10	4.90
E1	2.90	3.10	3.00
E3	2.85	3.05	2.95
e	-	-	0.65
L	0.40	0.80	0.60
a	0°	8°	4°
x	-	-	0.750
y	-	-	0.750
All Dimensions in mm			

Suggested Pad Layout

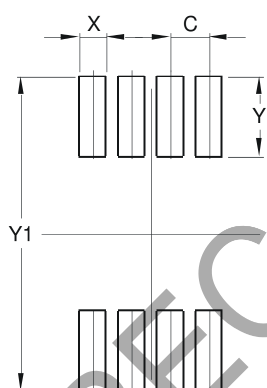
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) SOT25



Dimensions	Value (in mm)
Z	3.20
G	1.60
X	0.55
Y	0.80
C1	2.40
C2	0.95

(2) MSOP-8



Dimensions	Value (in mm)
C	0.650
X	0.450
Y	1.350
Y1	5.300

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