



AP22811

SINGLE CHANNEL POWER DISTRIBUTION LOAD SWITCH

Description

The 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.

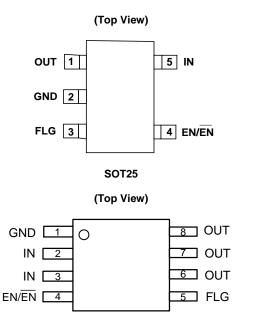
The device has fast short-circuit response time for improved overall system robustness, and has an integrated output discharge function to ensure completely controlled discharging of the output voltage capacitor. They provide a complete protection solution for applications subject to heavy capacitive 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 a standard Green SOT25 and MSOP-8 packages with RoHS compliant.

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
- Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)
- Halogen and Antimony Free. "Green" Device (Note 3)
- UL Recognized, File Number E322375
- IEC60950-1 CB Scheme Certified

Pin Assignments



MSOP-8

Applications

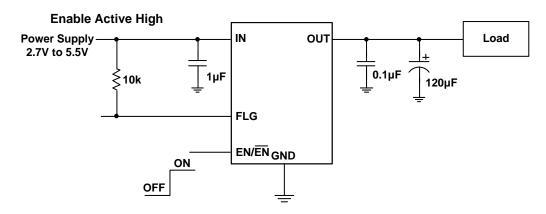
- Integrated Load Switches in Ultrabook PC's
- Power Up/Down Sequencing in Ultrabook PC's
- Notebook
- Netbook
- Set-Top Boxes
- SSD (Solid State Drives)
- Consumer Electronics
- Tablet PC
- Telecom Systems

Notes:

- 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
- 2. See http://www.diodes.com/quality/lead_free.html 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.



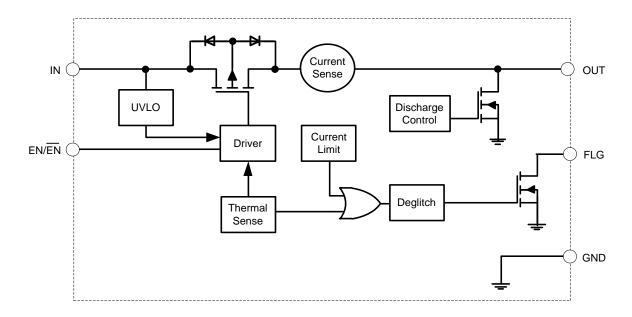
Typical Applications Circuit



Pin Descriptions

Pin Number		Pin Name	Firmation	
SOT25	MSOP-8	Pin Name	Function	
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.	
			Enable Input	
4	4	EN/EN	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 (@ $T_A = +25^{\circ}C$, unless otherwise specified.) (Note 4)

Symbol	Parameter	Parameter		
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/EN}	Enable Voltage		-0.3 to (V _{IN} +0.3)	V
IL	Load Current	Load Current		Α
T _{J(max)}	Maximum Junction Temperature	Maximum Junction Temperature		°C
T _{ST}	Storage Temperature	Storage Temperature		°C
D	R _{θJA} Thermal Resistance, Junction to Ambient	SOT25 (Note 6)	123	
Көја		MSOP-8 (Note 5)	165	°C/W
D	Thormal Posistones, Jungtion to Cose	SOT25 (Note 6)	33]
Kejc	R _{0JC} Thermal Resistance, Junction to Case		33]

Notes:

- 4. Stresses greater than the 'Absolute Maximum Ratings' specified above may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.
- affected by exposure to absolute maximum rating conditions for extended periods of time.

 5. Test condition for MSOP-8: Device mounted on 1"x1"/2"x2" 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
lout	Output Current	0	2	Α
V_{IL}	EN/EN Input Logic Low Voltage	0	0.5	V
V _{IH}	EN/EN Input Logic High Voltage	1.5	V _{IN}	V
T _A	Operating Ambient Temperature	-40	+85	°C

Note:

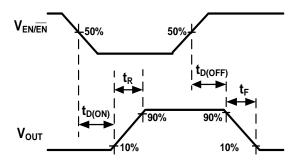
7. Refer to the typical application circuit.



Symbol	Parameter	Test Conditions	Min	Тур	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
IQ	Input Quiescent Current	Enabled, OUT = Open	-	80	_	μΑ
I _{LEAK}	Input Leakage Current	Disabled, OUT Grounded	-	0.1	1	μΑ
I _{REV}	Reverse Leakage Current	Disabled, V _{IN} = 0V, V _{OUT} = 5V, I _{REV} at V _{IN}	-	0.01	1	μΑ
-	Control Con Province	$V_{IN} = 5V$, $I_{OUT} = 1A$ $T_A = +25$ °C	-	50	65	0
R _{DS(ON)}	Switch On-Resistance	$V_{IN} = 3.3V, I_{OUT} = 1A$ $T_A = +25^{\circ}C$	-	60	90	mΩ
I _{LIMIT}	Over Load Current Limit	V _{IN} = 5V, V _{OUT} = 4.5V	2.2	2.7	3.2	Α
I _{SHORT}	Short-Circuit Current Limit	Enabled, Output short to ground		0.3	_	Α
V _{IL}	EN/EN Input Logic Low Voltage	V _{IN} = 2.7V to 5.5V		_	0.5	V
V _{IH}	EN/EN Input Logic High Voltage	V _{IN} = 2.7V to 5.5V	1.5	_	_	V
I _{LEAK-EN/EN}	EN/EN Input Leakage	$V_{IN} = 5V$, $V_{EN/\overline{EN}} = 0V$ and 5.5V	-	0.01	1	μΑ
I _{LEAK-O}	Output Leakage Current	Disabled, V _{OUT} = 0V	-	0.5	1	μΑ
t _{D(ON)}	Output Turn-On Delay Time	$C_L = 4.7 \mu F$, $R_{LOAD} = 10 \Omega$ @ $V_{IN} = 3.3 V$ Figure 1		1.7	_	ms
t _R	Output Turn-On Rise Time	$C_L = 4.7 \mu F$, $R_{LOAD} = 10 \Omega$ @ $V_{IN} = 3.3 V$ Figure 1	1.0	2.1	3.5	ms
t _{D(OFF)}	Output Turn-Off Delay Time	$C_L = 4.7\mu F$, $R_{LOAD} = 10\Omega$ @ $V_{IN} = 3.3V$ Figure 1		20	_	μs
t _F	Output Turn-Off Fall Time	$C_L = 4.7 \mu F$, $R_{LOAD} = 100 \Omega$ @ $V_{IN} = 3.3 V$ 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	μΑ
t _{BLANK}	FLG Blanking Time	Assertion or deassertion due to overcurrent and over-temperature condition	2	6	13	ms
t _{DIS}	Discharge Time	$C_L = 1\mu F$, $V_{IN} = 5V$, 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
[†] TRIG	Time from Reverse-Voltage Condition to MOSFET Turn off	V _{IN}	2	6	13	ms



Performance Characteristics



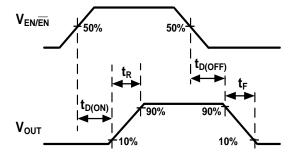
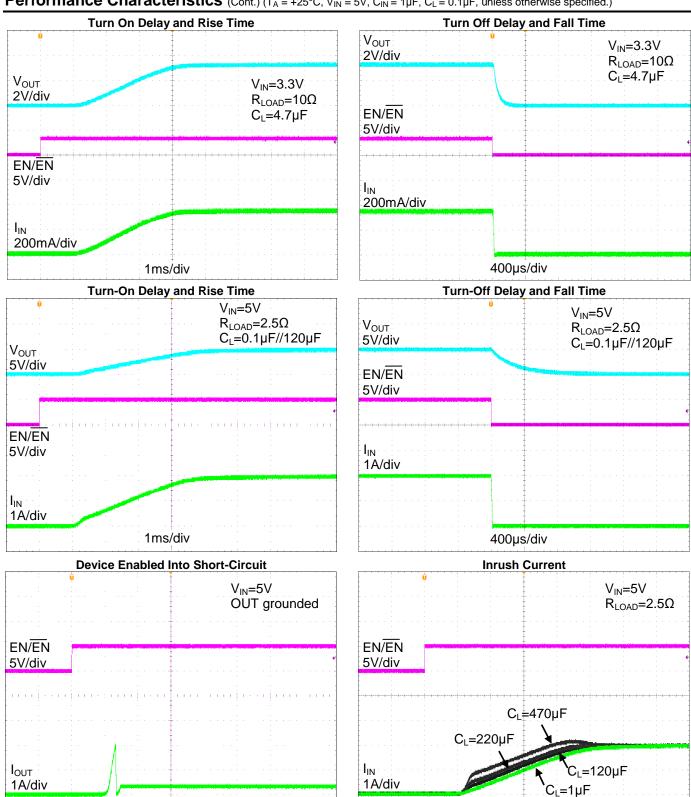


Figure 1. Voltage Waveforms: AP22811B (Active Low, Left), AP22811A (Active High, Right)



$\textbf{Performance Characteristics} \ \, \text{(Cont.)} \ \, \text{($T_A = +25^{\circ}$C, $V_{IN} = 5$V, $C_{IN} = 1$\mu$F, $C_L = 0.1$\mu$F, unless otherwise specified.)}$

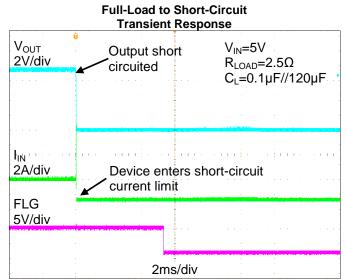


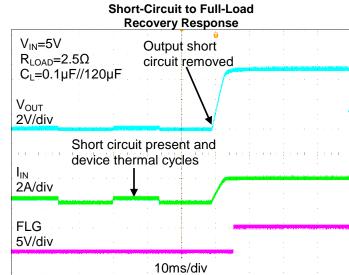
1ms/div

1ms/div

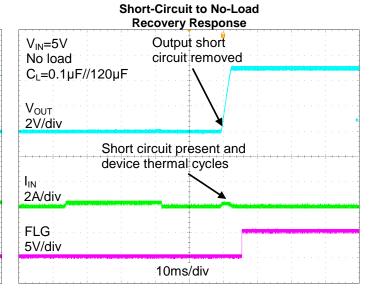


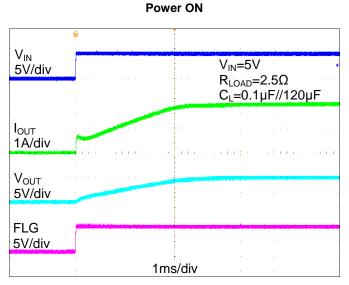
$\label{eq:cont.} \textbf{Performance Characteristics} \ \ (\text{Cont.}) \ \ (T_A = +25^{\circ}\text{C}, \ V_{IN} = 5\text{V}, \ C_{IN} = 1\mu\text{F}, \ C_L = 0.1\mu\text{F}, \ unless otherwise specified.})$

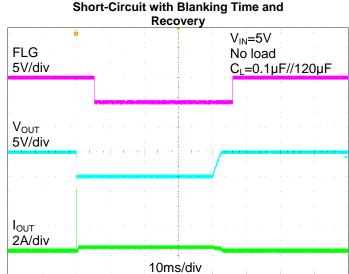




No-Load to Short-Circuit **Transient Response** Vout $V_{IN}=5V$ 2V/div Output short No load circuited $C_L=0.1 \mu F // 120 \mu F$ Device enters short-circuit current limit I_{IN} 2A/div FLG 5V/div 2ms/div

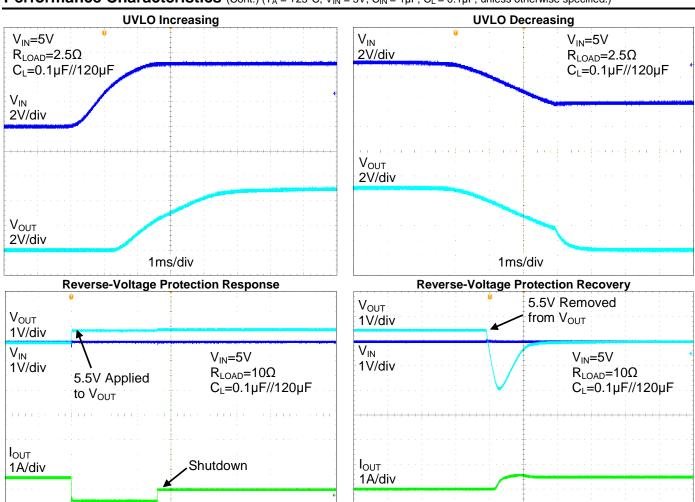








$\textbf{Performance Characteristics} \ \ (\text{Cont.}) \ \ (T_A = +25^{\circ}\text{C}, \ V_{IN} = 5\text{V}, \ C_{IN} = 1\mu\text{F}, \ C_L = 0.1\mu\text{F}, \ unless otherwise specified.})$



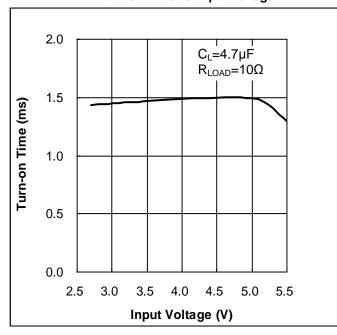
2ms/div

2ms/div

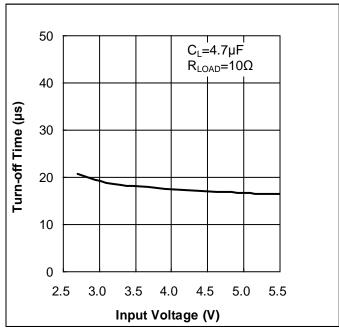


$\textbf{Performance Characteristics} \ \ (\text{Cont.}) \ \ (T_{\text{A}} = +25^{\circ}\text{C}, \ V_{\text{IN}} = 5\text{V}, \ C_{\text{IN}} = 1\mu\text{F}, \ C_{\text{L}} = 0.1\mu\text{F}, \ unless otherwise specified.})$

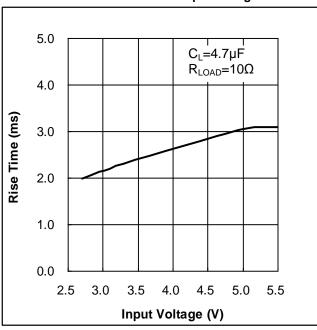
Turn-on Time vs. Input Voltage



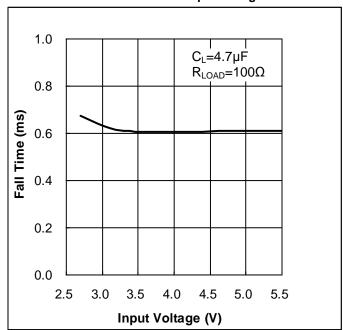
Turn-off Time vs. Input Voltage



Rise Time vs. Input Voltage



Fall Time vs. Input Voltage



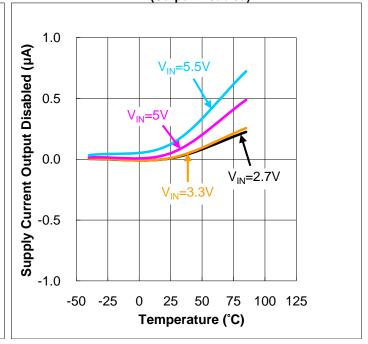


$\label{eq:cont.} \textbf{Performance Characteristics} \ \ (\text{Cont.}) \ \ (T_A = +25^{\circ}\text{C}, \ V_{IN} = 5\text{V}, \ C_{IN} = 1\mu\text{F}, \ C_L = 0.1\mu\text{F}, \ unless otherwise specified.})$

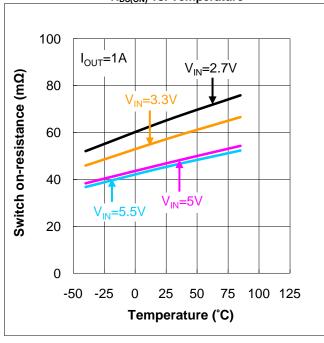
Supply Current vs. Temperature (Output Enabled)

125 Supply Current Output Enabled (µA) _{IN}=5.5V 100 75 $V_{IN}=2.7V$ $V_{IN}=3.3V$ 50 25 0 -50 -25 75 100 125 0 25 50 Temperature (°C)

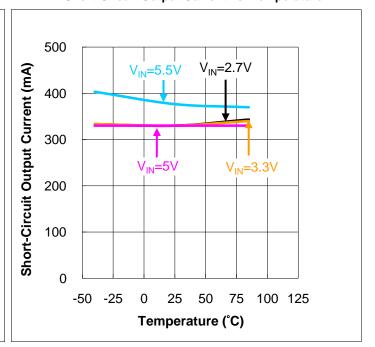
Supply Current vs. Temperature (Output Disabled)



R_{DS(ON)} vs. Temperature



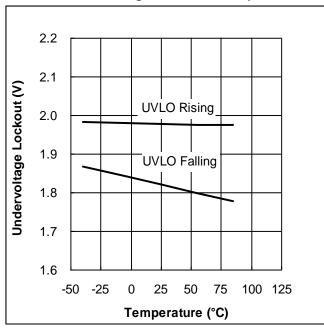
Short-Circuit Output Current vs. Temperature



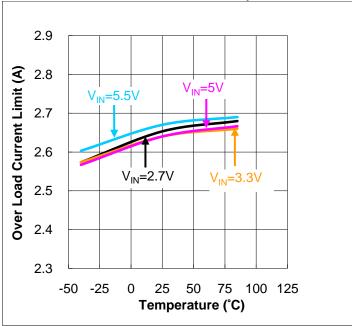


$\textbf{Performance Characteristics} \ \, \text{(Cont.)} \ \, \text{($T_A = +25^{\circ}$C, $V_{IN} = 5$V, $C_{IN} = 1$\mu$F, $C_L = 0.1$\mu$F, unless otherwise specified.)}$

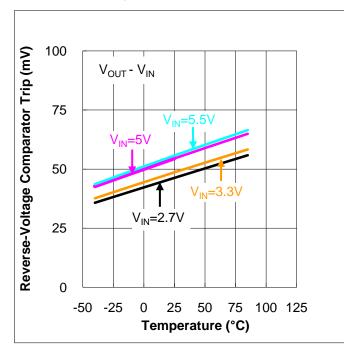




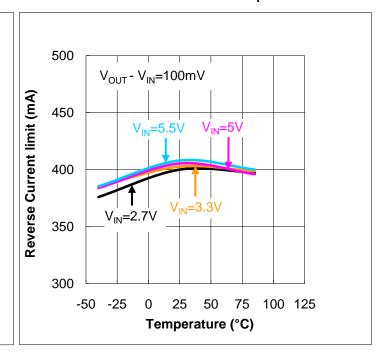
Over Load Current Limit vs. Temperature



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/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/EN signal low when applying or removing power.



Application Information (Cont.)

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 is 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

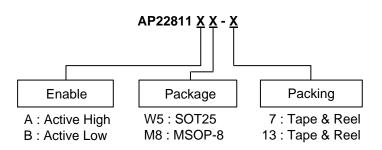
 $R_{\theta JA}$ = Thermal resistance

P_D = Total power dissipation

Board Layout Instruction

Placing input and output capacitors, $1\mu\text{F}$ and $0.1\mu\text{F}+100\mu\text{F}$ 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



Dorf Number	Part Number Package Code	Packaging	7" and 13" Tape and Reel		
Part Number			Quantity	Part Number Suffix	
AP22811AW5-7	W5	SOT25	3000/Tape & Reel	-7	
AP22811BW5-7	W5	SOT25	3000/Tape & Reel	-7	
AP22811AM8-13	M8	MSOP-8	2500/Tape & Reel	-13	
AP22811BM8-13	M8	MSOP-8	2500/ Tape & Reel	-13	



Marking Information

(1) SOT25

(Top View)

XXYWX

2

AP22811BW5-7

3

 $\frac{XX}{Y}$: Identification code \underline{Y} : Year 0~9

W: Week: A~Z: 1~26 week; a~z: 27~52 week; z represents 52 and 53 week

5Z

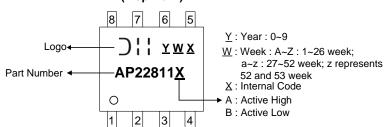
 \underline{X} : Internal Code

Part Number	Package Type	Identification Code
ΔΡ22811Δ\//5-7	SOT25	5V

SOT25

(2) MSOP-8



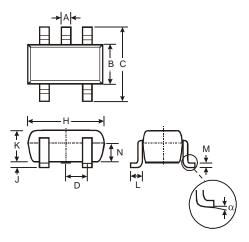




Package Outline Dimensions

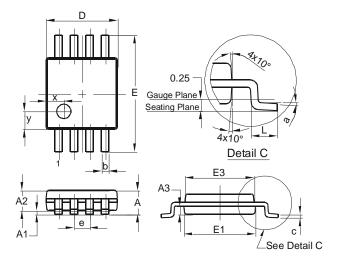
 $\label{prop:lease} Please see \ http://www.diodes.com/package-outlines.html \ for \ the \ latest \ version.$

(1) SOT25



	SOT25				
Dim	Min	Max	Тур		
Α	0.35	0.50	0.38		
В	1.50	1.70	1.60		
С	2.70	3.00	2.80		
D		_	0.95		
Н	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	M 0.10 0.20 0.15				
N	0.70	0.80	0.75		
α	0°	8°	_		
All Dimensions in mm					

(2) MSOP-8



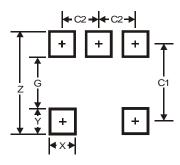
MSOP-8				
Dim	Min	Max	Тур	
Α	-	1.10	-	
A 1	0.05	0.15	0.10	
A2	0.75	0.95	0.86	
A3	0.29	0.49	0.39	
b	0.22	0.38	0.30	
С	0.08	0.23	0.15	
D	2.90	3.10	3.00	
Е	4.70	5.10	4.90	
E1	2.90	3.10	3.00	
E3	2.85	3.05	2.95	
е	1	1	0.65	
Г	0.40	0.80	0.60	
а	0°	8°	4°	
X	-	-	0.750	
у	-	-	0.750	
All Dimensions in mm				



Suggested Pad Layout

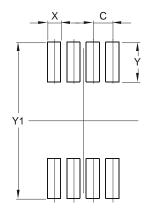
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(1) SOT25



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

(2) MSOP-8



Dimensions	Value (in mm)
C	0.650
Х	0.450
Υ	1.350
Y1	5 300

July 2017

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