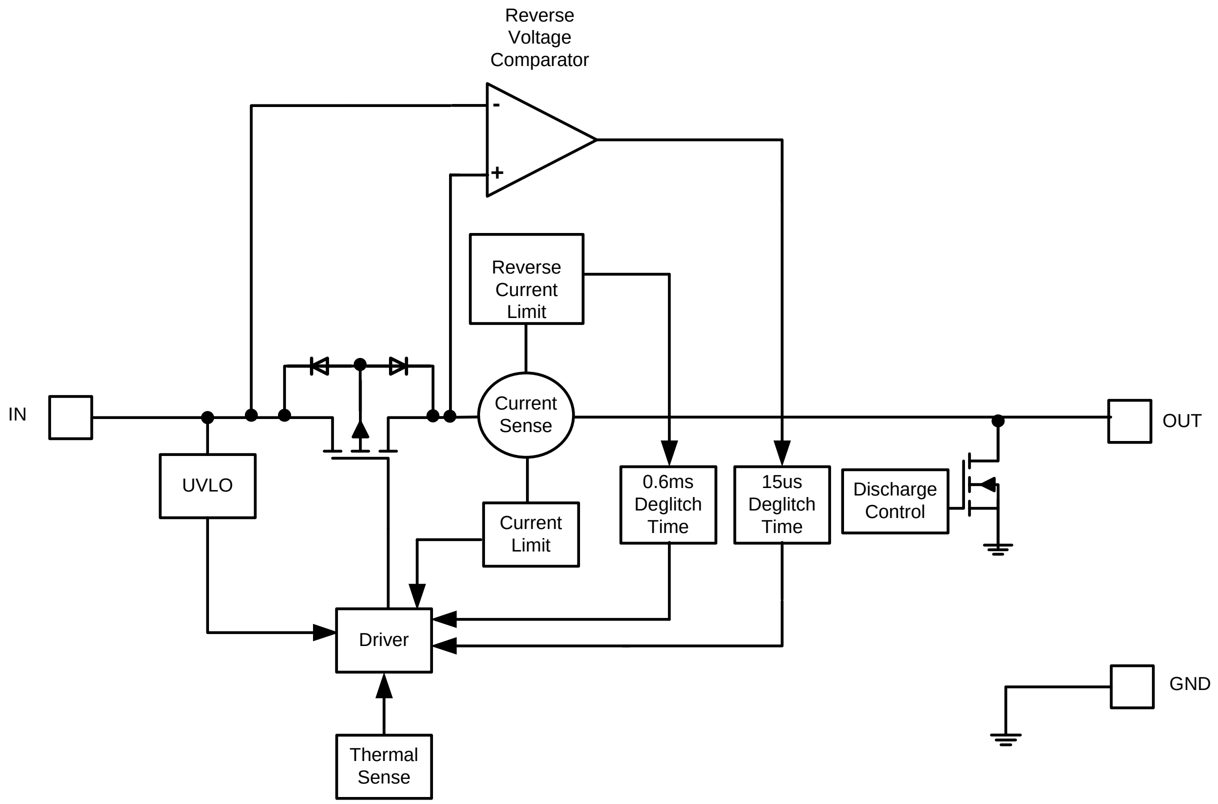
Pin Descriptions

Pin Name	Pin Number	Descriptions
GND	1	Ground
OUT	2	Switch output pin
IN	3	Voltage input pin

Function Block Diagram



Absolute Maximum Ratings

Symbol	Parameter	Ratings	Units
ESD HBM	Human Body Model ESD Protection	3	KV
ESD MM	Machine Model ESD Protection	300	V
V_{IN}	Input Voltage	6.5	V
V_{OUT}	Output Voltage	V_{IN} + 0.3	V
I_{load}	Maximum Continuous Load Current	Internal Limited	A
T_{Jmax}	Maximum Junction Temperature	150	°C
T_{ST}	Storage Temperature Range (Note 2)	-65 to 150	°C

Notes: 2. UL Recognized Rating from -30°C to 70°C (Diodes qualified T_{ST} from -65°C to 150°C)

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Units
V_{IN}	Input voltage	2.7	5.5	V
I_{OUT}	Output Current	0	1.0	A
T_A	Operating Ambient Temperature	-40	85	°C

Electrical Characteristics ($T_A = 25^oC$, $V_{IN} = +5.0V$, unless otherwise stated)

Symbol	Parameter	Test Conditions (Note 3)	Min	Typ.	Max	Unit
V_{UVLO}	Input UVLO	V_{IN} rising	2.00		2.65	V
I_Q	Input quiescent current	Above UVLO, I_{OUT}= 0		65	110	µA
I_{REV}	Reverse leakage current	V_{IN} = 0V, V_{OUT} = 5V, I_{REV} at V_{IN}		0.01	0.1	µA
$R_{DS(ON)}$	Switch on-resistance	V_{IN} = 5V, I_{OUT} = 1A		110	140	mΩ
		V_{IN} = 3.3V, I_{OUT} = 1A		140	170	
I_{LIMIT}	Over-load current limit	V_{IN} = 5V, V_{OUT} = 4V, C_L=10µF	1.1	1.5	1.9	A
I_{OS}	Short-circuit current	OUT connected to ground, C_L=10µF	0.2	0.6	1.0	A
T_{SHORT}	Short-circuit response time	From V_{OUT} < 0.6V to I_{OUT} = 0A (OUT shorted to GND) (See Figure. 1)(Note 7)		5		µs
I_{ROCP}	Reverse current limit	Above UVLO	0.3	0.5	0.7	A
T_{Trig}	Deglitch time from reverse current trigger to MOSFET turn off			0.6		ms
V_{OVP}	Output over-voltage trip point	Above UVLO (Note 4)	110%		120%	V_{IN}
T_{OVP}	Debounce time from output over-voltage to MOSFET turn off			15		µs
T_{ON}	Output turn-on time (Note 5)	C_L = 1µF, R_{load} = 5Ω (UVLO to 90% $V_{OUT-NOM}$)	1		4	ms
T_{DIS}	Discharge time	C_L= 1µF, from UVLO to V_{OUT} < 0.3V		500		µs
T_{SHDN}	Thermal shutdown threshold			150		°C
T_{HYS}	Thermal shutdown hysteresis			20		°C
$θ_{JA}$	Thermal Resistance Junction-to-Ambient	(Note 6)		180		°C/W

Notes:
3. Pulse-testing techniques maintain junction temperature close to ambient temperature; thermal effects must be taken into account separately.
4. During output over-voltage protection, the output draws approximately 60µA current.
5. Since the output turn-on slew rate is dependent on input supply slew rate, this limit is only applicable for input supply slew rate between 5V/0.2ms to 5V/1ms.
6. Device mounted on FR-4 substrate PCB, 2oz copper, with minimum recommended pad layout.
7. Applicable for output voltage slew rate ≤ 5V/30µs.

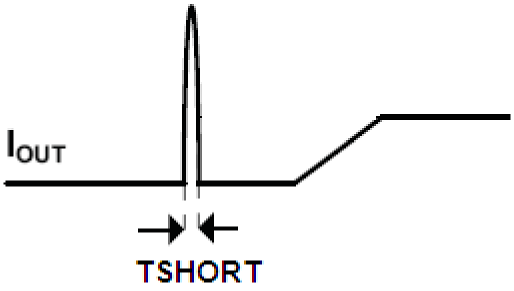
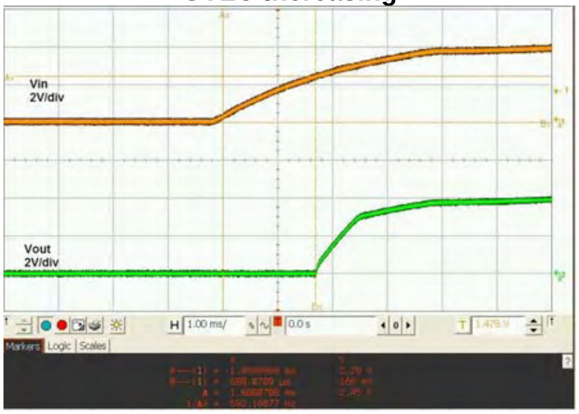


Figure 1. Short Circuit Response Time

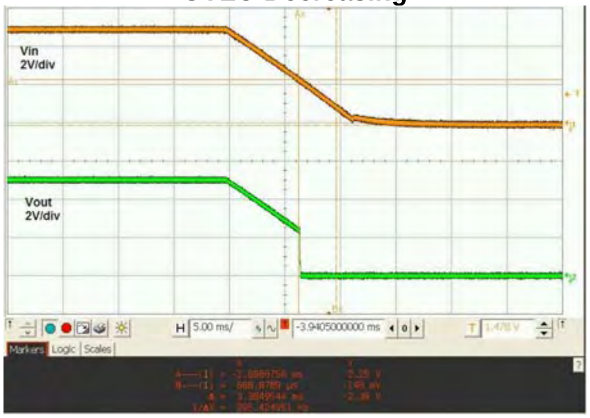
Typical Performance Characteristics

UVLO Increasing



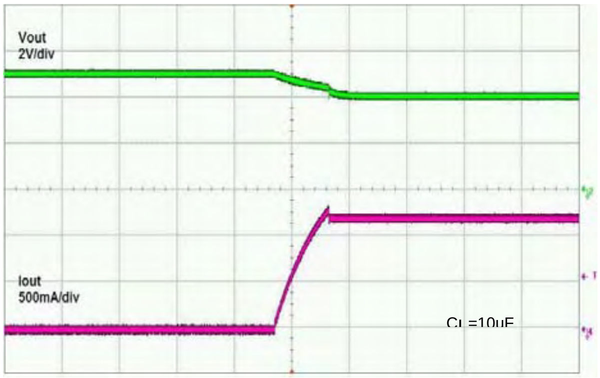
1ms/div

UVLO Decreasing



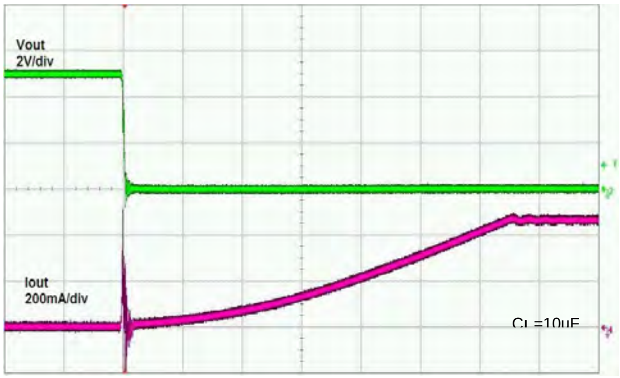
5ms/div

Over-Load Current Limit



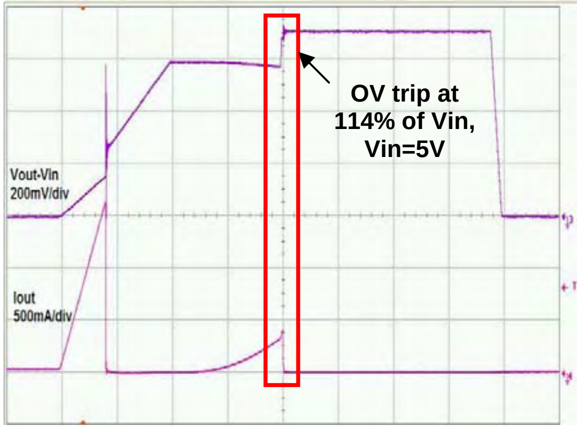
50ms/div

Short Circuit Current Limit



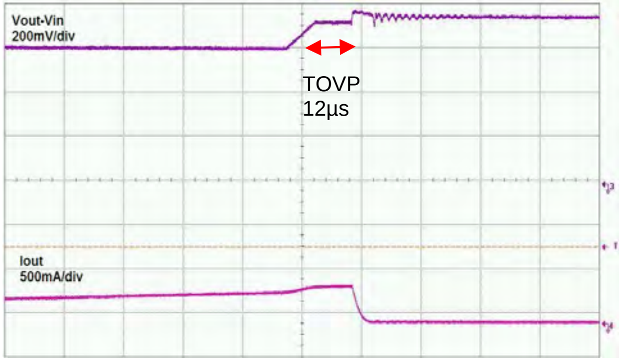
100us/div

Output Over Voltage Trip Point



500us/div

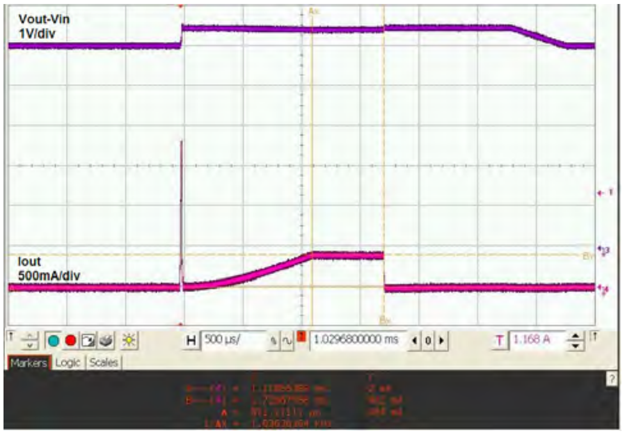
Debounce time from output over-voltage to MOSFET turn off
(Zoom in at red portion of previous waveform)



20us/div

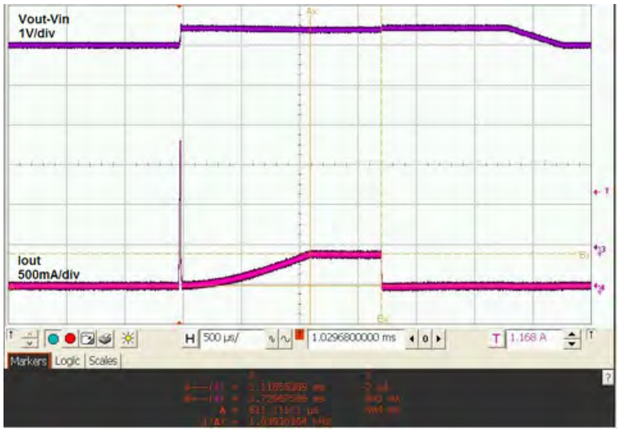
Typical Performance Characteristics (cont.)

Deglitch time from reverse current trigger to MOSFET turn off



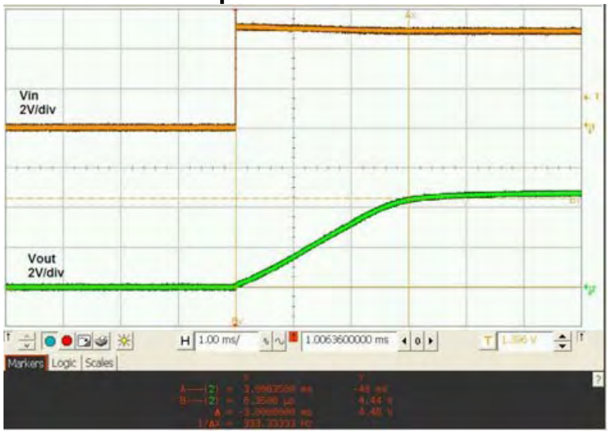
500us/div

Reverse Current Limit



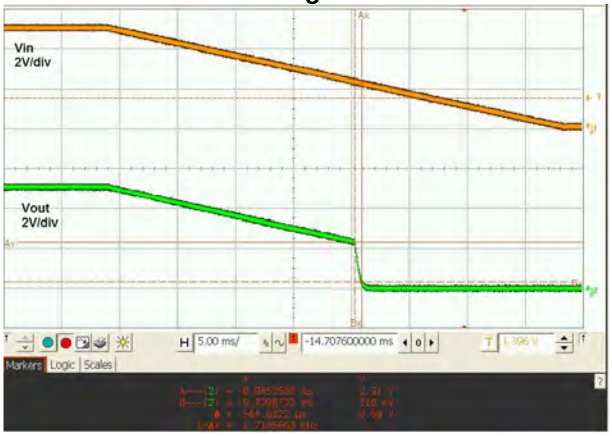
500us/div

Output Turn-on Time



1ms/div

Discharge Time



5ms/div

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Typical Performance Characteristics (cont.)

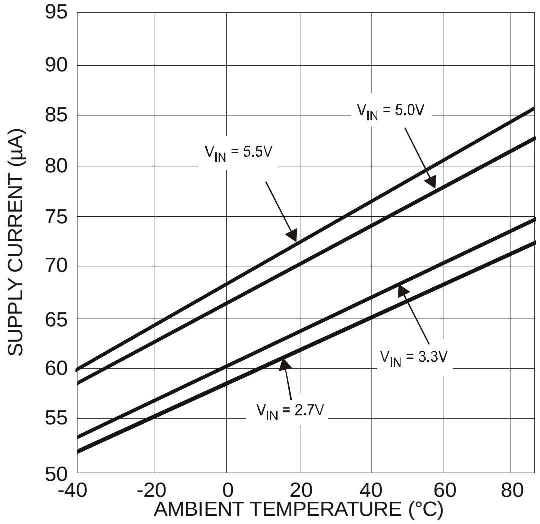


Fig. 1 Quiescent Supply Current vs. Ambient Temperature

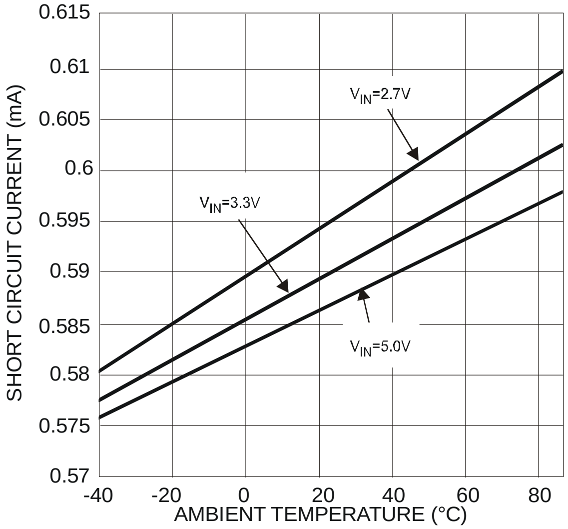


Fig. 2 Short Circuit Output Current vs. Ambient Temperature

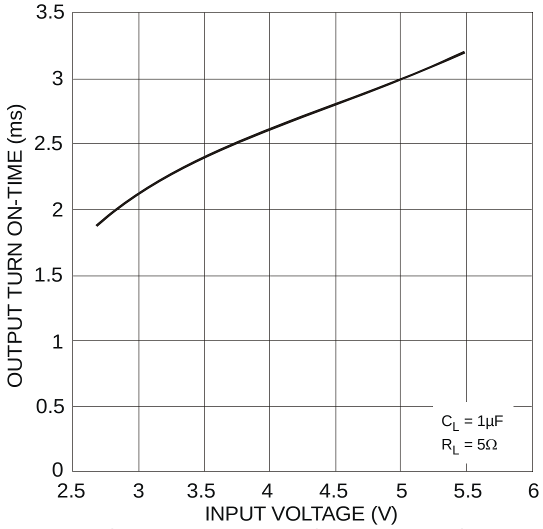


Fig. 3 Output Turn On-Time vs. Input Voltage

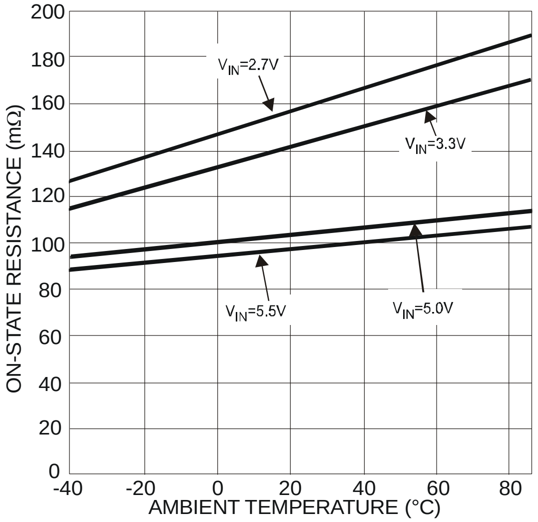


Fig. 4 Switch On-Resistance vs. Ambient Temperature

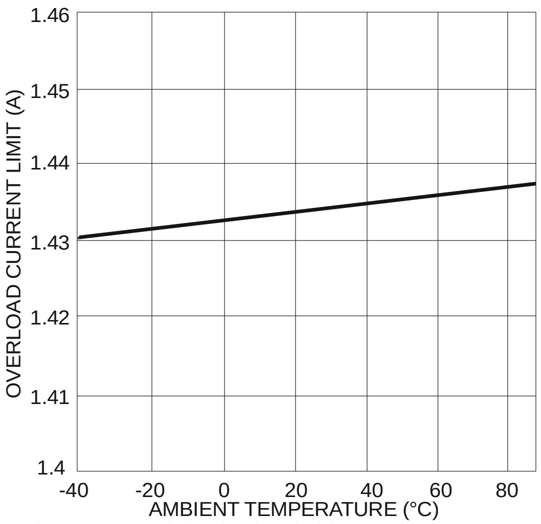


Fig. 5 Current Limit Trip Threshold vs. Ambient Temperature

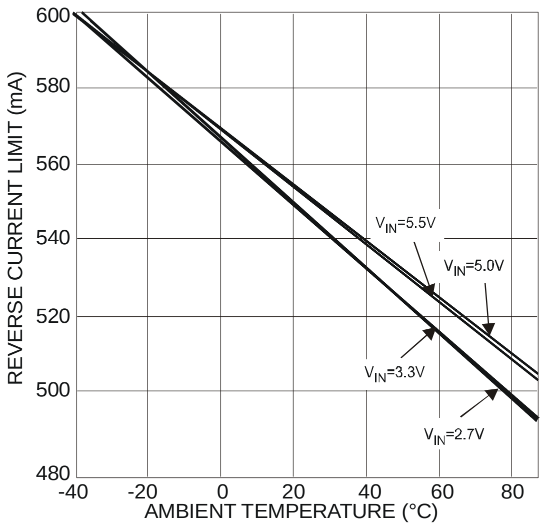


Fig. 6 Reverse Current Limit vs. Ambient Temperature

Application Note

Protection Features:

Under-voltage Lockout (UVLO)

Whenever the input voltage falls below UVLO threshold (~2.5V), the power switch is 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.

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.

The different overload conditions and the corresponding response of the AP2337 are outlined below:

NO	Conditions	Explanation	Behavior of the AP2337
1	Short circuit condition at start-up	Output is shorted before input voltage is applied or before the part is powered up.	The IC senses the short circuit and immediately clamps output current to a certain safe level namely I_{short}
2	Short-circuit or Overcurrent condition	Short-Circuit or Overload condition that occurs when the part is powered up and above UVLO.	• 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 (reached the over-current trip threshold), the device switches into current limiting mode and the current is clamped at I_{short} /I_{LIMIT}.
3	Gradual increase from nominal operating current to I_{LIMIT}	Load increases gradually until the current-limit threshold.	The current rises until I_{LIMIT}. Once the threshold has been reached, the device switches into its current limiting mode and is clamped at I_{LIMIT}.

Reverse Current Protection

The USB specification does not allow an output device to source current back into the USB port. In a normal MOSFET switch, current will flow in reverse direction (from the output side to the input side) when the output side voltage is higher than the input side. A ***reverse current limit*** feature is implemented in the AP2337 to limit such back currents. This circuit is activated by the difference between the output voltage and the input voltage (100mV TYP). After the reverse current circuit has tripped (reached the reverse current trip threshold), the current rises until I_{ROCP} level. When the fault exists for more than 600us, output device is disabled and shutdown. This is called the "Deglitch time from reverse current trigger to MOSFET turn off". Recovery from IROCP occurs when the output voltage falls to 101% of input voltage.

Over-Voltage Protection

The device has an ***output over-voltage*** protection that triggers when the output voltage reaches 114% (TYP) of input voltage. When this fault condition stays on for longer than 15us (This is called the "Debounce time from output over-voltage to MOSFET turn off") output device is disabled and shutdown. Recovery from ROVP occurs when the output voltage falls to 101% of input voltage.

Application Note (cont.)

Thermal Protection

Thermal protection prevents the IC from damage when the die temperature exceeds safe margins. This mainly occurs when heavy-overload or short-circuit faults are present for extended periods of time. The AP2337 implements a thermal sensing to monitor the operating junction temperature of the power distribution switch. Once the die temperature rises to approximately 150°C, the Thermal protection feature gets activated as follows: The internal thermal sense circuitry turns the power switch off thus preventing the power switch from damage. Hysteresis in the thermal sense circuit allows the device to cool down to approximately 20°C before the output is turned back on. This built-in thermal hysteresis feature is an excellent feature, as it avoids undesirable oscillations of the thermal protection circuit. The switch continues to cycle in this manner until the load fault is removed, resulting in a pulsed output.

Discharge Function

When input voltage is pulled, the discharge function is active. The output capacitor is discharged through an internal NMOS that has a discharge resistance of 100Ω. Hence, the output voltage drops down to zero. The time taken for discharge is dependent on the RC time constant of the resistance and the output capacitor. Discharge time is calculated when UVLO falling threshold is reached to output voltage reaching 300mV.

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

Ordering Information

AP 2337 SA - 7

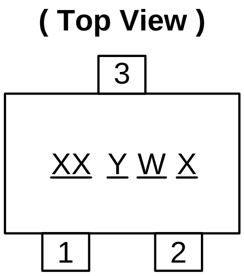
Package
SA : SOT23

Packing
7 : Tape & Reel

Device	Package Code	Packaging (Note 7)	7" Tape and Reel	
			Quantity	Part Number Suffix
AP2337SA-7	SA	SOT23	3000/Tape & Reel	-7

Notes: 7. Pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at http://www.diodes.com/datasheets/ap02001.pdf.

Marking Information

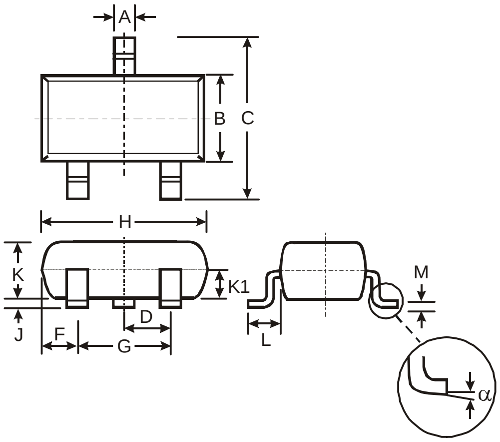


XX : Identification code
Y : Year 0~9
W : Week : A~Z : 1~26 week;
a~z : 27~52 week; z represents
52 and 53 week
X : A~Z : Internal code

Device	Package	Identification Code
AP2337SA-7	SOT23	KM

Package Outline Dimensions

SOT23



SOT23			
Dim	**Min**	**Max**	**Typ**
A	0.37	0.51	0.40
B	1.20	1.40	1.30
C	2.30	2.50	2.40
D	0.89	1.03	0.915
F	0.45	0.60	0.535
G	1.78	2.05	1.83
H	2.80	3.00	2.90
J	0.013	0.10	0.05
K	0.903	1.10	1.00
K1	-	-	0.400
L	0.45	0.61	0.55
M	0.085	0.18	0.11
α	0°	8°	-
All Dimensions in mm			

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