DESCRIPTION

AP8012A is a high performance offline PSR power switch for low power AC/DC charger and adapter applications. It operates in primary-side sensing and regulation.

Consequently, opto-coupler and A431 could be eliminated. Proprietary Constant Voltage (CV) and Constant Current (CC) control isintegrated as shown in the figure below.

In CC control, the current and output power setting can be adjusted externally by the sense resistor Rs at CS pin. In CV control, multi-mode operations are utilized to achieve high performance and high efficiency. In addition, good load regulation is achieved by the built-in cable drop compensation. Device operates in PFM in CC mode at large load condition and it operates in PWM with frequency reduction at light/medium load.

The chip consumes very low operation current. It achieves less than 75mW standby power to meet strict standby power standard.

AP8012A offers comprehensive protection coverage with auto-recovery feature including Cycle-by-Cycle current limiting, V_{DD} over voltage protection, feedback loop open protection, short circuit protection, built-in leading edge blanking, V_{DD} under voltage lockout (UVLO), OTP etc.

The AP8012A is available in SOP7 package.

ORDERING INFORMATION

Package Type	Part Number	
SOP7 SPQ: 2,500pcs/Reel	M7	AP8012AM7R
		AP8012AM7VR
Note	V: Halogen free Package R: Tape & Reel	
AiT provides all RoHS products		

FEATURES

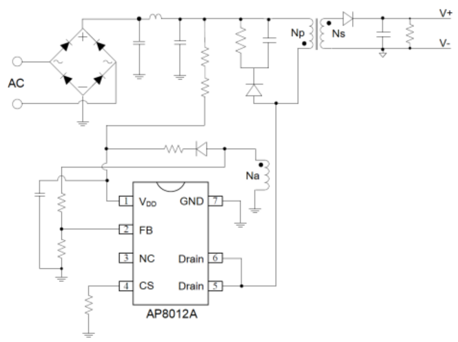
- Primary-side sensing and regulation without A431 and opto-coupler
- High precision constant voltage and current regulation at universal AC input
- Multi-mode PWM/PFM operation for efficiency improving
- Integrated 2A 650V MOSFET
- Good dynamic response with synchronous rectifier application
- Programmable CV and CC regulation
- Built-in primary winding inductance compensation
- Programmable cable drop compensation
- No need for control loop compensation
- Audio noise free operation
- Built-in leading edge blanking (LEB)
- Ultra low start-up current and low operating current
- Comprehensive protection coverage with auto-recovery
  On-chip OTP
  V_{DD} over voltage protection
  V_{DD} under voltage lockout with hysteresis (UVLO)
  Cycle-by-Cycle current limiting
  Feedback loop open protection
  Output short circuit protection
- Available in SOP7 package

APPLICATIONS

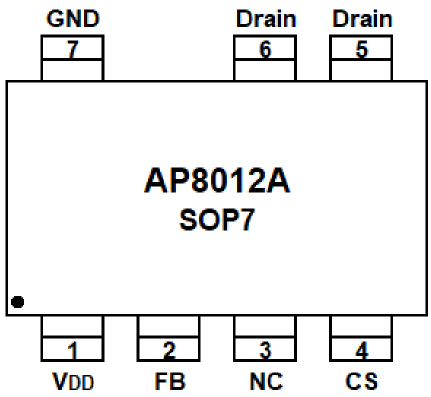
Low Power AC/DC offline SMPS for

- Industrial instruments: single / three-phase meters
- Outdoor monitoring / protection equipment
- AC / DC with high input voltage

TYPICAL APPLICATION



PIN DESCRIPTION



Top View

Pin #	Symbol	Functions
1	V_{DD}	Power Supply
2	FB	The voltage feedback from auxiliary winding. Connected to resistor divider from auxiliary winding reflecting output voltage
3	NC	NC
4	CS	Power MOSFET source
5,6	Drain	Drain of internal power MOSFET
7	GND	Ground

ABSOLUTE MAXIMUM RATINGS

V_{DD} Voltage	-0.3V ~ 28.5V
FB Input Voltage	-0.3V ~ 7.0V
CS Input Voltage	-0.3V ~ 7.0V
T_J, Min/Max Operating Junction Temperature	-40℃ ~ 150℃
T_A, Operating Ambient Temperature	-40°C ~ 125℃
Lead Temperature (Soldering, 10secs)	260℃, 10s

Stress beyond above listed “Absolute Maximum Ratings” may lead permanent damage to the device. These are stress ratings only and operations of the device at these or any other conditions beyond those indicated in the operational sections of the specifications are not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

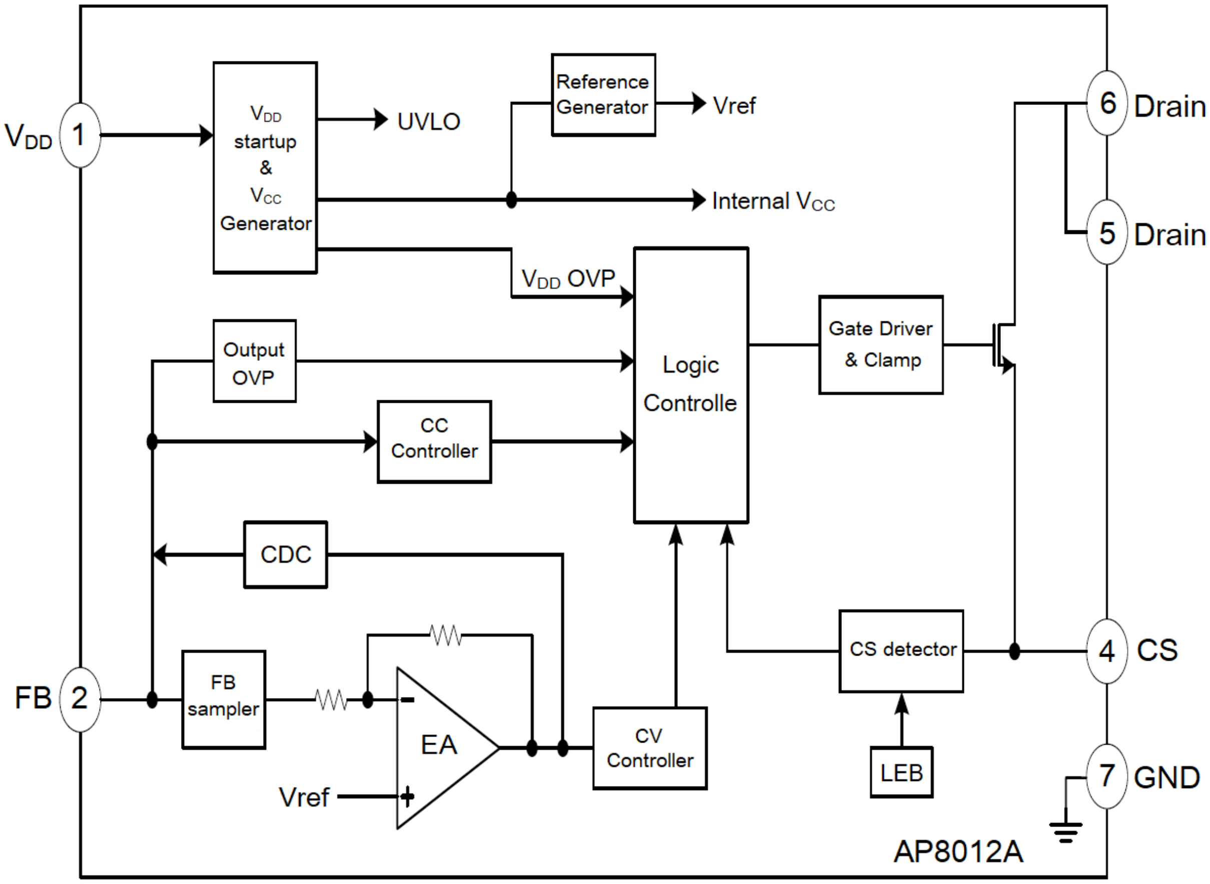
Parameter	Min	Typ	Max	Unit
V_{DD} Voltage	-	-	27	V
Ambient Operating Temperature	-40	-	85	°C
Maximum Switching Frequency	-	110	-	kHz

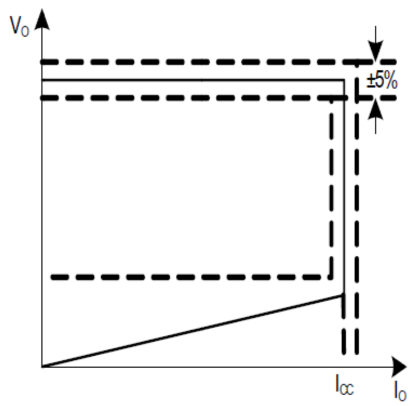
ELECTRICAL CHARACTERISTICS

T_A = 25℃, V_{DD}=15V, if not otherwise noted

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply Voltage (V_{DD}) Section						
Start Up Current	Istart	V_{DD}=UVLO_ FF- 1V	0	0.5	1	μA
Static Current	Ivdd		0.568	-	0.852	mA
V_{DD} Under Voltage Lockout Exit	UVLO(off)		14.5	16.0	19.5	V
V_{DD} Under Voltage Lockout Enter	UVLO(on)		6.5	7.0	7.5	V
V_{DD} Over Voltage Protection	V_{DD-OVP}		27	28	29	V
	V_{DD}		-	-	27	V
Current Sense Input Section						
LEB Time	TLEB		-	300	-	ns
Minimum Over Current Threshold	$V_{th\text{-}ocp\ min}$		485	500	515	mV
Maximum Over Current Threshold	$V_{th\text{-}ocp\ max}$		-	590	-	mV
CS Minimum Threshold	$V_{cs\ min}$		135	-	-	mV
FB Input Section						
Reference Voltage For Feedback Threshold	Vref-FB		2.475	2.5	2.525	V
Minimum Toff	Tpause-min		-	2.0	-	μS
Minimum Frequency	F-min		270	305	340	Hz
Maximum Frequency	F-max		110	-	-	kHz
Maximum Cable Compensation Current	Icomp-cable		40	45	50	μA
CC Mode Shut Down Threshold	Vth-cc shutdown		-	1.55	-	V
CC Mode Shut Down Debounce	TD-cc shutdown		1024	-	2048	Cycle
Output Over Voltage Protection						
Output Over Voltage Threshold	V-ovp		3.15	3.3	3.45	V
MOSFET Section						
MOSFET Drain-Source Breakdown Voltage	Bvds		650	-	-	V
Static Drain to Source On Resistance	R_{DSON}		-	4	-	Ω

BLOCK DIAGRAM

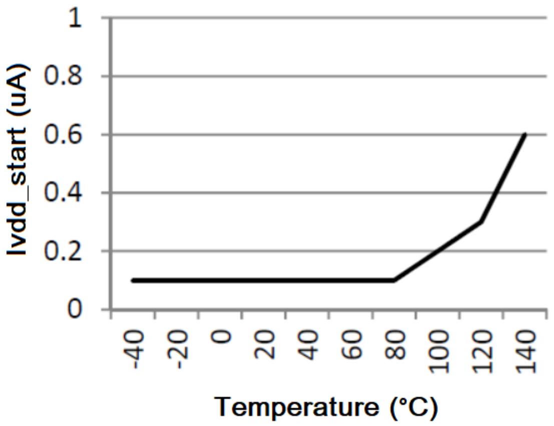




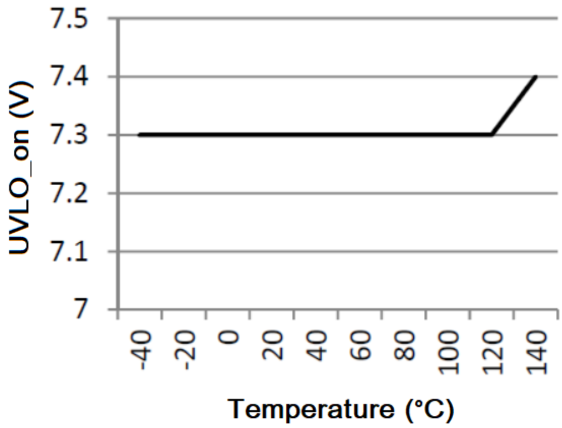
Typical CC/CV Curve

TYPICAL PERFORMANCE CHARACTERISTICS

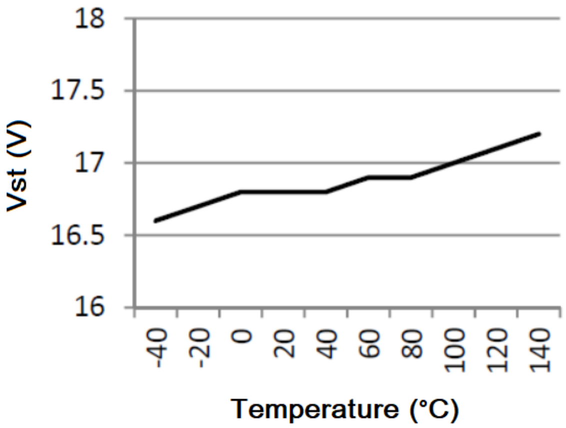
1. Ivdd_startup



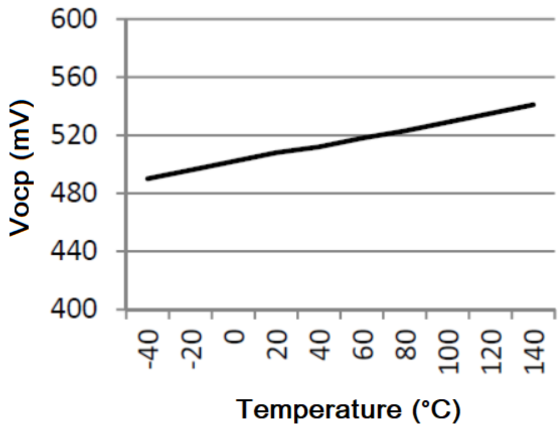
2. UVLO_on



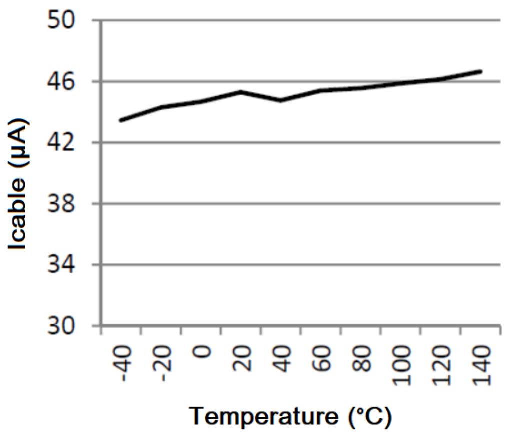
3. Vst vs. Temperature



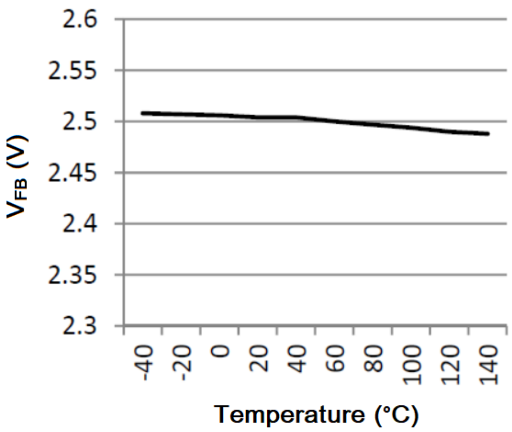
4. Vocp vs. Temperature



5. Icable



6. V_{FB}

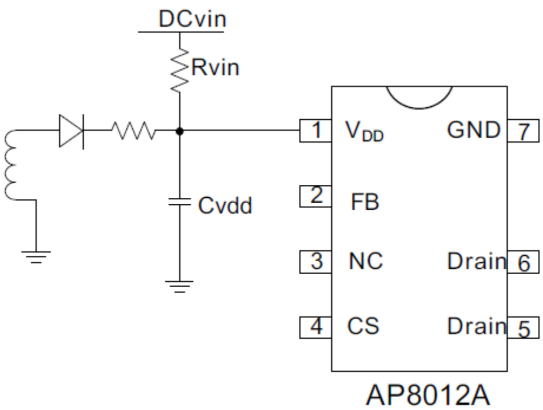


OPERATION DESCRIPTION

AP8012A is a cost effective PSR power switch optimized for off-line low power AC/DC applications including battery chargers. It operates in primary side sensing and regulation, thusopto-coupler and A431 are not required.
Proprietary built-in CV and CC control can achieve high precision CC/CV control meeting most charger application requirements.

Startup Current and Start up Control

Startup current of AP8012A is designed to be very low so that V_{DD} could be charged up above UVLO threshold level and device starts up quickly. A large value startup resistor can therefore be used to minimize the power loss yet achieve a reliable startup in application.



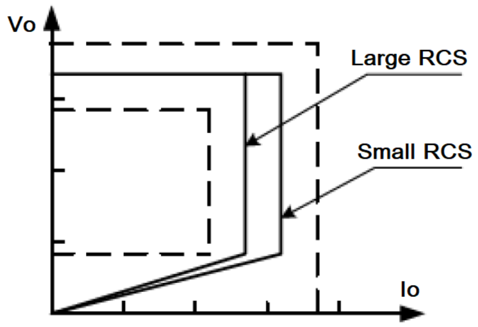
AP8012A Start Up

Operating Current

The operating current of AP8012A is as low as 650uA (typical). Good efficiency and less than 75mW standby power is achieved with the low operating current.

Adjustable CC point and output power

In AP8012A series, CC point and maximum value the output power can be adjusted externally, and the external current detection resistor R_{CS} (CS pin is described in the typical application diagram). The larger R_{CS}, the smaller CC point, the smaller output power, and vice versa are shown as follows:



RCS & CC, Output Power

Switching frequency

The switching frequency of AP8012A is adaptive to the output load.

For flyback operation in DCM, the maximum the output power is given by the following formula:

$$Po_{MAX} = \frac{1}{2} x\ L_p\ x\ F_{sw}\ x\ I_{peak}^{2}$$

among:

Po_{MAX} represents the maximum output power

L_p Indicates the primary side inductance of the inductance

F_{sw} Indicates the switching frequency of the system

I_{peak} Represents the peak current of the primary side

Through the above formula, it can be concluded that the maximum output power is caused by the primary inductance, and the switching frequency is caused by the internal locking of the system. The specific formula is as follows:

$$F_{sw} = \frac{1}{2\ x\ T}$$

Therefore, the sum of the products is fixed, the maximum output power and the constant current of CC mode will not change, and the change of primary winding inductance is as high as ±7%, and the change of primary winding inductance can be compensated.

Constant Current function

AP8012A detects the peak current of the inductor one by one. The CS terminal is connected to the input terminal of the internal peak current comparator. Compared with the internal threshold voltage, when the external voltage of CS reaches the internal detection threshold, the power tube turns off.

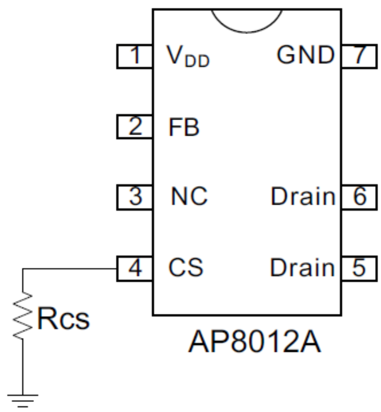
The expression of peak current of inductance at full load is as follows:

$$I_{P\_PK}(mA)=\frac{500}{R_{CS}}$$

The output of CS comparator also includes a 300 ns leading edge blanking time.

The calculation formula of output current is:

$$I_{CC}(mA)=\frac{N}{4}\times\frac{500}{R_{CS}}$$



CS Sampling Diagram

among:

I_{CC} is the current at the system output.

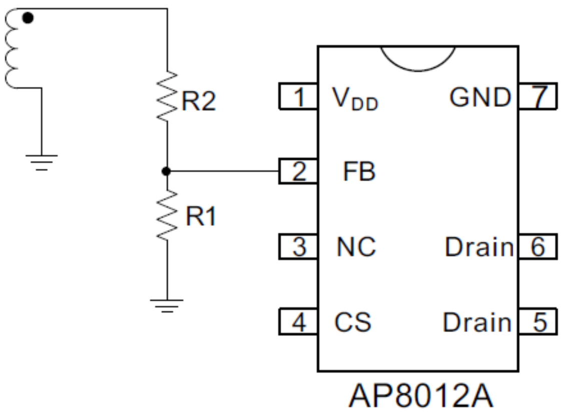
N Is the turn ration of the primary stag of the transformer.

R_{cs} Is the resistance between chip CS pin and GND.

Constant voltage control

The FB of AP8012A detects the feedback voltage of the auxiliary winding through the partial voltage of resistance R2 and R1, and the difference between the FB voltage and the reference voltage controls the frequency of the switch signal through the amplification of the error amplifier. In order to improve the accuracy of the output voltage, the leakage induction of the transformer is reduced as much as possible. The output voltage can be obtained by the following formula:

$$V_{OUT} = 2.5 \times (1+R2 / R1) \times (N_s / N_a) - Vf$$



Feedback Adjustment Diagram

among:

R1 and R2 are pull-up and pull-down resistances of auxiliary winding.

N_s and N_a Is the number of turns of the secondary and auxiliary windings of the transformer.

Vʄ Table output rectifier diode voltage drop.

Current detection and leading edge blanking

AP8012A provides cycle by cycle current limitation, and the power tube current is detected by resistance sampling connected to CS pin. When the power switch is on, there will be an opening spike on the sampling resistance. In order to avoid the misoperation caused by the opening spike, a 300 ns leading edge blanking time is set on the CS pin, so there is no RC filter circuit outside the CS pin.

Output line voltage compensation

In the constant voltage mode, the conventional chip adjusts the feedback voltage by changing the conduction time of the power tube, which does not include the voltage drop on the wire.

This leads to different output voltages due to the use of wires of different specifications and lengths. The AP8012A has a built-in line voltage drop compensation circuit for better load regulation.

AP8012A has the function of line loss compensation, which can compensate the voltage drop of output voltage on the wire.

Through the built-in current flowing into the resistance voltage divider, a compensation voltage is generated at the FB pin. As the converter load increase from no-load to the peak power point (the switching point between constant voltage and constant current), the voltage drop on the output wire will be compensated by increasing the reference voltage of the feedback pin. The controller determines the output load and the corresponding compensation degree according to the output of the state regulator. The proportion of the maximum compensation can be obtained by the following formula:

$$\frac{\Delta V}{V_{OUT}} = \frac{I_{comp\text{-}cable} \times (R1 / R2) \times 10^{-6})}{2.5} \times 100\%$$

among:

ΔV Is the compensation voltage.

V_{OUT} Is the output voltage.

R2 and R1 are the pull-up resistance of FB. Icomp is the compensation current.

CC mode shutdown function

In AP8012A series, when the chip is in CC mode, to prevent the chip from working under abnormal conditions, the chip feeds back to the FB pin of the chip of the auxiliary winding through the sampling output voltage. When the FB voltage is lower than 1.55V, and after 1024 and 2048 cycles, the chip is locked, and the system needs to be powered up again to resume work.

Optimize dynamic response

AP8012A optimizes the design of dynamic response performance to meet the needs of the adapter.

No abnormal sound work

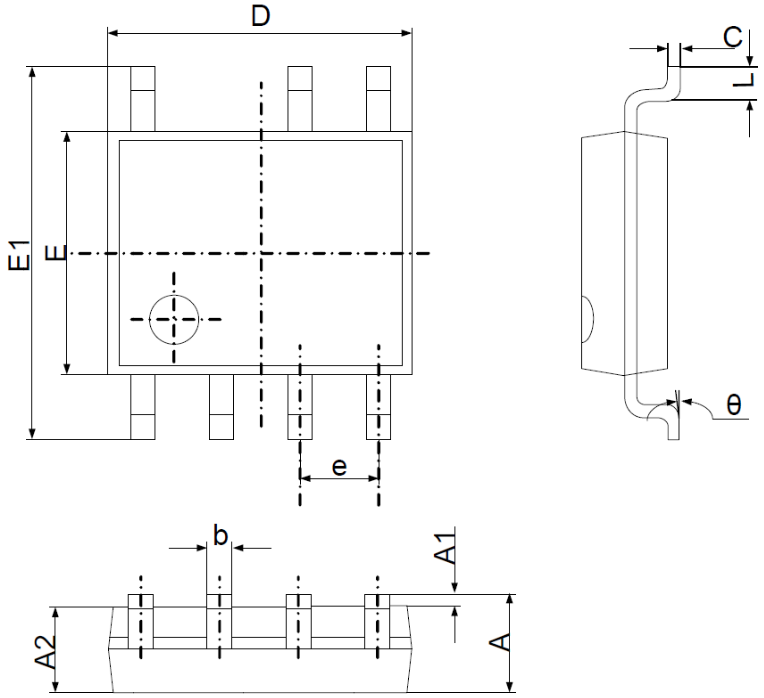
Under the constant voltage mode, the working frequency of AP8012A changes with the change of load, so that is has no abnormal sound during the whole working process from no-load to full load.

Protection control

AP8012A integrates protection functions, including V_{DD} over-voltage and under voltage protection, FB over under voltage protection, output short circuit protection, OTP protection and all pin suspension protection.

PACKAGE INFORMATION

Dimension in SOP7 Package (Unit: mm)



Symbol	Millimeters		Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0º	8º	0º	8º

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