PT2312E

CC/CV Primary-Side Green Mode Controller

GENERAL DESCRIPTION

The PT2312E is a high performance AC/DC power switch for charger and adaptor applications. Due to the PSR control, the PT2312E can provide accurate constant voltage (CV) and constant current (CC) regulation without opto-coupler and TL431.

The PT2312E adopts PFM method in CC control mode and PFM/PWM method in CV control mode. In order to achieve high performance, The PT2312E uses quasi-resonant (QR) switching to improve the efficiency, frequency shuffling technique to optimize EMI design and built-in cable drop compensation to meet good load regulation.

The PT2312E utilizes soft start control and multi-protection to meet high reliability, such as cycle-by-cycle current limiting, output OVP, VCC OVP/UVLO, sense resistor open/short protection, OTP etc.

PT2312E is offered in SOP-7 package.

FEATURES

- PSR without opto-coupler and TL431
- 5% CV and 5% CC regulation at universal AC input
- QR operation for high efficiency
- Frequency shuffling technique for EMI
- Built-in cable drop compensation
- Built-in adaptive current peak regulation
- Built-in primary side winding inductance compensation
- Built-in leading edge blanking (LEB)
- Power on soft-start
- Cycle-by-cycle current limiting
- VCC OVP/UVLO, Output OVP
- CS resistor open and short protection
- Over temperature protection(OTP)
- Auto-recovery after trigger protection

APPLICATIONS

- Adapters/Chargers
- LED Lighting
- Auxiliary Power Supplies

ORDERING INFORMATION

PACKAGE	TEMPERATURE RANGE	ORDERING PART NUMBER	TRANSPORT MEDIA	MARKING
SOP-7	-40℃ to 85℃	PT2312EESOG	Tape and Reel 2500 units	PT2312E xxxxxX

TYPICAL APPLICATION CIRCUIT

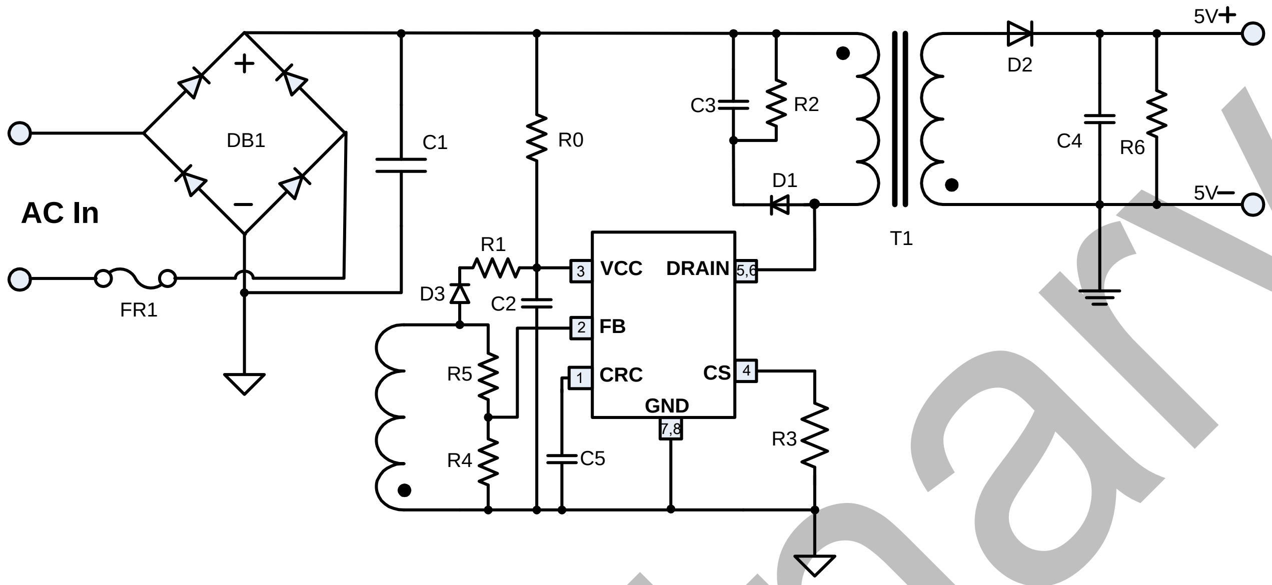


Figure1. Typical Application of PT2312E

PIN ASSIGNMENT

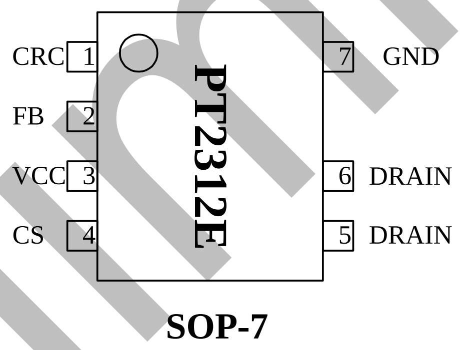


Figure 2. Pin Configuration of PT2312E (Top View)

PIN DESCRIPTIONS

PIN No.	PIN NAMES	DESCRIPTION
1	CRC	This pin connects a capacitor (10nF is recommended) to GND for system stability regulation
2	FB	Voltage feedback, The CV and CC regulation are realized based on the voltage sampling of this pin
3	VCC	The power supply for the IC. In order to get the correct operation of the IC, a capacitor with low ESR should be placed as close as possible to the VCC pin
4	CS	Primary Side Peak Current Detection Port
5,6	DRAIN	Open-drain of MOSFET
7	GND	The ground of the IC

ABSOLUTE MAXIMUM RATINGS (Note1)

SYM	PARAMETER	VALUE	UNIT
V_{CC}	Voltage at VCC to GND	-0.3 to 28	V
	Voltage at Drain to GND	0 to 650	V
	Voltage at FB, CS, CRC to GND	-0.3 to 6	V
T_J	Operating Junction Temperature	-40 to 150	℃
T_{STG}	Storage Temperature	-55 to 150	℃
T_{LEAD}	Lead Temperature (Soldering, 10 sec)	300	℃
θ_{JA}	Thermal Resistance (Junction to Ambient)	184	℃/W
	ESD (Human Body Model)	2500	V

Note 1: Stresses greater than those listed under “Absolute Maximum Ratings” may cause permanent damages to the device. Functional operation of the device at these or any other conditions beyond those indicated under “Recommended Operating Conditions” is not implied. For maximum safe operating conditions, refer to Electrical Characteristics.

SIMPLIFIED BLOCK DIAGRAM

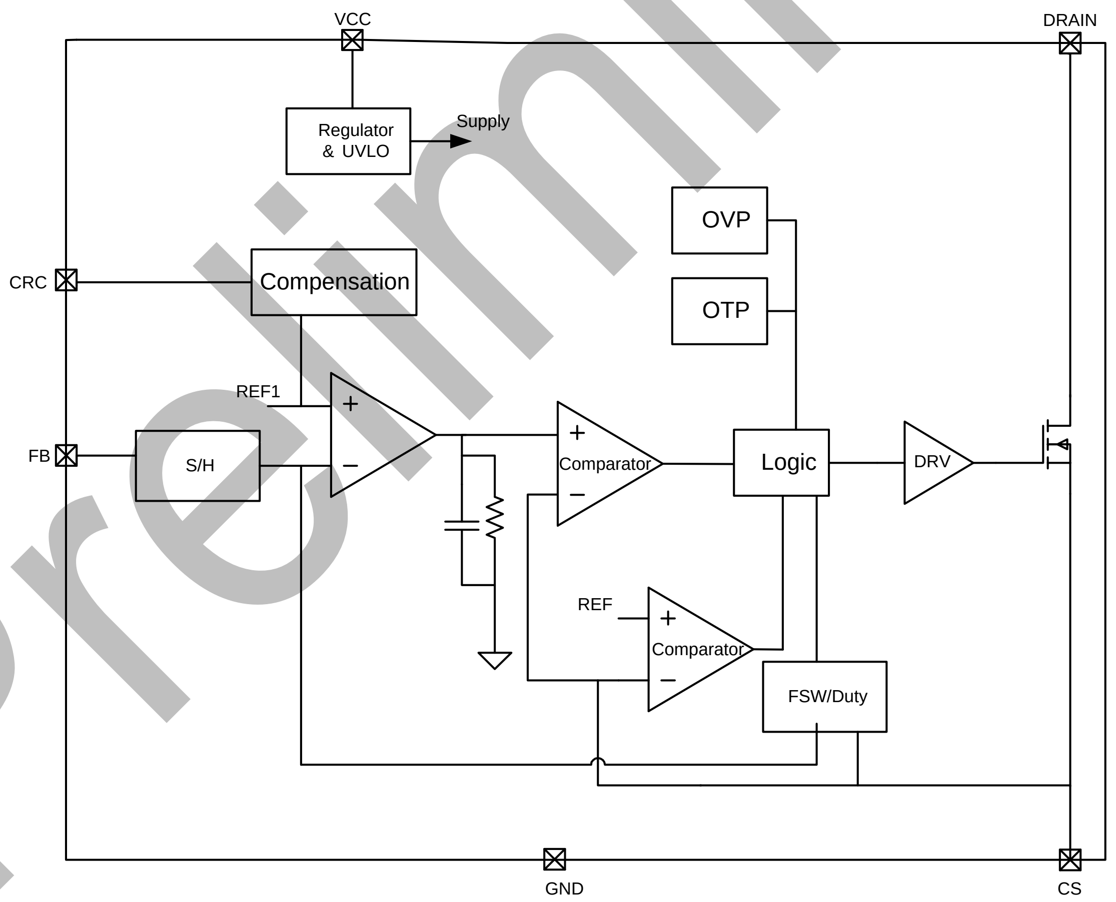


Figure 3. Simplified Block Diagram of PT2312E

ELECTRICAL CHARACTERISTICS

(TA=25℃, VCC=20.5V，unless otherwise specified)

SYMBOL	PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
Supply Voltage (VCC) Section						
VCC_{ON}	Turn-on threshold	VCC rising	18.5	20.5	22.5	V
VCC_{OFF}	Turn-off threshold	VCC falling	7.7	8.2	8.7	V
VCC_{OVP}	Over voltage protection threshold	Ramp VCC until gate shut down	23	24	25	V
VCC_{clamp}	Clamp voltage	I_{VCC} =10mA	25.5	27	28	V
ICC_{ST}	Start-up current	Before turn on, VCC=18V			1	μA
ICC_{OP}	Operation current	After VCC turn on			1	mA
ICC_{FAULT}	Protection current	Fault conditions		500		μA
Feedback (FB) Section						
VFB	Feedback Voltage	Operation at CV mode	2.475	2.5	2.525	V
VFB_{OVP}	FB OVP			3		V
IFB_{LEAK}	FB leakage current				0.1	μA
Icable	Cable compensation current		40	42.5	45	μA
Current Sense (CS) Section						
V_{CS}	CS current limit		0.485	0.5	0.515	V
T_{LEB}	LEB time			300		ns
Frequency Section						
F_{MIN}	Minimum frequency	No load		500		Hz
△f/Freq	Frequency shuffling range			7		%
OTP Section						
T_OTP	OTP temperature			160		℃
T_recovery	Recovery temperature			120		℃
Power MOSFET Section						
BV_{DSS}	Drain-Source breakdown Voltage		650			V
R_{DSON}	On Resistance	Static, Id=2.0A		4.0	4.8	Ω

OPERATION DESCRIPTION

The PT2312E is a high performance AC/DC power controller for charger and adaptor applications. Due to the PSR control, the PT2312E can provide accurate constant voltage (CV) and constant current (CC) regulation without opto-coupler and TL431, as shown in Figure 4.

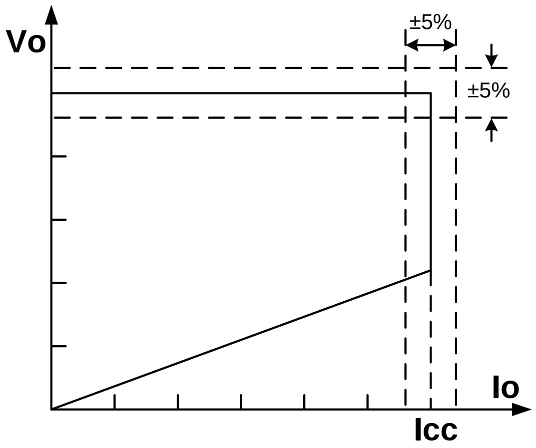


Figure 4. Typical CC/CV Curve

- **Start up Current and Start up Control**

The VCC of PT2312E could be charged up above UVLO threshold and starts up quickly because of the very low startup current. A large value startup resistor can therefore be used to minimize the power loss in application. In addition, soft-start is designed to assure the reliability.

- **Operating Current**

The operating current of PT2312E is about 1mA. Good efficiency is achieved with the low operating current together with 'Muti-mode' control features. Also, it is very important for low standby power design.

- **Constant Voltage Operation**

The PT2312E is designed for flyback system, which always works in DCM mode at both CC/CV control (Refer to Figure 1).

The controller works in PFM/PWM mode at CV operation. And the output voltage of system can be sensed via the divider of auxiliary winding. During primary MOSFET turn-on time, the secondary output diode is reversed, then the load current is supplied from the output capacitors. The current in the primary winding ramps up. Until MOSFET turns off, the primary current transfers to the secondary side and the output diode become conducting state. The waveform of auxiliary voltage reflecting the output voltage is shown in figure 5 and the equation is given by

$$V_{AUX} = \frac{N_{AUX}}{N_S} \cdot (Vo + Vd) \qquad (1)$$

Where Vd indicates the forward voltage on the output diode, N_{AUX}/N_S is the turn ratio.

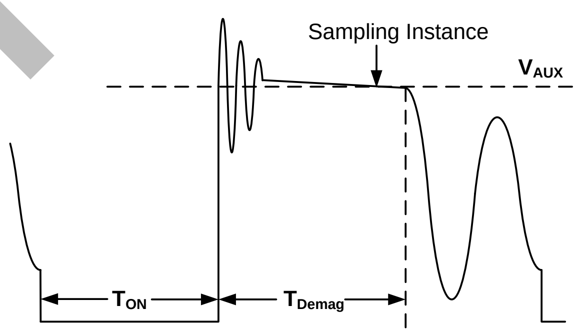


Figure 5. Auxiliary voltage waveform

The FB pin will detect the output voltage through the divider connected on the auxiliary winding, the auxiliary voltage is sampled at the two thirds of the de-magnetization time and will be hold until the next sampling. The FB signal will be compared with a internal reference (Vref) to get a error signal, which is used for voltage loop feedback at CV operation mode.

Constant Current Operation

When sampled voltage on FB pin is below Vref, the voltage feedback loop is not work and the system now works in CC operation mode. The switching frequency of system depends on the output voltage. This moment, the CS threshold (V_{CS}) will be kept at a constant value because of the saturation of the voltage loop, thus the constant output current can be achieved. The CC point and maximum output power can be adjusted by the external current sense resistor Rcs at CS pin, which is shown in typical application diagram. The output power is adjusted through CC point change. If a larger Rcs is selected, a smaller CC point will be get, meanwhile the smaller output power will be became to, and vice versa. Figure 6 shows the secondary current waveform on transformer.

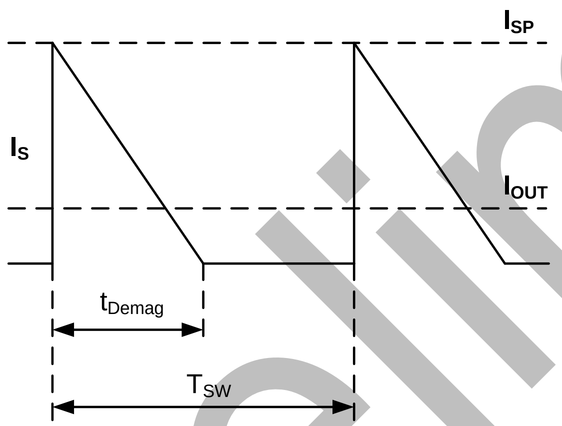


Figure 6. Secondary Current Waveform

According to the above, the output constant current is given by:

$$I_P = \frac{V_{CS}}{R_{CS}} \quad (2)$$

$$Iout = \frac{1}{2} \times I_{SP} \times \frac{t_{Demag}}{T} \quad (3)$$

$$I_{SP} = \frac{Np}{Ns} \times I_P \quad (4)$$

So :

$$Iout = 0.25 \times \frac{N_P}{N_S} \times \frac{V_{CS}}{R_{CS}} \quad (5)$$

Where: t_{Demag}/T is set to be 0.5 internally.

Quasi-Resonant Operation

The PT2312E incorporates a unique proprietary quasi-resonant switching scheme that achieves valley-mode turn on for every PWM/PFM switching cycle in CV operation. This unique feature greatly reduces the switching loss and dv/dt across the entire operating range of the power supply. Due to the nature of quasi-resonant switching, the actual switching frequency can vary slightly cycle by cycle, providing the additional benefit of reducing EMI. Together, this innovative control architecture makes the PT2312E to achieve highest overall efficiency and lowest EMI, without causing audible noise over entire operating range.

Operation switching frequency

The switching frequency is not set by external components, but depends on the load condition and the operation mode, it is adaptively controlled. For flyback operating in DCM, The maximum output power is given by

$$P_{OMAX} = \frac{1}{2} L_P F_{SW} I_P^{\,2} \quad (6)$$

Where Lp indicates the inductance of primary winding and Ip is the peak current of primary winding.

According to the equation 6, when the switching frequency (Fsw) is set, the maximum output power is proportional to the inductance of the primary winding as well as the square of the primary peak current. In order to compensate the change from variations of primary winding inductance, the switching frequency is locked by an internal loop, so that the switching frequency is

$$F_{SW} = \frac{1}{2t_{Demag}} \quad (7)$$

Here, t_{Demag} is the de-magnetization time, which is shown in figure 5. In CC mode, according to the equation 5, since the V_{CS} is an internal constant, the output current is proportional to the turn ratio and inversely proportional to the value of Rcs, it will not change with primary winding inductance changes. For a fixed system, the switching frequency is proportional to the output voltage when working in CC mode.

- **Frequency shuffling for EMI**

The frequency shuffling (switching frequency modulation) is implemented in PT2312E. The oscillation frequency is modulated so that the tone energy is spread out. The spread spectrum minimizes the conduction band EMI and therefore eases the system design.

- **Leading Edge Blanking**

The PT2312E is designed to offer cycle-by-cycle current limiting in current mode control. The switch current is detected by a sense resistor Rcs at CS pin. Because of the parasitic parameters, there will be a voltage spike on Rcs at the moment of power MOSFET turn on, which will lead to the wrong control logic. An internal leading edge blanking (LEB) circuit chops off the sensed voltage spike can be utilized to avoid this fault. Thanks to the LEB design, the RC filter on CS pin can be omitted.

- **Adjustable Cable Compensation**

A built-in cable drop compensation circuit is implemented to achieve good load regulation. An offset compensative current is added to FB pin, and the offset current changes with the load changes, thus the drop voltage on output cable can be compensated.

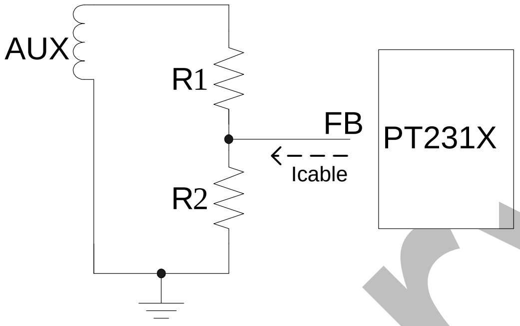


Figure 7. Cable compensation circuit

As shown in figure 7, set the cable compensation equation as

$$V_{ref}(1+\frac{R1}{R2}) - I_{cable} \cdot R1 = \frac{N_{AUX}}{N_S}(V_O + \Delta V + V_{cable}) \quad (8)$$

Here, V_{ref} is the feedback voltage equal to 2.5V, $\triangle V$ is the voltage drop on the output diode, V_{cable} is the voltage drop on the output cable and it is proportional to the load current. As the load current increases from no-load to full-load, I_{cable} will decrease from maximum (42.5μA) to 0, then the output voltage will increase. So a simple equation can be wrote as

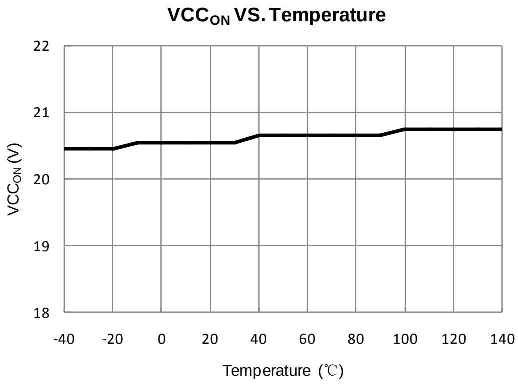
$$I_{cable} \cdot R1 = \frac{N_{AUX}}{N_S} \cdot V_{cable} \quad (9)$$

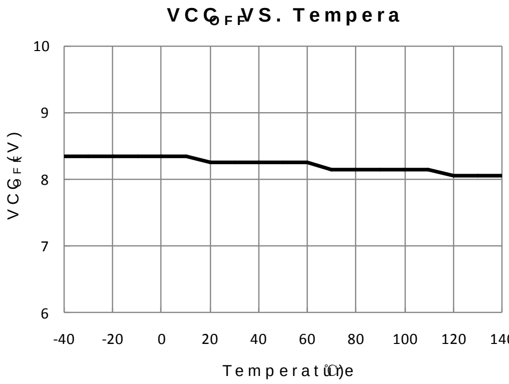
It is obvious that the compensative output voltage can be programmed by adjusting the resistance (R1) of the divider on auxiliary winding.

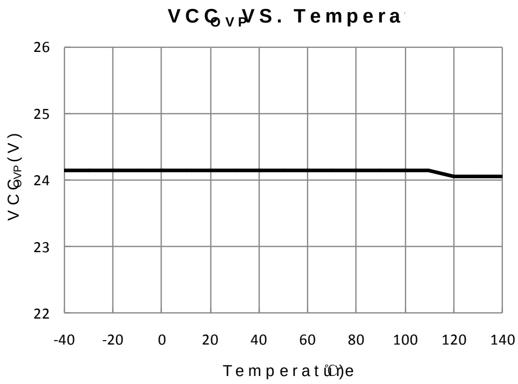
- **Protections**

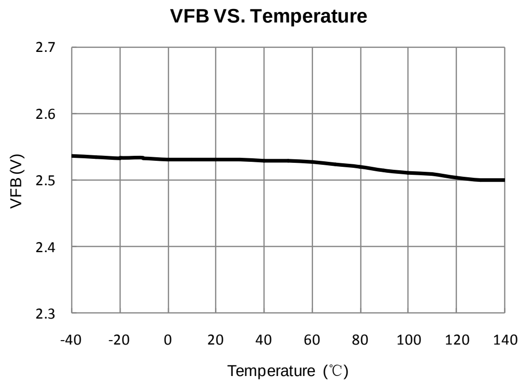
The PT2312E utilizes multi-protection to meet high reliability, such as cycle-by-cycle current limiting, output over voltage protection (OVP), VCC OVP/UVLO, CS resistor open/short protection, FB resistors open/short protection, over temperature protection etc.

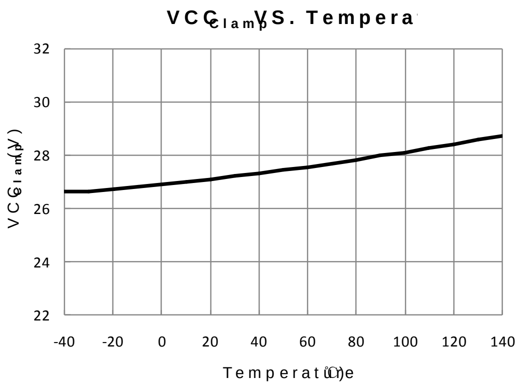
TYPICAL PERFORMANCE CHARACTERISTICS

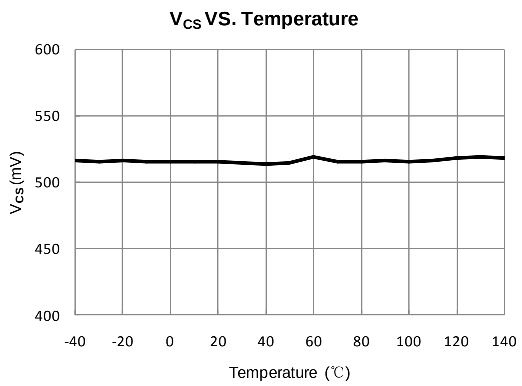


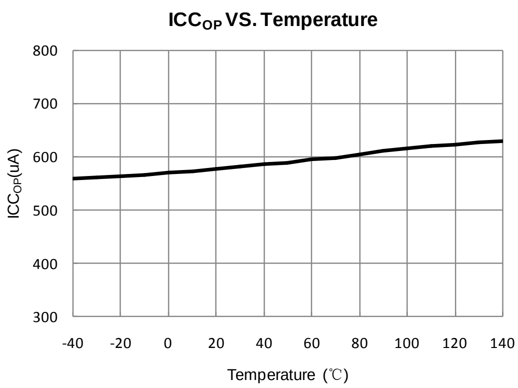


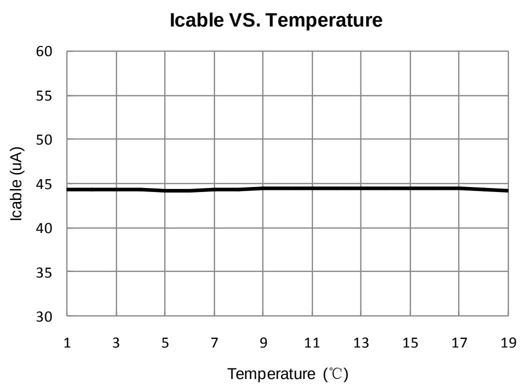






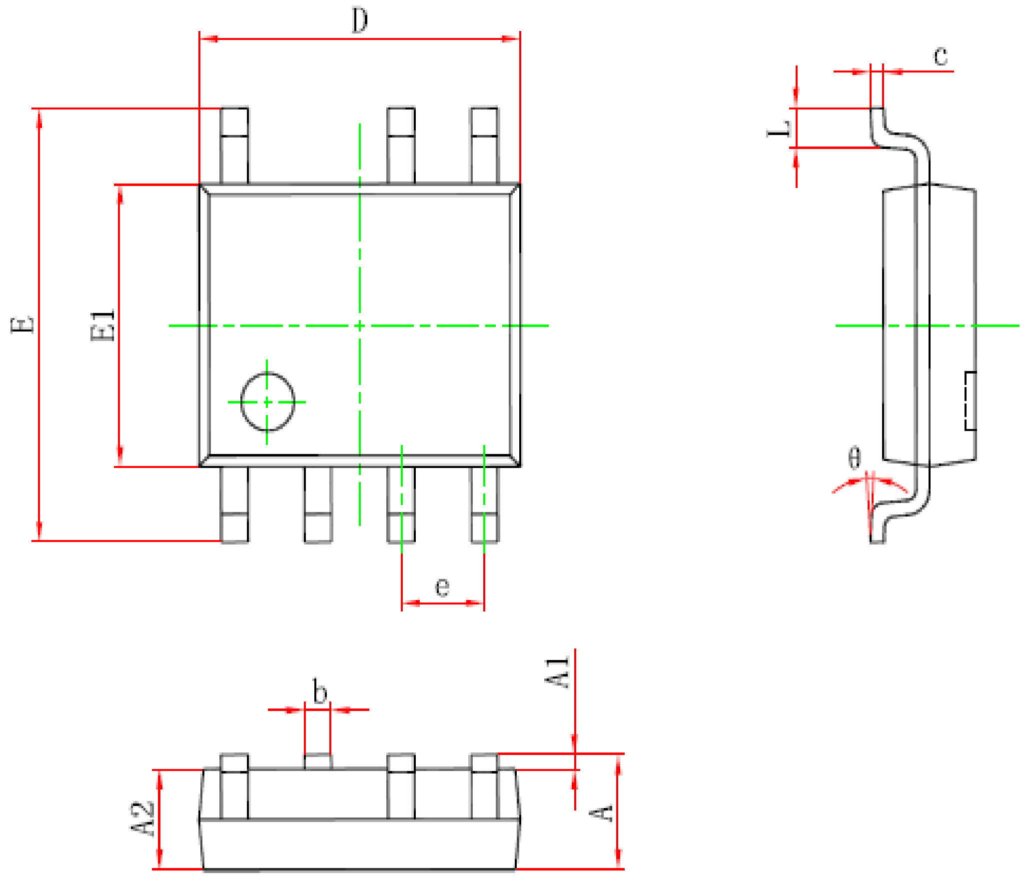






PACKAGE INFORMATION

SOP7 PACKAGE OUTLINE DIMENSIONS



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	1.250	1.650	0.049	0.065
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
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	0°	8°	0°	8°

IMPORTANT NOTICE

POWTWCH (SHANGHAI) CO., LTD. reserves the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services and to discontinue any product or service. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to POWTECH's terms and conditions of sale supplied at the time of order acknowledgment.

POWTECH warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in POWTECH's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent POWTECH deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

POWTECH assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using POWTECH components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

No POWTECH components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those POWTECH components which POWTECH has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of POWTECH components which have not been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use

Unless POWTECH has specifically designated certain components which meet ISO/TS16949 requirements, mainly for automotive use, POWTECH will not be responsible for any failure of such components to meet such requirements.