GENERAL DESCRIPTION

SMD535M is a high performance offline PWM power switch for low power AC/DC charger and adapter applications. It operates in primary-side sensing and regulation. Consequently, opto-coupler and TL431 could be eliminated. Proprietary Constant Voltage (CV) and Constant Current (CC) control is integrated as shown in the figure below.

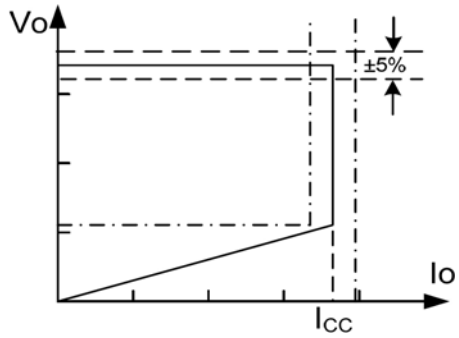


Fig.1. Typical CC/CV Curve

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 as well at large load condition and it operates in PWM with frequency reduction at light/medium load.

SMD535M offers power on soft start control and protection coverage with auto-recovery features including Cycle-by-Cycle current limiting, VDD OVP, VDD clamp and UVLO.

High precision constant voltage (CV) and constant current (CC) can be achieved by SMD535M.

FEATURES

- ±5% Constant Voltage Regulation at Universal AC input
- High Precision Constant Current Regulation at Universal AC input
- Primary-side Sensing and Regulation Without TL431 and Opto-coupler
- Programmable CV and CC Regulation
- Adjustable Constant Current and Output Power Setting
- Built-in Secondary Constant Current Control with Primary Side Feedback
- Built-in Adaptive Current Peak Regulation
- Built-in Primary winding inductance compensation
- Programmable Cable drop Compensation
- Power on Soft-start
- Built-in Leading Edge Blanking (LEB)
- Cycle-by-Cycle Current Limiting
- VDD Under Voltage Lockout with Hysteresis (UVLO)
- VDD OVP
- VDD Clamp

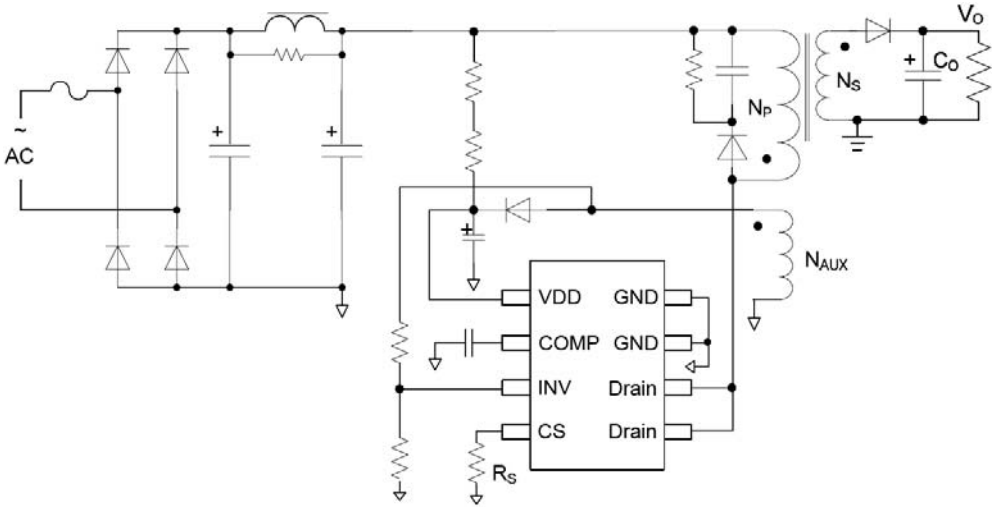
APPLICATIONS

Low Power AC/DC offline SMPS for

- Cell Phone Charger
- Digital Cameras Charger
- Small Power Adapter
- Auxiliary Power for PC, TV etc.
- Linear Regulator/RCC Replacement

SMD535M is offered in DIP8 package.

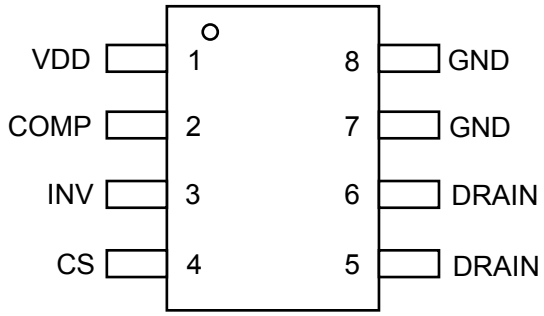
TYPICAL APPLICATION



GENERAL INFORMATION

Pin Configuration

The pin map is shown as below for DIP8.



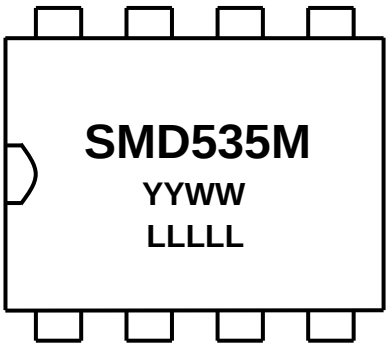
Absolute Maximum Ratings

Parameter	Value
Drain Voltage (off state)	-0.3V to Bvdss
VDD Voltage	-0.3 to V_{DD}_clamp
VDD Zener Clamp Continuous Current	10mA
COMP Voltage	-0.3 to 7V
CS input Voltage	-0.3 to 7V
INV input Voltage	-0.3 to 7V
Power Dissipation	1200mW
Thermal Resistance NOTE	75℃/W
Max Operation Junction Temperature Tj	150℃
Min/Max storage Temperature T-stg	-55 to 150℃
Lead Temperature (Soldering,10secs)	260℃

TERMINAL ASSIGNMENTS

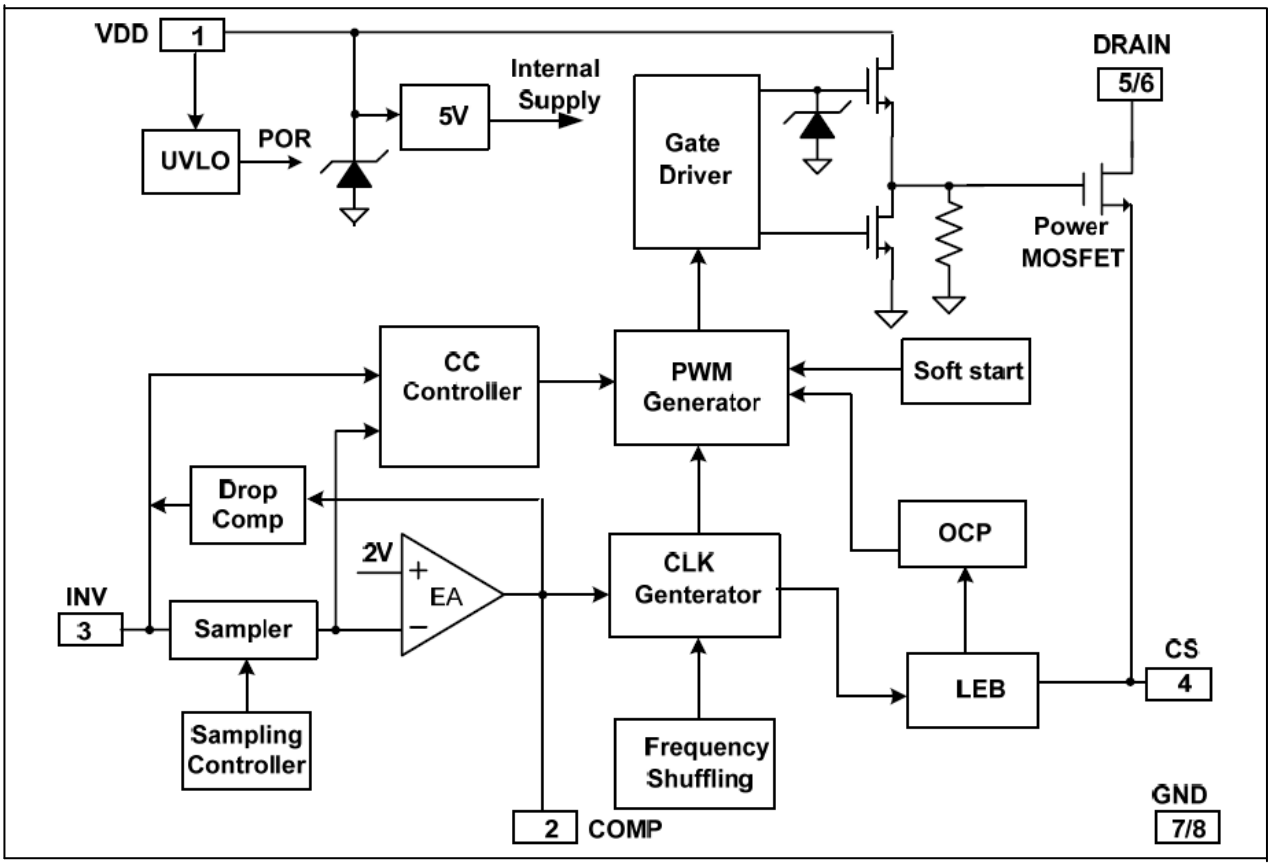
Pin Num	Pin Name	I/O	Description
1	VDD	P	Power Supply
2	COMP	I	Loop Compensation for CV Stability
3	INV	I	The Voltage feedback from auxiliary winding. Connected to resistor divider from auxiliary winding reflecting output voltage. PWM duty cycle is determined by EA output and current sense signal at pin 4.
4	CS	I	Current sense input
5/6	DRAIN	O	HV MOSFET Drain pin. The Drain pin is connected to the primary lead of the transformer
7/8	GND	P	Ground

Marking Information



SMD535: Product Name
M: DIP-8 with Pb-Free
MS: SOP-8 with Pb-Free
YY: Year Code (00~99)
WW: Week Code (01~52)
LLLLL: Lot Number Code

BLOCK DIAGRAM



ELECTRICAL CHARACTERISTICS

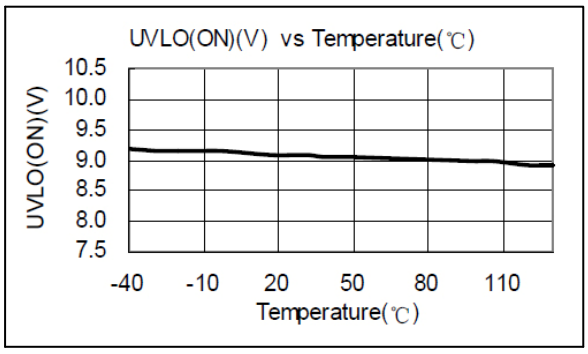
(T_A=25℃ if not otherwise noted)

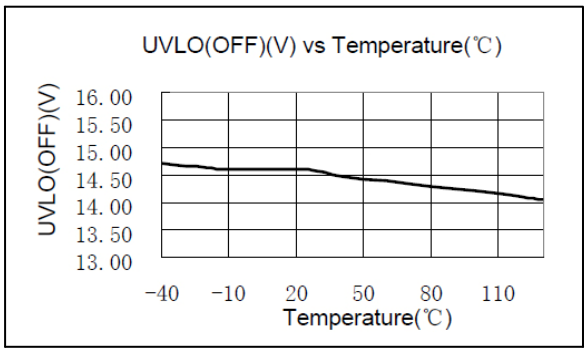
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
Supply Voltage (VDD)						
Standby Current	IDD _ST	VDD=13V		5	20	uA
Operation Current	IDD_Op	Operation Supply Current INV=1.96V, CS=0V, VDD=18V		2	3	mA
VDD Under Voltage Lockout Enter	UVLO(ON)	VDD falling	8.2	9.0	10.5	V
VDD Under Voltage Lockout Exit	UVLO(OFF)	VDD rising	13.5	14.8	16.0	V
Maximum VDD Clamp Voltage	VDD_Clamp	IDD=10mA	27	28.5	30	V
Over Voltage Protection Threshold	OVP	Ramp VDD until gate shut down	26	27.5	29	V
Current Sense Input						
LEB Time	T_LEB			625		ns
Over Current Threshold	Vth_OC		880	910	940	mV
OCP Propagation Delay	Td _OC			110		ns
Input Impedance	ZSENSE_IN		50			KΩ
Soft Start Time	T_SS			17		mS
Frequency Section						
IC Maximum Frequency	Freq_MaxNote 1		55	60	65	KHz
System Nominal Switch Frequency	Freq_Nom			50		KHz
System Start-up Frequency	Freq_startup	INV=0V, Comp=+5V		14		KHz
Frequency Shuffling Range	Δf/Freq			±3%		
Error Amplifier						
Reference Voltage for EA	Vref_EA		1.97	2.00	2.03	V
DC Gain of EA	Gain			60		dB
Max. Cable Compensation Current	I_COMP_MAX	INV=+2V, Comp=0V		37.5		uA
Power MOSFET Section						
MOSFET Drain Source Breakdown Voltage	BVdss	VGS=0V, ID=250uA	600			V
ON Resistance	Rdson	Static, Id=1A		4.9	5.5	Ω
Pulsed Drain-Source Current NOTE2	IDM				8	A
Continuous Drain Current	ID				2	A
Gate Threshold Voltage	VGS(th)	VDS=VGS, ID=250uA		2.50	3.00	V
Drain to Source Leakage Current	IDSS	VDS=600V, VGS=0V			10	uA
Gate Body Leakage Current	IGSS	VDS=0V, VGS=±20V			±100	nA
Drain-Source Diode Section						
Drain-Source Diode Forward Voltage	VSD	VGS=0V, IS=2A		0.9	1.4	V
Reverse Recovery Time	trr	VGS=0V, IS=2A, dIF/dt=100A/uS		490		nS
Reverse Recovery Charge	Qrr			0.8		uC

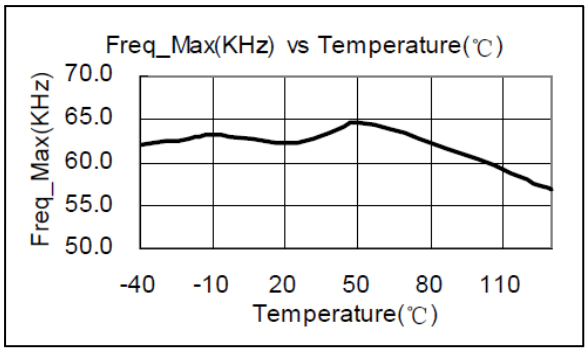
Note：

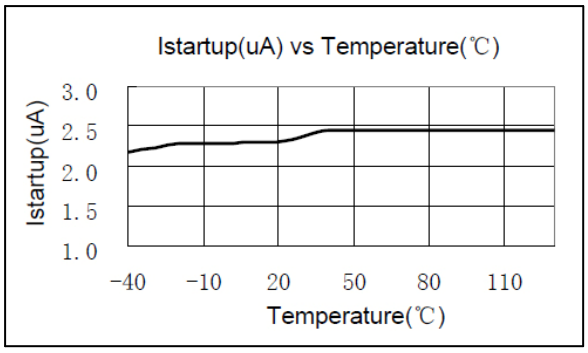
1. Freq_ Max indicates IC internal maximum clock frequency. In system application, the maximum operation frequency of 60Khz nominal occurs at maximum output power or the transition point from CV to CC.
2. Repetitive Rating: Pulse width limited by maximum junction temperature.

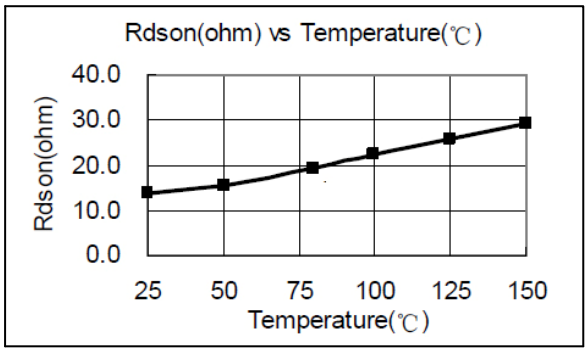
CHARACTERIZATION PLOTS











OPERATION DESCRIPTION

SMD535M is a cost effective PWM power switch optimized for off-line low power AC/DC applications including battery chargers and adapters. It operates in primary side sensing and regulation, thus Opto -coupler and TL431 are not required. Proprietary built-in CV and CC control can achieve high precision CC/CV control meeting most adapter and charger application requirements.

• Startup Current and Start up Control

Startup current of SMD535M is designed to be very low so that VDD could be charged up above UVLO threshold and starts up quickly. A large value startup resistor can therefore be used to minimize the power loss in application.

• Operating Current

The Operating current of SMD535M is as low as 2.5mA. Good efficiency is achieved with the low operating current together with 'Muti-mode' control features.

• Soft Start

SMD535M features an internal soft start to minimize the component electrical over-stress during power on startup. As soon as VDD reaches UVLO (OFF), the control algorithm will ramp peak current voltage threshold gradually from nearly zero to normal setting of 0.90V. Every restart is a soft start.

• CC/CV Operation

SMD535M is designed to produce good CC/CV control characteristic as shown in the Fig.1. In charger applications, a discharged battery charging starts in the CC portion of the curve until it is nearly full charged and smoothly switches to operate in CV portion of the curve.

In an AC/DC adapter, the normal operation occurs only on the CV portion of the curve. The CC portion provides output current limiting. In CV operation, the output voltage is regulated through the primary side control. In CC operation mode, SMD535M will regulate the output current constant regardless of the output voltage drop.

• Principle of Operation

To support SMD535M proprietary CC/CV control, system needs to be designed in DCM mode for flyback system (Refer to Typical Application Diagram on page1). In the DCM flyback converter, the output voltage can be sensed via the auxiliary winding. During MOSFET turn-on time, the load current is supplied from the output filter capacitor Co. The current in the primary winding ramps up.

When MOSFET turns off, the primary current transfers to the secondary at the amplitude of

$$I_S = \frac{N_P}{N_S} \times I_P \quad (1)$$

The auxiliary voltage reflects the output voltage as shown in fig.2 and it is given by

$$V_{AUX} = \frac{N_{AUX}}{N_S} \times (V_O + \Delta V) \quad (2)$$

Where △V indicates the drop voltage of the output Diode.

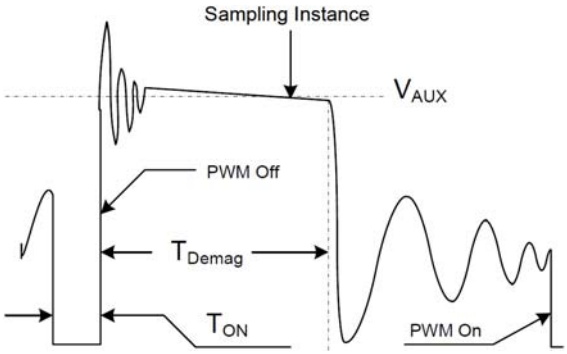


Fig.2. Auxiliary voltage waveform

Via a resistor divider connected between the auxiliary winding and INV (PIN 3), the auxiliary voltage is sampled at the end of the demagnetization and it is hold until the next sampling. The sampled voltage is compared with Vref (2.0V) and the error is amplified. The error amplifier output COMP reflects the load condition and controls the PWM switching frequency to regulate the output voltage, thus constant output voltage can be achieved.

When sampled voltage is below Vref and the error amplifier output COMP reaches its maximum, the switching frequency is controlled by the sampled voltage thus the output voltage to regulate the output current, thus the constant output current can be achieved.

• Adjustable CC point and output Power

In SMD535M, the CC point and maximum output power can be externally adjusted by external current sense resistor Rs at CS pin as illustrated in Typical Application Diagram. The output power is adjusted through CC point change. The large Rs, the smaller CC point is, and the smaller output power becomes, and vice versa as shown in Fig.3.

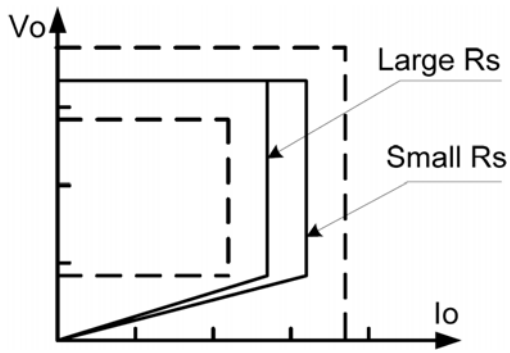


Fig.3 Adjustable output power by changing Rs

• Operation switching frequency

The switching frequency of SMD535M is adaptively controlled according to the load conditions and the operation modes. No external frequency setting components are required. The operation switching frequency at maximum output power is set to 60KHz internally.

For flyback operating in DCM, The maximum output power is given by

$$P_{O\_MAX} = \frac{1}{2} \times L_P \times F_{SW} \times I_P^2$$

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

Refer to the equation 3, the change of the primary winding inductance results in the change of the maximum output power and the constant output current in CC mode. To compensate the change from variations of primary winding inductance, the switching frequency is locked by an internal loop such that the switching frequency is

$$F_{SW} = \frac{1}{2T_{Demag}}$$

Since T-Demage is inversely proportional to the inductance, as a result, the product Lp and Fsw is constant, thus the maximum output power and constant current in CC mode will not change as primary winding inductance changes. Up to ±10% variation of the primary winding inductance can be compensated.

• Frequency shuffling for EMI improvement

The frequency shuffling (switching frequency modulation) is implemented in SMD535M. 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.

•Current Sensing and Leading Edge Blanking

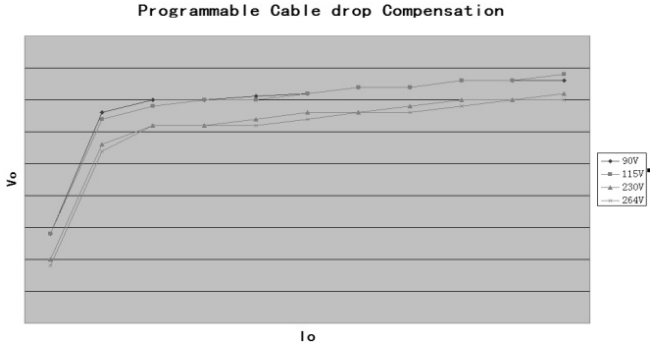
Cycle-by-Cycle current limiting is offered in SMD535M current mode PWM control. The switch current is detected by a sense resistor into the CS pin. An internal leading edge blanking circuit chops off the sensed voltage spike at initial internal power MOSFET on state so that the external RC filtering on sense input is no longer needed. The PWM duty cycle is determined by the current sense input voltage and the EA output voltage.

• Gate Drive

The internal power MOSFET in SMD535M is driven by a dedicated gate driver for power switch control. Too weak the gate drives strength results in higher conduction and switch loss of MOSFET while too strong gate drive compromises EMI. A good tradeoff is achieved through the built-in totem pole gate design with right output strength control.

• Programmable Cable drop Compensation

In SMD535M, cable drop compensation is implemented to achieve good load regulation. An offset voltage is generated at INV by an internal current flowing into the resister divider. The current is inversely proportional to the voltage across pin COMP, as a result, it is inversely proportional to the output load current, thus the drop due to the cable loss can be compensated. As the load current decreases from full-load to no load, the offset voltage at INV will increase. It can also be programmed by adjusting the resistance of the divider to compensate the drop for various cable lines used.



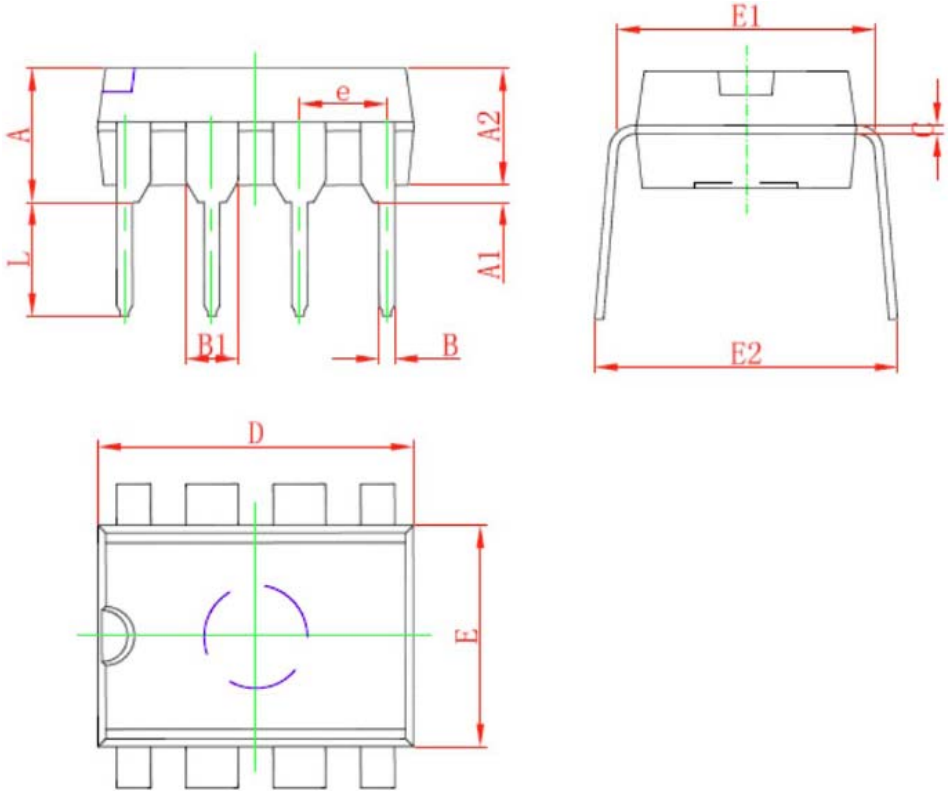
• Protection Control

Good power supply system reliability is achieved with its rich protection features including Cycle-by-Cycle current limiting (OCP), VDD clamp, Power on Soft Start, and Under Voltage Lockout on VDD (UVLO).

VDD is supplied by transformer auxiliary winding output. The output of SMD535M is shut down when VDD drops below UVLO (ON) limit and Switcher enters power on start-up sequence thereafter.

PACKAGE MECHANICAL DATA

DIP8 PACKAGE OUTLINE DIMENSIONS



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	3.710	4.310	0.146	0.170
A1	0.510		0.020	
A2	3.200	3.600	0.126	0.0142
B	0.380	0.570	0.015	0.022
B1	1.524(BSC)		0.060(BSC)	
C	0.204	0.360	0.008	0.014
D	9.000	9.400	0.354	0.370
E	6.200	6.600	0.244	0.260
E1	7.320	7.920	0.288	0.312
e	2.540(BSC)		0.100(BSC)	
L	3.000	3.600	0.118	0.0142
E2	8.400	9.000	0.331	0.0354