μP6326L5M

Offline AC-DC Primary Side Regulation Switcher

1. Description

The μP6326L5M is a high performance offline AC-DC switcher for mobile phone charger and adapter applications. The device uses Pulse Frequency Modulation (PFM) and Pulse Width Modulation (PWM) multi-mode to build Discontinuous Conduction Mode (DCM) fly back power supplies. The μP6326L5M uses forward winding for VCC supplies to meet lower standby power, faster startup time and smaller VCC capacitor.

The μP6326L5M provides accurate Constant Voltage (CV) and Constant Current (CC) without requiring TL431 and opto-coupler. It also eliminates the need of loop compensation circuitry while maintaining stability.

The μP6326L5M is equipped with both adjustable cable drop compensation function to meet various cables with different lengths and gauges and line voltage compensation function.

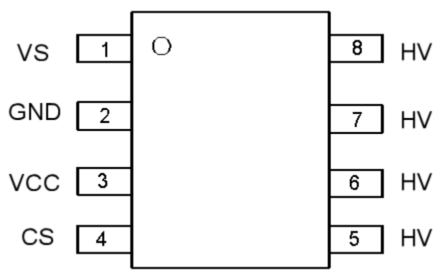
2. Applications

- Mobile Phone Charger
- E-tool Adapter
- LED Isolated Power Supply
- Standby Power Supply
- Digital Camera

3. Features

- Internal 700V Power BJT for AC Range: 85Vac~264Vac
- Output Power: 15W
- Less than 75mW Standby Power and 1s Startup Time
- High Precision Constant Voltage and Current Without TL431 and Opto-coupler
- Multi-mode PWM/PFM Operation for Efficiency and Audio Noise Improving
- Adjustable Cable Compensation (1%~8%)
- Excellent System ESD Performance
- No Need for Control Loop Compensation
- Valley Turn-on to Reduce Switching Loss and Improve EMI
- Operating Frequency Jitter Function for Conductive EMI Suppression
- DoE(VI)/CoC tier2 Compliant Efficiency
- Multiple Protections
  - ◆Over Temperature Protection(OTP)
  - ◆Output Over-Voltage Protection(OVP)
  - ◆Output Short Circuit Protection(SCP)
  - ◆Line Voltage OVP and VCC OVP
  - ◆VS Resistor Open/Short Protection
  - ◆CS Resistor Open/Short Protection
  - ◆IC Single Pin Floating Protection

4. Pin Assignments



SO-8 package

5. Pin Descriptions

Pin number	Pin Name	Pin Functions
1	VS	Voltage feedback. The CV and CC regulation are realized based on the voltage sampling of this pin
2	GND	The ground of the IC
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	Sense primary side current for turning off the integrated power BJT.
5,6,7,8	HV	The collector pin of the integrated power BJT

6. Absolute Maximum Ratings (Note 1)

Parameter	Name	Range	Unit
Collector voltage of Power BJT	HV	-0.5 to 700	V
Voltage at VCC to Ground	VCC	-0.5 to 38	V
VS input voltage	VS	-30 to 30	V
Voltage at CS to Ground	CS	-0.5 to 6	V
Maximum junction temperature	T_{JMAX}	150	°C
Lead temperature	T_{LEAD}	260	°C
Storage temperature	T_{STG}	-55 to 150	°C
Thermal resistance (Note 2)	θ_{JA}	100	°C/W
Human Body Mode ESD per ANSI/STM5.1-2001		+/-4000	V
Charged Device Model per JEDEC JESD22-C101F		+/-1000	V
Latchup test per JEDEC 78D		+/-200	mA

Note 1: Stresses over those listed under “Absolute maximum ratings” may cause permanent damages to the device. These are stress ratings only. Functional operation beyond those under “Recommended operating conditions” is not implied.

Note 2: The junction-to-ambient thermal resistance under natural convection is obtained in a simulation on a JEDEC-standard, high-K board, as specified in JESD51-7, in an environment described in JESD51-2a

7. Recommended Operating Conditions

Symbol	Parameter	Range	Unit
HV	Power device voltage	0~560	V
VCC	Supply voltage	4~32	V

8. Electrical Parameter

(Ta=25°C, unless otherwise specified)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Power supply(VCC pin)						
Quiescent current	I_{CC}	VCC= Vst-1V	280	380	480	µA
Startup voltage	V_{ST}		6	7.5	9	V
Minimum operating voltage	V_{UVLO}		2.85	3.2	4.5	V
Startup current	I_{ST}	VCC=Vst-1V		0.85	1.5	µA
Constant voltage control (VS pin)						
VS regulation voltage	V_{VS}		-2.91	-2.86	-2.81	V
Cable compensation current at Max load	I_{CAB}	Note 3		50		µA
Min. operating frequency	f_{MIN}			330		Hz
Constant Current Control (CS pin)						
Threshold voltage @40%~100% Load	V_{CSMAX}		560	590	620	mV
Threshold voltage @0%~5% Load	V_{CSMIN}	Note 3		200		mV
Pre-shutdown voltage	V_{CSPRE}/V_{CS}	Note 3		83		%
Leading edge blanking	T_{LEB}	At V_{CSMAX}	--	500	--	ns
Maximum duty of secondary winding conduction	D_{MAX}	Note 3		0.57		
Frequency jitter						
VCS modulation	$\Delta V_{CS}/V_{CS}$	Note 3	4	5	6	%
VCS modulation frequency	f_{MOD}	Note 3	0.8	1	1.2	kHz
Drive control (Note 3)						
Drive current	I_{DRV}			84		mA
Overdrive time	T_{OVD}			300		nS
Driving current rising time	T_{DR}	VCC=12V		65		nS
Pull down resistance	R_{DSON}			3		Ω
Sinking current rising time	T_{SR}	VCC=12V		35		nS
Protection function						
Shutdown Temperature	T_{OTP}	Note 3		160		°C
Temperature Hysteresis	T_{HYS}	Note 3		25		
VCC overvoltage protection	V_{CC_OVP}			36.5		V
VS over voltage	$\lvert V_{VS\_OVP}\rvert$			4		V
Short circuit voltage	$\lvert V_{VS\_HICCUP}\rvert$			0.4		V
Typical time under Vvs(SCP)	t_{SCP}	Note 3		64		ms

Note 3: These parameters are guaranteed by design and characterization

9. Functional Block Diagram

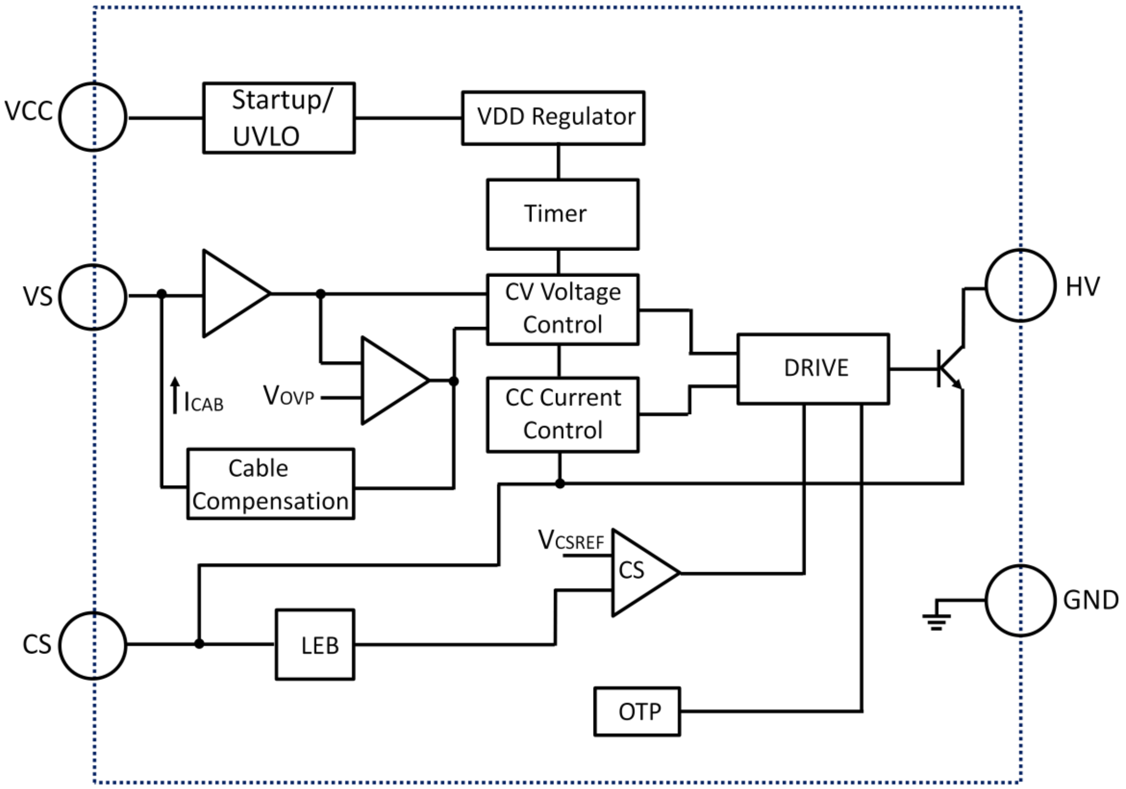


Fig.1, µP6326L5M block diagram

10. Typical Application

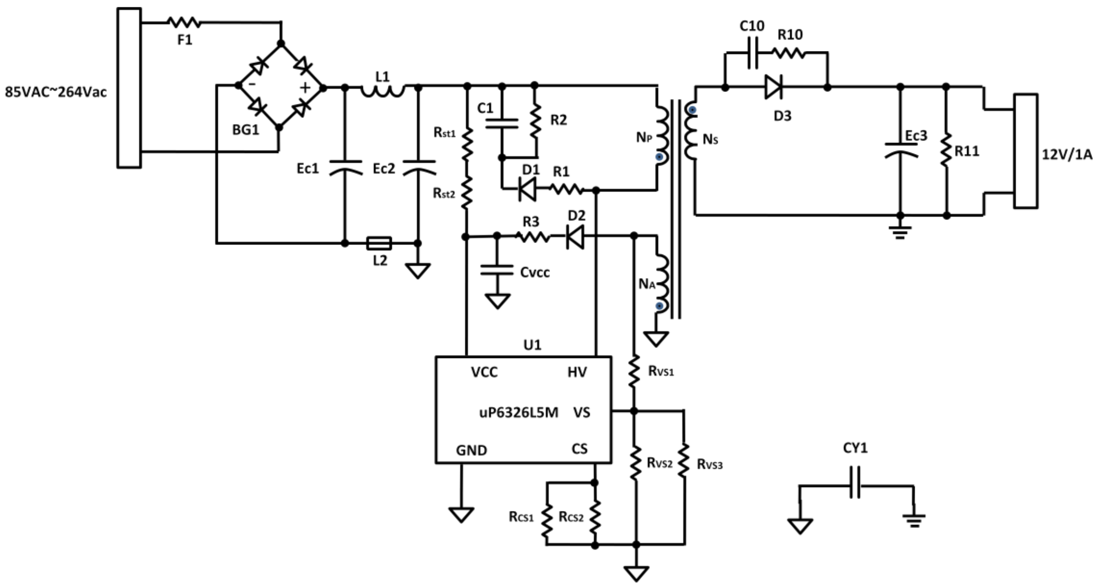


Fig.2, µP6326L5M 12V1A schematic

Ref.	Description	Qty.	Ref.	Description	Qty.
F1	2R 1W	1	Rst1、Rst2	10MΩ, 0805, 5%	2
EC1、EC2	10uF/400V, electrolytic	2	R1	100Ω,0805, 5%	1
EC3	470uF/16V, electrolytic	1	R2	200kΩ, 0805, 5%	1
C1	1nF/500V, 0805, ceramic	1	R3	2.4Ω, 0805, 5%	1
Cvcc	470nF/50V, 0805, ceramic	1	Rcs	0.91Ω, 1206, 1%	1
L1	330uH 0510	1	Rvs1	7.5kΩ, 0603,1%	1
L2	10uH 0805	1	Rvs2	6.8kΩ, 0603, 1%	1
CY1	Y1 KX101K	1	Rvs3	62kΩ, 0603, 1%	1
BD1	MBS10 1000V 1A	1	R11	650Ω, 0603, 5%	1
D1	1N4007，SOD-123	1	R12	15kΩ, 0603, 1%	1
D2	IN4148, SOD-123	1	U1	μP6326L5M SOP-8	1
D3	AK5100 DO27	1	T1	EE16W	1
Total Components:26					

Fig.3, μP6326L5M 12V1A BOM

11. Principle of Operation

The typical application circuit of μP6326L5M is a conventional flyback converter with a 3-winding transformer---primary winding (N_P), secondary winding (N_S) and auxiliary winding (N_A). The forward auxiliary winding is used for providing VCC supply voltage for IC and sensing the output voltage feedback signal to VS pin.

Fig.4 shows the typical waveforms which demonstrate the basic operating principle of μP6326L5M application. And the parameters are defined as following.

- **I_P**---The primary side current
- **I_S** ---The secondary side current
- **I_{PK}**---Peak value of primary side current
- **I_{PKS}**---Peak value of secondary side current
- **V_{SEC}**---The transient voltage at secondary winding
- **V_S**---The stable voltage at secondary winding when rectification diode is in conducting status, which equals the sum of output voltage V_O and the forward voltage drop of diode
- **V_{AUX}**---The transient voltage at auxiliary winding
- **V_A**--- The stable voltage at auxiliary winding when rectification diode is in conducting status, which equals the sum of voltage V_{CC} and the forward voltage drop of auxiliary diode
- **t_{SW}** ---The period of switching frequency
- **t_{ONP}** ---The conduction time when primary side switch is “ON”
- **t_{ONS}** ---The conduction time when secondary side diode is “ON”
- **t_{OFF}** ---The dead time when neither primary side switch nor secondary side diode is “ON”
- **t_{OFFS}** --- The time when secondary side diode is “OFF”

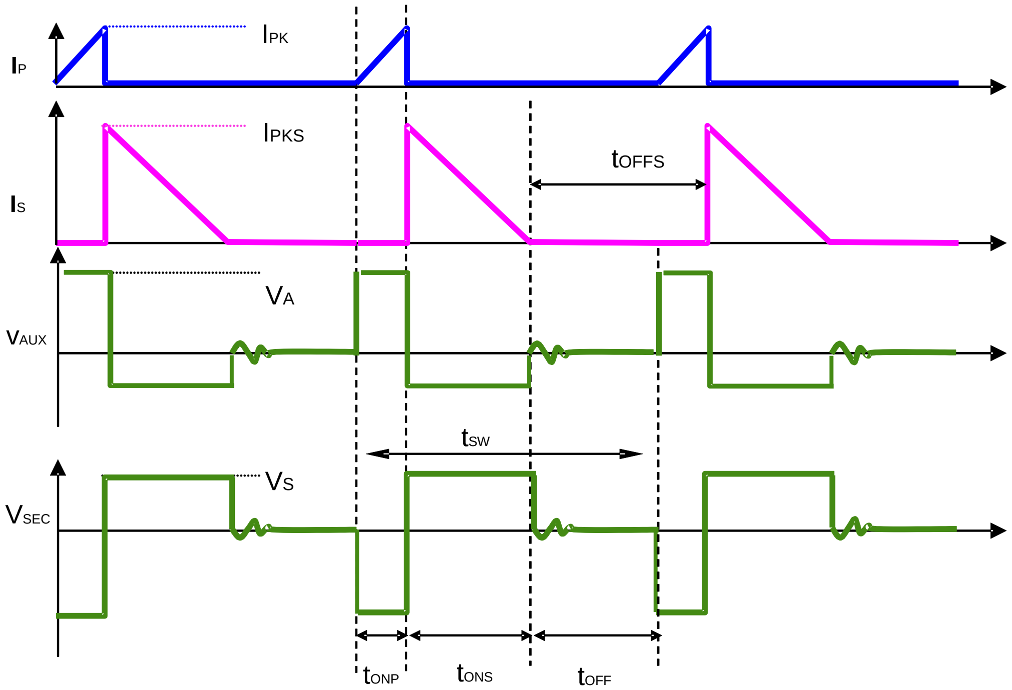


Fig.4 Typical Waveforms

11.1 Proprietary VCC Forward Power Supply

The µP6326L5M adopts the µPsemi's proprietary VCC forward power supply technology, which the polarity terminal of auxiliary winding is opposite to the commonly used flyback power supply.

In the traditional VCC flyback power supply, the forward voltage of auxiliary winding is Vo * N_{as}. The output voltage is very low when starting, Vo * N_{as} is less than VCC voltage and can't supply VCC power. At this stage the power consumption on VCC is depending on previous storage, so it is necessary to use the large VCC capacitance in order to maintain normal starting.

In the µPsemi's proprietary VCC forward power supply, as long as the primary side is switched on, the forward voltage of auxiliary winding is 1.414*Vac/Npa and can supply VCC power, which is independent of the output voltage. Therefore, the VCC forward power supply can use smaller VCC capacitor (470nf~1uf generally used), and the starting resistance can be about 20M to achieve lower standby power and faster startup time.

11.2 Constant Voltage (CV) Operation

Constant voltage operation occurs when the load is between no-load and full-load. Output voltage is sensed at the VS pin, which is connected to the auxiliary winding via resistors R_{VS1} and R_{VS2}. The VS waveform is sampled at t_{SAMPLE} , around 2/3 duration of the secondary winding conduction time(T_{ONS}). The sampled voltage is regulated at V_{VS} by the voltage control loop. The CV output is determined by the resistors R_{VS1}, R_{VS2} and the turn ratio of secondary winding to auxiliary winding (N_S/N_A). The output voltage at cable end is:

$$V_O = |V_{VS}| \times (1 + \frac{R_{VS1}}{R_{VS2}}) \times \frac{N_S}{N_A}$$

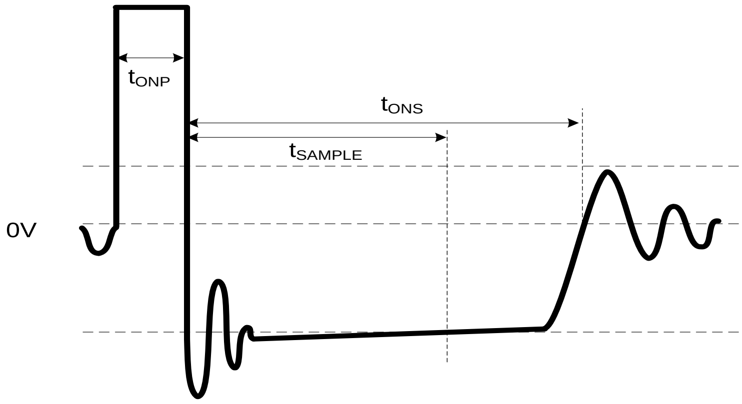


Fig.5 Auxiliary Voltage Waveform

11.3 Adjustable Cable Compensation

The VS pin source a current proportional to load current to generate cable compensation voltage. The cable compensation current at I_{OMAX} is I_{CAB}. The cable compensation voltage V_{CAB} can be adjusted by setting the R_{VS1}, R_{VS2} values. Neglecting the forward conduction voltage of second D2, the cable compensation voltage at full load is

$$V_{CAB} = I_{CAB} \times R_{VS1} \times \frac{N_S}{N_A}$$

The output voltage at PCB end is

$$V_{O\_PCB} = V_O + V_{CAB}$$

The cable compensation percentage is approximately

$$\frac{V_{CAB}}{V_O} = I_{CAB} \times R_{VS1} // R_{VS2} / |V_{VS}| - 0.05$$

For 5V2A typical application： R_{VS1} =10KΩ, R_{VS2} =13.3KΩ $\frac{V_{CAB}}{V_O}$=5%

The -0.05 item in the formula is to compensate load regulation.

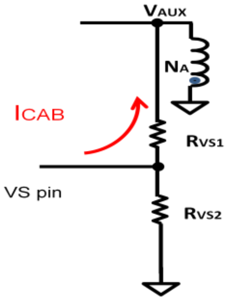


Fig.5. Adjustable Cable Compensation Circuit

11.4 Constant Current (CC) Operation

The μP6326L5M can work in constant-current (CC) mode. Figure 4 shows the secondary current waveforms. In CC operation mode, the CC control loop of μP6326L5M will keep a fixed proportion between D1 on-time t_{ONS} and D1 off-time t_{OFFS}. The fixed proportion is

$$\frac{t_{ONS}}{t_{OFFS}} = \frac{4}{3}$$

The relationship between the output current and secondary peak current I_{PKS} is given by:

$$I_{OUT} = \frac{1}{2} \times I_{PKS} \times \frac{t_{ONS}}{t_{ONS} + t_{OFFS}}$$

As to tight coupled primary and secondary winding, the secondary peak current is

$$I_{PKS} = \frac{N_P}{N_S} \times I_{PK}$$

Thus the output constant-current is given by:

$$I_{OUT} = \frac{1}{2} \times \frac{N_P}{N_S} \times I_{PK} \times \frac{t_{ONS}}{t_{ONS} + t_{OFFS}} = \frac{2}{7} \times \frac{N_P}{N_S} \times I_{PK}$$

11.5 Switching Frequency Control

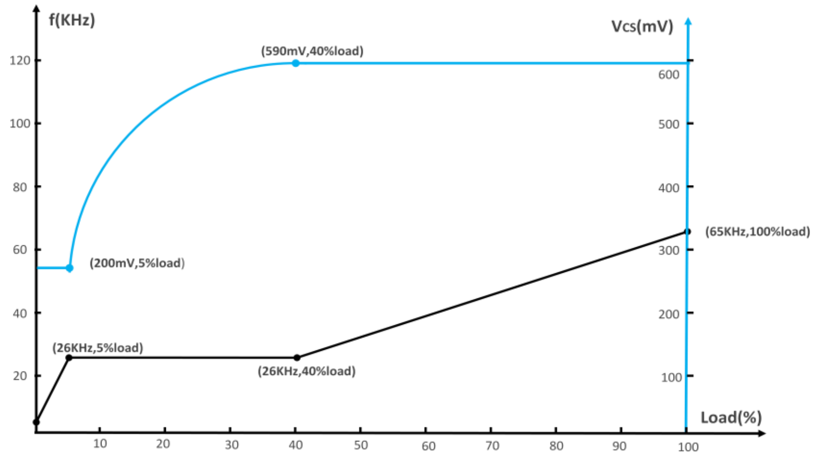


Fig.5, Switching frequency and CS voltage v.s. load current

The μP6326L5M works in Pulse Frequency Modulation (PFM) and Pulse Width Modulation (PWM) multi-mode to control output voltage and current. As shown in Fig.5, the CS voltage at the power device turnoff instant varies from V_{CSMIN} to V_{CSMAX} when the load increases from no load to full load. Operating frequencies varies from 500Hz at no load to up to 65kHz at full load. The power device is turned on when the ring voltage is down to its valley (quasi-resonant switching). This can reduce turn on losses of the power device. It can also generate switching period jittering to reduce EMI.

11.6 Short Circuit Protection (SCP)

Short Circuit Protection (SCP) detection principle is similar to the normal output voltage feedback detection by sensing VS pin voltage. When the detected VS pin voltage is below $|V_{VS\_HICCUP}|$ for a duration of about t_{SCP}, the SCP is triggered. Then the µP6326L5M enters auto-recovery mode that the IC immediately shuts down and then restarts, so that the VCC voltage changes between V_{ST} and UVLO threshold until V_{VS_HICCUP} condition is removed.

As to the normal system startup, the time duration of VS pin voltage below V_{VS_HICCUP} should be less than t_{SCP} to avoid entering SCP mode. But for the output short condition or the output voltage below a certain level, the SCP mode will be triggered. For typical 5V application, V_{SCP} is about 1V.

$$V_{SCP} = \left|V_{VS\_HICCUP}\right| \times (1 + \frac{R_{VS1}}{R_{VS2}}) \times \frac{N_S}{N_A} + I_{CAB} \times R_{VS1} \times \frac{N_S}{N_A} - V_{D2}$$

11.7 Line Voltage OVP

When the Line voltage is over a specified value voltage, power device will be turned off until the line voltage drops below $V_{LINE\_OVP.}$

$$V_{LINE\_OVP} = 0.707 \times V_{VCC\_OVP} \times \frac{N_P}{N_A}$$

11.8 Output Over Voltage Protection

When the output voltage is over a specified value V_{OVP} for 3 successive switching cycles, power device will be turned off until a new startup event begins.

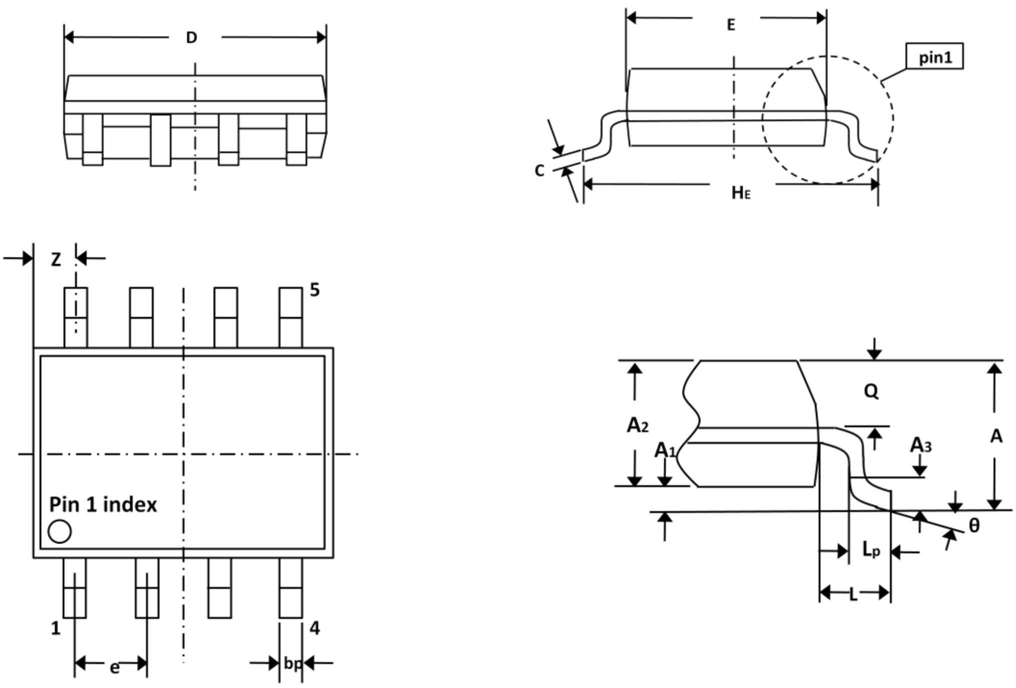
$$V_{OVP} = \left|V_{VS\_OVP}\right| \times (1 + \frac{R_{VS1}}{R_{VS2}}) \times \frac{N_S}{N_A} + I_{CAB} \times R_{VS1} \times \frac{N_S}{N_A}$$

12. Ordering Information

Part number	Mark ID	Package	Packing	Output power
µP6326L5M	6326L5M	SOP8	4000/Reel	10W~12W

13. Mechanical dimensions

SOP8



UNIT	A	A1	A2	A3	bp	c	D	E	e	HE	L	Lp	Q	Z	θ
mm	1.75MAX	0.10 0.25	1.25 1.65	0.25	0.31 0.51	0.17 0.25	4.8 5.0	3.8 4.0	1.27	5.8 6.2	1.05	0.4 1.2	0.6 0.7	0.3 0.7	0° 8°