

## Low Standby-Power Primary-Side Converter

### General Description

The PN8680M consists of a Low Standby-Power Primary-Side controller and a 650V avalanche-rugged smart power VDMOSFET, specifically designed for a high performance AC/DC charger or adaptor with minimal external components. PN8680M operates in primary-side sensing and regulation, so opto-coupler and TL431 could be eliminated. Because of internal HV Start-up circuit, the system with PN8680M can achieve less than 50mW standby power consumption (230VAC). In CV mode, multi-mode and quasi resonant technique is utilized to achieve high efficiency, avoid audible noise and make the system meeting Energy star class VI. Good load regulation is achieved by the built-in cable drop compensation. In CC mode, the current and output power setting can be adjusted externally by the sense resistor at CS pin. PN8680M offers complete protections including Cycle-by-Cycle current limiting protection (OCP), over voltage protection (OVP), over temperature protection (OTP) and CS open or short protection (CS O/SP) etc.

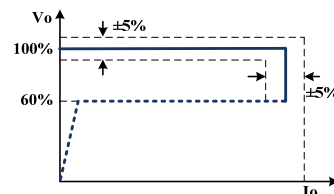
### Applications

- Switch AC/DC Adaptor
- Battery Charger

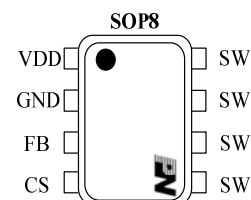
### Features

- Internal 650 V avalanche-rugged smart power VDMOSFET
- Internal HV Start-up Circuit, Standby power < 50mW
- Multi-mode technique
- $\pm 5\%$  CC Regulation at Universal AC input
- Primary-side Sensing and Regulation without TL431 and Opto-coupler
- Programmable Cable Drop Compensation
- No-need Control Loop Compensation Capacitance
- Excellent Protection Coverage:
  - ◇ Over Temperature Protection (OTP)
  - ◇ VDD Under/Over Voltage Protection(UVLO&OVP)
  - ◇ Cycle-by-Cycle Current Limiting (OCP)
  - ◇ Cs Short/Open Protection (CS O/SP)
  - ◇ Feedback Loop open Protection(OLP)

### Output Features

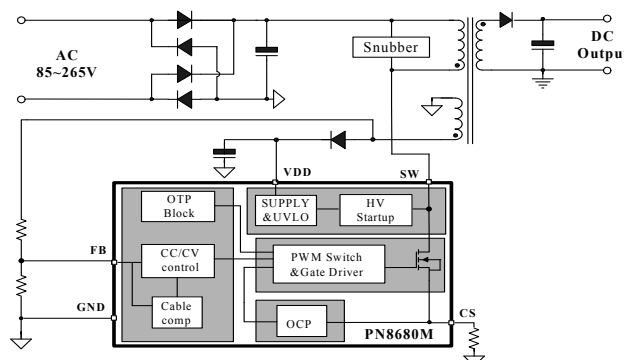


### Package/Order Information



Order code	Package	Typical power
		85~265 V <sub>AC</sub>
PN8680MSEC-R1	SOP8	12W
PN8680MSEC-R1C	SOP8	15W

### Typical Circuit



## Pin Definitions

Pin Name	Pin Number	Pin Function Description
VDD	1	Power supply
GND	2	Ground
FB	3	The voltage feedback from auxiliary winding. Connected to resistor divider from auxiliary winding reflecting output voltage.
CS	4	Current Sense Input
SW	5,6,7,8	Avalanche-rugged power MOSFET Drain pin. The Drain pin is connected to the primary lead of the transformer.

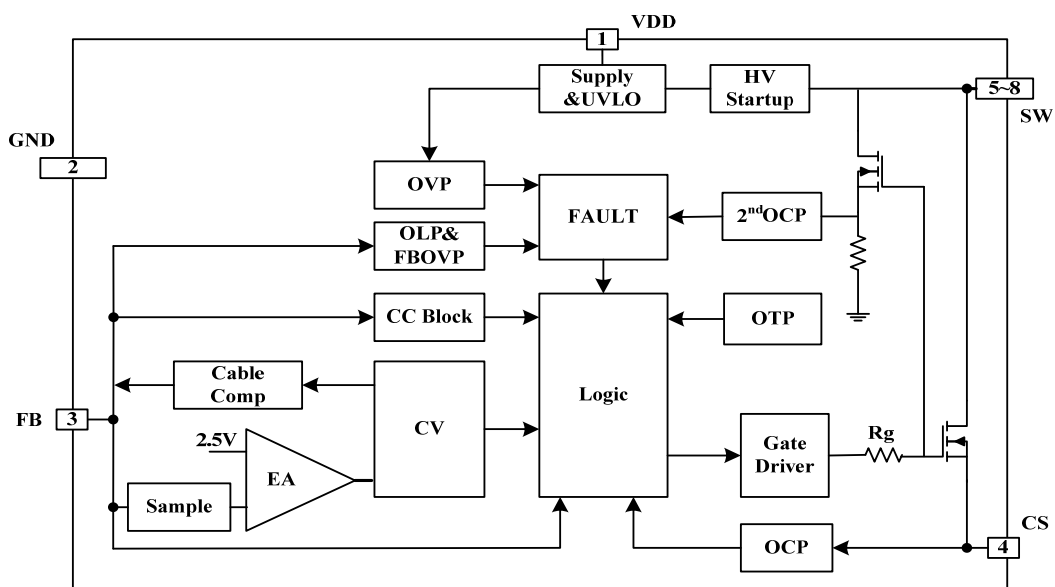
## Typical power

Part Number	Package	Adapter <sup>(1)</sup>
		85-265 V <sub>AC</sub>
PN8680M	SOP8	12W
PN8680MC	SOP8	15W

Note:

1. Maximum output power is tested in an adapter at 45°C ambient temperature, with enough cooling conditions.

## Block Diagram



## Absolute Maximum Ratings

Supply voltage Pin VDD.....-0.3~40V  
 Pin CS.....-0.3~5.5V  
 Pin FB(I<sub>FB</sub>≤10mA).....-1~5.5V  
 High-Voltage Pin, SW..... -0.3~650V  
 Operating Junction Temperature.....-40~150°C  
 Note: 1. Test standard: ANSI/ESDA/JEDEC JS-001-2017.

Storage Temperature Range.....-55~150°C  
 Lead Temperature (Soldering, 10Secs).....260°C  
 Package Thermal Resistance  $\theta_{JC}$  (SOP8) .....40°C/W  
 HBM ESD Protection <sup>(1)</sup> .....±3kV  
 Pulse Drain Current (T<sub>pulse</sub>=100us) .....3A

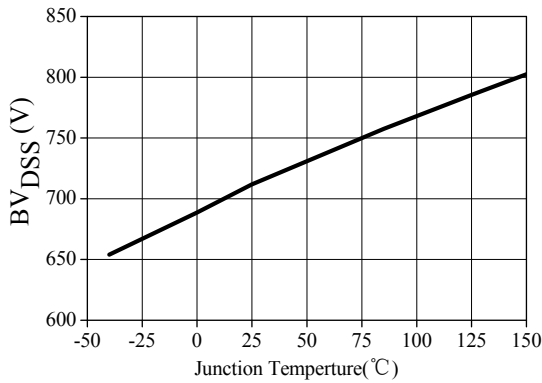
## Electrical Characteristics

(T<sub>A</sub> = 25°C, VDD = 21 V, unless otherwise specified)

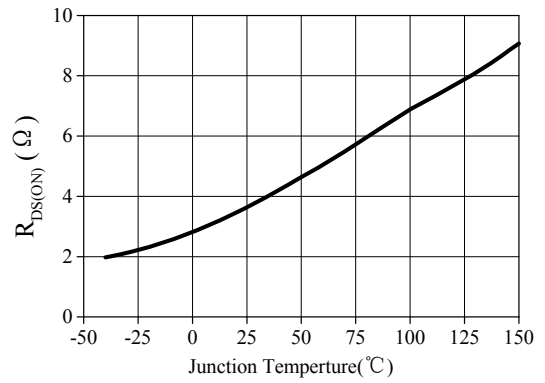
PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>Power Section</b>						
Break-down voltage	BV <sub>DSS</sub>	I <sub>sw</sub> = 250uA	650	720		V
Off-state drain current	I <sub>OFF</sub>	V <sub>sw</sub> = 500V	10	30	50	uA
Drain-source on state resistance-PN8680M	R <sub>DSON</sub>	I <sub>sw</sub> = 1A, T <sub>J</sub> = 25°C		3.6		Ω
Drain-source on state resistance-PN8680MC	R <sub>DSON</sub>	I <sub>sw</sub> = 1A, T <sub>J</sub> = 25°C		3.0		Ω
Start up threshold	V <sub>SW_START</sub>	VDD=VDD <sub>on</sub> - 1V		30		V
<b>Supply Voltage Section</b>						
Operating voltage range	VDD		10		30	V
VDD start up threshold	VDD <sub>on</sub>		14.5	16.5	18.5	V
VDD under voltage shutdown threshold	VDD <sub>off</sub>		7.5	8.5	9.5	V
VDD over voltage protect	VDD <sub>ovp</sub>		30	34	38	V
<b>Supply Current Section</b>						
VDD charge current	I <sub>DD_CH</sub>	VDD=VDD <sub>on</sub> -1V, V <sub>sw</sub> =100V	-1.5	-1.0	-0.6	mA
Operating current, switching	I <sub>DD</sub>	VDD = VDD <sub>on</sub> +1V	0.1	0.4	0.8	mA
Operating current after fault	I <sub>DD_FAULT</sub>	VDD=15V after fault		0.5		mA
<b>Current Sense Section</b>						
Current sense threshold	V <sub>TH_OC</sub>		485	500	515	mV
Maximum Current sense threshold	V <sub>TH_OC_MAX</sub>			560		mV
Minimum CS threshold	V <sub>es_min</sub>			170		mV
Leading Edge Blanking time	T <sub>LEB</sub>			300		ns
Maximum Ton	T <sub>onmax</sub>		35	40	50	us
OCP propagation delay	T <sub>D_OC</sub>			100		ns
<b>FB Section</b>						

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Reference voltage for feedback threshold	$V_{REF\_CV}$		2.475	2.5	2.54	V
Output over voltage protection threshold	$V_{FBOVP}$		2.85	3	3.15	V
Output under voltage threshold	$V_{UVP}$			1.55		V
Maximum cable compensation current	$I_{cable}$	$V_{FB}=0V$	33	36	39	uA
Minimum Toff	$T_{offmin}$	CC mode		5		us
Maximum Toff	$T_{offmax}$			2.2		ms
Output under voltage protection Blanking time	$T_{UVP}$	$F_{sw}=50kHz$	40		64	ms
<b>Thermal Section</b>						
Thermal shutdown temperature threshold	$T_{SD}$		135	150		°C
Thermal shutdown hysteresis	$T_{HYST}$			30		°C

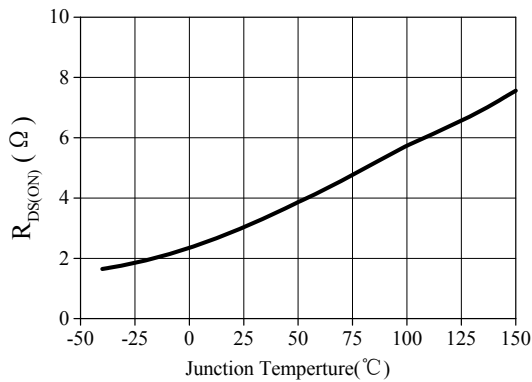
## Typical Characteristics Plots



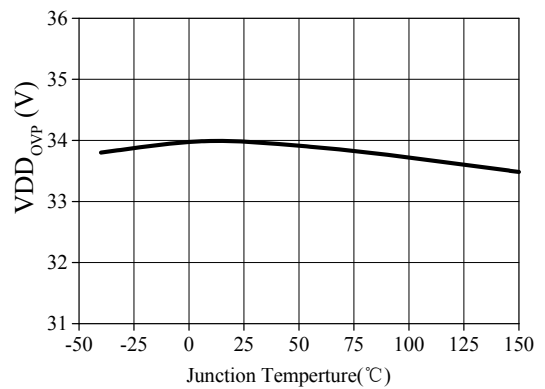
(a) BV<sub>DSS</sub> VS T<sub>j</sub>



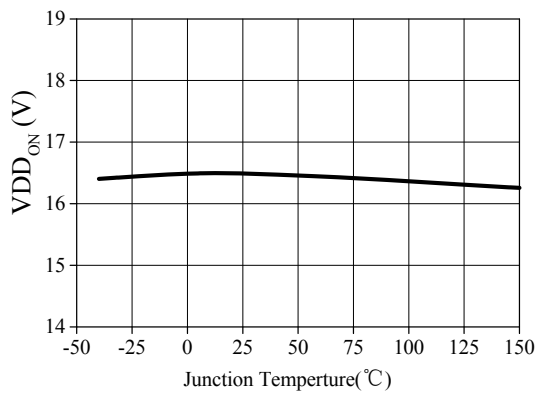
(b) R<sub>DS(ON)</sub> -PN8680M VS T<sub>j</sub>



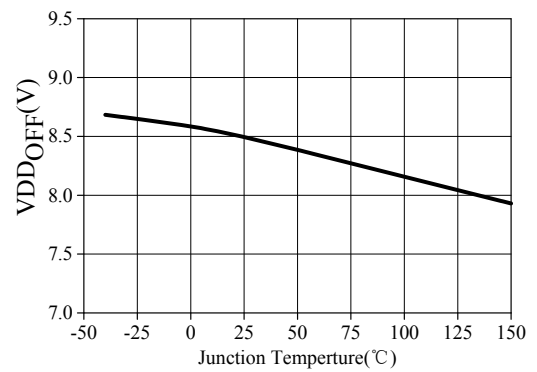
(c) R<sub>DS(ON)</sub> -PN8680MC VS T<sub>j</sub>



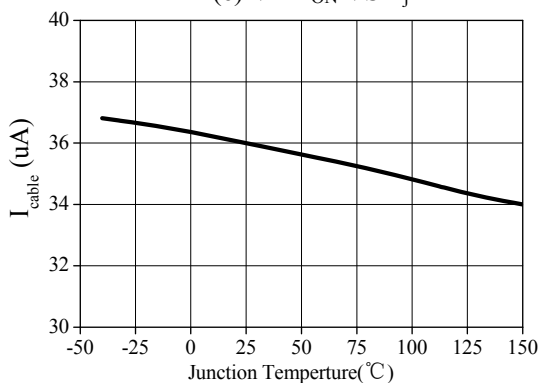
(d) V<sub>DD\_OVP</sub> VS T<sub>j</sub>



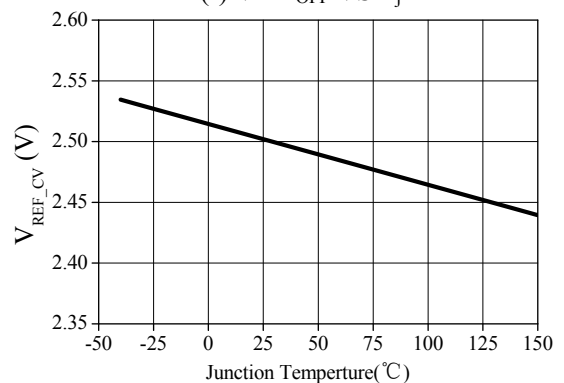
(e) V<sub>DD\_ON</sub> VS T<sub>j</sub>



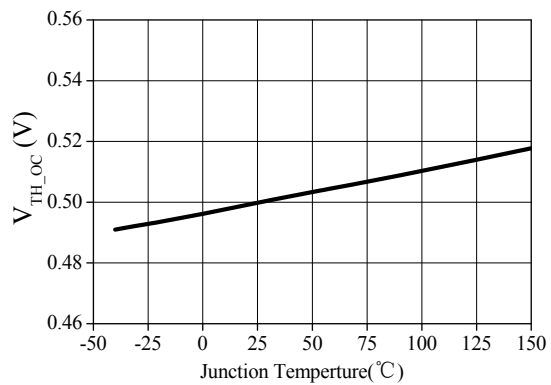
(f) V<sub>DD\_OFF</sub> VS T<sub>j</sub>



(g) I<sub>cable</sub> VS T<sub>j</sub>



(h) V<sub>REF\_CV</sub> VS T<sub>j</sub>



(i) V<sub>TH\_OC</sub> VS T<sub>j</sub>

## Functional Description

The PN8680M is a high performance CC/CV primary-side controller. PN8680M operates in primary-side sensing and regulation, so opto-coupler and TL431 could be eliminated. Proprietary built-in CV and CC control can achieve high precision CC/CV control meeting most charger and adaptor application requirements. Internal HV Start-up circuit and the chip's low consumption help the system to meet strict standby power standard.

### 1. HV Start up Control

At start up, the internal high-voltage start-up circuit provides the internal bias and charges the external VDD capacitor, so that PN8680M starts up quickly. When VDD reaches VDD<sub>on</sub>, the device starts switching and the internal high-voltage current source stops charging the capacitor. The device keeps in normal operation provided as long as VDD keeps above VDD<sub>off</sub>. After startup, the bias is supplied from the auxiliary transformer winding, the current of HV start-up circuit is designed to be very low so that the power consumption is very low.

### 2. CC Operation Mode

In CC operation mode, the PN8680M captures the auxiliary flyback signal at FB pin through a resistor dividing-network. The pulse width of the auxiliary flyback signal determines the PN8680M oscillator frequency. The higher the output voltage is, the shorter the pulse width is, and the higher the chip oscillator frequency is, thus the constant output current can be achieved.

The current waveform of DCM mode is shown in Figure 1. During MOSFET turn-on time, the current in the primary winding (I<sub>pri</sub>) ramps up. When MOSFET turns off, the energy stored in the primary winding is transferred to the secondary side, so the peak current in the secondary winding is

$$I_{sec\_pk} = I_{pri\_pk} \times N_{ps} \quad (1)$$

The output current is

$$I_O = \frac{I_{sec\_pk}}{2} \times \frac{T_{demag}}{T_p} = \frac{1}{2} N_{ps} \frac{V_{CS}}{R_{sense}} \frac{T_{demag}}{T_p} \quad (2)$$

Because V<sub>ipk</sub> is constant and T<sub>p</sub> is equal to tow times T<sub>demag</sub>, the output current I<sub>o</sub> is constant.

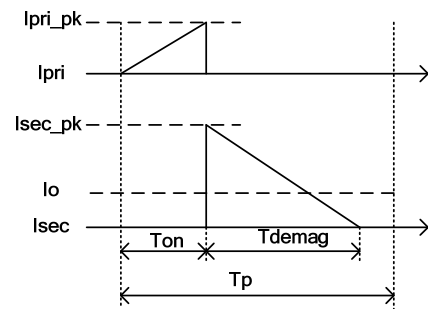


Figure 1 The current waveform of DCM mode

### 3. CV Operation Mode

In CV mode, PN8680M uses a pulse to sample V<sub>FB</sub> and it is hold until the next sampling. The sampled voltage is compared with V<sub>REF\_CV</sub> and the error is amplified. The error amplified output reflects the load condition and controls the switching off time to regulate the output voltage, thus constant output voltage can be achieved.

The relationship between the output voltage and V<sub>REF\_CV</sub> is

$$V_O = (V_{REF\_CV} \times \frac{R1 + R2}{R2}) \times \frac{N_S}{N_{AUX}} \quad (3)$$

N<sub>S</sub> means Secondary winding, N<sub>AUX</sub>

means Auxiliary winding

The PN8680M operates in PFM mode during heavy load mode, the peak current (I<sub>peak</sub>) of MOSFET and the chip frequency decreases while the output current decreases. When the switching frequency approaches to 25kHz, the PN8680M enters PWM mode, the chip frequency decreases slowly while the output current decreases, the I<sub>peak</sub> decreases while the output current decreases. Therefore the PN8680M can avoid audible noise, while achieving high efficiency at 25% load conditions. When V<sub>cs</sub> decreases to 170mV, the PN8680M enters Standby mode. In this mode, I<sub>peak</sub>

keeps around constant, the chip oscillator frequency decreases while the output current decreases. Figure 2 illustrates the relations of the switching frequency,  $I_{peak}$  and Loading for PN8680M.

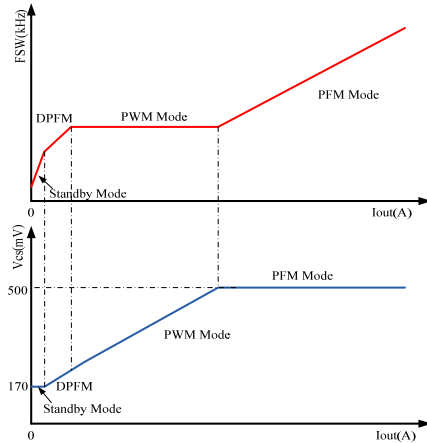


Figure 2. The Switching Frequency,  $V_{CS}$  VS. LOAD

## 4. Current Sensing and Leading Edge Blanking

Cycle-by-Cycle current limiting is offered in PN8680M. The switch current is detected by a sense resistor at CS pin. The CC set-point and maximum output power can be externally adjusted by external current sense resistor at CS pin. An internal leading edge blanking circuit chops off the sensed voltage spike at initial power MOSFET on-state so that the external RC filtering on sense input is no longer needed.

## 5. Programmable Cable Drop Compensation

In PN8680M, an offset voltage is generated at FB pin by an internal current flowing into the divider resistor, as shown in Figure 3. The Cable Drop Compensation block compensates the voltage drop across the cable. As the load current decreases from full load to no load, the voltage drop across the cable decreases. It can be programmed by adjusting the external resistor R2 or R1 at FB pin. The maximum compensation is

$$\frac{V_{cable}}{V_o} = \frac{I_{cable} \times (R2 // R1)}{2.5V} \quad (4)$$

Because of the influence of the chip's sampling position and devices of the system, the actual

maximum compensation is less than theoretical value.

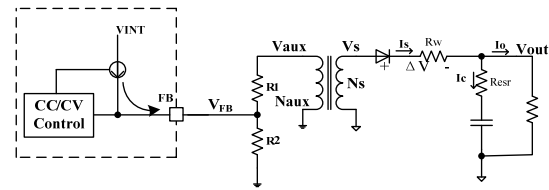


Figure 3  $I_{cable}$

## 6. Reference Negative Temperature Compensation

As shown in Figure 3, the voltage of FB pin is

$$V_{FB} = K(V_o + \Delta V), K = \frac{R2 \times N_{AUX}}{(R1 + R2) \times N_s} \quad (5)$$

Where  $\Delta V$  has a negative temperature coefficient, K is a constant.

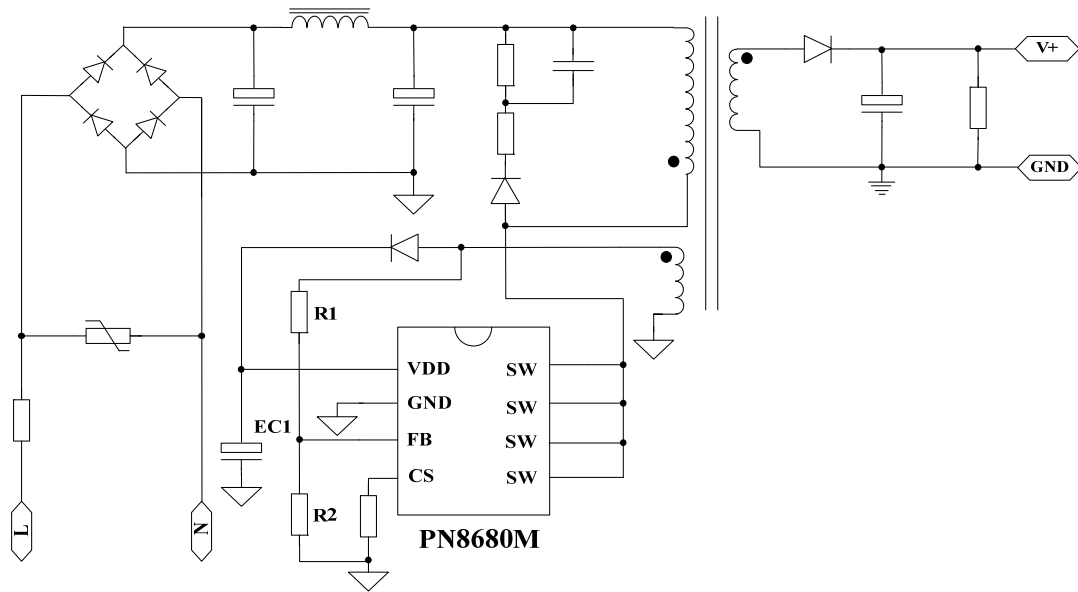
In PN8680M, the voltage reference uses the negative temperature compensation technology. At room temperature, the voltage reference is 2.5V. The voltage reference ( $V_{REF\_CV}$ ) decreases while the temperature of chip increases. The reference negative temperature compensation block compensates the  $\Delta V$ , thus the output voltage keeps constant at full range of temperature. The reference negative temperature compensation improves output precision.

## 7. Protection Control

The PN8680M has several self-protection functions, such as Cycle-by-Cycle current limiting (OCP), Over-Voltage Protection, Over-Temperature Protection, Feedback Loop open Protection, Output short circuit Protection, CS resistor open/short circuit Protection and Under Voltage Lockout on VDD. All protections are self-recovered.



## Typical Application

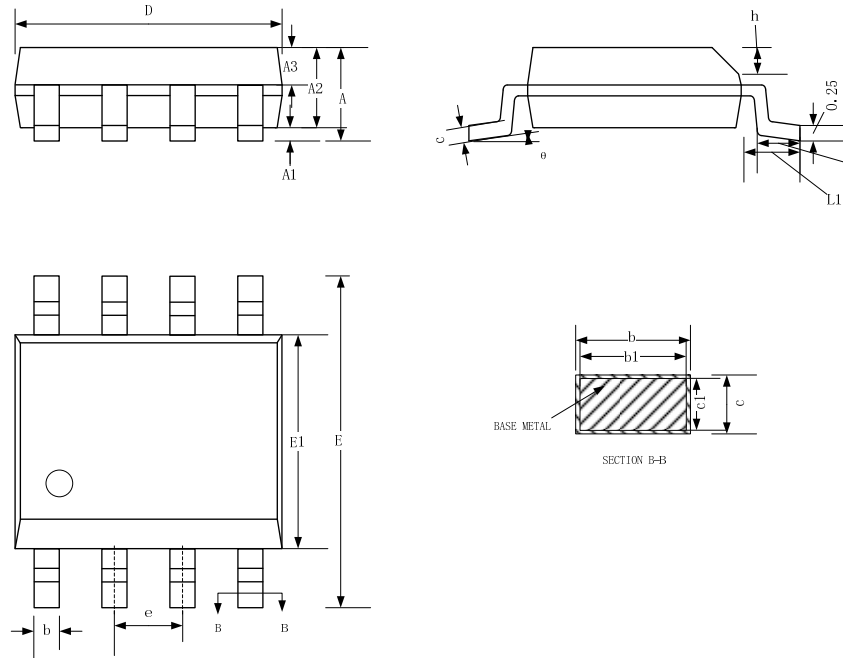


### **Component Parameter and Layout Considerations:**

1. VDD capacitor EC1 should be placed at the nearest place from the VDD pin and the GND pin.

## Package Information

### SOP8 Package Information



Size Symbol	Min.(mm)	Typ.(mm)	Max.(mm)	Size Symbol	Min.(mm)	Typ.(mm)	Max.(mm)
A	—	—	1.75	D	4.70	4.90	5.10
A1	0.10	—	0.225	E	5.80	6.00	6.20
A2	1.30	1.40	1.50	E1	3.70	3.90	4.10
A3	0.60	0.65	0.70	e	1.27(BSC)		
b	0.39	—	0.48	h	0.25	—	0.50
b1	0.38	0.41	0.43	L	0.50	—	0.80
c	0.21	—	0.26	L1	1.05(BSC)		
c1	0.19	0.20	0.21	θ	0°	—	8°

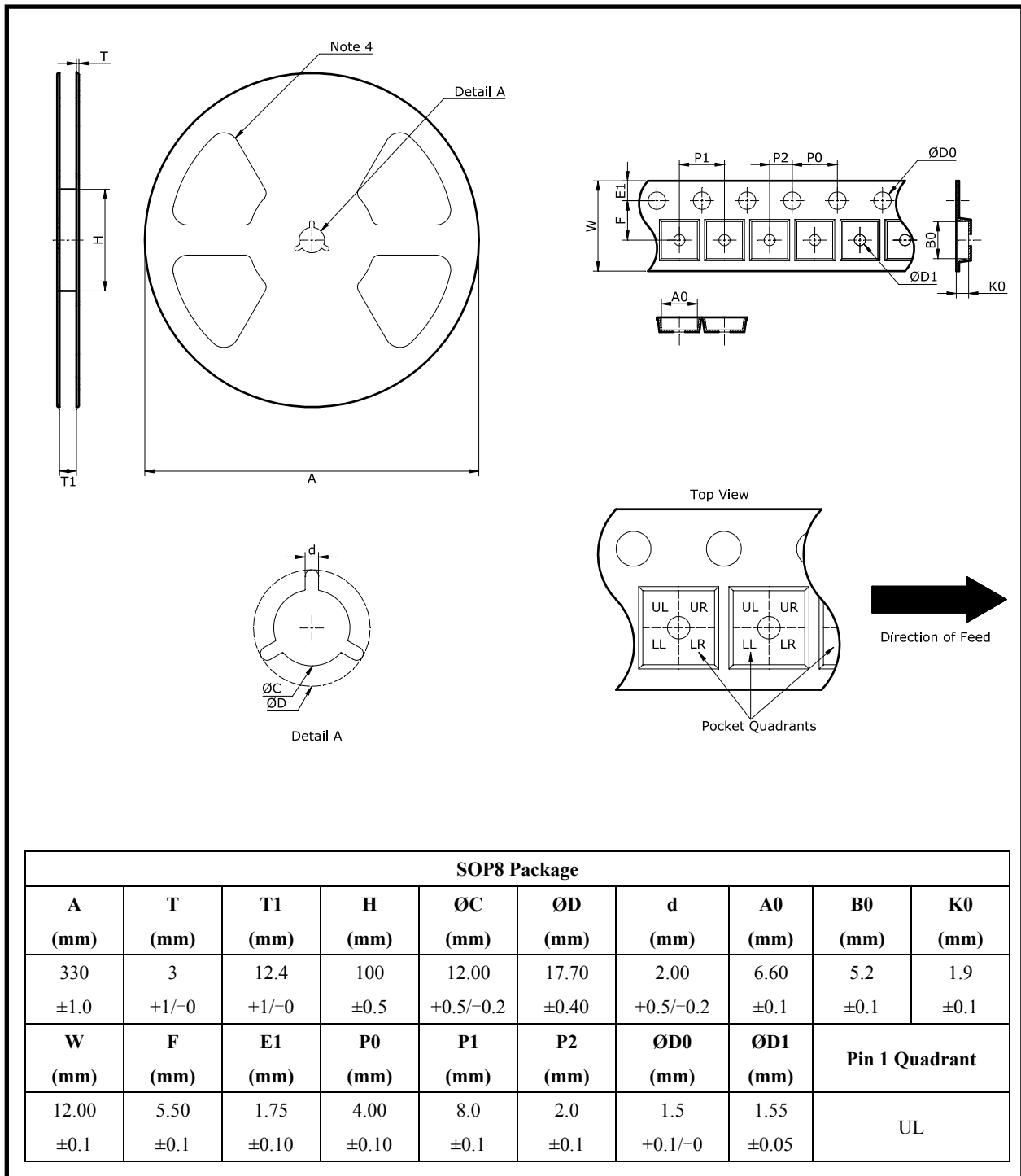
Order code	Top mark	Package
PN8680MSEC-R1	PN8680M YWWAXXXX	SOP8
PN8680MSEC-R1C	PN8680M YWWCXXXX	SOP8

Note: Y: Year Code; WW: Week Code; A/C: Version information; XXXX: Internal Code

#### Notes:

1. This drawing is subjected to change without notice.
2. Body dimensions do not include mold flash or protrusion.

## Tape and Reel Information



Notes:

1. This drawing is subjected to change without notice.
2. All dimensions are nominal and in mm.
3. This drawing is not in scale and for reference only. Customer can contact Chipown sales representative for further details.
4. The number of flange openings depends on the reel size and assembly site. This drawing shows an example only.

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