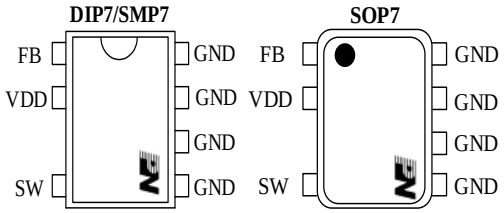
AC/DC Converter with Internal Self-Supply Circuit

General description

The PN8778P consists of an integrated PFM (Pulse Frequency Modulation) controller and 750V power MOSFET specifically designed for a high performance off-line converter with minimal external components. PN8778P has internal high voltage start-up and self-supply circuit, and complete intelligent protections including Over Current Protection (OCP), Over Load Protection (OLP), Under Voltage Lockout (UVLO), Over Voltage Protection (OVP) and Over Temperature Protection (OTP). Excellent EMI performance could be achieved with down modulation.

Package/Order Information



Order code	Package
PN8778PNS-A1	DIP7
PN8778PSS-A1	SOP7
PN8778PSM-A1	SMP7

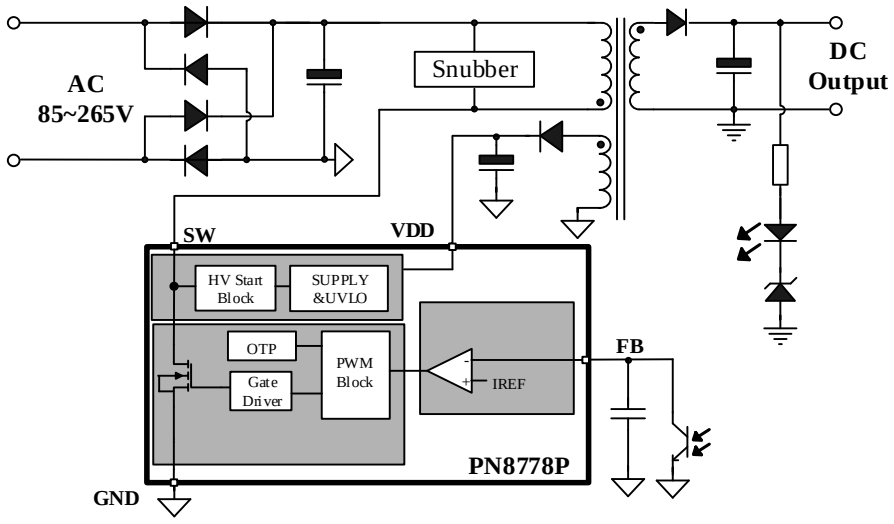
Features

- Internal 750V avalanche-rugged smart power MOSFET
- Internal HV Start-up Circuit
- Supporting isolation flyback and non-isolation flyback applications.
- No extra loop compensation
- Steady-state output power 16W@230VAC, Auxiliary power supply (DIP7, SMP7)
- Steady-state output power 14.5W@230VAC, Auxiliary power supply (SOP7)
- Frequency modulation for low EMI
- Excellent constant voltage regulation and High efficiency
- Excellent Protection Coverage:
  - ✧ Over Load Protection (OLP)
  - ✧ Over Current Protection (OCP)
  - ✧ Over Temperature Protection (OTP)
  - ✧ Over Voltage Protection (OVP)
  - ✧ Under Voltage Lockout

Application

- Household appliance
- LED Lighting
- Industrial control

Typical Circuit



Pin Definitions

Pin Name	Pin Number	Pin Function Description
FB	1	Output voltage feedback
VDD	2	VDD supply
SW	3	Drain of the internal MOSFET
GND	4, 5, 6, 7	Ground

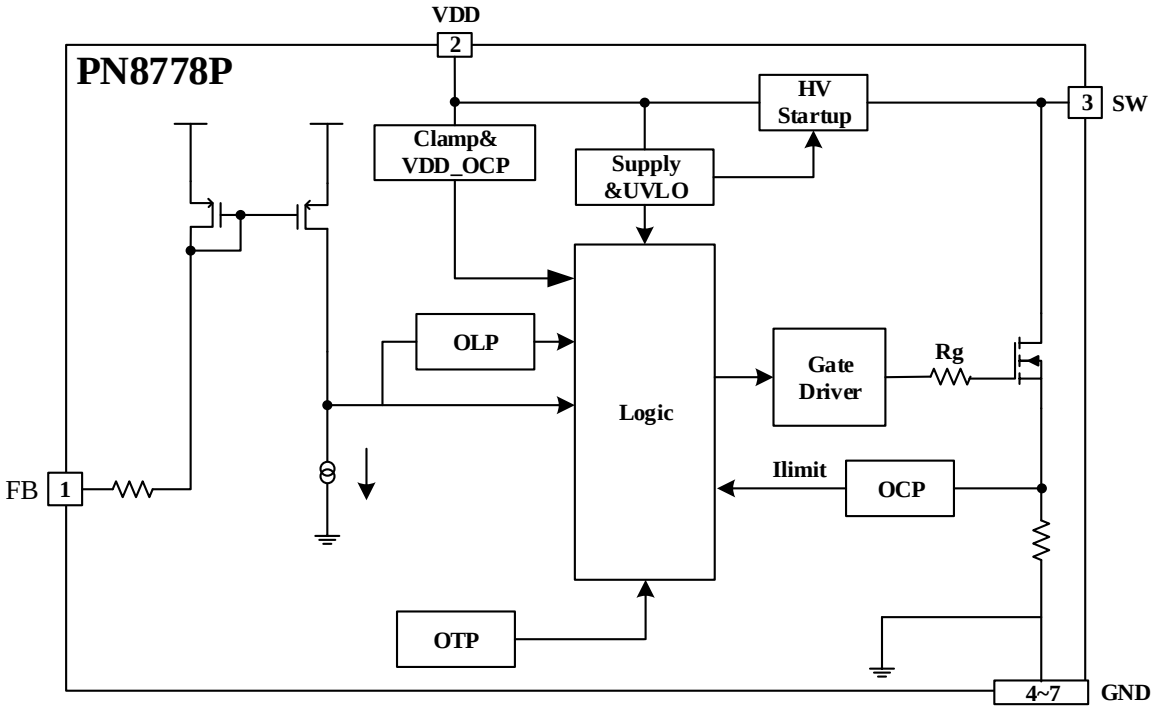
Typical Power

Package	Input Voltage	Steady output power –Auxiliary power supply(1)	Peak Power (2)
DIP7, SMP7	180-265V_{AC}	16W	25W
	85-265V_{AC}	10W	20W
SOP7	180-265 V_{AC}	14.5W	25W
	85-265 V_{AC}	9W	20W

Note：

1. Maximum output power in a semi enclosed design measured at 50℃ ambient temperature (with bias winding and bias components), Duration: 2 hours
2. Peak power in a semi enclosed design measured at 50℃ ambient temperature, Duration: 1 min

Block Diagram



Absolute Maximum Ratings

Supply voltage Pin VDD……-0.3~9V
High-Voltage Pin, SW…….…….…..…. -0.3~750V
FB Pin……..…….-0.3~9V
Operating Junction Temperature…….....……-40~150 ℃
Storage Temperature Range……..…. ….-55~150 ℃
Lead Temperature (Soldering, 10Secs)……...260 ℃

Package Thermal Resistance θ_{JC} (DIP7)……....…20 ℃/W
Package Thermal Resistance θ_{JC} (SOP7) ……....…40 ℃/W
Package Thermal Resistance θ_{JC} (SMP7)……..…16 ℃/W
HBM ESD Protection (1) ……..……..…..…±4kV
ESD Voltage Protection (2)……....……...8kV
Peak Drain Current……2.5A

Note：1. Test standard: ANSI/ESDA/JEDEC JS-001-2017.
2. Air discharge to pins of PN8778P with ESD Generator, Enterprise internal standards, for reference only.

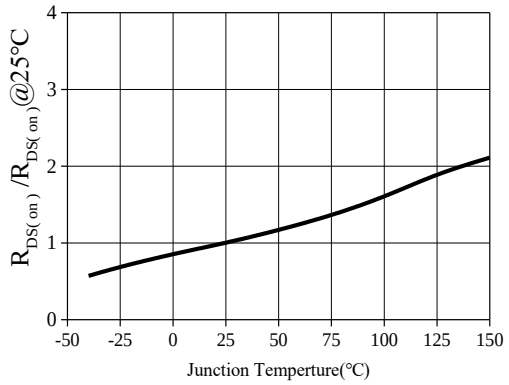
Electrical Characteristics

(T_A= 25 ℃, unless otherwise specified)

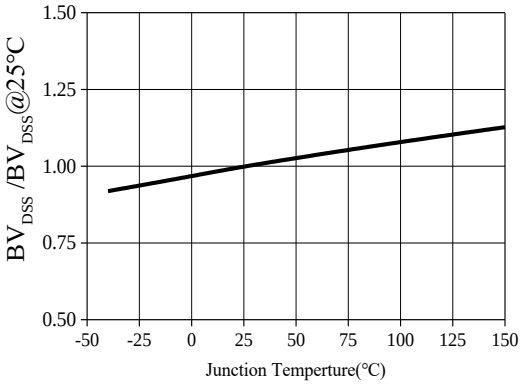
PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Power Section						
Drain Break-down voltage	BV_{DSS}	I_{SW} =250uA, T_J =25 ℃	750			V
Off-state drain current	I_{OFF}	V_{SW} =700V, T_J =25 ℃			90	μA
Drain-source on state resistance	$R_{DS(on)}$	I_{SW} = 0.3A, T_J =25 ℃		4.2		Ω
Start threshold	V_{SW_START}	DC level to convert to AC input voltage, divide by √2	55	72	100	V
Supply Voltage Section						
VDD self-supply turn off	VDD_{choff}	V_{SW} =30V, V_{FB}=0V	5.2	5.6	5.9	V
VDD self-supply open	VDD_{chon}	V_{SW}=30V, V_{FB}=0V	5.0	5.4	5.8	V
VDD clamp voltage	VDD_{clamp}	I_{DD}=3mA, V_{FB}=0V	6.2	6.6	7.0	V
VDD restart voltage	VDD_{RESET}	V_{SW}=30V, V_{FB}=0V	2.75			V
VDD charge current Off-state current	I_{DDch0}	VDD=0V	-9.5	-7	-4.5	mA
	I_{DDch1}	VDD=4V	-7.5	-4.5	-2.5	mA
Operating supply current	I_S	VDD=4V, V_{FB}=0V	100	230	300	uA
VDD self-supply turn off	I_{op}	VDD=6V, V_{FB}=5V	0.15	0.5	1	mA
VDD turn-off threshold current	I_{SD}		4	7	10	mA
Current Sense Section						
Drain current limit	I_{limit}	VDD=6V, V_{FB}=5V	590	640	690	mA
Drain current protection	I_{SCP}	VDD=6V, V_{FB}=5V	1.4×I_{limit}	1.5×I_{limit}	1.6×I_{limit}	mA
Leading edge blacking time	T_{LEB}			290		ns
Feedback Input Section						
Maximum frequency	fmax	VDD=6V , V_{FB}=5V	100	110	120	kHz
Maximum duty cycle	Dmax		62	65		%
MOSFET feedback turn-on Reference	I_{REF}	VDD=6V	-150	-115	-90	μA
OLP delay Time	T_{OLP}	Guaranteed by design		76		ms
Abnormal protection restart time	$T_{RESTART}$	Guaranteed by design		1.6		s

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Thermal Shutdown Section						
OTP threshold	T_{SD}	Guaranteed by design	135	150	165	℃
OTP Protect Hysteresis	T_{HYST}	Guaranteed by design		30		℃

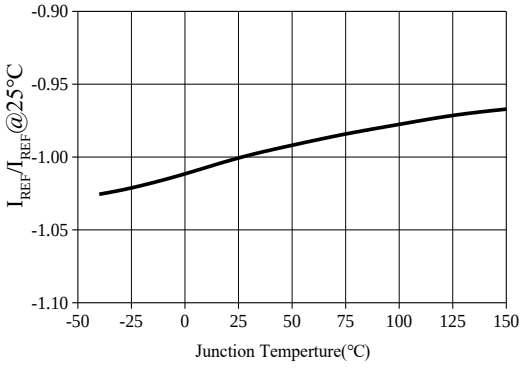
Typical Characteristics Plots



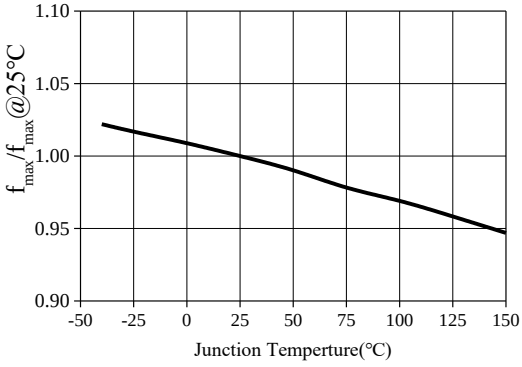
(a) $R_{DS(on)}$ VS T_j



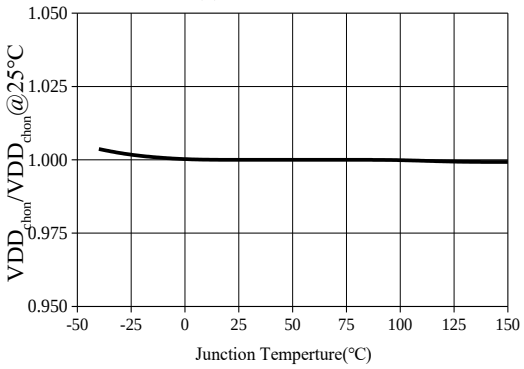
(b) BV_{DSS} VS T_j



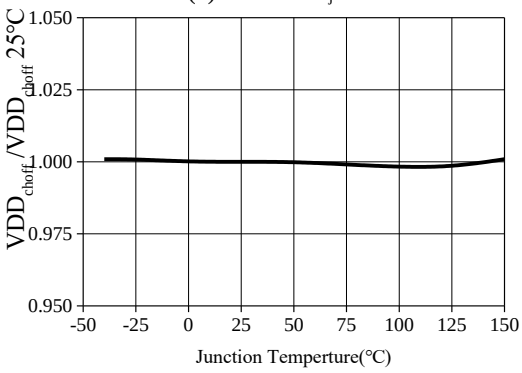
(c) I_{REF} VS T_j



(d) fmax VS T_j



(e) VDD_{chon} VS T_j



(f) VDD_{choff} VS T_j

Functional Description

The PN8778P consists of an integrated PFM controller and smart power MOSFET, specifically designed for a high performance off-line converter with minimal external components. PN8778P has internal high voltage start-up and self-supply circuit, and complete intelligent protections including Over Current Protection (OCP), Over Load Protection (OLP), Under Voltage Lockout (UVLO), Over Voltage Protection (OVP) and Over Temperature Protection (OTP). Excellent EMI performance could be achieved with Pulse Frequency Modulation.

1. Start up

At start up, the internal high-voltage current source supplies 5mA current to charges the external VDD capacitor. As this time, if SW voltage is lower than V_{SW_START}, VDD voltage maintain near VDD_{RESET}, when SW voltage is higher than V_{SW_START}, VDD voltage continue to raise, until VDD rises to VDD_{choff}, PN8778P starts switching and the internal high-voltage current source stops charging the capacitor. When VDD drops to $VDD_{chon,}$ PN8778P continues switching while the internal high-voltage current source returns to supplies 5mA current to charge the external VDD capacitor. The internal high-voltage regulator self-supplies the IC, so extra component is not needed for power supply.

The chip can also use extra component or VDD power supply to improve the chip working frequency. The reasonable power supply voltage should be above the VDD_{chon} and below the VDD_{clamp}.

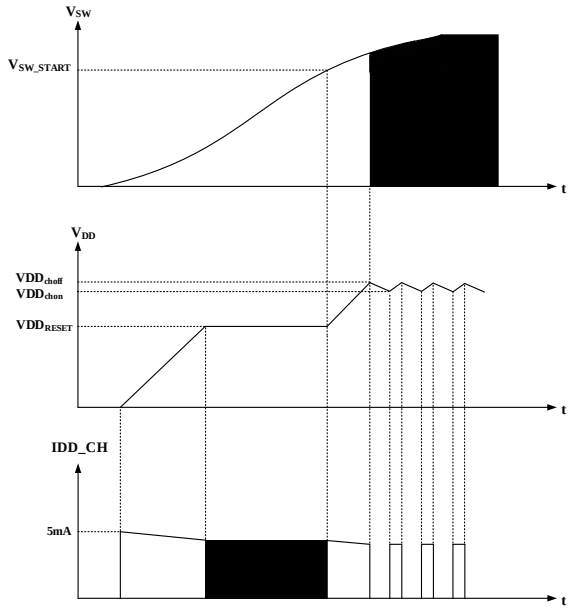


Fig. 1 High voltage self-powered startup

2. CV Operation Mode

In CV operation, PN8778P samples the feedback signal through FB pin. When the current flowing into the chip from the FB pin is less than I_{REF}, the IC turns on the integrated MOSFET to charge the energy storage inductor. When the current of the inductor reaches the peak current limit (I_{PEAK}), the integrated MOSFET is turned off.

3. PFM modulation

The IC operates in PFM mode, and I_{PEAK} is set to decrease with the decrease of the IC operating frequency (F_{SW}). When the IC switching cycle increase 1us， I_{PEAK} will decrease 10mA. As a result of the internal current sampling and the maximum current limit (I_{limit}), inductance is the only parameter of the frequency modulation when output voltage and output current are fixed.

4. Soft-Start up

In order to regulate peak current in deep CCM mode, PN8177 build in soft-start function, there are five stages. At the first stage, I_{PEAK} is 2/5 of I_{limit}, the maximum switching frequency is 1/2 of fmax; from 2 to 5 stage, I_{PEAK} is 2/5, 3/5, 4/5, 1 of I_{limit}. If the output voltage reaches the system design value before the end of soft-start up, the chip adjusts I_{PEAK} and working frequency according to PFM modulation.

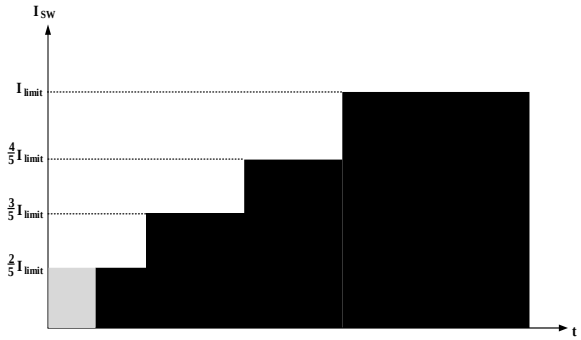


Fig. 2 Soft-Start up

5. Smart Protection Control

PN8778P has several smart self-protection functions, such as Over Current Protection (OCP), Over Load Protection (OLP), Under Voltage Lockout (UVLO), Over Voltage Protection (OVP) and Over Temperature Protection (OTP). And all these protections have self-recovery mode.

Over Load Protection (OLP) ------When IC is continuously operating at maximum frequency fmax and T_{OLP} is sustained, protection is triggered and IC enters the abnormal restart, the IC stops switching. VDD voltage oscillates between VDD_{choff} and VDD_{chon}. The internal timing reaches $T_{RESTART}$, the high voltage starting module stops supplying power, VDD voltage drops to VDD_{RESET}, IC restarts.

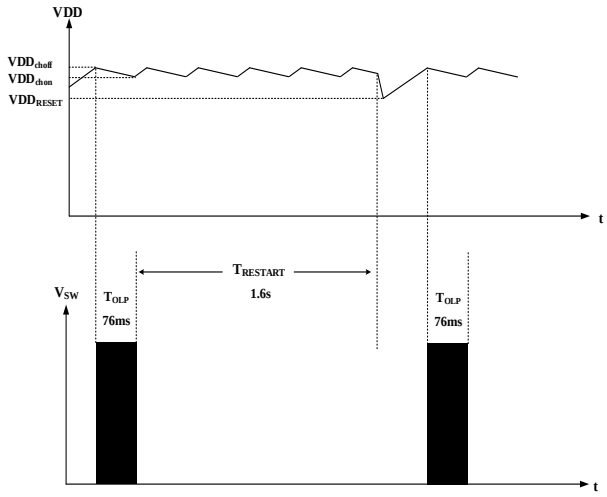


Fig. 3 Over load protection and automatic restart

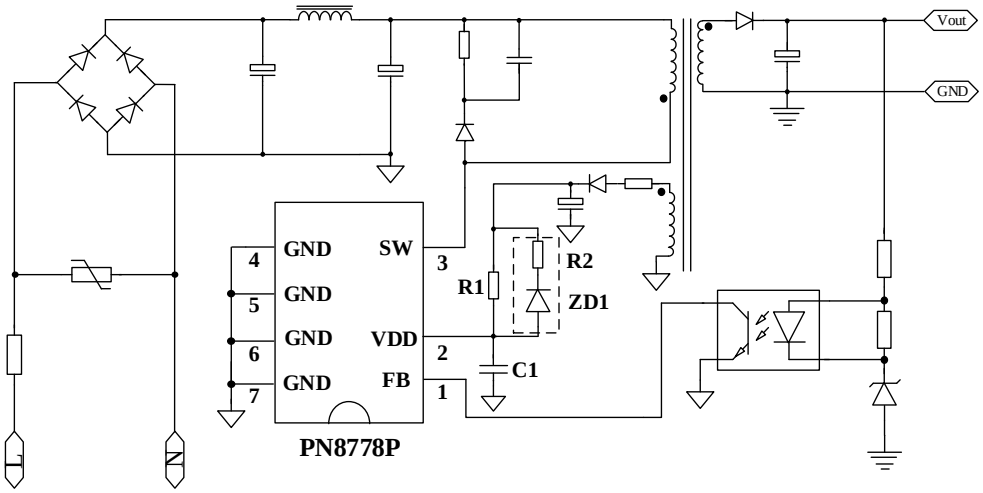
Over Current Protection (OCP) ------When IC detects the Drain current (the current in TLEB will be shielded) larger than I_{SCP} for three consecutive periods, IC triggers Over Current Protection, IC initiates an abnormal restart.

Over Temperature Protection (OTP) ------ If the inner junction temperature exceeds 150ºC, the IC will shut down switching, until the junction temperature falls to 120ºC.

Over Voltage Protection (OVP) ------IC provides Over Voltage Protection when the application system accesses the auxiliary bias windings. When the current flowing to the VDD is larger than I_{SD}, IC enters inbanormal restart state. At this time, IC stops switching, VDD voltage oscillates between VDD_{choff} and VDD_{chon}, the internal timing reaches $T_{RESTART}$, the high voltage starting module stops supplying power, VDD voltage drops to VDD_{RESET} ,IC restarts.

Under Voltage Lockout (UVLO) ------In startup phase, when the drain voltage is higher than threshold, the IC can normally start to work.

Typical Application

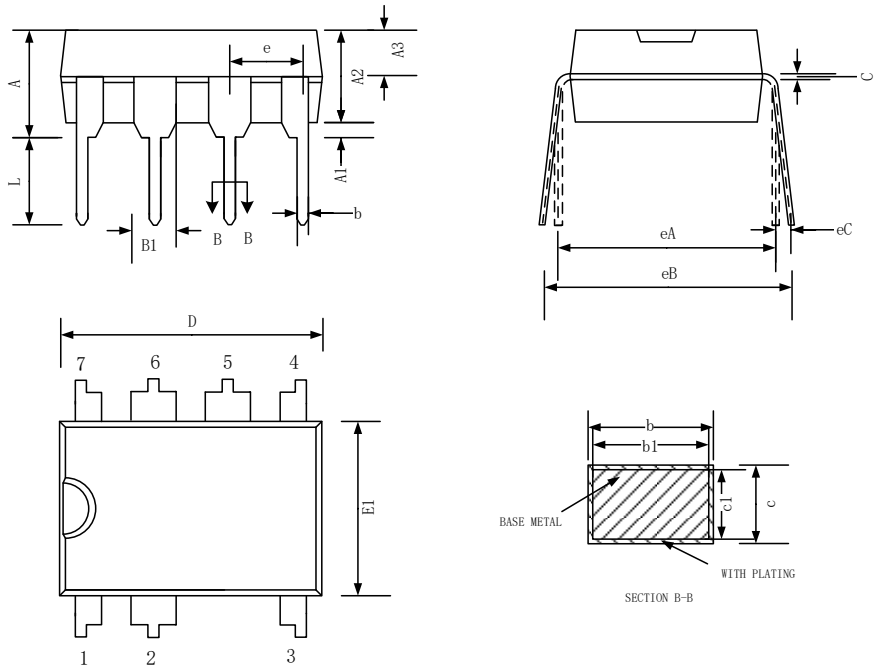


Component Parameter and Layout Considerations:

1. For isolation flyback applications, VDD capacitor C1 should be placed at the nearest place from the VDD pin and the GND pin.
2. Select resistor R1 reasonably according to the voltage of auxiliary winding to make VDD voltage higher than upper limit of VDD_{chon} and lower than VDD_{clamp}.
3. The VDD of PN8778P realizes the output over voltage protection function through R2 and ZD1. The withstand voltage of the voltage stabilizer ZD1 needs to be determined according to the voltage of the auxiliary winding. The R2 resistance is recommended to be 20~47ohm.

Package Information

DIP7 Package Information



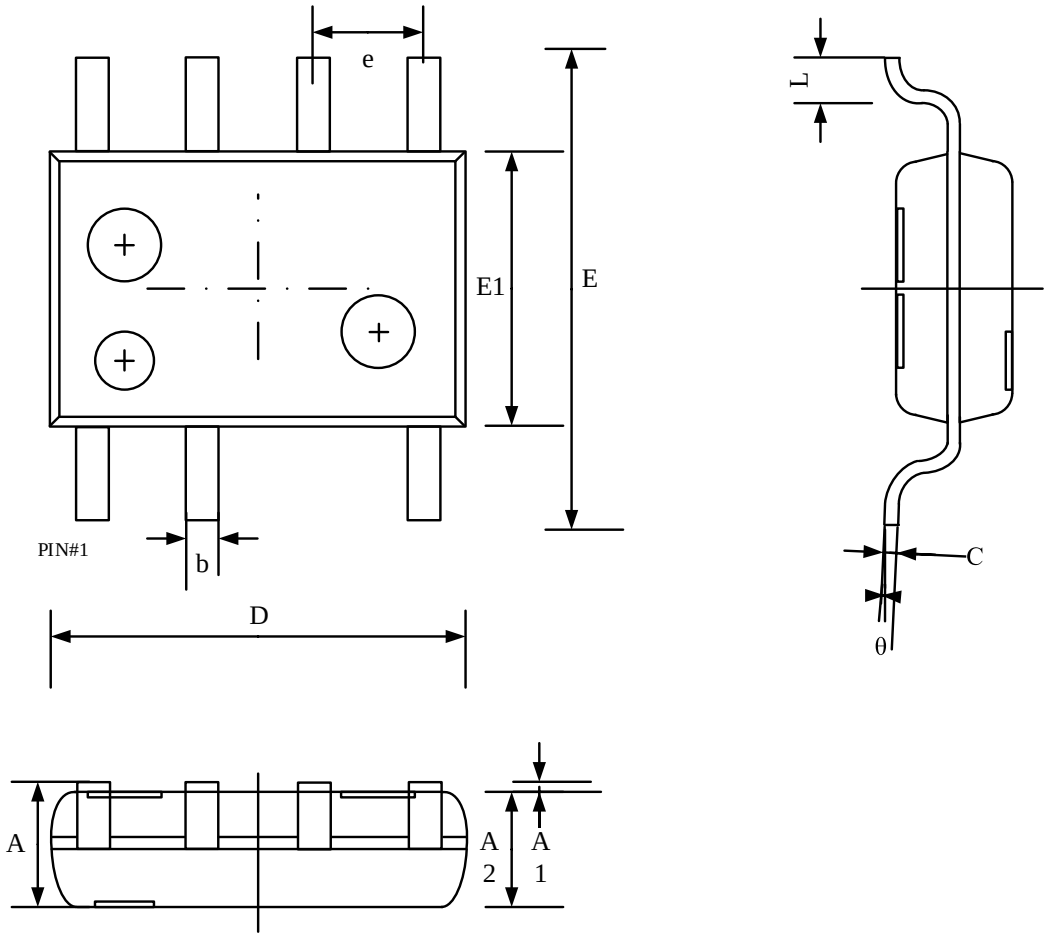
Size / Symbol	Min. (mm)	Max. (mm)	Size / Symbol	Min. (mm)	Max. (mm)
A	3.600	4.310	D	9.000	9.400
A1	0.510	---	E1	6.200	6.600
A2	3.200	3.600	e	2.54	
A3	1.540	1.650	eA	7.62	
b	0.380	0.570	eB	7.620	9.300
B1	1.52		L	3	---
c	0.210	0.360			

Top mark	Package
PN PN8778P YWWXXXXX	DIP7

Note: Y: Year Code; WW: Week Code; XXXXX: Internal Code

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

SOP7 Package Information



Size / Symbol	Min. (mm)	Max. (mm)	Size / Symbol	Min. (mm)	Max. (mm)
A	1.300	1.750	E	5.800	6.250
A1	0.000	0.250	E1	3.750	4.150
A2	1.250	1.600	e	1.27	
b	0.310	0.510	L	0.400	1.270
c	0.150	0.250	θ	0 °	12 °
D	4.700	5.100			

Top mark	Package
PN PN8778P YWWXXXXX	SOP7

Note: Y: Year Code; WW: Week Code; XXXXX: Internal Code

Notes:
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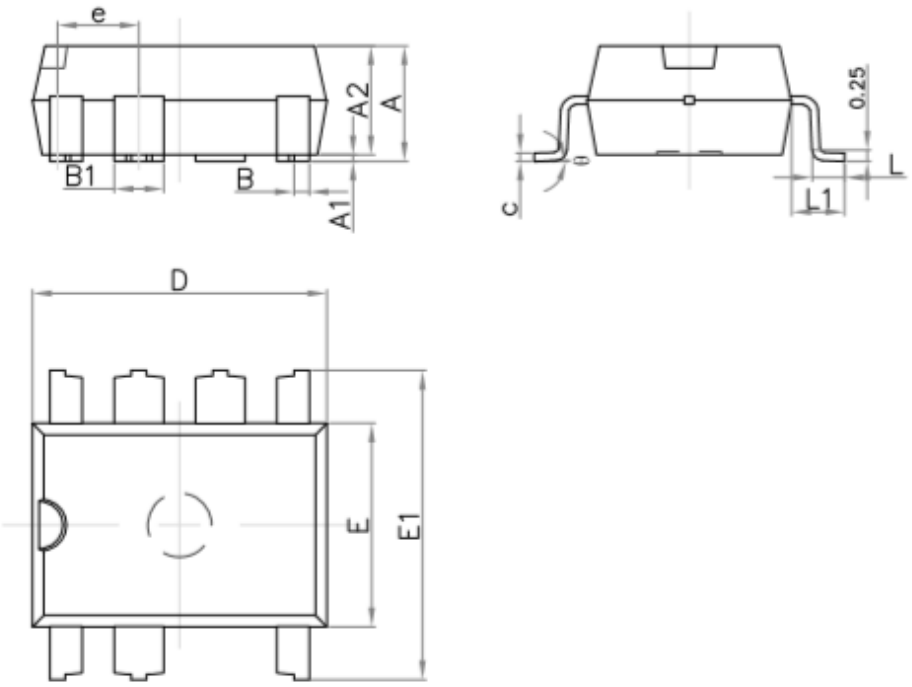
SMP7 Package Information



Size / Symbol	Min. (mm)	Max. (mm)	Size / Symbol	Min. (mm)	Max. (mm)
A	3.424	3.776	E	6.250	6.450
A1	0.100	0.300	E1	9.450	9.850
A2	3.324	3.476	e	0.540BSC	
B	0.440	0.520	L	0.920	1.120
B1	1.484	1.564	L1	0.065REF	
c	0.204	0.304	θ	0 °	8 °
D	9.100	9.300			

Top mark	Package
PN PN8778P YWWXXXXX	SMP7

Note: Y: Year Code; WW: Week Code; XXXXX: Internal Code

Notes:
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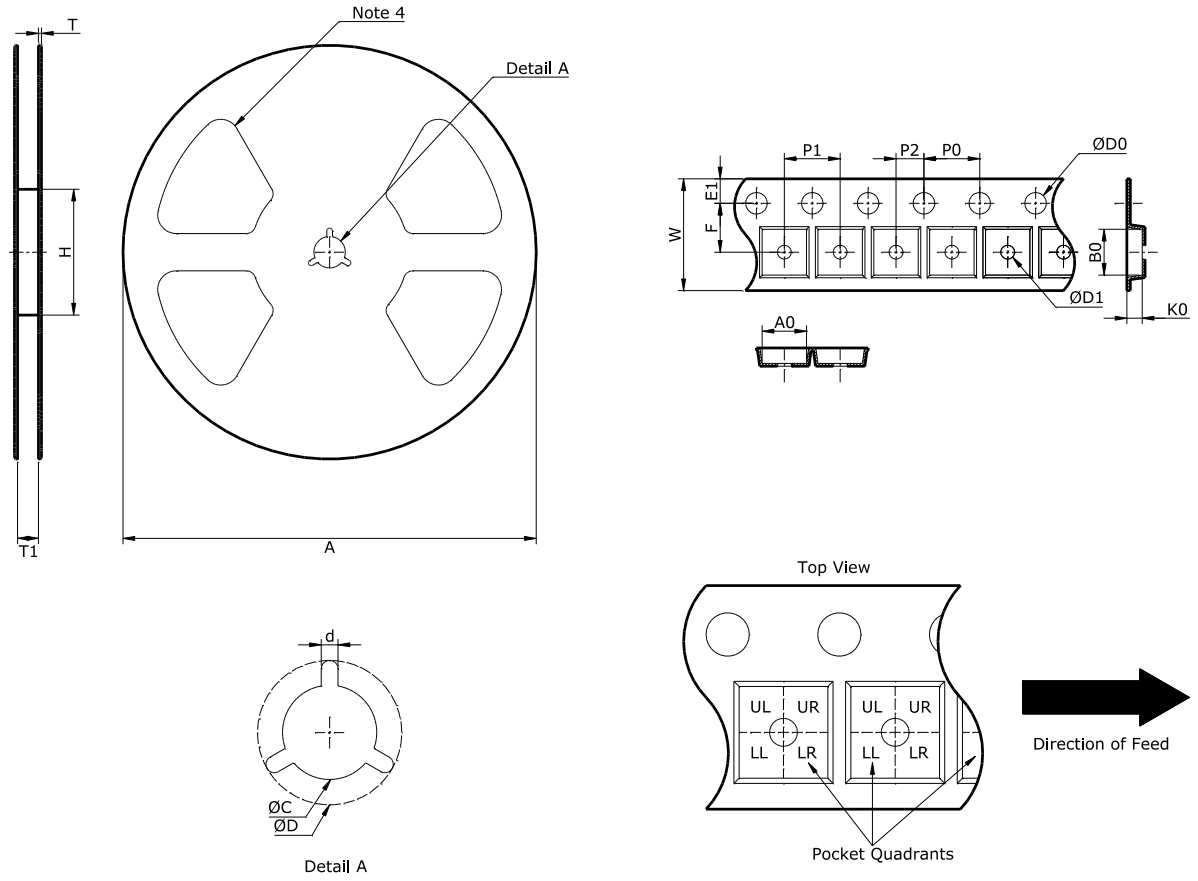
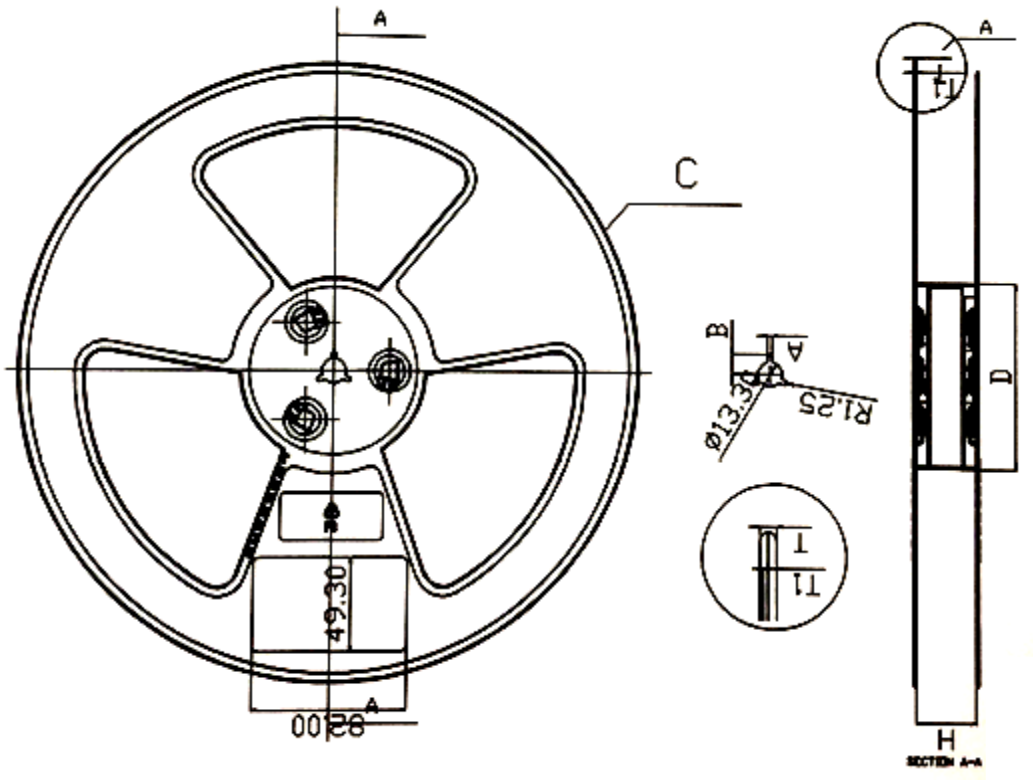
Tape and Reel Information SOP7



SOP7 Package								
A (mm)	**T (mm)**	**T1 (mm)**	**H (mm)**	**ØC (mm)**	**d (mm)**	**A0 (mm)**	**B0 (mm)**	**K0 (mm)**
330 ±2.0	3max	14 +4.5/-4	100 ±2	13.4 +0.2/-0.6	2.5 ±1	6.60 +0.1/-0.3	5.3 +0.2/-0.1	2 ±0.2
W (mm)	**F (mm)**	**E1 (mm)**	**P0 (mm)**	**P1 (mm)**	**P2 (mm)**	**ØD0 (mm)**	**ØD1 (mm)**	**Pin 1 Quadrant**
12.00 ±0.3	5.50 ±0.1	1.75 ±0.10	4.00 ±0.10	8.0 ±0.1	2.0 ±0.1	1.5 +0.1/-0	1.5 +0.25/-0	UL

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.

Tape and Reel Information SMP7



				Unit: MM
Material: PS		Unspecified tolerance: ±0.2		
H	12	16	24	32
C ±0.2	330	330	330	330
T1 ±0.2	1.45	1.45	1.45	1.45
B ±0.2	10.7	10.7	10.7	10.7
A ±0.2	2.5	2.5	2.5	2.5
T ±0.2	1.85	1.85	1.85	1.85
D ±0.2	100	100	100	100

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