PR8278/PR8278B

High Performance Current Mode PWM Controller

GENERAL DESCRIPTION

PR8278/PR8278B is a highly integrated current mode PWM controller with high voltage start up, optimized for high performance, and low standby power. It is suitable for cost effective offline flyback converter applications.

PWM switching frequency at normal operation is internally fixed and is trimmed to a tight range. In the condition of no load or light load, the IC operates in hiccup mode to minimize switching loss. Lower standby power and higher conversion efficiency is thus achieved.

High voltage startup is implemented in PR8278/PR8278B, which features with short startup time and low standby current.

PR8278/PR8278B offers complete protection coverage with auto-recovery including Cycle-by-cycle current limiting (OCP), over load protection (OLP), VDD under voltage lockout (UVLO), and over voltage (fixed or adjustable) protection (OVP). It also provides over temperature protection (OTP) with latched shutdown. Excellent EMI performance is achieved with frequency spreading technique.

The tone energy below 22KHz is minimized in the design and audio noise is eliminated during operation.

FEATURES

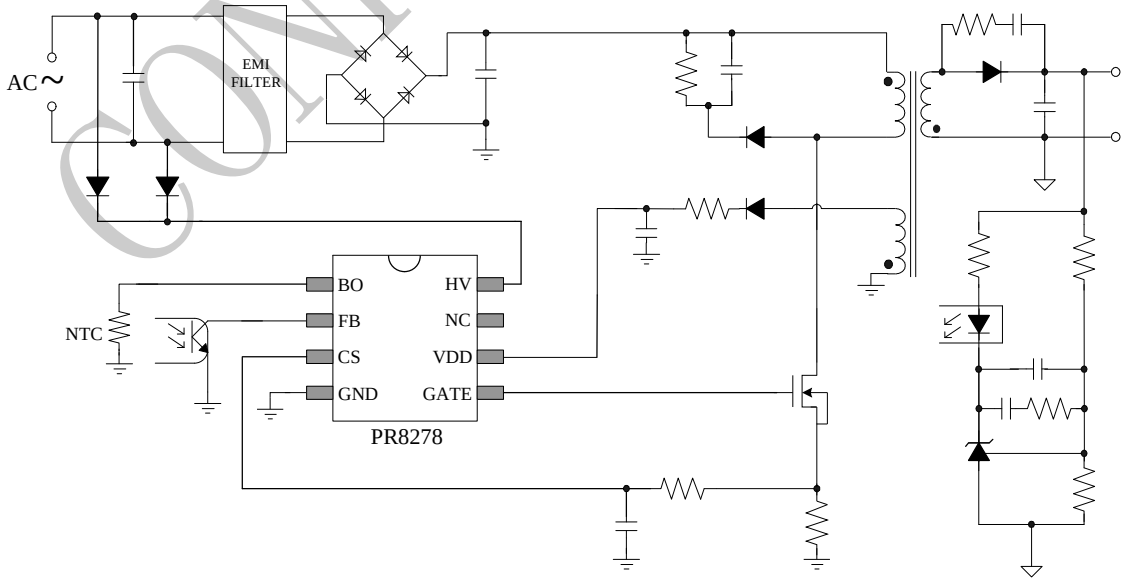
- Patented High-Voltage Startup Circuit
- Build in Patented X-cap discharge circuit (PR8278)
- Power-on Soft Start Reducing MOSFET Vds Stress
- Frequency spreading to Minimize EMI
- Hiccup Mode Control For Improved Efficiency and Minimum Standby Power Design
- Audio Noise Free Operation
- Comprehensive Protection Coverage
  - VDD Under Voltage Lockout with Hysteresis (UVLO)
  - Build-in/Adjustable OCP Compensation to Achieve Minimum OPP Variation over Universal AC Input Range
  - VDD-OVP (fixed/adjustable) and OLP with auto-recovery
  - Over Temperature Protection (OTP) with latched shutdown
- SOP8/DIP8 package

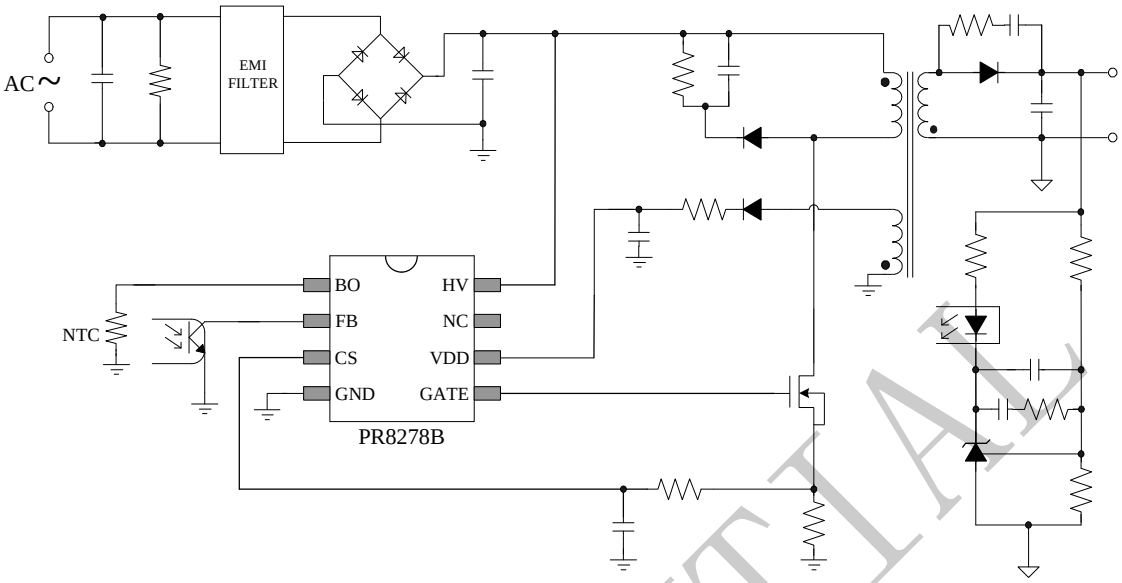
APPLICATIONS

Offline AC/DC flyback converter for

- Battery Charger
- Power Adaptor
- Open-frame SMPS

TYPICAL APPLICATION

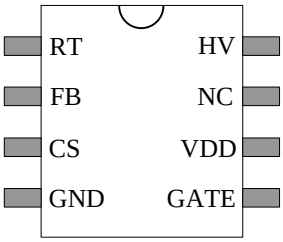




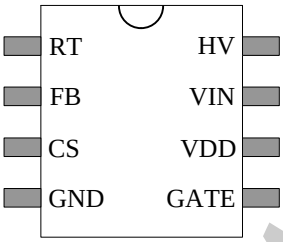
GENERAL INFORMATION

Pin Configuration

PR8278/PR8278B is offered in SOP8/DIP8 package, shown as below.



SOP8



DIP8

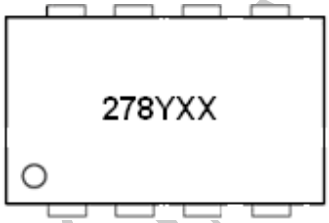
Order Information

Part Number	Description
PR8278/8278B	SOP8/DIP8 Pb-free in T&R

Package Dissipation Rating

Package	$R_{\theta JA}$(℃/W)
SOP8	150
DIP8	90

Marking Information



Y: Year Code
XX: Week Code(01-52)

Absolute Maximum Ratings

Parameter	Value
HV DC Supply Voltage	500 V
VDD DC Supply Voltage	30 V
VDD Zener Clamp Voltage	30 V
VDD DC Clamp Current	10 mA
FB Input Voltage	-0.3 to 7V
CS Input Voltage	-0.3 to 7V
RT Input Voltage	-0.3 to 7V
Min/Max Operating Junction Temperature T_J	-20 to 85 ℃
Min/Max Storage Temperature T_{stg}	-55 to 160 ℃

Note: VDD_Clamp has a nominal value of 30V.

Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. Exposure to absolute maximum-rated conditions for extended periods may affect device reliability

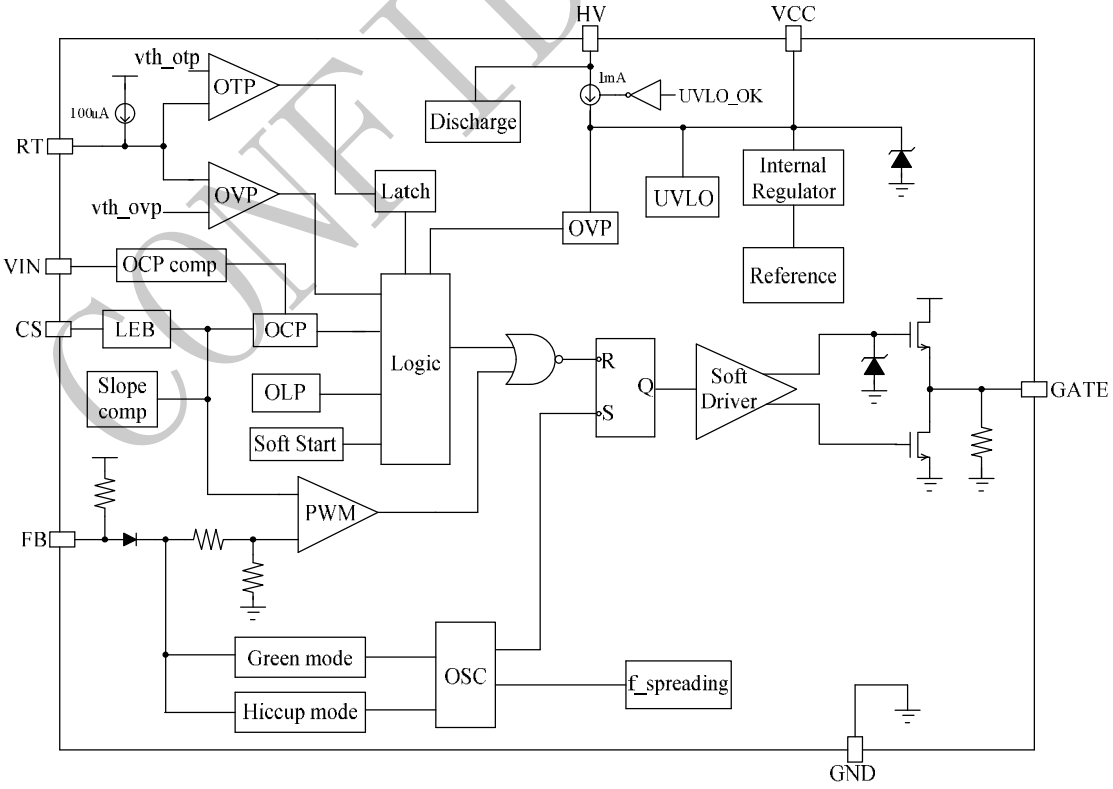
PIN ASSIGNMENTS

Pin #	Pin Name	I/O	Description
1	RT	I	Dual function pin. Either connected through a NTC resistor to ground for over temperature shutdown/latch (OTP) control or connected through Zener to VDD for adjustable over voltage protection (OVP).
2	FB	I	Feedback input pin. The PWM duty cycle is determined by voltage level at this pin and the current-sense signal at Pin 3
3	CS	I	Current sense pin, for sensing the MOSFET current.
4	GND	P	Ground.
5	GATE	O	Gate drive output to drive the external MOSFET.
6	VDD	P	Supply voltage pin
7	NC/VIN	I	NC/Line voltage sensing, Connected through a large value resistor to line voltage.
8	HV	I	Connect this pin to positive terminal of bulk capacitor to provide the startup current for the controller. When VCC voltage trips UVLO (on), this HV loop will be turned off to save the power loss of the startup circuit.

RECOMMENDED OPERATING CONDITION

Symbol	Parameter	Min/Max	Unit
VDD	VDD Supply Voltage	10 to 30	V
OTP	OTP Resistor Value	10	Kohm
TA	Operating Ambient Temperature	-20 to 85	℃

BLOCK DIAGRAM



ELECTRICAL CHARACTERISTICS

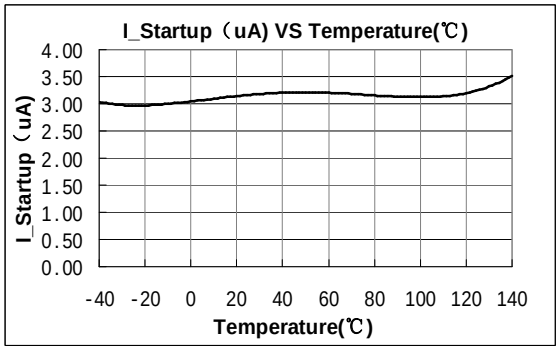
(T_A = 25℃, VDD=16V, unless otherwise noted)

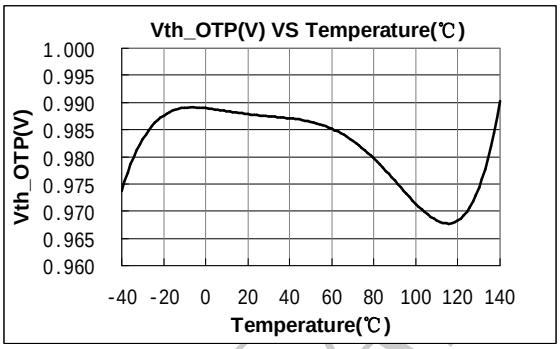
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
High Voltage Supply (HV)						
HV_MAX	Maximum DC Input Voltage		500			V
I_HV	High-Voltage Current Source	VDD< UVLO(on), HV=500V	0.5	1	1.5	mA
I_Off	Off-State Leakage Current	VDD> UVLO(off), HV=500V		1		uA
Supply Voltage (VDD)						
Istartup	VDD Start up Current	VDD=UVLO_OFF-1 V, measure current into VDD			320	uA
I_VDD_Operation	Operation Current	VFB=3V		1.5		mA
UVLO_ON	VDD Under Voltage Lockout ON		8.5	9.5	10.5	V
UVLO_OFF	VDD Under Voltage Lockout OFF		15	16	17	V
VDD_Clamp		I_{VDD}=10mA	28	29.5	31	V
OVP_ON	Over voltage protection voltage	CS=0.3V,FB=3V Ramp up VDD until OUT clock is off	25.5	27	28.5	V
Vlatch_release	Latch release voltage			8		V
Feedback Input Section(FB Pin)						
VFB_Open	VFB Open Loop Voltage			6		V
Avcs	PWM input gain ΔVFB/ ΔVCS			3		V/V
DC_MAX	Max duty cycle @ VDD=14V,VFB=3V,VCS=0.3V		75	80	85	%
Vref_green	The threshold enter green mode			2.35		V
Vref_Hiccup_H	The threshold exit Hiccup mode			1.45		V
Vref_Hiccup _L	The threshold enter Hiccup mode			1.35		V
IFB_Short	FB pin short circuit current	Short FB pin to GND and measure current		500		uA
VTH_PL	Power Limiting FB Threshold Voltage			5		V
TD_PL	Power limiting Debounce Time			30		mSec
ZFB_IN	Input Impedance			16		Kohm
Current Sense Input(CS Pin)						
SST	Soft start time			5		ms
T_blanking	Leading edge blanking time			220		ns
TD_OC	Over Current Detection and	From Over Current		120		nSec

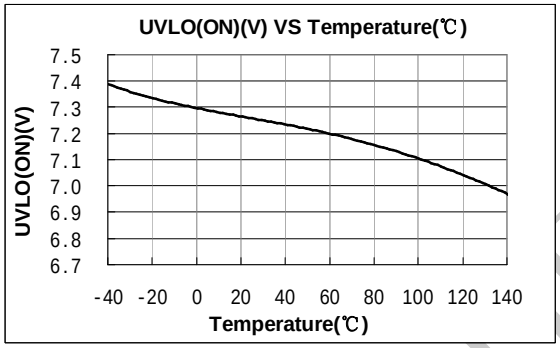
	Control Delay	Occurs till the OUT drive output start to turn off				
VTH_OC_0	Current Limiting Threshold at No Compensation (DIP-8)			0.9		V
VTH_OC_1	Current Limiting Threshold at Compensation1 (DIP-8)			0.8		V
VTH_OC_2	Current Limiting Threshold at Compensation2 (DIP-8)			0.7		V
VTH_OC	Internal Current Limiting Threshold Voltage with zero duty cycle			0.75		V
Vocp_clamping	CS voltage clamper			0.9		V
Oscillator						
FOSC	Normal Oscillation Frequency	FB=3V, CS=0.3V	60	65	70	KHz
△f_OSC	Frequency spreading range			+/-4		%
F_spreading	Spreading frequency			32		Hz
△f_Temp	Frequency Temperature stability			3		%
△f_VDD	Frequency Voltage Stability			1		%
F_Hiccup	Hiccup Mode Switch Frequency			22		KHz
Gate driver						
VOL	Ouput low level @ VDD=14V, Io=5mA			1		V
VOH	Ouput high level @ VDD=14V, Io=20mA		9			V
VO_CLAMP	Output clamp voltage			16.5		V
T_r	Output rising time 1V ~ 12V@ CL=1000pF			125		nS
T_f	Output falling time 12V ~ 1V@ CL=1000pF			50		nS
Over temperature protection						
IRT	Output current of OTP pin		95	100	105	uA
VOTP	Threshold voltage for OTP		0.95	1	1.05	V
Td_OTP	OTP debounce time			32		Cycle
VRT_FL	Float voltage at OTP pin			2.7		V
Vth_OVP	External OVP threshold voltage			4		V
X-cap discharge (PR8278)						
I_discharge	Discharge current		0.5	1	1.5	mA

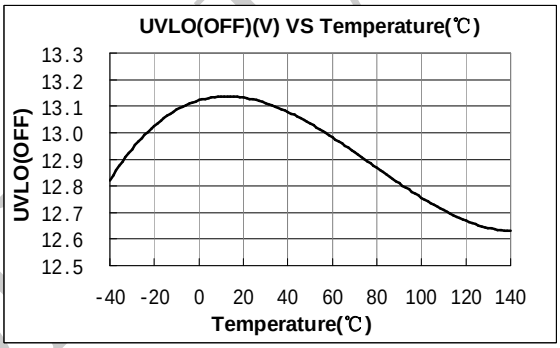
CHARACTERIZATION PLOTS

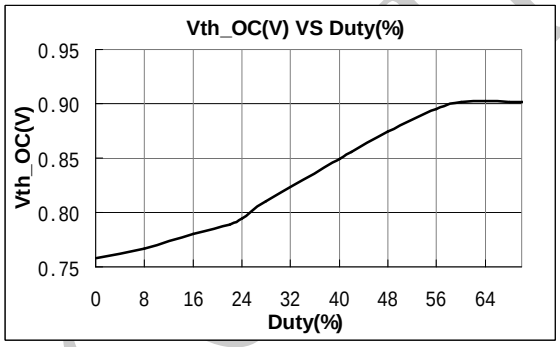
VDD = 16V, TA = 25℃ condition applies if not otherwise noted.

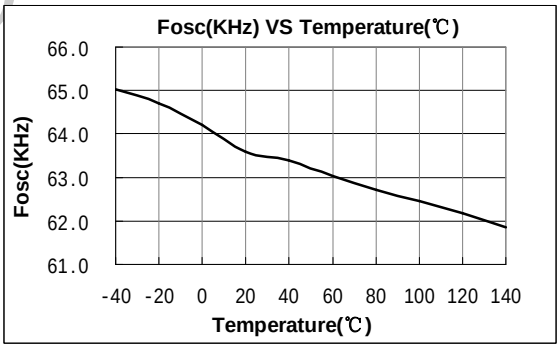












OPERATION DESCRIPTION

PR8278/PR8278B is designed for high performance, low standby power and cost effective offline flyback converter applications. The high voltage startup and Hiccup mode control circuit greatly reduces the standby power consumption and helps the system design to meet the international power conservation requirements.

High Voltage Startup
High voltage startup circuit is implemented in PR8278/PR8278B. During startup, A typical 1mA startup current will charge up the VDD bulk capacitor to UVLO_OFF, then the high voltage startup circuit shutdown with less than 1uA leakage current, this achieve short startup time and low standby current.

Operating Current
The Operating current of PR8278/PR8278B is low at 1.5mA. Good efficiency is achieved with its low operating current together with the Hiccup mode control features.

Soft Start
PR8278/PR8278B features an internal 5ms soft start to soften the electrical stress occurring in the power supply during startup. It is activated during the power on sequence. As soon as VDD reaches UVLO_OFF, the CS peak voltage is gradually increased from 0.15V to the maximum level. Every restart up is followed by a soft start.

Frequency spreading for EMI improvement
The frequency spreading (switching frequency modulation) is implemented in PR8278/PR8278B. 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.

Hiccup Mode Operation
At light load or zero load condition, most of the power dissipation in a switching mode power supply is from switching loss on the MOSFET, the core loss of the transformer and the loss on the snubber circuit. The magnitude of power loss is in proportion to the switching frequency. Lower switching frequency leads to the reduction on the power loss and thus conserves the energy.

The switching frequency is internally adjusted at no load or light load condition. The switch frequency reduces at light/no load condition to improve the conversion efficiency. At light load or no load condition, the FB input drops below Hiccup mode threshold level and device enters Hiccup Mode control. The Gate drive output switches only when VDD voltage drops below a preset level and FB input is active to output an on state. Otherwise the OUT drive remains at off state to minimize the switching loss and reduces the standby power consumption to the greatest extend.

The switching frequency control also eliminates the audio noise at any loading conditions.

Oscillator Operation
The switching frequency is internally fixed at 65KHz. No external frequency setting components are required for PCB design simplification.

Current Sensing and Leading Edge Blanking
Cycle-by-Cycle current limiting is offered in PR8278/PR8278B 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 due to snubber diode reverse recovery and surge OUT current of power MOSFET so that the external RC filtering on sense input is no longer needed. The current limiting comparator is disabled and cannot turn off the internal power MOSFET during the blanking period. The PWM duty cycle is determined by the current sense input voltage and the FB input voltage.

Internal Synchronized Slope Compensation
Built-in slope compensation circuit adds voltage ramp onto the current sense input voltage for PWM generation. This greatly improves the close loop stability at CCM and prevents the subharmonic oscillation and thus reduces the output ripple voltage.

Drive
The power MOSFET is driven by a dedicated OUT driver for power switch control. Too weak the OUT drive strength results in higher conduction and switch loss of MOSFET while too strong OUT drive results the compromise of EMI.

A good tradeoff is achieved through the built-in totem pole OUT design with right output strength and dead time control. The low idle loss and good EMI system design is easier to achieve with this dedicated control scheme.

Protection Controls
Good power supply system reliability is achieved with auto-recovery protection features including Cycle-by-Cycle current limiting (OCP), Over Load Protection (OLP), Under Voltage Lockout on VDD (UVLO), and fixed or adjustable VDD over voltage protection (OVP). Over temperature protection (OTP) is with latch shutdown. The OCP is line voltage compensated (built-in/adjustable) to achieve constant output power limit over the universal input voltage range.

At overload condition when FB input voltage

exceeds power limit threshold value for more than TD_PL, control circuit reacts to shut down the converter. It restarts when VDD voltage drops below UVLO limit 4 times. When an Over Temperature condition is detected, control circuit shutdowns (latch) the power MOSFET until VDD drops below 8V (Latch release voltage), and device enters power on restart-up sequence thereafter.

OTP

A NTC resister connected between pin OTP and GND sets the Over Temperature Protection threshold. A 100uA constant current outflow OTP pin into the NTC resistor. As the rise of temperature, the resistance of the NTC resistor decrease, when the voltage on OTP pin decrease to 1V, OTP becomes active, application circuit goes into latch shutdown mode.

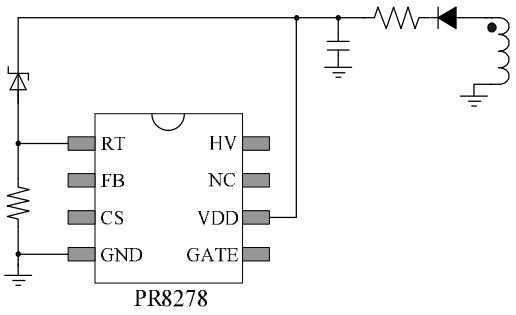
$$100uA \cdot [R_{nom} - K \cdot (T_{OTP} - T_{nom})] = 1V$$

$$T_{OTP} = T_{nom} + \frac{R_{nom} - 10Kohm}{K}$$

While K is the coefficient of the NTC resistor, R_{nom} is the resistance of the NTC resistor at normal temperature.

Output (adjustable) OVP through external Zener

A zener diode connected between pin VDD and OTP sets the output (adjustable) OVP function. When the voltage on OTP pin increase to 4V, output (adjustable) OVP becomes active, application circuit goes into latch shutdown mode.



$$V_{th\_OVP} = V_{zener} + 4V$$

X-cap discharge circuit

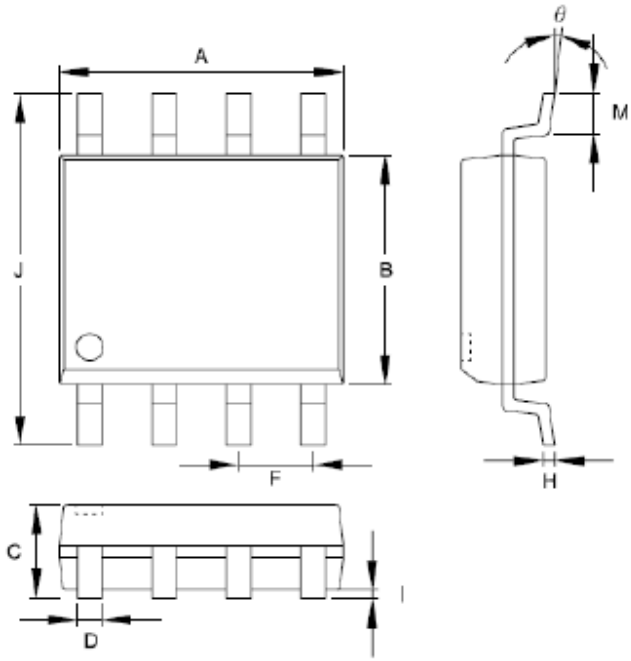
The EMI filter in the front end of the switched-mode power supply (SMPS) typically includes capacitor across AC line connector. Most of the safety regulations, such as UL1950 and IEC61010-1, require the capacitor be discharged to a safe level within a given time when the AC plug is removed from its receptacle. Typically, discharge resisters across the capacitor are used to make sure that capacitor is discharged naturally, which introduces power loss as long as it is connected to the receptacle.

The Patented X-cap discharge circuit built in PR8278 intelligently discharges the filter capacitor only when the power supply is unplugged from the power outlet. Since the X-CAP discharge circuit is disabled in normal operation, the power loss in the EMI filter can be virtually removed.

The discharge of the capacitor is achieved through the HV pin. Once AC outlet detaching is detected, the PWM gate remains off and VDD drops to VDD-OFF. Then VDD is charged up, which discharges the filter capacitor.

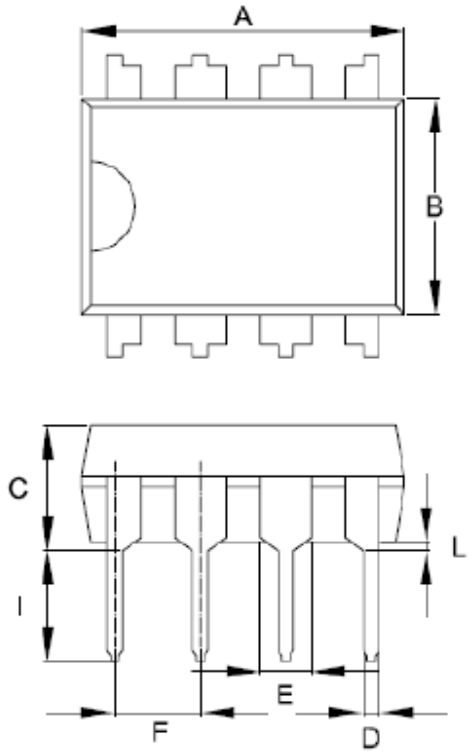
PACKAGE MECHANICAL DATA

SOP8



Symbols	Dimensions in Millimeters		Dimensions in Inch	
	MIN	MAX	MIN	MAX
A	4.801	5.004	0.189	0.197
B	3.810	3.988	0.150	0.157
C	1.346	1.753	0.053	0.069
D	0.330	0.508	0.013	0.020
F	1.194	1.346	0.047	0.053
H	0.178	0.229	0.007	0.009
I	0.102	0.254	0.004	0.010
J	5.791	6.198	0.228	0.244
M	0.406	1.270	0.016	0.050
θ	0°	8°	0°	8°

DIP8



Symbol	Dimension in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	9.017	10.160	0.355	0.400
B	6.096	7.112	0.240	0.280
C	-----	5.334	------	0.210
D	0.356	0.584	0.014	0.023
E	1.143	1.778	0.045	0.070
F	2.337	2.743	0.092	0.108
I	2.921	3.556	0.115	0.140
J	7.366	8.255	0.29	0.325
L	0.381	------	0.015	---------