High Performance Current Mode PWM Controller

GENERAL DESCRIPTION

OB2287 is a highly integrated current mode PWM controller for medium to large power offline flyback converter applications.

OB2287 enhances On-Bright's PWM controller series by offering the Brownout Detection and Protection (BOP).

OB2287 offers comprehensive protection coverage including Cycle-by-Cycle current limiting, internal Power-On Soft Start, VDD Under Voltage Lockout (UVLO), VDD Over Voltage Protection(OVP), VDD Clamp, Gate Clamp, Over Load Protection(OLP), Over Temperature Protection (OTP), Brownout Protection (BOP). OB2287 also features protections against pin open and short on selected pins.

On-Bright's proprietary OCP compensation can compensate CCM and DCM mode difference when used in universal AC input applications. Moreover, an internal 1-second restart timer prevents permanent OLP latch when the supply of the controller is provided by other DC sources. In applications where supply is self biased by auxiliary winding, this restart timer will not be triggered.

To achieve good EMI performance, On-Bright's proprietary built-in frequency shuffling is provided, together with soft switching control at the totem pole gate drive output.

To meet the increasing stringent standby power requirements, in light or No load, OB2287 operates in On-Bright's proprietary "Extended Burst Mode" without audible noise.

OB2287 is offered in SOP-8 and DIP-8 packages.

FEATURES

■ AC Line Brownout Detection & Protection (BOP)
■ Latch-off Mode Fault Protection
■ Internal Restart Timer
■ All pins floating protection and RI short protection
■ Proprietary Extended Burst Mode Control For Improved Efficiency and Minimum Standby Power Design
■ Audio Noise Free Operation
■ External Programmable PWM Switching Frequency
■ Built-in Frequency Shuffling for Better EMI
■ Internal Leading Edge Blanking
■ Proprietary OCP Compensation for Universal AC Input Range
■ High Precision Reference Voltage for OTP and Brownout Protection
■ Power-On Soft Start
■ Internal Synchronized Slope Compensation
■ 1A Peak Current Drive Sink Capability

APPLICATIONS

Offline AC/DC flyback converter for
■ Printer
■ Adaptor
■ LCD Monitor/TV/PC/Set-Top Box Power Supplies
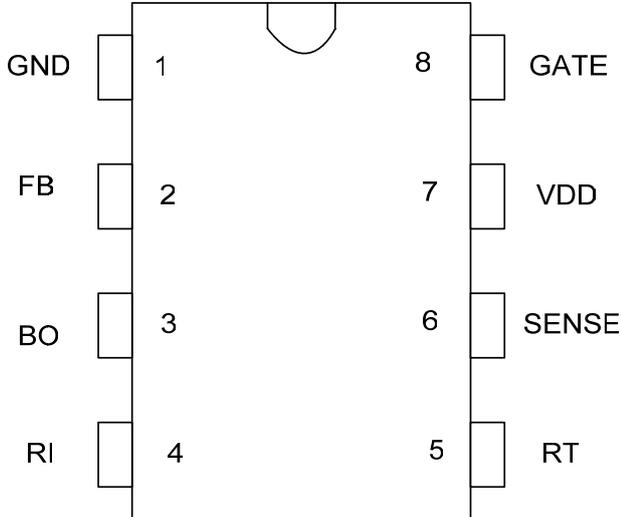■ Open-frame SMPS

TYPICAL APPLICATION
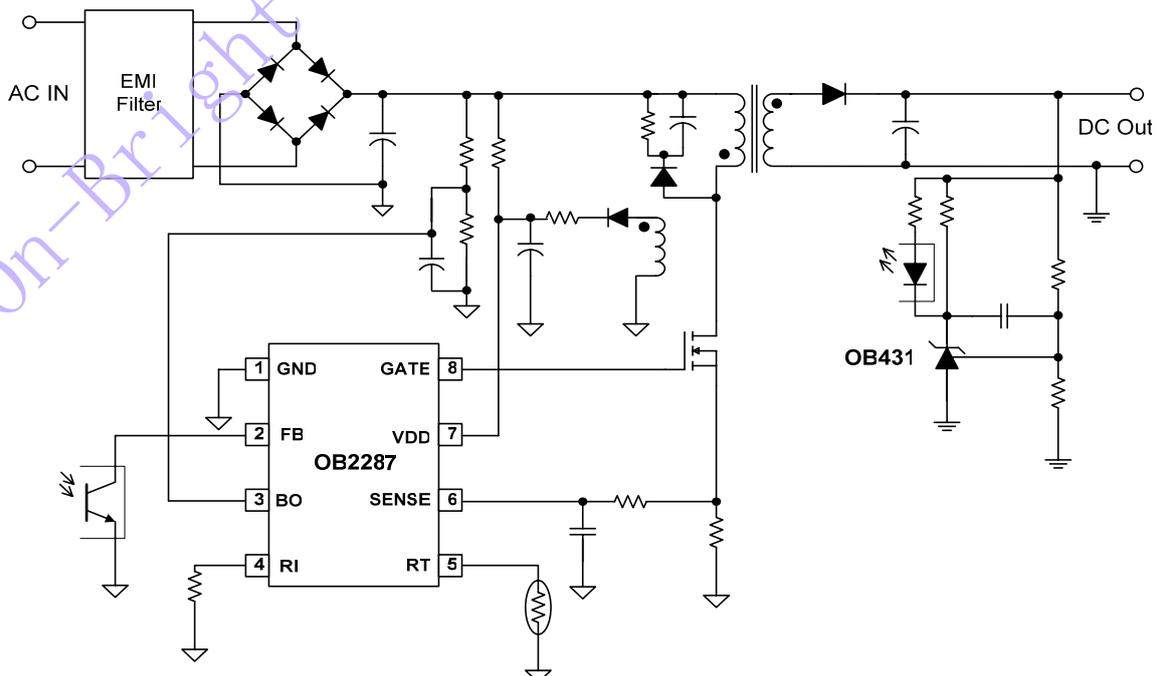
GENERAL INFORMATION

Pin Configuration

The pin map of OB2287 in DIP8 and SOP8 package is shown as below.

Pin		Pin	
GND	1	8	GATE
FB	2	7	VDD
BO	3	6	SENSE
RI	4	5	RT

Ordering Information

Part Number	Description
OB2287AP	DIP8, Pb-free
OB2287CP	SOP8, Pb-free

Note: All Devices are offered in Pb-free Package if not otherwise noted.

Package Dissipation Rating

Package	RθJA (°C/W)
DIP8	90
SOP8	150

Absolute Maximum Ratings

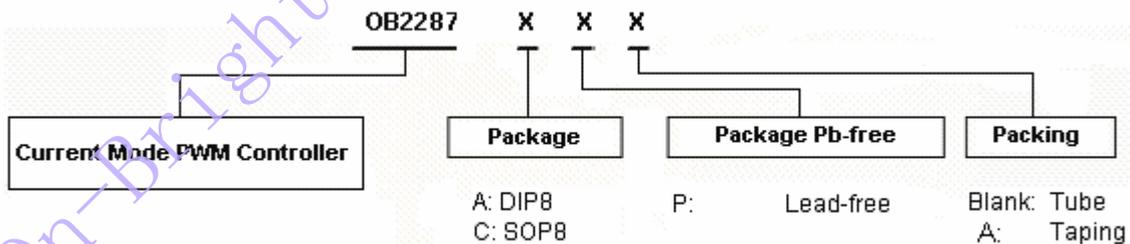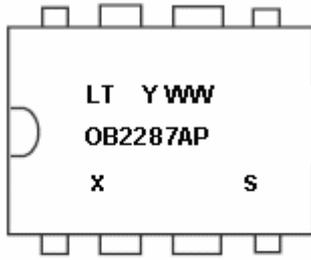| Parameter	Value
VDD Clamp Voltage	31 V
VDD Clamp Continuous Current	10 mA
V_{FB} Input Voltage	-0.3 to 7V
V_{SENSE} Input Voltage to Sense Pin	-0.3 to 7V
V_{RT} Input Voltage to RT Pin	-0.3 to 7V
V_{RI} Input Voltage to RI Pin	-0.3 to 7V
Min/Max Operating Junction Temperature T_J	-20 to 150 °C
Min/Max Storage Temperature T_{stg}	-55 to 150 °C
Lead Temperature (Soldering, 10secs)	260 °C

Note: Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute maximum-rated conditions for extended periods may affect device reliability.
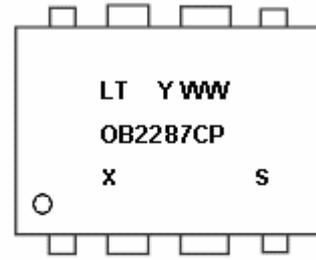
OB2287   X   X   X

Current Mode PWM Controller		Package	Package Pb-free	Packing

Package:
A: DIP8
C: SOP8

Package Pb-free:
P: Lead-free

Packing:
Blank: Tube
A: Taping

Confidential

OB_DOC_DS_8700

Marking Information

DIP8

```
    LT    Y WW
    OB2287AP
    X           S
```

A: DIP8 Package
P: Pb-free Package
Y: Year Code(0-9)
WW: Week Code(01-52)
X: Version
s: Internal Code

SOP8

```
    LT    Y WW
    OB2287CP
    X           S
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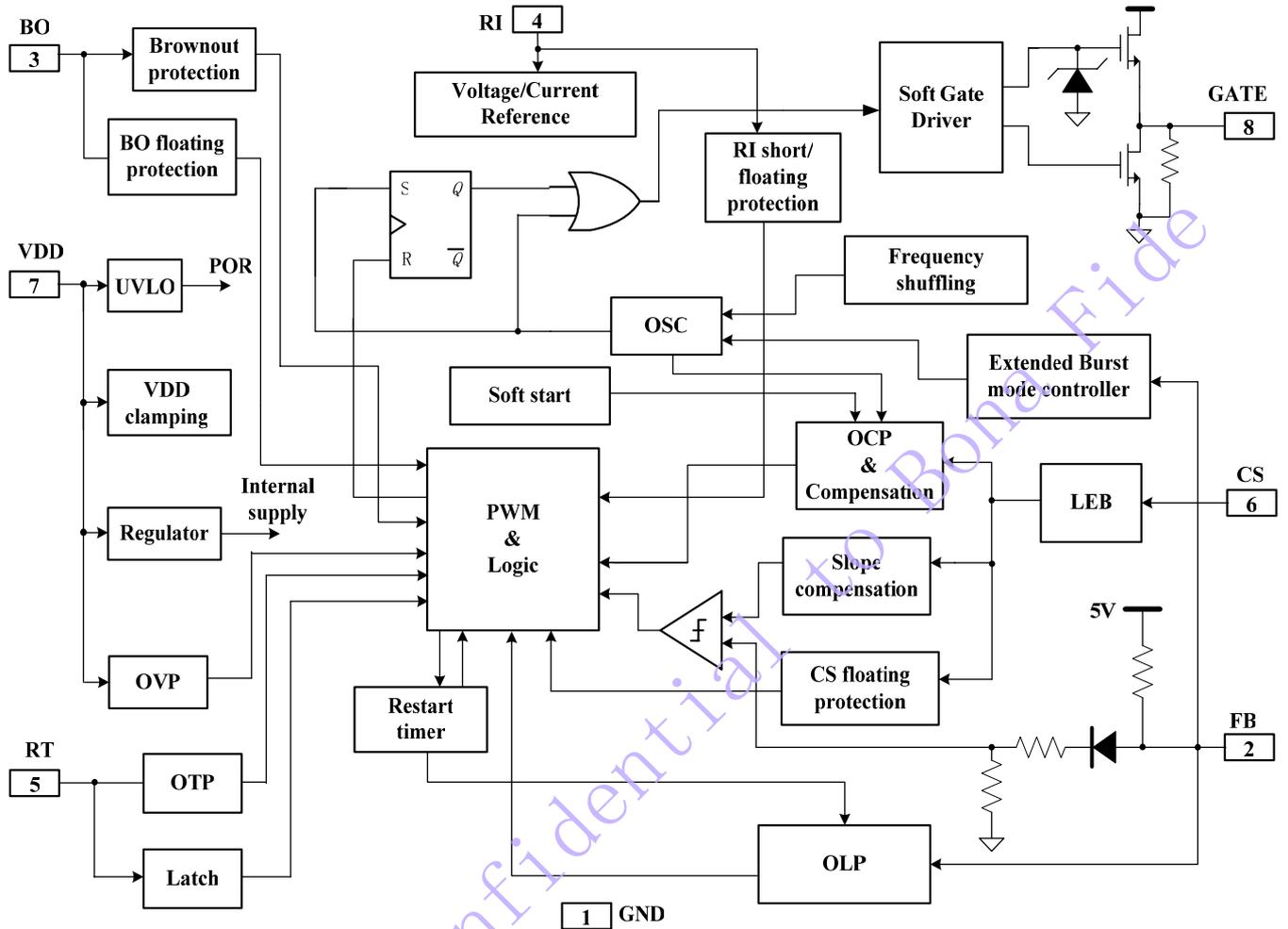
C: SOP8 Package
P: Pb-free Package
Y: Year Code(0-9)
WW: Week Code(01-52)
X: Version
s: Internal Code

TERMINAL ASSIGNMENTS

Pin Num	Pin Name	I/O	Description
1	GND	P	Ground
2	FB	I	Feedback input pin. PWM duty cycle is determined by voltage level into this pin and current-sense signal level at Pin 6.
3	BO	I/O	Connected a resistor divider from line voltage to this pin to detect line voltage. If this pin drops below 1.05V and lasts 50ms, PWM output will be disabled. When brownout is triggered, this pin will source an internal trimmed current for brownout hysteresis programming.
4	RI	I	Internal Oscillator frequency setting pin. A resistor connected between RI and GND sets the PWM frequency.
5	RT	I	Dual function pin. Either connected through a NTC resistor to GND for over temperature protection control or used as the latch shutdown control input.
6	SENSE	I	Current sense input pin. Connected to MOSFET current sensing resistor node.
7	VDD	P	DC power supply pin.
8	GATE	O	Totem-pole gate drive output for power MOSFET.

BLOCK DIAGRAM

RECOMMENDED OPERATING CONDITION

Symbol	Parameter	Min	Max	Unit
VDD	VDD Supply Voltage	11.5	25	V
RI	RI Resistor Value	10	40	Kohm
T_A	Operating Ambient Temperature	-20	85	^{o}C

ELECTRICAL CHARACTERISTICS

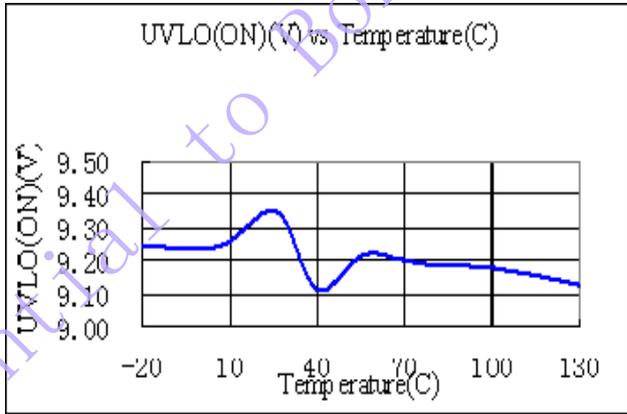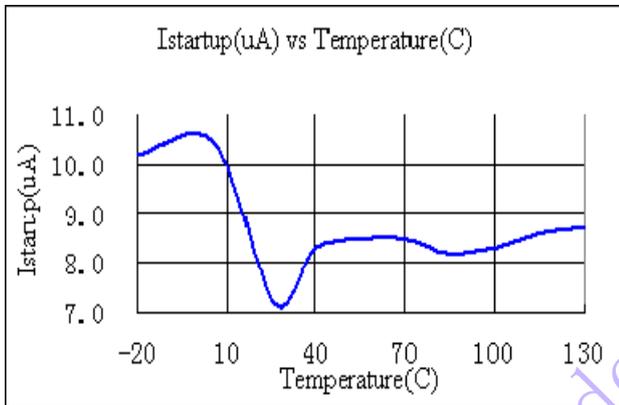(T_A = 25^{O}C, RI=20K ohm, VDD=16V, if not otherwise noted)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
Supply Voltage (VDD) Section						
I_VDD_Startup	VDD Start up Current	VDD=15V, Measure current into VDD		5	20	uA
I_VDD_Ops	Operation Current	V_{FB}=3V		2.3		mA
UVLO(Enter)	VDD Under Voltage Lockout Enter		8	9	10	V
UVLO(Exit)	VDD Under Voltage Lockout Exit (Startup)		14	15	16	V
OVP(Latch)	VDD Over Voltage Latch Trigger		26.5	28	29.5	V
OVP(De-Latch)	VDD Latch Release Voltage Threshold			6.5		V
I(Vdd)_latch	VDD bleeding current at latch shutdown when VDD = 8V			45		uA
T_D_OVP	VDD OVP Debounce time			100		uSec
V_{DD}_Clamp	V_{DD} Zener Clamp Voltage	I(V_{DD}) = 5 mA		31		V
T_Softstart	Soft Start Time			16		mSec
Feedback Input Section(FB Pin)						
A_{VCS}	PWM Input Gain	$\Delta V_{FB} / \Delta V_{cs}$		2.2		V/V
V_{FB}_Open	V_{FB} Open Voltage	VDD=18V		6		V
I_{FB}_Short	FB pin short circuit current	VDD=18V, Short FB pin to GND, measure current		1.1		mA
V_{TH}_0D	Zero Duty Cycle FB Threshold Voltage				1	V
V_{TH}_BM	Burst Mode FB Threshold Voltage			1.6		V
V_{TH}_PL	Power Limiting FB Threshold Voltage			4.4		V
T_D_PL	Power limiting Debounce Time			250		mSec
Z_{FB}_IN	Input Impedance			6		Kohm
Current Sense Input(Sense Pin) Section						
T_blanking	Sense Input Leading Edge Blanking Time	VDD=18V		350		nSec
V_{TH}_OC_0	Internal current limiting threshold	Zero duty cycle	0.68	0.7	0.72	V
T_D_OC	Over Current Detection and Control Delay	CL=1nf at GATE,		70		nSec
Oscillator Section						
F_{OSC}	Normal Oscillation Frequency		60	65	70	KHZ
ΔF(shuffle)/Fosc	Frequency shuffling range		-4		4	%

F_shuffle	Frequency shuffling cycling frequency			32		Hz
Δf_Temp	Frequency Temperature Stability	-20^{o}C to 100 ^{o}C		3		%
Δf_VDD	Frequency Voltage Stability	VDD = 12-28V,		3		%
Dmax	Maximum Duty cycle		75	80	85	%
Dmin	Minimum Duty cycle		-	-	0	%
RI_range	Operating RI Range		10	20	40	Kohm
V_RI_open	RI open voltage			2.0		V
F_BM	Burst Mode Base Frequency			22		KHZ
Gate Drive Output						
VOL	Output Low Level	Io = 30 mA (sink)			0.3	V
VOH	Output High Level	Io = 30 mA (source)	11			V
VG_Clamp	Output Clamp Voltage Level			18		V
T_r	Output Rising Time	CL = 1nf		70		nSec
T_f	Output Falling Time	CL = 1nf		30		nSec
Over Temperature Protection						
I_RT	Output Current of RT pin	VDD = 18V		100		uA
V_{TH}_OTP	OTP Threshold Voltage	VDD = 18V	1.015	1.05	1.115	V
V_{TH}_OTP_off	OTP Recovery Threshold Voltage	VDD = 18V		1.15		V
V_{TH}_RT_latch	RT Input Latch Threshold Voltage	VDD=18V		0.6		V
T_D_OTP	OTP De-bounce Time	VDD = 18V		100		uSec
V_RT_Open	RT Pin Open Voltage	VDD = 18V		3.2		V
Brownout Section						
Vth_BO	Brownout comparator threshold		1	1.05	1.1	V
T_D_BO	Brownout debounce time			50		ms
IBO_hys	BO output current for BO hysteresis programming			2		uA
Restart Timer Section						
RST_auto	Auto recovery Restart timer			1		Sec

CHARACTERIZATION PLOTS
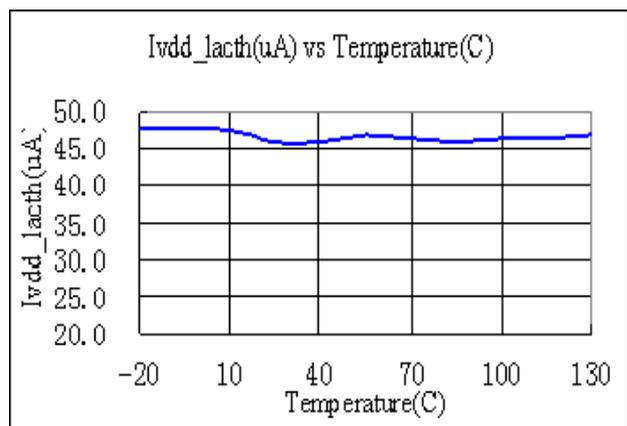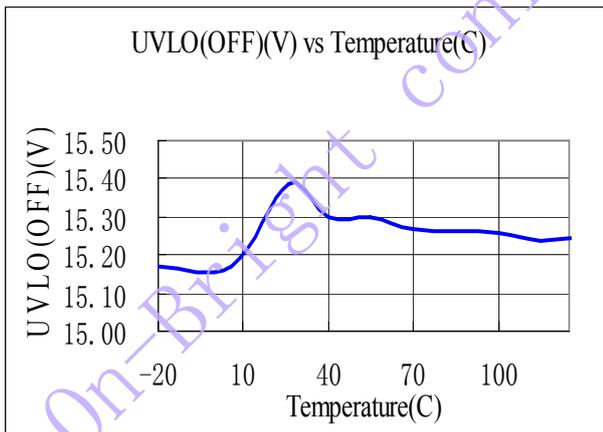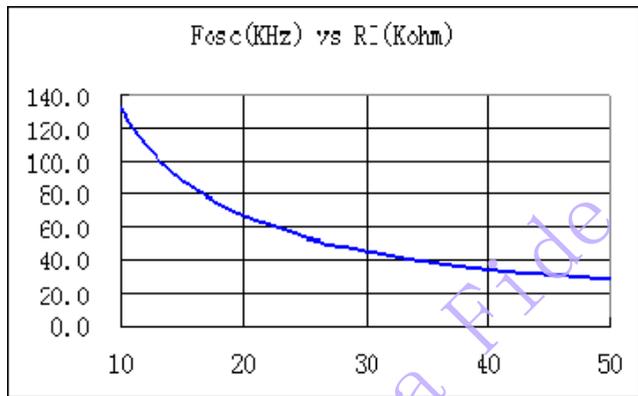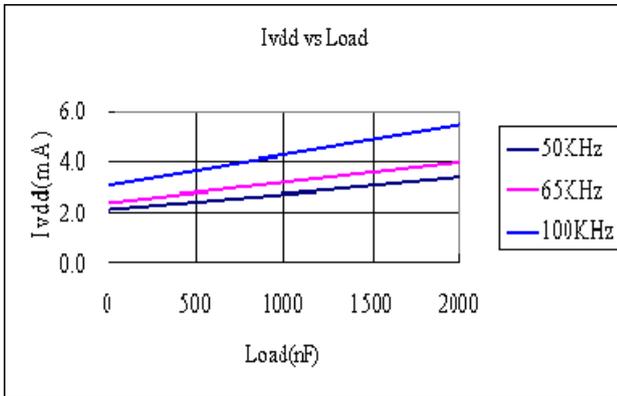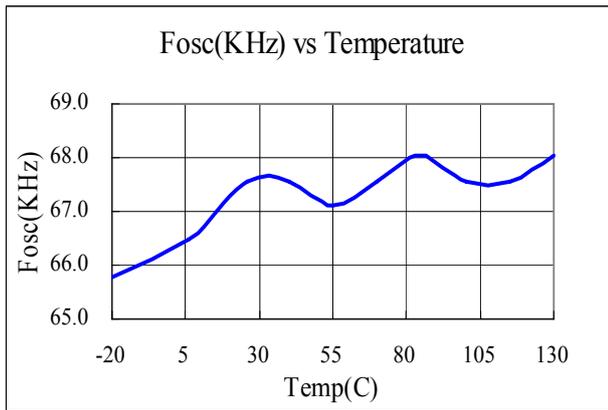
Ivdd vs Load

Fosc(KHz) vs RI(Kohm)

Istartup(uA) vs Temperature(C)

UVLO(ON)(V) vs Temperature(C)

UVLO(OFF)(V) vs Temperature(C)

Ivdd_lacth(uA) vs Temperature(C)

Fosc(KHz) vs Temperature

OPERATION DESCRIPTION

OB2287 is a highly integrated high performance PWM controller IC optimized for offline flyback converter applications. The versatile protections and high performance make it very suitable for medium-to-large power applications.

● **Startup Current and Start up Control**

Startup current of OB2287 is designed to be very low so that VDD could be charged up above UVLO(exit) threshold level and device starts up quickly. A large value startup resistor can therefore be used to minimize the power loss yet reliable startup in application. For a typical AC/DC adaptor with universal input range design, a 2 MΩ, 1/8 W startup resistor could be used together with a VDD capacitor to provide a fast startup and yet low power dissipation design solution.

● **Operating Current**

The Operating current of OB2287 is low at 2.3mA. Good efficiency is achieved with OB2287 low operating current together with extended burst mode control schemes.

● **Extended Burst Mode Operation**

At zero load or light load condition, most of the power dissipation in a switching mode power supply is from switching loss on the MOSFET transistor, the core loss of the transformer and the loss on the snubber circuit. The magnitude of power loss is in proportion to the number of switching events within a fixed period of time. Reducing switching events leads to the reduction on the power loss and thus conserves the energy.

OB2287 self adjusts the switching mode according to the loading condition. At from no load to light/medium load condition, the FB input drops below burst mode threshold level. Device enters Burst 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 gate drive remains at off state to minimize the switching loss thus reduce the standby power consumption to the greatest extend.

The nature of high frequency switching also reduces the audio noise at any loading conditions.

● **Oscillator/Frequency Shuffling Operation**

A resistor connected between RI and GND sets the constant current source to charge/discharge the internal cap and thus the PWM oscillator frequency is determined. The relationship between RI and switching frequency follows the below equation

within the specified RI in Kohm range at nominal loading operational condition.

$$F_{OSC} = \frac{1300}{RI(Kohm)}(Khz)$$

In OB2287, the proprietary frequency shuffling method can soften the EMI signature by spreading the energy in the vicinity of the main switching component and its harmonics. The magnitude of shuffling lies in the range of ±4% of the main switching frequency.

● **Current Sensing and Leading Edge Blanking**

Cycle-by-Cycle current limiting is offered in OB2287 current mode PWM control. The switch current is detected by a sense resistor into the sense pin. An internal leading edge blanking circuit chops off the sense voltage spike at initial MOSFET on state due to snubber diode reverse recovery so that the external RC filtering on sense input is no longer needed. The current limit comparator is disabled and cannot turn off the external 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 sub-harmonic oscillation and thus reduces the output ripple voltage.

● **Over Temperature Protection with Latch Shutdown**

A NTC resistor in series with a regular resistor should connect between RT and GND for temperature sensing and protection. NTC resistor value becomes lower when the ambient temperature rises. With the fixed internal current I_{RT} flowing through the resistors, the voltage at RT pin becomes lower at high temperature. The internal OTP circuit is triggered and shutdown the MOSFET when the sensed input voltage is lower than V_{TH}_OTP. OTP is a latched shutdown.

● **RT Pin Used as Latch Shutdown Input Control**

RT pin could also be used as a control input to implement system latch shutdown function.

An example is to implement system OVP protection with a latch shutdown function through a photo coupler and affiliated circuits. When OVP detection signal connected to RT is lower than V_{TH_OTP} OB2287 controls system into latch shutdown. The recovery of the AC/DC system could only be realized by resetting internal latch when VDD voltage drops below VDD_De-latch value. This could be achieved by unplugging/re-plugging of AC source in AC start-up configuration.

● **Brownout protection**

By monitoring the voltage level on pin BO during normal operation, the controller protects the SMPS against low main condition. When BO voltage level falls below 1.05V, and if it lasts for about 50ms, the controller stops pulsing until this level goes back and the operation resumes. By adjusting the resistor divider connected between the high input voltage and this pin, start and stop levels are programmable.
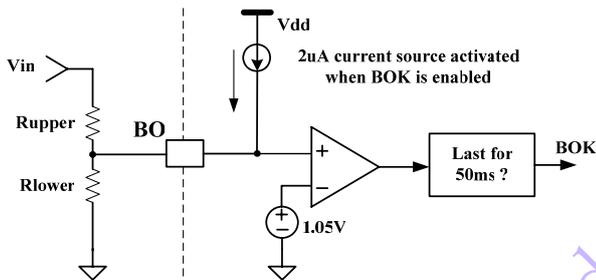
● **Restart timer**

In some special applications, such as LCDTV, the power supply of PWM stage is provided by other DC source and it is always on. The following diagram shows an AC/DC part of the LCDTV. The front end is a PFC stage, followed by a PWM stage. The PFC stage is controlled by PWM stage. A stand along standby converter provides the DC power supply for both PWM and PFC stages.
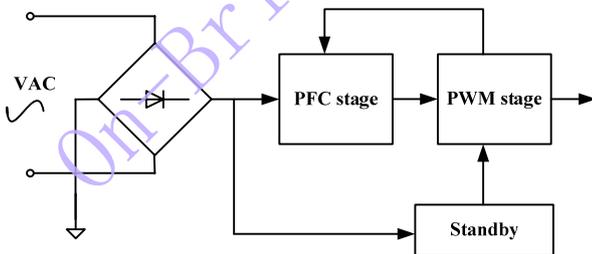
In such situations, when the over loading protection (OLP) occurs, PWM stage will be latched of and it will not recover since it is powered by the standby DC supply. OB2287 overcomes this by an internal restart timer. When OLP occurs, then the timer begins counting. When counting over, the OLP states will be cleared. System tends to restart and auto-recover. If OLP still exists, then another

counting cycle begins. The counting time in OB2287 is 1 second. Therefore, the nominal operation of OLP is not disturbed.

● **Pin floating and short protection**

OB2287 provides pin floating protection for RI, CS, FB, etc., and RI pin short protection. In cases when the pin are floating or RI pin is shorted to ground, PWM switching is disabled, thus protect the power system.

● **OCP compensation for CCM/DCM**

In OB2287, a proprietary OCP compensation is provided for better OCP performance in the universal input range. In conventional OCP compensation, only the gate delay is compensated. In OB2287, in addition to that, the mode difference between CCM and DCM is also compensated, since in 90VAC the system often works in CCM. In this way, a more accurate OCP is achieved over the entire line voltage range.

● **Overload Operation**

When over load (for example, short circuit) occurs, a fault is detected. If this fault is present for more than 250ms, OB2287 enters an auto-recovery soft burst mode. All pulses are stopped, VDD will drops below UVLO and the controller will try to restart, with the power-on soft start. The SMPS resumes operation if the fault has gone. Otherwise, a burst sequence starts again.

● **Soft Start**

OB2287 features an internal 16ms soft start to soften the constraints occurring in the power supply during startup. It is activated during the power on sequence. As soon as VDD reaches UVLO(exit), the peak current is gradually increased from nearly zero to the maximum clamping level 0.7V. The soft start is also activated during OLP sequence. Every restart attempt is followed by soft start.

● **Gate Drive**

The PWM output is connected to the Gate of an external MOSFET for power switch control. Too weak the gate drive strength results in higher conduction and switch loss of MOSFET while too strong gate drive output compromises the EMI.

Good tradeoff is achieved through the built-in totem pole gate drive 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. An internal 16.5V clamp is added for MOSFET gate protection at higher than expected VDD input.

PACKAGE MECHANICAL DATA

8-Pin Plastic DIP
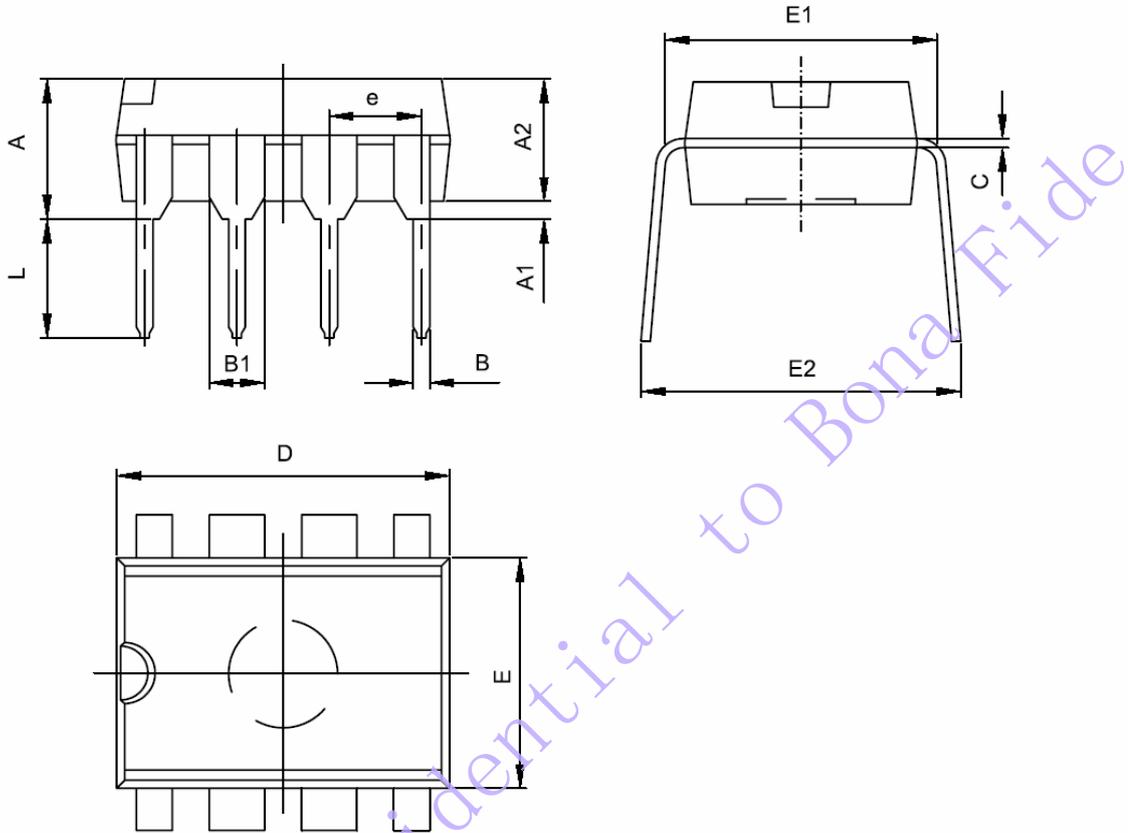
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	3.710	4.310	0.146	0.170
A1	0.510		0.020	
A2	3.200	3.600	0.126	0.142
B	0.360	0.560	0.014	0.022
B1	1.524(TYP)		0.060(TYP)	
C	0.204	0.360	0.008	0.014
D	9.000	9.400	0.354	0.370
E	6.200	6.600	0.244	0.260
E1	7.620(TYP)		0.300(TYP)	
e	2.540(TYP)		0.100(TYP)	
L	3.000	3.600	0.118	0.142
E2	8.200	9.400	0.323	0.370
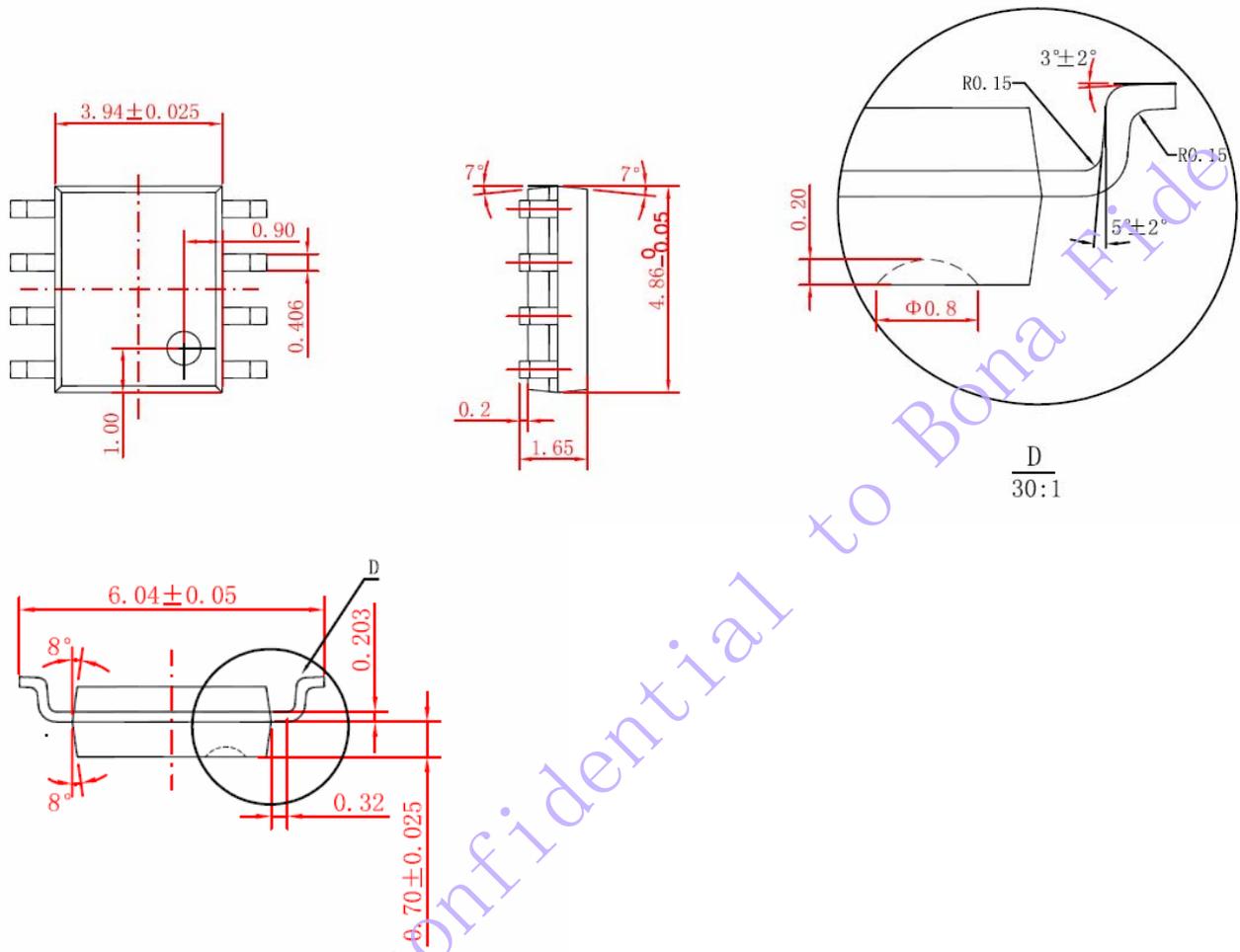
High Performance Current Mode PWM Controller

8-Pin Plastic SOP

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