OB2202

Quasi-Resonant Flyback PWM Controller

Product Specification

GENERAL DESCRIPTION

OB2202 is a highly integrated Quasi-Resonant (QR) controller optimized for high performance offline flyback converter applications.

At normal load condition, it operates in QR mode with minimum drain voltage switching. To meet the CISPR-22 EMI starting at 150KHz, the maximum switching frequency is internally limited to 130KHz. It operates in PFM mode for high power conversion efficiency at light load condition. When the loading is very small, the IC operates in 'Extended Burst Mode' to minimize the switching loss. As a result, lower standby power consumption and higher conversion efficiency can be achieved.

OB2202 offers comprehensive protection coverage including Cycle-by-Cycle Current Limiting, VCC Under Voltage Lockout(UVLO), Programmable Output Over Voltage Protection(OVP), VCC Clamp, Gate Clamp, Over Load Protection(OLP), On-chip Thermal Shutdown, Programmable Soft Start, Programmable Brownout Protection, Programmable Over Power Protection (OPP) Compensation, and External Latch Triggering, Max On-time Limit, etc.

OB2202 is offered in SOP-8 and DIP-8 packages.

FEATURES

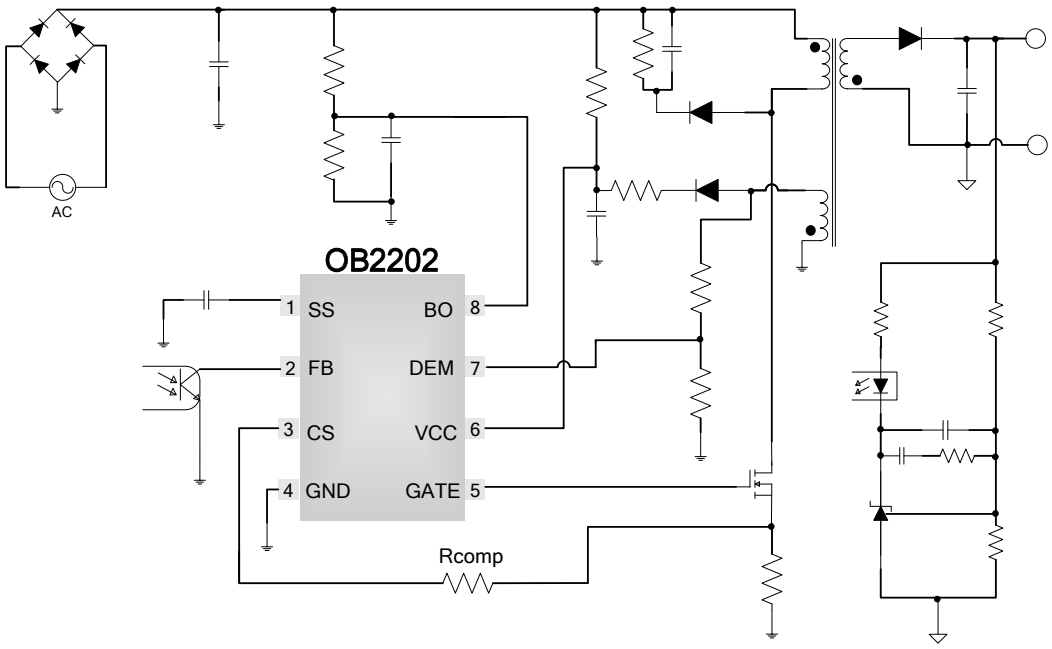
- Multi-Mode Operation
  Quasi-Resonant Operation at Normal Loading
  Pulse Frequency Modulation (PFM) Operation at Light Load
  Burst Mode at No Load
- Programmable Brownout Protection and Line OVP Protection
- Excellent OPP Compensation
- 130KHz Maximum Frequency Limit
- Internal Minimum T_off for Ringing Suppression
- 30us Maximum On Time Limit
- 50us Maximum Off Time Limit
- Internal Leading Edge Blanking
- Programmable Soft-start
- Cycle-by-cycle Current Limiting
- External Latch Triggering
- Internal Thermal Shutdown
- 1A Peak Current Sink/Source Capability
- Programmable Output OVP

APPLICATIONS

Offline AC/DC flyback converter for

- Power Adaptor and Open-frame SMPS
- LCD Monitor/TV/PC/Set-Top Box Power Supplies
- NB/DVD/Portable DVD Power Supplies

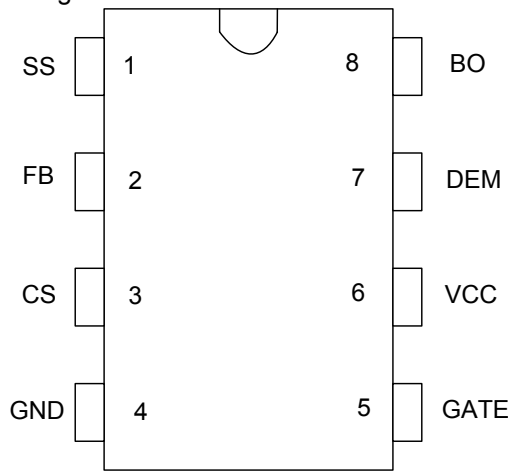
TYPICAL APPLICATION



GENERAL INFORMATION

Pin Configuration

The pin map of OB2202 in DIP8 and SOP8 package is shown as below.



Ordering Information

Part Number	Description
OB2202AP	8 Pin DIP, Halogen free in Tube
OB2202CP	8 Pin SOP, Halogen free in Tube
OB2202CPA	8 Pin SOP, Halogen free in T&R

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

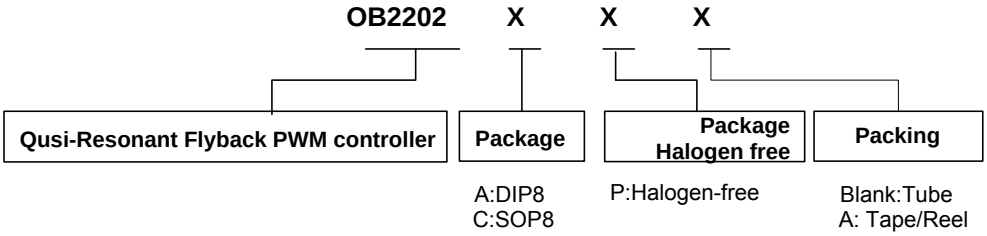
Package Dissipation Rating

Package	RθJA(℃/W)
DIP8	90
SOP8	150

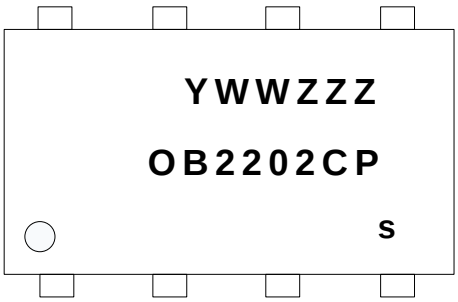
Absolute Maximum Ratings

Parameter	Value
VCC Zener Clamp Voltage	34 V
VCC Clamp Continuous Current	10 mA
SS Input Voltage	-0.3 to 7V
FB Input Voltage	-0.3 to 7V
CS Input Voltage	-0.3 to 7V
DEM Input Voltage	-0.3 to 7V
BO Input Voltage	-0.3 to 7V
Maximum Operating Junction Temperature T_J	-40 to 150 °C
Min/Max Storage Temperature T_{stg}	-55 to 150 °C
Lead Temperature (Soldering, 10secs)	260 °C

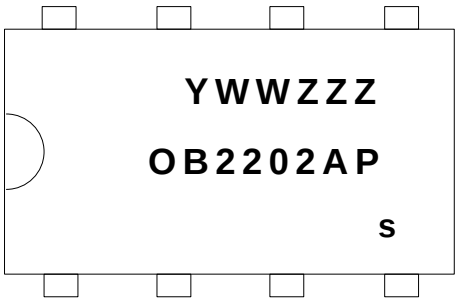
Note: Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to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



Marking Information



Y: Year Code
WW: Week Code (01-52)
ZZZ: Lot Code
C: SOP8
P:Halogen-free
s: Internal code(Optional)

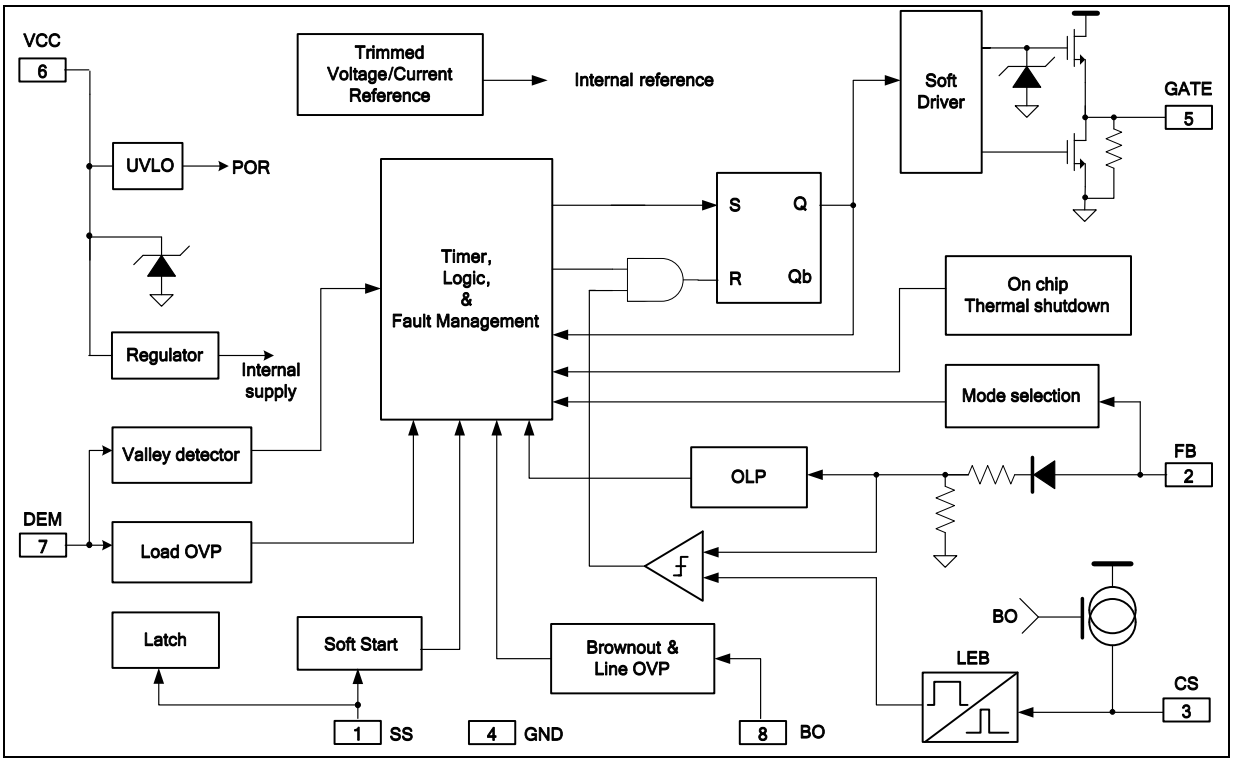


Y: Year Code
WW: Week Code (01-52)
ZZZ: Lot Code
A: DIP8
P:Halogen-free
s: Internal code(Optional)

TERMINAL ASSIGNMENTS

Pin Num	Pin Name	I/O	Description
1	SS	I/O	Multi-functional pin. One function is for soft-start programming by connecting a capacitor from SS to GND. Another function is for external latch triggering by pulling SS up to a voltage higher than 3.8V.
2	FB	I/O	Feedback input pin. PWM duty cycle is determined by voltage level into this pin and current-sense signal level at Pin 3. The voltage level at this pin also controls the mode of operation in one of the three modes: quasi-resonant (QR), pulse frequency modulation mode (PFM) and burst mode (BM).
3	CS	I	Current sense input.
4	GND	P	Ground for internal circuitry.
5	GATE	O	Totem-pole gate drive output for power MOSFET.
6	VCC	P	Chip DC power supply pin.
7	DEM	I/O	Input from auxiliary winding for demagnetization timing. Also this pin is used for output over voltage protection (Load OVP).
8	BO	I/O	Brownout and Line OVP detection pin. Connect a resistor divider from line voltage to this pin to detect line voltage. If this pin drops below 0.5V and lasts for 50ms, brownout protection will be triggered and PWM output will be disabled. This pin is also used as line OVP sense input.

BLOCK DIAGRAM



RECOMMENDED OPERATING CONDITION

Symbol	Parameter	Min	Max	Unit
VCC	VCC Supply Voltage	11	28	V
T_A	Operating Ambient Temperature	-20	85	°C

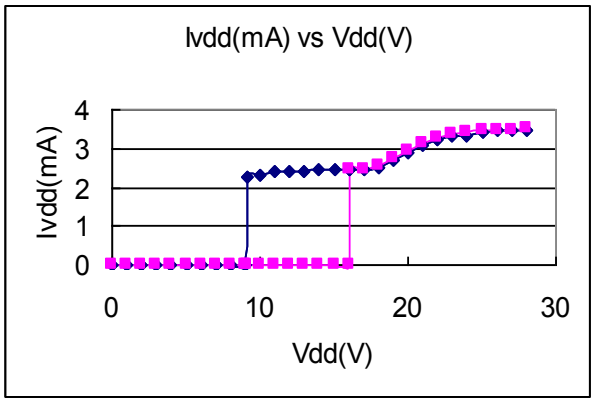
ELECTRICAL CHARACTERISTICS

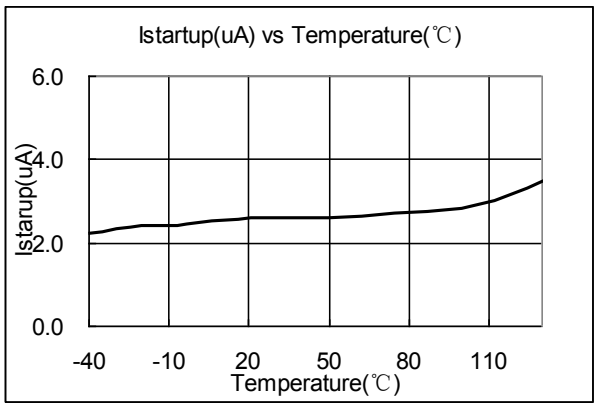
(T_A = 25°C, VCC=18V, if not otherwise noted)

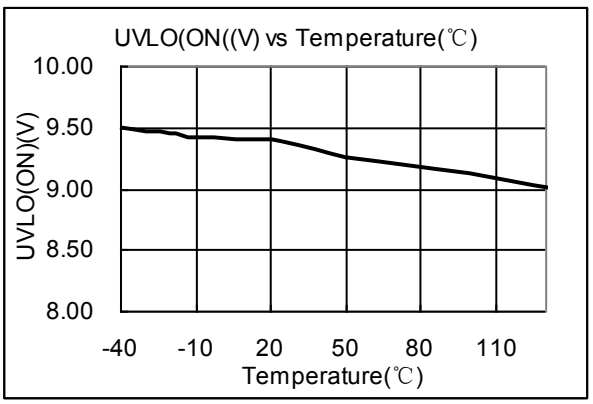
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
Supply Voltage (VCC) Section						
Istartup	VCC Start up Current	VCC =UVLO(OFF)-1.5V, Measure current into VCC		5	15	uA
I_VCC_quiet	Operation Current without switching	FB=3V		2.0	3.5	mA
I_VCC_operation	Operation current with switching	FB=3V, 1nF load at GATE		3.0	5.0	mA
UVLO(ON)	VCC Under Voltage Lockout Enter		7.8	8.8	9.8	V
UVLO(OFF)	VCC Under Voltage Lockout Exit (Startup)		14.8	15.8	16.8	V
OVP(ON)	VCC Over Voltage Protection Enter			33		V
VCC_Clamp	VCC Zener Clamp Voltage	I(VCC) = 5 mA		34		V
Feedback Input Section(FB Pin)						
A_{VCS}	PWM Input Gain	$\Delta V_{FB}/\Delta V_{cs}$		4.75		V/V
V_{FB} Open	FB Open Voltage			5.3		V
I_{FB}_Short	FB pin short circuit current	Short FB pin to GND, measure current		1.5		mA
V_{TH}_PFM_enter	Enter PFM mode threshold			1.4		V
V_{TH}_PFM_exit	Exit PFM mode threshold			1.5		V
V_{TH}_BM_enter	Enter Burst Mode threshold			0.5		V
V_{TH}_BM_exit	Exit Burst Mode threshold			0.7		V
V_{TH}_PL	Power Limiting FB Threshold Voltage			4.4		V
T_D_PL	Power limiting Debounce Time			80		mSec
Z_{FB}_IN	Input Impedance			4		Kohm
Current Sense Input(CS Pin) Section						
T_blanking	CS Input Leading Edge Blanking Time			350		nSec
V_{TH}_OC	Internal current limiting threshold		0.57	0.60	0.63	V
T_D_OC	Over Current Detection and Control Delay	CL=1nf at GATE,		100		nSec
Demagnetization Detection Section						
V_{TH}_DEM	Demagnetization comparator threshold voltage			75		mV
V_{TH}_DEM_hyst	Hysteresis for DEM comparator			20		mV
V_{DEM}_clamp(neg)	Negative clamp voltage			-0.5		V
V_{DEM}_clamp(pos)	Positive clamp voltage			5.8		V
T_{supp}	Suppression of the transformer ringing at start of secondary stroke			2		uSec

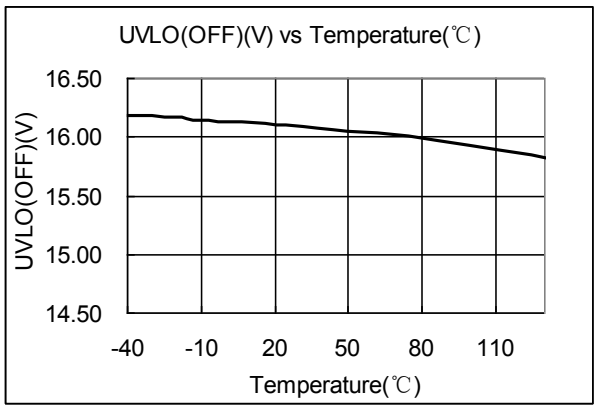
T_{OUT}	Timeout after last demag transistion			5		uSec
T_{DEM_delay}	Demag propagation delay			250		nSec
V_{TH}_OVP	Output OVP trigger point		3.55	3.75	3.95	V
T_OVP_delay	Output OVP deglitch time constant			7		Switching Cycle
Soft Start Section						
Iss	Soft start charge current		8	10	12	uA
V_{TH}_ss_exit	Soft start termination threshold			2.2		V
I_{SS}_clamp_sink	Maximum sink current capability when SS is clamped			120		uA
V_{SS}_clamp	SS pin high clamp voltage			5.8		V
Timer Section						
$F_{\_burst}$	Burst mode switching frequency			22		KHz
F_QR_clamp_h	Frequency high clamp in QR mode		115	130	145	KHz
F_QR_clamp_l	Frequency low clamp in QR mode		17	22	27	KHz
Ton_max	Maximum on time		20	30	40	uSec
Toff_max	Maximum off time		40	50	60	uSec
Thermal Protection						
T_shutdown	Thermal shutdown temperature			155		℃
Latch Protection						
V_latch_trigger	External latch trigger threshold voltage at SS pin	SS pin pull up current should be larger than 200uA		3.8		V
V_latch_release	VCC latch release voltage			6.3		V
Ivdd(latch)	VCC current when latch off	VCC=V_latch_release+1V		45		uA
Brownout Protection and Line OVP Protection						
Vth_BO	Brownout comparator threshold			0.5		V
Vth_line_OVP	Line OVP comparator threshold			2		V
T_D_BO	Brownout debounce time			50		mSec
IBO_hys	BO output current for BO hysteresis programming			1		uA
Gate Drive Output						
VOL	Output Low Level	Io = 100 mA (sink)			1	V
VOH	Output High Level	Io = 100 mA (source) VCC=20V	7.5			V
VG_Clamp	Output Clamp Voltage Level	VCC=20V		16.5		V
T_r	Output Rising Time	CL = 1nf		50		nSec
T_f	Output Falling Time	CL = 1nf		20		nSec

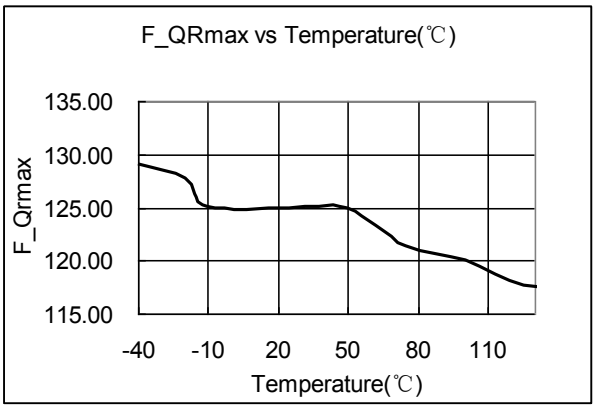
CHARACTERIZATION PLOTS

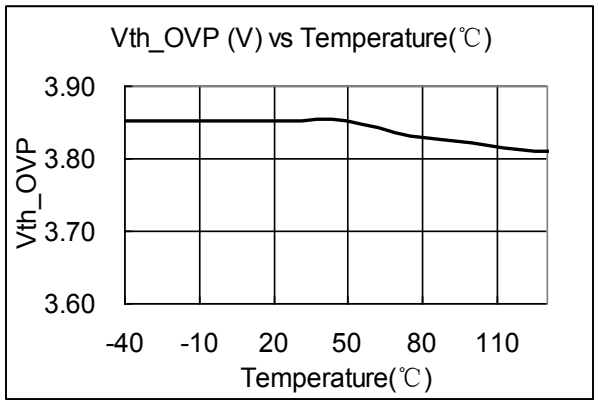


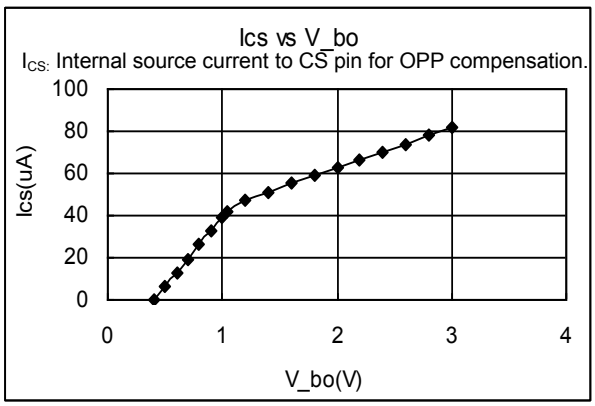












OPERATION DESCRIPTION

Quasi-Resonant (QR) converter typically features lower EMI and higher power conversion efficiency compared to conventional hard-switched converter with a fixed switching frequency. OB2202 is a highly integrated QR controller optimized for offline flyback converter applications. The built-in advanced energy saving with high level protection features provide cost effective solutions for energy efficient power supplies.

- **Startup Current and Start up Control**

Startup current of OB2202 is designed to be very low so that VCC could be charged up above UVLO(OFF) 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 VCC capacitor to provide a fast startup and yet low power dissipation design solution.

- **Operating Current**

The operating current of OB2202 is very low. Good efficiency is achieved by the low operating current together with extended burst mode control schemes at No/light conditions.

- **Multi-Mode Operation for High Efficiency**

OB2202 is a multi-mode QR controller. The controller changes the mode of operation according to FB voltage, which reflects the line and load conditions.

■ Under normal operating conditions (FB>Vth2, Figure 1), the system operates in QR mode. The frequency varies depending on the line voltage and the load conditions. Therefore, the system may actually work in DCM when 130KHz frequency clamping is reached. System design should be optimized such that the operation frequency is within the range specified at full loading conditions and in universal AC line input range.

■ At light load condition (Vth1<VFB<Vth2, Figure 1), the system operates in PFM (pulse frequency modulation) mode for high power conversion efficiency. In PFM mode, the "ON" time in a switching cycle is fixed and the system modulates the frequency according to the load conditions. Generally, in flyback converter, the decreasing of loading results in voltage level decreasing at FB pin. The controller monitors the voltage level at FB and control the switching frequency. However, the valley switching characteristic is still preserved in PFM mode. That is, when loading decreases, the system automatically skip more and more valleys and the switching frequency is thus reduced. In such way, a smooth frequency foldback is realized and high power conversion efficiency is achieved.

■ At zero load or very light load conditions (VFB<Vth1), the system operates in On-Bright's proprietary "extended burst mode". In this condition, voltage at FB is below burst mode threshold level, Vth1. The Gate drive output switches only when VCC voltage drops below a preset level or 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. In extended burst mode, the switching frequency is fixed to 22KHz, in this way, possible audio noise is eliminated.

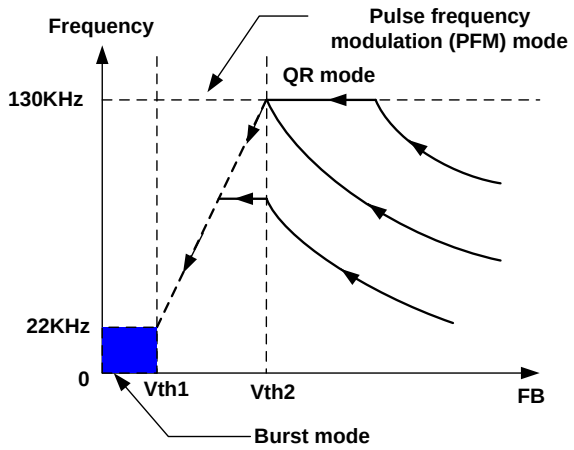


Figure 1

- **Demagnetization Detection**

The transformer core demagnetization is detected by monitoring the voltage activity on the auxiliary windings through DEM pin. This voltage features a flyback polarity. A new cycle starts when the power switch is activated. After the on time (determined by the CS voltage and FB), the switch is off and the flyback stroke starts. After the flyback stroke, the drain voltage shows an oscillation with a frequency of approximately $1/2\pi\sqrt{L_p C_d}$, where L_p is the primary self

inductance of the transformer and C_d is the capacitance on the drain node, as shown in Fig.2.

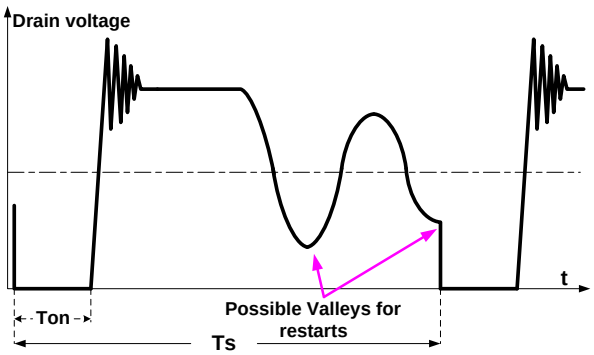


Figure 2

The typical detection level is fixed at 75mV at the DEM pin. Demagnetization is recognized by detection of a possible "valley" when the voltage at DEM is below 75mV in falling edge. DEM detection is suppressed during the ringing suppression time Tsupp (please refer to "**Ringing Suppression Timer**" section).

- **Current Sensing and Leading Edge Blanking**

Cycle-by-Cycle current limiting is offered in OB2202 current mode control. The switch current is detected by a sense resistor into the CS 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.

- **Maximum and Minimum On-Time**

The minimum on-time of the system is determined by the LEB time (typical 350ns). The IC limits the on-time to a maximum time of 30us (typical).

- **Ringing Suppression Timer**

A ringing suppression timer Tsupp is implemented in OB2202. In normal operation, Tsupp starts when CS reaches the feedback voltage FB, the external power switch is set to off state. During Tsupp, the external power switch remains in off state and cannot be turned on gain. The ringing suppression time is necessary in applications where the transformer has a large leakage inductance, particularly at low output voltages or startup. In OB2202, the ringing suppression timer Tsupp is set to 2us internally.

- **Programmable Brownout Protection and Line OVP Protection**

By monitoring the level on pin BO during normal operation, the controller protects the SMPS against low main condition, as shown in Fig.3. When BO level falls below 0.5V, brownout is triggered, the controller stops pulsing and disable internal source current for brownout hysteresis. BO pin is also used for line OVP sense input, when BO level is above 2.0V, line OVP is triggered and stops pulsing.

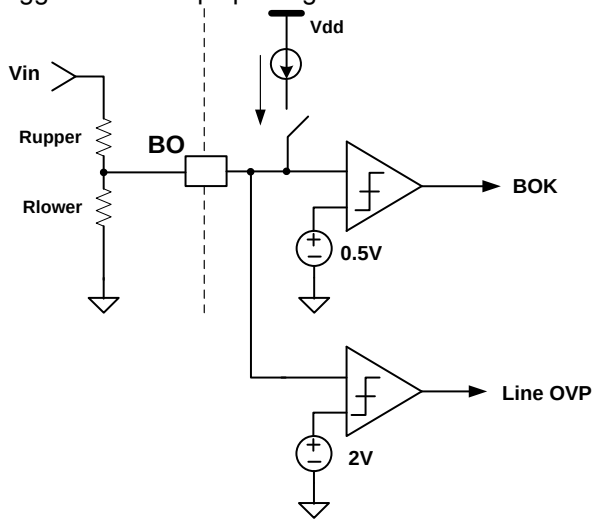


Figure 3

- **Maximum/Minimum Frequency Clamp**

According to the QR operation principle, the switching frequency is inversely proportional to the output power. Therefore, when the output power decreases, the switching frequency can become rather high without limiting. To meet the CISPR-22 EMI limit starting at 150KHz, the maximum switching frequency in OB2202 is internally limited to 130KHz. To prevent audio noise issue, the minimum switching frequency in QR mode is clamped to 20KHz.

- **On chip Thermal Shutdown**

OB2202 provides an on chip thermal shutdown. The IC will stop switching when the junction temperature exceeds the thermal shutdown temperature, typically 155 °C. The IC resumes normal operation when the junction temperature decreased below this temperature.

- **External Latch Triggering**

By externally forcing a level on pin SS (e.g.., with a signal coming from a temperature sensor) greater than 3.8V, OB2202 can be permanently

latched-off. To resume normal operation, VCC voltage should go below 6.3V (typical), which implies to unplug the SMPS form the mains.

- **Programmable Over Power Protection (OPP) Compensation**

The variation of max. output power in QR system can be rather large if no compensation is provided. In OB2202, an internal current which is a function of BO voltage is sourced out for Over Power Protection (OPP) compensation. By adjusting the external resistor Rcomp in series with CS pin (Pleae refer to Page 1), an excellent OPP performance can be realized in the universal input range.

- **Output Over voltage protection (OVP)**

An output over voltage protection (OVP) is implemented by sensing the auxiliary winding voltage at DEM pin during the flyback phase. The auxiliary winding voltage is a well-defined replica of the output voltage. The OVP works by sampling the plateau voltage at DEM pin during the flyback phase, as shown in Fig.4. A 2 us internal delay (plateau sampling) guarantees a clean plateau, provided that the leakage inductance ringing has been fully damped.

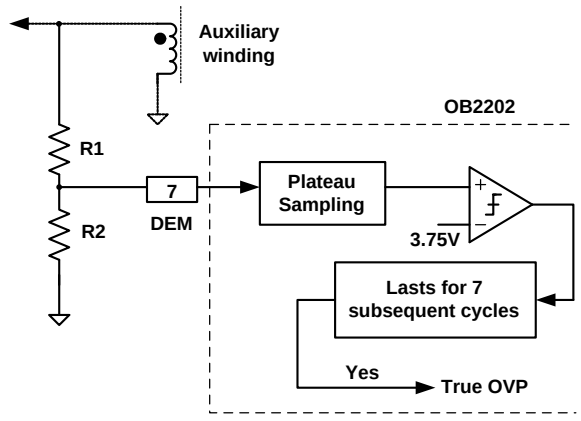


Figure 4

If the sampled plateau voltage exceeds the OVP trip level (3.75V), an internal counter starts counting subsequent OVP events. If OVP events are detected in successive 7 cycles, the controller assumes a true OVP and it enters a latch off mode and stops all switching operations. The counter has been added to prevent incorrect OVP detection which might occur during ESD or lightning events. If the output voltage exceeds the OVP trip level less than 7 successive cycles, the internal counter will be cleared and no fault is asserted.

- **Overload Operation**

When over load (for example, short circuit) occurs, the feedback current is below minimum value and a fault is detected. If this fault is present for more than 80ms, the controller enters an auto-recovery soft burst mode. All pulses are stopped, VCC will drops below UVLO and the controller will try to restart with the power on soft start. The SMPS enters the burst sequence and it resumes operation once the fault disappears.

- **Programmable Soft Start**

OB2202 features a programmable soft start to soften the constraints in the power supply during the startup. It is activated during the power on sequence. As soon as VCC reaches UVLO(OFF), an internal trimmed 10uA current is sourced from SS pin and charges the external programming capacitor, the peak current of CS pin is then gradually increased from zero. When SS pin reaches 2.2V, soft start process is over. After soft start process is over, SS pin is clamped to 2V. Every restart attempt is followed by soft start sequence.

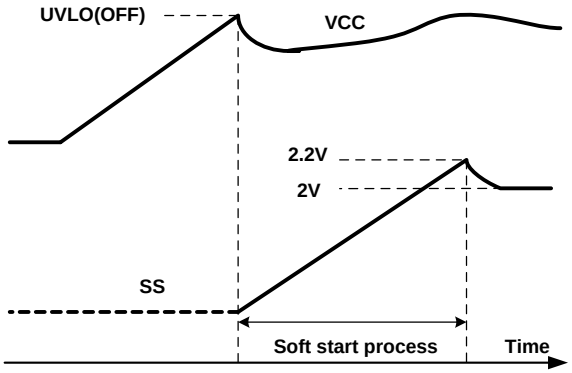


Figure 5

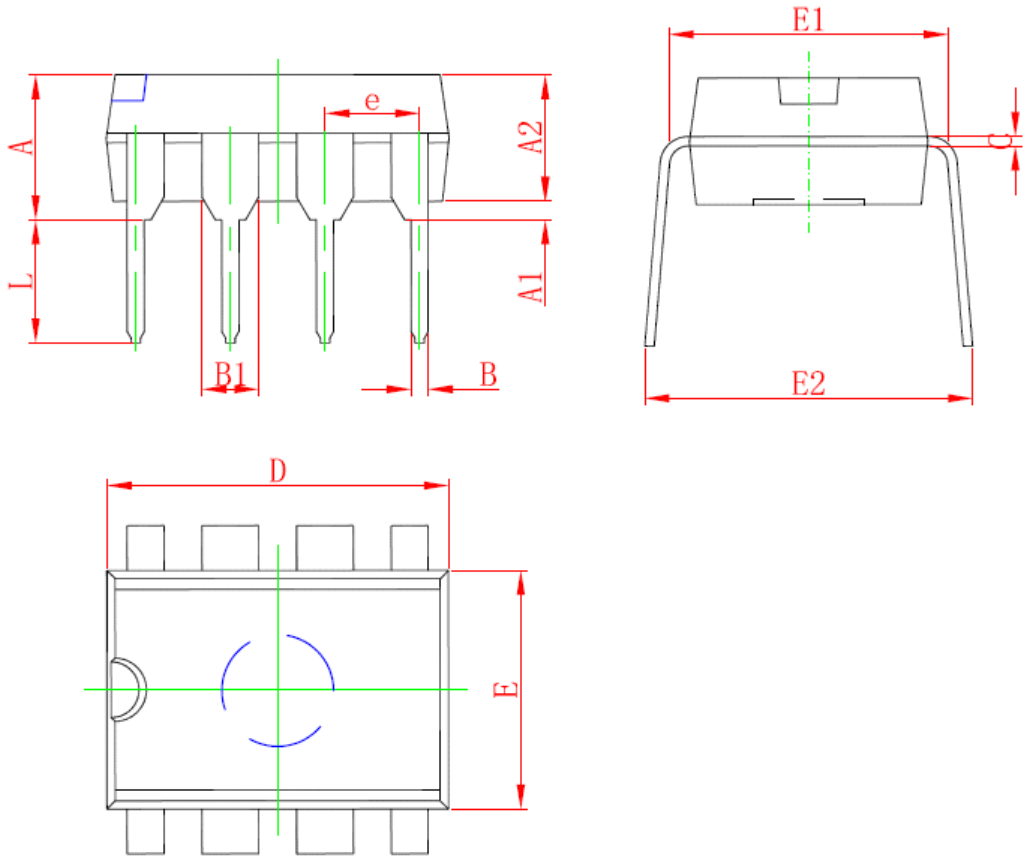
SS pin is also is used for external latch triggering (Please refer to "**External Latch Triggering**" section).

- **Gate Drive**

The GATE pin is connected to the gate of an external MOSFET for power switch control. Too weak the gate drive 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 high VCC voltage.

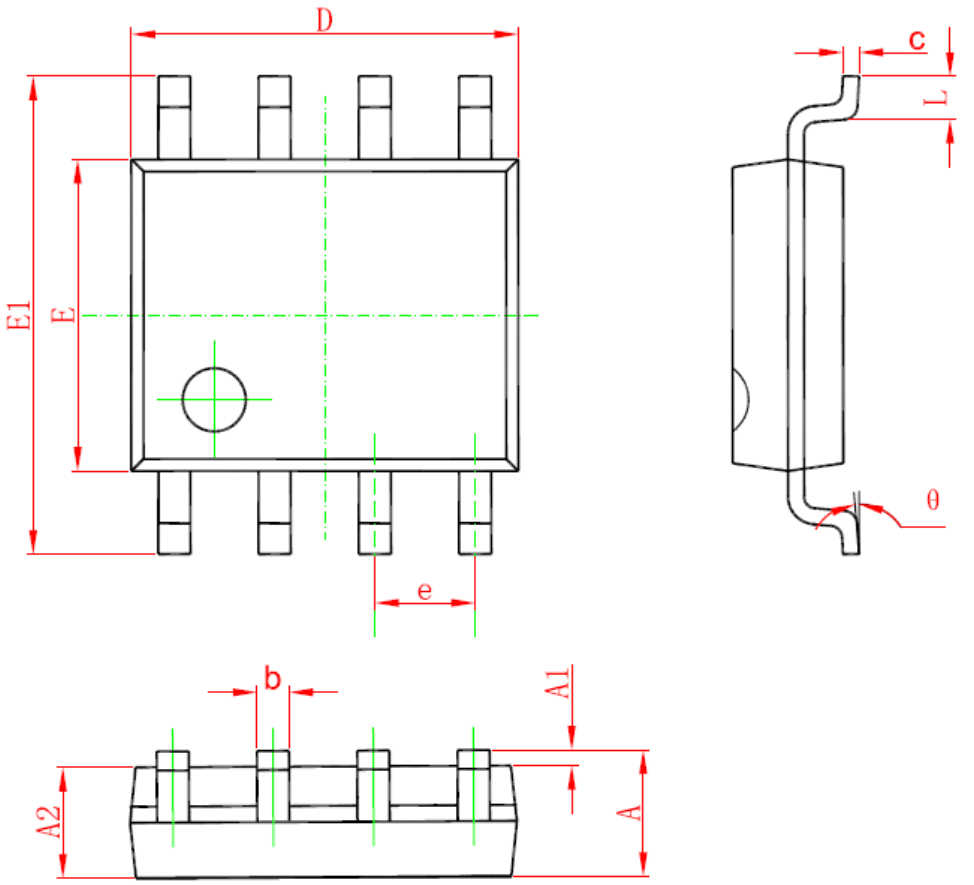
PACKAGE MECHANICAL DATA

8-Pin Plastic DIP



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	3.710	5.334	0.146	0.210
A1	0.381		0.015	
A2	2.921	4.953	0.115	0.195
B	0.350	0.650	0.014	0.026
B1	1.524 (BSC)		0.06 (BSC)	
C	0.200	0.360	0.008	0.014
D	9.000	10.160	0.354	0.400
E	6.096	7.112	0.240	0.280
E1	7.320	8.255	0.288	0.325
e	2.540 (BSC)		0.1 (BSC)	
L	2.921	3.810	0.115	0.150
E2	7.620	10.920	0.300	0.430

8-Pin Plastic SOP



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.650	0.049	0.065
b	0.310	0.510	0.012	0.020
c	0.100	0.250	0.004	0.010
D	4.700	5.150	0.185	0.203
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

IMPORTANT NOTICE

RIGHT TO MAKE CHANGES
On-Bright Electronics Corp. reserves the right to make corrections, modifications, enhancements, improvements and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete.

WARRANTY INFORMATION
On-Bright Electronics Corp. warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with its standard warranty. Testing and other quality control techniques are used to the extent it deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.
On-Bright Electronics Corp. assumes no liability for application assistance or customer product design. Customers are responsible for their products and applications using On-Bright's components, data sheet and application notes. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

LIFE SUPPORT
On-Bright Electronics Corp.'s products are not designed to be used as components in devices intended to support or sustain human life. On-bright Electronics Corp. will not be held liable for any damages or claims resulting from the use of its products in medical applications.

MILITARY
On-Bright Electronics Corp.'s products are not designed for use in military applications. On-Bright Electronics Corp. will not be held liable for any damages or claims resulting from the use of its products in military applications.