GENERAL DESCRIPTION

OB2633 is a highly integrated Quasi-Resonant(QR) controller with adaptive multi-mode regulation, optimized for high performance, low EMI, low standby power consumption and wide output voltage range Quick Charger(QC) solutions, together with secondary -side controllers, such as OB200x and OB2603x supporting Qualcomm Quick Charge QC3.0 protocol. The controller is as well compatible with cost effective offline flyback converter applications covering a wide output range.

At normal load condition, it operates in QR mode in high line input voltage. To minimize switching loss, the maximum switching frequency in QR mode is internally limited to 75 KHz. When the loading goes low, it operates in PFM mode with valley switching for high power conversion efficiency. When the load is very small, the IC operates in 'Extended Burst Mode' to minimize the standby power loss. Additionally, in the low line input voltage, the IC operates in fixed frequency (55KHz) CCM mode at the heavy loading. As a result, high conversion efficiency can be achieved in the whole loading range.

OB2633 offers complete protection including cycle-by-cycle current limiting (OCP), over load protection (OLP), over temperature protection (OTP), output short protection (SCP), output under voltage protection (UVP), output and VDD over voltage protection. Excellent EMI performance is achieved with On-Bright proprietary frequency shuffling technique.

The tone energy at below 22KHz is minimized to avoid audio noise during operation.

OB2633 is offered in SOT23-6 package.

FEATURES

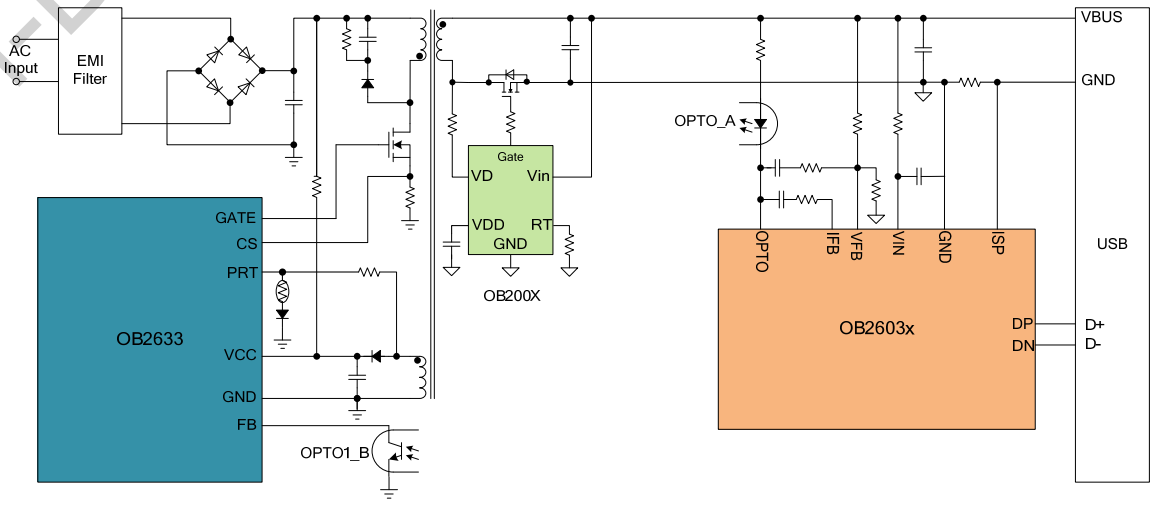
- Very wide range of supply voltage
- Multi-Mode Operation
  - 75KHz maximum clamping frequency in QR mode @ Full Load in high line voltage
  - 55KHz minimum clamping frequency in CCM mode @ Heavy Load in low line voltage
  - Valley switching operation @ Green mode
  - Burst Mode @ Light Load & No Load
- Power on soft start reducing MOSFET Vds stress
- Extended burst mode control for improved efficiency and low standby power
- Soft Start for elimination output over shoot
- Adaptive loop gain compensation with Iovp current detection
- Adaptive Frequency shuffling for EMI
- Low operating current at no/light load
- Audio noise free operation
- Comprehensive auto-recovery protection
  - o VDD under voltage lockout with hysteresis (UVLO)
  - o Cycle-by-cycle over current protection (OCP)
  - o Overload protection (OLP)
  - o Over temperature protection (OTP)
  - o VDD over voltage protection
  - o Output over voltage protection
  - o Output short protection (SCP)
  - o Output under voltage protection (UVP)
  - o Output diode short protection

APPLICATIONS

Offline AC/DC flyback converter for

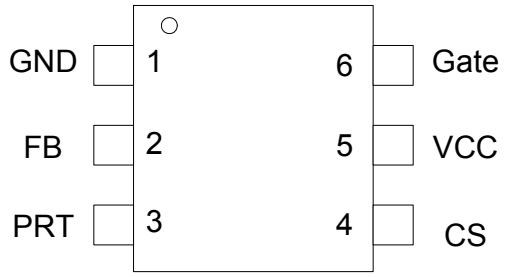
- Quick-charging AC/DC charges
- AC/DC Adapters with wide output range

TYPICAL APPLICATION



GENERAL INFORMATION

Pin Configuration



Ordering Information

Part Number	Description
OB2633MP	SOT23-6, Halogen-free in T&R

Package Dissipation Rating

Package	RθJA(℃/W)
SOT23-6	200

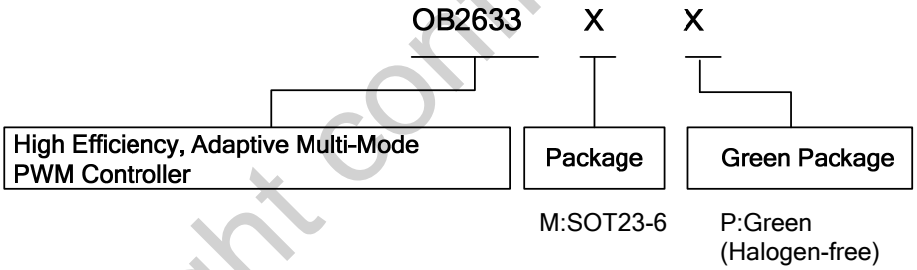
Recommended operating condition

Symbol	Parameter	Range
VCC	VCC Supply Voltage	12 to 48V

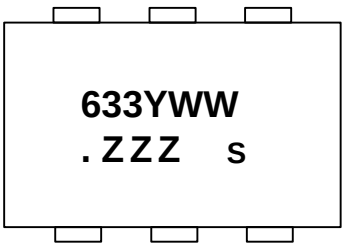
Absolute Maximum Ratings

Parameter	Value
VCC DC Supply Voltage	54V
FB Input Voltage	-0.3 to 7V
CS Input Voltage	-0.3 to 7V
PRT Input Voltage	-0.3 to 7V
Min/Max Operating Junction Temperature TJ	-40 to 150 ℃
Operating Ambient Temperature T_A	-20 to 85 ℃
Min/Max Storage Temperature Tstg	-55 to 150 ℃
Lead Temperature (Soldering, 10secs)	260 ℃

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

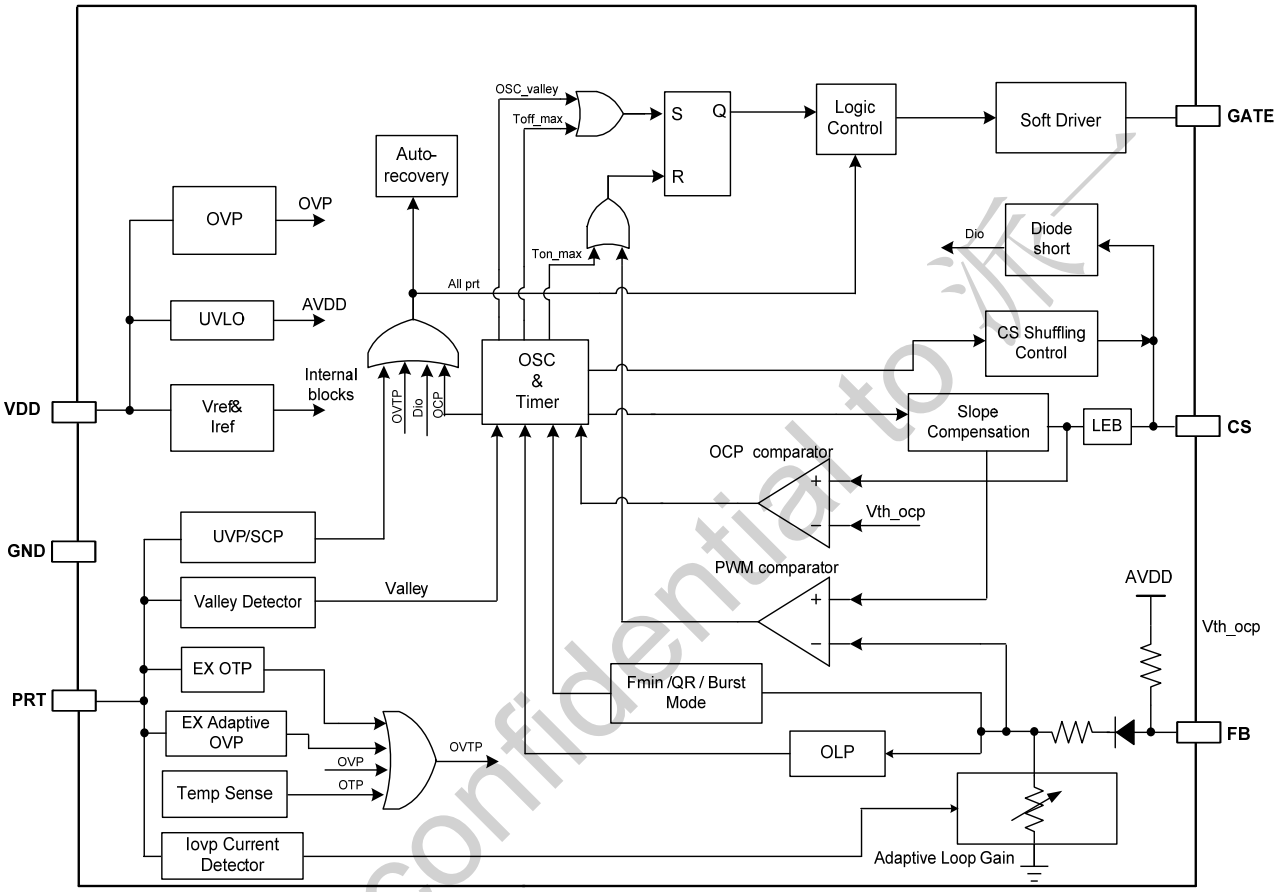


Y:Year Code
WW:Week Code(01-52)
ZZZ: Lot code
A:Character Code
S: Internal code

TERMINAL ASSIGNMENTS

Pin Num.	Pin Name	I/O	Description
1	GND	P	Ground
2	FB	I	Feedback input pin. The PWM duty cycle is determined by voltage level into this pin and the current-sense signal at Pin CS.
3	PRT	I	Multiple functions pin. Connecting a NTC resistor to ground for OTP detection. Connecting a resistor from Vaux can adjust IOVP, ISCP, IUVP trigger current and detect transformer core demagnetization. If all protections are needed, a diode should be connected between PRT pin and the NTC resistor.
4	CS	I	Current sense input
5	VCC	P	Power Supply
6	Gate	O	Totem-pole gate driver output for power MOSFET

BLOCK DIAGRAM



ELECTRICAL CHARACTERISTICS

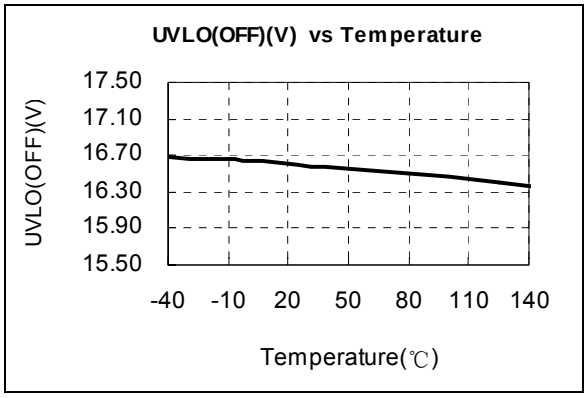
(T_A = 25℃, VDD=18V, unless otherwise noted)

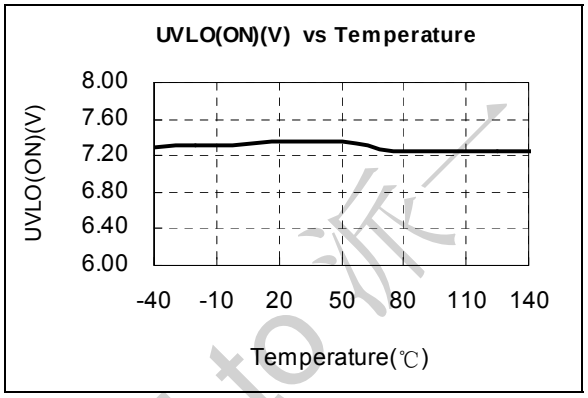
Symbol	Parameter	Test Conditions	Min	Typ.	Max	Unit
Supply Voltage (VDD)						
Istartup	VDD Start up Current	VDD=UVLO(OFF)-1V, measure leakage current into VDD		5	20	uA
I_VDD_Operation	Normal Operation Current	V_{FB}=3V, CL=1nF		2.8	3.2	mA
I_VDD_Burst	Burst Operation Current	V_{FB}=0.5V, CL=1nF		0.4	0.5	mA
UVLO(OFF)	VDD Under Voltage Lockout Exit (Recovery)		15.5	16.5	17.5	V
UVLO(ON)	VDD Under Voltage Lockout Enter			7.2		V
Vpull-up	Pull-up PMOS active			10		V
VOVP	Over voltage protection voltage	FB=3V Ramp up VDD until gate clock is off		52.5		V
Feedback Input Section(FB Pin)						
V_{FB}_Open	V_{FB} Open Loop Voltage			5.1		V
Avcs	PWM input gain ΔVFB/ΔVCS	Iovp>96uA with Hysteresis		3.5		V/V
		Iovp<90uA with Hysteresis		4.5		V/V
Ton_max	Max Ton time @ VDD=18V,VFB=3V,VCS=0.3V			12		us
Vref_green	The threshold enter green mode			2.2		V
Vref_burst_H	The threshold exit burst mode			1.25		V
Vref_burst_L	The threshold enter burst mode			1.15		V
I_{FB}_Short	FB pin short circuit current	Short FB pin to GND and measure current		210		uA
Z_{FB}_IN	Input Impedance			25		KΩ
V_{TH}_Openloop	The open loop FB Threshold Voltage			4.5		V
T_D_ Openloop	The open loop protection debounce Time			40		ms
Current Sense Input(CS Pin)						
SST_CS	Soft start time of CS threshold			4		ms
T_blanking	Leading edge blanking time			250		ns
T_D_OC	Over Current Detection and Control Delay	From Over Current Occurs till the gate driver output starts to turn off		90		ns
Vth_OCP_min	Internal current limiting threshold	@ Zero switching on time		0.55		V
Vth_OCP_max	Internal current limiting threshold	@ Max. switching on time		0.83		V
Oscillator						

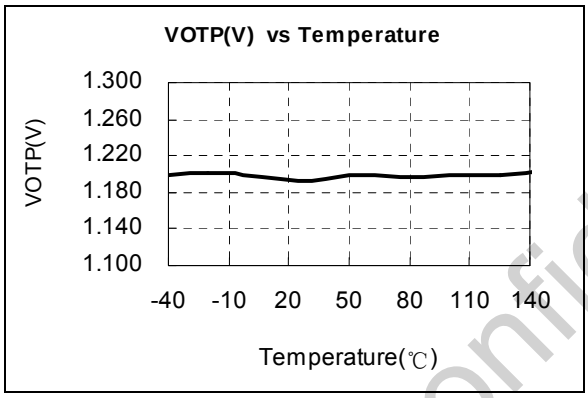
Fosc_max_QR	Average max clamp oscillation frequency in QR mode	VDD=15V, FB=3V,		75		KHz
∆f_OSC_QR	Frequency jittering of average clamp fmax_QR			±11		%
Fosc_min_CCM	Min clamp oscillation frequency in CCM mode	VDD=15V,FB=3V,		55		KHz
∆f_OSC_CCM	Frequency jittering of clamp fmin_CCM			±6.5		%
F_shuffling_CCM	Shuffling frequency clamp fmin_CCM			60		Hz
∆f_Temp	Frequency Temperature Stability			1		%
∆f_VDD	Frequency Voltage Stability			1		%
F_Burst	Burst Mode Switch Frequency			22		KHz
Gate driver						
VOL	Output low level @ VDD=15V, Io=20mA				1	V
VOH	Output high level @ VDD=18V, Io=20mA		8			V
V_clamping	Output clamp voltage			11.5		V
T_r	Output rising time 1.2V ~ 10.8V @ CL=1000pF			140		ns
T_f	Output falling time 10.8V ~ 1.2V @ CL=1000pF			55		ns
PRT pin						
Ibias	Output bias current expect during OVP detection			30		uA
IRT	Output current for external OTP detection		114	120	126	uA
VOTP	Threshold voltage for external OTP		1.14	1.2	1.26	V
Td_ex_OTP	EX OTP debounce time			60		Cycles
Ioutput_ovp	Current threshold for adjustable output OVP	When T_start<30ms		90		uA
		When T_start>30ms		216		uA
Td_output_ovp	Output OVP debounce time			8		Cycles
Iscp	SCP threshold			24		uA
Td_scp	SCP detect after startup			7.5		ms
Iuvp	UVP threshold			40		uA
Td_uvp	UVP detect after startup			15		ms
On Chip OTP						
OTP Level				155		℃
OTP exit				125		℃

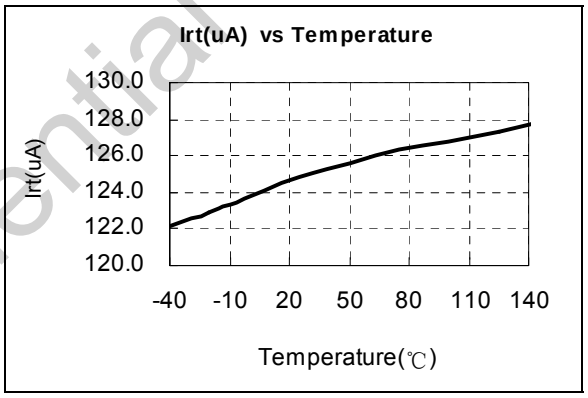
CHARACTERIZATION PLOTS

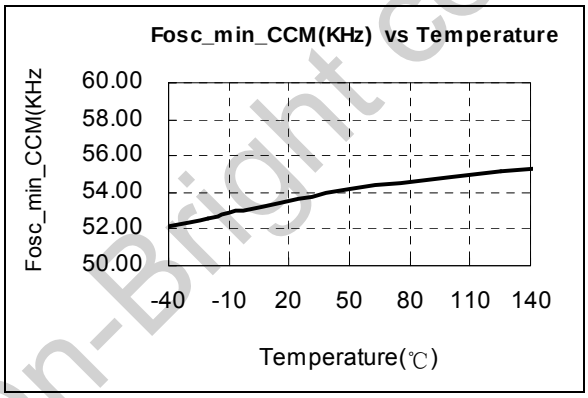
VDD = 18V, TA = 25℃ condition applies if not otherwise noted.

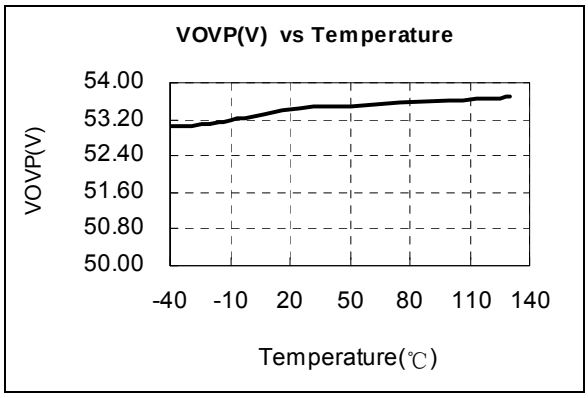


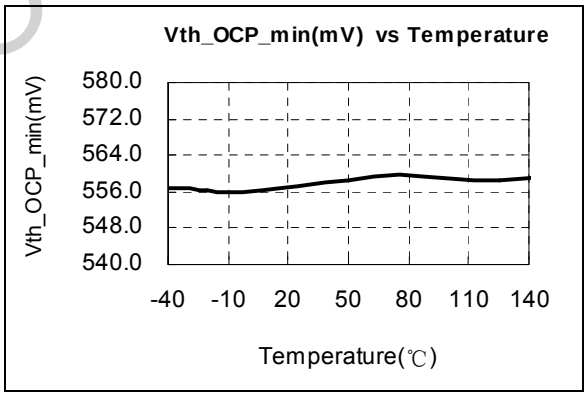


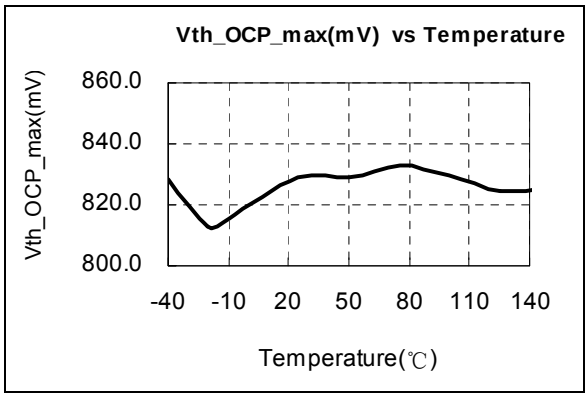


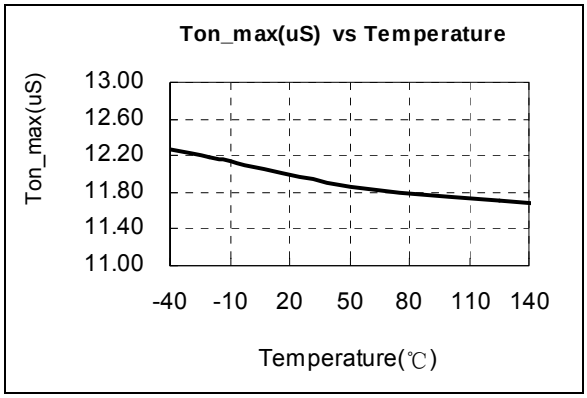












OPERATION DESCRIPTION

Quasi-Resonant (QR) converter typically features lower EMI and higher power conversion efficiency compared to conventional hard-switched converter with a fixed switching frequency. OB2633 is a highly integrated Quasi-Resonant(QR) controller with adaptive multi-mode regulation, optimized for high performance wide output voltage range Quick Charger(QC) solutions, together with secondary-side controllers, such as OB200x and OB2603x supporting Qualcomm Quick Charge QC3.0 protocol. The controller is as well compatible with cost effective offline flyback converter applications covering a wide output range. The 'Extended burst mode' control greatly reduces the standby power consumption and helps the design easily to meet the international power conservation requirements.

Startup Current and Start up Control

Startup current of OB2633 is designed to be very low so that VCC could be charged up above UVLO threshold level and device starts up quickly. A large value startup resistor can therefore be used to minimize the power loss yet achieve a reliable startup in application.

Operating Current

The Operating current of OB2633 is low at 2.8mA (typical). Good efficiency is achieved with OB2633 low operation current together with the 'extended burst mode' control features.

Soft Start

OB2633 features an internal 4ms (typical) 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 VCC reaches UVLO(OFF), the CS peak voltage is gradually increased from 0 V to the maximum level. Every restart up is followed by a soft start.

Adaptive Loop Gain Compensation

With On-Bright proprietary technology, an adative loop compensation is implemented to ensure the system loop stability for wide output voltage range according to Iovp current detection.

Adaptive Frequency shuffling for EMI improvement

In OB2633, Adaptive frequency shuffling (switching frequency modulation) is implemented over the universal input voltage and load range. when the fixed frequency CCM mode is reached, the triangular frequency shuffling will be automatically added to the system to improve the EMI performance. The magnitude of shuffling lies in the range of ±6.5%. When the system exits fixed frequency CCM mode, the random frequency shuffling will automatically replace the triangular frequency shuffling, and the range magnitude of shuffling increases by ±11%. 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.

Extended Burst Mode Operation

At light load or no load condition, most of the power dissipation in a switching mode power supply is from switching loss of the MOSFET, the core loss of the transformer and the loss of 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 Vref_burst_L (the threshold enter burst mode) and device enters Burst Mode control. The Gate drive output switches when FB input rises back to Vref_burst_H (the threshold exit burst mode). Otherwise the gate drive remains at off state to minimize the switching loss and reduces the standby power consumption to the greatest extend.

Multi Mode Operation for High Efficiency

OB2633 is a multi-mode QR/PWM controller. The controller changes the mode of operation according to line voltage and load conditions.

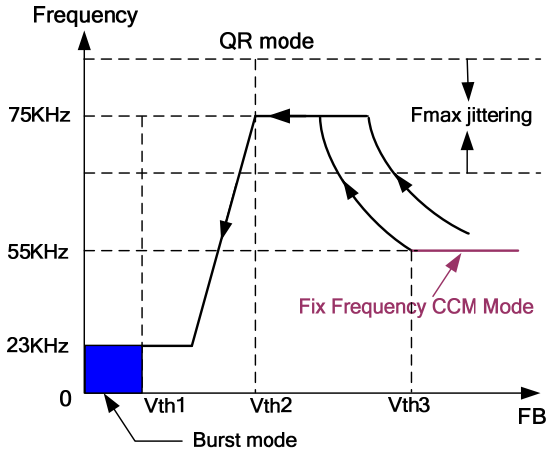


Fig. 1 Frequency vs Feedback voltage

At full load conditions (FB>Vth3, Figure 1), there are two situations: firstly, if the system input is in low line input range, the IC operates in fixed frequency CCM mode. Thus, small size

transformer can be used with high power conversion efficiency. Secondly, if the system input is in high line input range, the IC operates in QR mode. In this way, high power conversion efficiency can be achieved in the universal input range when system is at full loading conditions.
At normal operating conditions (Vth2<VFB<Vth3, 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 the average 75KHz frequency clamping is reached.

At light load conditions (Vth1<VFB<Vth2, Figure 1), the system operates in PFM (pulse frequency modulation) mode for high power conversion efficiency. Generally, in flyback converter, the decreasing of load 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 load decreases, the system automatically skip more and more valleys and the switching frequency is thus reduced. In such way, a smooth frequency fold-back is realized and high power conversion efficiency is achieved.

At no load or very light load conditions (VFB<Vth1), the system operates in On-Bright's proprietary "extended burst mode". In the extended burst mode, the switching frequency at below 22KHz is minimized to avoid audio noise during operation.

Current Sensing and Leading Edge Blanking
Cycle-by-Cycle current limiting is offered in OB2633 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 gate current of power MOSFET. The current limiting comparator is disabled and cannot turn off the power MOSFET during the blanking period. The PWM duty cycle is determined by the current sense voltage and the FB voltage.

Demagnetization Detection
The transformer core demagnetization is detected by monitoring the voltage activity on the auxiliary windings through PRT pin. This voltage features a flyback polarity. After the on time (determined by the CS voltage and FB voltage), the switch is off and the flyback stroke starts. After the flyback stroke, the drain voltage shows an oscillation with a frequency of approximately $1/2\pi\sqrt{L_pC_d}$, where L_p is the primary self inductance of primary winding of the transformer and C_d is the capacitance on the drain node.

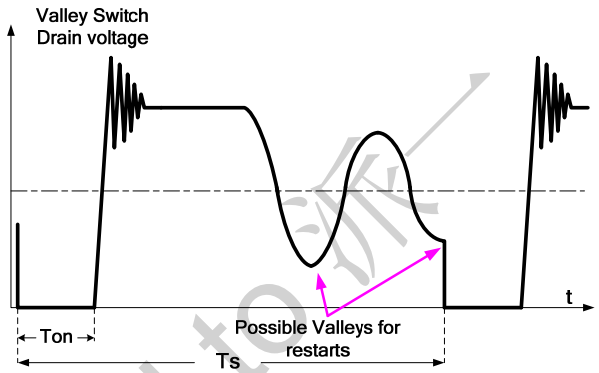


Fig. 2 Valley detection

The typical detection level is fixed at 85mV(typical) at the PRT pin. Demagnetization is recognized by detection of a possible "valley" when the voltage at PRT is below 85mV in falling edge.

Adaptive OCP Compensation
The variation of max output power in QR system can be rather large if no compensation is provided. The OCP threshold value is self adjusted lower at higher AC voltage. This OCP threshold slope adjustment helps to compensate the increased output power limit at higher AC voltage. In OB2633, with On-Bright proprietary technology, the OCP is line voltage compensated to achieve constant output power limit over the universal input voltage range. a proprietary OCP compensation block is integrated and no external components are needed. The OCP threshold is a function of the switching ON time. For the ON time less than Ton1, the OCP threshold changes linearly from 0.55V to 0.83V. For the ON time larger than Ton1, the OCP threshold is clamped to 0.83V, as shown in Figure 3.

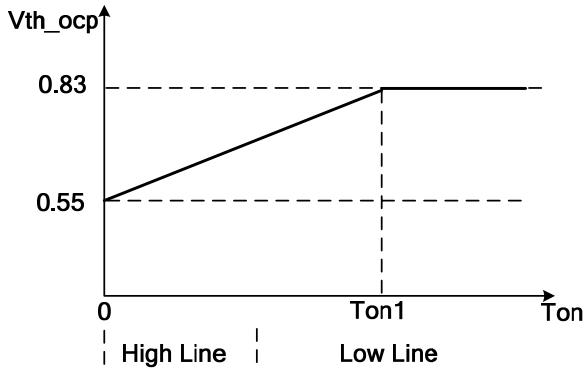


Fig. 3 OCP compensation

Adaptive Internal Synchronized Slope Compensation

In OB2633, when the fixed frequency CCM mode is reached, the slope compensation will be automatically added to the system. Built-in slope compensation circuit adds voltage ramp into 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. When the system exits fixed frequency CCM mode, the slope compensation will automatically disappear.

Dual Function of External OTP and Output OVP/UVP/SCP

On-Bright proprietary dual function of external OTP and output OVP provides feasible and accurate detection of external OTP through NTC resistor and output OVP. The dual function is realized through time-division technology as shown in the figure 4.

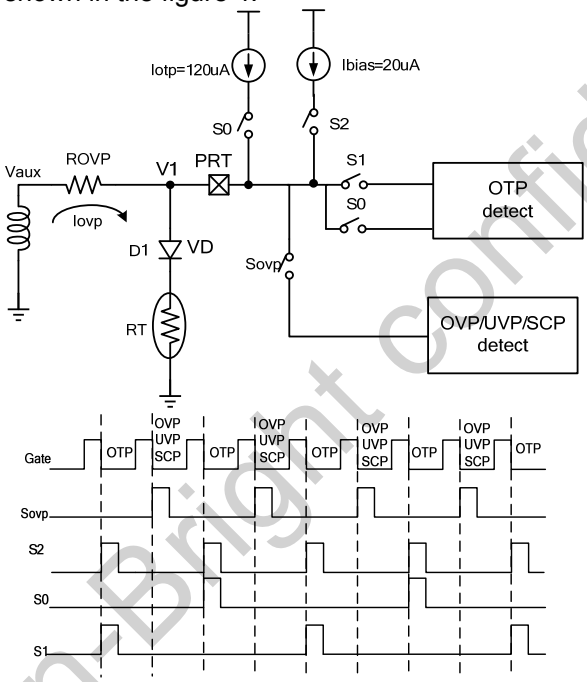


Fig. 4 PRT Pin protection timing

There is a 30uA(typical) bias current outflow when S2=1, that's S0= "1" or S1= "1". For external OTP detection, when switch control signal S1= "1", the 30uA (typical) current flows out from PRT pin. When switch control signal S0= "1", another 120uA (typical IRT) current flows out from PRT pin in addition to 30uA.

So the PRT pin voltage V1(s0) at phase S1="1" is:

$$V1(s1) = \frac{ROVP \cdot VD + RT \cdot Vaux + RT \cdot ROVP \cdot 30uA}{ROVP + RT}$$

The PRT pin voltage V1(s1) at phase S0="1" is

$$V1(s0) = \frac{ROVP \cdot VD + RT \cdot Vaux + RT \cdot ROVP(30uA + 120uA)}{ROVP + RT}$$

Vaux is the auxiliary winding demagnetization voltage.
VD is D1 forward voltage.
ROVP and RT are shown in fig4.

Voltage difference of ΔVotp at phase S0 and S1 phase is

$$\Delta V_{otp} = V1(s0) - V1(s1) = \frac{RT \cdot ROVP}{ROVP + RT} \cdot 120uA$$

This voltage difference cancels the effect of D1 diode forward voltage.

When ΔVotp< VOTP (1.2V typical), external OTP auto-recovery protection is triggered after 60 (typical) PWM cycles debounce.

For output OVP detection, when Sovp= "1", Iovp is equal to (Naux/Nsec)*(Vo+Vdiode)/ROVP. During the IC startup 30ms, If Iovp is larger than 90uA (typical Ioutput_ovp), lower output OVP is triggered. After 30ms, if Iovp is larger than 216uA (typical Ioutput_ovp), larger output OVP is triggered. The output OVP voltage is calculated as

$$V_{outovp} = \frac{Iovp\_th \cdot N_{sec} \cdot ROVP}{N_{aux}} - V_{diode}$$

Nsec is transformer secondary winding turns, Naux is transformer auxiliary winding turns, Vdiode is the secondary output diode forward voltage .

OVP auto-recovery protection is triggered after 8 Gate cycles debounce. By selecting proper Rovp resistance, output OVP level can be programmed.

For output UVP detection, when Sovp= "1", Iuvp is equal to (Naux/Nsec)*(Vo+Vdiode)/ROVP. After 15ms of the IC startup, If Iuvp is less than 40uA (typical Iuvp), UVP is triggered. The output UVP voltage calculation method is the same as output OVP detection. UVP auto-recovery protection is triggered after 8 Gate cycles debounce. By selecting proper Rovp resistance, output UVP level can be programmed.

For output SCP detection, when Sovp= "1", Isvp is equal to (Naux/Nsec)*(Vo+Vdiode)/ROVP. After 7.5ms of the IC startup, If Iscp is less than 24uA (typical Iscp), SCP is triggered. The output SCP voltage calculation method is the same as output OVP detection. SCP auto-recovery protection is triggered after 8 Gate cycles debounce. By selecting proper Rovp resistance, output SCP level can be programmed.

Protection Controls

Good power supply system reliability is achieved with auto-recovery protection features including

Cycle-by-Cycle current limiting (OCP), and Under Voltage Lockout on VDD (UVLO), output short protection (SCP), output under voltage protection (UVP), Over Temperature Protection (OTP), VCC and output Over Voltage Protection (OVP).

Pin Floating and Short Protection

OB2633 provides pin floating protection for CS, FB, PRT, etc., In cases when the pins are floating, Gate switching is disabled, thus protect the power system.

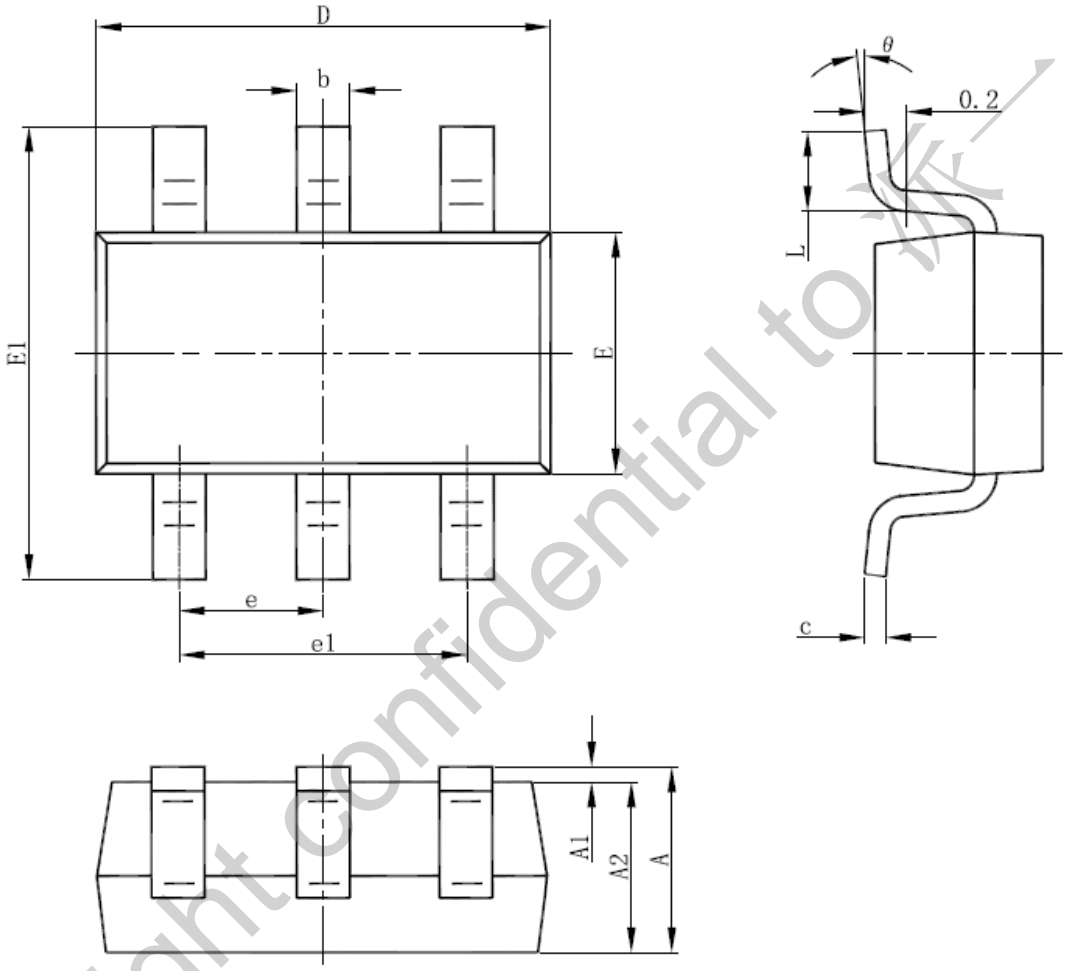
Driver

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

A good tradeoff is achieved through the built-in totem pole gate 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.

PACKAGE MECHANICAL DATA

SOT-23-6L PACKAGE OUTLINE DIMENSIONS



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.000	1.450	0.039	0.057
A1	0.000	0.150	0.000	0.006
A2	0.900	1.300	0.035	0.051
b	0.300	0.500	0.012	0.020
c	0.080	0.220	0.003	0.009
D	2.800	3.020	0.110	0.119
E	1.500	1.726	0.059	0.068
E1	2.600	3.000	0.102	0.118
e	0.950 (BSC)		0.037 (BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
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.