

GENERAL DESCRIPTION

OB2513xB/D is a high performance offline PSR power switch for low power AC/DC charger and adapter applications. It operates in primary-side sensing and regulation. Consequently, opto-coupler and TL431 could be eliminated. Proprietary Constant Voltage (CV) and Constant Current (CC) control is integrated as shown in the figure below.

In CC control, the current and output power setting can be adjusted externally by the sense resistor R_s at CS pin. In CV control, multi-mode operations are utilized to achieve high performance and high efficiency. In addition, good load regulation is achieved by the built-in cable drop compensation. Device operates in PFM in CC mode as well at large load condition and it operates in PWM with frequency reduction at light/medium load. The chip consumes very low operation current, it can achieve less than 75mW standby power.

OB2513xB/D offers comprehensive protection coverage with auto-recovery features including Cycle-by-Cycle current limiting, VDD over voltage protection, short circuit protection, built-in leading edge blanking, VDD under voltage lockout (UVLO), Programmable Brownout Protection, Programmable Line Over Voltage Protection, OTP etc.

OB2513xB/D is offered in SOP8 and SOP7 packages.

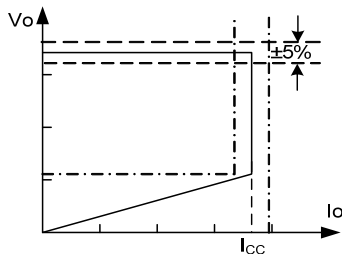


Figure.1. Typical CC/CV Curve

FEATURES

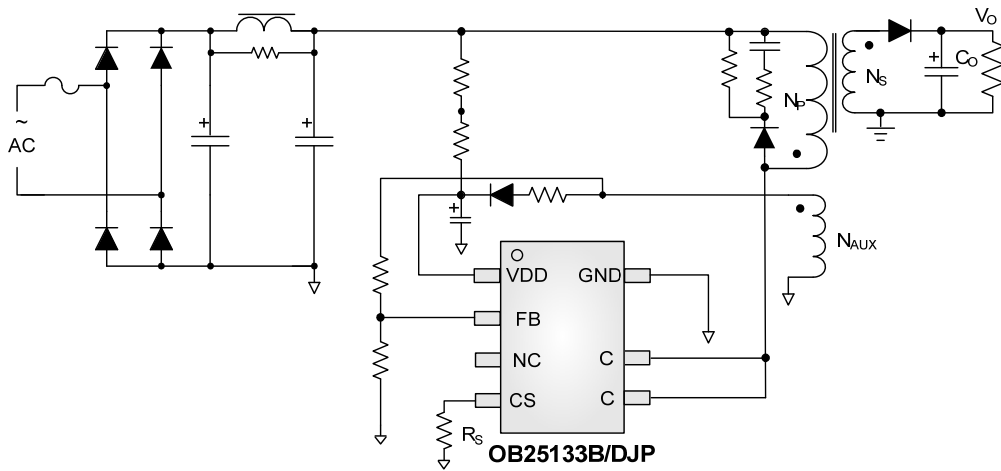
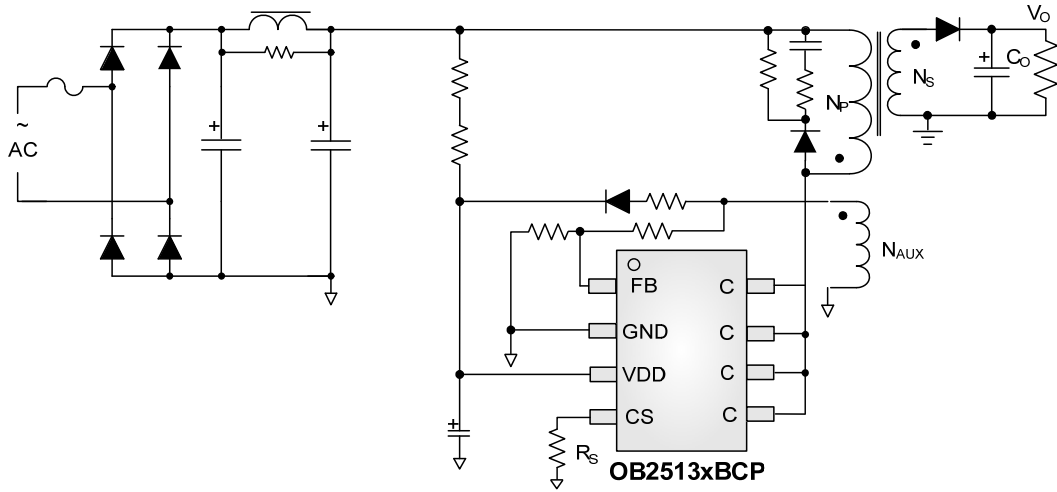
- Primary-side sensing and regulation without TL431 and opto-coupler
- High precision constant voltage and current regulation at universal AC input
- Multi-mode PWM/PFM operation for efficiency improving
- Quasi-resonant operation for highest overall efficiency
- Good dynamic response
- Programmable CV and CC regulation
- Built-in fixed cable compensation
- Built-in line voltage and primary winding inductance compensation
- Programmable Brownout Protection and Line OVP Protection
- No need for control loop compensation
- Audio noise free operation
- Internal BJT switch
- Built-in leading edge blanking (LEB)
- Comprehensive protection coverage with auto-recovery
 - VDD over voltage protection
 - VDD under voltage lockout with hysteresis (UVLO)
 - Cycle-by-cycle current limiting
 - Feedback loop open protection
 - Output short circuit protection
 - Over temperature protection (OTP)

APPLICATIONS

Low Power AC/DC offline SMPS for

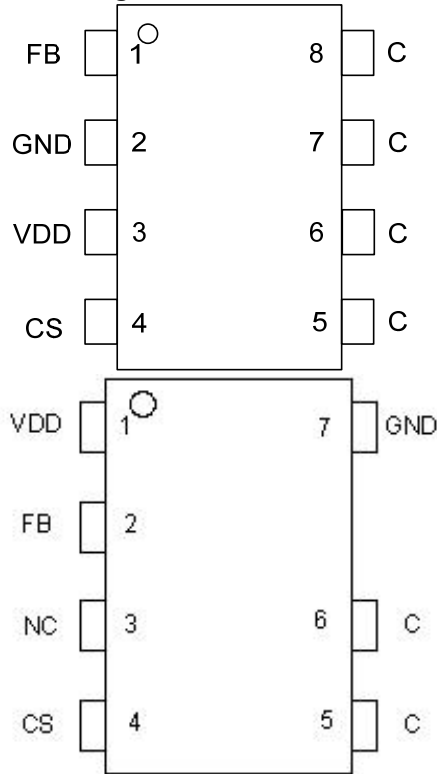
- Cell Phone Charger
- Digital Cameras Charger
- Small Power Adapter
- Auxiliary Power for PC, TV etc.
- Linear Regulator/RCC Replacement

TYPICAL APPLICATION



GENERAL INFORMATION

Pin Configuration



Package Dissipation Rating

Package	RθJA (°C/W)
SOP8	95
SOP7	95

Recommended Operating Condition

Symbol	Parameter	Range
VDD	VDD Supply Voltage	5 to 16V

Absolute Maximum Ratings

Parameter	Value
OB25133B/D CB Voltage	800V
OB25135/6B CB Voltage	750V
VDD Voltage	-0.3 to 20V
FB Input Voltage	-0.3 to 7V
CS Input Voltage	-0.3 to 7V
Min/Max Operating Junction Temperature T _J	-40 to 150 °C
Operating Ambient Temperature T _A	-20 to 85 °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.

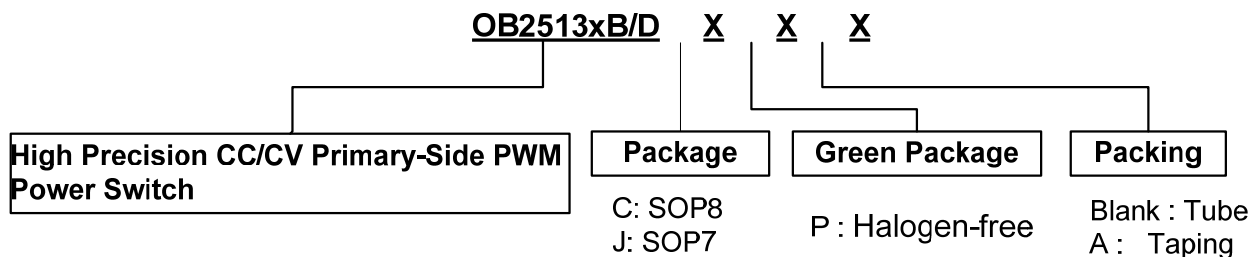
Ordering Information

Part Number	Description
OB25133BCP	SOP8, Halogen-free, Tube
OB25133BCPA	SOP8, Halogen-free, T&R
OB25135BCP	SOP8, Halogen-free, Tube
OB25135BCPA	SOP8, Halogen-free, T&R
OB25136BCP	SOP8, Halogen-free, Tube
OB25136BCPA	SOP8, Halogen-free, T&R
OB25133BJP	SOP7, Halogen-free, Tube
OB25133BJPA	SOP7, Halogen-free, T&R
OB25133DJP	SOP7, Halogen-free, Tube
OB25133DJPA	SOP7, Halogen-free, T&R

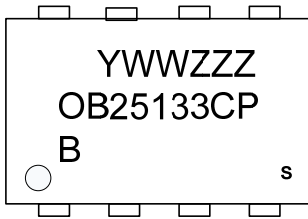
Recommended Output power Table

Product	Adapter ^{Note1}
	90V~264V
OB25133B/D	5W
OB25135B	10W
OB25136B	12W

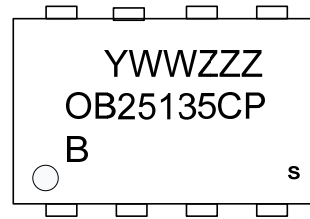
Notes: Maximum practical continuous power in an adapter design with sufficient drain pattern as a heat sink, at 40°C ambient



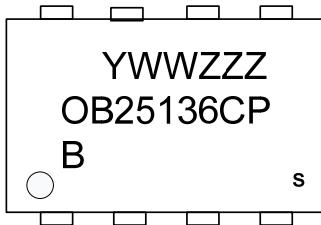
Marking Information



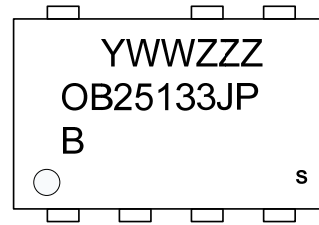
Y:Year Code
 WW:Week Code(01-52)
 ZZZ:Lot Code
 C:SOP8 Package
 P:Halogen-free
 B:Character Code
 S:Internal Code(Optional)



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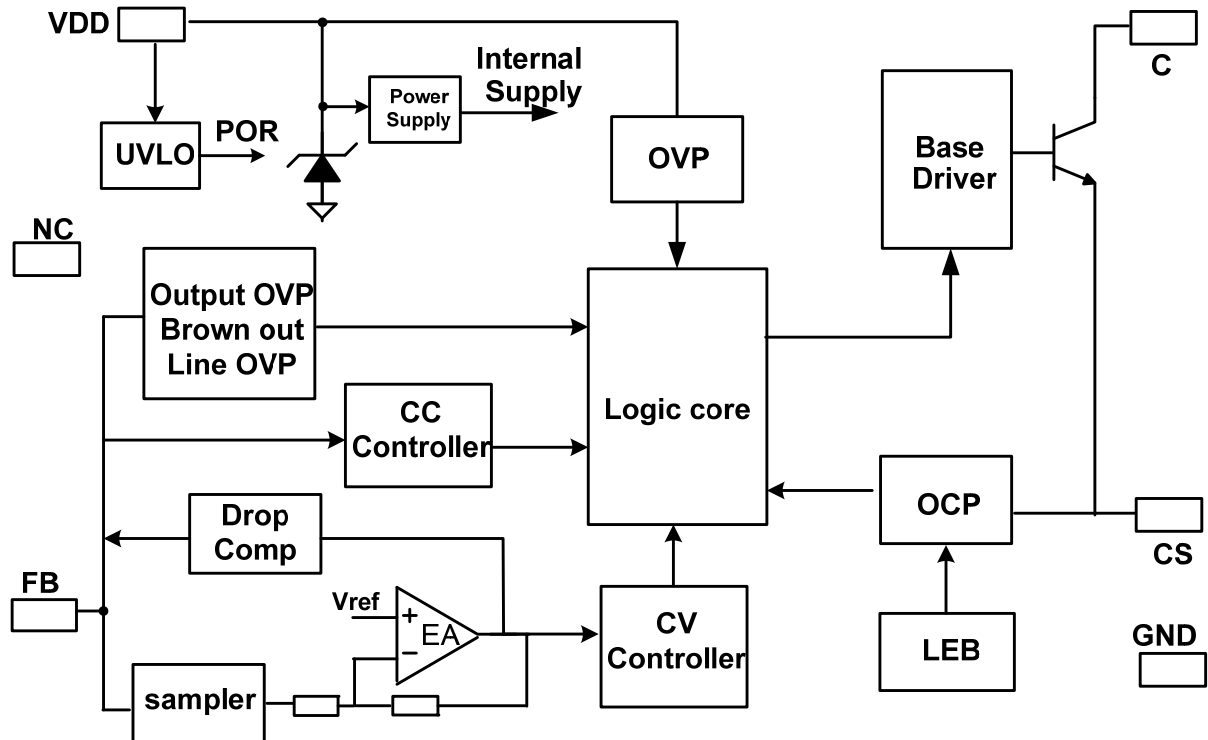
TERMINAL ASSIGNMENTS for OB2513xB/D

Pin Num	Pin Name	I/O	Description
1	FB	I	The voltage feedback from auxiliary winding. Connected to resistor divider from auxiliary winding reflecting output voltage.
2	GND	P	Ground
3	VDD	P	Power Supply
4	CS	I	Current sense input
5、6、7、8	C	P	HV BJT collector pin.

TERMINAL ASSIGNMENTS for OB2513B/DJP

Pin Num	Pin Name	I/O	Description
1	VDD	P	Power Supply
2	FB	I	The voltage feedback from auxiliary winding. Connected to resistor divider from auxiliary winding reflecting output voltage.
3	NC		
4	CS	I	Current sense input
5、6	C	P	HV BJT collector pin.
7	GND	P	Ground

BLOCK DIAGRAM



ELECTRICAL CHARACTERISTICS

(TA = 25°C, VDD=15V, if not otherwise noted)

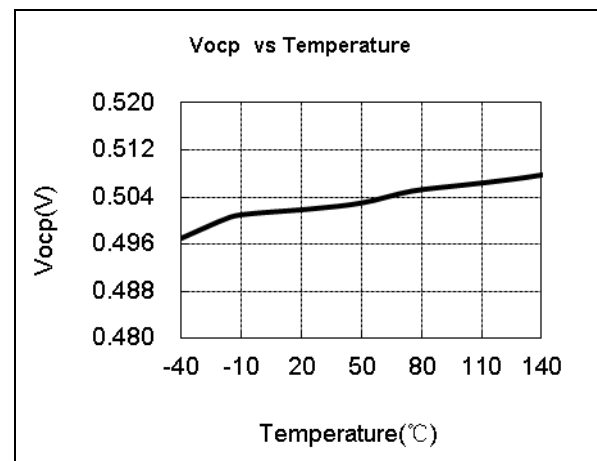
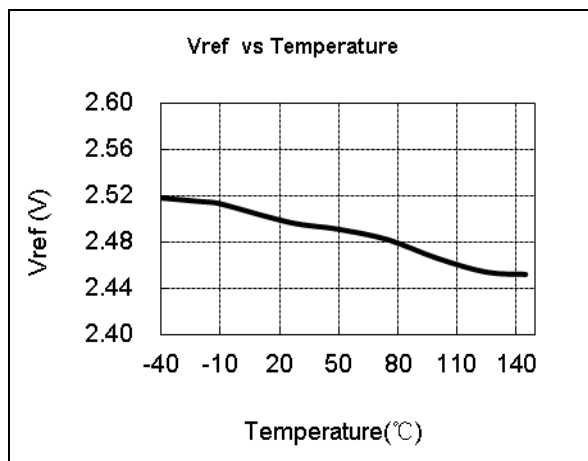
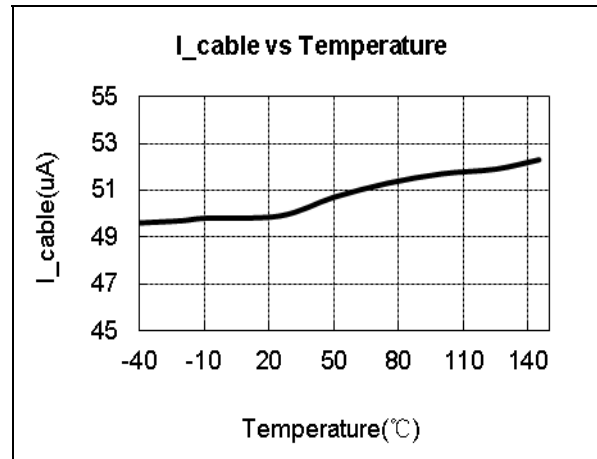
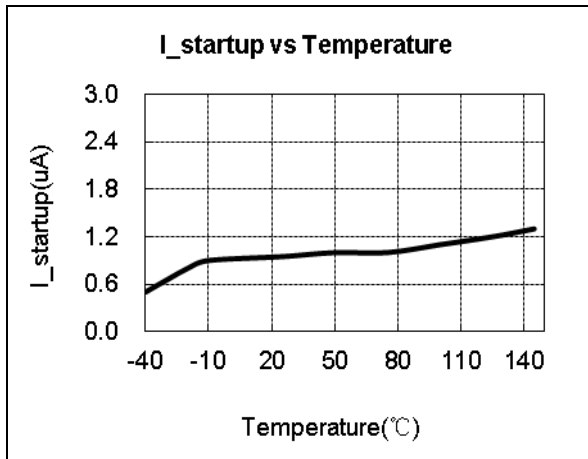
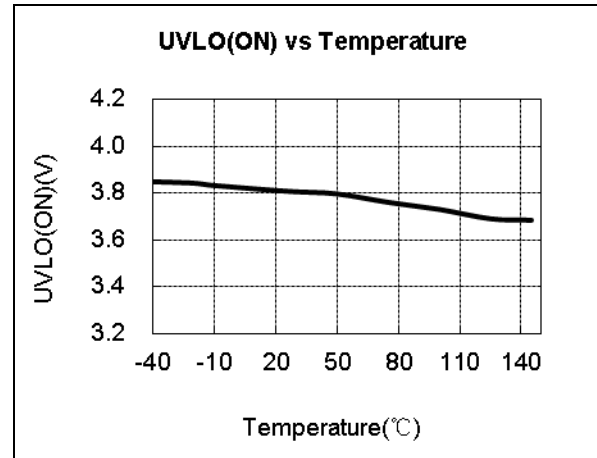
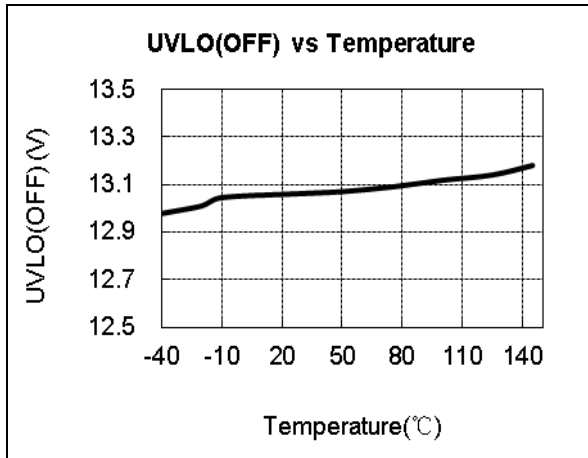
Symbol	Parameter	Test Conditions	Min	Typ.	Max	Unit
Supply Voltage (VDD) Section						
I _{start-up}	Start up current	VDD=UVLO_OFF-1V		1	3	uA
I _{op}	Operation current without switching			0.77	1.0	mA
UVLO(OFF)	VDD under voltage lockout exit		12	13	14	V
UVLO(ON)	VDD under voltage lockout enter		3.5	3.7	3.9	V
VDD_OVP	VDD over voltage protection		17	18	19	V
VDD_max	Max. Operating Voltage				16	V
Current Sense Input Section						
TLEB	LEB time			0.33		us
V _{th_ocp_min}	Minimum over current threshold		485	500	515	mV
V _{th_ocp_max}	Maximum over current threshold			600		mV
T _{on_max}	Maximum Ton			40		us
T _{d_oc}	OCP propagation delay			100		ns
FB Input Section						
V _{ref_fb}	Reference voltage for feedback threshold		2.475	2.500	2.525	V
T _{pause_min}	Minimum Toff			2.0		us
F _{min}	Minimum frequency		450	500	550	Hz
F _{max}	Maximum frequency		90			KHz
I _{comp_cable}	Maximum cable compensation current	OB25133BJP OB25133DJP OB2513xB/BCP		17.5 23		uA
I _{brown-out}	Brown-out threshold current			213		uA
T _{d_BO}	Brown-out protection debounce Time			40		ms
I _{lineovp}	Line OVP threshold current			960		uA
T _{d_lineovp}	Line OVP debounce time			120		ms
Output Over Voltage Protection						
V _{ovp}	Output Over voltage threshold		2.85	3.00	3.15	V
On chip Over temperature Section						
T _{otp}	Over temperature protection trigger point			165		°C
T _{otp_rec}	Over temperature protection recovery point			130		°C

Power BJT Section									
Parameter Product	V _{ceo} (V) <small>Note1</small>			V _{cbo} (V) <small>Note2</small>			I _c (A)		
	Collector-emitter breakdown voltage			Collector-base breakdown voltage			Collector Current	Peak	
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.
OB25133B/D		450		800				0.5	
OB25135B		450		750				1.2	
OB25136B		450		750				1.6	

Note1: Test condition: I_c=10mA, I_b=0

Note2: Test condition: I_c=10mA

CHARACTERIZATION PLOTS



OPERATION DESCRIPTION

OB2513xB/D is a cost effective PSR power switch optimized for off-line low power AC/DC applications including battery chargers. It operates in primary side sensing and regulation, thus opto-coupler and TL431 are not required. Proprietary built-in CV and CC control can achieve high precision CC/CV control meeting most charger application requirements.

Startup Current and Startup Control

Startup current of OB2513xB/D is designed to be very low so that VDD can be charged up quickly. A large value startup resistor can therefore be used to minimize the power loss in application.

Operating Current

The operating current of OB2513xB/D is as low as 550uA (typical). Good efficiency and low standby power is achieved with the low operating current.

CC/CV Operation

OB2513xB/D is designed to produce good CC/CV control characteristic as shown in the Figure. 1. In charger applications, a discharged battery charging starts in the CC portion of the curve until it is nearly full charged and smoothly switches to operate in CV portion of the curve. The CC portion provides output current limiting. In CV operation, the output voltage is regulated through the primary side control. In CC operation mode, OB2513xB/D will regulate the output current constant regardless of the output voltage drop.

Principle of Operation

To support OB2513xB/D proprietary CC/CV control, system needs to be designed in DCM mode for flyback system (Refer to Typical Application Diagram on page1).

In the DCM flyback converter, the output voltage can be sensed via the auxiliary winding. During BJT turn-on time, the load current is supplied from the output filter capacitor, Co. The current in the primary winding ramps up. When BJT turns off, the energy stored in the primary winding is transferred to the secondary side such that the current in the secondary winding is

$$I_S = \frac{N_P}{N_S} \cdot I_P \quad (1)$$

The auxiliary voltage reflects the output voltage as shown in Figure.2 and it is given by

$$V_{AUX} = \frac{N_{AUX}}{N_S} \cdot (V_O + \Delta V) \quad (2)$$

Where ΔV indicates the drop voltage of the output Diode.

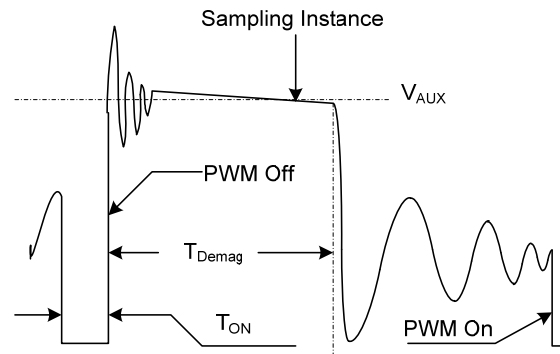


Figure 2 Auxiliary voltage waveform

Via a resistor divider connected between the auxiliary winding and FB, the auxiliary voltage is sampled and hold during the demagnetization cycle. The sampling instance is variable according to the demagnetization width. The output voltage can be monitored when the secondary current is small. Thus ΔV can be ignored. The sampled voltage is compared with reference voltage V_{ref_EA} and the difference is amplified by the error amplifier. The error amplifier output reflects the load condition and controls the switching off time to regulate the output voltage, thus constant output voltage can be achieved.

When the sampled voltage is below V_{ref_EA} and the error amplifier output reaches its maximum, the switching frequency is controlled by the sampled voltage to regulate the output current, thus the constant output current can be achieved.

Adjustable CC Point and Output Power

In OB2513xB/D, the CC point and maximum output power can be externally adjusted by external current sense resistor R_s at CS pin as illustrated in typical application diagram. The larger R_s , the smaller CC point is, and the smaller output power becomes, and vice versa as shown in Figure.3.

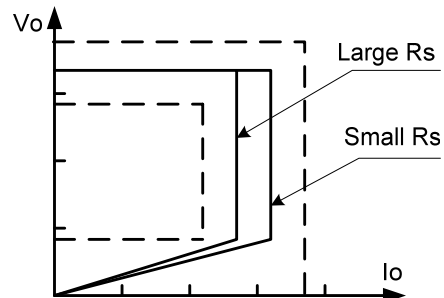


Figure 3. Adjustable output power by changing R_s

On Time OCP Compensation

The variation of max output current in CC mode can be rather large if no compensation is provided. The OCP threshold value is self adjusted higher at higher AC voltage. This OCP threshold slope adjustment helps to compensate the increased

output current limit at higher AC voltage. In OB2513xB/D, a proprietary OCP compensation block is integrated and no external components are needed. The OCP threshold in OB2513xB/D is a function of the switching ON time. For the ON time less than 4.0us (typical), the OCP threshold changes linearly from 500mV (typical) to 600mV (typical). For the ON time larger than 4.0us (typical), the OCP threshold is clamped to 600mV (typical), as shown in Figure 4.

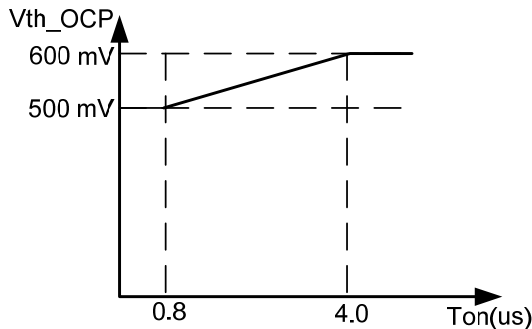


Figure.4. On time OCP compensation

Operation Switching Frequency

The switching frequency of OB2513xB/D is adaptively controlled according to the load conditions and the operation modes.

For flyback operating in DCM, The maximum output power is given by

$$P_{O_{MAX}} = \frac{1}{2} L_p F_{SW} I_p^2 \quad (3)$$

Where L_p indicate the inductance of primary winding and I_p is the peak current of primary winding.

Refer to the equation 3, the change of the primary winding inductance results in the change of the maximum output power and the constant output current in CC mode. To compensate the change from variations of primary winding inductance, the switching frequency is locked by an internal loop such that the switching frequency is

$$F_{SW} = \frac{1}{2T_{Demag}} \quad (4)$$

Since T_{Demag} is inversely proportional to the switching frequency, as a result, the product L_p and f_{sw} is constant, thus the maximum output power and constant current in CC mode will not change as primary winding inductance changes. Up to $\pm 7\%$ variation of the primary winding inductance can be compensated.

Cable Drop Compensation

In OB2513xB/D, cable drop compensation is implemented to achieve good load regulation. An offset voltage is generated at FB pin by an internal current flowing into the resistor divider. The current

is proportional to the switching off time, as a result, it is inversely proportional to the output load current, thus the drop due to the cable loss can be compensated. As the load current decreases from full-load to no-load, the offset voltage at FB will increase. It can also be programmed by adjusting the resistance of the divider to compensate the drop for various cable lines used.

The percentage of maximum compensation is

$$\frac{\Delta V}{V_{out}} = \frac{I_{comp_cable} \times R_1 // R_2 \times 10^{-6}}{2.5} \times 100\%$$

ΔV is load compensation voltage and V_{out} is output voltage;

For example: $R_1 // R_2 = 12.7\text{Kohm}$, when the cable current is 17.5uA, then the percentage of maximum compensation is

$$\frac{\Delta V}{V_{out}} = \frac{17.5 \times 12700 \times 10^{-6}}{2.5} \times 100\% = 8.9\%$$

when the cable current is 23uA, then the percentage of maximum compensation is

$$\frac{\Delta V}{V_{out}} = \frac{23 \times 12700 \times 10^{-6}}{2.5} \times 100\% = 11.7\%$$

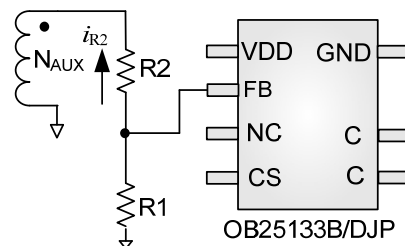
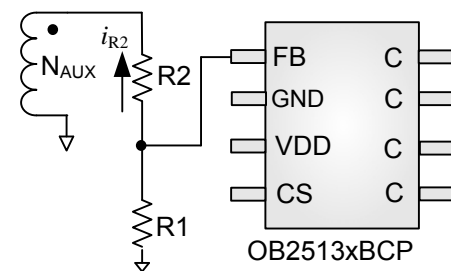


Figure.5

Programmable Brownout Protection and Line OVP Protection

By monitoring the current flowing through R_2 (i_{R2}) when the primary BJT is turned on, the controller protects the SMPS against the abnormal condition, as shown in Fig.5. When i_{R2} falls below $i_{brownout}(213\text{uA})$ brownout is triggered, the controller stops pulsing after 40ms later. when i_{R2} is above $i_{OVP}(960\text{uA})$, line OVP is triggered and stops pulsing after 120ms later.

The current flowing through R_2 (i_{R2}) is

$$i_{R2} = V_{AUX} / R2$$

The protection voltage is

$$V_{in} = R_2 i_{R2} N_P / (\sqrt{2} N_{AUX})$$

N_P is the turns of primary inductor, N_{AUX} is the turns of auxiliary inductor.

V_{AUX} is the voltage of auxiliary inductor when the primary BJT is turned on.

For example: $R_2=41\text{Kohm}$, the voltage of line OVP is

$$V_{OVP} = 41 \times 960 / \sqrt{2} \times \frac{116}{11} \times 10^{-3} = 293V$$

Current Sensing and Leading Edge Blanking

Cycle-by-Cycle current limiting is offered in OB2513xB/D. 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 power BJT on state so that the external RC filtering on sense input is no longer needed.

Protection Control

Good power supply system reliability is achieved with its rich protection features including cycle-by-cycle current limiting (OCP), output over voltage protection, VDD over voltage protection, short circuit protection, under voltage lockout on VDD (UVLO), programmable brownout protection, programmable line over voltage protection and over temperature protection (OTP).

VDD is supplied by transformer auxiliary winding output. The output of OB2513xB/D is shut down when VDD drops below UVLO (ON) and the power converter enters power on start-up sequence thereafter.

To prevent the circuit being damaged under abnormal conditions, OB2513xB/D provides over thermal protection function. When the die

temperature rises above over temperature threshold T_{otp} , the OB2513xB/D will shut down the base output and then latch the power supply off. The controller will remain latched until the die temperature drops below the recovery threshold T_{otp_rec} and the OB2513xB/D will reset at the same time.

PCB Layout Consideration

The following rules should be followed in OB2513xB/D PCB Layout:

- **The Area of Power Loop:** The area of the main current loop should be as small as possible to reduce EMI radiation, such as the primary current loop, the snubber circuit and the secondary rectifying loop (Red wire as shows in Fig.6&Fig.7). Drain pin increases the copper area of the drain terminal for heat dissipation (Green region as shows in Fig.8&Fig.9). And the PCB trace must be wide and short for thermal consideration.
- **Bypass Capacitor and FB divider resistor:** The bypass capacitor on VDD and the FB divider resistor should be placed as close as possible to pin out. And the negative node of VDD capacitor and the FB down resistor should be connected directly to the IC GND pin before single point connected to the negative node of the output capacitor. (Blue wire as shows in Fig.6&Fig.7)
- **Ground Path:** The GND path of the input power loop and IC controller path should be separated and connected at the negative terminal of input capacitor by single point, such as power sense resistor, the negative of the auxiliary winding and the IC GND. (White region as shows in Fig.8&Fig.9)

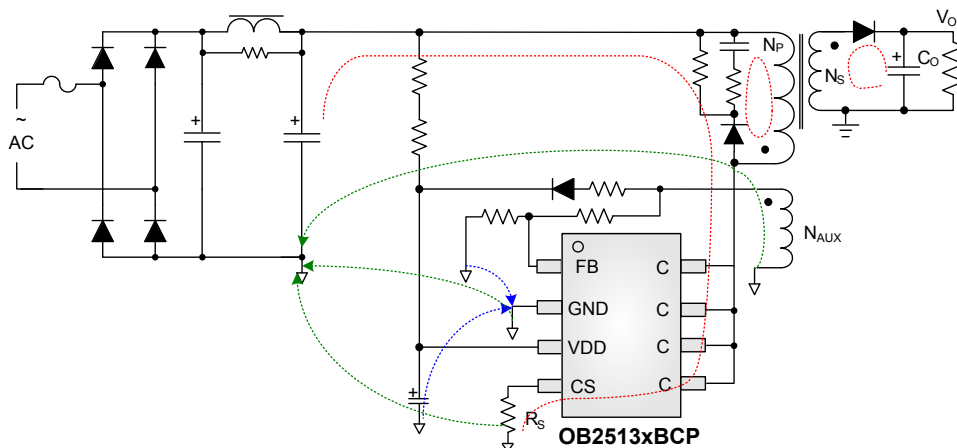


Fig.6 Flyback Schematic with OB2513xB/D

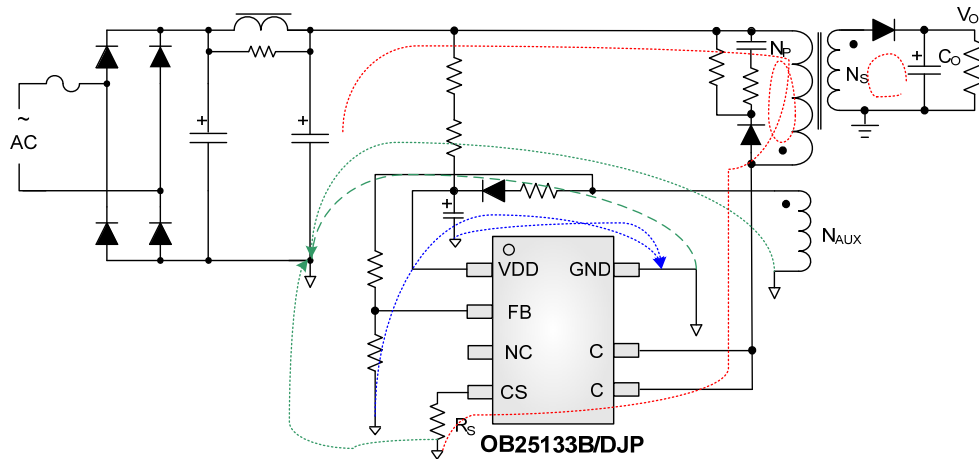


Fig.7 Flyback Schematic with OB2513B/DJP

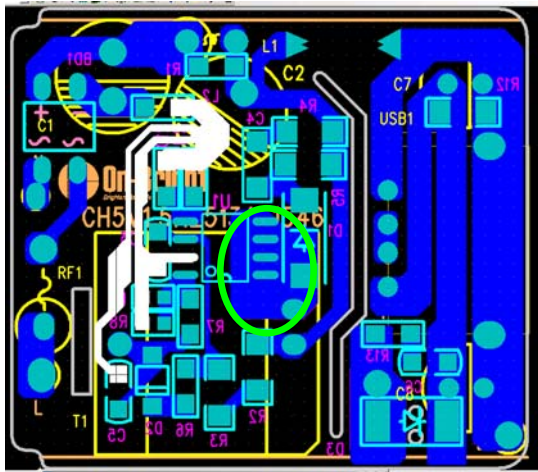


Fig.8 Recommend PCB Layout of OB2513xB/D

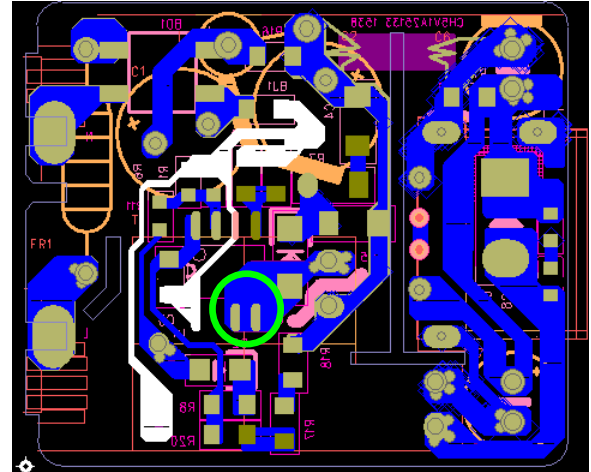
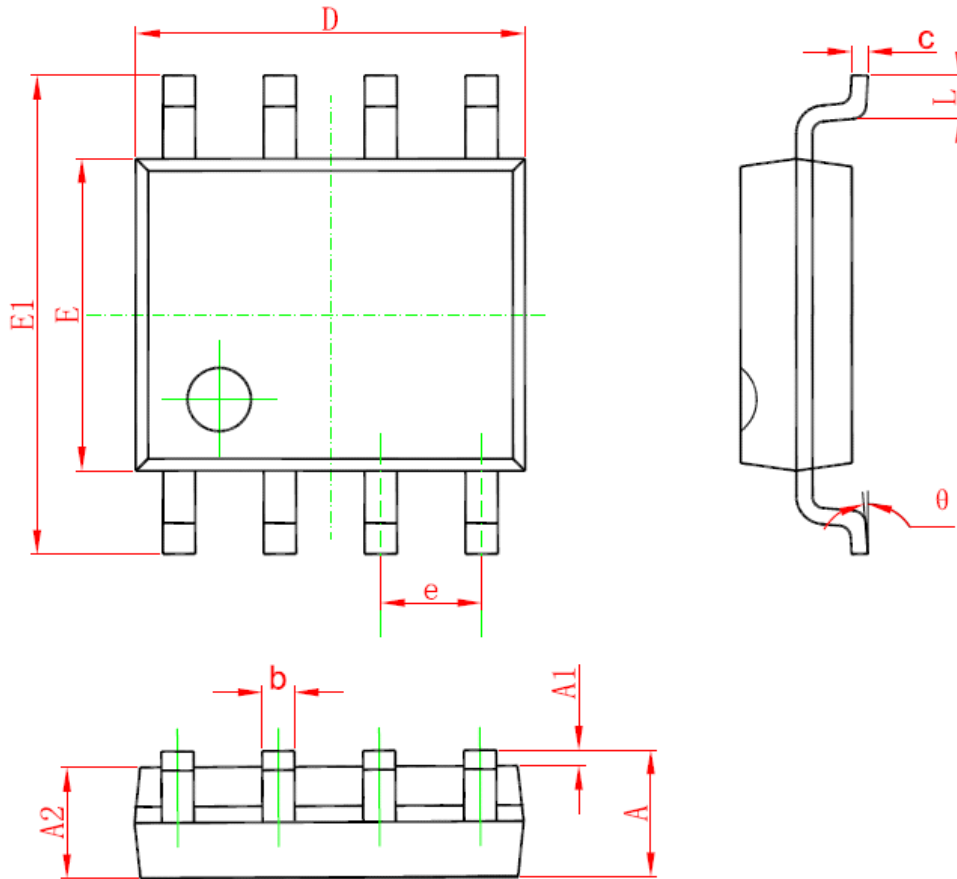


Fig.9 Recommend PCB Layout of OB2513B/DJP

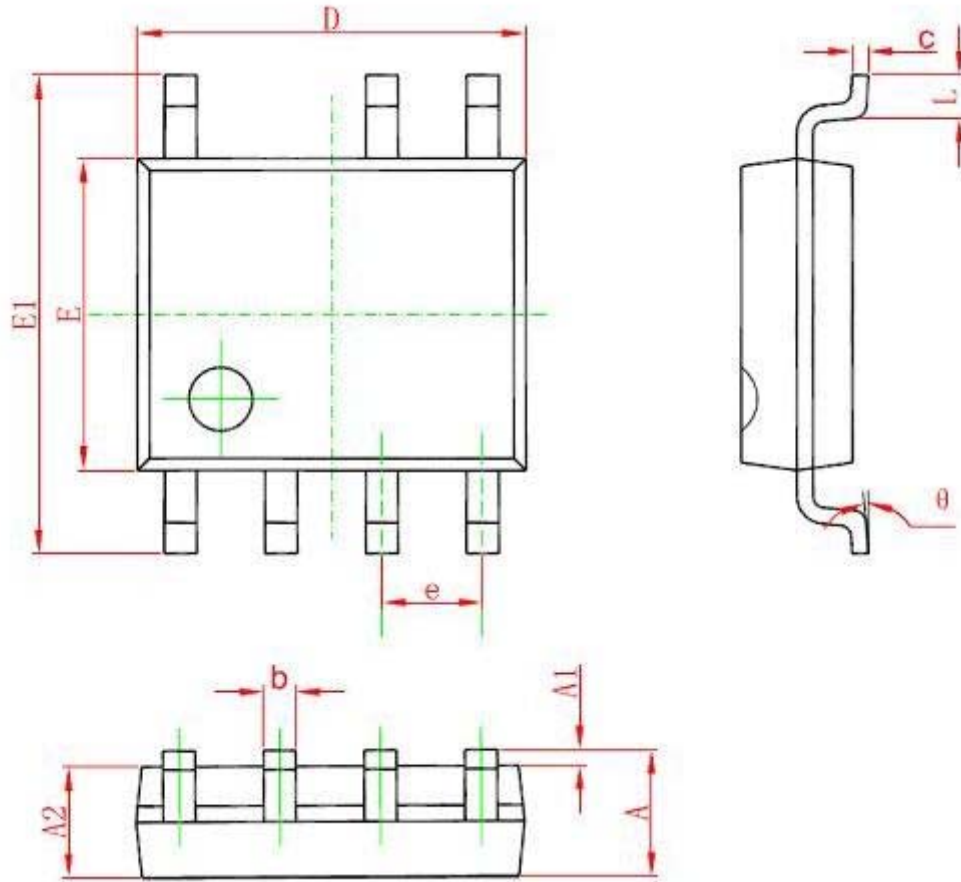
PACKAGE MECHANICAL DATA

SOP8 PACKAGE OUTLINE DIMENSIONS



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	0.170	0.250	0.006	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)		0.05 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

SOP7 PACKAGE OUTLINE DIMENSIONS



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°

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