AN1734
Application note

VIPower: VIPer12A single output reference board 85 to 264 VAC input, 6W output

Introduction

This is an off-line wide range VIPer12A single output general-purpose power supply. The internal oscillator of VIPer12A sets the switching frequency of 60kHz. It is set up for secondary regulation by controlling the current flowing into an optocoupler in the feedback configuration. The output is set for 12V at 0.5A, making the total output power of 6W.

The VIPer12A combines a dedicated current mode PWM controller with a high voltage power MOSFET on the same silicon chip. In low load condition, it operates in the automatic burst mode while in an overvoltage condition; it will operate in hiccup mode. Viper12A is available in two different packages: SO-8 and DIP-8.

- Switch mode general purpose power supply
- Burst mode operation in standby for Blue Angel operation
- Current mode control
- 75% Efficiency
- Auxiliary undervoltage lockout with hysteresis
- Output short circuit protection
- Thermal shutdown protection
- Meets EN55022 class B EMI specification

Operating conditions

Parameter	Limits
Input voltage range	85 to 264Vac
Input frequency range	50/60 Hz
Output voltage	V=12V
Output current	I=0.5A
Output power (peak)	6W
Efficiency	75% typical
Line regulation	+/- 0%
Load regulation	+/- 0.1%
Output ripple voltage	30mVpp
Safety	Short circuit protection
EMI	EN55022 Class B

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1 PCB lay-out

Figure 1., Figure 2., and Figure 3. show the board layout. The layout of the switching power supply is very important in order to minimize noise and interference. Power generating portions of the circuit are the main cause of noise and so high switching current loop areas should be kept as small as possible. This prevents radiated and conducted EMC noises and high frequency resonance problems.

In order to meet safety agencies' requirements, there needs to be an adequate clearance of about 6mm between the high and low voltage sides of the circuit. The power grounds need to be separated from the small signal grounds. The current in the power ground changes very quickly in time; resulting in large transient that induces voltage shifts, which in turn can disturb critical, sensitive small signal currents. Any disturbance or shift of ground in the small signal ground will upset critical reference paths. Therefore, poor grounding routing can manifest itself as poor load regulation, or excessive switching noises on the output.

Figure 1. Board top legend (not in scale)

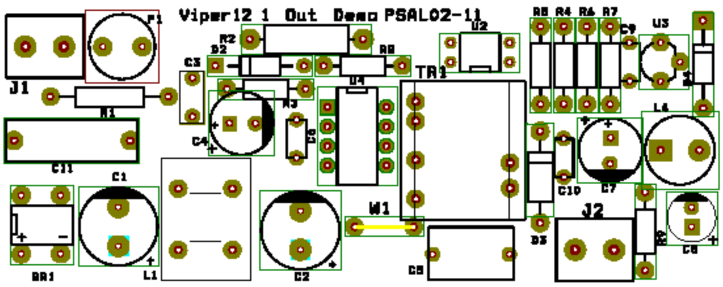


Figure 2. Board bottom foil (not in scale)

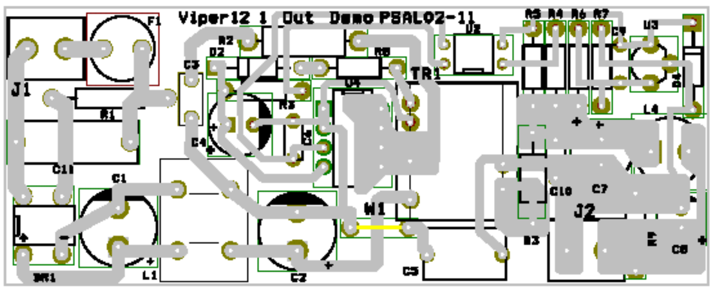


Figure 3. Board lay-out

2 General circuit description

This board is designed as a discontinuous flyback regulator delivering 0.5A at 12V. The AC input is rectified and filtered by the bridge BR1, the bulk capacitor C1, and C2 to generate the high voltage DC bus applied to the primary winding (pins 8-10) of the transformer, TR1. C1, L1, and C2 provide EMI filtering for the circuit.

R2 and C3 form the snubber circuit needed to reduce the leakage spike and voltage ringing on the drain pin of VIPer12A. The output voltage is regulated with a TL431 (U3) via an optocoupler (U2) to the feedback pin. The output voltage ripple is controlled with the capacitor, C7, with an additional LC PI filter configuration made up of L4 and C8. It is possible to modify the output voltages by changing the transformer turns ratio and modifying the resistance values of R6 and R7 in the feedback loop.

3 Waveforms

The following line and switching frequency ripple waveforms are taken at the input voltage of 85Vac.

Figure 4. Line frequency ripple - ripple = 30mVpp

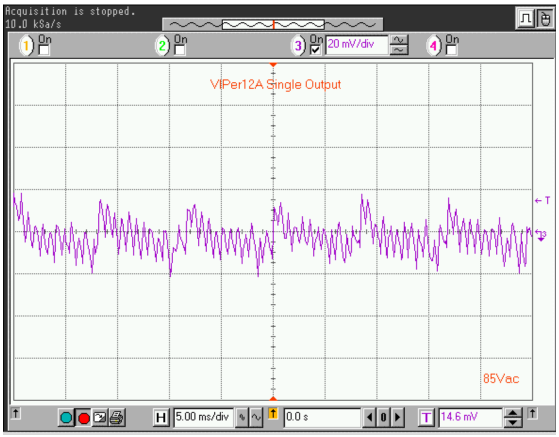


Figure 5. Switching frequency ripple - ripple=20mVpp

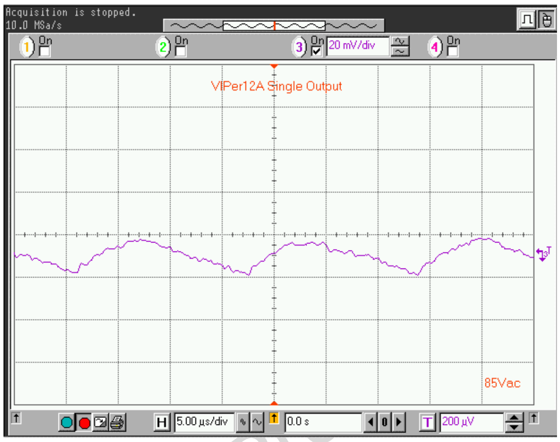
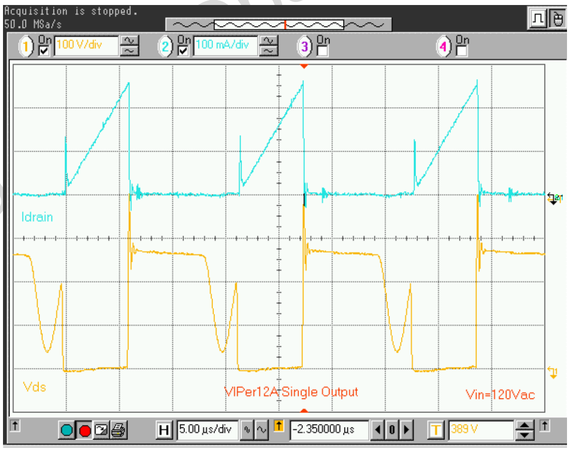


Figure 6. shows the drain voltage and drain current during normal operation at full load. The power supply operates in the discontinuous current mode as seen from the waveforms.

Figure 6. Vds and drain current at 120Vac and 0.5A load



4 Transient load response and turn ON delay

Figure 7. Transient response with 50% step change

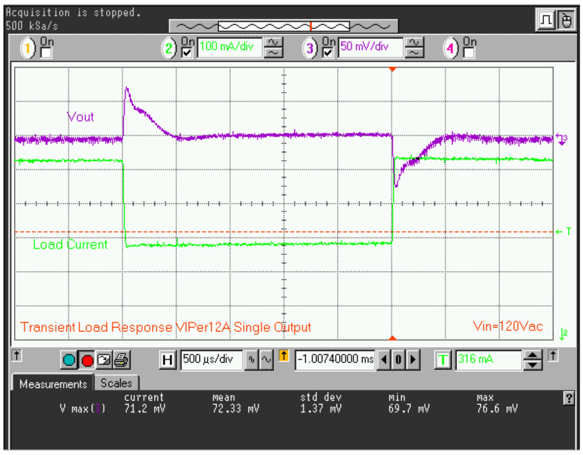


Figure 8. Turn ON delay

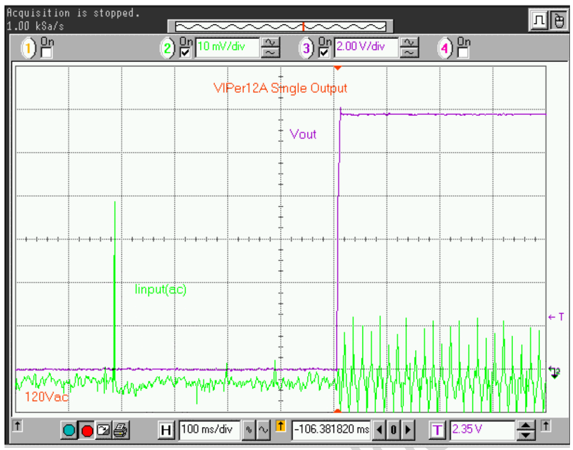


Figure 7. shows the transient load response when the output load is stepped from 0.25A to 0.5A at a line input of 120Vac. The result is 72mV or 0.6% dynamic regulation with a settling time of 500ms. Meanwhile, Figure 8 shows the turn-on delay of VIPer12A. At an input voltage of 120Vac, there is a turn-on delay of approximately 410ms.

5 Efficiency measurements

The measurements are taken at an input voltage of 120Vac. The typical efficiency measured is about 75%. *Figure 9.* shows the efficiency measured when Pout is set at different values from 1W to maximum value of 6W. *Figure 10.* shows the efficiency curve when the line input is varied from 85Vac to 264Vac while the output power is set at the maximum value of 6W.

Figure 9. Efficiency curve when output power is varied

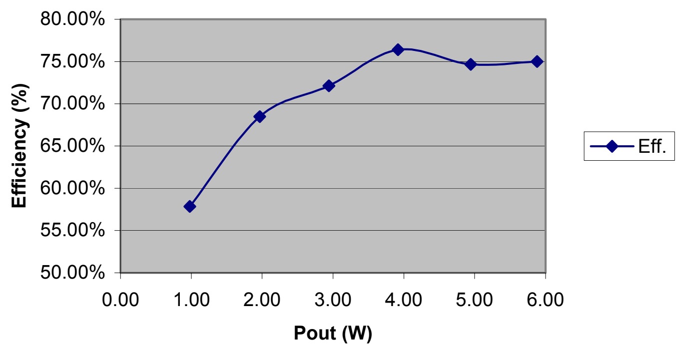
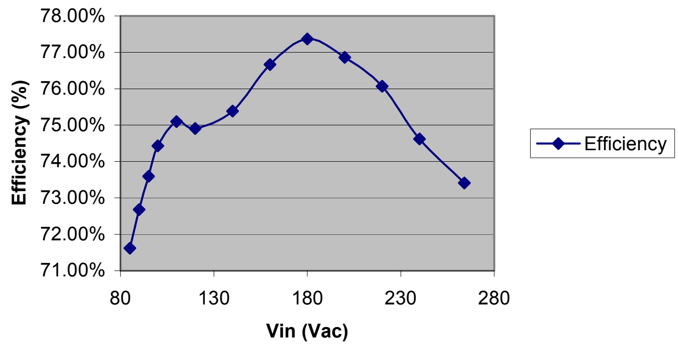


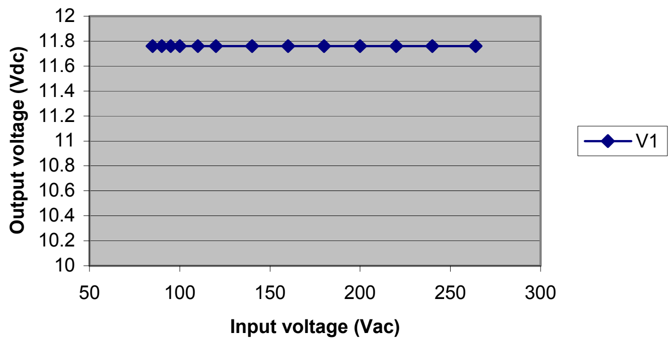
Figure 10. Efficiency curve vs. input voltage at maximum Pout



6 Line regulation

Here, the output power is kept at 6W while the line voltage is slowly increased from 85Vac to the maximum value of 264Vac. The board has a line regulation of 0%.

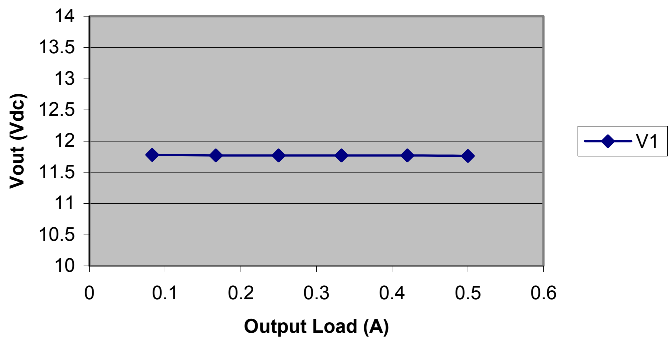
Figure 11. Line regulation



7 Load regulation

The output load is changed from 0.1A to full load 0.6A while the line input is kept at the nominal value of 120Vac. The board has a load regulation of +/- 0.1%.

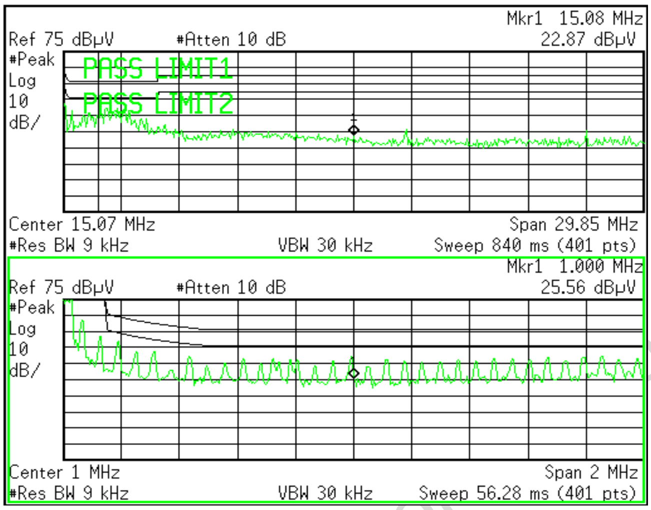
Figure 12. Load regulation



8 EMI results

EMI, the generation of conducted or radiated energy, is unavoidable in all switch mode power supplies. A few common causes of EMI problems are bad layout, or bad placement of the power switching components. The configuration of the common-mode line choke, L1, and decoupling capacitors, C1 and C2, made up the effective EMI filter on this board. For low power, this configuration saves the cost of using X capacitors. *Figure 13.* shows the board passing the European Norm, EN55022 Class B EMI.

Figure 13. EMI measurement



9 Output current and voltage capability

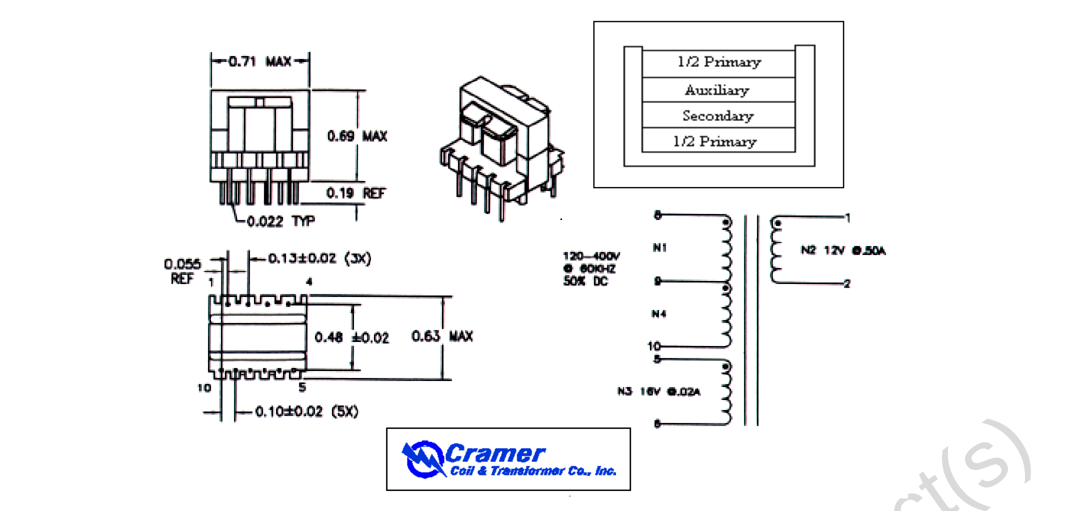
The standard voltage and current values for the reference board can be changed to deliver a different voltage and current value, with changes to the following components as detailed in *Table 1.*

Table 1. Change in output voltage and current

	TR1	R6	R7	C7	C8
5.0V 1.2A	CVP11-037	2.49kΩ 1%	2.49kΩ 1%	680µF/35V	220µF/35V
12V 0.5A	CVP11-021	13.3kΩ 1%	3.48kΩ 1%	330µF/25V	100µF/25V
15V 0.4A	CVP11-034	14.7kΩ 1%	2.94kΩ 1%	220µF/35V	100µF/35V
24V 0.25A	CVP11-036	13kΩ 1%	1.5kΩ 1%	100µF/50V	100µF/50V

10 Transformer specification

Figure 14. Mechanical drawings of the transformer



- Primary Inductance: 3.25mH ± 10%
- Primary Leakage Inductance:34µH typical

When the VIPer12A (U1) is on, energy is stored in the primary winding of transformer (10-8), TX1. This energy is transferred to the auxiliary winding (5-6), and to the output (1-2) when the VIPer12A is off. The auxiliary winding provides the bias voltage for the VIPer12A at pin 4 (V_{dd}).

11 Blue angel

When working in standby, the reference board consumes less than 1W total power consumption and therefore, meets the “Blue Angel” Norm. This unit operates in burst mode when the output load is reduced to zero and normal operation will resume automatically when the power gets back to a level higher than the standby power. The output voltage remains regulated even when the board operates in burst mode.

The total power consumption measured at 115Vac input with zero load at output is approximately 168mW, while at 230Vac input this value is about 248mW.

At 120Vac input, a minimum load of 52mA is needed to keep the input power consumption at less than 1W.

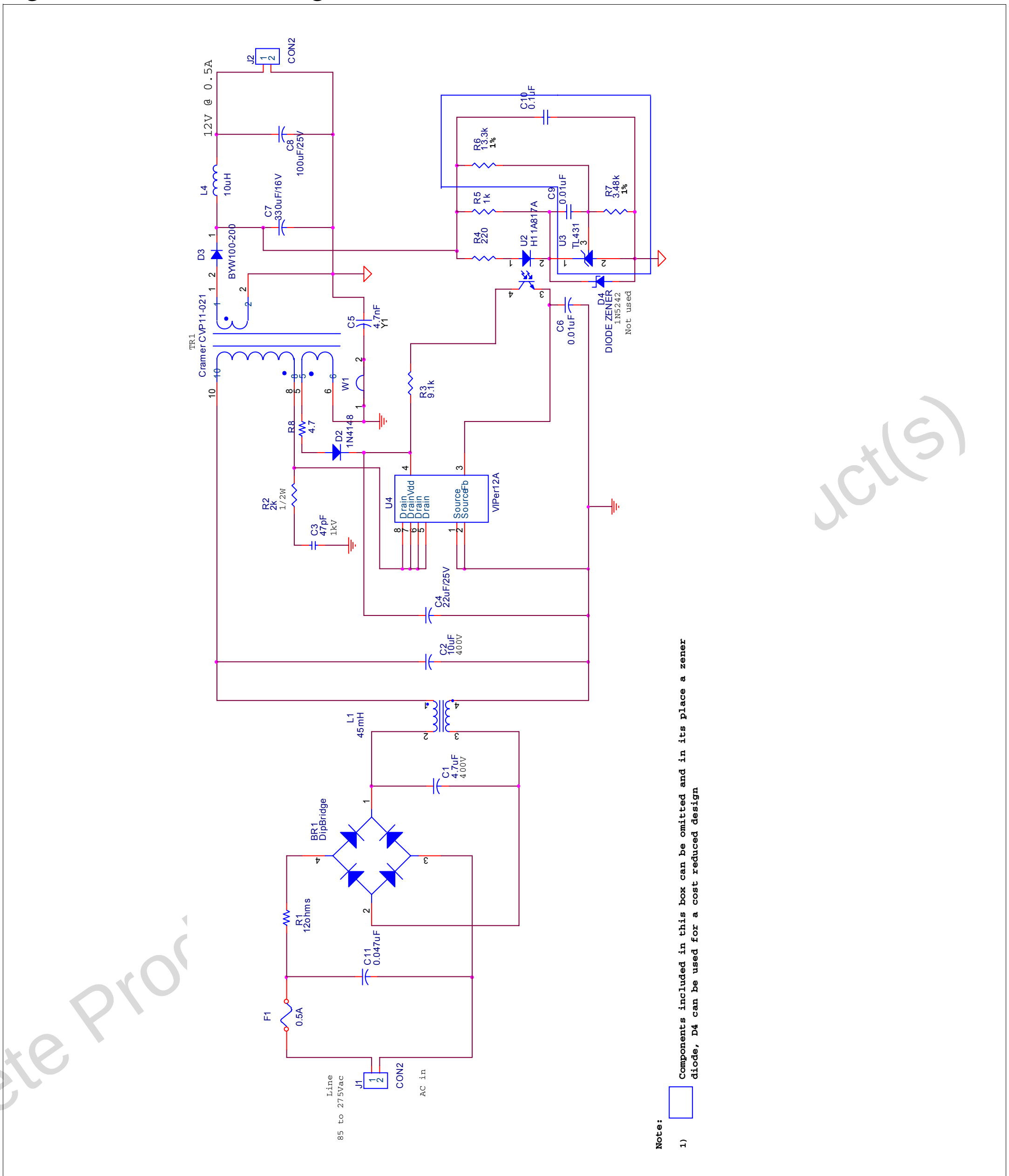
12 Component list

Table 2. Bill of material

Quantity	Reference	Description
1	BR1	600V, 1A bridge
1	C1	4.7µF/400V electrolytic
1	C2	10µF/400V electrolytic
1	C3	47pF 1kV ceramic
1	C4	22µF/25V electrolytic
1	C5	4.7nF/250V Y cap
1	C6	0.01µF/50V ceramic
1	C7	330µF/25V electrolytic
1	C8	100µF/25V electrolytic
1	C9	0.01µF/50V ceramic
1	C11	0.047µF/250V boxcap
1	D2	1N4148
1	D3	STMicroelectronics BYW100-200
1	F1	0.5A 250V Fuse
2	J1, J2	Connectors
1	L1	Compostar 2x45mH FUU10S-V24503-Q22650
1	L4	Coilcraft 10µH RFB0810-100
1	R1	12Ω 5% 1/4W Carbon composition
1	R2	2KΩ 5% 1/2W
1	R3	9.1KΩ 5% 1/4W
1	R4	220Ω 5% 1/4W
1	R5	1KΩ 5% 1/4W
1	R6	13.3KΩ 1% 1/4W
1	R7	3.48kΩ 1% 1/4W
1	R8	4.7Ω 5% 1/4W
1	TR1	Cramer coil transformer CVP11-021
1	U2	H11A817A or LTV817 optocoupler
1	U3	STMicroelectronics TL431
1	U4	STMicroelectronics VIPer12A
1	W1	Jumper wire

13 Schematic diagram

Figure 15. Schematic diagram



14 Revision history

Table 3. Revision history

Date	Revision	Changes
Jul. 2003	1	First issue
Jun. 2005	2	Schematic changed
Sept. 2005	3	Schematic modified
27-Jul-2006	4	- New template - Component list value modified