

LOW VOLTAGE INPUT POWER SUPPLY FOR PERSONAL COMPUTER

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ABSTRACT

This paper deals with the problem of a low voltage input power supply destined for feeding a personal computer, used as a server unit in the car. The solution based on push-pull resonant DC/DC converter (input 24 V, output 200 V) is described.

1 INTRODUCTION

Personal computers (PC) are usually fed from the standard AC mains. Input voltage levels are then 230 V AC or 115 V AC depending on the continent. Internal power supply of the PC must be adapted to these two levels. Lately these supplies are constructed as “universal input” types able to work with both levels without applying any additional power switch and with regard to the EMC standards, using also Power Factor Correction (PFC). More information on this problem can be found in [1].

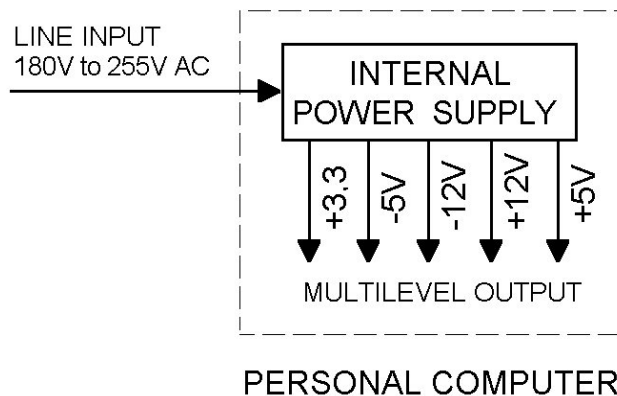


Fig. 1: Power supply system in the standard PC

In the special case when no AC line input is accessible (e.g. in vehicles) it's necessary to use the low input DC voltage usually 12 V or 24 V. The solution could be found in the replacement of internal power supply, shown in Fig. 1 with a new power supply constructed with an accordant low voltage input. However, this replacement avoids the computer warranty and moreover the possibility to feed the computer if needed from the standard AC mains without any back-replacement of power supply is lost.

The internal switching power supply of the PC works on principle with the DC voltage obtained by a rectification of an AC mains. That's why, the only effective way is to boost the low input DC voltage to the higher DC level, close to the computer supply input range. So that's sufficient to use a suitable DC/DC converter and there is no more need to design and construct a complicated power supply as a DC/AC converter with the sine wave output voltage. The both required possibilities of feeding the PC are shown in Fig. 2.

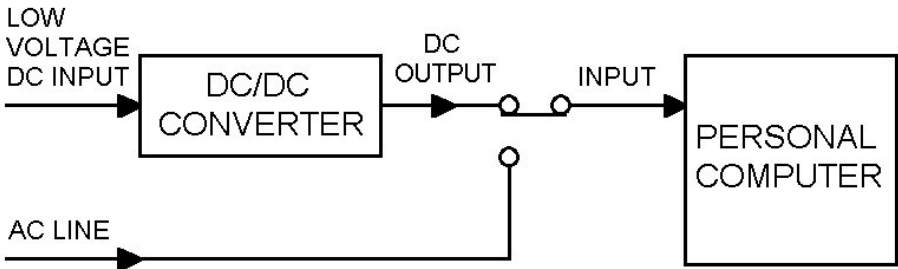


Fig. 2: Feeding of the PC

2 DC/DC CONVERTER DESIGN

The choice of the converter topology should meet requirements for high efficiency, low size and low weight. As a well suitable seems to be a resonant converter using push – pull topology. Schematics of this converter is shown in Fig. 3

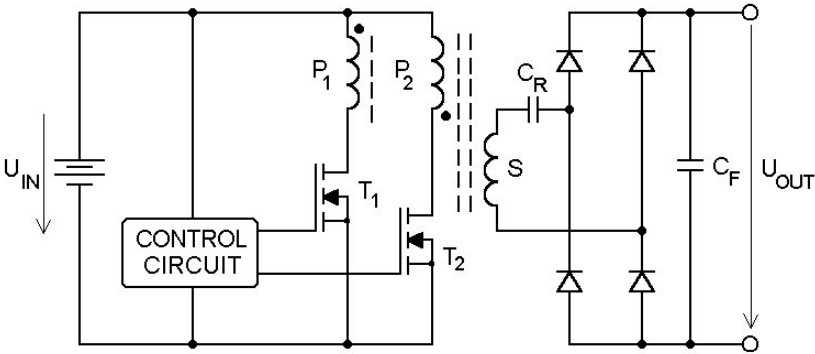


Fig. 3: Resonant Push-Pull converter

The circuitry of the converter is almost the same as in the classical push-pull. The main difference consists in the resonant capacitor C_R connected in series with the secondary winding of the transformer, which is directly connected to the output bridge rectifier terminated by the output capacitor C_F . The value of the capacitor C_R is calculated to be in

resonance with the secondary leakage inductance of the transformer. Then there is no voltage drop across this resonant circuit and the converter operates as a hard voltage supply with the output voltage determined by the converter input voltage U_{IN} and the transformer ratio. No output voltage or output current regulation e.g. by a duty cycle modulation is possible. The current i_s in the secondary winding is bipolar and sinusoidally shaped. If neglecting the magnetizing part the primary current has the same shape, but only one half-wave is present in each winding. Output capacitor C_F is necessary to provide a high frequency shorting on the output of the converter. For its value should pay the relation $C_F \gg C_R$.

Timing of gate drive signals and secondary current curves are expressed in Fig. 4.

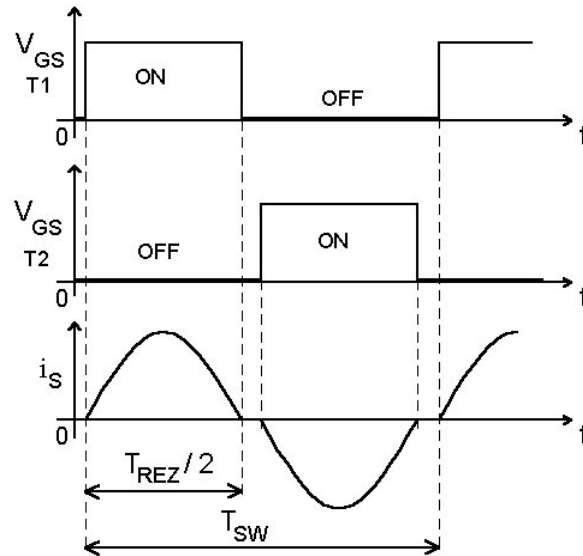


Fig. 4: Gate drive timing and secondary current shape

Transistors T1 and T2 are switched alternately with the constant duty cycle and constant switching frequency, each for the time shorter than one half of switching period T_{SW} to avoid cross-conduction as shown in figure above.

The required value of capacitor C_R can be calculated simply from the Thomson's relation:

$$C_R = \frac{1}{L_\sigma} \left(\frac{T_{REZ}}{2\pi} \right)^2$$

where L_σ is the secondary leakage inductance and $T_{REZ} / 2$ is the on-time of each transistor, see Fig. 4.

3 PRACTICAL REALIZATION

As mentioned above this converter operates as a hard voltage supply. That means that any inrush current presents in the output of the converter caused e.g. by switching the PC power supply to this converter induces current spikes also in all power semiconductors in the converter and could become the reason of their damage. It is necessary to use additional circuitry to avoid this situation and to make this converter reliable. Complete schematics of the realized solution is shown in Fig. 5

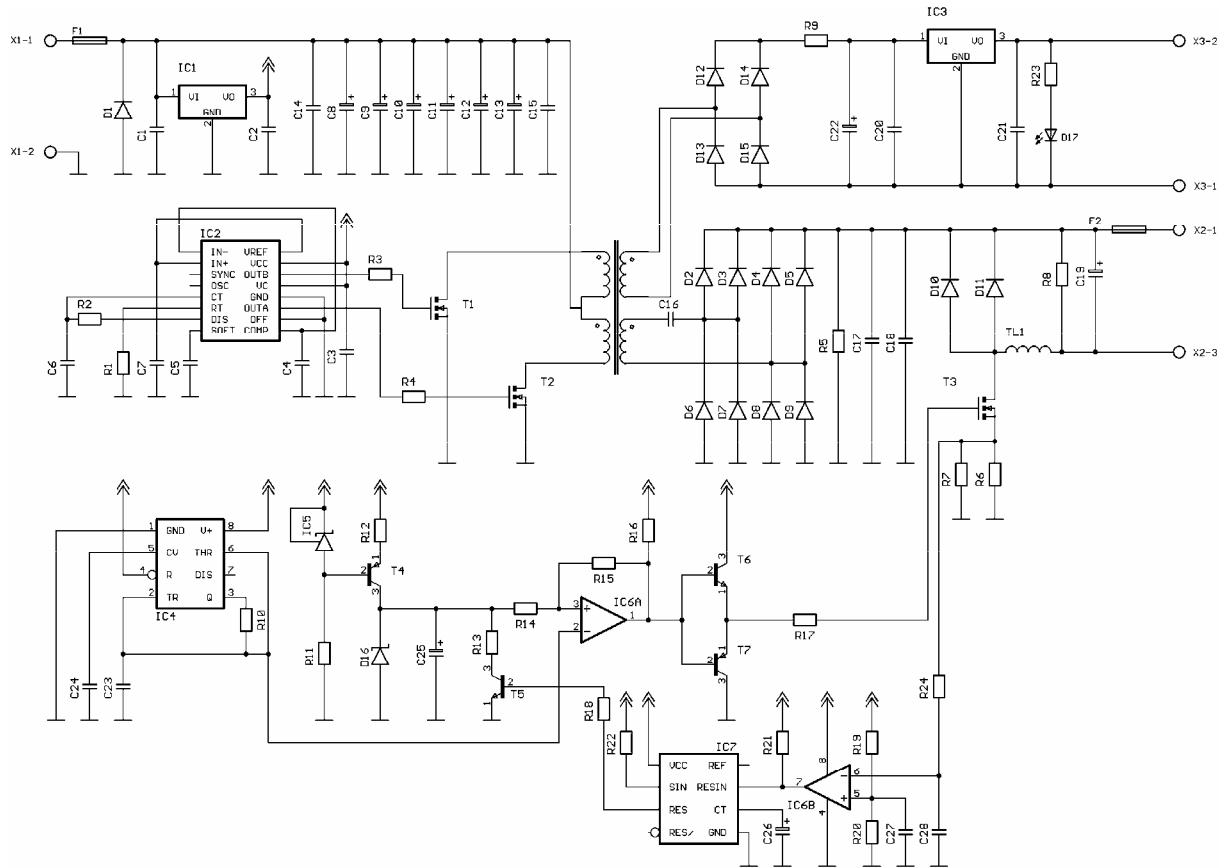


Fig. 5: Schematics of realized circuitry

Input voltage is fed from the input terminals X1 to the voltage intercircuit blocked by capacitors C8 to C15. Then it is regulated by IC1 to supply all control circuits. IC2 generates gate drive signals for switching transistors T1 and T2. The transformer has two secondary windings, the first is the main one with resonant capacitor C16 for supplying the PC, the second winding is auxiliary and provides low-power isolated supply for additional accessories (e.g for the hub) accessible in the X3 terminal. Transistor T3, diodes D10 and D11, inductance TL1 and the capacitor C19 are components of a step-down converter ensuring a slow run-up of the output voltage under special conditions. This soft-start initiates after converter turning-on, in the case of switching a capacitive load (e.g. PC) to the main output terminal X2 and in the case of overload or short-circuit. This protecting feature is provided through the continuous increasing the duty cycle of the T3 gate drive signal from 0 to 100 %. This signal is generated in the PWM section consisting of the sawtooth generator IC3, control voltage generator and a comparator IC6A. The control circuit IC7 and the comparator IC6B ensure the output current evaluation and the timing of mentioned protection. In the steady state the transistor T3 is turned-on. If the current through this transistor rises to the value adjusted by sensing resistors R6, R7 and a divider R19/R20, transistor is turned-off and after a preset delay, the soft-start is initiated.

Featured parameters of the realized converter

- Input voltage
- Output voltage

$$U_{IN} = 24 \text{ V DC } \pm 20 \%$$

$$U_{OUT} = 200 \text{ V DC } \pm 20 \%$$

- Nominal output power $P_N = 150 \text{ W}$
- Peak short-time output power $P_{MAX} = 500 \text{ W}$
- Measured efficiency $\eta = 95 \% @ 150 \text{ W}$
- Switching frequency $f_{SW} = 120 \text{ kHz}$
- Transformer weight $m_{TR} = 60 \text{ g}$

4 CONCLUSION

The introduced and practically realized power supply is destined for feeding a PC based server unit in the upper class coach. This unit includes an internal power supply with PFC and universal AC input from 90 V to 255 V, so the designed output voltage of 200 V DC is sufficient. One of the main requirements was to achieve a high efficiency for the best utilization of 24 V battery system ensuring the electrical power in the bus, when the combustion engine doesn't work. The achieved value of 95 % is high enough. This engineered power supply can be used for any other appliances having a switched mode power supply (SMPS) in their input, excepting the classical CRT monitor using an AC input for degauss operation. In addition the output voltage level of proposed power supply should be adapted to the input voltage range of the supplied device in any case.

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