

A. A Novel High-Frequency Switching DC Power Supply for Small Scale Resistance Spot Welding

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INTRODUCTION

This paper presents a novel, low cost power supply for small scale resistance spot welding. The design is based on a standard DC/DC power converter with a lead acid battery as primary source of power.

SYSTEM DESCRIPTION

The designed power supply consists of three major sections: the power section, the control electronics and the micro-controller. Figure 2 illustrates the system block diagram.

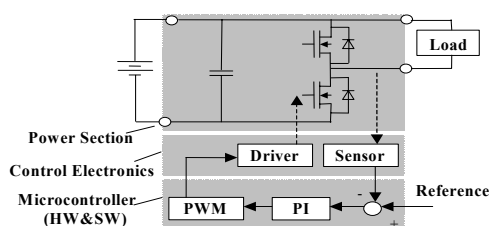


Figure 1. System block diagram

The power section is a DC/DC converter, which converts the input power from the 12V battery to an appropriate output voltage to feed the welder. Power MOSFETs are used as the switching components, which switch at a frequency of 20kHz. An output inductor is used to filter the output current. The control electronics section includes the driver circuits for the MOSFETs, the sensing circuits for voltage, and current. The micro-controller is the central control unit of the system, which includes both the hardware and the software. Based on the given reference and feedback signals, the micro-controller implements the control schemes and provides the PWM signal to drive the MOSFETs in the power section. An 8-bit micro-controller, PIC16F73 from Microchip Inc., is selected as the CPU of the system. This approach is now economically feasible with the introduction of MOSFETs capable of switching 100Amps for 3\$ and ones capable of switching 100's of amps for tens of dollars.

CONTROL SCHEMES

Four control modes are set in this power supply: voltage control mode, current control mode, power control mode, and generic control mode. The voltage control mode operates the supply in an open loop manner with the duty cycle specified by the user. In the current control mode, the load current is measured and the duty cycle adjusted to maintain a constant current. In the power control mode, the voltage and current are measured and the duty cycle adjusted to keep the power constant. A novel generic control scheme is discussed, which can cover all the three control modes above. Figure 2 presents the block diagram of the generic control scheme.

A variable called equivalent power (P_e) is defined as $P_e = V^\alpha \times I^{(1-\alpha)}$ where α is a control index, which has the range between 0 and 1. The reference (P_{ref}) and feedback (P_{eo}) are all based on this definition. The PI controller takes the error signal

(e) and calculates the duty ratio (D) of the PWM applied to the power supply. The generic control scheme can represent all three control schemes discussed above by using different control index α . When $\alpha = 0$, the equivalent power (P_e) equals to the current (I), therefore the generic control scheme is equivalent to the current control. When $\alpha = 1$, the equivalent power is the voltage, and the generic control scheme represents the voltage control. When $\alpha = 0.5$, the equivalent power is defined as the square root of the output power, and the generic control scheme is the same as the power control.

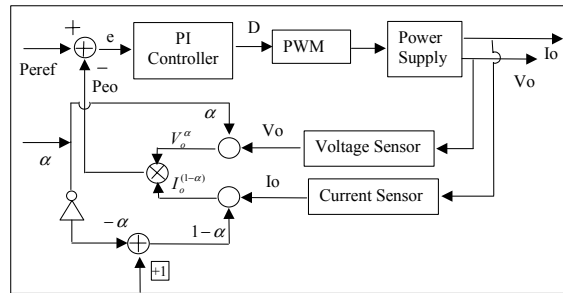


Figure 2. The novel generic control scheme

EXPERIMENTAL RESULTS

The experimental results show that the novel power supply can provide sufficient power and control the welding process successfully. Figure 5 presents the measured load voltage and current in the Current Control Mode.

Conclusions

Many welding quality issues can be related to type and quality of power supplied. This power supply provides the flexibility to explore whether constant power, current, voltage or some other intermediary control signal provides the most consistent welds.



Figure 3. Experimental results: supply voltage (top line) and current (bottom line) in current control mode.