DSP Controlled High Power Pulse Power supply

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Abstract

Pulse power supply is widely used in areas of industrial production. A high efficiency high power power supply is badly needed in mass production. And the parameter of a power supply such as: efficiency, power volume ,power factor ,and reliability is very important. In this paper a 20Kw pulse power supply is proposed, designed ,and implemented. The system is made up of two stages. First stage is dual ZVT-Buck converter controlled by DSP. Second stage is Full Bridge DC/DC converter controlled by analog devices. Both stage is voltage closed-loop control with over current protection .And output pulse frequency is 20-50Khz,voltage level is 200-1000V,and pulse width is 0-100% changeable. Stability and efficiency of the system is proven by the experimental results.

1. Introduction

Nowdays converters of power supply are designed to operate at higher frequency in order to make them smaller, lighter. However, that makes much large switching loss ,and high voltage, current stress to switching devices. The conventional soft switching technologies has much reduced loss and little stress to the switching devices even though no snubbers needed. In this article a DSP controlled pulse power supply is proposed. The power supply is made up of two stages. First is a AC/DC stage made up by Dual interleaving Buck chopper circuit controlled by DSP TMS 2808.The other stage is DC/DC stage controlled by both analog device UC3875 and DSP TMS320C2808. A 20Kw(1000V, 20A) / variable frequency(20-50Khz) pulse supply was designed, verified experimentally, and applied to a real unit. This paper includes its operating sequence, simulation and experimental results.

2. Proposed DSP controlled pulse power supply

Pulse power supply is widely used in areas of vacuum electroplate. High frequency high power is badly needed in industrial production. High power density, high efficiency and high reliability must be the major characteristic of such power supply. The frame of the whole supply is shown in Fig 1.

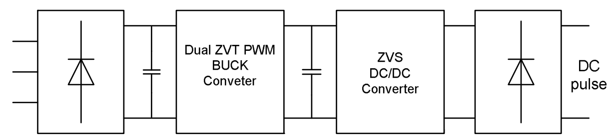

Figure 1.Diagram of the whole system

2.1. Chopper Circuit of voltage regulating stage

This stage is charge of regulating output voltage of the first stage. It is controlled by DSP F2808.AC/DC
stage is an uncontrolled rectifier. And chopper circuit(shown in Fig2) is a Dual interleaving ZVT-PWM buck circuit. It is a resonant circuit reducing much of the switching losses. Each of the ZVT-PWM Buck Circuit works under 50% Duty cycle. Due to certain output voltage and current strength of main switch can be cut off by half.

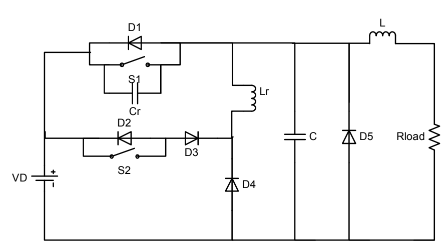

Figure 2.Diagram of ZVT Buck Circuit

2.2 DC/DC inverting stage

DC/DC inverting circuit is a "H" bridge topology shown in Fig 3. Fast IGBT is selected as the main

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switch. Phase shift zero voltage switching technology is adopted. Switching losses are much reduced.

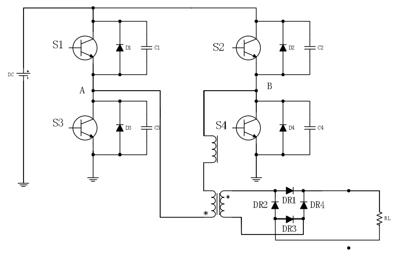

Figure 3. Diagram of ZVS Full-Bridge Circuit

2.3. DSP controller Circuit

The controller of the power supply is a DSP TMS320F2808.Sigals of dual buck converters are generated by the DSP through EPWM channels, feedback and set value are transmitted through I/O channels. And through SPI, DSP can be monitored and controlled by upper computers.

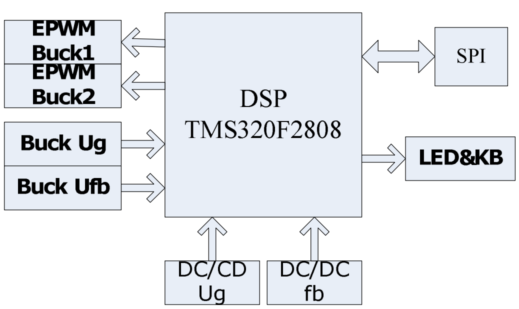

Figure 4. Diagram of control system

3. Simulation and Experimental Result

The proposed pulse power supply is examined as follows.

Buck stage :
Input voltage : AC 380V
Output Voltage:200-510V 25A
switching frequency : 40kHz
The maximum duty cycle: D_{max} =0.5
IGBT(F25N120ANTD) : 1200V, 25A

DC/DC stage:
Input voltage range:200V-510V
Output voltage and current : 200-1000VDC,20A
IGBT(SKM100GB128DN) : 1200V, 100A
Power Diode:IXYS DH60-18 ,60A 1800V
switching frequency : 20-50kHz
The maximum duty cycle D_{max} = 0.9
Transformer leakage inductance = 3.5uH
Additional inductance =20uH
Additional capacitor Cr = 680pF
The transformer turn ratio N = Np/Ns = 1/2.5
Dead Time : 0.77us

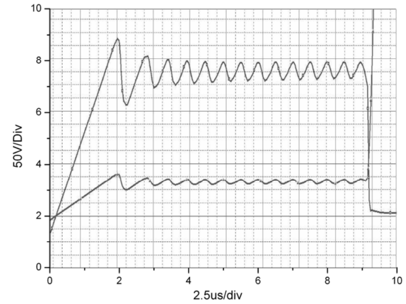

Figure 5. Simulation Diagram of ZVT Buck Circuit main switch

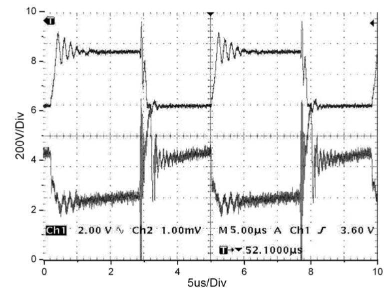

Figure 6. Simulation Diagram of ZVT Buck Circuit main switch

Figure 5 and 6 are the simulation and experimental results of the ZVT-PWM Buck circuit. And waveforms shows that using resonant technology switching losses are much reduced.

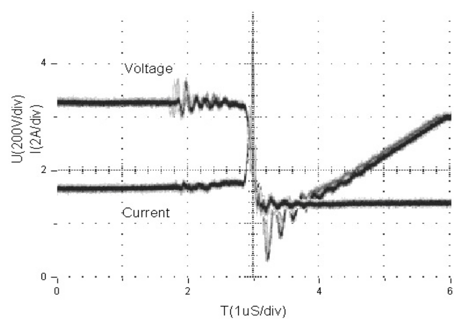

Figure7. Turn-on waveform of the IGBT in DC/DC stage

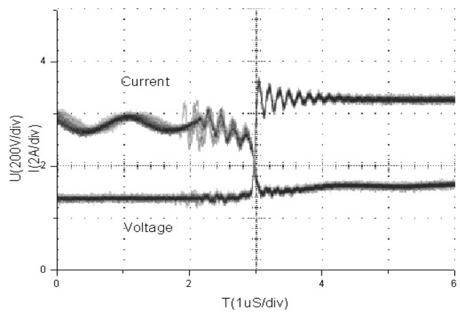

Figure8. Turn-off waveform of the IGBT in DC/DC stage

Fig. 7 and Fig. 8 are the waveforms of the main switches in DC/DC stage. In Fig. 7 and Fig. 8 voltage waveforms and current waveforms are seldom intersected, so the losses of the IGBTs are much reduced due to the resonant technology.

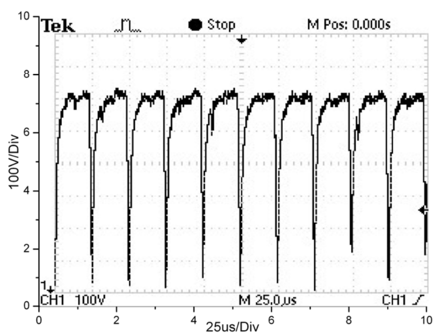

Figure 9. Voltage waveform of DC pulse output

Output voltage pulse waveforms are shown in Figure 9 about 90% Duty Cycle.

4. Conclusion

In this paper a two stage high power, pulse power supply is introduced. DSP is adopted as the main controller for both two stages. Reliability is increased by using a combination of digital and analog control. The experiment demonstrates the efficiency of power supply, and stability of the whole system.

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