

Research of Marine Oil Well Testing Technology

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Abstract

For marine oil well testing equipment totally depending on ground long-distance power supply, this article designed a set of DC power supply with small size, light weight, strong versatility, simple operation, electromagnetic compatibility and high intelligence, etc. It realized closed loop coordinated control of PI regulator of voltage and current, rapid adjustment of current, continuous adjustment of voltage and current and output of constant-voltage and constant-current. The power supply is composed of many link voltage power unit which achieved the continuous adjustable transform from single-phase low voltage AC 110V to DC voltage 0-1000V and current 0-10A through square wave pulse phase shifting control for IGBT inverter. The power supply design has innovative designing, advanced technology, superior performance, and has been applied in marine oil well testing industry.

Keywords: *marine oil well testing, DC power, high-frequency transformer, constant-current and constant-voltage*

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1. Introduction

The main purpose [1] of marine oil well testing is to achieve sampling and analyzing for liquid and rock stratum in the depth of the marine strata. Both extracting liquid and rock stratum need provide DC power supply for DC motor drive or AC motor inverter of well testing equipment [2-3], power supply needs nearly 10km (depth) long distance power transmission cable for power supply because it is set on the ground or offshore platform, the power supply is required to have a very good EMC performance. We developed a set of DC power supply with reliable operation under marine oil well testing environment, it adopted full digital control and intelligent high frequency power supply according to the features of testing well and actual requirements of applications, and adopted phase-shift PWM technology giving attention to both technology progressiveness and engineering practicability, and adopted constant current constant voltage power supply by studying double PI regulator closed loop coordinated control system for charging voltage and charging current, it has a very good practical significance.

2. Research Method

The structure diagram of new DC power supply system for marine oil well testing is shown in Figure 1, entered single-phase AC outputs needed DC voltage or current through the DC power supply. DC power supply system [4-5] consists of main circuit, control system, test circuit, the output voltage and current setting circuit. Main circuit is supported by single-phase rectifier bridge, filter capacitance, single-phase inverter bridge, high frequency transformer, high frequency rectifier, filter inductance capacitance component, control system is mainly composed of TMS320F28035 control circuit and power supply module circuit, drive circuit, PC display and a given operation module, detection module, current detection circuit is mainly composed of voltage detection module, the temperature detection module.

Main circuit of the power supply is composed of two groups of power converter, including former power converter (AC/DC/AC1) and after power converter (AC2/DC), its work principle is: input single-phase AC110V/60Hz sine wave voltage got DC 160V voltage through rectifying circuit composed of single-phase uncontrollable diode, then got high frequency square wave AC voltage with amplitude value of 160V and frequency of 48Hz through single phase IGBT inverter, then pass high frequency transformer and fast rectifier, final output voltage of DC

0V-1000V and output current of DC0A-10A are continuously adjustable, suitable for different logging instruments and logging depth. The transformation from AC1 to AC2 is done by high frequency transformer with superfine crystal core, which has realized the transformation from high frequency square wave AC voltage with amplitude value of 160V to high frequency square wave AC voltage with amplitude value of 1120V, also realized the electrical isolation between the input and output. Continuous adjustment of output voltage for the whole circuit depend on the IGBT single-phase inverter in former power converter with using PWM control method [6]. According to principle of transformer running which is that transformer iron core size is inversely proportional to the input AC voltage frequency, input voltage frequency of this power supply is 48KHz and iron core for superfine crystal core, this greatly reduces the volume and weight of the transformer, this is the main reasons that the power supply can greatly reduce device volume and weight than traditional power supply scheme. In order to get high frequency AC voltage (48KHZ), we used two levels of power converter. IGBT with IGW100N60H3 from Germany Infineon company, its biggest collector current $I_C=100A$, the county shoot interelectrode UCES = 600V, suitable for the switching frequency for 50KHz to 100KHz.

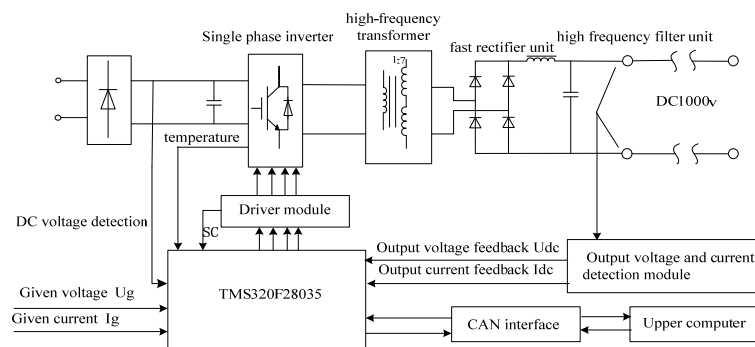


Figure 1. Structure Diagram of the DC Power Supply System

3. Control System Design

DSP TMS320F28035 control circuit is the core part of the new DC power supply control system [7], its block diagram is shown in Figure 2, control system consists of single chip microcomputer digital systems, analog interface circuit, driver circuit, CAN communication circuit and the PC machine display and operating circuit. Single chip microcomputer digital system composed of TMS320F28035 DSP and external terminal digital quantity input signal can complete all digital computing, external terminal control and 4-road phase shifting pulse output. Analog interface circuit is mainly composed of output voltage and current detection, temperature detection and conditioning, for the DSP for digital sampling. PWM signal from the DSP system can be converted to pulse signal to drive IGBT through drive circuit, and at the same time when IGBT happens short circuit or over current fault occurs, the fault signal was feedback to the DSP system. We can set all kinds of instructions and parameters given by keyboard, such as start and stop of power supply, set values for a given power output voltage and current, etc, it can display various running states and record history running malfunction for power supply.

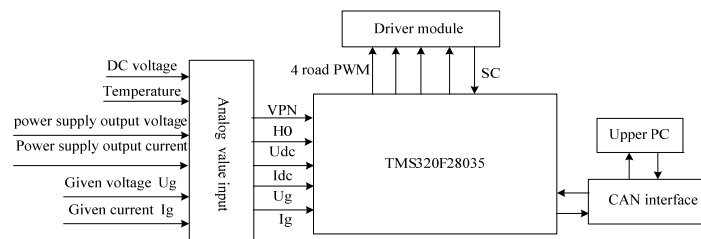


Figure 2. DC Power Supply System Structure Diagram

3.1. Algorithm Analysis of Control System

Constant current constant voltage closed loop control of the power system used software PI of DSP TMS320F28035 [8-9] to adjust, its algorithm is shown in Figure 3. Given voltage value U_g of the power supply from the keyboard or the PC setting output after sampling calculation of DSP and can adjust the power output voltage value U_{dc} , it is adjusted by using software PI regulator, the difference between U_{dc} and U_g is served as input of the PI controller, and its output U_g' as an input for constant current constant voltage function unit $F(u)$. If determine by calculation is constant voltage control, $F(u)$ will give corresponding phase-shifting angle θ to phase shifting pulse unit with output 4 road PWM [10] wave with phase-shifting angle for θ to control single-phase inverter, if regulating U_g , then θ changes to regulate U_{dc} , if U_g is fixed, we can adjust the value of θ through output value of the PI controller to realize the power constant voltage output. Power supply output current is adjusted by using software PI, the control principle between constant current output and constant voltage output.

The control of constant current and constant voltage is realized through calculation and judgment for function unit $F(u)$. Given current and voltage value (I_g, U_g), output value of the PI controller (I_g', U_g') and actual testing voltage and current value (U_{dc}, I_{dc}) are input of $F(u)$, the power supply system is the constant current or constant voltage control through the calculation of the judgment for $F(u)$ to output PWM wave with corresponding phase-shifting angle θ . The calculation of $F(u)$ is:

- If $I_g=0$ or $U_g=0$, $F(u)=0$, no output of power;
- If $U_{dc} > U_g$, $I_{dc} > I_g$, no output of power;
- If $U_g \geq U_{dc}$, $F(u)=I_g'$, constant current output of power;
- If $U_g < U_{dc}$, $I_g \geq I_{dc}$, $F(u)=U_g'$, constant voltage output of power.

Through the calculation for $F(u)$, the power system realized the closed loop coordinated control of PI current regulator and voltage PI regulator, automatic changing of constant current operation and constant voltage operation and continuous adjustment of the power output voltage and current.

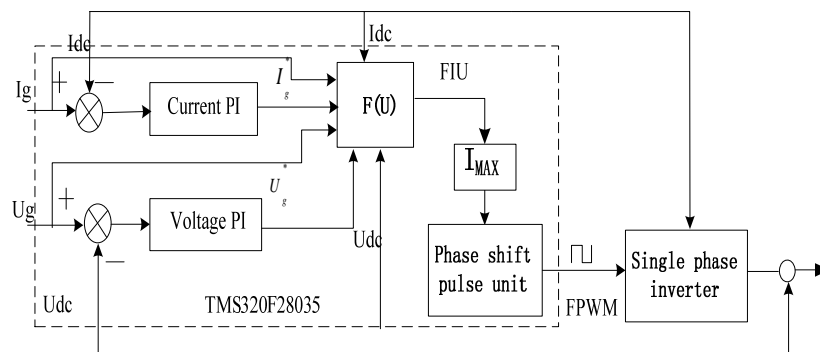


Figure 3. Control System Block Diagram Algorithm

3.2. Software Implementation of Control System

Power control system [11] makes the DSP TMS320F28035 as the core, it combines high-speed signal processing ability of DSP and is suitable for the optimized peripheral circuits of power control, the system has high cost performance. Using DSP internal rich integrated device can reduce DSP peripheral components. Its rich and powerful interrupt service system and frequently-used I/O interface make the algorithm programming convenient and greatly simplify the hardware circuit. Constant current constant voltage output system software flow chart is shown in Figure 4, it realized current PI regulator and voltage PI regulator coordinate closed-loop control through interrupt service program software design method.

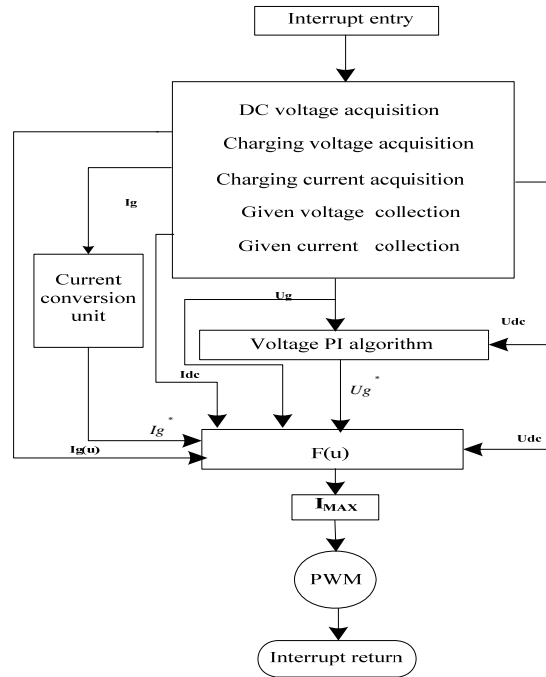


Figure 4. Interrupt Service Program Flow Chart

4. Results and Discussion

For the designed main circuit and control system of marine oil well testing DC power, we carried on the debugging, Figure 5 (including Figure 5(a) and Figure 5(b)) shows two road waveform for phase shift PWM, the other two ways completely complementary. Figure 5(a) shows the waveform as the phase-shifting Angle of 20°, Figure 5(b) shows the waveform as the phase-shifting Angle of 180°. The frequency of the phase shift PWM carrier waveform is 48K can be seen from Figure 6, the actual duty ratio is 47.5% because nof dead zone time. The power output voltage and current is continuously adjustable when phase-shifting angle changing from 0° to 180°, the power realized constant current constant voltage output and automatic switching through DSP PI regulator operation. Through the actual installation and operation test, the design of power supply can meet the requirements of practical application in anti-earthquake, moistureproof, electromagnetic compatibility and reliability, etc.

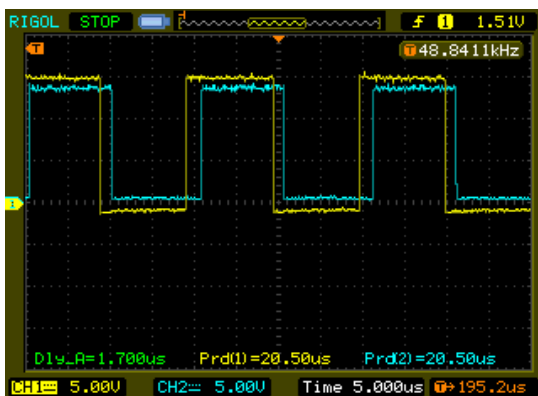


Figure 5(a). Phase-shift PWM Control Signal Waveform ($\theta=20^\circ$)

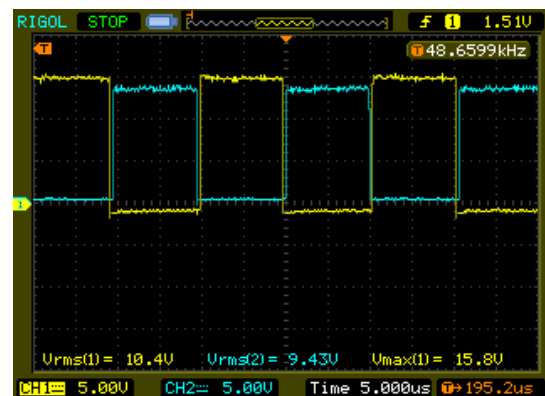


Figure 5(b) Phase-shift PWM Control Signal Waveform ($\theta=180^\circ$)

5. Conclusion

In view of marine oil well DC power supply, we developed main loop based on DSP TMS320F28035, control system and control algorithm, and realized the coordinated control of current PI and voltage PI. The designed control system of power supply has simple hardware circuit, modular design, quick current adjusted speed, good dynamic performance, convenient current voltage regulation, and constant current constant voltage operation and automatic switching. The design of this power supply device is novel with advanced technology and superior performance, it has popularization and application prospects in the industry of marine oil well testing.

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