The design and Implementation of Household Low-Power Inverter

Haifeng LIN, Ruili MAO, Hong WU
Beijing Information Technology College
Beijing, 100015,China

***Abstract*—This paper designs a kind of SPWM inverter power based on STM32. Through the boost link and SPWM inverter, get a high-quality sine wave AC that can set frequency and voltage. Based on the principle of Boost topology, using a high performance voltage type PWM control to drive the main circuit of MOS pipe. STM32 is as the system control core with 12 bit high precision D / A module precise control of output voltage. The system has good current protection function and intelligent detection load to control the work state of the system. Using embedded control technology has the advantages of simple structure for the power to control the whole system, realizes the digital and intelligent system. It can provides high quality AC power supply for the apparatus with high performance requirements.**

Keywords-Mathematics; Inverters; STM32 Single chip; Sinusoidal pulse width modulation; Voltage negative feedback;

I. INTRODUCTION

Nowadays, European countries and Japan, and other countries American government promote the implementation of solar photovoltaic projects, vigorously popularize solar residential areas, installing solar panels on residential roofs or on the wall [1-3]. Solar residential area in our country is also being developed. In this paper, the design of household photovoltaic inverter system is a residential, the system is suitable for independent power supply occasions, small household electrical appliances to meet the power demand for electricity. Selection of photovoltaic inverter system is a single-phase voltage source inverter, inverter main topology circuit adopts three tier architecture (DC-AC-DC), the DC-AC full bridge converter, high-frequency transformer, the isolation level after DC-AC full bridge converter. By software programming way to produce SPWM wave drive control power switch converter topology on tube, producing sinusoidal alternating current applicable. Since the STM32 series chip launched by semiconductor company use the latest ARM framework, it has advanced Cortex-M3 kernel with sleep 32 bit embedded processor, real-time performance, power consumption control outstanding, become the software system design of the chip choice. In this paper, the design of main topology in the control of inverter has different with the traditional way, find the control method can solve the fever serious problem for power switch inverter full bridge converter tube on the process of trying (MOSFE tube) work in the high frequency and high voltage conditions.

II. THE OVERALL SYSTEM STRUCTURE DESIGN

Figure 1 is a block diagram of the overall structure of the photovoltaic inverter system, system mainly composed of three parts of low voltage control module circuit, high-frequency step-up transformer, and high voltage control module circuit. The whole circuit is mainly completed work is the DC voltage of the solar panel output conversion for the household appliances work sinusoidal alternating voltage. The hardware design of the system relates to the strength of electrical binding, the work chip STM32F103VC in STM32 micro control system is CPU of the entire system in Figure 1, the chip work voltage is 3.3 V, the standard I/0 port can withstand voltage about 2 V-3.5 V, analog voltage device of low pressure port measurement but need to work with the system the STM32F103VC chip, thus adding a protection circuit module in the design of the system (i.e., an isolation transformer, a photoelectric isolation circuit), the low voltage control system and pressure control system is divided into two circuit board, which enable the basic safety and reliability for the whole circuit.

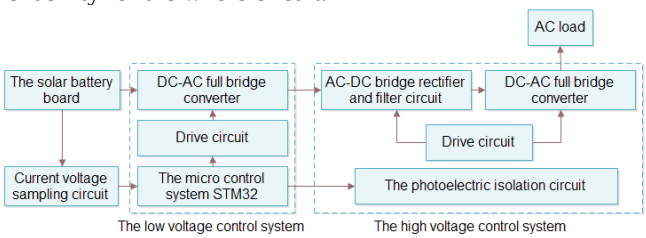


Fig.1 The overall block diagram of inverter

The photoelectric coupler in photoelectric isolation circuit have an input, output of more than 2.5 kV of electrical insulating ability, signal one-way transmission, strong anti-interference ability; the low voltage control system module includes a front stage DC-AC full bridge converter, a drive circuit, STM32 micro control system, the main work is the DC low voltage output by the solar battery board in the STM32 system to generate 4 SPWM wave to drive the power switch full bridge converter on the tube, so that the inverter for sinusoidal bipolar square wave pulse width variation of half wave table. Working voltage of the module is the actual amplitude of solar panel output voltage (about 12V), so the high-frequency transformer, the photoelectric isolation circuit and high voltage module work completely isolated, can effectively protect the micro control system; STM32; high voltage control system module comprises a bridge rectifier and filter circuit, DC-AC stage full bridge converter, photoelectric isolation circuit part, the module will

be the task of the sinusoidal high frequency transformer to boost after the half wave table width change bipolar square wave through the bridge rectifier and filter circuit converts the 100 Hz contains only positive half cycle sine wave, after class interval of full bridge converter tilting the positive half cycle to the negative half cycle into 220 V/50 H, sine wave. The entire system is around 320 V, in order to avoid the high voltage signal string into the low voltage module, the two modules of high pressure control system and low voltage control system is the key of design basis.

III. THE DESIGN OF SYSTEM HARDWARE

Figure 2 is the main power circuit topology circuit diagram of household photovoltaic inverter system, mainly is composed of the level of full bridge converter, high-frequency step-up transformer, a bridge rectifier, LC filter and the stage full bridge converter. The main system topology circuit adopts the traditional inverter topology design scheme, using the first start debugging the system is still the traditional control scheme, but in the process of debugging, found the power switch module circuit of high voltage control system of tube (MOSFET) work in the high frequency under the condition of high pressure hot serious, therefore, the paper proposed a control scheme of reverse, which can well improve the problem.

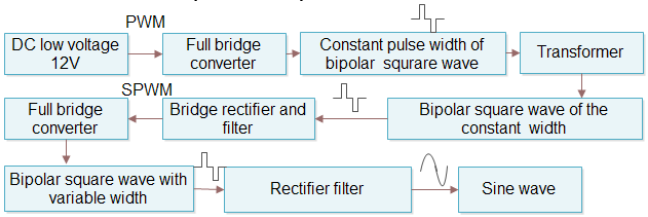


Fig.2 The traditional topological loop control chart

Figure 4 is a comparison of the traditional inverter control scheme, the main solution is the DC low voltage (solar panels or other power output) firstly through two pairs of complementary PWM wave control 4 power tubes on the stage full bridge converter bridge arm are converted into high frequency and low voltage side bipolar wave, then converted to high voltage direct current (amplitude is generally above 110 V) through the step-up transformer rectifier the filter circuit, and finally converts the sinusoidal alternating current of 220 V/50 Hz through the post stage full bridge converter rectifier filter circuit. Among them, two pairs of bridge arm on the level converter is respectively control by two pairs of complementary SPWM wave about 30 kHz drive, power switches in the stage on stage full bridge converter tube have high pressure tube under high frequency, power generating heat on the work in the environment. In order to alleviate hot power tube phenomenon, the paper use reverse control process that is as shown in figure 5.

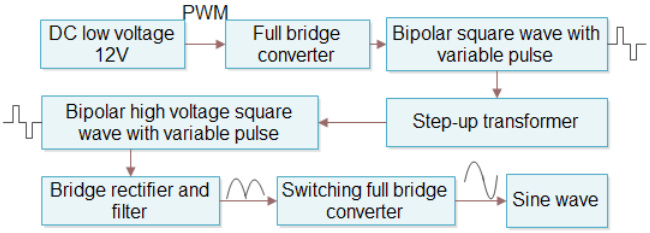


Fig.3 The main loop control graph is presented in this paper

Figure 3 is the control flow of ideas in this paper, and the difference lies different strategy before and after the two stage full bridge converter in the traditional control flow control: Figure 4 front stage full bridge converter directly using sinusoidal pulse width modulation algorithm to generate 4 SPWM wave to control the 4 power switching tubes. After the boost rectifier filter into the frequency of 100 Hz contains only positive half cycle sine wave; the biggest feature is the post stage full bridge converter as a flip of the switch, the switch frequency is 50 Hz, the full bridge converter on power two diagonal pair of tube every 20 ms turns turned on or off, will produce the positive half cycle sine wave flip interval to the negative half cycle standard sine alternating current.

IV. THE DESIGN OF SYSTEM SOFTWARE

The paper generate SPWM wave by the way of software, power main topology use phase shifting voltage full bridge inverter control strategy, figure 4 is the STM32 micro control system to produce two pairs of complementary phase difference of SPWM wave of 180 degrees, for driving and controlling the front stage full bridge converter. STM32F103VC chip senior timer TIM 1 has 4 independent output channels, can produce 3 pairs of complementary output PWM wave, and the dead time of the PWM output mode can be programmed.

Procedures for design ideas: set STM32F103VC TIM 1 timer as the PWM output mode of central alignment; TIM 1 cycle register TIM 1_ ARR, which makes PWM carrier wave frequency is 30 kHz; enable TIM 1 corresponding to CH1/CH1N, CH2/CH2N of two pairs of complementary channels, TIM 1 CH1, CH2 produced two phase difference 180. PWM waveform, the corresponding CH1N and CH2N generates two complementary PWM wave. At the same time, general purpose timer TIM2 set STM32F103VC to count up mode and configuration cycle register TIM2_ ARR, makes the TIM2 cycle counting T 20ms; enable comparison of TIM2 channel 1 interrupt, every T/64 generate an interrupt to read the corresponding pointer in the table of the sine wave pulse width value, update the TIM 1 TIM_ CCR1, TIM_ CCR2 the value of PWM wave width, update the corresponding values of W1, finally allows the TIM to produce two pairs of complementary phase 180. SPWM wave. Related process is as shown in Figure 5 (a) and (b).

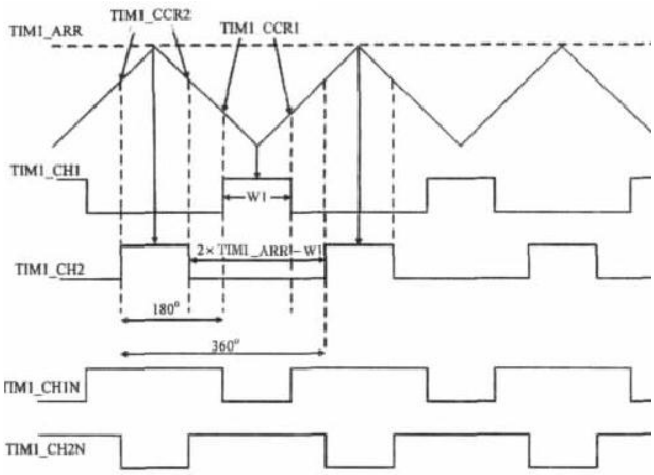
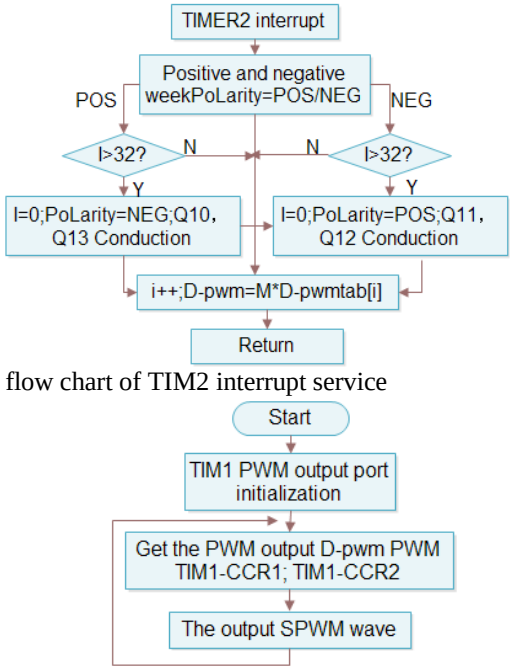


Fig.4 Phase shifter SPWM waveform



(a) flow chart of TIM2 interrupt service

(b) flow chart of TIM1 to produce SPWM wave

Fig.5 The software design process

V. CONCLUSIONS

This paper designed a small power household photovoltaic inverter system, the system power topological structure is as shown in figure 2. It's power supply by 100 W/12 V solar cell board, and suit for 220 V/50 Hz voltage electrical household appliances, SPWM carrier wave frequency is 30 kHz, the bus filter capacitor is 220 V /470uF electrolytic capacitor and CBB capacitor 105/630V with the power input end, the transformer primary turns and Secondary 1 turns ratio is 3:90, and the secondary turns ratio of 2 and 3 the is 3:4, the output filter inductance value is 1 036uH, a filter capacitor value is 3uF. High frequency transformer core with PQ3230, core docking not filling gap.

In order to verify the effectiveness of proposed control principle, Figure 6 is driving the front stage complementary full bridge converter left half bridge MOSFET tube two SPWM wave; figure 7 is a sine level after turning full bridge converter.

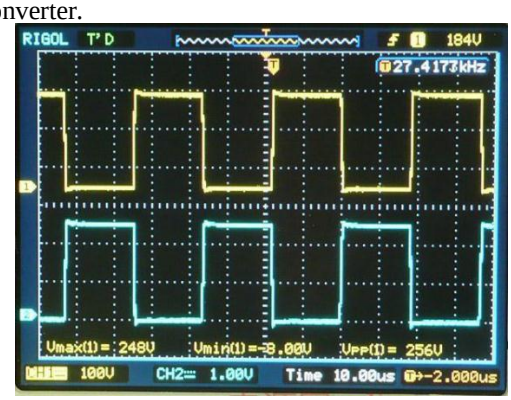


Fig.6 Two complementary SPWM wave

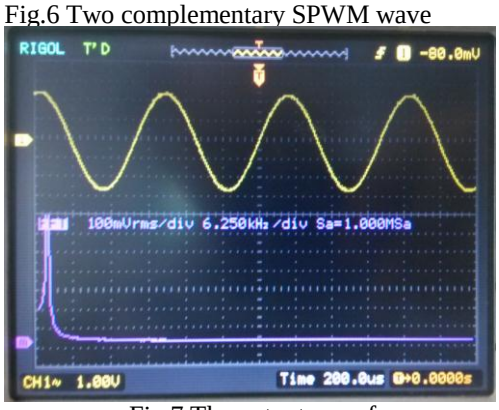


Fig.7 The output waveform

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