Inverter power supply design based on single chip microcomputer

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Abstract. The push-pull power boost and full-bridge inverter levels change in the control circuit, the first-stage booster circuit using SG3525 chip push-pull control, closed loop feedback; inverter part EG8010 complete SPWM modulation driver chip IR2110 be full-bridge inverter; after level output is sampled using a current transformer feedback, a double feedback loop, increasing the stability of the power; on protection, with output overload, short circuit protection, overcurrent protection, load protection and multiple protection features circuit, and enhance the reliability and security of supply; inverter power dependence of the clean, efficient, renewable solar energy resources, the use of solar photovoltaic cells lithium battery charging plate board, pre-24V lithium battery voltage through DC-DC conversion is about 400V DC high voltage, after the class by a full-bridge DC-AC circuit 400V voltage controlled by SPWM inverter is 220V, 50Hz AC sine standards for the use of electrical appliances.

Introduction

According to "China Renewable Energy Development Strategic Plan (2006-2020)" (draft) pointed out that China's future generation capacity planning objectives: by 2020 the total installed capacity of renewable energy 1.21×108KW, which total installed solar PV capacity up to 10× 105KW[1]. Research shows that one year to the total solar radiation on the earth's surface and 130 trillion tons of coal equivalent energy, solar total reserves can be called the greatest potential for energy development in the world today [2]. Under the strong pull "Bright Project" pilot projects and "power to the villages," engineering projects and other countries of the world PV market, the rapid development of China PV industry [3]. As the solar cell or battery is a DC power supply, when the load is an AC load, the inverter converts DC power into AC power is essential equipment. The so-called inverter, the rectifier means is the inverse transformation, the opening through the semiconductor power switching devices on and off action, the DC can be converted into AC power, a power conversion transpose [4].

Domestic power inverter by using frequency conversion method primarily transformation, frequency inverter is first transformed to produce 50Hz AC signal, and then use frequency booster produces 220V AC. This inverter is a simple structure, reliable operation, but this inverter is bulky, heavy, noisy, high prices, but also to be further improved efficiency [2][4]. With the development of power inverter and power electronics devices, high frequency inverters transform the way gradually inverter market. High frequency inverter power is transformed by high-frequency DC-DC conversion technology, low-voltage DC into high frequency low voltage DC, and then after a high-frequency step-up transformer is rectified into HVDC, HVDC if the sine transform, you can get 220V / 50Hz sine wave AC. This inverter control more links, circuit complexity, but because the use of high-frequency transformation, therefore, small size, light weight, low noise, high efficiency, renewable energy is the product of choice for power generation system [5][6].

Basic square wave inverter circuit is simple, but the output voltage waveform harmonic content is too large, that THD (current harmonic distortion) is too large; phase inverter circuit for multiple overlay THD improved, but the circuit complexity; and based on the positive selection of new single-chip pulse width modulation inverter technology to make up for these shortcomings, not only

harmonics decreases, the circuit is simple, controlled diversification, but also real-time dynamic output feedback, closed-loop control greatly improves the operation of inverter performance.

Principle and Calculation

A pulse width modulation inverter PWM (Pulse-Width Modulation) is made of a reference wave (typically a sine wave, a trapezoidal wave and may also use a square wave, etc.) to "modulation wave" (Modulation Wave), to N times positive modulation wave frequency triangle wave (sometimes with sawtooth) as "carrier" (Carrier Wave)[7]. Since the triangular wave or a sawtooth waveform of the vertical width of the linear change so that it intersects with the modulated wave, it is possible to obtain a set of equal amplitude and the width of the rectangular pulse train is proportional to the function value of the modulated wave is equivalent to the modulation wave, species replaced by analog switch, on-off control of the inverter switching tubes, the direct current into alternating current technology called pulse width modulation technology. If the modulation wave sine wave, triangle wave or sawtooth carrier, and called this modulation is sinusoidal pulse width modulation, the purpose is to generate SPWM signal.

Fig.1, a half sine wave N decile, can be seen as connected to each other the N pulse sequence, the width equal, but unequal amplitude, instead of using a rectangular pulse, amplitude, ranging from broad, overlapping midpoint, Impulse (narrow pulse area) equal to the duty cycle of the pulse series by sine law to change, so you can use the equivalent rectangular pulse to pulse being selected, and this is called SPWM rectangular pulse waveform. When the sine is maximum, the maximum pulse width, and the minimum interval between pulses, whereas, when the sine value is small, the pulse width is small, and the interval between pulses is greater, so that a waveform can SPWM the load current of the higher harmonic component is reduced greatly.

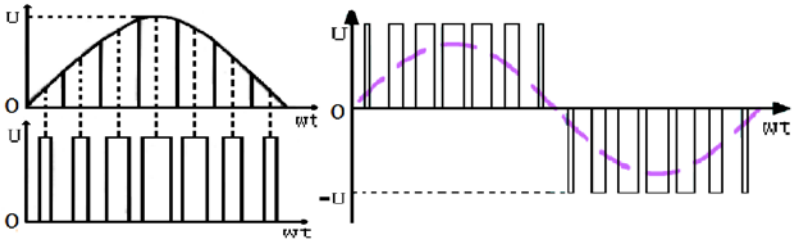

Fig.1 Sine waveform equivalent rectangular pulse sequence

Determines the reference wave frequency f_r is the output frequency f_o, the number of pulses per half cycle determined by the carrier frequency f_c. Changed by changing the reference sine wave amplitude modulation, output voltage peak from 0 to $U_{o\max}$ (maximum output pulse amplitude). If the j-th pulse width θ_j, effective value of the output voltage can be obtained:

$$\mathrm{U}_{\mathrm{outef}} = \sqrt{\frac{2p}{2\pi}\int_{(\frac{\pi}{p}-\theta)/2}^{(\frac{\pi}{p}+\theta)/2} {U_{o\max}}^2 d(\omega \mathrm{t})} = U_{o\max}\sqrt{\sum_{j=1}^{p}\frac{\theta_j}{\pi}} \tag{1}$$

Where p is the number of pulses per half cycle; θ_j is j-th for the first pulse width. The output voltage of the Fourier series expansion for:

$$U_0(t) = \sum_{n=1}^{\infty}(A_n \cos n\omega\theta + B_n \sin n\omega\theta) \tag{2}$$

The output voltage can be calculated by the formula on the Fourier series coefficients:

$$A_n = \sum_{j=1}^{p}\frac{2E}{n\pi}\left[\sin n\left(a_j+\theta_j\right) - \sin n\alpha_j\right] \tag{3}$$

$$B_n = \sum_{j=1}^{p}\frac{2E}{n\pi}\left[\cos na_j - \cos n\left(\alpha_j+\theta_j\right)\right] \tag{4}$$

Where α_j is the number of pulses per half cycle; θ_j is j for the first pulse width. The above description is unipolar SPWM wave parameters, eliminating all harmonic is less than or equal to 2P-1 times.

Hardware address software generation method is tedious calculations generation method, the disadvantage is not a real-time control and the proposed principle is that of the desired waveform as the modulating signal, the modulation signal as a carrier to accept, by modulating the carrier to obtain the desired SPWM waveform. You can use the analog circuits of the triangular wave carrier and sinusoidal modulation wave generating circuit, using a comparator to determine their intersection generate SPWM waves. Using SPWM chip peripheral circuit design is simple and easy to design feedback to improve the quality of the output waveform. This design uses hardware modulation methods, the use of models for EG8010 SPWM generation chip to complete the design.

The overall design of the solar inverter is mainly composed of lithium battery charge and discharge control circuit, PWM control and DC-DC boost circuit, power section SPWM driver and MOS tubes and overvoltage, undervoltage protection circuit. System block diagram shown in Fig.2.

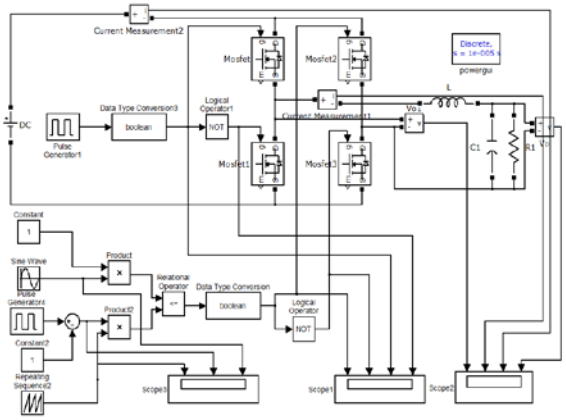

Fig.2 System Block Diagram

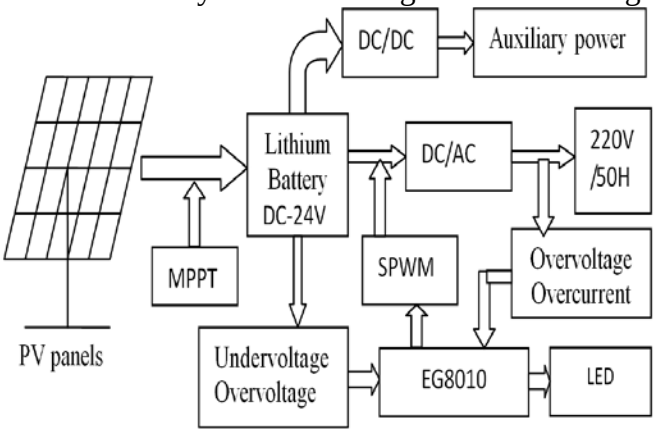

Fig.3 circuit simulation

The lithium group pre-24V DC-DC voltage by converting to 400V DC high voltage, after the class by a full-bridge DC-AC circuit 400V voltage controlled by SPWM inverter is 220V, 50Hz AC sine standards for the use of electrical appliances. In order to improve the power supply voltage regulation, load regulation and transient response characteristics, the choice of an ideal current-controlled PWM Controller SG3525 as the core control chip DC-DC boost circuit block diagram.

Simulation process

In order to verify the feasibility of the inverter design, reduce design flaws caused by subsequent losses, through the Matlab Simulink simulation capabilities can be easily and intuitively get results. Circuit was shown in Fig.3.

When unipolar modulation, tube drive waveform power switch as shown in Fig.4, part of the analysis is consistent with the DC-AC waveform, driving the same bridge arm opposite direction, one of them on the diagonal tubes do SPWM drive object, the other just sub input fundamental.

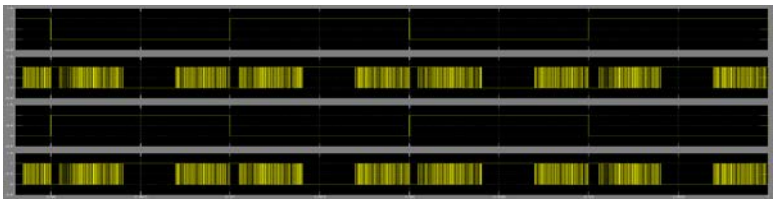

Fig.4 Power switch drive waveform simulation

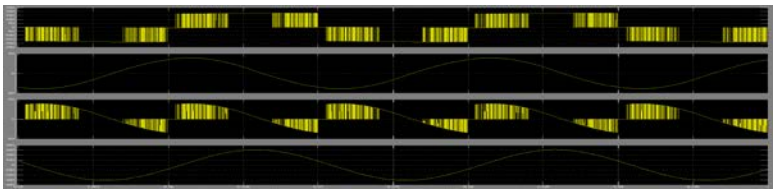

Fig.5 The simulation circuit output waveform

Waveform shown in Fig.5, respectively (top-down): H-bridge power MOSFET is turned on each other circumstances, it can be seen from the waveform, there is no pass-through phenomenon, and have a good dead-time control; load current waveform ; DC power supply loop current waveform; load voltage waveform, ie, after the AC waveform inverter. Waveform output derived from the theoretical basis of the inverter to verify the feasibility of the final output depending largely modulation effect and test the actual circuit.

Conclusion

Through theoretical design, hardware production, system commissioning, simulink simulation, produced a specific kind. Tested under voltage inverter input 22V, over-voltage 26V, the output voltage of 220V, 4.5%, the output frequency is 50Hz, 0.4%, efficiency can reach more than 90%, the power of 1000W, by selecting the device left margin, the instantaneous power can be up to 1500W, load adaptability. Able to effectively implement overcurrent, overvoltage, undervoltage protection function, the output voltage waveform is good, high efficiency, load adaptability. SG3525 binding EG8010 is used pure selection of new inverter drive scheme effectively to reduce harmonics and improve the purity of the AC output power, while guaranteeing a high current strong magnetic field environment is stable and reliable work. Experiments show that this scheme can be used as a solar power inverter production reference scenario, low cost, good performance, with some prospect of economic value.

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