DsPic33f Series Microprocessor Based Single-Phase Inverter Design and Implementation

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Abstract— The majority of the technological devices used with the development of the technology use the network voltage (220V-50Hz). Conversion must be done to obtain the mains voltage from the DC storage voltage sources. This conversion can be done by inverter. In this study, microprocessor-based inverter design is considered to transform the voltage from DC 12V battery to 50 Hz, 220V AC. The inverter circuit is designed as two different cards in the form of power and control circuits. Thanks to the filtering circuit connected to the output of the transformer on the power card, a smooth signal with a frequency of 50 Hz is obtained. The PWM signals used for sinusoidal generation of the signal are obtained by software based on the values in the previously created sinusoidal values table. Two separate alternating PWM signals were taken with increasing and decreasing order of table. As a result of applying these signals to MOSFET switching elements, sine wave signal is generated. The voltage value of the obtained sinus signal is amplified using the transformer. Filtering was performed to remove the noise generated in the raised sinusoidal signal and 200-220V pure sine signal was obtained.

Index Terms—, Single Phase Inverter, Microprocessor Control, DsPic, H-Bridge, .

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1 INTRODUCTION

Inverters are used in many industrial applications nowadays and become an indispensable element of industrial and energy based systems. The inverters are used to convert the DC voltage that they receive from sources such as battery, solar panel, used as DC source to AC source. Inverters are used in many areas such as motor control, uninterruptible power supplies, AC voltage sources, switched power supplies, induction heating [1]. Due to this reason, studies about inverters are increasing day by day and inverter technology is constantly evolving. Cost-reduced, locally designed and manufactured inverters are the preferred and accepted work for various AC power supply applications [2].

The inverters are designed and operated by using the DC input voltage so as to obtain the sinus signal in the first half period in the positive direction and in the second half period in the negative direction. The working period of the circuit is determined by positive and negative half-periods. Semiconductor elements such as BJT, MOSFET, and IGBT are used as switching elements in the inverters. These elements can be controlled by triggering with different switching techniques. İ PWM control technique is generally applied in inverters and most of today's inverters are PWM inverters [3-4].

The PWM control method is obtained by comparing the square wave or sine wave at a desired frequency and phase number with an alternative carrier voltage and this control method is called Pulse Width Modulation (PWM) [5]. There are three types of voltage-source PWM inverter main circuit: single-phase half-bridge voltage-source PWM inverter, single-phase full bridge voltage source PWM inverter and three-phase bridge voltage source PWM inverter [6-7]. By using a

transformer in the inverter system, both electrical isolation of the voltage is ensured and the output voltage is brought to the desired level. There are two types of transformers: Transformers producing output at mains frequency are heavy and large, High frequency transformers are small and light [8-9].

In the study, application of inverter circuit with single-phase voltage supply with transformer was carried out for network independent DC / AC power supply applications. The system is basically composed of control and power. Control and power card are designed. The dspic33fj32mc204 microprocessor was used for the control. PWM signals are generated from this control card and applied to the H-Bridge MOSFET switching elements in the power card. IR2112 type MOSFET driver integrations are used to enhance the signals required to drive the H bridge. The sine signal obtained from the H bridge is applied to the input part of the transformer and a system design is realized in which 200-220V voltage can be obtained from the output.

2 METARIAL AND METHODS

2.1 Inverter and Types of Inverter

Many different devices are used to save energy. All devices that convert alternating current to direct current or direct current to alternating current, and that adjust the voltages and frequencies properly are called inverters. The inverters do not generate electricity and pull all the energy they use from the battery. Figure 1 shows the flow diagram describing the operating principle of the inverter.
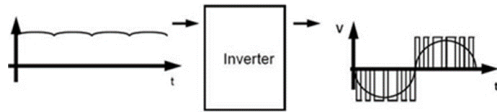
Figure 1. Inverter Working Principle

There are two types of inverters: a square wave and a full sine wave with a 220 volt AC output. The square wave inverter has an algorithm called Maximum Power Point Tracking (MPPT).

This algorithm, which is developed for maximum efficiency, automatically performs calculations on the current load in the system. Square wave inverter is suitable for low precision jobs such as lighting and heating. Square wave inverters can be used in household and kitchen appliances. A full sinusoidal inverter sets the incoming voltages and frequencies as a sinusoidal wave. Such inverters with operating frequencies of 50/60 Hz and efficiencies of 89% to 94% usually have a harmonic distortion rate of around 3%. Full sinusoidal inverter is advantageous for high loads and loads that with high starting current due to its high inductance capability.

2.2 PWM Types

PWM is a widely used method for adjusting the amplitude and frequency of the output voltage of an inverter [10]. Sinusoidal PWM (SPWM) and space vector PWM (SVPWM) techniques are the most widely used PWM techniques [11]. In the sinusoidal PWM technique, a reference sine signal is compared to a triangular wave signal that is larger than itself. In the comparison, the signal is generated by switching at intersecting points. Since the switching is done at high frequencies and the switching elements take a certain time to pass, the upper switch in the H-bridge MOSFET design must not pass through the lower switch before it is cut. Otherwise, the correct voltage at the input of the inverter will be short-circuit for a short time at this transition time. To avoid this, there is a short delay time called dead time during these transition times. After the interruption of the upper element, after waiting until the delay time, the lower semiconductor element is triggered by applying the trigger signal. Figure 2 shows the delay time (dead time) at the switch.
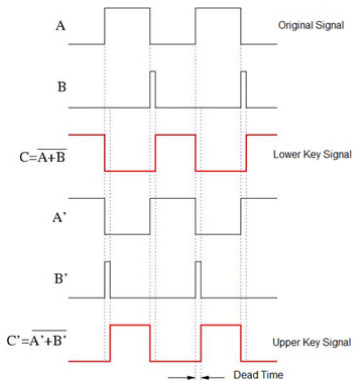

Figure 2. Time delay of switch (dead time)

3 DESIGNED INVERTER SYSTEM OVERVIEW

Turning the low-voltage DC power to AC is completed in two steps. The low-voltage DC power is converted to a high-voltage DC source and converted to an AC waveform using pulse width modulation (PWM) of the high DC source. As a different alternative, the low-voltage DC power is first converted to AC and then a transformer is used to increase the voltage to 220 volts. The block diagram of the designed inverter system is given in Figure 3.
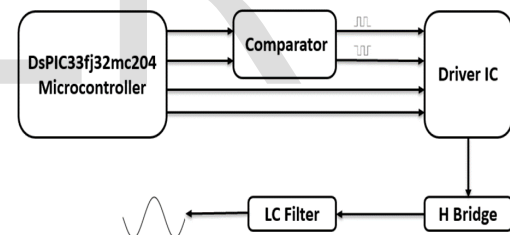

Figure 3. Block diagram of inverter design

As shown in the block diagram, the application of SPWM using a dsPIC33 series processor is discussed. The sinus signal was obtained by creating a sinusoidal waveform table. An alternation of this sinus signal consists of 256 values. The designed single-phase inverter system is shown in Figure 4.

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Figure 4. Single-phase inverter system

3.1 Circuit Design

The system consists of 2 cards including control and power card. The control board is the part where the PWM signals necessary for switching the MOSFETs in the H bridge circuit are generated via the microcontroller. The power card is the part where the drivers are sampled and where the MOSFETs are located. When the load is connected to the power card, the system is designed as 2 different cards to prevent damage to the control card due to excessive current draw. Figure 5 shows the design of the control board.
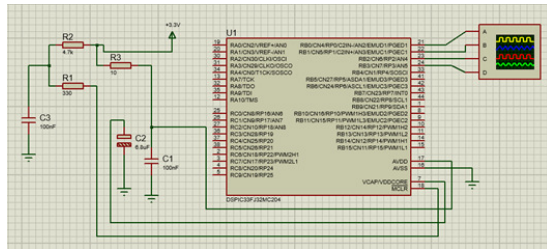

Figure 5. Control card design of the system

On the power card, H-bridge circuit topology is used and 4 NPN type MOSFET (Q1-Q2-Q3-Q4) switching elements are used. The IR2112 integration is used as the driver integration of these switching elements. These integrations meet the incoming 4 signals and trigger the MOSFETs according to the values they have taken from the sine table. The signal on the primary side of the transformer is distorted according to the sinus signal and there are parasites. First they are transformed to 220 V by transformer and LC filter application is done. With the filtering applied to the circuit, the sinus signal at the output is corrected and removed from the parasites. Figure 6 shows the design of the power card.
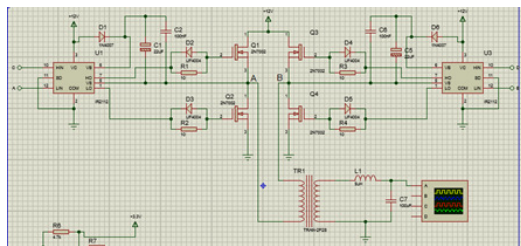

Figure 6. System power card design

4 EXPERIMENTAL RESULTS AND DISSCUSION

The output of the 512 pulsed sinusoidal waveform, which is generated at a switching frequency of 25 kHz, is as shown in Figure 7. For each alternans, it is necessary to pay attention to the alternans transition intervals called dead time with 256 pulse counts. Since the switching event is made at high frequency and the switching elements will take some time to cut, there is a 200 μS wait time (transition time) between the last pulse signal generated in the Q1-Q4 MOSFET and the first pulse signal generated in the Q2-Q3 MOSFET.
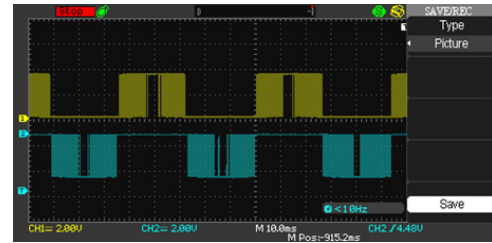

Figure 7. Square wave dashed by table values

The Q1 MOSFET, which is triggered by the pulse signals, must be triggered by the Q4 MOSFET that is crossed in order to be able to switch. Thus, sinusoidal pulse signals can be obtained from the points A and B of the MOSFETs that are triggered in pairs. After the MOSFETs are triggered, the signal from point A and B is shown in Figure 8 and the signal from transformer output after filtering is given in Figure 9. When measuring, it is seen that the probe is located at x10 and the signal's amplitude is about 200V. The signal is 6V - 50Hz voltage and it is a distorted signal before filtering. After the current signal filtering, it is observed that the sinus signal from the output of the transformer becomes smoother.
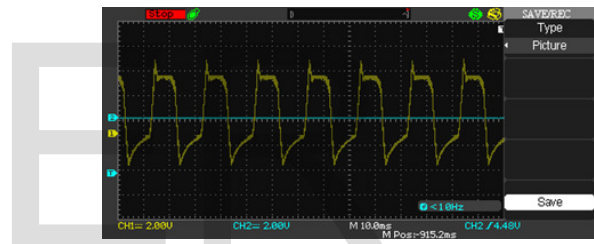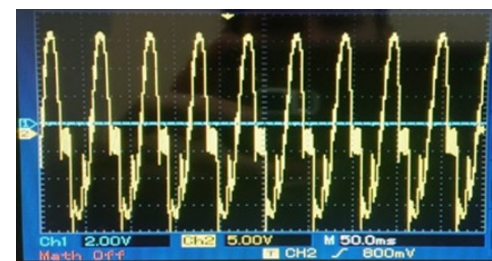

Figure 8. Sinus signal from points A and B

Figure 9. Sinus signal from transformer output

5 CONCLUSION

In this study, dsPIC microprocessor based single-phase inverter design was performed. It is aimed to obtain a sine signal voltage of AC 220V 50Hz by converting DC 12V voltage. By using the sine table, these values are converted to the pwm signal by the microprocessor and the sine signal is obtained. The system is designed to be basically composed of a control and power card. When the SPSM signals of the dsPIC processor are used on the control card, the control board triggered MOSFET drivers on the power board, resulting in low voltage AC output voltage from the MOSFET. Low AC voltage is transformed to 200V-220V by filtering H-Bridge circuit

output with transformer. A system implementation for systems that can operate with a single-phase AC signal has been implemented.

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