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Control of Single Phase Square Wave Inverter by SKYPER

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Abstract **–** The DC-AC converters are commonly known as inverters. It transforms direct current (DC) into alternating current (AC) at the desired output and frequency. Typically, the inverters are supplied by DC power source consisting of an electric power network and rectifier. A filter capacitor is added to the inverter's input terminals and provides a constant DC link voltage. The inverter behaves as an adjustable-frequency voltage source. Inverters can be divided into two classes voltage source inverters and current source inverters. The experimental setup, in this study, consists of a single-phase inverter and a full-bridge rectifier. The model is implemented using the MATLAB/Simulink program, utilizing the IGBT model as the switching device. The triggering process is executed using SKYPER32 PRO. The SKYPER platform is planned for robustness against external interference. Control of the IGBTs' ON/OFF switching state is facilitated by a Pulse Width Modulation (PWM) signal, integrated into the driver model for the control of the switching scheme. The experimental results verified that the SKYPER is successful in controlling of IGBTs for inverters by PWM.

Keywords – Inverter, Raspberry Pi, Matlab, IGBT, square wave

I. INTRODUCTION

The DC-AC converters are commonly known as an inverter which transforms direct current into alternating current at the desired output amplitude and frequency. The inverters are supplied by DC power obtained from an electric power network by using. A filter capacitor is used to obtain constant DC voltage input of the inverter. They behave as adjustable frequency voltage sources. Inverters are divided into two classes voltage source inverters (VSIs) and current source inverters (CSIs). Thyristors are operated as switches in VSIs. They require forced commutation turn off in the circuit. power MOSFETs, GTOs, power transistors, or IGBTs, which are used as switching elements in inverter circuits, provide self-commutation with base signals for controlled switching on and off.

Single-phase VSIs are designed as half-bridge or full-bridge circuits. VSIs are preferred in industrial applications such as AC drives and power supplies. Pulse Width Modulation (PWM) is applied to IGBTs to drive inverter. PWM signals are obtained from MATLAB/Simulink model download to Raspberry Pi.

The single-phase square wave VSI generates a square-shaped output voltage for a single-phase load. While inverters transfer power to the AC load, they are devices that also produce harmonics and disrupt power quality. Recently, microcontroller-based drive circuits have begun to be widely used instead of analog drive circuits.

A project utilizes a PIC16F73 microcontroller for generating a PWM signal which has a 4 kHz and uses STP55NF06 NMOSFET [1]. Another study proposes a passive LC circuit with robust second-order sliding mode control to increase the performance of the Maximum Power Point Tracking system [2]. Some authors have examined the advantages and disadvantages of single-phase inverter control methods and synchronization techniques in their studies [3]. One study attempted to solve the difficulties associated with the connection in a single-phase home grid of a grid-connected inverter that powered a low-voltage battery (48V) via a high-gain bidirectional converter [4]. In the literature, a double-input inverter design that can transfer electrical power from the photovoltaic panel simultaneously or separately has been designed [5]. Additionally, the authors made a critical review of various topologies based on common-mode behavior [6]. Eighteen well-known topologies are simulated and compared each other in view of performance.

In this study, a practical arrangement for a single-phase square wave inverter is formulated and controlled using a Raspberry Pi. Raspberry Pi's general-purpose I/O pins allow physical computing, allowing users to interact with the physical world and engage in creative hardware work [7]. In this context, the Matlab/Simulink platform is employed for programming the Raspberry Pi.

II. Single Phase Inverter Topology and Control

The power circuit Simulink model of single-phase inverter topology is given in Figure 1.

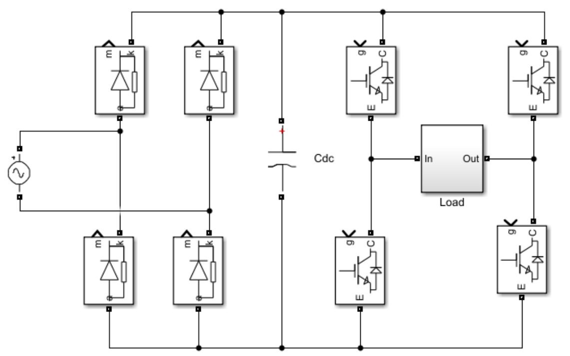


Fig. 1. The structure of the designed single-phase full-bridge VSI

In the full-bridge topology, the presence of 4 switches is vital. The AC output voltage is generated through the change between two branches of switching devices. The output voltage is obtained by equally opening and closing the cross arms of the IGBTs at certain time intervals within a period. DC voltages are obtained from single-phase uncontrolled rectifier. The output of the inverter works as a source for the AC load and transfers the power drawn from the grid to the load.

Instantaneous output voltage or load voltage can be written as below.

$$V_0(wt) = \sum_{n=1,3,5,}^{\infty} \frac{4V_{DC}}{n\pi} \sin(nwt) \tag{1}$$

RMS value of the fundamental component is calculated as follows.

$$v_{01(\mathrm{rms})} = \frac{4\,V_{DC}}{\sqrt{2}\pi} \tag{2}$$

A. *Pulse Width Modulation Control*

Internal control cards built into the inverter, eliminating the need for external control circuitry, can effectively manage the amplitude control of an inverter's output voltage. PWM control, which is widely used in the inverter, stands out as the most effective method of achieving this. In this application, a constant DC input voltage is given to the inverter and the production of AC voltage at the desired amplitude is achieved by regulating the on and off times of the switches. PWM control method provides great advantages. The first of these is providing control over the output voltage without the need for additional external components. Secondly, PWM contributes to minimizing low-order harmonics.

By using the PWM method, in case of open loop operation of the inverter, the output voltage is ensured to produce constant amplitude voltage needed for different loads. When pulse width modulation is used, reducing both the output voltage and harmonic content of the inverter and improving power quality can be achieved. The PWM block is utilized to produce a square waveform with a 50% duty cycle, a parameter that can be adjusted using a Raspberry Pi.

B. *SKYPER PRO Triggering Circuit*

SKYPER product, used in inverter control circuits, offers very good solutions for various applications in terms of durability and safety criteria.

The SKYPER family is engineered for resilience against external interference, surpassing the specified IEC standards, and incorporates an optimized interface with adjustable settings for enhanced flexibility.

The innovative SKYPER drive unit creates an interface between the IGBT modules and the controller, perfectly delivering the benefits of digital signal consistency while maintaining functionality. These devices have dual-channel IGBT driver units for 600, 1200 and 1700 V IGBT modules. The output current is 80 mA and a maximum switching frequency is 100 kHz. IGBT power modules up to 1000 A can be controlled safely. Additionally, SKYPER can drive external circuits for over temperature or overvoltage without requiring a separate power supply, facilitating independent transmission of error signals to the control unit.

III. Design of Single Phase Square Wave Inverter

In the application circuit, a single-phase rectifier is connected to the power network. DC voltage obtained from the rectifier is applied to the input of the single-phase inverter. Resistance is connected to the output of the inverter as a load to examine the out voltage. For security, the power network is isolated by a transformer and decreased to 24 V AC. Therefore, the input of the proposed system becomes 24 V AC.

Figure 2 illustrates the experimental setup. In this system, Raspberry Pi 4B [8] is used to produce PWM signals. These signals trigger the SKYPERs that drive IGBTs. For the first 5 seconds, a switch is used to charge and at the end, it discharges the capacitors. As shown in Figure 3, the designed inverter works well with constant triggering signals. In Figure 3a, the isolation transformer with current and voltage measurement screens is shown. In Figure 3b, duty cycle of the 8 kHz PWM signal is set to 0.45. This signal is demonstrated by blue lines. An interface board works in the complementary output mode and produces complementary PWM. It is demonstrated in Figure 3 that the system has input voltage as 23.6 V, and draws 0.610 A. The amplitude of the output voltage is red lines in Figure 3b. It shows that nearly 30 V square wave signal is obtained from the output terminal for a resistive load.

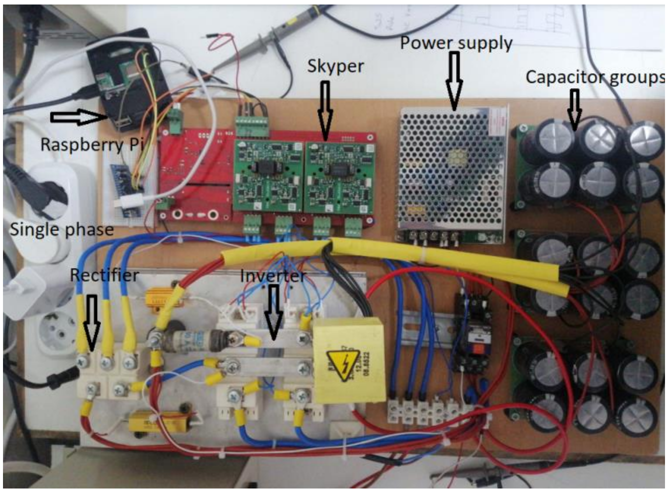
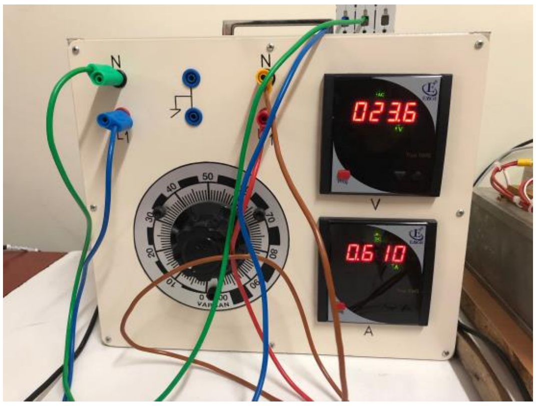
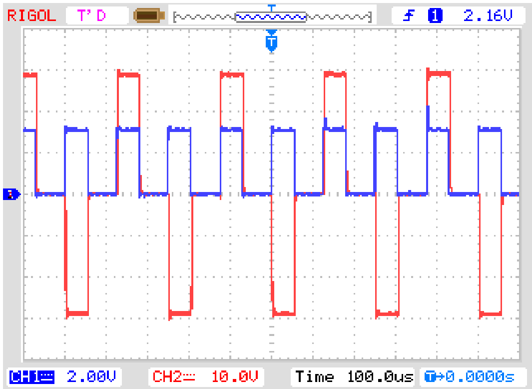


Fig. 2. The designed single phase VSI



(a)



(b)

Fig. 2. Experimental result of the designed system

IV. CONCLUSION

This study presents the design of single phase square wave inverter application. SKYPER PRO and electronics cards are used to adjust the output voltage of inverter. Raspberry Pi is used to produce triggering signals. It is demonstrated by experimental results that a clear voltage wave form is measured by the oscilloscope. The designed square wave inverter performs well in producing high frequency output.

Acknowledgment

The heading of the Acknowledgment section and the References section must not be numbered.

References

[1] A. A. Mamun, M. F. Elahi, M. Quamruzzaman, and M. U. Tomal, "Design and implementation of single phase inverter," *Int. J. Sci. Res.*, vol. 2, no. 2, pp. 163–167, 2013.

[2] B. Guo *et al.*, "Optimization design and control of single-stage single-phase PV inverters for MPPT improvement," *IEEE Trans. Power Electron.*, vol. 35, no. 12, pp. 13000–13016, 2020.

[3] D. Mathew and R. C. Naidu, "A review on single-phase boost inverter technology for low power grid integrated solar PV applications," *Ain Shams Eng. J.*, p. 102365, 2023.

[4] A. Patel, S. K. Yadav, and H. D. Mathur, "A Single-Phase Grid-Tied Converter System Integrating Solar PV, Battery and Compensating Power Quality," in *2023 IEEE IAS Global Conference on Renewable Energy and Hydrogen Technologies (GlobConHT)*, IEEE, 2023, pp. 1–6.

[5] M. A. Gaafar, M. Abu-Zaher, M. Orabi, and F. Zhuo, "Single-phase dual-input split-source inverter for photovoltaic systems," *Electr. Power Syst. Res.*, vol. 221, p. 109397, 2023.

[6] M. F. Kibria, A. Elsanabary, K. S. Tey, M. Mubin, and S. Mekhilef, "A comparative review on single phase transformerless inverter topologies for grid-connected photovoltaic systems," *Energies*, vol. 16, no. 3, p. 1363, 2023.

[7] E. Ilten, H. Calgan, and M. Demirtas, "Fuzzy Logic Level Control of a Coupled Tank System with Raspberry Pi Application," in *2nd International Conference on Contemporary Academic Research*, 2023, pp. 61–65.

[8] E. Ilten and M. Demirtas, "Fuzzy Logic Position Control of DC Motor with Raspberry Pi and Real-Time Monitoring on Simulink External Mode.," in *1st Bilsel Int. World Sci. Res. Congr World Sci. Res. Congr*, 2023, pp. 189–195.