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DSP based Voltage Source Inverter for an application of Induction Motor control

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Abstract. The paper presents a Single-phase inverter configuration dependent on IGBTs utilizing a Digital Signal Processor by the SPWM method. The equipment configuration is actualized utilizing IGBT Inverter Module. The equipment results are examined in the paper. The IGBT, which requires 15v of activating pulse to their individual gates, is taken care of through the isolation circuit. The circuit is intended to enhance the pulse from the DSP controller, up to the necessary abundancy, and goes about as an isolation circuit. The inverter input is given through the DC rectifier circuit with consistent voltage, and the output is Controllable AC with variable voltage and frequency.

1. INTRODUCTION

The transformation of Direct current into an Alternating current is done by a procedure called Inversion, and a gadget is called an inverter. Inverters are predominantly actualized where DC power needs to take care of into AC loads. Inverters have a significant impact on power electronics innovation and drives, for example, AC motor speed control. PWM strategy is most ordinarily utilized in Inverter Innovation. The PWM based inverters have more predominance than different kinds of inverters. PWM is produced from various sorts of controllers, here DSP Launchpad is utilized. The qualities of the PWM wave establish that the output voltage contains harmonics. Resonant filters are utilized at the inverter output terminals to alter the output voltage and current waveforms direct sine wave shape and decrease the nearness of harmonics on the load.

2. INVERTER

In general, there are two kinds of inverters, voltage source inverters (VSI) and current source inverters (CSI). At the point when an inverter has a consistent DC voltage source at its entering terminal, it is known as a VSI. At the point when the inverter DC source has a firm DC current source, the inverter is known as a CSI.

2.1 Half-Bridge Inverter

On account of RL load, the opposite load current moves through the diodes. They offer a substitute way to an inductive current, which proceeds so stream during the Turn OFF condition.

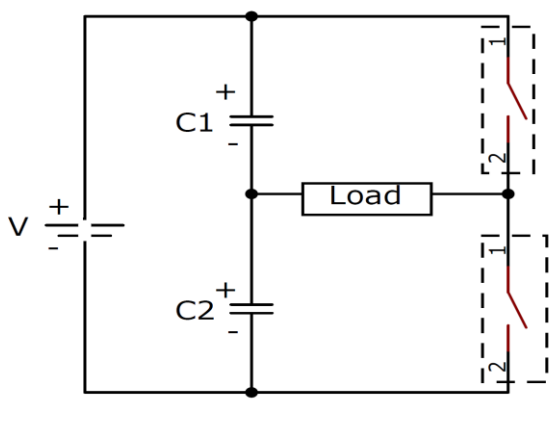


Fig.1. Half-bridge inverter

2.2 Full-Bridge Inverter

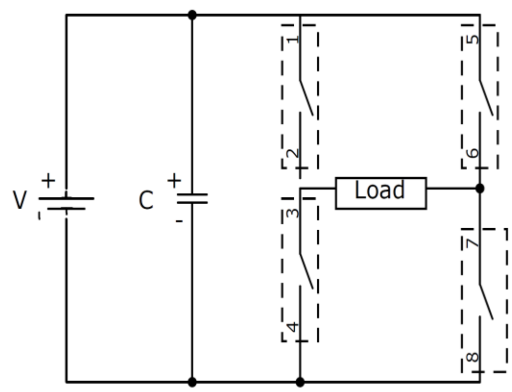


Fig.2. Full- Bridge Inverter

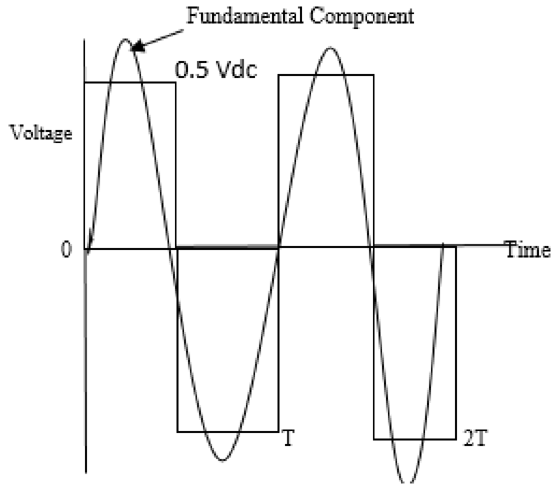


Fig.3. The voltage waveform of a Half-Bridge inverter

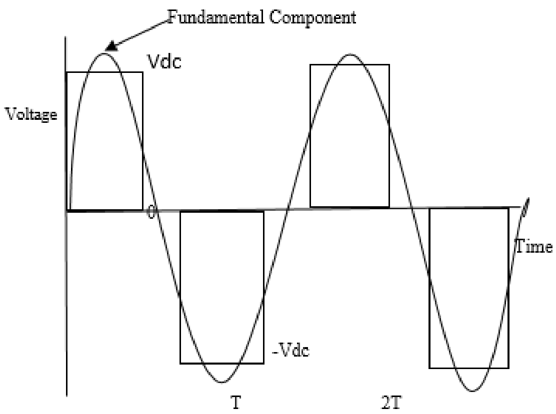


Fig.4. The voltage waveform of a Full-Bridge inverter

The load voltage representations shown in the above figures can be determined mathematically as

$$V_{xo} = \sum_{n=1,3,5}^{\infty} \frac{2V_{dc}}{n\pi} \sin(n\omega t) \quad (1)$$

$$V_{xy} = \sum_{n=1,3,5}^{\infty} \frac{2V_{dc}}{n\pi} [\sin(n\omega t) - \sin n(\omega t - \varphi) \quad (2)$$

$$V_{xy,1} = \frac{4V_{dc}}{\pi} \cos(\omega t - \frac{\varphi}{2}) \sin\frac{\varphi}{2} \quad (3)$$

$$V_{xy,rms} = 0.9V_{dc} \sin\frac{\varphi}{2} \quad (4)$$

As the PWM greatness differs, it brings about the difference in yield voltage.
In a full-connect inverter, IGBT's are utilized as switches that have appropriate qualities as required for the application. An IGBT is a unidirectional device, and it can just turn ON the forward way. For a single-phase inverter, it requires four signal contributions for each gate terminal of IGBT. Two signals at HIGH and the other to its complementary state.

3. ISOLATION CIRCUIT

The isolation circuit is one that assigns Pulse Width Modulation signals to inverter switches accordingly. A primary objective of an isolation circuit is to amplify the PWM signals and to isolate the DSP microcontroller from the inverter when the signal voltage exceeds. Fig.5 shows a functional pattern of a primary control circuit related to a dead-band and isolation circuits

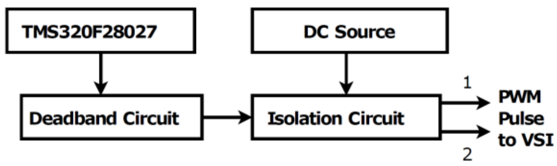


Fig.5. The Functional pattern of a controller circuit

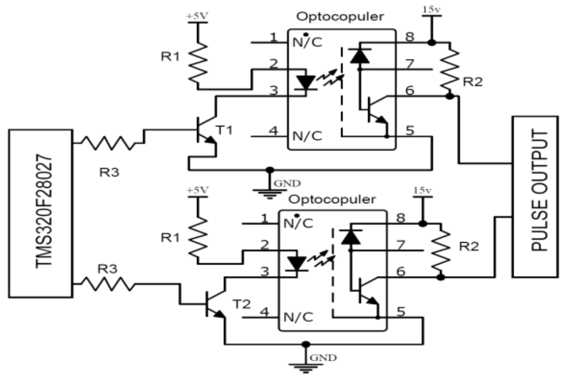


Fig.6. Schematic representation of an isolation circuit

3.1. Sinusoidal pulse width modulation

In the SPWM method, there are various quantities of output pulses per half cycle, and of the distinctive pulse width. The width of each pulse is fluctuating with respect to the plentifulness of a sine wave assessed at the Focal point of a similar pulse.
The rms ac output voltage

$$v_o = v_s\sqrt{\frac{p\delta}{\pi}} \rightarrow v_s\sqrt{\sum_{m=1}^{2p} \frac{\delta_m}{\pi}} \quad (5)$$

Where P = Total pulses and δ = Pulse Width

3.2. Dead-band circuit

TMS320F28027 can create the PWM signals in the wide range from a couple of 1 Hz to 100 kHz. In any case, because of a tremendous scope of PWM signals, now and again, the force switches may not recognize the required sign correctly, and this may prompt dormancy of the entire framework. To forestall such an issue, it is prescribed to gracefully a dead band for a brief period. Fig.7. Displays the G1 and G2 pulses got from a dead-band circuit.

Fig.7. The Dead region from a dead-band circuit

The PWM signals with the dead area are created from the dead-band circuit appeared in Fig.8. The output signals from the dead band circuit are given to an isolation circuit in this manner; it went to the switches.

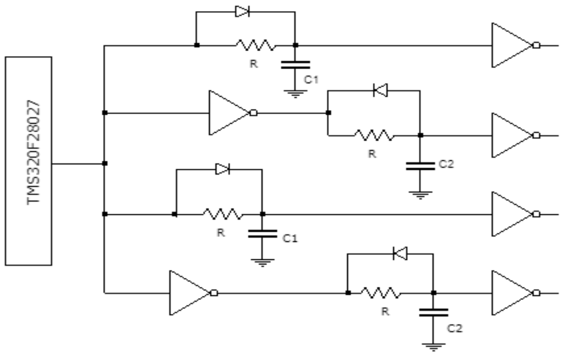


Fig.8. Schematic diagram of a dead-band circuit

The DSP TMS320F28027 launchpad is utilized for producing SPWM pulses. By thinking about the measures, the 50 Hz frequency is accomplished through a period time of 20 milliseconds (f= 1/T), the signals are to be produced inside the predetermined 20ms, which are similarly appropriated into 10ms HIGH and 10ms LOW. In the commonsense execution process, the applied program is formed and dumped into the DSP module utilizing CCS studio. At first, the output waveforms are found in a CRO to get exact and linear activating pulses, additionally limiting the errors.
The filter circuit is intended to decrease the harmonic levels at the output terminals before associating with burdens to secure a straight and unadulterated Sinusoidal Wave.

4. LC Filter

The L-filter accomplishes low attenuation of the inverter, a capacitor in parallel is expected to an extra lessening of the switching frequency. The frequency is determined from the condition given underneath

$$f_o = 1/2\pi\sqrt{LC} \quad (6)$$

The L decides the wave in the inductor current and lessens the low-frequency harmonics. The voltage over the inductor is:

$$V_L = V_{Ia} - V_{ga} \quad (7)$$

where V_{Ia} = Input Voltage and V_{ga} = filter output

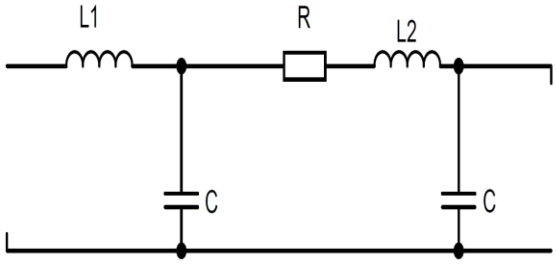


Fig.9. L-C filter topology

To calculate the inductor current, the values of VIa and Vga are expressed in equations given

$$VIa = 2/3V_{DC},\ V_{ga} = 1/2V_{DC} \quad (8)$$

$$V_L = 2/3V_{DC} - 1/2V_{DC} = 1/6V_{DC} \quad (9)$$

Line-to-Neutral Voltage

$$V_p = \frac{V_l}{\sqrt{3}} = \frac{\sqrt{2}V_s}{3} = 0.4714V_s \quad (10)$$

5. HARDWARE AND RESULT ANALYSIS

The expected equipment for the inverter is created, as appeared in Fig.10.schematic presentation. It is actualized in equipment with an isolation circuit, AC source, DC rectifier unit, IGBT module, TMS320F28027, Dead-band circuit, and an induction motor. The equipment arrangement is created, and results are confirmed by breaking down the qualities at various levels. A schematic appeared in fig.10 clarifies the framework of the inverter activity. Fig.11. Shows the inverter's equipment arrangement with outside DC source, IGBT module with associated capacitor bank, rectifier unit, Isolation Circuit, TMS320F28027 microcontroller, heat discharge fan, and measurement hardware with protection circuit. The voltage source inverter input is associated with the rectifier unit from AC mains of 240V. The Voltage from the DSP Launchpad is of just 2V appeared in fig.12(c). Be that as it may, as a prerequisite for the activating of IGBT's, the pulse required is 15V. The enhancement of the pulse adequacy is accomplished utilizing the amplifying or isolation circuit, which is planned to utilize Optocouplers and Transistors. An Isolation circuit is used to give protection between Driver Circuit and Power Circuit. The optocoupler is functioning as an isolating component in a circuit going about as an interface between the control circuit and the power circuit. The power circuit is given with more than 200V, and the conduction way can be hindered by separating the control or Isolation circuit.

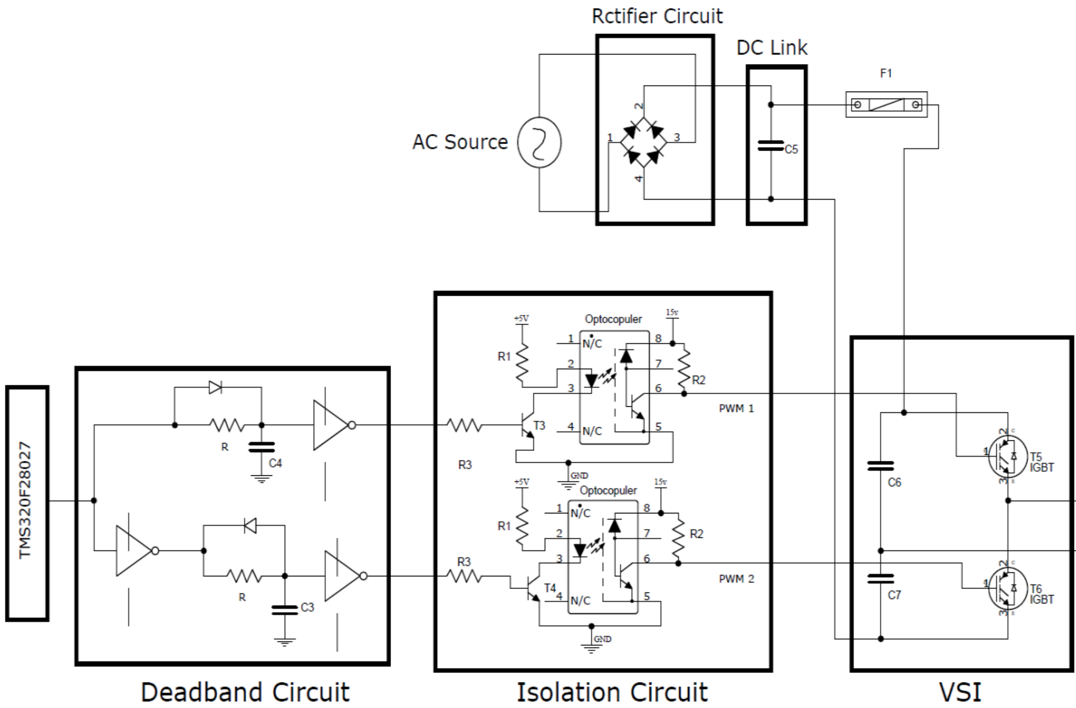


Fig.10. The schematic diagram for the inverter circuit

The IGBT switches module is associated with the Capacitor bank to keep up the steady voltage to be altered without interferences. The arrangement is outfitted with a thermistor, when overabundance heat produces while exchanging the cooling fan is naturally transformed on by switching the relays without hesitation by giving the thermistor signal.

At first, 12(a) demonstrates the non-inverting Pulses and its complementary pulses given to the switches S1S2 and S3S4 separately. Fig.12 (b) represents the PWM pulses with the dead band interference of 20µs I .e.50Hz exchanging recurrence. Fig 12(c) shows the 2v output from TMS320F28027. Also, 12(d) shows the enhanced 15v yield from the isolation circuit.

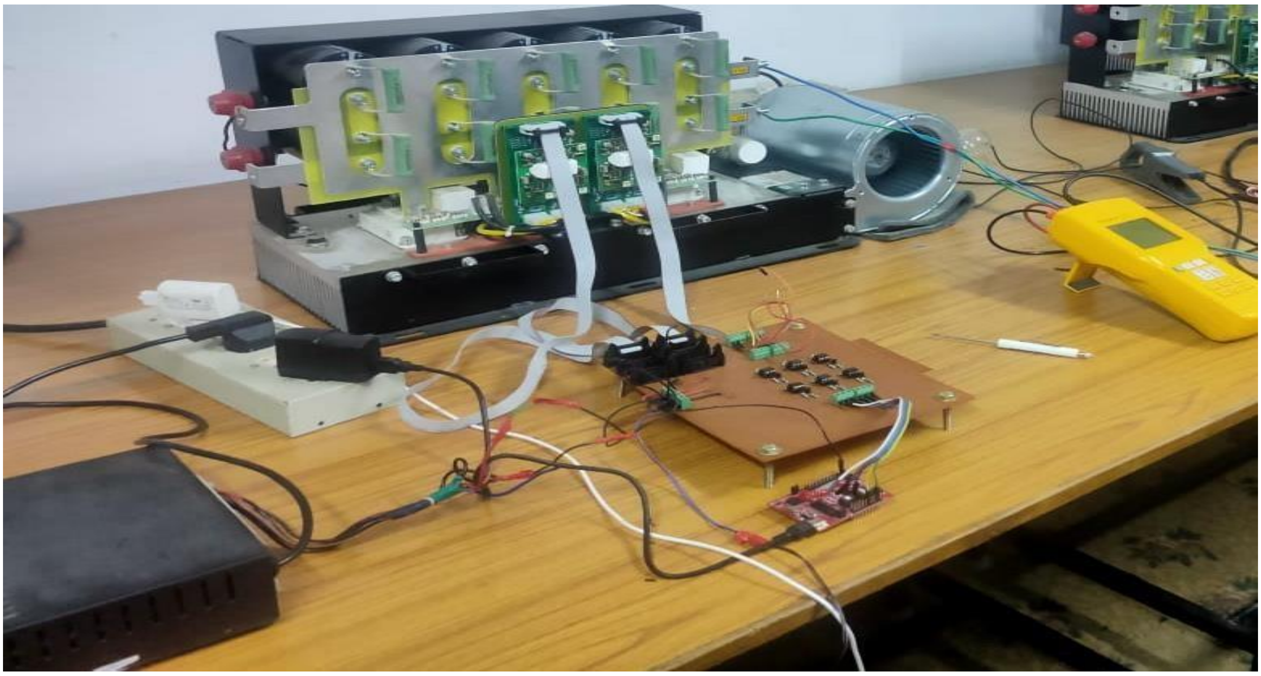
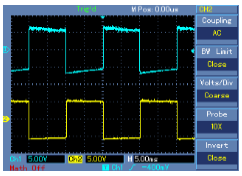
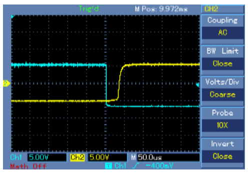


Fig.11. Hardware Implementation of Inverter

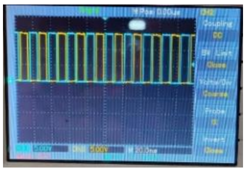


12(a)Pulse by microcontroller



12(b)Delay by Dead-band

12(c) 2v pulse from MCU



12(d) 15v pulse output

The resultant output of an inverter is a commonly square wave. The exhibition of the inverter is trialed without filters, and an induction motor of appraisals 230V and 1500watts is utilized as a load to withstand the harmonics nearness and non-linear sinusoidal waveform brought about by a variety of PWM. Fig.13 shows the output voltage, frequency, and harmonics presence in output terminals.

Fig.13. Hardware output voltage and frequency

The VSI with load execution examination appears in table.1.

Sl.No	Amplitude modulations	Output Load Voltages in Volts	Speed of IM in rpm
1.	1	237	1375
2.	0.8	228	1242
3.	0.6	214	1308
4.	0.4	209	1190

Table.1.Output load voltages with different amplitude and modulations

The further investigation of changing over square wave voltage separated into sinusoidal wave voltage by receiving a low pass filter with the arrangement of inductance L and shunt capacitance C are finished utilizing the MATLAB Simulink programming, where the outcomes have appeared in fig.14.

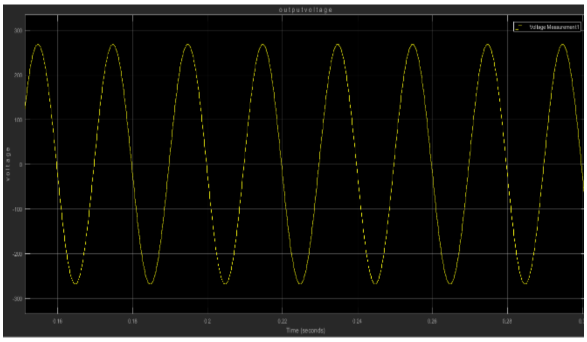


Fig.14. Simulation output of VSI with filter

6. CONCLUSION

The project Clarifies, single-phase voltage source inverter execution utilizing Digital Signal Processor TMS320F28027 Launchpad. The DSP controlled SPWM, took care of into the IGBT's, which creates the square type AC voltage waveform with various pulse widths in every half-cycle. The whole dead-band circuit can be dumped into DSP by giving the appropriate program. The voltage source inverter output can be sinusoidal with the shunt LC filter circuit used to regulate the voltage diminishing the Total Harmonic Distortion, which prompts smooth and reliable operation of the load. Along these lines, it tends to be summed up that TMS320F28027 DSP Launchpad is utilized proficiently for Voltage Source Inverters and flexible loads like Dynamic Voltage Restorer, Induction Heating and Controllable Loads.

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