# IMPLEMENTATION OF 3.5KVA PURE SINE WAVE INVERTER WITH dsPIC MICROCONTROLLER

by

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**ABSTRACT**
*The inconsistency of power supply in Nigeria has led to research in the quest of finding solutions in the power sector. The aim of this paper is to design and implement a pure sine wave inverter which can convert DC voltage to AC voltage at high efficiency and low cost. A dsPIC30F2010 microcontroller was used to generate the digital pulses needed to drive the H-bridge, which is made up of MOSFET drivers. By alternate switching the two arms of the H-bridge, the 48V DC voltage is converted to 34V AC voltage which is then boosted to 220V AC by the transformer. A low pass filter was used to filter out the high frequencies and thus isolate the harmonics so that a pure sine wave with 50Hz fundamental frequency was retained. Thus, the inverter produced a 220V, 50Hz AC output which can now be used to power any electrical/electronic equipment.*

**Keywords/Phrases:** *Mosfet, microcontroller, inverter, power, electricity, transformer, filter, voltage.*

## 1. INTRODUCTION

Electricity is indisputably an important facility that is crucial to a nation's economic development. It is beneficial to the smooth running of activities carried out in businesses, industries, hospitals, schools and homes all over the country (Savita Nema, 2019).

Due to the erratic nature of power supply in Nigeria, having an alternate means of power supply has become a necessity for all Nigerians. This can be achieved with the use of an AC-DC inverter and it can be used to operate any residential and commercial equipment (A. M. Thu and K. S. Lwin, 2017).

To design an inverter, many power circuit topologies and voltage control methods are used. The most important aspect of the inverter technology is the output waveform. The output voltage of a voltage source inverter (VSI) can be controlled through with the use of various switching devices to make it ideal for all types of loads (Isizoh A.N. 2020).

The works by utilized a Switch Mode Power Supply IC (SG3524) to generate the signal for the MOSFETS which helps to drive the transformer to produce an alternating waveform. With the need to implement additional functionalities such as overload control to the inverter, the use of Programmable Integrated Circuit (PIC) microcontrollers in inverter design was explored by M. Ehikhamenle and R. O. Okeke (2017).

The work presented in this paper explored the use of a dsPIC (Digital Signal Programmable Integrated Circuit) microcontroller which offers more advantages than the PIC microcontroller (P. A. Swati and N. Wagh 2016) and G. Ofualagba and K. C. Igbinoba (2021).

## II. METHODOLOGY

The system operates in two modes; Inverting mode and charging mode. At inverting mode, the system the DC source to AC signal which is used to power AC loads. In the charging mode, the system uses the mains AC signal as a source to charge the battery which is accomplished by the use of a rectification circuit that converts the AC signal to suitable DC signal for charging of the battery.

The inverter circuitry can be classified into two stages namely control stage and power stage.

### 2.1 CONTROL STAGE

This is the section that contains the changeover section and monitors the voltage, current and temperature levels to display accordingly. The battery voltage is sensed by using a voltage divider, hence reducing the voltage reaching the microcontroller pin by some factor. This circuit is required to be able to cut off the output when the voltage is less than the acceptable voltage of 45V and to cut off charging when the voltage is above the acceptable 55V. The output voltage sense is achieved by using series of resistors to lower the output voltage to a safe working voltage after passing through a rectification diode.

To ensure that a continuous and alternating waveform is being produced a digital signal processor, dsPIC30F2010, is utilized. It produces an AC-like waveform operating at 50HZ. This microcontroller was chosen for its faster processing speed, improved flash program and use of 16-bit for signal processing.

### 2.2 POWER STAGE

A simple circuit, containing a pair of four switching elements, with the load(transformer) at the center, are connected in a H-like configuration. The switching elements utilized was the MOSFET IRF4110 due to its fast switching response and because of its ability to handle higher voltages.

For the MOSFET switch to be turned on, the voltage at the gate terminal must be 10V higher than the drain terminal voltage. The drain of the high side device is connected to 48V DC power which is to be inverted into the 220V AC power. This is a problem because the 48V is the highest voltage in the system therefore, to drive MOSFETs in the H-Bridge, MOSFET driver IC is used with a bootstrap capacitor specifically designed for driving a half-bridge. For this design the TLP250 MOSFET driver was chosen, it is rated at 600V, with a gate driving current of 2A and a gate driving voltage of 10-20V. The turn on and turn off times are 120ns. The MOSFET driver operates from a signal input given from the microcontroller and takes its power from the battery voltage supply that the system uses. The driver is capable of operating both the high side and low side MOSFET, but in order to get the extra 10V for the high side device, an external bootstrap capacitor is charged through a diode from the 48V power supply when the device is off. Because the power for the driver is supplied from the low voltage source, the power consumed to drive the gate is small. When the driver is given the signal to turn on the high side device, the gate of the MOSFET has an extra boost in charge from the bootstrap capacitor, surpassing the needed 10V to activate the device and turning the switch on.

The switching device to be used Is determined by considering one that can handle at least twice the value of the maximum current and output voltage.

$$maximum\ current\ required = \frac{P}{V_{input}} \quad ..... (1)$$

$$Number\ of\ MOSFETs = \frac{P}{V_f} \quad .......... (2)$$

Where:
P = inverter power rating
$V_{input}$ = input voltage
$V_f$ = MOSFET handling voltage

The eight switching elements can be turned on and off independently (though there are some restrictions) to generate an AC voltage which is then boosted to 220V by the transformer. This is the typical voltage rating of any residential appliance.

An L-C low pass filter is used to filter the output of the transformer to ensure that a 220V pure sine wave signal is produced. The goal for this is to bring the critical frequency as close as possible to the desired 50Hz, removing other harmonics that crops up with the system.

$$L = \frac{\Phi}{NI} = \frac{BA}{NI} \quad .................. (3)$$

$$C = \frac{1}{4\pi^2 f^2 L} \quad .................. (4)$$

Where:
f = cut-off frequency = 50Hz
L = secondary winding inductance
C = shunt capacitor
Φ = flux linkage

When the inverter senses mains supply, the changeover section switches the inverter mode of operation. Here, the inverter operates in the charging mode; in the switching section, the MOSFETs switches only on one side of the H-Bridge. The transformer functions as a step-down transformer to reduce the 220V to 48V signal. Then the MOSFETs switch this signal only in one direction, thus, converting the AC signal to a DC signal.

The changeover is implemented using a relay circuit. The relay circuit is controlled by dsPIC30F2010 such that when there is power from the mains, the microcontroller sends signal to the relay circuit to switch the inverter

  

circuit to mains for charging and also to supply the load.
A schematic representation of how the different stages in the inverter are interconnected can be seen figure 1.

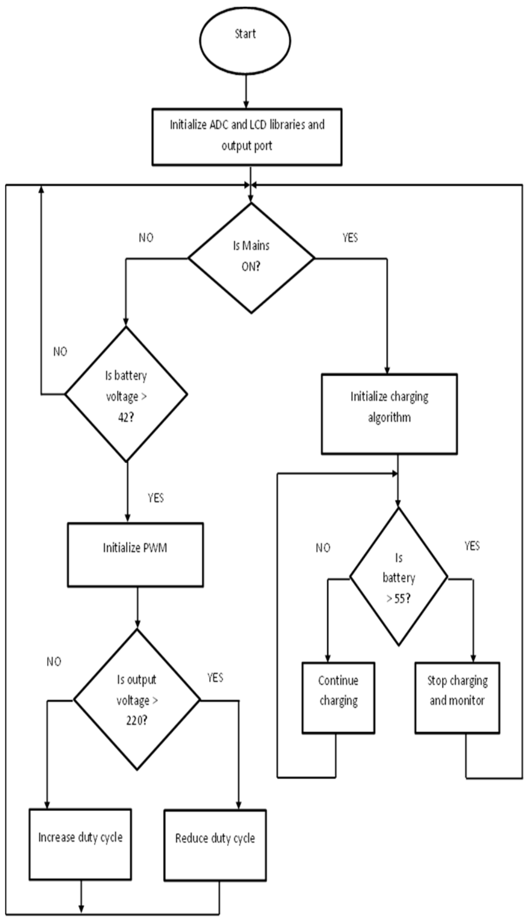


**Figure 1: Schematic Representation of How Different Stages in the Inverter are Interconnected**

## III. RESULT AND DISCUSSION

The circuitry was implemented in accordance with the different parts of the inverter system – control stage and power stage. These parts were implemented separately and tested so that once all the parts have given the desired results, they are integrated to form the inverter system.
After the sections of the system were integrated into a whole, few tests were carried out before the packaging of the system. The tests were majorly on the control stage and the power stage of the inverter.
In the control stage, emphasis was placed on the LCD display. When the inverter was operating in the inverting mode, the LCD display was able to display that it is in the inverting mode and it was able to tell the present voltage value of the battery. In the case of charging mode, the LCD display was able to tell the difference.
In the power stage, a test was carried out on the switching section using multimeter. A test of the DC voltage reading at the primary side of the transformer showed the voltage of the battery. Then a test of the voltage reading at the secondary side of the transformer showed an AC reading of 220V. When an oscilloscope was connected at the output of the inverter, the waveform output was sinusoidal.

## IV. CONCLUSION

The inadequacy of public power supply in our country calls for a temporary or an alternative source of power supply to be used in case of contingencies. The inverter is more environmentally friendly, easier to operate and requires very little maintenance compared to a generator.
The final design consisted of an H-bridge architecture that was built from 8 MOSFETs. These transistors act as switches that run current from the voltage source back and forth through a filter and attached load; this simulates a positive and negative voltage swing. The transistors are switched on and off at 50Hz in accordance with a pulse width modulation scheme. Once filtering is completed, a 50Hz sine wave can be seen at the output. These pulses were created using a dsPIC30F2010 chip contained within the enclosure.

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