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Sine wave Home Inverter

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Abstract- *The main aim of this project is to make a sine wave inverter and analysis the effect of different types of load on home appliances. In our project our objectives are to ensure the frequency of 50Hz, ensure the 50 percent duty cycle, ensure the output is sine wave, use this circuit up to 200W load, ensure 220VAC from 12VDC. There are many types of inverters in the market. Most of these are PWM inverters and Modified sine wave inverters and the efficiency of these are less than sine wave inverter. But the sine wave inverters are costly than other inverters. So we try to make an inverter which output is nearly pure sine wave. Inverter is the DC to AC voltage conversion. In our project we convert the 12VDC to 220VAC.Here we get the sine wave in two steps. The first one is the pulse generation with frequency control from DC source supply. The second one is the MOSFET technology for getting sine wave. We are able to get 50Hz frequency, 50 percent duty cycle and able to run the circuit up to 200Watt load. This output is better than other Transistor based inverters. The efficiency of this inverter is better than other inverters. This inverter is also cost effective than other sine wave inverters.*

Keywords: DC Source, Pulse Generator, Frequency Control, MOSFET Driver, Transformer.

1. INTRODUCTION

There exist two traditional converters: voltage-source(or voltage-fed) and current-source (or current-fed) converters(or inverters depending on power flow directions). Fig.1 shows the traditional three-phase voltage-source converter (abbreviated as V-source converter) structure. A dc voltage source supported by a relatively large capacitor feeds the main converter circuit, a three-phase bridge. The dc voltage source can be a battery, fuel-cell stack, diode rectifier, and/or capacitor. Six switches are used in the main circuit; each is traditionally composed of a power transistor and an anti parallel (or freewheeling) diode to provide bidirectional current flow and unidirectional voltage blocking capability.[1] The V-source converter is widely used. It, however, has the following conceptual and theoretical barriers and limitations.

• The ac output voltage is limited below and cannot exceed the dc-rail voltage or the dc-rail voltage has to be greater than the ac input voltage. Therefore, the V-source inverter is a buck (step-down) inverter for dc-to-ac power conversion and the V-source converter is a boost (step-up)

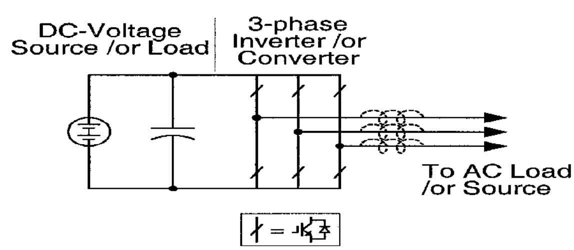

Fig. 1. Traditional V-source converter

rectifier (or boost converter) for ac-to-dc power conversion. For applications where over drive is desirable and the available dc voltage is limited, an additional dc-dc boost converter is needed to obtain a desired ac output. The additional power converter stage increases system cost and lowers efficiency.[2]

• The upper and lower devices of each phase leg cannot be gated on simultaneously either by purpose or by EMI noise. Otherwise, a shoot-through would occur and destroy the devices. The shoot-through problem by electromagnetic interference (EMI) noise's misgating-on is a major killer to the converter's reliability. Dead time to block both upper and lower devices has to be provided.

in the V-source converter, which causes waveform distortion,
etc.

• An output *LC* filter is needed for providing a sinusoidal voltage compared with the current-source inverter, which causes additional power loss and control complexity

Fig. 2 shows the traditional three-phase current-source converter (abbreviated as I-source converter) structure. A dc current source feeds the main converter circuit, a three-phase bridge. The dc current source can be a relatively large dc inductor fed by a voltage source such as a battery, fuel-cell stack, diode rectifier, or thyristor converter. Six switches are used in the main circuit, each is traditionally composed of a semiconductor switching device with reverse block capability such as a gate-turn-off thyristor (GTO) and SCR or a power transistor with a series diode to provide unidirectional current flow and bidirectional voltage blocking. However, the I-source converter has the following conceptual and theoretical barriers and limitations.

• The ac output voltage has to be greater than the original dc voltage that feeds the dc inductor or the dc voltage produced is always smaller than the ac input voltage. Therefore, the I-source inverter is a boost inverter for dc-to-ac power conversion and the I-source converter is a buck rectifier (or buck converter) for ac-to-dc power conversion. For applications where a wide voltage range is desirable, an additional dc–dc buck (or boost) converter is needed.[3]

The additional power conversion stage increases system cost and lowers efficiency.

• At least one of the upper devices and one of the lower devices have to be gated on and maintained on at any time. Otherwise, an open circuit of the dc inductor would occur and destroy the devices. The open-circuit problem by EMI noise's misgating-off is a major concern of the converter's reliability. Overlap time for safe current commutation is needed in the I-source converter, which also causes waveform distortion, etc.

• The main switches of the I-source converter have to block reverse voltage that requires a series diode to be used in combination with high-speed and high-performance transistors such as insulated gate bipolar transistors (IGBTs). This prevents the direct use of low-cost and high-performance IGBT modules and intelligent power modules (IPMs).

In addition, both the V-source converter and the I-source converter have the following common problems.

• They are either a boost or a buck converter and cannot be
a buck–boost converter. That is, their obtainable output voltage range is limited to either greater or smaller than the input voltage.

• Their main circuits cannot be interchangeable. In other words, neither the V-source converter main circuit can be used for the I-source converter, nor vice versa.

• They are vulnerable to EMI noise in terms of reliability.

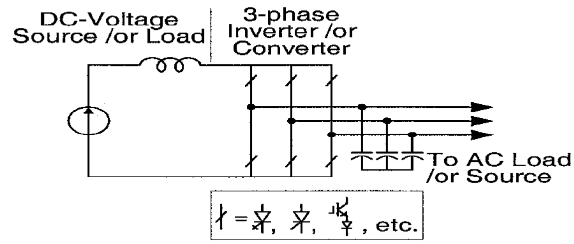

Fig. 2. Traditional I-source converter.

2. DESIGN PROCEDURE OF THE INVERTER

The design of the inverter is very simple. It is consist of a DC battery source, an IC 4047, MOSET and Transformer. The Fig:3 shows the complete circuit diagram of the inverter. Fig: 4 shows the block diagram of the entire circuit.

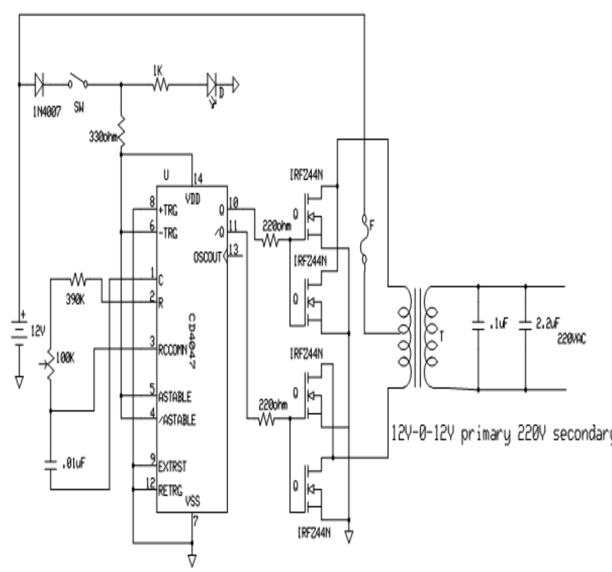

Fig 3: circuit diagram of inverter.

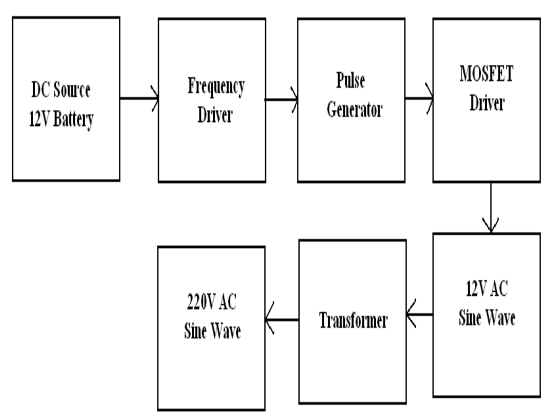

Fig 4: block diagram of the design

3. WORKING PROCEDURE OF INVERTER

This paper is based on the sine wave home inverter which performance is good enough than other types of inverters. This paper has two section. The first is the DC to AC conversion without changing the voltage limit. The other section is step up the AC voltage. Here we used MOSFET technology to generate the sine wave output. The performance of MOSFET is better than IGBT for low power equipments or loads. In this paper we analysis the effect of different types of load.

A. DC to AC conversion

Here we used a DC source as a battery(lead acid) for the input of the circuit. We used an IC 4047 Mono astable/ Astable Multivibrator as pulse generator. The working procedure of the IC is given bellow:

The IC 4047 can be used in both astable and mono stable mode. In this project we use it as astable mode for generating continuous pulse. Astable operation is enable by a high level on the ASTABLE input or a low level on the ASTABLE input, or both. The period of the square wave at the Q and Q outputs in this mode of operation is a function of the external components employed. 'True' input pulse on the ASTABLE input or "Complement" pulses on the ASTABLE input allow the circuit to be used as a getable multiviberator. By using astable mode we can get almost 50% duty cycle. In this IC4047 we connect 4,5,6,14 number pins to the supply voltage +12VDC and 7,8,9,12 number pins to the ground for getting free running pulse.[4] Here we use 1,2,3 number pins as a frequency controller. We get the output from 10 and 11 number pins. The output of the two pins are different by 180 degree phase angle.
Fig:4 shows the block diagram of the IC4047

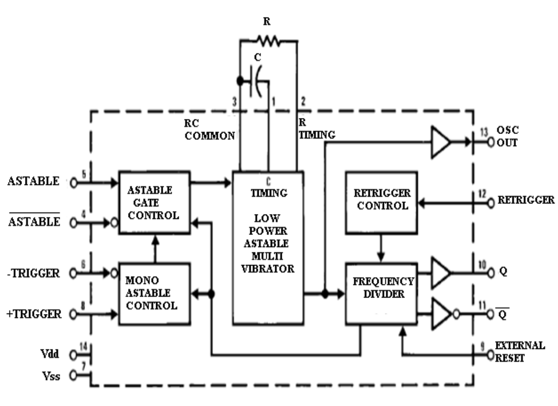

Fig-4: Block diagram of CD4047[4]

B. AC to AC conversion

After getting the pulse wave from the oscillator IC, then it gives to the MOSFETs IRFZ44N through resistors to its gate pin(1). All the source pin(3) of the MOSFETs are grounded. The output of the MOSFETs taken from the drain pin(2). [5]

Here we use two pair of MOSFET. Each pair connection is same. These MOSFETs used as switching device and cut the pulse wave as sine wave for sine wave output. This sine wave is not pure sine wave. From the MOSFETs we get 12VAC sine wave output This sine wave step up to 220VAC using a center tapped transformer. The transformed output can be used in the load.

The pair of MOSFET work as two types of Mode. One is inverting Mode and other is non inverting mode. In these two mode we get the two output which phase difference is 180degree to each other.

C. MOSFET Advantages :

1) High frequency applications (>200kHz).
2) Wide line or load variations.
3) Long duty cycles.
4) Low-voltage applications (<250V).
5) < 500W output power.
6) MOSFETs have a positive temperature coefficient, stopping thermal runaway.
7) The MOSFET also has a body-drain diode, which is particularly useful in dealing with limited freewheeling currents.

4. OUTPUT ANALYSIS

A. Output of IC

The output of the IC is pulse wave. From the IC we get two types of Output. One is inverted pulse and other is non inverter pulse. This pulse are given in the MOSFET as switching input. The Fig:5 and Fig:6 shows the inverted and non inverted pulse.

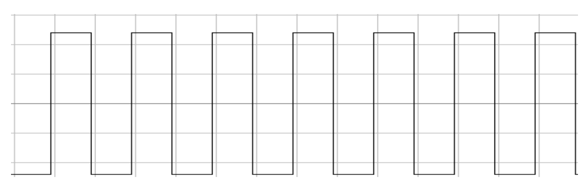

Fig 5: Inverted output

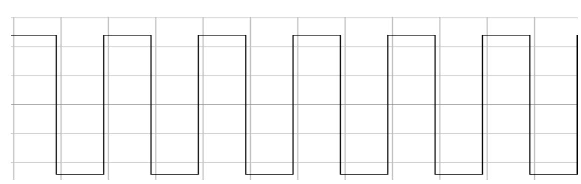

Fig 6: Non inverted output

B. Output of MOSFET

The MOSFET output is nearly sine wave. Its output voltage is 12VAC. The Fig:7 shows the output of the MOSFET.

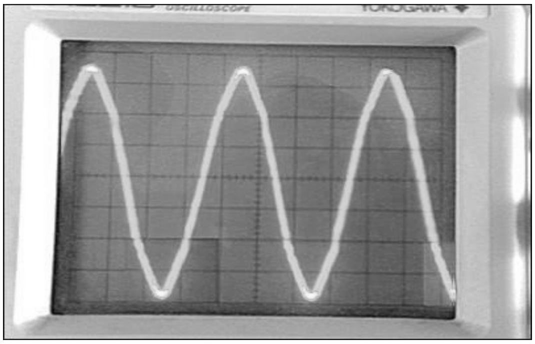

Fig 7: Output of the MOSFET

C. Output of the transformer

The Fig:8 shows the output of transformer which is nearly sine wave.

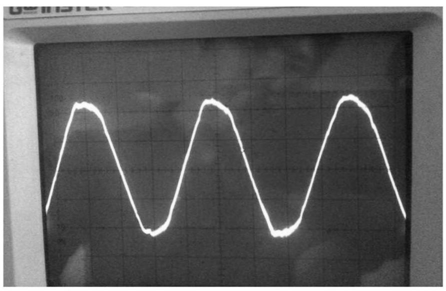

Fig 8: Transformer Output

5.EQUATION AND CALCULATION

A. Frequency calculation:

The frequency calculation of the IC is given below:

$f = 1/\ 4.40(R_2 + R_1)C$

Where, f= Frequency

R_1= 100KΩ variable

R_2 = 390KΩ

C= .01μF

For getting 50Hz R_1 is 64kohm,

Now,

f = 1/ 4.40(390kohm+64kohm)*.01μF

= 50.06Hz ~ 50Hz

B. Power Calculation :

Power calculation can be done using the load characteristics. Different types of load have different current consumption capacity. We use this circuit for 200W load. So the current rating of the primary DC supply will be

P = V*I [5]

Here, P = 200W

V = 12V

So the current rating of the primary side will be,

I= P/V=200/12= 16.66A ~ 17A

Using this equation we can calculate the primary current of any types of load.

C. Ampere Hour (Ah):

The capacity of the battery is represented in Ah. It is the amount of current a battery can give during one hour of charge / discharge cycle. High capacity batteries (100 Ah, 150 Ah) are used to power inverters to get sufficient backup time. The formula to select the battery power (Ah) is Load in watts / Voltage of battery x Backup hour.[6]

For running 200 watts load on 12 volt battery for 3 hours, then the capacity of the battery should be minimum 75 Ah.

Ah = 200 / 12 x 3 = 50 Ah. If the load increases (within the capacity of the inverter), backup time reduces.

6. SIMULATION OUTPUT

For comparing with the real output we simulate the circuit in the workbench simulator. We find that the simulated output and the physical output is almost similar. Here is given the simulated output of the MOSFET and the Transformer output. The Fig:9 shows the MOSFET Output.

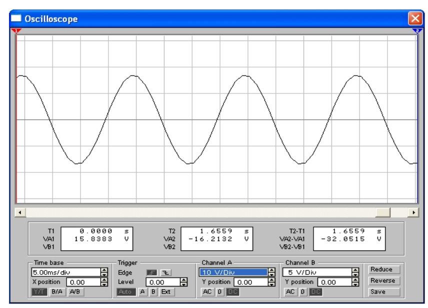

Fig 9: MOSFET Output

The MOSFET Output is sine wave and this output is nearly same with the physical oscilloscope output. The output voltage is 12VAC. Fig:10 shows the Transformer output, which is 220VAC.

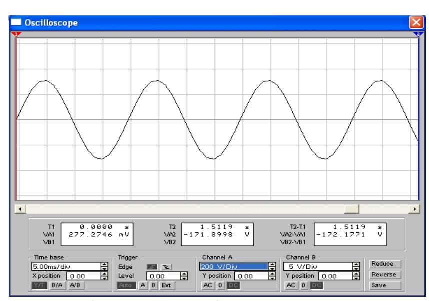

Fig 10: Transformer Output

The simulation output is sine wave. But in practical there are distortion in the output due to its physical construction. It can be removed using filter or using high efficiency Transformer.

7. CONCLUSION

This circuit can covert 12VDC to a 220VAC, 50 Hz sinusoidal waveform. Some of the more aggressive constraints were however not met. After reviewing the circuit we feel that the failure of this design constraint can be attributed to two possible factors. The first factor would be a loss of power in the transformer due to flux imbalance. Due to the large capacitance of the wires used on the primary side of the transformer, the primary winding acted more like an energy storage device than a magnetically coupled transformer winding. By using well turned transformer, It may illuminate the problem. The second factor is the current rating of the MOSFET. Due to the small current rating of MOSFET, we cannot use it for more power load in Watts. It can be illuminated using more pair of MOSFETs with the circuit. Using more pair of MOSFET It may able to use this circuit up to 800W. Then the cost of the circuit increases due to using high current rating of transformer. This inverter can be used in the PV cell or any other renewable energy sources along with the home appliances .

8. REFERENCES

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8. NOMENCLATURE

Symbol	Meaning	Unit
V	Voltage	(V)
I	Current	(A)
P	Power	(Watt)
F	Frequency	(Hz)
R	Resistor	(ohm)
C	Capacitor	(F)