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Designing of Solar Based Inverter for Rural Area Application

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ABSTRACT

The basis of this work is to provide electricity to villages and rural areas where there are fewer facilities for power transfer. The power transfer costs high which the rural area people cannot afford. To reduce this problem to some extent we can make use of renewable energy (solar energy). The solar panels produce DC power which we will convert to AC power using inverter operation. But present generation Inverters produce only square pulse or Sinusoidal wave with many harmonics and less efficient. This power may damage the inductor loads and reduce the efficiency. To overcome this problem lots of money needs to be invested which is not always affordable for the people who live in villages. In this work we are designing different inverters using with SG3525A PWM IC, ARDUINO for providing proper switching pulses to the MOSFETs to get maximum efficient output from inverter and this also helps in increasing the life cycle of the inverter. The cost of this inverter is less and the villagers can efficient make use of it for at least 20 years by installing this system.

Keywords: SG3525A, PWM IC, ARDUNO (AT MEGA 328P), MOSFET, solar energy, Opto-couplers

I. INTRODUCTION

In this work we designed different inverters for rural area applications. This inverter stores the solar power in the batteries by charging circuit in the day light. The DC electrical energy that is stored in the battery will be utilized during the night time, by our designed inverter. Our inverters generate the Alternating Current (AC) by using the stored electrical Direct Current from batteries. In this work we designed two types of inverters are Sg3525A PWM C based inverter and Adriano based inverter. These inverters and converts the DC supply to Ac supply. Mainly these inverters are designed for rural areas, because those areas couldn't have the electrical supply.

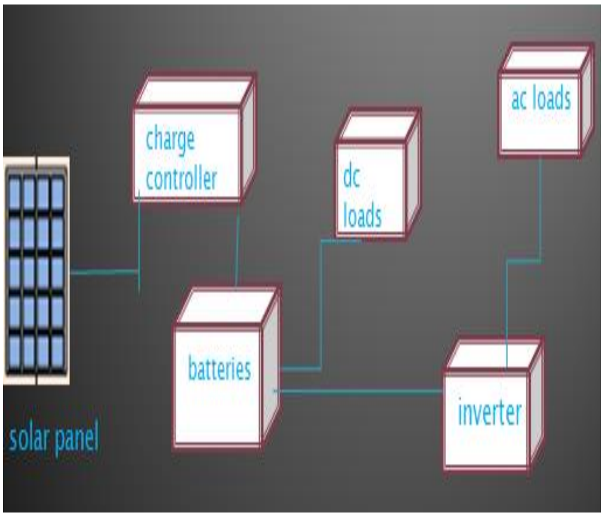

Figure 1: Block Diagram of inerter

II. DESCRIPTION

In this work we are designing the Solar based inverter for rural area applications. In this we are storing the Solar energy in the batteries with the help of the LM 317 charging circuit in day time The size of battery that is required for maintaining 6 hours of the Electrical load during night time is 12V/7AH. From this battery we are taking the DC supply and generating the AC supply by using our designed inverters. Theses inverters are:

SG3525A PWM IC based inverter, Adriano based inverter

In these inverter circuits mentioned above, DC power is connected to a transformer through the centre tap of the primary winding with proper switching of MOSFETs, the DC Source following two alternate paths through one end of the primary winding and then the other. The alternation of the direction of the current in the primary winding of the transformer produces alternating current (AC) in the secondary winding. The transformer of alternate paths through the end of the primary winding is grounded through MOSFET operation.

For the Producing Sinusoidal Wave of alternate current through MOSFETs, we are maintained Switching gate pulses with using Drivers. In this work we are using two different driver types.

These drivers are providing gate pulses to the MOSFETs for getting sinusoidal wave form. These MOSFETs of PWM switching operation we will get the alternating current from the ends of the transformer secondary winding. From this inverter we get the 10 Watts AC electrical load.

A.Sg3525A PWM IC INVERTER:

Circuit diagram:

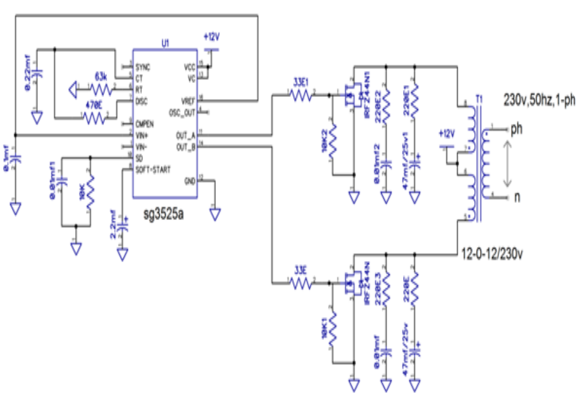

Figure 2 : Sg3525A PWM IC based inverter circuit

Components: Sg3525A PWM IC, R_t =63k, C_t = 0.22mf, R_d = 430e, RC filters, IRFZ44N MOSFETs, 12-0-12/230V Canter tapped transformer, 12v dc battery

Operation:

When we connect the MOSFET to the IC for getting gate pulse the output of the gate pulses are produced with more than the required output gate pulses frequency.

That frequency we will adjust by the below formula:

$F=1/(0.7*R_t+*R_d)*C_t)$.

$C_t = 0.22*10^{-6}$f

R_t= 63E

R_d = 430E

We will be substituting the these values in the above formula

We have the frequency of 100HZ

Then the IC produces the triangle pulse with 100HZ, these triangle pulses give the gate pulses to MOSFET for getting sinusoidal wave form.

For Proper Switching operation purpose we are connecting the Gate-Source resistor.

When the IC gives the gate pulse to the MOSFET the transformer of DC Supply is grounded through the MOSFET with pulse width modulation.

From this PWM operation is continuously runs and produces the Sine wave, this sine wave is filtered by the Low Pass filters(RC filter), and Step-up by the Transformer.

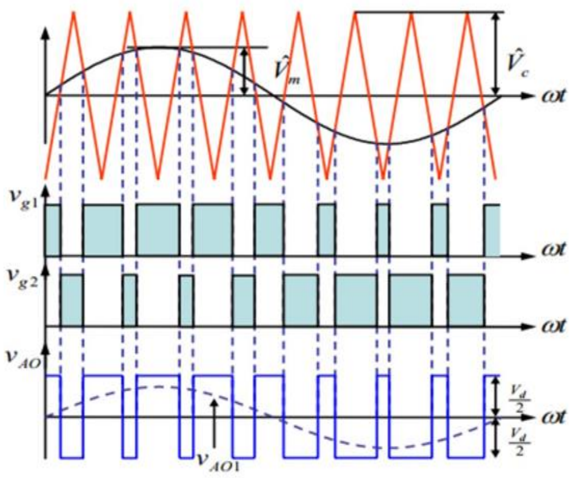

Figure 3 : Sg3525A PWM IC of triangle pulses, MOSFET 1 gate pulse,MOSFET 2 gate pulse, complete pulse width modulation for sinusoidal wave

Figure 4(i): output of IC based inverter with using RPS

Figure 4(ii): output of IC based inverter with using Solar panel

B.ARDUNO BASED INVERTER:

Circuit diagram:

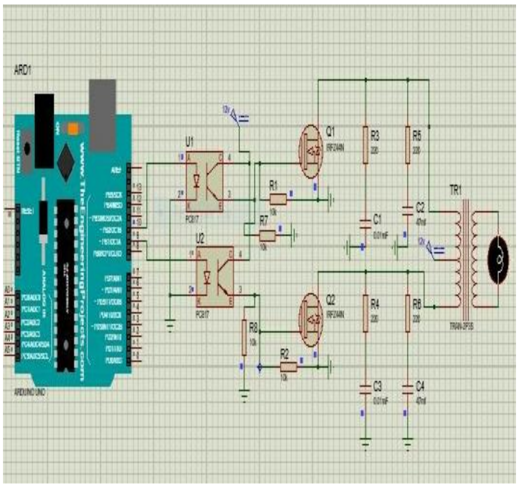

Figure 5 : ARDUINO based inverter circuit

Components: ARDUINO (AT MEGA 328P), Opto-coupler PC 817, MOSFETS IRFZ44N, 12-0-12/230V Canter tapped transformer, 12v dc battery

Operation:

Initially while connecting the ARDUINO to the MOSFETs for getting gate pulses, we have to dump the above program in the Adriano.

Then we start the operation of the Inverter, the Adriano supply's the gate pulse to the MOSFETS, and this produces the required sinusoidal wave form.

For getting proper switching operation we have connected gate-source resister.

And Adriano provides low current to the MOSFET gates, this current couldn't start the gate, for avoiding this problem we are adding the Opto-couplers.

When the gate pulses are produced from the Adriano the Opto-couplers

Are switched, the MOSFETs and transformer of PWM Dc supply should

be grounded through MOSFETs, and we get the sinusoidal wave form the transformer.

Program:

```
/* this code is for the producing the Switching gate pulses to the MOSFETs from Adriano to getting sinusoidal wave from inverter*/
1.const int SpwmArry[] =
{500,500,750,500,1250,500,2000,500,1250,500,750,500,500};
// Array of SPWM values (single pulse width modulation)
2. const int SpwmArryValues = 13;
 //Put length of an Array depends on SpwmArray numbers.(size of array)
// declare the output pins and choose PWM pins only
3.const int sPWMpin1 = 10;
4.const int sPWMpin2 = 9;
// enabling bool status of Spwm pins
bool sPWMpin1Status = true;
bool sPWMpin2Status = true;
// (our first declaration)
5. Voidsetup()
```

{
pinMode(sPWMpin1, OUTPUT);
pinMode(sPWMpin2, OUTPUT);
}
// (setting the pins to get output pulses from the Adriano)
6.void loop()
{
// Loop for Spwm pin 1
for(int i(0); i != SpwmArryValues; i++)
//for loop for repainting the first half cycle..with 10,000 microseconds)
{
if(sPWMpin1Status)
// it check the status of the pin..when status of pin is true, if condition is true and allow to the if condition, otherwise go to the else condition)
{
digital Write(sPWMpin1, HIGH);
//give the pulse to the from pin 1
delay Microseconds(SpwmArry[i]);
//pin 1 pulse generated up to spwmArry[i] time
sPWMpin1Status = false;
// status of pin 1 is changed to false
}
Else
//when if condition is fail then coming to this else condition and allowed to the else condition
{
digitalWrite(sPWMpin1, LOW);
// pin 1 is off the pulses generation
delayMicroseconds(SpwmArry[i]);
//pin one is off the pulses generation up to the spwmArry[i] time
sPWMpin1Status = true;
// now changed the status of the pin 1
}
//again going to for loop up to the failed the condition.
}
// come out from for loop when failed the condition of for loop
// Loop for Spwm pin 2
for(int i(0); i != SpwmArryValues; i++)
//for loop for repainting the second half cycle with 10,000 microseconds)
{
if (sPWMpin2Status)
/* it check the status of the pin. When status of pin is true , if condition is true and allow to the if condition, otherwise go to the else condition*/
{
digitalWrite(sPWMpin2, HIGH);
//give the pulse to the from pin 2
delayMicroseconds(SpwmArry[i]);
//pin 2 pulse generated up to spwmArry[i] time
sPWMpin2Status = false;
// status of pin 2 is changed to false
}
Else
//when if condition is fail then coming to this else condition and allowed to the else condition
{
digitalWrite(sPWMpin2, LOW);
// pin 2 is off the pulses generation
delayMicroseconds(SpwmArry[i]);
//pin one is off the pulses generation up to the spwmArry[i] time
sPWMpin2Status = true;
// now changed the status of the pin 2
}
//again going to the for loop up to the failed the condition.
}
// come out from for loop when failed the condition of for loop
}
//this 6th loop again repeat up to reset the Arduino….for every 0.02 seconds.

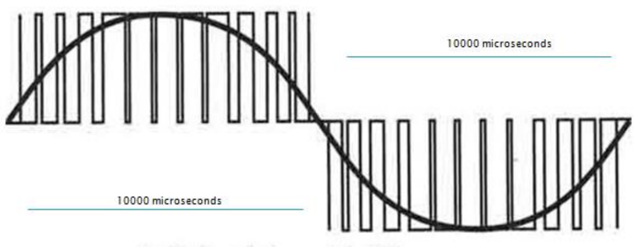

Figure 6 : ARDUNO produced gate pulse for MOSFET Switching getting sinusoidal output from inverter

Figure 7(i): Output of ARDUNO based inverter with using RPS

Figure 7(ii): Output of ARDUNO based inverter with using Solar panel

C.OPTO-COUPLERS:

We have to isolate the 5v to 12v by using the PC817 Opto-couplers. These Opto-couplers gets operated when they get the pulse from the Arduino then isolates the 12v supply to the gate of the MOSFET.

D.MOSFET:

We preferred MOSFET for the inverter operation because,

In power electronics voltage controlled gate pulse we have two elements.

These are IGBT and MOSFETs.

IGBT: These are used in high voltage, high current and low frequency operations.

MOSFETS: These are used in low voltage, low current and high frequency operations.

In this operation we use 12v and, 50 HZ so we choose the MOSFETS.

And their characteristics and ratings are observed from their datasheets.

E.RC FILTERS & TRANSFORMER:

In the PWM inverter operation we get the high harmonics from the MOSFETS.

So for avoiding these harmonics we have to use the low filters like resisters and capacitors.

This is for step-up voltage centre tapped transformer to the voltage from the 12v ac to 220v ac. It has ratings 220v, 1A.

III. MATHEMATICAL MODELLING

Output calculations of Arduino based inverter

Arduino supply:

7805 Regulator is used for ARDUINO 5v volts supply.

Input values:

Power P = 10 watt

Voltage V_{dc}= 12v

Current I_{dc}= P/V_{dc} = 10/12 = 0.833A.

Output values:Voltage V_s = 230 v

We have designed 10 watt inverter and loads used are three 3 watt bulbs. So

Current I_s = P/V*pf = 10/(230*0.8) = 0.054A

For Three bulbs the Required Current is 3* 0.054 =0.164A

Size of inverter:

Size of inverter = (Total load +(1+20%))/80%.

Total load = Electrical load /pf = 3*3 Watt/ 0.8 = 11.25 VA.

Size of inverter = (11.25+(1+20%))/80% = 12.75VA

Size of battery Required:

Total load of battery bank =(Total load * battery capacity)/battery voltage.

= (9*6 hours)/12V

Battery bank required = 4.5Ah.

Charging capacity:

Solar panel range = 10 watt, 12V.

Current output = 10/ 12 = 0.83 A

Battery charging hours = 5/ 0.83 = 6 hours

Final kit arrangement:

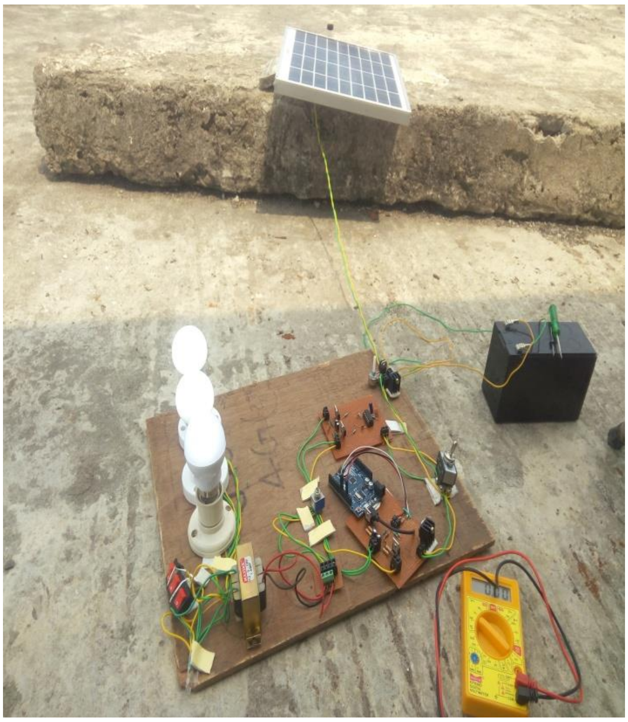

Figure 8 : Complete inverter kit

In this kit we have used the 10 Watt, 12V Solar panel, 12V, 7AH LED Acid battery, 12-0-12V to 230V step-up transformer, and three 3 watt LED bulbs.

For operating both the inverters on single kit we have used the DPDT (double pole double through) Switch for supply dividing, and TPST (terrible pole single through) Switch for dividing transformer terminals.

For operating the individual loads we used switches between loads.

IV. RESULTS

This inverter designed for rural area applications, for the ones living away from cities. This inverter charge from solar panel in day the within 6 hours. And supply electricity in night time up to 6 hours. This inverter designed with low cost because of this inverter available for 1500 rupees with 3 electrical loads. This inverter work at any areas (availability sun shine areas)

V. CONCLUSION

In this work we designed different inverters for rural area applications. This inverter stores the solar power in the batteries by charging circuit in the day light. The DC electrical energy that is stored in the battery will be utilized during the night time, by our designed inverter. Our inverters generate the Alternating Current (AC) by using the stored electrical Direct Current from batteries. In this work we designed two types of inverters are Sg3525A PWM C based inverter and Adriano based inverter. These inverters convert the Dc supply to Ac supply. Mainly these inverters are designed for rural areas, because those areas couldn't have the electrical supply. So we hope this work will be definitely useful to them. This inverter also costs very low and has better efficiency.

VI. ACKNOWLEDGMENT

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