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, ARDUINO (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.
generating the AC supply by using our designed inverters. These 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:**

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 = \frac{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 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 2:** SG3525A PWM IC based inverter circuit

**Figure 3:** SG3525A PWM IC of triangle pulses, MOSFET 1 gate pulse, MOSFET 2 gate pulse, complete pulse width modulation for sinusoidal wave
Components: ARDUINO (AT MEGA 328P), Optocoupler 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. Void setup()
```cpp
{  
  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 != SpwmArrayValues; 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)
      
      digitalWrite(sPWMpin1, HIGH);
      //give the pulse to the from pin 1
      delayMicroseconds(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.
  
  // 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
}
//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

  // Loop for Spwm pin 2
  for(int i(0); i != SpwmArrayValues; i++)
```
**Figure 6**: ARDUINO produced gate pulse for MOSFET Switching getting sinusoidal output from inverter

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 resistors 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 $V_{dc} = 12$ v
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 $= (11.25+(1+20%))/80% = 12.75$ VA
Size of battery Required:
Total load of battery bank $= (Total\ load * battery\ capacity)/battery\ voltage$.

$= (9*6\ hours)/12V$
Battery bank required $= 4.5$Ah.

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:
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**

We express our thanks to the support given by management in completing our work. We express our sincere gratitude & deep sense of respect to Dr. G. Joga Rao, HOD & Associate professor of the Electrical Department. We express our sincere thanks to our work guide K.Bapuji Assistant Professor for his support to completion of this work. We also thankful to the teaching and non-teaching staff of Electrical department for their direct as well as indirect help in our work.

**VII. REFERENCES**


[6]. Analysis and Modeling of Transformer less Photovoltaic Inverter Systems," by TamasKerekes, Aalborg University Institute of Energy Technology Denmark, August 2009

[7]. Li, X., Hui, D., & Lai, X. (2013). Battery energy storage station (BESS)-based smoothing control of photovoltaic (PV) and wind power generation fluctuations


