Proteus Based Simulation of PV Inverter for Rural Electrical Service

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Abstract: *In many remote or underdeveloped areas, direct access to an electric grid is impossible and a photovoltaic inverter system would make life much simpler and more convenient. With this in mind, this paper aims to design, and simulate PV inverter in proteus professional software. This inverter system could be used as backup power during outages, battery charging, or for typical household applications for rural especially. The principle is to adapt the output voltage of the solar module to the battery by using the technique of pulse width modulation (PWM). The sinusoidal pulse width modulated (PWM) waveform is generated from inverter in laboratory by 16 bit microprocessor through program developed using a novel technique of direct modulation strategy .The key features of the system are a true 50Hz, 230Vsinusoidal voltage output, a wide input range, and a power output of up to 350 watts. The overall goal is to design this system while minimizing component costs.. In addition, inverters in the lower price range typically lack most of the features. solar home lighting systems mostly comprises of solar panel, solar charger, battery & a inverter, The main motivation of this paper or the uniqueness of this project is to combine both the solar charger as well as inverter together to ATMEGA 32 RISC based which works up to 16MIBS which reduces the cost as well as the system becomes compact.*

Keywords: *Pv, Pwm, Mcu, Proteus, Dpwm, Pwm Charger.*

I. Introduction

India s off-grid solar (PV) market has three major segments: captive power plants (where the majority of generation is consumed at the source), telecom towers, and rural electrification. The market potential for these PV segments has created an off grid solar market in India. India like other developing countries has made tremendous progress in producing energy in agriculture sectors. However, it lags behind in meeting the entire energy demand in remote rural and its nearby suburban or urban areas. As a result, our country is facing acute shortage of power especially in those village areas where utility grids are either not available or its further extension is not possible due to costly affair. Even in the sub-urban or urban area of these villages where utility grids are available, only 20% electricity is available for end users and so they lack such basics of human need as lighting, irrigation, communication, primary health care facility, safe drinking water, education etc. Renewable energy is the only feasible option to electrify these villages and its surrounding areas.

Along with increases of demand for the new energy, and the key technologies of use new energy sources is how to integrate new energy into electrical energy. In this paper high computing speed, low-power single chip MCU ATMEGA 32 is used as the control chip, improve the inverter efficiency. This article also describes the structure of the inverter, control methods, focuses on software design and finally summarized.

The primary function of a charge controller in a stand-alone PV system is to maintain the battery at highest possible state of charge while protecting it from overcharge by the array and from over discharge by the loads [1]. Although some PV systems can be effectively designed without the use of charge control, any system that has unpredictable loads, user intervention, optimized or undersized battery storage (to minimize initial cost) typically requires a battery charge controller. The algorithm or control strategy of a battery charge controller determines the effectiveness of battery charging and PV array utilization, and ultimately the ability of the system to meet the load demands. Additional features such as temperature compensation, alarms, meters, remote voltage sense loads and special algorithms can enhance the ability of a charge controller to maintain the health and extend the lifetime of a battery, as well as providing an indication of operational status to the system caretaker.

Important functions of battery charge controllers and system controls are to [2]:

- Prevent Battery Overcharge*:* to limit the energy supplied to the battery by the PV array when the battery becomes fully charged.
- Prevent Battery Over discharge: to disconnect the battery from electrical loads when the battery reaches low state of charge.
- Provide Load Control Functions*:* to automatically connect and disconnect an electrical load at a specified time, for example operating a lighting load from sunset to sunrise.
- A series charge controller or series regulator disables further current flow into batteries when they are full. A shunt charge controller or shunt regulator diverts excess electricity to an auxiliary or "shunt" load, such as an electric water heater, when batteries are full.

Simple charge controllers stop charging a battery when they exceed a set high voltage level, and re-enable charging when battery voltage drops back below that level. Pulse width modulation (PWM) [2] and maximum power point tracker (MPPT) technologies are more electronically sophisticated, adjusting charging rates depending on the battery's level, to allow charging closer to its maximum capacity. Charge controllers may also monitor battery temperature to prevent overheating. Some charge controller systems also display data; transmit data to remote displays, and data logging to track electric flow over time [4].

II. System Block Diagram

2.1Inverter Drive circuit and Filter circuit design.

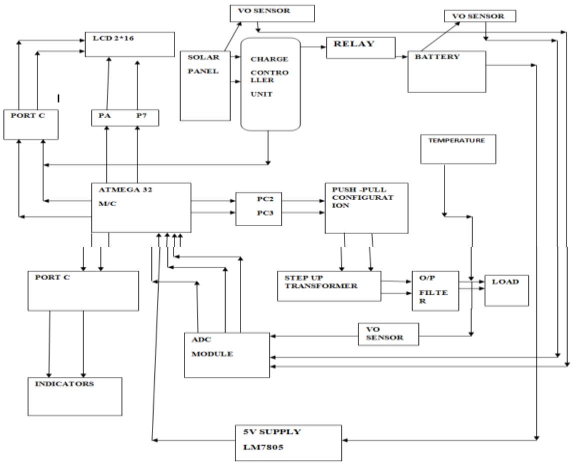

Figure: 1

ATMega32 microcontroller: It acts as the heart of the system. It controls and monitors entire system. The main function of this microcontroller is to generate SPWM signals. These signals are given to Half-bridge switches to convert dc voltage to ac voltage. Microcontroller also takes care of the protection. It protects the load from over voltage, under voltage.This system includes a feedback network where at the output AC is converted to DC using bridge rectifier and is properly isolated using an npn based opto coupler and a voltage divider circuit which is fed back to adc module of MCU and output voltage is regulated by controlling the duty cycle of the DPWM.

In the present work sinusoidal pulse width modulation (SPWM) technique is used to control the switches of the Halfe-bridge. This technique is widely used in inverter to digitize the power so that a sequence of voltage pulses can be generated by the on and off of the power switches. The pulse width modulation inverter has been the main choice in power electronics, because of its circuit simplicity and rugged control scheme.

After analysis and comparison, the part of the contra variance use half-bridge inverter circuit, Inverter Bridge is composed of FET IRF3205, using 2n3906 and 2 Bc547 as a driver circuit. Single-chip generated PWM signal, go though 2n3906 to control the inverter switching devices IRF3205 the shutdown of conduction, then inverter can produce sine wave outputs. But the sine wave contains many high-order harmonic generation, required the LC filter circuit to be smooth, non-standard high-order harmonic generation of sine wave. The size of capacitance and inductance values required theoretical calculations and the actual debugging to determine. In this design, we take C = 100uF, L = 40uH.

2.2 Pwm Control

A software program has been developed to generate sinusoidal pulses for N numbers in a half cycle using direct modulation strategy (DPWM) whose widths are proportional to amplitude of sine wave at sampled points (Fig.2). Mathematically the pulse width and corresponding notch width are expressed by (1) and (2) respectively as:

Pulse width (Pi)

$= K\ Pwm \times 2 \sin (2i - 1)\pi / (2*N)$. (1)

Where,

i = 1, 2, 3,…..N

K = Voltage Factor (0 –1)

P wm = (D – G) * 2

D = 180 / (2*N)

G = Minimum Gap between pulses (say 1degree) at K=1

N = Number of PWM pulses in Half sine wave (180 degree i.e. = 10 ms)

Notch width (Ti) $= 2D - [1/2(P_{i-1} + P_i)]$. (2)

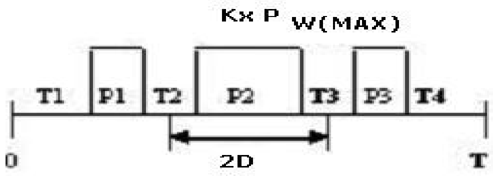

Figure 2: Programmable DPWM sinusoidal

Modulated (N = 3) half sine wave of 50 Hz . Y axis = Amplitude (5V), X axis = Total time (T) in half cycle i.e 180 degree =10ms.

III. System Software Design

3.1proteus Introduction

Proteus supports multiple mainstream microcontroller system simulation, such as 51 series, AVR series, PIC12 PIC16 series, PIC18 series, Z80 series, HC11 series, series, 68,000 series, etc. And provide software debugging function and its periphery connection device of RAM, ROM, keyboard, motor, LED, LCD, AD/DA, partial SPI device.

With the development of science and technology, the computer simulation technology has become an important sector of many design method of early. It is designed to be flexible, results, the process of unity. It can make the design time is shortened, cost reduction, also can reduce the risk of engineering. Believe in microcontroller application of PROTEUS can also have extensive application.

3.2Target specifications

3.2.1 Inverter specifications.

Frequency	50 Hz +/- 2Hz
Efficiency	>80 %
Output	350 watts, 12VDC ~ 220 V +/- 5
Harmonics	<5 %
spwm	Sine wave inverter
Mobility	Portable, microcontroller based
Protection circuits	yes

Table1

3.2.2 Solar charge controller specification:

- Prevents battery from being overcharged and damaged by the solar panel
- Compatible with 12 volt battery bank
- Overload, short circuit, and reverse polarity protected.
- LED's indicate charging status.

3.3 Simulation Results

3.3.1 pv inverter simulation

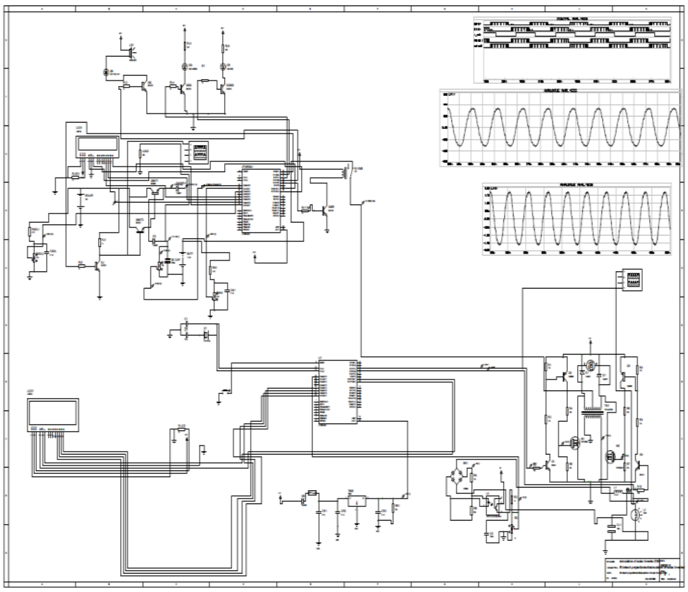

Figure 3: (Schematic of Proposed PV Inverter with battery charger.)

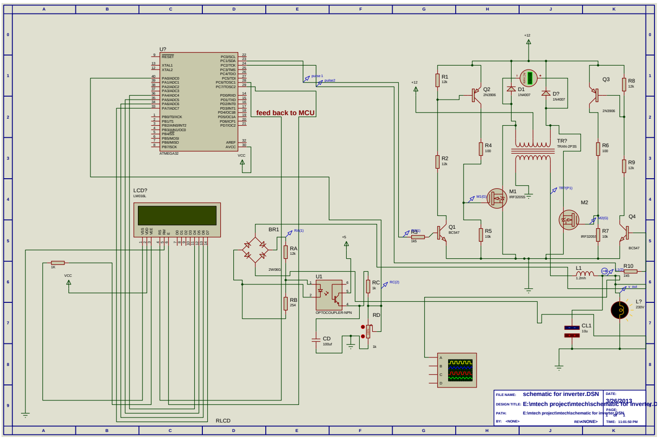

Fig4. (Schematic of inverter)

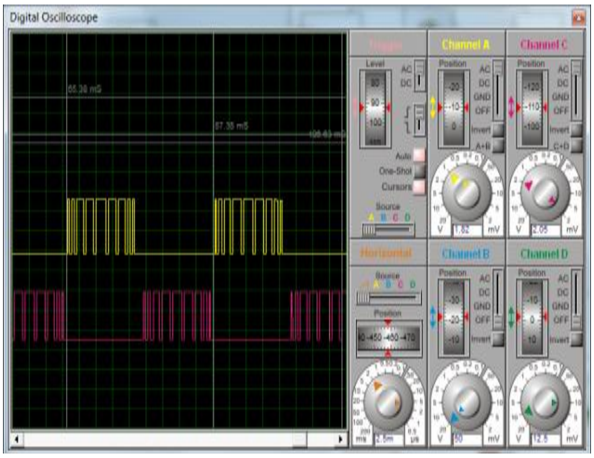

Fig5. (Pulse train drawing the mosfet T=20 ms, T_{ON}=10ms &T_{OFF}=10ms)

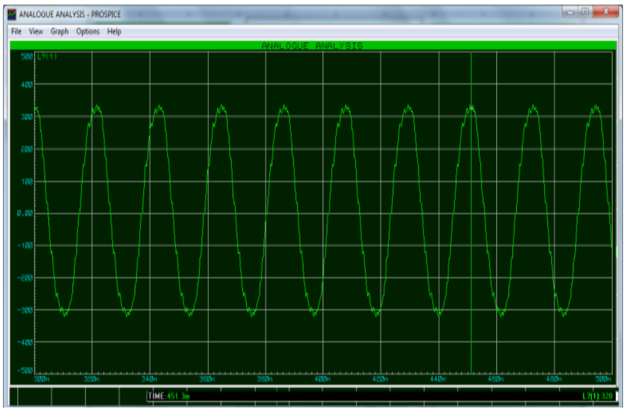

Fig6. (Output voltage waveform as per simulated resultsV_O=228 Volts).

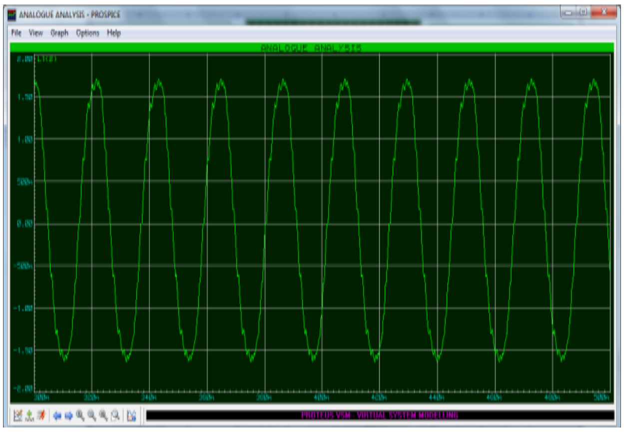

Fig7. (Current wave form as per simulated results I_O=1.7 Amps).

3.4 simulation of PWM charge controller

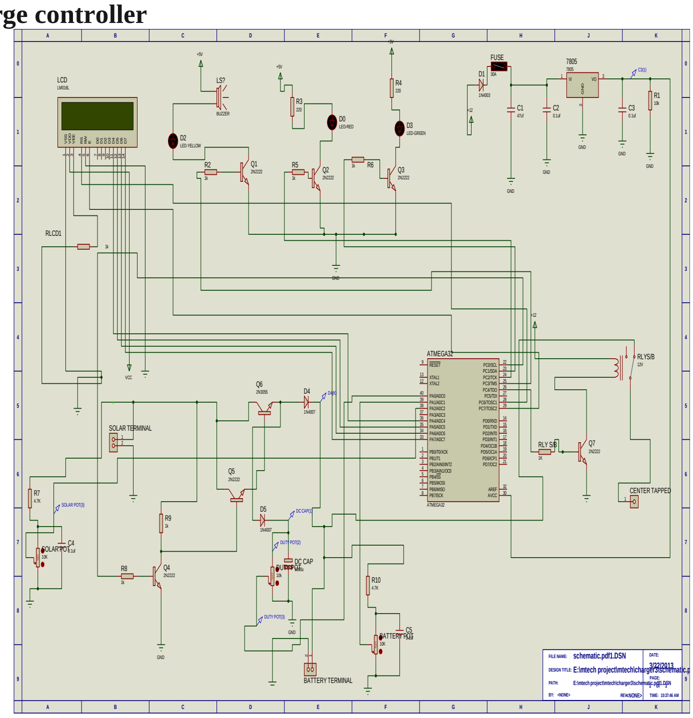

Figure 8(schematic of pwm based charge controller)

Solar Charge controller is a device, which controls the battery charging from solar cell and also controls the battery drain by load. The simple Solar Charge controller checks the battery whether it requires charging and if yes it checks the availability of solar power and starts charging the battery. Whenever controller found that the battery has reached the full charging voltage lavels, it then stops the charging from solar cell. On the other hand, when it found no solar power available then it assumes that it is night time and switch on the load. It keeps on the load until the battery reached to its minimum voltage levels to prevent the battery dip-discharge. Simultaneously Charge controller also gives the indications like battery dip-discharge, load on, charging on etc

OPERATION OF SYSTEM: Pulse Width Modulation (PWM) is the most effective means to achieve constant voltage battery charging by switching the solar system controller's power devices. When in PWM regulation, the current from the solar array tapers according to the battery's condition and recharging needs. In the fig 8 solar charge is controlled by controlling the duty cycle ,such that an optimum 13.75 volts is fed to battery for charging purpose.2N3055 NPN power transistor , Packaged in a TO-3 case style, it is a 15 amp, 60 volt is used as switching device Initially 50 %duty cycle is fed in MCU using PORT C0. As the solar voltage is unregulated the voltage is controlled by adjusting the duty cycle .Two reference voltage is fed in MCU, whenever solar voltage is < reference voltage V_1 (>> Pwm), similarly vice versa.

3.4 Simulation Results for PV Charger

The proposed charge controller is simulated by using Proreus ISIS 7 Professional for five cases listed in table 1 and the simulation results shown in figures 8-12.

Test no	Solar voltage	Battery voltage	Duty cycle%
1	18	11.0	96%
2	16	11.0	99%
3	10	12.0	35%
4	17	13.5	0%

Table 2

3.4.1Algorithm for Charge Controller

As microcontroller software works as sequential basis, it will perform these steps Sequentially.

1. Power On, RESET
2. Define Input / Output of the ports
3. Setup ADC for measurement
4. Start ADC Module
5. Measure ADC2, ADC3, ADC4, ADC5. ADC2 for 'Solar Voltage', ADC3 for 'Battery High Set', ADC4 for 'Battery Low Set' and ADC5 for 'Battery Voltage'
6. If 'Battery Voltage' < 'Battery High Set' and 'Solar Voltage' > 'Battery Voltage' then

   a. Switch ON Battery Charging
   b. Switch ON Charging LED
   c. Switch OFF Battery High LED
7. If 'Battery Voltage' > or = 'Battery High Set' then
   a. Switch OFF Battery Charging
   b. Switch OFF Charging LED
   c. Switch ON Battery High LED
8. If 'Solar Voltage' < 'Battery Voltage' then
   a. Switch OFF Battery Charging
   b. Switch OFF Charging LED
   c. Switch ON Load
9. If 'Battery Voltage' < or = 'Battery Low Set' then
   a. Switch OFF Load
   b. Switch ON Battery Low LED
10. If 'Battery Voltage' > 'Battery Low Set' then
   a. Switch OFF battery Low LED
11. Go to Step 5.

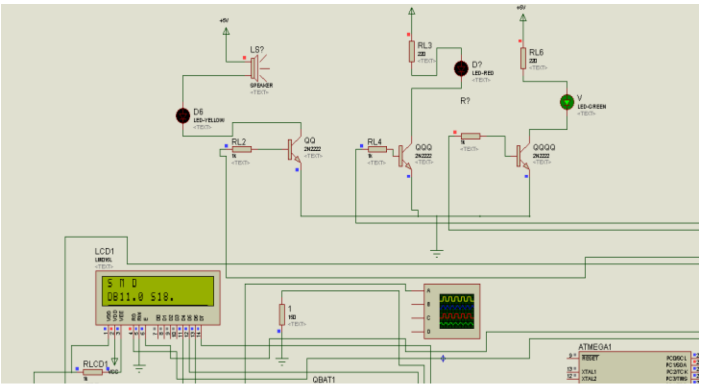

Figure: 9. (the above schematic refers to step no 6 of the algorithm).

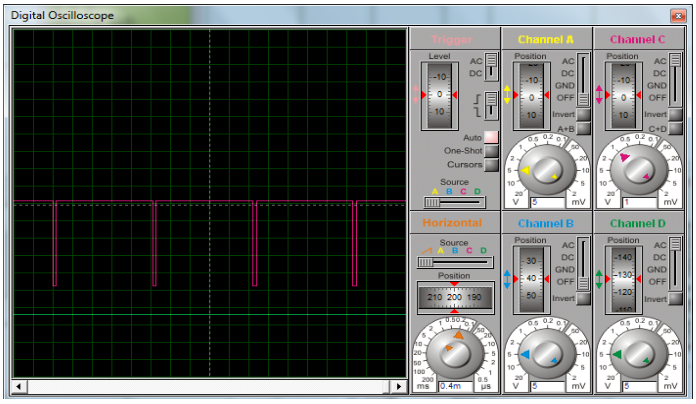

Figure: 10. Simulation Result for Test number 1(channel c represents the output of the MCU PWM signal)

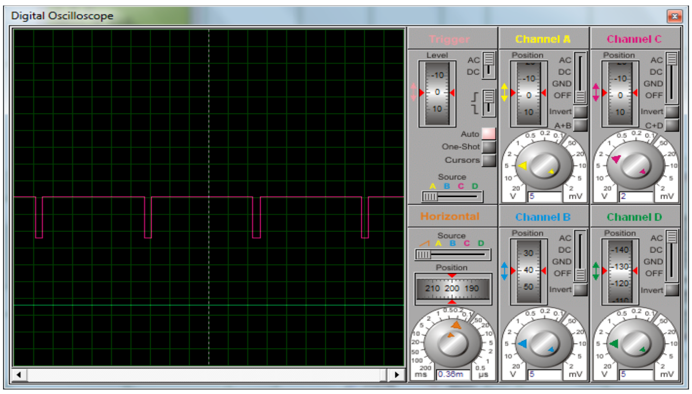

Figure: 11. Simulation Result for Test number 2(channel c represents the output of the MCU PWM signal).

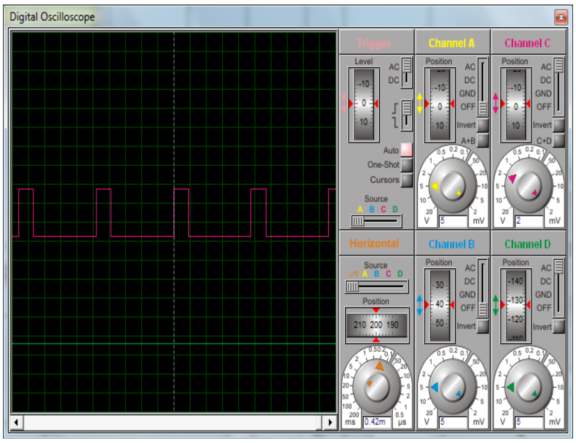

Figure: 12. Simulation Result for Test number 3(channel crepresents the output of the MCU PWM signal)

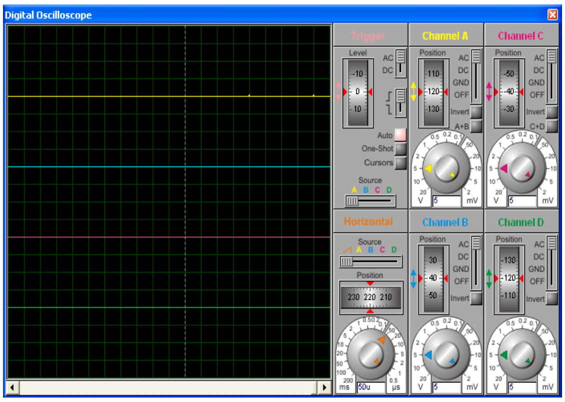

Figure: 13. Simulation Result for Test number 4(channel crepresents the output of the MCU PWM signal)

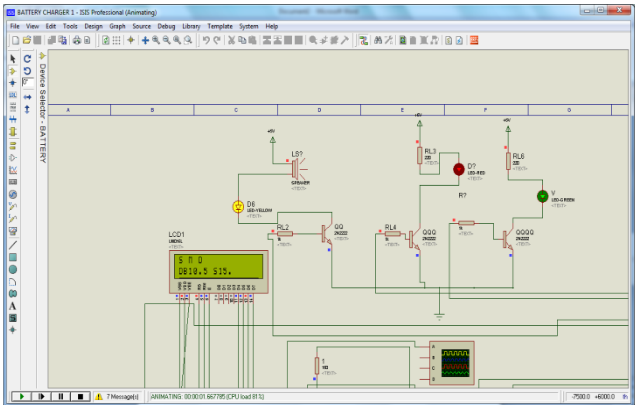

Figure13. (The above schematic refers to step no9 of the algorithm)

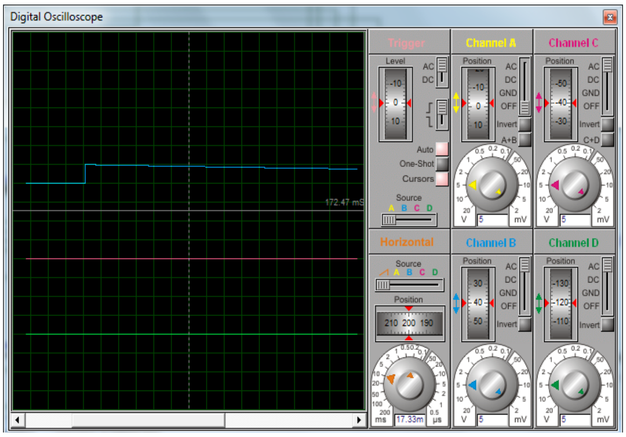

Figure14. (The above graph shows switching on; of the relay once battery reaches its low set point).

IV. Conclusion

The article is being simulated in the Proteus software, the hardware must be tested accordingly, Proteus not only make many MCU visualize, but also can visualize many MCU examples. Which is 80–90 % similar to real operating device? The above system does not require carrier signal or a comparator circuit as usually require in conventional triangular PWM generator circuit and thus reduces the cost as well as complexity in producing PWM base drive signals.

V. Acknowledgment

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