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Arduino based Charger testing Platform

K.Selvaraj[1],T.Santhosh[2],Mr.B.Kishore[3]

[1,2]Department of EEE,Dr.MCET,Pollachi,India

[3]Assistant professor, Department of EEE,Dr.MCET,Pollachi,India

Abstract: This paper presents a semi-automated electric vehicle charger testing platform using Arduino mega 2560 microcontroller board which can be used as a testing platform to test the functioning and reliability of electric vehicle chargers manufactured in electric vehicle manufacturing industries. Repetitive power On Off test and Line regulation test and Load regulation tests can be conducted using the proposed testing platform in different load condition. This method contains a SD card based data logging system to record the real time test data such as input voltage and current and output voltage current. The proposed system also offers a programmable constant current load setup so that the tests could be carried out in any load conditions. The constant current load setup is mainly based on controlling the gate voltage of a MOSFET operating in saturation or active mode of operation. The results of different test scenarios are presented.

Keywords: MOSFET, CC Load, Testing,SPI,SD card.

I. INTRODUCTION

Product Testing is one of the important processes in manufacturing of a product. The quality and performance of a product against real time operating conditions is checked while testing by creating expected load conditions and other up normal conditions such as voltage spikes and frequency variations artificially. This project describes a semi-automated system for the testing of electric vehicle battery charger manufactured in electric vehicle industries using Arduino mega 2560 microcontroller. By using this, reliability of the charger can be checked with minimum manpower. This system can be implemented in electric vehicle charger manufacturing industries where larger number of chargers has to be tested for the performance, reliability and quality. . Once the charger passed all the tests then it will be supplied to the customers for real time use.

In this work a semi-automated charger testing setup is presented using Arduino mega 2560 microcontroller. The system contains input and output devices such as keyboard and liquid crystal display (LCD) 16*2 for real time user interfacing purpose. The different test programs and different test conditions can be given as an input by the user through keypad interfaced with the microcontroller. A 2KVA Tap changing transformer is used to get various AC voltage level form 0-400 volts AC form the constant 230 volt 50 hertz single phase AC grid supply in order to conduct load regulation test. Depends on the user input, the voltage required for the test condition can be selected by controlling the relay connected to the taps of the multi tap transformer using Arduino. In this way input side of the charger is supplied with various AC voltages required for the test condition.

The output side of the charger is connected to a programmable constant current load [2] .The load current required for the test condition can be set through the keypad by the user. In this constant current load circuit Power MOSFET is used to get the load current by controlling the gate voltage of the MOSFET through an Operational amplifier circuit which is operating in open loop differential amplifier configuration [1]. By using the proposed system repetitive on off test, line regulation test, load regulation tests can be implemented in real time. Temperature variation test can be implemented by adding a suitable benchtop programmable temperature chamber with the proposed setup. The test data can be obtained through the SD card interfaced with the Arduino microcontroller through SPI communication protocol. Figure 1 shows block diagram of the complete test setup proposed in this paper. The input and output parameters of the electric vehicle charger are measured, displayed and stored using suitable sensors interfaced with the Arduino microcontroller.

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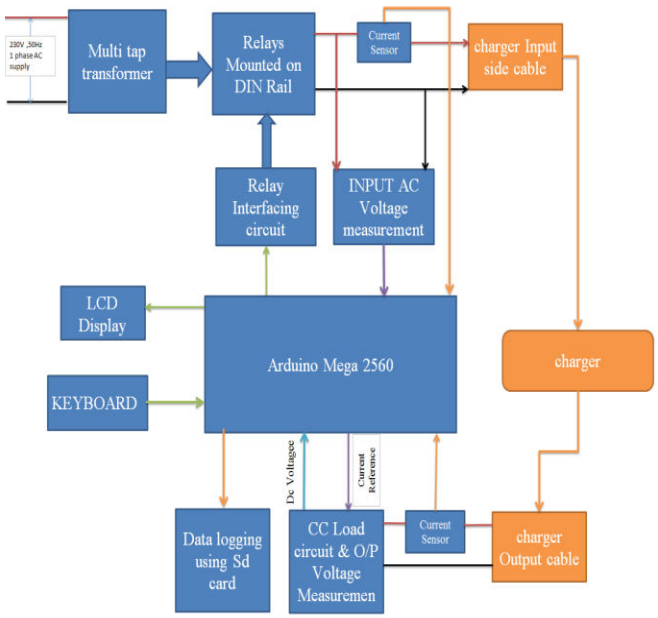

Figure 1. Block diagram of the proposed system

II. DESIGN

A. Multi Tap Transformer

In this 2KVA single phase Multi tap transformer is used get different AC voltages required for the test conditions from a 230 volt 50 hertz mains supply. Primary side of the transformer is supplied with 230 volt 50 hertz single phase AC supply. Secondary side has 13 taps which are capable of supplying 100 to 400 volts single phase AC voltage in 25 volts difference for each consecutive tap.

B. Relays

In this work electromechanical industrial grade socket mounting 12 Volt DC relays are used to switch between different taps of the multi tap transformer. Rated operating voltage of the relay contacts are 230 volt AC at 8 Amps. According to the data sheet these relays are capable of switching up to 440 volt AC [5]. The relays are connected in such a way that normally closed Terminal of a Relay is connected to the common terminal of next relay. This ensures that in any condition two taps of the multi tap transformer will not be short circuited. ULN 2003A is a low side load driver IC which has 7 parallel input and output channels so that it can drive seven different loads at same time It also has internal fly back diode to drive inductive loads such as motors and electromechanical relays. The inputs are compatible with various types of logic such as TTL and CMOS. Figure 2 shows the Multi tap transformer connected with relays.

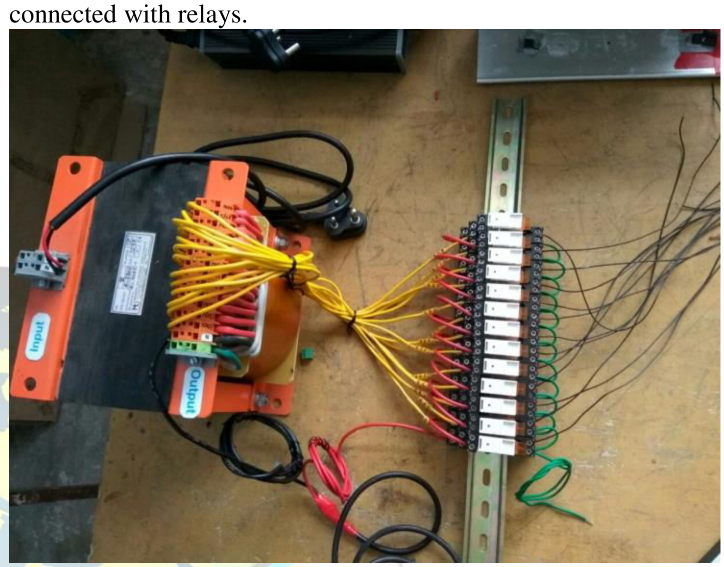

Figure 2. Tap changing transformer connected with relays

C. Relay interfacing circuit

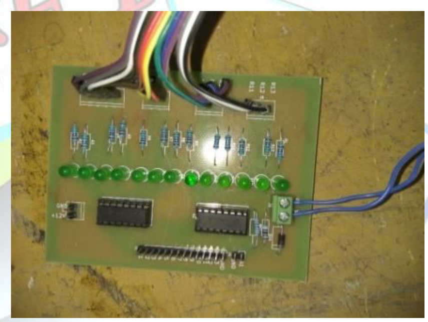

Figure 3. Relay interfacing circuit board

The relays are interfaced with Arduino mega microcontroller board through Relay driver IC ULN2003A [7]. These are high-voltage, high-current Darlington transistor arrays. It consists of seven NPN Darlington pairs that feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads such as motors and electromechanical relays. Each channel is capable of driving up to 500 mA current at a maximum voltage of 50 volts DC. The inputs are compatible with various types of logic such as TTL and CMOS. A printed circuit board (PCB)

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is designed and implemented for interfacing the relays with microcontroller along with led indication to identify the relay switched. For each relay there is a led to show the condition of relay.

D. Constant current load

In order to test the electric vehicle chargers under various load conditions a programmable constant current load circuit is designed using IRFB4321, LM324 OP-AMP and MCP41010 Programmable digital potentiometer. Current in the load circuit is controlled by varying the gate voltage of the MOSFET which is operating in saturation or active mode of operation. In linear mode, the MOSFET is on not fully but partially, behaving like a variable resistor. It is Possible to control the drain current, I_D in a linear fashion by controlling the gate source voltage VGS. Figure 4 shows the proteus simulation of adjustable constant current load.

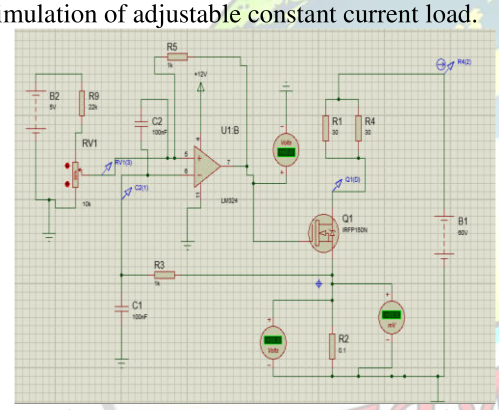

Figure 4. Constant current load circuit

LM324 Operational amplifier which is used in open loop differential amplifier configuration generates the gate voltage required to control the load current. The voltage across the shunt resistor is applied to the inverting terminal of the Operational amplifier. The reference voltage that is non inverting terminal of the op-amp is connected to the output of MCP41010 digital potentiometer and the actual current is sensed through the shunt resistor [4]. The differential amplifier amplifies the small difference between the reference and the actual voltage across the shunt resistor. By using this setup the drain current, can be set to a desired value simply by adjusting the MOSFET gate voltage. The value of drain current does not depend on the terminal voltage i.e. V_{DS} of the loaded device, that is the electric vehicle charger. Two 30 ohm dynamic braking resistor are used as parallel to dissipate the power.

These two resistors are capable of dissipating 550 watts of power. In order to cool these high power resistors a table fan is used for forced air cooling. This way the device under test is loaded with the constant current set by the user that passes through the shunt resistor and the load current can be kept constant over a range of time varying terminal voltages. Figure shows the simulation diagram of constant current load and PCB is designed and implemented in real time also shown in the figure.

E. voltage and current measurement

The input and output parameters such as input AC current and voltage, output DC voltage and DC current are measured using the analogue input pins of Arduino mega microcontroller by suitable circuits and require sensors. The input ac voltage is measured by using a potential transformer and voltage divider circuit and a diode to cut off the negative cycle of the AC voltage, because analog pins of the microcontroller only the positive voltage. The output DC voltage is measured using a voltage divider circuit constructed with the help of resistors. This voltage divider circuit converts high DC voltage into less than 5 Volt DC because the controller only accepts less than or equal to 5 volt DC. Both the currents that is input AC and output DC current are measured using ACS712 20 Amps Hall Effect based isolated current sensor. The sensor is capable of measuring up to 20Amps AC as well as DC currents. For AC current measurement applications the sensor has an offset voltage of 2.5 volts. The sensor has a sensitivity of 100milli volts per ampere.

III. IMPLEMENTATION

The complete system is implemented using Arduino mega microcontroller board along with input, output devices and test setup. The flow chart of the test setup program is shown in figure. The input parameters such test voltage, on time, off time and number of counts are obtained from the

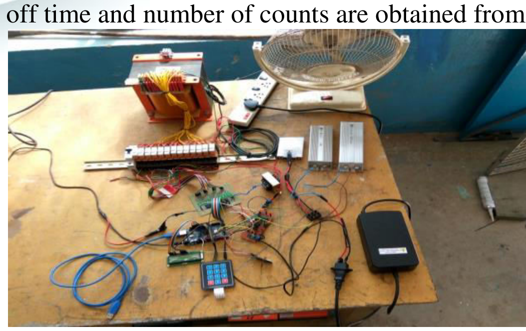

Figure 5. Testing setup

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user through 4*3 matrix keypad. A 16*2 Liquid crystal display (LCD) is used for displaying the input output parameters such voltage and current. While running the real time testing the parameters such as input voltage, current and output voltage and current are stored in an SD card which is interfaced with Arduino mega microcontroller through serial peripheral interface. If there is any error in the measured parameters then the test program will stop execution and indicates and error through LCD display. Figure 5 shows the complete testing setup.

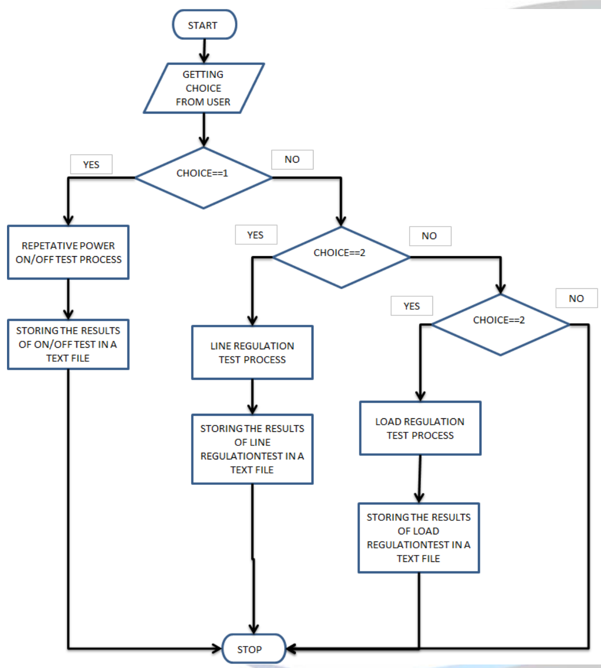

Figure 6. Flow chart of testing program

Figure 6 shows the flow chart of the testing program written into the Arduino mega microcontroller. The program gets choices from user through the matrix keyboard interfaced with the microcontroller and shows the data through the 16*2 LCD interfaced with the microcontroller. According to the user input the test setup switches the relays connected to the multi tap transformer. The load current controlled by the programmable constant current load circuit designed and implemented using the MOSFET and Op amp LM324N.

IV. CONCLUSION

Through this paper we proposed a low cost semi-automated electric vehicle charger testing platform which could be used to test the functionality and reliability of electric vehicle chargers manufactured in electric vehicle industries against real time voltage fluctuations and various environmental conditions. The system also contains a SD card based data logging system to store the test parameters such as voltage and currents as text file. This text file can in imported into a excel sheet in order to view the test data as a pictorial representation. The functionality of the charger can be checked for the graph obtained from the data stored in the text file.

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