Retraction

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Architecture of a HV Power Battery Protection Devices for Hybrid Electric Vehicles (HEV)

Mohan P. Thakre¹, Yogesh V. Mahadik², Nikhil Sardar³

¹ K. K. Wagh Institute of Engineering Education and Research, Nashik, India
² Government Polytechnic, Malvan, Sindhudurg, MH, India
³ School of Electrical Engineering, MIT AOE (D) Aland Pune, Maharashtra, India

mohanthakre@gmail.com¹, yogimahaforu@gmail.com², nbsardar@mitaoe.ac.in³

Abstract. The Hybrid Electric Vehicles (HEV) has high voltage battery whose voltage is higher than the people can endure. The proper insulation should be provided to the HV battery pack but sometime due to abnormal condition the battery insulation get failed. Whereas the HV battery not grounded to chassis if an abnormal condition occurred then a human being get electrified. To resolve the insulation failure this paper aims on Designing HV battery Protection system for Electric vehicles. In this paper we design control strategy and algorithm for battery isolation in electric vehicle. This paper aims to Designing the hardware circuit and algorithm for the isolation. These systems detect resistance in between battery pack chassis and maintain this resistance with standard resistance value. If it is failed to maintain resistance it turned off the battery Precharge switch to avoid malfunctioning. It is convenient, simple and less in cost.

Keywords: Electric vehicle, High Voltage Battery, Isolation, Control Algorithm.

1. INTRODUCTION

The Electric Vehicles has been rapidly get Research and development for energy and environment reason. The major part of an Electric Vehicle is Power train Drive, Batteries, Controller, Converter, etc. These major parts play important role in EV drive system if this system gets failed whole operation failed. The Electric powered vehicles not dependent on any internal combustion engines for propulsive powers, it depends on Electric powered traction Batteries which engaged with the motor drive system. HV battery is a main power source of an Electric vehicle. While Considering for EV HV/LV Batteries it must be small in size, light in weight, properly insulated and Cost. The HV battery safety precaution is a major concern for electric vehicles. Because this HV Battery face Different Atmospheric condition such as Temperature, corrosion, aging, Vibration and many more due to this HV battery performance decreases and it goes toward severe malfunction.

The HV battery should be properly insulated but sometimes grounding is not pro- vided. If insulation fails it draw large unwanted current. That unwanted current flows in a vehicle and human being get electric shocked and also internal as well as external electronic components get damaged within a system. Today all battery manufactures focused on battery size, maximum power and safety. There should be some autonomy to detect leakage as well as maintain isolation of battery with respective of chassis of an EV. In order to check proper insulation of an EV this system designed. By using this system the battery isolation is checked if isolation is ok then it allow to turn on the power supply for driving system. By using this system may minimize the significant of Leakage current to avoid person in the fault condition.

2. PROPOSED SYSTEM

2.1 Proposed System

In an electric vehicle there are two types of battery used for drive traction motors and auxiliary power supply respectively. The auxiliary power supply battery rating is not more than traction motor battery.
Auxiliary power supply battery used for lightning, conditioning, media player system, etc. In abnormal condition the high voltage battery delivers unwanted current. This system detects an unwanted electrical path with chassis in an EV. It consciously monitors and it is capable even battery is active or deactive and even experiencing large voltage variation in vehicle. Controller sensed this variation and compare this variation with standard values and controller trips the Pre-charge switch when isolation its fails to maintain standard value where HV battery pro- vide power to traction motor or drive system. If any fault occurred the unwanted current flows towards lower resistive part with respective ground. In electric vehicle high voltage battery is not providing any kind of ground, therefore unwanted current flow towards chassis. In between battery and chassis, there would be some resistance.

If this resistance decreases means unwanted signal introduced and isolation / insulation getting failed. To overcome this problem this system designed. Here constant current source hardware is designed where 0-50µA current introduced in between the negative terminal of battery with the respective chassis ground. The controller sense voltage across it. There would be some resistance this resistance would be a standard resistance. By using a constant current and sensed volt- age controller calculated the resistance. The standard resistance in between the chassis and battery insulation would be 100k ohm. If this resistance not maintained means that unwanted signal are introduced and then controller not allow for battery supply power. And it trips the Pre-charge switch.

2.2 Importance of Battery Isolation

While designing any electric vehicle one of the main concern on safety. It should meet some safety standards. It should be limit chemical spillage from batteries, securing batteries during crash and isolating the chassis from high voltage batteries/system to pre- vent electric shock. In this paper our prime focus isolating chassis from HV batteries. It caused by crash of electric vehicle, battery terminal shortage, temperature effects, poor insulation etc. during this time battery isolation get failed when driver driving a car and at that time driver and co-passenger get electric shock and it damaged internal as well as external components of electric vehicle. Sometimes due to short-circuit in electric batteries fire explosion caused.

3. CONTROL STRATEGY

Battery isolation means high resistance in between battery and chassis or it should be maintained. But some time due to abnormal condition the battery isolation get failed. To maintain the battery isolation this proposed system designed. As per automotive standard 100k resistance should be maintain in between chassis and battery. If this value change below considers the battery isolation is poor. This change in resistance caused due to crash in electric vehicle, short circuit, battery terminal insulation failure, charger fault, overheating, etc. there is two methods to find battery isolation in electric vehicle one constant
voltage method and another one is constant current source method to detect resistance. Here for constant source method is applying for this proposed system constant source generator designed. The simulation and experimental results are shown below.

The control strategy shown in Fig. 2, the controller is initializing its PWM signal, standard resistance, voltage sensing as well as calculation, duty cycle, frequency. The controller gives PWM signal to the constant current source generator as well as MOSFET switch as shown in Fig. 1. Constant current source generates constant current within range of 0-50 µA current. That constant current fed into the negative terminal of battery with respective chassis as shown in Fig. 1. Here some in test circuit the resistance and MOSFET are shown ideally there is no resistor but for experimentally we are keeping some resistance there. The 100k resistance is our standard resistance. And MOSFET switch is used for turn ON-OFF simultaneously the process with respective ground. The controller ADC pin sensed voltage across the resistance, it covert ADC value to digital value. In controller it calculate resistance and controller compare this resistance with standard resistance if it is equal the it allow to Precharge switch turn on if it is below 100k controller gives signal to turn off the battery Precharge switch. Where battery Precharge switch used in between battery power supply and traction drive system.

4. EXPERIMENTAL SETUP

4.1 Constant Current Source

The constant current source generating circuits were designed using the operational amplifier with rail-to-rail input, output swing. This op-amp is used because of the low current of value 300mV at input swing and at the output it will be limited within 40mV. The input signal is given at the junction terminal J2, the junction point J1 is for the input supply for the op-amp operation.
The feedback resistance and capacitor is connected for reducing the noise in the amplified output signal when connected to the isolation resistive load in order to maintain DC accuracy. The output signal is given to minimum load value of about 1kΩ loads connected to positive or negative terminals of battery to the respective ground point. If the load value is considered below 100kΩ, then output voltage will starts swinging up to 40mV according to the input supply. Hence the isolation resistance is considered based on the op-amp specifications especially for the current limitations. The denoted component design values are related to the standards which are considered from the datasheet of the op-amp selection. The designed circuit is simulated using the software and the results are considered. The constant current output is also scaled according to the change in input signal which is given in junction terminal J2.

4.2 Test Circuit

The test circuit is connected in between the negative terminal of the high voltage battery and the chassis of the vehicle. For testing the standard resistance value 100kΩ is considered as the load for the constant current source circuit. The MOSFET switch is used for turn on-off the circuit to get completes the circuit so that the resistance value can be calculated by sensing the voltage across the resistance. The ADC pins of the microcontroller where the sense values are calibrated and the resistance value is calculated in the software.

4.3 Simulation Design

The final experimental circuit diagram of a constant current source along with test circuit is shown below fig. 4. This circuit diagram is designed in Texas TINA-TI simulation software and controller. The controller has 50k internal resistance in ADC pin with respective ground so therefore 50k resistance is shown across isolation resistance Ri.
The voltmeter sensing voltage across it but practically we connect controller to sense the voltage. The hardware setup is developed in order to check the isolation in practical condition that is connected between the battery terminals and the chassis of the electric vehicle. As per the simulation results the sensing voltage and the constant current is obtained in the hardware setup mentioned in the Fig.5 and the waveform results are detailed in the following Fig.6 by testing the values at different test points.

4.4 Test Result

The proposed system output result is shown below after designing hardware and soft- ware. The constant current source delivering 33µA current in a test circuit and 100k ohm is an isolation resistance. The component selection is done by analyzing the data sheets of op-amp and the controller. The ADC pin of the controller have an in built 50k ohm resistance with respective ground, so the readings attained over the software involves the considerations of that in built resistance value. The current and sensed volt- age across load resistance will be in the form of PWM signal because input signal is PWM signal. The values of current and voltages are shown in simulation waveform diagram in Fig. 6 The AM1, AM2, AM3 are ammeter and VF1, VF2, VM1 are voltmeter were VM1 sensed voltage across load/isolation resistance.
Fig. 6. Simulation output waveform results

The controller sensed voltage across the resistor. The controller has 12 bit resolution to calculate ADC value with respective 12 bit resolution. And calculate voltage in terms of 4095. Here we are keeping 100k resistance the sensed voltage is 2 volt and its ADC value is 2481. If below 2481 ADC counts it does not allow turning on battery Precharge switch. The controller calculates resistance and compare with its resistance. Here for 100k and 99k result calculation shown below in Table 1.

| Parameters      | 100k  | 200k  |
|-----------------|-------|-------|
| Sensor sample   | 2481  | 2456  |
| Analog voltage  | 2     | 1.98  |
| Resistance      | 100.47k| 98.4k |
| Pulse           | 1     | 0     |

5. CONCLUSION

This proposed system provides a safety system for electric vehicle. The experimental testing and simulation of proposed system provide high voltage safety in electric vehicle. The constant current source method is effective than constant voltage source method. It is compatible to detect failure on single pole or on the both poles of high voltage battery. In abnormal condition it detects and trips the battery Precharge switch in electric vehicle power system. Also this system checks isolation when electric vehicle is active or Deactive. This system in future will integrate with battery management system.

REFERENCES

1. Yanhui Zhang et al 2020 IOP Conf. Ser.: Mater. Sci. Eng. 793 012061.
2. Wei Xuezhe, Bi Lu and Sun Zechang, "A method of insulation failure detection on electric vehicle based on FPGA," 2008 IEEE Vehicle Power and Propulsion Conference, Harbin, 2008, pp. 1-5, doi: 10.1109/VPPC.2008.4677526.
3. Wu. Zhen-jun and Wang. Li-fang, "A novel insulation resistance monitoring device for Hybrid Electric Vehicle," 2008 IEEE Vehicle Power and Propulsion Conference, Harbin, 2008, pp. 1-4, doi: 10.1109/VPPC.2008.4677682.
4. Zhang Haoming, Sun Yukun, Ding Shenping and Wang Yinghai, "Full-digital lithium battery protection and charging system based on DSP," 2008 27th Chinese Control Conference, Kunming, 2008, pp. 265-268, doi: 10.1109/CHICC.2008.4605354.
5. C. C. Chan, "The state of the art of electric and hybrid vehicles," in Proceedings of the IEEE, vol. 90, no. 2, pp. 247-275, Feb. 2002, doi: 10.1109/5.989873.
6. C. C. Chan, "The state of the art of electric and hybrid vehicles [Prolog]," in Proceedings of the IEEE, vol. 90, no. 2, pp. 245-246, Feb. 2002, doi: 10.1109/JPROC.2002.998932.
7. Han Peng, “Insulation and monitoring system for pure electric vehicle based on microcontroller unit”, International Scientific Journal Acta Technica, 62 No. 2C (2017), 23-34.
8. C. Zhou, S. Hu, W. Sha, Q. Liu, “Active detection system of insulation resistance in electric vehicle”, Journal of Electronic Measurement and Instrumentation, No. 05, (2013) 409-414.
9. Kwo Young, Caisheng Wang, Le Yi Wang, and Kai Strunz, “Electric Vehicle Battery Technologies”, Electric Vehicles Integration into Modern Power networks / Springer, (2013).
10. Gregory. J. Offer, Vladimir. Yufit, David. A. Howey, Billy. Wu and Nigel. P. Brandon, “Module design and fault diagnosis in electric vehicle batteries”, Journal of Power Sources, May (2012) 383-392.
11. Gregory J. Offer, Vladimir Yufit, David A. Howey, Billy Wu, Nigel P. Brandon, Module design and fault diagnosis in electric vehicle batteries, Journal of Power Sources, Volume 206,2012,Pages 383-392,ISSN 0378-7753,https://doi.org/10.1016/j.jpowsour.2012.01.087.
12. P. Prem, P. Sivaraman, J. S. Sakhti Suriy Raj, M. Jagabar Sathik & Dhafer Almakhles (2020) Fast charging converter and control algorithm for solar PV battery and electrical grid integrated electric vehicle charging station, Automatika, 61:4, 614-625, DOI: 10.1080/00051144.2020.1810506
13. K. W. E. Cheng, B. P. Divakar, Hongjie Wu, Kai Ding; and Ho Fai H, “ Battery-Management System (BMS) and SOC Development for Electrical Vehicles”, IEEE Transactions On Vehicular Technology, Vol. 60, No. 1, January 2011, pp. 76-88.
14. Vaibhav S. Guntuk, Mohan. P.Thakre, et.al, “A Novel 4-level Converter for Switched Reluctance Motor Drive in Plug-In HEVs”, IEEE Int. Conf. on Intelligent Computing and Control Systems (ICICCS 2019), Vaigai College of Engineering, Madurai, Tamil Nadu, India, 15-17 May 2019 ISBN: 922-1-7281-2214-6, pp. 626-631
15. Vaishnavi V. Hadke, Mohan P. Thakre, “Integrated Multilevel Converter Topology for Speed Control of SRM Drive in Plug-in-hybrid Electric Vehicle”, Proceedings of the 3rd IEEE Int. Conf. on Trends in Electronics and Informatics (ICOEI 2019), SCAD Clg. of Engg. & Tech., Tirunelveli, Tamil Nadu, India, 23-25 April 2019, CFP19J32-ART; ISBN: 978-1-5386-9439-8, pp. 1013-1018.
16. D. S. Maurya, P. D. JadHAV, R. S. Joshi, R. R. BendkhaLe and M. P. Thakre, “A Detailed Comparative Analysis of Different Multipulse and Multilevel Topologies for STATCOM,” 2020 International Conference on Electronics and Sustainable Communication Systems (ICESC), Coimbatore, India, 2020, pp. 1112-1117, doi: 10.1109/ICESC48915.2020.9155708.