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Modelling of Energy Management System for Autonomous Electric Vehicle

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Abstract

In this modern world with the increasing amount of pollution and need of smarter energy management we need proper electric vehicle; it's charging system and the grids which may stand out to be the most important sector to be focused upon.So at first, we have focussed on the affordable distribution and management of the power, well in this project we have come across the idea that if we provide power to any sector in form of desired packages then we can make the consumer more aware about their own usages because in general life everyone wastes energy some way or the other due to lack of consciousness well with power packages they will be awarded by self-monitoring their own usages in that case the unused amount of power data can be recorded and stored. The unused power can be sold out by the user to the grid monitored through IOT platform to ensure energy saving with the peoples own interest. This extra energy from the grid is stored in secondary power storage and then it is supplied to the charging stations which helps us to recover the losses in the power distribution, supply and usage as well. The energy supplied to the charging station is being stored within the fixed battery banks, these battery banks gives supply to the removable battery stacks to be used in the electric vehicle. For attaining better efficiency and better performance we have designed a better model of battery design. In which we have used 18650 li-ion batteries, each battery stack is deigned in series and parallel combination within the stack along with a new proposed deign of stack cooling and ventilation system. These stacks are connected to a parallel HV buss for required amount of power output. The cells within the battery stacks are monitored using the battery management and monitoring system[1] setup, the stacks are monitored using the battery management system, in case of any variation within the battery stack is found the particular stack is isolated by the controller and the spare stack is connected immediately after the instantaneous fault detection each stack is removable and can be charged separately and also within the system , this system also enables us to monitor the system statusover mail. This system enables the vehicle to manage its equilibrium and make the vehicle more efficient economically and regarding energy management and safety aspect.

Keywords**:** Energy management, smart grid, EV batteries, IOT, communication, charging station, UID- unique identification no.

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I. Introduction

Demand and expectation of proper energy saving, its utilization and management is increasing with the scarcity of power. Efficient non-conventional energy source and storage have marked the urge of evolution in the energy sector. The demand of efficient and cost-effective electric vehicles with efficient energy management in the power source sector is a need and necessity of today's world. To have control over needless loss of energy we need to build up smart infrastructure to make the newer technologies sustain. Smart grids are one of the main demands to be initialised within the country and installation of the smart meters even for the domestic purposes should be the utmost need. Energy management will be more convenient if we use energy in terms of data package system, we are creating a single interactive platform for the grid and the loads connected to it so that the user gets easy access to monitor the energy consumption of the loads allotted and connected to the supply so as to create a transparent platform which can be controlled remotely. We can even control its switching operations to manage the load sharing. The smart girds are mostly having the connectivity to the renewable energy resources in our proposed design. The grids are automated and are continuously monitored using the IOT platform through smart meters, here we are proposing a model that can monitor and control loads and the grid supply automatically over a particular iot platform. During over load or faulty situations within the grid the power control and management can be done easily with the below proposed model providing power to other loads and to the charging stations maintain zero energy loss and mismanagement. We have designed the charging stations in such a way that the batteries can directly and individually charged previously, which can be used using the battery exchange policy that once when the battery is drained the consumer can exchange the batteries with the already charged ones in the charging station in the below proposed concept. As the cars to be designed has to have removable battery stack for them the charging station have a fixed battery source which gets charged directly and it then supplies the energy to the battery packs connected to it. So that the user don't have to wait in the charging station to charge the batteries of the vehicle which saves the charging time in this fast pace life. In many recent models we have seen the companies making the vehicles which have the battery set up made of combination of small li-ion batteries[2] stacked in combination of series and parallel together stacked at the base of the vehicle so as to provide higher efficiency , space and weight equilibrium. This setup allows each cell to be monitored using the active cell [5] monitoring by the BMS attached to the stack which ensures that all the batteries are equally charged and drained at the same time explained in Figure 1, each cell have the specification of 3.7volts (18650 battery module) [4].

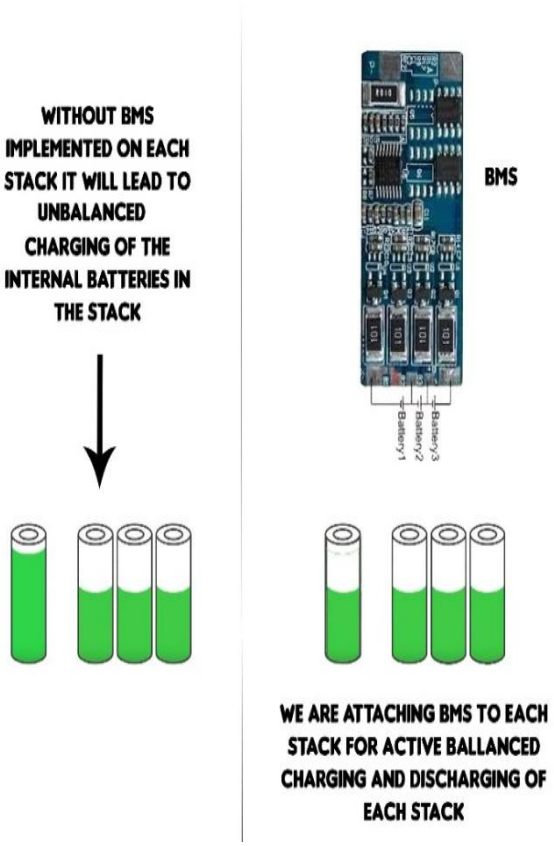


Figure 1: Active balancing of batteries in each stack using BMS

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The whole setup starting from the grid power supply to load management and vehicle power efficiency monitoring and maintenance this system will ensure an efficient system for consumers. This setup of will help consumers to better, efficient, safe and stable mobility without any further interruption.

II. MARKET SURVEY:

According to Germany's centre of solar energy and hydrogen research there are almost 5.6 million EV's on roads till now if most of the vehicle sold become electric by 2040 then there could be more than 1 billion EV's on roads.Future EV battery capacity may dwarf stationary battery capacity. In 2050, around 14 TWh of EV batteries would be available to provide grid services, compared to TWh of stationary batteries. Till now we have been introduced to the concept of continuous plug in charging method which has very extensive abnormal effect during peak demand that may increase with a range of about 3 gigawatts with uncontrolled charging methods, as for most of the time the car remains in the parking lots and with newly developed charging station in the parking areas the power consumption of electricity increases at a very high rate [19]. Previously introduced concept includes unidirectional control charging, vehicle to grid communication, vehicle to home communication all these concept have previously been introduced but the concept we are going to introduce will make these whole process more simple as in the proposed design we are not consuming energy continuously from the charging stations we are storing energy within the charging station and during peak load or over loaded conditions and for long distance and continuous supply cars can use overhead solar charging module so that the energy consumption is managed properly. Within the vehicle the batteries which are used are fixed battery system which gets a regulated and maintained output through the battery management devices installed within the battery but it still does not help in getting better efficiency and battery backup during faulty conditions unless and until the batteries are stabilised The tesla model S model of batteries are fixed to the base and if there is any internal fault the whole system is to be repaired due to is robust fixed design tesla also intended to bring fast swap charging system but it was not feasible in market as the total pack weighs around 641 kg in total which makes easy swapping battery model difficult for charging. There is a huge drawback in its cooling system as the cooling of each stack is not done in an efficient manner, the batteries in the stack goes through imbalanced cooling mechanism that leaves the batteries in the end to be warm.

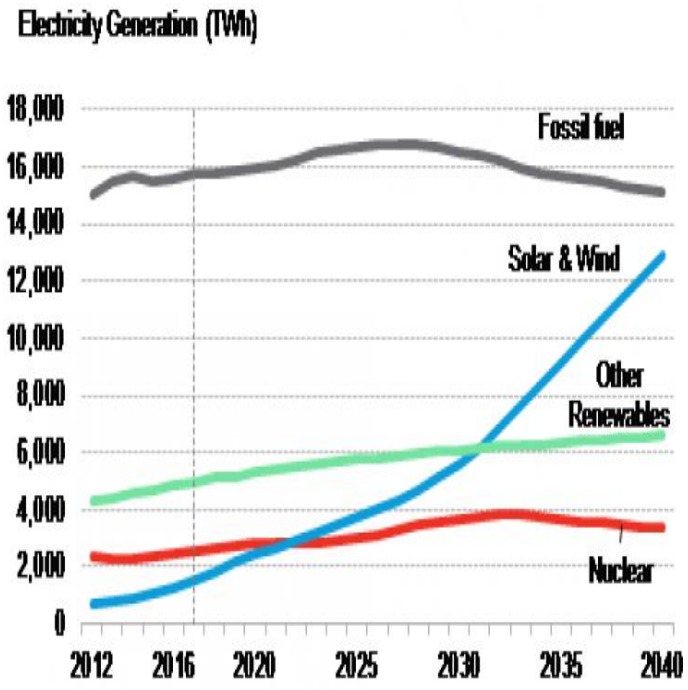


Figure 2: Estimation for demand of renewable energy grid by 2040 for the growth of ev

III. SYSTEM OVERVIEW:

1) Design of battery module and charging station for EV

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To construct the power supply model of the ev we have designed the battery structure in such a way that it becomes reliable sustainable and efficient as well. The ev's power bank must be constructed in such a way that the loads connected to it does not get effected with any power discrepancies or inefficiencies offered by the power set up. The battery stacks are fixed at the bottom of the vehicle connecting them in series and parallel combination making the battery set up extremely protective and providing better vehicular balance , ease in manufacture, safe in crash and better space management, so for that we have combined the concept of easily removable and manageable battery stack which will be well protected by proper heat and current insulation and sustained with proper ventilation system as in place of the linier cooling model we ate using the distributive cooling model, each stack will be connected with a plug in charging and cooling system. As we are designing the battery pack taking reference of a prototype models, for our model we are using bldc motor of particular specification of 48v, 3 KW power, and 64 amps. In each stack we are connecting 13 batteries each of 4 v and 3 Ah current capacity in series and then these series stacks are connected 6 in parallel. Each stack developed is connected to separate BMS that keeps the control of the output power. Each series stack is separated by an insulating sheet. All the cell connections are done using 2.3m ohm fuse wires and are connected to a shunt resistor of 0.05 ohm. Each stack rating of 52 v and 15 Ah. The total battery pack provides 3.1 kW of power to the system where the power is distributed to be used by the motor and the other connected loads to enable communication between the load and its control system. It provides an energy capacity of 3kwh. These stacks are connected in a VH buss, each stack is hugely ventilated and safety driven by hard metal casing with proper cooling mechanism [20] and ventilation. Charging stations are developed in such a way that the stacks are directly charged within the charging station. Where the user can give the uncharged stack for charging and replace it with the already charged stack. The internal charging and control mechanism is being controlled by controllers, converters and relays, in which 4 stacks are used as primary stack and the other one is secondary which gets activated during fault condition to provide uninterrupted power supply.

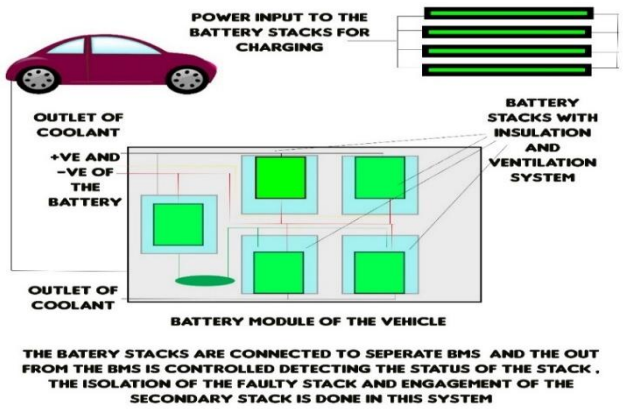


Figure 3: Battery and the Charging Station setup

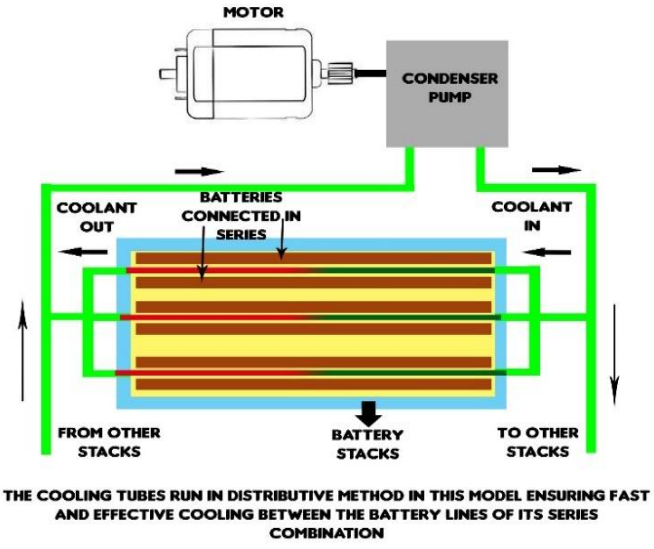


Figure 4: Effective cooling of the proposed design of the battery stacks in EV.

2) IOT based energy monitoring system:

IOT is widely used for remote monitoring of the parameters, we are using this set up for sensing the real time data of the attributes connected to the system and their variation with time, and we are monitoring these variations for rectifying and implementing corrective measures which could

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be accessible at any point at any place. In our battery monitoring system, each stack is connected to its on individual (battery management system circuit) which gives the stable output from the battery to be controlled easily. The data of the battery stack is transferred to the things speak platform using the node mcu module (Wi-Fi module) where the data of the battery is calibrated and can be accessed through the things speak iot platform through a particular user ID. During fault detection the status will be prompted through mail to the user whenever there will be a change in the parameters that will cross the predefined limit which is done using webhooks. The data will also be esured to be stored and monitored so as to have a proper acces to the user. Here we are calibrating the data using the IOT thingsspeak web service , it is an API service that will be a host to monitor various sensory actions at a cloud level. With this setup the user gets notified about the vehicles risks , its temperatur conditions within the system , leackage, overweight, condiotions which gets prompted as an interrupt to the user through mail and other web servicies connected to particular platform signed with UID.

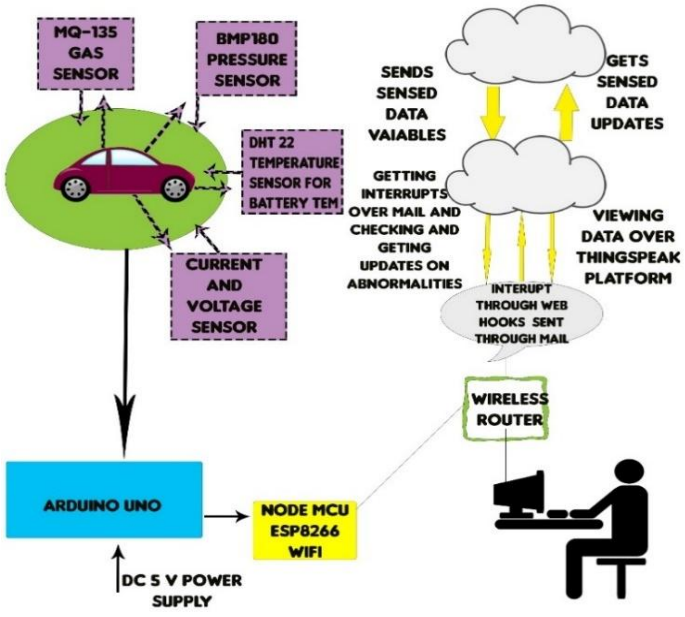


Figure 5: Battery monitoring system over the thingspeak Iot platform and generation of interrupt during fault detection within stack

3) Communication between smart grid and charging station:

Designing of the energy management [15] system which includes the communication between the charging station and other loads with fine balancing of power between the loads and the grids. Here in this project we are having smart grids[17] connected to renewable power sources and smart energy meters on the grids and loads as well, Using the concept of DC-DC transmission we are connecting different power sources to the grid, the power output which we can get its data will be collected through the smart meters can be viewed on the iot platform of cayenne during normal condition the primary grid supplies the power to the domestic load, battery bank for secondary storage and the charging station. When a fault is triggered or during over loaded condition the power supply is redirected and is fed from the charged battery bank to the domestic, industrial load and the charging station. This switching of power can be controlled by the raspberry pi and relay module which helps to monitor the data over the cayenne platform.

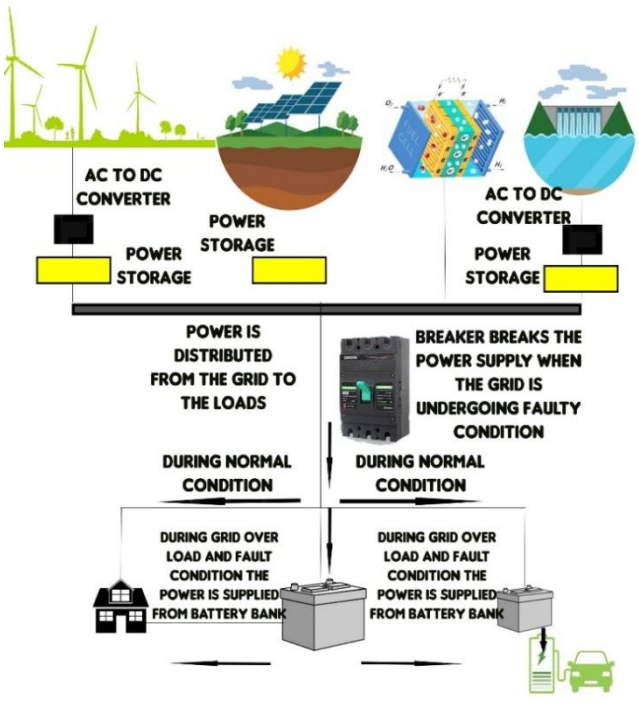


Figure 6: Energy control and management diagram

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IV. ALGORITHM:

CASE 1:

Here we are transferring the power of the renewable energy resources to the grid and the grid is supplying the power to the charging stations, the domestic load and the subsidiary battery bank in the form of DC-DC transmission. The unused power which is being stored within the secondary batter bank and the data which is recorded over the cayenne platform (power from the domestic loads) are being transferred to the battery bank to be supplied to the station, the whole power monitoring can be done using the cayenne iot platform which transfers the data using the Raspberry pi 4 to the online platform and the data collected there can be used and accessed using specific IDs for control through different grids. The cayenne is used to monitor the fault and trigger the fault interrupt to the relay through the raspberry pi whenever there is a fault in the grid the power is supplied directly from the subsidiary battery power source to the following loads [14].

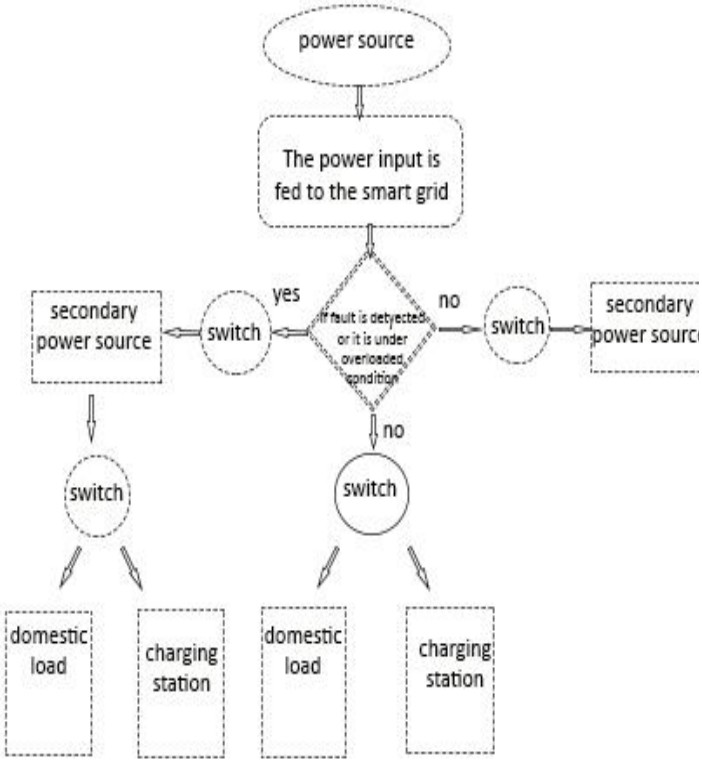


Figure 7: Energy management and monitoring of grid and loads connected over cayenne using raspberry pie

Step1: design the transmission and distribution system of power in such a way that the power from the grids are supplied using DC-DC transmission to domestic, industrial, secondary power backup unit and the charging station

Step2: the loads connected to the grid are metered using smart-meters which are directly connected through a particular user's id to the cayenne's iot platform so that the daily consumption of energy can be monitored and recorded so that it becomes easy for the provider to decide new and economical tariffs for the consumer.

Step4: whenever there is over load condition generated load sharing is done as the main grid supplies the current to the domestic loads and the secondary power unit supplies it to other industrial power sectors and charging stations.

Step 5: whenever a fault is generated within the grid the main power source is tripped using the breaker and the power is redirected from the secondary battery backup source to the loads.

The whole thing can be controlled using the Raspberry pie 3 and can be monitored on cayenne. The concept is stated in figure 7

CASE 2:

We are using the Active cell monitoring algorithm [15] and the battery management system [2] to identify the faults generated within the cell inside the stack[20], once the fault is detected the controller activates the breaker to break the supply from the faulted stack[22] and rearrange the connection to the spare battery stack it also give and active update about the battery status its charge rate and discharge rate along with its state of charge which can again be connected to the same IOT platform to be monitored. Concept is stated in fig 8.

Step 1: Each battery stack have been internally insulated and coolant passing system along the

series connections of the battery module are cooled in linear algorithm but in the proposed algorithm we are using distributive model of cooling, these stacks are separated by distanced encapsulation. Where each stack its own internal ventilation

Step 2: each stack is connected to the internal parallel connection through the plug-in system, whenever the BMS detects fault and trips the connection of that particular stack the secondary stack is switched on immediately for backup for maintain the overall efficiency of the system.

Step 3: Each stack can be removed easily for charging and can be plugged within its own plugin capsule.

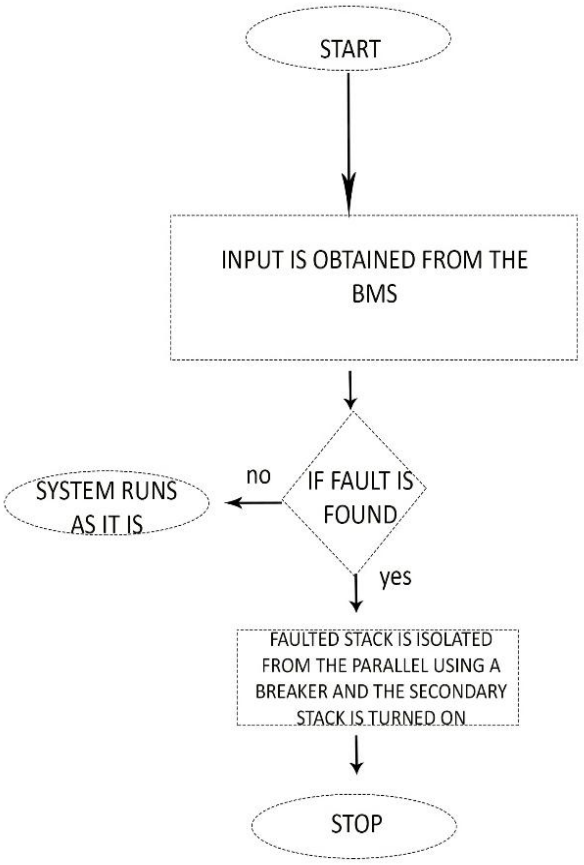


Figure 8: Fault detection and isolation of battery stack

CASE 3:

For parallel monitoring of the battery status, remote update of the battery efficiency and fault monitoring [11]. We connected the battery and the charging system to the controller, the Wi-Fi module (Nodemcu) connected to the Arduino, the data fed for monitoring is taken from li-po battery for the experimentation and sent on to the think-speak platform. we can get the real-time data of the charging [7] and discharging rate of the battery and the temperature of the battery module so that we can identify the fault level too. Whenever the values go out of the limit controlled by the Arduino, an interrupt is generated through the webhooks which sends an emergency mail with the detailed information about the battery performance [6] and the status to the user. Which can make the user alert about the system status and can also be used to identify the accidental issues generated. This mechanism can also be sent to the safety traffic control room giving the status of the car for immediate rescue, this algorithm will help to maintain the safety of the passengers of the vehicle more efficiently as the interrupts are prompted at real time with no delay. We are using the micro usb18650 charging module, li-po battery of 4 volts, 'Arduino Uno', 'ESP8266 (node mcu)', resistors and a dc load.

Step 1: login to thinks-peak and create the channels to be used. e.g.: charging and discharging voltage.

Step 2: we will use the 'ThingHTTP' app to trigger the IFFTTT applet to trigger an interrupt through mail.

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Figure 9: Step for execution and triggering of command writing the set of case for detection and execution of the fault.

Step 3: using the 'WEBHOOKS' services create a URL that is to be used in 'thingHTTP'.

Step 4: create an applet to link it to thingHTTP to google sheet and choose trigger in webhooks by typing an event name and enter your mail where u want to receive trigger.

Step 5: then again come to Thingspeak>apps>ThingHTTP, fill the information, then fill the conditions for the interrupt to occur in the thingHTTP, e.g.: if charging voltage is >=4.1 select action to be ThingHTTP and perform "the required interrupt name set"

Step 6: run the code on the Arduino ide platform after the proper connection. The network and action establishment procedure is stated in figure 10.

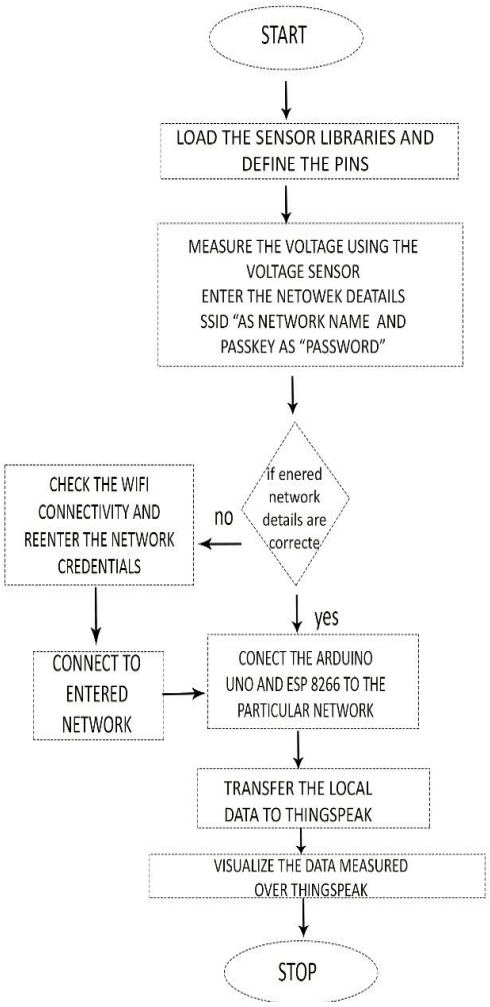


Figure 10: Flowchart representation of data representation and communication between the battery monitor and user over things peak

V. SIMULATION RESULTS:

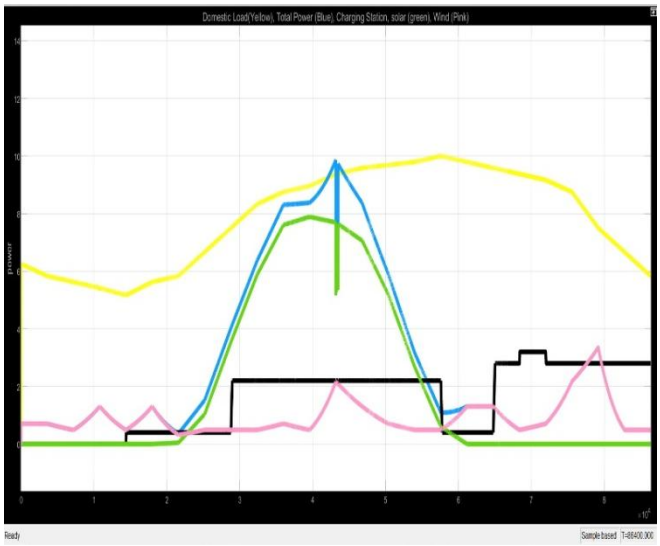


Figure 11: The above graph represents the total power supply to the grid with blue, green and

pink represents solar and wind, yellow represents domestic load consumption and the black is the representation of the charging station.



Figure 12: The above graph demonstrates the state charge of all the vehicles connected to the charging station.

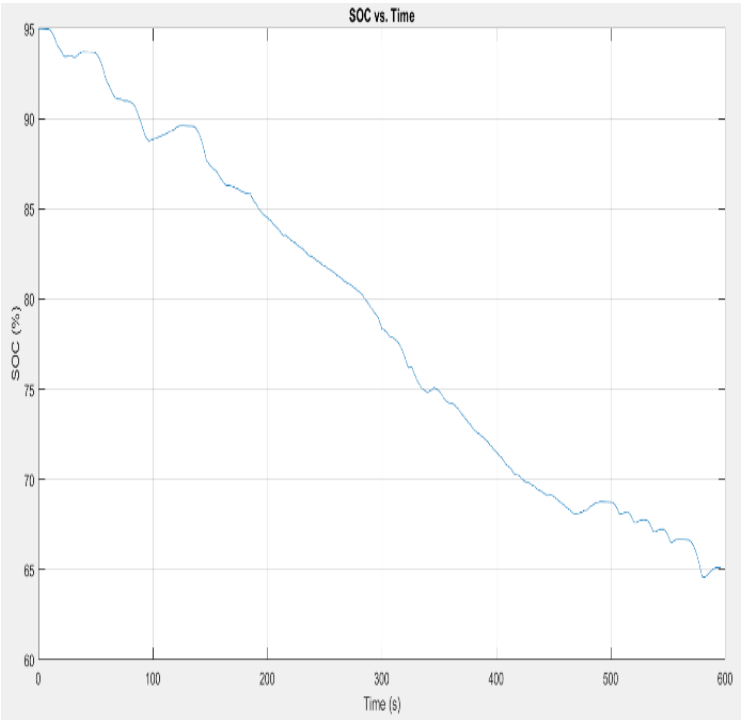


Figure 13: The graph represents the state of charge of the battery stack of the vehicle with time

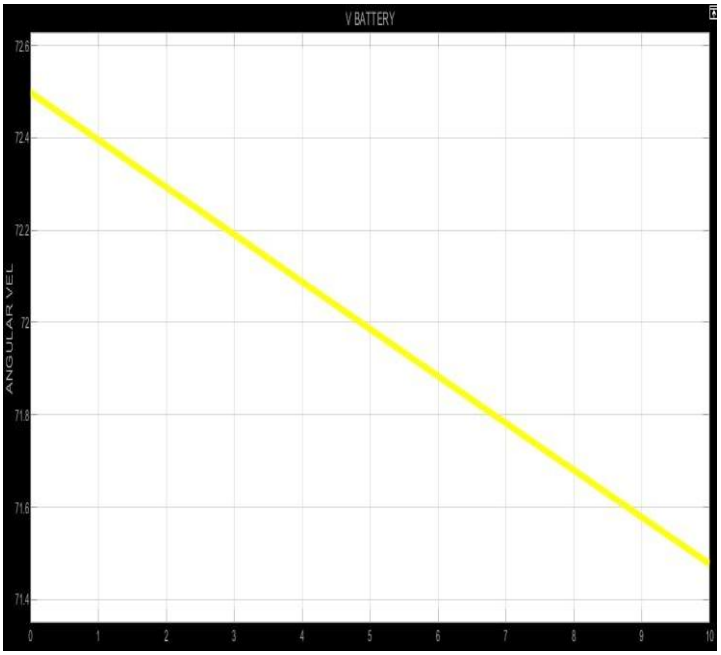


Figure 14: It represents the angular velocity of the vehicle with time represented with a graph of 10 seconds when at full power. To represent the final vehicular performance

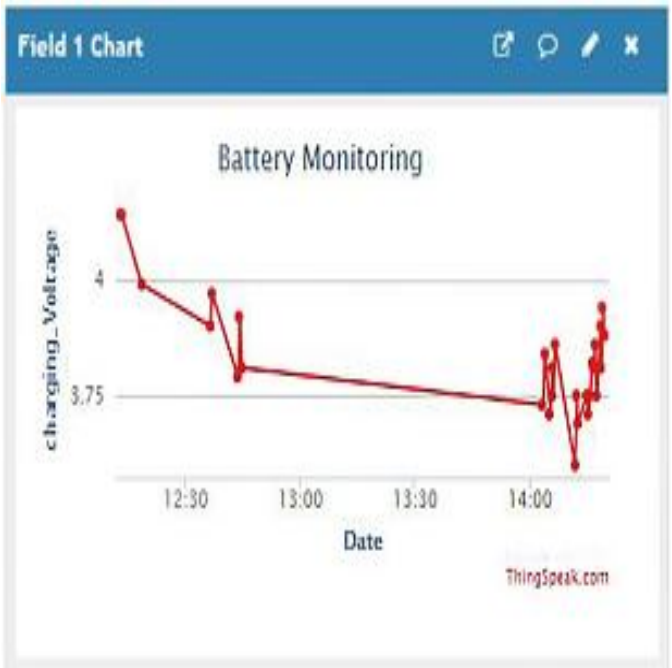


Figure 15: This is a real time graph shown to be monitoring the real time data values of the charging state of the battery, where for monitoring we have used 4 v battery for data collection over thing speak platform .

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Figure 16: This is a real time graph shown to be monitoring the real time data values of the discharging state of the battery, where for monitoring we have used 4 v battery for data collection over thing speakplatform.

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