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Vehicle to Grid Impacts on Power Quality

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Abstract- Electric Vehicles (EV) are provided with capacity batteries, which are powered from the grid. In this way, the EV are considered as a heap on the electrical organization. However, then again, power can be recuperated back to the lattice if there should be an occurrence of out use.

The expected expansion in the quantity of Electric Vehicles will effectively affect the power framework. Albeit the transmission framework may be affected, most of the effects will be seen at the appropriation framework level. These effects incorporate both the framework stacking conditions and power quality issues.

The electric vehicle (EV) Vehicle to Grid (V2G) framework alludes to that as an appropriated energy stockpiling unit, EV partakes in the guideline of force Grid through charging and releasing and leads two-way power change with the power Grid to keep up with the solidness of the Grid.

***Keywords**:- EV (Electric Vehicle), V2G (Vehicle To Grid).*

I. INTRODUCTION

The increase in global concern over depletion of fossil fuel reserves and their adverse effect on environment have resulted in fast development in technologies like renewable energy generation and EVs. “Conductive charging has been long introduced but is still not preferred due to tripping hazards, leakage from old cracked cables (particularly in cold zones), risk of electrical shocks etc. It is desired to reduce our dependency on fossil fuels and resulting environmental impacts in individual transportation has led to significant increase in the number of electric vehicles (EV) in recent years” [5]. “According to the international Energy Agency, the Global EV fleet grew by 2 million, exceeding 5.1 million in 2018 alone. The global automotive industry is investing heavily in EV technology to increase market penetration. This includes industry heavy-weights such as Ford, Toyota, Volkswagen, Nissan and Porsche. While generally regarded as a positive development, this electrification creates major challenges for power grids world-wide” [3].

Electrical appropriation networks are a particular sort of enormous scope frameworks that are intended to give the necessary capacity to the heaps while guaranteeing the dependability of hub voltages, for example the nature of administration. The new patterns towards the double-dealing of environmentally friendly power sources and incorporation of new administrations, for example the charging of the electrical vehicles, are presenting striking inconstancy of the powers that are conveyed or potentially ingested at terminal burdens. Such a fluctuation can risk the strength of the organization and the nature of the assistance.

“Electrical vehicles are one of the important technologies which have been developed rapidly and make the transportation vehicles fuel by electric power rather than the fossil fuels. On the whole the electric power is obtain from renewable energy sources, so the emission from the transportation are reduced. The rapid introduction of EV in the transportation market I the coming years and the development of new technologies like V2G show the importance of this research. There are lot of benefits from the transport using electrical power where electrical energy is derived from clean resources like sun using PV cells or from the wind using wind turbines or any other renewable energy resources”[1].

“The electric vehicle (EV) Vehicle to Grid (V2G) system refers to that as a distributed energy storage unit, EV participates in the regulation of power Grid in the form of charging and discharging and conducts two-way power conversion with the power Grid to maintain the stability of the Grid. The charging and discharging equipment of electric vehicles based on V2G technology belongs to nonlinear power electronic equipment. Disordered charging and discharging of electric vehicles will produce harmonic pollution to the power grid, bring adverse impact to the power quality of the grid, cause voltage distortion, power factor will be decline, and thus affect the normal operation and life of capacitors, transformers and other equipment. Studies on the influence of electric vehicle charging station on power quality and harmonic suppression methods can provide guidance for the construction of large-scale charging stations ”[6].

“Use of Electric vehicle gives multiple advantages that include more use of renewable energy, less use of non-renewable energy sources, clean environment and energy storage options. Electric vehicles are capable of serving a dual purpose in terms of distributed storage units and loads both upon their integration with the power grid”[7].

As a component of the public authorities offered to make India an electric vehicle country by 2030, Union vehicle serve Nitin Gadkari has reported setting up foundation for one e-charging booth at around 69K gas stations across India.

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II. GRID AND ELECTRIC VEHICLE

Now a days, the power demand is increasing vigorously this demand can't be controlled that's why we need to produce more energy to meet this demand we have one more solution else than producing more power we can withdraw power from that batteries of the vehicle. When the grid is supplied with the batteries of the vehicle this concept is called as Vehicle to Grid. Though it cannot provide power that can meet that requirement but still this is also the one more way to provide the power.

➢ *Vehicle to grid*

As its name would infer, V2G innovation alludes to the most common way of taking care of the power contained in an electric vehicle's batteries once more into the electrical network while it is parked at some place. This innovation frames part of a shrewd matrix, an electrical organization framework that utilizes data innovation to oversee energy utilization.

➢ *Power quality*

Power quality is a set of electrical boundaries that allows a piece of equipment to function in its intended manner without significant loss of performance or its life expectancy. Any power problem in Voltage, Current or Frequency deviations that results in mis-operation of consumer equipment or failure is power quality problem.

In case of power it is very necessary to maintain the power quality otherwise it will affect the end user (i.e. overheating of equipment, damaging the equipment, malfunctioning of equipment, etc.) The grid needs AC supply and the batteries are DC, while converting DC–AC there are some harmonic left in the system which cause distortion of voltage and current waveform, power factor reduces and creates disturbances like noise ,voltage spikes etc.

➢ *Power quality concern*

Now a day's consumers approach towards power quality is increasing tremendously due to following reasons:

- Use of sensitive equipment
- Use of solid state devices
- Awareness of power quality problem due to direct and indirect penalties enforced on consumers
- Disturbances to their electronic devices
- Deregulation of power system

III. SIMULATION MODEL

The V2G concept is all about the vehicle connected to grid. When the vehicle is connected to grid when it is fully discharged to get energized with the help of grid this can also feed the grid its power when the energy demand of the vehicle is mate this cycle is shown in the block diagram below. When the vehicle is connected to grid, it will affects grid performance factors the reason behind this is the grid has its own load before this charging of vehicle and the grid is designed to meet its load demand but the electrical vehicles are new in market to adopt this change grid will require more time so this is at its first step so there will be excess load on the grid in the form of these electrical vehicles. The effects on grid due to this load is observed with the help of this prototype.

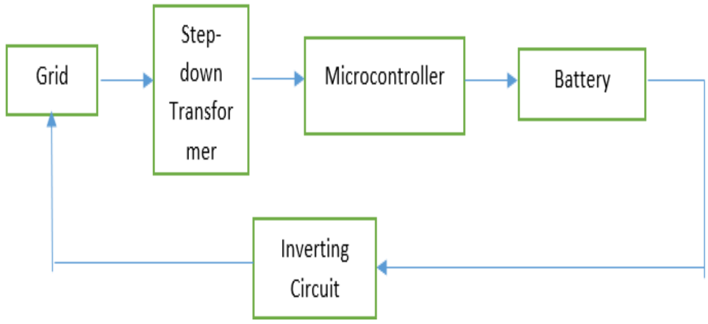

Fig.1 Block Diagram of V2G

The grid has large capacity but for the battery charging it has to be step-down at 230-0-12V after this the battery is supplied with 12V. All the blocks are connected to microcontroller (PIC18F4550). The battery is connected to the inverting circuit to feed back to the supply. The effect can be observed at different stages that is 1. Supply at initial stage (nothing at the output) 2. When battery is connected (regulated supply) 3. When battery is connected (unregulated supply) 4. When V2G is ready 5. V2G is ON and feeding back to the supply.

This simulation can be performed using different software like MATLAB, Power Simulator and Proteus software. Here we are using proteus software.

The vehicle-to-lattice (V2G) idea intends to streamline the manner in which we transport, use and produce power by transforming electric vehicles into 'virtual power plants'. Under this generally new idea, electric vehicles would store and dispatch electrical energy put away in organized vehicle batteries which together go about as one aggregate battery armada for 'top shaving' (sending power back to the framework when request is high) and 'valley filling' (charging around evening time when request is low).

IV. MODES OF OPERATION

➢ *Rectifier unit and step-down transformer*

A 220V AC primary to 15V-0-15V secondary transformer, two high power (1N5408) rectifier diodes, and a filter capacitor (C1 = 2200F) make up the step-down and rectifier. This setup resembles a full-wave rectifier with a filter circuit.

The AC input voltage is reduced by transformer X1 to 30V AC, which is rectified by two diodes D1 and D1 and filtered by capacitor C1.

This DC output has ripple, and the DC volt magnitude is around 28.5V (30V-0.7V-0.7V = 28.5V). The voltage drop across diodes D1 and D2 combined is approximately 1.5V.

➢ *Battery charging unit*

The charger circuit is built around a voltage regulator IC that may be adjusted (LM317T). The input pin of IC1 receives filtered DC voltage (LM317T). This IC can deliver a controlled voltage of 1.2V to 32V at a current of more than 5A. The protective diodes D3 and D4 safeguard against reverse polarity voltage sources.

The voltage at the output is controlled by transistors Q1 and Q2. When the battery is completely charged, the output is set to float charging, and when the battery is charging, the output is set to bulk charging. The adjustable voltage regulator in action.

The adjustable voltage regulator's output voltage (V0ut) is specified by the equation below,

$$V_{out=} V_{REF} \times \left[1 \times \frac{R_2}{R_1}\right] + I_{ADJ} \times R_2$$

Where, $R_2 = R_T = VR_1 = RV_2 + R_{10} + R_{11}$ i.e. combination of these three registors

$$R_1 = R_7 = 10kohm$$

$$V_{REF} = 4.90 \quad I_{ADJ} = 20.7\mu A$$

Therefore the above equation can be written as,

$$V_{OUT} = 4.90 \times \left[1 + \frac{R_2}{10000}\right] + 20.7\mu \times R_2$$

R_2 Theoretical Value Calculated Mathematically

The greatest voltage at which the 12V battery may be charged is around 13.8 V. So, assuming V OUT=13.8, calculating the value of resistance of R_2

$$13.8 = 4.90 \times \left[1 + \frac{R_2}{10000}\right] + 20.7 \times 10^{-6} \times R_2$$

$$\boldsymbol{R_2 = 17427.06\ ohm}$$

Now, calculating the value of VR_1

$$R_2 = VR_1 + R_{10} + R_{11}$$

$$VR_1 = 17427.06hm - 3000ohm - 3000ohm$$

Therefore, theoretical value of variable resistor VR_1 is,

$$\boldsymbol{VR_1 = 11427.06ohm}$$

Along these lines, change the wiper of variable resistor in the middle.

Presently how about we see the functioning of programmed charger stage in three unique cases.

- <u>CASE 1</u>

When both the transistor is OFF i.e. both the digital pin 14 and 15 of PIC18F4550 is low.

$$R_7 = 10kohm$$

Value of resistor RT is combination of all three resistors VR_1 (RV_1), R_{10} and R_{11} because these two transistor is off and does not conduct any voltage i.e. VR_1 = 11427.06 *ohm*

So, voltage output can be calculated as

$$V_{OUT} = 4.90 \times \left[1 + \frac{17427.06}{10000}\right] + 20.7\mu \times 17427.06$$

$$\boldsymbol{V_{OUT} = 13.79\ v}$$

We can say that,

$$\boldsymbol{V_{OUT} = 13.79 \approx 14\ v}$$

Thus, battery Charge at bulk stage

- CASE 2

When the Transistor Q1 (Charger OFF Transistor) is off and transistor Q2 (charge low transistor) is ON. At this case resistor R11 does not contribute any resistance to adjustable resistance because conducting transistor Q2 heavily conduct and pass all the voltage to ground from end point of R10.

Thus, equivalent resistance (Total) = 11427.06 – 3000 = 8427.06 ohm.

$$R_7 = 10kohm$$

$$R_T = 8427.06ohm$$

Therefore the output voltage V_{OUT} ,

$$V_{OUT} = 4.90 \times \left[1 + \frac{8427.06}{10000}\right] + 0.1744$$

$$V_{OUT} = 9.20\ v$$

Consequently, for this situation charger circuit keep up with just float charging state for example battery charger supply 13.2 voltage to battery at consistent rate. As we as a whole realize that battery have some interior obstruction and start to self-release at consistent rate and to address this issue we utilized here float charging idea.

- CASE 3

When both the transistor is on, at this case no resistor (i.e. VR2 (RV2), R10 and R11) contributes in R14 i.e. R14 become zero because transistor Q2 start to conduct and all the voltage is passes from collector to emitter to ground. So, output voltage can be calculated as,

$$V_{OUT} = 4.90 \times [1 + 0] + 0$$

$$V_{OUT} = 4.90\ v$$

➢ *Fixed Voltage Regulator*

Fix voltage controller 7815 and 7805 are utilized to drive the PIC18F4550 and furthermore used to work out the power utilization to observe whether or not the battery is great. 7805 is utilized to furnish the circuit with 5volt DC for the electronic parts utilized in the circuit.

➢ *Display unit*

Show unit is worked around 20×4 alphanumeric LCD and PIC18F4550 regulator. As this LCD depends on Hitachi so for contrast we needn't bother with variable resistor. A decent worth resistor is associated with VDD (pin 2) of LCD to ground as displayed in circuit chart.

The higher information pin of LCD (D4, D5, D6 and D7) is associated with regulator computerized pin (D4, D5, D6 and D7) separately. Where empower (E) and Reset/Set (RS) pin of LCD is associated with D3 and D2 individually as displayed in circuit graph.

➢ *Battery Status*

For checking battery status press the switch SW2 (SPDT) for checking the battery status. Circuit board get power from the battery and it measure the voltage from the voltage divider network formed using resistor R5 and variable resistor RV1.

Jumper is used for calibration the circuit for battery testing. The diode D9 is used for testing purpose.

➢ *Inverting Circuit*

When the battery charging status is showed full on the LCD the V2G shows ready i.e. V2G is ready to operate and can provide supply to input side.

- For V2G the battery voltage must exceed 13.9 volt otherwise it won't start.
- It operates up till the battery voltage reaches to 11 volt after it reaches to 11 volt it doesn't operate.
- For V2G one switch is provided which is operated manually but only after the V2G status on LCD is READY.
- Two MOSFETs (Q1 & Q2) are used in this inverting circuit for providing oscillations to the inverting circuit.

V. SOFTWARE CODE FOR CHARGER CIRCUIT

The product code for PIC18F4550 controlled 12v battery charger circuit is written in c programming language and assembled utilizing AVR IDE

- Adjustment of battery charging unit
- Associate all the circuit part as displayed in circuit outline
- Transfer code to PIC18F4550 regulator
- Short the jumper or switch of the microcontroller pin 16
- Interface the multimeter instead of battery, and set the multimeter in DC voltage estimation mode. (V test of multimeter is associated with result of diode D4 and COM test to GND of circuit).
- Change the wiper of VR1 until multimeter shows 14.2V perusing. In the event that multimeter peruses 14.2V fix the wiper of VR1.
- Change the VR2 until LCD show 14.2V and fix the wiper of VR2.
- Presently, eliminate the jumper and multimeter and interface the battery. PIC18F4550 controlled 12V battery EVEHICLE charger gadget is prepared to utilize.

VI. RESULT

Power quality is a set of electrical boundaries that allows a piece of equipment to function in its intended manner without significant loss of performance or its life expectancy.

Any power problem in Voltage, Current or Frequency deviations that results in mis-operation of consumer equipment or failure is power quality problem.

Power quality issues observed in this project are as follows;

➢ *Voltage unbalance*

The three voltages of the dynamic guides are in a perfect world comparable in size and time-moved by 1/3 of a period or then again 6.7ms. On the off chance that the single-stage homes are drawing equivalent current and are appropriately circulated across the three stages, than voltages will be adjusted. Practically speaking this is difficult to accomplish and the downstream voltages will in general be different in the three guides. This is called as voltage unbalance and may cause heating of machine.

➢ *Notching*

Notching is an intermittent voltage aggravation brought about by the ordinary activity of force electronic gadgets when current is commutated starting with one stage then onto the next.

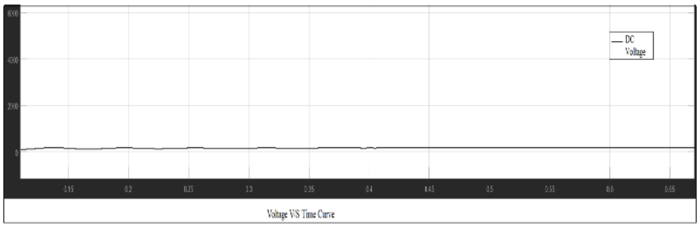

Fig.2 Notching Effect

➢ *Voltage fluctuation*

Voltage fluctuations are methodical varieties of the voltage envelope or a progression of irregular voltage changes, the size of which doesn't regularly surpass the voltage range 0.9 to 1.1 Pu.

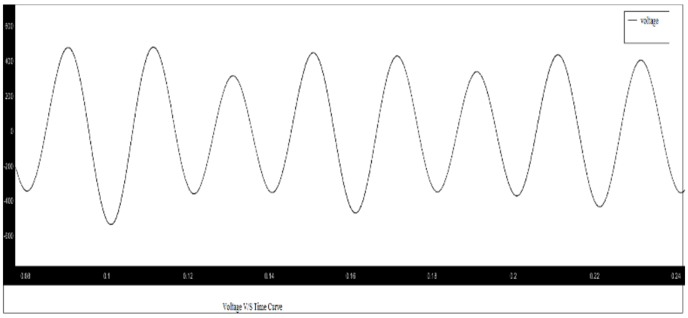

Fig.3 Voltage Fluctuation

- Voltage fluctuations are portrayed as a progression of irregular or ceaseless voltage fluctuations.

- Loads that can display ceaseless, fast varieties in the heap current size can cause voltage varieties that are frequently alluded to as glint.
- The term glint is gotten from the effect of the voltage fluctuation on lights to such an extent that they are seen by the natural eye to gleam. To be in fact right, voltage fluctuation is an electromagnetic peculiarity while flash is an unfortunate aftereffect of the voltage fluctuation in certain heaps.

➢ *DC Offset*

The presence of a dc voltage or current in an air conditioner power framework is named dc offset. Impacts:

- It might immerse the transformer internal winding causing extra warming and loss of transformer life.
- Direct current may likewise cause the electrolytic disintegration of establishing terminals and different connectors.

VII. CONCLUSION

By boosting the deployment of alternative vehicle technology, lowering inefficient investment in conventional generation, and facilitating the construction of renewable electricity sources, V2G networks have the potential to profoundly reshape both energy and transportation systems. Of course, such a historic change comes with a slew of challenges. The construction of a new recharging network necessitates new investment rather than the removal of current networks.

The case for V2G and sustainable energy production in the long run boils down to a decision. Separate the electric system from the car fleet. As a result, the cost of renewable energy will rise since we will need to create storage to match intermittent capacity. Alternatively, to intelligently integrate the vehicle and electric power networks by utilising the large untapped storage capacity of an emerging electric-drive car fleet to serve the electric grid.

The suggested technique can account for real data-based load patterns and give information that is useful for determining service quality. The algorithm has been applied to an IEEE benchmark network, taking into account the unpredictability of the loads linked at the three phases, as well as real Electric Vehicle recharging data, as an example.

The use of V2G technology at the distribution level of a power system with a high charging level of 220 Volts, 29.5 Ampere yields acceptable voltage distortion. The harmonic distortion at low voltage levels must not exceed the IEEE guidelines. V2G technology enables peak shaving for the load profile by generating power at a distribution during peak hours. This has an impact on frequency stability when a fault occurs.

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