Controlling Electric Vehicles' Charging Rate in a Radial Distribution System Using Decentralized Controllers

Abdullah Al Jebali, Mohammad Al Shaghab, Abdulrahman Al Harbi and Sulaiman Al Ghofaili

Advisor: Dr. Ali Al Awami

1- Abstract

Charging Electric Vehicles in the houses would negatively affect the supplying power grid, given the high power consumed by the battery. Decentralized controllers were used to overcome this issue. The controller would vary the charging rate depending on the bus voltage feeding each battery. This will insure maintaining the voltage level to a certain threshold point. In addition, correlation between the controllers is needed to fair charging rate. The result was a sustained charging system with controlled charging rate. Also, we studied the system and achieved feeding all batteries connected to the system with the same charging rate regardless of the voltage applied.

2- Introduction.

Electric vehicles are mobile machine designed to work using electrical power, mostly generated by natural resources. Nowadays, Electric Vehicles are coming strong to have their fair share in the car industry. Although EV promises a positive impact in the transportation future marketplace, charging EVs battery raises to be a major issue. To be able of charging an EV in the owner house, the power grid and transmission line should be capable of supplying enough power at all times so our vision in this project is to make charging EVs in the houses possible without affecting the power grid with overloading.

According to that our objectives are:

1- Eliminate the voltage valuation as long as possible.

2- having a fair distribution system with a fair charging rate.

3- Decentralized Controller.

The first part of the project was abut developing the old controller to use the controller sufficiently. The first objective is to feed the battery from one source. The second objective is to linearize the process of feeding the battery over a range of voltages and changing the charging rate. The two figures below shows the old controller and the new one

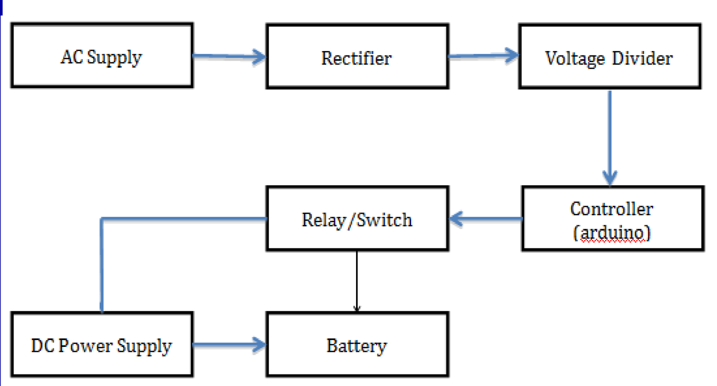

Figure 1: The block diagram of the old Decentralized controller

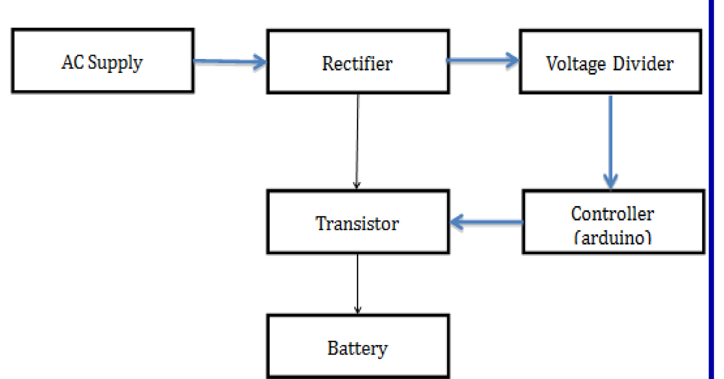

Figure 2: The modified block diagram

4- Circuit of the controller

- ✓ By this circuit we met the first objective of the project which was eliminating voltage valuation.
- ✓ Also we had achieve the linearity charging rate.

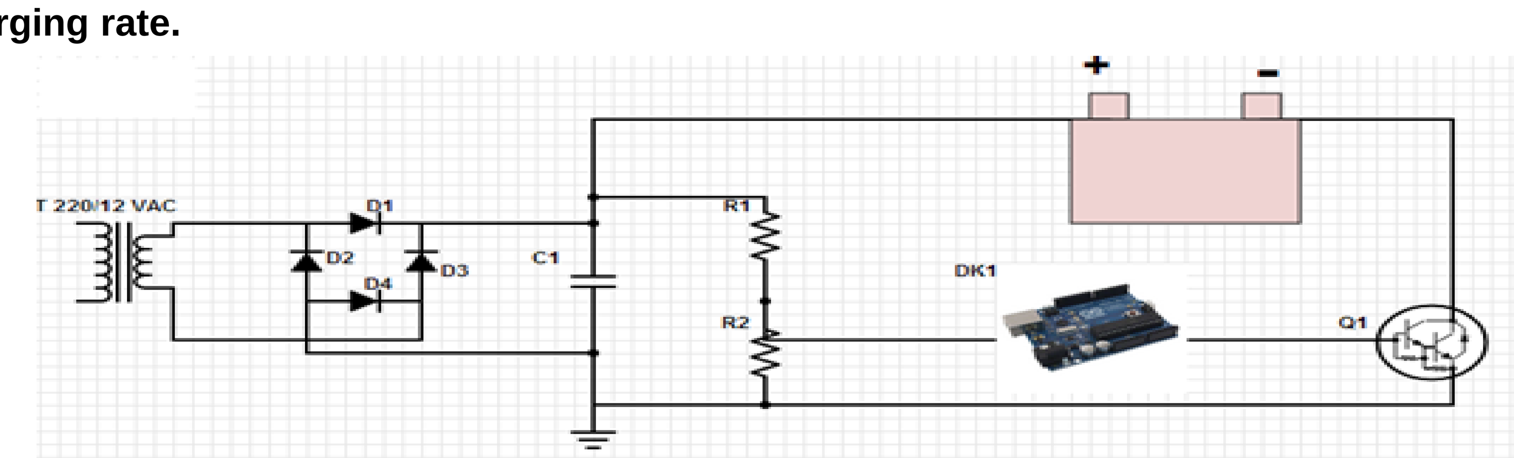

Figure 3: The controller unit circuit diagram

5- The old and new Power Voltage Characteristics.

✓ In the new controller the relation between the power drown to the battery and the supplied voltage is linear but in the old one it is not.

✓In next two plot the difference between the two controllers are clear so in the new controller we can adjust the charging rate to any value we want (30% , 50% .. Etc). The old controller is just on or off nothing in between.

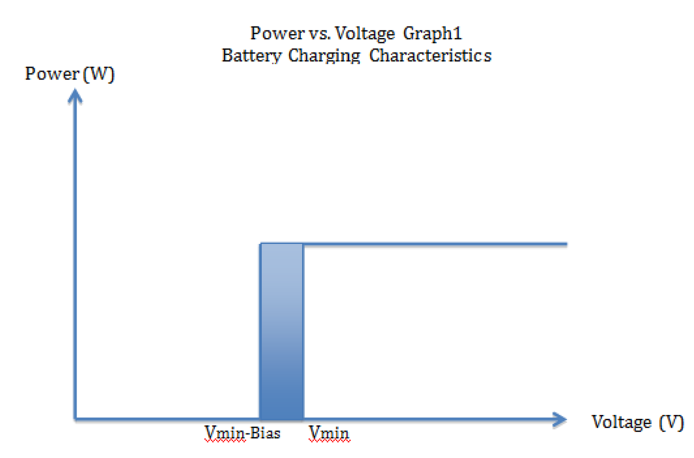

Figure 4: The Power Voltage characteristics of the old controller

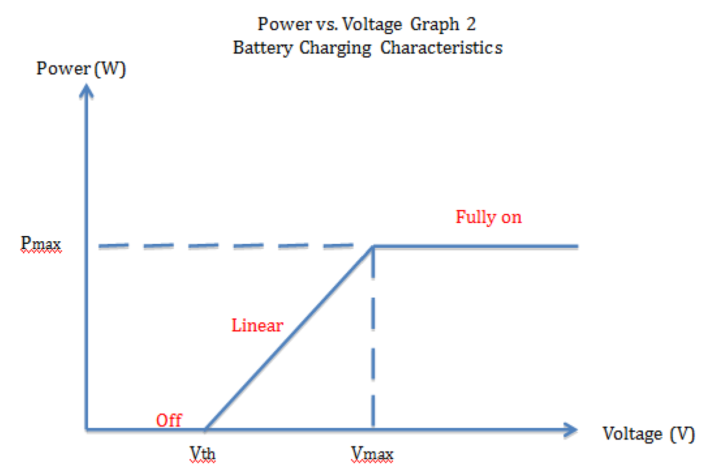

Figure 5: The modified Power vs. voltage characteristics

6- the distribution system.

✓It is a system used to deliver the electricity to the users. This system carries electricity from the transmission system and simply delivers it to the users.

✓In our case we have a radial distribution system which is a system with only one power source. If this one source goes off the power will be lost in the whole system as shown in Figure 6 below.

✓Also we had to represent the transmission line resistance with 0.7 ohms. We choose this value because we found that we can observe a voltage variation across the three buses. Figure 7 shows the distribution system with all the currants and voltages for the three buses.

Figure 6: Radial distribution system

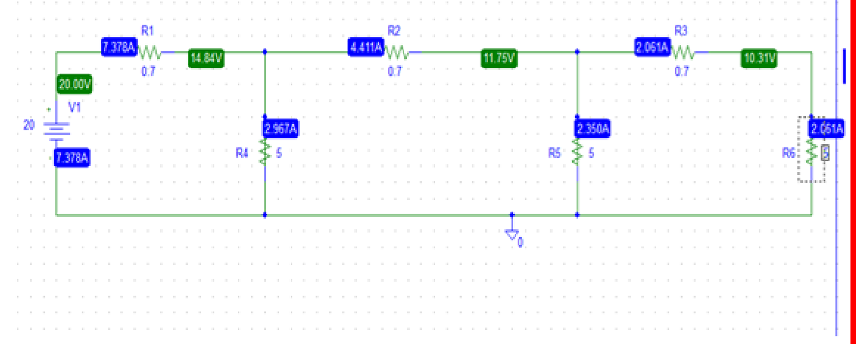

Figure7: A simulation of the distribution system in Pspice

7- Multiple controllers

The main task of this project is to build three different controllers for three different electric vehicles to meet our objectives .

After building one charging controller unit, we carried out making two more units. We would test our system to work with three batteries. At first, we built the new controllers with the same components in order to manage the charging rate of each of them with different set point. Along the progress, some changes in the system were made to overcome new obstacles.

7- Results and measurements

✓**Charging profile:** To study the behavior of the battery, we performed a charging profile. This profile helped in estimating the equivalence model of battery in simulation.

In Figure 8, The first plot represents the power and the battery voltage versus time. At first the battery voltage was very low which means that the battery is empty. Also the power at first was high because of the voltage difference between the battery voltage and the source voltage was high so the battery draws high current. Through time the voltage of the battery stabilized to one level around 12 V. Also the power through time fluctuated from 17 to 20 Watt because the voltages of the battery and the source became almost the same.

The second plot represents the source voltage and current Vs time. At first the current was high and the voltage was low due to the internal resistance of the transformer. Through time the current and the voltage came to one level around 1.6 Amperes, 12 volts respectively.

✓Charging rate profile:

We performed the current profile versus supply voltage for each bus as shown in Table3 and Figure 9 with (Vth=9 v).

Table 1: Charging Profile - Current and the coresbanednce source voltage

SUPLY VOLTAGE(V)	BUS 1 CURRENT(A)	BUS 2 CURRENT(A)	BUS 3 CURRENT(A)
6	0	0	0
7	0	0	0
8	0	0	0
9	0	0	0
10	0.87	0.67	0.93
12	1.22	0.92	1.05
14	1.58	1.37	1.33
16	1.83	1.67	1.5
18	2	1.9	1.75
20	2.3	2.1	1.95

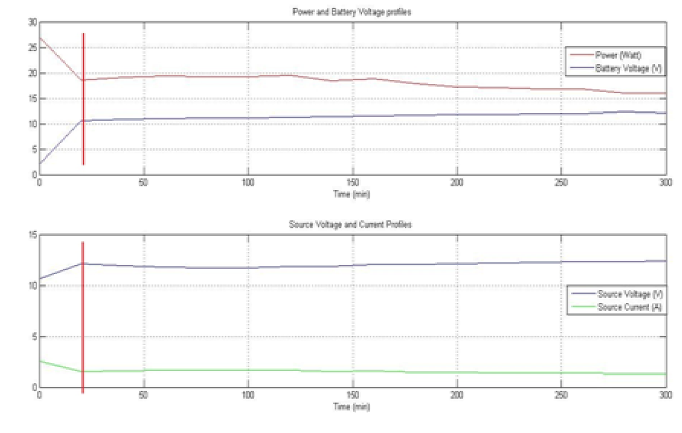

Figure 8: The Battery Charging Profile

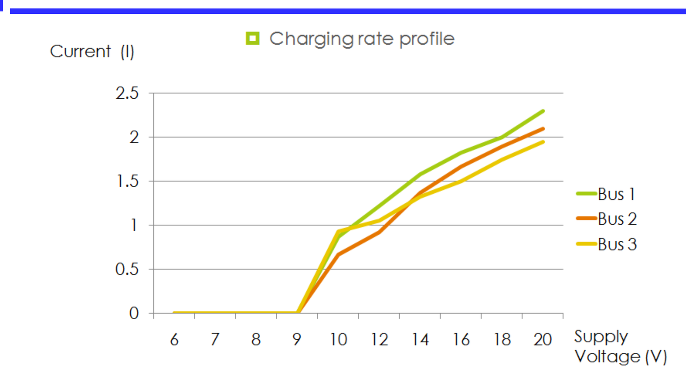

Figure 9: Charging Rate Profile

8- Conclusion.

The aim of our project is to make the charging of Electric Vehicles in the houses possible. Because of the problems facing this approach such as high power consumption, we studied the possibility of using decentralized controllers, which would manage charging the batteries. Designing charging units for each battery and constructing transmission line feeder to test our controllers were our goal. We have managed to develop a controller designed by the previous project to meet our objectives. Then, two more controllers were built to simulate and test three batteries charging at the same time. The transmission line however, was built in such a way that resistors were used in the line to simulate power losses. We came across many problems during the process of completing this project but we managed to overcome them. We had successfully designed and implanted a decentralized controller for each battery. These controllers were fed with different voltage levels. The controllers reduced the effect of voltage violations on the system by varying the power going to the batteries with approximately the same rate. Finally, we believe that the use of decentralized controllers to solve the problem of stabilizing the battery power consumption would be useful, if there are good understating of the power distribution system and better knowledge of the loads.

9- Recommendation.

In this project, the case of three batteries in a simple radial distribution system has been studied. To further examine the controller, a representation of other loads fed from the same supply should be introduced with each battery. This configuration would be more realistic and would also improve the controlling scheme. Our thoughts on that are statistics of every house usage in a year would be added to consideration to program the controller. Then, the threshold point could be rearranged and the power drawn is readjusted.

Another factor to consider is that the complexity of the system could be more difficult. Although, the fundamental job of our controllers could still be used but more accurate and fair distribution of the power is. Developing our controlling strategy to cover more complex systems has to be done.