Localized Control of Electric Vehicle Charging

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1- Abstract

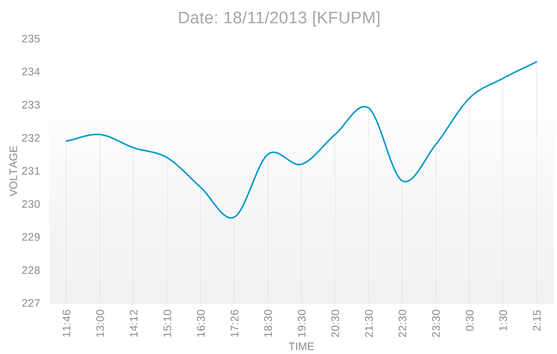
The objective of this project is to design and implement a decentralized charging strategy for electric vehicles (EVs). It is required to design a localized controller located at each EV that adjusts the EV battery's charging rate according to the voltage level at the power outlet that the EV is connected to.

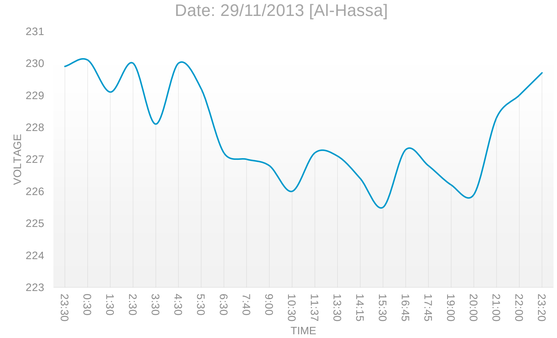
2- Why is This Important?

As the load on the power grid increases with the adoption of electric vehicles there will be definitely a drop in the voltage. To maintain a smooth voltage profile, here comes the design of a localized controller located at each electric vehicle that adjusts the electric vehicle battery's charging according to the voltage level at the power outlet that the electric vehicle is connected to. Hence, the voltage profile of the power grid will be smoothed in that way.

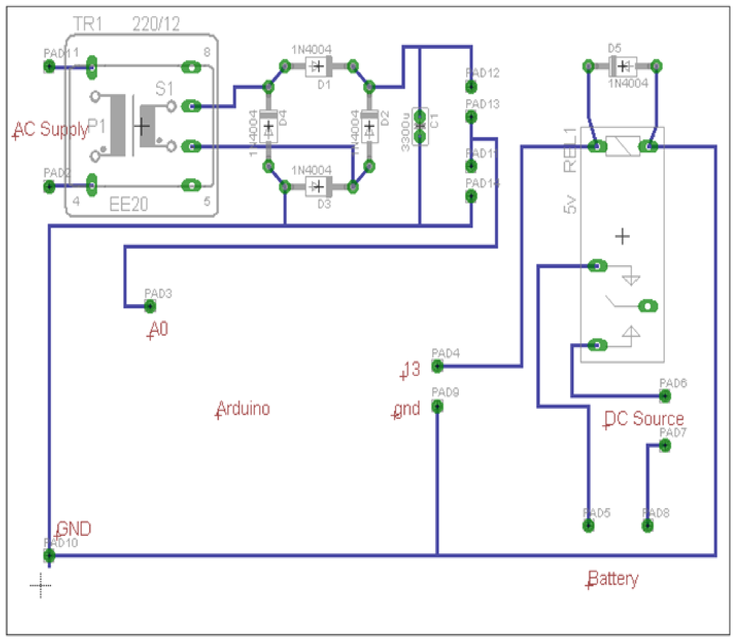
3-Voltage Profile

The two graphs below illustrate the voltage profile in KFUPM dorms and a residential area in Al-Hassa. It is clear from the graph that the voltage is not a constant 220 V. It varies base on the load in the electrical grid.





4- Controller Structure



The Arduino is mainly coded to check whether the outlet voltage is above 0.96 per unit. If the condition is satisfied, the Arduino activates the relay which is used as a switch between the battery and the source. On the other hand, the relay is deactivated, if the voltage drops to 0.945 pu

We used the rectified voltage (17 VDC) to feed the Arduino. However, the voltage is considered as a high input. we used the voltage divider to reduce the voltage from 17 VDC to a voltage that is lower than 5v. A voltage divider is a simple circuit that turns a high voltage into a lower one. Our circuit has two series resistors of 1k and 2.65k ohms respectively. The input voltage will be dived by 3.65 and the voltage across the 1k resistor will be feed to the Arduino.

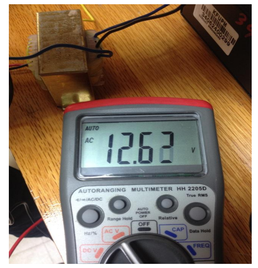
The equation used for choosing the converted voltage that goes to the Arduino controller is listed blow.

$$V_{DC\,(Arduino)} = \left[\left(\frac{V_P}{a} \times \sqrt{2}\right) - V_{Losses}\right] \times Voltage\ divider\ ratio$$

$$Where:$$
$$V_P = Primary\ Voltage$$
$$V_{Losses} = Dioded\ Losses$$
$$a = Transformer\ Ration \approx 18.01$$
$$Voltage\ divider\ ratio = \frac{1}{3.65}$$

5- How does it work?

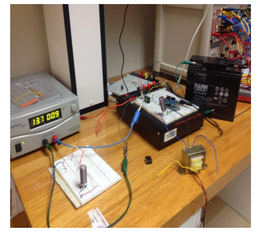
Outlet voltage is 228.8 V.



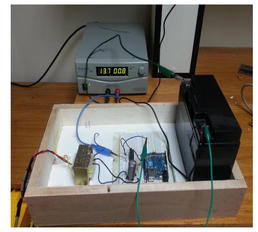
Transformer is used to step down the outlet voltage.

The voltage is rectified by the bridge rectifier.

The voltage that goes into the Arduino from the voltage divider.



The DC source charges the battery.



The Final Result

6- Future Improvements

- Make the controller more convenient to the user by using only one voltage source. That can be done by using bigger transformer to step the voltage and charge the battery at the same time.
- Control the charging current to adjust the charging time of the battery.
- Fabricate the controller circuit on the Printed Circuit Board