EV Charging Station

Design Document

Senior Design Group May12-22A

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Table of Contents

Executive Summary:

Gasoline vehicles have been used for too long, causing environmental issues on a global scale. It is the right time for a clean alternative energy source to take place. Over the decade, dependency on gasoline cars reduced availability for vehicles that run on cleaner energy. If Fuel cell and Hybrid vehicles are introduced into the Automobile market it would further limit our dependency on oil based products and produce more electric vehicles. Electric vehicles are more advanced compared to gasoline cars which brings many advantages and options. The only issue is the initial cost which might be fixed over time. An electric charger is the gasoline of today's world. Gasoline should be clean with the right amount of octane likewise the charger should meet the car's batteries requirements and be able to professionally and safely charge. A consumer should look for the most inexpensive and reliable charger in the market.

Product Description:

The client of this product design is Paragon INC, who requests the design of a charging station that is capable of charging a range of common battery capacities for their new line of vehicles designed to haul vending stations. The environment in which this product will be used will be in amusement parks and other kinds of fairs. This product is a safe and efficient method of charging a battery quickly and is compatible with a range of battery capacities depending on the consumer's needs. This product can be safely operated as long as the user uses their intuition to follow all safety procedures that are included. This station has other features that are designed for the convenience of the user. Aside from this product's primary purpose, this charging station is capable of informing the user of the battery's state of charge (SOC) remotely from a computer or a digital key FAB that is packaged with this product using Bluetooth technologies to transmit such information.

System Technical Constraints:

The constraints defining the design of this product include those that affect the rate at which these batteries may be charged, the cost of production, as well as mobility of this product. Some of the technical constraints that is included:

- Rate of Charge must be at maximum 6-8 hours to reach full capacity
- The Charging Station must be designed will all current standards
- Charger maintains battery life for 3-5 years
- State of Charge (SOC) indicator
- Be able to charge Lithium-Ion and Lead Acid Batteries
- Must be able to send user information about the estimated time to full charge and the approximate voltage level

System Non-technical Constraints:

This project also requires a number of constraints that are non-technical in nature but are of great importance to the overall success of the project. Each of these constraints is as follows:

- Charger is Safe
- Charger is Reliable
- Easy to use
- May be used for different capacities

Design Standards:

The standards that will be required for the design of this device are those that are currently being used in industry. The industry standards specific to electric vehicle charging stations are those being produced by Society of Automotive Engineers (SAE), IEEE, National Electric Code (NEC).

The National Electric Code (NEC) has publicized different levels of charging that determine the rates at which the vehicle may be allowed to charge. These levels are separated by two categories that are classified as residential charging and commercial charging. The design specification of this product allows the classification to be residential because the voltage and current requirements are low enough that commercial classification is not required.

NEC Basic Charging Station Requirements:

Circuit Breaker:

- Level I: a 15-20amp, single-pole breaker
- Level II: a 40 amp, two-pole breaker

EV Charging Stations:

- A 15-20 amp standard residential wall plug and socket for 120 volt charging
- Installation of 240 volt electric vehicle charging station must be a fixed structure and incapable of being portable. Other specifications will include:
    - Equipment must be labeled and listed
    - Connector compliance with SAE standards
    - Ground fault protection
    - Diagnostic capability, must be able to prevent batteries from being charged when batteries are damaged or in any unsafe condition
    - Connection that is unable to charge when connectors are not engaged.
    - Unable to charge when strain is put on connecting cable

The SAE International standards:

SAE Charging Configuration Ratings:

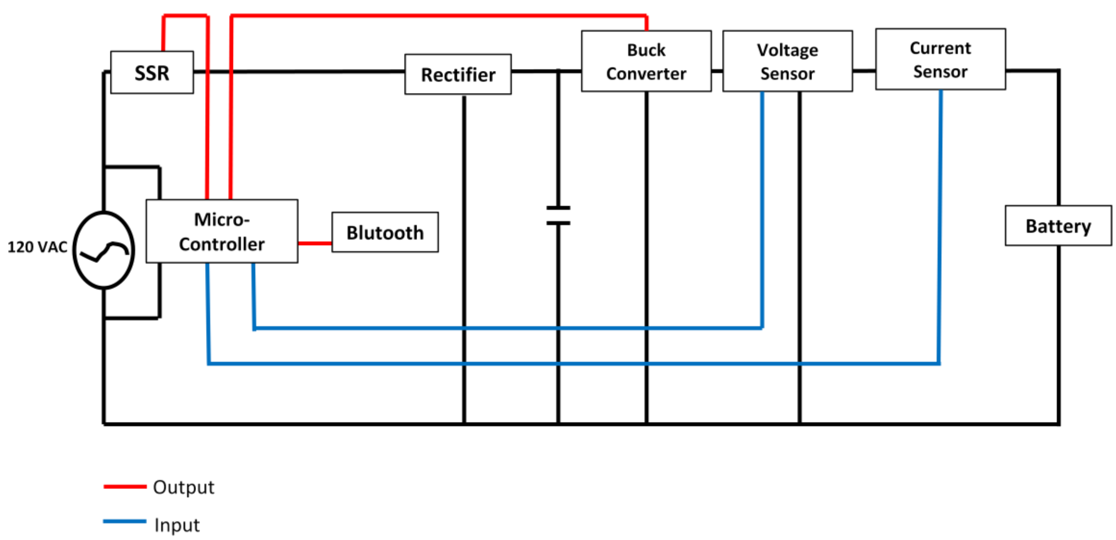
Connector Compliance: SAEJ1772 Standard

- DC Level I: EVSE includes an off-board charger
  - 200-500 V DC, up to 40kW (80A)
  - Estimated charge time (20kW off-board charger):
    - PHEV: 22 min. (SOC- 0% to 80%)
    - BEV: 1.2 hours (SOC- 0% to80%)

System Description and Components:

Charging Circuit Overview:

The charging circuit's input is the source that comes from a residential 120VAC wall source that can be found in any home or commercial industry. The circuit adapts this source to voltage levels that are battery capacity specific using a transformer designed to be able to make use of multiple ratio settings.



Shut Off System

To make a user friendly charging station we need to design a smart charging station. The user should be able to plug in their battery to the charging station and not need to worry about the battery charging for too long or blowing up. To do this we have to implement a shut off system so the charging station knows when to shut off when the battery is fully charged.

The shut off system we are using is a Steady State Relay (SSR). It has the functionality of being a digital switch. It takes in an AC voltage that it will effectively switch on or off. It does this with a DC input voltage. The DC voltage input can be from 3-32 Volts for our SSR, which will be supplied by our micro-controller. The SSR also has a built in snubber. A snubber is a safety mechanism to make sure the high voltage and current don't turn on the SSR when it is not triggered properly

Voltage Transformation and Regulation:

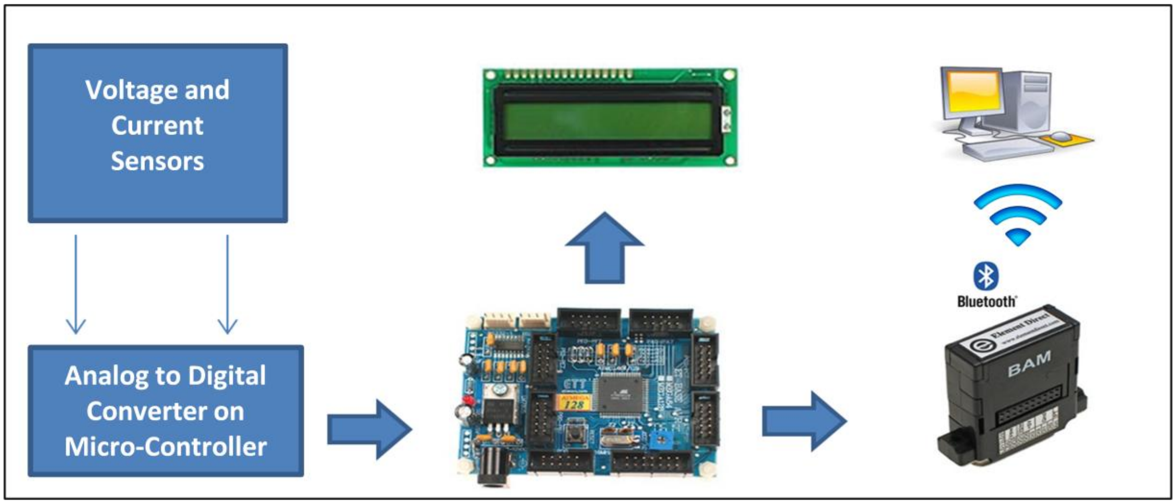
When designing a battery charger, determining the proper voltage of the connected batteries is key in determining the output of charger. We will need to convert the Alternating Current (AC) signal into a Direct Current (DC) signal. We will implement a full-wave rectifier to convert the signal and a voltage regulator to help keep the signal constant. Once we have the desired DC voltage we will then use a buck converter that is controlled by a pulse width modulated signal. The pulse width modulated signal will be sent from our microcontroller. The buck converter will then vary the voltage it will step down to. This will allow the batteries to charge and store the energy.

Remote Charging Interface (RCI):

The purpose of developing a Remote Charging Interface (RCI) is to keep the user updated with the batteries/battery state of charge and to allow the user to terminate the charging, remotely. Once the batteries are fully charged, an output flag would be raised on the microcontroller to stop the charging process. The Atmega controller board comes with an 8 channel built in analog to digital converter (ADC) that will be connected to step down (5V) from the battery. A 16x2 LCD screen will be directly connected to the board and will physically appear on the outside casing of the charging station. Both the LCD and RCI will display the same sort of data, simultaneously, as described under the user specification section. An Element Direct Bluetooth module will be used to send the data wirelessly. It's high speed, easy to step up and compatibility with blue-term, an Android application, makes it the best module available in market.

Components Required:

- Atmega 128 controller Board
- 16x2 LCD display
- Bluetooth Adaptor Module (BAM)
- Mobile device (Cellphone, Laptop)



Microcontroller Specifications:

- Includes Powerful Atmel ATMega128 Microcontroller with 128kb Internal Flash Program Memory
- Operating Speed at 16MHz with up to 16 MIPS throughput
- **In-Circuit Programming via ET-AVR ISP**
- **A massive 48 I/O points with easy to connect standard IDCC Connectors**
- **2 RS232 Connections with MAX232**
- **LCD Connector with Contrast Adjustment**
- **8 Channel 10-bit A/D Convertor**
- **Two 16-bit Timers with Two 8-bit Timers**
- 4kbyte EEPROM
- Power LED
- Reset Button
- Ideal as an Interchangeable Controller for Real-Time Systems

BAM(Bluetooth Adaptor Module) Specifications:

- 8 data bits.
- 57600 Baud rate.
- 0 stop bit.
- Compatible with both desktop, and with cell phone via BlueTerm application.
- Range approx. 100meters.

System Specifications:

User Interface Specification:

A User Interface (UI) for the remote charger is necessary, because it provides information to the user about the batteries that are charging. The UI allows us to display this information in a clear and understandable manner.

The User Interface for our charger will be designed to:

- Provide a user-friendly environment.
- Include simple and intuitive controls.

There will be two types of user interfaces.

The first will be an LCD screen with push buttons on the charging station housing.

Information available to the user will include:

- If the charging station is On or Off
- Voltage that is set to be charged at (12, 24, 36, 48 V)
- Current and Voltage level of battery
- Estimated time of the battery being fully charged

Information that will be displayed on the User Interface will include:

- Current voltage level of battery
- Estimated time of the battery being fully charged

Hardware specification:

The Atmega 128 Microcontroller and Bluetooth module that will be used in this design must be well protected from the high currents running through our system. In order to implement these features we must include voltage step down components and appropriate fusing.

The Atmega 128 Microcontroller will use a formula to determine the appropriate voltage and currents flowing into the batteries. The Microcontroller will be in charge of monitoring the amount of power flowing into the batteries and shut-off the system if certain boundaries are exceeded. This provides an additional level of safety by switching off the system before any fuses our blown. Not having to replace fuses removes the risk of the client opening the device and physically replacing the component.

Software Specification:

The purpose of the software that will be run on the Atmega 128 Microcontroller is to monitor the charging system and provide a User-Interface for the customer. The software will be programmed to include charging algorithms to provide a fast charging circuit without sacrificing the lifespan of the batteries. If time is allowed the software will also include different charging schemes to allow the customer to decide between a longer battery lifespan charge with slower charge times or a shorter battery lifespan charge with a faster charge rate. The coding language used will be JAVA.

While running the charging algorithm the software must also run the User Interface. When programming the software we have to ensure that the user can safely transition between the options without harming their person or the charging circuit.

Test Specification:

When testing our system there are several environmental, human, and electrical factors that must be taken into consideration.

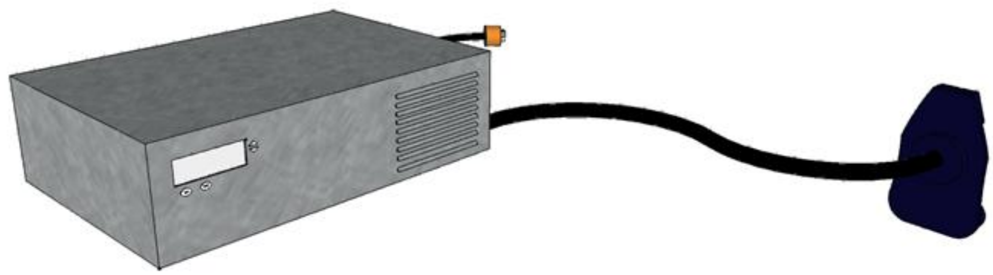
- Environmental
    - Thermal
    - Water
    - Dust
- Human
    - Electrostatic Discharge
    - Physical Damage
    - Improper Connection
- Electrical
    - Over-volt/Under-volt
    - Over-charge
    - Thermal Overload

When testing for these systems we have to be careful not to destroy our design. This would be costly for the University and would set back our timeline. We must also apply also safety standards in our testing procedures.

Project Enclosure

Our charging circuit needs to have the ability to operate in numerous weather conditions as well as be protected. For this we are planning on designing a casing made of a light weight sheet metal that will be able to weather the elements. We also need to make sure we can moisture and humidity off of our circuit. We are planning on using a cooling fan mounted inside the casing and also putting a filter on it to stop moisture from coming in.

Below is a 3D conceptual computer aided design of the casing.



Modeling and Simulation:

Our system will be modeled using the Cadence PSpice electrical circuit modeling software. This will allow us to run simulations of our circuit under the stresses listed in the **Test Specification** section. The system shall be modeled with all of the available components provided in the design software's libraries. All components not available in the software will either be manually implemented and tested or created for the software's use.

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