Operation Manual

Team 2

Electric Vehicle Range Extension

Members:

Taofeek Akintola (taofeek1.akintola)

Khaled Farhat (kf14d)

Luke Marshall (lsm13b)

Seth Rejda (slr13b)

Hafs Sakka (hos12)

Faculty Advisor

Dr. Chiang Shih

Sponsor

Dr. Michael Hays

Instructor

Dr. Chiang Shih

April 7, 2017

Table of Contents

ABSTRACT

This report includes all necessary information on the safe operation, troubleshooting, and maintenance of our electric vehicle. The overall function is first discussed, followed by the dimensions and locations of important system components. Then, the assembly of our vehicle is shown pictorially for easy visualization. This is followed by the listed operating instructions, troubleshooting for the various subsystems if any problems occur, and the proposed regular maintenance to avoid such problems.

1. Functional Analysis

This vehicle operates on power from three different power sources, the battery bank, the generator and power converter system, and the solar panel. When the generator system is switched on, a relay between the converters and the battery bank is closed and power begins to flow from the generator to the converters and into the battery bank. A control system utilizing the microcontroller and several current sensors adjusts the power output from the power converters to prevent the generator from being overdrawn. At all times the solar panel system is connected directly to the battery bank and is thus charging the system whenever sunlight is present. When the cart is being driven, power is supplied to the motor and cart's accessories from the battery bank.
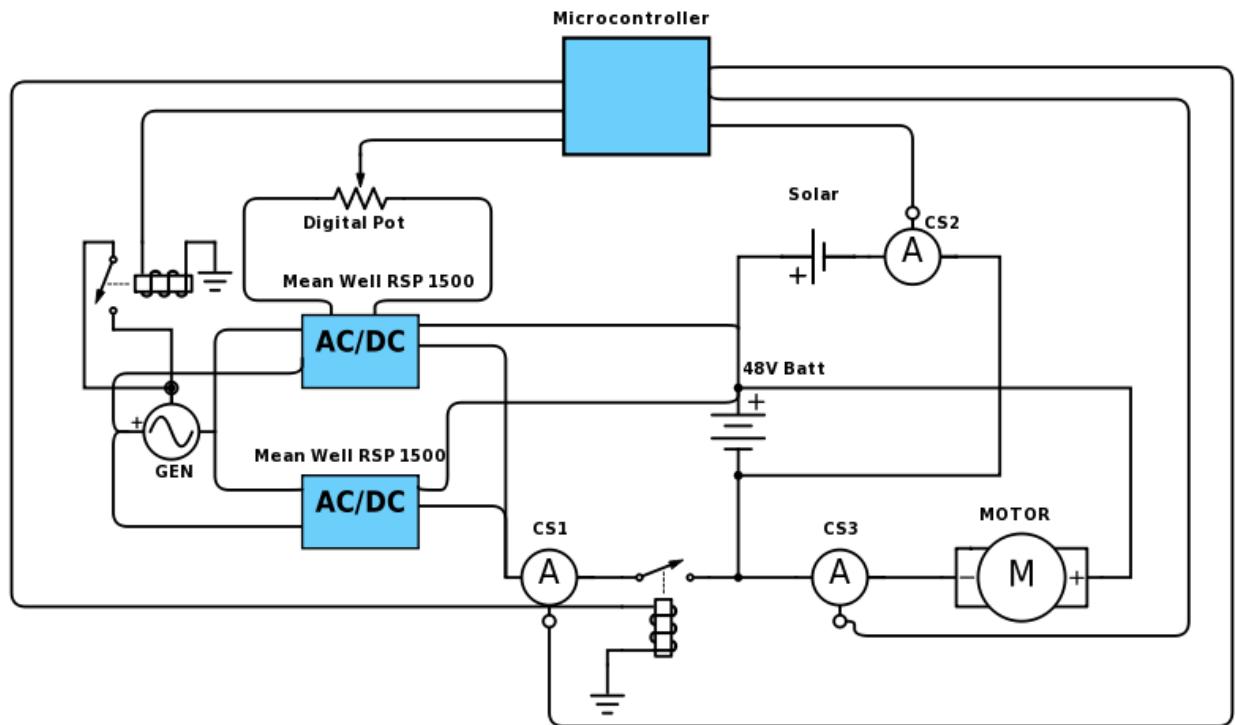
Figure 1. System Circuit Diagram

2. Project Specification

Arduino UNO

Microcontroller	ATmega328P
Operating voltage	5v
USB	14
Digital I/O Pins	6
Analog Input Pins	6
Flash Memory	32 KB
SRAM	2 K
EEPROM	1 K
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g

Figure 2. Arduino Uno   **Figure 3.** Arduino Uno Specs

Solar Panel

Figure 4. 280W Solar Panel Kit

The selected solar panel produces 280W of power in direct sunlight and has a highly efficient, built in MPPT charge controller.

Cummins 2500W Generator

Model: 2.5HGJBB-1121A

Weight: 125 lbs (57 kg)

Size: Length 22 in (560 mm), width 16.3 in (415 mm), height 12.8 in (325 mm)

LPG	No load	Half load	Full load
60 Hz	0.3 Gal/h (1.2 lb/h) 0.6 kg/h	0.4 Gal/h (1.6 lb/h) 0.7 kg/h	0.6 Gal/h (2.3 lb/h) 1.0 kg/h

Figure 5. Added Cummins Generator

3. Project Assembly

The overall project design utilizes a Cummins QG2800 generator and a 280 Watt Solar Roof Replacement Kit working simultaneously to power the vehicle. The generator provided by Cummins, Inc. uses natural gas in a propane tank as its fuel source. The solar roof was purchased from *Solar EV Systems* and was installed according to the directions by Team 2.

The generator and propane tank were mounted to the vehicle by the previous team. The generator was geld in place using two U-shaped brackets and two support rods. The U-shaped brackets secure each side of the generator with steel bolts. The U-shaped brackets are also attached to a piece of steel that lies across the rear support of the vehicle. A mount was designed to securely fasten the propane tank to the rear of the golf cart. The design also allows for easy exchange of propane tank along with keeping it away from any moving parts or in the way of passengers. This mounting will ensure that the generator and tank do not move while the cart is in motion.

Figure 8. Generator location and mount

Figure 9. Propane tank mount and location

The solar panel was mounted on in place of the existing roof of the vehicle. The original roof was taken off by Team 2, and the solar kit was mounted on simply using 4 steel bolts provided. The installed solar panel can be seen in Figure 10 below.

Figure 10. Electric vehicle with solar panel installed

4. Operation Instructions

Operating procedures

1.) Make sure battery cables are connected to the positive and negative terminals tightly.
2.) Make a visible check for any shorts or potential wiring issues.
3.) Switch both switches beneath the front bench seat on the black box labeled Tomberlin to the up position.
4.) Attach the positive battery cable to the red 12V starter battery beneath the main bench on the passenger side.
5.) Make sure the serial type cables are tightly connected to the small black box containing the microcontroller.
6.) Turn the ignition key to the run position.
7.) Connect the USB cable from the microcontroller to a laptop with the Arduino IDE installed and open the serial monitor.
8.) Numbers associated with the current sensor values, and battery voltages should appear.
9.) Switch the direction switch to the desired position.
10.) Release the parking brake.
11.) The cart is now ready to be driven.
12.) If the user desires to start the generator system, simply use the laptop to upload a code changing the generator start relay pin and converter relay pin to the high position.

5. Troubleshooting

<u>Generator Issues</u>

If the generator does not crank first listen for the starting relay when the code is uploaded. If the starting relay does not function check the wiring and potentially replace the associated transistor.

If the relay can be heard but the generator still does not crank first check that the correct relay is being actuated and then open the generator cover with the correct torx driver and check that the wiring to the generator start circuit is still connected to the wiring harness. If the circuit has come unplugged see the generator owner's manual for proper wiring.

If the generator will crank but still does not start first check that the gas fitting is tightly screwed into the propane tank noting that gas fittings are threaded backwards. Then make sure that the valve on top of the tank is open and try again. If the generator still does not start, see the generator owner's manual.

If the generator starts and runs but does not output power first stop the generator by sending a voltage to the stop relay or closing the propane tank valve. Next check that the 21A breaker located underneath the plastic cover on the bottom front right of the generator is flipped up. Open the propane tank valve and check again making sure that the converter plugs are tightly secured. If the generator still does not produce power, see the generator owner's manual.

<u>Solar Issues</u>

If the solar panel is not perceived to be producing power, first drive the vehicle to a sunlight area and check the function of the panel with the indicator led located by the solar panel plug. For interpretation of the led flash sequence see the solar panel owner's manual. If the light is red check to make sure the plug is tightly inserted in the solar panel and no corrosion is present, clean if necessary. If light is still red check to make sure that the other ends of the wire are tightly connected to the appropriate battery terminals. If problem persists, see the solar panel owner's manual.

<u>Controller Issues</u>

If the readings from the current sensors are not perceived to be accurate by either indicating a current is flowing when no current flow is present or by producing sporadic data, see the following section.

If nominal current flow is off by more than 2A check that the 12V starter battery is charged to a minimum of 12.5V. The power supply for the current sensors is delivered through a variable voltage reducer set to roughly 10.5V and the voltage reducer requires a positive potential of 2V to regulate voltage precisely. If the power supply for the sensors is off or fluctuates it will cause the output signal to fluctuate as well.

If current readings have no identifiable pattern or are very sporadic check that the sensors are plugged in and the wiring connection is sound with an ohm meter. If the wiring is faulty replace the wiring.

If the current sensors need to be recalibrated this can be done with the use of a standard ammeter and a AA battery. First loop a wire though the sensing hole multiple times, making sure that the wire is NOT tightly wrapped around the outside of the sensor but far away. Next connect the ammeter in line with the AA battery and record the voltage signal sent by the current sensor. Associated that voltage with the current recorded by the ammeter multiplied by the number of loops of wire. Repeat this process multiple times for solid readings.

If the digital potentiometer is not working correctly first disconnect the device from the converter and test the predicted resistance value with the value read from an ohmmeter. If the values do not correspond correctly, first check the code for errors. If problems persist check the wiring with the suggested wiring in the operator's manual for the digital potentiometer. If the device still does not work, consider replacing.

Cart Issues

If cart does not move first check the switches underneath the bench as described in the operating instructions are flipped up. Next check that the motion selector is set to forward or reverse. Then check that the parking break is released and try again. If cart still does not move but power is being supplied to the accessories, slightly push the cart forward and listen for a click and try again. If cart still does not move, see the owner's manual.

6. Regular Maintenance

It is important to charge the batteries after each use. Lead acid batteries will have a shorter life if left discharged for an extended period. Periodically check the electrolyte level in each of the batteries making sure the electrolyte fully covers all the lead plate. Regularly clean the solar roof of dirt and debris to maintain maximum power output. Close the propane take valve after each use to prevent propane leakage. Regularly change the generator oil and perform other maintenance in accordance with the generator owner's manual. Periodically clean all electrical connections of corrosion for minimum electrical resistance. Maintain tire inflation at 35 psig, especially when preforming performance tests.