# Memo

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From: EV Builder Kit Team
Team: 18
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Subject: Final Prototype Testing Report

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# 1.0 Summary of Equipment and Test Setup

### 1.1 Car Summary

On each car, there is a 3.7 volt lithium polymer (LiPo) battery which is used to power the vehicle. This battery is attached to a LiPo fuel gauge chip, which is able to take in a LiPo Battery connection. The fuel gauge chip has output pins which are fed directly to the Arduino Nano, as well as into a 5-Volt Voltage Booster. The direct feed to the Arduino Nano is for the purpose of measuring battery state, sending that data to the transceiver, so that it can be displayed properly on the Controller's LCD display. The 5-Volt voltage booster raises the 3.7 volt output from the battery to a 5 volt output, and feeds that voltage to power the Arduino Nano and dual H-Bridge motor controller.  The motor controller is connected to two DC motors, while the Arduino Nano is connected to the motor controller. The Nano can then control the motors by applying Pulse Width Modulation(PWM) and shifting between logic high to logic low on the connections to the motor controller. A transceiver module is also attached to the Nano, allowing an external controller to control the signals sent to the motor controller, and thus the motors from there. Additionally the Nano will also use the transceiver to send the battery data to display on the controllers.

A special heavy duty car was also created, utilizing larger wheels and more added on weights, but is functionally and electrically identical to the other cars created for the test.

To set up the test, first connect each car's microcontroller to a computer that has appropriate code for transmitting battery data and receiving controller input loaded onto it, then upload that code to the board. The computer will require the CH340 driver to be able to interface with the microcontrollers attached to the cars. Once the code is uploaded to each controller, then disconnect the Arduino from the computer, and clear out an area for the car to begin driving on.

### 1.2 Controller Summary

On each of the two controllers, there are 2 axial joysticks, which are connected to an Arduino Uno. The uno is able to take in the inputs from these joysticks, and use an attached transceiver chip to transmit an 3 bit message to the transceiver on the car. This allows the car to read the 3 bit message from the controller, and adjust its state accordingly. Furthermore, the controller will have a toggle switch you use to switch between which car you want to control. There is also an LCD attached to the controller displaying the miles and battery life of the car being driven.

To set up the test, first connect the car's Arduino Nano to a computer that has the code for a receiver loaded onto it, then upload that code to the board. At the same time upload the controller code to an Arduino Uno. Once the code upload process is complete, place the car down onto a clear out area. This should enable the controller to control the car, with the car being able to drive forward, backwards, turn left and right, and speed based on the strength of the joysticks. The controller also has multiple toggle switches to let the user decide which of three connected cars to interface with. The controller detects the state of each switch, and uses that to change the communication address for the controller's transceiver.

### 1.3.1 Charging Station Summary

For the solar charging station, an aluminum lamp with a hydroponic bulb is used. This is as the hydroponic bulb mimics the visible light spectrum that would be expected from the sun, which is where most of the energy from the solar panels are derived. This lamp will be directed towards a solar panel, which is connected to a Lithium Polymer Charging Chip. This chip is capable of using the power from the solar panel to recharge the battery, while also load balancing to the output as well. Additionally a DC adapter and a USB-C cable can also interface with this chip to provide power as well.

To set up the test, first plug in the lamp and clamp it on the edge of the kit. Turn the lamp towards the solar panel then connect the solar panel to the LiPo charging chip attached to the cars. The LiPo battery also has to be connected to the cars as well for the test to proceed. After verifying that charging occurs utilizing the solar panel setup, ensure that the same holds true using a DC wall plug adapter, and a USB type c cable.

# 2.0 Measurements Taken

## 2.1 Car Measurements

| 5.1 Car Scoring Sheet | | | |
|---|---|---|---|
| **Test** | **Observed Result for HDV** | **Observed Results for LDVs 1-5** | **Failure? (Y/N)** |
| Driving Forward | No Issue | No Issue | N |
| Driving Backwards | No Issue | No Issue | N |
| Turning Left | No Issue | No Issue | N |
| Turning Right | No Issue | No Issue | N |
| Objects on Car Secure | Yes | Yes | N |
| | | Overall Result: | Successful |

The tests showed that each car was able to drive itself forwards and backwards without any major issue, and that the process of turning was smooth for each vehicle. Due to the fact that the turning and driving of the car was successful, it can be seen that the power systems, transceiver set-up, and mechanical makeup of the cars are all functionally sound, and able to support all of the requirements. Thus the tests show that the cars by themselves should be fine. One issue that did come up during the testing was that cars would occasionally go haywire, but that is discussed in the next section, and is believed to be an issue with the controller setup.

| 5.2 Controller Scoring Sheet | | | |
|---|---|---|---|
| **Test** | **Controller 1** | **Controller 2** | **Failure? (Y/N)** |
| Controller moves car forward and backwards | No Issue | No Issue | N |
| Controller can send inputs for left and right turns | No Issue | No Issue | N |
| Controller can switch between the three linked cars | No Issue | No Issue | N |
| When controller untouched, cars should stop | No Issue | Issue | N |
| LCD is displaying the miles and battery life | No Mileage | No Mileage | N |
| | | Overall Result: | Successful |

Each of the controllers were successful in driving all three of the associated vehicles forwards, backwards, and turning. This indicates that the joysticks and toggle switches that are being used are functionally sound, and are providing the inputs required for the control logic to proceed as planned. Additionally each of the LCDs were able to display battery life info, and change that information upon a swap between vehicles, indicating that the controller is also properly receiving the data from the car. However there were two issues that were encountered during the test, which should be easy fixes. The first issue is that occasionally one of the cars being controlled will go haywire, and either shut off or get stuck in an infinite loop. This is because the connections that are being used on the controller are susceptible to static electricity, which overloads the transceiver, thus sending faulty information to the car controllers and causing an exception in the car code. The other issue was that mileage calculations were not implemented, as there was an error in the software that would cause the entire system to die when mileage was being displayed, and could not be remedied by the time of the test. However the controllers are shown to be working.

### 2.3 Charging Station Measurements

| 5.3 Charging Station Scoring Sheet | | | | |
|---|---|---|---|---|
| **Test** | **Solar** | **DC Adaptor** | **USB-C** | **Failure? (Y/N)** |
| LiPo Charger “Good” light color should be green | Y | Y | Y | N |
| LiPo Charger “Chg” light color should be red | Y | Y | Y | N |
| | | | Overall Result: | Successful |

The test showed that the setup for the charging station successfully works. The “Good” and “Chg " LED lights of the LiPo battery charging chip turned to the colors they were supposed to, so that it shows the chip is working and there is a flow of electricity going through to the car and recharging the battery in all three scenarios. This indicates that the charging methods we are planning to use in for this model are all valid, and can be utilized.

# 3.0 Conclusions

### 3.1 Car Conclusion

The results of the test show that the prototypes of cars are working as intended, and that the car is capable of driving, turning, and displaying key battery information without issue. This indicates that the circuitry selected for each car's operation is working, and is proper for the final vehicles. Additionally this means that the soldering is finished, so anything related to circuitry or electronics for the cars is completed.  As for the body of the car, the car's ability to turn and drive without issue indicate that the addition of weight to add traction was the correct move, and that apart from visual improvements, nothing else must be done for the car.

The final steps for this part of the project is to now create casing for the cars to make them safer for other people to use, and more pleasing to look at as well. This mainly consists of creating a case to put over the car body, and potentially adjusting the car's body for this as well.

### 3.2 Controller Conclusion

The results of the prototype testing were satisfactory because it accomplished everything that needed to be done. The controller is simple enough that any user can easily control the car. In addition, with the implementation of the switches, the controller is now able to control separate vehicles. Another thing the prototype showed was that the controller is portable after code upload, as there is now an associated battery pack. Now the last part of the controller that needs to be finished is the casing, and visualizations. This consists of implementing the mileage display on the LCD, along with creating a more organized/visually pleasing casing for the controller, which will also have the bonus of eliminating the static electricity issue.

### 3.3 Charging Station Conclusion

The results of the test show that the charging chip works and that the three different possibilities for charging (solar lamp, USB-C and DC Adapter) are all able to provide enough energy for the vehicle batteries to be recharged. Moving forward, all that needs to be done is to create finalized versions of these charging stations so that users are able to easily tell what method is being used, and what the real life equivalent of that would be. Additionally efforts will be needed to make the entire system visually appealing.