Faculty of Engineering and Applied Science

ENGR 4940U Capstone Systems Design for ECSE II

Design of Repurposed Electric Vehicle Battery for Residential Application

Team Members:

Armon Aryaie	100591975
Sameer Awan	100588654
Alan Deng	100588536
Ryan Hurtis	100522176
Murtaza Zaidi	100539844

Faculty Advisor: Dr.Vijay Sood
Course Coordinator: Dr.Qusay Mahmoud

Outline

- Introduction
- Problem Identification
- Our Solution VS Others
- Final Design
- Testings
- Results and Simulations
- Acknowledgement

The Growth of Electric Vehicles

- Rapid Growth in the EV industry
- **2013**-3,000 vs **2018**-93,000
- Average Life of EV battery is around 7 years
- Batteries will still have 80% useful life
- Battery Materials:
  - Metal
  - Wiring
  - Chemicals
  - Protective Materials

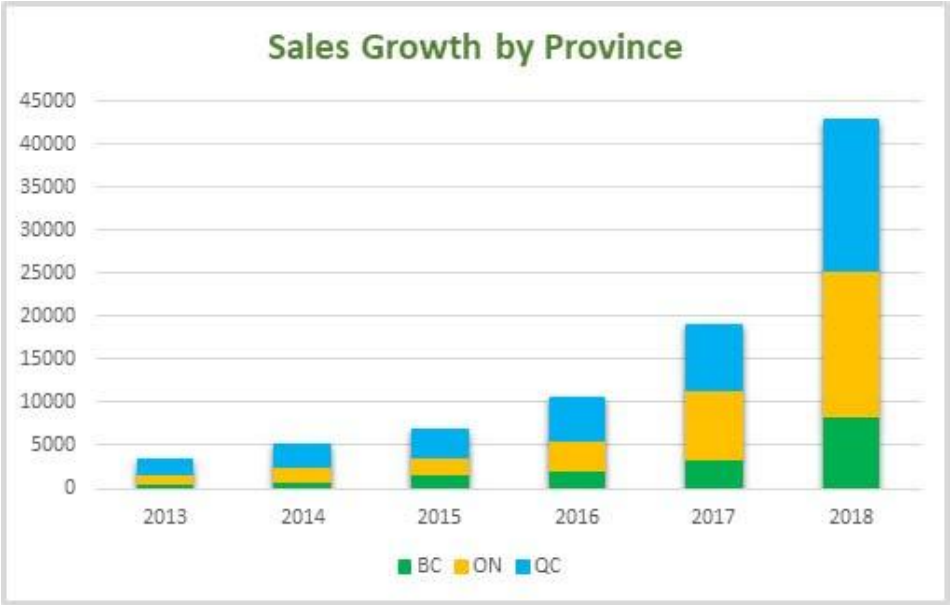


Fig 1: Sales growth of EV in Canada by Province

Problem Identification

Fig 2: Batteries in Landfills

What will happen to these EV batteries once they are decommissioned?

Our Solution

Fig 3: Our Peak Shaving System Reusing Used Fiat 500e Batteries

- Energy Storage System
- Repurpose EV Batteries
- Reduce, Reuse and Recycle
- Residential
- Peak shaving

Fig 4: Reduce,Reuse, Recycle Symbol

Comparison of Energy Storage Systems

Company	Spiers New Technology	Johan Cruijff Arena	Tesla	eCamion
Product	Watt Tower-Energy Storage System	Amsterdam Energy Arena	Tesla Power Wall	Community Energy Storage (CES)
Description/ Comparison	• Just an energy storage system • Reuses lithium Ion Batteries • Distributes to multiple loads **Focused purely on Tesla cells (18650)**	• For arenas • Solar panel charging • Sells back to local utility companies **Using Nissan Leaf cells**	• For homes • Solar panel charging • Sells back to local utility companies **Using only new cells**	• For Communities • Sells back to local utility companies • Power factor correction **Focused on using new cells**

Final Design

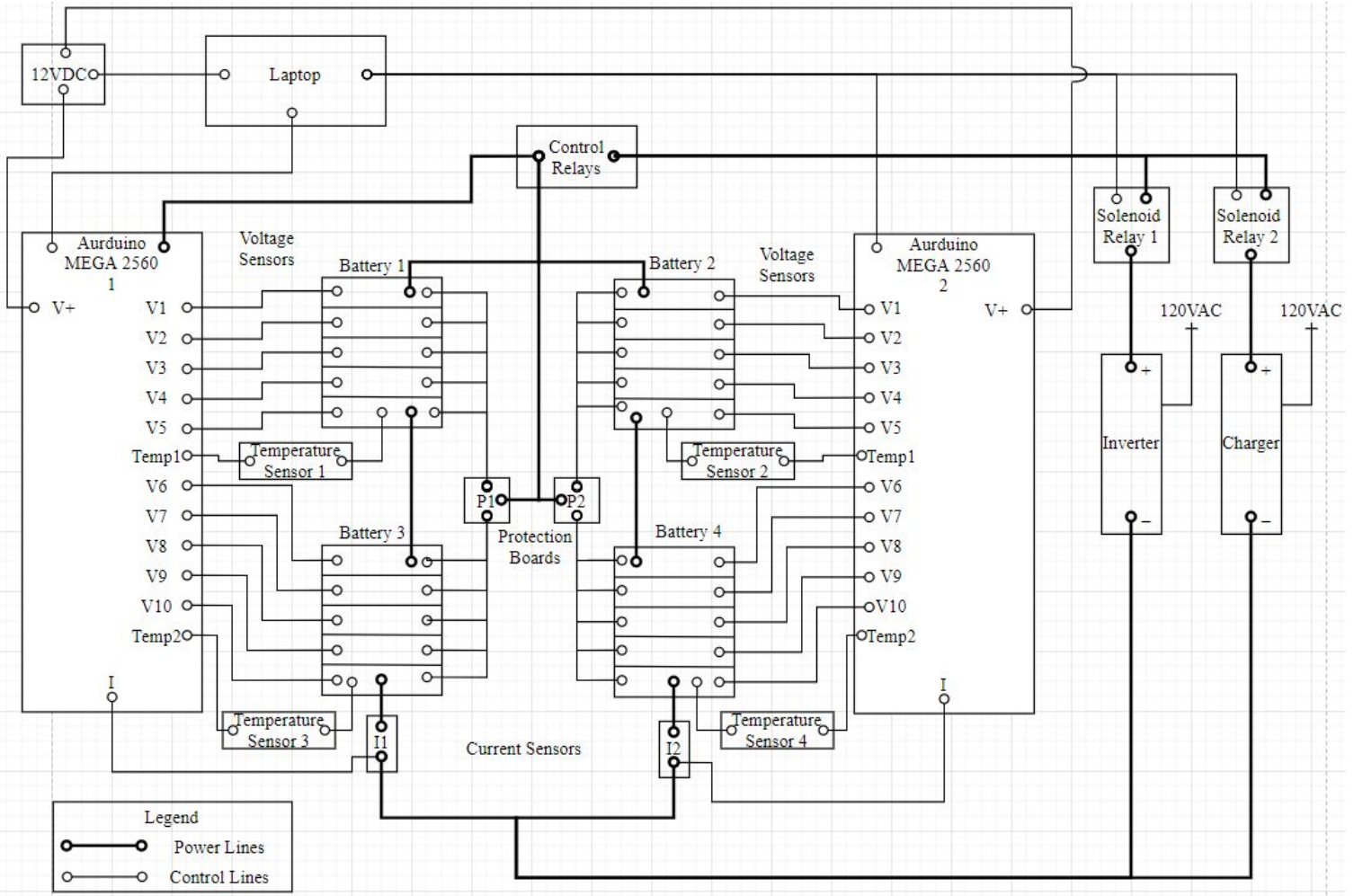


Fig 5: Schematic of Final Design

Main Components

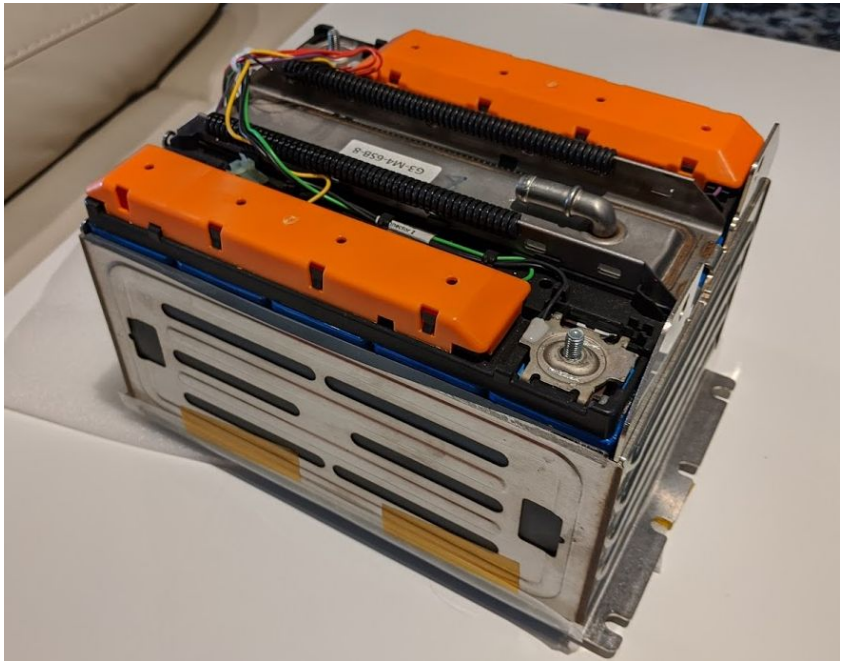


Fig 6: FIAT 500e Battery Module

Fig 7: 1000 W, 90-140 V_{AC} Grid Tie Inverter

Fig 8: DC Power Supply

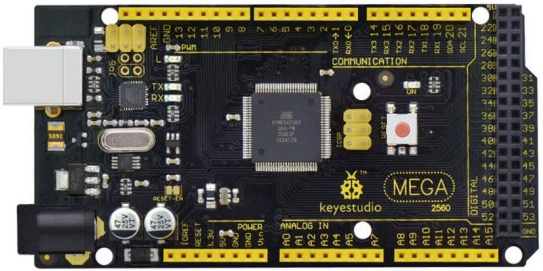


Fig 9: Arduino Mega

Fig 10: Solenoid Relay

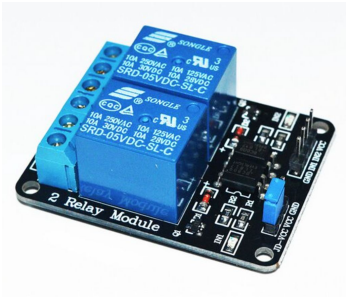


Fig 11: Arduino Relay

Fig 12: Slow Blow Fuse

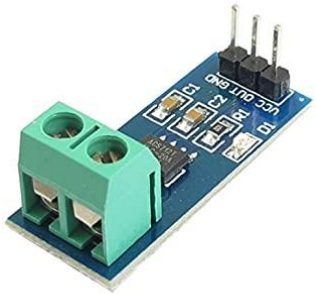


Fig 13: Current Sensor

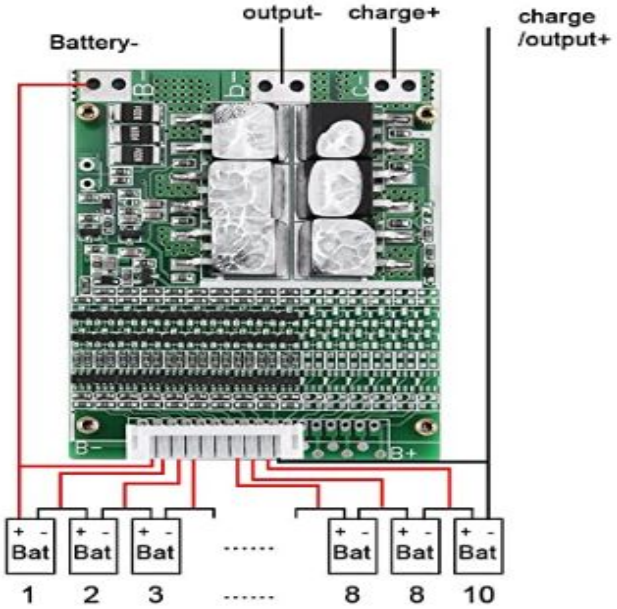


Fig 14: Battery Management System

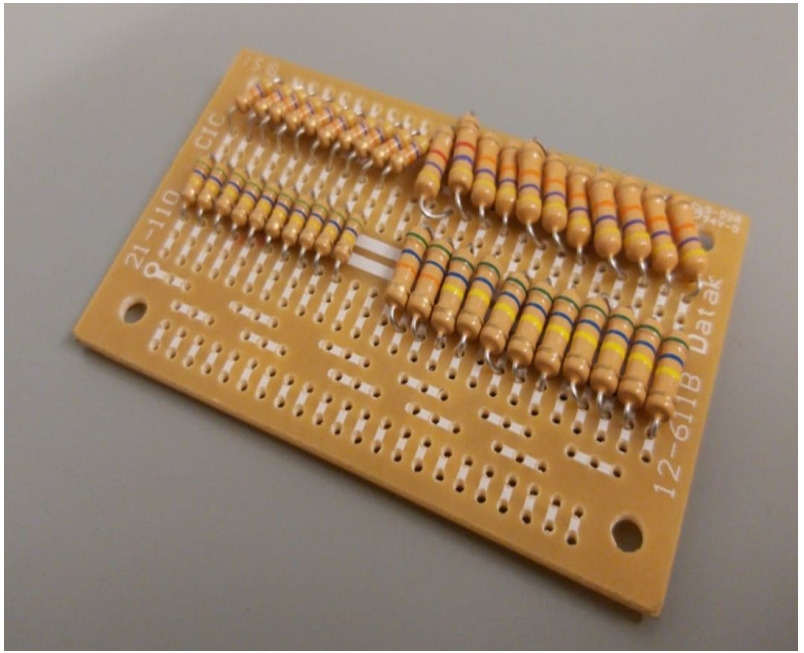


Fig 15: Voltage Sensor Circuit

Testings

Fig 16: Assembling The System

Individual Testings

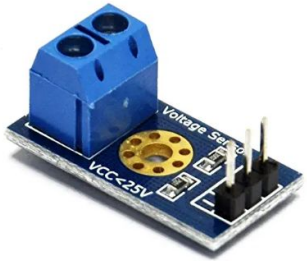


Fig 17: Voltage Sensor

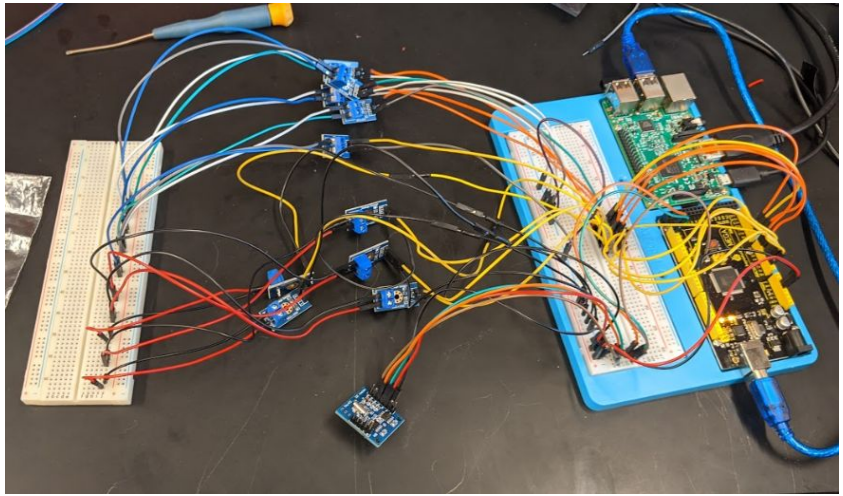


Fig 18: Setup for Voltage Sensor Test

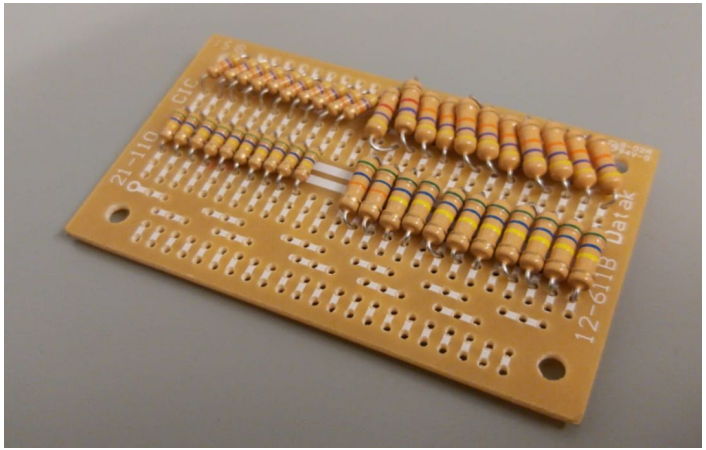


Fig 19: Voltage Sensor Circuit

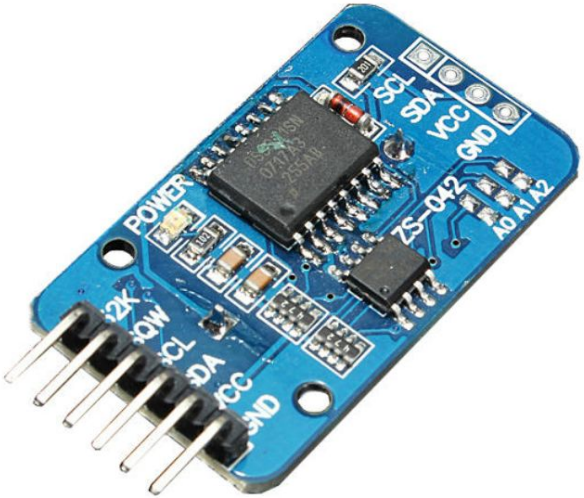


Fig 20: Arduino Real Time Clock

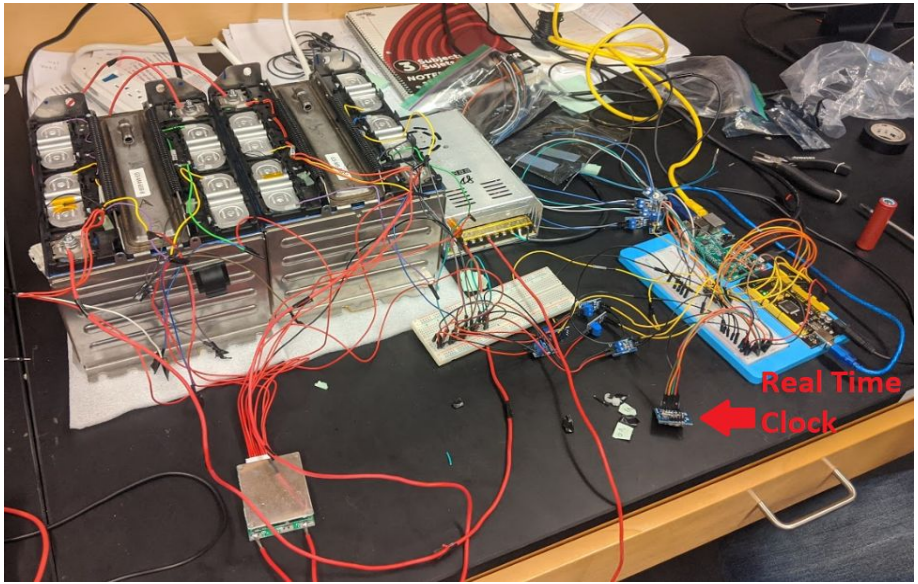


Fig 21: Testing Setup of Arduino Real Time Clock

Testing Issues

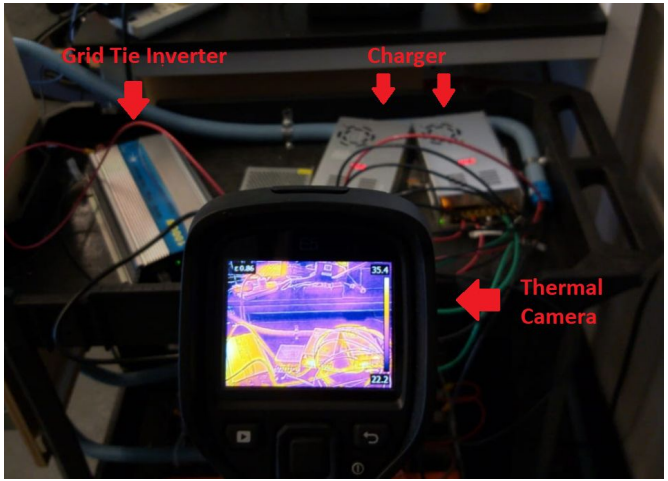


Fig 22: Scanning Grid Tie Inverter and Chargers Using Thermal Camera

Fig 23: Thermal Image of the Inverter

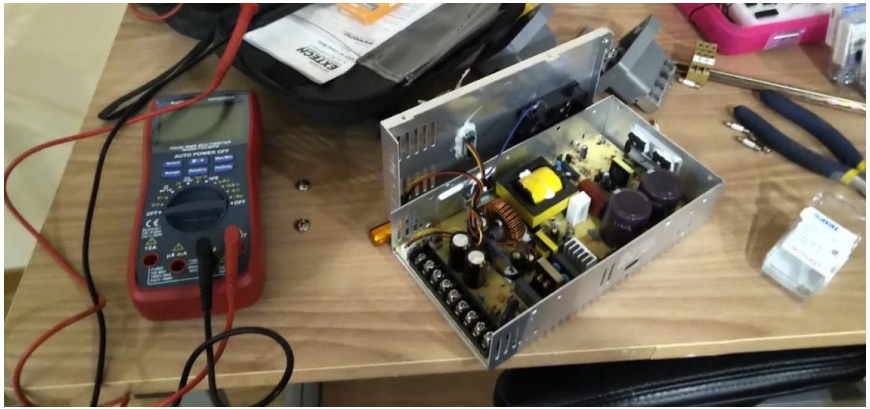


Fig 24: Broken Charger

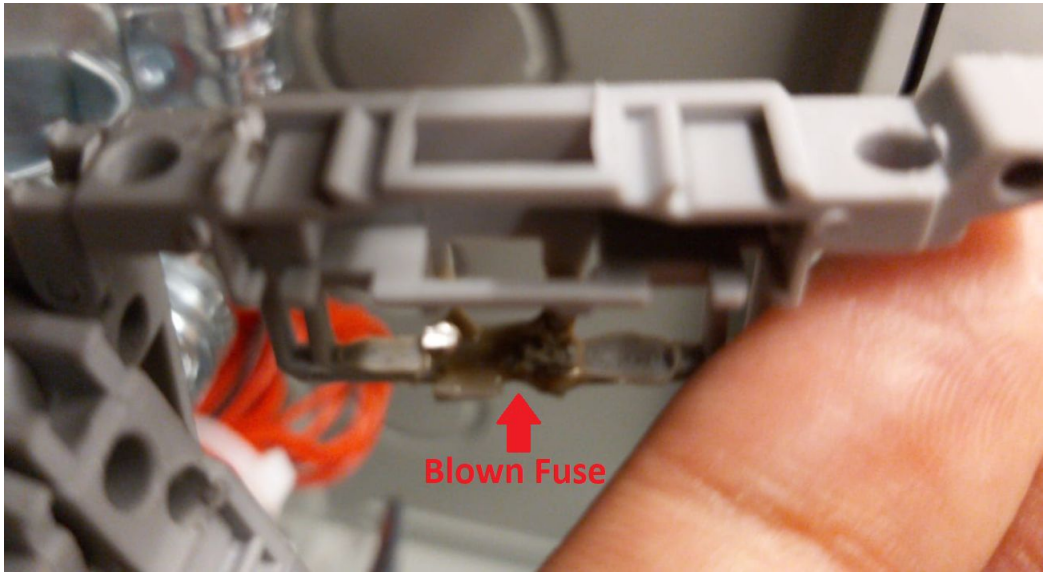
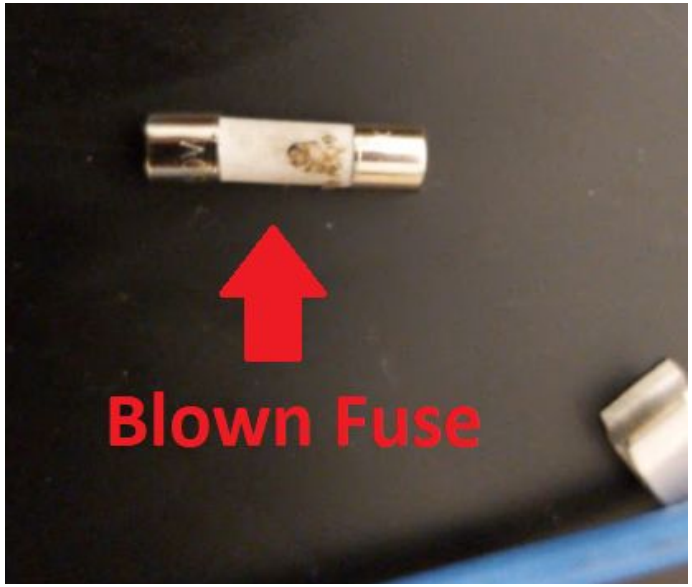


Fig 25: Blown Fuse Socket

Fig 26: Blown Fuse



Results and Simulations

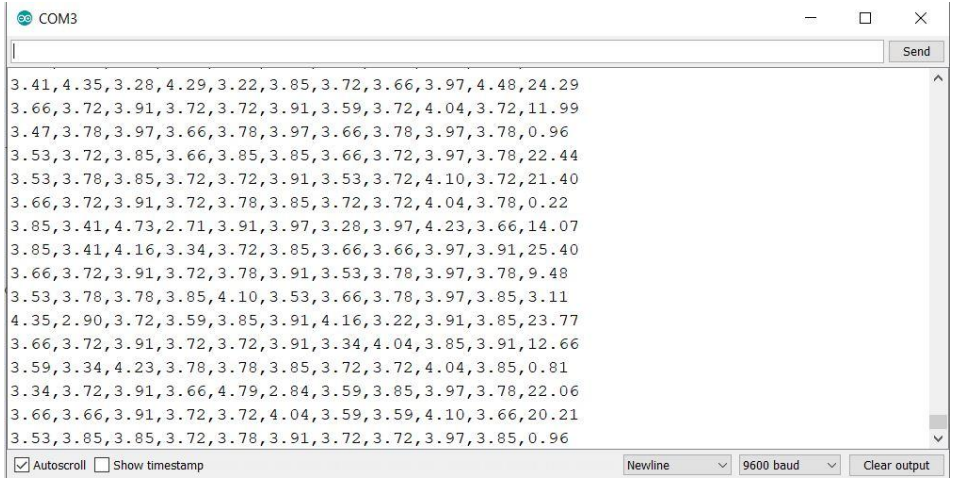
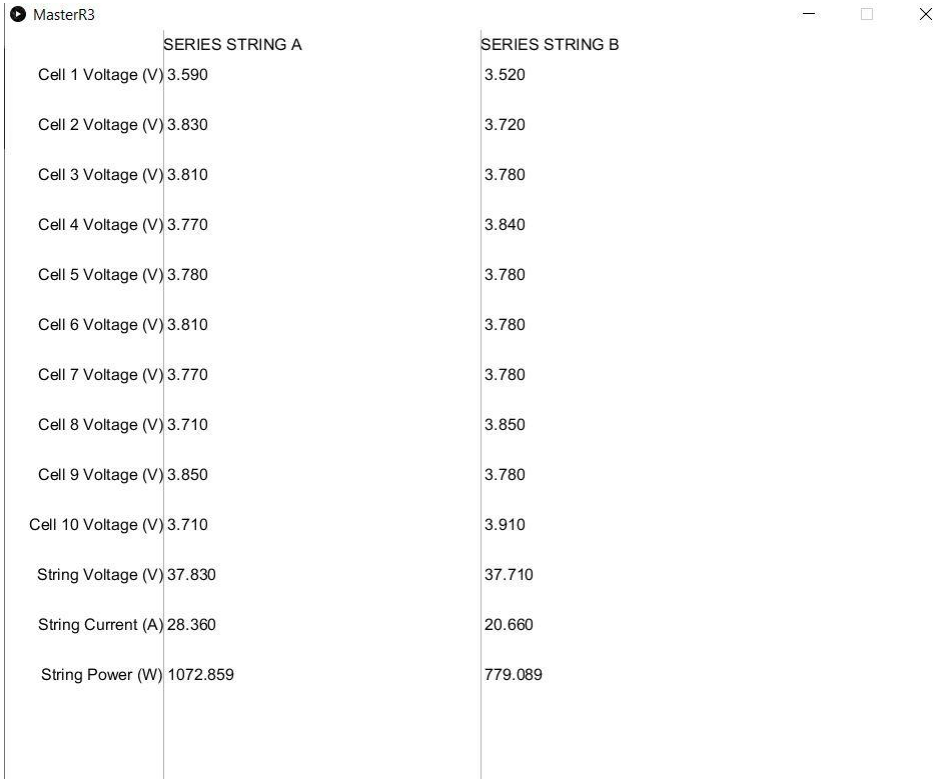


Fig 27: Serial Communication Monitor from the Arduino IDE

Fig 28: Processing GUI while the system is in the off state.

Results and Simulations



	SERIES STRING A	SERIES STRING B
Cell 1 Voltage (V)	3.590	3.520
Cell 2 Voltage (V)	3.830	3.720
Cell 3 Voltage (V)	3.810	3.780
Cell 4 Voltage (V)	3.770	3.840
Cell 5 Voltage (V)	3.780	3.780
Cell 6 Voltage (V)	3.810	3.780
Cell 7 Voltage (V)	3.770	3.780
Cell 8 Voltage (V)	3.710	3.850
Cell 9 Voltage (V)	3.850	3.780
Cell 10 Voltage (V)	3.710	3.910
String Voltage (V)	37.830	37.710
String Current (A)	28.360	20.660
String Power (W)	1072.859	779.089

Fig 29: GUI while the inverter circuit is on

	SERIES STRING A	SERIES STRING B
Cell 1 Voltage (V)	3.590	3.520
Cell 2 Voltage (V)	3.460	3.220
Cell 3 Voltage (V)	3.370	3.150
Cell 4 Voltage (V)	3.390	3.400
Cell 5 Voltage (V)	3.470	3.270
Cell 6 Voltage (V)	3.310	3.340
Cell 7 Voltage (V)	3.140	3.280
Cell 8 Voltage (V)	3.080	3.280
Cell 9 Voltage (V)	4.670	3.270
Cell 10 Voltage (V)	-0.070	3.340
String Voltage (V)	31.610	33.040
String Current (A)	-5.560	-5.260
String Power (W)	-175.752	-173.790

Fig 30: GUI while the charging circuit is on

Acknowledgements

Our capstone group would like to thank the following people for their contribution to this project:

- Dr. Vijay Sood for his guidance and mentorship
- Carmine Pizzurro eCamion for supplying us with batteries and data
- Jigneshkumar Patel, Ahmed Sheir and Mohammed Umar for giving guidance
- Canadian Industrial Solutions Limited for providing the tools and equipment
- Dan from Home Depot Oshawa for his guidance
- Dr. Qusay Mahmoud for providing guidelines

Thank You For Listening