The primary purpose of our project was to continue the development of the benchtop prototype electric vehicle through the application of a bi-directional converter which drives an electric motor using a battery pack. The key features of our project are as follows. There is a bi-directional converter which boosts and bucks voltage to transfer energy between the batteries, motor, and capacitors. The client will use a terminal to control the motor speed and be notified of measurements and fault-conditions associated with running the motor. The design chosen to control the bi-directional converter uses Proportional-Integral (PI) control. This was implemented with an Arduino microcontroller and an analog voltage sensor. The motor drive is inputted with DC from the converter and outputs three-phase AC to run the induction motor. The finished project is able to turn the motor using the battery with proper communication from the Arduino in order to do so. This project will give a future prototype electric vehicle team the opportunity to further develop this design.

The bi-directional converter is created using the same circuit as the boost converter apart from replacing the diode with a second IGBT. The boost converter portion is controlled using the PI method. The Discrete PI Controller block uses the backward Euler discretization method to calculate the control signal u(k) as shown below.

\[
\text{Discrete PI Controller block uses the backward Euler discretization method to calculate the control signal } u(k) \text{.}
\]

The first three lines of the Arduino code are from the top and control the setpoint for voltage (s), proportional constant (Kp), and integral constant (Ki). Lines four through eleven are from the main program loop. Line four reads and scales the measurement from the voltage sensor (PCB shown on the right), toggles an output pin which when connected to an oscilloscope can be used to verify the integral step size is constant. When looped continuously, this program performs the function of a PI controller.

Development for the bi-directional converter included implementing boost functionality to run the motor. PI control was used and implemented using MathWorks Simulink and the Arduino IDE (integrated development environment). The issues encountered during development, including those involving the Arduino communication and reset cycle, were solved. Documentation has been left for future development work on the Prototype Electric Vehicle.

The team would like to thank Dr. Donald Zinger for his guidance throughout the project design process. We would also like to thank Marcin Ciszek for releasing alarm code for the Arduino monitoring system. Finally, we appreciated having Fahad Alqahtani give his suggestions for improvement throughout the development process.

Acknowledgements