

Wheelchair Dynamometer

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Executive Summary

Fitness is an important aspect in today's society as a rapidly growing industry. Many people exercise to live a healthier lifestyle but also for sport performance. Several machines have been invented to exercise the body in different ways and help stay fit although there are very few machines specifically meant for wheelchair users. The wheelchair dynamometer is designed for wheelchair users, like an able-bodied individual, to exercise when needed as well as track performance parameters important in their field of sport. Some of the parameters of interest include the following: torque, speed, caloric expenditure, and distance traveled. With a difficulty resistance setting, the dynamometer can accommodate a wide range of users at different fitness levels. All of these parameters and settings are shown through the included touch display.

Background

As shown in Fig. 1, this is the wheelchair dynamometer built by the MAE department during the last academic year. While the system is mechanically complete, it is nonfunctional since the electrical system had not yet been designed. The electrical system is the main focus of this senior design project that continues based on the MAE team's previous work. A wheelchair user can use the ramp to get in between the rollers and lower the roller motion blocker. Through the display, they can record workout data and set specific settings. The inertial weights provide rotational inertia to closer simulate real-life rolling.

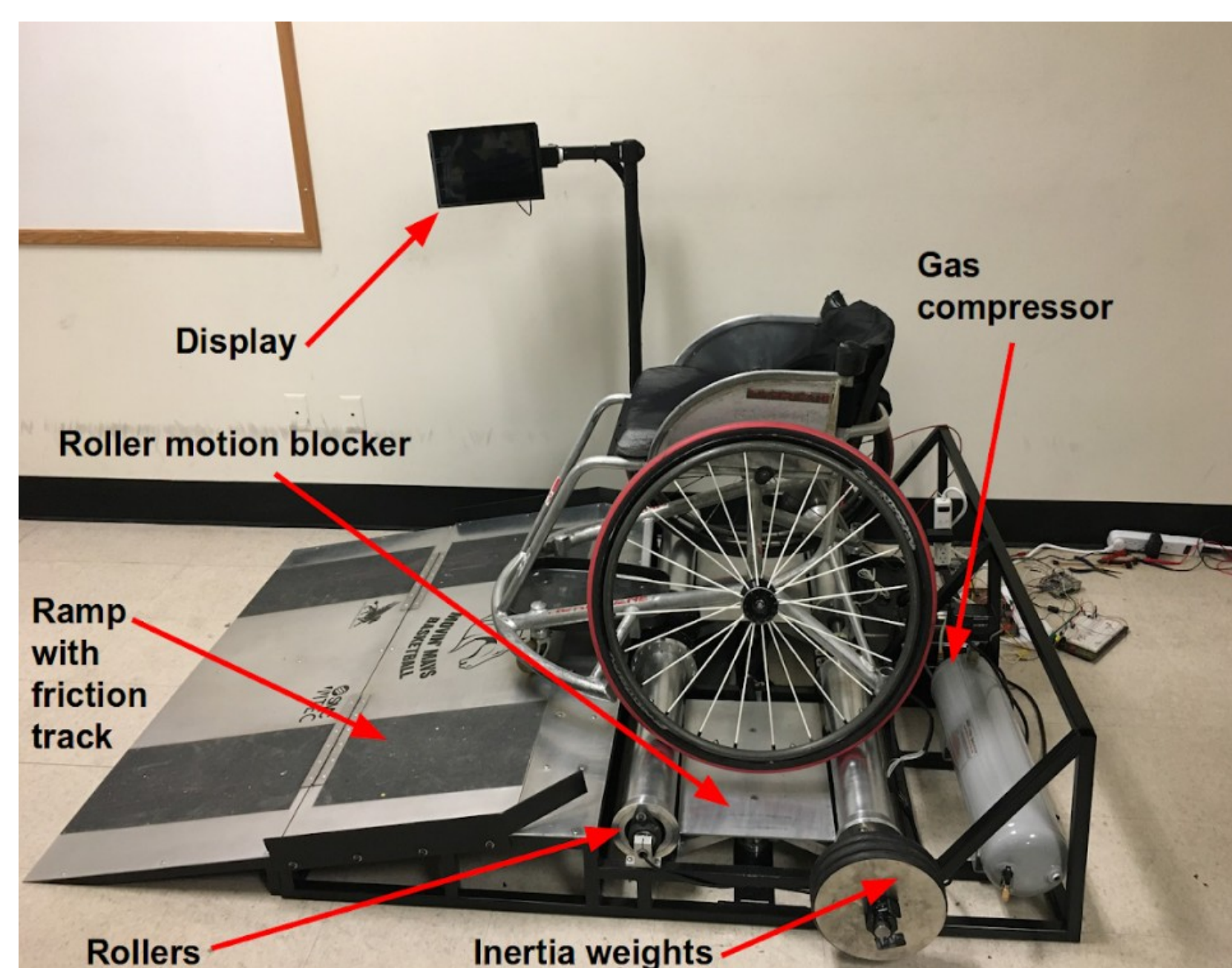


Figure 1. Wheelchair dynamometer system.

Conceptual Design Phase

For the dynamometer, we received some constraints on what the system should achieve. The dynamometer should support wheelchair athletes given maximum speed and torque information so the human power output should not break the system. Since the wheelchair racing speed record is 18 mph, the system is designed to allow a user to go up to 20 mph. Moreover, the system should record speed and torque information and from this, derive other important parameters. Since we require a web server for cross-platform support, a single board computer handles the main dynamometer system.

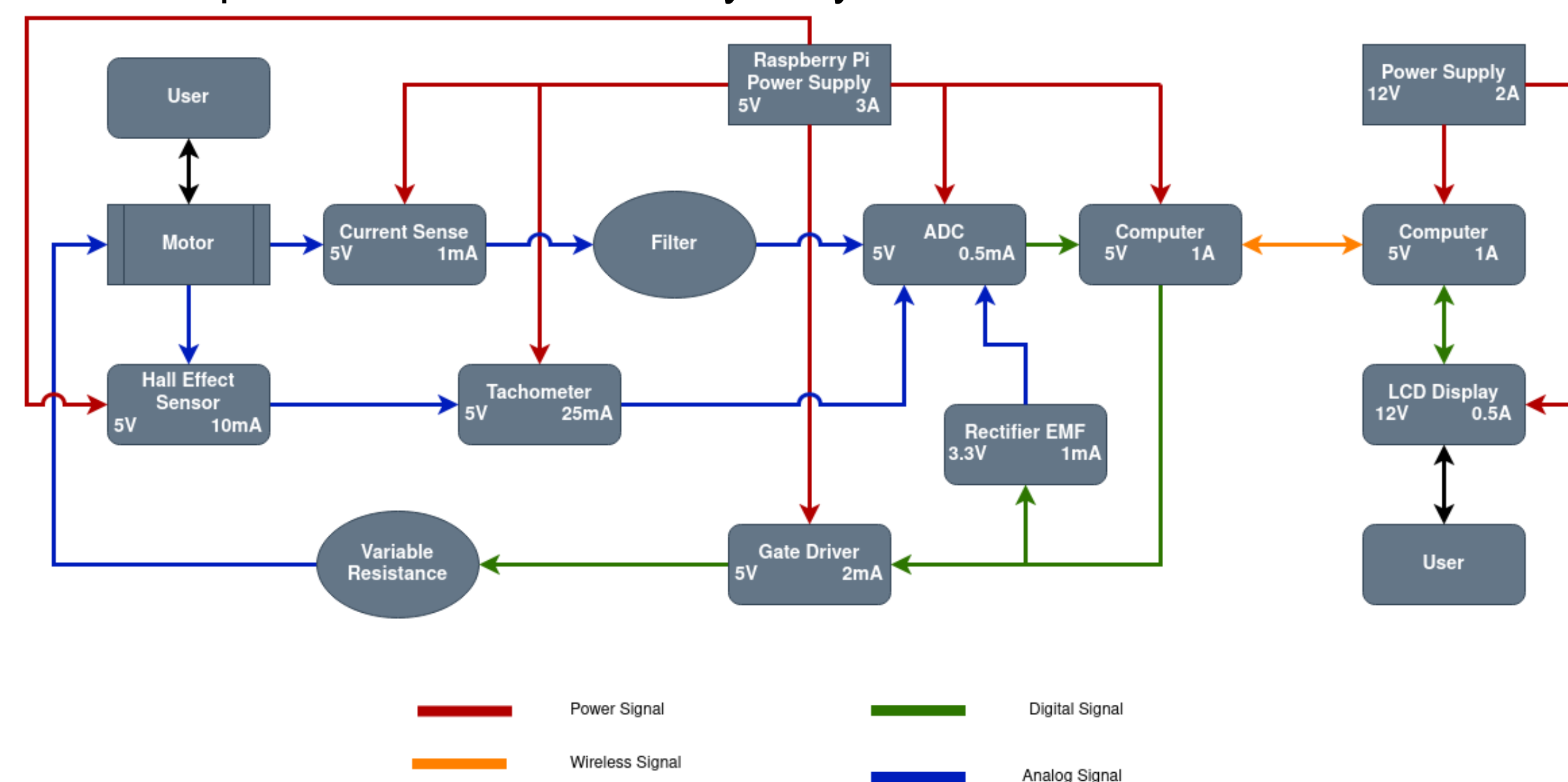


Figure 2. Block diagram for wheelchair dynamometer electrical system.

Detailed Design Phase

The variable resistance block is responsible for providing different workout resistance levels. A Simulink simulation was performed in order to determine how pulse width modulation (pwm) duty cycle affects shunt resistance seen by the motors as this determines the force required to overcome back emf. Furthermore, as seen by the results below, the shunt resistance is independent of user speed (voltage) which is exactly what we want. Otherwise, a more sophisticated feedback system is required.

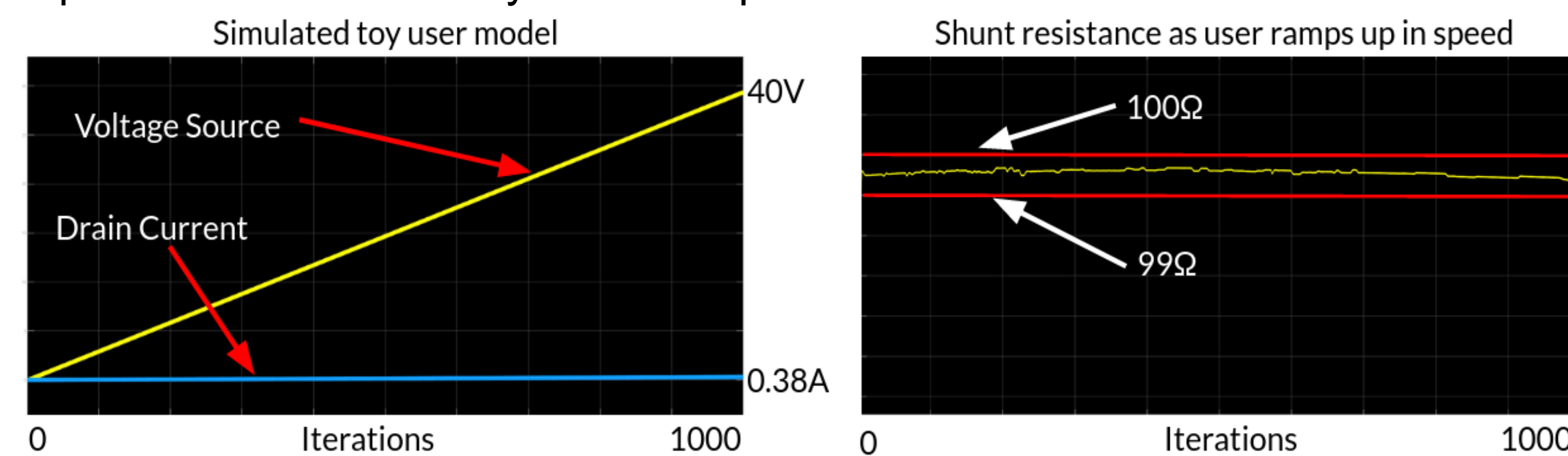


Figure 3. Simulink results of variable resistance model.

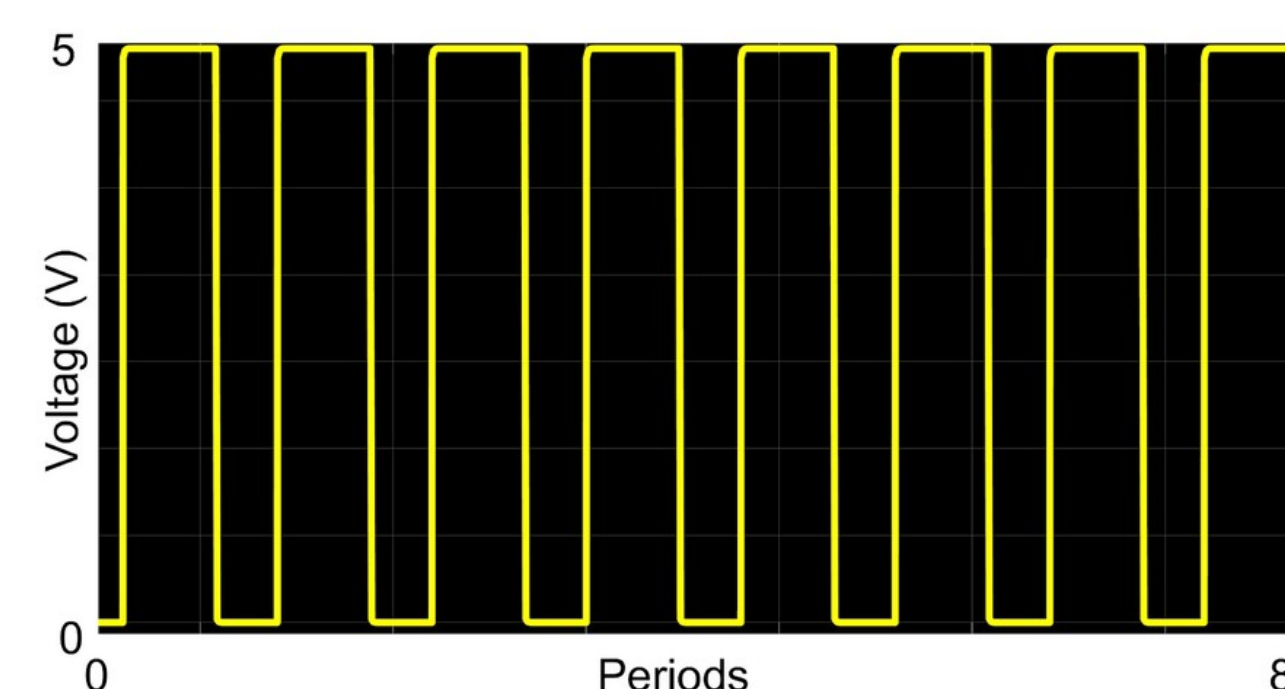


Figure 4. Simulink gate driver output.

The pwm signal in Fig. 4 is fed to a mosfet model that tricks the motor into thinking it's a resistor since the motor will apply a lowpass filter before seeing the variable resistance block. By doing this, it becomes more difficult or easier to roll on the dynamometer system.

Prototype & Results

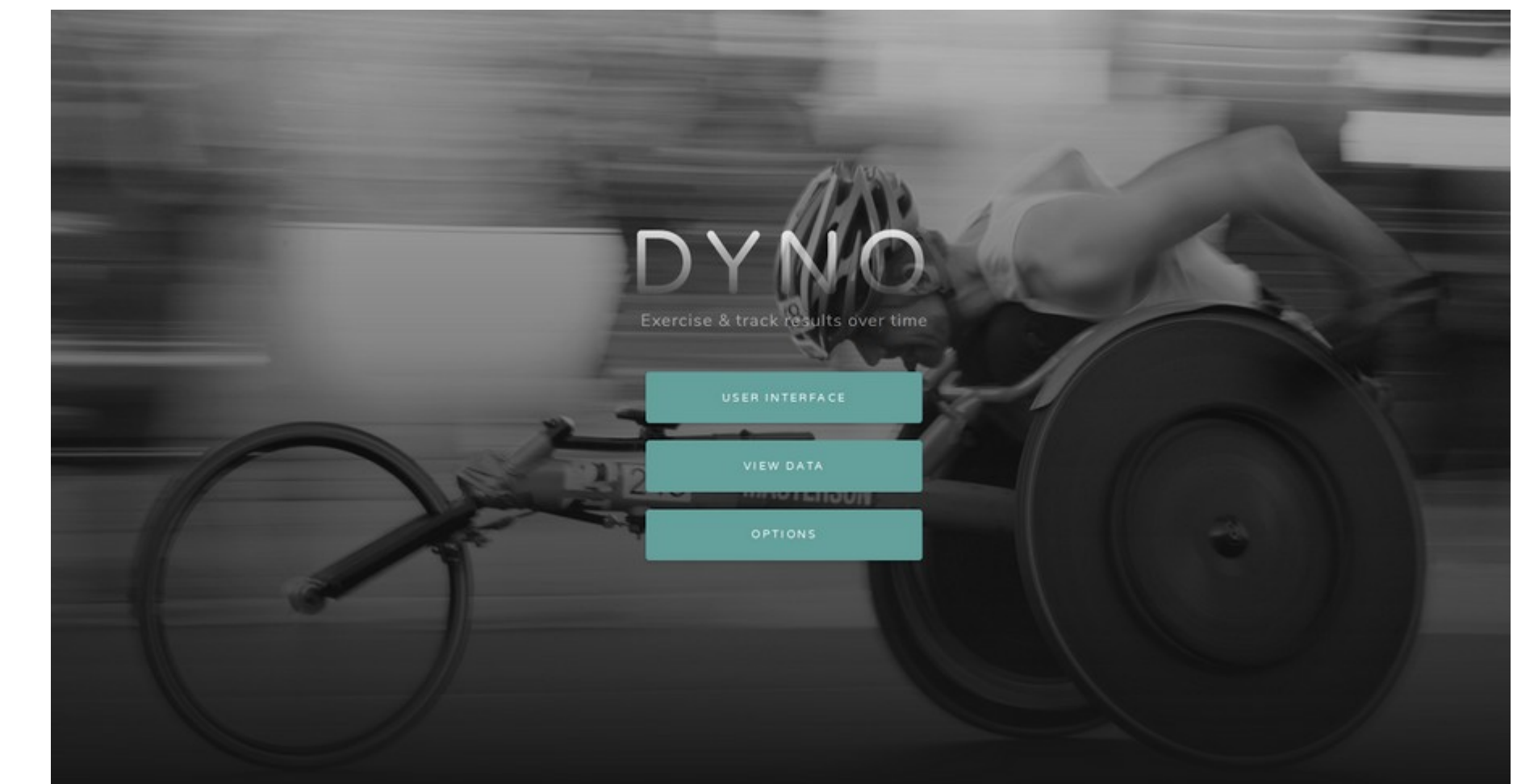


Figure 5. Main page for dynamometer system.

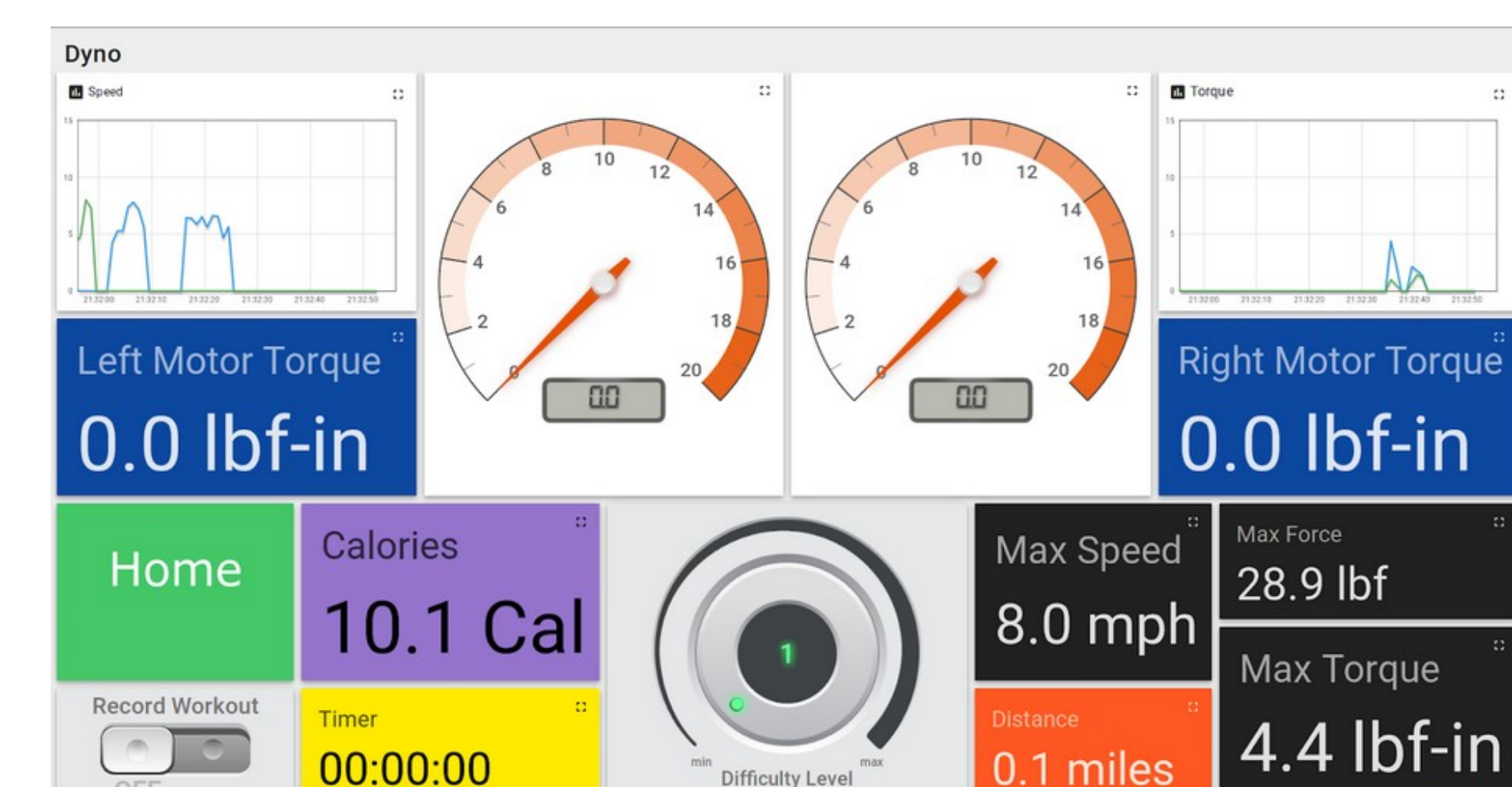


Figure 6. User interface for wheelchair dynamometer.



Figure 7. File indexer with previously recorded workout session data.

Conclusions

The wheelchair dynamometer is an innovative product initially intended to track the performance of athletic wheelchair users. Nevertheless, the extent of its use was expanded to further allow non-athlete wheelchair users to workout for general health and fitness purposes. As of today, there are not many wheelchair-specific workout machines available at gymnasiums and fitness centers. Therefore, the wheelchair dynamometer will greatly improve the quality of life of a large demographic who had previously limited options to routinely exercise at fitness and rehabilitation centers.