Virtual Cycling Reality

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Contents

1 Block Diagram

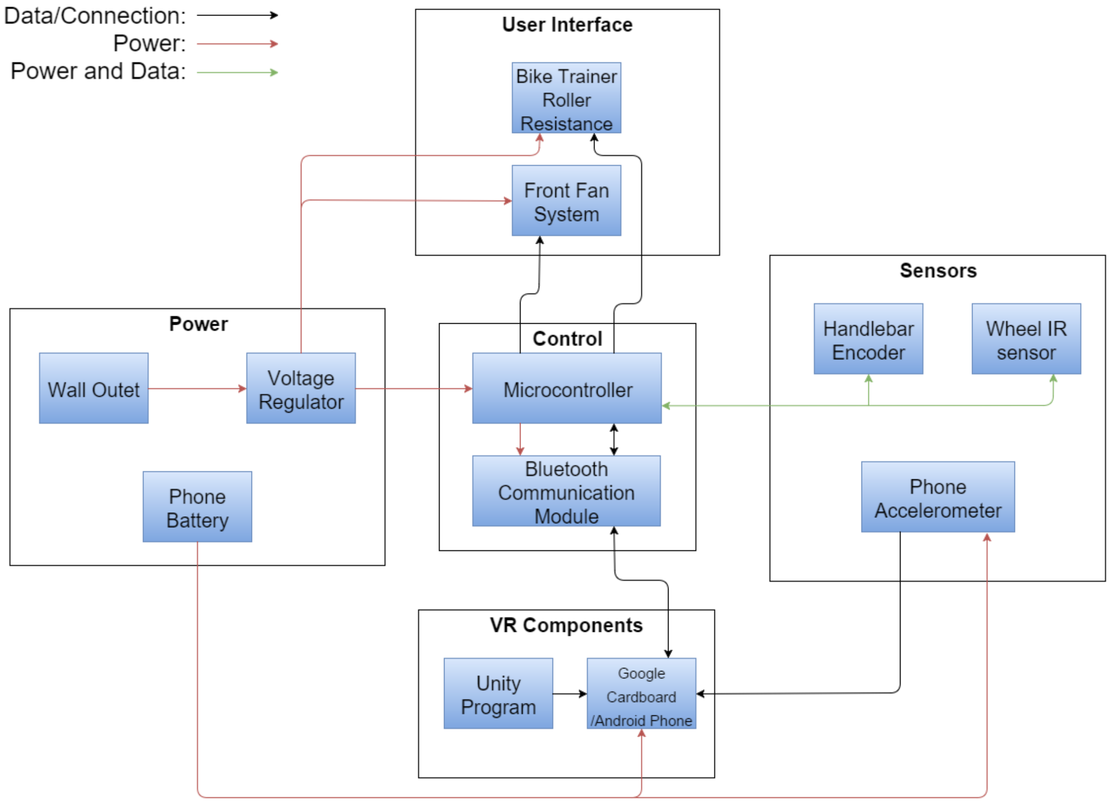

Figure 1: Block Diagram for Virtual Cycling Reality Project

2 Buck Converter Schematic

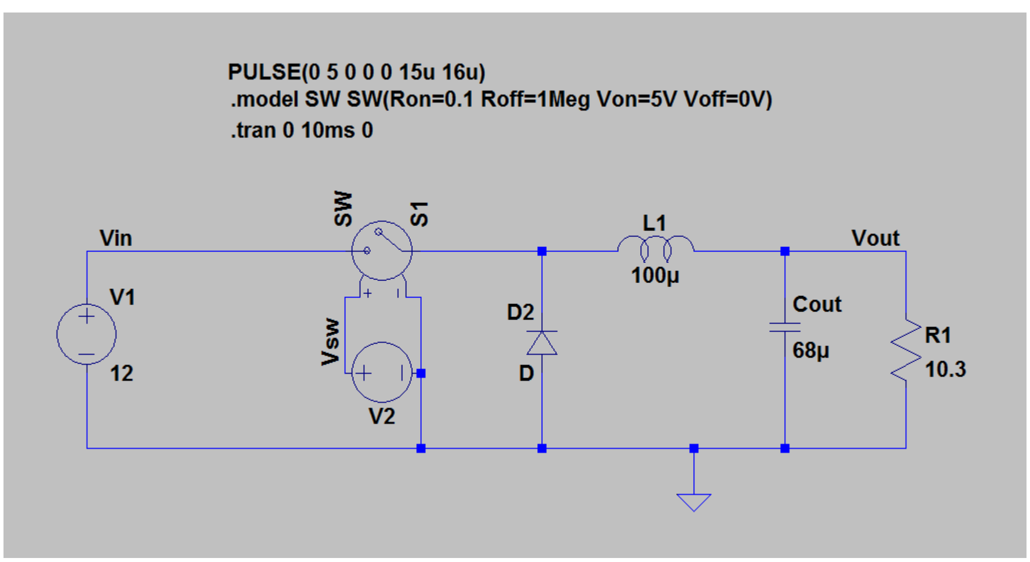

Figure 2: BuckConvert Block Schematic

3 Buck Converter Simulation Plots

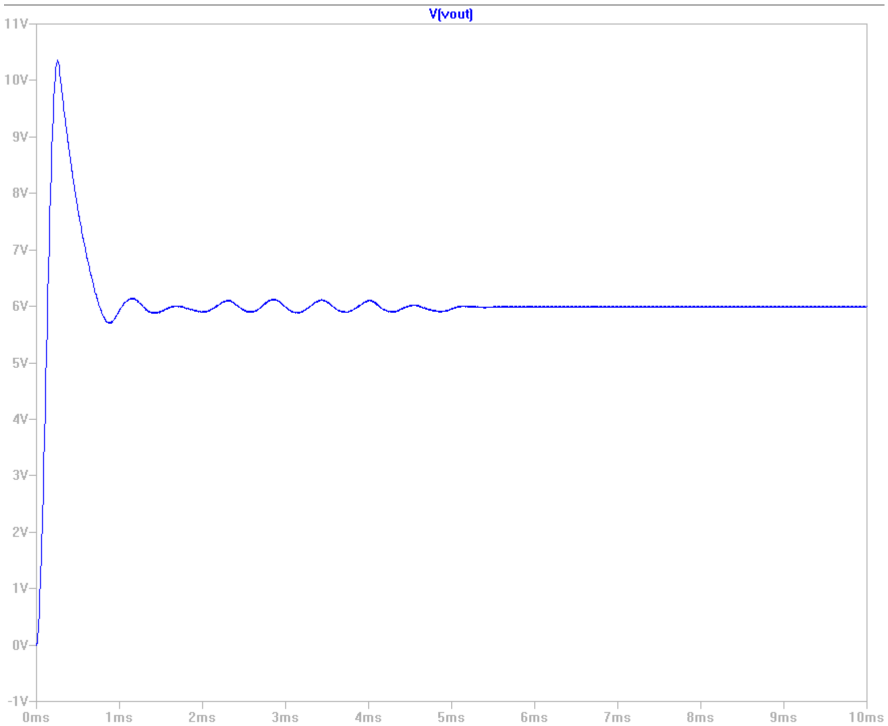

Figure 3: Vout at 50% duty Simulation Plots

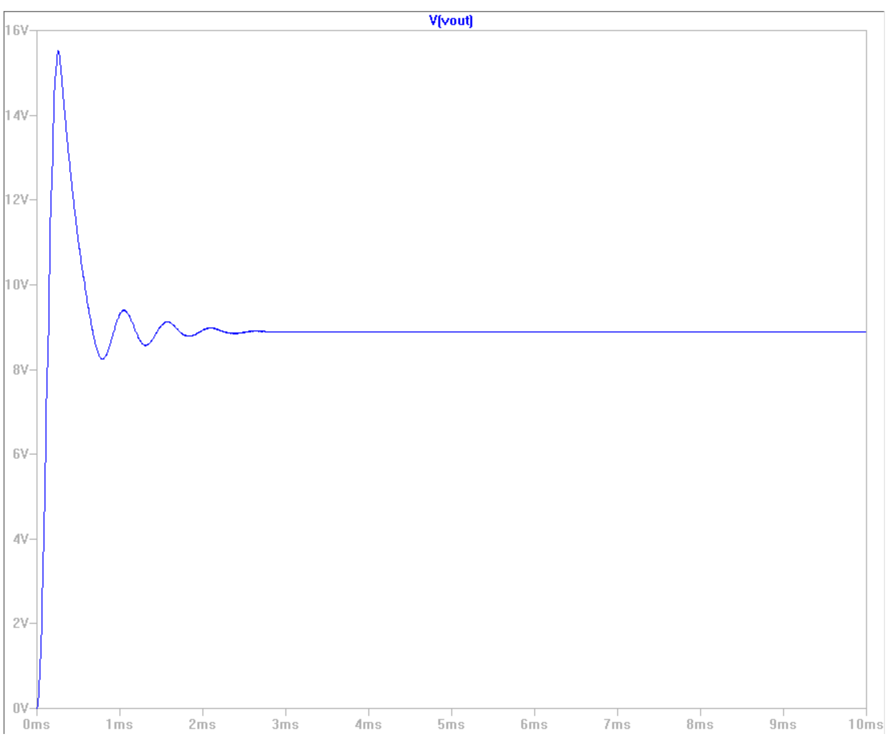

Figure 4: Vout at 75% duty Simulation Plots

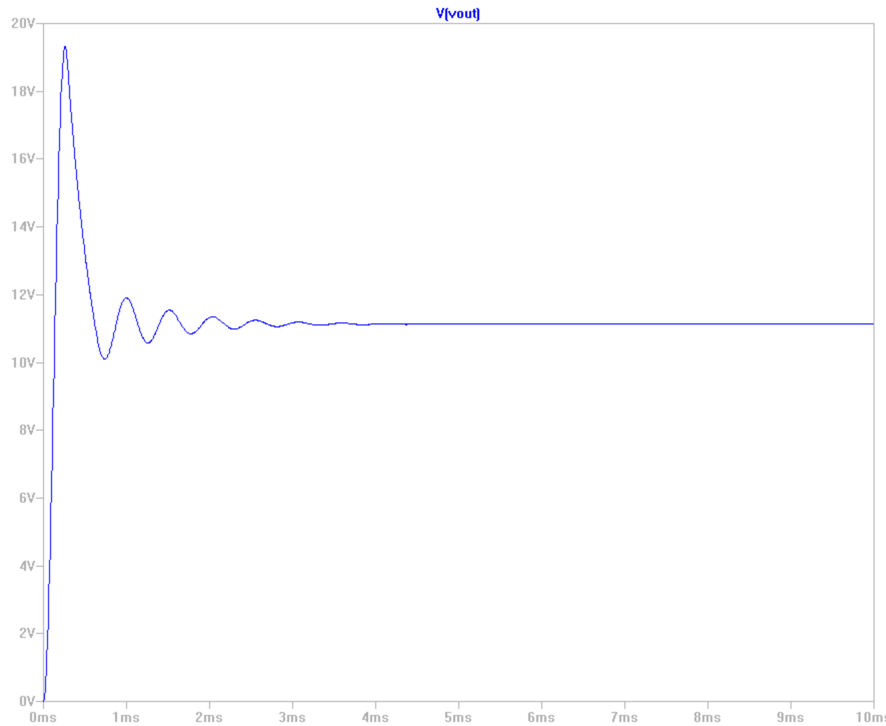

Figure 5: Vout at 93.75% duty Simulation Plots

4 Buck Converter Component Calculations

The relationship for the buck converter inductor calculation is given in Equation 1. This value was calculated for a minimum output voltage of $V_{out} = 6\ V$ which corresponds to a duty ratio $D = 0.5$. The switching frequency was chosen to be the maximum PWM output frequency of the Arduino Uno. This microcontroller can output at 62.5 kHz in fast PWM mode with 8-bit resolution.[1] The inductor ripple current Δi_L was chosen to be 40% of the maximum current of 1.2 A. Equation 2 shows the result of this calcluation. The output capacitor value was similarly determined. The equation for this calculation is show in Equation 3. The ripple voltage was arbitrarily chosen to be 1%. Equation 4 shows the result of this computation.

$$L = \frac{(V_{in} - V_{out}) \times (D \times \frac{1}{f_{sw}})}{\Delta i_L} \tag{1}$$

$$L = \frac{(12 - 6) \times (0.5 \times \frac{1}{62500})}{0.4 \times 1.2} = 102.86\ \mu H \tag{2}$$

$$C = \frac{\Delta i \times (1 - D) \times \frac{1}{f_{sw}}}{\Delta V_{ripple}} \tag{3}$$

$$C = \frac{0.467 \times (1 - 0.5) \times \frac{1}{62500}}{0.06} = 62.2\ \mu F \tag{4}$$

These calculated values for the capacitor and inductor were used to choose the values of the inductor and capacitor appearing in the circuit in section 2. The chosen values correspond to readily available component values.

5 VR Component Logic Flow

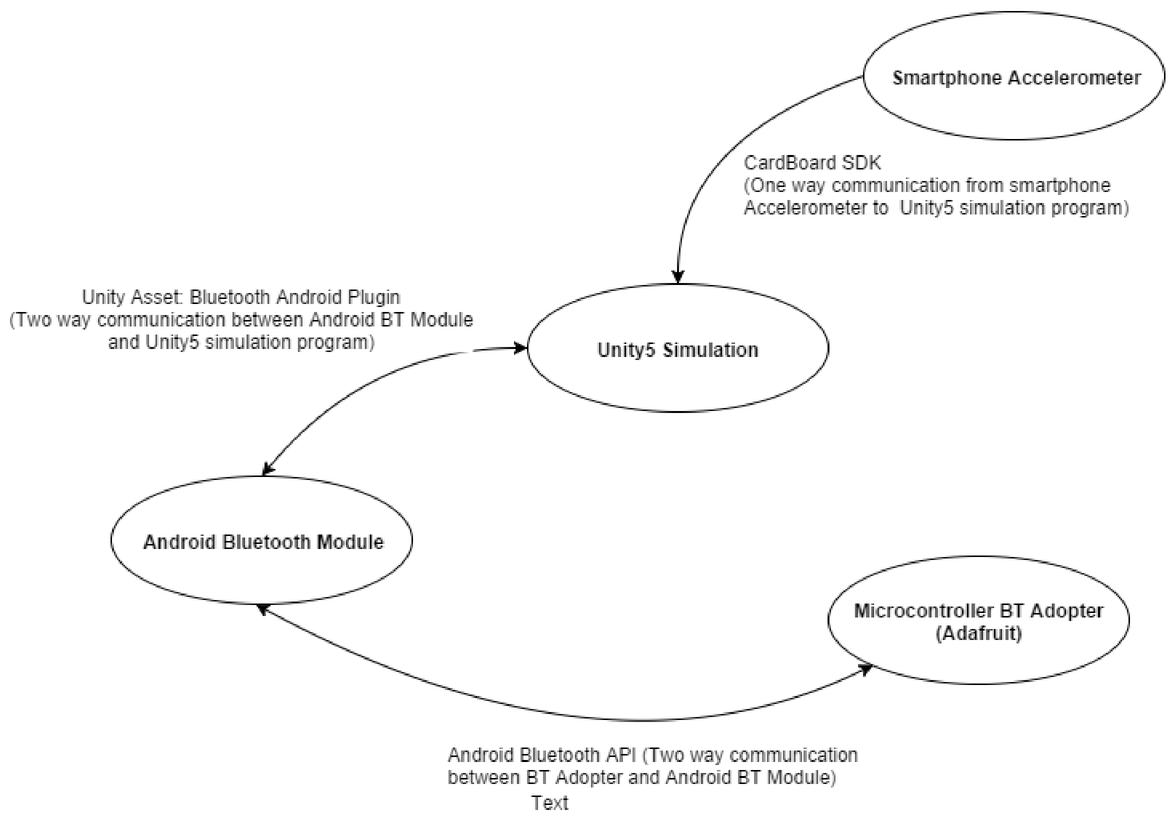

Figure 6: VR Component Logic Flow Chart

The communication between Microcontroller BT Adopter and Android BT Module is using Andriod Bluetooth API[2].
The communication between Android BT Module and Unity5 Program Simulation is using Unity Asset (Bluetooth Android Plugin)[3].
The communication between Unity5 Program Simulation and Smartphone Accelerometer is using CardBoard SDK[4].

6 Sensor Block Description

6.1 Sensors

There are total of three sensors being used in the project in order to track the user's physical movement. The sensor signals are being integrated into simulation inputs.

6.2 Handlebar rotary Encoder

In order to effectively measure the angle of the handlebars, a handlebar rotary encoder will be placed on the head tube of the bike. The voltage reading from the rotary encoder will be probed by the microcontroller in order to calculate the degrees of rotation of the handlebar. The voltage readings will need to be tuned to ensure that voltage ranges read can be quantized into approximate handlebar positions.

6.3 Phone Accelerometer

The built in accelerometer on the smart phone is being used to track the user's head movement. Its input directly feeds into the Unity Program, which is being used to control the simulation field of view. Due to the limitation of the accelerometer, only rotation movement will be support, the linear movement will not be support for the VR experience.

6.4 Wheel IR Sensor

The IR Sensor is installed on the bike stand. The IR sensor functions to record the speed of the rear wheel, the sensor inputs is being used as control input for the simulation as well as the control input for the front fan system. The IR sensor contains both IR emitter and IR receiver, four IR reflecting tapes are installed on the wheel spokes. The sensor voltage reading peaks when the IR reflecting tape passes in front of the the receiver. The frequency of IR sensor peaks will be used to calculate the speed of the bike.

7 Sensor Requirements and Verification

Components Requirements	***Testing Verifications***
Handlebar Encoder 1) Front handle bar able to support maximum rotation of 120 degrees in both directions. (clockwise and counter clockwise) 2) Able to accurately sense small rotations of the handlebars with +/- 5 degrees.	1) Sensors detect accurate reading at maximum rotation angle. Verified with a protractor. 2) Digital reading from the microcontroller will be compared with physical measurements from a protractor.
Phone Sensors 1) Detect three degrees of freedom head movements. (Yaw, Pitch and Row) 2) Stay within reasonable error range after 1 hour of continues use. The error range is +/- 10 degrees with respect to default orientation.	1) A group member will wearing the Gear VR head set and performing Yaw, Pitch and Row rotations. 2) A group member with a measuring stick attached to the helmet will start the simulation with facing forward in the simulation and physically. After extensive use of 1 hour, the member will facing forward in the simulation, and the angle of error of physical facing direction will be measured.

Wheel IR sensor	
1) Detect correct IR signal pulses correctly.	1) Measure voltage output from the IR sensor with voltage meter.
2) Able to calculate correct speed for the bike +/- 2 km/h.	2) The speed of the bike will be measured by bike speedometer, it will be compared with microcontroller speed output.
3) Minimum speed detection achieve 3 km/h.	2) The bike will be keep at speed of 2 km/h (measured by bike speedometer), the microcontroller speed output will be read, and should be able to output current speed with +/- 2 km/h error
4) Maximum speed detection achieve 30 km/h.	4) The bike will be keep at speed of 30 km/h (measured by bike speedometer), the microcontroller speed output will be read, and should be able to ouput current speed with +/- 2 km/h error

8 Safety Statement

The members of Virtual Cycling Reality strive to adhere to the safety rules and procedures outlined in the IEEE code of ethics. During the project lifecycle it is our goal to maintain a safe and productive work environment while minimizing potential risk to ourselves and equipment. This goal shall be accomplished by extensive communication/clarification within the group and also with course staff concerning lab and equipment safety. As Electrical and Computer Engineers in the process of designing a product it is imperative that we as a group understands the possible hazards and dangers that might arise. Therefore we as a group shall maintain the habit of researching all tools and components, as to better understand the risks associated with using them. Below are some of our groups objectives as we seek to accomplish our goal.

1. Research and understand the risk of components used in our design
2. To identify those risks, consider an appropriate response, and to note the response in our safety manual
3. Properly cite the designs and works of others
4. To inform course staff in the event of broken or malfunctioning equipment
5. Implement safe and cautious testing of our design, including:
   (a) Not eating or drinking in the lab
   (b) Wearing appropriate attire when working in the lab
   (c) Ensure that all equipment is turned off and put away correctly before leaving the lab
   (d) Prevent damage to ourselves and our equipment by ensuring that circuits are grounded and checking the safety rating on our equipment
6. To ask questions about unfamiliar tools or equipment to a course staff member, prior to using said items
7. Be able to recognize a state of emergency and to seek help from emergency responders

To conclude, the objectives and procedures mentioned here were conceived in adherence to the IEEE code of ethics. Throughout the semester we will strictly comply to these guidelines in order to ensure the completion of our project in a safe and secure manner.

References

[1] Arduino forum. [Online]. Available: https://forum.arduino.cc/index.php?topic=310753.0

[2] Android bluetooth api. [Online]. Available: http://developer.android.com/guide/topics/connectivity/bluetooth.html

[3] Unity android bluetooth plugin. [Online]. Available: https://www.assetstore.unity3d.com/en/#!/content/15179

[4] Google cardboard api. [Online]. Available: https://forum.arduino.cc/index.php?topic=310753.0