Electrical Overview

Year: 2017 Semester: Fall Team: 3 Project: Virtual Sport

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Assignment Evaluation:

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| --- | --- | --- | --- | --- |
| **Item** | **Score (0-5)** | **Weight** | **Points** | **Notes** |
| **Assignment-Specific Items** | | | | |
| **Electrical Overview** | 5 | x3 | 15 |  |
| **Electrical Considerations** | 5 | x3 | 15 |  |
| **Interface Considerations** | 5 | x3 | 15 |  |
| **System Block Diagram** | 5 | x3 | 15 |  |
| **Writing-Specific Items** | | | | |
| **Spelling and Grammar** | 5 | x2 | 10 |  |
| **Formatting and Citations** | 5 | x1 | 5 |  |
| **Figures and Graphs** | 5 | x2 | 10 |  |
| **Technical Writing Style** | 5 | x3 | 15 |  |
| **Total Score** | 100 | | |  |

5: Excellent 4: Good 3: Acceptable 2: Poor 1: Very Poor 0: Not attempted

General Comments:

*Well written with possible constraints identified.*

1.0 Electrical Overview

The fundamental components of our device consist of a 32-bit microcontroller, a Bluetooth LE module, an accelerometer, two pushbuttons, several vibration motors and linear actuators. The accelerometer collects the data of the hand orientation, tilt angle in a 3-dimensional space via I2C protocol. The microcontroller receives the hand orientation and pushbutton input status data and transmits the data to the data buffer. The microcontroller communicates with the VR application by sending the data stored in the data buffer to the app through the Bluetooth LE module that binds with the microcontroller via UART. It also handles the haptic instructions coming from the VR application and generates corresponding PWM signals to the vibration motors and the linear actuators through the haptic driver. The vibration motors provide haptic feedbacks of the collision of the sword in the virtual world and the linear actuators create shear and friction force when the user swings the virtual sword.

2.0 Electrical Considerations

2.1 Operating Voltage Considerations

The STM32F407 discovery board receives power from a computer through a mini-B USB connection or through external power sources of 3 V or 5 V as seen on board. The second powering option is adopted as the final product is expected to be a portable device. After summarizing all the operation voltages of each component [2] [3] [4] [5] [6], as the linear actuator is the only component that requires a 5 V operating voltage while other components require a maximum voltage of 3 V to avoid being burned, a separate voltage source of 5 V will be utilized for the linear actuators while all other components use 3 V voltage source. Two voltage regulators are required since none of the existing voltage sources are 5 V. Hence, a 9 V battery and a 9 V to 5 V voltage regulator are deployed to achieve the 5 V voltage to the linear actuators and another 5 V to 3.3 V voltage regulator is used to provide 3.3 V voltage to other components. The transfer efficiency, according to the datasheet [8], is as high as 90.5%.

2.2 Power Budget Considerations

As the operating voltages of all components are mentioned in 2.1, here lists out the operating voltage of each component as well as the current and power consumption of each one:

* STM32F4 Microcontroller:
  + Operating Voltage: 1.8 V ~ 3.6 V [1]
  + Maximum Current Consumption: 93 mA [1]
  + Quantity Used in the Project: 1
  + Power Consumption (Using 3.3 V): 306.9 mW
* ADXL345 Accelerometer:
  + Operating Voltage: 2.0 V ~ 3.6 V [2]
  + Maximum Current Consumption: 3 mA [2]
  + Quantity Used in the Project: 1
  + Power Consumption (Using 3.3 V): 9.9 mW
* HM10 Bluetooth LE:
  + Operating Voltage: 2.0 V ~ 3.7 V [3]
  + Maximum Current Consumption: 8.5 mA [3]
  + Quantity Used in the Project: 1
  + Power Consumption (Using 3.3 V): 28.05 mW
* DRV2605 Haptic Driver:
  + Operating Voltage: 2.0 V ~ 5.2 V [4]
  + Maximum Current Consumption: 3.5 mA [4]
  + Quantity Used in the Project: 1
  + Power Consumption (Using 3 V): 11.55 mW
* LRA Vibration Motor:
  + Operating Voltage: 2.7 V ~ 3.3 V [5]
  + Maximum Current Consumption: 80 mA [5]
  + Quantity Used in the Project: 4
  + Power Consumption (Using 3.3 V): 1056 mW
* GS-1502 Linear Actuator:
  + Operating Voltage: 3.7 V ~ 5.0 V [6]
  + Maximum Current Consumption: 550 mA\*
  + Quantity Used in the Project: 2
  + Power Consumption (Using 5 V): 5500 mW

Total Power Consumption: 6912.4 mW

(\*No datasheet of GS-1502 linear actuators found, but the maximum current consumption was found on the similar SG90 servo motor specification [7]).

According to the list above, all components use a 3 V voltage source while the linear actuators use a 5 V voltage source. In addition, the device also uses several pushbuttons with 10k Ohms pull-up resistors and their current and power consumption should be negligible.

2.3 Operating Frequency Considerations

The operating frequency of the device is mainly determined by the clock speed of the microcontroller. The higher clock speed is preferred as it reduces the latency from updates to displays. The STM32F407 has a maximum clock speed of 168 MHz [1] while the maximum SCL clock frequency of the ADXL345 I2C protocol is 400 KHz [2]. The project will use a slightly slower SCL clock to prevent undesirable effects.

3.0 Interface Considerations

3.1 UART Interface (Bluetooth)

A UART protocol will be used to connect the Bluetooth module. Two output pins from the microcontroller will be the TX and the RX line of the UART with the default baud rate of 9600. Each pack of data transmitted or received has 8 bits without parity bit. Following each pack of data, a stop bit is placed, informing the microcontroller to stop transmitting or receiving the data. Interrupt driven mode will be used to receive haptic command.

3.2 I2C Interface (Accelerometer)

The accelerometer transmits the position and orientation data of the hand to the microcontroller via I2C. It uses three output pins from the microcontroller as chip select, SCL and SDA lines. The maximum SCL frequency in the I2C protocol is 400 kHz according to the ADXL345 datasheet [2] and exceeding that will cause undesirable consequences. Since only one ADXL345 accelerometer is used, the chip select pin is always set to high and the SDA and SCL outputs require external pull-up resistors.

4.0 Sources Cited:

1. STMicroelectronics. *Discovery kit with STM32F407VG MCU* [Online]. Available: <http://www.st.com/content/ccc/resource/technical/document/datasheet/ef/92/76/6d/bb/c2/4f/f7/DM00037051.pdf/files/DM00037051.pdf/jcr:content/translations/en.DM00037051.pdf>
2. Analog Devices. *3-Axis Digital Accelerometer* [Online]. Available: <http://www.analog.com/media/en/technical-documentation/data-sheets/ADXL345.pdf>
3. JNHuamao Technology. *Bluetooth 4.0 BLE module Datasheet* [Online]. Available: <http://fab.cba.mit.edu/classes/863.15/doc/tutorials/programming/bluetooth/bluetooth40_en.pdf>
4. Texas Instruments. *DRV2605 Haptic Driver for ERM and LRA With Built-In Library and Smart-Loop Architecture* [Online]. Available: <http://www.ti.com/lit/ds/symlink/drv2605.pdf>
5. Jinlong Machinery & Electronics. *Coin Vibration Motors Product Specification* [Online]. Available: <http://www.vibration-motor.com/products/download/C0720B015F.pdf>
6. Go Teck. *Micro Servo GS-1502* [Online]. Available: <http://www.goteckrc.com/ProductShow.asp?ID=1>
7. Nettigo. *SG90 – SMALL HOBBY SERVO* [Online]. Available: <https://nettigo.eu/products/sg90-small-hobby-servo>
8. Murata Power Solutions. *Non-Isolated Switching Regulator DC-DC* [Online]. Available: <http://power.murata.com/data/power/oki-78sr.pdf>

Appendix 1: System Block Diagram

