Component Analysis

Year: 2018 Semester: Spring Team: 16 Project: Track-on-track

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Assignment Evaluation:

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| **Item** | **Score (0-5)** | **Weight** | **Points** | **Notes** |
| **Assignment-Specific Items** | | | | |
| **Analysis of Component 1** |  | x2 |  |  |
| **Analysis of Component 2** |  | x2 |  |  |
| **Analysis of Component 3** |  | x2 |  |  |
| **Bill of Materials** |  | x6 |  |  |
| **Writing-Specific Items** | | | | |
| **Spelling and Grammar** |  | x2 |  |  |
| **Formatting and Citations** |  | x1 |  |  |
| **Figures and Graphs** |  | x2 |  |  |
| **Technical Writing Style** |  | x3 |  |  |
| **Total Score** |  | | |  |

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

General Comments:

*Relevant overall comments about the paper will be included here*

IMPORTANT NOTE: The Bill of Materials is a separate document and should be downloaded and filled out for another assignment. The Bill of Materials is to be submitted separately, per the course calendar (possibly on a different week), and will graded collectively with this assignment.

1.0 Component Analysis:

The primary hardware components of the Track-on-track project will consist of a bluetooth transceiver, a GSM cell modem, an LCD, and a microcontroller.

1. Bluetooth Transceiver: The bluetooth transceiver will be responsible for communication with the user’s smartphone at close range, and this will be used to figure out if the user is moving further away from or closer to the device, and it will also be used to issue commands to the device.
2. GSM Cell Modem: The cell modem will have two primary responsibilities, the first of which is to find the coordinates that the device is located at, and the other is to send SMS text messages to the user’s phone.
3. LCD: The LCD will be used to display information to the user about the status of the device.
4. Microcontroller: The microcontroller will be responsible for managing the peripherals of the device along with interpreting sent/received communications.

*Describe briefly the components being analyzed in this section; don’t simply list components, but use no more than 1 complete sentence for each component being analyzed in your design. Analyze all major components in your design; it is expected that your design contains at minimum 3 major components.*

1.1 Analysis of Bluetooth Transceivers:

Bluetooth is important for the device to communicate with the user at close ranges. It will assist the user in finding the device by communicating the strength of the connection, allowing the user to tell if they are getting ‘hotter’ or ‘colder’ to the location of the device. In addition, bluetooth also gives the user a way to control the device. Certain features, such as the device’s speaker, will be able to be controlled by commands sent via bluetooth. Without bluetooth, the device will only be able to send a set of coordinates to the user, which will become less useful for pinpointing the device’s specific location.

One of the design constraints is the range at which the bluetooth can connect. Because the device’s goal is to connect with the user’s smartphone from an unknown location, the longer range it can connect from the better. The range is dependant on the transmission power of the device.

This constraint must be traded off with the amount of power used by the device. Because the device is battery powered, battery life is a prime concern. Unfortunately, low power consumption bluetooth transceivers usually come with the tradeoff of low range. However, for this device the bluetooth will be disabled for long periods of time, only being enabled upon request from the user, so range will be considered more important.

Another constraint is the methods the bluetooth device offers to connect to the microcontroller. There are many ways both in protocol and in physical packaging, but for Track-on-track, a device which can connect in UART and SPI is desired.

For these constraints, the following devices were selected: RN4020 Bluetooth Low Energy Module, EYSGCNZWY Bluetooth Low Energy Module, and CYBLE-212006-01 Bluetooth Low Energy Module

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| --- | --- | --- | --- |
|  | RN4020 [1] | EYSGCNZWY [2] | CYBLE-212006-01 [3] |
| Transmit Power | 7 dBm | 4 dBm | 7.5 dBm |
| Power Usage (dormant / active) | <900 nA / 16 mA | 600 nA / 5 mA | 1500 nA / 27 mA |
| Interfaces | AIO, PIO, SPI, UART | I2C, SPI, UART | I2C, SPI, UART |
| Connection Speed | 1 Mb/s | 1 Mb/s | 1 Mb/s |
| Size | 11.5 x 19.5 x 2.5 mm | 12.9 x 9.6 x 2.0 mm | 15.0 x 23.0 x 2.0 mm |
| Weight | 1.2 g | N/A | N/A |
|  | CHOSEN |  |  |

Of the three bluetooth modules, the RN4020 was chosen to be the best of the three. The EYSGCNZWY had significantly lower power draw comparatively, especially when it was in dormant mode, but this came at the expense of range, as having 4 dBm made it the weakest of the three. This one was also the smallest of the three, but not by such a degree that it overcomes its weaknesses. By contrast, CYBLE-212006-01 stood on the opposite end of the spectrum, trading increased power costs for more range. It had the highest dBm of the three, but it only beat out the RN4020 by .5 dBm. The power difference was more significant, drawing nearly double the RN4020 while dormant, and drawing 9 more mA while operating. While the CYBLE-212006-01 did offer a range advantage, it was determined this advantage was not enough to justify the additional power costs.

*For this and all other subsections of section 1.0, provide an analysis of your system component. For your component analysis, compare 2-3 candidate components for each major component choice. Discuss how the design constraints and usage case developed during your functional specification have driven and guided your component choice. Make sure to include which component was chosen for your system. Side-by-side comparison charts are highly appropriate here; be sure to include sources for more information on candidate components.*

1.1 Analysis of GSM Cell Modems:

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The GSM cell modem is the heart of our design as it provides both the ability to communicate despite the distance from the user and providing the ability to determine location information through GPS and cell towers. Most communication between user and device will be sent through this device. For our purposes, ease of use and being able to meet any unexpected needs are our main focus for this choice.

In the past, teams in ECE 477 have had trouble having 4G LTE cell modems in their project so because this part is so critical to our project, finding a modem that we can test with and get working early was a key concern. The two parts we were considering both had breakout boards available from Adafruit and had some example code for basic use cases.

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|  | SIMCOM 5320 [4] | SIMCOM 808 [5] |
| Cell support | Dual-Band UMTS/HSDPA 900/2100MHz  Quad-Band GSM/GPRS/EDGE 850/900/1800/1900MHz | Quad-band GSM/GPRS/EDGE 850/900/1800/1900MHz |
| Networking protocols | TCP/IP  FTP/FTPS/HTTP/HTTPS/SMTP/POP3/DNS/MMS | TCP/IP  FTP/HTTP/MMS/POP3/SMTP |
| Embedded Lua support | Yes | No |
| Interfaces | USB2.0, UART, SIM card, SPI, I2C, Keypad, GPIO, RTC, ADC | USB2.0, UART, SIM card, SPI, I2C, Keypad, GPIO, RTC, ADC |
| Average current (During a call, Power level = 5, GSM850) | 300 mA | 217 mA |
|  | CHOSEN |  |

When comparing the two the main difference that came into consideration was that one supports only 2G while the other supports both 2G and 3G based on the sim card inserted. While we didn’t anticipate any major need for the speeds of 3G, having the option to switch over if it’s necessary was desired. 2G networks also have less coverage than 3G and may not even be supported in the coming years as they’re phased out so if the device is to be used after this course then having a 3G option may be necessary.

The 5320 also has more software support making it more flexible than the 808. The 5320 offers the ability to run off of embedded Lua scripts which could allow us to speed up our development through using a high level language. It also offers more modern support for networking protocols in the situation that we find it necessary to use GPRS to communicate at all.

The main downside behind the 5320 is that by offering more flexibility and options it ends up costing more in power. Power is one of our biggest concerns for this project as this device is portable but doesn’t interact directly with the user that often. After careful consideration, we decided that because two of our PSSCs rely on our modem, flexibility would hold as more important over power consumption.

1.1 Analysis of LCDs:

LCD is the method which the Track-on-track device uses to communicate with the user when the user is in possession of the device. This is useful because it gives the user the ability to interact with the device directly, without having to use a secondary device like a phone. This is also useful for pairing the device during first time setup, and for displaying information directly to the user, such as battery life.

One constraint of the LCD is size and weight. The LCD that is chosen must be small enough to fit into the design without taking up an excess of space. In addition, it must be lightweight. This is because it will be carried along with the rest of the device, and while having a large LCD to display information to the user would be desirable, it is more important for it to be lightweight and of a relatively small size.

Another constraint is power consumption. As will all other components of our design, the LCD must be more conservative with its power. This may mean the design will end up incorporating a less well-lit, uglier LCD if it ends up being more efficient. Although the LCD will spend much of its time off, only being turned on when the user attempts to use the physical interface, this is still considered a priority due to the mobile nature of the project.

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|  | EA DOGS104W-A[[8]](https://www.mouser.com/ds/2/127/dogs104e-553061.pdf) | EA DIPS082-HNLED[[9]](https://www.mouser.com/ds/2/127/dips082e-274871.pdf) | NHD-0208AZ-FL-YBW[[10]](https://www.mouser.com/ds/2/291/NHD-0208AZ-FL-YBW-2946.pdf) |
| Lines x Characters | 4x10 | 2x8 | 2x8 |
| Power Usage | 1.45 mW | 5.4mW | 7.2mW |
| Size | 36mm x 25.4mm x 2mm | 40mm x 20mm x 5.01mm | 40mm x 35.4mm x 13mm |
| Interfaces | SPI, I2C | 8-bit Data Bus | 8-bit Data Bus |
| backlight | no backlight or seperate LED backlight | optional | optional |
|  | CHOSEN |  |  |

For the selection of the LCD display. Three LCDs are chosen. The reason for these three candidates is that these displays have reflective display mode, which needs no backlighting. Considering our power consumption constraints which is a very essential constraint for our project, backlighting is as important as the power we can save without it. On the other hand, these candidates are the smallest while at the same time can provide enough character displays to display battery life, signal strength, and the interaction menus for users. When it comes to interfaces, it is not important since the control of LCD display is easy either with general purpose I/O pins or SPI, I2C interfaces.

The EA DOGS104W-A LCD display is the smallest and thinnest display among them which can help make our project take less space. It consumes the least power when operated without backlight. It also has more capacity of characters. Moreover, with easy-to-use SPI interface, it can be connected to the SPI module of the microprocessor.

1.1 Analysis of Microcontrollers:

The microcontroller is the most important single aspect of the design, as it is the component which will regulate the communications coming from and going to the bluetooth, the GSM cell modem, and the physical interface.The microcontroller is also responsible for holding user settings such as turning on and off the audio alarm, and using the settings in its function. In addition, the microcontroller is responsible for encoding and decoding messages to and from the various peripherals.

Power consumption is the primary constraint for the microcontroller. The microcontroller may be able to spend much of its time in a partially dormant mode, but it will have to constantly check for interrupts coming to it through the cell modem. Thus, the microcontroller will constantly be burning through power whenever the device is on. Another factor in memory consumption is the type of memory. Flash memory is the standard for non-volatile storage, but in recent years FRAM has gained popularity. FRAM is a non-volatile storage which is prized for its low power consumption, making it something to look for in a microcontroller.

The memory size and calculation speed of the microcontroller will also come into play when deciding which microcontroller is right for this project. Memory is not a major concern, as the bulk of what will need to be stored will be the program itself. Therefore, only a few Kb of non-volatile storage should be more than enough for Track-on-track. Speed, while a notable concern, is not the most important aspect of the design. Because much of the Track-on-track device’s time will be spent waiting on information from much slower transmission protocols, an incredibly fast microcontroller may not be able to utilize its full potential. Speed, however, is still an important factor in making sure transmissions are taken in, decoded, and responded to as quickly as possible, meaning that speed will still weigh heavily in the decision.

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|  | MSP430F2618 [6] | MSP430FR69891 [7] |
| Non-Volatile Storage | 116 kB + 256 B Flash | 128 kB FRAM |
| RAM | 8 kB | 2 kB |
| Power | .460 mA @ 1 MHz | .375 mA @ 1 MHz |
| Number of UART | 2 | 2 |
| Number of SPI | 3 | 4 |
| Max Clock Frequency | 12 MHz | 8 MHz |
| Pin Count | 64 | 83 |
|  |  | CHOSEN |

For the microcontroller selection, two microcontrollers from the MSP430 family were chosen. This is because the MSP430’s are RISK processors, and the reduced instruction set is likely to reduce the complexity and the power consumption of the device. In addition, MSP430 is a family which is known for producing excellent low power microcontrollers, and low power is one of the main goals for the microcontroller of this device. From the family, two were selected as likely candidates. The MSP430F2618 offered greater amounts of RAM and a higher max clock frequency, which could potentially lead to much higher performance. However, the MSP430FR69891 had an additional SPI module and much more pins. The biggest draw by far however, was the fact that the MSP430FR69891 drew almost .1 mA less current than the MSP430F2618 did at 1 MHz. Because power consumption is the number one concern for Track-on-track, MSP430FR69891 was selected.

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2.0 Sources Cited:

[1] Microchip Technology Inc., “RN4020-V/RM120 Datasheet,” *Mouser*. [Online]. Available: <https://www.mouser.com/ds/2/268/50002279B-846406.pdf> [Accessed: 24-Jan-2018].

[2] Taiyo Yuden, “EYSGCNZWY Datasheet,” *Mouser*, 09-Aug-2016. [Online]. Available: <https://www.mouser.com/ds/2/396/TY_BLE_EYSGCNZ_DataReport_V1_3_20160809E-1090119.pdf> [Accessed: 25-Jan-2018].

[3] Cypress Semiconductor, “CYBLE-212006-01 Datasheet,” *Mouser*, 22-Jun-2017. [Online]. Available: <https://www.mouser.com/ds/2/100/002-15631_CYBLE-2X20XX-X1_EZ-BLE_PRoC_XR_Module_Da-1102459.pdf> [Accessed: 25-Jan-2018].

[4] “SIM5320,” *SIM5320 | SIMCom | smart machines, smart decision*. [Online]. Available: <http://simcom.ee/modules/wcdma-hspa/sim5320/>. [Accessed: 25-Jan-2018].

[5] “SIM808,” *SIM808 | SIMCom | smart machines, smart decision*. [Online]. Available: <http://simcom.ee/modules/gsm-gprs-gnss/sim808/>. [Accessed: 25-Jan-2018].

[6] Texas Instruments, “MIXED SIGNAL MICROCONTROLLER DATASHEET,” *ti*, 01-Nov-2012. [Online]. Available: <http://www.ti.com/lit/ds/symlink/msp430f2618.pdf> [Accessed: 25-Jan-2018].

[7] Texas Instruments, “MSP430FR698x(1), MSP430FR598x(1) Mixed-Signal Microcontrollers (Rev. C),” *ti*. [Online]. Available: <http://www.ti.com/product/MSP430FR69891/datasheet/abstract#SLAS7895249> [Accessed: 25-Jan-2018].

[8] Mouser.com. (2017). EA DOGS104-A. [online] Available at: <https://www.mouser.com/ds/2/127/dogs104e-553061.pdf> [Accessed 26 Jan. 2018].

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[9] Mouser.com. (2017). EA DOGS104-A. [online] Available at: [**https://www.mouser.com/ds/2/127/dips082e-274871.pdf**](https://www.mouser.com/ds/2/127/dips082e-274871.pdf) [Accessed 26 Jan. 2018].

[10] Mouser.com. (2017). EA DOGS104-A. [online] Available at: <https://www.mouser.com/ds/2/291/NHD-0208AZ-FL-YBW-2946.pdf> [Accessed 26 Jan. 2018].