# Component Analysis

**Year: 2017 Semester: Spring Team: 12 Project: Guitutar**
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**Assignment Evaluation:**

| Item | Score (0-5) | Weight | Points | Notes |
|---|---|---|---|---|
| **Assignment-Specific Items** | | | | |
| **Analysis of Component 1** | 4 | x2 | 8 | Use of price is iffy, EL ≠ LED |
| **Analysis of Component 2** | 5 | x2 | 10 | |
| **Analysis of Component 3** | 4.5 | x2 | 9 | Use of price was unfounded and kind of a surprise to the reader |
| **Bill of Materials** | 4 | x6 | 24 | |
| **Writing-Specific Items** | | | | |
| **Spelling and Grammar** | 5 | x2 | 10 | |
| **Formatting and Citations** | 4 | x1 | 4 | Remove hotlinks, use IEEE in-text citations |
| **Figures and Graphs** | 5 | x2 | 10 | |
| **Technical Writing Style** | 5 | x3 | 15 | |
| **Total Score** | 90/100 | | | |

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

**General Comments:**

I really liked this analysis. It was thorough and I think you have a great product. You're choosing components that are excellently optimized for your project. I only make the comments about cost because it becomes all too easy for teams to pick the lowest cost parts and ending up with buggy, breakable, and delicate solutions that keep them from achieving robust functionality when it comes time to prove PSSCs.

**Bill of Materials:** You need to look at all of the minimum hardware for your microcontroller and include the full possible list of hardware you may use on your PCB. You'll want to correctly assess the value of your project's product using this, so be specific and thorough!

## 1.0 Component Analysis:

The design for Guitutar requires five major components: Light source, a microcontroller, a vibration sensor, a Bluetooth transceiver, and a battery/charging circuit. The LEDs are the main indicator to tell the user what notes to press. The microcontroller is going to be the brains of the device and needs to be fast and powerful enough to regulate LED control, string powering and note interpreting, strum sensing, and Bluetooth connectivity. The vibration sensor is expected to determine if the user strummed the guitar strings by picking up the reverberations throughout the guitar. The Bluetooth transceiver is going to connect with an external controller that will tell the device what song to play and what mode to play. The battery needs to be able to power the LED array, Bluetooth transceiver, microcontroller, and provide power to the strings all while being rechargeable by USB connection.

## 1.1 Analysis of LEDs:

LED selection is a key component for the project as it serves as the main indicator to the user for what note or chord to press. The target design specifications for LED selection were package, size, and cost. The ideal LED would be one that is small enough that six of them can fit side by side and lie underneath each guitar string. The LED would also need to be able to be short enough where there would be no interference when the string is pressed down. The reason is because if the LED is higher than the fret, then the sound of the note would change. In regards to type of package, we had the option to choose surface mount, discrete, EL Tape, or strip LEDs. Discrete LEDs would work, but it requires careful fabrication of through-holes on the guitar neck for both circular and rectangular bulb shapes. In order to do this, the neck would need to be separated from the body, and then heated using an iron to remove the glue holding the decal plate. EL Tape was another low clearance option. However, it seems like there is no way to illuminate different sections of the tape; you can only illuminate the entire strip. The cost of EL Tape is also very high starting at $8.95 per meter. Strip LEDs would allow us to have a low profile as well as individually illuminate the LEDs. The downside to them is that we would need six LEDs per strip at a certain separation distance. For the Guitutar project, surface mount LEDs would be the best choice as they allow us to meet the design requirement of avoiding interference with the string when the string is pressed down. Multiple LEDs from different manufacturers were researched as seen below:

| Manu | P/N | Type | Length x Width (mm) | Height (mm) | Forward Voltage | Op. Current (mA) |
|---|---|---|---|---|---|---|
| Kingbright | APG1608QBC/D | 0603 SMD | 1.6 x 0.8 | 0.28 | 3.3 | 20 |
| Inolux | HT-170NB-5507 | 0805 SMD | 2.0 x 1.3 | 0.8 | 3.3 | 20 |
| TT Electronics | OVSARGB4R8 | 4-PLCC SMD | 3.2 x 2.8 | 2.1 | 3.2 | 20 |
| Bivar | R3BWC | Discrete Rectangle | 3.3 x 1.9 | 29.4 | 4.0 | 20 |
| Kingbright | APT3216LVBC/D | 1206 SMD | 3.2 x 1.6 | 0.75 | 2.65 | 2 |

We wanted to go with blue LEDs, which would lead us to selecting LEDs with a forward voltage of 3.3 V - 4 V. The best surface mount LED would be the APT3216LVBC/D from Kingbright. Trading off height for a larger package size allows better visibility for the user. This LED is moderately priced, has the best size, a low profile, and lowest power consumption out of the researched LEDs. The only complication compared to the Inolux LED is that it needs to be installed by reflow/wave soldering. The APT1608QBC/D and APG1608QBC/D have a good height, but the LEDs may be too small for someone to see under the strings. The PLCC LEDs are of good size, but they are more expensive than the other models and they are also would cause interference with the string. A downside of using any surface mounted LEDs would mean that we would have to build multiple PCBs of varying sizes to place on the neck. This would drive up costs for PCB building.

### 1.2 Analysis of Microcontroller:

The foundation for our microcontroller selection was to use a QFP since it is easy to solder, surface mountable to a PCB, and still powerful enough to meet our needs. Our original decision for a microcontroller was the recommended STM Arm Cortex-M3 32-bit, which allows USB 2.0, has 2 ADCs, and power saving modes. However, upon closer inspection, there was an inverse relation between flash memory and number of pins, so that the more pins we would need, the less memory there was available. Considering that we need a large number of I/O pins for the LED switch matrix, other options needed to be investigated. Other considerations were the 32-bit AVR UC3 by Atmel and the PIC32MX570F512L by Microchip. Both have similar capabilities, but the Atmel has a large power saving advantage, and the PIC has more flash memory and a higher pin count. Due to our need for many pins and possibly large memory, we decided to choose the PIC as our first option, but still order a sample of the Atmel in case we need another option after further consideration.

| Manu | P/N | Flash Memory | Operating Speed | Operating Voltage | I/O Pins | ADC Channels | PWM Timers | Timers |
|---|---|---|---|---|---|---|---|---|
| STMicroelectronics | STM32F030RC | 16-256 Kbytes | 48 MHz | 2.4-3.6V | 55 | 18 | 6 | 7 |
| Atmel | ATUC256L3U | 256 Kbytes | 50 MHz | 1.62-3.6V | 51 | 8 | 36 | 6 |
| Microchip | PIC32MX570F512L | 512 Kbytes | 50 MHz | 2.3-3.6V | 81 | 48 | 5 | 5 |

### 1.3 Analysis of Vibration Sensors:

A vibration sensor is needed in order for Guitutar to determine if the musician strummed the strings. A strum would cause a vibration to reverberate throughout the guitar. A piezoelectric vibration sensor would be a great choice as it is small enough to not get in the way of playing, will not cause any dampening or alteration of the sound, and will easily get a signal indicating a strummed string. A microphone would work as well, but the purpose of the sensor is to understand if the strings were strummed. A microphone would pick up extraneous noise and complicate the purpose of the sensor. Three sensors were researched: Minisense 100 (small horizontal with bead), LDT0-028K (large flat film), and 7BB-20-6L0 (Piezo element disc). The Piezo element disc was selected because it is a thin disc that would not take up a lot of space, can pick up vibration from a flat surface, 20 mm in diameter, and is the cheapest out of the three. The disc has a resonant frequency of 6.3 ± 0.6 kHz and has a low power consumption. The Minisense 100 requires the bead to be placed on the vibrating surface. Since the vibrating surface are the strings, any object resting on the strings would cause a change in sound clarity. The flat film piezo sensor would work just as well as the disc. The disc was selected over the film because of cost.

### 1.4 Analysis of Bluetooth Transceiver:

In order to communicate with the interface device such as a phone, Guitutar requires a communication interface to receive display information and transmit correctness values. The chosen interface for Guitutar was serial data transmission over Bluetooth using the Serial Port Profile (SPP), a Bluetooth interface that allows connected devices to transmit and receive data as if there was a physical connection between them. The protocol version, data rate, sensitivity, available serial interfaces, supply requirements, and price were considered in selecting a Bluetooth module. The four options found and analyzed as candidates for Guitutar are listed below:

| | Bluetooth Protocol | Data Rate | Sensitivity | Serial Interface | Voltage - Supply | Current - Receiving | Current - Transmit | Price |
|---|---|---|---|---|---|---|---|---|
| Microchip Technology BM78 | v4.2 | - | -92 dBm | UART | 3.3 ~ 4.2 V | 37 mA | 43 mA | $6.79 |
| Silicon Labs BLE113-A | v4.0 | 2 Mbps | -93 dBm | ISP, PWM, SPI, UART | 2.0 ~ 3.6 V | 14.3 mA | 18.2 mA | $11.40 |
| Silicon Labs BLE112-A-V1 | v4.0 | 2 Mbps | -85 dBm | SPI, UART | 2.0 ~ 3.6 V | 25 mA | 36 mA | $11.40 |
| Rigado LLC BMD-300-A-R | v4.2 | 2 Mbps | -96 dBm | I²C, I²S, SPI, UART | 1.7 ~ 3.6 V | 10.4 mA | 17 mA | $11.71 |

Ultimately, the primary choice was made to use the Microchip Technology BM78 to support SPP. This choice was made because the primary purpose of our use of Bluetooth is to replace what would have been a wired serial interface with a wireless connection which is the exact purpose that SPP is designed to perform. Additionally, the BM78 utilizes Bluetooth v4.2 and UART and has an average sensitivity, moderately accessible supply, and has the lowest price. The BM78 does not list a data rate on DigiKey or explicitly within its datasheet, so, as an alternative, the Silicon Labs BLE113-A-M256K has been considered as it has a listed data rate, more serial interface options, and lower voltage and current supply requirements.

### 1.5 Analysis of Batteries and Charging Circuit:

Battery selection is a key component for the Guitutar project since one of the design constraints was to keep the entire device mobile. The selected battery also needs to be able to store enough power for it to provide power to the microcontroller, LEDs, strings, and Bluetooth receiver. All

132 LEDs would not be powered at the same time so there is no large constraint with the LEDs. To keep the design mobile, a charging circuit that uses USB as a charging method would need to be implemented. Two choices were researched: Adafruit's PowerBoost 1000 and SparkFun's Battery Babysitter. The PowerBoost 1000 can take an input from a 3.7-volt battery and steps it up to 5.2 volts, and it has a charging rate of 1000mA. It also has built in power indicator LEDs to alert the user if the battery is low. The Battery Babysitter has a DIP switch selectable charge rate of 100mA, 500mA, or 1.5A. It also features power-path management so the circuit is guaranteed power as well as an I2C that measures its charge percentage and remaining capacity. Both charging circuits are similar in design and purpose. We decided on using the Adafruit PowerBoost 1000 because it is smaller, fits the aesthetic of the guitar, charges at a safe 1000mA rate, and fits the selected battery model. The battery selected has a maximum charge rate of 1.5A and the Battery Babysitter has a setting for 1.5A charge rate. It was safer to choose the 1A charge rate of the PowerBoost 1000 for the battery so we were not charging it at its maximum charging rate. We also decided on using the 6600mAh battery as it provides us with plenty of power and a longer battery life. It also ensures that all peripherals have adequate power. The other option was a 1000mAh Lithium Ion battery. Even though this battery was thinner, the 6600mAh battery will ensure all peripherals would be powered and the battery would have good battery life.

## 2.0 Sources Cited:

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