

MOTION SENSING GUITAR PEDAL CONTROLLER

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Abstract

The following report details the design process of the Motion Sensing Guitar Pedal Controller. The two-part system switches guitar pedal effects based on motion sensors mounted on the body of the guitar. The report will examine in detail the design of each subsystem, motivate the utility of the device, state the total projected cost of the device, and highlight future improvements that can be made to the current iteration of the project.

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1. Introduction

1.1 Purpose

Modern guitar effects pedals allow musicians to shape tone using parameters such as gain, delay time, and modulation depth. However, adjusting these parameters in real time often requires manual knob turning or additional expression pedals, which can interrupt performance flow. While some professional systems allow limited foot-based control, expressive lower-body motion is largely unused as a control input. Musicians performing live often move dynamically as part of their performance. Currently, these gestures have no direct interaction with the audio processing system.

A device that translates natural motion into real-time control of audio effects would enhance expressive capability without requiring additional manual adjustments. We propose a design of a two-part, printed circuit board (PCB) based embedded system that integrates real-time signal processing with motion sensing to create a gesture-responsive multi-effects guitar pedal switching system. The sensing device detects when the user kicks near each light emitting diode (LED) indicator to switch pedal effects on and off, improving the flow of a guitarist's performance, as the upper body is already preoccupied. A pedal control device wirelessly communicates with the sensing device to route the guitar's signal through the pedals as desired. An LED display attached to the sensing device will also help the guitarist track which pedal effects are on and off during the performance. Figure 1 below shows a visual aid displaying the physical setup of the system.

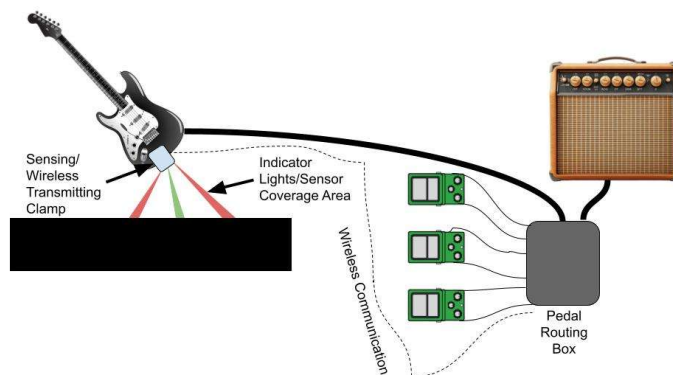


Figure 1: Visual Aid of Guitar Pedal System Setup

1.2 Functionality

The high-level requirements of the project are as follows. First, motion sensing toggles the desired pedal after a gesture is made in front of the respective sensor. The performer should be able to move freely around the stage without being close to their pedals. The motion sensors allow a way for them to toggle pedals while being far away. Second, each pedal zone must provide a clear visual indication of its on/off

status using LEDs to ensure visibility under stage lighting conditions. The performer should be able to know which of their effects are on or off at any given time. The LED display makes it obvious to the performer which effects are enabled without them having to listen as they play. Finally, the device must process and output the corresponding audio effect quickly enough so that guitar play is smooth and uninterrupted to ensure performance suitable for live guitar playing. The system should be an effective switching method in a live performance. Without low latency, the performer will not be able to make real time decisions about how they want their guitar to sound.

1.3 Subsystem Overview

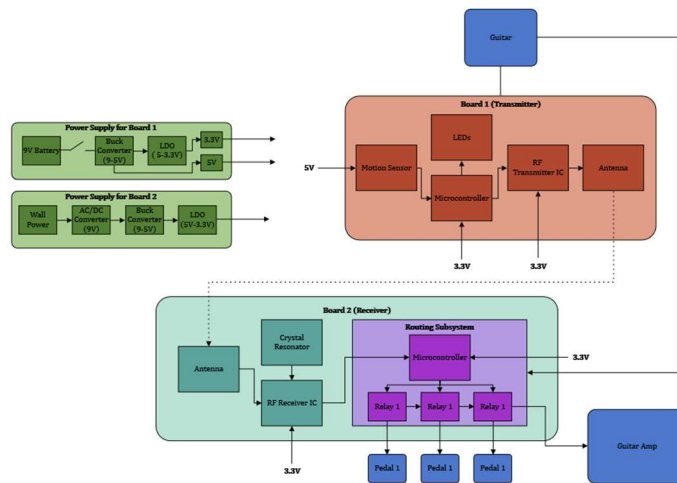


Figure 2: High Level Block Diagram

The pedal effect toggling begins on the transmitting board located on the guitar. The sensing subsystem uses three infrared (IR) distance sensors to detect the performer’s kicking gesture beneath the guitar. The ATMEGA328 microcontroller (MCU) takes this information, and outputs a control signal to the LEDs in the lighting subsystem as well as a digital On-Off Keying (OOK) signal to the wireless transmitter integrated circuit (IC) (part of the wireless subsystem). The wireless subsystem converts the digital OOK signal into a 433 MHz signal which is output via antenna.

Next, the antenna on the receiver board takes the 433 MHz signal and converts it to a digital signal, which is then sent to the microcontroller (ATMEGA328) on the receiver and decoded into the on/off state of the three guitar pedals. Once the receiver board knows which pedals to turn on or off, it sends control signals to the audio routing subsystem, which uses relays to route the audio signal through or around the desired pedals. This routing results in the desired pedal effects being toggled.

The transmitter board is powered by a 9 V lithium-ion battery, which is immediately converted to 5 V by a buck converter and then to 3.3 V by a low dropout regulator (LDO). The receiver board is powered by a wall power to 12 V DC plug, which is similarly converted to 5 V by a buck converter, and then 3.3 V by an LDO. The 5 V rails and 3.3 V rails power all the necessary components on both boards.

2 Design

2.1 Design Details

The sections below detail each of the five subsystems and their role in fulfilling the high-level requirements

2.1.1 Power Management Subsystem

Both printed circuit boards (PCBs) (one for transmitting/sensing and one for receiving/routing) need consistent DC power supplied to operate. The transmitting/sensing PCB is battery powered by a 9 V lithium-ion battery, attached to the PCB via a battery mount. These batteries provide a maximum discharge current of 1500 mA, which is more than enough to accommodate the entire PCB. The PCB will contain an adjustable buck converter that is set to output 5 V. The output voltage is set by a resistor divider connected to the output of buck converter. Equation (2.1) shows the output voltage as a function of both resistor values according to the datasheet of the buck converter.

$$V_{out} = 1.23 * \left(1 + \frac{R2}{R1}\right) \quad (2.1)$$

Choosing $R2 = 6.8 \text{ k}\Omega$ and $R1 = 2.2 \text{ k}\Omega$ yields an output voltage of 5 V. The 5 V will then be converted to 3.3 V using an LDO. The 5 V rail powers the three motion sensors and the LEDs, while the 3.3 V rail powers the microcontroller, the associated control signals, and the wireless transmitter.

The receiving PCB will be powered by wall power with an AC/DC converter. The 12 V DC coming from the converter can be sent through the same buck converter and LDO configuration as on the transmitter board to produce a 5 V rail and 3.3 V rail. The 3.3 V rail powers the microcontroller and the audio routing subsystem and the 5 V rail powers the receiver part of the wireless subsystem.

Figure 3 below shows the buck converter and LDO schematic. In this schematic R2 represents R2 and R3 represents R1 in equation (2.1).

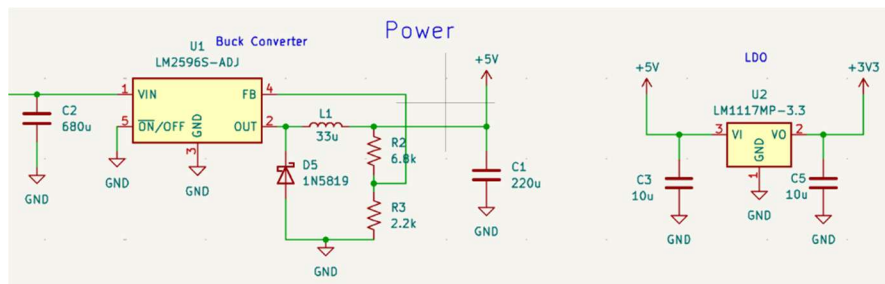


Figure 3: Buck Converter and LDO Schematic

2.1.2 Sensing Subsystem

The goal of the sensing subsystem is to detect when the performer kicks in a particular region beneath the guitar and update the status bit (used by the audio routing and lighting subsystems) of its respective pedal effect in the microcontroller. The three sensors are mounted such that one points straight down from the base of the guitar, one points diagonally down and to the left from the base of the guitar, and the other points diagonally down and right from the base of the guitar. This configuration allows for three distinct sensing regions for the performer to kick into.

The sensors used are infrared (IR) analog distance sensors (GP2Y0A21YK0F) which output an analog voltage inversely proportional to the distance sensed. They utilize optical triangulation, meaning they calculate distance by primarily using the angle of the reflected IR light and not the intensity, making them less sensitive to changes in the surrounding environment. The three sensors are connected to the transmitting/sensing board via three pin Japan Solderless Terminal (JST) connectors. One pin for the 5 V rail (Vcc), one pin for ground, and one pin for the analog output voltage. The analog output of each sensor is connected directly to the microcontroller via analog General Purpose Input Output (GPIO). Note that although the sensor is powered by 5 V, its analog output has a maximum value of 2.7 V which is below the microcontroller's rated 3.3 V. The electrical schematic of the sensors is shown in Figure 4 below.

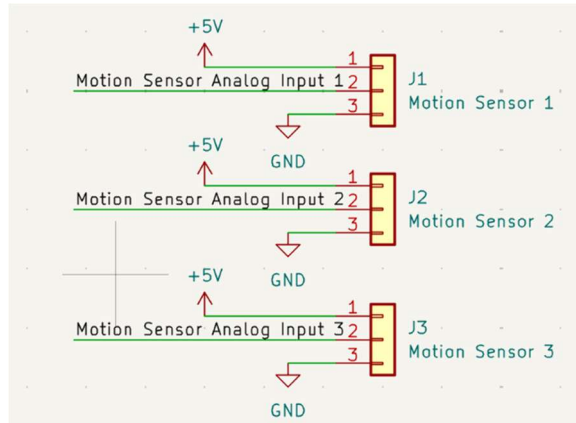


Figure 4: Schematic of JST Motion Sensing

According to the sensor datasheet, the sensing region is between 10 cm and 80 cm away from the sensor. This range is ideal because 80 cm is roughly the distance between the base of the guitar and the ground for most performers. The analog output voltage is inversely proportional to distance sensed.

To translate the three analog signals into on/off signals for each of the three relays, we will use the microcontroller to store three bits of data indicating the state of the relays. Additionally, the microcontroller will poll the sensors every 50 ms (the minimum polling time on the sensor datasheet is 39 ms) and update an exponential moving average of each of the three sensors. If any of the three moving averages exceed a certain threshold, which is easily adjustable within the code, the corresponding status bit will flip. After a bit flip, the microcontroller will wait 0.5 s before flipping another bit to avoid double triggers on just one gesture in front of the sensors. The exponential moving average provides protection against outlier readings from the sensors as one extreme value will not be enough to move the average above the threshold. Additionally, the code includes an adjustable parameter which changes the time constant of the exponential moving average, allowing for a change in sensor sensitivity.

2.1.3 Lighting Subsystem

The lighting subsystem provides visual feedback to indicate the on/off status of each pedal. Each pedal zone is equipped with a red-green-blue (RGB LED) (XPLDCL-00-0000-0000HC6AAAE2) and is controlled by the microcontroller located on the transmitting/sensing board. The LEDs are bright enough to project a region of color onto the ground in the general direction of the sensing area so that the user knows where to kick to activate the motion sensors.

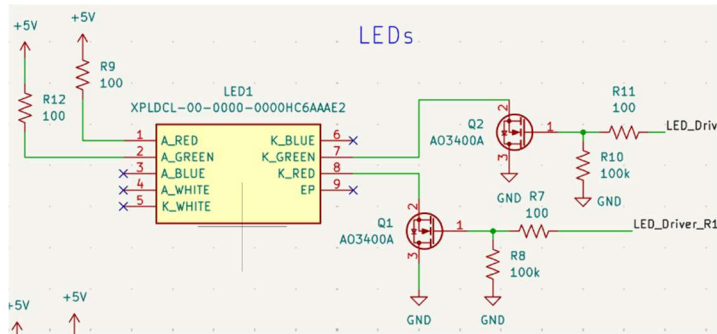


Figure 5: Schematic of one of three LEDs

Each LED has four different display colors, but we will only utilize red and green. Red will indicate off, while green will indicate on. As shown in Figure 5, each LED is 3.3 V and has a typical operating current of 90 mA, therefore we will include a 50 Ω resistor in series with each terminal of the LED in use. The LEDs will be turned on and off by a low side switch utilizing an N-Channel MOSFET (NMOS) that uses a GPIO signal from the microcontroller (MCU) as the gate voltage. A total of six switches will be used, two for each of the three LEDs. The red switches will have a GPIO signal equal to the inverted status relay bit meant to turn the LED on and off. The green switches will have a GPIO signal equivalent to the relay bit. This way, when the relay bit is high (indicating a pedal effect in use), the LED will be green. When the relay bit is low, the LED will turn red since the inverter bit will activate the red LED low side switch.

2.1.4 Wireless Communication Subsystem

The wireless communication subsystem enables the two ATMEGA328 microcontrollers to exchange pedal states in real time using an RF transmitter and receiver. The transmitter subsystem consists of a microcontroller connected to an RF transmitter integrated circuit (PIC12LF1840T39A-I/ST), which is connected to a 433 MHz antenna via an SMA connector. Between the transmitter IC and antenna, we designed a matching network to ensure maximum power transfer from the transmitter to the 50 Ohm antenna. The receiver subsystem consists of an identical antenna to that of the transmitter, matching network, RF receiver integrated circuit (MICRF229YQS-T5), and a crystal resonator IC (ABM3-13.560MHZ-B2-T) connected to two pins (RO1 and RO2) of the receiver acting as a local oscillator.

The microcontroller connected to the sensing subsystem encodes pedal activation/deactivation as digital pulses using on-off keying (OOK) at 433 MHz and transmits them wirelessly to the receiver connected to the microcontroller that is part of the routing subsystem. Each pedal's state is represented by a distinct digital pulse sequence, ensuring proper communication between the transmitter and receiver. This includes an eight-bit sequence indicating the beginning of a pedal toggling, followed by three information bits, each of which representing whether the respective pedal should be on or off, followed by six bits indicating the end of the communication. This bit sequence will only be transmitted when there is an update to the relay state bit in the transmitter PCB's MCU. The transmitter IC will be powered by 3.3 V and the receiver IC will be powered by 5 V. This subsystem contributes directly to the high-level requirement for real-time detection and feedback, allowing pedal activations to trigger LEDs and audio effects with minimal latency.

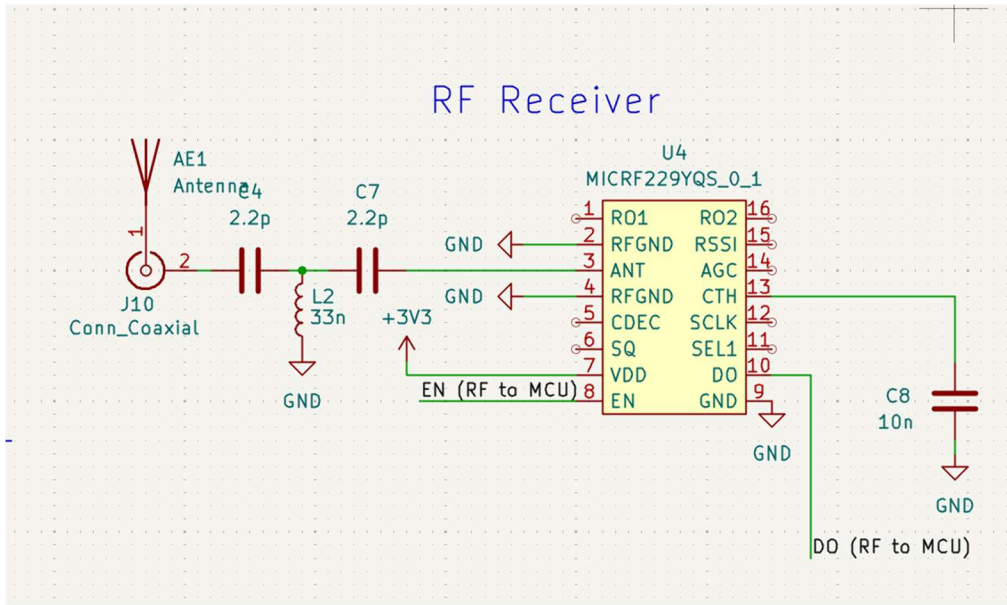


Figure 6: RF receiver connection to antenna through matching network (excluding crystal)

2.1.5 Audio Signal Routing Subsystem

The goal of the signal routing subsystem is to take the guitar signal input and the three GPIO signals indicating the status of each pedal, route the signal to apply the corresponding effects, and output it to the amp. It consists of six 3 V double pull double throw electromechanical relays (two per pedal) and eight audio jacks (one for the guitar, one for the amp, and two for each pedal). The six relays are located on the receiving/routing board and are wired in a way that allows an on/off GPIO signal to direct the audio signal back and forth between a guitar pedal and a bypass. Nearly all guitar equipment, especially guitars, pedals, and amps, utilize quarter inch cables to connect to each other. These cables contain a signal path and a return path (sometimes referred to as ground). It is therefore necessary to use two relays per pedal, one to route the signal path and one to route the return path. Figure 7 shown below contains a diagram of the relay connections used in our design.

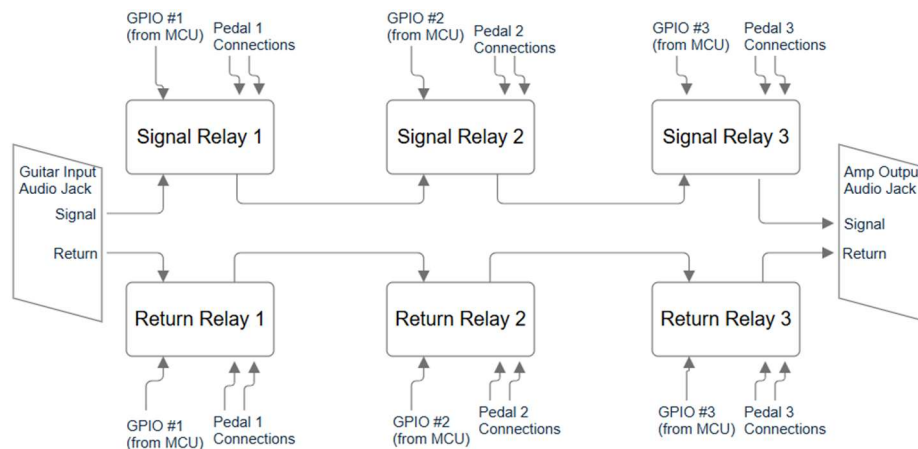


Figure 7: Relay Configuration Diagram

When the relays are in the off position and the coil is de-energized, the relay directs the audio signal directly from the input of the relay to the output without routing it through the associated pedal, effectively bypassing it. This can be seen in Figure 8 (schematic of a single relay) when both switches in the relay are flipped to the right, the input (pin 3) is connected directly to the output (pin 6) and the pedal is completely disconnected from the circuit. When the coil is energized, both switches flip to the left, guitar pedal connections (pins 2 and 5), effectively applying the pedal effect between the input and output of the relay.

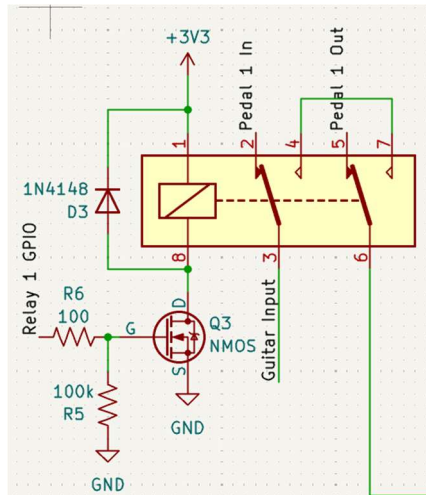


Figure 8: Schematic of a Single Relay

The microcontroller GPIO is not strong enough to energize the coil of the relay because its typical output current is 20 mA while the relay requires 46.7 mA for normal operation. To solve this issue, the relay coil is connected directly to the 3.3 V rail and connected to ground via a low side switch. The switch utilizes an N-channel MOSFET (AO3400) to control current flow from the relay to ground. When the GPIO connected to the gate outputs near 0 V, the gate source voltage is lower than the threshold voltage and the MOSFET is off, meaning no current flows from the drain to the source. When the GPIO outputs 3.3 V, the gate source voltage is higher than the threshold voltage (typically 1.05 V for AO3400) the MOSFET turns on allowing current to flow to ground, energizing the coil.

Additional circuit protection considerations include a 100 Ω resistor placed between the GPIO and the MOSFET gate to limit inrush current during switching to protect the microcontroller. Also, a 100 k Ω pull down resistor is placed between the MOSFET gate and ground to prevent unwanted switching when the GPIO is in a high impedance state. Finally, a flyback diode is placed across the terminals of the relay coil to protect it from reverse current.

2.2 Tolerance Analysis

A potential risk in the power subsystem is the thermal dissipation of the voltage regulator when stepping down from 6 V to 3.3 V, particularly because the regulator's heat must be dissipated through the limited area of the PCB. Excessive heat could lead to thermal shutdown or reduced reliability, violating the requirement for continuous, stable operation. High power LEDs will also draw a lot of current, so it is vital that we protect circuits from these LEDs.

Assume the 3.3 V subsystem draws a maximum current of:

$$\lambda = \frac{c}{f} = \frac{300\text{MHz}}{915\text{MHz}} = 0.3279\text{m} \quad (2.2)$$

The regulator must drop:

$$V_{\text{drop}} = V_{\text{in}} - \lambda V_{\text{out}} = 6 - 3.3 = 2.7 \text{ V} \quad (2.3)$$

Power dissipated in the regulator:

$$P_{\text{dissipation}} = V_{\text{drop}} \cdot I_{\text{load}} = 2.7 \cdot 0.25 = 0.675 \text{ W} \quad (2.4)$$

Assuming a regulator thermal resistance to ambient through the PCB of:

$$\Theta_{JA} \approx 80 \text{ C/W} \quad (2.5)$$

The expected junction temperature at $T_A = 40 \text{ C}$ ambient:

$$T_J = T_A + P_{\text{dissipation}} \cdot \Theta_{JA} = 40 + 0.675 \cdot 80 \approx 94 \text{ C} \quad (2.6)$$

This is below typical maximum junction ratings (125–150 °C), but it leaves little margin for higher ambient temperatures or increased current draw.

In terms of protecting the LEDs and surrounding circuitry:

$$3 \text{ LEDs} \times 30 \text{ mA} = 90 \text{ mA per LED} \quad (2.7)$$

$$4 \times 90 \text{ mA} = 360 \text{ mA} \quad (2.8)$$

360 mA total for the four options of colors in each LED. 360 mA is easily accounted for by the PCB.

Adding current resistors will limit overheating and power through the LED from our buck converters:

$2.7 \text{ V} / 30 \Omega = 90 \text{ mA}$ which is more than enough to power the red LED. By choosing a resistor of around 30Ω , we limit the current to a close value required for the LED, ensuring proper operation and thermal safety.

Each color requires a different voltage. Green requires 3.3V which means a 36Ω resistor would satisfy the current requirement. It is important that the microcontroller switches between colors without overheating anything.

2.3 Requirements and Verification

2.3.1 Power Verification

Table 1: Requirements and Verification of Power Subsystem.

Requirements	Verification
<ul style="list-style-type: none"> Each board must provide within 5% of the designated voltage value for each IC (i.e. buck converter or LDO). 	<ul style="list-style-type: none"> Test voltage outputs with a digital multimeter at both the power IC and the IC requiring that voltage level Consistently probe each rail before each use of the board to ensure that the power subsystem can stay within 5% for the several weeks of testing
<ul style="list-style-type: none"> The 9 V battery connected to the transmit board will provide a lifespan of the entire semester 	<ul style="list-style-type: none"> After each use, the battery will be probed to verify that voltage was not significantly lost. Additional protection circuitry may be implemented if it is confirmed that the battery will not last long enough

Results:

Using a digital multimeter, we recorded the voltage values supplied by the power system to be very close to the desired 3.3 V and 5 V supplies (within 5%):



Figure 9: Probed voltage difference between ground and 3.3 V output of LDO

This verifies that our first requirement was met. Likewise, we probed the 9 V battery throughout the semester to ensure we were not drawing too much power to make sure the battery would last until the end of the creation of our project. When we tested the battery before our final demo, the voltage was above 8.9 V, verifying our second requirement. Both requirements were for the power subsystem were proven to be met through our verification methods.

2.3.2 Sensing Verification

Table 2: Requirements and Verification of Sensing Subsystem

Requirements	Verification
<ul style="list-style-type: none"> Each sensor must be able to correctly detect an object 	<ul style="list-style-type: none"> Before mounting each sensor, connect it to the PCB via the JST connector and keep the MCU connected via USB to a debugger.

<p>within 80 cm and update its associated relay status bit accordingly.</p>	<ul style="list-style-type: none"> Wave in front of the sensor at 80 cm, 55 cm, and 10 cm, each time observing the corresponding status bit to make sure it flips. Repeat for all three sensors.
<ul style="list-style-type: none"> The sensing subsystem must only flip one bit per detection, allowing a new flip two seconds after the previous one. 	<ul style="list-style-type: none"> Connect all three sensors to the PCB via their JST connectors, keep the MCU connected via USB to a debugger, and mount all three sensors in a manner similar to the final guitar attachment mounting. Wave in front of one of the sensors, then wave in front of all three sensors for the next two seconds. Ensure that only the first status bit has flipped and nothing else.

Results:

We were able to get motion sensors to detect motion and toggle the pedals, however, they could not sense motion up to 80 cm like we intended. We tested the sensors at 4 different distances. Below shows the sensing functionality for each distance.

Distance	Functionality
10 cm	Good
30 cm	Good
55 cm	Moderate
80 cm	Poor

Therefore, half of the first requirement was met because the sensors could not detect up to 80 cm but did update their relay status bit accordingly. To prove the second requirement (only one bit would flip when the sensors were activated), we connected all three sensors to the PCB and waved in a path that would cover all three sensors in one motion. When we did this, only the first sensor that was activated would update its corresponding status bit, thus verifying we met this requirement.

2.3.3 Lighting Verification

Table 3: Requirements and Verification Table for Lighting Subsystem

Requirements	Verification
<ul style="list-style-type: none"> LEDs correctly display status bits stored in the MCU 	<ul style="list-style-type: none"> Code the microcontroller to set the three status bits to 0, representing all off-state LEDs. Probe all six LED GPIO lines to ensure correct voltages (3.3 V for logical 1 lines). The three inverted GPIO lines going to the red switches should represent a logical 1, and the three normal GPIO lines going to the green switches should represent a logical 0. Verify that all three LEDs display a red light to confirm the switches and GPIOs function correctly. Repeat except reverse the three status bits, probe for opposite voltages, and look for green lights instead.

Results:

Throughout the testing of the lighting subsystem, we used a multimeter to ensure the correct voltage (3.3 V) was supplied to both the red and green inputs of the LED. Once we found the desired voltage was being supplied to the LED, we programmed the microcontroller to make the LED red for a “pedal off” status, and green for a “pedal on” status. After we were able to control the color of the LED based on the status bits of the microcontroller, we connected it to the sensing subsystem so that motion sensor activation would switch the LED from red to green. Our verification methods proved the functionality of the lighting subsystem.

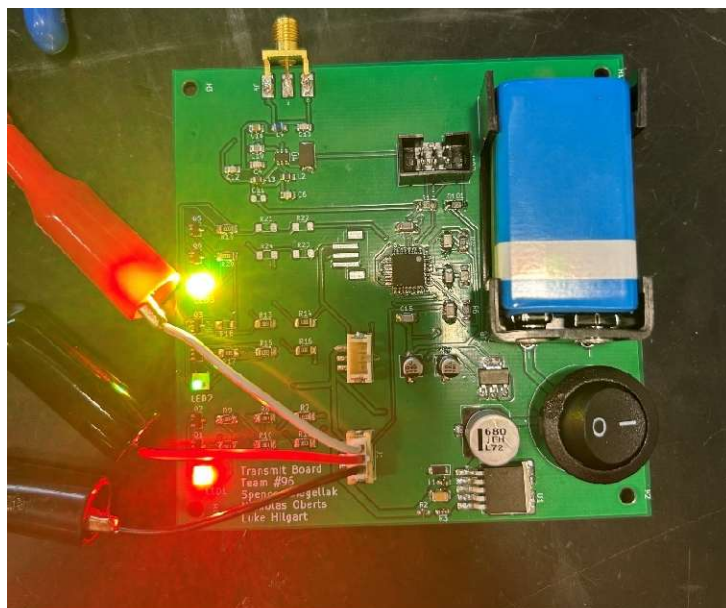


Figure 10: LED indication during testing

In our final design, we only used two pedals, so we did not program the microcontroller for three LEDs. Additionally, we decided to change the LED indication from showing red when the pedal is off to being off when the pedal is off. We found this to be a better indication of pedal statuses because the lights were very bright and were difficult to differentiate between when they were all on at the same time.

2.3.4 Wireless Verification

Table 4: Requirements and Verification of Wireless Subsystem

Requirements	Verification
Must communicate all pedal states simultaneously over a distance of at least 5 meters, suitable for a typical pedalboard layout.	<ul style="list-style-type: none"> • Tests at different distances in a 5 m radius circle around the pedal board to confirm communication at different locations • Spectrum analyzer tests will confirm whether the pulses are being transmitted wirelessly through the antennas
Must correctly encode and decode which pedals are to be activated/deactivated.	<ul style="list-style-type: none"> • Tests for every possible combination of pedal states (eight total) • Stating which pedal should be toggled before motioning to confirm the system works as desired

	<ul style="list-style-type: none"> • Spectrum analyzer tests will confirm whether potential bugs are caused by issues with the signal or with the routing subsystem
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Results:

The wireless subsystem was the one subsystem that we could not implement. Using verification methods for the first subsystem requirement (must communicate all pedal states simultaneously over a distance of at least 5 meters, suitable for a typical pedalboard layout), we were able to prove that our RF transmitter and receiver were communicating. We connected the transmitter PCB to a spectrum analyzer and saw a pulse centered at 433 MHz when we activated one of the motion sensors.

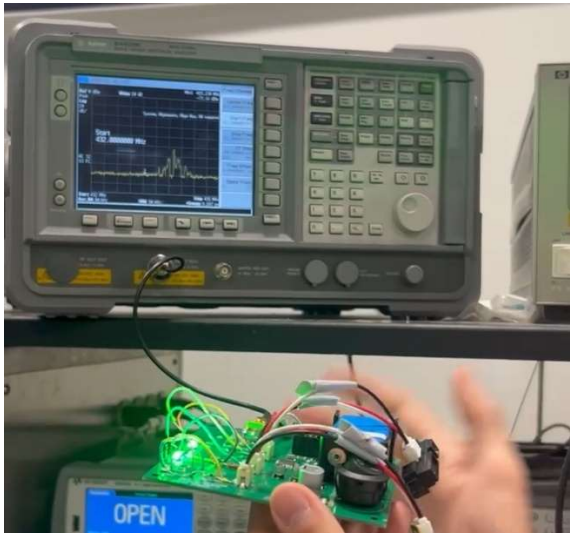


Figure 11: Spectrum analyzer plot displaying transmitter output

We connected antennas to the PCBs and connected the output of the receiver to an LED to show whether it was able to receive the transmitter output. Although the LED changed when we motioned in front of a sensor, the signal was very noisy, and we could not fulfill the second subsystem requirement: must correctly encode and decode which pedals are to be activated/deactivated. We decided to wire the boards together to ensure the functionality of the other subsystems, instead of having a device with unreliable and faulty communication that worked wirelessly.

2.3.5 Audio Verification

Table 5: Requirements and Verification Table for Audio Subsystem

Requirements	Verification
<ul style="list-style-type: none"> • Allow a free path for the audio signal when the MCU outputs a logical 0 to the relay. 	<ul style="list-style-type: none"> • Program microcontroller to tie relay GPIO pins PA13, PA14, and PA15 to LOW. • Plug in the guitar and amp to their associated audio jacks on the PCB and turn them on and play the guitar to generate an audio signal. • Probe the audio signal at the input and output pins of each relay with an oscilloscope and verify that the signals are nearly identical.

<ul style="list-style-type: none"> • Apply desired pedal effects to the guitar signal based off logical 1 GPIO outputs from the MCU. 	<ul style="list-style-type: none"> • Program Microcontroller to tie one of the three relay GPIO pins to 1 and the other two to 0. • Plug in the guitar and amp to their associated audio jacks on the PCB as well as the selected guitar pedal and turn all the devices on. • Play the guitar while probing the audio signal at the input and output of the relays, verifying that the signal is mixed and the pedal effect has been applied. • Connect the guitar directly to the pedal and the pedal directly to the amp, play the guitar again, and listen to verify the correct effect was applied before. • Repeat once each for all three relays.
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The above requirements and verifications in Table 5 were tested during the assembly of the final project. For the first requirement, a simple program was uploaded to the microcontroller setting all three pedal's GPIOs to LOW. First, we verified that the signal pins of the guitar and amp were connected while the program was running via a continuity test using the lab bench multimeter. We did the same for the return pins. Both tests were successful. We then plugged in the guitar and amp into their respective audio jacks in the circuit and verified that no pedal effects were applied while the program was running. These two successful tests verified the first requirement.

For the second requirement, we uploaded a program to the microcontroller which cycled through all eight combinations of pedal effects, waiting 10 seconds in between switches (for example pedal one on, pedal two off, pedal three on). While the program was running, we played the guitar while listening for each pedal effect to toggle. Through listening to each of the effects get applied, we verified the second requirement successfully.

3. Cost and Schedule

3.1 Cost Analysis

Table 6: Parts cost table

Parts	Manufacturer	Quantity	Price	Total Cost
3 Pin JST-Connector: B3B-PH-SM4-TB	JST Sales America Inc.	3.00	1.56	\$ 128.89
AC/DC WALL MOUNT ADAPTER 5V 2.8W	Phihong USA	1.00	2.28	
Antennas	Kaunosta	1.00	9.99	
CAP ALUM 680UF 20% 35V SMD	Panasonic Electronic Components	2.00	2.98	
CAP CER 1.5PF 50V COG/NPO 0402	Johanson Technology Inc.	1.00	0.16	
CAP CER 10000PF 16V X7R 0402	Murata Electronics	2.00	0.16	
CAP CER 10PF 50V COG/NPO 0402	Murata Electronics	3.00	0.3	
CAP CER 10UF 10V X5R 0402	Murata Electronics	4.00	0.32	
CAP CER 2.2PF 50V COG/NPO 0402	Johanson Technology Inc.	3.00	0.54	
CAP CER 220UF 2.5V X6S 1206	Murata Electronics	2.00	1.84	
Crystal Resonator ABM3-13.560MHZ-B2-T	Abracon LLC	1.00	0.96	
DC POWER JACK, SMT, HORIZONTAL	GCT	1.00	0.95	
FIXED IND 22NH 500MA 500 MOHM	Murata Electronics	2.00	0.32	
FIXED IND 33NH 50MA 2.1 OHM SMD	KEMET	3.00	0.3	
FIXED IND 33UH 10MA 3.12 OHM SMD	Murata Electronics	2.00	0.4	
FIXED IND 56NH 100MA 3.9 OHM SMD	Murata Electronics	2.00	0.4	
Flip Switch: Multicomp 1MS1T1B1M1QE	ECE Shop	2.00	6.82	
IC MCU ATmega328	Microchip Technology	2.00	3.64	
IC REG BUCK ADJ 3A 8SOIC	Texas Instruments	2.00	3.3	
LDO LM1117MP	Texas Instruments	2.00	2.82	
MOSFET N-CH 60V 4A SOT223	STMicroelectronics	9.00	14.31	
Motion Sensor: GP2Y0A21YK0F	SHARP/Socle Technology	3.00	28.29	
RELAY TELECOM DPDT 2A 3V	Panasonic Electric Works	3.00	5.79	
RES 100 OHM 1% 1/4W 1206	YAGEO	9.00	0.9	
RES 2.2K OHM 1% 1/10W 0603	YAGEO	2.00	0.2	
RES SMD 6.8KOHM 0.01% 1/10W 0805	Susumu	2.00	6.56	
RF Receiver: MICRF229YQS-T5	Microchip Technology	1.00	2.78	

RF transmitter: PIC12LF1840T39A-I/ST	Microchip Technology	1.00	2.28	
Schottky Diode: 1N5819HW-FDICT-ND	Diodes Incorporated	4.00	1.16	
Through Hole Audio Jack: 2223-MJ-63022A-ND	Same Sky	8.00	11.52	
XLAMP LEDs	Cree LED	3.00	14.76	

Labor Costs:

We decided a fair wage would be \$20/hour for each of us, and we plan to work on the project for an average of 15 hours per week. Therefore, each of us should get paid an average of \$300 per week. We plan to finish the project in ten weeks, but we will not be working over spring break. This puts us at a total of \$2700 per person, and \$8100 total for labor cost.

3.2 Schedule

Table 7: Schedule

Week	Luke	Spencer	Nick
3/2	Receiver board PCB design/order (All) Design review with instructor/TA	Transmitter board PCB design/order (All) Design review with instructor/TA	Transmitter board PCB design/order (All) Design review with instructor/TA
3/9	(All) Breadboard demo for both boards (All) Teamwork evaluation (All) New PCB order (if necessary)	(All) Breadboard demo for both boards (All) Teamwork evaluation Transmitter board soldering (All) New PCB order (if necessary)	(All) Breadboard demo for both boards (All) Teamwork evaluation Receiver board soldering (All) New PCB order (if necessary)
3/23	Transmitter microcontroller programming (All) New PCB order (if necessary)	Receiver microcontroller programming (All) New PCB order (if necessary)	PCB performance checks with power, wireless communication, etc. (All) New PCB order (if necessary)
3/30	(All) Testing and debugging	(All) Testing and debugging	(All) Testing and debugging
4/6	(All) Team contract assessment (All) Progress demo	(All) Team contract assessment (All) Progress demo	(All) Team contract assessment (All) Progress demo
4/13	(All) Testing and debugging (All) Begin final report	(All) Testing and debugging (All) Begin final report	(All) Testing and debugging (All) Begin final report
4/20	(All) Testing and debugging (All) Mock demo/presentation (All) Complete final report first draft	(All) Testing and debugging (All) Mock demo/presentation (All) Complete final report first draft	(All) Testing and debugging (All) Mock demo/presentation (All) Complete final report first draft
4/27	(All) Final demo/presentation	(All) Final demo/presentation	(All) Final demo/presentation
5/4	(All) Finish final report	(All) Finish final report	(All) Finish final report

4. Conclusion

4.1 Accomplishments

In summary, our two-board system allows guitarists utilize motion sensing to activate foot pedals as they choose. This is possible because of the success of the sensing subsystem to correctly detect gestures, the success of the lighting subsystem to correctly display pedal states, the success of the audio routing subsystem to toggle the pedal effects, and the success of the power subsystem to reliably power both boards. These successes were realized by a variety of in lab tests throughout the design process.

4.2 Uncertainties

The biggest uncertainty is RF wireless implementation. Some minor uncertainties included fly wiring affecting the audio quality, grounding techniques, and the distance of the motion sensing. For wireless, we would have to implement working PCBs for both with their respective matching circuits to properly test and debug. Due to time constraints, we decided to try wireless modules in conjunction with the PCBs, but that was unsuccessful too.

4.3 Future Work and Alternatives

Our main goal moving forward is to get fully functioning wireless communication between transmitting PCB and receiving PCB. Once we accomplish this, we can attach the transmitting PCB to the guitar to allow the guitarist to move around while controlling the pedals, as intended. We also want to experiment with different motion sensors, as the ones we used could not detect motion up to the desired distance. Testing other sensors such as heat sensors or digital sensors would show us the best way to detect pedal toggling by the guitarist. Lastly, we want to find a way to clean up the guitar audio signal when no pedals are activated. Currently, the path from the guitar straight to the amp, bypassing the pedals, causes a lot of noise in the audio signal. We think either creating a separate path to the amp that does not go through the relays, or using thicker cables with better signal integrity instead of wires could clean up the guitar signal and get rid of the background noise.

4.4 Societal Impact, Engineering Standards, and Ethics

As engineers, we are responsible for designing safe, reliable, and socially responsible devices. Our motion-sensor guitar pedal system is built with consideration for user safety and accessibility. We have ensured that the device does not pose hazards to performers or audiences, avoids misuse of laser or infrared components, and respects privacy (no cameras or audio recording will be used beyond the user's guitar input).

The motion-sensor guitar pedal project has positive societal impacts including increased accessibility for musicians with limited hand mobility and an easier way to integrate multiple sound modifications into one guitar performance. Potential negative impacts are minimal but include the possibility of distraction from bright LEDs. These risks are mitigated through user instructions and proper labeling to ensure the device contributes positively to musical performance.

5. Citations

- [1] “Calculating the Power Dissipation and Junction Temperature of an LDO Regulator”, Available at: <https://toshiba.semicon-storage.com/us/semiconductor/knowledge/e-learning/basics-of-low-dropout-ldo-regulators/chap4/chap4-2.html>
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- [4] *IEEE Code of Ethics*, IEEE, 2020. [Online]. Available at: <https://www.ieee.org/about/corporate/governance/p7-8>
- [5] *Motion Sensor Datasheet (GP2Y0A21YK)* https://global.sharp/products/device/lineup/data/pdf/datasheet/gp2y0a21yk_e.pdf
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- [7] *Low-Dropout Linear Regulator Datasheet (LM1117m)* <https://www.ti.com/lit/ds/symlink/lm1117.pdf>
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