
Dwight Look College of
ENGINEERING
TEXAS A&M UNIVERSITY

# Team 28: Guitar Entertainment System

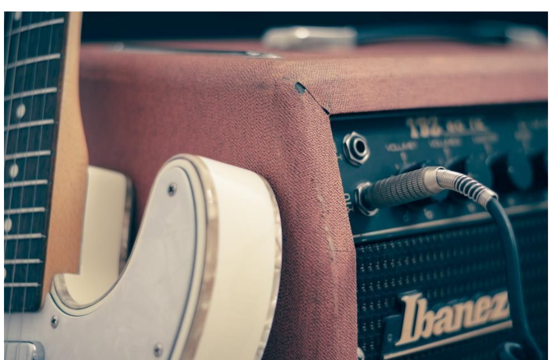
## Bi-Weekly Update 4

Rishabh Ruikar, Monte Martin III, Rawan Ibraheem
Sponsor: Souryendu Das (TA)

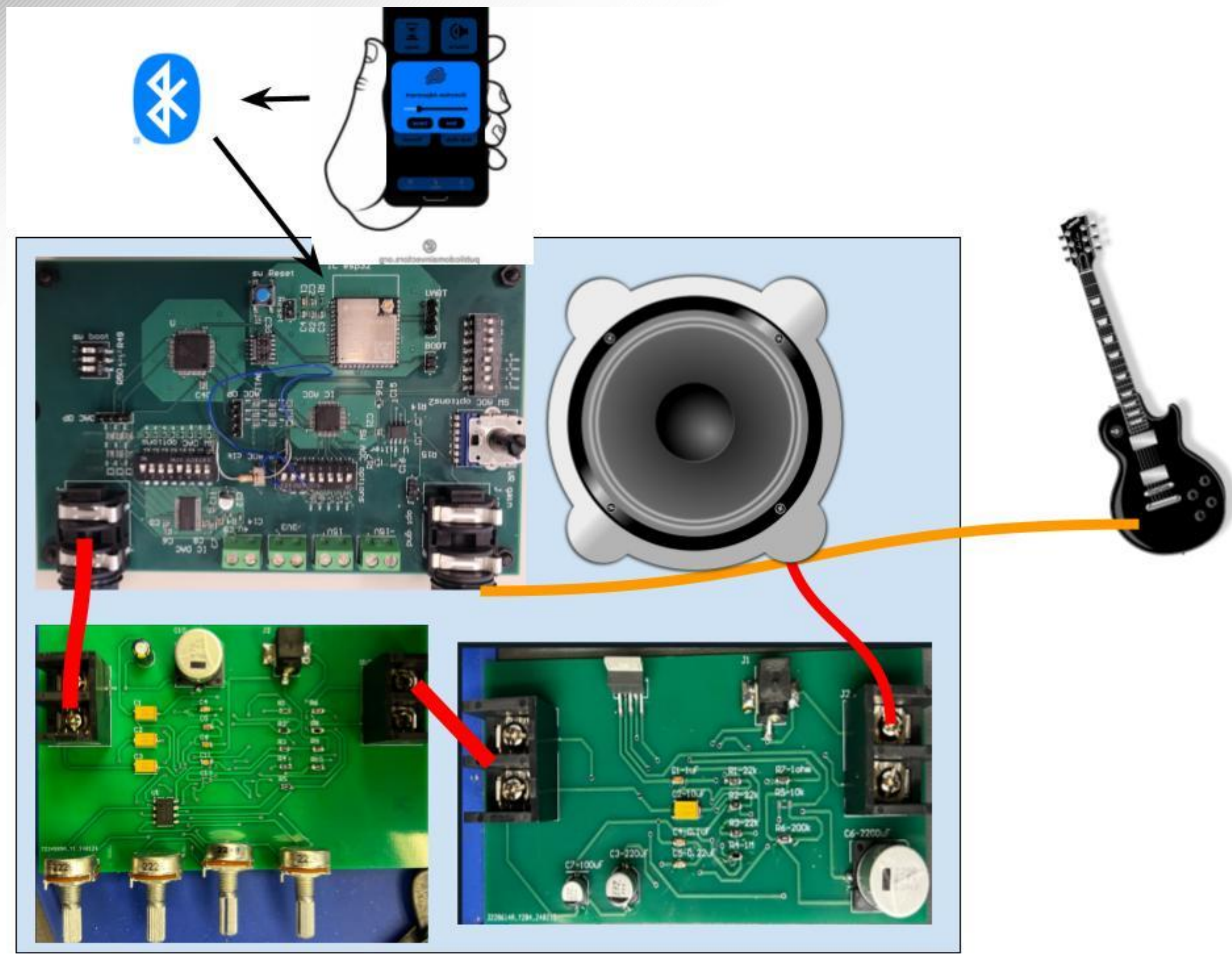
# Project Summary

- Problem Statement: Current guitar amplifiers and effects systems often present a steep learning curve, deterring those with limited technical experience from fully exploring their sound potential.

- Solution Proposal: Developing a user-centric guitar sound system, combining an amp, pedals, and a Bluetooth-connected app. This system simplifies sound customization through intuitive controls and presets, making advanced sound manipulation accessible to all skill levels.




# Integrated System Diagram



# Project Timeline

| | | | | | |
|---|---|---|---|---|---|
| Preamplifier testing complete (completed 3/5) | Pedal and app integration (completed 2/15) | Pedal and amplifier integration(to be complete by 3/7) | Final Integration (completed 3/19) | System Test (to complete by 3/21) | Validation (to complete by 4/1) |

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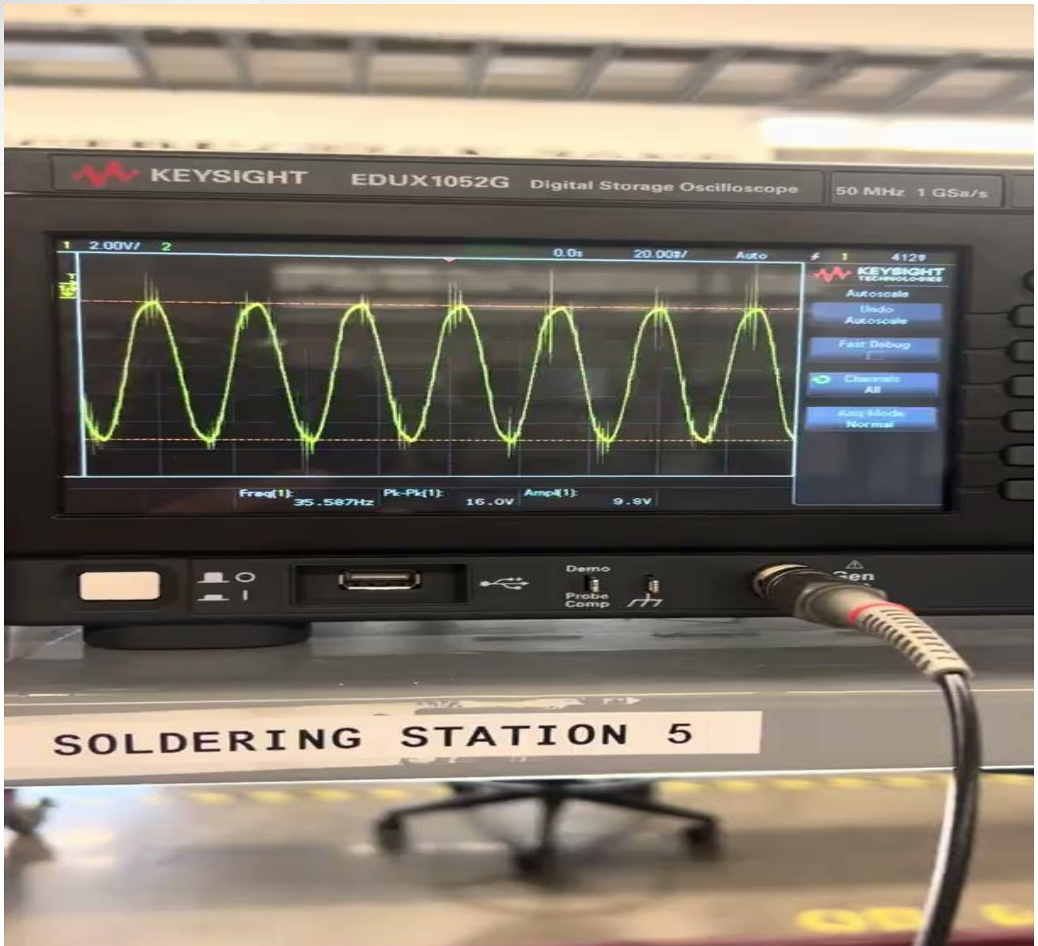
# Rishabh Ruikar: Amplifier

| Accomplishments since last update<br>17 hrs of effort | Ongoing progress/problems and plans until the next presentation |
|---|---|
| • Tested Preamplifier (results in following slide)<br>• Found out amplifier is running too hot during testing (115°C+), new heatsink order has been placed | • Preamp and amplifier will be integrated<br>• Full system integration *will be complete* before next presentation<br>• Strain testing will occur after next presentation |

- Performed comprehensive evaluations on guitar preamp settings: treble, bass, mid, and gain
- Analyzed adjustments' effects on tonal quality and distortion across various sine wave inputs
- Plan to deepen analysis when hooked up to pedal system with complex harmonic waves, scrutinizing preamp's tonal versatility and signal integrity

# Rishabh Ruikar: Amplifier



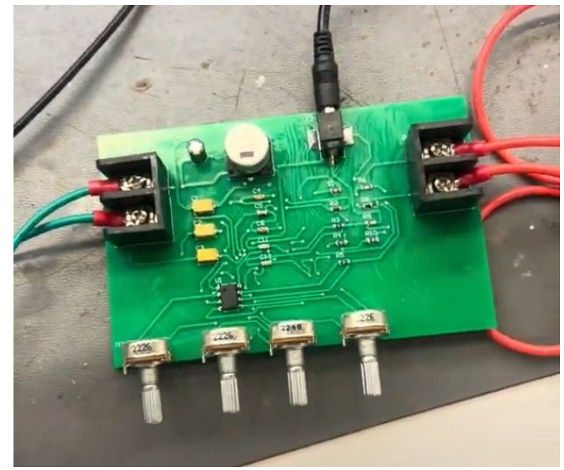
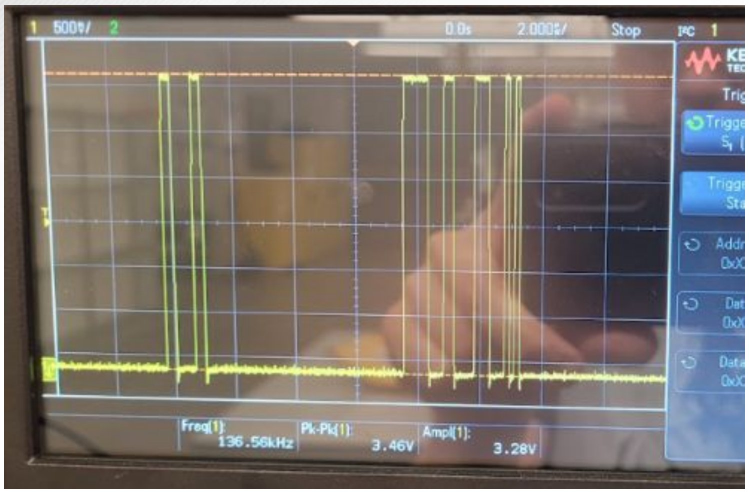



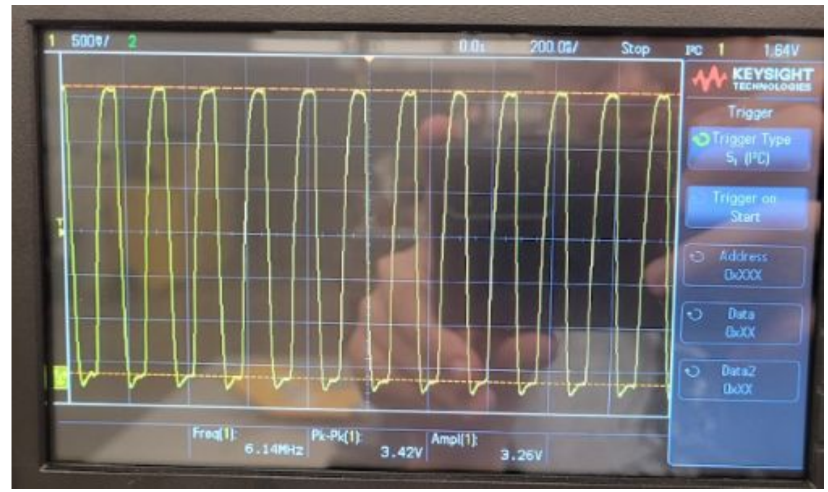
Figure 1:
1kHz Sine Wave with 1V Amplitude and 2V P2P

# Monte Martin: Pedals

| Accomplishments since last update<br>40 hrs of effort | Ongoing progress/problems and plans until the next presentation |
|---|---|
| • Validated ADC, STM32, DAC<br>• Finished soldering<br>• Verified that the STM32 is installed and can be programmed/debugged with JTAG | • Test integration of effects on STM32<br>• Test ESP32 bluetooth connection range and signal strength<br>• Test integration with amplifier subsystem<br>• Test full integration |

# PCB Validation



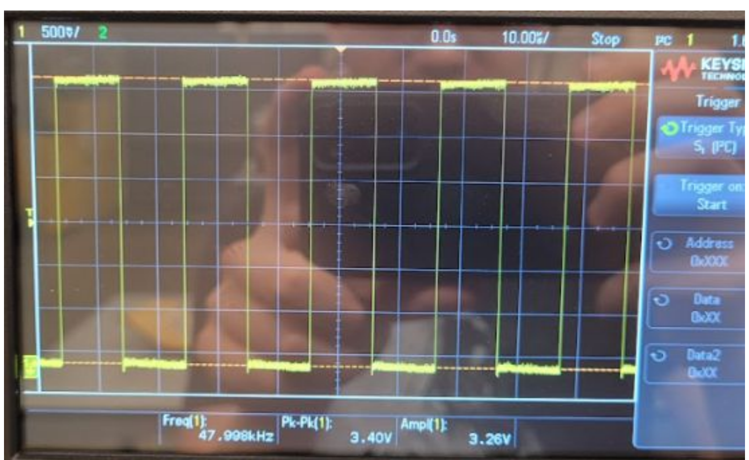
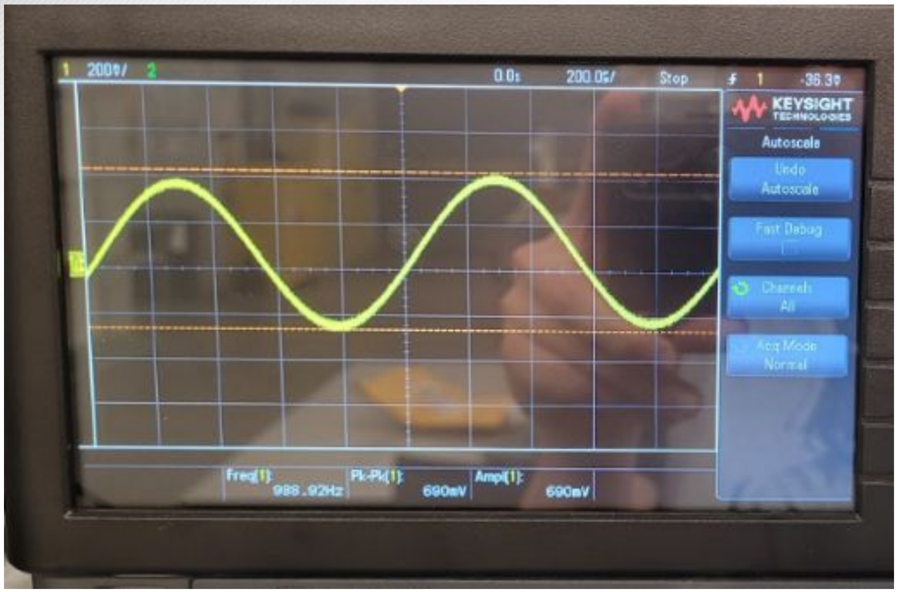




Figure 2. ADC serial data, clock, and word select.

# PCB Validation



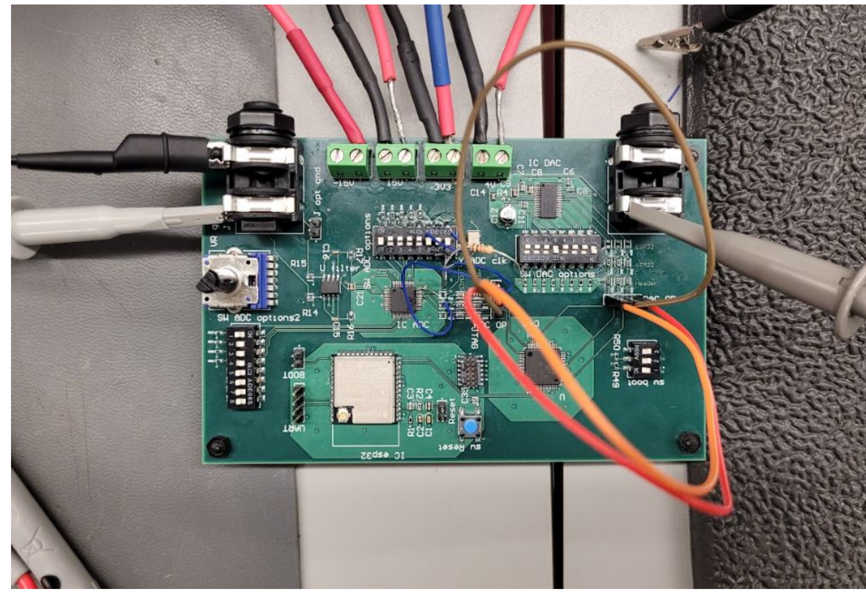
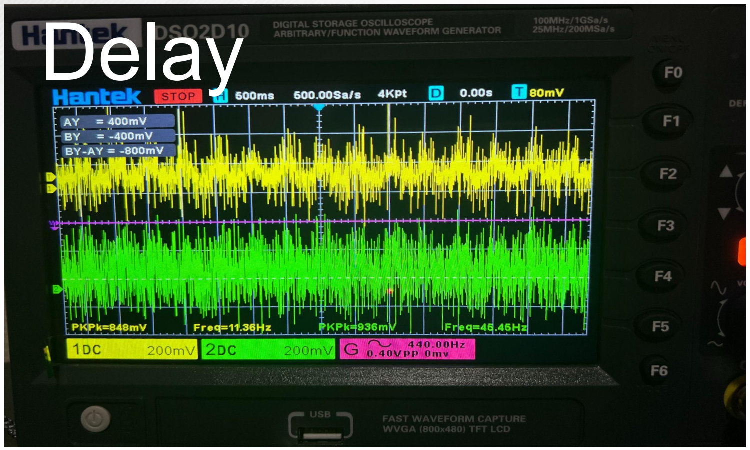



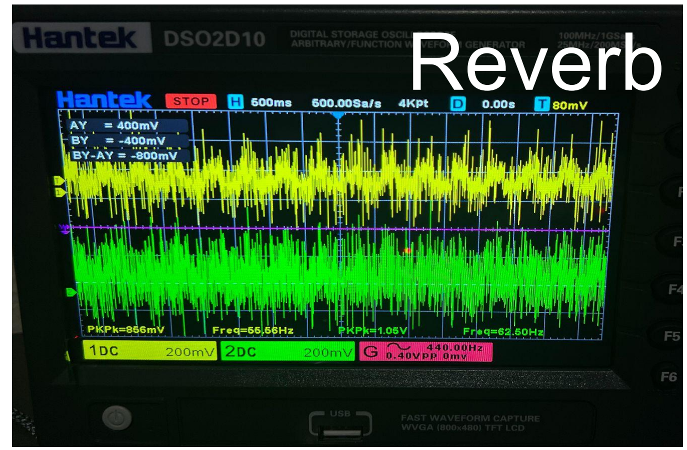
Figure 3. Validation of DAC analog output verified by oscilloscope, and validation of A to D and D to A conversion.

# Rawan Ibraheem: Application and MCU

| Accomplishments since last update<br>22 hrs of effort | Ongoing progress/problems and plans until the next presentation |
|---|---|
| ● Implemented delay, reverb, and volume effects on the STM32<br><br>*Delay*<br>*Y(t) = X(t-delay)*<br><br>*Reverb*<br>*f = feedback factor*<br>*O(t) = (1-f)X(t) + fY(t)* | ● Validate reverb and delay by measuring T60 (decay time) and comparing it to the original signal<br>● Implement distortion, chorus, and wah-wah<br>● Program the ESP32 and STM32 on the completed pedal PCB |

# Rawan Ibraheem: Application and MCU




Volume Adjustment


Figure 4. Verification of applied sound effects.

# Integration Progress

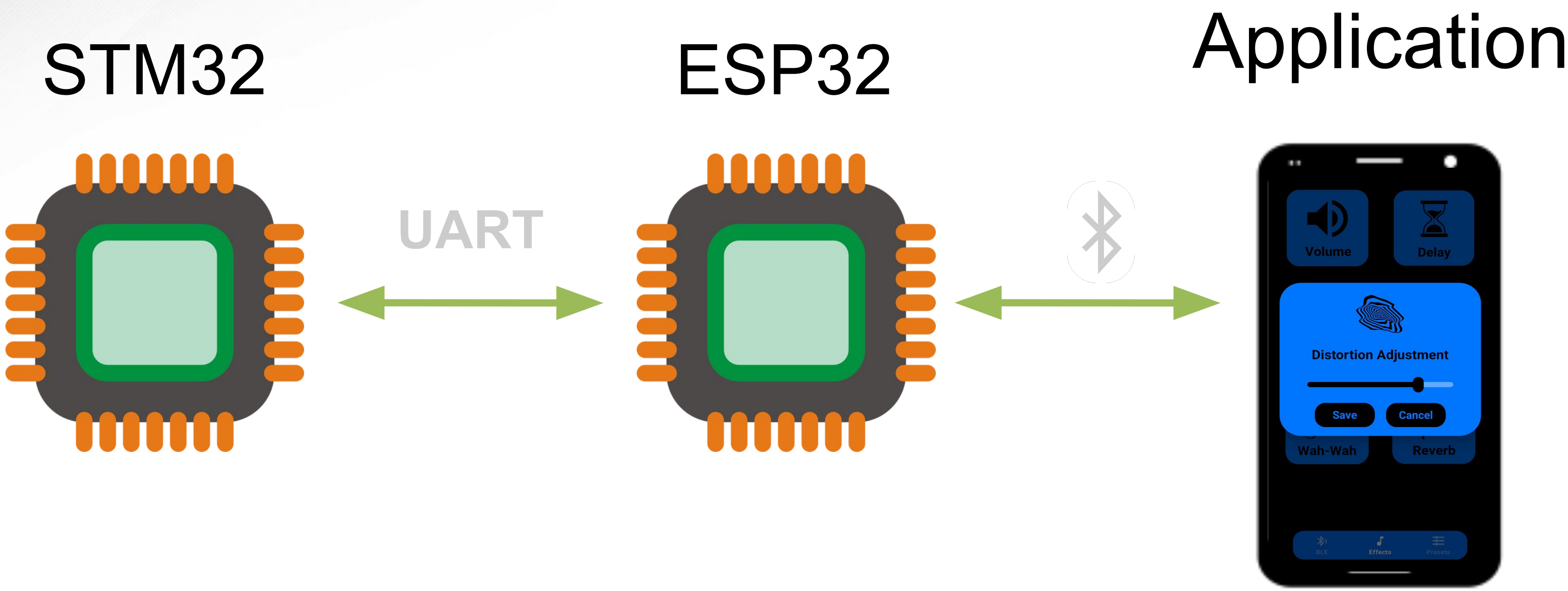



Figure 5: Overview of MCU Integration.

# Integration Progress With App

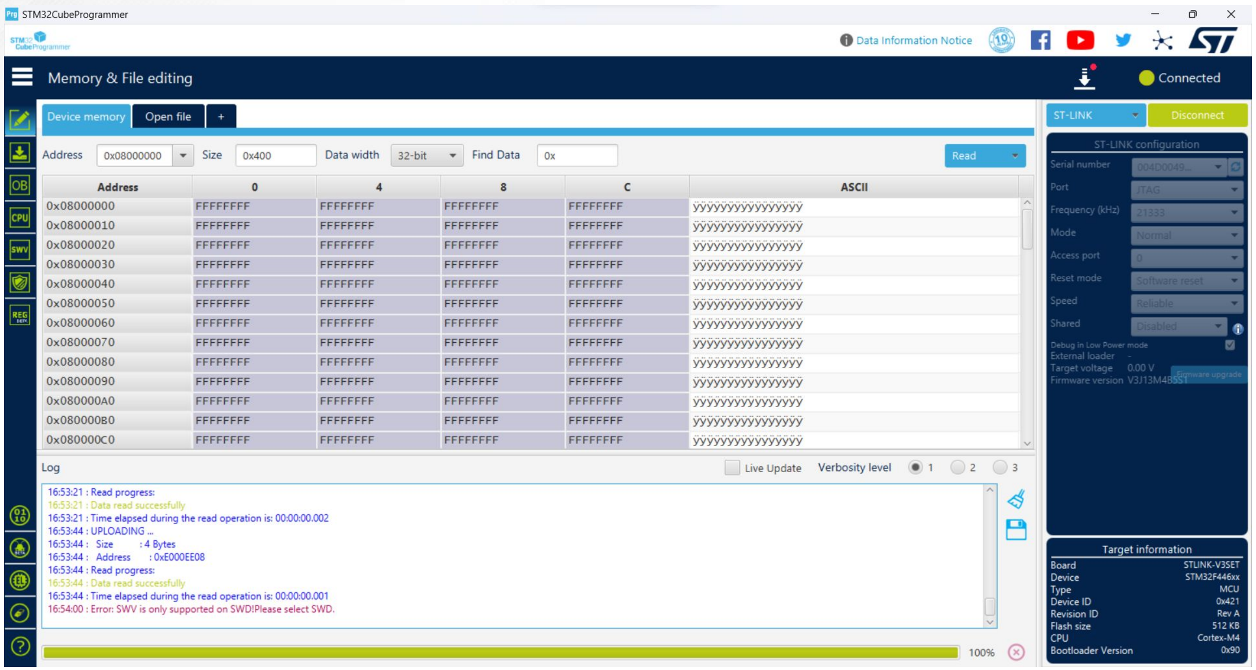



Figure 6. STM32 on pedal PCB is fully functional and programmable, no hardware faults.

# Execution Plan

| Task | Owner | 1/22 | 1/29 | 2/5 | 2/12 | 2/19 | 2/26 | 3/4 | 3/11 | 3/18 | 3/25 | 4/1 | 4/8 | 4/15 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Send out new pre-amplifier and amplifier PCBs for manufacturing. | Rishabh | | | | | | | | | | | | | | | In Progress |
| Solder parts onto amplifier PCBs | Rishabh | | | | | | | | | | | | | | | Not Started |
| Utilize a signal generator to produce sine waves, square waves, and pink noise for testing the amplifier's signal integrity and frequency response, aiming for a flat response within ±0.5 dB across 20 Hz to 20 kHz. | Rishabh | | | | | | | | | | | | | | | Completed |
| Conduct dynamic range measurements, aiming for a dynamic range of over 120 dB to capture the full spectrum of audio without distortion or noise intrusion. | Rishabh | | | | | | | | | | | | | | | Behind schedule |
| Execute thermal management tests, ensuring the amplifier maintains operational temperatures below 50°C under full load conditions to guarantee long-term stability. | Rishabh | | | | | | | | | | | | | | | |
| Test pedal PCB and redesign. | Monte | | | | | | | | | | | | | | | |
| Send out pedal PCB for manufacturing. | Monte | | | | | | | | | | | | | | | |
| Solder parts onto pedal PCB | Monte | | | | | | | | | | | | | | | |
| Test and Validate PCB | Monte | | | | | | | | | | | | | | | |
| Ensure that there isnt any signal loss when transfering to amplifier | Monte | | | | | | | | | | | | | | | |
| Test the Pedal PCB with the application and ensure there is sound output | Monte | | | | | | | | | | | | | | | |
| Ensure that ESP32 can send signals to STM32 to adjust sound effects | Rawan | | | | | | | | | | | | | | | |
| Code each sound effect in STM32 using development board and function generator | Rawan | | | | | | | | | | | | | | | |
| Begin designing housing | All | | | | | | | | | | | | | | | |
| Begin 3D printing housing design | All | | | | | | | | | | | | | | | |

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# Validation Plan

| Subsystem | Paragraph | Deliverable | Methodology | Owner | Completion | Completion Date |
|---|---|---|---|---|---|---|
| MCU & Application | 3.2.1.5 | ESP32 can communicate with STM32 | Terminal COM port connected to STM32 displays the applied sound effects | Rawan | Completed | 2/15/2024 |
| MCU & Application | 3.2.1.5 | STM32 can apply each sound effect (volume, distortion, reverb, chorus, delay, wah-wah) | Use a function generator and an osciliscope to test input and output signal when sound effect applied and process input and output data through USB connection to computer | Rawan | Incomplete | |
| MCU & Application | 3.2.1.4 | Application reports errors connecting to ESP32 or STM32 | Implement pop-up window that displays warnings in Android application | Rawan | Incomplete | |
| MCU & Application | 3.2.1.4 | MCU can send signal to STM32 within 1 second | Use oscilloscope to measure the input and output signal | Rawan | Incomplete | |
| ADC/DAC, DSP | 3.2.1.2 | Practical Filter eliminates noise and creates a differential signal | Use oscilloscope to provide an input signal and the output signal | Monte | Completed | 1/15/2024 |
| ADC/DAC, DSP | 3.2.1.2 | STM32 communicates with the ESP32 with less then 10 ns of delay | Check data readouts from STM32 and ESP32 | Monte | Incomplete | |
| ADC/DAC, DSP | 3.2.1.2 | All effects work as intended, with outputs within 5 dB of calculated values | Use oscilloscope to provide an input signal and the output signal | Monte | Incomplete | |
| ADC/DAC, DSP | 3.2.1.2 | have less than 10 ns of delay between signal input and output | Use an oscilloscope to measure delay between input and output signals | Monte | Incomplete | |
| ADC/DAC, DSP | 3.2.1.2 | The delay function can create up to 2 seconds of delay without loss of signal quality | Use a timer and oscilloscope to measure delay and signal quality | Monte | Incomplete | |
| ADC/DAC, DSP | 3.2.1.2 | ADC, DAC, and DSP all can communicate within 10 ns of delay when tested seperately | Osciliscope to send and recieve analog, ESP32 dev to send and recieve digital through i2S | Monte | Incomplete | |
| ADC/DAC, DSP | 3.2.1.2 | The system can take in up to 2.1 V rms signals and output them without any clipping or loss of signal quality | Oscilloscope and function generator | Monte | Incomplete | |
| Amplifier | 3.2.3.3 | Preamplifier is able to create at least a 10dB gain from 3 types of sine waves- 50Hz(bass), 1kHz (mid), 5kHz (treble) | For each frequency test (50 Hz, 1 kHz, 5 kHz), apply a constant-level sine wave, measure the preamp's output, and analyze the amplitude and harmonic content to evaluate its frequency response and distortion characteristics. | Rishabh | Completed | 3/3 |
| Amplifier | 3.2.3.3 | Validate the frequency response curve by comparing it against the amplifier's specified performance criteria, ensuring it meets the expected flatness within ±0.5 dB across the 20 Hz to 20 kHz range, using calibrated measurement equipment for accuracy. | Using software-based audio signal generators, generate a frequency sweep from 20 Hz to 20 kHz to test audio equipment. | Rishabh | Incomplete | |
| Amplifier | 3.2.3.3 | Aim for a flat response within ±0.5 dB across 20 Hz to 20 kHz | Using a signal generator to produce sine waves, square waves, and pink noise for testing the amplifier's signal integrity and frequency response. | Rishabh | Incomplete | |
| Amplifier | 3.2.3.1 | Aim for a dynamic range of over 120 dB to capture the full spectrum of audio without distortion or noise intrusion. | Generate 1 kHz sine, measure output and noise, calculate dynamic range. | Rishabh | Incomplete | |
| Amplifier | 3.2.3.2 | Ensure the amplifier maintains operational temperatures below 100°C under full load conditions to guarantee long-term stability. | Load testing, send peak sine waves constantly for about 30 minutes | Rishabh | Incomplete | |
| All | N/A | User can adjust sound effect signal multiple consecutive times. | One user will repeatedly adjust sound effects in one minute as another user plays the guitar, to ensure system operates as intended. | All | Incomplete | |
| All | N/A | User can play the guitar while adjusting the sound effect. | One user will control the mobile application while another plays the guitar. | All | Incomplete | |
| All | N/A | System experiences no failure when tested outdoors. | Fully integrated system is taken outside into an open and windy area, each sound effect is tested. | All | Incomplete | |
| All | N/A | User can plug in an active and passive pickup guitar. | Function generator to simulate active and passive pickups and oscilloscope will be used to see the readings. | All | Incomplete | |
| All | N/A | System experiences no failure when tested in a place with high signal noise pollution. | System will be tested in the FEDC where other teams are working on Bluetooth-based projects. | All | Incomplete | |
| All | N/A | SNR of calculated delay sound effect vs Pedal PCB output waveform is a minimum of 25 dB | Matlab will be used to compute the desired effect from the input waveform measured by the oscilloscope. Ouput of pedal PCB will be saved to a csv file and the data will be compared in Matlab. | All | Incomplete | |

# Validation Plan (cont.)

| | | | | | | |
|---|---|---|---|---|---|---|
| All | N/A | SNR of calculated chorus sound effect vs Pedal PCB output waveform is a minimum of 25 dB | Matlab will be used to compute the desired effect from the input waveform measured by the oscilloscope. Ouput of pedal PCB will be saved to a csv file and the data will be compared in Matlab. | All | Incomplete | |
| All | N/A | SNR of calculated distortion sound effect vs Pedal PCB output waveform is a minimum of 25 dB | Matlab will be used to compute the desired effect from the input waveform measured by the oscilloscope. Ouput of pedal PCB will be saved to a csv file and the data will be compared in Matlab. | All | Incomplete | |
| All | N/A | SNR of calculated wah-wah sound effect vs Pedal PCB output waveform is a minimum of 25 dB | Matlab will be used to compute the desired effect from the input waveform measured by the oscilloscope. Ouput of pedal PCB will be saved to a csv file and the data will be compared in Matlab. | All | Incomplete | |
| All | N/A | SNR of calculated reverb sound effect vs Pedal PCB output waveform is a minimum of 25 dB | Matlab will be used to compute the desired effect from the input waveform measured by the oscilloscope. Ouput of pedal PCB will be saved to a csv file and the data will be compared in Matlab. | All | Incomplete | |

# Thank you for listening.