GEORGE MASON UNIVERSITY

Arbitrary Waveform Generator Final Presentation
Department of Electrical and Computer Engineering

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German Kuznetsov
Hussain Zainal
Vikram Arunachalam
Yifei Gao
William Denham

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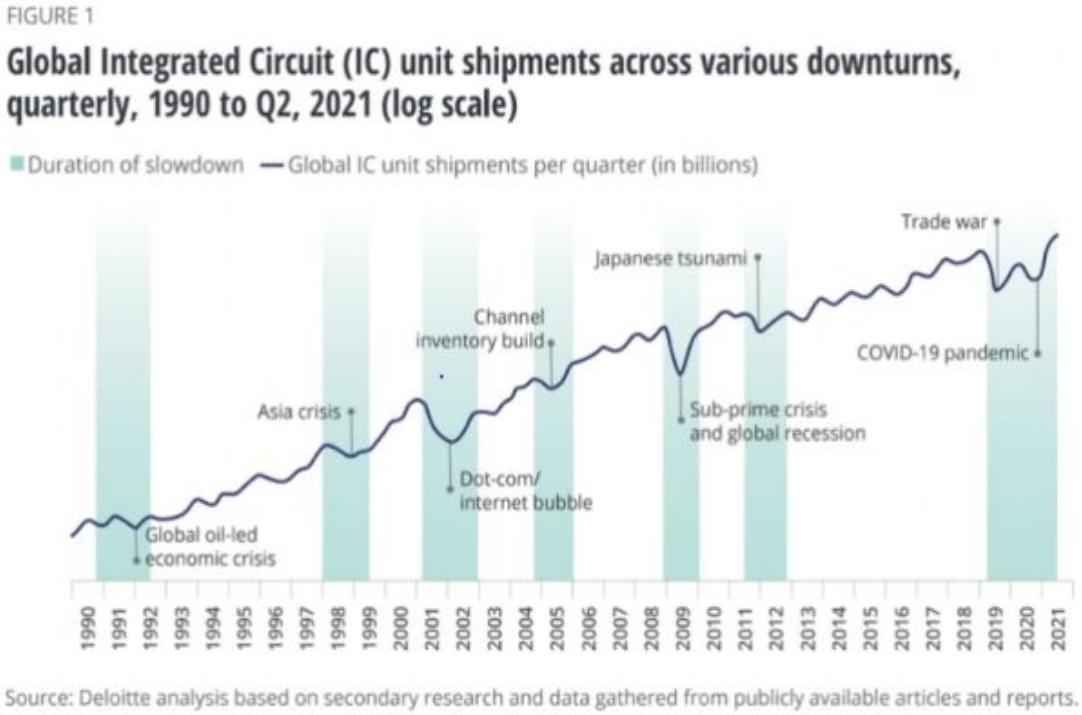
Team Member Introduction

- Bill Denham - Project Manager/ PCB Designer
- James Schaeffler - MCU Developer
- Yifei Gao - MCU Developer / Test Engineer
- German Kuznetsov - PCB Designer
- Hussain Zainal - GUI Developer
- Vikram Arunachalam - GUI Developer

Project Overview and Identification of Need

- Demand for Portable Lab Equipment due to COVID-19 Online Class Shift
- COVID-19 Pandemic Induced Chip Shortage
- Propose an affordable USB All-In-One Lab Device alternative to the AD2 or ADALM200
- Design and Construct an Arbitrary Waveform Generator to pair with Logic Analyzer, Power Supply and Oscilloscope

- Three Teams: Microcontroller, GUI, and Front-End
  - Microcontroller: Yifei and James
  - GUI: Vikram and Hussain
  - Front-End: German and Bill

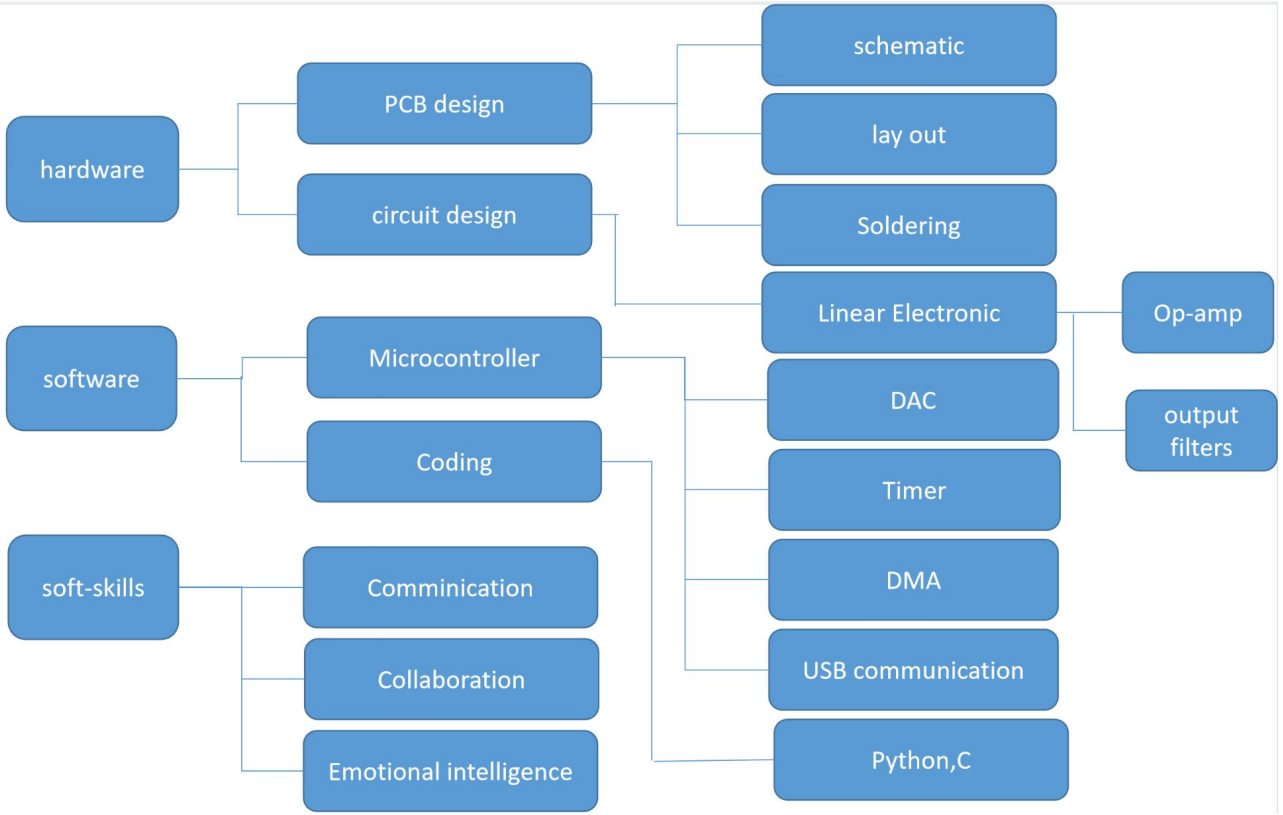


Above: The chip industry has seen a half-dozen dips and shortages over the decades.

Image Credit: Deloitte

Background Phenomenology

- High Level Programming Languages - Python and C
- Microcontrollers (MCU)
  - Digital-Analog-Converters (DAC)
  - Timers
  - Direct Memory Access (DMA)
- Printed Circuit Board (PCB) Design
- Low-level discrete electronics - OpAmps, Power Regulators, Buck Converters
- Surface Mount (SMD) Soldering
- Knowledge of KiCad and Autodesk Inventor

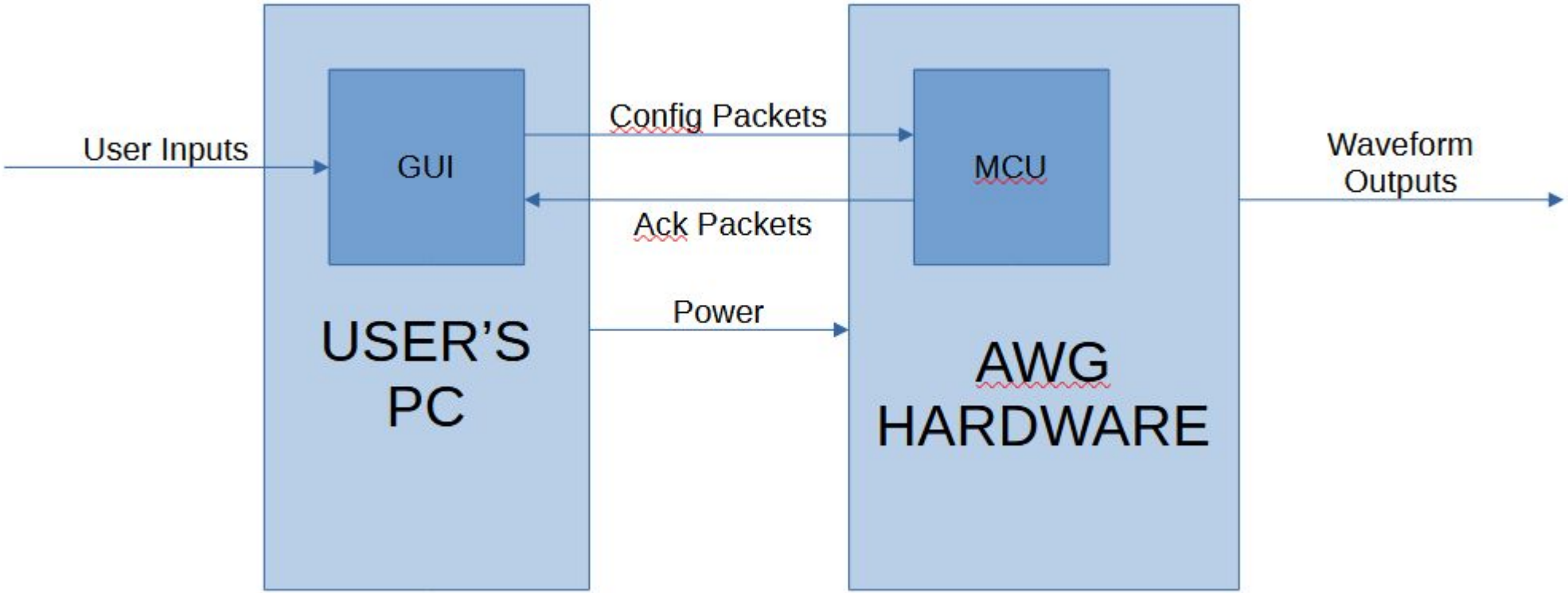


Project Requirements

- **Input/output requirements:**
  - 2 analog output channels.
  - Communication of the device is via USB
- **Function requirements**
  - Create arbitrary waveforms, triangular, rectangular, sine.
  - Bandwidth: around 2MHz.
  - The Sample Rate: around 5 Msps
  - The output: peak-to-peak 5V, adjustable +-2.5V
  - 20 mA load.
  - output display the wave, frequency, amplitude and offset selected
- **Technology and System-Wide Requirements:**
  - Cheap
  - Device and GUI must be able to operate on Linux, Windows, and Mac OS Personal Computers

Functional Decomposition / System Overview

- GUI Software
- MCU Software
- AWG Hardware



Functional Decomposition PCB/Hardware

- ±12V Switching Mode PSU
- 2 Analog channels:
  - Gain Control
  - Offset Control

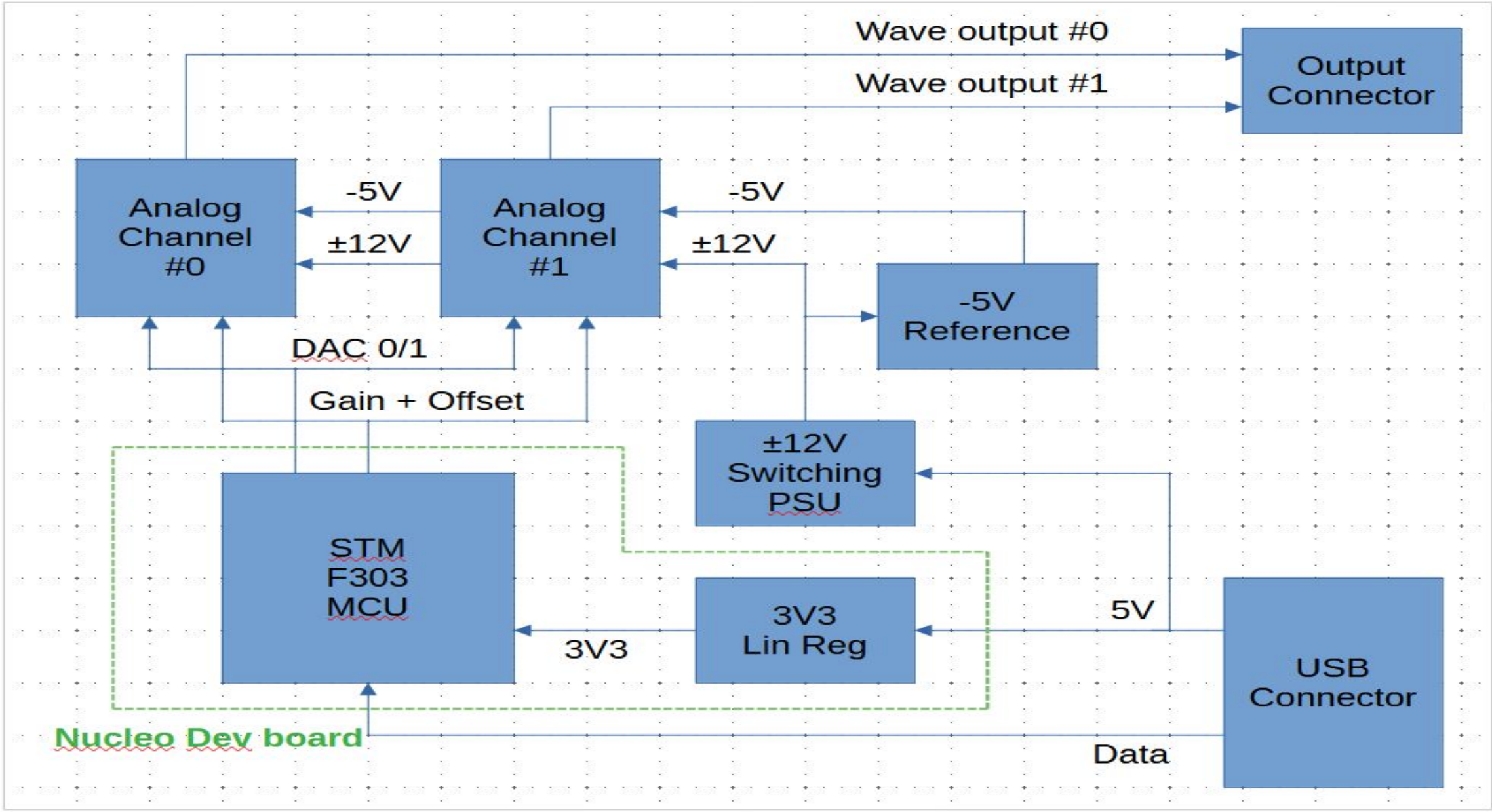
Functional Decomposition MCU Software

- GUI <-> MCU Connection
- PWM based Offset voltage generation
  - Timers / GPIO
- Gain control
  - GPIO
- Wave generation
  - DAC
  - DMA
  - Timers

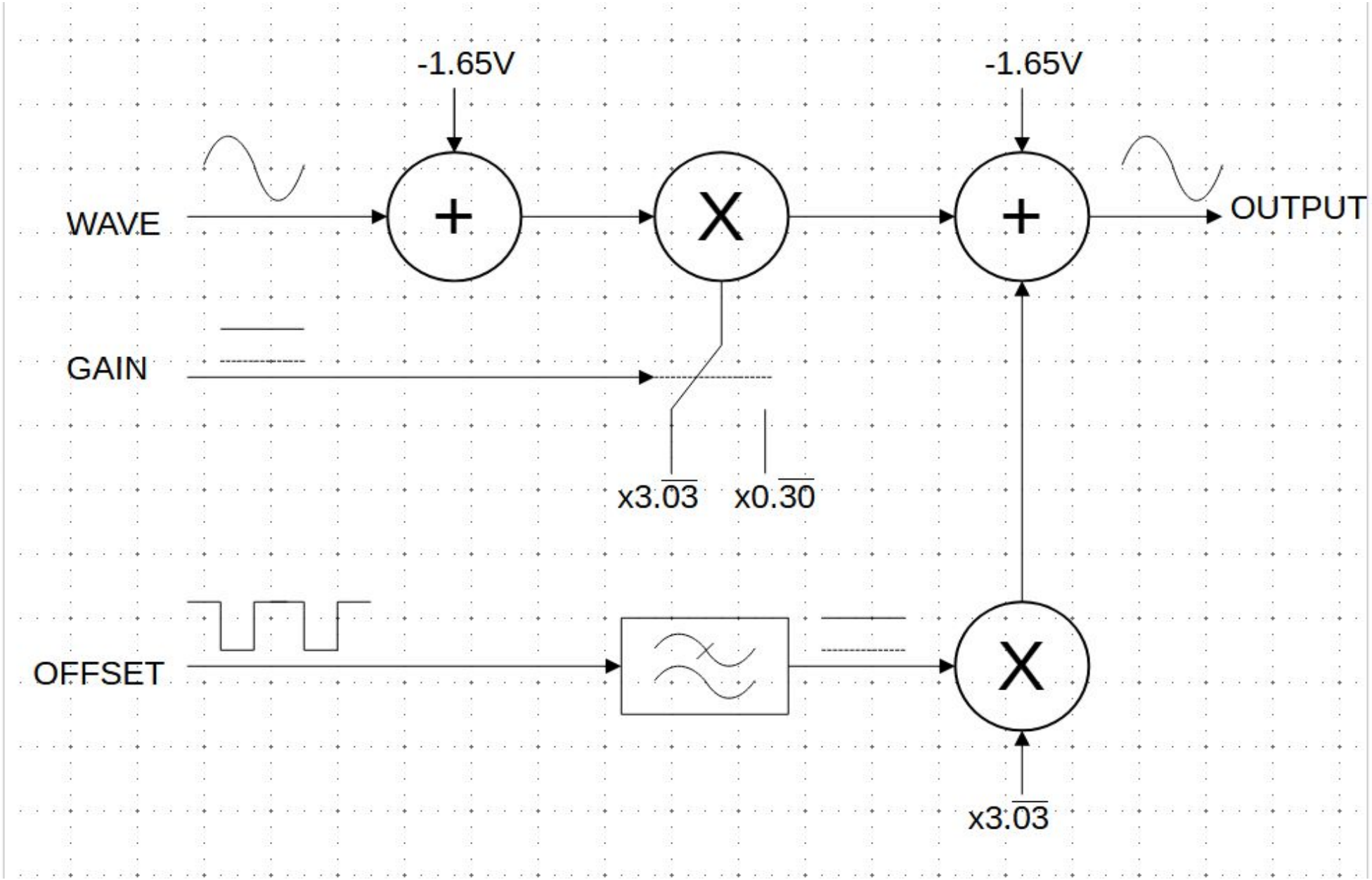
Functional Decomposition GUI Software

- qweerqwer

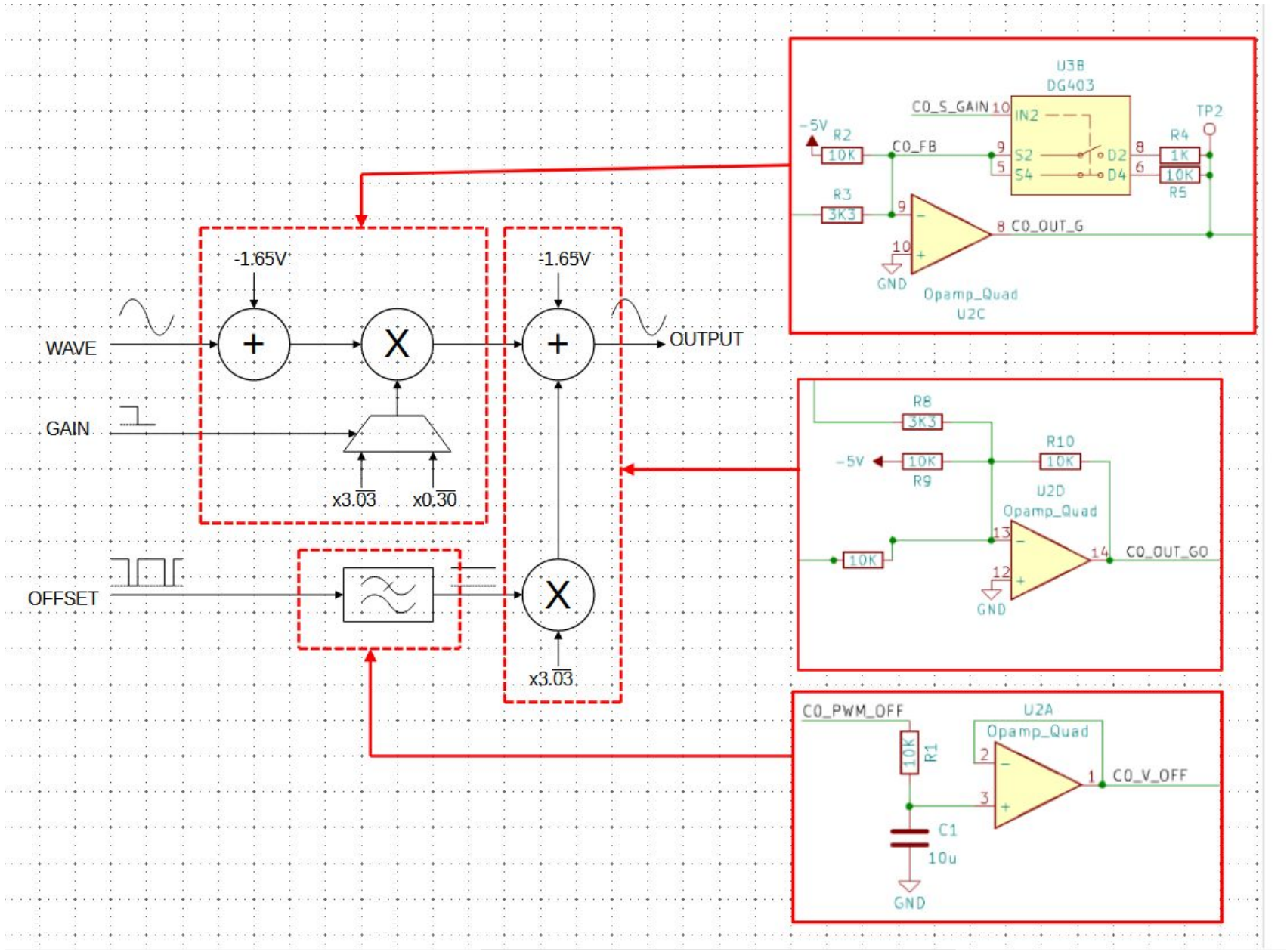
AWG Hardware overview



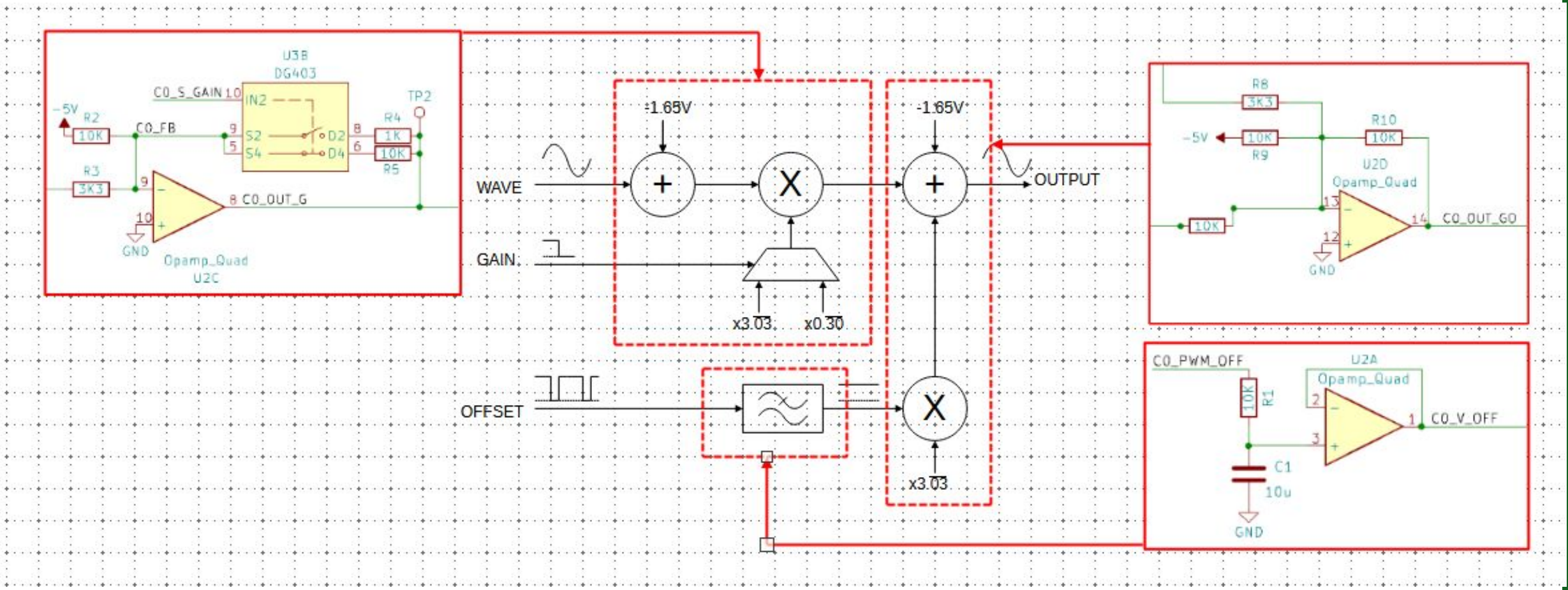
Analog Channel overview (maybe remove this and keep one of the next to)



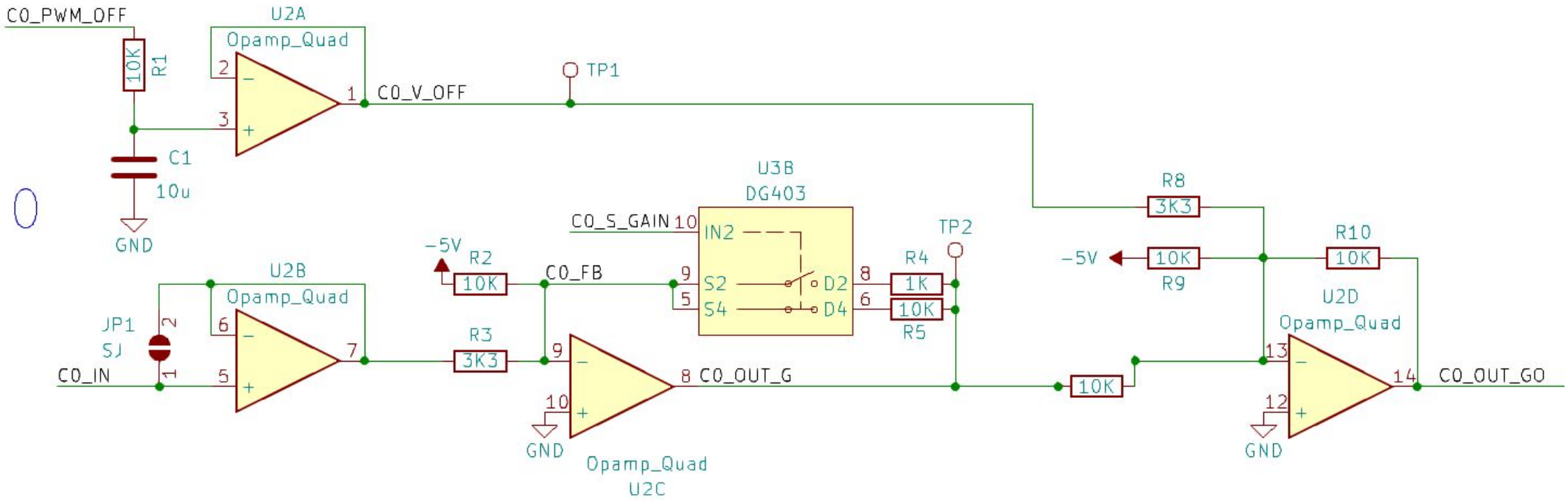
Analog Channel overview (remove one of these)



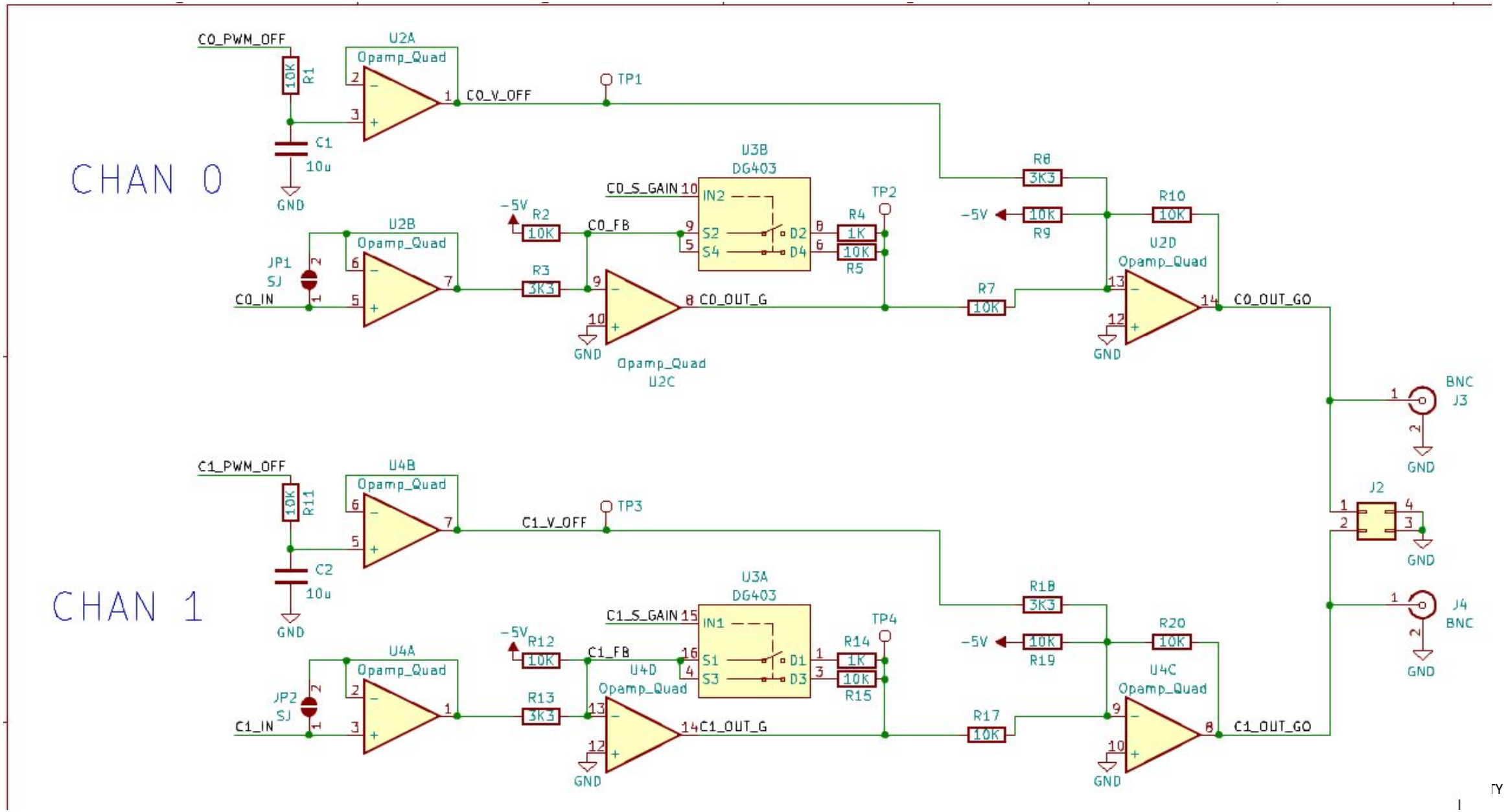
Analog Channel overview (remove one of these)



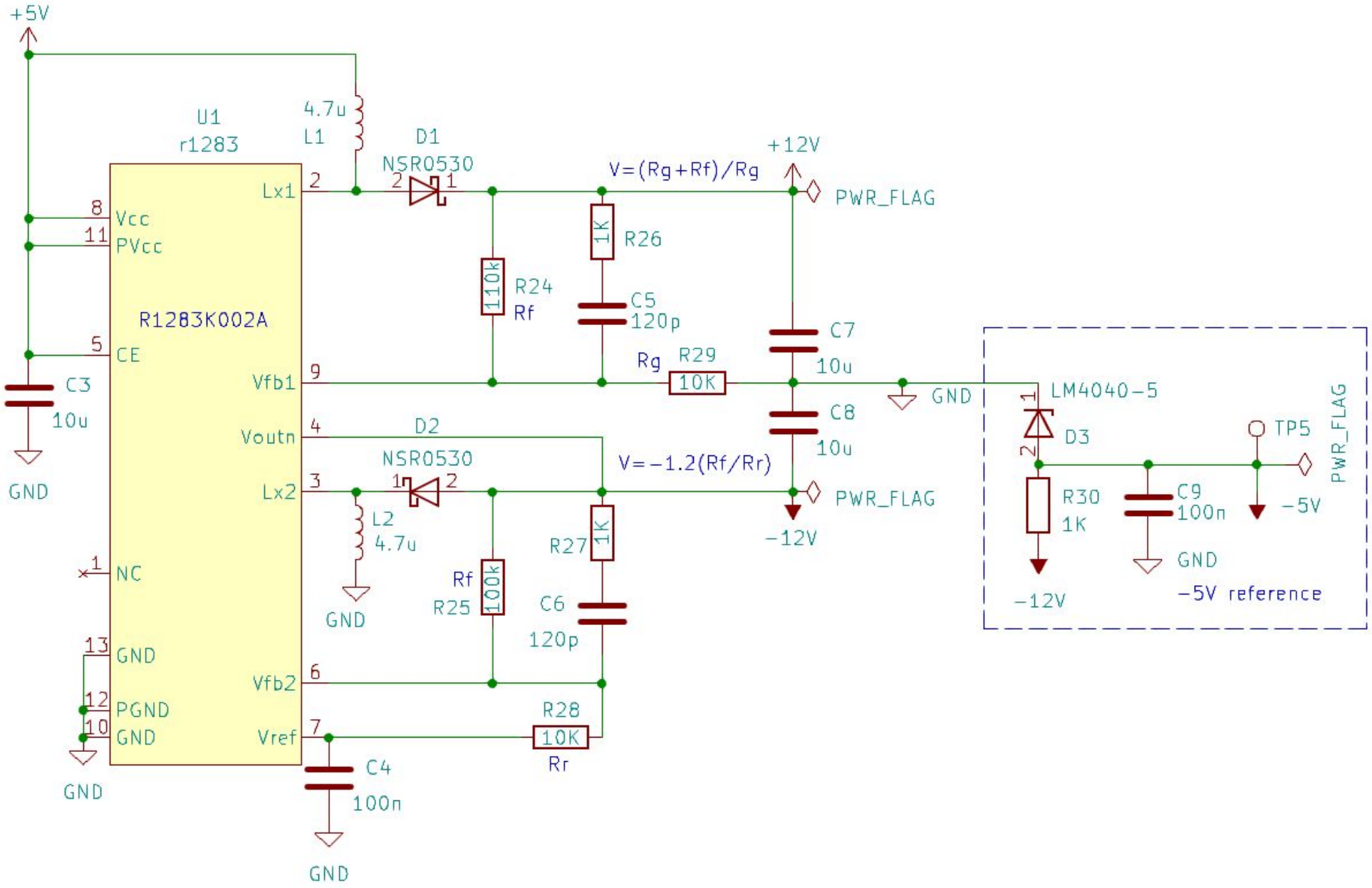
Analog channel Schematic



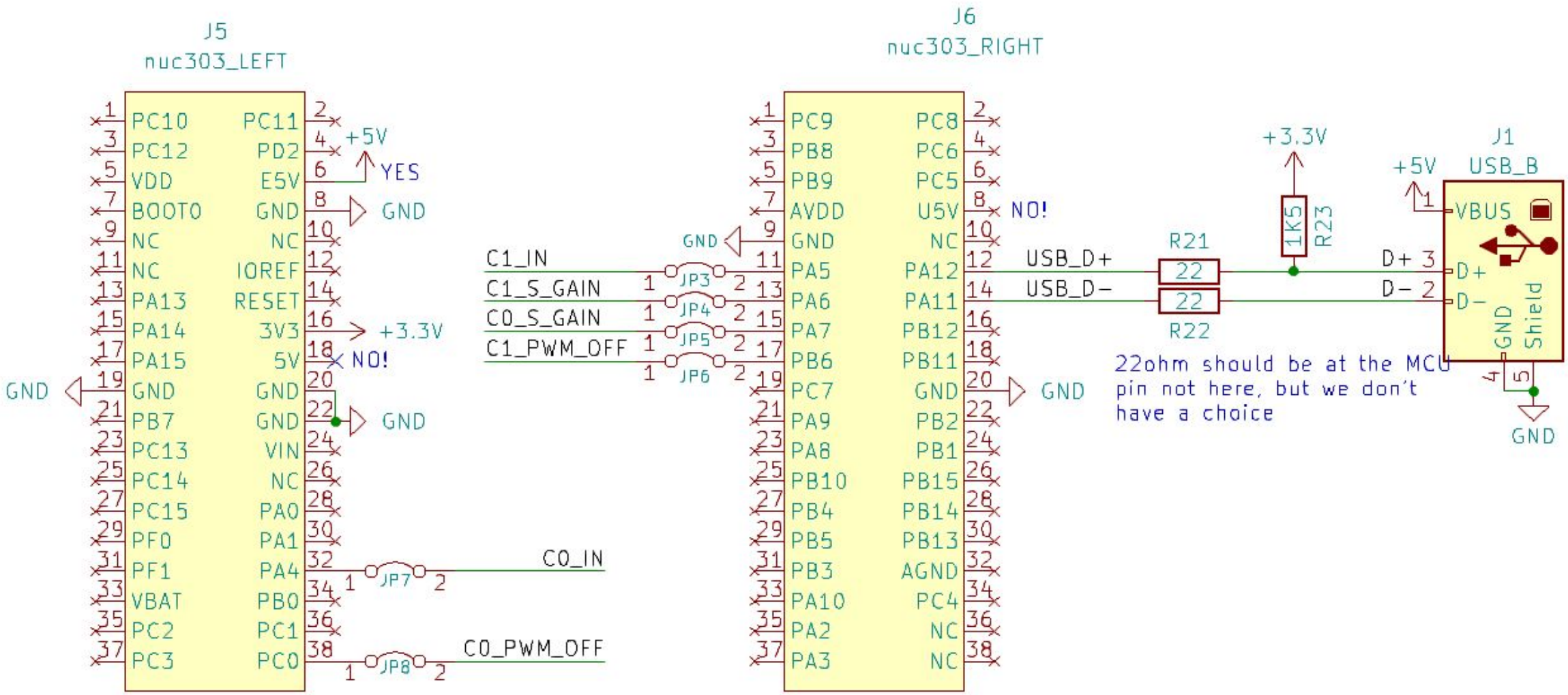
Analog channel Schematic



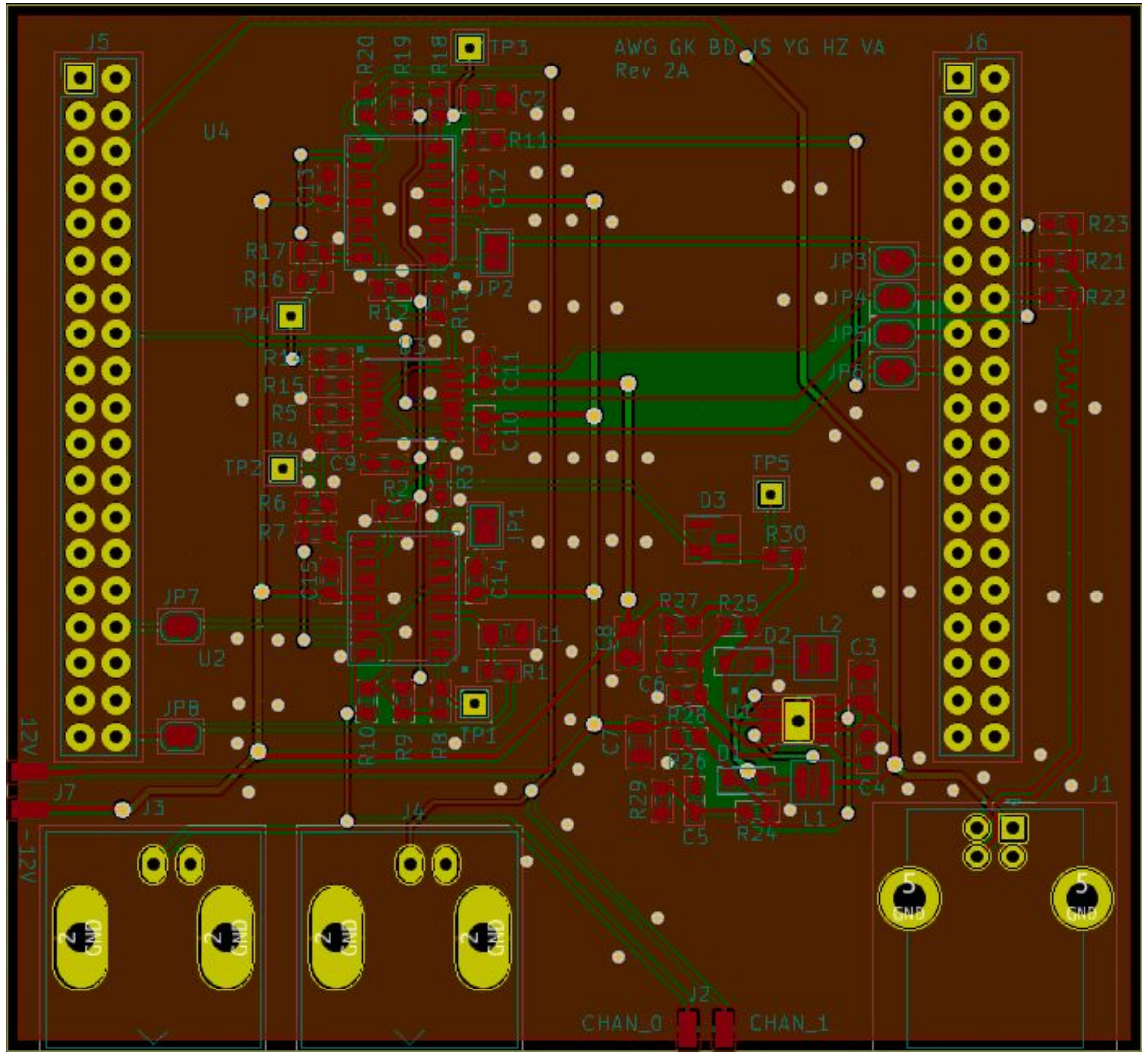
PSU Schematic

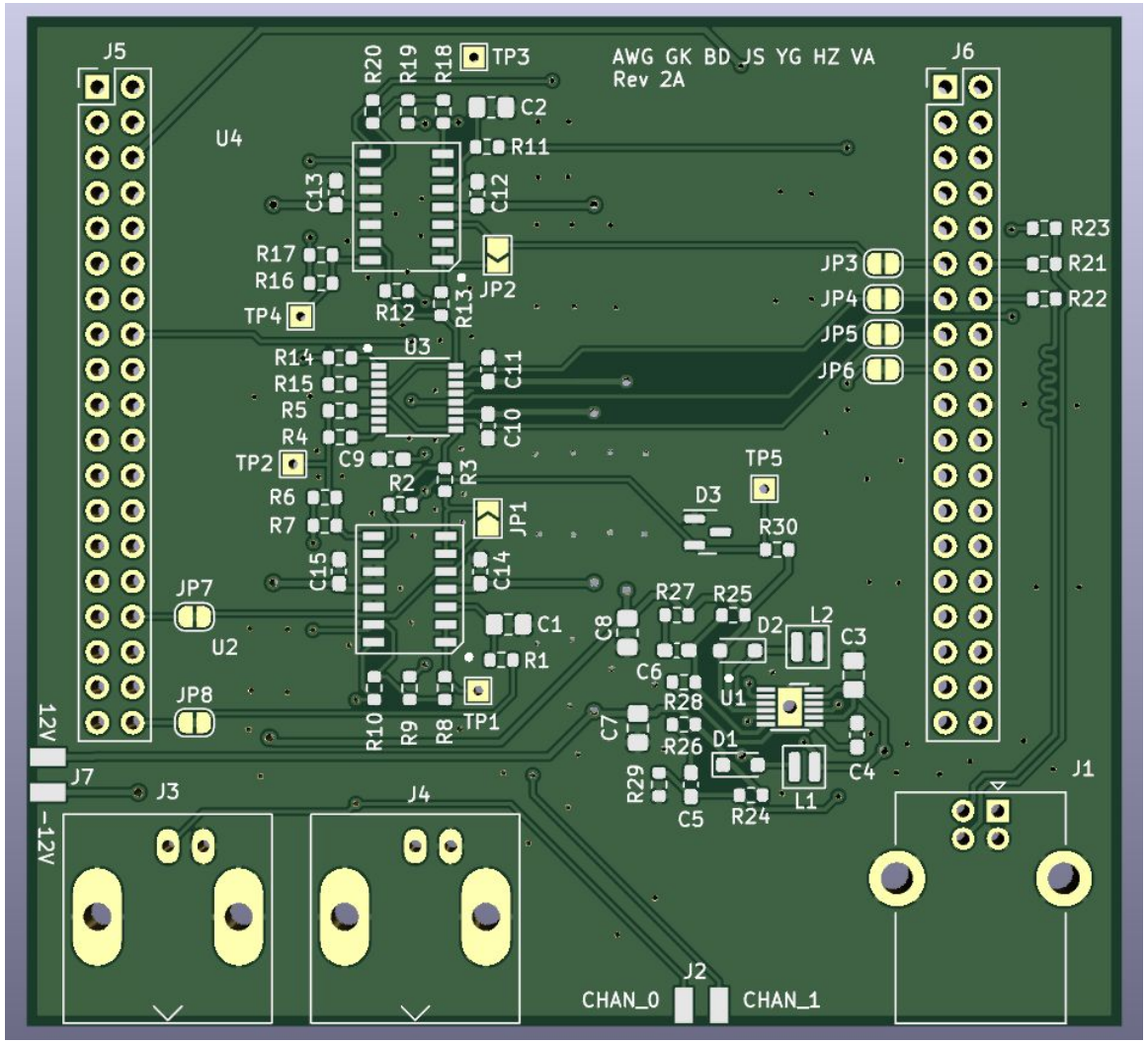


Connectors Schematic (maybe cut this)



PCB Layout


AWG GK BD JS YG HZ VA
Rev 2A
CHAN_0
CHAN_1


AWG GK BD JS YG HZ VA
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CHAN_0
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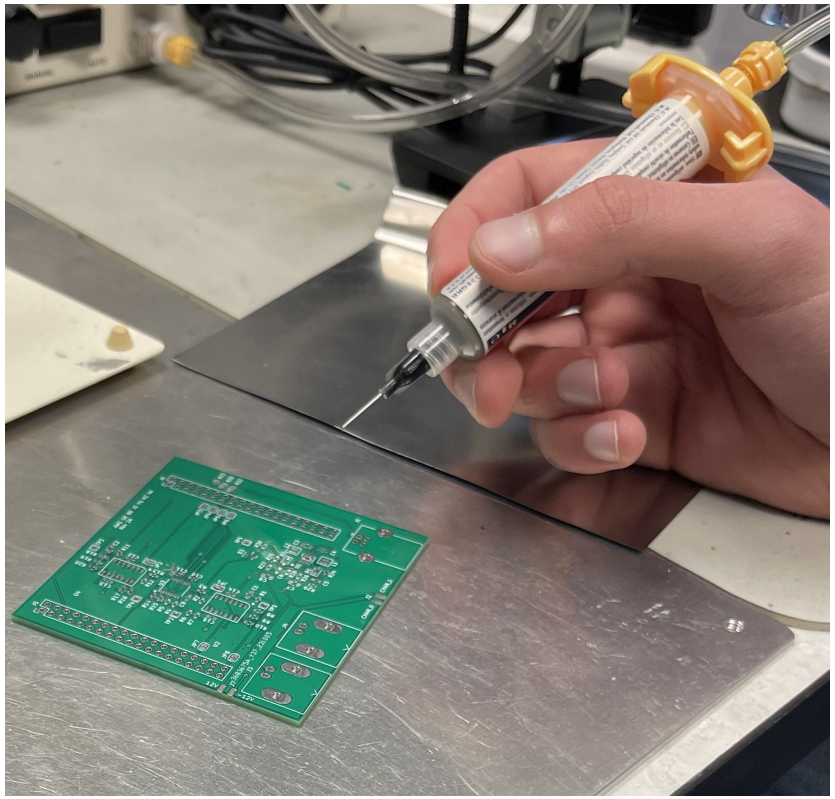
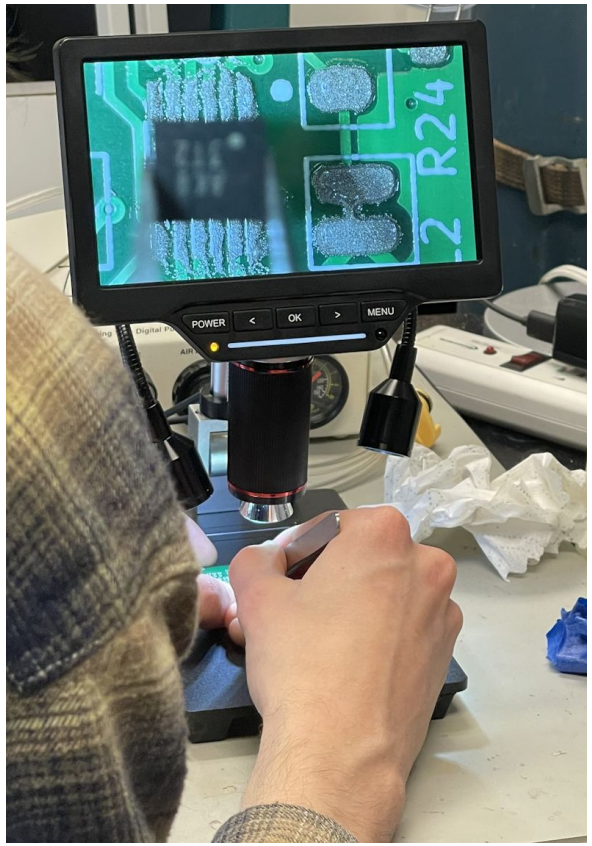
PCB Assembly



Step 1) Solder paste

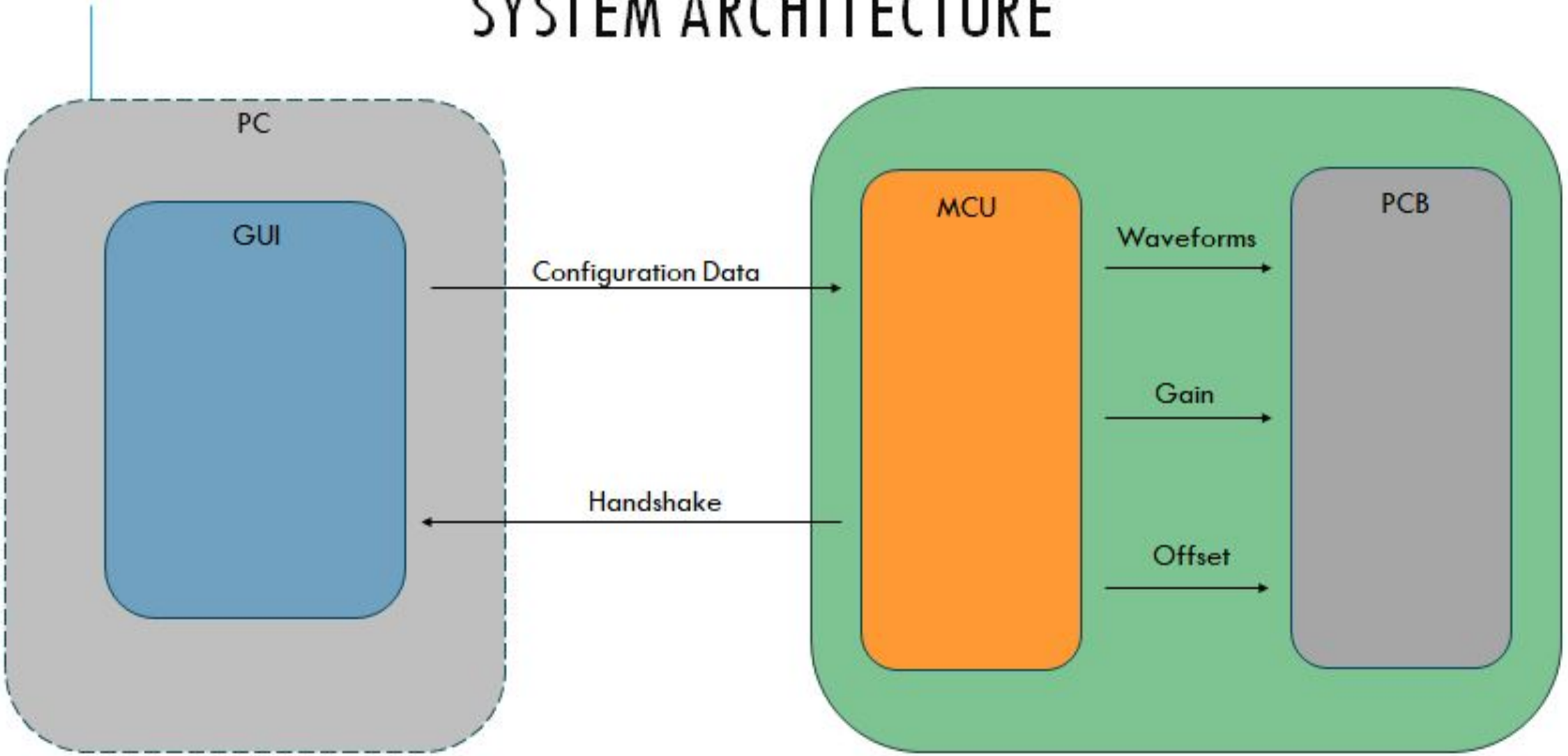


Step 2) Component placement

Step 3) Reflow Oven

Step 4) Manual Touchup

SYSTEM ARCHITECTURE



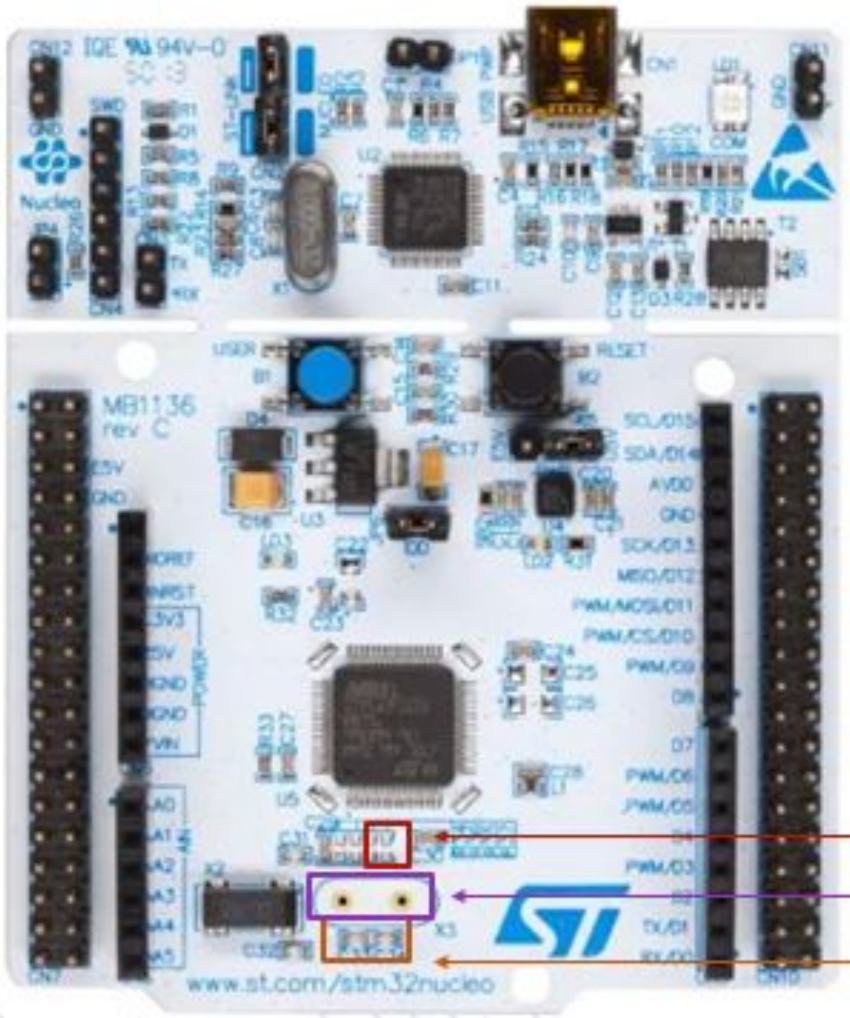
MCU- Hardware Modifications

HSE oscillator on-board from X3 crystal (not provided): for typical frequencies and its capacitors and resistors, refer to the STM32 microcontroller datasheet. Refer to the AN2867 Application note for oscillator design guide for STM32 microcontrollers.The X3 crystal has the following characteristics: 8 MHz, 16 pF, 20 ppm, and DIP footprint. It is recommended to use 9SL8000016AFXHF0 manufactured by Hong Kong X'tals Limited.

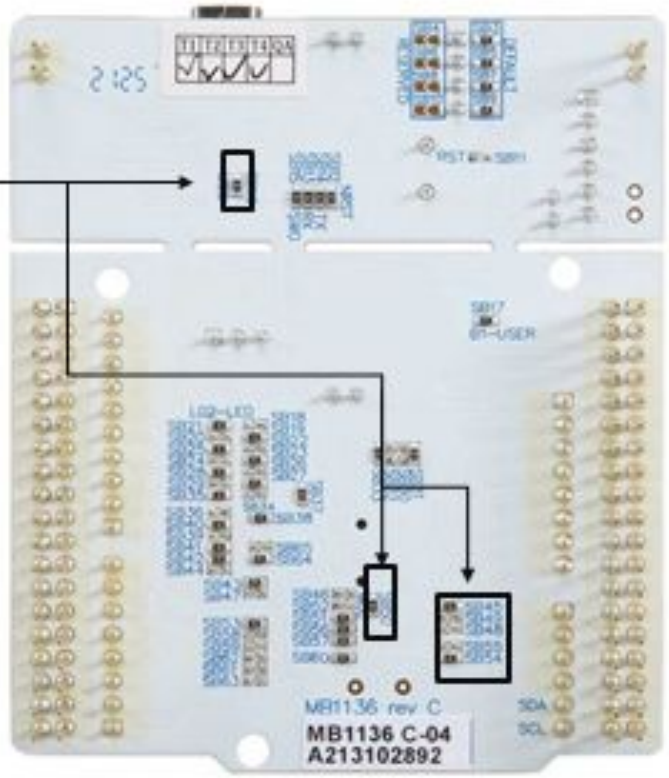
The following configuration is needed:

- SB54 and SB55 OFF
- R35 and R37 soldered
- C33 and C34 soldered with 20 pF capacitors
- SB16 and SB50 OFF

MCU – Hardware Modifications



Remove



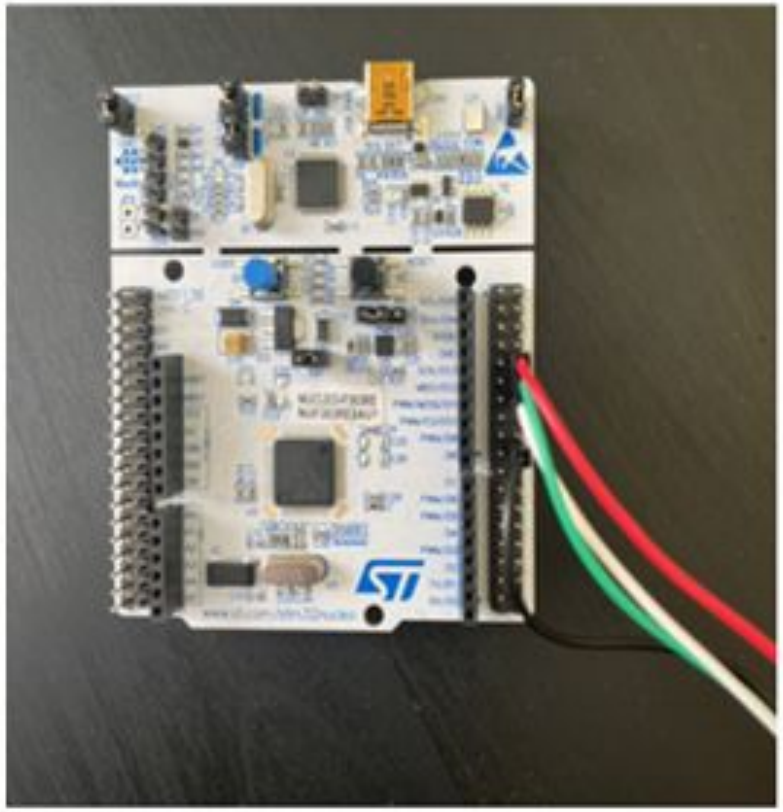
Soldered

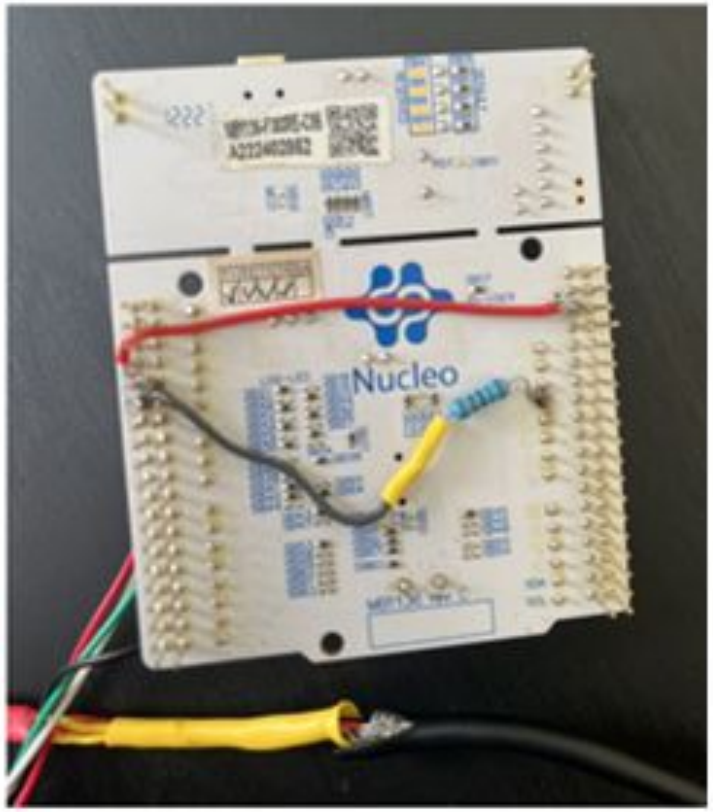
Add 8 MHz Crystal

Add 20 pF Capacitors

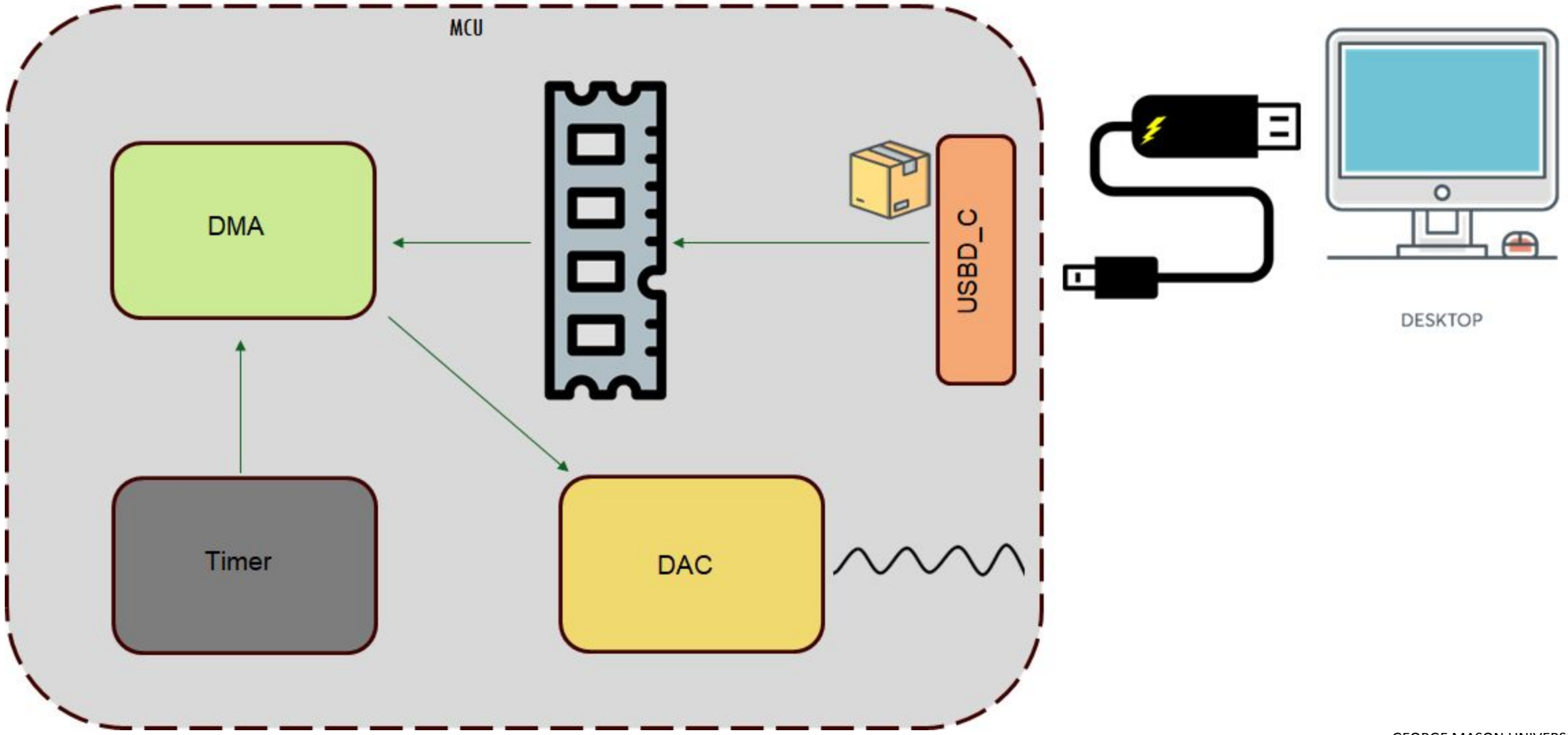
MCU – HARDWARE MODIFICATIONS

Need better pics of board

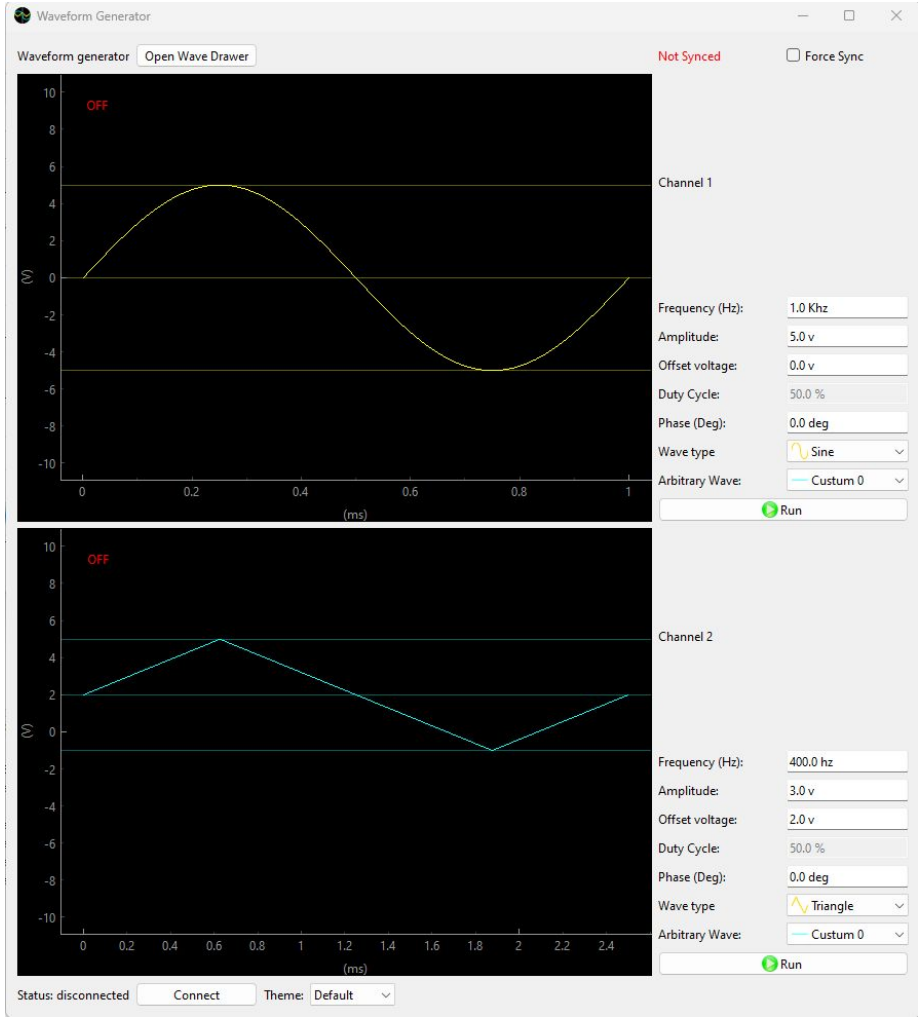




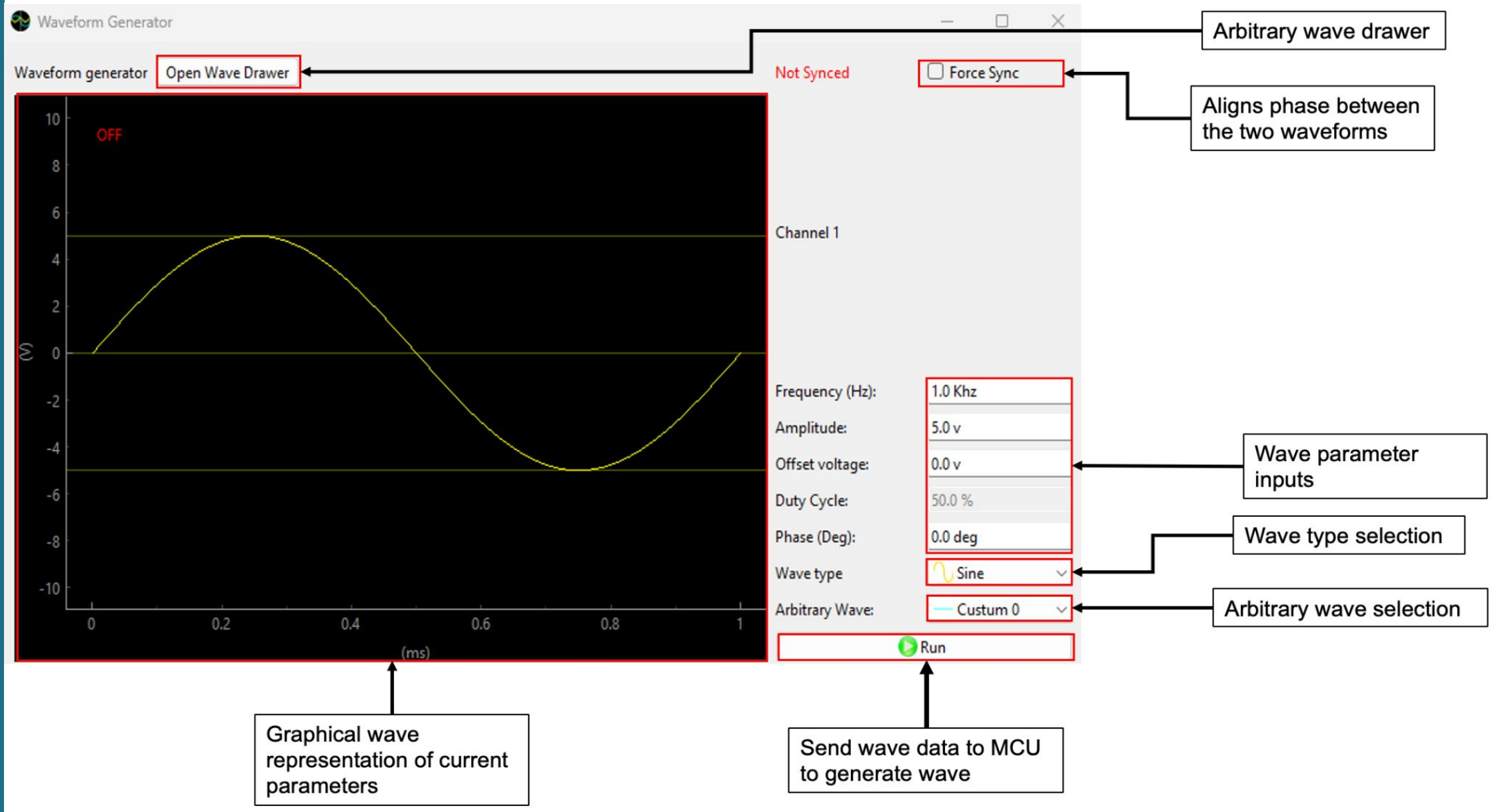
Connection



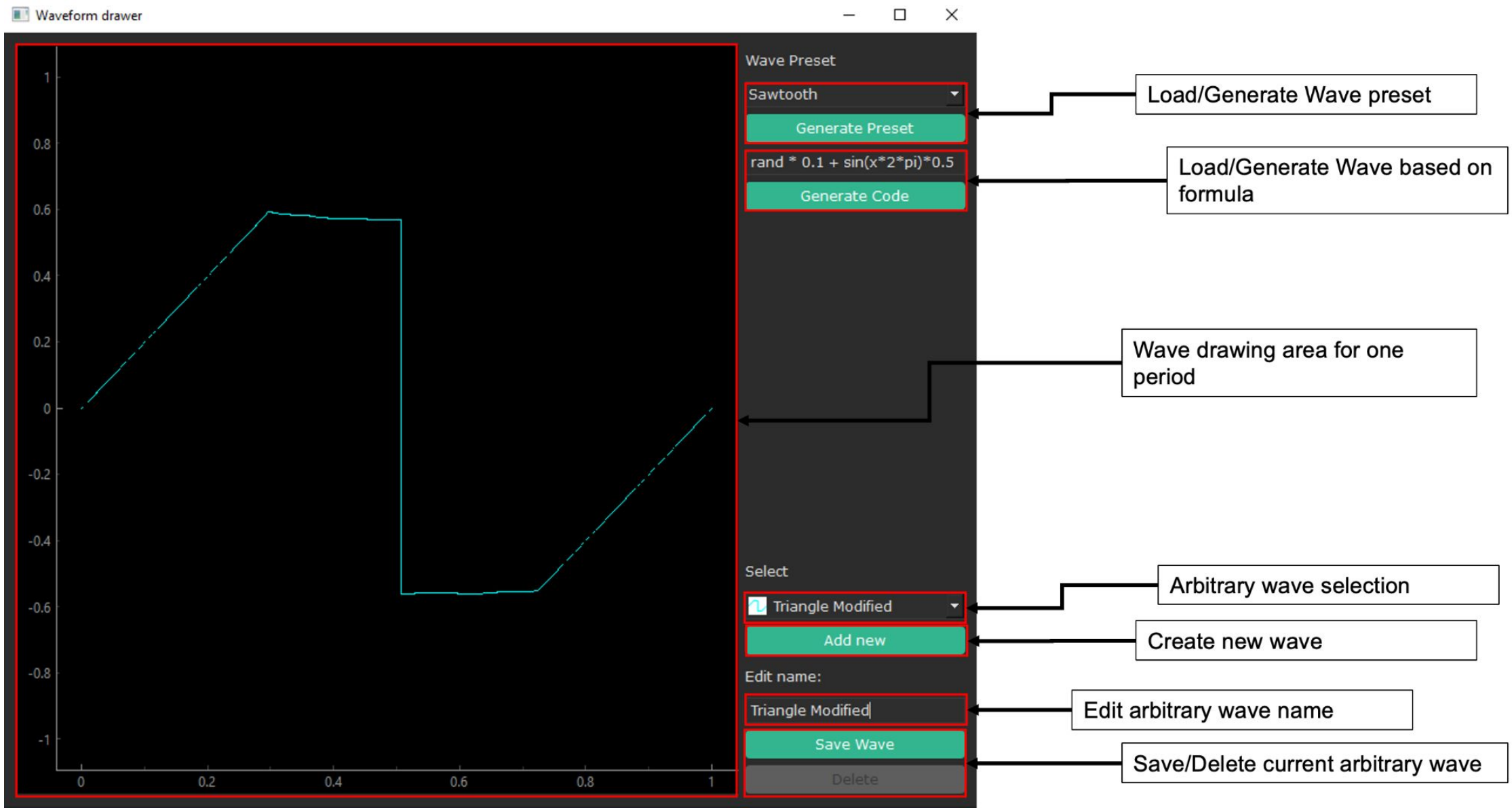
Graphical User Interface (GUI)



GUI Breakdown

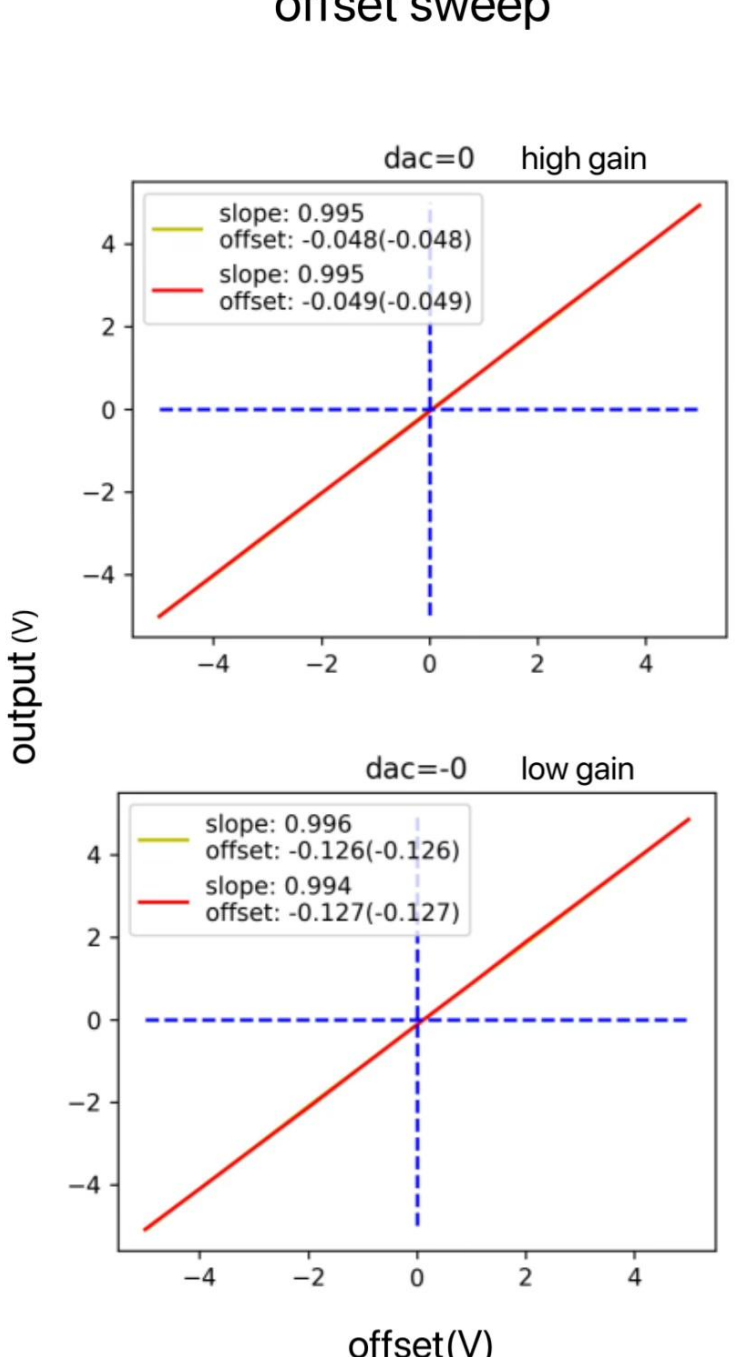


Arbitrary Waveform Drawer Breakdown

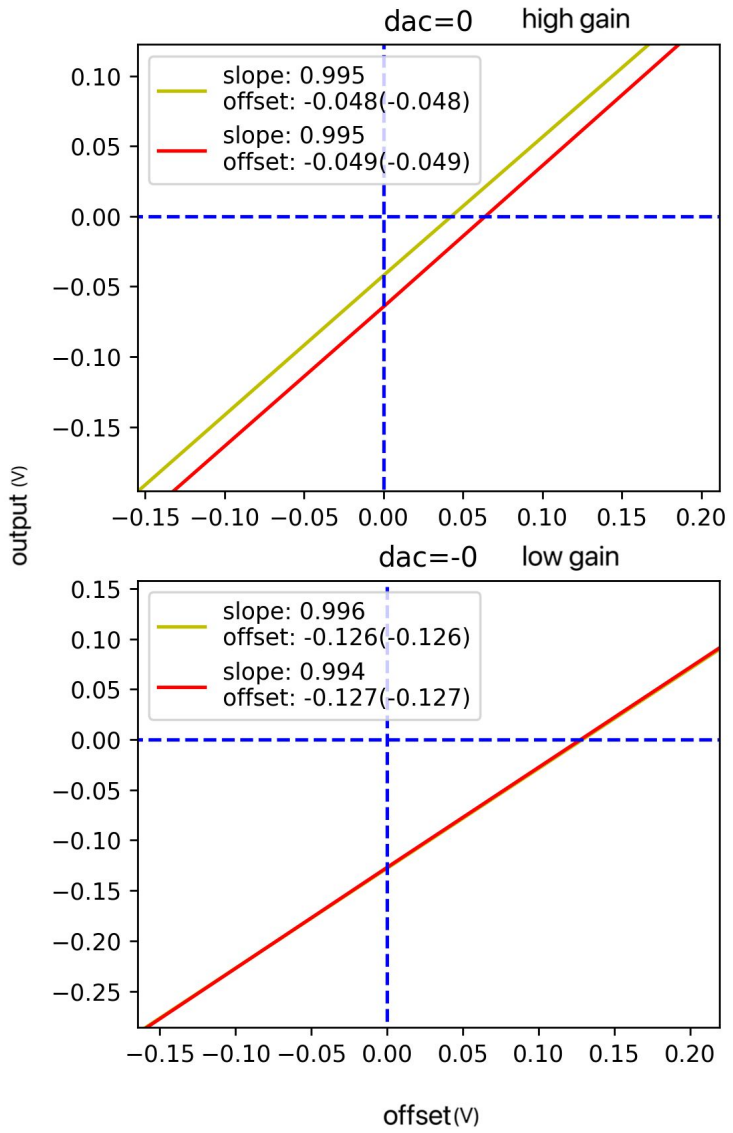


MCU & PCB Integration Testing - Offset Sweep

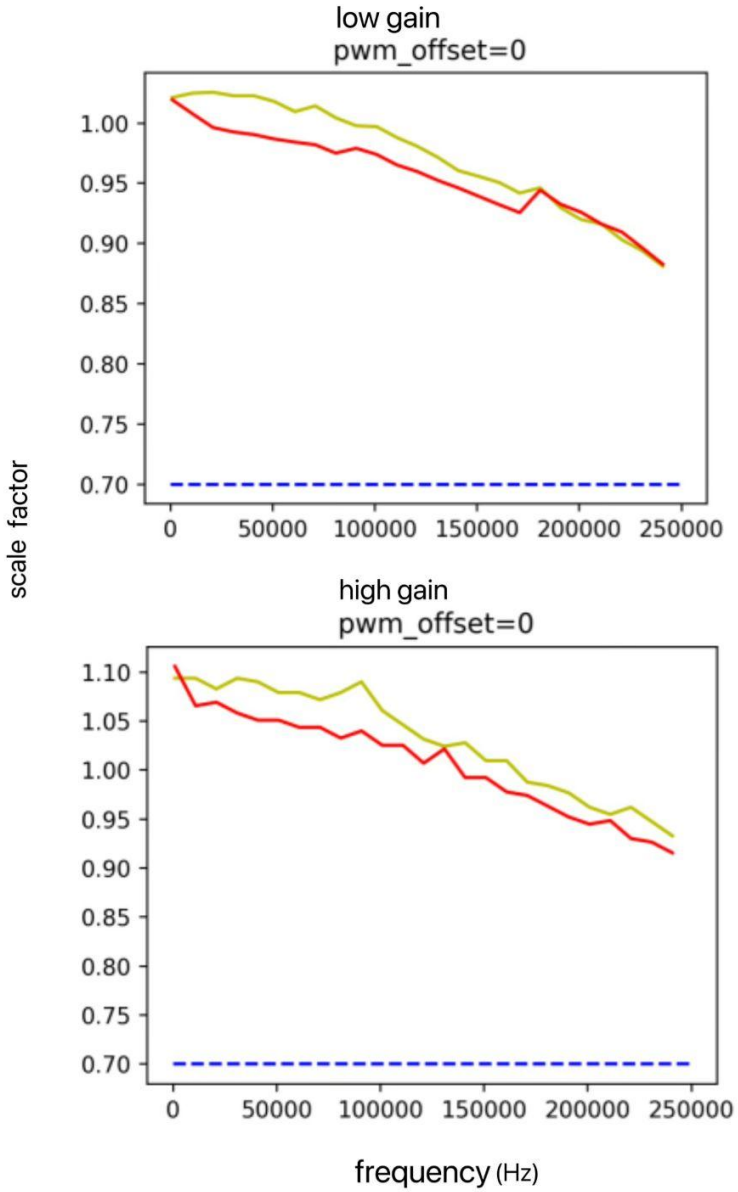
output=dac+offset



Offset Sweep Error Analysis



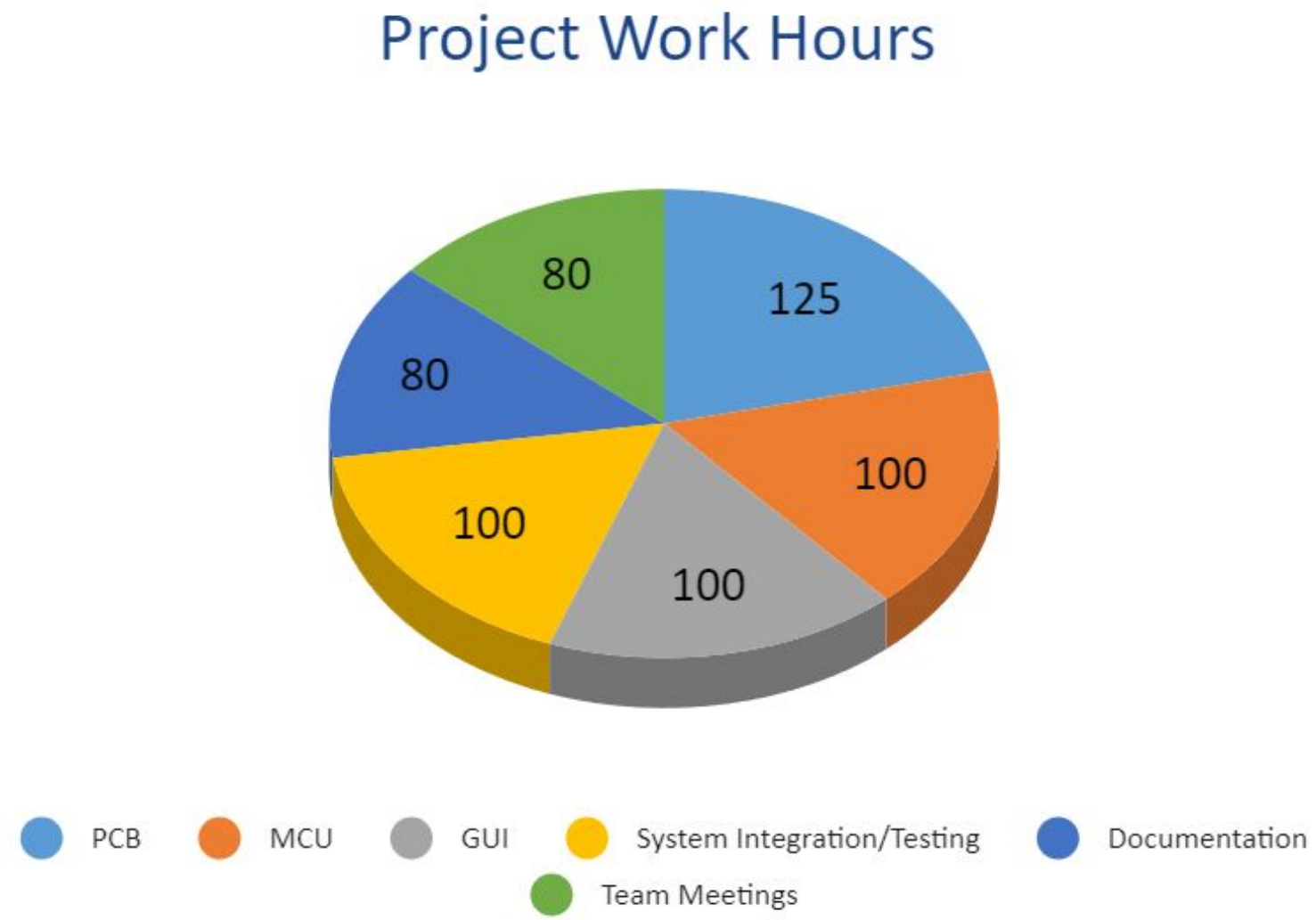
MCU & PCB Integration Testing - frequency response



Device Demonstration Video

Project Management - Funds Spent

Project Management - Project Work Hours



Project Management - Lessons Learned

- PCB:
  - Choose proper sizes of discrete components
  - Allow adequate time for creating custom footprints
  - Balance compactness of component placement with ease of assembly
- GUI:
  - Limit the amount of packages imported to avoid clashes.
  - Prioritize making modular code.
- MCU:
  -
- Project Management / Team Dynamics:
  - Cross-Function/Domain Teaming - Being able to work across hardware and software domains
  - Time Management - Adhering to hard deadlines, with other class commitments
  - Team Dynamics - Proper mix of Technical Skills and Soft Skills allow for the most efficient engineering teams

Questions