Master Bus Processor

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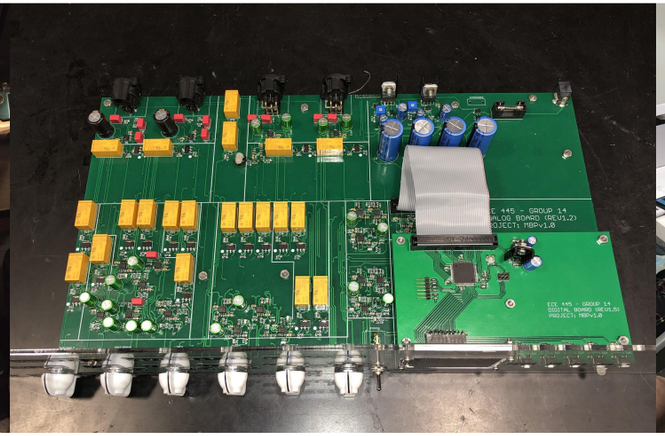
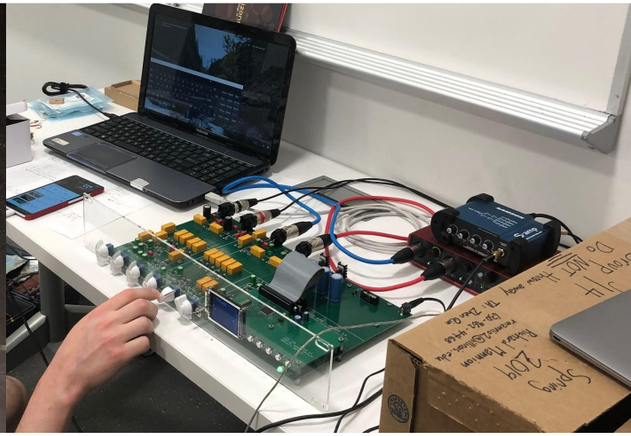
ECE 445 - TA: Zhen Qin





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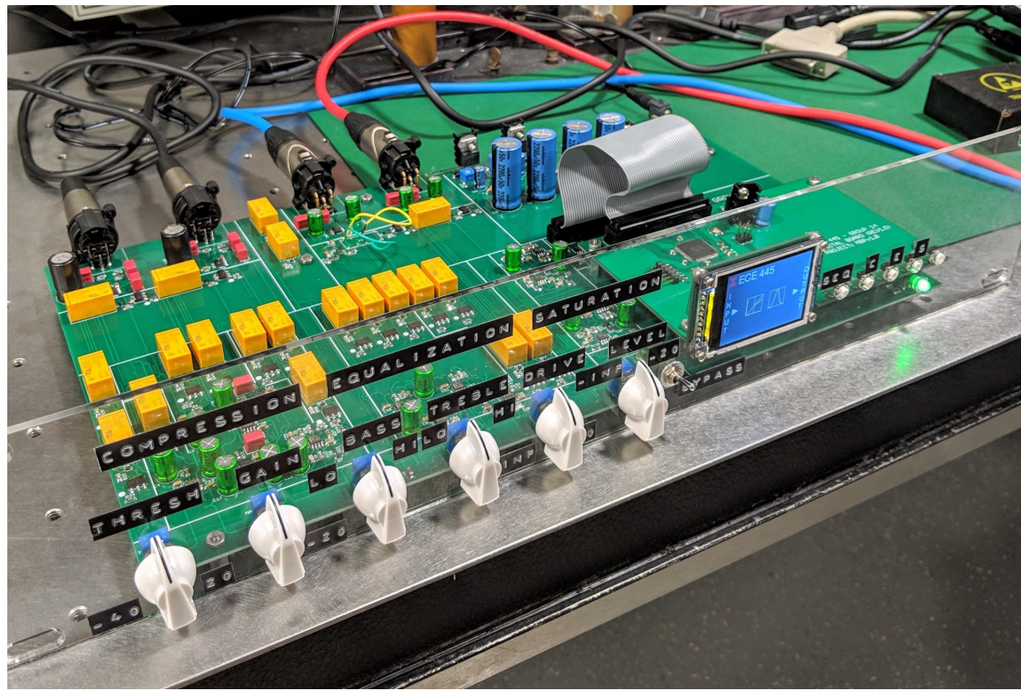
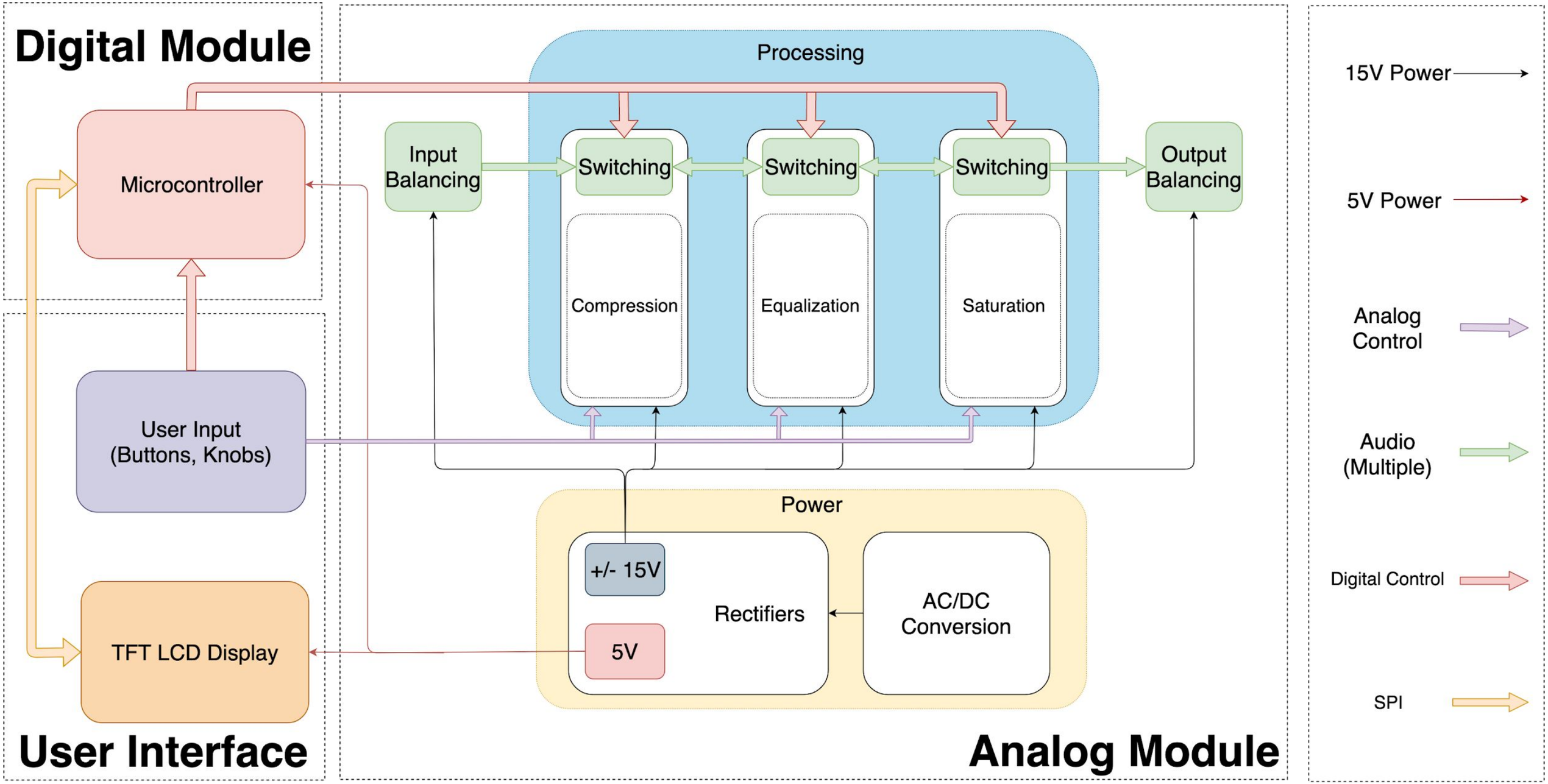
Introduction

- Why Analog?
  - Many Musicians and Audiophiles find it “much deeper and fuller”
  - Reduces the number of digital/analog conversions
- Existing Product → Rupert Neve Portico II
  - Too Expensive → $4000
  - Not Flexible → Audio chain constant
- Want a Hybrid
  - Flexibility of Digital Control
  - Fidelity of Analog Processing
  - Breakdown Cost Barrier
    - leverage modern design techniques



Objective

- Affordability
  - Sub $2500 price point → prototype has $500 in parts
- Performance
  - ***Compression***: automatic gain control
  - ***Equalization***: filter banks
  - ***Saturation***: harmonics
- Accessibility
  - 2 knobs per analog block
  - 5 buttons total with LCD display


Digital Module
Microcontroller
User Input
(Buttons, Knobs)
TFT LCD Display
User Interface
Processing
Input
Balancing
Switching
Switching
Switching
Output
Balancing
Compression
Equalization
Saturation
Power
+/- 15V
5V
Rectifiers
AC/DC
Conversion
Analog Module
15V Power
5V Power
Analog
Control
Audio
(Multiple)
Digital Control
SPI

Design: Power Conversion and Rectification

- ***Requirement:*** Convert 120 V AC to 18-30 V DC
- ***Verification:*** Measure voltage with max load (14 relays on)
- ***Result:*** DC voltage measurement of 26 V

Design: Voltage Regulation

- ***Requirement:*** Provide 1.8 V to 5.5 V for digital control, -15.8 V to -14.0 V for negative rail and 14.0 V to 15.8 V for positive rail for analog blocks
- ***Verification:*** Measure voltage with max load (14 relays on)
- ***Result:***

Desired Voltage	5 V	15 V	-15 V
Measured Voltage	5.07 V	14.87 V	-15.01 V

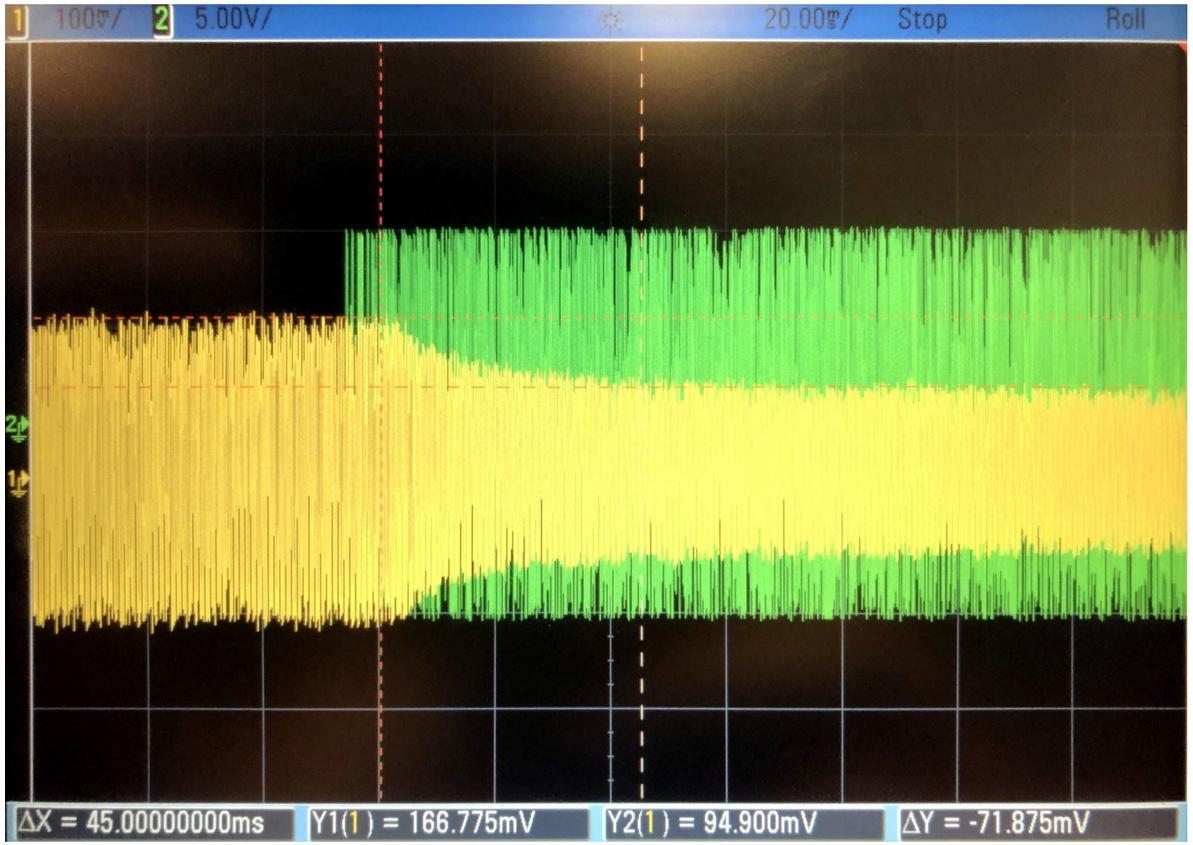
Design: Compression

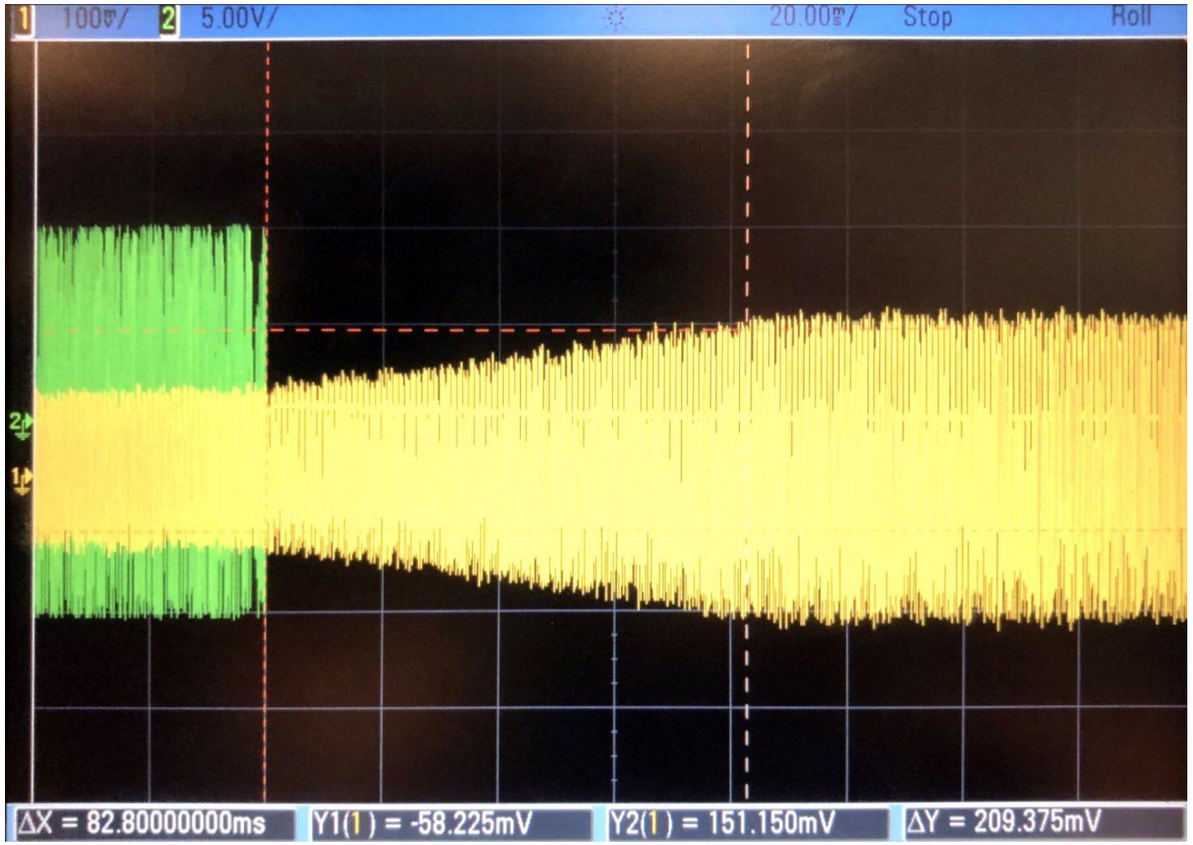
- ***Requirement:*** Provide 20 dB gain reduction
- ***Verification:*** Input 1 kHz sine wave and measure gain reduction
- ***Result:*** 20.3 dB gain reduction

Design: Compression

- ***Requirement:*** Provide 100 ms response time
- ***Verification:*** Input signal signal over threshold on ch 2 and measure the response on 1 kHz sine wave on ch 1
- ***Result:***
  - 45.0 ms attack
  - 82.8 ms release

Design: Compression

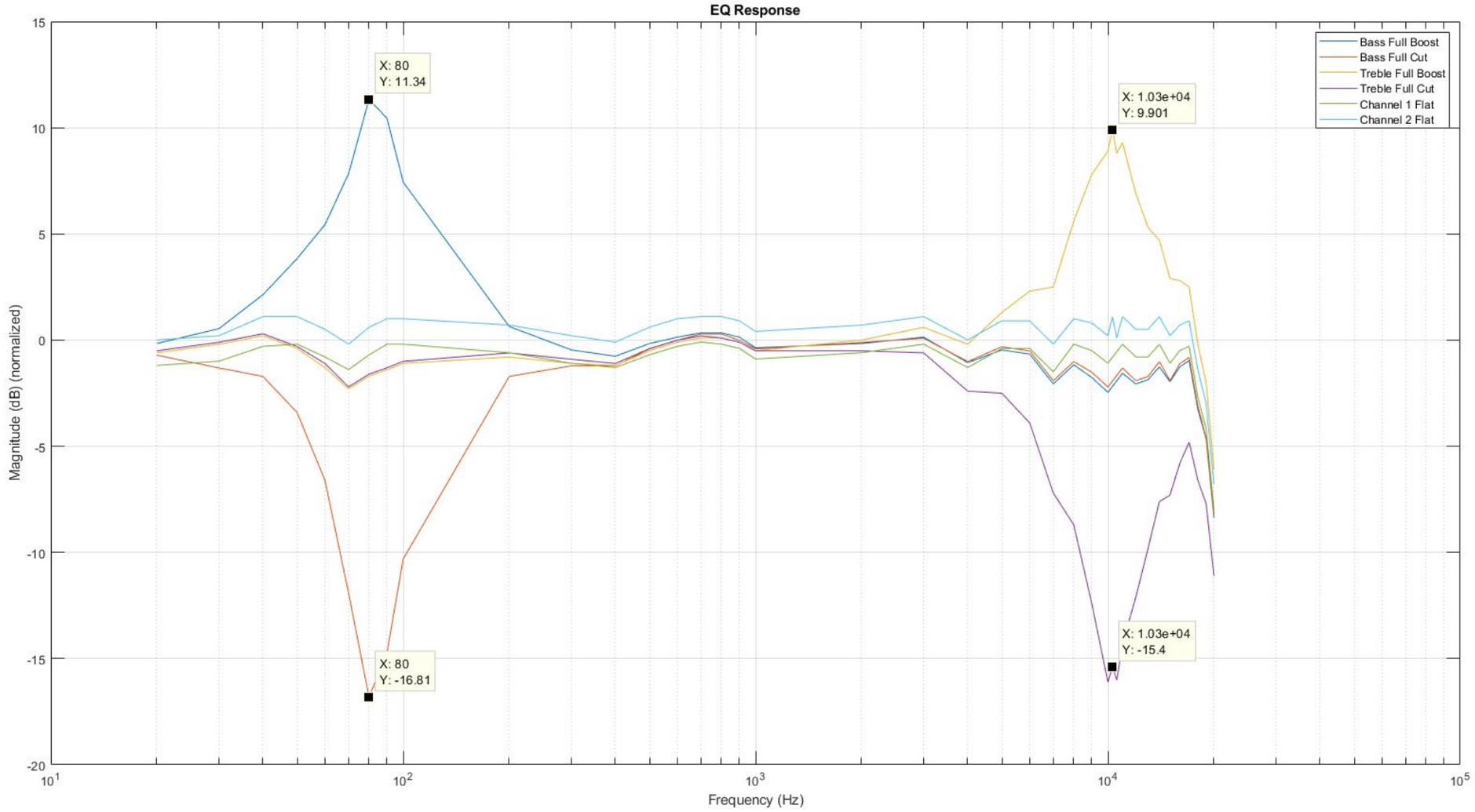




Design: Equalization

- ***Requirement:*** Bands in the region of 70-90 Hz / 9-11 kHz
- ***Verification:*** Sweep input from 20 Hz - 20 kHz
- ***Result:***
  - Low Band Center Frequency of 80 Hz
  - High Band Center Frequency of 10.3 kHz

Design: Equalization



Design: Saturation

- ***Requirement:*** Contribute 0-10% total harmonic distortion
- ***Verification:*** Input 3 kHz input and measure harmonics
- ***Result:*** With full drive/level

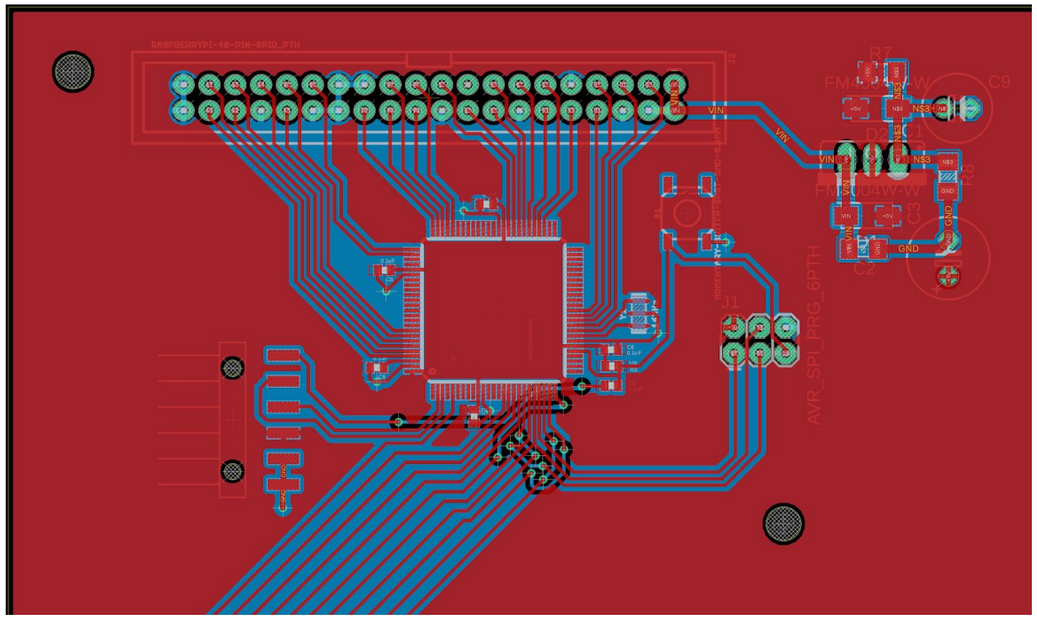
$$\text{THD (percent)} = \frac{total\ power\ of\ all\ harmonics\ above\ fundamental}{total\ output\ power\ of\ signal}$$

THD = 0.1186 %

Harmonic	1st	2nd	3rd	4th	5th	6th
Frequency	3 kHz	6 kHz	9 kHz	12 kHz	15 kHz	18 kHz
Gain (normalized)	0 dBm	-39.3 dBm	-30.6 dBm	-44.3 dBm	-37.9 dBm	N/A

Design: Microcontroller

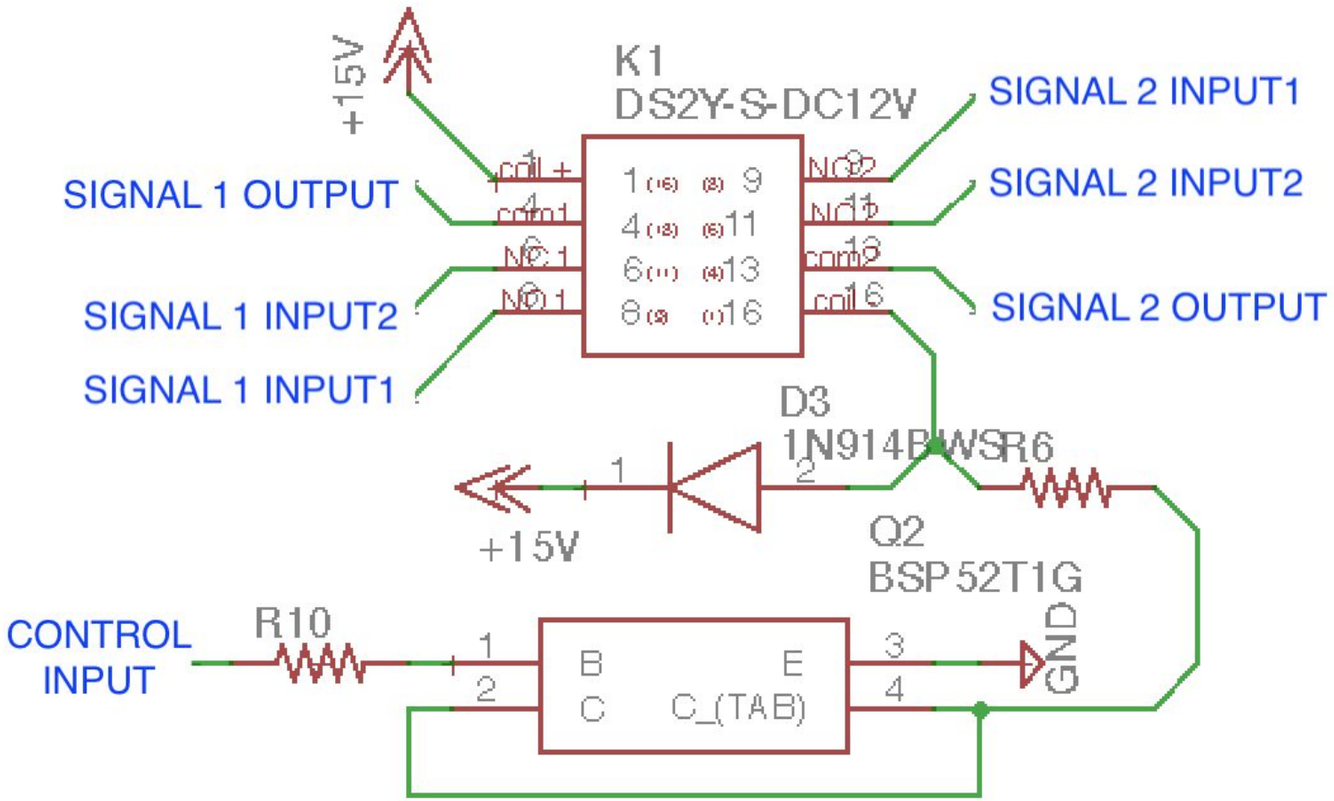
- ***Requirement:*** 20 output, 5 input, SPI, non-volatile memory
- ***Verification:*** Refer to datasheet and count pins
- ***Result:*** ATmega-1280 had all required pins

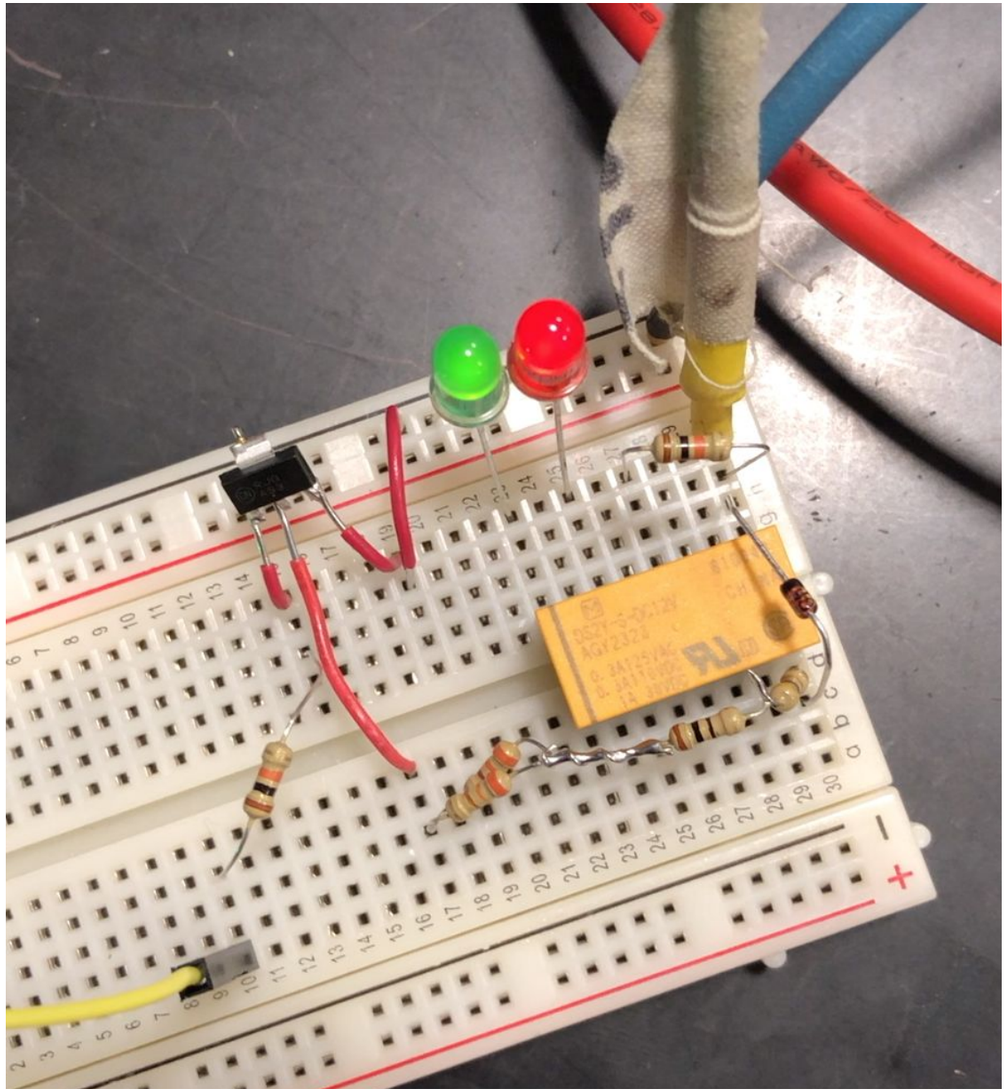


Design: Switch Control

- ***Requirement:*** Less than 40 mA per line, 200 mA total
- ***Verification:*** Create test circuit and measure input current
- ***Result:*** Control line current of 0.371 mA
  - worst case of 14 relays on → 5.194 mA total

Design: Switch Control



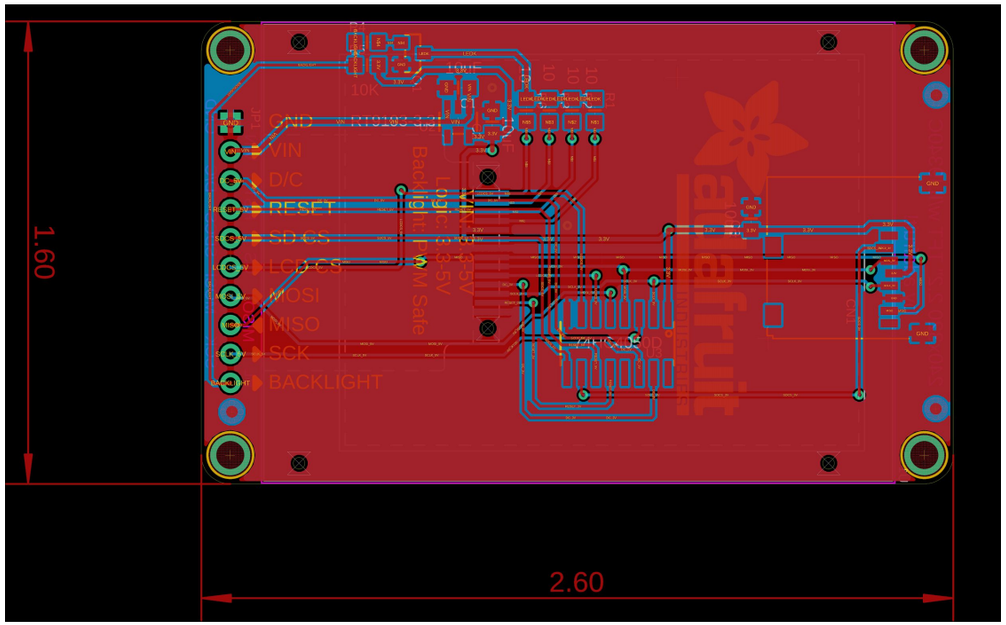


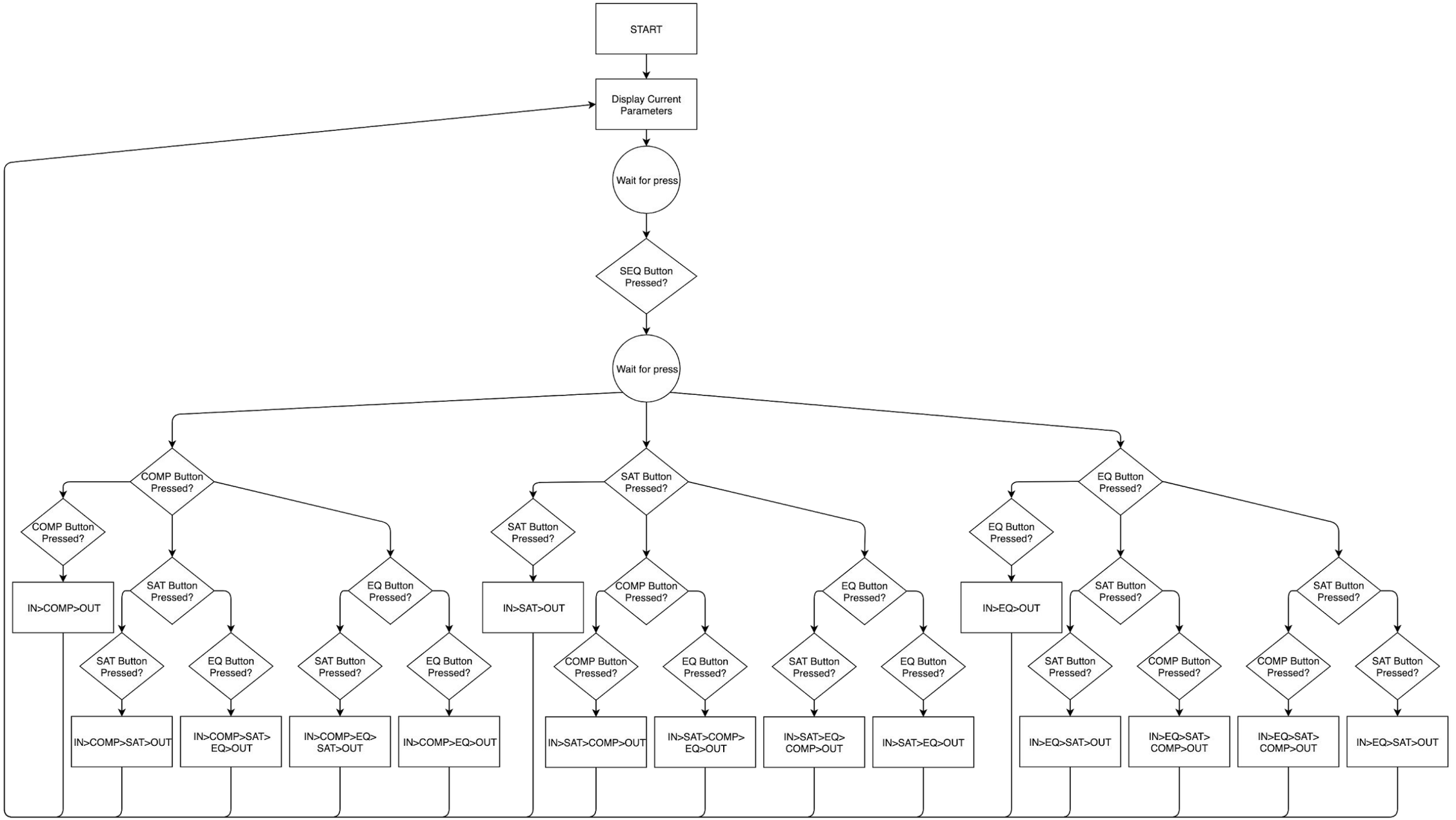
Design: Switch Control

- ***Requirement:*** Must have less than 0.01% distortion
- ***Verification:*** Use max hold to measure distortion on frequency analyzer
- ***Result:*** No measurable distortion was detected

Design: LCD Display

- ***Requirement:*** Must fit in a 1U space (1.75” tall)
- ***Verification:*** Use cad drawing to measure height
- ***Result:*** Measured height of 1.6” tall




START
Display Current Parameters
Wait for press
SEQ Button Pressed?
Wait for press
COMP Button Pressed?
SAT Button Pressed?
EQ Button Pressed?
COMP Button Pressed?
SAT Button Pressed?
EQ Button Pressed?
IN>COMP>OUT
SAT Button Pressed?
EQ Button Pressed?
SAT Button Pressed?
EQ Button Pressed?
IN>COMP>SAT>OUT
IN>COMP>SAT> EQ>OUT
IN>COMP>EQ> SAT>OUT
IN>COMP>EQ>OUT
SAT Button Pressed?
COMP Button Pressed?
EQ Button Pressed?
IN>SAT>OUT
COMP Button Pressed?
EQ Button Pressed?
SAT Button Pressed?
EQ Button Pressed?
IN>SAT>COMP>OUT
IN>SAT>COMP> EQ>OUT
IN>SAT>EQ> COMP>OUT
IN>SAT>EQ>OUT
EQ Button Pressed?
SAT Button Pressed?
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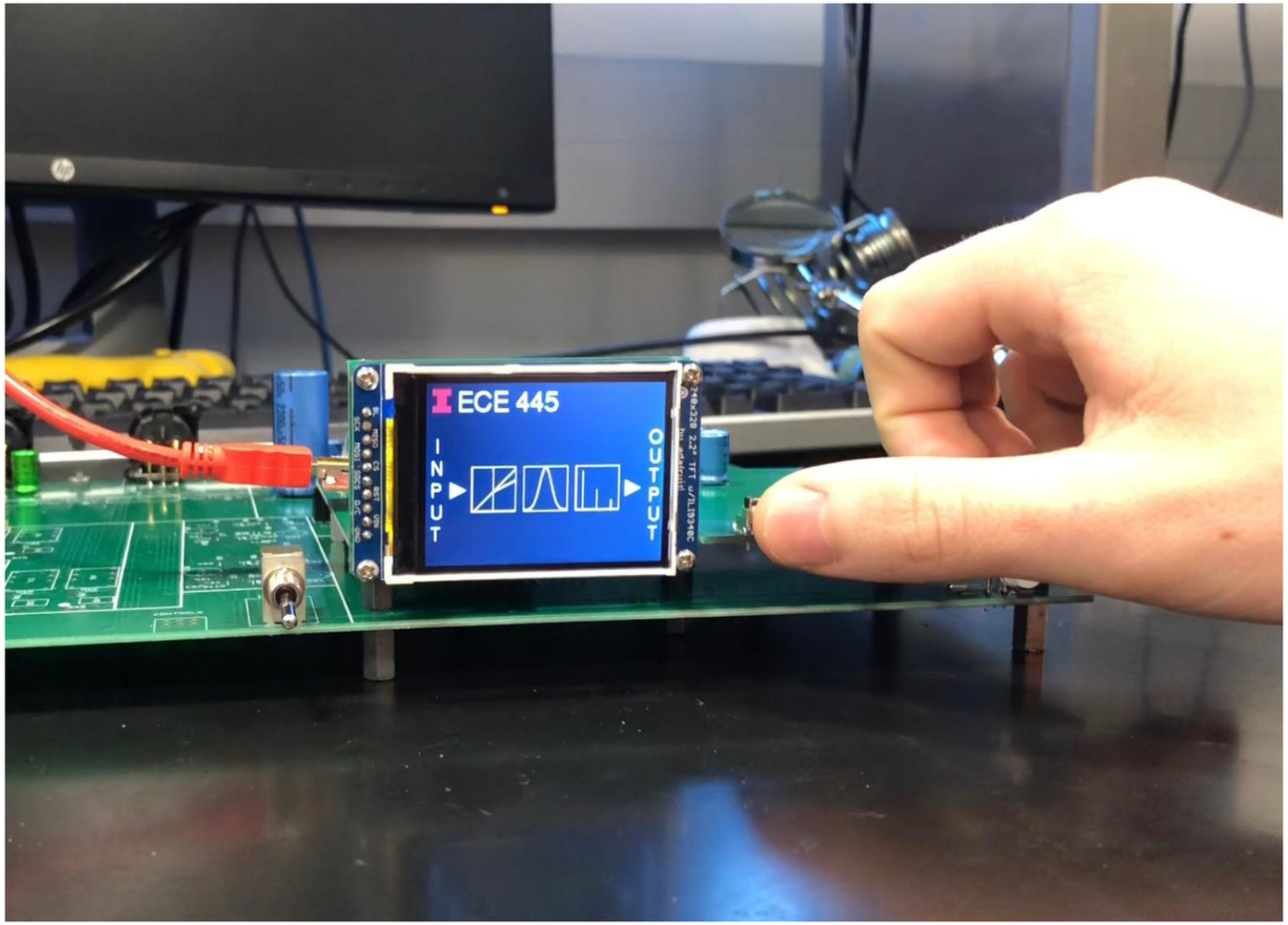
IN>EQ>OUT
SAT Button Pressed?
COMP Button Pressed?
SAT Button Pressed?
COMP Button Pressed?
SAT Button Pressed?
IN>EQ>SAT>OUT
IN>EQ>SAT> COMP>OUT
IN>EQ>SAT> COMP>OUT
IN>EQ>SAT>OUT

Design: UI



Conclusion

- Requirements have been satisfied for all blocks!

Future Work

- Monitoring and DSP functions
- Knob Recall
- Chassis
- Upgraded Processing Blocks