Indian Institute of Technology, Bombay
Department of Electrical Engineering

EE 344
Electronic Devices Lab
Milestone 3
Initial subsystem testing review

DSO

Submitted by -

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Harsh Lulla
Harsh Choudhary

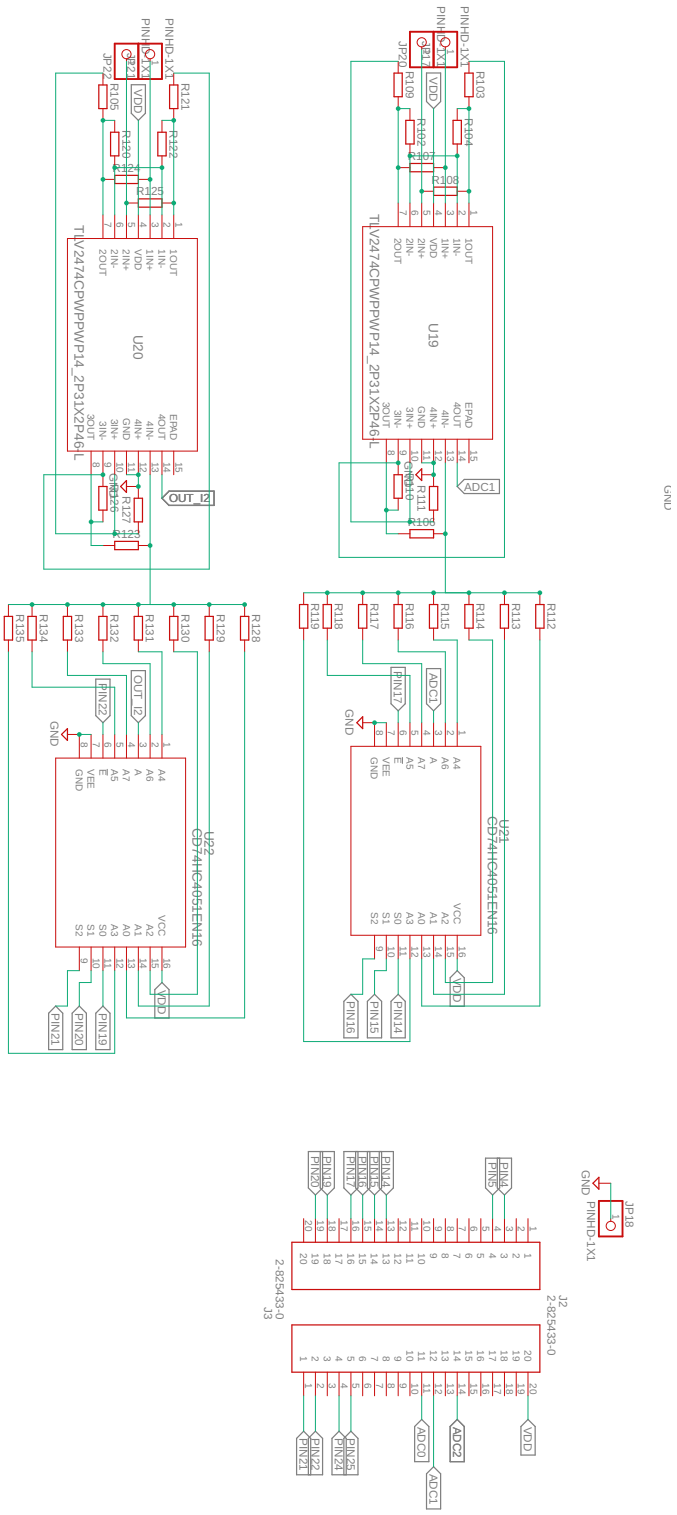
Guided by -

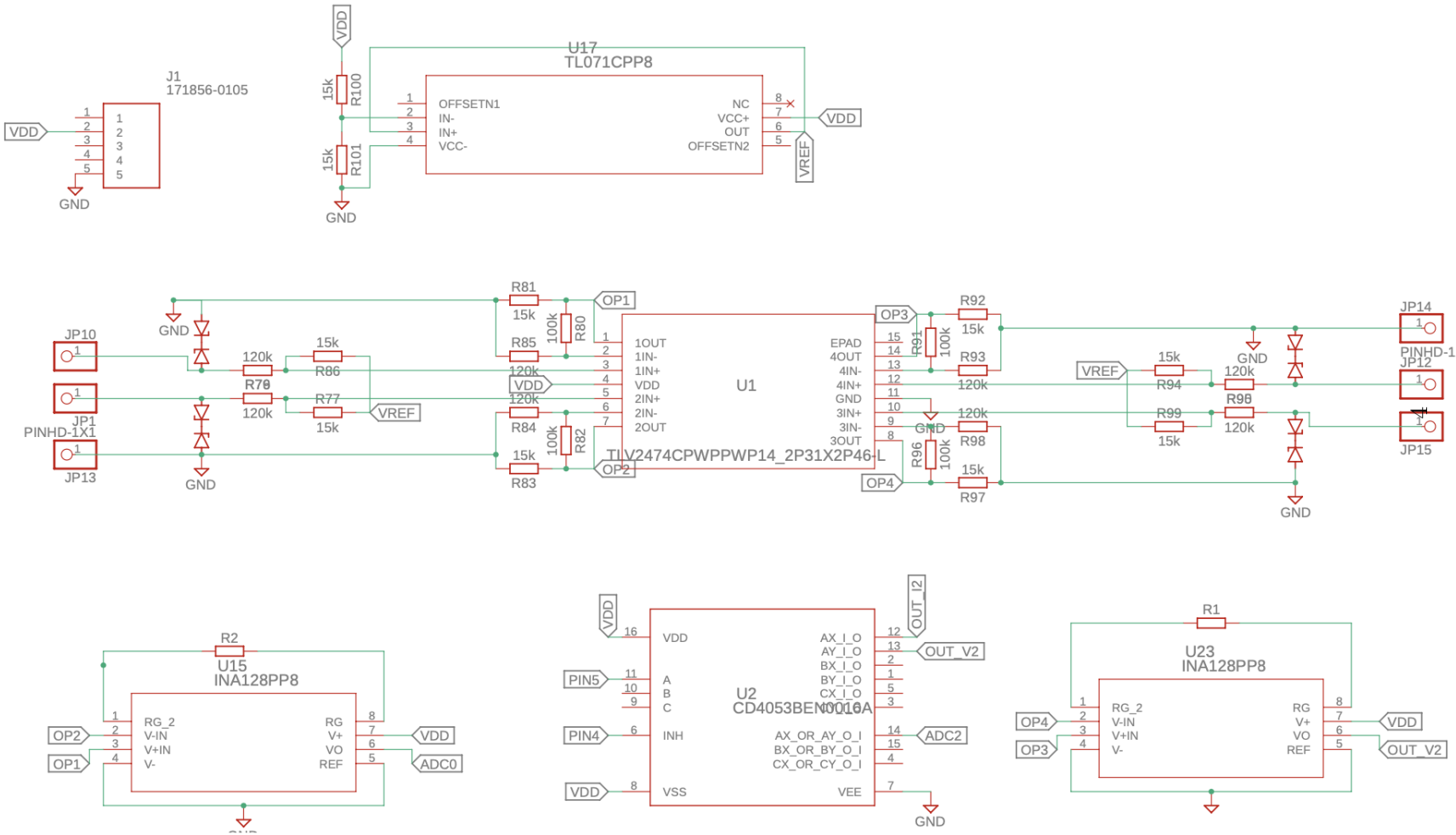
Prof. Joseph John
Prof. PC Pandey

Contents

1 Design

1.1 Circuit Schematic




J1
171856-0105
VDD
GND
U17
TL071CPP8
R100
15k
R101
15k
OFFSETN1
IN-
IN+
VCC-
NC
VCC+
OUT
OFFSETN2
VREF
JP10
JP1
PINHD-1X1
JP13
120k
R86
R78
R77
R81
R85
R84
R83
100k
R80
R82
OP1
OP2
U1
TLV2474CPWPPWP14_2P31X2P46-L
1OUT
1IN-
1IN+
VDD
2IN+
2IN-
2OUT
EPAD
4OUT
4IN-
4IN+
GND
3IN+
3IN-
3OUT
OP3
OP4
R91
R92
R93
R96
R97
R98
R99
R94
JP14
JP12
JP15
PINHD-1
U15
INA128PP8
R2
RG_2
V-IN
V+IN
V-
RG
V+
VO
REF
ADC0
U2
CD4053BEN0016A
OUT_I2
OUT_V2
PIN5
PIN4
A
B
C
INH
VSS
AX_I_O
AY_I_O
BX_I_O
BY_I_O
CX_I_O
AX_OR_AY_O_I
BX_OR_BY_O_I
CX_OR_CY_O_I
VEE
ADC2
U23
INA128PP8
R1

1.2 PCB Layout

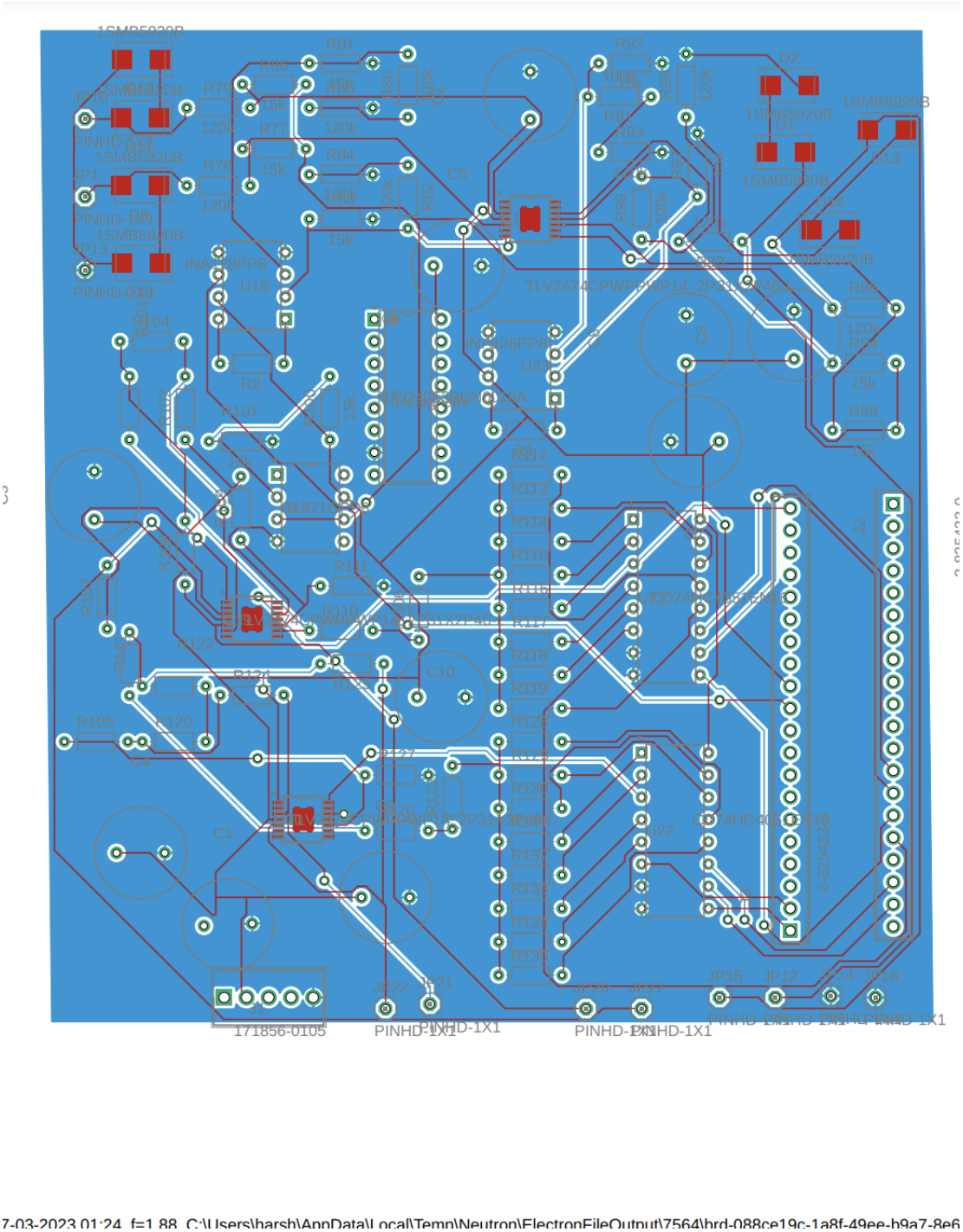


Figure 1:

1.3 CAD Design

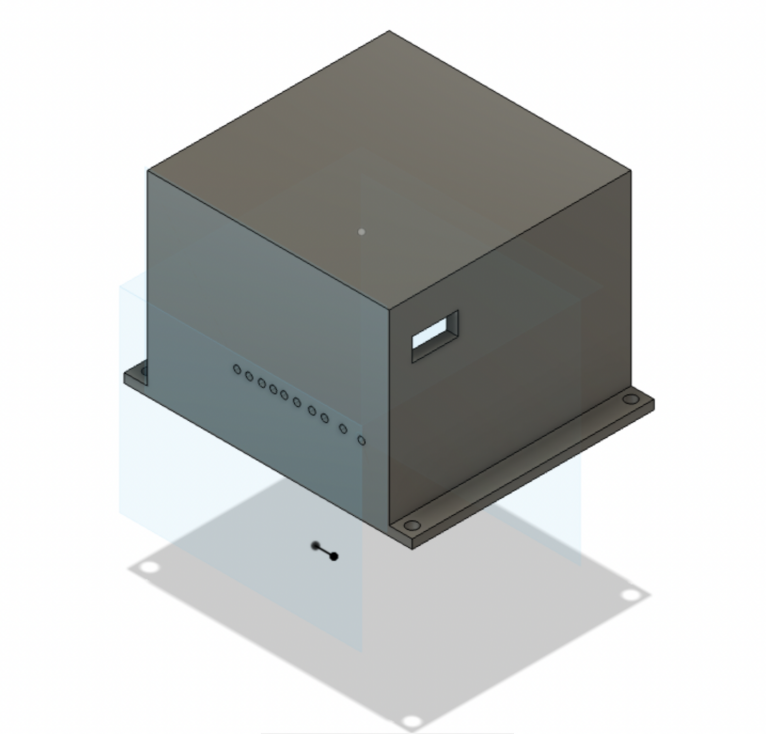


Figure 2: Home View

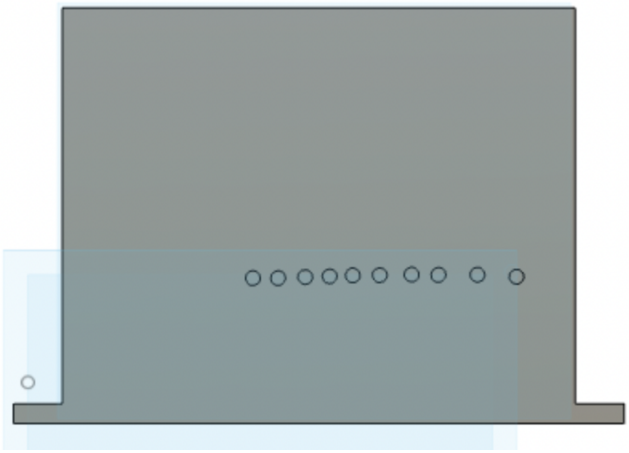


Figure 3: Front View

2 Description of the test setup and test method

2.1 Overvoltage protection circuit

We have used the following circuit with two Zener diodes of breakdown voltage in series

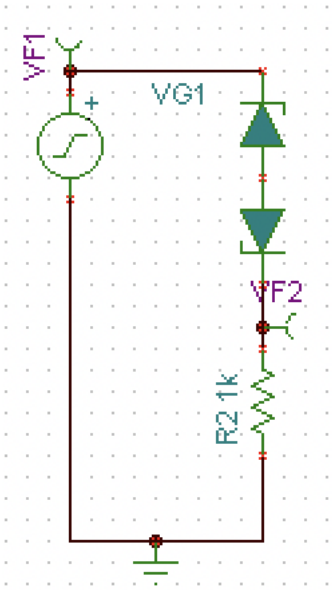
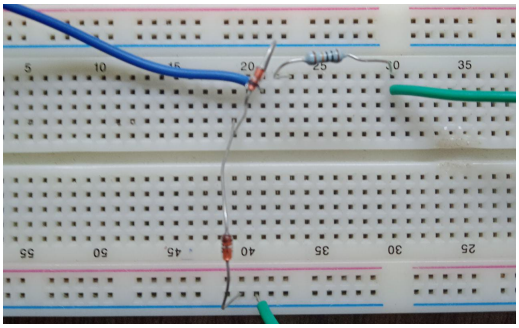


Figure 4: Over Voltage protection using Zener Diodes

For testing it we have connected a resistor and ammeter to the circuit as shown



2.2 Voltage Scaling and shifting

We have used the following circuit for linear transformation of input voltage to fit it in the 0-5V range

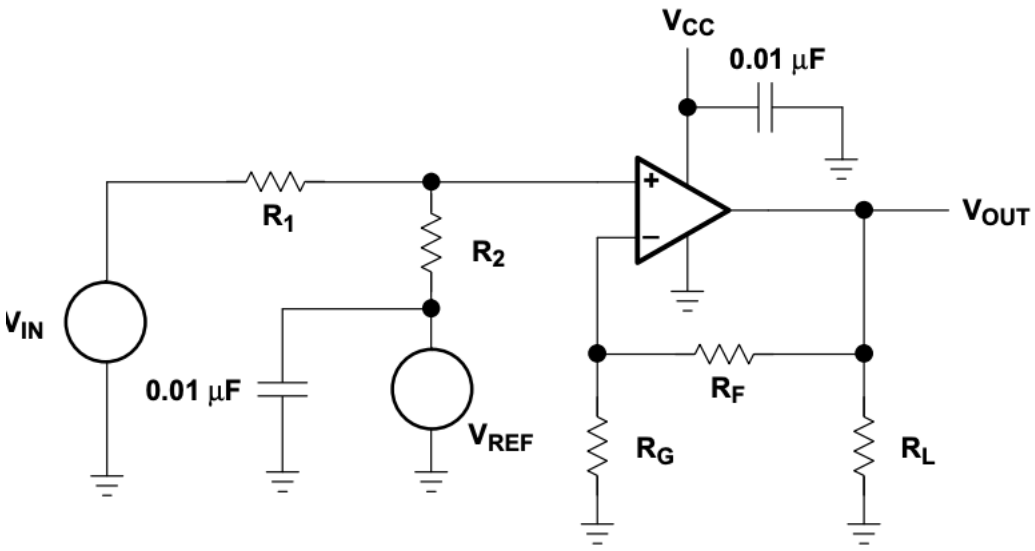


Figure 5: voltage scaling and shifting using Op amp

For testing it we have made the shown circuit on the breadboard and plotted the voltage curve vs Input voltage Curve

2.2.1 Issues Faced

- Earlier we were using TL071 op amp for this purpose, it was giving incorrect results so we changed to TLV 2474 which is a rail-to-rail op-amp
- Due to finite resistances at the inverting terminal, it drew significant current, so we decided to use a voltage buffer in between.
- In the previous report, we had proposed a simpler circuit with 3 resistors but it was giving large errors in the output.

2.3 Amplification circuit

We are using INA128 for this purpose, it is an instrumentation amplifier. To take the difference between the two input voltages, it has high input impedance and we have set gain approximately equal to 1

For testing, we had simply given differential input from a voltage generator and checked it using an oscilloscope.

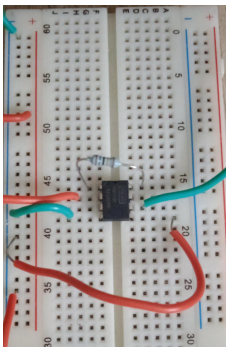


Figure 6: Testing of instrumentation Amplifier for high Rg

2.4 I to V converter

For testing, we had given current input and measured the output of the circuit using an oscilloscope as shown.

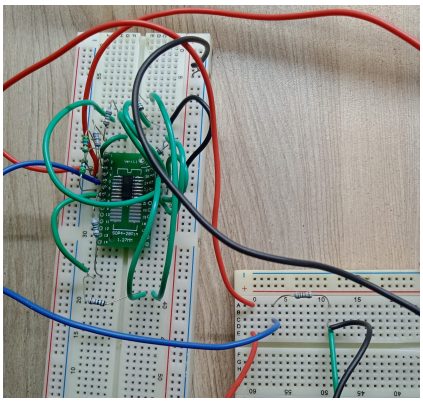


Figure 7: Test Setup for I to V converter on breadboard

We were guided to use this but we were not able to get correct results in the simulation and on a breadboard.

2.5 Bluetooth Transmission

2.5.1 Issues Faced

- We were not able to access it with laptop using the cable as it provided was only for power transmission and was not to be used for data transmission
- It was not getting connected with other Bluetooth devices, we found that reason for it was that raspberry pi pico sometimes does not behave properly, if we take power from it so we decided to use a separate power supply

To transmit data from Bluetooth, we connected the HC05 module to the microcontroller

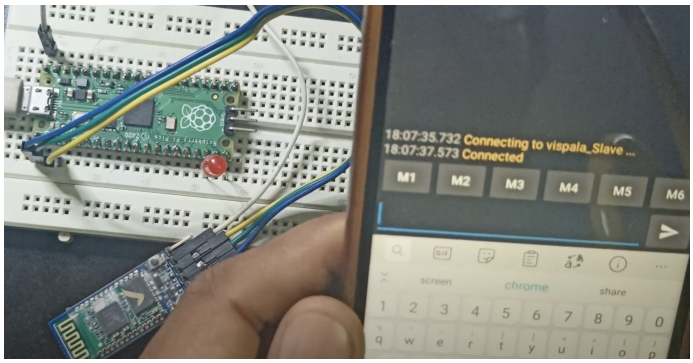
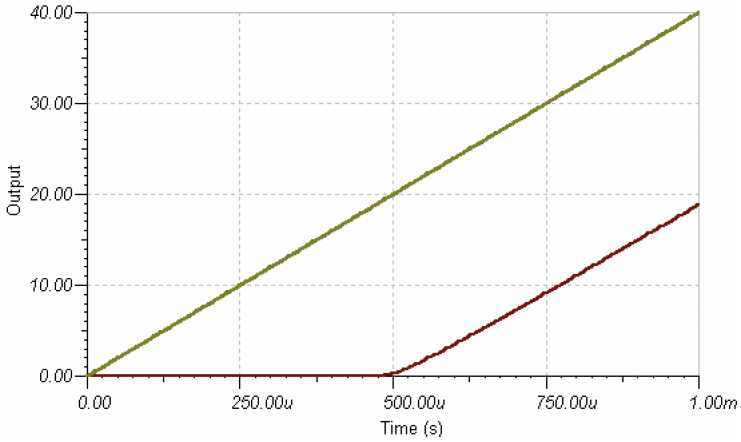


Figure 8: Testing Bluetooth transmission using Rpi Pico and HC-05

3 Test Results

3.1 Over voltage protection circuit

Simulation results for the following circuit are as shown:



While testing on a breadboard, the knee point was at 22.6 volts

3.2 Voltage Scaling and shifting

With this circuit, We have scaled it down by a factor of 1/8 and shifted it by 2.5 volts to bring it in the range of 0 to 5. For this purpose we set resistor values as R2, RF equals 15k ohms, and R1, Rg equals 120k ohms

Input Voltage	Expected Output Voltage	Output Voltage
-16	0.5	0.56
-8	1.5	1.49
-4	2	1.93
4	3	2.95
8	3.5	3.47
12	4	4.02
16	4.5	4.34
20	5	4.95

3.3 I to V converter

We are getting unpredictable outputs for this, till now, we have tried it on simulation tool and on breadboard.

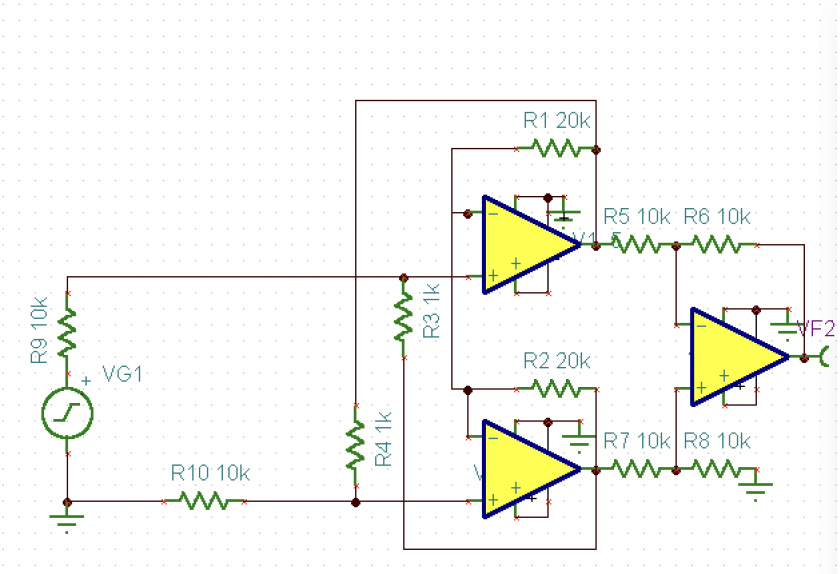


Figure 9: I to V conversion Circuit for simulation in Tina-Ti

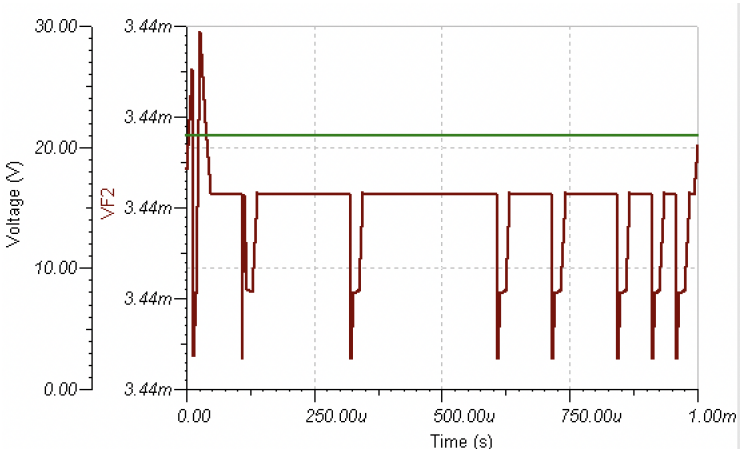


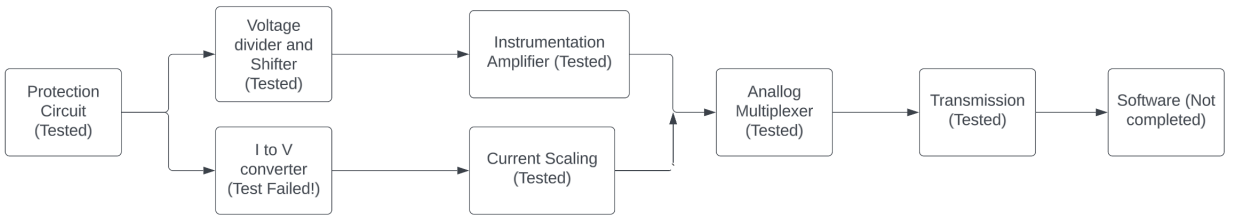
Figure 10: Simulation Results

3.4 Other Results

- Instrumentation Amplifier INA128 was successfully tested for the required voltages.
- Bluetooth Transmission from Microcontroller to mobile phone was successful
- ON-resistance of Multiplexer came out to be 125 ohms, so we needed to connect higher load resistance between the i/o pin of the microcontroller and ground
- Scaling of the voltage corresponding to current was done using inverting amplifier, multiplexer and the microcontroller
- We were able to make a GUI which displays the plot for random data

3.5 Block Diagram and Test Percentage No

- As per the importance of different tests, we can infer that Test Percentage No is around 0.70



4 Next Step

4.1 Work to be done

1. Coding for Microcontroller: The code for transmitting the instructions from laptop to hardware is to be written.

2. Debugging current to voltage convertor: It failed multiple times in testing for all the groups, so we will try to investigate the source of the error if possible, otherwise, we will use a simpler converter which uses a sense resistor as shown

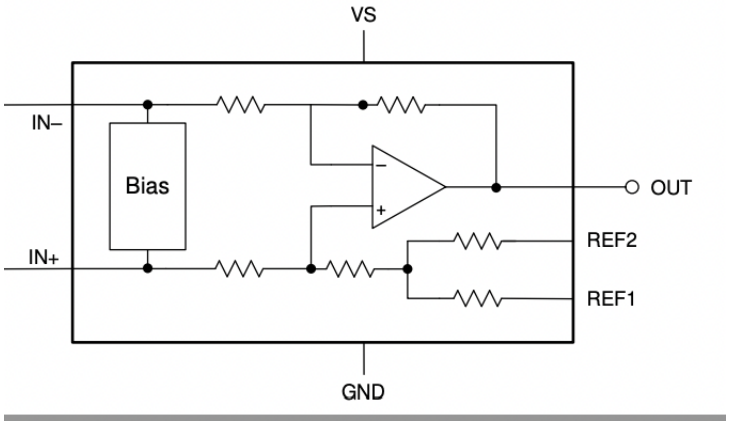


Figure 11: I to V conversion using sense resistance

3. Completing the GUI: We are working on the GUI which is based on Numpy, PyBluez, PyQtgraph, and PySide, it is the intermediate sketch of our oscilloscope output

4. Soldering: We have 4 measurement circuits and they are various components that need to be soldered after getting the PCB for the circuit

5. Dividing the PCB: As described above, we have a relatively large circuit and to make the device portable, we are planning to divide the PCB into 2 halves and make changes in so that we can stack them one over another using double-sided pin headers.

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4.2 Work Distribution

- Coding For microcontroller: Harsh Lulla, Harsh Choudhary
- Debugging: current to voltage converter: Harsh Choudhary
- Soldering: Abhinav Ghunawat, Harsh Lulla
- Completing GUI: Harsh Lulla
- Dividing the PCB: Harsh Choudhary

4.3 Day-Wise Timeline

27/03	Debugging I to V converter and modifying the PCB for printing
29/03	Soldering and 3-D printing of the packaging
3/04	Soldering and Testing of PCB for voltage input part
5/04	Soldering and Testing of PCB for current input part
10/04	Integrating the hardware and software
31/03	Coding for microcontroller
31/04	Completing the GUI

5 References

1. I to V converter from Pg no.156 Burr-Brown-The handbook of linear IC applications
2. I to V conversion using sense resistance, application note of INA 240
3. Voltage Converter and shifter from Section 4-9 Op Amps for Everyone by Ron Mancini