Zewail City of Science and Technology

Advanced Electric Circuits
CIE 301

Stage III report - Load Cell

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January 8, 2024

Contents

1 Extracting the Raw Signal

1.1 Load Cell setup

- A piece of wood was used to fix the load cell. This was done to get the correct raw signal to be processed as shown in figure 1.

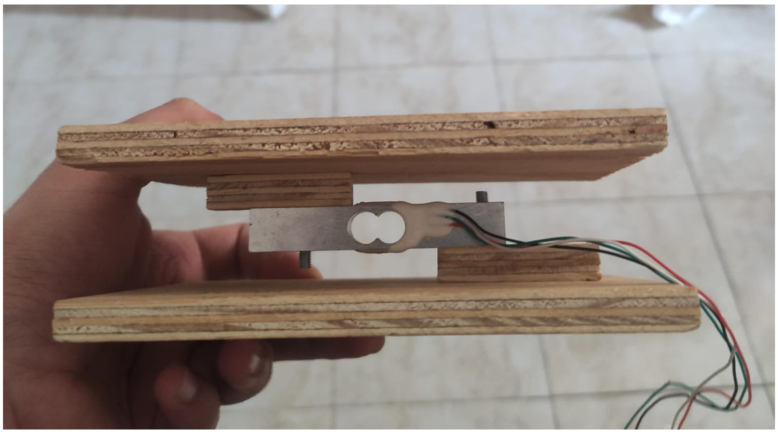

Figure 1: Load cell fixed with a piece of wood.

- From the datasheet, we were able to get the proper connection between the load cell and the Analog discovery as shown in figures 3 and 2.

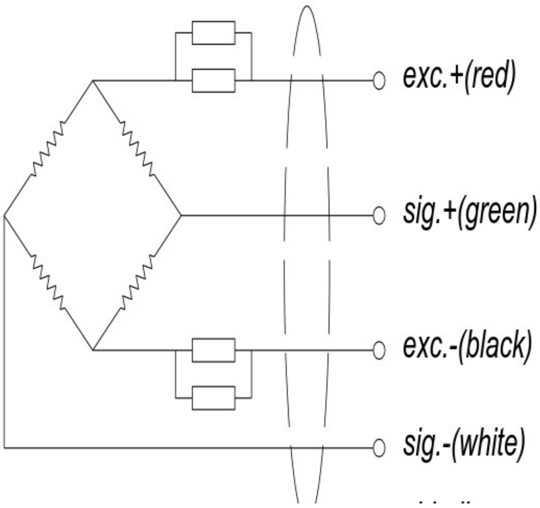

Figure 2: Connections of the Load Cell to Analog Discovery.

- Analog Discovery was connected to the load to extract the signal. A setup of the connection is shown in figure 3

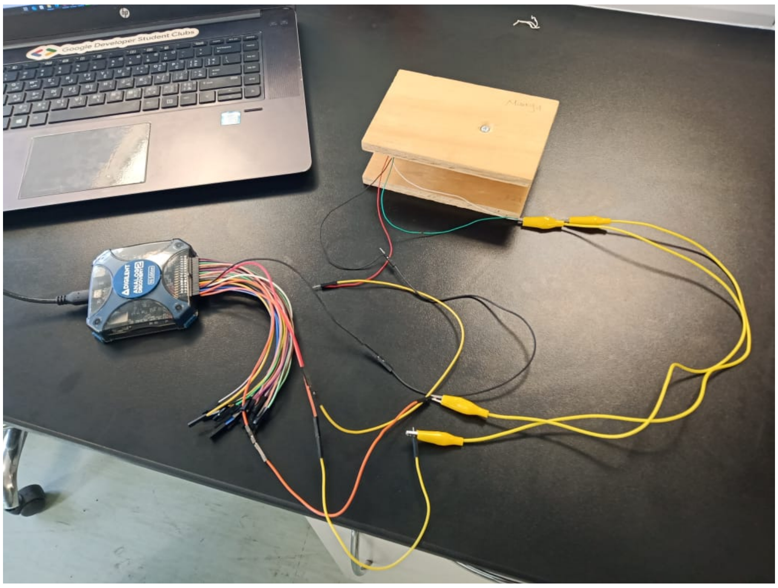

Figure 3: Load cell connected with Analog Discovery.

- Using Analog Discovery with WaveForms software, data points for the raw signal were obtained and loaded into LTSpice as shown in figure 4.

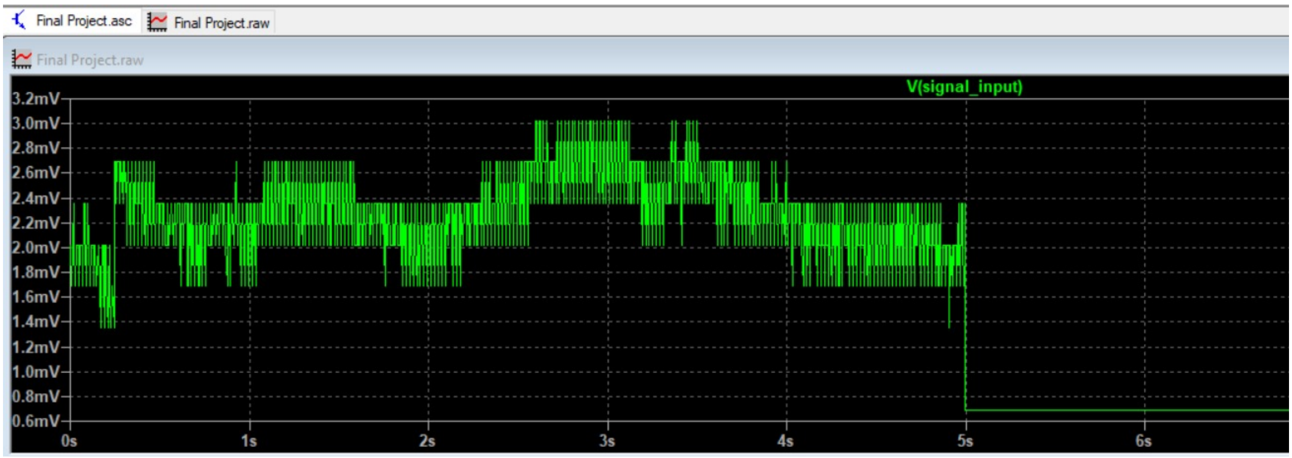

Figure 4: Raw signal on LTSpice.

1.2 Analysis of the Raw Signal

From the datasheet of the load cell, it was stated that the output voltage ranges from 0.85 to 1.15 mV and the voltage increases with increasing the mass. It's clear that the signal from figure 4 that the signal is noisy. So, a proper filter is designed to filter the signal from the noise to process the signal.

2 Finding Cutoff Frequency

- The highest magnitude obtained equals -96.8932 dB at a frequency equal to 15.744 Hz as shown in figure 5.
- The cutoff frequency is decided to be at 15 Hz.

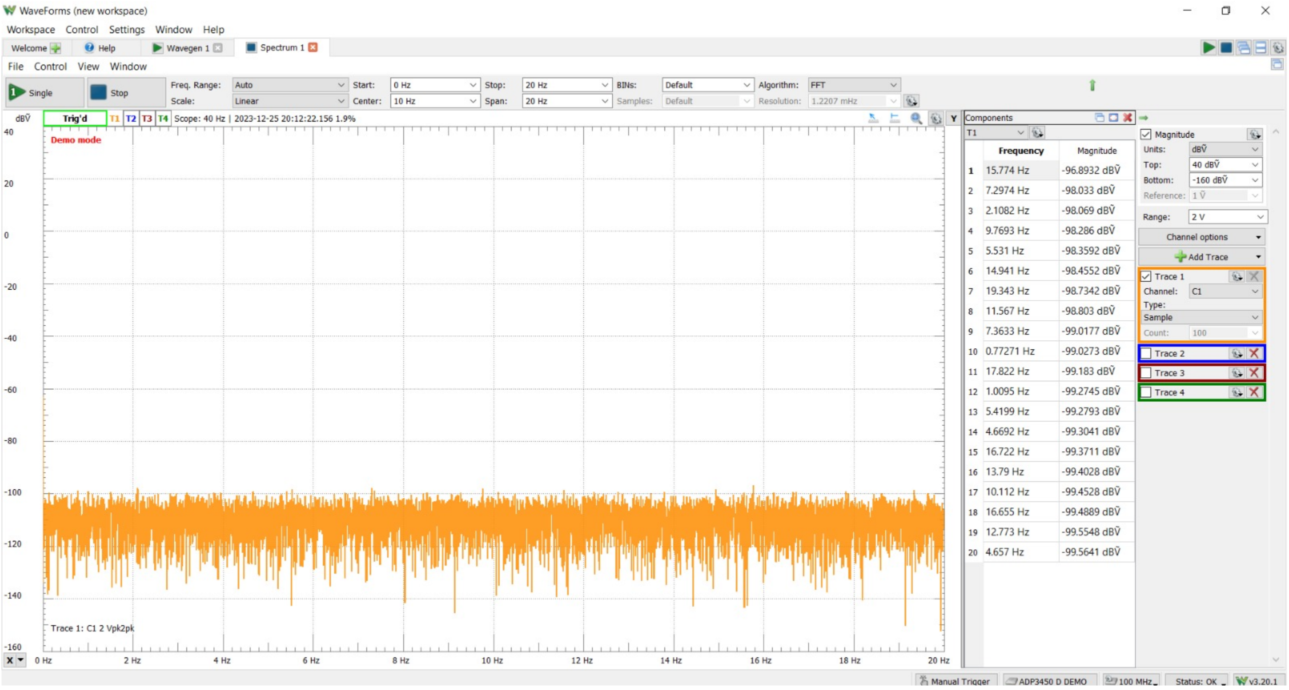

Figure 5: Spectrum of the extracted signal.

3 Design Suitable Filter

- By using the "Analog Filter Wizard" design tool, this was the design chosen to be our active filter depending on the chosen cutoff frequency and with a gain equal to 320 V/V. Figure 6 shows the design of the filter used to filter the raw signal and the amplifier used to amplify it.

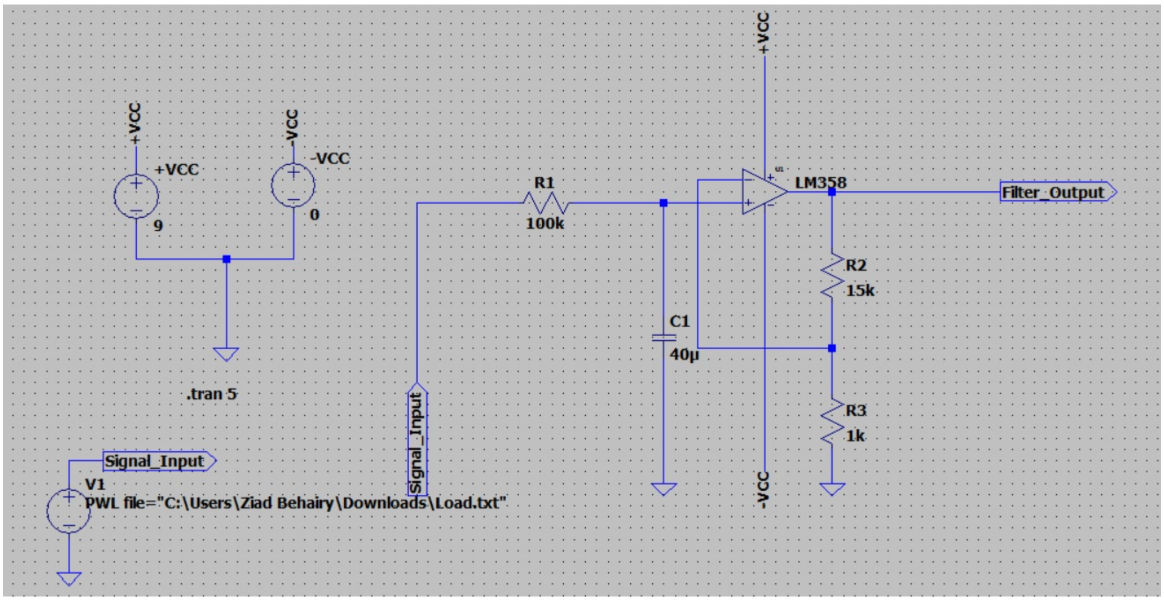

Figure 6: Design of the filter used with the raw signal.

- The active low pass filter graph was obtained from the "Analog Filter Wizard" design tool, figure 7.

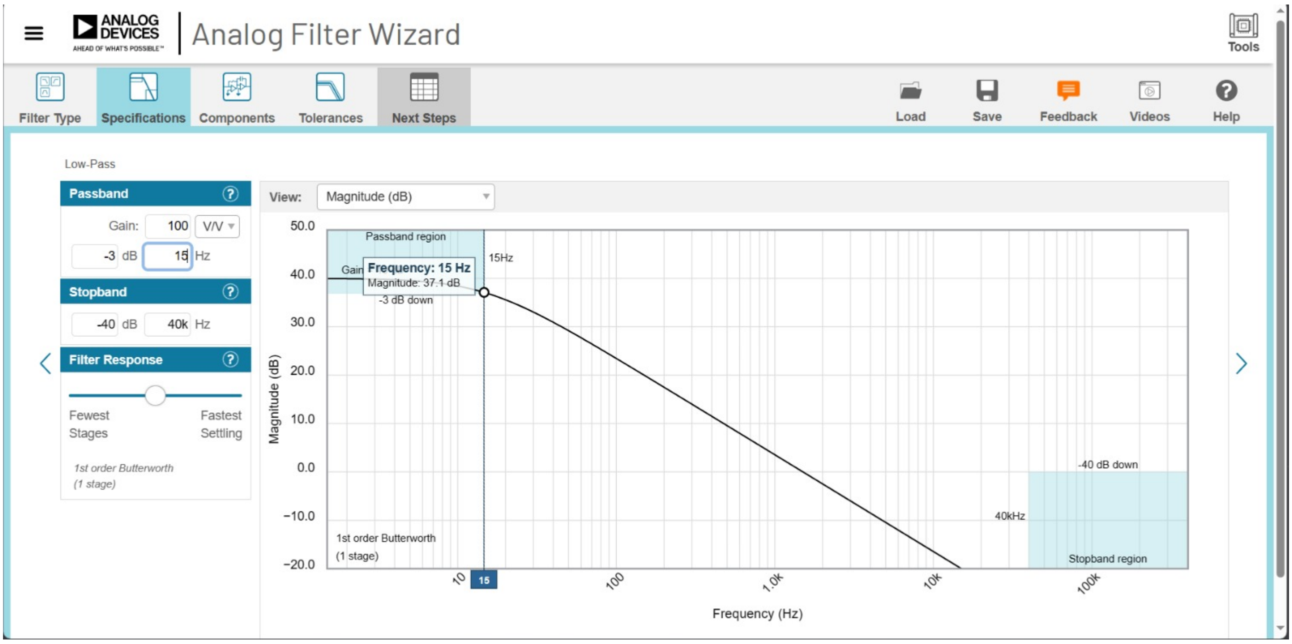

Figure 7: Design of the Filter and amplifier used with the raw signal.

4 Checking The Designed Filter On LTSpice (Filtered signal)

- The model of LM358 was imported to LTSpice to use it in the hardware of the circuit. Figure 8 shows the filtered signal curve on LTSpice.

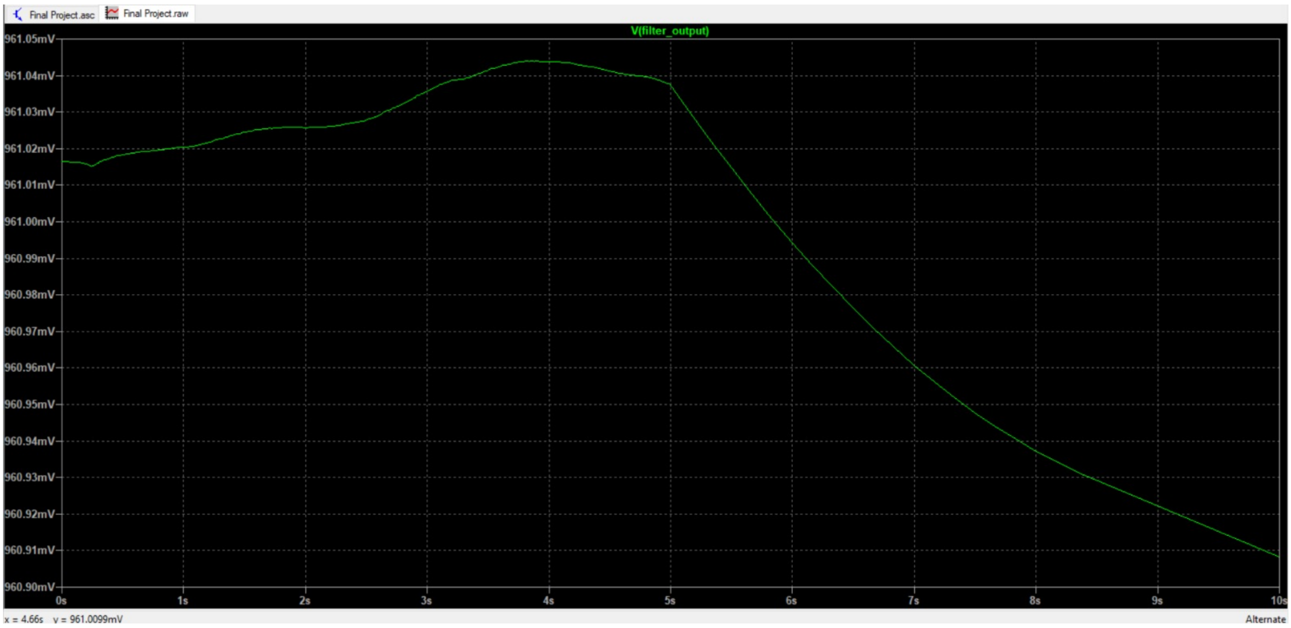

Figure 8: Filtered signal.

5 Amplification for the Filtered Signal (Final Output)

- Figure 9 shows the design of the amplifier used. We used a non-inverting amplifier where the output voltage is given by

$$V_{\text{out}} = \left(1 + \frac{R_f}{R_{\text{in}}}\right) V_{\text{in}}$$

The gain is given by

$$A_v = \frac{V_{\text{out}}}{V_{\text{in}}} = \left(1 + \frac{R_f}{R_{\text{in}}}\right)$$

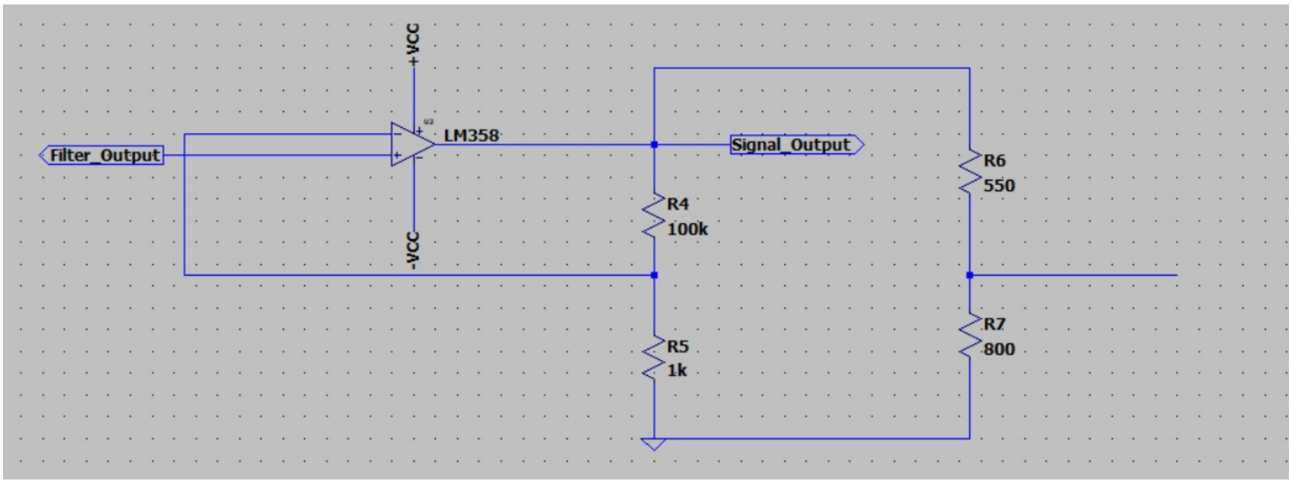

Figure 9: Design of the Amplifier used with the raw signal.

- Figure 10 shows the final filtered and amplified signal on LTSpice. The final output signal voltage was adjusted between 4 and 5 V to process the signal and use it with NodeMcu, which will enable us to read the mass put on the load cell via a mobile.

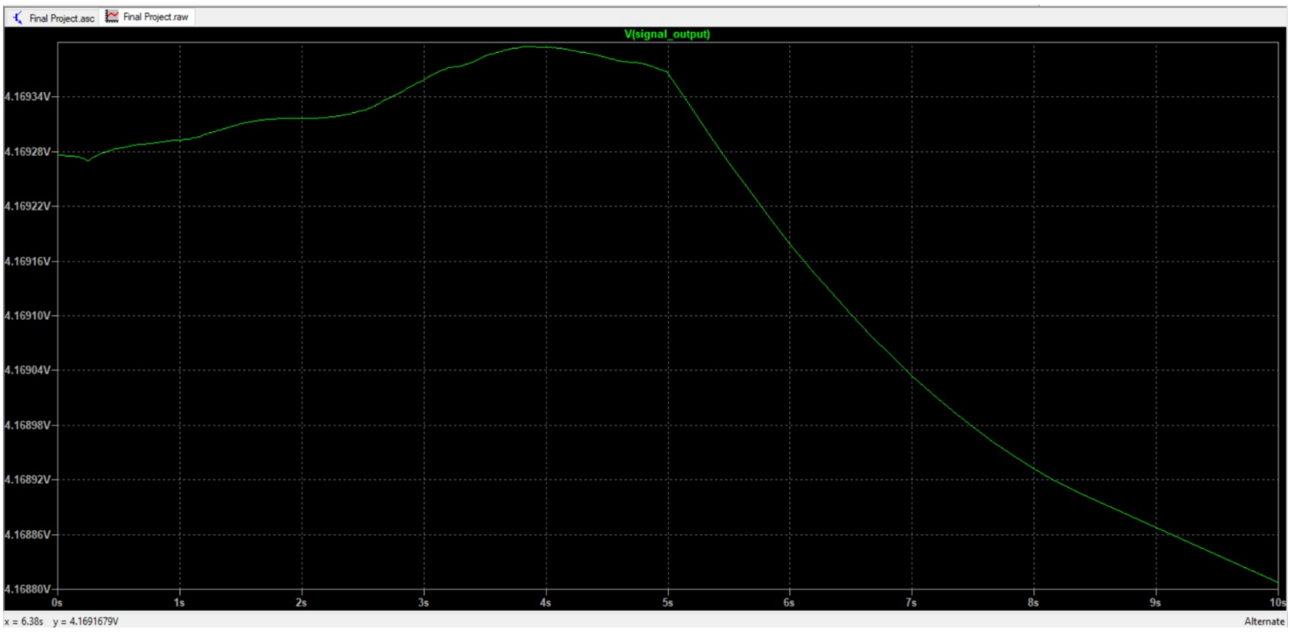

Figure 10: Filtered signal.

6 Final working circuit

6.1 LM358

We used LM358 as an amplifier in our circuit. Figure 11 shows a schematic of the amplifier.

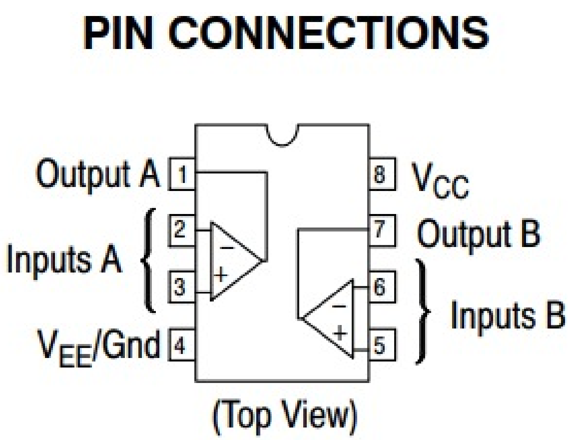

Figure 11: LM358 schmatic.

We also utilizied its datasheet shown in figure 12 to know the range of voltage for the amplifier.

LM258, LM358, LM358A, LM358E, LM2904, LM2904A, LM2904E, LM2904V, NCV2904

MAXIMUM RATINGS (T_A = +25°C, unless otherwise noted.)

Rating	Symbol	Value	Unit
Power Supply Voltages Single Supply Split Supplies	 V_{CC} V_{CC}, V_{EE}	 32 ±16	Vdc
Input Differential Voltage Range (Note 1)	V_{IDR}	±32	Vdc
Input Common Mode Voltage Range	V_{ICR}	−0.3 to 32	Vdc
Output Short Circuit Duration	t_{SC}	Continuous	
Junction Temperature	T_J	150	°C
Thermal Resistance, Junction−to−Air (Note 2) Case 846A Case 751 Case 626	$R_{\theta JA}$	238 212 161	°C/W
Storage Temperature Range	T_{stg}	−65 to +150	°C
Operating Ambient Temperature Range LM258 LM358, LM358A, LM358E LM2904, LM2904A, LM2904E LM2904V, NCV2904 (Note 3)	T_A	 −25 to +85 0 to +70 −40 to +105 −40 to +125	°C

Figure 12: Datasheet of LM358.

6.2 Hardware Implementation

Figure 13 shows the final hardware implementation of the circuit.

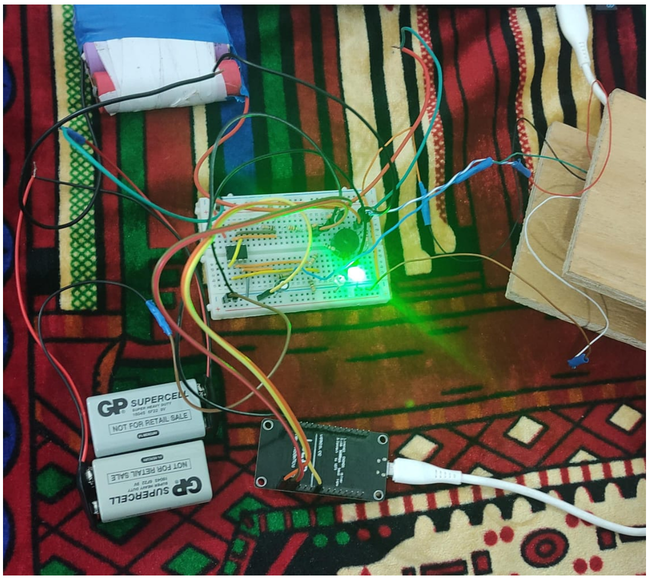

Figure 13: Hardware implementation of the circuit.

Using this circuit with the raw signal, shown in figure 14, we obtained the desired filtered signal, shown in figure 15.

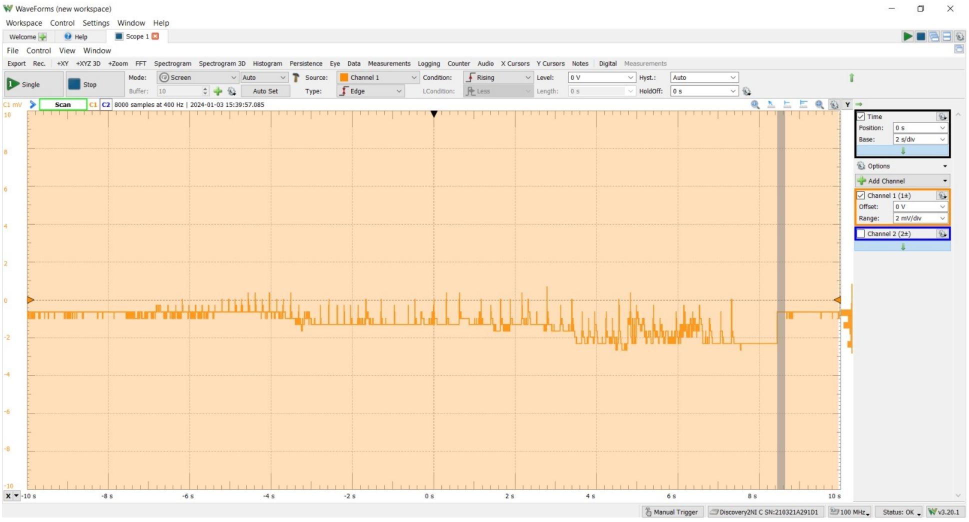

Figure 14: Raw signal.

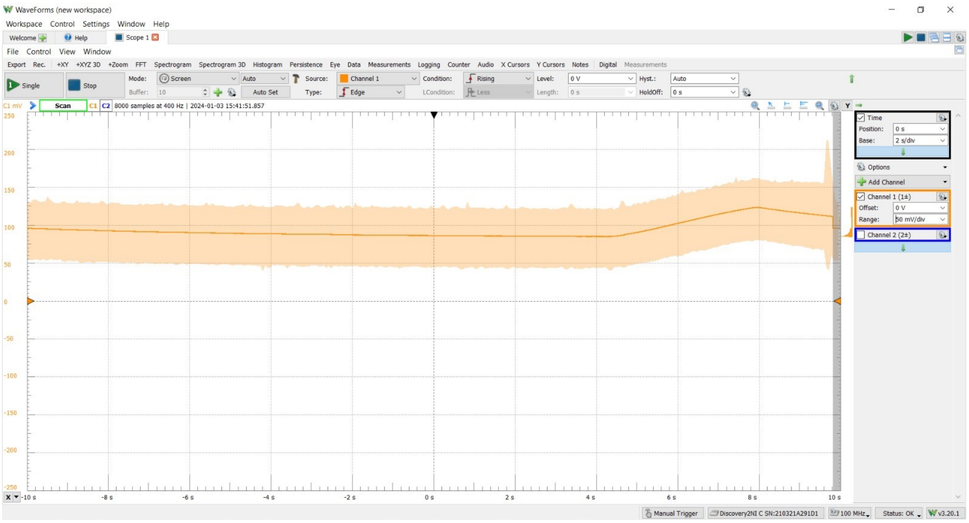

Figure 15: Filtered signal.

Then, we got the final amplified signal shown in figure 16.

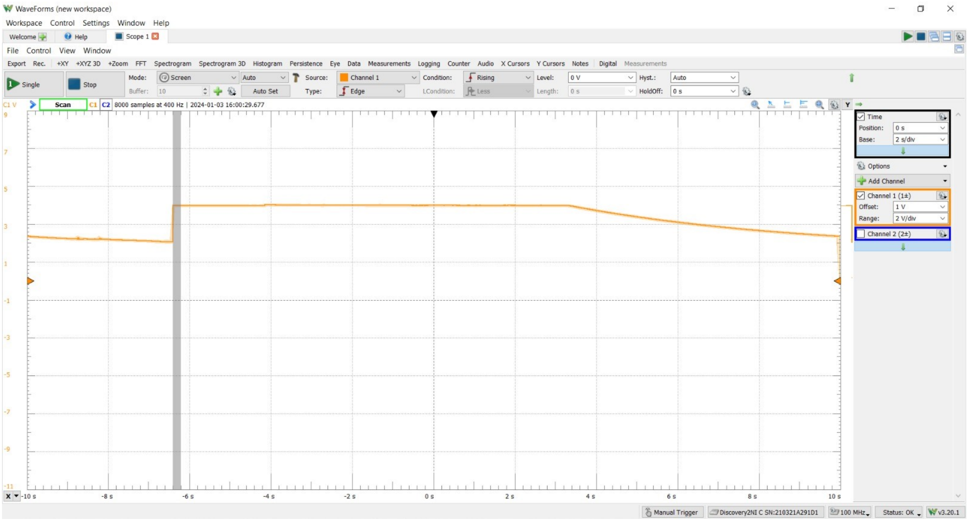

Figure 16: Amplified signal.

6.3 Bonus part: Transferring the signal to readable measurements

The final output signal voltage was adjusted between 4 and 5 V to process the signal and use it with NodeMcu, which will enable us to read the mass put on the load cell via a mobile as shown in figure 17.

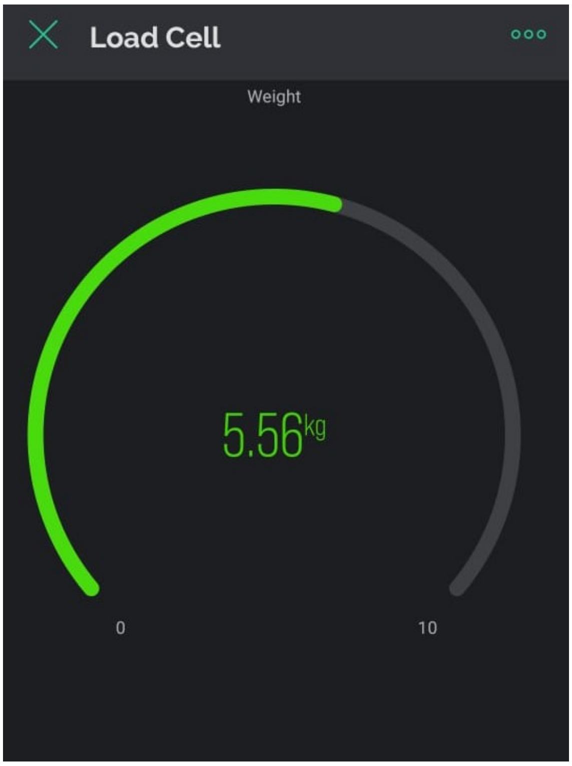

Figure 17: Reading on mobile.

If the reading approaches 8 Kg, the load cell gives a red light, indicating that it is about to reach the maximum value it can read, which is 10 Kg, as shown in figure 18.

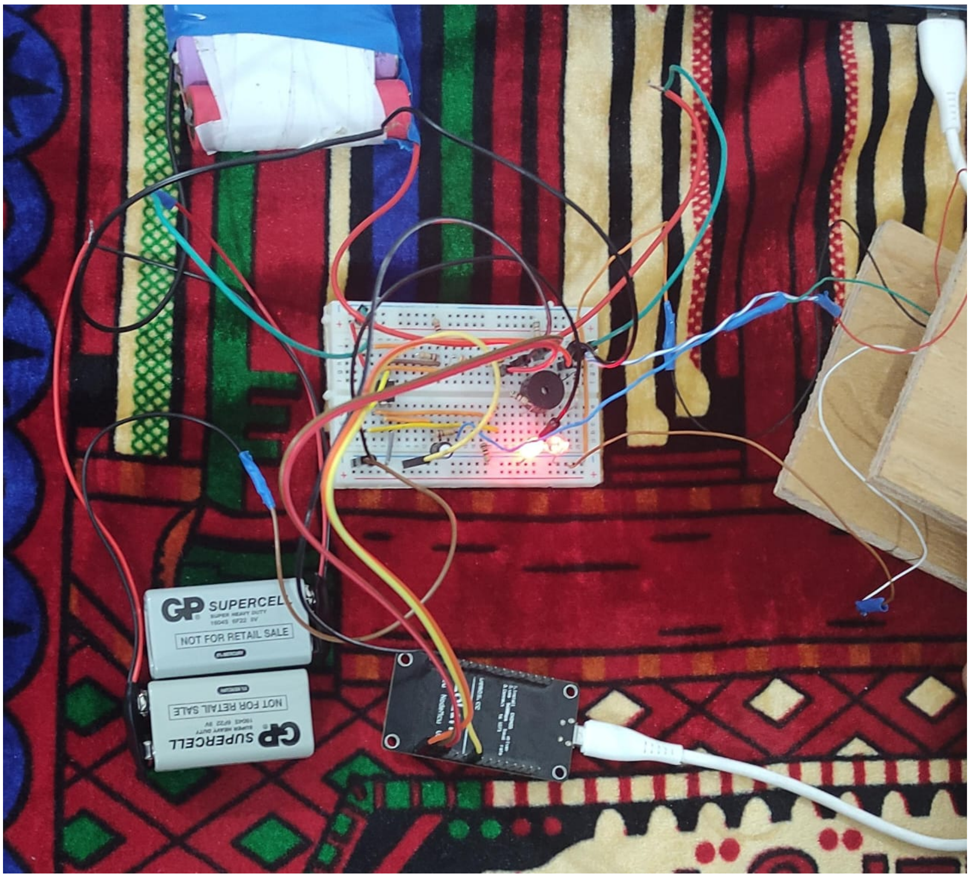

Figure 18: The load cell gives a red light, indicating it is about to reach 10 Kg.