

Write Up

Monday, May 1, 2023 3:20 PM

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Pre-Lab:

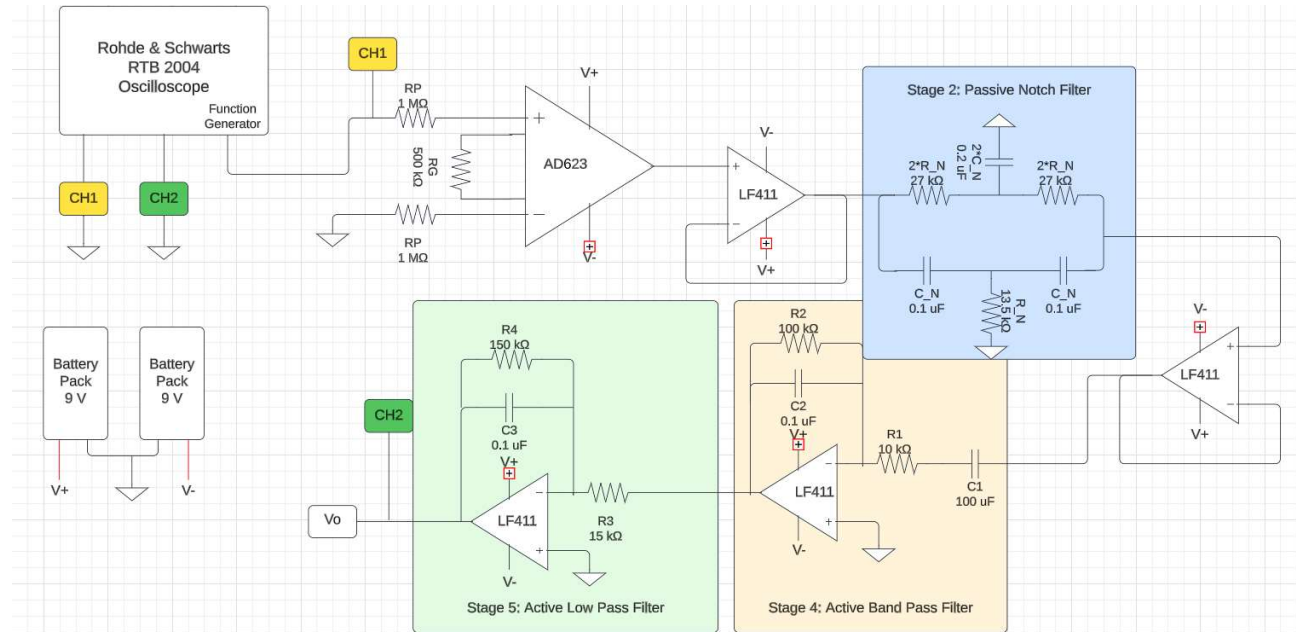


Figure 1: Circuit schematic of improved ECG circuit

Procedure:

NOTE: The color and placement of the oscilloscope probes from Figure 1 correspond to the colors of the oscilloscope outputs in all the following screenshots

Step 1:

Table 1: Ideal and measured values of components for instrumentational op-amp	RP1 [MΩ]	RP2 [MΩ]	RG [kΩ]
Expected	1	1	2.2
Measured	0.98	0.98	2.1

Stage 2:

Table 2: Ideal and measured values of components for stage 2 (passive notch filter)	CN1 [nF]	CN2 [nF]	2CN [nF]	2RN1 [kΩ]	2RN2 [kΩ]	RN [kΩ]
Expected	100	100	200	27	27	13.5
Measured	102.1	102.2	203.5	26.7	26.7	13.3

Stage 4:

Table 3: Ideal and measured values of components for stage 4 (active bandpass filter)	R1 [kΩ]	R2 [kΩ]	C1 [μF]	C2 [nF]
Expected	10	100	100	100
Measured	9.8	98	102.1	103.8

Stage 5:

Table 4: Ideal and measured values of components for stage 5 (active lowpass filter)	R1 [k Ω]	R2 [k Ω]	C1 [nF]
Expected	15	150	100
Measured	14.85	149.6	104.8

Step 3:

Table 5: Circuit behavior for stage 2 at center frequency as shown in Figure 1

Frequency [Hz]	Vin [mVpp]	Vo [mVpp]	Gain [V/V]	Gain [dB]
60	20	1.9	0.095	-0.44

Step 4:

Table 6: Circuit behavior for stage 4 at corner frequencies as shown in Figure 1	Frequency [Hz]	Vin [mVpp]	Vo [mVpp]	Gain [V/V]	Gain [dB]
Corner 1	0.16	20	125	6.25	15.9
Corner 2	10.6	20	168	8.4	18.5

Step 5:

Table 7: Circuit behavior at corner frequency as shown in Figure 1

Frequency [Hz]	Vin [mVpp]	Vo [mVpp]	Gain [V/V]	Gain [dB]
10.6	20	144	7.2	17.2

Step 7:

Table 8: Circuit components and behavior of circuit divider for the instrumentation amp input	R1 [k Ω]	R2 [k Ω]	Vin [mVpp]	Vo [mVpp]	Gain [V/V]	Gain [dB]
Expected	1	10	20	1	0.05	-26
Measured	.98	9.9	20	3	0.15	-16.5

Step 8-9:

Table 9: Data points of input and output of ECG circuit from manual frequency sweep

Frequency [Hz]	Vin [mVpp]	Vo [Vpp]	Gain [V/V]	Gain [dB]
0.1	3	1.2	400	52
0.2	3	4.0	1333	62.5
0.3	3	5.8	1933	65.7
0.4	3	6.8	2267	67.1
0.5	3	7.4	2467	67.8
0.6	3	7.7	2567	68.2
0.7	3	8	2667	68.5
0.8	3	8	2667	68.5
0.9	3	8.1	2700	68.6
1	3	8.2	2733	68.7
2	3	8.2	2733	68.7

3	3	7.8	2600	68.2
4	3	7.4	2467	67.8
5	3	7.0	2333	67.4
6	3	6.4	2133	66.6
7	3	5.8	1933	65.7
8	3	5.3	1767	64.9
9	3	4.7	1567	63.9
10	3	4.3	1433	63.1
20	3	1.5	500	54
30	3	0.57	190	45.6
40	3	0.19	63.3	36
50	3	0.07	23.3	27.3
60	3	0.02	6.7	16.5
70	3	0.03	10	20
80	3	0.035	11.7	21.4
90	3	0.045	15	23.5
100	3	0.045	15	23.5
200	3	0.033	11	20.8
300	3	0.02	6.7	16.5

Step 10:

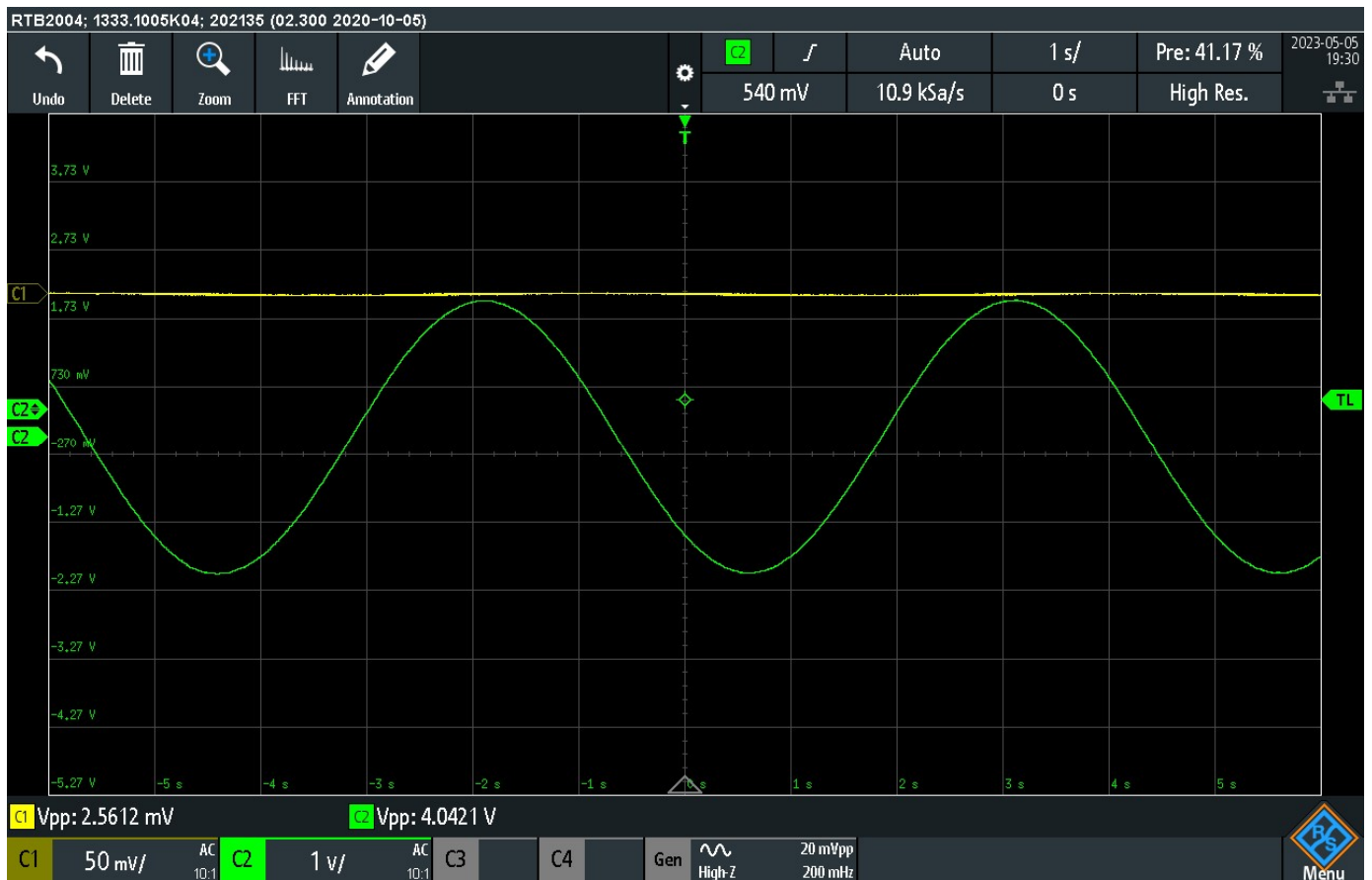


Figure 2: Voltage input (CH1: yellow) at 3 mVpp sine wave and voltage output (CH2: green) of ECG circuit at a corner frequency of 0.16 Hz

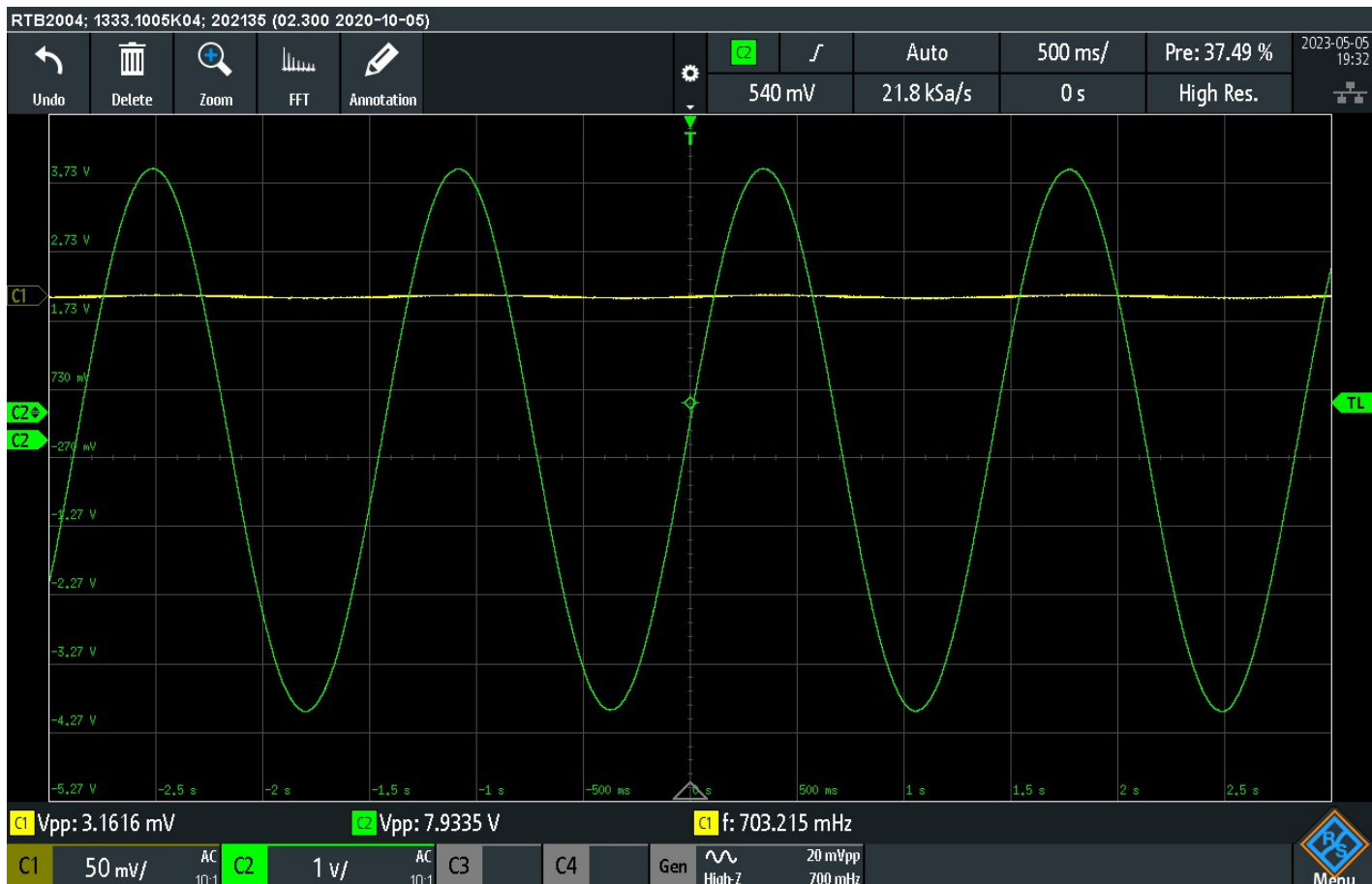


Figure 3: Voltage input (CH1: yellow) at 3 mVpp sine wave and voltage output (CH2: green) of ECG circuit at a pass band frequency of 0.7 Hz

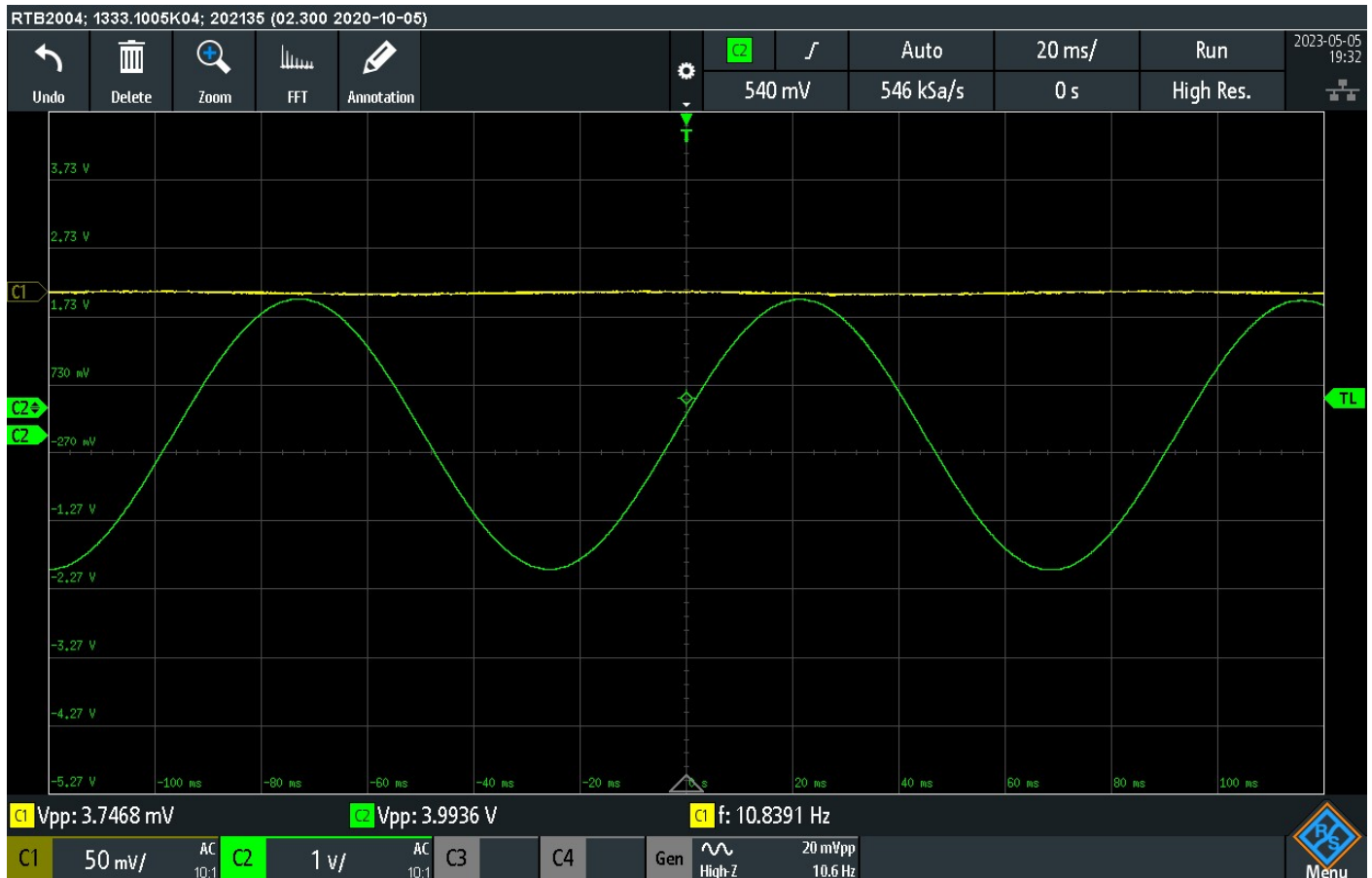


Figure 4: Voltage input (CH1: yellow) at 3 mVpp sine wave and voltage output (CH2: green) of ECG circuit at a corner frequency of 10.6 Hz





Figure 5: Voltage input (CH1: yellow) at 3 mVpp sine wave and voltage output (CH2: green) of ECG circuit at a frequency with descending gain at 30 Hz

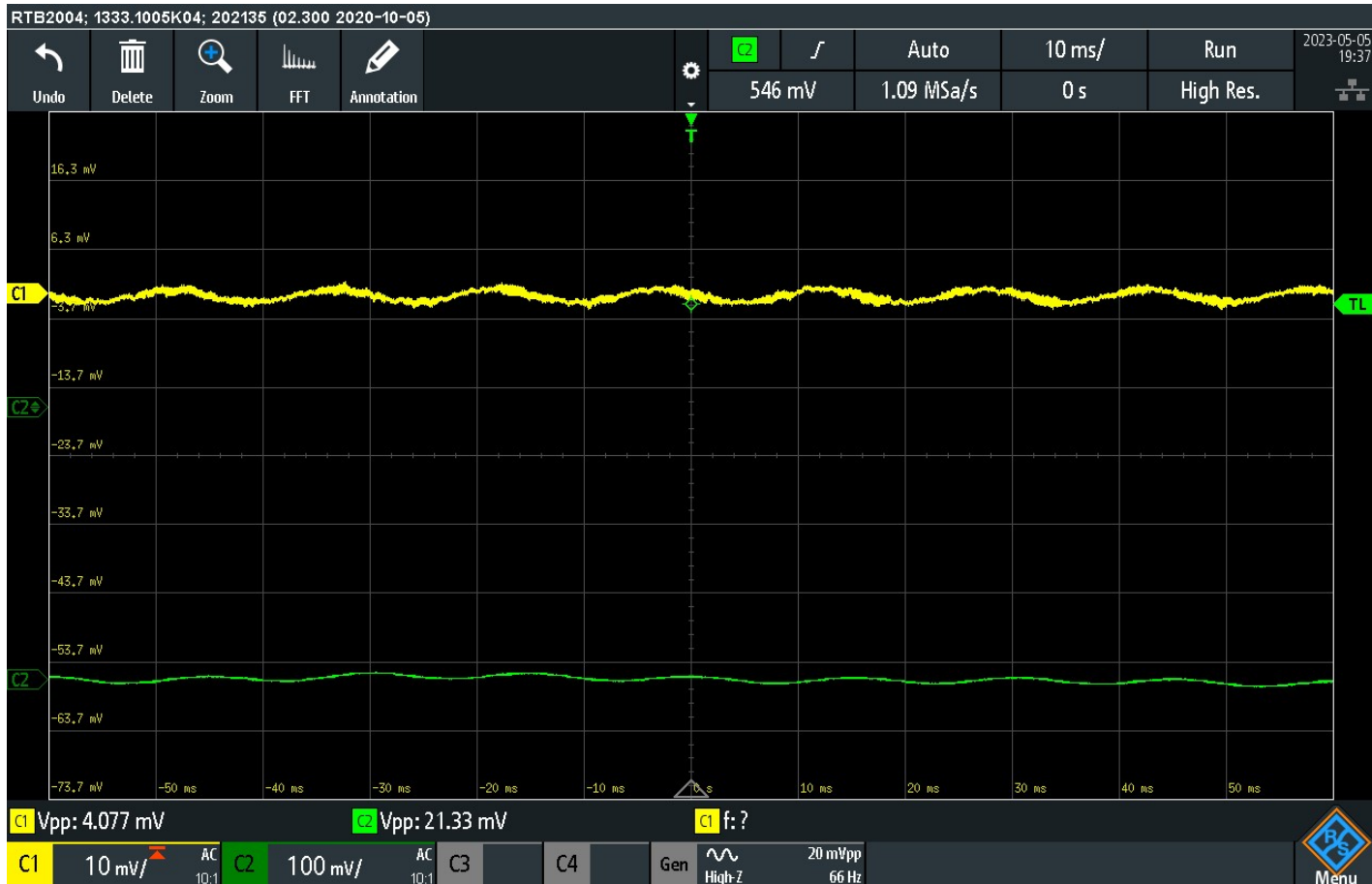
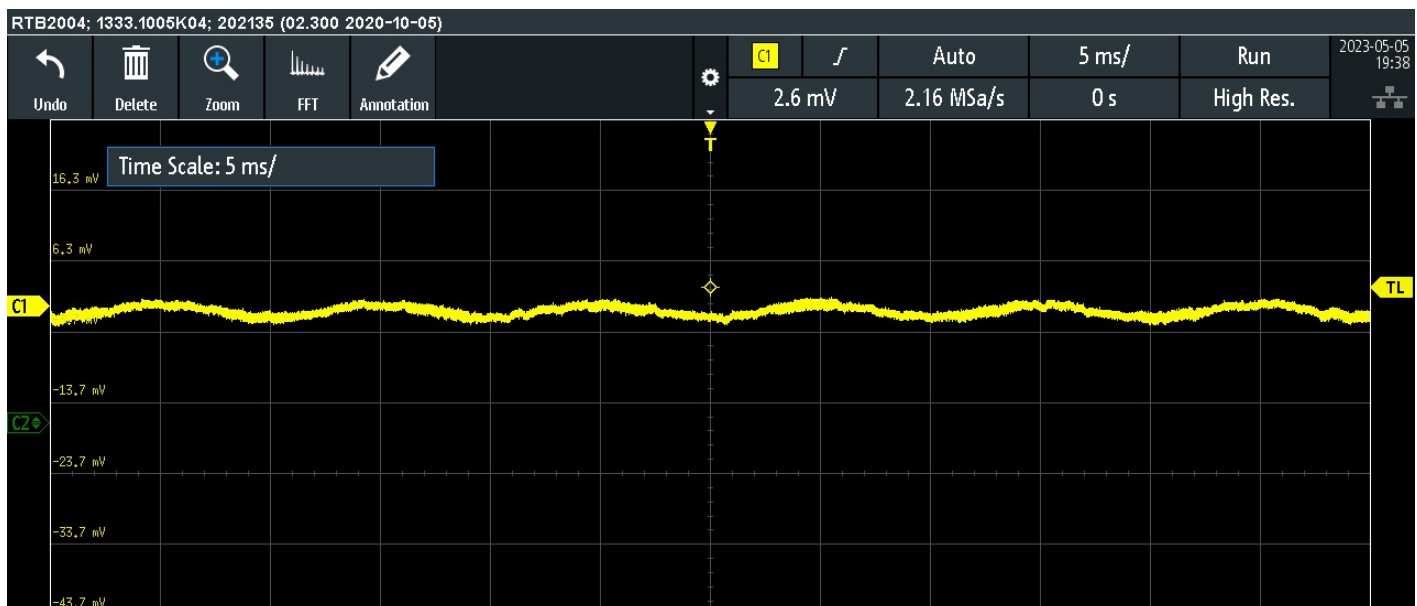


Figure 6: Voltage input (CH1: yellow) at 3 mVpp sine wave and voltage output (CH2: green) of ECG circuit at the center frequency of 60 Hz



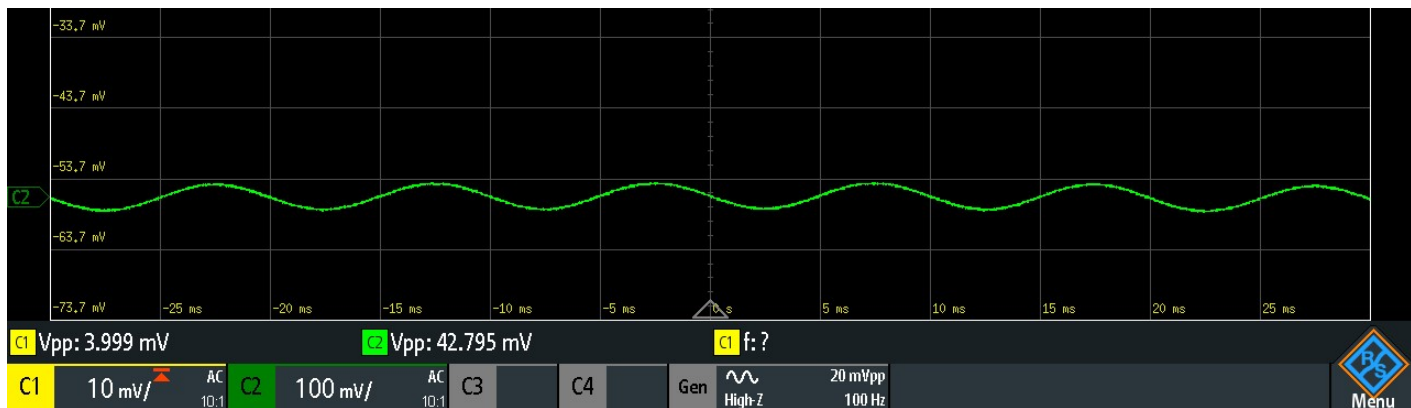


Figure 7: Voltage input (CH1: yellow) at 3 mVpp sine wave and voltage output (CH2: green) of ECG circuit at a higher frequency of 100 Hz

Step 11-12:

Table 10: Data for finding slewrate of ECG circuit in Figure 1 at 2 Hz

Delta V [Vpp]	Delta t [ms]	Slewrate [V/s]
7.68	116	138

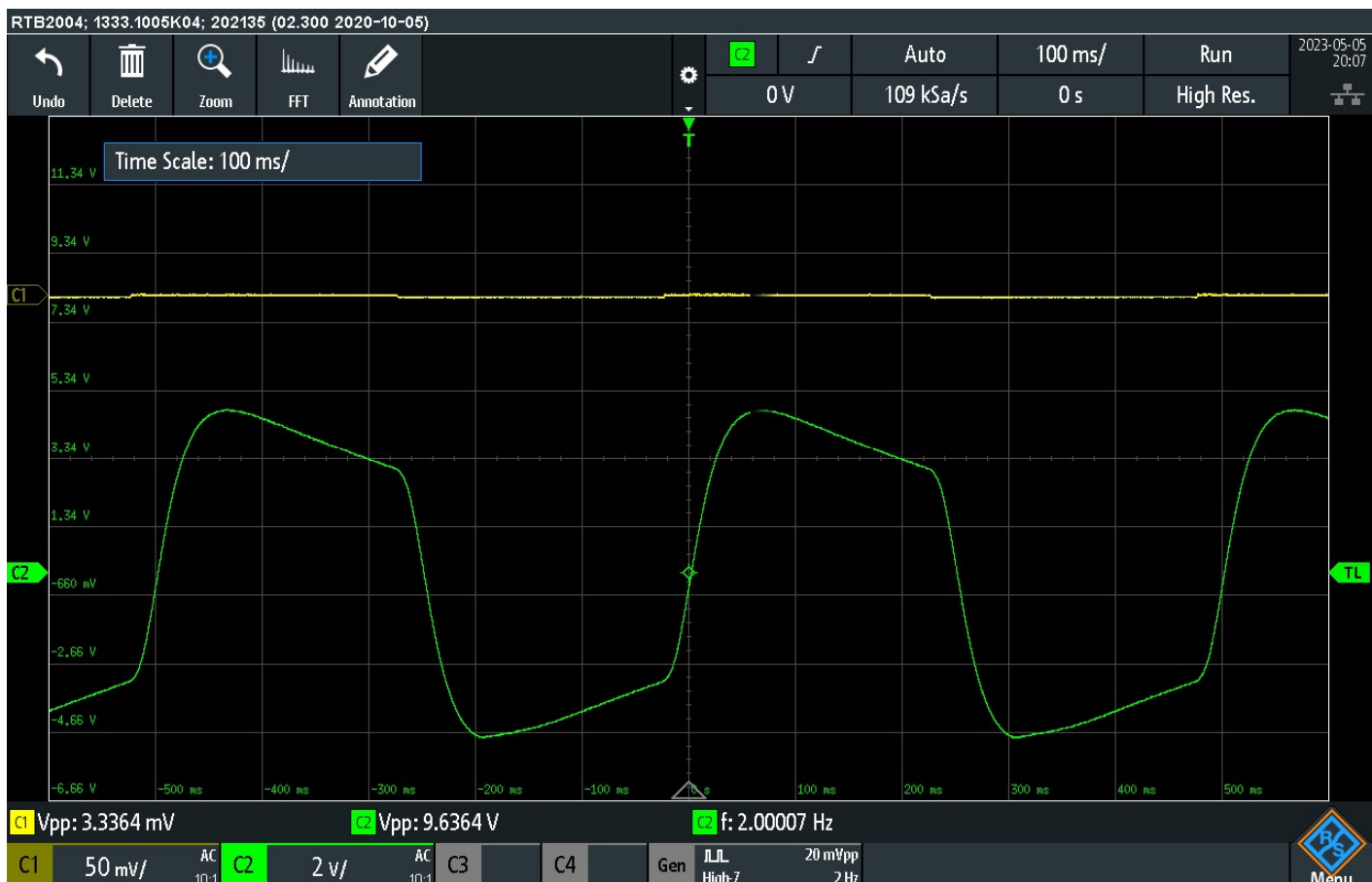


Figure 8: Voltage input (CH1: yellow) at 3 mVpp pulse wave with 50% duty cycle and voltage output (CH2: green) of ECG circuit at a frequency of 2 Hz

Part 2:

Note: Potentiometer resistance used for the following images in place of RG was a 5 kΩ potentiometer



Figure 9: Voltage input (CH1: yellow) at 3 mVpp sine wave and voltage output (CH2: green) of ECG circuit at a frequency of 2 Hz with the RG potentiometer tuned all the way to the left



Figure 10: Voltage input (CH1: yellow) at 3 mVpp sine wave and voltage output (CH2: green) of ECG circuit at a frequency of 2 Hz with the RG potentiometer tuned all the way to the right



Figure 11: Voltage input (CH1: yellow) at 3 mVpp sine wave and voltage output (CH2: green) of ECG circuit at a frequency of 2 Hz with the RG potentiometer turned in the middle between the right and the left