ELEC ENG – 2CJ4

Laboratory Experiments (Set 3)

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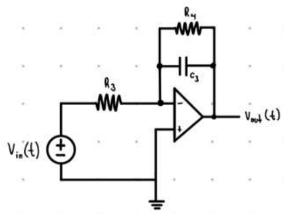
1.

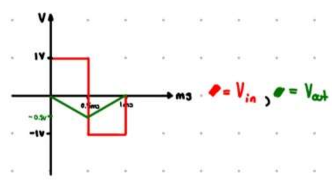


$R_3 = 10K\Omega$, $R_4 = 2.2M\Omega$, $C_3 = 100nF$

$$V_{out} = -\frac{1}{R_3 C}\int_0^t V_{in}(t)\,dt + V_{in}(0) \qquad \text{aside: } \frac{1}{R_3 C} = \frac{1}{10K\Omega(100nF)} = 1000$$

a) Square Wave: $V_{in} = \begin{cases} 1V & \text{for } 0ms \le t \le 0.5ms \\ -1V & \text{for } 0.5ms \le t \le 1ms \end{cases}$

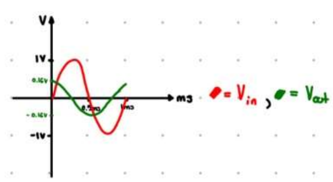
for $0ms \le t \le 0.5ms$:
$$-1000\int_0^{0.5} V_o(t)\,dt + V_o(0)$$
$$= -1000\int_0^{0.5} 1\,dt + 0$$
$$= -1000t\Big|_0^{0.5}$$



for $0.5ms \le t \le 1ms$:
$$-1000\int_{0.5}^{1} V_o(t)\,dt + V_o(0.5)$$
$$= -1000\int_{0.5}^{1} -1\,dt + 0.5$$
$$= 1000t\Big|_{0.5ms}^{1ms}$$

$$\therefore V_o = \begin{cases} -1000t & \text{for } 0ms \le t \le 0.5ms \\ 1000t & \text{for } 0.5ms \le t \le 1ms \end{cases}$$

b) Sine Wave: $V_{in} = \sin(2000\pi t)$



$$V_{out} = -1000\int_0^{0.5} \sin(2000\pi t)\,dt + V_{\cancel{in}}(0)$$
$$= \frac{-1000}{2000\pi}\left(-\cos(2000\pi t)\right)\Big|_0^{0.5} = 0.16\cos(2000\pi t)\Big|_0^{0.5}$$

$$V_{out} = \frac{-1000}{2000\pi}\left(-\cos(2000\pi t)\right)\Big|_{0.5}^{1} + V_{in}(0.5) = 0.16\cos(2000\pi t)\Big|_{0.5}^{1} + V_{in}(0.5)$$

2.

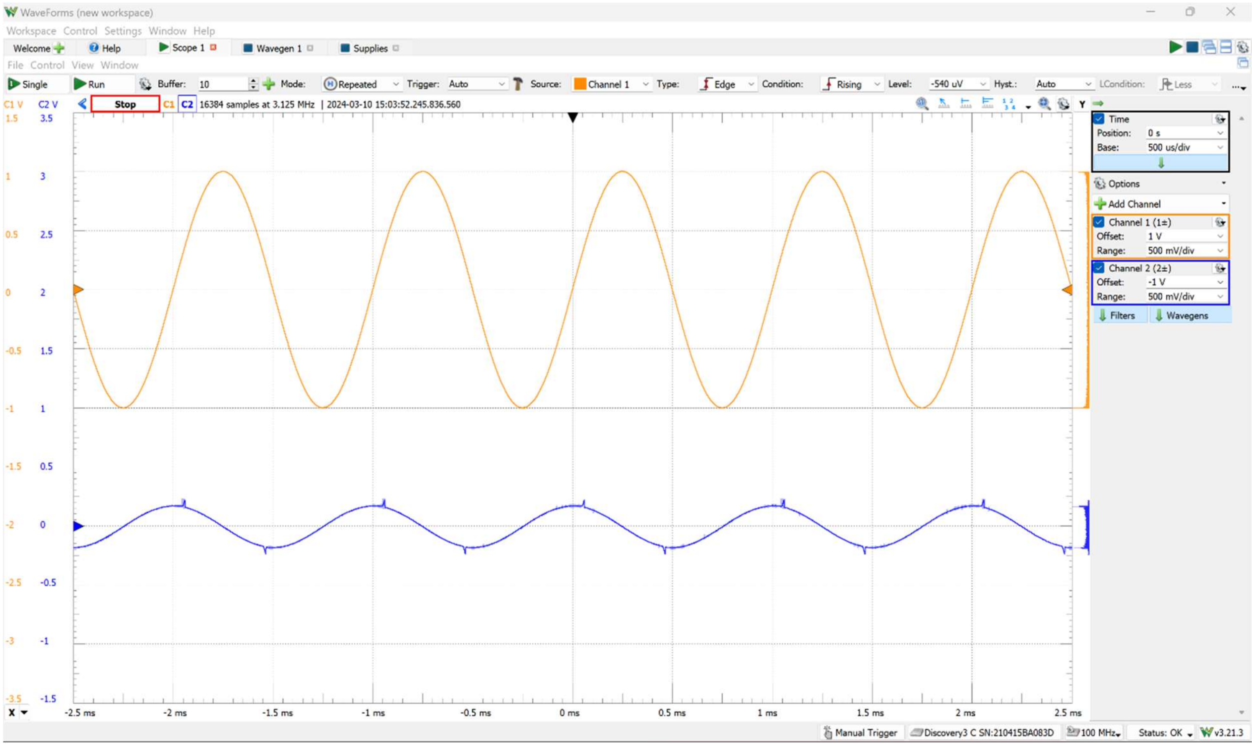


Figure 1 - Channel 1 (Yellow) -> Sinusoidal Input (2 V_{PP}, 1KHz); Channel 2 (Blue) -> Output

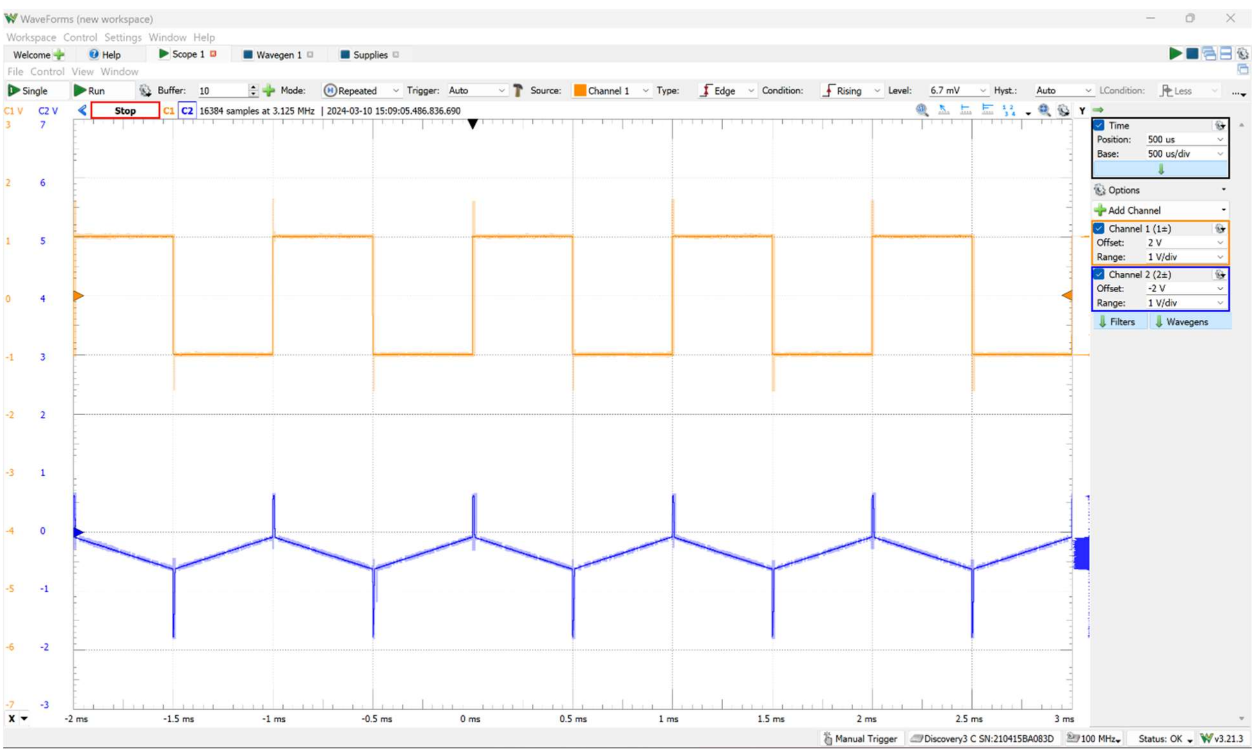


Figure 2 - Channel 1 (Yellow) -> Square Input (2 VPP, 1KHz); Channel 2 (Blue) -> Output

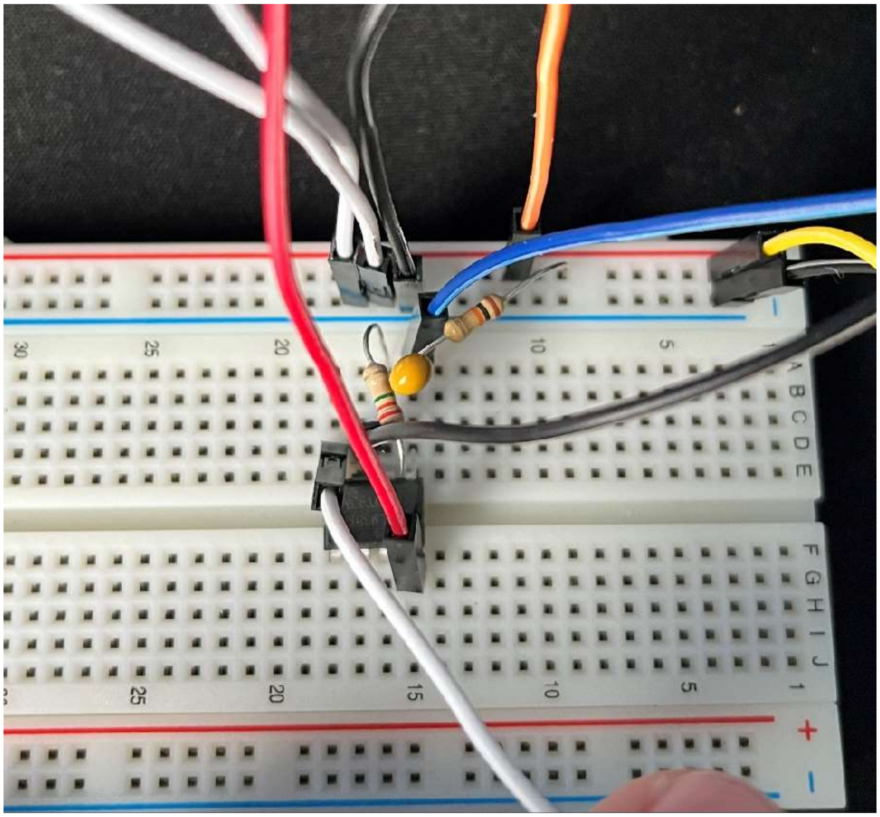


Figure 3 - Circuit Design

As we compare the findings from the experiment to the analytical calculations, we can see that the findings do indeed match up. The experiment results in a similar output from the integrator circuit as the analytical calculation does. There are however some discrepancies with the output in the experiment which were determined to be poor connections due to the quality of the components that were used in the experiments. If better quality components were utilized, the output graph would look even more like the output determined by the analytical solution.

3.

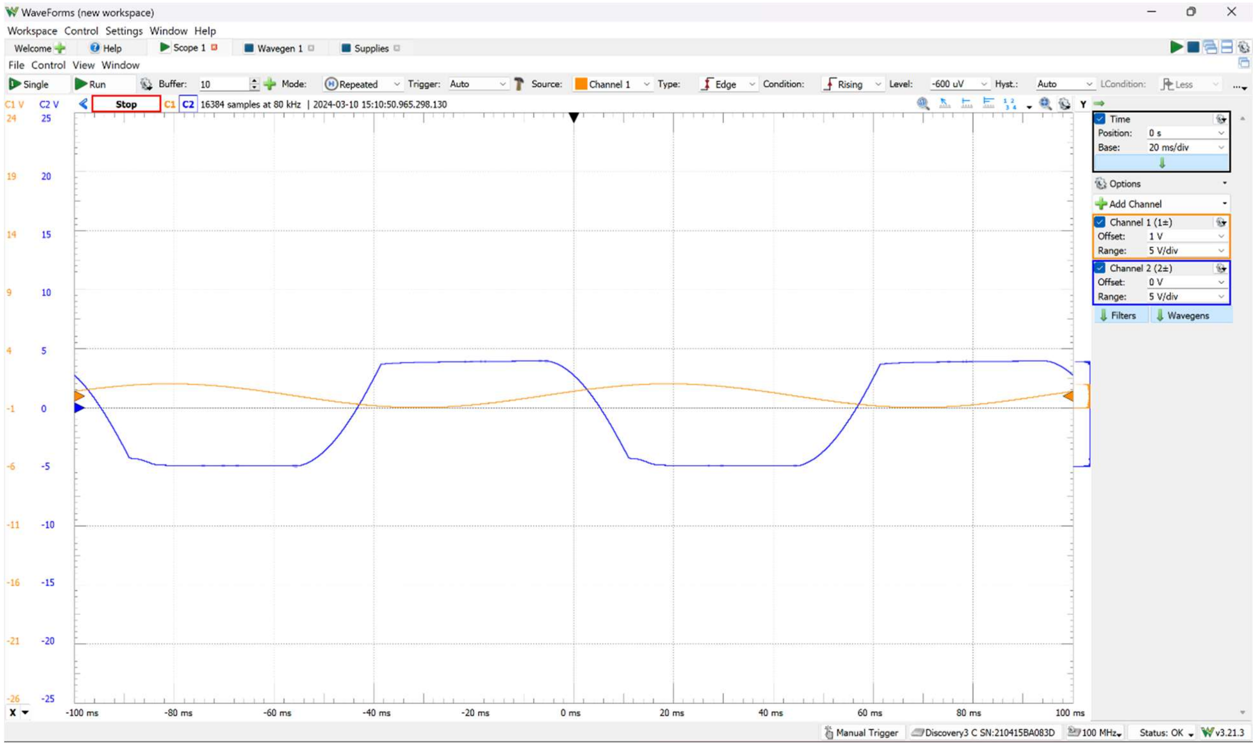


Figure 4 - Channel 1 (Yellow) -> Sinusoidal Input (2 VPP, 10Hz); Channel 2 (Blue) -> Output

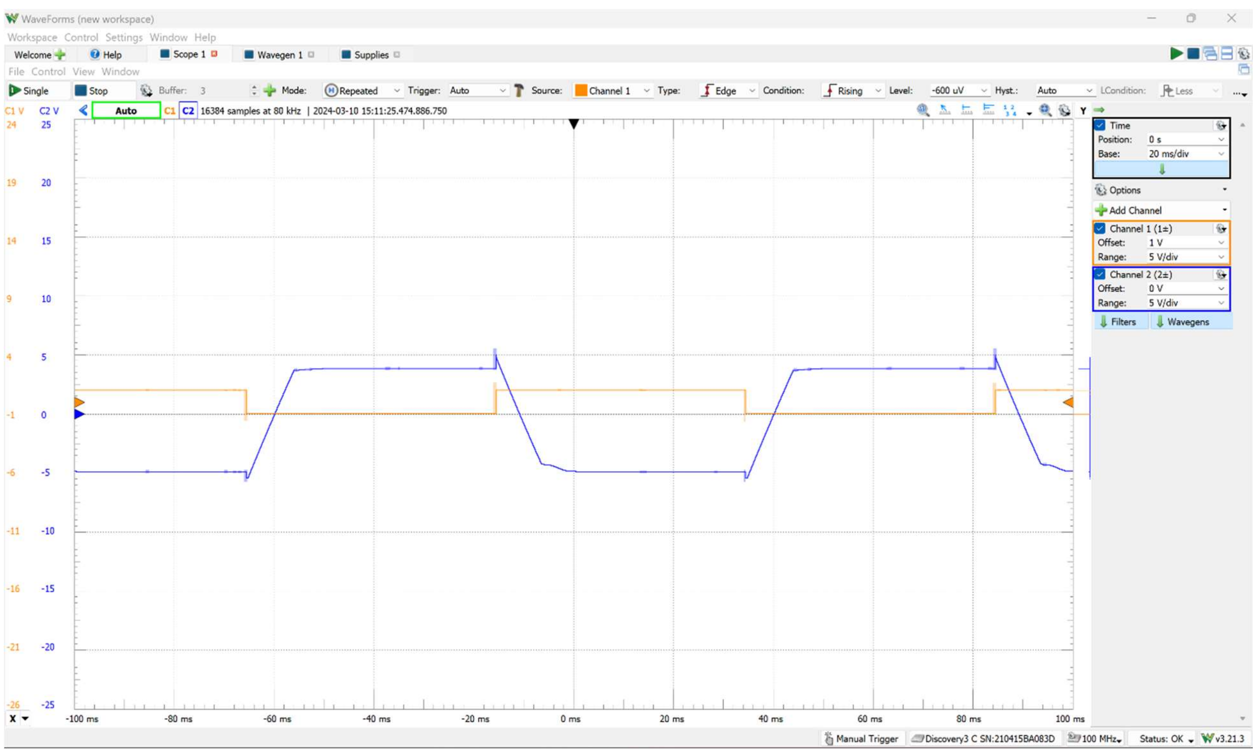


Figure 5 - Channel 1 (Yellow) -> Sinusoidal Input (2 VPP, 10Hz); Channel 2 (Blue) -> Output

When the frequency of the integrator circuit drops below 10Hz, we notice that the circuit begins to fail and does not operate correctly. This occurs due to the output of the integrator circuit being proportional to the frequency. Through the equation shown below, as the value of omega, representing the frequency, decreases, the value of the output voltage will continue to grow. This is shown in the graphs as the output voltage has become significantly larger than the input voltage to the integrator circuit. $V_{OUT} = -\frac{R_4}{R_3}\left(\frac{1}{1+j\omega C_3 R_3}\right)$