— PHYS 375: Lab 3 – AC signal and capacitors —

Purposes
Get familiar with the usage of an oscilloscope and a function generator. Understand how a
digital multimeter works with AC signal. Show that the current flowing in a capacitor is
proportional to the time derivative of the voltage across the capacitor.

1 Measuring AC signal

Build the circuit shown in Figure 1. Setup the oscilloscope to measure the output voltage of the
circuit $V_f$. Take $R = 33 \, \text{k}\Omega$. The alternating current (AC) voltage is provided by a function
generator (set to sinusoidal mode). Set the output voltage $V$ of the function generator such that
at $f \approx 100 \, \text{Hz}$, the voltage $V_f$ peak value reads 5 V approximately on the oscilloscope.

![Circuit Diagram]

Figure 1: Circuits part 1.

- Measure the peak value on the oscilloscope $\hat{V}_f$.
- Measure the peak-to-peak value using the oscilloscope $V_f^{PP}$.
- Insert a digital multimeter in parallel to the oscilloscope and measure the $V_f^{dmm}$.
- Compute the ratio $\hat{V}_f/V_f^{dmm}$. Does this ratio agree with what derived in the handout?
- What is the cut-off frequency of this filter. Describe in what sense this circuit acts as a high pass filter.
- Redo the above set of measurement for the cases of a square and rectangular signals.
- For these two types of signal try to vary the duty cycle of the function generator and interpret the change in $V_f^{dmm}$.
2 Derivative of a signal

Build the circuit shown in Figure 2. Setup the oscilloscope to measure the output voltage of the circuit $V_f$. Take $C = 0.001 \, \mu F$. The alternating current (AC) voltage is provided by a function generator (set to sinusoidal mode). Set the output voltage $V$ of the function generator such that at $f \simeq 100 \, \text{Hz}$, the voltage $V_f$ reads 5 V approximately.

![Figure 2: Circuits part 2.](image)

1. Setup a digital multi meter to measure the current flowing in the circuit

2. For various frequency, measure the current flowing through the circuit and the voltage across the capacitor. The Oscilloscope will give you a peak value while the digital multi-meter will provide an rms value of the current

3. Compute the impedance modulus $|Z|$ of the system (remember to convert all quantities to the same type of either peak or rms).

4. Plot $|Z|$ versus the frequency $f$. Does the curve match the expected dependency of the impedance versus $f$.

5. Replace the digital multimeter by small resistor ($R = 500 \, \Omega$) and monitor the voltage across the resistor on the second channel of the oscilloscope. Set the frequency to 100 Hz, and sketch the signals you observe on the oscilloscope.

6. Repeat step 5 for a square and triangular signal. Is one of the signal the time derivative of the other?