Lab 4; AC Power Analysis

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EEL3112C: Circuits 2

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**Objectives:**

The goal of this lab was to find the average and root-mean square (RMS) values for the voltage of circuits with three different waveform shapes as well as the RMS current and complex power of said circuits. This was performed with the same impedance, but first with a sinusoid, then a square wave, and lastly a ramp (triangle) wave, all with the same amplitude and frequency.

**Equipment:**

* Resistor
* Capacitor
* AC Voltage Source (Function Generator)
* Multimeter (Oscilloscope)

**Theory Development:**

The root mean square (RMS) voltage of any signal is , where is the signal’s period. After substituting the basic equations for sinusoid, square, and ramp waves into this equation, special formulae are derived for the RMS value of these waveforms. For a sinusoidal wave, , where is the peak voltage. Similarly, for a square wave, , and for a ramp wave, .

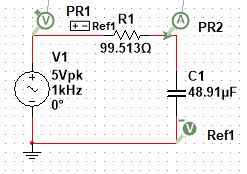
In the same manner, the RMS current can also be found by simply switching every V for an I in the above formulae. Alternatively, given the circuit’s impedance, it can be found by dividing the RMS voltage by the impedance. With both the RMS voltage and current acquired, the complex power () is .

**Methods/Procedures:**

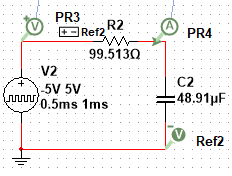
After constructing the RC series circuit and connecting it to the function generator, the oscilloscope was connected to measure the peak, average, and RMS voltage over the two components. With the input signal being a sinusoid first, the average and RMS voltages were recorded, and the latter was utilized to derive the current and complex power, knowing the total impedance. This was then repeated with the same peak voltage, but for a square wave and ramp wave.

**Circuit Diagrams:**

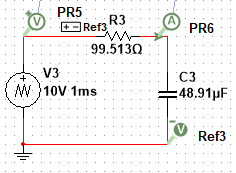
Sinusoid:



Square Wave:



Ramp Wave:



**Results (Theoretical and Experimental):**

| Theoretical | | | | |
| --- | --- | --- | --- | --- |
| Wave Type |  |  |  |  |
| Sinusoidal |  |  |  |  |
| Square |  |  |  |  |
| Ramp |  |  |  |  |

| Experimental (Multisim) | | | | |
| --- | --- | --- | --- | --- |
| Wave Type |  |  |  |  |
| Sinusoidal |  |  |  |  |
| Square |  |  |  |  |
| Ramp |  |  |  |  |

| Experimental (Hardware) | | | | |
| --- | --- | --- | --- | --- |
| Wave Type |  |  |  |  |
| Sinusoidal |  |  |  |  |
| Square |  |  |  |  |
| Ramp |  |  |  |  |

**Results Analysis and Discussion:**

Interestingly, there was only marginal error between the theoretical, simulated, and actual values for each parameter with all three waveforms. Between the theoretical and simulated values, the stray difference between the values was likely due to Multisim rounding all numbers shorter than they were calculated to be. As for the real values, however, the causes of the values being slightly lower than expected were most likely limited to the internal resistance inside the capacitor and the breadboard metal.

**Conclusion:**

Being the effective voltage of an input signal, the RMS voltage is important for numerous applications. Most notably, it is useful for comparing an AC signal to a DC one that would output similar power through a resistor of the same magnitude as the impedance. As proven by this experiment, it can be easily calculated for sine, square, and ramp waves and be used to determine the complex power output.

Reference: <https://physics.stackexchange.com/questions/41779/why-do-we-use-root-mean-square-rms-values-when-talking-about-ac-voltage#:~:text=Attempts%20to%20find%20an%20average,direct%20currents%20(or%20voltage)>.