Facilitator’s Guide to Module 12:
Introduction to Sinusoidal Steady-State Analysis

Introduction

In many first courses on linear circuits, the analysis of sinusoidally driven circuits and the calculation of ac power is studied. In this module, the analysis of sinusoidally driven circuits in the time domain is covered very briefly, mainly to illustrate that it is tedious. The Phasor transform and Phasor analysis techniques are introduced to greatly simplify the analysis of these circuits. While Phasor diagrams are interesting, it is the experience of this author that Phasor diagrams do not add significant value at this point. So they are not introduced here. The analysis of instantaneous and average power is then introduced with a strong emphasis on sinusoidally driven circuits. Complex power is then introduced along with some Phasor diagrams to illustrate various power relations and their calculations. The main emphasis of the module is on developing the basic tools used in the field.

Prerequisites

Before starting this module, it will be helpful to be familiar with;

- circuit elements such as resistors, capacitors, inductors and sources[1],
- basic circuit analysis techniques,
- the sine and cosine function along with their derivatives and integrals,
- Euler’s Identity and complex numbers or imaginary numbers.

Outcomes

With careful study, by the end of this module, one should be able to;

- transform a circuit driven by a sinusoidal source from the time domain into the Phasor domain.
- analyze circuits in the Phasor domain using complex numbers to find a circuit’s sinusoidal steady-state response.
- define and find the effective or root-mean-squared (RMS) value of a waveform.
- Calculate the real, reactive and complex power in sinusoidally driven circuits.

Module Overview.

This module consists of a sequence of 29 videos with self-assessment questions keyed to specific videos. The videos provide an alternative to in-class lectures and reading the textbook. The videos can be assigned in place of regularly scheduled lectures or as additional material. It is expected that the course instructor, will supplement the module with additional questions and perhaps some problem solving tutorials and one or two laboratory exercises.

1. Students who are unfamiliar with capacitors and inductors as circuit elements are strongly encouraged to familiarize themselves with the first half of Module 11

Module Contents for Circuit Analysis with Sinusoidal Sources

Characterizing Sinusoids and Time Domain Analysis

1. AC1a Introduction: An introduction to sinusoidally driven circuits.
2. AC1b Sine Characterization: Defining sine waves; amplitude, frequency and phase.
3. AC1c Example: An example of time domain analysis, illustrating its tediousness.

Circuit Analysis with Complex sources

4. AC2a Background to Complex: Generating complex sources with Euler’s identity.
5. AC2b Complex Sources: Analysis of a simple circuit driven by a complex source.

Phasor Analysis

6. AC3a Phasor Introduction: Introduction to and definition of Phasors.
7. AC3b Analysis Techniques: Verification of analysis techniques in the Phasor domain.
8. AC3c Impedance 1: Circuit elements in the Phasor domain and the impedance concept.
9. AC3d Impedance 2: Finding the impedance of inductors and capacitors.
10. AC3e Example: A simple example of using Phasor analysis.
11. AC3f Combine Impedance: Using series and parallel combinations to simplify analysis.
12. AC3g Example: A more complicated example of Phasor analysis.

Module Contents for Power Calculations in Sinusoidally Driven Circuits

Instantaneous and Average Power

1. PW1a Introduction: Introduction and calculation of instantaneous power.
2. PW1b Example: An example of instantaneous power for a sinusoidally drive RL circuit.
3. PW1c Average: Calculating the average power for periodic waveforms.
4. PW1d Example: An example of calculation the average value of a general cosine function.
5. PW1e Sin Average: An example of average power for a sinusoidally drive RL circuit.

Effective or RMS Power

6. PW2a Effective: Defining the effective or RMS value of a waveform.
7. PW2b Example: An example illustrating the calculation of the effective value of cosine.
8. PW2c Power: Computing power with the effective voltage.
9. PW2d Example Offset: An example that finds the effective value of an offset sine wave.
10. PW2e Example 2 sines: An example that finds the effective value of two sine waves.

Complex Power

11. PW3a Complex: Introduction to complex power.
12. PW3b PF: The power factor.
13. PW3c Example: An example showing the calculation of complex power and Phasor diagrams.
14. PW3d: Triangle: The power triangle.
15. PW3e Example: An example of power calculations using the power triangle.
16. PW3f PF Correction: Power factor correction.
17. PW3g PF Example: An example illustrating power factor correction.
    - Each major section is followed by problems keyed to the material.