PSPICE and the Frequency Domain

The problems in Chapter 10 (Irwin, 4th ed) involve analysis in the frequency domain; the thread connecting to the time domain is implied but not specifically used for these problems. All sources are assumed implied to be sinusoidal, all of the same frequency. Frequency is not given explicitly; but rather subsumed by specifying reactance rather than inductance and capacitance. Analysis in the frequency domain is simplified because the known exponential nature of the particular solution allows conversion of the integro-differential volt-ampere relations for inductors and capacitors into algebraic expressions. Thus

\[ V = j\omega LI \] for an inductor;
\[ V = \frac{I}{j\omega C} = jX_CI \] for a capacitor;
\[ V = RI \] for a resistor;
\[ V = ZI = (R+jX)I \] for a combination of RLC

A reminder about terminology — impedance \( Z \), reactance \( X \), resistance \( R \). The inverse coefficients, (older units are mhos, newer are Siemans) are admittance \( Y \), susceptance \( B \), conductance \( G \).

Because the transformation to the time domain is not involved in these problems Chapter 10 is in a sense an exercise in complex arithmetic. The formal analysis procedures remain just as they are for resistive circuits; the new thing is the complex coefficients for the constitutive relations of the circuit elements and the associated complex arithmetic. In this latter respect you must be at ease with conversion between polar and rectangular forms of a complex number. In general it is easier to multiply and divide in the polar form; it is easier to add and subtract in the rectangular form. Another useful relation, \((A + jB)(A-jB) = A^2 + B^2\), is useful for division in rectangular form. And for completeness we can make reference to the Euler Theorem.

A number of circuit analysis illustrations are provided in the text, several more are available in the MHM2 folder on the MacHall server, and in the ECE210 folder on the 201ELB server. This note provides a template for use with PSPICE to analyse the problems in chapter 10, providing 'answers' for comparison after you work on a problem. Refer to ECE 210-Sine Notes for several illustrations. The notes included need not be copied for actual use each time!

**Title Line: One-Loop RLC Circuit**

*Note: PSPICE uses the first non-empty line as a title, whether you meant it to be so used or not. A not uncommon error is to have the first line of the circuit description adopted as the title. Make the title meaningful so that you don't have to figure out later what it is you computed. Add useful comments (start line with an *). Incidentally keep in mind that PSPICE looks for a netlist file ending in the extension '.cir'.

* What follows next is a description of the circuit. See Irwin for details; it is very straightforward. Note however that PSPICE expectes to see values for capacitance and inductance. For the chapter 10 problems it is \( X_L \) and \( X_C \) (or \( B_L \) and \( B_C \) ) that is given. Simply assume \( \omega = 1 \) radian/second, so that \( L = X_L \), \( C = 1/X_C \), etc.

* For the purpose of the present analysis an independent sinusodidal source is specified in PSPICE as follows

\[ \text{SOURCE_NAME} \ +\text{Node} \ -\text{Node} \ AC \ \text{Strength} \ \text{PhaseAngle} \]

* PSPICE interprets this to mean a source: \( \text{Strength} \cos(\omega t + \text{PhaseAngle}) \)

* In Chapter 10 problems sources are specified as \( S\angle\theta \). Since the question is not raised in these problems we can assume arbitrarily that the time domain source is \( S\cos(\omega t + \theta) \).
Here is a simple netlist; sketch the circuit diagram from the netlist.

Vsource 1 0 AC 12 45 ; 12cos(ωt+45˚)
C12 1 2 10 ; ωC = 0.1Ω
R23 2 3 4 ; R = 4Ω
L30 3 0 2 ; ωL = 2Ω

The type of analysis used is that called out by the .AC command. This is used more generally for computations over a range of frequencies, but for the present purpose we use it for just the one frequency ω/2π = 1/2π = .159155 Hz.

The .AC command to be used is listed below. The LIN indicates frequencies are to be selected at equal intervals over a specified frequency range. The next two items specify the start and end frequencies for the computation; for the present purpose these are the same so that only a single frequency (corresponding to ω = 1) is used.

.AC LIN 1 .159155 .159155

Any or all of the branch voltages and currents can be tabulated, in either rectangular or polar form, or both. The rectangular form is obtained by adding a suffix R, I (real, imaginary) to the specification of a voltage or current. For the polar form use M, P* (magnitude, phase in °). Thus VM(2,3) provides the magnitude of the voltage drop from node 1 to node 2, while VI(1,2) provides the imaginary part.

The .PRINT command actually prepares a table for subsequent printing. However the file (with the extension changed to '.out') also can be viewed on the monitor. The following illustration calls for rectangular and polar components of all branch voltages and currents.

.PRINT AC VR(1), VI(1), VM(1), VP(1), IR(VS), II(VS), IM(VS), IP(VS)
+ VR(1,2), VI(1,2), VM(1,2), VP(1,2), IR(C12), II(C12), IM(C12), +
  IP(C12), VR(2,3), VI(2,3), VM(2,3), VP(2,3), IR(R23), II(R23), +
  IM(R23), IP(R23), VR(3), VI(3), VM(3), VP(3), IR(L30), II(L30), +
  IM(L30), IP(L30),

Finally tell PSPICE that there is no more to the file.

.END

Data from the '.out' file follows.

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<th>VM(1)</th>
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