Chapter 16

Series-Parallel ac Networks
OBJECTIVES

• Develop confidence in the analysis of series-parallel ac networks.
• Become proficient in the use of calculators and computer methods to support the analysis of ac series-parallel networks.
• Understand the importance of proper grounding in the operation of any electrical system.
INTRODUCTION

• In general, when working with series-parallel ac networks, consider the following approach:
  – Redraw the network, using block impedances to combine obvious series and parallel elements, which will reduce the network to one that clearly reveals the fundamental structure of the system.
  – Study the problem and make a brief mental sketch of the overall approach you plan to use. Doing this may result in time- and energy-saving shortcuts.
INTRODUCTION

– After the overall approach has been determined, it is usually best to consider each branch involved in your method independently before tying them together in series-parallel combinations.

– When you have arrived at a solution, check to see that it is reasonable by considering the magnitudes of the energy source and the elements in the circuit.
FIG. 16.1 Example 16.1.
FIG. 16.2 Network in Fig. 16.1 after assigning the block impedances.
FIG. 16.3 Example 16.2.

FIG. 16.4 Network in Fig. 16.3 after assigning the block impedances.
ILLUSTRATIVE EXAMPLES

**FIG. 16.5** Example 16.3.

**FIG. 16.6** Network in Fig. 16.5 after assigning the block impedances.
FIG. 16.7 Example 16.4.

FIG. 16.8 Network in Fig. 16.7 after assigning the block impedances.
**FIG. 16.9** *Determining the voltage $V_{ab}$ for the network in Fig. 16.7.*

**FIG. 16.10** *Basic transistor amplifier.*
ILLUSTRATIVE EXAMPLES

FIG. 16.11 Network in Fig. 16.10 following the assignment of the block impedances.
ILLUSTRATIVE EXAMPLES

FIG. 16.12 Example 16.6.
FIG. 16.13 Network in Fig. 16.12 following the assignment of the subscripted impedances.
ILLUSTRATIVE EXAMPLES

**FIG. 16.14** Example 16.7.
FIG. 16.15 Network in Fig. 16.14 following the assignment of the subscripted impedances.
ILLUSTRATIVE EXAMPLES

**FIG. 16.16** Finding the total admittance for the network in Fig. 16.14 using the TI-89 calculator.
ILLUSTRATIVE EXAMPLES

FIG. 16.17 Converting the rectangular form in Fig. 16.16 to polar form.
ILLUSTRATIVE EXAMPLES

FIG. 16.18 Example 16.8.
FIG. 16.19 Network in Fig. 16.18 following the assignment of the subscripted impedances.
FIG. 16.20 Finding the total impedance for the network in Fig. 16.18 using the TI-89 calculator.
FIG. 16.21 *Ladder network.*
LADDER NETWORKS

FIG. 16.22 Defining an approach to the analysis of ladder networks.
GROUNDING

- **Ground potential is zero volts at every point in a network that has a ground symbol.**
  - An *earth ground* is one that is connected directly to the earth by a low-impedance connection.
  - A second type is referred to as a *chassis ground*, which may be *floating* or connected directly to an earth ground.
FIG. 16.23 Demonstrating the effect of the oscilloscope ground on the measurement of the voltage across resistor $R_1$. 

(a) Short introduced by ground connection

(b)
FIG. 16.24 Three-wire conductors: (a) extension cord; (b) home outlet.
FIG. 16.25 Complete wiring diagram for a household outlet with a 10 $\Omega$ load.
**FIG. 16.26** Demonstrating the importance of a properly grounded appliance: (a) ungrounded; (b) ungrounded and undesirable contact; (c) grounded appliance with undesirable contact.
APPLICATIONS

• The vast majority of the applications appearing throughout the text have been of the series-parallel variety.

• The following are series-parallel combinations of elements and systems used to perform important everyday tasks.

• The ground fault circuit interrupter outlet employs series protective switches and sensing coils and a parallel control system, while the ideal equivalent circuit for the coax cable employs a series-parallel combination of inductors and capacitors.
GFCI (Ground Fault Circuit Interrupter)

**FIG. 16.27** GFCI outlet: (a) wall-mounted appearance; (b) basic operation; (c) schematic.
GFCI (Ground Fault Circuit Interrupter)

FIG. 16.28 GFCI construction: (a) sensing coils; (b) solenoid control (bottom view); (c) grounding (top view); (d) test bar.
FIG. 16.29 Determining the voltage across $R_1$ and $R_2$ using the VPRINT option of a PSpice analysis.
FIG. 16.30 The resulting magnitude and phase angle for the voltage $V_{R1}$ in Fig. 16.29.
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** AC ANALYSIS  TEMPERATURE = 27.000 DEG C

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** AC ANALYSIS  TEMPERATURE = 27.000 DEG C

** FIG. 16.31  The VPRINT1 (V_{r1}) and VPRINT2 1 V_{r2} response for the network in Fig. 16.29.**
FIG. 16.32 The PSpice response for the voltage between the two points above resistors $R_1$ and $R_2$. 
FIG. 16.33 Determining the voltage between the two points above resistors $R_1$ and $R_2$ by moving the ground connection in Fig. 16.29 to the position of $VPRINT2$. 
FIG. 16.34 *PSpice response to the simulation of the network in Fig. 16.33.*
FIG. 16.35 Using the Multisim oscilloscope to determine the voltage across the capacitor $C_2$. 
FIG. 16.36 Using Multisim to display the applied voltage and voltage across the capacitor $C_2$ for the network in Fig. 16.35.
FIG. 16.37 Using the **AC Analysis** option in Multisim to determine the magnitude and phase angle for the voltage $V_{C2}$ for the network in Fig. 16.35.