**Chapter 5 –Circuit Simplification**

**P5.1.7** Determine *IX* in Figure P5.1.7.



**Solution:** **Initialize.**All given values and the required *IX* are entered.

**Simplify.** No meaningful simplifications can be made.

**Deduce. Step 1:***VO* = -5×5 =-25 V,so that the dependent source is replaced with an independent voltage source of 5 V, with reversed polarity, as shown.**Step 2:**The 5 Ω resistor is now redundant as far as the rest of the circuit is concerned and can be removed.



**Implement.***IX* can be determined by superposition. With the 5 V source applied alone, *IX*1 = -5/14 A. With the 10 V source applied alone, *IX*2 = -10/14. With the 5 A source applied alone, *IX*3 = 5×10/14. It follows that *IX* = (-5 – 10 + 50)/14 = 35/14 = 2.5 A.



**Check.** The circuit is a two-essential node circuit. The voltage of the upper node with respect to the lower node is (10 + 4*IX*) V. From KCL at the upper node, 5 = *IX* + (15 + 4*IX*)/10, or 50 = 10*IX* + 15 + 4*IX*, or IX = 35/14 = 2.5 A.

**P5.1.9** Determine the power dissipated in the 5 Ω resistor due to each source in Figure P5.1.9, and the total power dissipated in this resistor. Note that it should be evident from superposition that the dependent source does not contribute to current in this resistor.



**Solution:** If the dependent source is replaced by an independent source and applied alone, with the two current sources set to zero, no current flows through the 5 Ω resistor.



If the 2 A source is applied alone, with the 4 A source set to zero, the current through the 5 Ω resistor is 2 A, and the power dissipated is 4×5 = 20 W.

If the 4 A source is applied alone, with the 2 A source set to zero, the current through the 5 Ω resistor is 4 A, and the power dissipated is 16×5 = 80 W. If the two sources are applied together, the current through the 5 Ω resistor is 6 A, and the power dissipated is 36×5 = 180 W.



**P5.1.16** The resistance values in Figure P5.1.16 are not specified. It is given that: i) When *VSRC* = 5 V and *ISRC* = 1 A, *VO*1 = 2 V, and ii) when *VSRC* = 5 V and *ISRC* = 0, *VO*2 = 1 V. Determine *VO* when *VSRC* = 0 and *ISRC* = 2 A.



**Solution:** Since the circuit is LTI, *VO* = *K*1*VSRC + K*2*ISRC.* From the second condition, 1 = 5*K*1 *+* 0, so that *K*1 = 0.2; From the first condition, 2 = 0.2×5 *+ K*2×1, which gives *K*2 = 1. Hence, *VO* = 0.2*VSRC + ISRC.* Under the required conditions, VO = 0.2×0 *+* 1×2 = 2 V.



**P5.1.20** Determine *VO* in Figure

**Solution:** Replace the dependent source by an independent source *ISRC*. With the 10 V source acting alone,  =, A and

 A.



With the 10 A source acting alone, the 8 Ω resistor is in series with the parallel combination of 2 Ω and 4 Ω. The total resistance is 8 + 8/6 = 28/3 Ω. The current in 8 Ω resistor is A and A.



When the dependent source is replaced by an independent source *ISRC* applied alone, the upper 2 Ω resistor is in series with the parallel combination of 2 Ω and 4 Ω. The total resistance is 2 + 8/6 = 10/3 Ω. The current in 2Ω resistor is A and A.



From superposition, *IX* = – . Substituting *ISCR* = 4*IX*, *IX* = 25/17 – 20/17 – (32/17)*Ix*, which gives *IX* = 5/49 A.



In the original circuit, *Va* = 2*Ix* = 10/49 A. The current in the 4 Ω resistor is (10 – 10/49)/4 = 120/49 A. From KCL at the lower node, *VO*/8 =120/49 – 25/49 = 95/49, or *VO* = 760/49 = 15.51 V.

**P5.1.23** Determine *VO* in Figure P5.1.23.



**Solution:** Replace the dependent source by an independent current source *IY*. With the 10 V source acting alone, *IX*1 = -10/6 =

-5/3 mA.

With the 3 mA source acting alone, it follows from current division that, *IX*2 = 3×(2/6) = 1 mA.

With the *IY* source acting alone, it follows from current division that *IX*3 =*IY*×(2/6) = *IY*/3.



From superposition, *IX* = -5/3 + 1 + *IY*/3. Substituting *IY* = 5*IX*, *IX*(1 – 5/3) = (1 – 5/3), which gives *IX* = 1 mA.

From the original circuit, it follows from KCL that the current in the lower 2 kΩ resistor is 8 mA, and the current in the upper 2 kΩ resistor is 7 mA. Hence VO = 2×7 + 2×7 = 30 V.



**P5.2.5** Determine *VO* in Figure P5.2.5 using scaling.P5.2.5



**Solution:** Assume *IX* = 1 A; the dependent source is 4 A, the current in the 5 Ω resistor is 5 A, and the voltage across it is 25 V. The voltage at the next node is 26 V and the current in the 26 Ω resistor is 1 A. The current in the 8 Ω resistor is 2 A, and the voltage at the next node is 42 V. The current in the 14Ω resistor is 3 A. The current in the 1Ω resistor is 5 A, and the voltage at the source is 47 V. Since the given source voltage is 4.7 V, all voltages and currents are divided by 10. The dependent soirce current is therefore 0.4 A, and *VO* = 10×0.4 = 4 V.



**P5.2.7** Determine *IO* in Figure P5.2.7.



**Solution: Initialize.**All given values and the required *VTh* are entered. The nodes are labelled.

**Deduce.***Ix* = -3 A, the dependent source becomes an independent source of 12 V and reversed polarity.

**Simplify.** The 10 Ω resistor in parallel with the 30 V source and the 20 Ω resistor in series with the 0.75 A source are redundant for the purpose of calculating *IO* and are removed. The 15 Ω and 13 Ω resistances are combined into a 28 Ω resistance, the circuit becoming as shown.



**Explore.**There is no node or mesh where a single unknown can be introduced and its value determined from KCL or KVL.

**Plan.** The 30 V source and the resistors can be transformed into a single source connected to node ‘a’. The circuit becomes a two-essential-node circuit that allows determining *IO*.



**Implement.**The 30 V source in series 50 Ω is transformed to a 0.6 A current source in parallel with 50 Ω. This, in parallel with 50 Ω becomes 25 Ω. The 0.6 A current source in parallel with 25 Ω is transformed to a voltage source of 15 V in series with 25 Ω. This, in series with 35 Ω becomes 60 Ω. The circuit becomes as shown. *Vac* = 28(*IO* – 12) V. It follows from KCL that: ,,

, ,  A.

**P5.2.16** Determine *ISRC* in Figure P5.2.16 assuming all resistances are 1 Ω.



**Solution:** The circuit is symmetrical with respect to the diagonal and could be split into two half circuits, as shown in the figure for one half circuit.

Combining the resistors, the circuit becomes as shown. It follows that the current due to one half circuit is 7 A, so that the current due to the complete circuit is 14 A.

