**Homework 4**



**P4.1.14** Derive TEC looking into terminals

‘ab’ in Figure P4.1.14.

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

**Simplify.** No meaningful simplifications



can be made.

**Deduce.** The 1 A source current flows through the 5 Ω resistor, producing a voltage drop of 5 V. The current through the upper 10 Ω resistor is zero, so that the current through the lower 10 Ω resistor is zero, and the voltage across this resistor is zero. From KVL starting at node ‘b and going CW:-5 + 0 + 5 – *VTh* = 0, which gives *VTh* = 0.

To determine *RTh*, the sources are set to zero. The 10 Ω resistor on the left is short-circuited, leaving the remaining resistors in series. It follows that *RTh* = 25 Ω.



**P4.1.36** Derive TEC between terminals ‘ab’ in Figure P4.1.36.

**Solution:** **Initialize.** All given values are entered. *VTh* is marked, and the nodes are labelled.



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

**Deduce.** No immediate

deductions can be made.

**Explore.** Every node has

two unknowns and every mesh has two unknowns, so it is not possible to introduce a single

unknown that can be determined from KCL or KVL.

**Plan.** It is seen that if the current in the 60 Ω resistor is *I*, then *VTh* = *Vab* = 20 + 60*I* + 60. Hence, if *I* can be determined, *VTh* follows. A general procedure for finding a current through a resistor is to derive TEC seen by the resistor.

**Implement.** If the 60 Ω resistor is removed from the circuit and a current *IX* assigned through the circuit, it follows from KVL starting at node ‘b’ and moving CW that: +20 – 30(*IX* – 1) – 60 – 20(*IX* +2) = 0, or, -3*IX* – 2*IX* + 2 + 3 – 6 – 4 = 0, or, -5*IX* – 5 = 0, or, *IX* = -1 A. It is seen that *Vdb* = 20 V, and *Vcb* = 20(-1 +2) = 20 V. Hence nodes ‘c’ and ‘d’ are at the same voltage, which means that *I* = 0 in the 60 Ω resistor, so that *VTh* = 80 V.



To determine *RTh*, the sources are set to zero. Node ‘c’ becomes the same as node ‘a’ and node ‘d’ the same as node ‘b’. The three resistors are in parallel, as when they are redrawn between the two nodes. (30||60) = 20 Ω, and (20||20) = 10 Ω. Hence, *RTh* = 10 Ω.



**P4.1.39** Derive NEC looking into terminals ‘ab’ in Figure P4.1.39.



**Solution:** **Initialize.** All given values are entered. Nodes ‘a’ and ‘b’ are short circuited, and *IN* indicated.

**Deduce.** Because of the short-circuit, *VX* = 0, the 0.5 A current flows through the short circuit, which makes *IN* = 0.5 A. Note that *IY* = 0, so that both dependent sources become short circuits.



We will determine *VTh* = *VX*. On open circuit, 0.5 = -*IY*, and flows through the 5 Ω resistor. From KVL, the voltage across the 5 Ω resistor is 0.5*VX*. Hence, 0.5*VX* = 5×0.5, so that *VTh* = 5 V. It follows that *RN* = 5/0.5 = 10 Ω.



**Check.** As a check, *RN* will be derived by applying a test voltage source *VT*. This makes *VX* = *VT*, so that the voltage drop across the 5 Ω resistor is 0.5*VT*, and the current through this resistor is *IT*. It follows that 0.5*VT* = 5*IT*, so that *VT*/*IT* = *RN* = 10 Ω, as before.

**P4.2.1** Determine, according to the substitution theorem, (a) the independent voltage source, (b) the independent current source, and (c) the resistance that can replace the dependent current source in Figure P4.2.1 without affecting the rest of the circuit.



**Solution:** From KCL, 3 = 3*Ix*, so *Ix* = 1 A. From KVL, *Vx* = 2 + 2×1 = 4 V. It follows that the 2*Ix* source can be replaced by: (a) an independent voltage source of 4 V, (b) an independent current source of 2 A, or (c) a resistance of 4/2 = 2 Ω.



**P4.2.9** Determine *Rin* in Figure P4.2.5 by applying the source absorption theorem, where *IX* is in amperes.



**Solution:** The current of the VCCS is *VX*/50 A in the direction of a voltage drop *VX* V across the source. It follows that this source is equivalent *VX*/*(VX*/50) = 50 Ω.

Consider the CCVS and the 20 Ω resistor. The voltage across the combination is *VX* = 1000*IX*, as shown. The voltage drop across the 20 Ω resistor is 220*IX*, and the current through this resistor is 220*IX*/20 = 11*IX* A. This current is in the direction of a voltage rise through the source. The source is therefore equivalent to a resistance -1220/11. In series with 20 Ω, this becomes: Ω. This resistance in parallel with 1000 Ω is:  Ω. This resistance in parallel with 50 Ω is:  Ω.

