2. Each resistance, inductance, reciprocal capacitance, and voltage source in N_2 is divided by the factor $1 + A_v$.

The circuit reduction technique for Fig. A.1-9(b) states that all voltages in N_1 and N_2 remain unchanged if the controlled source $A_i i_1$ is replaced by a open circuit and if:

1. Each conductance, reciprocal inductance, capacitance, and current source in N_1 is multiplied by the factor $1 + A_i$, or
2. Each conductance, reciprocal inductance, capacitance, and current source in N_2 is divided by the factor $1 + A_i$.

Example A.1-6

Application of the Source-Reduction Technique

The circuit of Fig. A.1-10(a) is to be simplified using the source-reduction technique.

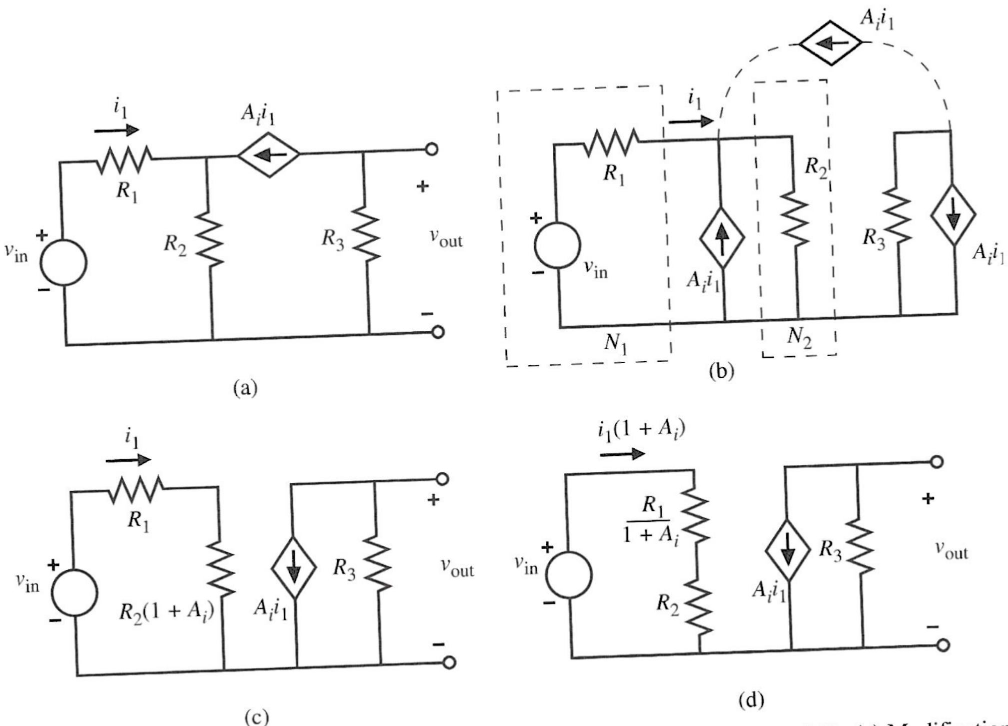

Figure A.1-10 Current reduction. (a) Original circuit. (b) Identification of N_1 and N_2. (c) Modification of N_2. (d) Modification of N_1.

SOLUTION

In order to apply the technique, the circuit has been redrawn as shown in Fig. A.1-10(b). Note that the presence of a resistor (R_3) in series with the current source does not affect the technique. Figure A.1-10(c) shows the modification of N_1 and Fig. A.1-10(d) shows the modification of N_2 by the source-reduction technique. The resulting simplified circuits are suitable for chain-type calculations.

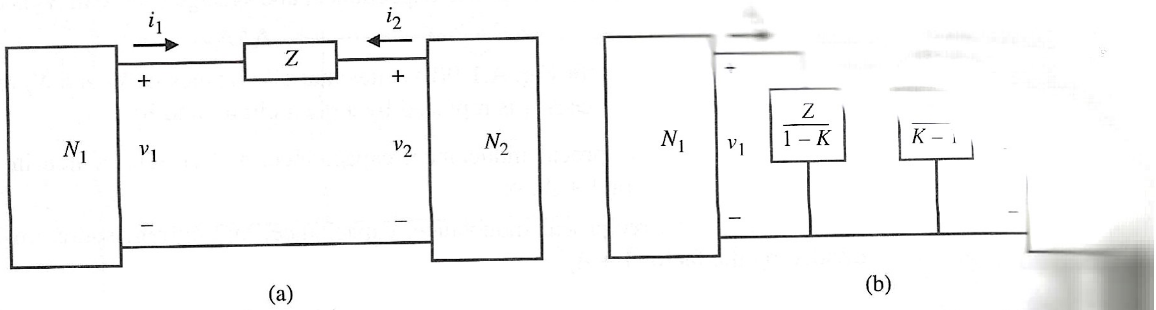

Figure A.1-11 Miller simplification. (a) Original circuit. (b) Equivalent circuit of (a).

The last simplification technique presented here is called the *Miller simplification*. Th technique is good for removing bridging elements in a circuit and accounting for their eff on the forward gain of a circuit. Figure A.1-11(a) shows the circumstance in which the Miller simplification can be used. We assume that an impedance Z is connected between two net works. We use an impedance since the Miller simplification technique is often employed when the bridging element is reactive. We shall also switch to complex-signal notation. The key aspect of the Miller simplification is that V_2 can be expressed in terms of V_1. This expres sion should be real for best results. If $V_2 = KV_1$, then it can be shown that the impedance se from N_1, Z_1, can be written as

$$Z_1 = \frac{V_1}{I_1} = \frac{V_1}{(V_1 - V_2)/Z} = \frac{ZV_1}{V_1 - KV_1} = \frac{Z}{1-K} \quad \text{(A.1-}$$

and the impedance seen from N_2, Z_2 is

$$Z_2 = \frac{V_2}{I_2} = \frac{V_2}{(V_2 - V_1)/Z} = \frac{ZKV_1}{KV_1 - V_1} = \frac{ZK}{K-1} \quad \text{(A.1-}$$

Typically, K is negative and greater than unity. An example will illustrate the applicatio the Miller simplification technique.

Example A.1-7

Application of the Miller Simplification Technique

Consider the circuit of Fig. A.1-2. Assuming that R_2 is much greater than R_3, use the Mill simplification technique to remove R_2.

SOLUTION

If R_2 is much greater than R_3, then we may assume that most of the current $g_m v_1$ flows thro R_3. Therefore, the voltage v_{out} may be expressed as

$$v_{out} = -g_m R_3 v_1 = K v_1 \quad \text{(A.1-}$$

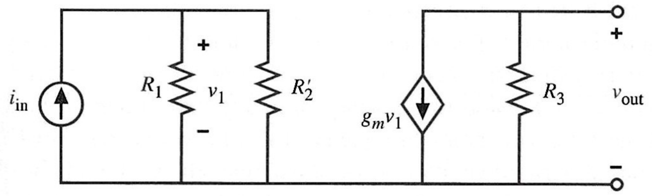

Figure A.1-12 The result of applying the Miller simplification concept.

Therefore, Fig. A.1-2 can be redrawn as Fig. A.1-12, where the resistor R'_2 is given as

$$R_2' = \frac{R_2}{1-K} = \frac{R_2}{1+g_m R_3} \tag{A.1-21}$$

We have not placed a resistor of value $R_2K/(K-1)$ in parallel with R_3 for the following reason. If g_mR_3 is greater than unity, then $R_2K/(K-1)$ is approximately R_2. However, we used the assumption earlier in the problem that R_2 is greater than R_3. Consequently, it would not be consistent to place the resistor R_2 in parallel with R_3.

If the controlled source in Fig. A.1-2 had been a voltage source rather than a current source, then it would not have been necessary to make the assumption used in Example A.1-7. In this case, R_2 would have been reflected into both N_1 and N_2. Figure A.1-3 shows a case where R_3 could be removed by the Miller simplification and reflected into both N_1 and N_2 according to Eqs. (A.1-18) and (A.1-19).

Although other simplification techniques could have been included, the above are the ones most useful in analyzing linear active circuits. The material of the book presents many further illustrations of the use of the concepts presented in this appendix. Problems that illustrate the principles developed here can be found at the end of the problems in Chapter 1.