

FIGURES FOR CHAPTER 4

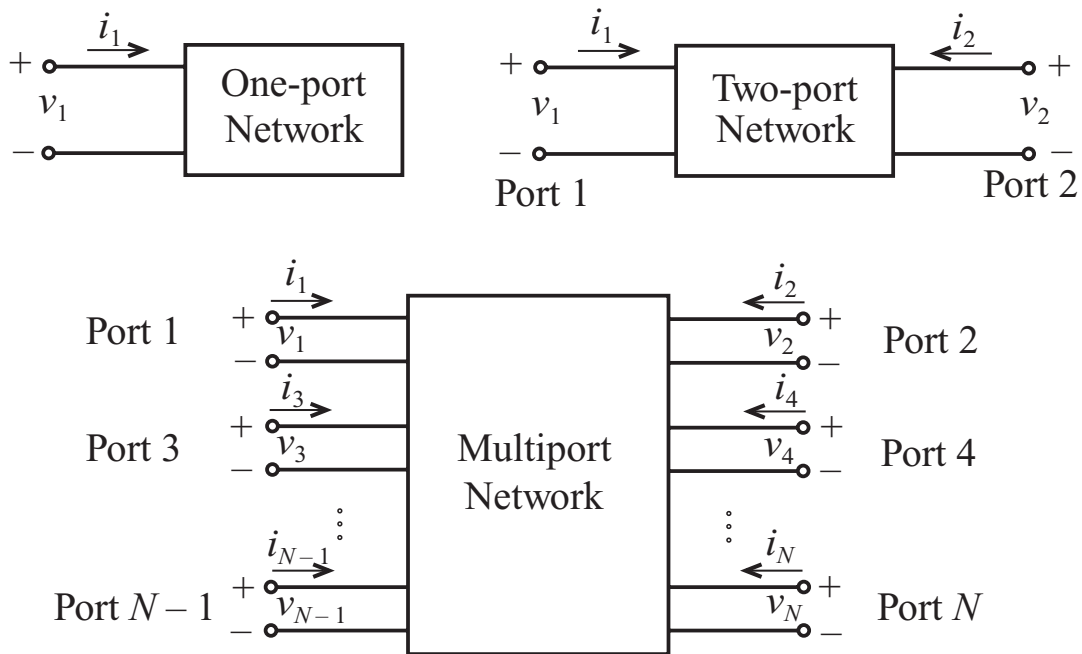


Figure 4-1 Basic voltage and current definitions for single- and multiport network.

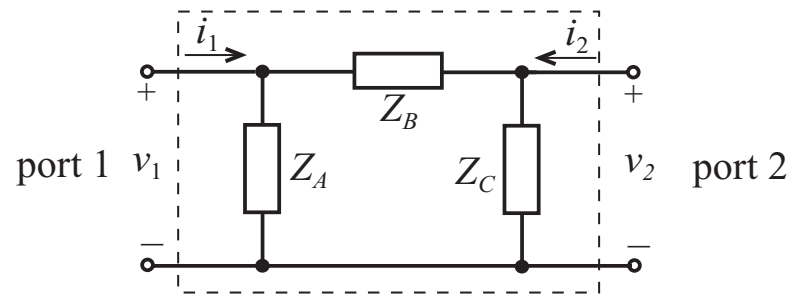


Figure 4-2 Pi-network as a two-port network.

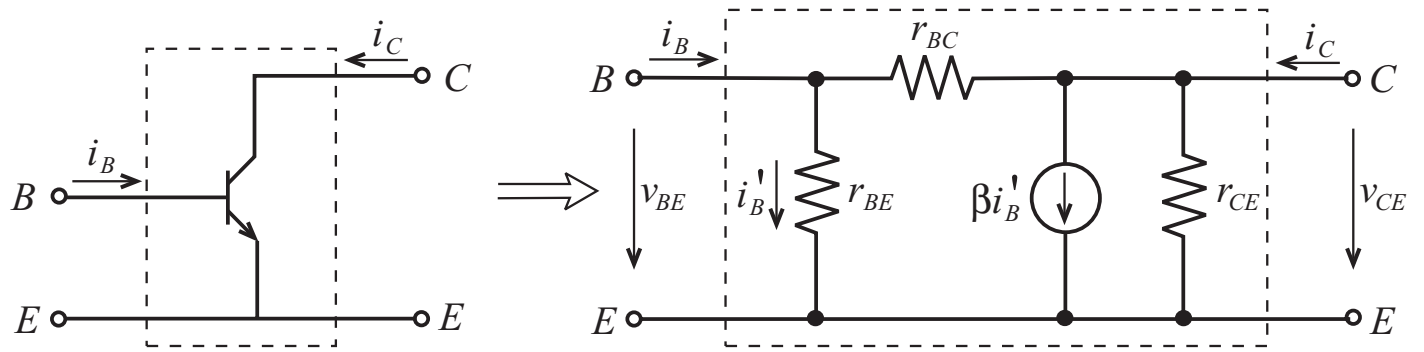


Figure 4-3 Common-emitter low-frequency, small-signal transistor model.

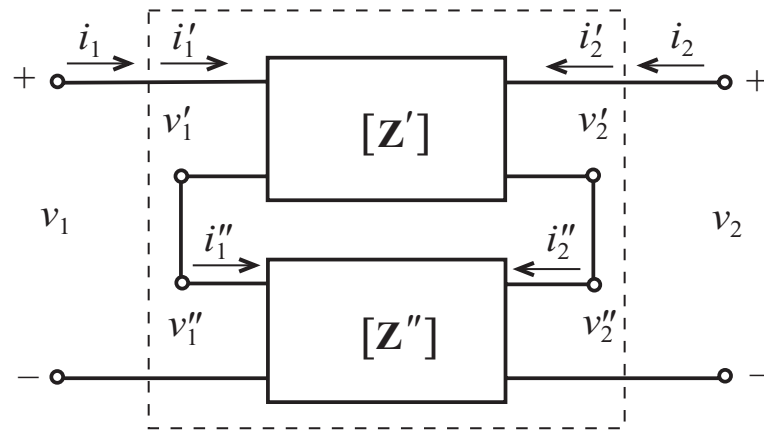


Figure 4-4 Series connection of two two-port networks.

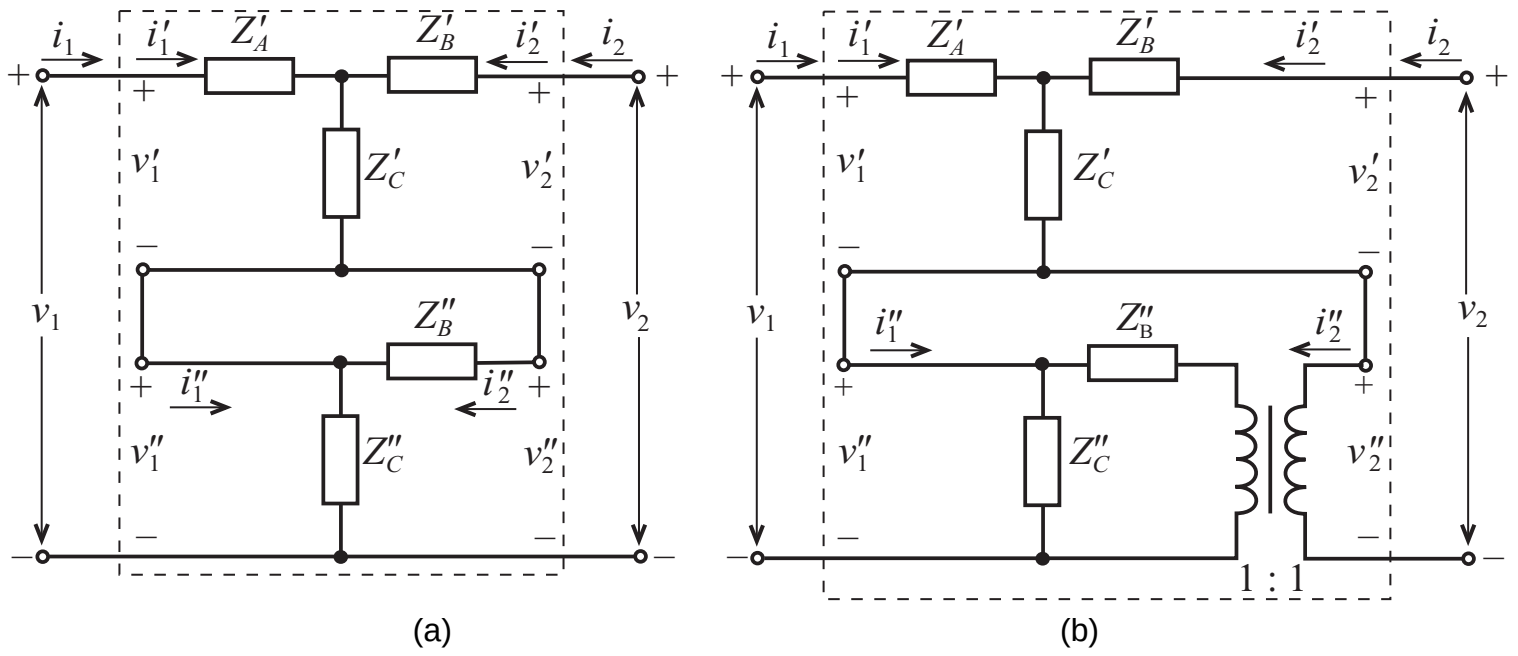


Figure 4-5 (a) Short circuit in series connection. (b) Transformer to avoid short circuit.

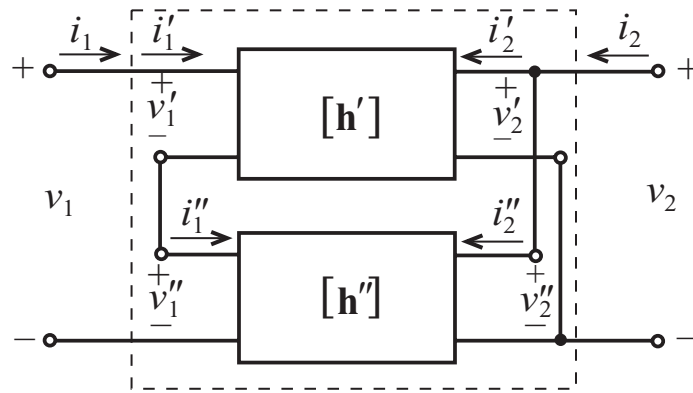


Figure 4-6 Connection of two-port networks suitable for hybrid representation.

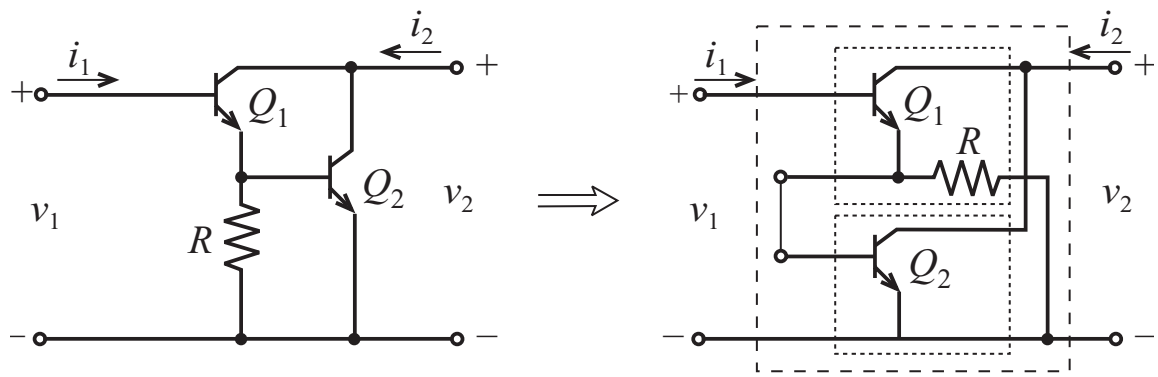


Figure 4-7 Series connection of two hybrid networks.

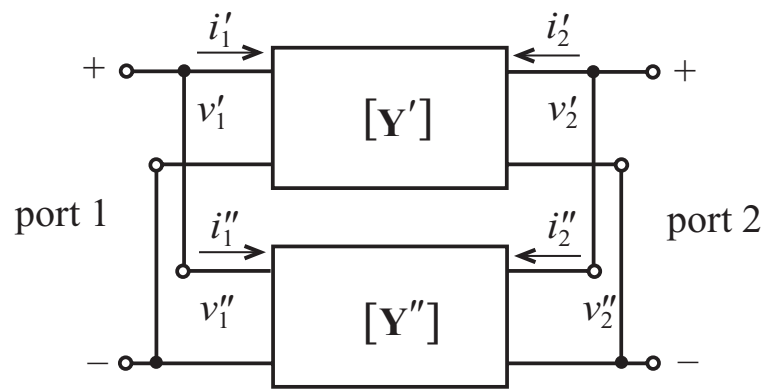


Figure 4-8 Parallel connection of two two-port networks.

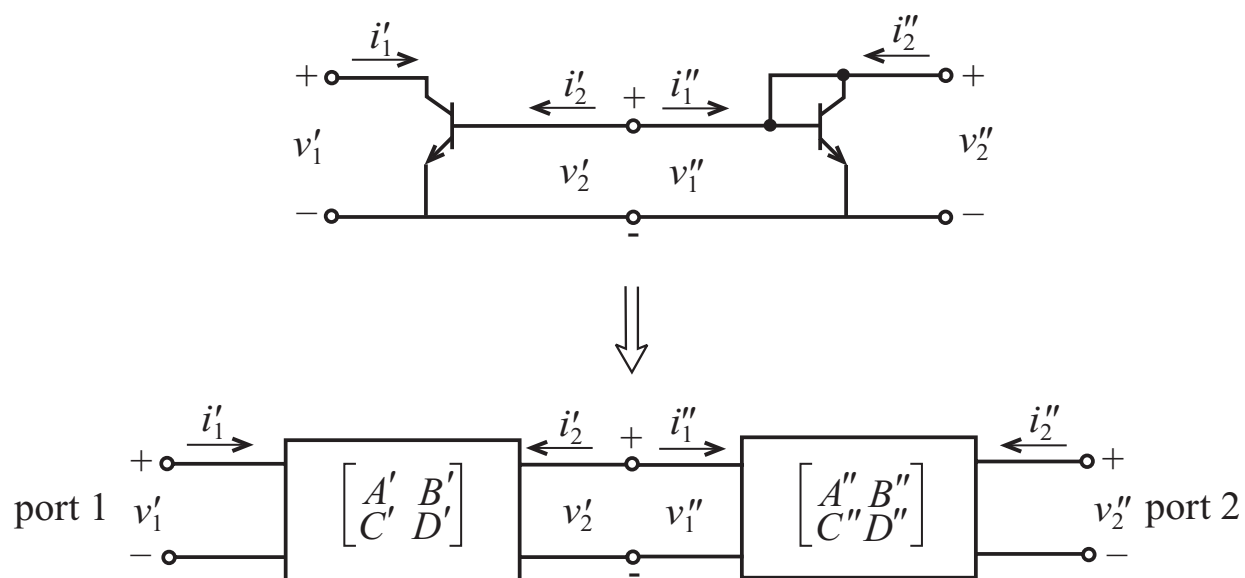


Figure 4-9 Cascading two networks.

Table 4-1 ABCD-Parameters of Some Useful Two-Port Circuits.

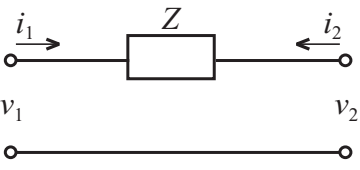
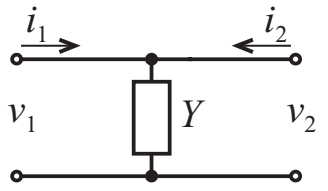
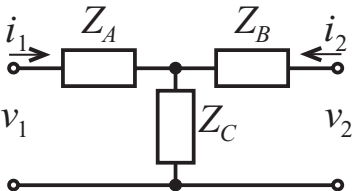
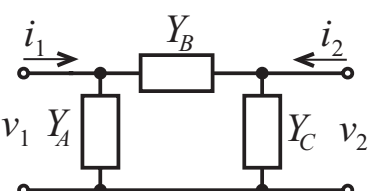
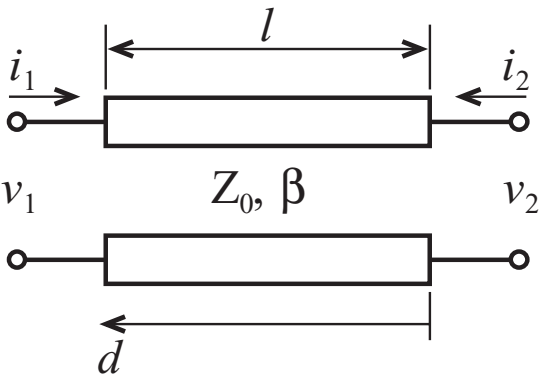
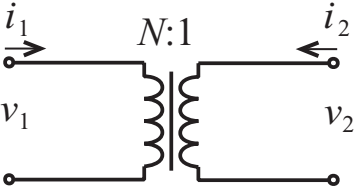
Circuit	ABCD-Parameters	
	$A = 1$ $C = 0$	$B = Z$ $D = 1$
	$A = 1$ $C = Y$	$B = 0$ $D = 1$
	$A = 1 + \frac{Z_A}{Z_C}$ $C = \frac{1}{Z_C}$	$B = Z_A + Z_B + \frac{Z_A Z_B}{Z_C}$ $D = 1 + \frac{Z_B}{Z_C}$
	$A = 1 + \frac{Y_B}{Y_C}$ $C = Y_A + Y_B + \frac{Y_A Y_B}{Y_C}$	$B = \frac{1}{Y_C}$ $D = 1 + \frac{Y_A}{Y_C}$
	$A = \cos \beta l$ $C = \frac{j \sin \beta l}{Z_0}$	$B = j Z_0 \sin \beta l$ $D = \cos \beta l$
	$A = N$ $C = 0$	$B = 0$ $D = \frac{1}{N}$

Table 4-2 Conversion between Different Network Representations

	[Z]	[Y]	[h]	[ABCD]
[Z]	$\begin{array}{cc} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{array}$	$\begin{array}{cc} \frac{Z_{22}}{\Delta Z} & -\frac{Z_{12}}{\Delta Z} \\ -\frac{Z_{21}}{\Delta Z} & \frac{Z_{11}}{\Delta Z} \end{array}$	$\begin{array}{cc} \frac{\Delta Z}{Z_{22}} & \frac{Z_{12}}{Z_{22}} \\ -\frac{Z_{21}}{Z_{22}} & \frac{1}{Z_{22}} \end{array}$	$\begin{array}{cc} \frac{Z_{11}}{Z_{21}} & \frac{\Delta Z}{Z_{21}} \\ \frac{1}{Z_{21}} & \frac{Z_{22}}{Z_{21}} \end{array}$
[Y]	$\begin{array}{cc} \frac{Y_{22}}{\Delta Y} & -\frac{Y_{12}}{\Delta Y} \\ -\frac{Y_{21}}{\Delta Y} & \frac{Y_{11}}{\Delta Y} \end{array}$	$\begin{array}{cc} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{array}$	$\begin{array}{cc} \frac{1}{Y_{11}} & -\frac{Y_{12}}{Y_{11}} \\ \frac{Y_{21}}{Y_{11}} & \frac{\Delta Y}{Y_{11}} \end{array}$	$\begin{array}{cc} -\frac{Y_{22}}{Y_{21}} & -\frac{1}{Y_{21}} \\ -\frac{\Delta Y}{Y_{21}} & -\frac{Y_{11}}{Y_{21}} \end{array}$
[h]	$\begin{array}{cc} \frac{\Delta h}{h_{22}} & \frac{h_{12}}{h_{22}} \\ -\frac{h_{21}}{h_{22}} & \frac{1}{h_{22}} \end{array}$	$\begin{array}{cc} \frac{1}{h_{11}} & \frac{h_{12}}{h_{11}} \\ \frac{h_{21}}{h_{11}} & \frac{\Delta h}{h_{11}} \end{array}$	$\begin{array}{cc} h_{11} & h_{12} \\ h_{21} & h_{22} \end{array}$	$\begin{array}{cc} -\frac{\Delta h}{h_{21}} & -\frac{h_{11}}{h_{21}} \\ -\frac{h_{22}}{h_{21}} & -\frac{1}{h_{21}} \end{array}$
[ABCD]	$\begin{array}{cc} \frac{A}{C} & \frac{\Delta ABCD}{C} \\ \frac{1}{C} & \frac{D}{C} \end{array}$	$\begin{array}{cc} \frac{D}{B} & -\frac{\Delta ABCD}{B} \\ -\frac{1}{B} & \frac{A}{B} \end{array}$	$\begin{array}{cc} \frac{B}{D} & \frac{\Delta ABCD}{D} \\ -\frac{1}{D} & \frac{C}{D} \end{array}$	$\begin{array}{cc} A & B \\ C & D \end{array}$

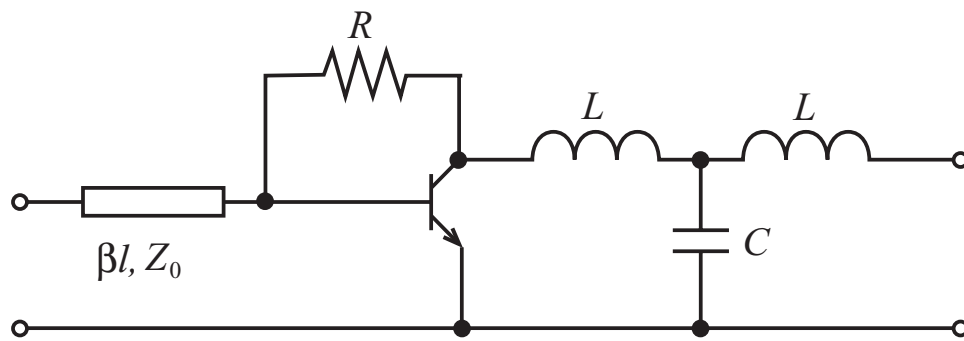


Figure 4-10 Microwave amplifier circuit diagram.

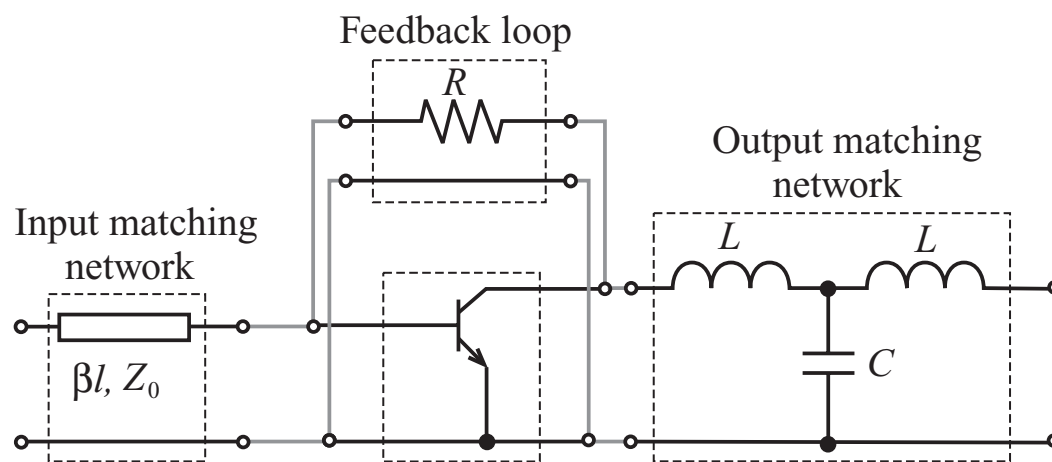


Figure 4-11 Subnetwork representation of the microwave amplifier.

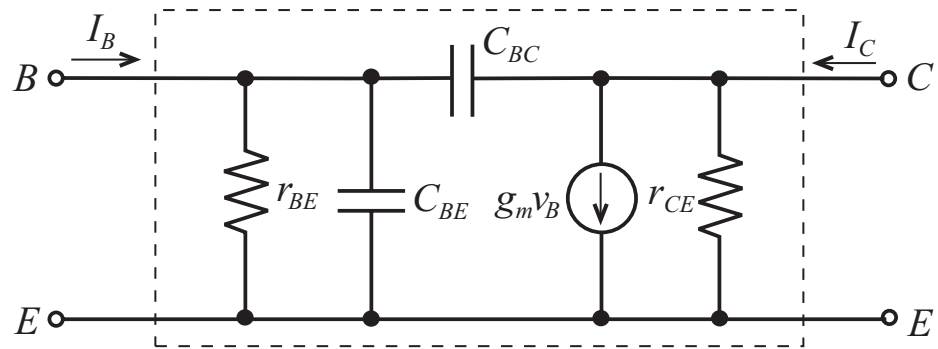


Figure 4-12 High-frequency hybrid transistor model.

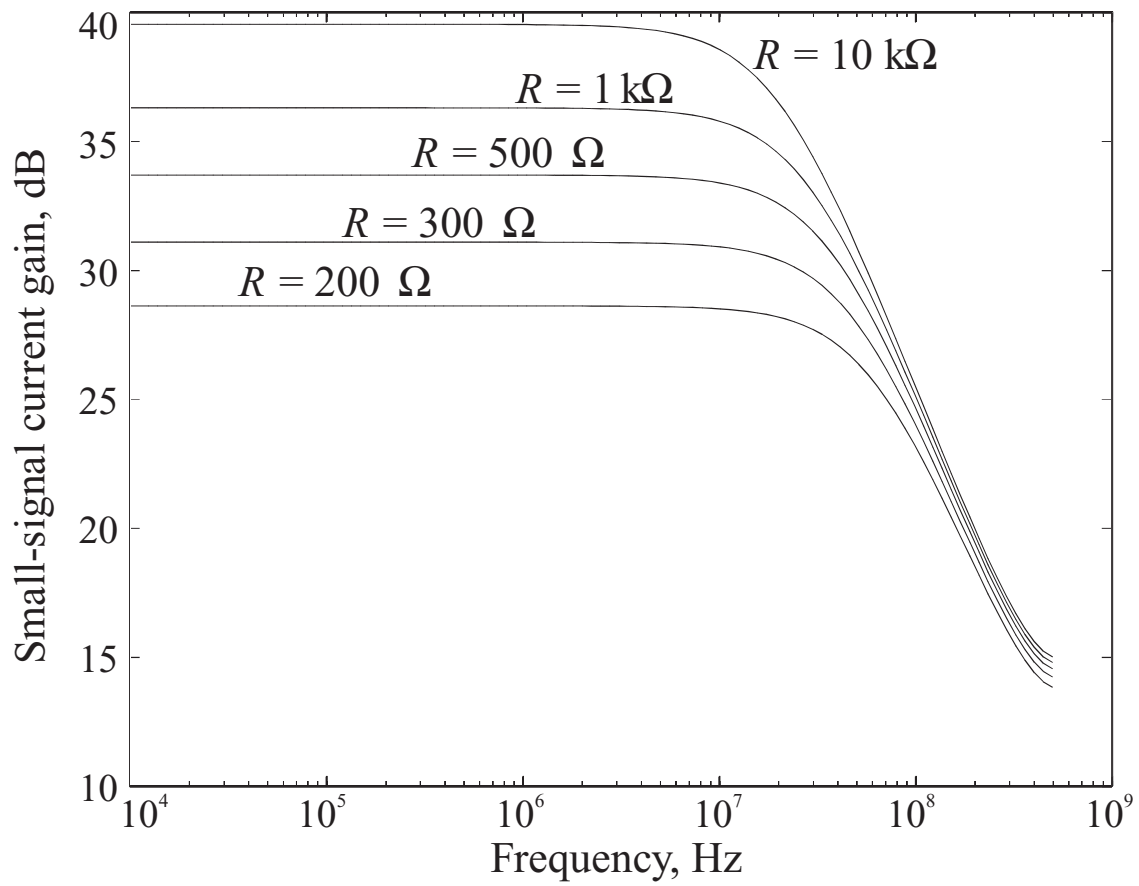


Figure 4-13 Small-signal current gain of the amplifier versus frequency for different values of the feedback resistor.

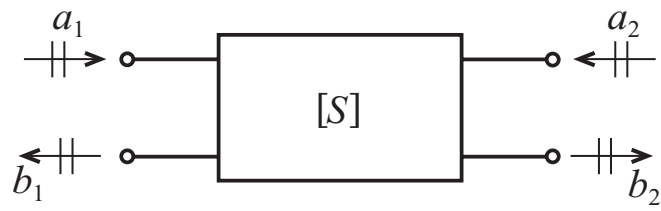


Figure 4-14 Convention used to define S -parameters for a two-port network.

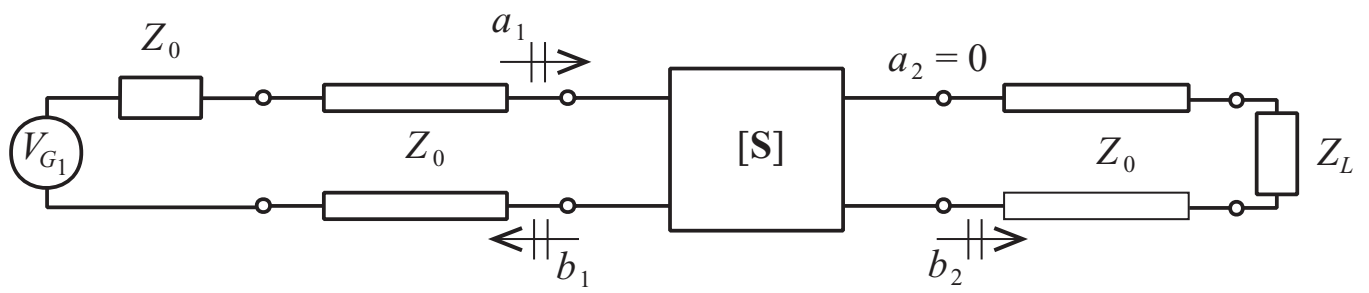


Figure 4-15 Measurement of S_{11} and S_{21} by matching the line impedance Z_0 at port 2 through a corresponding load impedance $Z_L = Z_0$.

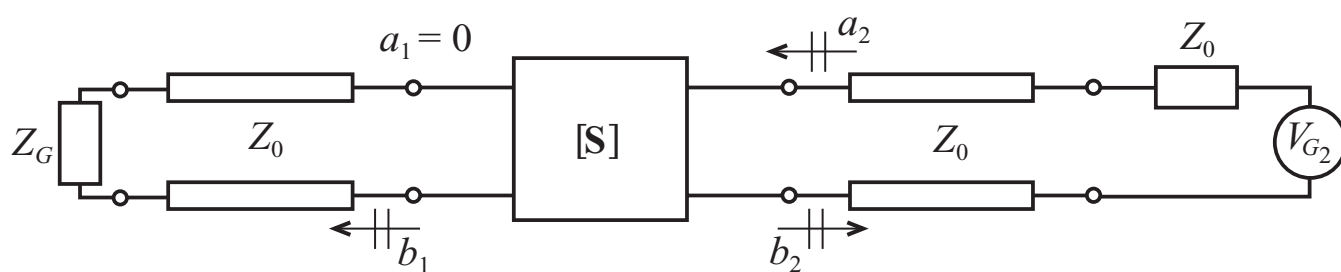


Figure 4-16 Measurement of S_{22} and S_{12} by matching the line impedance Z_0 at port 1 through a corresponding input impedance $Z_G = Z_0$.

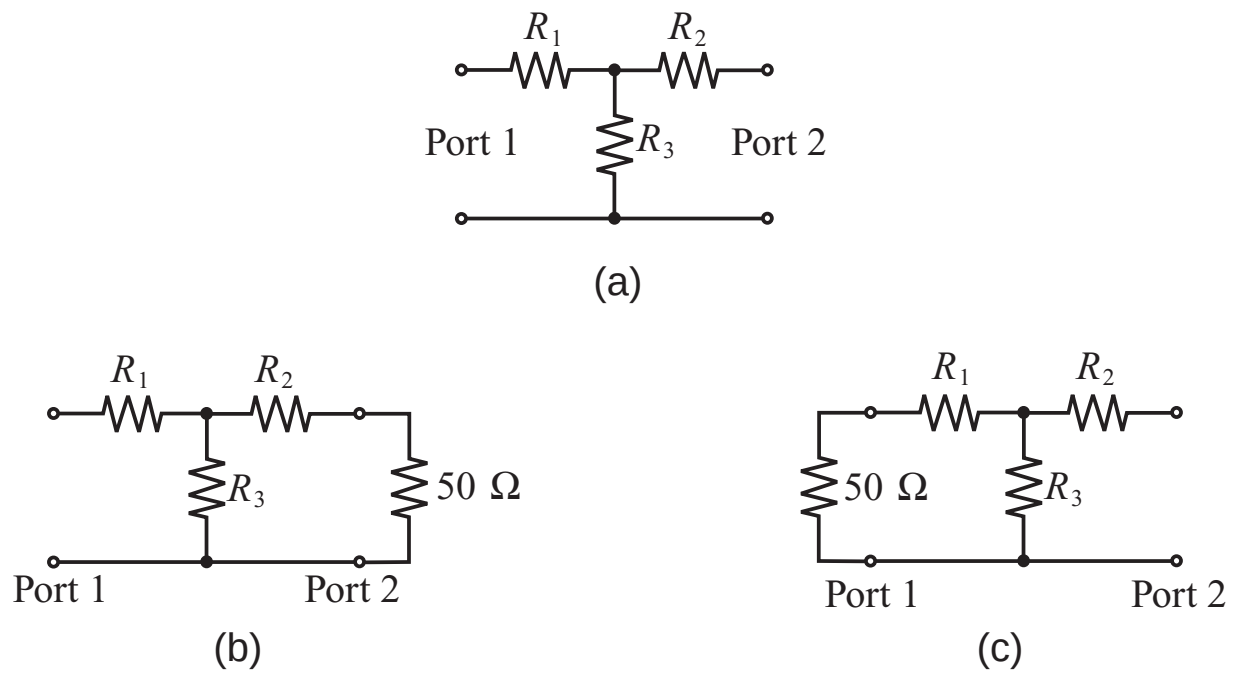


Figure 4-17 *S*-parameter computation for a *T*-network. (a) circuit diagram; (b) circuit for S_{11} and S_{21} measurements; (c) circuit for S_{12} and S_{22} measurements.

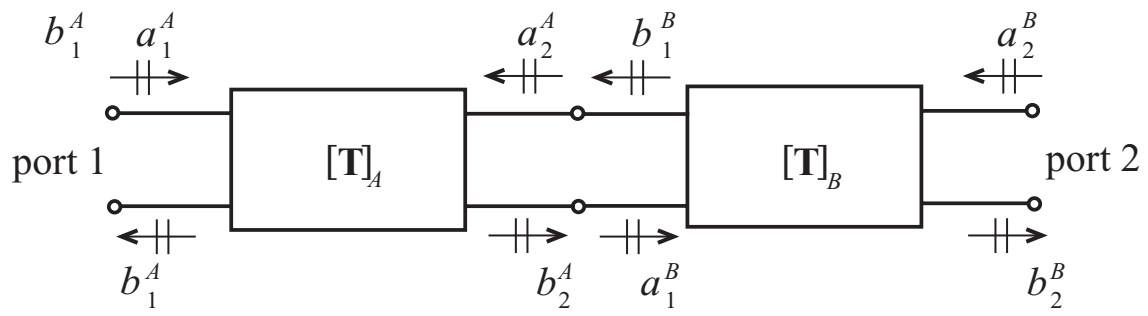


Figure 4-18 Cascading of two networks A and B.

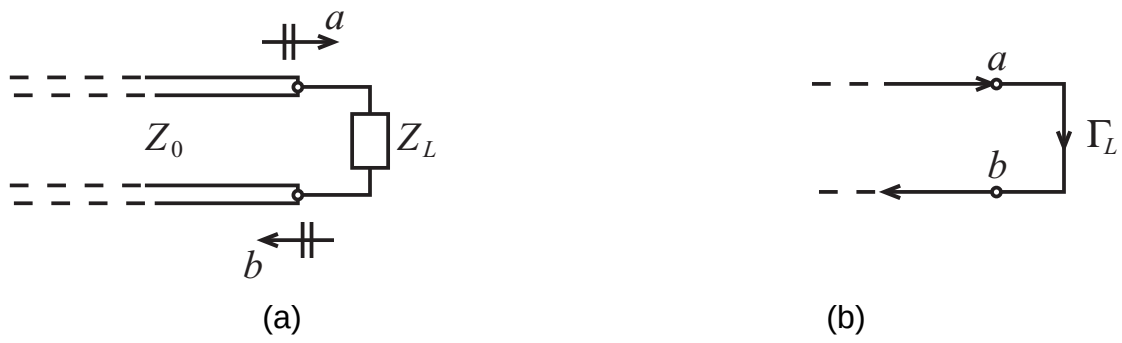


Figure 4-19 Terminated transmission line segment with incident and reflected S -parameter description.
 (a) Conventional form, and (b) Signal flow form.



(a) Source node a , which launches wave.



(b) Sink node b , which receives wave.



(c) Branch connecting source and sink.

Figure 4-20 Generic source node (a), receiver node (b), and the associated (c) branch connection.

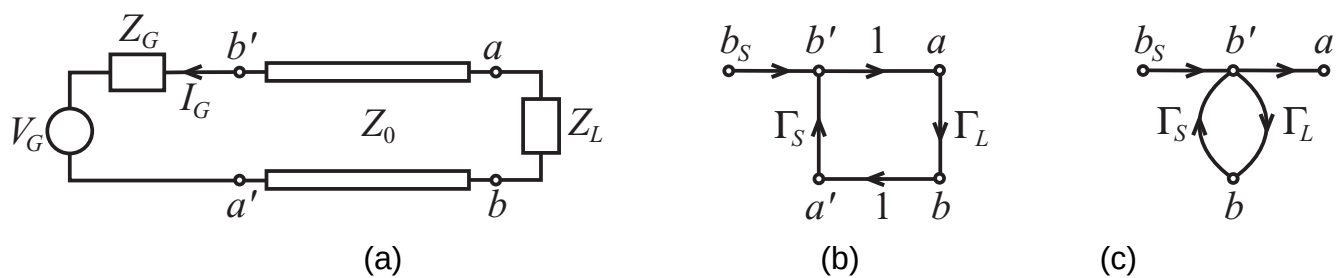


Figure 4-21 Terminated transmission line with source. (a) conventional form, (b) signal flow form, and (c) simplified signal flow form.

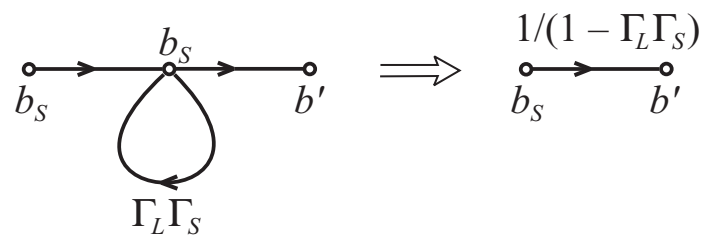
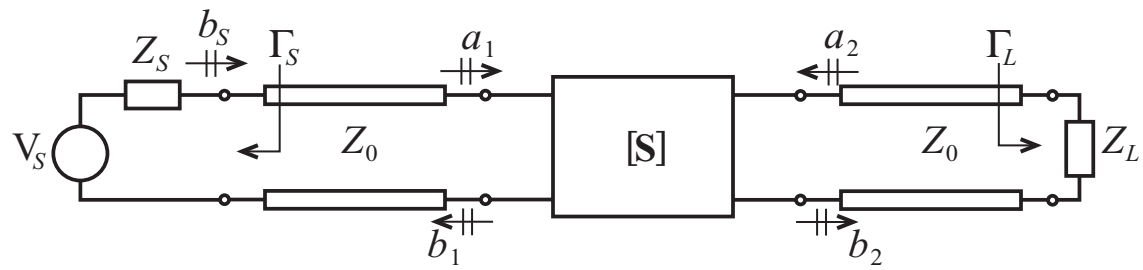


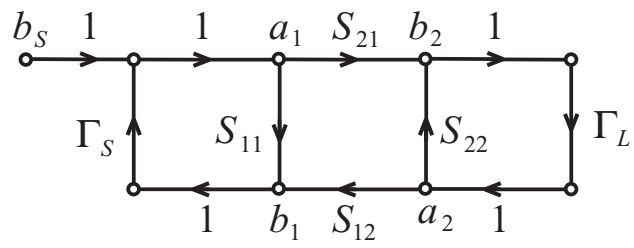
Figure 4-22 A self-loop that collapses to a single branch.

Table 4-3 Signal flow chart building blocks

Description	Graphical Representation
Nodal Assignment	
Branch	
Series Connection	
Parallel Connection	
Splitting of Branches	
Self-loop	

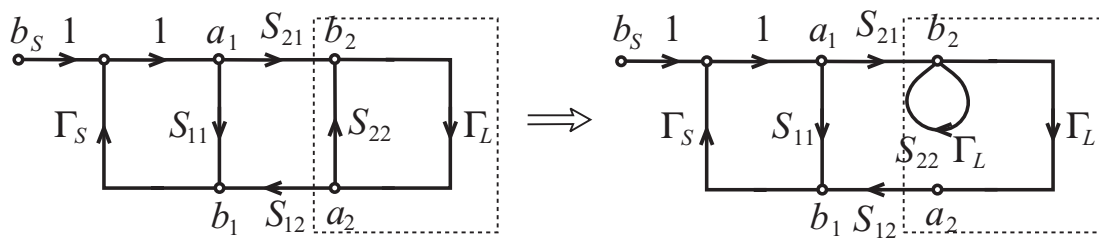


(a) Circuit representation

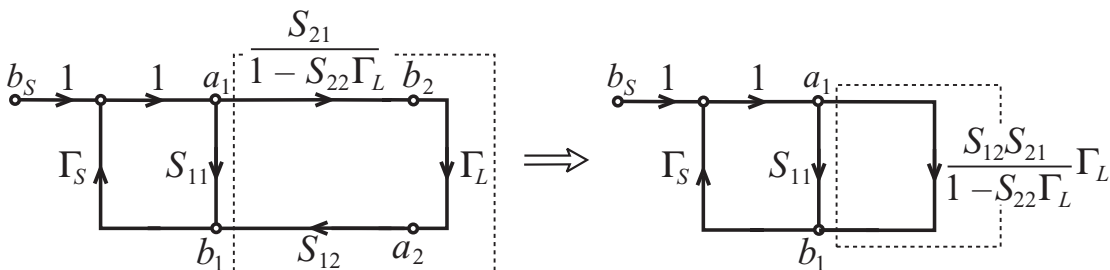


(b) Signal flow chart

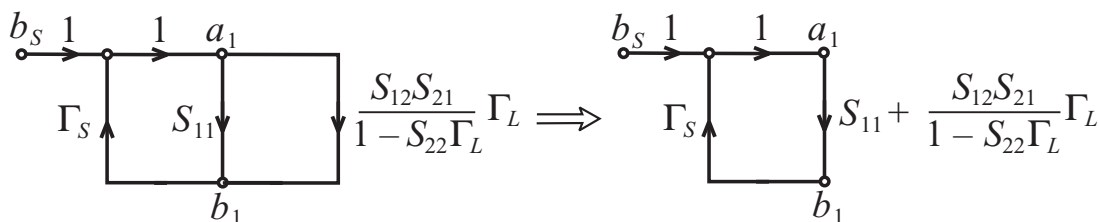
Figure 4-23 Sourced and terminated two-port network.



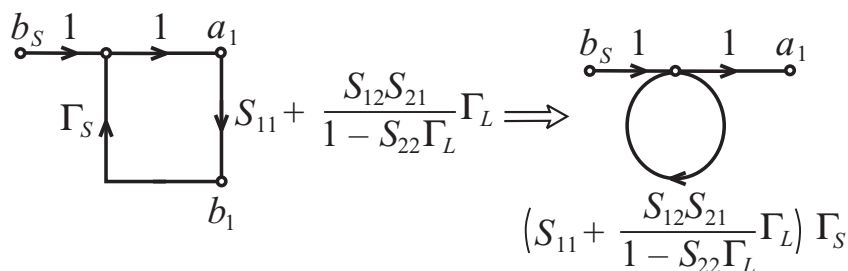
Step 1



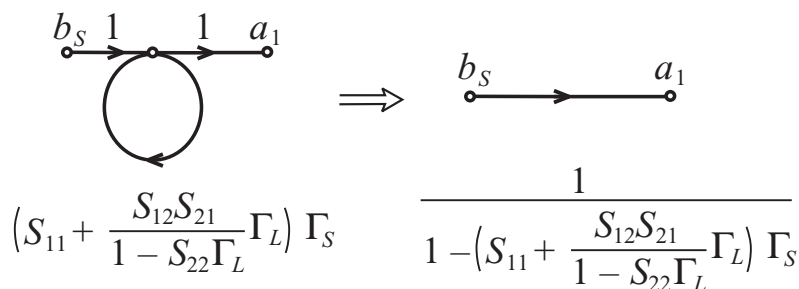
Step 2



Step 3



Step 4



Step 5

Figure 4-24 Step-by-step simplification to determine the ratio a_1/b_s .

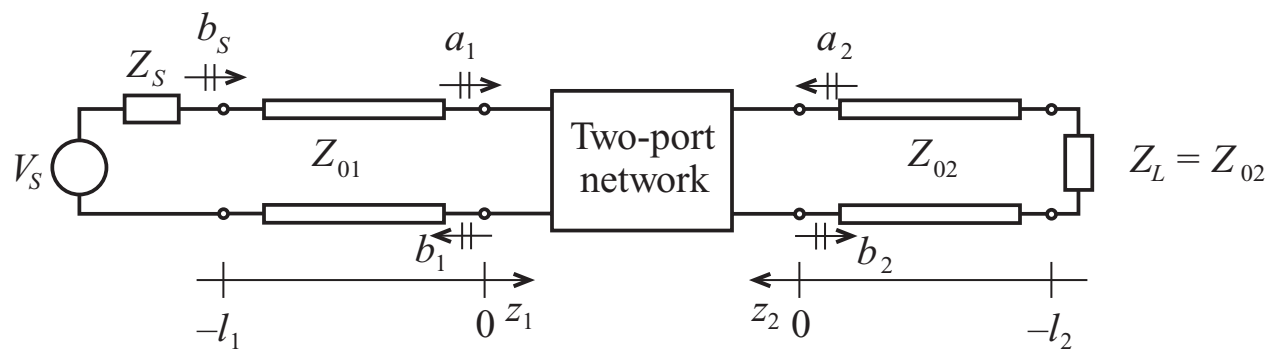


Figure 4-25 Two-port network with finite-length transmission line segments.

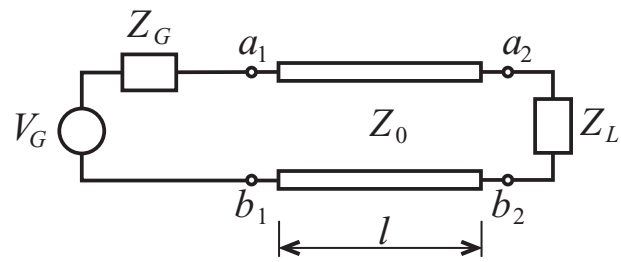


Figure 4-26 Transmission line attached to a voltage source and terminated by a load impedance.

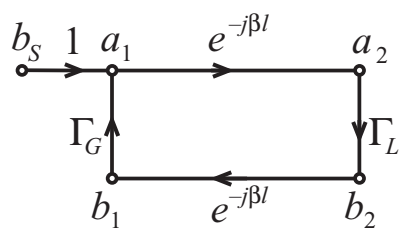


Figure 4-27 Signal flow chart diagram for transmission line system in Figure 4-26.

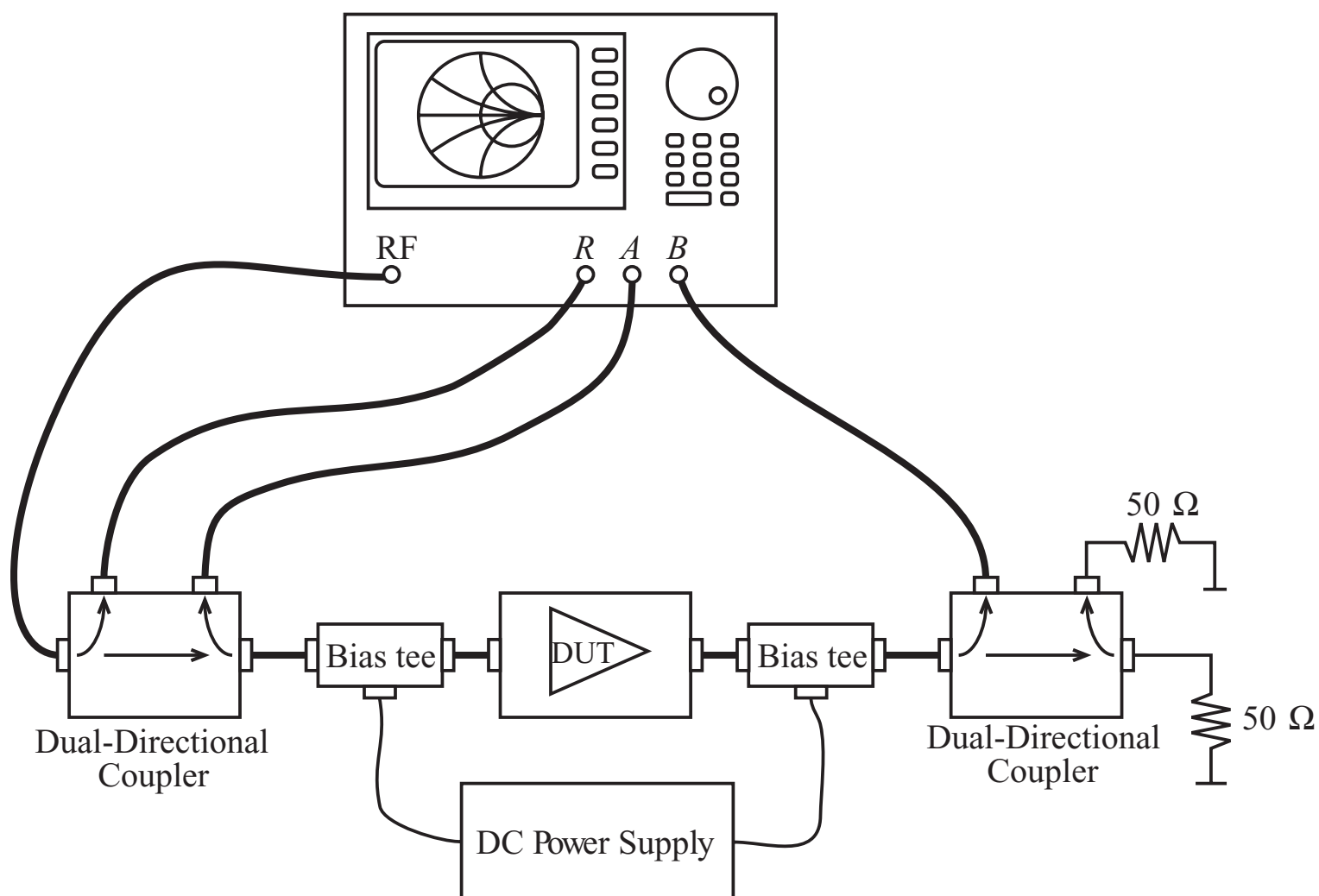


Figure 4-28 Measurement system for S_{11} and S_{21} parameters using a network analyzer.

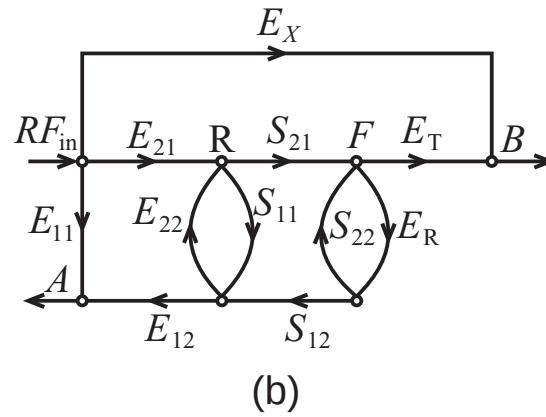
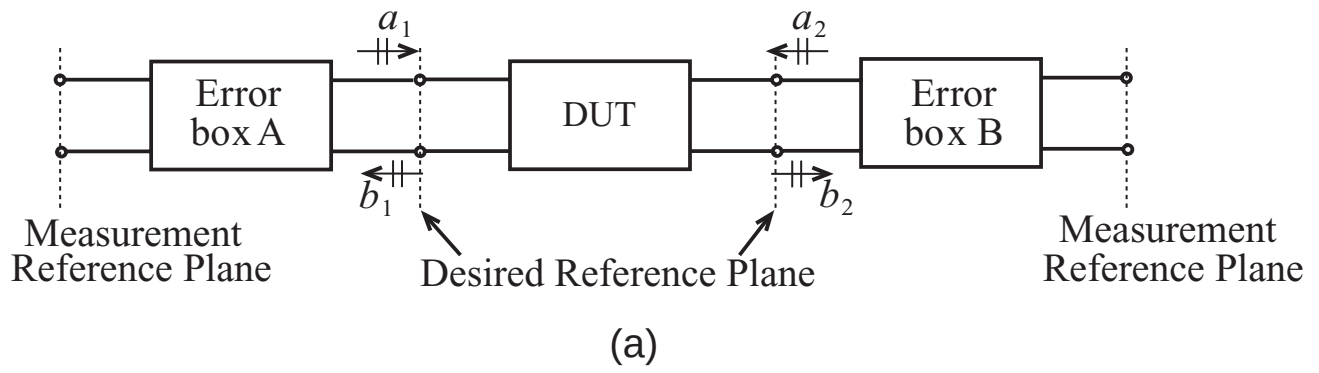
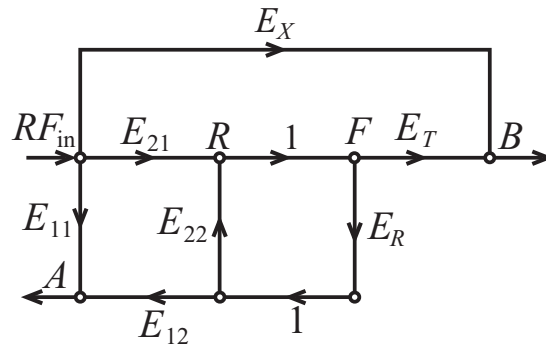
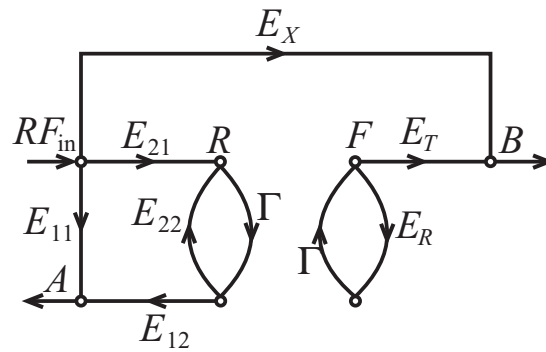


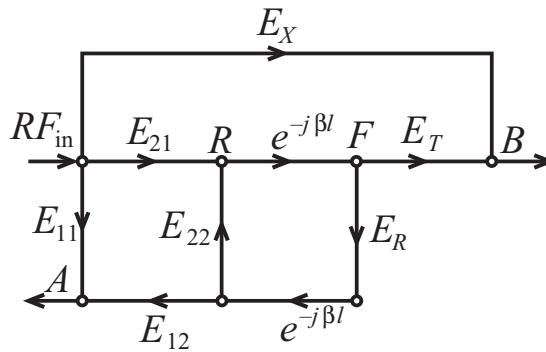
Figure 4-29 (a) Block diagram of the setup for measurement of S-parameters of a two-port network; (b) signal flow chart of the measurement test setup.



(a) Through



(b) Reflect



(c) Line

Figure 4-30 Signal flow graphs of TRL method: (a) Through, (b) Reflect, (c) Line configurations.