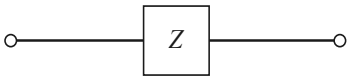
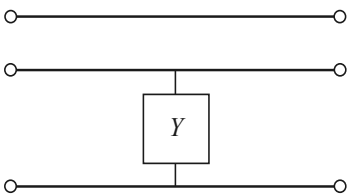
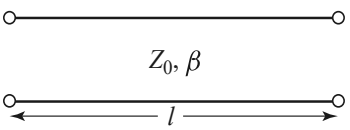
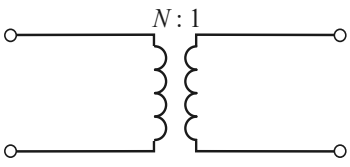
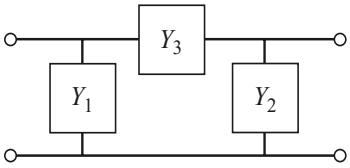
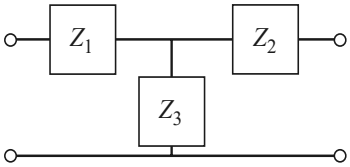


TABLE 4.1 *ABCD* Parameters of Some Useful Two-Port Circuits

Circuit	<i>ABCD</i> Parameters	
	$A = 1$ $C = 0$	$B = Z$ $D = 1$
	$A = 1$ $C = Y$	$B = 0$ $D = 1$
	$A = \cos \beta$ $C = jY_0 \sin \beta$	$B = jZ_0 \sin \beta$ $D = \cos \beta$
	$A = N$ $C = 0$	$B = 0$ $D = \frac{1}{N}$
	$A = 1 + \frac{Y_2}{Y_3}$ $C = Y_1 + Y_2 + \frac{Y_1 Y_2}{Y_3}$	$B = \frac{1}{Y_3}$ $D = 1 + \frac{Y_1}{Y_3}$
	$A = 1 + \frac{Z_1}{Z_3}$ $C = \frac{1}{Z_3}$	$B = Z_1 + Z_2 + \frac{Z_1 Z_2}{Z_3}$ $D = 1 + \frac{Z_2}{Z_3}$

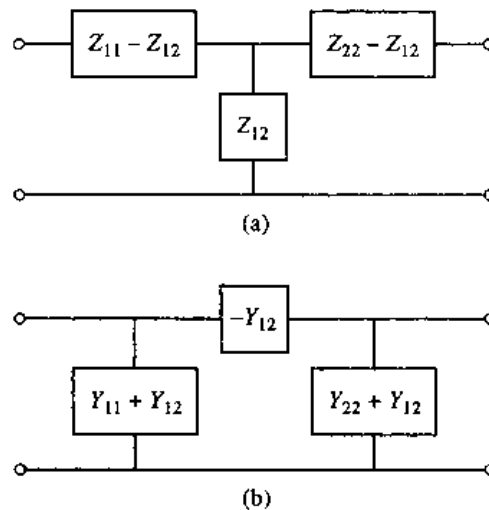


FIGURE 4.13 Equivalent circuits for a reciprocal two-port network. (a) T equivalent. (b) π equivalent.

TABLE 4.2 Conversions Between Two-Port Network Parameters

	S	Z	Y	$ABCD$
S_{11}	S_{11}	$\frac{(Z_{11} - Z_0)(Z_{22} + Z_0) - Z_{12}Z_{21}}{Z}$	$\frac{(Y_0 - Y_{11})(Y_0 + Y_{22}) + Y_{12}Y_{21}}{Y}$	$\frac{A + B/Z_0 - CZ_0 - D}{A + B/Z_0 + CZ_0 + D}$
S_{12}	S_{12}	$\frac{2Z_{12}Z_0}{Z}$	$\frac{-2Y_{12}Y_0}{Y}$	$\frac{2(AD - BC)}{A + B/Z_0 + CZ_0 + D}$
S_{21}	S_{21}	$\frac{2Z_{21}Z_0}{Z}$	$\frac{-2Y_{21}Y_0}{Y}$	$\frac{2}{A + B/Z_0 + CZ_0 + D}$
S_{22}	S_{22}	$\frac{(Z_{11} + Z_0)(Z_{22} - Z_0) - Z_{12}Z_{21}}{Z}$	$\frac{(Y_0 + Y_{11})(Y_0 - Y_{22}) + Y_{12}Y_{21}}{Y}$	$\frac{-A + B/Z_0 - CZ_0 + D}{A + B/Z_0 + CZ_0 + D}$
Z_{11}	$Z_0 \frac{(1 + S_{11})(1 - S_{22}) + S_{12}S_{21}}{(1 - S_{11})(1 - S_{22}) - S_{12}S_{21}}$	Z_{11}	$\frac{Y_{22}}{ Y }$	$\frac{A}{C}$
Z_{12}	$Z_0 \frac{2S_{12}}{(1 - S_{11})(1 - S_{22}) - S_{12}S_{21}}$	Z_{12}	$\frac{-Y_{12}}{ Y }$	$\frac{AD - BC}{C}$
Z_{21}	$Z_0 \frac{2S_{21}}{(1 - S_{11})(1 - S_{22}) - S_{12}S_{21}}$	Z_{21}	$\frac{-Y_{21}}{ Y }$	$\frac{1}{C}$
Z_{22}	$Z_0 \frac{(1 - S_{11})(1 + S_{22}) + S_{12}S_{21}}{(1 - S_{11})(1 - S_{22}) + S_{12}S_{21}}$	Z_{22}	$\frac{Y_{11}}{ Y }$	$\frac{D}{C}$
Y_{11}	$Y_0 \frac{(1 - S_{11})(1 + S_{22}) + S_{12}S_{21}}{(1 + S_{11})(1 + S_{22}) - S_{12}S_{21}}$	$\frac{Z_{22}}{ Z }$	Y_{11}	$\frac{D}{B}$
Y_{12}	$Y_0 \frac{-2S_{12}}{(1 + S_{11})(1 + S_{22}) - S_{12}S_{21}}$	$\frac{-Z_{12}}{ Z }$	Y_{12}	$\frac{BC - AD}{B}$
Y_{21}	$Y_0 \frac{-2S_{21}}{(1 + S_{11})(1 + S_{22}) - S_{12}S_{21}}$	$\frac{-Z_{21}}{ Z }$	Y_{21}	$\frac{-1}{B}$
Y_{22}	$Y_0 \frac{(1 + S_{11})(1 - S_{22}) + S_{12}S_{21}}{(1 + S_{11})(1 + S_{22}) - S_{12}S_{21}}$	$\frac{Z_{11}}{ Z }$	Y_{22}	$\frac{A}{B}$
A	$\frac{(1 + S_{11})(1 - S_{22}) + S_{12}S_{21}}{2S_{21}}$	$\frac{Z_{11}}{Z_{21}}$	$\frac{-Y_{22}}{Y_{21}}$	A
B	$Z_0 \frac{(1 + S_{11})(1 + S_{22}) - S_{12}S_{21}}{2S_{21}}$	$\frac{ Z }{Z_{21}}$	$\frac{-1}{Y_{21}}$	B
C	$\frac{1}{Z_0} \frac{(1 - S_{11})(1 - S_{22}) - S_{12}S_{21}}{2S_{21}}$	$\frac{1}{Z_{21}}$	$\frac{- Y }{Y_{21}}$	C
D	$\frac{(1 - S_{11})(1 + S_{22}) + S_{12}S_{21}}{2S_{21}}$	$\frac{Z_{22}}{Z_{21}}$	$\frac{-Y_{11}}{Y_{21}}$	D
$ Z = Z_{11}Z_{22} - Z_{12}Z_{21}; \quad Y = Y_{11}Y_{22} - Y_{12}Y_{21}; \quad Y = (Y_{11} + Y_0)(Y_{22} + Y_0) - Y_{12}Y_{21}; \quad Z = (Z_{11} + Z_0)(Z_{22} + Z_0) - Z_{12}Z_{21}; \quad Y_0 = 1/Z_0.$				