nich is defined by the y-parameters discussed previously. The intrin-
stance can be lumped with the extrinsic base resistance as well as the
t resistance.

device properties are often expressed in terms of z- (impedance), and
arameters, we describe them briefly. For the y-parameter discussed
n § 8-2, i_1 and i_2 are the independent variables describing a network
and 2. For z-parameters, the independent variables are v_1 and v_2.
neters, they are i_1 and v_2. For convenience, we write out the relevant
s:

$$\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} \tag{4-90}$$

$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} \tag{4-91}$$

$$\begin{bmatrix} v_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} i_1 \\ v_2 \end{bmatrix} \tag{4-92}$$

etermined y's for both the common-base and the common-emitter
ons. Once these parameters are known, the z- and the h-parameters
determined. For example, let us find z_{11} in terms of the y-parameters.
-91), z_{11} is the ratio of v_1 over i_1 when $i_2 = 0$, Eq. (4-90) implies that:

$$v_2 = -\frac{y_{21}}{y_{22}} v_1 \tag{4-93}$$

g this result into Eq. (4-90), it is found that:

$$i_1 = y_{11}v_1 - y_{12}\frac{y_{21}}{y_{22}}v_1 = \left(\frac{y_{11}y_{22} - y_{12}y_{21}}{y_{22}}\right)v_1 \tag{4-94}$$

tly, z_{11} is

$$z_{11} = \left.\frac{v_1}{i_1}\right|_{i_2=0} = \frac{y_{22}}{\Delta y} \tag{4-95}$$

$$\Delta y = y_{11}y_{22} - y_{12}y_{21} \tag{4-96}$$

is a conversion table for the small-signal parameters. z_{11} expressed
) is indeed listed at the proper entry in the figure. The derivations of
onships are straightforward and not discussed further.

$z' = z/R_o$. $y' = yR_o$. $h_{11}' = h_{11}/R_o$; $h_{12}' = h_{12}$; $h_{21}' = h_{21}$; $h_{22}' = h_{22}R_o$.

	s_{11}	s_{12}	s_{21}	s_{22}
z_{11}'	$\frac{(z_{11}'-1)(z_{22}'+1)-z_{12}'z_{21}'}{(z_{11}'+1)(z_{22}'+1)-z_{12}'z_{21}'}$	$\frac{2z_{12}'}{(z_{11}'+1)(z_{22}'+1)-z_{12}'z_{21}'}$	$\frac{2z_{21}'}{(z_{11}'+1)(z_{22}'+1)-z_{12}'z_{21}'}$	$\frac{(z_{11}'+1)(z_{22}'-1)-z_{12}'z_{21}'}{(z_{11}'+1)(z_{22}'+1)-z_{12}'z_{21}'}$
y_{11}'	$\frac{(1-y_{11}')(1+y_{22}')+y_{12}'y_{21}'}{(1+y_{11}')(1+y_{22}')-y_{12}'y_{21}'}$	$\frac{-2y_{12}'}{(1+y_{11}')(1+y_{22}')-y_{12}'y_{21}'}$	$\frac{-2y_{21}'}{(1+y_{11}')(1+y_{22}')-y_{12}'y_{21}'}$	$\frac{(1+y_{11}')(1-y_{22}')+y_{12}'y_{21}'}{(1+y_{11}')(1+y_{22}')-y_{12}'y_{21}'}$
h_{11}'	$\frac{(h_{11}'-1)(1+h_{22}')-h_{12}'h_{21}'}{(1+h_{11}')(1+h_{22}')-h_{12}'h_{21}'}$	$\frac{2h_{12}'}{(1+h_{11}')(1+h_{22}')-h_{12}'h_{21}'}$	$\frac{-2h_{21}'}{(1+h_{11}')(1+h_{22}')-h_{12}'h_{21}'}$	$\frac{(1+h_{11}')(1-h_{22}')+h_{12}'h_{21}'}{(1+h_{11}')(1+h_{22}')-h_{12}'h_{21}'}$

	z_{11}	z_{12}	z_{21}	z_{22}
y_{11}'	$\frac{z_{22}'}{z_{11}'z_{22}'-z_{21}'z_{12}'}$	$\frac{-z_{12}'}{z_{11}'z_{22}'-z_{21}'z_{12}'}$	$\frac{-z_{21}'}{z_{11}'z_{22}'-z_{21}'z_{12}'}$	$\frac{z_{11}'}{z_{11}'z_{22}'-z_{21}'z_{12}'}$
h_{11}'	$\frac{1}{h_{11}'}$	$-\frac{h_{12}'}{h_{11}'}$	$\frac{h_{21}'}{h_{11}'}$	$\frac{h_{11}'h_{22}'-h_{12}'h_{21}'}{h_{11}'}$

	y_{11}	y_{12}	y_{21}	y_{22}
z_{11}'	$\frac{y_{22}}{y_{11}y_{22}-y_{21}y_{12}}$	$\frac{-y_{12}}{y_{11}y_{22}-y_{21}y_{12}}$	$\frac{-y_{21}}{y_{11}y_{22}-y_{21}y_{12}}$	$\frac{y_{11}}{y_{11}y_{22}-y_{21}y_{12}}$
h_{11}'	$\frac{1}{y_{11}}$	$-\frac{y_{12}}{y_{11}}$	$\frac{y_{21}}{y_{11}}$	$\frac{y_{11}y_{22}-y_{21}y_{12}}{y_{11}}$

	h_{11}	h_{12}	h_{21}	h_{22}
z_{11}'	$\frac{z_{11}z_{22}-z_{21}z_{12}}{z_{22}}$	$\frac{z_{12}}{z_{22}}$	$-\frac{z_{21}}{z_{22}}$	$\frac{1}{z_{22}}$
y_{11}'	$\frac{1}{y_{11}}$	$-\frac{y_{12}}{y_{11}}$	$\frac{y_{21}}{y_{11}}$	$\frac{y_{11}y_{22}-y_{21}y_{12}}{y_{11}}$
h_{11}'	$\frac{(1+s_{11})(1+s_{22})-s_{12}s_{21}}{(1-s_{11})(1+s_{22})+s_{12}s_{21}}$	$\frac{2s_{12}}{(1-s_{11})(1+s_{22})+s_{12}s_{21}}$	$\frac{2s_{21}}{(1-s_{11})(1+s_{22})+s_{12}s_{21}}$	$\frac{(1-s_{11})(1-s_{22})-s_{12}s_{21}}{(1-s_{11})(1+s_{22})+s_{12}s_{21}}$

FIGURE 4-17. Conversion table between the s-, y-, z-, and h-parameters.