TABLE 5.1

Unloaded BJT Transistor Amplifiers

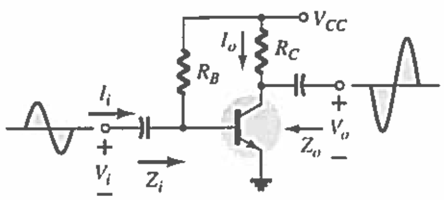
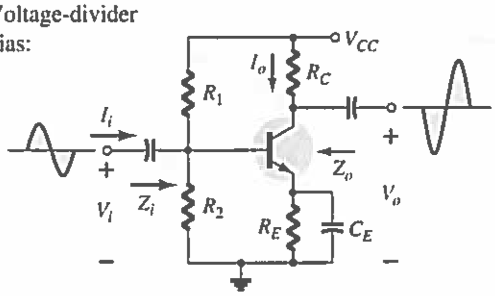
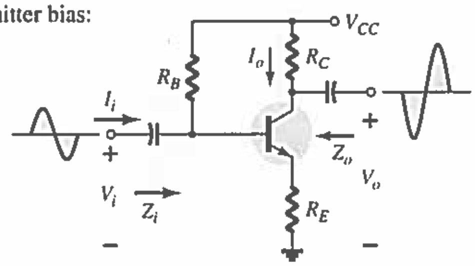
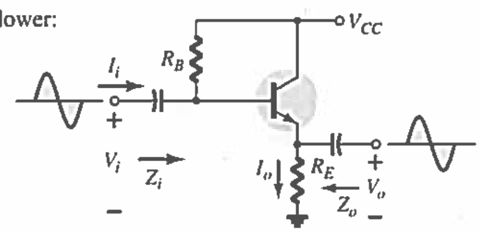
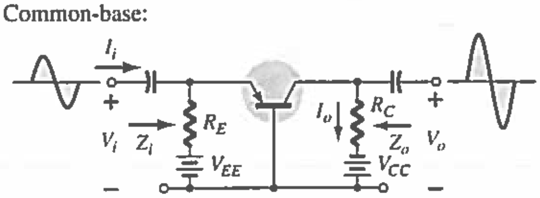
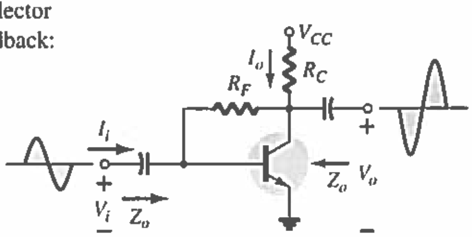
Configuration	Z_i	Z_o	A_v	A_i
Fixed-bias: 	Medium (1 kΩ) $= \boxed{R_B \Vert \beta r_e}$ $\cong \boxed{\beta r_e}$ $(R_B \geq 10\beta r_e)$	Medium (2 kΩ) $= \boxed{R_C \Vert r_o}$ $\cong \boxed{R_C}$ $(r_o \geq 10R_C)$	High (−200) $= \boxed{-\dfrac{(R_C \Vert r_o)}{r_e}}$ $\cong \boxed{-\dfrac{R_C}{r_e}}$ $(r_o \geq 10R_C)$	High (100) $= \boxed{\dfrac{\beta R_B r_o}{(r_o + R_C)(R_B + \beta r_e)}}$ $\cong \boxed{\beta}$ $(r_o \geq 10R_C,$ $R_B \geq 10\beta r_e)$
Voltage-divider bias: 	Medium (1 kΩ) $= \boxed{R_1 \Vert R_2 \Vert \beta r_e}$	Medium (2 kΩ) $= \boxed{R_C \Vert r_o}$ $\cong \boxed{R_C}$ $(r_o \geq 10R_C)$	High (−200) $= \boxed{-\dfrac{R_C \Vert r_o}{r_e}}$ $\cong \boxed{-\dfrac{R_C}{r_e}}$ $(r_o \geq 10R_C)$	High (50) $= \boxed{\dfrac{\beta(R_1 \Vert R_2)r_o}{(r_o + R_C)(R_1 \Vert R_2 + \beta r_e)}}$ $\cong \boxed{\dfrac{\beta(R_1 \Vert R_2)}{R_1 \Vert R_2 + \beta r_e}}$ $(r_o \geq 10R_C)$
Unbypassed emitter bias: 	High (100 kΩ) $= \boxed{R_B \Vert Z_b}$ $Z_b \cong \beta(r_e + R_E)$ $\cong \boxed{R_B \Vert \beta R_E}$ $(R_E \gg r_e)$	Medium (2 kΩ) $= \boxed{R_C}$ (any level of r_o)	Low (−5) $= \boxed{-\dfrac{R_C}{r_e + R_E}}$ $\cong \boxed{-\dfrac{R_C}{R_E}}$ $(R_E \gg r_e)$	High (50) $\cong \boxed{-\dfrac{\beta R_B}{R_B + Z_b}}$
Emitter-follower: 	High (100 kΩ) $= \boxed{R_B \Vert Z_b}$ $Z_b \cong \beta(r_e + R_E)$ $\cong \boxed{R_B \Vert \beta R_E}$ $(R_E \gg r_e)$	Low (20 Ω) $= \boxed{R_E \Vert r_e}$ $\cong \boxed{r_e}$ $(R_E \gg r_e)$	Low (≅1) $= \boxed{\dfrac{R_E}{R_E + r_e}}$ $\cong \boxed{1}$	High (−50) $\cong \boxed{-\dfrac{\beta R_B}{R_B + Z_b}}$
Common-base: 	Low (20 Ω) $= \boxed{R_E \Vert r_e}$ $\cong \boxed{r_e}$ $(R_E \gg r_e)$	Medium (2 kΩ) $= \boxed{R_C}$	High (200) $\cong \boxed{\dfrac{R_C}{r_e}}$	Low (−1) $\cong \boxed{-1}$
Collector feedback: 	Medium (1 kΩ) $= \boxed{\dfrac{r_e}{\dfrac{1}{\beta} + \dfrac{R_C}{R_F}}}$ $(r_o \geq 10R_C)$	Medium (2 kΩ) $\cong \boxed{R_C \Vert R_F}$ $(r_o \geq 10R_C)$	High (−200) $\cong \boxed{-\dfrac{R_C}{r_e}}$ $(r_o \geq 10R_C)$ $(R_F \gg R_C)$	High (50) $= \boxed{\dfrac{\beta R_F}{R_F + \beta R_C}}$ $\cong \boxed{\dfrac{R_F}{R_C}}$

TABLE 5.2
BJT Transistor Amplifiers Including the Effect of R_s and R_L

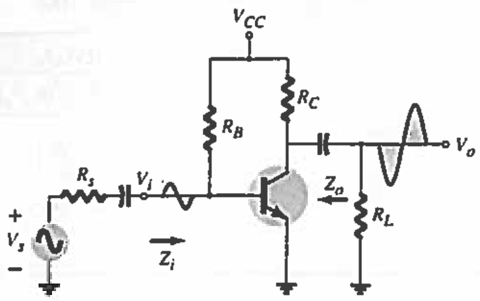
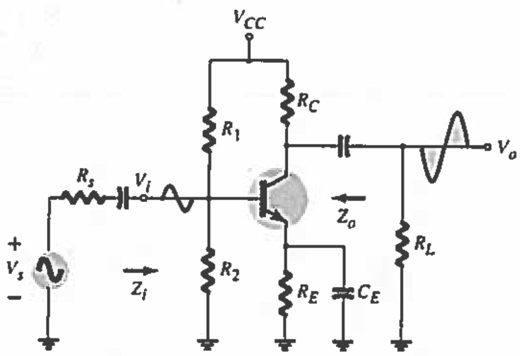
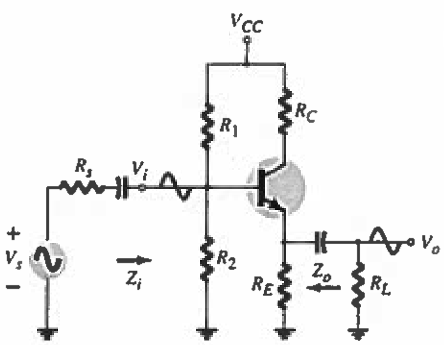
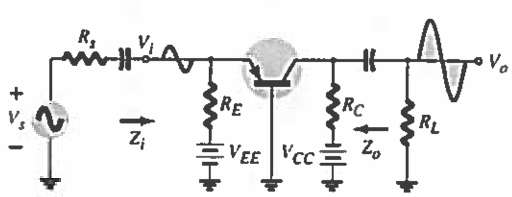
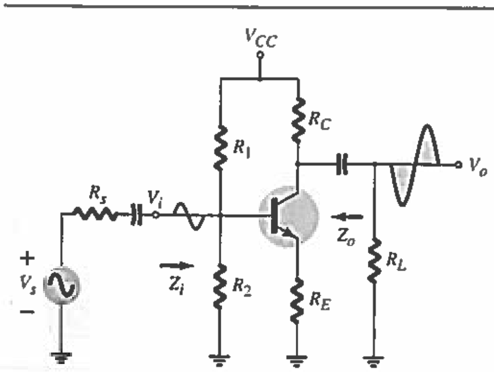
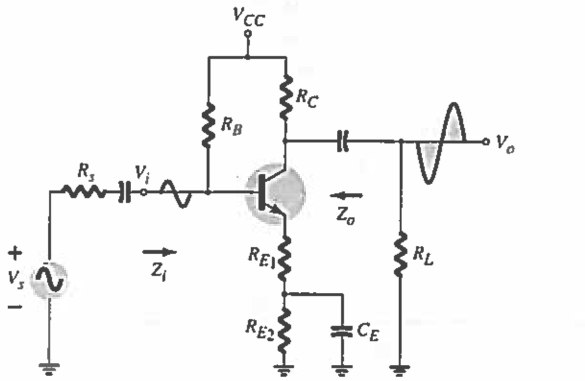
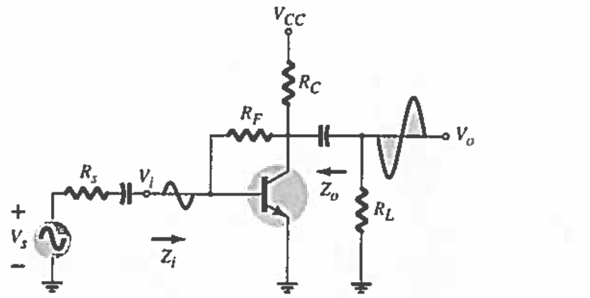
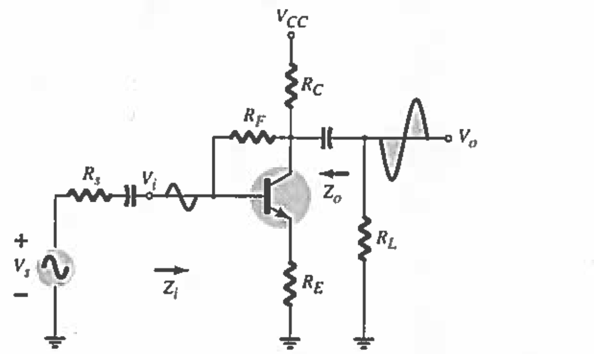
Configuration	$A_{v_L} = V_o/V_i$	Z_i	Z_o
	$\frac{-(R_L \parallel R_C)}{r_e}$	$R_B \parallel \beta r_e$	R_C
	Including r_o: $-\frac{(R_L \parallel R_C \parallel r_o)}{r_e}$	$R_B \parallel \beta r_e$	$R_C \parallel r_o$
	$\frac{-(R_L \parallel R_C)}{r_e}$	$R_1 \parallel R_2 \parallel \beta r_e$	R_C
	Including r_o: $\frac{-(R_L \parallel R_C \parallel r_o)}{r_e}$	$R_1 \parallel R_2 \parallel \beta r_e$	$R_C \parallel r_o$
	$\cong 1$	$R'_E = R_L \parallel R_E$ $R_1 \parallel R_2 \parallel \beta(r_e + R'_E)$	$R'_s = R_s \parallel R_1 \parallel R_2$ $R_E \parallel \left(\frac{R'_s}{\beta} + r_e\right)$
	Including r_o: $\cong 1$	$R_1 \parallel R_2 \parallel \beta(r_e + R'_E)$	$R_E \parallel \left(\frac{R'_s}{\beta} + r_e\right)$
	$\cong \frac{-(R_L \parallel R_C)}{r_e}$	$R_E \parallel r_e$	R_C
	Including r_o: $\cong \frac{-(R_L \parallel R_C \parallel r_o)}{r_e}$	$R_E \parallel r_e$	$R_C \parallel r_o$
	$\frac{-(R_L \parallel R_C)}{R_E}$	$R_1 \parallel R_2 \parallel \beta(r_e + R_E)$	R_C
	Including r_o: $\frac{-(R_L \parallel R_C)}{R_E}$	$R_1 \parallel R_2 \parallel \beta(r_e + R_e)$	$\cong R_C$

TABLE 5.2 (Continued)

BJT Transistor Amplifiers Including the Effect of R_s and R_L

Configuration	$A_{v_L} = V_o/V_i$	Z_i	Z_o
	$\dfrac{-(R_L \parallel R_C)}{R_{E_1}}$	$R_B \parallel \beta(r_e + R_{E_1})$	R_C
	Including r_o: $\dfrac{-(R_L \parallel R_C)}{R_{E_1}}$	$R_B \parallel \beta(r_e + R_E)$	$\cong R_C$
	$\dfrac{-(R_L \parallel R_C)}{r_e}$	$\beta r_e \parallel \dfrac{R_F}{\lvert A_v \rvert}$	R_C
	Including r_o: $\dfrac{-(R_L \parallel R_C \parallel r_o)}{r_e}$	$\beta r_e \parallel \dfrac{R_F}{\lvert A_v \rvert}$	$R_C \parallel R_F \parallel r_o$
	$\dfrac{-(R_L \parallel R_C)}{R_E}$	$\beta R_E \parallel \dfrac{R_F}{\lvert A_v \rvert}$	$\cong R_C \parallel R_F$
	Including r_o: $\cong \dfrac{-(R_L \parallel R_C)}{R_E}$	$\cong \beta R_E \parallel \dfrac{R_F}{\lvert A_v \rvert}$	$\cong R_C \parallel R_F$

packaged system relates to the actual amplifier or network. The system of Fig. 5.61 is called a two-port system because there are two sets of terminals—one at the input and the other at the output. At this point it is particularly important to realize that

the data surrounding a packaged system is the no-load data.

This should be fairly obvious because the load has not been applied, nor does it come with the load attached to the package.

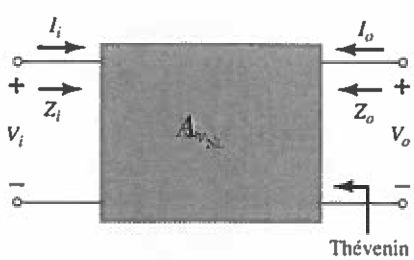


FIG. 5.61

Two-port system.

TABLE 8.1

Z_i, Z_o, and A_v for various FET configurations

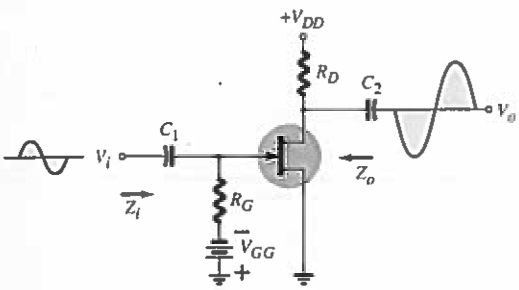
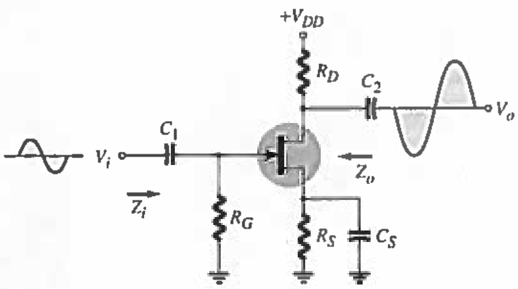
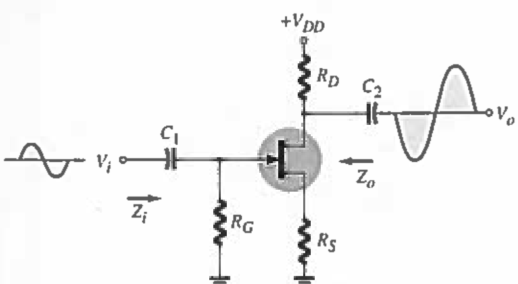
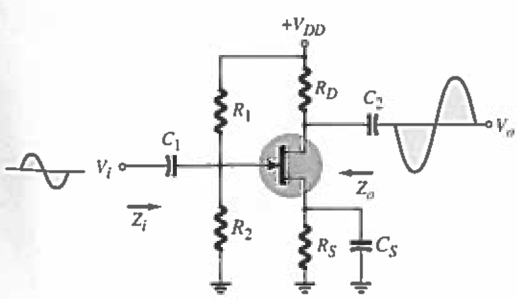
Configuration	Z_i	Z_o	$A_v = \frac{V_o}{V_i}$
Fixed-bias [JFET or D-MOSFET]  	High (10 MΩ) $= \boxed{R_G}$	Medium (2 kΩ) $= \boxed{R_D \Vert r_d}$ $\cong \boxed{R_D}$ $(r_d \geq 10 R_D)$	Medium (−10) $= \boxed{-g_m(r_d \Vert R_D)}$ $\cong \boxed{-g_m R_D}$ $(r_d \geq 10 R_D)$
Self-bias bypassed R_S [JFET or D-MOSFET]  	High (10 MΩ) $= \boxed{R_G}$	Medium (2 kΩ) $= \boxed{R_D \Vert r_d}$ $\cong \boxed{R_D}$ $(r_d \geq 10 R_D)$	Medium (−10) $= \boxed{-g_m(r_d \Vert R_D)}$ $\cong \boxed{-g_m R_D}$ $(r_d \geq 10 R_D)$
Self-bias unbypassed R_S [JFET or D-MOSFET]  	High (10 MΩ) $= \boxed{R_G}$	$= \boxed{\dfrac{\left[1 + g_m R_S + \dfrac{R_S}{r_d}\right] R_D}{\left[1 + g_m R_S + \dfrac{R_S}{r_d} + \dfrac{R_D}{r_d}\right]}}$ $= \boxed{R_D}$ $r_d \geq 10 R_D$ or $r_d = \infty\ \Omega$	Low (−2) $= \boxed{\dfrac{g_m R_D}{1 + g_m R_S + \dfrac{R_D + R_S}{r_d}}}$ $\cong \boxed{\dfrac{g_m R_D}{1 + g_m R_S}}$ $[r_d \geq 10(R_D + R_S)]$
Voltage-divider bias [JFET or D-MOSFET]  	High (10 MΩ) $= \boxed{R_1 \Vert R_2}$	Medium (2 kΩ) $= \boxed{R_D \Vert r_d}$ $\cong \boxed{R_D}$ $(r_d \geq 10 R_D)$	Medium (−10) $= \boxed{-g_m(r_d \Vert R_D)}$ $\cong \boxed{-g_m R_D}$ $(r_d \geq 10 R_D)$

TABLE 8.1
(Continued)

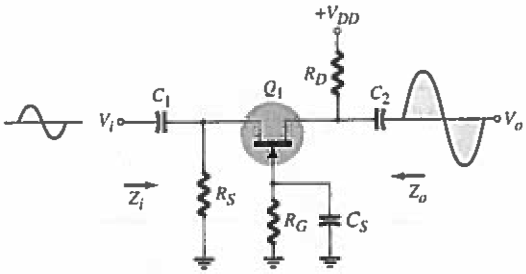
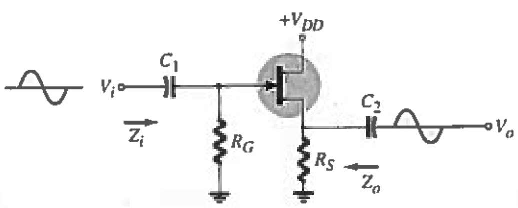
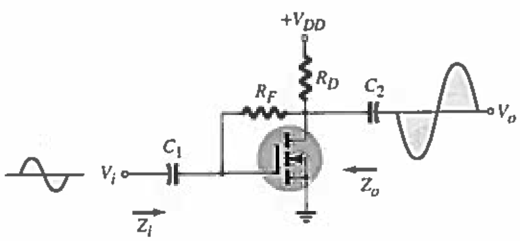
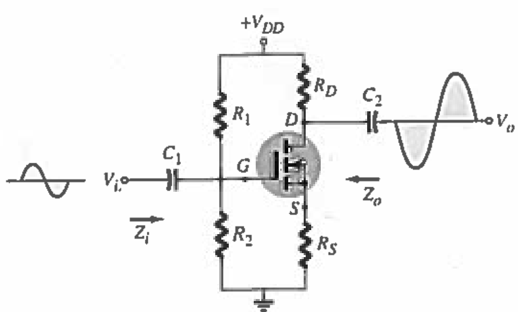
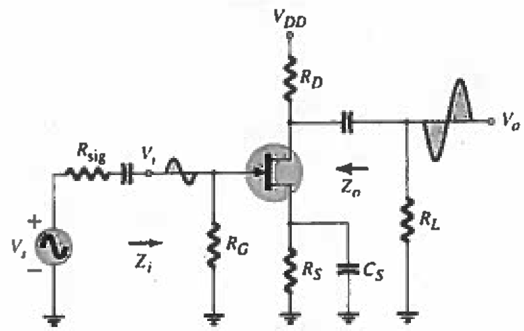
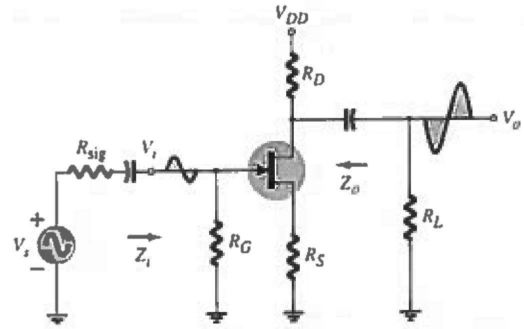
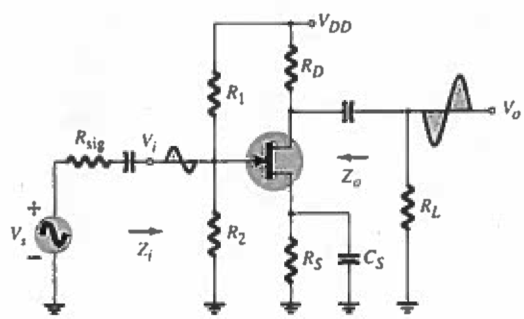
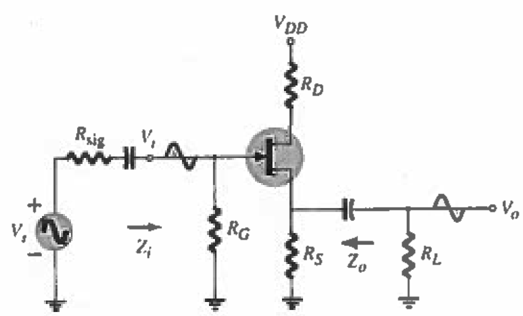
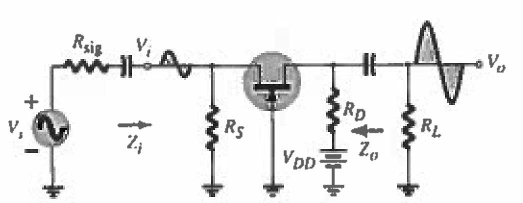
Configuration	Z_i	Z_o	$A_v = \dfrac{V_o}{V_i}$
Common-gate [JFET or D-MOSFET] 	Low (1 kΩ) $= \boxed{R_S \Vert \left[\dfrac{r_d + R_D}{1 + g_m r_d}\right]}$ $\cong \boxed{R_S \Vert \dfrac{1}{g_m}}$ $(r_d \geq 10\,R_D)$	Medium (2 kΩ) $= \boxed{R_D \Vert r_d}$ $\cong \boxed{R_D}$ $(r_d \geq 10\,R_D)$	Medium (+10) $= \boxed{\dfrac{g_m R_D + \dfrac{R_D}{r_d}}{1 + \dfrac{R_D}{r_d}}}$ $\cong \boxed{g_m R_D}$ $(r_d \geq 10\,R_D)$
Source-follower [JFET or D-MOSFET] 	High (10 MΩ) $= \boxed{R_G}$	Low (100 kΩ) $= \boxed{r_d \Vert R_S \Vert 1/g_m}$ $\cong \boxed{R_S \Vert 1/g_m}$ $(r_d \geq 10\,R_S)$	Low (<1) $= \boxed{\dfrac{g_m(r_d \Vert R_S)}{1 + g_m(r_d \Vert R_S)}}$ $\cong \boxed{\dfrac{g_m R_S}{1 + g_m R_S}}$ $(r_d \geq 10\,R_S)$
Drain-feedback bias E-MOSFET 	Medium (1 MΩ) $= \boxed{\dfrac{R_F + r_d \Vert R_D}{1 + g_m(r_d \Vert R_D)}}$ $\cong \boxed{\dfrac{R_F}{1 + g_m R_D}}$ $(r_d \geq 10\,R_D)$	Medium (2 kΩ) $= \boxed{R_F \Vert r_d \Vert R_D}$ $\cong \boxed{R_D}$ $(R_F, r_d \geq 10R_D)$	Medium (−10) $= \boxed{-g_m(R_F \Vert r_d \Vert R_D)}$ $\cong \boxed{-g_m R_D}$ $(R_F, r_d \geq 10R_D)$
Voltage-divider bias E-MOSFET 	Medium (1 MΩ) $= \boxed{R_1 \Vert R_2}$	Medium (2 kΩ) $= \boxed{R_D \Vert r_d}$ $\cong \boxed{R_D}$ $(r_d \geq 10\,R_D)$	Medium (−10) $= \boxed{-g_m(r_d \Vert R_D)}$ $\cong \boxed{-g_m R_D}$ $(r_d \geq 10\,R_D)$

TABLE 8.2

Configuration	$A_{v_L} = V_o \| V_i$	Z_i	Z_o
	$-g_m(R_D \| R_L)$ Including r_d: $-g_m(R_D \| R_L \| r_d)$	R_G R_G	R_D $R_D \| r_d$
	$\dfrac{-g_m(R_D \| R_L)}{1 + g_m R_S}$ Including r_d: $\dfrac{-g_m(R_D \| R_L)}{1 + g_m R_S + \dfrac{R_D + R_S}{r_d}}$	R_G R_G	$\dfrac{R_D}{1 + g_m R_S}$ $\cong \dfrac{R_D}{1 + g_m R_S}$
	$-g_m(R_D \| R_L)$ Including r_d: $-g_m(R_D \| R_L \| r_d)$	$R_1 \| R_2$ $R_1 \| R_2$	R_D $R_D \| r_d$;
	$\dfrac{g_m(R_S \| R_L)}{1 + g_m(R_S \| R_L)}$ Including r_d: $= \dfrac{g_m r_d(R_S \| R_L)}{r_d + R_D + g_m r_d(R_S \| R_L)}$	R_G R_G	$R_S \| 1/g_m$ $\dfrac{R_S}{1 + \dfrac{g_m r_d R_S}{r_d + R_D}}$
	$g_m(R_D \| R_L)$ Including r_d: $\cong g_m(R_D \| R_L)$	$\dfrac{R_S}{1 + g_m R_S}$ $Z_i = \dfrac{R_S}{1 + \dfrac{g_m r_d R_S}{r_d + R_D \| R_L}}$	R_D $R_D \| r_d$