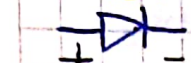
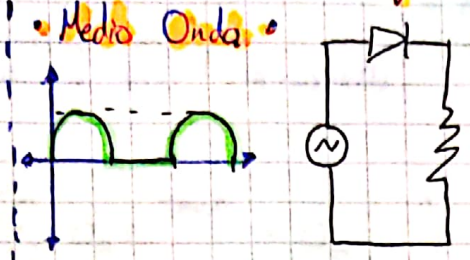
Analoga I

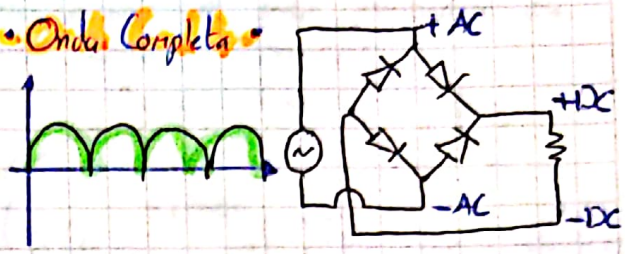
Diodos



Medio Onda



Onda Completa



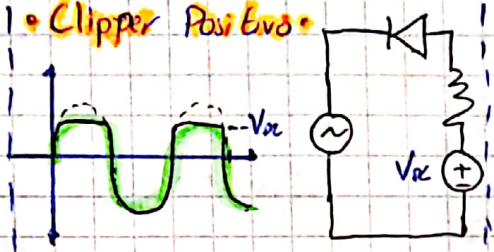
Carga C

$V_C = V_{in}(1 - e^{-t/RC})$

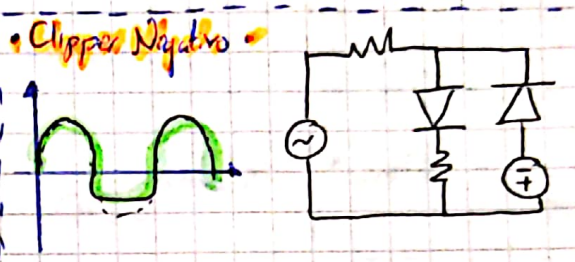
Descarga C

$V_C = V_{in}\, e^{-\frac{t}{RC}}$

Clipper Positivo



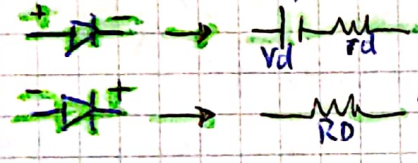
Clipper Negativo



Corriente diodo

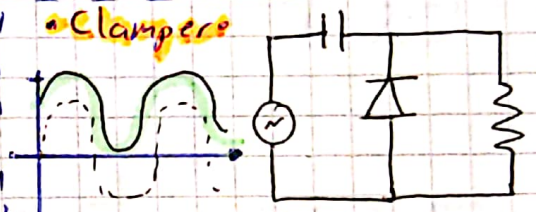
$$I_D = I_S\left(e^{\frac{Vd}{\eta V_T}} - 1\right) \qquad V_T = \frac{KT}{q_{elemental}}$$

- I_S = Corriente de desplazamiento
- $V_\gamma = Vd$



- Vd = Entre 0.5 y 0.6 V
- n = Entre 1 y 2.

Clampers



- Si $I_d \gg I_S$:

$$I_d \simeq I_S \exp\left(\frac{Vd}{\eta V_T}\right)$$

$I_d = \frac{V_{DC} - V_D}{R}$ Recta de carga del diodo.

Valor RMS

$$V_{RMS} = \sqrt{\frac{1}{T_2 - T_1}\int_{T_1}^{T_2} V(t)^2 dt}$$

- $V_{RMS} = \frac{V_P}{\sqrt{2}}$

Valor Medio

$$V_{prom} = \frac{1}{T_2 - T_1}\int_{T_1}^{T_2} V(t)\,dt$$

- $V_{prom} = V_{DC} = \int_0^{\pi} V_p \sin(\omega t)\,dt = \frac{2V_p}{\pi}$

Fuente de voltaje rizado Filtrado

- $V_{rpp} = V_p - V_p e^{\frac{-T/2}{RC}}$ → Onda original

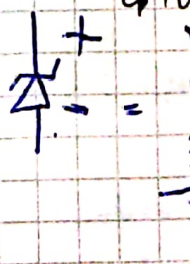
↳ $e^{-T/2RC} \simeq 1 - \frac{T}{2RC}$ Si $RC \gg T/2$ ↳ $V_{rpp} = \frac{V_p I}{RC} = \frac{V_p}{fRC}$ → ONDA YA RECTIFICADA.

↳ $V_{DC} = V_p - \frac{V_{RPP}}{2}$

Zener Fuente regulada

↳ Funciona en P. directo como diodo normal.

V_{ZO} a I_{ZO} y P_{ZMAX}.



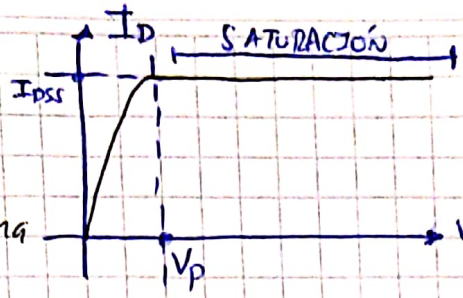
= Mantiene

Analoga (II)

• JFET → Fuentura.

↳ $V_{GS} = 0V \rightarrow I_D = I_S$

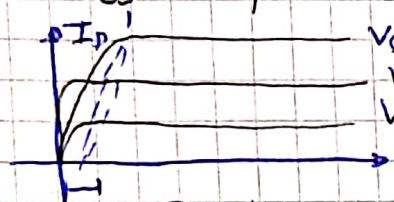
↳ I_{DSS} = Corriente maxima de saturación.



• En $V_{DS} = V_p$ se tiene estrangulamiento del canal.

↳ $V_{GS} < 0V$ (canal N) → Mas grande $|V_{GS}|$ mas pequeño I_{DSS}

• Si $V_{GS} = -V_p \rightarrow I_{DSS} = 0A$ • $r_d = \frac{r_o}{\left(1 - \frac{V_{GS}}{V_p}\right)^2}$ • r_o = resistencia en $V_{GS} = 0V$.



Región ohmica = Resistencia controlada por voltaje.

• $I_D = I_{DSS}$ $(V_{GS} = 0V)$

• $V_{GS} = V_p$ $(I_D = 0A)$

• Amplificacion lineal Vseñal en V_{GS}.

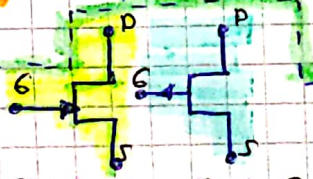
↳ En potencia. JFETN = JFETP.

• Transferencia.

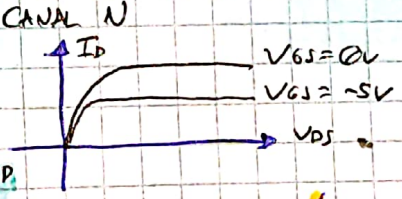
$$I_D = \underbrace{I_{DSS}}_{\text{CONSTANTES}} \left(1 - \frac{V_{GS}}{V_p}\right)^2$$

• $I_G \cong 0A$

• $I_D = I_S$



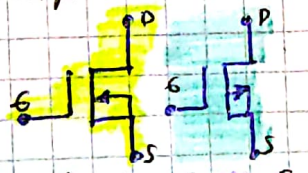
• Nosfet (Empobrecimiento) → CANAL N



$I_D = I_{DSS} = I_S$.

↳ $V_{GS} = 0V$ → Comportamiento del JFET

↳



→ $I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_p}\right)^2$

• JFET y MOSFET de empobrecimiento (Normalmente abiertos)

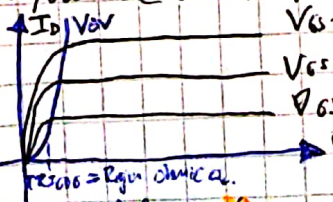
• MOSFET (Enriquecimiento) → $V_{GS} > 0V$ → Se empieza a formar el canal

↳ $V_{GS} = 0V \rightarrow V_{GS} \neq 0$ da $I_D = 0A$ ↳ Voltaje Umbral = V_T "constante" (Canal formado)

• $V_T = V_{TH} = V_{GS(TH)}$ → NMOS → 0.3V – 1V

• $V_{sobremarcha} = V_{OV} = V_{DS(sat)} = V_{GS} - V_T$ (QUE TAN ENCENDIDO ESTA)

↳ Aumentar $V_{GS} > V_T$ → Se saturara I_D despues de un V_{DS} para todo V_{DS}.



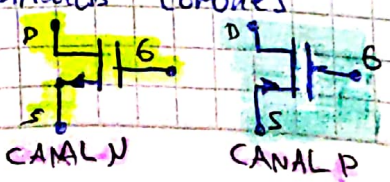
↳ $V_{DS} \geq V_{GS} - V_T = V_{OV}$ SATURACION.

• $V_{GS} < V_T \rightarrow I_D \cong 0A$

• $V_{GS} \geq V_T \rightarrow I_D = K(V_{GS} - V_T)^2$ $(I_D = I_S)$ $(I_G \cong 0A)$

↳ $K = \frac{I_{D(Encendido)}}{(V_{GS(Encendido)} - V_T)^2}$

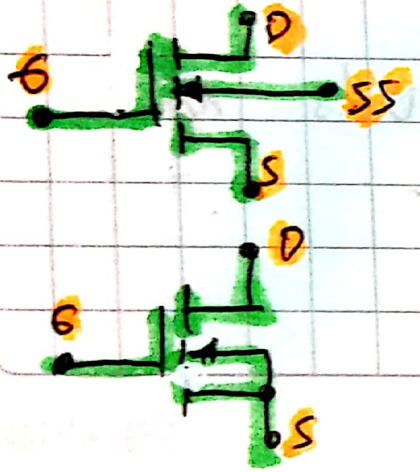
• Simbolos comunes



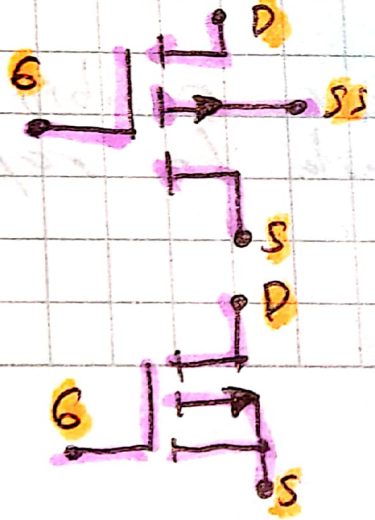
- Simbolos

FORMAL

CANAL N



CANAL P



USADO

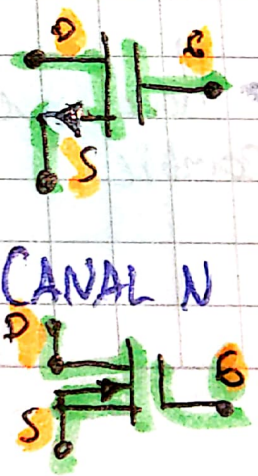


TABLA 6.3

Transistores de efecto de campo

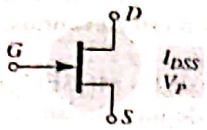
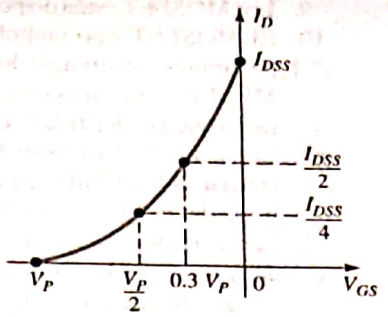
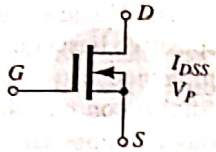
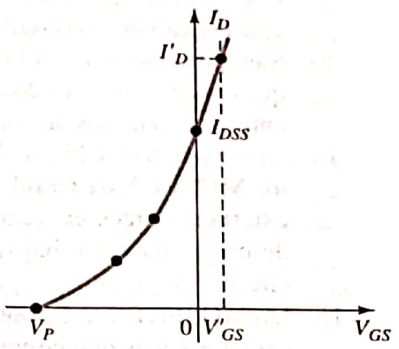
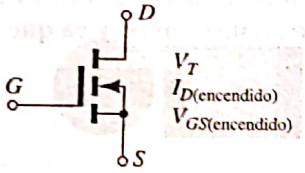
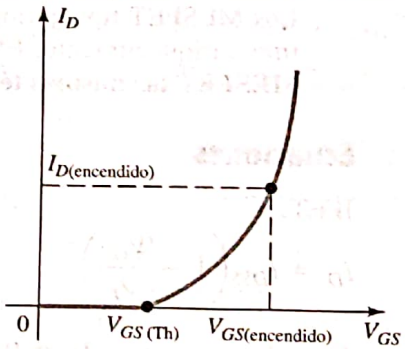
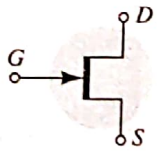
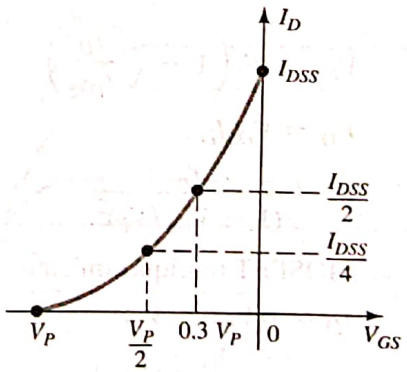
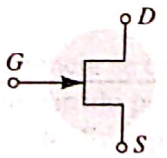
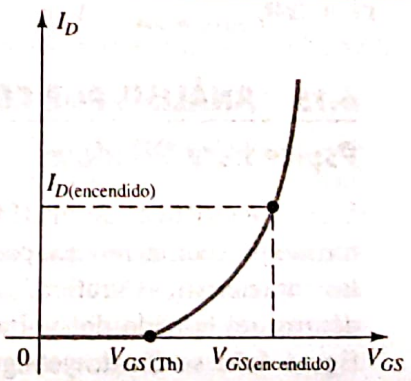
Tipo	Símbolo y relaciones básicas	Curva de transferencia	Resistencia y capacitancia de entrada
JFET (canal *n*)	$I_G = 0\ \text{A}, I_D = I_S$  $I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$		$R_i > 100\ \text{M}\Omega$ C_i: (1 – 10) pF
MOSFET tipo empobrecimiento (canal *n*)	$I_G = 0\ \text{A}, I_D = I_S$  $I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$		$R_i > 10^{10}\ \Omega$ C_i: (1 – 10) pF
MOSFET tipo enriquecimiento (canal *n*)	$I_G = 0\ \text{A}, I_D = I_S$  $I_D = k\,(V_{GS} - V_{GS\,(\text{Th})})^2$ $k = \frac{I_{D(\text{encendido})}}{(V_{GS(\text{encendido})} - V_{GS\,(\text{Th})})^2}$		$R_i > 10^{10}\ \Omega$ C_i: (1 – 10) pF
MESFET tipo empobrecimiento (canal *n*)	$I_G = 0\ \text{A}, I_D = I_S$  $I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$ $I_G = 0\ \text{A}, I_D = I_S$		$R_i > 10^{12}\ \Omega$ C_i: (1 – 5) pF
MESFET tipo enriquecimiento (canal *n*)	 $I_D = k\,(V_{GS} - V_{GS\,(\text{Th})})^2$ $k = \frac{I_{D(\text{encendido})}}{(V_{GS(\text{encendido})} - V_{GS\,(\text{Th})})^2}$		$R_i > 10^{12}\ \Omega$ C_i: (1 – 5) pF

TABLA 7.1
Configuraciones de polarización con FET.

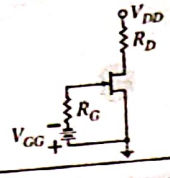
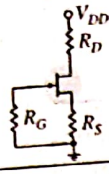
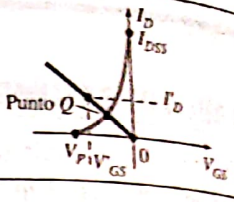
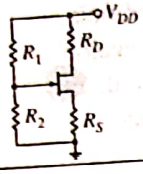
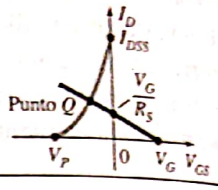
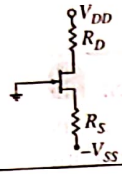
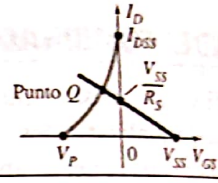
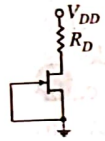
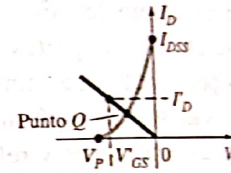
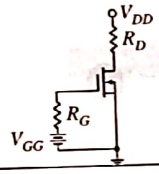
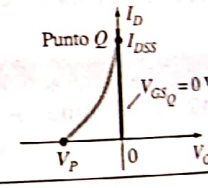
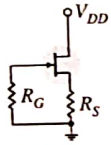
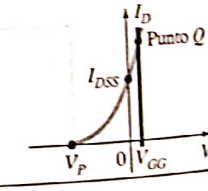
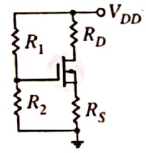
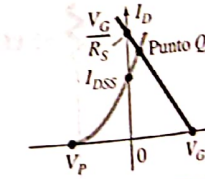
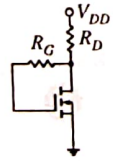
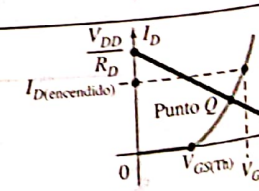
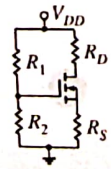
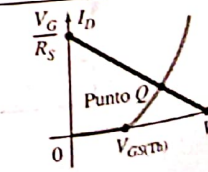
Tipo	Configuración	Ecuaciones pertinentes	Solución gráfica
Polarización fija del JFET		$V_{GS_Q} = -V_{GG}$ $V_{DS} = V_{DD} - I_D R_S$	
Autopolarización del JFET		$V_{GS} = -I_D R_S$ $V_{DS} = V_{DD} - I_D(R_D + R_S)$	
Polarización por medio de divisor de voltaje del JFET		$V_G = \frac{R_2 V_{DD}}{R_1 + R_2}$ $V_{GS} = V_G - I_D R_S$ $V_{DS} = V_{DD} - I_D(R_D + R_S)$	
JFET en compuerta común		$V_{GS} = V_{SS} - I_D R_S$ $V_{DS} = V_{DD} + V_{SS} - I_D(R_D + R_S)$	
JFET ($R_D = 0\ \Omega$)		$V_{GS} = -I_D R_S$ $V_D = V_{DD}$ $V_S = I_D R_S$ $V_{DS} = V_{DD} - I_S R_S$	
Caso especial con JFET ($V_{GS_Q} = 0$ V)		$V_{GS_Q} = 0$ V $I_{D_Q} = I_{DSS}$	
Polarización fija del MOSFET tipo empobrecimiento (y MESFET)		$V_{GS_Q} = +V_{GG}$ $V_{DS} = V_{DD} - I_D R_S$	
Polarización por medio de divisor de voltaje del MOSFET tipo empobrecimiento (y MESFET)		$V_G = \frac{R_2 V_{DD}}{R_1 + R_2}$ $V_{GS} = V_G - I_S R_S$ $V_{DS} = V_{DD} - I_D(R_D + R_S)$	
Configuración de realimentación del MOSFET tipo enriquecimiento (y MESFET)		$V_{GS} = V_{DS}$ $V_{GS} = V_{DD} - I_D R_D$	
Polarización por medio de divisor de voltaje del MOSFET tipo enriquecimiento (y MESFET)		$V_G = \frac{R_2 V_{DD}}{R_1 + R_2}$ $V_{GS} = V_G - I_D R_S$	

TABLA 8.1

Z_i, Z_o, y A_v para varias configuraciones de FET.

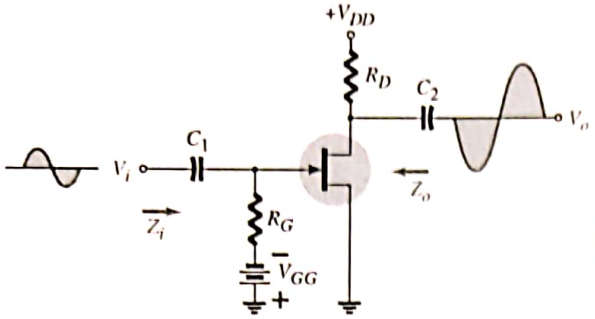
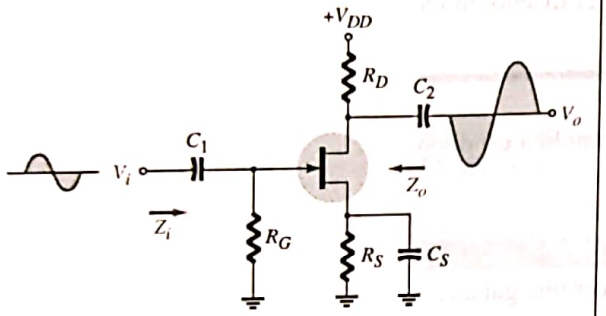
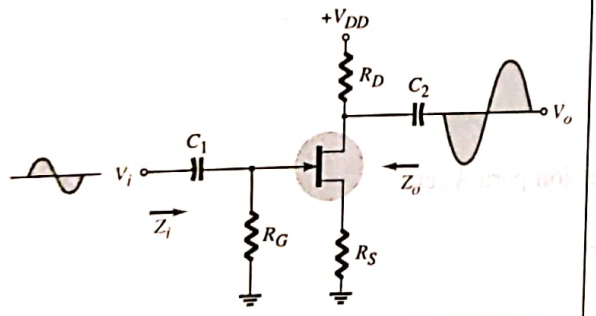
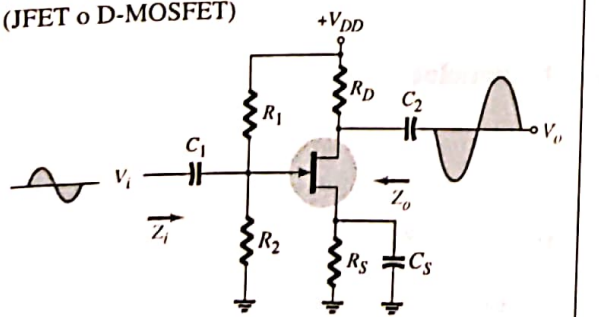
Configuración	Z_i	Z_o	$A_v = \frac{V_o}{V_i}$
Polarización fija (JFET o D-MOSFET) 	Alta (10 MΩ) $= R_G$	Mediana (2 kΩ) $= R_D \Vert r_d$ $\cong R_D$ $(r_d \geq 10\,R_D)$	Mediana (−10) $= -g_m(r_d \Vert R_D)$ $\cong -g_m R_D$ $(r_d \geq 10\,R_D)$
Autopolarización con R_S con capacitor de puenteo (JFET o D-MOSFET) 	Alta (10 MΩ) $= R_G$	Mediana (2 kΩ) $= R_D \Vert r_d$ $\cong R_D$ $(r_d \geq 10\,R_D)$	Mediana (−10) $= -g_m(r_d \Vert R_D)$ $\cong -g_m R_D$ $(r_d \geq 10\,R_D)$
Autopolarización con R_S sin capacitor de puenteo (JFET o D-MOSFET) 	Alta (10 MΩ) $= R_G$	$= \dfrac{\left[1 + g_m R_S + \dfrac{R_S}{r_d}\right] R_D}{\left[1 + g_m R_S + \dfrac{R_S}{r_d} + \dfrac{R_D}{r_d}\right]}$ $= R_D$ $r_d \geq 10\,R_D$ or $r_d = \infty\,\Omega$	Baja (−2) $= \dfrac{g_m R_D}{1 + g_m R_S + \dfrac{R_D + R_S}{r_d}}$ $\cong -\dfrac{g_m R_D}{1 + g_m R_S}$ $[r_d \geq 10(R_D + R_S)]$
Polarización con divisor de voltaje (JFET o D-MOSFET) 	Alta (10 MΩ) $= R_1 \Vert R_2$	Mediana (2 kΩ) $= R_D \Vert r_d$ $\cong R_D$ $(r_d \geq 10\,R_D)$	Mediana (−10) $= -g_m(r_d \Vert R_D)$ $\cong -g_m R_D$ $(r_d \geq 10\,R_D)$

TABLA 8.1
(Continuación)

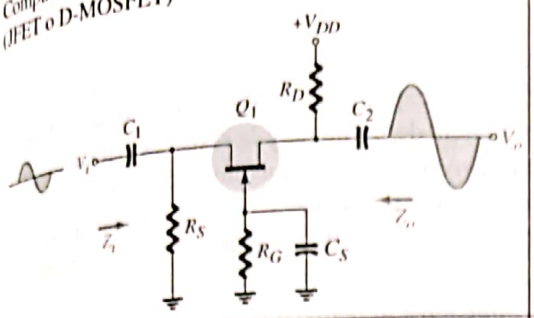
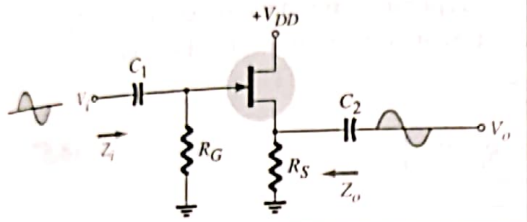
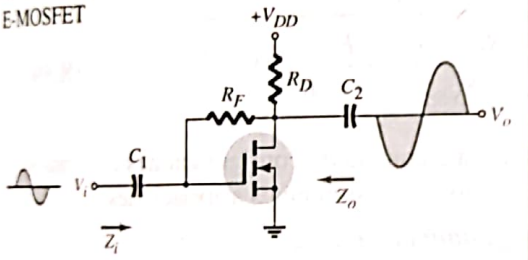
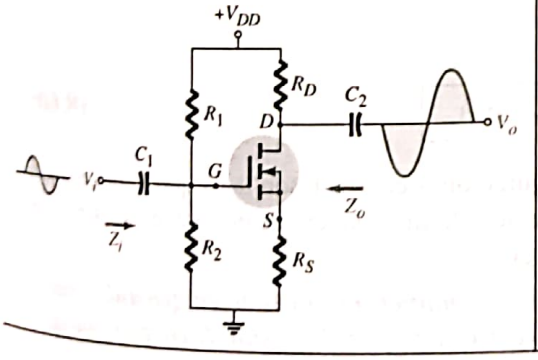
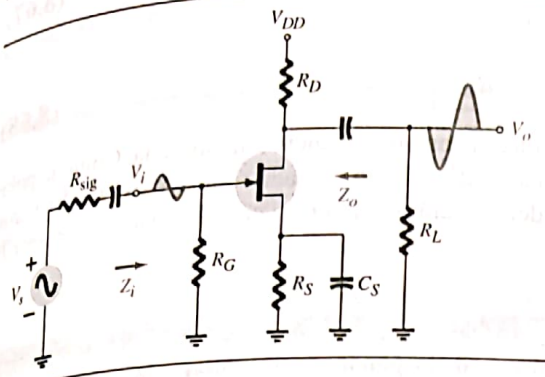
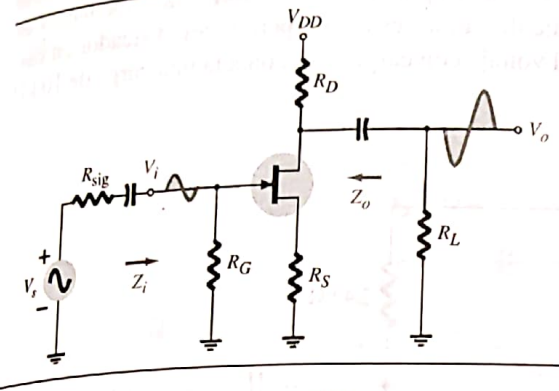
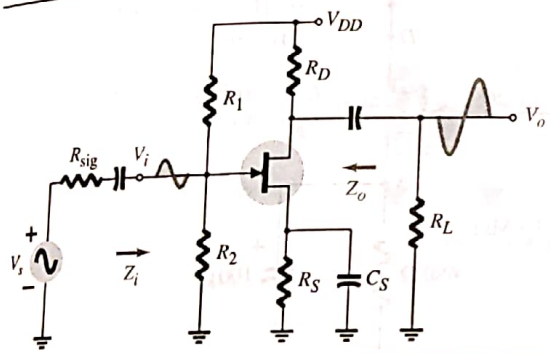
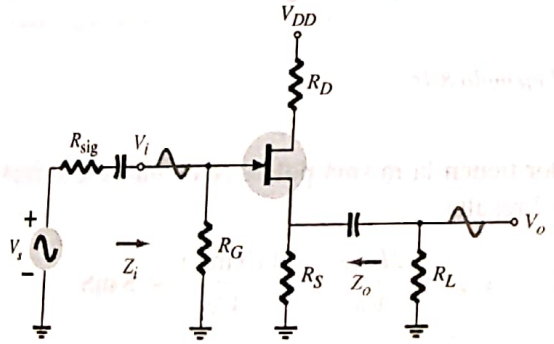
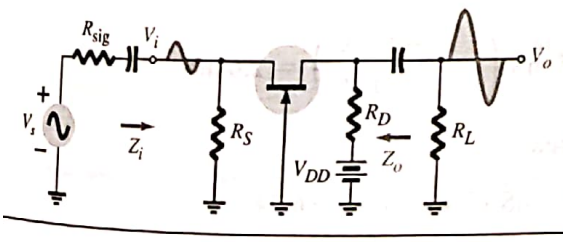
Configuración	Z_i	Z_o	$A_v = \frac{V_o}{V_i}$
Compuerta común (JFET o D-MOSFET) 	Baja (1 kΩ) $= R_S \Vert \left[\frac{r_d + R_D}{1 + g_m r_d} \right]$ $\cong R_S \Vert \frac{1}{g_m}$ $(r_d \geq 10 R_D)$	Medium (2 kΩ) $= R_D \Vert r_d$ $\cong R_D$ $(R_D \geq 10 R_D)$	Mediana (+10) $= \frac{g_m R_D + \frac{R_D}{r_d}}{1 + \frac{R_D}{r_d}}$ $\cong g_m R_D$ $(r_d \geq 10 R_D)$
Seguidor de fuente (JFET o D-MOSFET) 	Alta (10 MΩ) $= R_G$	Baja (100 kΩ) $= r_d \Vert R_S \Vert 1/g_m$ $\cong R_S \Vert 1/g_m$ $(r_d \geq 10 R_S)$	Baja (<1) $= \frac{g_m(r_d \Vert R_S)}{1 + g_m(r_d \Vert R_S)}$ $\cong \frac{g_m R_S}{1 + g_m R_S}$ $(r_d \geq 10 R_S)$
Polarización mediante realimentación del drenaje E-MOSFET 	Mediana (1 MΩ) $= \frac{R_F + r_d \Vert R_D}{1 + g_m(r_d \Vert R_D)}$ $\cong \frac{R_F}{1 + g_m R_D}$ $(r_d \geq 10 R_D)$	Medium (2 kΩ) $= R_F \Vert r_d \Vert R_D$ $\cong R_D$ $(R_F, r_d \geq 10 R_D)$	Mediana (−10) $= -g_m(R_F \Vert r_d \Vert R_D)$ $\cong -g_m R_D$ $(R_D, r_d \geq 10 R_D)$
Polarización por divisor de voltaje E-MOSFET 	Mediana (1 MΩ) $= R_1 \Vert R_2$	Mediana (2 kΩ) $= R_D \Vert r_d$ $\cong R_D$ $(r_d \geq 10 R_D)$	Mediana (−10) $= -g_m(r_d \Vert R_D)$ $\cong -g_m R_D$ $(r_d \geq 10 R_D)$

TABLA 8.2

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