5.11 THE JUNCTION FIELD-EFFECT TRANSISTOR (JFET)

The **junction field-effect transistor,** or JFET, is perhaps the simplest transistor available. It has some important characteristics, notably a very high input resistance. Unfortunately, however (for the JFET), the MOSFET has an even higher input resistance. This, together with the many other advantages of MOS transistors, has made the JFET virtually obsolete. Currently, its applications are limited to discrete-circuit design, where it is used both as an amplifier and as a switch. Its integrated-circuit applications are limited to the design of the differential input stage of some operational amplifiers, where advantage is taken of its high input resistance (compared to the BJT). In this section, we briefly consider JFET operation and characteristics. Another important reason for including the JFET in the study of electronics is that it helps in understanding the operation of gallium arsenide devices, the subject of the next section.

Device Structure

As with other FET types, the JFET is available in two polarities: *n*-channel and *p*-channel. Fig. 5.69(a) shows a simplified structure of the *n*-channel JFET. It consists of a slab of *n*-type silicon with *p*-type regions diffused on its two sides. The *n* region is the channel, and the *p*-type regions are electrically connected together and form the gate. The device operation is based on reverse-biasing the *pn* junction between gate and channel. Indeed, it is the reverse bias on this junction that is used to control the channel width and hence the current flow from drain to source. The major role that this *pn* junction plays in the operation of this FET has given rise to its name: Junction Field-Effect Transistor (JFET).

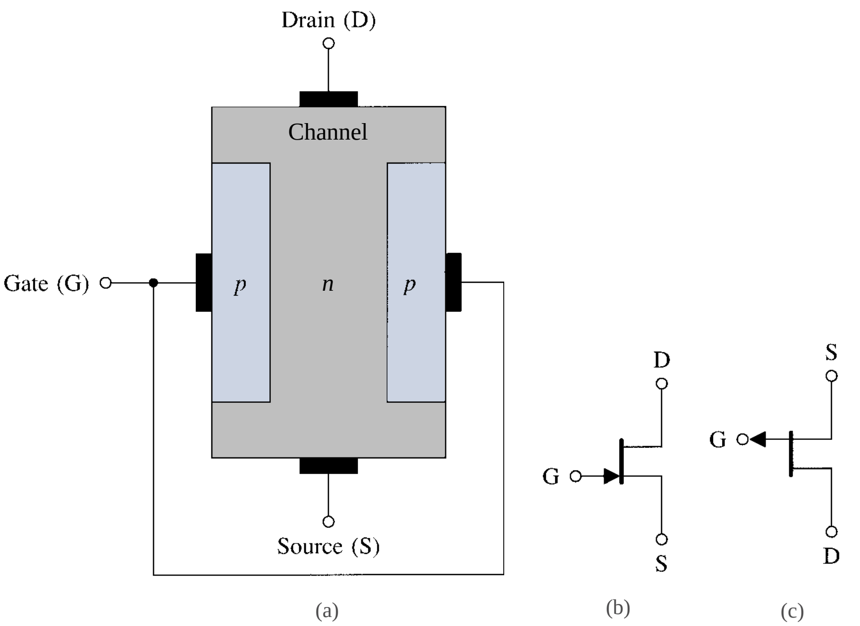

FIGURE 5.69 **(a)** Basic structure of *n*-channel JFET. This is a simplified structure utilized to explain device operation. **(b)** Circuit symbol for the *n*-channel JFET. **(c)** Circuit symbol for the *p*-channel JFET.

CHAPTER 14

14.1 (a) 0.693 R_DC; (b) $0.5R_DC$, for a 21.5% reduction 14.2 1.52; 0.97 V; 1.69 V; 1.2 V; 2.5 V; 0.28 V; 0.81 V; 0.69 V 14.4 $r \approx 2.1$; $NM_{L\max}$ 0.731 V 14.6 1.33 14.23 9.38 ns 14.30 3 ms; 333 Hz 14.33 2.27 GHz 14.35 33.3 MHz; high 13 ns; low 17 ns 14.38 0.33 V/V; 8.95 V/V; 0.37 V/V 14.39 (a) −1.375 V, −1.265 V; (b) −1.493 V, −1.147 V 14.41 21.2 14.43 7 cm 14.45 $(W/L) = 5\ \mu\text{m}/1\ \mu\text{m}$; 6.5 μA 14.46 2.32 V; 3.88 mA 14.47 For R_1: 50%; 36.5 kΩ; 20%; 91.1 kΩ; for R_2: 50%; 6.70 kΩ; 20%; 16.7 kΩ; 50%; $R_1/R_2 = 5.45$; 20%; $R_1/R_2 = 5.45$ 14.48 83.2 ps; 50.7 ps; 67.0 ps 14.50 $(W/L)_{NA} = (W/L)_{NB} = 2(W/L)_N$; $(W/L)_{PA} = (W/L)_{PB} = (W/L)_P$

CHAPTER 15

15.10 2.236 V; 100 V/V 15.12 1024; 1024; 400 pF; 225 pF; 220 fF/bit; 2.8 times 15.13 60% 15.29 41 mV 15.31 0.4 pA 15.32 1.589 mA/V; 11.36 μm; 34.1 μm; 1.56 ns 15.33 680 μA/V; 0.482 V; 0.206 V; 50%; 7.5 ns 15.38 9; 512; 18; 4608 NMOS and 512 PMOS transistors 15.39 9; 1024; 4608; 512; 5641; 521 15.44 0100, 0000, 1000, 1001, 0101, 0001, 0110, and 0010 15.46 2.42 ns; 23 ns, 3.16 V; 1.90 ns

CHAPTER 16

16.1 1 V/V, 0°, 0 dB, 0 dB; 0.894 V/V, –26.6°, –0.97 dB, 0.97 dB; 0.707 V/V, –45.0°, –3.01 dB, 3.01 dB; 0.447 V/V, –63.4°, –6.99 dB, 6.99 dB; 0.196 V/V, –78.7°, –14.1 dB, 14.1 dB; 0.100 V/V, –84.3°, –20.0 dB, 20.0 dB; 0.010 V/V, –89.4°, –40.0 dB, 40.0 dB 16.5 0.5088 rad/s; 3 rad/s; 5.9 16.9 $T(s) = 0.2225\,(s^2+4)/[(s+1)(s^2+s+0.89)]$ 16.11 $T(s) = 0.5/s^3 + 2s^2 + 2s + 1$; poles at $s = -1, -1/2 \pm j\sqrt{3}/2$, 3 zeros at $s = \infty$ 16.13 28.6 dB 16.19 $R_1 = 10$ kΩ; $R_2 = 100$ kΩ; $C = 159$ pF 16.21 40 dB 16.23 $T(s) = -(S - \omega_0/\ S + \omega_0)$; 2.68 kΩ, 5.77 kΩ, 10 kΩ, 17.3 kΩ, 37.3 kΩ 16.25 $T(s) = 10^6/(s^2 + 10^3 s + 10^6)$; 0.707 rad/s; 1.15 V/V; 1.21 dB 16.33 $L = 500$ mH; $C = 20$ nF 16.35 $s^2/(s^2 + s/RC + 1/LC)$ 16.39 $L_1/L_2 = 0.2346$; $|T| = L_2/(L_1 + L_2)$; $|T| = 1$ 16.43 $R_1 = R_2 = R_3 = R_5 = 3.979$ kΩ; $R_6 = 39.79$ kΩ; $C_{61} = 6.4$ nF; $C_{62} = 3.6$ nF 16.44 $C_4 = C_6 = 1$ nF; $R_1 = R_2 = R_3 = R_5 = R_6 = 159.16$ kΩ 16.49 $C = 10$ nF; $R = 15.92$ kΩ; $R_1 = R_f = 10$ kΩ; $R_2 = 10$ kΩ; $R_3 = 390$ kΩ; 39 V/V 16.51 ±1% 16.55 $R_3 = 141.4$ kΩ; $R_4 = 70.7$ kΩ 16.57 $4/RC$; 2; 8 V/V 16.59 High-pass; 1 V/V; $R_3 = 141.4$ kΩ; $R_4 = 70.7$ kΩ 16.64 0; $2Q^2/A$

CHAPTER 17

17.1 (a) $\omega = \omega_0$, $AK = 1$; (b) $-2Q/\omega_0$; (c) $\Delta\omega_0/\omega_0 = -\Delta\phi/2Q$ 17.5 20 dB; ±180° 17.9 $1/RC$;¾;¾ 17.10 $1.15/RC$ 17.15 20.3 V 17.17 *1*; 29*R*; $0.065/RC$ 17.23 2.01612 MHz to 2.0172 MHz 17.25 (a) $V_{TL} = V_R(1 - R_1/R_2) - L_+R_1/R_2$, $V_{TH} = V_R(1 + R_2/R_1) - L\_R_1/R_2\,L\_$; (b) $R_2 = 200$ kΩ, $V_R = 47.62$ mV 17.28 (a) +12 V or −12 V 17.29 $V_Z = 6.8$ V; $R_1 = R_2 = 37.5$ kΩ; $R = 4.1$ kΩ 17.33 $V_Z = 6.8$ V; $R_1 = R_2 = R_3 = R_4 = R_5 = R_6 = 200$ kΩ; $R_7 = 5.1$ kΩ; triangle with period of 100 μs and ±7.5 V peaks 17.35 96 μs 17.38 (a) 9.1 kΩ; (b) 13.3 V 17.39 $R_A =$ 21.2 kΩ; $R_B = 10.7$ kΩ 17.41 $V = 1.0996$ V; $R = 400$ Ω; Table rows, for v_O, θ, 0.7 sin θ, error % are: 0.70 V, 90°, 0.700 V, 0%; 0.65 V, 63.6°, 0.627 V, 3.7%; 0.60 V, 52.4°, 0.554 V, 8.2%; 0.55 V, 46.1°, 0.504 V, 9.1%; 0.50 V, 41.3°, 0.462 V, 8.3%; 0.40 V, 32.8°, 0.379 V, 5.6%; 0.30 V, 24.6°, 0.291 V, 3.1%; 0.20 V, 16.4°, 0.197 V, 1.5%; 0.10 V, 8.2°, 0.100 V, 0%; 0.00 V, 0°, 0.0 V, 0%. 17.42 2.5 V 17.55 10 mV, 20 mV, 100 mV; 50 pulses, 100 pulses, 200 pulses