Solutions to *The Art of Electronics 3rd Edition*

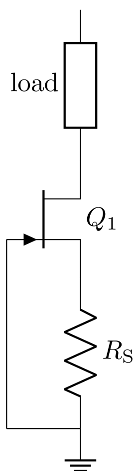
February 12, 2024

Contents

Solutions for Chapter 3

Exercise 3.1

Figure 1.1: JFET current source



From Figure 3.21 of the book, one can see that a drain current equal to 1 mA corresponds to a gate-source voltage of −0.6 V. Therefore:

$$\boxed{R_S = \frac{0.6\,\mathrm{V}}{1\,\mathrm{mA}} = 600\,\Omega}$$

Exercise 3.2

At $V_{GS} = V_{G0}$:

$$r_{GS} = r_{G0} = \frac{1}{2k\,(V_{G0} - V_{th})}$$

The ratio between r_{DS} and R_{G0} returns:

$$\boxed{\frac{r_{DS}}{r_{G0}} = \frac{2k\,(V_{G0} - V_{th})}{2k\,(V_{GS} - V_{th})}}$$

Exercise 3.3

Being g_m the differential conductance of the FET operated in aturation region, it can be expressed as:

$$g_\mathrm{m} = \frac{\partial I_\mathrm{D}}{\partial V_\mathrm{GS}} = \frac{\partial}{\partial V_\mathrm{GS}} k\left(V_\mathrm{GS} - V_\mathrm{th}\right)^2 = 2k\left(V_\mathrm{GS} - V_\mathrm{th}\right)$$

Therefore:

$$\boxed{g_\mathrm{m} = \frac{1}{r_\mathrm{DS}}}$$

Exercise 3.4

(a) The voltage across the drain-gate capacitance when the JFET is switched on ($V_\mathrm{DS} = 0\,\mathrm{V}$) is equal to 50 V-10 V=40 V. Considering a maximum current across this capacitance equal to 1 mA:

$$\boxed{t_\mathrm{ON} = \frac{40\,\mathrm{V}\,200\,\mathrm{pF}}{1\,\mathrm{mA}} = 8\,\mathrm{\mu s}}$$

(b) Since the current is equal to the charge over time, we have:

$$\boxed{t_\mathrm{ON} = \frac{40\,\mathrm{nC}}{1\,\mathrm{mA}} = 40\,\mathrm{\mu s}}$$

Exercise 3.5

The 1 pF drain-source capacitance happens to be in series with the 10 kΩ load resistance. The capacitive reactance is:

$$X_\mathrm{DS} = \frac{1}{2\pi 1\,\mathrm{MHz}\,1\,\mathrm{pF}} = 160\,\mathrm{k\Omega}$$

Therefore, the feedthrough is given by:

$$\boxed{20\log_{10}\frac{10\,\mathrm{k\Omega}}{10\,\mathrm{k\Omega} + 160\,\mathrm{k\Omega}} = -25\,\mathrm{dB}}$$

Exercise 3.6

In this case, the output 10 kΩ resistance is in parallel with the 50 Ω R_ON resistance. Their equivalent resistance is about 50 Ω. Similarly to the previous exercise, the feedthorugh is given by:

$$\boxed{20\log_{10}\frac{50\,\Omega}{50\,\Omega + 160\,\mathrm{k\Omega}} = -70\,\mathrm{dB}}$$

Exercise 3.7

Figure 1.2: Zero ohm R_{ON}

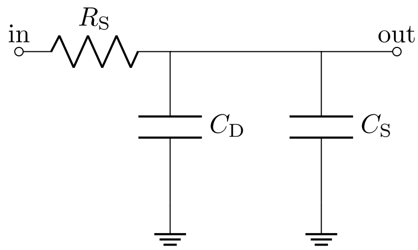
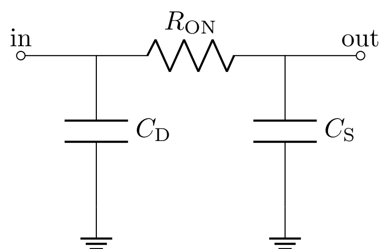


Figure 1.3: $75\,\Omega$ R_{ON}



For this exercise we assume that the load resistance of $100\,\mathrm{k}\Omega$ does not load the circuit.

(a) The circuit is that of Figure 1.2. Since $C_{\mathrm{D}} = C_{\mathrm{S}} = C_{\mathrm{T}} = 8\,\mathrm{pF}$, there is a single pole at the frequency f_{p}:

$$\boxed{f_{\mathrm{p}} = \frac{1}{4\pi R_{\mathrm{S}} C_{\mathrm{T}}} \approx 1\,\mathrm{MHz}}$$

(b) In this case the circuit is depicted in Figure 1.3. The circuit has one pole at DC and another pole at f_{p}:

$$\boxed{f_{\mathrm{p}} = \frac{1}{2\pi R_{\mathrm{ON}} C_{\mathrm{T}}} \approx 265\,\mathrm{MHz}}$$

Exercise 3.8

Figure 1.4: OFF-OFF

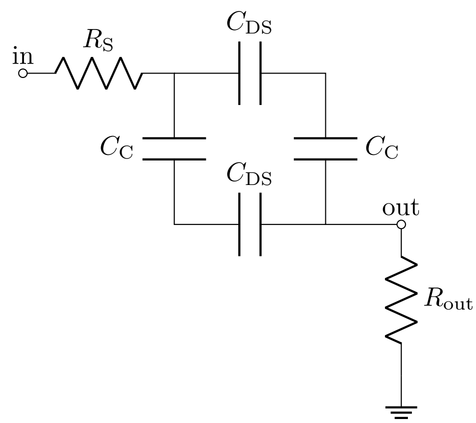


Figure 1.5: OFF-ON

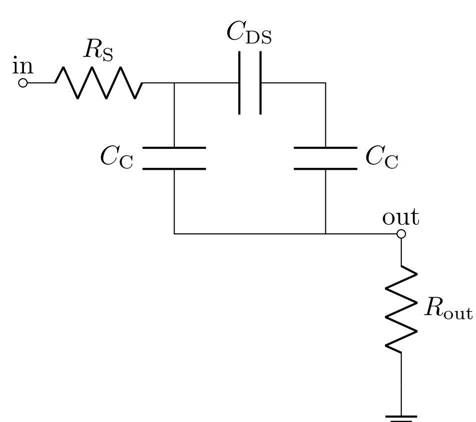


Figure 1.6: ON-OFF

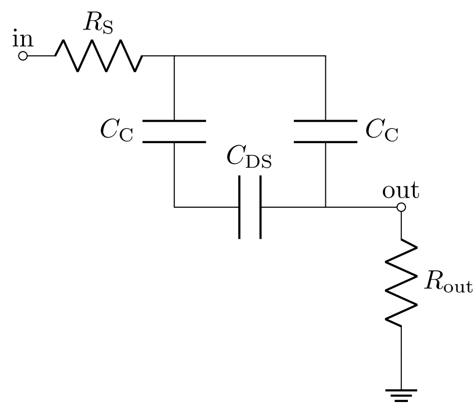
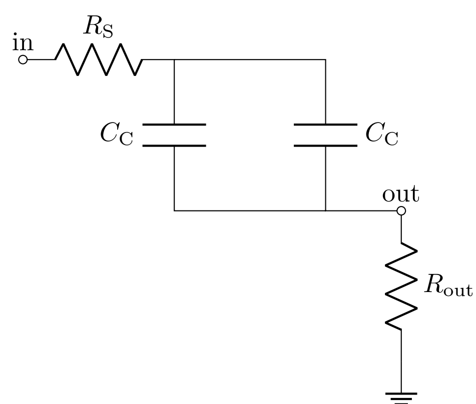


Figure 1.7: ON-ON



(a) In this case the reference circuit is depicted in Figure 1.4. The cross-coupling is given by:

$$\boxed{20\log_{10}\frac{R_{out}}{R_{out}+R_S+0.5(X_C+X_{DS})}=-10.75\,\mathrm{dB}}$$

being $X_C = \frac{1}{2\pi f\, C_C} = 320\,\mathrm{k}\Omega$ and $X_{DS} = \frac{1}{2\pi f\, C_{DS}} = 160\,\mathrm{k}\Omega$

(b) In this case the reference circuit is depicted in Figure 1.5. The cross-coupling is given by:

$$\boxed{20\log_{10}\frac{R_{out}}{R_{out}+R_S+\frac{X_C(X_C+X_{DS})}{2X_C+X_{DS}}}=-9.6\,\mathrm{dB}}$$

(c) In this case the reference circuit is depicted in Figure 1.6. The cross-coupling is the same as before

(d) In this case the reference circuit is depicted in Figure 1.7. The cross-coupling is given by:

$$\boxed{20\log_{10}\frac{R_{out}}{R_{out}+R_S+0.5X_C}=-8.6\,\mathrm{dB}}$$

Exercise 3.9 **TODO: write solution**

Exercise 3.10 **TODO: write solution**

Exercise 3.11 **TODO: write solution**

Exercise 3.12 **TODO: write solution**

Exercise 3.13 **TODO: write solution**

Exercise 3.14 **TODO: write solution**

Exercise 3.15 **TODO: write solution**

Exercise 3.16 **TODO: write solution**

Exercise 3.17 **TODO: write solution**

Exercise 3.18 **TODO: write solution**