The FET Small-Signal Model

A transistor used in a **small-signal** amplifier must be biased to a specific DC **operating point** (i.e. Q-point). EECS 312 and EECS 412 alums will likewise recall that proper FET **operating region** (e.g., cutoff, triode, and saturation) for amplifier operation is:

→

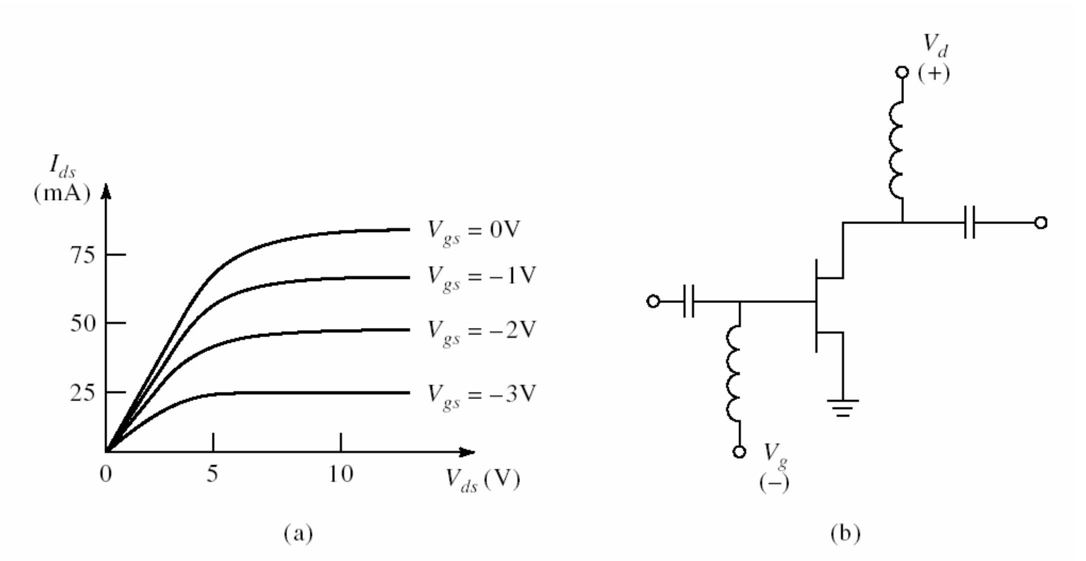

Figure 10-35 (p. 524)
(*a*) DC characteristics of a GaAs FET; (*b*) biasing and decoupling circuit for a GaAs FET.

Former EECS 412 students will likewise recall that we could form a **small-signal model** for a biased transistor, which included transconductance g_m and output resistance r_o (your book calls this last value R_{ds}).

Likewise, for high-frequency applications (like microwave circuits!), we included **parasitic capacitances** C_{gs} , C_{ds} , and C_{gd} in the model:

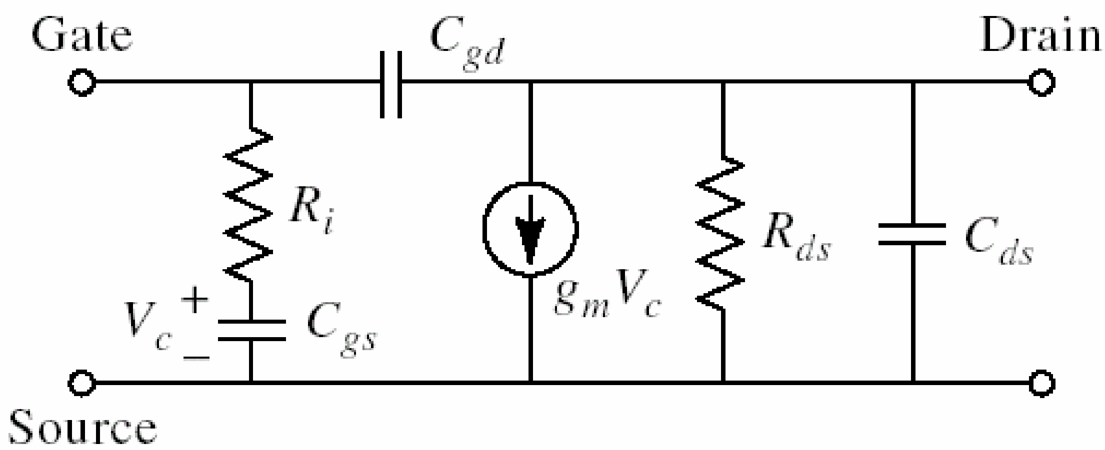

Figure 10-34 (p. 524)
Small-signal equivalent circuit for a microwave FET in the common-source configuration.

From this two-port model, we can **calculate** approximate values of the biased transistor **scattering matrix**—as a function of frequency!

However, to get more **precise** answers, we often directly **measure** the scattering parameters with a network analyzer.

However we determine them, we **typically** find that $|S_{21}| \gg 1$, while $|S_{12}| \ll 1$.

This of course means:

1) We get more power **out** of port 2 than we put **into** port 1.

2) The device is **not** reciprocal.

This is possible because our device is **not** passive, nor linear, nor reciprocal.

Likewise, we will typically find that $|S_{11}|$ and $|S_{22}|$ are **relatively large**. In other words, the ports of a biased transistor are **poorly matched**!

For example, from page 539 we find a biased transistor at 10GHz with:

$$|S_{11}| = 0.45 \qquad |S_{12}| = 0.01$$

$$|S_{21}| = 2.05 \qquad |S_{22}| = 0.40$$

We will require **matching networks** to maximize amplifier gain.