University of California, Berkeley *Fall 2017*
EECS 142/242A *Prof. A. Niknejad*

Midterm Exam (closed book/notes)

Name (Last, First)

SID

EE 142 or 242A

Guidelines: Closed book. You may use a calculator. Do not unstaple the exam. In order to maximize your score, write clearly and indicate each step of your calculations. We cannot give you partial credit if we do not understand your reasoning. Feel free to use scratch paper.

Scattering parameters are defined by incident and reflected waves

$$v_1^- = s_{11}v_1^+ + s_{12}v_2^+$$

$$v_2^- = s_{21}v_1^+ + s_{22}v_2^+$$

Two-port parameters are defined in terms of voltage and current as follows. For Y parameters:

$$i_1 = Y_{11}v_1 + Y_{12}v_2$$

$$i_2 = Y_{21}v_1 + Y_{22}v_2$$

For the Z two-port parameters, the role of voltage and current are interchanged

$$v_1 = Z_{11}i_1 + Z_{12}i_2$$

$$v_2 = Z_{21}i_1 + Z_{22}i_2$$

Hybrid parameters use a mix of voltage and current as independent variables

$$v_1 = H_{11}i_1 + H_{12}v_2$$

$$i_2 = H_{21}i_1 + H_{22}v_2$$

whereas G or inverse hybrid use current and voltage as independent variables

$$i_1 = G_{11}v_1 + G_{12}i_2$$

$$v_2 = G_{21}v_1 + G_{22}i_2$$

Common two-port equation (note that Y can be replaced with H, Z, or G if you are careful to keep impedance / admittance consistent when dealing with the load/source):

$$Y_{in} = Y_{11} - \frac{Y_{12}Y_{21}}{Y_L + Y_{22}}$$

$$Y_{out} = Y_{22} - \frac{Y_{12}Y_{21}}{Y_S + Y_{11}}$$

The voltage gain of a two-port can be written as

$$A'_v = \frac{-Y_S y_{21}}{(Y_S + y_{11})(Y_L + y_{22}) - y_{12}y_{21}}$$

or as

$$A'_v = \frac{A_{vu}}{1 + T}$$

where T is identified as the loop gain

$$T = A_{vu} f = \frac{-y_{12}y_{21}}{(Y_S + y_{11})(Y_L + y_{22})}$$

and

$$A_{vu} = A'_v|_{y_{12}=0} = \frac{-Y_S y_{21}}{(Y_S + y_{11})(Y_L + y_{22})}$$

The power gain of a two-port is given by

$$G_p = \frac{P_L}{P_{in}} = \frac{|Y_{21}|^2}{|Y_L + Y_{22}|^2} \frac{\Re(Y_L)}{\Re(Y_{in})}$$

The maximum gain is given by

$$G_{max} = \left|\frac{Y_{21}}{Y_{12}}\right| (K - \sqrt{K^2 - 1})$$

where K is the stability factor

$$K = \frac{2\Re(Y_{11})\Re(Y_{22}) - \Re(Y_{12}Y_{21})}{|Y_{12}Y_{21}|}$$

The input impedance looking into a transmission line terminated in Z_L is given by

$$Z_{in}(-\ell) = Z_0 \frac{Z_L + jZ_0 \tan(\beta\ell)}{Z_0 + jZ_L \tan(\beta\ell)}$$

MOS Square Law Device Physics (Saturation)

$$I_{DS} = \mu C_{ox} \frac{W}{L} \frac{1}{2} (V_{GS} - V_T)^2 (1 + \lambda V_{DS})$$

$$C_{GS} = \frac{2}{3} W \cdot L C_{ox}$$

$$\omega_T = \frac{g_m}{C_{gs}} = \frac{3}{2} \frac{\mu(V_{GS} - V_T)}{L^2}$$