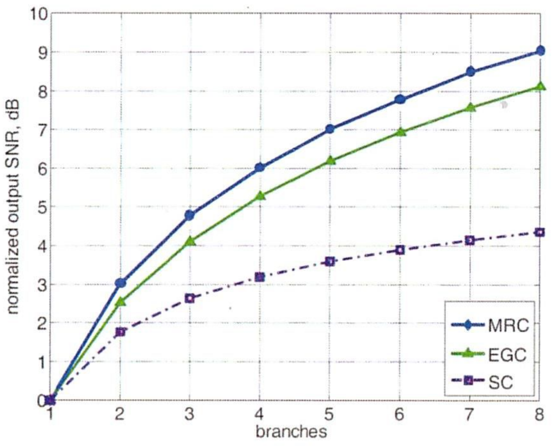
ELT-45106 RF equipment for wireless networks
Final examination (Ari Asp)
26.2.2018 (calculator allowed)

You have to answer to all five (5) questions. Check equations from next page.

1. Explain the why IP3 causes more problem than IP2.

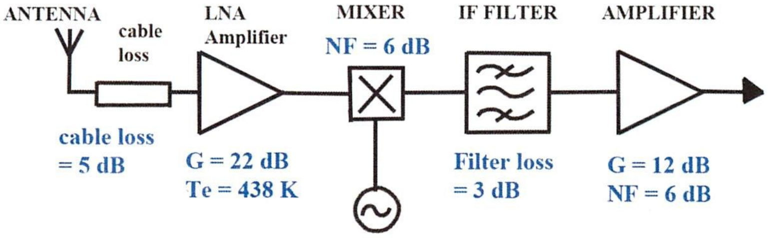
2. What are main differences between Near field and far field. Explain at least two different criteria how do you know you are working in far field.

3. Explain following figure. What kind of systems are behind those curves and what are the main theorethical differences between them?



4. Explain VSWR. When it occurs?

5. A receiver front is following:



Calculate the total NF and Te for output.

Draw a figure and note all the calculations.
Hint:

$$F_{cas} = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \ldots + \frac{F_n - 1}{G_1 G_2 \ldots G_{n-1}}$$

$$T_{cas} = T_{e1} + \frac{T_{e2}}{G_1} + \frac{T_{e3}}{G_1 G_2} + \ldots + \frac{T_{en}}{G_1 G_2 \ldots G_{n-1}}$$

Some (more or less) useful equations:

$$G_a = \frac{p_1}{p_i}, G_b = \frac{p_2}{p_1}, G_c = \frac{p_o}{p_2}$$

$$v_n = \sqrt{\frac{4hfBR}{e^{hf/kT} - 1}}$$

$$P_n = \frac{\left(\frac{v_n}{2}\right)^2}{R} = \frac{v_n^2}{4R} = \frac{\left(\sqrt{4kTBR}\right)^2}{4R} = kTB$$

$$\frac{p_o}{p_i} = \frac{p_1}{p_i}\frac{p_2}{p_1}\frac{p_o}{p_2} = G_a G_b G_c$$

$$10\log_{10}\frac{P_1[W]}{1mW}$$

$$A_z = \int \mu I(z') \frac{e^{-j\beta(r - z'\cos\theta)}}{4\pi r} dz' = \frac{\mu e^{-j\beta r}}{4\pi r} \int I(z') e^{j\beta z'\cos\theta} dz'$$

$$\frac{10^{\frac{P[dBm]}{10}}}{1000}$$

$$\log_{10}\frac{p_o}{p_i} = \log_{10} G_a + \log_{10} G_b + \log_{10} G_c$$

$$10\log_{10}\frac{p_o}{p_i} \qquad \lambda = \frac{c}{f}$$

$$Y = \frac{P_1}{P_2} = \frac{T_1 + T_e}{T_2 + T_e} > 1$$

$$2f_1 - f_2 \cdot \quad 2f_2 - f_1$$

$$F = \frac{CNR_{in}}{CNR_{out}}$$

$$\beta = \frac{2\pi}{\lambda} = \omega\sqrt{\mu\varepsilon}$$

$$A_z = \iiint_{v'} \mu J_z \frac{e^{-j\beta R}}{4\pi R} dv'$$

$$R = 0.62\sqrt{L^3/\lambda}$$

$$\operatorname{div} \mathbf{D}(\mathbf{r},t) = \rho(\mathbf{r},t)$$

$$\operatorname{div} \mathbf{B}(\mathbf{r},t) = 0$$

$$0 \text{ dBd} = 2.15 \text{ dBi}$$

$$R_a = R_r + R_l$$

$$R = \frac{2L^2}{\lambda}$$

$$\operatorname{curl} \mathbf{E}(\mathbf{r},t) = -\frac{\partial \mathbf{B}(\mathbf{r},t)}{\partial t}$$

$h = 6.546 \cdot 10^{-34}$ Jsec, Planck's constant

$c = 299\,792\,458$ *m/s*, speed of light

$k = 1.38 \cdot 10^{-23}$ J/°K, Boltsmann's constant

$$\frac{V_{max}}{V_{min}} = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

$$Z_a = R_a + jX_a$$

$$-20\log_{10}|\Gamma| \text{ dB}$$

$$\operatorname{curl} \mathbf{H}(\mathbf{r},t) = \frac{\partial \mathbf{D}(\mathbf{r},t)}{\partial t} + \mathbf{J}(\mathbf{r},t)$$

$$F_{cas} = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \ldots + \frac{F_n - 1}{G_1 G_2 \ldots G_{n-1}}$$

$$SSL_{dB} = 20\log_{10}\frac{|F(SSL)|}{|F(\max)|}$$

$$F(\theta,\phi) = g(\theta,\phi) \cdot f(\theta,\phi)$$

$$T_{cas} = T_{e1} + \frac{T_{e2}}{G_1} + \frac{T_{e3}}{G_1 G_2} + \ldots + \frac{T_{en}}{G_1 G_2 \ldots G_{n-1}}$$

$$V(z) = V_0^+ e^{-j\beta z} + V_0^- e^{j\beta z}$$

$$T_e = T_o(F - 1) \Leftrightarrow F = 1 + \frac{T_e}{T_o}$$

$$D = \frac{U_{max}}{U_{ave}} \qquad \varepsilon_r = \frac{P}{P_{in}} \qquad G = \varepsilon_r D \qquad U = \frac{dP}{d\Omega}$$

$$NF = 10 \cdot \log(f)$$

$$I(z) = I(0)\sin\left[\beta\left(\frac{L}{2} - |z|\right)\right]$$

$$AF = \sum_{n=0}^{N-1} A_n e^{jn\psi} \qquad \psi = \beta d\cos(\theta) + \alpha$$

$$G(\theta,\phi) = \frac{4\pi U(\theta,\phi)}{P_{in}}$$

$$P = \frac{1}{2} I^2 R_a$$

$$AF = I_0 e^{-j\xi_0} + I_1 e^{-j\xi_1} + I_2 e^{-j\xi_2} + \cdots I_M e^{-j\xi_M}$$

$$N_{UL\_R} = k \cdot T \cdot B \cdot F_R \cdot G_{T\_UL}$$

$$N_{UL\_BS} = k \cdot T \cdot B \cdot F_{BS}$$

$$N_{UL} = N_{UL\_R} + N_{UL\_BS} = k \cdot T \cdot B\left(F_{BS} + G_{T\_UL} \cdot F_R\right)$$

$$AF = A_0 e^{j(N-1)\psi/2}\frac{\sin(N\psi/2)}{\sin(\psi/2)} \qquad f(\psi) = \frac{\sin(N\psi/2)}{N\sin(\psi/2)}$$

$$p(\gamma_i) = \frac{1}{\gamma_0} e^{-\gamma_i/\gamma_0}, \qquad \gamma_0 \ge 0$$

$$P_\Gamma(\gamma) = \Pr[\Gamma \le \gamma] = \Pr\left[\max\{\Gamma_i \le \gamma\}\right] = \Pr[\Gamma_1, \Gamma_2, \cdots \Gamma_M \le \gamma] = \left(1 - e^{\gamma_i/\gamma_0}\right)^M$$

$$P_\Gamma(\gamma_t) = \Pr[\Gamma \le \gamma_t] = \Pr[\Gamma_1, \Gamma_2, \cdots \Gamma_M \le \gamma_t] = \prod_{i=1}^{M} P_{\Gamma_i}(\gamma_t)$$