ELT-45106 : RF Equipment for Wireless Networks — Exam 16.12.2016

Compiler: Ari Asp — <u>Answer to all questions!</u>

Calculators are allowed in this exam. — <u>Remember the kaiku feedback</u>

1. Explain shortly diversity methods

2. Explain the two reasons why 3. order intermodulation products are much more difficult to handle than 2. order intermodulation products for receiver.

3. Using the values given in Figure 1, calculate the noise power at the receiver output, after the 2. amplifier. If the cable loss increases 2 dB (from 4 -> 6 dB), is it possible to compensate by changing parameters of amplifiers? What would be new values of those parameters?

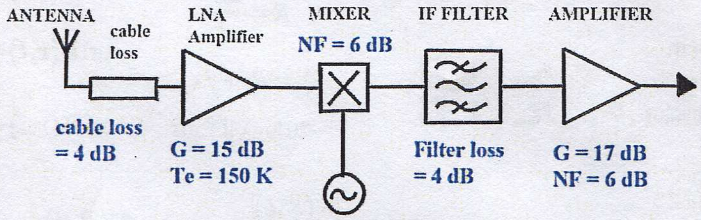
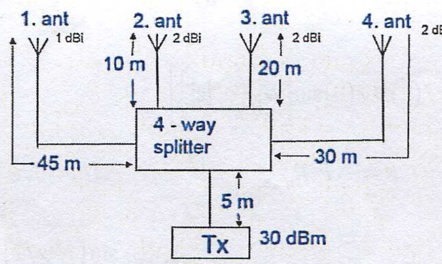
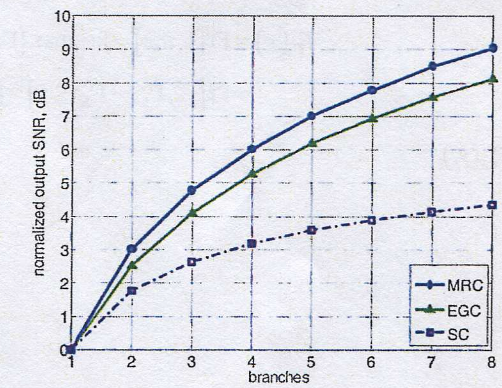


Figure 1. Reveiver structure

4. Calculate the EIRP at each antenna for the DAS (Distributed Antenna System) given below. The power level at the transmitter is 30 dBm. The manufacturer of the feeder (1/2") promises a loss of 6.0 dB/100m at the carrier frequency. Gain of antenna 1 = 1 dBi, and for antenna 2,3 and 4 Gain = 2 dBi.



5. Explain following figure. What kind of systems are behind those curves and what are the main differences between those systems? Explain structure principles of those systems.



NOTE: Formulas are in the following page if you need them.

Some (more or less) useful equations for ELT-45106 exam:

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

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

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

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

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

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

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

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

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

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

$$2f_1 - f_2, \quad 2f_2 - f_1$$

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

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

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

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

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

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

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

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

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

$$R_a = R_r + R_l$$

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

$h = 6.546\cdot10^{-34}$ Jsec, Planck's constant

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

$k = 1.38\cdot10^{-23}$ J/°K, Boltsmann's constant

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

$$Z_a = R_a + jX_a$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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