ELT-45107 RF equipment for wireless networks

Final examination, the first one, (Ari Asp)
4.3.2021 (calculator allowed)

You have to answer to all five (5) questions.

1. Explain shortly the following solutions:
   a) What is the difference between dBi and dBd –values?
   b) What is the difference between Switch and Stay and Switch and Examine –methods?

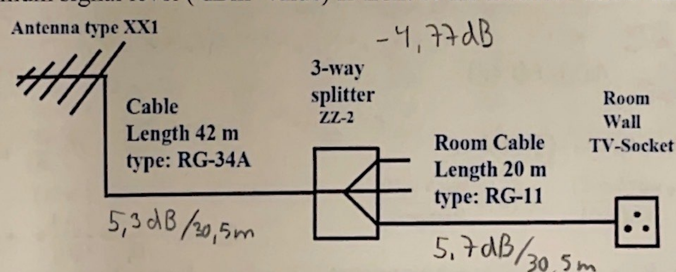
2. What techniques or methods are described by next formulas?

   a) $P_{\Gamma_i} = \Pr[\Gamma_i \le \gamma] = 1 - e^{\gamma_i/\gamma_0}$

   b) $E[\Gamma] \approx M\gamma_0$

   c) $E[\Gamma] \approx \frac{\pi}{4} M\gamma_0$

3. If you have a TV-antenna system in which you have an antenna, cables, splitter and wall socket (all specifications of those components are attached in this exam paper, check them carefully) and the system is working at 430 MHz center frequency. The minimum signal level at the wall socket has to be 47 dBµV. What has to be the minimum signal level (dBm -value) in front of the antenna? Show calculations.



4. What are advantages and problems in direct-conversion receivers?

5. Using the components given in following figure, calculate what will be the Noise Figure in the output (after the filter). Frequency is 400 MHz. Show calculations as a proof !

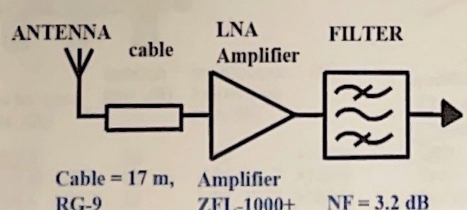


Figure 1. Structure of the receiver

Here are more or less useful equations:

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

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

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

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

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

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

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

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

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

$10\log_{10}\frac{p_o}{p_i}$

$\lambda = \frac{c}{f}$

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

$Z_a = R_a + jX_a$

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

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

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

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

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

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

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

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

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

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

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

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

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

0 dBd = 2.15 dBi

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

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

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

$\varepsilon_r = \frac{P}{P_{in}}$

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

$D = \frac{U_{\max}}{U_{ave}}$

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

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

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

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

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

$R_a = R_r + R_l$

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

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

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

$\frac{V_0^-}{V_0^+} = \frac{Z_L - Z_0}{Z_L + Z_0}$

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

dBmV = 46.9897 + $dBm_{50\Omega}$

dBmV = 48.7506 + $dBm_{75\Omega}$

dBµV = 60 + dBmV

dBµV = 106.98 + $dBm_{50\Omega}$

dBµV = 108.75 + $dBm_{75\Omega}$

$P_\Gamma(\gamma_t) = \Pr[\Gamma \le \gamma_t]$

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

$\psi = \beta d\cos(\theta) + \alpha$

$G = \varepsilon_r D$

$AF = \sum_{n=0}^{N-1} A_n e^{jn\psi}$

$VSWR = \frac{V_{max}}{V_{min}}$

$U = \frac{dP}{d\Omega}$

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

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

$f(\psi) = \frac{\sin(N\psi/2)}{N\sin(\psi/2)}$

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

$RL = -20\log_{10}|\Gamma|$

$P_\Gamma(\gamma) = \Pr[\Gamma \le \gamma] = \Pr[\max\{\Gamma_i \le \gamma\}]$

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

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

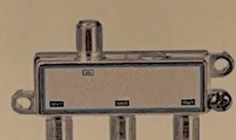
100 ft = 30.5 m

Amplifiers

Model Number	Connec-tor	Imped. (Ohms)	F Low (MHz)	F High (MHz)	Gain . (dB) Typ	NF (dB). Typ	Out. IP3 (dBm) Typ.
ZFL-750+	SMA	50	0.2	750	18	6	18
ZFL-750B+	SMA	50	0.2	750	18	6	18
ZFL-1000+	SMA	50	0.1	1000	17	6	18
ZFL-1000B+	SMA	50	0.1	1000	17	6	18
ZFL-1000H+	SMA	50	10	1000	28	4	33
ZFL-1000HB+	SMA	50	10	1000	28	4	33
ZFL-1000LN+	SMA	50	0.1	1000	20	2.9	14
ZFL-1000LNB+	SMA	50	0.1	1000	20	2.9	14
ZFL-1000VH+	SMA	50	10	1000	20	4.5	38
ZFL-1000VH2X+	SMA	50	10	1000	28	5	38
ZFL-1000VH2+	SMA	50	10	1000	28	5	38
ZFL-1000VH2B+	SMA	50	10	1000	28	5	38
ZFL-1000VHB+	SMA	50	10	1000	20	4.5	38
ZFL-1000VHX+	SMA	50	10	1000	20	4.5	38
ZFL-1200G+	SMA	50	10	1200	23	6.5	22
ZFL-1200GB+	SMA	50	10	1200	23	6.5	22
ZFL-1200GH+	SMA	50	10	1200	29	5.5	28
ZFL-1200GHB+	SMA	50	10	1200	29	5.5	28
ZFL-2000+	SMA	50	10	2000	20	7	25
ZFL-2000B+	SMA	50	10	2000	20	7	25
ZFL-2000G+	SMA	50	10	2000	20	7.5	17
ZFL-2000GB+	SMA	50	10	2000	20	7.5	17
ZFL-2000GH+	SMA	50	10	2000	27	5.5	25
ZFL-2000GHB+	SMA	50	10	2000	27	5.5	25
ZFL-2000X+	SMA	50	10	2000	20	7	25
ZFL-2500+	SMA	50	500	2500	28	8	27
ZFL-2500B+	SMA	50	500	2500	28	8	27
ZFL-2500VH+	SMA	50	10	2500	20	5.5	35
ZFL-2500VHB+	SMA	50	10	2500	20	5.5	35
ZFL-2500VHX+	SMA	50	10	2500	20	5.5	35

Table 1. Datasheet of amplifiers

Components for task 3, the TV-antenna system



Type ZZ-2

MHz	Insertion Loss (max. dB)	Isolation (min. dB)	Input/Output Return Loss (min. dB)	RFI
5-42	3.3/7.5	30	20	>130dB
42-860	4.8/7.9	28	22	>130dB
860-1000	5.3/8.5	28	20	>130dB

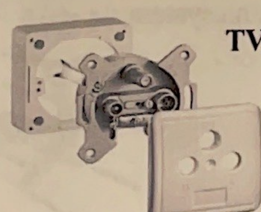
Specifications: Antenna type XX1
- **Channels: Ch. 13 - 69**
- **Frequency Range: 470 - 862 MHz**
- **Gain: 12 dB**
- **Front - Back Ratio: > 20 dB**
- **Impedance 75 ohm.**

Table 2. Cable attenuations

Table of coaxial cables

30,5 m

Type (/U)	MIL-W-17	$Z_0(\Omega)$	Dielectric Type	Capacitance (pF/ft)	O.D. (in.)	dB/100 ft @400 MHz	Vmax (rms)
RG-4		50.0	PE	30.8	0.226	11.7	1,900
RG-5		52.5	PE	28.5	0.332	7.0	3,000
RG-5A/B		50.0	PE	30.8	0.328	6.5	3,000
RG-6	/2-RG6	76.0	PE	20.0	0.332	7.4	2,700
RG-6A	/2-RG6	75.0	PE	20.6	0.332	6.5	2,700
RG-8		52.0	PE	29.6	0.405	6.0	4,000
RG-8A		52.0	PE	29.6	0.405	6.0	5,000
RG-9		51.0	PE	30.2	0.420	5.9	4,000
RG-9A		51.0	PE	30.2	0.420	6.1	4,000
RG-9B		50.0	PE	30.8	0.420	6.1	5,000
RG-10		52.0	PE	29.6	0.463	6.0	4,000
RG-10A		52.0	PE	29.6	0.463	6.0	5,000
RG-11	/6-RG11	75.0	PE	20.6	0.405	5.7	4,000
RG-11A	/6-RG11	75.0	PE	20.6	0.405	5.2	5,000
RG-12	/6-RG12	75.0	PE	20.6	0.463	5.7	4,000
RG-12A	/6-RG12	75.0	PE	20.6	0.463	5.2	5,000
RG-17A		52.0	PE	29.6	0.870	2.8	11,000
RG-22	/15-RG22	95.0	PE	16.3	0.405	10.5	1,000
RG-22A/B	/15-RG22	95.0	PE	16.3	0.420	10.5	1,000
RG-23/A	/16-RG23	125.0	PE	12.0	0.650	5.2	3,000
RG-24/A	/16-RG24	125.0	PE	12.0	0.708	5.2	3,000
RG-34	/24-RG34	71.0	PE	21.7	0.625	5.3	5,200
RG-34A	/24-RG34	75.0	PE	20.6	0.630	5.3	6,500



TV -socket

- Design tightening enhanced to meet the specifications of cable operators live.
- Separate bands TV / FM - SAT.
- Improved Shield.
- Loss: 3.2 dB
- Live fast and secure setting.
- Firm clamping vivo.