TKK/LH

S-72.3310 Transmission Media in Communications
EXAMINATION 27.5.2005

ONLY FIVE BEST ANSWERS ARE TAKEN INTO ACCOUNT
Lecture and exercise material can be freely used in examination.

---

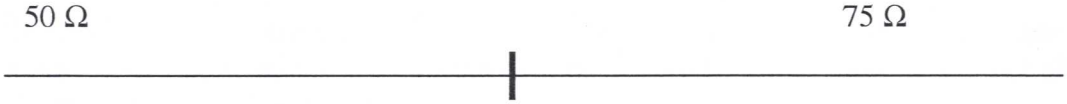
1. How does the surface resistance R_S of a round copper wire depend on the following factors: a) Temperature, b) Frequency, c) Conductivity. d) Diameter of wire at:
1.1 Low Frequencies and at
1.2 High Frequencies?
1.3 What is the surface resistance R_S of a 1 m long 0,5 mm thick round copper wire at 100 MHz and 10 degree C?
Ref.: Conductivity of copper is 58 Sm/mm^2 (T=20 degree C) and its temperature coefficient is – 0,39% /degree C.

---

2. What is the corresponding power level in dBm of a transmission line system where the voltage level is 107 dBµV and the nominal impedance is 50 Ω?

The above 50 Ω transmission line system is matched to a 75 Ω system
a) with an ideal transformer or
b) with a 150 Ω parallel matching resistor.
c) The 50 Ω system is connected direct without matching to the 75 Ω system.

a) Transformer
b) 150 Ω parallel matching resistor



c) Direct without matching

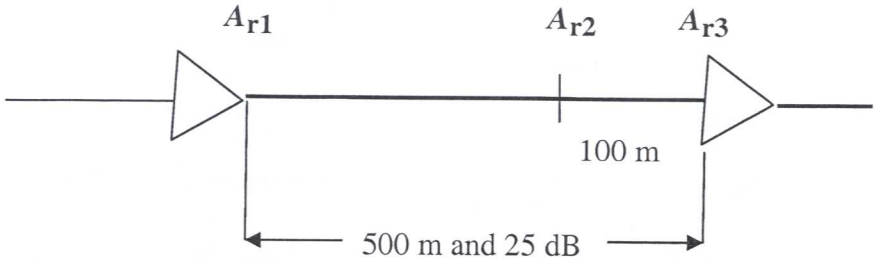
How do the power level and voltage level change from the 50 Ω side to the 75 Ω side in cases a) and b).

d) In case c), what are the return loss (heijastusvaimennus) A_r and reflection loss (sovitusvirhevaimennus) A_S at the connecting point?

e) In case c) what are the power level and voltage level in the 75 Ω transmission line after being connected to the 50 Ω transmission line system with an original power level of 0 dBm (107 dBµV/50 Ω)?

---

3. A repeater section of a cable television system is about 500 m and attenuation (vaimennus) at 400 MHz is 25 dB. At the 100 m distance of the end of the repeater section there is a reflection point, which return loss (heijastusvaimennus) is A_{r2}=18 dB. Return loss of the repeaters at both ends of the repeater section is 15 dB (=A_{r1}=A_{r3}). Calculate the worst case forward echo attenuation (Mitfluss-Dämpfung, myötävuovaimennus) caused by the reflections A_{r1}, A_{r2} and A_{r3}. All reflection coefficients are resistive. The reflection losses (sovitusvirhevaimennukset) A_S are not taken into account.



---

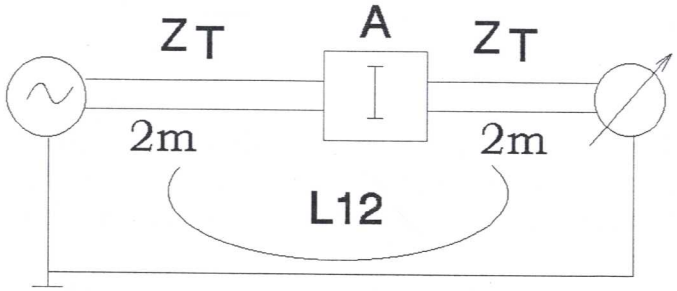
4. Estimate the effect of structural inhomogeneity (rakenteellinen epähomogeenisyys) to the transmission properties of a 34,8 dB (4,0 Np) attenuating repeater section.
The periodic structural inhomogeneity gives a spike which return loss measured from the near-end is A_p = 14 dB. (1 Np = 8,7 dB or 1 dB = 0,115 Np).

a) What is the forward echo attenuation (Mitfluss-Dämpfung, myötävuovaimennus) A_q?
b) What is the maximum capacity C [bit/s/Hz] which could be achieved if the corresponding forward echo were white noise with a signal to noise ratio S/N = A_q?

Ref.: According to Shannon $C \approx \frac{1}{3}\left(\frac{S}{N}/\text{dB}\right)$[bit/s/Hz]

---

5. What should be the maximum resulting transfer impedance Z_T of the test leads (cable assemblies) if we like to measure 80 dB attenuation at 2 MHz with an accuracy of 0,1 dB? The ground loop inductance L_{12} = 1μH.



Guidance: To achieve Δ = 0,1 dB accuracy the "roundtrip" attenuation has to be about 40 dB above the attenuation of the test object. The attached monogram can be used.

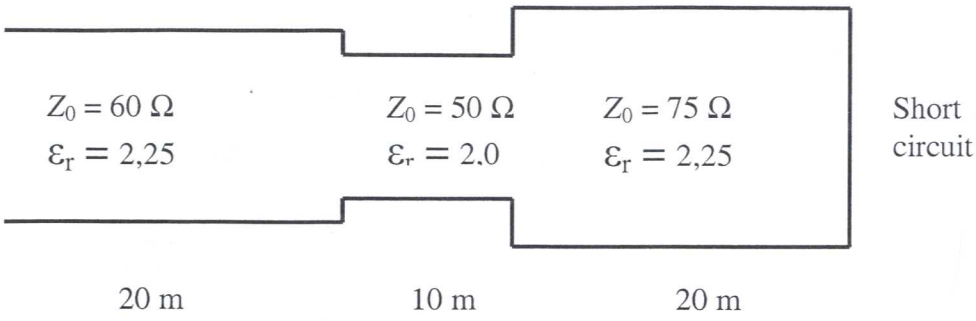
---

6. The image attenuation of a 75 Ω attenuator is 25 dB.
What is the operational attenuation (A_B or $A_{kä}$, käyttövaimennus) when measured with a 50 Ω Network Analyzer (with an estimated accuracy of 0,1 dB)?

How much does the forward echo attenuation (Mitfluss-Dämpfung, myötävuovaimennus) A_q influence the test result?

---

7. The lossless line below is measured with a) 20 ns (half amplitude) $\sin^2$-pulse and with b) 20 ns (10 % to 90% amplitude) rise time step.



Draw the a) pulse response and b) step response and provide the figure with time and amplitude scale.
c) What is the mathematical relation between step response and pulse response?

---

8. The power levels of –28 dBm and –63 dBm were measured at the far end of the disturbing (1) and disturbed (2) line, correspondingly. At the near end of line (2) the measured power level was –50 dBm. Both lines are identical and their operational attenuation is 23 dB. All impedances are Z=100 ohm.
Define, calculate and draw a picture for:

a) NEXT, near end crosstalk (A_n)

b) FEXT, far end crosstalk (A_f)

c_1) EL-FEXT, equal level far end crosstalk (Δ_f)

c_2) ACR-F, Attenuation to crosstalk Ratio at the Far-end

c_{3a}) "S/N-F", Signal to crosstalk Noise ratio at the Far-end

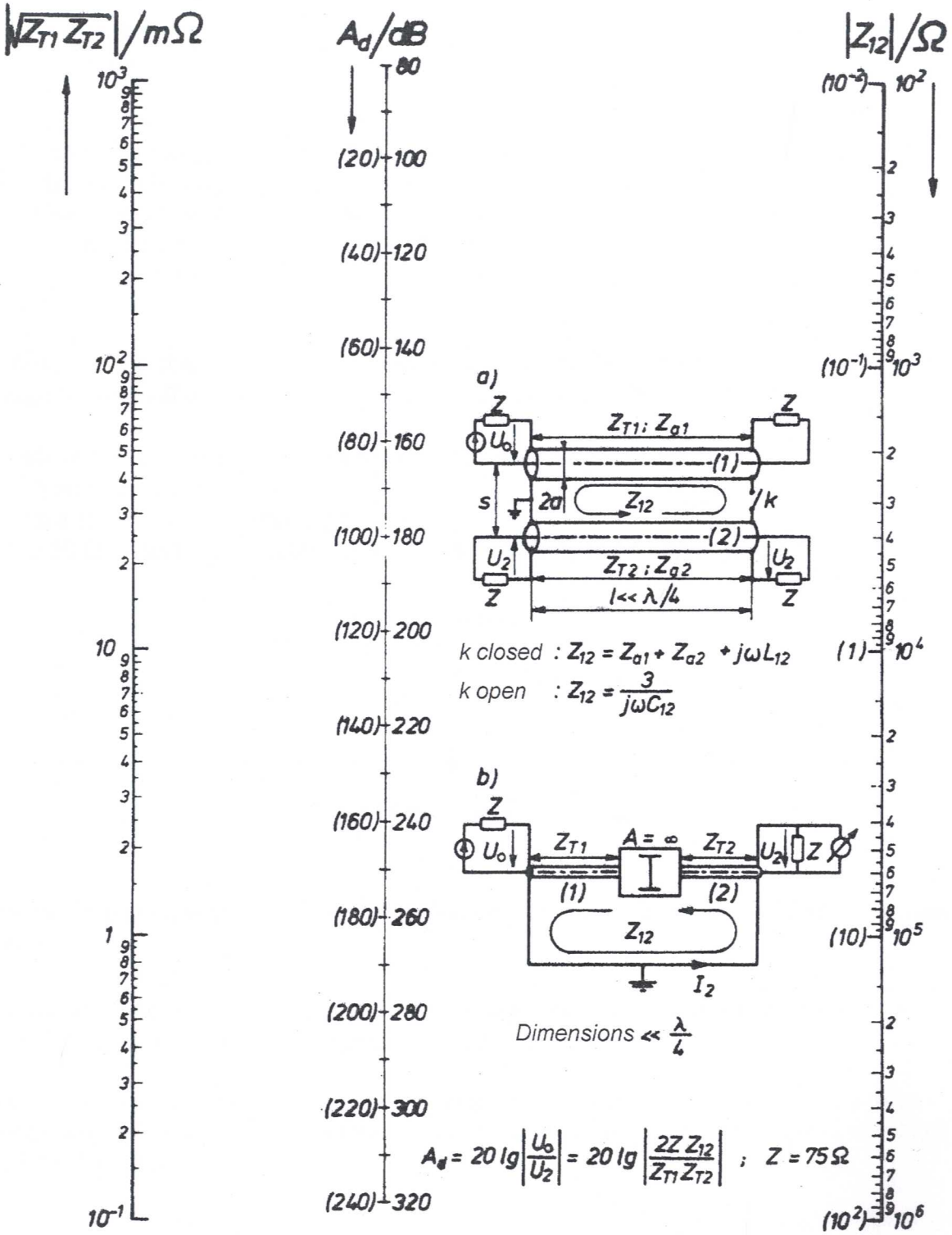
c_{3b}) Capacity bit/s/Hz which could be transmitted due to "S/N-F", see task 4

d) The transmitted power level of the generator.

---

9. Optical fibers are now being increasingly deployed closer to the user premises.

a. Mention at least three key benefits that the fiber transmission medium provides over other commonly used transmission media (copper cables, RF wireless etc.).
b. With the aid of simple diagrams, describe two ways in which fibers are being deployed in the local access network (also known as, last mile, local loop etc.).
c. A 80 km point-to-point fiber link uses a single mode fiber with an attenuation coefficient of 0,2 dB/km. The maximum transmitter power is 1,0 mW and the receiver sensitivity is –25 dBm. Carry out a link power budget analysis and evaluate the available link (power) margin in dB.


$|\sqrt{Z_{T1} Z_{T2}}|/m\Omega$
A_d/dB
$|Z_{12}|/\Omega$
a)
b)
$Z_{T1}; Z_{a1}$
$Z_{T2}; Z_{a2}$
Z_{12}
$l \ll \lambda/4$
k closed : $Z_{12} = Z_{a1} + Z_{a2} + j\omega L_{12}$
k open : $Z_{12} = \frac{3}{j\omega C_{12}}$
$A = \infty$
Dimensions $\ll \frac{\lambda}{4}$
$A_d = 20 \lg \left|\frac{U_0}{U_2}\right| = 20 \lg \left|\frac{2Z Z_{12}}{Z_{T1} Z_{T2}}\right|$; $Z = 75\Omega$