TKK /LH
S-72.3310 Transmission Media in Communications
EXAMINATION 17.5.2005

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

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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?

Ref.: Conductivity of copper is 58 Sm/mm^2 (T=20 degree C) and its temperature coefficient is
– 0,39% /degree C.

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

The above 50 Ω 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.

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a) Transformer
b) 150 Ω parallel
    matching resistor

50 Ω   75 Ω

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c) Direct without matching

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

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

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3. A repeater section of a cable television system is about 400 m and attenuation (vaimennus) at 400 MHz is 20 dB. At the 100 m distance of the end of the repeater section there is a reflection point, which return loss (heijastusvaimennus) is $A_{r2}=20$ 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.
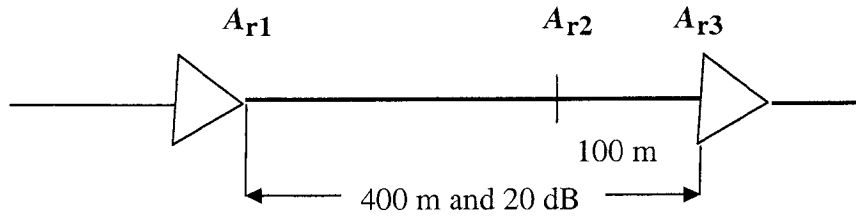

4. Estimate the effect of structural inhomogeneity (rakenteellinen epähomogeenisyys) to the transmission properties of a 30,5 dB (3.5 N) attenuating repeater section.
The periodic structural inhomogeneity gives a spike which return loss measured from the near-end is $A_p = 14$ dB.   (1 Np = 8,7 dB or 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?

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

5. How much in dB is the improvement of the screening efficiency (SE) of a connector, which is equipped with double contacts, when referring it to the connector with single contact? Calculate the improvement of SE in decibels at 1, 100 and 300 Mhz. - In figures contact resistances are frequency independent $R_{y1} = 0,3$ mΩ and $R_{y2} = 3$ mΩ and mechanical dimensions of the connectors $d_1 = 10$ mm, $d_2 = 20$ mm and x = 22 mm, which give a double contact loop inductance L_{12} of 3,05 nH.
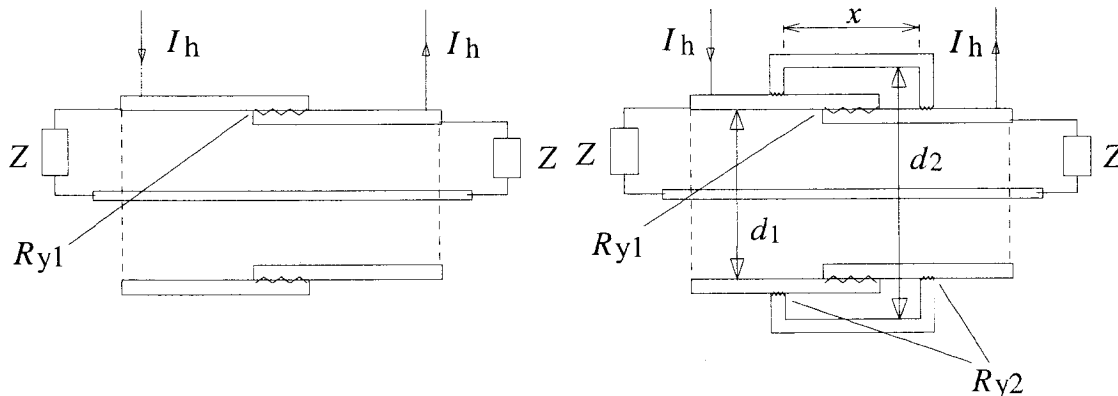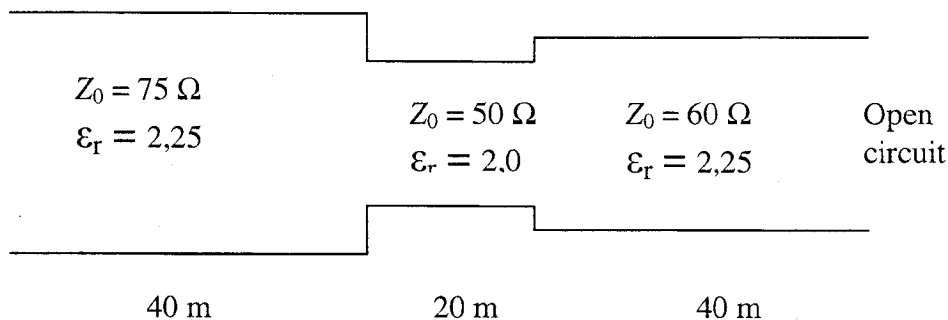
6. The image attenuation al of a 75 Ω line is 20 dB.

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 (Mitfluss-Dämpfung, myötävuovaimennus) A_q influence the test result?

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7. The lossless line below is measured with a) 50 ns (half amplitude) $\sin^2$-pulse and with b) 50 ns (10 % to 90% amplitude) rise time step.

$Z_0 = 75\ \Omega$
$\varepsilon_r = 2,25$

$Z_0 = 50\ \Omega$
$\varepsilon_r = 2.0$

$Z_0 = 60\ \Omega$
$\varepsilon_r = 2,25$

Open circuit

40 m   20 m   40 m

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?

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8. The power levels of –28 dBm and –68 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 –55 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

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9. The fiber transmission media offers clear benefits over other legacy transmission media (e.g. twisted copper pairs). But fiber also has notable performance limitations.
       a. What are the two impairment effects that limit the capacity and/or range of fiber links?
       b. A 100 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.