S-72.423 Exercise 1.

Return your answer no later than on Tuesday 07.10.2003 at 16:00 into the course's P.O. box at the third floor of the E-wing.

Please, include the following information in your answers:
- Your name
- Your student number

It may be that you won't find answers to the questions straight from the lecture material. You may have to look for information from the textbooks and Internet. Good luck for information search!
To this exercise you may answer in English, Finnish or Swedish.

1. DESIBELS (once again...)

dBm and **dBμV** are defined by following formulas:

$$P(dBm) = 10 \cdot lg\left(\frac{P}{1\,mW}\right) \qquad U(dB\mu V) = 20 \cdot lg\left(\frac{U}{1\,\mu V}\right)$$

a) Sensitivity requirement of the GSM Base Station is –104 dBm. Calculate the corresponding power in watts. Calculate also the corresponding voltage when the nominal impedance of the system is 50 Ω. Represent the corresponding voltage in dBμV form.

Solution:

$$-104 = 10 \cdot lg\left(\frac{P}{1\,mW}\right) \Rightarrow P = 1\,mW \cdot 10^{\frac{-104}{10}} \approx 39{,}8\ fW$$

$$P = \frac{U^2}{R} \Rightarrow U = \sqrt{P \cdot R} = \sqrt{1\,mW \cdot 10^{\frac{-104}{10}} \cdot 50\,\Omega} \approx 1{,}41\,\mu V$$

$$U(dB\mu V) = 20 \cdot lg\left(\frac{U}{1\,\mu V}\right) \approx 2{,}99\ dB\mu V$$

b) In the system of 75 ohms dBm can be converted into dBμV without calculating watts and volts first. The equation will be as follows

A dBm = B dBμV - C and B dBμV = A dBm + C

Determine C and prove by using example calculation that the equation works.

Solution:

$P = 1\,mW \cdot 10^{\frac{P(dBm)}{10}}$ $\qquad P = \frac{U^2}{R} \Rightarrow U = \sqrt{P \cdot R}$

$$U(dB\mu V) = 20 \cdot lg\left(\frac{U}{1\,\mu V}\right) = 10 \cdot lg\left(\frac{U}{1\,\mu V}\right)^2 = 10 \cdot lg\left[\frac{P \cdot R}{(1\,\mu V)^2}\right] = 10 \cdot lg\left[\frac{1\,mW \cdot 10^{\frac{P(dBm)}{10}} \cdot R}{(1\,\mu V)^2}\right] =$$

$$P(dBm) + 10 \cdot lg\left[\frac{1\,mW \cdot 75\,\Omega}{(1\,\mu V)^2}\right] = P(dBm) + 108{,}75,\ \textit{so the}$$ c = 108,75.

For example: 2 $dB\mu V = 20\,lg\left(\frac{U}{1\,\mu V}\right) \quad => \frac{U}{1\,\mu V} = 10^{\frac{2}{20}} \quad => U \approx 1{,}2589\mu V$

$P = \frac{U^2}{R} \qquad => X\,dBm = 10\,lg\frac{\frac{U^2}{R}}{1mW} \approx -106{,}7508$

==> 2 $dB\mu V$ = -106,75 $dBm + 108{,}75$.

2. SHANNON'S THEOREM & BITS and BAUDS OF MODEMS

[Reference: Voipio, Uusitupa: Tietoliikenneaapinen (in Finnish) or Internet]

a) Shannon's third and the most famous theorem 'information capacity theorem' determines a theoretical upper limit to an error-free transmission. Up to this limit it is possible to reduce amount of errors into arbitrarily small by choosing a suitable error coding.

$$C = B \cdot \log_2(1 + \frac{P}{N_0 B})\ \frac{bit}{s}$$

, where C is the highest possible bit rate, B is a bandwidth of the channel, P is an average received power and term N_0 is caused by a Gaussian distributed noise (additive white Gaussian noise, AWGN) whose one-sided power spectral density is N_0.

Calculate the smallest possible signal to noise ratio (SNR) of a telephone connection. Bandwidth of the connection is 3,1 kHz and wanted bit rate is 33000 bit/s.

$$33000\,\frac{bit}{s} = 3100\,Hz \cdot \log_2(1 + \frac{P}{N_0 B}) \Rightarrow \frac{P}{N_0 B} = 2^{\frac{33000}{3100}} - 1 \approx\hat{=} 32\,dB$$

b) According to a modem recommendation V.34 bit rate of the 512QAM modulation can be 28800 bit/s. Now the modem is able to transmit 512 different symbols to a telephone line. How many bits can be transmitted per one symbol when the information has not been compressed? What is the symbol rate (baud rate) at the time?

Solution:

$2^X = 512 \quad \Rightarrow Log_2(512) = X \quad X = 9 \quad -> \quad 9\ bits$

$$R_s = \frac{28{,}8\,\frac{kbit}{s}}{9\ bit} = 3200\ Bd$$

3. Write in full length the following acronyms: Solutions:

- OSI	Open Systems Interconnection (ISO 9646-1)
- PSTN	Public Switched Telephone Network
- N-ISDN	Narrowband Integrated-Services Digital Network
- GSM	Global System for Mobile communications (Groupe Speciale Mobile)
- ATM	Asynchronous Transfer Mode
- WCDMA	Wideband Code Division Multiple Access
- SS7	Signaling System 7
- IP	Internet Protocol
- IN	Intelligent Network
- SMS	Short Message Service
- PLMN	Public Land Mobile Network
- TCP	Transmission Control Protocol
- UDP	User Datagram Protocol
- LAN	Local Area Network
- SDH	Synchronous Digital Hierarchy
- STM	Synchronous Transfer Mode
- VPN	Virtual Private Network
- EDGE	Enhanced Data rate for GSM Evolution

4. Pulse Code Modulation in PSTN

a) Please fill in the missing words:

Recommendation ___________ specifies PCM (Pulse Coded Modulation) of voice frequencies. To generate a PCM signal, an analogue speech signal is sampled at ________ Hz and converted into a ________ bit code word.

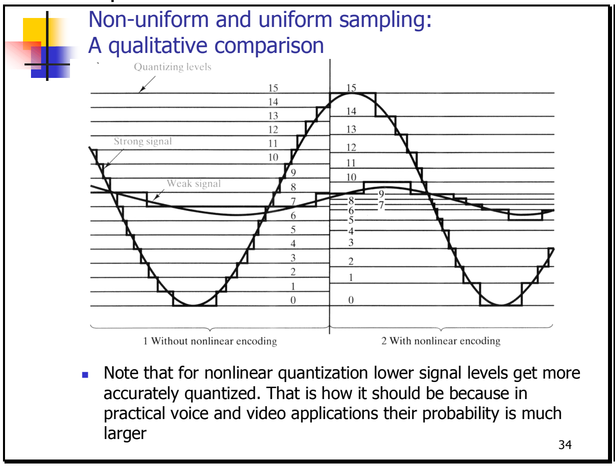
Solution:

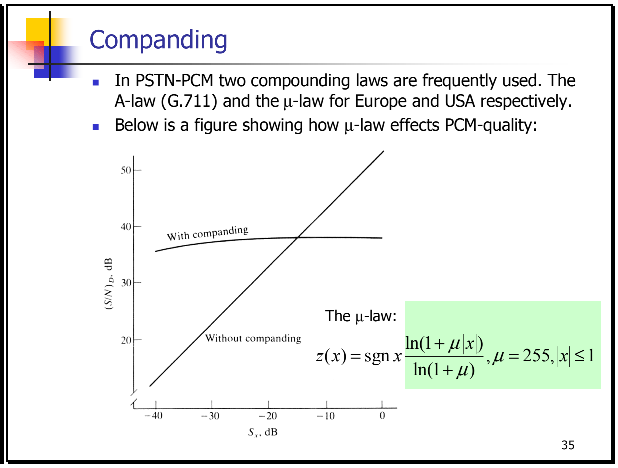
Recommendation ___**G.711**____ specifies PCM (Pulse Coded Modulation) of voice frequencies. To generate a PCM signal, an analogue speech signal is sampled at __**8000**__ Hz and converted into a ___**8**____ bit code word.

b) Find out why A-law (or µ-law) is used?

Solution:

Without using compounding laws the signal to noise ratio would be worse when (voice) signal consist lower amplitudes.





5. Compare circuit switching and packet switching.

Solution:

SEE:
http://www.comlab.hut.fi/opetus/423/a/2_pstn1.ppt (slide 38)

Circuit switching	vs.	**Packet switching**
- developed for voice		- developed for data
- well specified delay		- variable delays
- echo problems		
		- statistical multiplexing
- PSTN		- Ethernet
- Time/space switch		- header etc.
- dedicated path		

etc.