Université Laval
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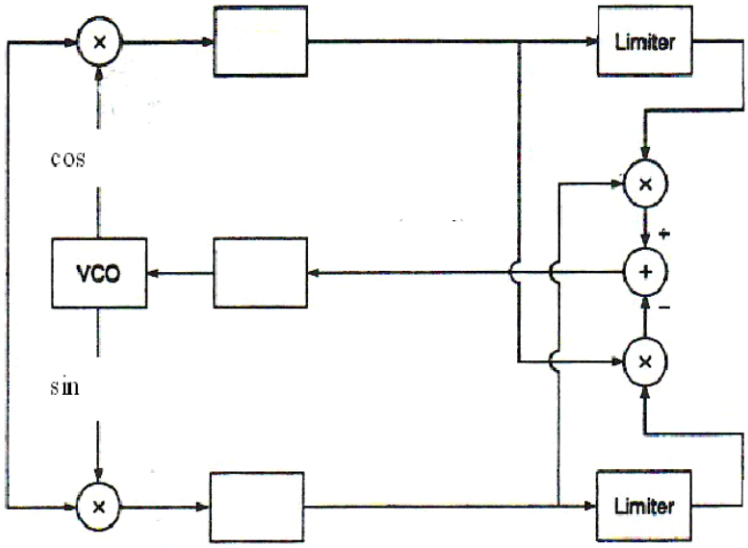
Département de génie électrique
et de génie informatique

GEL10280: Communications numériques
2004 Final Exam

Wednesday 28 April 2004; Duration: 08h30 - 10h20
Two pages of notes allowed; calculator allowed

Problem 1 (25 points over 100)

Here is a schematic of a Costas loop for QPSK.



A. (10 points) Complete the empty boxes for a first order PLL.

B. (10 points) Indicate in the schematic provided where we find the following :

   a. incoming signal
   b. error signal
   c. control signal
   d. data estimates
   e. phase estimate

C. (5 points) How could you change the PLL to assure that the asymptotic error is zero when the phase varies linearly with time (a ramp)?

Problem 2 (25 points over 100)

Here is the parity matrix of a (7,4) block code:

$$P = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

A. (5 points) How many bit errors can be corrected?

B. (5 points) Give the generating matrix of a systematic version of the code.

C. (10 points) Give the syndrome table.

D. (5 points) What is the output (the 4 message bits) of the decoder for received block

$$\begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 1 & 1 \end{bmatrix}?$$

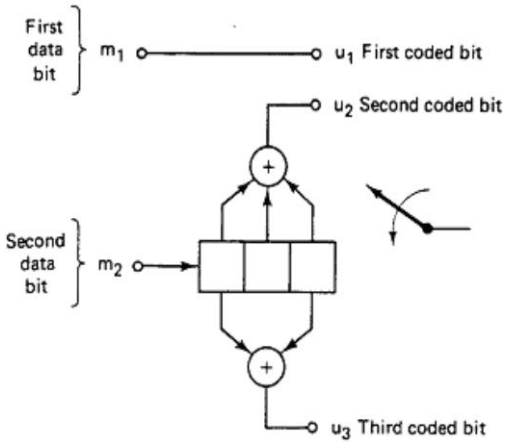
Problem 3 (20 points over 100)

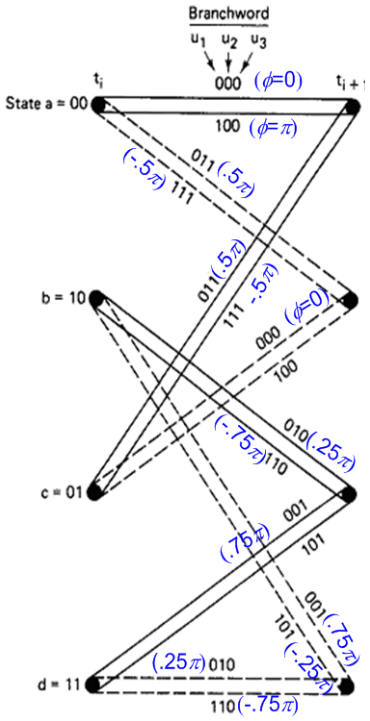
The desired user in a DS-CDMA system is located at the edge of the cell, where the power control is not able to keep the interfering signals at the same received energy as the desired user. In fact, the interfering signals arrive with twice the energy of the desired user

For a signal-to-AWGN of 15 dB and a spreading gain of 127, how many users can be supported and guarantee a bit error rate of 10^{-3} for the desired user?

Note : $Q(3.1) = 10^{-3}$

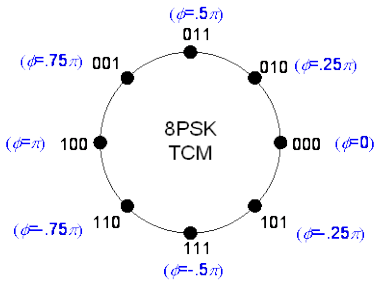
Problem 4 (30 points over 100)



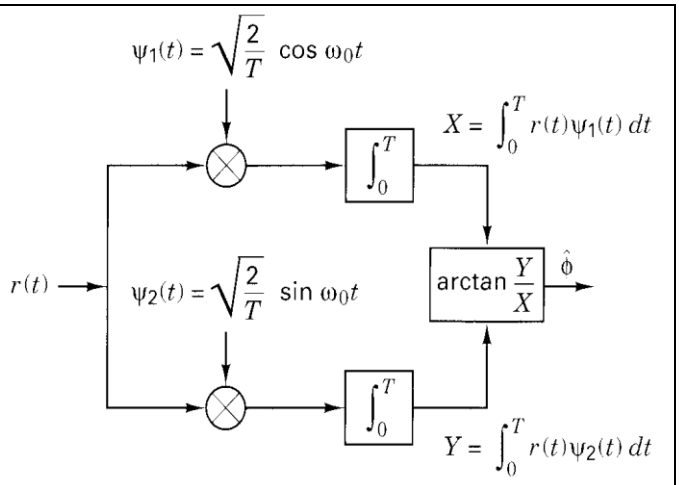


The encoder and encoding trellis for a TCM system with code rate of 2/3. Assume the initial register states are zero.

Here are the signal space representation and the receiver for 8PSK TCM



Correspondance des mots de codes et symboles (phase)



You should find the output of the TCM decoder that exploits soft decisions in a Gaussian channel. The sequence of phase estimates that outputs from the 8PSK receiver is:

$$\begin{bmatrix} -1.4 & 1.2 & 3 & .8 \end{bmatrix}$$

You should find the most probable path in the trellis decoder using Euclidean distances. You should indicate the results of your calculations on the sheet provided containing empty decoder trellises.

Hint: Local distance - $dist\left(\underline{u}_1, \underline{v}_1\right) = \sqrt{\left(u_{1x} - v_{1x}\right)^2 + \left(u_{1y} - v_{1y}\right)^2} = 2\sin\left|\frac{\phi - \hat{\phi}}{2}\right|$