Çankaya University – ECE Department – ECE 376

2013 Spring Term **March 2013**

Experiment 5 : Multidimensional Signals – ASK, PSK, QAM

Experiment coded in MATLAB is given on course webpage.

1. Download the model file named MultidimSig_Exp5.mdl.
2. This experiment is in the form of model file and intended to show you signal constellations ASK, PSK and QAM and get the signal time waveforms, basis functions from there.
3. A sample calculation for QAM at M = 8 is shown below.
4. Repeat the same for all modulation types at M = 4, 8 and 16.
5. Plot all relevant waveforms, graphs in your lab notebook.
6. Include your general comments

Sample calculation for QAM at M = 8.

The modulators will accept user set Mary input or random Mary input. At the moment ASK modulator is connected to user defined Mary block, while the other modulators are connected to random Mary generator. Modulator blocks will supply the signal vectors $\mathbf{s}_1 \cdots \mathbf{s}_M$ outputs in complex notation, as given by (3.7) of "ECE376_ Dimensionality of Signals_ASK_PSK_QAM_FSK_Jan 2013_HTE". This is also valid for ASK, but since ASK is one dimensional signal vectors for ASK is real. Signal vector outputs $\mathbf{s}_1 \cdots \mathbf{s}_M$ outputs are printed in workspace by typing sQAM for instance.

Presently, the settings are for M = 8 and the stoptime is set to 7, so when we run the model file MultidimSig_Exp5.mdl, we get exactly 8 Mary signals and 8 $\mathbf{s}_m$ signal vector. Note that M ary levels are arranged as $0 \cdots M-1$, while our signal vectors are numbered as $\mathbf{s}_1 \cdots \mathbf{s}_M$.

Now type on workspace (Command Window)

- sQAM (1:4).', we get for instance (limited to the first four signal vectors)
- -0.4082 - 0.4082i -0.4082 + 0.4082i -1.2247 + 0.4082i -1.2247 - 0.4082i.

To see what M ary levels created these $\mathbf{s}_m$ signal vectors, type

- sMaryQAM (1:4), we get for instance (again limited the first four signal vectors)
- 3 2 0 1

This means that 3 + 1 , so the first signal is, $\mathbf{s}_4$ and placed on the QAM constellation diagram as shown below in Fig. 1. Note that we obtain the position of $\mathbf{s}_4$ by double clicking on "Rectangular QAM Modulator Baseband", then clicking on "View Constellation" button. It is possible to confirm that the average energy in this 8 QAM is 1 Joule, by squaring summing the lengths of all signal vectors $\mathbf{s}_1 \cdots \mathbf{s}_8$ and dividing the result by 8 (test this by connecting Signal From Workspace block to the input of Rectangular QAM Modulator Baseband and running the model file and then typing on the workspace sum(abs(sQAM).^2)/8). From Fig. 1, in the notation of ECE376_ Dimensionality of Signals_ASK_PSK_QAM_FSK_Jan 2013_HTE", $\mathbf{s}_4$, $s_4(t)$ and the related $\psi_1(t)$ and $\psi_2(t)$ can be obtained as follows

$$\mathbf{s}_4 = [-0.4082,\ -0.4082]\ ,\ \psi_1(t) = \begin{cases} \sqrt{2} & 0 \le t \le 0.5 \\ 0 & \text{otherwise} \end{cases}\ ,\ \psi_2(t) = \begin{cases} \sqrt{2} & 0.5 \le t \le 1 \\ 0 & \text{otherwise} \end{cases}$$

$$s_4(t) = -0.4082\psi_1(t) - 0.4082\psi_2(t)\ ,\ s_4(t) = \begin{cases} -0.5773 & 0 \le t \le 1 \\ 0 & \text{otherwise} \end{cases}\ ,\ \varepsilon_{s_4} = 1/3 \qquad (1)$$

The corresponding plots of $s_4(t)$ and $\psi_1(t),\ \psi_2(t)$ are in Fig. 2.

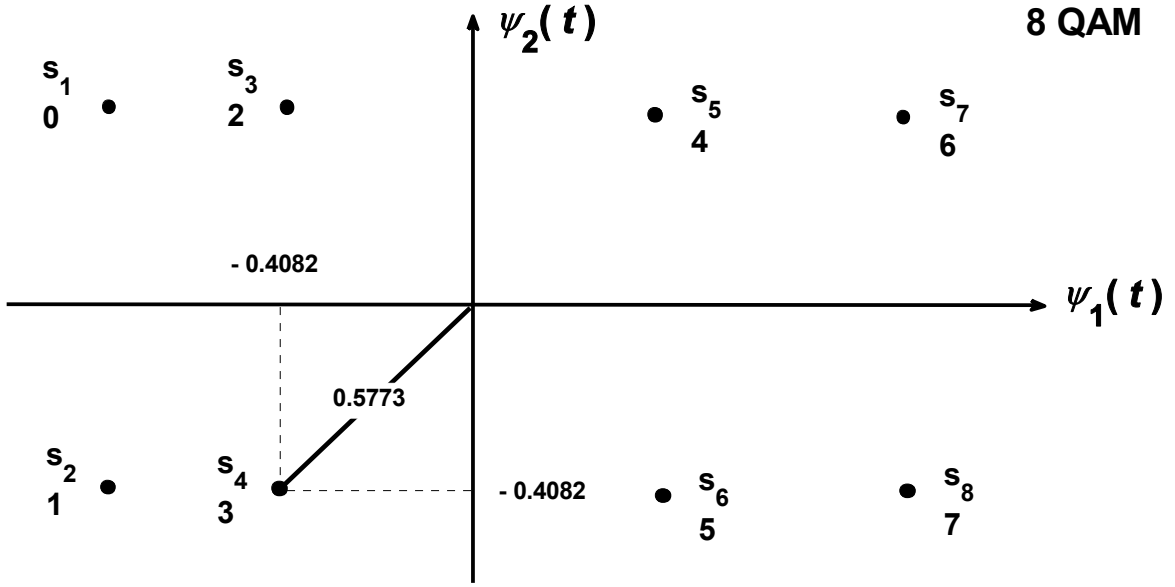

Fig. 1 8 QAM constellation given by Matlab.

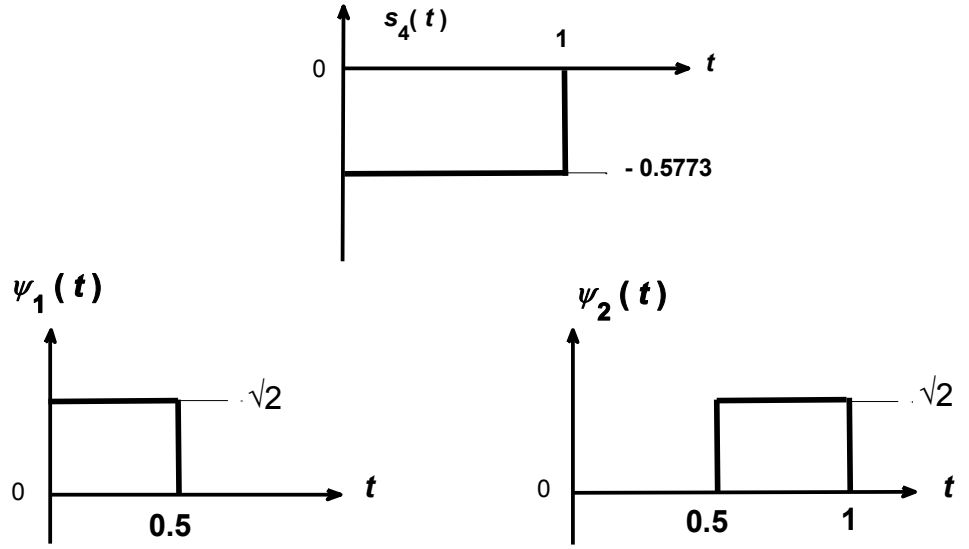

Fig 2. Plots of $s_4(t)$ and $\psi_1(t),\ \psi_2(t)$ for 8 QAM of Matlab.