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Digital Communications

Lab Session I

November 5th, 2008

1 Digital Transceiver for 16-QAM Modulation

The goal of this lab session is to investigate digital tranmitters and receivers for 16-QAM signals used for example in the WiMAX, HSDPA and 3GPP-LTE systems. You are to hand-in a report answering all the questions outlined in the associated MATLAB files and provide the required figures. If you do not finish in the supervised period of the session, you can continue to work on the exercise this week and hand in your report next week.

1.1 QAM Digital Modulator

Here we are concerned with complex baseband equivalent transmit signals of the form

$$\tilde{s}(t) = \sum_i a_k \psi(t - kT)$$

where $a_k \in \mathcal{S}$ and $\psi(t)$ is some bandlimiting pulse-shape. S will be a QAM alphabet as shown in Figure 1. We will concern ourselves with a digital representation of such signals, that is

$$\tilde{s}(n) = \sum_i a_k \psi(n - Mk), \tag{1}$$

where M is the oversampling factor, or equivalently the number of samples per symbol period T. The oversampling factor is arbitrary, but is usually dictated by technological constraints, and is typically ≥ 2. The real transmitted signal before D/A conversion is assumed to be of the form

$$s(n) = \mathrm{Re}\left(\tilde{s}(n) e^{2\pi j f_{\mathrm{IF}} n}\right)$$

where f_{IF} is some digital intermediate frequency. The signals are transmitted across dispersive channels ($h(n)$) and subject to additive noise at the receiver ($z(n)$), namely

$$r(n) = s(n) * h(n) + z(n) \tag{2}$$

These are shown in Figures 2 and 3.

1.2 Digital Receivers

We will consider two receiver structures as shown in Figures **??** and **??**. Build both receivers in MATLAB/OCTAVE and answer the corresponding questions in the supplied files.

2 MATLAB Files

The supplied MATLAB/OCTAVE files are

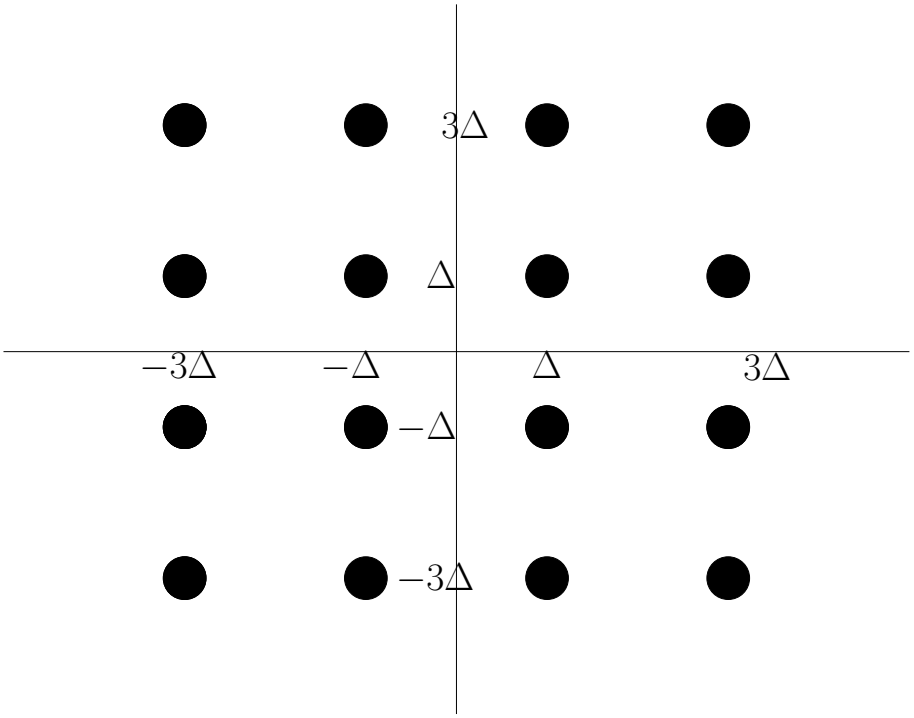

Figure 1: 16-QAM Modulation

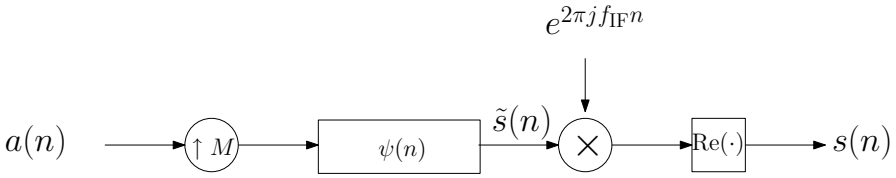

Figure 2: Transmitter

1. `TP1_top.m` - The top-level file. Answer all questions and provide the required figures mentioned here. You are to hand in this file! Note that most of the explanations are embedded in the file.
2. `channel.m` - generates a multipath radio channel
3. `rraised_cosine.m` - generates a root-raised cosine pulse shape (truncated) - this is the $\psi(n)$.
4. `QAM_MOD.m` - generates a frame of QAM (4,6, or 256) symbols

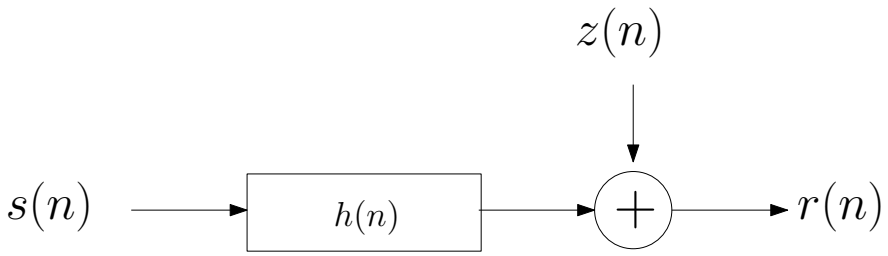

Figure 3: Channel

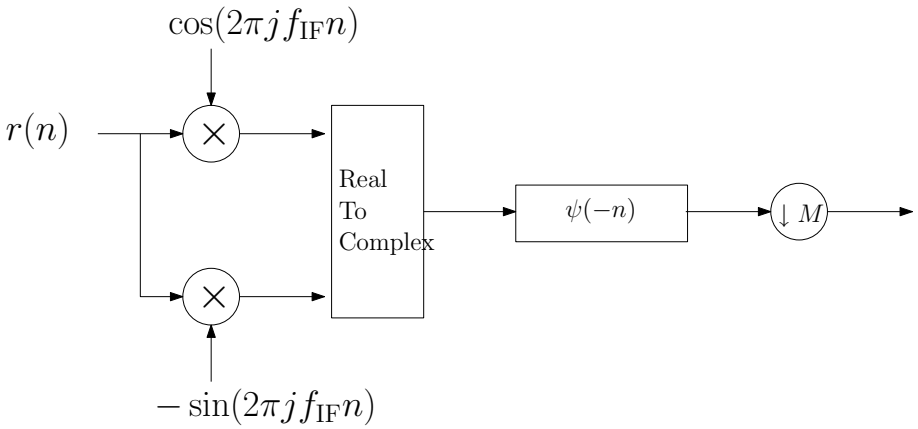

Figure 4: Receiver 0 (Direct Quadrature Downconversion)

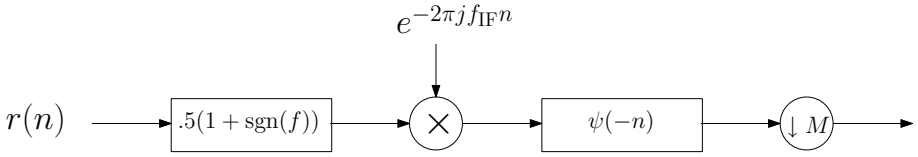

Figure 5: Receiver 1 (Hilbert filter)