Digital symbol

Technology, Development

If M1= 2k1 and M2 == 2k2 , the combined amplitude and phase-modulation method results in the simultaneous transmission of k1 + k2 = log2M1M2 binary digits occurring at a symbol rate Rb=(k1+ k2). Figure 1. 3 shows the functional block diagram of a QAM modulator [3]. It is clear that the geometric signal representation of the signals give by 1. 3 and 1. 4 is in terms of two-dimension signal vectors of the form Si= (EsA0i , EsAsi) m= 1, 2,.... , M There are many types of signal space constellations. Figure 1. 4 shows th samples of rectangular and circular signal space constellations [3].

1. 2 Noise in Communications Noise in communications can cause distortion of the transmitted signal. There are a variety of noise sources, such as galaxy noise, terrestrial noise amplifier noise, and unwanted signals from other sources [4]. An unavoidable cause of noise is the thermal motion of electrons in any conducting media. This motion produces thermal noise in amplifiers and circuits which corrupt the signal in an additive fashion; that is, the received signal, r(t), is the sum of the transmitted signal, s(t), and the thermal noise, n(t).

The statistics o thermal noise have been developed using quantum mechanics and are well known [1]. Figure 1. 4: (a) Rectangular and (b), (c) Circular QAM Signal Constellation The main statistical characteristic of thermal noise is that the noise amplitudes . are distributed according to a normal or Gaussian distribution. The, probability density function (pdf), p(n.), of the zero-mean noise voltage is shown as (1. 6) Where ? 2 is the noise variance. We will often represent a random signal as the sum of a Gaussian noise random variable and a dc signal: z = a + n (1. 7)

Where z is the random signal, a. is the de component, and n is the Gatissian noise random variable. The pdf, p(z) is shown as (1. 8) Where ? 2 is the noise variance of n. The primal, spectral characteristic of thermal noise is that its power spectral density is the same for all frequencies of interest in most communication systems. Therefore, a simple model for thermal noise assumes that its power spectral density Gn(f) is flat for all frequencies, as shown in Figure 1. 5 [4], and is denoted as follows: watts/hertz Where the factor of 2 is included to indicate that Gn(f) is a two-sided power spectral density.

When the noise power has such a reform spectral density, we refer to it as white noise. The adjective " white" means that white light contains equal amounts of all frequencies within the visible band of electromagnetic radiation. Figure 1. 5: (a) Power spectral density of white noise (b) Autocorrelation function of white noise From the characteristics of white noise, any two different samples of a White noise process are uncorrelated. Since thermal noise is a Gaussian process and the samples are uncorrelated, the noise samples are also independent [2].

Therefore, the effect on the detection process of a channel with additive white Caussian noise (AWGN) is that the noise affects each transmitted symbol independently. The term " additive" means that it is simply superimposed or added to the signal [4]. Since thermal noise is present in all communication systems and is the prominent noise source for most systems, the thermal noise characteristics, additive, white and Gaussian, are most often used to model the noise in communication systems. 1. 3 Demodulation and Detection The received signal is transmitted over the channel.

We assume that the transmitted signal is transmitted by Additive white Gaussian Noise (AWGN). In addition, we assume that a carrier-phase offset is introduced in the transmission of the signal through the channel. Therefore the received signal, r(t), may be expressed as r(t) = A0ig(t)cos(2? f0t + ?) + Asig(t), sin(2? f0t + ?) + n(t) (1. 10) Where, n (t) is the AWGN signal, and ? is the carrier phase offset. We express the simple AWGN channel model in Figure 1. 6. In addition, the AWGN, n (t) can be expressed as follows. In this section we consider the performance of QAM systems that employ rectangular signal constellations.

Rectangular QAM signal constellations have the distinct advantage of being easily generated as two PAM signals improved on phase quadrature carriers. In addition, they axe easily demodulated. For rectangular signal constellations in which M = 2k, where k is even, the QAM signal constellation is equivalent to two PAM signals on quadrature carriers, each having signal points. Because the signals in the phase quadrature components are perfectly separated by coherent detection, the probability of error for QAM is easily determined from the probability of error for PAM.

Specifically, the probability of a correct decision for the M-ary QAM system is [3] Where is the probability of error of a PAM average power in each quadrature signal of the equivalent QAM system, By appropriately modifying the probability of error for M-ary PAM, we obtain: (1. 17) Where is the average SNR per symbol [3]. Thus, the probability of a symbol error for the

M-ary QAM can be expressed as [3]. (1. 18) We note that this result is exact for M= 2k when k is even. Otherwise, when k is odd, there is no equivalent. -ary PAM system.

This is no problem, however, because it is quite easy to determine the error rate for a rectangular signal set. If we employ the optimum detector that base. -, its decisions on the optimum distance metrics given by Equation 1. 15, it relatively straightforward to show that the, symbol-error probability is tightly tipper-bound as (1. 19) , for any k > 1, where is the average, SNR per bit [3]. The probability of a symbol error is plotted in Figure 1. 8 as a function of the average SNR per bit. Figure 1. 8 : Proobability of a symbol error for QAM [3] Chapter 2 Implementation

In this chapter, we discuss about the implementation methods of the 16-QAM communication system. The following section describes %n implementation of simulation method. 2. 1 Simulation of the 16-QAM Communication System Our simulator of the 16-QAM communication system is described as follows. First, we create the source information using the random member generator (RNG). Then the signal constellation space is created and the source data is mapped into the signal constellation to produce the QAM signal to be transmitted over the signal channel. In addition, we generate the 4-AWGN channel over which the source signal is to be transmitted.

At the receiver side, we receive the corrupted signal and compute the distance between the received signal and the transmitted signal using the characteristic, of signal space. After the simulator completes the minimum distance between the received signal and the transmitted signal, it makes a decision from which the source signal is transmitted. If the received signal is not the same as the transmitted signal, we accumulate the number of errors. Finally, we calculate the probability of error from the total number of errors over the number of samples.