Chapters 9.3-9

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Modulation Schemes not Requiring Coherent References

- In this section, now we consider two modulation schemes that you do not need to require the acquisition of a local reference signal in phase coherence with the received carrier.

Differential Phase-Shift Keying (DPSK)

- The implementation of a such a scheme presupposes two things;
  1. The unknown phase perturbation on the signal varies slowly that the phase is constant from one signalling interval to next.
  2. The phase during a given signalling interval bears a known relationship to the phase during the preceding signalling interval bears a known relationship to the phase during the preceding signalling interval.

Table 9.3 Differential Encoding Example

Message sequence:		1	0	0	1	1	1	0	0	0
Encoded sequence:	1	1	0	1	1	1	1	0	1	0
Reference digit:	↑									
Transmitted phase:	0	0	π	0	0	0	0	π	0	π

Differential Encoding Message Sequence

- An arbitrary reference binary digit is being selected as an initial digit of the sequence
- For each digit , the present digit used as a reference
- 0 in the message sequence is encoded as a transition from state of reference digit to the opposite state in the encoded message sequence
- 1 encoded as no change of state

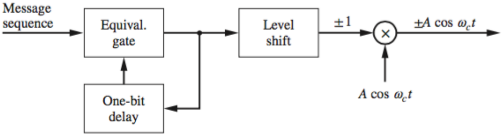
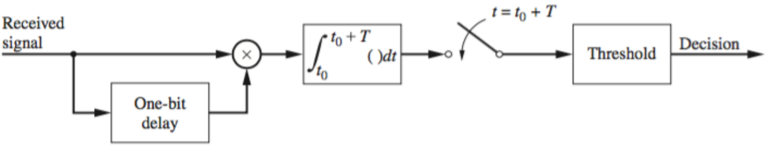


Figure 9.16
Block diagram of a DPSK modulator.

Figure for Differential Encoding Message Sequence

Table 9.4 Truth Table for the Equivalence Operation

Input 1 (Message)	Input 2 (Reference)	Output
0	0	1
0	1	0
1	0	0
1	1	1



Differential Encoding Message Sequence

- After the reference bit and plus the first encoded bit, signal input become $S_1 = A\cos(\omega_c)t$ and $R_1 = A * cos(w_c) * t$
- Than the output correlator is; $v_1 = \int_0^T A^2\cos^2(\omega_c t)dt$ which eventually become $\frac{1}{2}A^2T$
- The optimum detector for binary will become $l = x_k x_k - 1 + y_k y_k - 1$
- Without a loss of of generality, we can choose $\theta = 0$; we found outputs at $t = 0$ to be:
  - $x_0 = \frac{AT}{2} + n_1$ and $y_0 = n_3$ and where $n_1 = \int_{-T}^{0} n(t)\cos^2(\omega_c t)dt$
  - $n_3 = \int_{-T}^{0} n(t)\sin^2(\omega_c t)dt$. Similarly, at the time $t = T$, the outputs are ; $x_1 = \frac{AT}{2} + n_2$ and $y_1 = n_4$
  - $n_2 = \int_0^T n(t)\cos^2(\omega_c t)dt$
  - $n_4 = \int_0^T n(t)\sin^2(\omega_c t)dt$

Important Figure for Differential Encoding

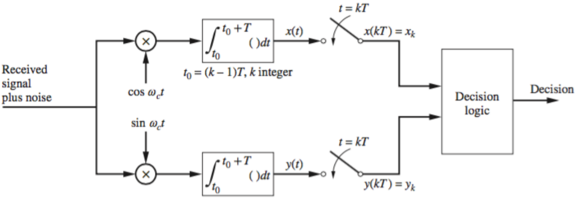


Figure 9.18
Optimum receiver for binary differential phase-shift keying.

If $\ell > 0$, the receiver chooses the signal sequence

$$s_1(t) = \begin{cases} A\cos(\omega_c t + \theta), & -T \le t < 0 \\ A\cos(\omega_c t + \theta), & 0 \le t < T \end{cases} \tag{9.95}$$

as having been sent. If $\ell < 0$, the receiver chooses the signal sequence

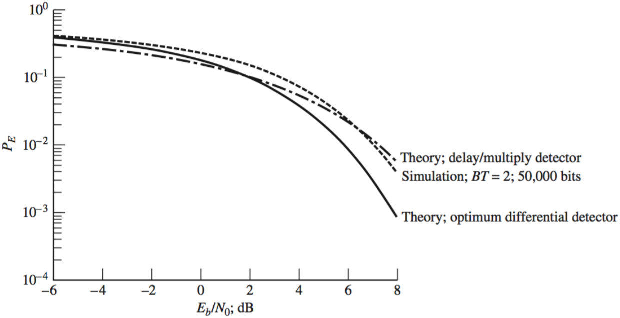
$$s_2(t) = \begin{cases} A\cos(\omega_c t + \theta), & -T \le t < 0 \\ -A\cos(\omega_c t + \theta), & 0 \le t < T \end{cases} \tag{9.96}$$

- It follows as $n_1, n_2, n_3 and n_4$ are uncorrelated and zero-mean Gaussian random variables with variances $\frac{N_0 T}{4}$ and they are independent.
- Expression for Probability error
  $P_E = Pr[(\frac{AT}{2} + n_1)(\frac{AT}{2} + n_2) + n_3 n_4 < 0]$
- We can define new gaussian random variables such as:

$$\omega_1 = \frac{n_1}{2} + \frac{n_2}{2}$$
$$\omega_2 = \frac{n_1}{2} - \frac{n_2}{2}$$
$$\omega_3 = \frac{n_3}{2} + \frac{n_4}{2}$$
$$\omega_4 = \frac{n_3}{2} - \frac{n_4}{2}$$

- Probability can be written in terms of Gaussian variables: $P_E = Pr[(\frac{AT}{2} + \omega_1)^2 + (\omega_3)^2 < (\omega_2^2 + \omega_4^2)]$
- Gaussian variables will also let us define the Ricean random variables. Ricean random variable will become: $R_1 = \sqrt{(\frac{AT}{2} + \omega_1)^2 + \omega_3^2}$
- Also Rayleigh random variable will become $R_2 = \sqrt{\frac{\omega_2^2}{\omega_4^2}}$
- If we also define the bit energy E_b as $A^2 \frac{A^2 T}{2}$ will give; $P_E = \frac{1}{2} e^{(\frac{-E_b}{N_0}}$ for the optimum DPSK receiver.
- At the large values $\frac{-E_b}{N_0}$ values of ; $P_E = Q[\sqrt{\frac{-E_b}{N_0}}] = Q[\sqrt{z}]$

- Following result obtained by using the asymptotic approximation; $P_E = \dfrac{e^{(-E_b/N_0)}}{2\sqrt{\pi \frac{E_b}{N_0}}}$



Comparison of Digital Modulation Systems

- Bit error probabilities are compared in Figure 9.22 for the modulation schemes that considered in this chapter. Note that the curve for antipodal binary PAM is identical to BPSK
- Also bit error probability of antipodal PAM becomes worse the larger M. Curves move more to the right as M gets larger

Important figure for Chapter 9

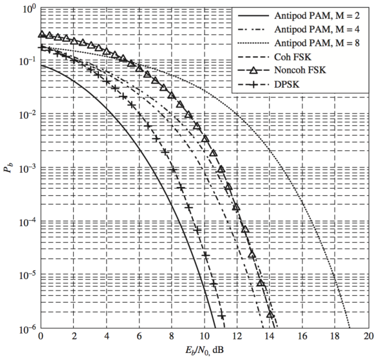


Figure 9.22
Error probabilities for several binary digital signaling schemes.

- Non-coherent binary FSK and PAM with M=4 have almost identical performance at large signal-to-noise ratios.
- In addition to cost and complexity implementation, there are many other considerations in choosing one type of digital data system over another.
- Some channels, where the channel gain, phase or when both are in effect,we use a noncoherent system may be dictated because of impossibility of establishing a coherent reference at the receiver under such conditions. They will be referred as "fading".

Multipath Interference

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Equalization

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Equalization by Zero Forcing

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Equalization by Minimum Mean-Squared Error

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Tap Weight Ajustment (LMS Algorithm)

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