University of Mumbai

Program: Electronics and Telecommunication Engineering

Curriculum Scheme: Rev2019

Examination: TE Semester V

Course Code: ECC-501 and Course Name: Digital Communication

Time: 2 hour 30 minutes | Max. Marks: 80

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Q1. Choose the correct option for following questions. All the Questions are compulsory and carry equal marks

Question Number	Correct Option (Enter either 'A' or 'B' or 'C' or 'D')
Q1.	**A**
Q2.	**D**
Q3.	**A**
Q4	**C**
Q5	**D**
Q6	**A**
Q7	**A**
Q8.	**B**
Q9.	**B**
Q10.	**A**

Q.2

A. Explain with suitable diagram and equations Integrate and Dump Filter in the receiver section. Also explain the probability of error for Integrate and Dump receiver

Expected Solution:

The integrate and dump filter is a coherent or synchronous receiver that requires a local carrier reference signal having the same frequency and phase as the transmitted carrier signal.

- An integrate-and-dump filter, also known as correlation receiver, is a form of the optimum filter, which is different from the matched filter implementation.

• Additional circuitry is required at the receiver to generate the coherent local carrier reference signal.

• In a correlation receiver, it is required that the integration operation should be ideal with zero initial conditions.

• In practical implementation of the correlation receiver, the integrator has to be reset.

• That means the capacitor has to be discharged or dumped (hence the name integrates and dump filter) at the end of each signaling interval in order to avoid ISI.

• The bandwidth of the filter preceding the integrator is assumed to be wide enough to pass the received signal accompanied with white Gaussian noise without any distortion.

Yes. It can be used to implement the matched filter for a rectangular pulse input signal. The integrator computes the area under the rectangular pulse. The output is then sampled at t = T (duration of the pulse). The integrator is restored back to its initial condition immediately.

• It is essential that the time constant of the integrate-and-dump filter circuit must be very much greater than the pulse width.

• Under this condition, the practical circuit of the integrate and dump correlation receiver will

approximate quite close to an ideal integrator.

• It will also operate as an ideal receiver with the same probability of error.

• The correlation receiver performs coherent detection by using the local reference signal which is

inphase with the input received signal component.

• Therefore, the sampling and discharging of the capacitor (dumping action) must be carefully

synchronized.

Q.2 B. **Explain with suitable diagram the concept of Eye Diagram.**

Expected Solution:

An eye pattern, also known as an eye diagram, is a practical technique for determining

the effects of the degradations introduced by intersymbol interference into the digital pulses as the

signals travel through the channel to the receiver.

• An eye pattern is a simple and convenient tool for studying the effects of ISI and another channel

impairments in digital transmission.

• An eye pattern provides information about the state of the channel and the quality of the incoming pulse.

• This information is useful for the detection of digital input signal.

An analog oscilloscope is generally used to plot an eye diagram on its display.

• The received pulse input which may be dispersed in time due to channel noise and ISI, is given to the vertical input of the oscilloscope.

• A sawtooth type time base generator is provided to its horizontal input.It has same time period as incoming data, that is, sweep rate is nearly same as the symbol rate.

• The symbol clock is applied to the external trigger input.

• At the end of the fixed time interval, the signal is wrapped around to the beginning of the time axis.

• Thus, an eye diagram consists of many overlapping curves.

An eye diagram is used for finding the best decision point where the eye is most widely opened.

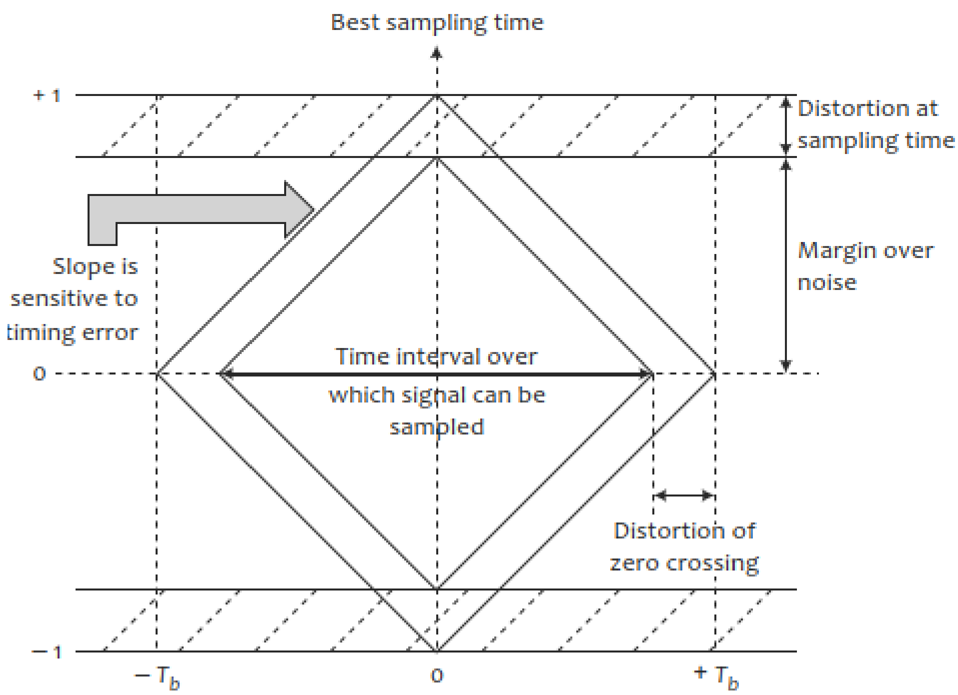
• When the received bit pattern is ideal (free of any errors), the oscilloscope display will show two

vertical lines across its display.

• If the bit sequence is slightly distorted, the oscilloscope display shows the pattern which is very

similar to the human eye, the central portion of the pattern representing the opening of the eye.

• If the received digital signal is further distorted, the eye appears to have closed.



The vertical lines labeled as +1, 0, and – 1 correspond to the ideal received amplitude levels.

• The horizontal lines, separated by the signaling interval, Tb, correspond to the ideal decision times.

• The eye opening is the area in the middle of the eye pattern. As intersymbol interference increases, the eye opening reduces. If the eye is closed completely, it is next to impossible to avoid errors. The effect of pulse degradation is a reduction in the size of the ideal eye.

Q.3 B **MSK is called shaped 'Shaped QPSK'. Justify with relevant expression as waveforms. Discuss the merits and demerits of MSK as compared to QPSK.**

Expected Solution:

MSK is a special case of binary continuous phase FSK modulation technique in which the change in carrier frequency from symbol 0 to symbol 1 or vice versa is exactly equal to one-half the bit rate of input data signal.

As a form of FSK, the MSK signal is given by the expression

$$V_{MSK}(t) = \begin{Bmatrix} \sqrt{\frac{2E_b}{T_b}} \cos\left[2\pi f_1 t + \theta(0)\right] & \text{for binary 1} \\ \sqrt{\frac{2E_b}{T_b}} \cos\left[2\pi f_2 t + \theta(0)\right] & \text{for binary 0} \end{Bmatrix}$$

where Eb is the transmitted signal energy per bit, Tb is the bit duration, the phase q(0) denotes the value of

the phase at time t = 0.

The two frequencies f1 and f2 satisfy the following equations:

$$f_1 = f_c + \frac{1}{4T_b}; \text{ and } f_2 = f_c - \frac{1}{4T_b}$$

In MSK, the spacing between f1 and f2 is minimum that can be used and allow successful

detection of the received signal at the receiver. That is why it is called minimum shift keying digital modulation technique.

When MSK is viewed as a special case of OQPSK, the carrier signal is multiplied by a sinusoidal function. Mathematically, the MSK signal can be expressed as:

$$v_{MSK}(t) = I(t)\cos\left(\frac{\pi t}{2T_b}\right)(\cos(2\pi f_c t) + Q(t - T_b)\cos\left(\frac{\pi t}{2T_b}\right)\sin(2\pi f_c t)]$$

MSK is derived from OQPSK by replacing the rectangular pulse with a half-cycle sinusoidal pulse.

• The inphase and Quadrature signals are delayed by intervals Tb from each other.

• MSK has the following properties:

For a modulation bit rate of fb, the high frequency, f1 = fc + (0.25fb) when binary level is high (1), and the low frequency, f2 = fc + (0.25fb) when binary level is low (0).

The difference frequency, fd = f1 – f2 = 0.5 fb, or 1/(2Tb), where Tb is the bit interval of NRZ

signal. The MSK signal has a constant envelope. MSK modulation makes the phase change linear and limited to ±p/2 over a bit interval Tb. This enables MSK technique to provide a significant improvement over QPSK.

Q,.3 B Derive the expression for error probability of a matched filter and justify that Pe does not depend on the shape of the input waveform

The matched filter is an optimum detector of a known pulse in the presence of additive white noise.

n order to enhance the detection of the pulse signal s(t), the design of the linear time-invariant filter is required to be optimized so as to minimize the effects of noise at the filter output in some statistical sense.

The resulting output signal of the linear filter may be expressed as y(t) = s0(t) + n0(t)

where s0(t) is the output signal component and n0(t) is the output noise component of the input signal x(t). The output peak pulse signal-to-noise ratio, z is defined as

$$\zeta = \frac{|s_0(T)|^2}{E\,[n_0^2(t)]}$$