Examination 2018

Question 1

- (a) Discuss the different types of pulse analogue modulation and compare their performance in the presence of additive white Gaussian noise.

Solution

- Pulse analogue modulation:

- PAM,
- PTM: PWM, and PPM.

- In PAM: change amplitude of pulses in sympathy with the amplitude of the modulating signal.

- Advantages: simplicity of modulation and demodulation and time division multiplexing
- Disadvantage: susceptibility to noise.

PWM: the width of the pulses is varied in sympathy with the amplitude of the modulating signal.

Advantage: amplitude of the pulse does not carry information; less affected by noise can use limiting circuit.

Disadvantage: pulses take more time on the time axis, which makes time multiplexing difficult.

Synchronisation: derived from pulse edges to convert the width into amplitude which enables the use of PAM detector.

- PPM: position of the pulses carries the information
- Advantage: power advantage over PWM and noise performance over PAM

- Disadvantage: start information of the pulses is lost requires a synchronisation circuit at the receiver.

- PWM and PPM: demodulated using an integrator, that converts PTM pulses into PAM.

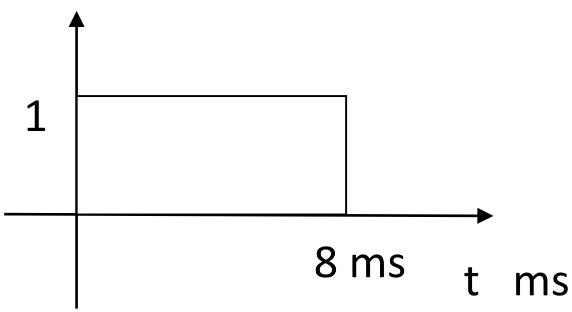
- Noise: PAM is less tolerant to additive noise than PWM or PPM.

- In PTM: if noise is of the same magnitude as the pulses it rapidly engulfs the signal threshold.

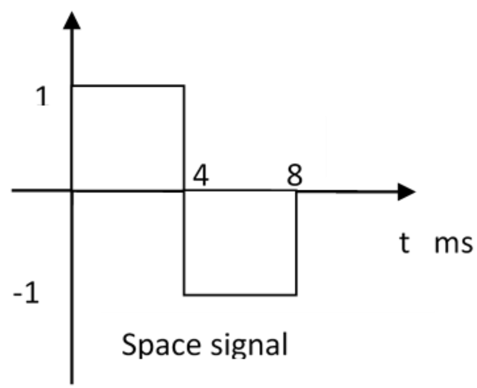
- Vertical edges cannot be transmitted since channels tend to be band-limited, hence PTM is also affected by noise.

Question 1.c

Binary information is transmitted using baseband signals of the form shown in Figure Q.1. Design a correlation detector and find the probability of bit error assuming that the additive white Gaussian noise has a single sided power density equal to 1×10^{-3} watts/Hz.

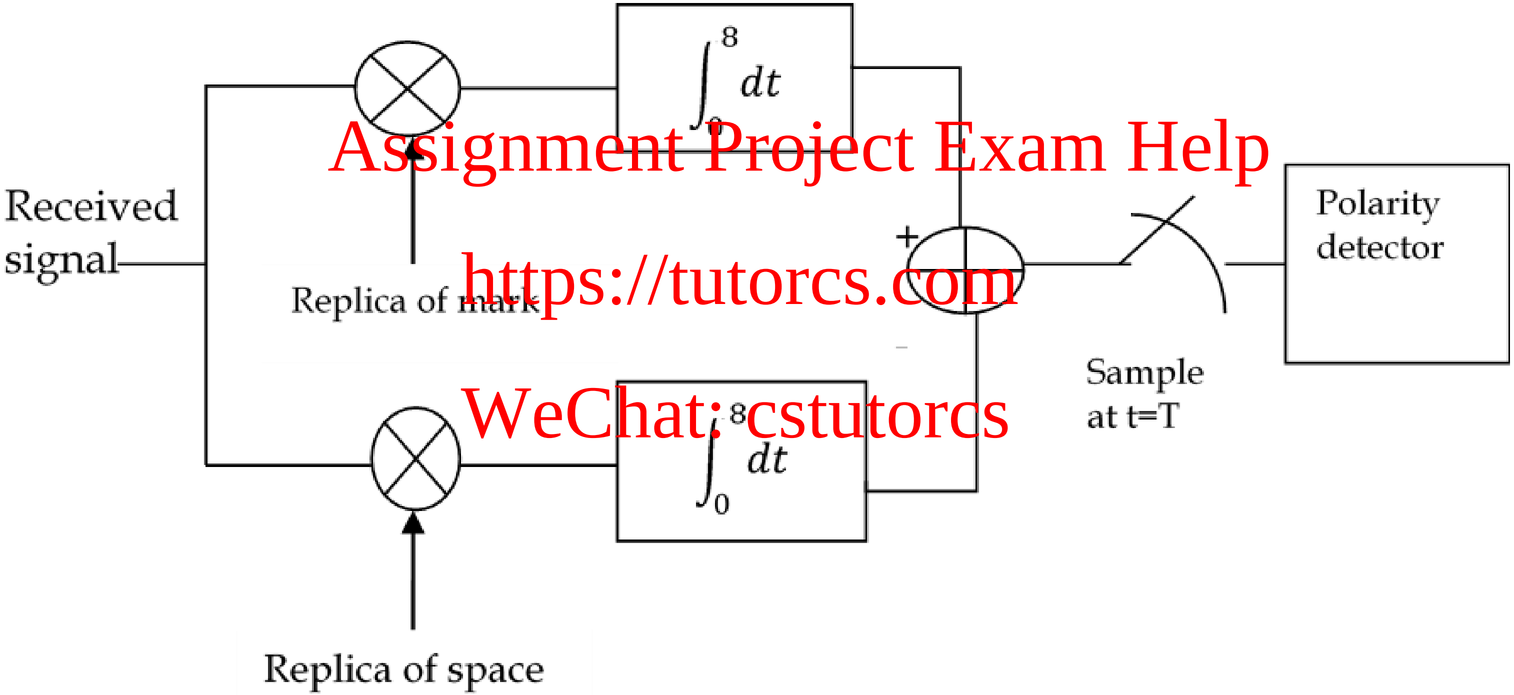


Mark signal



Space signal

Solution


Received signal
Replica of mark
Replica of space
$\int_0^8 dt$
$\int_0^8 dt$
+
−
Sample at t=T
Polarity detector

Solution Cont.

- Bit error rate is found using the following equation

$$P_e = \frac{1}{2} erfc \sqrt{\frac{E(1-\rho)}{2N_o}}$$

- To evaluate the above we need the correlation coefficient.

$$\rho = \frac{\int_0^8 s_{mark}(t) s_{space}(t) dt}{\sqrt{\int_0^8 s(t)^2_{mark} dt \ \int_0^8 s(t)^2_{space} dt}}$$

- Evaluating the above integral for the given waveforms gives 0.

- We also need to evaluate the energy per bit

The energy is equal to $V^2T = 8x10^{-3}$ Joules

$$P_e = \frac{1}{2} erfc \sqrt{\frac{8X10^{-3}(1-0)}{2X1X10^{-3}}}$$

= 1/2 (erfc(2))

Using the given table gives $2.3x10^{-3}$

Question 2.a

Discuss the three basic forms of bandpass digital modulation methods: ASK, PSK, FSK.

Solution

Digital data modulation:

Modulate a carrier: amplitude (ASK), 1 transmit the carrier 0 no transmission.

Frequency (FSK) two different frequencies: 1 and 0

Phase (PSK): two different phases e.g.
transmission of 1: carrier with zero phase
transmission of 0: carrier with 180 phase.

Question 2.b

- Discuss the synchronisation requirements for the coherent detector for FSK, showing how these requirements can be achieved.

Solution

Coherent detection of FSK:

multiply with a local replica followed by an integrator and a polarity detector to compare the output between the mark and space correlators.

Requirements:

1. the local replica is synchronized with the received signal in phase and frequency,
2. sampling of the polarity detector is synchronized to the bit duration to sample the peak of the detector output

Q.2.c (i) Explain the diffraction mechanism of propagation

Diffraction occurs when LOS is obstructed by a dense body with large dimensions compared to the wavelength or by a surface with large irregularities.

Secondary waves behind the obstructing body (Huygens' principle).

Diffraction: shadowing

Hill tops and buildings are usual diffraction obstacles

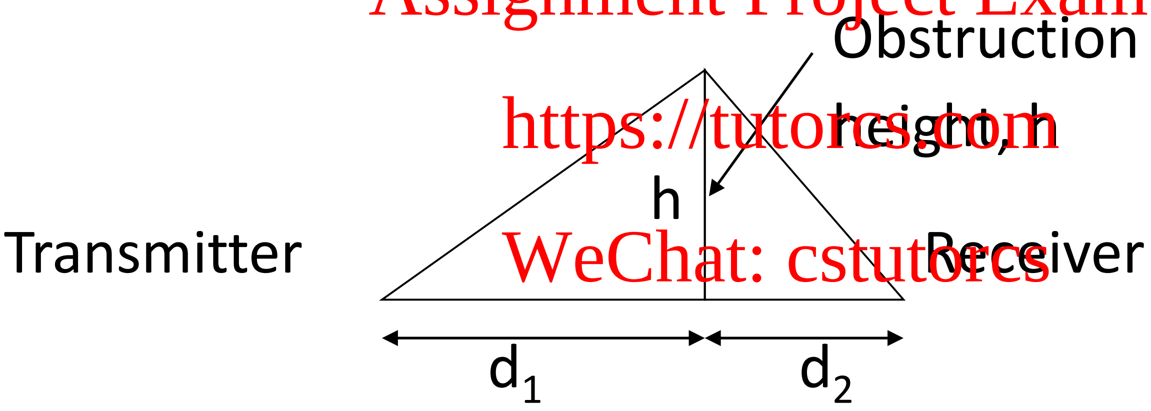
Question 2.c (ii)

For the geometry of Figure Q.2.a show that the excess phase $\Delta\phi$,, caused by the obstruction, with respect to the line of sight can be written in terms of the Fresnel-Kirchhoff diffraction parameter, ν, which is equal to

$$\nu = h\sqrt{\frac{2(d_1 + d_2)}{\lambda d_1 d_2}}$$

Question 2.c.(ii)

- Assume $h \ll d_1, d_2$.



Solution

- Considering the geometry of Figure Q.2.a, the difference in path length between the diffracted path and the LOS path ($d=d_1+d_2$) can be found as follows:

$$\Delta R = \sqrt{h^2 + d_1^2} + \sqrt{h^2 + d_2^2} - d$$

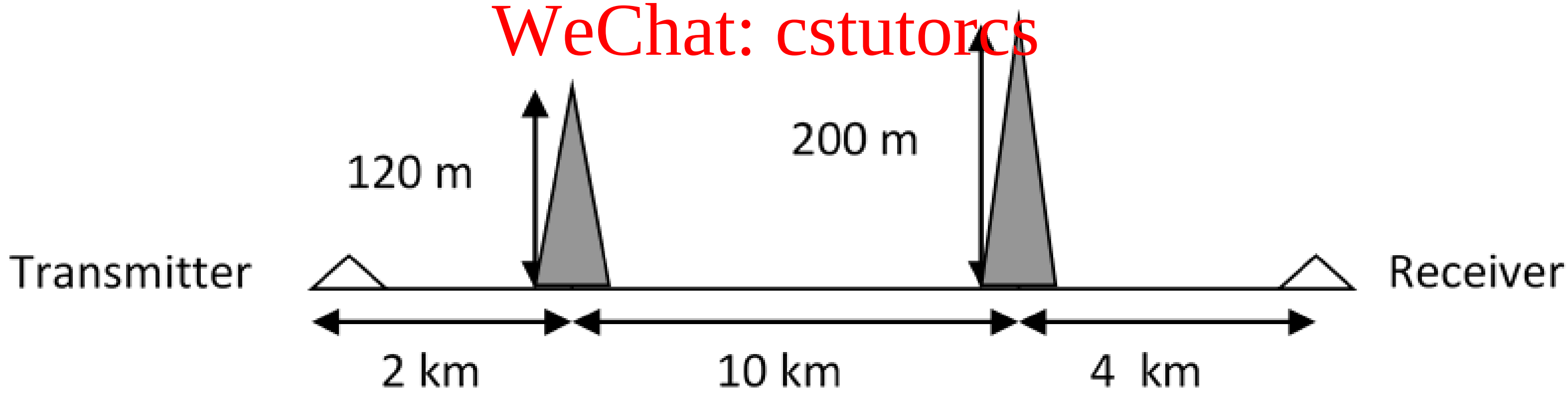
- Assuming that $h \ll d_1, d_2$, the above equation can be simplified to

$$\Delta R \cong \frac{1}{2} h^2 \left(\frac{d_1 + d_2}{d_1 d_2} \right)$$

The range difference can be converted to a phase difference i.e.

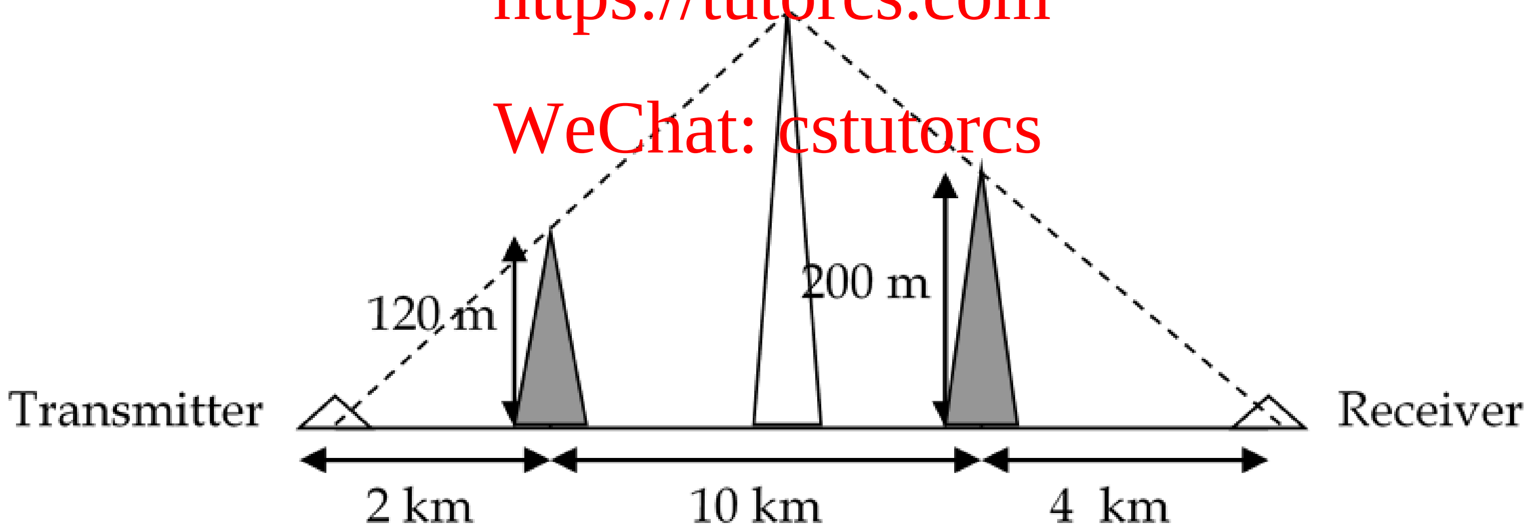
$$\Delta \phi = \frac{2\pi \Delta R}{\lambda} \qquad \Delta \phi = \frac{2\pi \Delta R}{\lambda} = \frac{\pi}{2} \nu^2$$

- For the geometry of Figure Q.2.b compute the diffraction loss coefficient ν, using the Bullington method for a 900 MHz carrier frequency.



Solution

draw the dashed lines to identify the height, h of the equivalent obstacle as per the Bullington method.



We can use the following

$$\frac{h}{0.2} = \frac{d_1}{4}, \frac{h}{0.120} = \frac{d_2}{2}$$

$$0.50 d_1 = 0.60 d_2, and\ d_1 + d_2 = 16\ km$$

$$\Delta R \cong \frac{1}{2} h^2 \left(\frac{d_1 + d_2}{d_1 d_2} \right) = \frac{1}{2} (0.06 d_2)^2 \left(\frac{16}{1.2 d_2^2} \right) = 0.0288$$

$$\Delta \phi = \frac{2\pi \Delta R}{\lambda} = \frac{\pi}{2} \nu^2$$

which gives a diffraction coefficient of 19.6 where the wavelength is computed to be equal to 33.3 cm.