Durham University - School of Engineering & Computing Sciences
Examination Answer Sheet 2016/2017 – Engineering Exams

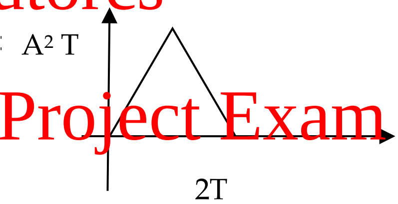
A

Exam ref: ENGI4121-WE01	Paper Title: Communications Systems		
Section:	Question:	Total marks for question:	Sheet 1 of 4
Question set by: Sana Salo		Answer checked and approved by:	

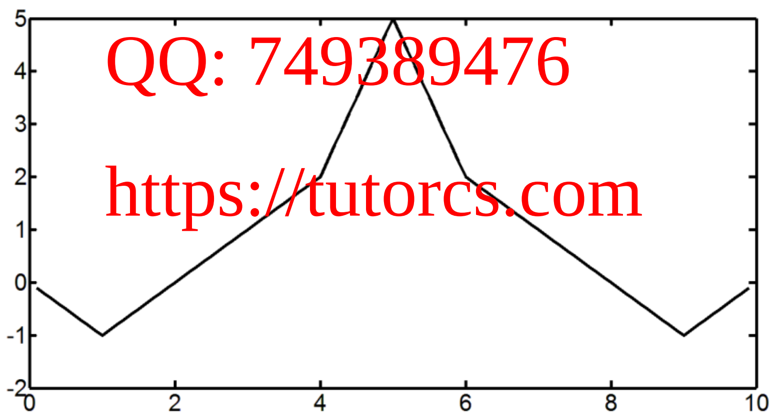
Q part	Answer	Mark allocated
Q.1 (a)	The matched filte[...]m f(t) is found by taking the convolution of f(t) with f(T-t) where [...] waveform.	

For the waveforms of bird and enemy jet, the output of the matched filter is a triangular waveform which extends over 2T with a maximum value equal to A^2T where A is equal to 1 and T=1 for the bird waveform and 5 for the enemy jet.

Matched filter output for the first two waveforms: bird and enemy jet

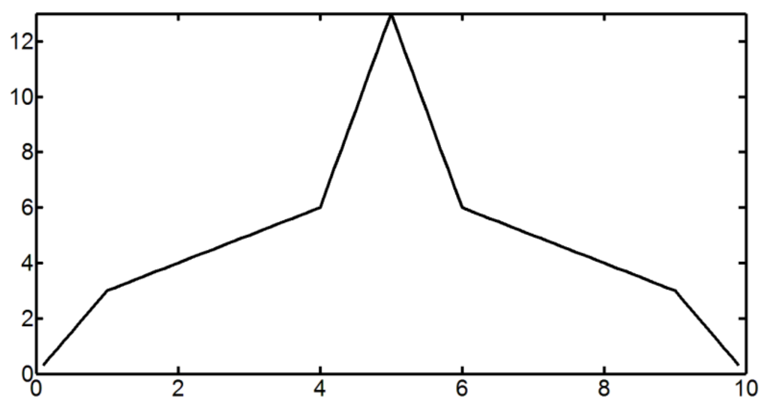


4%



8%

Matched filter output for a friendly jet



8%

Matched filter output for the commercial airline

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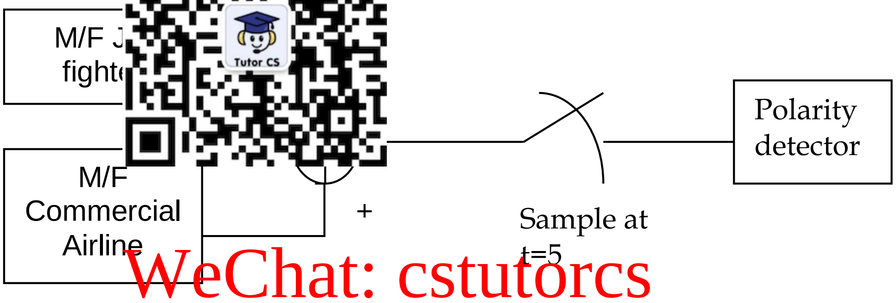
(b)



10%

(c)

For the detector to make an error corresponds to the probability of noise being greater than 5. This makes the output of the detector positive and the detector identifies a commercial airline. 10%

Using the pdf of the Gaussian noise with zero mean and variance of 2, this corresponds to the following integral

$$\text{The probability of error} = \int_5^\infty \frac{1}{\sqrt{4\pi}} \exp\frac{-(x)^2}{4}\,dx$$ 10%

Substituting for $t = \dfrac{x}{2}$

The probability of error reduces to $\dfrac{1}{\sqrt{\pi}}\displaystyle\int_{\frac{5}{2}}^{\infty} e^{-t^2}\,dt$ 12%

P_e =0.5 erfc(2.5) (The 0.5 appears since the complementary error function has 2 in the numerator) 8%

Using the values from the table, erfc(2.5)~ 0.0004 5%
Hence, the probability of error is 0.0002 i.e. 0.02%

(d)

(i)

The sampling rate is less than twice the maximum frequency, hence a component at 24 kHz-16 kHz = 8 kHz will appear at the output of the converter. 5%

This is usually avoided by using a low pass filter to ensure that the highest frequency component into the ADC is less than half the sampling frequency.

(ii)

The signal is sampled at 24 kHz i.e. there is a sample every 41.6 µsec. With eight bits per sample each bit will now occupy 5.2 µsec which corresponds to 192 kHz data rate for synchronous transmission. 10%

(iii)

For synchronous transmission, synchronisation requirements are for both bit identification and word identification where bit identification can be achieved through bit formatting such as using Manchester code, return to zero and bipolar transmission. Other techniques involve using highly stable oscillators at the transmitter and receiver to lock the clocks at both ends of the link or using an external reference such as GPS or MSF Rugby. 5%

The other requirement is to ensure word synchronisation. In parallel transmission this is achieved by connecting the bits directly but for serial transmission it is necessary to 5%

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identify the start … …rd. This can be achieved by transmitting a code word every so m… …e code word must satisfy certain requirements such as its auto-… …ould be distinct with a single peak and the synch word should hav… …ccurrence in the data stream. An example of such code is the …

Q.2 (a) (i) — 5%

Simplex transmission is one way transmission while duplex allows two way transmissions. Example of simplex transmission is paging where the receiver cannot communicate back. Telephony wired or wireless are forms of duplex operation.

(ii) — 10%

Frequency division multiplexing (FDM) is used to allocate different users different frequencies to transmit over the same transmission medium. Usually these frequencies are fixed and allocated for all time such as radio and TV transmission. FDMA is a form of frequency multiplexing where the user is allocated the frequency band when needed i.e. to access the network and then loses that frequency after use.

(iii) — 10%

CDMA is a form of multiple access technique to a radio network where each user is allocated different code. The codes of the different users are orthogonal to each other. Hence all users occupy the same bandwidth at the same time which results in a frequency reuse cell structure of one. This is the form of multiplexing used in 3G mobile radio networks.

(b) — 15%

In open loop power control the mobile adjusts its transmitted power on the basis of the received signal strength. Whereas in closed loop power control, the base station sends a control signal to the mobile to adjust its output power. The problem in the open loop method is that in frequency division duplex transmission due to the frequency selectivity of the radio channel the mobile is adjusting its output power level on the basis of the received signal at a different frequency. Hence it can result in transmitting the wrong signal level. In closed loop the base station measures the received signal strength at the correct frequency and instructs the mobile to adjust its output accordingly. This method can result in a delay and if the base station is using the received signal strength as a function of interference it might instruct a mobile to increase its output to combat the interference of other users which in turn can result in higher interference to the other users.

(c) (i) — 5%

$$y(t) = x(t) + \beta x(t - \tau_m)$$
$$Y(\omega) = X(\omega)\left(1 + \beta e^{-j\omega\tau_m}\right)$$

The transfer function is given by the ratio which is equal — 5%

$$H_c(\omega) = 1 + \beta(\cos\omega\tau_m - j\sin\omega\tau_m)$$

For $\boldsymbol{\beta}$=1 this reduces to — 5%

$$\left|H_c(\omega)\right|^2 = 2(1 + \cos\omega\tau_m)$$

The transfer function would go through minima when the cosine term goes to -1 which would occur at $\omega\tau_m = (2n+1)\pi$ or equivalently at frequencies $f = \dfrac{2n+1}{2\tau_m}$ — 5%

A sketch of the frequency response is shown below

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5%

(ii)

The time *difference* between the direct path, R_1 and the ground-reflected path R_2 is proportional to the difference between the two paths i.e. R_2-R_1. From figure Q.3.1.b and using the approximation $\sqrt{1+\varepsilon} \cong 1+\frac{\varepsilon}{2}$, expressions for R_1 and R_2 can be found to be 5%

$$R_1 = d\left[1+\frac{(h_T-h_R)^2}{d^2}\right]^{1/2} \cong d\left[1+\frac{1}{2}\left(\frac{h_T-h_R}{d}\right)^2\right]$$ 5%

and

$$R_2 = d\left[1+\frac{(h_T+h_R)^2}{d^2}\right]^{1/2} \cong d\left[1+\frac{1}{2}\left(\frac{h_T+h_R}{d}\right)^2\right]$$ 4%

The difference $\Delta R = R_2 - R_1$ reduces to

$$\Delta R = \frac{2h_T h_R}{d}$$ 3%

Hence the time difference is equal to the path difference divided by the speed of light i.e.

$$\tau_m = \frac{2h_T h_R}{cd}$$ 3%

(iii)

The electric field at the receiver can be found from the given relationship to be 0.94 mV/m 4%

The received power, P is given by

$$P = \frac{E^2 A}{\eta} = \frac{E^2 \lambda^2 G_R}{120\pi(4\pi)}$$ 4%

Substituting in the above equation gives a received power level equal to

-113.77 dBW 4%
or -83.77 dBm. 3%