Communication Systems 3

Prof Martin P.J. Lavery

Past Paper 2023

Q1

Q1 In spectral band limited communications, it is important to consider the frequency component contained within any signal transmitted over the system.

(a) Explain the difference between Fourier Series, Fourier Transform and Discrete Fourier Transforms. For each, specify where each can be used to analyse the frequency components of a signal. [6]

Q1

Q1 In spectral band limited communications, it is important to consider the frequency component contained within any signal transmitted over the system.

(a) Explain the difference between Fourier Series, Fourier Transform and Discrete Fourier Transforms. For each, specify where each can be used to analyse the frequency components of a signal. [6]

Fourier series can determine frequencies of period function. {2}
Fourier transform can be computed frequency components for arbitrary complex functions. {2}
Discrete Fourier Transform is for frequency components of sampled data, sample error add extra frequency components {2}

Q1

Q1 In spectral band limited communications, it is important to consider the frequency component contained within any signal transmitted over the system.

(b) In radio communication schemes, we commonly use a carrier frequency, which is subsequently modulated to carry the information. Explain the meaning of the following terms: (i) baseband and (ii) sidebands. As part of your answer explain how the Nyquist sampling limit is different for measuring the baseband signal compared to signal sidebands. [6]

Q1

Q1 In spectral band limited communications, it is important to consider the frequency component contained within any signal transmitted over the system.

(b) In radio communication schemes, we commonly use a carrier frequency, which is subsequently modulated to carry the information. Explain the meaning of the following terms: (i) baseband and (ii) sidebands. As part of your answer explain how the Nyquist sampling limit is different for measuring the baseband signal compared to signal sidebands. [6]

Baseband is the highest frequency of data.
Sidebands are the frequency components either side of the carrier.
System must have suitable bandwidth and sample frequency to measure the double the baseband frequency or cover both side bands.

Q1

Q1 In spectral band limited communications, it is important to consider the frequency component contained within any signal transmitted over the system.

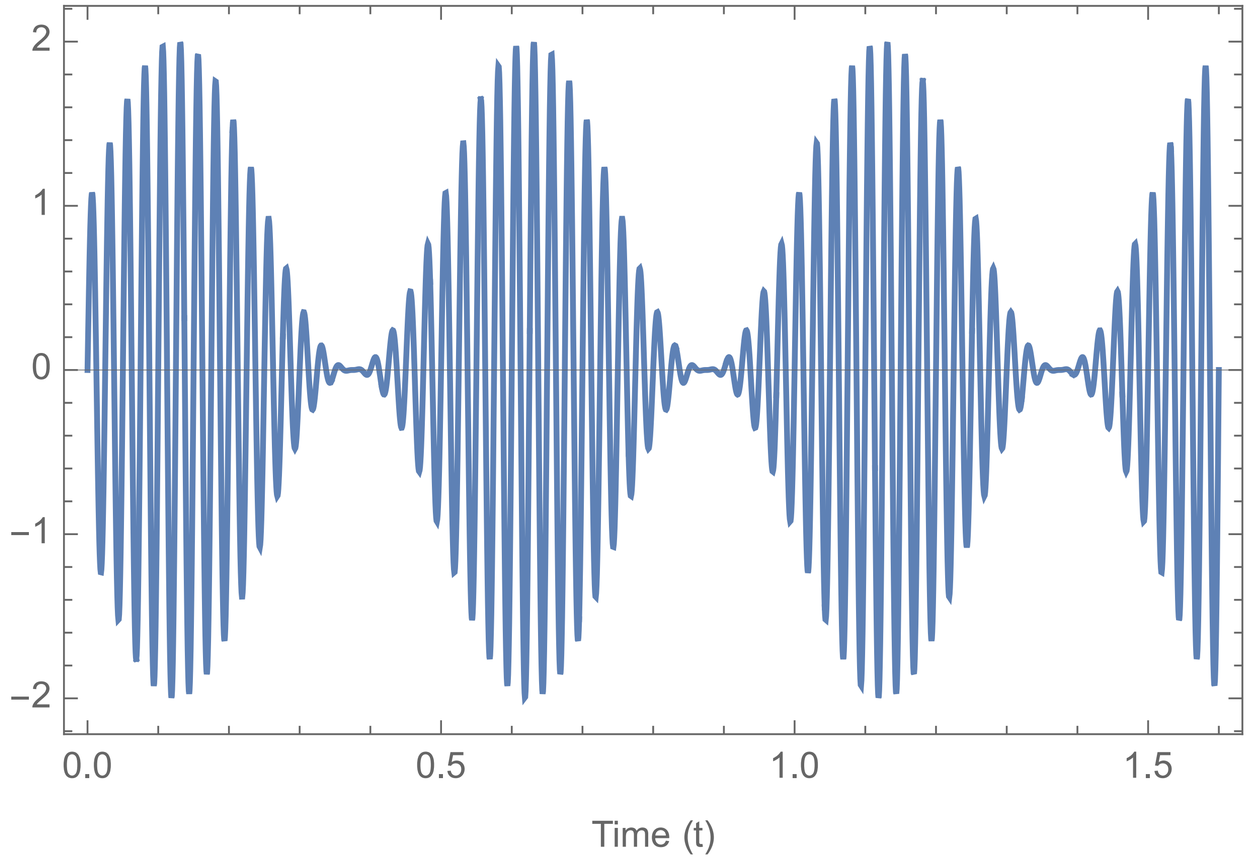
(c) Considering an amplitude modulated signal, draw a plot for the amplitude modulated signal. Chose a suitable carrier and modulation frequency for a single tone being transmitted over the channel with a DC bias of 1V. [6]

Q1

Q1 In spectral band limited communications, it is important to consider the frequency component contained within any signal transmitted over the system.

(c) Considering an amplitude modulated signal, draw a plot for the amplitude modulated signal. Chose a suitable carrier and modulation frequency for a single tone being transmitted over the channel with a DC bias of 1V. [6]

$$y(t) = [\mathrm{DC} + m\sin(2\pi\nu_m t)]A\sin(2\pi\nu_c t)$$



Q1

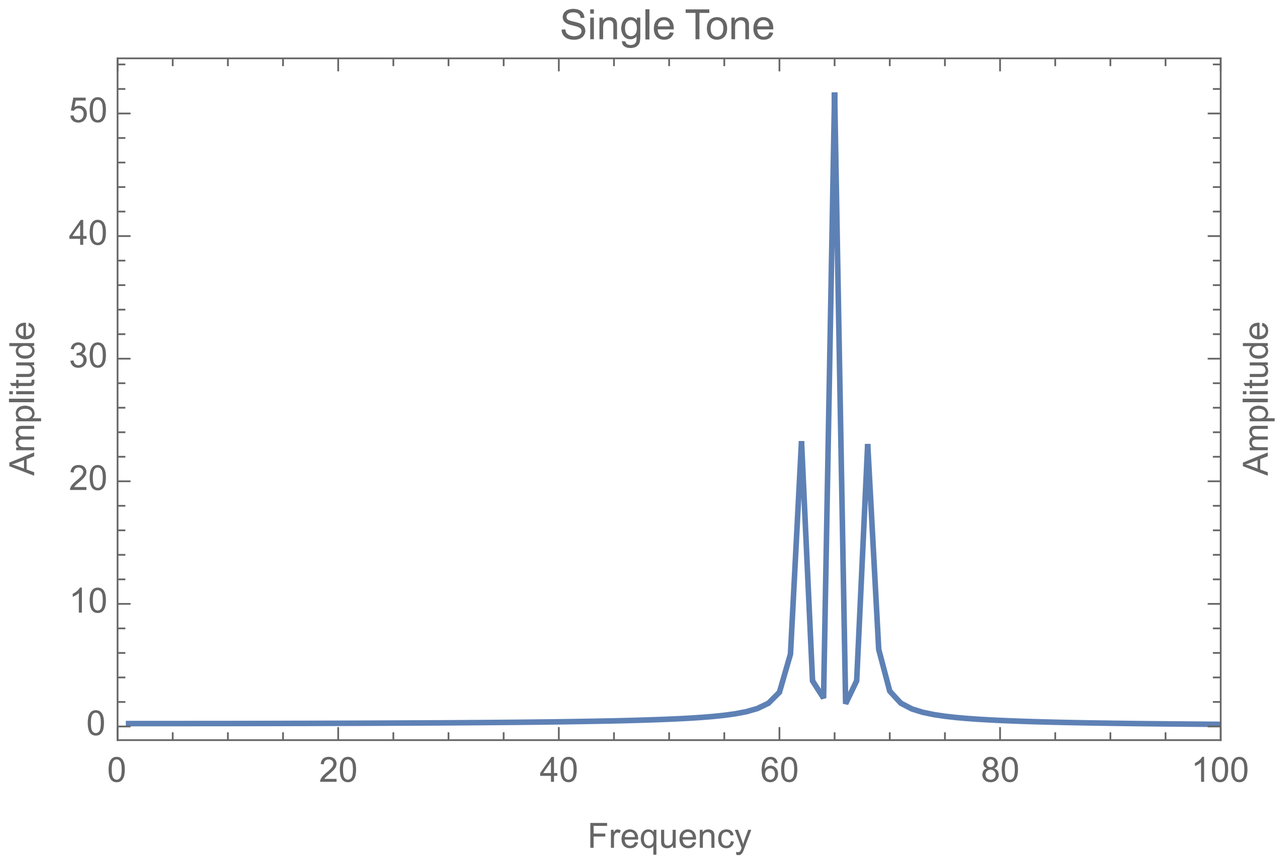
Q1 In spectral band limited communications, it is important to consider the frequency component contained within any signal transmitted over the system.

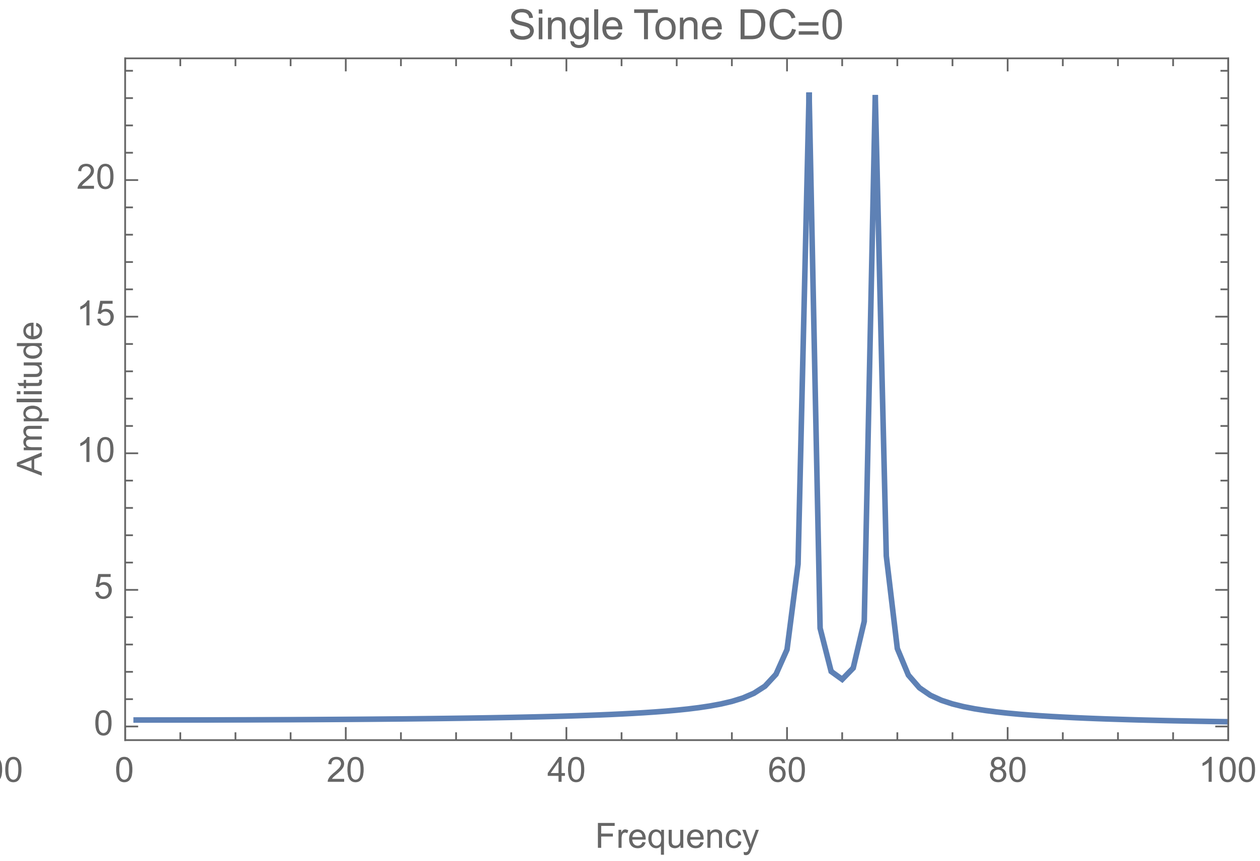
(d) Draw a plot of the Fourier Transform for the single tone in (c). Describe what happens when you reduce the DC value to 0 and explain what will happen to peaks in the diagram. [3]

Q1

Q1 In spectral band limited communications, it is important to consider the frequency component contained within any signal transmitted over the system.

(d) Draw a plot of the Fourier Transform for the single tone in (c). Describe what happens when you reduce the DC value to 0 and explain what will happen to peaks in the diagram. [3]





Q1

Q1 In spectral band limited communications, it is important to consider the frequency component contained within any signal transmitted over the system.

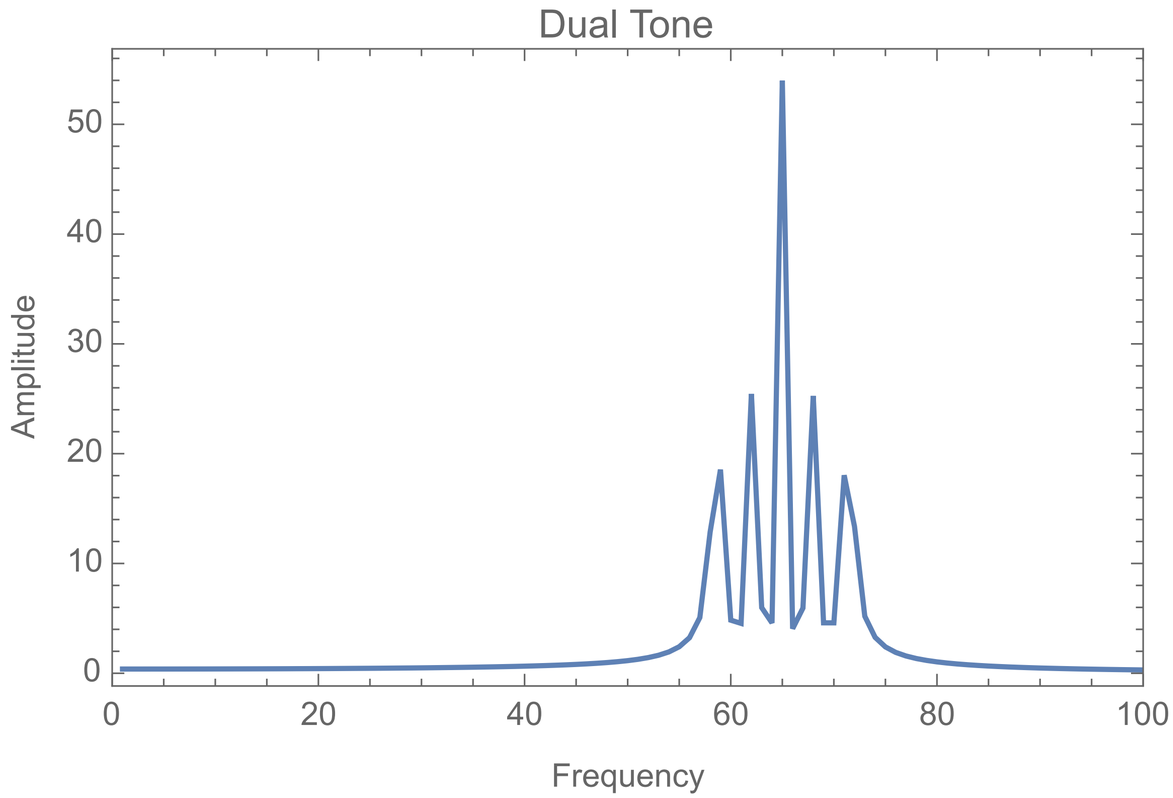
(e) Draw the plot of the Fourier Transform for a dual-tone signal being transmitted with one at a harmonic frequency of the tone used in (c).Please explain any differences in the carrier and channel bandwidth required two transmit both frequencies.[3]

Q1

Q1 In spectral band limited communications, it is important to consider the frequency component contained within any signal transmitted over the system.

(e) Draw the plot of the Fourier Transform for a dual-tone signal being transmitted with one at a harmonic frequency of the tone used in (c).Please explain any differences in the carrier and channel bandwidth required two transmit both frequencies.[3]

Bandwidth must be appropriate to cover all the carrier must be greater than the highest frequency component such that left hand side band has a frequency is above 0 Hz.



Q1

Q1 In spectral band limited communications, it is important to consider the frequency component contained within any signal transmitted over the system.

(f) A filter circuit will change the signal measured. Explain what we will see in the time domain of the signal from (d) when it is connected to a filter circuit, centred on the carrier frequency and has a bandwidth of:

(i) half the lowest frequency tone

(ii) twice the lowest frequency tone

(iii) six times the lowest frequency tone

Q1

Q1 In spectral band limited communications, it is important to consider the frequency component contained within any signal transmitted over the system.

(f) A filter circuit will change the signal measured. Explain what we will see in the time domain of the signal from (d) when it is connected to a filter circuit, centred on the carrier frequency and has a bandwidth of:

(i) half the lowest frequency tone

Only carrier will be measured

(ii) twice the lowest frequency tone

Only carrier first tone will be measured

(iii) six times the lowest frequency tone

Both tones will be measured

Q2

Q2 Coding can be used to detect if errors in transmission have occurred.

(a) Explain what parity bits are used for in the coding of information and give an example of binary sequence that includes a single parity bit. [3]

Q2

Q2 Coding can be used to detect if errors in transmission have occurred.

(a) Explain what parity bits are used for in the coding of information and give an example of binary sequence that includes a single parity bit. [3]

Determining the sequency is either odd or even, a parity bit will either 0 or 1. Such as (1 0 0 0) is odd, therefore with a parity bit (1 0 0 0 1) will be added.

Q2

Q2 Coding can be used to detect if errors in transmission have occurred.

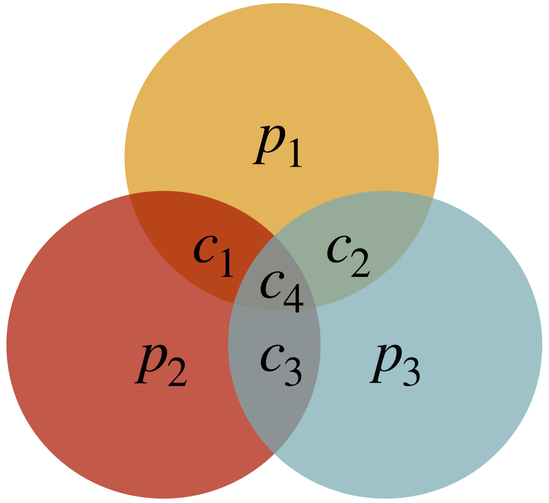
(b) Using 7:4 Hamming coding, code a suitable message and determine the binary sequence that would be transmitted in a communication system. [4]

$$\text{Generator Matrix} = \begin{pmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 & 1 & 1 \end{pmatrix}$$

Q2

Q2 Coding can be used to detect if errors in transmission have occurred.

(c) A binary sequence (1 0 1 1 0 1 1) is received using a systematic ordered Hamming code. Determine if this is an error free message. If not, determine the location of the bit error and correct the message. [4]



Q2

Q3 Optical fibre transmission is used for high-speed communications.

(a) Describe why fibers are used for high-capacity communications and why an optical carrier is important for the high data rate achievable. [2]

Q2

Q3 Optical fibre transmission is used for high-speed communications.

(a) Describe why fibers are used for high-capacity communications and why an optical carrier is important for the high data rate achievable. [2]

Baud rate cannot be higher then carrier frequency. Optical carrier is >100Thz, therefore high potentiation for information transmission.

Q2

Q3 Optical fibre transmission is used for high-speed communications.

(b) Describe what governs the spectral efficiency of the fibre transmission system with signals with an optical power of 10dBm in fibre and discuss the approaches available to maximise the spectral efficiency of a fibre communication system. [2]

Q2

Q3 Optical fibre transmission is used for high-speed communications.

(b) Describe what governs the spectral efficiency of the fibre transmission system with signals with an optical power of 10dBm in fibre and discuss the approaches available to maximise the spectral efficiency of a fibre communication system. [2]

Primary limited by electrical SNR as optical power is relatively low, meaning no SBS. High order modulation formats such as PAM or QAM effectively use available SNR.

Q2

Q3 Optical fibre transmission is used for high-speed communications.

(c) Describe the differences between optical transmission in single mode, step-index multimode and graded index fibre. Use an appropriate diagram to support your description of the propagation of light for each fibre type. [5]

Q2

Q3 Optical fibre transmission is used for high-speed communications.

(d) Discuss what limits the data rate in step-index multimode fibre and how this varies with respect to graded index fibre. [3]

Q2

Q3 Optical fibre transmission is used for high-speed communications.

(d) Discuss what limits the data rate in step-index multimode fibre and how this varies with respect to graded index fibre. [3]

The multiplex paths in step index multimode, result in temporal spreading of data, limiting the possible maximum baud rate. Graded index mitigated this due to the refractive index profile is designed to minimize mode group delays, limiting the effect of temporal spreading (dispersion).