XMUT220 Signals and Systems

Tutorial 5a: Time and Frequency Characteristics (Introduction)

A. Fundamentals of Time and Frequency Characteristics

1. In the time-domain, parameters such as time, time constant, rise time, peak time, settling time, overshoot and steady-state error are typically used for its analysis.

   a. What is time-domain analysis? Which system is typically analysed with the time-domain analysis? What does time-domain analysis measure (i.e. say for example an electronic signal)? List several devices used in the time-domain analysis. [10 marks]

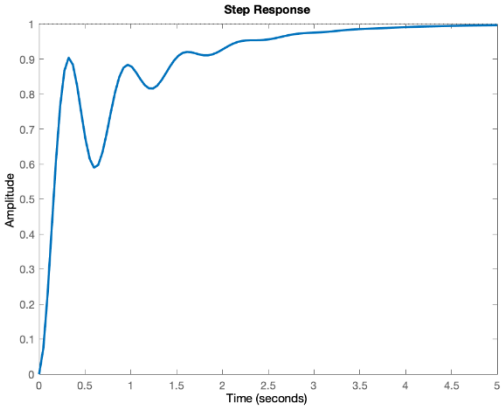
   b. Complete the following table with description and application of the given time-domain parameters. [14 marks]

Time Domain Parameters	**Description**	**Use/Application**
Time constant		
Rise time		
Peak time		
Settling time		
Overshoot		
Steady-state error		

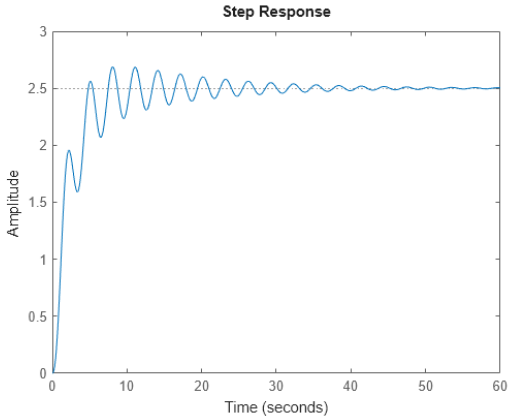
2. The transient response such as the step response is often used in the time-domain analysis for measuring the characteristics and performance of the system.

a. What variables are extensively used in time domain analysis? What measuring instrument is used for measuring these variables? What does a typical graph/plot in time domain analysis says about itself? [6 marks]

b. Analyse the following transient responses of the systems in terms of its response time, settling time, and steady-state error. [6 marks]



System A



System B

3. Frequency domain analysis involves parameters such as magnitude, gain, phase shift, frequency, cut-off frequency, bandwidth, and phase/gain margins.

a. What is frequency domain analysis? Which field uses this type of analysis? Which system is suitable for its use? Which concept is fundamental in frequency domain analysis (i.e. related with the concept of transformation)? [8 marks]

b. Complete the following table with the description and use of the listed frequency domain parameters. [14 marks]

Frequency Domain Parameters	**Description**	**Use/Application**
Magnitude		
Gain		
Phase shift		
Frequency		
Cut-off frequency		

Bandwidth		
Gain/phase margins		

4. Some systems in engineering are better off analysed using the time-domain analysis compared with the frequency-domain analysis, or vice versa.

   a. Compared with time domain analysis, why people resort to frequency domain analysis? List important parameters/variables in frequency domain analysis? What instrument is used for its measurement? Give a common example where frequency domain analysis is useful. [8 marks]

   b. Fill in the blanks given in the table below with relevant answers. [8 marks]

Context	**Time domain analysis**	**Frequency domain analysis**
Transient response of RLC circuit		
Components of a complex signal		
Filter circuit design		
Vibration measurements		

5. There are some aspects of time domain analysis that make it different from the frequency domain analysis, or vice versa.

   a. What is the difference between time and frequency domain analysis? [2 marks]

   b. Fill in the blanks given in the table below with relevant answers. [6 marks]

Aspect	**Time Domain Analysis**	**Frequency Domain Analysis**
Data usage		
Methods		

Applications		

6. Signal transformation is often utilised in the time and frequency domain analysis for conversion from one domain to another.

   a. What signal transformation techniques are useful in time and frequency domain analysis? Describe also its applications. [4 marks]

   b. Fill in the blanks given in the table below with relevant answers. [5 marks]

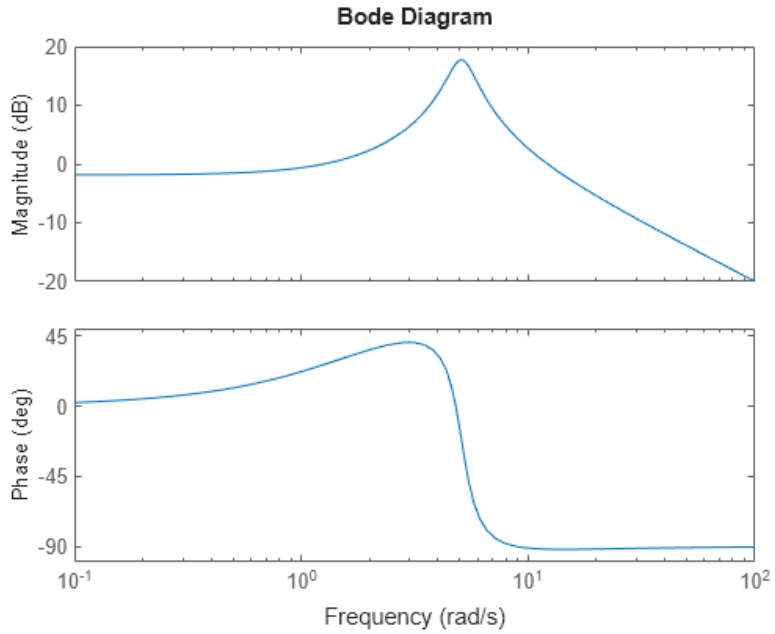
From	**To**	**Transform Method**
Discrete signal	Frequency component	
Analogue signal	Frequency component	
Complex calculus equation	Simpler algebra equation	
Recurrent signal	Frequency component	
Image/raw data	Processed data	

7. Frequency domain analysis is commonly performed using magnitude and phase shift as measured parameters against the operating frequency of the system.

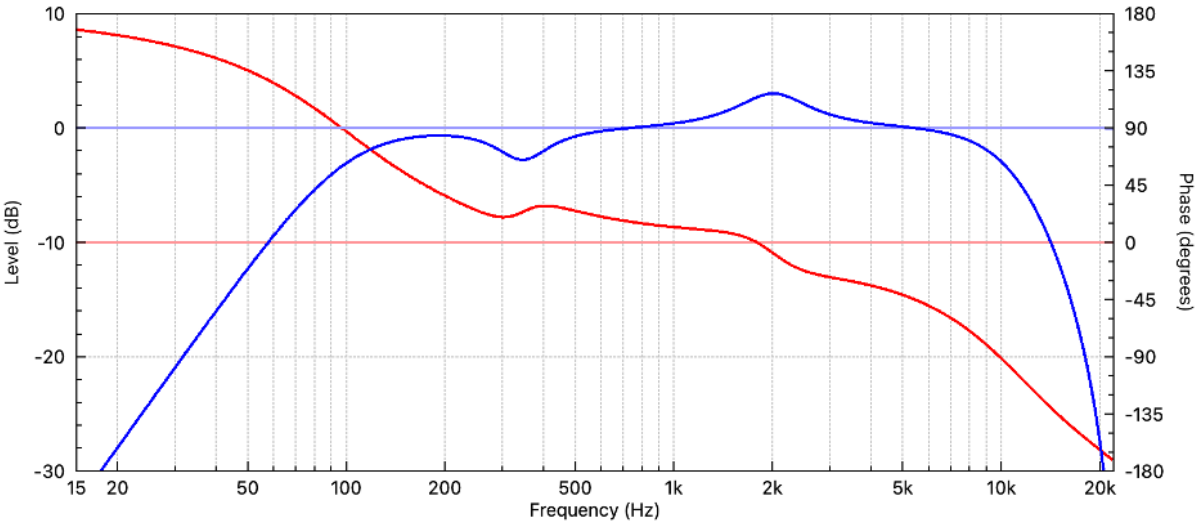
   a. Describe the significant of magnitude and phase in frequency domain analysis and its use for in understanding the behaviour of the system? [4 marks]

   b. Analyse the following frequency response plots in terms of its magnitude and phase shift. [4 marks]

   System 1: Signal Filter



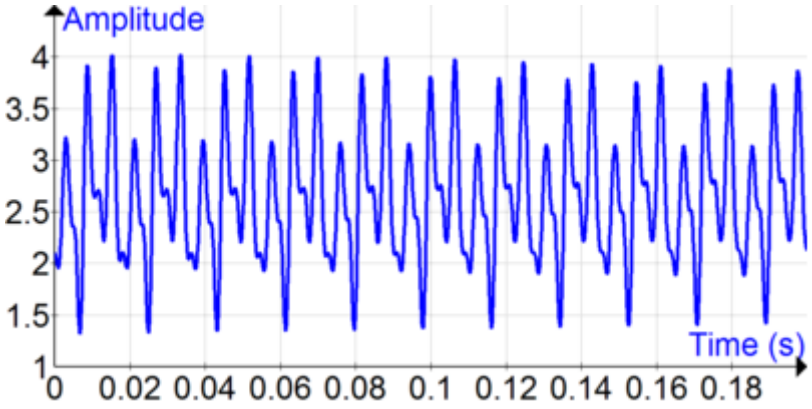
System 2: Audio Amplifier



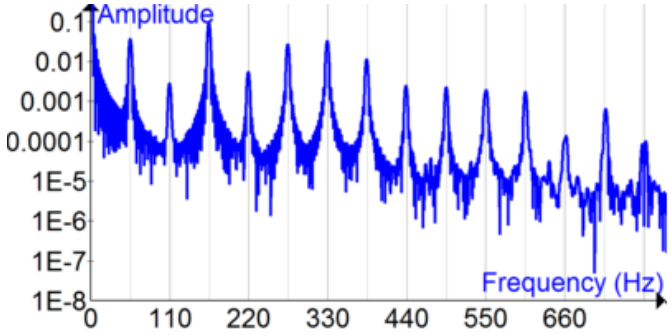
B. Applications of Time and Frequency Characteristics

8. The following time and frequency domain graphs/plots are referring to the bass guitar signals plucked as open string for the A note (55 Hz). What can you tell about its significant?

[4 marks]

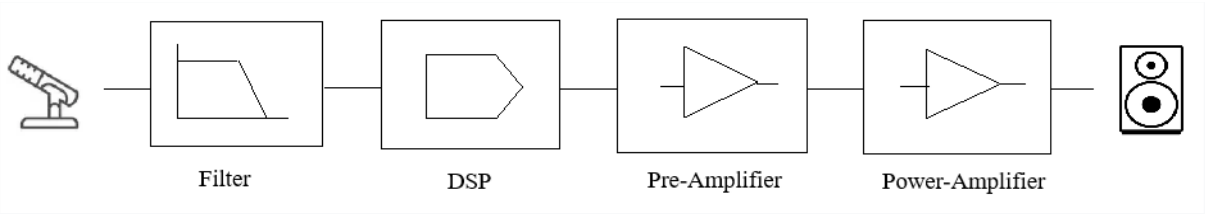


Plot a: Time-domain plot of bass-guitar's open-string A note (55 Hz)



Plot b: Frequency-domain plot of bass-guitar's open-string A note (55 Hz)

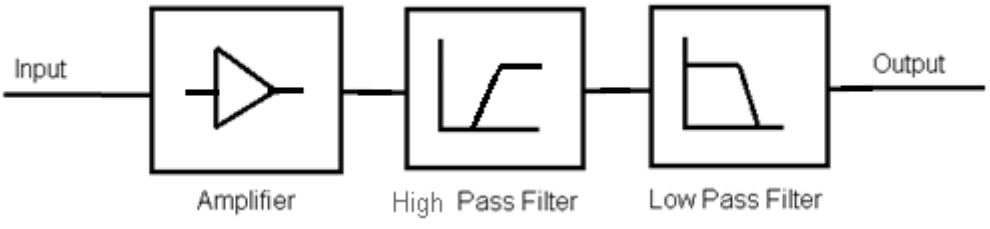
9. The following audio signal processing system works on capturing audio sounds through the microphone, filtering the signal by removing unwanted noise, performing sound reproduction process in the digital signal processing unit of the system, and amplifying the signal before delivering to the speaker.



By applying time and frequency domain analysis through plots of representation of the signals in the time and frequency domain, describe how it works? [4 marks]

10. The following block diagram describes a receiver system used in the communication system. The receiver has an operational frequency of 10 Hz (ω_n).

The cut-off frequency of the low-pass filter is $10\omega_n$ and the cut-off frequency of the high-pass filter is $0.1\omega_n$.



By using the plots of time and frequency representation of signals in time and frequency domain, describe the working principle of the system. [4 marks]