

THE UNIVERSITY OF BRITISH COLUMBIA  
Department of Electrical and Computer Engineering

ELEC 391 – Electrical Engineering Design Studio II

## **Spectrum Analyzers and Filters – Review Questions**

The purpose of this short self-quiz is to help you review the essential parts of the lecture on *Spectrum Analyzers and Filters*. Most of the answers can be found in the lecture notes.

SQ3R – Survey, Question, Read, Recite, Review
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### **1. Decibels**

- 1.1. What is a decibel?
- 1.2. Why is it convenient to express power ratios in decibels?
- 1.3. How are dBm, dBW and dBV defined?

### **2. Principles of Fourier Analysis**

- 2.1. What is a Fourier series?
- 2.2. What is the Fourier series synthesis equation?
- 2.3. What is the Fourier series analysis equation?
- 2.4. What are the Dirichlet conditions?
- 2.5. Given the Fourier coefficients  $c_k$  of the Fourier series representation of a signal, how does one determine the amplitude, power and phase spectra of the signal?
- 2.6. What is a line spectrum?

### **3. Spectrum Analysis**

- 3.1. Why would an engineer want to measure the spectrum of a signal?
- 3.2. Give four methods for measuring the frequency content of a signal and list their strengths and limitations.
- 3.3. What are the key differences between Fourier theory and spectrum analyzer measurements?

- 3.4. How does one configure a spectrum analyzer to measure the frequency content of an arbitrary signal?

#### **4. Filter Analysis and Design**

- 4.1. What is a filter?
- 4.2. What are two important classes of filters?
- 4.3. What is filter analysis?
- 4.4. What is filter synthesis?
- 4.5. Give an example of an application that requires a frequency shaping filter.
- 4.6. Give an example of an application that requires a frequency selective filter.
- 4.7. What is the function  $H(s)$  and what is the significance of the variable  $s$ ?
- 4.8. How does one design a filter using the pole-zero approach?
- 4.9. What is meant by the order of a filter?
- 4.10. How are the poles of a low-pass Butterworth filter of order  $n$  configured and in what sense is a Butterworth filter considered to be optimal?
- 4.11. How can one use MATLAB to determine the poles and/or polynomial coefficients of a low pass Butterworth filter of order  $n$ ?
- 4.12. How are the poles of a low-pass Chebyshev filter of order  $n$  configured and in what sense is a Chebyshev filter considered to be optimal?
- 4.13. How are the poles of a low-pass Bessel filter of order  $n$  configured and in what sense is a Bessel filter considered to be optimal?

#### **5. Frequency Modulation**

##### *General*

- 5.1. What is a general expression for an FM modulated signal?
- 5.2. Give an expression for the instantaneous frequency of an FM signal in terms of the amplitude of the modulating frequency?
- 5.3. What is the frequency deviation constant?
- 5.4. How can one implement an FM modulator? Sketch its transfer function.

- 5.5. Give two methods by which one can implement an FM demodulator. Sketch their transfer functions.

*Sinusoidal Modulation of an FM Signal*

- 5.6. Why is Fourier analysis of FM signals generally very complicated?
- 5.7. What is special about the case of a sinusoidal message signal?
- 5.8. What is the modulation index?
- 5.9. Give an expression for an FM signal that arises when the message signal is sinusoidal.
- 5.10. What is the form of the spectrum of an FM signal when the message signal is sinusoidal?
- 5.11. What is Carson's (bandwidth) rule?

**Spectrum Analyzers: Sweep and Bandwidth Considerations**

1. What is a preselector?
2. What does the bandwidth of the resolution bandwidth filter affect?
3. What does the bandwidth of the video filter affect?
4. Under what conditions will the spectrum be oversampled (or undersampled)?
5. Give an expression for the time that a spectrum analyzer dwells in each frequency resolution element.
6. What form does the frequency response of the resolution bandwidth filter generally take?
7. Give an expression for the sweep time required to allow the resolution bandwidth filter to fully charge within each frequency resolution element when  $VB \geq RB$ .
8. Give an expression for the sweep time required to allow the resolution bandwidth filter to fully charge within each frequency resolution element when  $VB \ll RB$ .
9. What will happen if the sweep time is set manually to less than the recommended values?
10. How will doubling the resolution bandwidth affect the noise floor?
11. How will doubling the resolution bandwidth affect the required sweep time?