ECE 2610 Midterm Review
Dr. Wickert, Spring 2011

Coverages

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Chapter 2: Important Concepts

- Basic sine and cosine function properties, e.g., \( \sin \theta = \cos(\theta - \pi/2) \) and other
- A continuous-time sinusoidal signal, \( A \cos(\omega_0 t + \phi) \), is controlled by three parameters
  - The period \( T_0 \) s and frequency \( f_0 \) Hz and \( \omega_0 \) rad/s both are inversely related to the period
- Time shifting waveforms to the left or right by \( t_0 \), e.g., \( y(t) = x(t - t_0) \)
  - For a sinusoid time shift is related to phase shift (notes p. 2-12)
- Complex number arithmetic, must know this!
  - Rectangular form \((x + jy)\) for adding and subtracting
  - Polar form \( re^{j\theta} \) multiplying and dividing
  - Euler’s formula and Euler’s inverse formulas (very useful in ECE)
- Complex exponential signals, \( Ae^{j(\omega_0 t + \phi)} \)
  - Rotating phasor interpretation
  - Phasor addition rule in the sum of sinusoids

\[
\sum_{k=1}^{N} A_k \cos(\omega_0 t + \phi_k) = A \cos(\omega_0 t + \phi)
\]

we find \( A \) and \( \phi \) using

\[
\sum_{k=1}^{N} A_k e^{j\phi_k} = Ae^{j\phi}
\]
Chapter 3: Important Concepts

- Two-sided line spectrum for a sum of sinusoids obtained from a sequence of frequency/complex amplitude pairs that correspond to the \( \pm \) frequency of each sinusoid and a complex amplitude that corresponds to the magnitude and phase of each sinusoid
  - Euler’s formula key to making this connection
  - DC/constant/zero frequency terms are treated as a special case
- Beat notes and AM, and how the sum of two sinusoidal signals is related to the product of two sinusoidal signals
- Periodic waveforms and Fourier series
  - Fourier synthesis formula (sum complex exponentials to approximate \( x(t) \))
  - Fourier analysis formula (integrate to get coefficients)
  - Simple Fourier series properties, such as computing \( a_0 \)
  - The spectrum of a Fourier series (harmonically related sinusoids having a fundamental frequency)
  - Differences in convergence properties for say a square wave versus a triangle wave
- FM chirp signals (linear chirp)
  - Instantaneous frequency
  - The spectrogram

Chapter 4: Important Concepts

- Sampling sinusoidal signals to form sinusoidal sequences
  - \( \omega_0 = 2\pi f_0 \Rightarrow \hat{\omega}_0 \) via \( \hat{\omega} = \omega T_s = 2\pi f_0 / f_s \)
  - The choice of sampling rate and the sampling theorem
  - Alias frequencies and the principal alias band \( \hat{\omega} \in [-\pi, \pi] \) or \( f \in [-f_s/2, f_s/2] \)
  - The concept of the folding frequency and viewing the alias frequencies as in the Figure on notes p. 4-13
  - Aliasing in a linear chirp signal
- Ideal reconstruction and the ideal C-to-D converter, we map from \( \hat{\omega} \) back to frequency in Hz using \( f = (\hat{\omega} f_s) / (2\pi) \)
  - zero-order hold versus linear interpolation
  - The spectrum view of sampling and reconstruction, i.e., the D-to-C keeps only those frequencies on the principle alias interval for reconstruction
Chapter 5: Important Concepts

- Finite impulse response filtering using a simple moving average filter and the feed-forward difference equation
  - Calculating the output using a simple table (notes p. 5-3)
- The general FIR filter
- Unit impulse sequence, $\delta[n - n_0]$, where $n_0$ is an arbitrary sequence (time) shift
- The impulse response, $h[n]$
- The delay system, $y[n] = x[n - n_0]$
- Convolution sum view of FIR filtering
  - Calculating the output of an FIR filter using the convolution sum view, and a (more than one works) table approach
- The use of MATLAB’s filter function to numerically obtain the output of an FIR filter given $x[n]$ and the filter coefficients $\{b_k\}$; be familiar with how this works so you can interpret simple code statements
- Implementation of FIR filters using the building blocks of a multiplier, adder, and unit delay
  - Difference equation to block diagrams (direct form) and back
  - Other forms converting to difference equation
- Linear time invariant systems
  - Proving whether or not a system is time invariant
  - Proving whether or not a system is linear
- Convolution and LTI systems
  - Convolution operator
  - Convolution is commutative
  - Convolution is associative
- Cascaded LTI systems: $h[n] = h_1[n]*h_2[n]$
- Moving average filters as an example