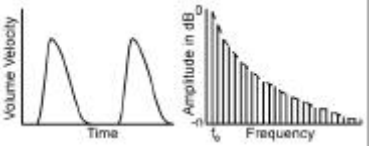


Preamble (2-3)

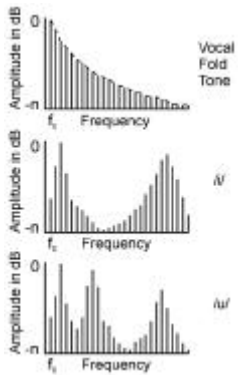
- Signal below is complex-periodic with a fundamental frequency and harmonics
 - ◆ A line spectrum
 - ◆ Smooth envelope with no sharp prominences
- Sounds similar to a “buzz”
- Produced by vibration of vocal folds during, e.g., vowel production



Ch6-1

Preamble (3-4)

- The sound wave will be altered or “reinforced” by a process called resonance, or filtering, to produce the various vowels of the language
 - ◆ /i/ as in beat
 - ◆ /u/ as in boot
 - ◆ and so forth



Ch6-2

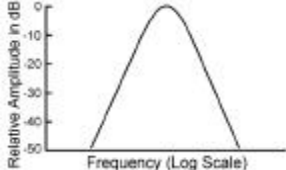
The Principle of Resonance (6)

- Periodic force (me) is applied to an elastic system (mass-spring system)
- System is forced to vibrate at frequency of applied force, not at f_{nat} of the system
- The closer the frequency of the applied force to the natural frequency (f_{nat}) of the system, the greater the amplitude of vibration

Ch6-3

RESONANCE AND FILTER CURVES (10-11)

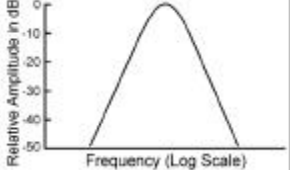
- Does Not represent a sound wave spectrum
- The curve describes a frequency-selective elastic system
- The curve is called:
 - ◆ Resonance curve
 - ◆ Filter curve
 - ◆ System transfer function
 - ◆ Amplitude response
 - ◆ “Frequency Response”



Ch6-4

RESONANCE AND FILTER CURVES (12)

- Note the natural frequency at 0 dB
- What happens above & below the natural frequency?
 - ☑ Amplitudes are diminished (attenuated) for frequencies remote from f_{nat}
- The resonator, or filter, is a frequency-selective system



Ch6-5

Summary (13)

- Mass and stiffness of elastic system determine its natural, or resonant, frequency
- Elastic system is forced to vibrate at frequency of applied force
- Amplitude of vibration of elastic system is greatest when driving frequency equals natural frequency of system

Ch6-6

ACOUSTIC IMPEDANCE & RESONANCE (14)

- Two components of impedance (Z):
 - ◆ Energy dissipating - Resistance (R)
 - ◆ Energy storage - Reactance (X)
- The magnitude of resistance (R) is independent of frequency
 - ◆ Thus, R does not contribute to determination of f_{nat}
- What components of Z, therefore, determine f_{nat} ?
 - ☑ X_m (mass reactance)
 - ☑ X_c (compliant reactance)

Ch6-7

Effects of Impedance on Resonance Curve (20-24)

- Shape of resonance curve, & location in frequency domain, determined by impedance (Z) of system: R, X_m , & X_c
- ◆ Below f_c : compliance dominant
- ◆ Above f_c : mass dominant
- ◆ Progressive increase of resistance, not just impedance
- ◆ Is natural frequency affected? ☑ No

Ch6-8

Effects of Impedance on Resonance Curve (25)

- As R increases from B to C to D:
 - ◆ More energy is dissipated
 - ◆ Damping increases
 - ◆ System becomes more broadly tuned

Ch6-9

Admittance (26)

- Impedance emphasizes opposition to motion; opposition to transfer of energy
- Admittance refers to the inverse; energy accepted, or admitted, to a system

Ch6-10

System Tuning (28)

- The figure compares two resonant systems (not signals)
- Narrow tuning at left
- Good generator of sound: Why?
 - ◆ lower resistance
 - ◆ less damping
 - ◆ longer free vibrations at f_{nat}

Ch6-11

System Tuning (29)

- Broad tuning at right
- Good receiver of sound: Why?
 - ◆ higher resistance
 - ◆ more damping
 - ◆ brief free vibrations
 - ◆ can be forced to vibrate with maximum amplitude over a wide range of frequencies

Ch6-12

Impedance Matching (30-31)

- Apply vibrating force (driver) to elastic system (load)
 - ◆ Power transferred to system
 - ◆ System forced to vibrate
- Maximum power transfer occurs when Z of driver = Z of load
- Sounding board of a piano
- Air cavity above the vocal folds
 - ◆ Do not amplify sound
 - ◆ Z s are matched
 - ◆ Maximum transfer of power

Ch6-13

FREQUENCY-SELECTIVE SYSTEMS: FILTERS (32-34)

- A: Amplitude spectrum of input signal
- B: System transfer function (resonance, or filter, curve)
- C: Amplitude spectrum of output signal

Ch6-14

FREQUENCY-SELECTIVE SYSTEMS: FILTERS (35)

- A: Amplitude spectrum of input signal -- white noise
- B: Transfer function of system
- C: Amplitude spectrum of output signal
 - ◆ Frequency-limited (band-limited) white noise

Ch6-15

PARAMETERS OF A FILTER (36-42)

- Five parameters of filter curves
 - ◆ 1. Center (natural) frequency, f_c
 - ◆ 2. Upper cutoff frequency, f_u
 - ◆ 3. Lower cutoff frequency, f_L
 - ◆ 4. Bandwidth, Δf
 - ◆ 5. Attenuation (rejection) rate

Ch6-16

Attenuation Rate In dB/octave (43)

- Filter A: 10 dB / octave
- Filter B: 15 dB / octave
- Attenuation rate quantifies the *selectivity* of a filter

Ch6-17