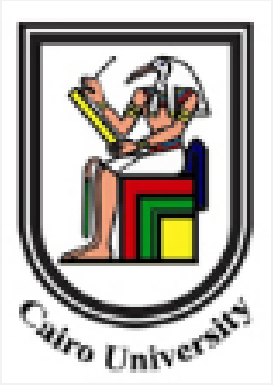


Department of Systems and Biomedical Engineering

SBE 405 Medical Instrumentation IV: Ultrasound Imaging (4)

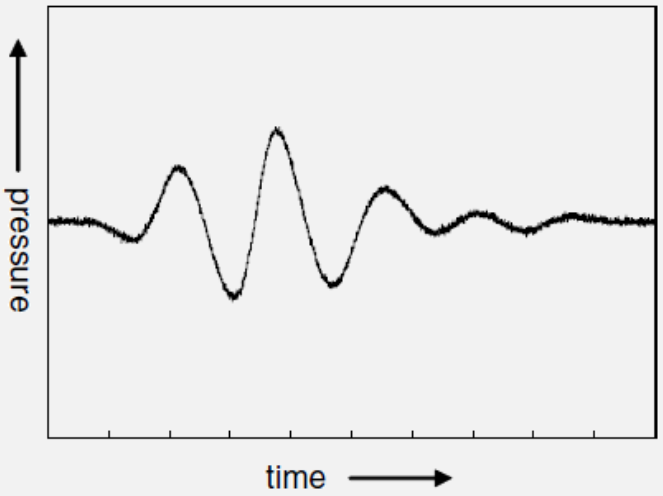
Ahmed M. Ehab Mahmoud, PhD

Department of Systems and Biomedical Engineering, Cairo University, Giza, Egypt.

Office: Room of Department Faculty, left wing (computer laboratory section), 2nd floor, Architecture building, Faculty of Engineering.
Email: a.ehab.Mahmoud @eng1.cu.edu.eg
a.ehab.Mahmoud@gmail.com

Ultrasound Pulse and Spectrum

- To produce a distinct echo which corresponds to a particular interface, ultrasound must be transmitted in the form of a short burst or pulse.



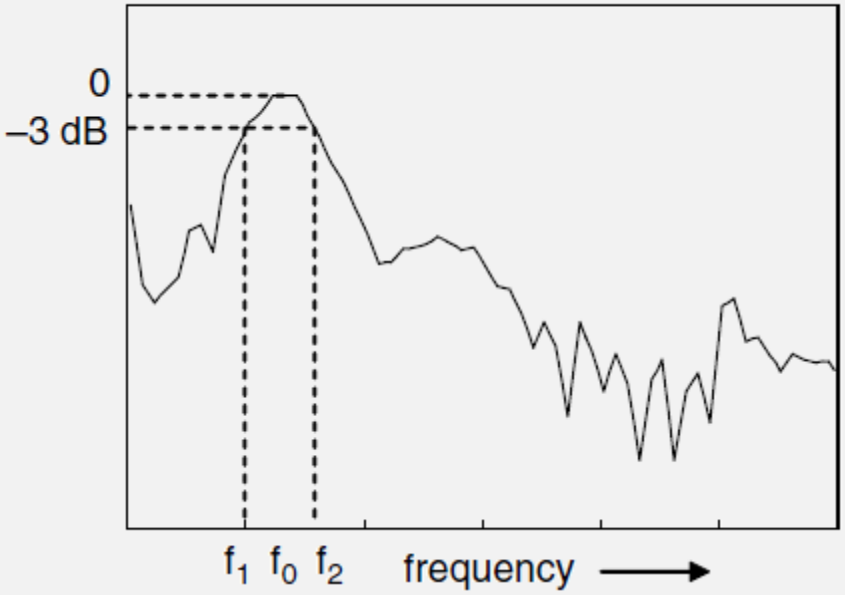
- To allow echoes from closely spaced interfaces to be resolved separately, the pulse must be short.

Axial Resolution=Spatial Pulse Length (SPL)/2 = Tc/2
where T is the effective pulse time

Ultrasound Pulse and Spectrum

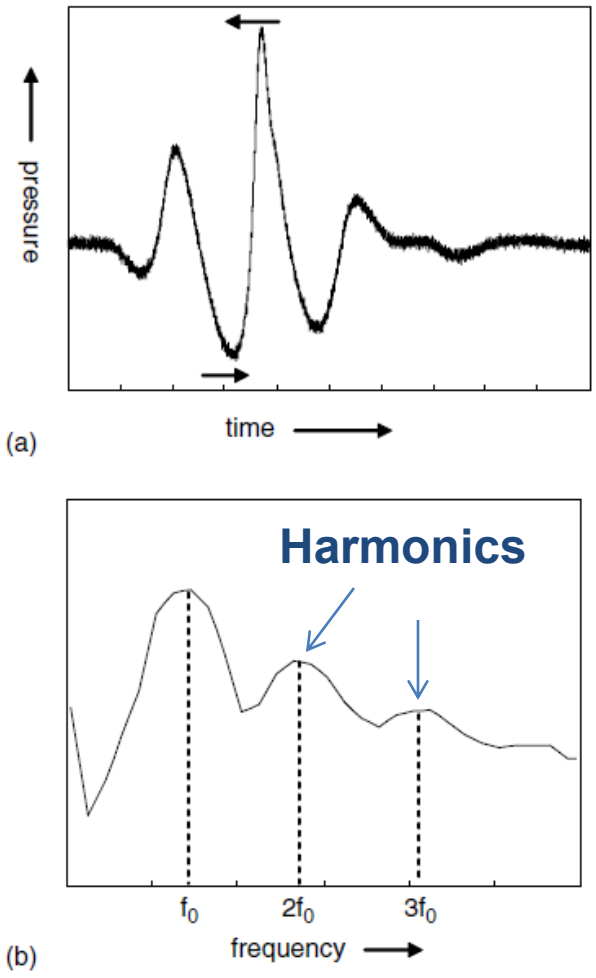
- The graph of amplitude versus frequency for a pulse is termed the pulse spectrum.

- The width of the spectrum is commonly measured in terms of the −3 dB bandwidth, which is the difference between frequency values above (f_1) and below (f_2) the peak frequency (f_0) at which the amplitude of the spectrum has fallen by 3 dB from its maximum value.



Non-Linear Propagation

- At high pressure amplitudes (>1 MPa), non-linear propagation effects become noticeable.
- In the high-pressure (compression) parts of the wave, particle motion is in the direction of propagation, resulting in a slight increase c, whereas in the low-pressure (rarefaction) parts of the wave motion is in the opposite direction and c is slightly reduced.
- The rapid changes in pressure in the compression part appear in the pulse spectrum as high frequency components.



Harmonic Imaging

- In harmonic imaging, a pulse is transmitted with fundamental frequency f_0, but due to non-linear propagation echoes return from the tissues contain energy at harmonic frequencies $2f_0$,$3\ f_0$,etc.
- Second harmonic imaging 1- reduces noise and side lobe artifacts, and 2- improve depth penetration.

Harmonic Imaging provides low-noise images

Fundamental image

Acoustic Pressure and Intensities

Instantaneous intensity

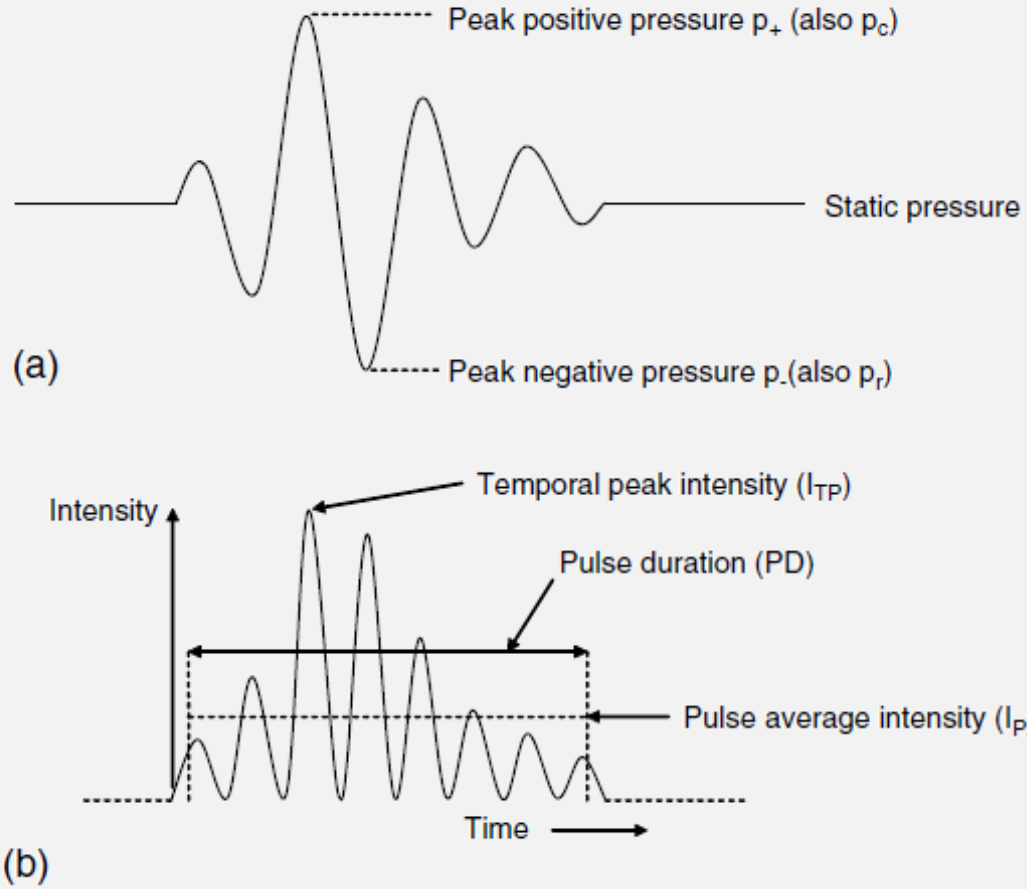
$$I = \frac{P^2}{z}$$

Pulse duration

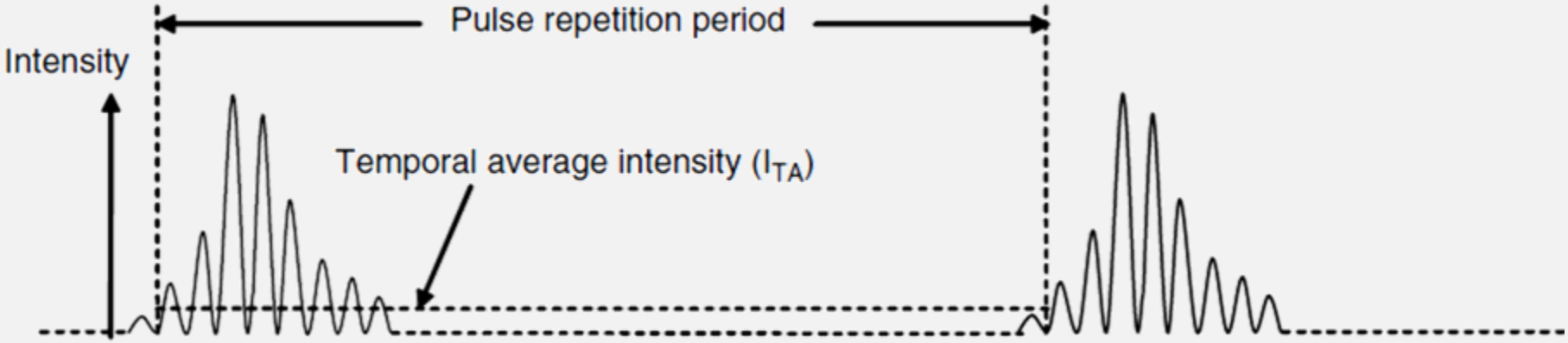
$$\mathrm{PD} = 1.25 \times \left(T_{90} - T_{10} \right)$$

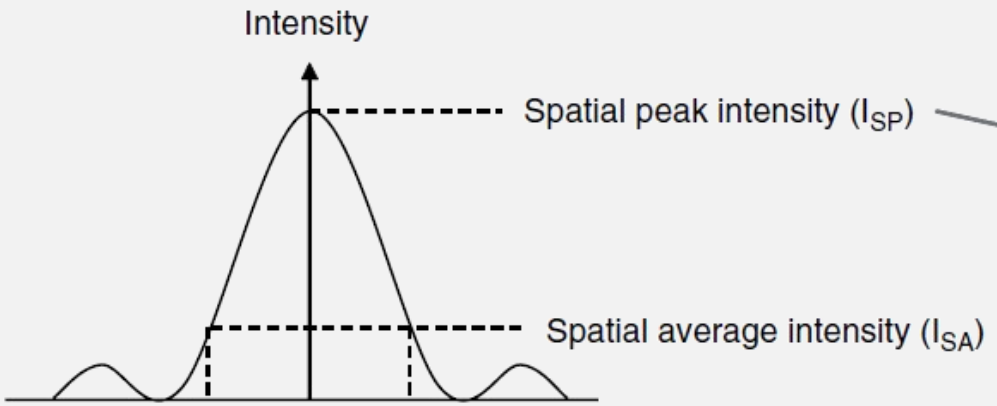
Pulse average intensity

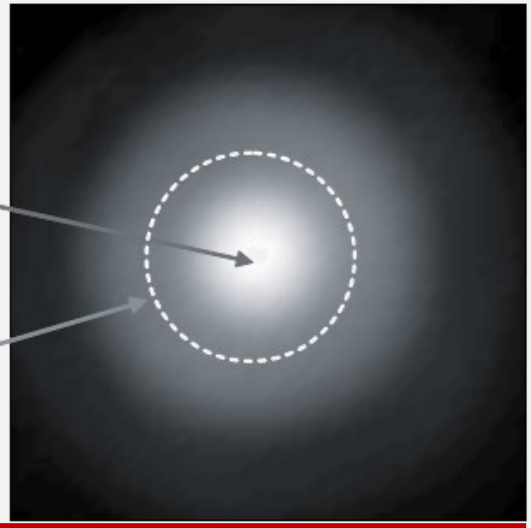
$$I_{PA} = \mathrm{PII} / \mathrm{PD}$$



Acoustic Pressure and Intensities







Acoustic Pressure and Intensities

- I_{sptp}: the spatial peak temporal peak intensity is the maximum value in the pulse at the point in the beam where it is highest.

- I_{sppa}: the spatial peak pulse average intensity is the average value over the pulse duration at the point in the beam where it is highest.

- I_{spta}: the spatial peak temporal average intensity is temporal average intensity at the point in the beam where it is highest.

- I_{sata}: the spatial average temporal average intensity is the temporal average intensity averaged over the beam area (usually −6 dB area).

What to study

1- Lecture notes
2- Up to page 16 in the first reference book. Parts discussed during the lecture