Homework #7

1. It is known that the speed of US in soft tissue is about 1540 m/s. (1) What is the wavelength of 1-MHz US in soft tissue? (2) What is the wavelength of 10-MHz US in soft tissue?

Solution

$$C = \lambda \times \nu$$

So:

For 1-MHz:

$$\lambda = \frac{C}{\nu} = \frac{1540m/s}{1{,}000{,}000/s} = 1.54 \times 10^{-3}(m) = 1.54mm$$

For 10-MHz:

$$\lambda = \frac{C}{\nu} = \frac{1540m/s}{10{,}000{,}000/s} = 1.54 \times 10^{-4}(m) = 0.154mm$$

2. Two US signals differs in intensity by 20 dB, what is the ratio of their intensities?

Solution

$$dB = 10\log_{10}\left(\frac{I_1}{I_0}\right)$$

So:

$$20dB = 10\log_{10}\left(\frac{I_1}{I_0}\right)$$

$$\Rightarrow \frac{I_1}{I_0} = 10^2 = 100$$

3. An ultrasonic wave of 10 MHz with an intensity of 5 mW/cm^2 is incident on a flat boundary normally between two media with acoustic impedance Z_1 and Z_2. Assume that the attenuation in the two media can be neglected. The reflected power is 0.4mW/cm^2. (a) What is the transmitted intensity, (b) If impedance Z_1 is 1.34×10^6 kg/(m^2 sec) , find Z_2 .

Solution:

(a)

$$I = I_r + I_t$$

I=5mW/cm^2

I_r =0.4 mW/cm^2

Therefore,

$$I_t = I - I_r = 5 - 0.4 = 4.6\ (mW / cm^2)$$

(b)

$$\frac{I_r}{I} = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2 = \frac{0.4}{5} = \frac{2}{25}$$

$$\Rightarrow \frac{Z_2 - Z_1}{Z_2 + Z_1} = \pm\frac{\sqrt{2}}{5}$$

$$\Rightarrow Z_2 = \frac{5+\sqrt{2}}{5-\sqrt{2}} \times Z_1 = 2.4 \times 10^6 (kg /(m^2 \sec)$$

or

$$\Rightarrow Z_2 = \frac{5-\sqrt{2}}{5+\sqrt{2}} \times Z_1 = 0.75 \times 10^6 (kg /(m^2 \sec)$$

4. An US echo signal is half as intense as the original signal. Express the drop in intensity in decibels.

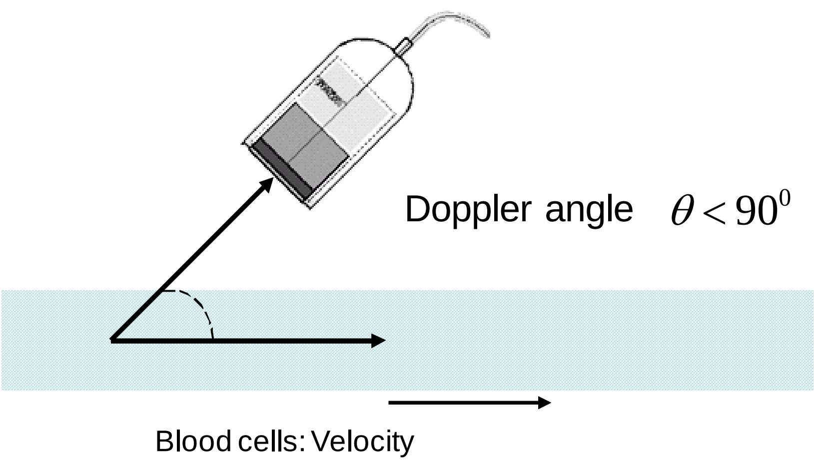
Solution

$$dB = 10\log_{10}\left(\frac{I_1}{I_0}\right)$$

$$\frac{I_1}{I_0} = 0.5$$

$$\Rightarrow dB = 10\log_{10}\left(\frac{I_1}{I_0}\right) = 10\log_{10}(0.5) = 10\times(-0.3dB) = -3dB$$

5. An 8 MHz ultrasound pulse Doppler flow meter is used to monitor blood flow in a carotid artery. The probe is marking an angle 25^0 with respect to the direction of flow. Suppose the speed of the blood flow in the artery is uniform throughout the lumen and is approximately 50cm/sec. Please calculate the Doppler frequency shift. The speed of sound in the tissue is 1540 m/s.



Solution:

$$\Delta f = f_r - f_i = \frac{2 f_i V \cos\theta}{C} = \frac{2\times 8\times 10^6\times 0.5\times\cos 25^0}{1540} = 4.7\times 10^3 (Hz)$$