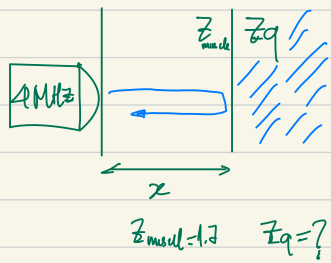
1. $L_{total} = L_{attenuation} + L_{reflection} = -60.5$

$L_{attenuation} = -\alpha_{muscle} \cdot f \cdot x = \left(\frac{1.1}{10^{-2}} \frac{dB}{m \cdot MHz}\right)(4MHz) \cdot 1540\frac{m}{s} \cdot 55\times10^{-6}s = -37.27\ dB$

$L_{reflection} = -60.5 - (-37.27) = -23.23\ dB$



Let Z_q is the aucoustic impedance of the material on the other side of boundary

The reflected component is the residual that did not get through boundary:

$$R = 1 - T = 1 - \frac{2Z_q}{Z_{muscle} + Z_q} = \frac{Z_{muscle} - Z_q}{Z_{muscl} + Z_q}$$

$$L_{reflection} = 20 \times \log_{10}(R) = -23.23\ dB$$

then $R = \frac{Z_{muscl} - Z_q}{Z_{muscle} + Z_q} = 10^{-23.23/20} = 0.0689 = \delta$

$$Z_{muscle} - Z_q = \delta(Z_{muscle} + Z_q)$$

$$Z_q = Z_{muscle}\left(\frac{1-\delta}{1+\delta}\right) = 1.48\ kg\,m^{-2}s^{-1} \times 10^6$$

Thus we have a watery cyst

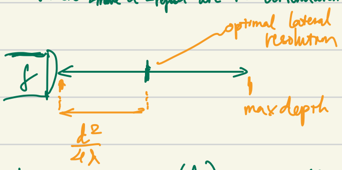
2. $f_D = -\frac{2v_a}{c} f_t$

$$v_a = -\frac{1}{2}\frac{f_D}{f_t} \cdot c = \frac{-1}{2} \cdot \frac{-1000}{2\times10^6} \times 1540 = 0.385\ m/s$$

Direction: away from transducer

3. Bandwidth $= -100\,dB = L_{total} = L_{move} + L_{reflect}$

where L_{move} & $L_{reflect}$ are the attenuation caused by moving through tissue & reflection at boundary



$$L_{reflect} = 20\log_{10}\left(\frac{A_r}{A_i}\right) = 20\log_{10}(0.01) = -40\,dB$$

$$L_{move} = L_{total} - L_{reflect} = -100 - (-40) = -60\,dB$$

$$L_{move} = -\alpha_0 f x$$

$$= -\alpha_0 \cdot f \cdot 2(\text{maxdepth})$$

$$= -\alpha_0 f \cdot 4\frac{d^2}{4\lambda}$$

$$= -\alpha_0 \cdot f^2 \cdot \frac{d^2}{c}$$

Thus

$$-60 = -\frac{0.9}{10^{-2} \times 10^6} \cdot f^2 \frac{(20\times10^{-3})^2}{1540}$$

$$f = 1.6\,MHz$$