Frequently asked questions

Question:

What is acoustic matching?

Is it necessary to assemble my transducer with an acoustic matching layer?

Answer:

In many cases piezoelectric transducers are used for sending wave fronts from the piezoelectric transducer into a different media, for example body-tissue or steel, and then analysing the returning echo in order to determine the distance and nature of the various details inside this media.

Acoustic waves (or any other form of waves) that are transmitted onto a different material however unfortunately tend to reflect from its boundaries. Sound waves, in for instance a metal bar, will tend to circulate inside it, rather than propagate freely into the surrounding air. The wave will not cross the boundary between the metal bar and air very easily, but tends to bounce off the interior walls and keep "reflecting" inside the metal bar, like a ricocheting bullet, until it finally runs out of energy and dies out. In the case of a metal bar, this can take relatively long time, since metal is not very "lossy".

If the transmitted waves from a transducer, as described above, bounce from the external walls, it is clear, that the transmitted signal will be very weak, and that the returning echoes cannot be differentiated from the internally circulating waves.

The problem is that the acoustic impedances of different materials often are very different. It is thus very difficult for the sound waves to travel directly from the heavy “high impedance” piezoelectric ceramic into the lighter “low impedance” materials such as air, body tissue, or even light metals.

The reason for this can be explained by the difference in the wavelength through different materials. The sound velocity is often directly dependent on the density of the material. PZT with a density of 8 g/cm 3 for example has a sound velocity, v, of approximately 4000 m/s, while water with a density of 1 g/cm 3 has a sound velocity of only 1500 m/s.

The wavelength is then defined by the formula:

$$\lambda = \frac{v}{f}$$

If a transducer for example has an operation frequency of 1 MHz, this gives a wavelength of 4 mm in PZT, while it is only 1.5 mm for water. This difference is too large for the waves to propagate directly from PZT to water or vice-versa without significant reflection.

If a single or more intermediate layers are used in-between the PZT and water the sound waves are however allowed to gradually propagate into the next media without the necessity to change its wavelength by very much. The optimum acoustic impedance should be in-between the impedances on each side of the matching layer:

$$Z_{matching} = \sqrt{Z_{transducer} \cdot Z_{media}}\ ,$$

Where the acoustic impedance is defined by the speed of sound of the material and its density, ρ, according to the formula: $Z_{acoustic} = v_{sound} \cdot \rho$

In practice this is obtained either be choosing a glass, light metal, or by making a suitable mixture of metal powder and epoxy.

For most transducers the thickness of the layer should be equal to one fourth the wavelength of the ultrasound in the matching layer (λ/4 wave matching). The sound-waves, which are reflected from the outer surface of the matching layer back to the inner surface of the layer, will then have travelled 2·λ/4 = λ/2 wavelength. It will however be 180° out of phase with the originally transmitted sound-waves. The reflected waves are thus cancelled out due to destructive interference.