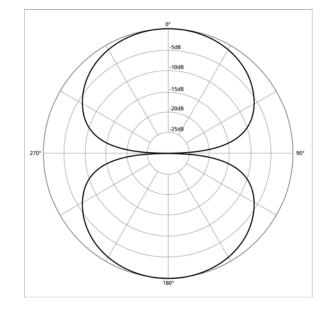
The over-pressure *difference* signal is input to an *integrating* op-amp, which electronically carries out the above integral operation. The voltage signal output from the integrating op-amp is thus *proportional* to the 1-D particle velocity $\tilde{u}_r(\vec{r},t) = \tilde{u}_r(\frac{1}{2}(\vec{r_1} + \vec{r_2}),t)$! Using 3 such microphone pairs (in orthogonal *x-y-z* orientation) thus yields the full 3-D particle velocity $\tilde{u}(\vec{r},t)$!

The use of matched pairs of omni-directional pressure microphones separated by a small distance $\Delta z \ll \lambda$ to measure the local pressure gradient $\Delta_z \tilde{p}(\vec{r},t)/\Delta z$ and thereby infer (*i.e.* compute) the local 1-D particle velocity $\partial \tilde{u}_z(\vec{r},t)/\partial t$ is known as the so-called *p***-***p* method.

If the diaphragm of the pressure microphone is <u>fully-open</u> (*i.e.* not enclosed), such a microphone {of characteristic longitudinal/z-dimension d} measures the local over-pressure <u>difference</u> $\Delta \tilde{p}_{dia}(\vec{r},t) = \tilde{p}_{dia}^{front}(\vec{r},t) - \tilde{p}_{dia}^{rear}(\vec{r},t)$ for $d \ll \lambda - i.e.$ it becomes a <u>differential-pressure</u> microphone. Furthermore, it is obvious that differential pressure microphones have a vectorial-type directional response, since the voltage signal output from this microphone will reverse its sign if the differential pressure microphone is rotated about its symmetry axis by 180°. The angular response of a differential pressure microphone is therefore vectorially described by $\Delta \tilde{p}_{dia}(\vec{r},t)\hat{n}$ where \hat{n} is defined as the **outward** pointing unit vector from the front surface of the microphone diaphragm. For a sound wave with vector wavenumber $\vec{k} = |\vec{k}| \hat{k} = k\hat{k} (\hat{k} ||$ to the propagation direction), the **angular** response of the differential pressure microphone is $\Delta \tilde{p}_{dia}(\vec{r},t)\hat{n}\cdot\hat{k} = \Delta \tilde{p}_{dia}(\vec{r},t)\cos\Theta$ where Θ is the 3-D opening angle between \hat{n} and \hat{k} .

Thus when: $\Theta = 0^{\circ}$, $\hat{n} \cdot \hat{k} = \cos \Theta = +1$ and: $\Delta \tilde{p}_{dia}(\vec{r}, t) \hat{n} \cdot \hat{k} = +\Delta \tilde{p}_{dia}(\vec{r}, t)$. When: $\Theta = 90^{\circ}$, $\hat{n} \cdot \hat{k} = \cos \Theta = 0$ and: $\Delta \tilde{p}_{dia}(\vec{r}, t) \hat{n} \cdot \hat{k} = 0$. When: $\Theta = 180^{\circ}$, $\hat{n} \cdot \hat{k} = \cos \Theta = -1$ and: $\Delta \tilde{p}_{dia}(\vec{r}, t) \hat{n} \cdot \hat{k} = -\Delta \tilde{p}_{dia}(\vec{r}, t)$.

The polar response of a *differential* pressure microphone is a *figure-8 pattern*, as shown below:



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