



SCIENCE FOR THE BENEFIT OF HUMANITY

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# A Novel Unidirectional Active Microphone

RU 1023

## Technology Summary

Amplification underlies the functioning of many biological and engineering systems. Simple electrical, optical, and mechanical amplifiers are usually reciprocal, that is the backward coupling of the output to the input equals the forward coupling of the input to the output. Unidirectional amplifiers are special non-reciprocal devices in which the output does not couple back to the input even though the forward coupling persists. Examples of unidirectional amplifiers include operational amplifiers in electrical engineering and magneto-optical devices in microwave technology.

Mechanical amplification can enhance the detection of a weak signal by raising its amplitude above the noise level. Biology employs this strategy in hearing: mechanosensitive hair cells in the vertebrate inner ear actively amplify weak sounds and thereby greatly lower the threshold of hearing. In contrast, microphones - the ear's technological analogue - are passive devices that do not employ mechanical amplification but rely on subsequent electronic signal processing. One difficulty in implementing mechanical amplification in microphones is the reciprocity described above, which leads to undesired feedback and hence highlights the need for a mechanism to implement unidirectional mechanical amplification.

Our scientists have constructed an active microphone that mimics the mechanical function of hair cells, which provide piezoelectric coupling between the input and output resulting in unidirectional amplification. This dynamic microphone can detect weak signals and there is no audible distortion, and could be used in various applications where the sensitive detection of mechanical signals at specific frequencies is required, such as sonar, sonography, or seismography.

## Advantage

Improved detection of weak signals and elimination of distortion/audio feedback

## Area of Application

Improvement for microphones, sonar devices, sonographic devices (e.g. ultrasound), and seismological devices.

## Stage of Development

A prototype of the active microphone is available

## Inventors

Dr. James Hudspeth and Dr. Tobias Reichenbach

## Patent Information

U.S. Patent 9,084,051 (issued July 14, 2015)

## References

Reichenbach, T. & A. J. Hudspeth (2011). [Unidirectional mechanical amplification as a design principle for an active microphone](#). Phys. Rev. Lett., vol. 106, p. 158701.

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