Komunikačná akustika

L06: Mikrofóny

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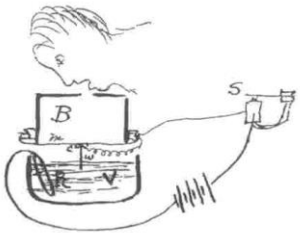
Čo je mikrofón ?

- Je to akusticko-elektrický senzor, ktorý sníma zvuk a mení ho na elektrický signál
- Skladá sa z akusického prijímača a elektroakustického meniča
- Typické oblasti masívneho používania mikrofónov sú napr.:
  - telekomunikácie a rádiokomunikácie (v telefónoch a rádiových vysielačkách),
  - načúvacie prístroje pre sluchovo postihnutých,
  - ozvučovacie systémy (tzv. „public address systems“ v kongresových halách a posluchárňach),
  - rozhlas, televízia a filmový priemysel
  - nahrávacie hudobné štúdiá,
  - počítače (nahrávanie zvuku, rozpoznávanie reči, VoIP a pod.),
  - atď.

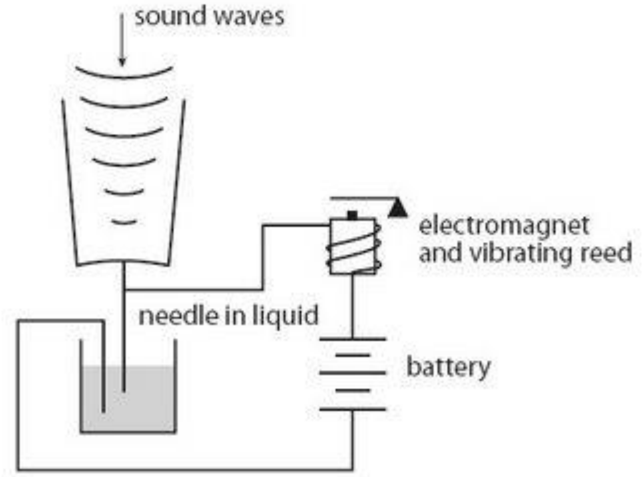
História mikrofónov

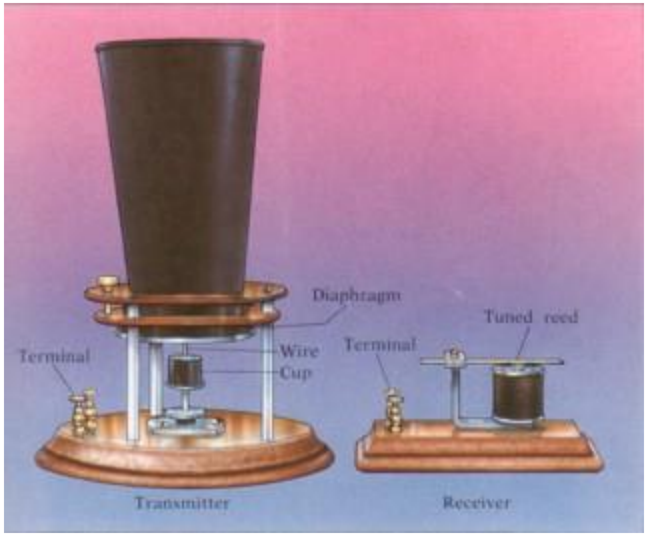
- Johann Philipp Reis (1861) – membrána spojená ihlou, ktorá tlačila na kovový kontakt – výsledkom bol spínaný prúd (v rytme kmitania membrány) – použitie v jednom z prvých tónových telegrafov.
- Bellov tekutinový transmitter (Bell's liquid transmitter) – 1876 - Alexander Graham Bell.
- Uhlíkový mikrofón – 1877 - skonštruovaný nezávisle Davidon Edwardom Hughesom, Emile Berlinerom a Thomasom A. Edisonom.
- Kondenzátorový mikrofón – 1916 - Edward Christopher Wente - Bellove Laboratória (Bell Labs).
- Piezoelektrický mikrofón – 1919 - Alexander Nicolson – Seignettova soľ - v tom čase bez komerčného nasadenia.
- Dynamický mikrofón (moving coil microphone) – 1923 – skonštruovaný E. C. Wentem a Albertom L. Thurasom – Western Electric. Komerčne nasadený v 30tych rokoch.
- Páskový mikrofón (ribbon microphone) – 1923 - Harry F. Olson – RCA Research.
- Elektretový kondenzátorový mikrofón - 1938 - Bogen Company



Bell's liquid transmitter

- A metal cup is filled with water with a small amount of sulfuric acid added
- A sound wave caused the diaphragm to move, forcing a needle to move up and down in the water.
- The electrical resistance between the wire and the cup was then inversely proportional to the size of the water meniscus around the submerged needle.





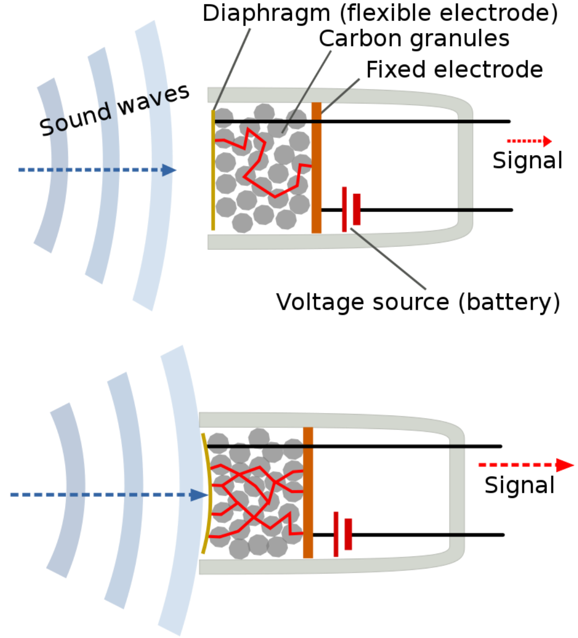
Súčasné typy mikrofónov

(podľa fyzikálneho princípu činnosti)

- Kondenzátorové mikrofóny
  - DC-biased condenser microphone
  - RF condenser microphones
  - Electret condenser microphone
- Dynamic microphone
  - Moving-Coil microphone
  - Ribbon microphone
- Carbon microphone
- Piezoelectric microphone
- Fiber optic microphone
- Laser microphones
- MEMS microphone

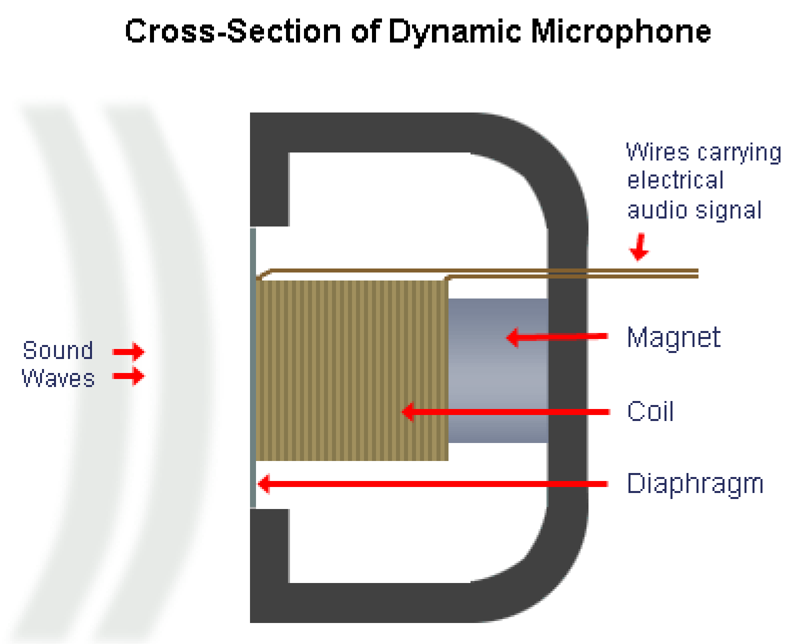
Uhlíkový mikrofón

- Vyvinutý nezávisle Davidon Edwardom Hughesom, Emile Berlinerom a Thomasom Edisonom (1877)
- Operation of carbon microphone - when a sound wave presses on the conducting diaphragm, the granules of carbon are pressed together and decrease their electrical resistance.
- The principal advantage of carbon microphones over other microphone designs is that they can produce high-level audio signals from very low DC voltages, without needing any form of additional amplification or batteries.
- Carbon microphones are also widely used in safety-critical applications such as mining and chemical manufacturing, where higher line voltages cannot be used, due to the risk of sparking and consequent explosions.



Moving-coil dynamic microphone

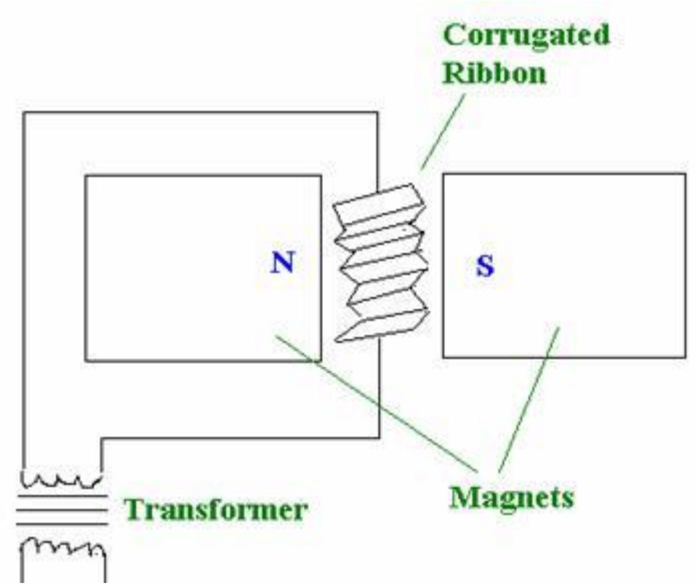
- Moving-coil microphones use the same dynamic principle as in a loudspeaker, only reversed. A small movable induction coil, positioned in the magnetic field of a permanent magnet, is attached to the diaphragm. When sound enters through the windscreen of the microphone, the sound wave moves the diaphragm. When the diaphragm vibrates, the coil moves in the magnetic field, producing a varying current in the coil through electromagnetic induction.
- A single dynamic membrane does not respond linearly to all audio frequencies. Some microphones for this reason utilize multiple membranes for the different parts of the audio spectrum and then combine the resulting signals. Combining the multiple signals correctly is difficult and designs that do this are rare and tend to be expensive.
- They are robust, relatively inexpensive and resistant to moisture. This, coupled with their potentially high gain before feedback, makes them ideal for on-stage use.



Ribbon microphone

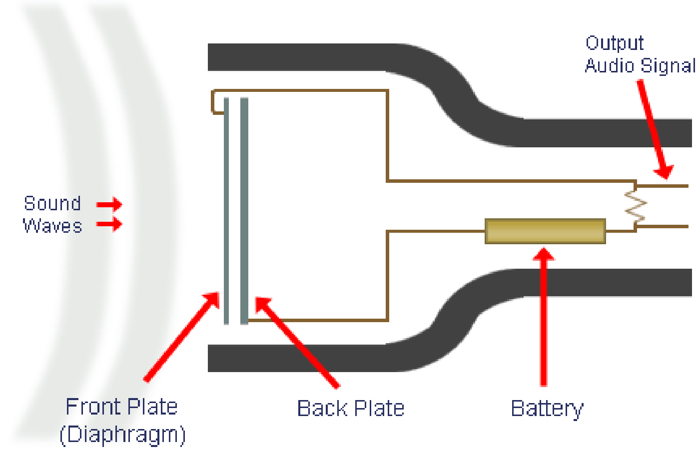
- Ribbon microphones employ electromagnetic induction to convert sound to voltage.
- A long thin strip of conductive foil moves within a magnetic field to generate a current hence voltage.
- The foil's lower weight when compared to a moving coil gives it a smother and higher frequency response.
- However the relatively low output requires a step up transformer.

- Ribbon microphones are good for quality studio recording of acoustic instruments though can be delicate, for instance you wouldn't want to put one in front of a bass cabinet.



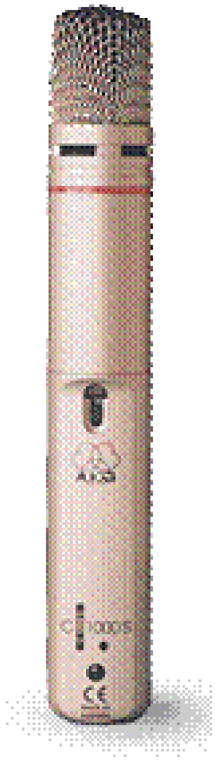
Kondenzátorový mikrofón

- A capacitor has two plates with a voltage between them.
- One of these plates is made of very light material and acts as the diaphragm.
- The diaphragm vibrates when struck by sound waves, changing the distance between the two plates and therefore changing the capacitance.
- Condenser microphones require power from a battery or external source (phantom power).
- The resulting audio signal is stronger signal than that from a dynamic.
- Condensers also tend to be more sensitive and responsive than dynamics, making them well-suited to capturing subtle nuances in a sound.
- They are not ideal for high-volume work, as their sensitivity makes them prone to distort.



Electret microphone

- The electret condenser mic uses a special type of capacitor which has a permanent voltage built in during manufacture.
- This is somewhat like a permanent magnet, in that it doesn't require any external power for operation.
- However good electret condenser mics usually include a pre-amplifier which does still require power.
- However the diaphragm requires a larger mass to hold the electrostatic charge adversely effecting frequency response.
- However, recently some high quality examples have begun to appear such as the AKG C1000S. Called ‘Back Electrets’ they can have similar diaphragms to traditional condenser microphones by applying the electrostatic charge to the rigid back plate.



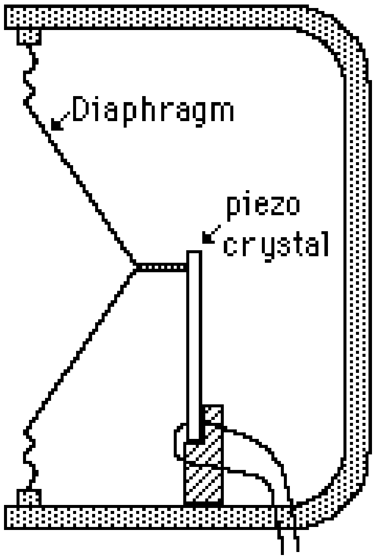
RF condenser microphones

- RF condenser microphones use a comparatively low RF voltage, generated by a low-noise oscillator.
- The signal from the oscillator may either be amplitude modulated by the capacitance changes produced by the sound waves moving the capsule diaphragm, or the capsule may be part of a resonant circuit that modulates the frequency of the oscillator signal.
- Demodulation yields a low-noise audio frequency signal with a very low source impedance.
- The absence of a high bias voltage permits the use of a diaphragm with looser tension, which may be used to achieve wider frequency response due to higher compliance.

SENNHEISER MKH 816T (RED DOT) LONG SHOTGUN MICROPHONE

Piezoelectric (crystal) microphone

- A crystal microphone or piezo microphone uses the phenomenon of piezoelectricity—the ability of some materials to produce a voltage when subjected to pressure—to convert vibrations into an electrical signal.
- The frequency response of crystal microphones is often limited to a relatively narrow band restricting their application.
- Piezoelectric transducers are often used as contact microphones to amplify sound from acoustic musical instruments, to sense drum hits, for triggering electronic samples, and to record sound in challenging environments, such as underwater under high pressure.

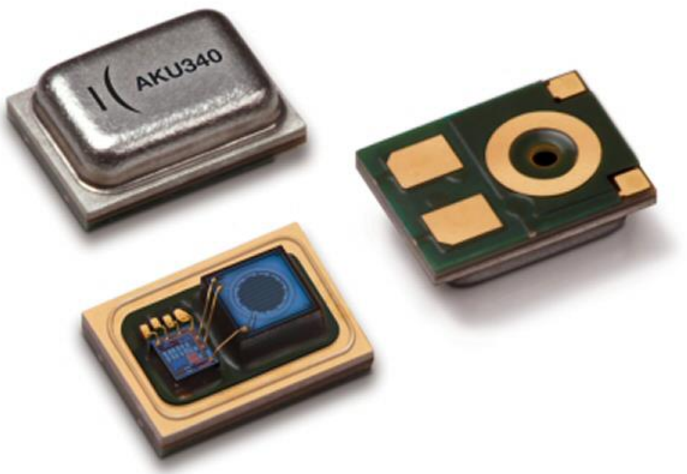


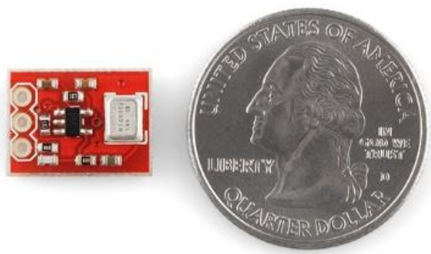
Fiber optic microphone

- A fiber optic microphone converts acoustic waves into electrical signals by sensing changes in light intensity.
- During operation, light from a laser source travels through an optical fiber to illuminate the surface of a reflective diaphragm.
- Sound vibrations of the diaphragm modulate the intensity of light reflecting off the diaphragm in a specific direction.
- The modulated light is then transmitted over a second optical fiber to a photo detector, which transforms the intensity-modulated light into analog or digital audio for transmission or recording.
- Fiber optic microphones possess high dynamic and frequency range, similar to the best high fidelity conventional microphones.
- Fiber optic microphones are robust, resistant to environmental changes in heat and moisture, and can be produced for any directionality or impedance matching.
- The distance between the microphone's light source and its photo detector may be up to several kilometers without need for any preamplifier or other electrical device, making fiber optic microphones suitable for industrial and surveillance acoustic monitoring.

MEMS microphone

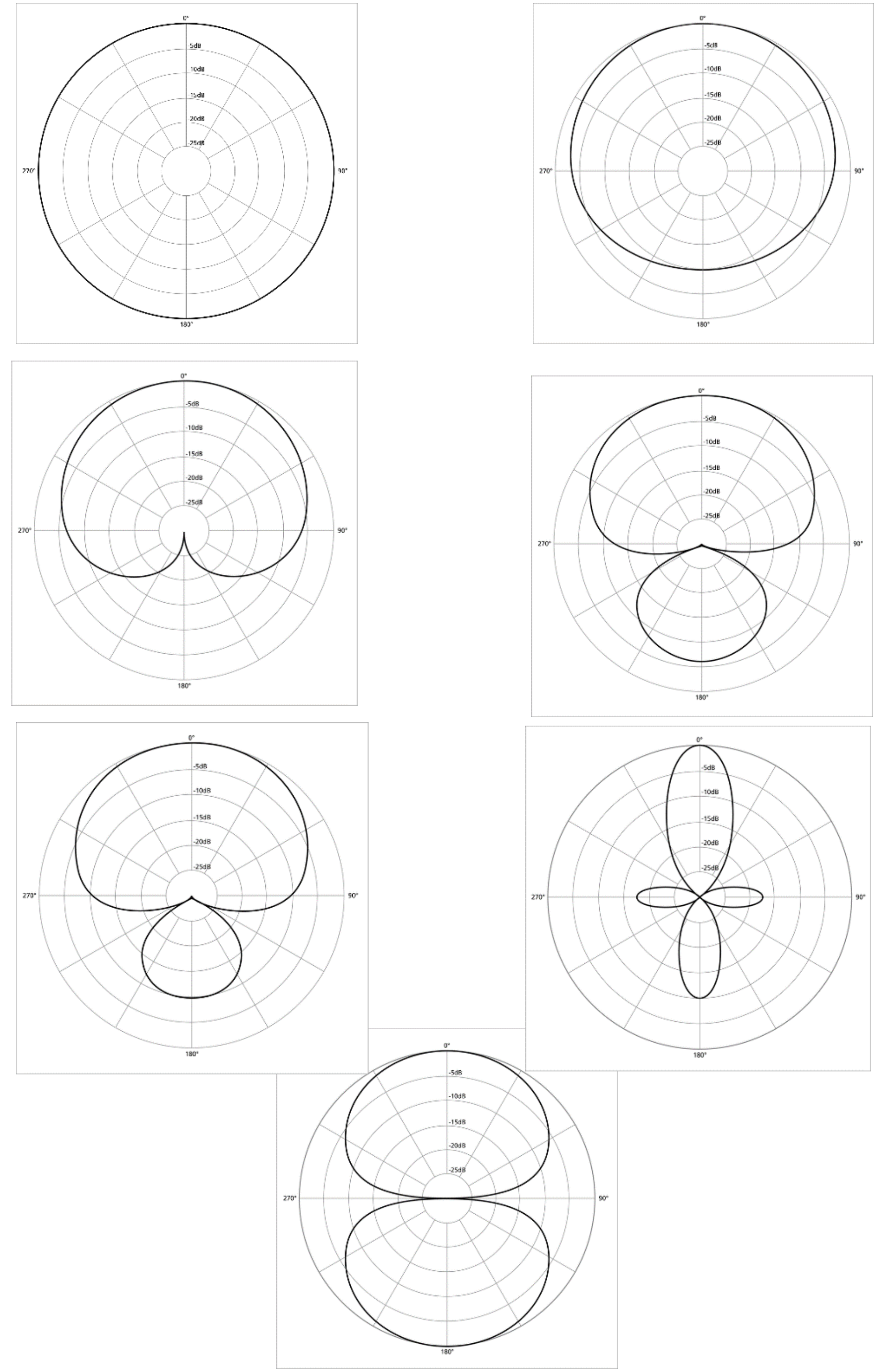
- The MEMS (MicroElectrical-Mechanical System) microphone is also called a microphone chip or silicon microphone.
- A pressure-sensitive diaphragm is etched directly into a silicon wafer by MEMS processing techniques, and is usually accompanied with integrated preamplifier.
- Most MEMS microphones are variants of the condenser microphone design.
- Digital MEMS microphones have built in analog-to-digital converter (ADC) circuits on the same CMOS chip making the chip a digital microphone and so more readily integrated with modern digital products.





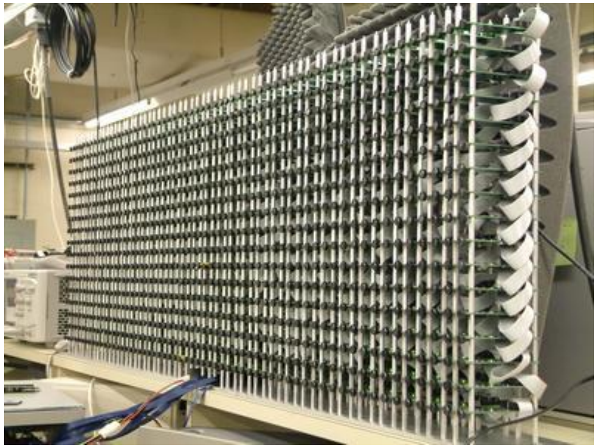
Typy mikrofónov
(podľa smerových vlastností)

- Every microphone has a property known as directionality.
- This describes the microphone's sensitivity to sound from various directions.
- The types of directionality are divided into three main categories:
  - **Omnidirectional.** Picks up sound evenly from all directions (omni means "all" or "every").
  - **Unidirectional.** Picks up sound predominantly from one direction. This includes subcardioid, cardioid and hypercardioid, supercardioid and shotgun, microphones.
  - **Bidirectional.** Picks up sound from two opposite directions.



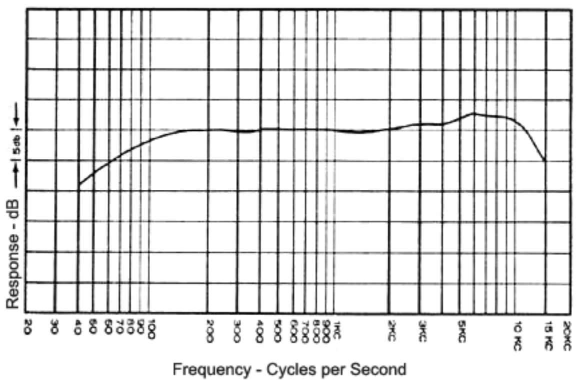
Špeciálne typy mikrofónov

- Lavalier microphone
  - A small electret or Ribbon diaphragm used for television, theatre, and public speaking applications in order to allow for hands-free operation.
- Wireless microphone
- Contact microphone
  - Throat microphone
- Parabolic microphone
- Stereo microphone
- Noise canceling microphone
- Microphone arrays



Vlastnosti mikrofónov

- Microphone sensitivity.
  - When choosing a microphone pressure sensitivity is an important parameter.
  - A microphone’s sensitivity (pressure sensitivity) is defined as the voltage generated in response to a certain pressure input.
- Microphone Frequency Response
  - Flat response
  - Tailored response



- Microphone Impedance
  - (Low impedance is better than high impedance)
  - Low Impedance (less than 600Ω)
  - Medium Impedance (600Ω - 10,000Ω)
  - High Impedance (greater than 10,000Ω)

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