Microphones

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Partially based on:

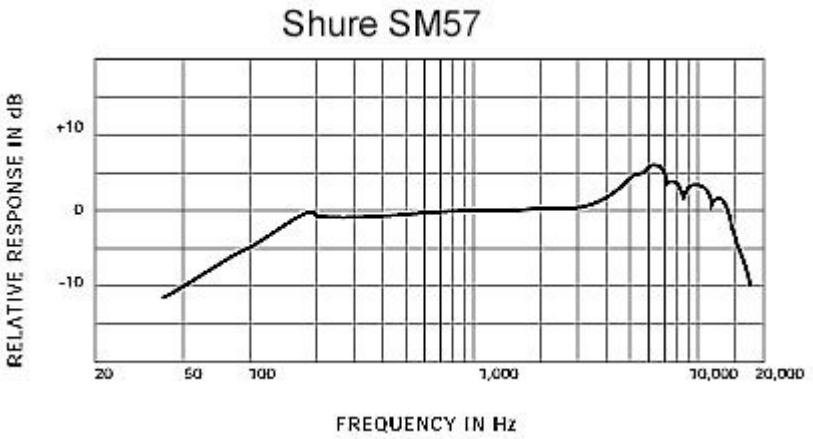
- Christopher Ariza. 21M.380 Music and Technology: Recording Techniques and Audio Production. Spring 2012. Massachusetts Institute of Technology: MIT OpenCourseWare, https://ocw.mit.edu. License: Creative Commons BY-NC-SA.
- Digital Audio Production IT3038PA, NITEC Digital Audio & Video Production. 2013. Institute of Technical Education College West.

Microphones

- Microphones are transducers
- Transduction:
  - conversion of one form of energy to another form
- Acoustic ➔Electrical

Microphones

- Transducers always act as a filter
- A frequency domain graph (frequency response curve) is used to show the effect of transduction
- All mics have a diaphragm
- A diaphragm is a thin piece of material that vibrates in response to sound waves to produce electric signals



Microphone Specifications

- Frequency response curves
- Transient response
  - accurately capture abrupt or sudden change in level
- Self-noise
  - identify the microphones internal noise floor
- Sensitivity
  - Given as negative dB: -57 dB (higher number means more sensitive)
  - Amount of boost required to raise input to 0 dBu
- Maximum SPL

Microphone Parts

- Diaphragm
  - Large: greater than a few centimeters
  - Small: Smaller diaphragms have less off-axis coloration
- Capsule
  - contains diaphragm as well as mount and possibly a pre-amp
- Transduction Method
  - Magnetic Induction
  - Variable Capacitance
- Transducer Type
  - Condenser (Variable Capacitance)
  - Moving Coil or Dynamic (Magnetic Induction)
  - Ribbon (Magnetic Induction)

Magnetic Induction

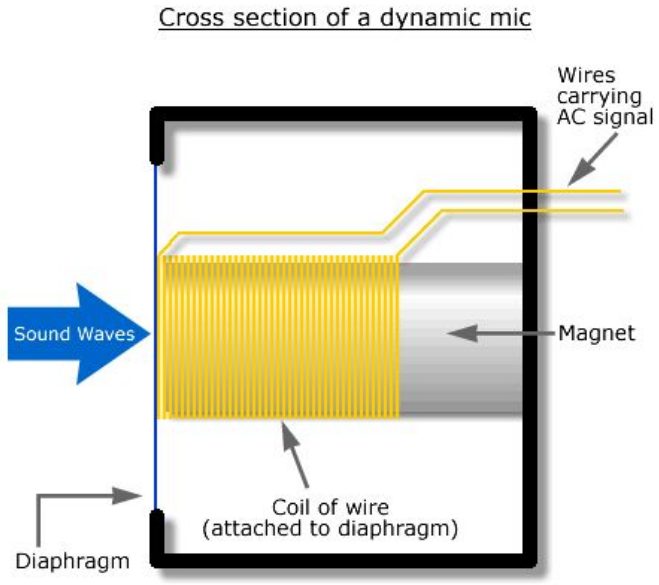
- Electromagnetic force
- Moving metal in a magnetic field produces voltages
- Induce a voltage with a magnet
- Used in ribbon and dynamic mics
- Do not require power to operate

Variable Capacitance

- Electrostatic force
- Two closely-spaced, parallel plates: one fixed, one acts as a diaphragm
- Stored charge, between plates, varies due to acoustical pressure
- Requires power to charge plates (usually 48 V phantom power)
- Output is very small small; must be amplified in microphone

Dynamic Microphones

- Metal is a coil attached to a diaphragm that moves within a magnetic field
- Have big magnets: heavy
- Diaphragm must move relatively large distance: slower transient response
- Durable, can handle high SPLs
- Inexpensive and most commonly used

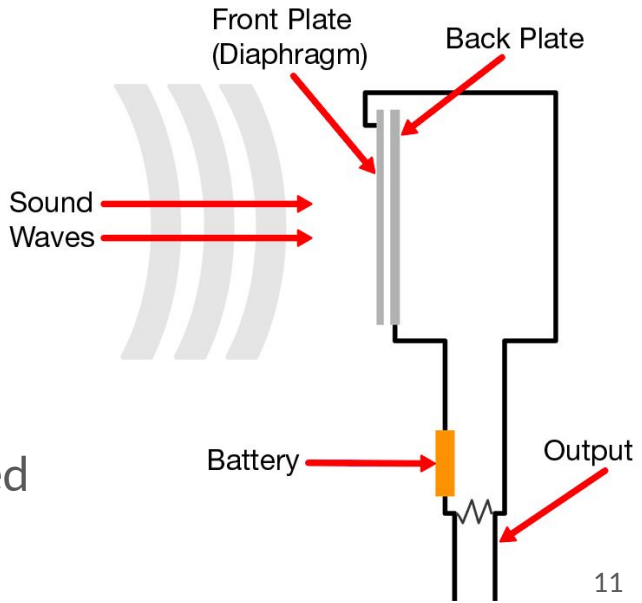


Dynamic Microphones

- May colour sound between 5 and 10 kHz
- Does not capture high frequencies well
- Phantom power not necessary, does not hinder performance
- Often used in close-miking, within a foot of source; can be very close
- Generally used in concerts and live performances

Condenser Microphones

- Diaphragm made from very thin material:
  - high sensitivity
- Diaphragm must move relatively small distance:
  - fast transient response
- Phantom power necessary
- Delicate and accurate
- Cannot handle high SPLs: distortion or damage
- Internal preamp may be transistor- or tube-based

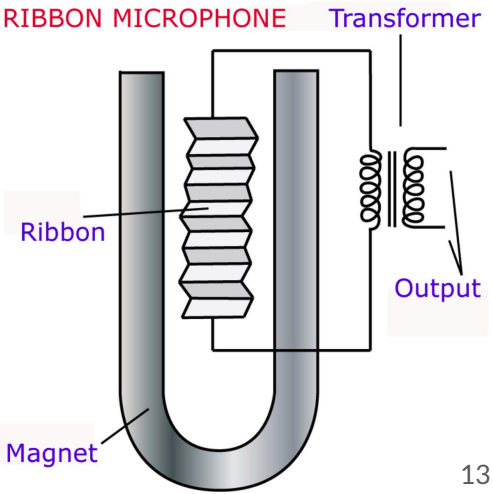


Condenser Microphones

- Often offers less coloration: Sounds more natural than a Dynamic microphone
- More sensitive frequency response and can pick up the subtle nuances of a performance more effectively
- The standard for most studio applications that require maximum clarity, subtlety and detail in the recording

Ribbon Microphones

- Metal is a thin ribbon
- Ribbon suspended between poles of a magnet
- Old ribbon mics were very fragile and unreliable
- Newer models are better
- Known for warm sound when used in close proximity
- Phantom power can cause old models to fry



Directional Response

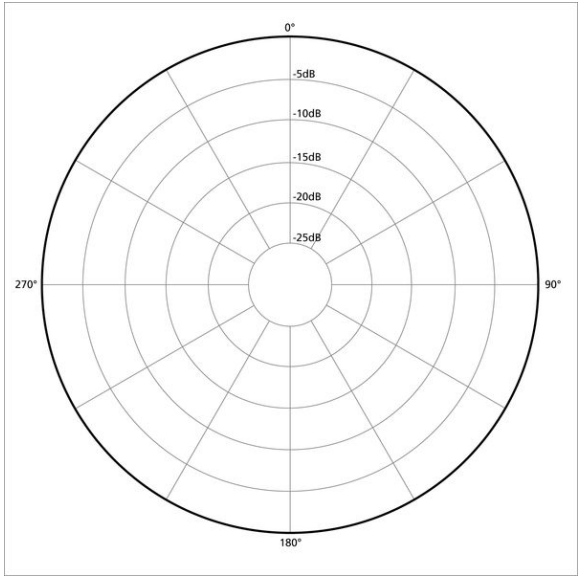
- Microphones pick up sound in various patterns (due to pressure or pressure gradient)
- Called polar pattern, pickup pattern, or directional response
- Microphones have a “front” or primary point of address, called on-axis
- Degrees are used to describe off-axis position (reverse is 180 degrees off-axis)
- Pickup patterns are in expanding three-dimensional spaces

Directional Response

- Different pickup patterns have different directional “pull” (sensitivity, or directional response)
- Some microphones have variable patterns with switches or interchangeable capsules
- The types of directional response are divided into three main categories: Omnidirectional, Bidirectional, Unidirectional
- A polar pattern is a graph to show directional properties of microphones.
- Often found in microphone user manuals or promo material.

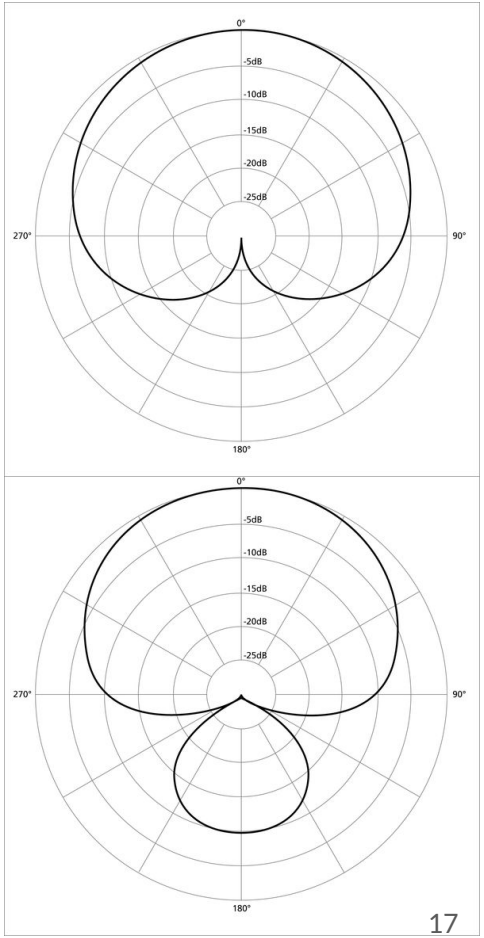
Omnidirectional

- Gather sound from all around, called an “omni”
- Useful for gather reflections and space of a sound
- Not considered a “directional” microphone
- No proximity effect



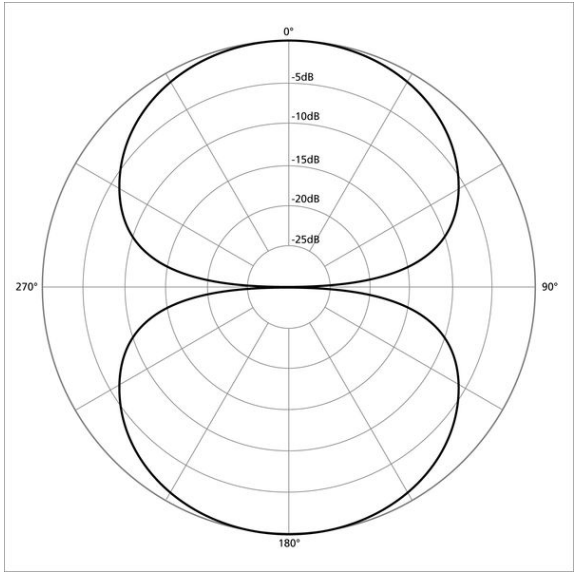
Unidirectional

- Gather sound from one primary direction
- Useful for focusing in on a singular sound source
- Various types of cardioids: reject sound from the rear
- Cardioid:
  - Sound is picked up mostly from the front
- Super-cardioid:
  - Exaggerated version of cardioid pattern
  - Very directional; eliminates most sound from sides & rear, also called ‘Shotgun’ microphones



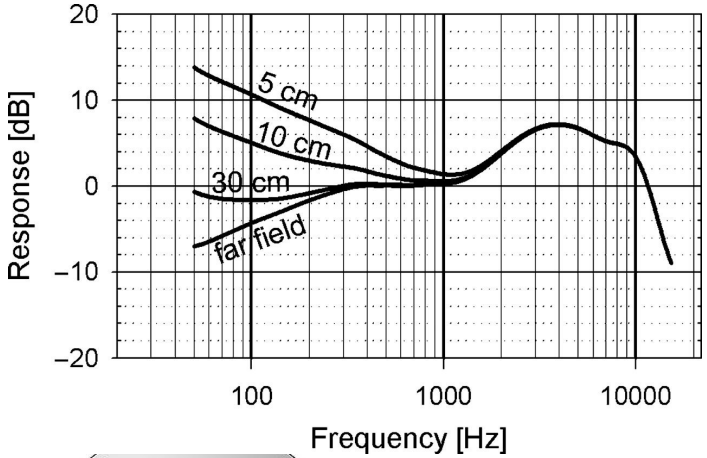
Bidirectional

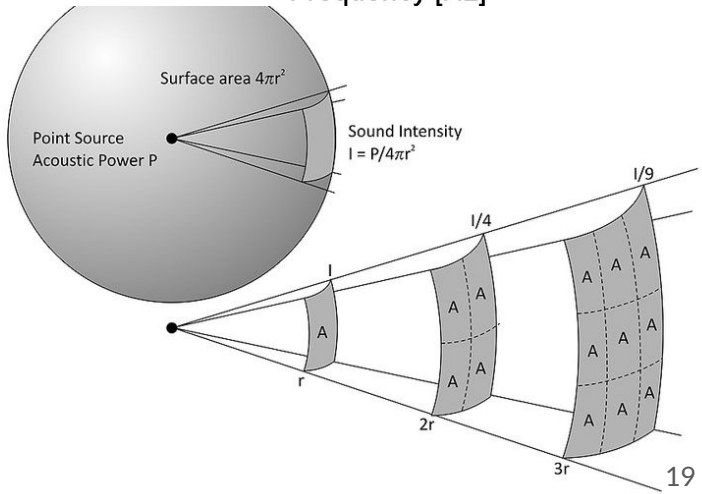
- Gather sound from two sides, called a “figure-eight”
- Useful for complete side rejection and rejection
- Useful for capturing reverse reflections
- Useful for getting two sources into one channel
- Common polarity of ribbon microphones



Proximity Effect

- Bass frequencies are exaggerated when sound source is very close to directional microphones (cardioid or figure-eight)
- Present in bidirectional or unidirectional microphones
- Low cut filters are often provided on microphones to mitigate





Stereo versus Mono Microphone Techniques

- Instruments that are large or have diverse points of resonance or movement are often captured in stereo:
  - Piano, harp, percussion keyboard (marimba, xylophone, vibraphone), acoustic guitars, leslie speaker cabinets
- Instruments and sound sources that have a focused output are often captured in mono:
  - Single drums, brass, woodwinds, and other aerophones, string instruments: violin, bass, cello, speaker cabinets

Microphone Techniques: Close Captures

- In general, monophonic captures are close
- Closeness offers an intimate sound and good isolation (least leakage)
- Closeness may remove or reduce reflections (ambience, reverb)
- Closeness can lead to unbalanced frequency response
- Closeness can lead to undesirable air-bursts or physical contact
- Ribbons (figure eight), dynamic (cardioids), and large-diaphragm condensers (cardioids) most often used

Microphone Techniques: Vocals

- Lots of air, mouth noises, and breathing
- Proximity to nose can increase nasal sound
- Always use pop-screens to avoid plosives
- From 6 to 20 inches recommended
- Large diaphragm condensers always preferred

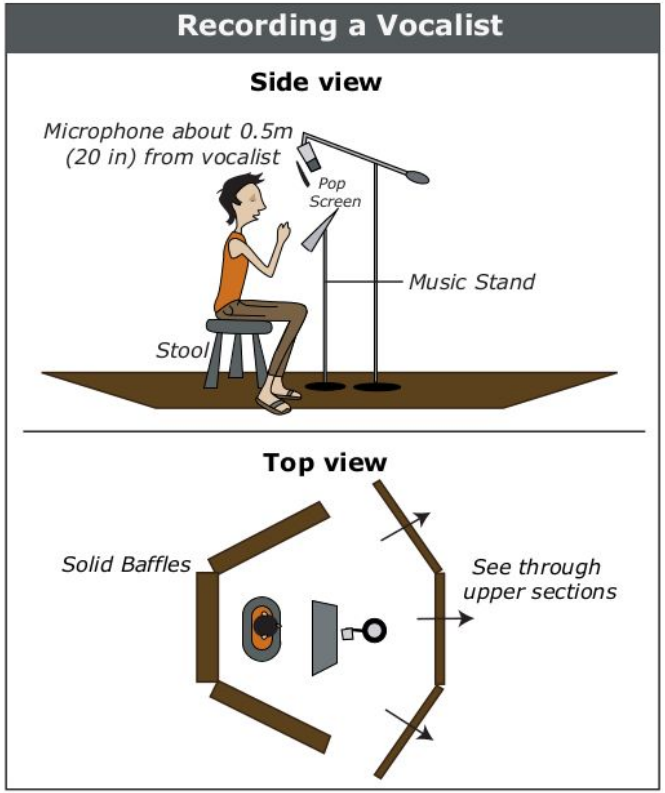


Image by MIT OpenCourseWare.

Microphone Techniques: Strings

- Close captures of strings can be very unnatural
- Often need some space for resonance and smoothing
- f-holes and sound holes offer focus of output
- Microphone diaphragm should be aligned to plane of sound board
- Radiation is in three dimensions
- Favour large-diaphragm condensers

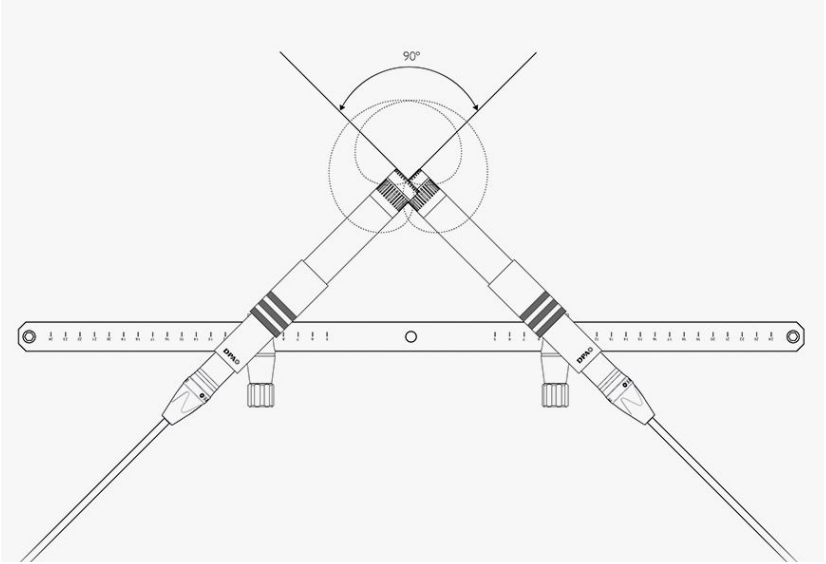
Stereo Microphone Techniques

- Why stereo?
  - depth or distance of sound source
  - distance of the sounds from the listener (perspective)
  - spatial sense of the acoustic environment, ambience or room.
- How?
  - use two microphones
  - positioning of the two microphones is important for a true stereo image

- Common techniques:
  - XY Configuration
  - ORTF Configuration
  - A/B or Spaced Pair

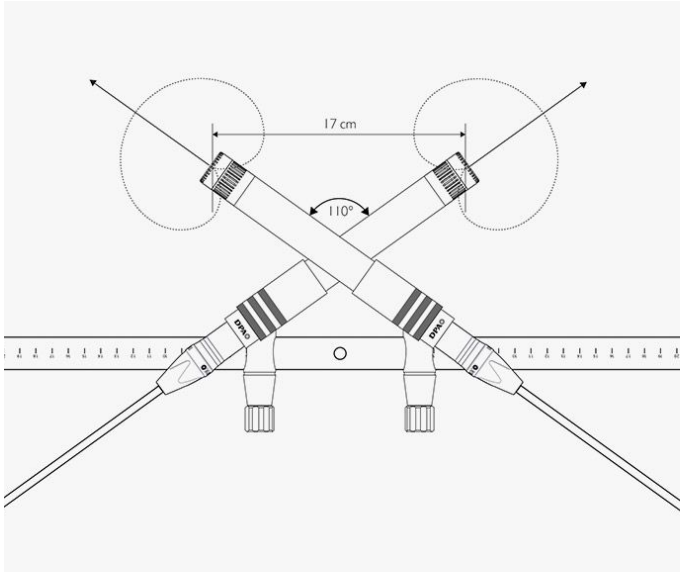
XY Configuration

- Two cardioid microphones placed at a 90 degree angle to each other
- Microphone on the left is wired to the right channel, and vice versa
- Lose a little depth, but lack of ambient information
- Best used in a difficult-sounding room, to "zoom in" on the sound
- Choice for close-miking applications



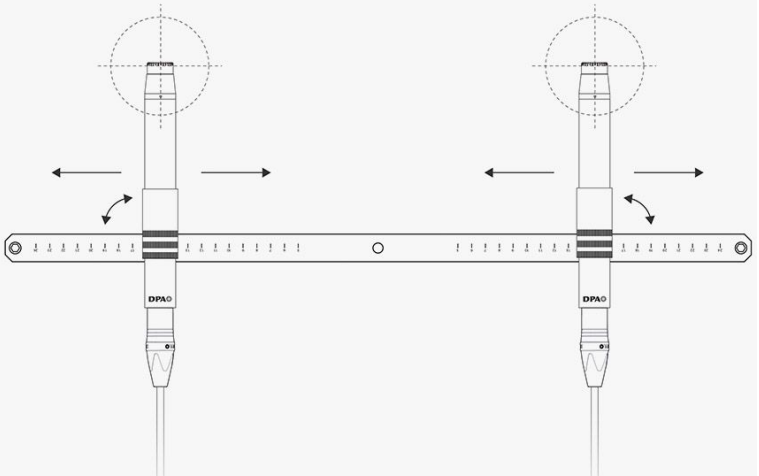
ORTF Configuration

- Two first order cardioid microphones
  - with a spacing of 17 cm between the microphone diaphragms
  - with an 110° angle between the capsules
- Reproduce stereo cues similar to how human ear perceives directional information
- Works well in poor acoustical environments
- Well-suited for concert taping



A/B or Spaced Pair Configuration

- Two microphones are pointed straight ahead at a source
- Simplest stereo technique to use, but there's not much stereo image
- Not useful for taping further back, due to lack of a good stereo image
- Preferred method for taping close to the speakers to get a cleaner sound
- Can sound good on acoustic guitar



Study, Experience, and Experimentation

- Conventional approaches based on practice and experience
- Creative approaches based on experimentation
- Walk around and listen
- Think of sound in three dimensions
  - Three dimensional radiation
  - Sound takes time to travel: 331 m/s
  - Sound travels in space: amplitudes diminish with distance
  - Reflections matter: opportunities for comb filtering / phasing distortion

Microphones: Summary

- First stage of transduction
- Permanently alters the sound of the source
- Primary considerations:
  - microphone type
  - microphone position
  - acoustical environment

Self-study Homework

- Microphone techniques
  - https://ocw.mit.edu/courses/music-and-theater-arts/21m-380-music-and-technology-recording-techniques-and-audio-production-spring-2012/lecture-notes/MIT21M_380S12_lec14.pdf
- Stereophonic microphone techniques
  - https://www.youtube.com/watch?v=7FwJS_5F6QQ
  - https://www.prosoundweb.com/channels/recording/stereo_microphone_techniques/
- https://www.dpamicrophones.com/mic-university