

# MICROPHONES



Audio Engineering I

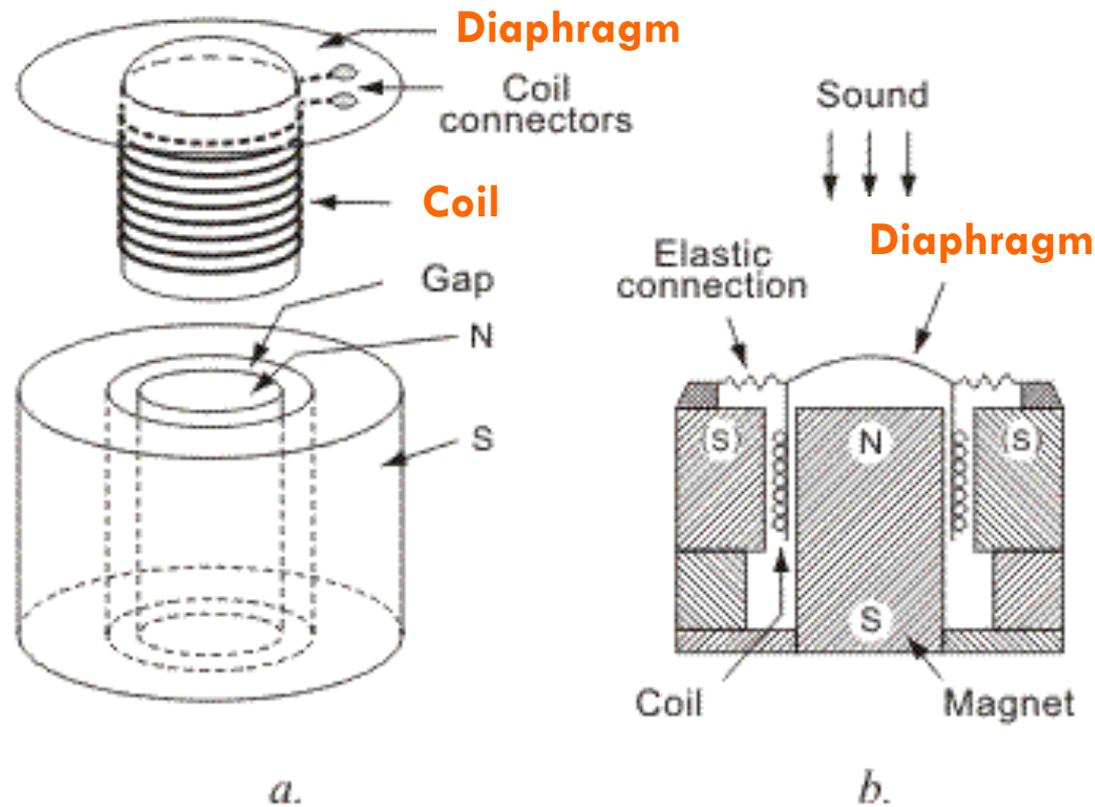
# MICROPHONE TYPES

Dynamic

Ribbon

Condenser

# Dynamic Microphones



Sl. 8.2. Dynamic microphone: a - internal structure, b - cross section

## □ Theory of *electromagnetic induction*:

- “Whenever an electrically conductive metal cuts across the flux lines of a magnetic field, a current of a specific magnitude and direction will be generated within that metal.”
- Dynamic mics and Ribbon mics operate on this principle.

# Dynamic Microphones

## □ Characteristics

- Durable
- Relatively inexpensive
- Not sensitive to changes in humidity
- Don't need external power
- Usually have a resonant peak in mid-frequency response
- Weak in frequency response over 10 kHz

# Dynamic Microphones

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## Applications

- Sound reinforcement
- Snare drum miking
- Guitar miking
- Voice-over and broadcast

# Ribbon Microphones

- Diaphragm is an extremely thin strip of aluminum foil
- Thinness of the foil gives it a great high-frequency response
- Weaker output signal than a dynamic
- Fragile
- Relatively flat frequency response
- Don't need external power to operate
- Relatively expensive

# Ribbon Microphones

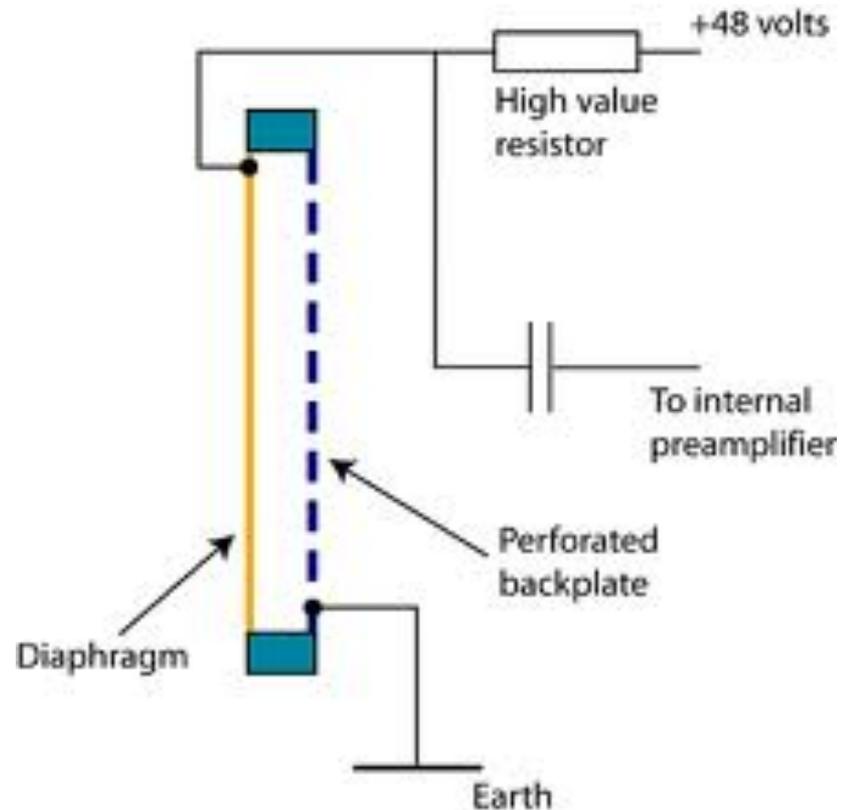
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## Applications

- Cymbals
- Bass
- Piano
- Electric and acoustic guitars
- Brass instruments

# Condenser Microphones

- Condenser = capacitor: holds an electric charge
  - ▣ 2 electrically-charged plates: a movable diaphragm and a fixed backplate
  - ▣ Sound waves move the diaphragm and change the electric voltage of the capacitor



# Condenser Microphones

- Diaphragm responds very quickly
  - ▣ Great high-frequency response
  - ▣ Responds well to short attack times (*transient response*) i.e. drums & cymbals
- Two types: small- and large-diaphragm
  - ▣ Small diaphragm condenser mics have a single pickup pattern and a relatively flat frequency response
  - ▣ Large diaphragm condenser mics can have multiple pickup patterns and have a peak in the 8-12 kHz range, making it a favorite of vocalists.
- Requires Phantom Power – supplied by all audio interfaces/mixers (+48V)
  - ▣ Some mics (especially older mics) run on a vacuum tube and require their own external power box

# Condenser Microphones

- Extended high and low frequency response
- Good ones are relatively expensive
- Cheap ones can have inconsistent frequency response
- Requires internal or external power (phantom power)
- Humidity and temperature affect performance
- Good transient response

# Condenser Microphones

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## Applications

- Cymbals
- Drum overheads
- Piano
- Acoustic guitar
- Vocals
- String sections

# Phantom Power

- Required for **condenser** microphones to work
- +48 V
- Transported to the microphone through pins 2 and 3 of the audio cable (pin 1 is a ground)

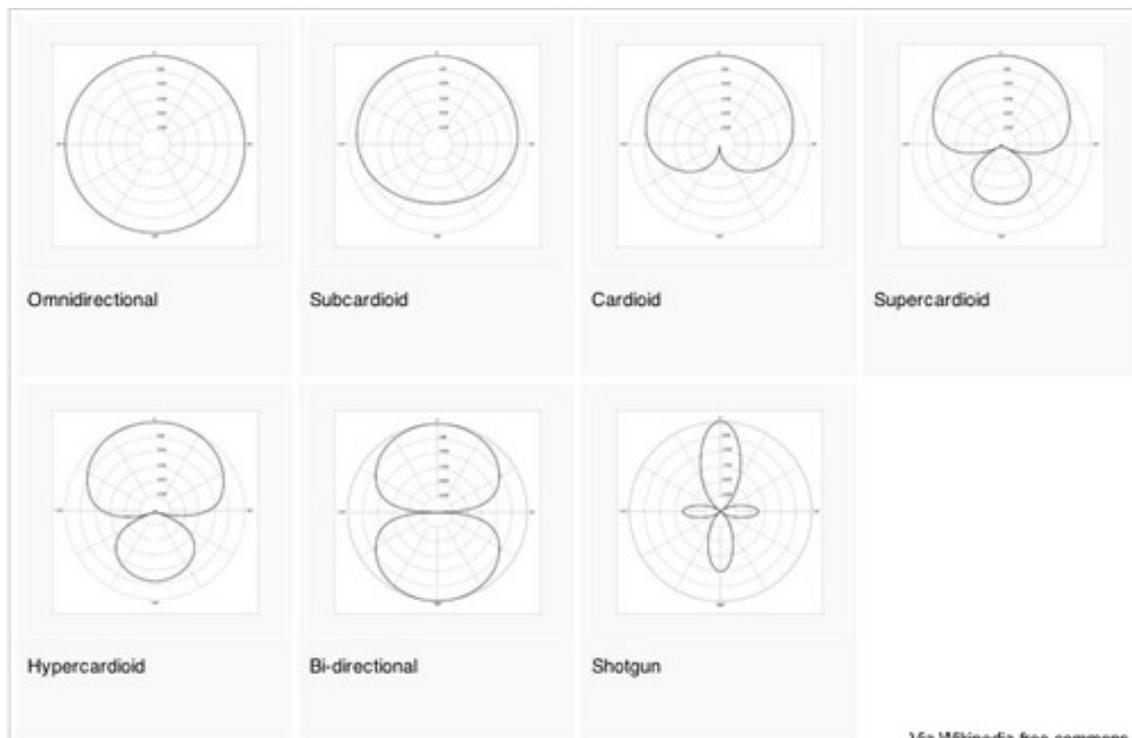


# DIRECTIONAL PATTERNS

# DIRECTIONAL RESPONSE

- A microphone's sensitivity at various angles
- Depicted on a chart called its *polar pattern*

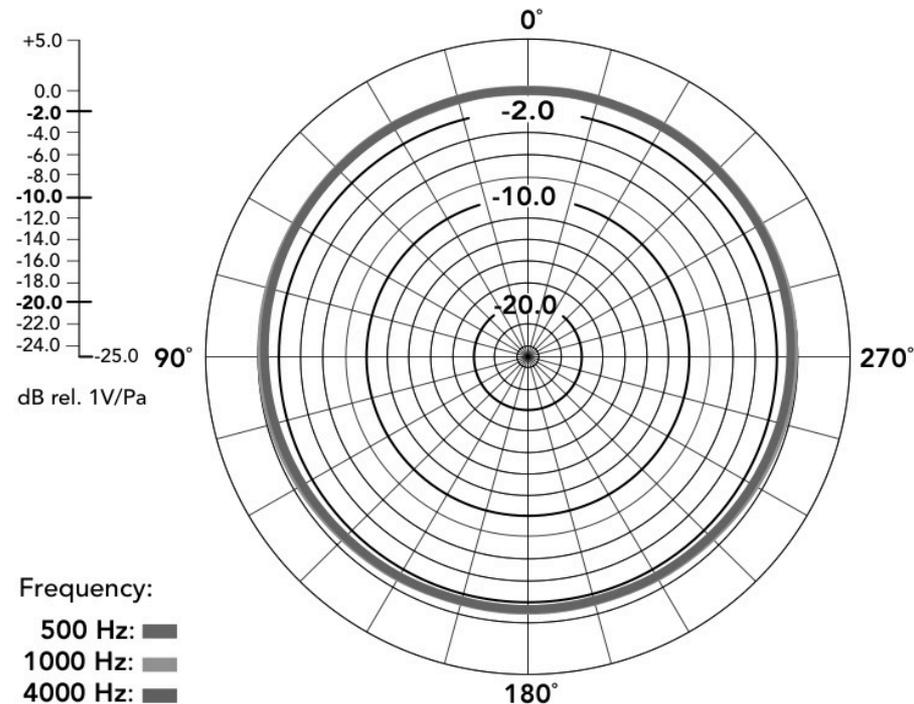
- Omnidirectional
- Bidirectional
- Cardioid
- Supercardioid
- Hypercardioid
- Shotgun



# Omnidirectional Polar Pattern

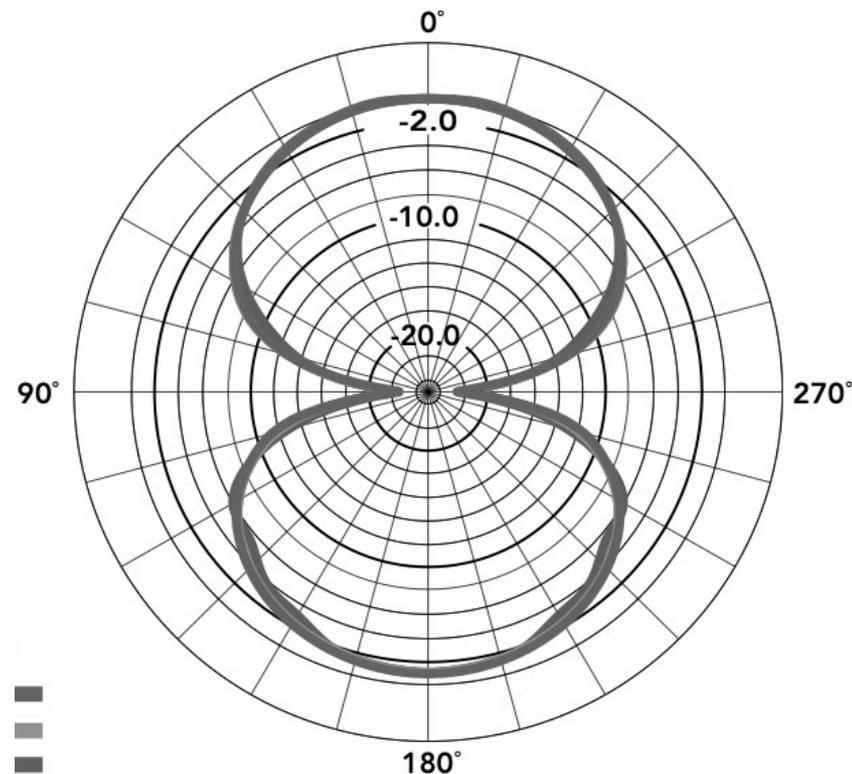
Front of microphone

- Picks up sound from all directions equally
  - ▣ So, it picks up the sound source and also ambient sounds
- In theory, it picks up sound from all directions, but not always across all frequencies.  $180^\circ$  off-axis may be dampened because of the microphone casing
- Not used as much as other patterns but very versatile



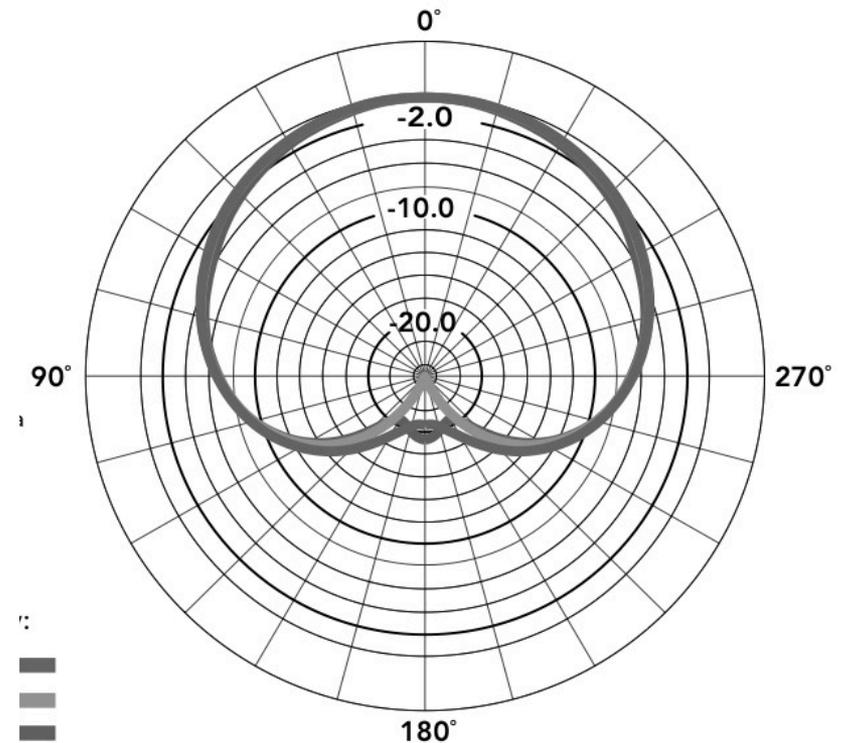
# Bidirectional (Figure-8) Polar Pattern

- Traditional ribbon mics are often bidirectional, as well as many condenser mics
- The diaphragm is exposed to sound waves from either side
  - ▣ Sounds from the back will be  $180^\circ$  out of phase with the same sound from the front.
  - ▣ Sounds from the side reach the front and back sides simultaneously. They produce opposite pressures on the front and back of the diaphragm, so they are phase-cancelled out.
- Figure 8 mics reject sound from the sides very well!



# Cardioid Polar Pattern

- “Cardio” = heart
- Caused by:
  - ▣ Combining an omni and a figure8 pickup, out of phase so one end is canceled out
  - ▣ “Ports” cut behind the diaphragm, that let in slightly delayed sound and cancel out one end.
- Most hand-held mics are cardioid





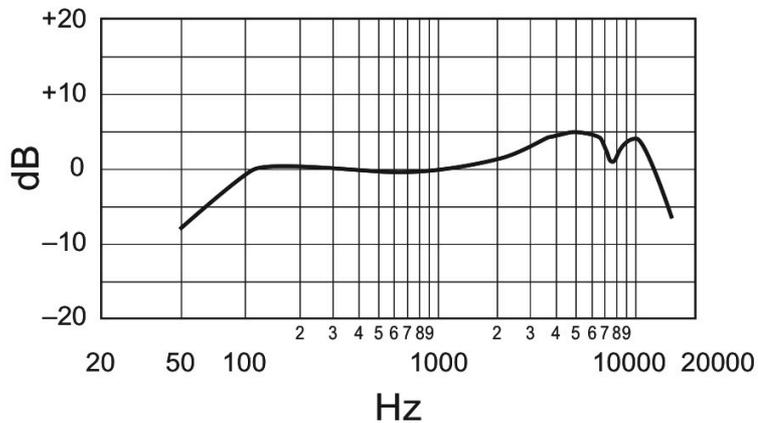
## Polar Patterns Video



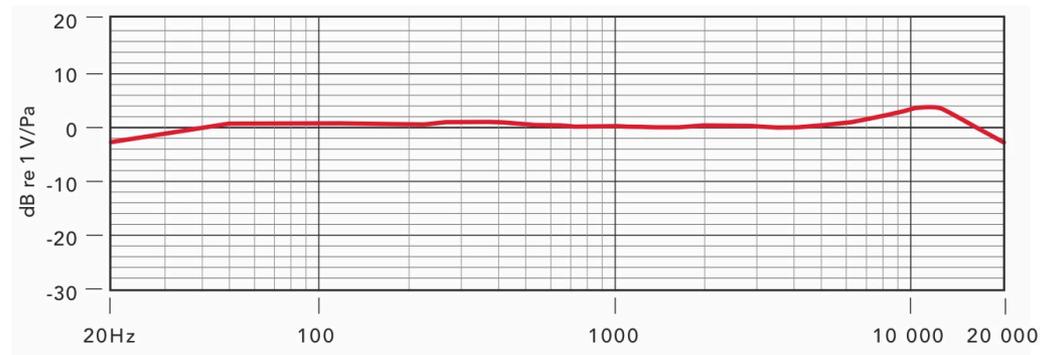
# FREQUENCY RESPONSE

# Frequency Response Curves

- Flat frequency response responds equally to all frequencies, but every mic has a unique curve
- Mics have different frequency responses from different angles and distances: on-axis is usually ideal placement



Shure SM-58 (dynamic cardioid)



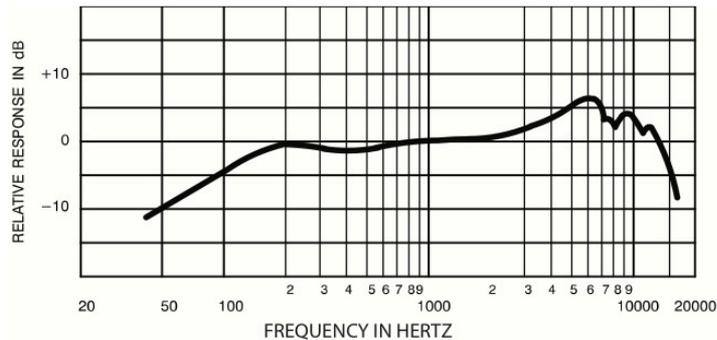
Røde K2 (condenser omni)

# Frequency Related Issues

- Low frequency rumble from floors
  - ▣ To prevent:
    - Use a shock mount
    - Use a microphone with a low frequency roll off (most dynamics)
    - Use a low-frequency cancelling filter in the preamp or mixer
  
- Proximity effect
  - ▣ Boost in low frequencies when a directional (not omni) mic is within about 1 ft of the sound source
    - Some mics have a low freq. roll-off filter you can turn on
    - Omni mics have no proximity effect
    - Sometimes the bass boost is desired!

# Shure SM-57

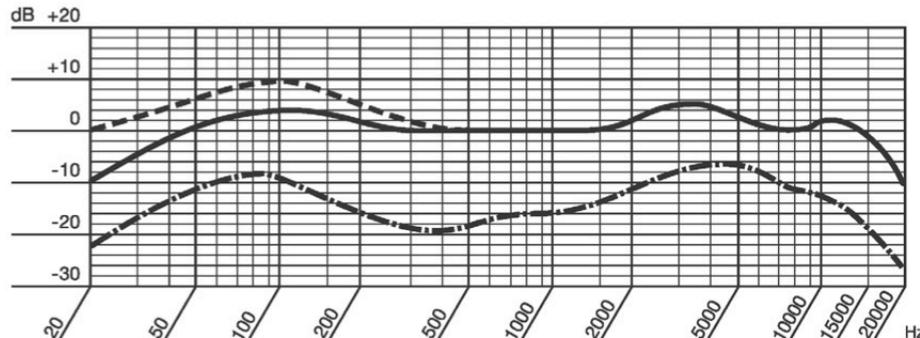
One of the most popular microphones in the world  
Dynamic Cardioid



Applications: vocals, guitar amplifiers, snare drums

# AKG D112

- Known for ability to handle high level signals from bass drums and bass guitars
- Descendent of the D12
- Dynamic Cardioid
- Low resonance frequency (around 100 Hz)

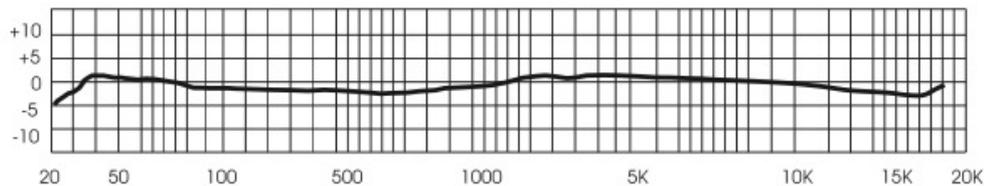


- Applications: Bass drum, Bass guitar, trombone & tuba



# Royer R121

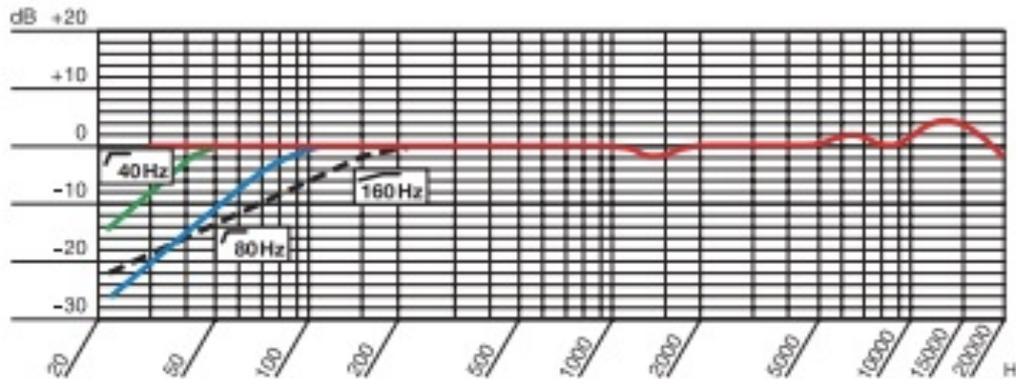
- “Modern” ribbon microphone – much more durable, stronger signal, and greater SPL tolerance than traditional ribbon mics
- Bidirectional (Figure 8) Ribbon



- Applications: Drum overheads, brass, strings, piano, even guitar amps and kick drums

# AKG C414

- Large-diaphragm condenser microphone
- Multiple polar patterns: Omni, Wide Cardioid, Cardioid, Hypercardioid, Figure 8

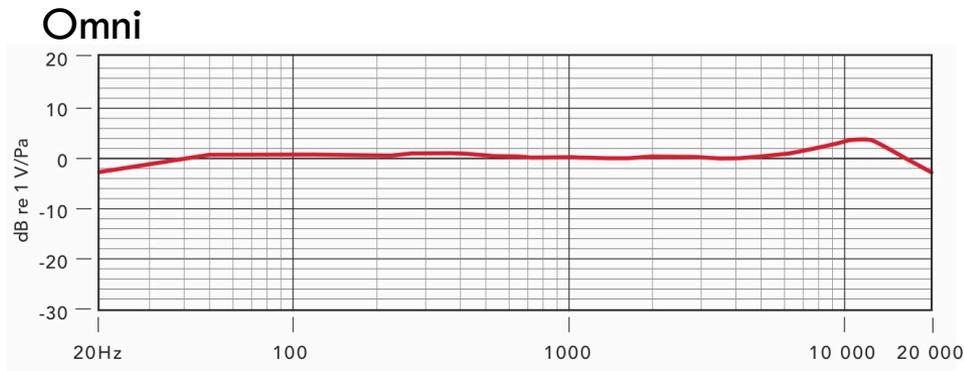


- Applications: Vocals, Piano, Strings, Brass, Acoustic Guitar, Bass, Woodwinds, Bass Drum



# Røde K2

- Large diaphragm condenser mic
- Multiple polar patterns – variable control
- Has a vacuum tube and uses its own power supply instead of phantom power



- Applications: vocals, acoustic guitar, drum overheads, piano



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- Recording Hacks' Microphone Database

# Terms to know

## Microphone types

- Dynamic
- Condenser
  - ▣ Large Diaphragm
  - ▣ Small Diaphragm
- Ribbon

## Polar patterns

- Omnidirectional
- Bidirectional (Figure 8)
- Cardioid
- Supercardioid
- Hypercardioid

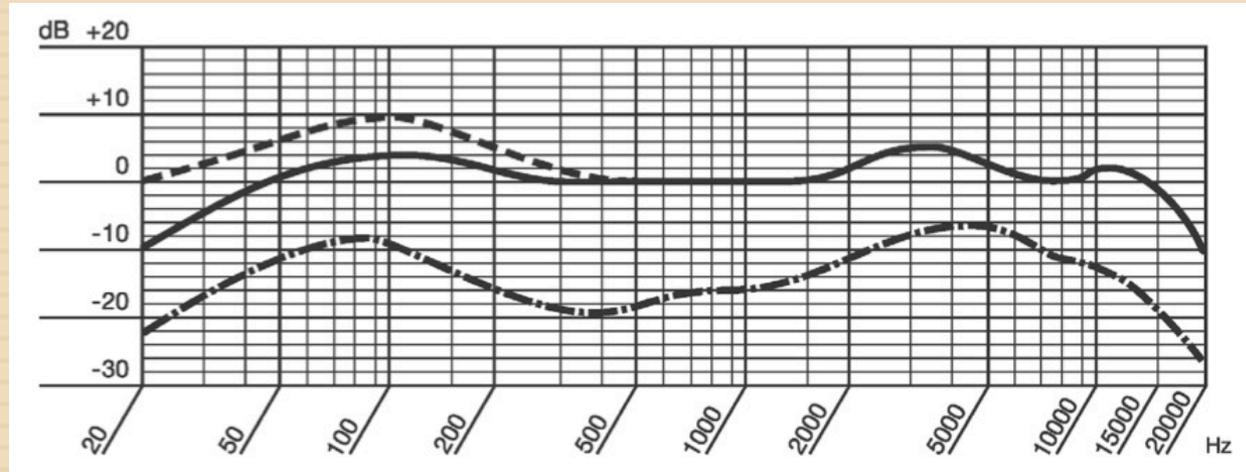
Read pp. 111-125

# MICROPHONES

## Part 2



A0	27.50		A# 0	29.14
B0	30.87			
C1	32.70		C# 1	34.65
D1	36.71		D# 1	38.89
E1	41.20			
F1	43.65		F# 1	46.25
G1	49.00		G# 1	51.91
A1	55.00		A# 1	58.27
B1	61.74			
C2	65.41		C# 2	69.30
D2	73.42		D# 2	77.78
E2	82.41			
F2	87.31		F# 2	92.50
G2	98.00		G# 2	103.8
A2	110.0		A# 2	116.5
B2	123.5			
C3	130.8		C# 3	138.6
D3	146.8		D# 3	155.6
E3	164.8			
F3	174.6		F# 3	185.0
G3	196.0		G# 3	207.6
A3	220.0		A# 3	233.1
B3	246.9			
C4	261.6		C# 4	277.2
D4	293.7		D# 4	311.1
E4	329.6			
F4	349.2		F# 4	370.0
G4	392.0		G# 4	415.3
A4	440.0		A# 4	466.2
B4	493.9			
C5	523.2		C# 5	554.4
D5	587.3		D# 5	622.2
E5	659.3			
F5	698.5		F# 5	740.0
G5	784.0		G# 5	830.6
A5	880.0		A# 5	932.3
B5	987.8			
C6	1046		C# 6	1109
D6	1175		D# 6	1245
E6	1319			
F6	1397		F# 6	1480
G6	1568		G# 6	1661
A6	1760		A# 6	1865
B6	1976			
C7	2093		C# 7	2217
D7	2349		D# 7	2489
E7	2637			
F7	2794		F# 7	2960
G7	3136		G# 7	3322
A7	3520		A# 7	3729
B7	3951			
C8	4186			



# FREQUENCY AND PITCH

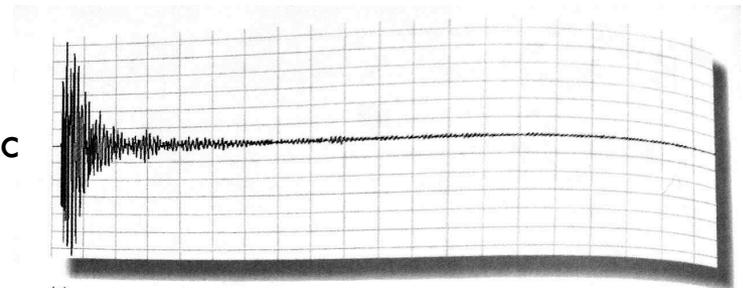
Frequency Chart

# Review

- What are the three main types of microphones
  - Dynamic
  - Condenser
  - Ribbon
- Which type of microphone requires external power to operate?
  - Condenser
- What is a polar pattern?
  - A chart showing a microphone's directional pickup
- What are the main polar patterns?
  - Omni
  - Bidirectional (Figure 8)
  - Cardioid
  - Supercardioid/Hypercardioid

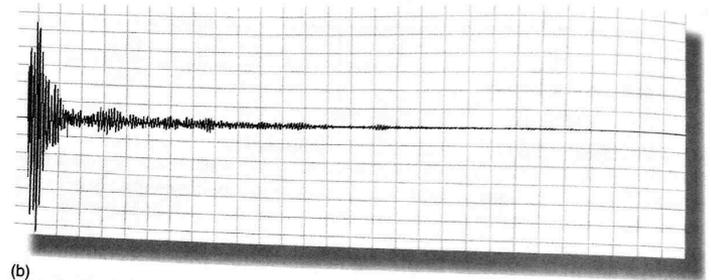
# Transient Response

Shure SM58 - Dynamic



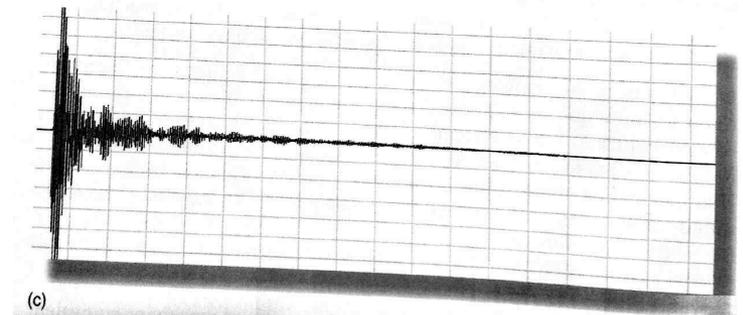
(a)

RCA 44BX - Ribbon



(b)

AKG C3000 - Condenser



(c)

# Microphone Characteristics

- Sensitivity Rating
  - ▣ A mic's output level in volts
  - ▣ Determines the amplification (by the pre-amp) needed to bring the mic to line level
    - A higher sensitivity rating means a microphone will emit a stronger output signal (-37 dBV/Pa vs. -56 dBV/Pa)
- Equivalent Noise Rating
  - ▣ A microphone's electrical self noise
    - Usually pretty low
- Overload Characteristics
  - ▣ How much SPL a mic can take before distorting
    - Dynamic mics – usually can take around 140 dB
    - Condenser mics – the condenser doesn't distort, but it could overload the built-in preamp
      - Switchable attenuation pad

# Microphone Characteristics

## □ Impedance

- ▣ The lower the impedance rating, the better
- ▣ Most professional mics have an impedance rating of around  $200\Omega$  (ohms), which is a relatively low impedance.
  - Not very susceptible to electromagnetic hum (interference)
  - Somewhat susceptible to electrostatic pickup, but use of balanced cable cancels this out.

# Balanced / Unbalanced Lines

## □ Balanced Cables

- Uses 3 wires to transmit audio signal
  - Pin 1 - ground
  - Pin 2 – positive
  - Pin 3 – negative
- Pins 2 & 3 carry the exact same audio signal, but in reverse phase.
- Any noise picked up along the way is picked up by both cables equally
- At the connection, wire 3's polarity is switched again. Audio signals are in phase and boosted, noise is now out-of-phase and cancels out!

# Balanced / Unbalanced Lines

Balanced



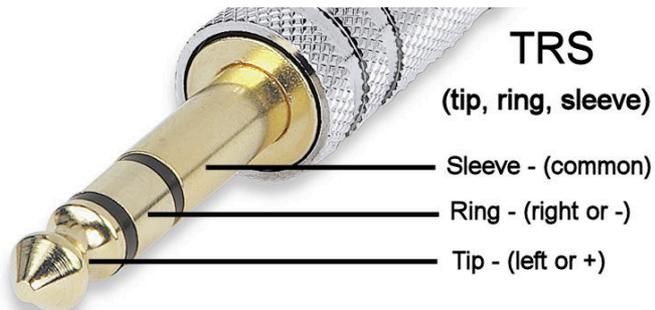
Unbalanced

TS (tip, sleeve)



TRS

(tip, ring, sleeve)



# Recording Applications

- Drums
  - Cardioid dynamics on drums (i.e. SM57 on snare/toms, Sennheiser 421 on toms, AKG D112 on Kick)
    - Or... condenser mics on snare and toms if desired
    - Large diaphragm condensers also work well on kick (i.e. Neumann U47FET)
  - Cardioid small diaphragm condenser on hi-hat (i.e. AKG 451)
  - Pair of small- or large- diaphragm condensers for overheads
- Electric Guitar
  - Using 1 mic: Dynamic cardioid close to speaker, or condenser a few feet back (or both)
- Acoustic Guitar
  - Small diaphragm cardioid condenser, 6-8" away
  - Large diaphragm condensers and ribbons also work well

# Recording Applications

## □ Vocals

- ▣ Large diaphragm condenser (remember the 10-12k boost – adds crispness to vocals)
- ▣ Some vocalists have a personal mic preference. The best way is to test several

## □ Piano

- ▣ Recorded in stereo – 2 large-diaphragm condenser mics, or a large diaphragm for the low strings and small diaphragm for the high strings

## □ Strings

- ▣ Condenser mics (or ribbon if you have one)

- Mic Application Chart – see chart on p. 149
- Mic Comparison
- Look at spec sheets for specific mics
  - ▣ AKG 451
  - ▣ Sennheiser 421
  - ▣ Neumann/Telefunken U47
  - ▣ REVIEW:
    - Røde K2
    - Shure SM 57/58
    - AKG D112

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- Read pp. 125 “Transient Response”-130  
“Balanced/Unbalanced Lines” (7<sup>th</sup> ed. page #s)