
3. THE GAIN CHAIN

GAIN

Mixers have at least 3* volume controls:

- **The “gain” or “trim” knob at the top of each channel**
- **The fader at the bottom of each channel**
- **The master fader for output**

Why so many? What’s the difference?

** There are usually other assorted faders and volume knobs scattered across the board, too. Even EQ changes signal level.*

CHAIN

- The **gain knob** adjusts the preamp input, usually from **.001** volts to **.01**. *It sets the **character** of the input signal.*
- The **channel fader** adjusts the modified, post-effects signal, usually from **.01** to **.1** volts, to **blend levels with other signals**
- The **master output fader(s)** send all signals to the main amplifier, raising signal levels from **.1** to **1** volts

TERMS

- The **noise floor** is the amount of undesired sound inherent in an input device, noticeable when there is no input and the gain is turned up. We want to minimize noise.
- **Headroom** is the difference between signal level and **clipping** (onset of distortion). We want enough headroom to avoid clipping on transient peaks.
- **Gain staging** is the setting of each amplification component to achieve desired levels.
- **Unity gain** is the point where an amplifying element is neither increasing nor decreasing gain, usually marked as 0 (zero)
- **Sound character** is a qualitative, not quantitative (amplitude), aspect of a signal's sound caused by an amplifier.
- **Clean** is no noticeable distortion; **saturation** is mild distortion; **dirty** is severe distortion; **transparency** is no noticeable change to signal other than level

TECHNIQUES

1. **Sound tech style: maximize headroom and minimize noise.**
 - A. **Set channel fader to **unity gain**.**
 - B. **Adjust preamp gain for max clean volume. Turn up until it just **clips** (distorts). An LED warning light, usually labeled “peak”, “clip”, or “OL”, will light up to indicate clipping; otherwise you have to use your ears**
 - C. **Turn down preamp gain knob by -15dB* to make some headroom. This avoids constant fiddling with fader.**

** Note that clipping and headroom tolerances vary from model to model.*

TECHNIQUES

2. Recording engineer style: Maximize sound character.

- A. Set channel fader to unity gain.**
- B. Slowly bring up preamp gain with input present and listen closely to sound character. Different preamps have different characteristics. Find the sound character best suited to this input.**
- C. Avoid destructive clipping! Listen to your ears AND the LED warning light.**
- D. Adjust the channel fader to blend with other channels (while listening for character changes, too).**
- E. “Ride” the channel fader (not gain knob) while recording to avoid peak clipping**

TECHNIQUES

3. *Balancing levels.*

- A. Pull down all faders**
- B. Bring up main element/track so that it peaks between -12dB and -6dB (just below clipping).**
- C. One-by-one, bring other faders up to complementary levels**
- D. Don't clip on master out!**

All techniques are valid and useful!

TECHNIQUES

Remember:

- **Gain is not volume, it's sensitivity**
- **EQ affects gain (signal level)**
- **Send/return and effects like reverb and compression can change gain**
- **Headphones are useful as microscopes for single channels, but keep headphone levels low enough to protect your ears while simultaneously high enough to hear artifacts in input channels. Use speakers for evaluating the whole mix.**

TAKEAWAYS

- The **gain chain** is a series of signal amplifiers that raise electronic signal levels by 3 orders of magnitude (1000 x)
- **Gain staging** is the process of setting levels in those amplifiers for best input signal and least noise (undesired characteristics)
- **Sound quality** encompasses control of desired and undesired signal characteristics
- **Every knob and fader** contributes to gain (affects signal level and quality)

REFERENCES

- <https://musicproductionnerds.com/understanding-gain-structure>
- <http://homerecordinglab.com/how-to-set-proper-audio-recording-levels/>
- <https://www.orpheusaudioacademy.com/gain-vs-volume/>

4. MICROPHONES

TERMS

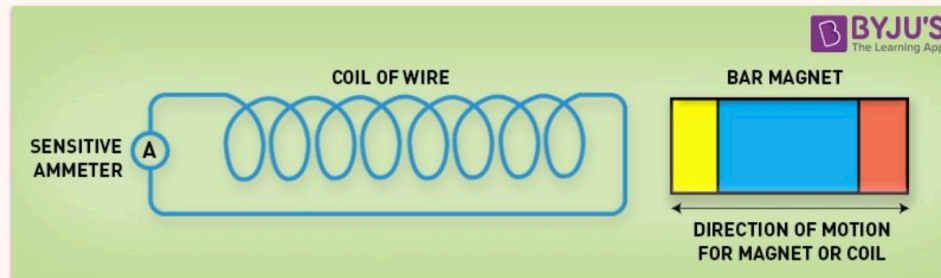
Microphone parts

- **Capsule**
- **Diaphragm**
- **Coil**

Microphone Types

- **Dynamic**
- **Condenser**
 - **Solid-state vs. Tube**
- **Ribbon**
- **USB**
- **Electret**
- **Lavalier**

FARADAY'S LAWS

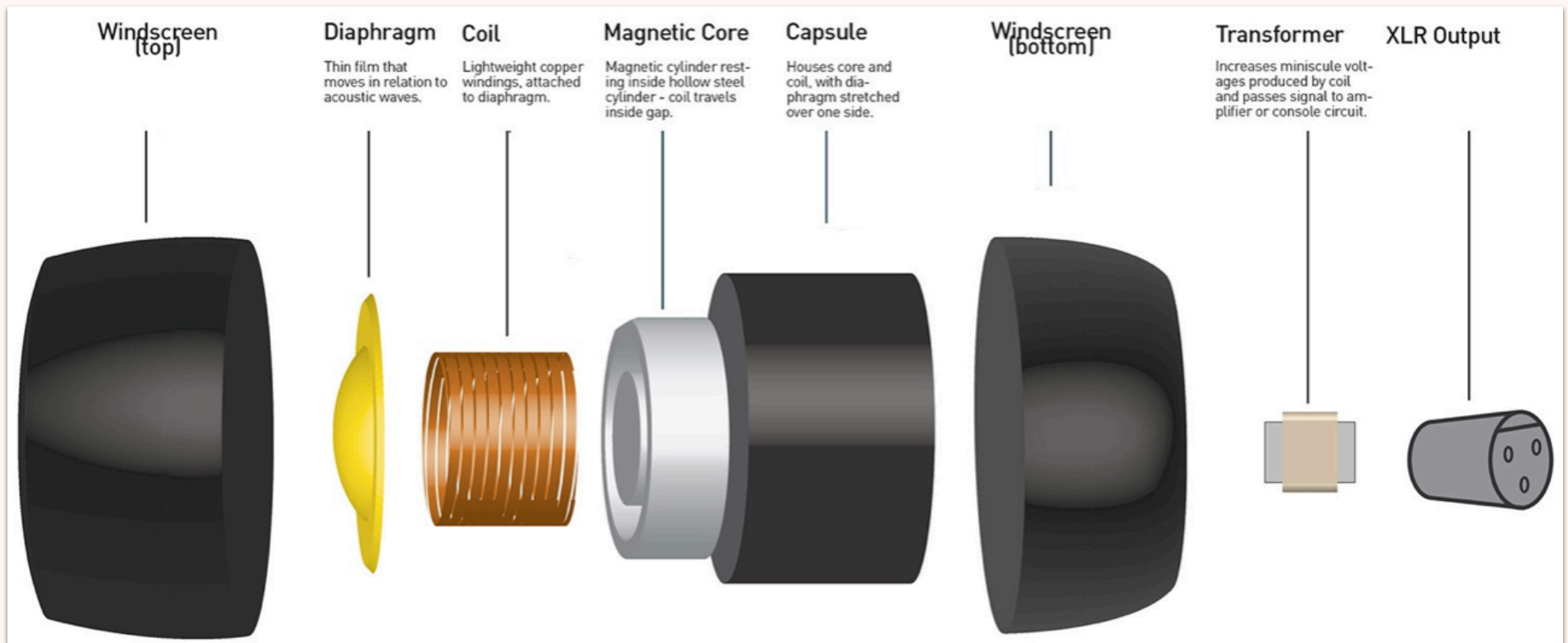


<https://byjus.com/physics/faradays-law/>

1. Whenever a conductor is placed in a varying magnetic field, an electromotive force (emf) is induced. If the conductor circuit is closed, a current is induced, which is called induced current.
2. The induced emf in a coil is equal to the rate of change of flux linkage.

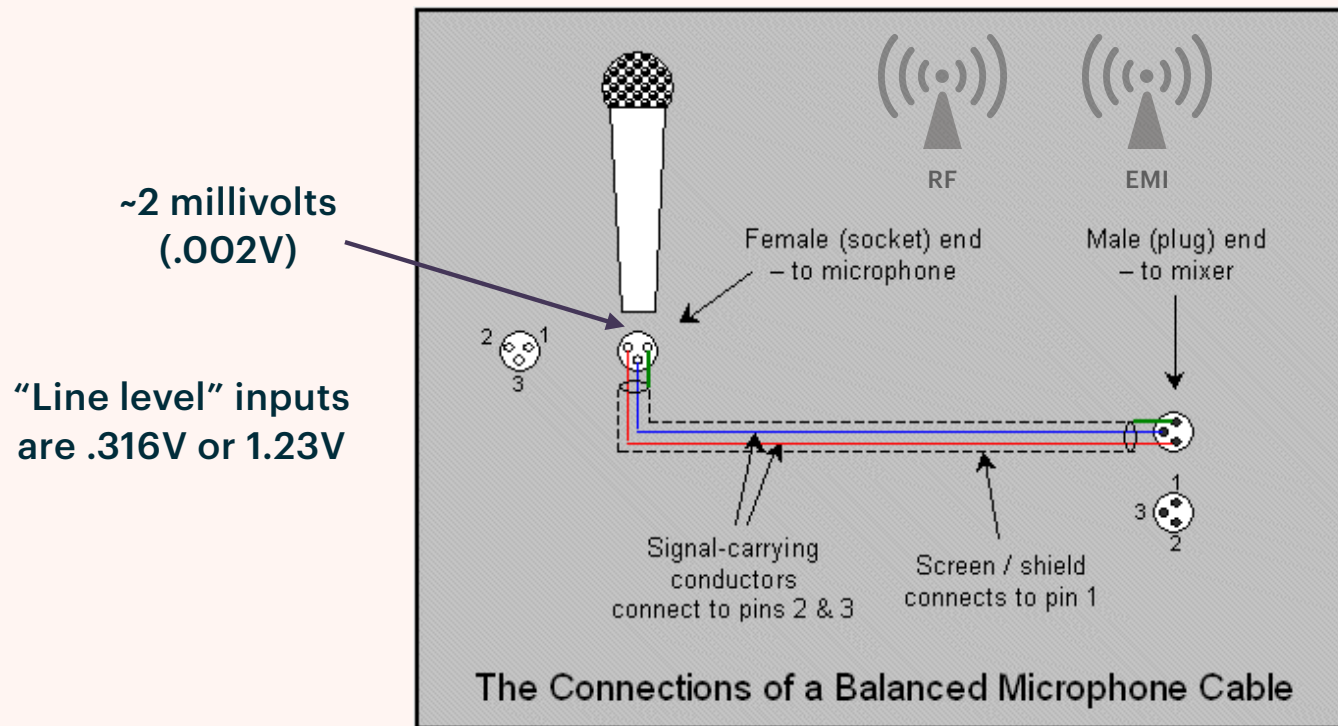
$$\varepsilon = -N \frac{\Delta\phi}{\Delta t}$$

DYNAMIC MIC



https://www.rfvenue.com/hubfs/Imported_Blog_Media/parts_of_mic_final_2-1.jpg

TANGENT - CABLE



<https://static-assets.imageservice.cloud/21565/mic-cord-wiring-diagram-wiring-diagram.gif>

Quality cable:

- **XLR Housing (metal)**
- **Shielding (ground shield + braided sheath)**
- **Strain Relief (flex polymer)**
- **Construction!**

TANGENT - CABLE

DON'T:

- **Run AC (power) cable next to audio cable**
- **Coil audio cable like your extension cords, use over/under technique**
- **Wrap cable tightly around mic stands (or battery packs...). For stands:**
 - **2-3 loose wraps**
 - **Wrap center**
 - **Use clips (or velcro ...)**

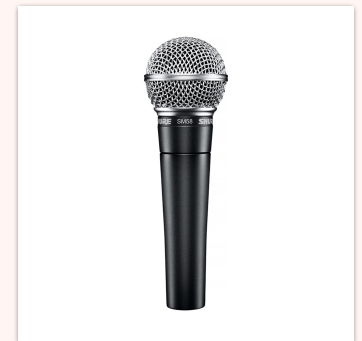
DYNAMIC MIC

Pros:

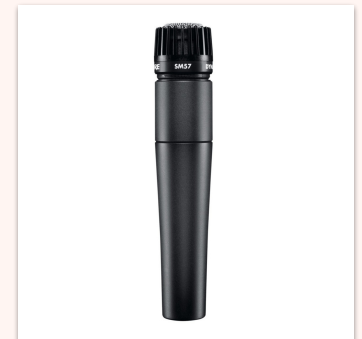
- **Sturdy**
- **Relatively cheap**
- **No external power**
- **Handles high SPL**
- **Drums, amps, even vox**

Cons:

- **Less sensitive**
- **Reduced sound quality**

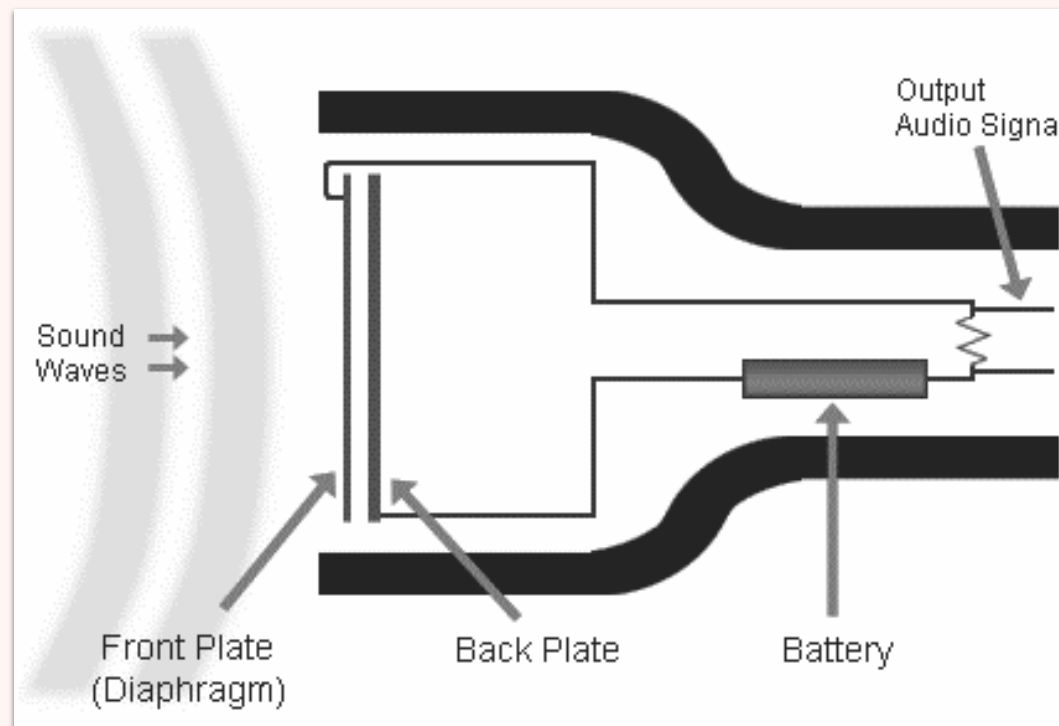


Shure SM-58



Shure SM-57

CONDENSER MIC



CONDENSER MIC

Pros:

- **Sound quality**
- **Sensitivity/nuance**
- **Can be smaller**
- **Strings, wind, nature, VOX**

Cons:

- **Higher cost**
- **External power**
- **Fragile at high SPL**
- **Needs better pre-amps**
- **Higher noise floor**
- **Affected by temp & humidity**
- **Touchy on stage**



Neumann TLM 103



Shure KSM32

CONDENSER MIC

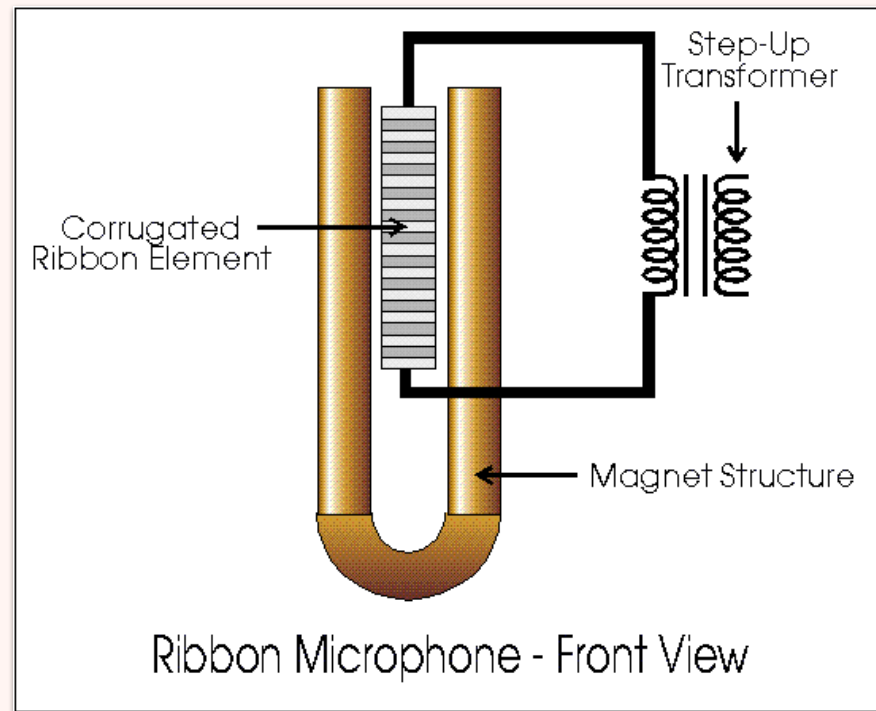
Tube (analog):

- **Warmth, compression, pleasant distortion**
- **Detail & harmonics**
- **Multiple pattern**
- **Usually costly**
- **Specific power supply/preamp adds complication**

Solid-State (digital):

- **Sturdier**
- **Cheaper**
- **“Brittle” distortion**

RIBBON MIC



RIBBON MIC

Pros:

- **Low noise**
- **Start relatively cheap**
- **No external power**
- **Handles high SPL**
- **Guitar amps, vox**

Cons:

- **Quality depends on every component = costly**
- **Pre-amp sensitivity is complicated**
- **Passive vs. active -> blown mics**
- **Touchy for stage use**



Rode NTR

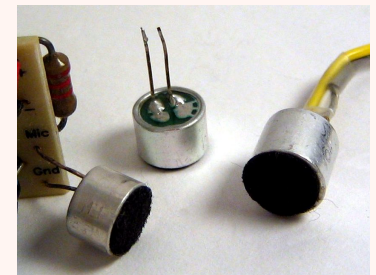
USB, ELECTRET MIC

USB:

- **Contains all parts including pre-amp**
- **Delivers digital input**
- **Convenience!**
- **Better for podcasts than stage**
- **Lower sound quality**

Electret:

- **Stable electrostatic capacitor**
- **Small & cheap**
- **Voice range**
- **Condenser, but low quality***
- **Not for stage use**



Electret

LAVALIER MIC

Pros:

- **Discreet**
- **Portable / Wireless**
- **Hands-free**

Cons:

- **Clothing rustle, beard scrape**
- **Sound quality**
- **Battery power**

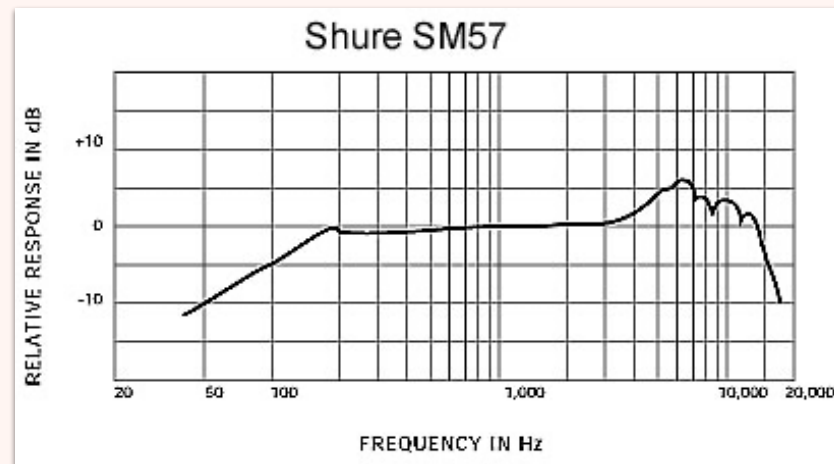
Tips:

- Mount on lapel/collar close to mouth (defeat omni)
- Use “stickies”, tape, foam windscreen, ... to avoid rustle
- Inside necktie, shirt collar, shirt buttons, center of bra



Lavalier Mic

FREQUENCY RESPONSE



- Flat = equal sensitivity to all frequencies = not “colored” by mic
- Mic sensitivity is never completely flat
- Objective description of mic capabilities. Example: snare drum fundamental is 150Hz - 250Hz, which fits the above chart. SM-57 is famous as snare mic.

TERMS

Microphone (polar) patterns

- **Omnidirectional**
- **Cardioid**
- **Supercardioid/
Hypercardioid**
- **Figure-8**
- **Coincident pairs**

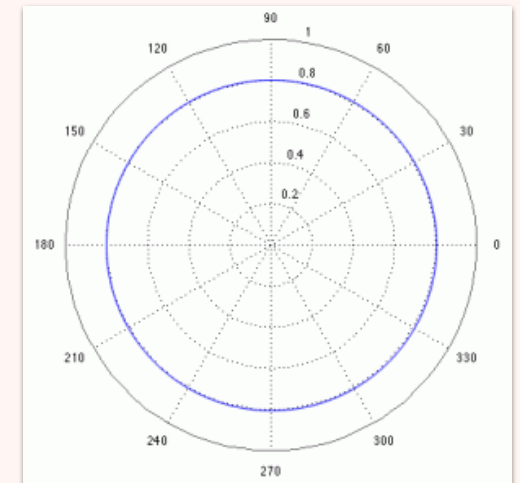
Diaphragm Size

- **Small - Medium-Large**

PATTERNS

OMNIDIRECTIONAL:

- **Equal in all directions**
- **No proximity effect**
- **Default for all mics until extra engineering changes it**

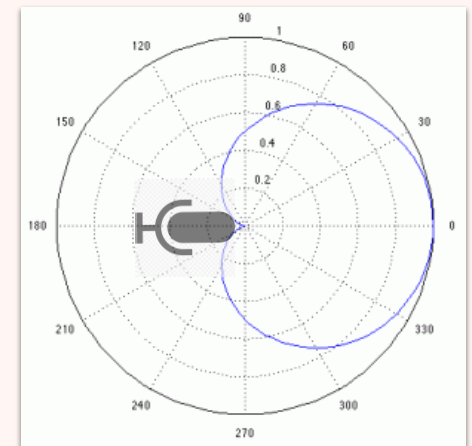


PATTERNS

CARDIOID:

- **Sensitive to front, reject side and rear**
- **Most popular**
- **Proximity effect:**

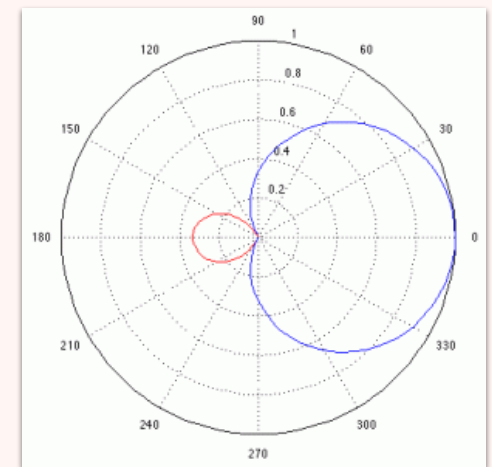
Increased bass response when close to source



PATTERNS

HYPERCARDIOID:

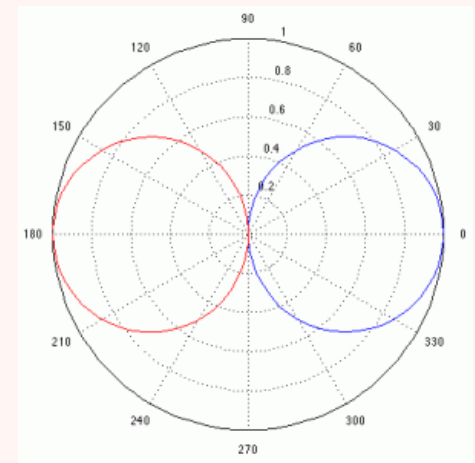
- **Sensitive to front, more side rejection but with rear sensitivity (see lobe)**
- **Most popular**
- **Supercardioid has smaller rear lobe/sensitivity**



PATTERNS

FIGURE-8:

- **Sensitive to front and back, rejects side**
- **Aka bi-directional**
- **Useful for 2 voices, singing guitarist, recording in stereo**

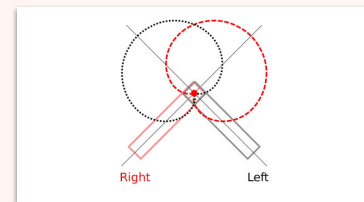


COINCIDENT PAIRS

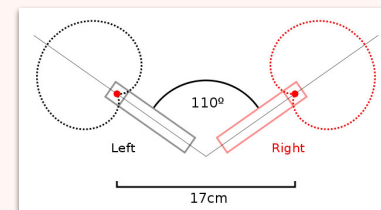
- **Enhanced stereo imaging**

- **Types:**

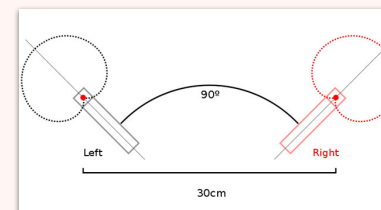
- **X/Y**
- **ORTF**
(Office de Radio-Television Diffusion Francaise)
- **NOS**
(Nederlandse Omroep Stichting)
- **Faulkner Array (2 figure-8s)**
- **Blumlein Array (2 figure-8s)**



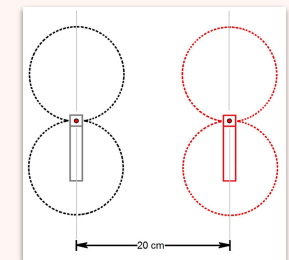
X/Y



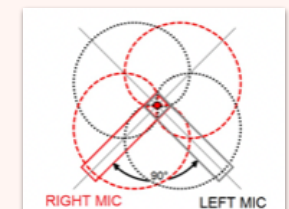
ORTF



NOS



Faulkner



Blumlein

DIAPHRAGM SIZE

SMALL:

- **Aka Pencil Mics**
- **Ultra-responsive**
- **Measurement mics**
- **Acoustic guitar, hi hat, drum overhead - sharp transients**



MEDIUM:

- **Subjective & controversial**
- **Intermediate**

LARGE:

- **Switchable patterns**
- **Use on most anything**
- **Beware high SPL, but some are made to handle high levels**



TAKEAWAYS

- **Microphone parts: Capsule, Diaphragm, Coil**
- **Microphone Types : Dynamic, Condenser, Ribbon**
 - **Definition**
 - **Pros and Cons of each type**
- **Diaphragm sizes: characteristics of small & large**
- **Polar patterns**
- **Mic cable characteristics**
 - **Over-under technique**

REFERENCES

- <https://www.sweetwater.com/insync/studio-microphone-buying-guide/>
- <https://ledgernote.com/columns/studio-recording/types-of-microphones/>
- <https://blog.landr.com/microphone-types/>
- https://www.rfvenue.com/hubfs/Imported_Blog_Media/parts_of_mic_final_2-1.jpg
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- <https://kettnercreative.com/live-events/how-to-wrap-cables-over-under-technique/>

5. EQ

TERMS

- **Frequency bands:**
 - **Sub-bass: $\leq 60\text{Hz}$**
 - **Bass: $60\text{Hz}-250\text{Hz}$**
 - **Low Mids: $250\text{Hz}-500\text{Hz}$**
 - **Midrange: $500\text{Hz}-2\text{kHz}$**
 - **High Mids: $2\text{kHz}-4\text{kHz}$**
 - **Presence: $4\text{kHz}-6\text{kHz}$**
 - **Brilliance: $\geq 6\text{kHz}$**
- **Subtractive EQ**

GUIDE

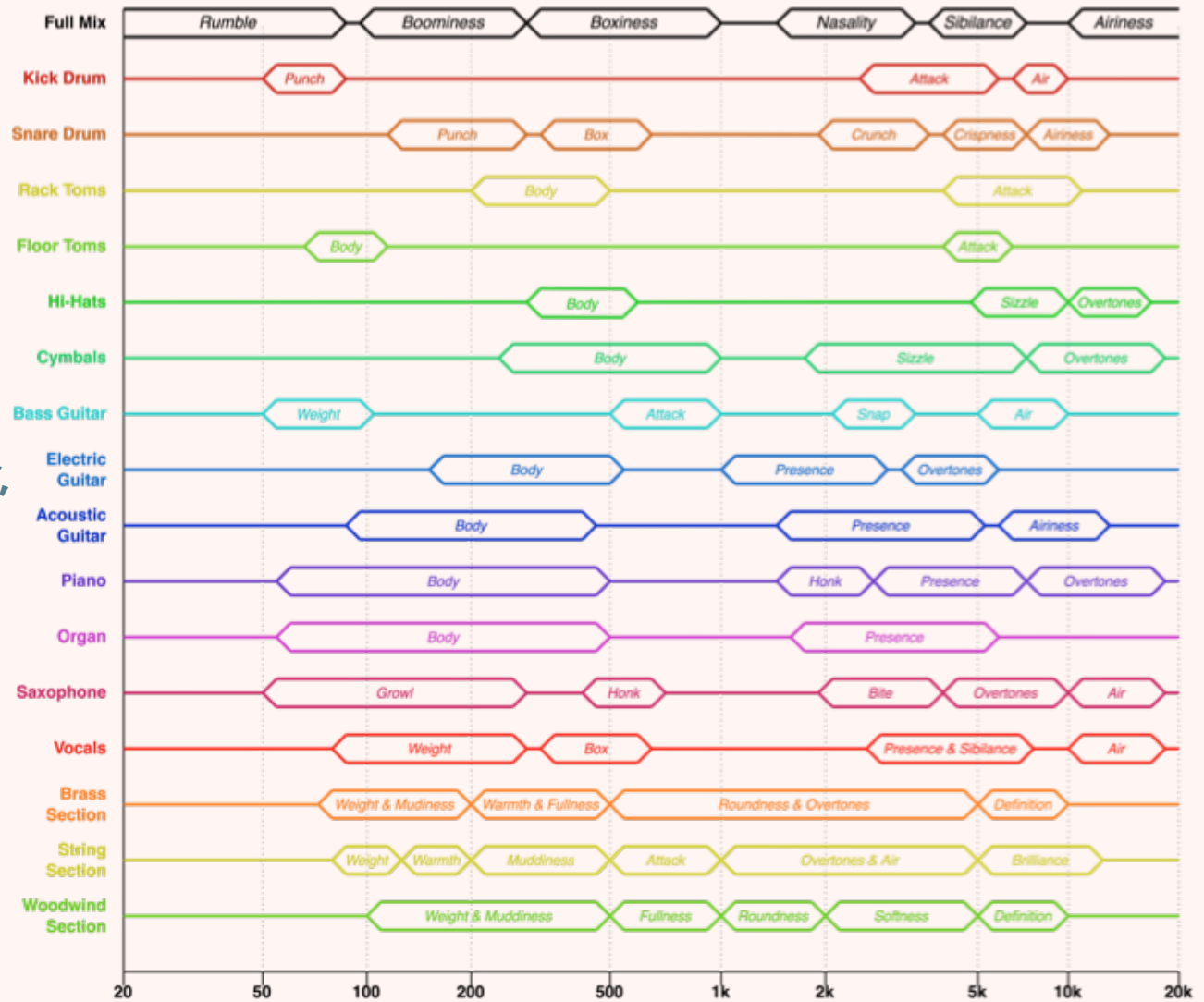
- **Sub-bass: <60 Hz**
 - **Felt more than heard**
 - **Hi Pass for most instruments, but consider kick, bass, synth**
- **Bass: 60 - 250 Hz**
 - **Lots of energy, remove where not needed**
 - **Boost for fullness; Cut boominess**
- **Low Mids: 250 - 500 Hz**
 - **Bass harmonics, fundamentals of many instruments**
 - **Boost for body & fullness; Cut boxiness and muddiness**

GUIDE

- **Midrange: 500 - 2 kHz**
 - **Attack/transients, some presence**
 - **Boost for fullness, color, attack; Cut boxiness, nasality**
- **High Mids: 2k - 4kHz**
 - **Bite, presence, character**
 - **Boost for character; Cut nasality, harshness**

GUIDE

- **Presence: 4k - 6kHz**
 - **Presence and definition for most instruments**
 - **Boost presence; Cut sibilance, harshness**
- **Brilliance: >6 kHz**
 - **Upper harmonics and air**
 - **Boost crispness, air, brightness; Cut air, brittleness**



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From "Mixing Cheat Sheet",
mynewmicrophone.com

GUIDE

Subtractive EQ:

- **Cut frequencies instead of boosting them**

People instinctively turn up good sounds, but that frequently overloads a room with sound energy. It's better to remove negative energy (unpleasant sounds).

TIPS

1. Most sound techs turn up levels on “good” sounds. This adds too much energy to room. Instead, remove bad sounds. Example:

Sweepable mid:

- **Turn up level (boost)**
- **Slowly sweep from lowest freq to highest**
- **Some frequency will sound the worst; stop there**
- **Turn down level to cut that frequency**

“CUT THE SUCK”

TIPS

1a. Bad vox or out-of-tune instruments can be somewhat mitigated with the sweep method. For sour singers, cut EQ in the vox range, 1 kHz - 3kHz. Use “cut the suck” technique to find offending frequency. For instruments, check the frequency chart range, sweep for offending freq, and cut it.

TIPS

Bass frequencies add energy and muddy sound. Cut energy overload where possible:

- **Remove low end rumble by using hi pass filter (almost) everywhere.**

Some instruments compete for range (e.g., guitar & keyboard). “Mirror image” EQ settings:

- **Boost track A at low end and cut at high end.**
- **Cut track B at low end and boost at high end.**

TIPS

Increase **high end** frequencies to make signal sound **closer**; decrease to push it **further away**.

Similarly, decrease **reverb pre-delay** to bring it closer, and increase to push it away.

Pan elements to right and left to widen sound. You can also duplicate tracks/inputs, mirror image the EQ, then pan hard left and hard right.

Note that bass is usually kept mono and centered.

TAKEAWAYS

- **EQ shapes elements and trims energy levels**
- **EQ adds clarity and builds sound stage**
- **EQ separates overlapping instrument ranges**

REFERENCES

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- **Mastering Audio: The Art and the Science, 2nd Edition, Bob Katz**
- **The Mastering Engineer's Handbook, 4th Edition, Bobby Owsinski**
- mynewmicrophone.com