Microphones

Engr 0501: Music Engineering Music Engineering Laboratory

Overview

- Characterizing microphones
 - Frequency response
 - Polar patterns
- Types of microphones
- Choosing the right microphone
- Multi-mic recording techniques
 - Piano
 - Guitar
 - Problems with multi-mic recordings

Frequency Response

- Microphone response (usually in dB) as a function of frequency
- Typically provided by the microphone manufacturer
- Extremely useful in determining which microphone to use for a particular application
 - Choosing a mic with the appropriate frequency response can eliminate the need for post-processing EQ
- Microphones intended for live vs studio use may have different frequency responses — some live-sound microphones have high-frequency boosts to allow instruments/vocals to "cut through the mix"



Frequency response for the Behringer XM8500 dynamic microphone (cardioid) - \$20



Frequency response for the Neumann U87 large diaphragm condenser microphone (cardioid) - \$3600

Tailoring the Frequency Response: SM Series

- Industry standard vocal (SM58) and instrument (SM57) *dynamic* microphones
- Same capsule the only difference is the mechanical housing (including the pop filter for the SM58)
- Both commonly used for live sound, while the SM57 is also widely used in many studios for electric guitars
 - SM57 has an extended high-frequency response (better for instruments)
 - SM58 has a boost in the 2kHz 4kHz range (added presence/clarity for vocals, can help vocals project better in a mix)
 - SM57 has a cut from 200Hz 500Hz (can result in "muddiness)
 - SM58 has a cut from 300Hz 1kHz ("honky/ nasal" sound)



Shure SM57



Shure SM58





Polar Pattern

- How sensitive a microphone is to sound coming from different directions
- Sound level as a function of direction
- Determined by the design of the microphone capsule
- Polar patterns are frequencydependent
- Some microphones have different capsules to change the polar pattern
- Very important to consider when setting up microphones in the studio — which sound sources are desired, which should be rejected



Polar pattern for the Sennheiser e865 condenser microphone (supercardioid)



Types of Polar Patterns



Omnidirectional







Cardioid

Supercardioid

Figure-of-eight



Directional



Subcardioid



Hypercardioid

Types of Microphones: Dynamic

- Wire coil suspended surrounding a cylindrical magnet by a diaphragm
- Sound causes movement of the diaphragm, resulting in a change in the magnetic field which causes current flow
- Larger mass of the coil results in reduced sensitivity to low sound levels
- Tend to be very robust and inexpensive
- Popular models: Shure SM57/58, Sennheiser 421





Shure SM58



Shure SM57



Sennheiser 421

Types of Microphones: Condenser

- Capsule consisting of a charged diaphragm and a backplate
- Sound pressure results in movement of the diaphragm, which changes the capacitance between the plates
- Available in different polar patterns (cardioid, hypercardioid, omnidirectional)
- Large and small diaphragm variants. Large diaphragm capsules have an extended low-frequency response, while small diaphragm capsules can have an extended high-frequency response.



Neumann U87 capsule

DIAPHRAGM CASE

DIAPHRAGM

BACKPLATE



Popular models: Neumann U87, AKG C414, Neumann KM184

Types of Microphones: Ribbon

- Corrugated metal ribbon (aluminum) between magnets
- Sound pressure causes movement of the ribbon in the magnetic field, which induces current
- Both the front and rear of the ribbon are exposed, which gives rise to the "figureof-8" polar pattern
- Off-axis (90°, 270°) sound sources exert equal forces on both sides of the ribbon and cancel out
- Natural roll-off of high-frequencies (compared to the "bump" in most condenser microphones)
- · Low mass of the ribbon results in the ability to track fast sound transients
- Ribbon can be very fragile (especially older models), and can be damaged by wind gusts or being stored horizontally
- Popular models: RCA R44 (out of production), Coles 4038, AEA R84, Royer R121



http://www.diyaudiocomponents.com/ribboninfo.php





Choosing the Right Microphone for the Job

- In most cases, any microphone can be used for a particular application
- However, certain microphones will be better-suited for particular applications
- There are a number of factors to consider when choosing a microphone:
 - Characteristics of the sound being recorded (frequency response)
 - Recording an instrument versus a vocalist vocals tend to benefit from a high-frequency "boost" in the 3kHz - 10kHz range, while many acoustic instruments benefit from an extended frequency response which preserves high-frequency harmonic content
 - Rejection of undesired sound sources (polar pattern)
 - Singer-songwriter —use different microphones for vocals and guitar, but need to eliminate bleed from one instrument to the other microphone
 - Sound level (maximum SPL of the microphone)
 - Some very loud instruments (kick drum, electric guitar) can damage very sensitive microphones (such as older ribbon mics)



Of the microphones available in the MEL, extended frequency response of the Rode NT5 (left) is better suited for acoustic instruments than the Sennheiser e865 vocal mic (right)

	Microphone Type	Commonly Used Microphones	MEL Microphones	Placement Suggestions
Vocals	Large-diaphragm condenser	Neumann U87 AKG C414	CAD E100S Sennheiser e865	6" - 12" from vocalist, slightly elevated
Piano	Large or small - diaphragm condenser	Neumann U87 AKG C414 Neumann KM84	Rode NT5 CAD E100S	(1) Inside, pointed at hammers(2) Outside (lid open), perpendicular to strings
Guitar (Acoustic)	Large or small - diaphragm condenser	Neumann 184	Rode NT5 CAD E100S	6" - 12" from guitar, pointed at the location where the neck meets the body
Guitar (Electric)	Dynamic Ribbon	Shure SM57 (Dynamic) Sennheiser 421 (Dynamic)	Rode NT5	~1" from the speaker, on-center or slightly off-center
Bass	Direct Input (DI)			
Drums	Condenser Dynamic	Neumann U87/184 (overhead) Sennheiser 421 (toms/kick) Shure SM57 (snare/toms)		
Violin	Large-diaphragm condenser	Neumann U87 AKG C14	CAD E100S	Above and behind the performer, with the capsule pointed roughly at the bridge
Brass	Large-diaphragm condenser	Neumann U87 AKG C14	CAD E100S Rode NT5	(1) ~6' from the instrument(2) above and behind performer (can mask key noise)
Woodwind	Large-diaphragm condenser	Neumann U87 AKG C14	CAD E100S Rode NT5	3' - 6' away, pointed towards the middle of the instrument

Multi-mic Setup: Piano

- Generally best to use omni-directional capsule with pairs (or more) of small diaphragm condenser microphones (Rode NT5)
- Arrangement 1: Spaced near-mic setup
 - Small-diaphragm condensers pointed towards hammers
- <u>Arrangement 2:</u> Coincident pair nearmic setup
 - XY coincident pair, pointing downwards towards the hammers
- Arrangement 3: Room-mic setup
 - Lid fully open
 - Small-diaphragm condensers perpendicular to strings





Multi-mic Setup: Acoustic Guitar

- Arrangement 1: XY
 - Pair of small-diaphragm condenser microphones
 - Coincident, 90° apart
 - ~6" from the point where the neck meets the body
- <u>Arrangement 2:</u> Fretboard + bridge
 - Pair of small-diaphragm condenser microphones
 - Mic 1 pointed at point where the neck meets the body (6" 12" from fretboard)
 - Mic 2 pointed at bridge (6" 12" from top)
 - Risk of high-frequency masking from hand movement



A coincident pair of condenser microphones in an XY arrangement



Approximate microphone placement for Arrangement 2 (fretboard + bridge)

Phase Discrepancies with Multi-mic Setups

- Sound takes time to propagate through the air if multiple microphones are used to record the same source, the placement of the microphones may result in the same sound hitting microphones at different times.
- Effectively, the sound recorded by one mic is a delayed copy of the sound recorded by the other mic.
- When combining the two sound sources this can result in *comb filtering*, where a particular frequency and its harmonics are filtered out of the combined signal, while other frequencies are reinforced.
- Maximal phase reinforcement comes when the two signals are in phase with one another, with phase differences resulting in some degree of comb filtering.
- To avoid this, either use coincident pairs of microphones, or make sure that the mics are spaced sufficiently apart. A ratio of 3:1 (*distance between mics* : *distance to sound source*) is commonly suggested.
- To easily determine if two signals are in phase with one another, use the *Trim* or *Precision Delay* plug-ins in Digital Performer. This allows you to invert the phase of a track.
- Phase issues are less of a concern when tracks are hard-panned (i.e., panned all the way to the right and left) in a stereo mix, but can be very troublesome in mono. It is a good idea to check for phase cancellation for all multi-mic tracks just in case somebody is listening to your music in mono.



Trim

