Fundamentals of Sound and Microphones

Introduction

This document provides a deep dive into the foundational elements of sound and microphones, tailored for music production and sound engineering students.

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Fundamentals of Sound

What is Sound?

Sound is a vibration that propagates as an acoustic wave through a transmission medium such as a gas, liquid, or solid. In air, sound is a sequence of pressure waves that travel through the air and are interpreted by the ear and brain.

Frequency:

Frequency is the number of oscillations (vibrations) of a sound wave per second, measured in Hertz (Hz). Human hearing typically ranges from 20 Hz to 20,000 Hz (20 kHz). Low frequencies sound like bass, and high frequencies sound like treble.

Amplitude:

Amplitude is the height of the sound wave, determining the loudness. Greater amplitude means a louder sound. It is measured in decibels (dB).

Wavelength:

Wavelength is the distance between two consecutive points of similar phase in a wave, such as two adjacent crests. Wavelength and frequency are inversely proportional.

Phase:

Phase refers to the position of a point in time on a waveform cycle. It is important in multi-microphone setups to avoid phase cancellation.

Velocity of Sound:

In air at 20°C (68°F), sound travels at approximately 343 meters per second.

Human Hearing Range:

Humans can hear from 20 Hz to 20,000 Hz. Sensitivity peaks between 2 kHz to 5 kHz, which is why these frequencies are crucial in mixing.

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Dynamic Range:

The difference between the quietest and loudest sounds that can be heard. The human ear has a dynamic range of about 120 dB.

Signal Flow:

Understanding how sound travels through a system-from source to microphone to preamp, interface, DAW, and speakers-is essential in production.

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Microphones Explained

Microphones: How They Work

A microphone converts acoustic energy (sound waves) into electrical signals. This is done via a diaphragm that moves with the air pressure of sound waves.

Types of Microphones:

1. Dynamic Microphones: Use electromagnetic induction. Durable and great for live sound. E.g., Shure SM58, Sennheiser e835.
2. Condenser Microphones: Use a capacitor; require phantom power. Sensitive and great for studio recordings. E.g., Audio-Technica AT2020, Neumann U87.
3. Ribbon Microphones: Use a thin metal ribbon to pick up sound. Warm, vintage tone. E.g., Royer R-121.
4. Lavalier Microphones: Small and used for speech, especially in film and TV.
5. USB Microphones: Integrated interface; plug directly into computers. E.g., Blue Yeti.

Microphone Polar Patterns:

1. Cardioid: Heart-shaped pattern, picks sound from front. Ideal for vocals.
2. Supercardioid: Tighter front pickup, slight rear pickup.
3. Hypercardioid: Even narrower than supercardioid.
4. Omnidirectional: Picks up sound equally from all directions.
5. Bidirectional (Figure-8): Picks up sound from front and back.
6. Shotgun: Highly directional, used in film and field recording.

Popular Microphones:

- Shure SM58 (Dynamic)
- Shure SM7B (Dynamic, studio)
- Neumann U87 (Condenser)
- AKG C414 (Condenser, multi-pattern)
- Rode NT1-A (Condenser, low noise)
- Sennheiser MKH416 (Shotgun)