Technical Reference: MIDI to Frequency Conversion

Technical Writing Portfolio — Audio Engineering

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1 Introduction

In digital audio workstation (DAW) development, converting MIDI note numbers into Hertz (Hz) is a fundamental computational task. This document outlines the mathematical relationship between semitones and frequency, based on the Equal Temperament scale where the A4 reference pitch is set to 440 Hz.

2 Mathematical Principles

The relationship between frequencies in equal temperament is logarithmic. Every octave represents a doubling of frequency, divided into 12 semitones.

2.1 The Semitone Ratio

The constant used to calculate the interval between adjacent semitones is the twelfth root of two ($2^{1/12}$):

$$a = \sqrt[12]{2} \approx 1.059463094359 \tag{1}$$

2.2 The Conversion Formula

To calculate the frequency f for any MIDI note n, where MIDI note 69 corresponds to A4 (440 Hz), the formula is:

$$f(n) = 440 \cdot 2^{\frac{n-69}{12}} \tag{2}$$

3 Software Implementation (C)

The following C snippet demonstrates the practical implementation of this formula for use in a real-time audio oscillator.

Listing 1: C implementation of MIDI to Frequency conversion

```c
#include <stdio.h>
#include <math.h>

double midiToFrequency(int midiNote) {
    // Reference pitch for A4 is 440Hz, which is MIDI note 69
    double referencePitch = 440.0;
    int referenceNote = 69;

```

```
    // Calculate frequency using the pow function
    return referencePitch * pow(2.0, (midiNote - referenceNote) / 12.0);
}
```

4 Data Representation: 2's Complement

In 16-bit digital audio systems, the amplitude of the signal is stored using the **2's Complement** binary system. This allows for the representation of both positive and negative voltage values, essential for reproducing the sinusoidal oscillations of sound waves within a fixed bit-depth ($-32,768$ to $+32,767$).