Lesson 4

Digital v Analogue

Teacher Guide

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The comparison between digital and analogue sound quality is a complex topic that depends on various factors, including the source, equipment, and personal preferences. Here are some key points to consider:

1. **Digital Sound:**
   1. **Pros:**
      1. Digital audio can be stored and transmitted without degradation over long distances.
      2. It allows for precise reproduction of the original recording.
      3. Digital formats can support various sound enhancements and processing techniques.
   2. **Cons:**
      1. In some cases, digital audio can be subject to compression, leading to a loss of data and reduced sound quality.
      2. Digital audio may introduce artefacts (unintended sounds or distortions) when converted between different formats.
2. **Analog Sound:**
   1. **Pros:**
      1. Analog signals are continuous and can provide a smooth, natural representation of sound.
      2. Analog equipment can introduce a unique warmth and character to the audio, which some people prefer for certain types of music.
      3. Analog recordings can capture nuances and subtleties that might be lost in digital conversion.
   2. **Cons:**
      1. Analog signals can be susceptible to interference and degradation over long distances.
      2. Analog recordings on physical media (like vinyl records) may have inherent limitations and imperfections.

In practice, the perceived "better" quality depends on the listener's preferences, the quality of the equipment used, and the nature of the audio source. High-quality digital recordings and playback systems can provide excellent sound reproduction that many people find indistinguishable from analogue sources. However, some audiophiles appreciate the unique characteristics of analogue sound and the experience of vinyl records.

It's essential to note that advancements in digital audio technologies, such as high-resolution audio and lossless compression formats, have significantly improved the fidelity of digital sound.

**Lesson 4 Analogue to Digital Convertors**

In this lesson, we will use the Pico board to perform an ADC conversion. The Raspberry Pi Pico has **four 12-bit ADC** channels, but one of them is connected to the**internal temperature sensor**. The remaining **ADC** is found at **GPIO26**, **GPIO27**, and **GPIO28** as **ADC0**, **ADC1**, and **ADC2**, respectively.

These ADCs are crucial for a wide range of applications that require precise measurements of real-world signals, such as temperature, light intensity, and audio.

**Characteristics of RP2040 ADCs:**

* Resolution: 12 bits, providing a digital representation of the analogue signal with over 4096 discrete values. Micropython automatically converts these 12 bits into 16-bit values, giving readings between 0 and 65,535.
* Sampling Rate: Up to **125,000 samples per second**, enabling the capture of fast-changing analogue signals.
* **Input Voltage Range:** **0 to 3.3V,** allowing the ADC to measure a broad range of analogue signals.

**Examples of Real-World Applications of ADCs:**

**1. Temperature Measurement:**

ADCs are commonly used in temperature sensors to convert the analogue voltage generated by the sensor into a corresponding digital value, which represents the temperature in degrees Celsius or Fahrenheit. This data can then be used to control heating or cooling systems, monitor industrial processes, or assess the performance of electronic devices.

**2. Light Intensity Measurement:**

Photodiodes and light-dependent resistors (LDRs) generate analogue voltages proportional to the light intensity they receive. ADCs convert these voltages into digital values, allowing the microcontroller to accurately measure light levels. This information is employed in applications such as automatic brightness adjustment in smartphones, light sensors for traffic lights, and solar power monitoring systems.

**3. Audio Processing:**

Microcontrollers equipped with ADCs can capture analogue audio signals from microphones or guitar pickups. The ADC converts the analogue waveforms into digital data, which can then be processed and analysed by the microcontroller. This enables applications such as audio recording, audio signal processing, and music synthesis.