Digital audio

Digital audio is audio, or simply sound, signal that has been recorded as or converted into digital form, where the sound wave of the audio signal is encoded as numerical samples in continuous sequence, typically a CD audio quality which is 16 bit sample depth over 44.1 thousand samples per second. Digital audio is the name for the entire technology of sound recording and reproduction using audio signals that have been encoded in digital form. Following significant advances in digital audio technology during the 1970s, it gradually replaced analog audio technology in many areas of audio engineering and telecommunications in the 1990s and 2000s.

Audio levels display on a digital audio recorder (Zoom H4n)

In a digital audio system, sound of an analog electrical signal is converted with an analog-to-digital converter (ADC) into a digital signal, typically using pulse-code modulation. This digital signal can then be recorded, edited, modified, and copied using digital audio workstation computers, audio playback machines and other digital tools. When the sound engineer wishes to listen to the recording on headphones or loudspeakers (or when a consumer wishes to listen to a digital sound file of a song), a digital-to-analog converter (DAC) performs the reverse process, converting a digital signal back into an analog signal, through an audio power amplifier and sending it to a loudspeaker.

Digital audio systems may include compression, storage, processing and transmission components. Conversion to a digital format allows convenient manipulation, storage, transmission and retrieval of an audio signal. Unlike analog audio, in which making copies of a recording results in generation loss, a degradation of the signal quality when using digital audio, an infinite number of copies can be made without any degradation of signal quality

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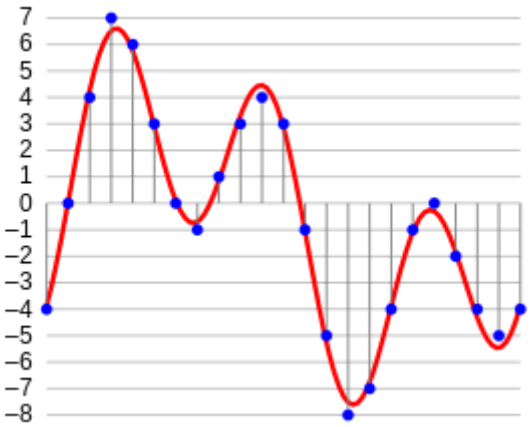
Overview

Digital audio technologies are used in the recording, manipulation, mass-production, and distribution of sound, including recordings of songs, instrumental pieces, podcasts, sound effects, and other sounds. Modern online music distribution depends on digital recording and data compression. The availability of music as data files, rather than as physical objects, has significantly reduced the costs of distribution.[1] Before digital audio, the music industry distributed and sold music by selling physical copies in the form of records and cassette tapes. With digital-audio and online distribution systems such as iTunes, companies sell digital sound files to consumers, which the consumer receives over the Internet.

An analog audio system converts physical waveforms of sound into electrical representations of those waveforms by use of a transducer, such as a microphone. The sounds are then stored on an analog medium such as magnetic tape, or transmitted through an analog medium such as a telephone line or radio. The process is reversed for reproduction: the electrical audio signal is amplified and then converted back into physical waveforms via a loudspeaker. Analog audio retains its fundamental wave-like characteristics throughout its storage, transformation, duplication, and amplification.



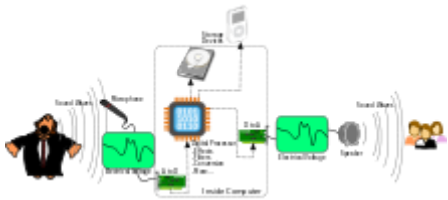
A sound wave, in red, represented digitally in blue (after sampling and 4-bit quantization).

Analog audio signals are susceptible to noise and distortion, due to the innate characteristics of electronic circuits and associated devices. Disturbances in a digital system do not result in error unless the disturbance is so large as to result in a symbol being misinterpreted as another symbol or disturb the sequence of symbols. It is therefore generally possible to have an entirely error-free digital audio system in which no noise or distortion is introduced between conversion to digital format, and conversion back to analog.

A digital audio signal may optionally be encoded for correction of any errors that might occur in the storage or transmission of the signal. This technique, known as channel coding, is essential for broadcast or recorded digital systems to maintain bit accuracy. Eight-to-fourteen modulation is a channel code used in the audio compact disc (CD).

Conversion process

A digital audio system starts with an ADC that converts an analog signal to a digital signal.[note 1] The ADC runs at a specified sampling rate and converts at a known bit resolution. CD audio, for example, has a sampling rate of 44.1 kHz (44,100 samples per second), and has 16-bit resolution for each stereo channel. Analog signals that have not already been bandlimited must be passed through an anti-aliasing filter before conversion, to prevent the aliasing distortion that is caused by audio signals with frequencies higher than the Nyquist frequency (half the sampling rate).


The lifecycle of sound from its source, through an ADC, digital processing, a DAC, and finally as sound again.

A digital audio signal may be stored or transmitted. Digital audio can be stored on a CD, a digital audio player, a hard drive, a USB flash drive, or any other digital data storage device. The digital signal may be altered through digital signal processing, where it may be filtered or have effects applied. Sample-rate conversion including upsampling and downsampling may be used to conform signals that have been encoded with a different sampling rate to a common sampling rate prior to processing. Audio data compression techniques, such as MP3, Advanced Audio Coding, Ogg Vorbis, or FLAC, are commonly employed to reduce the file size. Digital audio can be carried over digital audio interfaces such as AES3 or MADI. Digital audio can be carried over a network using audio over Ethernet, audio over IP or other streaming media standards and systems.

For playback, digital audio must be converted back to an analog signal with a DAC which may use oversampling.

History in recording

Pulse-code modulation was invented by British scientist Alec Reeves in 1937[2] and was used in telecommunications applications long before its first use in commercial broadcast and recording. Commercial digital recording was pioneered in Japan by NHK and Nippon Columbia and their Denon brand, in the 1960s. The first commercial digital recordings were released in 1971.[3]

The BBC also began to experiment with digital audio in the 1960s. By the early 1970s, it had developed a 2-channel recorder, and in 1972 it deployed a digital audio transmission system that linked their broadcast center to their remote transmitters.[3]

The first 16-bit PCM recording in the United States was made by Thomas Stockham at the Santa Fe Opera in 1976, on a Soundstream recorder. An improved version of the Soundstream system was used to produce several classical recordings by Telarc in 1978. The 3M digital multitrack recorder in development at the time was based on BBC technology. The first all-digital album recorded on this machine was Ry Cooder's *Bop till You Drop* in 1979. British record label Decca began development of its own 2-track digital audio recorders in 1978 and released the first European digital recording in 1979.[3]

Popular professional digital multitrack recorders produced by Sony and Mitsubishi in the early 1980s helped to bring about digital recording's acceptance by the major record companies. The 1982 introduction of the CD popularized digital audio with consumers.[3]

Technologies

Digital audio broadcasting

Sony digital audio recorder PCM-7030

- Digital Audio Broadcasting (DAB)
- HD Radio
- Digital Radio Mondiale (DRM)
- In-band on-channel (IBOC)

Storage technologies

- Digital audio player
- Digital Audio Tape (DAT)
- Digital Compact Cassette (DCC)
- Compact Disc (CD)
- Hard disk recorder
- DVD-Audio
- MiniDisc
- Super Audio CD
- Blu-ray Disc (BD)
- Various audio file formats

Digital audio interfaces

Audio-specific interfaces include:

- AC'97 (Audio Codec 1997) interface between integrated circuits on PC motherboards
- Intel High Definition Audio - modern replacement for AC'97
- ADAT interface
- AES3 interface with XLR connectors, common in professional audio equipment
- S/PDIF - either over coaxial cable or TOSLINK, common in consumer audio equipment and derived from AES3
- AES47 - professional AES3-style digital audio over Asynchronous Transfer Mode networks
- I²S (Inter-IC sound) interface between integrated circuits in consumer electronics
- MADI (Multichannel Audio Digital Interface)
- MIDI - low-bandwidth interconnect for carrying instrument data; cannot carry sound but can carry digital sample data in non-realtime
- TDIF, TASCAM proprietary format with D-sub cable
- A2DP via Bluetooth

Several interfaces are engineered to carry digital video and audio together, including HDMI and DisplayPort.

Any digital bus can carry digital audio. In professional architectural or installation applications, many digital audio Audio over Ethernet protocols and interfaces exist.

See also

- Digital audio editor

Notes

1. Some audio signals such as those created by digital synthesis originate entirely in the digital domain, in which case analog to digital conversion does not take place.

References

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