Digital Audio Broadcasting

UA - Information and Coding
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From Waves to Digits: Radio Evolution

DAB by Comparison

"DAB is a digital radio broadcasting system that converts audio signals into digital data for transmission. Unlike traditional analog broadcasting, which sends continuous waves, DAB transmits audio as compressed digital signals."

Development Motivations:

Spectrum Congestion

- Radio bands were crowded
- Major cities were running out of available frequencies
- Interference between stations

Quality Demands

- Growing consumer expectations
- Need for consistent reception quality
- Desire for CD-like sound

Digital Revolution

- Transition to digital
- Align radio with other digital media
- Opportunity for new features and services
- Analog susceptibility to interference

	AM/FM	DAB
Signal Technology	Analog continuous waveform	Digital binary data stream (ones and zeros)
Signal Quality	Gradually degrades with distance/interference (static, hiss)	Maintains perfect quality until signal loss ("digital cliff")
Frequency Usage	One frequency per station (FM: ~200 kHz per station; AM: ~10 kHz per station)	Multiple stations in one (1.5 MHz bandwidth carrying 6-18 stations)
Interference	• Susceptible to electrical interference • Affected by buildings and terrain • Weather impacts signal quality	• Resistant to interference • Error correction capabilities • More robust in urban environments

	AM/FM	DAB
Additional Content	• Audio only	• Program information • Song titles/artist • News headlines • Weather updates
Reception Method	• Requires precise frequency tuning • Signal strength varies by location • Manual retuning needed when moving	• Automatic station tuning • Station selection by name • Automatic station switching to strongest signal
Power Requirements	Lower power consumption in receivers	Higher power consumption due to digital processing

02

Advantages of DAB

Crystal Clear Sound

- Consistent Quality
- No interference
- Enhanced dynamic range
- Better stereo separation

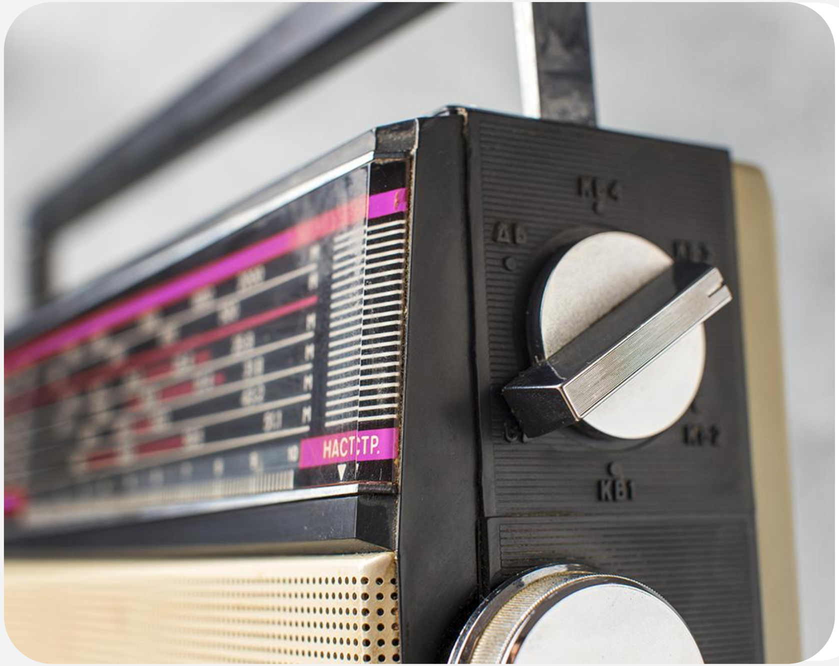
Beyond Just Audio

- Program-associated data
    - Electronic Program Guide
- Emergency warning system
    - Station selection by name
- Automatic tuning

- Better stereo separation

Making the most of radio waves

- Multiple stations per frequency
- Lower transmission power
- Flexible bandwidth allocation



03
How DAB Works

The Digital Audio Chain

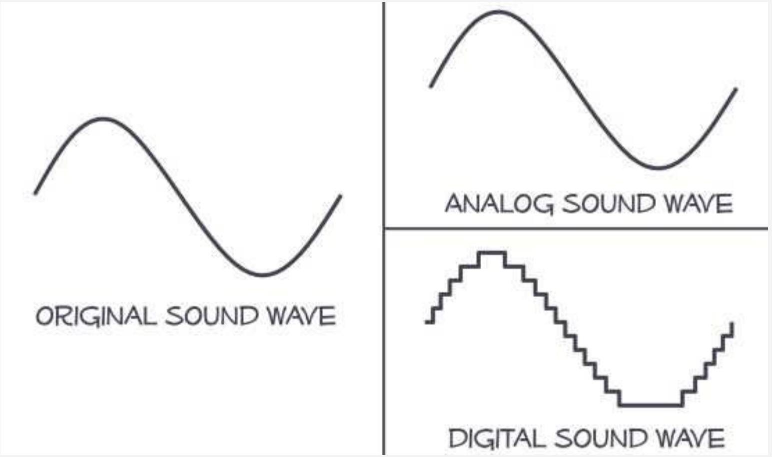
1. Sampling
2. Quantization
3. Compression
4. Multiplexing
5. Transmission

Step 1: Sampling

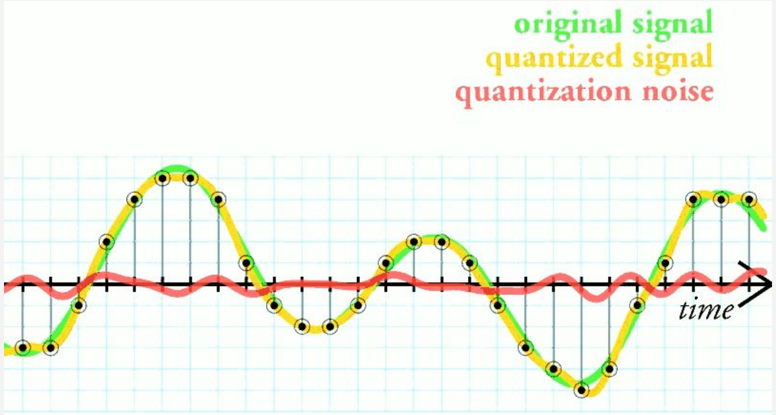
- Sampling is the first step in converting analog audio to digital.

- DAB samples audio at 48 kHz (that means, 48 thousand samples per second).

- The human hearing range is from 20 Hz to 20 kHz, and following the Nyquist theorem, it was agreed to use 48 kHz as the sampling rate.



Step 2: Quantization



- Each sample is assigned a 16-bit digital value, providing 65 536 possible levels to represent the amplitude.

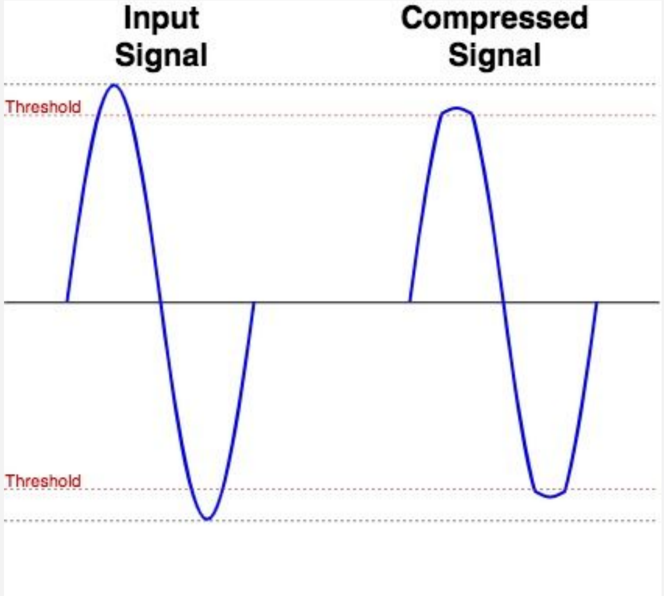
- This creates CD-quality resolution, but results in a high raw bitrate: 48000 samples/second × 16 bits × 2 channels = 1.536 Mbps.

- This raw data rate is too high for efficient transmission, which is why compression is essential.

Step 3: Compression (Making it Smaller)

There are two main compression standards when we talk about Digital Audio Broadcasting. Those are:

- MPEG Audio Layer II (MP2)
- AAC+ (HE-AAC v2)



MPEG-1 Audio Layer II (MP2)

- Older system, used in the first version of DAB.
- Uses psychoacoustic modeling (analyzes what the human ear can and can't hear).
- Removes sounds that humans wouldn't notice anyway.
    - For example, if there's a loud drum beat happening at the same time as some quieter sounds, it can remove the latter, because humans wouldn't detect them.
- Combines common elements between left and right channels to save space.
- Only sends the differences between channels when necessary.
- Uses a fixed bitrate, meaning it always uses the same amount of data regardless of the audio content.
- Typical bitrates: 128-192 kbps per station

AAC+ (HE-AAC v2)

- Newer, more efficient system, used in DAB+.
- Spectral Band Replication
  - Only transmits the lower frequencies in full
  - Recreated higher frequencies using information about how they relate to lower ones
  - Basically it is the same as sending instructions for rebuilding the high notes, instead of sending the actual notes
- Parametric Stereo
  - Sends mono audio and instructions for creating stereo
  - Is much more efficient than sending two full channels
- Results in better sound quality at lower bitrates
- Is about 30% more efficient than the previous MP2
- Typical bitrates: 48-96 kbps per station
- Can fit more radio stations in the same frequency
- Transmission is more reliable

Steps 4 and 5: Multiplexing and Transmission

Multiplexing combines multiple compressed audio streams into one transmission:

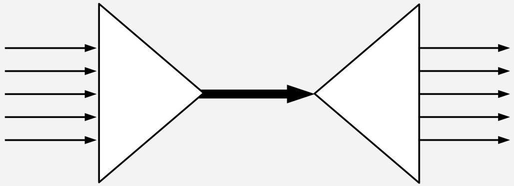
- Multiple radio services combined
- Error correction data added
- Service information included
- Organized into transmission frames

All of these points make it so that each multiplex (in this case, each frequency) is able to carry multiple radio stations plus associated data services.

DAB uses COFDM (Coded Orthogonal Frequency-Division Multiplexing) for robust transmission:

- Signal spread across multiple carriers
- Resistant to multipath interference
- Synchronized transmitter network
- Error correction and interleaving

This provides reliable reception even in moving vehicles.



Error Correction

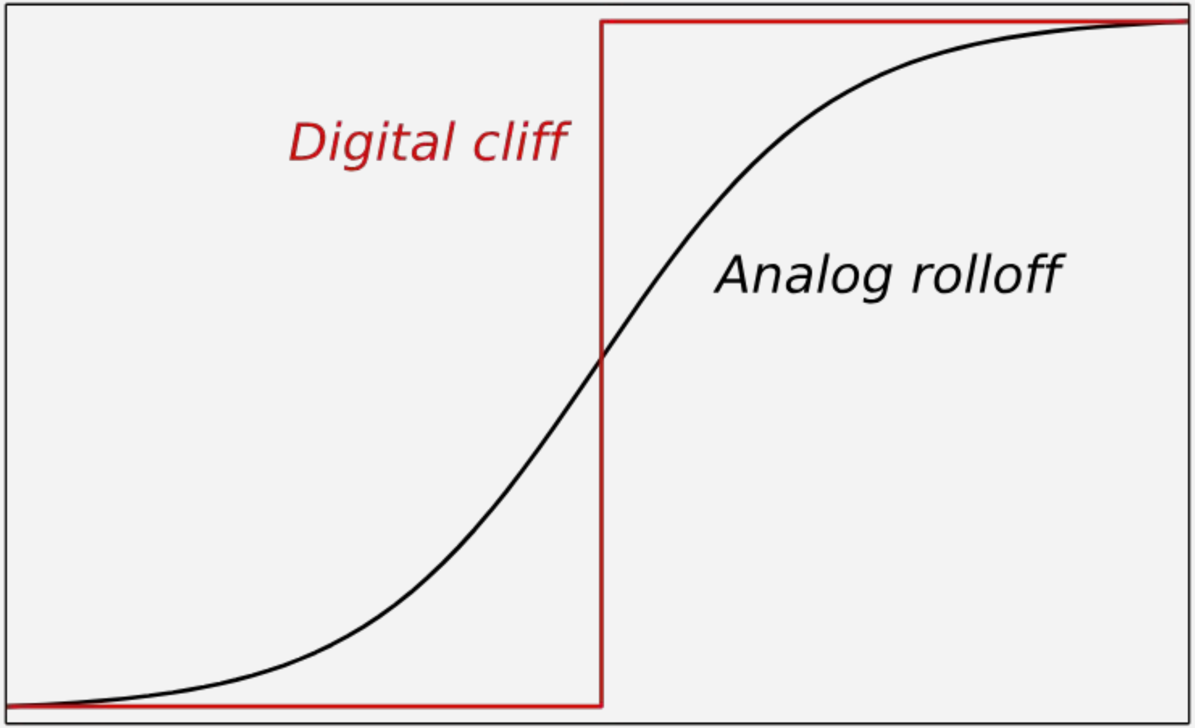
DAB implements multiple layers of error protection to ensure reliable transmission. The main techniques are:

1. Convolutional Coding
   - Acts as the first line of defense
   - Adds redundant bits to the data stream
   - More important audio data gets stronger protection
   - Less critical data gets less protection to save bandwidth
2. Reed-Solomon Coding
   - Provides additional protection in DAB+
   - Can correct burst errors (groups of consecutive errors) and is effective at fixing damaged data blocks
   - Particularly important for digital audio where small errors can cause noticeable problems
3. Time Interleaving:
   - Spreads data over time, so if interference affects one moment, the damage is spread out
   - Makes it easier for error correction to fix
4. Frequency Interleaving:
   - Spreads data across different frequencies, so if some frequencies are damaged, not all data is lost
   - Works together with time interleaving for better protection

04

Disadvantages of DAB

The Digital Cliff



Implementation Challenges

- High initial setup costs
- Need for synchronized transmitters
- Coverage planning complexity
- Requires new receiving equipment

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