

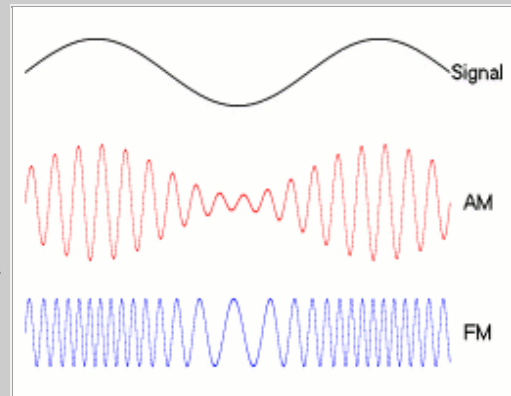
# FM MODULATION

## Definition

**Frequency modulation (FM)** conveys information over a carrier wave by varying its frequency which is directly proportional to the instantaneous value of the input (carried) signal.

## Basics

In telecommunications, **frequency modulation (FM)** conveys information over a carrier wave by varying its frequency (contrast this with amplitude modulation, in which the amplitude of the carrier is varied while its frequency remains constant). In analog applications, the instantaneous frequency of the carrier is directly proportional to the instantaneous value of the



An audio signal (top) may be carried by an AM or FM radio wave.

input signal. Digital data can be sent by shifting the carrier's frequency among a set of discrete values, a technique known as frequency-shift keying.

FM is commonly used at VHF radio frequencies for high-fidelity broadcasts of

music and speech. Normal (analog) TV sound is also broadcast using FM. A narrowband form is used for voice communications in commercial and amateur radio settings. The type of FM used in broadcast is generally called wide-FM, or W-FM. In two-way radio, narrowband narrow-fm (N-FM) is used to conserve bandwidth. In addition, it is used to send signals into space.

FM is also used at intermediate frequencies by most analog VCR systems, including VHS, to record the luminance (black and white) portion of the video signal. FM is the only feasible method of recording video to and retrieving video from magnetic tape without extreme distortion, as video signals have a very large range of frequency components — from a few hertz to several megahertz, too wide for equalisers to work with due to electronic noise below -60 dB. FM also keeps the tape at saturation level, and therefore acts as a form of audio noise reduction, and a simple limiter can mask variations in the playback output, and the FM capture effect removes print-through and pre-echo. A continuous pilot-tone, if added to the signal — as was done on V2000 and many Hi-band formats — can keep mechanical jitter under control and assist timebase correction.

FM is also used at audio frequencies to synthesize sound. This technique, known as FM synthesis, was popularized by early digital synthesizers and became a standard feature for several generations of personal computer sound cards.

## **Applications in radio**

Edwin Armstrong presented his paper: "A Method of Reducing Disturbances in Radio Signaling by a System of Frequency Modulation", which first described FM radio, before the New York section of the Institute of Radio Engineers on November 6, 1935. The paper was published in 1936.

Wideband FM (W-FM) requires a wider bandwidth than amplitude modulation by an equivalent modulating signal, but this also makes the signal more robust against noise and interference. Frequency modulation is also more robust against simple signal amplitude fading phenomena. As a result, FM was chosen as the modulation standard for high frequency, high fidelity radio transmission: hence the term "FM radio" (although for many years the BBC called it "VHF radio", because commercial FM broadcasting uses a well-known part of the VHF band; in certain countries, expressions referencing the more familiar wavelength notion are still used in place of the more abstract modulation technique name).

FM receivers employ a special detector for FM signals and exhibit a phenomenon called capture effect, where the tuner is able to clearly receive the stronger of two stations being broadcast on the same frequency. Problematically however, frequency drift or lack of selectivity may cause one station or signal to be suddenly overtaken by another on an adjacent channel.

Frequency drift typically constituted a problem on very old or inexpensive receivers, while inadequate selectivity may plague any tuner.

An FM signal can also be used to carry a stereo signal: see FM stereo. However, this is done by using multiplexing and demultiplexing before and after the FM process, and is not part of FM proper. The rest of this article ignores the stereo multiplexing and demultiplexing process used in "stereo FM", and concentrates on the FM modulation and demodulation process, which is identical in stereo and mono processes.

A high-efficiency radio-frequency switching amplifier can be used to transmit FM signals (and other constant-amplitude signals). For a given signal strength (measured at the receiver antenna), switching amplifiers use less battery power and typically cost less than a linear amplifier. This gives FM another advantage over other modulation schemes that require linear amplifiers, such as AM and QAM.

In audio and music **frequency modulation synthesis** (or **FM synthesis**) is a form of audio synthesis where the timbre of a simple waveform is changed by frequency modulating it with a modulating frequency that is also in the audio range, resulting in a more complex waveform and a different-sounding tone.

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