FM vs. AM: Technical Considerations

If electrical signals could be seen, they would look like the figures shown here. (Actually, they *can* be seen, on an instrument called an oscilloscope, which resembles a small television set.) If one were to whistle into a microphone with a pure low-frequency audio tone, the microphone would convert the voice into an electrical signal like Fig. 1.
An essential portion of a radio transmitter produces a much higher frequency electrical signal

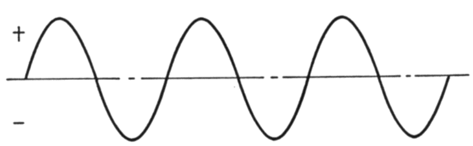

Figure. 1. A pure audio tone converted into an electrical signal.

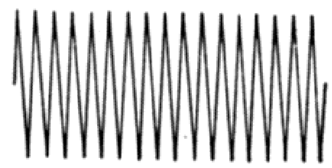

Figure. 2. A carrier wave produced by a radio transmitter.

called the carrier wave like Fig. 2. To transmit intelligence, the radio transmitter must somehow superimpose the voice signal on the carrier wave, a process called modulation. (The radio receiver *demodulates,* or separates the desired audio signal from the carrier wave.)

Amplitude modulation or AM was the first type of modulation developed, early in the 20th century. When the amplitude or height of the carrier is changed in time with the audio signal, the result would look like Fig. 3

Instead of modulating the amplitude of the carrier, one can use the audio signal to change the

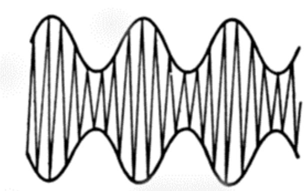

Figure 3. An amplitude modulated radio signal.

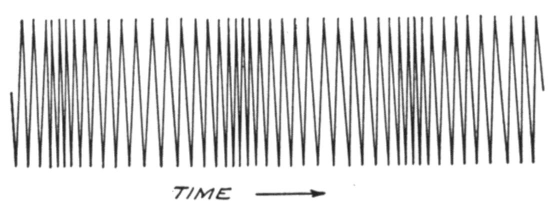

Figure 4. A frequency modulated radio signal, modulated by the same audio signal as in Fig. 3.

frequency of the carrier, and that is frequency modulation. If the carrier were frequency modulated by the same audio signal as in Fig. 3, the result would look like Fig. 4. The frequency increases and decreases, but the amplitude of the modulated signal stays constant. The same intelligence has been transmitted. Of course a symphony concert with its multitude of sounds would produce a much more complicated looking waveform.

<u>Questions About AM vs. FM:</u>

Why is FM more static-free than AM?

Static is caused by things like lightning discharges or electrical discharges from nearby motors or other electrical devices, and those discharges produce small bursts of radiated energy. The AM receiver picks up the bursts of static along with the desired signal and adds them together. Static shows up as sharp vertical peaks (spikes) on the modulated waveform, and AM radios respond to them. However, in an FM receiver, the amplitude of the signal does not matter—only changes in frequency matter—so there is no static with FM.

If it is better, why didn't people use FM in the early days of radio?

AM was discovered first, and tends to be simpler. In the early days of radio, mathematicians thought they had "proved" that FM would not work as well as AM, but their analyses were oversimplified. E. H. Armstrong showed that if one used a sufficiently wide bandwidth, FM works just fine. For FM to work well, a much wider channel (bandwidth) is required than with an AM station. At the frequencies used in the AM broadcast band (roughly 550 to 1700 kilohertz) there is insufficient spectrum "space" to permit the wide channels needed for FM, but there is sufficient channel space available at the higher frequencies now used for FM (88 to 108 Megahertz). Another problem was that in the early days of radio, the vacuum tubes then available did not work well at the high frequencies where FM needed to operate. Another benefit of FM: the wider channels occupied by FM stations can accommodate modulation with wider frequency excursions than those from AM stations, so FM stations broadcast with much higher fidelity.

Why can you sometimes hear far away stations on AM but not on FM?

That has to do not with the difference between AM and FM, but rather *the different radio propagation conditions* in the AM band vs. the FM band. At the frequencies used in the AM broadcast band, signals can bounce off the ionosphere, especially at night, and be reflected back to earth at considerable distances from the transmitter, as shown in the figure below. But signals at the much higher frequencies used for FM generally do *not* bounce off the ionosphere, and so FM reception is limited to more or less a line-of-sight path.

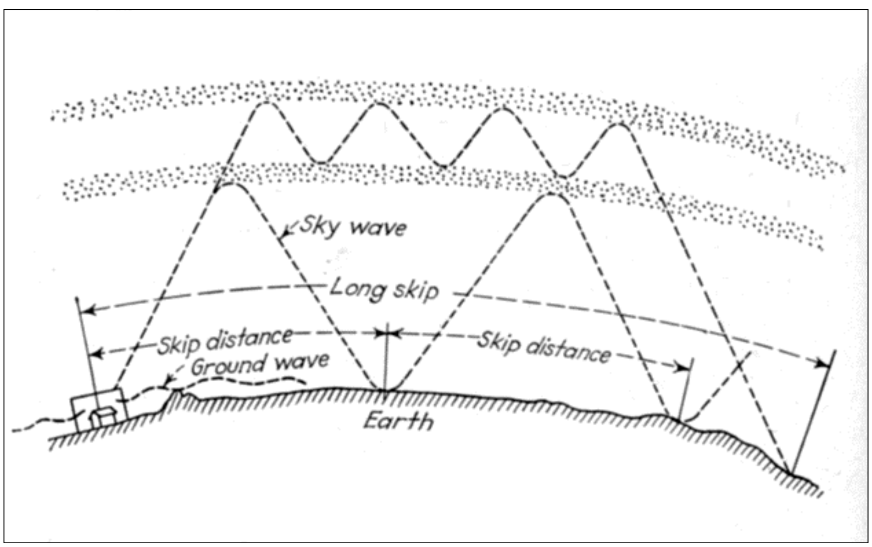

Figure 5. Charged particles in the ionosphere can reflect radio signals, which can then come back to earth quite some distance away from the transmitter.. These reflected signals often shows up at the frequencies used in the AM broadcast band, especially at night, but NOT at the much higher frequencies used for FM.