Integral Parts of a Typical FM Receiver

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Antenna

The first of the many important parts of a typical FM receiver must be the device by which radio waves are captured. The size of a FM receiver antenna will determine its ability to detect FM band wavelengths or fractional derivatives thereof.   The electromagnetic variations of the incoming radio frequency (RF) cause variations in current and voltage to be detected in the antenna's physical construction, and these variations are passed on the next important section of the typical FM receiver: The RF Amplifier.

Tuning/Selectivity Portion of FM Receiver Inputs

Before discussing the manner in which the minute variations received from the antenna are amplified to useable levels, one must define which particular frequency or frequencies are to be amplified. After all, the antenna itself receives all frequencies of which its construction allows. One must "tune" the received comprehensive RF, so that only the desired RF is passed onward to the RF amplifier. Various methods of tuning can be implemented, but each performs the similar task of filtering out unwanted frequencies, bands, or bandwidths, while passing the appropriate information to the RF amplifier section.

The tuning section also plays a crucial role in the FM heterodyning process. The tuned RF is routed to the Local Oscillator, which in turn feeds the Mixer/IF Generator. The net effect is that the tuning section helps the intelligence riding on the incoming radio waves to be transferred to and used by other significant components of the FM receiver.

RF Amplifier

RF amplifiers are perhaps the most significant component(s) in the front end of the FM receiver. Whereas AM receivers detect varying amplitudes in the range of 30 uV, FM receivers can detect incoming signals near the 1 uV range. Because of this great sensitivity, FM RF amplifier(s) must be able to produce high amounts of gain while maintaining very low noise characteristics. Any noise added in a gain stage will cause a decrease in overall signal to noise ratio of the RF amplifier, a compounding effect of noise upon noise, and possibly cause phase distortions at the Discriminator. It is for this reason that the RF amplifier component(s) are to be held high in importance.

Local Oscillator

In radio receivers, Local Oscillators shift incoming tuned frequencies to a specified range above or below the incoming tuned frequency. Its usefulness is not fully realized by its frequency-shifting role alone, but also in its ability to change its output frequency as defined by the tuned input frequency. In typical FM receivers, the L.O. has an output of 10.7 MHz above or below the incoming tuned RF, depending on the particular intermediate frequency desired, and the method in which the L.O. frequency is created. Therefore, the output function of a typical FM receiver L.O. is specified as: (RF_{tuned} +/- Desired IF value in Hz.) This output frequency then feeds the Mixer, and plays a critical part in FM Heterodyning.

Mixer/IF Generator

FM Heterodyning takes place at the Mixer. The amplified RF signal, and the L.O. output are combined in such a fashion that 4 signal components are produced. The mixer produces the original RF, the original L.O. frequency, the sum of the original RF and the original L.O frequency, and the difference between the original RF and original L.O. frequency. The difference is called the Intermediate Frequency. The significance of this IF signal is that though the signal is the difference of the originals, the original RF intelligence is transferred to and is contained within the newly formed IF signal. Mixing effectively takes a received RF frequency and moves it to a different, intermediate frequency, while retaining the original intelligence.

IF Amplifier

Like the RF amplifier, the IF amplifier must effectively amplify the incoming signal. In the case of Intermediate Frequencies, amplification and filtering are often utilized simultaneously. It is also not uncommon for several stages of IF amplifiers to used in succession. The amplified IF output then proceeds to Limiter, Automatic Gain Control, and Discriminator circuitry.

Limiter

In cases where the amplitude of the IF amplifiers may vary greatly above a certain desired threshold, Limiters are used to, in effect “limit,” the varying output to a consistent level. Since amplitude variations are not required in frequency modulation discrimination, a constant, useable-output level is all that is needed to complement to the following sections of the FM receiver.

Limiters can also be used in transient noise suppression. Instantaneous spikes occurring in the IF sine wave are flattened when a limiter is applied. Unfortunately, large voltage spike cause distortions in the phase relations of the varying-frequency IF. These phase distortions cannot be removed, and are transferred to the Discriminator.

The final important usefulness of limiters is that they can play a key part in Automatic Gain Control feedback circuits. When used in combination, Limiters and AGCs can effectively maintain stable gain across RF and IF sections.

Automatic Gain Control

Automatic Gain Controls seek to maintain useable levels throughout the FM receiver. Though similar to limiters in end-result, AGC components control overall output levels of RF and IF amplification sections by the use of feedback. In the case where a limiter feeds the overall output back to the AGC circuit, the AGC varies its control over the independent RF and IF gain stages, effectively varying each sections gain, to compensate for overall shifts in signal amplitude. This increases the stability of the circuit as a whole, and continues to regulate as needed during operational shifts or anomalies.

Discriminator

The Discriminator is the most important element of the FM receiver rear-end. Like its AM counterpart, the discriminator detects and translates the original intelligence back to its original state. For FM receivers, the original intelligence is usually audio frequency information.

The manner in which the Discriminator extracts the IF-imbedded information varies from design to design. The level of circuit complexity ranges from a few discrete components, to a small armada of ICs. In the end all discriminators do essentially the same thing.

De-Emphasis

In the Event that Pre-emphasis was used in the transmitting circuit, De-Emphasis must be applied to the audio-range frequencies before amplification. Pre-Emphasis is an audio frequency equalization technique where high frequencies are given a 6dB/octave rise in gain following a crossover frequency of approximately 13.333 kHz or an RC time constant of 75uS. This is done to raise the signal to noise ratio among higher audio frequencies, for the reason that noise seems more prevalent or noticeable when it resides in the higher audio-frequency bands. De-Emphasis then, is 6dB/octave decrease is gain at a crossover frequency of 13.333 kHz.

Audio Amplification

The final integral part of a typical FM receiver is the audio amplifier. The discriminated' and de-emphasized' signal is given a considerable power gain, so as to allow for the audio signal to drive sound transducers such as speakers or headphones.

Conclusion

The initial electromagnetic radio waves are thus transformed from frequency to frequency, and ultimately to sound pressure waves. The typical FM receiver extracts all of the original information encoded by frequency modulation and converts it to something useable. Though Fm receivers can differ from design to design, the necessary parts are always present in some shape or form. Knowing these, one can design, troubleshoot or operate any typical FM receiver.