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A. M. Modulation Monitor

• The audio which can be recovered in the home receiver is highly dependent upon the modulation that is taking place in the transmitter. It is important, therefore, that this modulation process be continuously monitored at the broadcasting station with an FCC approved modulation monitor. The monitor, essentially an operational test instrument that provides accurate data on the modulation taking place, permits adjustments to modulation levels during programming. The monitor contains a number of important functions and circuits, but we only have space to discuss a few of the most important ones.

THE SIGNAL

When modulation is taking place in the transmitter, the output signal is a modulated rf wave that contains three components: the rf carrier, and two equal sidebands that are above and below the carrier. This is a full, double sideband signal. Each one of the sidebands will carry the entire program modulation intelligence. But even though the complete information is contained in each sideband and technically we can recover the full program audio from either one, because of the demodulation process, both sidebands should be identical in every respect or the recovered audio will suffer in some manner. The sidebands are not audio signals—they are rf wave components that vary at the audio modulation rate.

DEMODULATION

Demodulation is the reverse process of modulation. The demodulator removes the modulation intelligence from the modulator rf wave and converts this back into the original audio signal. All other functions and metering circuits work with the audio signal that appears at the output of the demodulator, so consequently the demodulator is the most important circuit in the monitor. The accuracy of its performance will determine the accuracy of the entire monitor. Even if every other circuit and function of the monitor performed perfectly, none could yield any more accurate data than the accuracy of the signal presented to them.

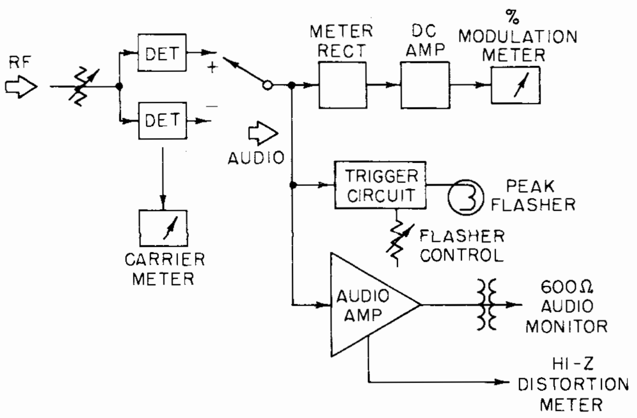
THE DETECTOR

The circuit most commonly used for demodulation in an a.m. monitor is the diode detector. The diode does have some shortcomings, but when the circuit is well designed and operated within its parameters, it will produce the necessary accuracy in results.

The diode, its filter and load make up the detector circuit. The diode removes the sidebands from the modulated wave by rectification, the filter removes the rf components from the rectified carrier, and the output voltage is developed across the load resistor. This is a peak detector whose output is a d.c. voltage that varies at the audio modulation rate. The variation in amplitude of this d.c. voltage is a replica of the original audio signal.

The filter design is important to the detector's operation. The value selected for the capacitor must be such that it will remove only the rf component, leaving the audio envelope component intact. If the value is too large, it will remove the higher audio

Figure 1. The basic monitor circuits.



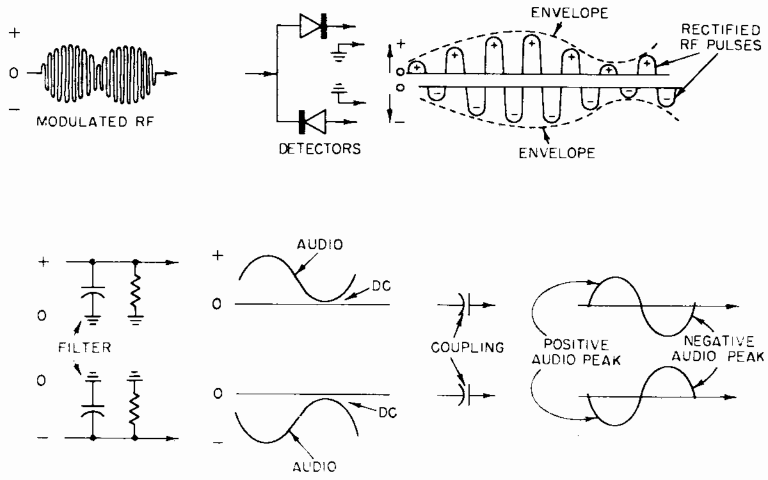


Figure 2. Detection process. (Rf waveforms are shown exaggerated,

frequency components and produce a poor audio bandpass for the detector. And if the value is made very large, then the circuit becomes a d.c. power supply instead of a detector. The load must be high in resistance value or it will affect the detector's efficiency and make it work at somewhat less than a peak detector.

DETECTION

Two separate detector circuits are used in monitors to provide two independent output signals. These detectors are placed in opposite polarity to the rf wave so that one detector will rectify the positive going half of the wave, and the other detector will rectify the negative going half of the wave. Each of these detectors is recovering the same modulation information but the separate outputs are out of phase with each other. The output of each detector can be selected by a front panel (+) or (−) peak modulation switch. Whichever detector is selected by this switch will then feed all the other circuits of the monitor.

In a.m. modulation, it is important that the positive and negative audio modulation peaks are observed and measured, so this is why they are made selectable. The audio peaks could be split by a phase splitter but the common practice is the use of two detectors. This makes things less complicated, gives a better review of the modulated wave, and makes the following circuits more simple in design.

The output of the detector which rectifies the positive half of the rf wave is a varying d.c. voltage that is positive with respect to ground. When the d.c. component is removed by a coupling capacitor, the resulting audio signal positive peak is in phase with the original audio—that is, both positive audio peaks are in the positive direction. The output of the detector which rectifies the negative half of the rf wave is a varying d.c. voltage that is negative with respect to ground, and the recovered audio signal is out of phase with the original audio. Therefore, the original positive audio peak is now going negative while the original negative peak is now in a positive direction. As far as the monitor circuits are concerned, regardless of which audio peak is selected for observation, they see only positive going voltages at their inputs.

SENSITIVITY

The diode detector is somewhat insensitive and requires a relatively large input signal or it will become non-linear and produce a distorted output. This lack of sensitivity is no real problem since the monitor is designed to couple directly to the transmitter output circuit by coaxial cable. In this arrangement, however, there is a danger that too much signal may be applied to the diode. This would overload the circuit and produce a distorted output, and it can damage the diode and circuit components.

The semi-conductor diode does not produce a "clean" baseline (a.c. signal zero axis line). Some reverse current will flow on the reverse half cycle of the a.c. signal and this will allow part of that half-cycle to appear in the output. The forward conduction curve of the diode exhibits a bend at the portion where the conduction begins. When the input a.c. signal is too small in amplitude, then operation is in this area of the curve and the output will be very non-linear. The input signal must be large enough so that the operation is on the straight line portion of the forward conduction curve. Some

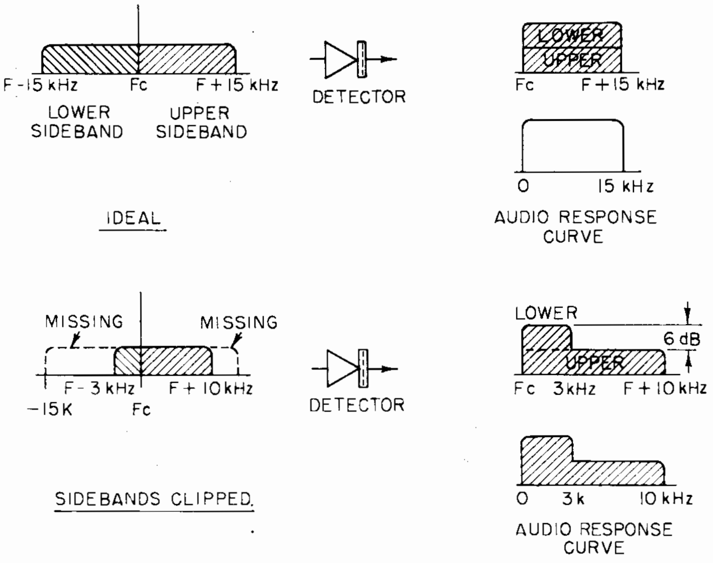


Figure 3. Non-symmetrical sidebands affect the amplitude response curve of the recovered audio.

monitors forward bias these detectors almost to the point of conduction in order to improve their linearity. But even with this design technique, the input level must be carefully adjusted.

SELECTIVITY

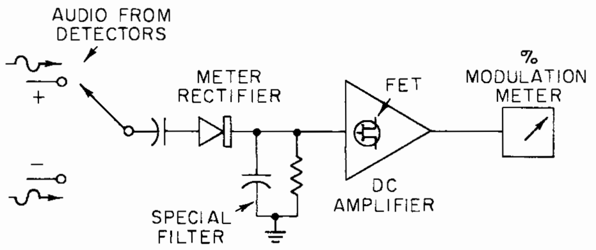
The diode is a non-selective device that will rectify any a.c. signal that appears at its input with enough amplitude to make the diode conduct. The diode cannot distinguish the various components of the modulated wave, but will rectify the instantaneous voltages of all the components present at its input at any instant. In so doing, the diode is recovering *both* sidebands at the same time and adds them together in its output (in phase). It is because of this detector action that both sidebands should be identical in every respect. When they are not, when they are added together in the detector output, the audio will suffer according to the differences of the sidebands.

For example, assume that sideband slipping has removed most of the lower sideband because of faulty tuning. If we used a sweep signal to modulate the transmitter, the waveform of the sweep envelope at the output of the detector would appear similar to the FCC's *Ideal Detector Curve* for t.v. picture transmission. In the bandpass area where both sidebands are present and equal in amplitude, these are added together in the detector output. But in the area where the lower sideband is missing, only the voltage of the upper sideband is present, so the voltage amplitude is down one-half, or 6 dB. Sideband clipping in this case has produced a very poor audio bandpass for the system. (The t.v. receiver, by the way, corrects for the unequal sideband transmission by having its IF response curve sloped.)

CARRIER LEVEL

The average value of the carrier does not change during modulation. If any change does occur, this is termed *carrier shift*. FCC rules require that any carrier shift be kept within a 5 per cent tolerance. A number of conditions can cause carrier shift in the transmitter, but a measurement of this factor is also a measure of transmitter performance under modulation conditions. The output of the detector is a d.c. voltage that is derived from the rf carrier, so the current flowing in the

Fig. 4. The modulation meter circuit is a high impedance fet meter with special



detector output circuit is measured with a front panel meter which is labeled *Carrier Level* or similar terminology.

Metering the d.c. current of the detector in this manner serves two useful purposes. Since this meter measures the output of the detector, then it can be used to set the rf input to the detector properly. And since any change in the average carrier value will change the average current in the detector output, a proportional amount, we can read the carrier shift directly from this meter.

MODULATION METERING

The modulation percentage caused by either the positive or negative audio peaks is measured with a high impedance voltmeter circuit that is the equivalent of a vtvm or fet meter. This is a quasi-peak indicating circuit and it must contain special damping and meter ballistics, according to the FCC rules.

The positive or negative modulation peaks selected by the switch will feed the audio signal to a meter rectifier circuit. The output of this rectifier circuit is a varying d.c. voltage that now has the special damping, and this voltage is amplified by a d.c. amplifier which drives the front panel modulation meter. The r-c filter in the rectifier circuit provides the special damping characteristics. The meter face has two scales: one in percentage for modulation of program, the other in dB for tone modulation and testing.

PEAK FLASHER

Since the modulation meter cannot follow peaks because of its characteristics, a true peak indicating circuit is provided. This is an electronic circuit, such as a Schmitt Trigger or similar circuit, which has its threshold sensitivity preset by the front panel flasher control. When an audio peak exceeds this threshold, the trigger will fire and turn on a lamp or other visual device to warn that a peak has exceeded its setting. This circuit will catch many peaks that do not show up on the modulation meter.

OTHERS

The monitor will provide an audio output for aural monitoring and for making distortion measurements. Individual models also provide many other features. But regardless of the features, the monitor should be kept in calibration, good repair and operated properly. Next month we will discuss some of the problems that can occur in monitoring. ■