FM MONITOR

(CONTINUED FROM PAGE 21)

circuit. The thyratron is tripped by a triggered amplifier tube which has the modulation signal impressed on its control grid, together with a given amount of negative bias voltage as determined by the dial-potentiometer setting. Whenever a modulation peak exceeds the applied DC bias, a pulse of plate current is generated in the amplifier, which is then used to trip the thyratron. The lamp operates on positive modulation peaks. This is not significant, except when asymmetrical modulation is present, at which times the agreement between the modulation meter and the over-modulation lamp will depend upon the meter polarity used.

The second modulation indicator consists of a semi-peak response meter circuit, which can be set to respond to negative or positive modulation swings, or both simultaneously. There are two semi-peak response diodes, each used to operate an independent VT voltmeter tube. An R-C network is placed in the grid circuits of each of these tubes. This permits a rapid rise in the grid potential with increasing modulation amplitude, and a slow response to decreasing a-m plitudes. During modulation, the meter indications appear to float along the peaks of the modulation signal. This dynamic-response characteristic meets FCC requirements. It is illustrated by Fig. 10.

For FM applications, there is no preference for monitoring any one polarity of the modulation signal, as is the case in an AM transmitter. Operators are mainly interested in the maximum modulation swing regardless of polarity. Hence, the ability to monitor both simultaneously is advantageous. This is especially true when asymmetrical program material is encountered. The maximum modulation peaks may shift from one polarity to the other as the program changes, thus requiring continual shifting of the meter polarity to assure an indication of the true maximum peak swing. By setting the meter to respond to both polarities simultaneously, this operating complication can be avoided.

Center-Frequency Indicator Characteristics ★ The stability and accuracy of the center-frequency indications are dependent upon several circuits. The monitoring crystal affects the center frequency meter directly. After the initial installation and the usual frequency check and adjustment, it has been found that long-term stabilities in the order of 1 part per million can be expected. This will account for a change in the center-frequency indicator of 100 cycles.

A second factor to be considered is the discriminator center-frequency stability. This includes the discriminator, compensating circuits, and associated diodes. These circuits will not cause an effective shift in discriminator center frequency greater than .066%, or an indication of 100 cycles on the center frequency indicator.

These account for errors in the center-frequency indicator, and will amount to only 2 parts per million, or 200 cycles.

Changes in meter circuit sensitivity can be neglected, since they are proportional to the full-scale deflection of the meter, and are negligible by comparison with other factors.

Since a balanced DC vacuum-tube voltmeter is used to drive the center-frequency meter, any change in the zero setting will affect the meter directly. This has been reduced to a value of less than 200 cycles for extended periods. A panel switch has been provided so that this zero setting can be checked (once a day is adequate), and hence drift in the zero does not influence the ultimate accuracy of the center-frequency indicator. If this check is not made, the overall instability will approach a maximum of 400 cycles. Continuous recordings of the center frequency are feasible, a feature which is not possible without this high overall stability, regardless of the ultimate accuracy.

The extreme linearity of the discriminator results in a negligible shift in indicated center frequency under full modulation conditions. Therefore, the monitor can be used to test transmitters for this characteristic.

External Indicators ★ Arrangements are provided for connecting to remote indicators. The meters used are currently available types, with a minimum of special requirements, and can be connected without affecting the calibration. The remote overmodulation-peaks indicator is a standard 3- to 6-watt, 115-volt mazda lamp.

Test Equipment ★ One of the most difficult problems associated with the development of the monitor was that of determining the overall performance characteristics in the absence of a perfect test source. Each component was first tested separately. The discriminator was checked statically, using a precisely calibrated potentiometer. A characteristic was obtained which indicated a maximum of .05% departure from linearity over a range of ±100 kc.

The audio fidelity measuring system was considered satisfactory when overall tests resulted in a residual distortion below 0.1%, and the residual noise measured less than −80 db.

Other portions of the instrument were given long-term calibration tests. To ascertain its stability characteristic for extended periods, the discriminator was operated from a 150-kc. signal derived from our primary-frequency standard.

By operating the IF system from a stable, noise free, 150-kc. source, the residual equivalent FM noise level was measured to be less than −80 db for the combined IF, discriminator, and audio output systems.

Overall tests of the complete monitor were made with a specially developed phase-modulated FM test-source, operated from the 50-kc. output of the primary frequency standard, multiplied to 102.4 mc. This provided a source of extremely stable FM signals, and was very useful for determining the shift in the indicated center frequency of the monitor with applied transmitter modulation. It further served as a comparison test source for fidelity measurements. A second test source employed a local FM oscillator for overall tests of residual noise and distortion. It was obviously impossible to construct a perfect test source, and there were practical limits imposed upon the two test units. By comparing the results obtained from each of these two different types of modulators, a relative measure of the monitor performance was obtained. Consistent results showed a measured distortion level of 0.25% over a wide range of modulating frequencies and transmitter modulation levels for both test sources. The modulating oscillator was known to have 0.1% distortion. On the basis of the tests on the monitor, made by insertion of an IF signal, it was adjudged that most of the remaining distortion was actually generated within the test sources. While these tests cannot be used to define rigorously the residual distortion within the monitor, they are indicative of the results that may be expected.

The same is true for the noise measurements, where the results indicated a noise level of −70 db for the entire system, with the conclusion that the FM test sources were again the limiting factor.