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TV Station Monitor

BY

C. A. CADY

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A PULSE-COUNTER CIRCUIT IN AN OFFSET-TYPE MONITOR—*By* C. A. CADY*

THE requirements of video-transmitter frequency monitors have seen many changes since the first prewar television transmitters began operating. It was then generally accepted practice to use a heterodyne frequency meter, and to record measurements at discreet intervals. A transmitter frequency tolerance of perhaps plus or minus 0.01% was easily maintained by such procedure.

Post-war developments, and the increasing congestion of the high-frequency bands culminated in the issuance by the FCC of a frequency tolerance specification of plus or minus 0.001%, and the added requirement of continuous monitoring. These conditions could not be met with equipment then available.

Initial Monitor Design:

One of the simplest and most flexible methods of frequency monitoring consists of measuring the difference, or beat, frequency between a monitoring crystal oscillator and the transmitter carrier frequency. For high frequencies, a harmonic of the monitoring crystal is used. By employing a pulse-counter type of frequency meter, Fig. 3, to indicate the beat frequency, a very flexible arrangement is obtained, covering a wide range of carrier frequencies, and capable of measuring a considerable range in transmitter frequency error.

A monitor of this type was commercially available for AM broadcast and utility services, and of a design readily adaptable for television. At that point, the limited demand did not appear to warrant development of a special-purpose monitor for television.

That monitor used the zero-beat system, with the monitoring oscillator set to the channel frequency, and a frequency meter indicating the audio beat between monitor and transmitter. There are two inherent disadvantages to such a system for services where narrow frequency tolerances are allotted: first, the monitor does not give a recognizable indication when the transmitter is exactly on frequency, and secondly, some auxiliary means such as a manually operated push button is required to determine whether the transmitter frequency is high or low.

*Engineer, General Radio Company, Cambridge 39, Mass.

Fig. 1. The General Radio direct-reading frequency monitor for TV transmitters

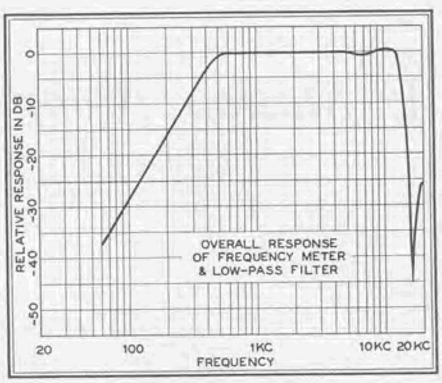

Fig. 2. Overall response of TV monitor

Offset-Frequency Type:

Offset-frequency monitoring is standard with other broadcast services, including the FM sound broadcast for television,[1] and it was recognized that, as soon as performance requirements became more definite, an offset-frequency type of monitor would be needed for the video transmitter.

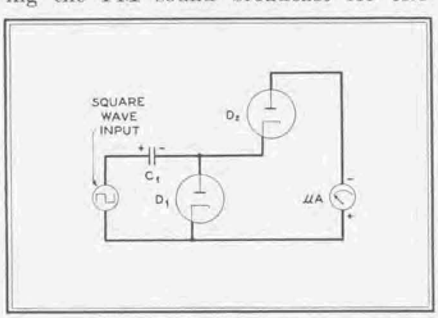

Fig. 3. Simplified pulse-counting circuit

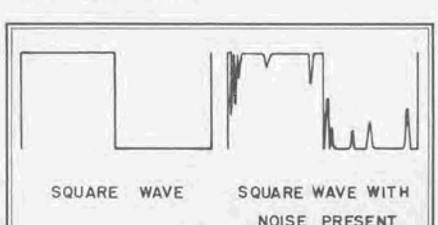

Fig. 4. Noise-peak effect on waveform

In the offset-frequency method of monitoring, the monitor frequency is offset from the channel frequency to give a known audio-frequency beat when the transmitter is exactly on frequency. The deviation meter scale is calibrated directly in transmitter frequency deviation, rather than in beat frequency.

Now, by the inclusion of the offset frequency feature and other refinements, the older high-frequency monitor has been redesigned to meet the specific requirements of picture transmitter monitoring. Fig. 1 is a panel view of the instrument.

The exact scale arrangement stems from present FM monitor practice, and has two ranges conforming to the transmitter channel frequency. Thus, for channels 2 to 6 the meter range becomes 3-0-3 kc; or for channels 7 to 13 it is 6-0-6 kc. By locating the crystal harmonic on the *low* side of the desired channel frequency, the resultant beat frequency increases with increasing transmitter frequency error toward the plus, or high side. While this mode of operation is somewhat arbitrary, it results in a meter scale reading from minus left, to plus right, in accordance with accepted practice.

If a monitor were designed to operate as just outlined, the limiting condition would appear when it was operated with an extreme frequency error on the minus or low side, where a 6-kc. deviation would correspond to zero beat. Erratic indications would be obtained as zero beat is approached. Fortunately, this limitation can be easily avoided. Without changing the scales, the amount of offset can be increased by an arbitrary amount, and electrical suppression of the meter at its extreme left, or mechanical-zero position, introduced. It is important to re-

[1] "FM Monitor has Pulse-Counter Discriminator," by C. A. Cady, *FM* AND TELEVISION, December, 1947.

member that we still have essentially a frequency meter, even though it is no longer calibrated directly as such. The normal mechanical zero of the meter will thus be at the extreme left end of the scale, at the zero DC point. Making use of this fact, a small fixed bucking-potential can be introduced which will deflect the meter in reverse by a predetermined amount, in the absence of a beat frequency. As the beat frequency increases from zero, the meter will remain off scale, in reverse, until the DC potential developed by the pulse-counter circuit equals the applied fixed potential. Further increase in the beat frequency will cause a proportionate deflection upscale on the meter.

The amount of zero-beat suppression should be sufficient to avoid operating within a range which includes most of the low-frequency video-synchronizing pulses. The maximum amount of zero-beat suppression is limited by the requirements of sensitivity, and linearity of the scale.

An arbitrary frequency suppression of 500 cycles for the lower range was chosen as a good compromise between obtaining the desired sensitivity and avoiding the majority of synchronizing-pulse frequencies. The actual beat frequency produced is thus 500-3500-6500 cycles on the lower channels, and 1000-7000-13,000 cycles for the higher channels. This makes for simplicity of initial calibration procedure, and with the use of reversible meter scales provides an easy method of changing ranges in the field.

The highest beat frequency obtained will be 13,000 cycles, when the deviation meter scale is indicating a transmitter frequency error of plus 6,000 cycles. To avoid interference from the line-frame video frequency of 15,750 cycles, a low-pass filter is used which has an attenuation peak at this frequency. Frequencies below 500 cycles are attenuated within the frequency meter itself.

Frequency Discrimination:

From the foregoing, it is evident in Fig. 2 that the monitor must operate with a beat-frequency range of 500 to 13,000 cycles maximum. The question now arises as to how the frequency meter can distinguish between the desired beat frequency and the normal television picture-video frequency components present within this range. For an answer to this, a consideration of the energy distribution in a television video signal is required. A large percentage of the energy contained in the video modulation consists of blanking and synchronizing pulses, occurring at a uniform rate, at frequencies below 500 cycles. Likewise, the 15,750- and 31,000-cycle video frequencies are a source of energy, at fixed frequencies.

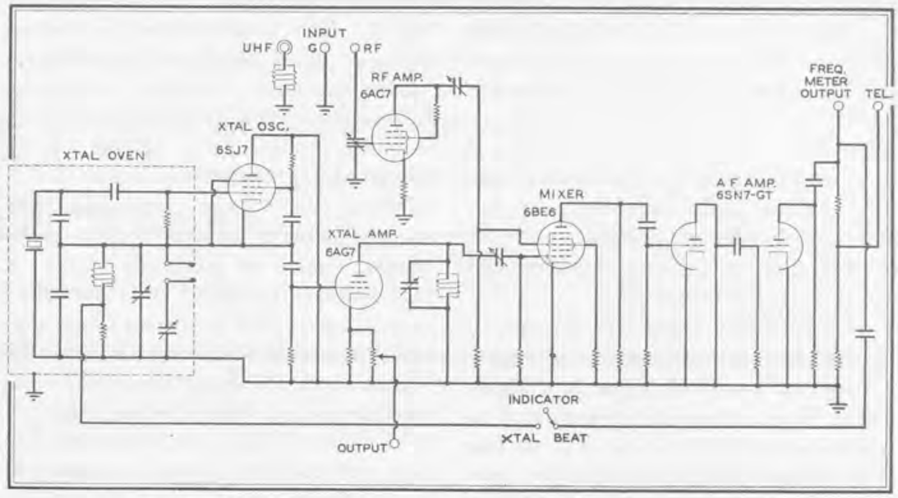

Fig. 5. Simplified schematic circuit diagram of frequency monitor unit

Within the range of 500-13,000 cycles, the energy consists of rapidly changing frequencies caused by the actual picture transmission, and hence is transient in nature. On the other hand, the beat frequency is steady and of large magnitude compared to any single transient component. An analogy might be that of a steady-state signal in the presence of a moderate noise level of limited bandwidth.

Circuit Details:

The frequency meter is a pulse-counter type, as shown in Fig. 3. It is operated from a square wave of constant amplitude, obtained by passing the beat-frequency through a series of limiting amplifiers. Noise peaks in the upward direction are thereby removed, and cannot affect the waveform. Noise peaks in the downward direction can affect the waveform as shown in Fig. 4. Since the capac-

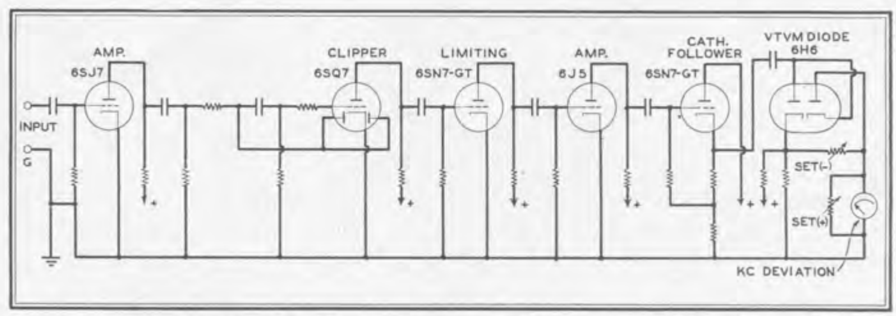

Fig. 6. Functional schematic of the frequency meter section of the TV monitor

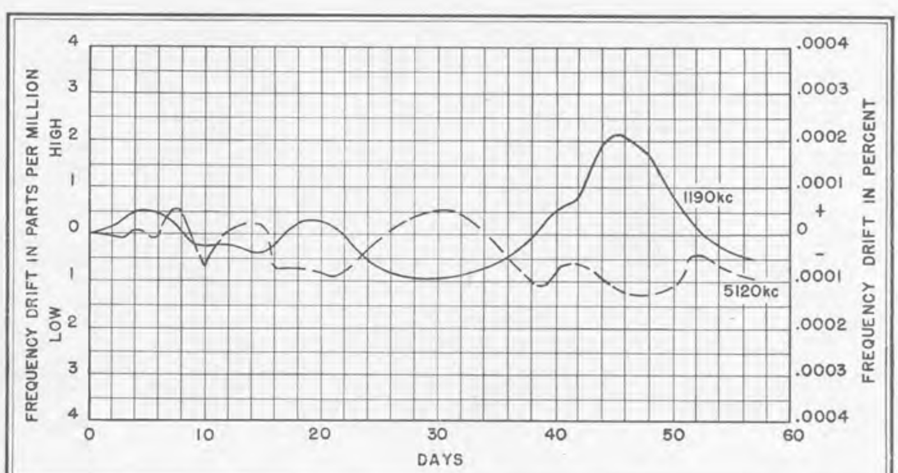

Fig. 7. Sixty-day record of frequency drift in a type 1182-T TV frequency monitor

itor C-1 is charged to the peak value of the square wave, the transient noise pulses can have only a minor effect upon the DC current through the microammeter.

The complete monitor is in two sections; one comprising a monitoring crystal oscillator, buffer amplifiers, detector and beat-frequency amplifier, and the other a series of limiting amplifiers and the frequency meter circuit.

An elementary schematic diagram of the monitor section is shown in Fig. 5. The crystal oscillator circuit is a highly stable design, temperature-regulated to minimize frequency drift. Up to four crystals can be mounted within the oven.

An elementary schematic diagram of the frequency meter section is shown in Fig. 6. The beat-frequency is successively amplified and limited to develop a square waveform of constant amplitude. Below 500 cycles, the response of the amplifier drops rapidly. Power supply regulation is provided to minimize the effects of line-voltage variations. The square wave is applied to the pulse counter circuit, as previously noted. A bias voltage is derived from the plate supply, and is used to provide a zero suppression, and is adjustable via the SET − control. A DC meter shunt SET + is used to control the full-scale deflection of the meter. Once the instrument has been calibrated, it is merely necessary to reverse the meter scale and halve, or double, the capacitor C-1, in order to change range. For convenience, this capacitor is made from two matched capacitors of equal value; one alone being used for the 6-0-6 kc. range and both in parallel for the 3-0-3 kc. range.

Provision is made for connecting remote meters, and adjustments are provided for setting the monitor reading in agreement with an independent frequency measurement. The accuracy of the monitor crystal frequency is 0.001%; but measurements indicate that the stability is considerably improved after the instrument has been in continuous operation for some time. This is apparent in Fig. 7, which shows the frequency drift of the monitor over a period of 60 days.