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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

A FREQUENCY MONITOR FOR TELEVISION VIDEO TRANSMITTERS

Also

IN THIS ISSUE

● **TELEVISION TRANSMITTERS** need two types of frequency monitor, an f-m type for the audio channel and an a-m type for the video. Monitoring requirements for the audio transmitter are met by the TYPE 1170-A F-M Monitor[1], which is specifically designed for both television and f-m broadcast applications. For video transmitters, however, agreed standards of performance have only recently become available.

When only a very few stations were on the air, the general requirements were met reasonably well by the general-purpose TYPE 1175-A

[1]"TYPE 1170-A F-M Monitor for Broadcast and Television Services," *Experimenter*, October, 1947.

Figure 1. Panel view of the complete video frequency monitor.

Frequency Monitor[2], and from the experience gained in early installations, changes in design were made to improve performance and to extend the range to all television channels[3]. Recently, however, monitoring requirements for television have been more definitely established, since the Federal Communications Commission has prepared a proposed draft of "Parts 15 and 16 of the Rules and Standards Concerning Television Broadcast Stations." To meet these requirements, the General Radio Type 1182-T Television Video Monitor has been designed.

This video monitor, like its general-purpose predecessors, consists of a monitor unit and a deviation indicator unit. The over-all principle of operation is the same, except that the frequency-offset method of indication is used, in order that the direction of the deviation be indicated. All modifications have been worked out in cooperation with transmitter manufacturers, who have been supplying these monitors as standard equipment with television transmitters.

The monitor unit is a Type 1175-BT Frequency Monitor[3], which consists of a stable crystal oscillator, a harmonic generator, a mixer, and an output amplifier. The elementary circuit is shown in Figure 3.

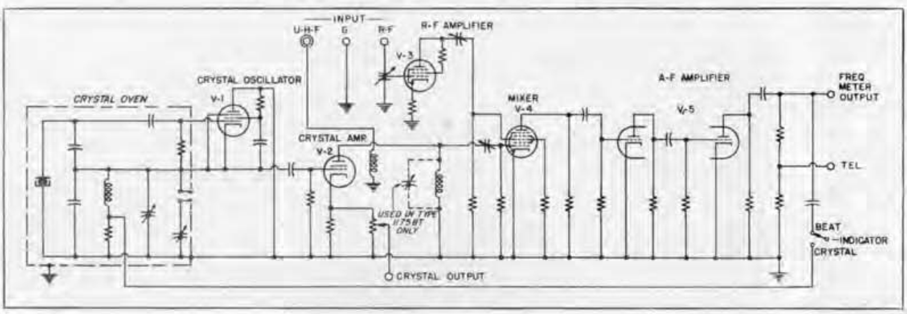
[2]"A Versatile Monitor for Use from 1.6 to 150 Megacycles," *Experimenter*, February, 1947.
[3]"A Frequency Monitor for Television Video Transmitters and Other A–M Services," *Experimenter*, September, 1947.

The frequency indicator is a Type 1176-AT Frequency Deviation Meter, a modification of the standard Type 1176-A Frequency Meter. The beat frequency to be measured is passed through a series of amplifiers and clippers to develop a square wave, which is then applied to a pulse counter circuit. Unidirectional pulses are applied to a d-c microammeter, whose deflection is proportional to the number of pulses per unit time, and hence to the frequency. Figure 4 shows the basic circuit.

ZERO BEAT VS. OFFSET-FREQUENCY MONITORING

When a monitor is designed for maximum flexibility to cover a wide range of applications, the so-called "zero-beat" method of frequency monitoring offers many advantages. This method consists essentially of measuring the difference frequency between a crystal fundamental (or harmonic) frequency, which has been adjusted to the desired channel frequency, and the actual transmitter frequency. The difference frequency can be indicated on a multi-range, direct-reading frequency meter, which provides a means for determining the transmitter frequency error over a considerable range. This system is particularly useful when the applications involve monitoring over a wide range of carrier frequencies and where the transmitter frequency tolerance is expressed as a varia-

Figure 2. Elementary schematic diagram of the monitor unit.



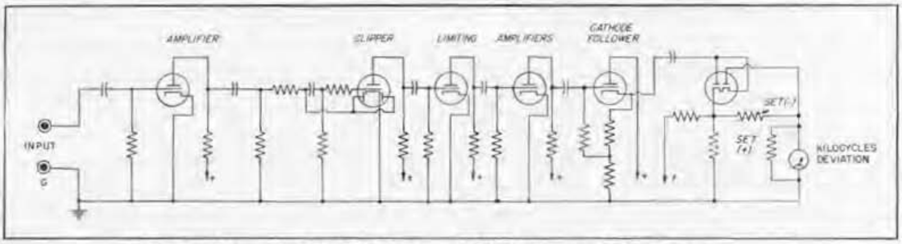


Figure 3. Elementary schematic diagram of the frequency deviation meter.

ble percentage of the carrier frequency.

Disadvantages of such an arrangement are (1) the lack of a direct indication of the direction of the deviation, that is, whether the transmitter frequency is high or low, and (2) the limited region near zero frequency error, where the system becomes inoperative since it lacks a d-c response. The first of these limitations can be taken care of by providing for a temporary frequency shift of the crystal oscillator, and the second by limiting the low frequency cutoff of the frequency measuring circuit to a value comparable to the instantaneous stability of the transmitter.

For specific monitoring applications such as standard broadcast transmitters, continuous monitoring is essential. A direct-reading meter scale, calibrated in plus and minus channel frequency error, has become the accepted practice. This can be achieved by employing the "offset crystal-frequency" principle, which differs from the zero-beat method only in that the monitoring crystal frequency is adjusted to give a known frequency difference between one of its harmonics and the required transmitter channel frequency. Thus, when the transmitter is exactly on channel frequency, the beat-frequency produced within the monitor detector circuit will be this predetermined value. If the crystal offset frequency amounts to slightly more than the half-scale value of the calibrated meter scale, then the beat frequency will not be required to pass through zero over any part of the normal range of the monitor. A comparison between the two monitoring systems is shown in Figure 4.

In the zero-beat method, the frequency meter indicates the beat frequency directly and hence cannot distinguish between positive and negative transmitter frequency shifts. The offset method employs a meter scale calibrated in plus and minus deviations about a zero center. The actual beat frequency corresponding to the zero center point of the deviation meter is mainly determined by the deviation range, the sensitivity requirements of the system, and the low frequency response. As the offset frequency increases, the sensitivity decreases because the $\Delta f/f$ becomes smaller. Very low beat frequencies should be avoided to minimize interference from power-line hum or television synchronizing signals.

By setting the crystal frequency on the *low* side of the desired transmitter channel frequency, the direction of the beat frequency will follow the direction of the actual transmitter shift. Should the transmitter frequency be incorrectly set on the wrong side of the crystal frequency, this condition will be reversed. This provides a check to determine proper operation. An alternative test can be made by shifting the crystal

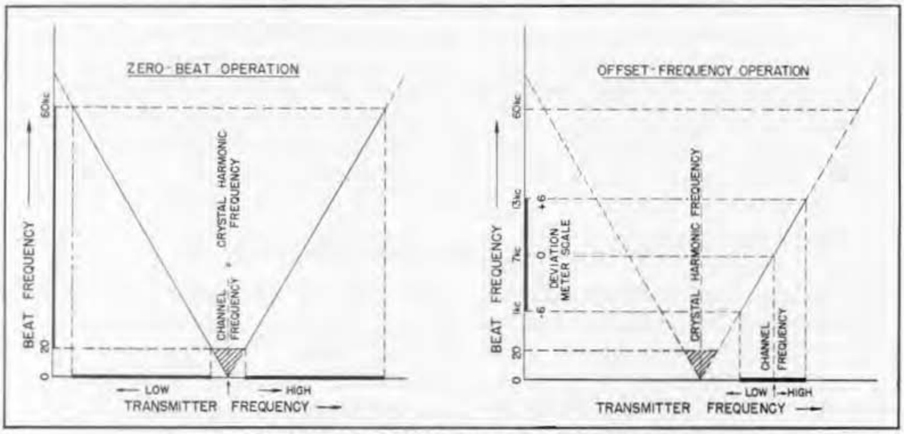


Figure 4. Graphical comparison of zero-beat and offset-frequency monitoring.

frequency itself, by a small amount. In this case, *decreasing* the *crystal* frequency should produce an *increase* in the beat frequency.

DETAILS OF THE 1182-AT TELEVISION FREQUENCY MONITOR

The Type 1176-AT Frequency Deviation Meter is designed especially for television video frequency monitoring. When used in conjunction with the Type 1175-BT Frequency Monitor as a part of the Type 1182-AT Television Monitor, it provides a direct indication of the video transmitter frequency deviation from the assigned channel frequency. In accordance with FCC proposals, two alternative scale ranges are available, 3-0-3 kc for TV channels 2-6 inclusive, and 6-0-6 kc for TV channels 7-13 inclusive. The scales, shown in Figure 2, are identical to those used on the Type 1170-A F-M Monitor[1], which has found wide application as a frequency and modulation monitor for television aural transmitters.

[1] Loc. cit.

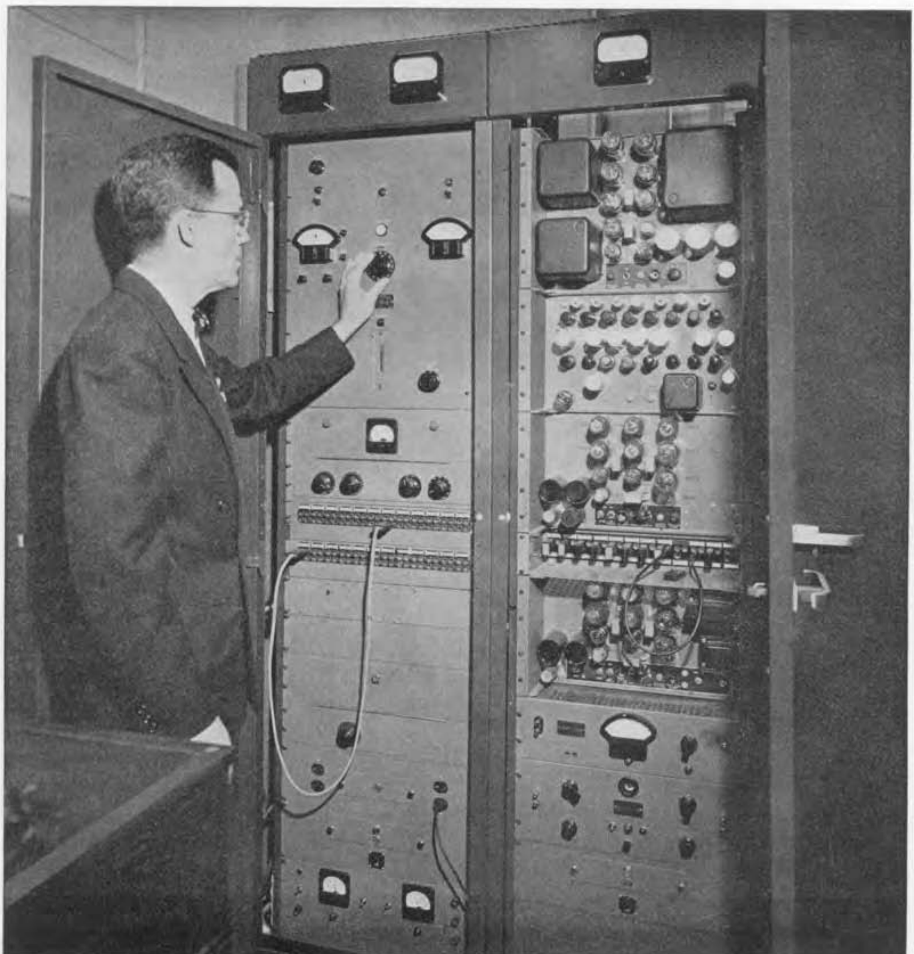
The 3-0-3 kc range employs an offset crystal harmonic frequency of –3500 cycles; the 6-0-6 kc range has just twice this value, or –7000 cycles. To obtain a full-scale range of 6 kc, electrical suppression is used in the d-c meter circuit to balance out the meter current corresponding to an input signal of 500 cycles. A standard d-c microammeter meter is used, having normal left deflection for zero d-c current, but the meter is calibrated with a zero center scale. The scale zero is made to coincide with the crystal harmonic offset frequency, thus indicating correct transmitter channel frequency when this beat frequency is obtained. Internal adjustments are provided to calibrate the meter at both ends of the scale. Scale ranges can be easily interchanged by reversing the meter scales which have alternative calibrations on either side, and making one internal connection change. Because of the different offset frequency, a change in the monitor crystal frequency is also required.

Since the highest beat frequency developed by the monitor is 13 kc, obtained when operating at the +6 kc deviation point with the 6-0-6 kc scale, a low-pass filter is inserted ahead of the frequency meter to eliminate the television line-frame frequency of 15,750 cycles and its harmonics. This filter unit is a plug-in device which attaches to the rear of the frequency monitor.

The lowest beat frequency developed is 500 cycles, obtained when operating at the –3 kc deviation point with the 3-0-3 kc scale; hence the response of the frequency deviation meter is made to fall off rapidly for frequencies below this point to minimize the interference from low frequency television synchronizing signals.

The complete monitor is arranged for relay rack mounting, with the TYPE 1175-BT Frequency Monitor mounting above the TYPE 1176-AT Frequency Deviation Meter, and thus provides for easy access to the crystal oven. Spare crystals can be mounted within the oven and selected by means of a panel switch.

Figure 5. General Radio television monitors installed at WBAL-TV, Baltimore. The video monitor is at the lower right, the f-m monitor at the upper left. Shown operating the latter is R. S. Duncan, Chief Engineer.



Three tuning adjustments are reached through holes in the chassis. It is not necessary to change these adjustments, except possibly during the initial installation, and the settings are not critical.

To bring the monitor readings into agreement with an external frequency check, a small adjustment has been provided which will shift the crystal frequency by a small amount. For reasons of maximum stability, this control is located within the temperature-controlled crystal oven and can be reached through an access hole in the side of the oven.

— C. A. Cady

FEATURES OF THE TELEVISION VIDEO MONITOR

1. High sensitivity, requiring negligible power from transmitter.
2. High-stability, temperature-controlled, crystal oscillator.
3. Operates directly from transmitter-modulated signal. Indication is unaffected by television video modulation.
4. Direct indication of frequency drift from assigned channel.
5. Panel switch for stand-by operation.
6. Provision for remote frequency deviation meter.
7. Panel indicator to check crystal oscillation.
8. Panel indicator to check monitor output.
9. Adjustment to set monitor in agreement with frequency measuring service.
10. Spare crystal positions (3) selected by panel switch.
11. Switch for check of crystal offset frequency.
12. No critical adjustments.

SPECIFICATIONS

Transmitter Frequency Range: 160 to 220 Mc.

Deviation Range: 3-0-3 kc for television channels 2 to 6 inclusive; 6-0-6 kc for channels 7 to 13 inclusive.

Accuracy: Crystal frequency, when monitor is received, is within ±10 parts per million (0.001%) of specified channel frequency. Center-frequency reading can be adjusted to bring monitor into agreement with frequency measuring service.

Stability: ±0.001%.

Input Impedance: High-impedance circuits for channels 2 to 6, coaxial line for channels 7 to 13. Complete coupling directions are included in the operating instructions.

Vacuum Tubes:

1—6AC7	1—6BE6
1—6AG7	1—OD3/VR150
1—6E5	1—6SQ7
1—6SN7GT	1—6J5
1—6H6	1—OA3/VR75
2—6SJ7	1—6V6
2—6X5	1—Amperite 3-4

Accessories Supplied: All tubes, connecting cable, and power cords; plug-in filter; one quartz plate.

Mounting: 19-inch relay rack panel. Walnut end frames are available for table mounting; see price list below.

Dimensions: Panel, 19 x 12¼ inches, overall; depth behind panel, 11¼ inches, overall.

Net Weight: 42 pounds.

Type		*Code Word*	*Price*
1182-T	**Video Frequency Monitor**	ALERT	**$675.00***

*For General Radio Black Crackle Panel Finish.

This instrument is covered by U. S. Patents Nos. 1,967,185; 2,012,497; 2,362,503; and is licensed under patents of the American Telephone and Telegraph Company, and under patents and patent applications of G. W. Pierce.

VARIACS USED WITH INCANDESCENT LAMPS AND OTHER RESISTIVE LOADS

Variac adjustable transformers should never be subjected to load currents in excess of five times their rated current. Unfortunately, certain loads draw large inrush currents when cold. A modern 120-volt incandescent lamp measured by the writer showed a ratio of cold-to-hot current of 13.9 to 1. Heating devices exhibit similar though less severe characteristics.

Variac instructions specifically state, "Always set Variac to zero before switching to avoid surges." Apparently, some Variac users have interpreted this as having reference to reactive loads (predominantly inductance or capacitance), but it applies just as fully to resistive loads of the type under discussion. If the instructions are followed, full voltage will not be applied to the cold load, and, as the Variac is turned up to line voltage from zero, the load will have time to heat sufficiently to limit the inrush current to a reasonable value.

If the load must be switched rapidly off and on at full voltage, it should be disconnected from the Variac and connected to the line before so doing. A "snap-action" toggle switch or relay may be used to change the load from Variac to line. Such switching introduces no perceptible flicker and avoids throwing a cold load across the full Variac output. The Variac setting should, of course, be zero whenever the load is cold.

A choke coil in series with an "inrush" load will serve to limit the surge without seriously reducing the load operating voltage. The choke should have an inductance sufficient to limit the load current to five times the Variac rated current even with a zero resistance load. Under the worst conditions such a choke will reduce the load voltage by not more than 4 per cent. The inductance may be calculated by the formula

$$L = \frac{\text{Load Volts}}{31.4\, f\, I_R}$$

where L = inductance in henrys
f = frequency in cycles/second
I_R = Variac rated current in amperes

The choke must be large enough to maintain its inductance at five times the rated current and must be capable of carrying the load current continuously. Unfortunately, chokes that will effectively limit the output of the larger Variacs are, themselves, bulky and expensive, a factor that often makes their use impracticable.

Another alternative is to reduce the load until its inrush current falls within the Variac limitation, but this reduces the load unduly as compared with either the choke or switch method.

— Gilbert Smiley

MISCELLANY

TELEVISION MODEL OF THE F-M MONITOR

The General Radio Company now supplies complete monitoring equipment specifically designed to meet the requirements of television broadcasting. For monitoring the video transmitter, use the TYPE 1182-T Television Video Monitor described above. For the audio transmitter, use the TYPE 1170-AT F-M Monitor, the television model of the F-M Monitor described in the *Experimenter* for October, 1947.

RECENT VISITORS to our plant and Laboratories — *From India:* Mr. Gopal Chandra Sen, Lecturer in Mechanical Engineering, College of Engineering and Technology, Bengal; Mr. Ram Vepa, Indian Institute of Science, Bangalore; and Mr. P. Chawla, New Delhi.

— *From Switzerland:* Dr. Julius E. Weber, Swiss Aluminum Co., Ascona; Dr. E. Bruno Siegrist, Geneva; and Mr. Gerald Nenn, Geneva.

ERRATUM — In our August issue it was stated that Warburton-Franki, Ltd., manufacture Variacs in Melbourne, while the city that should have been mentioned is Sydney. The editor offers his apologies to Australian readers of the *Experimenter* and hastens to assure them that he knows these two cities are some 400 miles apart.

THE General Radio EXPERIMENTER is mailed without charge each month to engineers, scientists, technicians, and others interested in communication-frequency measurement and control problems. When sending requests for subscriptions and address-change notices, please supply the following information: name, company address, type of business company is engaged in, and title or position of individual.

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