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# The Oscilloscope in Audio

• One of the most useful test instruments in the broadcast station is the cathode ray oscilloscope: most generally referred to as the 'scope. These are available today from the most simple to the most sophisticated—and with a price tag to match. The scope allows us to measure and observe the waveform of the signal under test. This instrument can be used in many ways and in a variety of circumstances throughout the station. This month we will touch on a few of the areas it can be useful in audio work at the station.

## THE SCOPE

Regardless of whether it is a simple or a very sophisticated instrument, each one is essentially a cathode ray tube with a pair of horizontal and vertical deflection plates. A finely focused beam of electrons is shot from the cathode to the faceplate which glows under the influence of that beam. The electrostatic force across the pairs of deflection plates which is caused by the applied voltages, forces the beam to be deflected accordingly. By moving the beam in accordance with the applied voltages at the deflection plates, the beam traces out the waveform of those voltages on the faceplate of the tube. The force across the horizontal plates moves the beam across the tube face horizontally, and that across the vertical plates moves the beam vertically.

To develop voltages of enough amplitude to create electrostatic forces of sufficient magnitude, internal amplifiers are provided for both sets of plates. The signal which is amplified and applied to the horizontal plates is from an internal oscillator or an external sweep source. The vertical amplifier increases the magnitude of the signal under test and is applied to the vertical plates. The horizontal sweep must be synchronized to the vertical signal for a stationary pattern, and the interaction of these two signals thus "draws" the waveform on the faceplate.

## WHAT IT MEASURES

The oscilloscope is a voltage measuring instrument, as well as its ability to display the waveform of the signal for our observation. The scope will measure d.c. voltages but in the majority of instances our concern is for a.c. voltages of whatever type. The scope performs best with those signals which are more repetitive in nature rather than fleeting transients. It will measure transients but the trace will appear and disappear as fleeting as the transients themselves. A different type of scope, the storage scope, is needed for true observation and measurement of transients.

Since the full signal waveform is applied and appears on the CRT trace, voltage is measured in peak-to-peak values. The usual a.c. voltmeters and similar instruments measure in rms values. When actual voltage values are the purpose of the test, observation of the peak-to-peak waveform can mislead the engineer if he is comparing this value against, for example, voltmeter noted markings or indications on a block or schematic diagram. He may believe the measured voltage is far too high for that point in the circuit and thus be led to wrong conclusions: which leads to wasted time in trying to correct the wrong problem. The p-p values of the observed waveform are 2.83 times higher than the rms value as would be measured on a regular a.c. voltmeter.

Since the scope is a voltage measuring instrument it has a high impedance, unbalanced input. The usual value of this impedance is about 1 megohm. For many types of circuits this is adequate isolation. Yet in some critical circuits this amount will cause loading effects, so a 10:1 probe is often used. This probe ordinarily presents about 10 megohms to the circuit under test, but it also reduces the voltage applied to the scope itself to 1/10th of its original value. A 10 volt circuit signal voltage for example, would be reduced to 1 volt applied to the scope input. For voltage measurements the engineer must take this into consideration and multiply the measured value on the scope by 10 to obtain the original signal amplitude.

## A.M. MODULATION

Perhaps the most important question to the a.m. broadcast station is whether the audio signal produced in the studio is being properly added to the rf carrier of the station. A correctly calibrated modulation monitor is required by the FCC to

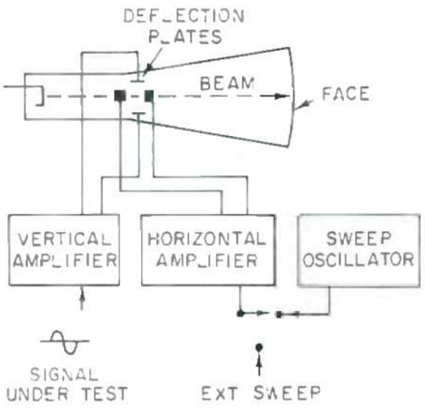


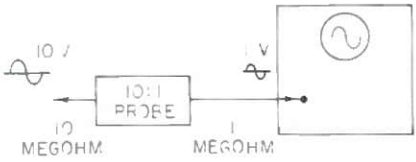

*Figure 1. The basic scope.*

be in operation all the time, yet no one can guarantee that the monitor will stay in calibration all the time. The oscilloscope can observe the modulated rf carrier directly and thus can be used as an independent modulation indicator as well as a device to calibrate the monitor itself.

Calibration of the modulation monitor can best be done with sine wave signal as the audio modulation on the carrier. Attach the scope probe to the modulated rf input of the modulation monitor and observe the modulated rf waveform directly on the scope. Increase the amount of modulation of the carrier until the two negative peaks of the envelope just touch each other. This is 100 per cent negative modulation (and the most important). With the carrier correctly modulated then check the modulation monitor. Adjust the carrier input control of the monitor so that the carrier level meter reads exactly 100. Make sure the modulation meter peak select switch is set to monitor negative modulation peaks and then observe the modulation meter. It should also read exactly 100 per cent modulation. Rotate the peak flasher control to 100 per cent and the peak light should begin to flash. If these conditions do not occur, then the monitor is out of calibration and must be recalibrated. Perform the adjustments as per the instruction manual for that monitor.

Observation of the modulated carrier on the scope with programming can also reveal some important facts. The wave-

*Figure 2. A 10:1 probe gives greater isolation, but also reduces voltage applied to scope.*



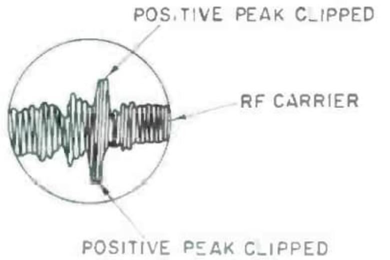



*Figure 3. A clipped positive modulation peak can mean incorrect polarity of audio processor or saturation in modulator.*

form in this instance will not be as steady as when sine wave is used, so observe both the positive and negative modulation peaks closely. If there is no audio processor which clips audio positive peaks but you observe a flattening of the positive peaks on the modulation envelope, there is a problem in the transmitter modulator: saturation is occurring on the positive peaks. And if the negative peaks are flattening out at the zero carrier baseline, the carrier is overmodulated in the negative direction. If the monitor does not show overmodulation on negative peaks: the monitor is out of calibration and must be recalibrated. Some stations use a processor which selects the highest peak and makes this positive for modulation and clips the negative peak (asymmetrical modulation). In this instance again observe the positive and negative modulation peaks. If the positive peak is clipped this means that the cable leads between the processor and transmitter have reversed polarity and must be corrected. But assuming the polarity has not been reversed and the negative modulation peak is clipped, observe the flat top of the clipped peak for tilt. If tilt is present (that hadn't been observed before), something has changed in the transmitter audio sections or modulator which is now limiting the audio low frequency response.

## CART MACHINE PHASING

Stations in stereo often find that cartridge tapes do not always provide the best quality because of phasing errors that result from the cartridge and tape guidance in the machine. With better cartridges today designed specifically for stereo the machine head can be adjusted to provide an optimum phasing. And since the exact number of degrees of phase error is not as important as is the minimum or zero error, the Lizzajous scope pattern can be used for observation and whatever adjustment is needed. To obtain this pattern on the scope the Left audio signal is fed to the scope's vertical amplifier and the Right audio signal is fed to the scope's horizontal amplifier. Either a single or a dual trace scope may be used. In the case of the dual trace scope the Right audio is fed to the 2nd vertical amplifier input, but then this amplifier is switched internally to feed the horizontal amplifier and the results are the same and the same pattern.

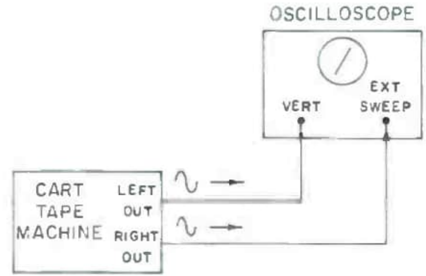
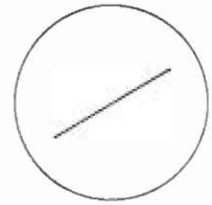
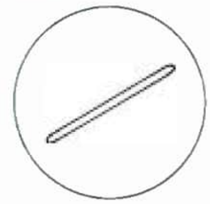



*Figure 4. The proper connection of the stereo output of the tape machine to the scope for phase observation.*

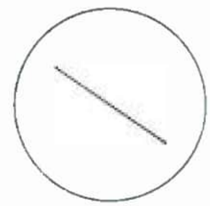
Before measuring the phase error of the tape machine it is important to measure the internal phase error of the scope. To do this feed both the vertical and the horizontal inputs of the scope with the same signal at the same time. This will produce a straight line from the lower left quadrant to the upper right quadrant of the scope face. If there is not a straight line and the trace is opened up somewhat, this is the internal phase error. This can't be changed and is what the tape machine must be adjusted for. Once the scope is checked out, connect the audio outputs of the tape machine. Connect the Left output to the scope's vertical input, the Right audio output to the scope's horizontal input. Play a standard NAB stereo test cartridge used for alignment and response measurements. The first thing to observe is if the lines on the scope are still in the same quadrants of the scope face. If they are straight lines from the lower right to upper left quadrants, there is a polarity reversal of one of the audio channels. Check the scope connections for proper polarity, and if these are correct, check the leads at the playback head. Assuming that polarity is correct, then observe the flatness of the line, that is, if the two lines are closed or there is an opening or small oval shape to them. Be especially watchful at the higher audio frequencies of 10 kHz and above as phase errors are more critical in this region. If there is an opening, gently "tweak" the azimuth alignment of the play head to flatten the lines. Be careful not to overdo it and do not overcorrect for the scope's own phase error.



*(A) Correct phase between Left and Right audio.*



*(B) Small amount of phase error.*



*(C) One channel with wrong polarity.*

*Figure 5. Lissajous scope patterns show phasing.*

## TROUBLESHOOTING

The scope can be very useful in some types of problems as a signal tracer, as well as a device to let us observe and identify that which may be causing the problem. Consider harmonic and intermodulation distortion. These can occur because of the lack of headroom in some units. Use the scope to observe the audio somewhere along the chain. Be observant of the audio peaks and look for intermittent clipping of the stronger peaks. If this is happening, move the scope down the chain and observe some more. If clipping is not now evident, the offending unit has just been passed. Check its gain controls to see if they are set properly. If they are, then some component has changed within the unit and repairs are in order.

Noise can be observed on the scope but when it is low in level it can be below the gain capability of the scope. One way to do this is to use the distortion analyzer and its internal amplifier to bring the noise up to scope level and at the same time maintain proper impedance and isolation of the unit. It isn't necessary to calibrate the analyzer unless you are interested in a specific noise ratio to audio. Leave audio off the channel or preamplifier, increase the analyzer meter gain and observe at the scope output for the noise. Rather than measurement, the scope is serving the purpose of identifying the particular type of noise. This, in itself, is often an important part of troubleshooting problems and can point to the source of trouble. ■