

mainly to delay the other, there is no penalty. With this arrangement you not only solve the problem but have a valuable conventional-scope feature—calibrated sweep delay. Borrowing familiar terminology we call one of the ramps the *delaying* sweep and the other the *delayed* sweep. The 5S14N and 7S14 bring calibrated delayed-sweep technology to the sampling world for the first time in an inexpensive sampling scope package.

Trailing Edge Tags Along Too

Using sweep delay instead of sweep magnification prevents another kind of problem—that of losing sight of a particular region of a waveform when merely trying to change the time per division. This happens if you inadvertently change the delay range when you mean only to change the time per division. This can easily happen when the delay-range switch and the time-per-division switch are operated by the same knob or are concentric interlocking knobs. In the 5S14N/7S14 two-ramp sweep delay system, the two knobs are not locked together. Therefore, the time delay doesn't change when you change the time-per-division knob.

Two Time Markers—A Happy Pair

In conventional delayed-sweep scopes the beginning of a bright segment of the trace identifies the end of the delay interval and the beginning of the delayed-sweep ramp. The sweep represented by the bright segment is displayed when the delaying sweep is selected as the

CRT time base. When delayed sweeps are selected, the beginning of the trace corresponds to the beginning of the bright segment. This system works very well when identifying particular pulses in a pulse train, for example. But for delay measurements it leaves some doubt about where the delay interval commences.

What you would like to have is a bright spot in the trace, to show you where delay started. To produce such a bright spot at the fastest sweep rates of a conventional scope would require the generation of very narrow, high-amplitude pulses. But that tough requirement is not applicable to sampling scopes since the displayed equivalent-time sweeps are relatively slow. Accordingly, we've included just such a capability as a standard feature in the 5S14N/7S14.

With these plug-in units, two bright dots appear in the trace when the delaying sweep is selected. The first dot corresponds to time-zero and the second dot corresponds to the end of the delay interval—the point at which the delayed-sweep ramp starts. The position of the first dot is even controllable. With the DELAY ZERO control, it can be positioned anywhere over at least the first 9 divisions of the trace, allowing the user not only to know where delay starts but to choose where it starts. The second dot can be positioned anywhere on screen to the right of the first dot with the 10-turn precision DELAY TIME MULT dial. Each full turn of the dial

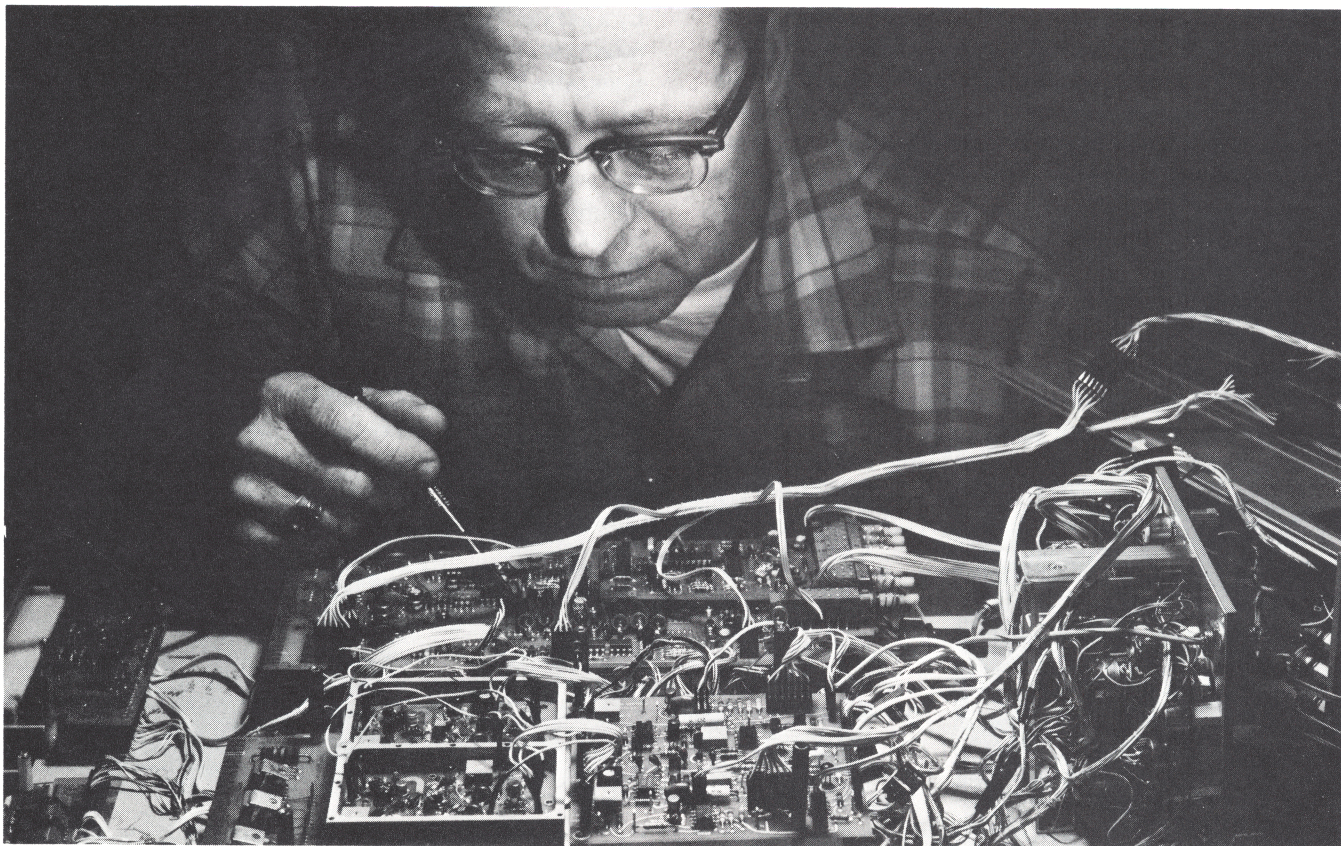


Fig. 2. Manufacturing economies are achieved by testing and calibrating circuit boards before installation in the plug-in

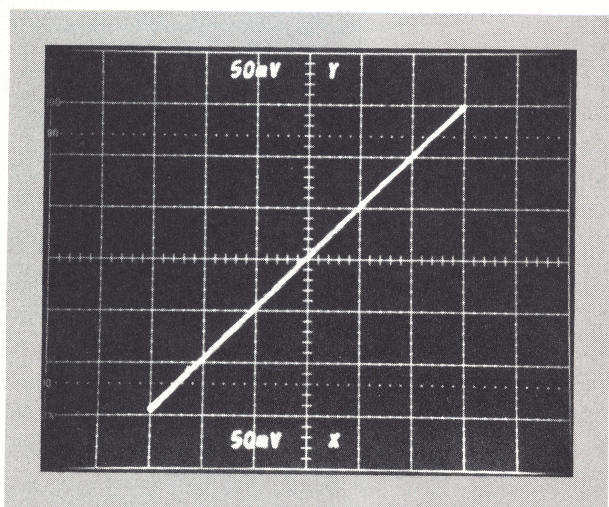


Fig. 1. An X-Y display of two sinewave signals in phase.

are harmonically related. Other uses for the Lissajous display are to check distortion of a signal or as a "null detector" for accurately matching phase. X-Y phase measurements with sampling can be made up to the bandwidth limit of the sampler. This is possible since sampling requires high-frequency circuitry only at the input to the system; low-frequency techniques are used through the amplifiers and to produce the display.

The prime prerequisite for the X-Y measurement is a dual-trace sampling system which has the X-Y display feature—some single-trace sampling vertical plug-in units can be installed in a horizontal compartment to provide the "X" portion of the display. To set up the units for correct display, set the vertical mode switch to X-Y and the time-base triggering controls to free run so it produces strobe pulses. Then, connect one of the signals to both inputs through a power divider and identical cables (the same cables which will be used for the measurement). Here's where the delay-matching adjustment comes in handy! Adjust this delay control for a straight-line display, slanted from the upper right-hand corner of the CRT to the lower left-hand corner. Now carefully adjust the deflection factors of both channels, using the variable controls as necessary, to obtain a display that is exactly six divisions both vertically and horizontally. Then, if necessary, readjust the delay for as straight a line as possible (if the sine-wave has any distortion, it will be impossible to get a straight line). The display should appear similar to Fig. 1, indicating that the cables and two channels have been matched for minimum difference. If you're using a sampler that doesn't have the delay-matching feature, use the X-Y phase measurement method shown in Fig. 2 to determine how much phase shift is involved in the display. This inherent phase shift must be included in the final calculation of phase.

The smoothing controls on either channel should not be used unless the display requires it. If noise is excessive, on the display, adjust the smoothing controls of both channels the same amount (time-base triggering must be adjusted so the strobe pulses are triggered on one of the signals when using smoothing). Then, check that the display still indicates correct delay matching between channels. If necessary, repeat the delay-matching procedure.

Disconnect the power divider and connect the signals to be measured to the two inputs using the same cables as before. Check that the display is still six divisions both vertically and horizontally; adjust the deflection factor as necessary for the correct display. A difference in phase between the two signals is shown by the amount of opening in the loop. A circle display shows 90° phase

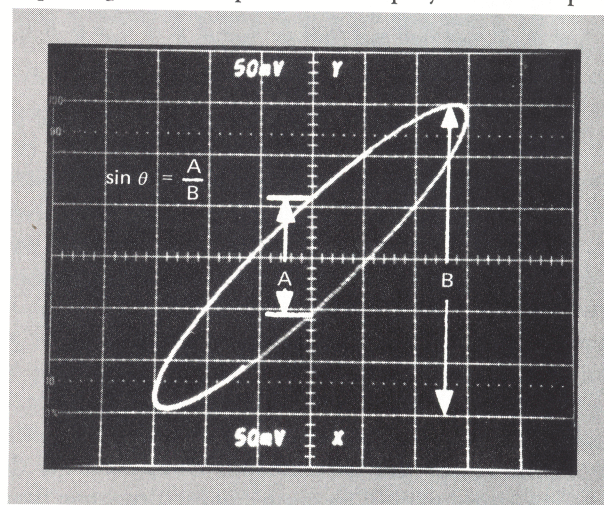


Fig. 2. Phase shift is easily calculated from this X-Y display.

difference and a straight line from upper left to lower right shows 180° phase shift. The phase difference between two signals can be measured accurately by using the method shown in Fig. 2 to calculate the sine of the phase angle between the two signals. The angle can then be obtained from a trigonometric table.

If the instrument you are using cannot be adjusted to offset the inherent phase shift between the two channels and the cables, take this into account in the final calculation. It's often difficult to determine if this inherent phase shift should be added to, or subtracted from, the final result. To resolve this, use the method given under Dual-Trace Phase Measurements to determine if the inherent phase shift is leading (greater than 0°) or lagging (less than 0°). Maintaining one signal as a reference, repeat this check after measuring the phase on the Lissajous display to determine if the signal being measured is leading or lagging the reference. Now, algebraically add the inherent phase shift of the system and the measured phase shift between the signals to determine the overall phase shift.