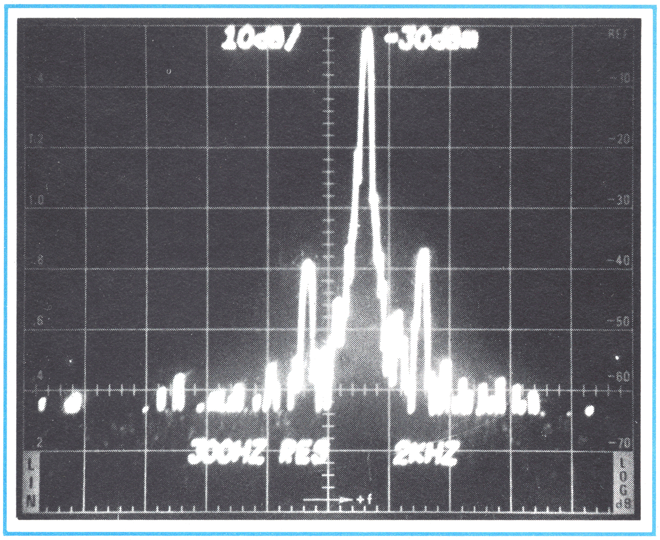


Fig. 5. Resolution afforded by the 300 Hz filter is evidenced in this photo showing 2 kHz sidebands merging with the carrier 60 dB down.

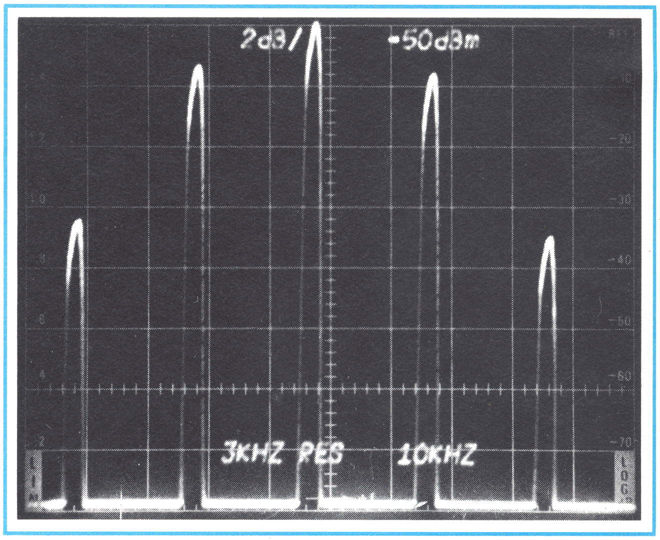


Fig. 6. Signals differing in amplitude by less than 2 dB are easily measured on the 7L12.

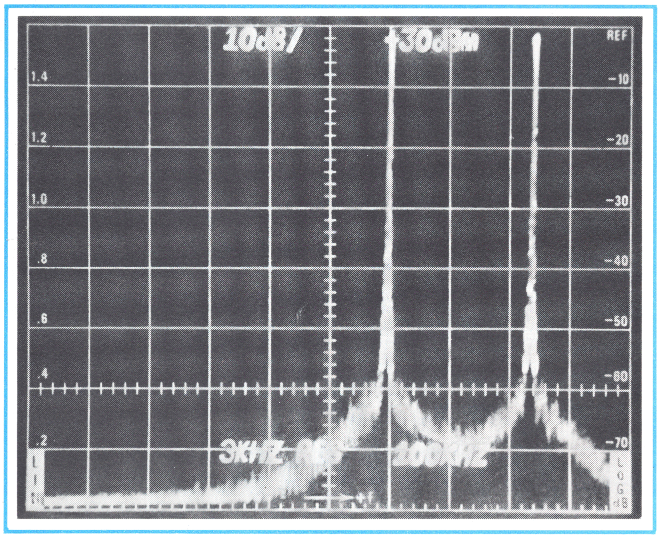


Fig. 7. Low intermodulation distortion is illustrated in this photo showing absence of third order products for two —30 dBm signals.

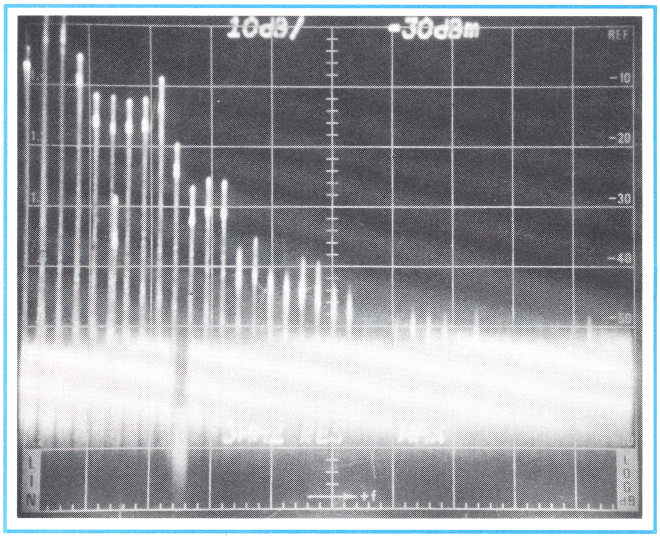


Fig. 8. Maximum frequency span of 1800 MHz is displayed with negative-going marker indicating frequency dial setting.

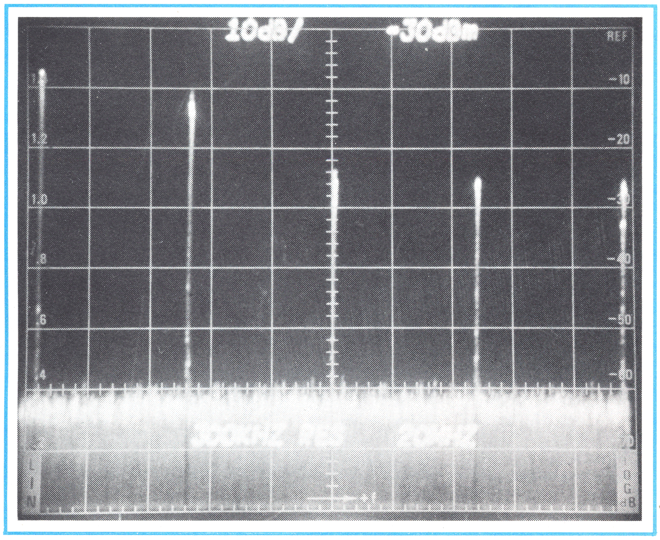
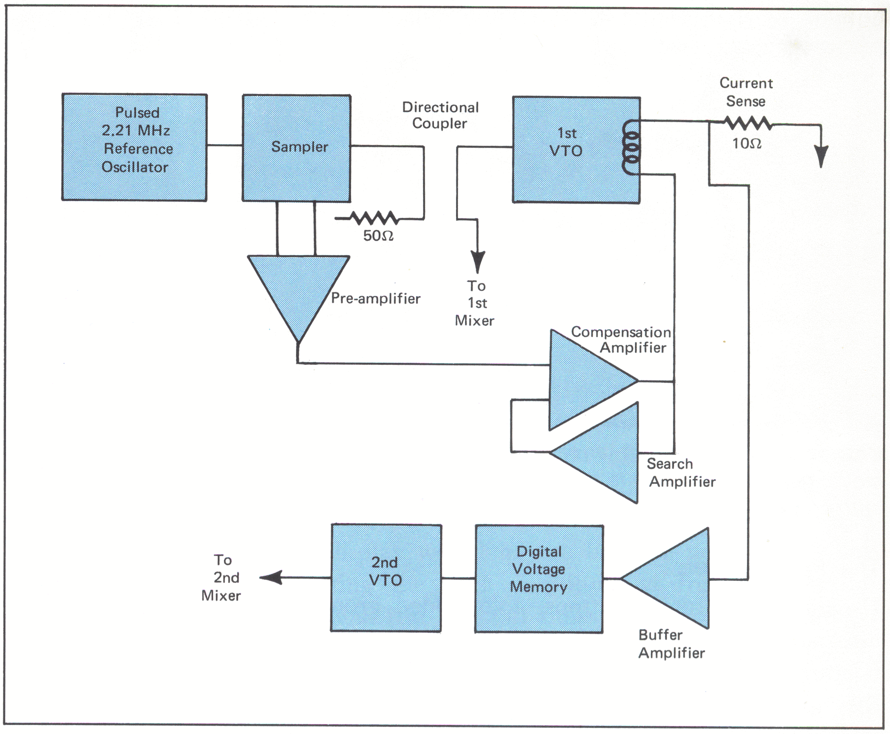


Fig. 9. Frequency span is reduced to 20 MHz/div showing a 200 MHz window of the marker area in Fig. 8.

(d) Finding the Signal—Finding your signal is easy with the 7L12. Figure 8 shows the maximum frequency span capability of 1800 MHz. Here the frequency dial selects the position of a negative-going marker which indicates the part of the spectrum to be selected. Figure 9 shows the details of the comb lines as the span is reduced to 20 MHz per division. The choice of center or start sweep capability is also of considerable convenience. Thus, Figure 10 shows the 0-Hz marker in the center with an approximately 10-MHz signal and its harmonics to either side. The left-hand edge of the screen conveys no information since it's a mirror image of the right-hand side. Setting the frequency control to the start rather than center sweep results

Frequency Stabilization Techniques

by F. Telewski



Block diagram of the 7L12 phase lock system.

When spectrum analyzers were first conceived, designers soon became aware of the necessity of a circuit block referred to as the phase lock. The necessity for phase lock is determined by two parameters: the sensitivity of the first voltage tunable oscillator (VTO) and the narrowest span width which the instrument is to possess.

Let us assume that a VTO will respond with 100% integrity to its tuning command. Consider what stability may be achieved with good power supply regulation in today's swept front end spectrum analyzers. Typical VTOs have tuning sensitivities of 200 MHz/volt, or equivalently 200 Hz/μV. Since one normally does not like to live with a spec of less than 100 μV of noise on the sweep voltage, the oscillator will jitter 20 kHz at zero sweep. In modern analyzers with display spans of less than 20 kHz, this amount of instability is unacceptable.

This problem can be eliminated by stabilizing the first VTO with phase lock circuitry and sweeping the signal with a second VTO whose sensitivity is in the order of 1 MHz/volt, thereby providing stabilities in the order of 100 Hz.

Another advantage of the phase lock technique of oscillator stabilization is that the first VTO may be made as essentially pure as the reference which is used for the stabilization. This is important in reducing the phase noise on VTOs which use low Q resonators.

In general, the concept of phase lock involves the comparison of an oscillator (known as the locked oscillator) to a reference oscillator via a phase detector. The output of the phase detector is a voltage proportional to the phase difference ($\Delta\phi$) between the oscillators. This voltage is amplified, filtered, and fed back in a manner so as to tune the locked oscillator (first VTO) and maintain a constant $\Delta\phi$. As the gain increases, the $\Delta\phi$ becomes smaller and vice versa. It is important to note here that while we have mentioned a phase difference ($\Delta\phi$), there is no frequency error (ΔF). When the first VTO is locked, its long-term frequency stability is as good as that of the reference oscillator.

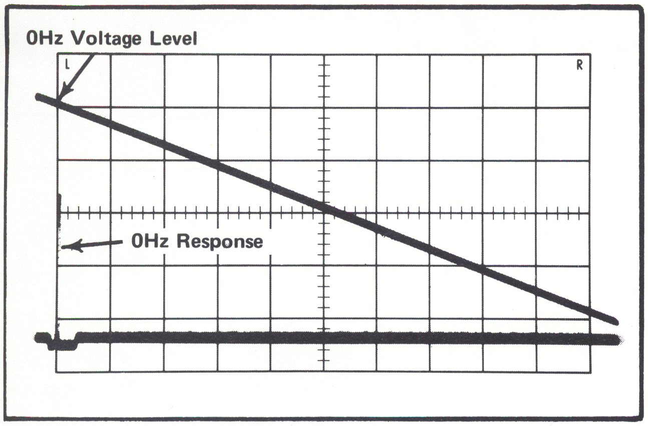
PHASE LOCK SYSTEMS

Phase detection is classically accomplished in two manners. IF mixing is a technique in which two signals (reference and locked oscillator) are fed into a mixer which yields a voltage related to the phase difference between them. This, of course, requires that we have a reference tone at each frequency at which we desire a lock. Circuitry for this type of system is somewhat more complex than the alternative.

Alternatively, a DC sampler may also be used as a phase detector. The sampler is a fast switch driven by a pulse generator which acts as the reference oscillator. The pulse generator supplies a short (typically < 100 ps) pulse which activates the switch, allowing a small portion of the locked oscillator waveform to pass through. These "samples" are integrated and form the voltage proportional to the phase difference between the generator and the locked oscillator. This system has an advantage in that it will yield outputs at discrete multiples of the pulse generator frequency.

Generally speaking, the DC sampler circuitry is less complex than the IF mixer system and therefore leads to a smaller and more economical package.

To date, the principal disadvantage of the sampling system was the very high output impedance of the sampling gate (typically 1 MΩ). This weakness has been overcome with development of a low impedance



Test scope display when setting R550, center frequency adjustment.

THE IF SECTION

While we're discussing alignment, you will find that T208 and T210 have considerable effect on sensitivity. These should be set for peak signal. Low amplitude when in the 3-kHz resolution position indicates that the 100-kHz filter is not aligned over the 3-kHz filter. If you have removed the power regulator board for servicing and inadvertently reversed the connector on P711 or P712 you will have a similar symptom.

IF gain is contributed by Q208, U240 and U260. Q208 is the most likely suspect if gain through the IF section is low.

The IF section also contains the circuitry for gated operation of the 1401A. If trouble is suspected in this area, you can bypass the gate by placing a jumper between Pin 1 and 4 of P208.

THE SWEEP CIRCUIT

Because the sweep adjustments interact, more difficulty with calibration has been experienced in this area than in any other. The following procedure will help set the sweep adjustments properly:

1. Set up the 1401A and test scope as detailed in step 5 of the manual calibration/adjustment procedure.
2. Set R575 (CF Cal) on the sweep circuit board about 1/3 turn from full CCW.
3. Connect the test scope probe to TP554 and adjust the test oscilloscope EXT HORIZONTAL GAIN for about 10.5 divisions centered horizontally.
4. Adjust R555 (CF Centering) for 0 V at TP554.
5. Switch FREQ SPAN MHz/div to 20 and adjust R540 (CF Balance) for 0 V at the center of the sweep.
6. Switch FREQ SPAN MHz/div to SEARCH and adjust R550 (Search CF) for 0 V at the left graticule line.
7. Continue as shown in the manual for the remaining sweep adjustment, commencing with step 8.

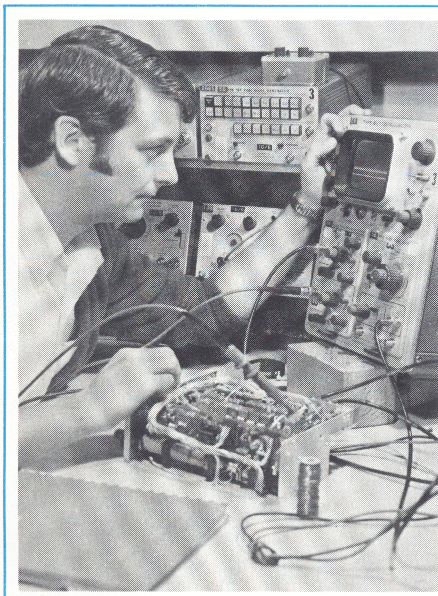
When adjusting the sweep shaper the following points may be noted:

a. Step 12 of the procedure calls for measuring the voltage across R108. This cannot be done without removing the gate-calibrator board. An alternate method is to measure the voltage at L858 on the sweep board. It should be approximately 1 V more negative than at TP826.

b. If the 0-Hz response moves appreciably ($\approx$0.5 cm) when adjusting R415 it usually indicates R800 will have to be set to a different voltage level and R850 readjusted.

c. It is not always necessary to adjust R410 to R415 from their preset positions to achieve proper sweep shaper adjustment.

Using these service hints and the calibration and maintenance procedures outlined in the manual you should be able to keep your 1401A in good working order. If you have difficulty, don't hesitate to call your TEKTRONIX Field Engineer.



***Bob Williams**, pictured at left, is a staff engineer in Production Test. Bob has been with Tek six years, working primarily with spectrum analyzer products. He started his electronics career in the Navy as an Electronic Technician. Bob's leisure time is largely filled with his wife and three children; he does admit to an occasional stint at the bowling lanes.*

*Co-author **John Ross**, at right, also works in Production Test. He joined Tektronix nearly six years ago upon graduation from Spokane Community College. He, too, likes to bowl; however, electronics is John's main hobby as well as vocation. He has a charming wife and year-and-a-half old daughter.*