HAM RADIO

By Joseph J. Carr, K4IPV

Build a Spectrum Analyzer

At one time, spectrum analyzers were found only in the most well-equipped engineering laboratories. Spectrum analyzers are devices that are used to display signal amplitude along the vertical axis and frequency along the horizontal axis on an oscilloscope's CRT. Such devices typically cover a rather wide frequency range. That allows them to "spot" signals over wide portions of the electromagnetic spectrum.
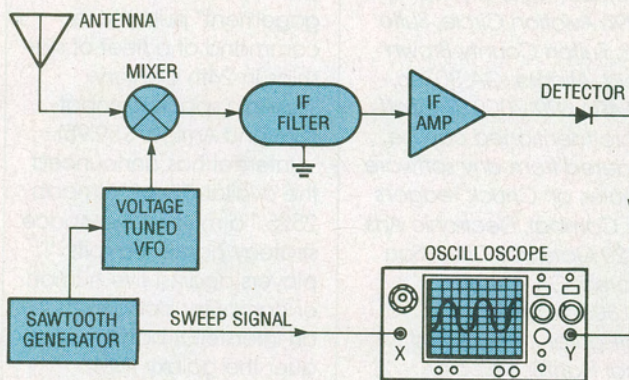

Fig. 1. Block diagram of a spectrum analyzer.

HOW IT'S USED

Federal Communications Commission (FCC) engineers use spectrum analyzers to keep track of signals within an area by detecting stations as they come on and go off the air. They also use spectrum analyzers to see how much second and third harmonics are being radiated from a transmitter; the less, the better. A spectrum analyzer can also be used to determine the effectiveness of a transmitter's tuning circuitry, or to test the effectiveness of antenna-tuning units.

In addition, spectrum analyzers might be used to find the source of electromagnetic interference.

When intermodulation occurs, any number of frequencies might be involved. A spectrum analyzer allows the engineer to correlate signals on the CRT with the interference.

Another use for the spectrum analyzer is as a panadapter. Basically, a narrow-band spectrum analyzer that's designed to operate at the intermediate frequency (IF) of a receiver, it is connected between the output of the mixer and the input of the first IF filter. The panadapter allows continual visual monitoring over a narrow band of frequencies centered around the receiver's IF, allowing you to analyze the spectral content of a single received signal, or it can be used to analyze spectral content over a larger band of frequencies (up to a few hundered kHz). One use for a panadapter in ham applications would be to look for quiet spots on a band.

HOW IT WORKS

Figure 1 shows the block diagram of a typical spectrum analyzer. The input is coupled to an RF mixer, where it is mixed with the RF output of a local oscillator (LO) that consists of a voltage-tuned, variable-frequency oscillator (VTVFO), whose instantaneous frequency is controlled by the output of a sawtooth generator; that signal also controls the X-axis deflection on the oscilloscope.

The output of the mixer circuit is filtered to retrieve the difference frequency (RF − LO), or IF of the analyzer. The output of the filter is then amplified and fed to a detector to produce a DC level. As the LO signal mixes with the incoming RF, deflections or "blips" on the trace indicate the spectral content of the band of interest.

SAMPLE HOMEBREW CIRCUIT

Figure 2 shows the schematic diagram for a simple spectrum analyzer, whose RF front-end is built around an NE602N double-balanced mixer (U1). (The NE602N is available from Digi-Key Corp., PO Box 677, Thief River Falls, MN 56701-0677; Tel. 800-344-4539.) The NE602N's internal oscillator is used as the VTVFO in this circuit. Its configuration is similar to that used in the band sweeper discussed last month.

Applying a sawtooth waveform to V_t causes U1 to sweep from the frequency obtained when the sawtooth is zero up to the frequency obtained when the sawtooth is at its maximum value. The signal produced by U1's internal oscillator as a result of the applied sawtooth waveform is mixed with the incoming signal from the antenna (ANT1), which is coupled through a pair of coils (L2 and L3) to pins 1 and 2 of U1.

There of two options for L2 and L3. The first option is to use a 10.7 MHz, transistor-radio type, IF transformer (IFT) for L2 and L3. To use the IFT in that capacity, the small capacitor must be removed (or crushed). The IFT windings must then be reversed in the circuit; that is the primary of the IFT is connected as the secondary and vise-versa. The
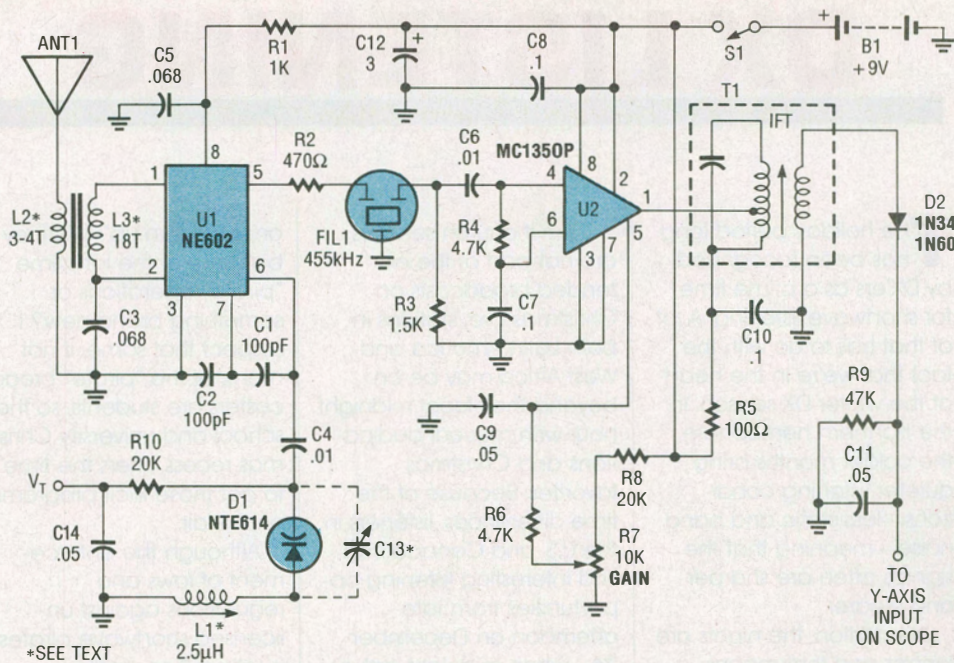
Fig. 2. The schematic diagram for the spectrum analyzer circuit. The circuit is built around an NE602N, which is supported by several semiconductors and passive components.

Fig. 3. Here's an alternate tuning network for the spectrum analyzer.

This trace shows a single frequency from a signal generator.

second option is to wind your own coils. The two coils can be wound on a single a T-37 or T-50 red or yellow torroidial core in transformer fashion. First wind 18 turns of #26 enamel coated wire on the core for L3. For L2, wind 3 to 4 turns of the same wire on the core.

The output of U1 (the difference or IF signal) is applied to FIL1—a 4-kHz wide, 455-kHz (center frequency), AM ceramic filter (also available from Digi-Key), which determines the circuit's IF range. From FIL1, the IF signal is fed to U2 (an MC1350P RF/IF amplifier) for amplification. The output of U2 is coupled to D2 (a 1N34 germanium diode), which is used as an AM detector, via T1 (a 455-kHz IF transformer), and is applied to the Y-axis of an oscilloscope.

Diode D1, an NTE614 varactor diode with a capacitance of 33-pF, allows U1's internal oscillator to be tuned from 10 MHz to 15 MHz. The varactor diode used in your unit will depend on the frequency coverage desired. For many HF circuits, diodes

PARTS LIST FOR THE SPECTRUM ANALYZER

SEMICONDUCTORS
U1—NE602 double-balanced mixed, integrated circuit
U2—MC1350P RF/IF amplifier, integrated circuit
D1—NTE614 33-pF varactor diode
D2—1N34 or 1N60 germanium diode

RESISTORS
(All fixed resistors are ¼-watt, 5% units.)
R1—1000-ohm
R2—470-ohm
R3—1500-ohm
R4, R6—4700-ohm
R5—100-ohm
R7—10,000-ohm potentiometer
R8, R10—20,000-ohm
R9—47,000-ohm

CAPACITORS
C1, C2—100-pF, ceramic-disc
C3, C5—.068-pF, ceramic-disc
C4, C6—.01-μF, ceramic-disc
C7, C8, C10—0.1-μF, ceramic-disc
C9, C11, C14—.05-μF, ceramic-disc
C12—3-μF, 16-WVDC, electrolytic
C13—See text

INDUCTORS
L1—2.5-μH (see ext)
L2—See text
L3—See text
T1—455-kHz IF transformer (Digi-Key part #TK-1301 or equivalent)

ADDITIONAL PARTS AND MATERIALS
FIL1—455-kHz ceramic filter (Digi-Key part #TK-2330, or similar)
B1—9-volt transistor-radio battery
S1—SPST switch
Perfboard materials, enclosure, Amidon L-57-2 or similar insulated coil form, battery holder and connector, etc.
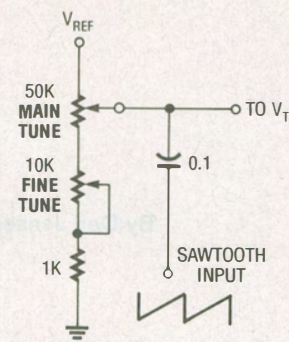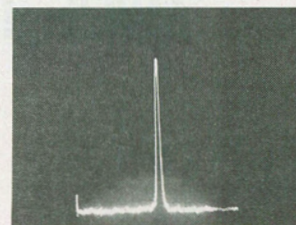
with maximum capacitances of 33 pF, 100 pF, or 365 pF are exceptable, but keep in mind that the frequency change is the square root of the capacitance change. Inductor L1, a 2.5-μH homebrewed unit wound on an Amidon L-57-2 shielded coil form, must resonate at the desired frequency, given the capacitance of D1. The number of turns needed for L1 depends on the wire diameter used and will have to be determined experimentally. To reduce the frequency range, or custom tailor the circuit's tuning range, a fixed or variable-trimmer capacitor (C13) can be shunted across D1. The value of C13 depends on the desired tuning range.

ALTERATIONS

The V_t input to the circuit can be altered, as shown in Fig. 3, so that a DC voltage can be combined with the sawtooth waveform. That would allow the center fre-

quency of the swept region to be set by a 10k potentiometer, while the sweep width is set by the sawtooth amplitude.

One of the problems with a varactor-tuned oscillator is that the relationship between voltage and frequency is nonlinear. A somewhat improved version of the tuned circuit is shown in Fig. 4. In that variation of the V_t input, a pair of identical varactors (D1 and D3) are connected cathode-to-cathode. That circuit is more linear (hence is more suitable) for spectrum analyzer and panadapter circuits.

However, the capacitance seen by L1 is one-half the capacitance of either diode alone. That phenomenon occurs because the coil effectively sees two identical capacitors in series, so the total capacitance is half of either unit.

The circuit in Fig. 4 also serves as a decent radio receiver, especially if you provide an audio amplifier to follow the detector. An LM386 low-power audio amplifier should do for that.

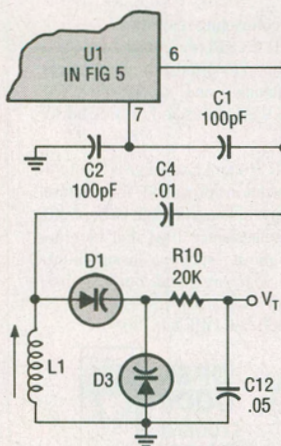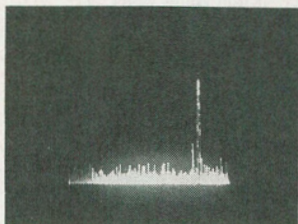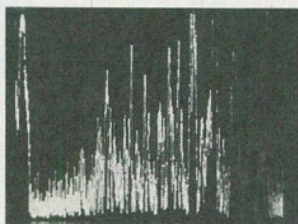Ramsey Electronics (793 Canning Parkway, Victor, NY,

The signal shown here is that of a child's CB walkie talkie.

Here's a segment of the HF spectrum from about 40-meters to a little higher than the 20-meter band taken in the evening with all bands open.

14564; Tel. 716-924-4560) offers low-cost, varactor-tuned, NE602/LM386 receiver kits. They can be modified to make a panadapter or spectrum analyzer that operates within the tuning range of the kits. I've built one and reported on it in this column previously. I also modified it by adding a sawtooth to the tuning voltage, making it into a sweep receiver.

One thing that voltage tuning of a receiver or spectrum analyzer offers is the potential for computer-driven tuning. If you use a voltage output digital-to-analog converter (DAC), it is possible to use an eight-bit binary word from a computer port to drive the tuning of the receiver/analyzer to a desired frequency.

Note: Most signal generators do not have a sawtooth output. Also, many of the published circuits produce a poor sawtooth. I have a circuit for a digitally controlled sawtooth generator. Send an SASE for a free copy of the schematic to c/o *Ham Radio*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ∎

Fig. 4. Using this circuit as the V_t input to the spectrum analyzer results in more linear tuning for the circuit.