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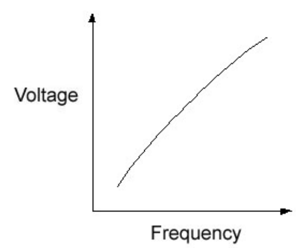
QRV? "Seeing" Radio Signals

Last week, a friend of mine told me that he had just bought a new ICOM IC-756PRO. He said that what he liked the most on the rig was the bandscope—that fancy thing that tells you where the guys with the 10 KHz wide signals are.

That got me to thinking—have you ever wondered how one of those things works? It is quite simple if you think about it. All it really takes is (1) a way to scan the band looking for signal levels, and (2) a way of measuring and plotting signal levels. Measuring signal levels is pretty easy—nearly all commercial rigs, and a lot of kits, have a device that does that. It is called the "S-meter." And most commercial rigs (and nearly *all* VHF rigs) have a scanning device—usually implemented using a thing called a Voltage Controlled Oscillator or VCO.

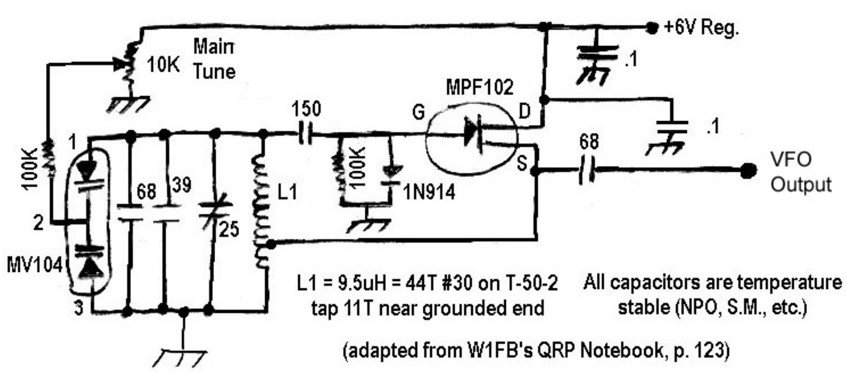
The Voltage Controlled Oscillator

The simplest VCO can be built using a component called a varactor diode. All diodes have an interesting property in that when they are reverse biased, they behave just like a capacitor. As the reverse bias voltage is increased, the capacitance is reduced. Most diodes can be used as varactor diodes (for example, the 1N4001—the cockroach of rectifier diodes, available at any Radio Shack store—is often used in simple NE602 receiver circuits, such as in Vectronics and Ramsey kits), however, certain diodes perform better than others.



Frequency changes in a VCO

The following circuit (values are for 80M) is an example of a VCO built using a MV104 varactor diode (available from Mouser, Digikey, etc.).

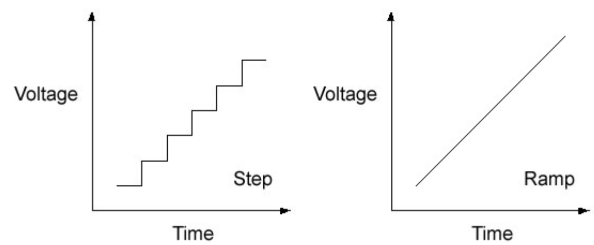


Varactor tuned VFO or VCO.

The MV104 varactor diode has two diodes in it, connected "back-to-back." Using two diodes in this way prevents the alternating RF voltage (in the oscillator) from driving the diode into "forward conduction" (that is, during one half of the cycle, the sum of the reverse bias and the RF voltage could go negative and the diode is no longer reverse biased). The down-side is that you have two "capacitors" in series, so the total capacitance is cut in half.

In this circuit, the Main Tune (10K) variable resistor varies the reverse bias voltage on the MV104 in the VFO tank circuit. The elegance in this circuit is its simplicity. However, it does come at a cost—for one thing, the variable capacitance changes over a range of voltages, normally in the range of 1 or 2 Volts to about 20 Volts; if your voltage falls outside of the range, the varactor will not perform properly (in the example VFO/VCO circuit, it is possible for the voltage to drop below 1 Volt at the low end of the tuning range).

A scanner is simply a receiver that uses a VCO over a selected range of frequencies. Special circuitry varies the voltage applied to a VCO either in steps (e.g. "channels") or in a "ramp" (also called a "sweep"). The "scanner" component of the bandscope uses ramp voltage control, since HF frequencies are not channellized. As the voltage increases, the frequency increases in a (nearly) linear fashion.

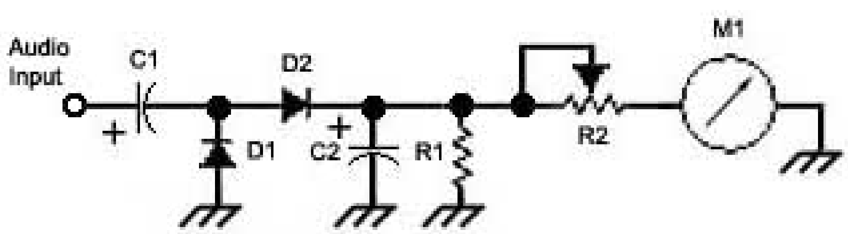


Voltage stepping and ramping.

Measuring Signal Strength

Many simple QRP rigs do not have frills like Automatic Gain Control (AGC) and an S-meter. How is it, then, that even without a visual indication of signal strength, you can send and receive RST reports? Well, to the ear, signal strength becomes loudness when transduced by a speaker (or headphones). And the ear is a fairly decent detector of relative loudness (1 dB is defined as the smallest perceptible change in loudness that the ear can hear).

Recovering a DC signal that is proportional to the signal strength from the detector stage of a receiver and measuring it with a meter or other indicator is one way to obtain a visual indication of signal strength. See the following diagram.



Signal strength detector circuit.

In this basic signal strength detector circuit, diodes, D1 and D2, form a voltage doubler that rectifies the audio energy coupled in via C1. The resistor, R1, (say, 1M Ohm) and the capacitor C2 (say, 4.7 uF) form an RC circuit—the larger the R (resistance) or C (capacitance) the longer it takes to charge and/or discharge the capacitor. The rectified current charges the capacitor to a certain level, depending on the signal strength of the signal and as the signal strength drops, the resistor discharges the capacitor. The delay this introduces in charging and discharging serves to "smooth out" the voltage that is constantly varying, and keeps the needle from jumping around wildly.

The variable resistor, R2, limits the current going through the meter, M1, and is used to calibrate the signal strength indicator. The circuit can be connected directly to the audio output of a receiver, making it a "signal strength" receiver. This device is useful to compare relative signal strengths, but does not indicate absolute received signal strength (since some radios might be more sensitive on some bands than on others). To make more practical use of this circuit as an S-meter in a receiver, you should put an isolation buffer (a *unity gain amplifier* with a high impedance input) followed by an audio amplifier, and connect it in the audio chain *before* the volume control.

Putting it Together

We now have two of the basic elements of a bandscope—a VCO and a way of measuring signal strength. Sweep the VCO over a fixed portion of the band, convert the RF to audio, measure or *sample* the signal strength over the sweep bandwidth, and plot the results (say, signal strength on a Y-axis and voltage or frequency on the X-axis). Voila! You have a bandscope!

Ah, you say, but how do I sweep the VCO, and how do I automatically graph the resulting signal strength? Well that is, as Paul Harvey says, "the rest of the story." It is actually quite simple using a *ramp generator* circuit and a *Cathode Ray Tube* (CRT). We'll talk about that in the next installment of this column. Hopefully, you'll begin to see that from some pretty basic and simple building blocks, we will build up a fairly useful piece of test equipment that will help us in all sorts of ways. Oh, by the way, that bit of bandwidth over which you sweep your VCO is also called *spectrum*—and so the technical term for this bandscope we've been describing is a *spectrum analyzer*.

But until then, let's just grab a little bit of that spectrum and get QRV, shall we?

72 de Mike, KO4WX