IRCA Technical Column

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(the article below is one of the many new items which will be appearing in the upcoming third edition of A DXer's Technical Guide)

Frequency Selective Voltmeters and their Uses in the Radio Hobby

by Don Moman

A Frequency Selective Voltmeter (hereafter abbreviated "FSVM") isn't a familiar term among most radio hobbyists. (They may also be referred to as Wave Analyzers by certain manufacturers; related to the family of Electromagnetic Interference or EMI Receivers) But when you think about the individual words, the FSVM really is a tunable radio receiver (the frequency selective part) with an accurate "S" meter (the voltmeter part). Like radio receivers, they come in many variations. Some are poorly suited for our purpose in that they do not easily allow one to listen to the signal we are measuring. Some others are very well suited and it's primarily those units we are interested in.

With the telecommunications industry doing more fiber and digital, the need for these type of analog measurements is greatly reduced and I think we will see a lot more of these kind of units being declared surplus and offered to the hobbyists (eventually) at a good deal.

Some useful information on various models will be included at the end of this article, but there is considerably more information out there on the various models. Some places to look - catalogs from the major test equipment manufacturers give complete details and specs. Test equipment suppliers often have catalogs as well, many of which can be found on-line if you have internet capability. The Tucker Electronics homepage has a most informative section on FSVMs.

Who makes FSVMs? Don't look for the familiar names in amateur radio here like ICOM, Kenwood or Yaesu. Instead, it's the big players in the test equipment world like Hewlett Packard, Tektronix, Sierra, Cushman, Seimens, Wandel and Goltermann, Rhode & Schwartz, Telefunken and others. Even though you may find this equipment as surplus at low prices, you should never use the word "cheap" around this type of equipment. All the units I've seen are extremely well made, using high quality components and construction, and designed to exacting specifications. This article will try to offer a few tips as to which units are desirable, and give the user some basic knowledge to make a decision if one shows up at a surplus shop or ham fleamarket.

What's in an average FSVM? The FSVM is designed to measure the voltage level of various signals, usually in a telecommunications type environment. To this end, there is a large meter to display the voltage level (usually in dBm, which can be related back to our more familiar μV and "S" meter readings). Later models will have more digital features and can often display readings in various formats. There needs to be a way to adjust the sensitivity of the meter, and this is done with a series of accurate attenuators. Some units will measure with a full scale sensitivity of -100 or -110 dBm, which is very good and easily the equal of the best communications receiver. Check the most sensitive position - if it's only -70 or -80 dBm it may not be that desirable for our use.

There also must be some way to set the frequency. Accuracy is crucial and even the older models have quite accurate dials, sometimes with crystal calibrators and the like. Many models use a series of rotary switches to set each digit of the frequency. Precise but not very handy to tune through the band! Some models have a PLL system that lets you set the main tuning to the

nearest megahertz or 100 kHz and then tune through the band segments, much like the Racal RA17 and other similar early PLL designs. Newer models with digital readouts often display the frequency to 10 Hz or even greater resolution. Later sets will have computer control, keypad entry, scanning, memories and even spectrum analysis capability and a price tag to match.

The frequency coverage is obviously important. Most will measure down to a few kilohertz, but the upper end is more of a concern. Nearly all that I have seen cover at least through the medium wave band, and many go up to 6, 18 or 32 megahertz. A variety of inputs is provided, but one isn't likely to find a socket to fit the familiar PL259 coax connector. N, BNC or other connectors are more common. A variety of input impedances are provided, usually 50 or 75, 124 and 600 ohms. The higher impedances usually function only over a portion of a unit's coverage, so the lowest impedance input is the important one.

Front end RF filtering or selectivity is not generally used, presumably since it would compromise the final accuracy because of the difficulty in keeping filter passband variations within a fraction of a db. Although the front end has good resistance to strong signals, it still can overload and produce spurious responses. Some models have a warning light to indicate such overload, in which case you just adjust the attenuator control until the light goes out. A preselector or some form of RF selectivity would be desirable in very strong signal situations. A tuned loop would work very well. Even without any help in the front end, I've found most behave as equal to or better than decent HF communications receivers.

IF selectivity is provided, but one must check the available bandwidths carefully. Most of the units I've seen provide several narrow filters, like 100 or 400 Hertz, plus something in the 1-3 kHz range. Most have an USB/LSB mode function, often labeled with a sloping left or right facing triangle, to indicate which sideband is being tuned. With the narrow filtering, these units make good CW receivers. If you are into beacon DX on longwave, then FSVMs are easily able to tune between the various carrier and audio tones. For medium wave, they can be useful for measuring split frequencies and for early detection of carriers way before they are strong enough to produce audio. Speaking of audio - nearly all units have an audio output but it may not be labelled as such. Many of the units I am familiar with have a built in monitor speaker with a headphone jack and volume control. If you don't see such features, look on the rear panel. There are usually a variety of inputs and outputs - audio can be lurking at one or more of these. A "Recorder" output is usually demodulated audio; it will be referring to a chart recorder, not a tape recorder, but just hook up an external audio amp and you will have plenty of audio.

One drawback is lack of automatic gain control (AGC). I mentioned earlier that the input level is adjusted (usually manually) with an attenuator. Most serious communications sets have the ability to turn the AGC off, important in some situations, but most of the time it's nice to have the AGC on, to regulate the audio level when tuning from weak to strong signals and back. In addition to the manual level adjustments, one of the units (HP 3586) has a "quasi AGC" mode in which it can switch in 5 dB attenuators as needed. This makes for rather choppy audio levels as the signal fades. Still, for serious DXing this isn't a handicap we can't learn to live with.
Since the FSVMs contain nearly all the components that are important in a high performance receiver, it would be an obvious starting point for one desiring to build their own receiver, but not wanting to do everything right from scratch. Add your own custom IF and audio stages, with AGC, and you could come up with very good receiver performance at a minimal cost.

Other uses: Most of the units I've used make good to excellent long and mediumwave receivers, and those that cover the HF bands do an excellent job there. I'm not sure one would be my first choice as a main receiver but they can be a real asset in many situations. If the tuning scheme is cumbersome with rotary or decade thumbwheels to set the frequency, then they are well suited to monitoring a certain frequency of interest. Some of the more modern units, such as the HP models, have the GPIB feature which will allow computer control.

At this location (near Edmonton, Alberta) DXing the MW band for European signals consists of many nights where hets are audible, a few nights where the strong signals produce audio, and perhaps one or two magic evenings when audio is everywhere. I use one of these FSVMs (Seimens D2007, see descriptions below) to monitor one of the more consistent split frequencies and keep checking the signal strength. The signal meter is analogue and large (4" across), making

it very useful to keep an "eye" on a certain frequency. I just set mine to the 80 hz BW, tune to a split MW frequency and check the carrier strength as it fades up and down. With the 80 hz filter, the effect of random splatter from adjacent channels is reduced, so you can still detect the carrier, kind of a "distant early warning" system for DX. After a little practice, you can develop a good feel for the state of the band by watching the carrier and how it fades. With the narrow filter, two or more carriers on the same channel can easily be detected by the sub audible heterodyning of the carrier frequencies (SAH).

Because they incorporate such an accurate RF voltmeter, they can be put to good use around the technical side of the DX workbench. Even if the absolute accuracy of the unit is in doubt (it may not have seen a calibration lab for many years) the relative accuracy is almost certain to still be very good and thus it can be very handy for checking loss through an antenna switch or coaxial cable, gain through an amplifier, or RF and IF filter response. Accuracy to 0.1 dB is common and several units display readings down to 0.01 dB. Because of the high quality of construction, FSVMs stay accurate unless they have been abused or "tweaked". On a variety of units that I have, all measured the same signal source and agreed to within a fraction of a dB. If you are measuring in a 50 ohm world, and your FSVM has only a 75 ohm input, you will have to take that into account for absolute measurements, but for most practical hobby use, this is of little concern.

Many FSVMs make an accurate frequency counter within their tuning range and may offer several degrees of accuracy higher than your main HF receiver. The HP 3586 displays frequency to 0.1 Hz! Some have an output on the rear panel that can be used as a signal generator, actually called a tracking generator, since it follows or tracks the frequency as the receiver unit is tuned. If this output is coupled back to the input through whatever circuit (filter, amplifier, switch etc.) you are testing, you can manually sweep the frequency and get an accurate response for the device you are testing. Great for sweeping unknown or verifying various crystal or ceramic IF filters, for example. Older units often had this generator as a separate unit, with the capability to hook the two units together to achieve the tracking function.

Availability and Desirability of Various Models: Other than some of the HP models (info was derived from HP catalogues for the 302, 310, 312 and 3581) all my comments come from “hands on” use and are my opinions based on that use. The units are all used sets, often well used, but the comments relating to their performance are based on sets that I believe to be functioning properly. Manuals are scarce so the majority of operating functions described are from what I could discern from the labeled controls and jacks. I may be doing some of the more modern sets (especially the HP 3745 and 3586) an injustice by not knowing what other features might be available. As indicated, some units have a battery option, making them at least portable although far from shirt pocket size.

Hewlett Packard

- **302A** upper frequency range is 50 kHz, not of much use as a receiver.

- **310A** 1 kHz to 1500 kHz, odometer style readout, IF BW of 0.2, 1.0 and 3.0 kHz. 10 μV full scale and 75 dB dynamic range. AM/SSB demodulation capability. $2000 in 1964

- **312A** covers up to 17 MHz, Nixie tube readout. Otherwise similar to the 310A. ~$4000 in 1967.

- **3590A** up to 620 kHz, sweep capability. 3 μV full scale sensitivity, IF BW of 0.01, 0.1, 1.0 and 3.0 kHz. ~$5000 in 1968.

- **3581** only up to 50 kHz. Modern but not useful as a receiver. ~$11,000 in 1989.

- **3586** 50 Hz to 32.5 MHz, LED readout to 0.1 Hz, IF BW of 0.02, 0.4 and 3.1 kHz. +20 to -130 dBm autoranging sensitivity, USB/LSB capability with internal speaker/volume control. Tuning knob or direct keypad entry. Has a mode that actually measures the carrier frequency - to xx xxx.xxx x kHz. ~$17,000 in 1989. Built in tracking generator. Many features and measurement options - HIGHLY desirable as a receiver. I have a couple of these, one for the test bench and one at the listening position.

- **3745/3746** 50 Hz to 32.5 MHz with sweeping function, X&Y outputs - for use as a spectrum display unit. I have a couple of these and while they do a neat job as a spectrum display, it doesn't seem to make too good a receiver. The 3746 was ~$20,000 in the 1989 catalogue - the description seems to be very similar to the 3745 that I have.

Seimens

- **D364** 200 Hz to 1.6 MHz, film frequency display to 5 kHz resolution. Good for a field strength meter, but limited usefulness for MW DX, bandwidth variable from 80 Hz to 3.0 kHz. Audio indirectly available at recorder output. Portable with battery and AC built in.

- **D2007** 6 kHz to 18.6 MHz, PLL at 100 kHz steps, 0-100 kHz dial or continuously variable (no PLL). Battery option. IF BW of 0.08, 1.74 and 6.0 kHz, USB/LSB selection with internal speaker/volume control. Excellent sensitivity, good filter bandwidths and a nice tuning dial make this one of my favorites. The signal meter is analog and large (4" across), making it very useful to keep an eye on a certain frequency. I just set mine to the 80 Hz BW, tune to a split MW frequency and check the carrier strength as it fades up and down. W2007 is the companion signal generator unit.

- **D2008** a modern digital readout version of the 2007 (display to 10 Hz above 1 MHz, 1 Hz below) -110 dBm full scale sensitivity, 0.02 and 1.74 kHz filters. AFC, USB/LSB with volume/built in speaker.

Wandell & Goltermann

- **ATS 463** mechanical digital readout to 6 MHz. Accessory unit provides SSB audio and speaker.

- **ATS 611** 6 kHz to 18.6 MHz. Digital readout to 10 Hz. IF BW of 0.024, 0.400 and 1.740 kHz. USB/LSB demod output (BFO offset of either 1.0 or 2.0 kHz) with sync capability. 600 ohm audio out (OK for headphone). ATS 610 is the "transmitter" (i.e. signal generator) companion.

Cushman

- iCE-21 individual digits selectable to 19.999 MHz. IF BW of .2 or 2.3 kHz with AM/USB/LSB capability and built in speaker. Looks like it should be a nice unit but mine is inoperative, so I can't comment further.