A guide to radio test equipment

What do you really need?

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It's boring, but necessary. That just about sums up many peoples' attitude towards test equipment. Though it might not get as much use as the station transceiver, it can be worth its weight in gold when something goes wrong and you need to fix it fast.

This month we look at five items of test equipment most commonly found in the amateur shack. We describe each instrument, list its uses around the shack and point out features to look for when buying.

Multimeter

The multimeter is *the* fundamental item of test equipment that all amateurs should own. The cheaper multimeters (around $30) allow voltage, current and resistance measurement as well as transistor, diode and audible continuity testing. More expensive instruments may include features such as capacitance measurement, frequency counters, bargraphs, temperature ranges, computer connections and mains voltage ratings.

Practical uses for multimeters around the shack include:

- Testing antenna and power connections with continuity tester function.
- Verifying transceivers are being fed with the correct voltage.
- Checking polarity of power connections.
- Measuring the current drawn by station equipment.
- Making voltage and current checks when developing or troubleshooting circuits.

There are two main types of multimeters – analogue and digital. Both have their pros and cons.

Digital meters are so cheap these days that no amateur need be without one. They are easy to use and fairly accurate. There is no need to estimate the indicated value when the meter needle is between two closely-spaced markings. The cheapest digital meters also have functions (eg transistor tester) that are missing from analogue meters of equivalent price.

Analogue meters have advantages over digital for some purposes. Analogue movements are particularly good at displaying varying voltages, such as audio signals. Also, when aligning transmitters, the fact that you've reached a peak (or dip) when making an adjustment is often more important than the actual value of the voltage (or current). An analogue movement is better at displaying such trends. Some of the better digital instruments have a bar graph function that combines the best features of both meters in one, but some users still prefer to keep the analogue meter handy.

Other features that amateurs should consider when buying a meter are: 20 amp DC current range (most HF transceivers draw up to 20 amps), audible continuity indicator (though missing from budget meters, it's *very* useful), capacitance, inductance and frequency measurements. The last functions may not work as well on the multimeter as on specialised instruments designed for a single task, but are still useful for much amateur work, especially when budgets are tight.

SWR/Power Meter

SWR and power meters cover a wide span. The cheaper meters provide relative indication of the standing wave ratio (SWR) only and do not measure transmitted power. Slightly more advanced meters include RF power output and field strength indication as well. Most of these meters were designed for the 27 MHz CB market, but give useful relative indications up to 148 MHz. At lower HF frequencies (around 3.5 MHz) the sensitivity of these meters falls off dramatically so they can be useless at low transmit powers.

The better meters, such as the Revex range sold in Australia, operate over a wider frequency range than the CB-type meters mentioned above. Their sensitivity is more uniform across the specified frequency range, which may be as much as 1.8 to 1300 MHz. Accuracy is also better, and the use of N-type connectors reduce losses and impedance variations at UHF.

Practical uses for SWR and power meters include:

- SWR measurements – These are almost mandatory for anyone who installs or constructs antenna systems and wishes to obtain the best performance from them, especially with modern equipment.
- RF power measurements – useful for testing transmitters or ensuring one is adhering to licensed power limits.
- Field strength measurements – useful for crude checks of handheld transceivers or antenna or feedline radiation. Measurements given are relative only. Not all SWR/power meters include this function, but a separate field strength meter is very easy to build.

The SWR/power meter runs a close second to the multimeter as the test equipment item of most use around the amateur shack. The SWR function is most important, as modern HF transceivers do not deliver their full output power if the SWR is high. For such tests, even a relative-reading meter is sufficient. Those who repair, align or construct transmitting equipment are advised to obtain one of the better quality meters with output power indication.

Dip Oscillator

A dip oscillator is one of the main instruments used by the radio experimenter. People who experiment with antennas or build and align tuned circuits as used in HF transmitters and receivers will get most use from them. Applications for dip oscillators include:

- Testing tuned circuits in receivers and transmitters. A dip oscillator can give a reasonable indication of resonant frequency.
- Checking resonance of antennas such as mobile whips.
- Measuring unknown capacitors and inductors (especially handy for un-marked variable capacitors and inductors).
- An RF signal generator to provide test signals to align homebrew receivers or IF strips.
- As a crude beat frequency oscillator (BFO) to allow an AM receiver to tune SSB/CW signals.
- To monitor the quality of AM transmissions and listen for clicks on CW – some dip oscillators have an earphone socket for this purpose.
- RF field strength meter for antenna, feedline and RF leakage tests (though the author prefers to use a separate instrument with antenna for this).

The dip oscillator does all this and more in one or two transistors. It consists of a wide range RF oscillator and a meter. When the dip oscillator's coil is brought close to a tuned circuit that is resonant at the oscillator's frequency, the meter needle dips.

What is happening is that the tuned circuit being tested is sucking RF energy out of the dip oscillator's coil, thus causing the meter needle to dip towards zero. The resonant frequency of unknown tuned circuits can be determined by holding the dip oscillator coil close to it and tuning the oscillator until the meter current drops. The dip oscillator's tuning control is normally calibrated in MHz to allow a direct reading of approximate resonant frequency.

Most dip oscillators come in a long narrow case with plug-in coils on the end. This is so that they can be stuck deep into the innards of radio equipment. Commercially-made dip oscillators can be hard to find and quite expensive new. However they are very easy to build and require just one specialised component (dual gang variable capacitor – common at hamfests). This makes them popular amateur construction projects.

Dip oscillators are not known for their accuracy and longterm frequency stability. The need to perform mathematical calculations is another drawback compared to direct-reading instruments. For a cheap and simple test instrument that can do lot, the dip oscillator was second only to the multimeter for many amateurs.

More recently the antenna analyser has come into favour, replacing both the dip oscillator and RF noise bridge. They are now considered an essential for antenna experimenters. A successful Australian unit was developed by VK5JST and is currently (May 2012) available as a kit.

RF Signal Generator

RF signal generators provide a signal at a frequency set by the user. The best RF signal generators have good frequency coverage and stability, easy tuning (possibly via keypad as well as knob), in-built digital frequency readout, synthesised frequency generation and calibrated output levels. These come in 19-inch rack cabinets, and being intended for the professional, have price tags to match.

For most amateur applications, however, cheaper hobbyist-type instruments (eg Dick Smith Q1312 or older valve equivalents) will do the job quite nicely and come up at hamfests.

Such instruments do not seem to be readily available new anymore. Instead consider a computer-controlled DDS unit which offers amazing frequency stability and accuracy for a fraction of the price of the old stand-alone units.

Like the dip oscillator, RF signal generators are versatile instruments. However, due to their larger dial, better frequency stability and calibrated output levels, signal generators are superior for many purposes. Amateur uses for RF signal generators include:

- Test oscillators for receiver construction and alignment. The ability to directly inject signals (rather than rely on RF pickup) and control output levels makes signal generators ideal.

- Receiver converters. A signal generator can be a makeshift local oscillator when testing converters or mixer stages.
- Certain antenna tests, especially when it is not desired to cause interference to others by radiating a high power signal.
- A BFO for AM receivers when receiving CW/SSB signals. The ability to vary RF output level and easier tuning on the signal generator makes this technique superior to using a dip oscillator.
- A low power transmitter. People have had CW contacts merely by connecting a keyed signal generator to an antenna! However best results will be achieved if attention is paid to matters such as impedance matching to the antenna, quality of keying, frequency stability and suppression of harmonics.

Cathode Ray Oscilloscope

Leaving aside those lucky few with spectrum analysers, RF test sets and other exotic equipments with five figure price tags, the cathode ray oscilliscope (or CRO) is the most advanced piece of test equipment that most of us can reasonably aspire to own.

If you intend to experiment with receivers and build the odd transmitter, you will not need a CRO. You can certainly get a homebrew CW, AM, FM or DSB station on the air without a CRO. However, if you wish to get the best performance and signal quality from homebrew or repaired equipment, a CRO is the way to go.

Amongst other things, a CRO allows you to see waveforms from transmitters and oscillators. As you peak a tuned circuit, you can see the signal getting stronger. If you adjust a transmitter's power output setting too high, you may see the waveform depart from a smooth sine wave to one with odd troughs and bumps. If using an RF power meter, the needle might suddenly jerk up, but the signal still sounds good in the receiver. With a CRO you see things you don't always hear on a receiver and, by moving the probe back from the output stage, you can identify the stages that are introducing distortion.

CROs, especially for higher RF frequencies, are more expensive than any other test equipment item described here. They might not be used often. However they are extremely valuable when used properly, and can provide a better insight into the actual operation of a circuit than any other instrument. For amateur purposes, maximum frequency that a CRO will go up to is important. The author's unit will go up to over 50 MHz – sufficient for most amateur work. Dual trace CROs are preferred.

Other items

In addition to the test equipment items mentioned above, ownership of an HF communication receiver (preferably with a digital readout) would be an advantage. The general coverage receivers included in recent HF transceivers are fine, though a separate receiver is preferred if your workshop is some distance from the main station.

For VHF/UHF experimenters, a tunable VHF/UHF receiver will also be desirable. Many amateur rigs cover a fair chunk of the VHF/UHF spectrum. One of the great receivers of the 1980s and 1990s was the Icom ICR7000. The Uniden Bearcat UBC9000XLT scanner, though it lacks SSB and misses most UHF TV channels, was much cheaper but still very versatile. A frequency counter is nice to have, but not essential if you already have a good receiver with accurate digital readout.

Conclusion

This item has looked at the items of test equipment that the amateur should own. If your interests are mainly operating, the first two items are only really necessary. However, if you'd like to keep your equipment in top operating order, wish to make repairs, modifications or build new projects, all of the items described above will be useful.

Notes

An earlier version of this article appeared in *Amateur Radio, August* 2000.

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