What Good is an S-Meter?

Many hams use S-meters all the time to give signal reports. After learning the value of an S-meter, this author no longer uses one!

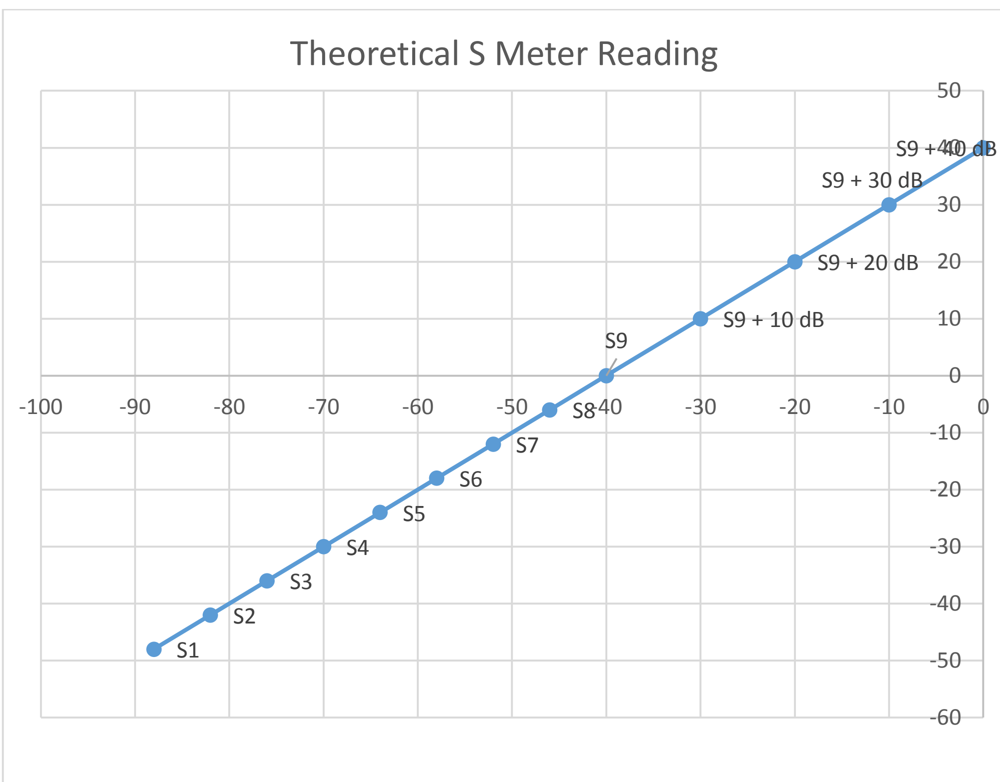
An S-meter can help determine if one signal is stronger than another, but more important is <u>how much stronger</u>? A S-meter <u>fails</u> to adequately tell you that.

One S-unit is defined as a 6 dB change in power. So if one increased the station's power from 100 Watts to 400 Watts, you would expect the S-meter on the receiving end to increase by 1 S-unit. In this paper we study seven rigs (Kenwood, Yaesu and ICOM brands). In the S7 to S9 range, dB steps vary from 1.1 to 6.7 per S-unit! Commonly, the dB step averages 3-5 decibels.

Here is a chart of an ideal, theoretical S-Meter readout. Manufacturers normally calibrate receivers at S9. The meter may be adjusted to produce this reading with an input of -73 dBm at the 50 ohm input of the receiver, but manufacturers vary.

Note that this calibration is <u>not</u> with respect to the antenna. If, for example, the antenna's impedance is significantly higher, power transfer from the antenna into the radio will suffer. Signal levels will be lower than if they were fed to an input with a matching impedance. Many antennas vary in impedance over various frequency ranges, particularly in the case of wideband designs.

The theoretical S-meter shows a linear pattern of readings across the entire received power spectrum. Therefore, S9+ 20 dB is 20 dB greater. S4 is 30 dB lower than S9. That is 6 dB times 5 S-unit steps equals 30 dB.



Seven HR rigs were studied. They were chosen because the rigs were readily available to the author. In general rank order from the rig with the most accurate S-meter to the worst, they are:

- Kenwood TS-570D(g)
- Kenwood TS-590S
- Kenwood TS-2000
- Kenwood TS-680S
- ICOM 706 MKIIG
- Yaesu FT-857D
- ICOM 706

Conclusions are reached only on the 20 meter band. This was done to compare to earlier studies conducted by Greg Ordy W8WWV.

The test methodology was:

- Use a Lodestar SG-4160B RF signal generator set at 14.2 MHz.
- Tune the receiver to 14.2 MHz USB.
- Ensure the RF gain was wide open.
- Turn off the receiver pre-amplifier.
- Adjust the DSP filter bandwidth to a low cut frequency of 0 Hz and high cut of 5,000 Hz.

- Adjust the RF signal so that the S-meter scale deflected to S9+40 dB, the normalized setting for measurements.

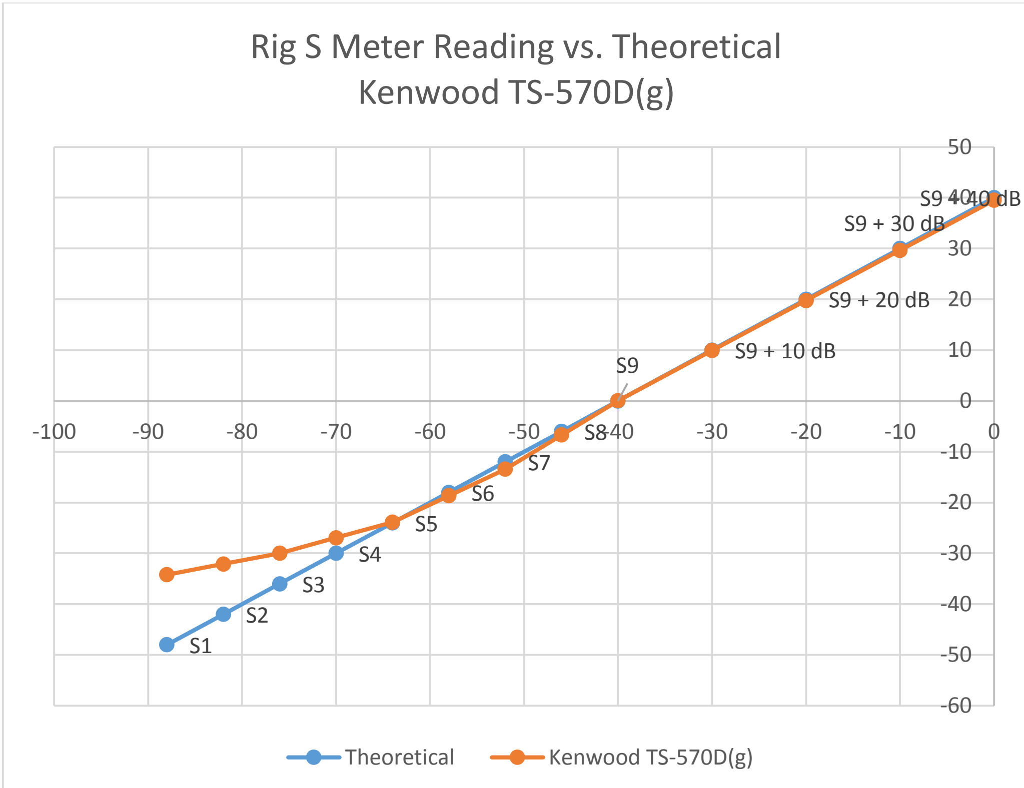
- Use a calibrated MFJ-762 Step Attenuator to attenuate the signal enough to achieve meter deflection at scaled readouts. For example, with the ICOM 706, 35.1 dB attenuation was sufficient to achieve an S9 reading, instead of the theoretical 40 dB attenuation.

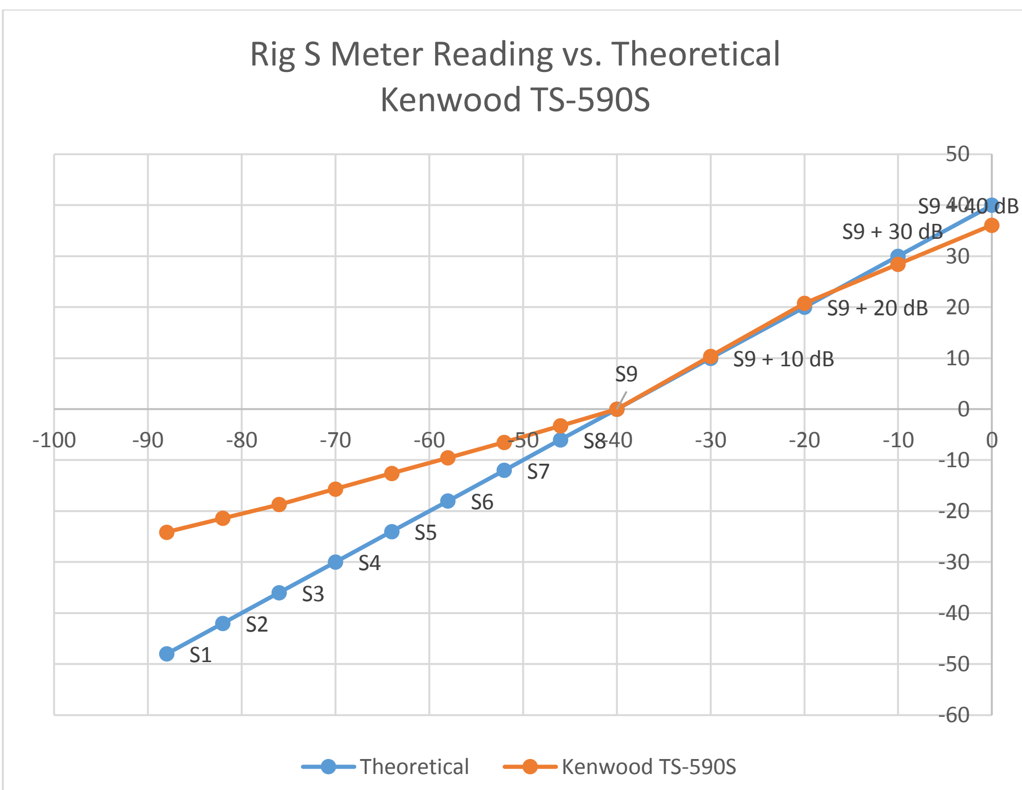
- Once all measurements were completed, re-normalize the results so that S9 equaled 0 dB. Therefore, in the previous example, the ICOM 706 S-meter would require a 35.1 dB increase in received power in order to deflect its S-meter to S9+40 dB.

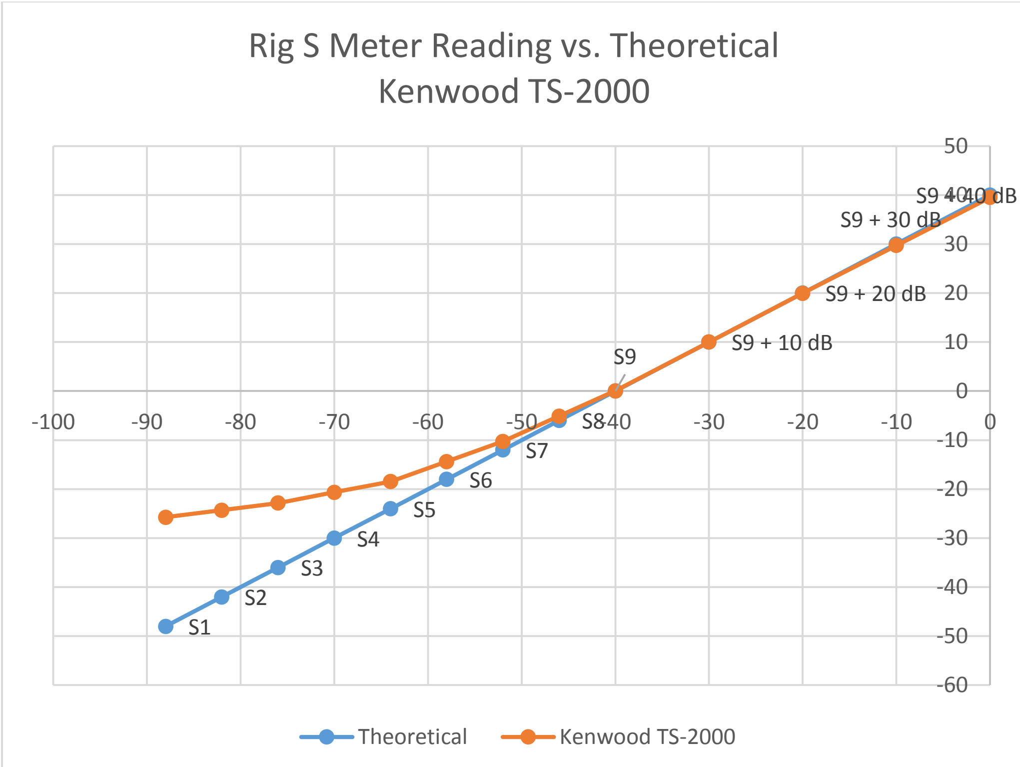
- Graphically plot the results of each receiver relative to the theoretical S-meter scale.

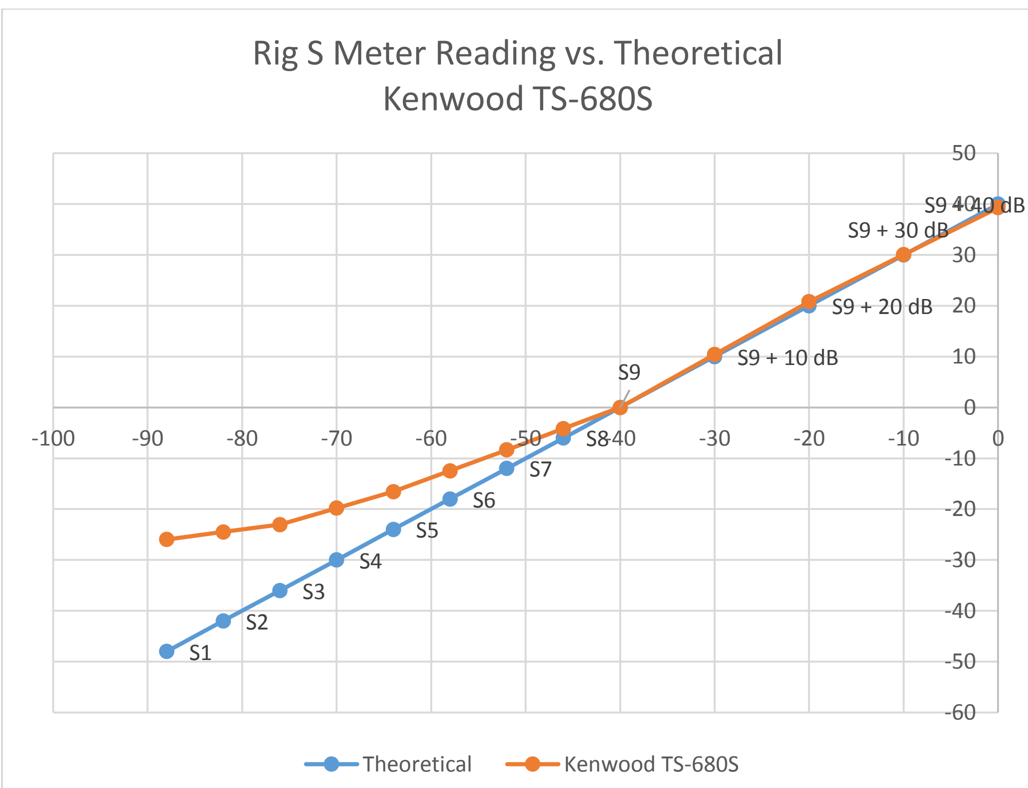
Prior to studying this topic and conducting research, this author thought S-meters were pretty useful instruments. But we discovered that S-meters are neither very accurate nor consistent.

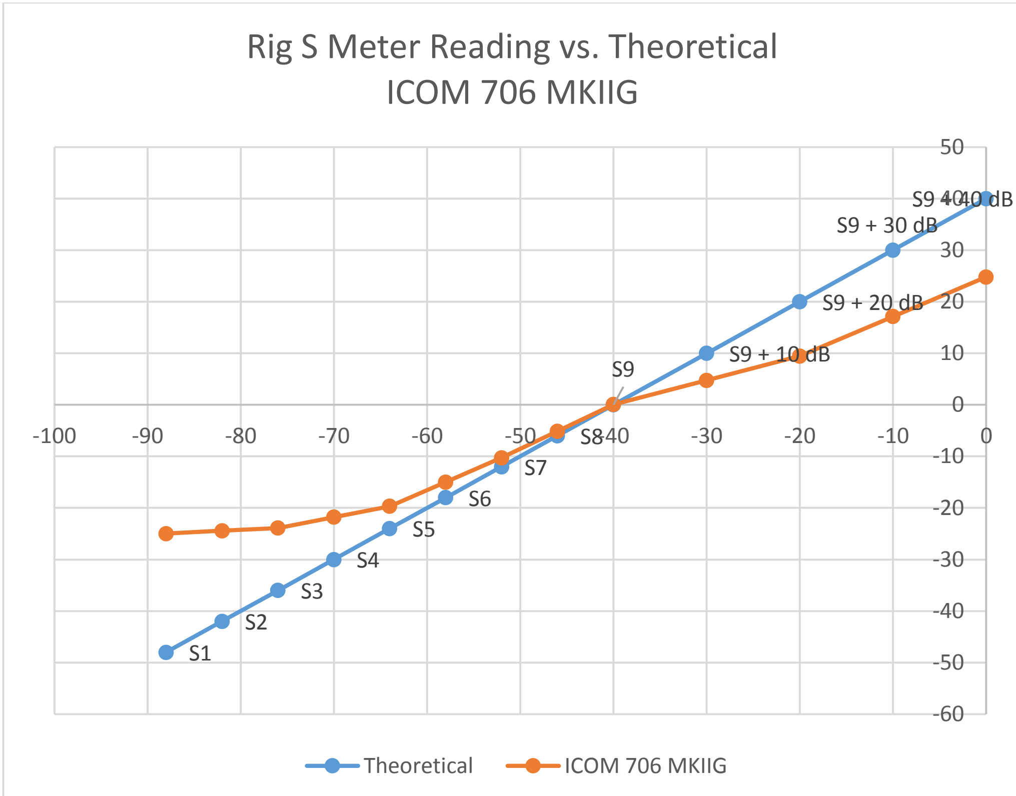
Charts of the findings per receiver follow.


Rig S Meter Reading vs. Theoretical
Kenwood TS-570D(g)
S1
S2
S3
S4
S5
S6
S7
S8
S9
S9 + 10 dB
S9 + 20 dB
S9 + 30 dB
S9 + 40 dB
Theoretical
Kenwood TS-570D(g)

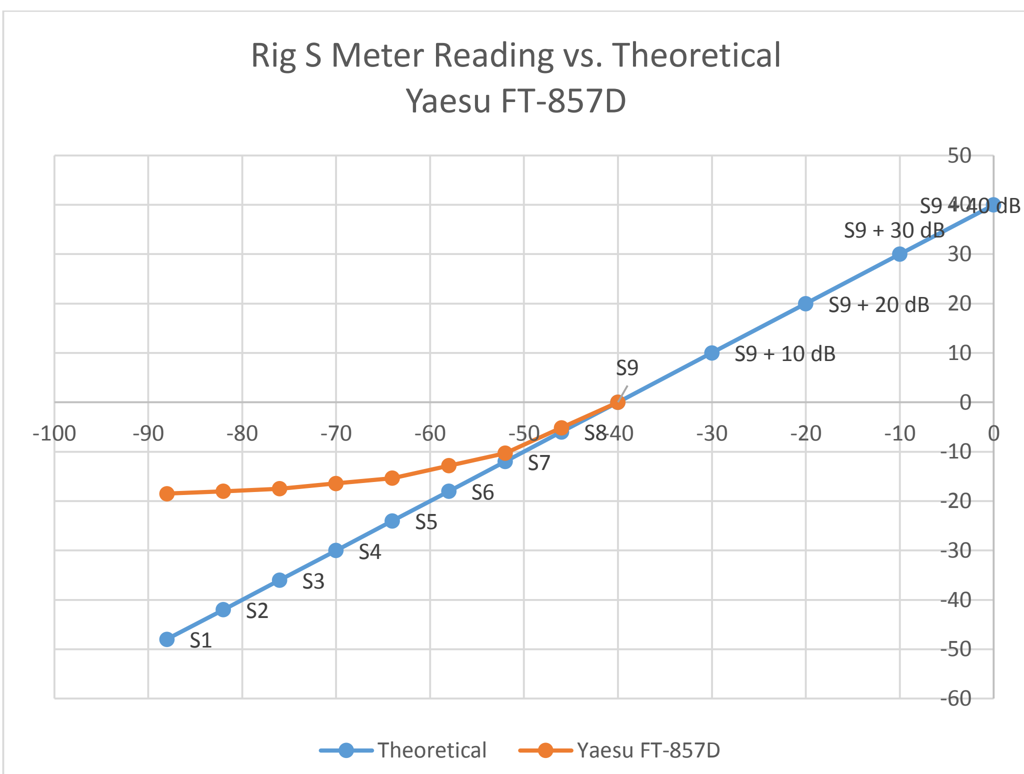

Rig S Meter Reading vs. Theoretical
Kenwood TS-590S
S1
S2
S3
S4
S5
S6
S7
S8
S9
S9 + 10 dB
S9 + 20 dB
S9 + 30 dB
S9 + 40 dB
Theoretical
Kenwood TS-590S

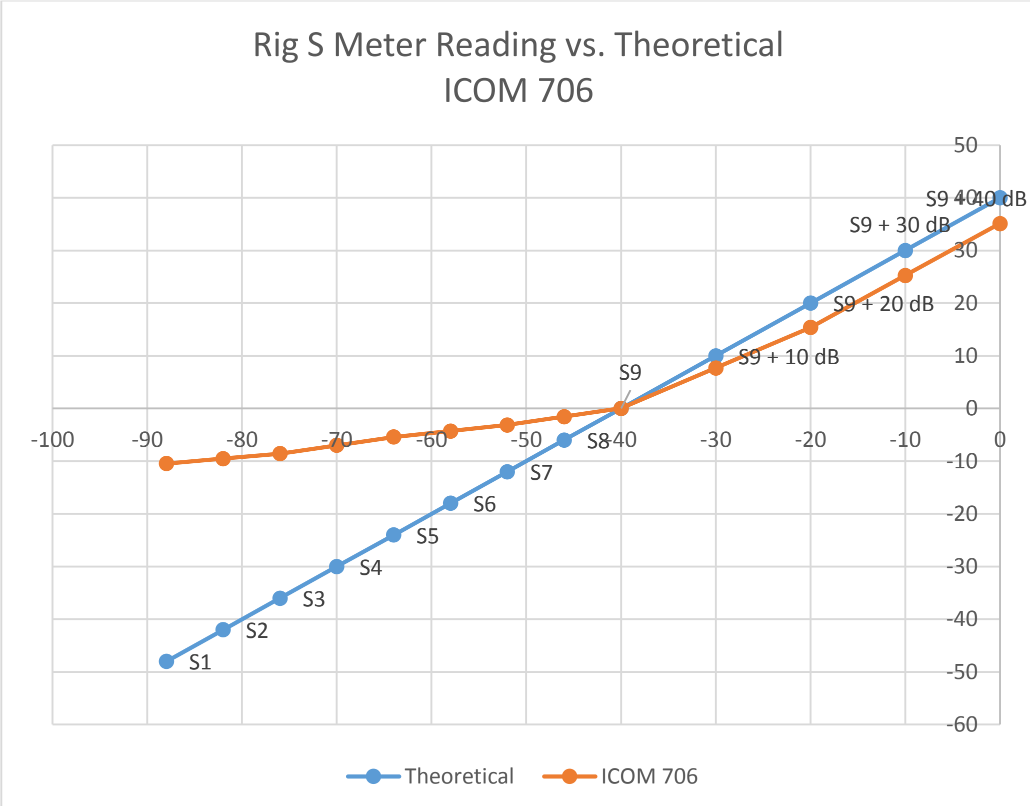

Rig S Meter Reading vs. Theoretical
Kenwood TS-2000
S1
S2
S3
S4
S5
S6
S7
S8
S9
S9 + 10 dB
S9 + 20 dB
S9 + 30 dB
S9 + 40 dB
Theoretical
Kenwood TS-2000


Rig S Meter Reading vs. Theoretical
Kenwood TS-680S
S1
S2
S3
S4
S5
S6
S7
S8
S9
S9 + 10 dB
S9 + 20 dB
S9 + 30 dB
S9 + 40 dB
Theoretical
Kenwood TS-680S



Note that the Yaesu FT-857D is incapable of giving S-meter readings in the +10 and above dB range.





We may observe the following from this research.

- Assuming an accurate manufacture's S-meter calibration at S9, most S meters are linear and accurate in the +10 dB and above range, with the notable exception of the ICOM 706 MKIIG which gives particularly bad readings for very strong signals.

- Most rigs do a particularly poor job of giving accurate S meter readings below about S7.

  - The Kenwood TS-570D(g) is remarkably good down to S5.
  - The ICOM 706 is remarkable poor with any reading below S9.

- Once the signal gets below about S6 for most rigs, the S-meter power curve becomes non-linear and flattens. This means meter readings for these rigs are deceptively wrong. The dynamic range of measurement is poor. For example, it only takes a 25.8 dB reduction below S9 for the Kenwood TS-2000's S-meter to read S1, whereas S1 should be represented by an 88 dB reduction in power.

This author no longer uses an S-meter. Improved results have been achieved by turning off the AGC circuitry and reducing the RF gain for better signal-to-noise (SNR) copy.

In lieu of an S-meter, a calibrated, computer-based audio oscilloscope measures signals at mV levels. This can be readily translated to a familiar S-unit for ease of communications with other hams.

Larry WB9KMW @ wb9kmw.com