

VSWR Meter Operation.

A- VSWR Measuring Equipment and Techniques

Equipment Setup and Characteristics: A typical setup of equipment used in VSWR measurements is shown in *Figure 1*. The signal generator (Klystron, Gun diode, HP 8620) should be amplitude modulated at the tuned frequency of the VSWR meter amplifier.

If the klystron of a signal generator is modulated at the grid or repeller, undesirable harmonics and frequency modulation effects will be present. Square wave modulation reduces these effects.

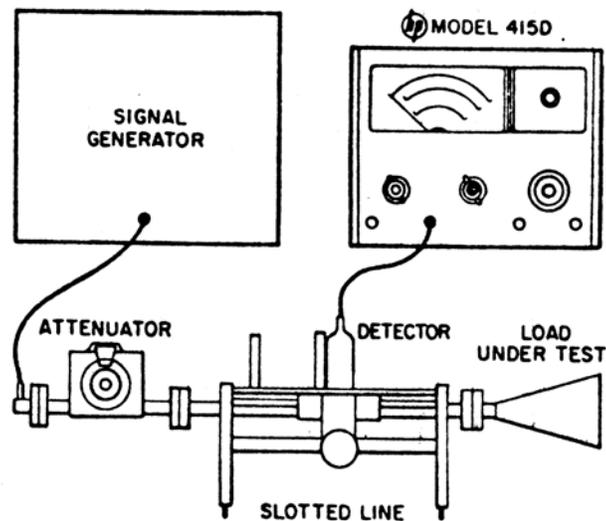


Figure 1.

Detector Probe Penetration: A general rule in slotted line measurements is to use minimum penetration of the detector sampling probe. The power picked up by the sampling probe causes a distortion in the standing wave pattern. The effect on the pattern is greater as the probe penetration is increased and this may be explained by considering the probe as an admittance shunting the line. The impedance in a standing wave pattern is greatest at a voltage maximum. A shunt admittance such as the probe lowers these impedances, causing the measured **SWR** to be lower than the true **SWR**. The maxima and minima are shifted from their natural position and this effect is more pronounced at a voltage maximum than at a voltage minimum.

An exception to the minimum penetration rule occurs when it is desired to examine in detail a voltage minimum in a high SWR measurement: For this, greater probe penetration can be tolerated since the voltage minimum corresponds to a low impedance point in the line. This applies only at the voltage minimum.

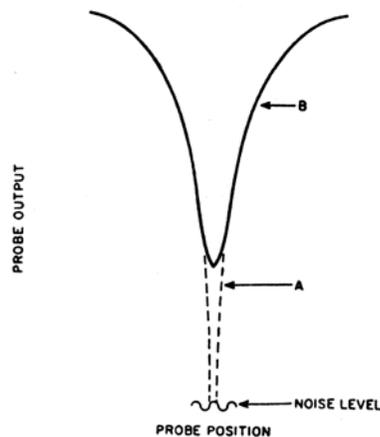
Use of Crystal Detectors: When a crystal detector with a matched load resistor is used, the VSWR meter INPUT SELECTOR must be set to the XTAL 200K position to obtain accurate square-law response. With an unloaded crystal, use the setting which gives maximum sensitivity, usually the XTAL 200 Ohms position.

Locating Maximum or Minimum: It is more desirable to locate a voltage minimum than a voltage maximum, since the former results in less probe loading on the line. With a low SWR, the voltage minimum is fairly broad, and locating the exact point of the minimum is difficult with a single measurement. A more accurate procedure is to note the probe carriage position at two equal output readings on either side of the minimum, then average the two readings.

Errors from Signal Sources: Signal sources may introduce some undesirable characteristics in slotted line measurement techniques. When possible, the effect of RF harmonics, incidental FM signals, and spurious signals should be minimized.

RF harmonics: RF harmonics are a common cause of errors in SWR measurements. These harmonics are generally excessive only with a coaxial signal output since this type of output often passes harmonics more efficiently than the fundamental. With coaxial systems it is common for the harmonic standing wave pattern to be equal to or greater than the fundamental standing wave. Thus the slotted line probe may be erroneously tuned to a second harmonic. Even if a probe is tuned properly, the presence of harmonics may still couple sufficient energy into the probe to give wrong readings. To minimize the possible effects from harmonics, a signal generator used as the source should be rated low in harmonic content. Suitable low pass filters may be inserted between the signal source and the other equipment to reduce harmonic effects.

INCIDENTAL FM SIGNALS. The effect of excessive incidental frequency modulation on SWR is illustrated in Figure 2. The trough at the minimum does not reach the normal value, instead appearing at a higher level. Other parts of the pattern may also be distorted by excessive incidental fm, and careful measurements are required for correct SWR readings. With a klystron-type signal source, fm may occur if the klystron power supply is not properly filtered. Sine wave modulation of a klystron will result in incidental fm in the source output. The presence of incidental fm can be detected by investigating the depth of a minimum when the load



is a short as in *Figure 2*.

SPURIOUS SIGNALS: In tuning a klystron, ordinarily the repeller voltage is adjusted for maximum power at a desired frequency. Then if square wave modulation of the klystron is added without regard to the operating voltages, the repeller voltage excursions will be incorrect. On square wave peaks the repeller voltage will not stabilize at maximum power output but will swing between two points which may not lie in the desired, or even the same mode. The result is closely-spaced frequencies and the typical, result on a standing wave pattern is illustrated in Figure 3. When square wave modulation is used, it is necessary to adjust the repeller voltage and the modulating voltage so the modulating peaks will lie at the maximum of the desired repeller mode and the modulating troughs do not lie in a mode. It is also desirable that the rising and falling portions of the modulating voltage do not pass through undesired modes.

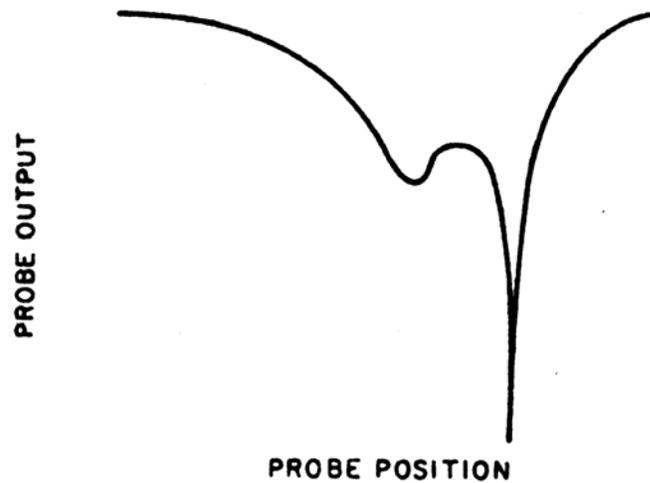


Figure 3.

B- SWR Measurement Procedure.

The VSWR meter may be used to measure a standing wave ratio as a direct reading or as a decibel reading to be converted to SWR. Normally the measurement of SWR will lie in a range from 1:1 to 10:1 (low). However, measurements greater than 10:1 (high) may be made. The expand Switch of the VSWR meter allows full scale presentation of any 2.5 db segment of the 10 db steps. Figures 4 and 5 permit conversion of db to SWR.

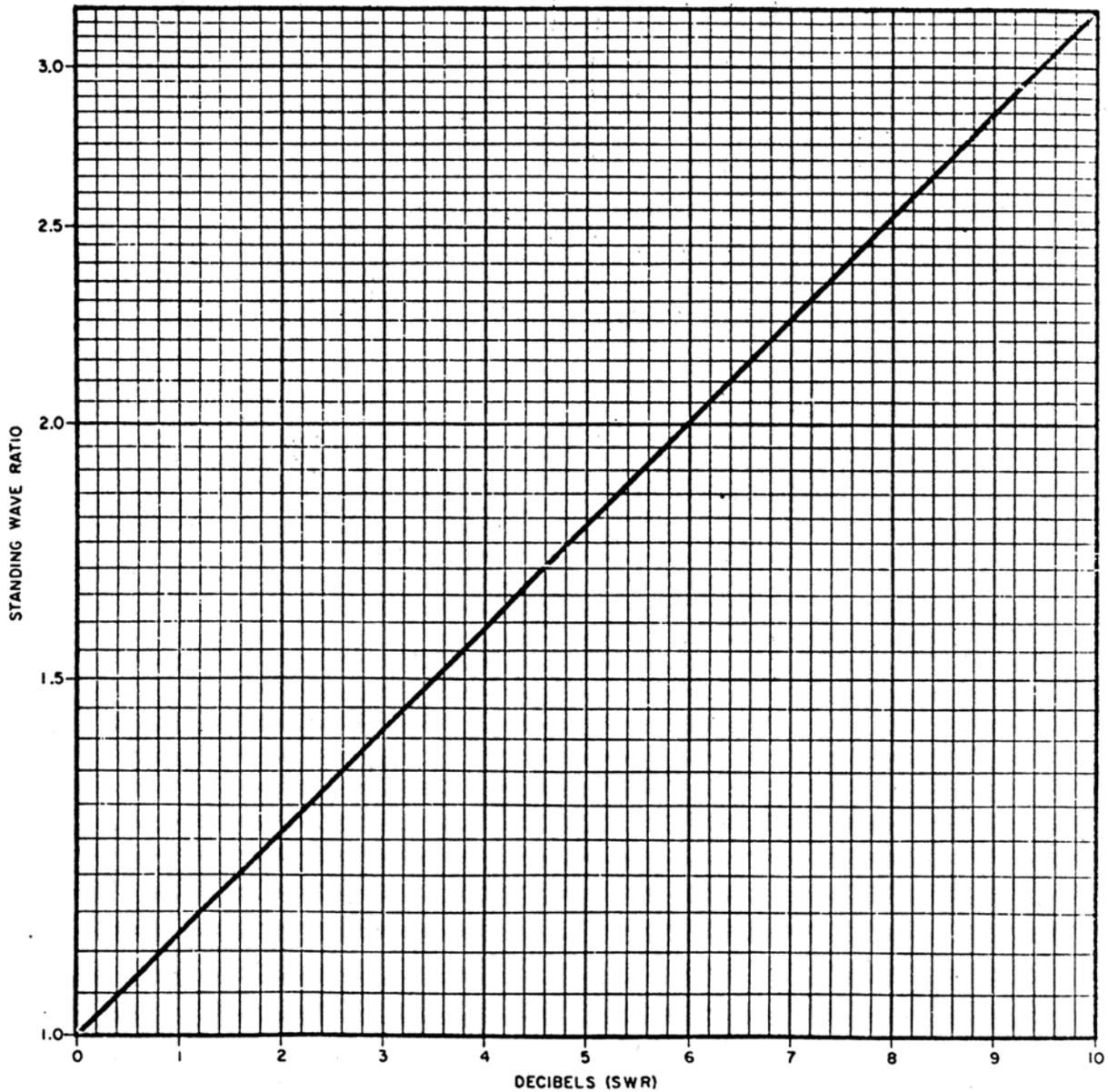


Figure 4

LOW SWR (1:1 to 10:1) : When measuring SWR in the low range, proceed as follows:

Turn VSWR Meter POWER switch to AC.

- a- Set INPUT SELECTOR for type detector being used. The XTAL (crystal) 200K position gives the proper load on crystal detectors for optimum square law detection.
- b- Connect detector cable to INPUT.
- c- Set GAIN and VERNIER controls to about 1/2 maximum.
- d- Set RANGE switch to 40 db or 50 db, EXPAND switch to NORM (normal) position. Adjust probe penetration to obtain an on-scale reading.
- e- Peak the VSWR Meter (i.e. move needle to right) by adjusting the modulation frequency of the signal source, if adjustable. Frequency peaking is also achieved by adjusting the FREQ (frequency) control on the front panel of the VSWR meter. Reduce probe penetration to keep needle on scale.
- f- Peak the VSWR meter by tuning the probe detector, if tunable. Reduce probe penetration to keep needle on scale.
- g- Peak the VSWR meter by moving the probe along the line, reducing probe penetration to keep needle on scale.
- h- Adjust GAIN and VERNIER of VSWR meter and/or output power from signal source to obtain a SWR reading of exactly 1.0.
- i- Move the probe along the line to a voltage minimum (needle moves to left). Do not retune probe or detector.
- j- If the indicated SWR is between 1 and 3.2, greater accuracy in a reading is possible if the EXPAND function is used. For a SWR between 1 and 1.3, a SWR scale is provided for a direct reading when the EXPAND switch is changed to the 0.0 position. If the SWR is between 1.3 and 3.2, the EXPAND db scale may be used to obtain an accurate db reading for conversion to SWR using Figure 4. For SWR between 3.2 and 10, a scale on the meter provides the reading. Refer to Figure 6 and obtain the SWR reading as follows:

- 1- For a reading between 1 and 1.3 on the 1 to 4 SWR scale after step 10 above, change the EXPAND switch to 0.0. This SWR segment is then expanded to full scale and the reading is taken from the 1 to 1.3 DB scale.
- 2- If needle is between 1.3 and 3.2 after step j, note the reading on the 0 to 10 DB scale and change EXPAND switch to a position which normalizes the beginning of the proper 2.5 db segment. For example, if the reading is approximately 8.4 db, then change EXPAND switch to 7.5. The reading is then the sum of the needle indication on the 0 to 2.5 DB scale and the EXPAND switch setting (for example, $0.95 + 7.5 = 8.45$ db). Locate this db reading on Figure 4 and note the corresponding SWR value (8.45 db is read as SWR of 2.66).
- 3- After step j, if the needle is to the left of 3.2 (possibly to the left, off-scale) on the 1 to 4 SWR scale, change the RANGE switch to the next 10 DB position above the initial setting. The SWR is then indicated directly on the 3.2 to 10 db scale.

High SWR (Above 10:1): A reading is possible on the VSWR meter for SWR greater than 10. If the indication is more than 10 after step j (3), change the RANGE switch to the next 10 db position (now two steps, or 20 db, above the initial setting). Read the SWR on the 1 to 4 SWR scale and multiply the reading by ten. Here, again, a db reading may be converted to SWR using Figure 5. The reading used for converting is the amount of db above the initial RANGE switch setting in step 3.

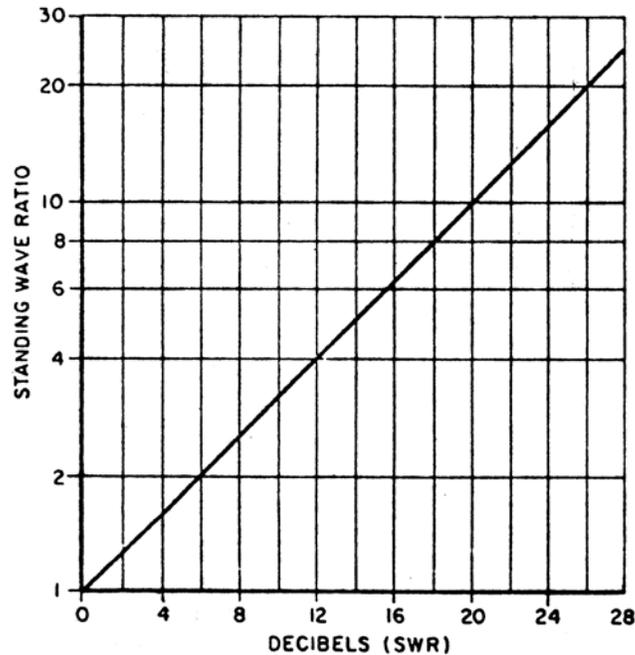


Figure 5.

C. Panel Descriptions for model 415D VSWR Meter (see Figure 7).

- 1- AC AND CHARGE: Indicator lights when POWER switch is in AC or BATTERY CHARGE position.
- 2- POWER: This switch selects the desired power source to the Model 415D.
- 3- INPUT: BNC connector for an input from the signal source.
- 4- INPUT SELECTOR: The XTAL 200K or the 200 Ohms positions take an input from a crystal detector matched for one of these impedances.
- 5- BIAS CHECK: Used only when a bolometer is used in place of the crystal diode.
- 6- FREQ: This adjustment allows variation of the center frequency of the tuned amplifier by 5% when using 1000 cps.
- 7- BANDWIDTH: This adjustment changes the bandwidth: 15 cps to 100 cps.
- 8- RANGE: Settings of this switch provide different signal input attenuation values. Steps are indicated in 10-db increments.
- 9- EXPAND: Settings of this switch allow full scale expansion of 2.5 db portions of the 10-db meter scale.
- 10- GAIN: This variable control allows an initial setting of a reference on the meter.
- 11- VERNIER: This variable control provides a fine adjustment of the initial reference.
- 12- METER MECHANICAL ADJUSTMENT: Adjustment screw for exact setting of meter needle.

