INTRODUCTION to S W R MEASUREMENTS

As in most matters involving the technical side of antennas, "SWR" can be complex beyond the understanding and concern of many radio communicators. .In this discussion we will attempt to simplify the SWR subject. Although most of this information relates to Mobile Installations, exactly the same applies to Base Stations, and portable operation.

"SWR" is the common abbreviation for "Standing Wave Ratio". It may, in some circles, be referred to as "VSWR (voltage standing wave ratio). Never the less … it is the same. For the most part the term has been reduced to SWR since the calculation can involve either voltage or current. The voltage/current is measured in a transmission line scenario that involves a source (in this case, a radio capable of transmitting radio signals) and a load (everything from the coaxial connector at the radios output to the end of the antenna).

In simple terms, SWR compares the maximum amount of voltage or current that can be delivered by the radio to the minimum voltage or current that actually leaves via the transmission line and antenna. If everything, from the radio end connector to the base of the antenna is perfect, and if the antenna is perfectly tuned to the testing frequency, SWR will be 1:1. That is, every bit of power that the radio has to deliver is leaving the radio. For frequencies below 30 MHz SWR below 2.0:1 is acceptable. Granted, lower SWR means more power leaving the radio but, at 2.0:1 the loss does not amount to more than 1/2 dB, even on very long transmission lines. A loss of 1/2 dB is an undetectable change in actual signal strength. Short of having an easy to tune antenna, fighting to achieve SWR in the 1.3:1 to 1.6:1 range when it is already at 2.0:1 probably isn't worth the time and effort.

Many people believe that SWR only involves the antenna but that is an inaccurate assumption. When you place an SWR meter between the radio and the antenna it cannot decipher one component from another. A defective connector, bad coaxial cable, faulty or improperly installed stud mount or a defective and perhaps untuned antenna may all return the same results on the meter. Not only that, but how the antenna is mounted will also play a big part in the resulting SWR readings. For instance, on a ground-plane dependent mobile antenna, if the mount doesn't have a chassis ground the results could be higher than expected SWR. Just as well, if the antenna is mounted on the vehicle in a way that hampers its ability to radiate the applied energy into free space, you will experience less than optimum SWR.

Antennas, for the purpose of this discussion, will only be resonant at one primary frequency. For example, on 2 Meters, centre frequency is 146 Mhz.

If the antenna is tuned to be resonant on 146 Mhz, the further away from that frequency you are, the higher the SWR will be. On occasion you may hear someone say the "SWR should dip at the centre frequency". With the antenna tuned at 146 Mhz, if you were to plot the SWR from 144 to 148 Mhz, the results would be curved line with both 144 Mhz and 148Mhz being equal but higher than 146 Mhz. The steepness of the line as it leaves the centre frequency indicates the bandwidth of the antenna. The flatter the line, the broader the bandwidth.

To accomplish the lowest SWR on frequency 146 Mhz (centre frequency dip) you need to check SWR on 144 and 148Mhz. The SWR difference between these two frequencies will tell you if the antenna is electrically short (146 Mhz resonant frequency too high) or electrically long (146 Mhz resonant frequency too low). With that in mind, the SWR meter is placed in-line between the radio and the coaxial cable that feeds the antenna. The next step involves meter calibration. In this case, calibration involves measuring the radios maximum output potential. Depending upon the meter design, the switch on the meter will be in the Reference (REF) or Forward (FWD) position (in this position the radios maximum power is established). With the transceiver tuned to 144 Mhz, the microphone button is depressed and the calibration knob on the meter is turned until the meter needle aligns itself with the calibration line on the meter face.

This is establishing a reference point for the radios maximum output at the Frequency selected, whatever it may be. Once calibrated, the meter switch is changed to the Reverse (REV) or SWR position and the SWR reading is noted and recorded. Now tune to 148 Mhz, place the meter into the FWD or REF position and recalibrate by depressing the microphone button and turning the meter adjustment knob. Once calibrated, switch meter to the REV or SWR position and record the SWR reading. The modern SWR Meter measures both Forward and Reverse Power using a X - Dual Meter. E.g. Daiwa CN460 and Daiwa CN103. No Calibration required.

NOTE: If at anytime during the SWR measurement process the meter needle jumps to the extreme right edge of the scale (pegging the needle), do not operate the radio. You most likely have a short in the coaxial cable, connections or the antenna stud mount that must be repaired prior to any further action.

SWR (standing wave ratio), is a measurement of how efficiently your antenna system will radiate the power available from your transceiver. In simple terms, your radio would like to radiate all of its power, but can only

do so if the other components co-operate. Bad coax and mounts, or inefficient antennas and ground plane can cause system bottlenecks. The easiest way to understand the concept is to think of it in terms of water flow. That is, if you put a one inch faucet on a two inch pipe, your potential output will be restricted by the one inch outlet. So goes antenna systems. Setting your antennas SWR will reduce the restriction of radiated power.

Mobile antennas can only be made to resonate at one specific frequency. The goal of the antenna manufacturers is to build the antenna to resonate at a frequency in the middle of the available band and make it broad- banded enough to keep the off-frequency related SWR at the two extreme ends of the band below 2.0:1. With added traps a single antenna can be tuned for multiple bands. It should be noted that if you communicate on one or two adjacent frequencies anywhere within the band, you can tune your antenna to achieve optimum performance on those frequencies. Most people, however, prefer to use the entire bandwidth when tuning.

THINGS YOU WILL NEED

1. Knowledge of what not to do.
2. Properly installed antenna system (mount, coax and antenna) that was designed for the required Frequencies and type of transceiver you will be using and has been tested for shorts and opens in continuity. Note: Many Antenna are DC Grounded so don't assume your antenna is faulty because it shows a short Circuit. And an open Circuit on your Antenna could mean it is Capacitive Coupled.
3. Functional Transceiver.
4. SWR meter. (See "SWR Meter Hook-Up")
5. Short piece of coaxial cable (jumper) with PL-259 connectors on both end.

SWR METER HOOK-UP

The SWR of the antenna, without feedline, can be measured by placing the SWR meter in-line at the antenna instead of at the radio. However, the coax can help or hinder performance. In the end, your SWR should be checked at the radio end because all components will be a part of the final operational system being used.

SWR TESTING REMINDERS:

1.Remember to check for continuity, shorts and opens in your coax and mount installation first.

2.Take measurements in an open area with the vehicle's doors and hatches closed.

3.All measurements should be taken with antenna fully assembled and in its permanent location, unless you plan to use it at multiple locations and or on various vehicles.

4.THE SET UP

5.If already connected, disconnect the coaxial cable from the radio. Connect the coax cable that normally connects to the back of the radio to the SWR meter connector marked "Antenna" or "Ant". Now, connect one end of the jumper cable to the back of the radio and the other end to the SWR meter connection marked "Transmitter" or "Xmit". Your SWR meter is now in series (in-line) with your radio and antenna.

Since you've already read the earlier comments, you should now have your vehicle in an open area, with all doors closed. Turn your radio on and tune to lowest Frequency for which you may want to Transmit on. If your radio has side band operation, make sure you are in AM or FM mode before doing SWR tests.

The following assumes that your SWR meter has a standard set of switches, knobs and meters. That is, there will be at least one switch with the marking Forward (FWD) in one position and Reference (REF or SWR) in the other. There will also be a knob or sliding controller marked "Set" or "Adjust". If the common configuration does not match your meter you will need to rely on the meters manual for assistance.

The new Cross Needle type Meter requires no setting up and/or adjustment. It will simply tell you the Forward Power and Reflected power. Where both needle Cross will indicate the SWR.

With the radio on the lowest Frequency and the SWR meters switch in the Forward (FWD) position, depress the transmit switch (key up) located on the microphone. While holding the unit in this transmit mode, adjust the meter needle to the set position using the Set or Adjust knob on the meter. As soon as the needle is in alignment with the corresponding mark on the meter face, flip the switch to the Reference (REF) position. The meter is now showing your SWR. Note the value and quickly release the microphone switch. Record this reading on your paper to the nearest 1/10th. i.e. 1.8, 2.3, 2.7, 1.4, etc.

Now, switch your radio to the mid Frequency e.g. 146 Mhz. Place the meter switch in the Forward (FWD) position, depress the microphone switch and adjust the meter to place the needle on the Set position of the meter face. Once in the set position, place the meter switch in the Reference (REF) position and note the reading. Release the microphone switch and write this value down to the nearest tenth of a point. Note: If your antenna system is closely matched to the radio you may get little or no movement from the meter needle on this frequency. This is normal and to be expected if using commercially designed Antenna and Hardware Systems.

Finally, tune your transceiver to the highest 2M Frequency (148 Mhz). Place the meter switch in the Forward (FWD) position, depress the microphone switch and adjust the meter to place the needle on the Set position of the meter face. Once in the set position, place the meter switch in the Reference (REF) position and note the reading. Release the microphone switch and write this value down to the nearest tenth of a point.

With these three readings, you can determine many things about your system. For instance ...

- If SWR on frequencies 144, 146 and 148 Mhz is below 2.0, your transceiver can be safely operated on any Frequency without causing damage.
- If SWR on all frequencies is above 2.0 but not in the "red zone" (normally over 3.0), you may be experiencing coaxial cable reaction (bad quality, wrong length, etc.), insufficient ground plane, or have an ungrounded antenna mount.

If SWR is in the "red zone" on all frequencies, you probably have an electrical short in your coax connectors, or your mounting stud was installed incorrectly and is shorted.

DO NOT USE YOUR RADIO UNTIL YOU HAVE FOUND THE PROBLEM.

If the SWR on 148 Mhz is greater than that on 144, and shows no dip anywhere in between, we need to assume your antenna is tuned for somewhere below 144 Mhz. It is then considered to be "LONG" and reduction of physical height and/or conductor length will correct this situation. This is of course if all other possible reasons are checked out ensuring the rest of the installation is okay. Only then should you consider shorting you antenna, small sections at a time, measuring the SWR as you go.

ADJUSTING SHORT ANTENNAS

If SWR on 144 Mhz is greater than that on 148, your antenna is considered to be "SHORT" and increasing the physical and/or electrical length of the antenna is required to correct this situation.

NOTE: The shorter the antenna and higher the frequency, the more sensitive it is to adjustments. Make smaller adjustments on shorter antennas. Diamond and Daiwa VHF and UHF Antennas **should not be adjusted**.

The Installation:

The vehicle, in mobile installations, is just as important as the antenna and other components. The antenna is the radiating unit, the vehicle is the reflecting unit. All transmit antennas need a reflective unit. What effect does the vehicle have? Plenty! If you were to install and tune your antenna on a bumper mount then move it to the roof, you would see a change in the SWR. This is due to the change in the antenna's position relative to the vehicle surface. Location is important.

It isn't always feasible, or practical to mount the antenna in the optimum position on any vehicle. Nonetheless, whenever you set aside performance for convenience, you will need to settle for what you can get. Regardless of location, check that your antenna is tuned. Tuned antennas will give you the best performance you can expect from an antenna mounted in any given location. Most of all, remember that untested installations can cost you big bucks. Operating transmitters when the SWR is high can cause damage. Don't rely on protection Circuits in the Rig.

Even if you have your system installed by a professional, it is helpful for you to know what can affect its performance.. If you have purchased an Antenna system and are unsure of it's performance... ask the dealer you bought it from for advise. If you bought it from us, we are more than happy to check out a vehicle installation.

Most Warranties do not cover RF Output Semiconductors. Always check your SWR and tune your antenna before using a new Antenna and make monthly checks to ensure your system is operating correctly.