

## Technical Service Bulletin 030630

### VSWR Diagnosis with Directional Couplers

This service bulletin contains a procedure for locating transmission line VSWR problems and quick verification of reverse power meter calibration.

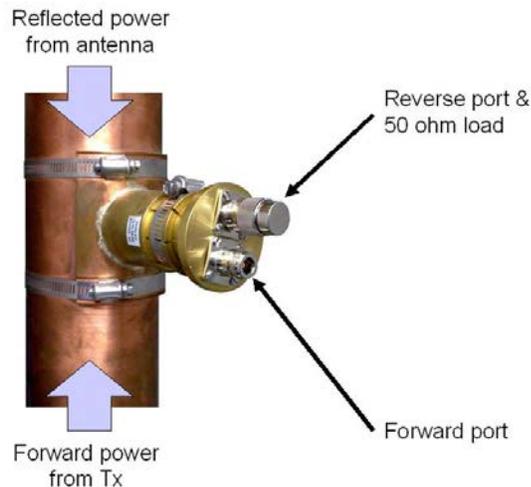
Procedure 030630: VSWR Diagnosis with Directional Couplers	
Applicability	All transmitter types.
Prerequisites	None.
Equipment Required	Spectrum analyzer, 50 ohm RF cable.
Comments	Procedure to interpret directional coupler signals to obtain additional information on RF system VSWR performance. Do not trust any coupler that appears to have been tampered with. Never attempt to mechanically adjust a directional coupler without the proper equipment (network analyzer).

1. Connect 50 ohm RF coaxial cable to forward port of directional coupler.
2. Ensure that good quality 50-ohm RF load (or RF attenuator >20dB) is connected to reverse port of directional coupler.

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**NOTE:** RF energy always couples to the first port it encounters in a two-port directional coupler. That is, forward power coming from the transmitter will couple to the sample port closest to the transmitter. Reverse power coming back from the antenna will couple to the sample port closest to the antenna.

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3. Tune spectrum analyzer to desired RF channel. Note level of forward signal on analyzer screen.
4. Swap positions of sample cable and 50-ohm load on forward and reverse ports of directional coupler (cable to reverse port, load to forward port).
5. Observe level of reverse signal on spectrum analyzer. Difference between forward and reverse levels on spectrum analyzer is RF system return loss (RL) in dB. Interpret system VSWR performance according to Table1.

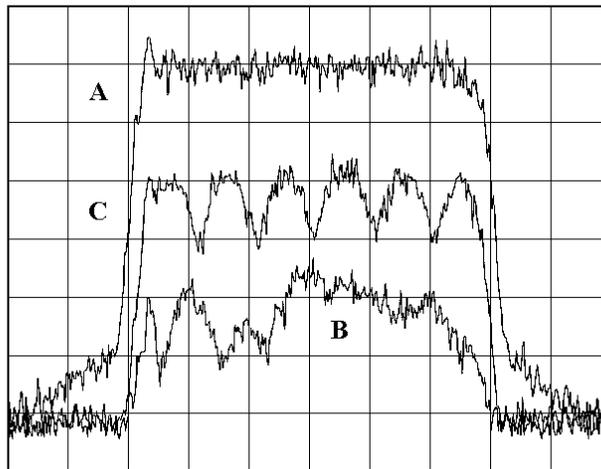


Figure 1. Examples of spectrum analyzer results.

Trace A: forward coupler reference.

Trace B: reverse coupler measurement with excellent >36dB return loss.

Trace C: reverse coupler measurement with mediocre 20dB to 26dB return loss.

**Table 1. Return Loss Interpretation**

Return Loss	Reflected Power	VSWR	Interpretation
10 dB	10%	1.92:1	Extremely Poor
20 dB	1%	1.22:1	Marginal
26 dB	0.25%	1.11:1	Good
32 dB	0.06%	1:05:1	Excellent

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**NOTE:** Ideally, the return loss should be greater than 20dB at all frequencies in the television channel. For analog (NTSC/PAL) systems, the most important frequency is that of the visual carrier, since the majority of the signal energy is concentrated at that frequency. The aural carrier frequency is also important, but to a lesser extent. For DTV systems, all frequencies have equal importance because the transmitted signal power density is equally distributed throughout the channel bandwidth.

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6. Verify calibration of transmitter reflected power meter by inserting measured value of return loss at visual carrier frequency (for NTSC/PAL), or maximum measured return loss value in channel - 3 dB (for DTV), into formula below. If calculated value does not approximately agree with transmitter meter readings, recalibrate transmitter meters according to official Comark procedures.

$$\text{(Reflected power in percent)} = 100 * 10^{(0.1 * RL)}$$

7. If a well defined frequency-periodic effect is evident in reflected signal trace, use analyzer markers to determine frequency spacing between adjacent nulls.
8. Calculate approximate distance to mismatch according to formula.

**(Distance to mismatch in meters) =**

$$(1/2) * (\text{velocity of propagation in m/s}) / (\text{frequency between adjacent nulls})$$

...with the velocity of propagation being:

$3 \times 10^8$  m/s for air filled rigid coaxial transmission line

$2 \times 10^8$  m/s for Teflon-filled coaxial transmission line

$(3 \times 10^8) / (\text{SQRT}(1 - (328/\text{frequency in MHz})^2))$  for WR1800 waveguide

$(3 \times 10^8) / (\text{SQRT}(1 - (393/\text{frequency in MHz})^2))$  for WR1500 waveguide

$(3 \times 10^8) / (\text{SQRT}(1 - (514/\text{frequency in MHz})^2))$  for WR1150 waveguide

For example, trace C in Figure 1 has a null periodicity of 900 kHz. This corresponds to a mismatch approximately  $(0.5) * (3E+8) / (900E+3) = 166$  meters from the coupler in an air-filled rigid line.

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**NOTE:** In general, rapidly repeating nulls are characteristic of a mismatch far downstream (i.e. the antenna), while a single, wide null is characteristic of a mismatch nearby to the coupler. If no null structure is apparent on a given coupler, it may still be possible to locate the mismatch by repeating this test on a nearby directional coupler. It should be noted that this method does not return a "laboratory quality" measurement. It can be useful in some circumstances, nonetheless.

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**NOTE:** Special care must be taken when a bandpass filter is present downstream from the directional coupler. The high-Q channel bandpass filters used at the output of many Comark transmitters will “appear” as approximately 300 to 600 meters of transmission line, depending on the number of cavities employed and their group delay response. That is, the filter reflected power trace normally possesses multiple nulls across the channel bandpass.

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9. Move RF sample cable to other reverse directional couplers farther downstream in RF system and repeat spectrum analyzer measurement. If high reflected power level is not present on a downstream coupler, impedance mismatch problem is before coupler in RF system.
10. Procedure complete.

At Comark, we are constantly striving to improve the satisfaction of both our new and existing customers. Please do not hesitate to contact Comark Customer Service with any questions you may have concerning the contents of this service bulletin.

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