

**FIELD TUNING INSTRUCTIONS**  
**FOR WP-678-R2 and WP-665-R2**  
**4-CAVITY BpBr CIRCUIT DUPLEXERS**

**HIGHLIGHTS**

- (1) The duplexer is factory-tuned to the exact frequencies appearing on the decal with use of a spectrum analyzer/tracking generator and no further tuning or "touching up" is required.
- (2) To maintain maximum isolation, use double-shielded type cable (RG-142 or RG-214) to connect the duplexer to the transmitter and receiver.
- (3) The duplexer includes interconnecting cables between cavities which are critical in length. Do not change.
- (4) With some transmitters, the length of the cable between the transmitter chassis and the duplexer may have to be optimized to obtain a proper impedance match (see instructions).

**INSTALLATION**

The three input connectors are marked "Low Freq. Input", "High Freq. Input" and "Antenna". Connect your equipment to the appropriate connector. The frequency is the only concern. All of the four cavities are built to handle the power output of a transmitter.

**EQUIPMENT REQUIRED FOR FIELD ALIGNMENT**

The duplexer is factory tuned to the exact operating frequencies prior to shipment from the factory. No further field tuning or adjustment is normally required. If it becomes necessary to change the operating frequencies of the duplexer, it can be field tuned if a spectrum analyzer with a tracking generator is available. In addition a 50 Ohm load will be required.

**EXPLANATION OF TUNING ADJUSTMENTS**

Each section of the duplexer includes two bandpass-reject cavities. The coupling loop of each bandpass-reject cavity is fixed and can not be adjusted. For proper alignment, each section of the duplexer must be tuned to two different frequencies: (1) the frequency to be passed and (2) the frequency to be attenuated or rejected by the filter. Cavities

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1 & 2 are always used to pass the lower of the two frequencies and reject the higher frequency. Cavities 3 & 4 are always used to pass the higher and reject the lower frequency.

The threaded Invar tuning rod is the "pass" frequency adjustment and the trimming capacitor is the "reject" frequency adjustment. The reject frequency adjustment must always be the last adjustment made to each cavity. Adjustment of the capacitor moves the notch (reject frequency) closer to or farther from the pass frequency but does not change the pass frequency alignment. Rotation of the threaded tuning rod changes alignment of the "pass" frequency as desired, but also changes alignment of the notch to some undetermined frequency. For this reason, the "pass" frequency adjustment is made first and the "reject" frequency is made last.

### **PREPARE THE CAVITIES FOR REALIGNMENT (Pre-tune)**

**NOTE:** These first six steps are preliminary steps and a high degree of accuracy in the frequency or amplitude is not required. Even though high accuracy is not needed, these steps are necessary in order to obtain accuracy in the final steps of tuning the duplexer.

- (1) Connect the equipment as shown in Figure 1. Set the analyzer center frequency to the lower of the two frequencies and adjust the sweep setting as to include the full response curve (see Plot 1).
- (2) Loosen the hex nut which locks the threaded tuning rod of the four cavities and then rotate the threaded tuning rod of cavities 1 & 2 for minimum loss into the analyzer at the pass frequency.
- (3) Remove the dust covers on each of the four capacitors. The capacitors are located between the connectors on each cavity. Adjust the capacitors on cavities 1 & 2 so as to obtain a symmetrical response about the center frequency as shown in Plot 1.
- (4) Connect the equipment to the duplexer as shown in Figure 2. Set the analyzer to the higher of the two frequencies.
- (5) Rotate the threaded rods on cavities 3 & 4 for minimum loss into the analyzer at the pass frequency.
- (6) With analyzer still tuned to the higher frequency, adjust the capacitors on cavities 3 & 4 to obtain a symmetrical response about the center frequency as in Plot 1.

The duplexer is now in the proper preliminary state to "fine tune" to the distinct transmit and receive frequencies.

**NOTE:** For all "fine tune" steps use horizontal and vertical scales on the analyzer which will yield highly accurate and reliable frequency and amplitude measurements. Typical response curves are given in Plots 1-6. The duplex curve (Plot 6) shows the full response of both sides of the duplexer.

#### **TUNE "PASS" FREQUENCY OF CAVITIES 3 & 4**

- (7) Check the analyzer center frequency to be sure it is still adjusted to the higher frequency and leave equipment as in Figure 2.
- (8) Rotate the threaded tuning rod of Cavities 3 & 4 for minimum loss at center frequency into the analyzer. (See Plot 2) Tune one cavity then the other since there is some interaction between the two cavities.

#### **TUNE "PASS" FREQUENCY OF CAVITIES 1 & 2**

- (9) Reconnect the equipment as shown in Figure 1.
- (10) Set the analyzer center frequency to the lower of the two frequencies.
- (11) Rotate the threaded tuning rod of Cavities 1 & 2 for minimum loss at center frequency into the analyzer. (See Plot 3)
- (12) Tighten the hex nuts which lock the tuning rods of Cavities 1 & 2.

#### **RE-TUNE "PASS" FREQUENCY OF CAVITIES 3 & 4**

- (13) Repeat Steps 7 & 8. This is a precautionary step to insure that Cavities 3 & 4 are properly tuned. Interaction between cavities can cause misalignment, particularly if the new "pass" frequency of Cavities 1 & 2 is close to the old "pass" frequency of Cavities 3 & 4.
- (14) Tighten the hex nuts which lock the tuning rods of Cavities 3 & 4.

#### **TUNE "REJECT" FREQUENCY OF CAVITIES 1 & 2**

- (15) Connect the equipment as shown in Figure 3. Terminate the antenna port

with a 50 Ohm dummy load.

- (16) Change the vertical scale of the analyzer system to 10 dB per division and set the center frequency of the analyzer to the higher of the two duplex frequencies.
- (17) Tune the trimming capacitors on cavities 1 & 2 for maximum rejection at center frequency. This rejection will be greater than 90 dB so take appropriate steps to increase the sensitivity/dynamic range of your analyzer system to accurately tune the rejection notch. (See Plot 4)
- (18) Replace the dust covers on the capacitors of cavities 1 & 2.

#### TUNE "REJECT" FREQUENCY OF CAVITIES 3 & 4

- (19) Leave the equipment connected as shown in Figure 3.
- (20) Set the center frequency of the analyzer to the lower of the two duplex frequencies.
- (21) Tune the trimming capacitors on cavities 3 & 4 for maximum rejection at center frequency. This rejection will be greater than 90 dB so take appropriate steps to increase the sensitivity/dynamic range of your analyzer system to accurately tune the rejection notch. (See Plot 5)
- (22) Replace the dust covers on the capacitors of cavities 3 & 4.
- (23) The duplexer is now ready for use.

## **CABLE LENGTH BETWEEN TRANSMITTER AND DUPLEXER**

The length of the coaxial cable between the transmitter and the duplexer might be a critical length with some transmitters because of an impedance mismatch. A mismatch condition can exist between a transmitter, cavity filter/duplexer, and/or antenna since all of these components can vary from an absolute impedance of 50 Ohms. As an example, a transmitter, or duplexer, or antenna will probably be listed as having a "nominal" impedance of 50 Ohms and a VSWR (referenced to 50 Ohms) of 1.3 to 1 or 1.5 to 1. At a VSWR of 1.5 to 1, the antenna, or duplexer, or antenna could have an impedance of anything from 33 to 75 Ohms and still be within specifications. (At 1.3 to 1 VSWR, the impedance can be anything from 38 to 65 Ohms). In a worst-case-scenario, the transmitter might have an actual impedance of 33 Ohms, the duplexer 75 Ohms and the antenna 33 Ohms. As such, system performance will be degraded and yet, all components will individually meet manufacturers specifications. This impedance mismatch problem can usually be resolved by "optimizing" the length of coax cable between transmitter and duplexer and/or by installing one of the impedance-matcher PI Networks available through Wacom and other sources.

If a transmitter is overly sensitive to a mismatched load impedance, a variety of symptoms might appear, including one or more of the following:

- (1) The transmitter might generate numerous spurious radiations.
- (2) The transmitter output power might become erratic, either too high or too low as measured on a wattmeter.
- (3) The insertion loss of the duplexer might measure normal with sweep equipment but measure too high or too low on a wattmeter when connected to the transmitter.
- (4) The reflected power might change when the length of cable between transmitter and first cavity is changed.
- (5) Use of a ferrite isolator at output of transmitter solves the forward power and reflected power problem, and eliminates change in reflected power when length of cable between the isolator and the first cavity is changed. (In this instance, the ferrite isolator can be used to reveal the symptoms or as a solution to the problem.)

The above problems might be reduced or minimized by optimizing the length of cable between the transmitter and first cavity of the duplexer. The optimum length of cable can be found by the following procedure:

- (1) Tune the transmitter into a 50 Ohm dummy load according to the manu-

facturers instruction.

- (2) Connect the duplexer to the transmitter. The transmitter output signal should feed through the wattmeter, then through the duplexer then into a dummy load. If there is an impedance mismatch the duplexer will de-tune the transmitter and the cable length should be optimized.
- (3) Using short lengths of cable (no longer than 1" @ 900 MHz, 2" @ 460 Mhz, 6" @ 160 MHz, 24" @ 40 MHz) or right angle elbow connectors, gradually increase the length of the cable between the transmitter and duplexer until the optimum length (no de-tuning effect) is found. Up to four of these short cables should be tried.
- (4) When the proper cable length is determined, i.e., when the system is operating as it should, replace all of the short and long lengths of cables, right angle elbow connectors and wattmeter with one continuous length of cable of equivalent electrical length. Do not overlook the fact that the wattmeter was a part of the cable length between the transmitter and duplexer during this process. If the wattmeter is removed from the circuit, the cable length without the wattmeter must be lengthened by some amount in order to be the same equivalent electrical length as the cable with the wattmeter in the circuit.

### SPECTRUM ANALYZER/TRACKING GENERATOR CONNECTIONS

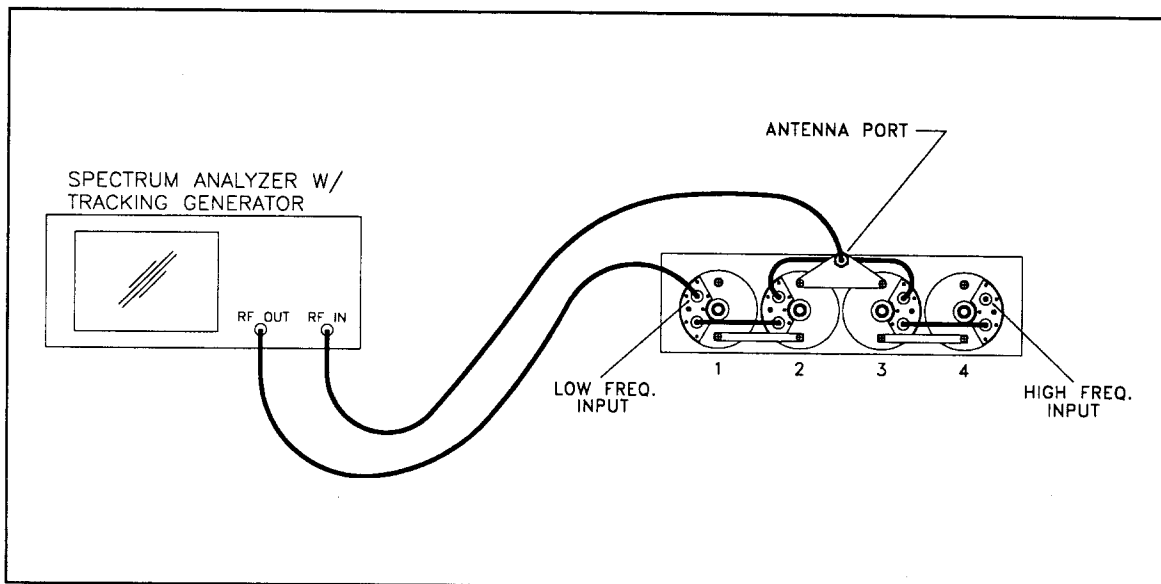


Figure 1. Hook-up for tuning of low pass.

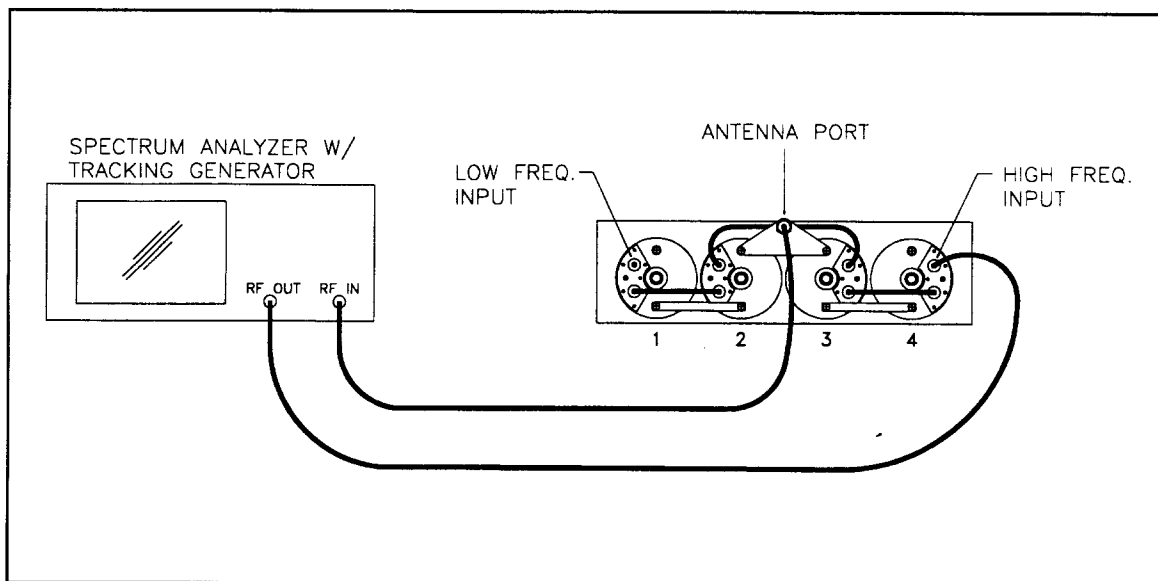


Figure 2. Hook-up for tuning of high pass.

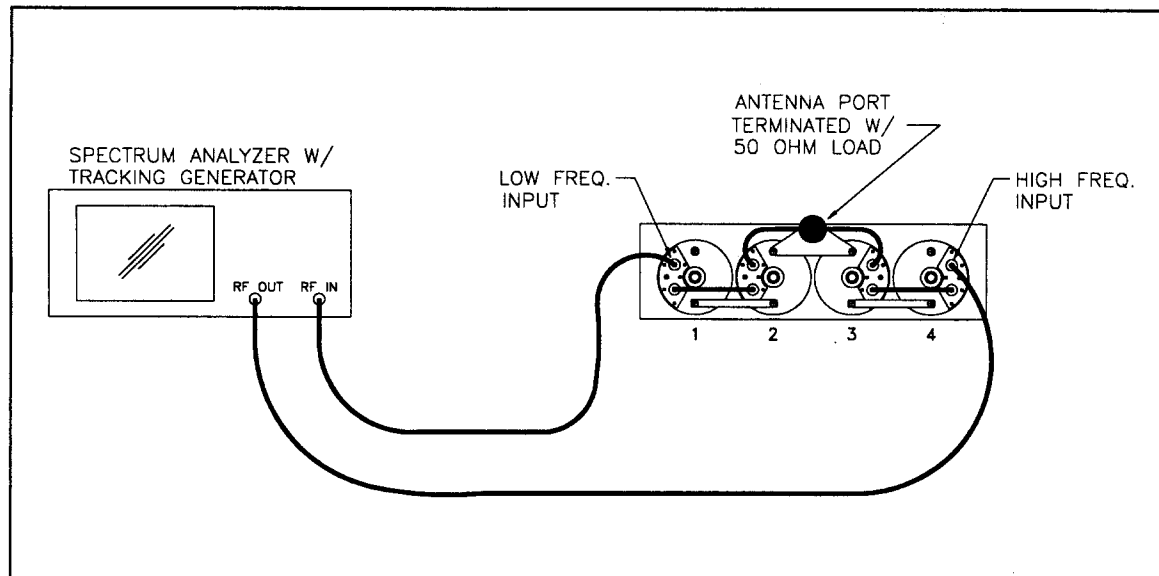
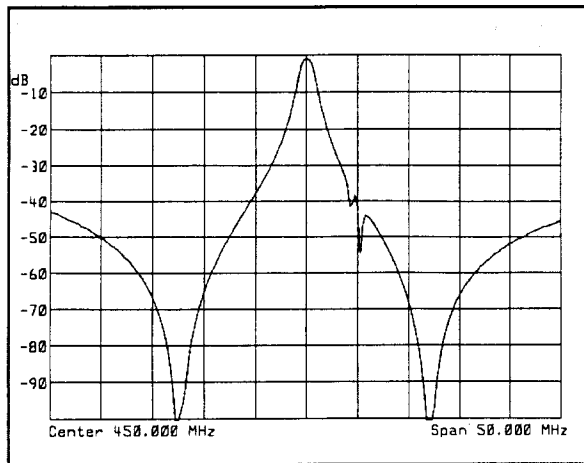
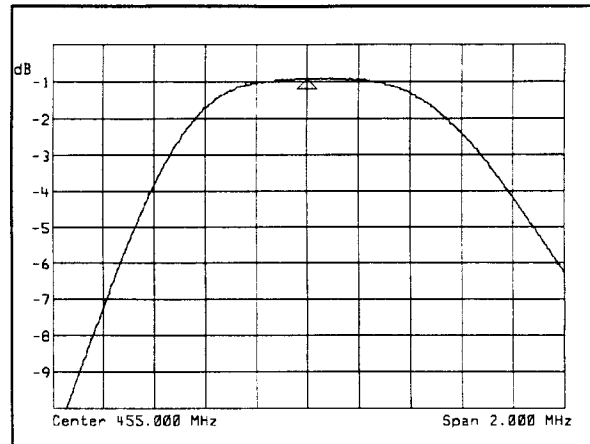


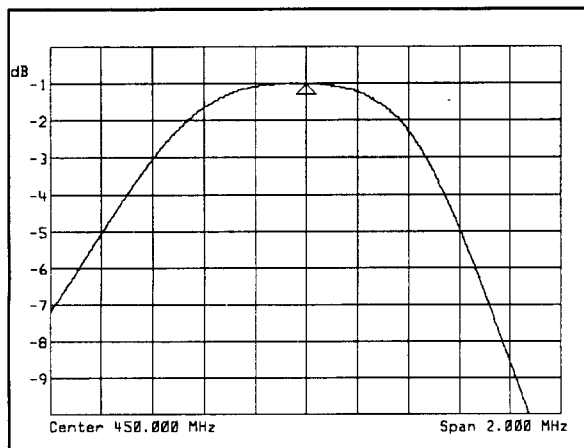
Figure 3. Hook-up for tuning of reject notches.



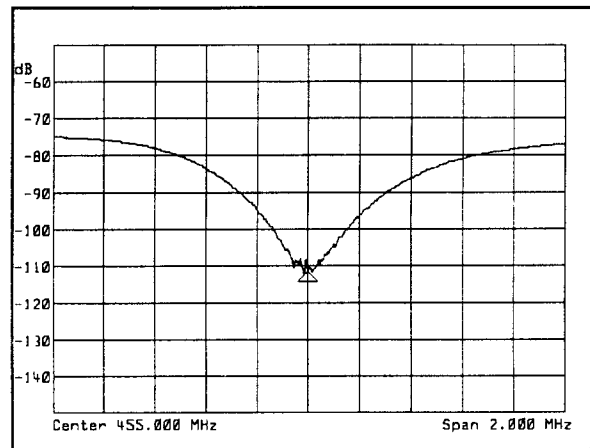
Plot 1. Symmetrical response curve.



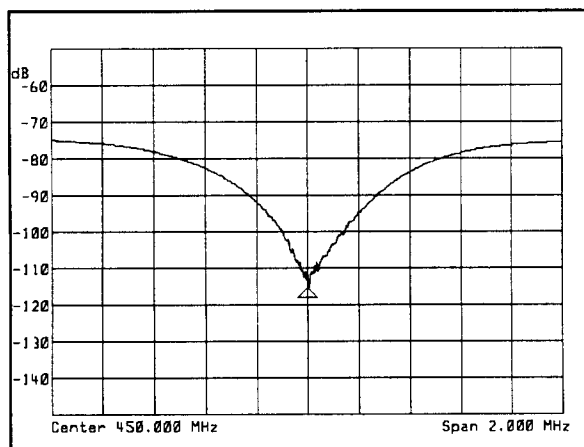
Plot 2. High Pass response curve.



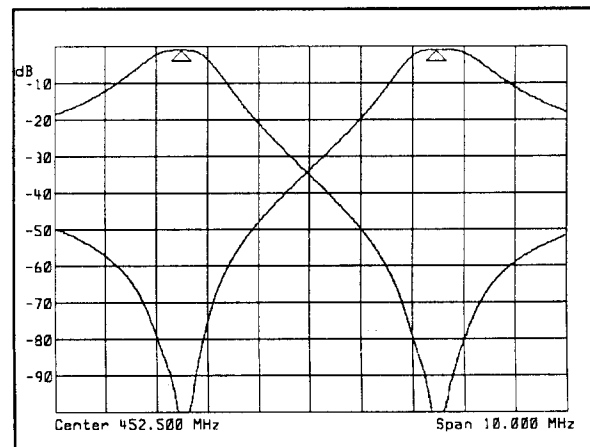
Plot 3. Low pass response curve.



Plot 4. High reject response curve.



Plot 5. Low reject response curve.



Plot 6. Full duplex response curves.