FIELD TUNING INSTRUCTIONS

4-CAVITY RpBr CIRCUIT DUPLEXER

WP-604  WP-629
WP-609  WP-639
WP-612  WP-641
WP-621  WP-652

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
field 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 chassis.

(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 might 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". If the transmit frequency is lower than the receive frequency,
the transmitter should be connected to the connector marked "Low Freq. Input"
and the receiver connected to the connector marked "High Freq. Input". If
the transmit frequency is higher than the receive frequency, the transmitter
should be connected to the connector marked "High Freq. Input" and the receiver
connected to the input marked "Low Freq. Input".

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 the following equipment is available:

(1) A 50 ohm signal generator (with 3 dB or 6 dB pad) capable of producing a
signal at the transmit and receive frequencies.

(2) A 50 ohm, crystal controlled receiver tuned to the desired transmit
frequency.

(3) A 50 ohm, crystal controlled receiver tuned to the desired receive
frequency.

(4) Two 50 ohm 3 dB (or 6 dB) pads.

(5) a 50 ohm load.
The 50 ohm pads are used during alignment to help isolate the duplexer from the signal generator and receivers. Signal generators and receivers are supposed to be 50 ohm devices but many are not. If the signal generator and/or receivers do not present a 50 ohm impedance at the ports of the duplexer, the impedance mismatch will tend to "pull" the signal off frequency and result in improper alignment of the cavities. As noted above, the 50 ohm pads will help minimize the effects of an impedance mismatch.

EXPLANATION OF TUNING ADJUSTMENTS

For proper alignment, each cavity filter in the duplexer must be tuned to two different frequencies: (1) the frequency to be passed by the cavity and (2) the frequency to be attenuated or rejected by the cavity. The threaded Invar tuning rod is the "pass" frequency adjustment and the stub is the "reject" frequency adjustment. The "reject" frequency adjustment (stub) must always be the last adjustment made to each cavity. Adjustment of the stub 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 unknown frequency. For this reason, the "pass" frequency adjustment is made first and the "reject" frequency adjustment is made last.

Cavities 1 & 2 are always tuned to pass the lower of the two frequencies and reject the higher of the two frequencies. Cavities 3 & 4 are always tuned to pass the higher frequency and reject the lower frequency. All four cavities have the same power handling capability therefore either section of the duplexer can be used for transmitter or receiver.

PREPARE THE CAVITIES FOR REALIGNMENT

(1) Loosen the hex nut which locks the threaded tuning rod on each of the four cavities. The tuning rod should now be free to rotate in either direction.

(2) Loosen the hose clamps on each of the four stubs so the rexolite rod can be adjusted (in and out). Leave the clamp slightly tight to prevent the rexolite rod from sliding out of the stub.

(3) Pre-set the stubs on each BpBr Circuit Cavity by positioning the rexolite rod at the appropriate position. The "appropriate pre-set position" of the rexolite rods for your particular duplexer can be found on the Duplexer Check Sheet supplied with your duplexer; or you can call the factory for details. With rexolite rods properly set at the pre-set position, the frequency response curve of each BpBr Circuit Filter should be similar to the illustration in Fig. 1, if viewed on a spectrum analyzer with sweep equipment.

WACOM PRODUCTS, INC.
P.O. BOX 21145 • 6900 N. HWY. 6 • WACO, TEXAS 76702 • (817) 848-4435 • FAX 817-848-4209
TUNE "PASS" FREQUENCY OF CAVITIES 1 & 2

(3) Connect the equipment to the duplexer as shown in Figure 1.

(4) Set the signal generator to the lower of the two duplex frequencies and check the discriminator of Receiver #1 to determine that the signal generator is exactly on the desired frequency.

(5) Rotate the threaded tuning rods of Cavities 1 & 2 for maximum reading on an unsaturated relative signal strength metering point (such as first limiter or low IF amplifier) of Receiver #1. Keep the metering point below saturation by continuing to reduce the signal from the signal generator. Tune each cavity several times because of interaction between cavities.

TUNE "PASS" FREQUENCY OF CAVITIES 3 & 4

(6) Leave the equipment connected as shown in Figure 1 and set the signal generator to the higher of the two duplex frequencies. Check the discriminator of Receiver #2 to determine that the signal generator is exactly on the desired frequency.

(7) Rotate the threaded tuning rods of Cavities 3 & 4 for maximum reading at the metering point of Receiver #2. Keep the metering point below saturation. Tune each cavity several times.

(8) Tighten the hex nuts which lock the tuning rods of Cavities 3 & 4.

RE-TUNE "PASS" FREQUENCY OF CAVITIES 1 & 2

(9) Repeat Steps 3, 4 & 5. This is a precautionary step to insure that Cavities 1 & 2 are properly tuned. This Step 9 is not necessary if the duplexer is being re-tuned to new frequencies that are close to the old frequencies. Step 9 is mandatory if the new "pass" frequency of Cavities 1 & 2 is close to the old "pass" frequency of Cavities 3 & 4.

(10) Tighten the hex nuts which lock the tuning rods of Cavities 3 & 4.

TUNE "REJECT" FREQUENCY OF CAVITIES 1 & 2

(11) Connect the equipment as shown in Figure 2.

(12) Set the signal generator to the higher duplex frequency and check the discriminator of Receiver #2 to make sure the signal generator is exactly on the desired frequency. The output level from the signal generator will have to be increased in order to obtain a detectable reading on the next step.

(13) Adjust the rexolite rod of stubs A & B (Cavities 1 & 2) in or out for minimum reading at the metering point of Receiver #2. The output level of the signal generator will have to be continuously increased to obtain a detectable reading but saturation of the metering point must be avoided.

(14) Tighten the clamps of stubs A & B.
TUNE "REJECT" FREQUENCY OF CAVITIES 3 & 4

(15) Connect the equipment as shown in Figure 3.

(16) Set the signal generator to the lower frequency and check the discriminator of Receiver #1 to make sure the signal generator is exactly on frequency. The output level from the signal generator will have to be increased in order to obtain a detectable reading on the next step.

(17) Adjust the reedite rod of stubs C & D (Cavities 3 & 4) in or out for minimum reading at the metering point of Receiver #1. The output level of the signal generator will have to be continuously increased to obtain a detectable reading but saturation must be avoided.

(18) Tighten the clamps of stubs C & D. 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. (All transmitters do NOT have a 50 ohm output impedance)

In this event, the length of cable will have to be optimized. The need for this optimization will be apparent if the output power of the transmitter is reduced by more than the amount absorbed in the duplexer due to insertion loss. (Note that ½ dB insertion loss = transmitter power loss of 11%; 1 dB = 20%; 1.5 dB = 29%; 2 dB = 37%; 3 dB = 50%)

The optimum length of cable between the transmitter and the duplexer can be found by the following procedure:

(1) Tune the transmitter into a 50 ohm dummy load (or antenna) according to the instruction book.

(2) Connect the duplexer to the transmitter. The transmitter output signal should feed through the duplexer, then through a wattmeter then into a dummy load (or antenna). If there is an impedance mismatch the duplexer will detune the transmitter and the cable length should be optimized.

(3) Cut a length of RG8, RG9 or RG142 type cable to the approximate length that will be required to interconnect the transmitter to the duplexer. Attach connectors and connect to transmitter.

(4) Using short lengths of coaxial cable (approximately 2" @ 450 MHz; 4" @ 150 MHz; 8" @ 70 MHz), or UC646 right elbow connectors, gradually increase the length of the above coaxial cable between the transmitter and duplexer over a half-wavelength (at the operating frequency) until the optimum length (no de-tuning effect) is found. (Note: a UC646 elbow is equal to approximately 1/4" of RG8 or RG9 type cable). A half-wavelength (cable) at the operating frequency can be found by:
Length (in inches) of \( \frac{3894}{\text{Freq. in MHz}} \) wavelength

Example: At 152.03 MHz, \( \frac{1}{2} \) wavelength (cable equals 25.61 inches. Therefore, the random length of cable (above paragraph 3) should be increased approximately 4" at a time, and the transmitter-filter match checked at each length, until a total of 26" of additional cable has been tried. At some length within this 26", the match will be optimized and that length should be noted.

(5) When the proper cable length is found, replace the longer cable length (paragraph 3) and the short lengths of cable and the UG646 elbows (paragraph 4) with one continuous length of cable of equivalent electrical length. The cable length is now optimized.
FIELD TUNING INSTRUCTIONS
for
4 CAVITY BpBr Circuit™ DUPLEXER

FIGURE 1

RECEIVER #2
operating on higher freq.

3 dB pad

High Freq. Input

4

3

D

C

Antenna

3 dB pad

SIGNAL GENERATOR

Low Freq. Input

1

2

A

B

RECEIVER #1
operating on lower freq.

3 dB pad

Cavities 1 and 2 are tuned to pass the lower frequency and reject the higher frequency.

Cavities 3 and 4 are tuned to pass the higher frequency and reject the lower frequency.

FIGURE 2

High Freq. Input

4

3

D

C

Antenna

50 ohm load

3 dB pad

SIGNAL GENERATOR operating on higher freq.

Low Freq. Input

1

2

A

B

RECEIVER #2
operating on higher freq.

3 dB pad

FIGURE 3

High Freq. Input

4

3

D

C

Antenna

3 dB pad

SIGNAL GENERATOR operating on lower freq.

Low Freq. Input

1

2

A

B

50 ohm load

RECEIVER #1
operating on lower freq.

3 dB pad

WACOM PRODUCTS, INC.
P.O. BOX 21145 • 6900 N. HWY. 6 • WACO, TEXAS 76702 • (817) 848-4435 • FAX 817–848-4209
**BpBr Circuit®**

**BANDPASS-REJECT DUPLEXERS**

**MIN. FREQ. SPACING:** 500 KHz  
**POWER:** TO 350 WATTS

**WP-641**  
144-174 MHz

**WP-621**  
118-144 MHz

**U. S. PATENT**  
No. 4,080,601

**ADVANTAGES OF THE BpBr CIRCUIT**: Assuming a given insertion loss at the pass frequency, comparison of the performance of the BpBr Circuit filter versus other types of bandpass-reject filters will reveal the BpBr Circuit filter provides superior bandpass characteristics near the pass frequency and a significantly wider notch at the frequencies to be attenuated. These features result in superior transmitter to receiver isolation, superior protection to and from other nearby radio systems, and greater stability over a wide temperature range. In addition, field tuning of a BpBr Circuit filter is considerably easier than field tuning of most other types of bandpass-reject filters.

**MODEL WP-641** is designed for use with duplex stations operating in the 144-174 MHz band when the separation between transmit and receive frequencies is 500 kHz or more. It consists of four 8” OD cavities interconnected with double shielded coaxial cable in a bandpass-reject configuration. It is generally suitable for use with all types of duplex stations, particularly the latest solid state types which require attenuation of transmitter sideband noise over a wide portion of the spectrum. Model WP-205 cabinet is available as an optional item.

**MODEL WP-621** is identical to the above model but designed for use with duplex stations operating in the 118-144 MHz band when the Tx and Rx frequency separation is 500 kHz or more.

**CONSTRUCTION**: The top end-plate and outer conductor, made of chromated aluminum, are heliarc welded for improved conductivity. Coupling loops are made of copper; both sections of the cavity center conductor are made of silver plated copper. The tuning rod is made of Invar. Quality materials are used throughout the duplexer to assure top performance and long life. Galvanic corrosion is minimized by the use of similar materials and by passivating dissimilar materials which are in contact.

**TUNING**: The duplexer is factory tuned to the exact transmit and receive frequencies prior to shipment from the factory. No further field adjustment is normally required. If desired, the duplexer can be field tuned to new frequencies within its operating band by rotating the threaded tuning rod ("pass" frequency alignment) and adjusting the length of the adjustable stub ("reject" frequency alignment) of each filter.

**INSTALLATION**: The duplexer can be mounted in any position but is normally mounted vertically, with the tuning rods up. Double-shielded coaxial cable (such as RG-214 or RG-142) must be used to interconnect the duplexer to the transmitter and receiver chassis if maximum isolation is to be maintained. A suitable duplexer installation cable kit (Part No. 30090) is available as an optional item.

**BpBr Circuit®** is a Trademark of Wacom Products, Inc.
**Typical Duplex Response Curves**

**Electrical Data**

<table>
<thead>
<tr>
<th>Model WP-621</th>
<th>Model WP-641</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuning Range</td>
<td>118-130 MHz</td>
</tr>
<tr>
<td>B Range</td>
<td>130-144 MHz</td>
</tr>
<tr>
<td>Minimum Frequency Separation</td>
<td>0.5 MHz or more</td>
</tr>
<tr>
<td>Maximum Power Input (continuous duty)</td>
<td>350 watts</td>
</tr>
<tr>
<td>Insertion Loss (Tx and Rx to antenna)</td>
<td></td>
</tr>
<tr>
<td>at 0.5 MHz separation</td>
<td>1.5 dB</td>
</tr>
<tr>
<td>at 1.0 MHz separation</td>
<td>1.5 dB</td>
</tr>
<tr>
<td>Attenuation at Tx Freq. and Rx Freq.</td>
<td></td>
</tr>
<tr>
<td>at 0.5 MHz separation</td>
<td>85 dB</td>
</tr>
<tr>
<td>at 1.0 MHz or more separation</td>
<td>95 dB</td>
</tr>
<tr>
<td>Isolation (midway between channels)</td>
<td></td>
</tr>
<tr>
<td>with 0.5 MHz separation</td>
<td>55 dB</td>
</tr>
<tr>
<td>with 1.0 MHz separation</td>
<td>75 dB</td>
</tr>
<tr>
<td>Maximum VSWR (Ref. 50 ohms)</td>
<td>1.3 to 1</td>
</tr>
<tr>
<td>Temperature Range</td>
<td>-30° to +60°C</td>
</tr>
<tr>
<td>Number of Cavity Filters</td>
<td>4</td>
</tr>
</tbody>
</table>

**Mechanical Data**

<table>
<thead>
<tr>
<th>Model WP-621</th>
<th>Model WP-641</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions:</td>
<td>8&quot; OD x 29&quot;</td>
</tr>
<tr>
<td>Individual Cavity (not incl. tuning rod)</td>
<td>17&quot; x 19&quot; x 36&quot;</td>
</tr>
<tr>
<td>Duplexer (D x W x H) with tuning rods fully extended</td>
<td>UHF Female (Type N optional)</td>
</tr>
<tr>
<td>Connector Terminations (Tx, Rx, Ant)</td>
<td>Gray enamel</td>
</tr>
<tr>
<td>Finish</td>
<td>42 lbs.</td>
</tr>
<tr>
<td>Net Weight</td>
<td>50 lbs.</td>
</tr>
<tr>
<td>Shipping Weight</td>
<td>WP-205</td>
</tr>
<tr>
<td>Optional Cabinet</td>
<td>Dimensions, cabinet, (D x W x H)</td>
</tr>
<tr>
<td></td>
<td>Shipping Weight (Cabinet &amp; Duplexer)</td>
</tr>
</tbody>
</table>

**Ordering Information**

- Model WP-621: Duplexer with Tx on ___ MHz and Rx on ___ MHz
- Model WP-641: Duplexer with Tx on ___ MHz and Rx on ___ MHz
- Model WP-205: Optional Cabinet

When ordering, specify exact Tx and Rx frequency.
When returning this duplexer at some future date, the studs should be preset to specific positions during the initial tuning of the ‘pass’

A. For frequency band of 144 - 148 MHz.
B. On ‘low pass’ cavities, pull the refluxite rod OUT so that 1/4", inches of rod is exposed.
C. On ‘high pass’ cavities, push the refluxite rod IN so that 1/8", inches of rod is exposed.

After the pass frequency adjustment is completed, the studs will be changed to new positions during the reject frequency adjustment, but it is helpful always to start the tuning procedure with the studs of this particular duplexer preset at the following positions:

Tx to Rx ISOLATION: 1.5 dB
At Tx Freq: 92 +
At Rx Freq: 1.5 dB

INSERTION LOSS: 1.5 dB
Tx to Ant: 1.5 dB
Rx to Ant: 1.5 dB

Tx Frequency 145.725
Rx Frequency 145.125

DATE: Aug 4, 1993

WACOM PRODUCTS, INC.
PO BOX 21145 • WACO, TEXAS 76702 • (517) 948-4435 • FAX 817-848-4209

INSPECTOR: John Rello