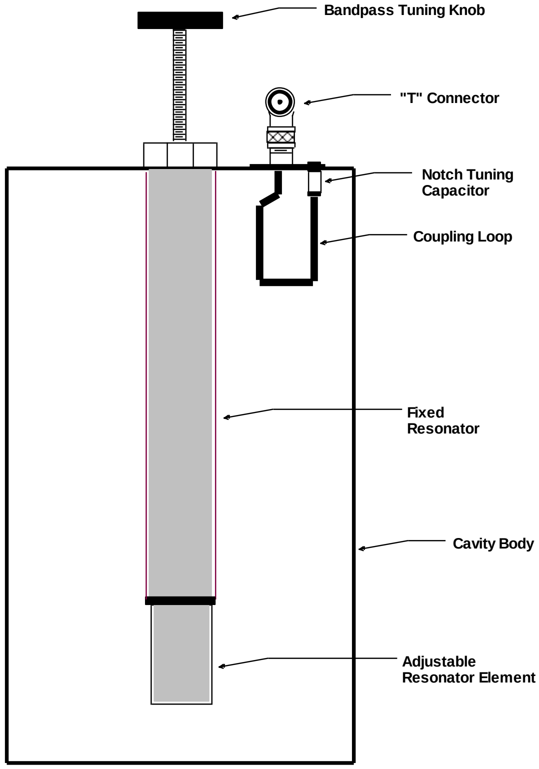
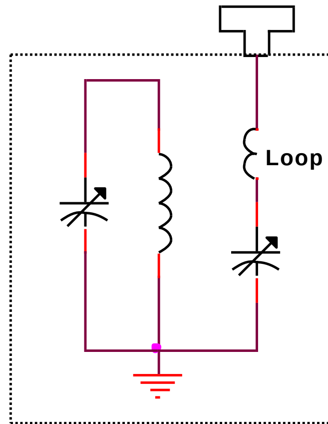
HOW THE Bp-Br CAVITY WORKS

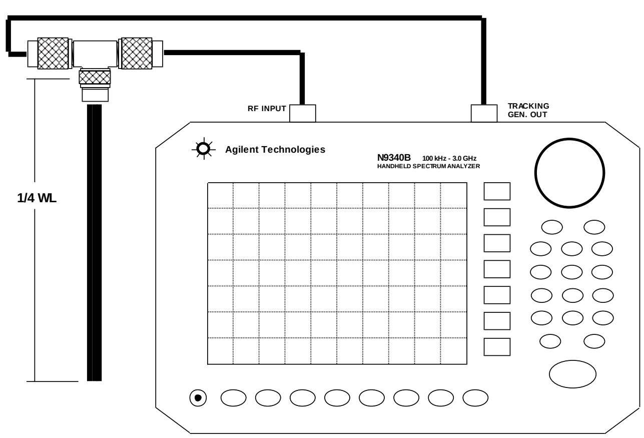


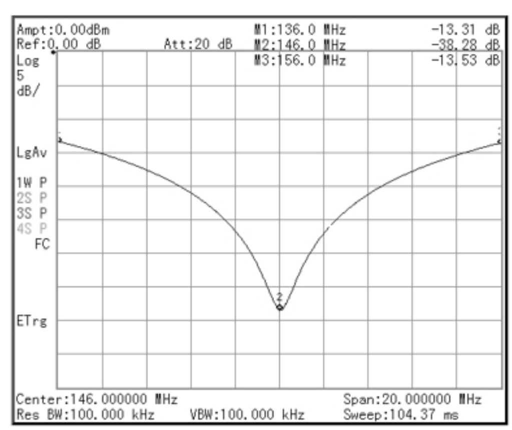


Bp-Br Electrial Diagram

Introduction - Band-pass Band-reject "Bp-Br cavity filters are the most common filter used to construct duplexers for amateur radio repeaters. These filters allow repeaters to use a single antenna by isolating the receiver and transmit signals from each other. Information on how these filters accomplish this task is not readily available, so the objective of this document is to explain how they work. Note: Most radio amateurs do not understand "Smith Charts", but they are familiar with frequency, impedance and SWR, so focus on these values in the top right hand corner.

Coaxial Cavity Resonator - Cavity resonators are similar to a **λ/4 wavelength** section of coaxial cable that is being used as a stub. Photo below shows the resonant response of a λ/4 wavelength section of RG-8 coax.





The resonant frequency of this λ/4 wavelength cable shown on page 1 was 146.0 MHz, but the insertion loss was 13.5 dB because of the cables Q value. The term "Q" is a dimensionless value defining a "quality of merit" of tuned circuits. For a cavity, Q is a measurement of its narrow bandwidth of either pass or notch capabilities. The Q value of cavities depends on the cavity body diameter which range from 4 to 10 inches.

Coupling Loops - The coupling loops determine if the cavity resonator is going to be configured to perform as a Bandpass, Notch or Bandpass Band-Reject cavity. There's no magic formula for loops, I've seen many shapes and sizes. The Loops in some cavities can be rotated which allows control of the insertion loss and reject level. If the loop is fixed, it is usually positioned facing the fixed resonator which provides minimum insertion loss. Rotating the loop away from the minimum insertion loss position will increase the amount of notch rejection. The loop used in Bp-Br cavities is coupled to common ground via an adjustable capacitor which is used to set the notch frequency.

How a Bp-Br Cavity Works - To illustrate how the Bp-Br works I used a single 8" λ/4 wavelength Wacom cavity adjusted to a notch frequency of 146.04 MHz and a pass frequency of 146.64. An Agilent N9340B Spectrum Analyzer and MRS Vector Network Analyzer were used to make all of the measurements.

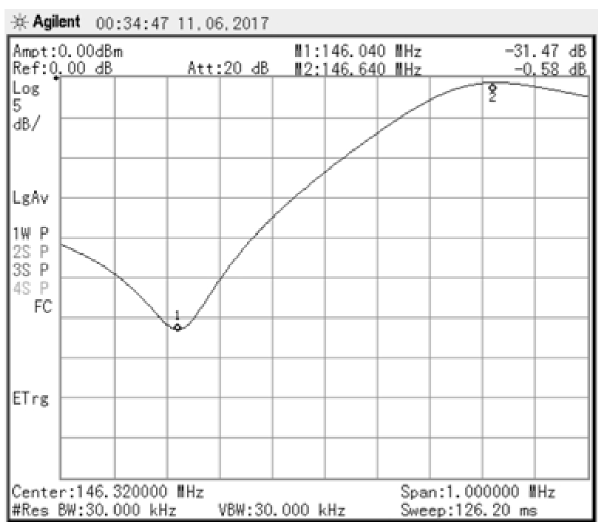


Figure 1

Figure 1 shows the response of the Wacom Bp-Br cavity adjusted to 146.04 MHz (notch) and 146.64 MHz (pass) frequencies. The pass (146.64 MHz) attenuation is **0.58 dB** and the notch (146.04 MHz) rejection was **31.47 dB.**

Pass Frequency (146.64 MHz) – Any well designed cavity will have very little insertion loss at the pass frequency. Bp-Br cavities have a single "T" connector attached to the coupling loop and the pass frequency has to pass through this connector without being attenuated. See Figure 2

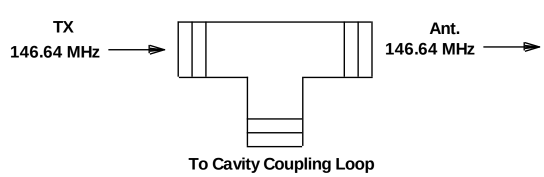


Figure 2

The cavity resonator tuning knob is adjusted for minimum attenuation of the pass frequency. Figure 1 shows that the Wacom cavity insertion loss was only 0.58 dB at the pass frequency. To measure the cavities characteristics at 146.64 MHz, the T connector was removed and the vector network analyzer (VNA) was attached to the loop port.

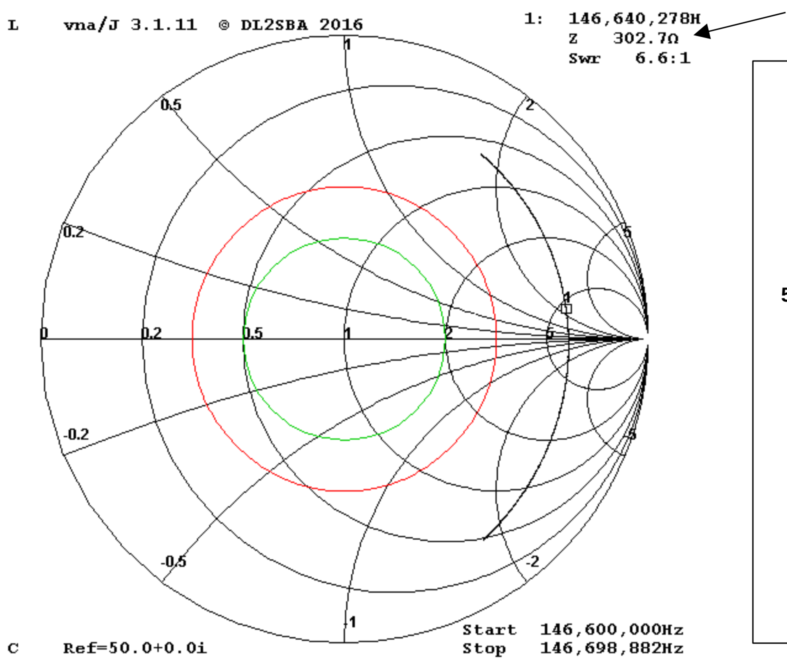


Figure 3

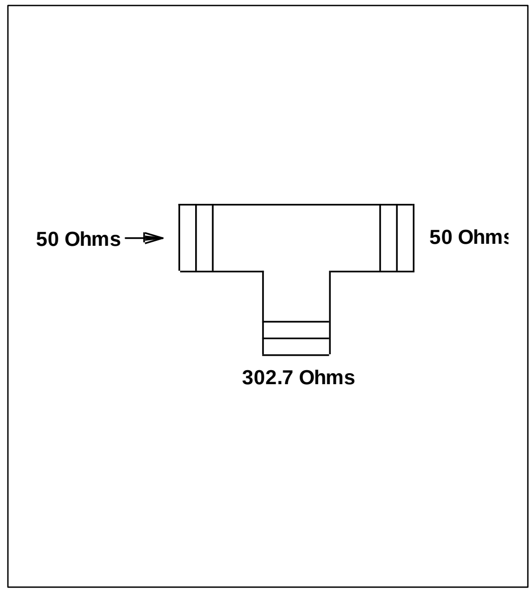


Figure 4

The VNA smith chart (Figure 3) shows that the cavity loop connector port has an impedance (Z) of 302.7 ohms when the resonator is tuned to 146.64 MHz's. This high impedance prevents the pass frequency from being absorbed by the cavity. See Figure 4. The RF energy of the 146.64 MHz signal would continue through the Tee connector to the load or antenna and not enter the cavity.

Reject Frequency (146.04 MHz) – To measure the cavities characteristics at the reject frequency, the test setup shown by Figure 5 was used. This test setup provides a 50 ohm load to both T connector ports. Because this setup duplicates a normal system the VNA was configured to sweep the pass and reject frequencies.

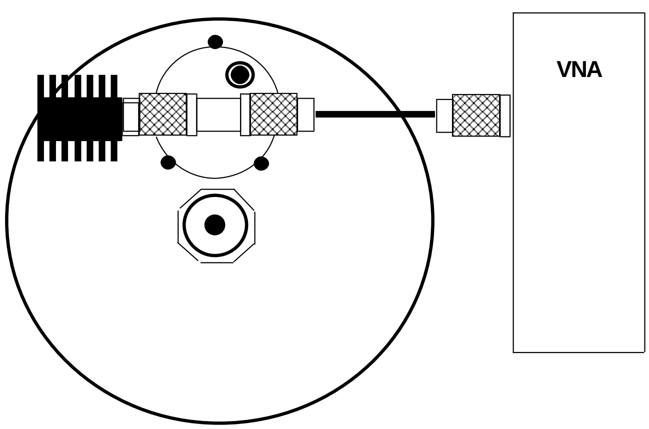


Figure 5

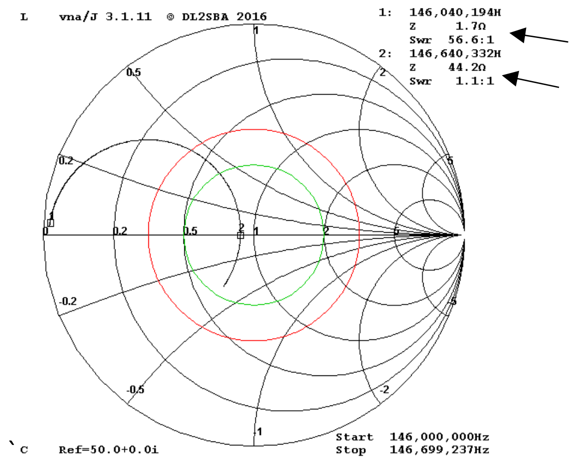


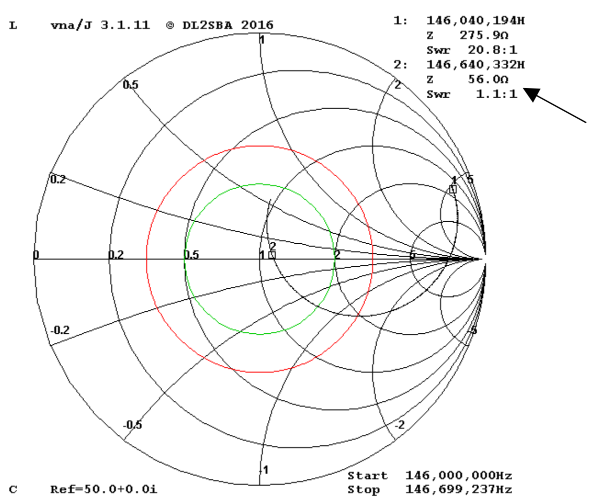
Figure 6

Figures 6 show that reject frequency (146.04 MHz) impedance (Z) is 1.7 ohms which acts like a short to the reject frequency. Figure 1 shows that the cavity attenuation at the reject frequency was 31.47 dB.

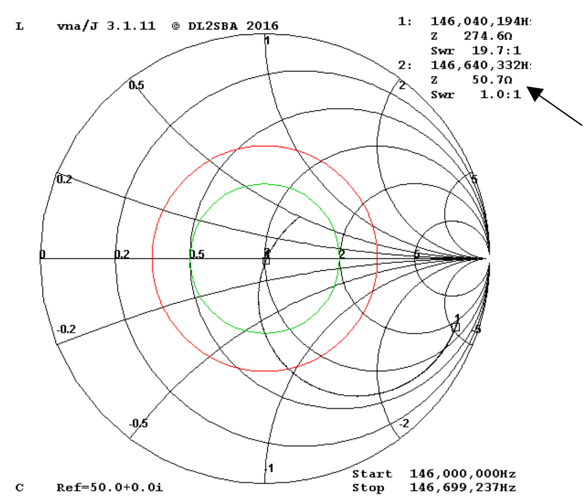
This measurement also shows that the pass frequency (146.64 MHz) was 44.2 ohms. It's very seldom that the cavity terminal impedance is 50 ohms, with duplexers this problem is corrected with interface cables.

Interface Cables – Interface cables are advertised as being λ/4 wavelength, but adding λ/4 wavelength cables between cavities will destroy the cavity impedance and response. The length of these cables are usually selected by experimenting with different cable lengths while measuring impedance. The coupling loop, T connector are part of the equation, so these cables are always shorter than λ/4 wavelength.

The following test demonstrates how this Wacom cavity reacted to different interface cable lengths.



14.5" Cable



15.5" Cable

Summary – The mystery of how a Bp-Br cavity passes and rejects frequencies is actually fairly simple. The cavity resonator creates a high impedance the keeps the pass frequency from entering the cavity. The coupling loop and capacitor is a series resonant circuit that shorts the reject frequency to ground.

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