VHF Bp-Br Repeater Duplexers

DB-4062 Duplexer

This article was written to provide amateur radio repeater owners, builders, and installers with information about duplexers that is not usually found in handbooks. This article requires that you have an advanced understanding of how antennas, receivers, transmitters work and a knowledge of electronic test instruments.

Duplexers not only allow repeaters to use a "single" antenna, they also play a major role in the installations performance. The majority of radio repeaters used by amateurs operate at VHF frequencies. The frequency spacing between the transmitter and receiver is only 600 kHz in this band. Because of this close frequency spacing, a duplexer must use bandpass/band-reject (Bp-Br) cavities to provide enough noise suppression between the repeaters transmitter and receiver.

Contents

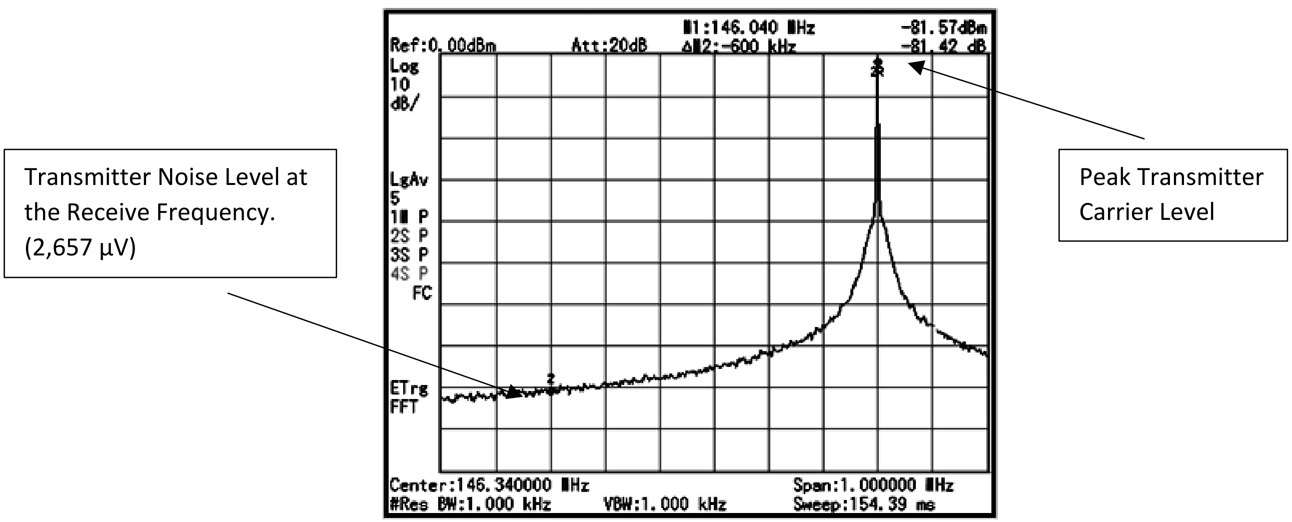
Test Equipment Used

- Thunderbolt GPS Frequency Standard
- Keysight N9340B Spectrum Analyzer with Tracking Generator Option
- KC901S Vector Network Analyzer

- 40 dB Attenuator (500W)
- Texscan RA-54 50 dB Step Attenuator
- 50 ohm N Type Termination (2)
- Decibel Products DB-4062 Duplexer
- Bird 43 Power Meter
- Welz CT-150 50 Ohm Load (150W)
- HP 8753C Network Analyzer

Selecting a Bp-Br Duplexer

Duplexers are expensive, so it's very important that the duplexer you purchase provides the proper amount of isolation between the repeaters transmitter and receiver. Repeater manufacturers will suggest the type of duplexer needed for their repeater and usually offer to sell you one. If you are building the repeater from scratch, you'll need to figure out the type of duplexer that is needed. All transmitters create RF noise on each side of the carrier frequency (See example below). You might see this RF noise identified as spectral regrowth, phase-noise or white noise, but most duplexer manuals just refer to it as "transmitter noise". Because the RF noise occurs at the same frequency as the repeaters receiver, the duplexer must suppress this noise to a level that's below the receivers input sensitivity level. If this noise is not isolated from the repeaters receiver, it will "desense" the receiver's sensitivity and cause a weak signal problem.



Transmitter Noise Measurement

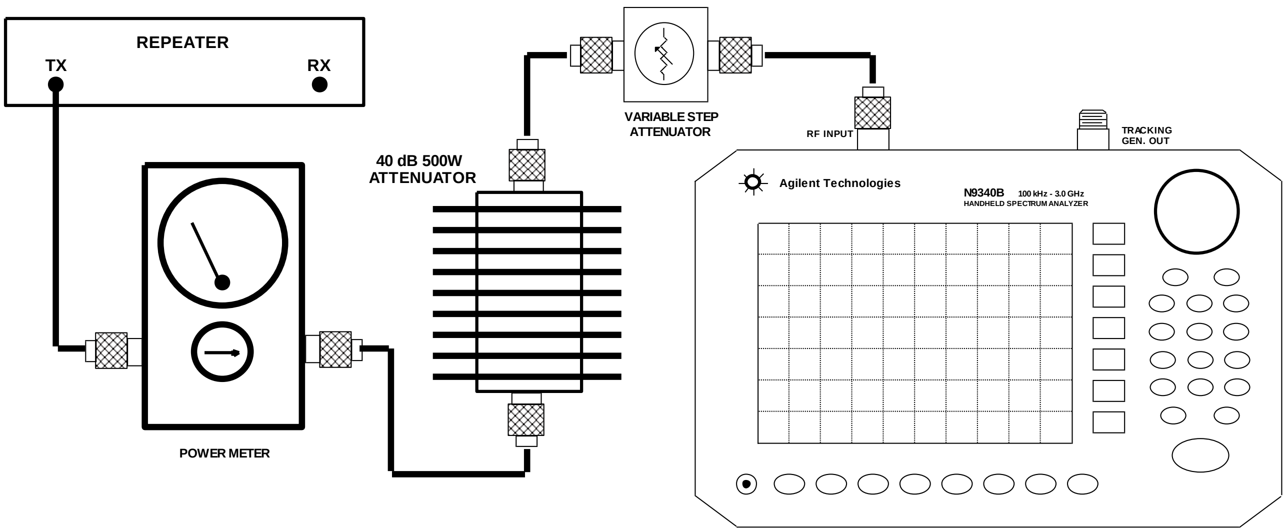
Selecting the proper duplexer requires that you know or measure the repeaters transmitter receive frequency's **absolute noise** level and receiver's input **sensitivity** value. These are the primary values needed to calculate the duplexers noise suppression requirements. Manufacturers of repeaters measure the transmitter's noise characteristics, but the transmitter's absolute noise level is usually never included in their specifications. Individuals who are building their repeater from scratch will have to measure the transmitter's absolute noise level in order to calculate the duplexers noise suppression requirements.

Measuring Transmitter Noise

Two methods of measuring transmitter noise is illustrated below.

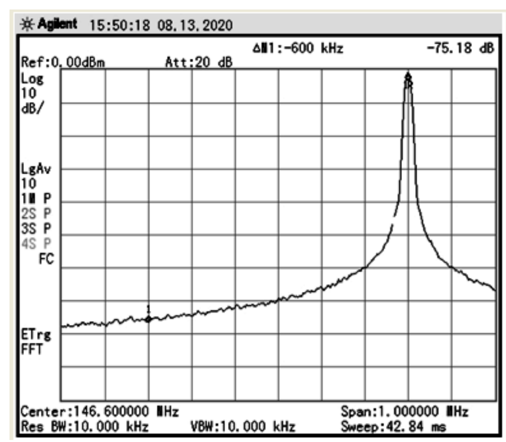
Method 1: Demonstrates the transmitter noise measurement results of a Bridgecom BCR-50-DV repeater.
Method 2: Demonstrates the transmitter noise measurement of a 146.04/64 repeater.

Method 1



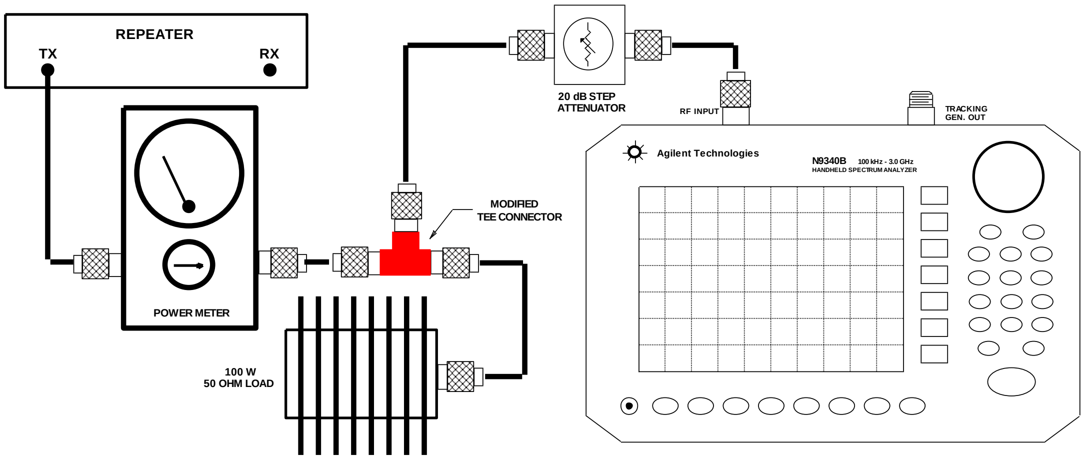
Spectrum Analyzer Settings

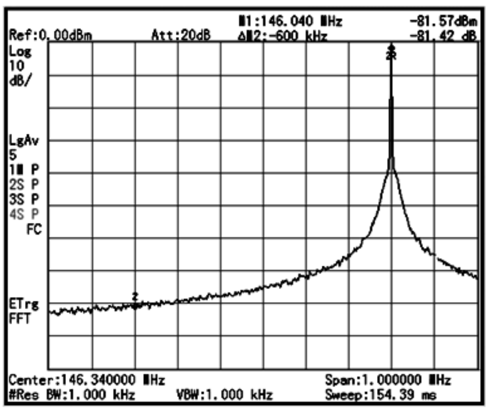
1. The repeater frequency of 146.30/90 was used for this example, so the SA center frequency was 146.6 and with a Span of 1 MHz.
2. Resolution and Video bandwidth is 10kHz
3. Detector set Peak Positive
4. Marker set carrier frequency and Delta 600 kHz
5. Trace set to Max Hold and Averaging 5
6. Signal is applied to SA and step attenuator is adjusted so carrier is at the 0.0 dBm Ref. line.



The transmitter noise measurement was used to determine the difference between carrier level and noise level at the 600 kHz receive frequency. In this case, the value was 75.18 dB. The power meter reading was 50W (+46.99 dBm) at the repeater transmit carrier frequency. Subtracting the 75.18 by 46.99 = **-28.19** dBm which equals the **absolute noise** level. Note: The noise test must be made at the same output power level the repeater will be operating at. Ensure the spectrum analyzers dynamic level is great enough that the 600 kHz offset frequency does not reach the analyzers noise floor. Just looking at the spectrum analyzers screen, one might assume that this RF noise level would not be a problem, but -28.19 dBm equals to a signal level of 8,901 µV which would destroy the receivers 0.2 µV input sensitivity.

Method 2





This test allows you to use a standard 50 Ω load, but requires you to modify a Tee connector so the spectrum analyzer is not destroyed. Tee Connector Modification: Remove the connector center pin and break off the fingers and replace the center pin. The connector modification provides 40 to 50 dB of attenuation across a frequency of 144 – 148 MHz.

The delta between the 146.04/64 was 81.57 dB at a transmitter output power of 45W (46.5 dBm), so the **absolute noise** level is -35.07 dBm (-81.57 dB – 46.5 dBm = -35.07 dBm).

Calculating Minimum Duplexer Isolation

Bridgecom Repeater Calculation:

Receiver Sensitivity	**-121 dBm (0.2 µV)**
Absolute Noise Level	**-28.19 dBm (8,901 µV)**
TX Cavity Rejection	**92.8 dB**
Tee/RX Cavity Insert Loss	**-5.25 dB**
Minimum Duplexer Suppression	**87.55 dB**

146.04/64 Repeater Calculation:

Receiver Sensitivity	**-117 dBm (0.3 µV)**
Absolute Noise Level	**-35.07 dBm (2,657 µV)**
TX Cavity Rejection	**81.93 dB**
Tee/RX Cavity Insert Loss	**- 4.50 dB**
Minimum Duplexer Suppression	**77.43 dB**

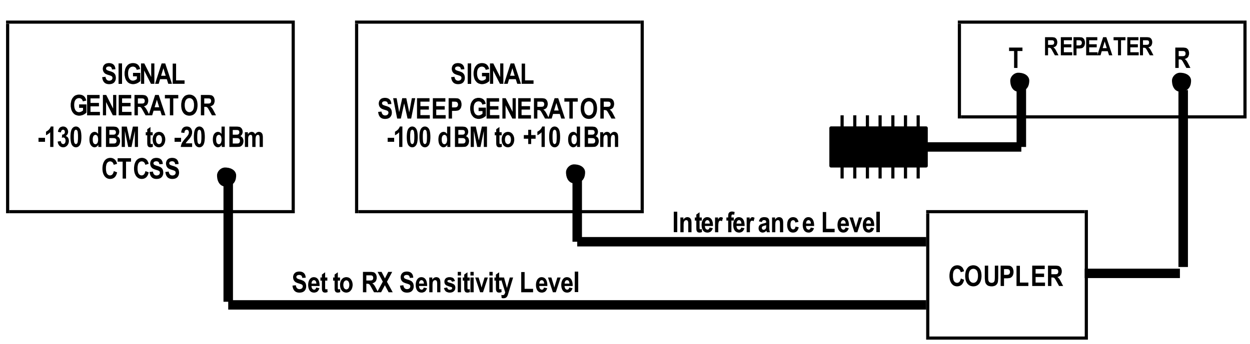
Most duplexer calculations only include the receiver sensitivity and the transmitter absolute noise level, but I've also added the duplexer's antenna Tee connector and receive cavity insertion loss to the duplexer calculation. When the transmitter's receive frequency noise passes through the duplexer's antenna Tee connector, the antenna absorbs about 3 dB of the noise and the receive cavities absorb another 2 dB due to insertion loss.

Never select a duplexer that just makes the minimum calculated suppression number. Duplexers are tuned with all the ports terminated with 50 ohms, but it's seldom that the repeater's receiver, transmitter and antenna will all have an impedance of 50 ohms. Any impedance connected to the duplexer that is not 50 ohms can detune the duplexer. Duplexer internal components can oxidize over time thereby causing the duplexer to deviate from the original specs. Temperature can also change the duplexer's alignment if it's not located in a controlled environment. To compensate for all of these effects, always add 10 dB to the calculated minimum number, which means you would need to acquire a duplexer with 97.55 dB of isolation for the Bridgecom repeater and 87.43 for the 146.04/64 repeater. The maximum isolation for a 4 cavity duplexer is about 90 dB and a 6 cavity duplexers can provide more than 100 dB, so the Bridgecom repeater would require a 6 cavity duplexer.

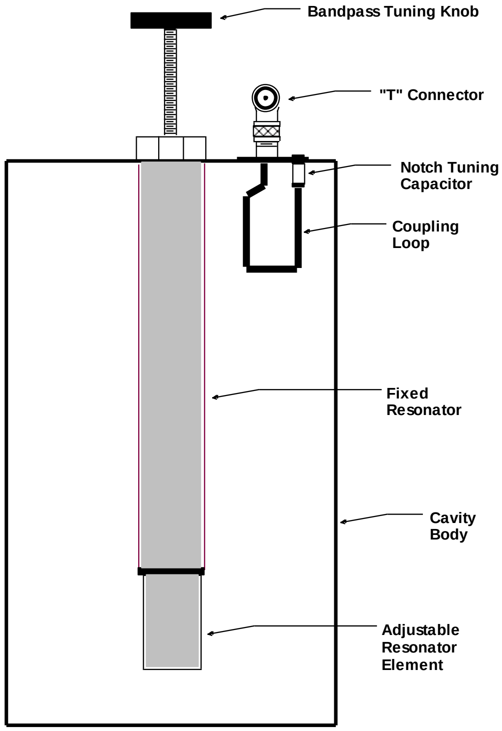
Adjacent-Channel Rejection Ratio (ACRR)

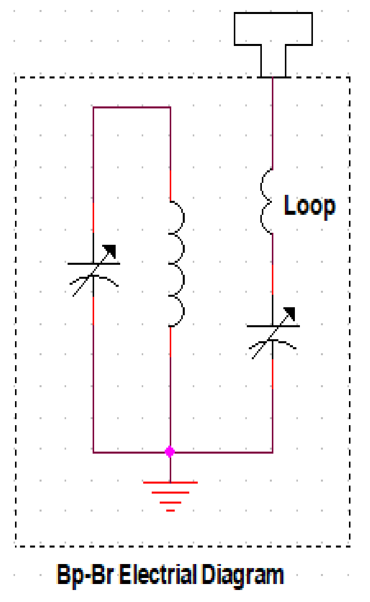
If you're wondering why only the repeaters transmitter's **absolute noise** is considered during the duplexer minimum suppression calculation, it's because that most of the transmitter's RF energy is radiated by the antenna. Any amount of the transmitter's RF energy that is not radiated by the antenna is easily suppressed by the receive cavities. All receiver's normally have a degree of rejection to out of band frequencies. The ACRR test is a measurement ratio in (dB) between a receivers' input sensitivity against a similar signal on another frequency. I occasionally use this test on amateur radio receivers to determine at what transmit frequency level receiver desensitization occurs.

Below is an ACRR measurement of a Yaesu FTM-3100 transceiver for an offset of 600 kHz: RX input sensitivity was -121 dBm (0.2 µV) and -38 dBm (2,820 µV) was required to detect a noise level change. The ACRR specification is **83 dB** (121 -38 = 83). Note: The Selectivity specification for this transceiver is 60 dB @ 28 kHz. Due to a receivers inherit suppression of the transmitters frequency and the minimal amount of suppression needed by the receive cavities, some repeater owners will replace one receive Bp-Br cavity with a band-pass (Bp) cavity which provides more rejection to out-of-band signals.



Bp-Br Cavity Design and How They Work





How the cavity Tee connector port reacts to impedance holds the secret of how Bp-Br cavities work. In this case, the cavity pass frequency was adjusted to 146.90 MHz and the reject frequency to 146.30 MHz.

Figure 1 shows that with the bandpass adjustable resonator element adjusted to 146.90 MHz, it acts like a parallel resonant circuit which produces a high impedance (415.2 ohms) at the cavity Tee port. This causes the 146.90 MHz frequency to pass thru the Tee connector with only 0.65 dB of insertion loss.

Figure 2 show when the loop capacitor is adjusted to 146.30 MHz, the loop inductance and capacitor form a series resonant circuit and provides a low impedance (5.3 ohms) path to ground for the 146.30 MHz frequency.

Figure 1

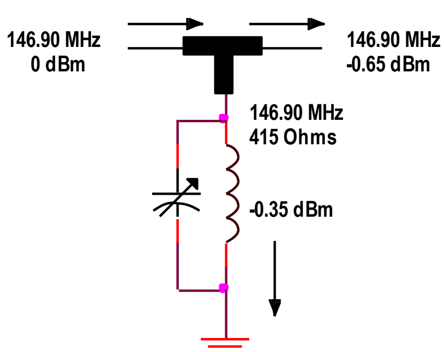
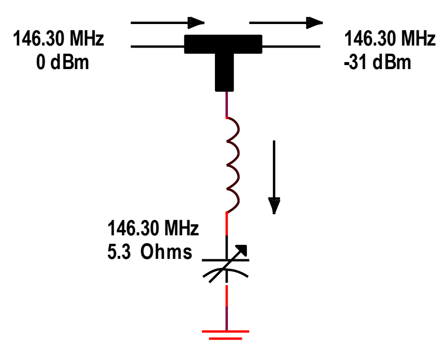
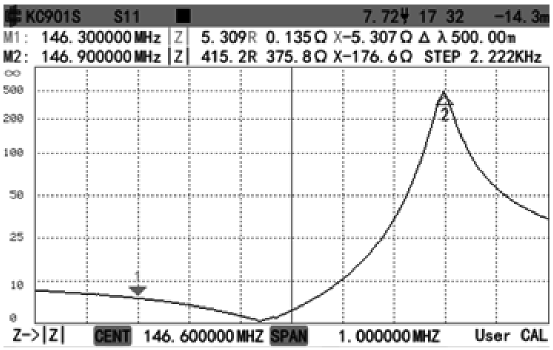
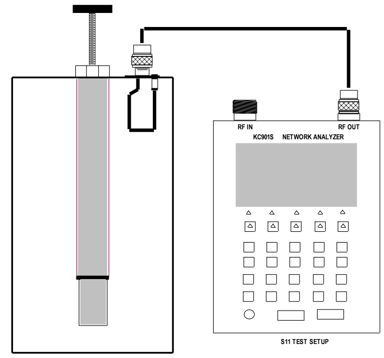


Figure 2







This VNA S11 Measurement of cavity port shows the impedance values from the pass and reject frequencies. Note: Normalize the VNA cable before taking this measurement.

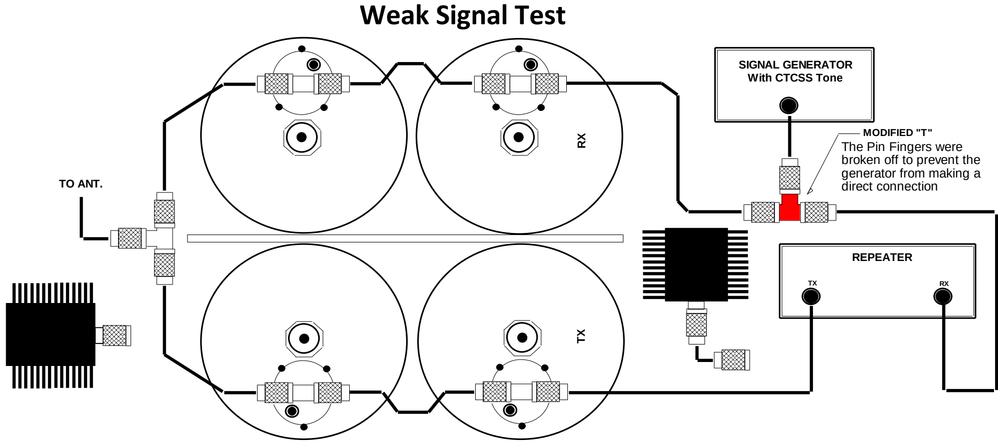
Receiver Desensitization Test

If you are not hearing any weak stations on the repeater, the receiver probably has a "desense" problem. Receiver desensitization usually occurs when the duplexer transmit cavities don't provide enough suppression to the transmitter's absolute noise. On rare occasions, an off frequency signal will desense the receiver, but due to a receiver's selectivity it takes a very strong signal to cause this issue. Repeaters that have been in-service for a long period of time may have duplexers that have deteriorated to a point whereby the transmit cavities are not providing enough suppression. If there are any devices connected to the duplexer ports in which the impedance has changed, this can detune the duplexer and cause receiver desense problems.

Testing the repeater for a desense problem is very easy if the repeater has a speaker and you can disable the transmitter from the front panel. While at the repeater, when you hear a weak noisy signal on the speaker, disable the transmitter while the weak station is transmitting. If the noisy station becomes clear when the transmitter is disabled, you have "desense" problem.

If your repeater does not have an internal speaker or the ability to disable the transmitter, the "Weak Signal Test" setup below can be used. This test allows you to inject a weak noisy signal into the receiver and eliminate the transmitter with a load. You can also use a load to bypass the antenna to eliminate the antenna as the possible problem.

Weak Signal Test

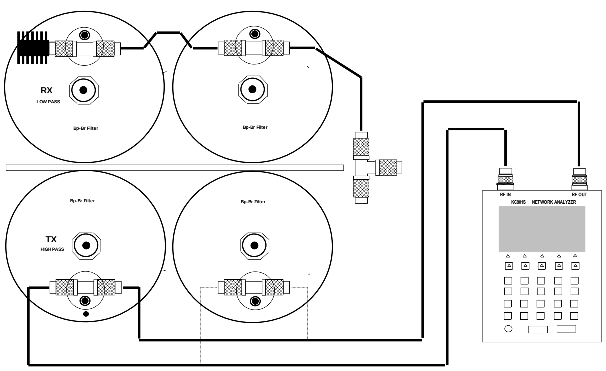


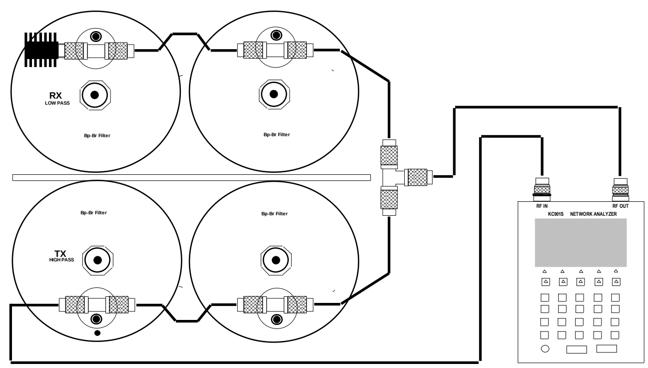
Cavity Cable lengths and Type

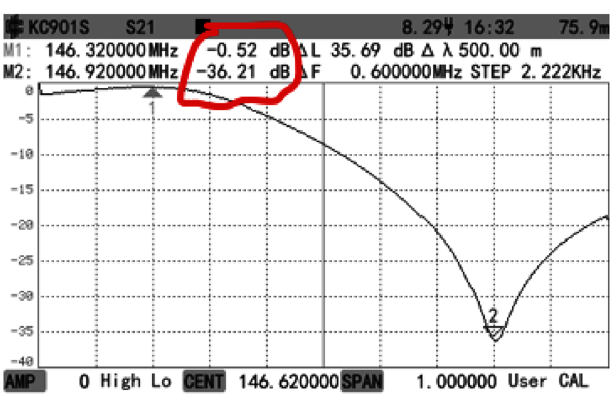
Some documents I've read claim that the cable length does not have any effect on the cavity rejection performance, but my testing has verified otherwise when checking Bp-Br duplexers manufactured by Decibel Products and Wacom.

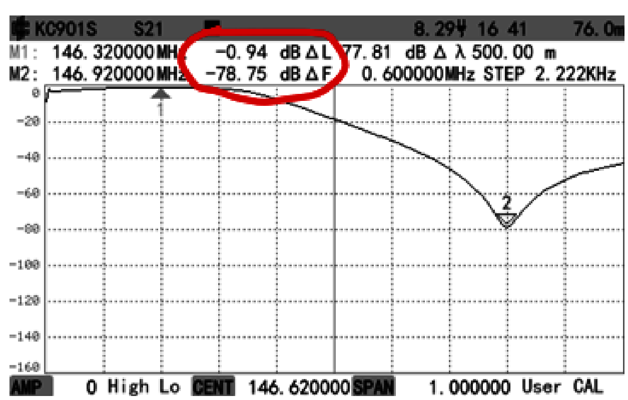
For Bp-Br cavities, those ¼ λ cables between the between the duplexer cavities are not there for **impedance matching**. The purpose of the ¼ λ cables is to transform the low impedance of the series resonant notch circuit to a high impedance which is seen by the next cavity. This actually makes the next cavities' suppression more effective because its series resonant circuit is more efficient with a higher impedance. It's not uncommon to have individual cavities that have a notch suppression of 35 dB, but when a 2 cavity duplexer is assembled, it measures 80 dB on each side. The ¼ λ cables on each side of the antenna Tee connector are not for impedance matching either, but to present a high impedance between the TX and RX frequencies which isolates one side from the other.

The following is an example of how the cavity inter-connecting cables can affect the total rejection value. Using a 4 cavity DB-4060 duplexer, the two low-pass cavities were individually tested for rejection, then tested coupled with the connecting cables.





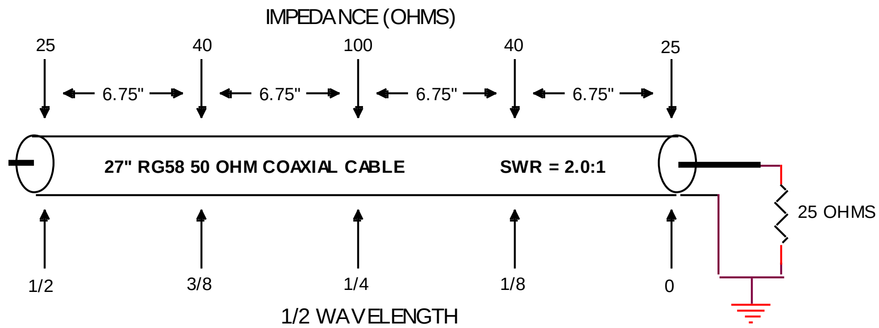




Each Cavity Rejection -36.2 dB @ 146.92 MHz **Both Cavities connected with a 10.5 inch Cable**

The 2 individually tested had identical rejection values of 36.2 dB, which equals to a total 72.4 dB, but connecting the 2 cavities together resulted in rejection value 78.75 dB. The 10.5 inch interconnecting cable increased the rejection by 6.35 dB.

The drawing below is an example of how this impedance transformation occurs. When one end of the coaxial cable is terminated with 25 ohms, the impedance is transformed to 100 ohms at ¼ λ. Notice that the terminated impedance (25 ohms) repeats itself at every ½ λ. If the cable was terminated with 50 ohms, the impedance would remain at 50 ohms at any wavelength. This length of RG58 cable is 13.5 inches at the ¼ λ point at 146 MHz.

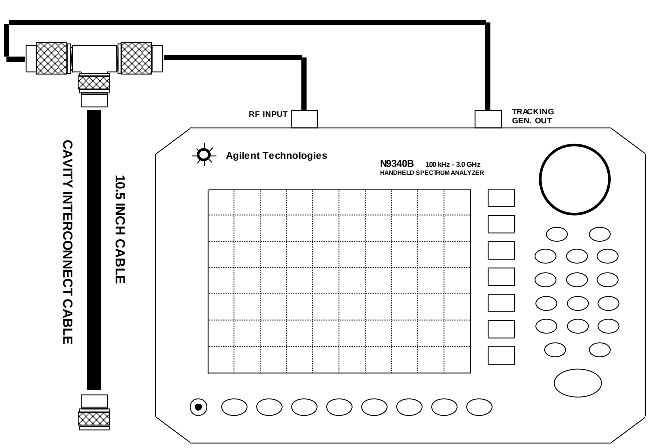


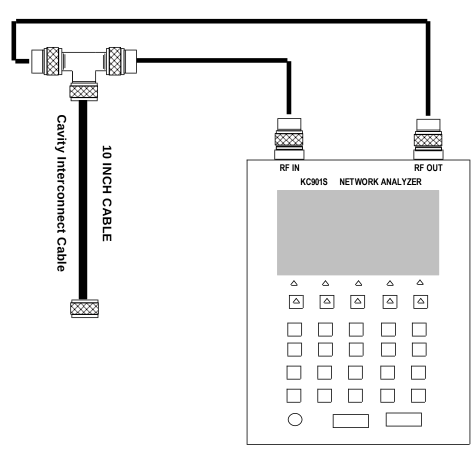
If you remove one of the cables from between two cavities it will be physically shorter than a ¼ λ. The cavity loop and Tee connector are part of the ¼ λ which makes having an accurate formula for these cables impossible. The Decibel Products DB4060 & DB4062 WCB are popular duplexers used for amateur radio repeaters and the cable length between the high-pass cavities is approximately **10 inches** on the high-pass side and **10.5 inches** for the low-pass side. At one time, Wacom had a rack of pre-made cables starting with a cable length of about 9 inches, with lengths increasing in ¼ inch increments to 13 inches. These cables were used to obtain the best suppression level between each pair of cavities.

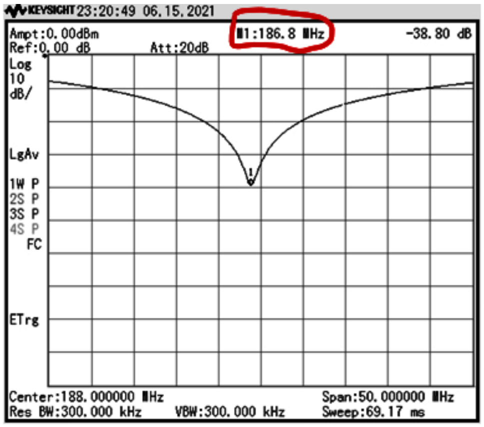
If you encounter a damaged cable, attempt to determine the cables resonant frequency with a spectrum analyzer that has a tracking generator or a two port VNA by removing the good cable from the same side. The replacement cable can be a different type of cable, but it needs to be double shielded (silver plated) cable. Don't use a cable like LMR-400, which has a braided shield over an aluminum shield. Ignore the original cable length, your objective is to make new cable that has the exact same wavelength as the good cable.

Either test setup below can be used to determine the original cables wavelength and then duplicate a new cable that matches the original cables wavelength.

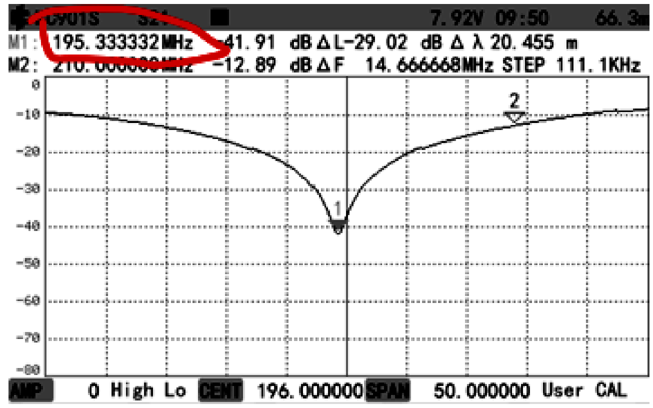
Caution: Don't use a cable from the other duplexer side, that cable may shorter or longer.







10.5” Cable Resonant 186.8 MHz



10” Cable Resonant 195.3 MHz

Repairing and Tuning Bp-Br Cavity Duplexers

Since duplexers are a “passive” device which contains no active electronic parts, repeater operators have a tendency to install and simply ignore them. However, this is not a good practice because over a long period of time the resonant element finger-stock, coupling loops and cavity inner surface oxidizes. This causes a reduction in the repeater transmit output power and poor receive sensitivity. This issue is usually not detected until the repeater users start complaining.

Manufacturers use Vector Network Analyzers (VNA) like the Agilent E5080E which has a dynamic range of 150 dB. A new E5080E VNA will cost you 125K. I occasionally see a used one on eBay for 40K, so it’s not a test instrument you’re likely to see on an amateur radio operator’s test bench. However, it’s possible to accurately test and tune duplexers with less expensive equipment.

If possible, obtain the manufacturers specifications on the duplexer that you are going to repair and tune. The duplexer used in this article is a Decibel DB-4062 which is a 6 cavity duplexer. The majority of amateur radio repeaters use 4 cavity duplexers, but the repair and tuning procedure is identical.

Manufacturers Specification

ELECTRICAL DATA

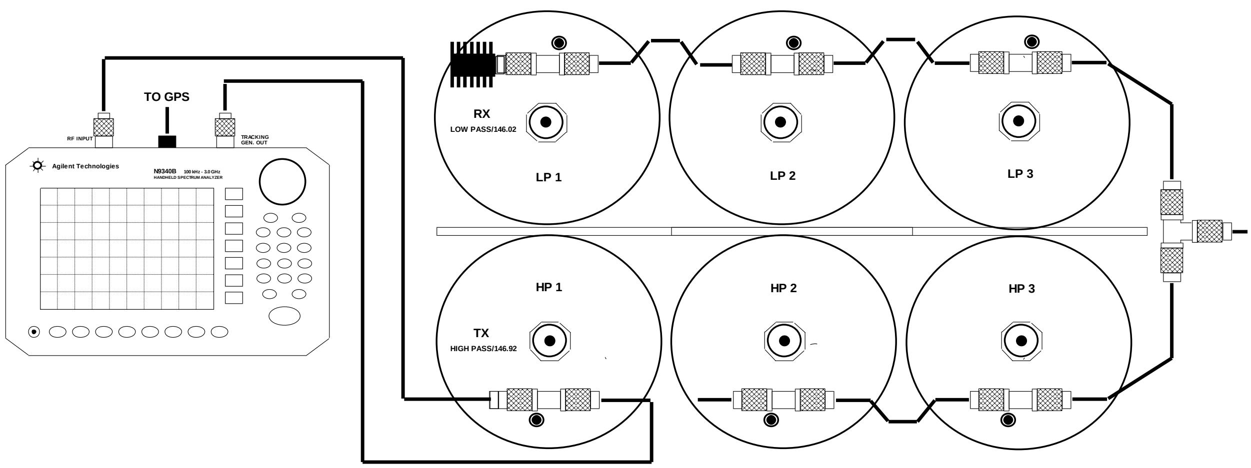
	Model DB-4060	Model DB-4062
Frequency range	144-174 MHz	144-174 MHz
Frequency separation	0.5 MHz or more	0.3 MHz or more
Maximum power input (continuous duty)	400 watts	400 watts
Insertion loss (transmitter to antenna and receiver to antenna)		
at 0.3 MHz separation		2.2 dB
at 0.5 MHz separation	1.5 dB	
Transmitter noise suppression at receive frequency	80 dB	100 dB
Receiver Isolation at transmit frequency	80 dB	100 dB
Maximum VSWR (referenced to 50 ohms)	1.5 to 1	1.5 to 1
Temperature range	—30°C to + 60°C	—30°C to + 60°C
Number of cavity filters	4	6

Initial Duplexer Evaluation:

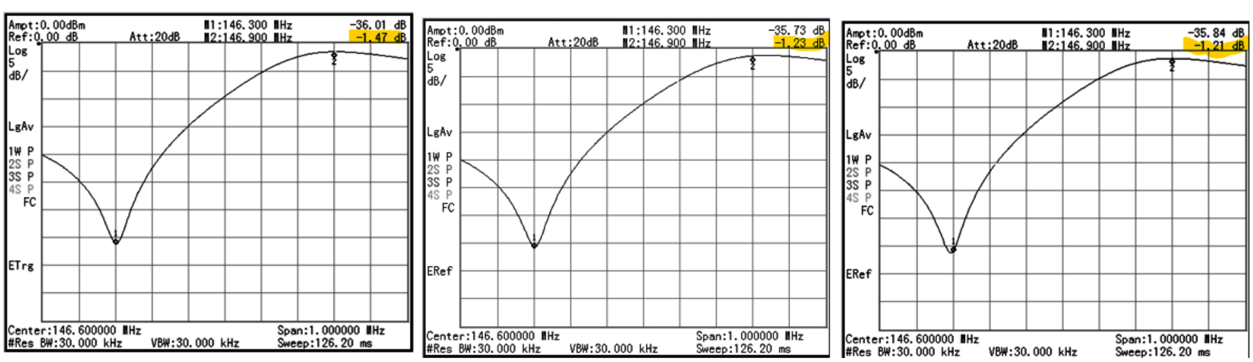
This procedure will be used to determine what repairs are required to restore the duplexer to the manufacturers specifications. The repeater duplexer used in this example was a 6 cavity DB4062 using 146.30 MHz (RX) and 146.90 MHz (TX) frequencies. Number each cavity before you start the evaluation. Start the evaluation process by testing **each individual** cavities response characteristics. The test setup below was used to test each cavity. Note: The measurements were taken with an Agilent N9340B SA with a tracking generator. The GPS frequency standard signal was connected to the instruments reference port to ensure accuracy.

Spectrum Analyzer settings		
	1. Mode	Tracking Generator
	2. Center Frequency	146.6 MHz
	3. Frequency Span	1 MHz
	4. Marker 1	146.30 MHz
	5. Marker 2	146.90 MHz
	6. Scale/DIV	5 dB

Note: With these settings, both RX and TX cavities can be tested without changing any analyzer setting.



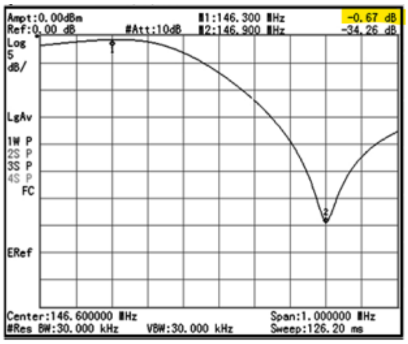
Transmit (TX) cavity Test results

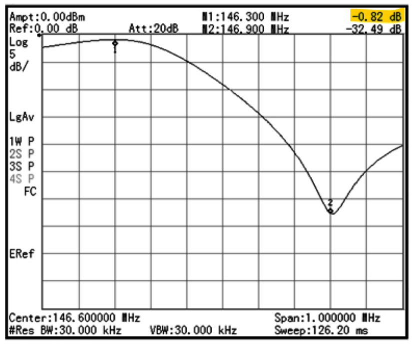


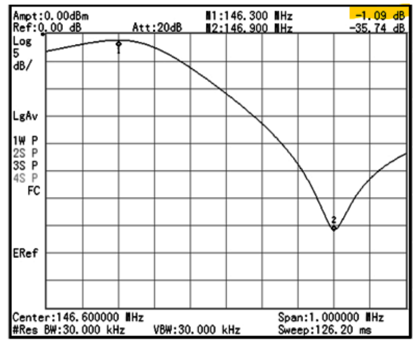
HP 1 **HP 2** **HP 3**

I've highlighted the High Pass insertion loss of this cavities. All of the TX cavities had similar insertion loss readings. According to the manufactures specifications, the maximum duplexer insertion loss is 2.2 dB. The total insertion loss for the 3 cavities was **3.91** dB which would result in low TX output power. The noise suppression was 33 to 36 dB which is in the normal range for a single cavity.

Low Pass receive (RX) cavity test results.







LP 1 **LP 2** **LP 3**

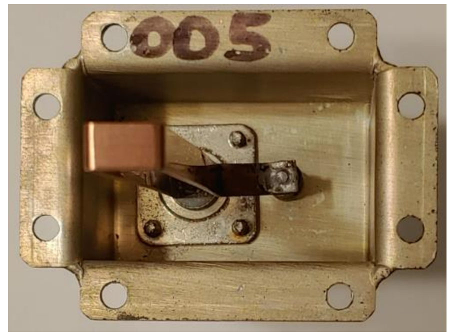
I've highlighted the Low Pass insertion loss which equaled to 1.9 dB. The RX insertion values were within the manufactures specifications. The TX cavities have a major problem, but RX duplexer cavities tested ok. Since the duplexer has been in service for over 20 years (8/2000), all of the cavities will need to be refurbished.

Restoration Process:

Solving insertion loss problems requires that the cavity bottom cover to be removed so you can clean the resonator adjustable plunger. DB4062 cavity bottom covers are attached to the cavity with 4 rivets that must be drilled out. Apparently Decibel didn't use a template to drill these holes, so it's important to mark one of the holes before removal to save time later during reassembly. Once the bottom cover is removed, turn the resonant adjustment knob screw all the way down until the resonator protrudes out of the cavity. See photos below:

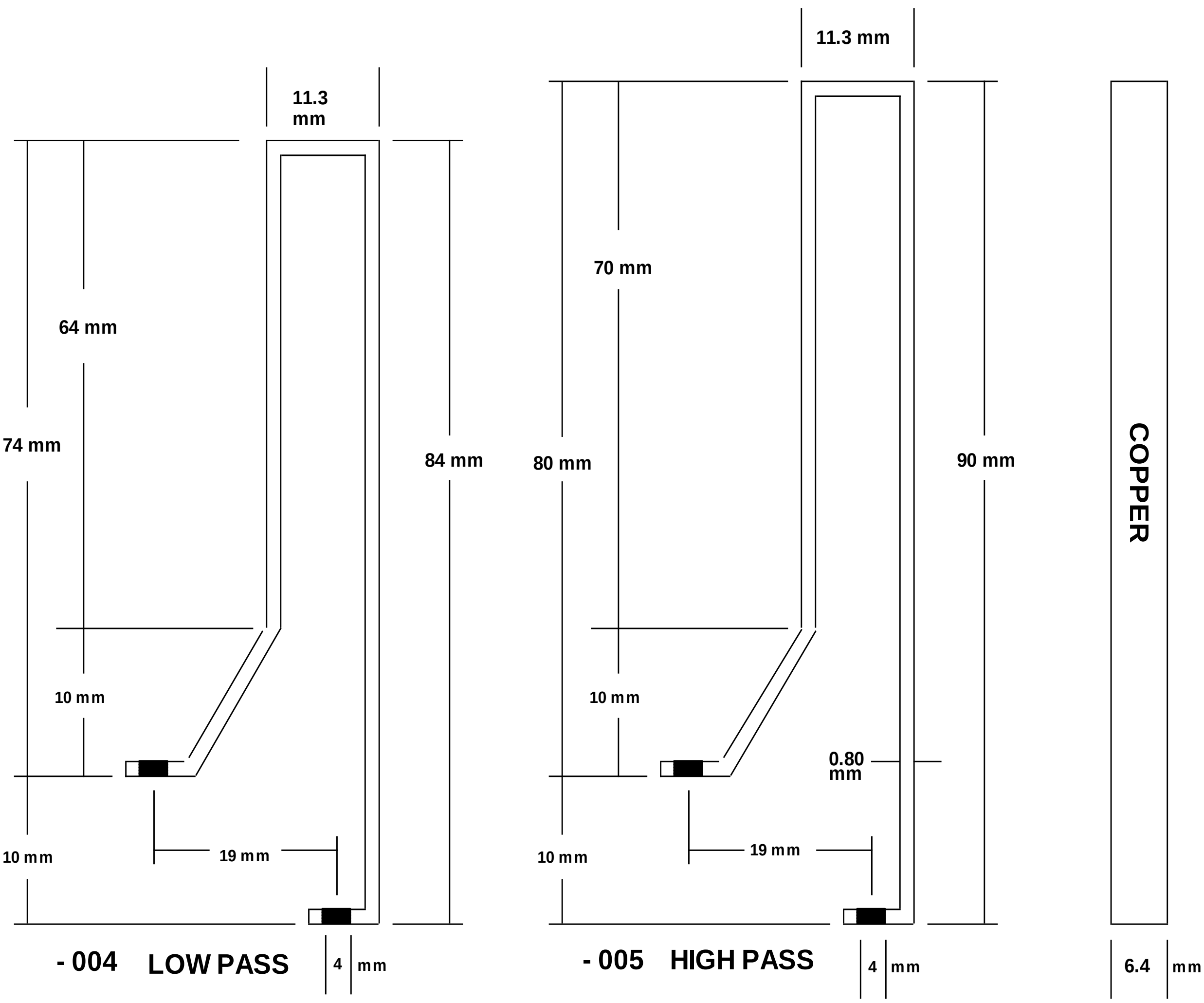
After the resonator plunger is extended as far as possible, clean and polish the plunger area just below the finger-stock. **CAUTION:** Be careful not to damage the finger-stock. I prefer to use a metal polish called "NEVER-DULL", which can be purchased from Lowes to clean the plunger surface. Clean the polish residue off with isopropyl alcohol. Once cleaned, adjust the plunger through the finger-stock several times and then repeat the cleaning process again. Use the same cleaning procedure on all of the duplexer cavities. The bottom covers were reinstalled using 8-32 x ¼ Stainless Steel screws and nuts.

The next task is to clean and polish the cavity coupling loops seen on the next page. The loop assembly can be removed from the cavity top by removing 8 screws. The condition of the loop and variable capacitor controls the amount of transmitter noise suppression and receiver isolation. These suppression and isolation values are sometimes referred to as the "Notch" value in some specifications.



The 005 number on the assembly flange indicates that this coupling loop goes in a High Pass cavity. Coupling loops with 004 numbers go in the Low Pass cavities. If the coupling loop assembly flange does not have any number markings or if you need to verify that the marking is correct, you can compare the loop dimensions as seen below.

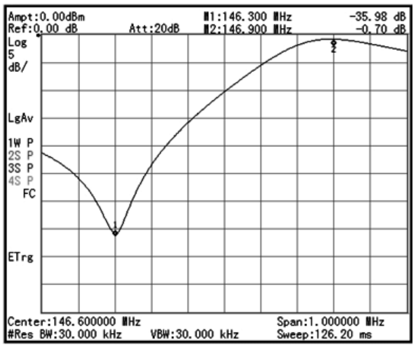
DB4060/62-WC-B Duplexer Loop Dimensions

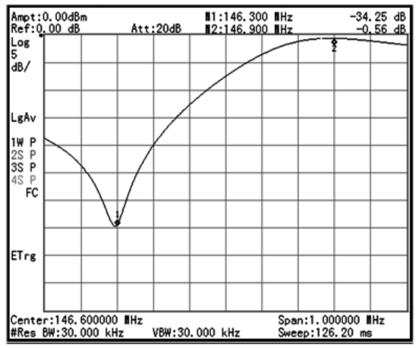


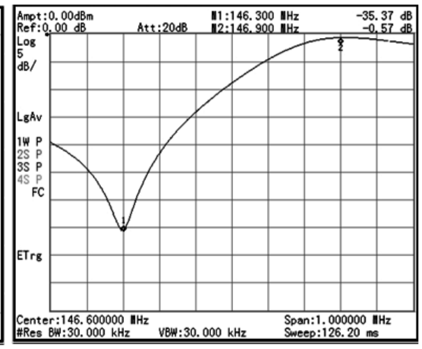
After the duplexer components have been cleaned, polished and assembled, it's time to verify that all the cavities are working properly.

Verification Test and Pre-Tuning Procedure:

The test and pre-tuning starts by using the individual cavity test setup used on page 2. The cavity resonators **must be** adjusted **first** to the repeaters transmit or receive frequency, then the capacitor is adjusted to the notch frequency.

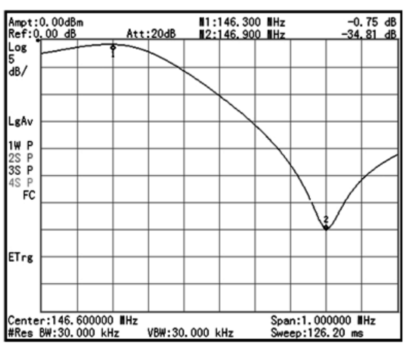


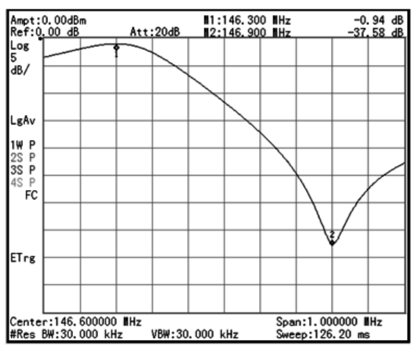


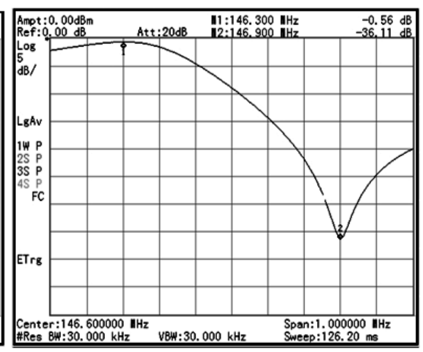


HP 1 **HP 2** **HP 3**

The total insertion loss is now 1.83 dB, compared to the 3.91 dB measured before cleaning the resonator adjustable element. Total transmitter noise suppression was 105.8 dB and this value will increase to a higher level when the ¼ λ cables are installed.







LP 1 **LP 2** **LP 3**

The total insertion loss is 1.85 dB and the total receive transmitter isolation 108.52 dB.

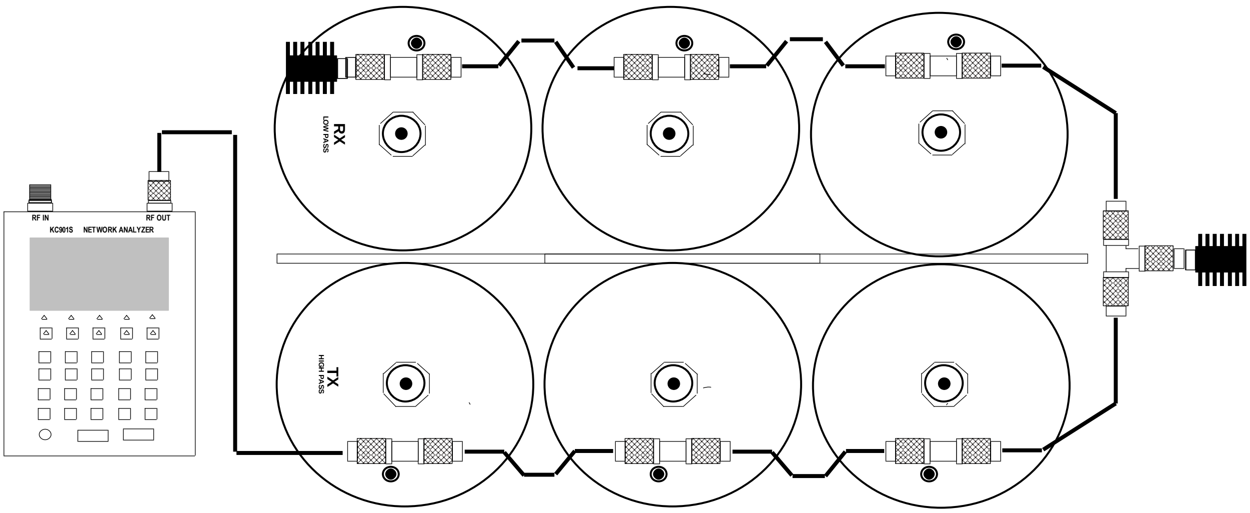
Once all the cavities have been tested and sweep tuned, they are connected together with the proper length cables. These cables are sometimes referred to as ¼ λ cables, but they are not electrically ¼ λ long because each cavity tee and loop equal to part of their length. The original cable lengths are 10 inches on High Pass cavities and 10.5 inches cables on the Low Pass side. These cables need to have a silver-plated braid and be double shielded like RG-214.

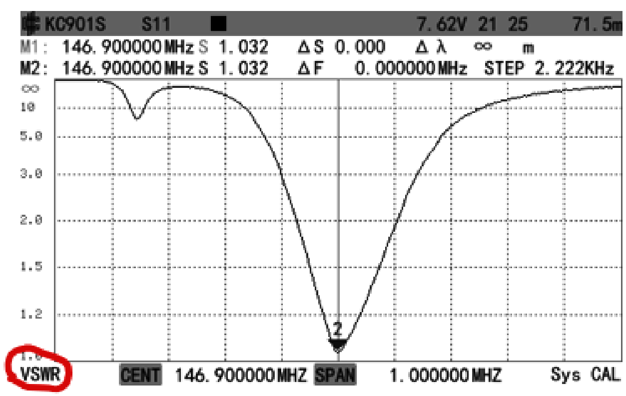
Final Tuning Procedure:

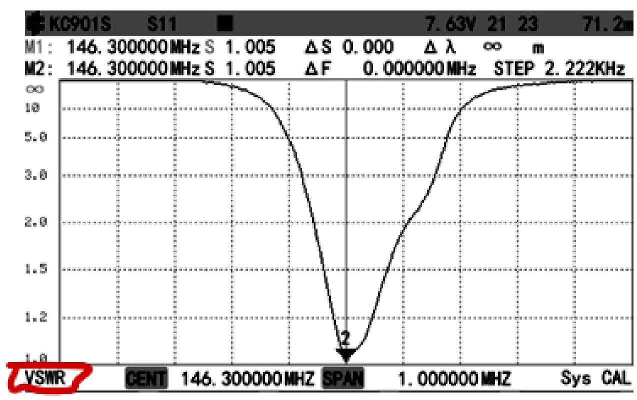
When the individual tuned cavities are connected together, there's some interaction between them so a final tuning process is required. Just about any VNA can be used to tune a single cavity, but a VNA with a dynamic range of 140 dB might be required to test a 6 cavity duplexer.

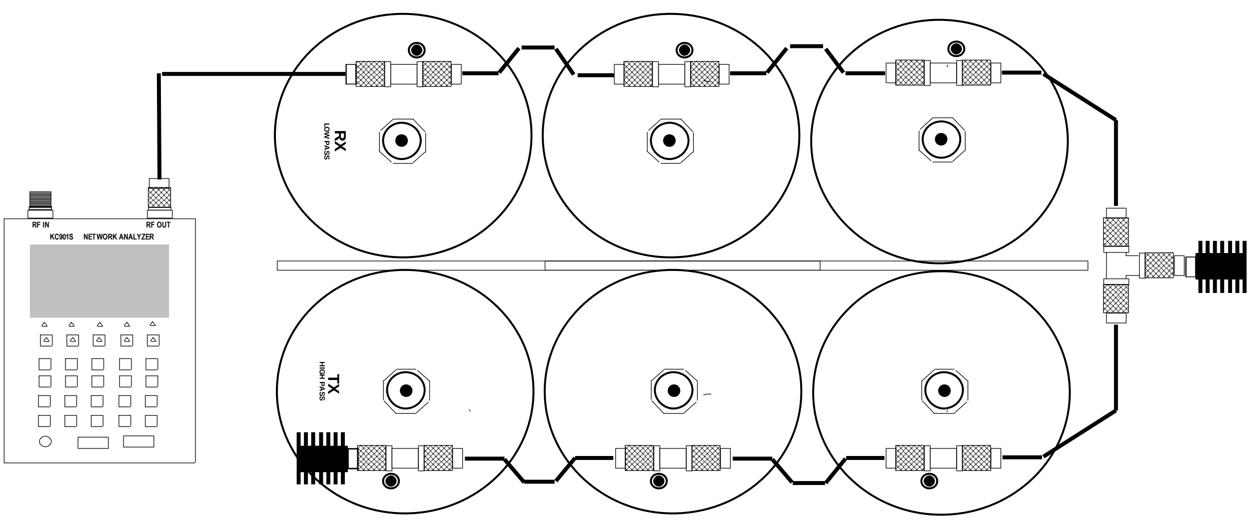
I'm going to use an alternate method of tuning that can be used either a 4 or 6 cavity duplexer without the expensive VNA. Before starting the final tuning, I what to emphasize the importance of using an accurate frequency. The rejection notch bandwidth is very narrow and being off frequency a few Hz's can reduce the effectiveness of the transmitter's noise suppression.

The 6 cavity duplexer is the most challenging to tune. Using the test setups below, the VNA's VSWR test mode is used to adjust the TX High Pass and RX Low Pass resonator knobs for the best readings a 146.90/146.30 MHz.

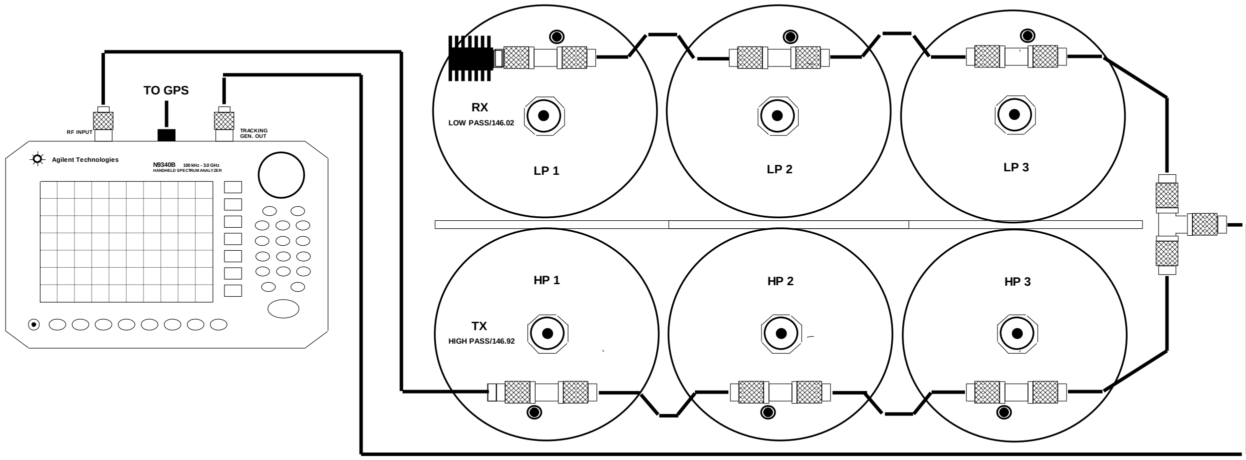








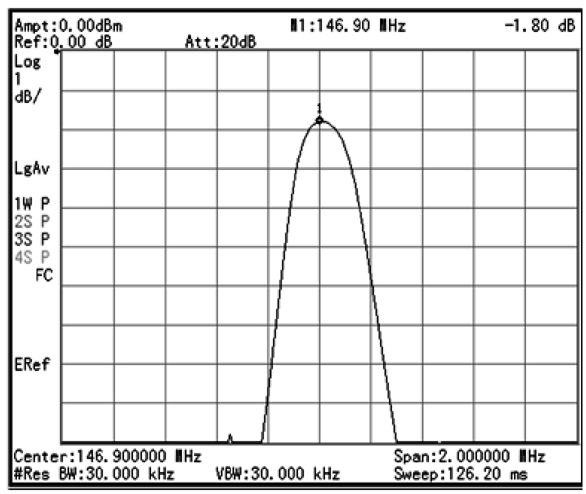
If the duplexers were properly designed, VSWR will usually provide the best RX and TX insertion Loss. Use the next test to measure the insertion loss to verify this is true. If you change any of the resonator settings, check the VSWR again to make sure it's within the manufacturer's 1.5:1 spec.

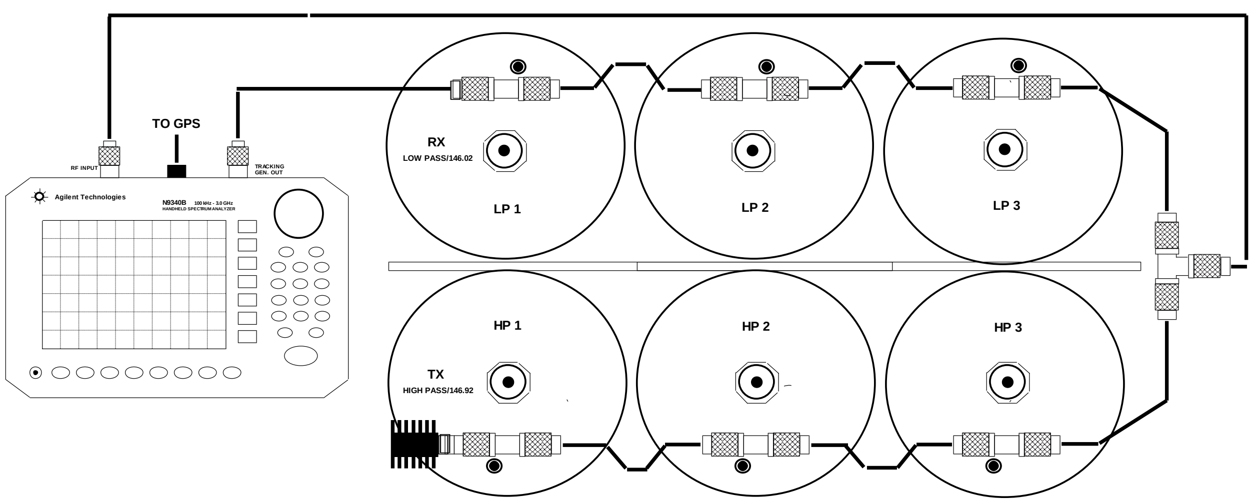


TX cavity sweep test setup

Spectrum Analyzer Settings

1. Mode Tracking Generator
2. Center Frequency 146.90 MHz
3. Frequency Span 2 MHz
4. Scale/DIV 1 dB
5. Maker 1 146.90 MHz

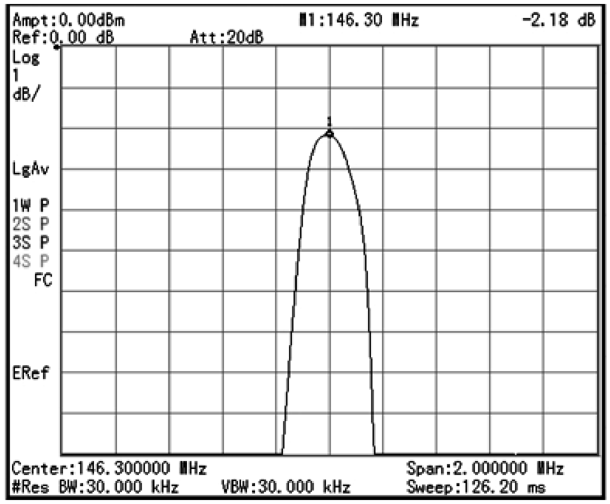




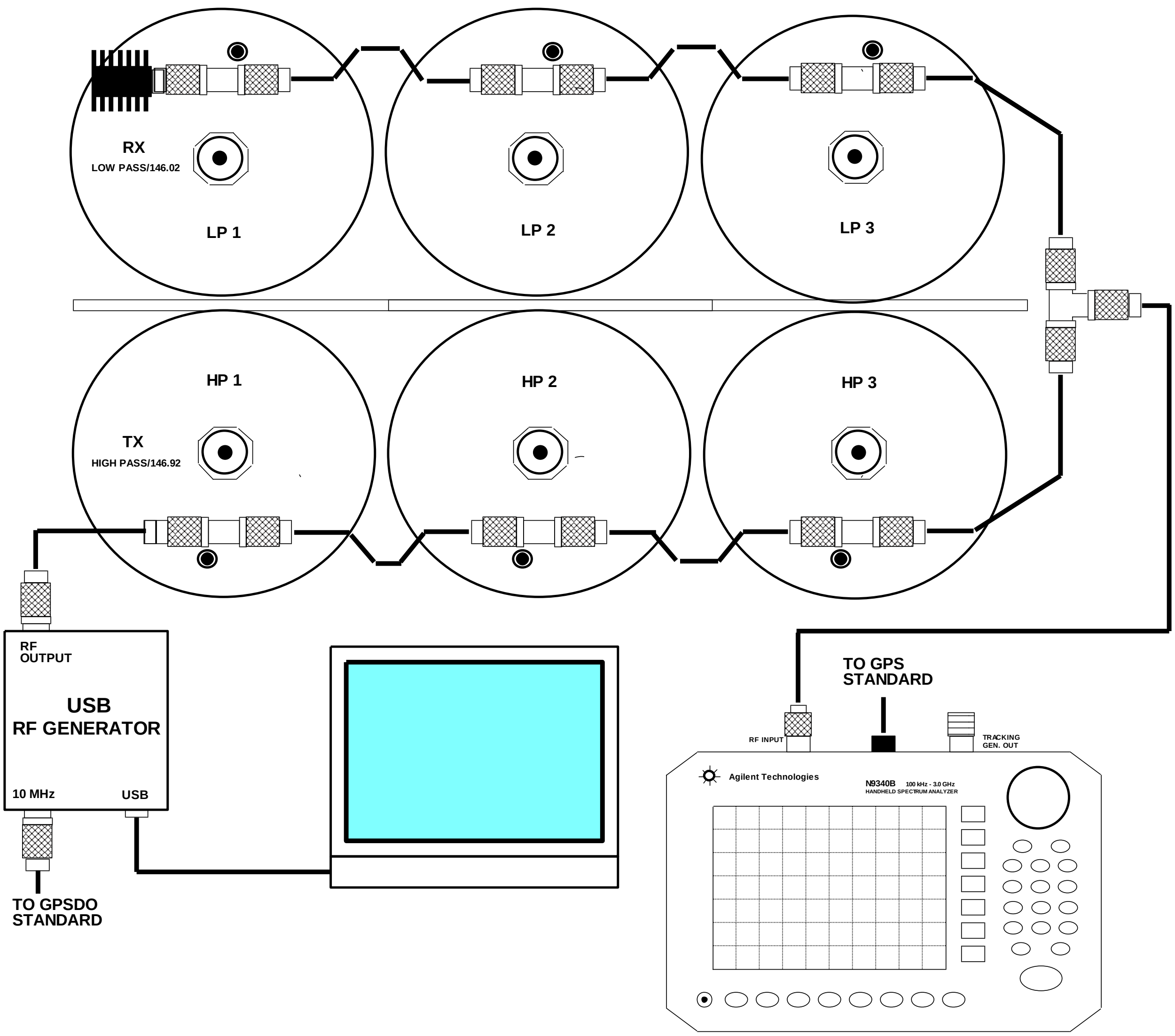
TX cavity sweep test setup

Spectrum Analyzer Settings

1. Mode Tracking Generator
2. Center Frequency 146.30 MHz
3. Frequency Span 2 MHz
4. Scale/DIV 1 dB
5. Maker 1 146.30 MHz



Now the transmitter noise suppression and receiver isolation rejection levels must be tuned,

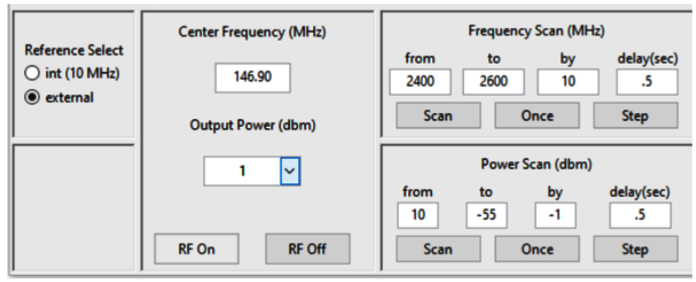


Spectrum Analyzer Settings

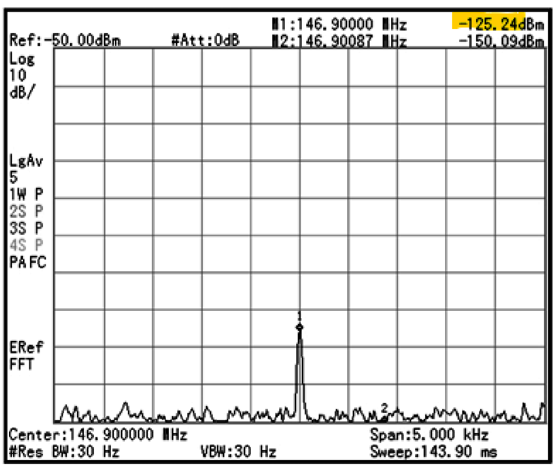
1. Mode Spectrum Analyzer
2. Center Freq. 146.90 MHz
3. Preamp On
4. Att. 0 dB
5. Marker 146.90 MHz
6. Scale/DIV 10 dB
7. Span 5 kHz

RF Generator Setting

1. Output Freq. 146.90 MHz
2. RF Output Level 0 dBm
3. 10 MHz Reference Ext. GPS Standard

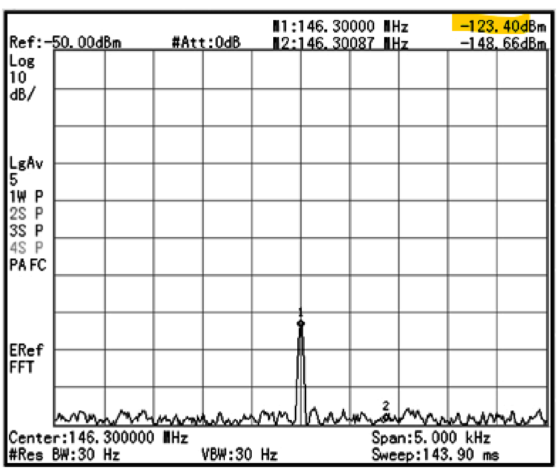


Note: The signal generator must have an output that will supply 0 dBm, have a low spurious level and be well shielded.



This measurement method allows you to determine if the noise suppression and receiver isolation meet the manufacturers specification. As a last resort, you can replace the spectrum analyzer with a 2M receiver, open its squelch and listen for a null. This will not allow you to determine if the rejection level meets the manufactures specifications.

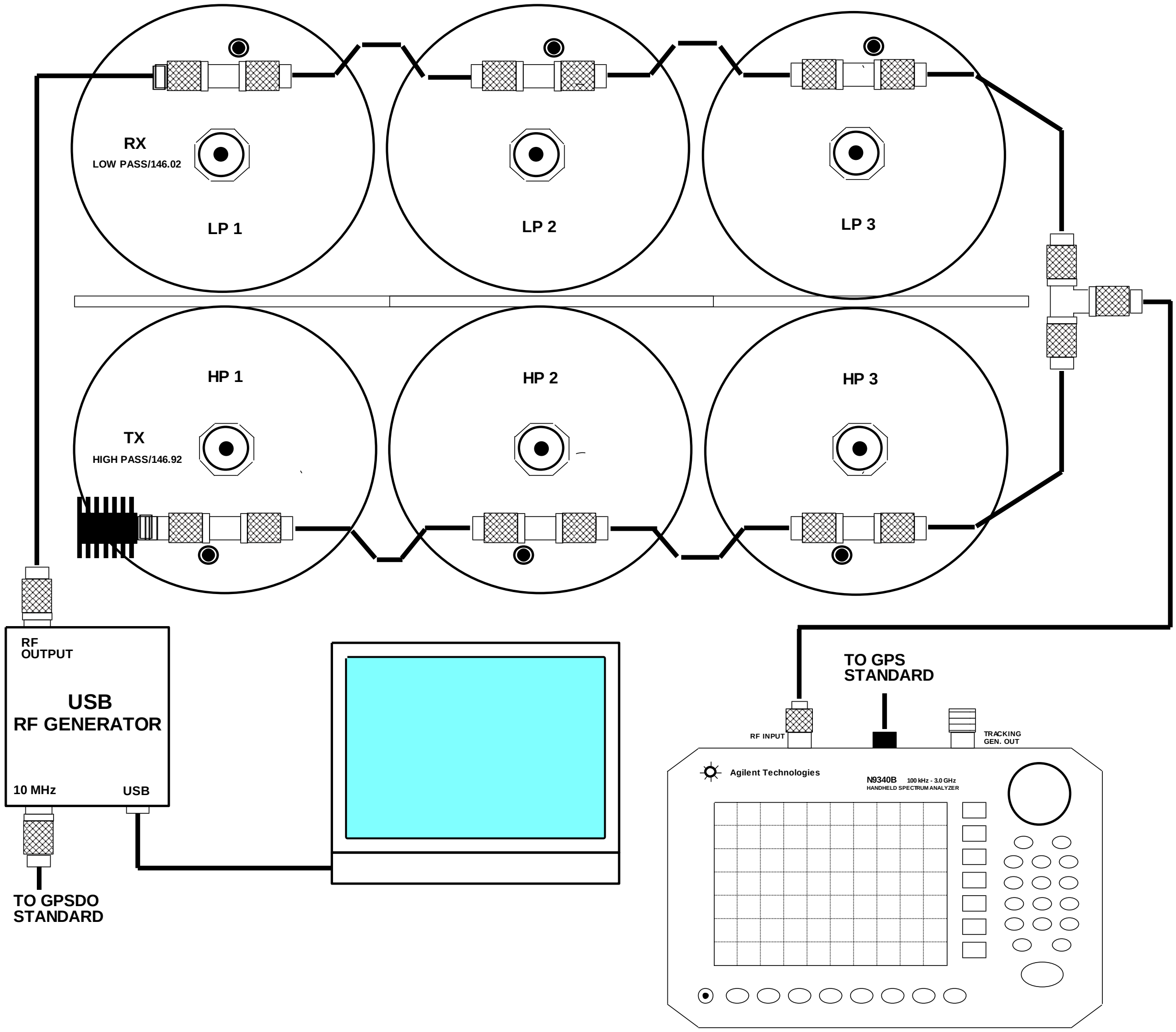
Note: The signal generator must have an output that will supply 0 dBm, have a low spurious level and be well shielded.



The RF generator output is adjusted for 0 dBm so the notch level can be read directly. Since this noise suppression level determines the sensitivity of the repeaters receiver, it's important that the generators be accurate.

The Agilent N9043B Spectrum has a noise floor near 150 dBm at a span of 5 kHz. This is better than you might encounter with other spectrum analyzers. Note: No noise averaging was used during this measurement.

The test setup on the next page is used to measure the receive isolation notch level.



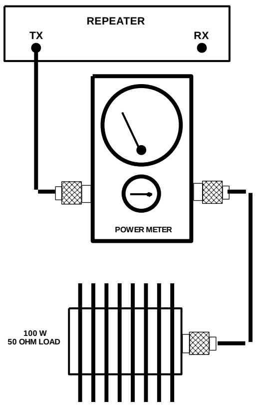
The suppression levels of 125 dB and 123 dB is well below the manufacturers 100 dB specification

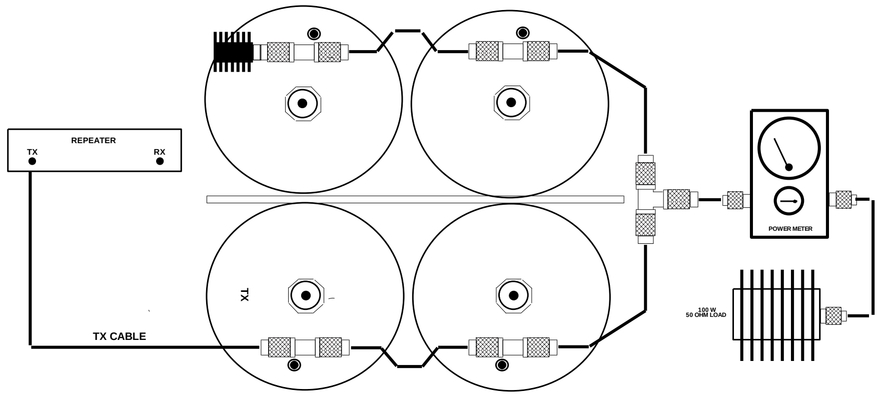
Installing Duplexers

Duplexers are very sensitive to impedance mismatches and the performance of a perfectly tuned duplexer can be destroyed by connecting any device to a port that's not 50 ohms. This requires that transmitter, antenna and receiver impedance tested to ensure they do not detune the duplexer.

Transmitter Impedance: Connecting a transmitter that's not 50 ohms not only detunes the transmit cavities, it also affects the antenna and receive ports. The first clue that the transmitter's output impedance is not 50 ohms is when the power measured at the duplexer antenna port is lower than calculated. If the TX cavity insertion loss is 2 dB and the transmitter output 50W, the power measured at antenna port should be 31W.

Transmitter Test Setup





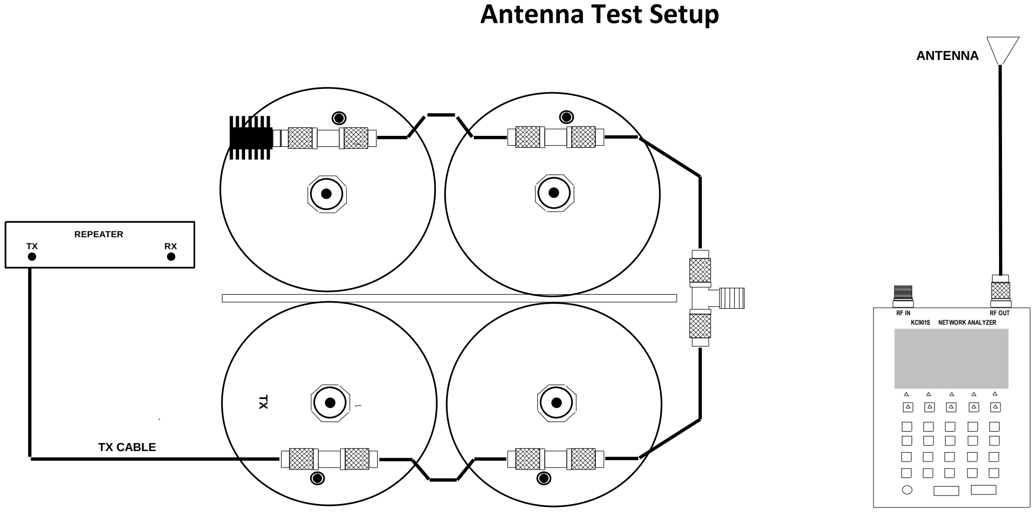
Transmitter Test Setup

Never turn the band-pass tuning knob when attempting to correct an output power problem.
Test the transmitter's output power by measuring the power when connected directly to a 50 ohm load. If you don't know the TX cavity insertion loss, it will need to be measured. The typical insertion loss for a 4 cavity duplexer is 1.6 dB and 2.2 dB for a 6 cavity unit.

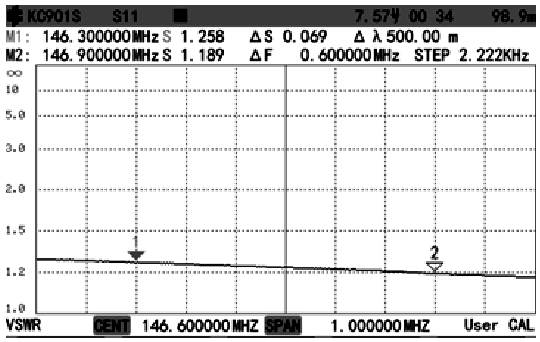
If the transmitter impedance does not match the duplexer insertion loss, you will need to change the TX cable length. The easiest way to change the cable length, is to add connector adapters until the correct output power is obtained. Then make a new cable that is equal to the modified cables length.

Antenna Impedance Test: There's several ways to measure the antennas characteristics, but the best way is with a VNA. The VNA allows you to make measurements without adding any additional feedline which very important. In this case, I measured the characteristics of a Ringo Ranger antenna and set the markers at 146.90/30 repeater frequencies.

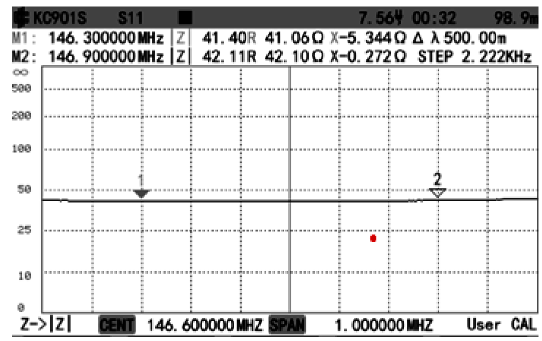
Antenna Test Setup



Looking at the antennas VSWR, the 146.30 MHz (RX) frequency reading was **1.258:1** which would be considered as good value if it was connected to your mobile radio. The impedance measurement shows that the impedance 41.0 and 42.1 ohms, which not be a impedance match for the duplexers antenna port.

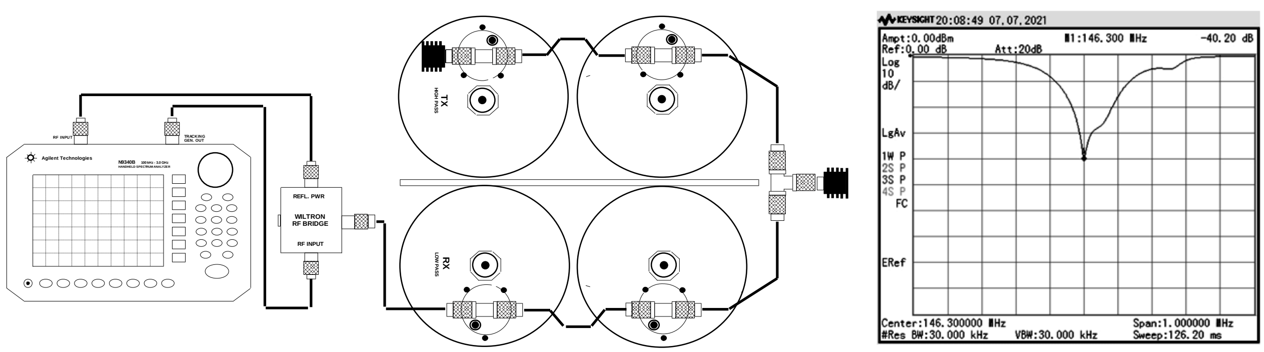


VSWR

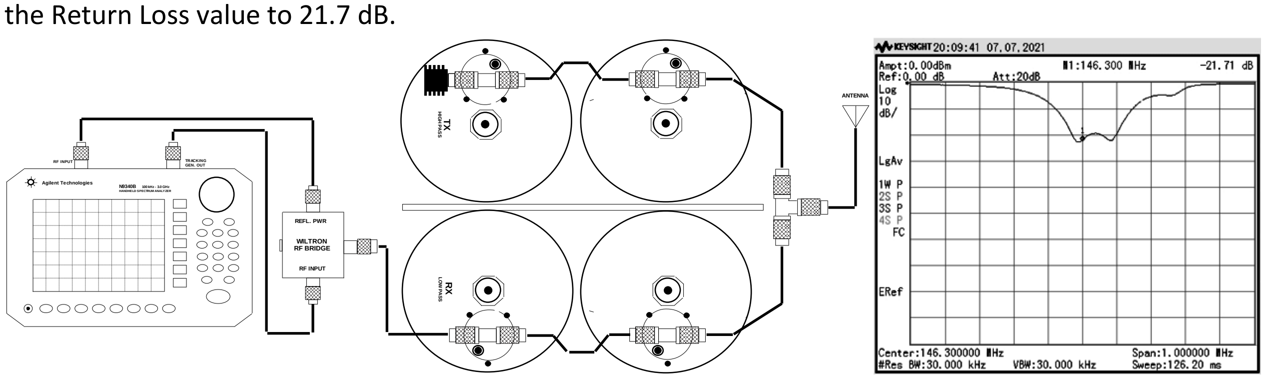


Impedance (Z)

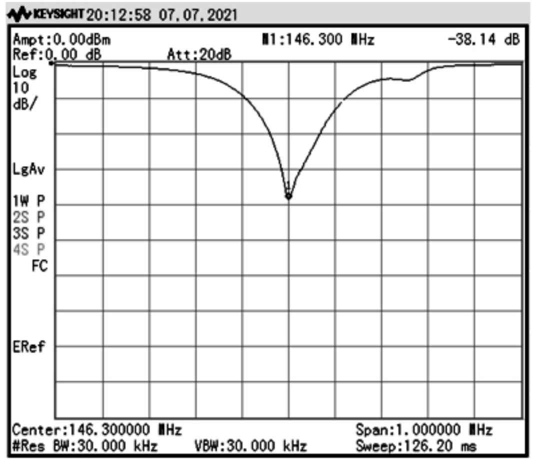
Receiver Port Impedance Test: The duplexer's antenna port was terminated with a 50 ohm load and a Return Loss Bridge was used to measure the RX port value. This test showed RX port Return Loss as being 40.2 dB with 50 ohm load which equals to a VSWR of 1.02:1. and an impedance of 51 ohms.



Replacing the 50 ohm load with the antenna not only caused a change in Return Loss response, it reduced the Return Loss value to 21.7 dB.



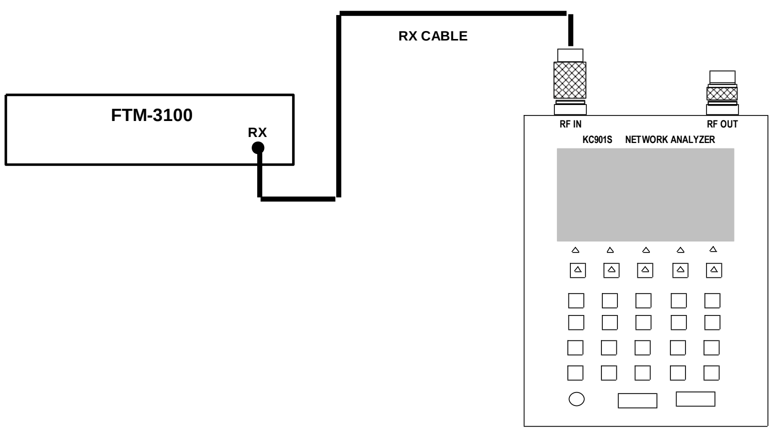
The screen plot below shows the results of adding 12.5 inches to the antenna feedline, the duplexers tuning was restored and the Return Loss was 38.14 dB. Note: Page 9 of this documents explains how the impedance of a coaxial cable can change when not terminated with 50 ohms. In this case, this phenomena was used to correct the impedance mismatch.

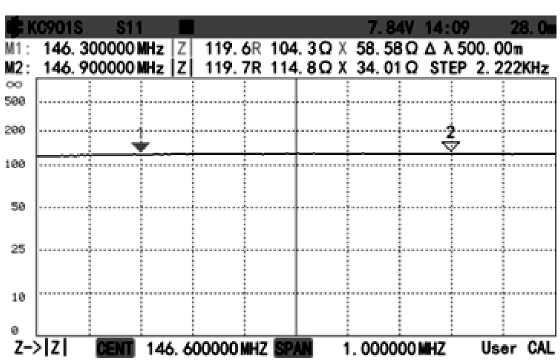


Receive port Return Loss with the antenna feedline length increased by 12.5 inches.

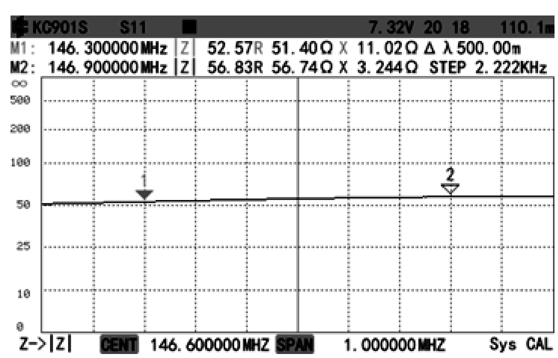
Receiver Impedance Test: Repeater manufacturers and amateur radio repeater builders are using a standard mobile transceiver as their receiver. This simplifies the repeater design, but these types of receivers are usually designed to cover a broad frequency range without any tuning. I've found that these receivers have a broad impedance range also, which can detune the duplexer. The test setup below can be used to select a receiver cable length that will provide the duplexer RX port with the correct impedance.

This test setup is used to test a Yaesu-3100R/E Transceiver. The transceivers manual specification section did not list a spec for the receiver input impedance.





36 Inch Cable



44 Inch Cable

Connecting the Yaesu transceiver to the duplexer RX port with a 36” cable would destroy the RX cavity tuning and result in weak signal receiving problems.   The 44” cable would provide 52.5 ohm match to the RX port at the 146.30 MHz RX frequency.

End of Document

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