AMATEUR REPEATER DESIGN

The design of amateur radio repeaters have changed in recent years. The BridgeCom BCR-50V repeater I recently purchased (see Figure1) allows you to program the repeaters transmit and receive frequencies, plus select the output power level. Notice that two Maxon mobile transceivers were used for the repeaters receive and transmitter. The use of mobile transceivers has become common practice in recent amateur repeater designs. They have eliminated the need for you to purchase crystals for the repeaters transmit and receive frequencies. Transceivers also have broadband receive and transmitter circuits that require no tuning. Previous repeater designs used narrow circuits that were tuned to the crystals frequency.

Figure 1

Most amateur repeaters use a single antenna and this requires that repeater be connected to a duplexer to accomplish this. What hasn't changed in recent years is the duplexer. Duplexers are purchased from the manufacture already tuned for the repeaters receive and transmit frequencies. Why are duplexers purchased already tuned? They are tuned with vector network analyzers (VNA) that have a high dynamic range of 130 dBm. This is not an instrument that's found in most amateur's tool box. Sorry, the Nano VNA dynamic's range is only about 60 dBm!

Duplexer tuning is also very sensitive to the impedance that's connected to any of its four ports and these broadband mobile transceivers don't always provide this required 50 ohm impedance. If you are having performance problems with a repeater that's using mobile transceivers, it's probably because the duplexer is being detuned by an impedance mismatch.

Icom ID-RP2000v - After this repeater was installed, amateur's complained that they could hear the repeater, but was having problems reaching the machine. My first test was to determine receive duplexer's insertion loss. See Figure 2. Connecting a VNA to the duplexer's antenna port and measured the return loss (RL) with the receiver's cable connected to a 50Ω load. The RL measured 27 dB which equals to a match efficiency of 99.8%. The 50Ω load was disconnected from the receiver cable and the receiver was attached to the duplexer cable. The RL measured 5.7 dB which equals to a match efficiency of 73.08%. The receiver's 25.53Ω impedance caused a 46.08% loss in the receive efficiency. Note: This type of test only checks the duplexer's insertion loss and receiver characteristics.

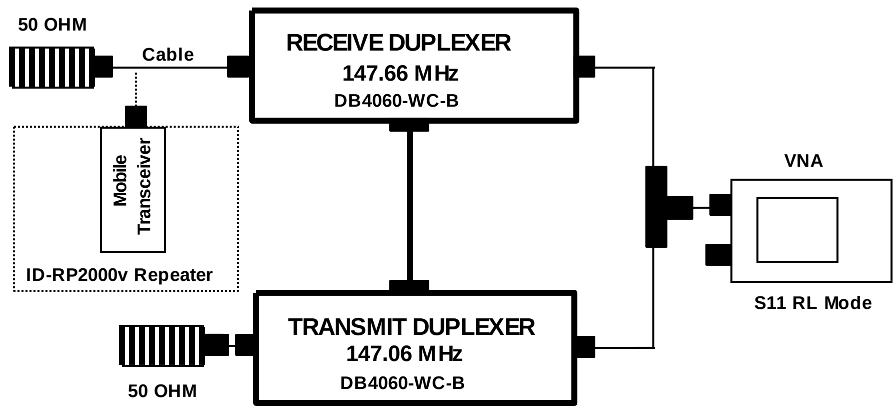


Figure 2

Figure 3 shows how a pre-amplifier was used to correct the impedance mismatch between the mobile transceiver and duplexer, it also improved the receiver's sensitivity.

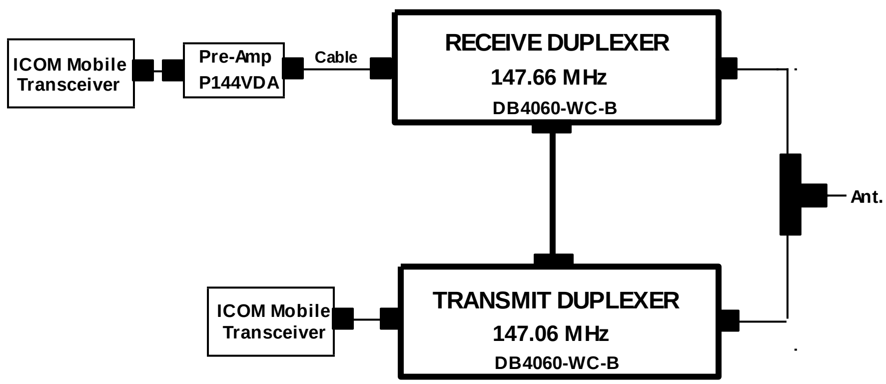


Figure 3

The following repeater is another example of how using mobile transceivers with their broadband circuits can cause problems when the repeater is attached to a duplexer. This repeater happens to a homebrewed version, see figure 4.

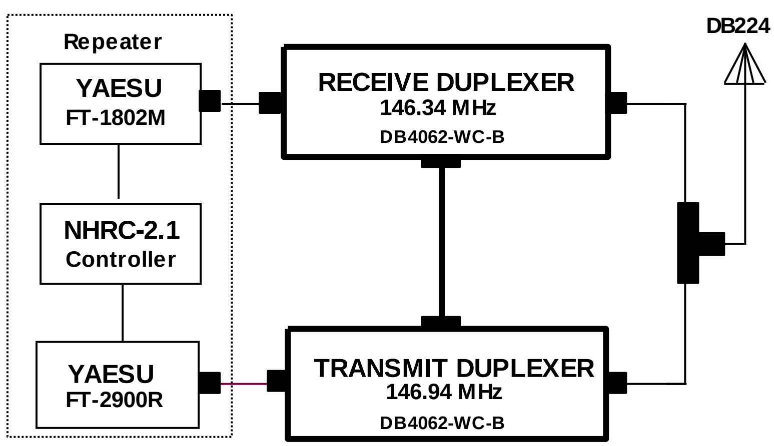


Figure 4

This repeater was having some noise and duplexer problems. The receiver impedance measured 18 +j9 ohms, so a pre-amp was installed to correct the impedance mismatch to the duplexer. In this case, the pre-amp increased the receiver's sensitivity to -134 dBm (0.045 µV), which also increased the noise problem. The FT-1802M has a sensitivity -120 dBm (0.21 µV) which is better than most commercial repeaters, so it was decided to use tuner to correct receiver high impedance problem. John Keith (W5BWC) designed and built a tuner that solved mismatch problem. The repeater site is located on a mountain where other commercial radios might interfere with the repeater, so a bandpass filter was added to the receive system. Figure 5 shows what this repeater duplexer receive input looks like.

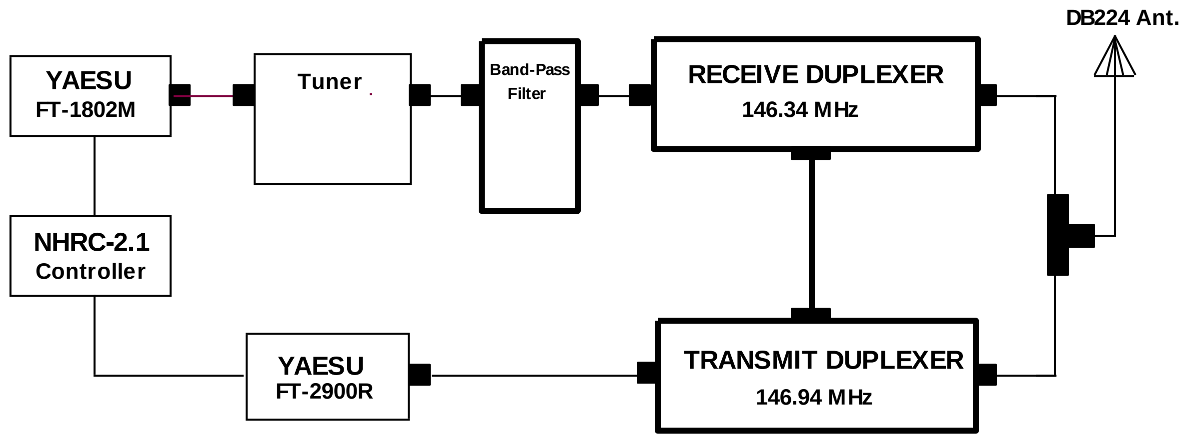


Figure 5

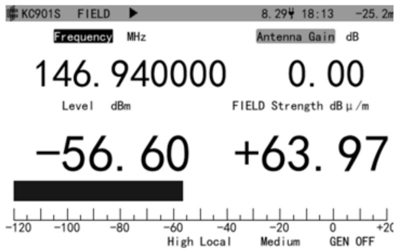
This repeater configuration made sure that receive duplexer cavities see a 50Ω impedance, but every time the weather made major temperature change, the repeater would start having noise problems. The building where the repeater was located has no temperature control. This type of problem usually occurs when the duplexer is not suppressing either the transmitter's white noise or the transmitter's frequency is descending repeaters receiver. Retuning the duplexer would usually cure the noise problem until the next weather temperature made a major change.

During one of my duplexer retuning procedures, I discovered that the FT-2900R transceiver's transmitter impedance was detuning the duplexer receive cavities. The receive cavities are responsible for suppressing the transmitters output power which can desense the repeaters receiver. Measuring the transmitter's output impedance is not very easy task and correcting the transceivers transmitter's output impedance would be a challenge. To verify that the FT-2900R mobile transceivers transmitter's output was detuning the duplexer, the duplexer was retuned. The duplexer transmit suppression value was 119 dBm and the receive cavities provided 114 dBm of suppression.

Figure 6 shows the method used to measure how much of the transmitters 18.5W (42.7 dBm) was being seen by the repeaters receiver. This measurement method was also used to adjust the receive cavities for maximum transmitter power rejection. Note: The cavity rejection adjustments do not affect the duplexer cavities insertion loss, so the receiver's sensitivity is not changed by these adjustments.

The initial reading showed that the receiver was seeing -56.6 dBm (**334.4 µV**) when the repeater was keyed. The cavities were adjusted when the repeater was keyed and the value was-85.0 dBm (**12.57 µV**).

My VNA’s Field Strength mode was used during these measurements. You could use a spectrum analyzer if its sensitivity range meets the requirements.



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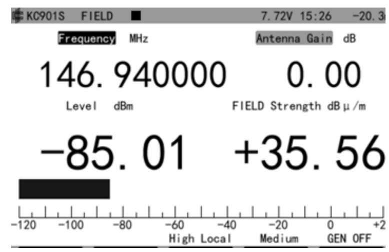

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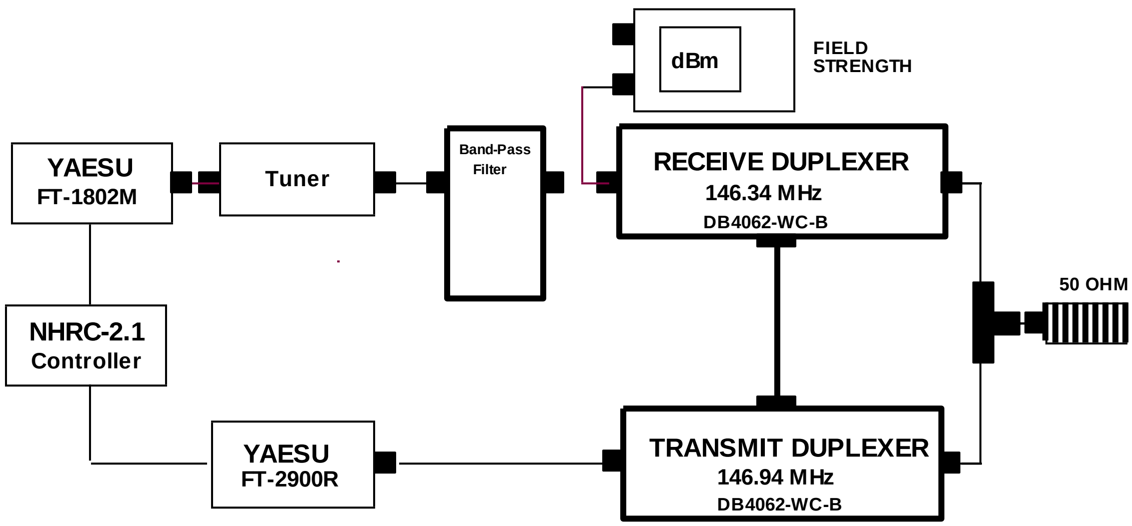

Figure 6

Apparently the 334.4 µV is very close to this receiver’s desense threshold and any small change to the receive suppression level would cause noise problems. At 12.57 µV, the transmitter should never cause problems.

Summary – The original repeaters narrow band circuits that were tuned for a particular frequency. The first repeater I worked on was a SCR1000 made by Spectrum Communications. The receive circuit had 8 adjustment and the transmitter had 3. They went out of business about 25 years ago, but I still have their service manual. These original repeater designs used separate RF compartments to prevent RF leakage between the receiver and transmitter. I’ve tested a few of these mobile transceivers and the RF leakage was high, so I recommend keeping them separated as far as possible. Most of the transceiver repeater problems I have encountered has been impedance incompatibilities with the duplexer. I’m not against using mobile transceivers in repeater designs, but they do add some new challenges for the repair technician.

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