Duplexer Tuning Using the EAGLE Return Loss Bridge

1.0 Introduction

A duplexer allows the simultaneous operation of a transmitter and receiver with a single antenna. The duplexer provides enough attenuation of the transmitter signal, and transmitter parasitics, to prevent overloading or desense of the receiver. A duplexer is divided into a transmit and receive section. The duplexer has three ports they are the Antenna port, TX port and RX port. A properly tuned duplexer meets the following requirements:

1. Transmitter to Antenna port-minimum loss at transmitter frequency.
2. Transmitter to Antenna port-maximum loss at receiver frequency.
3. Antenna to receiver port-minimum at receiver frequency.
4. Antenna to receiver port-maximum at transmitter frequency.
5. Return Loss better than 15 dB @ respective ports and frequencies.

While duplexers are factory tuned, in most cases, field retuning sometimes necessary. This may be because of aging, or to set up on new frequencies. Duplexer manufacturers often use RF network analyzers to set up duplexers. This type of equipment is not often found in a two-way shop so technicians resort to using signal generators, spectrum analyzers, wattmeters, general coverage receivers and who knows what else.

With the advent of modern communications service monitors, which include a spectrum analyzer/tracking generator, it is now possible to do swept measurements of duplexers with something two-way shops already have. With the addition of the EAGLE return loss bridge reflection measurements can also be made. This makes retuning duplexers quick and easy!

2.0 Equipment Setup

This application note assumes that you have a communications service monitor that is equipped with a spectrum analyzer and tracking generator. In order to accomplish the reflection measurements a return loss bridge is also required.

You will also need three coaxial cables with the proper connector, a coax feed thru and a termination. The termination, when checked with the bridge, should yield 30 dB of return loss or more at the frequencies of interest. All of this equipment is available from EAGLE in our standard bridge kits. It is recommended that the cables be of the double shielded type. Adaptors, if used should also be high quality and in good condition. If possible adaptors should be avoided. EAGLE also makes cables that have different connectors on each end to avoid the use of adaptors.

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2.0 Equipment Setup-continued

There are two types of setups that will be used to measure the duplexers. The first one, illustrated in figure 2.1, will use the tracking generator hooked thru the duplexer to the spectrum analyzer in the service monitor. This one will be used whenever the stop band of the duplexer is being measured.

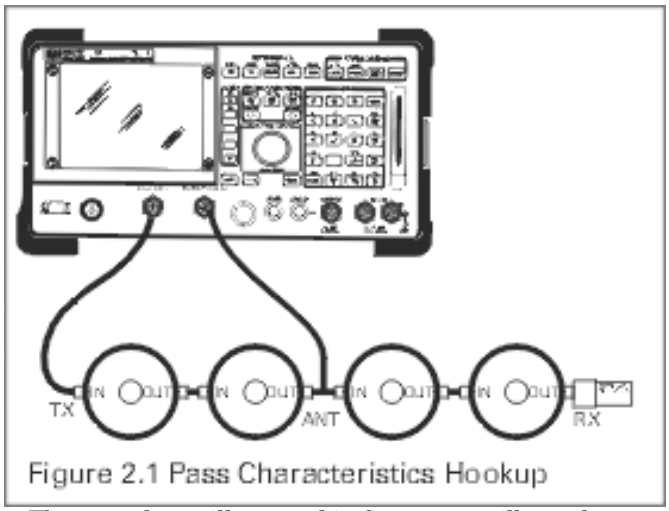

Figure 2.1 Pass Characteristics Hookup

The second one, illustrated in figure 2.2, will use the return loss bridge and will measure the reflected power of the duplexer. This one will be used when the passband is being tuned and to measure the reflected power (return loss) in the passband.

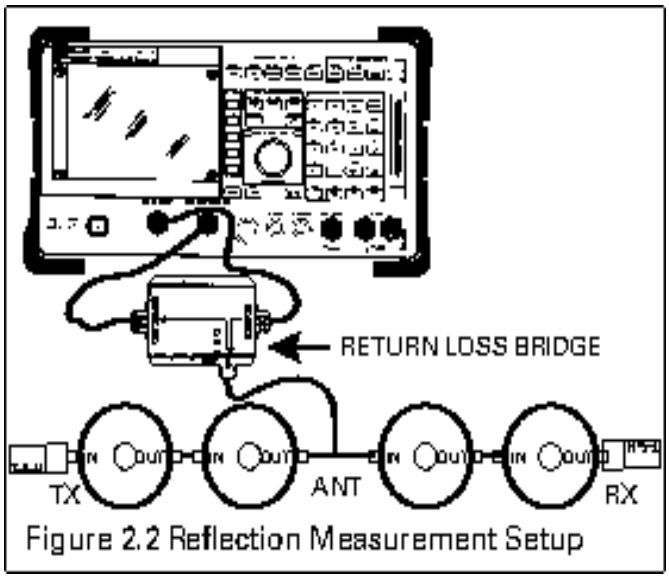

Figure 2.2 Reflection Measurement Setup

Should you not be familiar with return loss measurements and the use of The return loss bridge please refer to EAGLE application note: Return Loss Bridge Basics This is located o our website at:www.eagle-1st.com/notes/note_toc.htm This note covers return loss basics. It shows how to hook the bridge up and what the measurements mean.

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3.0 Tuning the Duplexer

Before testing or tuning the duplexer consider this first: is this a new unit that I want to verify, a new unit that I want to retune, a unit that has been removed from field service that needs tuning to a different frequency or a defective unit removed from service from repair? The answer to the above question will determine your next course of action. If it is anything other than removed from service for repair you can consider that there is no problem with it and just follow the instructions for retuning. If, however, the unit was removed for repair it is probably defective in some way. In that case go directly to troubleshooting section (section 4.0) and after you have either determined that there is no problem or fixed the problem than return here.

The first thing to do is verify that the duplexer is functioning properly before you attempt to tune it to another frequency. If you are dealing with a duplexer because it is not functioning properly than the first thing to do is to isolate the problem and fix it. It makes no sense to attempt to tune or retune a duplexer that is broken Now you are probably asking, "Well, how do I know that the duplexer is OK?" To answer that lets hook it up and test it. But the first time through do not adjust it to your new frequencies. Just verify that it is working on its present frequencies. For troubleshooting techniques refer to section four in this document. **General Information** When installed the transmitter, receiver and antenna are connected to the obvious ports. In our tests each port will be connected to something; therefor if you are running a test and one of the ports is not connected you are doing something wrong.

Analyzer Operation

For operation of your analyzer refer to the instruction manual supplied with the instrument.
References to the equipment are as follows: the generator refers to the signal generator or tracking generator port of the service monitor. The analyzer refers to the spectrum analyzer contained in the communications service monitor.
Insure that the instruments are calibrated as per section 2.0 for each test. This nulls out errors associated with cable losses and inaccuracys in the instrument itself. Refer to operators manual for your instrument.
Adjust the analyzer so that the span covers both the transmit and the receive frequency of the duplexer. Lets assume TX is 144.1 and RX is 144.7 In this case set analyzer for 144-145 MHz sweep.
Connect the generator to the analyzer using the coaxial female/female adaptor. Use memory feature to zero out errors.

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3.0 Tuning the Duplexer-continued

Transmitter Section

You can do either section first but the transmitter section has been chosen. Once choosing a particular method it is usually good to stick to that one.
First terminate the RX port with the 50 ohm terminator.
Second connect the generator to the TX port.
Third connect the analyzer to the Antenna Port.
Note: if easy to do disconnect the receive section from the antenna port initially.
Look at screen and observe position of the notch and the pass. Adjust the notch for the proper frequency (this would b the receive frequency.)
Note: If you can't find the notch or the pass increase the spa until you find these. Then course tune both of these to the approximate frequency and decrease span. Make sure you recalibrate if required.
Next, adjust the pass using the pass adjustment of the duplexer. Refer to duplexer manual for information. At this point do not worry too much about getting this exact at this point.
Reconnect the receive section, if it was disconnected and not if notch changed. If it did readjust to proper frequency.
This completes the TX adjustments for the moment.

Receiver Section

Remove the termination from the RX port
Remove generator from TX port and connect to RX port
Connect the termination to the TX port
Adjust the notch so that it is on the TX frequency. Use procedure above if the notch is not in the span of the analyzer.
Adjust the pass so it is on the RX frequency, or close to it, thi will be taken care of in the next step.

Passband Finetuning Connect the bridge to the analyzer as shown in Figure 2.2.
Connect the DUT port to the Antenna port on duplexer.
Terminate the TX and RX port on the duplexer.
Note: it is best to use a coaxial adapter to connect the DUT port of bridge to Antenna port. This will give a better indication of true return loss of this port.
The sweep will show return loss notches at the receive and the transmit frequency. Remember since this is showing hov much power is being reflected a low reading is good. By carefully adjusting the TX section you will notice that the notch at the TX frequency will get shallower and deeper. Adjust the TX side for the deepest notch. Repeat the same with the RX side.
When finished with this then hook up as above to insure that nothing has changed in regard to the RX notch in TX side and TX notch in RX side.
This completes the tuning of the duplexer.

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4.0 Troubleshooting Duplexers

Determine History of Duplexer

When troubleshooting a duplexer the first step is to consider where this particular duplexer came from. If it is a brand new unit the most effective procedure is somewhat different then a unit that has been returned from field service

Determine the exact problem

Connect the duplexer and determine if the problem affects just one side or both sides.

If the problem affects both sides either there is a lot wrong with the duplexer or it is going to be very simple. The simple solution is the "Tee" junction is shorted or open or one of the coax's from the TX or RX side to the "Tee" is shorted. Check for these things first. If the problem is just one side then you can eliminate the entire other side. At this point disconnect the bad side and verify that the good side is 100% OK before proceding.

Remember too that duplexers are very symmetrical in their construction. They are basically a filter that has a bandpass charecteristic with a notch on one side of the curve. The typical VHF/UHF unit consists of either two or four cavity or helical resonator type band-pass filters.

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4.0 Troubleshooting Duplexers-cont

Unless blasted by lightning it is unlikely that one of the filt units itself has failed. Therefor, with a new unit you can almost rule out a problem with a cavity. With a new unit verify that all of the coaxs work. Remove them from the system and use your Analyzer to measure them. Don't rely on an ohmmeter as they may be ok at DC but have some od problem at the operating frequency. When you have the coa connected exercise it to make sure that it is not intermittant. Remember someone else probably tested this assembly and found it good.

Next, with the coaxs disconnected inspect the cavity connectors. Insure that the center pin is in place and there is no foriegn matter.

The next step is to test each cavity. It should have a pass anc notch somewhere increase the span of your analyzer to 10% of center frequency. If you don't find a notch and a pass ther you're dealing with a bad cavity.

If the pass or notch are not on the desired frequency then simply retune the cavity to the proper notch and pass using the same procedure as above. Then reconnect the cavity anc retest the duplexer.

There may be other obscure problems that can occur with duplexers but the above problems will cover trouble areas in about 90% of the cases.

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19 Jun 2004 css-a