



Application Note:

Duplexer Tuning with the Freedom Communications System Analyzer

FCT-1005A

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Introduction

Duplexers isolate RF transmitters and receivers connected to a common RF line or antenna. A Duplexer passes transmitter power at one frequency while preventing it from reaching a receiver tuned to a different one. Signals propagating at the receiver frequency are blocked from reaching the transmitter. This is accomplished with a variety of filtering devices and hookup configurations. Filter elements include band-pass, band-reject, and notch types implemented with sharply tuned resonant circuits. Hookups incorporate multiple individual filter elements chained together to determine which signal frequencies can propagate down a particular RF path. Several elements can also be combined into one device housing, such as a pass-reject filter. A typical Duplexer configuration is depicted in Figure 1.

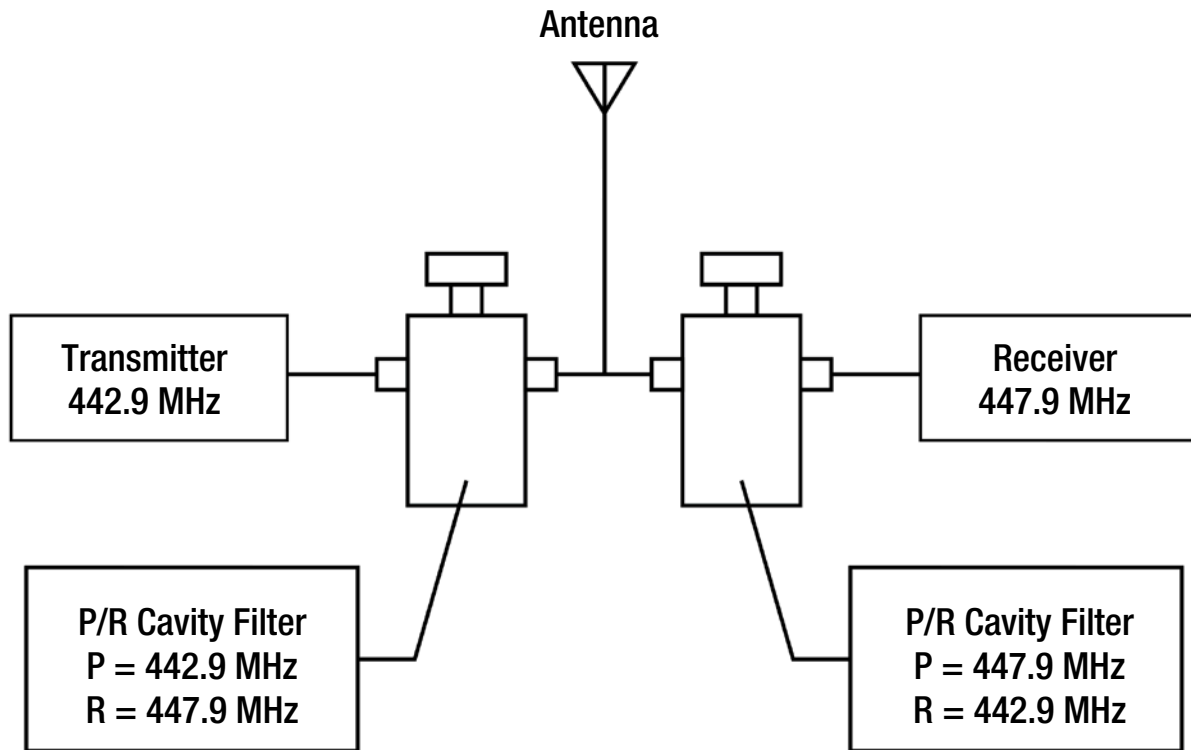


Figure 1 – Typical Duplexer configuration using Pass-Reject cavity filters

This application note focuses on tuning a pass-reject Duplexer filter using the R8000 analyzer. The settings and measurement results illustrated are similar for other individual Duplexer filter elements or configurations that include them in a combined RF path. It is assumed that the operator of the R8000 is familiar with general operation of the analyzer and the specific test requirements for the duplexer under test. Refer to the R8000 Operator's Manual for additional information.

Test Overview

The R8000 Tracking Generator Instrument provides a convenient way of aligning individual Duplexer elements, multi-element sections, or entire RF signal paths. This function sets up the R8000 RF generator in a sweeping mode for simultaneous use with the Spectrum Analyzer display. The Spectrum Analyzer is lock stepped with and tracks the Generator frequency. The R8000 then displays a response curve over the frequency range of interest.

An overview of testing a Duplexer using the R8000 is as follows: RF power from the Generator side of the R8000 is applied to one port of the Duplexer filter element or RF path under test. The Monitor side is hooked to the other port. In a 3 port configuration the port for the untested path is terminated with a resistive load to match the transmission line impedance - typically 50 or 75 Ohms. The Tracking Generator frequency range and RF power are set appropriately for the Duplexer

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element or path being tested. The Display scale is adjusted to center the response vertically, and markers are placed at critical tuning frequencies.

Once the response curve is displayed on the R8000, the tuning adjustments for the Duplexer are manipulated to get the desired response curve. In the case of a pass-reject filter the displayed curve shows a peak at the pass frequency and a valley at the reject frequency. Generally this filter has two adjustments with some degree of interaction. Several adjustments are usually needed to set an acceptable insertion loss at the pass frequency, while providing the required “notch” depth at the reject frequency. The simultaneous display of both these parameters on the R8000 provides quicker tuning as compared to older techniques using stand-alone RF generators and signal detectors.

Test Setup

Figure 1 shows the R8000 hookup for testing an individual pass-reject cavity filter. To maximize S/N for the measurement use the RF Gen Out and Antenna ports for the Generate and Monitor sides of Tracking Generator operation. The ports on the cavity filter may be labeled for a specific connection, and if so follow that convention – i.e. hook the RF Gen Out port on the R8000 to the Transmit/Input port on the cavity. Otherwise they can be treated as symmetrical connections.



Figure 1 – Hookup to test a Pass-Reject cavity filter on the R8000 analyzer

Test Procedure

Set the R8000 configuration as follows:

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- Press the blue “Instrument” hard key and select “Tracking Generator”.
- Select “Start Frequency” and set to the lower end of the test frequency range. Ex:
 - 440.000 MHz.
- Select “Stop Frequency” and set to the upper end of the test frequency range. Ex:
 - 450.000 MHz.
- Select “Reference Level” and set for desired view considering the maximum peak response of the filter. Depending on the expected peak insertion loss a good starting point is a level equal to or greater than the Output Level (set later in this procedure). Ex: 0 dBm.
- Select “More 1 of 4”. The default values for “Vertical Scale”, “# of Points”, and “Display Mode” are 10 dB /div, 200, and Normal, respectively. These values work well for typical alignments but adjust as necessary to suit display viewing requirements— see R8000 Operator’s Manual.
- Select “Markers” and set to “Absolute”. Then press “Select Marker” and choose
- “1”. Using the Tuning Knob adjust the marker position to the pass frequency for the filter. Ex: 442.7 MHz. Select marker “2” and adjust the position to the reject frequency. Ex: 447.9 MHz.
- Select “More 2 of 4”. The soft keys on page 3 are marker navigation related and speed the measurement process once an initial response curve is displayed.
See R8000 Operator’s Manual for additional detail.
- Select “More 3 of 4”, and then select “Output Level”. Adjust the level to ensure adequate signal propagates through the filter to produce a noise free response. Ex: 0 dBm
- Select “Attenuation” and adjust to ensure the RF Monitor Antenna port isn’t overdriven. Ex: 20 dB. The combination of Output Level and Attenuation setting must meet the following requirement: (Output Level – Attenuator setting) is equal to or less than -20 dBm.
- Leave the Preamplifier off unless lower parts of the response are noisy. When used the combination of Output Level and Attenuation setting must meet the following requirement: (Output Level – Attenuator setting) is equal to or less than
 - -40 dBm.
- Select “Gen Port” and set to “RF In/Out”. Select “Monitor Port” and set to
- “Antenna”

Once the initial configuration is set the R8000 should display a response curve similar to that of Figure 2.

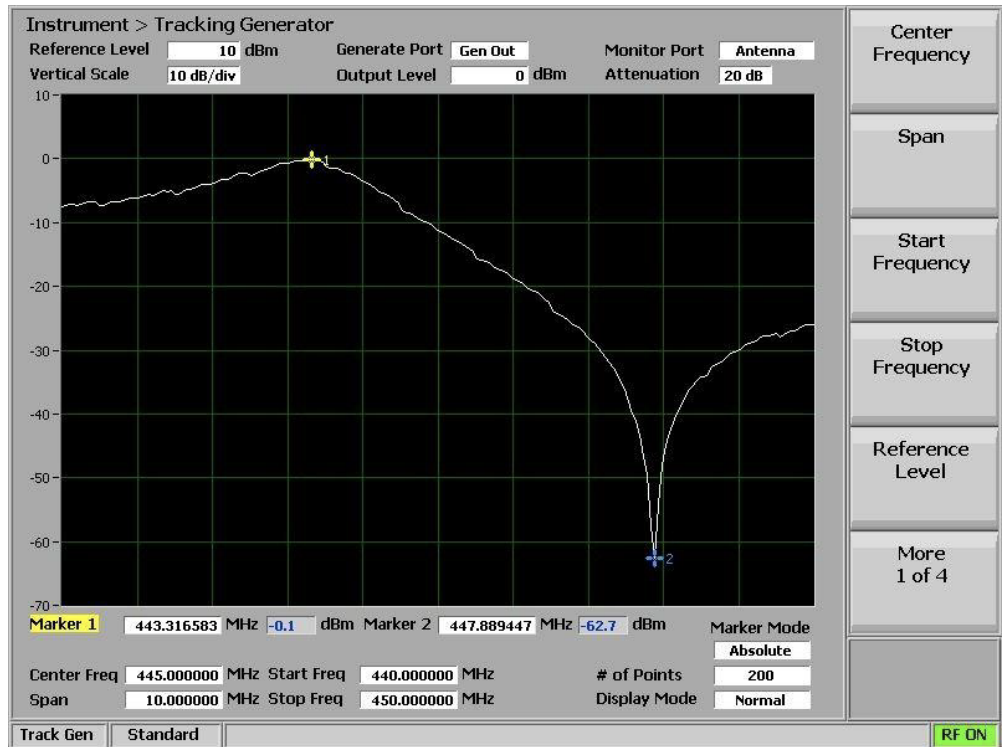


Figure 2 – Pass-Reject cavity filter response on the R8000 analyzer

If the response curve doesn't match the Duplex manufacturer's specification then tuning adjustments are used to align the filter. On combined Duplex pass-reject filters these adjustments interact with each other. The threaded tuning shaft generally shifts the frequencies of the pass band peak and the reject notch simultaneously. However the reject frequency adjustment usually has little effect on the pass band. So the pass band peak is tuned first, and then followed by the notch frequency adjustment.

Working the adjustments back and forth, the response curve peak and valley are aligned to the target frequency points indicated by the markers. The filter is considered tuned when the peak insertion loss and notch depth match the manufacturer's specifications at those frequency points.

This procedure can be used as a guideline for measuring and tuning other filter elements or an entire RF path in a Duplexer configuration. By tuning an RF path the effects of hookup cable length and attached elements can be accommodated for best Duplexer performance. Consult the Duplexer manufacturers specific test details for appropriate use of the R8000 analyzer.