Frequency Checks of the GBT RF/IF/LO System

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1. Test Setup

Frequency checks of the GBT RF/IF/LO system were made on January 18, 2001. The tests were made using the L-band and C-band receivers and the spectral processor. A test tone was generated with LO1B and injected into the RF section of the appropriate receiver. LO1A was used to tune the receiver. The IF signals from the receiver were transmitted to the GBT electronics room on optical fiber drivers, numbers 1 and 3. The nominal setting of the test tone for the L-band receiver was 1420.0068 MHz, and the test tone setting for the C-band receiver was 4500.0068 MHz.

The RF/IF/LO system was initially configured with a glish script (`setups_rcvr1_2.g`). Additional refinements to the system were made through CLEO.

The spectral processor was configured in its total power, spectral line mode with 1024 channels spaced over a nominal bandwidth of 78 kHz, giving a frequency resolution of about 78 Hz. The IF requested of the spectral processor was 250 MHz. However, the IF the machine can accommodate appears to be slightly bandwidth dependent, and the actual IF used by it was 249.9990625 MHz. the machine accepted the 250 MHz IF setting for large bandwidths (e.g. 40 MHz).

The tuning and frequency stability of the RF/IF/LO system were checked as follows. The test tone was first tuned so that most of its power was concentrated into a single frequency channel (number 411) of the spectral processor. The fact that the test tone was found in the predicted channel immediately indicated that the tuning of the entire system is excellent. The frequency of the test tone was then varied in 7 Hz increments on either side of channel 411, and the amplitudes of the signals in channels 410, 411, and 412 were recorded. The total change in test tone frequency was 77 Hz, which was approximately the width of a single frequency channel in the spectral processor.

Ron wrote a CLEO script (`aqdRepeatStub.tcl`) that carried out these tests in an automated fashion.

2. Data Analysis

The data were analyzed with an IDL procedure (`Ttone.pro`). The procedure estimates the shape of the bandpass by passing the raw data through a median filter. The procedure then normalizes the raw data by the estimated bandpass shape. As can be seen in Figure 1, the test tone and any sources of narrowband RFI can be easily identified with the procedure. The test tone appears at a frequency of 4500.0068 MHz. Additional features in the spectrum may be due to a combination of saturating the input of the spectral processor (e.g. intermodulation products) and the boxcar windowing function used in detection (i.e. the equally-spaced harmonics on either side of the tone may be the sidelobes resulting from the Fourier transform of the boxcar window). The units of the ordinate in the figure can be thought of as dB above the receiver's system temperature.

3. Results

Figure 2 shows the results of the test for the L-band receiver. The amplitude of the signal recorded in channel 411 for each test tone setting is shown by the dotted line. Similar data for channels 410 and 412 are shown by the solid and dashed lines, respectively. The amplitude in each channel varies with scan number (test tone frequency), indicating that the spectral processor detected the 7 Hz frequency changes. The maximum signal recorded in channel 411 occurred at scan 5 when the test tone was precisely tuned to the frequency of the channel. Note the symmetry of the channel 411 data about the center of the figure. Also note the mirror image symmetry of the data from channels 410 and 412 about the figure center. The symmetry is further evidence for the excellent tuning of the system.

Figure 3 shows similar data recorded from the C-band receiver. The fact that the spectral processor was able to accurately detect a 7 Hz change in a 4.5 GHz test tone implies that the frequency stability and tuning of the entire system are better than a part in about 10^9.

4. Lessons Learned

The test tone is injected into the receiver at the noise source coupler. This means that the noise source switch must be permanently enabled for the tone to be continuously present in the RF/IF. Enabling the tone can be done through the receiver's CLEO screen by turning on the noise source and disabling the external switching signal for the noise source.

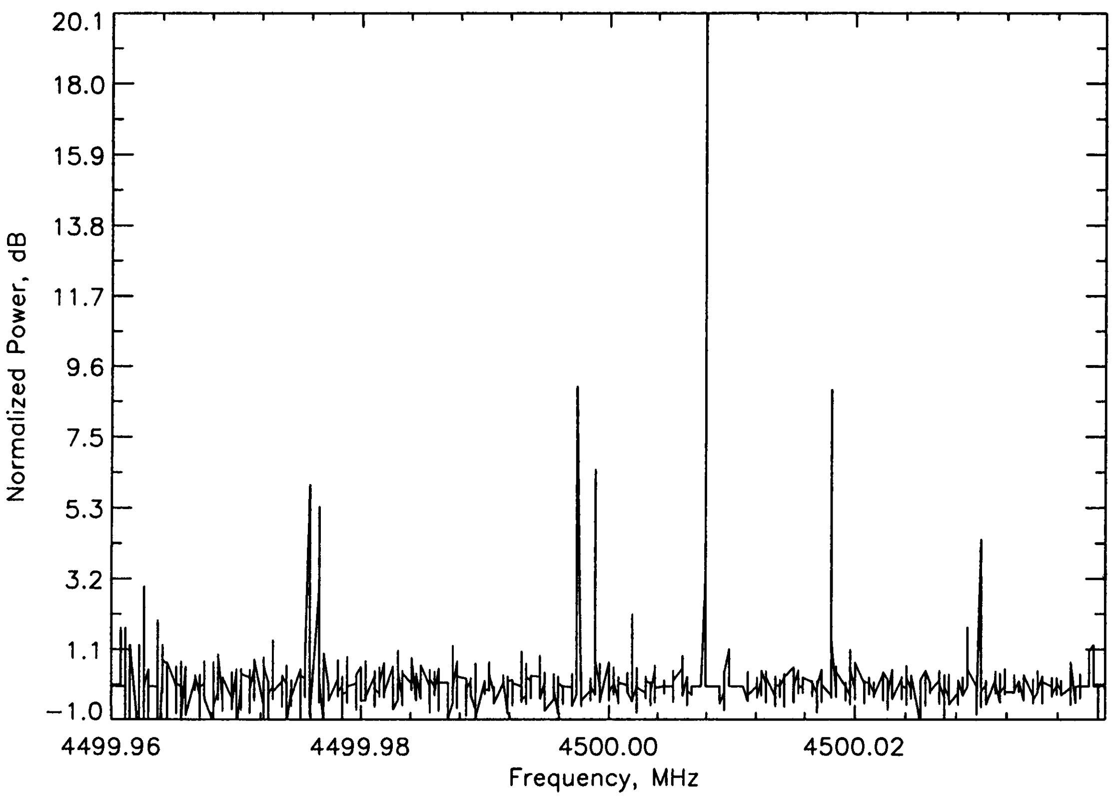

Fig. 1.— Frequency check of the C-band receiver at 4500 MHz. The test tone is located near 4500.0068 MHz. Additional features in the spectrum may be due to a combination of saturating the input of the spectral processor and the boxcar windowing function used in detection.

The data recorded from one IF input to the spectral processor were corrupted. This is supposedly due to a faulty IF switch at optical fiber driver number 1.

The indicated frequency span of the HP 8569B spectrum analyzer that is located in the electronics room is the span per division (e.g. MHz/div) in the instrument's display, and not the span of the entire display.

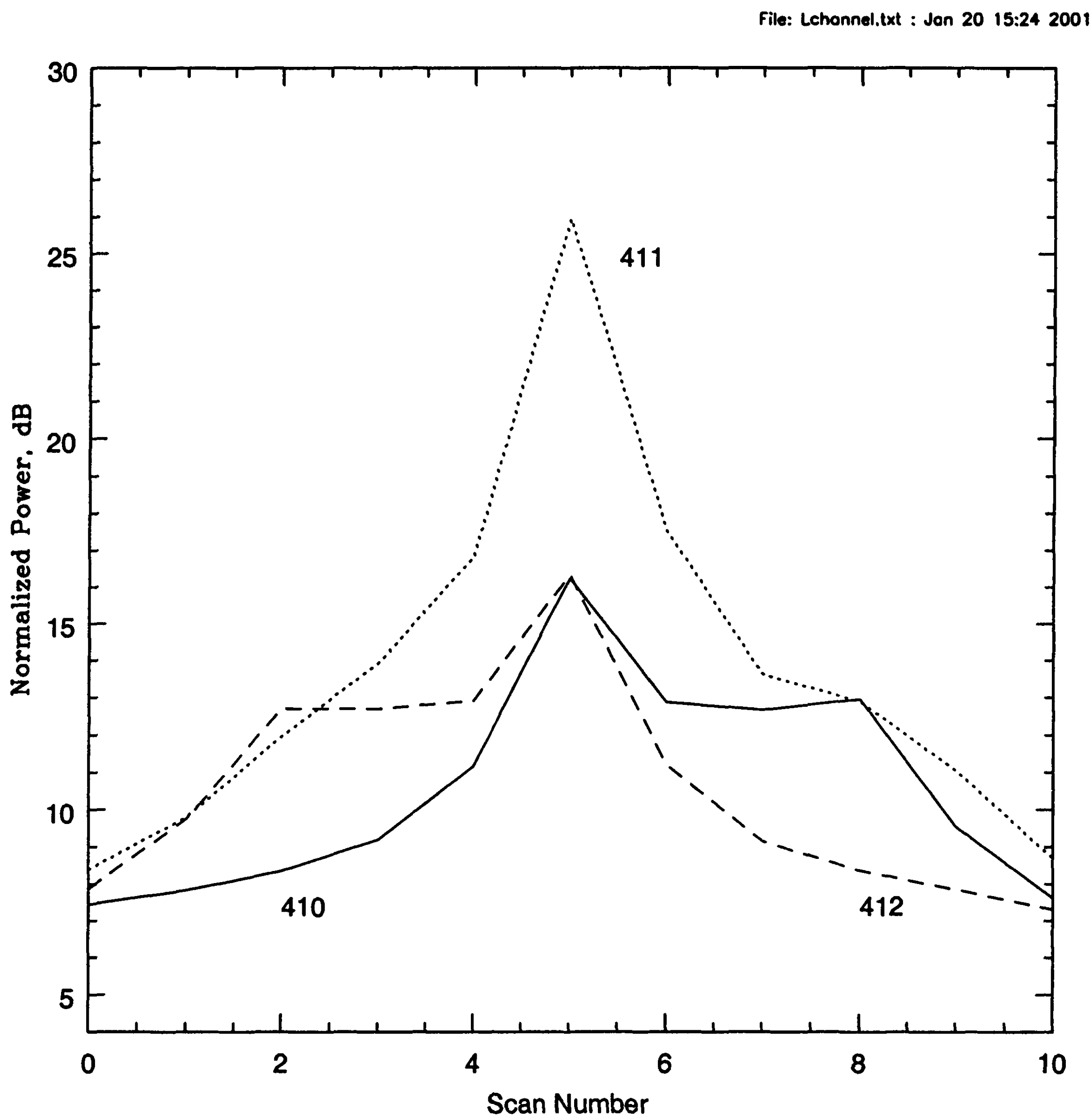

Fig. 2.— Amplitude response at L-band of three adjacent frequency channels (410, 411, and 412) to a change in test tone frequency. Each scan number corresponds to a 7 Hz change in frequency. The nominal frequency of the test tone was 1420.0068 MHz.

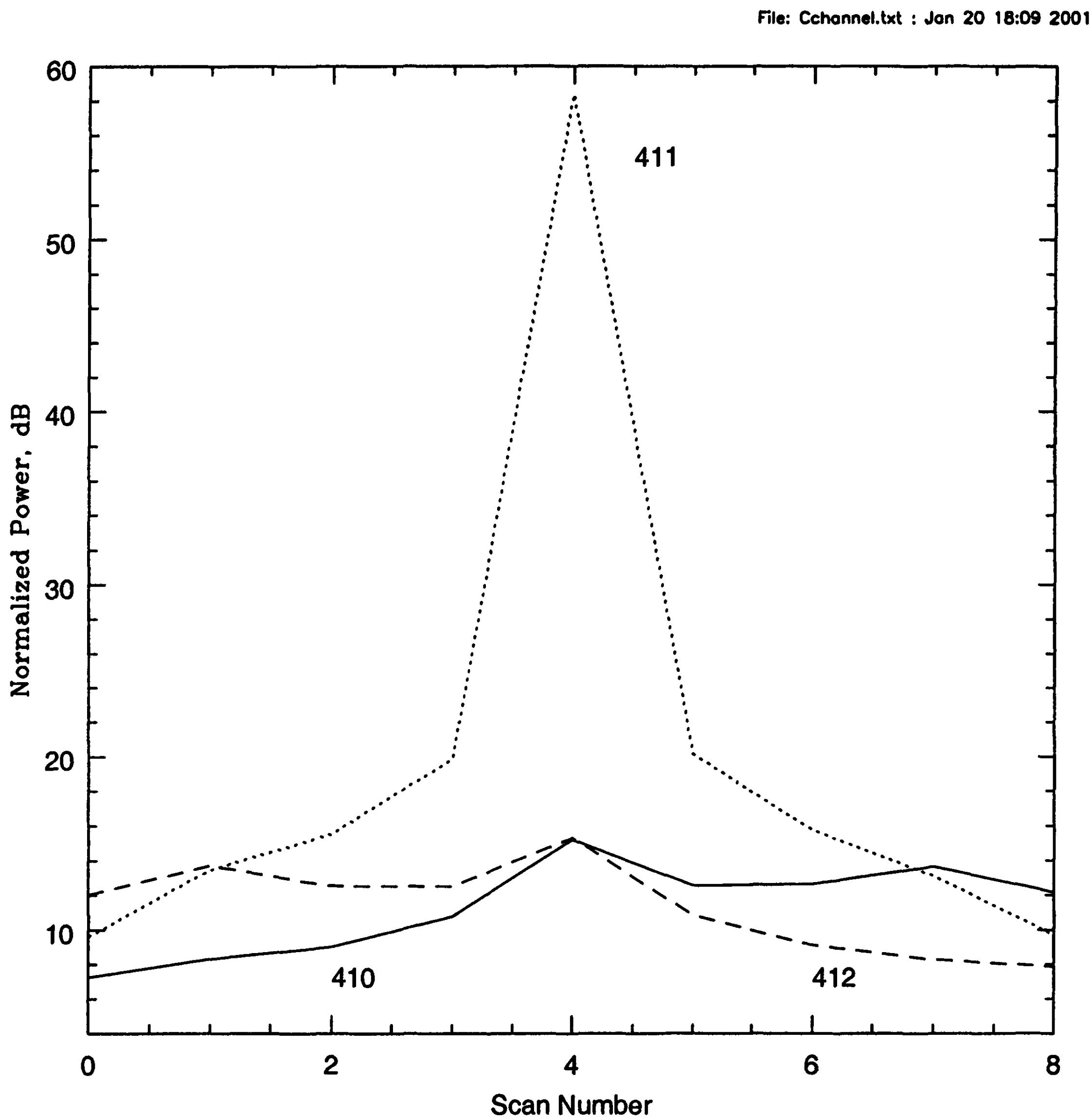

Fig. 3.— Amplitude response at C-band of three adjacent frequency channels to a change in test tone frequency. The nominal frequency of the test tone was 4500.0068 MHz.