

NATIONAL RADIO ASTRONOMY OBSERVATORY  
GREEN BANK, WEST VIRGINIA

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Title:                   **A RECEIVER TEST PROGRAM USING THE  
DIGITAL CONTINUUM RECEIVER (DCR)**

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# A RECEIVER TEST PROGRAM USING THE DIGITAL CONTINUUM RECEIVER

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James R. Coe

## General

The RECTEST program uses the DCR to measure the receiver noise temperature, calibration signal, and gain versus frequency. The Digital Continuum Receiver monitors the receiver output with hot and cold loads on the input. The Universal Local Oscillator can be automatically stepped through the designated test frequencies.

## Receiver Test Set Up

Connect the receiver output to be measured to Channel A of the DCR. The DCR must control calibration signal with the cal on during Phase 0.

To control the ULO the GPIO BUS INTERFACE UNIT (EDIR No. 237, R. F. Bradley) is connected to the ULO with the bifurcated cable. This cable has the ULO connector on one end and the J2 and J3 connectors on the other. The output from GPIO 13, at the rear of the 9826, is cabled to the GPIO input on the GPIO BUS INTERFACE UNIT.

## Preparing a New Disk

A separate disk should be used for each receiver. To prepare a new disk, type in CALL Diskprep. Then press the EXECUTE key.

The Diskprep Subprogram provides instructions for initializing a new disk, storing the RECTEST program and creating the data files.

## The Automeasure Test Procedure

The AUTOMEAS procedure sets the Local Oscillator to the required frequencies and controls the DCR to measure the receiver output. The hot load, cold and then the hot load are connected to the input. Receiver noise temperatures, calibration signal and receiver gain are computed from the measured data. The receiver temperature is calculated using

$$(T_{\text{hot}} - T_{\text{cold}}) / ((R_{\text{cvr\_h}} / R_{\text{cvr\_c}}) - 1) - T_{\text{cold}}$$

Rcvr\_h is the measured receiver output minus the offset with the hot load on the input. Rcvr\_c is the same with the cold load on the input.

The noise calibration signal is:

$$(T_{\text{hot}} - T_{\text{cold}}) * (R_{\text{cvr\_c\_cal}} - R_{\text{cvr\_c}}) / (R_{\text{cvr\_h}} - R_{\text{cvr\_c}})$$

The noise temperature, cal, and gain are plotted versus frequency. A hard copy of the plots or tabulations can be made using the DUMP GRAPHICS or DUMP ALPHA keys.

When the AUTOMEAS procedure is selected the receiver parameters and test frequencies are loaded from the RCVRCHR and TESTFREQ disk files. Then the test load temperatures are entered from the disk file HOT\_COLD.

If changes in this info are made it is stored on the disk. Then the ULO is set to the receiver midband frequency. The program prompts SET ATTENUATORS FOR 5 TO 7 V ON A-VCO ANALOG OUTPUT METER WITH THE HOT LOAD CONNECTED TO THE RECEIVER INPUT. This sets the input level to the DCR. Then the input signal must be removed to measure the DC offsets.

The DCR is set up for two phase operation. Each phase period is .2 second long. The integration time is 5 phase periods or 1 second. The measurements are displayed and stored. Each of the measurements is repeated six times. The prompt RECONNECT INPUT TO CHANNEL A is displayed. The program then converts the first test frequency and sets the ULO output as required. It measures the receiver output, subtracts the offsets, and stores the cal on (Phase 0) and cal off (Phase 1) data for three integrations. The program sets the frequency and measurements are made until all the frequencies have been covered.

The program prompts CONNECT COLD LOAD TO RECEIVER and the measurements are made again for each test frequency. After the cold load measurements are completed the hot load is reconnected for the final measurements at each frequency. Then the receiver temperature is computed using the 6 sets of measured data. The average and the rms error are calculated. The rms error is the standard deviation of the mean. The calibration signal level  $T_{\text{cal}}$  and its rms error and the receiver gain are determined. These receiver parameters are tabulated. Turn on the printer (switch is on the back) and press the DUMP ALPHA (SHIFT and ALPHA) keys to obtain a hard copy of the data.

Then the prompt DO YOU WANT TO STORE TEST DATA ON THE DISK? is displayed. Pressing the YES key k4 displays the disk catalog and ENTERFILE NAME (10 CHARS MAX). Type in the file name and press the ENTER key. If the date is used it must be in the format 3\_21\_85 since "/" is not a valid file name character. Any upper or lower case letter, 0 thru 9, and the under bar \_ are valid filename characters.

If you want to measure another channel with the same test frequencies, select AUTOMEAS. The second time through it does not measure the offsets. Of course, if you want to start over, press PAUSE and RUN.

### Plot

The plotting subroutine lets you select plots of TREC, TCAL, or GAIN. The vertical scale is set automatically to match the data.

To obtain a plot from the printer press the DUMP GRAPHICS (SHIFT and GRAPHICS) keys. The program returns to the MAIN MENU. To plot the other functions select PLOT.

### Set ULO

SET ULO is used to select one frequency from the ULO unit. This is useful if repeated measurements are needed at a fixed frequency. The SET ULO procedure prompts Enter ULO Output Frequency in MHz. The program divides the input by four and sets the ULO synthesizer to give the requested output frequency.

### MEAS. NT

This procedure measures the noise temperature, calibration signal, and gain at one frequency. It does not control the ULO. To save the test data taken in this mode you must enter the test frequency as required.

### Measure 1/f Subprogram

This procedure can be used to determine the low frequency noise spectrum of the receiver. The subprogram samples the receiver output, transforms these time samples using an FFT algorithm and displays the frequency spectrum and then the power spectrum.

The maximum spectrum bandwidth is 30 Hz. Selecting the bandwidth determines how often the samples are taken. The samples are made at a rate that is twice the bandwidth. A 30 Hz bandwidth requires sampling 60 times each second.

The resolution is set by the number of channels selected. The FFT algorithm requires this number to be 16, 32, 64, 128, or 2 N.

There are two other inputs required. The IF bandwidth is used to calculate the rms noise per channel. This predicted rms level is displayed on the linear plot by a straight horizontal line. The other input required is the number of spectra to be averaged. The display X MINUTES FOR ONE SPECTRUM lets you figure out how long N spectra will take.

After the needed inputs are entered, the program takes the samples and determines the average level. This level is subtracted from all samples. The number of samples taken is twice the number of channels selected.

The program samples the inputs, performs the FFT, and then averages the frequency spectrum and plots the results. First the frequency spectrum is plotted. Then the power spectrum is computed and plotted. The maximum channel value sets the vertical scale on the plots.

The ratio of the maximum channel value to the expected rms is shown on the plots. The expected rms is recomputed for each spectrum average. To make a hard copy of the plots, press PAUSE and then the DUMP GRAPHICS keys.

Figure 1 shows the tabulated and plotted receiver measurements using RECTEST program Automeas.

Figures 2 and 3 illustrate the power spectrum output using RECTEST subprogram to Measure 1/f.

9\_23\_85X1

FREQ	TREC	ERMS	TCAL	ERMS	GAIN(dB)
450.0	50.8	.14	6.71	.04	104.3
500.0	15.0	.03	7.05	.03	109.9
550.0	13.6	.02	6.88	.02	109.7
600.0	18.2	.04	6.95	.03	108.8
650.0	20.6	.03	6.91	0.00	107.9
700.0	16.0	.02	6.54	.01	108.3
750.0	30.9	.05	6.42	.03	104.6

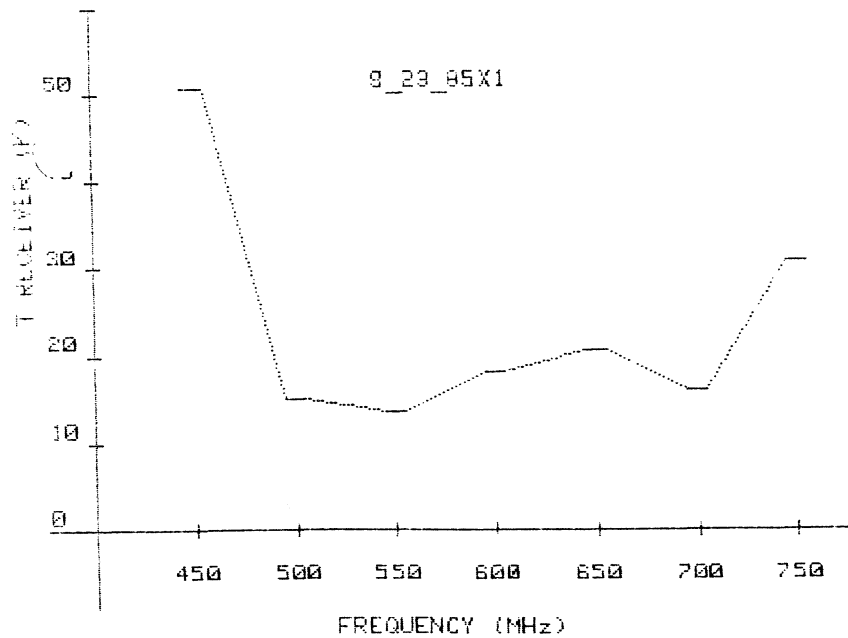


Figure 1. Receiver Noise Temperature using the RECTEST program Automeas.

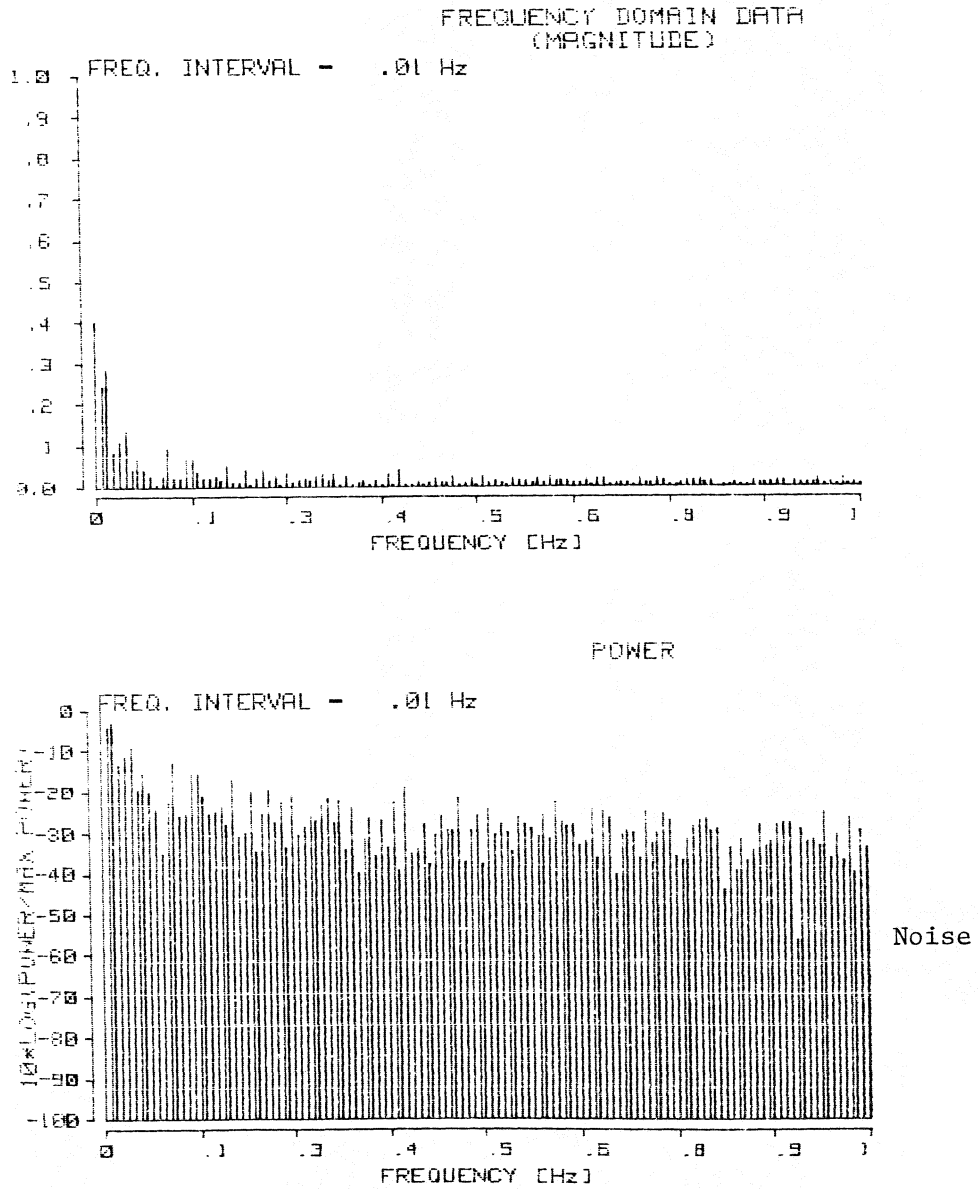
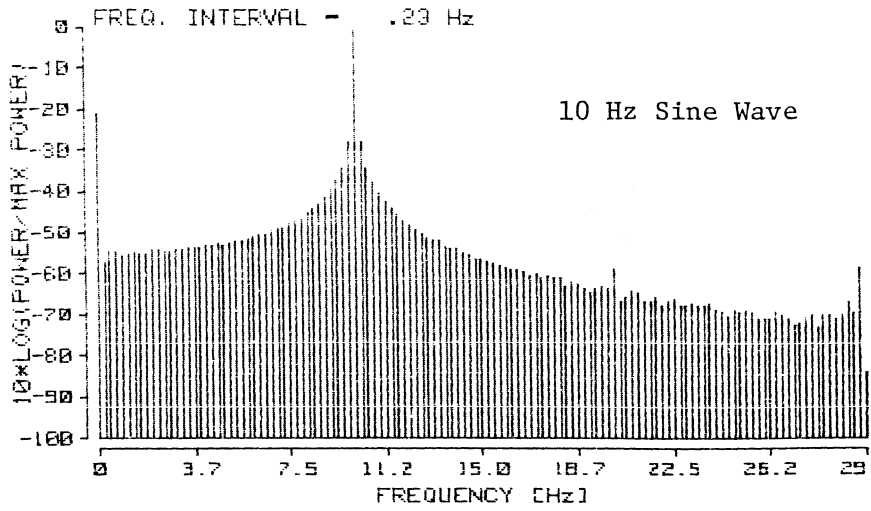
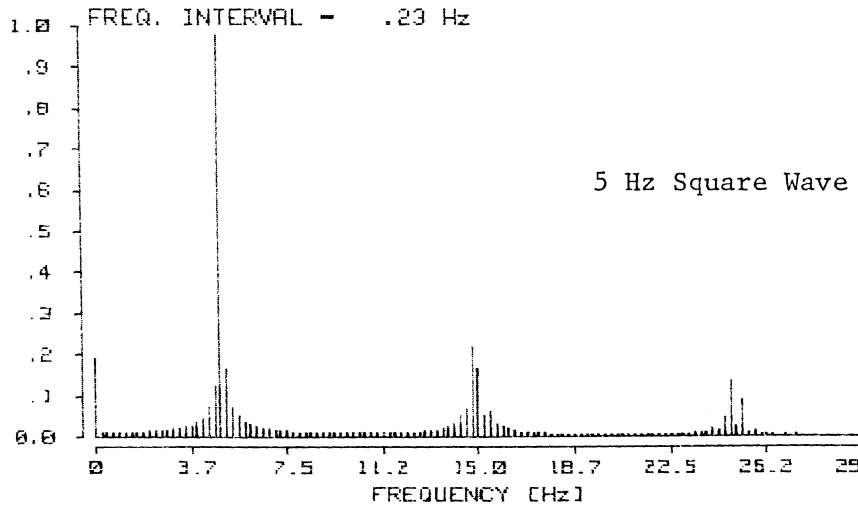


Figure 2. Frequency and Power Spectra using RECTEST Subprogram Measure 1/f.

POWER



FREQUENCY DOMAIN DATA  
(MAGNITUDE)



POWER

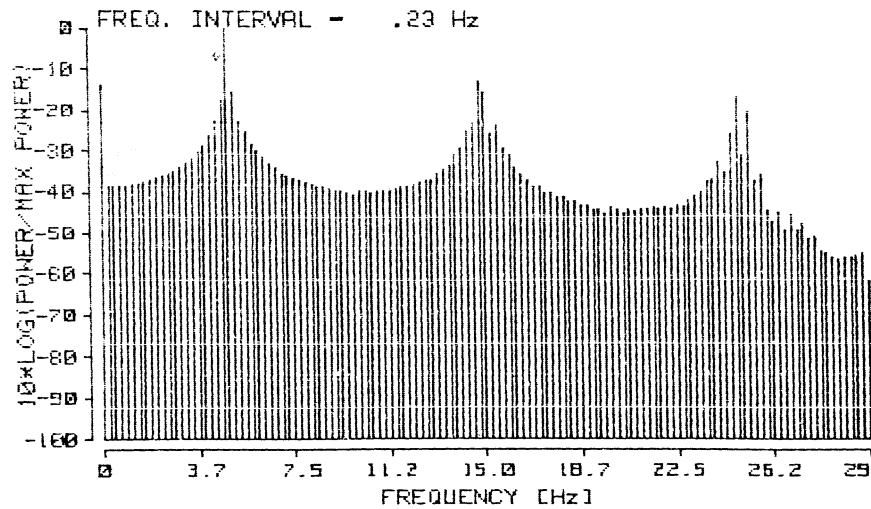


Figure 3. Frequency and Power Spectra with the Sine and Square Wave Inputs