

Tunable Wideband Receiver (TWB) – Data Processing Description

December, 2013

The tunable wideband receiver (TWB) can be manually tuned to any frequency of interest between 17 and 33 MHz. The receiver has a 2 MHz wide IF output, centered on 3.8 MHz. This undetected IF output signal is sampled by a Gage CS1220 high speed analog to digital converter (ADC) using software named GageScope. The digitizer is configured to sample the IF output waveform at a rate of 10 million samples per second (100 nsec sample period) with 12-bit resolution.

The Gage ADC has 4 MB of onboard memory which is filled in about 1/5 of a second (actually 209.6961 msec). The GageScope software reads the CS1220's 12-bit ADC samples and stores them as 16 bit integers using two bytes per sample. As soon as it is filled, the memory content is transferred to a unique file on the computer hard drive, a process which takes about 182 msec. During the transfer, no new data is being collected, so there is a 182 msec "dead time" between the end of the data in one file and the beginning of the data in the next file. That is, there are about 392 milliseconds—the "cycle time"—between the start of one Gage data file and the start of the next Gage data file. The cycle time can vary by a few milliseconds each time a data file is written to disk; however, this is bearable since the Jovian emission features being analyzed—e.g., individual S bursts—are, with any luck, wholly contained within individual Gage data files.

After the raw time-domain data has been recorded to disk in a series of Gage data files, the data is then run through a software FFT in blocks of 2048 samples (each block represents 204.8 μ sec of time domain data). An FFT produces n output bins for n input samples; however, when the input samples are real (real voltage only, as recorded by the Gage ADC) instead of complex (voltage plus phase information), the FFT spectral data output is mirrored at output bin number $n/2$. That is, FFT output bins $n/2+1$ through n (e.g., bins 1025 through 2048) contain a mirror image of bins 1 through $n/2$ (e.g., bins 1 through 1024). For this reason, bins 1025 through 2048 are discarded. In this way, each Gage data block of 2048 samples yields spectral data extending from DC to 5 MHz (FFT output bins 1 through 1024). Each FFT output spectrum contains 1024 frequency channels, one channel per FFT output bin. The resolution bandwidth of the FFT output is 4.88 kHz; i.e., each FFT output bin is 4.88 kHz wide. Each individual FFT spectrum—one set of 1024 FFT output bins, which is one "sweep" in the waterfall display—represents 204.8 μ sec of time domain data. Each 209.6961 ms long time domain Gage data file yields 1023 separate FFT spectra.

The TWB receiver IF output band extends from 2.8 to 4.8 MHz, while the 1024 channel FFT output spectrum covers DC to 5 MHz. The FFT bins covering the spectrum between 2.8 and 4.8 MHz are selected for further processing. Channel 574 (also referred to as FFT bin 574) maps to 2.8 MHz – the lower edge of the TWB receiver IF. Channel 984 maps to 4.8 MHz. Therefore, there are $984 - 574 + 1 = 411$ FFT bins, or 411 channels, covering the 2 MHz IF output

After passing through FFT processing and winnowing the number of output channels, the resulting 2 MHz wide slice of channelized spectral data is written to an SPS file in a manner emulating an FSX-4 swept frequency radio spectrograph. This allows the TWB output to be

reviewed and analyzed using Radio Sky Spectrograph (RSS). RSS cannot display the TWB output in real time; this method works for post processing only.

Since there are roughly 153 Gage data files for a 1 minute observation using the TWB, and 1023 FFT spectra (“sweeps”) per Gage data file, plus 889 dummy FFT sweeps per file to account for the dead time between the Gage data files, there are $153 \times (1023 + 889) = 292,536$ sweeps in the SPS file created for every minute of TWB observation.

The ability to display milliseconds on the spectrogram time axis was added with version 2.2.22 of RSS. An update is available here:

http://radiosky.com/spec/Spectrograph_Update_2_2_22.exe

To display milliseconds in RSS, click on the “View” menu item, then click on “Show Milliseconds.”

TWB Data Timing Diagram – Gage CS1220 Digitizer Signal Files and Conversion to SPS Data File

10 Msamp/s sample rate

59.976 seconds of observation					
Gage Data File #1		Gage Data File #2		Gage Data File # 153	
Cycle time 392 ms		Cycle time 392 ms		Cycle time 392 ms	
Data Sampling 209.6961 ms	Write to disk 182.3039 ms	Data Sampling 209.6961 ms	Write to disk 182.3039 ms	Data Sampling 209.6961 ms	Write to disk 182.3039 ms
1023 FFT sweeps (data)	889 sweeps (dead time)	1023 FFT sweeps (data)	889 sweeps (dead time)	1023 FFT sweeps (data)	889 sweeps (dead time)
1912 sweeps to SPS file		1912 sweeps to SPS file		1912 sweeps to SPS file	
292536 sweeps to SPS file					

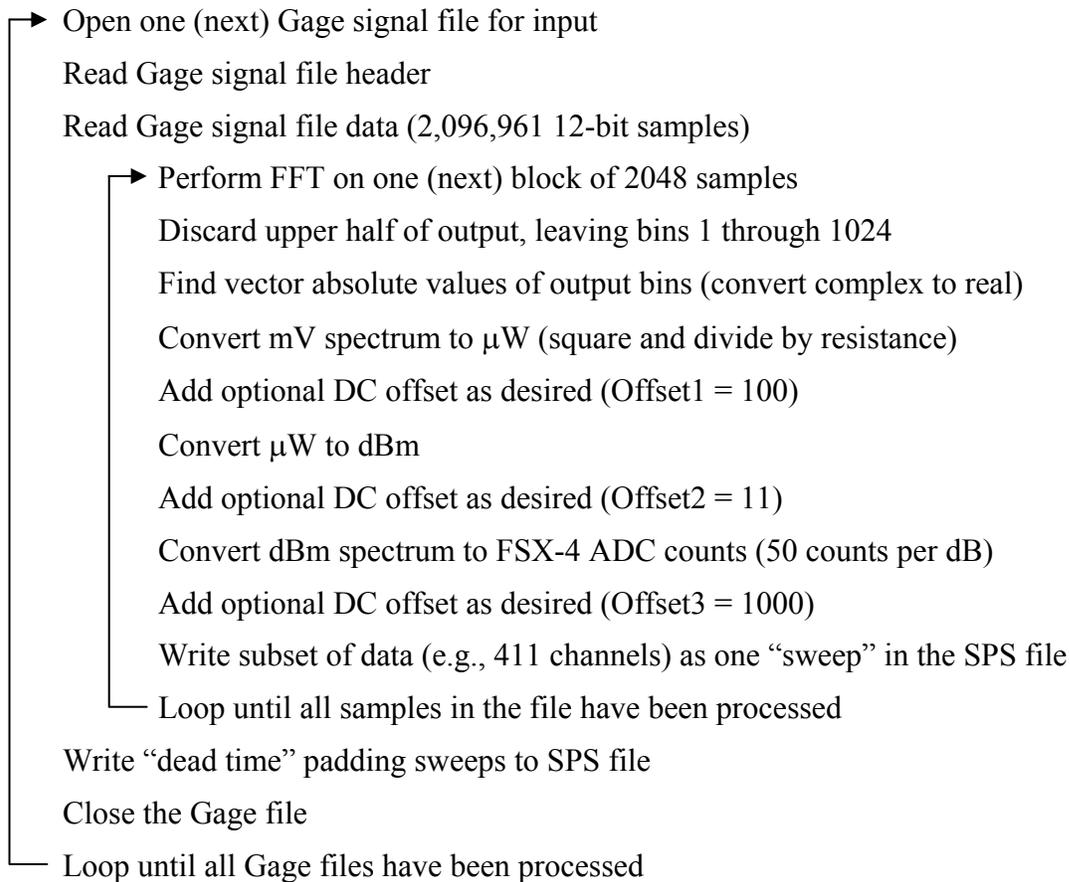
Gage Signal File to SPS Data File Conversion Routine

Mathematica processing time: 1 hour to convert 60 seconds of TWB data into SPS data.

Open target directory

Count input files

Create new SPS file and write header info



Close the SPS file

Print PDF conversion analysis report

$$SPS_i = \text{ADC counts per dB} \left[10 \log \left(\frac{|FFT_i|^2 + \text{Offset1}}{R} \right) + \text{Offset2} \right] + \text{Offset3}$$

$$SPS_i = 50 \left[10 \log \left(\frac{\frac{|FFT_i|^2}{50} + 100}{1000} \right) + 11 \right] + 1000$$

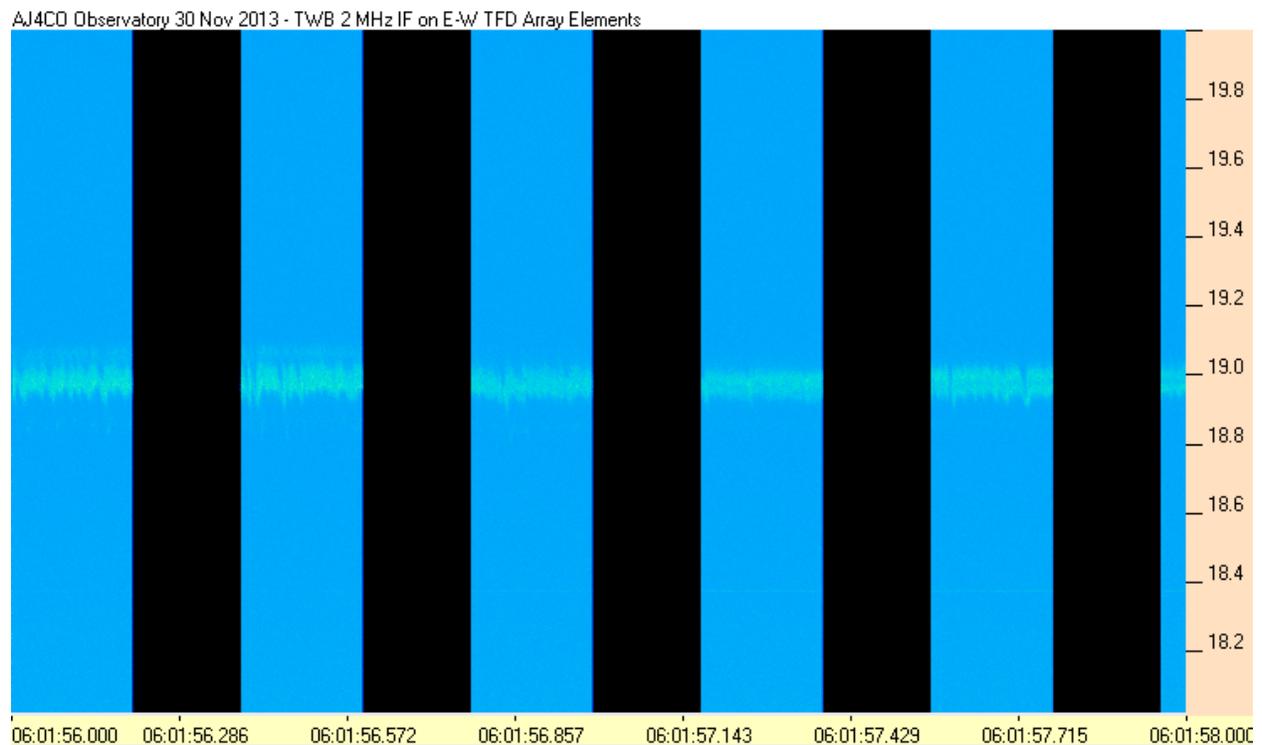
Example spectrogram 1

This is two seconds of TWB observation of an Io-B N event.

The numbers on the vertical axis represent the RF input in MHz to which the TWB was tuned, in this case the 2 MHz band centered at 19 MHz.

The vertical blue stripes each represent the 209.6961 msec during which the Gage ADC was taking data.

The black stripes represent the 182 msec during which the GageScope software was writing the contents of the CS1220's RAM to the computer's hard disk.



Example spectrogram 2

This is a zoomed in view of the spectrogram shown above.

In this view, RSS has zoomed in on the data so that 200 msec fills the width of the window. The window is 700 pixels wide, so each vertical column of pixels represents the average spectrum during 285.7 μ s.

