Note on scaling in GWB
12/11/2018

On the basis of experimental study done by Sandeep Chaudhari[1] and Harshavardhan Reddy, the optimum power level of the input baseband signal to be fed to utilize all the 8-bits of iADC is -13 dbm. This document gives the reasoning behind the scaling factors that were used to get the output counts to a desired value depending the output data type.

Scaling in interferometry :

a. Scaling factor :

In interferometer mode of GWB, the user has flexibility to select the number of spectrals channels (from 2048 to 16384 in steps of integral power of 2) and integration time. Also, including the normalizing factor of 2 * pi for FFT, the scaling factor applied is (2 * PI * No. of FFT points * No. of FFTs integrated). With this scaling factor, the self counts are dependent only on the input signal power, GAB bandwidth and GWB bandwidth and not on the number of spectral channels and integration time.

b. Power equalization :

With the scaling factor applied, the self counts at the power level of -13 dbm over 200 MHz bandwidth when correlator is running at 200 MHz bandwidth were observed to be 150 and when the input signal is low pass filtered to 100 MHz then the counts were observed to be 300. Hence, it was decided to equalize power to 150 counts when the GAB bandwidth (LPF selection) is equal to GWB bandwidth (Case i), 300 counts when GAB bandwidth is half of GWB bandwidth (Case ii) and 600 counts when GAB bandwidth is quarter of GWB bandwidth (Case iii).

Case i : a. When GWB bandwidth is 400 MHz and GAB LPF is 400 MHz
b. When GWB bandwidth is 200 MHz and GAB LPF is 200 MHz
c. When GWB bandwidth is 100 MHz and GAB LPF is 100 MHz

Case ii : a. When GWB bandwidth is 400 MHz and GAB LPF is 200 MHz
b. When GWB bandwidth is 200 MHz and GAB LPF is 100 MHz

Case iii : a. When GWB bandwidth is 400 MHz and GAB LPF is 100 MHz

Scaling in beamformer :

a. IA beam :

In IA beam, the voltages (FFT output) from antennas are converted to intensity, then addition of intensities over antennas and time is performed. The output is converted from floating point to short int to reduce the output data rate and hence scaling is required. It was decided to keep the output value to 2048 (1024 for each polarization) when the input power level is -13 dbm over 200 MHz bandwidth to account for the increase in power levels because of fluctuations from astronomical sources. Hence, the scaling factor (division) is (No. of spectral channels * No. of antennas added in GAC * No. of FFTs integrated * K) where K is a constant whose vlaue is 1.8399.

b. PA beam :

In PA beam, the voltages (FFT output) from antennas are added, converted to intensity and then addition over time is performed. The output is converted from floating point to short int to reduce the output data rate and hence scaling is required. It was decided to keep the scaling factor (division) same as IA beam i.e; (No. of spectral channels * No. of antennas added in GAC * No .of FFTs integrated * K) where K is a constant and same value as in IA beam. This was decided considering that the inputs from the antennas will be partially correlated.

To account for any other changes and fluctuations (both IA and PA beams), a scaling value (multiplication) which the user can select over GUI is provided.

c. Voltage beam :

In Voltage beam, the voltages (FFT output) from the antennas are added. The ouptut is converted from floating point to char to reduce the data rate. Hence, it was decided to scale the output down with the scaling factor (sqrt(No. of spectral channels) * sqrt(No. of Antennas added in GAC) * Kv) where Kv is a constant (value is 1) to keep the 3 sigma of real and imaginary values of voltages (FFT output) to 128 when the input is -13 dbm over 200 MHz bandwidth.