Memo: Testing Horn Signal Chain Power Levels

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Abstract

In order to ease future understanding and debugging of issues with the horn signal chain, we have generated this report inputting a known test tone and noise into the signal chain. We have then followed its evolution as it moves through the signal chain, verified power levels and frequency shifts, so that future users may be better able to track down faults quickly.

1 Introduction

The basic layout of the signal chain is this: it takes a low power 1.4GHz signal incoming from the horn, filters and amplifies and downconverts it, enabling us to sample it adequately and do astronomy with the data. A full signal chain is shown in Fig. 1. In order to be able to collect reasonable data, two key things must be true of the signal chain:

1. The mixers must be shifting the frequencies of the signal in the way we expect, such that the band that we do end up sampling is the one that contains the 21cm signal from the horn.

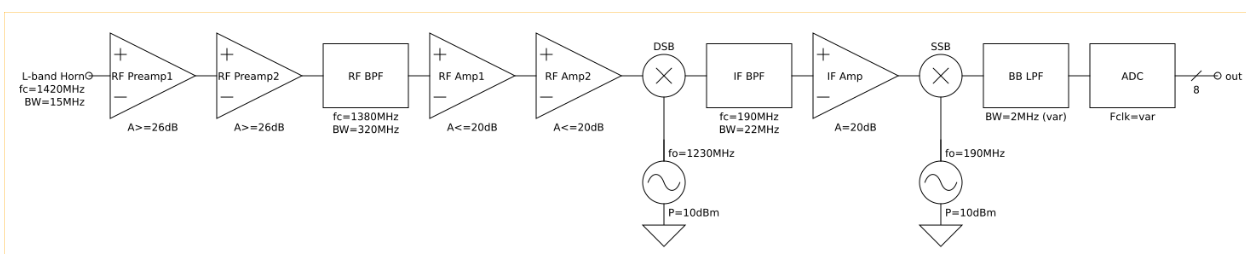

Figure 1: The full horn signal chain from the L-band horn to the PicoScope 2000 digital sampler. Note that the second pair of RF amplifiers has a gain specification of 20 dB each, but the combined gain output is only about $A_{total} \approx 30$ dB in reality.

2. The amplifiers must be providing enough gain in order to toggle enough bits in the ADC that we can actually see it, while also not generating strong reflections that overwhelm the system.

So let us first figure out how much power we need at the ADC. Let's say we want a 100 mV signal incoming to the ADC. Using Ohm's Law, a 100 mV signal would generate $P_{mW} = 0.04$ mW. Now, using Eq. (1), we can convert that into $P_{dBm} = -14$ dBm at the picosampler.

$$P_{dBm} = 10 \log_{10} \left(\frac{P_{mW}}{1 \text{ mW}} \right) \tag{1}$$

2 Method

The average power from incoming from the horn is about $P = -58$ dBm. We attempted to construct a similar signal within the lab using a noise source and a signal generator. The NOD5250 noise generator was set to maximum attenuation (i.e. attenuator = 10), and was measured to be outputting broadband noise around $P = -47$ dBm. We wanted the tone to be small but trackable, so that was set at $\nu = 1421$ MHz and $P = -40$ dBm. These were combined using a backwards splitter, and the power levels were verified using a spectrum analyzer. Post-cabling and combination, the tone had a power level of approximately $P = -43$ dBm.

From here, we measured the power at multiple points within the signal chain. The results of these measurements are shown in Table 3.

3 Results

All measurements are taken at the output of the given location.

Sample Location	**Power Level**	**Tone Frequency**
First Bandpass Filter	-45 dBm	1421 MHz
Back-to-Back Amplifiers	-9 dBm	1421 MHz
DSB Mixer	-16 dBm	191 MHz
Second Bandpass Filter	-17.5 dBm	191 MHz
Amplifier	3 dBm	191 MHz
SSB Mixer (Variable Filter Input 1)	-10 dBm	1 MHz
SSB Mixer (Variable Filter Input 2)	-10 dBm	1 MHz
Variable Filter (Output 1)	-14 dBm	1 MHz
Variable Filter (Output 2)	-12 dBm	1 MHz