Subject: Gain *Measurements versus Feed Probe Position and Length*
Memo: 2, Revision 1
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This note is a follow up on previous hot/cold load tests with a feed horn. Previous tests were carried out with feed probe location was determined by the scaling of a microwave waveguide feed, where the efficiency of the probe was not critical to its use. For the microwave feed at the waveguide horn, before the first amplifier, efficiency is critical.

Measurements

The second measurements were carried out on July 1, 2015 under good weather conditions.

FIGURE 1: MEASUREMENT OF THE INTENSITY (COUNTS) WHILE THE FEED HORN WAS POINTED AT THE SKY (ELEVATION = 45) AND AT THE GROUND (ELEVATION = -90).

At frequency 1420 MHz, while pointing at the ground, the measured intensity is 526 counts and while pointing at the sky the intensity is 356. The difference, hot - cold counts, called DeltaC, is 170.
Assuming a ground temperature of 300K and the cold sky temperature of 10K, the System Temperature, Tsys, over the feed Gain, G, ratio may be calculated. In The Scale factor, S, corresponds to the amplification in the IF chain. The equations below work through an estimate of the system temperature gain ratio. Equations (1) and (2) present the formulas describing the relationship between the measured intensities, in counts, and system temperature and hot and cold loads.

$$C_{hot} = S (T_{sys} + G T_{hot}) \quad (1)$$
$$C_{cold} = S (T_{sys} + G T_{cold}) \quad (2)$$

Next solving for the scale factor S:

$$C_{hot} - C_{cold} = S*G*(T_{hot} - T_{cold}) \quad (3)$$
$$S = Delta_C / (G*(T_{hot}-T_{cold})) \quad (4)$$

And finally solving for T_sys/G:

$$C_{hot} * G *(T_{hot}-T_{cold})/(C_{hot}-C_{cold}) = T_{sys} + G T_{hot}$$
(5)

$$T_{sys} = C_{hot} * G * (T_{hot} - T_{cold})/DeltaC - G T_{hot} \quad (6)$$
$$T_{sys}/G = (C_{hot} * (T_{hot} - T_{cold})/Delta\ C) - T_{hot} \quad (7)$$

From the measurements at 1420 and 1420.9 MHz respectively values for Tsys/G are determined:

$$Tsys/G = (526 * 290K/170) - 300K = 897\ K - 300\ K = 597\ K \quad (8)$$

The consistency of the two measurements suggests that the T/G measurement is good and a representative estimate is 597 K.

Conclusion

A horn feed probe location was optimized and connected with a pair of amplifiers to provide sufficient gain for a second measurement of the system gain of a small radio frequency transient detector.

The system is capable of measurement of the system temperature to gain ratio. The efficiency of the horn has improved, but not as good as needed for astronomical research. This value is still found to be much larger than expected and further study is required.

Because the feed port position was optimized, yet the system temperature did not sufficiently improve, it seems likely that lower noise amplifiers are needed and improved total gain.