

## Gain Stability Testing For Front End and Back End Assemblies

Notes by L. D'Addario, 2003-07-14

### 1. Front End Assembly

- An input signal source whose fractional power stability is better than  $3e-5$  on all time scales of interest (10 msec to 100 sec) is required. It should be placed completely across the input window of the band being tested, so that no other signal source can be seen within the RF band. A room temperature thermal load whose physical temperature is stable to .01 K is recommended.
- Measurements shall consist of recording the measured total power at an IF output port using a power meter whose stability is better than  $3e-5$  over the same time range, and whose bandwidth covers the 4-12 GHz IF range. An ALMA Downconverter/Baseband Processor with its built-in square law detectors is recommended. The power shall be recorded with a sampling interval of 10 msec and an integrating time of 9 msec for each sample.
- Measurements shall be recorded for at least 1000 sec (1e5 samples).
- The data shall be analyzed to determine the Allan variance
$$\sigma^2(2, T, 0.9T)$$
over the range  $T = 10$  msec to 100 sec.
- Results should be at or below the limit line in the attached plot.
- Repeat at several representative LO frequencies in each band.

### 2. Downconverter/Baseband Processor/Second LO Assembly

- An input signal source whose fractional power stability is better than  $3e-5$  on all time scales of interest (10 msec to 100 sec) is required. It should be connected directly to one of the 4-12 GHz IF input ports. A stable CW signal generator is recommended. In that case, measurements should be repeated at 4.5, 8.0, and 11.5 GHz, with the second LO tuned to 8.0, 11.0, and 14.0 GHz, respectively.
- Measurements shall consist of recording the measured total power from the appropriate built-in baseband and IF square law detectors. The power shall be recorded with a sampling interval of 10 msec and an integrating time of 9 msec for each sample.
- Measurements shall be recorded for at least 1000 sec (1e5 samples).
- The data shall be analyzed to determine the Allan variance
$$\sigma^2(2, T, 0.9T)$$
over the range  $T = 10$  msec to 100 sec.
- Results should be at or below the limit line in the attached plot.

### 3. Common Considerations

- Environmental conditions, including room air temperature stability, power line voltage stability, and the relative direction of gravity (tipping) should approximate those expected on an ALMA antenna. Controlled air should be supplied at the same flow rate by the same path as will be used in the antenna.
- If the test conditions are substantially better or worse than the expected field conditions, it should be noted on the test report.
- Besides the Allan variance results specified here, separate measurements should be made of

the coefficient of total power with respect to room air temperature and tipping, if possible.

#### 4. Discussion

- At  $T=.05$  sec and  $a=.04$  sec, appropriate to beam switching by fast nutation, the limits are half of the Allan variance that results from thermal noise at an effective bandwidth  $B=7$  GHz. If both the FE and BE components just meet this limit, the net Allan variance will be double that of the thermal noise and the rms error in total power will be root-2 larger. For shorter intervals  $T$ , the limit keeps the variance at half of the thermal noise value.
- At  $T=0.5$  sec and  $a=.025$  sec, appropriate to OTF imaging at low frequencies, the limits are about 0.25 of the thermal Allan variance. If this mode is dominant, the limits might be relaxed somewhat.
- At  $T=100$  sec, the limit is about  $1e-6$ , which allows for an rms calibration error contribution of 0.1% if absolute astronomical calibration is done at this interval. The slope of the limit curve is then +1, which corresponds to a random walk in gain. This determines the error for longer and shorter calibration intervals.

