

LWA-OVRO Memo No. 11

**Requirement for Maximum
Intermodulation-Produced RFI**

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I. INTRODUCTION

The LWA is subject to strong RFI outside our desired observing band of 20-85 MHz, including FM radio at 88-108 MHz and HF radio at 3-20 MHz. FM radio signals are primarily local and nearly line-of-sight; the power level is stable. The HF radio signals are primarily distant and arrive by reflections from the ionosphere; the power level is highly variable.

The out-of-band signals are suppressed by filtering in the analog signal path so that by the time the entire signal is digitized it is well within the dynamic range of the digitizer [1]. However, non-linearity anywhere in the analog signal path can produce intermodulation among the RFI signals such that the intermodulation products fall within the observing band; these cannot be suppressed by filtering. Therefore non-linearity must be small enough to keep the in-band products sufficiently small. What is sufficiently small? This memo proposes a design criterion to achieve an acceptable level.

II. PROPOSED LIMIT

It is known experimentally that the signals at the outputs of the antenna Front End Assemblies have total power in the >85 MHz band about 29 dB above the total power in the 20-85 MHz observing band, and that the total power in the <20 MHz band is highly variable, with peak of about 25 dB above the observing band [3]. Given this information, and as long as non-linearity is small, the total power of in-band intermodulation (IM) products can be reliably predicted from published or measurable properties of components in the signal path [2].

Proposed limit: The analog signal path shall be designed so that the worst-case predicted total power in the observing band due to intermodulation among out-of-band signals is $<1\%$ (<-20 dB) of the total power in the observing band.

III. DISCUSSION

Whereas the out-of-band signals are strong, it is difficult to achieve the proposed limit. The current ARX design is predicted to achieve -29 dB IM in the worst case [2], but tests of optical link components show that -20 dB can just barely be achieved. Yet the limit may not be sufficient.

Although the total intermodulation power can be predicted, the spectrum of the out-of-band signals is complicated (especially for <20 MHz), so is the spectrum of the intermodulation is also complicated. The desired signal from the sky has a spectrum that is far from flat [4]; its peak at 33 MHz is about 8.1 dB above its minimum at 85 MHz. Therefore, in some frequency channels the IM will be much worse than -20 dB relative to the sky signal, and in other channels it will be much better.

Furthermore, the IM is likely to be correlated among antennas. Especially on long baselines where the correlation coefficient of the sky signal is small, IM at -20 dB can contribute significantly to measured visibilities.

To do better will require substantial design changes, all of which have undesirable trade-offs as well as increased cost. We need to know:

- What IM level is acceptable?
- To what extent can we allow higher receiver temperature so that we are no longer sky-noise-dominated at the low and high ends of the observing band?

REFERENCES

- [1] L. D'Addario, "Effective Dynamic Range of Digitizers in the OVRO-LWA Telescope." LWA-OVRO memo, 2019 April 27.
- [2] L. D'Addario, "Next Generation Analog Receiver Design: Amplifier Selection." LWA-OVRO memo, 2019 May 25.
- [3] L. D'Addario, "RFI Environment at the OVRO LWA: Quantitative Measurements." LWA-OVRO memo, 2019 April 20.
- [4] L. D'Addario, "Spectra of OVRO-LWA signals at correlator: predicted vs. observed." LWA-OVRO memo, 2019 April 26.