

LWA ARX Requirements - On Beyond Rev H

Authors

Greg Taylor (UNM)
Jayce Dowell (UNM)

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1 Introduction

This documents describes the requirements for the next generation Analog Signal Processing (ASP) for the Long Wavelength Array (LWA). The current ASP design has been described in Craig et al 2009 (see LWA Memo 219); and LWA Memo 119 (Ellingson et al. 2009) the ASP contains:

- Analog Receiver (ARX): This is the antenna receiver which provides adequate gain and selectivity prior to digitization. There are 512 ARX receiver channels (dual pol) for a full LWA station, and 128 channels (dual pol) for an LWA mini stations. Other numbers of stands are also possible.
- Power Conditioning and Distribution (ASP-PCD): The power for the receivers and front-end electronics (FEE).
- Monitor and Control System (ASP-MCS): ASP Monitor and Control to station MCS
- Electromechanical Design (ASP-EMD): Receiver packaging and racking layout

2 ARX

Owing to wide interest in the LWA design we need to build additional ASP subsystems for roughly 4 full stations (2 in Peru, retrofit LWA1 and LWA-SV in New Mexico; and 4 mini-stations (LWA-NA, Texas Tech, ASU, and one more). This build will require 32 ARX boards/station plus 3 spares. Based on past experience we expect 0-2 boards out of every 37 to be defective and unusable. Thus the number of boards/station desired is 37. This leads to a total build of 185 boards. At a conservative estimate of \$1500/board this represents an expenditure of \$277,500.

The latest revision of the LWA ARX board is Rev H (D’Addario et al 2020 and D’Addario & Marwaha 2019; OVRO-LWA memos 8 and 9). There are two fundamental issues with using the existing Rev H design which are (1) the lack of availability of the amplifiers; and (2) the difficulty of maintaining the board owing to the small component sizes and the isolating cans (piping).

The Rev G board is currently in use at LWA-SV. This board has a few issues including: 1) The output from the board is to Cat 5 connectors. The Cat 5 connectors introduce significant coupling across signal chains, and the latest digitizer design which mounts to the SNAP2 boards uses MMCX connectors; (2) The long traces on the output of the Rev G board may cause some coupling; (3) This design dates back to 2015 so there are likely some obsolete components; (4) The placement

of the FM filter resulted in undesired reflections. For filter shapes and the affect of the attenuator settings see Figures 1 and 2.

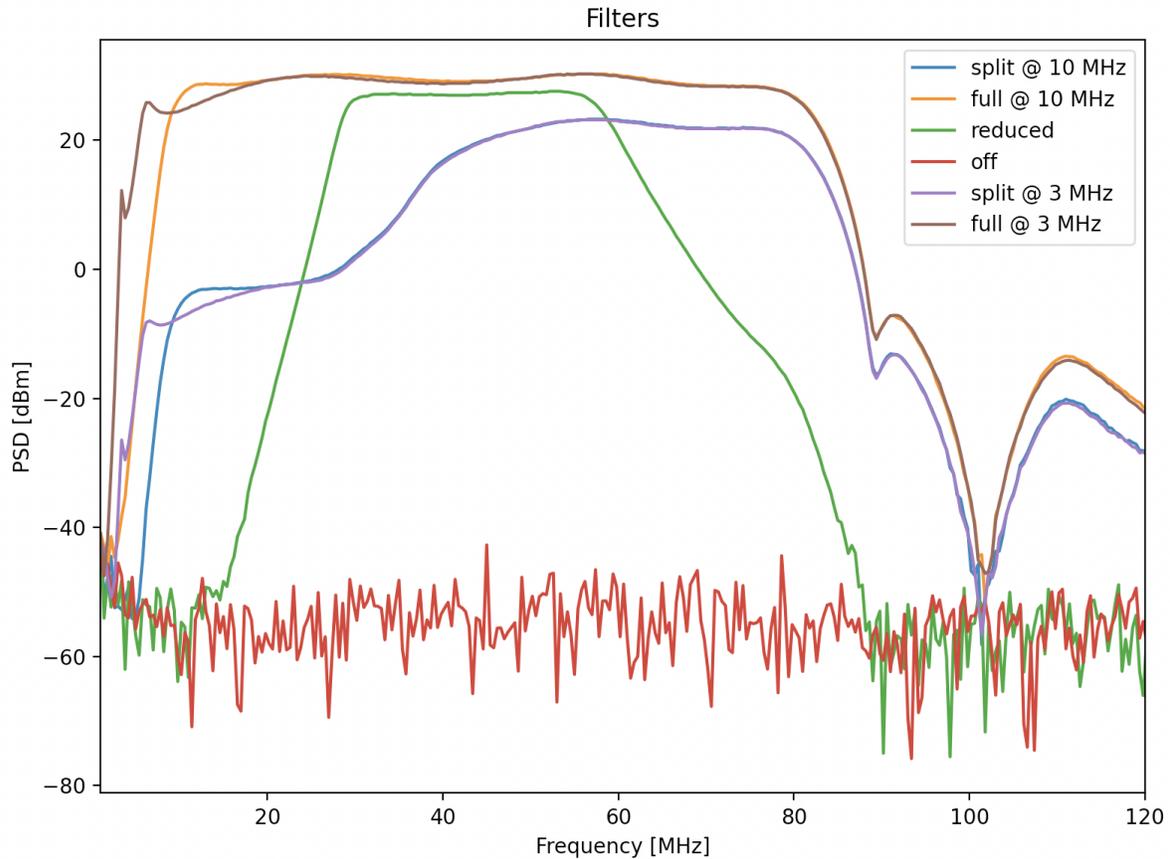


Figure 1: Plot of the Rev G filters used at LWA-SV.

2.1 ARX Board Requirements

Given the problems with the Rev G and Rev H boards, and the significant sum involved in the planned build, a redesign of the board seems justified. Below are the list of requirements for the ARX board:

1. The board should be relatively easy to maintain, similar to ARX Rev G.
2. Impedance matching should be improved over the Rev G board. We should look at Rev H board to see what was done. Including pads on the board if needed.
3. The FM filter should be removed with a filter that rolls over at 70 or 80 MHz. These filters should be close to the beginning of the chain to exclude FM early on.
4. The output lanes and Cat 5 connectors for the channels should be replaced with MMCX connectors.

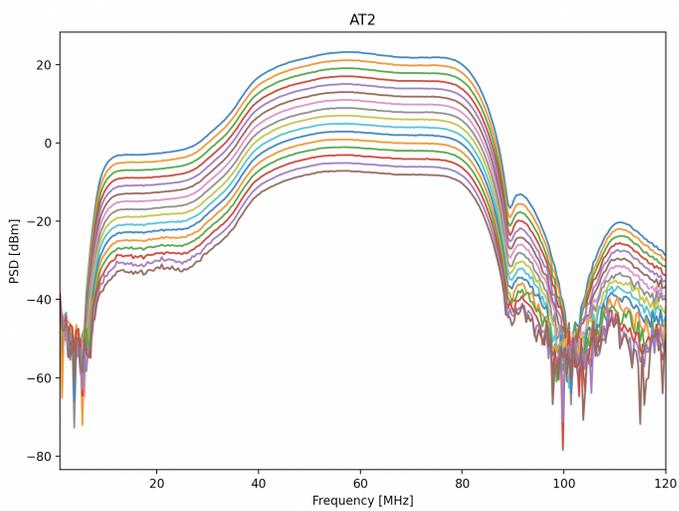
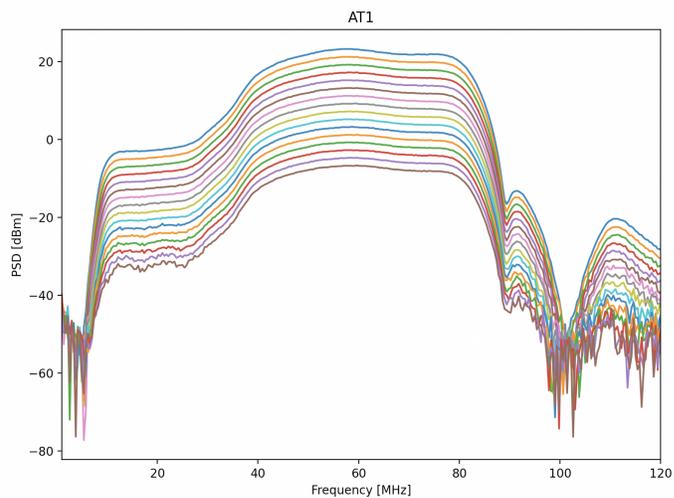
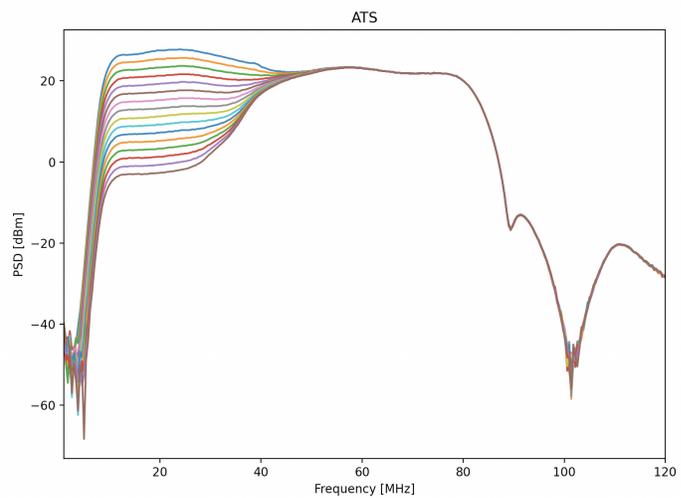


Figure 2: ATS, AT1 and AT2 attenuator settings.

5. Isolation between channels should be improved over the Rev G to at least 30 dB with a target of 40 dB or better. If necessary piping could be considered although there are trade-offs with maintainability. Consider partial piping to get much of the benefits.
6. Reverse bias protection on the power inputs. This to avoid blowing up boards that have not been wired in correctly.
7. Keep the same hardware control interface (Serial Peripheral Interface or SPI) to make field testing easier at one of the stations (probably LWA-SV). Some changes to the control software may be necessary to handle added monitors and controls.
8. On-board temperature monitoring if that works with whatever control interface we have. Consider analog output. Not every channel, could just be center of the board.
9. Desired filter chains (1) Wide open to allow useful signals down to 3 MHz and/or up to 83 MHz; (2) Filters that protect from RFI at 3-10 and up to 20 MHz. (3) Protection from CB radio at 27 MHz when necessary. (4) Reasonable fall-back configuration in the case of strong RFI at the site of a future station. (5) Protection from FM band.
10. No significant self-generated RFI from the board itself that appears in the output channels from a given board or other ARX boards. Avoid oscillation.
11. A cost/board in production with a target price of \$1500 each.
12. Linearity over range in power received at least as good as Rev G.
13. Individually control the FEE power for each antenna.

The following items are desirable but not strictly required.

1. A step size of 0.5 dB in the attenuators. Rev H has 0.5 dB. Rev G has 2 dB steps.
2. Protection from front-end shorts. In the past we have had ARX channels damaged when a front-end has a short.
3. A way to get rid of the 7 V regulator to simplify design.
4. On-board RF power monitoring if that works with whatever control interface we have.
5. On-board FEE current monitoring if that works with whatever control interface we have.

2.2 ASP Monitor and Control

ASP Monitor and Control should be based off the Rev G boards in order to allow for extensive field testing at the LWA-SV station.

2.3 Power Conditioning and Distribution

The copper bussbar design used at LWA-SV should be adopted (see Fig. 3). At LWA1 the steel bussbar eventually reached extreme temperatures and melted the ring terminal connections.



Figure 3: Image of the copper bussbar installed at in the ASP rack at LWA-SV.

3 Summary

A set of requirements is presented for the next revision ARX board for retrofit of the current LWA stations or for future LWA stations. This board should be designed taking advantage of our considerable experience with previous generations. Given the nature of electronic parts to become obsolete, and for RFI conditions to change, we recognize that this may not be the final generation but we hope that it will have a significant shelf life.

References

Craig, J., 2009, LWA memo #219

D'Addario, L. & Marwaha, N 2019, OVRO-LWA Memo #8

D'Addario, L. 2020, OVRO-LWA Memo #9

Ellingson, S., 2009, LWA memo #119