Maximum allowed emission levels for the LWDA electronics

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November 12, 2005

Abstract

The Long Wavelength Demonstrator Array (LWDA) is a low-frequency (10-80 MHz) dipole array that will be located next to the VLA. RFI emission measurements of the LWDA electronics are required to ensure that the equipment will not limit future astronomical observations, both at the VLA as well as at the LWDA itself. The electronics emission levels are thus needed to be controled on a continous range of frequencies between 10 MHz up to 50 GHz. Here we derive maximum allowed emission levels from the LWDA electronics. These limits should be used to determine whether shielding of the electronics is required.

1 Defining the harmful signal level

It is standard practice to define an interfering signal to be harmful to astronomical observations if it exceeds the rms noise level by more than 10% (Thompson, Moran & Swenson 1998). In other words, a non-detrimental interfering signal must have a signal to noise ratio SNR ≤ 0.1. Here we outline how to estimate acceptable emission levels (for more details, see Perley 2002).

First we assume $F_{\rm RFI}$ [$\rm Wm^{-2}$] is the power flux density of the interfering signal incident at the antenna, and $F_{\rm N}$ [$\rm Wm^{-2}$] is the minimum detectable power flux density. Then, the SNR can be written as:

$$SNR = \frac{F_{\rm RFI}}{F_{\rm N}} = \frac{F_{\rm RFI}\lambda^2 G_r \sqrt{\Delta t}}{4\pi k T_{\rm sys}\sqrt{\Delta\nu}} \leq 0.1 \tag{1}$$

where $T_{\rm sys}$ is the system temperature, $\Delta\nu$ is the bandwidth, Δt is the integration time and G_r is the receiving antenna gain. In astronomical observations (especially for spectral line applications) the bandwidth is commonly expressed in velocity units, where $\Delta V = c\Delta\nu/\nu$ [$\rm kms^{-1}$]. Eq. 1 can now be rewritten solving for the harmful threshold level F_{RFI} of the interfering signal:

$$F_{\rm RFI} \leq \frac{0.4\pi k T_{\rm sys} \nu^{2.5} \sqrt{\Delta V}}{c^{2.5} \sqrt{\Delta t}} \quad (2)$$

Here a 0dB gain ($G_r = 1$) is adopted, assuming that the interfering signal will enter via a sidelobe rather than via the mainlobe. The true value of this gain factor is not known, and the level of the interfering signal is further likely to change when the signal moves around in the sidelobe patterns. Therefore, a 0dB gain appears to be a reasonable, conservative estimate. Note that $F_{\rm RFI}$ is the allowed power flux density within the channel bandwidth $\Delta\nu$. For a noise limited system, Eq. 2 can be used for any observing frequency, integration time and velocity resolution.

2 Detrimental levels for LWDA electronics

Given that the LWDA will be located next to the VLA, the electronics emission levels must be determined both for LWDA as well as for EVLA frequencies (a more or less continous range between 10 MHz up to 50 GHz). Further, to ensure that LWDA electronics will not disturb EVLA observations, it is reasonable to adopt the same emission goals as NRAO enforces for their electronics. For this purpose, NRAO has assumed a typical EVLA observation to be of 9 hours integration, using a spectral channel width of 1 kms^{-1} (Perley 2002). Using these values in Eq. 2, Table 2 list the resulting harmful threshold power flux densities. Note that these are the emission levels incident at the receiving antenna, thus space loss will be a helpful shielding factor in particular for the emission in the EVLA bands.

Table 1: Harmful Threshold Power Flux Densities.

Band	Frequency MHz	$T_{\rm sys}$ K	$\Delta\nu$ kHz	$F_{\rm RFI}$ Wm^{-2}	S Jy	$F_{\rm RFI}$ dBWm^{-2}
4/LWDA	0.074	5000	0.3	4.6×10^{-22}	154	-213
P	0.327	170	1.1	6.4×10^{-22}	59	-212
L	1.5	26	5.0	4.4×10^{-21}	89	-204
S	3.0	29	10.0	2.8×10^{-20}	280	-195
C	6.0	31	20.0	1.7×10^{-19}	846	-188
X	10.0	34	33.3	6.7×10^{-19}	1999	-182
U	15.0	39	50.0	2.1×10^{-18}	4208	-177
K	23.0	54	76.7	8.5×10^{-18}	11058	-171
A	34.0	45	113.4	1.9×10^{-17}	16560	-167
Q	45.0	66	150.1	5.6×10^{-17}	36979	-163

3 A note on ITU levels

The standard ITU levels given in ITU-R RA.769 are typically 8-10 dB higher than the levels given in Table 2. This is because in the ITU levels a velocity resolution of 3 kms^{-1} and 2000s integration is used. The ITU levels are globally adopted upper limits for protecting operations at current radio telescopes, but they are not tailored to specific routine observations at radio telescopes such as for instance the VLA. Even though the sensitivity of radio telescopes have increased dramatically in recent years, the ITU levels have not changed since 1979. Therefore, it is *essential* that LWDA puts a more conservative limit to internally generated RFI, in order to enable future high sensitive astronomical observations at the EVLA and the LWA.

4 References

Perley, R., 2002, EVLA Memo 46, 'Minimum RFI Emission Goals for EVLA Electronics'

Thompson, Moran & Swenson, 'Interferometry and Synthesis in Radio Astronomy', 1998, Krieger Publishing Company