RFI measurements at the Yebes Observatory 40-m radiotelescope receivers' room

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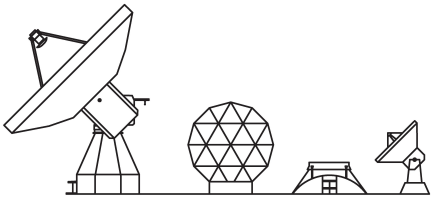

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1 Introduction

RFI measurements were carried out the 6^{th} of June 2019, at the receivers' room of the Yebes Observatory 40-m radiotelescope. The purpose of this test was to evaluate the self-generated RFI signals that are produced by electronic devices installed in this room, where the low-noise cryogenic receivers of the radiotelescope are placed.

These measurements show that the most polluted band is below 3 GHz. For highest frequencies only local oscillator leakage signals are present.

In this report, the measurement setup is presented as well as the different scenarios in which the process were done.

2 Measurement setup

The instrumentation used in this test was the following:

- DC-26.5 GHz logarithmic antenna from **Rohde & Schwarz**.
- Two low-loss 2.92 mm coaxial cables.
- 0.5-26.5 GHz **Hewlett Packard** preamplifier, model 83017A.
- DC-50 GHz spectrum analyzer, model N9962A, from Keysight.

The block diagram of this setup is shown in Figure 1.

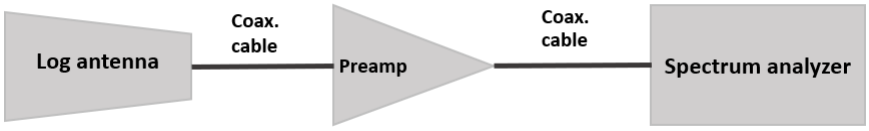

Figure 1: Measurement setup scheme.

Three different scenarios were considered in order to perform the measurements. Scenario type A took place at the receivers' room, and type B at servo motor room, in a lower floor.

- **Scenario A1:** All electronic devices and local oscillators (LO's) are switched on. From now on we will refer to this scenario as "everything ON".
- **Scenario A2:** Some electric devices such as the radiotelescope local control panel (LCP), the antenna mirror system (AMS), pressure and temperature control systems, Optic Fiber modules, a desktop computer, the HOT/COLD load control system (controlled by a Raspberry Pi 3B+),

LO signals and downconverters (some of them with a fixed LO integrated inside) are switched OFF. In this report this scenario will be referred to as "everything OFF".

- **Scenario A3:** The same scenario as A2 but the AMS switched on.
- **Scenario A4:** The same scenario as A3 but the LCP switched on.
- **Scenario B1:** The RFI antenna is inside the servo motor room and the RFI environment is collected under antenna movement.
- **Scenario B2:** The RFI antenna is pointing to the power electronic racks.

3 RFI Spectrum

Several graphs are shown and explained in detail depending on the corresponding scenario.

3.1 Scenario Type A

The RFI spectrum measured at the receivers' room with all devices and receivers switched ON is shown in Figures 2 and 3. In both graphs the LO signals are labelled to check their frequencies.

In Figure 2 the LO fundamental frequency at 4.15 GHz (LO from C-band receiver) and its harmonics and sub-harmonics are marked (at OL/2, OLx2, OLx3/2, OLx5/2, OLx3, OLx7/2 and OLx4 frequencies).

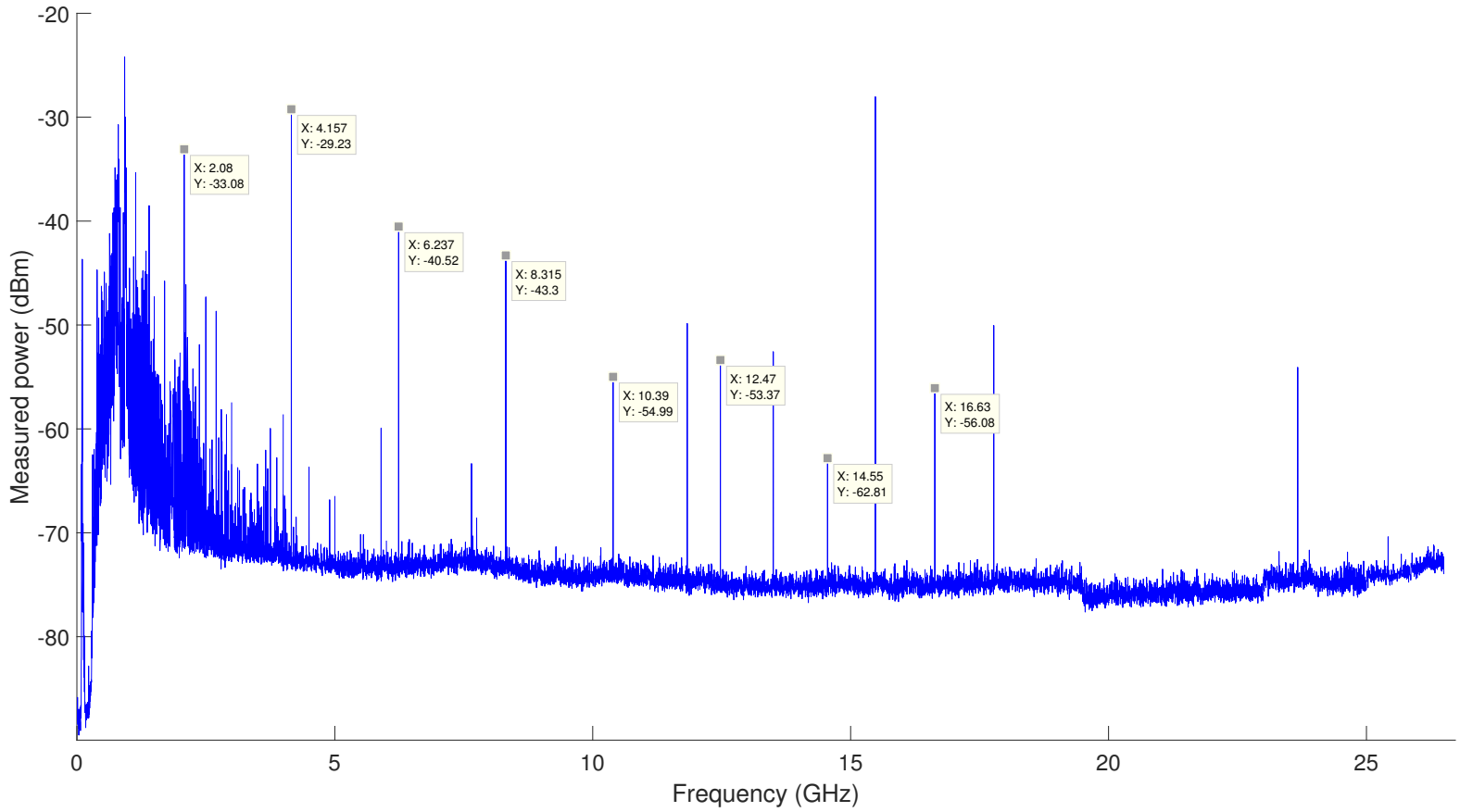

Figure 2: RFI spectrum in scenario A1. The labelled signals correspond to the C-band OL leakage and its harmonics and sub-harmonics.

Frequency (GHz)	OL module	Harmonic
2.08	C band	x1/2
4.158	C band	Fundamental
6.238	C band	x3/2
8.315	C band	x2
10.4	C band	x5/2
12.48	C band	x3
14.55	C band	x7/2
16.63	C band	x4
11.83	W band	Fundamental
13.50	K band	OL fixed. Fundamental
15.48	K band	Fundamental

Table 1: List of RFI leakeage due to the local oscillators located at the receivers' room

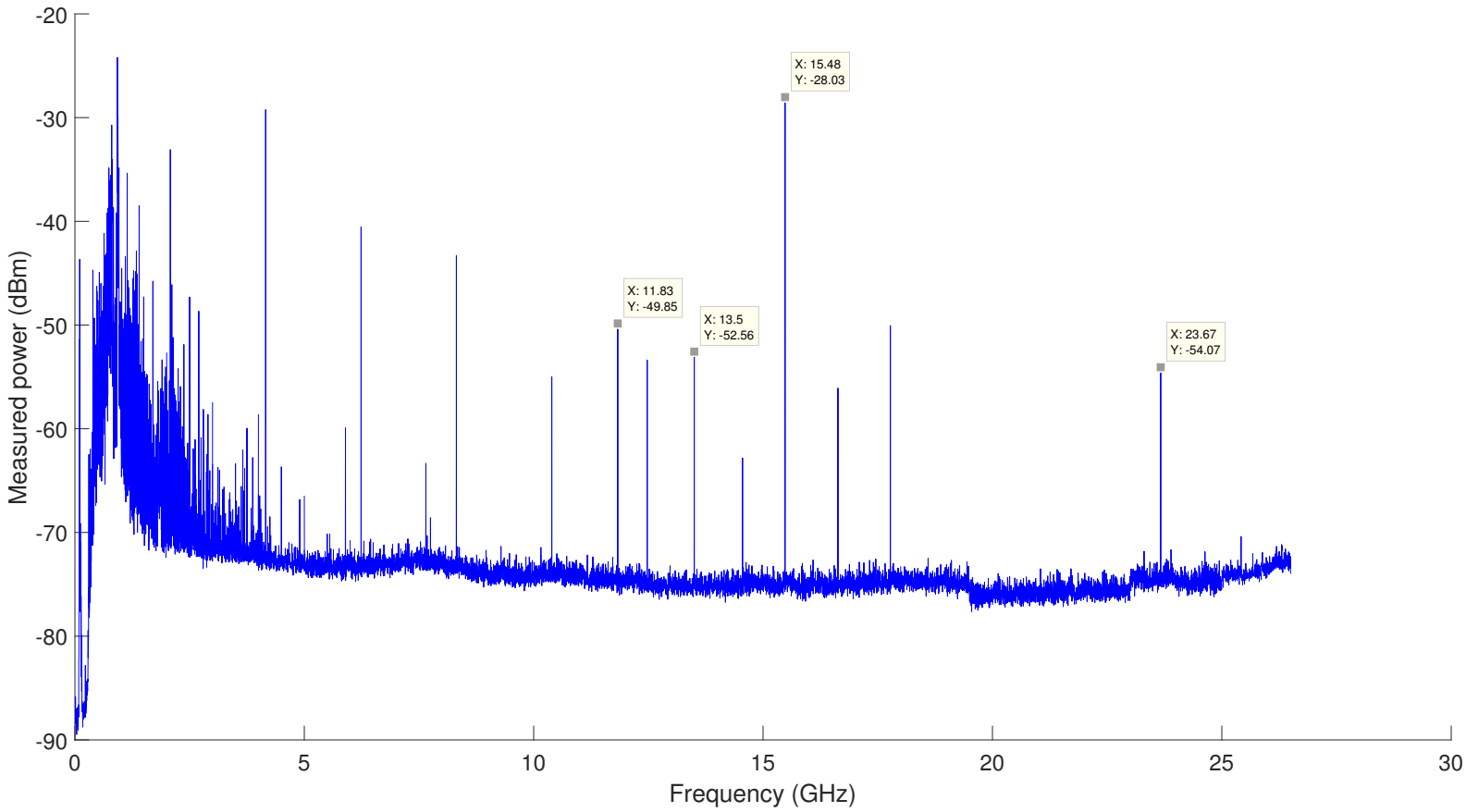

Figure 3: RFI spectrum in scenario A1. The labelled signals correspond to the W-band OL leakage and its harmonic (11.83 and 23.66 GHz) and K-band LO leakage (15.48 GHz).

As it can be seen that the most polluted band is below 3 GHz, so this band is analyzed in detail in Figure 5. The period of these peaks is 20 MHz, which could be related with the clock signal of the Profibus. Some external RFI sources as FM broadcast radio, GSM, UMTS and LTE are still present.

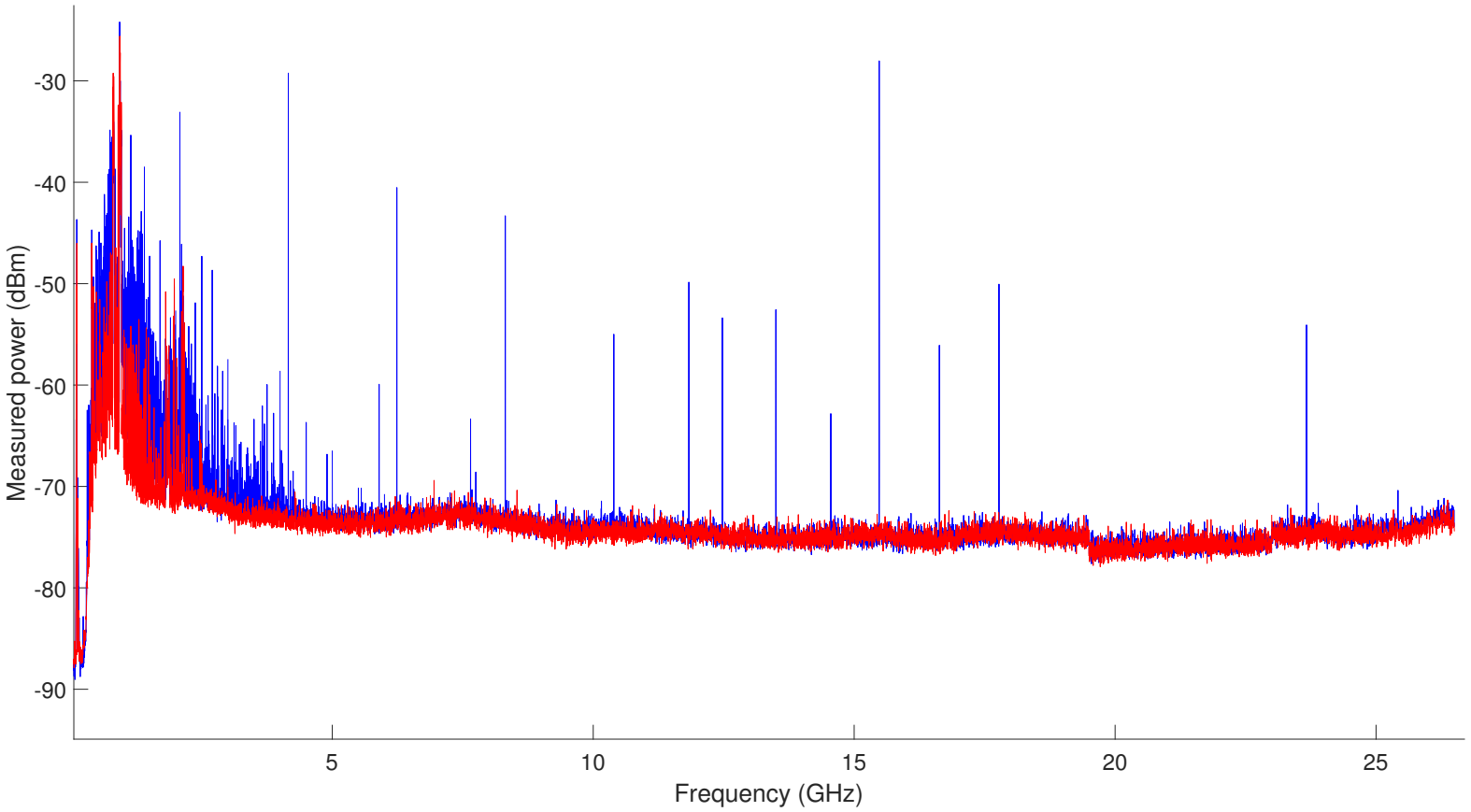

Figure 4: RFI spectrum at scenario A1 (blue) vs. scenario A2 (red).

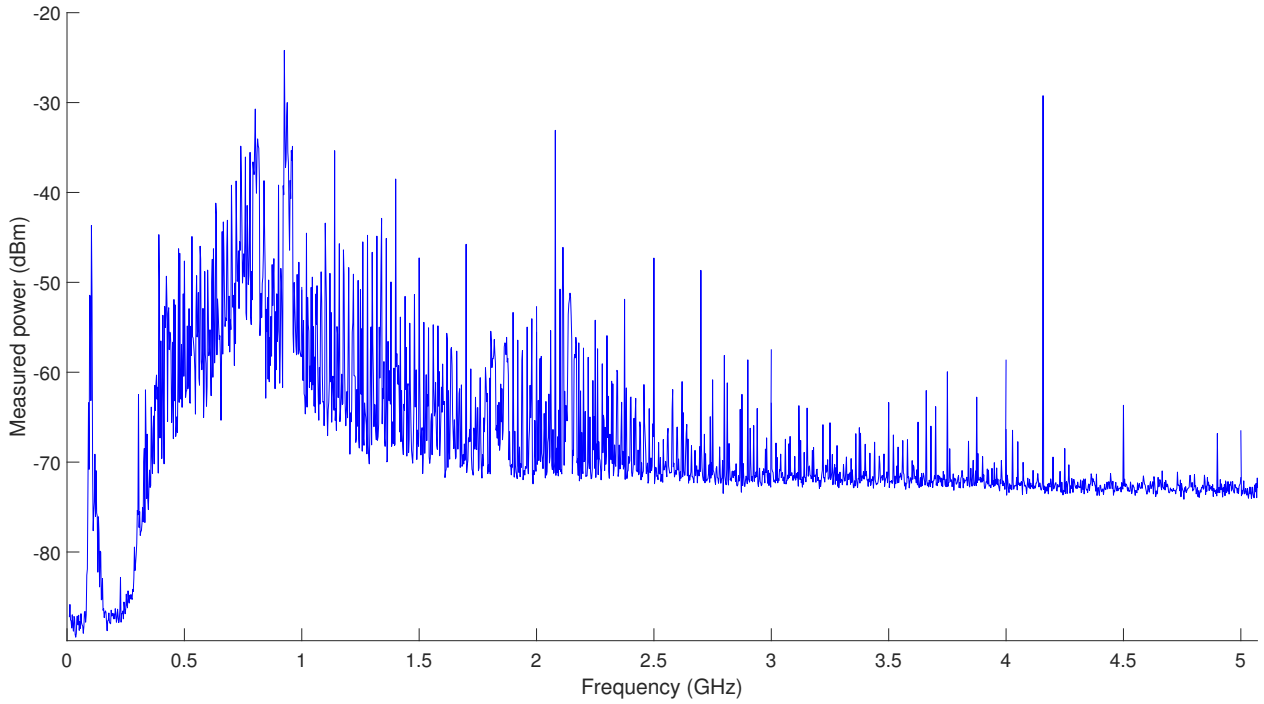

Figure 5: RFI spectrum up to 5 GHz with everything ON (scenario A1).

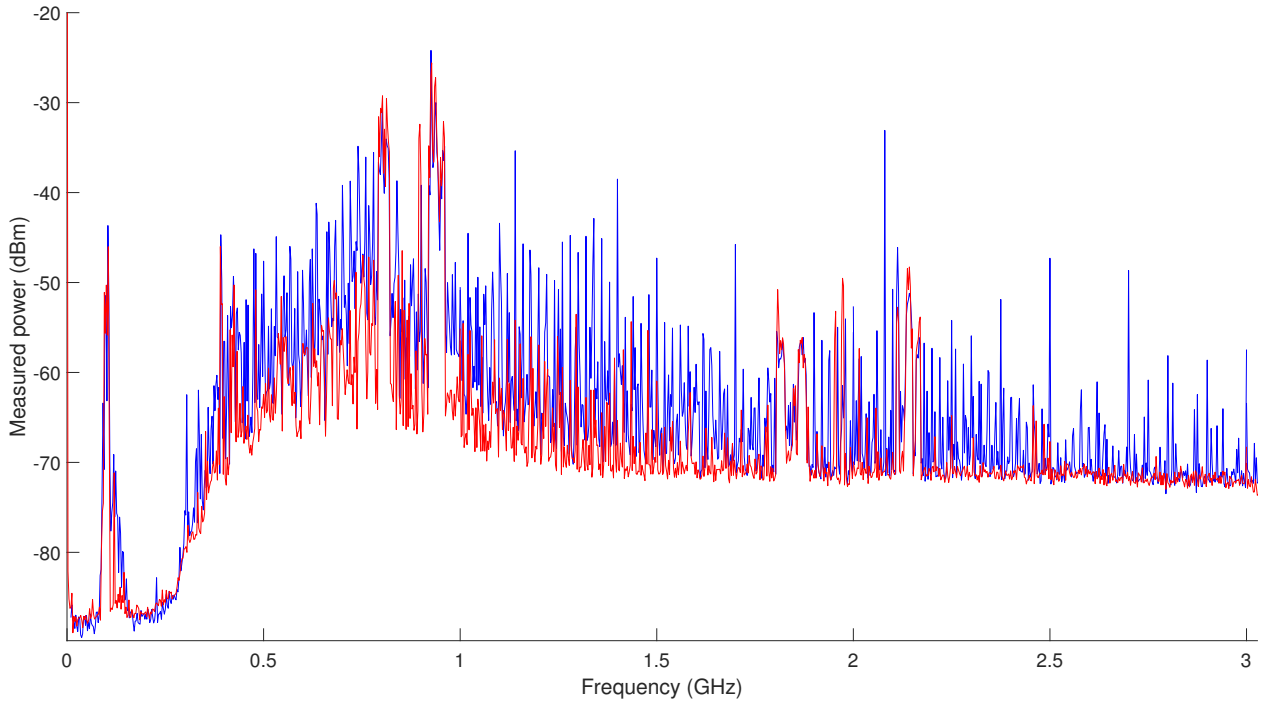

Figure 6: Main RFI signals at scenario A1 (blue) vs. scenario A2 (red).

In Figures 5 and 6 (in detail) the scenario A1 (everything ON in blue) is compared with A2 (everything OFF in red).

As it can be seen in Figure 6, even with most of electronic devices switched off there is still some RFI signals that could be related with Profibus cables, and some servo electronics present at the servo room.

Figure 7 shows in detail the pulse train of 48 MHz when everything is OFF (red graph) and the 20 MHz pulse train that appears when everything is ON (but in relation with the LCP).

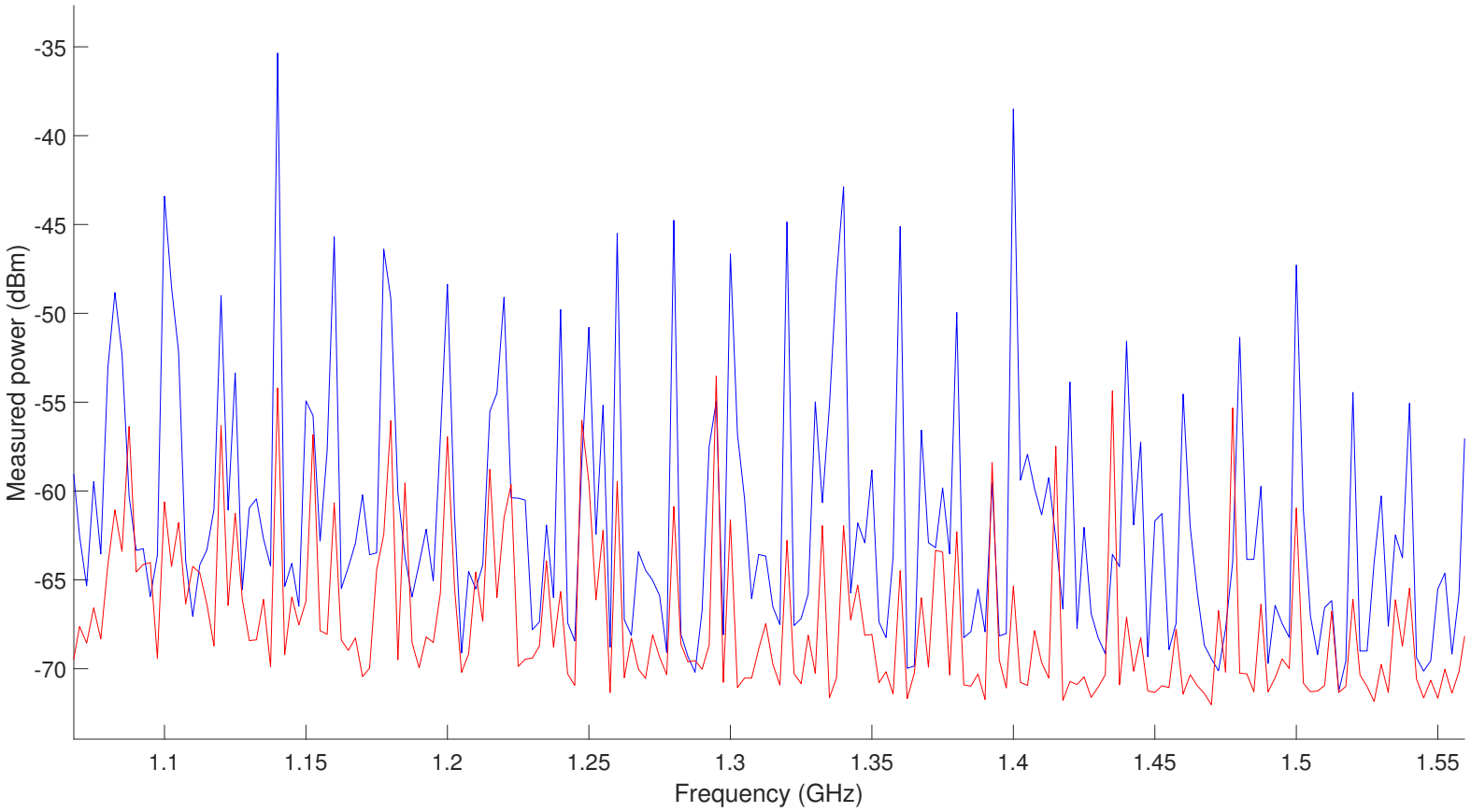

Figure 7: RFI spectrum at scenario A1 (blue) vs. scenario A2 (red).

The next step was to switch ON the AMS to measure its contribution to the RFI. After that, the LCP is switched ON. In Figure 8 the blue trace shows the scenario A2, the red one shows the scenario A3 and the green one the scenario A4. With this results it can be concluded that the LCP is the most RFI polluting source in the receivers' room and it should be switched OFF when not in use, which is most of the time.

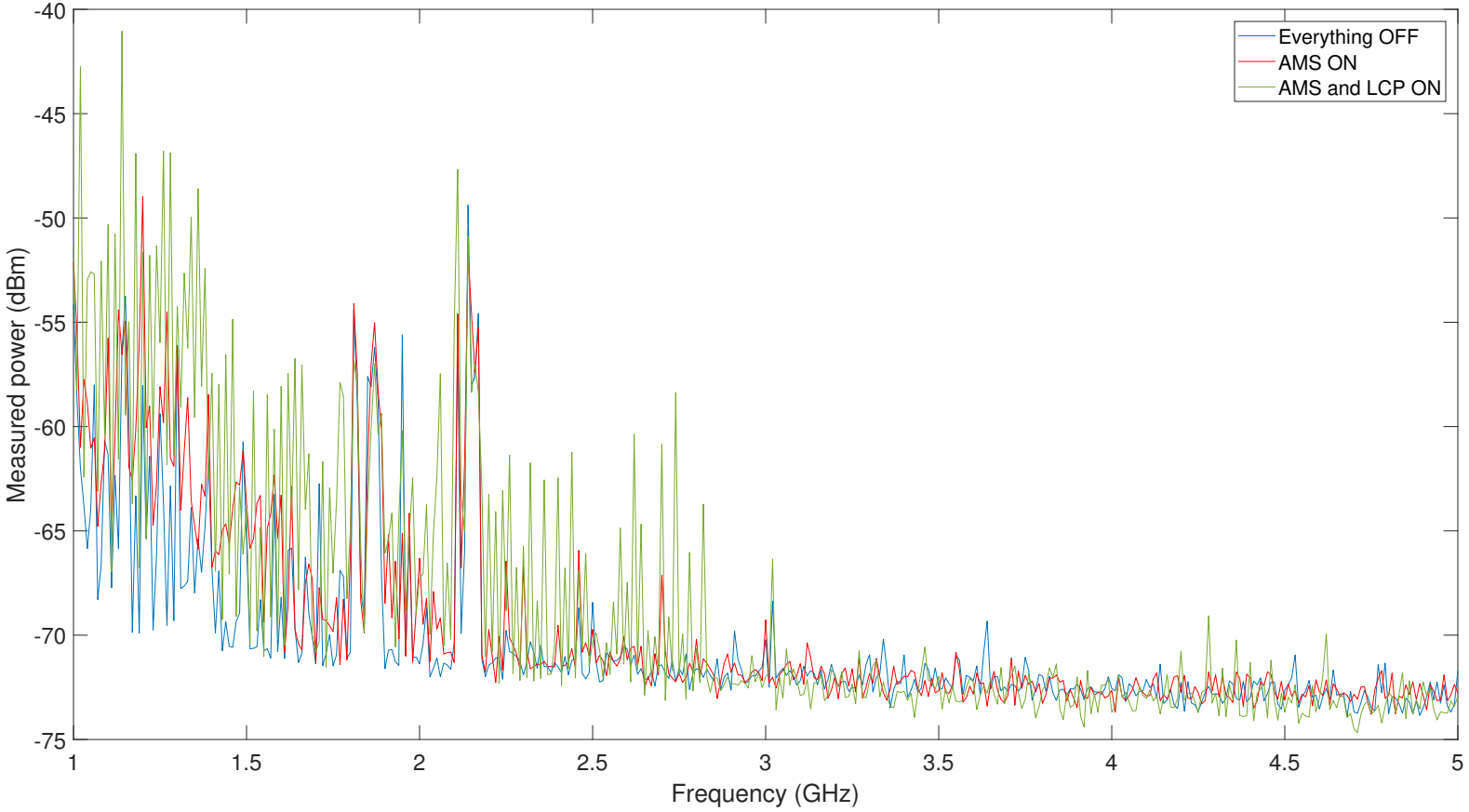

Figure 8: RFI environment in scenario A2 (blue), A3 (orange) and A4 (green).

In Figure 8 the RFI environments at A2, A3 and A4 scenario are shown. It can be seen that the AMS generates some RFI at frequencies below 2 GHz but the main source of RFI is the LCP located at the receivers' room, which introduces almost every signal up to 3 GHz. The main RFI signal is a a train of 20 MHz separated pulses.

3.2 Scenario Type B

In this scenario, the RFI was monitored at the servo room when the antenna is stopped and also when the antenna was moving but no significant changes were reflected.

In contrast, several RFI signals appeared when the RFI antenna was pointing to the power electronic racks. These two situations were reflected in Figure 9.

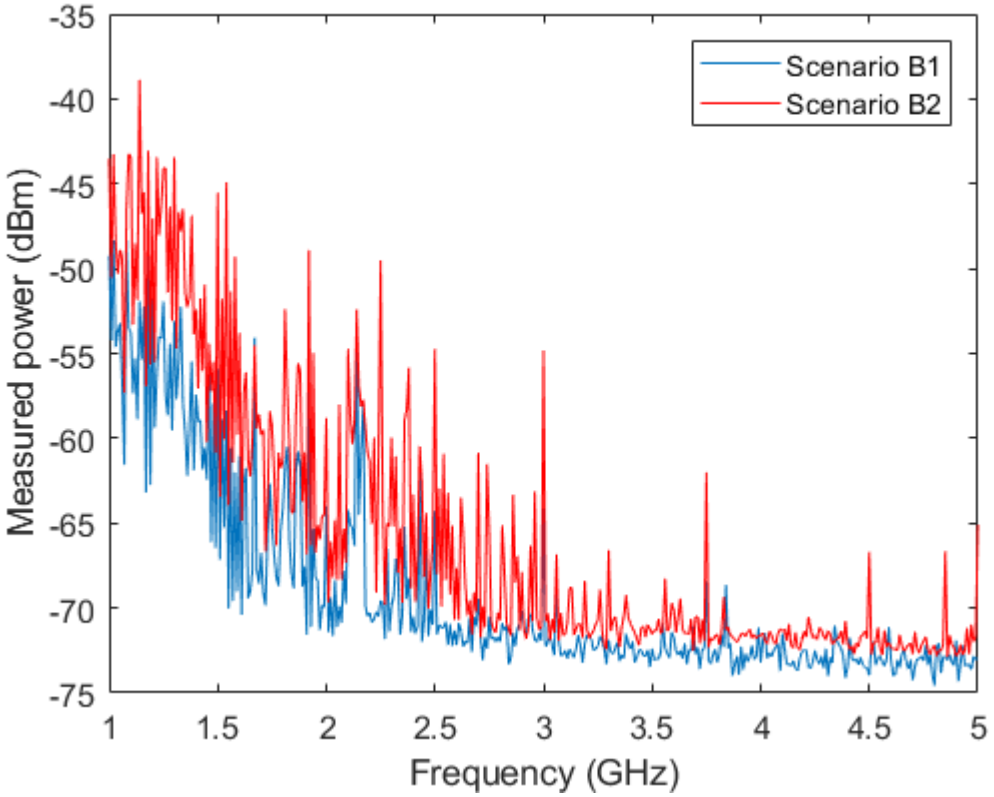

Figure 9: RFI present at servo room

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