

# **SOCIS Application Document**

Applicant: Emilio José Martínez Pérez

For SatNOGS mentoring organization



**SatNOGS**

# 1. Personal info:



My name is Emilio Martínez. I'm a Spanish Telecommunication Engineering (MSc) student at University of Granada. I'm an enthusiast of space-related technology and I would like to focus my professional career on the space industry when I finish my studies.

Because of this, I enrolled in an aerospace developing group at University of Granada called GranaSAT. This group is formed by students and professors with the goal of designing and developing a Cubesat mission. Currently I'm developing my master's thesis about the Communications System of our Cubesat and the satellite-earth link. Specifically I'm designing the Cubesat communication hardware, defining the link budget and improving the ground station capabilities in order to reach a reliable communication. The GranaSAT ground station is shown in Figure 1.



Figure 1. GranaSAT Ground Station

Besides, last year GranaSAT team was selected to participate in DLR, SNSB and ESA BEXUS programme. During the programme we designed and developed a multi-sensor ADS (Attitude Determination System) for our Cubesat, based in Star Tracker, Horizon sensor and magnetometer. This ADS was tested under near-space conditions during a stratospheric flight. Some pictures of GranaSAT launch campaign are shown in Figure 2 and Figure 3.



Figure 2. GranaSAT Team @ Kiruna, Sweden



Figure 3. Star Tracker image taken at 27.5 km

The responsibilities and the tasks assigned to me in the project were diverse. First of all, my colleagues pointed me as the Team Leader, including tasks such as management, organization and budget control. Then I was also responsible for the electronic design and PCB building, as well as responsible for the ADS magnetometer module, including its data analysis and code algorithm.

A copy of the final document provided to BEXUS managers can be downloaded on the following link:  
[http://granasat.ugr.es/images/BEXUS/Doc/BX19\\_GRANASAT\\_SED\\_v5-0\\_15Jan15.pdf](http://granasat.ugr.es/images/BEXUS/Doc/BX19_GRANASAT_SED_v5-0_15Jan15.pdf)

Participating in BEXUS programme gave me the chance to improve my technical and team-work skills. I also learned how to deal with new tasks for me, such as managing and scheduling a project, leading a team, applying ESCC specifications, scheduling a test campaign, writing a project documentation or working on a technical field I am not familiar with.

With all the experience I have obtained for being part of GranaSAT team and for participating in BEXUS programme I may consider myself as the most appropriate candidate to participate in SOCIS programme and to develop my skills for SatNOGS organization. This is a new challenge for me and I would be more than excited to start it!

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## 2. Project Proposal:

### 2.1. Main overview

The project proposed that would be carried out at SOCIS programme is based on the ideas list provided by the mentoring organization: a diplexer, a low noise amplifier and a polarisation switch.

After consulting to the SatNOGS managers about their needs and their preferences of the ideas they provided and performing an analysis of the SatNOGS project, and following my own experience in amateur ground station field, the project I propose for developing in SOCIS programme is the one that follows:

**A pre-amplifier with an integrated antenna polarization switch for cross YAGI-UDA UHF band antenna, and a UV diplexer module for the SatNOGS ground station.**

A block diagram of the proposed project is shown in figure 4. The parts to be developed are the UHF antenna sub-system and the diplexer. The other modules are shown for reference.

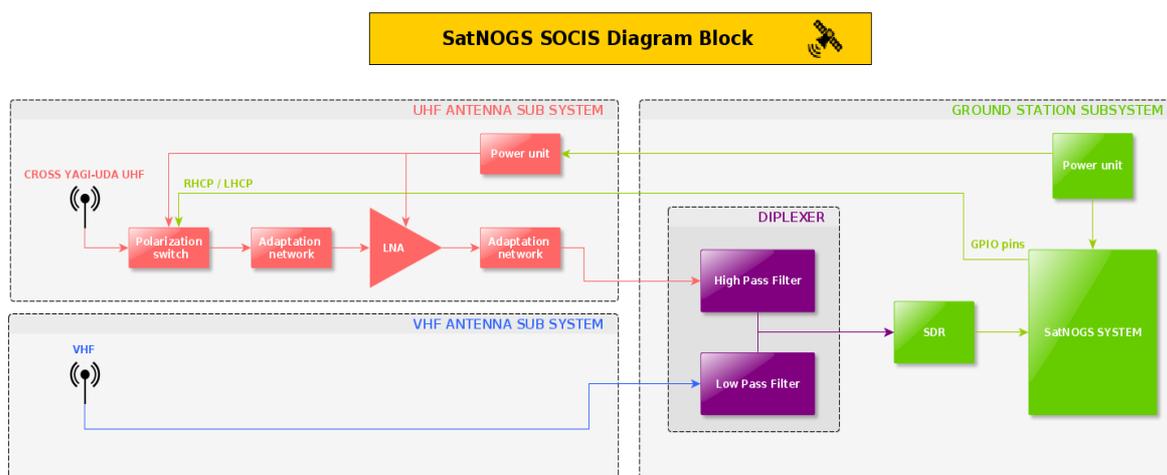


Figure 4. Project block diagram

With this project, a combination of each idea proposed by the mentoring organization can be implemented, getting a complete and full functional system indispensable for any ground station:

- Cross Yagi-Uda antenna as radiating element.
- Polarisation switch for LHCP (Left Hand Circular Polarisation) and RHCP (Right Hand Circular Polarisation) polarisation.
- Pre-amplifier stage based in LNA (Low Noise Amplifier).
- Diplexer which allows connect on of two elements to a single input.

Due to the number of elements to be designed and implemented, a single band of frequency was preferred, being the UHF band the selected one. This decision was made because to the most of amateur satellite sends their telemetry data in this band of frequencies, instead of the VHF band.

Once this hardware has been designed and manufactured, only a few changes are needed to adapt it from UHF band to VHF band. For this purpose, it will only be necessary to modify the LNA adaptation network and the transmission lines, which allows the change of the polarisation, in order to adapt their size to the new electrical wave length.

## 2.2. Subsystems in detail

In this section the subsystems will be explained each one in detail, highlighting their most relevant points.

### a) Diplexer

The diplexer will be developed with two filters for splitting the radio spectrum in two parts, a higher and a lower one. Both parts of the diplexer are shown in Figure 5. A wide diversity of filters are available in the market, such as SAW filters and filters on chip, or handmade filters such as Cebyshev filter or Butterworth filter: all are eligible options once the requirements of the diplexer are defined.

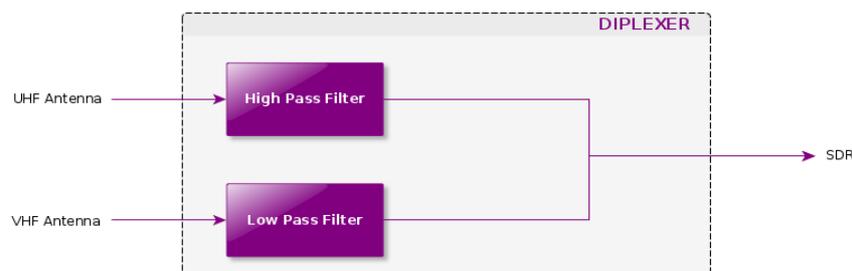


Figure 5. Diplexer

### b) Low Noise Amplifier

In order to guarantee a good performance and according to the requirements of the system, a commercial LNA will be selected. If we want to reach a simple design, the MAX2640 LNA is a good candidate to have into account: its needed adaptation network is small, so only a few extra passive components are required. In addition, it is a chip designed to operate into UHF band.

The use of a simple schematic – as shown in figure 6 – allows a quick design phase and it facilitates the performance of design and the soldering works of the prototype, reducing it to a few days. This will be an important point for the SatNOGS community.

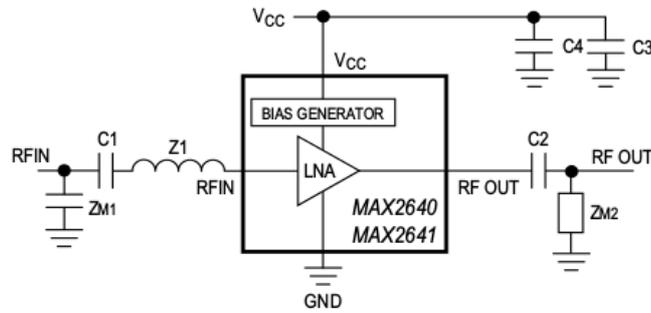


Figure 6. Maxim LNA schematic

### c) Polarisation Switch

In order to get circular polarisation in a cross Yagi-Uda antenna in 'x' mode, the difference in cable length has to be a quarter wave. We can obtain a RHCP or LHCP just by changing the relative length of the transmission lines.

The power divider could be a quarter wave segment of 35 ohm cable or two quarter wave segments of 75 ohm in parallel. The RF switch used to carry out the switching could be a simple chip if the power of the received signal is sufficiently small, as it happens at amateur ground stations.

The design proposed is shown in Figure 7. The advantage of this design is that the hardware is interchangeable among frequency bands by just replacing the transmission lines.

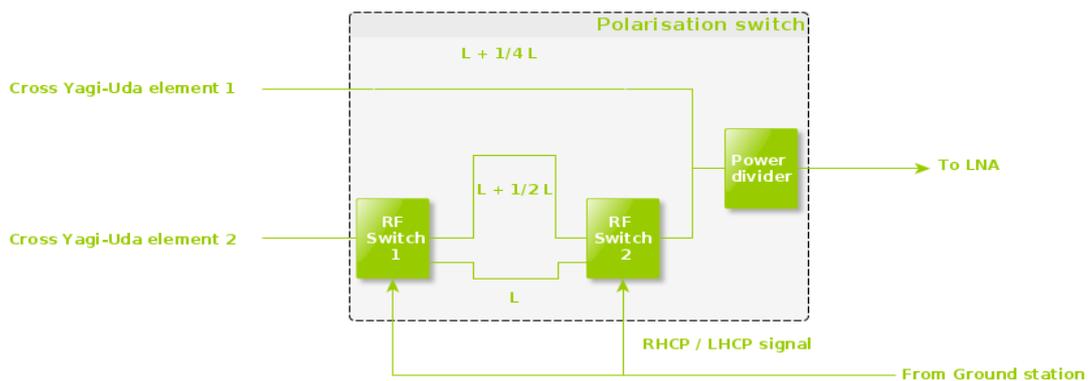


Figure 7. Polarisation switch

### d) Cross YAGI-UDA Antenna

This element of the project could be the hardest to achieve by starting from scratch. Because of this reason, a tested and reliable design will be used.

There are a lot of Yagi-Uda antennas designed by amateur radio operators and the most appropriate design will be selected after setting the antenna requirements. This antenna selection shall be made with its author's authorisation.

A couple of antennas designed by amateur radio operators are shown as example in Figure 8 and Figure 9.



Figure 8. PA3GUO antenna design



Figure 9. SP5MG antenna design

### 2.3. Project scheduling

A simple Gantt chart has been created in order to schedule the three month duration of this project. The detailed information about the project scheduling is provided below and shown in Figure 7:

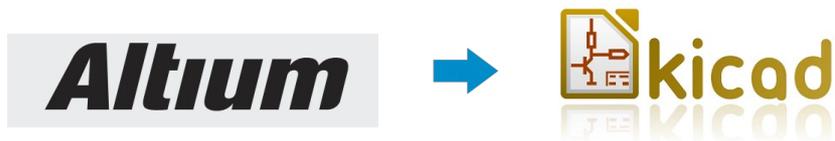
- During the first week (week 23) the focus will be on the documentation work and requirement setting.
- After knowing the system requirements, the design phase will start and last three weeks (week 24, 25 and 26). Due to the simplicity of this design, this time shall be enough for the first design iteration.
- After the designing phase, the prototype building should start the week 27 at the most and it will have a duration of seven weeks (until week 33). If any correction in the design has to be performed, it will be assigned in this phase. Meanwhile the cross Yagi-Uda antenna is developed, the polarisation switch will be tested with the antennas placed in the facilities available to me.
- Week 34 and 35 are spare days at the of the programme in case of delay in any task.
- Finally, week 36 is reserved for writing the documentation required by mentoring organization and SOCIS managers.



Figure 7. Gantt chart

## 2.4. Software to be used

The software to be used to design the PCBs is a relevant point in the project. The University of Granada in Spain has an Altium sponsorship and it is the software I have learned to design PCBs and I am more experimented with. In addition, I have used another EDA (Electronic Design Automation) software, such as Eagle or KiCad, although my expertise is not as higher as with Altium. For these reasons, I propose to start with Altium in order to reach a fast and fluent design. Once the design is finished, these PCB projects should be copied to KiCad software for the final release to the SatNOGS community.



Moreover, the philosophy of open source will be followed. For this reason, the use of a Git repository, such as GitHub, is a desirable option.

## 2.5. Facilities available

Table 1 lists the facilities available at my university which I might use during the development of the project. The access of these facilities is free for me because I am a member of the aerospace group of the University of Granada called GranaSAT.

<p>Soldering station</p> 	<p>Power supply - PROMAX</p> 
<p>Circuit Board Plotter – LPKF Protomat S62</p> 	<p>Wave form generator – HP</p> 
<p>Vectorial Network Analyser – Agilent E5071C</p> 	<p>Spectrum Analyser / Signal Analyser – Anritsu MS2830A</p> 
<p>Wimo X-Quad Yagi antenna: 70 cm and 2 m band</p> 	<p>GranSAT ground Station: Radio ICOM IC-9100 Radio KENWOOD TS-2000 Rotor YAESU G-450A</p> 

Table 1. Facilities available