Setting up a Student Satellite Receiving System in the United Arab Emirates

Yousef El-Haj, Mustafa Harbaji, Lutfi Albasha
Department of Electrical Engineering,
College of Engineering
American University of Sharjah
Sharjah, United Arab Emirates
e-mail: lalbasha@aus.edu

Nidhal Guessoum
Department of Physics
College of Arts and Sciences
American University of Sharjah
Sharjah, United Arab Emirates
e-mail: nguessoum@aus.edu

***Abstract*—The successful setting up of a research satellite system (signal receiving and data acquisition station) in the United Arab Emirates is reported. The process of drawing up the basic system architecture and determining the essential requirements of the receiving station that isthe satellite dish and components and the reception unit (hardware and software) is described. The challenges encountered and the mitigations and report on the success achieve so far: system set up, signal acquisition, quick data analysis and image processing is discussed. Preliminary conclusions are presented from this first phase of the project.**

Keywords- satellite receiving station; EUMETSAT; students project

I. INTRODUCTION

The aim of this project is to set up a satellite reception station by students in a multi-phase timeline. There are various educational, scientific, and technical objectives to this project – the first of its kind in the region. A few similar projects have been undertaken elsewhere [1, 2, 3].

In the first phase, the station was constructed from a blueprint as recommended by the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT).

EUMETSAT's network provides useful meteo-rological and environmental data; its scheme allows it to transmit weather, climate, and geographical data to large regions of the world [4]: the data is sent to a ground station (the European uplink) which acts as a router; then the received signal is sent to a geostationary satellite.

In order to receive the signal in the United Arab Emirates (UAE), the need arised to turn to the Atlantic Bird 3 geostationary satellite, which receives the data from the African Service station. Atlantic Bird 3 covers mainly the African continent; however, the UAE is just within the footprint covering Africa [5]. This has posed an interesting challenge, that had to be dealt with.

This paper presents a project of building a receiving station that can receive EUMETSAT satellite data. In the first phase, the receiving station was built from off-the-shelf components; that is, the station was assembled from components that are available in the market. Students then moved to the second phase where the receiving station was designed and built essentially from scratch. The main task was to build the appropriate receiver for obtaining a good-quality satellite signal (a good signal-to-noise ratio). The second phase, well under way, will be considered complete once the data, thus obtained and analyzed, matches with that from Phase One. A later phase will consist of a full scientific analysis of the data [6].

The first task was to perform a simulation analysis on the link budget to determine the required technical specifications of the needed components as shown in Figure 1. This analysis considers the signal strength, the data type, the hardware, software and components gain, noise and linearity requirements.

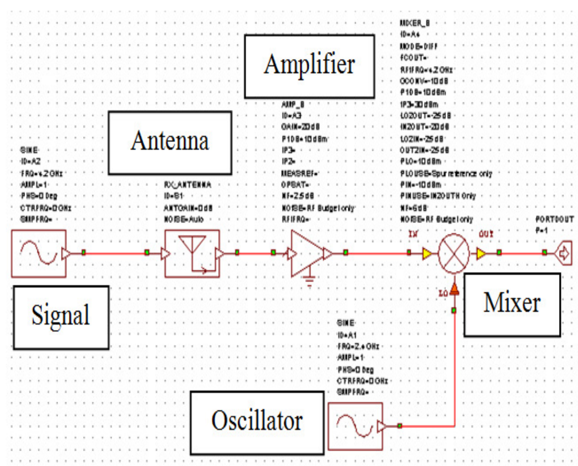

Figure 1: Block diagram of the simulation analysis using AWR tool of the Low Noise Block (LNB)

II. PROCEDURE

The next task was to assemble the receiving station using ready-made components in order to acquire, record, and test the signal from the Atlantic Bird 3 satellite. A block diagram showing the main components of the station is given in Figure 2.

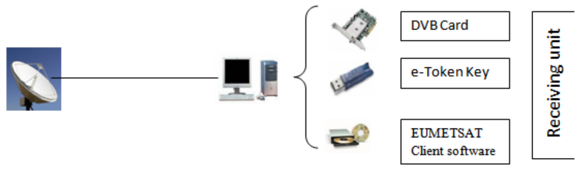

Figure 2 – Block diagram of the project

A. *The satellite dish and Low Noise Block (LNB)*

An essential part of any receiving station is the antenna. At United Arab Emirates, it is possible to receive both Ku-band and C-band signals, but the geographical coverage of the C-band signal is much better as recommended by EUMETSAT . Figure 3, at the end of the paper, adapted from a EUMETSAT diagram, shows the recommended satellites for each region.

An appropriate Low Noise Block converter (LNB) had to be selected for the purpose of receiving a C-band signal; however, we installed an LNB with a duality feature for the future possibility of using the Ku band (perhaps with a different satellite). Figure 4 shows the LNB used and its band frequency specifications.

Figure 4: LNB selected in the AUS Student Satellite receiving station.

As can be read on the LNB shown in Figure 4, the frequency of the input signal is in the range of 3.4 to 4.2 GHz for the C band (with the possibility of detecting signals in the Ku band range of 10.7 to 12.75 GHz). The output frequency of this LNB for the C band is 950 to 1750 MHz, with a gain of 65 dB. For the Ku band, the output frequency would be 950 to 2150 with 65 dB gain. Nevertheless, the noise level of the LNB in the C band is 17^{o} K, and for the Ku band it is 0.5 dB.

Another major consideration in the design is the antenna's dish size. According to EUMETSAT recommendations (Table 1 below) and taking into account the expected signal level due to the geographical location of the station (almost at the edge of the satellite's footprint, as seen from Figure 2) the size of the dish to be used in this area should be at least 3.7 meter.

TABLE I. RECOMMENDED DISH SIZE ACCORDING TO THE COVERED REGIONS BY EUMETSAT

Band	Location	Antenna Size
Europe (Ku-band)	within the "core" geographical footprint of the spacecraft, the area bounded by the inner contour depicted in the Hot Bird™ 6	85cm or larger
Europe (Ku-band)	within the "extended" geographical coverage (remote European islands, Turkey East of Ankara and Eastern European countries)	1.8m or larger
Africa (C-band)	within the "core" geographical footprint , the area bounded by the inner contour depicted in the Atlantic™ Bird 3	2.4m or larger
Africa (C-band)	within the "extended" geographical coverage (e.g. Madagascar, La Reunion, Mauritius and parts of North America)	3.7m or larger
South America (C-band)	within the area bounded by the 39 dBW contour depicted in the NSS806 graphic	2.4m or larger
South America (C-band)	smaller antennas may be sufficient, depending upon individual location, for details for your location, please contact the EUMETSAT User Service	1.8m or larger

For this work we elected to use a 4.2 meter dish, shown in Figure 5,to receive a good signal as much as posiible

Figure 5 – AUS Student Satellite Station's receiving dish

B. *Personal Computer (PC) Receiving Station*

The DVB card used in our station is the Technisat™ SkyStar 2, which is one of the recommended DVB cards for receiving EUMETSAT broadcasts. The card is shown in Figure 6, as installed in a PCI slot of a computer.

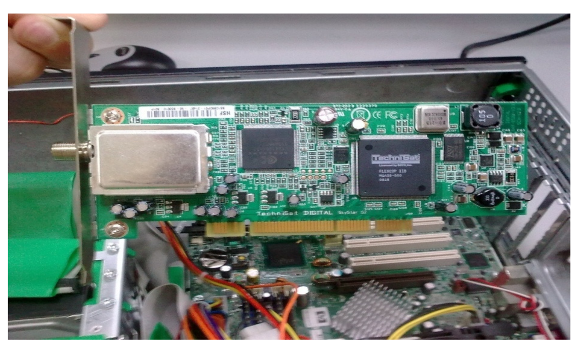

Figure 6 – Technisat™ SkyStar 2 DVB PCI Card

Figure 7 shows the LNB frequency setting on the DVB card and the corresponding received signal quality and strength.

This, however, was not enough to ensure receiving the right signal and data. For that, the EUMETCast Client Software is used, both to insure the integrity of the signal, and to decode the incoming data.

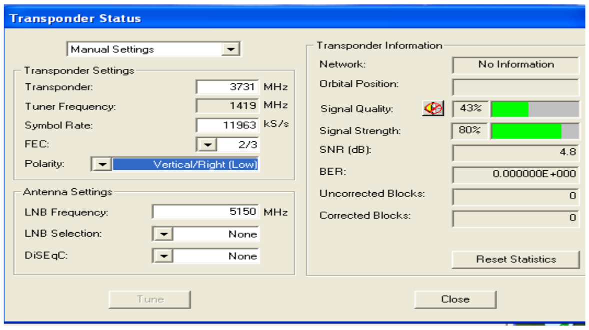

Figure 7 – Technisat™ SkyStar 2 DVB Card Transponder Status

C. *The Client Software*

The EUMETCast Client Software is provided by EUMETSAT to access, decode, and process the received signal through the DVB card. This software is a client/server system linking the server at the EUMETCast uplink site with the system at the user side. When the software is installed and run, it showed an "Active" status (figure 8), thus confirming that a signal was being received and the system was establishing a connection to try to decode it.

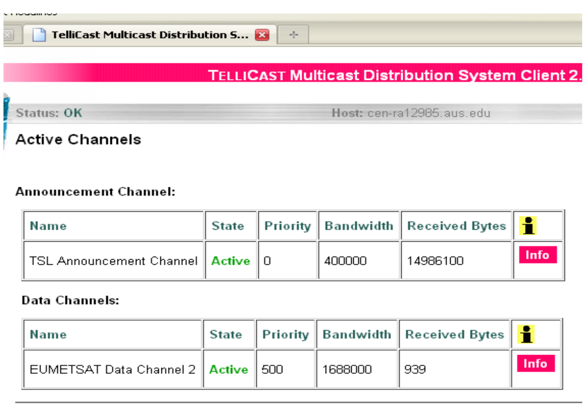

Figure 8 – EUMETSAT Client Software

The connection has indeed been fully established. The signal could then be analyzed for validity by a visualizing software (see Figure 9). In a later phase, the scientific analysis of the data can be undertaken, extracting real information from the data/images.

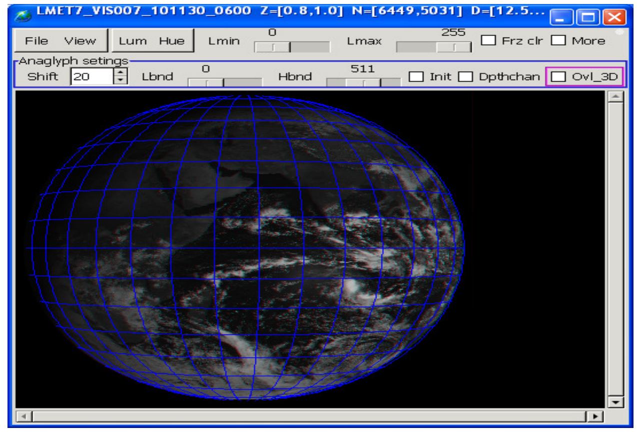

Figure 9 – Visualized picture of the downloaded data

III. DISCUSSION: WORK SO FAR AND CHALLENGES ENCOUNTERED

The main objective of this project is educational, that is for the students to acquire scientific knowledge and technical skills and apply them in a concrete task of a modern field. This is clearly being achieved with the successful setting up and completion of the main parts of the project and with the outcomes now produced (Figure 9).

Indeed, the outcomes that had been set for this project, or at least its first phases, are:

- Constructing an electronic blueprint for the station;
- Assembling the station;
- Testing the reception of the satellite signal;
- Ensuring the integrity and validity of the data;
- Producing images.

All the above objectives have been achieved and by visualizing the data, phase one has been completed successfully.

This first part of the project, though simple in concept and apparently straight-forward to implement (assembling dish, LNB, and computer hardware, and installing and executing the appropriate software), was actually far from trivial and raised some very useful issues, which were tackled as pedagogical (learning) opportunities.

Once the EUMETSAT satellite network and its data had been settled, the remained part was to determined which specific satellite was needed to target and how to ensure that a good signal was to be detected and recorded. As the UAE is located at a far point of the contour footprint of the Atlantic Bird 3 satellite's C band coverage area, the dish size had to be at least 3.7 meters wide, though for the reasons explained above aconclusion was drawn to havea satellite about 4.2 meter. However, most markets in the UAE offer only dishes that range between 90 and 120 centimeter in diameter. However, a company which would install a 4.2 meter parabolic dish was found.

Once the dish was installed, wthe strength of the signal was checked. The Technisat™ SkyStar 2 DVB PCI Card software contains a pre-setting for most used satellites, like Hotbird 13E and Nilesat 101/102 7 W (see Figure 10), a setting which can determine and show the signal strength and quality.

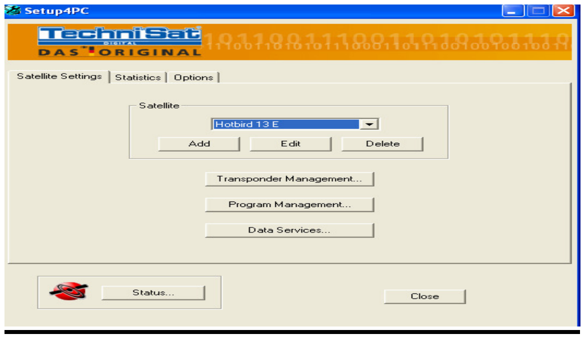

Figure 10 – Hotbird example for available Satellites

Not surprisingly, the Atlantic Bird 3 satellite is not included in this pre-setting, as it is not a satellite which consumers normally access. To overcome this issue, we updated the software of the Technisat™ SkyStar 2 DVB PCI card manually by contacting the manufucature. After this modification, access to the signal from Atlantic Bird 3 was possible. But in order to make sure that we were indeed receiving a real signal we measured the Signal-to-Noise ratio, using the following connection:

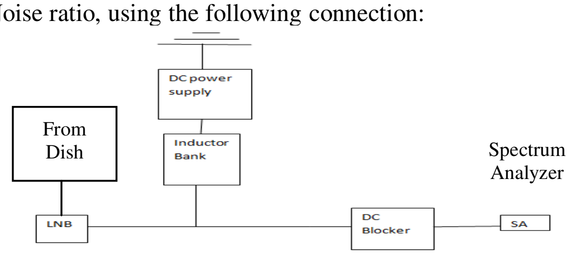

Figure 11: Testing the Signal using Spectrum Analyzer Circuit Diagram

The DC power supply is adjusted to 14 Volt to model the vertical polarization. The inductor bank acts as an open circuit in which the final circuit diagram in AC small signal analysis will be the model of the LNB and SA only. By testing the signal we found a signal-to-noise ratio of 65 dB.

IV. CONCLUSIONS

In this report we have summarized the main steps and procedures we followed in setting up a satellite receiving station in the UAE. Phase One of our project has enabled us to acquire multi-faceted experience and expertise on such a project. It was important to start with a phase in which we take ready-made components and assemble them, as this helps the project participants begin with basics before launching into more ambitious electronic design topics.

This project has now moved to Phase 2, as the first phase has been completed and a signal has been obtained and confirmed by visual display of the data, and the learning has been substantial and important.

The project is now proceeding with the building of a receiver unit, mainly the DVB card, from scratch. We anticipate this part of the project to be both challenging and of great potential rewards, as the students will be able to show their technical knowledge, skills, and capabilities, and may produce units that might be of much better performance than the ready-made components that were used in Phase 1. All in all, the receiver should have a high sensitivity to receive the signal at high SNR that is to have a signal strength of 4.9 dB, as the UAE is located at the far edge of the satellite footprint.

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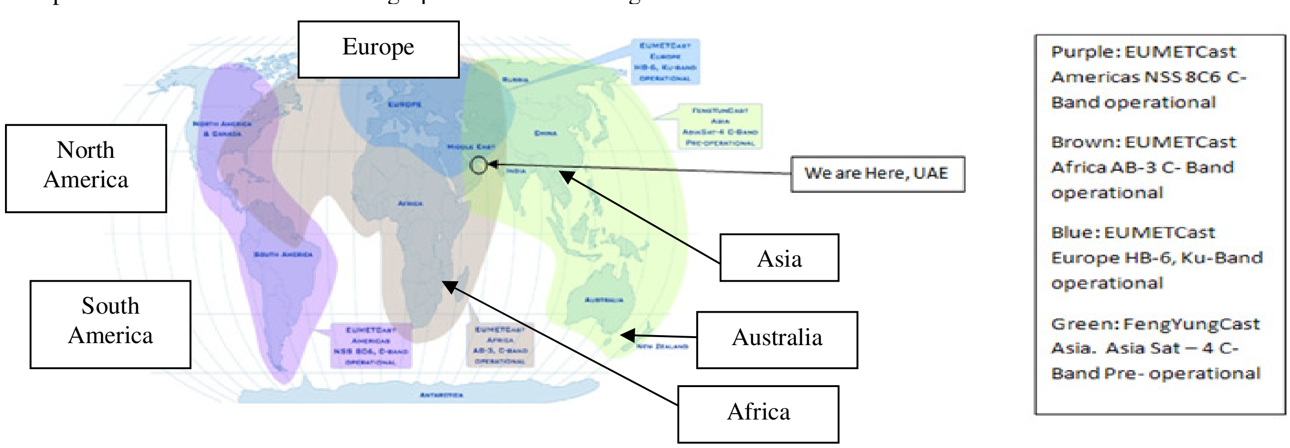

Figure 3 – The location of UAE with respect to the contour of the footprint of the Atlantic Bird, C-Band

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