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Mexican Earth Station for Reception of Scientific Data from Mexican and Foreign Satellites, Tracking, Telemetry and Command

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Abstract

A few months ago, the Faculty of Engineering of the National Autonomous University of Mexico (UNAM) design and install along with an American company the first satellite earth station that has the following technical capabilities: reception of scientific data, images from the space, Telemetry, images of the earth from the satellite, tracking and command. Mexico is one of the countries that invests a lot of money to obtain satellite images of Mexican territory; this factor becomes more complex when you consider that in our country there are very poor ground infrastructure dedicated to the receipt of such images, Telemetry, command, etc. In the next few years, Mexico will have its own scientific microsatellite (Condor Scientific Microsatellite) and need to be prepared with the minimum infrastructure to control them effectively. The earth station operates in the S, X band and has a special X/Y type system, and its technical characteristics make it very attractive and cheaper than other stations. Its geographical location near the Ecuador makes it interesting for NASA and research institutions from Spain and Russia. This article presents the terrestrial infrastructure, features and examples of operation of the station. The earth station is part of the first Mexican national laboratory space of the engineering faculty of the UNAM achieved with support from CONACyT-UNAM.
Keywords: earth station, satellite, telemetry, command, tracking.

Acronyms/Abbreviations

CONACYT-National Council of Science and Technology
UIT–International Telecommunication Union
UNAM–National Autonomous University of Mexico
UAT–Unidad de Alta Tecnologia
EF–Engineering Faculty
MAI –Moscow Aviation Institute
LEO–Low Earth Orbiting
GPS–Global positioning System
LNA–Low Noise Amplifier

1. Introduction

The main objective is to present the earth station that will serve as valuable instrument for receiving scientific information from microsatellite Condor UNAM-MAI, (collaboration between Mexico and the Russian Federation) telemetry, tracking and command [1].

In the last ten years, universities around the world have begun to develop small satellites (Nano and Microsatellites) for different scientific and engineering applications. The majority of satellites are launched into near circular orbits with altitudes of 200 to 1200 km. Therefore, there is a need to receive and interpret the telemetry signals and sending command to satellites, for example, Cubesat type (low cost). In fact, different countries are being implemented satellite dishes offering capacity to receive signals from Radio Frequency and to send commands within S band (2-4 GHz) mainly.

The earth station is designed and installed to meet mission control functions of microsatellites developed in Mexico and international collaboration.

The earth station is designed to be compatible with the technical requirements necessary to collaborate internationally in scientific and educational projects.

The earth station is intended primarily for the operation of satellites developed in Mexico and require terrestrial infrastructure capable of receiving low resolution satellite images using the X (8 to 12 GHz) band.

1.1 Planning the Mexican Earth Station

Planning of the Mexican earth station is developed considering the technical requirements of some of the microsatellites that are being developed in Mexico. So, the earth station includes the basic elements: Satellite dish 3.2m, Polarizer, low noise amplifier, power amplifier, Down-Converter for S band (IF: 70MHz) and Down-Converter for X band (IF: 720MHz) which includes software integration with the system´s Monitor and Control (M&C) and software LEO satellite tracking. In Fig. 1 shows the general scheme of planning of the Mexican Earth Station for Reception of Scientific Data from Mexican and Foreign Satellites, Tracking, Telemetry and Command.

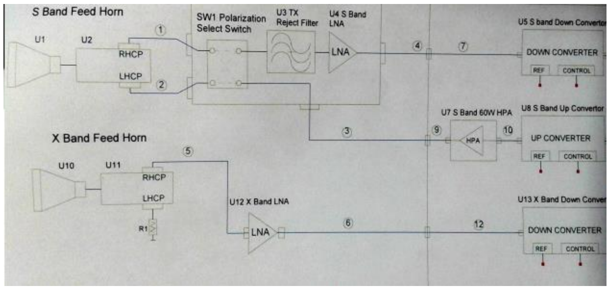

Fig. 1. General Scheme of the Mexican Earth Station

1.2 Earth Station Facilities Design

An Earth station antenna is required to communicate with our Low Earth Orbit (LEO) microsatellite Condor. The scientific mission requires an antenna that can operate simultaneously in S and X band. The S-band portion of the feed-system is required to uplink (Tx) Command Control signals to the satellites and downlink Telemetry Monitor signals from the satellite. The X-band section of the feed-system is specifically implemented for to receive (Rx) Scientific data and low-resolution images from the satellite. The feed-system is not required to transmit in X-band.

In Fig. 2 shows the antenna installed on top of the "National Laboratory in Space Engineering and Automotive" (CONACYT-UNAM). Juriquilla, Queretaro.

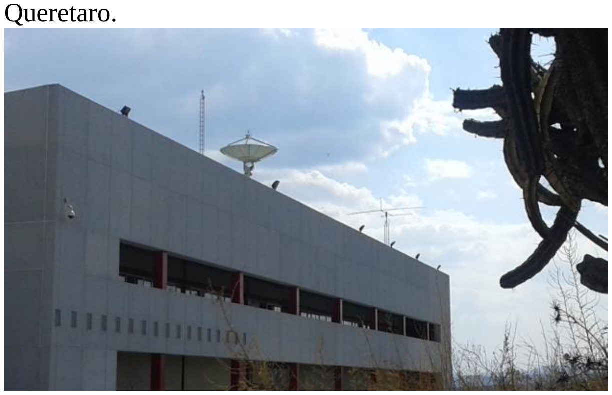
Fig. 2. Antenna on the top of National Laboratory

2. Material and methods

Some of the essential characteristics of the Mexican earth station are compared with other developed infrastructures in Europe mainly, S-band with selectable TX/Rx feed assembly and one LNA, frequency range 2200-2300MHz, transmit reject filters. The basic targets specifications at S-Band are shown below. See Table. 1.

Table 1. Basic targets specifications at S - band

Mexican Earth Station	Baesystems
(Rx) 2.200-2.290 GHz	(Rx) 2.200-2.300 GHz
(Tx) 2.025–2.110 GHz	(Tx) 2.025–2.120 GHz
Rx: LHCP and RHCP Tx: RHCP	Rx: LHCP and RHCP Tx: RHCP

The earth station has fully integrated software includes all satellite scheduling and full remote monitor and control function software to perform automatous program track. The basic targets specifications at X-Band are shown below. See Fig. 3.

Table 1. Basic targets specifications at X - band

Mexican Earth Station	Baesystems
(Rx) 8.0 – 8.4 GHz	(Rx) 8.0 – 8.5 GHz
Rx: RHCP (LHCP)	Rx: RHCP.

3. Theory and calculation

The earth station antenna is one of the important subsystems of the RF terminal because it provides a means of transmitting the modulated RF carrier to the Microsatellite Condor within the uplink frequency spectrum and receiving the RF carrier from the satellite whiting the downlink frequency spectrum.

Our technical requirements are:

1.- The antenna must have a highly directive gain. The antenna radiation pattern must have a low sidelobe level to reduce interference from unwanted signal. 2.- The antenna must have a low noise temperature and 3.- The antenna must be easily steered so that a tracking system can be employed to point the antenna beam accurately toward the microsatellite taking into account the satellite´s drift in position [2]. The gain is perhaps the key performance parameter of an earth station antenna. The gain is given by:

$$G = \eta\ (4\pi A/\lambda^2) \qquad (1)$$

Where: A = antenna aperture area (m^2)
λ = radiation wavelength (m)
η = antenna aperture efficiency ($\eta < 1$)

3.1 Antenna Gain to Noise Temperature Ratio

We have another important parameter: the antenna gain to Noise temperature ratio G/T that is a figure of merit commonly used to indicate the performance of the earth station antenna and the LNA in relation to sensitivity in receiving the downlink carrier (S or X) from the microsatellite. Therefore, the earth station system noise temperature referred to the input of the LNA is:

$$T = T_s + T_e$$
$$T = T_A / L_1 + (L_1 - 1)\ T_0 + T_{e2} + T_{e3}/G_2 \qquad (2)$$

Where:
T_s = Noise temperature of the noise source

T_e = Equivalent noise temperature
T_A = Antenna noise temperature
T_0 = Surface temperature (290 K)
T_{e2} = Equivalent noise temperature
T_{e3} = Equivalent noise temperature (DownConverter)
G_2 = Antenna gain referred to the input of the LNA
L_1 = waveguide loss

Therefore, the antenna gain referred to the input of the low noise amplifier is

$$G = \text{Receive antenna gain} - L_1 \quad (3)$$

Thus the antenna gain to noise temperature ratio in decibels per kelvin is

$$G/T = G\ (\text{dB}) - 10 \log T \quad (4)$$

Under these conditions, the earth station has the following approximate value: 18 dB/K at 3º antenna elevation for 3.4-meter dish. Although this approach results in a higher insertion-loss and a slight degradation in Gain to Noise-Temperature Ratio (G/T), it has the advantage of significantly reducing the size, weight and cost of the feed system (see fig. 3).

Fig. 3. The antenna feed

3. Results

We have achieved together with TCS Communications Systems implement our own earth station reception of scientific information and images of low resolution. The antenna has the ability to receive in S and X bands with good performance mainly good IF signal level.

4. Discussion

Our microsatellite Condor will transmit only in polarization RHCP whereby the LHCP port is terminated with a coaxial load. The performance of the earth station is good in general terms because we have been able to receive RF signal from Terra, Jason 2, etc., but we need a larger antenna if we want to receive satellite signals from Landsat or Spot. Unfortunately, this requirement increases the cost of the earth station.

6. Conclusions

It has been achieved to design and install together with an American company the first satellite earth station that has different technical capabilities: reception of scientific data, images from the space, Telemetry, scientific data and low-resolution images from the satellite, tracking and command. Mexico is one of the countries that invests a lot of money to obtain satellite images of Mexican territory. Now we are almost ready to collaborate with other universities dedicated to the operation of CubeSat's and Microsatellites.

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