THE DOWN CONVERTER IN-HOUSE DEVELOPMENT PHASE 2 : LESSON AND LEARNING

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ABSTRACT: The communication between the control ground station and the satellite is the most important part to receive and command the information between both. Thailand by Geo-Informatics and Space Technology Development Agency (GISTD) has received the data of the Earth Observation satellite by the receiving station for more than a decade. In 2008, the THAICHOTE satellite was the first Earth observation satellite owned by Thailand. THAICHOTE's S-band control ground station performs receiving the telemetry and transmitting the telecommmand to the satellite. In this decade GISTDA's operators and engineers have gained more experience to operate the satellite and maintain the ground control station. GISTDA has initiated the improvement the performance of the operation system and first developed the in-house S-band antenna system named WATER. The main objective is to improve the operational procedures and building capability of GISTDA engineers.

This paper presents the development of the GISTDA ground control station and focuses on the first in-house manufactured down converter. Since 2017 the in-house converter phase 1 has been developed, which is related to understanding of the down converter. This paper presents the in-house down converter phase 2, which is consist of the prototype specification and the lesson and learning for GISTDA's engineers from this project.

The down converter for S-band converts the frequency from 2GHz to 70 MHz. This project is the co-operation between GISTDA and Mahanakron University of Technology, Thailand. Experts have transferred their knowledge in the area of satellite communication to GISTDA engineers via hands-on development and training courses. The prototype has been subjected to a factory test. It is ready to be integrated and tested with THAICHOTE existing S-band station. GISTDA has a plan to develop a small satellite in the near future. This in-house development down converter will be a benefit by supporting the multi mission ground station.

1. INTRODUCTION

The first Earth Observation (EO) satellite owned by Thailand is the **TH**ailand **E**arth **O**bservation **S**atellite (THEOS), which has been in orbit since 2008. The THAICHOTE is another name for THEOS assigned by the late King RAMA IV. The ground control station has been established and used for THEOS's operation since its launch in 2008. The main sections of GISTDA ground control station consists of:

- S-band station
- Satellite command center
- Flight Dynamics System for Orbital Analysis
- Mission planning center

Figure 1 demonstrates the section in the GISTDA ground control station. The S-band station functions based on S-band frequency of the uplink at 2035.96 MHz and the downlink at 2211 MHz. The system operates with an Intermediate Frequency (IF) of 70 MHz. The satellite control center functions and mission plan are sent to the telecommand and mission plan to the satellite, in addition it receives the telemetry from the satellite. The flight Dynamic system consists of the orbit determination, orbit prediction and orbit control. The mission planning center performs mission planning everyday based on user requirement.

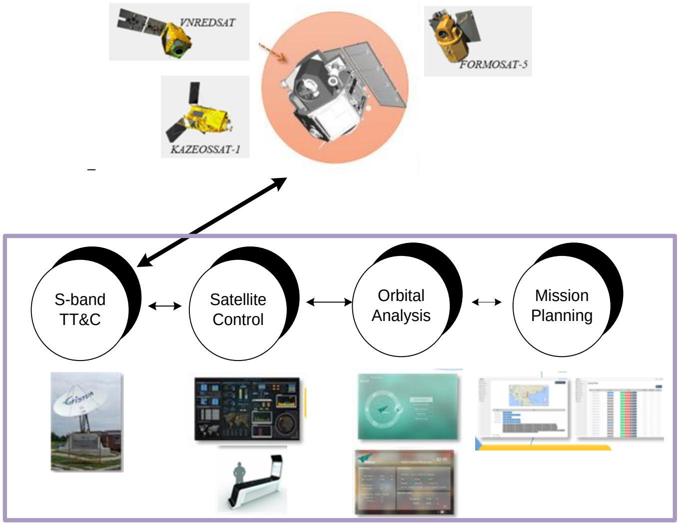

Figure 1. GISTDA satellite ground control station

For more than one decade, GISTDA has gained experience in satellite control operation and maintenance. During this period, GISTDA has developed many in-house tools (Jaranon,2015). The objectives of the development is to reduce the operating time with higher accuracy and lower risk of human errors (S. Channumsin et al., 2019),(S.Channumsin et al., 2017). This paper presents the in-house down converter development in phase 2, which is a cooperation with Mahanakorn University of Technology. The down converter is now being prepared to test with the THAICHOTE's ground control station. GISTDA will use the developed down converter as a spare part after the on-site test.
This project gives GISTDA more experience for developing the communication technology in the future. It is very important to integrate the space technology knowledge to be able to support space technology capability for the future of Thailand (Vongsantivanich et al., 2014). The rest of the paper is organized as follows: Section II describes the down converter prototype; the next section details the testing plan. The project learning is described in section IV and the final section details the conclusions.

2. THE DOWN CONVETER PROTOTYPE

The down converter prototype has specification of the input frequency range between 2,200 GHz to 2,300 GHz. The IF output is 70 ± 20 MHz. The External Reference Clock is 10 MHz with the input and output impedance 50 Ω. The size is about 19 inches. There is a ventilator fan on the back and on the side of the prototype. This prototype uses the revers engineer therefore during the development the adjustment of some parameters has been performed to make sure it functions as expect.
The block diagram of the Super-Heterodyne with dual-IF Topology has been used for this prototype, which are demonstrated in Figure 2 (L3 Marda-MITEQ, 2018). The real existing down converter has been studied to understand each component via reverse engineering. This process contributes to the team learning the concept of each circuit and understanding the design of each device. The down converter consists of many components, such as, the isolator, direction coupler, band pass filter, low noise amplifier, attenuator, etc. Each component has been reviewed and its functions simulated before implemented on the printed circuit board. This project used the simulation program named LineCalc ADS.

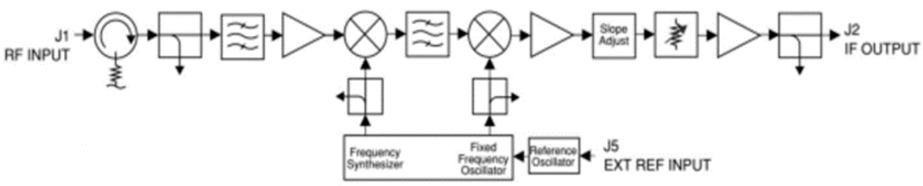

Figure 2. Down converter diagram from Nardo-MTEQ (S.Channumsin et al.,2017).

The basic concept to develop this down converter is separated into 2 sections; Electronic and Mechanic. The electronic part consists of many components as mentioned above. The mechanical part has to be designed with the layout that can fit all the components in the rack, which will be located with other devices at the ground control station room. The circuit boards of each device have been reviewed, simulated and integrated together. Figure 3 demonstrates an example of the band pass filter coupled resonator. Also, Figure 4 illustrates the VCO MAX2606 and VCO ROS-404-219 during performing measurement of the phase noise.

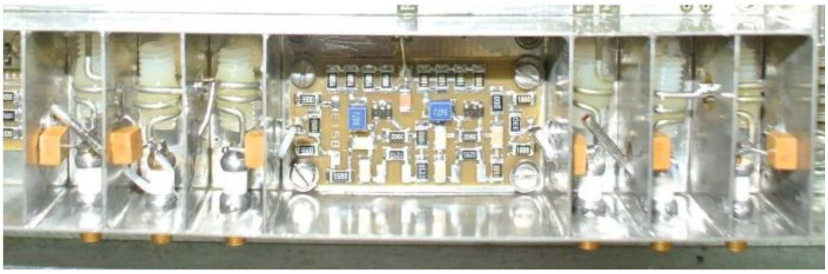

Figure 3. An example of PCB board for the band pass filter of the coupled resonator.

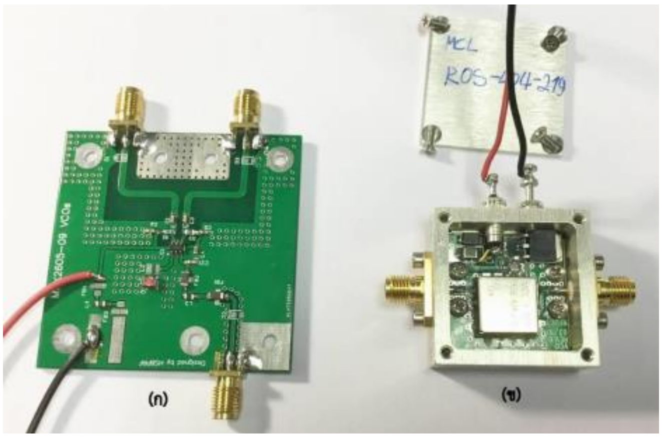

Figure 4. An example of the VCO MAX2606 and VCO ROS-404-21

The in-house down converter, demonstrated in Figure 5, has been developed using the super-Heterodyn receiver diagram invented by Edwin H. Amstrong (Behzad, 2011).

Figure 5. The in-house down converter prototype.

3. TESTING PLAN

GISTDA has a long term plan on developing all parts of the ground control. In the part of S-band station, the in-house TT&C system has been developed with the name WATERs (Wise Antenna of Transmission Execution & Receiving system) project and has been operated for THAICHOTE operation since 2017 (Likhit et al.,2018). The RF-IF subsystem of the down converter prototype have been testing by using the input signal at frequency from 2200-2300 MHz at the point A as demonstrates in Figure 6. The output IF signal at point B is 70 MHz as demonstrates in Figure 7.

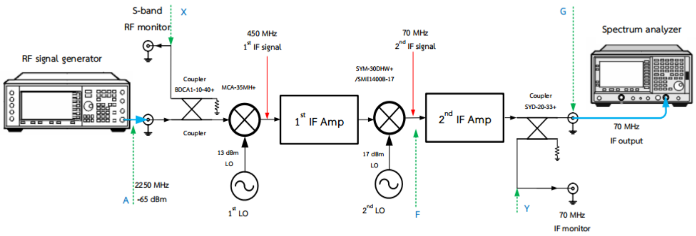

Figure. 6 The block diagram of IF-RF prototype

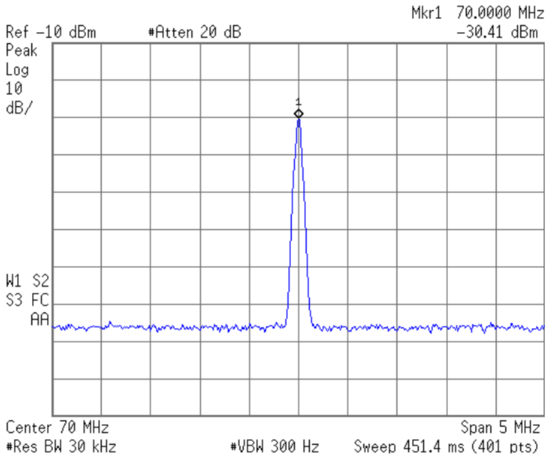

Figure. 7 IF output signal of the down converter prototype

GISTDA has a plan to test the in-house down converter prototype with the existing ground control satellite. The procedure of the testing has been organized, and will be performed when the Ground station has the available schedule for the testing.

4. PROJECT LEARNING

The success of this in-house prototype development depends on the power of the reverse engineering technique. The project was started by sketching out the design base through team brainstorming. The learning process during the study of the real down converter has given the team the concept of its function and alternative design.

On the job training is the recommended method to transfer specialist skills and knowledge through hands on activities to the engineers. Moreover, the academic education is also very important for providing the fundamental knowledge to the team. Figure 8 and Figure 9 illustrate GISTDA's engineers performing testing at the laboratory and participating in training courses by experts from a university.

Figure. 8 GISTDA's engineers performing testing at the laboratory.

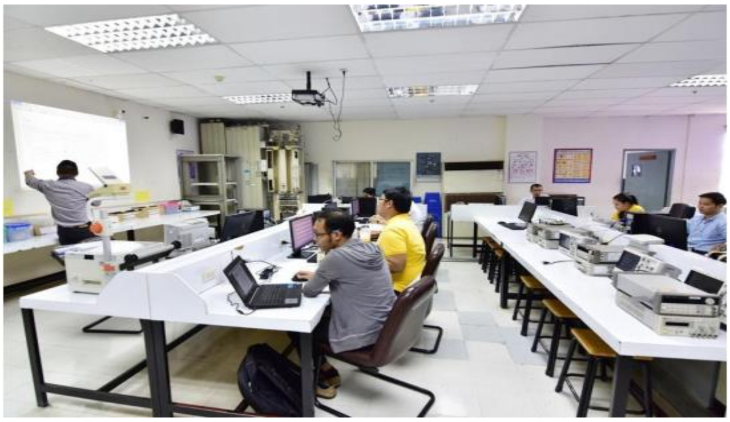

Figure. 9 GISTDA's engineers attended training courses by experts at Mahanakorn University of technology.

5. CONCLUSION AND FUTURE WORK

The new in-house down converter development project and process has been described in this paper. The project is running based on the reverse engineering from an existing down converter. The functions and behaviors of each electronic circuit have been reviewed, studied, designed and simulated.

The execution of the relevant tests of the S-Band down converter have been performed. The test setup with the simulation signal between 2200-2300 MHz can provided the output IF signal at 70 MHz Therefore, the final down converter prototype is finished and ready for integrating with the THAICHOTE's ground control station for final on-site testing. The expected time for this test is according to the available time slot from THEOS ground station.

This project is under the support from GISTDA and the Thai government, it is a small part to build up the new platforms of space technology for sustainable technology in Thailand.

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