Development of Automatic G/T Measurement Program for THAICHOTE Ground Station

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***Abstract* – A figure of merit for operating earth stations can be evaluated by G/T measurement. The performance of receiver must be retained quality for handling a weak power. Currently, the development of new S-band antenna system for THAICHOTE satellite series is being performed by GISTDA so that G/T measurement program is also required to be one of that parts. Particularly, this program attempts to be automatic function by starting from the sun tracking to G/T solution. This paper will describe the methodology and assessment of accuracy by referring to the original system.**

***Index Terms* — G/T measurement, Receiving system performance, Sun tracking**

1. Introduction

An antenna system for earth station is generally evaluated figure of merit for receiving antenna system by G/T measurement. G/T is meant antenna gain-to-noise-temperature. Normally, if the system does not have the completed function, G/T must be calculated by excel manually. G/T measurement is generally performed by two main activities; installing ground station and preventive maintenance. G/T measurement is similar to a simulation test by using source from a nature but this paper has selected the sun because of the strongest extraterrestrial source and including all of frequency ranges [1]. Conceptually, automatic G/T measurement program (AGT) has designed to operate from sun tracking to G/T solution by needing some information. For initiative development and demonstrating to proving the solution, this program has developed based on MATLAB firstly. If new S-band antenna has been finished, the program from MATLAB would be applied to any software for compatibility with the system. The following section will describe the detail of computing and comparison with the original system.

2. Platform G/T Measurement Program

According to AGT program is attempted to be automatic function for ground station, the program will require few information for obtaining and computing the result by itself. First of all, due to the sun was selected to be source in this measurement, the sun tracking shall be essential for antenna pointing. AGT program has also designed to support the accurate azimuth and elevation angles [2]. Moreover, for the other information, solar flux density, weather at test site and operating frequency (*f*) are highly required to fill in. Another important parameter is Solar Flux Density which it can be looked for at NOAA website by using the information from the place of observatory which is close to test site by distance and latitude. Furthermore, the observing frequency should be also close to operating frequency. Moreover, in case of operating frequency is not the same as observing frequency exactly. This program can compute the solar flux density for operating frequency by using (1). Fig.1 shows flow chart of AGT program for describing the methodology of the program.

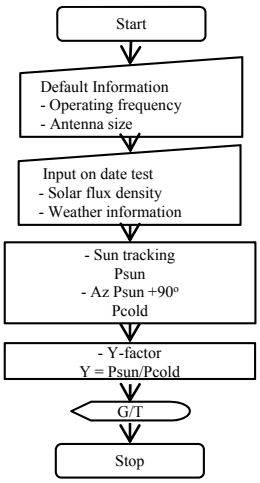

Fig.1 Program Flowchart

$$S = [Sf_1/Sf_2]^{\alpha}.Sf_2 \quad (\mathrm{W/m^2/Hz}) \quad (1)$$

Where

$$\alpha = \log(f/f_2)/\log(f_1/f_2) \quad (2)$$

$$G/T = 10log\left[\frac{8\pi k(Y-1)K_1K_2}{S\lambda^2}\right] \ (\mathrm{dB/k}) \quad (3)$$

Where, *S* is solar flux density at operating frequency which is computed by using solar flux density at lower (Sf_1) and higher (Sf_2) operating frequency. Meanwhile, (f_1) and (f_2) are observing frequency. During operating of measurement, the attenuation factor can be taken into account by (K_1) which is an atmospheric attenuation and it can be computed by weather information including temperature and percentage of humidity at test site [3]. Moreover, for (K_2), it is a relative angular size of the source with respect to the antenna's beamwidth. The computing of (K_2) will include wavelength (λ) and antenna size information [4]. Certainty, these factors can be automatically computed by AGT program.

After that, the antenna shall be moved to the sun for acquiring noise power. Accordingly, this program is able to compute the antenna pointing. When the antenna acquired

noise power (P_{sun}) completely at sun tracking, the azimuth angles will be at least shifted by ±90 degrees for acquiring power of cold sky (P_{cold}). Consequently, Y-factor (Y) can be computed by dividing P_{sun} and P_{cold} in Watts unit. Finally, G/T can be computed by using (3) from previous information. Where, k is the Boltzmann constant (1.38×10^{-23} J/K) [5].

3. Assessment G/T measurement program

This section attempts to analyze between AGT program computation and realistic operation for proving capability of AGT program. The methodology of assessment includes two parts; comparison of sun tracking and P_{sun}, P_{cold} including G/T measurement.

(1) Sun tracking

To verify the accuracy of sun tracking, the result of AGT program shall be compared with the original system which is CORTEX antenna control unit system. It was delivered by Zodiac Aerospace Company. As described in fig.2, azimuth and elevation angles for sun tracking from both programs AGT and CORTEX have a few differences. The differences do not exceed 1 degree for azimuth angles while it is close to zero for elevation angles.

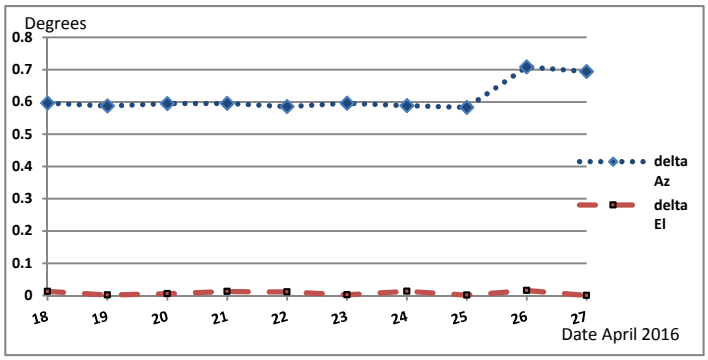

Fig. 2 Comparison of sun tracking

(2) Acquiring power from sun sky and cold sky

As already described in the introduction, GISTDA is still developing new S-band antenna system. Therefore, this measurement has been performed for proving AGT program with the original system. Thus, the methods of measurement have been separated in two methods. These tests are performed in the same as frequency of 2211 MHz, diameter antenna of 4.5 m and Right Hand Circular Polarization (RHCP) at THAICHOTE ground station, Chonburi, Thailand.

G/T measurement for the original system has been performed by software of Monitoring and Control (M&C) which was delivered by Indra Sistemas, S.A. M&C requires only solar flux density of 2695 MHz. Then, M&C will control sun tracking through CORTEX and afterward the power sensor in M&C system will read and record until reporting G/T measurement.

In cast of G/T measurement of AGT program, the information of solar flux density of both 1415 MHz and 2695 MHz and weather at test site are needed to obtain. Moreover, P_{sun} can be measured by obtaining azimuth and elevation angles from AGT program to CORTEX. Consequently, P_{cold} can be measured by shifting azimuth angles from sun tracking to ±90 degrees. As already described in fig.3, P_{sun} and P_{cold} from both measurements are very close together although each of measurements is different of about 10 minutes. The measurements have been performed within 10 times.

Fig.4 shows the result of G/T measurement for both tests that a few differences can be seen. The maximum of difference can appear from the difference of acquiring P_{sun} and P_{cold}.

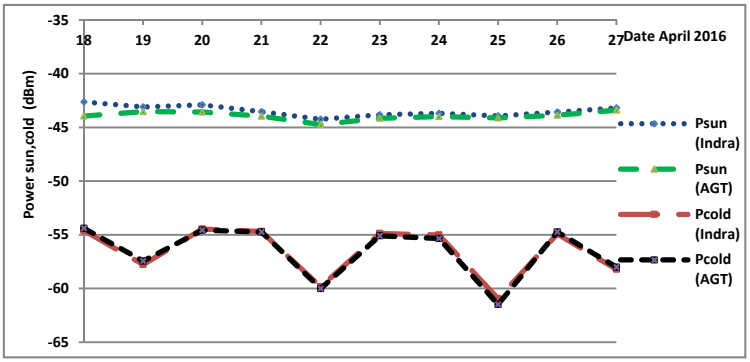

Fig.3 Result of P_{sun} and P_{cold}

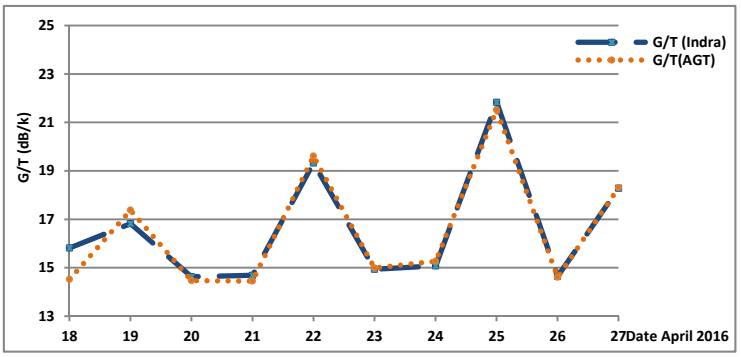

Fig.4 Result of G/T

4. Conclusion

As a result, G/T measurement of the program (AGT), which is developed by GISTDA, can be efficient for ground station. GISTDA expected to install this program for new S-band antenna system for TT&C mission within this year. For more benefits, this program shall be also installed in image receiving antenna at GISTDA for preventive routine maintenance because current system does not have G/T automatic program.

References

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