Integration and Installation of The Low Cost C-band Receiving System for Himawari-8 Satellite

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Abstract—At present, satellites play an important role in daily life. There are various applications which people daily use from the satellites. Their applications accommodate humans for more comfortable and more secure environment. Furthermore, under the climate change circumstance, the monitoring of our earth by satellites is becoming more important due to the fact of the satellites can easily capture the earth from the top view. Satellite data can be used to support area of interested depending on the applications. This paper presents the setting one kind of the system for monitoring the earth at low cost. The weather forecast satellite such as Himawari-8 (Japanese meteorological satellite) consists of various band sensors which can be properly used to monitor the earth. The low cost receiving station is performed by self-integration following JMA recommendation. Moreover, we also select the components locally. As a result, self-integration system can reduce the cost more than turnkey system 50 percentage and working is perfect.

Keywords—HimawariCast: C-band; ground station

I. INTRODUCTION

Himawari[1] is the Japanese geostationary meteorological satellite operated by the Japan Meteorological Agency (JMA). The original name of Himawari is Geostationary Meteorological Satellites (GMS). Since the launch of GMS-1 (Himawari 1) in 1977, there have been three generations of the satellite, including GMS, MTSAT and Himawari. Himawari is able to observe area of the East Asia and western pacific regions providing observation data every 10 minutes. Timely, accurate and comprehensive information about natural resources forms the basis of effective resources management. It is now widely recognized that the monitoring and assessment of these resources, in terms of both quantity and quality, require adequate meteorological, hydrological and other related data [2]. Thus, Himawari information and frequent update are appropriate for earth monitoring.

The Himawari observation data is widely used in various meteorological activities such as weather forecasting, and tropical cyclone tracking. Meteorological agencies, in East Asia, Southeast Asia, Australia and New Zealand usually use the information from Himawari for their own weather monitoring and forecasting combining with other information. The information from Himawari has also been distributed to those who would like to use it. There are three ways to get the information. The first is the cloud service for one department per country. For Thailand, that is the Thai Meteorological Department. The second is the Archive Server for universities and research institutes, which are managed by Japanese researchers. The last one is HimawariCast which is a service for general users who want to use the information for studying or researching this information of which can be received by the installation of C-band antenna and signal receiver system. However, the system is still expensive and not all the people can access to the data.

Geo-Informatics and Space Technology Development Agency (GISTDA) is the agency which has its own satellite and ground station for the earth observation satellite (EOS). GISTDA produces the information from satellite sensor to serve users in various applications. The information and application can be used to monitoring weather forecasting, cyclone tracking, flood situation, prevention of forest intrusion and research. Before Himawari-8, GISTDA received information from MTSAT-2 (Himawari-7). Has experience in the operation these satellites. After Himawari-8 launched to replace the MTSAT-2, a low cost station has been installed. Technically, installation manual is supported by JMA recommendation (www.jma-net.go.jp). The source of information of the recommendation, step of installation, application of the system, cost comparison and future work will be described in detail.

II. HIMAWARICAST

As mention earlier, Himawari-8 information is published to users via HimawariCast system as shown in Fig. 1. The operation of this system starts from Himawari-8 transmitting its raw data to JMA ground base station and then it converts raw data to imagery (full data) and sends to communication satellite operator for transmitting to communication satellite (JCSAT-2B). After that, JCSAT-2B will broadcast to end-users who want to use the information. Everyone can receive the information from Himawari-8 by installing the receiving system. It can be set up by JMA recommendation consisting of C-band antenna, low noise block downconverter (LNB), band pass filter (BPF), DVB-S2 receiver and computer with SATAID software [3]. The detail of each component will be explained in the next topic. The information from HimawariCast are compressed in High Rate Information Transmission (HRIT) and Low Rate Information Transmission (LRIT) formats which have the advantage that they can be opened directly by SATAID.
III. THE INTEGRATED SYSTEM

Since GISTDA needs new receiving system for Himawari-8 observation data reception, the self-integration turned out to be a better solution than having a turnkey system in term of cost. Almost all the components in this system are based on JMA recommendation with the using of local products in Thailand. Fig. 2 show the integration of the receiving system described in the sub-section below.

![Fig. 1 Overview of the HimawariCast system](image)

**A. Antenna**

Even though several types of antenna can be used for receiving satellite signal, the 'prime focus type' was selected to be installed for feed horn in this integration because its structure is simple, easier to assemble and suitable for C-band receiving. Fig. 4 (a) show 3 m. of mesh type C-band antenna which is used in our system. In Thailand, the prime focus type product is commonly used and affordable. According to JMA recommendation, the antenna diameter should be considered by the receiving location that guarantees a circuit operating ratio from contours of JCSAT-2B shown in Fig.3. The recommendation suggests the size of antenna diameters which users should consider. For Thailand at least 2.4 m. should be selected The properties of this antenna (Fig.4(a)) are as follows.

- **Input frequency range**: 3,400 - 4,200 MHz (At 4,148 MHz)
- **Construction**: Prime Focus Aluminum
- **Diameter**: 300 cm.
- **Focal Length**: 114 cm.
- **f/D Ratio**: 0.38
- **C-band Gain**: 39.40 dB
- **Weight**: 55 kg.

**B. Feed horn and scalar ring**

The main feature of feedhorn is the responsibility to convey the reflected waves from the surface of the antenna to the LNB. The diameter of feedhorn depends on diameter of antenna. Fig. 4(b) shows feedhorn and scalar ring which are used with 3 m antenna.

![Fig. 3 Antenna diameters that guarantees a circuit operating ratio of at least 99.5% (www.jma-net.go.jp)](image)

**Fig. 4 (a) A 3 m. C-band antenna which is commonly sold in Thailand (b) A C-band single polarity feedhorn for 3 m. antenna**

- **Input frequency range**: 3400 - 4200 MHz (At 4,148 MHz)
- **LNB Flange**: CPR-229
- **Feed strut configuration**: Tri or Quad

**C. LNB**
The main feature of LNB is band pass filter and low noise amplifier for amplifying the satellite signal. Then, it also converts high frequency to low frequency for receiver. Local oscillator circuit, 5,150 MHz is used for this LNB to generate local frequency for satellite frequency refutation at the mixer. For example, frequency range that receiver can receive is 950 – 2,150 MHz but satellite frequency is 4,148 MHz. After mixer, the frequency is about 1,002 MHz (5,150 MHz minus 4,148 MHz).

The properties of this LNB are as follows.

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input frequency range</td>
<td>3,400 – 4,200 (At 4,148 MHz)</td>
</tr>
<tr>
<td>LO. Frequency</td>
<td>5,150 MHz</td>
</tr>
<tr>
<td>LNB flange</td>
<td>CPR-229G, F-type 75 Ohms</td>
</tr>
<tr>
<td>Noise temperature</td>
<td>20 to 30 K</td>
</tr>
<tr>
<td>Input / Output VSWR</td>
<td>2.2:1</td>
</tr>
<tr>
<td>Conversion gain</td>
<td>62 dB (Typical)</td>
</tr>
<tr>
<td>Output P1dB</td>
<td>9 dBm</td>
</tr>
<tr>
<td>LO. stability</td>
<td>1.0 ppm ± 5 kHz</td>
</tr>
</tbody>
</table>

**D. Receiver**

Generally, input impedance for C-band receiver is 75 Ohms. Thus, specification is used for receiver selection. Based on JMA recommendation, Novra S300D [4] is suggested as a receiver. It provides the function of DVB-based IP data receiver / routers which is operated based on digital video broadcasting satellite second generation (DVB-S2). The properties of this receiver are as follows.

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input frequency range</td>
<td>950 - 2,150 MHz (At 1,002 MHz)</td>
</tr>
<tr>
<td>Demodulation</td>
<td>QPSK: 100 Ksps to 45 Msps (DVB-S2) Nyquist root filter: 0.2, 0.25, 0.35 rolloff</td>
</tr>
<tr>
<td>Decoding FEC</td>
<td>DVB-S2</td>
</tr>
<tr>
<td>Input connector</td>
<td>F-type, 75 Ohms</td>
</tr>
<tr>
<td>Input signal level</td>
<td>-70 dBm to -25 dBm</td>
</tr>
</tbody>
</table>

**IV. THE INSTALLATION AND RESULTS**

The antenna installation process is similar to that of direct-to-home television system (DTH). There are 2 factors to consider, firstly, the direction of signal must avoid the obstacles such as trees and buildings and secondly, the base of installation should be able to support the weight of the antenna. The parameters for setting direction of signal include elevation and azimuth angles as shown in Fig. 5. Before calculation, position of the satellite must be known. According to JCSAT-2B which is used to broadcast, its position is 154E of GEO satellite. Elevation angle [5] \( \alpha \) refers to the angle between the beam pointing direction, directly towards the satellite, and the local horizontal plane (1). It is the up-down angle.

\[
\tan \alpha = \frac{R + H}{R \cos \theta \cos \phi} \sqrt{1 - \cos^2 \theta \cos^2 \phi} \quad \text{Degree} \quad (1)
\]

When \( \theta \) is latitude of antenna location.

\( \phi \) is the longitude difference of satellite and antenna locations.

\( R \) is the radius of the Earth (6,370 Km).

\( H \) is the height of satellite orbit (35,680 Km).

Azimuth angle [5] \( \beta \) refers to the rotation of the whole antenna around a vertical axis. It is the side to side angle. Typically, you loosen the main mount bracket and swing the whole dish all the way around in 360 degrees. Azimuth calculation is shown in (2), (3)

\[
\tan \beta = \frac{\tan \phi}{\sin \theta} \quad (2)
\]

\[
\beta = \tan^{-1} \left[ \frac{\tan \phi}{\sin \theta} \right] \quad \text{Degree} \quad (3)
\]

When \( \theta \) is latitude of antenna location.

\( \phi \) is the longitude difference of satellite and antenna locations.

![Fig. 5 Antenna installation and parameters](image-url)

As mentioned earlier GISTDA already had the turnkey system which was used to receive MTSAT-2. The antenna size is 3.8 m. and is capable of receiving Himawari-8 too. For recycling and comparison purpose, 3.8 m. antenna is installed near the new 3 m. antenna. From calculation, azimuth and elevation angle of both antennas are directed to 101 and 28.2 degrees respectively. The installed antennas are shown in Fig. 6(a) and 6(b), they are pointing in the same direction.
After installations, we use signal level meter to measure the signal level and carrier-to-noise ratio from LNB during receiving. The results of measurement are shown in Table 1.

Table 1 Results from signal level meter.

<table>
<thead>
<tr>
<th>Antenna</th>
<th>Signal level (dBm)</th>
<th>Carrier to noise ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>The 3.8 m. antenna</td>
<td>-38.1</td>
<td>10.6</td>
</tr>
<tr>
<td>The 3 m. antenna</td>
<td>-47.0</td>
<td>9.5</td>
</tr>
</tbody>
</table>

From Table 1, it should be noted that the signal level and carrier-to-noise ratio between 3.8 m. antenna and 3 m. antenna are not much different. Moreover, both antennas give the signal level which are higher than minimum level of receiver. Thus, we can conclude that the 3 m. antenna is workable for this system. Finally, we use the SATAID software to convert the data to SATAID type files for applications. The example of image in SATAID type file is shown in Fig. 7.

V. THE COST ESTIMATION

This topic compares the cost of the receiving systems which include installation costs, tax and shipping cost.

Table 2 Price of self-integration and turnkey systems.

<table>
<thead>
<tr>
<th>System</th>
<th>Cost estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnkey system</td>
<td>35,592 USD</td>
</tr>
<tr>
<td>Self-integration system</td>
<td>5,000 USD</td>
</tr>
</tbody>
</table>

Table 2 shows the estimated costs of the 2 receiving systems. The first is turnkey system which consists of 3.8 m. antenna that is imported, feedhorn, LNB, DVB-S2 receiver, server and the software for productions. On the other hand, although the cost of integrated system is less than the cost of turnkey system, the server and production software are not included.

VI. CONCLUSIONS AND FUTURE WORKS

GISTDA has successfully integrated the system (3 m.) including testing and comparing with turnkey system (3.8 m.). The outcomes of both systems have indicated that the performance conforms with HimawariCast standard and cost of installation is reduced as well. The project not only adds skill and experience of GISTDA personal, but also supports the opportunity of receiving Himawari-8 observation data in addition to data access through internet. Moreover, the system also continues to be used to receive observation data from the MT-SAT to Himawari 8/9 in the future as well.

In the future, GISTDA plans to develop the mobile Himawari-8 receiving system as well. Particularly, some rural areas or forest areas that have no access to the internet but need observation data to monitor the weather of their areas. The concept is just reducing the diameter of antenna and modifying the mechanics for mobility including improving power by increasing performance of the amplifier for receiving signal.

REFERENCES