4-6 Earth Stations for WINDS Regenerative Communication Mode

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WINDS has two communications modes. One of them is a regenerative communication mode. JAXA is developing USAT and VSAT for this mode. This paper describes the characteristics and functions of these earth stations for WINDS.

Keywords
WINDS, Earth station, Ka-band, Satellite communications

1 Introduction

The Wideband InterNetworking Engineering Test and Demonstration Satellite (WINDS) communications experiment system features two communication modes: regenerative mode and bent-pipe mode. With respect to the regenerative mode, the Japan Aerospace Exploration Agency (JAXA) is developing extremely small experimental earth stations consisting of either the Ultra-Small-Aperture Terminal (USAT) or the Very-Small-Aperture Terminal (VSAT). This article describes the functions and performance factors of the earth stations for the WINDS regenerative communication mode.

2 Overview and structure of earth stations for WINDS regenerative communication mode

2.1 Overview of earth stations for WINDS regenerative communication mode

JAXA is developing two types of earth stations for the WINDS regenerative communication mode (referred to as “regenerative user stations” below): the Ultra-Small-Aperture Terminal (USAT) and the Very-Small-Aperture Terminal (VSAT).

A regenerative user station processes association requests and communicates with another earth station based on the resources (i.e., frequencies, data rates, and communication slots) assigned by the Network Management Center (NMC).

Table 1 shows an overview of the specifications of the earth stations.

2.2 Ultra-Small-Aperture Terminal (USAT)

The Ultra-Small-Aperture-Terminal (USAT) is an earth station developed for installation in homes and similar locations. A significant characteristic of the USAT is seen in its ability to provide high-speed communication at a downlink rate of 155 Mbps using an ultra-small antenna with a diameter of 45 cm. Figure 1 shows the external appearance of the USAT. Figure 2 shows a block diagram of the USAT.

The USAT mainly consists of the antenna unit, LNC/ODU, IDU, and TA, and can transmit data at rates of 1.5 Mbps or 6 Mbps and receive data at a rate of 155 Mbps.

(1) Antenna unit

Table 2 shows the major performance factors of the antenna unit.
(2) LNC/ODU

The major functions of the LNC/ODU consist of frequency conversion from an IF signal in the 800-MHz band to an RF signal in the 28-GHz band, RF signal-level variability in the 28-GHz band, and frequency conversion from an RF signal in the 18-GHz band to an IF signal in the 800-MHz band. Table 3 shows the major performance factors of the LNC/ODU.

(3) IDU

The IDU mainly provides Time Division Multiple Access (TDMA) synchronization, communication data modulation and demodulation, and communication data interfacing. Figure 3 shows the external appearance of the IDU. The touch keys on the surface provide the interfaces for various settings.

The detailed functions of the IDU are listed below.

- Reception functions
  - Reference burst detection and synchronization
  - TDMA frame synchronization
  - Quadrature Phase Shift Keying (QPSK) demodulation, Reed-Solomon decoding, derandomization of regenerative signals
  - Extraction of notification messages from the notification slot and extraction of user data by VPI/VCI
  - User data reassembly
  - Acquisition of transmission frequency, slot, and the VPI/VCI from the association response indicated in the notification message
  - Measurement of C/N0 attenuation in reception

The IDU measures the reception level of the RB transmitted by the satellite and
calculates the difference from the standard reception C/N0 value.

- Transmission functions
  (viii) Setting of the transmission frequency based on the assignment information
  (ix) Association data generation
  (x) Generation of AAL frames and ATM cells based on VCI/VPI of the association data
  (xi) Generation of AAL frames and ATM cells based on VCI/VPI of the user data
  (xii) Reed-Solomon coding, randomization, and QPSK modulation output
  (xiii) Transmission level control and transmission timing control

The IDU calculates propagation delay based on the notification information and the position of the user station, adds the processing delay of the user station, and determines the transmission timing.

- Common functions
  (xiv) Experimental user terminal interface
  (xv) Man-machine interface

The major performance factors of the IDU are listed below.

(i) Modulation method: QPSK (814 M IF)/MF-TDMA
(ii) Data rate: User data transmission
Association request data transmission (1.5 Mbps)
User data reception (155 Mbps)

(iii) Filter characteristics: Root-Nyquist Filter (a = 0.5)
\( \sin x/x \) aperture correction in transmission only

(iv) TDMA frame structure: time slot (2 ms)
Frame (40 ms, 20 time slots)
Super frame (640 ms, 16 frames)

(v) Error correcting code: RS code \((255, 223)\)/randomizer \((X^8 + X^7 + X^5 + X^3 + 1)\)

(vi) Experimental user interface: Ethernet (1000Base-T) IP data

(4) Terminal adapter (TA)
The terminal adapter (TA) is installed between the IDU and the experimental user terminal and provides a 1000Base-T LAN communication interface to the user in the experiment. Figure 4 shows the TA interface connection.

Control and monitoring of the ODU unit is also possible from the TA through the control monitor of the IDU unit and the IDU unit itself. For the user interface to control the TA, we use a network interface based on standard HTML format, which enables control and monitoring of the TA, IDU, and ODU units from a generic terminal such as a personal computer. Users in the experiments do not need to concern themselves with the one-way connection pair constituting the two-way connection in a given experiment, but rather can easily establish a two-way IP connection by operating the TA of the calling station. This connection pair is provided through the terminal adapter (TA).
2.3 Very-Small-Aperture Terminal (VSAT)

The Very-Small-Aperture Terminal (VSAT) is an earth station developed for installation in schools and SOHOs. A significant characteristic of the VSAT is seen in its ability to provide high-speed uplink and downlink communications at the rate of 155 Mbps using an antenna with a diameter of 1.2 m.

Figure 6 shows the external appearance of the VSAT.

The VSAT mainly consists of the antenna unit, LNC/ODU, TWTA, IDU, and TA, and can transmit data at rates of 1.5 Mbps, 6 Mbps, 24 Mbps, or 51 Mbps × 3, with data reception at a rate of 155 Mbps. The TA of the VSAT has the same structure as that of the USAT. The interfaces with the experimental user terminals are also the same. In addition to the communication modes exhibited by the USAT IDU, the VSAT IDU also supports the transmission modes of 24 Mbps, 51 Mbps, and 51 Mbps × 3.

(1) Antenna unit

Table 4 shows the major performance factors of the antenna unit.

(2) ODU/LNC/TWTA

The major functions of the ODU/LNC consist of frequency conversion from an IF signal in the 800-MHz band to an RF signal in the 28-GHz band, RF signal level variability in the 28-GHz band, and frequency conversion from an RF signal in the 18-GHz band to an IF signal in the 800-MHz band. The function of the TWTA consists of power amplification of the Ka-band uplink signal. Table 5 shows the major performance factors of the

<table>
<thead>
<tr>
<th>Item</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antenna aperture</td>
<td>1.2 m</td>
</tr>
<tr>
<td>Gain</td>
<td>6.0 dB (5.7–7.0 GHz)</td>
</tr>
<tr>
<td>Polarization</td>
<td>Linear</td>
</tr>
<tr>
<td>Antenna noise temperature</td>
<td>&lt;0.4 K (28.3 GHz)</td>
</tr>
<tr>
<td>Gain</td>
<td>6.0 dB (800 MHz)</td>
</tr>
<tr>
<td>EIRP</td>
<td>&gt;66.7 dBW</td>
</tr>
<tr>
<td>Transmit power</td>
<td>&gt;20 dBW</td>
</tr>
<tr>
<td>Spurious radiation</td>
<td>&lt;1.0 mW</td>
</tr>
<tr>
<td>Power efficiency</td>
<td>&gt;0.10 (×3)</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>&lt;100 W</td>
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<tr>
<td>TA</td>
<td>60 W/sec</td>
</tr>
<tr>
<td>Assembly time</td>
<td>4 hours except for point adjustment</td>
</tr>
</tbody>
</table>
Conclusions

This article describes the functions and structures of the earth stations for the WINDS regenerative communication modes. The WINDS satellite is scheduled for launch in the winter of fiscal 2007. After launch, diverse experiments will be performed using these earth stations. Going forward, we plan to verify the interfaces within the WINDS satellite system and make full preparations for the smooth execution of the planned experiments.

References


Table 5 Performance factors of LNC/ODU

<table>
<thead>
<tr>
<th>ODU/LNC</th>
<th>LNC/ODU characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input frequency</td>
<td>8440MHz</td>
</tr>
<tr>
<td>Output Frequency band</td>
<td>27.30GHz to 28.15GHz (0.8GHz band)</td>
</tr>
<tr>
<td>Frequency stability</td>
<td>±1X10⁻⁷ (short-term)</td>
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<tr>
<td>Variable range of gain</td>
<td>&lt;79.5dB</td>
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</table>

<table>
<thead>
<tr>
<th>LNC/ODU</th>
<th>LNC characteristics</th>
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<tbody>
<tr>
<td>Input frequency</td>
<td>Fc-1: 14.792GHz, Fc-2: 17.972GHz, Fc-3: 18.758GHz, Fc-4: 18.841GHz</td>
</tr>
<tr>
<td>Output frequency</td>
<td>8440MHz</td>
</tr>
<tr>
<td>Output Frequency band</td>
<td>Center Frequency ±100MHz (0.5GHz band)</td>
</tr>
<tr>
<td>Frequency stability</td>
<td>±1X10⁻⁷ (short-term)</td>
</tr>
<tr>
<td>Noise figure</td>
<td>&lt;1.5dB at 25°C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LNC/ODU</th>
<th>LNC characteristics</th>
</tr>
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<tbody>
<tr>
<td>Input frequency</td>
<td>27.50GHz to 28.00GHz</td>
</tr>
<tr>
<td>Declared power</td>
<td>25.72dB</td>
</tr>
<tr>
<td>Gain</td>
<td>77dB (89dB back off)</td>
</tr>
<tr>
<td>NF/IBW characteristics</td>
<td>Gain: 85dB, NF: 0.12dB, IBW: 120Hz</td>
</tr>
<tr>
<td>Phase non-linearity</td>
<td>&lt;0.0030° at 27.2±26.1GHz, App: 26.3±26.9GHz</td>
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