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.

Table 1 Earth stations for regenerative communication mode

	Ultra Small Aperture Terminal (USAT)	Very Small Aperture Terminal (VSAT)
frequency	Transmit : 27.5～28.1GHz Receive : 17.7～18.3GHz	
Antenna Aperture	45cm	1.2m
Data Link	Transmit : association (1.5Mbps) Traffice Data(1.5M/6Mbps) Receive : Signaling(155Mbps) Traffice Data (155Mbps)	Transmit : association (1.5Mbps) Traffice Data (1.5M/6M/24M/51M /51Mbps×3bps) Receive : Signaling (155Mbps) Traffice Data (155Mbps)
Modulation	UP : QPSK (Burst) DOWN : QPSK (Burst)	
access method	UP : MF-TDMA DOWN : MF-TDMA	
Pointing	Manual	

Fig.1 External appearance of USAT

(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

(i) Reference burst detection and synchronization

(ii) TDMA frame synchronization

(iii) Quadrature Phase Shift Keying (QPSK) demodulation, Reed-Solomon decoding, derandomization of regenerative signals

(iv) Extraction of notification messages from the notification slot and extraction of user data by VPI/VCI

(v) User data reassembly

(vi) Acquisition of transmission frequency, slot, and the VPI/VCI from the association response indicated in the notification message

(vii) Measurement of C/N_0 attenuation in reception

The IDU measures the reception level of the RB transmitted by the satellite and

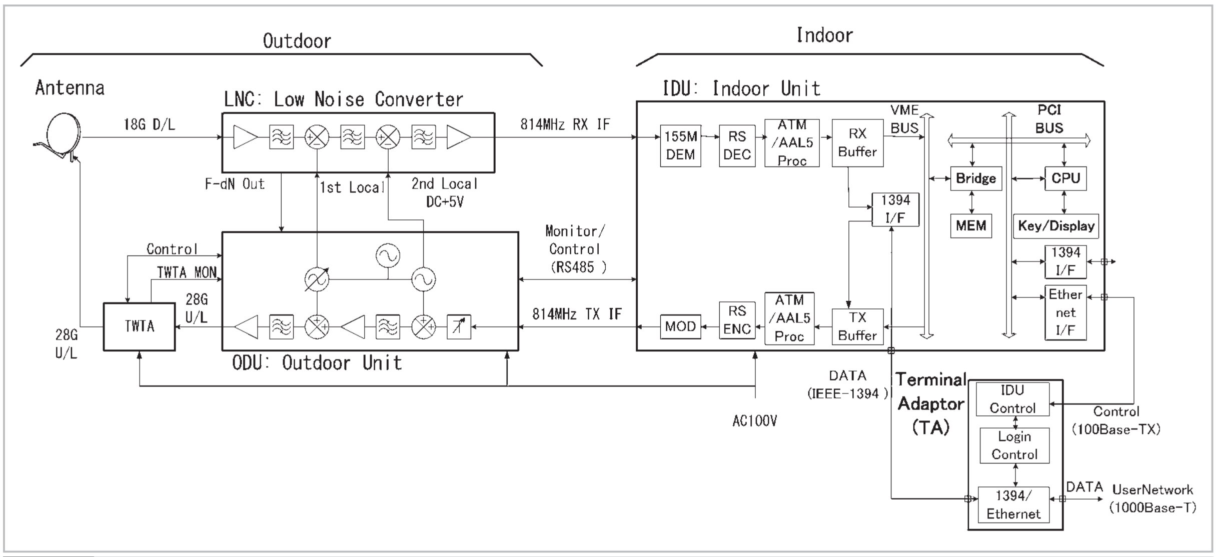

Fig.2 Block diagram of USAT

Table 2 Major performance factors of USAT antenna unit

Item	characteristics
Frequency	27.5GHz～28.1GHz(transmit) 17.7GHz～18.3GHz(receive)
Antenna Aperture	45cm φ
Gain	>35.5dBi (@17.7GHz) >39.3dBi (@27.5GHz)
polarization	linear
Antenna noise temperature	<70K
Beam width	>100λ／D degreee (λ : wavelength、D : Antenna Aperture)
Sidelobe	100λ/D° ≦φ≦7° <25-25*log φ (dBi) 7° ≦φ≦9.2° <+5.5(dBi) 9.2≦φ≦48° <29.6-25*log(dBi) 48° ≦φ≦180° <-10(dBi) ITU-R S.524-8 compliance
EIRP	>48.8dBW
G/T	>11.5dB/K
Pointing	manual EL:fine adjustment 25° ～65° AZ: coarse adjustment 360° (fine adjustment±90°)
Power endurance	>20W(CW)
survival wind speed	60m/sec
Assemble time	2hours except point adjustment

Table 3 Performance factors of LNC/ODU

ODU Item	ODU characteristics
Input frequency	814MHz
Output frequency	Fu-1 : 27.537GHz、Fu-2 : 27.5925GHz、Fu-3 : 27.648GHz Fu-4 : 27.722GHz、Fu-5 : 27.7775GHz、Fu-6 : 27.833GHz Fu-7 : 27.907GHz、Fu-8 : 27.9625GHz、Fu-9 : 28.018GHz
Output Frequency band	27.5GHz～28.1GHz (0.5dB BW)
Frequency stability	<1×10⁻⁷ (short, long span) with Doppler shift compensation
Declared power	>20W (saturation)
Variable range of gain	>15dB
Spurious level	<43+10logP P:Output Power (W)
AM/PMcharacteristics	<5deg/dB (27.5～28.1GHz)@10W output
Phase nonlinearity	< ±0.01rad (27.5～28.1GHz any ±7MHz)
LNC Item	**LNC characteristics**
Input frequency	Fd-1:17.7925GHz、Fd-2:17.9775GHz、Fd-3:18.1625GHz
Output frequency	814MHz
Output frequency band	Center frequency > ±100MHz (0.5dB width)
Frequency stability	1×10⁻⁷ (short, long span)
Noise figure	<1.5dB @25℃

calculates the difference from the standard reception C/N_0 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

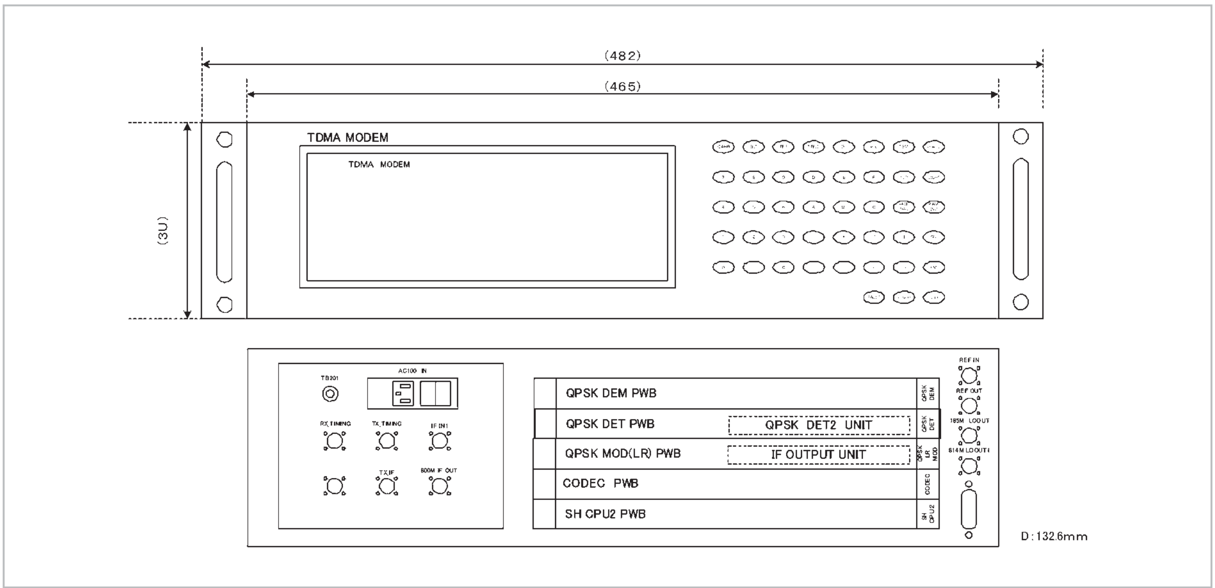

Fig.3 *External appearance of USAT IDU*

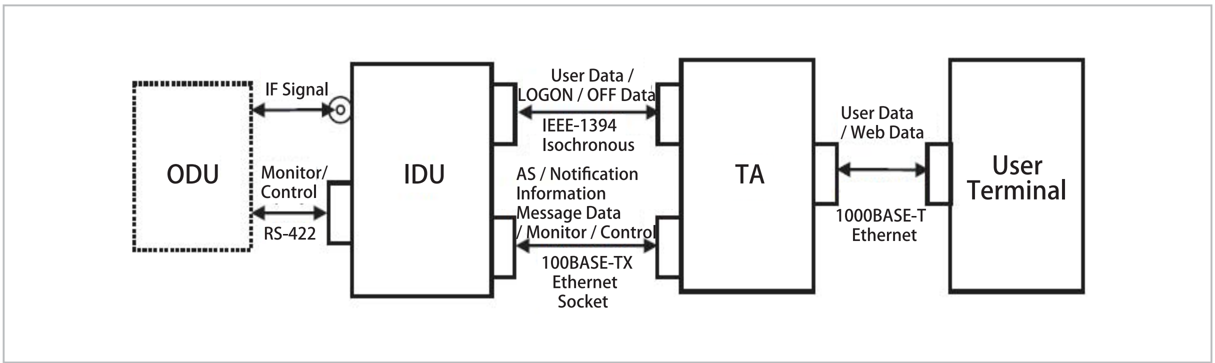

Fig.4 *Terminal adapter interface*

(1.5 Mbps/6 Mbps)
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 function is implemented via mutual request and response of the Logon Server/Client installed in the TA of each user station. Figure 5 shows the configuration of an example experiment based on the 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.

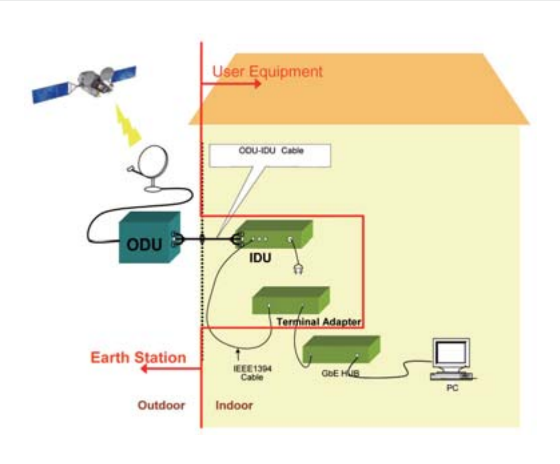

Fig.5 *Example user station interface*

Fig.6 *External appearance of VSAT*

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 4 *Major performance factors of VSAT antenna unit*

Item	Characteristics
Frequency	27.5GHz～28.1GHz (Transmit) 17.7GHz～18.3GHz (Receive)
Antenna Aperture	1.2m φ
Gain	>44.0dBi (@17.7GHz) >47.6dBi (@27.5GHz)
polarization	Linear
Antenna noise temperature	<85K
Beam width	<100λ／D degree (λ : wavelength, D : antennaaperture)
Sidelobe	ITU-R s.580-5 compliance
EIRP	>66.7dBW
G/T	>19.0dB/K
Pointing	Manual EL: coarse adjustment 0° ～70° (Fine adjustment ±90°) AZ: coarse adjustment 360° (Fine adjustment ±10°)
Power endurance	>150W (CW)
survival wind speed	60m/sec
Assemble time	4hours except point adjustment

Table 5 Performance factors of LNC/ODU

ODU Item	ODU characteristics
Input frequency	814MHz
Output frequency	Fu-1 : 27.537GHz、Fu-2 : 27.5925GHz、Fu-3 : 27.648GHz Fu-4 : 27.722GHz、Fu-5 : 27.7775GHz、Fu-6 : 27.833GHz Fu-7 : 27.907GHz、Fu-8 : 27.9625GHz、Fu-9 : 28.018GHz
Output Frequency band	27.5GHz～28.1GHz (0.5dB BW)
Frequency stability	$<1\times10^{-7}$ (short/long span)
Variable range of gain	>30dB
Variable range of gain	<-60dBc
LNC Item	**LNC characteristics**
Input frequency	Fd-1:17.7925GHz、Fd-2:17.9775GHz、Fd-3:18.1625GHz
Output frequency	814MHz
Output Frequency band	Center frequency ±100MHz (0.5dB band)
Frequency stability	$<1\times10^{-7}$ (short/long span)
Noise figure	<1.5dB @25℃
TWTA Item	**TWTA characteristics**
Frequency	27.5GHz～28.9GHz
Declared power	>20.72dBW
Gain	>70dB (@10dB back off)
AM/PMcharacteristic	<5deg/dB (27.5～28.1GHz)@20.72dBW
Phase nonlinearity	<±0.07rad (27.5～28.1GHz any ±25.9MHz)

ODU/LNC/TWTA.

4 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.

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