Satellite Transponder Equipment in Active Worldwide Use

KOJIMA Masanobu, YAMASA Yasuhiko, SUZUKI Wakou

Abstract

Among the space businesses of NEC, the business related to communications/broadcasting satellite transponder equipment has achieved a large number of sales, even to the severe overseas satellite market, and its excellent technology and reliability are highly evaluated by worldwide satellite manufacturers. NEC is attempting to expand this business field by developing new devices and standardizing equipment while putting emphasis on areas with high added value. This paper is intended to introduce the present status of transponder equipment as well as perspectives for its future.

Keywords

communications satellite, broadcasting satellite, transponder, LNA, frequency converter, SSPA, TWT, antenna

1. Introduction

Our overseas sales of communications/broadcasting satellite transponder equipment began with Intelsat-IV in the 1970s. Since then, we have supplied equipment for various communications/broadcasting satellites around the world. The number of satellites for which we have supplied equipment up to the present is over 150 (**Fig. 1**).

With technical abilities and reliability that meet the stringent requirements of commercial satellites, our equipment has earned high evaluations from worldwide satellite manufacturers, as well as a high share among them.

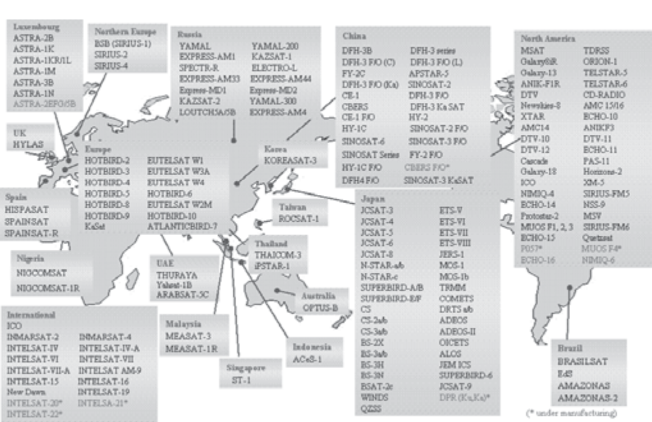

Fig. 1 Satellites using NEC's satellite transponder equipment (Partially including TTC equipment).

This paper introduces the present status of transponder equipment for the overseas market and perspectives for its future.

2. Communications/Broadcasting Satellite Transponders

Fig. 2 shows a simplified configuration of the block diagram of a communications/broadcasting satellite transponder. The configuration of an actual satellite is much more complex than this figure because multiple transponders are mounted, switching between active and redundant pieces of equipment is required in the case of failure and switching of transmission paths is also necessary to provide various services. The main functions of a transponder are 1) receiving a faint signal from the ground; 2) amplifying it with low noise; 3) converting it to a frequency to be transmitted to the ground; 4) limiting bandwidth to prevent unnecessary signal emission; 5) amplifying power to a level for transmission to the ground; 6) transmitting the signal to the ground.

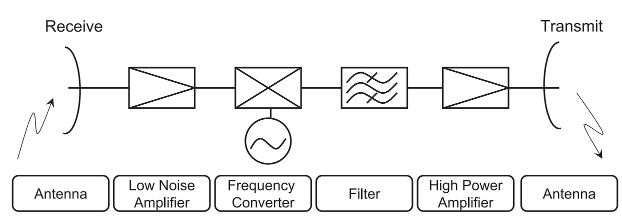

Fig. 2 Basic configuration of a communications/broadcasting satellite transponder.

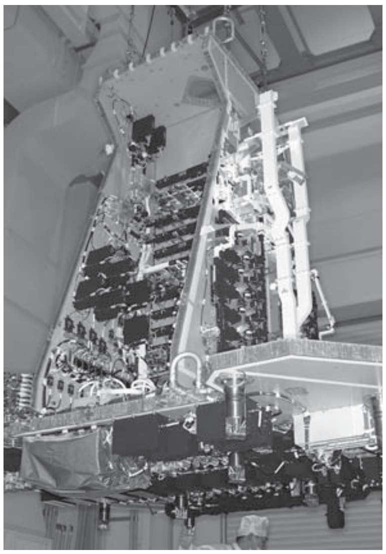

Photo 1 Transponder of the Express-AM1 (Russia).

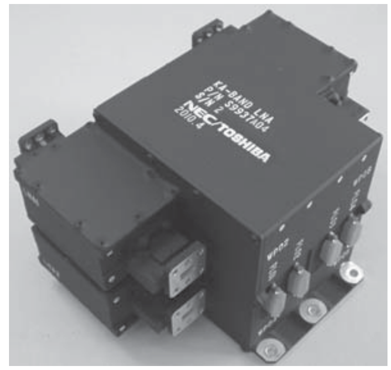

Photo 2 Block LNA (Low-noise amplifier).

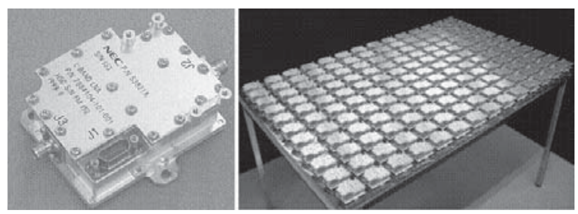

Photo 3 L-band LNA (Low-noise amplifier).

The transponder is generally organized by combining multiple pieces of equipment, each of which provides one of the above functions. When we refer to transponder equipment, we mean these individual pieces of equipment.

NEC has achieved sales of large quantities of such equipment, but, as well as individual pieces of equipment, the corporation also has experience supplying whole transponder systems to overseas satellite manufacturers, for example in the cases of the Express-AM1 and the BSAT-2C (**Photo 1**). In the future, we will endeavor to supply whole transponder systems, because their added values are higher than those of individual pieces of equipment.

3. Low–Noise Amplifier (LNA)

At present, one of the leading products among our transponder equipment is the low-noise amplifier (LNA). The LNA is used to amplify a received faint signal with low noise and is therefore required to have excellent noise and wideband characteristics. The LNA is a single-function equipment with a compact size and its specifications are not much dependent on the specifications of individual satellites. As two to four LNAs with the same specifications are often used in fixed communications on the C, Ku and Ka bands, we have developed a new equipment called the Block LNA, which consists of a set of four LNAs with standard specifications, and supply it to many overseas satellite manufacturers (**Photo 2**[*1]). The Block LNA allows users to select any number of LNAs from 1 to 4 without design change and can therefore meet user requirements very flexibly. We have already supplied a total of 100 Block LNA sets (corresponding to 400 LNA units) as of 2010.

The L-band LNA is used in mobile communications and it sometimes happens that more than 100 LNA units are mounted on a single satellite. We have therefore developed a compact LNA by separating the peripheral circuitry, including the power supply, as shown in **Photo 3** . We have already supplied more than 1,000 units of this model.

Current LNAs use the GaAs FET as an amplification device, but we are studying standardization and cost reduction using MMICs as well as a device that can meet the increasingly severe over power input requirements.

4. Frequency Converter

A frequency converter is used to convert the frequency of a

[*1] This photo shows the Ka-band model.

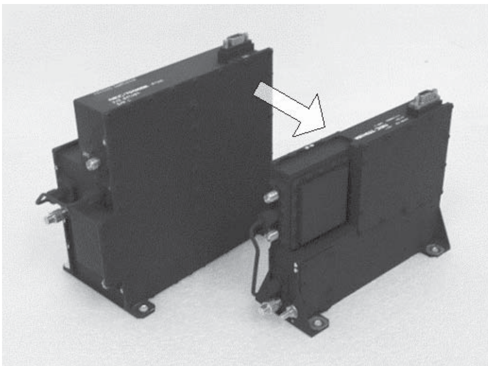

Fig. 3 Ku-band frequency converters (Left: Current model; Right: Newly developed model).

received signal into a frequency for use in transmission to the ground. For instance, the Ku-band frequency converter converts signal frequency from the 14-GHz band to the 12-GHz band. The main characteristics required for a frequency converter include low spurious emissions, linearity and a stable local frequency. Particularly in the case of frequency conversion for satellite equipment, the input and output frequencies are close, so reducing spurious emissions from the mixer becomes a key design issue. In addition, since frequencies often vary due to satellites and communication channels, the manufacturing of frequency converters is characterized by high-mix, low-volume production.

Up to the present we have achieved sales of about 2,000 frequency converters. The frequency converter is one of our main equipment, as evidenced by the fact that we received orders for four series of satellites in 2010.

Aiming at further increasing our share, we have changed our equipment configuration from the connection of multiple single-function modules in the past to the MCM (Multi-Chip Module), which incorporates multiple functions in a single module. The new compact frequency converter has succeeded in implementing a weight of about 60% of that of the previous configuration (**Fig. 3**).

In the future, we will promote standardized design in place of the previous design method of dealing with individual specifications in order to reduce costs further.

5. Solid State Power Amplifier (SSPA)

The output power required for communications/broadcasting satellites is on the order of tens to hundreds of watts. Demands for the C or higher band and several tens of watts are usually dealt with by electron tubes called traveling-wave tubes (TWTs), while those for the C or lower band and tens of watts are dealt with by solid state power amplifiers (SSPAs) using semiconductor devices. The SSPA is superior to the TWT amplifier (TWTA) in reliability and linear characteristics but its power efficiency and maximum output power are inferior. Therefore, its use as a final-stage amplifier for communications/broadcasting satellites is limited.

Current SSPAs mainly use GaAs FET devices. However, as the withstanding voltage of GaAs FETs is low, the maximum output power of satellite-use devices is only around 10 W per device. Meanwhile, the GaN FET, featuring high withstanding voltage and high output power, has recently been developed as a new device and has already been put to practical use in ground communications. A prototype GaN FET designed for satellite mounting has already achieved an output power of more than 20 W per device in the S band. We also plan to evaluate it for use in SSPAs and then launch an SSPA using it into the market. Since the GaN FET can improve SSPA power efficiency and maximum output power, it is expected that the part of the market that had previously been monopolized by the TWTA will be replaced by the SSPA, thereby leading to the expansion of the SSPA market.

6. Traveling-Wave Tube Amplifier (TWTA)

The traveling-wave tube (TWT) is an RF signal amplification device used by power amplifiers. It is used widely in ground microwave communications systems and earth stations for satellite communications, as well as in satellite-borne transponders.

Since RF amplifiers for satellite transponders require high efficiency and high reliability, R&D of TWTs featuring higher efficiency than that of semiconductor chips has been conducted actively since the mid-1980s.

The TWT is a kind of electron tube and is used to amplify an RF signal by making use of the helix forming the RF circuit and the interaction of electron beams. **Fig. 4** shows the structure of a typical TWT for satellite use. The TWT can operate on a wide frequency range, from the L band (1.5 GHz) to the V band (60 GHz), and its main features are efficiency and output power higher than those of semiconductor devices. As a result of development emphasizing features required for satellite use, such as long life, high reliability, compact size and light weight, the TWT has now become the core equipment for

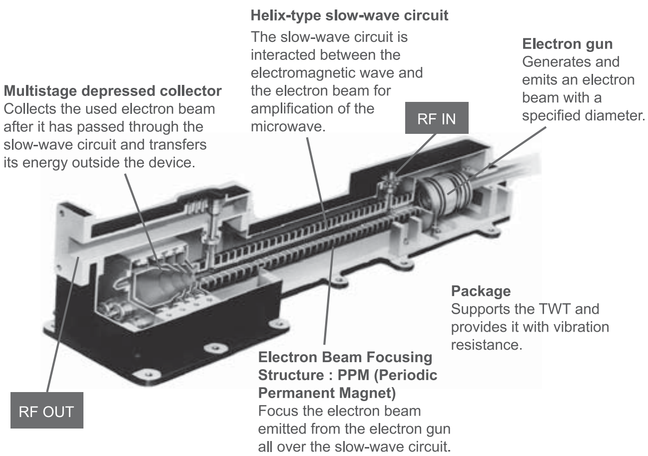

Fig. 4 Structure of a space-borne TWT.

satellite transponders. A considerable number of TWTs are currently used on space-borne power amplifiers.

We are presently developing a TWT for use in new fields, such as for ion engines and for the radar to be borne on the ASNARO (Advanced Satellite with New system ARchitecture for Observation). We will continue product development by also eyeing supply for large communications/broadcasting satellites in the future.

7. Antenna

The antenna is the equipment characterizing each communications/broadcasting satellite's mission. Its functions include the formation of multibeams and contoured beams and the tracking of aircraft or other satellites. At NEC, we possess advanced antenna technologies thanks to our experience developing a large number of satellite-borne antennas, but competition in the antenna market is still severe due to the presence of many advanced overseas manufacturers. We therefore aim to accelerate market entry for antennas developed with our original technologies and to emphasize the supply of whole transponder systems including antennas. The antennas developed with our original technologies include the radial line slot antenna and the mesh deployment antenna. Both of these antennas are much lighter than previous parabolic antennas for satellite use and can be supplied at lower cost. These antennas, based on our original technologies, will be the tools of our entry into overseas markets.

8. Conclusion

The communications/broadcasting satellite market is expected to advance steadily, with about 20 satellites launched per year. As increases in satellite size are increasing the number of transponders per satellite, the market for communications/broadcasting satellite-borne transponders is also expected to expand, though the rise will be rather small. For the future, we will attempt to increase our share in the satellite market by developing new devices and reducing prices through standardization. In addition, we should not limit our business in this field to the sale of traditional individual pieces of equipment. We will also release new types of equipment into the market, emphasizing the sale of transponder systems that give higher added values than those of individual pieces of equipment, and we will expand our overseas business with them.

Authors' Profiles

KOJIMA Masanobu
Manager
RF System Group
Space Engineering Division
NEC TOSHIBA Space Systems, Ltd.

YAMASA Yasuhiko
Manager
RF Sensor Payload Group
Space Engineering Division
NEC TOSHIBA Space Systems, Ltd.

SUZUKI Wakou
Senior Manager
Engineering Department
Microwave Tubes Division
NETCOMSEC Co., Ltd.

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