RECEIVE-ONLY STATION FOR
BROADCASTING SATELLITE EXPERIMENTAL

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ABSTRACT

Receive-only stations (ROS), located in nine places in Japan, were developed as one of ground facilities for a series of experiments using the Medium -scale Broadcasting Satellite for Experimental Purpose (BSE). Each ROS is aimed at receiving broadcast from the BSE and obtaining basic data for design of future satellite broadcasting system through evaluation of picture quality and measurement of video/sound transmission characteristics. This report describes the system design and hardware of the ROS.

Introduction

The ROS has following characteristics:

(1) Simultaneous reception of two broadcast channels of the satellite.

(2) Measurement of video/sound transmission characteristics.

(3) Measurement of reception level and collection of reception data and meteorological data.

(4) Regular or occasional transmission of collected data.

This receiver is designed and manufactured in order that it may operate with stability for the long testing period.

System Design

(1) Location

Location of nine ROS's are shown in Fig. 1 together with contours of equi-gain of satellite transmission antenna (12 GHz).

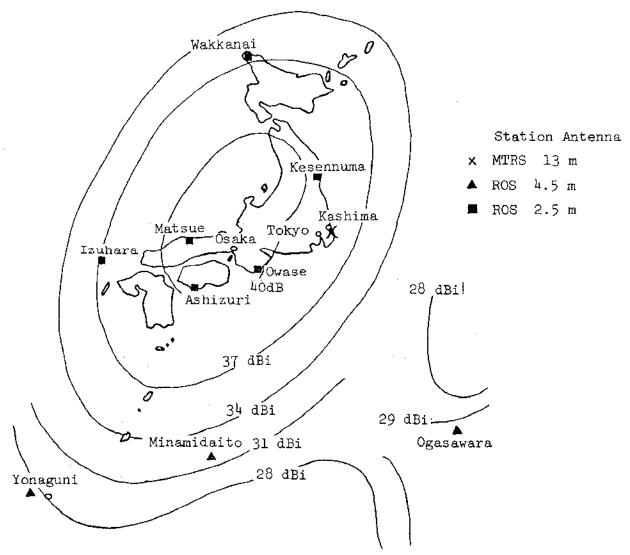

Fig. 1 The BSE antnna radiation pattern and ground station location

(2) Link Budget

Table 1 shows down link budget of typical two stations (Matsue, and Yonaguni)

Rain attenuation is assumed to be 1.0 dB (99% time rate) here, though it depends upon location of installation. Receiving level of the satellite is -70∿-80 dBm in all over Japan. All stations satisfy the video signal to noise ratio (weighted), 45 dB MIN.

(3) Classification of ROS

ROS's are classified to two types: the high sensitivity type with a low satellite antenna gain (28∿32 dBi) for remote island, and medium sensitivity type with a high satellite antenna gain (35 dBi MIN) for main land.

The former employs a receiving antenna of 4.5 mφ diameter and the latter an antenna of 2.5 mφ.

Composition of ROS

Fig. 2 shows construction of high and medium sensitivity type ROS's and their blockdiagrams. The high sensitivity type has a simple tracking equipment. SHF converter converts received SHF signal to the 1st-IF of UHF band (305∿485 Mhz). FM receiver gives video/sound signal and direct reading of receiving level.

Data collection terminal collects receiving level signals and meteorological data which are stored in a memory. Order-wire receiver/transmitter is equipped in high sensitivity type station for remote island only, and use for telephone communication and data transmission.

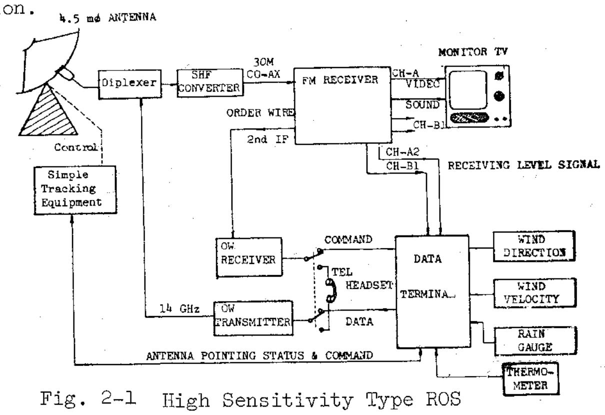

Fig. 2-1 High Sensitivity Type ROS

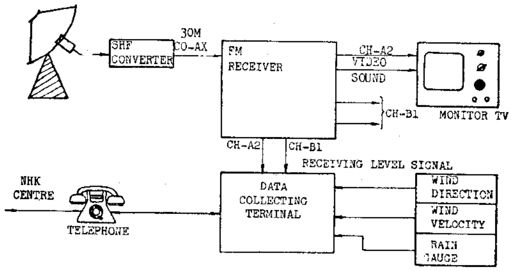

Fig. 2-2 Medium Sensitivity Type ROS

Table 1 DOWN LINK BUDGET, ROS

ITEM \ ROS	Matsue	Yona-guni
Latitude Longitude Distance (km)	35° 27' 34" 133° 03' 21" 37,617	24° 26' 41" 122° 57' 30" 36.619
(Satellite) E.I.R.P *1 (dBm)	88.3	74.8
PROPAGATION LOSS *2 (dB)	206.5	206.3
(ROS) *3 ANTENNA GAIN (dB)	48.8	52.5
POINTING ERROR LOSS (dB)	0.5	1.0
RECEIVING LEVEL (dBm)	-70.5	-80.0
NOISE TEMP (°K)	600°K	660°K
C/N *4 (dB)	26.7	16.7
(C/N) *5 up-LINK (dB)	36.0	36.0
(C/N) total	26.3	16.7
S/N IMPROVEMENT (dB)	31.1	31.1
S/N (dB) (WEIGHTED)	57.4	47.8

Note

*1. Including Feeder loss (1.7dB) and Pointing loss (0.5dB)

*2. Including Atmospheric loss (1.0dB)

*3. Matsue st. has a 2.5 mϕ Dish and Yona-guni St. Has a 4.5 mϕ Dish Antenna.

*4. Receiver Noise Band-width is 27 MHz

*5. Up Link is supposed from KASHIMA MTRS to BS

Specification & Performance of ROS

Specification and performance of major equipments are shown in Table 2.

Equipment Outline of ROS

1. ANTENNA

The ROS's antennas are designed and constructed as follows:

(a) Highest G/T (b) Uniform distribution of amplitude and phase at the opening of antenna reflector. (c) Suppression of spill-over power. Surface modification is applied to main and sub-reflector for (a)∿(c). (d) The medium sensitivity type uses the simplest step horn. The high sensitivity type employs a corrugated horn as it is used for transmission, too. (e) Accomplishment of axis-symmetry directivity. Major performances of antenna are shown in Table 2. A polar mount is used to enable the programmed tracking. Overall efficiency of antenna is about 77% and 70% for medium and high sensitivity types, respectively.

A simplified tracking system has been newly developed and used for the high sensitivity antenna which has a beam width as narrow as 0.38°. The reasons for this are: (a) The satellite is positioned in the fixed point with a holding accuracy of ±0.1°. (b) The satellite's locational variation is predictable. (c) The tracking system is inexpensive.

Staying position of satellite is divided into four assigned sectors, and antenna pointing direction is changed by proper time interval due to the timer instructions.

The receiving antenna can track the satellite with a pointing error with 2.0 dB max.

2. LOW-NOISE FM RECEIVER

Low noise SHF converter has the following characteristics.

(a) Received SHF signal is directly converted to UHF band. (b) Planer circuit mounted in waveguide is employed achieving small size and high performance. (c) Noise temperature lower than 550°K(BW=180 MHz, -10° ∿45°C) is accomplished. (d) Two types of SHF local oscillators are used. While X'tal oscillator and multiplier system is used in the high sensitivity type which is equipped with an OW transmitter, the medium sensitivity type station employs a high stabilized GUNN oscillator with dielectric resonator. (e) Noise figure of an IF amplifier is less than 1.3 dB.

System and function of FM receivers are as follows:

(a) Branching of CH-A2 and CH-B1 by branching filters.
Effect of group delay is reduced by maintaining BWs of CH-A2 and CH-B1 at 70 MHz and 90 MHz, respectively. (b) Conversion to second intermediate frequency (IF_{2nd}=140 MHz) and band width limitation (BW ≒ 27MHz). (c) Equalization of reciever's input level variation within 1dB of AGC output by means of AGC amplifier. (d) AM noise suppression by more than 24 dB using limiter. (e) Limitation of FM triangle noise bandwidth at 4.2 MHz after FM detection. Elimination of sound subcarrier by less than -36 dB. (f) Transmission of D.C. voltage output of receiving level signal by detection and log-amplification after branching of the second converter.

Test data of low noise receiver are shown in Fig.4.

In addition to the above demodulation type receiver, two stations employ FM-AM direct conversion type receivers in the CH-A2 system for experimental purpose.

Furthermore, the high sensitivity stations are equipped with AM-TV modulators for re-broadcasting experiment.

3. ORDER-WIRE TRANSMITTER RECEIVER

High sensitivity stations have order-wire transmitter/receiver, as mentioned above, and able to perform one-to-one communication with MTRS (main transmit & receive station), A-type and B-type of TTRS (transportable transit & receive station). Automatic transmission of daily collected data is also possible to the NHK center through MTRS for a long testing period.

They have following features.

(1) Transmission output is 3W using TWT.
(2) Noise bandwidth is 50 kHz and reception pull-in range is ±120 kHz.

4. Data collecting terminal

Data collecting terminal has the following functions and feature:

(1) Collection of one-minute average data of receiving level signals.
(2) Collection of meteorological data (wind direction and velocity, rainfall and temperature).
(3) Transmission of collected data upon calling of the NHK center.
(4) Command signal is transmitted through telephone lines to stations on the main land, and through order-wire links to stations on remote islands.
(5) Power ON-OFF operation of OW-TX are depend on calling from the NHK center.

Application

Seven of nine stations are unattended. All equipments are working with expected performance for two and a half years since their installation.

Table 2. MAIN PERFORMANCE OF R.O.S.

1. **ANTENNA**

Main Refledtor Dia	4.5 mø		2.5 mø
FREQUENCY RANGE	11.95 12.13 GHz	14.426 14.430 GHz	11.95 12.13 GHz
Polarization		±10°	"
GAIN *1	52.5 dBi MIN.	54.0 dBi MIN.	48.8 dBi
V.S.W.R.*1	1.25 MAX.	1.3 MAX.	1.25 MAX.
Pointing Characteristics*2	$10.5 + 20 \log_{10} \varphi/\varphi_o$ dB or $10 \log_{10}$ Go dB MIN. φ ; ANGLE from Main Beam φ_o; HALF POWER Beam width G_o: Gain at Main Beam		
Beamwidth	0.38°	0.32°	0.65°

2. **LOW NOISE RECEIVER**

NOISE TEMP	550°K MAX.		
FREQUENCY CHARACTERISTICS	VIDEO	60 Hz ~ 3.58 MHz	±0.5 dB MAX.
		3.58 ~ 4.18 MHz	+0.5 -1.0 dB MAX.
	SOUND	50 Hz ~ 13 kHz	±0.5 dB MAX.
Receiving Bandwidth	27 MHz		
S/N	at -80 dBm Input level 31 dB(p-p/rms) MIN. Emphasis OFF, Unweighted		
DG & DP	7%, 5° MAX. (APL 10 90%)		
INTERMODULATION	-40 dB MAX.		
WAVEFORM DISTORTION	$K_p \leq 2$ Chroma delay ≤200 nS Rectangular wave, line & field 4% MAX.		
SOUND krill factor	at 400, 1000, 5000 Hz when 100% Modulation 1% MAX. when 200% Modulation 3% MAX.		
Dispersal suppression	45 dB MIN.		

*1. Including Diplexer
*2. CCIR Rec. 215-3 Curve A

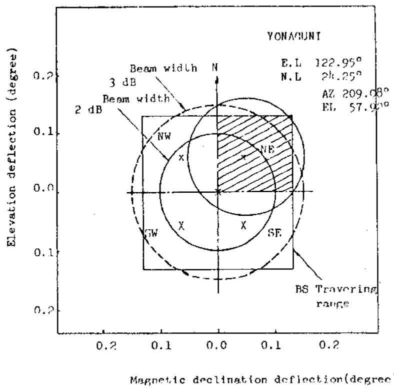

Fig. 3

BS travelling range & Pointing of 4.5 mø ANTENNA

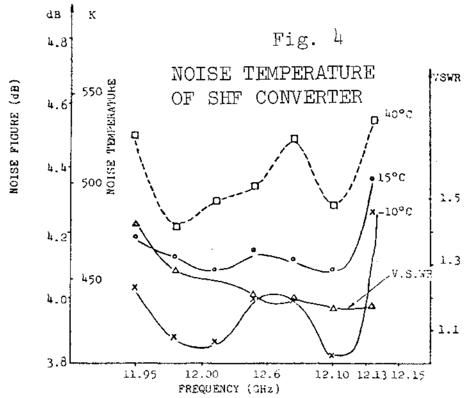

Fig. 4

NOISE TEMPERATURE OF SHF CONVERTER

Fig. 4-1 NOISE TEMPERATURE & INPUT VSWR OF SHF CONVERTER

Four concentrated experiments were carried out during this period. Data have been collected by these experiments and daily data collection in order to determine main performance and functions of receive-only stations with operational satellite.

Conclusion

All equipments of each ROS are operating as scheduled. Data from each station have been used for confirmation of satellite antenna pattern and analysis of sattelite's drift and 12 GHz transmission characteistics for meteorological conditions such as rain attenuation, satisfying the initial objective of installation of ROS's.

Acknowledgement

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