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TECHNICAL ASPECTS OF THE JAPANESE BROADCASTING SATELLITE EXPERIMENTS

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Abstract

After a successful launch of the Japanese Medium-Scale Broadcasting Satellite for Experimental Purpose (BSE) "Yuri" in April 1978, check-outs of the satellite and the transponder were conducted by the National Space Development Agency of Japan (NASDA) for three months. In July, Radio Research Laboratories (RRL) of the Ministry of Posts and Telecommunications (MOPT) and Nippon Hoso Kyokai (NHK: Japan Broadcasting Corporation) initiated various kinds of satellite broadcasting experiments which will be continued for three years. This paper presents brief description of the BSE program and the preliminary results of the experiments.

1. Introduction

The primary purpose of the BSE experiments is a study and technical evaluation of the performance of the 12GHz satellite broadcasting system having a maximum EIRP per channel of 58 dBW, for the transmission of two color television signals. The results of these experiments will contribute to the establishment of technical standards for operational direct satellite broadcasting systems of the future. The BSE program was initiated by MOPT in 1972 with the cooperation of NHK and conceptual and preliminary designs of the medium scale broadcasting satellite system were worked out. In 1973, the BSE program was incorporated in the Japanese Space Development program by the Space Activities Commission and the preliminary design results were transferred to NASDA which was responsible for the development of the satellite and its placement in geostationary orbit. BSE was launched by a Delta 2914 vehicle on April 8, 1978 JST from Cape Canaveral, U.S.A. and put into transfer orbit 23 minutes 54 seconds after lift off.

The BSE was finally placed at the predetermined 110°E geostationary position on April 26, after successful attitude control maneuvers, Apogee Kick Motor firing, and transfer while in drift orbit into its zero-momentum three axis stabilized operational attitude control state. Earth stations for the BSE experiments consists of the Main Transmit and Receive Station (MTRS), two types of Transportable Transmit and Receive Stations (TTRSs), ten Receive-Only Stations (ROSs) and many Simple Receive Equipments (SREs). The MTRS is installed at Kashima Branch of RRL, some 80 km from Tokyo, and the other stations and installations are provided by NHK.

Plans for the BSE experiments were Studied by the BSE program committee consisting of MOPT, RRL, and NHK, with the assistance of NASDA and the spacecraft contractor. A comprehensive experiment plan was developed to fully utilize the capabilities of the space segment to carry out the fundamental technical experiments which are necessary to satisfy the objectives of the BSE program. After the experiments were selected they were reviewed and evaluated by advisory committee to the MOPT. These primarily technical experiments will be performed for three years. Advanced plans for the third year, to demonstrate the feasibility of the direct satellite broadcasting, are presently under consideration.

2. System Description

The total BSE Experiment system is shown in Fig. 1.

2-1. Spacecraft

One of the significant objectives of the BSE program is to provide good quality television signals from geostationary orbit to small, simple, inexpensive fixed or transportable terminals. The spacecraft configuration was designed to meet these objectives with zero-momentum, three-axis attitude stabilization to produce a pointing precision of better than 0.2 degree (3σ). The satellite has shaped beam antenna covering the Japanese mainland with gain above 37dBi and the surrounding remote islands with a gain above 28 dBi in 12GHz band. The transponder provides 50 and 80MHz bandwidth RF channels with an effective isotropic radiated power per channel of 58dBW. Details are the subject of another paper in this issue.

2-2. Main Transmit and Receive Station (MTRS)

The MTRS located at Kashima Branch of RRL is the key station in the BSE program and provides not only television signal transmission and reception, but also Ku-band TT & C operation. The antenna is a 13 meter paraboloid with a near-field Cassegrain feed, on an Az-El mount. It is mounted on the roof of the three story main building where two high power TWT amplifiers and 600°K low noise converters from 12GHz to 400MHz are installed. The instrumentation also includes Dicke type 12GHz radio meter working in and out of television transmission band and 14/12GHz loop back test translator.

The output power of television transmitters is contineously variable from 40 to 2000 watts depending upon the required power flux density at the satellite.

The first floor of the main building houses the television experiment, BSE operational control, on-line and off-line computer system rooms, plus other utility rooms. Wide band 140MHz FM modulators, demodulators, and other television baseband signal test equipments are installed in the television experi ment room, with out-going or in-coming signals connected through IF switching board. TT & C subsystem equipments such as the command signal generator and modulator, telemetry signal demodulator and decommutator, and ranging equipment are installed in the control room.

2-3. Transportable Transmit and Receive Station (TTRS)

For field transmitting and receiving, two types of TTRSs will be applied. Type A is intended to access the BSE from any place throughout Japan including the surrounding islands. It comprises a 4.5 meter diameter antenna and a cabin where 2 kW television transmitter and two 12GHz receivers are housed. Special features of this terminal are the high power, K-band Klystron, low noise receivers, and a simple automatic antenna tracking mechanism. The Klystron is fully forced air cooled with maximum RF output of 2.5 kW. It is tunable to any of five pre-assigned channels between 14.0 and 14.5 GHz.

A low noise receiver employs a unique SHF techniques developed by NHK Technical Research Laboratories inserting mounted planer circuit into the wave guide.

TTRS type B is fully mobile and equipped with a 25kVA power supply generator. The antenna is 2.5 meter diameter and its pointing is manually controlled. Other communication equipments and their functions are similar with those of type A terminal's.

2-4. Receive-Only Stations (ROSs)

The ROSs are used for the evaluation of community reception of television signals broadcast from the satellite, for the measurement of transmission characteristics, and for the observation of propagation effects at SHF, such as attenuation due to rain. In an advanced experiment ROSs will be used to provide television signals for communities in remote islands or other geographically-isolated regions. Each station is capable of receiving two television channels and each channel provides two outputs one is used for the measurement of the transmission characteristics and the other, an amplitude-modulated vestigial-sideband signal which is compatible with the terrestrial system M with NTSC color, may be fed to a rebroadcast transmitter or a cable-distribution system. In the remote islands, a 4.5 meter parabolic antenna is used with a Cassegrain feed and a simple tracking device to enable following of the daily drift of the satellite. On the mainland, a simpler antenna with 2.5 meter diameter is applied. ROS antenna diameters are selected to cope with attenuation of up to 7 dB due to rain. A mobile type ROS with a 1.6 meter parabolic antenna is used for the measurement of transmission characteristics of television signals within the mainland.

2-5. Simple Receive Equipment (SRE)

The SRE consists of an antenna, a frequency converter (outdoor unit), and FM-AM converter (indoor unit).

The frequency converter and FM-AM converter perform the following functions;

Outdoor unit
- down conversion of the incoming signal
- amplification of the FM signal

Indoor unit
- selection of the desired channel
- demodulation of the FM signal
- de-emphasis of picture signal
- cancellation of energy dispersal
- re-modulation in VSB-AM

Re-modulation in VSB-AM is needed because most of the television sets currently available can not be fed with a baseband signal. If they had interface terminals with picture and sound stages, the re-modulation would not be necessary. The frequency converter employs new techniques developed by NHK Technical Research Laboratories. A planer circuit mounted in a waveguide demonstrates very high sensitivity and low noise. Characteristics of the receiver recently developed are;

- Noise Figure 3.75 dB
- Differential Gain (APL 50%) 1 %
- Differential Phase (APL 50%) 1°
- Cross Modulation (920 kHz) -54 dB
- S/N (Input level -80 dBm)
  Picture S/N 48 dB (Weighted, Emph. On)
  36 dB (Unweighted, Emph. Off)
- Sound S/N 56 dB (Picture Modulation, Off)

The indoor unit has functions of FM-AM conversion, and a coaxial cable IF output of 360MHz.

An adjustable local oscillator for tuning is incorporated the last stage of this unit and feeds a UHF-AM television signal to the home TV set.

2-6. Ground Terminal Network

Communication and data networks are provided to support the BSE program. All operations with the BSE are controlled by the MTRS in Ku-band, which coordinates all experimenter requirements and schedules the spacecraft operations and activities of the participating ground stations. MTRS maintains real-time voice contact and data networks with MOPT, NHK and NASDA Tracking and Control Station. Both MTRS and NHK have the automatic data processing systems which are configured differently to meet experimenter needs. Experiment data transmission and reception of participating ground stations of NHK are performed daily through telephone line on the mainland and via BSE in-band talk channel on the remote islands.

2-7. Experimenters' unique Equipments

Each experimenter who intends unique experiments applying BSE prepared such equipments:

- Multi-channel sound multiplexed television system
- PCM-FM sound transmission system
- Multi-channel still picture broadcasting system
- Automatic television signal measuring system applying vertical interval test signals
- Up-Link control system from the multiple ground stations
- PCM-TV transmission system
- Ranging system using TV synchronous signals
- Standard time and frequency signals distribution system via satellite

3. Experiment Program

Fundamental technical experiments selected by the BSE program committee are;

(1) Evaluations of broadcasting service area
(2) Experiments on TV signals transmission
(3) Experiments on radio wave propagation
(4) Experiments on frequency sharing
(5) Experiments on operation and control of satellite broadcasting system
(6) Experiments on satellite broadcasting signals reception

Brief descriptions of each experimental item will be described in the following sections.

3-1. Evaluations of broadcasting service area

The effective service area will be evaluated by measuring field strength and received TV signals quality at many places throughout Japan of various geographical and weather conditions. The satellite antenna was designed to have a suitable radiation pattern as shown in Figure 2 for providing high quality color TV broadcasting services to whole Japan territory, and the antenna beam pointing accuracy will be kept within ±0.2 degrees (3σ). It is expected that high quality color TV of 45dB S/N (TASO grade 1) could be received with rainfall attenuation margin of 2 dB, which corresponds to 99.9% of the time, when SREs of 1 to 1.6 meters antenna size are used in the mainland or ROSs of 2.5 to 4.5 meters antenna size are used in the surrounding remote island islands.

Data obtained around the service fringe are great important because variations of the field strength at these area will give much informations about the spacecraft attitude stability.

3-2. Experiments on TV signals transmission

The standard of TV signal transmission parameters in the BSE program is determined as shown in Table 1, considering compatibility with existing home TV sets.

Basic transmission characteristics will be measured in both radio frequency and baseband frequency stages in the satellite loop back circuits at the MTRS and/or TTRSs. In the radio frequency stages, system signal level diagram, up- and down-links path characteristics are measured. In the baseband tests, transmission characteristics of video and sound signals are measured under various modulation parameters in order to investigate the optimum transmission form.

3-3. Experiments on advanced television broadcasting system

With the purpose of developing advanced TV broadcasting techniques or useful application ways of satellite broadcasting system, various kinds of signals transmission experiments will be conducted.

3-3-(1) Multi-channel sound multiplexed television system

The standard television system in the BSE program is FM-TV with a single accompanying sound signal which is multiplexed by 4.5 MHz frequency modulated sub-carrier.

The sound multiplexing system is designed to transmit several sound signals using two sub-carriers 4.5 MHz and 5.05 MHz. The 4.5 MHz sub-carrier carriers main sound signal is compatible with the terrestrial television broadcasting. The 5.05 MHz sub-carrier is capable of transmitting up to six 5 kHz sound signals.

3-3-(2) PCM-FM sound transmission

The purpose of the experiment is to provide data to establish sound programme broadcasting as a means of broadcasting high quality stereophonic or multi-channel sound programmes.

In the sound multiplex transmission, the technical problems are to reduce intermodulation for high quality signal-to-noise ratio and techniques in tuning of the required channel in the receiver.

3-3-(3) Multi-channel still picture broadcasting system

This experiment is designed to evaluate the relationship between the error probability in digital information and transmission characteristics for analogue type still picture broadcasting system.

Approximately 50 still picture television programmes, each consisting of a series of still color picture and accompanying sound, can be transmitted simultaneously by using a television channel exclusively.

3-3-(4) Experiments on automatic television signal quality assessment

Throughout the satellite lifetime experiments, the transmission characteristics will be continuously measured and recorded using automatic television signal measuring system.

This system consists of the VITS (Vertical Interval Test Signal) inserter and the digital data processor of transmission characteristics. The transmission data will be collected without causing any disturbance to television programme in service.

This system provides highly accurate measurement since each digitalized sampling datum is stored in arbitrary memory which enables to obtain mean values of characteristics using the digital computer, even data signals are of noisy. The VITS is of CCIR Rec. 473-1.

3-4. <u>Experiments on radio wave propagation</u>

The most important factor is the rainfall attenuation in the 12 GHz satellite broadcasting system design. According to the preliminary studies, it is considered to be adequate that the link reliability would be secured by taking rainfall attenuation margins of 1, 2 and 7 dB for 99, 99.9 and 99.99% of the time respectively.

However, the rainfall attenuation prediction is not straight-forward but quite complicated because of localities, seasonal and year to year variations. In the BSE program, rainfall attenuation data of the 12 GHz down link signals, beacon or TV signal, will be obtained at all available ground terminals distributed throughout Japan for the whole experimental period in order to make statistical and regional analysis for getting actually required link margins.

In addition to these studies, some special investigations of radio wave propagation will be made at the MTRS. Propagation studies in the 14 GHz uplink will also be carried out by using the data of ground transmitting powers and satellite telemetry data.

3-5. <u>Experiments on frequency sharing</u>

The purpose of the experiments are to investigate the mutual radio frequency interferences in 12 GHz and 14 GHz bands and provide for more effective utilization and regulation of the radio spectrum.

3-5-(1) Measurement of interference relating to 14 GHz band

The experiments are designed to investigate mainly,

- the mutual interferences between the broadcast satellite up-path to the fixed satellite service
- the interference to the terrestrial telecommunications systems from the broadcast satellite up-path

3-5-(2) Measurement of interference relating to 12 GHz band

The experiments are conducted in the following items;

- the interference to the satellite broadcast reception from the terrestrial broadcasting
- the interference to the satellite broadcast reception from the adjacent satellite broadcasting channel

3-6. <u>Experiments on control and operation of satellite broadcasting system</u>

3-6-(1) Experiments on spacecraft control technologies

The Kashima MTRS has Ku-band TT & C facilities, and operation and control techniques of the zero-momentum type three-axis stabilized spacecraft are studied. How to keep the position and attitude of the spacecraft precisely within the required accuracies of ±0.1 deg. and ±0.2 deg. respectively for three years in minimum fuel consumption is the most interesting technical matters as well as general house-keeping and on-board mission equipment operations.

3-6-(2) Experiment on access to the satellite from the multiple ground stations

For viewers the broadcasting program should be enjoyable without any unacceptable noise or other effects whenever the program transmitting station is switched from one to another.

The experiment is planned to evaluate newly developed transmitter control technique which reduces switching time to less than 1 millisecond.

3-7. <u>Experiment on satellite broadcasting signal reception</u>

BSE system is designed, as a medium-scale broadcast satellite, to cover the whole territory with high quality color television (TASO Grade 1) using 1.6 meter diameter antenna in Japan mainland and 4.5 meter antenna in the surrounding remote islands with reasonable rainfall attenuation margin.

3-7-(1) Experiment on individual reception

In order to evaluate the feasibility of direct home-reception of satellite broadcasting signals, various kinds of antenna and receiver configurations are prepared, and the best compromise between hardware cost and level of reception quality is investigated.

Through the field tests in the urban and rural areas, the following items are measured.

- day-to-day variations in picture and sound quality
- long term reliability
- the effects of weather conditions; snow, rain, temperature, wind, and ice deposit on antenna and feeder
- natural circumstance; mountains, woods, and trees
- artificial obstacles; buildings, railway, airplane, and glass window

3-7-(2) Experiments on community reception

In the cable television system, basic configuration of the ground receiver and its output terminal are just the same as those of individual reception, and VSB-AM signal in VHF is fed to the existing cable network.

For re-broadcasting by terrestrial broadcasting station, the signal from the space is converted to VSB-AM by re-modulation, and fed to the terrestrial transmitter in the IF band.

Receive Only Station will be used for this purpose and the antenna diameter is 2.5 meter in the mainland and 4.5 meter in the remote islands.

4. Preliminary Experiment Results

The available reports are preliminary and partial except the BSE initial performance check-out, so it is inappropriate to evaluate in a scientific view at this time. This part of the paper is description of observations based on evidence available to date.

4-1. Amplitude/Delay Characteristics of the BSE Transponder

An example of measured amplitude/delay frequency characteristics of the BSE satellite transponder (solid curves) and the similar characteristics compressated with an equalizer (dashed curves) is shown in Fig. 3. It shows that delay characteristics are fairly well compensated without any significant change in amplitude characteristics.

4-2. BSE Link Budget (TV Channel)

An example of radio frequency link levels between the MTRS and the BSE is shown in Table 2 which results show good experiments with calculated (design) values.

4-3. Amplituds/Delay Characteristics of the MTRS

Examples of amplitude/delay frequency characteristics for baseband loop-back and satellite loop-back cases measured at the MTRS is shown in Fig. 4.

4-4. Evaluation of the BSE broadcasting service area

The measurements of the received carrier level, video signal-to-noise ratio, and television signal quality assesment were performed by the MTRS, the TTRSs and the ROSs.

These measurements were not conducted simultaneously, so that operating conditions (weather, pointing errors of the satellite antenna, etc.) were not similar.

The results are shown in Table 3.

4-5. Preliminary Performance Measurements

a. The television signals characteristics both for the baseband loop and the satellite loop back cases were measured at the MTRS and the TTRSs. As shown in the Table 4, 5, and 6, the results are quite satisfactory and recognized no degradation.

b. Initial video and audio channel performances were measured at all the ROSs and the SREs. The typical results are shown in Table 7 and 8.

4-6. Results of VITS automatic TV signal signal measurements

An example of the received television signal characteristics measured by the automatic television signal measuring system is shown in Table 9. In Table 10, video signal to noise ratio measured consecutively during the same session is shown. These copies were printed out on the attached typewriter.

4-7. Experiments on access to the satellite from the multiple ground stations

Television program switching tests were perfomed via the satellite applying the uplink transmitter control technique. The principles of the switching technique is as follows.

According to the subjective tests on the influence of the viewer's visual and auditory senses caused by TV program switching, the signal intermission should be less than 1 millisecond.

Refer to Fig. 5, the switching que-signal is sent considering round trip time from A (on-the-air) to B (stand-by station), delay time in the B, and delay time from B to the satellite. Here, the total of them should be equal to the sum of delay time A and delay time from A to the satellite.

That is;

$$t_A + t_B + D_B + t_B = D_A + t_A$$

then, $$D_B + 2t_B = D_A$$

Where,
- t_A : delay time from A station to the satellite
- t_B : delay time from B station to the satellite
- D_A : delay time between que-signal transmission and power turn-off at A station
- D_B : delay time between que-signal reception and power turn-on at B station

This means that,

- if D_A is fixed constant, D_B depends on t_B
  that is,
- B station knows its round time to the satellite ($2t_B$), as long as D_A is always fixed constant, B station can easily set D_B.

In the satellite tests of program switching, if the broadcast program is switched during the field blanking interval the viewers do not recognize any noise on the screen.

This technique will be realized as,

- B station synchronizes its synchro-

nous generator by $2t_B$ prior to A's
- A station turns off its transmitter during the field blanking interval.

Fig.6 shows the best case with RF intermission 10 milliseconds when the two stations controlled the power turn-off and turn-on maintaing real-time voice contact.

Fig.7 shows the result of the switching performed in the field blanking interval by synchronizing both station employing the control system.

4-8. Digital TV Transmission

The object of digital TV experiments is to obtain fundamental data for comparing usual FM with digital modulation having efficient coding in TV transmission, and also to know the possibility of digital TV broadcasting. As shown in the system diagram of Fig. 8 , PCM. TV modem and PSK modem in the CS experiment terminal were utilized in this experiment. The PCM-TV modulator generates DPCM signal of 64 Mb/s, which is converted into 4- or 8-phase PSK signal of 64Mb/s in 140MHz IF frequency band. The 4- and 8-phase PSK signal have bandwidths of ±32 and ±21 MHz respectively. Baseband characteristics in satellite loop-back were measured and bit error rate (BER) below 10^{-7} was obtained. Received TV pictures were of best quality without any degradation except for quantization noise.

To simulate the change of down-link C/N, noise was added of the input of PSK demodulator. Fig.9 shows measured S/N vs. BER. S/N shows little change for BER greater than 5×10^{-5}. Fig.10 shows measured BER vs. Eb/No curves for both satellite loop-back and PSK modulator to demodulator configuration.

Eb/No difference of these two curves for the same BER is thought as degradation due to the operation in the saturated domain of the up-converter and the satellite's last stage TWT. Decrease of up-converter input level by 16 dB from reference level resulted in the optimum performance, improving Eo/No by 2.5 dB. The experiment of changing operational point in satellite's TWT will be done in the near future, in the hope of obtaining better agreement of the two measured curves.

4-9. Range measurement of broadcast satellite utilizing television sync-pulse

A simple and inexpensive method of range measurement of broadcast satellite utilizing sync-pulses contained in television waveform has been proposed and an experimental ranging equipment is developed to demonstrate the capability of the system.

Although the system provides the range data only after the satellite is placed in the geostationary orbit and the communication link is established, it affords the capability of continuous measurement of range data while the regular television broadcasting is carried on, without an additional telemetering channel.

The first experiment to measure the distance to the BSE was done from the Main Transmit and Receive Station at Kashima, to extract the delay time of the satellite transponder which was found to be 150 nsec.

The following measurements are carried out from NHK's transmit and receive station at OSAKA and the collected data are being analyzed at the Technical Research Laboratories in Tokyo, with application to orbit determination calculation to investigate the effectiveness of this TV Ranging System.

5. Summery

The primary aim of the BSE is to verify a zero-momentam three-axis stabilized attitude control satellite technology that would be powerful enough to provide high quality color television to simple, low noise, and inexpensive earth terminals.

The excellent performance of the BSE and its experiments has been very satisfactory to all concerned and we hope much data and experience will be achieved to complete the program.

6. Aknowledgements

The results presented in this paper represent the efforts paid by many people who have been participated in the BSE program. Particular gratitude is extended to NASDA, personnel who have been elaborating in the works of the BSE development.

7. References

(1) T. Ishida et al., "Program of Medium-scale Broadcasting Satellite for Experimental purposes" AIAA paper 76-255, April '76.

(2) K. Tsukamoto et al., "The Japanese Broadcast Satellite and Communications Satellite Experiments" IAF Paper IAF-76-219, October '76.

(3) H. Kaneda et al., "Experiments with the Japanese BSE program" AIAA Paper 78-753, April '78.

(4) Y. Konishi "12 GHz FM Broadcast Satellite Receiver" Microwave Journal pp.55-62; Jan 1978.

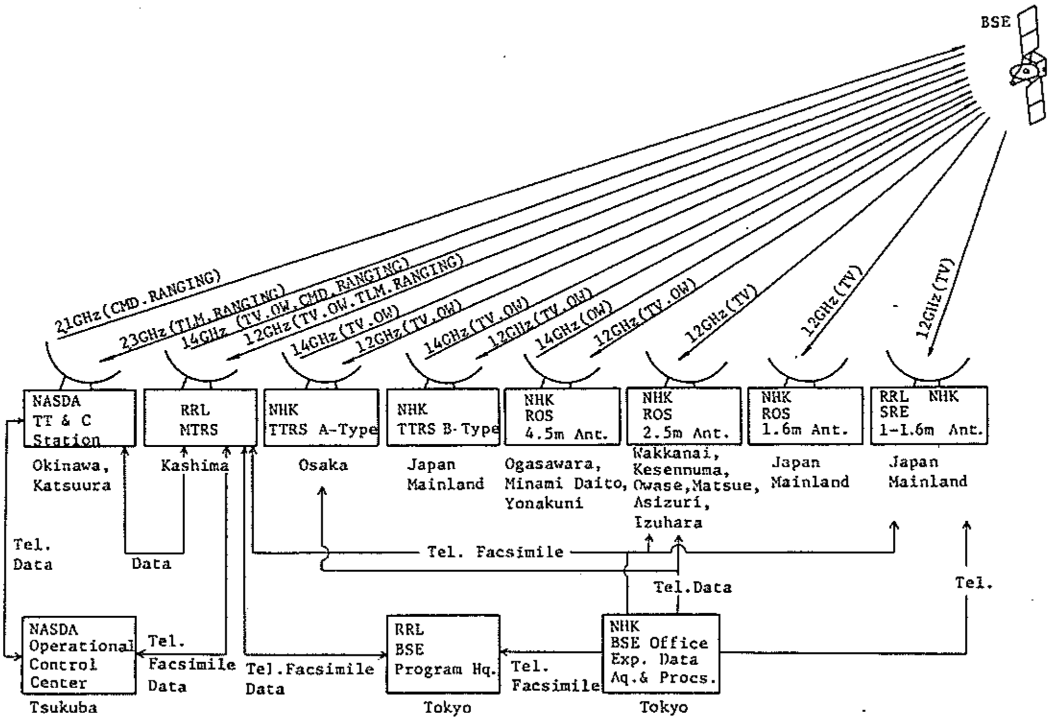

Fig. 1. The total BSE experiment system

Table 1 Standard parameters of TV signal transmission in BSE program

System	NTSC Standard System M (525 lines, 30 frames/sec)
Modulation	FM, Freq. dev. 12 MHz(p-p)
Sound subcarrier	
Frequency	4.5 MHz
Modulation	FM, Freq.dev.±25 kHz (0-p)
Sound/Video ratio	1/6
Emphasis	CCIR Rec. 405-1
Dispersal	22dB (600 kHz p-p) in triangle wave form

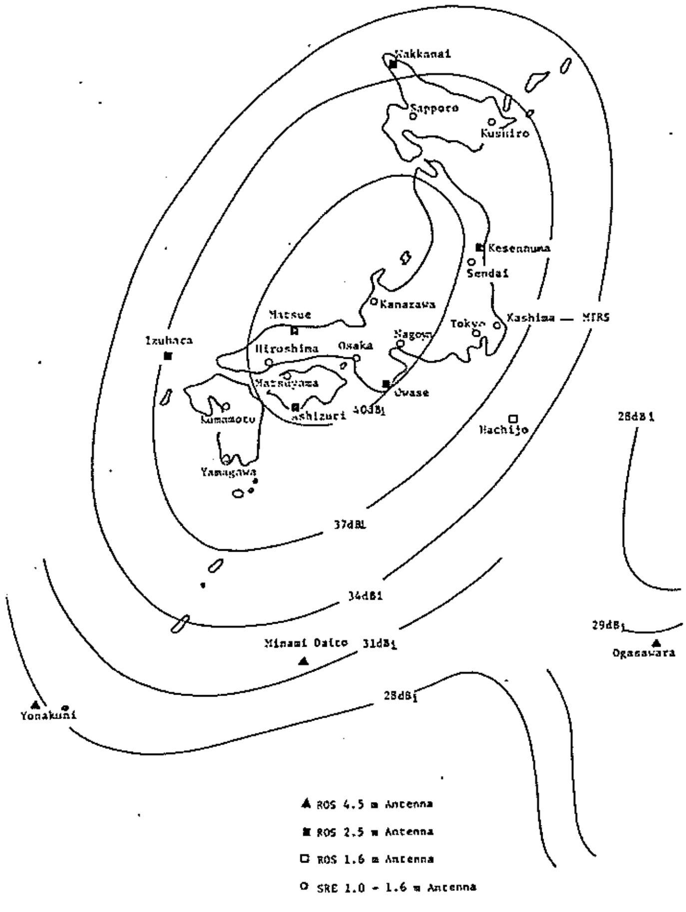

Fig.2 The BSE antenna radiation pattern and ground station locations

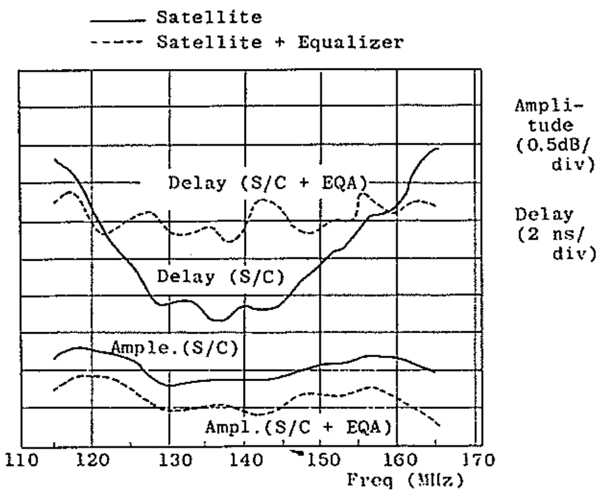

Fig.3 Amplitude/Delay Characteristics of the BSE Satellite Transponder.

Table 2 RF Link Level Diagram

Link	Section	Parameter	Unit	Color TV circuit (Calcu.)	Ch.A1 (meas.)	Ch.B1 (meas.)
Up-link	Main station	EIRP.	dBw	81.0	82.1	82.2
	Propa-gation	Free space attenuation	dB	-207.2	-207.3	-207.4
		Antenna pointing loss	dB	-2.1	-	-
	Satel-lite	Antenna effective gain	dBi	38.4	38.5	38.5
		Received input level	dBm	-59.9	-58.4	-57.5
		System noise power	dBm	-92.1	-92.6	-92.6
		Up-link' C/N	dB	32.2	34.2	35.1
Down link	Satel-lite	100W TWTA output power	dBw	20.0	19.9	20.3
		Transmit power circuit loss	dB	-1.8	-1.7	-1.7
		Antenna effective gain	dBi	38.1	37.6	37.6
		EIRP.	dBw	56.3	55.8	56.2
	Propa-gation	Free space attenuation	dB	-205.7	-205.8	-205.9
		Antenna pointing loss	dB	-2.3	-	-
	Main station	Antenna effective gain	dBi	62.0	61.9	61.9
		Received input level	dBm	-59.7	-60.3	-59.3
		System noise power	dBm	-95.3	-95.8	-95.6
		Down-link C/N	dB	35.6	35.5	36.3
Overall quality		Overall C/N	dB	30.6	32.9	34.3
		Received Picture S/N (Weighted)	dB	60.0	62.3	63.7

Table 3 Measurements of Received Television Signal Characteristics

Location	Station	Antenna Diameter	Received Carrier Level: Calculated	Received Carrier Level: Measured	Weighted S/N
Kashima	MTRS	13 m	-59.9 dBm	-59.8 dBm ∿ -60.2	59 dB
Osaka	TTRS A-type	4.5	-66.7	-63 ∿ -64.5	58
Tokyo	TTRS B-type	2.5	-74.0	-73 ∿ -74	54
Wakkanai	ROS	2.5	-75.9	-77.5 ∿ -81.2	47
Kesennuma	ROS	2.5	-72.8	-72.8 ∿ -74.4	48
Owase	ROS	2.5	-71.2	-72.4 ∿ -74	50
Matsue	ROS	2.5	-70.6	-72 ∿ -73	49
Ashizuri	ROS	2.5	-70.6	-69.7 ∿ -71.3	54
Izuhara	ROS	2.5	-73.1	-75.4 ∿ -76.2	49
Ogasawara	ROS	4.5	-75.3	-78.6 ∿ -81.6	45
Yonakuni	ROS	4.5	-79.1	-77.5 ∿ -79.5	48
Minami Daito	ROS	4.5	-74.2	-73.5 ∿ -74	51
Hachijo	ROS	1.6	-80.7	-81 ∿ -83.3	45

Fig.2 The BSE antenna radiation pattern and ground station locations

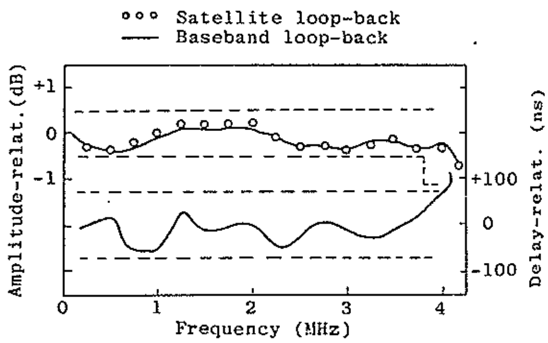

Fig.4 Amplitude/Delay Characteristics of A channel

Table 4 Measured results of baseband characteristics at the MTRS

Measured item	Content	Baseband loop-back A ch	Baseband loop-back B ch	Satellite loop-back A_1 ch	Satellite loop-back B_1 ch
Waveform distortion					
field-time	Sag (%)	2.0	1.0	1.0	0.5
line-time	Luminance bar (%)	1.0	1.5	1.5	1.5
"	Streaking (%)	4.0	3.5	5.5	4.5
short-time	2 T pulse/bar (%)	1.0	1.5	1.0	3.0
"	Overshoot (%)	4.0	2.0	3.5	2.0
Chrominance-luminance inequalities	Gain difference (%)	1.0	1.0	2.5	4.0
	Delay time difference(ns)	8	36	32	64
Non-linear distortion	DG (%)	1.5	3.0	5.0	4.0
	DP (deg.)	0.5	0.9	2.7	1.6

Table 5 Measurements of Initial TTRS A-type Performance

Measured Item	Content	Baseband loop-back		Satellite loop-back	
		A-2Ch.	B-1Ch.	A-2Ch.	B-1Ch.
Waveform Distortion					
Field-time	Sag (%)	0.0	0.0	0.0	0.0
Line-time	Luminance bar (%)	2.0	2.0	1.0	1.5
Short-time	2T Pulse/Bar (%)	1.0	2.0	0.5	1.0
Non-linear	DG (%)	1.0	1.5	2.5	3.5
Distortion	DP (deg)	0.6	2.5	1.3	1.5
Signal-to-Noise Ratio	Weighted S/N (dB) Ratio	59	58	58	56
Sound Channel Characteristics	Signal-to-Noise Ratio (dB)	67	69	66	64
	Distortion (%)	Less 0.7	Less 0.9	Less 0.8	Less 0.8

Table 6 Measurements of Initial TTRS B-type Performance

Measured Item	Content	Baseband loop-back		Satellite loop-back	
		A-2Ch.	B-1Ch.	A-2Ch.	B-1Ch.
Waveform Distortion					
Field-time	Sag	0.0	0.0	0.0	0.0
Line-time	Luminance bar (%)	0.0	0.0	-1.5	1.0
Short-time	2T Pulse/Bar (%)	0.5	0.5	0.5	0.5
Non-linear	DG (%)	0.5	1.0	1.5	0.5
Distortion	DP (deg)	0.5	0.8	0.7	1.0
Signal-to-Noise Ratio	Weighted S/N (dB)	53	55	54	55
Sound Channel Characteristics	Signal-to-Noise Ratio (dB)	55	57	54	56
	Distortion (%)	Less 0.8	Less 0.45	Less 0.8	Less 0.7

Table 7 An example of initial television signal measurements at NHK Tokyo by ROS

Measured item	Content	ROS 2.4m A-2 Ch.
Waveform distortion		
Line-time	Luminance bar (%)	0.1
"	Streaking (%)	-1.0
Short-time	2T Pulse/bar (%)	1.3
"	Over shoot (%)	-3.6
Chrominance-luminance inequalities	Gain difference(%)	1.0
	Delay-time difference (ns)	43
Non-linear distortion	DG (%)	1.4
	DP (deg.)	2.0
Signal-to-Noise ratio	S/N Weighted (dB)	49

Table 8 An example of initial television signal measurements at NHK Tokyo by SRE

Measured item	Content	SRE 1.0m A-2 Ch.	SRE 1.6m A-2 Ch.
Waveform distortion			
Line-time	Luminance bar (%)	0.1	-0.3
"	Streaking (%)	1.5	5.5
Short-time	2T Pulse/bar (%)	5.8	-3.9
"	Over shoot (%)	-9.3	-4.2
Chrominance-luminance inequalities	Gain di ference(%)	1.0	0.0
	Delay-time difference (ns)	110	295
Non-linear distortion	DG (%)	2.9	2.7
	DP (deg.)	2.4	3.3
Signal-to-Noise ratio	S/N Weighted (dB)	42	47

1. MTRS transmission - Reception by ROS 2.4m Ant. at NHK Tokyo
KS-SR3-A2 08/31 15:16

LEVEL(IRE)	PICTURE		SYNC		BURST	
	99		42		40	
FREQ.(MHz)	0.50	1.00	2.00	3.00	3.58	4.20
(DB)	-0.1	-0.3	0.1	0.4	0.5	-3.8
DISTORTION	LUM.BAR(%)	2T/BAR RATIO(%)		2T OVERSHOOT(%)		
	0.1	1.1		-3.8		
C/L	C/L GAIN(DB)	L-C DELAY(NS)		STREEKING(%)		
	1.0	44		-0.9		
S/N	S/N (DB)	DG(%)		DP(DEG)		
	49	1.3		2.0		

2. TTRS A-type transmission, Osaka - Reception similar to 1.
KA-SR3-A2 08/31 15:34

LEVEL(IRE)	PICTURE		SYNC		BURST	
	98		41		46	
FREQ.(MHz)	0.50	1.00	2.00	3.00	3.58	4.20
(DB)	-0.4	-0.9	-0.6	0.5	1.1	-1.3
DISTORTION	LUM.BAR(%)	2T/BAR RATIO(%)		2T OVERSHOOT(%)		
	-0.3	-2.8		-2.0		
C/L	C/L GAIN(DB)	L-C DELAY(NS)		STREEKING(%)		
	1.4	51		-0.8		
S/N	S/N(DB)	DG(%)		DP(DEG)		
	49	1.3		2.1		

3. TTRS B-type transmission, Tokyo - Reception similar to 1.
KB-SR3-A2 08/31 16:08

LEVEL(IRE)	PICTURE		SYNC		BURST	
	100		41		44	
FREQ.(MHz)	0.50	1.00	2.00	3.00	3.58	4.20
(DB)	-0.5	-0.8	-0.8	-0.3	-0.0	-2.8
DISTORTION	LUM.BAR(%)	2T/BAR RATIO(%)		2T OVERSHOOT(%)		
	0.8	-2.4		0.0		
C/L	C/L GAIN(DB)	L-C DELAY(NS)		STREEKING(%)		
	0.3	31		-1.2		
S/N	S/N (DB)	DG(%)		DP(DEG)		
	49	2.3		3:4		

Table 9 Examples of VITS automatic measurements

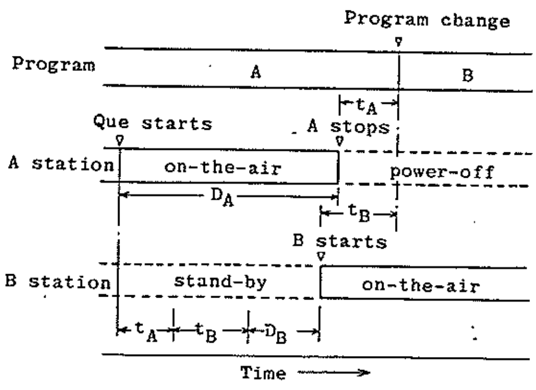

Fig.5 Program switching time sequence

			S/N	S/N(DB)
Ex.1	KS-SR3-A2	08/31	15:06	48
	KS-SR3-A2	08/31	15:08	48
	KS-SR3-A2	08/31	15:10	48
	KS-SR3-A2	08/31	15:12	49
	KS-SR3-A2	08/31	15:14	49
	KS-SR3-A2	08/31	15:16	49
	KS-SR3-A2	08/31	15:18	49
	KS-SR3-A2	08/31	15:20	48
Ex.2	KA-SR3-A2	08/31	15:32	48
	KA-SR3-A2	08/31	15:34	49
	KA-SR3-A2	08/31	15:36	49
	KA-SR3-A2	08/31	15:38	48
	KA-SR3-A2	08/31	15:40	50
	KA-SR3-A2	08/31	15:42	49
	KA-SR3-A2	08/31	15:44	49
	KA-SR3-A2	08/31	15:46	49
Ex.3	KB-SR3-A2	08/31	16:02	50
	KB-SR3-A2	08/31	16:04	49
	KB-SR3-A2	08/31	16:06	49
	KB-SR3-A2	08/31	16:08	49
	KB-SR3-A2	08/31	16:10	49
	KB-SR3-A2	08/31	16:12	49
	KB-SR3-A2	08/31	16:14	49
	KB-SR3-A2	08/31	16:16	49

POINT ALL/ONE/FROM-TO ? A
DATA FORMAT ALL/INDIVIDUAL ? 1
LEVEL/FREQ/DIST/SN/CL ? C

Table 10 Examples of VITS automatic measurements corresponds to Table 9.

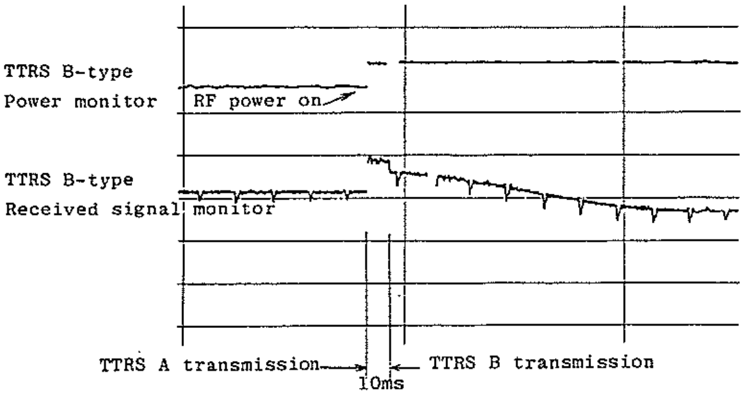

Fig.6 RF switching 10ms intermission

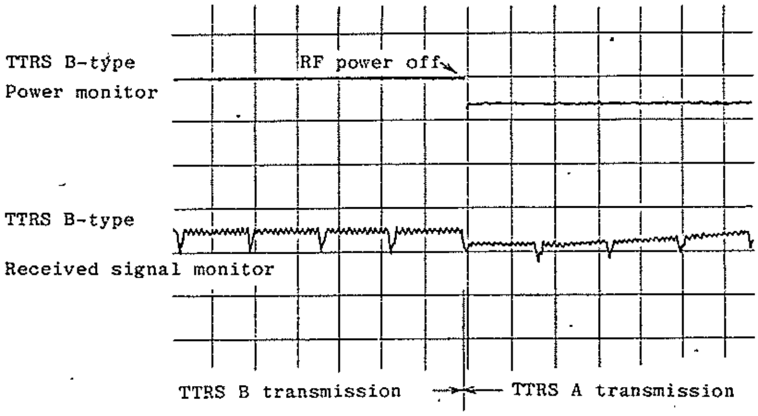

Fig.7 RF switching within the vertical synchronous interval

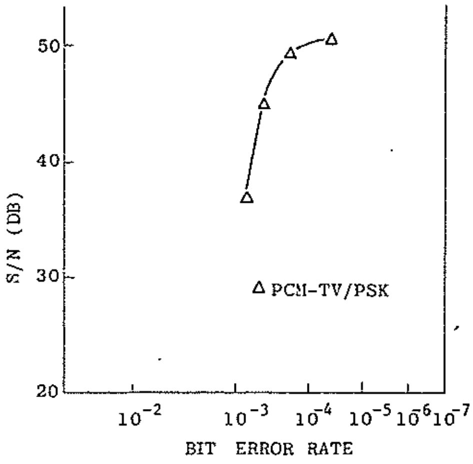

Fig.9 BER-S/N Characteristics

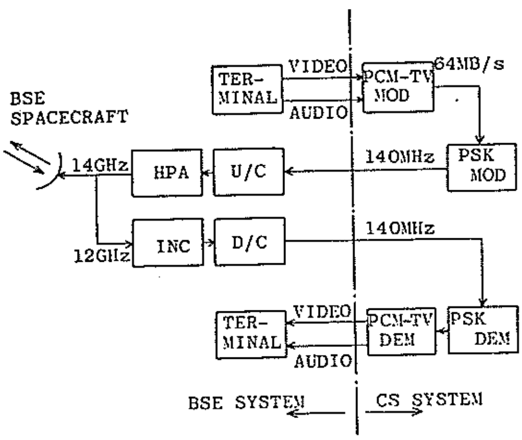

Fig.8 Digital TV Experiment System

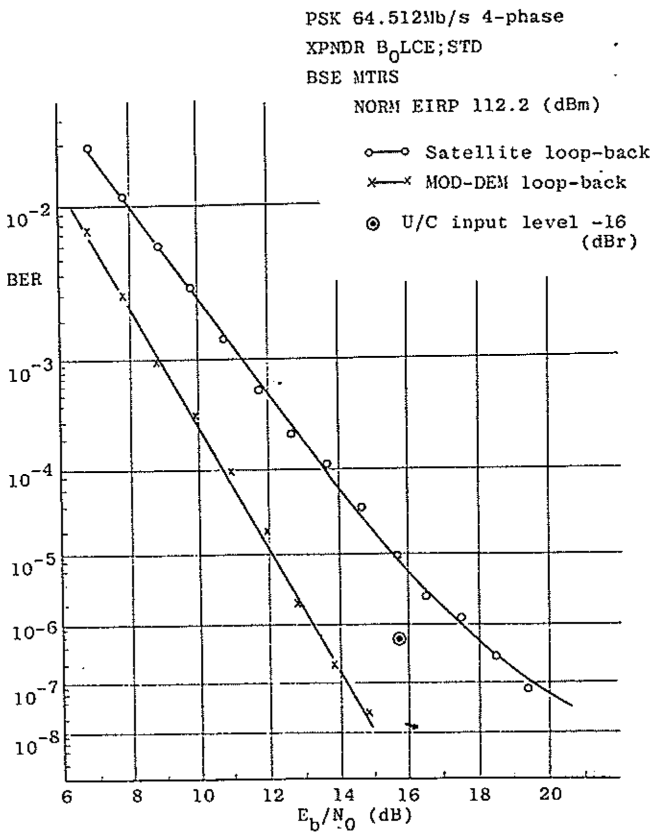

Fig.10 BER-E_b/N_0 Characteristics