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STUDY REPORT
ON
PLANT RENOVATION PROJECT OF
THE SENTOSA－1 EARTH STATION
IN
THE REPUBLIC OF SINGAPORE

Vol. 1

JULY 1986

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

PREFACE

In response to the request of the Government of the Republic of Singapore, the Government of Japan decided to conduct a study on Plant Renovation Project of the Sentosa-1 Earth Station and entrusted the study to the Japan International Cooperation Agency (JICA).

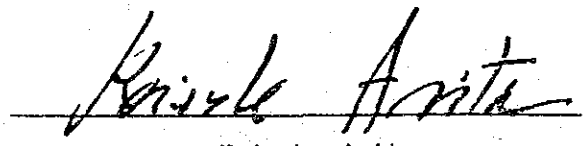
The JICA sent to Singapore a study team headed by Mr. Hikotada Takeuchi, Director, Training Department, Japan Telecommunications Engineering and Consulting Service, from March 18th to 31st, 1986.

The study team exchanged views on the Project with the officials concerned of the Singaporean Government and conducted a field survey.
After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that the report will serve for the improvement of satellite communication in Singapore and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Singaporean Government for their close cooperation extended to the team.

July, 1986



Keisuke Arita
President
Japan International
Cooperation Agency

CONTENTS

CHAPTER 1

Introduction

1. Introduction

1.1 Background and Objectives of the Study

(1) Background

The SENTOSA-1 Earth Station which was constructed in the Republic of Singapore in 1971 will reach its design life of 15 years in 1986. In 1983, the Government of Singapore requested the Government of Japan to conduct study to determine the feasibility of extending the earth station's service life.

In response, the Japan International Cooperation Agency (JICA) conducted preliminary studies (in 1984 and 1986) to establish the terms of reference. As a result, SCOPE OF WORK covering the actual procedures and contents of the full scale study was agreed upon, by the both governments. A field survey was conducted during March 18-31, 1986.

(2) Objectives

The study was conducted for the Plant Renovation Project--the type normally implemented by the Japanese government to assist in the renovation of a deteriorated plant that had been constructed in economic cooperation with the local government.

The study's objectives were: to investigate the feasibility of extending the service life of SENTOSA-1; to estimate the length of time that the service life can be extended; and to make recommendations about the refurbishment necessary for extending the earth station's service life.

The investigation items, as agreed in the SCOPE OF WORK, included:

(1) The deterioration State of SENTOSA-1 Antenna

(2) Reuse plan beyond the design life of 15 years

The following items were requested in recommendations:

(1) Feasibility on refurbishment of the SENTOSA-1 antenna

(2) Estimate of the extension in life span

(3) Framework for necessary refurbishment work

(4) Rough cost estimation for refurbishment work

(5) Implementation schedule for refurbishment work

1.2 Organization of the Study and Implementation Schedule

(1) Study Team and Advisory Committee

The team for this study and Advisory Committee to provide advisory services were organized by JICA in March, 1986.

The member lists are shown in Table 1-1 and 1-2.

(2) The study was conducted in accordance with the following schedule.

Details of the field survey schedule are shown in Table 1-3.

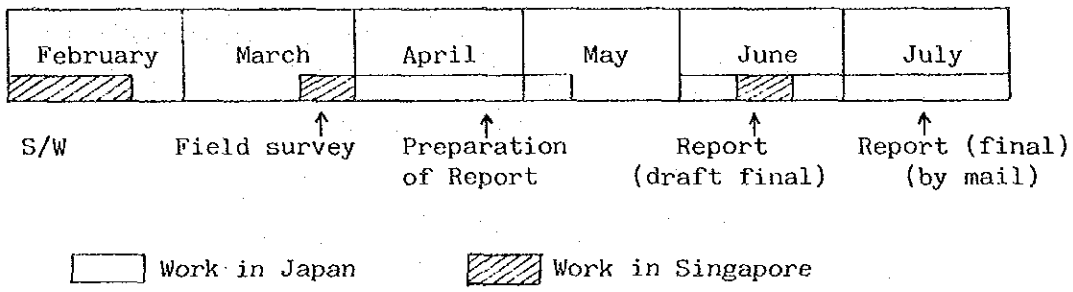


Table 1-1: JICA Study Team

Name	Duty in charge	Present Post
Hikotada TAKEUCHI	Leader (Transmission System)	Japan Telecommunications Engineering and Consulting Service (JTEC)
Tadashi YASUKAWA	Antenna Servo-Drive System	JTEC
Keiji MAKINO	Antenna Servo-Drive System	JTEC
Fujio HORI	Antenna Structure & Mechanical Drive System	JTEC

Table 1-2: JICA Advisory Committee

Name	Duty in charge	Present Post
Shinichi TAKEUCHI	Chairman	Special Advisor for International Cooperation, Ministry of Posts and Telecommunications
Nobuhiro TAKEUCHI	Member (Satellite Communication Operation Plan)	Deputy Director of Administration Division, Telecommunications Bureau, Ministry of Posts and Telecommunications
Hachiro SHIBAZAKI	Member (Satellite Communication System)	Senior Staff, Second Maintenance Division-Transmission System, Maintenance Dept., Tokyo District Office, KDD
Kazuo ICHIHARA	Coordination	Staff, 2nd Development Survey Div., Social Development Cooperation Dept., Japan International Cooperation Agency (JICA)

Table-1-3 SENTOSA-1 Earth Station Field Survey Schedule

	Mar. 18 Tue	19 Wed	20 Thu	21 Fri	22 Sat	(23) Sun	24 Mon	25 Tue	26 Wed	27 Thu	28 Fri	29 Sat	(30) Sun	31 Mon
Mechanical Check of Antenna Structure (under Operation) (Backup structure, Center Hub, Yoke, etc.)				←	—	→								
Operation Check of Antenna Drive System (under Operation)				←	—	→								
Operation Check of Transmit/Receive System (under Operation) Confirmation of operation/maintenance				←	—	→								
Investigation on TDMA Operation (under Operation)					←	→								
Prepatation for investigation		←	—	→										
Ceasing period of Operation						←	— Ceasing of Operation —				→			
Check of Antenna Structure (EL Shaft, AZ Bearing, Reducer, etc.)							←	—	—	—	→			
Check of Antenna Drive System							←	—	—	—	→			
Confirmation for restarting of Operation (TELECOMS)											→ Telecoms			
Traffic Transition to/from BKT-1A (TELECOMS)			←	— Telecoms	—	→						← Telecoms	—	→
Staying Period of Members of JICA Advisory Committee									←	—	—	—	—	→
Preparation for Progress Report											←	—	→	
Meeting and Reporting		—										P/R		
Traveling Schedule	● Study Team arrives								● Members of JICA advisory committee arrive					● All Member leave

1.3 Contents of the Report

Based on the field survey, the team prepared recommendations on the feasibility of extending the service life of the SENTOSA-1 antenna beyond its design life, and on the length of time that the service life can be extended.

An outline of investigations into the antenna's structure and mechanical drive system, and antenna servo-drive system are presented in Chapter 2. To enable clearer understanding of the report; the investigation procedure; the results of checking the antenna's structure and mechanical drive system; and the test results / data for the servo-drive system are presented in Annexes 1,2 and 3, respectively.

Chapter 3 presents an evaluation of the investigation results, together with a summary of the refurbishment items requiring immediate attention and an identification of the problems in each system.

In Chapter 4, two sets of refurbishment requirements (for extending the service life by 5 years and by 10 years) based on the evaluation are presented in detail.

Annex 4 lists all equipment that require refurbishment or replacement, along with the recommendations. Annex 5 presents rough cost estimates for the 5-year and 10-year extensions.
In addition, photos taken during the field survey are compiled in Volume 2. They serve as test data and provide information for refurbishment planning.

CHAPTER 2

Outline of the Investigation

2. Outline of the Investigation

The present condition of the antenna system was carefully investigated in order to examine the possibility of prolonging the service life. The followings are the major points of investigation.

(1) Rust and cracks on the surface of structure.

(2) Degradation of drive system.

(3) Degradation of servo system.

This Chapter contains the outline of investigation performed at the site. The detailed procedure of investigation is shown in the ANNEX 1.

2.1 Mechanical Investigation Items

2.1.1 Investigation contents

The following items were investigated concerning mechanical parts and structure of antenna system.

(1) Peeling off, crack, degradation of paint
(2) Rust of structure, water leakage
(3) Crack of welding part (refer to Annex 1)
(4) Oil leak, corrosion, wearing of gears and bearing
(5) Looseness of bolts and nuts
(6) Abnormal sound of drive system (refer to Annex 1)
(7) Azimuth perpendicular
(8) Distortion of structure
(9) Check of Lubricant (refer to Annex 1)

2.1.2 Items checked during operation

(1) Back-up Structure
(2) Center Hub
(3) Bull Gear Mount
(4) Yoke
(5) HPA Room
(6) Feed Room

2.1.3 Items checked during the ceasing of operation

(1) Elevation Shaft
(2) Concrete Tower
(3) AZ Bearing
(4) AZ/EL Reducer
(5) EL Bearing
(6) AZ/EL Bull Gear
(7) Main Ref.

2.2 Servo Drive System

2.2.1 Test items conducted during the ceasing of operation

1) Auto Position Loop Transient Response Test:

To check the degradation of overall system characteristics based on the result of auto position transient response measurement.

2) Error Voltage Gradients and Crosstalk test of Tracking Receiver:

To check the degradation of error voltage gradients and crosstalk of tracking receiver output using the satellite.

3) Manual Position Loop Step Response:

To check the closed loop step response of position loop (SCA-DCPA-ANGLE DET-ACU) and confirm the stability of the response.

4) Tachometer Loop Frequency Response/Step Transient Response:

To check the degradation of closed loop (DCPA-DRIVE MOTOR-TACHOMETER) response.

5) Velocity and Acceleration Test:

To check the driving velocity range (Maximum and Minimum speed) and confirm the function of DCPA and Drive Motor.

6) Drive Test (Wide Angle):

To confirm that the antenna is able to be driven without any problem over a wide angle range.

7) Degradation of Drive Motor:

To check the degradation of Azimuth and Elevation Drive Motor.

8) Degradation of Angle Detector:

To check the degradation of angle detector due to aging change.

9) Control/Monitor and Alarm Function Test:

To confirm that the control, monitor and alarm functions in antenna control console are operating normally.

2.2.2 Test items conducted under the operation

1) To verify the actual situation of the following existing equipment prior to full investigation to be conducted during the ceasing of operation.

- Tracking Down Converter & Tracking Demodulator
- Antenna Control Console
- Antenna Drive System

2) Investigation of interface condition of the equipment to be refurbished:

To obtain the necessary information in order to design the equipment to be refurbished.

CHAPTER 3

Evaluation for the Investigation Result

3. Evaluation for the Investigation Result

The following two important points have to be considered in the service life extension of a large antenna:

(i) Whether the mechanical structure, mechanical drive system and servo-drive system can continue to be maintained in good condition.

(ii) Whether the refurbishment cost is considerably lower than the cost of constructing a new antenna.

From this considerations, the study team has concluded that the SENTOSA-1 Antenna can be used beyond its design life.

The points of refurbishment work requiring immediate attention and an identification of the problems in each system are summarized paragraph 3.1. The evaluation detailed in this chapter is shown the deterioration state of each system in paragraph 3.2, 3.3 and 3.4 respectively.

3.1 Summary

(1) Antenna structure and mechanical drive system.

a) Antenna Structure

Cracks and extensive corrosion have not been detected during this survey.

However, many corrosive points and water pooling points have been found. These points are necessary to be repaired during the regular maintenance period or a special repair period.

b) Drive mechanism

Abnormal sounds have not been detected from AZ/EL reducers and AZ/EL bearings under normal operating conditions. Therefore, all drive mechanism will work in the future assuming proper maintenance.

However, all brakes for the AZ/EL reducers and AZ bearing lubrication system should be replaced during the special repair period.

(2) Servo-drive system

In the on-site survey, appearance and electrical performance have been checked for the tracking and drive & servo equipments.

a) The commutator surface of four AZ Drive Motors are threading and may develop further threading or grooving.

b) Insulation resistance of EL No. 1 and No. 2 motors were decreasing, so that it is necessary to clean and dry the motors.

c) Drive control power amplifier

Most contacts of relays and terminals and the characteristics of AZ amplifier were degraded, then rapid refurbishment should be required.

d) Some limit switches and safty switches were rusty.

e) Dehydrator B is out of order.

3.2 Antenna Structure and Mechanical Drive System

(1) Subreflector (photograph 1.1.1)
Bracket of subreflector is rusted, but it is not serious.

(2) Tripod (photograph 1.2.1 - 1.2.4)
Almost all members and bolts are partially rusted.
The connection hardware at the top suffered considerably from water pooling. Practical residual life of the tripod might be several years.

(3) Main reflector panel (photograph 1.3.1 - 1.3.6)
Two panels are damaged and rear faces of panels are rusted.
No problem practically.

(4) Panel Support (photograph 1.4.1 - 1.4.2)
Almost all bases are partially corroded though only a few bolts are rusted. It is preferable to replace ten percents of bases with new ones.

(5) Backup structure and Center hub (photograph 1.5.1 - 1.6.7)
Almost all members and some bolts are partially rusted.
Some joints of members have water pooling and are corroded considerably. As the joints are important structural parts, they need to be repaired to withstand the maximum wind speed specified.

(6) EL shaft and shaft box (photograph 1.7.1 - 1.7.3)
Though they have rusted partially, no crack was found through color dye-check at weld zone, EL shaft and joint plates.
It seems that they have been in good condition as a whole.

(7) Bullgear Mount (photograph 1.8.1 - 1.8.6)
The bullgear mount has rusted partially. There was a water pooling with corrosion. Water which had entered into the concrete counter weight was found seeping out through the joint of the steel cover.
Though it is not so serious, it is preferable to seal the concrete surface to protect the inner surface of the steel cover from corrosion.

(8) Yoke (photograph 1.9.1 - 1.9.8)
Plates are partially rusted but no rust was found on bolts.
It seems that good condition has been kept as a whole.

(9) HPA and Feed room (photograph 1.10.1 - 1.11.3)
Both sides of floor and area around door are partially rusted.
It is not serious.

(10) Concrete tower (photograph 1.12.1 - 1.12.4)
Some hair crack and one big crack were found on the concrete tower. However they are not serious defects.

(11) EL Bearing and Plummer block (photograph 1.13.1 - 1.13.2)
There is slight oil-leakage through oil seal but no abnormal sound. No serious problem was detected.

(12) AZ Bearing
No abnormal sound was detected. No problem was detected.

(13) AZ/EL Speed reducers (photograph 1.15.1 - 1.16.2)
Abnormal sound was detected in AZ speed reducer with manual handle. The brake seems to be the source of the sound.
There was no problem in the gearboxes.
Brakes in the speed reducers should be replaced.

(14) AZ Gear and EL Bullgear (photograph 1.17.1 - 1.18.2)
There is scarcely abrasion on the teeth.
It is no problem to use them in the future.

(15) AZ/EL Lubrication system

AZ lubrication unit (oil pump unit) is necessary to replace with new one to protect AZ bearing from invasion of rust for long term operation.

(16) AZ perpendicular

There is no problem in practical use.

3.3 Antenna Servo-Drive System

(1) AZ Drive Motors (Photograph 2-1-3, 2-1-4, 2-1-5)

Commutator surface is threading.

The commutator surface will develop further threading or grooving, so mending the surface and cleaning are necessary.

(2) EL Drive Motors (Photograph 2-2-5)

1) As shown in Test Data (Degradation of Drive Motor in Annex 3), insulation resistance was degraded.
To prevent flashover, drying and cleaning are necessary.

2) Rust from the PLICA tube adhered to EL No. 2 Drive motor, then cleaning is necessary.

(3) DCPA (Photograph 2-3-2 to 2-3-6)

1) Because DCPA (AZ and EL) and Feeder panel are installed in the Antenna foundation room, the enviromental condition is severer than that of control rooms with air-conditioner. Therefore, internal terminals and electrical parts had rust and Azimuth No. 3/4 single drive operation under DCPA Maintenance mode was not operated (Relays 1 BR and 2 BR were not energized).
The loose contact of some relays was one of the cause of this trouble. This will be a sign of the degradation of all contacts.

2) As shown in Azimuth Tachometer loop transient response (Data sheet 9-2), the characteristics of AZ NO. 1/2 amplifier was degraded.

3) DCPA should be replaced with new model.

(4) Antenna Control Console (Photographs 2-5-1 to 2-5-8)

1) The follow up speed of the angle indication and cable Wrap Up indicator are delayed by comparison with that of antenna position control when the antenna runs at the maximum speed (0.3°/sec).
And the movement of the follow up mechanism does not operate smoothly.
2) 0.01 deg digit of Azimuth angle indication displays only even numbers.
3) These trouble shows the degradation of the follow-up servo mechanism, which is composed of servo motor, encoder and brush selector circuit.
4) It is necessary to replace some parts of follow-up servo mechanism.

(5) Servo Control Amplifier (Photographs 2-6-1 and 2-6-2)

1) Switching operation of servo bandwidth (3-stage) and servo type, and selction of on-line and standby SCA are operating normally.
2) As shown in Data sheets 6-3 and 2-3, the characteristics under the following condition is degraded, but no problem in practical use.

EL axis
SCA A
Servo Type I
Servo Bandwidth Narrow

(6) Tracking Demodulator (Photographs 2-7-1 and 2-7-2)

The result of Error Voltage gradient and crosstalk (Data sheet 3 and 4) shows that the Tracking Demodulator and tracking Down Converter are operating normally.

(7) Tracking Down Converter (Photographs 2-8-1 to 2-8-3)

4 GHz LNA and coaxial attenuators are temporarily installed on the Tracking Down Converter instead of 31335B Tunnel Diode Amp.
Because it has already been difficult to supply the spare TD Amp, 4 GHz LNA was substituted.

(8) AZ Angle Detector (Photograph 2-9-4)

Because the enviromental condition is severe (high humidity and high temperature), some dirt and rust are adhered.
And the bellows coupling which connects between the input shaft of AZ Angle detector and azimuth axis (elevator shaft) is eccentric.
It is supposed that slight eccentricity at upper part of elevator shaft causes eccentricity of this bellows coupling.
There is no problem in practical use under auto-tracking.
But if the antenna is driven for wide angle range, it is desirable to perform centering adjustment.

(9) EL Angle Detector (Photographs 2-10-1 to 2-10-3)

Because the EL angle detector is installed in the Feed room with air-conditioner, mechanical and electrical condition are in good condition.

(10) AZ Limit Switches and Cams (Photograph 2-11-2 to 2-11-4)

1) Limit switches and cams are rusty.
2) Azimuth CW limit switch operated at abnormal angle (for example arround 87 deg),
though normal operating position is 267 deg.
Mechanical position of AZ CW limit switches was out of order, but it is no problem at normal operation angle range.

(11) EL Limit Switches and Cams (Photographs 2-12-1 to 2-12-3)

Mechanical and electrical condition is good.

(12) 400 Hz Power Supply (Photograph 2-13)

Photograph 2-13 shows that Terminals were rusty, and cooling Fan has been added to prevent overheat of equipment.

(13) Dehydrator

Dehydrator B is out of order.
Dehydrator A operates normaly and its operation time exceeds 20508 hours. And the compressor operates every about 50 minutes. It is necessary to replace with new one.

(14) Servo Loop Characteristics

1) Tachometer loop step transient response shows that some oscillation appears in the response under Azimuth 1/2 single drive mode.
Therefore, in the servo characteristics under Azimuth dual drive mode, some oscillation appears. Because it was confirmed that the output waveform of AZ No.1 and No. 2 TG were normal status measured by synchroscope in Azimuth 3/4 single drive mode, it is concluded that Azimuth No. 1 Drive Amp of DCPA was degraded and it is not reliable.
So remaining test items were measured under AZ 3/4 single drive condition.

2) Velocity and Acceleration

i) Maximum velocity of AZ and EL is about 0.3 deg/sec

ii) Acceleration of both axes are more than 0.3 deg/sec·sec

iii) Minimum speed are less than 0.002 deg/sec

These results are found to be satisfactory.
Because AZ minimum velocity (See Data sheet 12) was measured under 3/4 single drive mode, delay time, that is, backlash of AZ Gear reduction system was observed.

3) Drive Test
The antenna can be driven without any problem for wide angle range, excluding AZ CW limit switch operation (refer to para 3.3 (8)) and abnormal sound was detected near AZ No. 4 brake (refer to para 3.2 (13))

4) Manual position loop Transient response
In AZ transient response test under AZ 3/4 single drive mode delay time was observed, but the settling time was within the specified 3.5 sec including delay time, and as shown in Data sheet 5-7, delay time was not observed in AZ transient response under AZ dual drive mode (anti-backlash drive).
Some oscillation only appears in the following combination due to the degradation of SCA characteristics.

SCA	:	A
Axis	:	EL
Servo Type	:	I
Servo Bandwidth	:	Narrow

5) Test data of error gradient and crosstalk
(Data sheet-3,4) shows that error gradient is approx. 20 V/deg and crosstalk is not more than -14 dB. This data shows that Tracking Down Converter and Tracking Demodulator are operating normally.

6) Auto position loop Transient Response
Same symptom as that of manual position loop was observed. This is caused by the partial degradation of SCA characteristics, but there is no problems in practical use.

3.4 HPA Configuration and Considerations for Future Operation

1) Amount of space in room

There is no space available in the HPA room. The addition of any extra equipment is thus not possible unless the room is expanded. However, expansion to the azimuth deck is not recommended, because a weight imbalance would occur and the load on the azimuth bearing would increase over the specified design value.

2) Evaluation of HPA configuration

At present, on the A-Pol. side, two 3 kW TWT HPAs are allocated as message carriers, and one unit is for TV transmission. These were installed in 1978, and appear to be well maintained. However, the two 300-W TWT HPAs operating on the B-Pol. were installed in 1974. Because of their lower maintenance efficiency and large space occupation, their replacement should be considered for future. At present, TV transmission is possible on both A Pol. and B Pol., but it is suggested to assign A-Pol. only for TV transmission via IOR major path. This configuration without ratio combiner on the B-Pol. would require lower HPA output power.

3) HPA configuration for future operation

Table 3-1 shows INTELSAT operational plans and related parameters corresponding to use of the SENTOSA-1 antenna for IOR major path operation. From this table, HPA's total output power under the existing configuration is estimated to be approximately 250W (assuming that antenna gain from HPA output is 60 dB).

Then, when a carrier is assigned to B-Pol., as shown in the plan up to the end of 1988 (Table 3-1, B), the output power of these devices is estimated to become approximately 25W, (assuming that antenna gain from HPA output is 60 dB). These data suggest that the existing configuration will be able to operate up to 1988 year end.

4) A plan to introduce TDMA to the IOR major path is not yet decided by INTELSAT. Nevertheless, if TDMA system in A-Pol. is introduced in future with a lower EIRP (eg. 86 dBW) the 3 kW TWT HPA can meet the requirements of TDMA operation by providing a linearizer. The linearizer can provide a 6 dB improvement in IM products or an equivalent 3 dB extension of HPA saturation power.

Table 3-1 INTELSAT V SATELLITE OPERATIONAL PLAN

A) IND-16T-M ACTUAL TRAFFIC

	SIZE MHZ	CH	1) Fr	2) Fm	3) Ftop	UP/DOWN BEAM	TRANSMIT FREQUENCY	POL	MAX 4) EIRP
F1	20.00	492	558	2200	2044	EH/WH	5981.000	A	81.3
F2	5.00	132	223	529	552	EH/EH	6039.250	A	80.0
F3	2.50	36	168	307	156	G/G	6376.250	A	71.9

B) I-18-D-63 YEAR END 1988 (Major Path)

F1	10.00	132	430	1020	552	EZ/EZ	6041.750	B	74.0
F2	2.50	36	168	307	156	EH/WZ	6164.750	A	71.4
F3	20.00	492	558	2200	2044	EH/WH	6204.000	A	81.3
F4	2.50	36	168	307	156	G/G	6333.750	A	71.9

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note: 1) Fr, Test Tone Deviation

2) Fm, Multi Channel Deviation

3) Ftop, Base Band Maximam Frequency

4) EIRPs are included the correction factor of receive Antenna gain of the IS-V satellite and geographical advantage at the Earth Station.

CHAPTER 4

Recommendations

4. Recommendations

4.1 Feasibility of Service Life Extension

Based on the evaluation made in chapter 3, this chapter presents the judgement of the study team that the use of SENTOSA-1 beyond its design life is possible for a time span of 5 years or 10 years.

4.2 Period of Service Life Extension

4.2.1 The decision of the period is to be made at TELECOMS' option, however the study team would rather recommend as feasible 5 years' extension through the appropriate refurbishment indicated in "5 years items" of paragraphs 4.3 and 4.4. The reasons are as follows:

(1) The antenna is well maitained.

(2) Main structural and mechanical parts of the antenna have been found to be in good condition.

(3) The main refurbishment items are only the replacement of the tripod supporting a subdish, mending of DC motor, replacement of DCPA and mending of speed reducer.

(4) The cost estimation shows a lower cost than for the construction of a new antenna (estimated at JU$ 3m).

(5) 5 years' life extension can meet the INTELSAT proposed plan with very much higher probability than a 10 years extension.

4.2.2 On the other hand, based on the evaluation in Chapter 3, 10 years prolongation of the antenna will require many refurbishment items which are recommended in para 4.3 & 4.4.

It will have a higher cost and longer period of construction. Cost should be compared between the refurbishment of the aged antenna and the installation of a new standard A antenna specified by INTELSAT in March 1986.

For the communication system, no special rearranvement for HPA configuration is necessary untill 1988 year-end, however the aged 300W TWT HPA can be replaced by a new type for 10 years' prolongation, because it may be difficult to prepare the parts for maintenance, and the new type occupies a much smaller space so as to allow room for installing a 19-inch rack. This modification will meet the requirements for installation of up-converter for TDMA and linearizers.

The provision of linearizers is recommended when TDMA is introduced into A-pol via IOR major path.

4.3 Antenna Structure and Mechanical Drive System

Replacements, modification and repainting of the antenna structure and mechanical drive system for prolongation of life time are described in detail below.

The antenna could be repainted during the periodical maintenance. Therefore the repainting work is dropped from the recommendation for the prolongation for five years.

	Item	For five years' prolongation	For ten years' prolongation
(1)	Subreflector	*	Repaint the whole surface after removing the rust.
(2)	Tripod	Replace with new one	Same as left
(3)	Main reflector panel	*	Repaint front surface and repair the damaged panels on site. (revetting)
(4)	Panel support	-	Replace all panel supports with new ones.
(5)	Backup Structure	-	Cut and replace the corroded joints Replace all bolts with new one
		Fill the dead corner with sealant to prevent water pooling	Same as left
		*	Repaint all the members after removing the rust.
(6)	EL shaft and shaft box	*	Repaint the whole surface after removing the rust.

Item	For five years' prolongation	For ten years' prolongation
(7) Bullgear Mount	*	Repaint the whole surface after removing the rust.
	Fill the dead corner with sealant to prevent water pooling. Cover the exposed surface of concrete with covering material.	
(8) Yoke	*	Repaint the whole surface after removing the rust
	Seal joints with sealant	
(9) HPA/Feed Room	*	Repaint the whole surface after removing the rust
	Replace damaged tiles on the floor with new ones.	Replace tiles on the floor with new ones.
(10) Concrete tower (sole plates)	Repair for mortar peeling	same as left
	Remove cracks	
	Remove the rust, apply inorganic zinc rich paint and seal with sealant	same as left
(11) EL Bearing and plummer block	Replace of oil seal	same as left
	Supply new grease	
	*	Repaint the plummer block after removing rust.
(12) AZ Bearing	Replace oil	same as left
(13) AZ/EL speed reducer	Replace brakes and grease	same as left
	*	Repaint after removing the rust
	Replace cover of bearing for pinion of EL speed reducer	same as left

Items	For five years prolongation	For ten years' prolongation
(14) AZ gear and EL bullgear	Remove rust	same as left
		Replacement all bolts and shims of EL bullgear with new ones.
	Supply new grease	same as left
(15) AZ/EL Lubrication system	Replace oil pump unit for AZ Lubrication	same as left
(16) Others		
(16.1) Buffer	-	Replace the buffers with new ones.
(16.2) Stow device	-	Replace the stow device with new one.

NOTE) * : As five years prolongation of life time is considered to be possible provided that the proper maintenance is performed by the customer, these items are categorized here.

- : No work required

4.4 Servo-Drive System

The study team recommends refurbishing for the equipments in order to obtain more reliable operation and easy maintenance on the bases of this survey report, and from the reason described below, most equipment will be replaced for 10 years prolongation.

(i) There is difficulty of suppling spare units and spare components for the existing equipments because of 15-year time passed and rapid technical revolution.

(ii) In the SENTOSA No.1 earth station, there are no spare panels and spare components, excluding brushes for motors and tachometer generator and some nixie tubes for antenna position display.

(iii) In recent technology, Tracking Down Converter Tracking demodulator, servo control amplifier, DCPA and Antenna Control Console have become more compact and reliable.

For 5 years prolongation, The study team recommends to replace only degraded equipments neccesary for rapid refurbishment and to supply some parts for preventive maintenance. For 10 years prolongation, compact and reliable new system is recommended.

	Item	For five years' prolongation	For ten years' prolongation
1.	AZ Drive Motor	mending	replace
2.	EL Drive Motor	cleaning	replace
3.	DCPA	replace with new model	replace with new model
4.	ACU	Supply some electrical parts for follow up servo	replace with new model*1

Item	For five years' prolongation	For ten years' prolongation
5. Servo Control Amp	readjustment	functions will be included to new ACU
6. Tracking DEM	-	replace with new model*2
7. Tracking D/C	-	replace with new model
8. 400 Hz Power Supply	-	Not used
9. AZ Angle Detector	readjustment	replace with new model
10. EL Angle Detector	-	replace with new model
11. AZ Limit Switches and cams	-	replace with new one
12. EL Limit switches	-	replace with new one
13. Safety switches (i) Main ref Hatch (ii) Stow pin Hole (iii) Manual Handle	replace with new ones	replace with new ones
14. Stow Lock Device	checking	replace
15. Dehydrator	replace with new one	replace with new one
16. Others		
(1) Filter boxes	replace with new gasket	replace with new gasket
(2) Plica tube	replace with new one	replace with new one

*1: Component of new Antenna Control Console

(1) Antenna Control Panel

- digital angle display
- mode selection
- status indication
- servo cont. Amp function

(2) Power Supply

(3) Time Code Generator

*2 : New Tracking Demodulator will be installed in the ACU.
The function of existing Tracking Angle Error Panel and VCO Control Panel are included in the new Tracking Demodulator.

*3 : - No work required.

4.5 Renovation Schedule

The time schedule of renovation work is assumed as the attached milestone schedule.

The total implementation schedule will be divided into the following two phases.

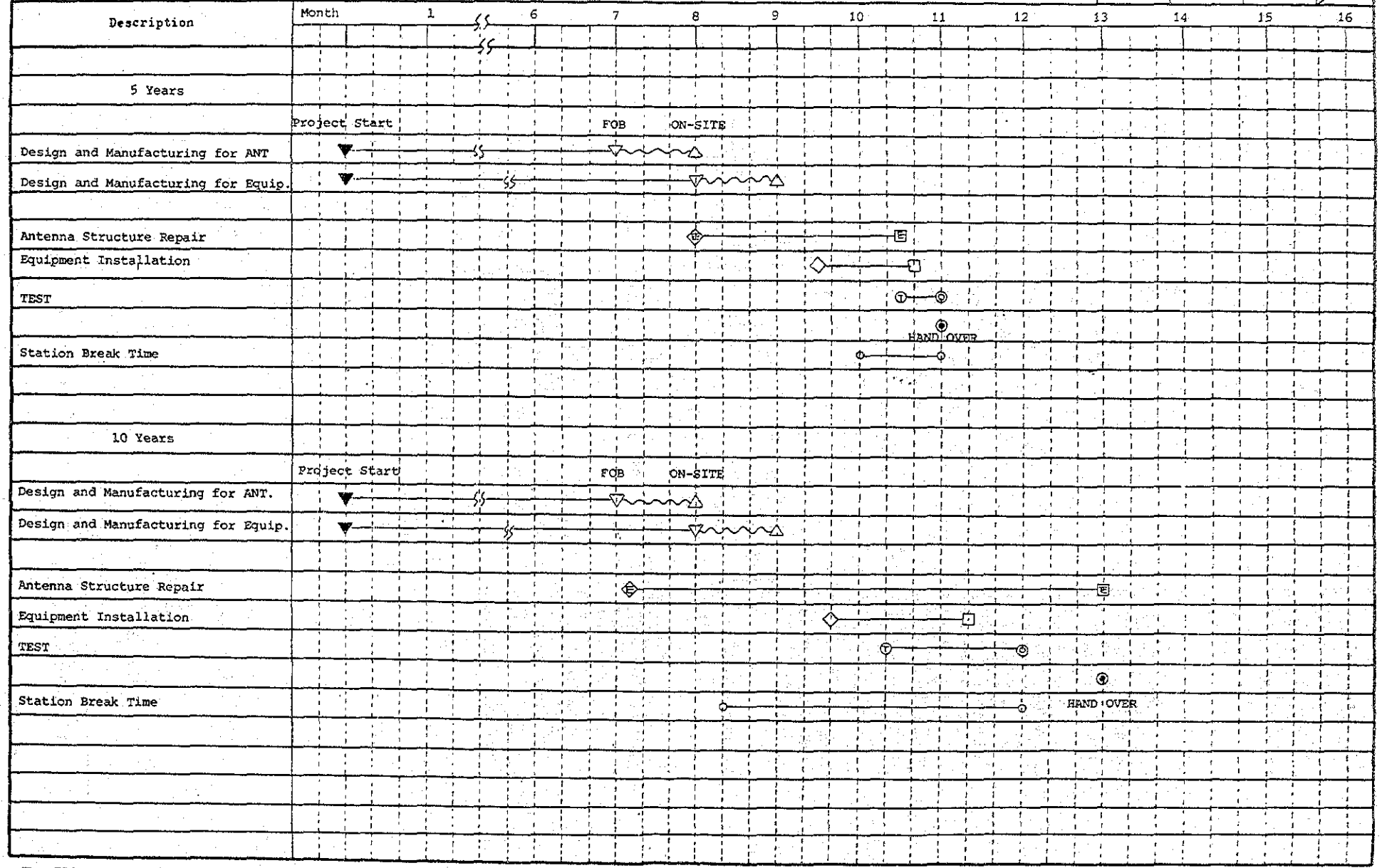
1) Design and Manufacturing of Equipment and Materials
2) On-site Installation and Testing Work

The required period of on-site activities may change according to the weather condition during the site work.

MILESTONE SCHEDULE

DATE 13 MAY 1986

CUSTOMER	PROJECT	APPD.	CHECK	ENG.
Singapore TELECOMS	Singapore Renovation Schedule			

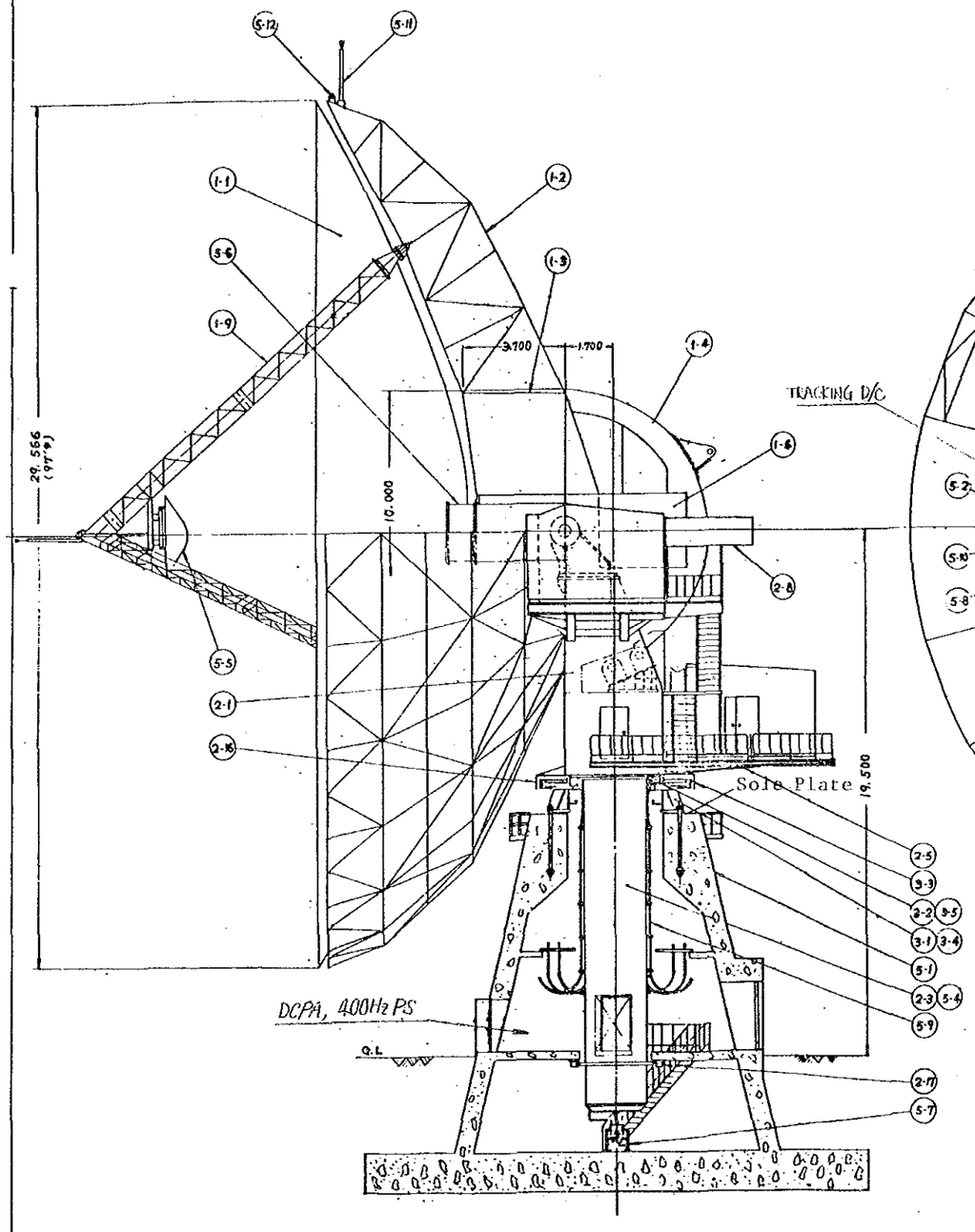


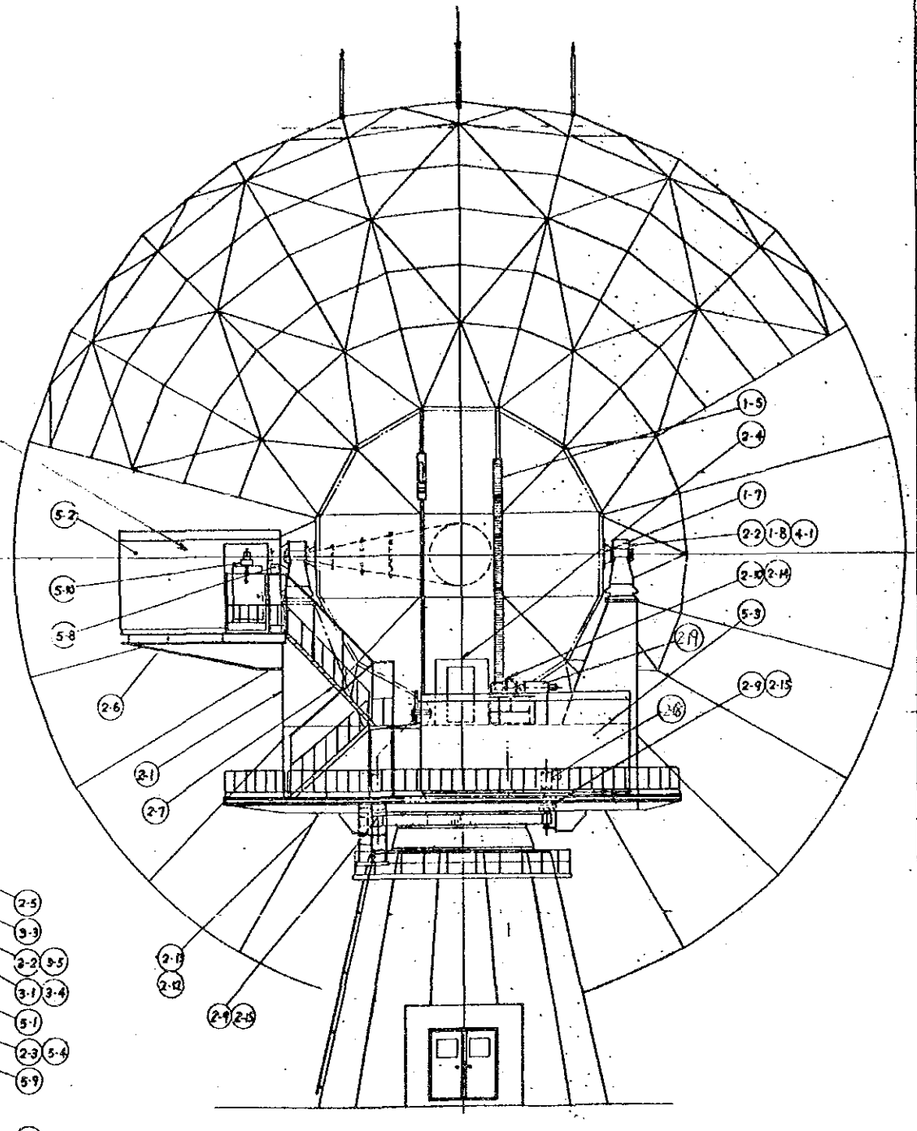
▼ : EDC ▽ : FOB △ : ON-SITE ◇ : INSTALLATION START □ : INSTALLATION COMPLETION Ⓣ : TEST START ◎ : TEST COMPLETION ◉ : HAND OVER

～～～～～ : TRANSPORTION ——— : ACTIVITY ⋈ : PORT ARRIVAL Ⓔ : ANT ERECTION START [E] : ANT ERECTION COMPLETION

Ⓒ : CIVIL START [C] : CIVIL COMPLETION ○ ACTIVITY NAME ○ : SPECIAL ACTIVITY : KEY EVENT - - - - - : STORAGE OR IDLE TIME

SST-088





MARK	NAME
1-1	SURFACE PANEL
1-2	BACK UP STRUCTURE
1-3	CENTER HUB
1-4	EL BULL GEAR MOUNT
1-5	EL BULL GEAR
1-6	COUNTER WEIGHT
1-7	EL SHAFT
1-8	EL BEARING
1-9	TRIPOD
2-1	YOKE
2-2	PILLOW BLOCK
2-3	ELEVATOR SHAFT
2-4	TRACTION MACHINE ROOM
2-5	HPA ROOM FLOOR BEAM
2-6	FEEDROOM FLOOR BEAM
2-7	STAIR WAY
2-8	HOIST SUPPORT
2-9	AZ CYCLO REDUCER
2-10	EL CYCLO REDUCER
2-11	EL BUFFER
2-12	EL LOCK DEVICE
2-13	EL LOCK & BUFFER BASE
2-14	EL CYCLO REDUCER BASE
2-15	AZ CYCLO REDUCER BASE
2-16	AZ BULL GEAR COVER
2-17	ELEVATOR SHAFT SUPPORT
2-18	AZ DRIVE MOTOR
2-19	EL DRIVE MOTOR
3-1	STEEL BASE
3-2	AZ BEARING
3-3	AZ BULL GEAR
3-4	ANCHOR FRAME & ANCHOR BOLT
3-5	AZ BEARING FORCED LUBRICATI
	NG DEVICE
4-1	GREASE LUBRICATING DEVICE
5-1	CONCRETE TOWER
5-2	FEED ROOM (EQ 4 ton)
5-3	HPA ROOM (EQ 12 ton)
5-4	ELEVATOR
5-5	SUB REELECTOR
5-6	CONICAL HORN
5-7	AZ ANGLE SENSER
5-8	EL ANGLE SENSER
5-9	CABLE WRAP
5-10	0.5 TON HOIST
5-11	LIGHTNING ROD
5-12	AIRCRAFT WARNING LIGHT

SCALE 1000 mm

SINGAPORE

97 Ft ANTENNA

146 - 337148 - X

ANNEX 1

Procedures of Investigation

C O N T E N T S

1. Antenna Structure and Mechanical Drive System

1.1 Crack detection (dye panetrant test)

(1) Purpose of the test

To detect crack an material surface.

(2) Test Equipment

1. Cleaner
2. Dye
3. Developer

(3) Test Procedure

Step 1. Remove paint on the surface to be checked

Step 2. Clean the surface by the cleaner

Step 3. Spray the dye on the surface

Step 4. Clean the surface by the cleaner

Step 5. Spray the developer on the surface

Step 6. Observe if crack appears as red lines on white surface of developer.

1.2 Spectrum analysis of EL/AZ Bearing and speed reducers

(1) Purpose of the test

To diagnose bearing from analysis of vibration and sound.

(2) Test Set-up

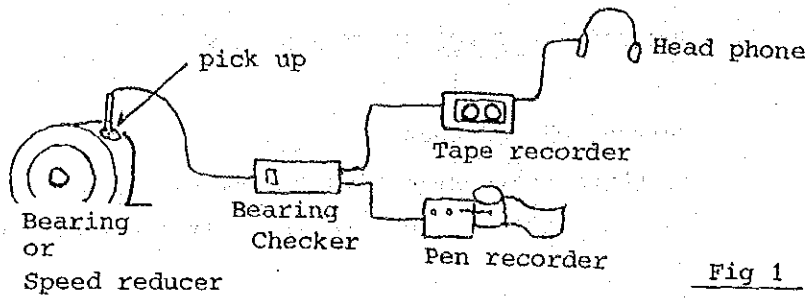


Fig 1

(3) Test Equipment

1. Pick up for sound and vibration
2. Bearing checker
3. Taperecorder & Headphone
4. Pen recorder

(4) Test procedure

Step 1. Record sound and vibration as shown in Fig. 1.

Step 2. Analize spectrun of recorded vibration data.

1.3 Chemical check of oil and grease

(1) Purpose of the test

To check invasion of water and rust in oil or grease.

(2) Procedure

Step 1. Sample libricant in EL/AZ bearings and speed reducers.

Step 2. Chemical analysis of the oil and grease.

2. Antenna Servo-Drive System

2.1 AUTO POSITION LOOP TRANSIENT RESPONSE

1. Purpose of the test

   To check the degradation of overall system characteristics based on the result of Auto Position Transient Responce measurement.

2. Test set-up

   Refer to the Fig.-1

3. Test Equipment

   4 Pen Chart Recorder

   Function Generator

4. Test Procedure

   Step 1 Setting antenna system automatic tracking mode by using satellite beacon frequency.

   Step 2 Applying the square wave form signal at the aproximately ± 0.2 Vp-p to the TEST IN terminal of AZ (EL) gain control panel of Servo Control Amplifier (SCA) by means of function generator, transient response is measured and recorded the tracking angle error at the SCA test output by means of chart recorder.

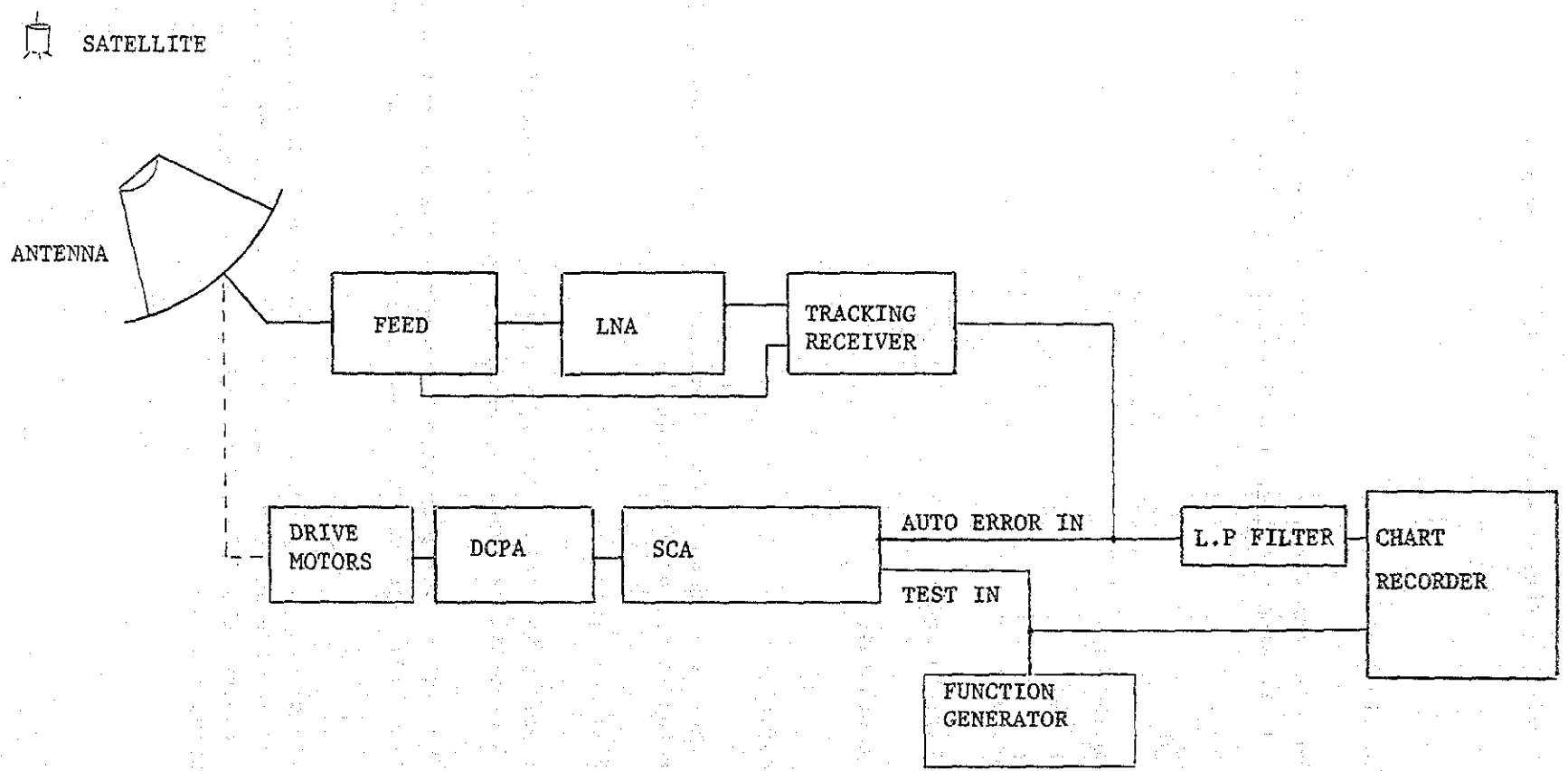


Fig. 1 Auto Position Loop Transient Response Connection Diagram

2.2 ERROR VOLTAGE GRADIENT AND CROSSTALK OF TRACKING RECEIVER

1. Purpose of the test

To check the degradation of error voltage gradients and cross-talk of tracking receiver output using satellite.

2. Test set-up

Refer to the Fig.-2

3. Test Equipment

4 Pen Chart Recorder

Function Generator

4. Test Procedure

Step 1 Pointing antenna to the direction of satellite precisely by means manual position mode.

Step 2 Fixing azimuth angle firmly.

Step 3 Applying the triangular wave form signal to SCA of EL TEST IN terminal by means of function generator.

Step 4 The azimuth angle crosstalk and error voltage gradients for elevation angle are measured and recorded by means of chart recorder.

Step 5 The elevation angle cross-talk and error voltage gradients for azimuth angle are measured and record as well as above procedure when elevation angle is fixed firmly instead of azimuth angle.

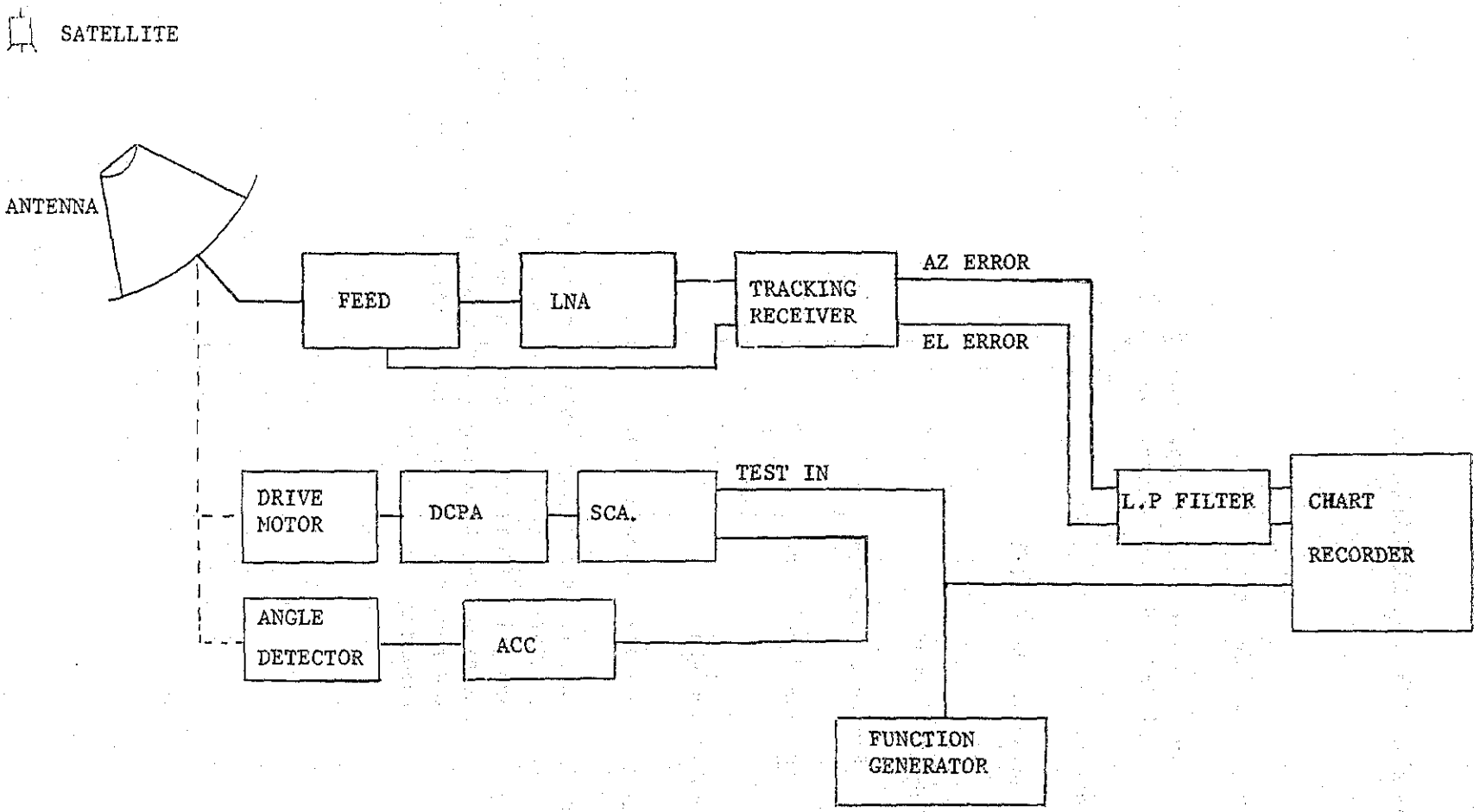


Fig. 2 Error Voltage Gradient and Crosstalk of Tracking Receiver Connection Diagram

2.3 MANUAL POSITION LOOP STEP RESPONSE

1. Purpose of the test

   To check closed loop step responce of position loop (SCA-DCPA -ANG DET-ACU) and confirm the stability of the response.

2. Test set-up

   Refer to the Fig.-3

3. Test Equipment

   4 Pen Chart Recorder

   Function Generator

4. Test Procedure

   Step 1 Setting antenna system to Manual Position mode .

   Step 2 Applying the square wave form signal at the aproximately ±0.1Vp-p to the TEST IN terminal of AZ (EL) Servo Control Amplifier (SCA) in the stage succeeding to demodulator by means of function generator, transient response is measured and recorded the demodulator output by means of chart recorder.

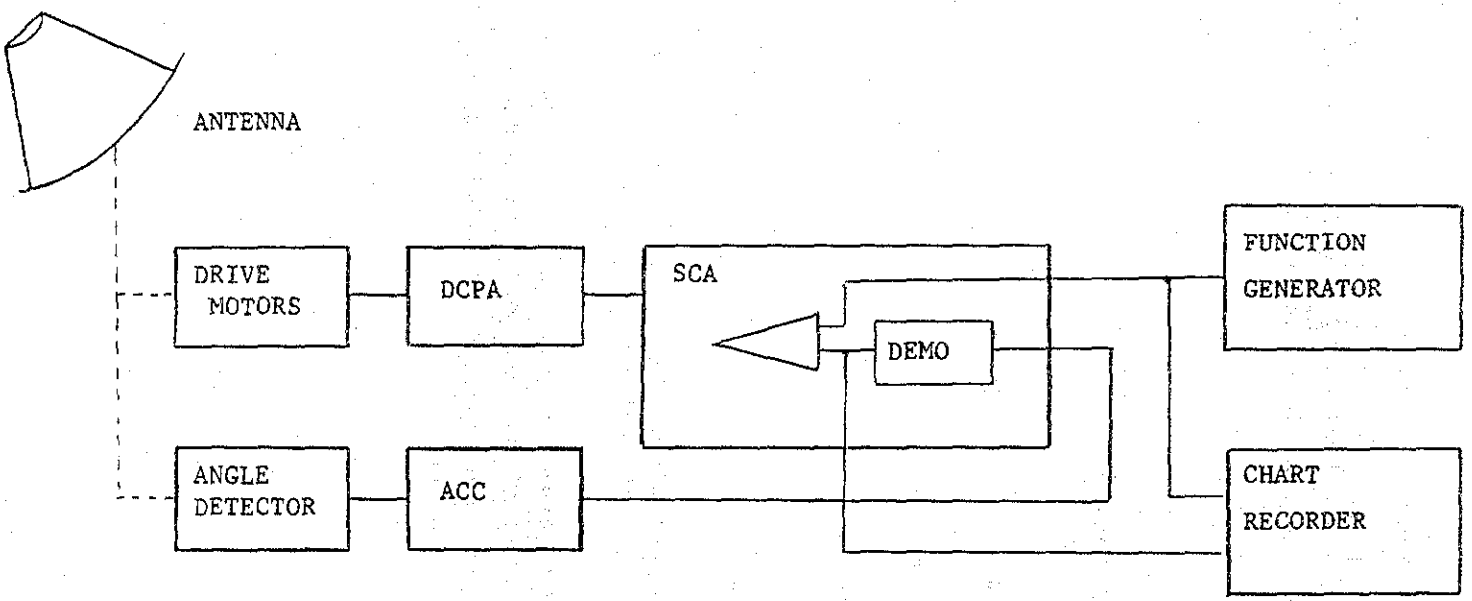


Fig.3 Manual Position Loop Step Response Connection Diagram

2.4 TACHOMETER LOOP STEP TRANSIENT RESPONSE

1. Purpose of the test

To check the degradation of closed loop (DCPA - DRIVE MOTOR - TACHOMETER) step transient response.

2. Test set-up

Refer to the Fig.-4

3. Test Equipment

4 Pen Chart Recorder

Function Generator

4. Test Procedure

Step 1 Select Maintnance position of azimuth (or elevation) DCPA MAINTENANCE/REMOTE switch.

Step 2 Applying square waveform signal to DCPA at the ±1 V (equivalent to±0.03 deg./sec.) by means of function generator ,the tachometer are measured and recorded by means of chart recorder.

2.5 TACHOMETER LOOP FREQUENCY RESPONSE

1. Purpose of the test

   To check the degradation of closed loop (DCPA - DRIVE MOTOR - TACHOMETER) frequency response.

2. Test set-up

   Refer to the Fig.-4

3. Test Equipment

   4 Pen Chart Recorder

   Function Generator

4. Test Procedure

   Step 1 Select Maintnance position of azimuth (or elevation) DCPA MAINTENANCE/REMOTE switch.

   Step 2 Applying sine waveform signal to DCPA at the frequency from 0.1 Hz to approximately 10 Hz by means of function generator ,the tachometer are measured and recorded by means of chart recorder.

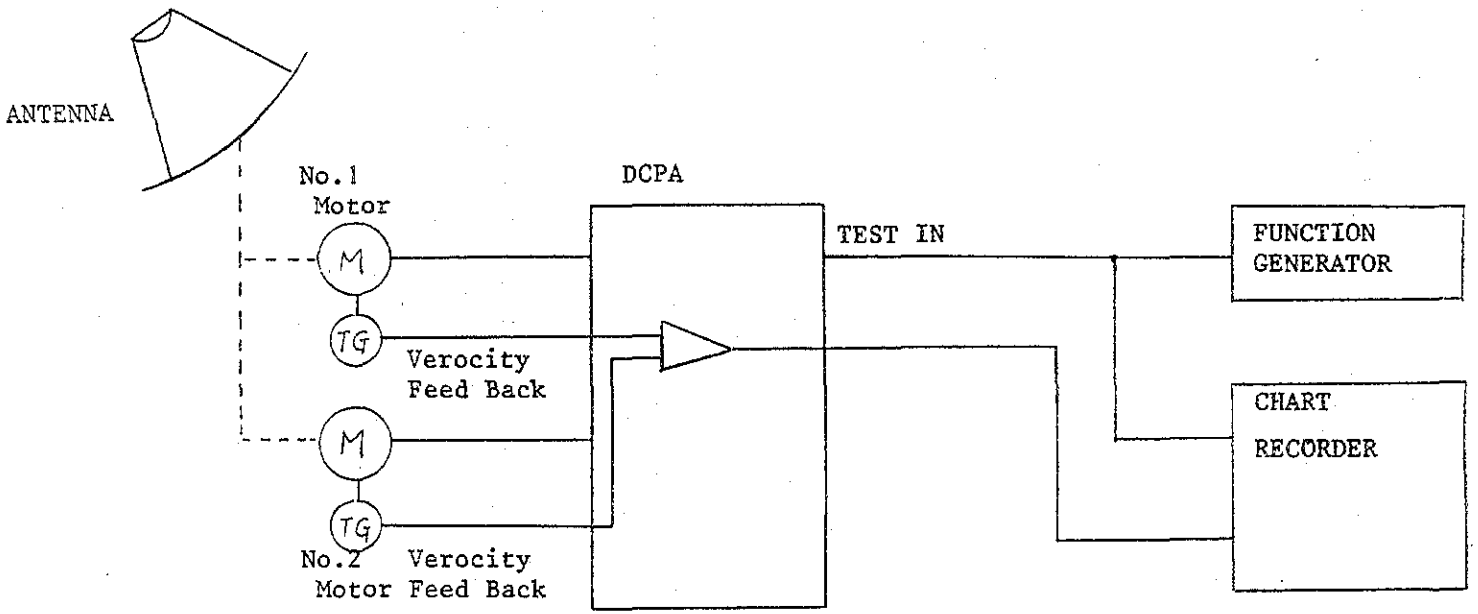


Fig. 4 Tachometer Loop Frequency / Step Transient Response Connection Diagram

2.6 VELOCITY AND ACCELRATION TEST

1. Purpose of the test

   To check the driving velocity range (Maximum and Minimum speed) and confirm the function of DCPA and Drive Motor.

2. Test set-up

Acceleration	Refer to the Fig.-5
Minimum Velocity	Refer to the Fig.-6

3. Test Equipment

   4 Pen Chart Recorder

   Function Generator

4. Test Procedure

   Maximum Speed

   Step 1 Select Maintenance position of azimuth (or elevation) DCPA MAINTENANCE/REMOTE switch.

   Step 2 Setting the potentionmeter of DCPA to maximum (aprox. 10 V).

   Step 3 The antenna driving velocity per certain period is measured and recorded by observing the Angle Indicator and Time-code Generator or stop-watch.

   Acceleration

   Step 1 Select Maintenance position of azimuth (or elevation) DCPA MAINTENANCE/REMOTE switch.

   Step 2 Appying the ±5 Vp-p square wave form signal to the DCPA by means of function generator,the tachometer are measured and recorded by means of chart recorder.

Minimum Speed

Step 1 Setting antenna system to Manual Position mode.

Step 2 Applying the triangle wave form signal(e.g.0.01 Hz 0.6Vp-p) to SCA of TEST IN terminal by means of function generator.

Step 3 The response through the angle detector is measured and recorded by means of chart recorder.

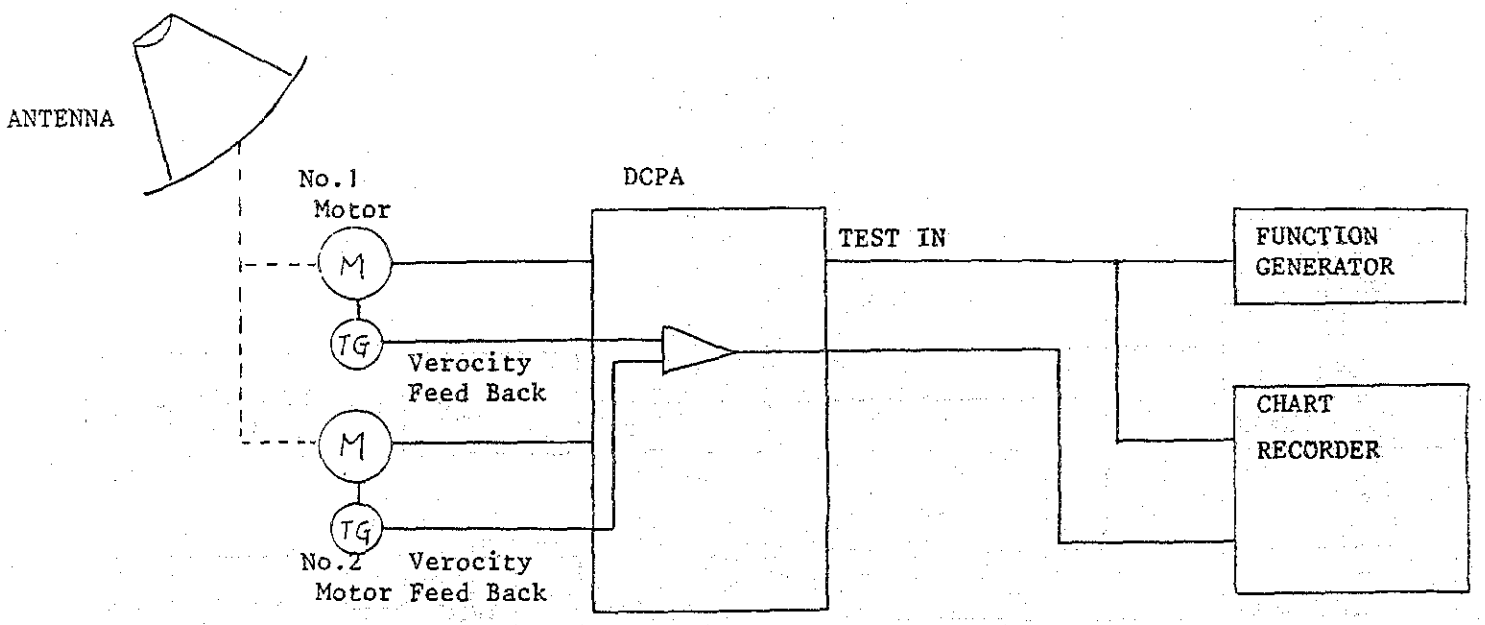


Fig.5 Velocity and Acceleration Connection Diagram

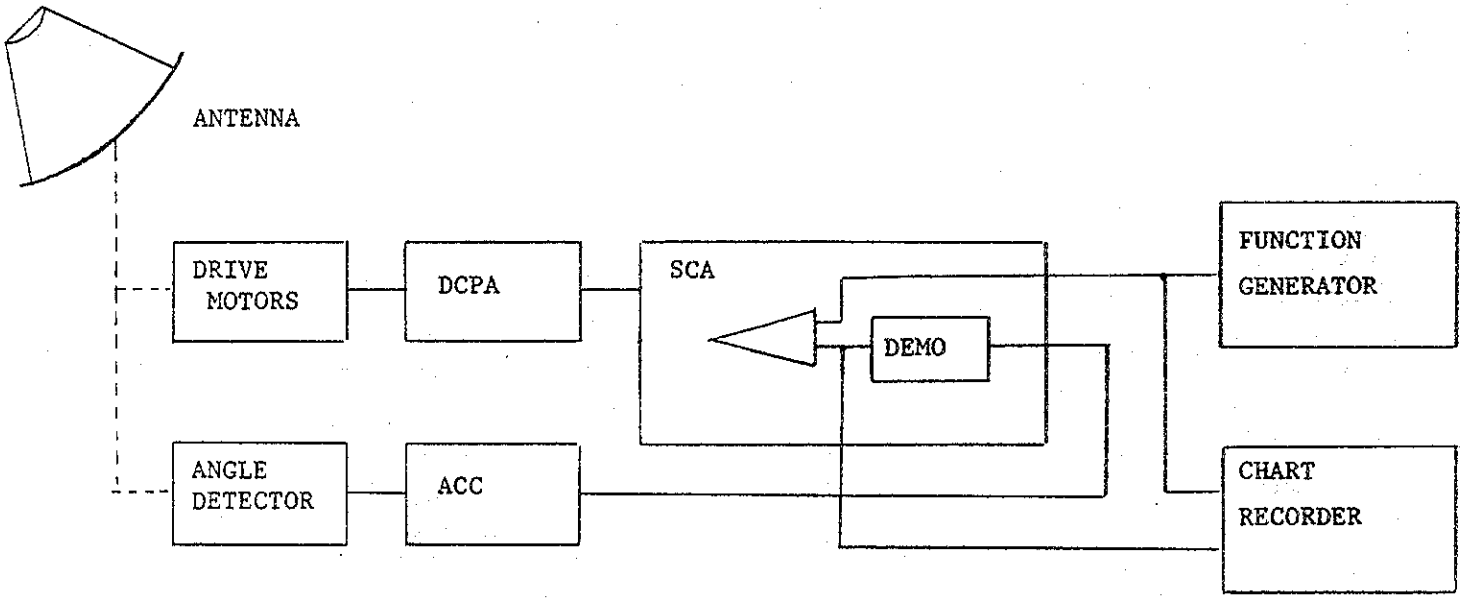


Fig. 6 Velocity and Accelaration Connection Diagram

2.7 DRIVE TEST

1. Purpose of the test

   To confirm that the antenna is able to be driven without any problem for wide angle range.

2. Test set-up

   None

3. Test Equipment

   None

4. Test Procedure

   Step 1 Setting antenna system to Slew mode .

   Step 2 Turning the slew mode volume to maximum, it is confirmed visually that all the drive mechanisms are smoothly driven while the antenna is travelling from 0 to 90° for EL angle and from -180 ° to +180 ° for AZ angle respectively.

2.8 DEGRADATION OF DRIVE MOTOR

1. Purpose of the test

   To check the degradation of Azimuth and Elevation Drive Motor in the view of mechanical point.

2. Test set-up

   None.

3. Test Equipment

   Insulation Tester

4. Test Procedure

   Step 1 Opening the cover for commutator of drive motor, the wering of brushes, damage of commutator and apperance of sparks are changed visually.

   Step 2 The inslation between rotator and stator of drive motor is checked by means of insulation tester.

   Step 3 The insulation between rotator and ground stator and ground of drive motor are checked by means of insulation tester.

2.9 DEGRADATION OF ANGLE DETECTOR

1. Purpose of the test

   To check the degradation of angle detector due to utilization in many years.

2. Test set-up

   None

3. Test Equipment

   None

4. Test Procedure

   Step 1 Open the cover of angle detector .

   STep 2 It is confirmed visually that the mechanical degradation of angle detector are not discovered.

2.10 CONTROL/MONITOR AND ALARM FUNCTION TEST

1. Purpose of the test

   To confirm that the control,monitor and alarm function in antenna control console are operating normally.

2. Test set-up

   None

3. Test Equipment

   None

4. Test Procedure

   Every volt/current meters,indicator lamps and control and alarm function of each equipment such as Operation Mode Select,Antenna Position Control, Alarm and Status, VCO Control etc are checked visually.

3. Test Equipment and Tools

	TEST EQUIPMENT	SPECIFICATION
1)	Function Generator	Output Waveform: Sinewave, Rectangular-wave Triangular Wave, Positive Pluse Negative Pulse Output Volt: 0 - ±10V (adjustable) Frequency Range: 0.005 - 50 Hz (adjustable)
2)	Digital Voltmeter	Resistance : 0 - 500 MΩ Voltage : AC/DC 0 - ±300V Current : DC 0 - 300 mA
3)	Oscilloscope	Number of CH : 2 CH Voltage : AC/DC ±300V Sweep Time : 50ns - 20 ms
4)	Oscilloscope Camera	It shall be fitted with above oscilloscope of item 3.
5)	4 pen chart recorder	Sensitivity : 10mV - 50mV/cm Frequency Range: DC - 50 Hz Quantity of chart : 4 rolls
6)	Tacho-Meter	RPM : Max 3000
7)	Tranceiver	TX Output Power: 500mW or more
8)	Spanners Full set 10mm - 27 mm	
9)	Hera (Scraper)	
10)	Sand Paper	
11)	Safety Belt	
12)	Helmet	
13)	Working Light with Power Cable	

14) Gloves

15) Thinner

16) Grese EP-2

17) White Paint

18) Cotton Waste

19) Disk Grider

20) File (Half round 12")

21) Power Cable (Drum)

22) Magic Ink (Red)

23) Magic Ink (Black)

24) Hammer

25) Monkey Spanner

26) Measure (2m)

27) Light (200W)

28) Level

29) Bearing checker

30) Recorder Paper

31) Camera (ordinary type)

32) Solvent for Dye Penetrant Check

33) Thickness Guage

34) Insulation Tester

ANNEX 2

Checking Result of the Antennas Structure and Mechanical Drive System

1. Subreflector

Appearance (photo 1.1.1)

1) Paint

Degradation	:	whole part
Peeling off	:	none
Crack	:	none

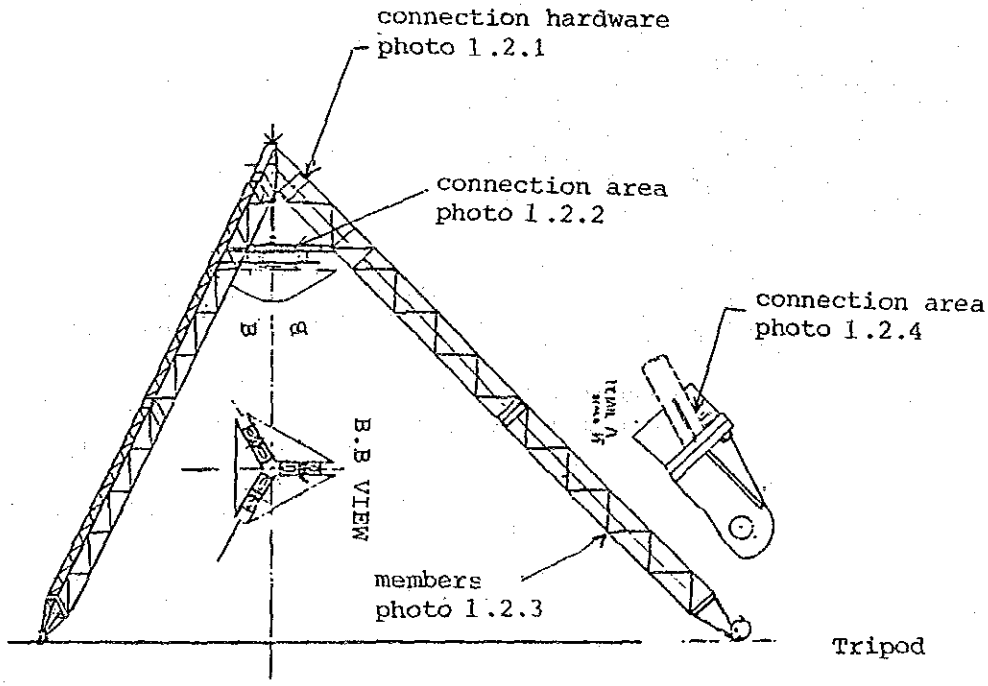
2) Rust : some rust at connection area

3) Crack : none

2. Tripod

Appearance

1)	Paint	:	whole members (photo 1.2.1 - 1.2.4)
	Peeling off	:	"
	Crack	:	"
2)	Rust	:	some members and connection hardware (photo 1.2.1 - 1.2.4)
3)	Corrosion	:	two connection areas (photo 1.2.1, 1.2.2)
4)	Distortion	:	none
5)	Crack	:	none
6)	Bolt		
	Rust	:	many bolts and nuts (photo 1.2.1, 1.2.2, 1.2.4)
	Loosening	:	none
	Crack	:	none



3. Panel

Appearance

1) Paint (front face)

Degradation	:	whole panels (photo 1.3.1)
Peeling off	:	" (")
Crack	:	some panels (")

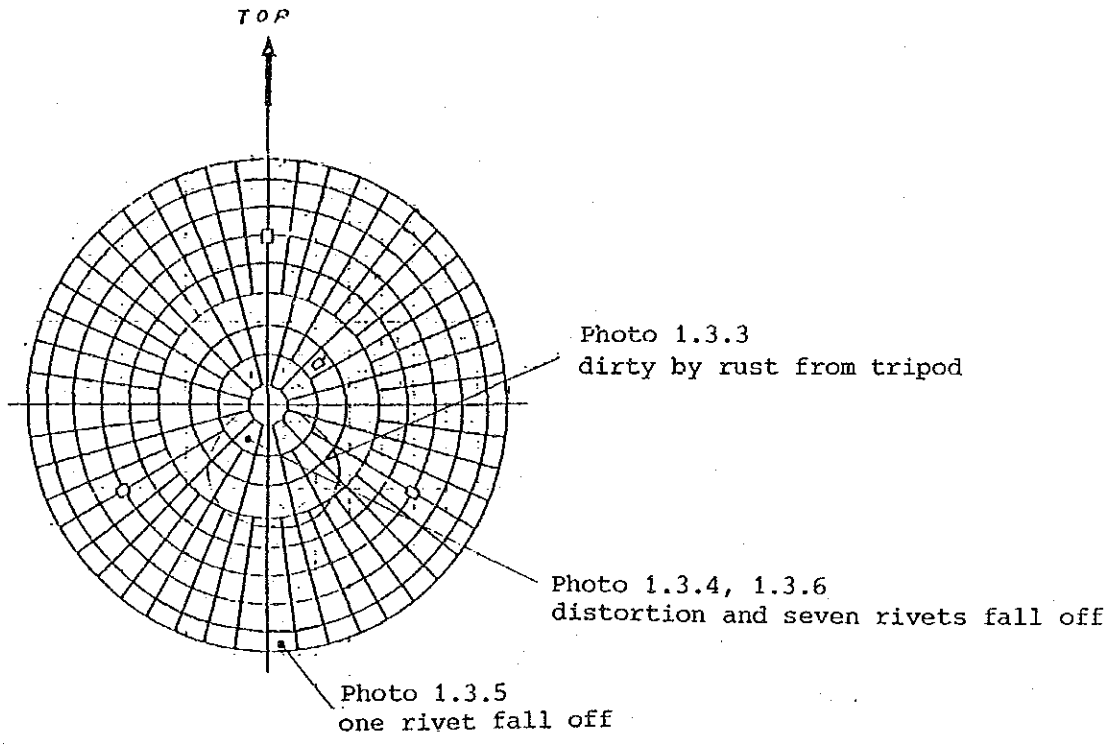
2) Rust : rear face of whole panels (photo 1.3.2)

3) Dirt : moss on almost all panels (photo 1.3.5)
rust dropped from tripod (photo 1.3.3, 1.3.4)

4) Corrosion : none

5) Distortion : one panel (photo 1.3.4)

6) Rivet : fall off in two panels (photo 1.3.5, 1.3.6)



MAIN REF. PANEL

4. Panel Support

Appearance (photo 1.4.1, 1.4.2)

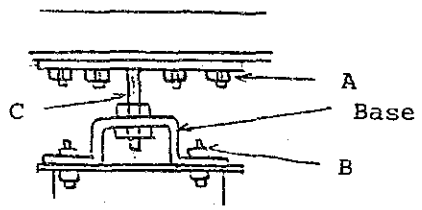
1) Paint

Degradation	:	all panel support
Peeling off	:	"
Crack	:	"

2) Rust : some rust on base

3) Bolt

Rust	:	No bimetalic corrosion on bolt A and C
		some rust on bolt B
Loosening	:	bolt A
Crack	:	none



5. Backup Structure

Appearance

1) Paint

Degradation	:	whole members (photo 1.5.1 - 1.5.5)
Peeling off	:	" (")
Crack	:	some members (photo 1.5.1, 1.5.2)

2) Rust : " (photo 1.5.1 - 1.5.3, 1.5.5)

3) Corrosion : several connection (photo 1.5.1, 1.5.2)

4) Distortion : two gusset plates (photo 1.5.3)

5) Dirt : moss on many members

6) Bolt

Rust	:	some rust (photo 1.5.5)
Corrosion	:	none
Crack	:	none
Loosening	:	none

7) Weld zone : no crack at water pooling places and joint parts between backup structure and center hub. (photo 1.6.4)

6. Center Hub

Appearance

1) Paint

Degradation	:	all members (photo 1.6.1 - 1.6.6)
Peeling off	:	some members
Crack	:	none

2) Rust : some members (photo 1.6.1 - 1.6.5)

3) Corrosion : none

4) Distortion : none

5) Dirt : moss or many members (photo 1.6.3, 1.6.4)

6) Bolt

Rust	:	few rust (photo 1.6.2)
Corrosion	:	none
Crack	:	none
Loosing	:	none

7) Weld zone : no crack at joint parts with backup structure, EL shaft box and bullgear mount (photo 1.6.4 1.6.7)

7. EL Shaft and Shaft Box

Appearance

1) Paint

Degradation : outside of shaft box and EL shaft (photo 1.6.6, 1.7.1)

Peeling off : joint plate and some bolt head (photo 1.7.1)

Crack : "

3) Rust : some rust on joint plate

4) Corrosion : none

5) Distortion : none

6) Crack : no crack on EL shaft and joint plate (photo 7.1.1, 1.7.3)

7) Dirt : moss on some plates

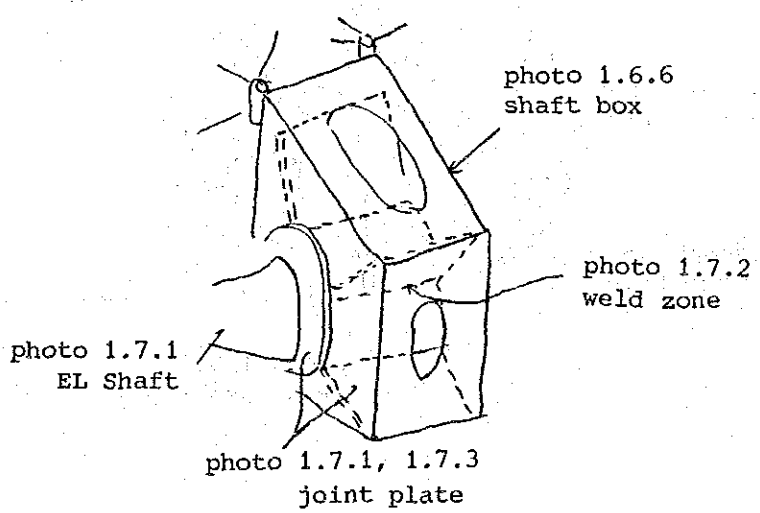
8) Bolt

Rust : none

Corrosion : none

Loosening : none

9) Weld Zone : same as center hub
no crack at weld zone between EL shaft and joint plate (photo 1.7.2)



8. Bullgear Mount

Appearance

1) Paint

Degradation	:	all members (photo 1.8.1 - 1.8.6)
Peeling off	:	plate mumbers and joint plates (photo 1.8.1, 1.8.3)
Crack	:	"

2) Rust : " (photo 1.8.1, 1.8.3, 1.8.4)

3) Corrosion : water pooling place and drain hole (photo 1.8.4, 1.8.6)

4) Distortion : none

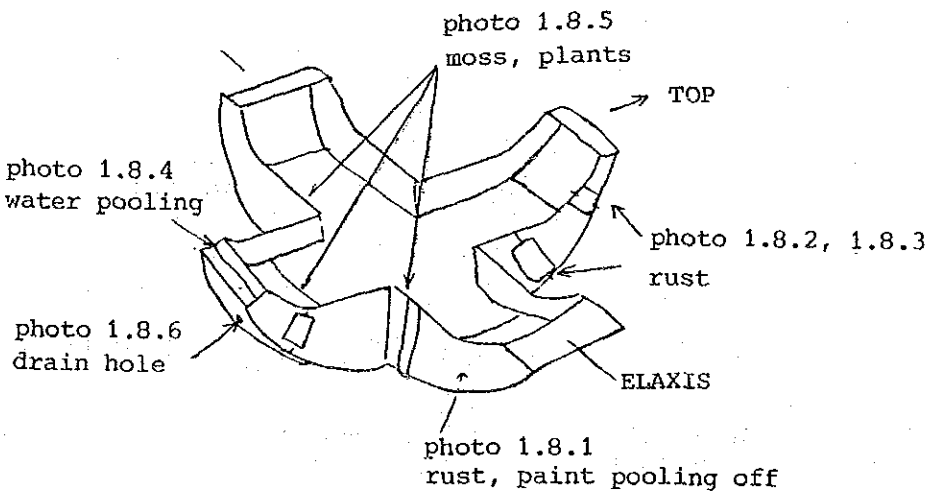
5) Crack : none

6) Dirt : growth of moss and plants on concrete (photo 1.8.1, 1.8.5)

7) Bolt

Rust	:	some bolts (photo 1.8.3)
Corrosion	:	none
Crack	:	none
Loosening	:	none

8) Weld zone : same as center hub



9. Yoke

Appearance

1)	Paint		
	Degradation	:	outside of yoke (photo 1.9.1)
	Peeling off	:	outside and inside of yoke (photo 1.9.1, 1.9.2)
	Crack	:	none
2)	Rust	:	joint plates, plummer block base and inside of yoke (photo 1.9.1, 1.9.2)
3)	Corrosion	:	none
4)	Water pooling	:	none
5)	Water leackage	:	one joint area (photo 1.9.6)
6)	Bolt		
	Rust	:	none
	Corrosion	:	none
	Crack	:	none
	Loosening	:	none
6)	Weld zone	:	no crack (photo 1.9.3)

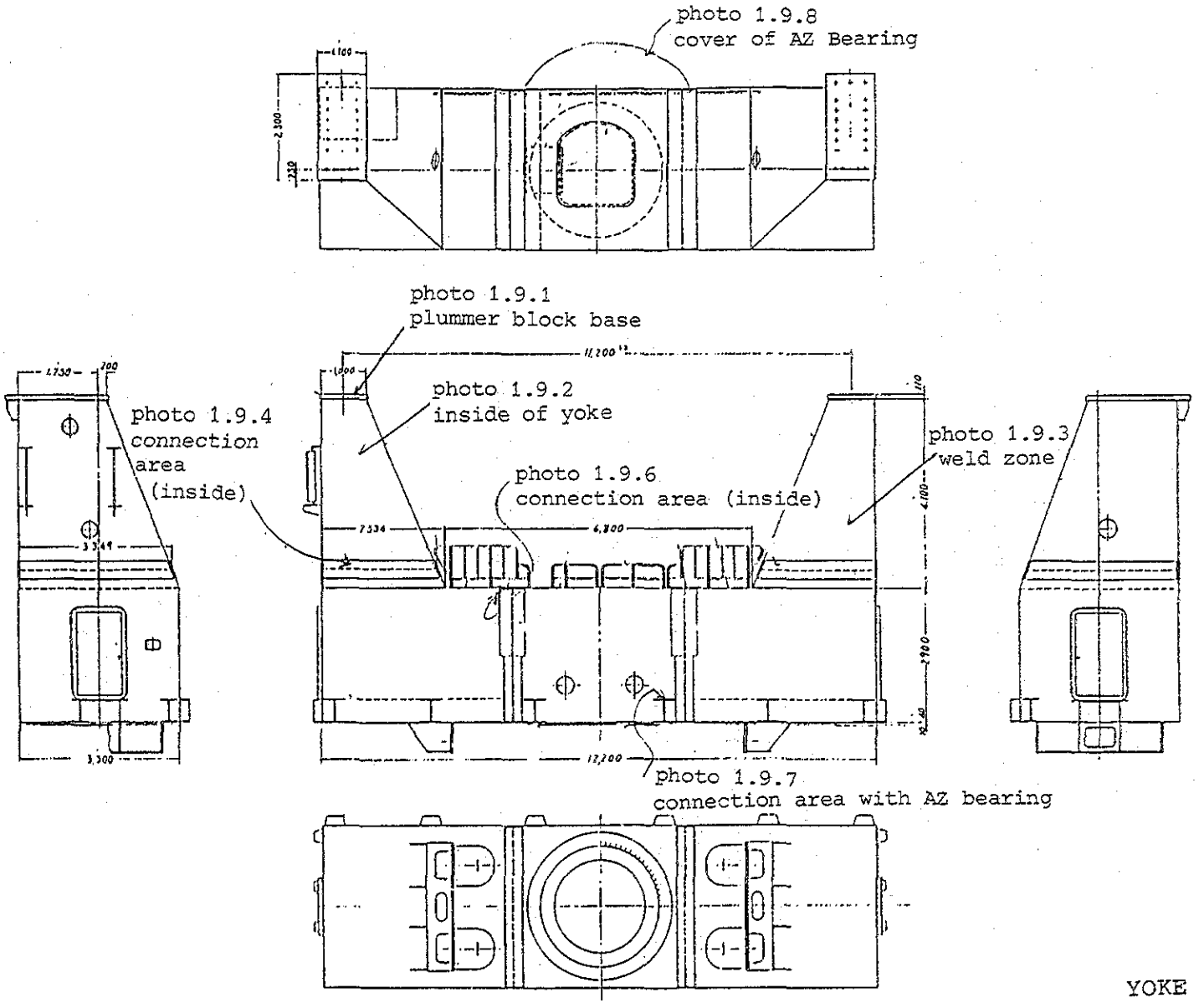


photo 1.9.8
cover of AZ Bearing
photo 1.9.1
plummer block base
photo 1.9.2
inside of yoke
photo 1.9.4
connection
area
(inside)
photo 1.9.6
connection area (inside)
photo 1.9.3
weld zone
photo 1.9.7
connection area with AZ bearing

YOKE

10. HPA Room

Appearance (photo 1.10.1 ~ 1.10.3)

1) Rust : around the door, both floor sides
2) Water pooling : none
3) Water leakage : none

11. Feed Room

Appearance (photo 1.11.1 ~ 1.11.3)

1) Rust : around the door, top and bottom surface of floor
2) Water pooling : none
3) Water leakage : none

12. Concrete Tower and AZ Bearing bese

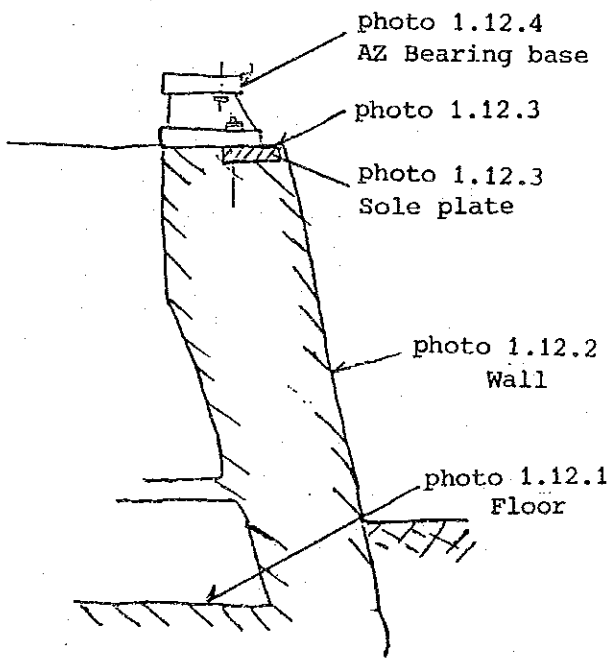
Apperance

1. Concrete Tower

1)	Pealing off	:	seven places on top of the concrete (photo 1.12.3) tower
2)	Crack	:	hair crack on floor and wall (photo 1.12.1, 1.12.2)
		:	crack on top of concrete tower (photo 1.12.3)
3)	Rust	:	mortar peeled from seven sole plates (photo 1.12.3)

2. AZ Bearing base (photo 1.12.4)

1)	Rust	:	none
2)	Bolt		
	Rust	:	none
	Corrosion	:	none
	Crack	:	none
	Loosening	:	none



13. EL Bearing and Plummer Block

Apperance (1.13.1 - 1.13.2)

1) Rust : some rust on both plummer blocks (photo 1.13.1)
2) Crack : no crack on both plummer blocks
3) Oil Leakage : Oil leakage from oil seals (photo 1.13.2)
4) Rust at the inside of plummer block : none

Analysis

- Spectrum analysis : Good, Refer to Analysis Report-1
- Check of water invasion and rust : Refer to Analysis Report-2

14. AZ Bearing

Analysis

- Spectrum analysis : Good, Refer to Analysis Report-1
- Check of water invasion and rust : Refer to Analysis Report-2

15. EL Speed Reducer

Apperance (photo 1.15.1)

1) Rust : some rust on casing
2) Crack : none
3) Oil leakage : connection area
4) Distortion : seal cover of bearing for pinion (photo 1.15.2)

Analysis

- spectrum analysis : Good, Refer to Analysis Report-1
- Check of water invasion and rust : Refer to Analysis Report-2

16. AZ Speed Reducer

Appearance (photo 1.16.1, 1.16.2)

1) Rust : some rust on casing
2) Crack : none
3) Oil leakage : joint part of brake box
4) Abnormal sound : one with manual handle

Analysis

The same as EL speed Reducer

17. EL Bullgear and pinion

Appearance (photo 1.17.1, 1.17.2)

1) Rust : some rust on teeth and conection bolts
2) Crack : none
3) Pitching : none
4) Abrasion : Negligible

18. AZ gear and pinion

Appearance (photo 1.18.1, 1.18.2)

1) Rust : some rust on teeth
2) Crack : none
3) Pitching : none
4) Abrasion : Negligible

19. AZ/EL Lubrication System

Operation check : good
Abnormal sound : none
Oil or Grease leakage : none

20. AZ perpendicular (At EL operation angle)

Maximum indication : 0.006 degrees, good

21. Buffer

Apperance (photo 1.12.1, 1.12.2)

1) Oil leakage : none
2) Rust : some rust on base

ANALYSIS REPORT-1

Vibration and Sound Analysis

GENERAL

This report is made according to vibration and sound recorded by Bearing Checker.

1. ANALYSIS FOR VIBRATION CHECK OF AZ/EL BEARINGS AND AZ/EL SPEED REDUCERS

1.1 Measurement Results

Measurement results are shown in Table 1.

(1) ENV and DC mean the ones for the vibration on each bearing caused by R.M.S (Root Mean Square) mode operation of the antenna structure. These data are shown in Fig. 1.1.1 - 1.9.2.

(2) Each value of ENV and DC in Table 1 is taken from Fig. 1.1 - 1.9.2.

(3) Peak factor = $\frac{\text{ENV RMS}}{\text{DC RMS}}$

1.2 Conclusion

We assume that AZ/EL Bearings and speed Reducers are no problem in practical use judging from peak factor in Table 1.
In case of less than 6.2 in peak factor, bearing is judged as normal condition.

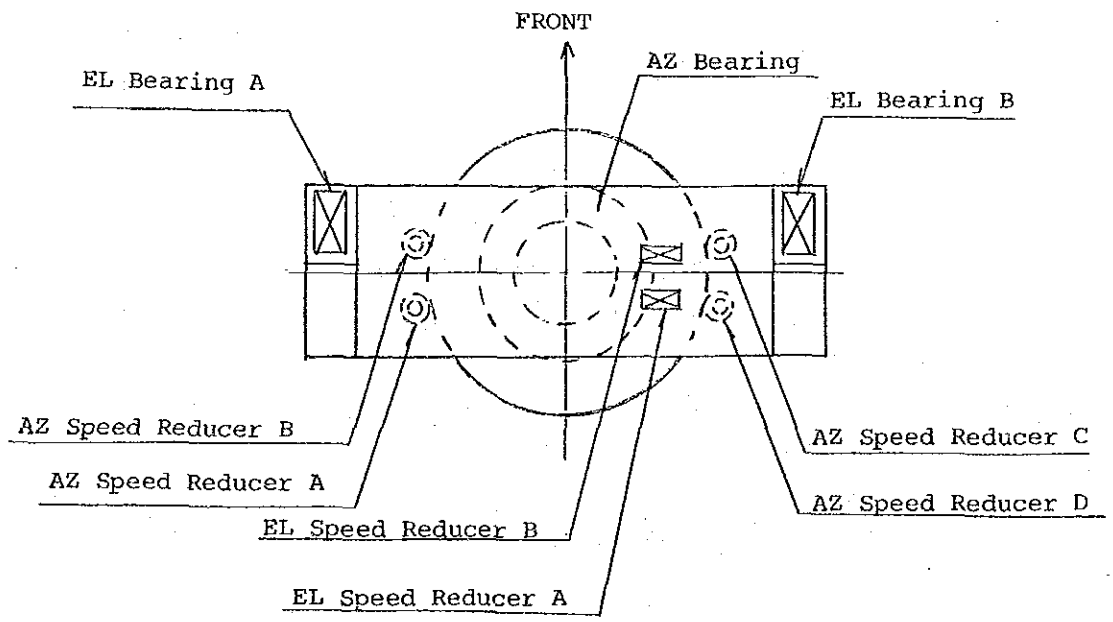


Table 1

No.	COMPONENT	ENV	DC	PEAK FACTOR
1.	AZ Bearing (Fig 1.1.1, 1.1.2)	0.15	0.05	3.0
2.	EL Bearing A (Fig. 1.2.1, 1.2.2)	0.003	-	-
3.	EL Bearing B (Fig. 1.3.1, 1.3.2)	0.02	0.008	2.5
4.	EL Speed Reducer A (Fig. 1.4.1, 1.4.2)	0.3	0.2	1.5
5.	EL Speed Reducer B (Fig. 1.5.1, 1.5.2)	0.3	0.7	0.4
6.	AZ Speed Reducer A (Fig. 1.6.1, 1.6.2)	0.3	0.2	1.5
7.	AZ Speed Reducer B (Fig. 1.7.1, 1.7.2)	0.15	0.18	0.83
8.	AZ Speed Reducer C (Fig. 1.8.1, 1.8.2)	0.5	0.2	2.5
9.	AZ Speed Reducer D (Fig. 1.9.1, 1.9.2)	1.5	0.4	3.75

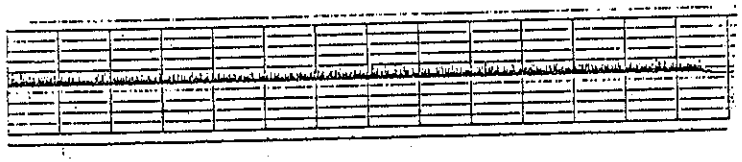


Fig 1.1.1 ENV MODE

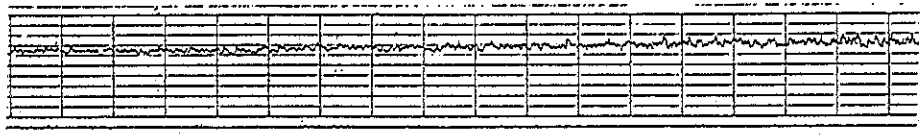


Fig 1.1.2 DC MODE

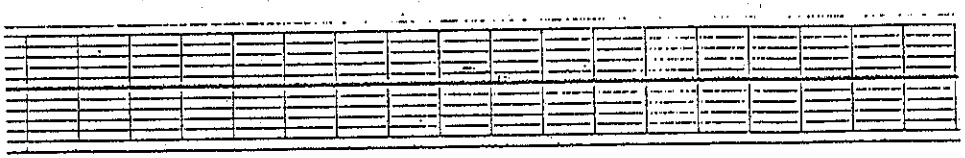


Fig 1.2.1 ENV MODE

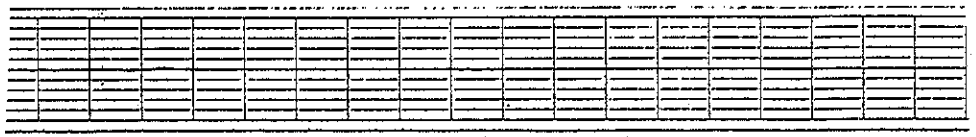


Fig 1.2.2 DC MODE

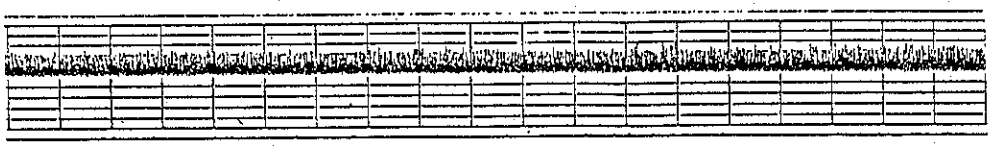


Fig 1.3.1 ENV MODE

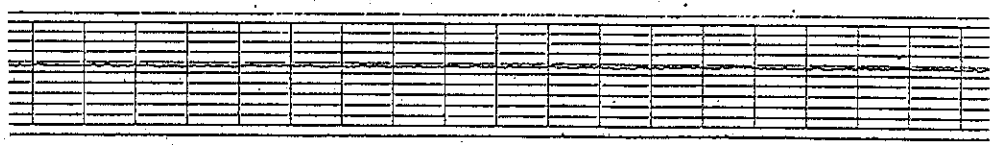


Fig 1.3.2 DC MODE

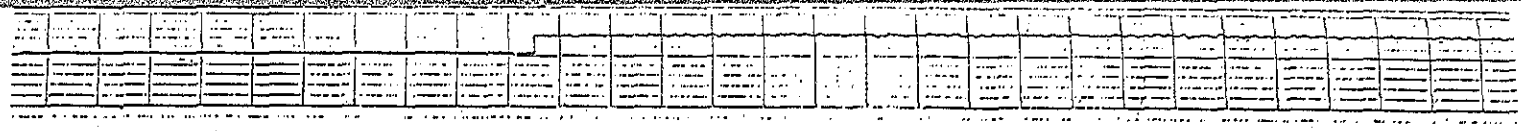


Fig 1.4.1 ENV MODE

Fig 1.4.2 DC MODE

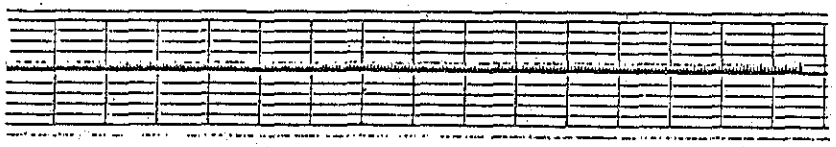


Fig 1.5.1 ENV MODE

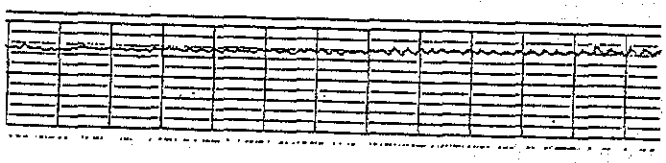


Fig 1.5.2 DC MODE

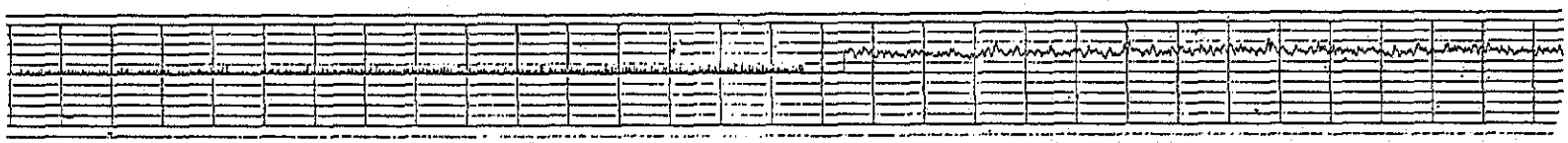


Fig 1.6.1 ENV MODE

Fig 1.6.2 DC MODE

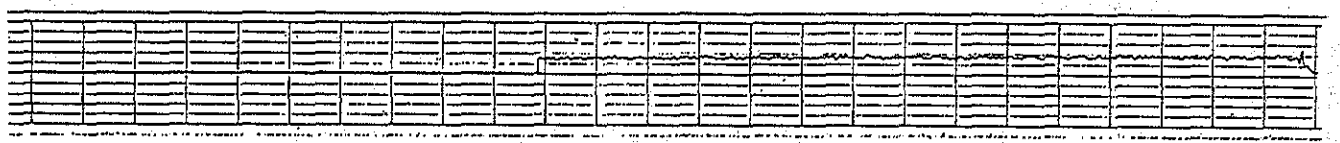


Fig 1.7.1 ENV MODE

Fig 1.7.2 DC MODE

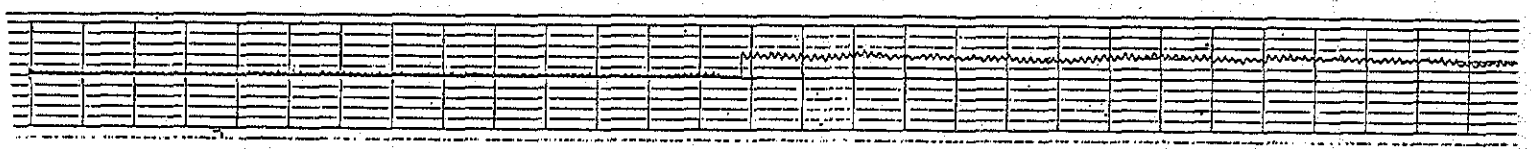


Fig 1.8.1 ENV MODE

Fig 1.8.2 DC MODE

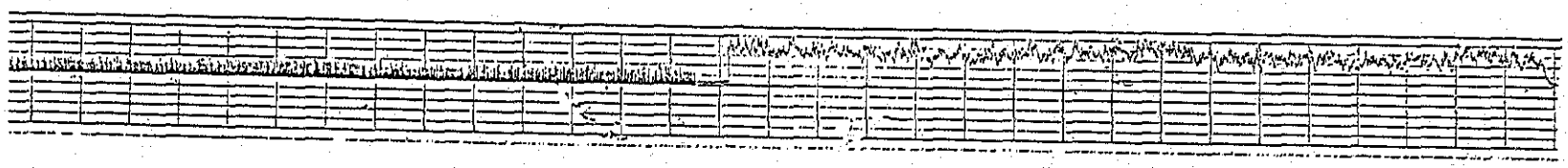


Fig 1.9.1 ENV MODE

Fig 1.9.2 DC MODE

2. SOUND ANALYSIS FOR AZ/EL BEARINGS and AZ/EL SPEED REDUCERS

2.1 Analysis Results

Analysis has been made based on the sound recorded on the subject components during rotational movement of the antenna and the data for sound frequency as shown in Fig. 2.1.1 - 2.9.2 obtained from the forementioned sound record. The analysis results are shown in Table 2.

Table 2

No.	COMPONENT	EVALUATION	JUDGEMENT
1.	AZ Bearing	No remarkable peaks and pulse in analyzed ENVELOPE wave mode. Peak of natural frequency revealed in analyzed SPECTRUM wave mode. However no remarkable peak in SPECTRUM wave mode. (Refer to Fig. 2.1.1, 2.1.2)	No problem in practial use
2.	EL Bearing A	same as above (Refer to Fig. 2.2.1, 2.2.2)	"
3.	EL Bearing B	same as above (Refer to Fig. 2.3.1, 2.3.2)	"
4.	EL Speed Reducer A	Periodical peaks revealed in analyzed ENVELOPE wavemode. We assume that it will be caused by other sourse not related to the bearing damage. However we think the damage is small and no problem in practical use because peak factor Table 1 is smaller than 6.2. (Refer to Fig. 2.4.1, 2.4.2)	"
5.	EL Speed Reducer B	Same as AZ Bearing (Refer to Fig. 2.5.1, 2.5.2)	"
6.	AZ Speed Reducer A	Same as AZ Bearing (Refer to Fig. 2.6.1, 2.6.2)	"

NO.	COMPONENT	EVALUATION	JUDGEMENT
7.	AZ Speed Reducer B	Same as AZ Bearing (Refer to Fig. 2.7.1, 2.7.2)	No problem in practical use
8.	AZ Speed Reducer C	Periodical peaks revealed in analyzed ENVELOPE wave mode. We assume that it will be caused by other sourse not related to the bearing damage. However we think the damage is small and no problem in practical use because peak factor in Table 1 is smaller than 6.2. (Refer to Fig. 2.8.1, 2.8.2)	"
9.	AZ Speed Reducer D	" (Refer to Fig. 2.9.1, 2.9.2)	"

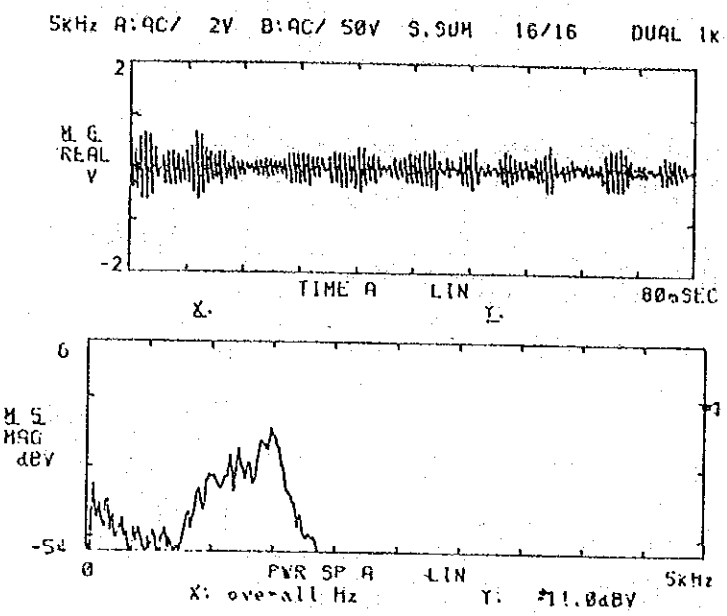


Fig 2.1.1

ENVELOPE

Fig 2.1.2

SPECTRUM

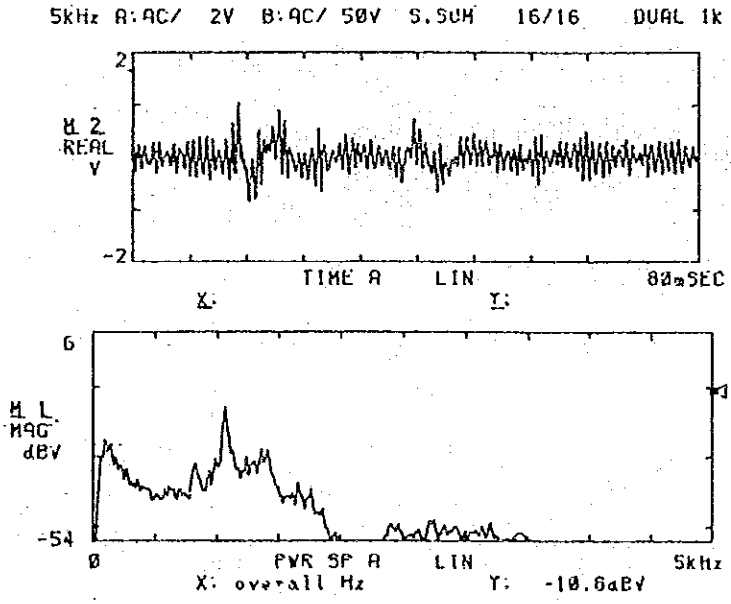


Fig 2.2.1

ENVELOPE

Fig 2.2.2

SPECTRUM

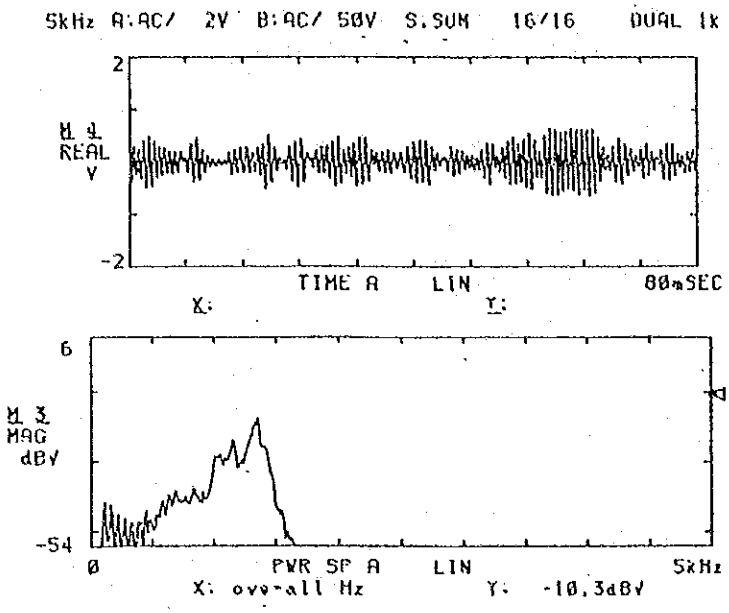


Fig 2.3.1

ENVELOPE

Fig 2.3.2

SPECTRUM

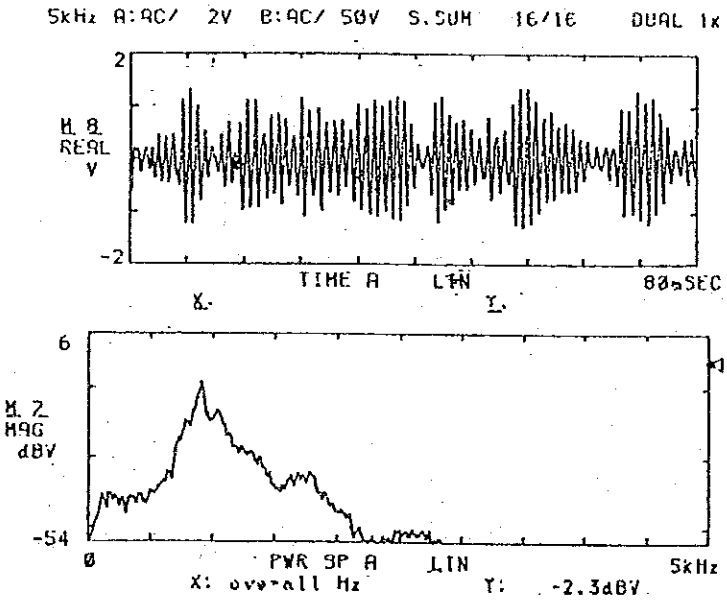


Fig 2.4.1

ENVELOPE

Fig 2.4.2

SPECTRUM

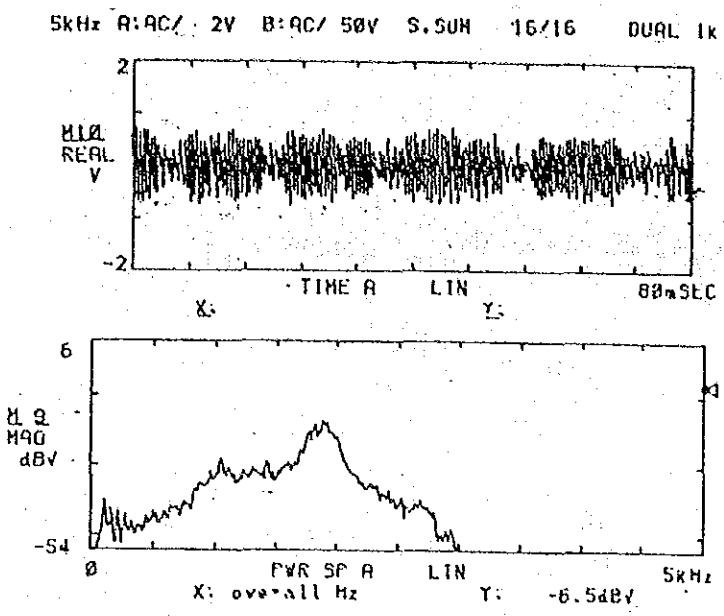


Fig 2.5.1

ENVELOPE

Fig 2.5.2

SPECTRUM

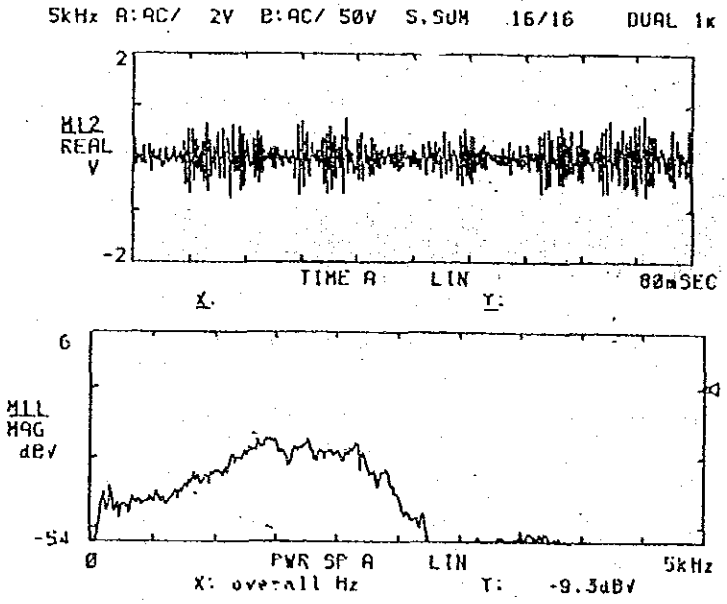


Fig 2.6.1

ENVELOPE

Fig 2.6.2

SPECTRUM

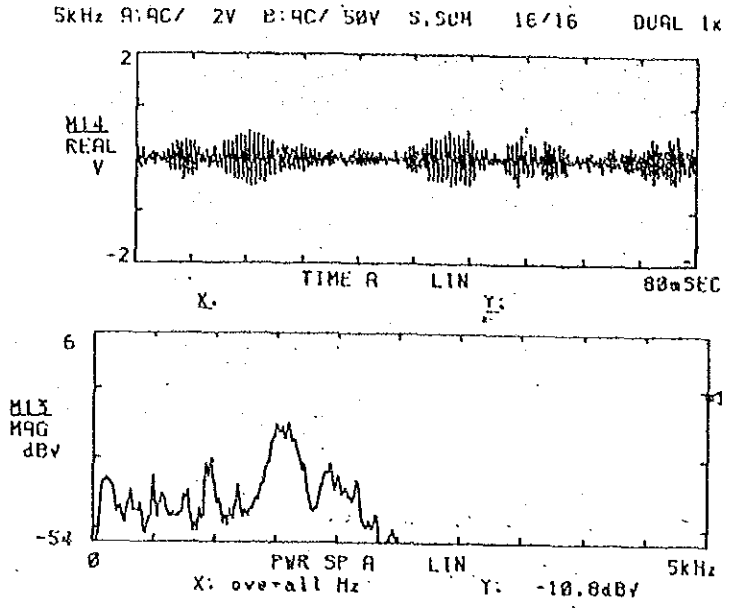


Fig 2.7.1

ENVELOPE

Fig 2.7.2

SPECTRUM

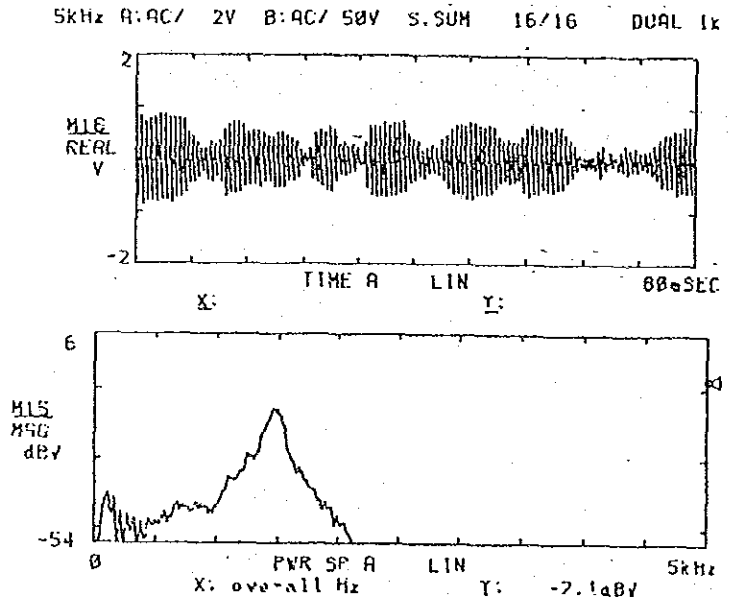


Fig 2.8.1

ENVELOPE

Fig 2.8.2

SPECTRUM

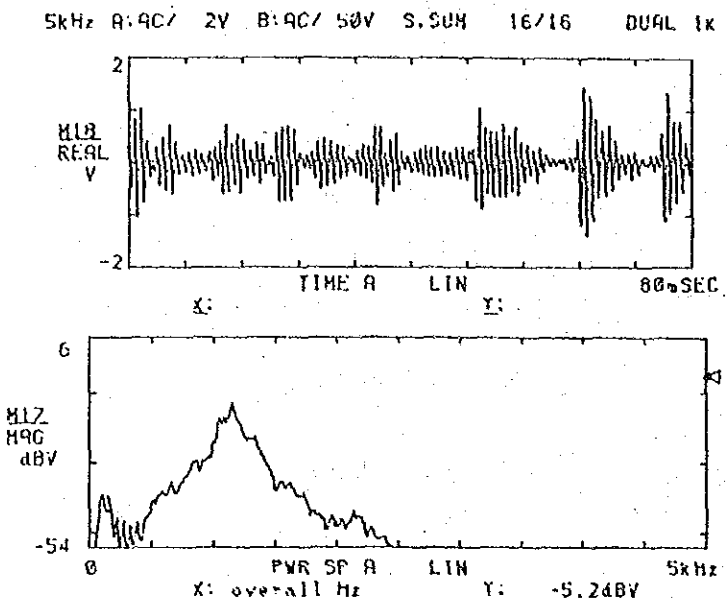


Fig 2.9.1

ENVELOPE

Fig 2.9.2

SPECTRUM

ANALYSIS REPORT-2

Lubricant Check

Table 1

NO.	COMPONENT	OIL/GREASE NAME	VISCOSITY	WATER wt%	SiO2 wt%	Fe wt%
1.	AZ Bearing	TELLUS41	-	0.2	none	-
2.	EL Bearing B	EP1	Spec. meet	0.40	0.05	0.03
3.	AZ Speed Reducer A	No.7	Spec. meet	0.24	none	45PPM
4.	" B	"	"	0.23	"	0.01
5.	" C	"	"	0.27	"	0.01
6.	" D	"	"	0.24	"	0.06
7.	EL Speed Reducer A	"	"	0.28	"	0.12
8.	" B	"	"	0.32	"	0.13

Note:

1. SiO2 (Oxide Silicon) shows mixture of dust
2. Fe shows mixture of ferrovs metal