ATS-6 MILLIMETER WAVELENGTH PROPAGATION EXPERIMENT

D. B. Hodge and R. C. Taylor

The Ohio State University

ElectroScience Laboratory

Department of Electrical Engineering
Columbus, Ohio 43212

Report 3863-3

March 1975

Quarterly Report for Period 15 July - 14 October 1974

Prepared for
GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland 20771

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle
ATS-6 MILLIMETER WAVELENGTH PROPAGATION EXPERIMENT

5. Report Date
March 1975

6. Performing Organization Code

7. Author(s)
D. B. Hodge and R. C. Taylor

8. Performing Organization Report No.
ESL 3863-3

9. Performing Organization Name and Address
The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering, Columbus, Ohio 43212

10. Work Unit No.

11. Contract or Grant No.
NAS5-21983

12. Sponsoring Agency Name and Address
NASA
Goddard Space Flight Center
Greenbelt, Maryland 20771

13. Type of Report and Period Covered
Quarterly Report
15 July - 14 Oct. '74

14. Sponsoring Agency Code
60

15. Supplementary Notes

16. Abstract

The OSU Fixed 20/30 GHz Ground Terminal is described in detail. This terminal is being used for path diversity measurements in the ATS-6 Millimeter Wavelength Propagation Experiment. The current status and summary of operations are reviewed.

17. Key Words (Selected by Author(s))
Millimeter Wave
Attenuation
Radiometry
Propagation
ATS-6

18. Distribution Statement

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
U	U	13	

*For sale by the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

CONTENTS

	Page
INTRODUCTION	1
FIXED TERMINAL	1
FIXED ANTENNA	1
FRONT END	4
RECEIVER BANDWIDTH	4
LINK PARAMETERS	4
DIGITAL DATA SYSTEM	12
OPERATIONS	12
CURRENT STATUS	12
REFERENCES	13

INTRODUCTION

The primary objective of the ATS-6 Millimeter Wavlength Propagation Experiment is the determination of reliability improvement resulting from the use of path diversity on millimeter wavelength earth-satellite communication links. This objective is being accomplished by measuring the path attenuation observed on 20 and 30 GHz ATS-6 downlinks at two spatially separated ground terminals.

Previous reports described the complete experiment and measurements to be performed [1] and the detailed characteristics of the Transportable 20/30 GHz Ground Terminal [2]. This report presents the characteristics of the Fixed 20/30 Ground terminal. The current status of the experiment and summary of operations are also reviewed.

FIXED TERMINAL

The Fixed 20/30 GHz Ground Terminal is located at the Ohio State University ElectroScience Laboratory Satellite Communication Facility, 1320 Kinnear Road, Columbus, Ohio. The geographical location of this site is latitude 40° 00' 10" and longitude 83° 02' 30" W; the site elevation is 252 m above sea level. Both the OSU High Resolution Radar/Radiometer and Low-Resolution Radar Systems are also located at this site [3]. In addition, a 13/18 GHz Comsat ATS-6 up-link terminal is located at this site.

The instrumentation at the Fixed Terminal consists of 20 and 30 GHZ Martin-Marietta phase lock loop receivers. 20 and 30 GHz radiometers were constructed by OSU following the design presented in Reference 4 and were added to these receivers.

The digital data handling for the entire experiment is performed at the fixed terminal. This function consists of digitizing and formating data obtained at the Fixed Terminal; these data are then merged with the data obtained from the two remote terminals as well as the High Resolution Radar/Radiometer System. All data are then recorded in real time on a single digital magnetic tape.

The physical arrangement of equipment at the Fixed Terminal is shown in Fig. 1.

FIXED ANTENNA

The 20/30 GHz Fixed Terminal antenna is a 4.6 m. Cassegrainian fed, parabolic antenna (Fig. 2). The RMS surface tolerance of this antenna is 0.64 mm or 0.043λ at 20 GHz and 0.064λ at 30 GHz. The antenna is mounted on an azimuth-over-elevation-over-azimuth pedestal

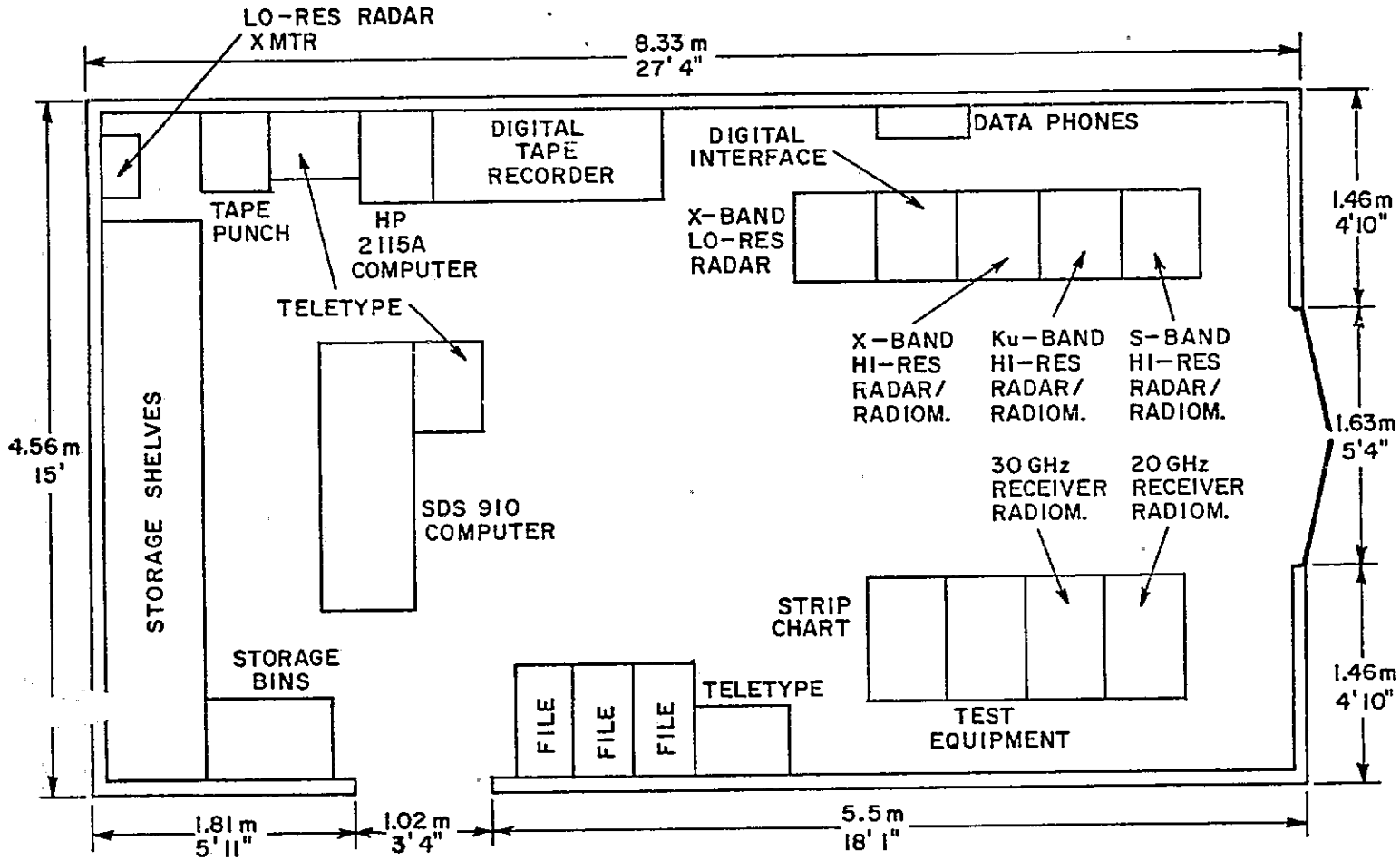

Fig. 1. Fixed terminal physical arrangement.

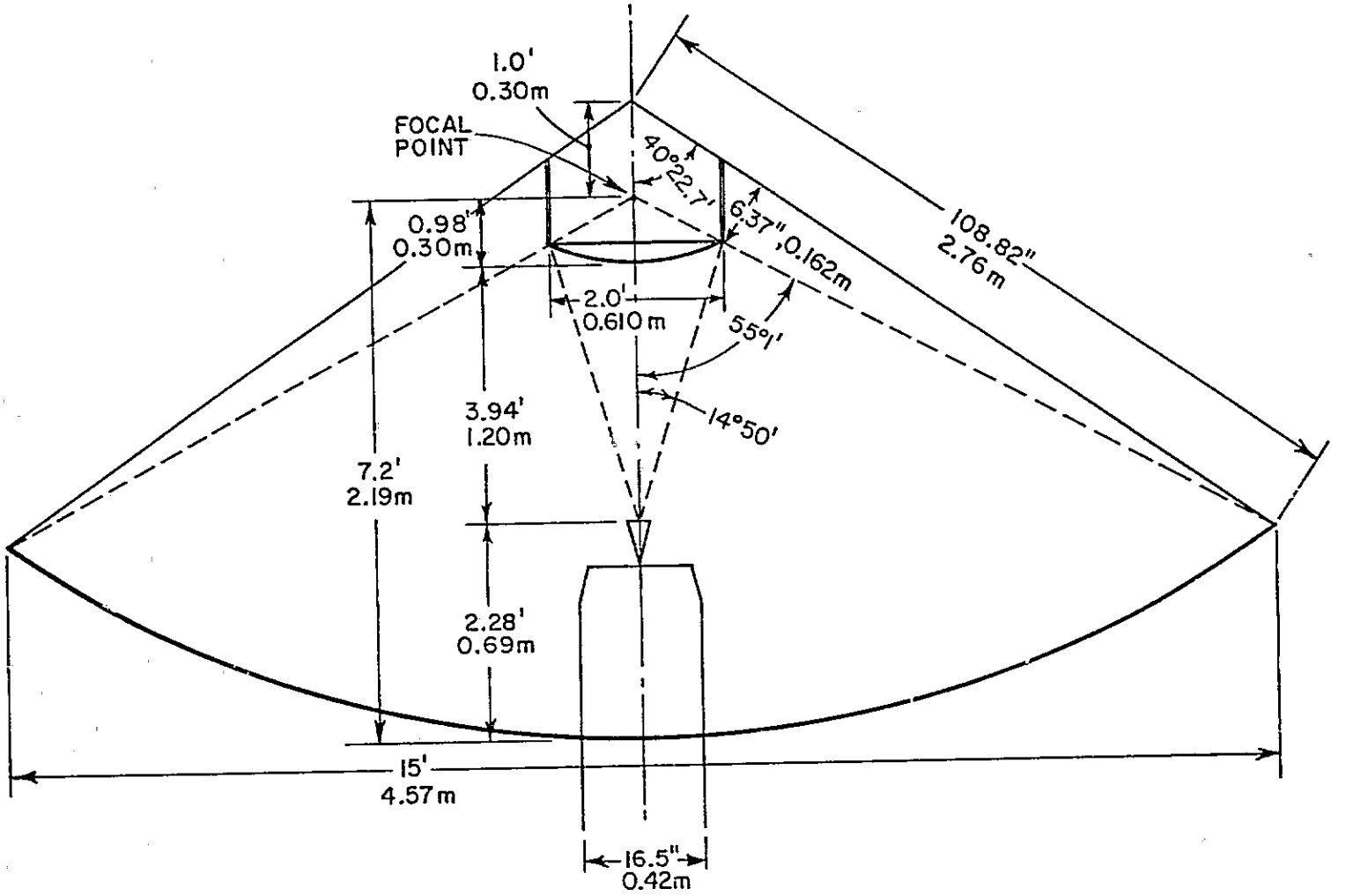

Fig. 2. 15 ft. fixed terminal antenna.

so that the polarization can be remotely controlled. A square, corrugated horn is used to feed the antenna. The feed horn and the packaging of front end hardware are identical to those used for the OSU Transportable Terminal and were described in Reference 3.

The Fixed Terminal feed horn patterns are shown in Fig. 3. The measured SWR of this feedhorn was 1.20 at 20 GHz and 1.19 at 30 GHz.

The patterns of the Fixed Terminal antenna were measured using the 20 and 30 GHz ATS-6 downlinks. These patterns are shown in Figs. 4 and 5. The gain of the Fixed antenna is estimated to be 53.9 dB at 20 GHz and 57.5 dB at 30 GHz.

FRONT END

The RF front ends for the 20/30 GHz receivers and radiometers are essentially identical to those used for the Transportable Terminal. The electrical design has been described in Reference 4 and the physical arrangement of components was presented in Reference 2. The RG-9 coaxial cable carrying the 1.05 GHz IF signal from the RF front end to the fixed receivers is 135 ft (41 m) long and has an attenuation of 12.4 dB.

RECEIVER BANDWIDTH

The 2.5 KHz response of the quadruple superheterodyne phase lock loop receivers built by Martin Marietta are presented in Figs. 6 and 7. The receivers at the Fixed Terminal have somewhat wider bandwidths, 64 and 65 Hz, than those at the Transportable Terminal, 47 and 48 Hz.

LINK PARAMETERS

The link parameters are the same of those listed in Table 1, Reference 2, with the exception of 0.6 dB additional coax loss in the case of the Fixed Terminal. The calculated signal levels at the input of the Fixed Terminal 1.05 GHz PLL receivers are -76 dBm at 20 GHz and -85 dBm at 30 GHz. These levels are for the 20 GHz cw/Dish and 30 GHz cw/Horn modes. Measured dynamic ranges at the Fixed Terminal are 55 dB at 20 GHz (8/27/74) and 51 dB at 30 GHz (1/24/75).

Calibration curves obtained using the ATS-6 signals and introducing attenuation at the inputs to the 1.05 GHz PLL receivers are shown in Fig. 8. Calibration curves for the PLL receivers using locally injected 1.05 GHz signals are presented in Fig. 9.

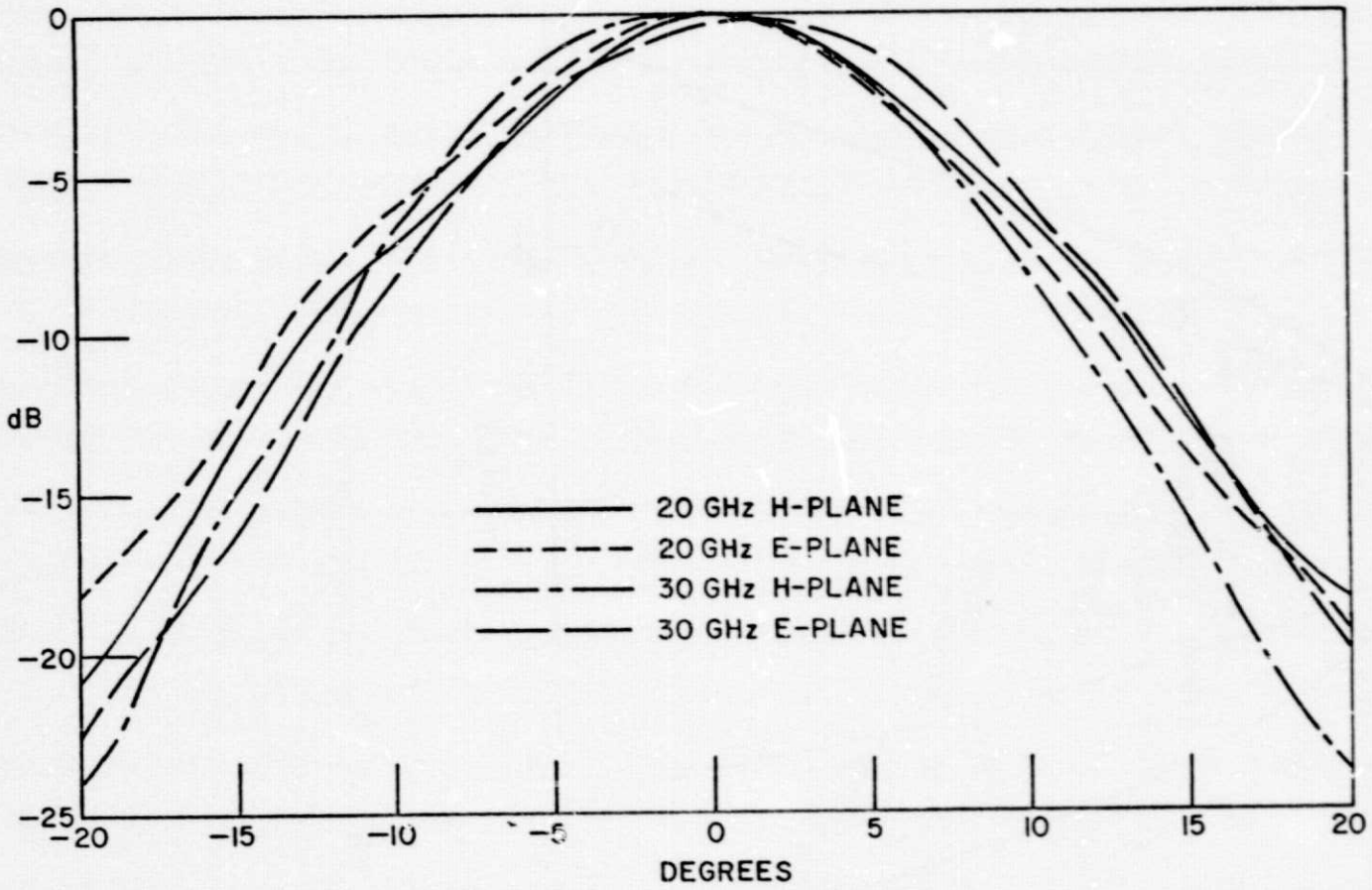

Fig. 3. Fixed feed horn patterns.

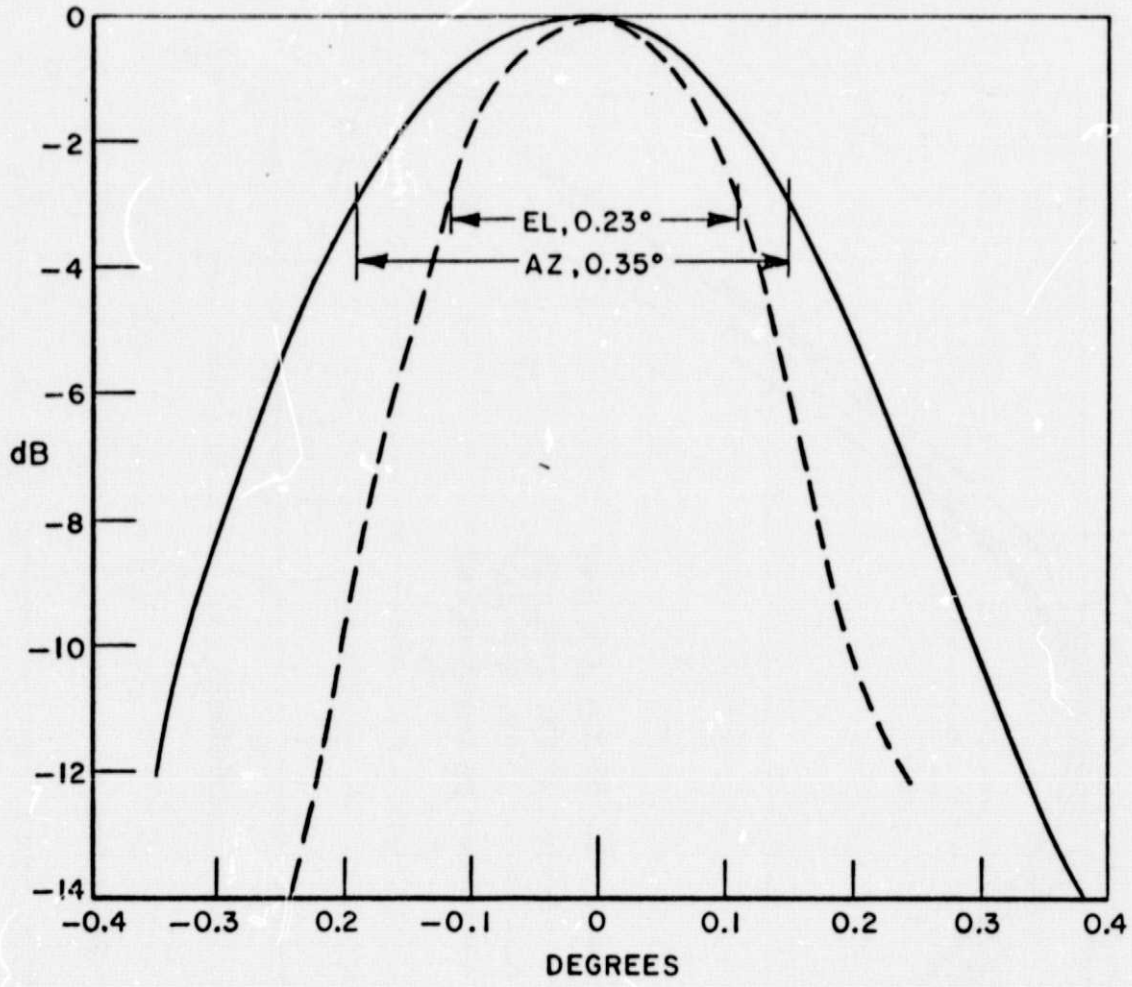

Fig. 4. Fixed antenna pattern -20 GHz.

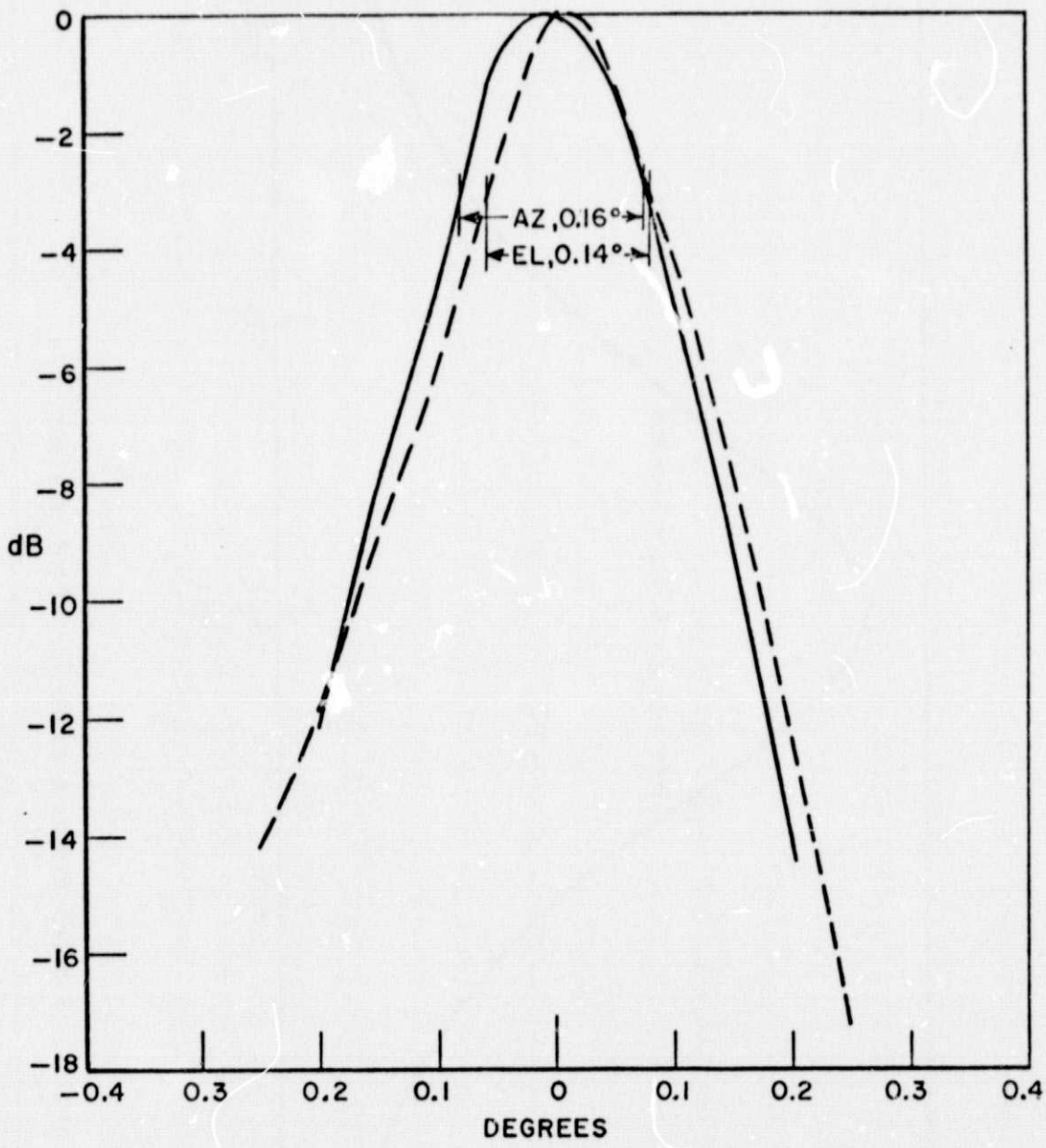

Fig. 5. Fixed antenna pattern -30 GHz.

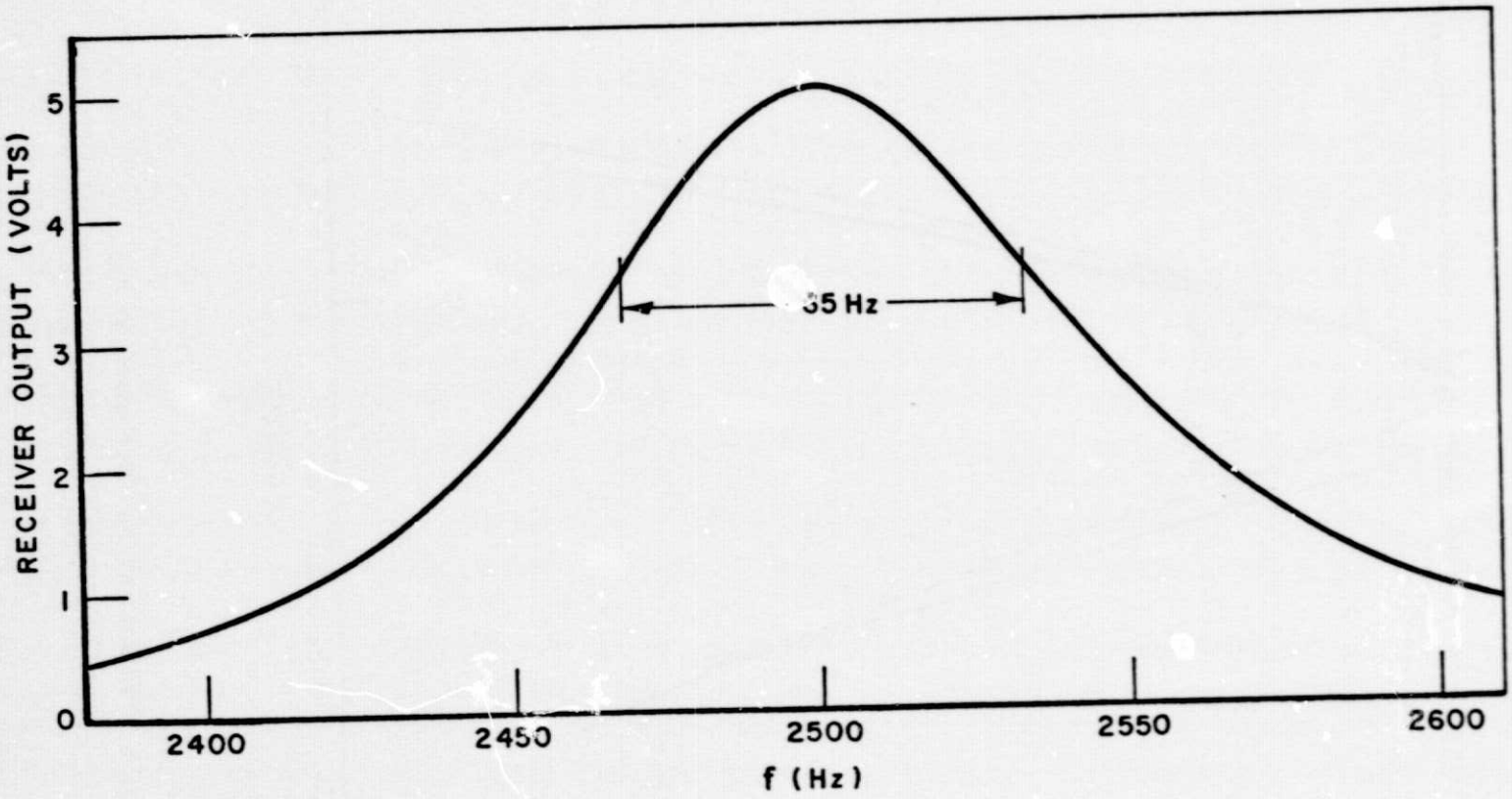

Fig. 6. 2.5 KHz response of 20 GHz fixed receiver.

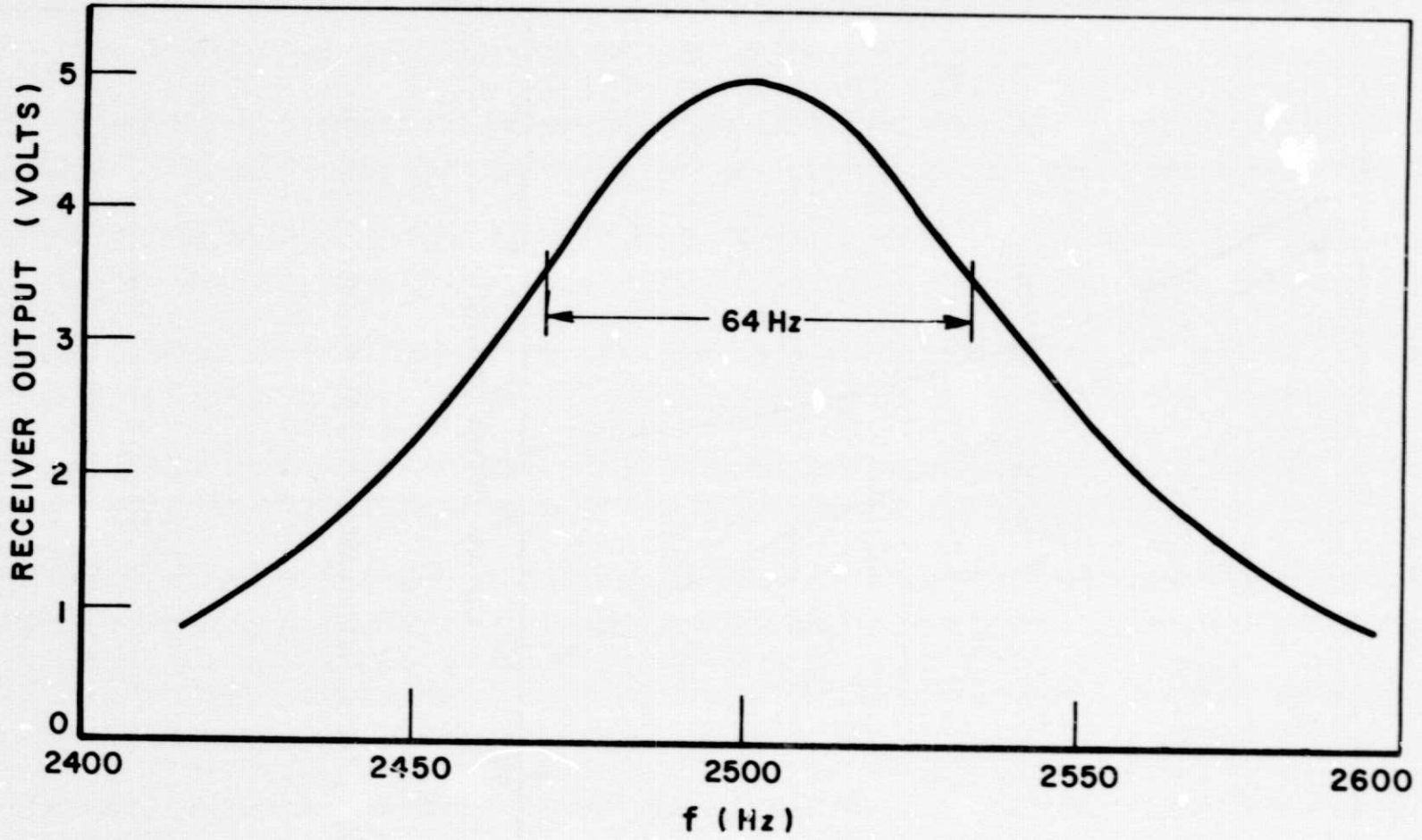

Fig. 7. 2.5 KHz response of 30 GHz fixed receiver.

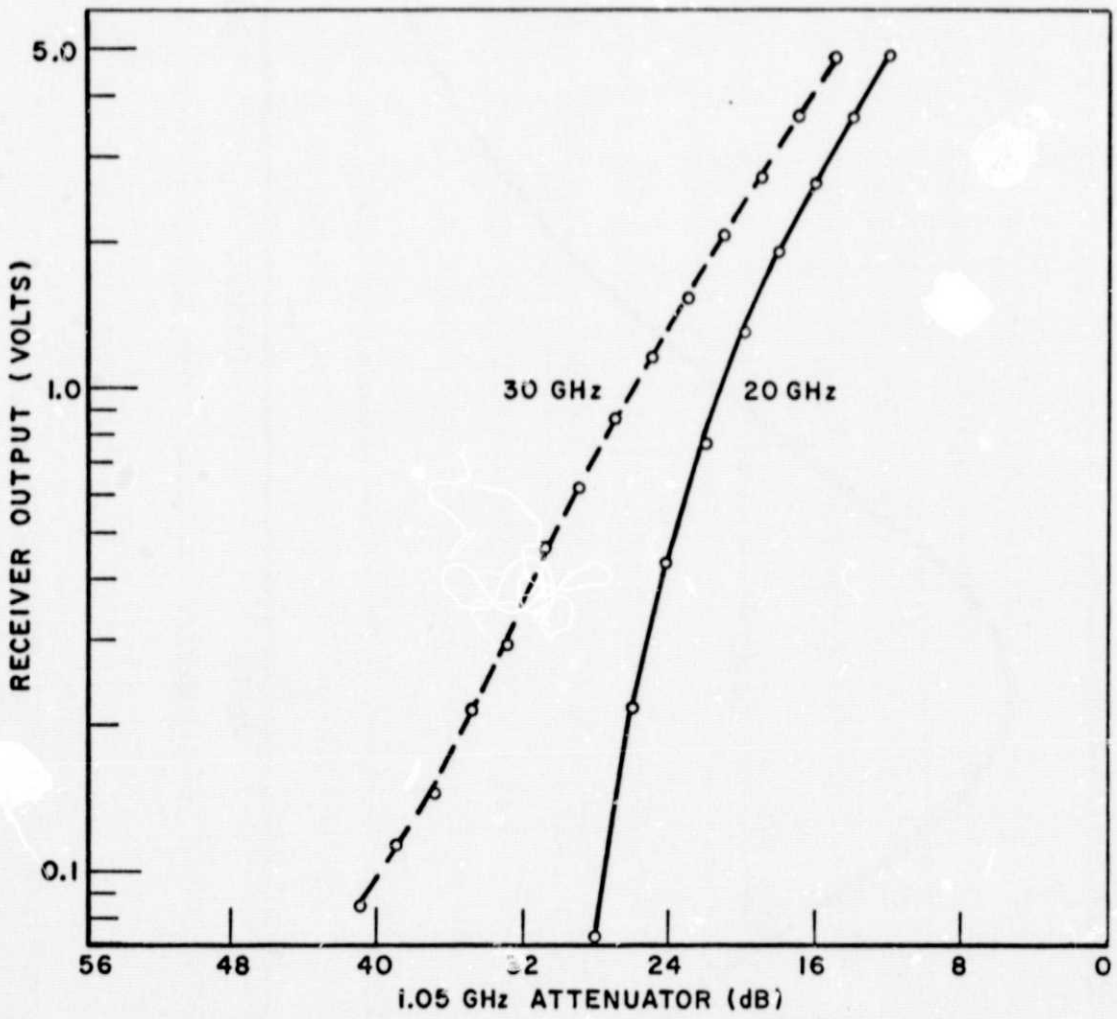

Fig. 8. Link calibration using ATS-6 signal (1/24/75).

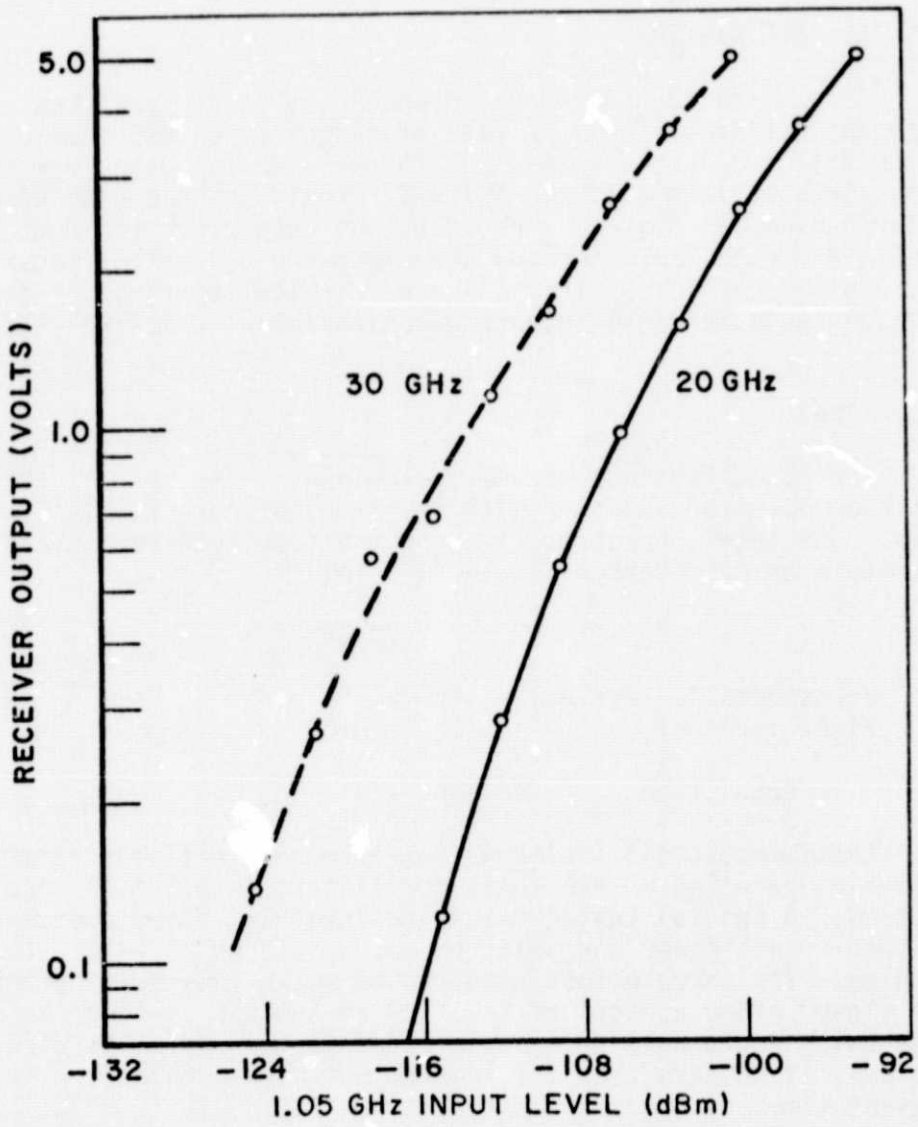

Fig. 9. Receiver calibration (9/4/74).

DIGITAL DATA SYSTEM

Each of the various data channels and status switches at the Fixed Terminal are digitized at a rate of either 10 or 200 samples/second. These data are then formated and merged with the data from the Transportable Terminal, the Third Terminal, and the High Resolution Radar/Radiometer System. The resulting data block is input into a HP-2115A digital computer and then recorded on digital magnetic tape. The digital channel assignments are identical to those at the Transportable Terminal and are given in Table 2, Reference 2.

OPERATIONS

The Fixed Terminal became operational on August 21, 1974, and has been operated together with the Transportable Terminal since that time. The total operating times of the four receivers at these two terminals as of December 17, 1974, were:

	20 GHz	30 GHz
Transportable Terminal	2,124 min.	3,038 min.
Fixed Terminal	880	1,354

Total time: 7,396 min.

Considerable difficulty was experienced initially in maintaining reliable operation of the local oscillators in all four receiver systems. A special tuning technique involving simultaneous monitoring of both output power and spectrum was developed to alleviate this problem. The large effort required to solve this critical problem has slowed other aspects of the program and has limited the amount of data which would have been anticipated at this point in time. Nevertheless, it appears that the problem has been adequately solved at the present time.

CURRENT STATUS

At the present time all four receivers and four radiometers at the Fixed and Transportable Terminals are operational. These two Terminals remain at a separation distance of 7 m (23 ft) for comparison of terminal characteristics and for comparative measurement of possible scintillation effects. It is anticipated that the Transportable Terminal will be moved to a separation distance of approximately 10 Km in March, 1975.

REFERENCES

1. D. B. Hodge, "ATS-F Millimeter Wavelength Propagation Experiment," Report 3863-1, July 1974, The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; prepared under Contract NAS5-21983 for NASA Goddard Space Flight Center.

2. D. B. Hodge and R. C. Taylor, "ATS-6 Millimeter Wavelength Propagation Experiment," Report 3863-2, September 1974, The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; prepared under Contract NAS5-21983 for NASA Goddard Space Flight Center.

3. D. B. Hodge and R. C. Taylor, "The Ohio State University ElectroScience Laboratory Radar/Radiometer Facilities for Precipitation Measurements," Report 2374-13, March 1973, The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; prepared under Grant No. NGR-008-080 for National Aeronautics and Space Administration.

4. C. D. Calhoon, Jr., "ATS-F Millimeter Wave Experiment Ground Receiver Systems for NASA Sponsored Participating Stations," NASA GSFC Rept. X-751-73-3, January 1973.