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REPEATER(U) ARMY MISSILE COMMAND REDSTONE ARSENAL AL
ADVANCED SENSORS DIR. J S COLE ET AL. JAN 84
UNCLASSIFIED DRSMI/RE-84-1-TR SBI-AD-E950 551 F/G 17/9

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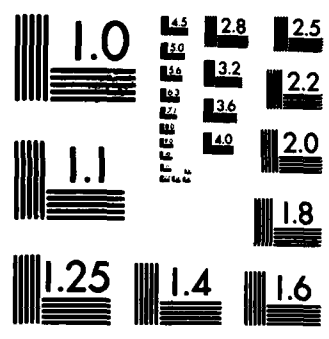
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TECHNICAL REPORT RE-84-1

TEST AND EVALUATION OF A COHERENT 35 GIGAHERTZ
RADAR REPEATER

John S. Cole
Lloyd W. Root
Advanced Sensors Directorate
US Army Missile Laboratory

JANUARY 1984



U.S. ARMY MISSILE COMMAND

Redstone Arsenal, Alabama 35898

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER RE-84-1	2. GOVT ACCESSION NO. ADA145714	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Test and Evaluation of a Coherent 35 Gigahertz Radar Repeater		5. TYPE OF REPORT & PERIOD COVERED Technical Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John S. Cole Lloyd W. Root		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Commander US Army Missile Command ATTN: DRSMI-RE Redstone Arsenal, AL 35898		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Commander US Army Missile Command ATTN: DRSMI-RPT Redstone Arsenal, AL 35898		12. REPORT DATE January 1984
		13. NUMBER OF PAGES 54
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Radar Repeater Radar System Radar Target Simulator		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report details the design, construction test, and evaluation of a 35 GHz radar repeater used to calibrate Independent Research and Development radars. (Continued)		

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I. INTRODUCTION

In field measurements when radar system parameters are constantly varying over many dB, comparative target calibration, where a calibration device is measured simultaneously with the target, provides the best possible calibration because the variations in radar parameters are removed from the measurement process. Simple corner reflectors used as calibration devices have greater multipath problems than do high gain antenna used to simulate targets. A large corner reflector attached to a helicopter flying at more than 1000 feet Above Ground Level (AGL) with the radar to be calibrated in a "chase" helicopter, would seem to provide a clutter free calibration of both aimpoint and the polarimetric channels. Unfortunately, the helicopter cross section, though more than an order of magnitude smaller than the corner reflector, will cause sufficient pollution of the polarimetric phase channels and of the angle tracker (in the polarimetric mode) so that it will serve, at best, as an amplitude calibration technique (in the nonpolarimetric angle track mode). Corner reflectors used on the ground had the same problem. Boresight calibration on the ground before a captive flight test is not generally possible because of both ground clutter and the specular image from flat terrain.

One solution that seems practical is to use a telephone pole with a reflector mounted on it. The minimum range that boresight or amplitude calibration could occur for most radars is about 100 meters because of the Sensitivity Time Control (STC) and its minimum operating range. The beamwidth of radar seekers is from 4 to 10 degrees and the elevation angle must subtend several beamwidths to minimize multipath. At 100 meters range and 16 degrees elevation a telephone pole 29 meters high is required. With the repeater one could mount the transmit and receive antenna on a pole only one third as high (32 feet) at one third the range if the repeater had a range delay on the order of 200 feet. A second problem that would be overcome is that by flying the repeater on a helicopter (rather than a corner reflector), the 200 foot delay in range for the electronic repeated target would occur in empty space and be free of all the pollution that normally is associated with the calibration of polarimetric radars. The necessity of using a repeater becomes apparent when the seeker, operating in its polarimetric mode, won't not track tree line clutter. To characterize tree line clutter and perform a "fly up" (to evaluate the seeker at ever increasing grazing angles) is not possible from a helicopter unless one could track a target at or near the tree clutter. Since the target being tracked has to be at least two range bins away from the tree line clutter to minimize pollution of the data in adjacent range bins, the obvious solution was to track a coherent repeater immersed in the tree line and covered by an anechoic material to minimize its contribution to the clutter. By tracking the repeater the seeker antenna would always be pointed at the clutter cell under test. It would have its electronic target away from the measurement range bin and would provide a real time pulse to pulse calibration signal relatively free of ground clutter at the higher grazing angles because of its range delay.

The need for a coherent repeater can therefore be established and can be improved with phase and amplitude control to provide a dynamically changing calibration target of known characteristics. One outstanding advantage of a

portable repeater is its capability to be mounted inside a tactical vehicle such as a tank or APC. This provides a viable, elegant solution to the dynamic measurement calibration problem at minimum cost.

II. SYSTEM DESCRIPTION

A. Overview

During FY 83 the RF Guidance Technology Branch of the Advanced Sensors Directorate, USAMICOM, designed and constructed two 35 GHz coherent radar repeaters (transponders) for use in field calibration of Independent Research and Development radars. Each repeater consists of a dc regulated prime power supply, a receive antenna, an input attenuator, three RF amplifiers, two delay lines, an output attenuator, and a transmit antenna. Figure 1 is a schematic of the repeater. The receive and transmit antennas can be set for right-hand circular, left-hand circular, or linear polarization. The linear polarization can be oriented at any slant angle desired by rotating the antenna in its mount. In normal use it is oriented at a slant angle of 45°. The antennas are mounted on a gun stock equipped with a variable power telescopic sight. A mounting base is attached to the bottom of the gun stock to allow attachment to the quadrapod stand which comprises the body of the repeater. During static testing the gun stock is mounted on the quadrapod; during dynamic testing the gun stock is hand held or can be dynamically positioned on its mount.

B. Radar Cross-Section as a Function of Repeater Gain

For a passive reflector, radar cross-section is defined as the ratio of power reflected toward the source per unit solid angle to the incident power density. Radar cross-section can be expressed as:

$$\sigma = \lim_{R \rightarrow \infty} 4 \pi R^2 \left| \frac{E_r}{E_i} \right|^2$$

where

σ = radar cross-section

R = range

$\left| E_r \right|^2$ = reflected power magnitude

$\left| E_i \right|^2$ = incident power magnitude

For a repeater with no time delay, reflected power is equatable to the effective radiated power of the repeater. The incident power density is:

$$\text{Power density} = \text{Effective Radiated Power of radar} / 4\pi R^2$$

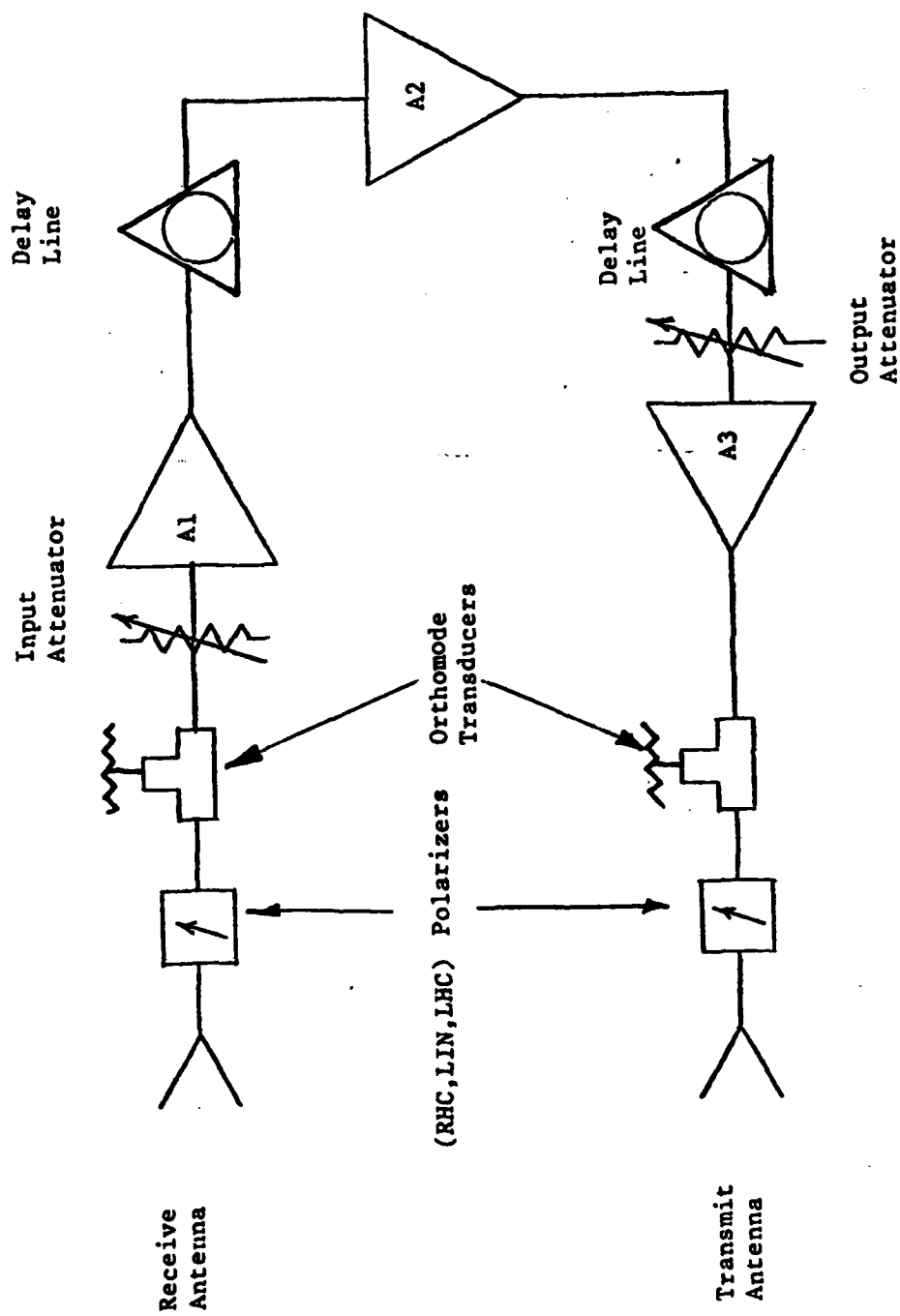


Figure 1. 35 GHz coherent repeater.

For a received wave which is co-polarized with the receive antenna:

$$\sigma = 4\pi R^2 \left(\frac{\text{ERP rep}}{\text{ERP rad}} \right) \quad (1)$$

where

ERP rep = Effective radiated power of repeater

ERP rad = Effective radiated power of radar

The ERP of the repeater as a function of the radar ERP is:

$$\text{ERP}_{\text{rep}} = \frac{\text{ERP rad } A_R G_L G_T}{4\pi R^2} \quad (2)$$

A_R = effective area of receive antenna of repeater

G_L = loop gain of repeater

G_T = gain of repeater transmit antenna

$$A_R = \frac{G_R \lambda^2}{4\pi} \quad (3)$$

G_R = gain of repeater receive antenna

λ = wavelength of transmitted signal

Substituting equation (2) into equation (1) yields:

$$\sigma = 4\pi R^2 \left(\frac{\text{ERP rad } A_R G_L G_T}{\text{ERP rad } 4\pi R^2} \right) \quad (4)$$

Cancelling like terms:

$$\sigma = A_R G_L G_T$$

Substituting equation (3) into equation (4) the radar cross-section becomes:

$$\sigma = \frac{G_R \lambda^2 G_L G_T}{4\pi} \quad (5)$$

Because the transmit and receive antennas are identical:

$$G_T = G_R = G_A \quad (6)$$

The equation for the radar cross-section of a repeater with no time delay is:

$$\sigma = \frac{G_A^2 G_L \lambda^2}{4\pi} \quad (7)$$

This is the expression for radar cross-section if time delay is zero. The delay line provides a means to transpose the repeater transmitted signal in range (see Section I). Because of the time delay, the apparent radar cross-section is increased by the range correction factor defined below:

$$\text{Range Correction Factor} = \frac{R + \Delta R}{R}^4 \quad (8)$$

R = range to repeater

ΔR = range delay of repeater signal

The equation for radar cross-section becomes:

$$\sigma = \left(\frac{G_A^2 G_L \lambda^2}{4\pi} \right) \left(\frac{R + \Delta R}{R} \right)^4 \quad (9)$$

Figure 4 is a plot of the range correction factor for repeater serial number one. Figures 2 and 3 compare the theoretical and laboratory measured gain for the two repeaters. $P_{\text{signal}} = P_{\text{out}} - P_{\text{noise}}$.

The loop gain G_L is determined by the input and output attenuator, and the polarization of the receive and transmit antennas.

$$G_L = \frac{G_{\text{max}} N}{A} \quad (10)$$

G_{max} = maximum loop gain

A = attenuator setting

N = Polarization mismatch factor

The polarization mismatch factor N varies from zero to one. If the radar transmitted waveform is copolarized with the repeater receive and transmit antennas, then the polarization mismatch factor is one. A three dB mismatch (i.e., radar polarization RHC, repeater receive polarization LIN, repeater transmit polarization RHC) is represented by $N=1/2$. A six dB mismatch (i.e., radar polarization RHC, repeater receive polarization LIN, repeater transmit polarization LIN) is represented by $N=1/4$. For the case where the repeater receive antenna is cross polarized with the radar, $N=0$. Table 1 defines N for some common polarization combinations.

$f = 35 \text{ GHz}$

Repeater

Ser # 001

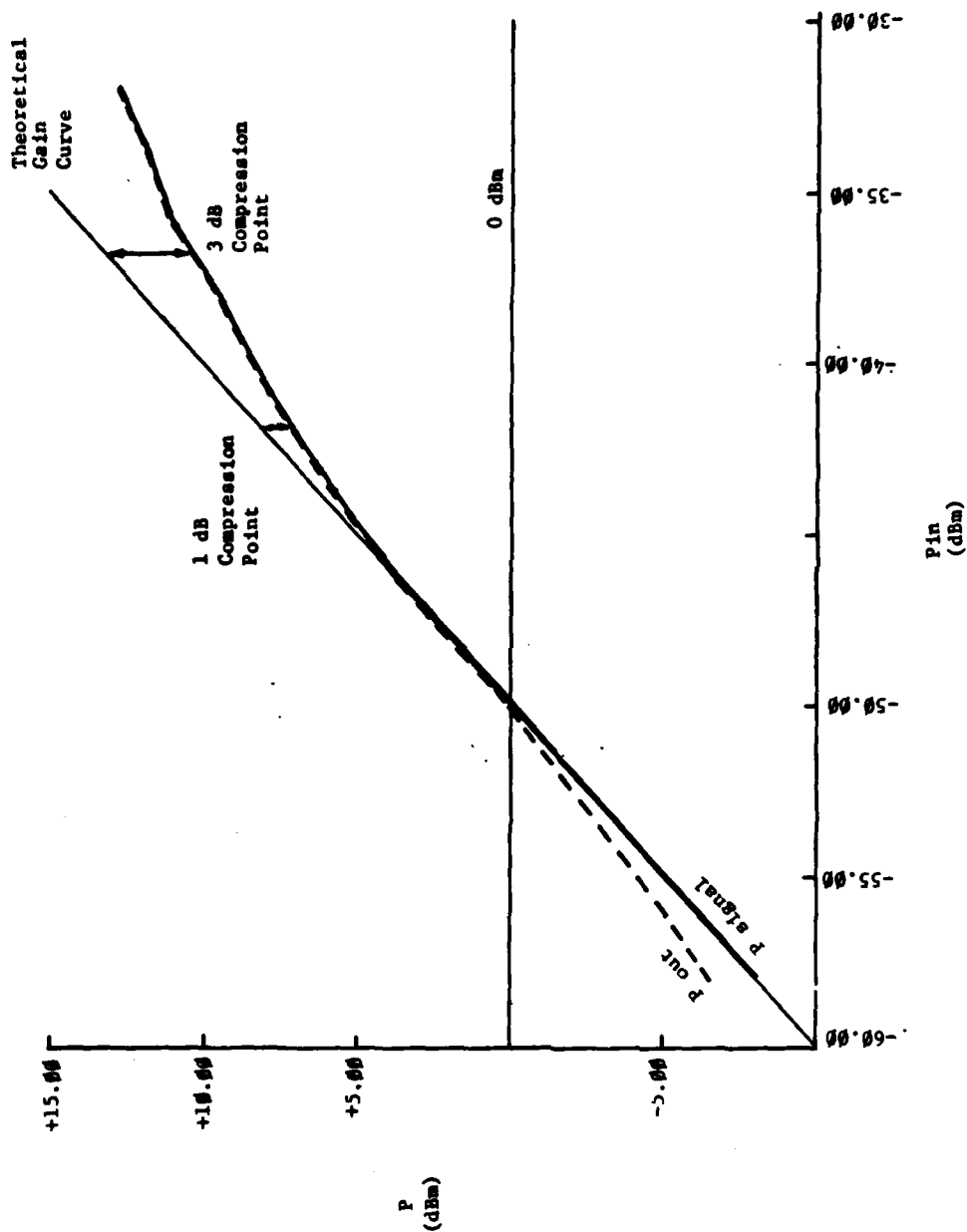


Figure 2. Comparison of theoretical and measured gain.

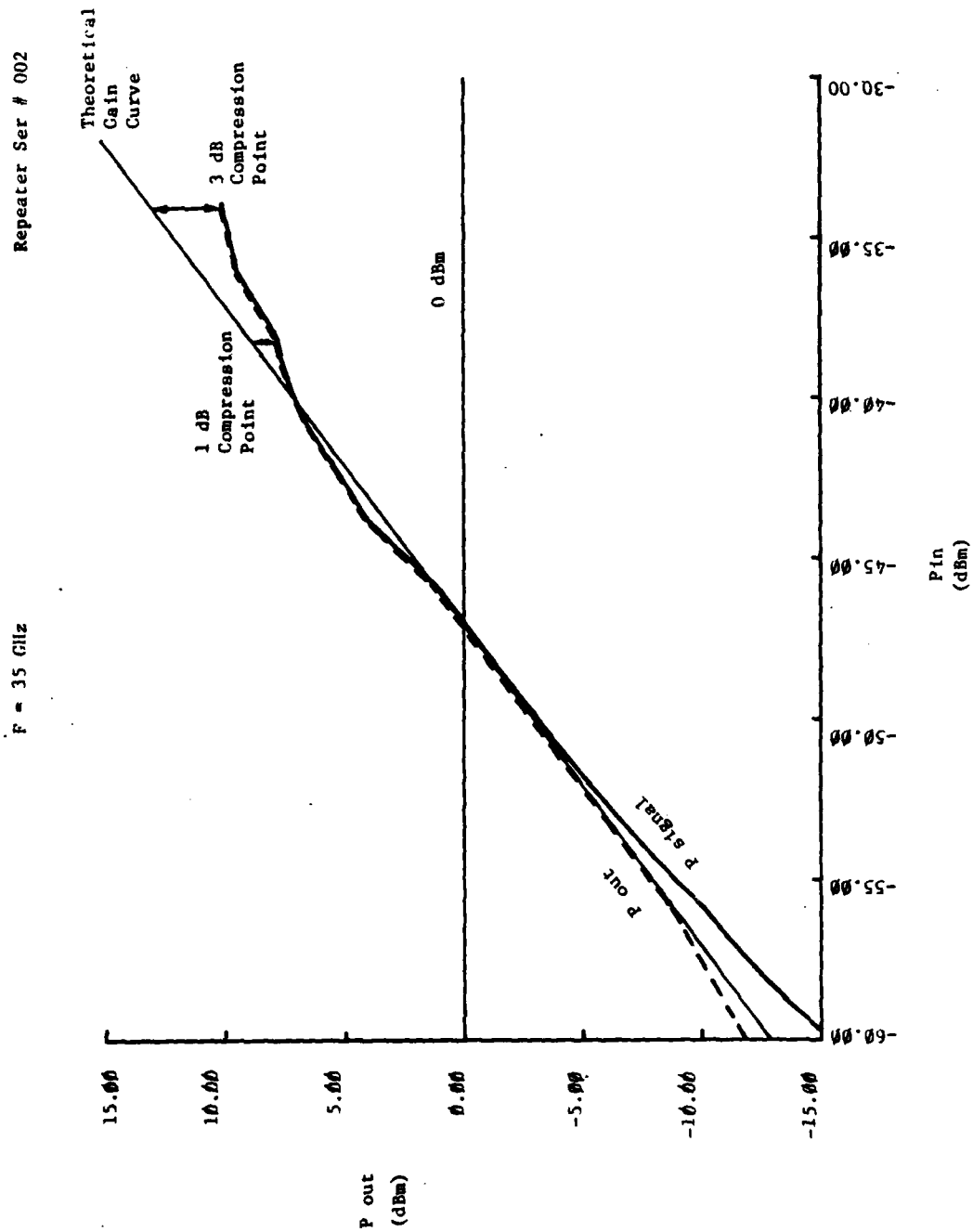


Figure 3. Comparison of theoretical and measured gain.

Example: Range Correction Factor

$\Delta R = 59.3 \text{ m}$

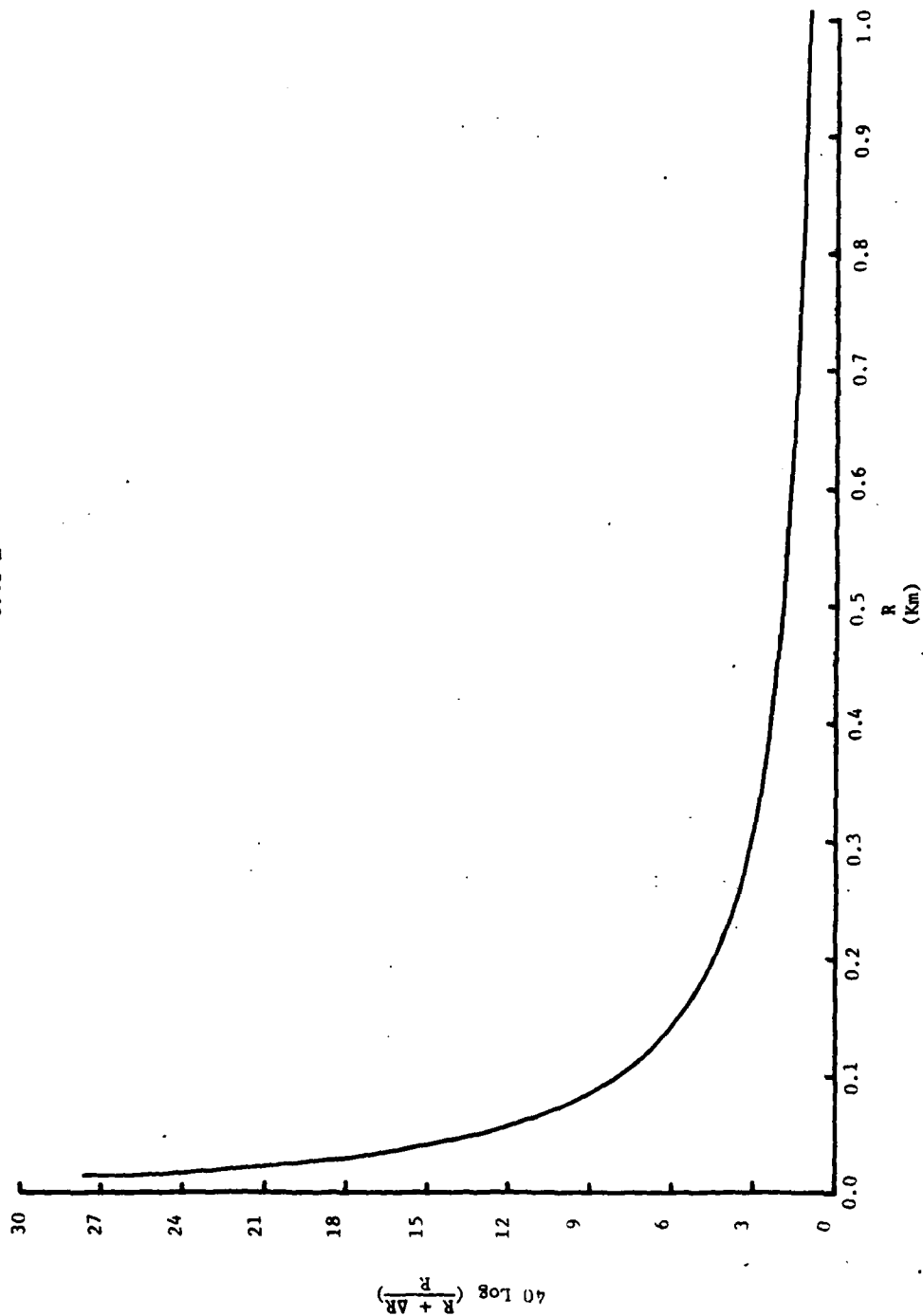


Figure 4. Range correction factor.

TABLE 1. POLARIZATION MISMATCH FACTOR (N)

		RADAR RECEIVE CHANNEL					
		RHC	LHC	RHC	LHC	RHC	LHC
R E P E A T E R	RHC	1	0	0	1	1/2	1/2
	LHC	0	0	0	0	0	0
	LIN	1/2	0	0	1/2	1/4	1/4
		RHC		LHC		LIN	
		REPEATER TRANSMIT POLARIZATION					

Radar Polarization = RHC transmit, RHC, LHC receive. The repeater antennas are oriented at 45° .

		RADAR RECEIVE CHANNEL					
		RHC	LHC	RHC	LHC	RHC	LHC
R E P E A T E R	RHC	0	0	0	0	0	0
	LHC	1	0	0	1	1/2	1/2
	LIN	1/2	0	0	1/2	1/4	1/4
		RHC		LHC		LIN	
		REPEATER TRANSMIT POLARIZATION					

Radar Polarization = LHC transmit, RHC, LHC receive. The repeater antennas are oriented at 45° .

TABLE 1. POLARIZATION MISMATCH FACTOR (N) - Continued

		RADAR RECEIVE CHANNEL					
		HOR	VERT	HOR	VERT	HOR	VERT
R R P E E O P C L E E A A I R T V I E E Z R A T I O N N	RHC	1/2	1/2	1/2	1/2	1/2	1/2
	LHC	0	0	0	0	0	0
	LIN	1/4	1/4	1/4	1/4	1/4	1/4
		RHC		LHC		LIN	
		REPEATER TRANSMIT POLARIZATION					

Radar Polarization = RHC transmit, Horizontal, Vertical receive. The repeater antennas are oriented at 45°.

		RADAR RECEIVE CHANNEL					
		HOR	VERT	HOR	VERT	HOR	VERT
R E P E A T E R	RHC	0	0	0	0	0	0
	LHC	1/2	1/2	1/2	1/2	1/2	1/2
	LIN	1/4	1/4	1/4	1/4	1/4	1/4
		RHC		LHC		LIN	
P O L A R I Z A T I O N		REPEATER TRANSMIT POLARIZATION					

Radar Polarization = LHC transmit, Horizontal, Vertical receive. The repeater antennas are oriented at 45°.

TABLE 1. POLARIZATION MISMATCH FACTOR (N) - Continued

		RADAR RECEIVE CHANNEL					
		HOR	VERT	HOR	VERT	HOR	VERT
R R P E E A A I T V I E Z R A T I O N	RHC	1/4	1/4	1/4	1/4	1/4	1/4
	LHC	1/4	1/4	1/4	1/4	1/4	1/4
	LIN	1/4	1/4	1/4	1/4	1/4	1/4
		RHC		LHC		LIN	
		REPEATER TRANSMIT POLARIZATION					

Radar Polarization = Horizontal transmit, Horizontal, Vertical receive.
The repeater antennas are oriented at 45°.

		RADAR RECEIVE CHANNEL					
		HOR	VERT	HOR	VERT	HOR	VERT
R R P E E A A I T V I E Z R A T I O N	RHC	1/2	1/2	1/2	1/2	1/2	1/2
	LHC	0	0	0	0	0	0
	LIN	1/4	1/4	1/4	1/4	1/4	1/4
		RHC		LHC		LIN	
		REPEATER TRANSMIT POLARIZATION					

Radar Polarization = Vertical transmit, Horizontal, Vertical receive.
The Repeater antennas are oriented at 45°.

In final form radar cross-section as a function of repeater gain is:

$$\sigma = \left(\frac{G_A^2 G_{\max} N \lambda^2}{4 \pi A} \right) \left(\frac{R + \Delta R}{R} \right)^4 \quad (11)$$

C. Input Attenuator Setting as a Function of Range and Radar Effective Radiated Power

For linear operation the input attenuator must be set so the input power is at the proper level. The desired input power (P_{in}) is found in Table 1. P_{in} is defined as:

$$P_{in} = \frac{ERP_{rad} A_R}{4 \pi R^2} \quad (12)$$

where:

A_R = Effective area of repeater receive antenna

ERP_{rad} = Effective radiated power of radar

R = Range to radar

A_R is defined as:

$$A_R = \frac{G_A \lambda^2}{4 \pi} \quad (13)$$

where:

G_A = Gain of receive antenna

λ = Wavelength

Substituting (6) into (5):

$$P_{in} = \frac{ERP_{rad} G_A \lambda^2}{(4 \pi)^2 R^2} \quad (14)$$

Modifying P_{in} by the input attenuator setting (A_{in}):

$$P_{in} = \frac{ERP_{rad} G_A \lambda^2}{(4 \pi)^2 R^2 A_{in}} \quad (15)$$

Solving for A_{in} :

$$A_{in} = \frac{ERP \text{ rad } G_A \lambda^2}{(4\pi)^2 R^2 P_{in}}$$

Table 2 contains a listing of the important parameters of the two repeaters. Given the ERP of the radar under test, frequency of operation, and range to the radar, the input attenuation is computed using the relationship defined above. The input attenuator settings versus dB of attenuation are found in Appendix C.

TABLE 2. P_n IS TERMINATED NOISE POWER OUTPUT

Serial Number	G	Gmax	P_{in}	ΔR	P_n
001	21 dB	51.8 dB	-50+2 dBW	59.3 meters	-11.8 dBW
002	21 dB	49 dB	-47+2 dBW	60.4 meters	-14.6 dBW

III. NOISE ANALYSIS

The gain/frequency characteristics of amplifier #11535 were measured and can be characterized as an average gain of 39.36 dB from 34.5 GHz to 35.5 GHz and 41.2 dB between 35.5 GHz and 36.8 GHz. The noise figure was measured across the entire band and found to be 13 dB for an effective noise temperature of 5496 degrees Kelvin. The lower 1 GHz band had an effective noise density (from the noise figure) of -71.1 dBW/GHz at the input which implies -31.94 dBW/GHz at the output. The upper 1 GHz band had an equivalent noise input power density of -70.2 dBW/1.25 GHz or an output noise power of -28.99 dB/1.25 GHz. Adding these two output noise powers together provides a total output noise of -27.2 dBW which agrees with the noise power output measured from amplifier #11535. Noise powers of the other amplifiers ranged from -28 dBW to -30 dBW with noise figures from 13 to 14 dB. The output noise power of the repeater (consisting of three amplifiers and two delay lines) is -12.9 dBW in the 34.5 to 35.5 GHz window and -6.2 dBW in the 35.5 to 36.75 GHz window. These two noise powers add to give -5.33 dBW noise power difference. The attenuation of the flexguide and the attenuator (set at zero dB attenuation) was measured as 2.4 dB in both regions so the output noise power should have been -7.7 dBW. The actual noise power measured was -12.6 dBW which is about 5 db error so the delay from line loss was of the order of 32 dB. From this we

assume a -19.5 dBm/GHz noise power density in the 34.5 to 35.5 GHz band and -13.5 dBm for the 35.5 to 36.75 GHz band. Thus, if the radar's detection bandwidth were 20 MHz the noise power would be 17 db below the -19.5 dBm/GHz value or -36.5 dBm peak noise power within the 20 MHz radar detection band or a linear dynamic range of 36 dB (Odbm linear output). The attenuator is located in front of the last amplifier stage because the noise density is reduced by the value of attenuation providing a linear dynamic range up to as much as 61 dB.

The average gain for repeater Serial #1 from 34.5 to 35.5 GHz was 51.8 dB and 55.8 dB for the region 35.5 to 36.58 GHz. The -71.2 dBm/GHz equivalent input noise density yielded an output noise density of -16.9 dBm. The 2.5 db difference represents the loss of one attenuator and flex wave guide on the input which is excluded from the effective input noise level to the first amplifier. The upper band has an effective input noise of -70.9 dBm/1.08 GHz with an output noise density of -12.6 dBm/1.08 GHz. These two noise power densities add to give -11.2 dBm noise. The measured noise power output was -11.8 dBm for repeater #1 and -14.6 dBm for repeater #2 which had about 2.8 dB less overall gain.

IV. REPEATER OPERATION

A. Assembly

Referring to the photographs in Appendix A, assemble the repeater. The feet are attached to the Quadrapod legs with the spring clips. Insert the tripod head mounting base legs into the top of the Quadrapod legs. Install and loosely secure the turnbuckles. Carefully raise the repeater platform, insert the fastening bolts and tighten the nuts. Tighten the turnbuckles until the tripod head mounting base is steady. Mount the tripod head and gun stock. Insuring the flexguide is aligned properly, connect the antennas to the repeater. Mount the battery and secure it with the wing nuts. Connect the battery cable and verify BATT light is on. The repeater is now ready for use.

B. Operation

1. Using the telescopic sight, aim the repeater at the radar.
2. Set the receive and transmit polarizers for the polarization desired.
3. Using the correct values of Pin (see Table 2), ERP rad, and range, set the input attenuator for linear operation (attenuator settings are in Appendix C).
4. Set the output and input attenuator for the radar cross-section desired.
5. Turn on the repeater.
6. Verify 15 V light is lit.
7. Repeater may be left on while changing attenuators and polarizers.

V. EGLIN AIR FORCE BASE FIELD TEST

A. Description of Test

During August 1983 a test of both repeaters was performed at Range C-52A, Eglin AFB, Florida (see Figure 5). This test was performed in conjunction with a Defense Advanced Research Projects Agency and Air Force funded program called CERBERUS. A 35 GHz polarimetric radar located at the top of a 270 foot tower was the test vehicle. Both repeaters were tested at slant ranges of 210 meters and 659 meters. The radar transmitted waveform was left hand circular, the receiver outputs were right hand and left hand circular, in phase and quadrature. Quick look instrumentation was used to generate inverse Fourier Transforms of the frequency domain data. Calibration of the repeaters was accomplished by comparing transform data of calibrated corner reflectors with repeater return signal transform data. The relationship of reflector voltage, repeater voltage, and radar cross-section is:

* Range 1 = 210 m

* Range 1 = 210 m

N

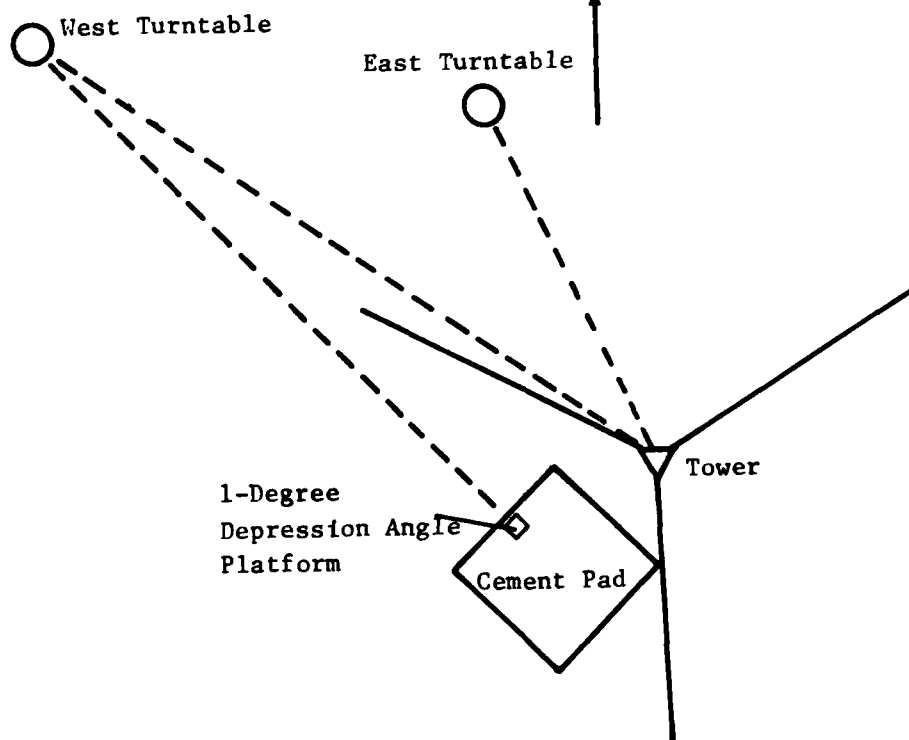


Figure 5. Range C-52A geometry.

$$\sigma = \left(\frac{V_{\text{ref}}}{V} \right)^2 \left(\frac{R + \Delta R}{R} \right)^4$$

σ = radar cross-section of repeater signal

σ_{ref} = radar cross-section of reflector

V_{ref} = transform voltage of reflector

V = transform voltage of repeater signal

R = range to repeater

ΔR = range delay of repeater

Other recorded data included radar manual gain control voltage and IRIG time.

B. Data

Figure 6 is a plot of radar cross section versus repeater attenuator setting for both repeaters. The receive and transmit antennas are both co-polarized with the radar. The straight line is a least square curve fit of the data. From this data the gain of repeater number one was found to be 52.7 dB, and repeater two was 48 dB. These data agree very well with the laboratory data. The difference between lab and field gain data for repeater one was .7 dB, for repeater two 1.0 dB. Figures 7 through 13 are examples of transform data collected at Eglin AFB. Each range bin is 10.5 meters long. ΔR was calculated by measuring the range displacement between a corner reflector collocated at the repeater and the repeater return. The differences in the right hand and left hand channels amplitude for linear transmit can be attributed to a known gain imbalance in the test radar. Quantitative analysis of cross polarization isolation is not possible with these data due to the cross coupling inherent in the test radar. Lab measurements of a repeater antenna indicate there is 22 dB of cross polarization isolation. The axial ratio of the antennas is approximately 1.2.

VI. CONCLUSIONS

The coherent repeater provides a low cost means to calibrate polarimetric radars. Problems with clutter pollution and target range cell pollution are eliminated. The portability of the repeater makes it a natural choice for calibration and tracking of moving vehicles (i.e., tanks, trucks and APCs) as well as a convenient static test calibration device. Future plans for these repeaters include upgrading, by contractor, to microprocessor control and pulse to pulse polarization agility.

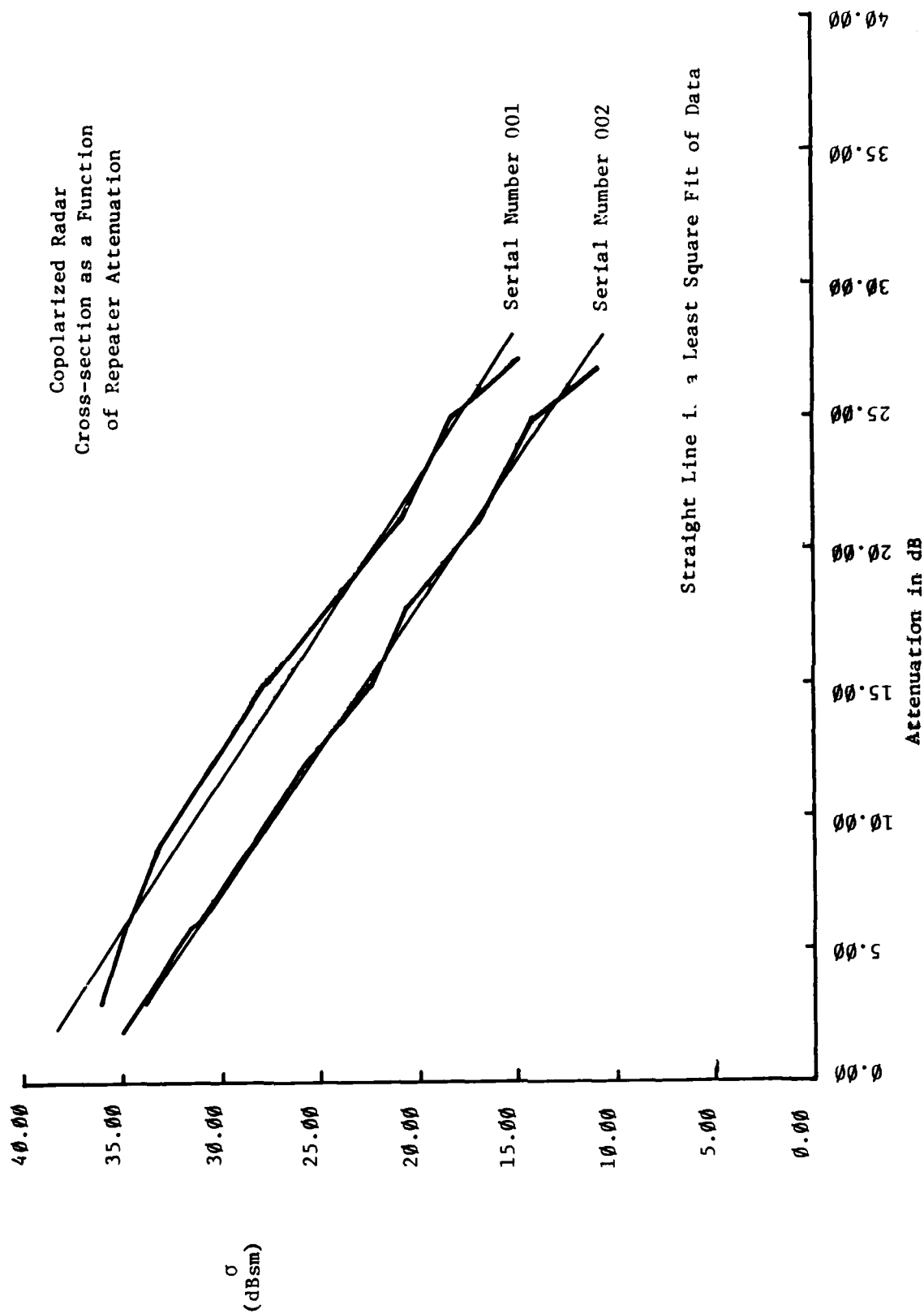


Figure 6. Copolarized radar cross-section as a function of repeater attenuation.

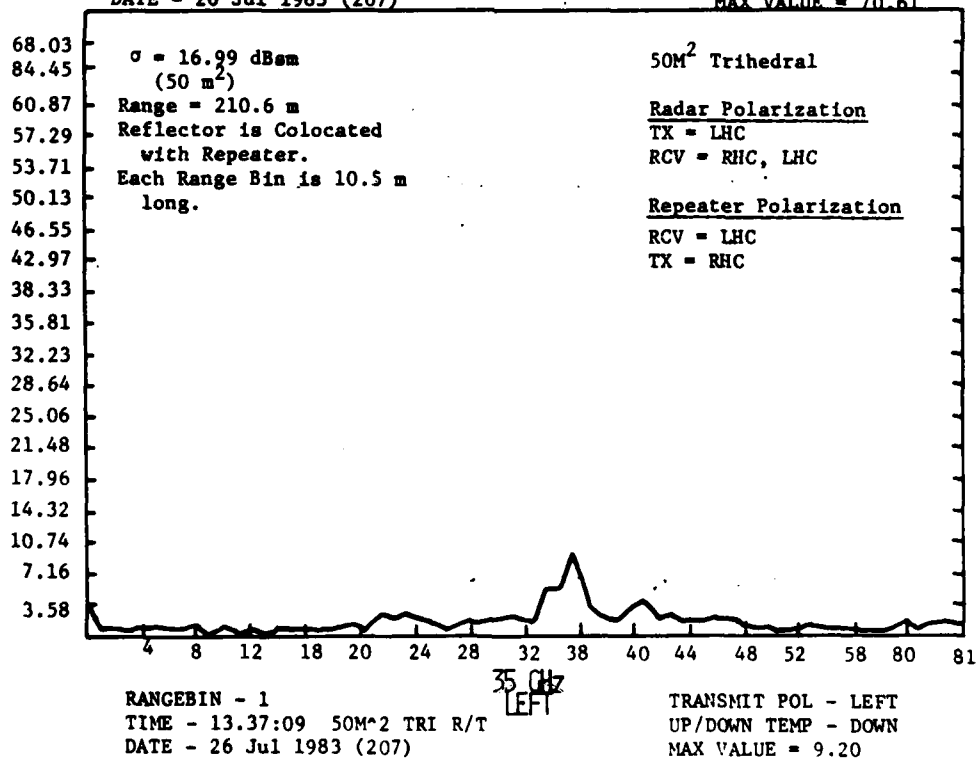
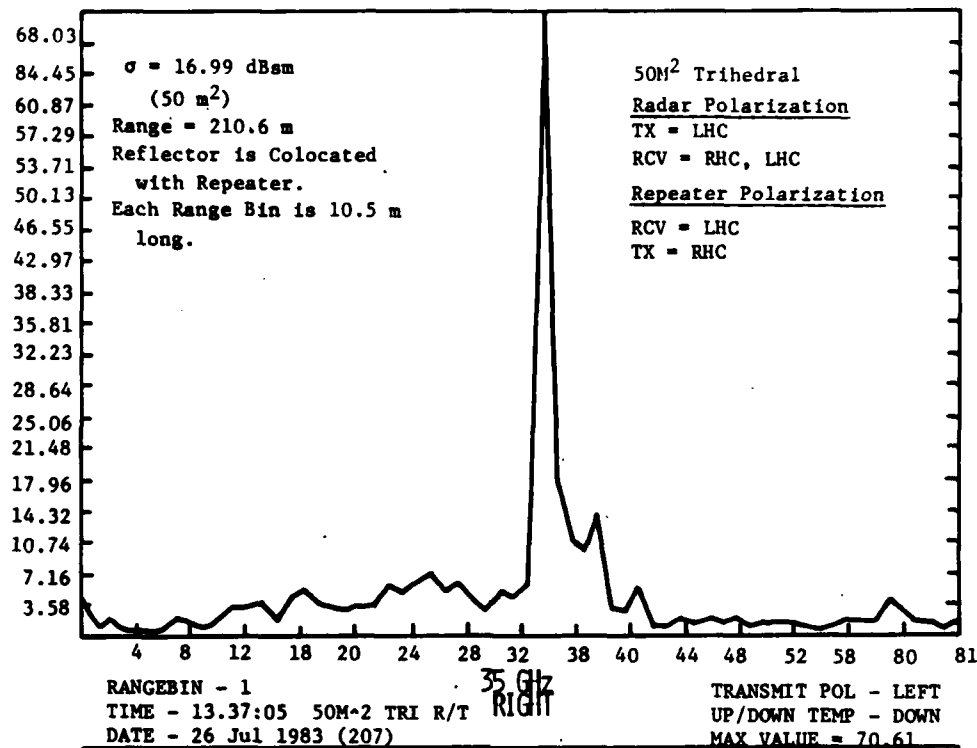


Figure 7. Transform of 50 M² corner reflector.

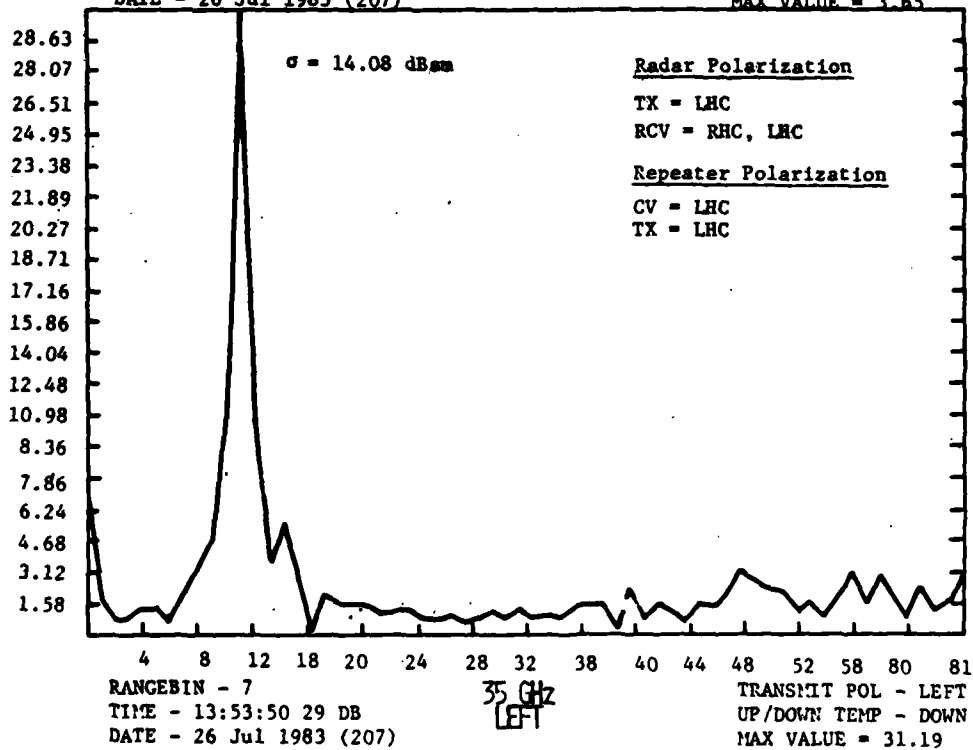
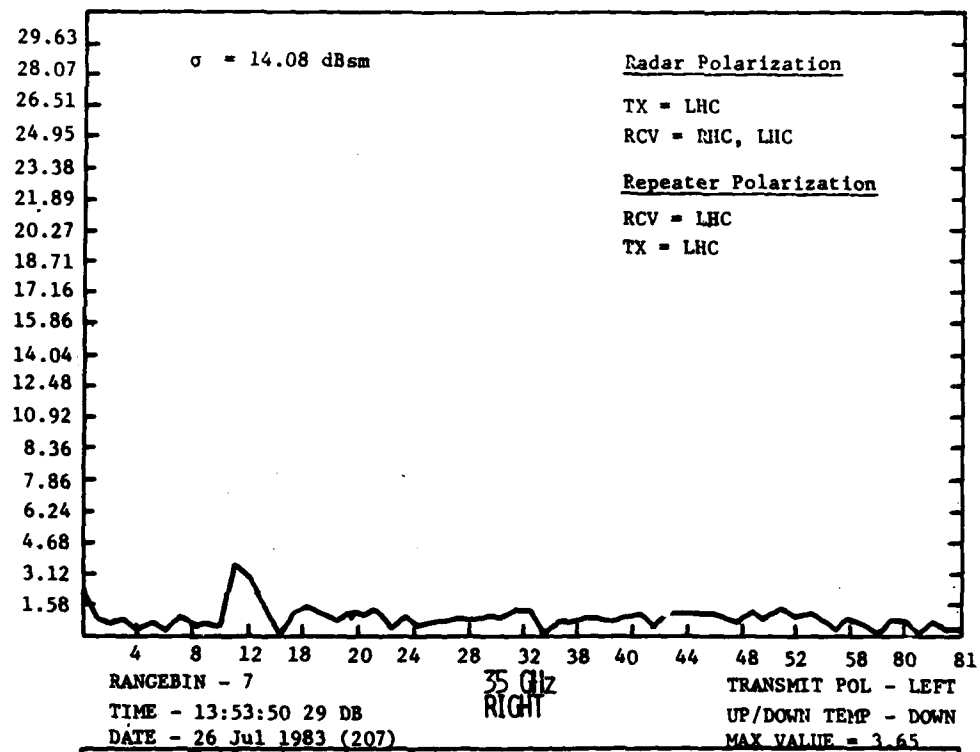


Figure 8. Transform of repeater - RCV LHC, TX LHC.

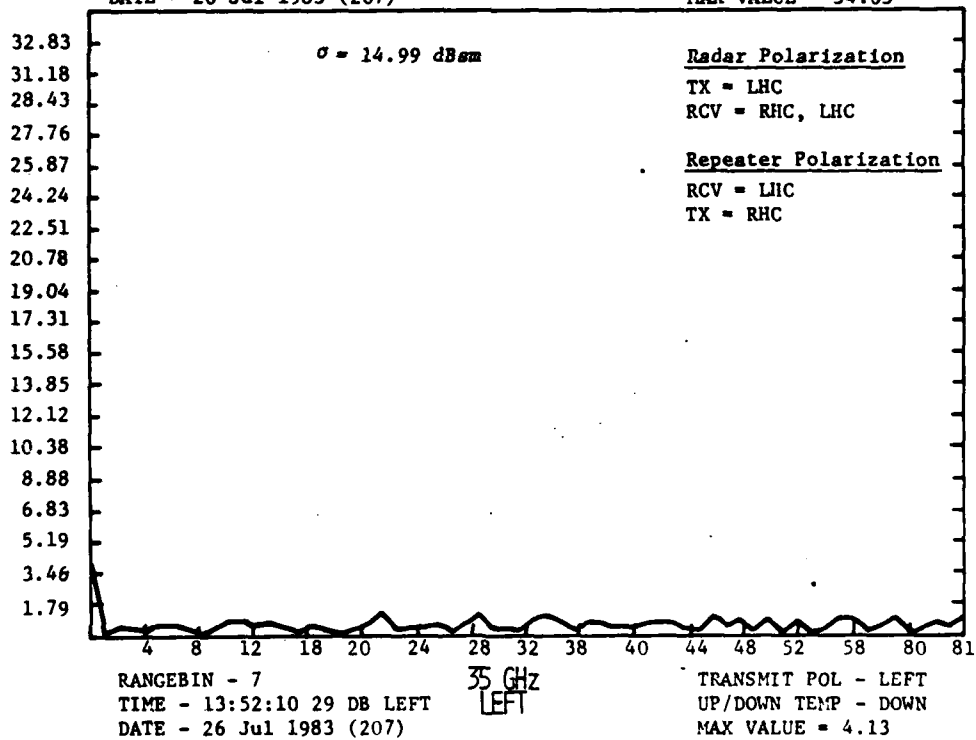
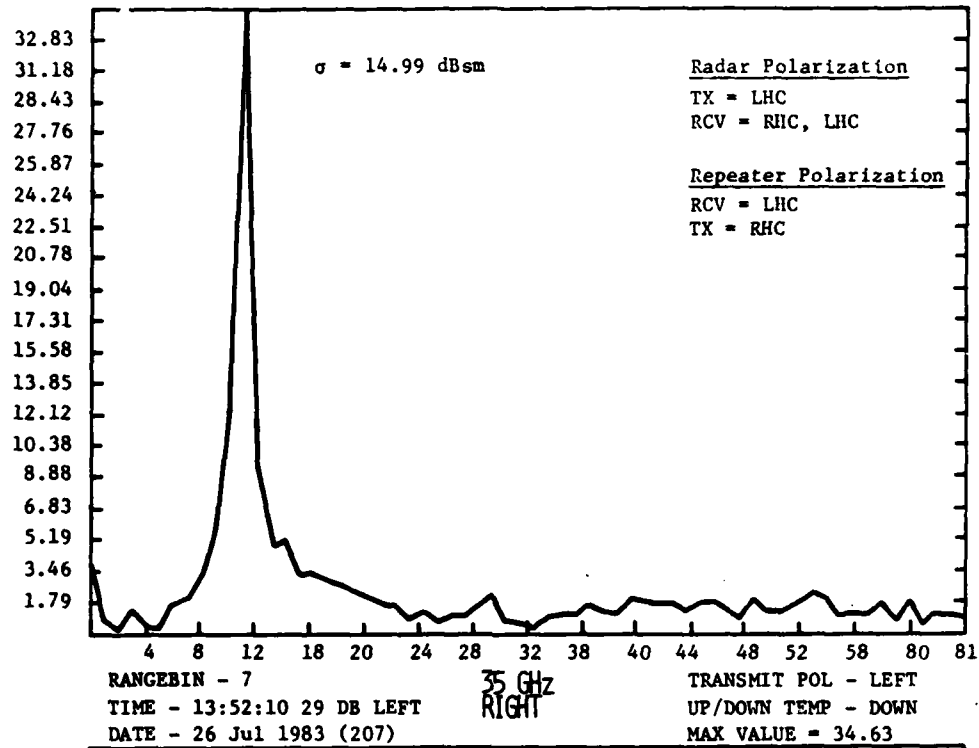


Figure 9. Transform of repeater - RCV LHC, TX RHC.

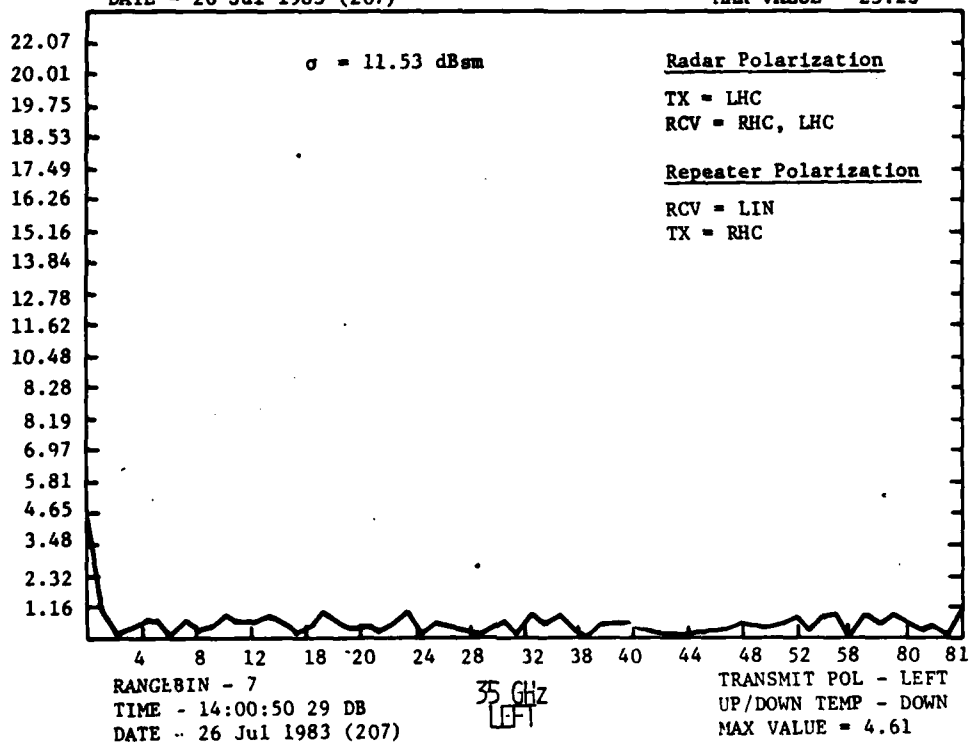
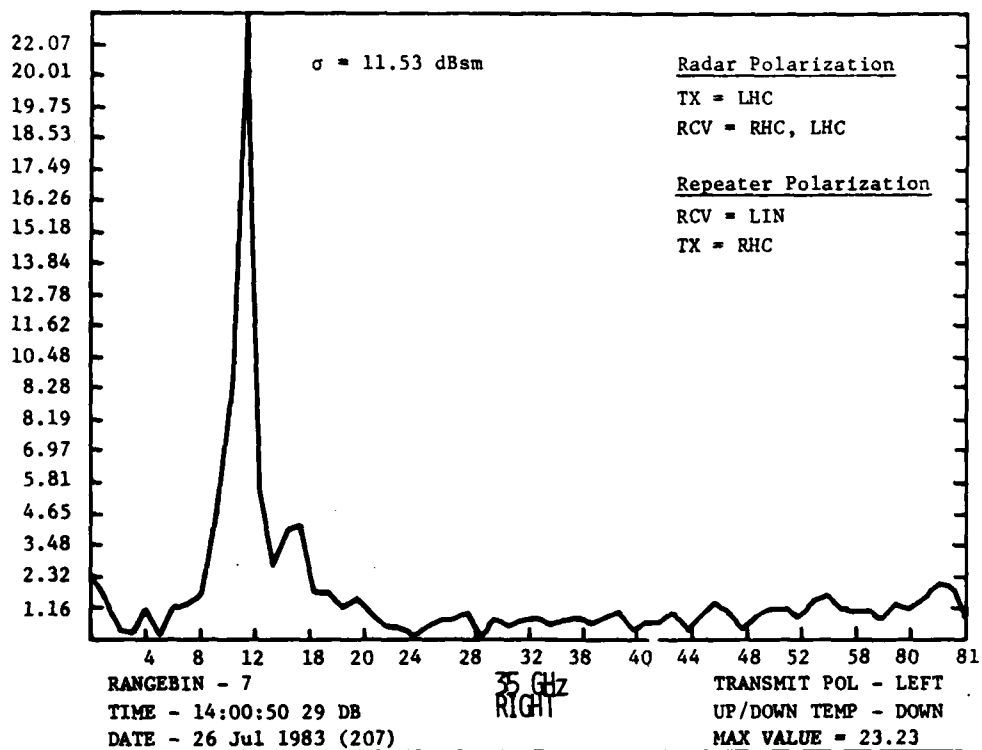


Figure 10. Transform of repeater - RCV LIN, TX RHC.

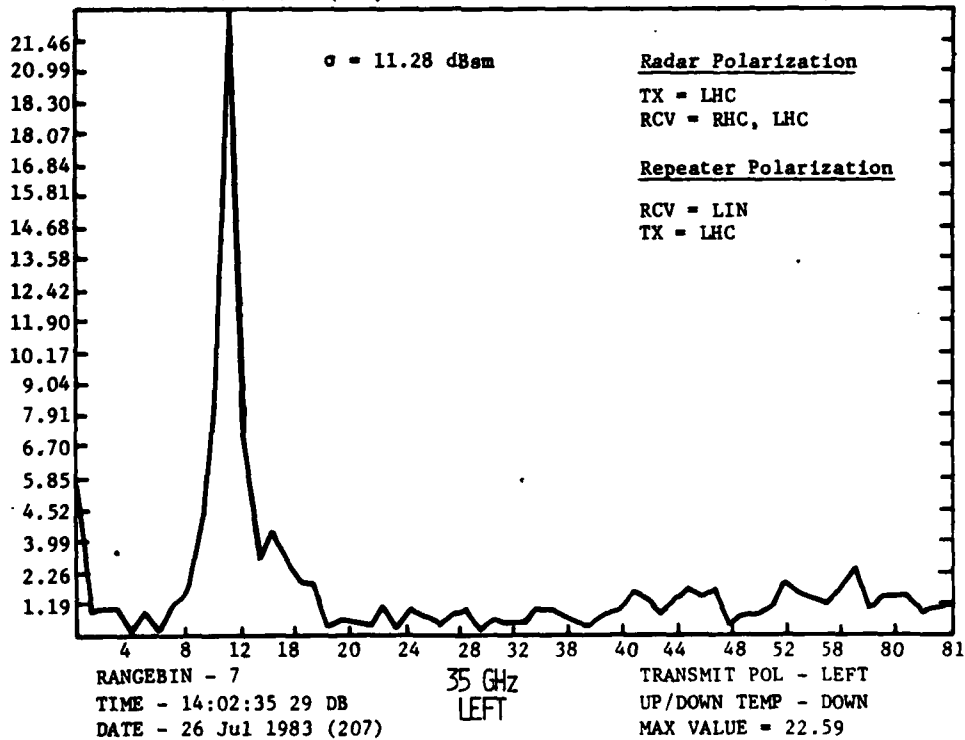
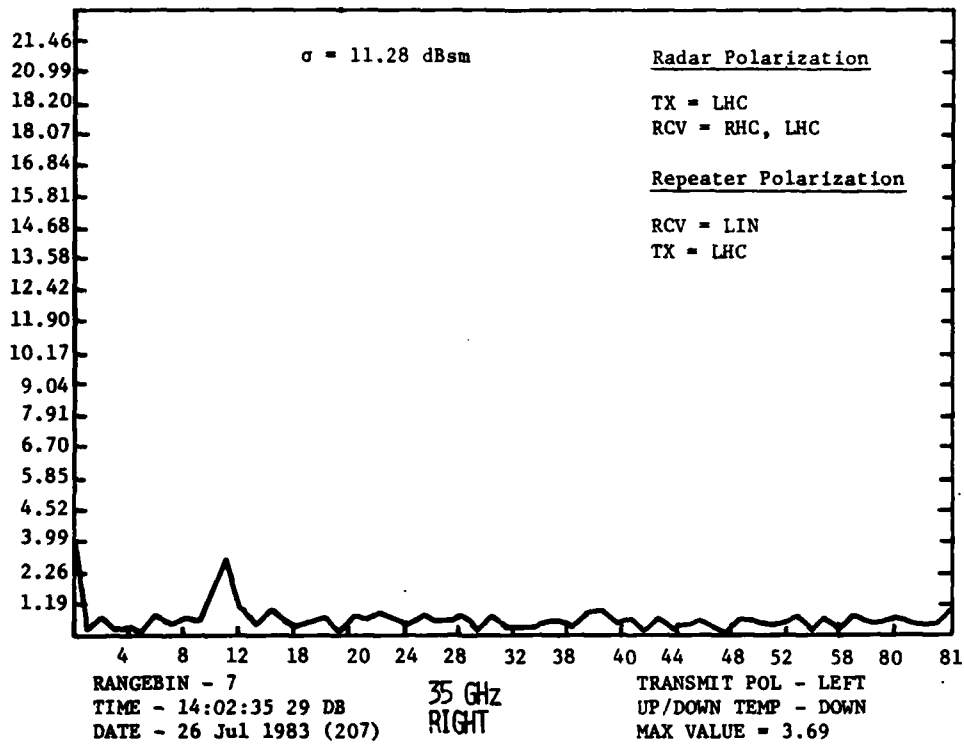


Figure 11. Transform of repeater - RCV LIN, TX LHC.

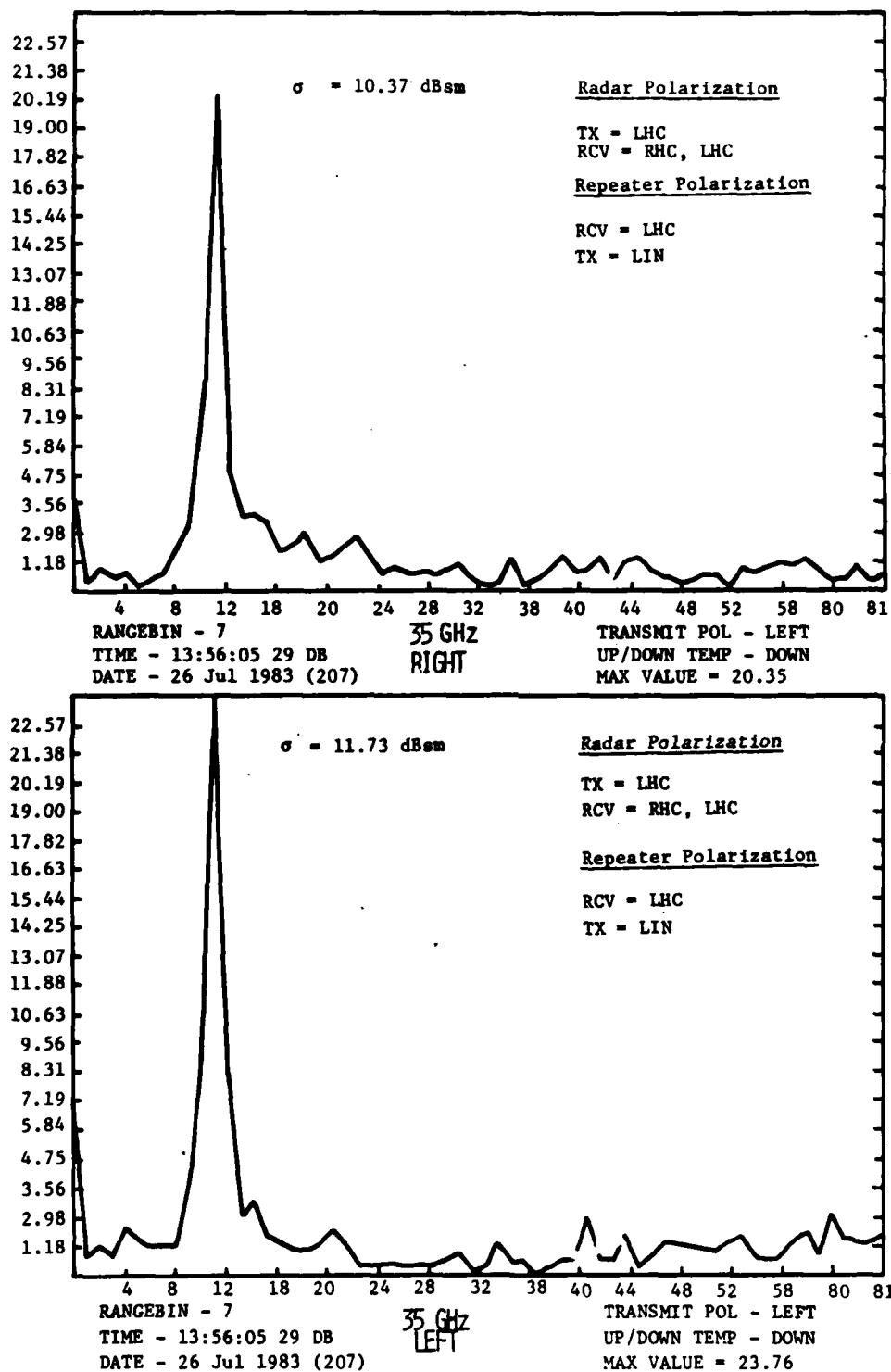


Figure 12. Transform of repeater - RCV LIN, TX LIN.

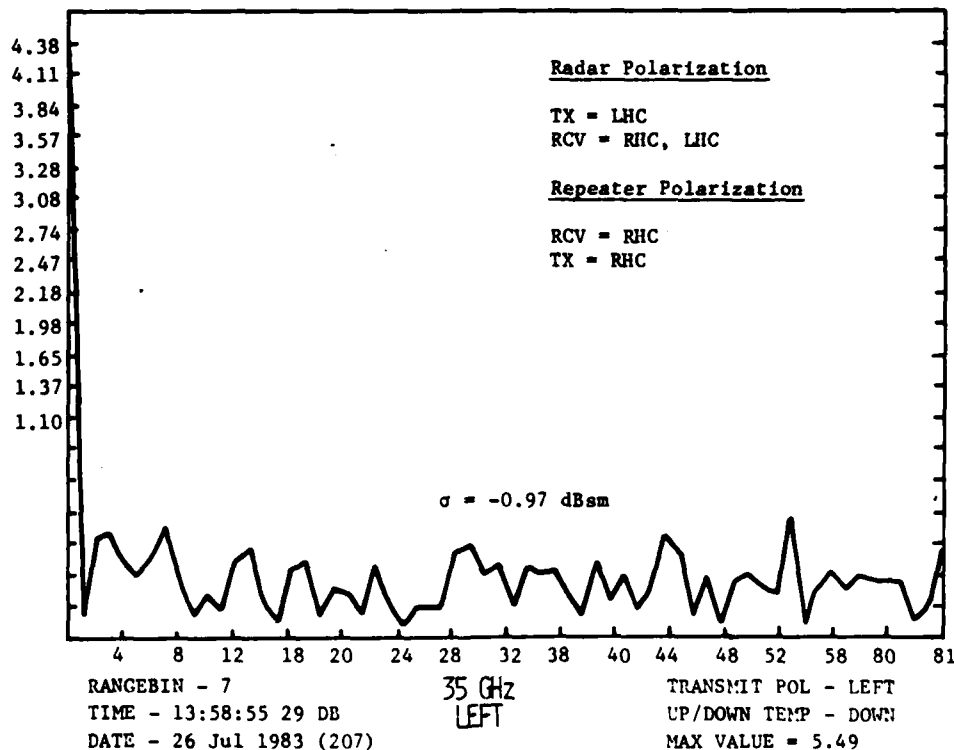
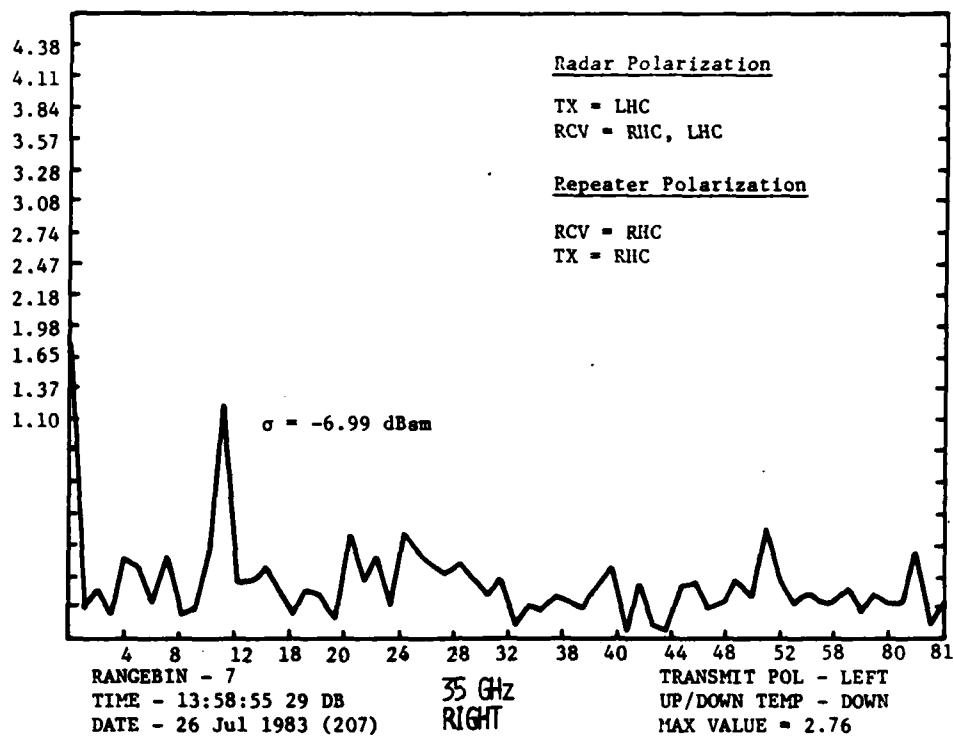


Figure 13. Transform of repeater - RCV RHC, TX RHC.

APPENDIX A
PHOTOGRAPHS OF REPEATER

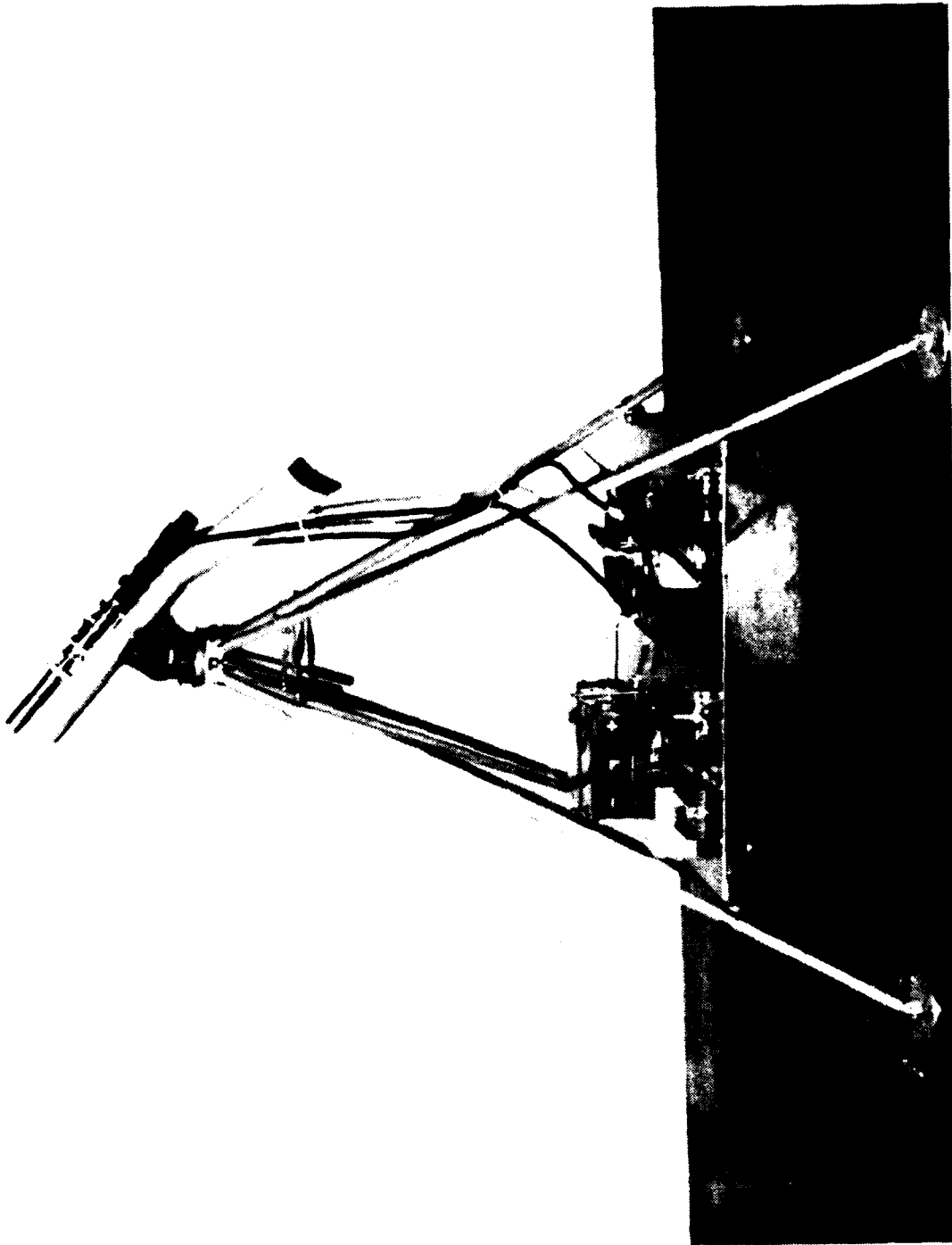


Figure A-1. 35 GHz repeater.

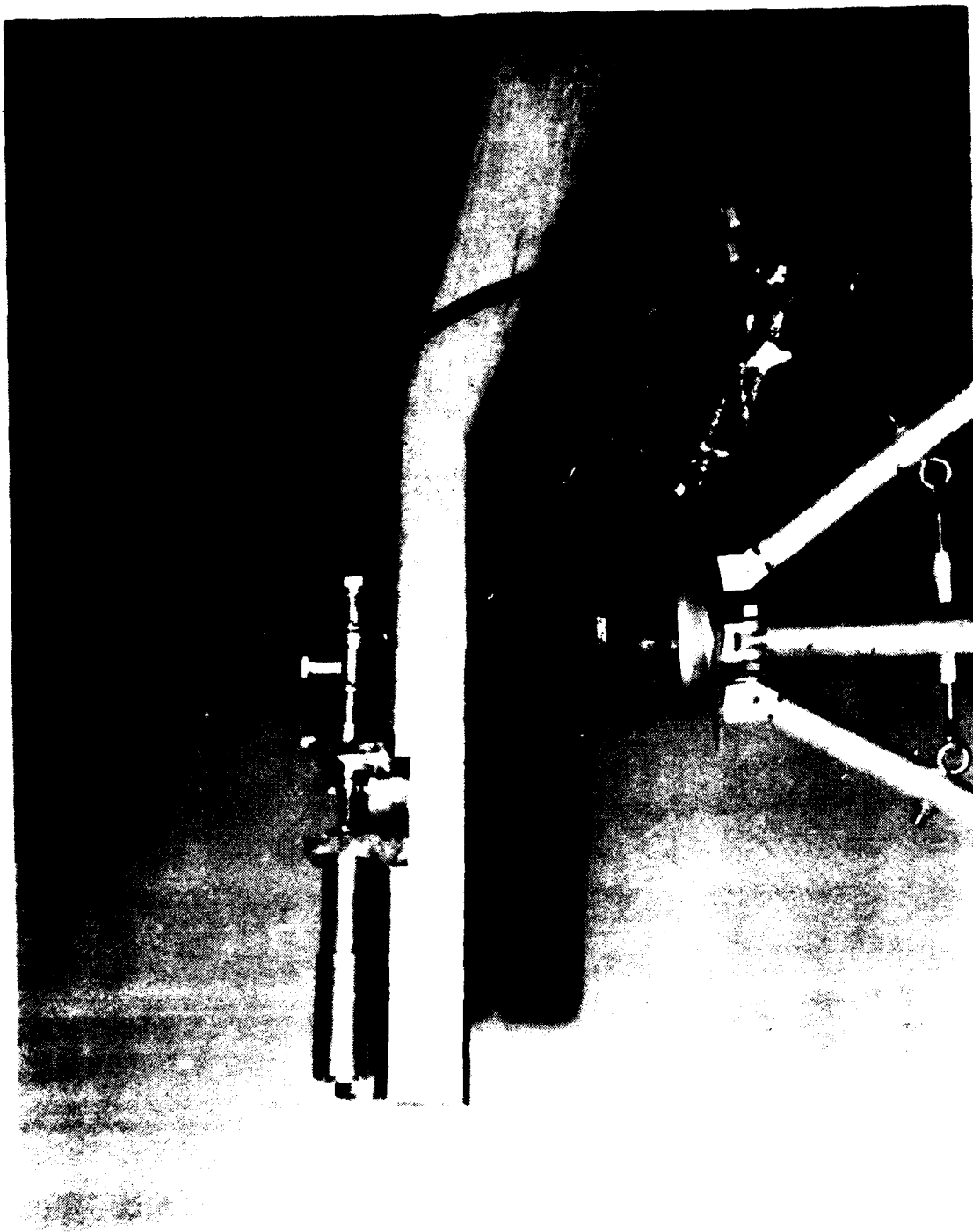


Figure A-2. Antennas mounted on tripod.



Figure A-3. Antennas hand held.

APPENDIX B

SWITCHING REGULATOR

The series pass transistor in a conventional series regulator must be able to drop the voltage between the input and output at the load current. A switching regulator, however, is capable of high efficiency operation even with large differences between the input and output voltages. For this reason switching regulators are useful in battery-powered equipment where the required output voltage is considerably lower than the battery voltage.

The method by which a switching regulator produces a voltage conversion with high efficiency can be explained as follows and with the aid of Figure B-1. Q1 is a switch transistor which is turned on and off by a pulse waveform with a given duty cycle, and D1 is a catch diode which provides a continuous path for the inductor current when Q1 turns off. The voltage waveform on the emitter of Q1 will be a rectangular wave, while the output of the LC filter will be the average value of the switched waveform.

IC-1 is an LM305 integrated voltage regulator and is used as the control element for the circuit. This device contains, on a single silicon chip, the voltage reference, an operational amplifier, and the circuitry for driving a PNP switch transistor. Q3 and Q2 are used to increase the drive current for Q1 to provide the required output current. The output voltage is set by the resistor network of R5, R6, and R7.

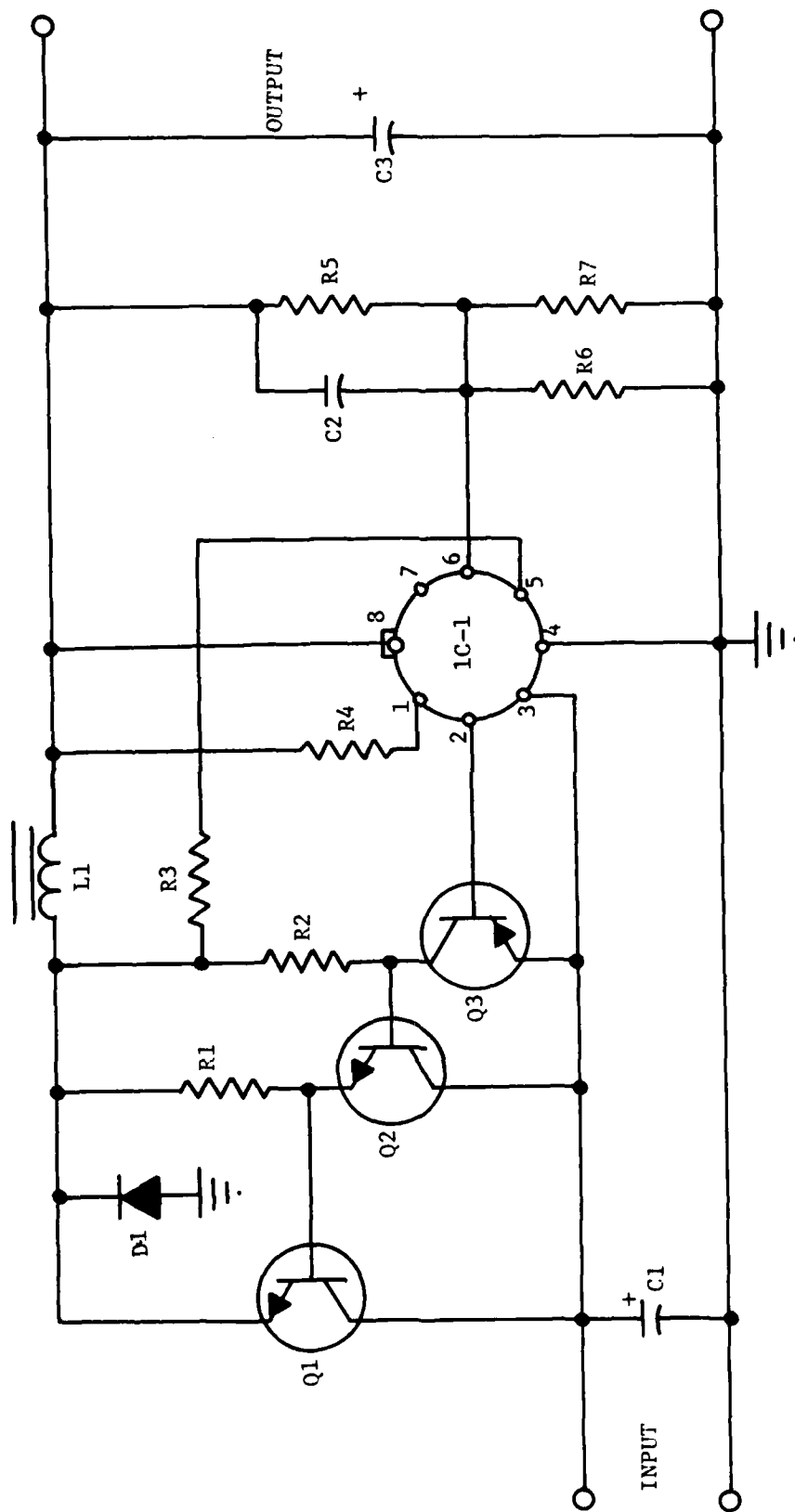


Figure B-1. Schematic of voltage regulator.

APPENDIX C
ATTENUATOR CALIBRATION DATA

REPEATER 001

ATTENUATOR SERIAL NO. 184

F - 35.0 GHz

<u>ATTENUATION (dB)</u>	<u>DIAL SETTING</u>
1.0	290
2.0	336
3.0	368
4.0	397
5.0	422
6.0	446
7.0	468
8.0	489
9.0	509
10.0	530
12.0	566
14.0	602
16.0	656
18.0	668
20.0	699
22.0	728
24.0	754
25.0	766

REPEATER 001

ATTENUATOR SERIAL NO. 186

F - 35.0 GHz

<u>ATTENUATION (dB)</u>	<u>DIAL SETTING</u>
1.0	308
2.0	354
3.0	388
4.0	416
5.0	442
6.0	466
7.0	488
8.0	508
9.0	528
10.0	548
12.0	584
14.0	618
16.0	652
18.0	682
20.0	710
22.0	738
24.0	766
25.0	778

REPEATER 002

ATTENUATOR SERIAL NO. 183

F - 35.0 GHz

<u>ATTENUATION (dB)</u>	<u>DIAL SETTING</u>
0.0	156
1.0	303
2.0	351
3.0	386
4.0	418
5.0	444
6.0	469
7.0	494
8.0	516
9.0	538
10.0	559
12.0	598
14.0	634
16.0	668
18.0	700
20.0	732
22.0	759
24.0	786
25.0	797

REPEATER 002

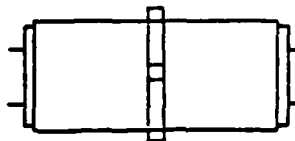
ATTENUATOR SERIAL NO. 185

F - 35.0 GHz

<u>ATTENUATION (dB)</u>	<u>DIAL SETTING</u>
1.0	296
2.0	342
3.0	376
4.0	404
5.0	432
6.0	456
7.0	478
8.0	500
9.0	522
10.0	543
12.0	580
14.0	616
16.0	650
18.0	682
20.0	714
22.0	744
24.0	769
25.0	782

APPENDIX D
MISCELLANEOUS COMPONENT DATA

001

SWITCHABLE CIRCULAR POLARIZERATE 1-24-83
SMTRG MODEL 250 - A 883S.N. 56W.O. 7781072V.S.W.R. AND AXIAL RATIO VS. FREQUENCY

Q. (Gc)	AXIAL RATIO		V.S.W.R.
	Left	Right	
34.50	0.5	0.6	1.09
35.0	0.5	0.5	1.08
35.5	0.7	0.6	1.12

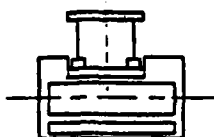
Date 12-14-82
SM

DCI

W.O. 7791073

TRG MODEL A881-250

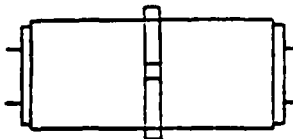
S/N 122



V.S.W.R and Isolation Vs. Frequency

EQ. (Gc)	V.S.W.R.		ISOLATION (db.)
	THRU-PORT	SIDE-PORT	
34.50	<1.15	1.15	>35.0
34.75	<1.15	1.12	>35.0
35.0	<1.15	1.12	>35.0
35.25	<1.15	1.17	>35.0
35.50	<1.15	1.16	>35.0

001

SWITCHABLE CIRCULAR POLARIZERDATE 1-24-83
SMTRG MODEL 250 - A 883S.N. 54W.O. 7781072V.S.W.R. AND AXIAL RATIO VS. FREQUENCY

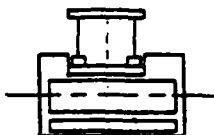
Q. (Gc)	AXIAL RATIO		V.S.W.R.
	Left	Right	
34.50	0.9	0.9	1.14
35.0	0.9	0.7	1.12
35.5	1.0	1.10	1.16

Date 12-14-82

001

W.O. 779,073

SM

TRG MODEL A981-250S/N 120

V.S.W.R and Isolation Vs. Frequency

EQ. (Gc)	V.S.W.R.		ISOLATION (dB.)
	THRU-PORT	SIDE-PORT	
34.50	< 1.15	1.20	> 35.0
34.75	< 1.15	1.18	> 35.0
35.0	< 1.15	< 1.10	> 35.0
35.25	< 1.15	< 1.10	> 35.0
35.50	< 1.15	< 1.10	> 35.0



Test Performance Data Sheet

Customer APPLIED TECHNOLOGY LAB P.O. or Contract Number DA2K51-82-C-0049
FORT EUSTIS

[illegible]VSWR INPUT $\leq$ 1.5:1 OUTPUT $\leq$ 1.5:1

STABLE UNDER RF DRIVE OF -25 dBm INPUT POWER

PRIMARY POWER +15 Vdc, < 2 amps

Test Operator B. Ramsey Date 1/28/83

Quality Control _____ Date JAN 29 1969

Note 1: At 1 dB Compression Point

Note 2: At Saturation



SOLID STATE AMPLIFIERS

Test Performance Data Sheet

Model Number VSK 7407 RA Serial Number 11535

Customer Dr. Curtis P.O. or Contract Number DAAR 51-82-C-0049

Frequency (GHz)	Noise Figure (dB)	Gain (dB)	Pout (dBm)
34.5	< 13	> 35	> +11
35.0	< 13	> 35	> +11
35.5	< 13	> 35	> +11

VSWR INPUT $\leq 1.5:1$ OUTPUT $\leq 1.5:1$

STABLE UNDER RF DRIVE OF $\frac{1}{4}$ dBm INPUT POWER

PRIMARY POWER $+15 \text{ Vdc } I < 2.0 \text{ A}$

Test Operator [Signature] Date: 4-14-82

Quality Control [Signature] Date: APR 5 1983

Note 1: At 1 dB Compression Point

Note 2: At Saturation

SOLID STATE MICROWAVE DEVICES, INC. 20000 W. 10TH AVE. DENVER, CO 80233



SOLID STATE AMPLIFIERS

Test Performance Data Sheet

Model Number VSK-7407RA Serial Number 11449
Customer APPLIED TECHNOLOGY LAB
FT. EUSTIS P.O. or Contract Number DAK51-82-C-0049

Frequency (GHz)	Noise Figure (dB)	Gain (dB)	Pout (dBm)
34.5	< 13	> 35	> +10
35.0			
35.5			

VSWR INPUT $\leq 1.5:1$ OUTPUT $\leq 1.5:1$

STABLE UNDER RF DRIVE OF -25 dBm INPUT POWER

PRIMARY POWER $+15$ Vdc @ ≤ 2 A

Test Operator G. Kinder/B. Ramsey Date 2-24-83

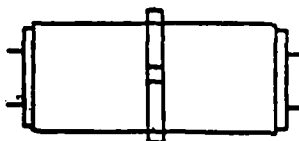
Quality Control [Signature] Date FEB 25 1983

Note 1: At 1 dB Compression Point

Note 2: At Saturation

solid state microwave/3251 oicott st/santa clara/ca/bernia 95050

002

SWITCHABLE CIRCULAR POLARIZERATE 1-24-83
SMTRG MODEL 260 - A 883S.N. 55W.O. 7781072

V.S.W.R. AND AXIAL RATIO VS. FREQUENCY

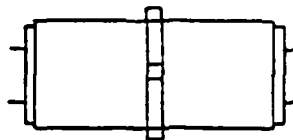
Q.(Gc)	AXIAL RATIO		V.S.WR.
	Left	Right	
34.50	0.7	0.8	1.09
35.0	0.6	0.8	1.10
35.5	0.9	1.0	1.18

C02

SWITCHABLE CIRCULAR POLARIZER

DATE 1-24-83TRG MODEL 260 - A 883S.N. 53W.O. 7781072

SM



V.S.W.R. AND AXIAL RATIO VS. FREQUENCY

F.(Gc)	AXIAL RATIO		V.S.W.R.
	Left	Right	
34.50	0.4	0.5	1.10
35.0	0.4	0.4	1.04
35.5	0.5	0.6	1.08



SOLID STATE AMPLIFIERS

002- Test Performance Data Sheet

Model Number VSK-7407RA Serial Number 11279

Customer FT. EUSTIS P.O. or Contract Number DAAK51-82-C-0049

Frequency (GHz)	Noise Figure (dB)	Gain (dB)	Pout (dBm)
34.5	< 13	> 35	> +10
35.0	< 13	> 35	> +10
35.0	< 13	> 35	> +10

VSWR INPUT $\leq 1.5:1$ OUTPUT $\leq 1.5:1$

STABLE UNDER RF DRIVE OF _____ dBm INPUT POWER

PRIMARY POWER +15 Vdc @ < 2 A

Test Operator B. Ramsey/G. Kinder Date 2-16-83

Quality Control  Date FEB 18 1983

Note 1: At 1 dB Compression Point

Note 2: At Saturation

solid state microwave/3251 olcott st./santa clara/california 95050



SOLID STATE AMPLIFIERS

Test Performance Data Sheet

Model Number VSK-7407RA Serial Number 11485
APPLIED TECHNOLOGY LAB
Customer FT. EUSTIS P.O. or Contract Number DAAKSI-82-C-0049

Frequency (GHz)	Noise Figure (dB)	Gain (dB)	Pout ¹ (dBm)
34.5	< 13	> 35	> +10
35.0			
35.5			

VSWR INPUT $\leq$ 1.5:1 OUTPUT $\leq$ 1.5:1

STABLE UNDER RF DRIVE OF _____ dBm INPUT POWER

PRIMARY POWER +15 Vdc @ < 2 A

Test Operator B. Ramsey/G. Kinder Date 2/25/83

Quality Control (signature) Date _____

Note 1: At 1 dB Compression Point

Note 2: At Saturation



SOLID STATE AMPLIFIERS

002 Test Performance Data Sheet

Model Number VSK 7407 RH Serial Number 11553

Customer Ft. Eustis P.O. or Contract Number DAAR 51-82-C0047

Frequency (GHz)	Noise Figure (dB)	Gain (dB)	Pout (dBm)
34.5	< 13	> 35	> +13
35.0	< 13	> 35	> +13
35.5	< 13	> 35	> +13

VSWR INPUT ≤ 1.5:1 OUTPUT ≤ 1.5:1

STABLE UNDER RF DRIVE OF N/A dBm INPUT POWER

PRIMARY POWER +15Vdc @ < 1.5A

Test Operator [Signature] Date 3-16-82

Quality Control [Signature] Date MAR 13 1982

Note 1: At 1 dB Compression Point

Note 2: At Saturation

Date 12-14-82
SM

002

W.O. 7781073

TRG MODEL A881-250

S/N 121



V.S.W.R and Isolation Vs. Frequency

EQ. (Gc)	V.S.W.R.		ISOLATION (dB.)
	THRU-PORT	SIDE-PORT	
34.50	< 1.15	1.18	> 35.0
34.75	< 1.15	1.12	> 35.0
35.0	< 1.15	< 1.10	> 35.0
35.25	< 1.15	1.10	> 35.0
35.50	< 1.15	1.13	> 35.0

Date 12-14-82

602

W.O. 7791C73

SM

TRG MODEL A881-250S/N 119

V.S.W.R and Isolation Vs. Frequency

EQ. (Gc)	V.S.W.R.		ISOLATION (dB.)
	THRU-PORT	SIDE-PORT	
34.50	< 1.15	1.14	> 35.0
34.75	< 1.15	< 1.10	> 35.0
35.0	< 1.15	< 1.10	> 35.0
35.25	< 1.15	< 1.10	> 35.0
35.50	< 1.15	1.14	> 35.0

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