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COLLEGE OF ENGINEERING
DEPARTMENT OF ELECTRICAL ENGINEERING
Radiation Laboratory

VOR PARASITIC LOOP COUNTERPOISE-II: INTERIM REPORT NO. 5

1 August - 31 October 1970

By
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Contract Monitor: Mr. Sterling R. Anderson

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1. Introduction

This is the Fifth Interim Report on Contract FA69-WA-2085, Project 330-001-03N, "VOR Parasitic Loop Counterpoise Systems-II", and covers the period 1 August to 31 October 1970.

During this period we have completed the full scale electrical and mechanical design of the non-uniformly excited double parasitic loop counterpoise antenna assembly to be tested at the Manheim Road VOR facility of NAFEC. We (Mr. Joseph E. Ferris) have also participated in the full scale field strength measurements of the Manheim Road VOR facility. The results of these tests are summarized below.

2. Test Results from Manheim VOR Facility at NAFEC

Use was made of a 75-foot vertical pole located 300 feet from the center-line of the 150-foot VOR counterpoise. A vertical track had been attached to one side of the vertical pole and oriented so that antennas could be pointed toward the VOR facility and readily raised and lowered by use of a rope. Two antenna receiving probes were used: 1) a 100 MHz dipole attached to a 4-foot vertical pole, and 2) a three-element Yagi attached to a 2-foot vertical pole. Data were collected over a range of 15.5 - 79 feet and 13.5 - 77 feet above the ground respectively for the dipole and Yagi.

The heights noted in Tables I through V were arrived at by running the antenna trolley to the stop at the top of the pole and referring to this as 75 feet. The trolley was then lowered in 5-foot increments as noted in the tables. With the dipole located at the lowest height we choose to use (10 on the tables), its height above the ground was measured and found to be 15.5 feet.

Energy received by the antenna probes was fed either to an Empire Device NF-105 receiver or to a Micro-Tel Wide Range receiver. The NF-105 has an internal metering system such that data is read directly from the NF-105. However, the Micro-Tel receiver uses an external metering device. For these tests two external meters were used: 1) a Hewlett-Packard Model 415 Standing Wave Indicator, and 2) a Scientific-Atlanta Model 1831 Digital Lin/Log Display.

The area between the VOR facility and the 75-foot pole consists primarily of marsh grass approximately 5-6 feet tall and a 10-foot fence that encloses the VOR facility. It is estimated that the fence is approximately 75 feet from a vertical line through the center of the counterpoise.

Tables I through V show raw data as well as normalized data, all obtained with the above equipment. As is obvious, all data were normalized to the signal received with the detecting antenna located at the top of the 75-foot pole. The data shown in Tables I and II were recorded to determine the repeatability of the measurements. The only difficulty in repeating occurs at the nulls which exist in the field strength (see Fig. 2). Data for Tables I and II were collected using the 100 MHz dipole with the VOR Goniometer off. Table III data used the 100 MHz dipole with the VOR Goniometer activated. For Tables IV and V, a three-element Yagi (tuned for 109 MHz) was used as the detection; the VOR Goniometer was on and off respectively.

A principal reason for collecting this data has been to see if it would be possible to measure the radiation pattern of the full scale VOR antenna system in the range of $90^o < \theta < 102^o$. To aid in this investigation use was made of both theoretical and tenth-scale experimental data available for the Alford Loop 150-foot counterpoise system. Figure 1 is a plot of typical theoretical and tenth-scale experimental data in the range of $90^o < \theta < 102^o$. Figure 2 is a plot of the data collected from the full scale Manheim Road VOR facility. This full scale data has been extrapolated from the data shown in Tables I through V and obtained using University of Michigan equipment. The reader is reminded that there is approximately a two-foot difference between the height calibration for the dipole and the Yagi.

It appears, from a comparison of the data shown in Figs. 1 and 2, that the two curves have basically the same curvature in the range $90^o < \theta < 102^o$. It is believed that the fluctuations noted in the full scale data are caused by multipath effects. However, the fluctuations are substantially smaller than one would expect if the area between the VOR system and the 75-foot tower was flat and a perfect conductor. Because this ground is covered with a relatively tall (5 - 6 feet) growth of marsh grass, energy propagating into the grass is believed to be substantially attenuated, therefore, minimizing fluctuations in the resulting data. More detailed analyses of the results are in progress.

As noted above essentially two pieces of test equipment (Empire Devices NF-105 and a Micro-Tel Wide Range receiver) were used to collect field strength data. A review of the above data shows that either instrument may be used. However, there are disadvantages in planning a future measurement system based on the NF-105 since the output of this equipment is of an analog format only. A second disadvantage is its limited dynamic range (10 dB) . To obtain wider range precision 10 dB attenuators are provided internally such that a total range of 100 dB is achievable. In contrast, the Micro-Tel Wide Range receiver has a 40 dB dynamic range and when used with a piece of equipment such as the Scientific-Atlanta Lin/Log display it can provide a continuous 40 dB output without switching. Through the use of the Lin/Log display unit, the user has the capability to collect data both in analog or digital format. The digital format is a very attractive option in view of the greater use engineers are making of digital computers today for data analysis.

In making the field strength measurements discussed here, the University of Michigan equipment used was the same as that used to make antenna measurements. During Mr. Ferris' visit, an attempt was made to collect data in the air using the University of Michigan equipment. However, no data were obtained because the large number of other near-by navigational aids operating at frequencies near those used by the Manheim Road VOR facility created interference. As a consequence, it was quite difficult to determine which signal was from the Manheim facility. This problem could be overcome through the use of a YIG filter.

It should be noted that two companies which make antenna pattern measuring equipment are;

Micro-Tel Corporation, 1406 Shoemaker Road
Baltimore, MD, 21209 (301) 823-6227

Scientific-Atlanta, Inc., P.O. Box 13654
Atlanta, GA 30324, (404) 938-2930 .

It is suggested that both of these organizations be contacted to learn more about their product line and how they may be used to satisfy NAFEC requirements.

3. Conclusion

The above summarizes the current status of the contract. During the coming period data will be collected from the full scale testing of the VOR parasitic loop counterpoise antenna.

TABLE I.

Patterns Below 150' Counterpoise
(Receiving Antenna-Dipole; Goniometer off)

	Raw Data			Normalized Data		
Ht.	415	SA	ED	415	SA	ED
75ft.	31.0dB	9.9 dB	86.5dB	0dB	0dB	0dB
70	31.4	10.1	86.2	0.4	0.2	0.3
65	32.6	11.7	84.5	1.6	1.6	2.0
60	33.4	12.4	83.8	2.4	2.5	2.7
55	33.2	12.2	84.0	2.2	2.3	2.5
50	35.8	14.7	81.0	4.8	4.8	5.5
45	34.6	13.6	82.7	3.6	3.7	3.8
40	35.6	14.7	81.4	4.6	4.8	5.1
35	39.4	18.4	78.8	8.4	8.5	7.7
30	36.4	15.4	80.5	5.4	5.5	6.0
25	39.6	18.7	77.5	8.6	8.8	9.0
20	42.2	21.5	75.3	11.2	11.6	11.2
15	39.4	19.4	78.5	8.4	9.5	8.0
10	42.4	21.0	74.5	11.4	11.1	12.0

10-13-70 Test at Manheim Ave. No. 001

NOTE: SA = Scientific Atlanta Meter, ED = Empire Device Meter,
415 = Hewlett-Packard Meter.

TABLE II.

Patterns Below 150' Counterpoise
(Receiving Antenna-Dipole; Goniometer off)

	Raw Data			Normalized Data		
Ht.	415	SA	ED	415	SA	ED
75ft.	31.0dB	10.0dB	83dB	0 dB	0dB	0dB
70	31.4	10.5	82.8	0.4	0.5	.2
65	32.6	11.9	81.8	1.6	1.9	1.2
60	33.2	12.1	82.3	2.2	2.1	0.7
55	33.3	12.3	81.9	2.3	2.3	1.1
50	35.1	14.4	80.5	4.1	4.4	2.5
45	34.2	13.4	81.7	3.2	3.4	1.3
40	35.5	14.8	79.5	4.5	4.8	3.5
35	40.2	19.4	76.5	9.2	9.4	6.5
30	36.4	15.2	80.5	5.4	5.2	2.5
25	41.4	20.5	74.9	10.4	10.5	8.1
20	43.2	22.2	73.2	12.2	12.2	9.8
15	38.8	18.1	77.0	7.8	8.1	5.0
10	42.6	21.9	73.3	11.6	11.9	9.7

10-13-70 Repeat of No. 001 No.002

TABLE III.

Patterns Below 150' Counterpoise
(Receiving Antenna-Dipole; Goniometer on)

	Raw Data			Normalized Data		
Ht.	415	SA	ED	415	SA	ED
75ft.	31.0dB	10.0dB	85.0dB	0dB	0dB	0dB
70	31.6	10.7	84.2	0.6	0.7	0.8
65	33.0	12.1	82.3	2.0	2.1	2.7
60	33.4	12.6	82.0	2.4	2.6	3.0
55	33.4	12.5	82.3	2.4	2.5	2.7
50	35.6	15.0	79.8	4.6	5.0	5.2
45	34.3	13.8	81.0	3.3	3.8	4.0
40	36.1	15.1	79.4	5.1	5.1	5.6
35	39.5	19.0	75.0	8.5	9.0	10
30	36.7	16.0	-	5.7	6.0	-
25	41.2	20.8	-	10.2	10.8	-
20	41.9	21.0	-	10.9	11.0	-
15	39.0	17.3	-	7.0	7.3	-
10	43.2	21.5	-	12.2	11.5	-

Repeat of No. 001 No. 003

NOTE: The readings of the ED meter below 30 feet are not dependable and hence are not included.

TABLE IV.
Patterns Below 150' Counterpoise
(Receiving Antenna-3 Element Yagi; Goniometer on)

	Raw Data			Normalized Data		
Ht.	415	SA	ED	415	SA	ED
75ft.	21.0dB	0.1dB	97.2dB	0dB	0dB	0dB
70	22.0	1.1	95.8	1.0	1.0	1.4
65	23.5	2.5	94.0	2.5	2.4	3.2
60	23.5	2.5	93.5	2.5	2.4	3.7
55	24.8	3.8	91.4	3.8	3.7	5.8
50	26.0	5.2	90.3	5.0	5.1	6.9
45	25.2	4.3	91.0	4.2	4.2	6.2
40	28.0	7.5	88.4	7.0	7.4	8.8
35	29.1	7.9	88.0	8.1	7.8	9.2
30	28.2	7.5	88.6	7.2	7.4	8.6
25	35.4	14.3	81.5	14.4	14.2	15.7
20	29.8	9.4	87.5	8.6	9.3	9.7
15	31.7	10.7	85.3	10.7	10.6	11.9
10	35.8	14.8	81.0	14.8	14.7	16.2

10-13-70 No. 004

TABLE V.

Patterns Below 150' Counterpoise
(Receiving Antenna-3 Element Yagi; Coniometer off)

	Raw Data			Normalized Data		
Ht.	415	SA	ED	415	SA	ED
75ft.	21.0dB	0.9dB	95.1dB	0dB	0dB	0dB
70	22.4	1.4	93.3	1.4	1.4	1.8
65	23.8	2.9	91.9	2.8	2.9	3.2
60	23.7	3.1	92.3	2.7	3.1	2.8
55	25.0	4.3	90.7	4.0	4.3	4.4
50	26.4	5.8	89.1	5.4	5.8	6.0
45	25.7	5.0	89.8	4.7	5.0	5.3
40	28.5	8.0	86.9	7.5	8.0	8.2
35	28.6	7.7	86.7	7.6	7.7	8.4
30	28.8	8.5	86.2	7.8	8.5	8.9
25	36.6	16.1	78.5	15.6	16.1	16.6
20	30.0	9.6	84.7	9.0	9.6	10.4
15	32.5	11.8	82.2	11.5	11.8	11.9
10	36.8	16.4	77.8	15.8	16.4	17.3

10-13-70 No. 005

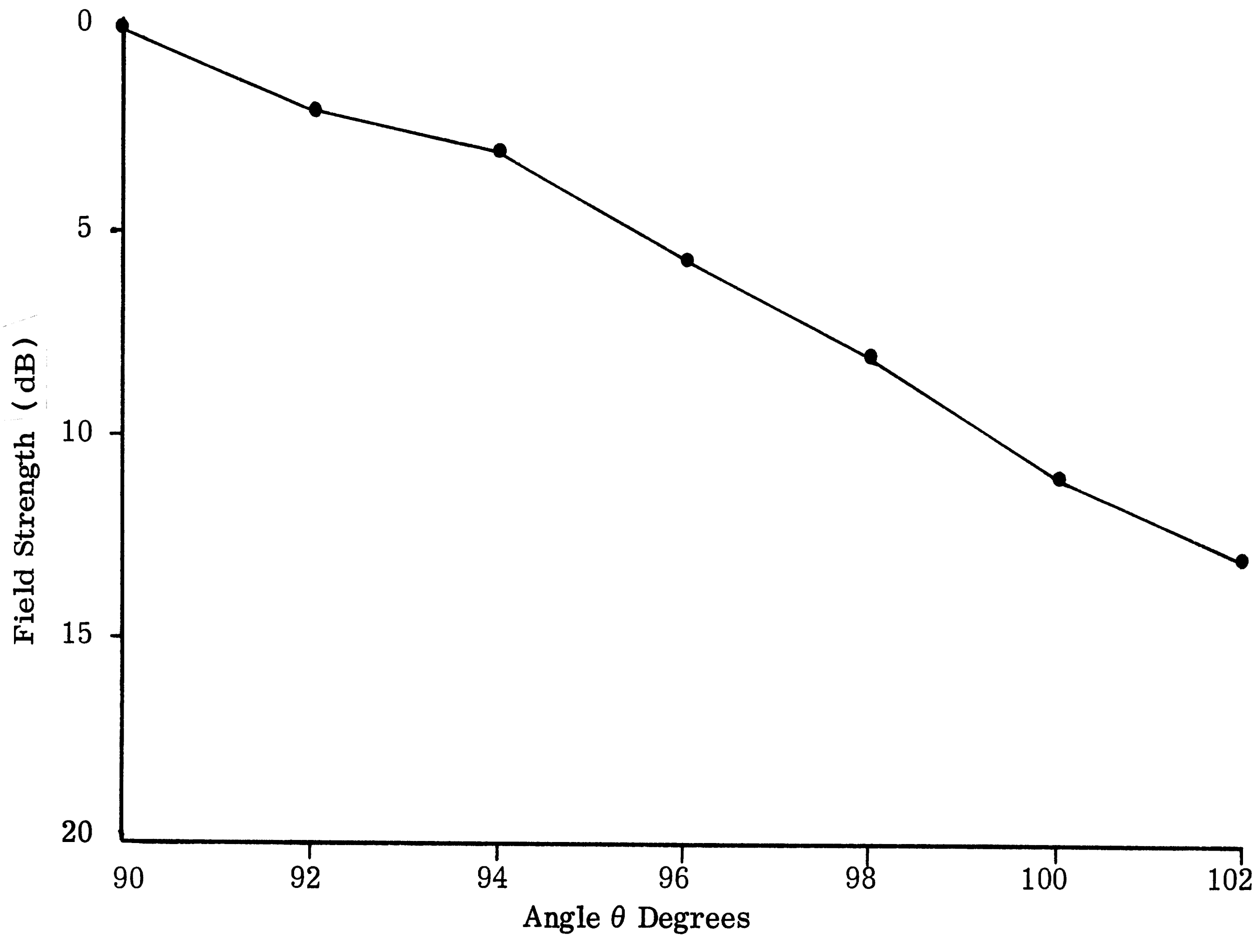

FIG. 1: 1/10 Scale Model of Manheim Facility in Free Space as determined by theory and experiment.

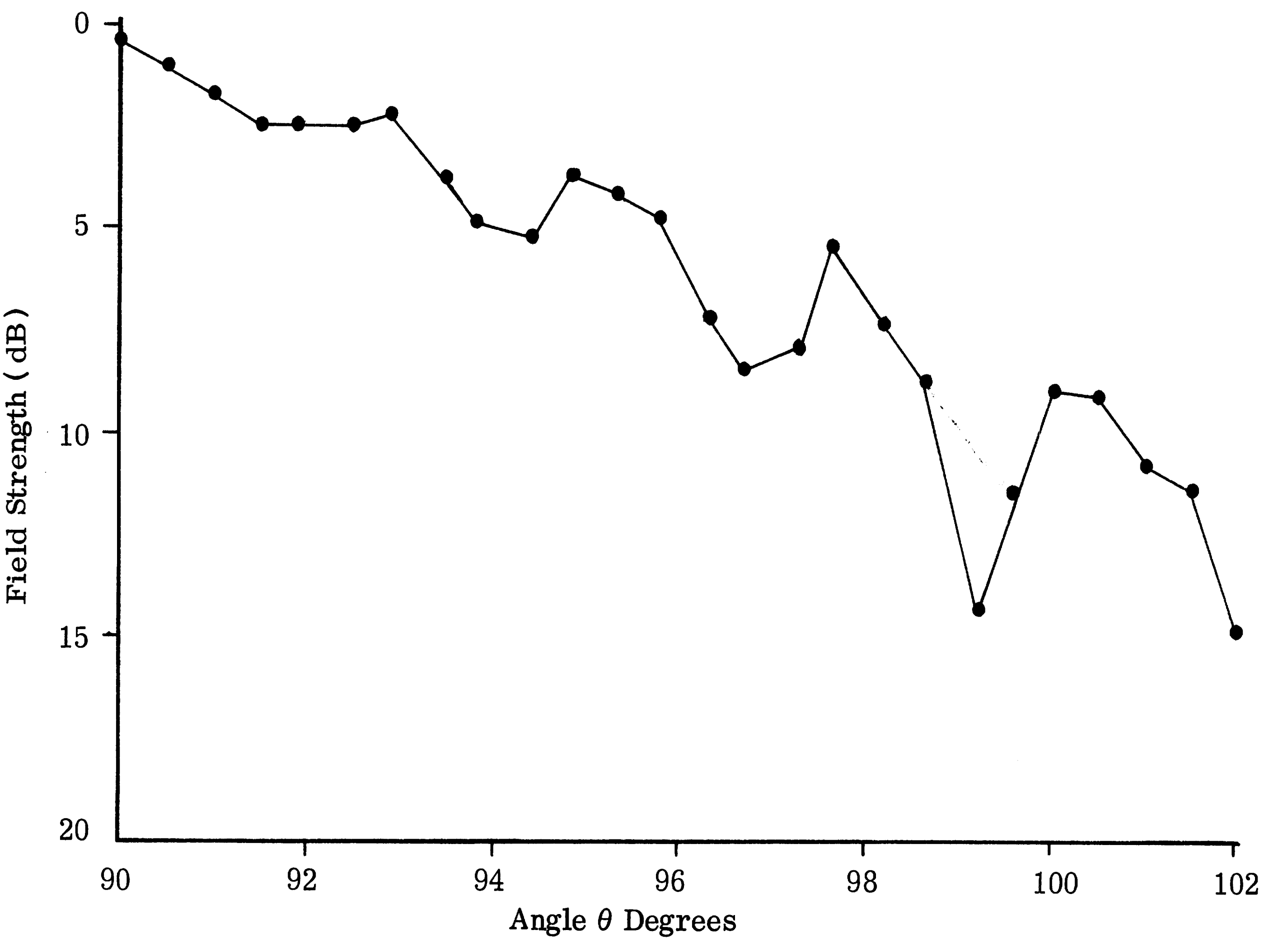

FIG. 2: Field Strength Produced by the Full Scale Manheim Facility (using University of Michigan Equipment at NAFEC).