NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO
VERY LARGE ARRAY PROJECT

VLA ELECTRONICS MEMORANDUM NO. 162

ESTIMATION OF THE ACCURACY OF THE PULSE REFLECTION TEST SET FOR HELIX WAVEGUIDE ATTENUATION MEASUREMENTS

J.W. Archer

October 1977

1.0 INTRODUCTION

A number of factors contribute to the errors involved in the measurement of the total round trip attentuation of a length of helix waveguide using the pulse reflection test set. Consequently, the range of attentuation values that may be accurately measured with the equipment is restricted.

Provided that the preliminary adjustment of the test set has been correctly carried out, the error sources may be broadly classified as follows:

a) errors due to departure of the pulse detection system response from a square law characteristic, including the effects of pulse amplifier saturation and pulse amplifier D.C. offsets.

b) uncertainty due to random fluctuations in the output record due to test system noise.

c) errors in calibration and setting up of shutter.

Each classification will now be examined in more detail.

2.0 CHARACTERISTICS OF PULSE DETECTION SYSTEM

Two diode detector/video amplifier units are available for use with the test set. Both have been tested (with the same test set) to investigate the accuracy of the power low response. The measurements were made with the test set set up to measure the attentuation of a 2.8 km length of waveguide. The mean "reference" and "signal" reflected pulse energy values were recorded as the transmitted pulse power was varied. The test configuration is shown in Figure 1.

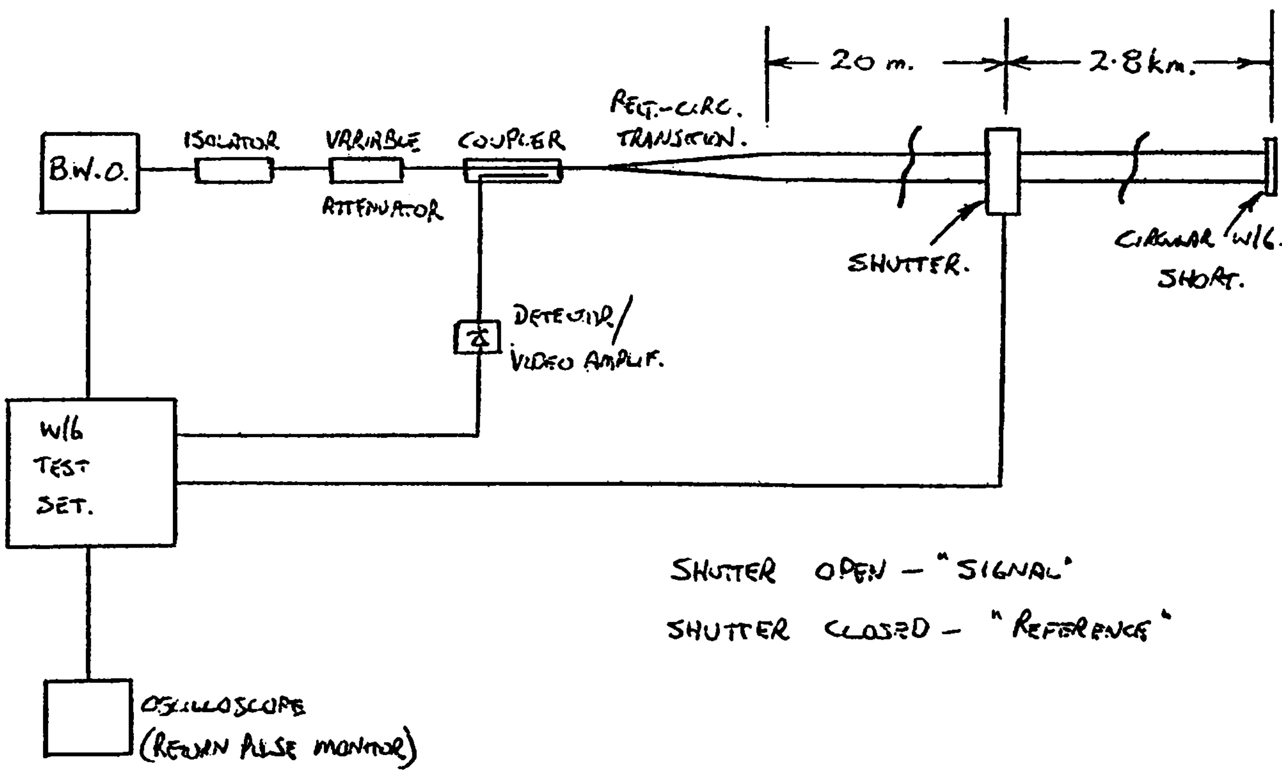


FIGURE 1

The resulting mean response, for signal and reference pulses centered in the detection gate, is shown in Figure 2. For detector No. 1 the law is given by:

$$V_{out} = (P_{in})^{9.990 \pm 0.005} \qquad \text{(@ 40 GHz)}$$

and saturation occurs at a return (reference) pulse height of about 0.25 V, as observed on the CRO. This condition corresponds to an attenuator setting of about 15 dB.

For detector No. 2 the law is:

$$V_{out} = (P_{in})^{0.9815 \pm 0.005} \qquad \text{(@ 40 GHz)}$$

with saturation at 0.20 V pulse height, corresponding to an attenuator setting of about 16.5 dB.

The measurement error due to non-power law responses is a function of the total round trip waveguide attenuation. The error as a function of one-way attenuation is plotted in Figure 3 for both detectors. Although this source of error is not presently compensated for in routine test set measurements, it can readily be taken into account using the curves of Figure 3.

The return "reference" pulse height should be kept less than 0.2 volts peak on the monitor CRO screen to avoid errors due to pulse amplifier saturation.

3.0 TEST SET NOISE

The meter readings in "ratio" mode at a fixed frequency vary continuously at a fixed waveguide attenuation due to system noise fluctuations and sampling errors. The rms deviation from the mean value has been determined by noting the meter values at each sample over a period of 10 minutes and performing the appropriate statistics. The rms error due to system noise is once again a function of total waveguide attenuation. The rms variation in the ratio count remains essentially independent of varying waveguide attenuation at a value of ± 10 counts. The estimated uncertainty in measured round trip attenuation is shown as a function of one-way waveguide attenuation in Figure 4.

4.0 SHUTTER ALIGNMENT ERRORS

For swept measurements, errors arise due to the misalignment between the shutter and the waveguide axis. Such offsets give rise to variations in the power reflected from the shutter as a function of frequency which should, in principle, be able to be calibrated during the initial setting up procedure. If this is not done at each sample frequency, then a typical peak-to-peak variation in the "reference" pulse measurement with frequency of about ± 20 counts (about 5000) is observed. This corresponds to a peak error of 0.02 dB in measured attenuation when the data is normalized to a count of 5000.

5.0 CONCLUSIONS

Figure 5 shows the total expected rms error in a single frequency measurement of waveguide attenuation due to test set errors and noise, as a function of the total one-way attenuation of the waveguide under test. For waveguide attenuation near 1.2 dB/km, the error remains less than ± 0.05 dB/km rms as total waveguide attenuation increases, provided total waveguide one-way length is less than 10 km. The uncertainties given by Figure 5 are valid provided the data is normalized by the corrected "reference" data from the shutter tests. If 5000 is assumed the nominal value for the shutter/short tests, then a further constant uncertainty of ± 0.02 dB must be added to the above results for swept measurements.

FIGURE 2

DETECTOR NO. 1.

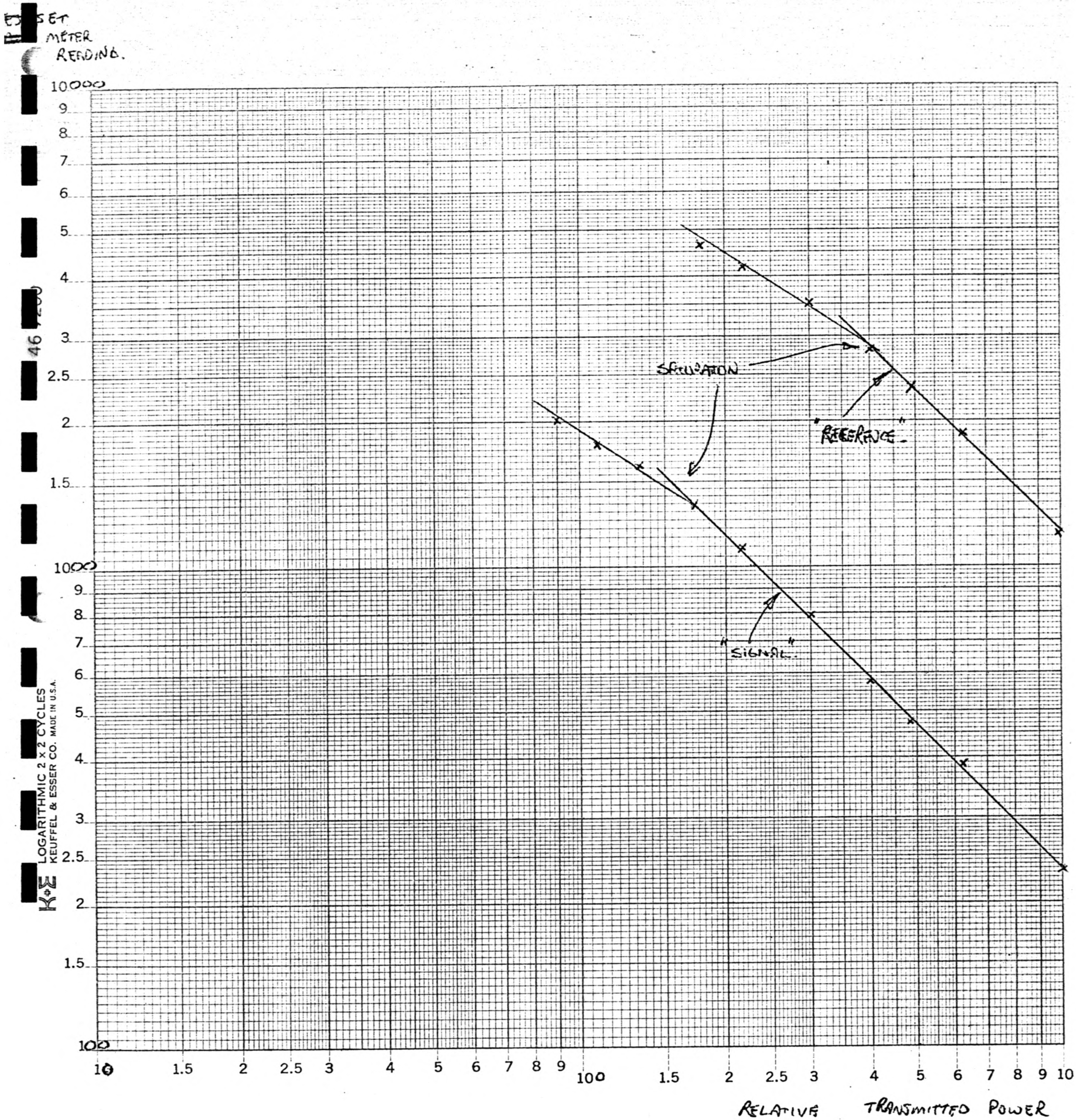
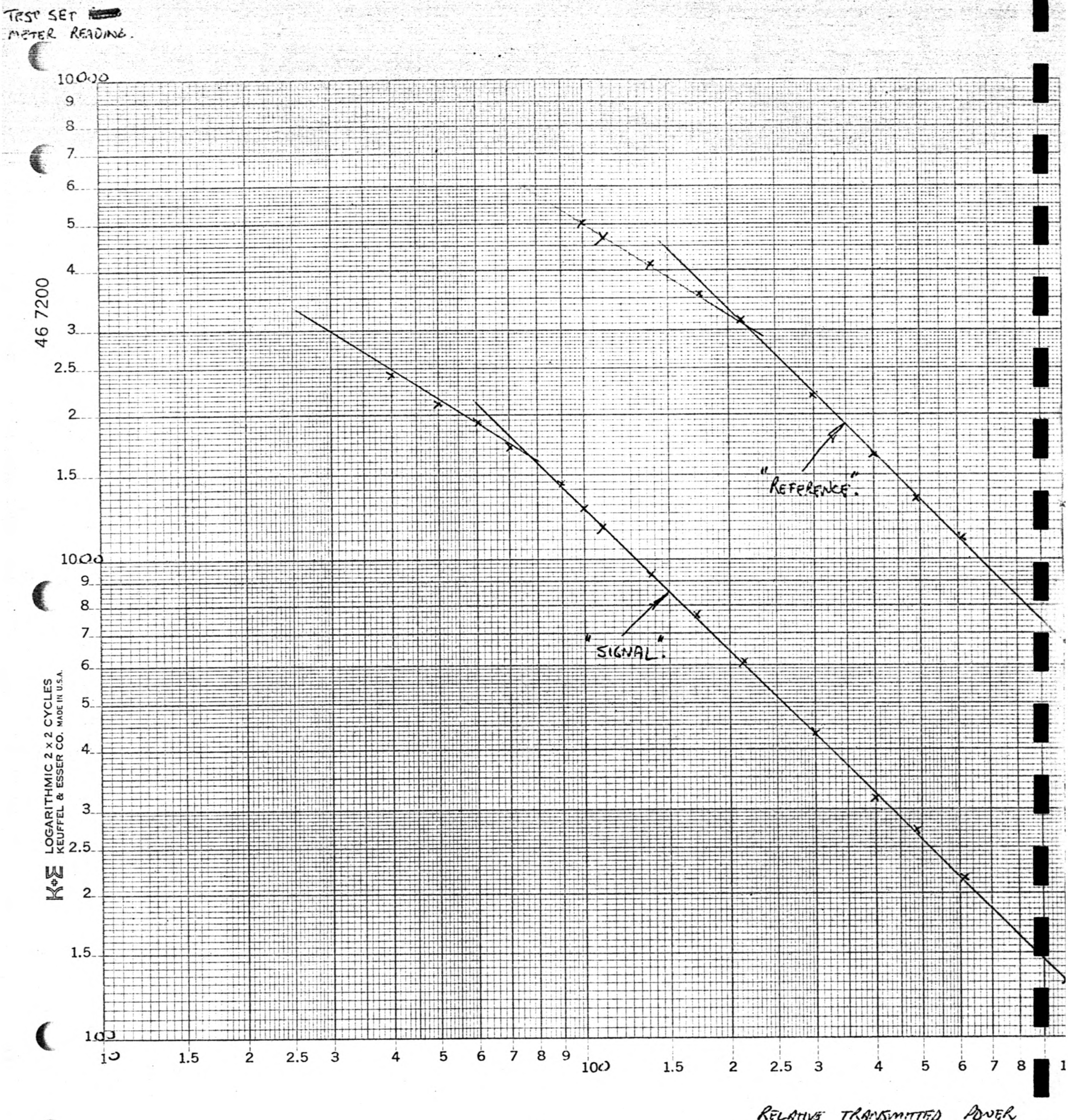


FIGURE 2

DETECTOR NO. 2.



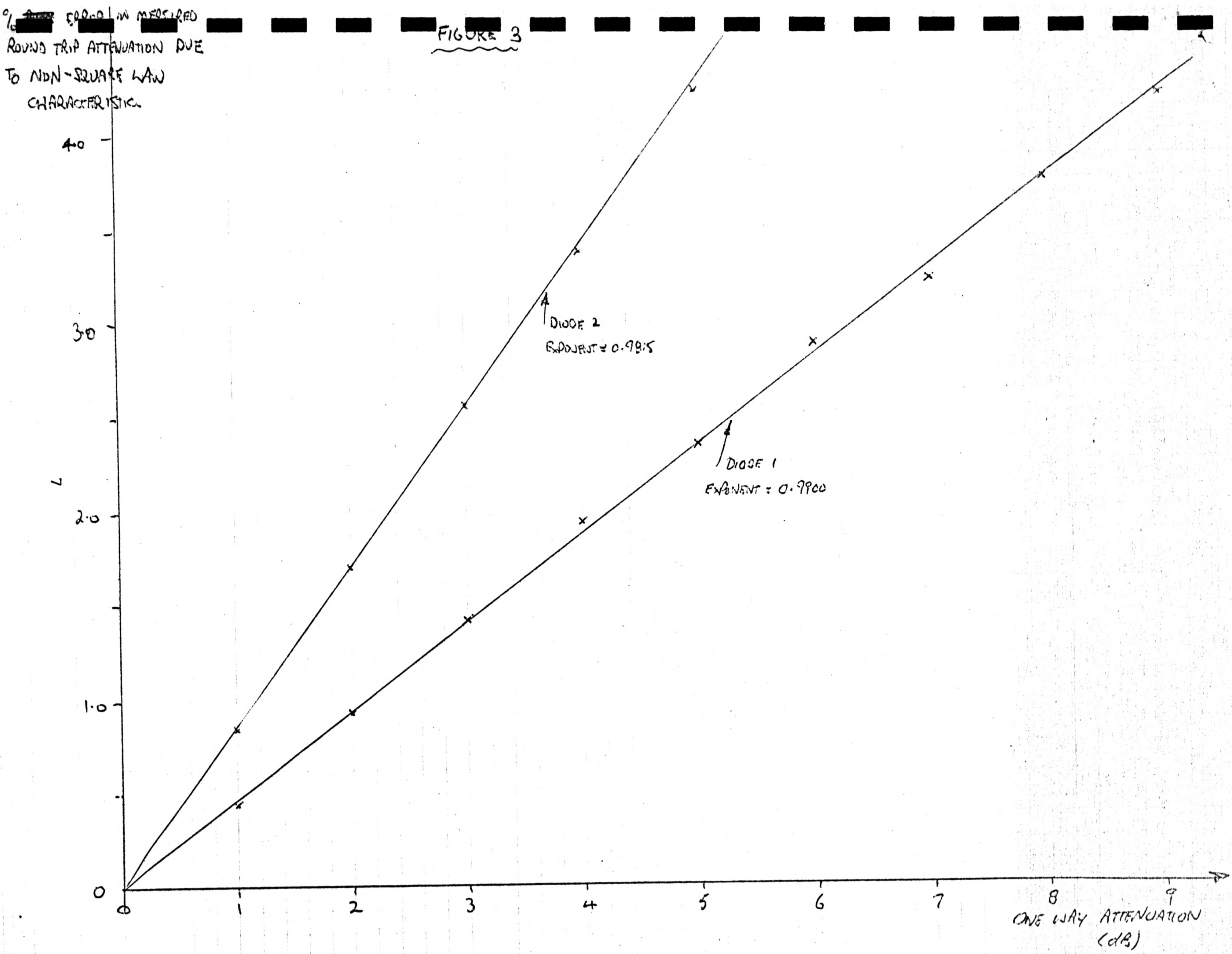
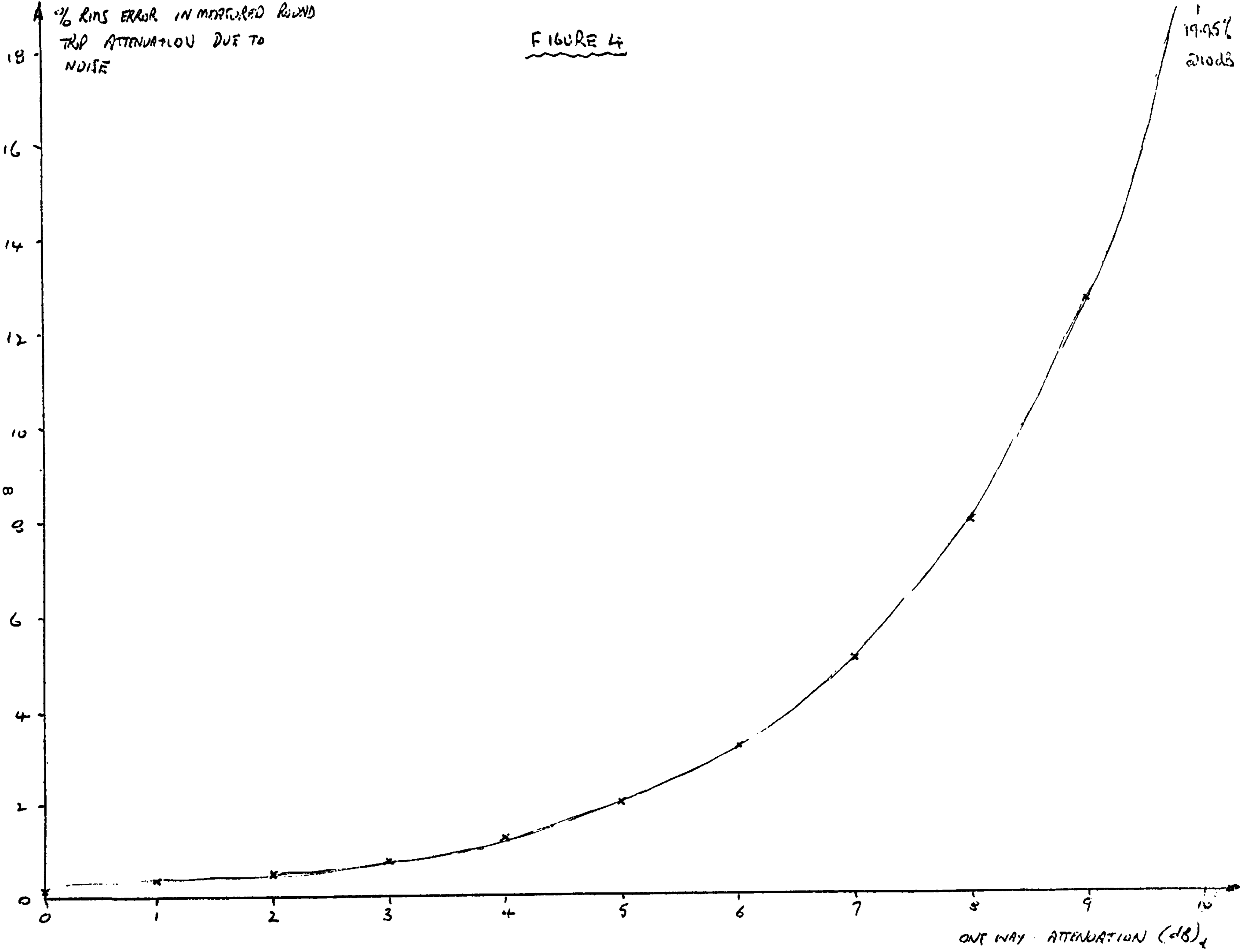

% [redacted] ERROR IN MEASURED
ROUND TRIP ATTENUATION DUE
TO NON-SQUARE LAW
CHARACTERISTIC
4.0
3.0
2.0
1.0
0
DIODE 2
EXPONENT = 0.9815
DIODE 1
EXPONENT = 0.9900
0
1
2
3
4
5
6
7
8
9
ONE WAY ATTENUATION
(dB)

FIGURE 3

FIGURE 4


% RMS ERROR IN MEASURED ROUND TRIP ATTENUATION DUE TO NOISE
19.95% @10dB
ONE WAY ATTENUATION (dB)
0
1
2
3
4
5
6
7
8
9
10
2
4
6
8
10
12
14
16
18

FI[redacted] 5[redacted]

DETECTOR No. 1