

GLD1907



**MONTANA COLLEGE OF MINERAL SCIENCE AND TECHNOLOGY**  
**BUTTE, MONTANA 59701**

February 25, 1987

Howard P. Ross  
University of Utah Research Institute  
Earth Science Laboratory  
391 Chipeta Way, Suite C  
Salt Lake City, Utah 84108-1295

Dear Howard,

Enclosed is the data on the rock samples you sent up. We had to saw one of the samples as it split after saturation. I'll send along an invoice with the samples.

Regards,

A handwritten signature in cursive script, appearing to read "W. R. Sill".

William R. Sill, Chair  
Department of Physics and  
Geophysical Engineering

Encl:

WRS:wi

## ELECTRICAL MEASUREMENTS - SAMPLES 4228, 4450, 4625, 4733

Electrical measurements were performed on four core samples of volcanic rock. The summary of the measurements are presented in Table 1. Listings of the data and plots of the amplitude and phase as a function of frequency are in the Appendix. The frequency range of the measurements is  $10^{-2}$  to  $10^2$  Hz. Two different solutions of NaCl were used to saturate the samples under vacuum; these were .01 and .1 molar. After soaking in these solutions for several days the resistivity of the bath solution was measured. The .01 M solution "equilibrated" at 5  $\Omega\text{m}$  and the .1 M at 1  $\Omega\text{m}$ . At the lower salinity there was an obvious contamination of the .01 M salt solution by residual "salts" in the samples and this is fairly typical. Extrapolation of the 1  $\Omega\text{m}$  and 5  $\Omega\text{m}$  data to a solution resistivity of 10  $\Omega\text{m}$  gives the results in the last column of Table 1.

Porosity was determined from the difference in wet and dry weights and the volume of the sample. Sample 4228 had a very low porosity and this was checked several times. This sample also has a measured resistivity that is independent of the solution resistivity, indicating that surface conduction is the dominant process in this sample. The other samples show a more normal change in resistivity with solution resistivity which indicates a more typical trade off between bulk pore water conduction and surface conduction.

TABLE 1  
SUMMARY OF MEASUREMENTS

Sample (wrt KB)	D (cm)	L (cm)	Porosity (%)	$\rho_r$ ( $\Omega m$ ) in $\rho_w = 5\Omega m$	$\rho_r$ ( $\Omega m$ ) in $\rho_w = 1\Omega m$	$\rho_r$ ( $\Omega m$ ) extrapolated to $\rho_w = 10\Omega m$
4228	4.7	12.3	.5 (?)	236 (?)	245	240
4450	4.7	11.9	10.6	15.0	11.5	17
4625	4.7	6.9	14.8	28.4	16.1	36
4733	4.7	12.3	16.3	18.5	12.8	22

Porosity determined from wet and dry weight measurements

$\rho_w$  = measured resistivity of saturating solution

APPENDIX 1

DATA LISTINGS

FILE: UURI\_4228M SAMPLE: 4228 Date: FEB0987

Temp.: 24.4 °C Geometric Factor: .0141 Solution resistivity: 5.18 ohm-m

Frequency (Hz)	Resistivity (ohm-m)	Phase Diff. (rad)
9.766E-03	2.358E+02	-2.558E-03
1.953E-02	2.357E+02	-1.759E-03
3.906E-02	2.360E+02	-2.398E-03
9.766E-02	2.355E+02	-2.056E-03
1.953E-01	2.352E+02	-3.202E-03
3.906E-01	2.348E+02	-3.662E-03
9.766E-01	2.344E+02	-6.215E-03
1.953E+00	2.339E+02	-1.004E-02
3.906E+00	2.327E+02	-1.457E-02
9.766E+00	2.297E+02	-2.043E-02
1.953E+01	2.273E+02	-1.958E-02
3.906E+01	2.256E+02	-1.789E-02
9.766E+01	2.238E+02	-2.010E-02

FILE: UURI\_4450M SAMPLE: 4450 Date: FEB1087

Temp.: 22.7 °C Geometric Factor: .0146 Solution resistivity: 5.18 ohm-m

Frequency (Hz)	Resistivity (ohm-m)	Phase Diff. (rad)
9.766E-03	1.525E+01	-1.311E-03
1.953E-02	1.514E+01	-2.311E-03
3.906E-02	1.507E+01	-1.770E-03
9.766E-02	1.497E+01	-2.463E-03
1.953E-01	1.493E+01	-2.863E-03
3.906E-01	1.490E+01	-3.428E-03
9.766E-01	1.483E+01	-4.174E-03
1.953E+00	1.478E+01	-4.541E-03
3.906E+00	1.474E+01	-5.048E-03
9.766E+00	1.468E+01	-5.704E-03
1.953E+01	1.463E+01	-5.273E-03
3.906E+01	1.458E+01	-4.602E-03
9.766E+01	1.454E+01	-4.762E-03

FILE: UURI\_4625M SAMPLE: 4625 Date: FEB1287

Temp.: 23.8 °C Geometric Factor: .0251 Solution resistivity: 5.18 ohm-m

Frequency (Hz)	Resistivity (ohm-m)	Phase Diff. (rad)
9.766E-03	2.821E+01	-4.357E-03
1.953E-02	2.810E+01	-4.189E-03
3.906E-02	2.800E+01	-3.959E-03
9.766E-02	2.790E+01	-5.350E-03
1.953E-01	2.782E+01	-5.833E-03
3.906E-01	2.774E+01	-5.860E-03
9.766E-01	2.764E+01	-6.140E-03
1.953E+00	2.755E+01	-6.485E-03
3.906E+00	2.747E+01	-6.724E-03
9.766E+00	2.735E+01	-6.778E-03
1.953E+01	2.726E+01	-6.368E-03
3.906E+01	2.718E+01	-6.107E-03
9.766E+01	2.710E+01	-5.305E-03

FILE: UURI\_4733M SAMPLE: 4733 Date: FEB0987

Temp.: 24.4 °C Geometric Factor: .0141 Solution resistivity: 5.18 ohm-m

Frequency (Hz)	Resistivity (ohm-m)	Phase Diff. (rad)
9.766E-03	1.805E+01	-2.930E-03
1.953E-02	1.812E+01	-3.791E-03
3.906E-02	1.813E+01	-3.611E-03
9.766E-02	1.807E+01	-4.969E-03
1.953E-01	1.821E+01	-5.364E-03
3.906E-01	1.820E+01	-6.239E-03
9.766E-01	1.816E+01	-7.203E-03
1.953E+00	1.812E+01	-8.007E-03
3.906E+00	1.807E+01	-9.026E-03
9.766E+00	1.798E+01	-9.725E-03
1.953E+01	1.792E+01	-9.836E-03
3.906E+01	1.786E+01	-9.573E-03
9.766E+01	1.779E+01	-9.520E-03



FILE: 4228\_UURIm SAMPLE: 4228 Date: FEB1687

Temp.: 21.6 °C Geometric Factor: .0141 Solution resistivity: 1.20 ohm-m

Frequency (Hz)	Resistivity (ohm-m)	Phase Diff. (rad)
9.766E-03	2.448E+02	-2.423E-03
1.953E-02	2.451E+02	-7.562E-04
3.906E-02	2.450E+02	-1.792E-03
9.766E-02	2.446E+02	-2.190E-03
1.953E-01	2.444E+02	-3.089E-03
3.906E-01	2.442E+02	-3.960E-03
9.766E-01	2.438E+02	-5.995E-03
1.953E+00	2.432E+02	-9.642E-03
3.906E+00	2.421E+02	-1.473E-02
9.766E+00	2.388E+02	-2.131E-02
1.953E+01	2.363E+02	-1.975E-02
3.906E+01	2.344E+02	-1.820E-02
9.766E+01	2.325E+02	-2.099E-02

FILE: 4450\_UURIm SAMPLE: 4450 Date: FEB1987

Temp.: 21.8 °C Geometric Factor: .0146 Solution resistivity: 1.20 ohm-m

Frequency (Hz)	Resistivity (ohm-m)	Phase Diff. (rad)
9.766E-03	1.146E+01	-3.004E-03
1.953E-02	1.139E+01	-2.525E-03
3.906E-02	1.134E+01	-2.961E-03
9.766E-02	1.130E+01	-3.095E-03
1.953E-01	1.128E+01	-3.243E-03
3.906E-01	1.125E+01	-3.497E-03
9.766E-01	1.122E+01	-3.858E-03
1.953E+00	1.119E+01	-4.273E-03
3.906E+00	1.116E+01	-4.683E-03
9.766E+00	1.112E+01	-5.181E-03
1.953E+01	1.109E+01	-5.095E-03
3.906E+01	1.106E+01	-4.970E-03
9.766E+01	1.103E+01	-4.812E-03

FILE: 4625\_UURIm SAMPLE: 4625 Date: FEB1987

Temp.: 21.6 °C Geometric Factor: .0251 Solution resistivity: 1.20 ohm-m

Frequency (Hz)	Resistivity (ohm-m)	Phase Diff. (rad)
9.766E-03	1.578E+01	-4.532E-03
1.953E-02	1.574E+01	-4.218E-03
3.906E-02	1.570E+01	-4.643E-03
9.766E-02	1.564E+01	-4.761E-03
1.953E-01	1.560E+01	-4.999E-03
3.906E-01	1.556E+01	-5.364E-03
9.766E-01	1.550E+01	-5.623E-03
1.953E+00	1.546E+01	-6.202E-03
3.906E+00	1.541E+01	-6.248E-03
9.766E+00	1.534E+01	-6.792E-03
1.953E+01	1.529E+01	-6.522E-03
3.906E+01	1.524E+01	-6.184E-03
9.766E+01	1.519E+01	-6.456E-03

FILE: 4733\_UURIm SAMPLE: 4733 Date: FEB1987

Temp.: 22.0 °C Geometric Factor: .0141 Solution resistivity: 1.20 ohm-m

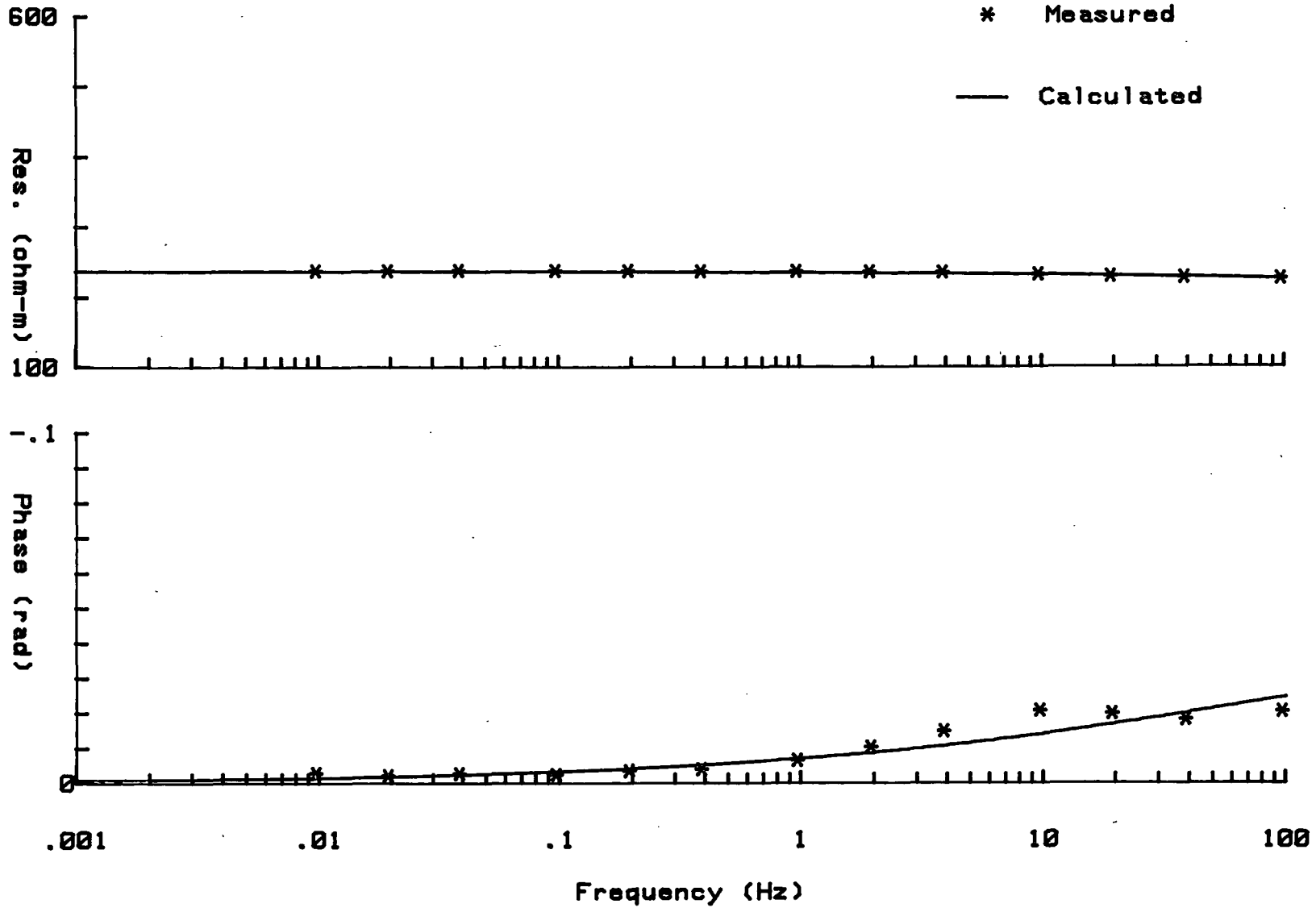
Frequency (Hz)	Resistivity (ohm-m)	Phase Diff. (rad)
9.766E-03	1.269E+01	-4.449E-03
1.953E-02	1.265E+01	-3.975E-03
3.906E-02	1.261E+01	-4.193E-03
9.766E-02	1.257E+01	-4.611E-03
1.953E-01	1.253E+01	-4.996E-03
3.906E-01	1.250E+01	-5.775E-03
9.766E-01	1.245E+01	-6.550E-03
1.953E+00	1.241E+01	-7.245E-03
3.906E+00	1.236E+01	-8.422E-03
9.766E+00	1.229E+01	-9.409E-03
1.953E+01	1.224E+01	-9.637E-03
3.906E+01	1.218E+01	-1.019E-02
9.766E+01	1.210E+01	-1.066E-02

## APPENDIX 2

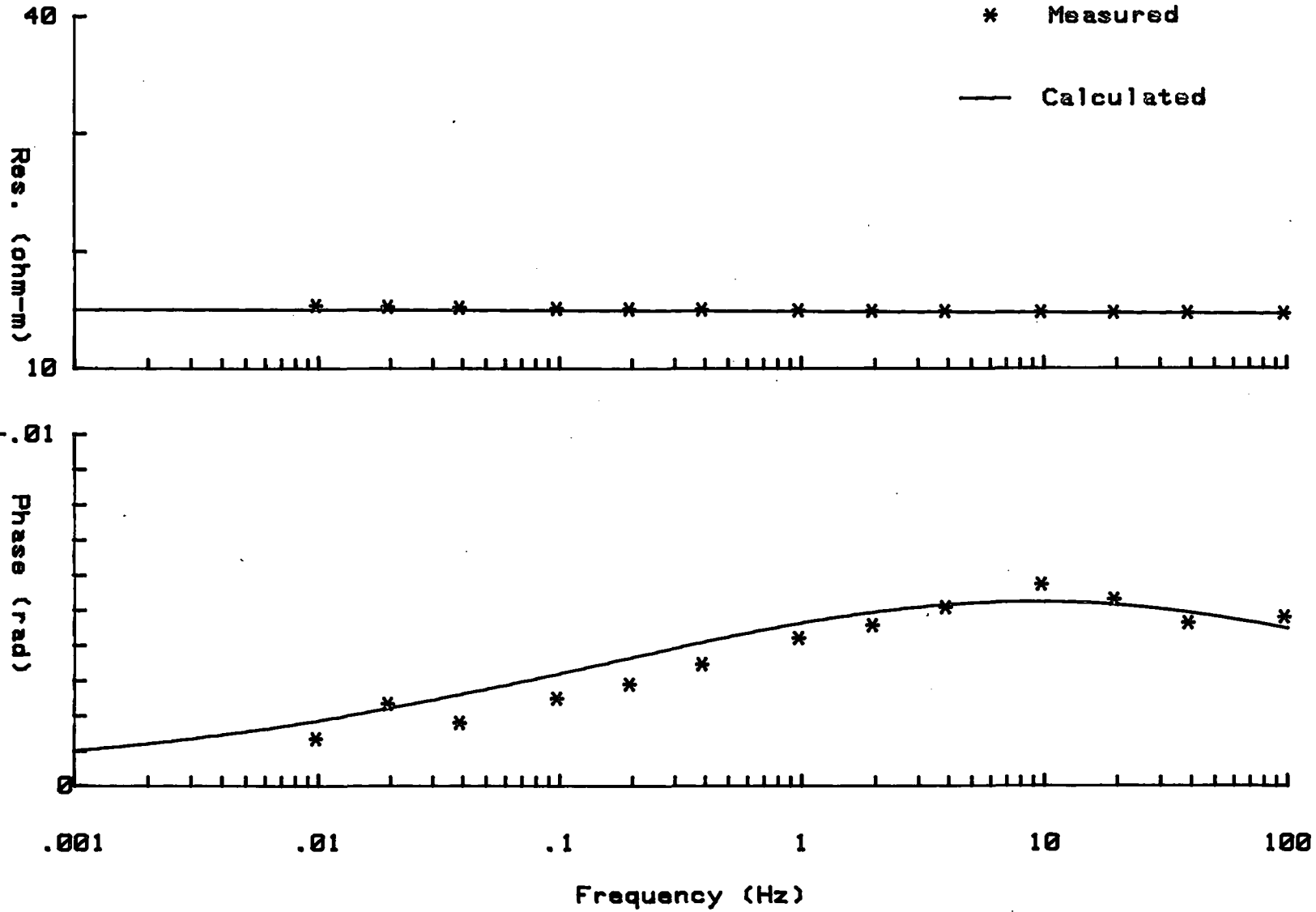
PLOTS OF AMPLITUDE AND PHASE

AT  $R_{\omega} = 5$  ohm-meter

FILE: UURI\_4228M SQUARE ERROR: .7 ohm-m  
R= 236.5 ohm-m M= .21 T= .0001 s C= .36



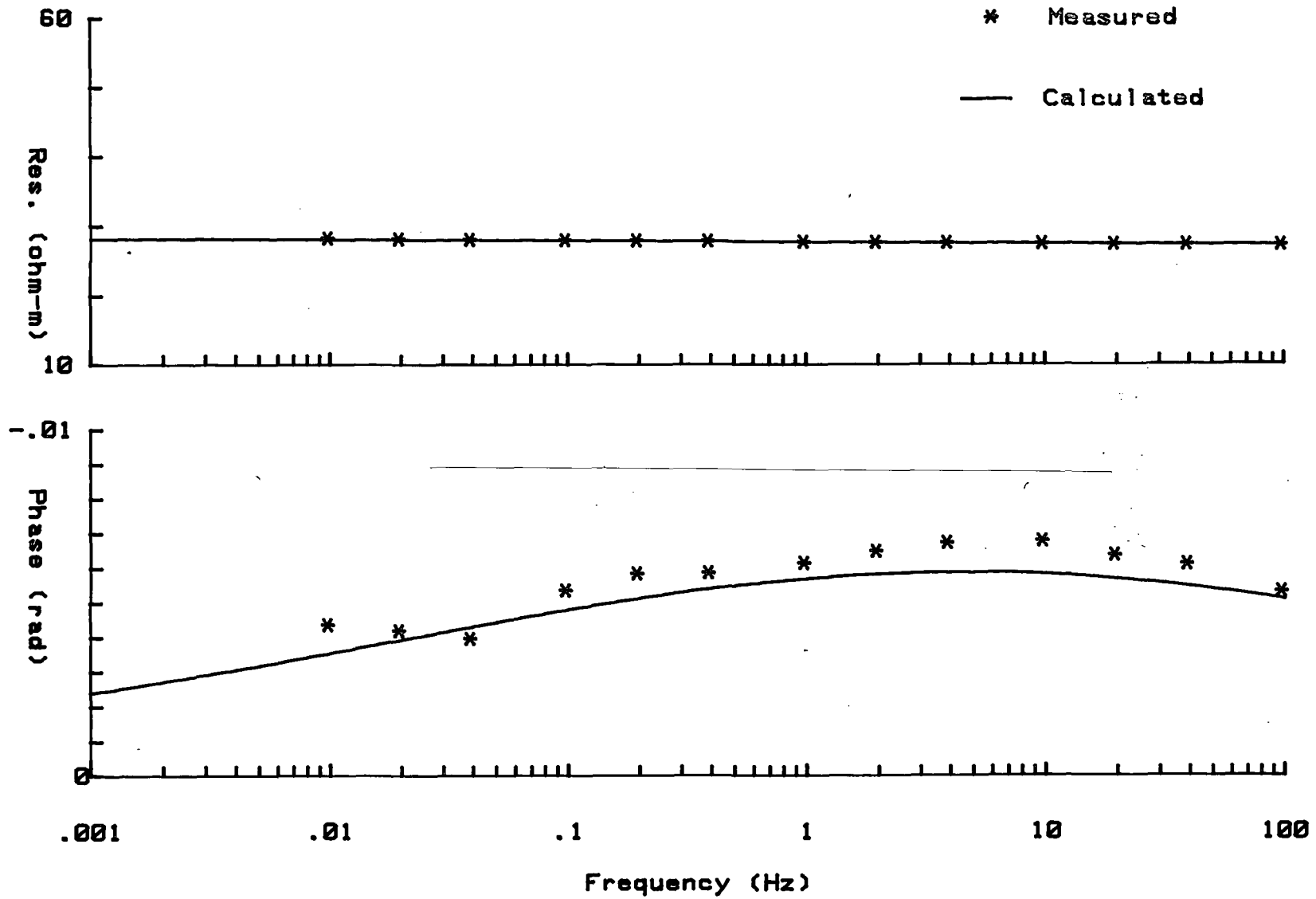
FILE: UURI\_4450M    SQUARE ERROR:    .1 ohm-m  
R= 15.0 ohm-m    M= .04    T= .0200 s    C= .32



FILE: UURI\_4625M    SQUARE ERROR:    .1 ohm-m  
R= 28.4 ohm-m    M= .06    T= .0430 s    C= .24

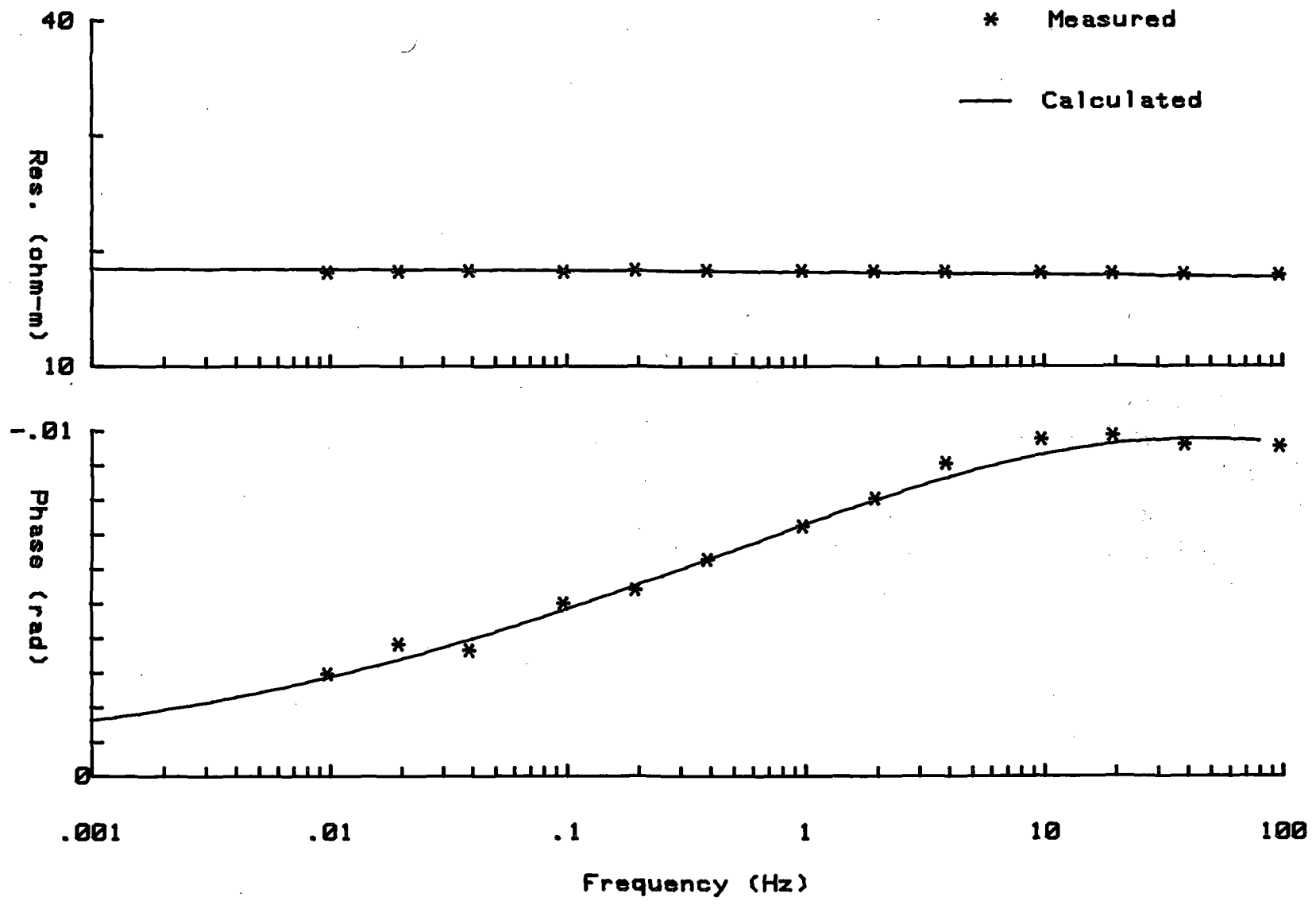
\* Measured

— Calculated





FILE: UURI\_4733M SQUARE ERROR: .1 ohm-m  
R= 18.5 ohm-m M= .08 T= .0042 s C= .29

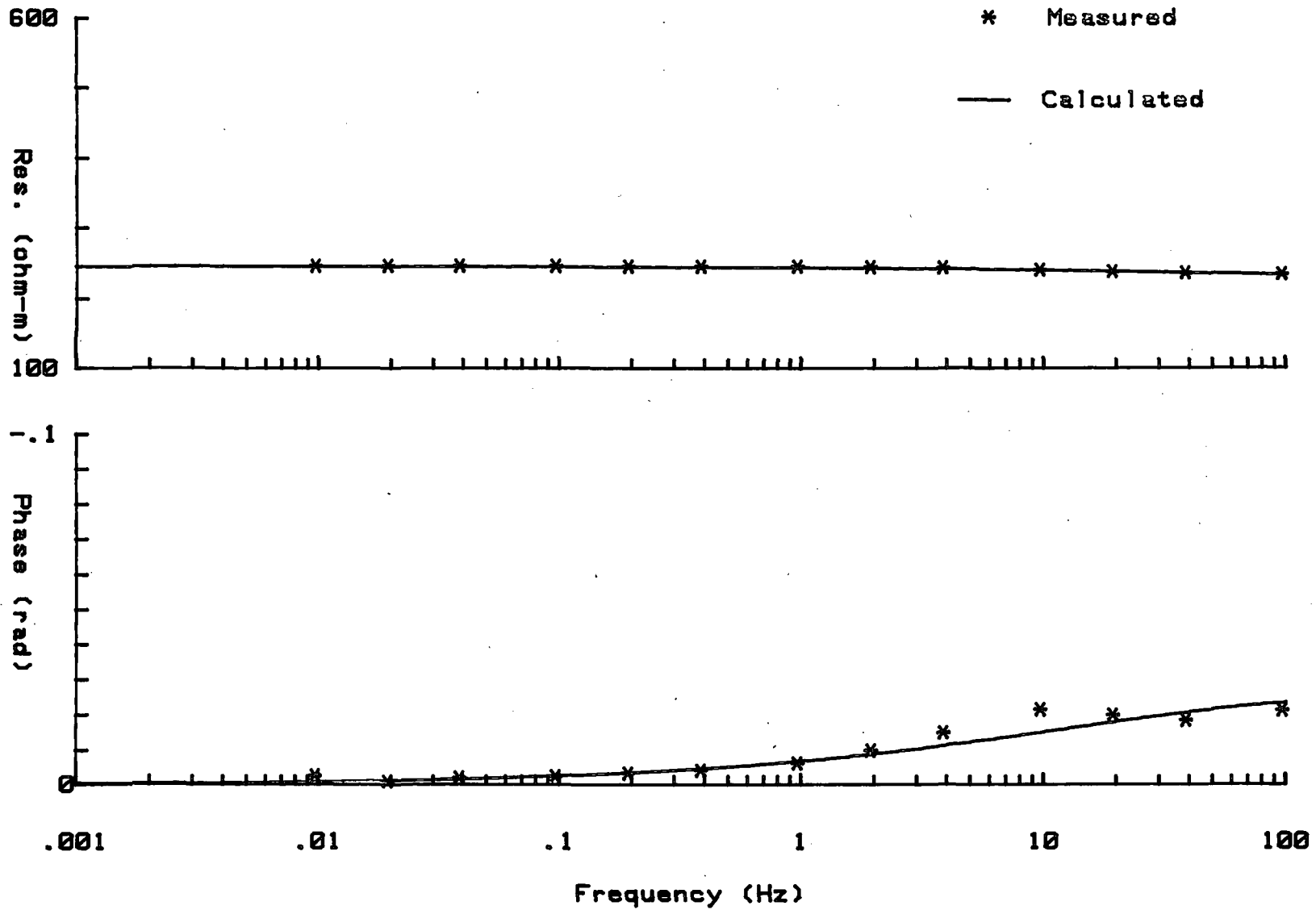


APPENDIX 3

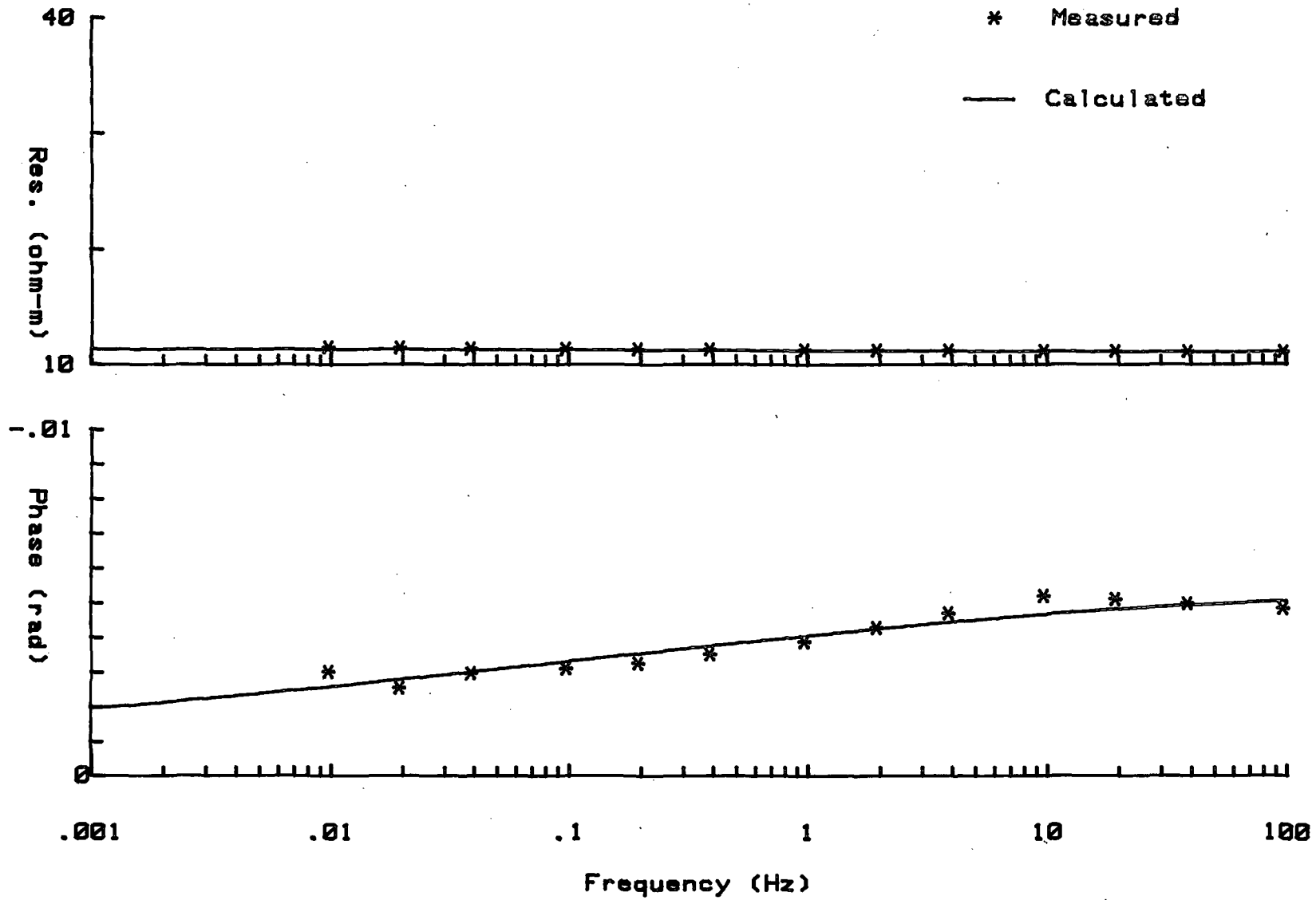
PLOTS OF AMPLITUDE AND PHASE

AT  $R_{\omega} = 1$  ohm-meter

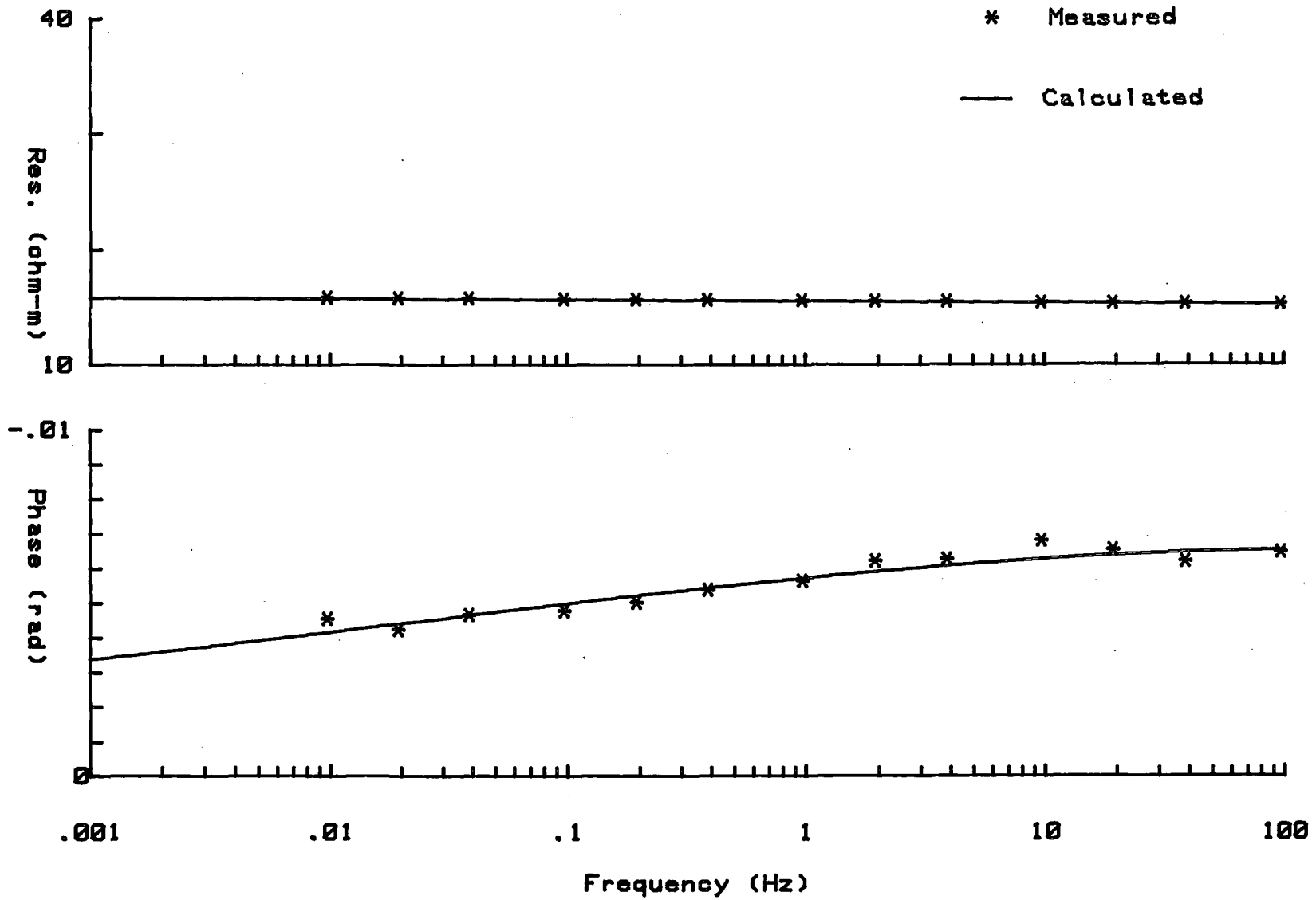
FILE: 4228\_UURIm SQUARE ERROR: .6 ohm-m  
R= 245.3 ohm-m M= .12 T= .0009 s C= .44



FILE: 4450\_UURIm SQUARE ERROR: .03 ohm-m  
R= 11.47 ohm-m M= .08 T= .0006 s C= .16



FILE: 4625\_UURIm SQUARE ERROR: .02 ohm-m  
R= 16.10 ohm-m M= .11 T= .0014 s C= .14



FILE: 4733\_UURIm SQUARE ERROR: .02 ohm-m  
R= 12.78 ohm-m M= .10 T= .0014 s C= .23

