

Interaction Application Memos

Memo 37

Free Space Scale Model Measurements of the A-7E

ABSTRACT

Frequency domain data are presented for the surface currents and charges measured in an anechoic chamber on an A-7E model to simulate the aircraft response in a free space environment. A model 1/48 in scale was measured over the frequency range 118 to 4400 MHz, simulating 2.46 to 91.7 MHz full scale. Data for 49 transfer functions are presented. These include ten test points measured for three excitations chosen to correspond to those used in the ATHAMAS I (HPD) and ATHAMAS II (VPD) full scale measurements.

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PREFACE

The author is indebted to H. Yoon who performed the measurements, W. Rasey who typed the manuscript and, last but not least, W. D. Prather of AFWL/NTMOP for his support and encouragement.

I. INTRODUCTION

The data presented here were obtained for the Air Force Weapons Laboratory and Defense and Space Systems Group of TRW, Inc., to determine the surface response extrapolation function [1] for the A-7E aircraft. The test points and excitation conditions were chosen to correspond to those of the full scale measurements made in the ATHAMAS I (Horizontally Polarized Dipole) and ATHAMAS II (Vertically polarized Dipole) simulators at Kirtland AFB.

Data are presented for ten locations or test points on the aircraft under three different excitation conditions: (i) top incidence, E parallel to the fuselage; (ii) top incidence, E perpendicular to the fuselage; and (iii) nose-on incidence, E vertical. The measured quantities are the axial surface current density component J_a , the circumferential surface density component J_c , and the normal electric field component E_n . Of the 90 measurement situations possible, 49 dominant ones were selected and measured. The results are presented in the form of amplitude and phase plots as functions of the full scale frequency. Data in digital form on magnetic tape (IBM format) have been furnished to TRW.

[1] Carl E. Baum, "Extrapolation Techniques for Interpretating the Results of Tests in EMP Simulators in Terms of EMP Criteria," AFWL Sensor and Simulation Note 222, 1977.

II. THE MODEL

Most of our previous scale model measurement programs have used two (or more) different scale models of an aircraft to provide complete coverage of the frequency range desired, but for the present program the only models that we could find of the A-7E aircraft whose size was appropriate to our facility were 1/48 scale. Ultimately, we obtained three separate and distinct models manufactured by Scalecraft (SC-4014), Monogram (5418) and Precise Model Co. of Elyria, OH. The last one is, as the name suggests, a precision model for display purposes and was ordered first, but when it was late in arriving, we purchased the Scalecraft model kit. When assembled, the model was found to lack the external fuel tanks. We therefore purchased the Monogram kit and attached the fuel tanks from it to the Scalecraft model. Since neither kit contained the B-61, we modeled it ourselves according to the dimensions provided by AFWL. A further modification was the removal of the radome and the canopy, which are non-metallic on the full scale aircraft, and the metal framing around the actual canopy was modelled using copper wire.

After the model was assembled and the above modifications made, the joins and any surface imperfections were filled in with plastic putty, which was sanded to a smooth finish. The entire model, minus the radome and canopy, was then covered with several coats of silver paint (Dupont No. 4817). Finally, the length and wingspan of the model were measured to determine the scale factor to be used in

converting the measured frequencies to the full scale ones. Table 1 lists the fuselage and wing scale factors, and since the two are very close, the single scale factor 1/48.13 was used for all of the data processing.

Table 1: A-7E Model Scale Factors

<u>Model</u>	<u>Length (cm)</u>	<u>Wingspan (cm)</u>	<u>Fuselage Scale*</u>	<u>Wingspan Scale*</u>
A-7E (1/48)	29.21	24.55	1/48.13	1/48.10

*The scale factors are based on the full scale (overall) length of 21.79 m and a wingspan of 18.31 m.

Figure 1 shows the model used in the measurements. In the top photograph, the model with the Air Force markings is that made by the Precise Model Co., and the sphere to the left is the three-inch diameter sphere used for calibrating the system. The lower photograph is a close-up of the model showing the accessories and the holes (covered with adhesive copper tape) which have been drilled to accommodate the sensors. Figure 2 is a plan view of the aircraft giving the full scale dimensions.

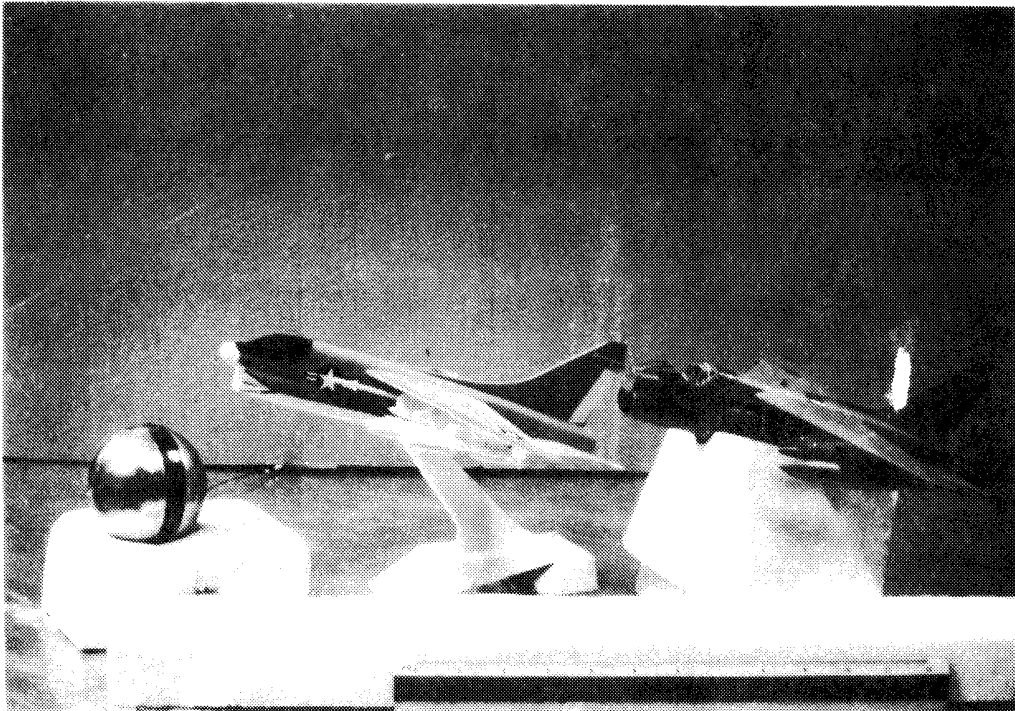
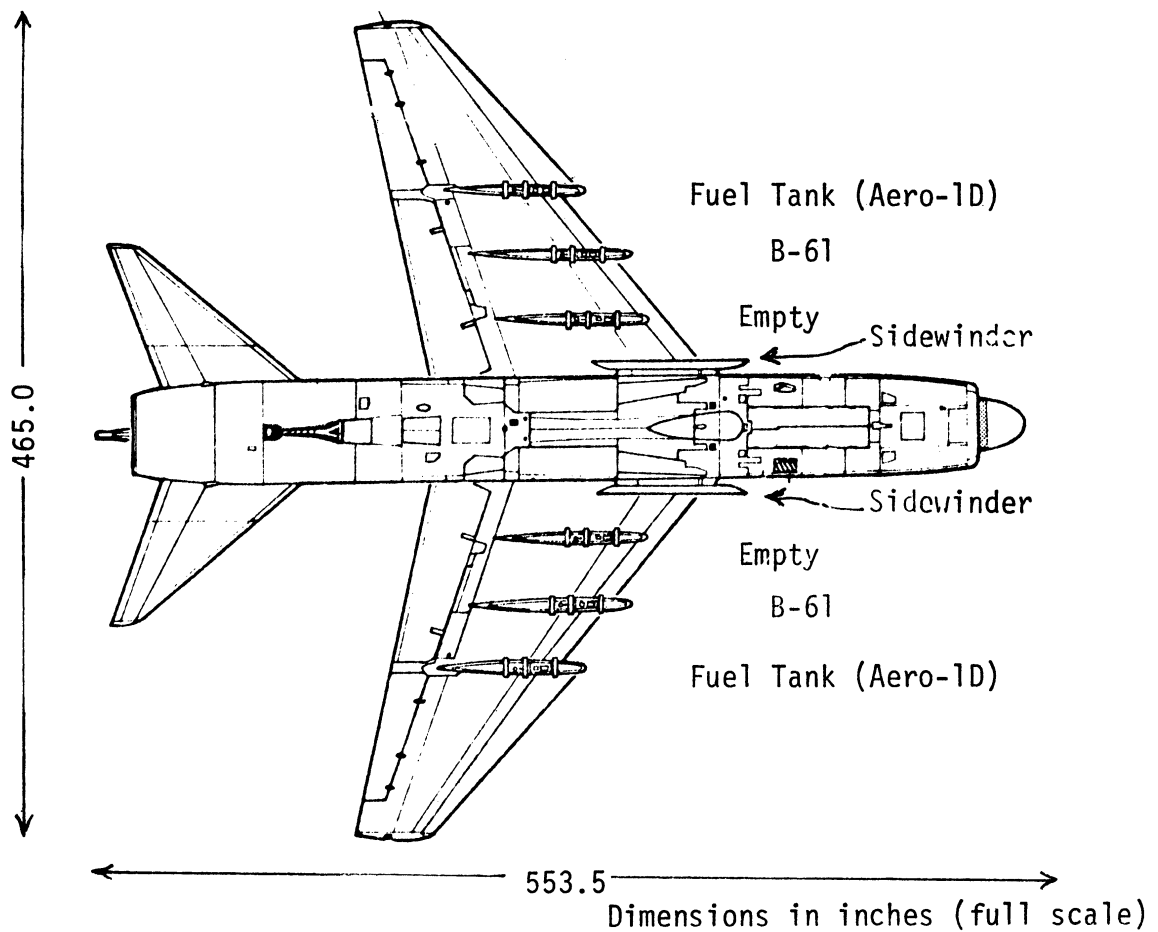


Fig. 1: Photographs of the model used in the measurements.



Notes:

- (a) Radome and canopy removed; canopy framing simulated with wires.
- (b) Armament as shown in sketch.
- (c) Lossy foam inserted in exhaust and intake, 0.5 inches inside opening.

Fig. 2: Pertinent aircraft specifications.

III. THE MEASUREMENTS

The measurements were made in the Radiation Laboratory's anechoic chamber, a facility especially designed, constructed, and instrumented for this type of surface field measurement. The measurement procedures were similar to those used in previous programs [2 through 6] apart from changes resulting from the continued upgrading of the facility and the measurement techniques. The most recent changes have been the extension of the low frequency operation from 125 MHz down to 118 MHz, and the interfacing of the HP 9845B calculator with which most of the data is now processed and plotted. A block diagram of the facility is shown in Fig. 3.

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- [2] Valdis V. Liepa, "Sweep Frequency Surface Field Measurements," University of Michigan Radiation Laboratory Report NO. 013378-1-F; Sensor and Simulation Note 210, 1975.
 - [3] Valdis V. Liepa, "Current and Charge Measurements on Scale Model E-3A Aircraft," University of Michigan Radiation Laboratory Report No. 015814-1-F; Interaction Application Memo 29, 1978.
 - [4] Valdis V. Liepa, D. M. Brown, F. E. Lenning, R. L. Turcotte, "Measurements of Surface Fields on Scale Model E-4B Aircraft," University of Michigan Radiation Laboratory Report No. 016708-1-F; Interaction Application Memo 33, 1979.
 - [5] Valdis V. Liepa, "Scale Model Measurements of the F-16A," University of Michigan Radiation Laboratory Report No. 017463-1-F; Interaction Application Memo 35, 1980.
 - [6] Valdis V. Liepa, "Scale Model Measurements of the B-52," University of Michigan Radiation Laboratory Report NO. 017463-2-F; Interaction Application Memo 36, 1980.

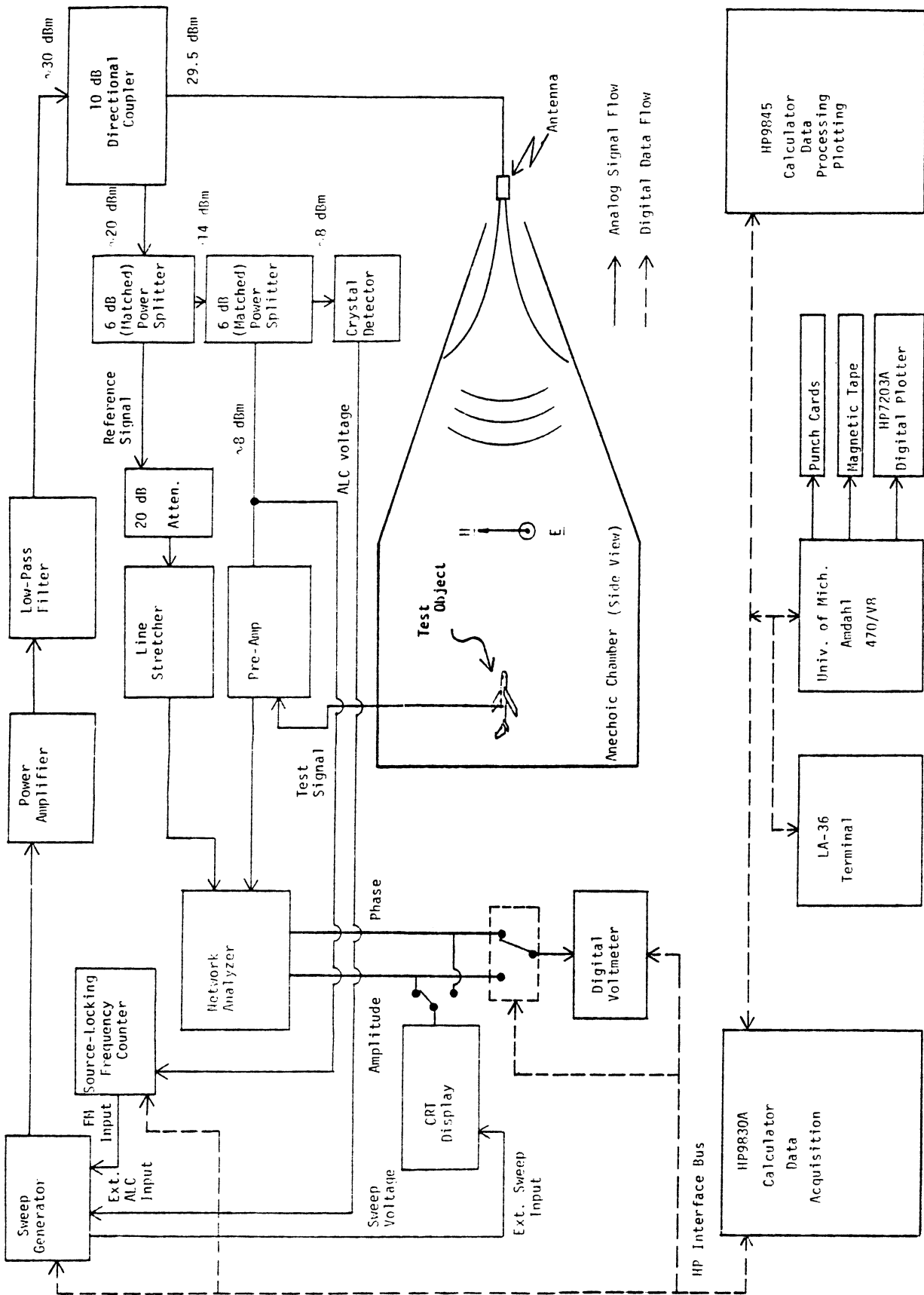
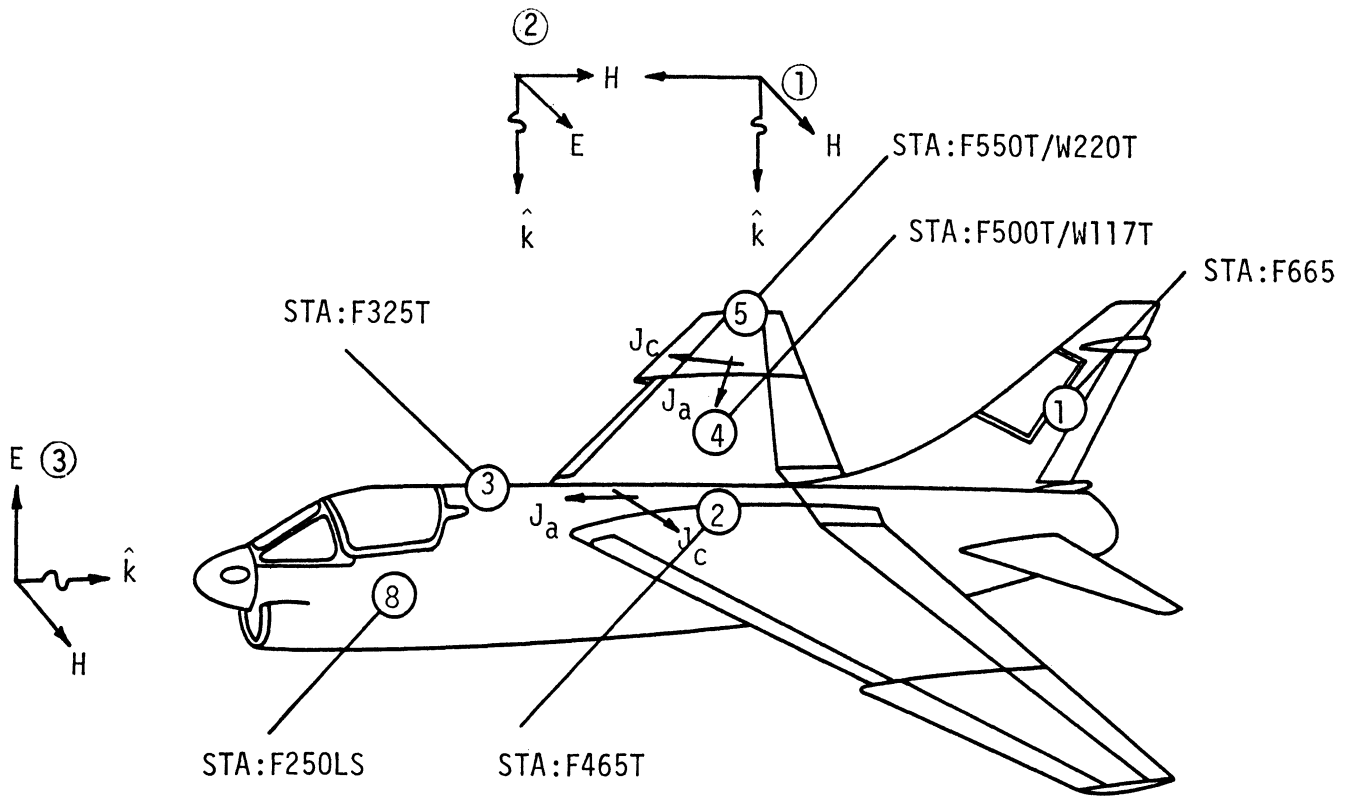


Fig. 3: Block diagram of the facility.

Current and charge measurements were made at ten locations on the model as indicated in Fig. 4. On the fuselage the locations are identified by station numbers giving in inches the full scale distances measured from a reference point 182 inches ahead of the nose. The wing stations are located on the line bisecting the wing at a distance (in inches) given by the station number measured perpendicularly from the center line of the fuselage. Table 2 lists the station numbers of the test points and describes their locations.

The measurements were made for three different illuminations each having a prescribed polarization referenced to the fuselage of the aircraft (see Fig. 4). In our measurements the directions of illumination and polarization are often referred to as orientations since these are fixed relative to the chamber and can be changed only by suitably orienting the model. Figure 4 also shows the direction of the measured current on the top and bottom of the aircraft. In all cases the component J_c is perpendicular to J_a . The data presented are normalized relative to the incident field, i.e., J/H_0 for the surface current data and E_n/E_0 for the charge data. The phase is referenced to that of the incident field at the station where the measurement was made, based on the $e^{i\omega t}$ time convention.

The model was supported by a styrofoam pedestal using a styrofoam cradle to orient the model appropriately relative to the incident field. Since the incident field is horizontally polarized, top incidence with E parallel to the fuselage requires that the model rest on a wingtip with its top facing the transmitting antenna.



- ① E parallel to fuselage, top incidence.
- ② E perpendicular to fuselage, top incidence.
- ③ E vertical, nose-on.

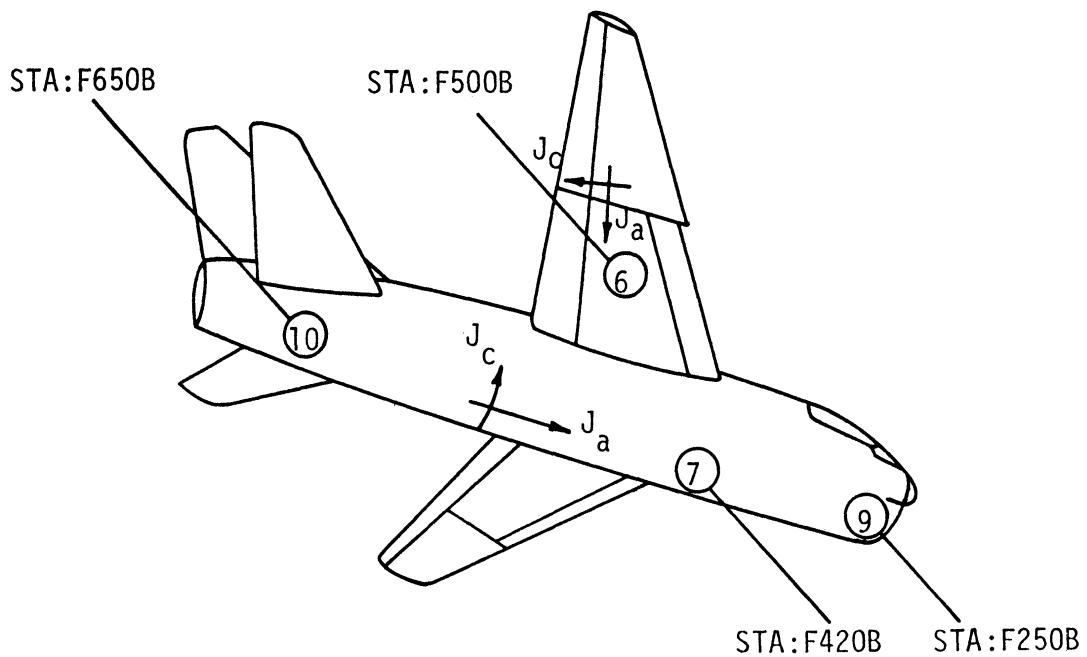


Fig. 4: Locations of measurement stations (see Table 2 for details).

TABLE 2
MEASUREMENT LOCATION DESCRIPTION

Test Point	Station Number	Location
1	F665	Vert Stab, Left Side 483 in. from nose 90 in. up left side; 77.1 in. above fuselage
2	F465T	Top Mid Fus. 283 in. from nose 10 in. left of center line
3	F325T	Top Fwd. Fus. 143 in. from nose on center line
4	F500, W117T	Top Mid Wing (R) 318 in. from nose 117 in. off center line
5	F550, W220T	Top Wing Tip (R) 368 in. from nose 220 in. off center line
6	F500, W117B	Bottom Mid Wing (R) 318 in. from nose 117 in. off center line
7	F420B	Bottom Fwd. Fus. 238 in. from nose center line
8	F250LS	Fwd. Fus. Left Side 68 in. from nose center line; 14.8 in. down from window
9	F250B	Bottom Fwd. Fus. 68 in. from nose center line
10	F650B	Bottom Aft. Fus. 478 in. from nose center line

Unless stated, measurements are taken along or from the fuselage axis.

All of the current and charge measurements were made using miniature surface-mounted probes or the free space current loop shown in Fig. 5. To mount the probes, holes were drilled in the model and the probe lead passed through to the other side. When not in use a hole was taped over with conductive adhesive copper tape (see Fig. 1), and as far as we can ascertain, the taping had no effect on the measurements.

With the present model, the routing of the miniature coaxial cables through the interior made it necessary to break out the engine and air intake baffles, leaving the model virtually hollow. Because of the possibility of interior resonances which could affect the data, charge measurements were made at STA:325T, top illumination, with (a) the model hollow, (b) the air inlet and exhausts closed off with metallic tape, and (c) the inlet and exhausts plugged with absorber. No significant differences were found. Figures 6 and 7 show the measured data for the hollow and absorber-stuffed model, respectively. The amplitudes are indistinguishable and the slight difference in phase is due to a minute shift of the model location between the two measurements. We remark that the noisy data at frequencies above 50 MHz were caused by an equipment malfunction which was corrected prior to the actual A-7E data measurements. Then measurements were all made using the model with the absorber in place, since this was felt to simulate the full scale situation most closely.

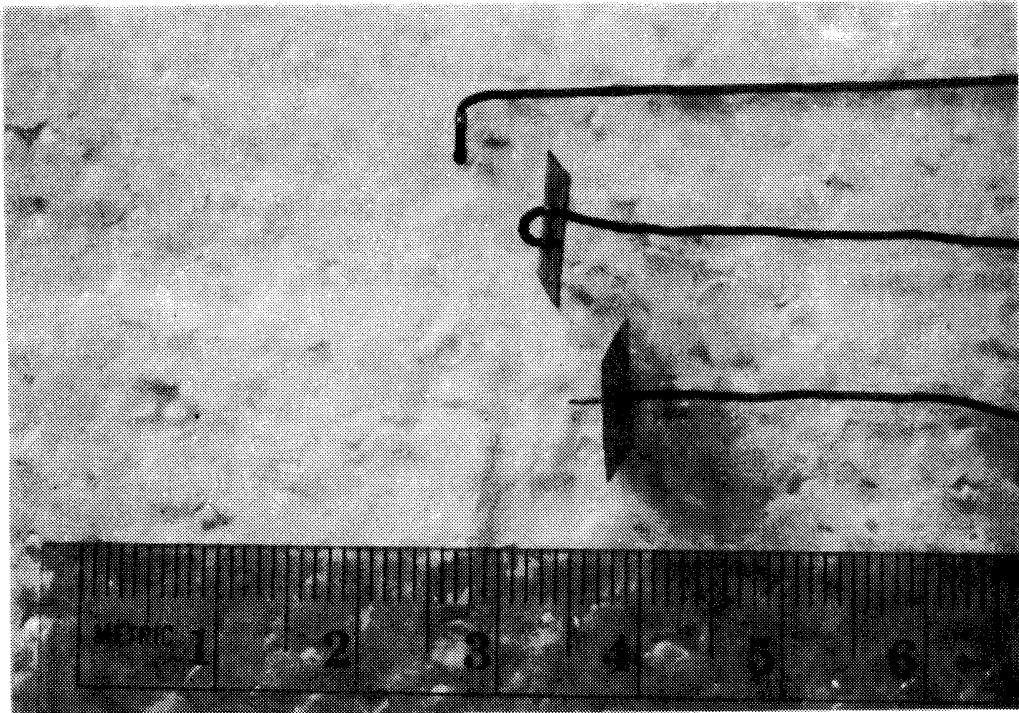


Fig. 7: Probes used in the measurements. The upper one is the free space loop, the center one in the surface mounted current loop, and the lower one is the charge probe. Note that each is less than 3 cm in size. The coax is 0.020 inch diameter, 50 ohm.

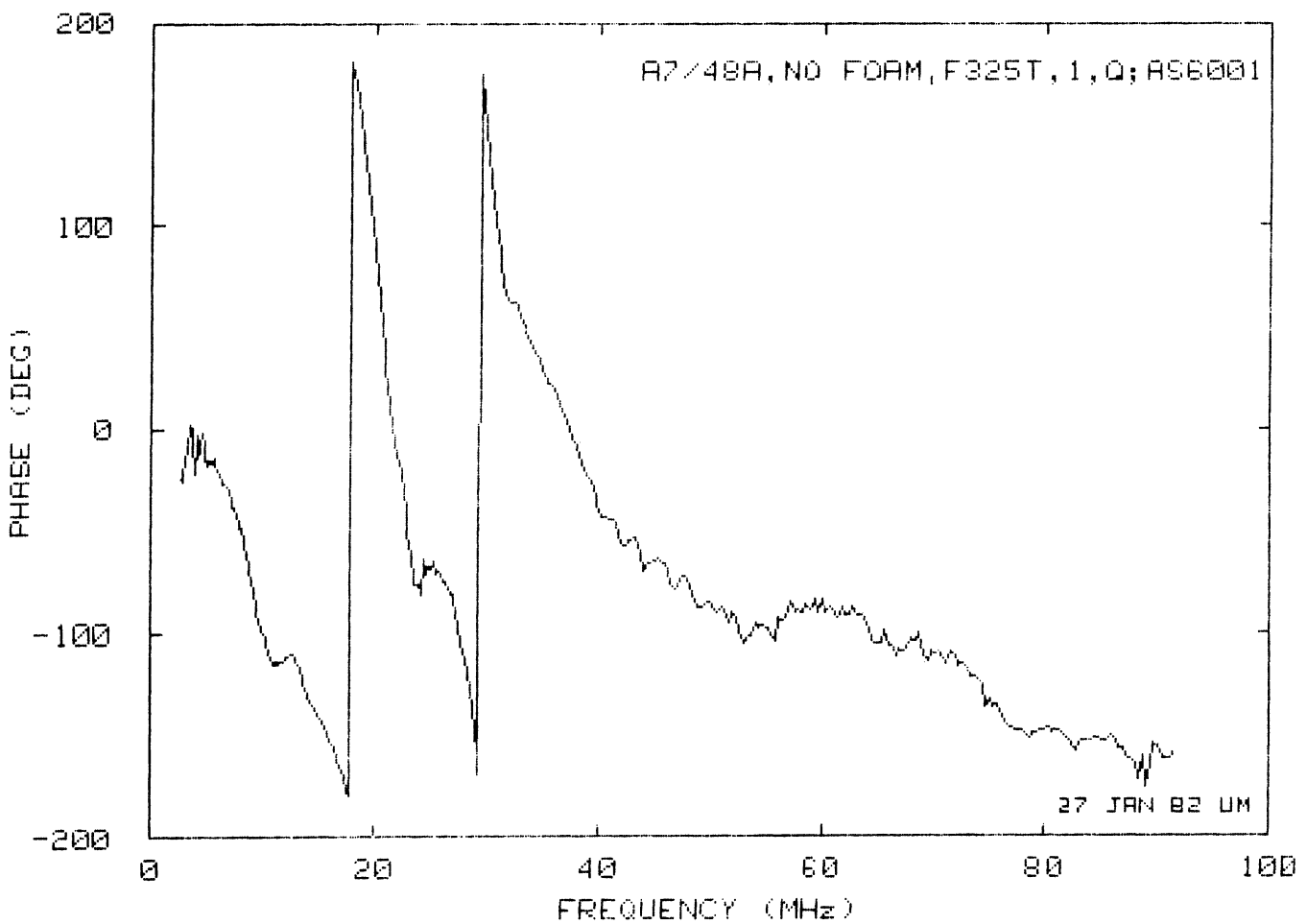
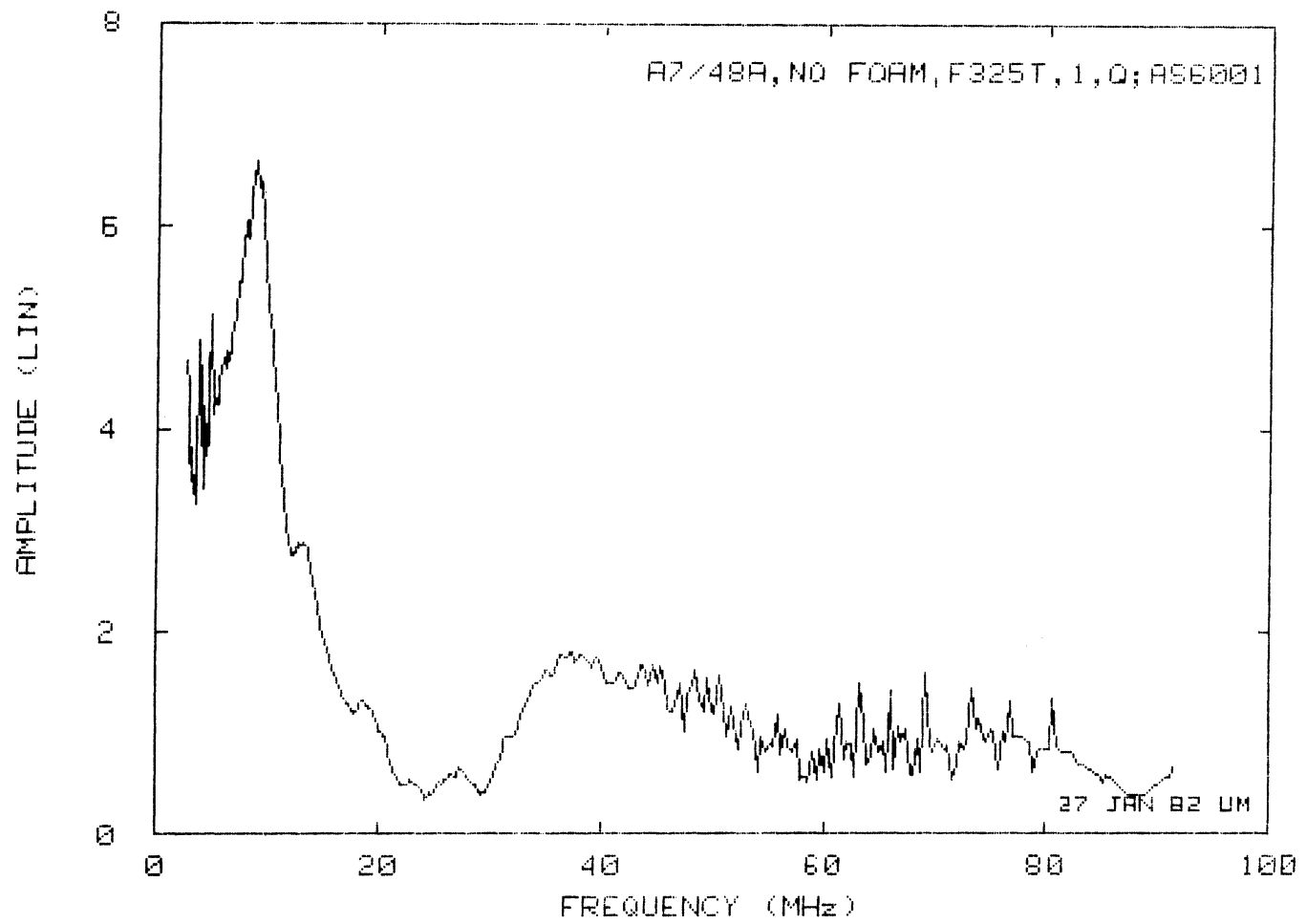


Fig. 6: Charge measurement at STA:F325T, orientation 1 with the air inlet and exhausts open.

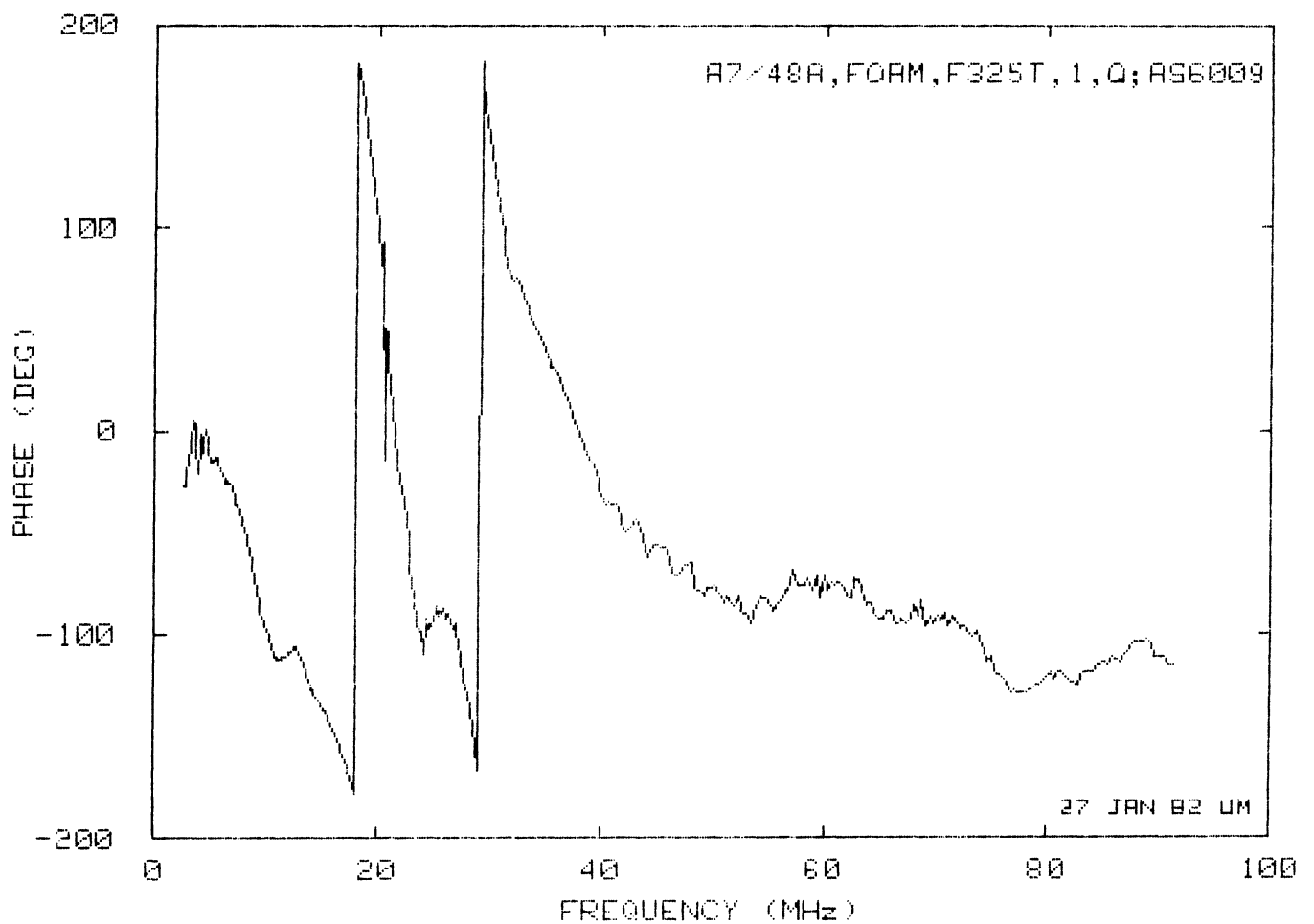
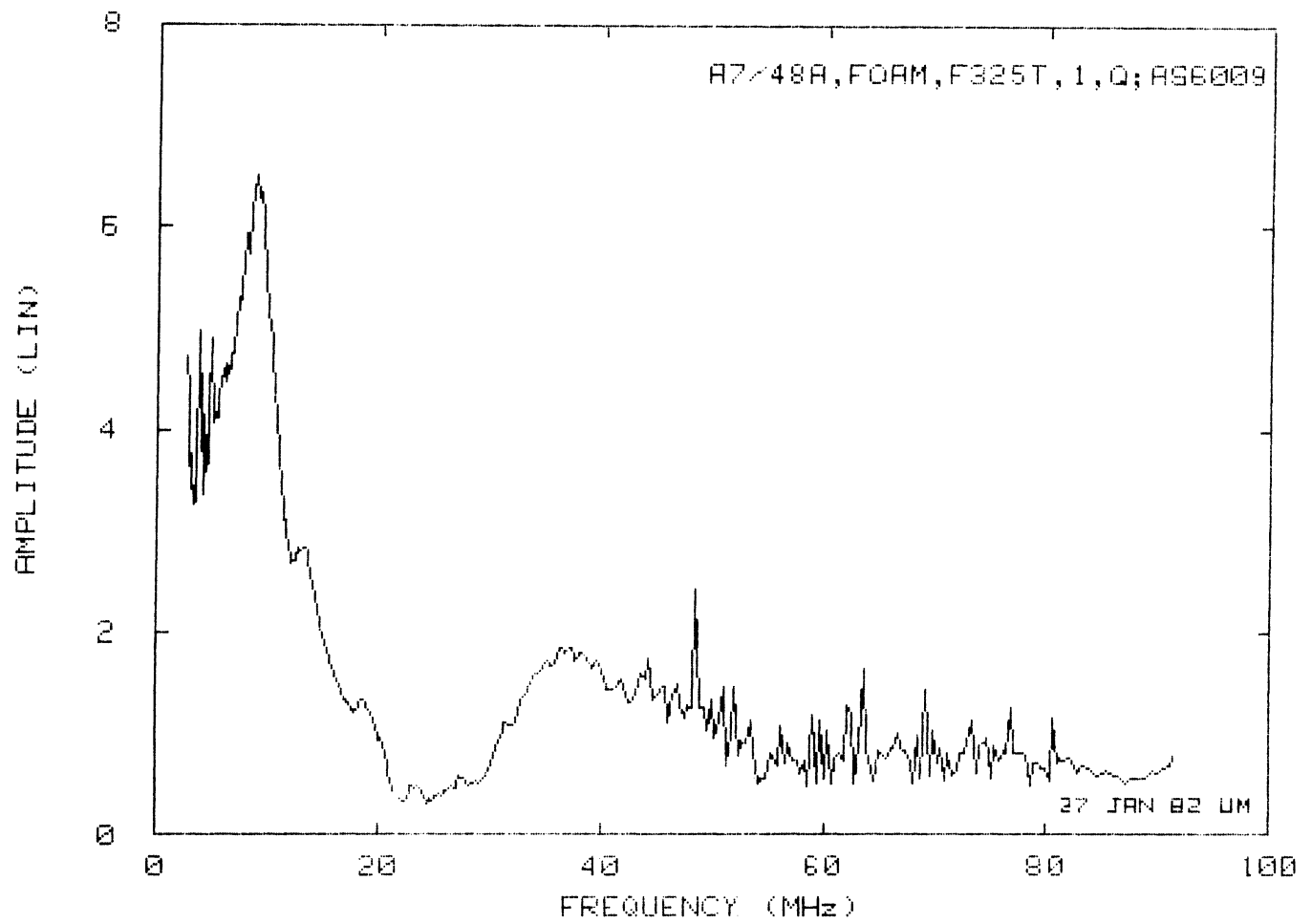


Fig. 7: Charge measurement at STA:F325T, orientation 1 with the air inlet and exhausts plugged with absorber.

IV. DATA

The data are expressed as functions of the full scale frequency and generally cover the range 2.46 to 91.7 MHz. There are some slight differences in coverage in a few cases because of the occasional failure of the network analyzer to lock onto a (usually initial) frequency, and the resulting data points have been removed. The sampling rate is non-uniform, and typically is

4.8 MHz	in	118-1000 MHz range
9.6 MHz	in	1000-2100 MHz range
16.8 MHz	in	2100-4400 MHz range

where these are the model frequencies.

Table 3 lists the cases for which data are presented and gives the plot numbers. The legend in the upper right-hand corner of each plot identifies (1) the model used, (2) the measurement station, (3) the orientation (see Fig. 4), (4) the field component measured, and (5) the data file name, which is the same as the plot number.

Table 4 is a sample of the data format which has been used for the data supplied to TRW. The data are also stored on IBM compatible tape at the University of Michigan.

TABLE 3
A-7E SCALE MODEL MEASUREMENT MATRIX

Test Pt.	Excitation Measurement Station	1 OVERHEAD E FUS			2 OVERHEAD E FUS			3 NOSE-ON E-VERT		
		J _A	J _C	E _N	J _A	J _C	E _N	J _A	J _C	E _N
1	F665	7017*		6817				7025		6825
2	F465T	6033		6565		6625		6057	7001	6949
3	F325T	6157		6601				6049		6609
4	F500,W117T	7041	7073	6201	7057	6541		7049		6209
5	F550,W220T			6901		6649				6909
6	F500,W117B	7425	7465	6849	7441	6865		7433		6857
7	F420B	6101		6665				6141		6673
8	F205LS	7525		7473		7509		7533		7501
9	F250B			6741						6749
10	F650B	6109		6925				6149		6933

*All data files are preceded by AS, i.e. AS7017

Table 4. Sample Data

FORMAT

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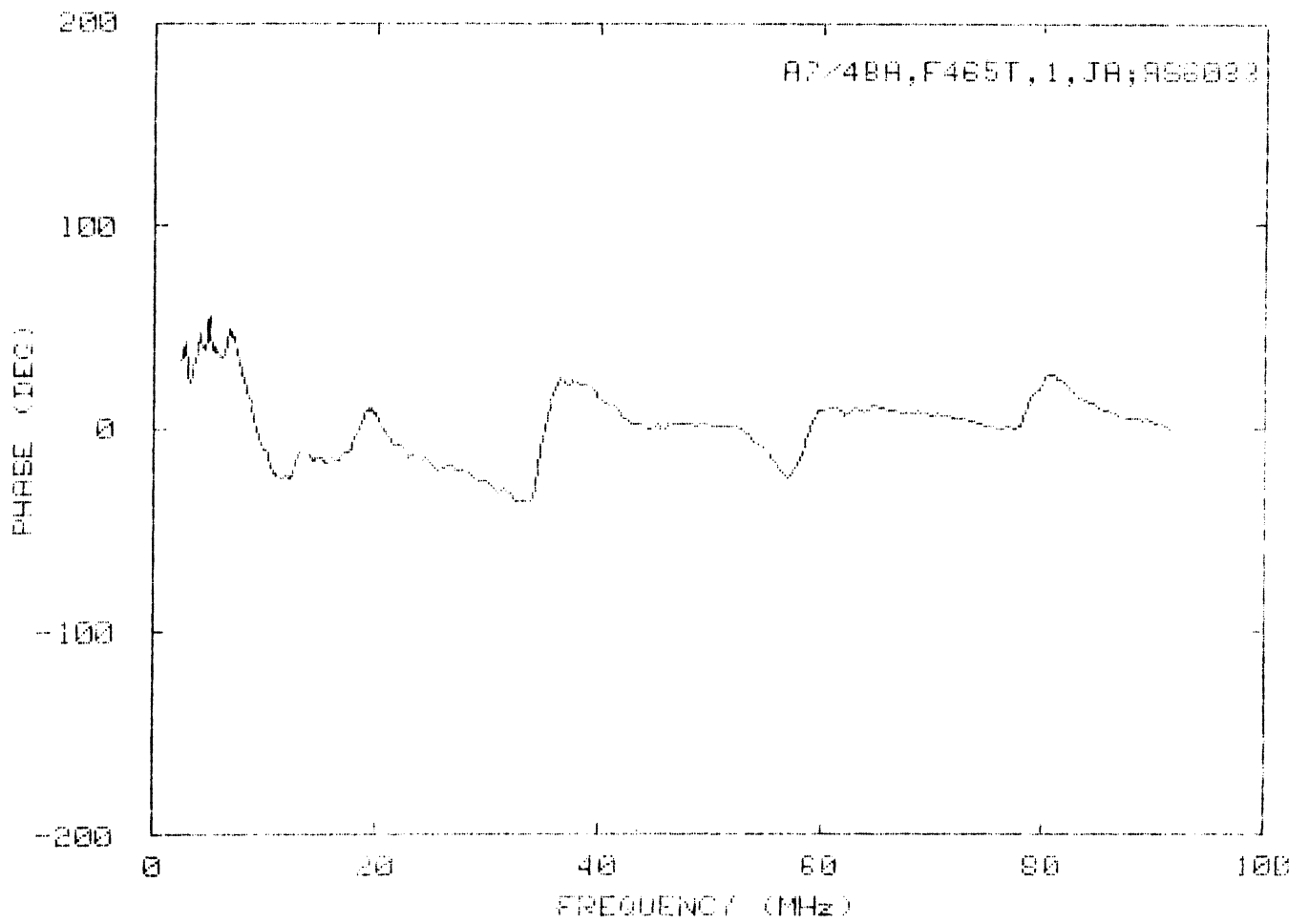
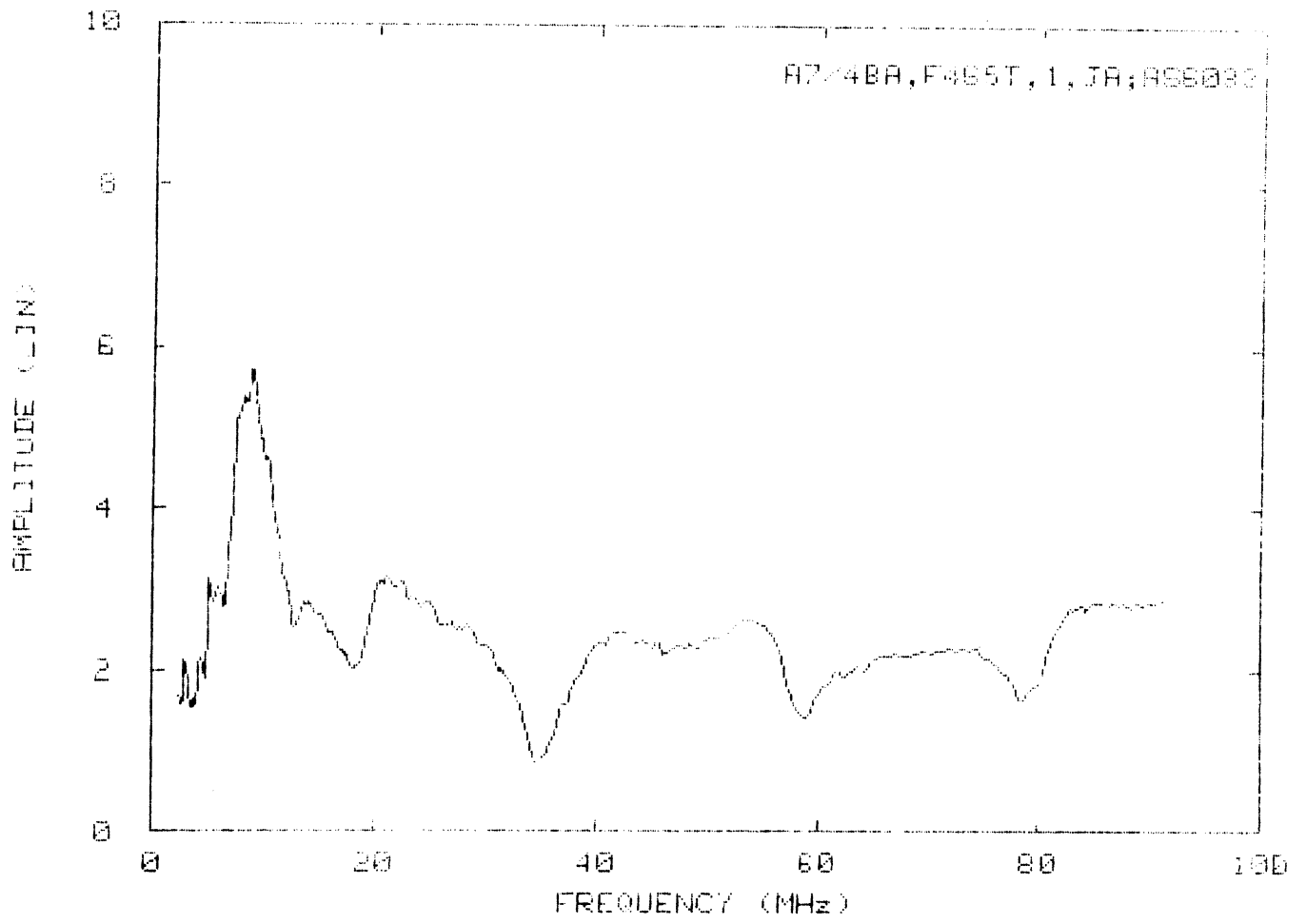
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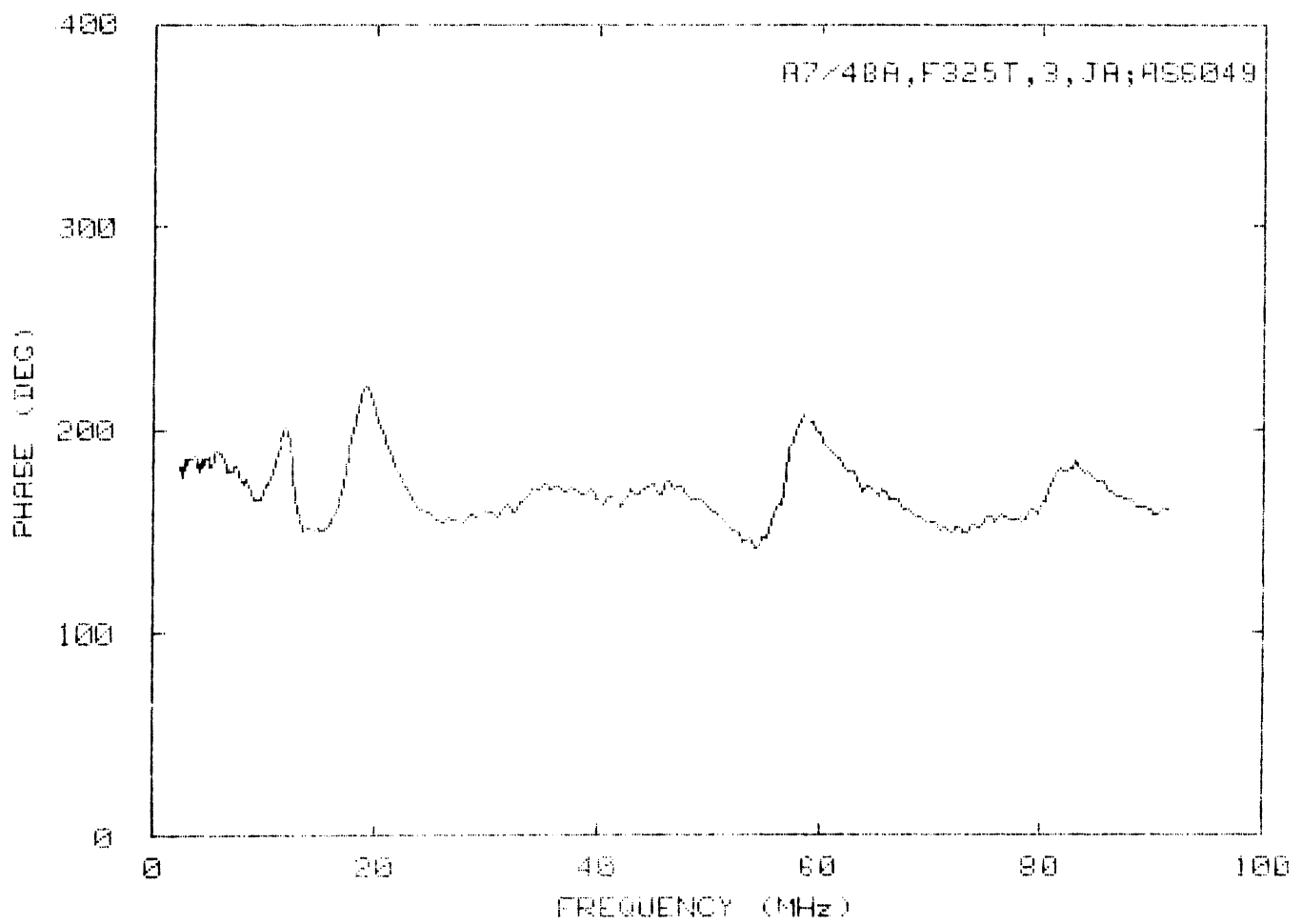
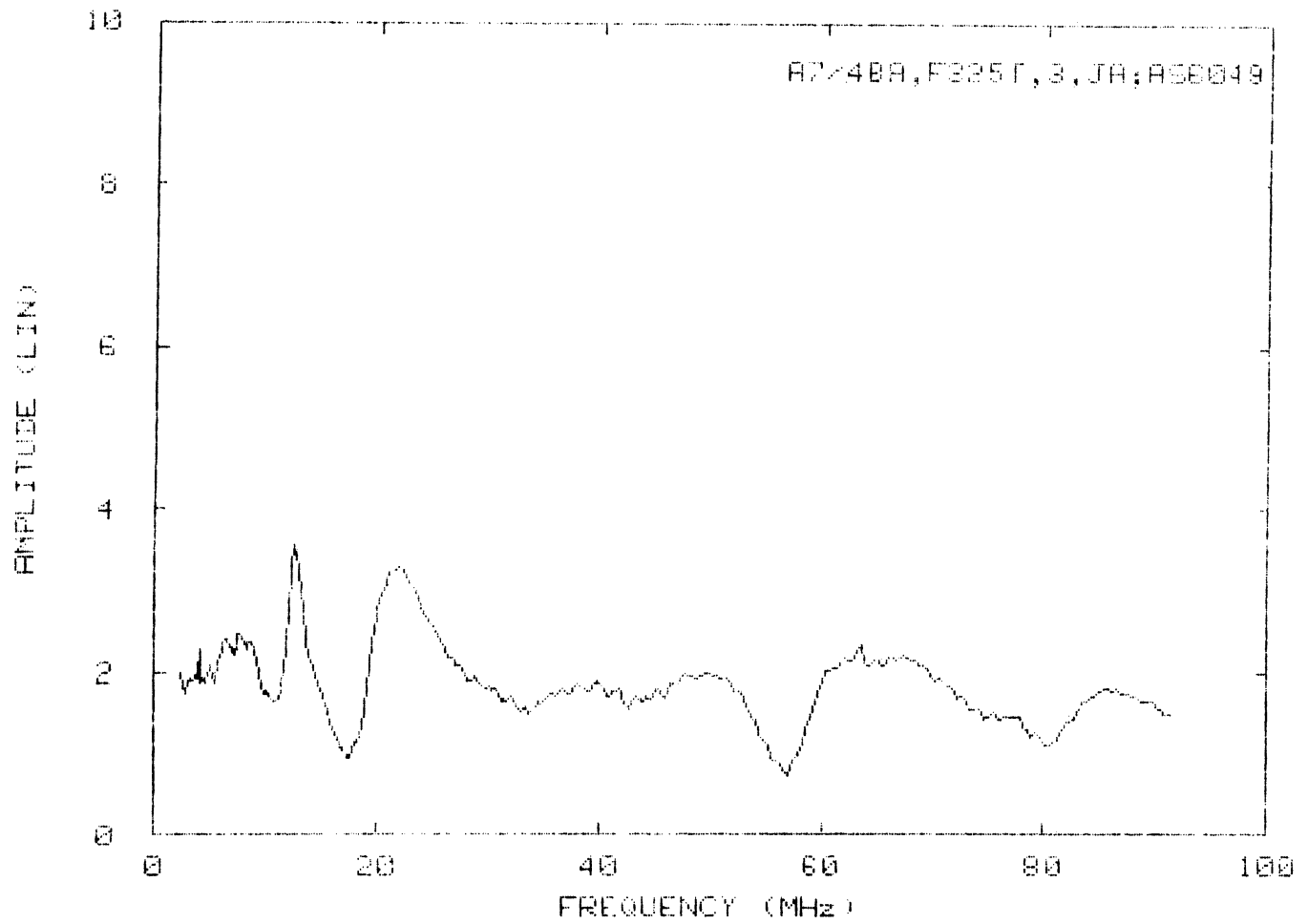
where NN is the number of data points in the set.

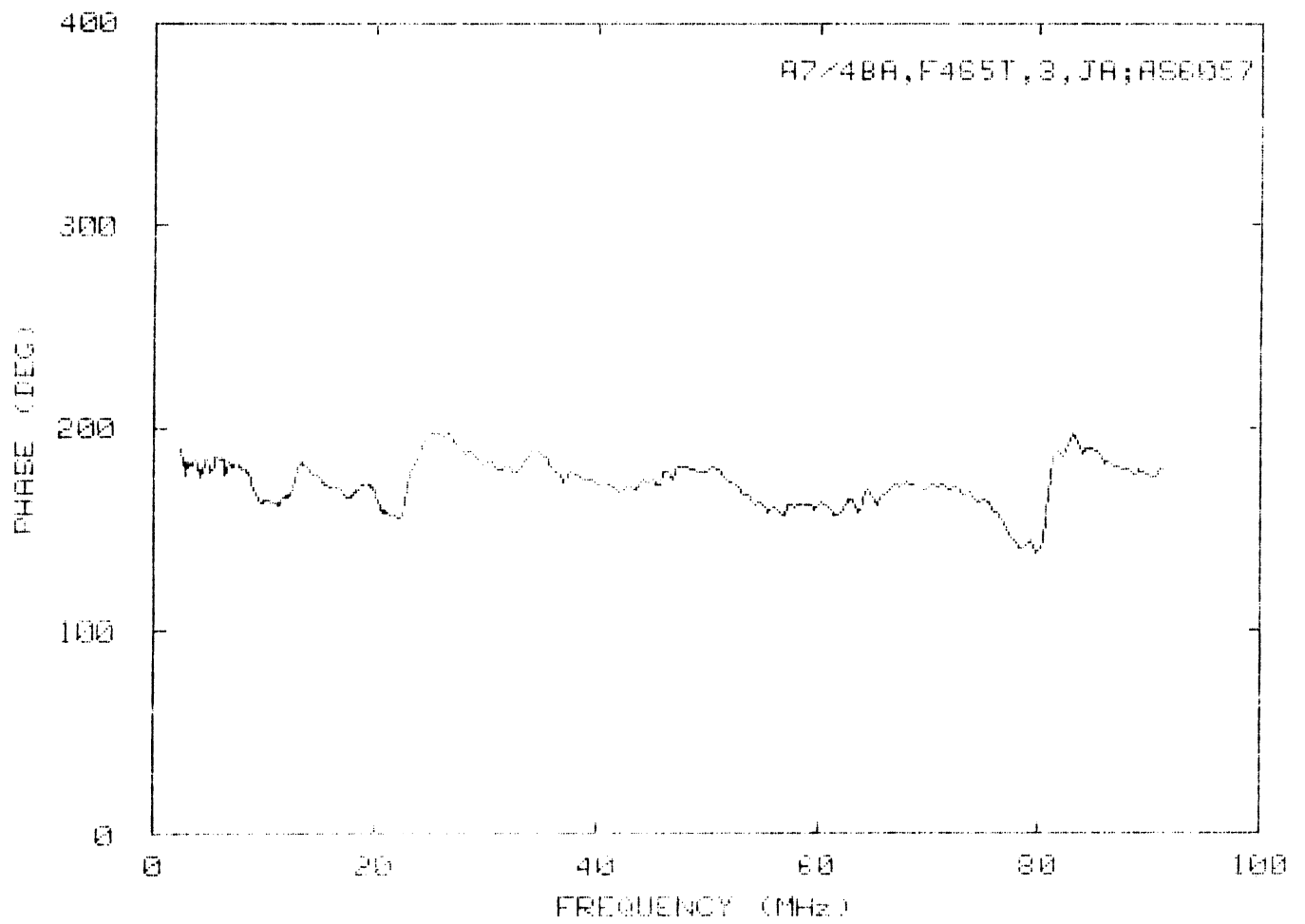
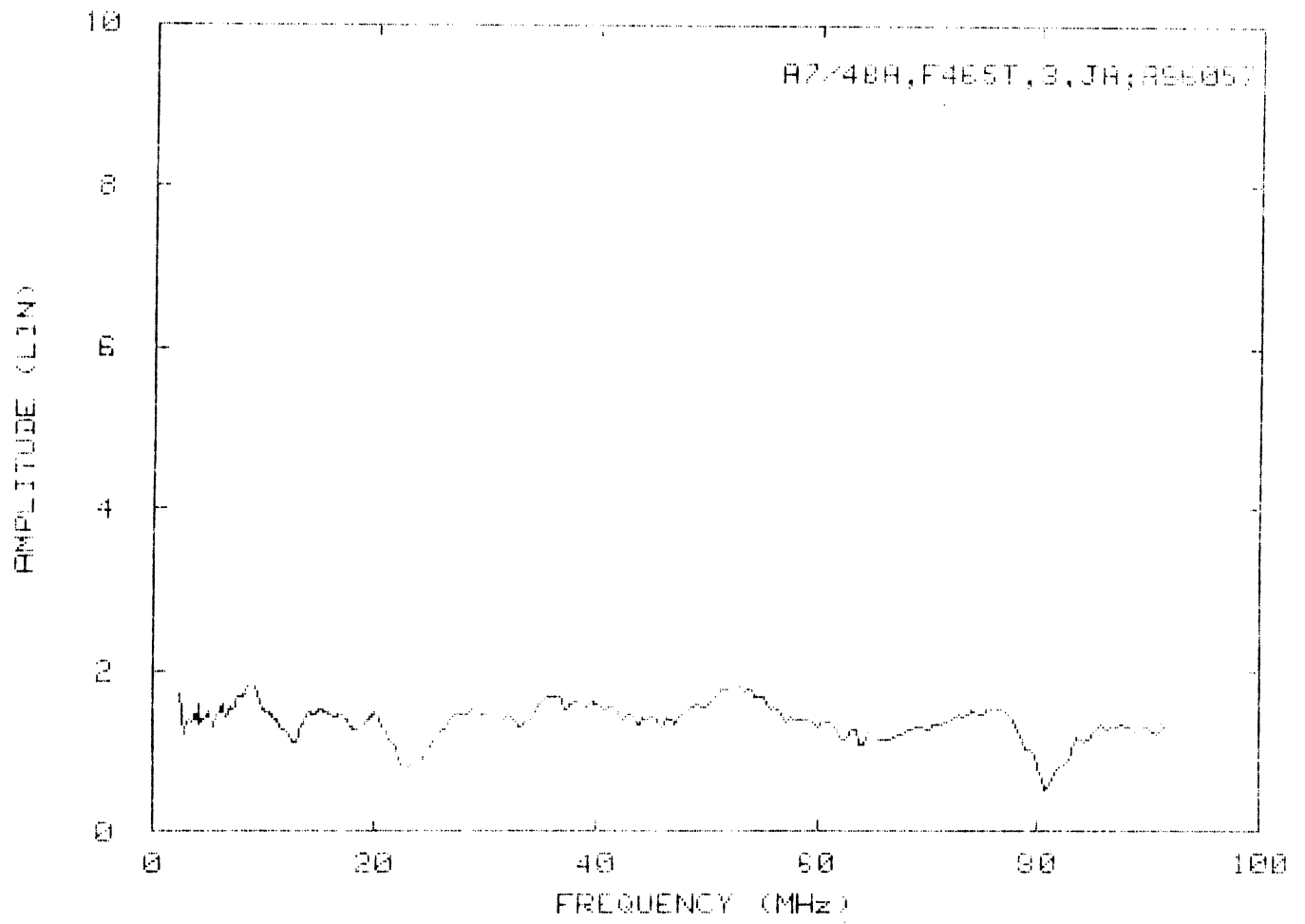
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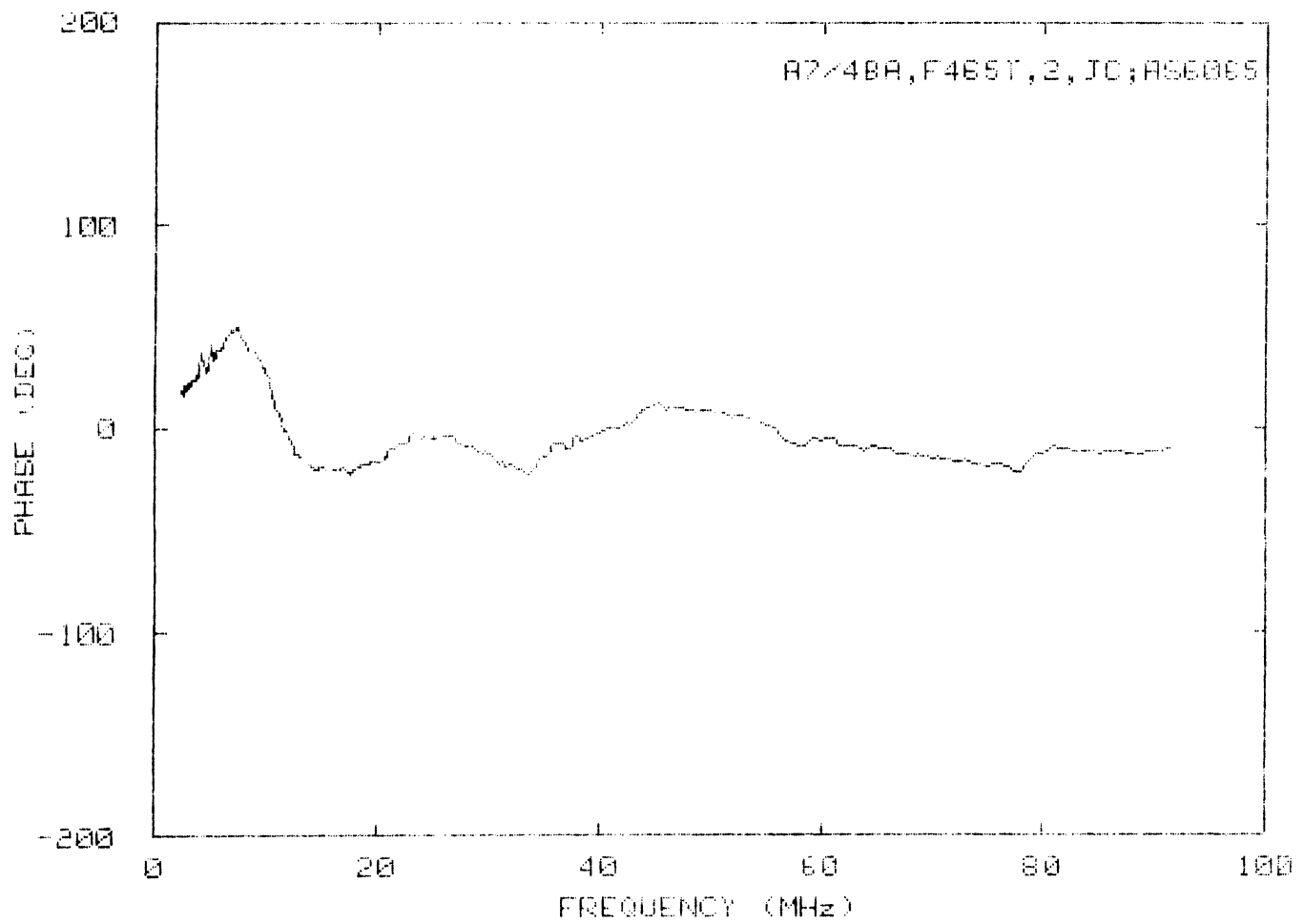
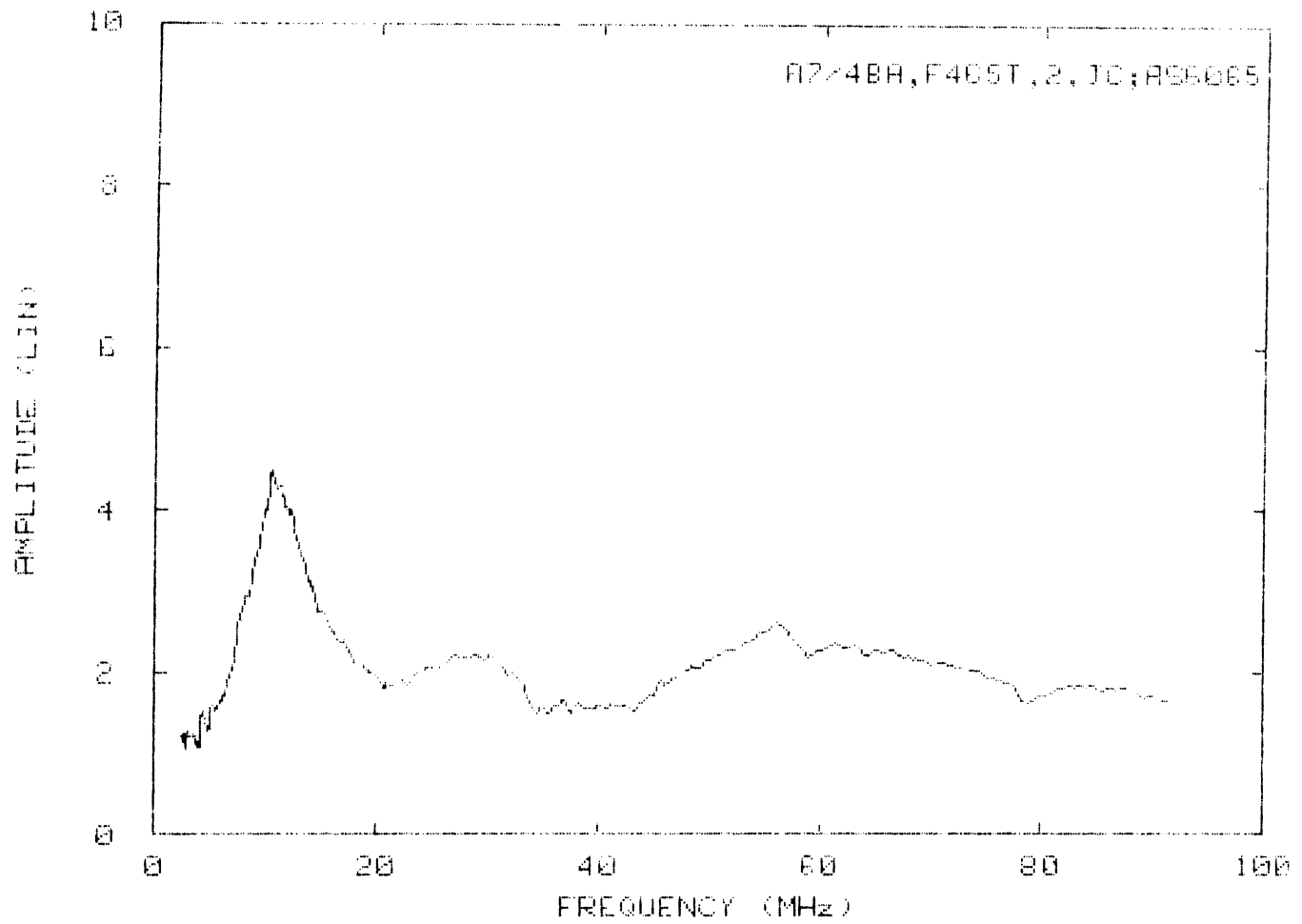
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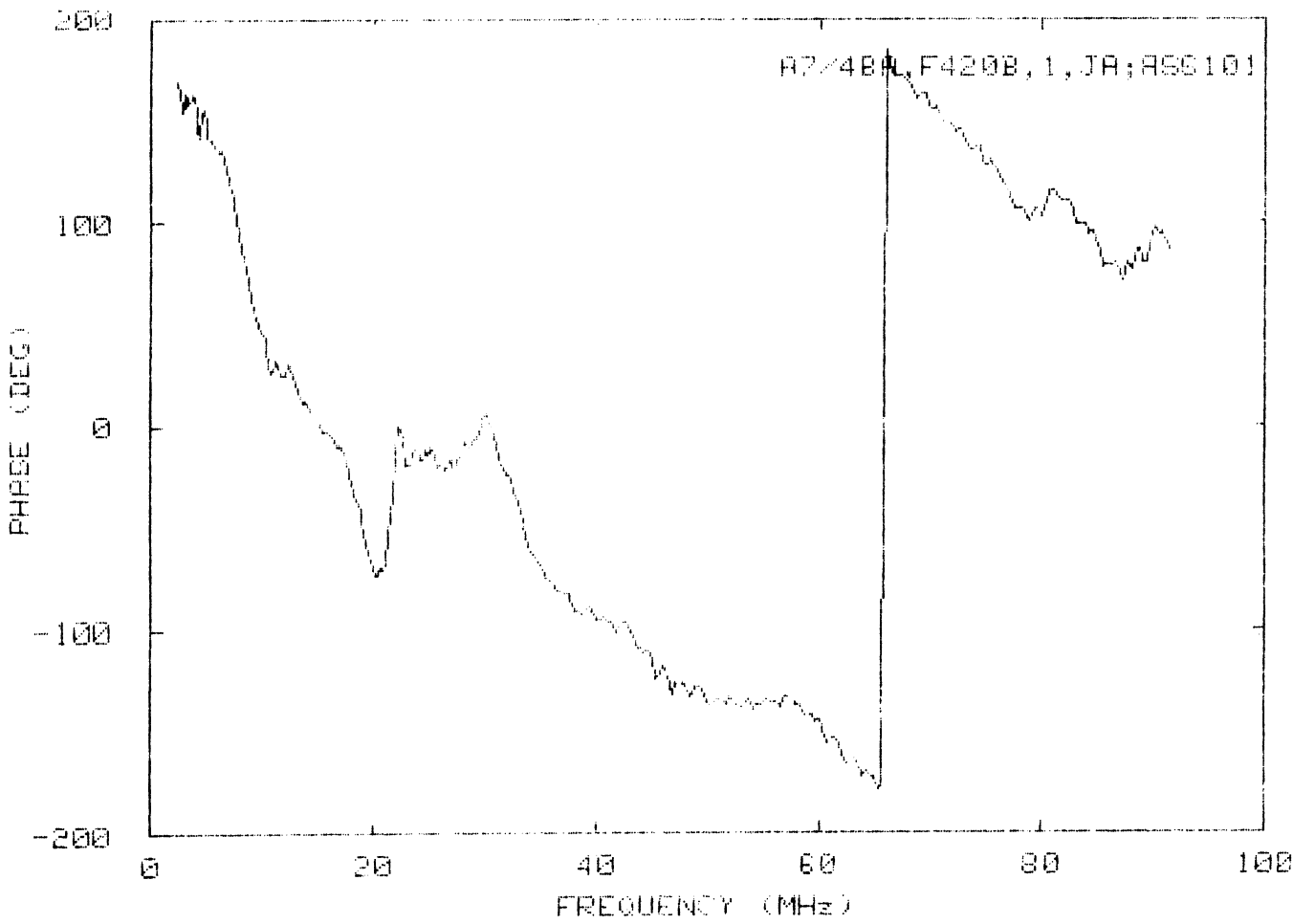
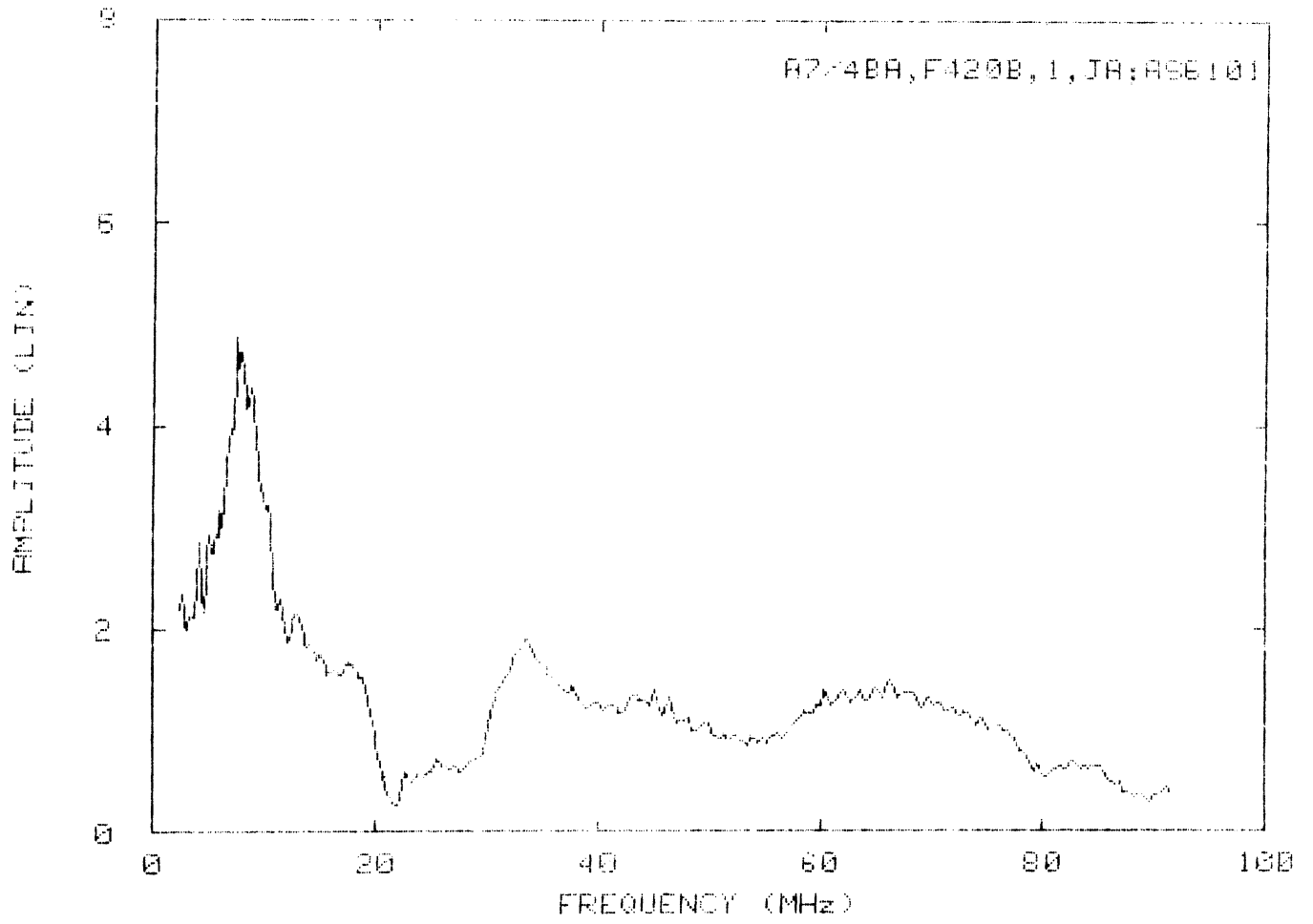
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6      2.461   1.669  33.29   2.560   1.639   36.42   2.660   1.580   37.15
7      2.760   1.610  43.19   2.860   2.118   38.82   2.959   2.070   31.16
8      3.059   2.076  28.29   3.159   1.983   24.73   3.259   1.916   22.16
9      3.358   1.720  21.59   3.458   1.573   26.84   3.558   1.614   30.47
10     3.658   1.637  32.11   3.757   1.572   34.65   3.857   1.609   35.69
      .
      .
      .
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146    85.902   2.834   8.02  86.251   2.821   7.08  86.600   2.868   6.44
147    86.949   2.836   5.52  87.298   2.805   5.80  87.648   2.845   5.00
148    87.997   2.902   4.70  88.346   2.785   5.00  88.695   2.833   4.52
149    89.044   2.836   3.63  89.393   2.801   3.96  89.742   2.858   3.38
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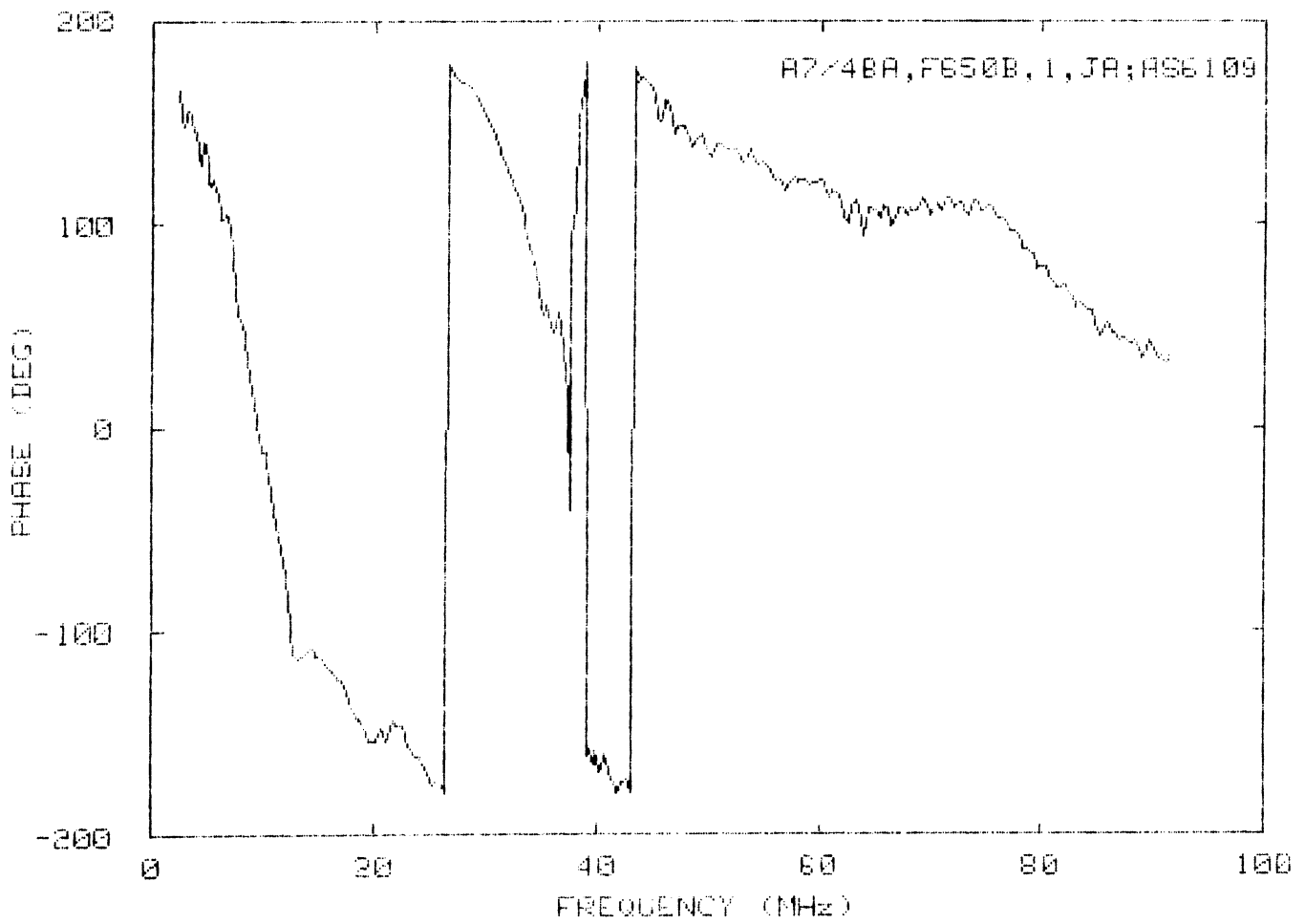
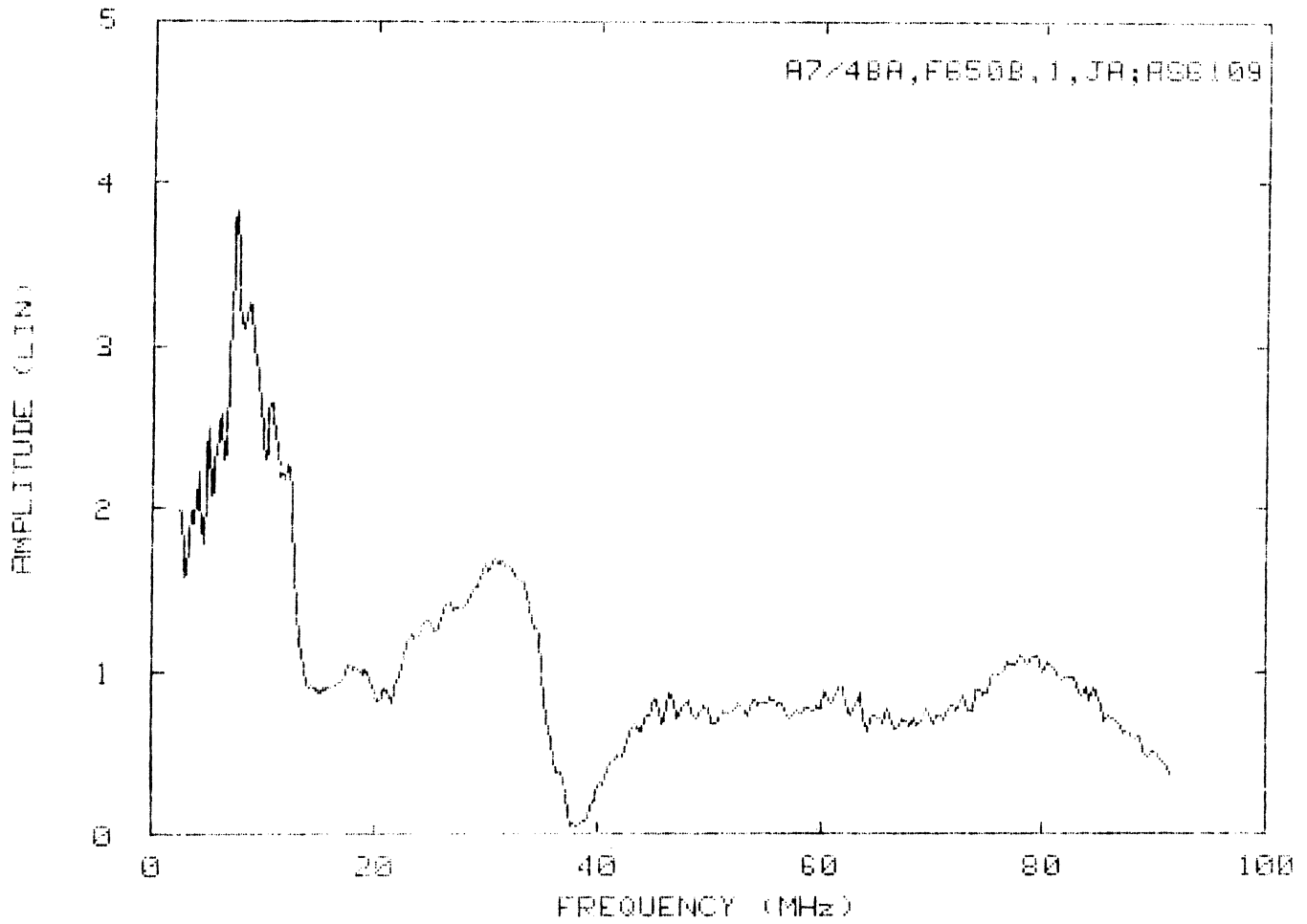




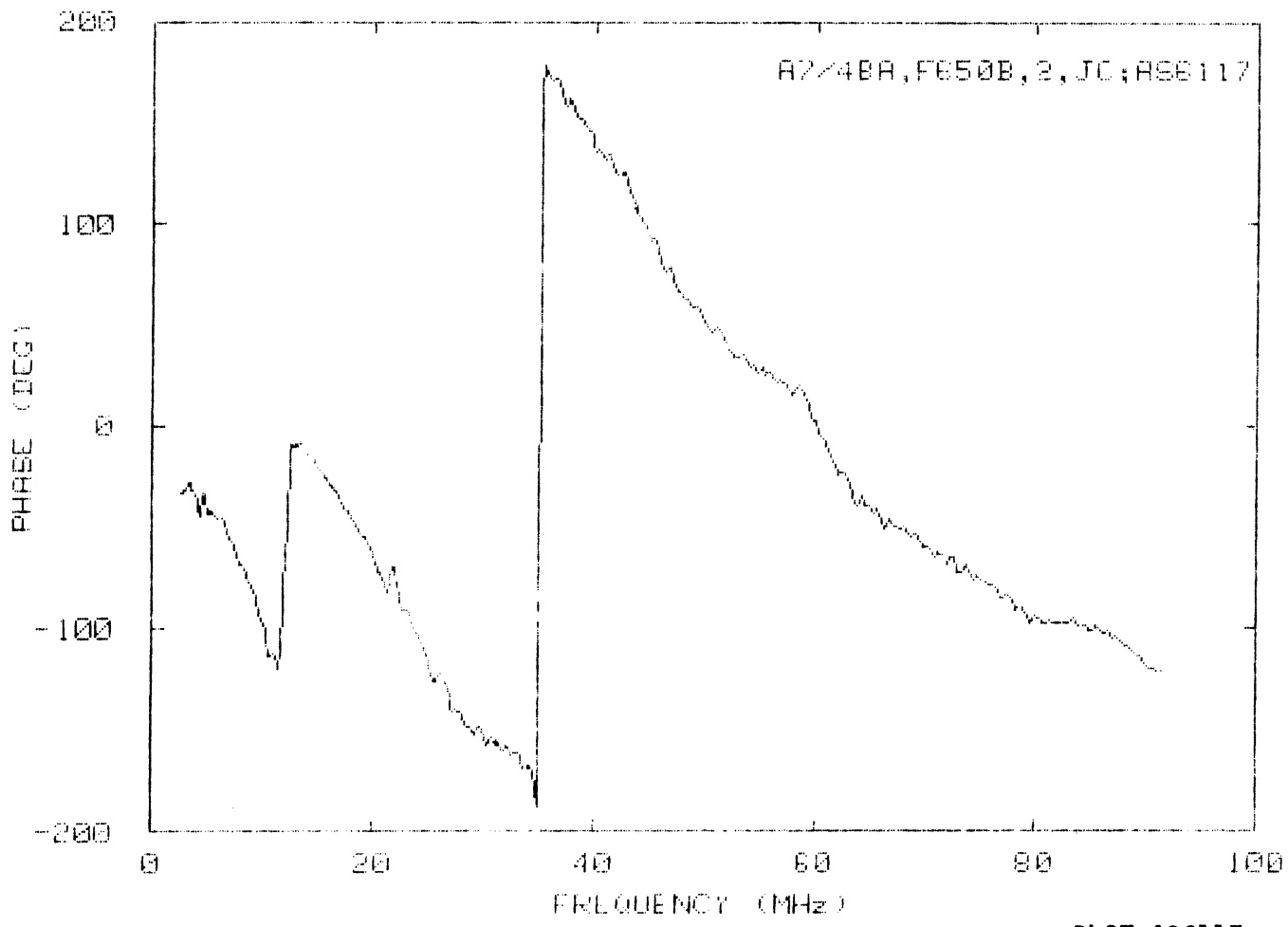
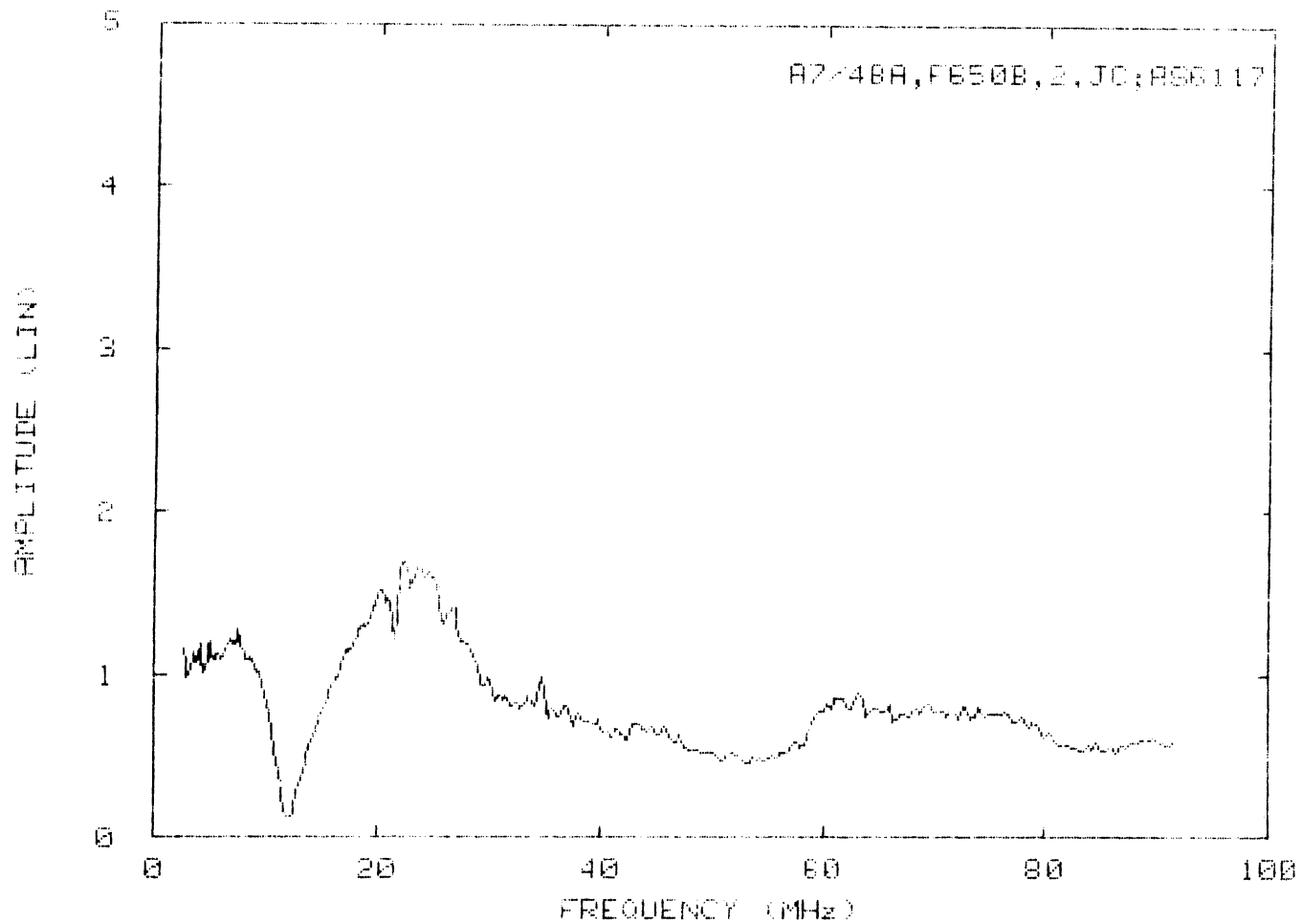




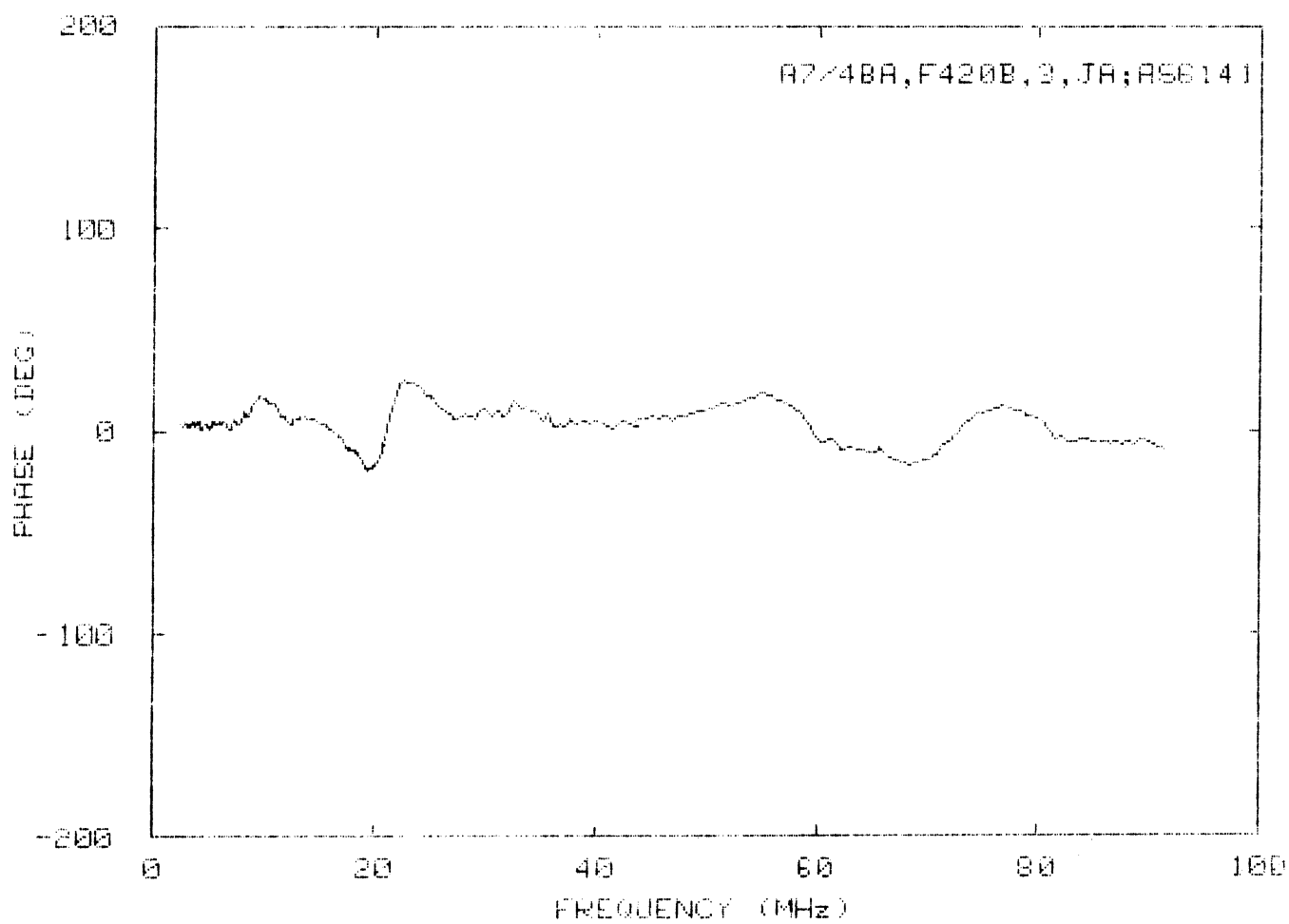
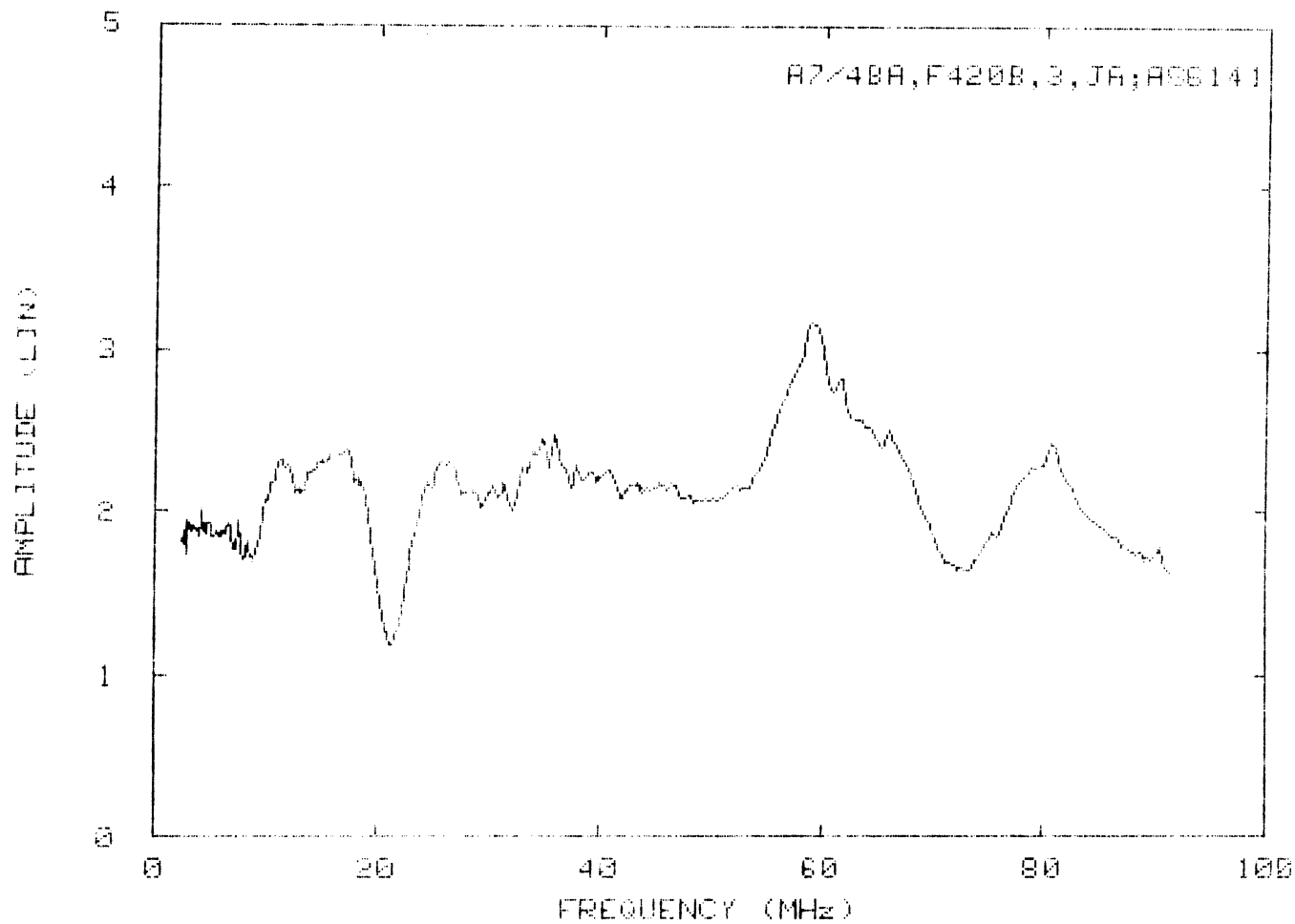
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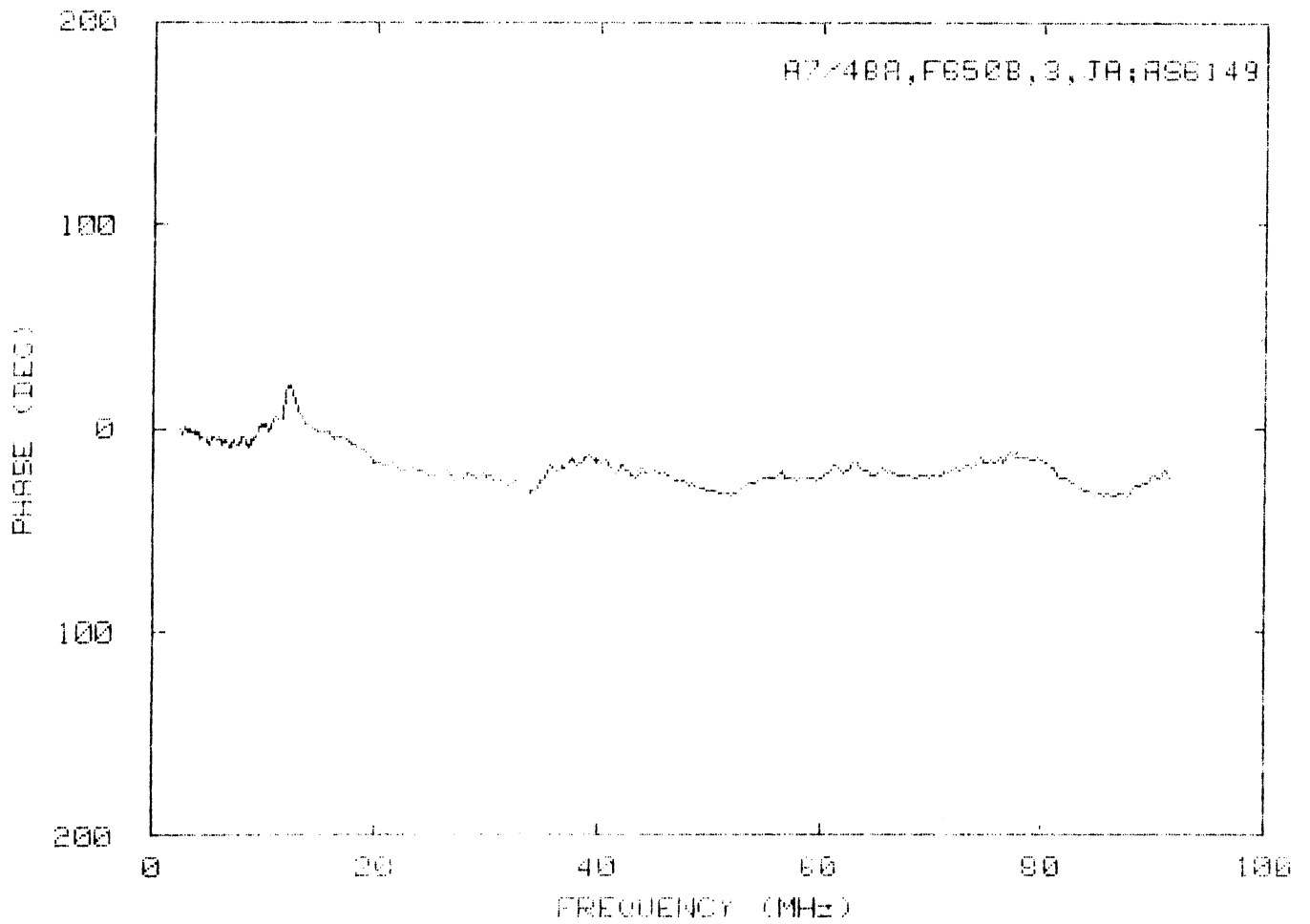
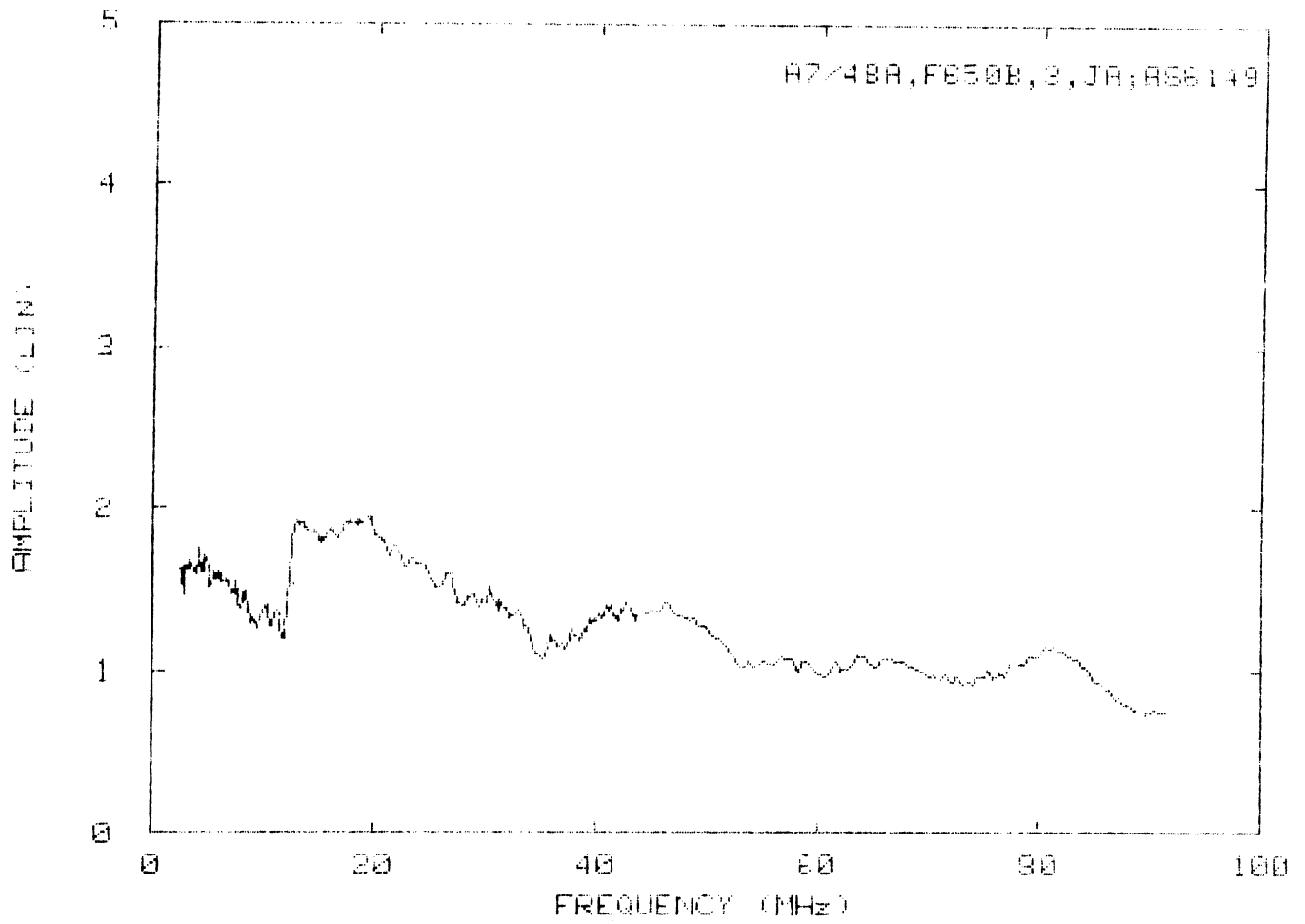
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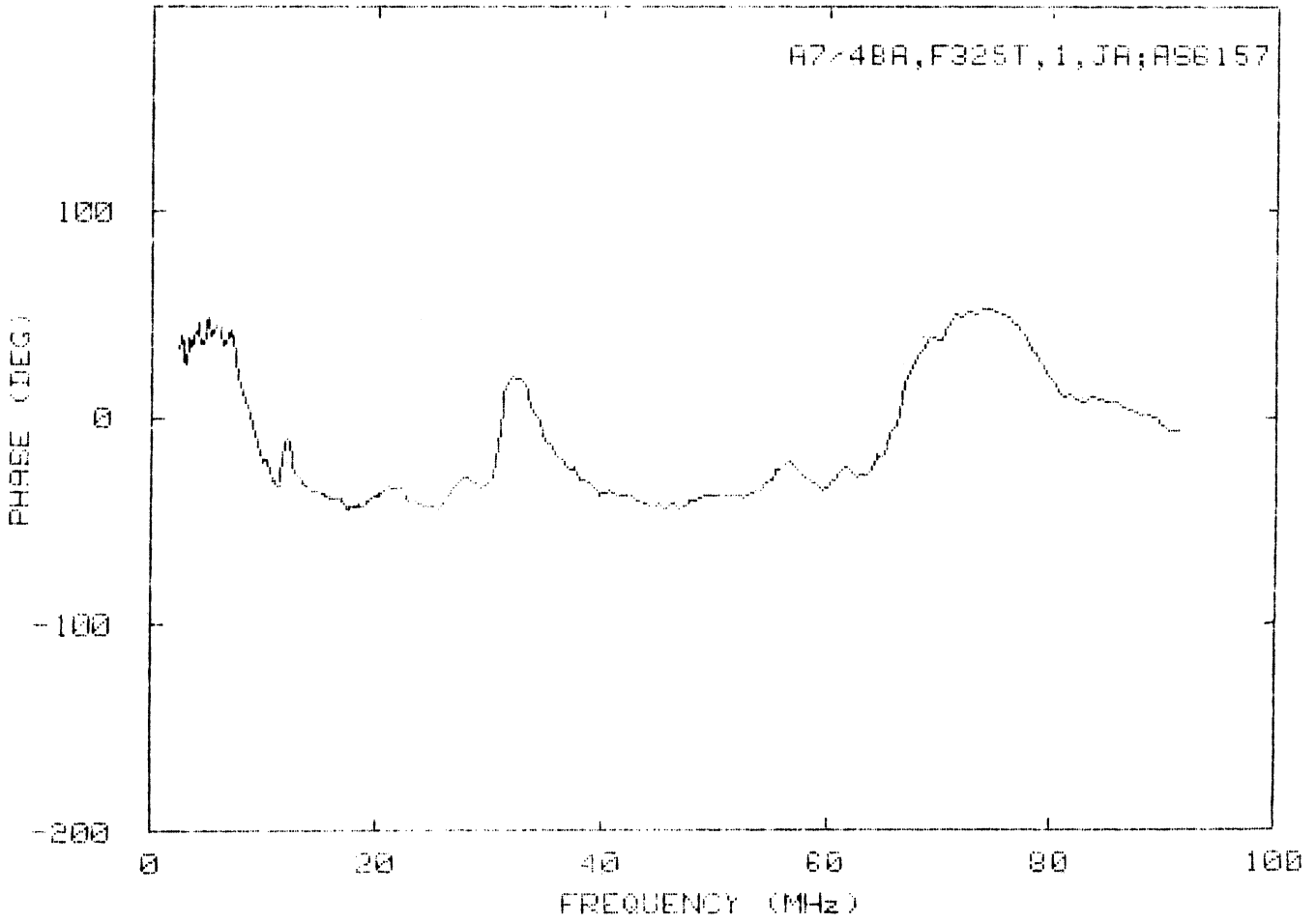
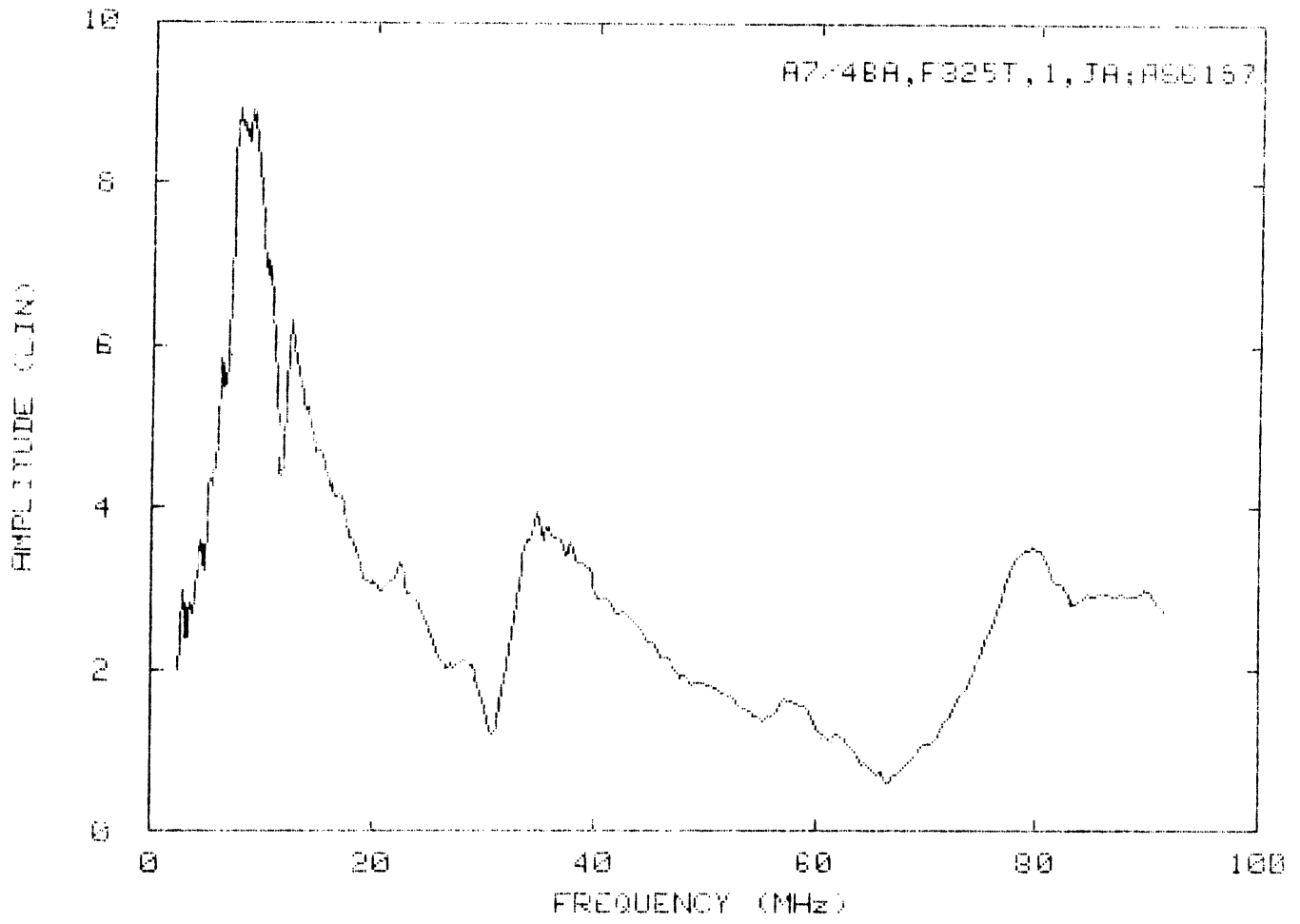
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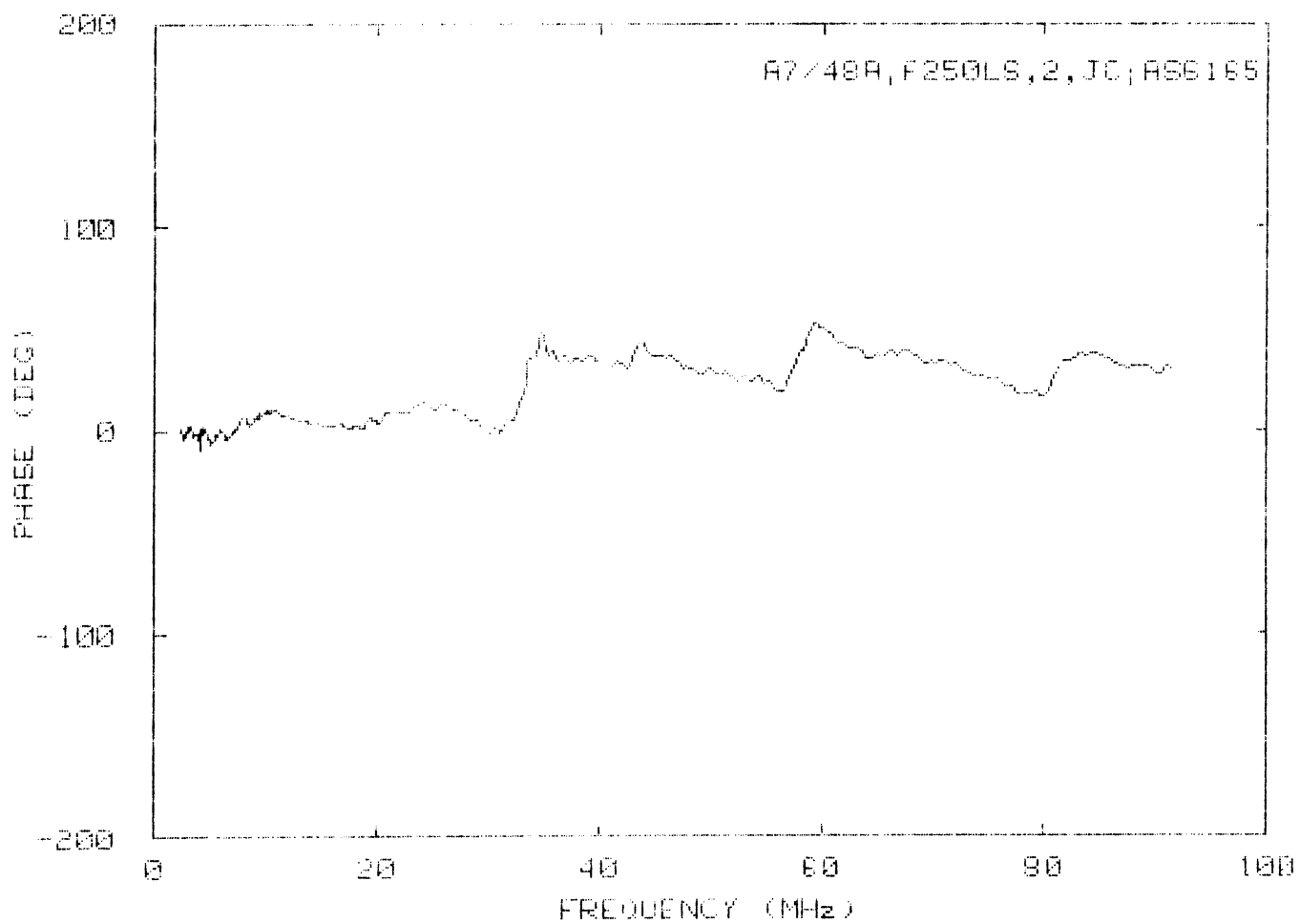
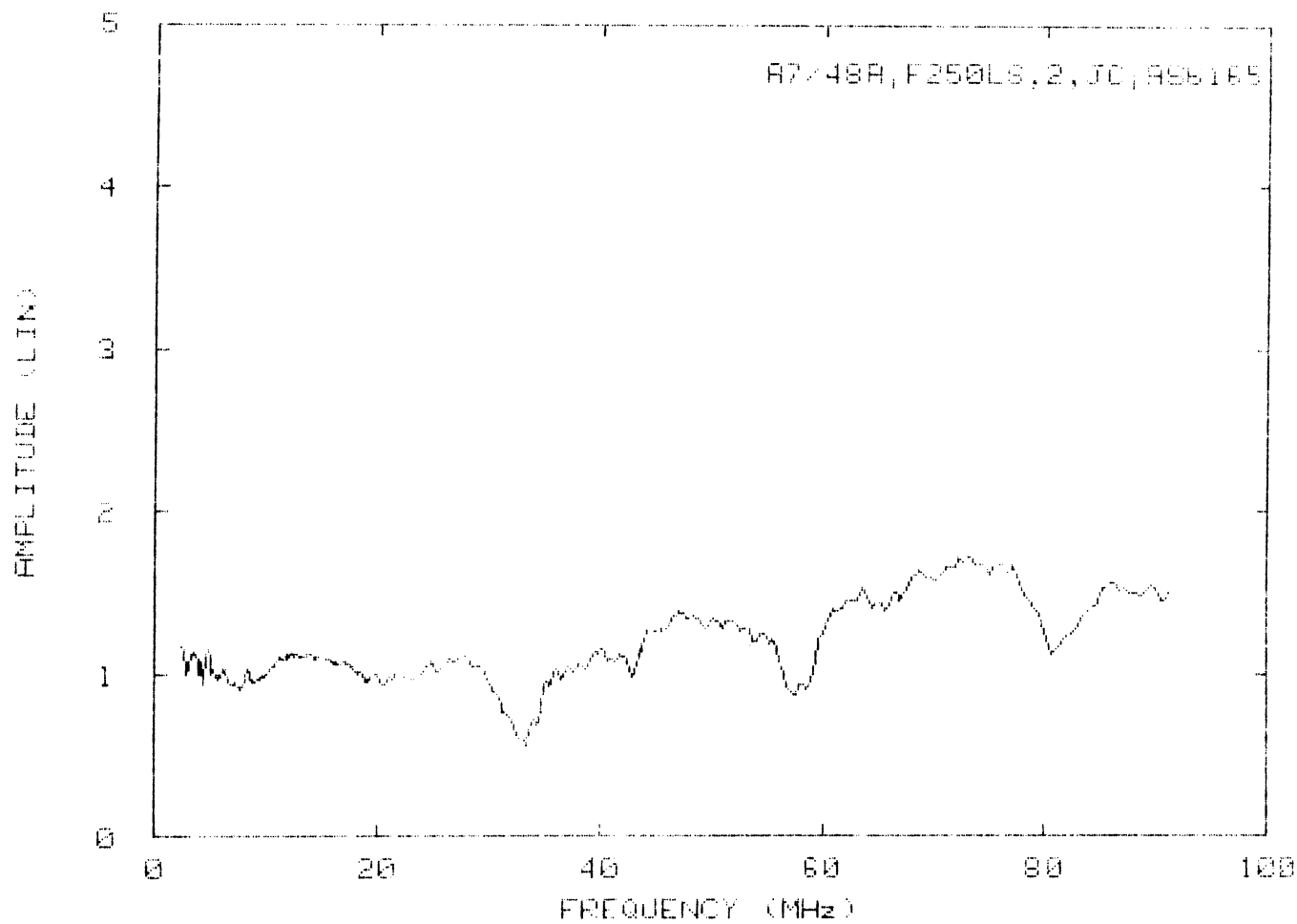
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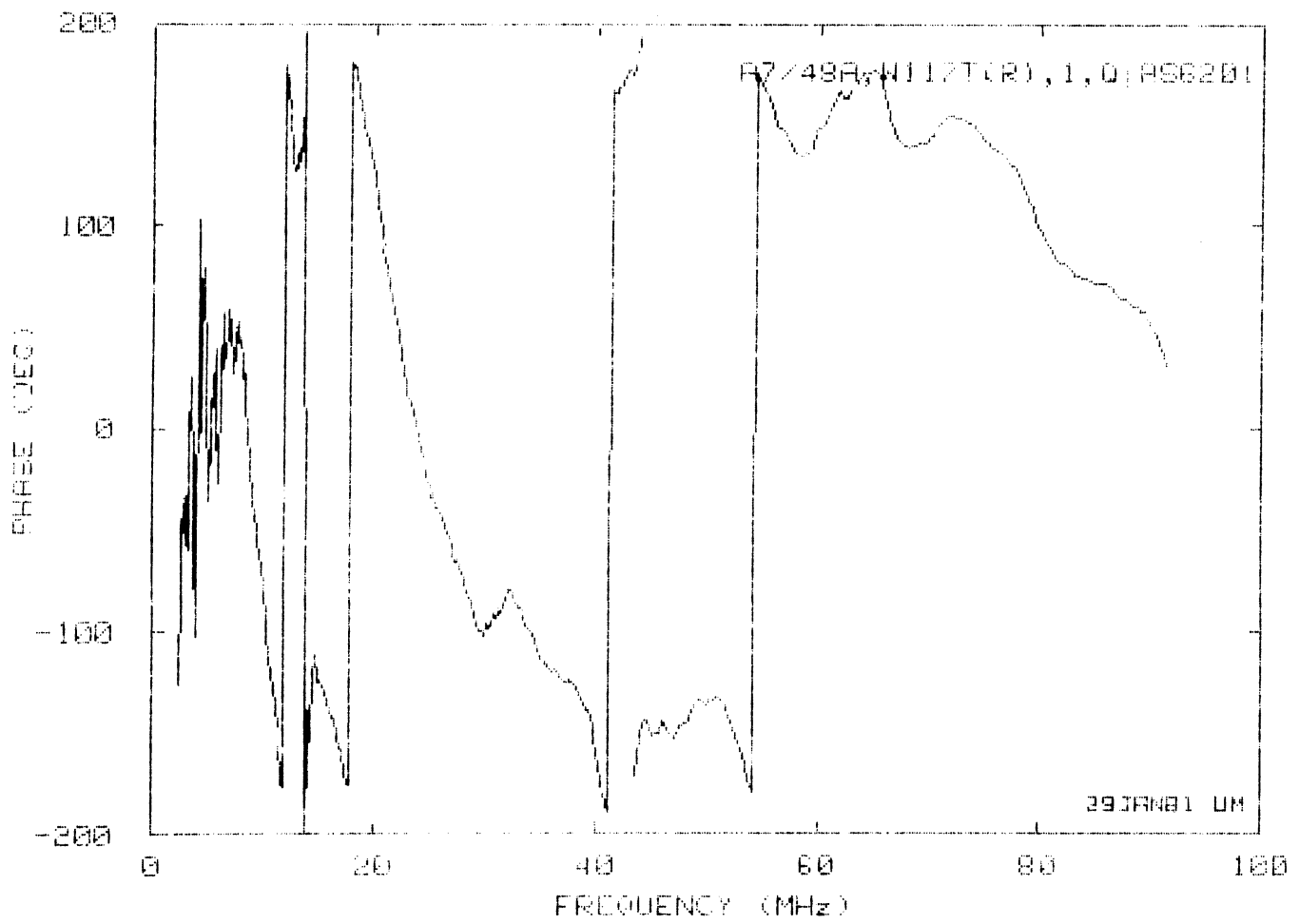
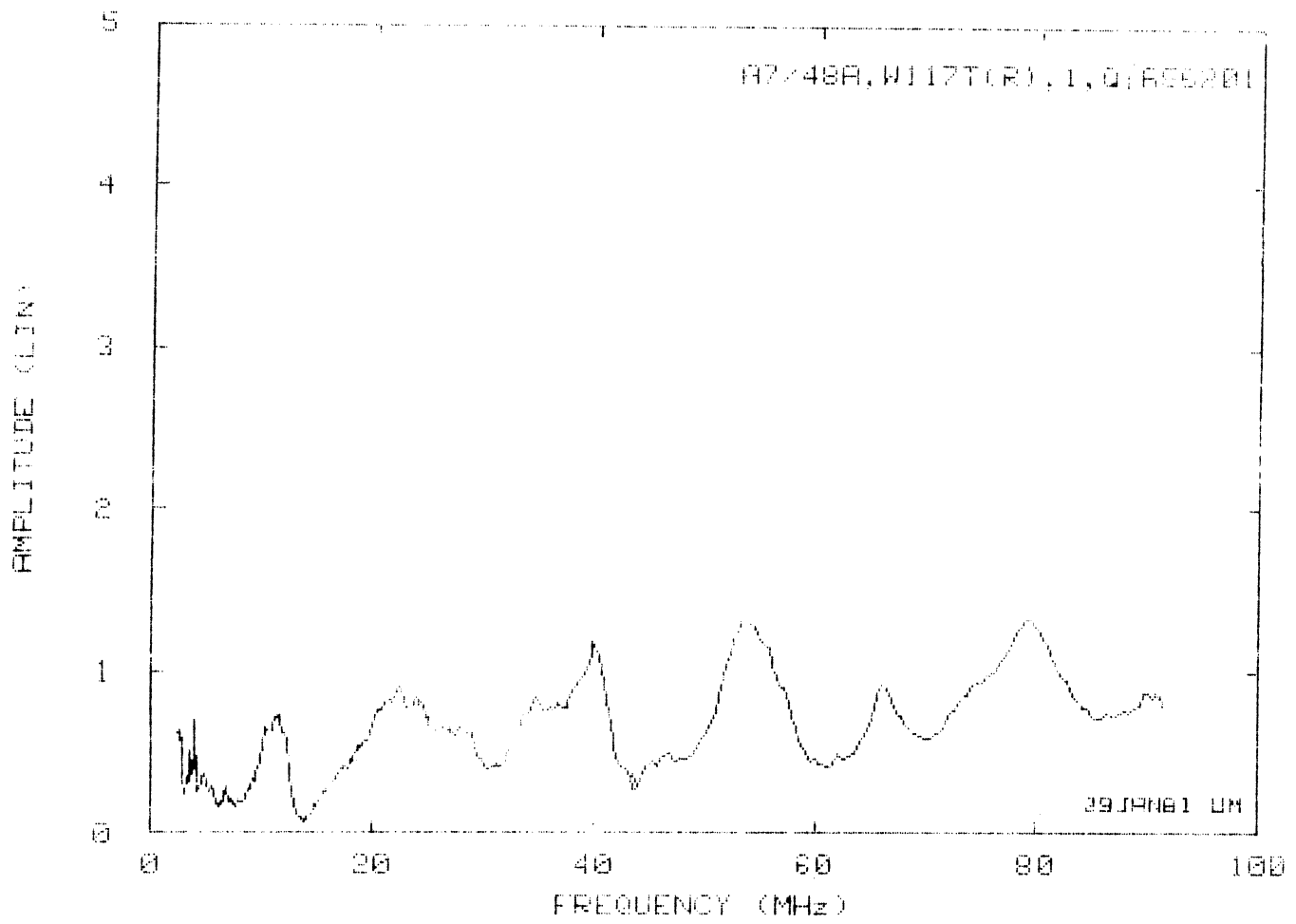
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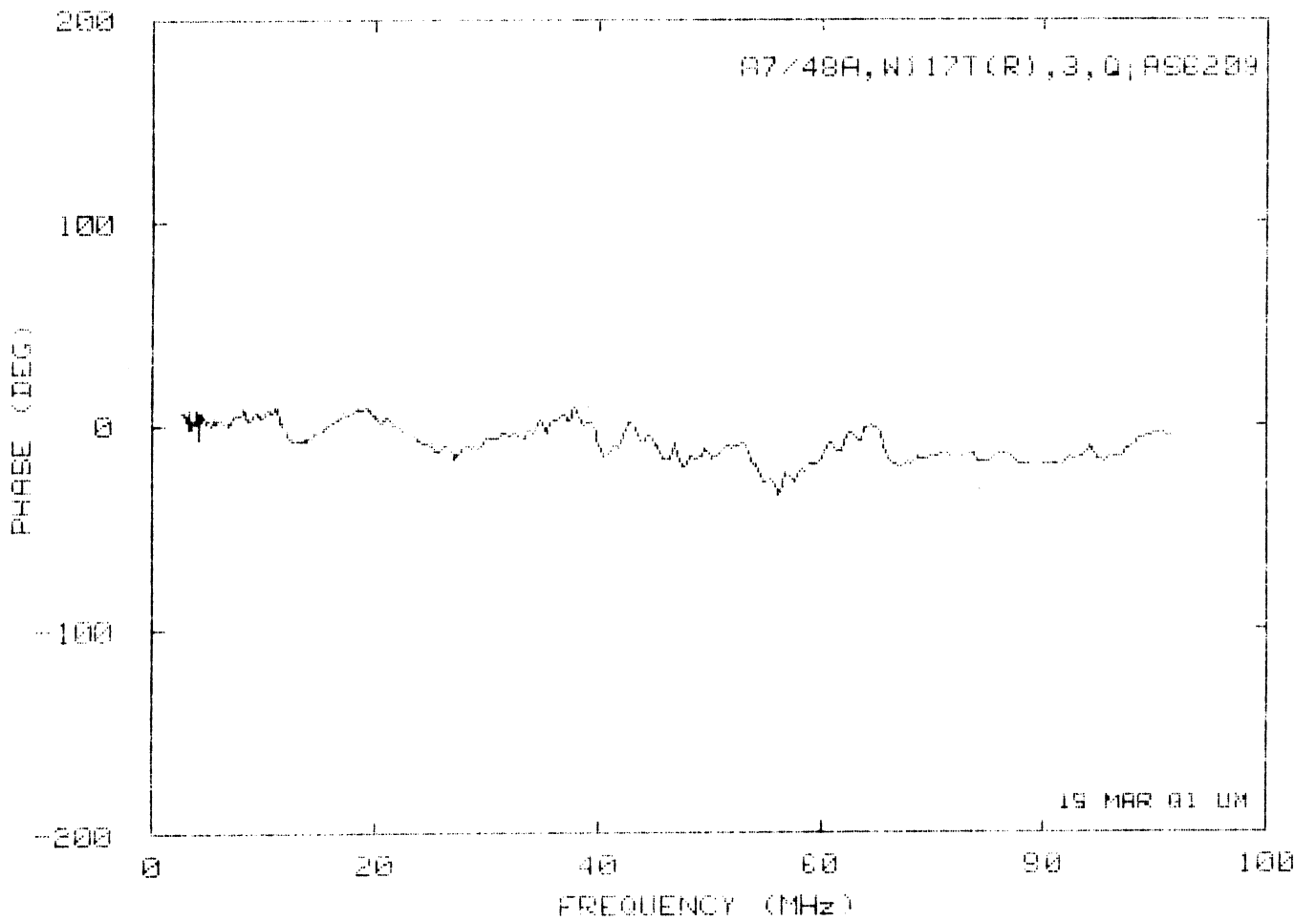
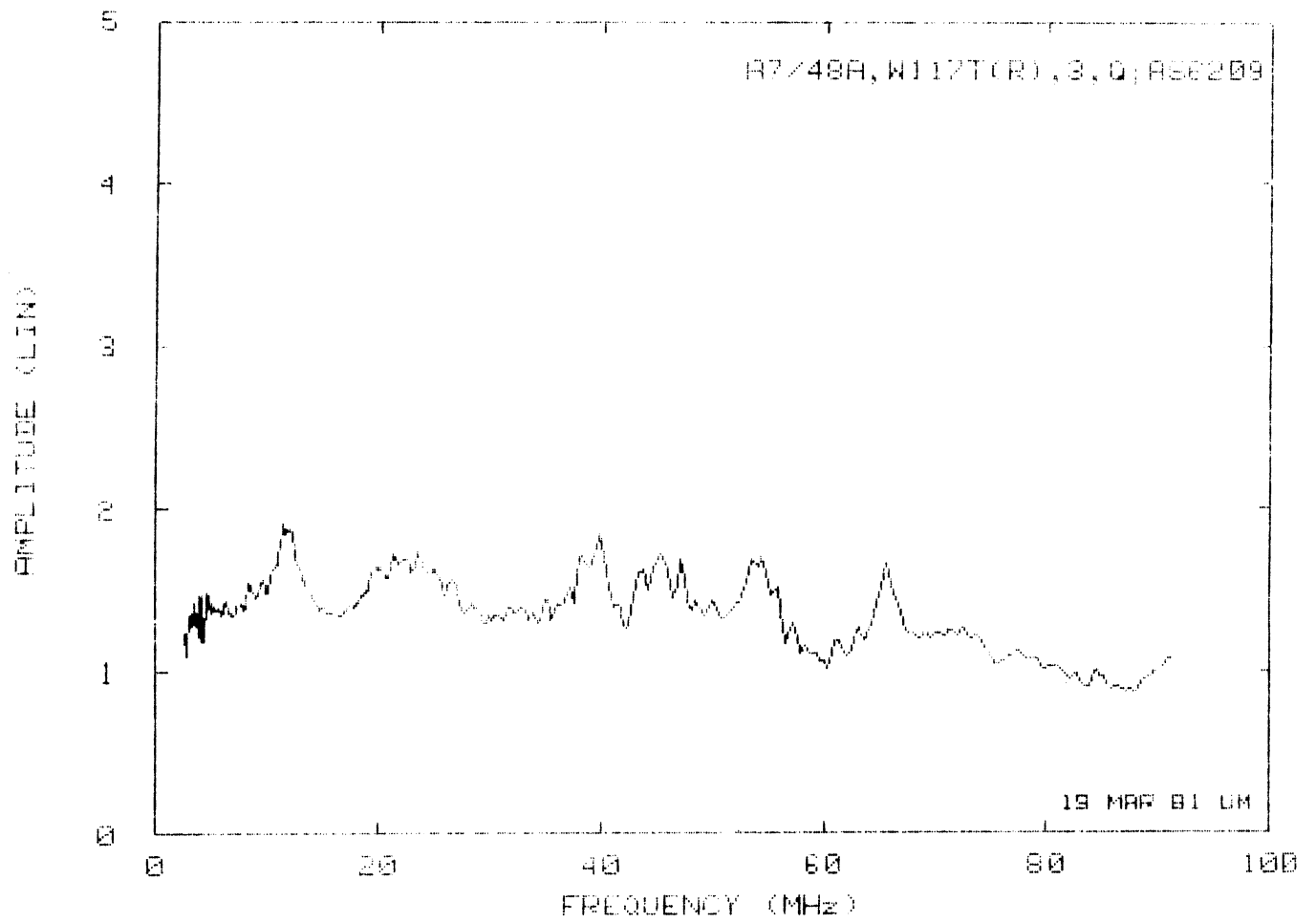
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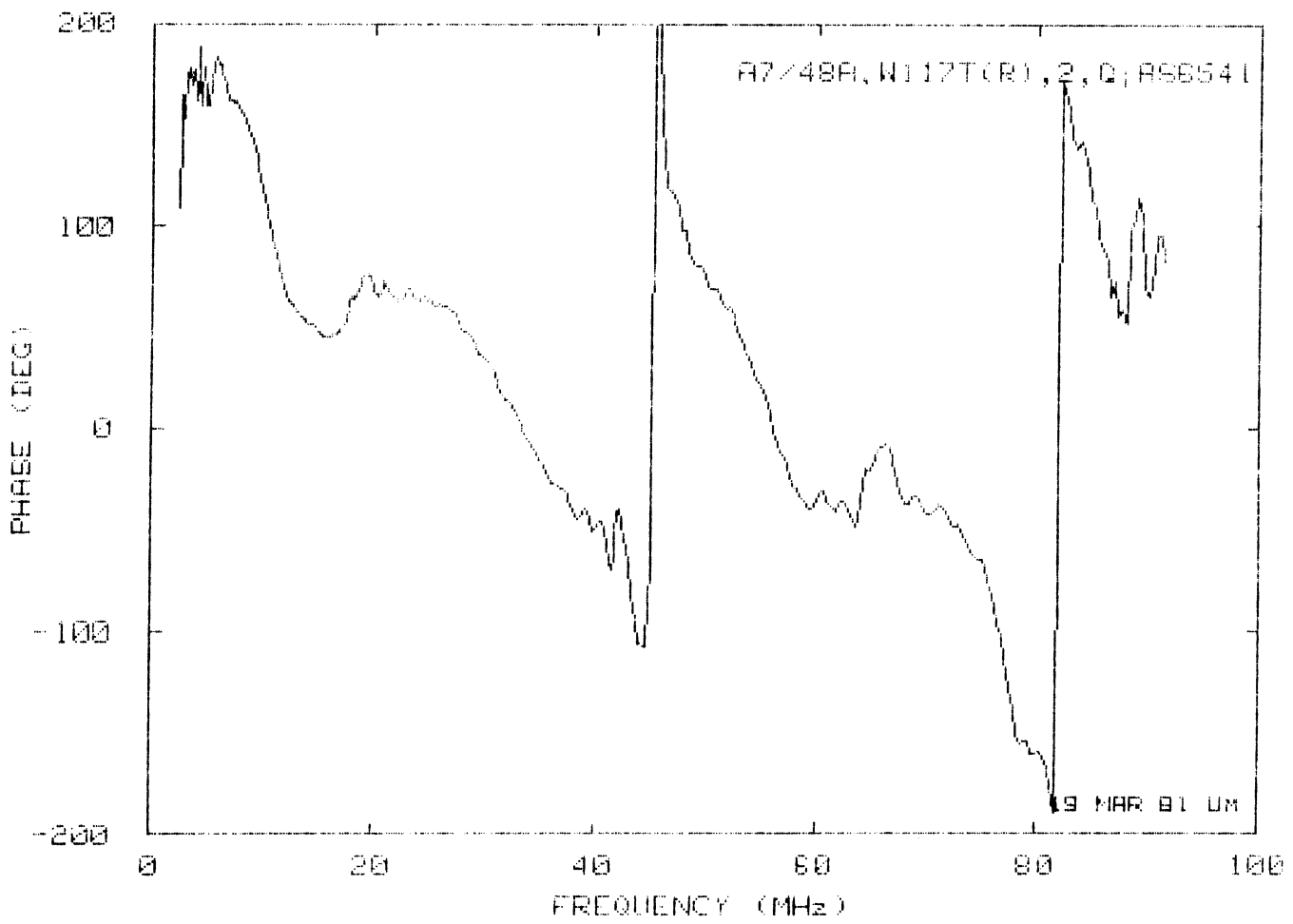
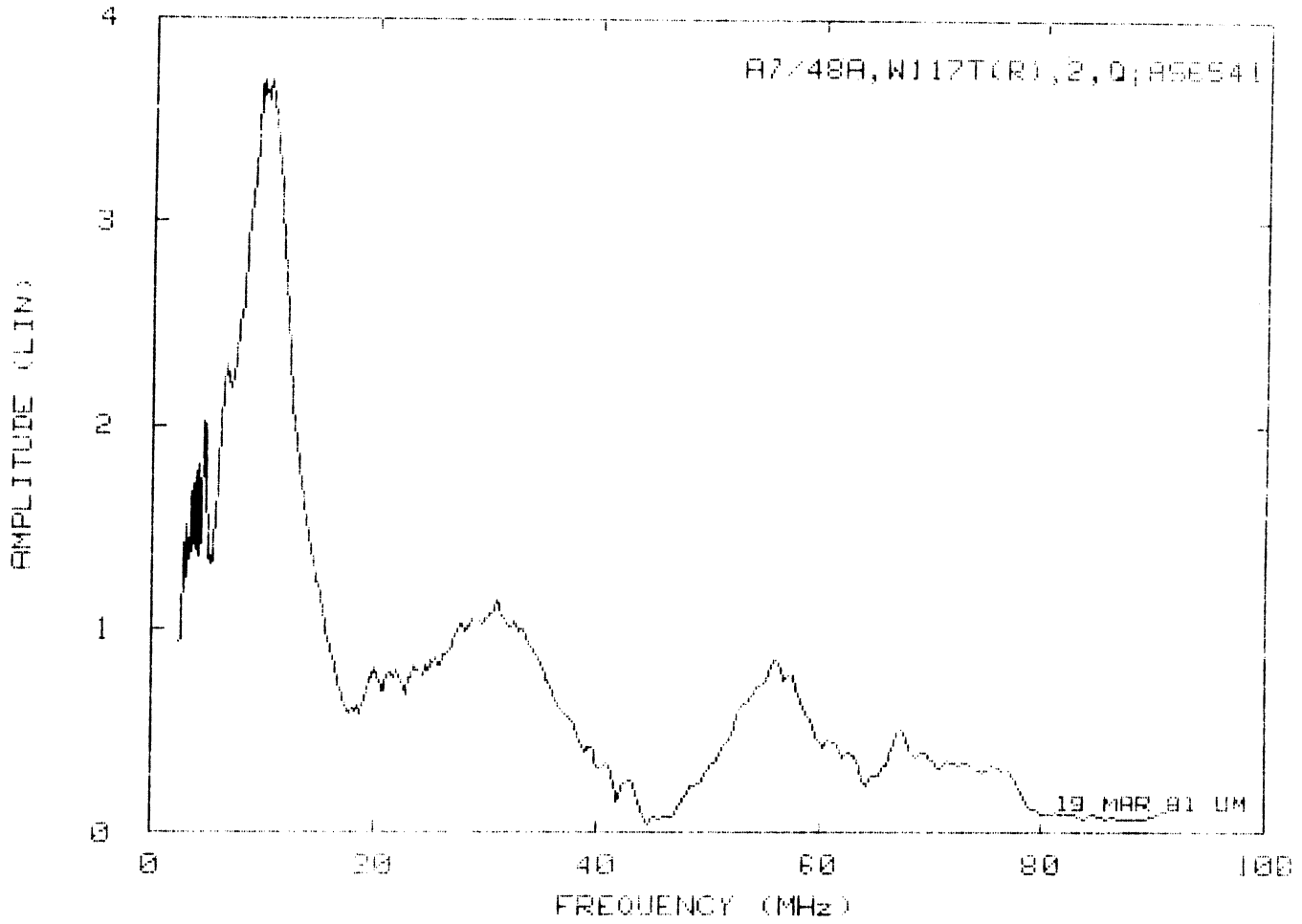
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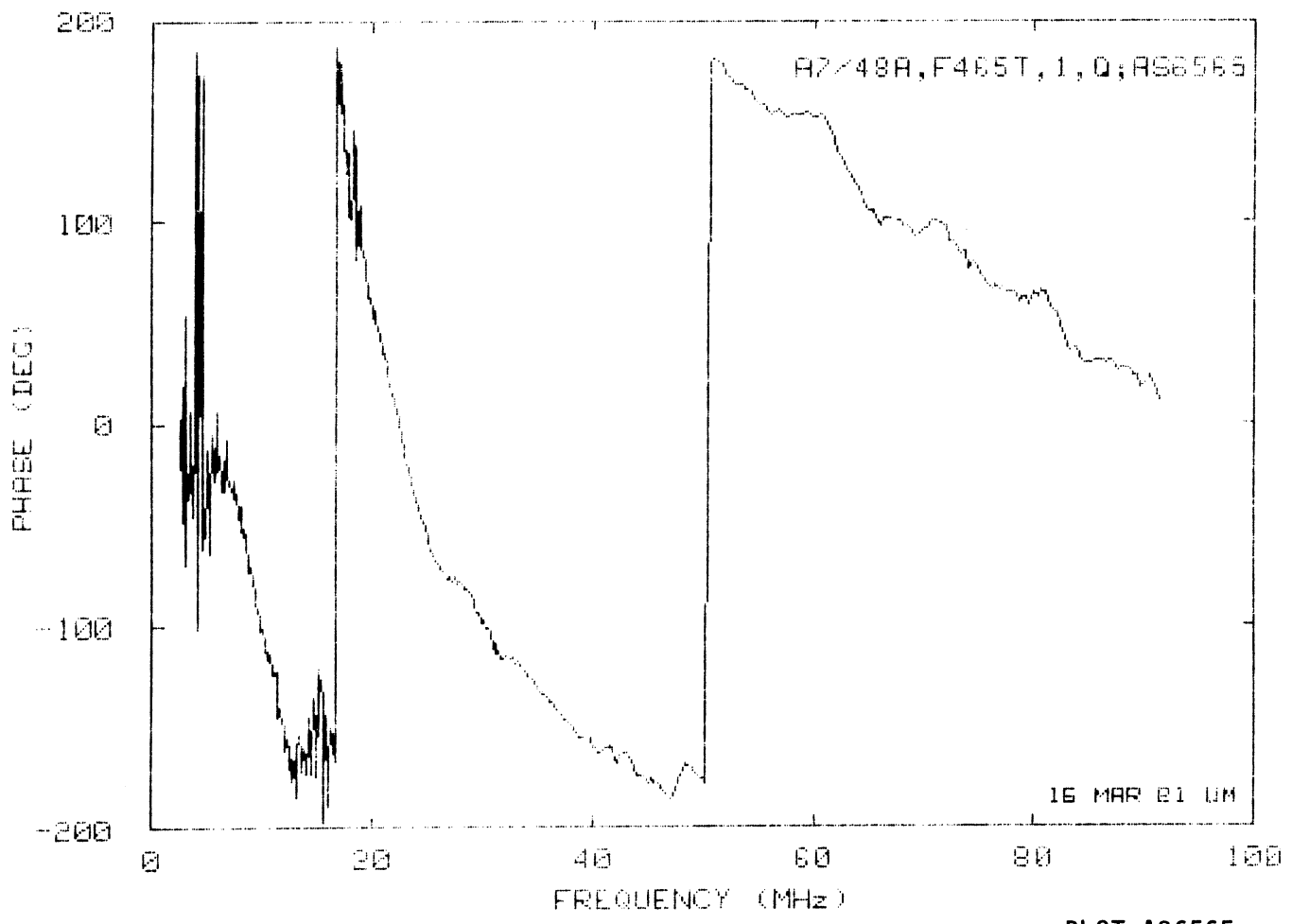
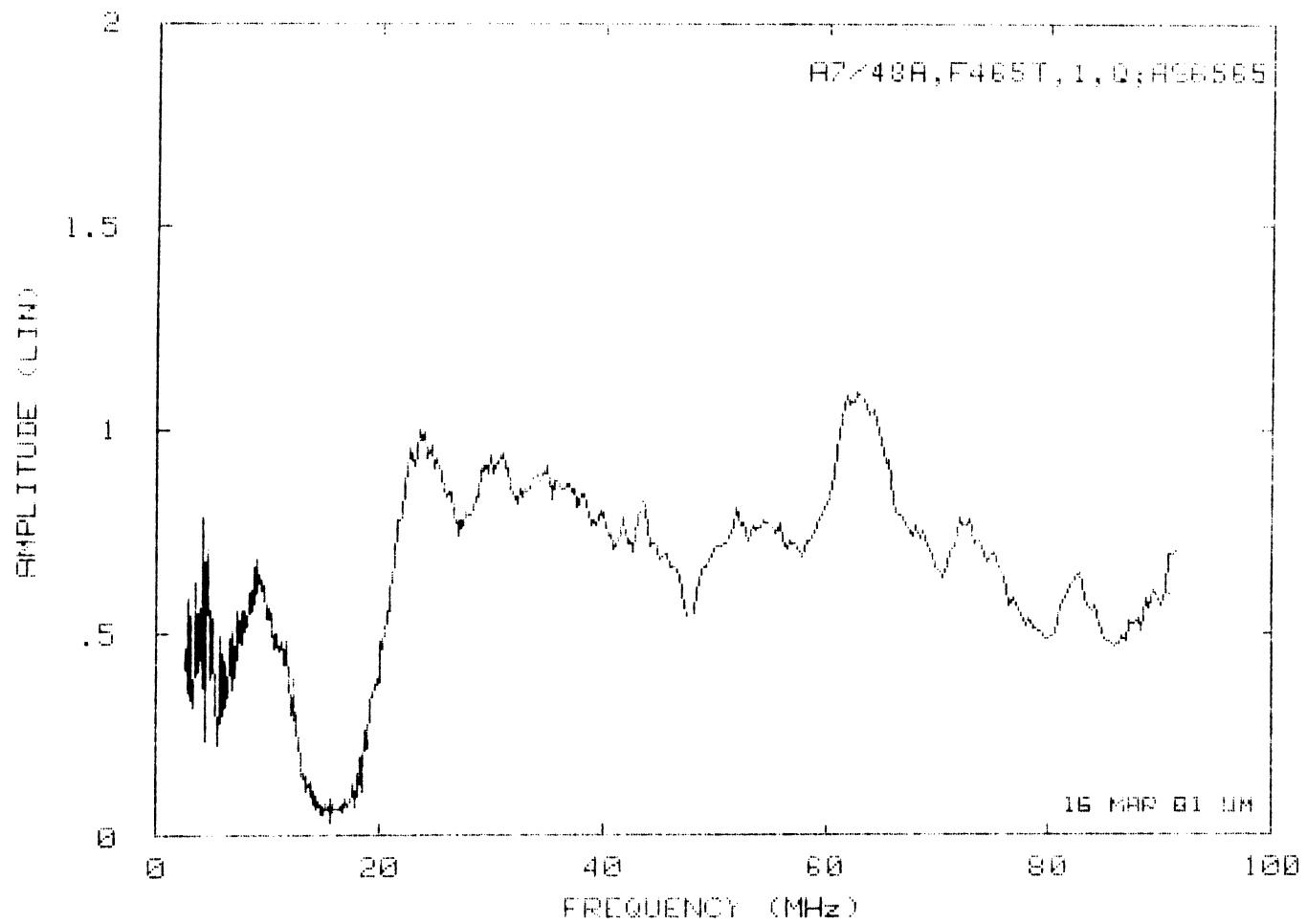
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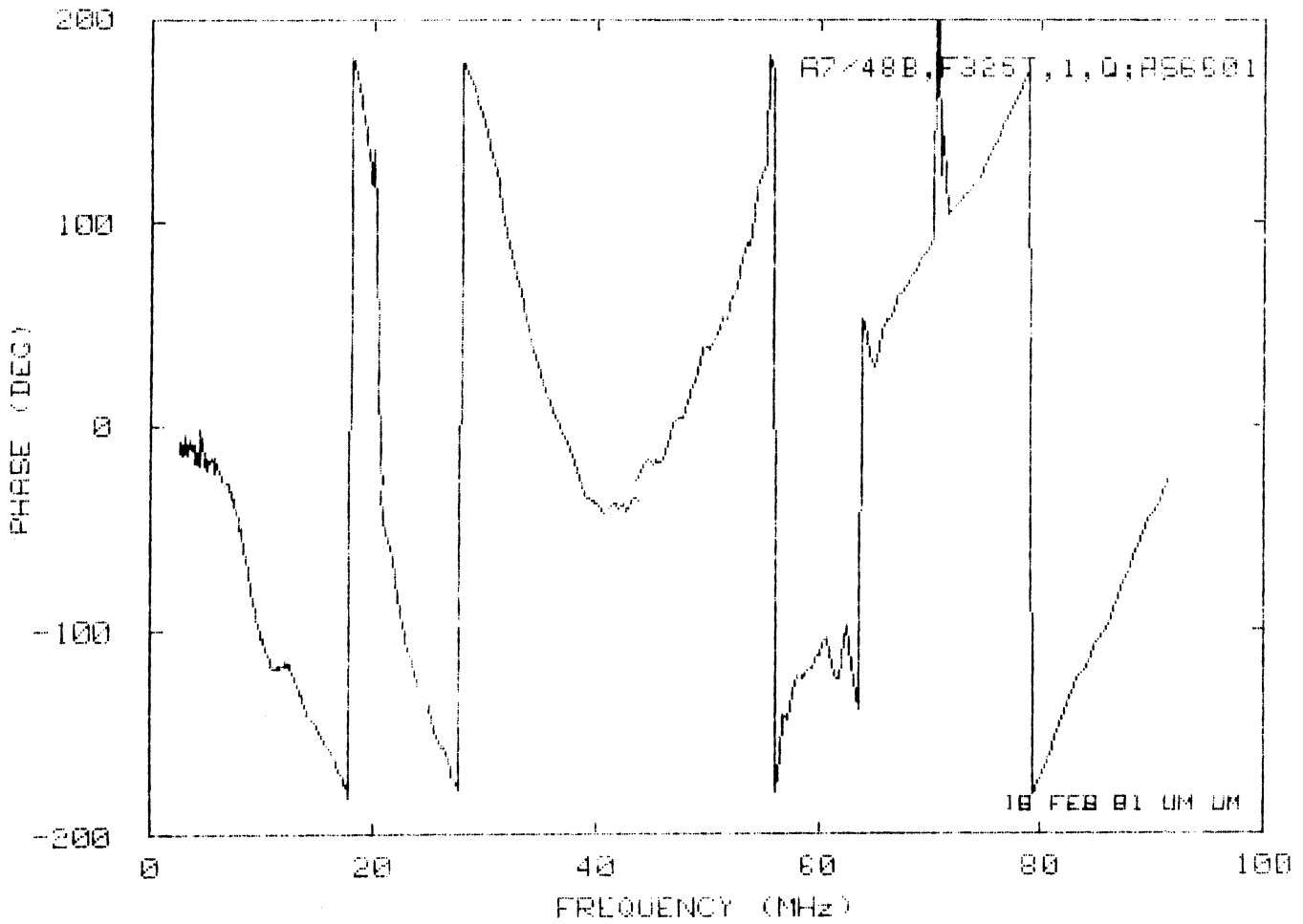
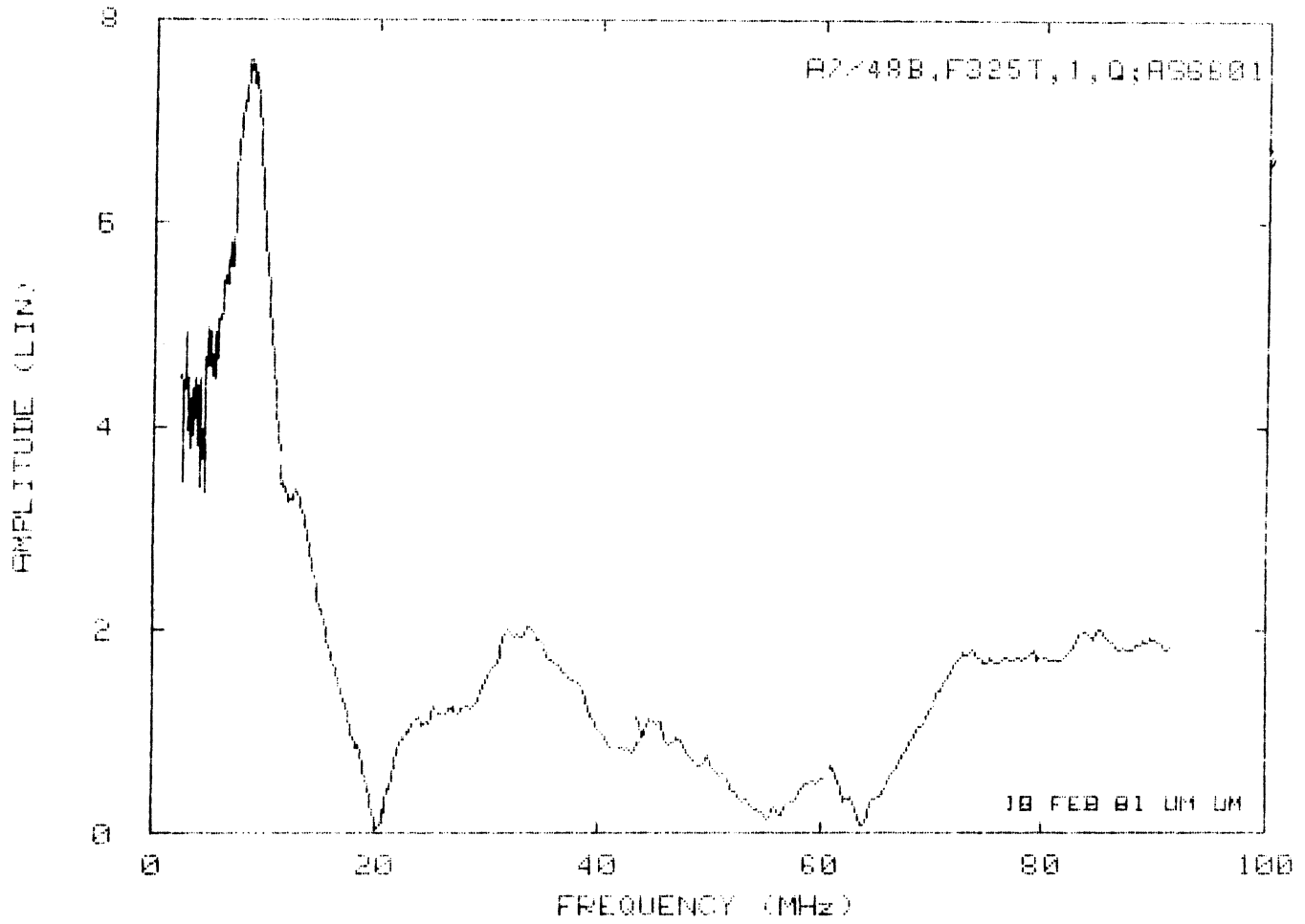
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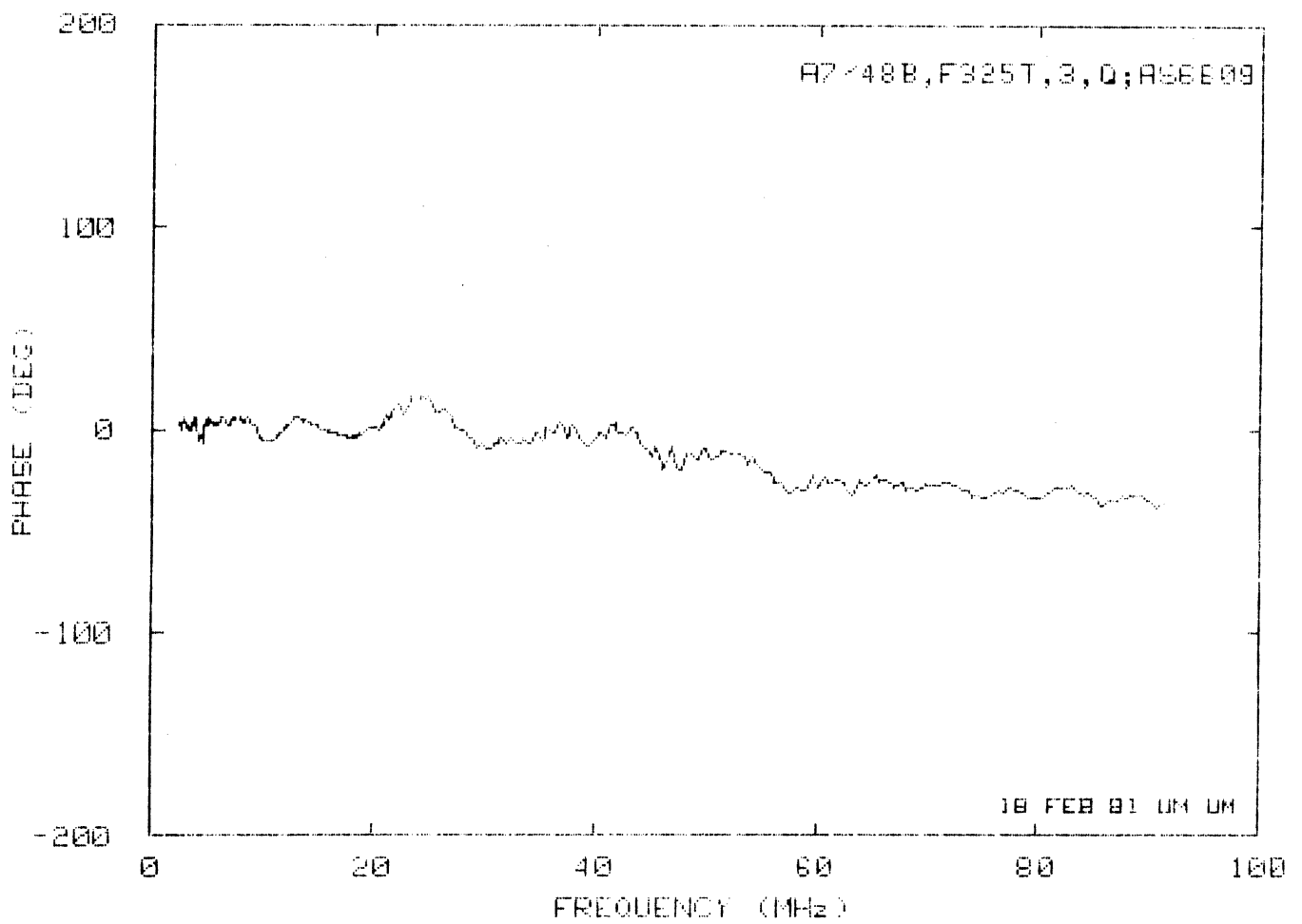
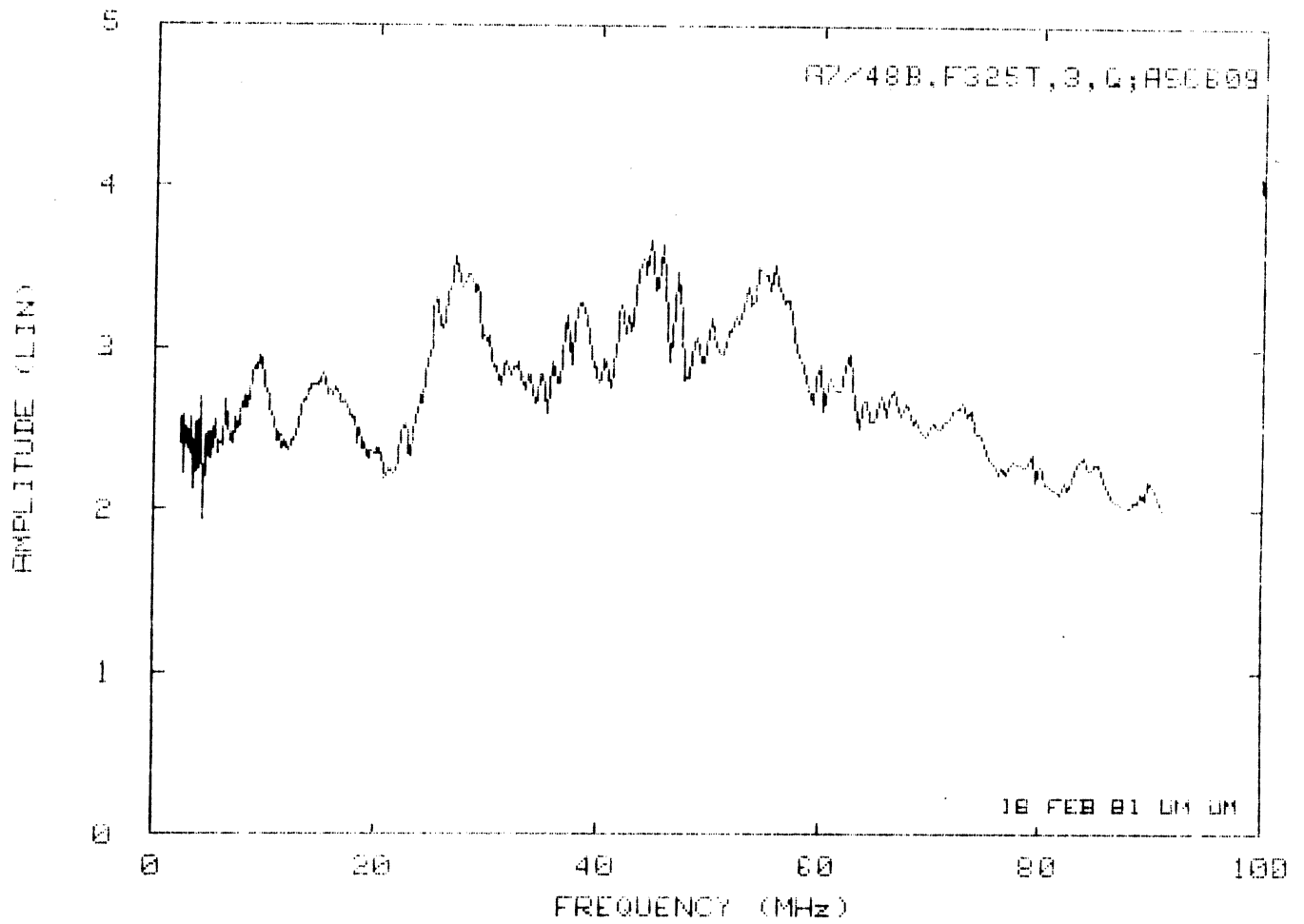
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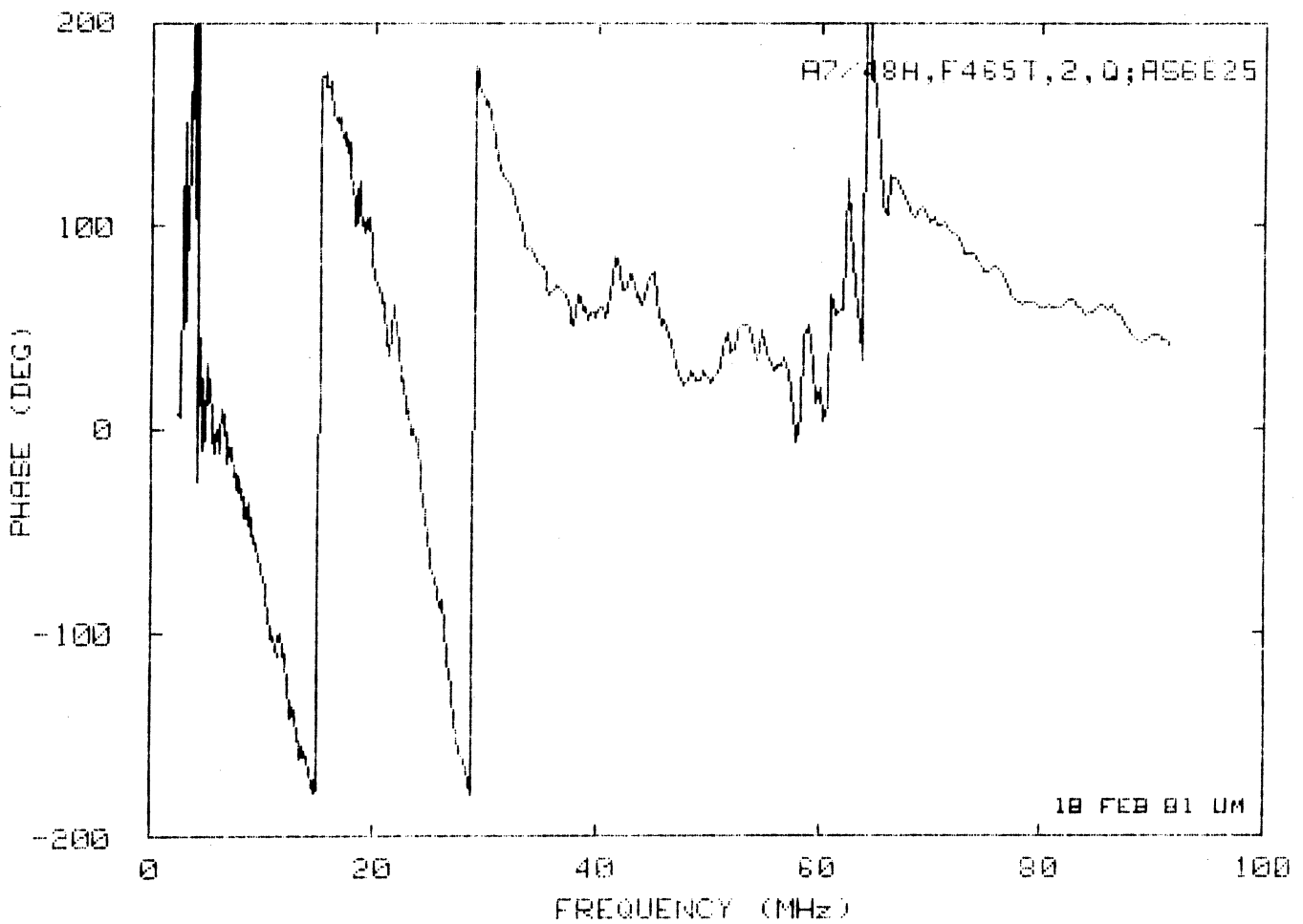
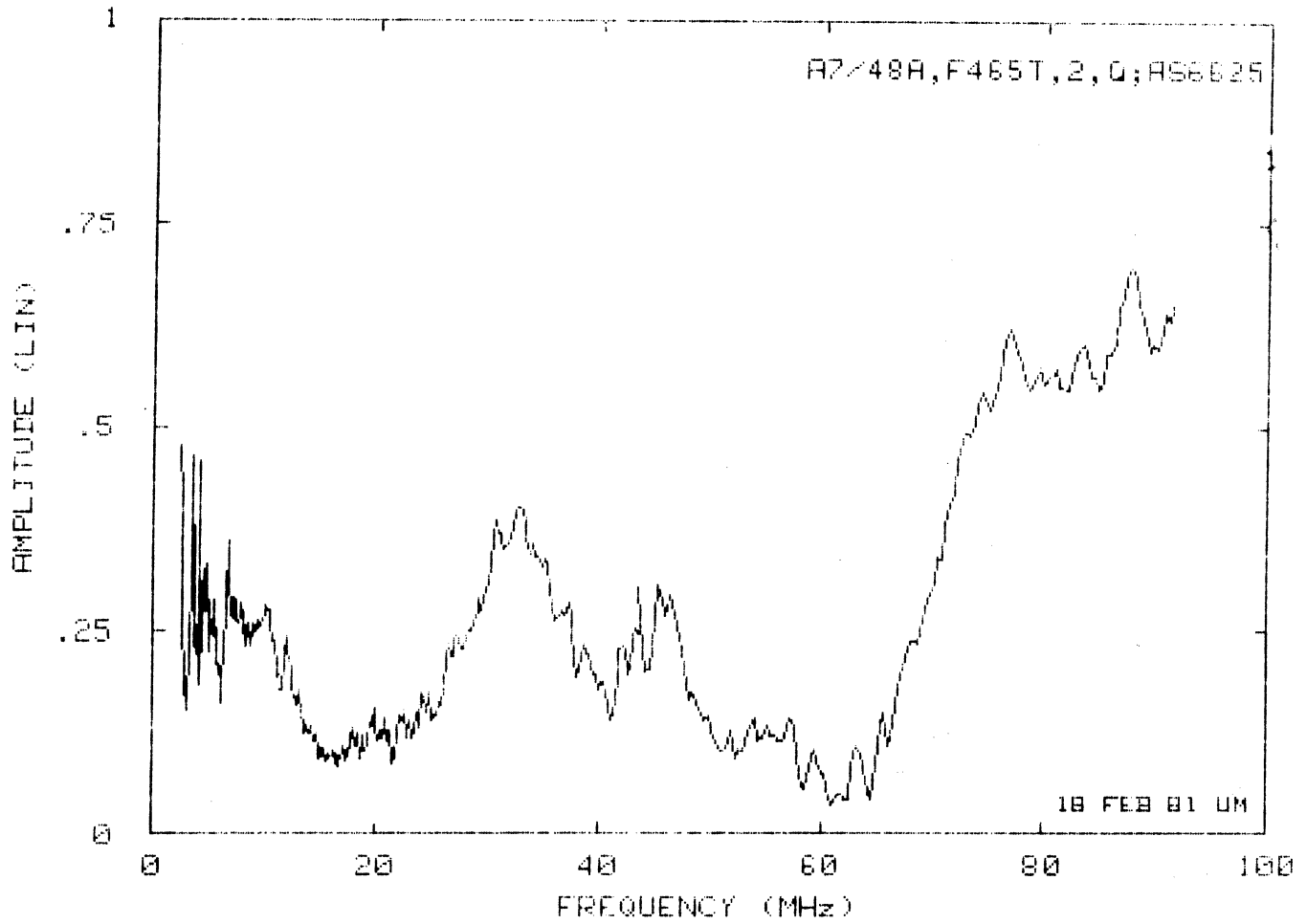
PLOT AS6565



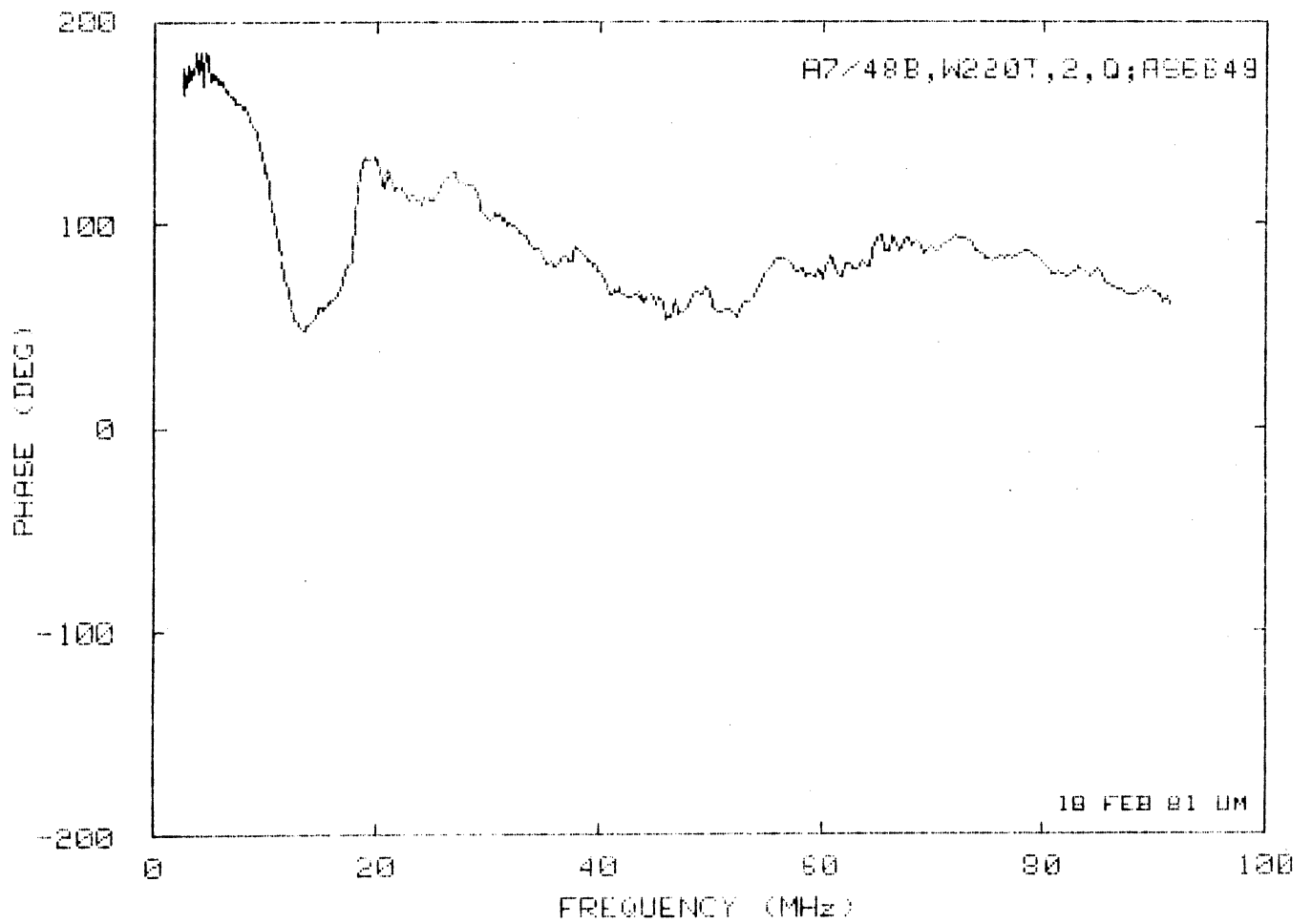
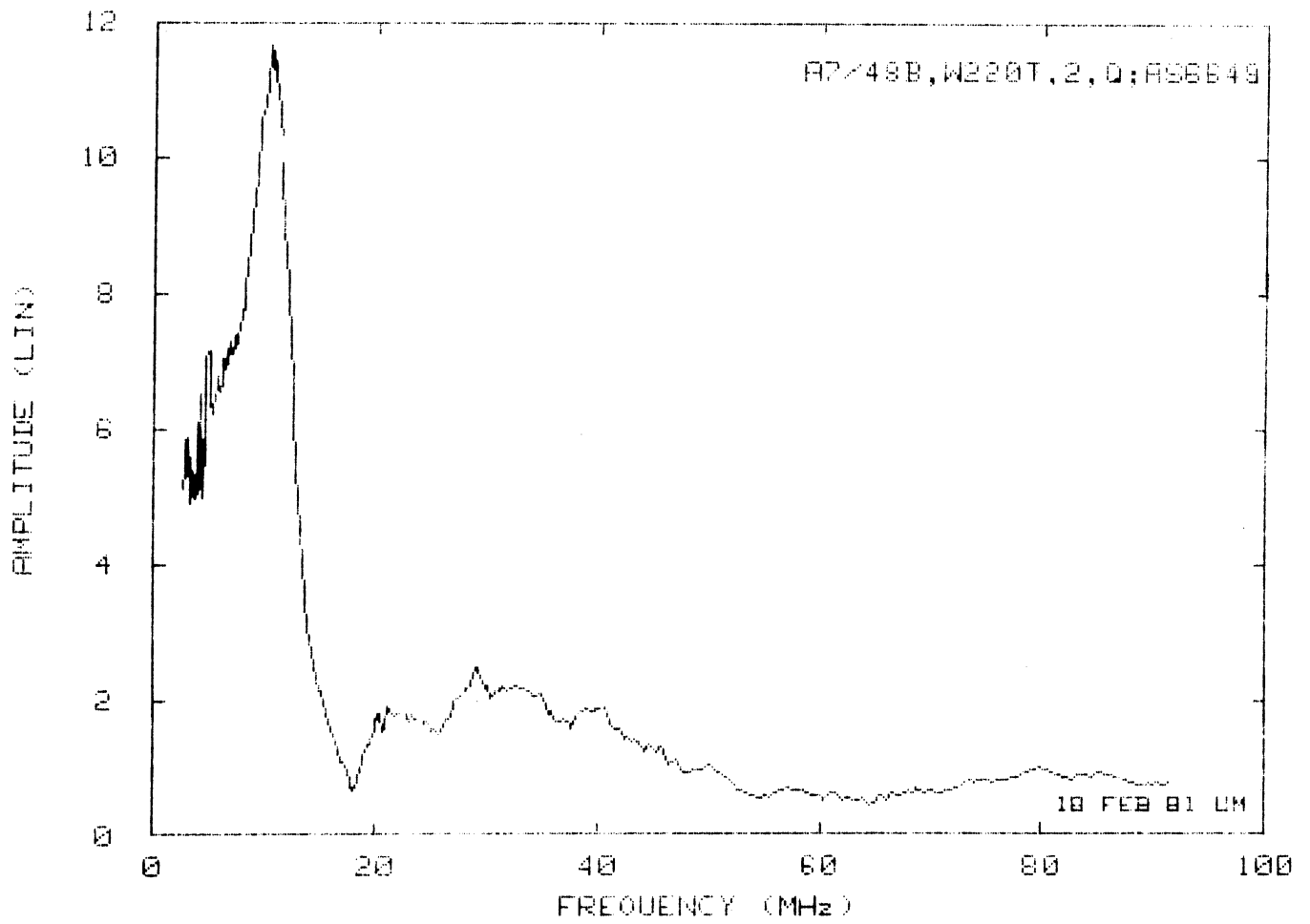
PLOT AS6601



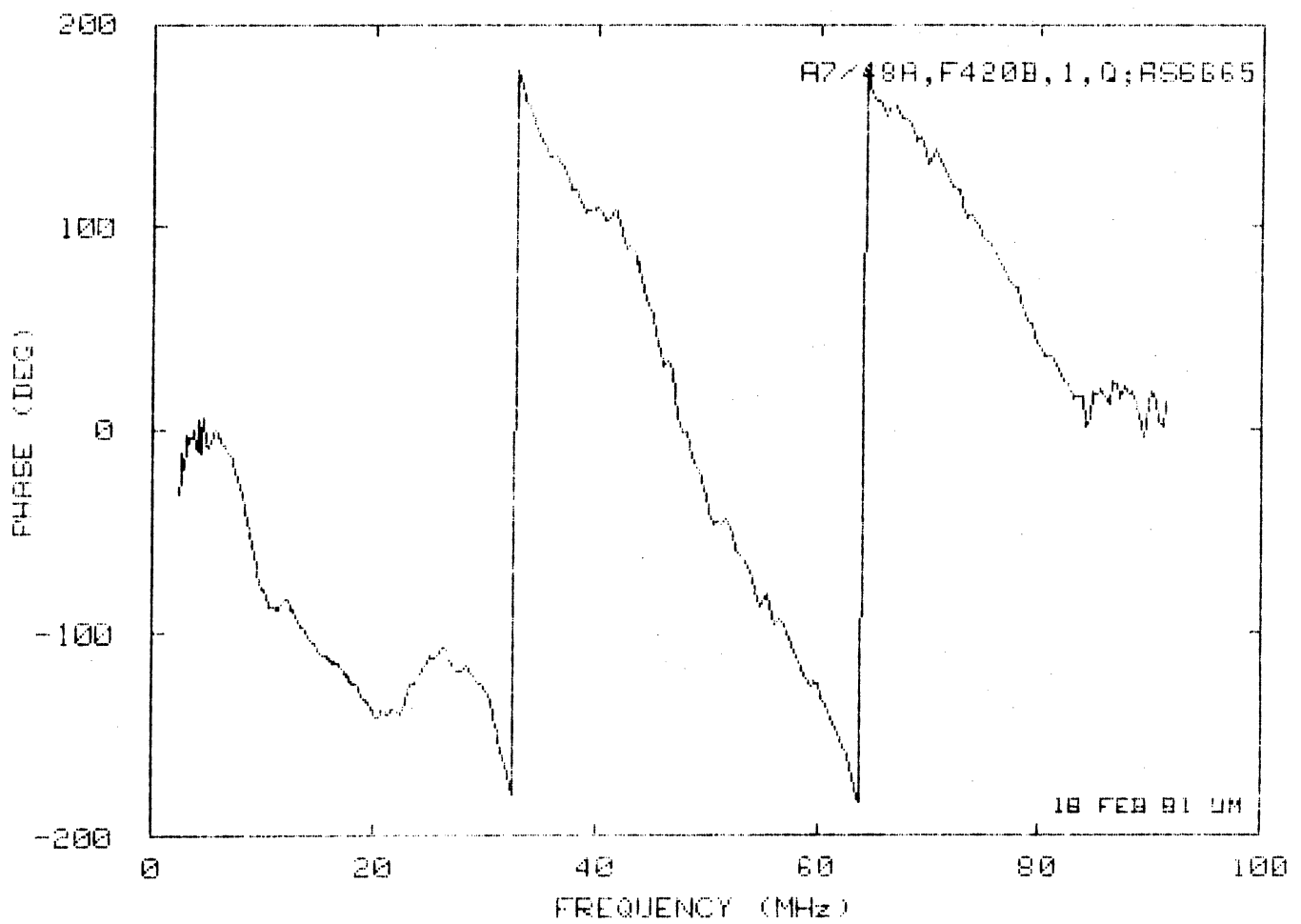
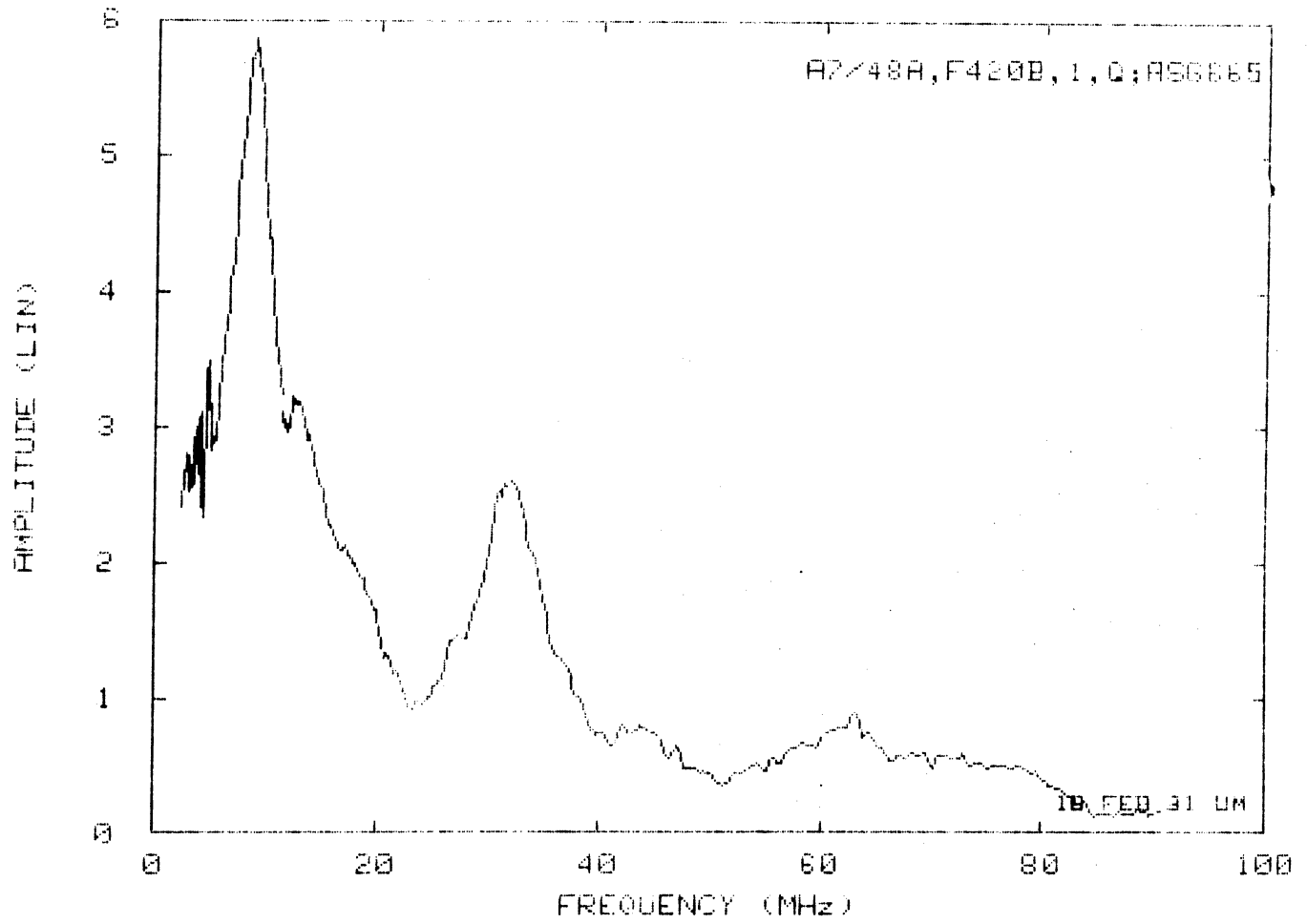
PLOT AS6609



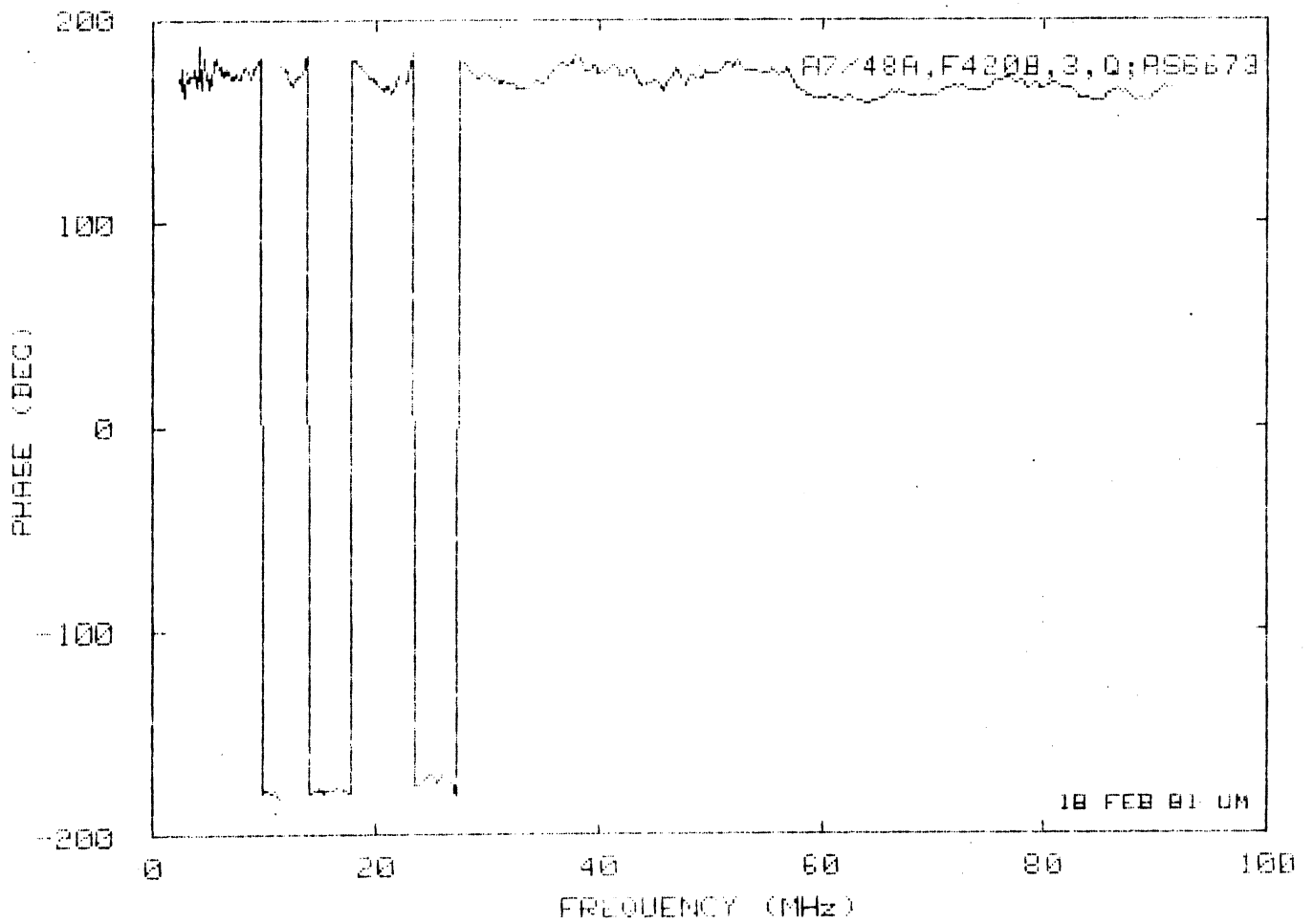
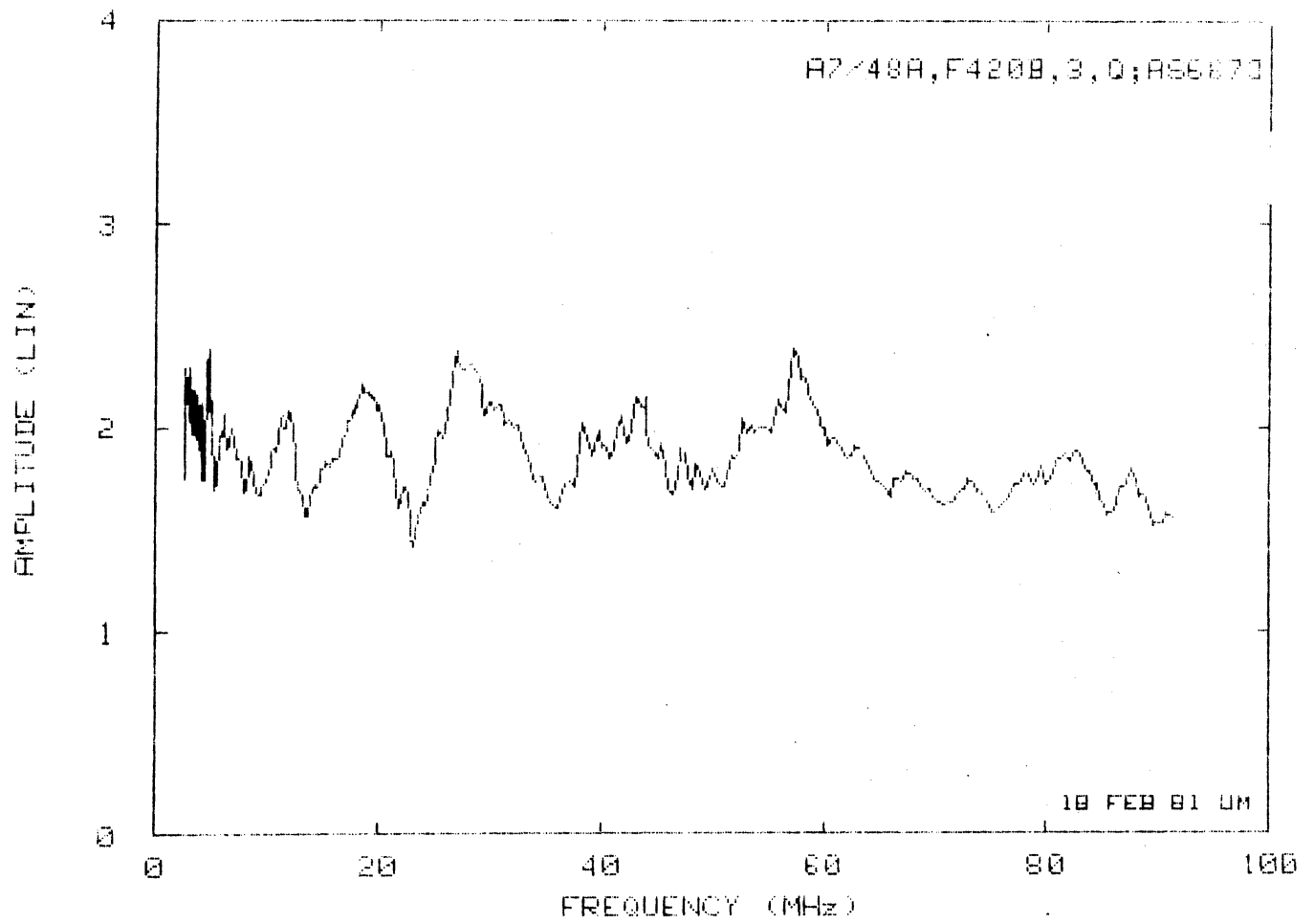
PLOT AS6625



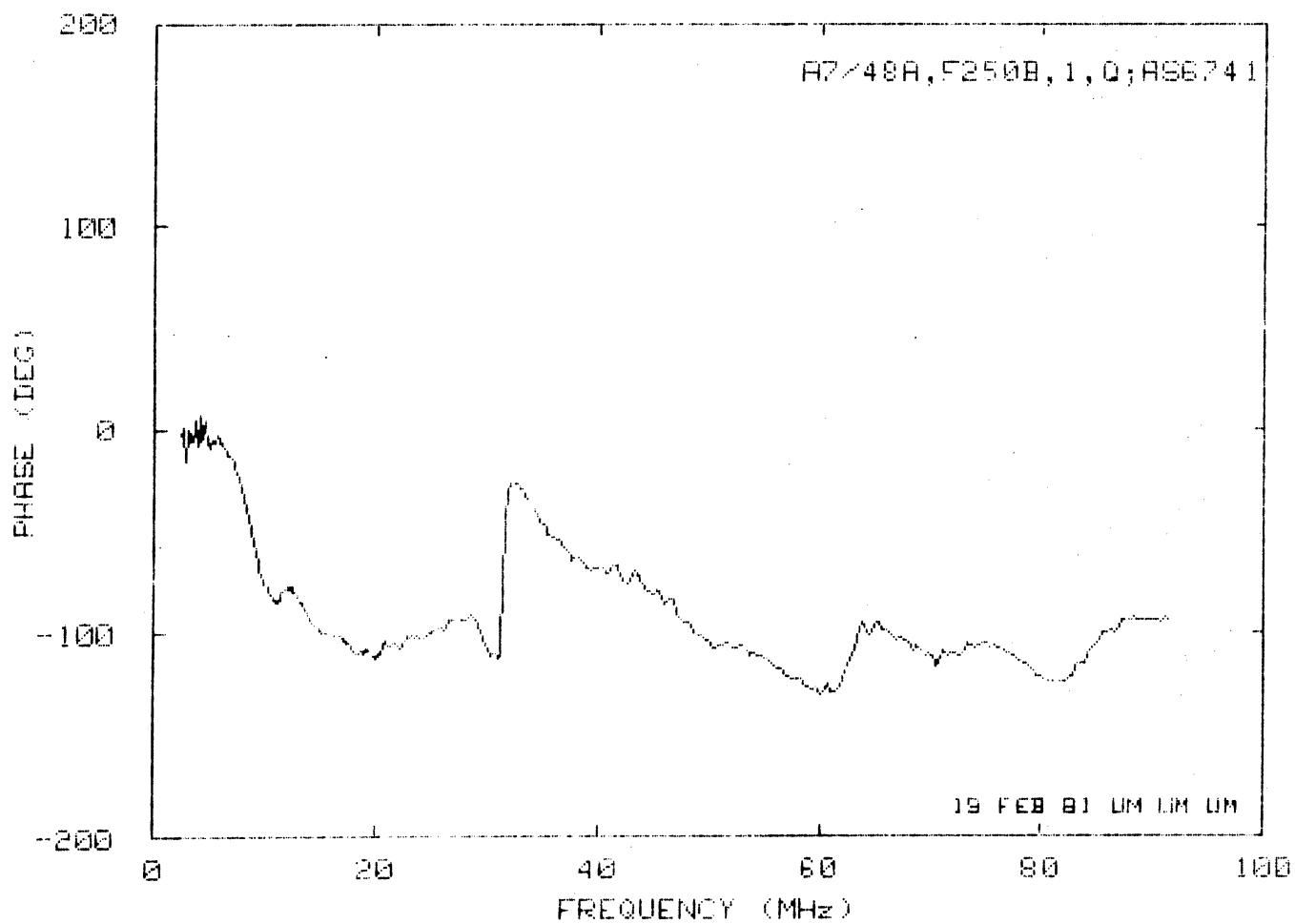
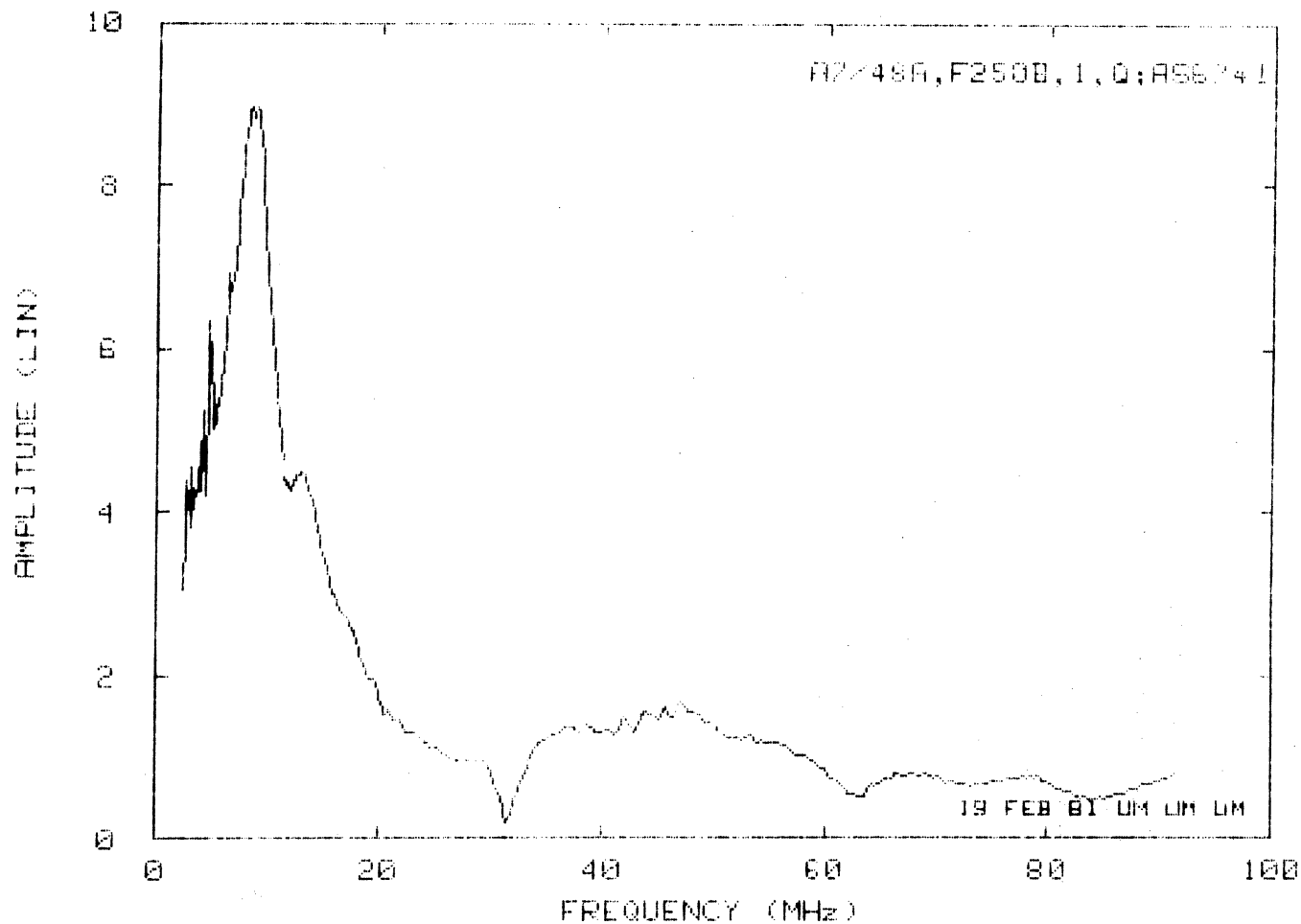
PLOT AS6649



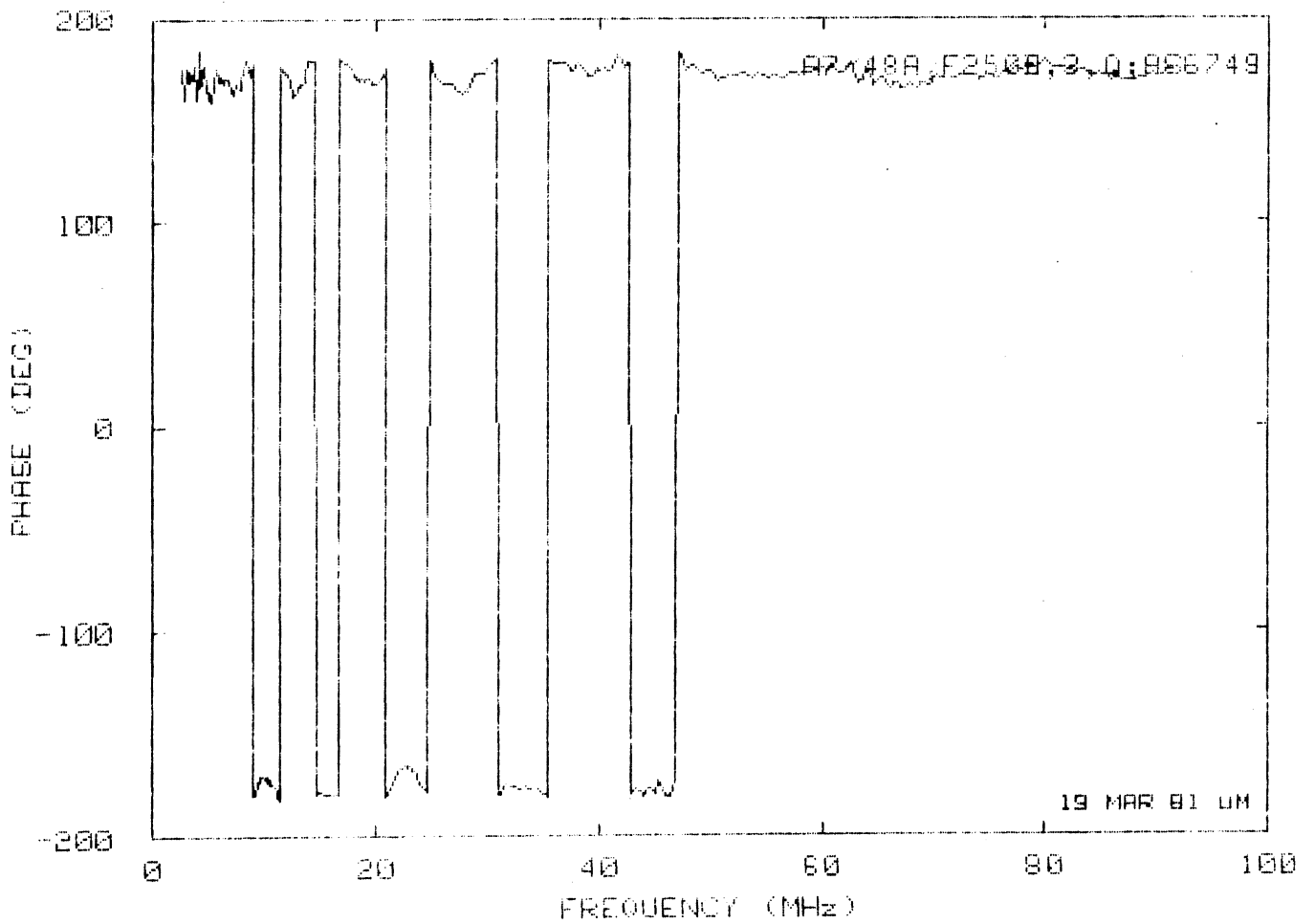
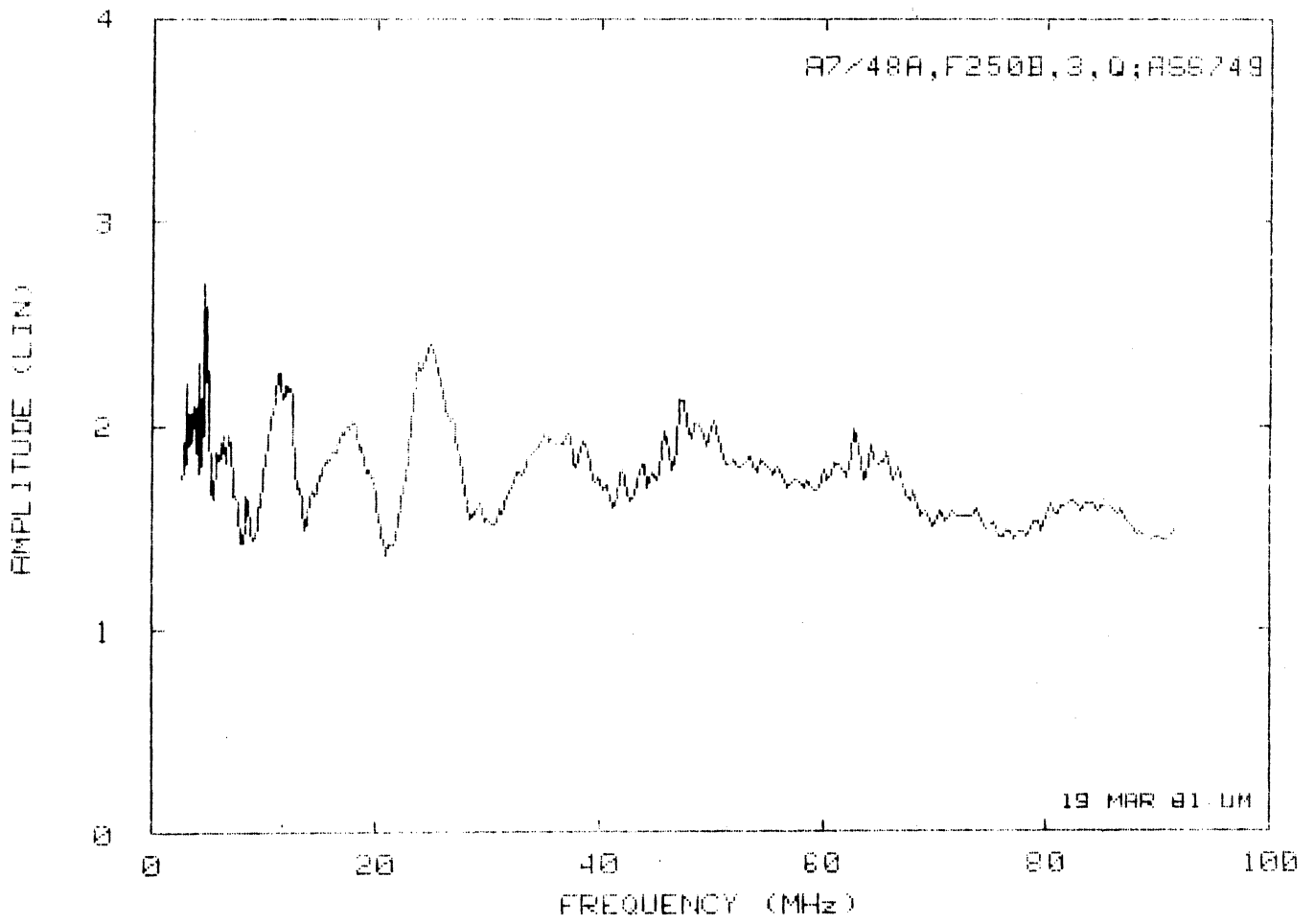
PLOT AS6665



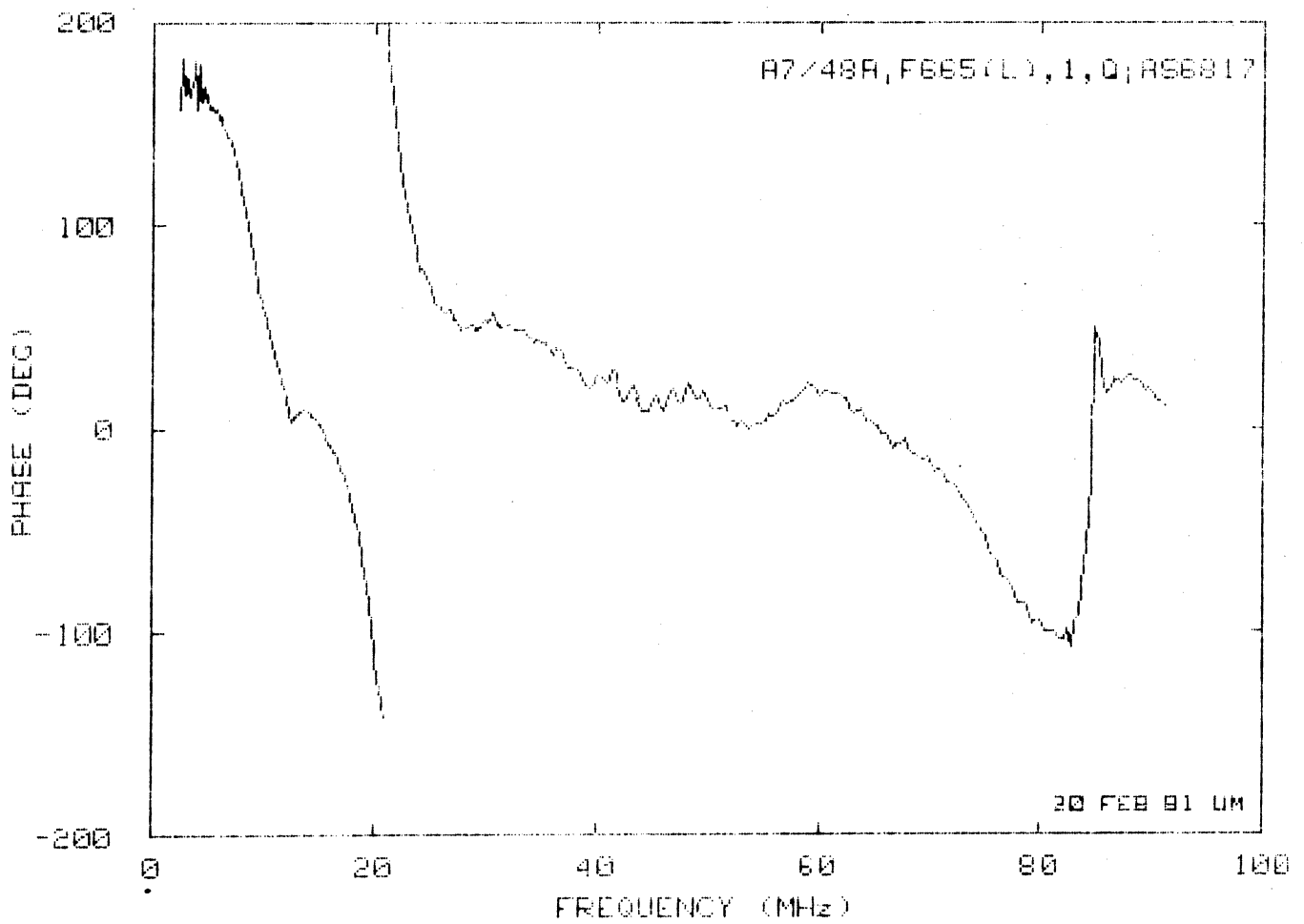
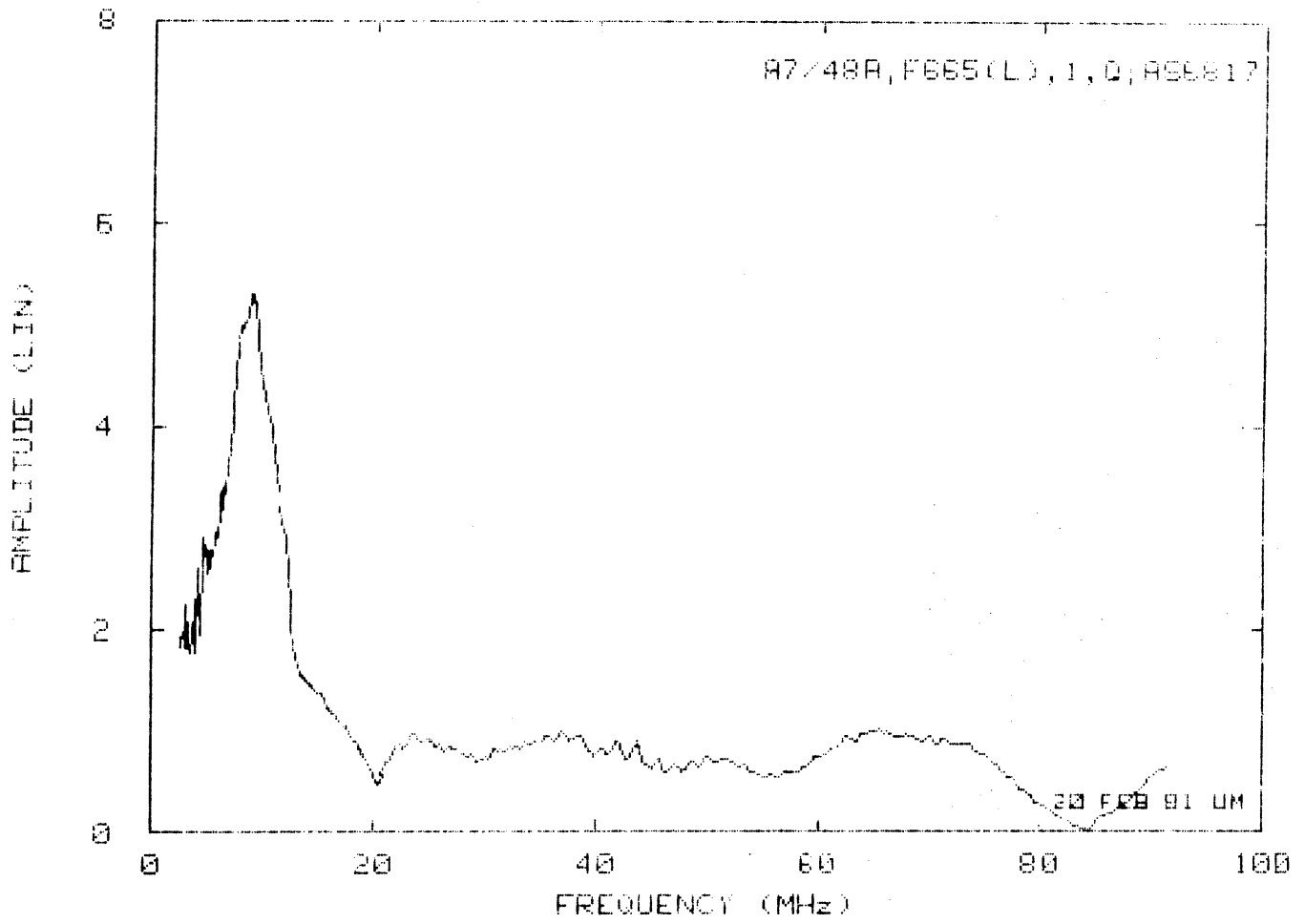
PLOT AS6673



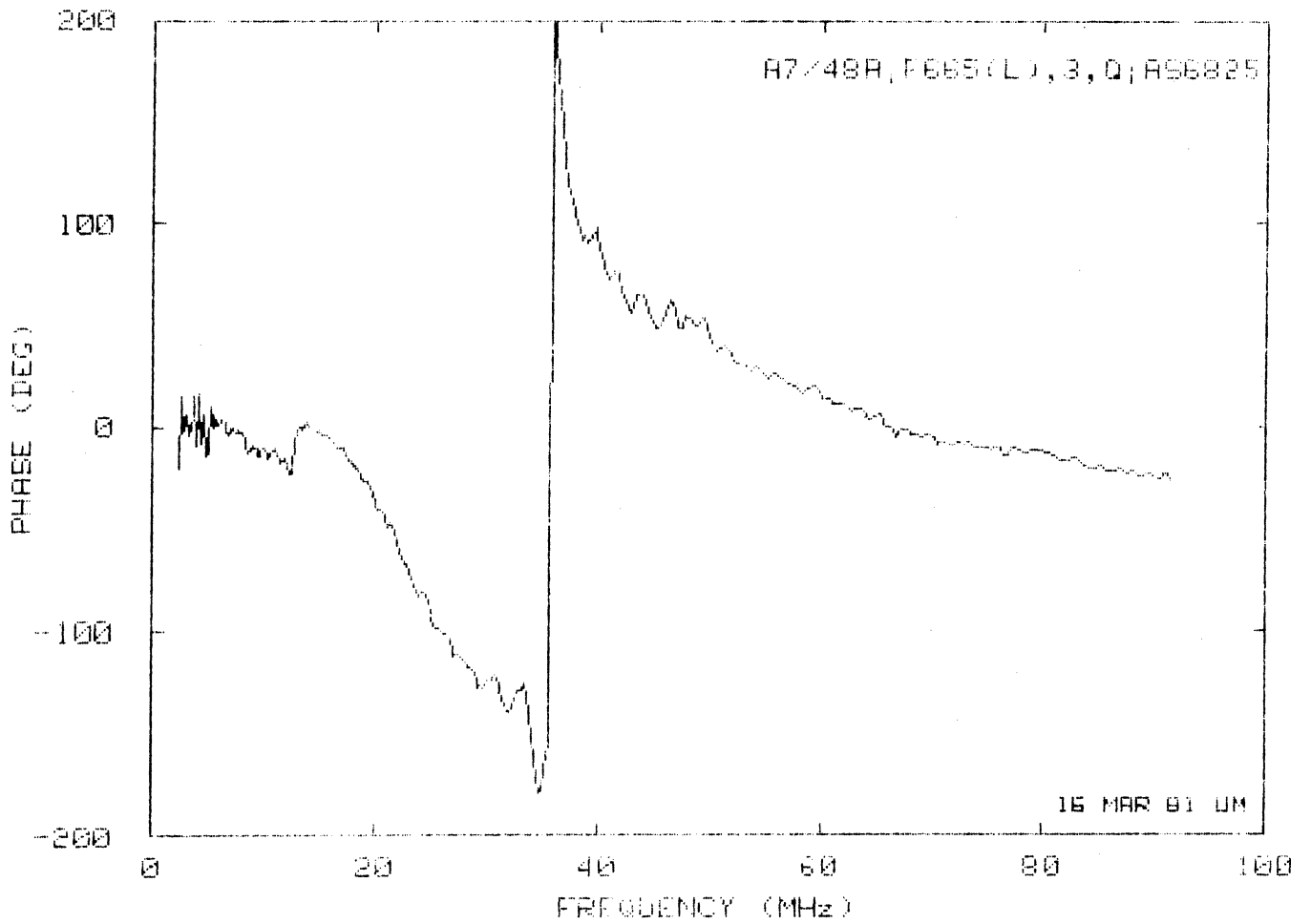
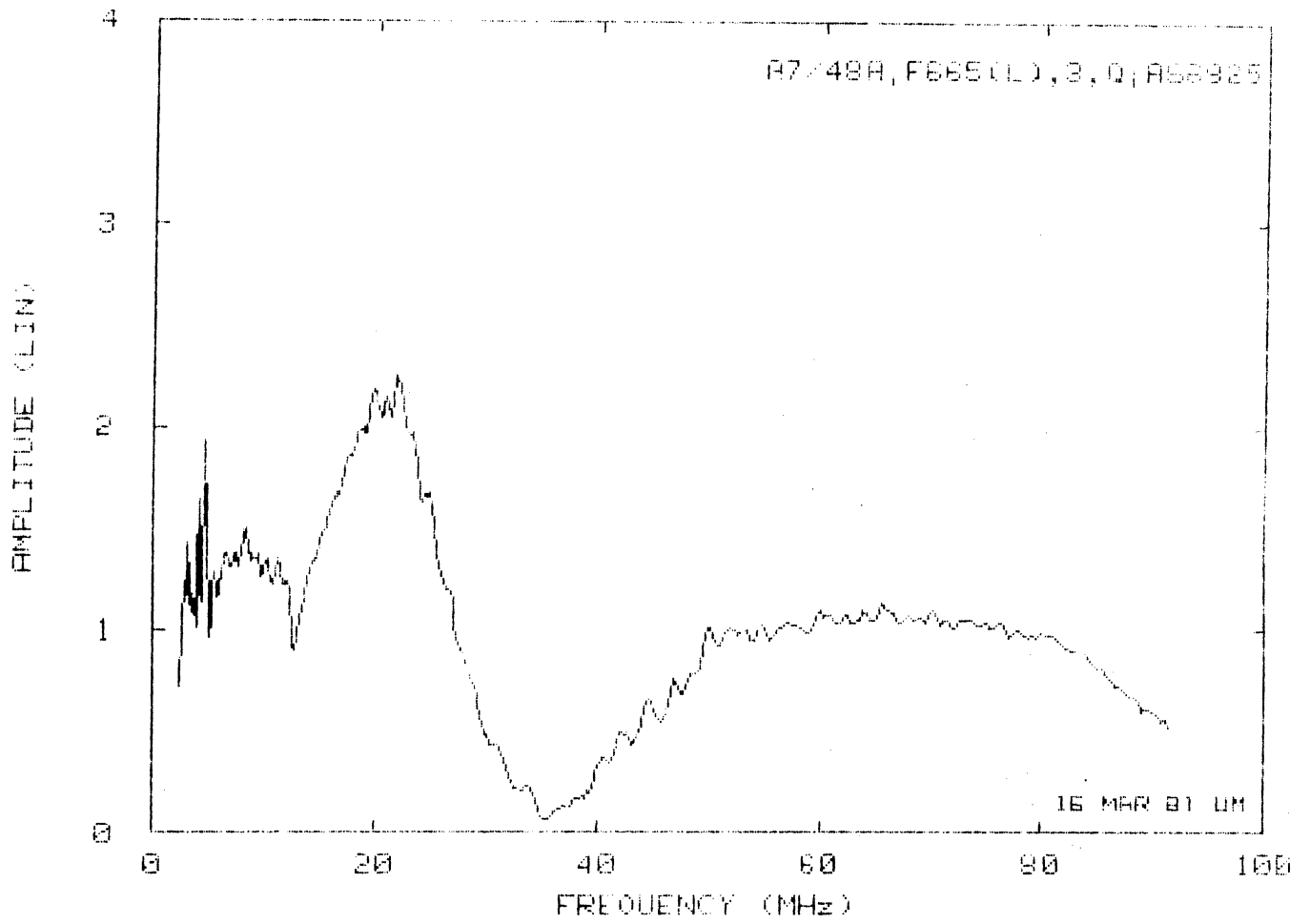
PLOT AS6741



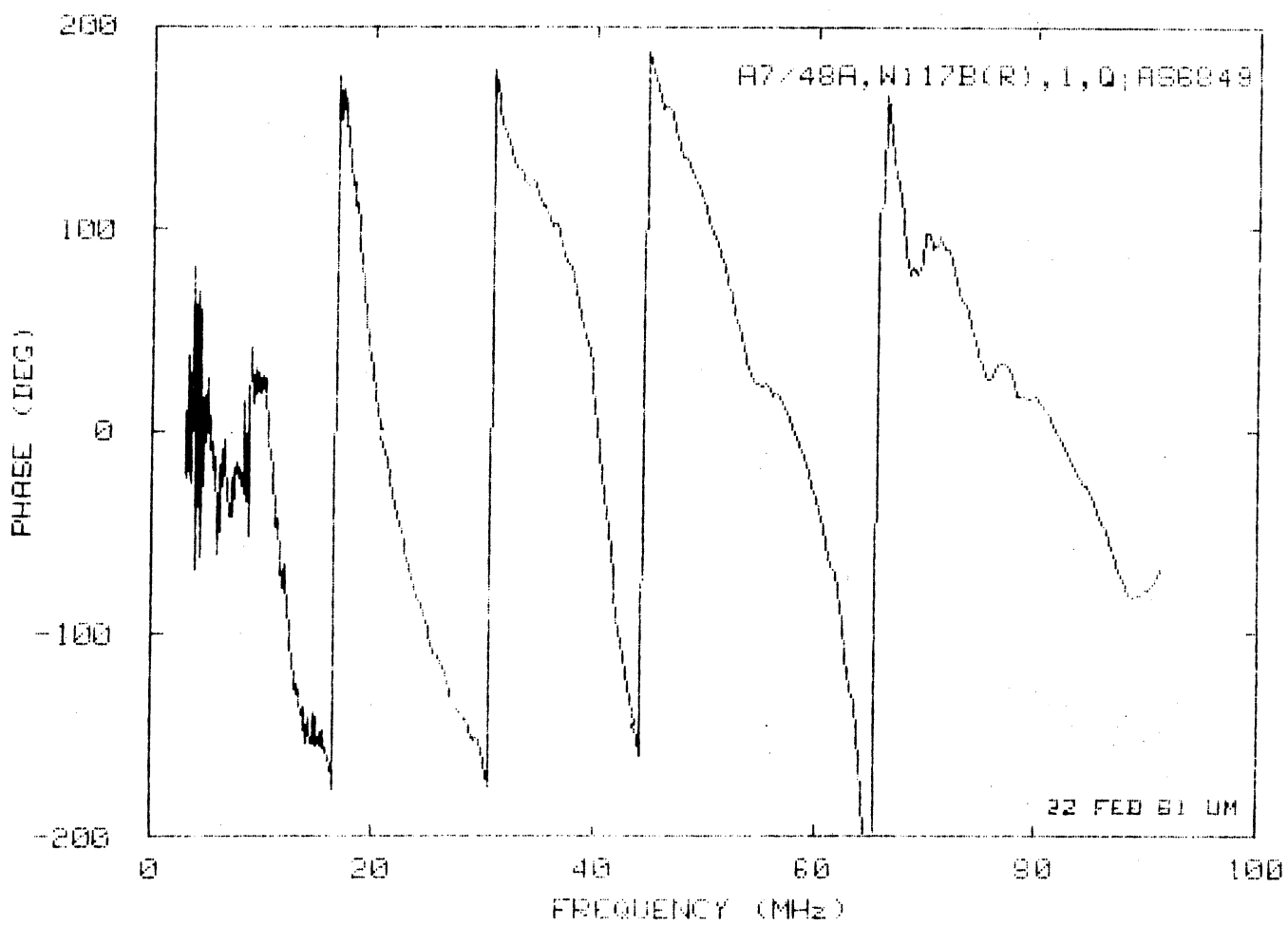
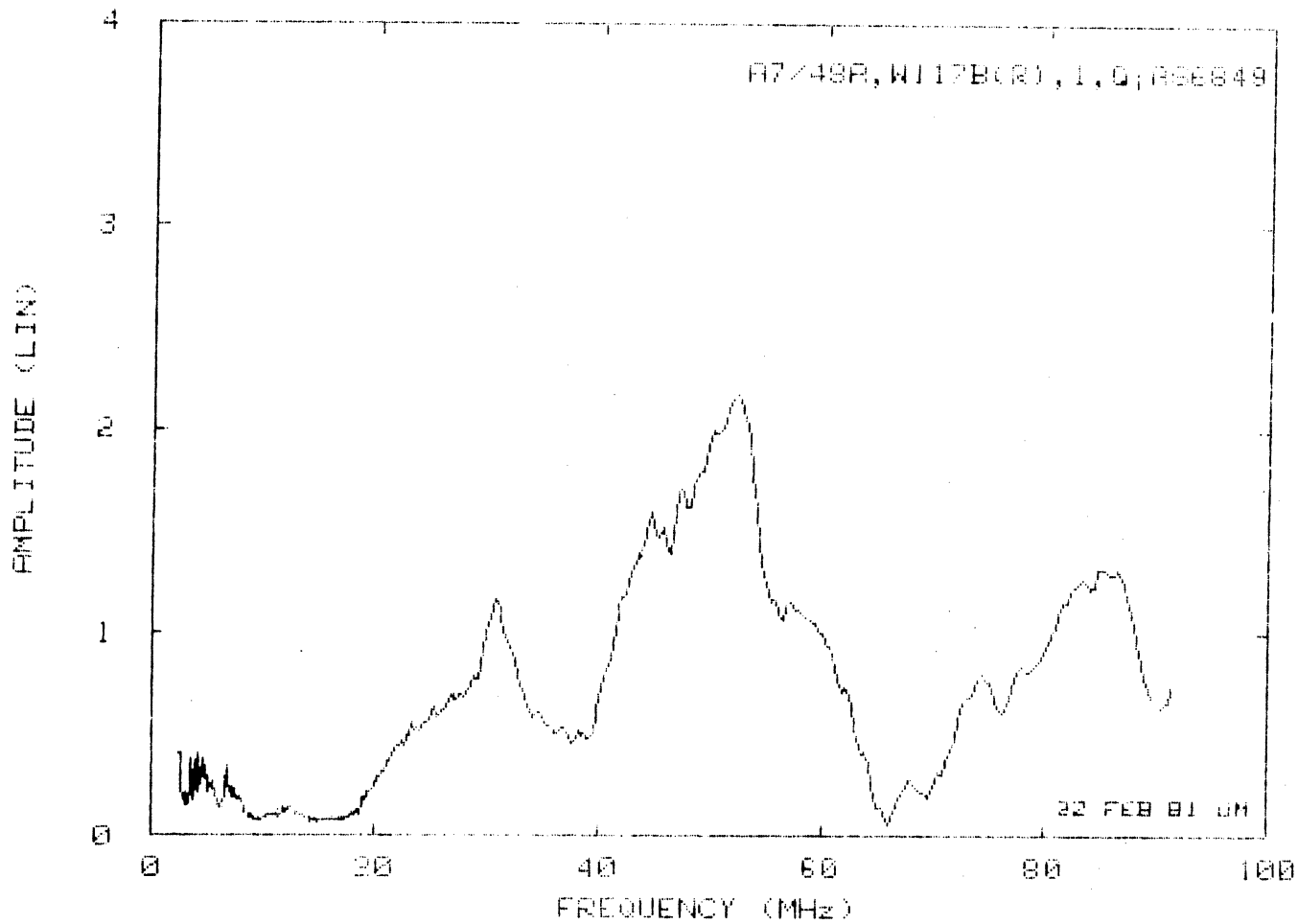
PLOT AS6749



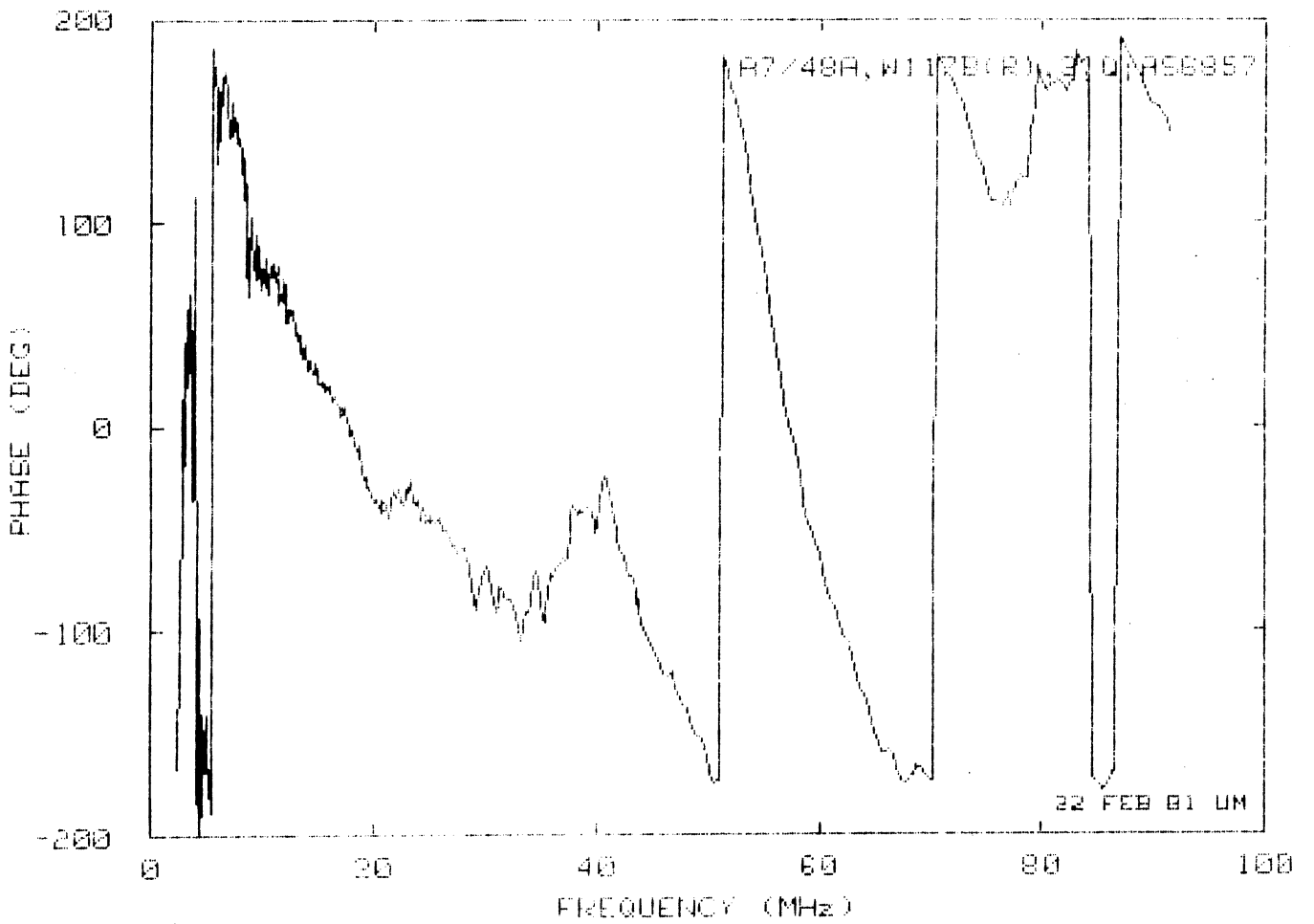
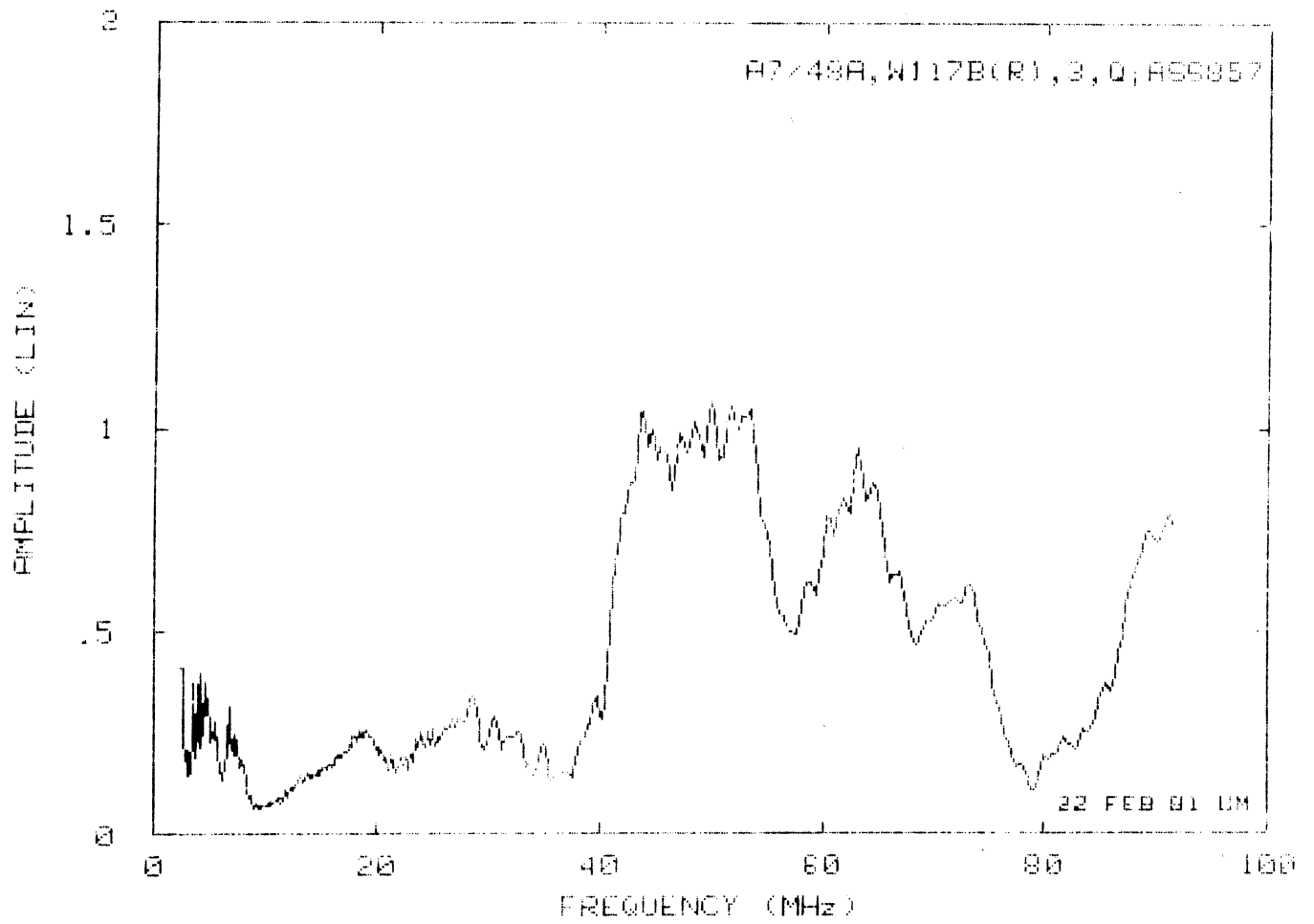
PLOT AS6817



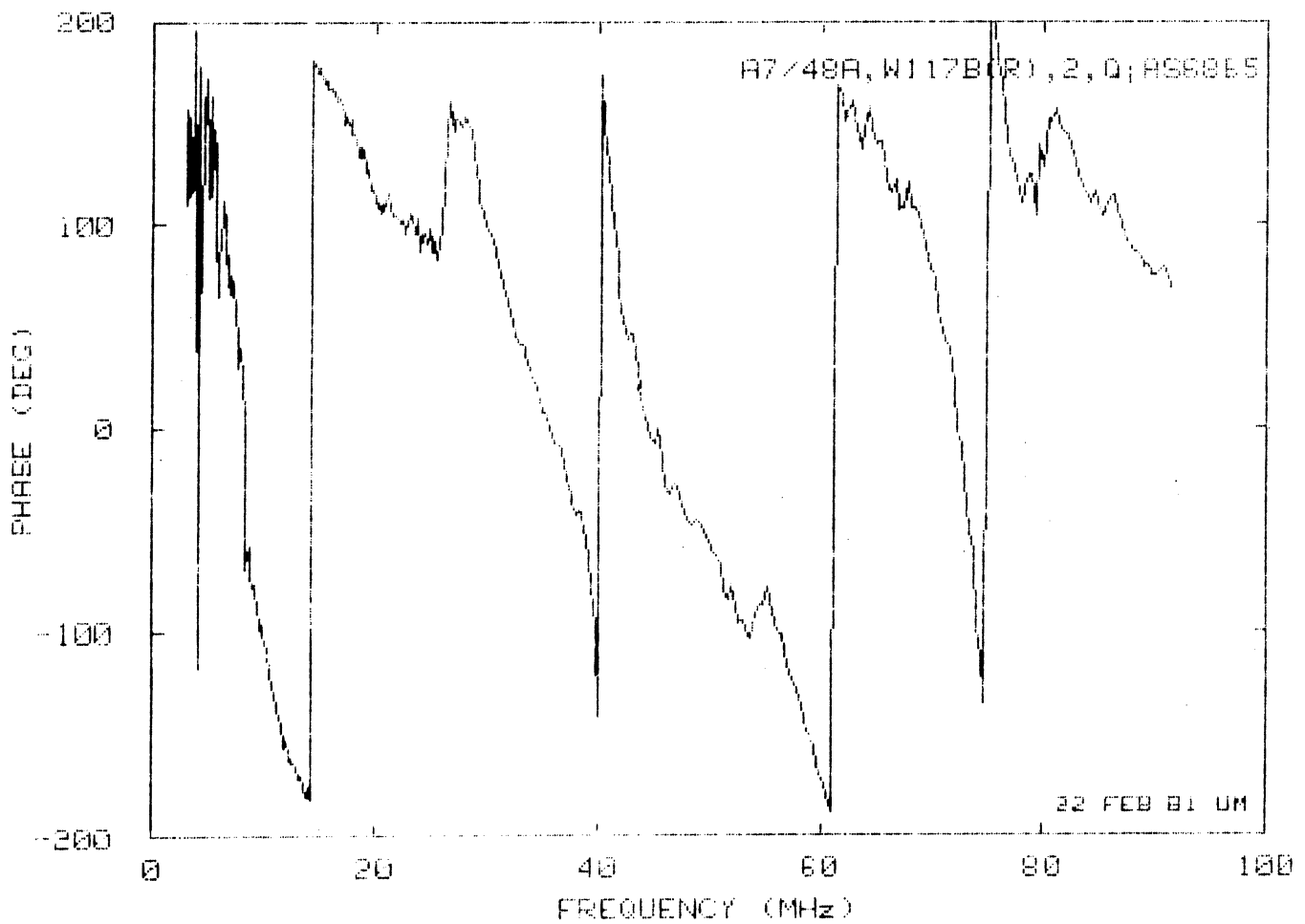
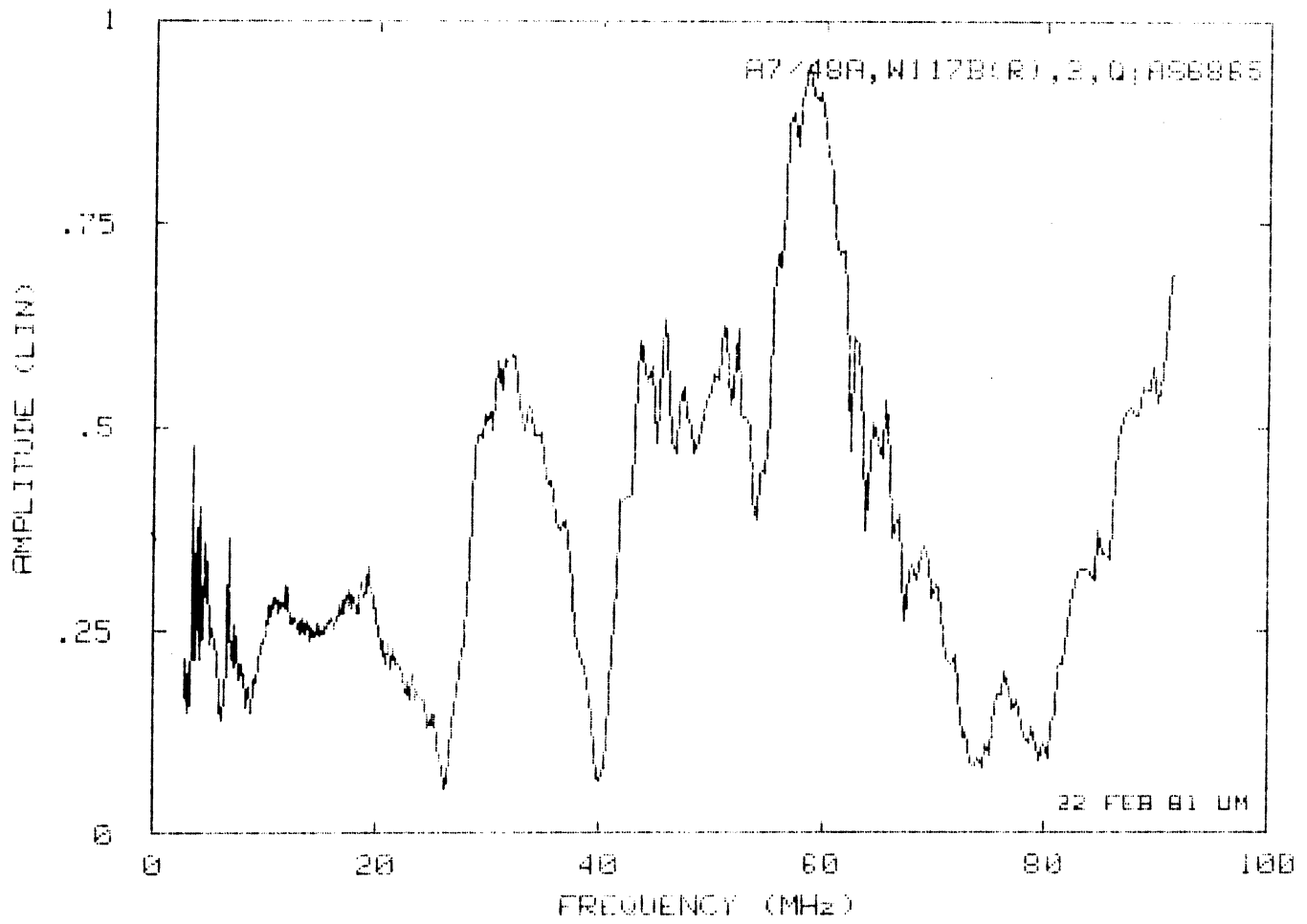
PLOT AS6825



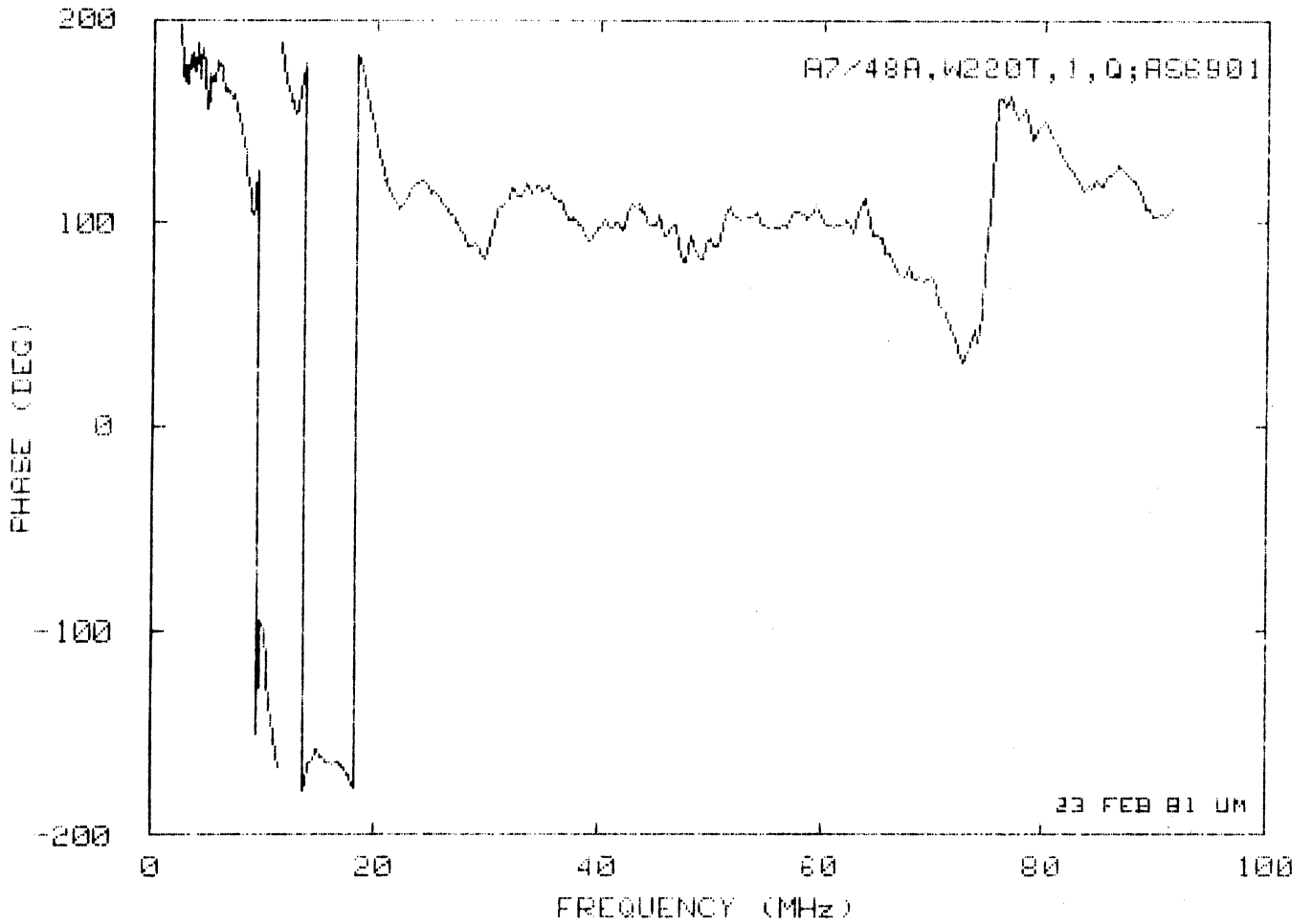
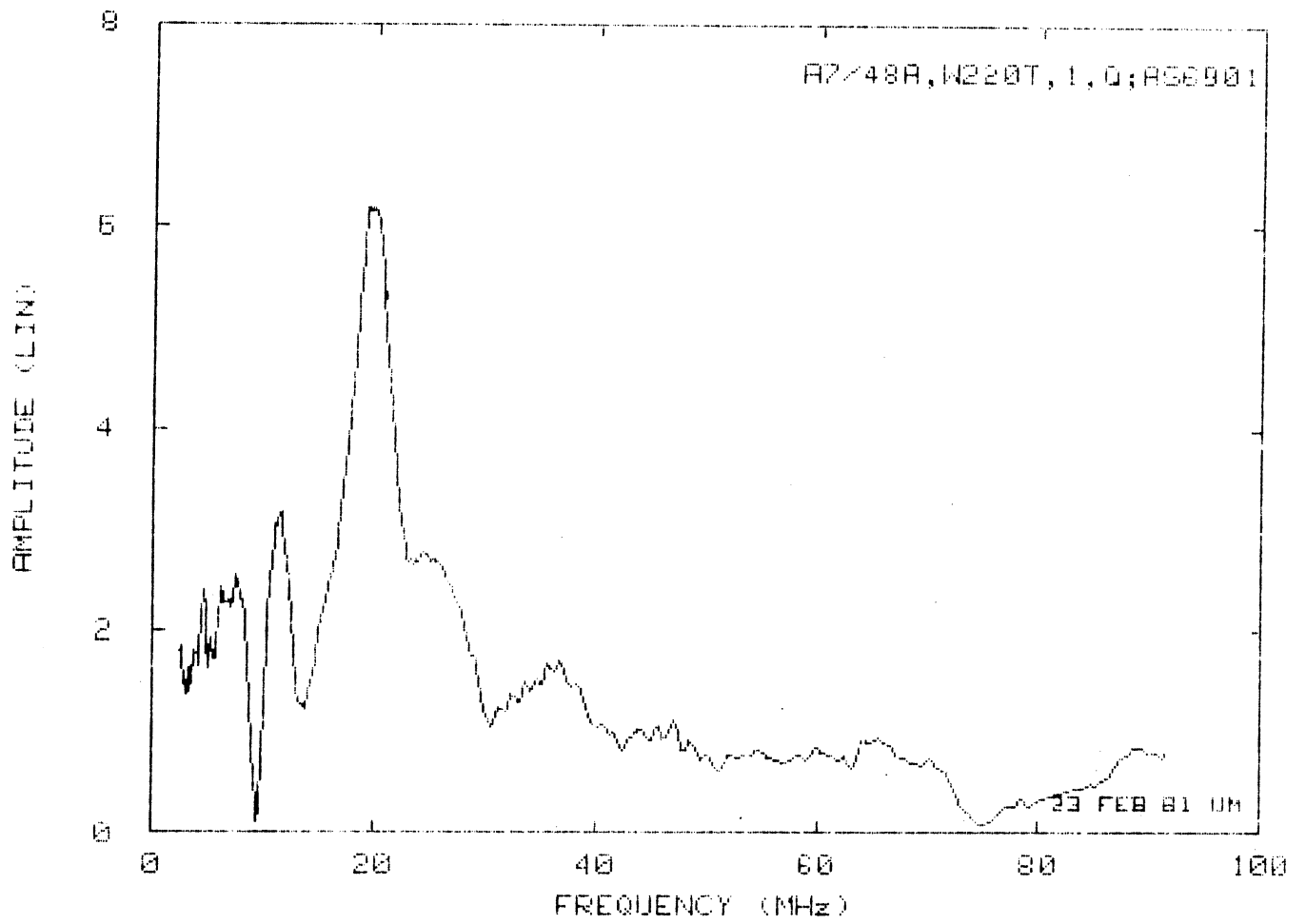
PLOT AS6849



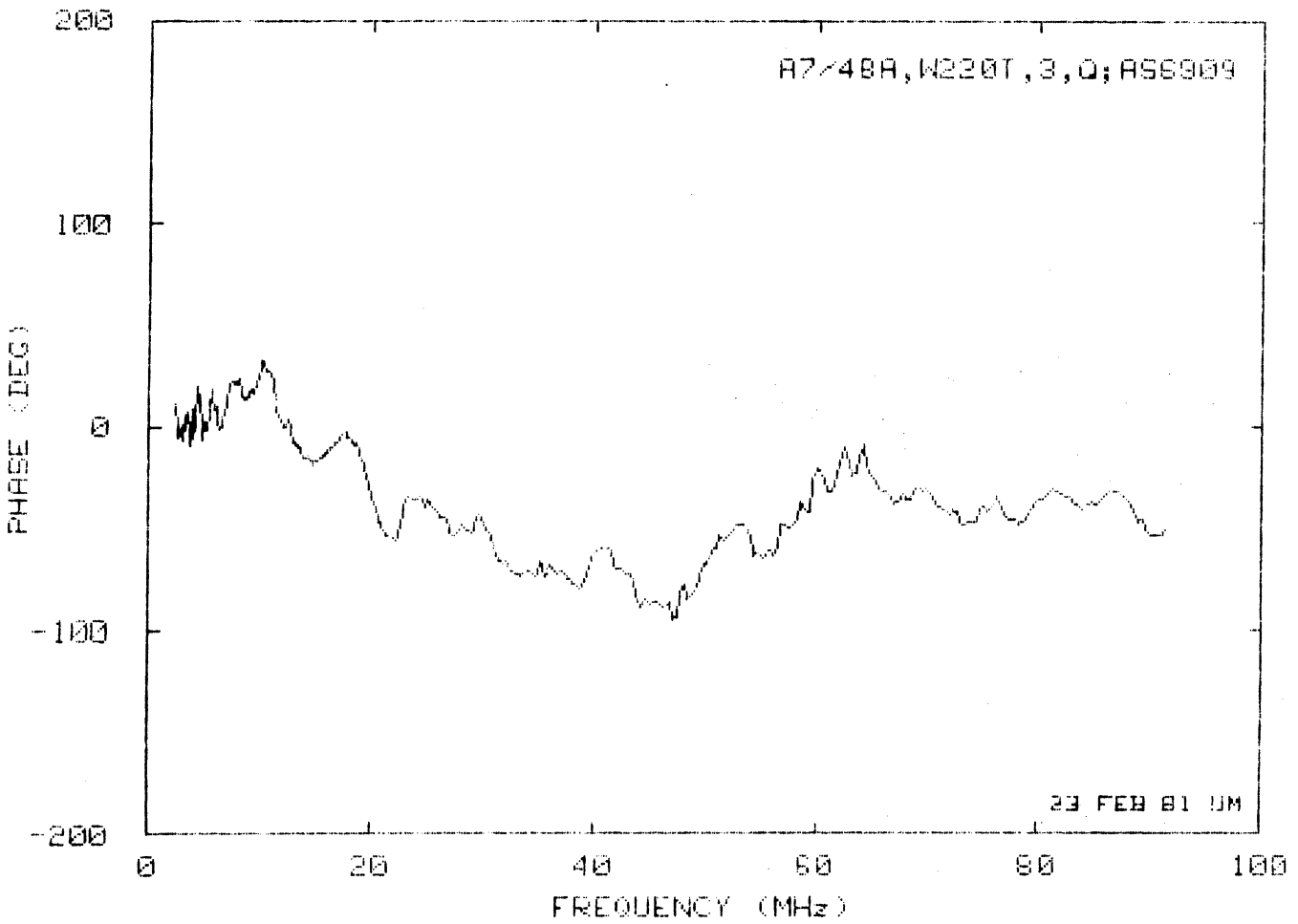
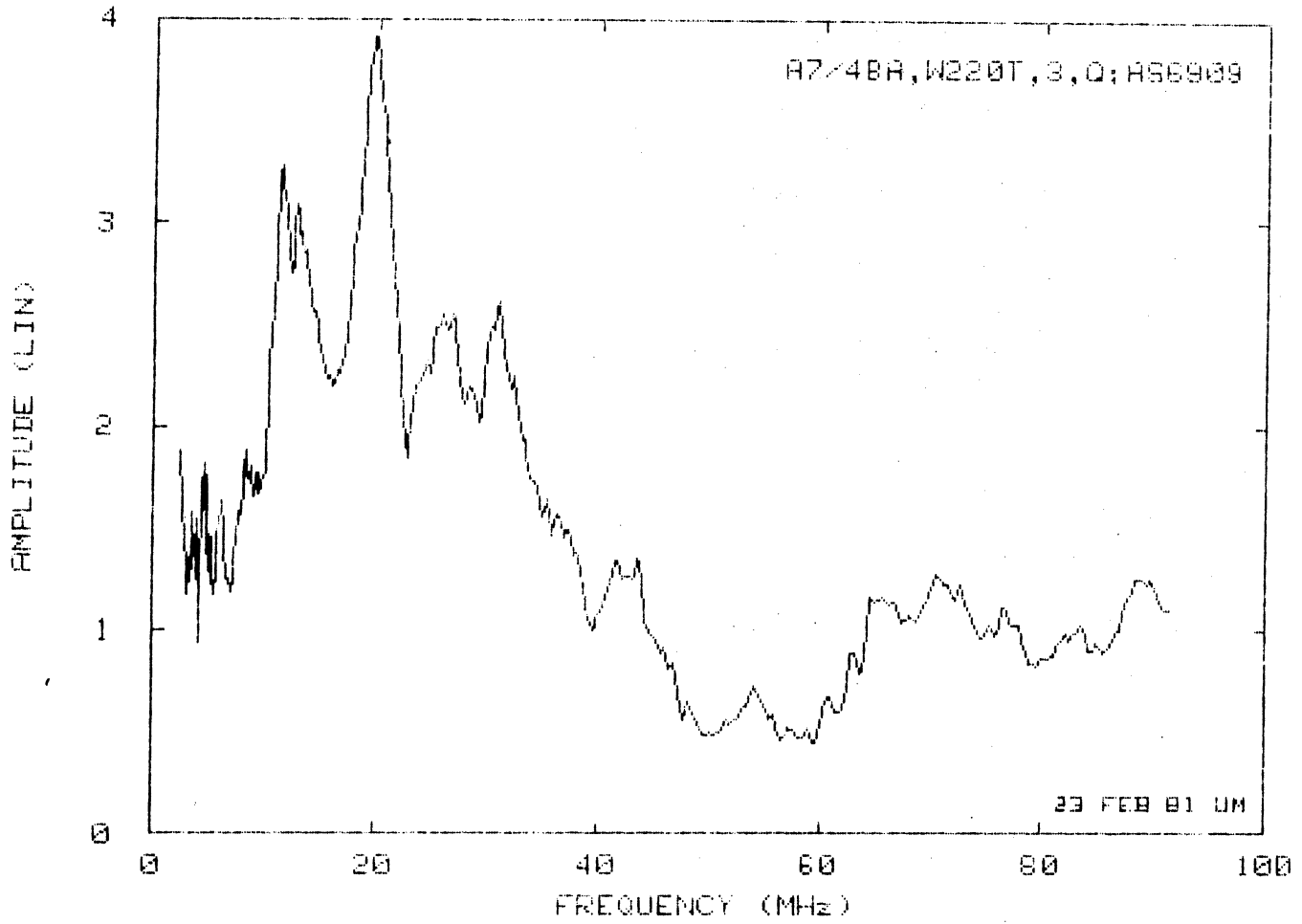
PLOT AS6857



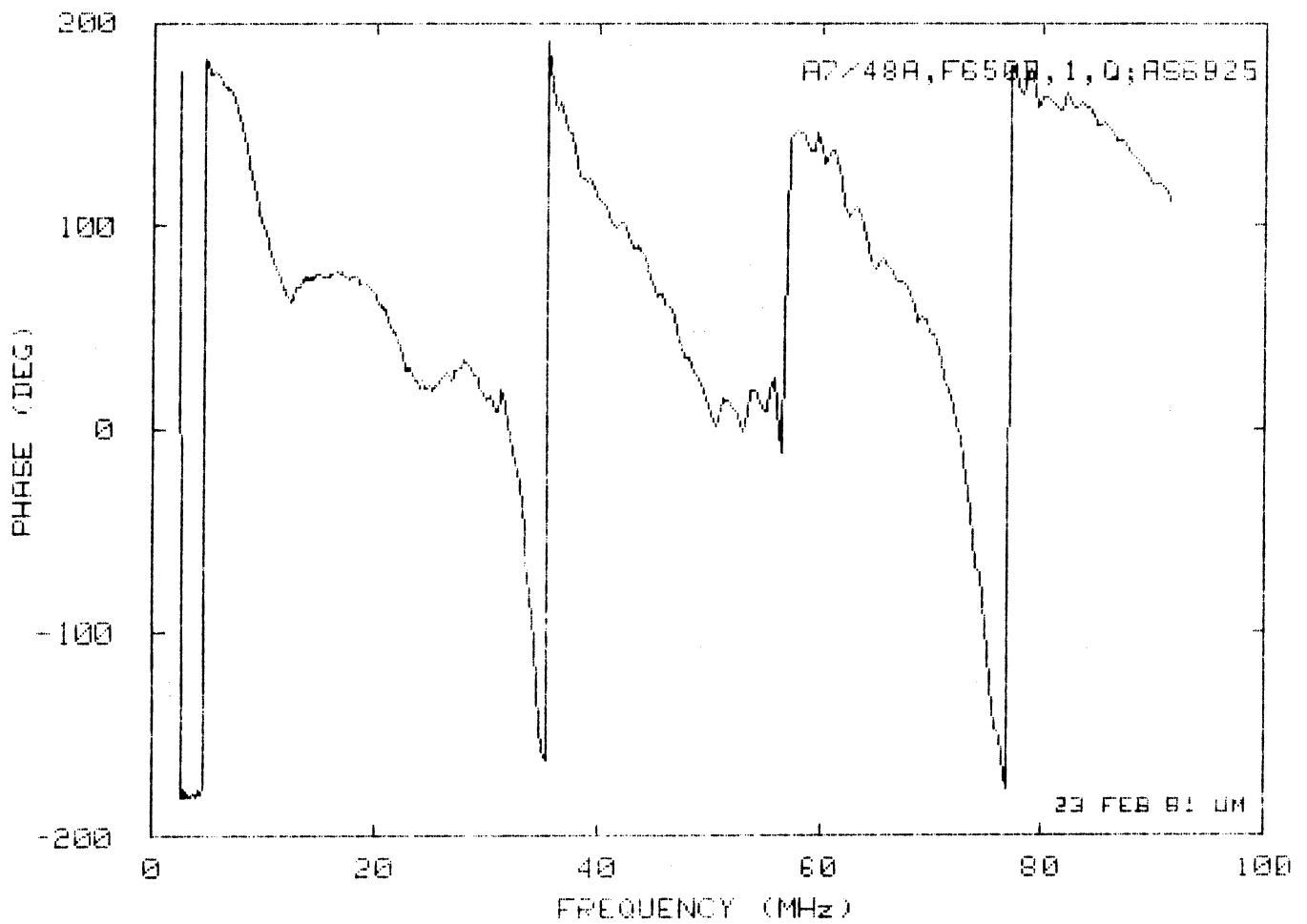
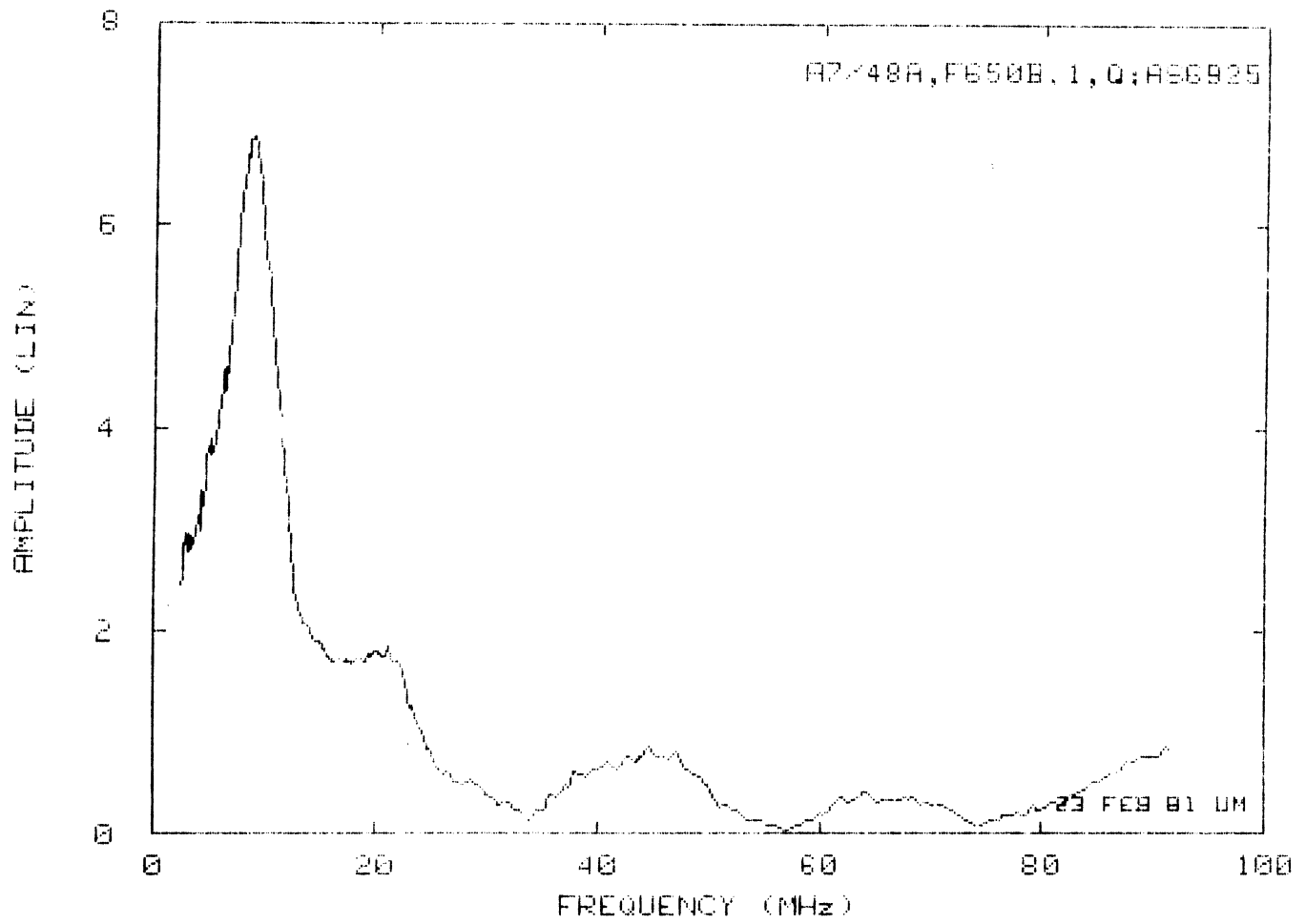
PLOT AS6865



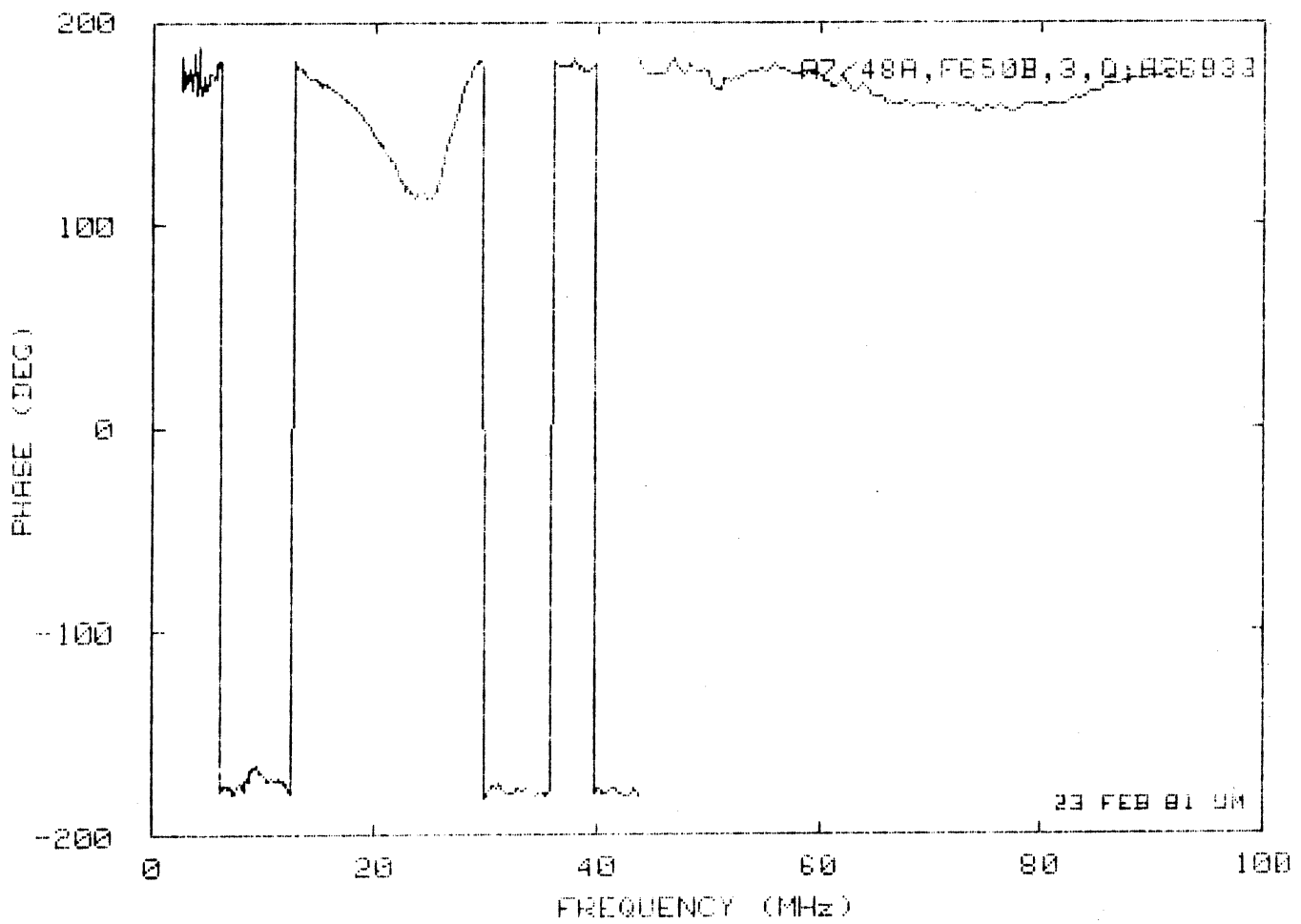
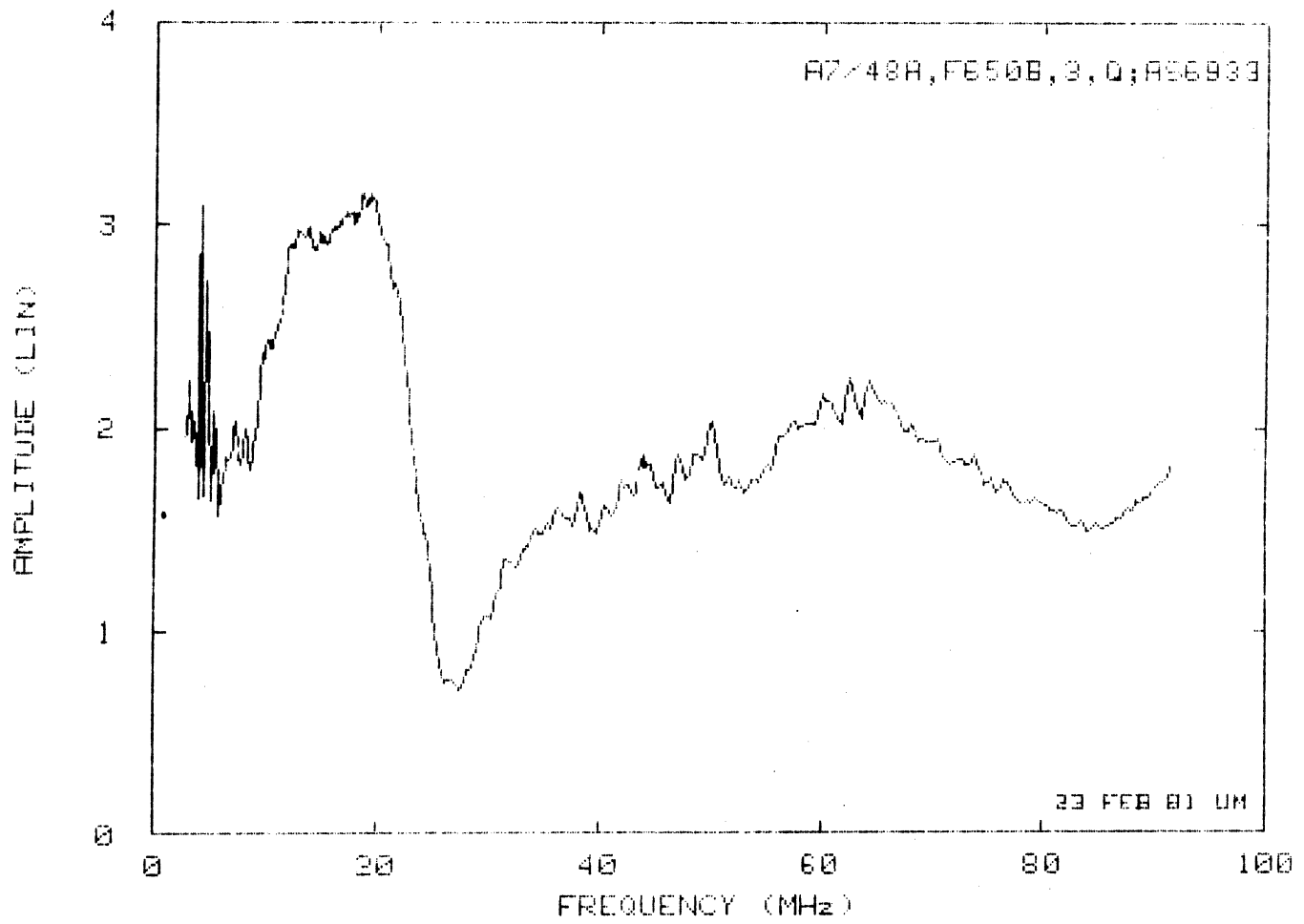
PLOT AS6901



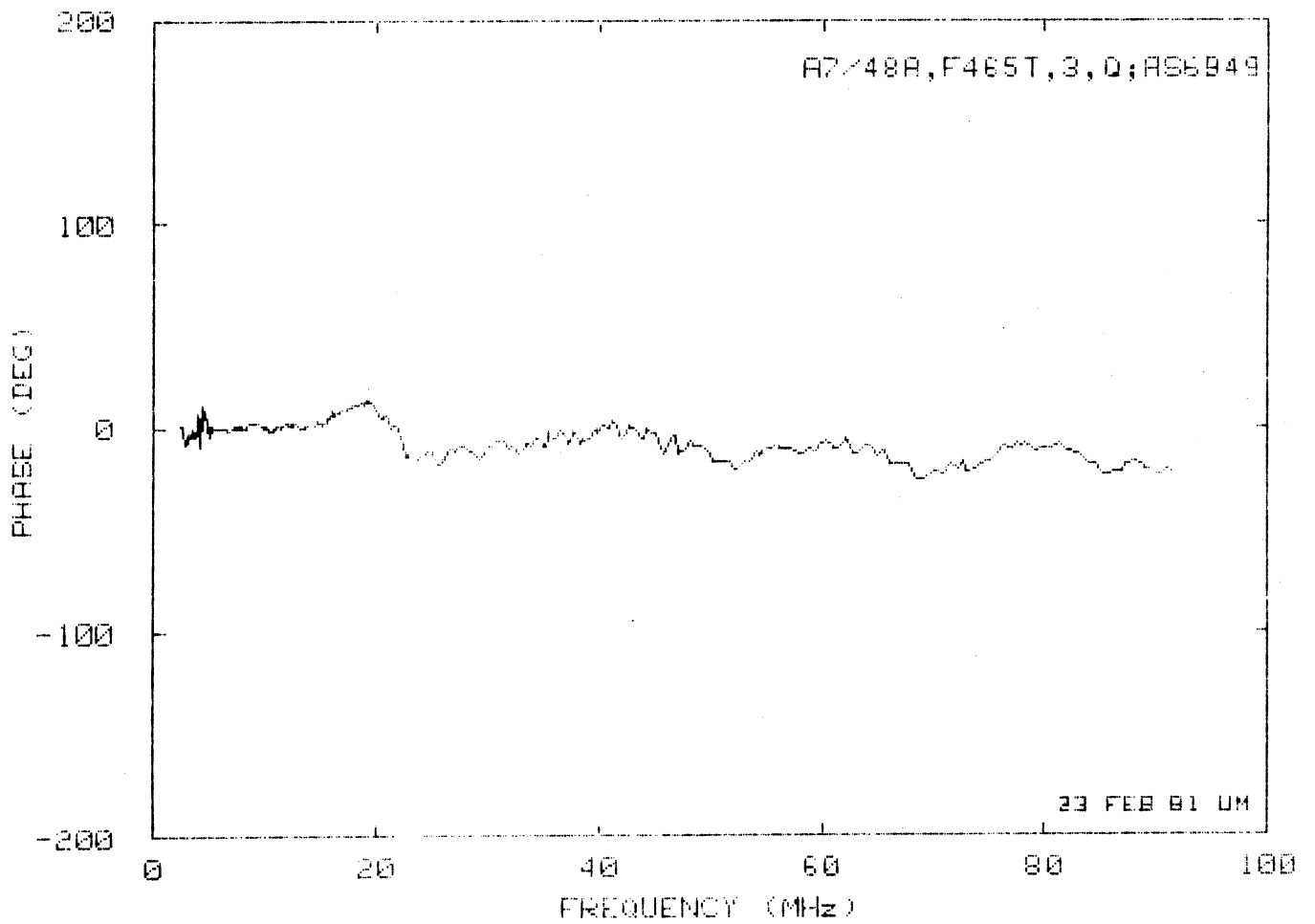
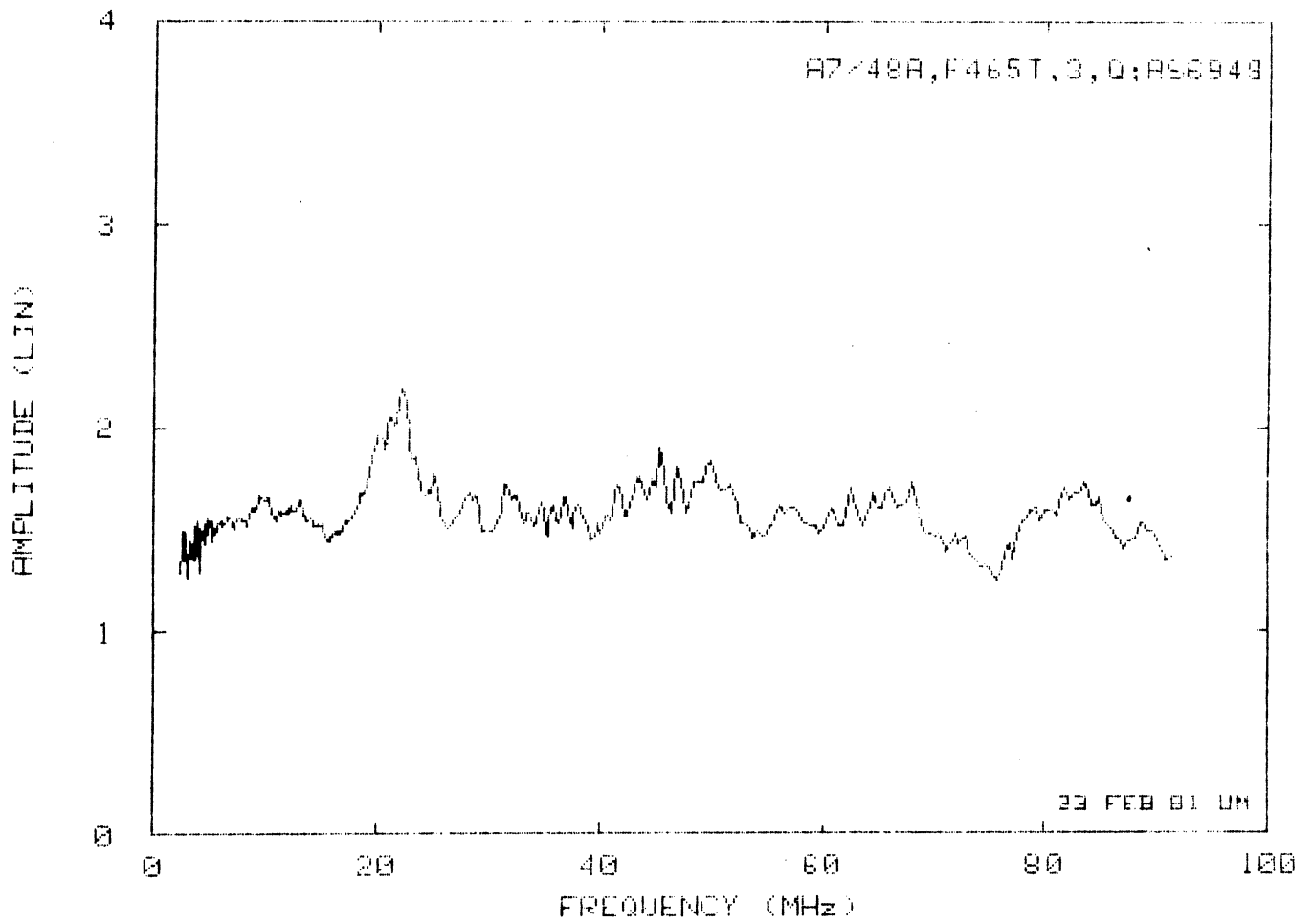
PLOT AS6909

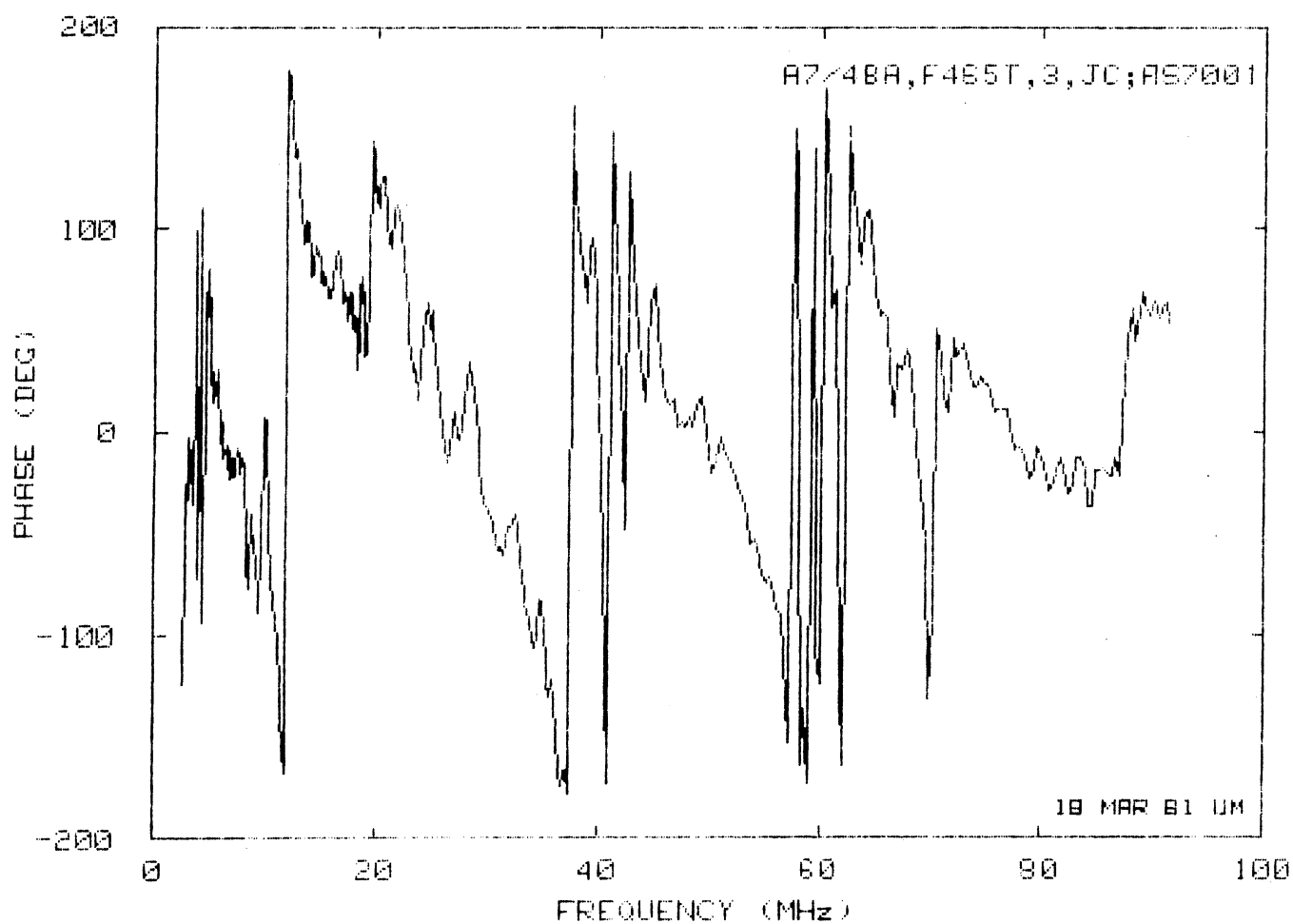
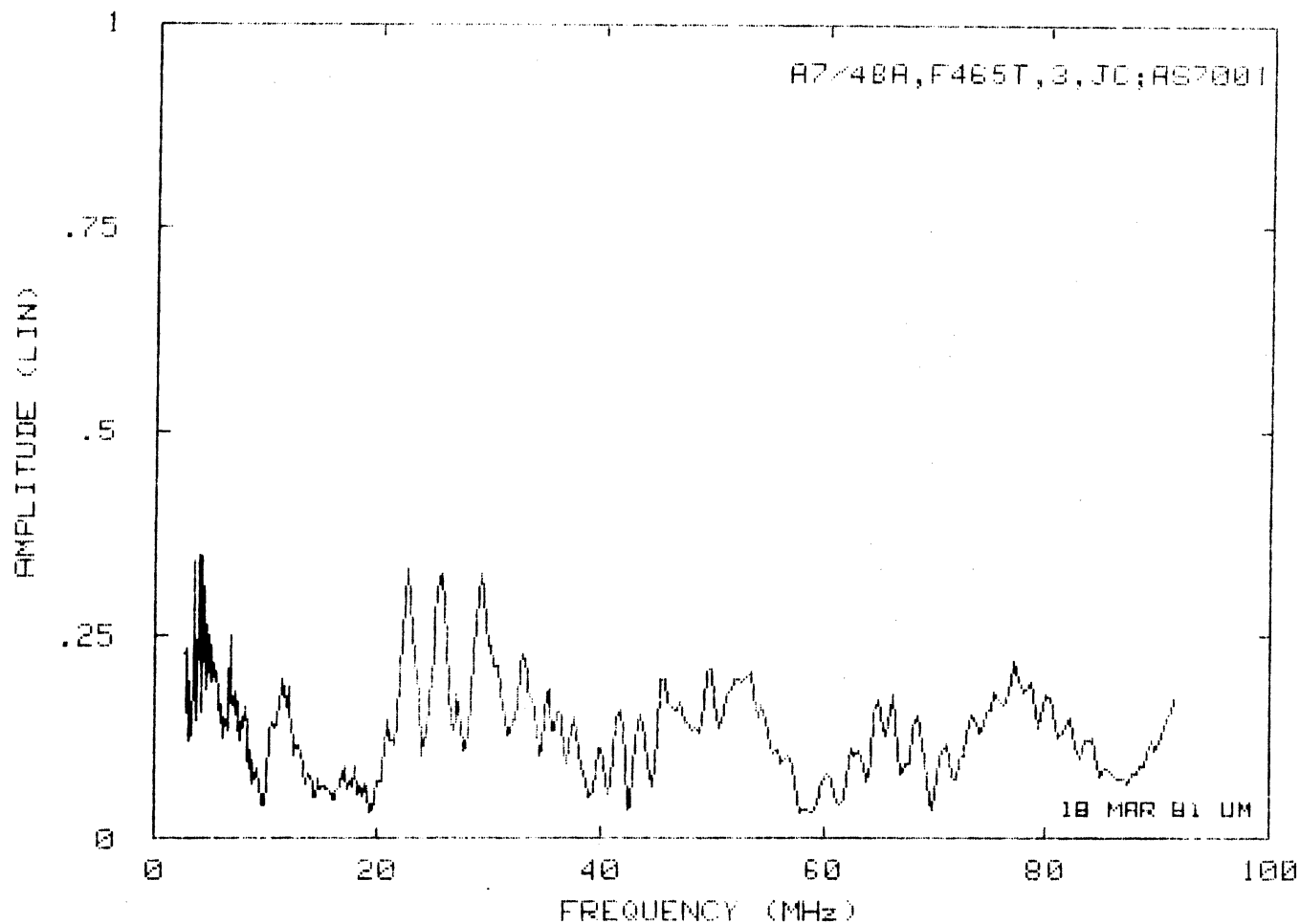


PLOT AS6925

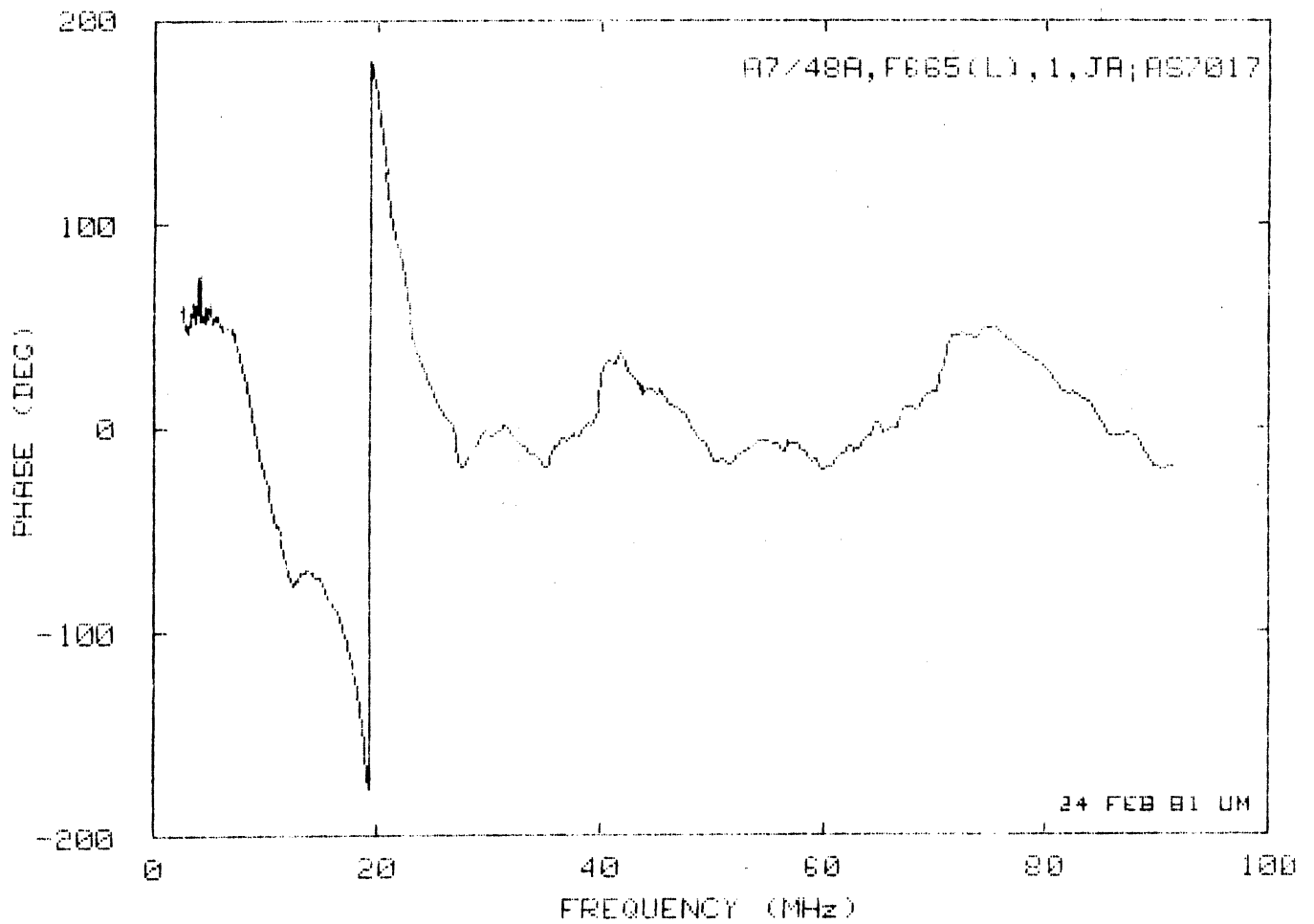
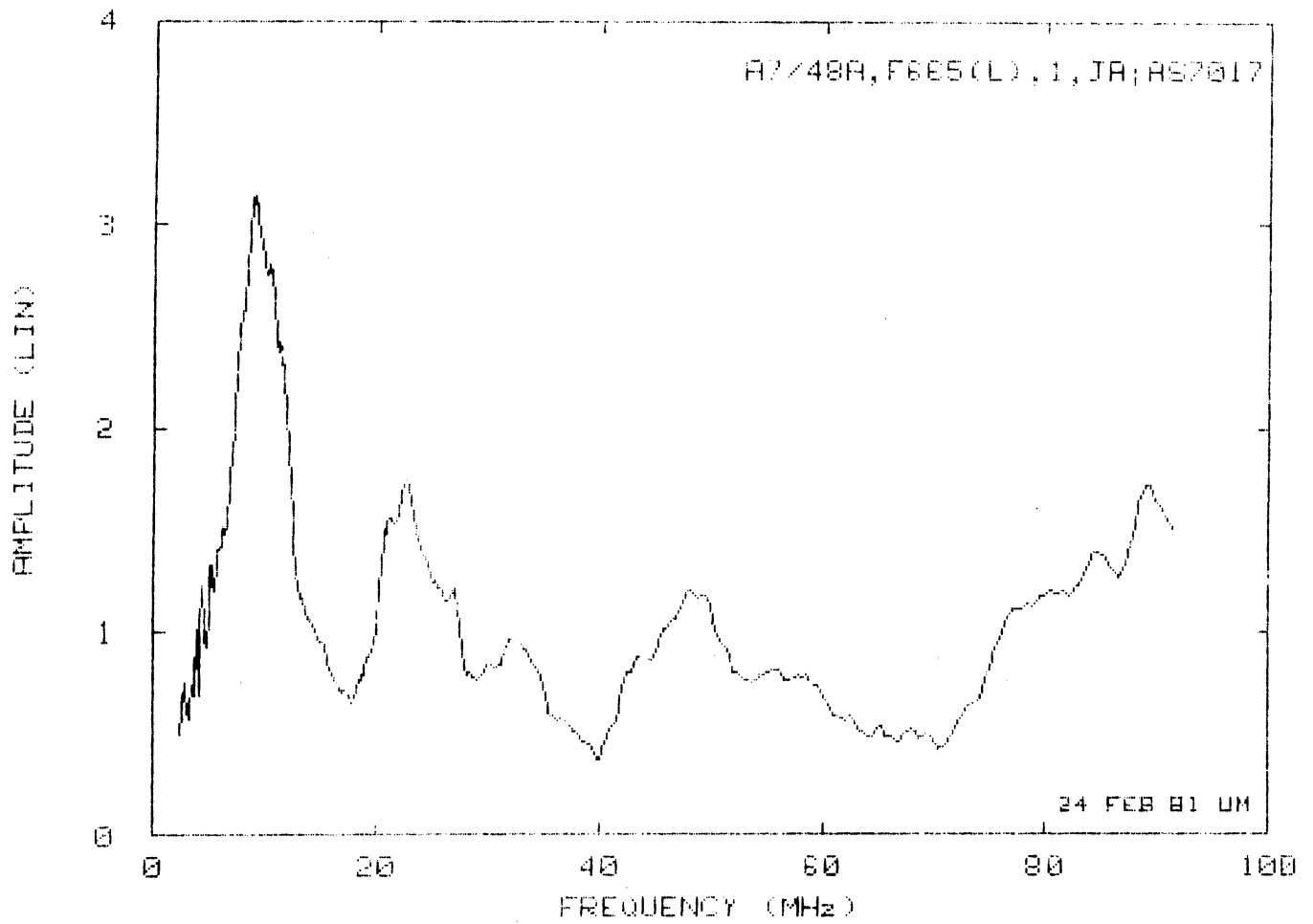


PLOT AS6933

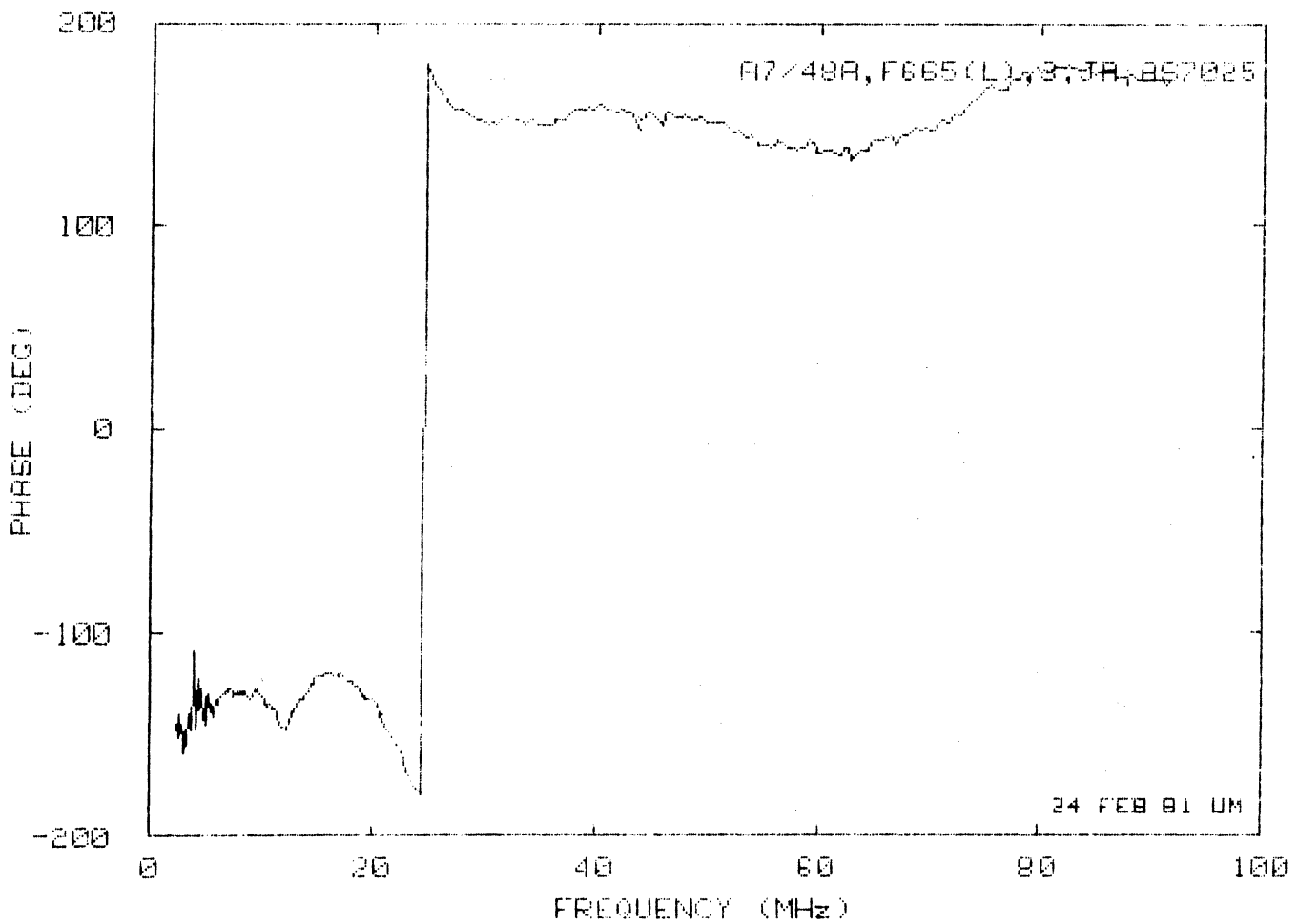
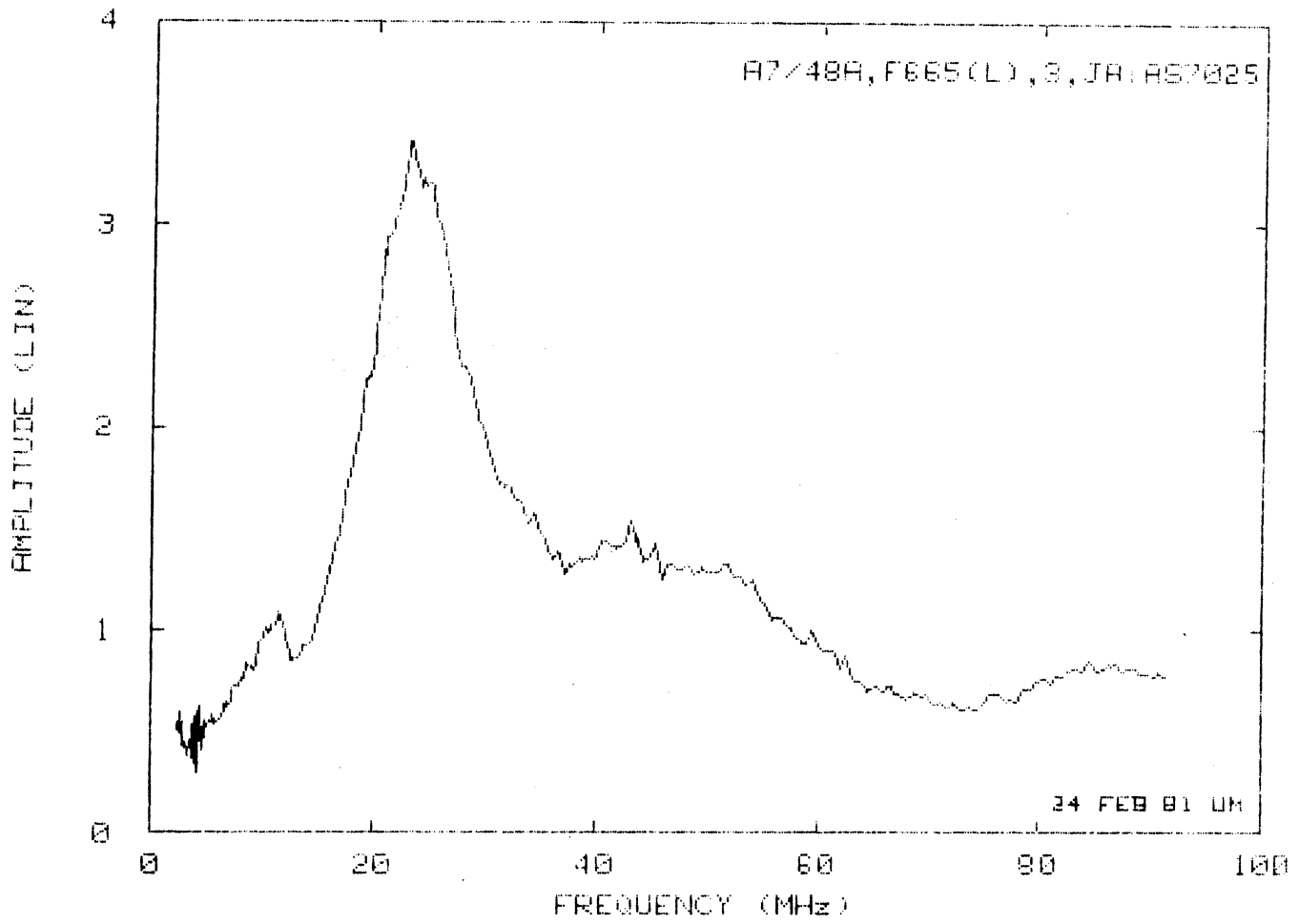




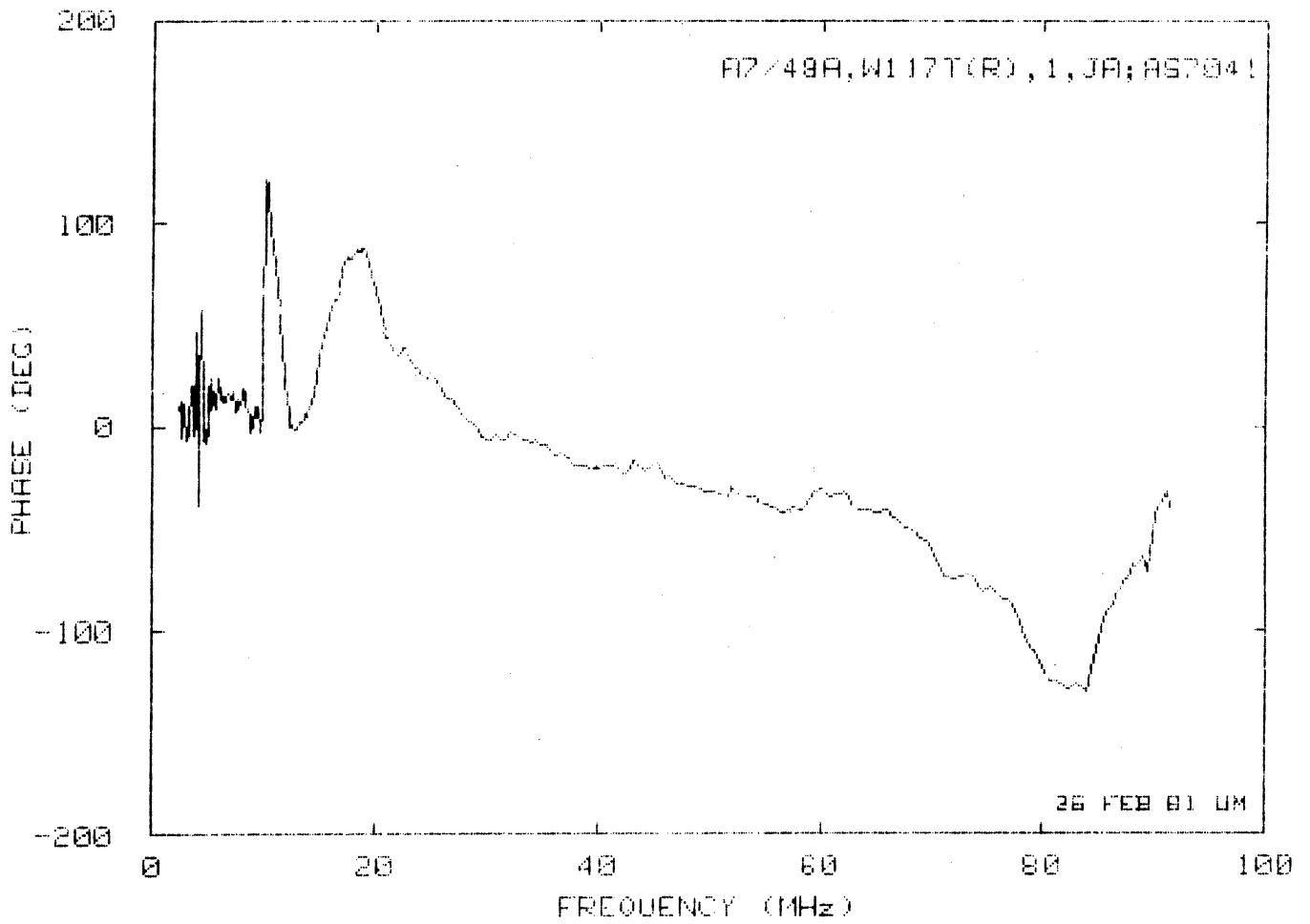
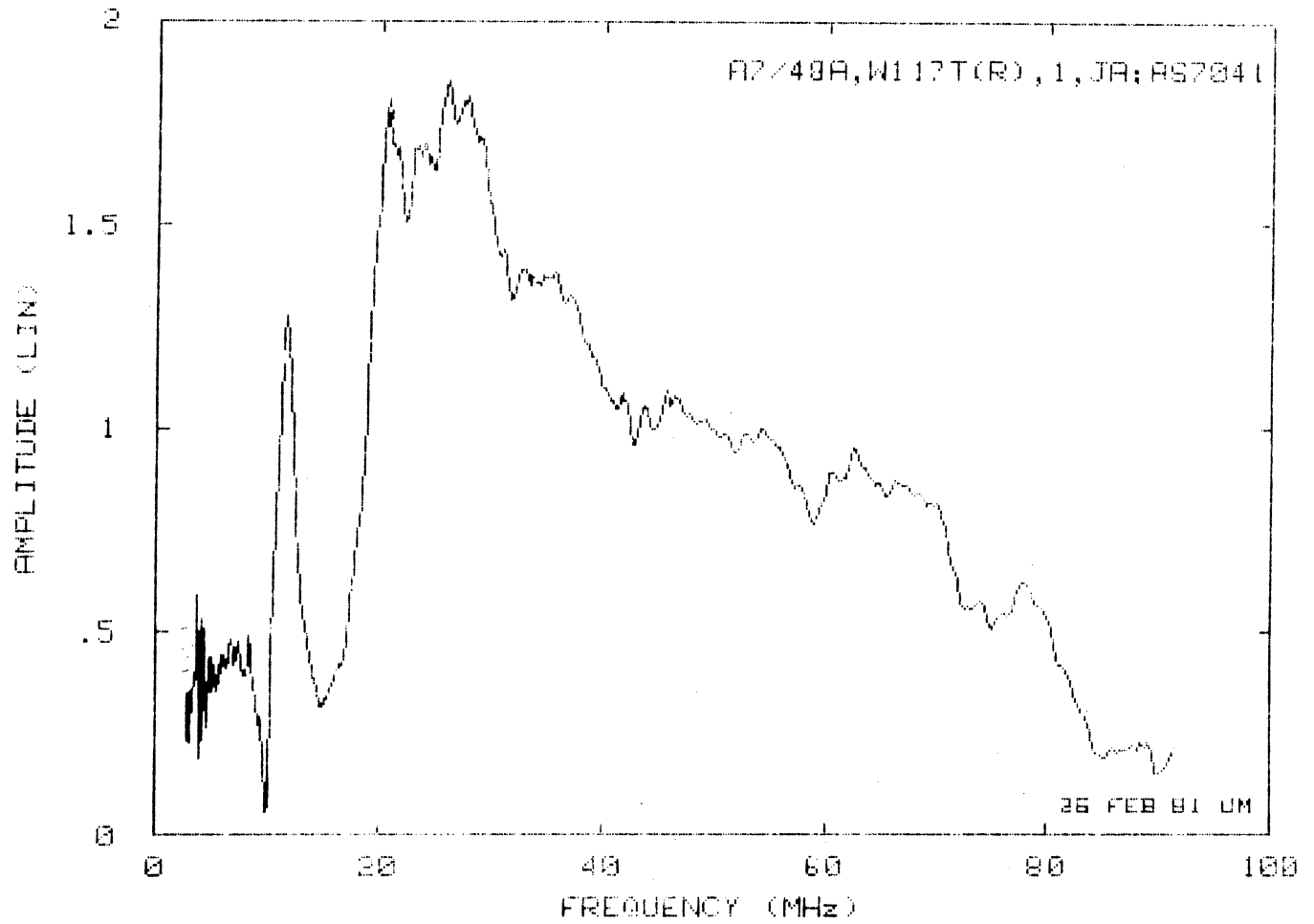
PLOT AS7001



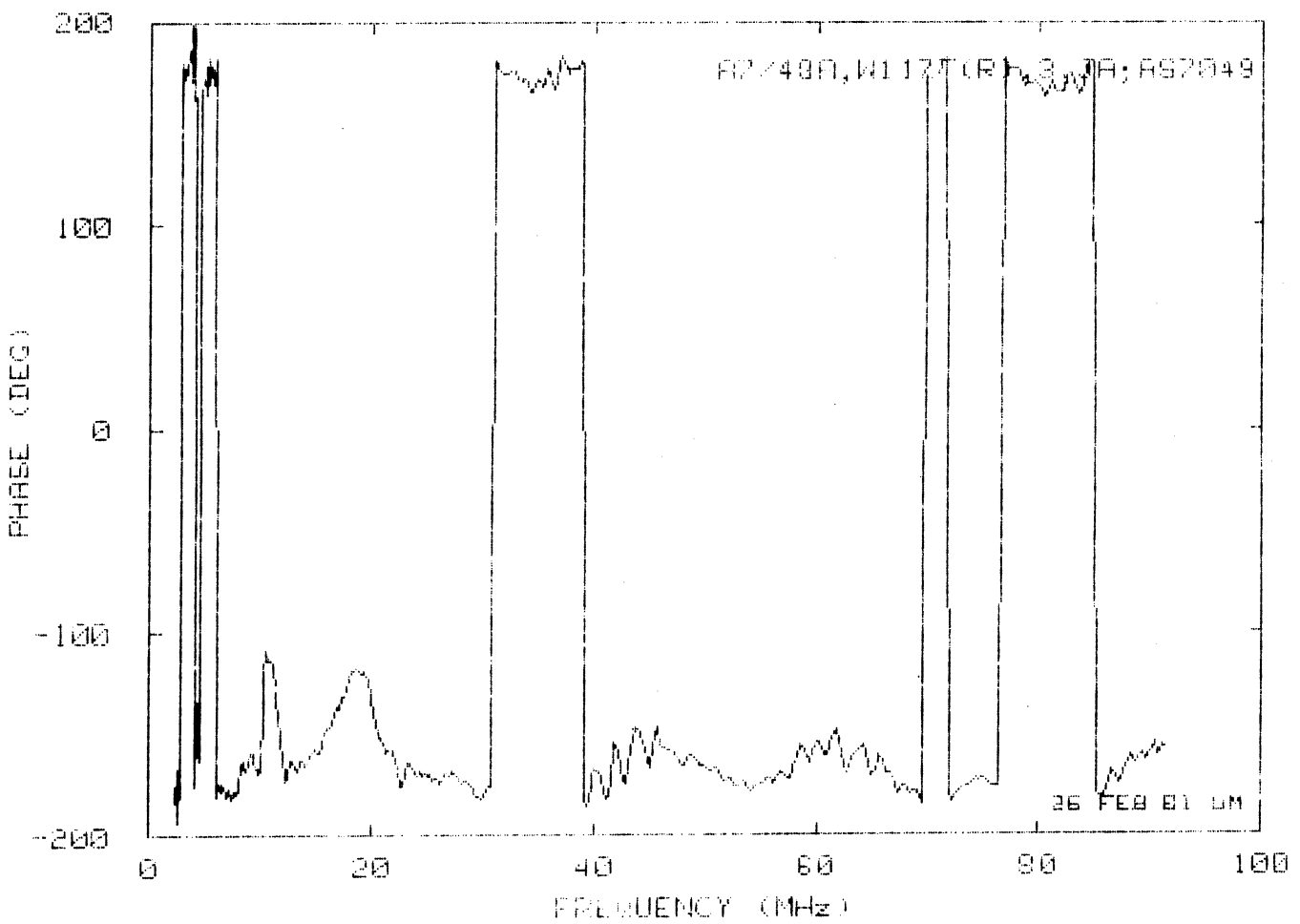
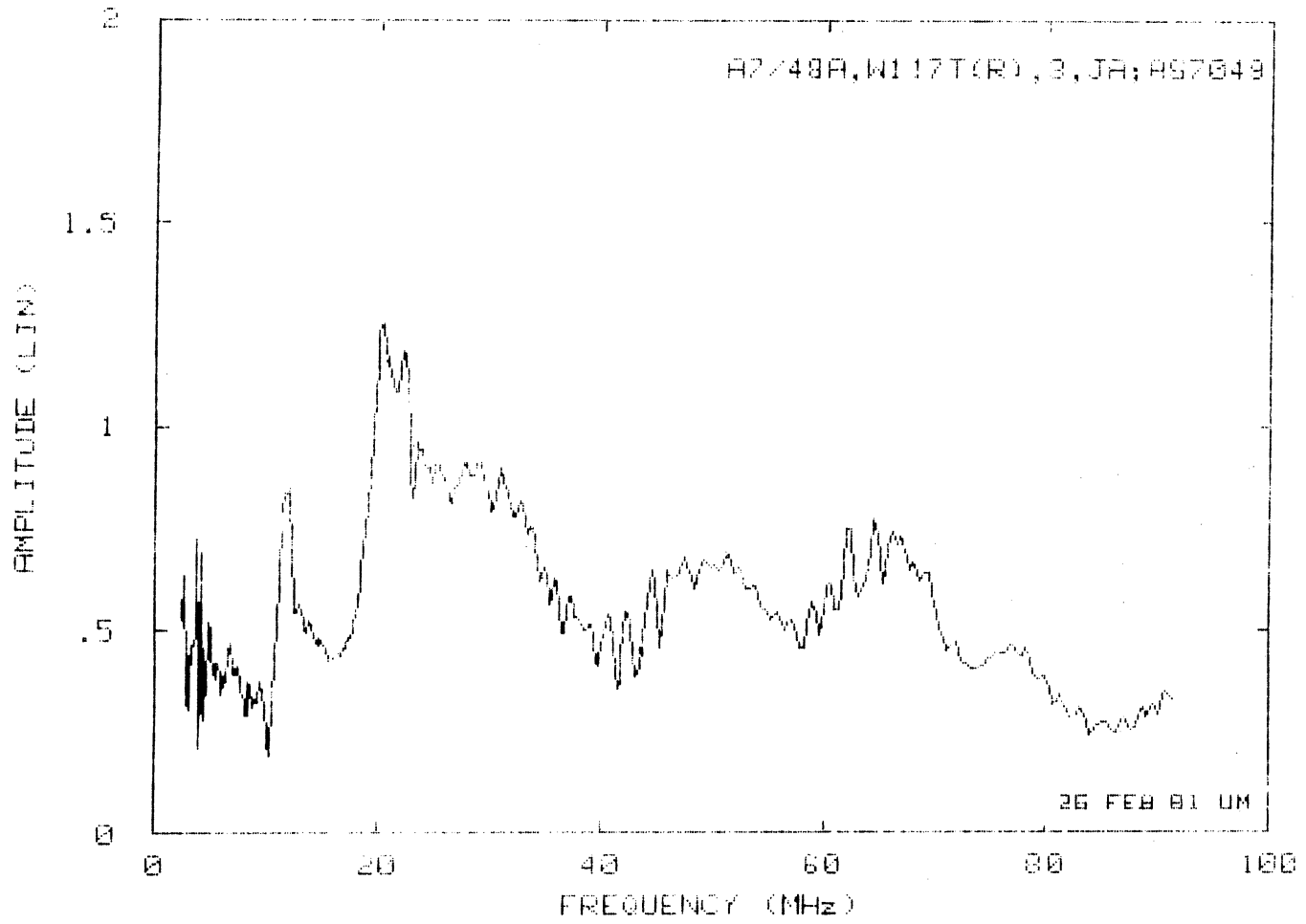
PLOT AS7017



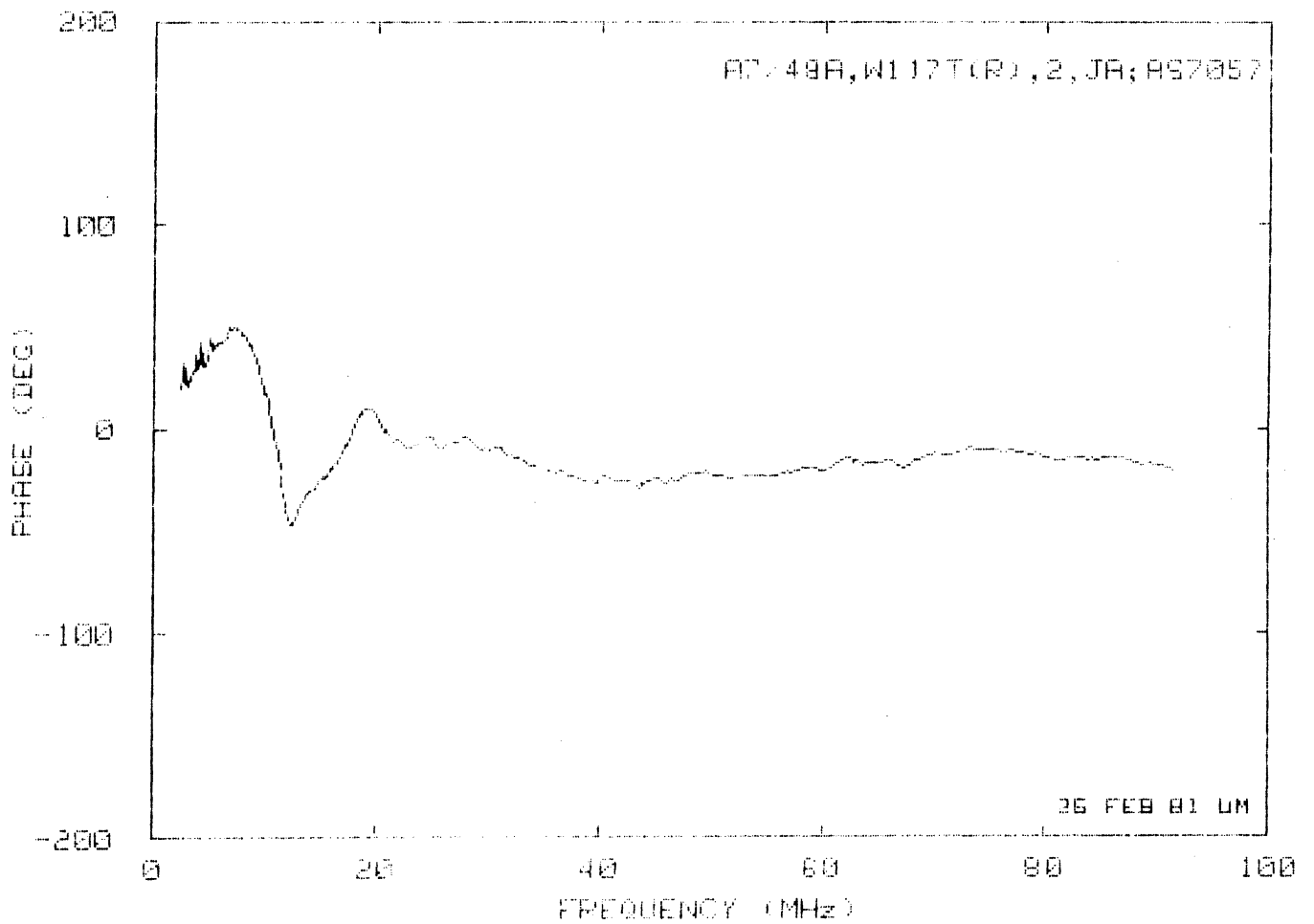
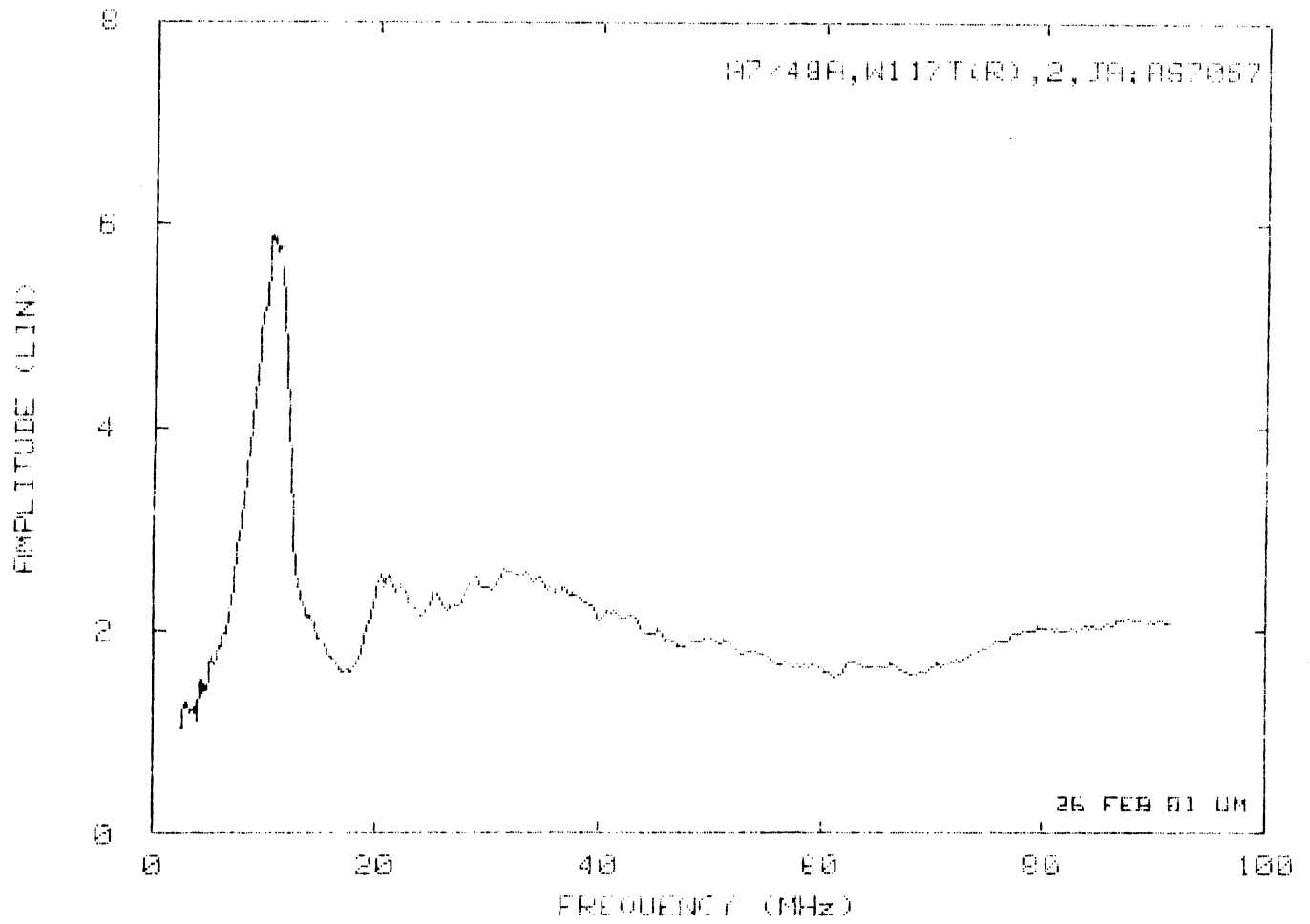
PLOT AS7025



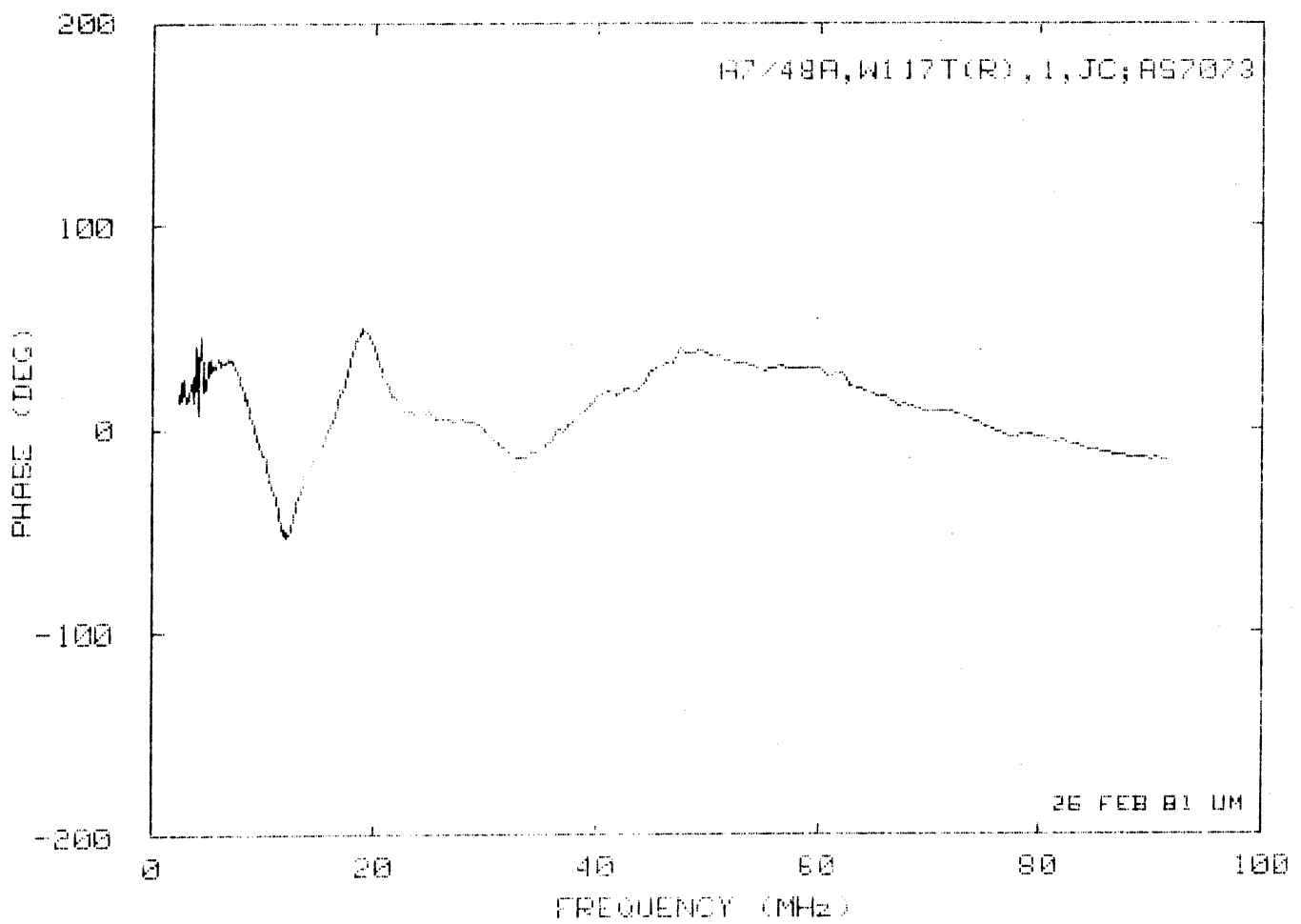
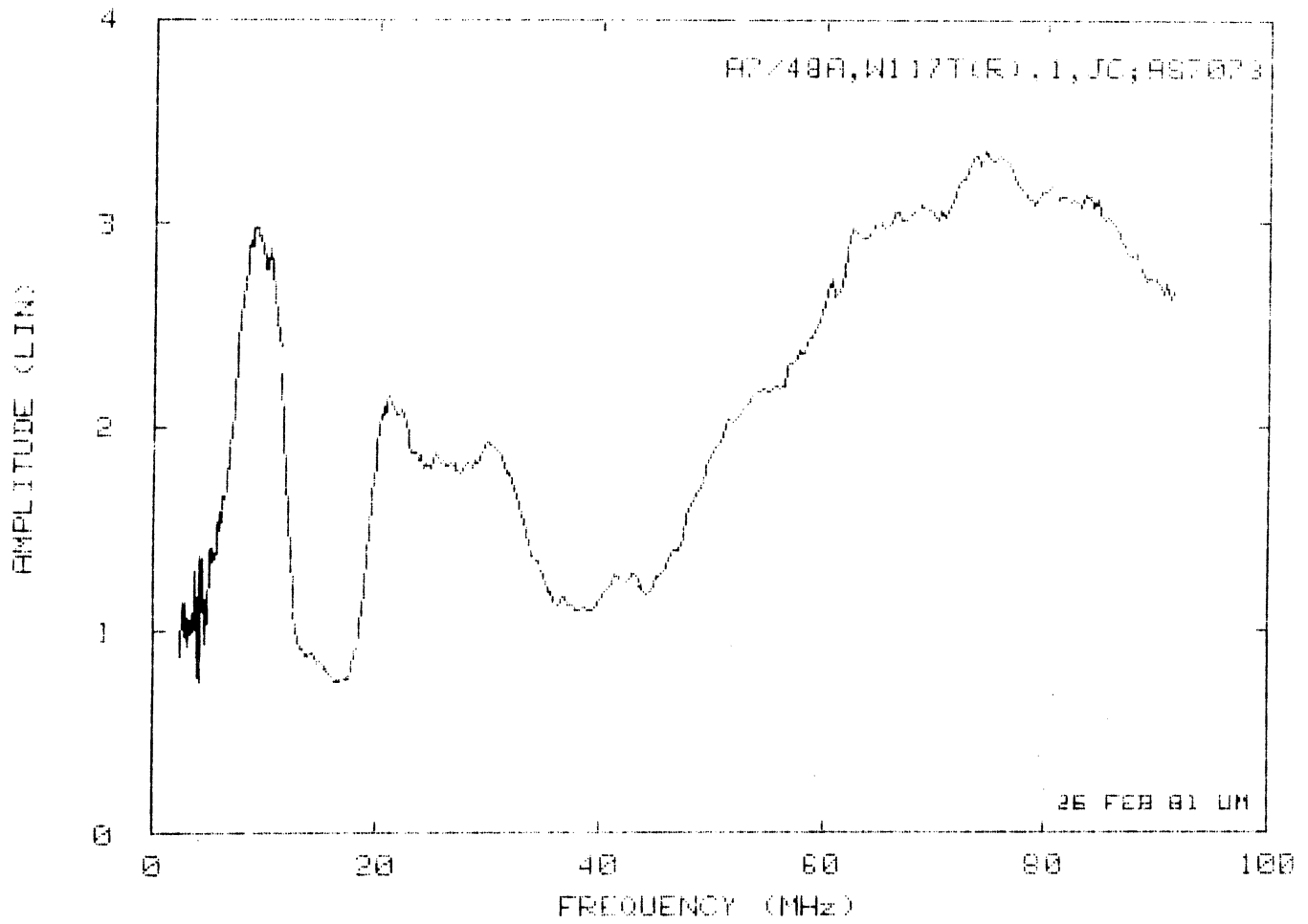
PLOT AS7041



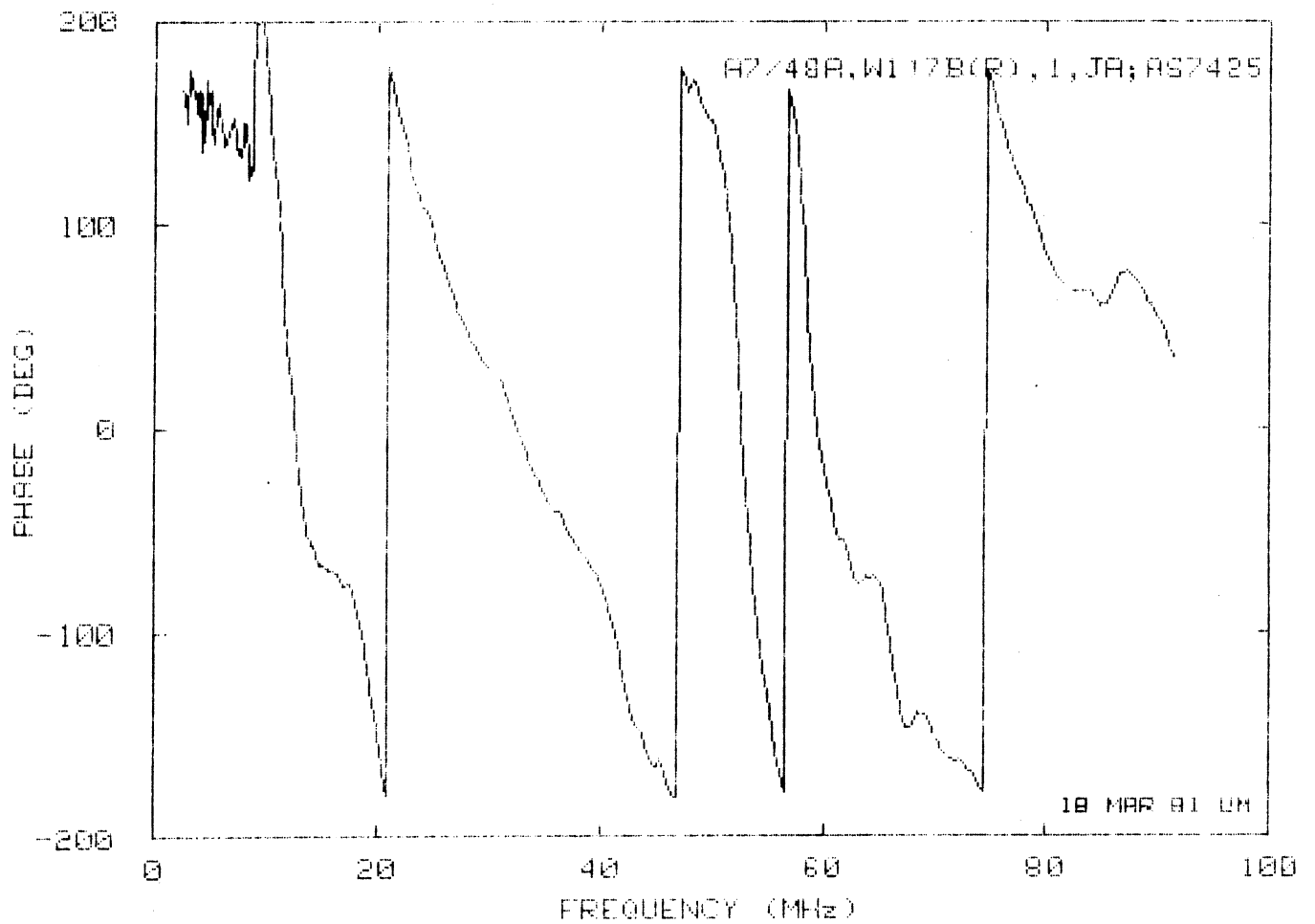
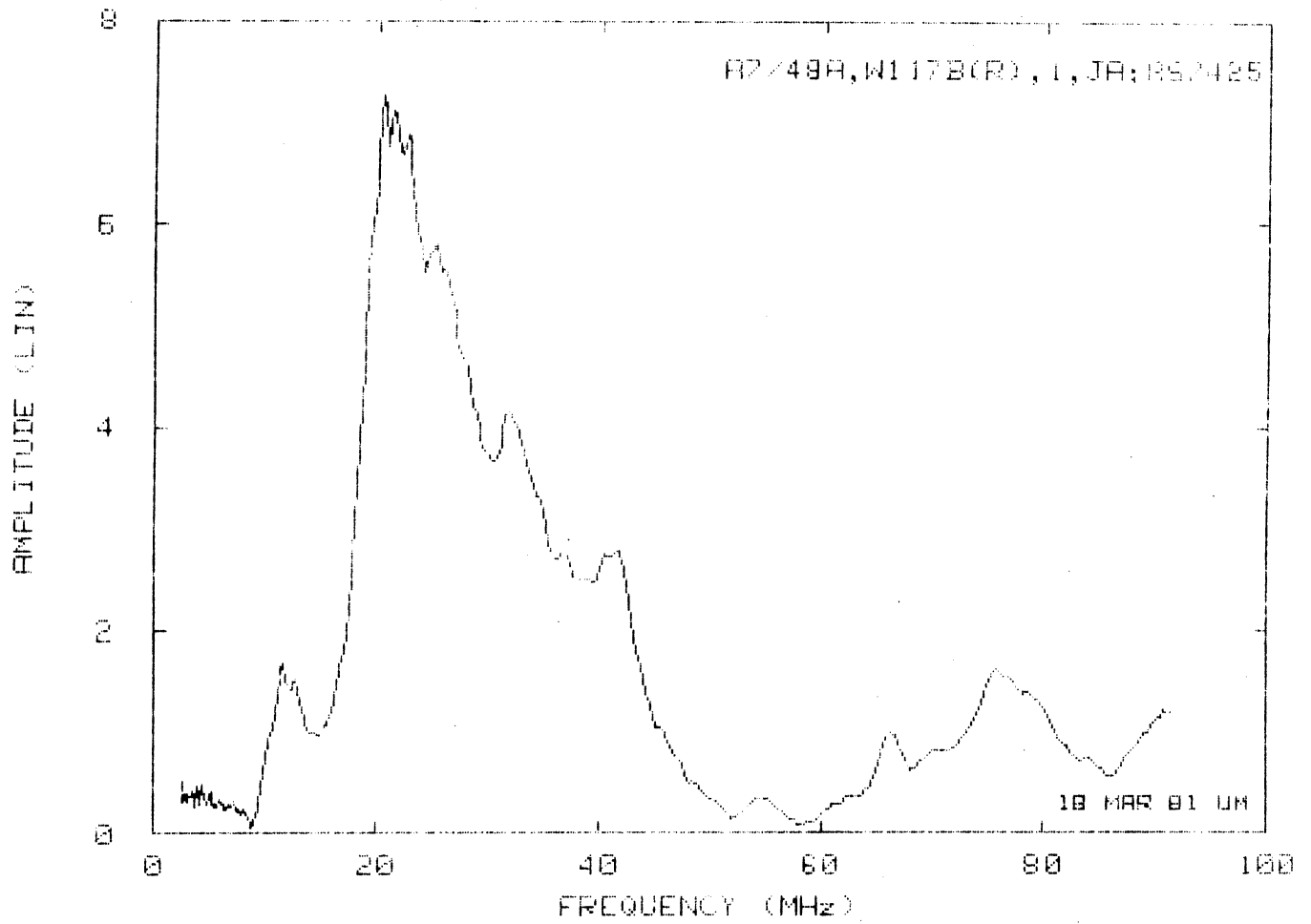
PLOT AS7049



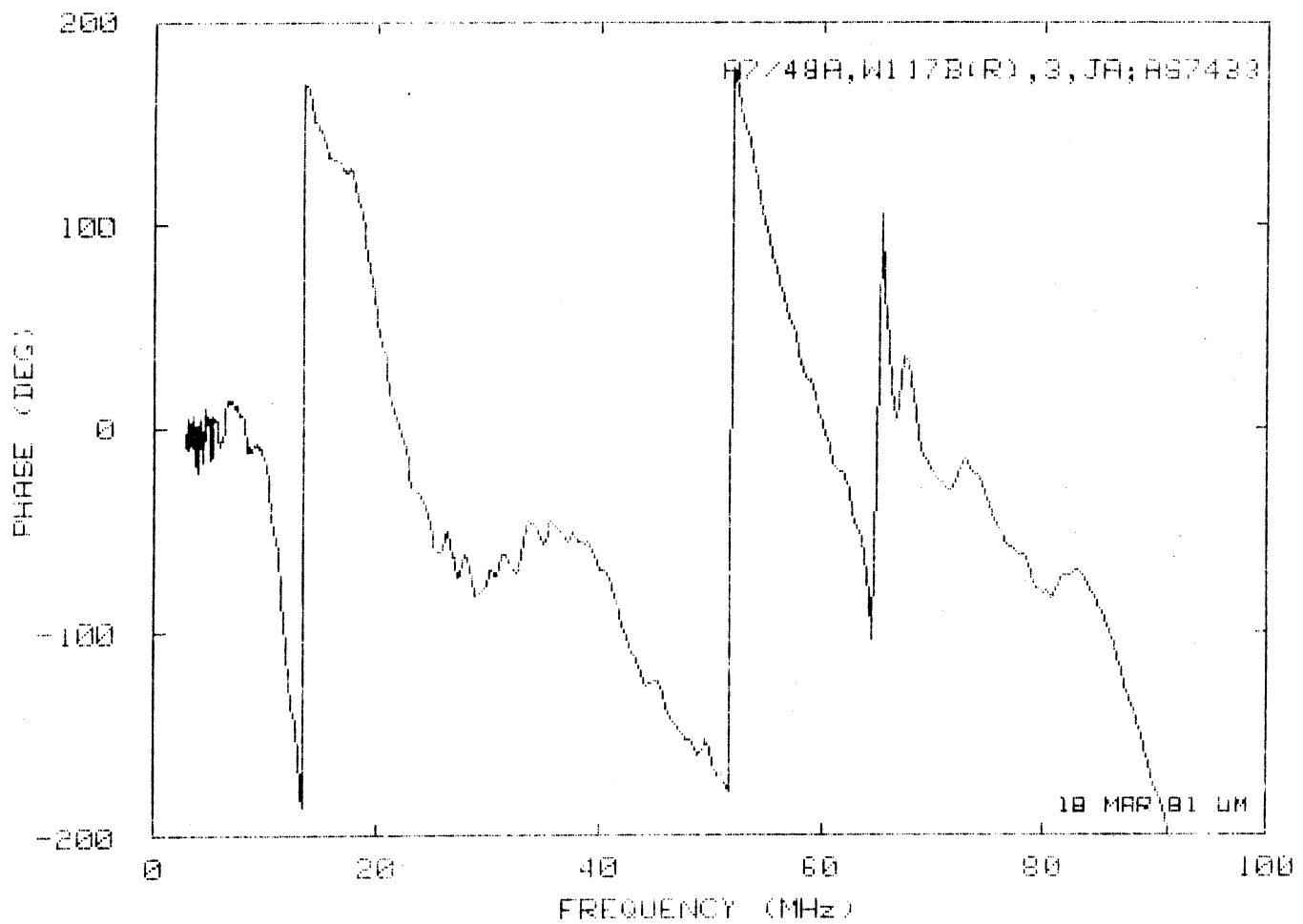
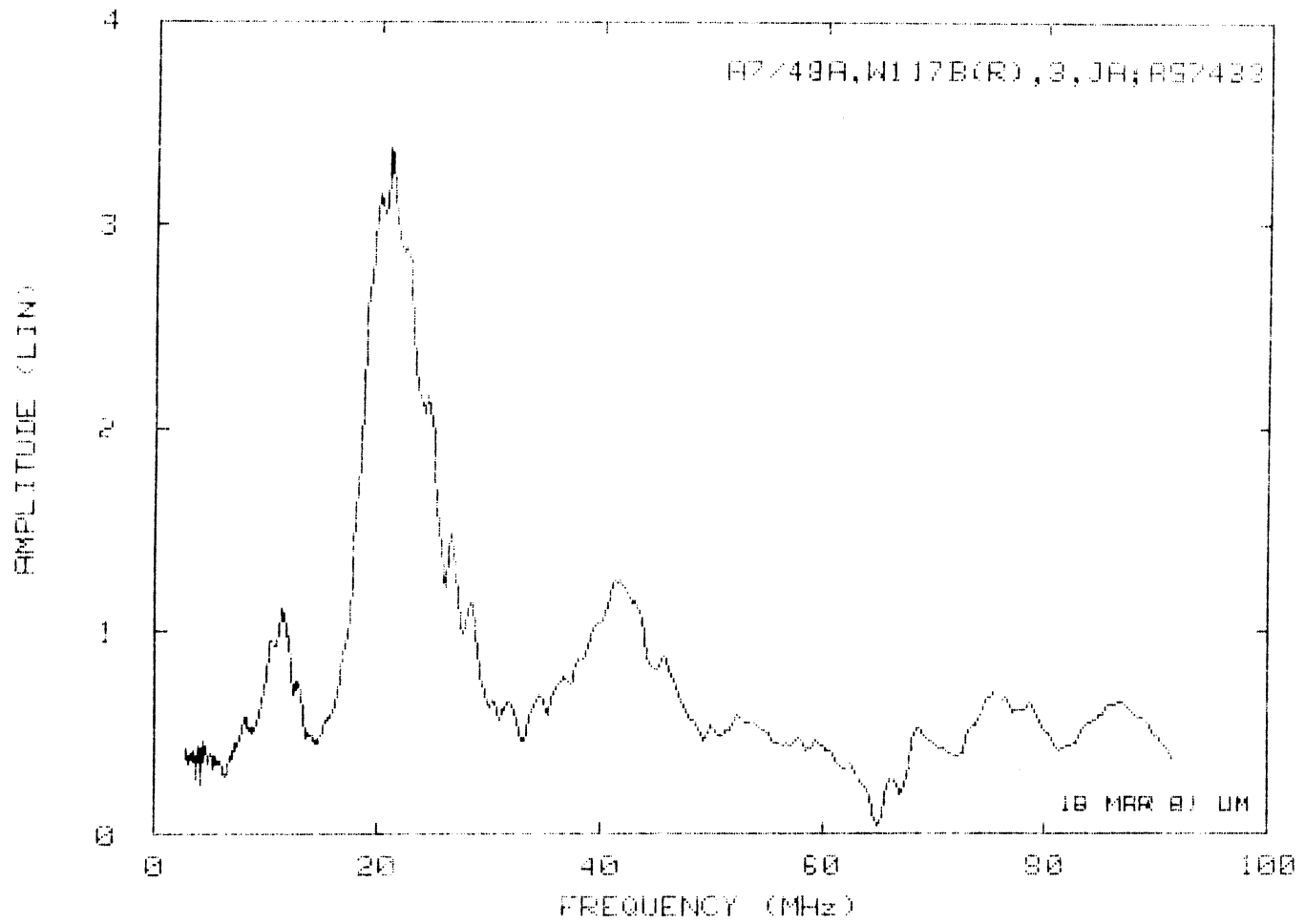
PLOT AS7057



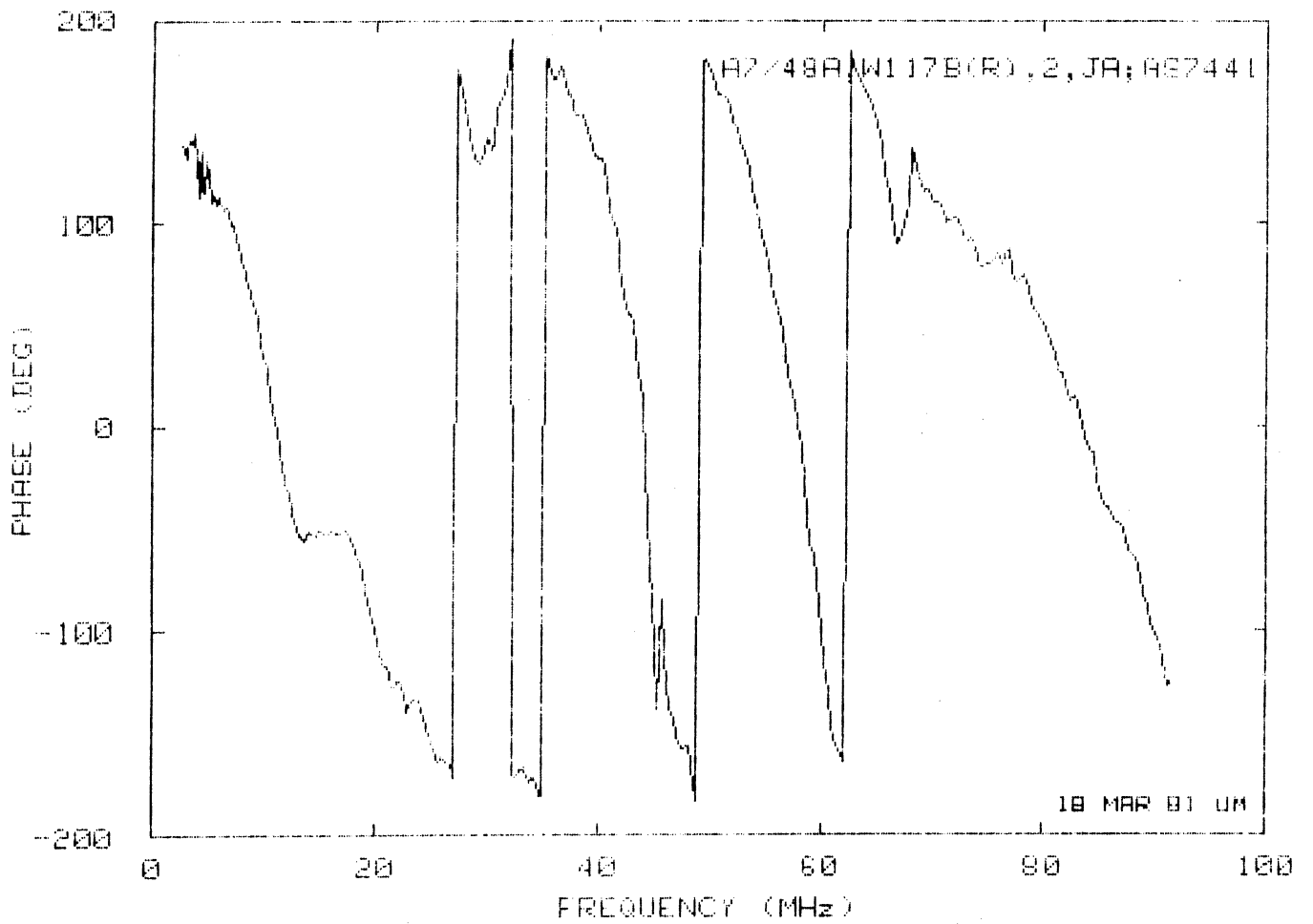
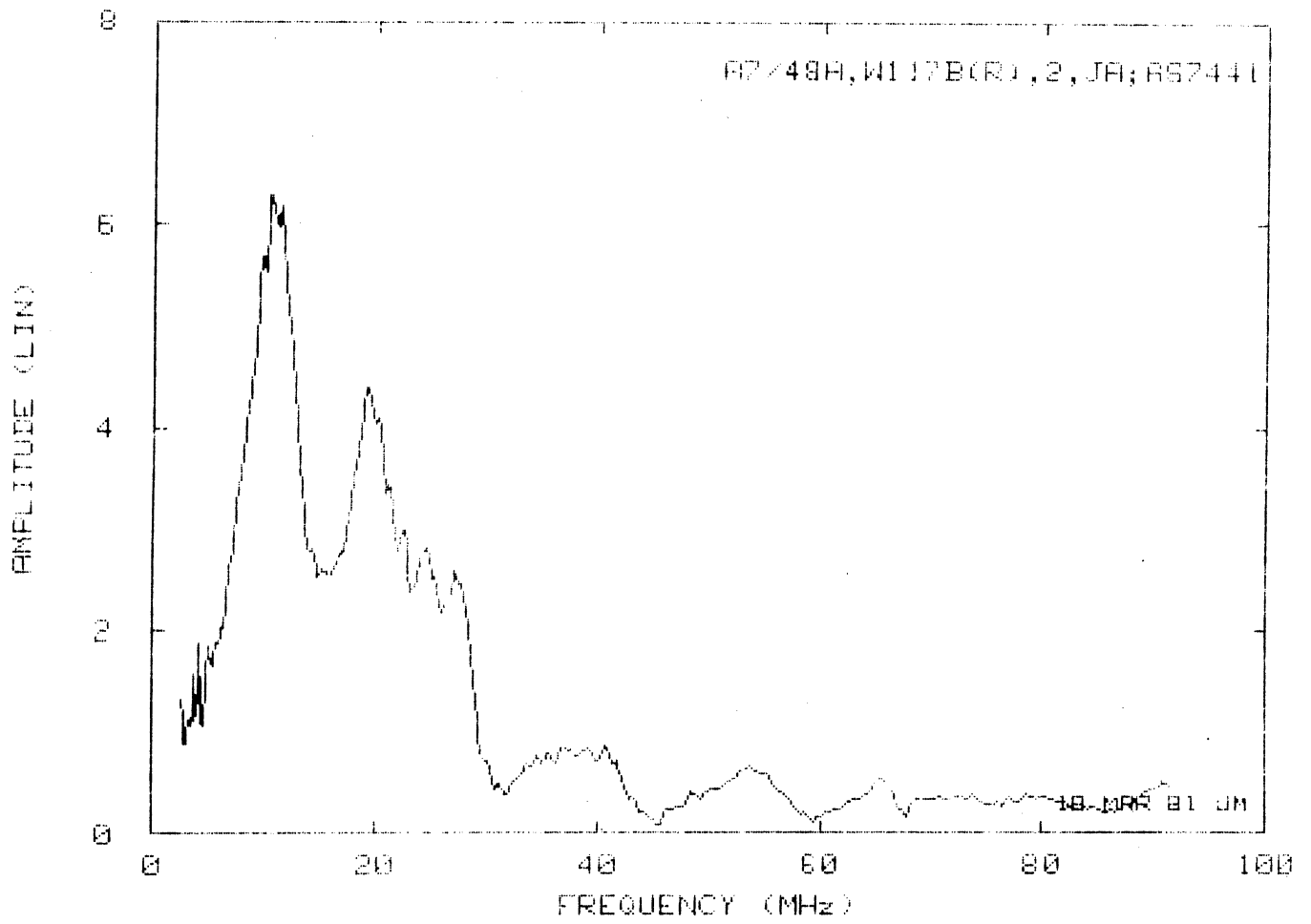
PLOT AS7073



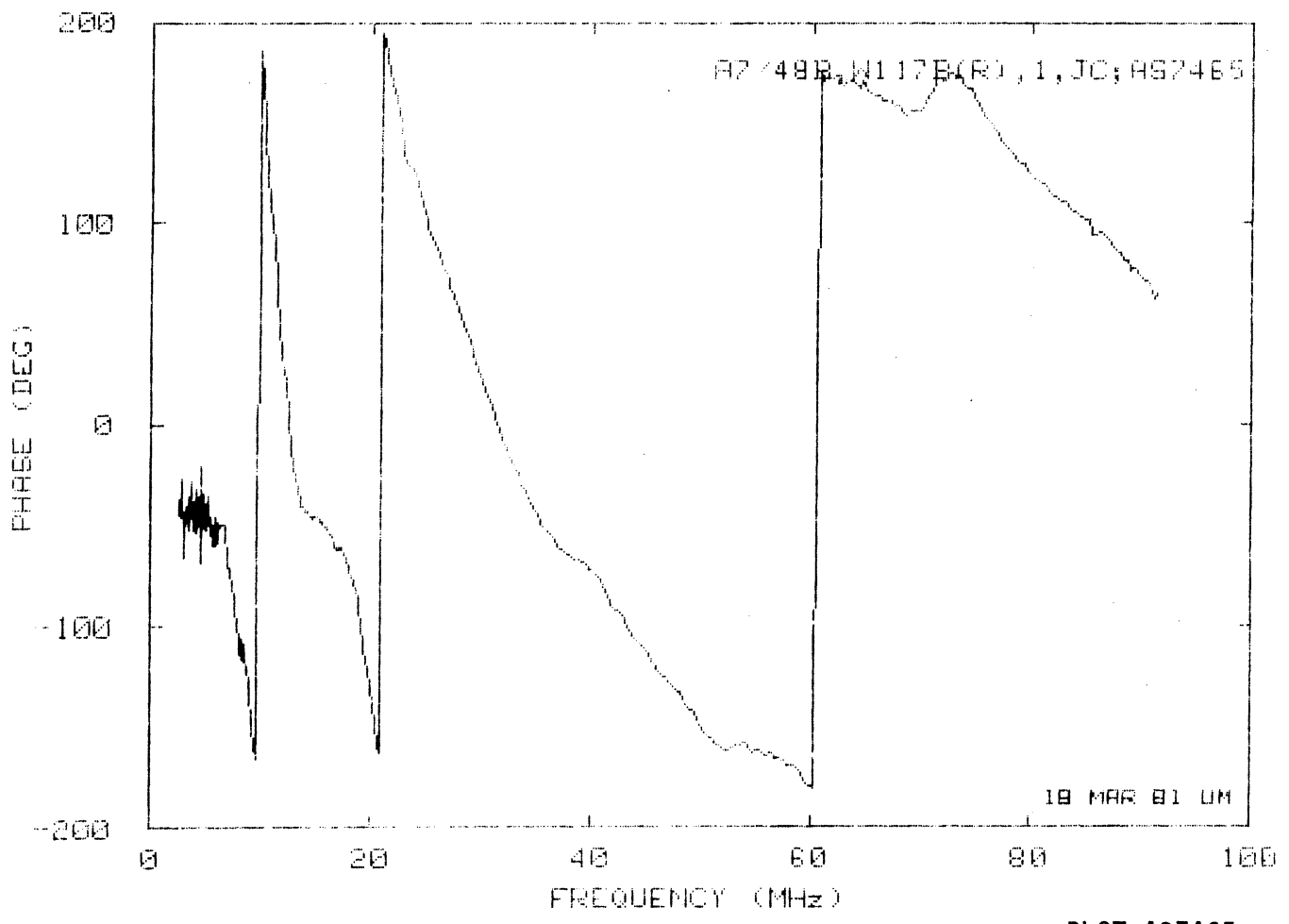
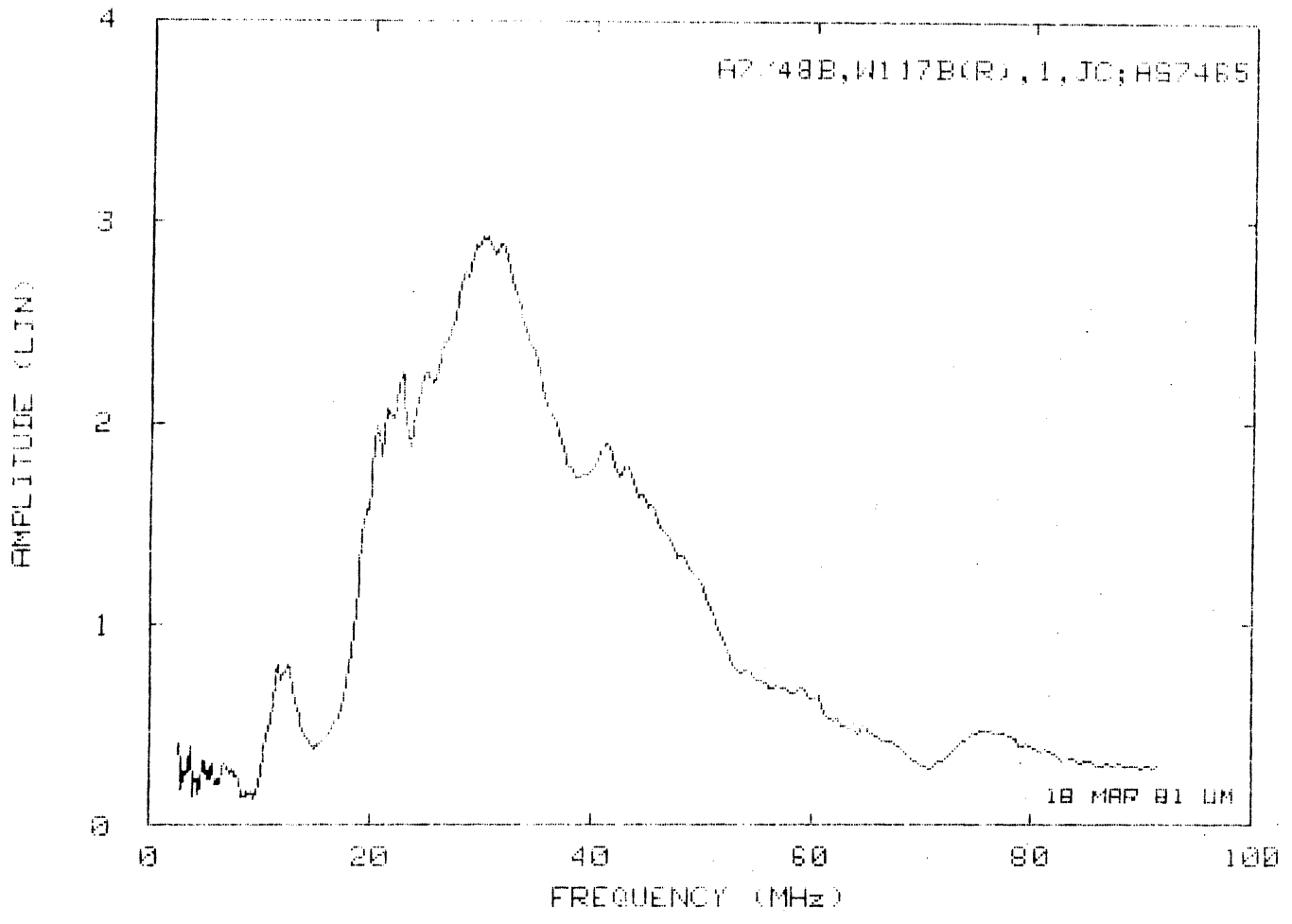
PLOT AS7425



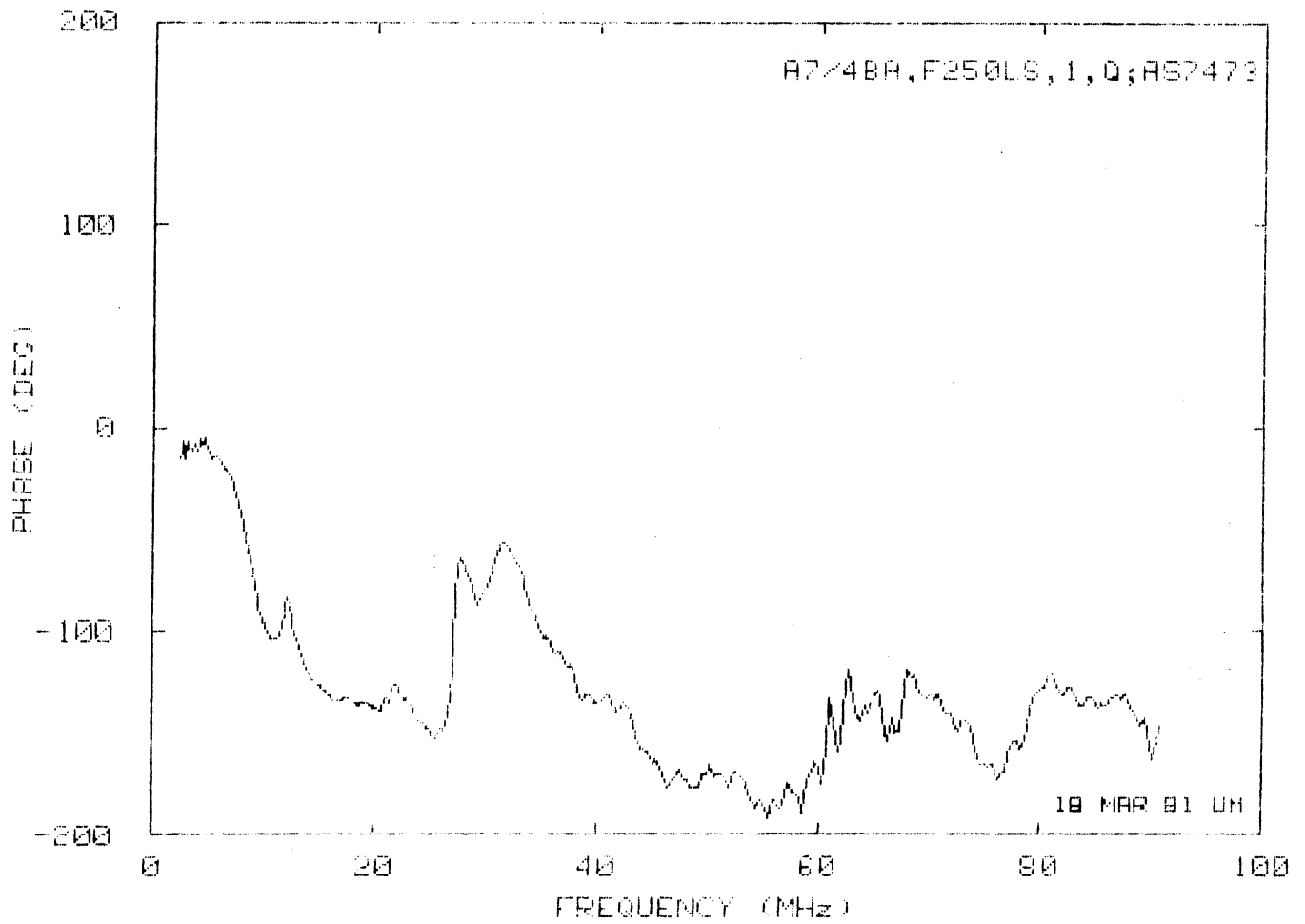
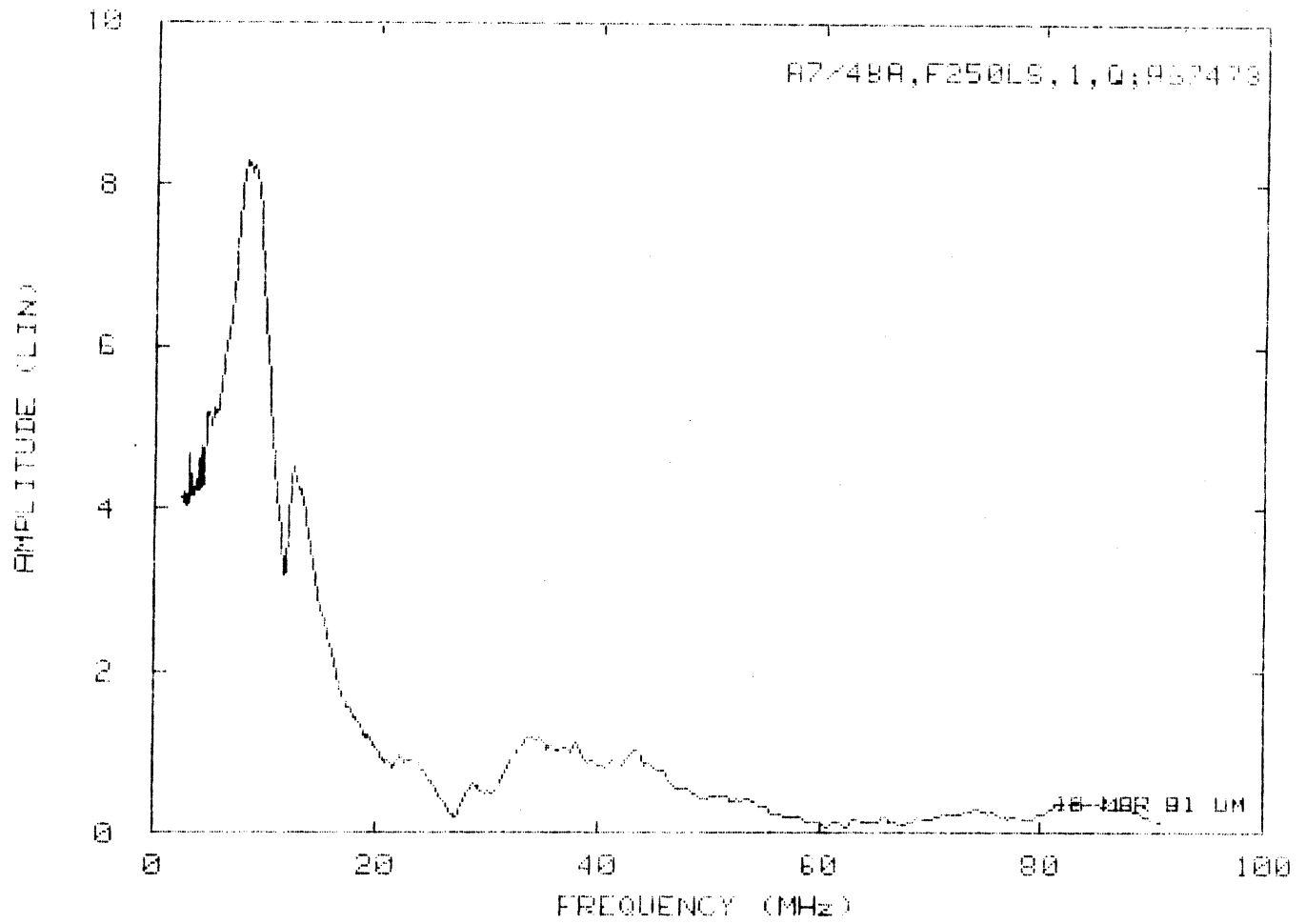
PLOT AS7433



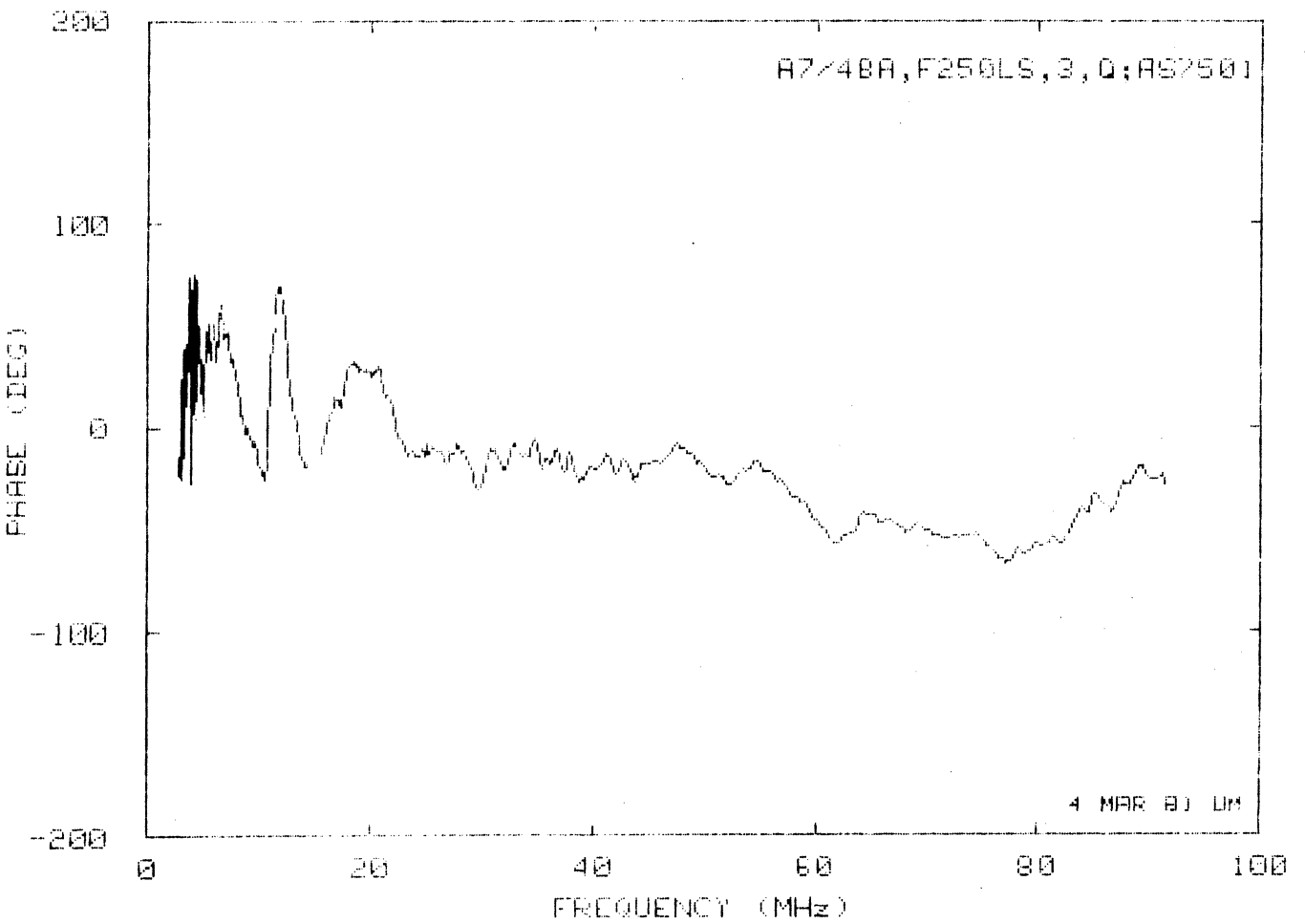
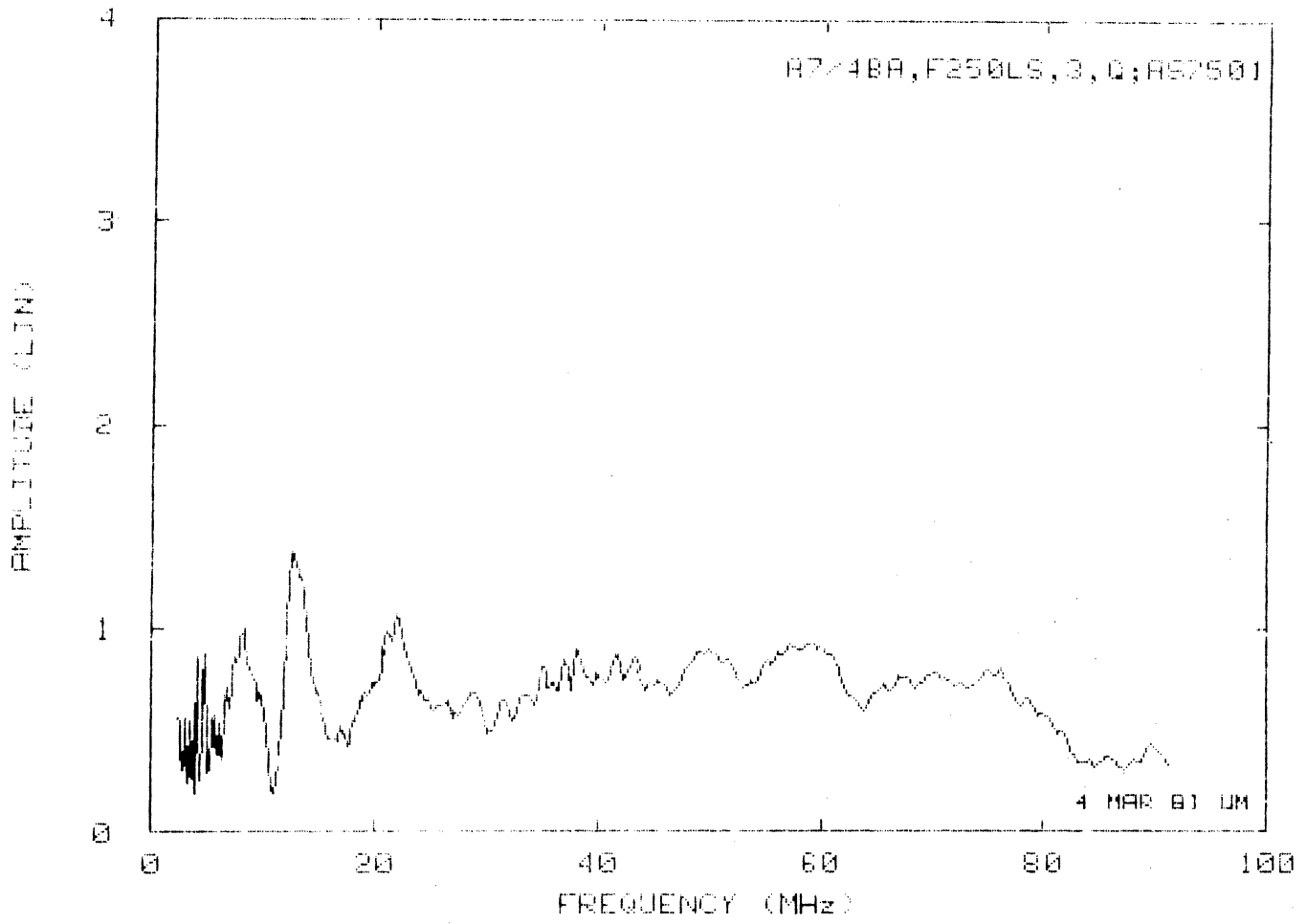
PLOT AS7441



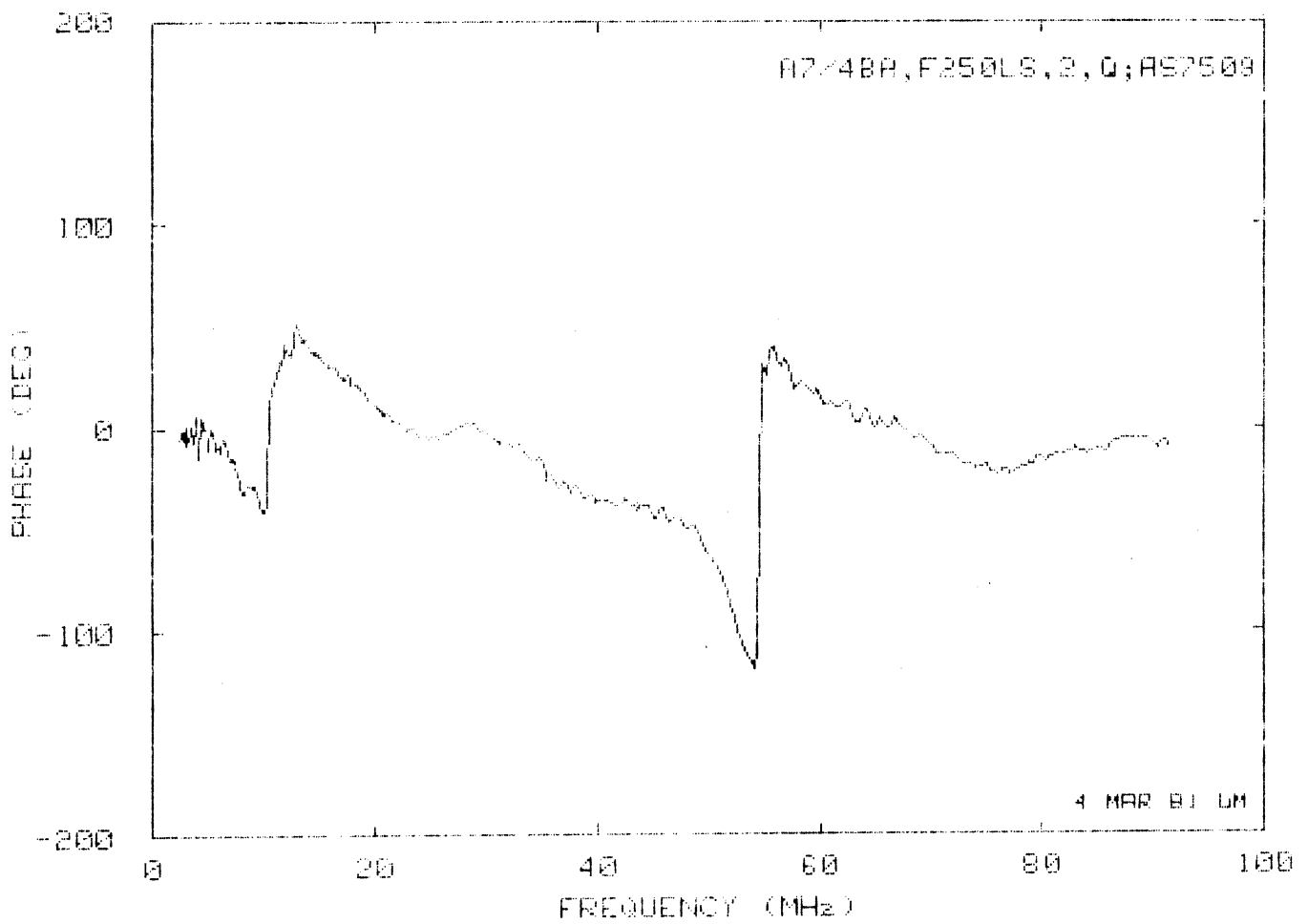
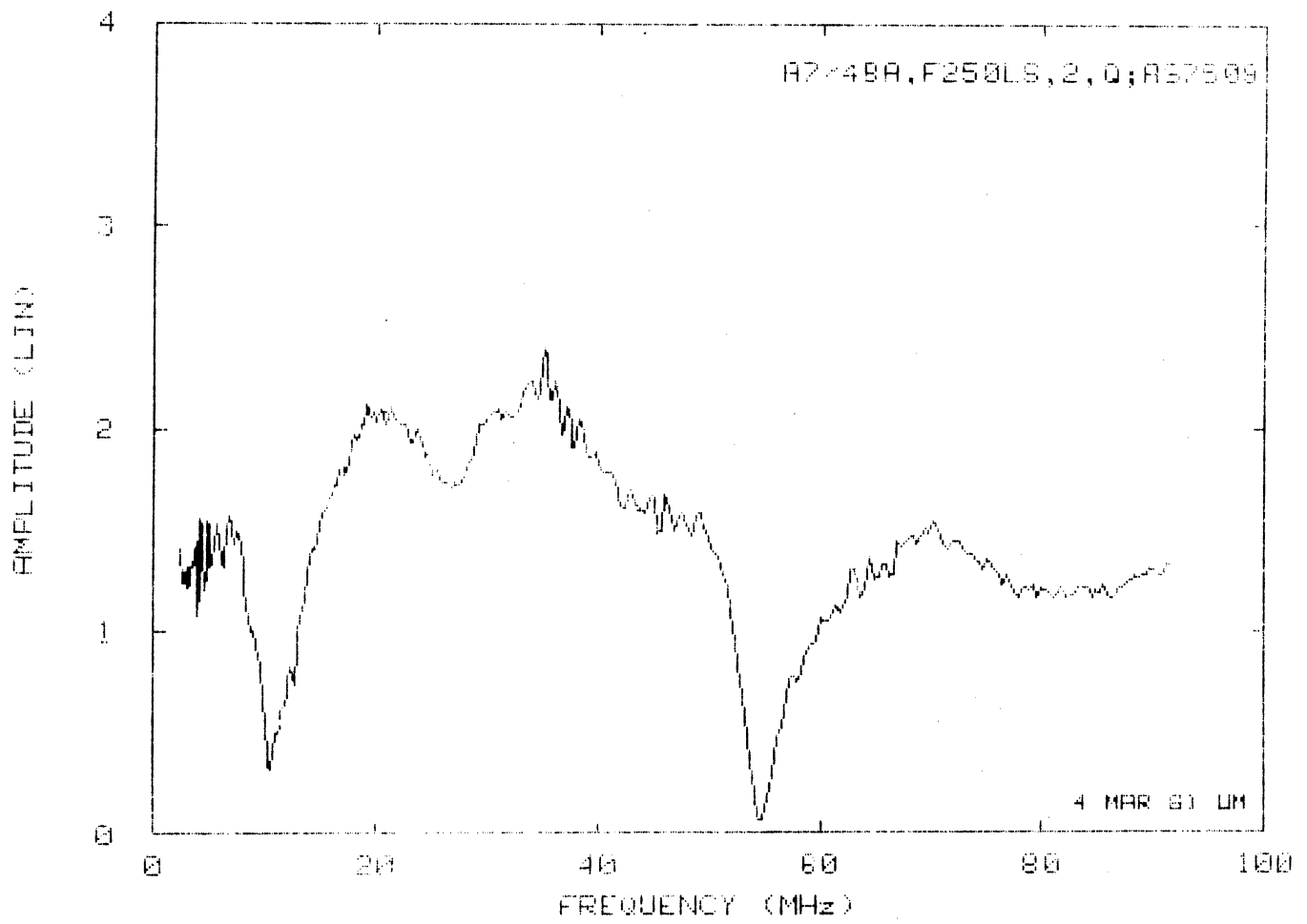
PLOT AS7465



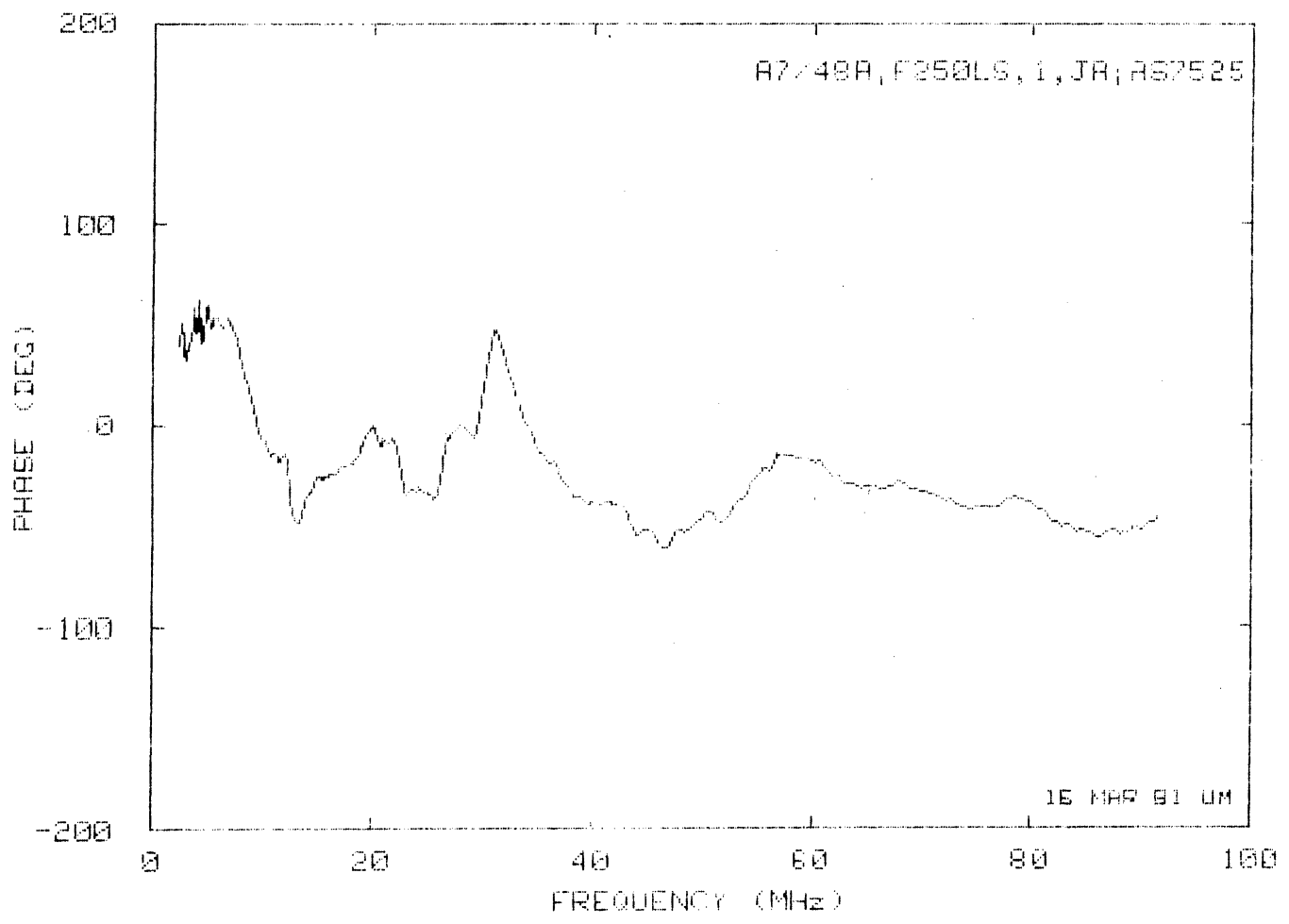
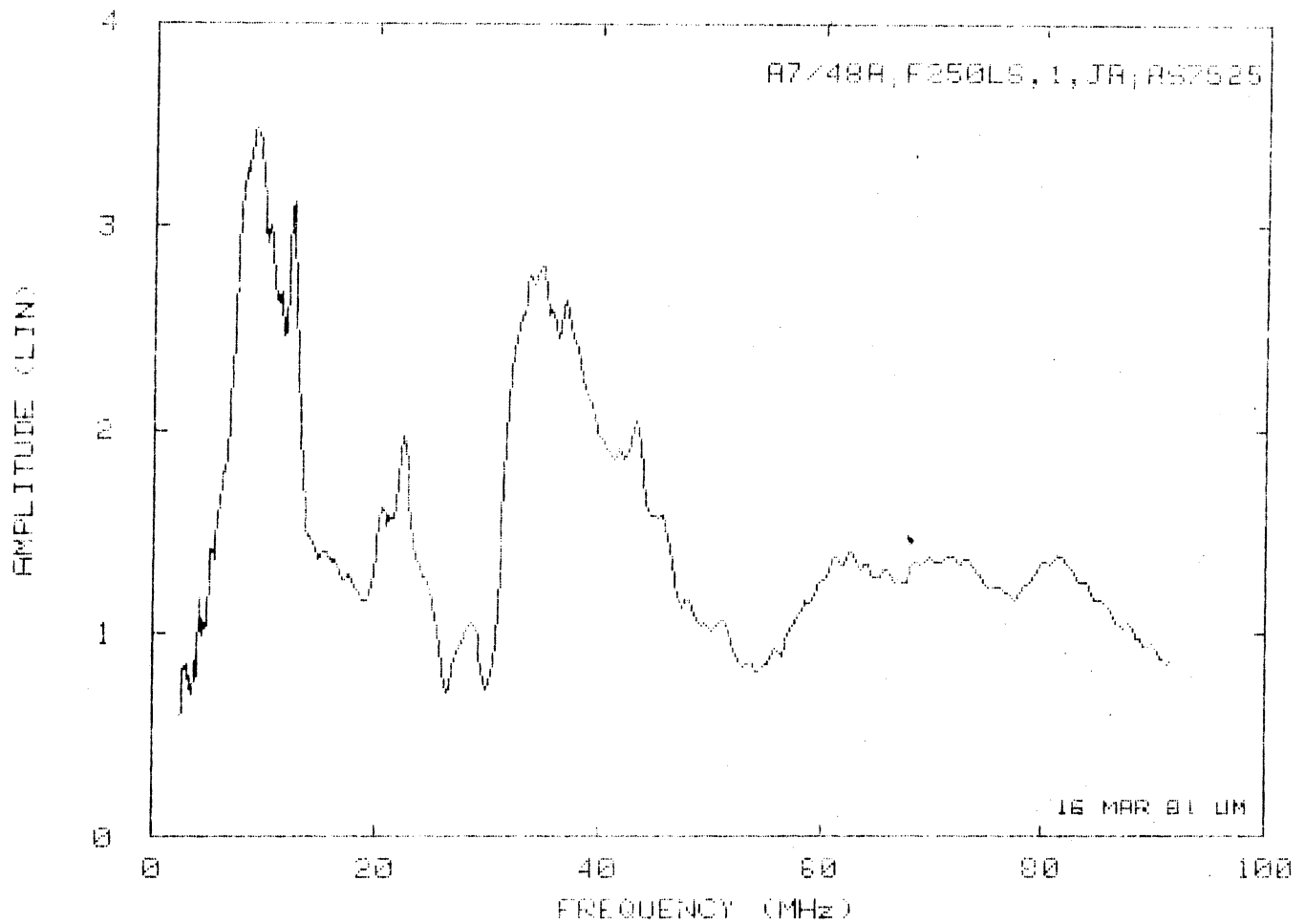
PLOT AS7473



PLOT AS7501



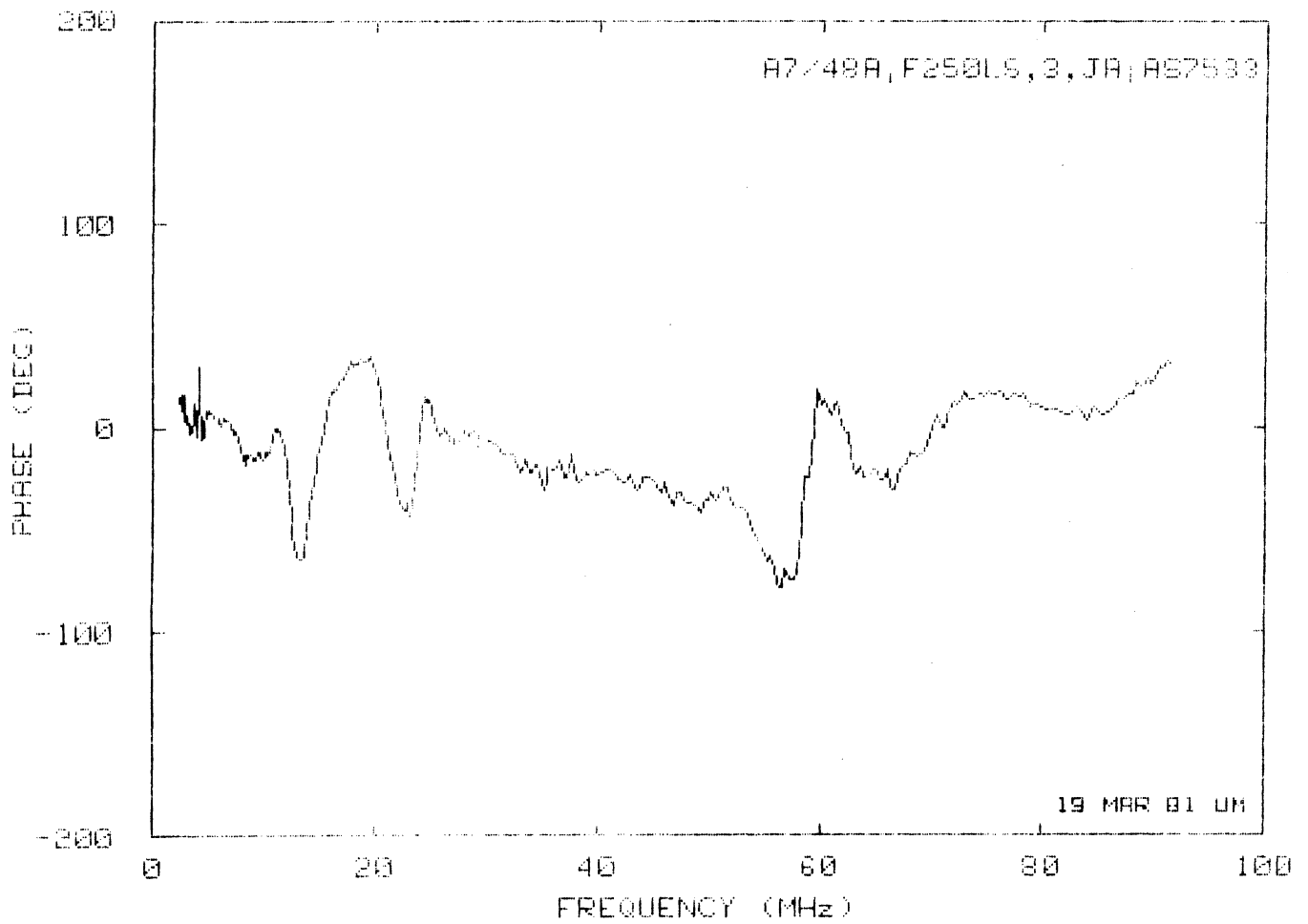
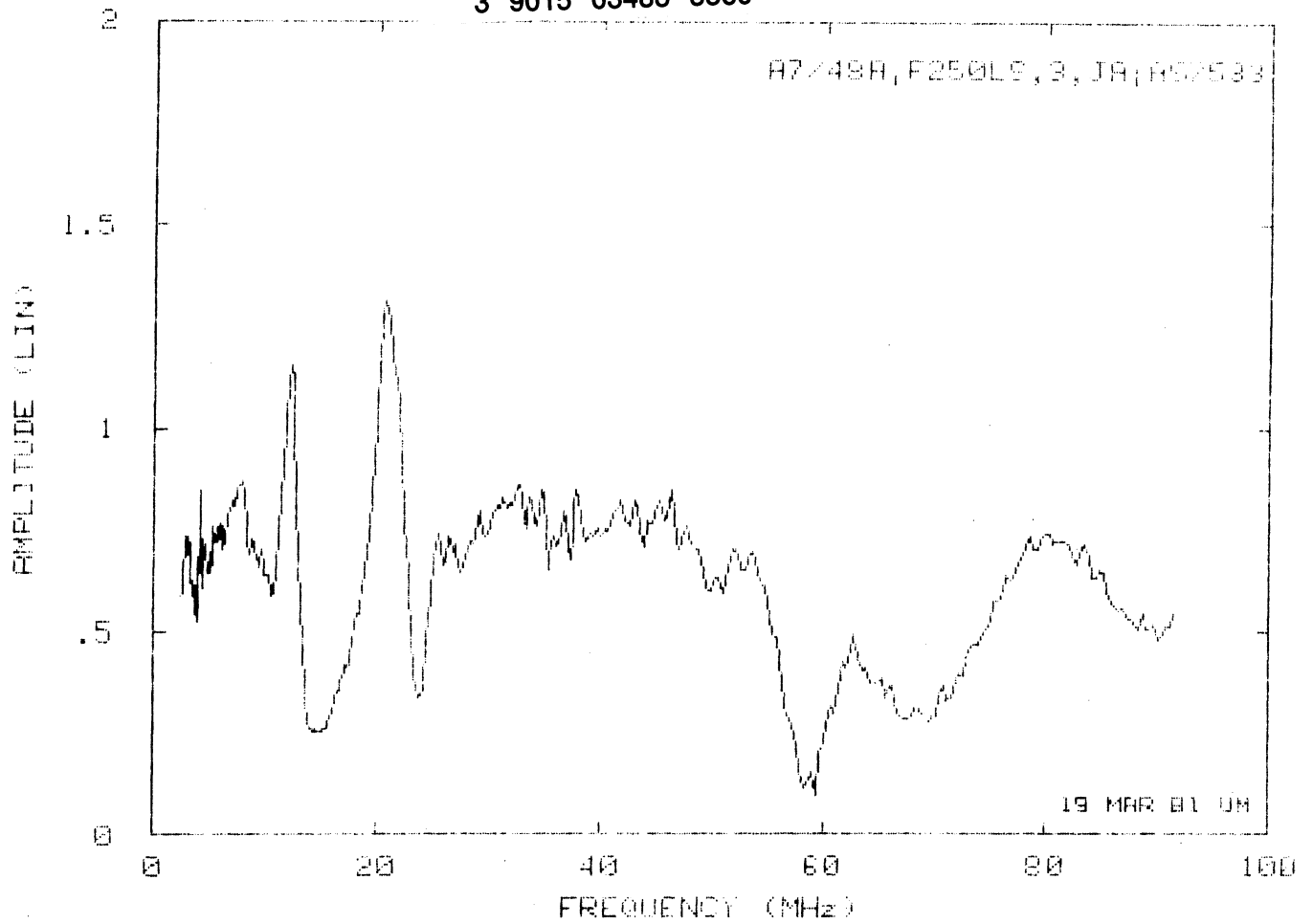
PLOT AS7509



PLOT AS7525



3 9015 03483 8360



PLOT AS7533