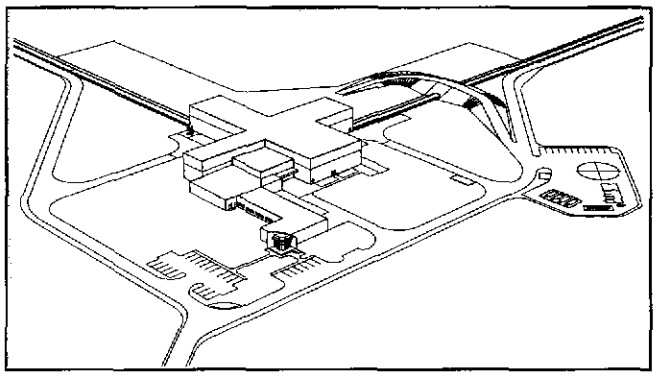


Civil Construction

LIGO Technical Foundation Analyses

Appendix B -- Computer Results For Acoustically Induced Vibrations

December 4, 1995

LIGO
Laser Interferometer Gravitational-Wave Observatory
California Institute of Technology
The Ralph M. Parsons Company
Contract Number: PP150969

LIGO Document LIGO-C950297-02-TB

Appendix B

Computer Results For Acoustically Induced Vibrations

Section 1

- 68 Inch LVEA -- LIGO Acoustic Criteria
- 68 Inch LVEA -- Marshall Long's SPL
- 36 Inch LVEA -- LIGO Acoustic Criteria
- 36 Inch LVEA -- Marshall Long's SPL
- 18 Inch LVEA -- LIGO Acoustic Criteria
- 18 Inch LVEA -- Marshall Long's SPL

Section 2

- 68 Inch Mid Station -- LIGO Acoustic Criteria
- 68 Inch Mid Station -- Marshall Long's SPL
- 36 Inch Mid Station -- LIGO Acoustic Criteria
- 36 Inch Mid Station -- Marshall Long's SPL
- 18 Inch Mid Station -- LIGO Acoustic Criteria
- 18 Inch Mid Station -- Marshall Long's SPL

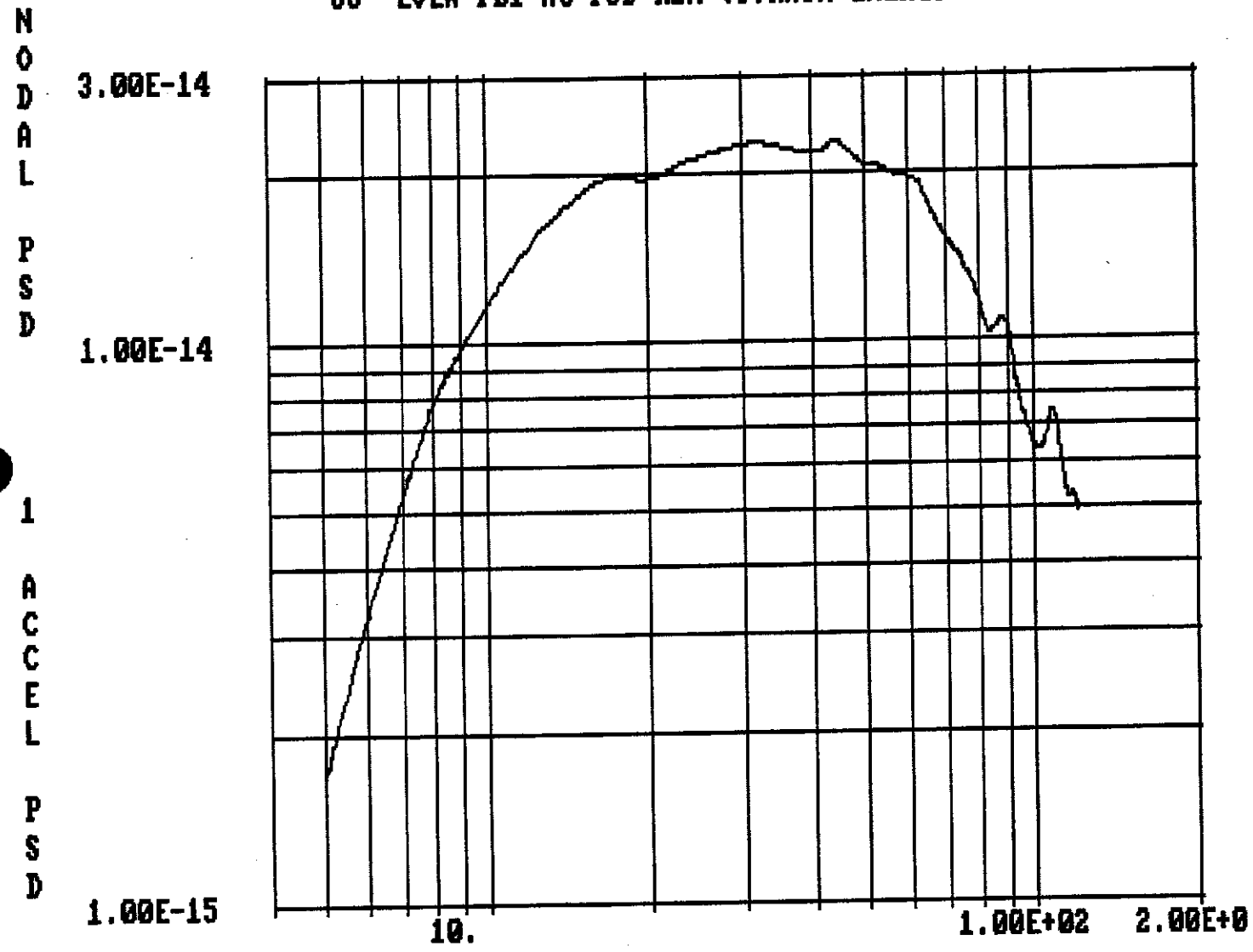
Section 3

- 68 Inch LVEA -- LIGO Acoustic Criteria Uncorrelated

```
 68" LVEAPB1 LIGO Acoustic Spectra (STRAIN ENERGY DAMPING)
START3                              3         1        3.0       5.0      120.0
RMS
PRINT
          2  230  230
          2  774  774
          2  792  792
          2 1520 1520
          2 2183 2183
END
MODES
            1       180      99.0
END
PSD         3         1
NODES                 230         3       774         3       792         3
NODES                1520         3      2183         3
END
START PSD INPUT       1
 1 3 3 2 1            1.0    2.9E-9                          -81           1
 6          1         4.0      50.0       8.0      57.0      16.0      61.0
 6         -7        31.5      64.0      63.0      66.0     125.0      62.0
ALL DONE
```

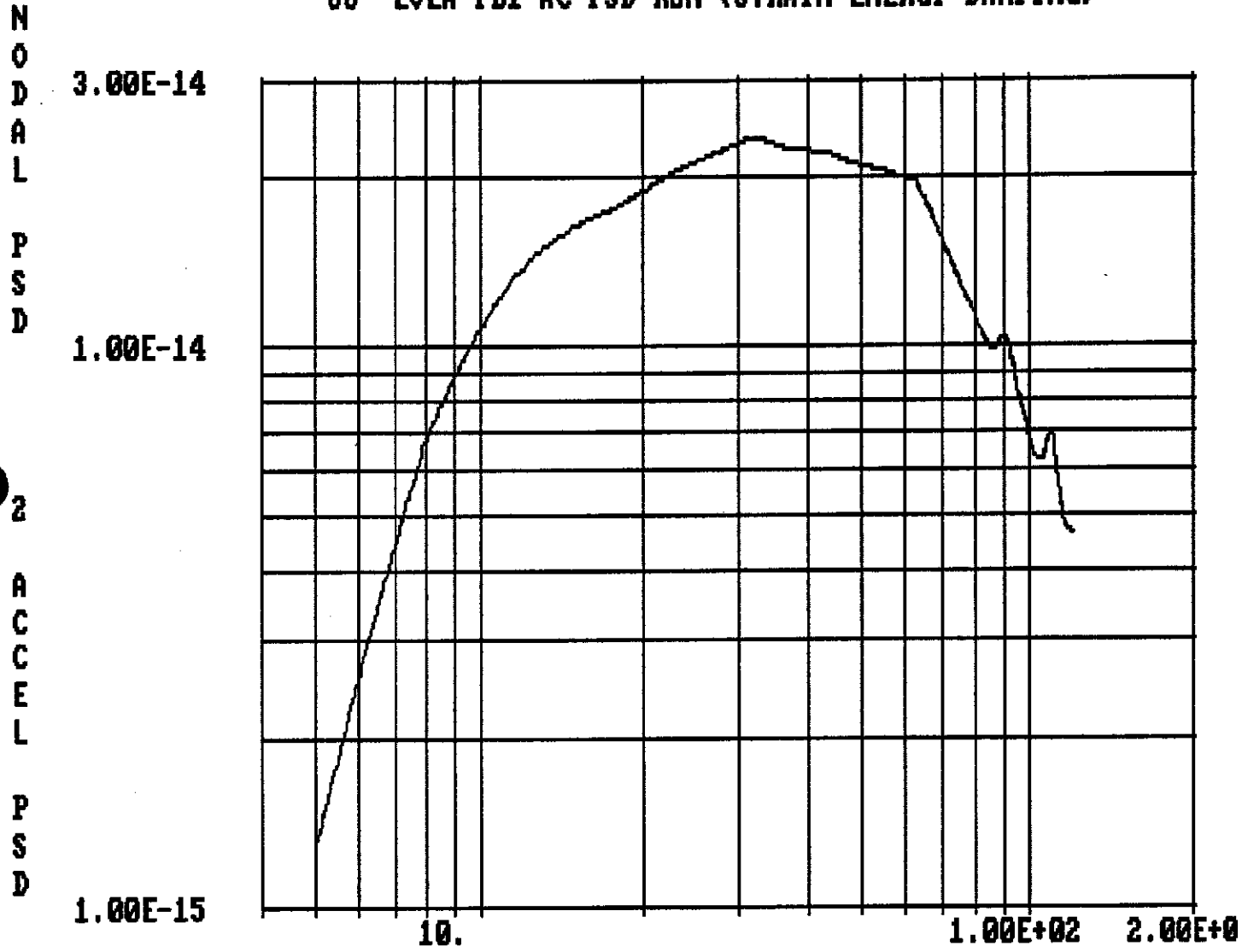
Node 230 X3

68" LVEA-PB1 AC PSD RUN (STRAIN ENERGY DAMPING)



Node 774 X3

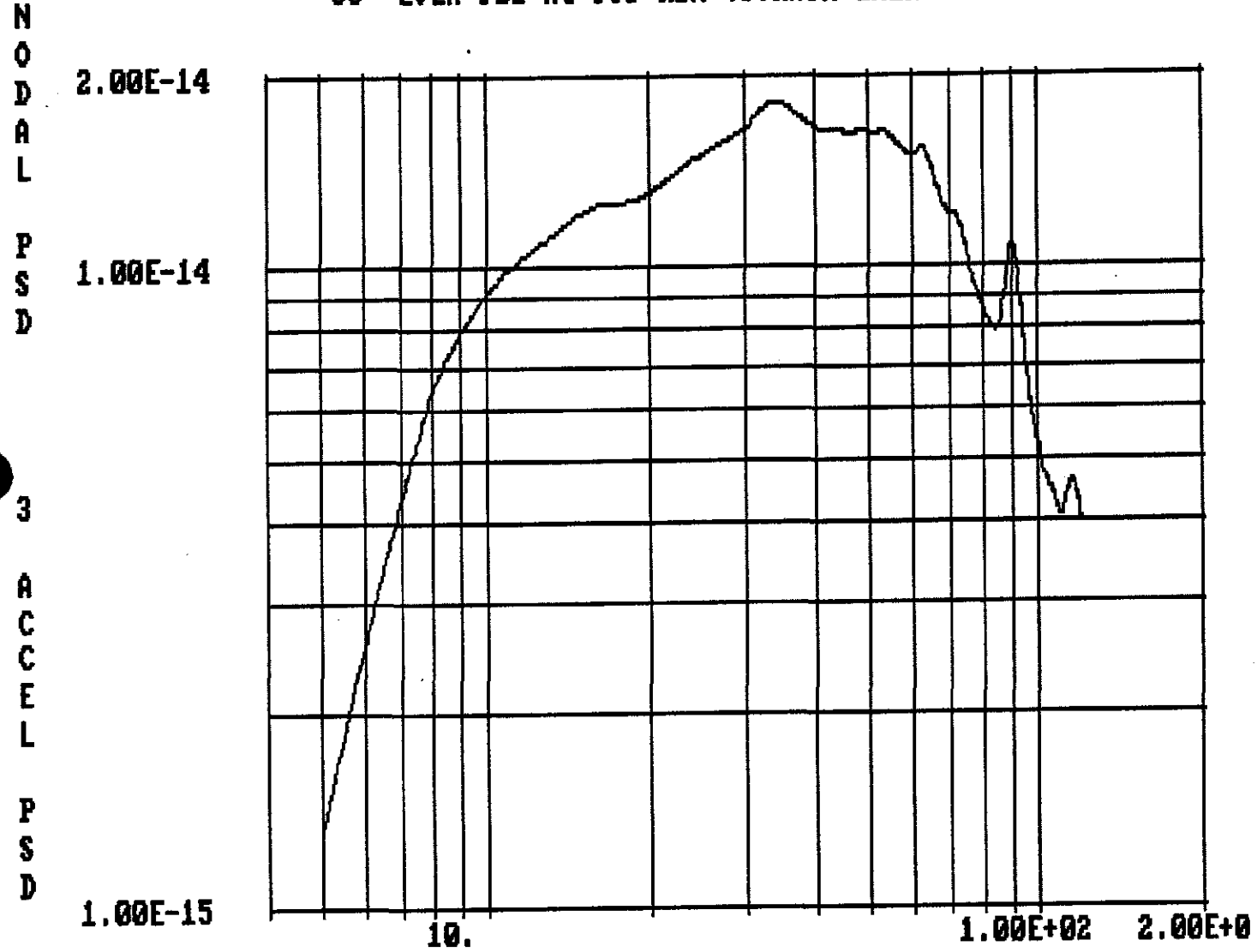
68" LVEA-PB1 AC PSD RUN (STRAIN ENERGY DAMPING)



FREQUENCY (HZ) PLOT NO = 2

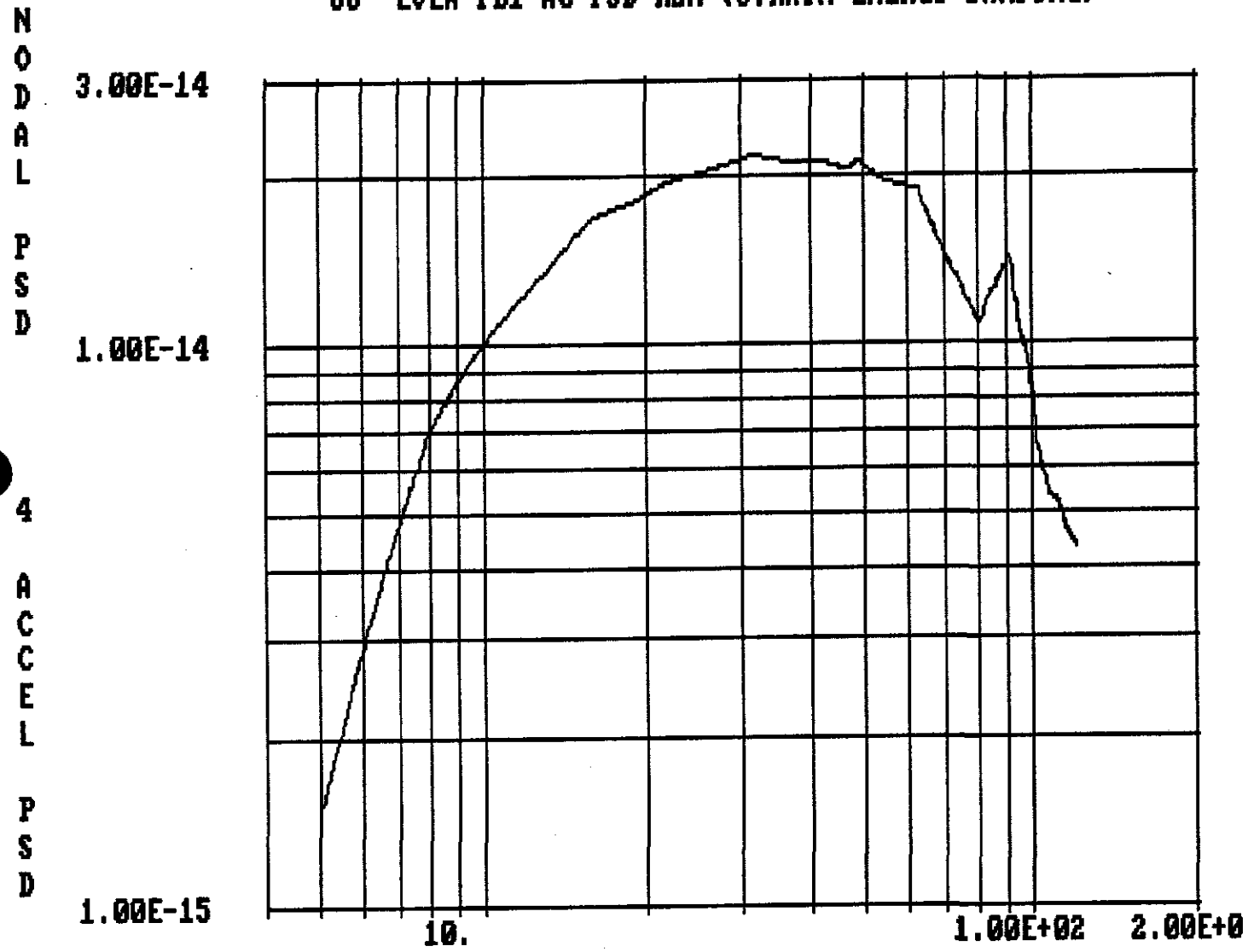
Node 792 X3

68" LVEA-PB1 AC PSD RUN (STRAIN ENERGY DAMPING)



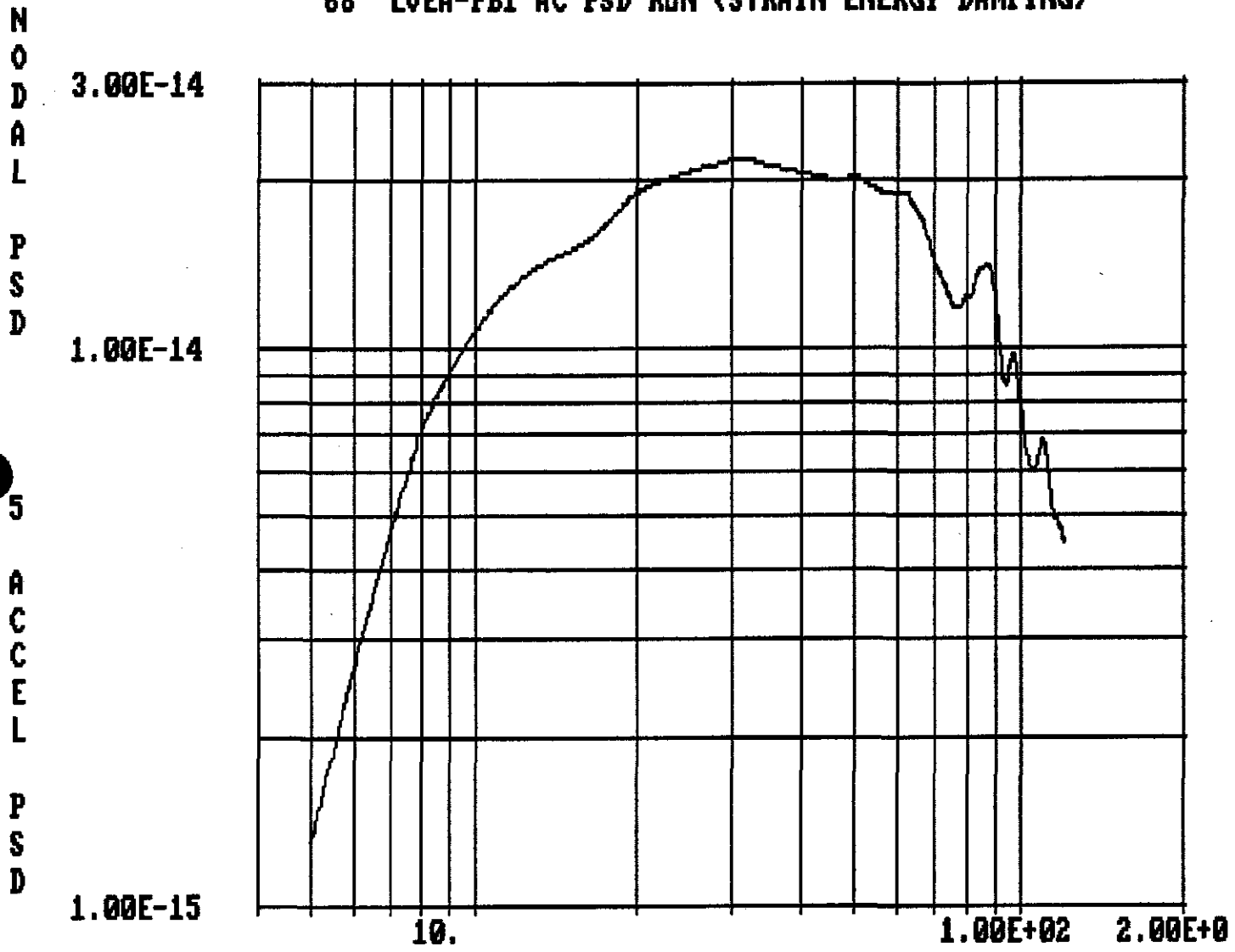
Node 1520 X3

68" LVEA-PB1 AC PSD RUN (STRAIN ENERGY DAMPING)



Node 2183 X3

68" LVEA-PB1 AC PSD RUN (STRAIN ENERGY DAMPING)

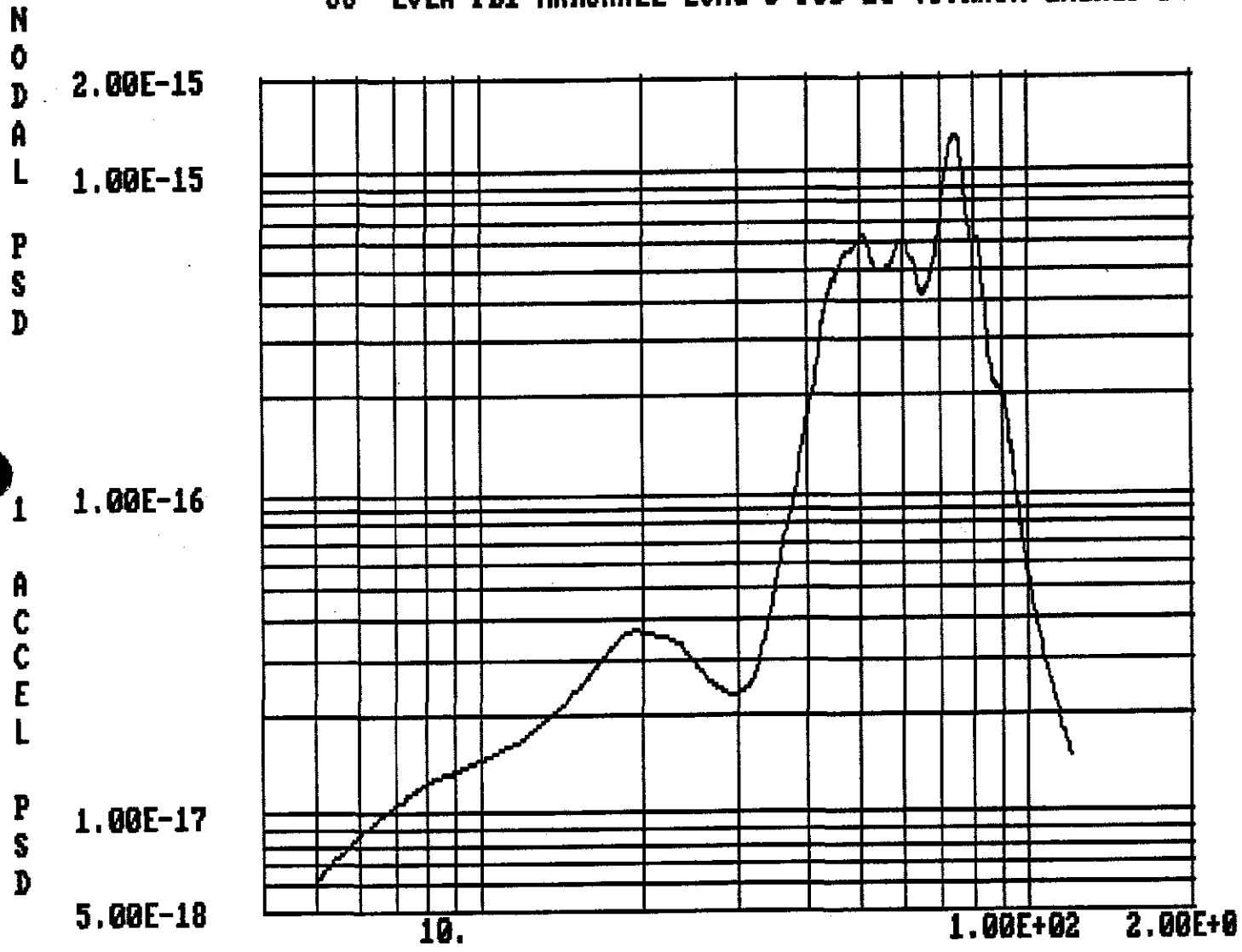


FREQUENCY (HZ) PLOT NO = 5

```
68" LVEA-PB1 MARSHALL LONG'S PSD-UC (STRAIN ENERGY DAMPING)
START3                  3      1     3.0     5.0    120.0
RMS
PRINT
      2  230  230
      2  774  774
      2  792  792
      2 1520 1520
      2 2183 2183
END
MODES
       1     180     99.0
END
PSD      3       1
NODES           230       3     774       3     792       3
NODES          1520       3    2183       3
END
START PSD INPUT   1
 1 3 3 2 2        1.0   2.9E-9                -81          1
 6       1      4.0     50.0      8.0     50.0     16.0     49.0
 6      -7     32.0     48.0     63.0     58.0    125.0     49.0
ALL DONE
```

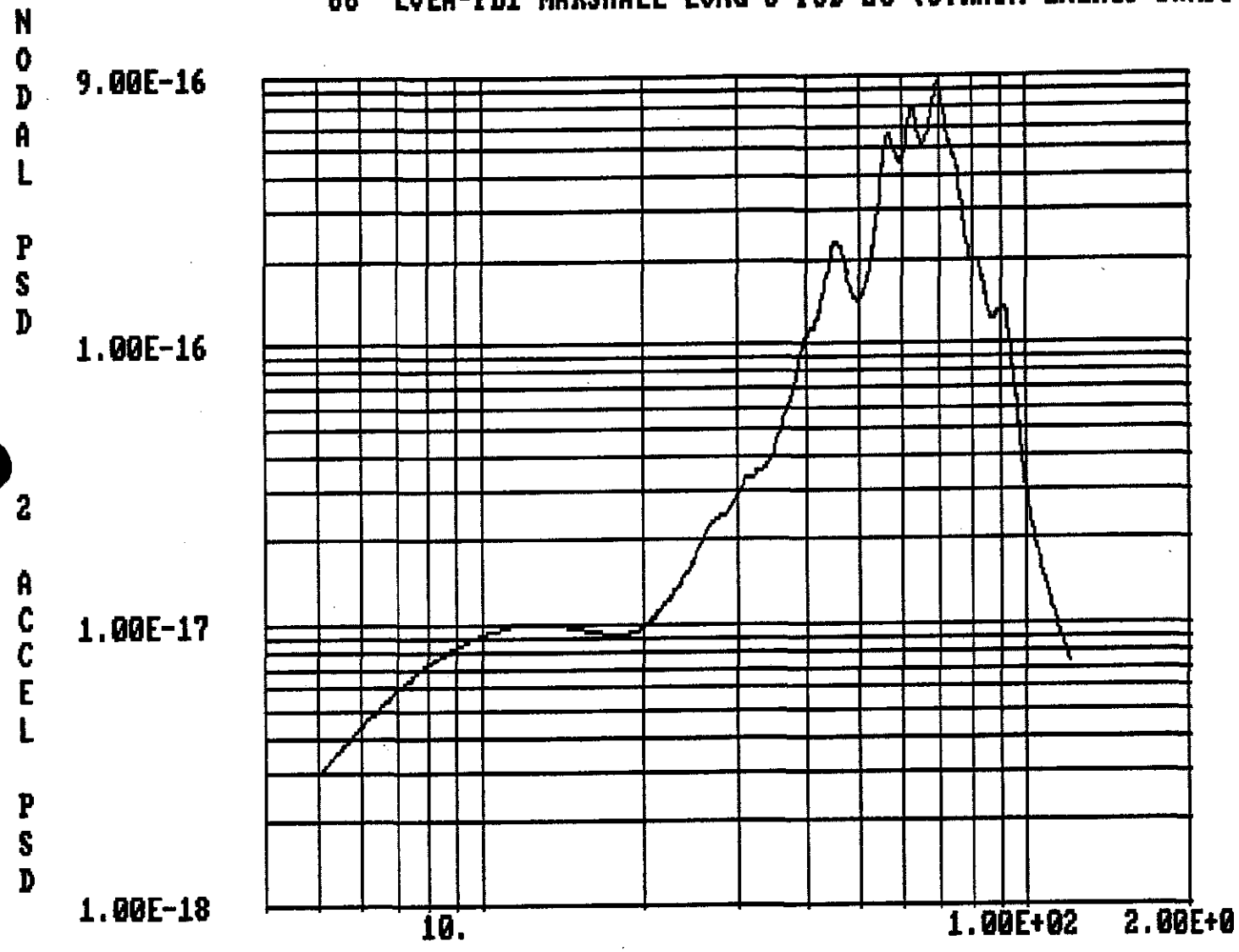
Node 230 X3

68" LVEA-PB1 MARSHALL LONG'S PSD-UC (STRAIN ENERGY DAMPI



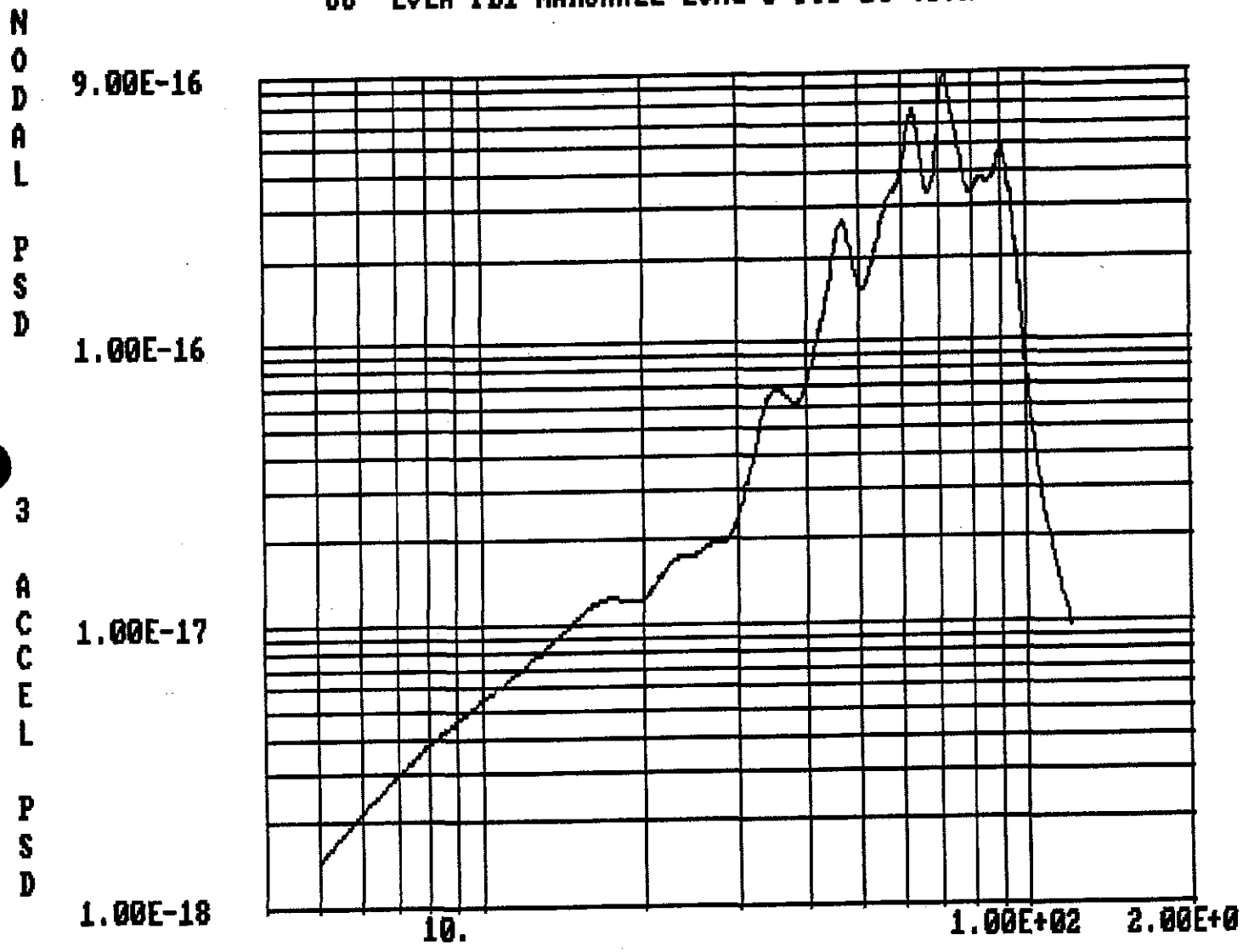
Node 774 X3

68" LVEA-PB1 MARSHALL LONG'S PSD-UC (STRAIN ENERGY DAMPI



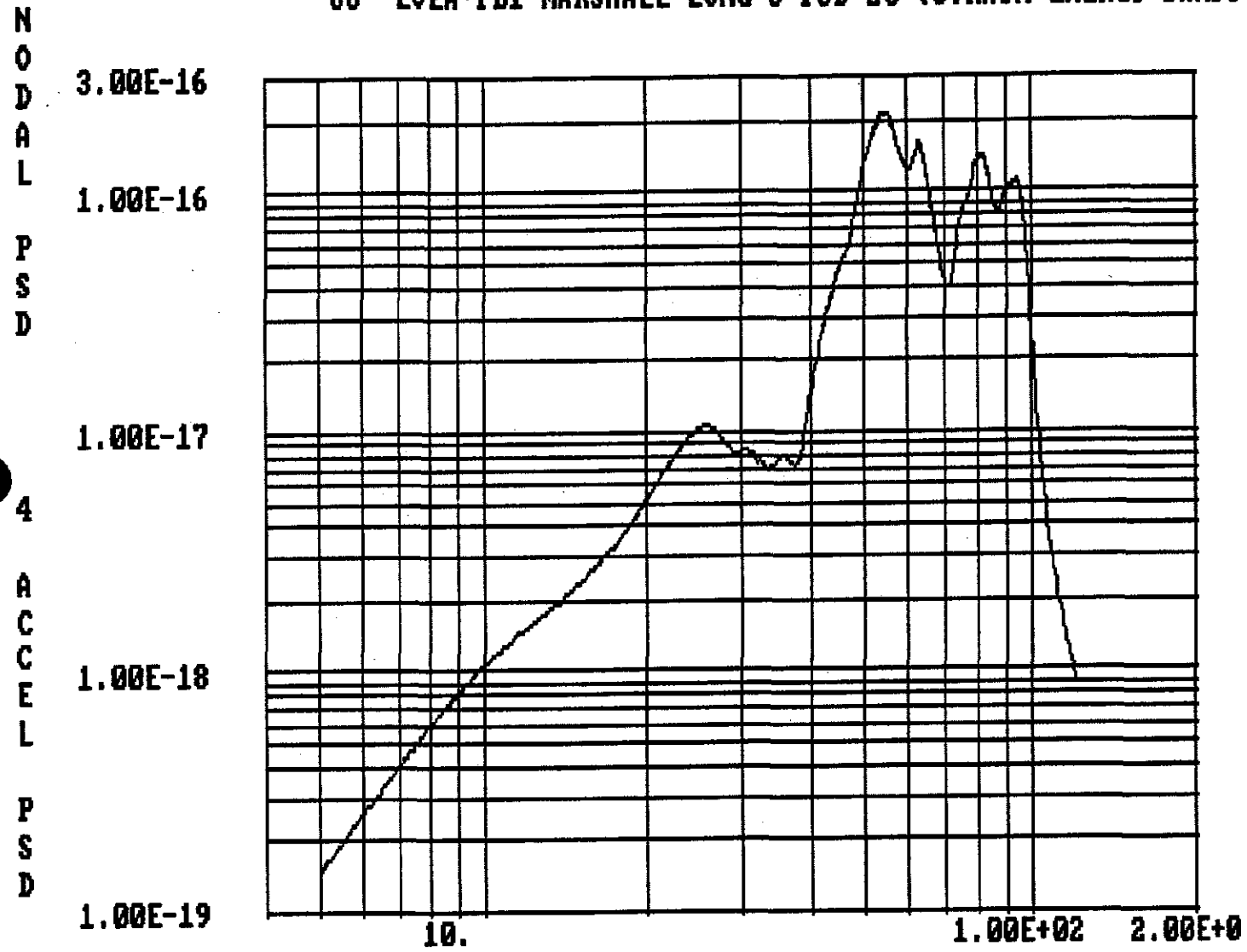
Node 792 X3

68" LVEA-PB1 MARSHALL LONG'S PSD-UC (STRAIN ENERGY DAMPI



Node 1520 X3

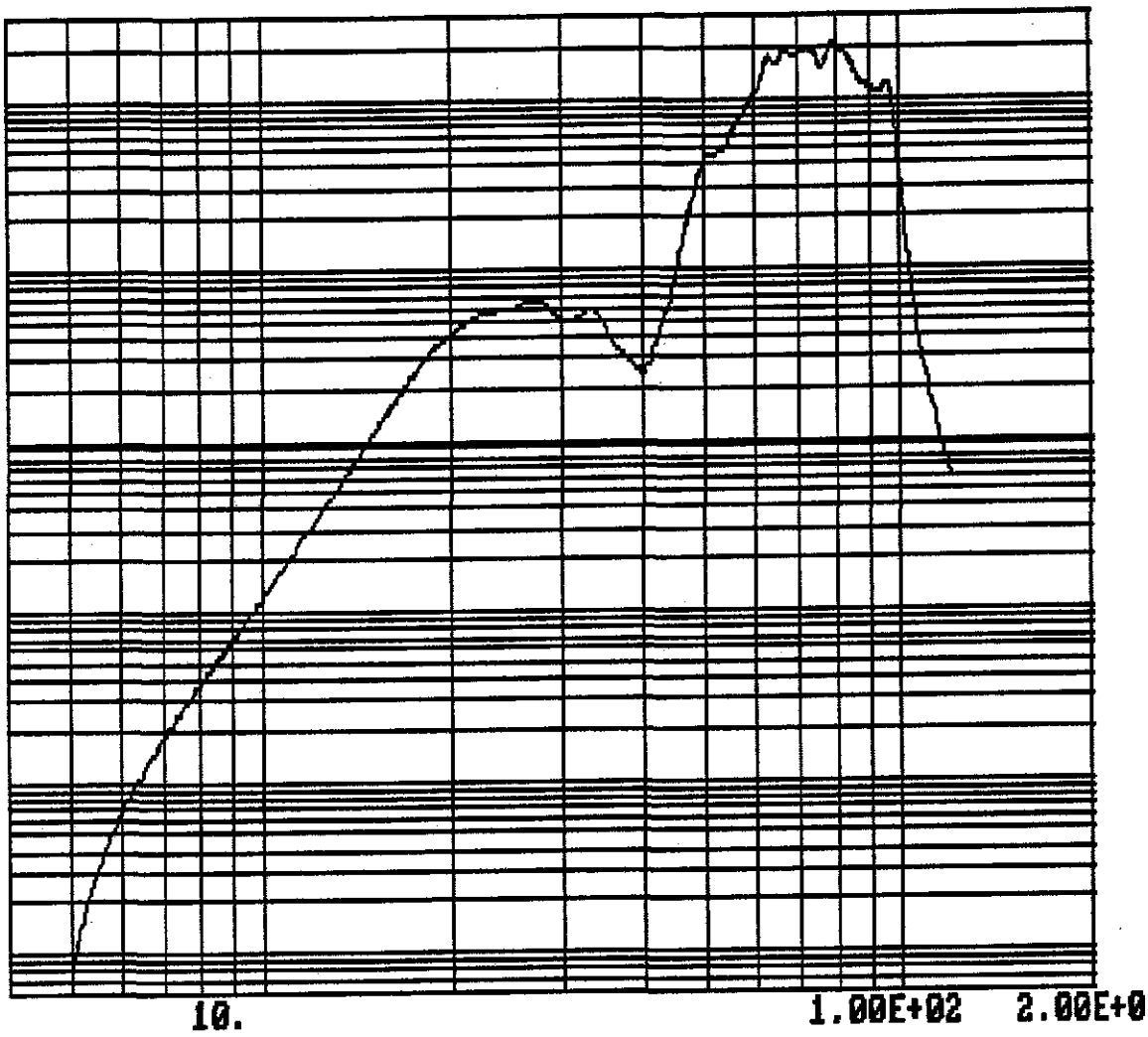
68" LVEA-PB1 MARSHALL LONG'S PSD-UC (STRAIN ENERGY DAMPI



FREQUENCY (HZ) PLOT NO = 4

Node 2183 X3

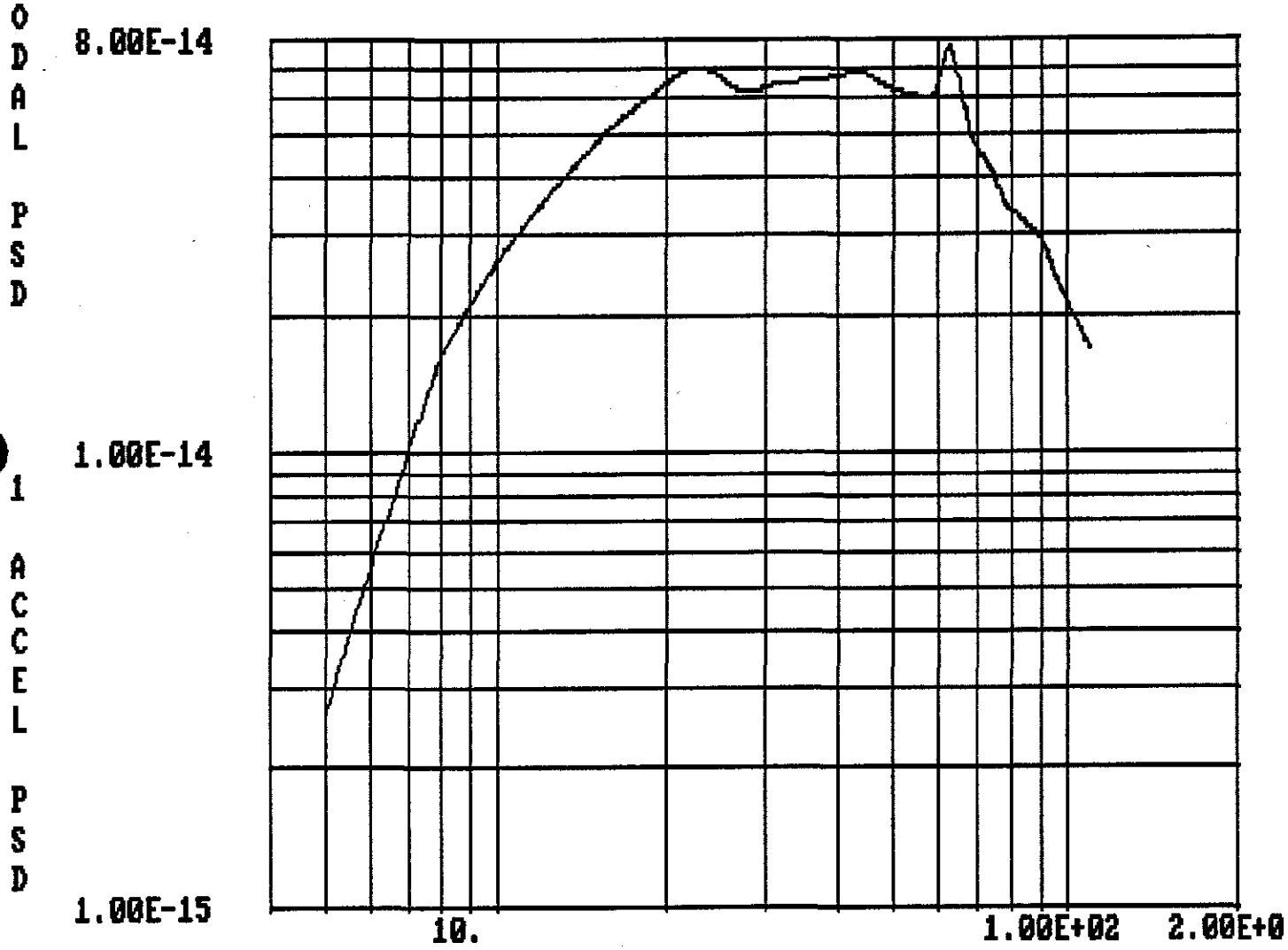
68" LVEA-PB1 MARSHALL LONG'S PSD-UC (STRAIN ENERGY DAMPI



```
 36" LVEAPB1 LIGO'S ACOUSTIC SPECT (STRAIN ENERGY DAMPING)
START3                              3         1        3.0       5.0      110.0
RMS
PRINT
          2  230  230
          2  774  774
          2  792  792
          2 1520 1520
          2 2183 2183
END
MODES
            1       220      99.0
END
PSD         3         1
NODES               230         3       774         3       792         3
NODES              1520         3      2183         3
END
START PSD INPUT     1
 1 3 3 2 1          1.0    2.9E-9                          -81             1
 6          1       4.0      50.0       8.0      57.0      16.0     61.00
 6         -7      31.5      64.0      63.0      66.0     125.0     62.00
ALL DONE
```

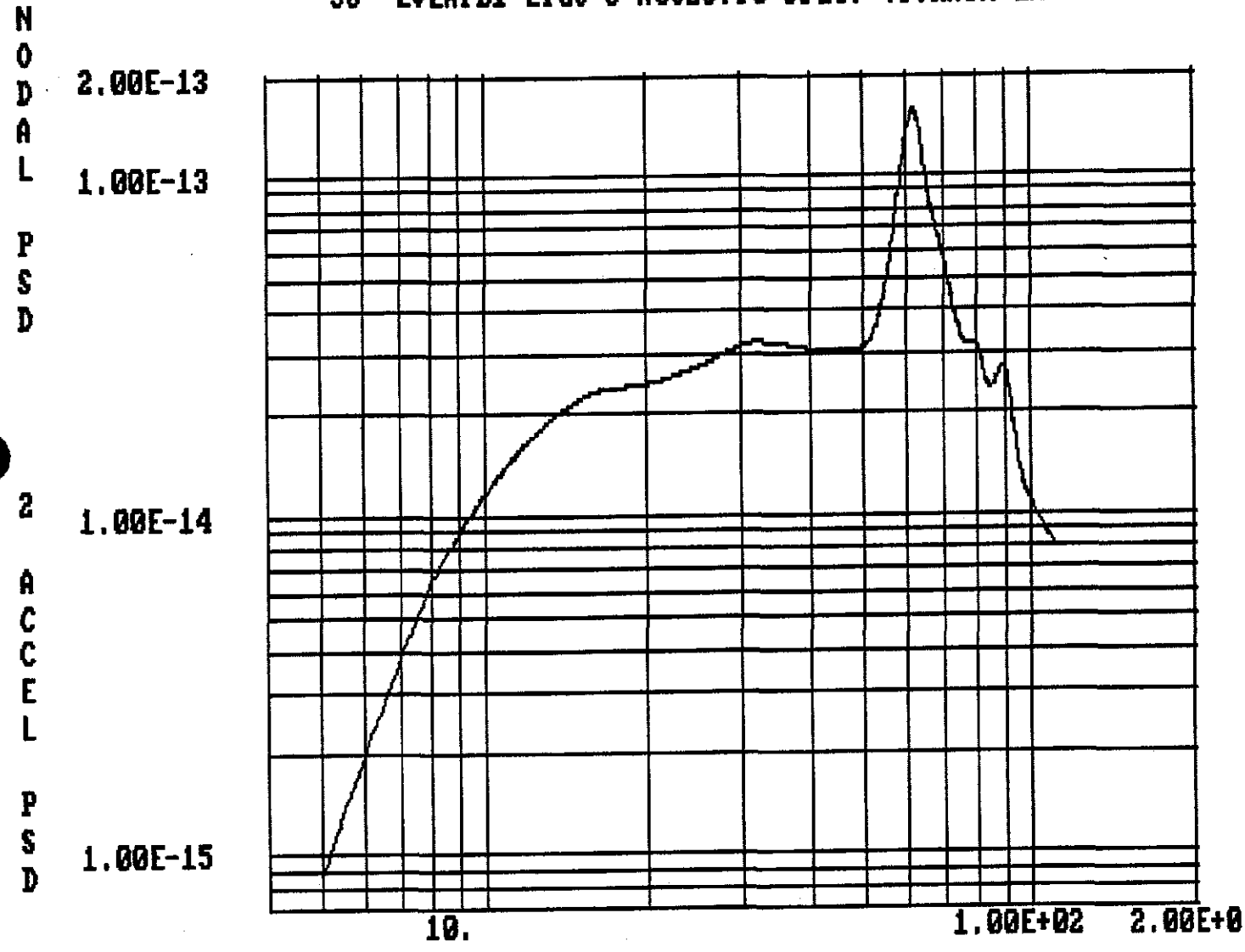
Node 230 X3

36" LVEAPB1 LIGO'S ACOUSTIC SPECT (STRAIN ENERGY DAMPING



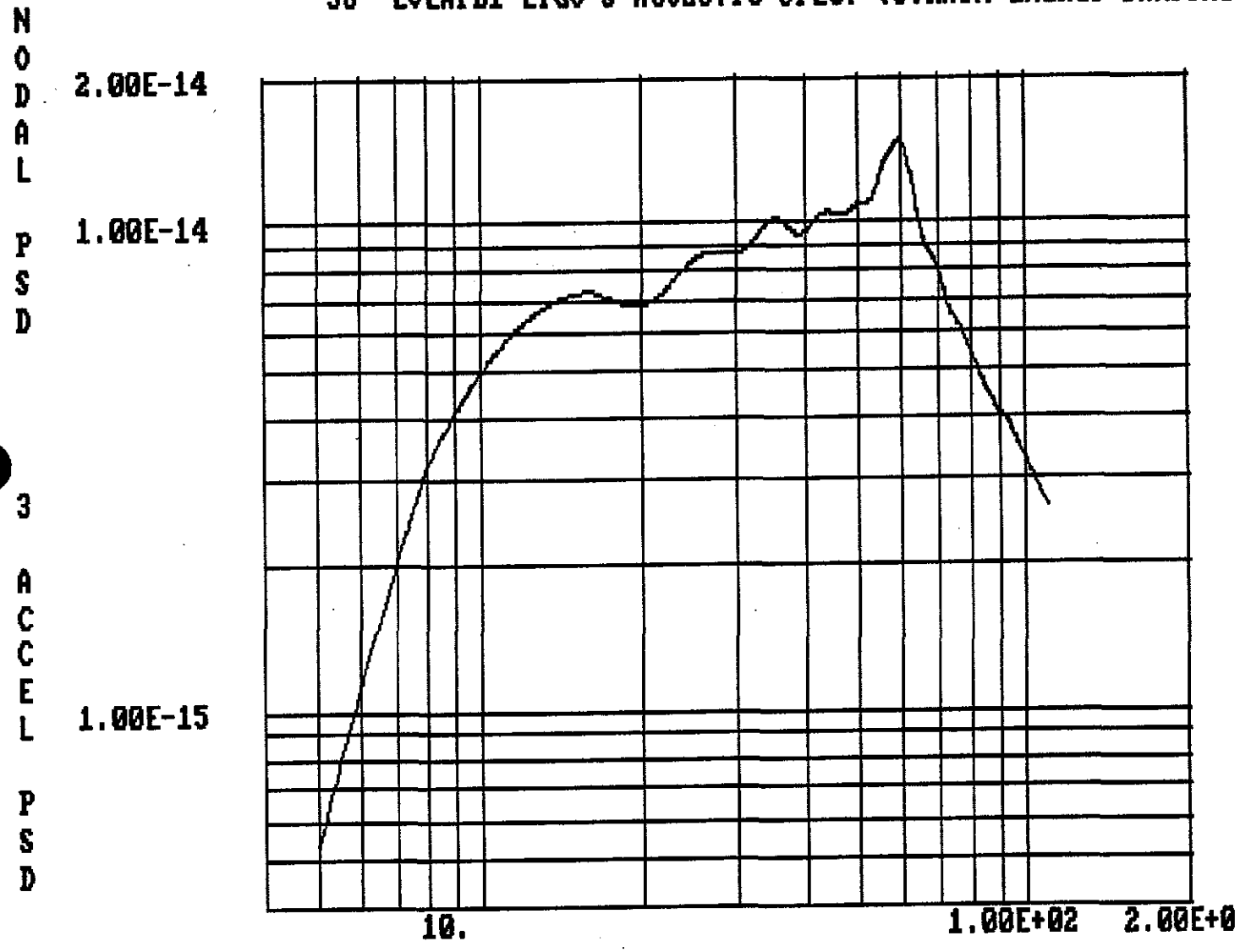
Node 774 X3

36" LVEAPB1 LIGO'S ACOUSTIC SPECT (STRAIN ENERGY DAMPING



Node 792 X3

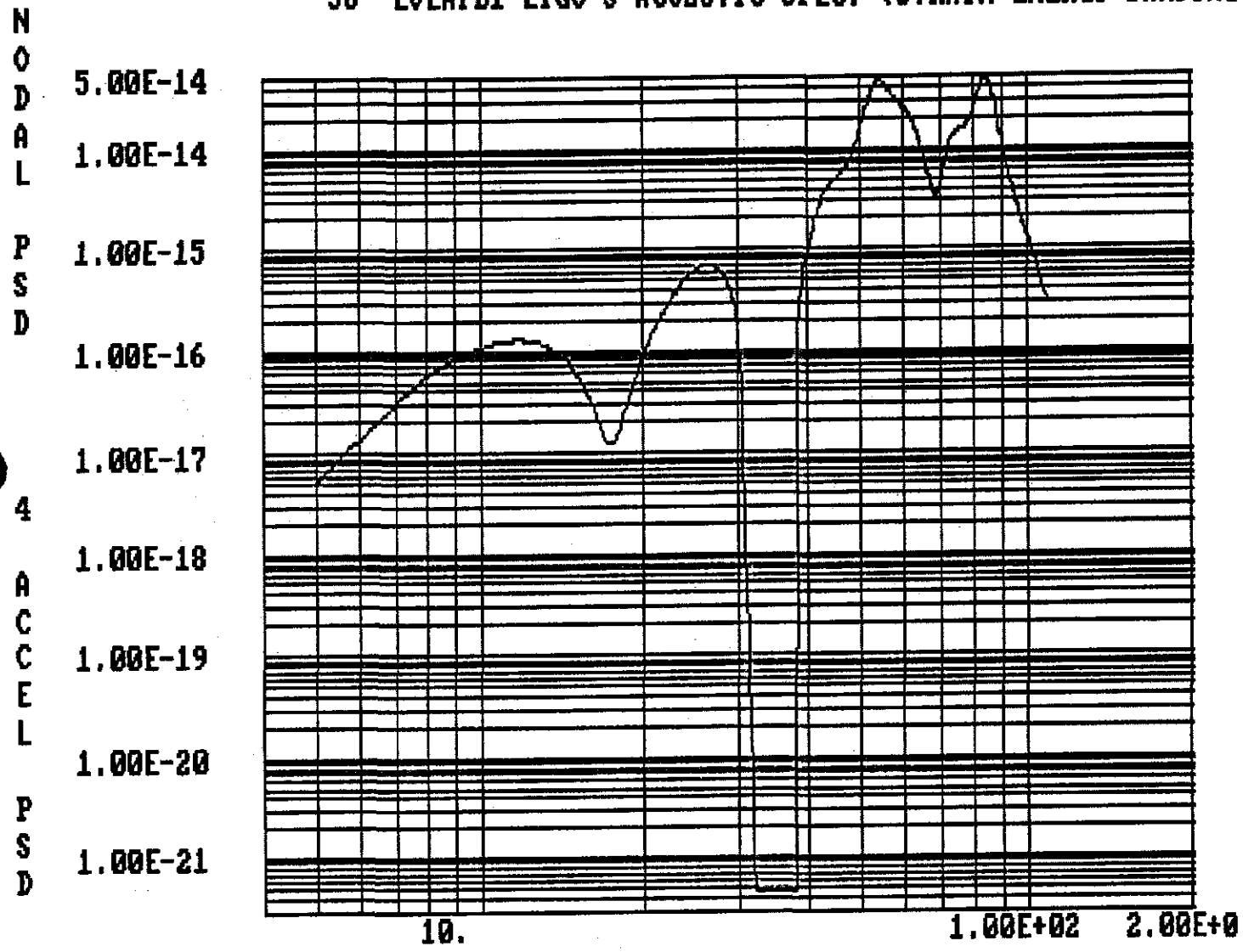
36" LVEAPB1 LIGO'S ACOUSTIC SPECT (STRAIN ENERGY DAMPING



FREQUENCY (HZ) PLOT NO = 3

Node 1520 X3

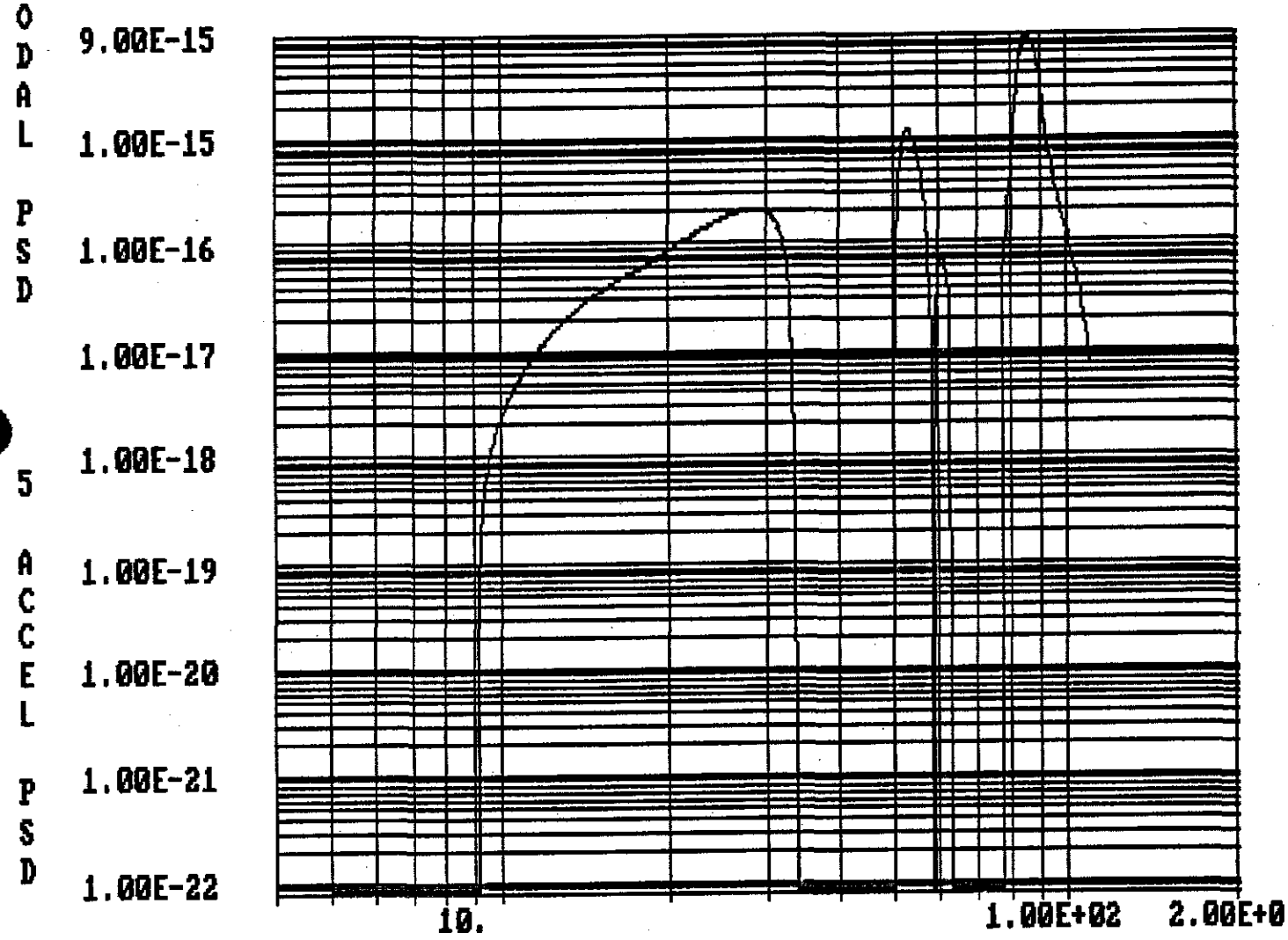
36" LVEAPB1 LIGO'S ACOUSTIC SPECT (STRAIN ENERGY DAMPING



FREQUENCY (HZ) PLOT NO = 4

Node 2183 X3

36" LVEAPB1 LIGO'S ACOUSTIC SPECT (STRAIN ENERGY DAMPING

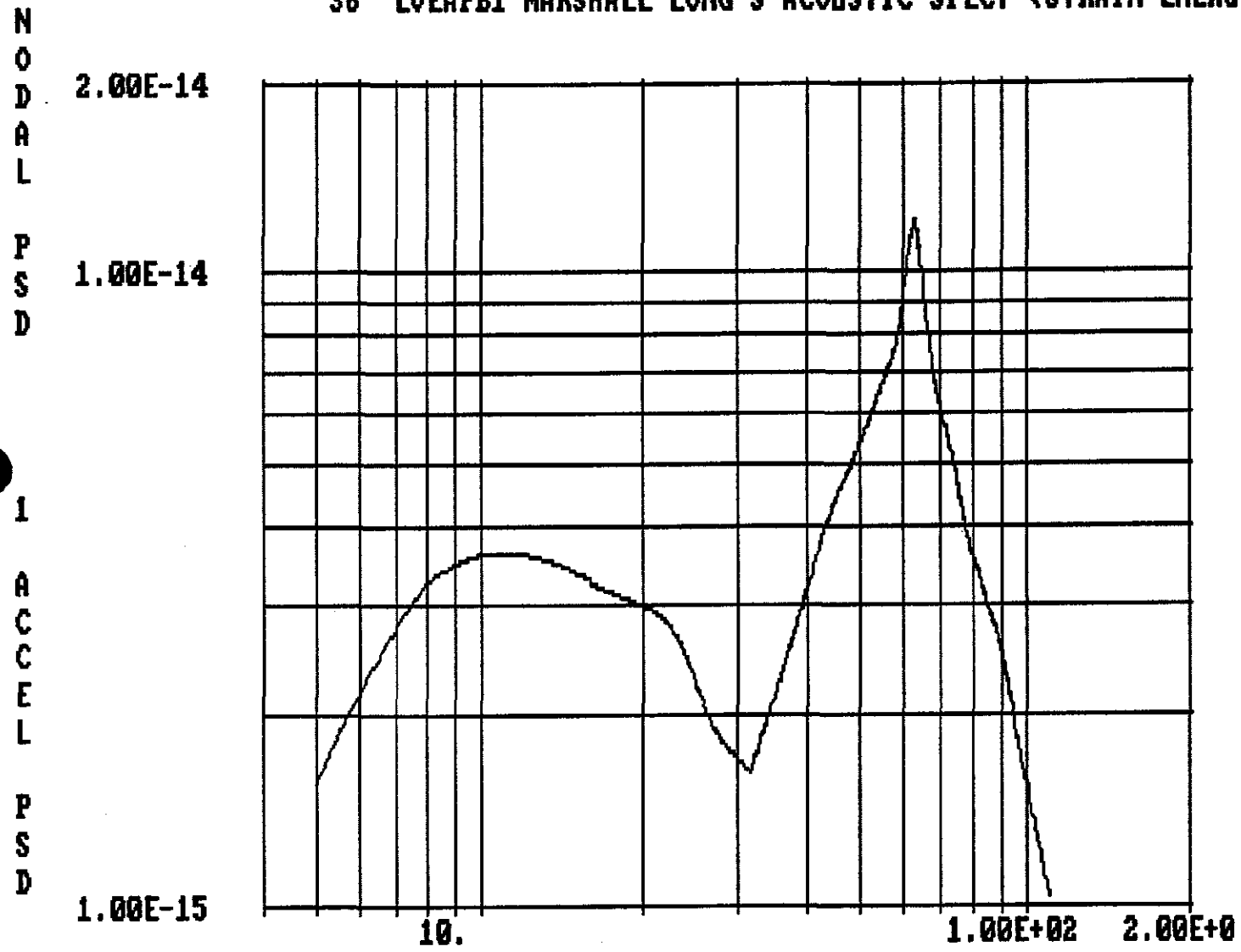


FREQUENCY (HZ) PLOT NO = 5

```
 36" LVEAPB1 MARSHALL LONG'S ACOUSTIC SPECT (STRAIN ENERGY DAMPING)
START3                              3         1       3.0       5.0      110.0
RMS
PRINT
          2  230  230
          2  774  774
          2  792  792
          2 1520 1520
          2 2183 2183
END
MODES
            1       220      99.0
END
PSD         3         1
NODES                 230         3       774         3       792         3
NODES                1520         3      2183         3
END
START PSD INPUT       1
 1 3 3 2 1            1.0    2.9E-9                          -81           1
 6          1         4.0      50.0       8.0      50.0      16.0      49.00
 6         -7        31.5      48.0      63.0      58.0     125.0      49.00
ALL DONE
```

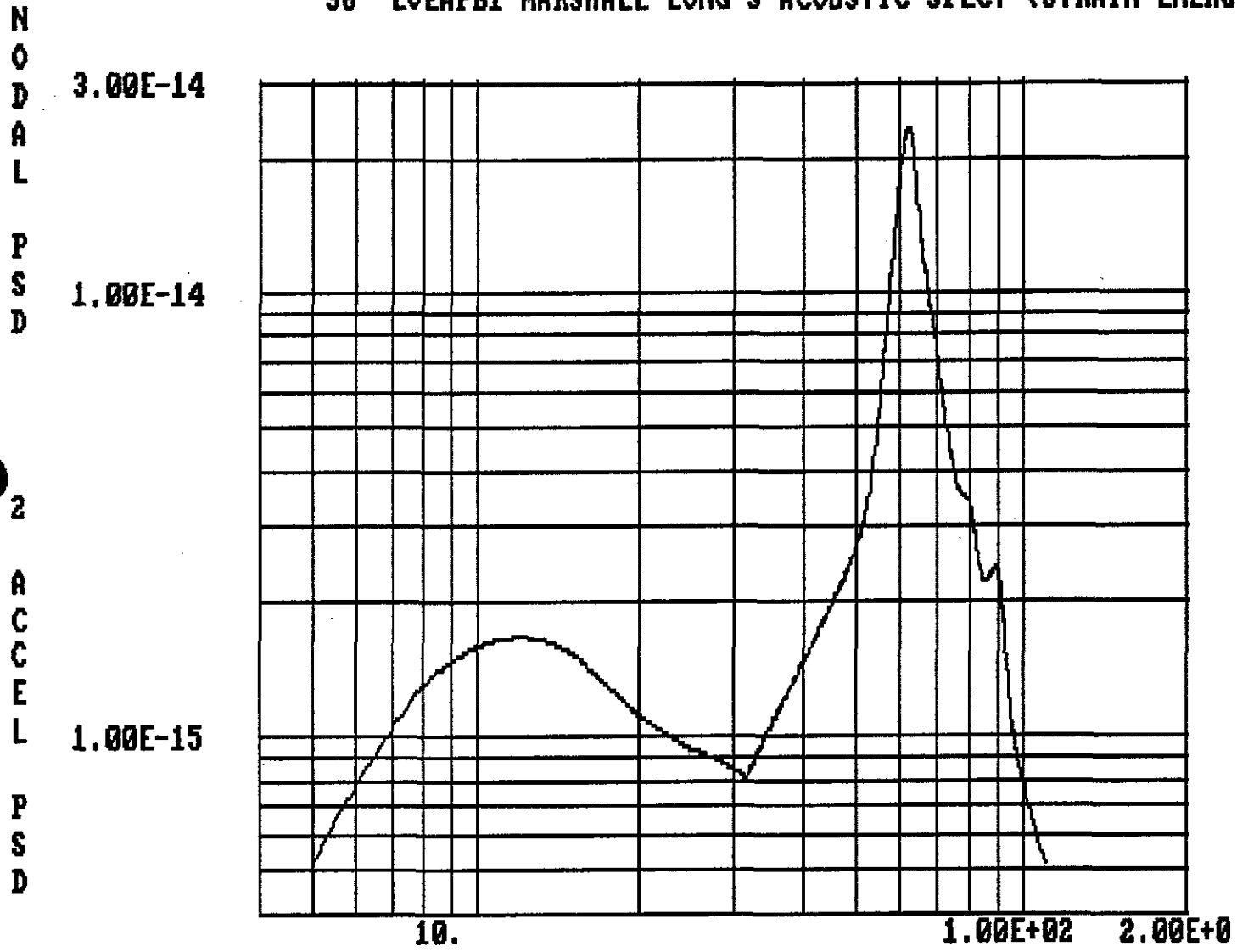
Node 230 X3

36" LVEAPB1 MARSHALL LONG'S ACOUSTIC SPECT (STRAIN ENERG



Node 774 X3

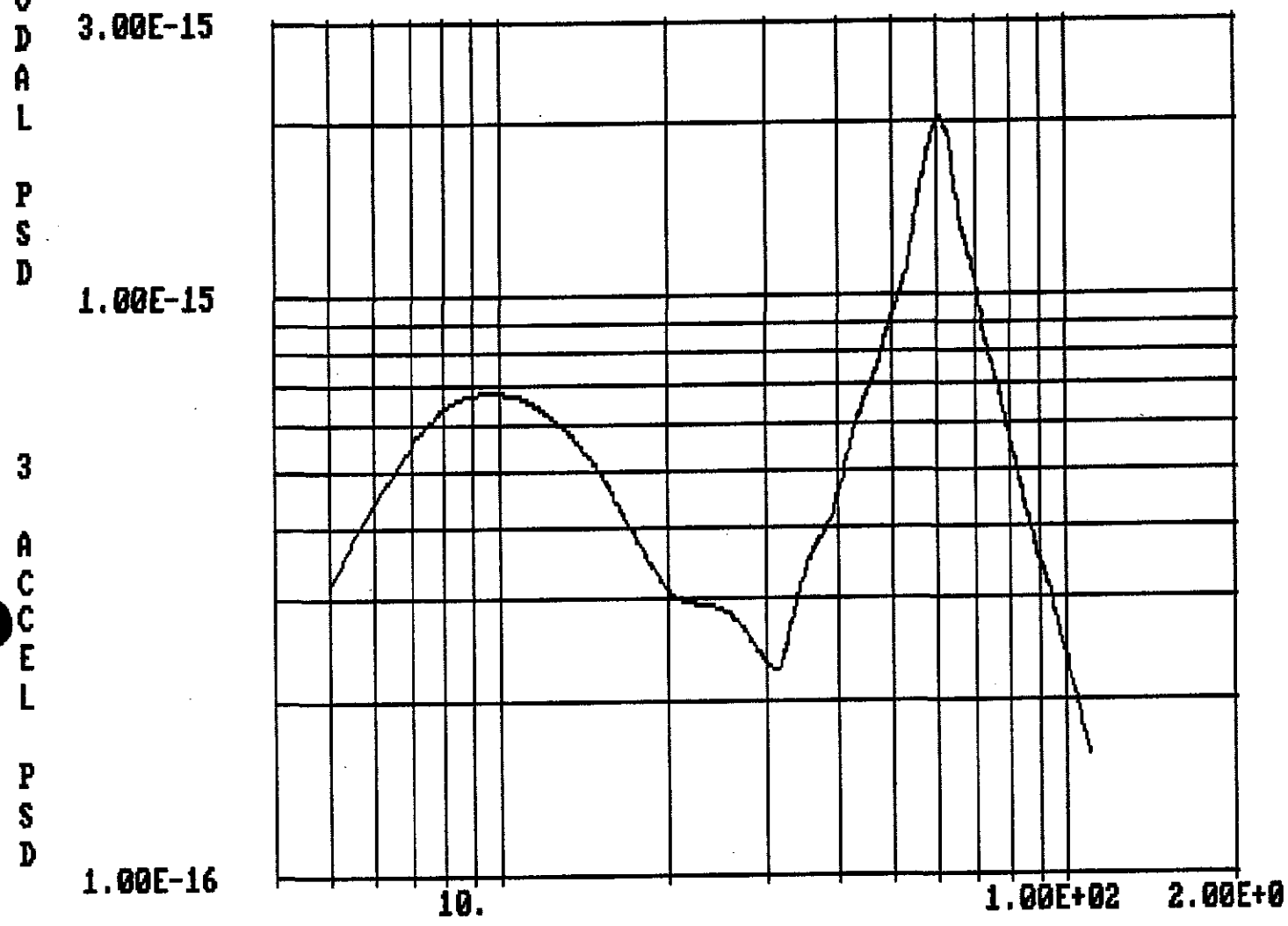
36" LVEAPB1 MARSHALL LONG'S ACOUSTIC SPECT (STRAIN ENERG



FREQUENCY (HZ) PLOT NO = 2

Node 792 X3

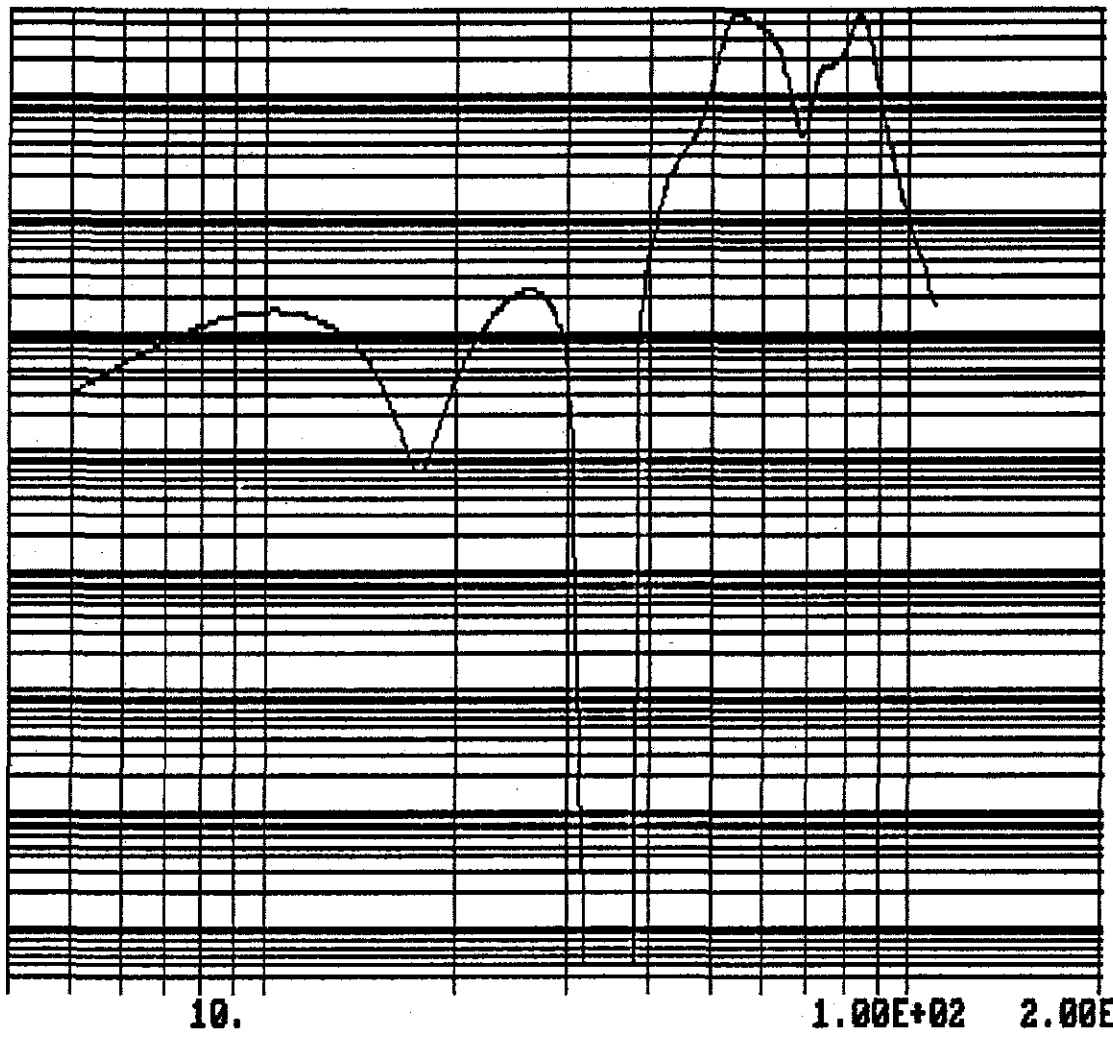
36" LVEAPB1 MARSHALL LONG'S ACOUSTIC SPECT (STRAIN ENERG



FREQUENCY (HZ) PLOT NO = 3

Node 1520 X3

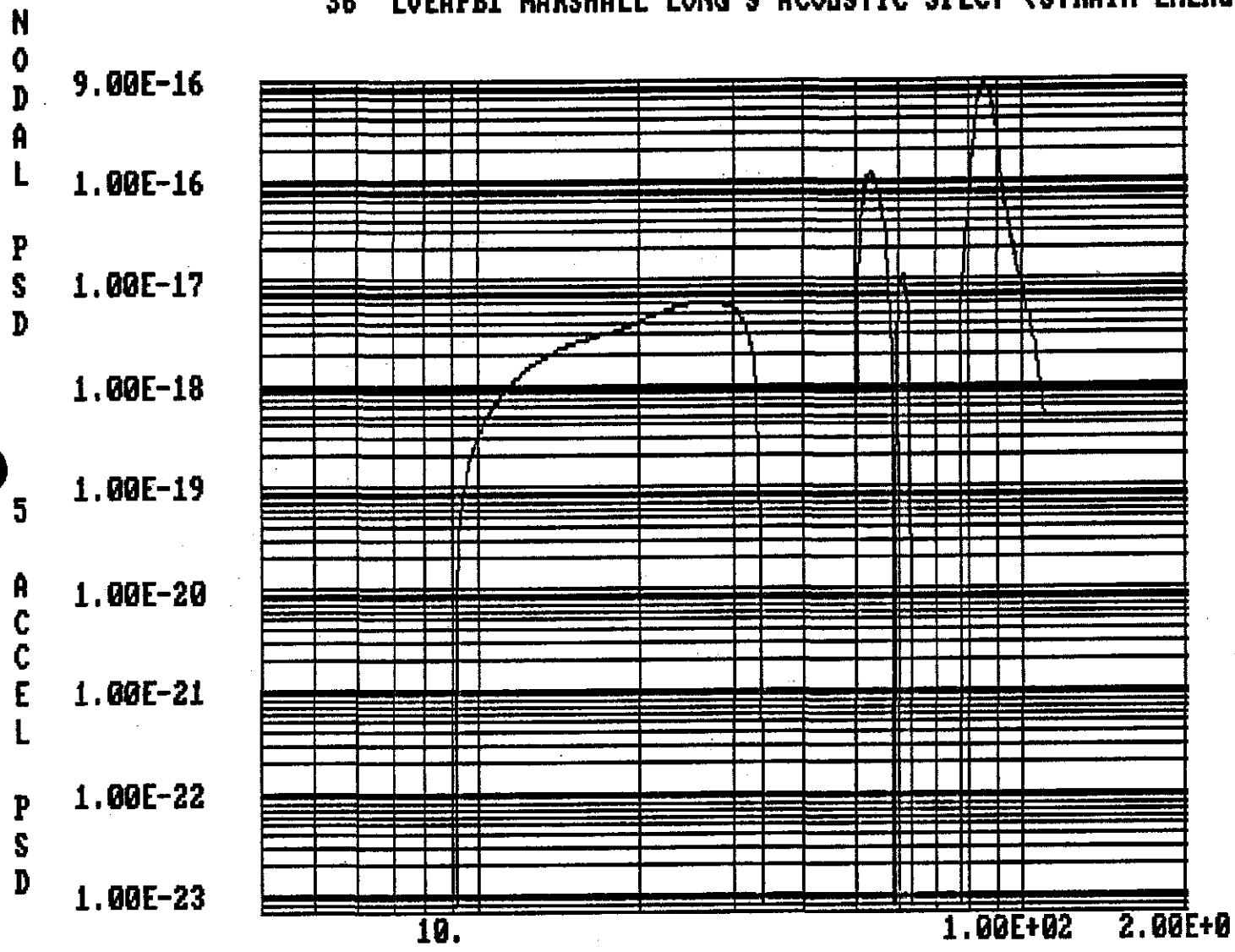
36" LVEAPB1 MARSHALL LONG'S ACOUSTIC SPECT (STRAIN ENERG



FREQUENCY (HZ) PLOT NO = 4

Node 2183 X3

36" LVEAPB1 MARSHALL LONG'S ACOUSTIC SPECT (STRAIN ENERG

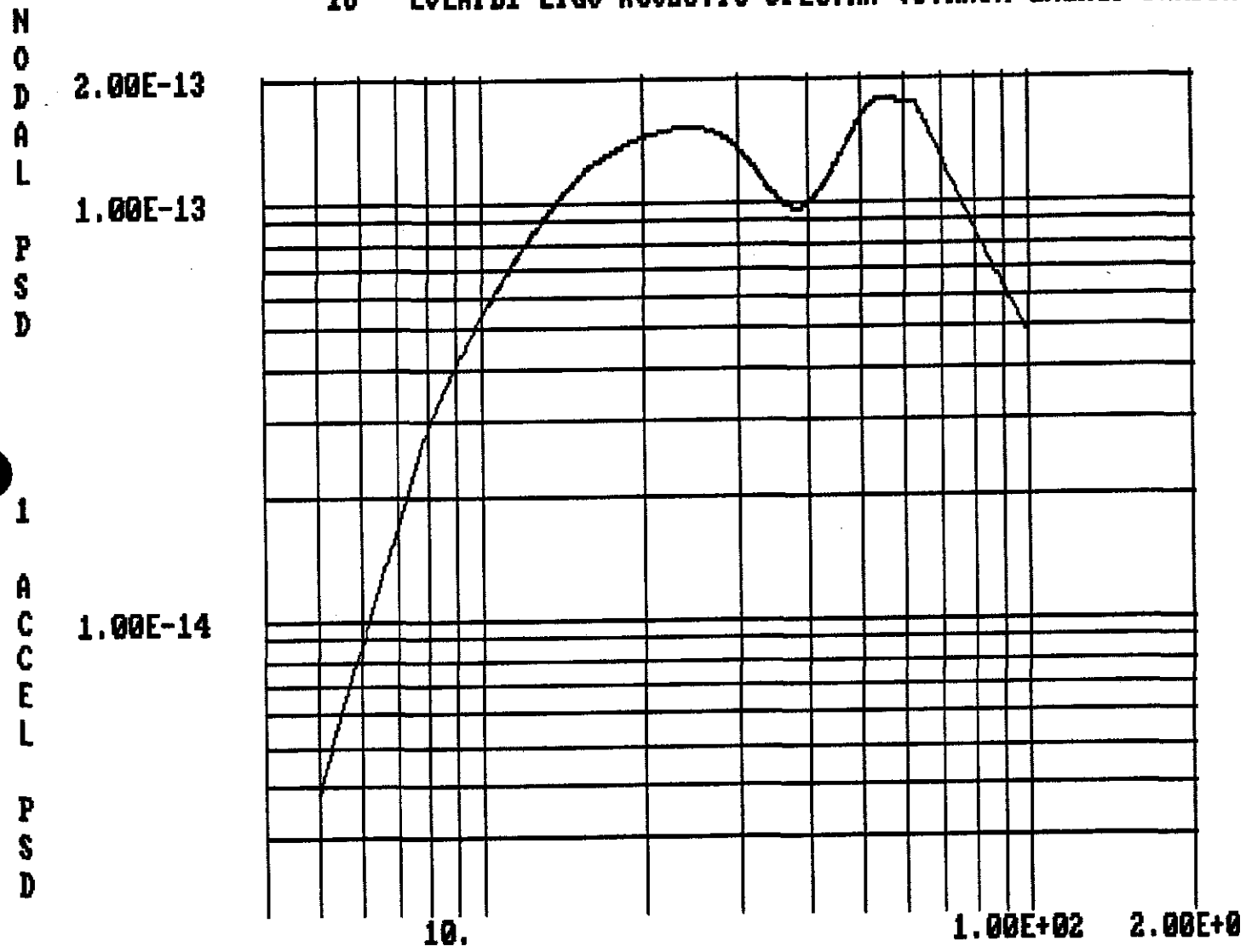


FREQUENCY (HZ) PLOT NO = 5

```
p
 18"  LVEAPB1 LIGO ACOUSTIC SPECTRA (STRAIN ENERGY DAMPING)
START3                              3         1       3.0       5.0     100.0
RMS
PRINT
          2  230  230
          2  774  774
          2  792  792
          2 1520 1520
          2 2183 2183
END
MODES
            1       250      99.0
END
PSD         3         1
NODES                 230         3       774         3       792         3
NODES                1520         3      2183         3
END
START PSD INPUT      1
 1 3 3 2 1           1.0    2.9E-9                          -81             1
 6          1        4.0      50.0       8.0      57.0      16.0     61.00
 6         -7       31.5      64.0      63.0      66.0     125.0     62.00
ALL DONE
```

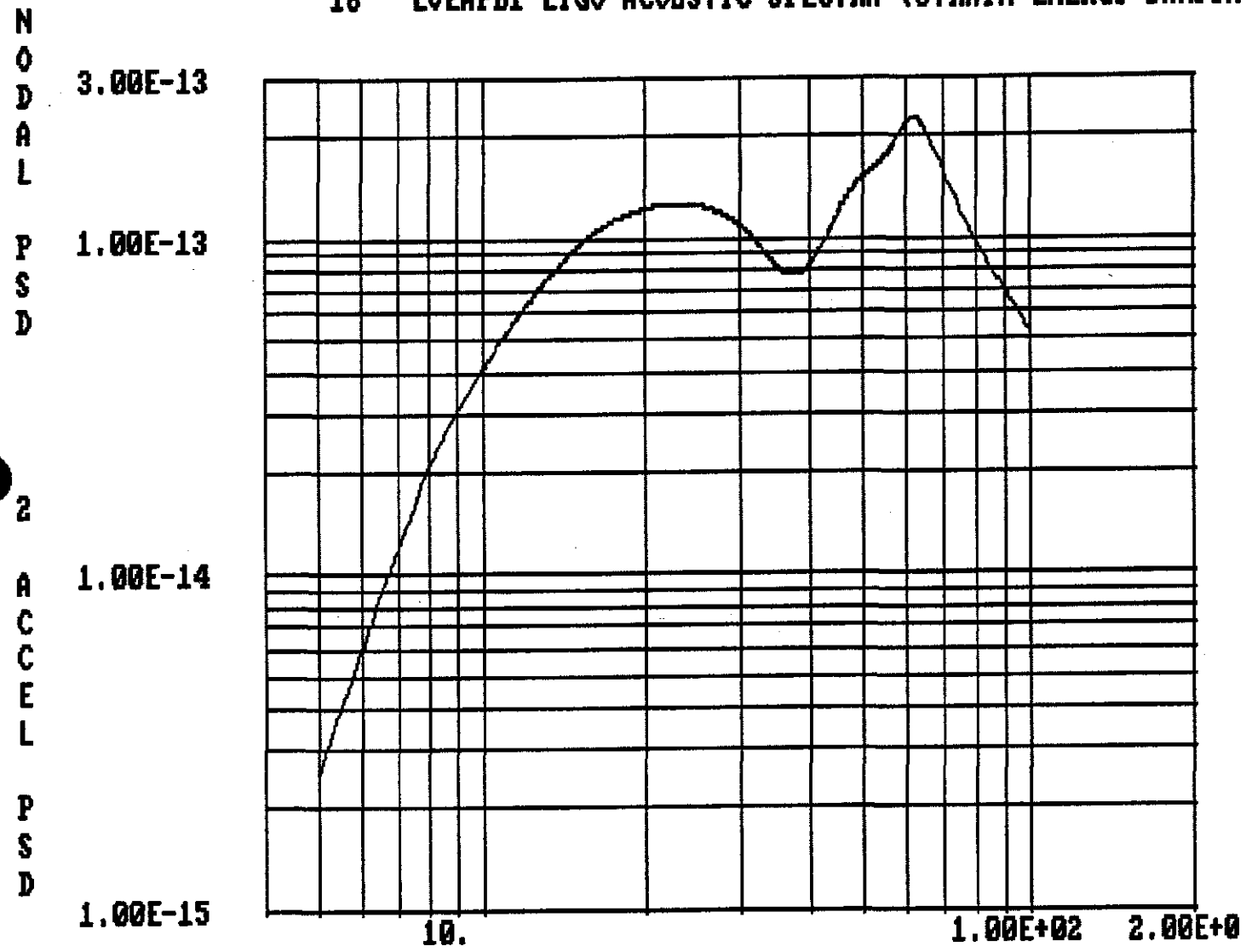
Node 230 X3

18" LVEAPB1 LIGO ACOUSTIC SPECTRA (STRAIN ENERGY DAMPIN



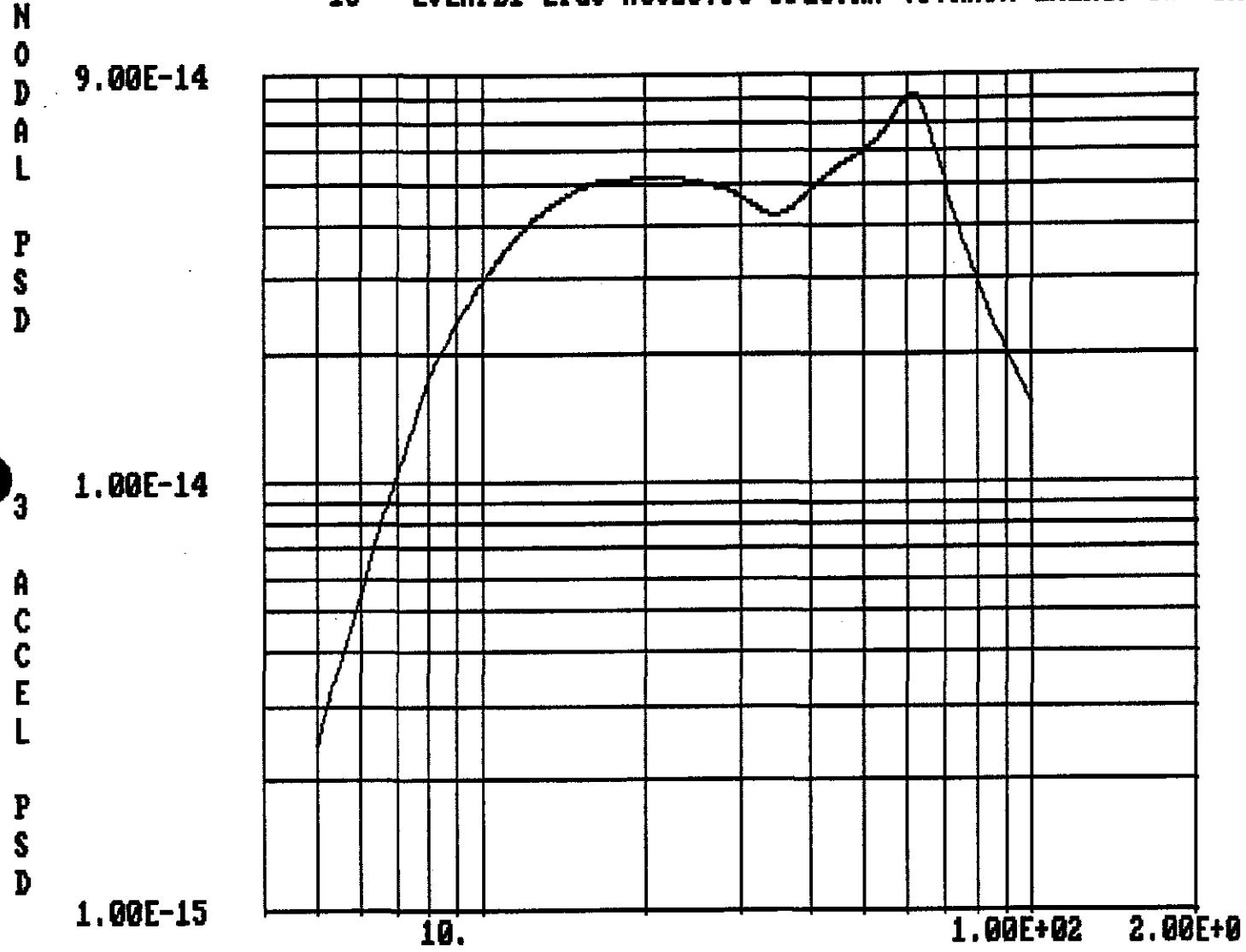
Node 774 X3

18" LVEAPB1 LIGO ACOUSTIC SPECTRA (STRAIN ENERGY DAMPIN



Node 792 X3

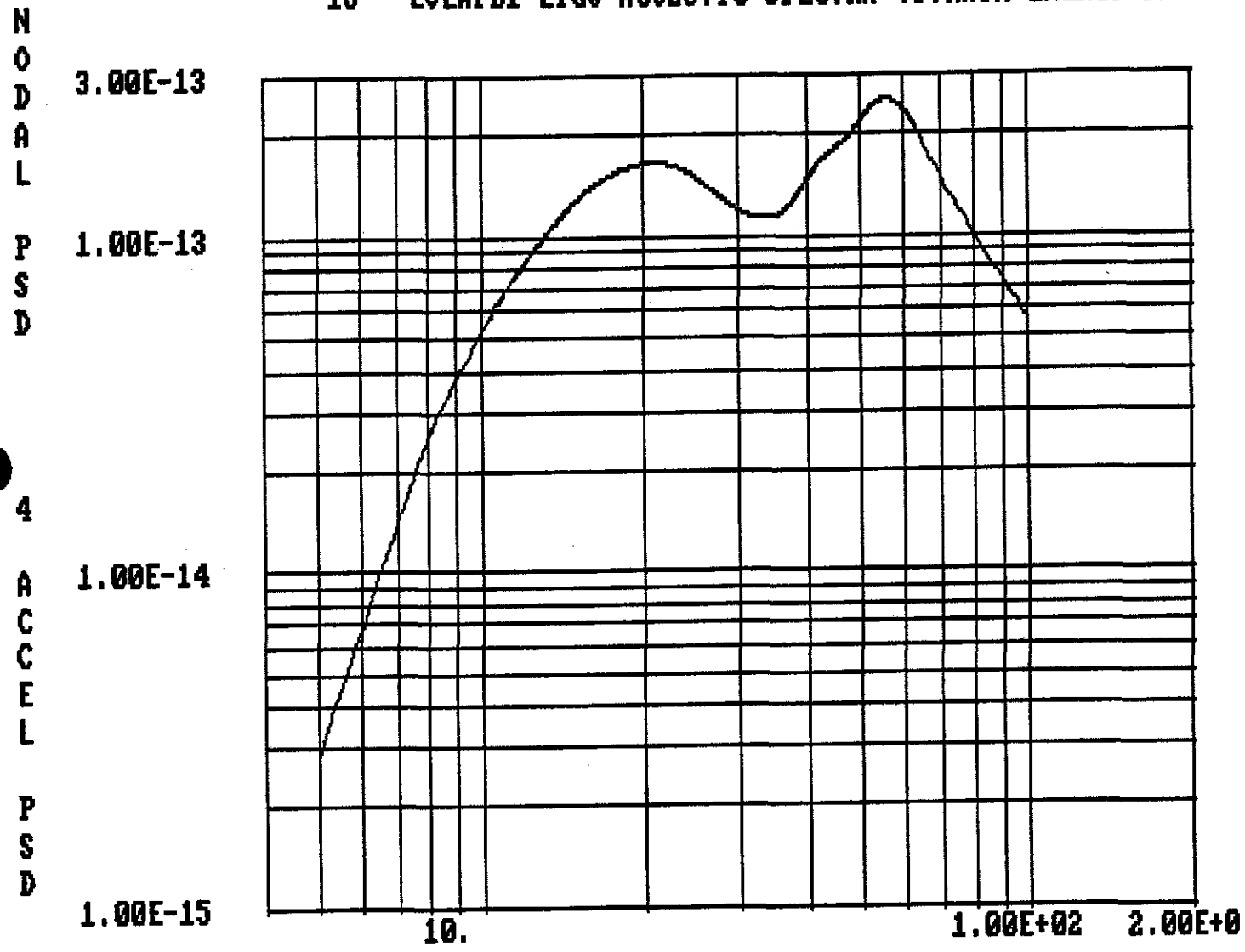
18" LVEAPB1 LIGO ACOUSTIC SPECTRA (STRAIN ENERGY DAMPIN



FREQUENCY (HZ) PLOT NO = 3

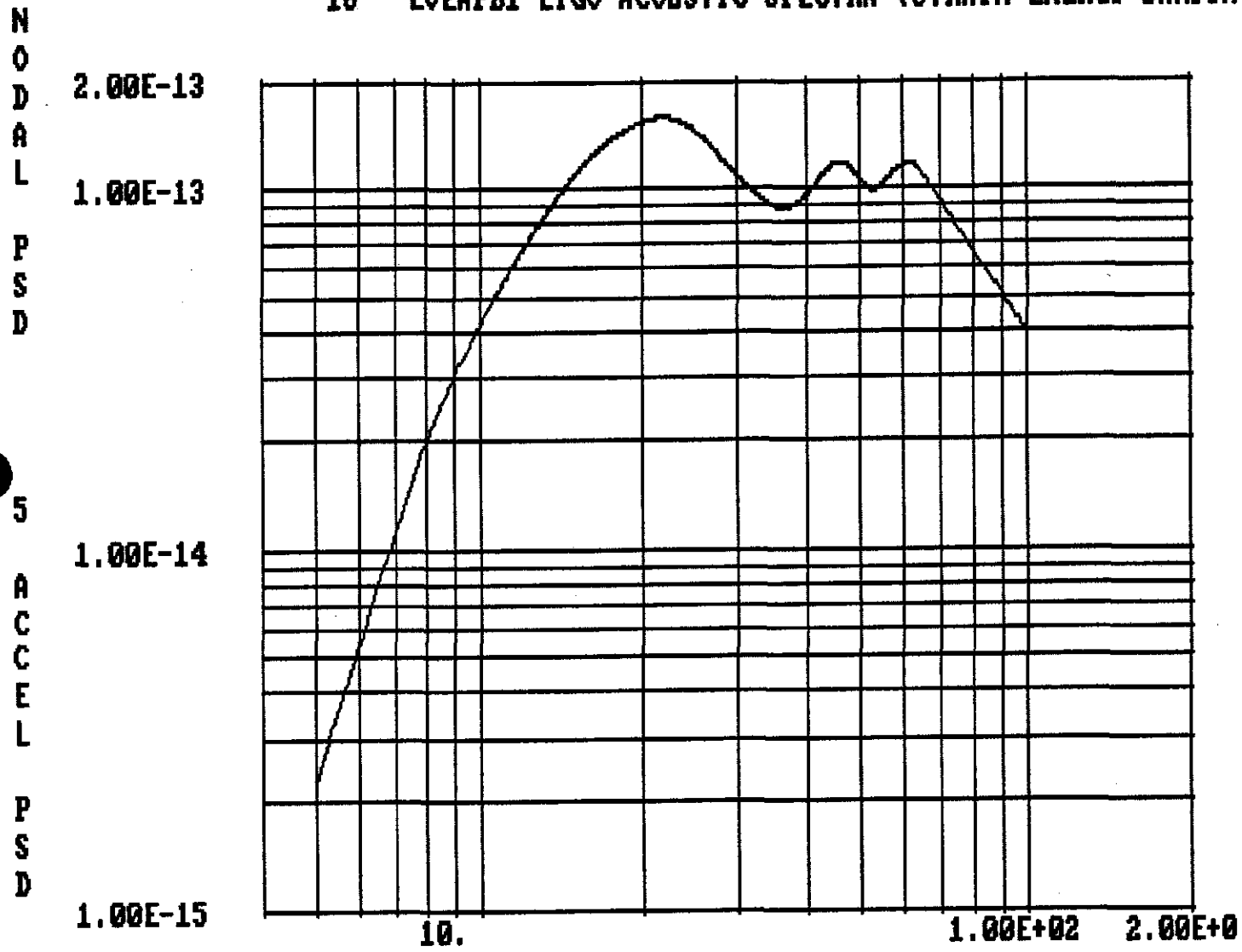
Node 1520 X3

18" LVEAPB1 LIGO ACOUSTIC SPECTRA (STRAIN ENERGY DAMPIN



Node 2183 X3

18" LVEAPB1 LIGO ACOUSTIC SPECTRA (STRAIN ENERGY DAMPIN

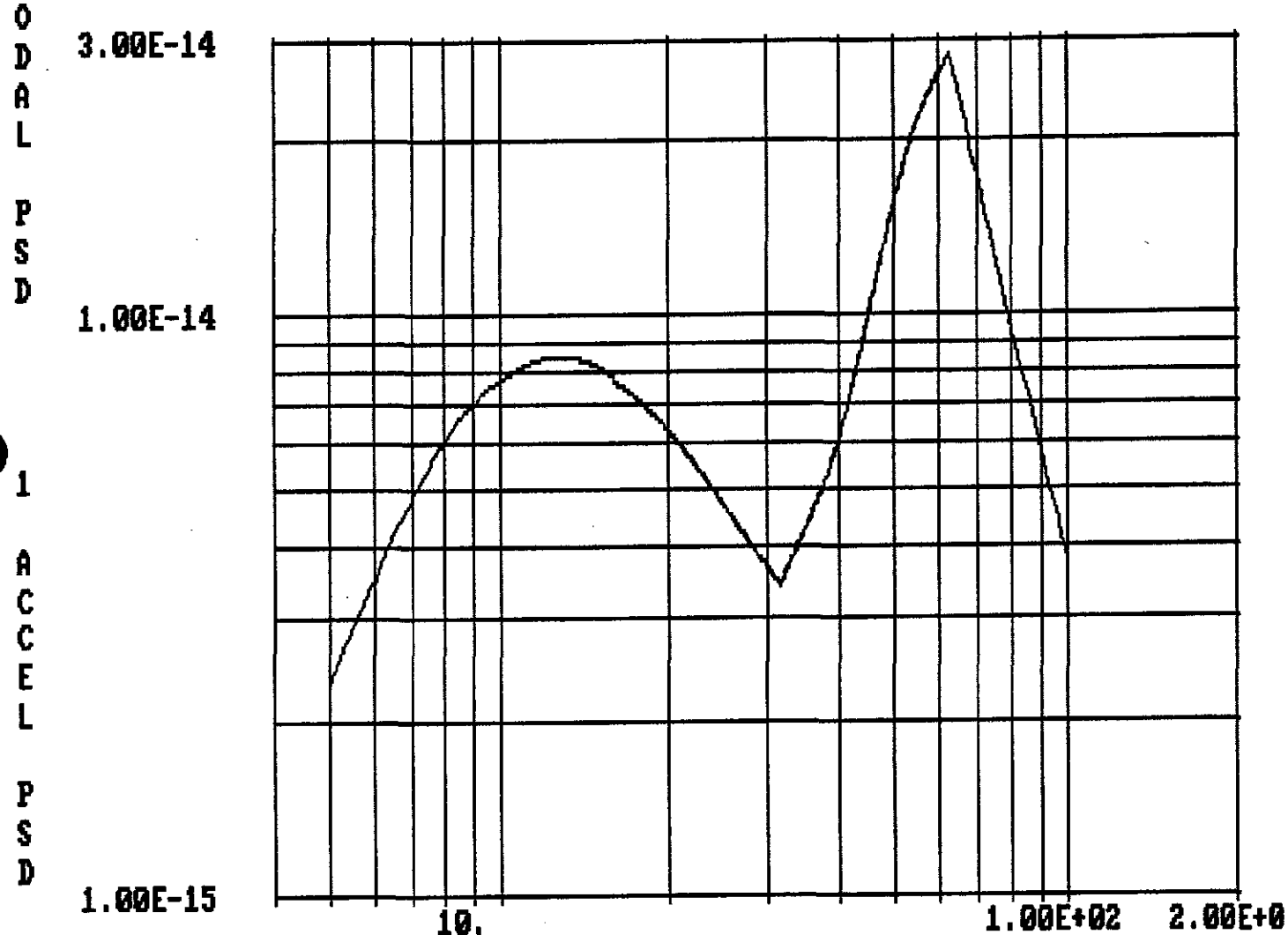


FREQUENCY (HZ) PLOT NO = 5

```
 18"  LVEAPB1 MARSHALL LONG'S ACOUSTIC SPECTRA (STRAIN ENERGY DAMPING)
START3                              3         1       3.0       5.0     100.0
RMS
PRINT
          2  230  230
          2  774  774
          2  792  792
          2 1520 1520
          2 2183 2183
END
MODES
             1       250      99.0
END
PSD          3         1
NODES                230         3       774         3       792         3
NODES               1520         3      2183         3
END
START PSD INPUT     1
 1 3 3 2 1          1.0    2.9E-9                          -81             1
 6          1       4.0      50.0       8.0      50.0      16.0     49.00
 6         -7      31.5      48.0      63.0      58.0     125.0     49.00
ALL DONE
```

Node 230 X3

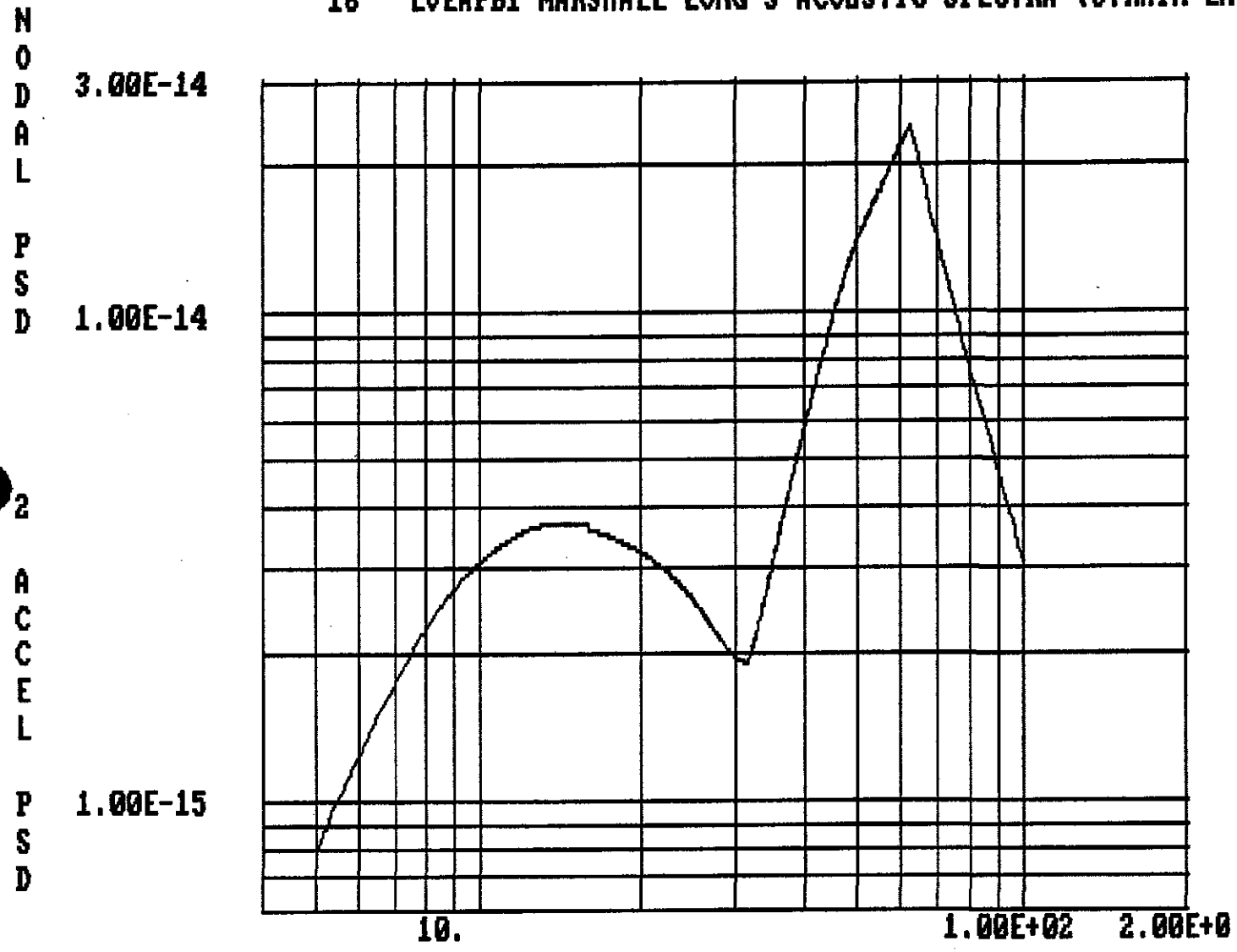
18" LVEAPB1 MARSHALL LONG'S ACOUSTIC SPECTRA (STRAIN EN



FREQUENCY (HZ) PLOT NO = 1

Node 774 X3

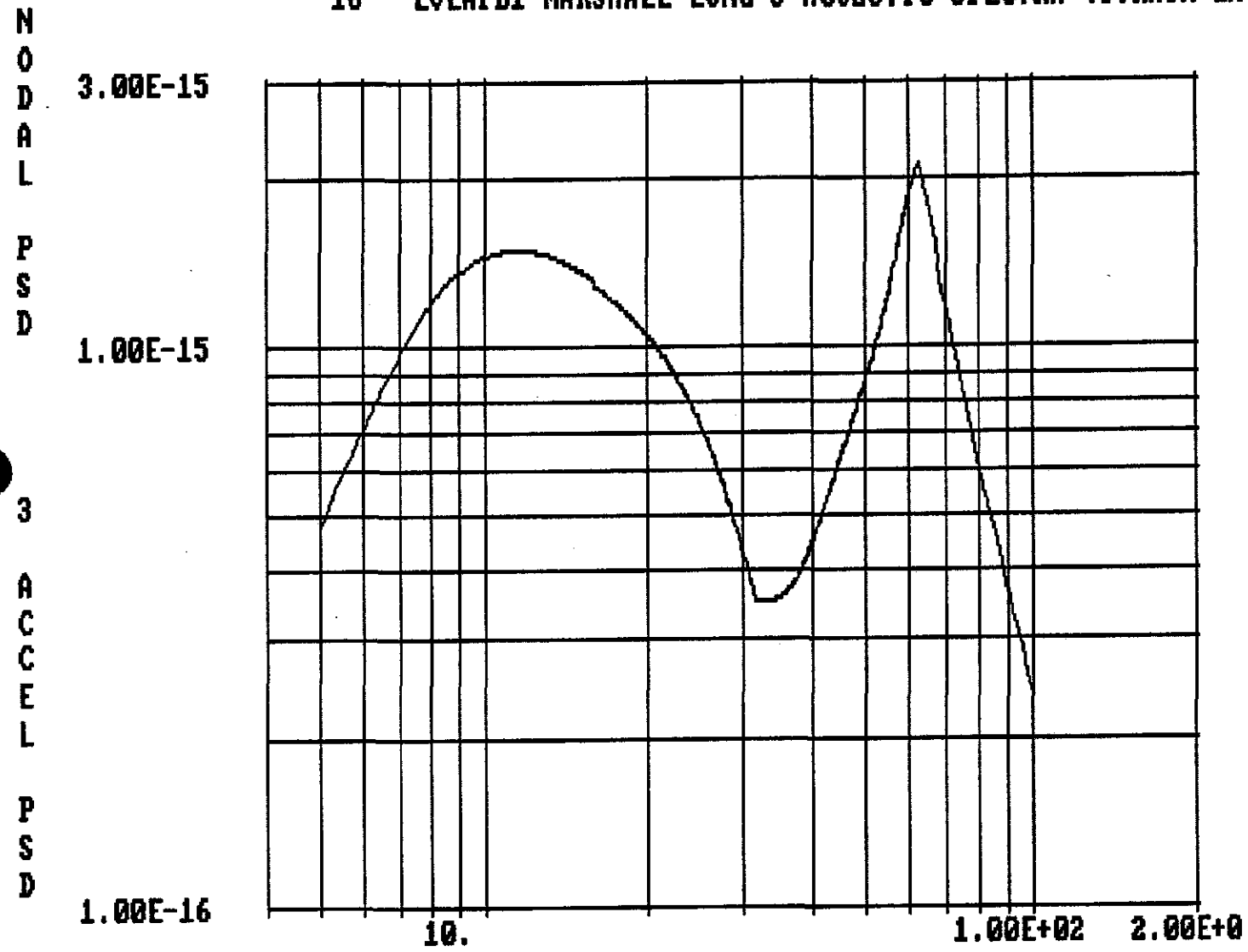
18" LVEAPB1 MARSHALL LONG'S ACOUSTIC SPECTRA (STRAIN EN



FREQUENCY (HZ) PLOT NO = 2

Node 792 X3

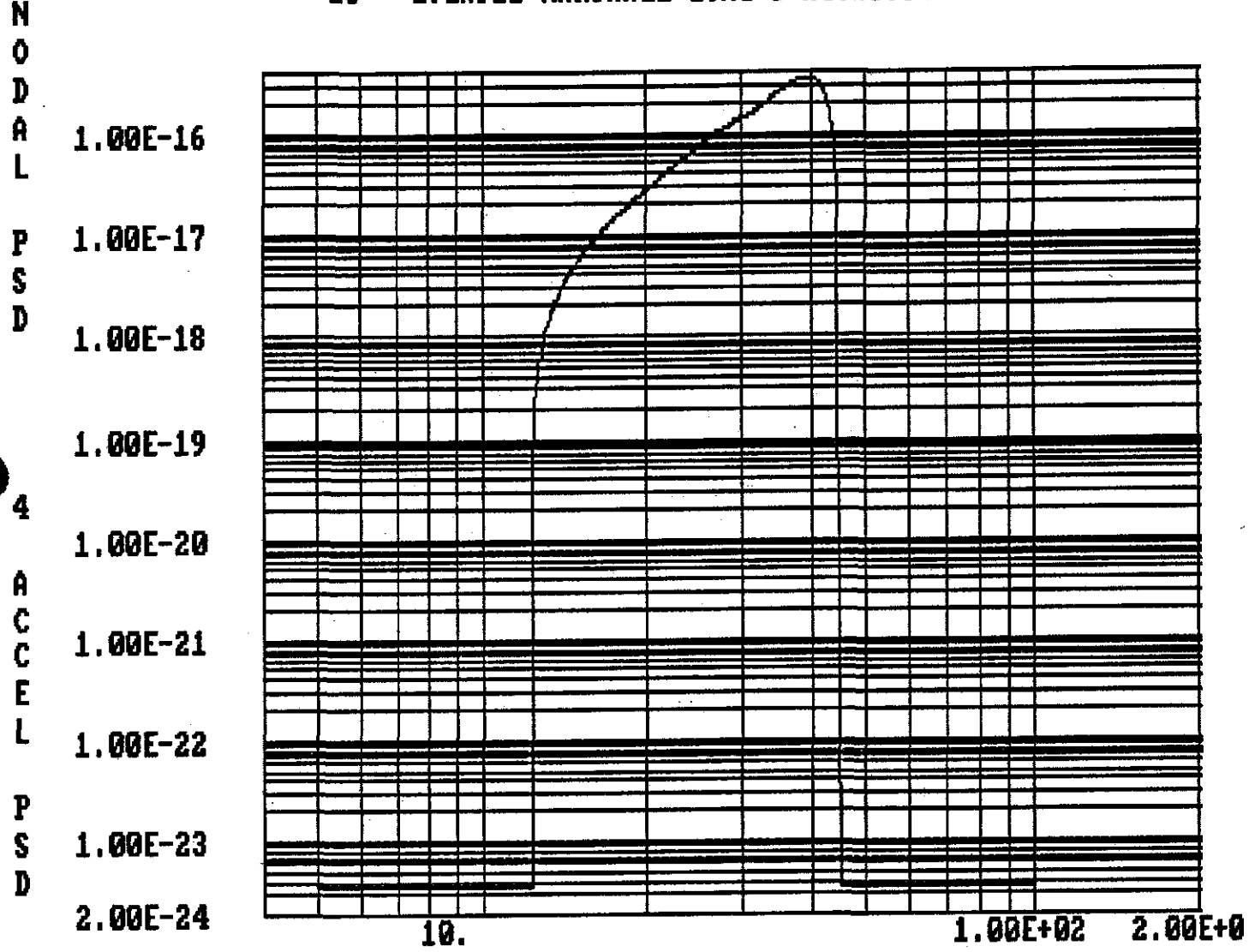
18" LVEAPB1 MARSHALL LONG'S ACOUSTIC SPECTRA (STRAIN EN



FREQUENCY (HZ) PLOT NO = 3

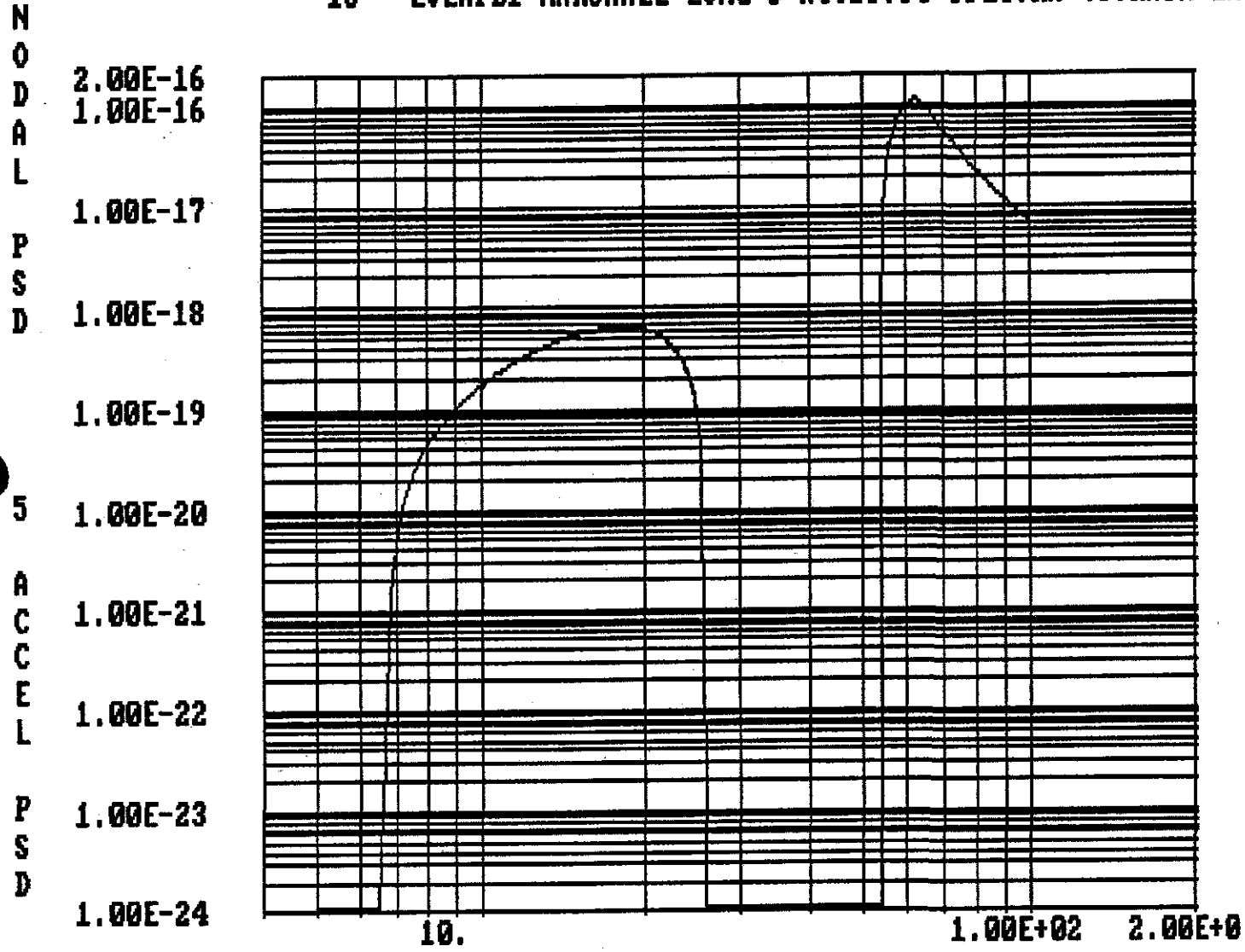
Node 1520 X3

18" LVEAPB1 MARSHALL LONG'S ACOUSTIC SPECTRA (STRAIN EN



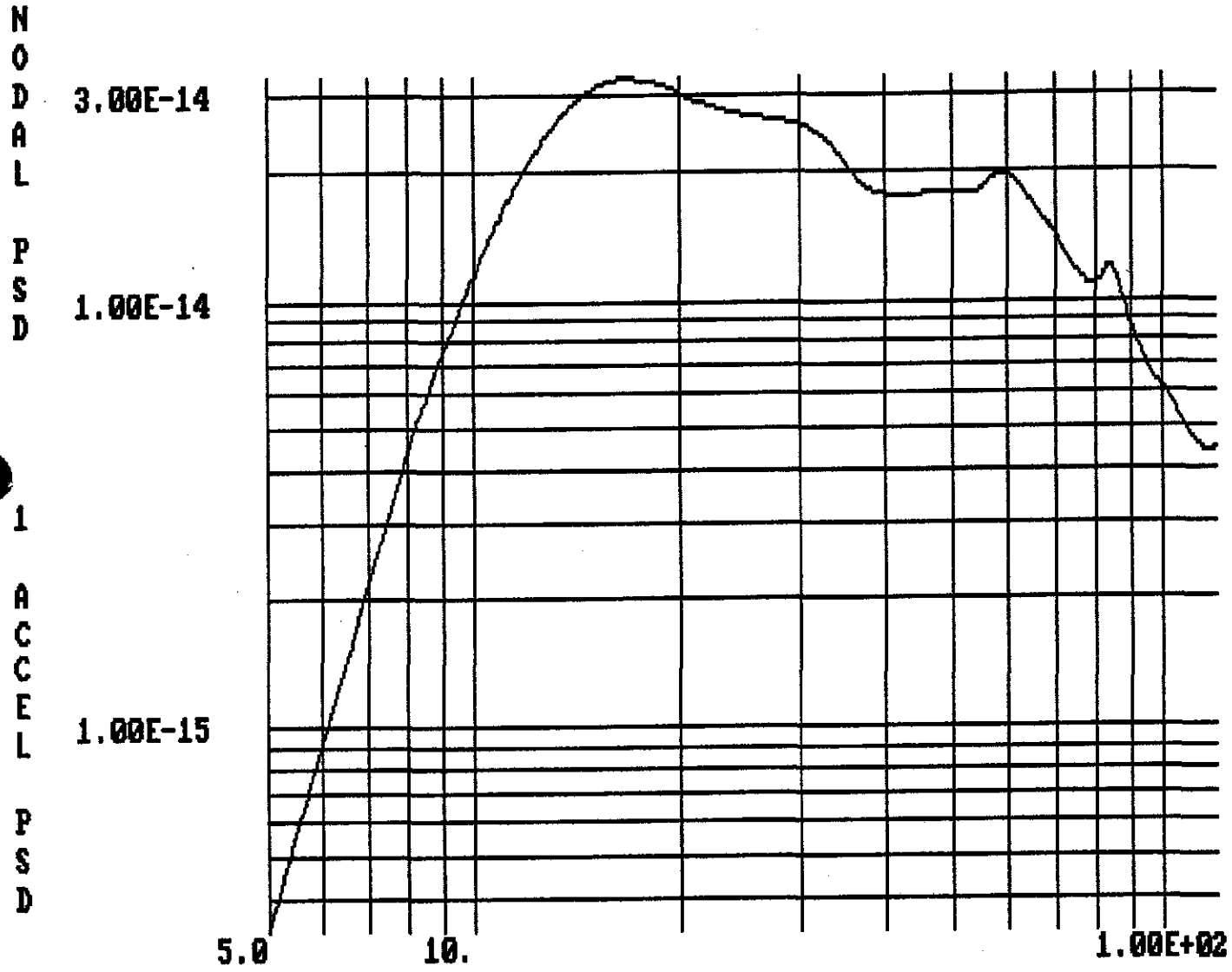
Node 2183 X3

18" LVEAPB1 MARSHALL LONG'S ACOUSTIC SPECTRA (STRAIN EN



```
 68" MIDPB1 LIGO ACOUSTIC SPECT (STRAIN ENERGY DAMPING)
START3                          3        1       3.0       5.0      120.0
RMS                                         1
PRINT
         2    9    9
         2   13   13
END
MODES
           1         6       99.0
           7        36       99.0
END
PSD        1         1
NODES              150          3
END
START PSD INPUT      1
 1 3 3 2 1         1.0     2.9E-9                       -81           1
 6         1       4.0       50.0      8.0     57.0     16.0       61.0
 6        -7      31.5       64.0     63.0     66.0    125.0       62.0
ALL DONE
```

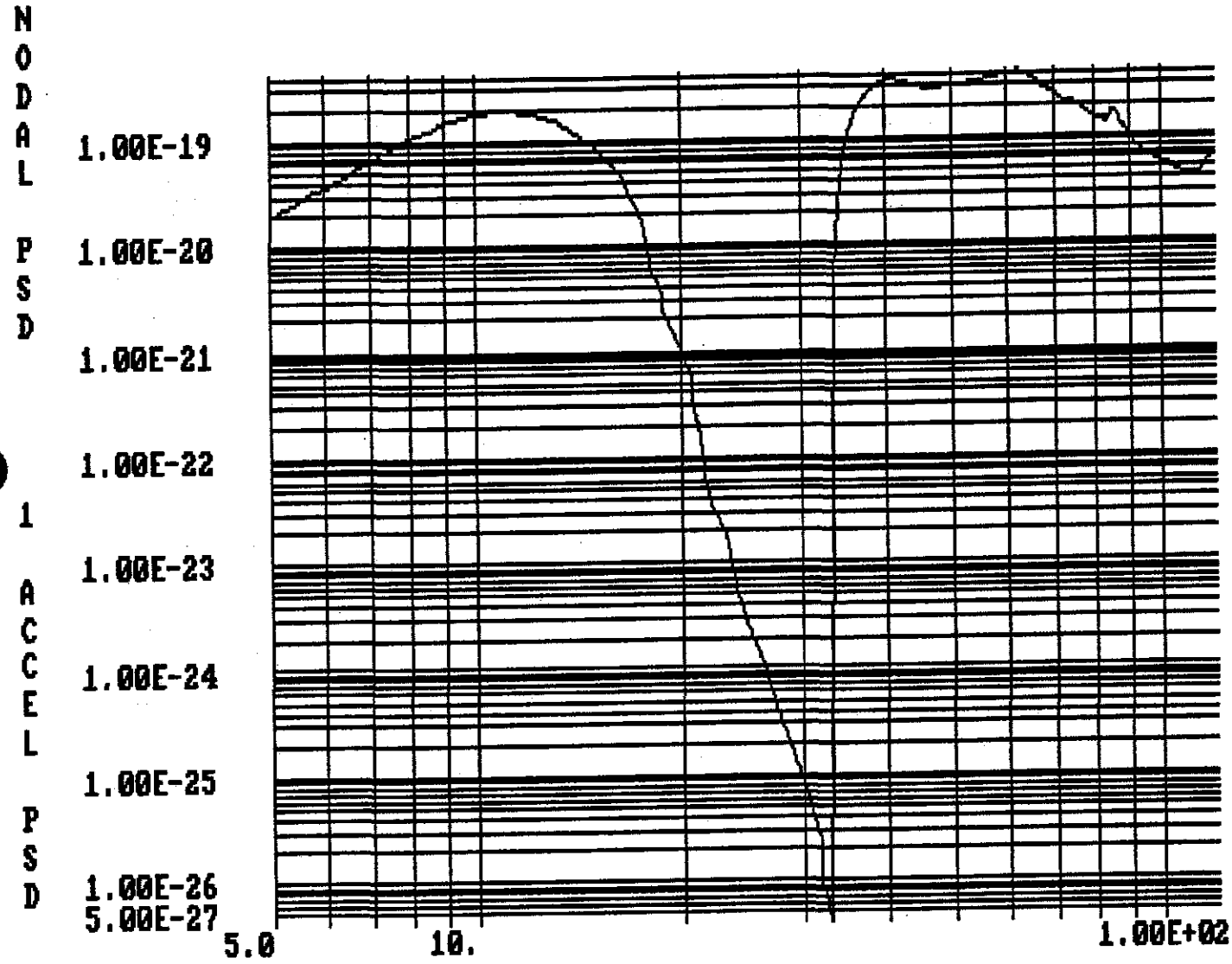
68" MIDPB1 LIGO ACOUSTIC SPECT (STRAIN ENERGY DAMPING)



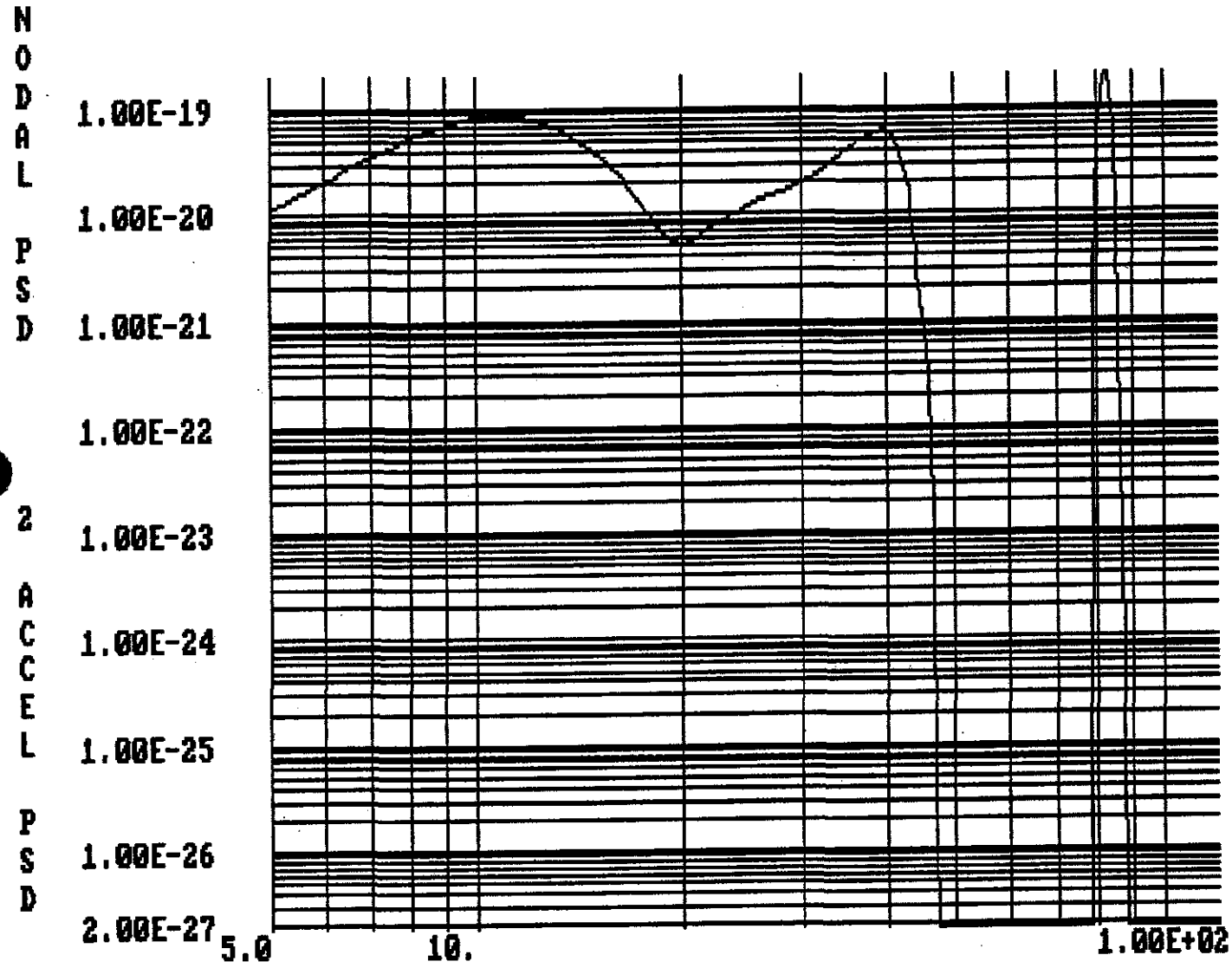
FREQUENCY (HZ) PLOT NO = 1

```
 68" MID-PB1 ACOUSTIC PSD SPECT (STRAIN ENERGY DAMPING)
START3                        3         1       3.0       5.0      120.0
RMS                                        1
PRINT
         2    9    9
         2   13   13
END
MODES
           1         6       99.0
           7        36       99.0
END
PSD        1         1
NODES              150          1       150         2       150         3
END
START PSD INPUT      1
 1 3 3 2 1         1.0     2.9E-9                          -81          1
 6         1       4.0       50.0       8.0      50.0      16.0      49.0
 6        -7      32.0       48.0      63.0      58.0     125.0      49.0
ALL DONE
```

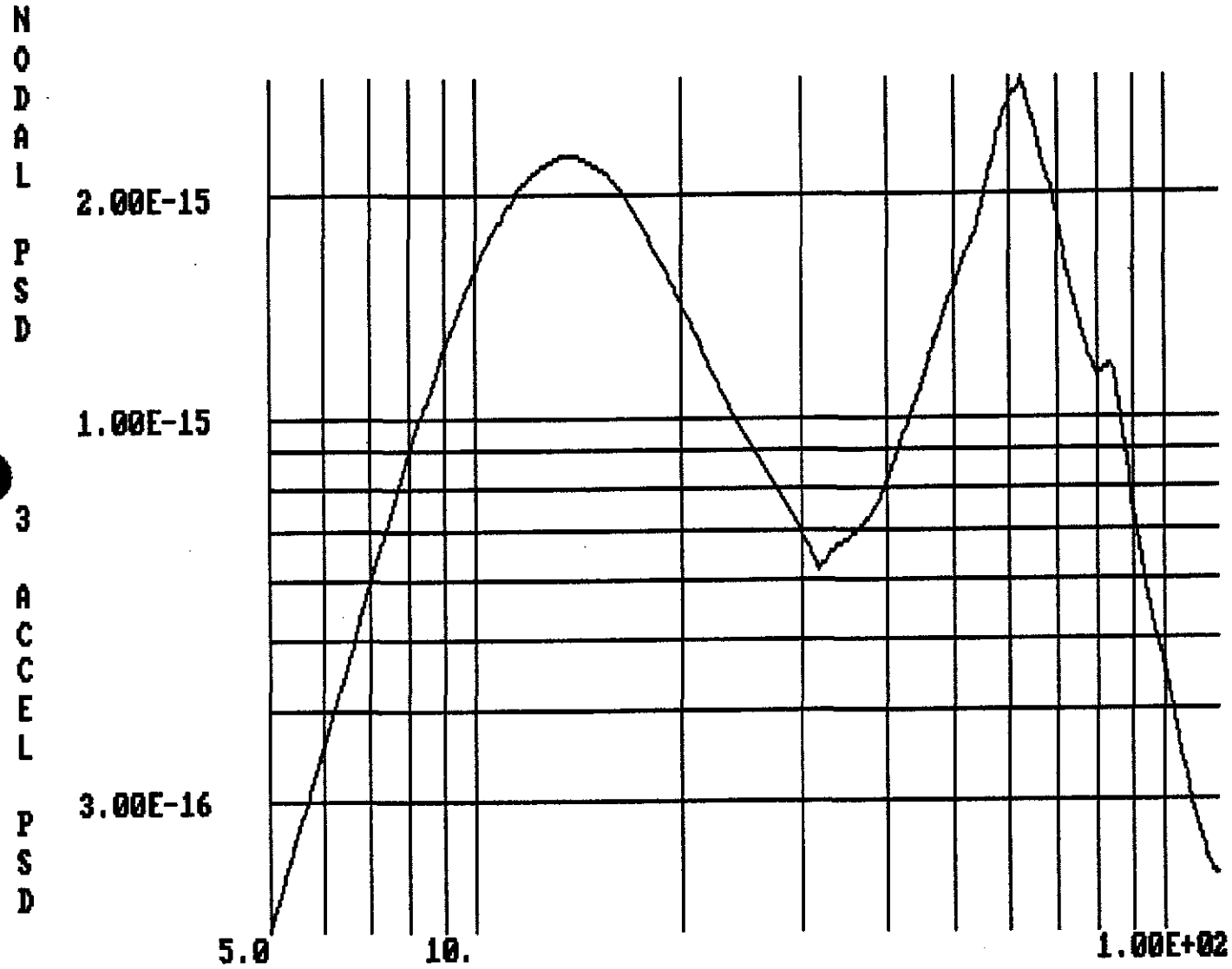
68" MID-PB1 ACOUSTIC PSD SPECT (STRAIN ENERGY DAMPING)



68" MID-PB1 ACOUSTIC PSD SPECT (STRAIN ENERGY DAMPING)



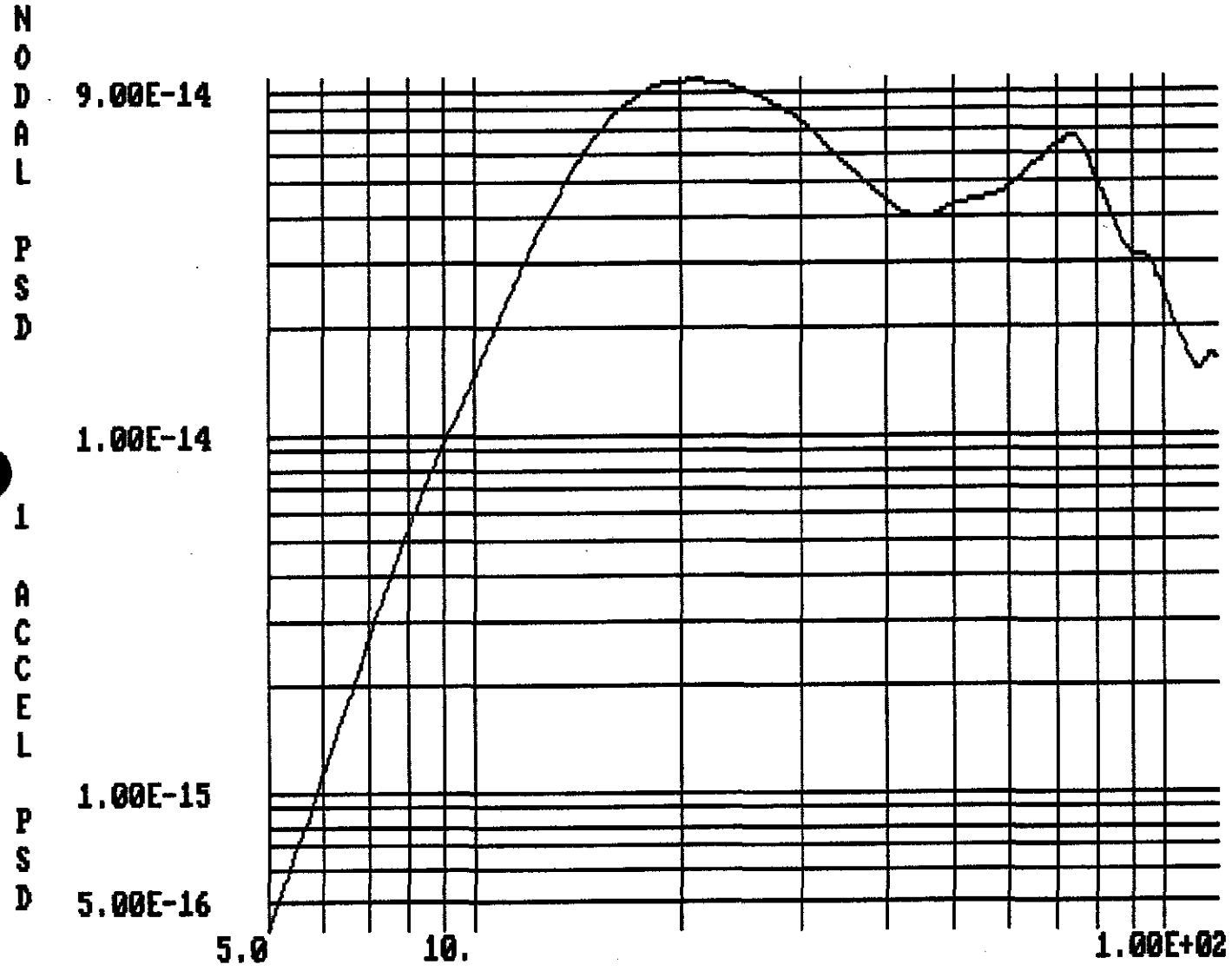
68" MID-PB1 ACOUSTIC PSD SPECT (STRAIN ENERGY DAMPING)



FREQUENCY (HZ) PLOT NO = 3

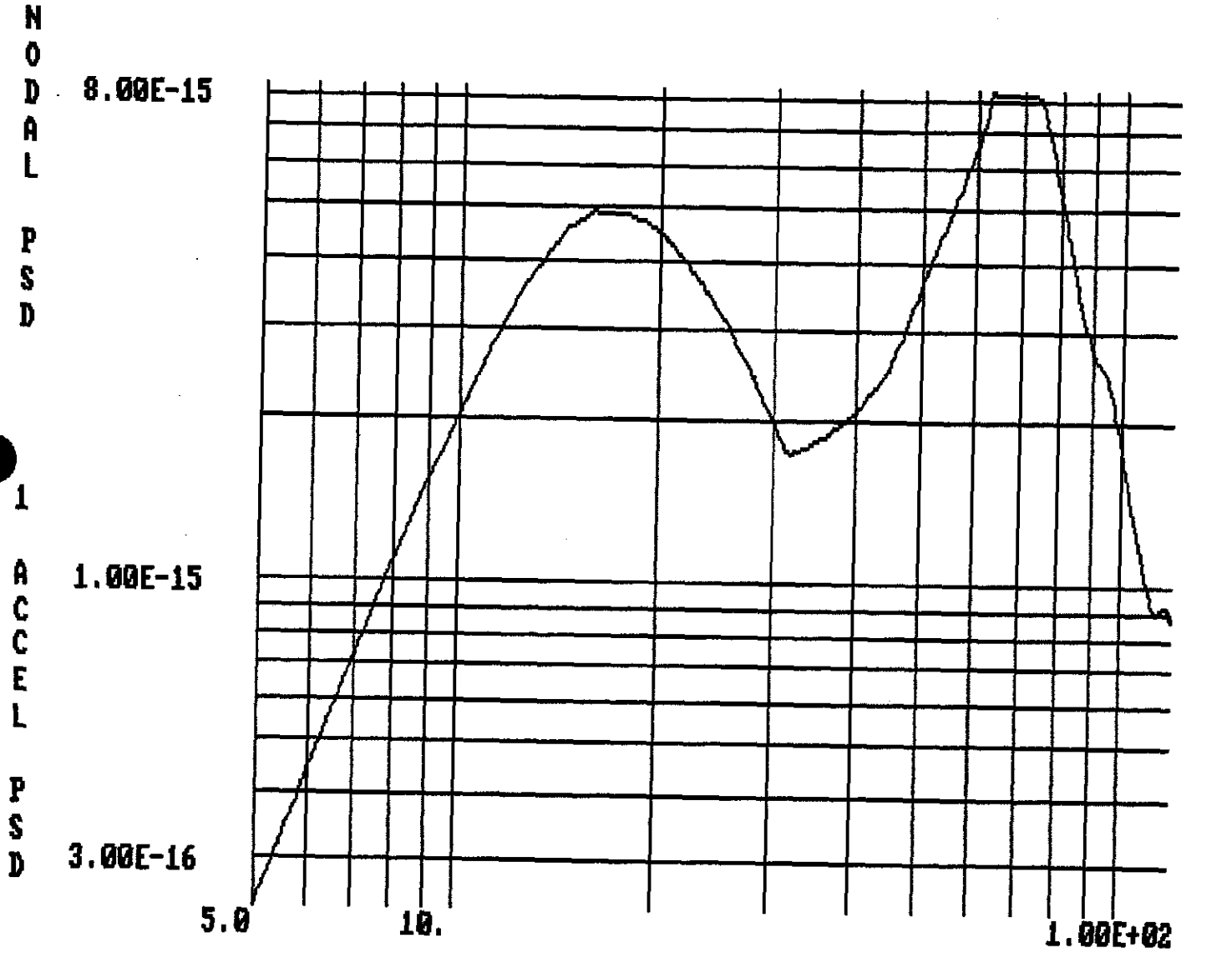
```
 36" MIDPB1 LIGO Acoustic Spect (STRAIN ENERGY DAMPING)
START3                                    3         1        3.0        5.0        120.0
RMS                                                    1
PRINT
         2    9    9
END
MODES
           1         6         99.0
           7        50         99.0
END
PSD        1         1
NODES              150            3
END
START PSD INPUT      1
 1 3 3 2 1         1.0     2.9E-9                                 -81                1
 6         1       4.0       50.0       8.0       57.0       16.0       61.0
 6        -7      31.5       64.0      63.0       66.0      125.0       62.0
ALL DONE
```

36" MIDPB1 LIGO Acoustic Spect (STRAIN ENERGY DAMPING)



```
 36" MIDPB1 Marshall Long's Acoustic Spect (STRAIN ENERGY DAMPING)
START3                                 3         1        3.0       5.0      120.0
RMS                                                 1
PRINT
         2    9    9
END
MODES
           1         6       99.0
           7        50       99.0
END
PSD        1         1
NODES              150          3
END
START PSD INPUT      1
 1 3 3 2 1         1.0     2.9E-9                            -81              1
 6         1       4.0       50.0        8.0      50.0      16.0           49.0
 6        -7      31.5       48.0       63.0      58.0     125.0           49.0
ALL DONE
```

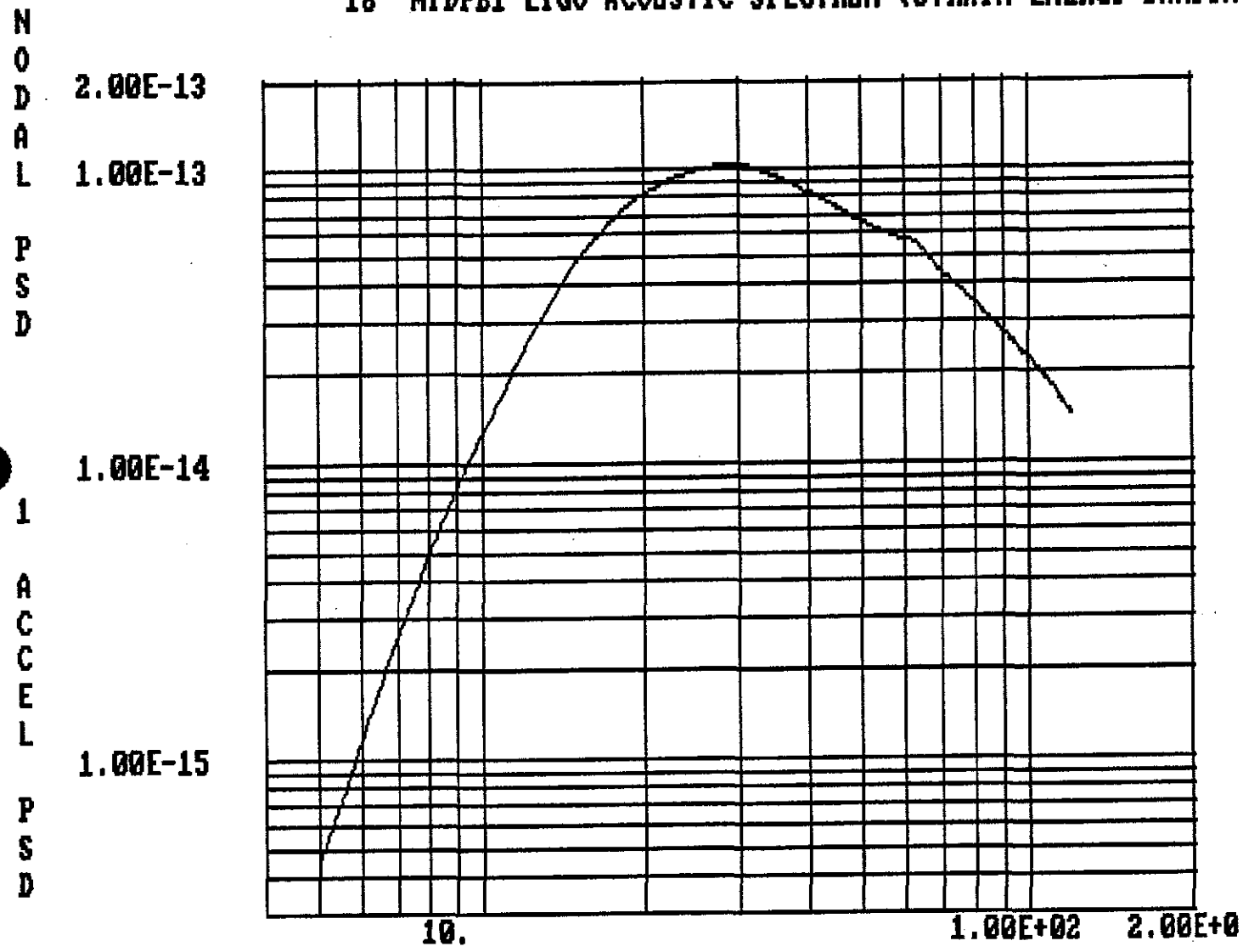
36" MIDPB1 MARshall Long's Acoustic Spect (STRAIN ENERGY



```
 18" MIDPB1 LIGO ACOUSTIC SPECTRUM (STRAIN ENERGY DAMPING)
START3                                3         1        3.0       5.0       120.0
RMS                                                1
PRINT
         2    9    9
         2   13   13
END
MODES
           1         6         99.0
           7        70         99.0
END
PSD        1         1
NODES              150            3
END
START PSD INPUT    1
 1 3 3 2 1         1.0      2.9E-9                           -81                 1
 6         1       4.0        50.0       8.0      57.0      16.0              61.0
 6        -7      31.5        64.0      63.0      66.0     125.0              62.0
ALL DONE
```

Node 150 X3

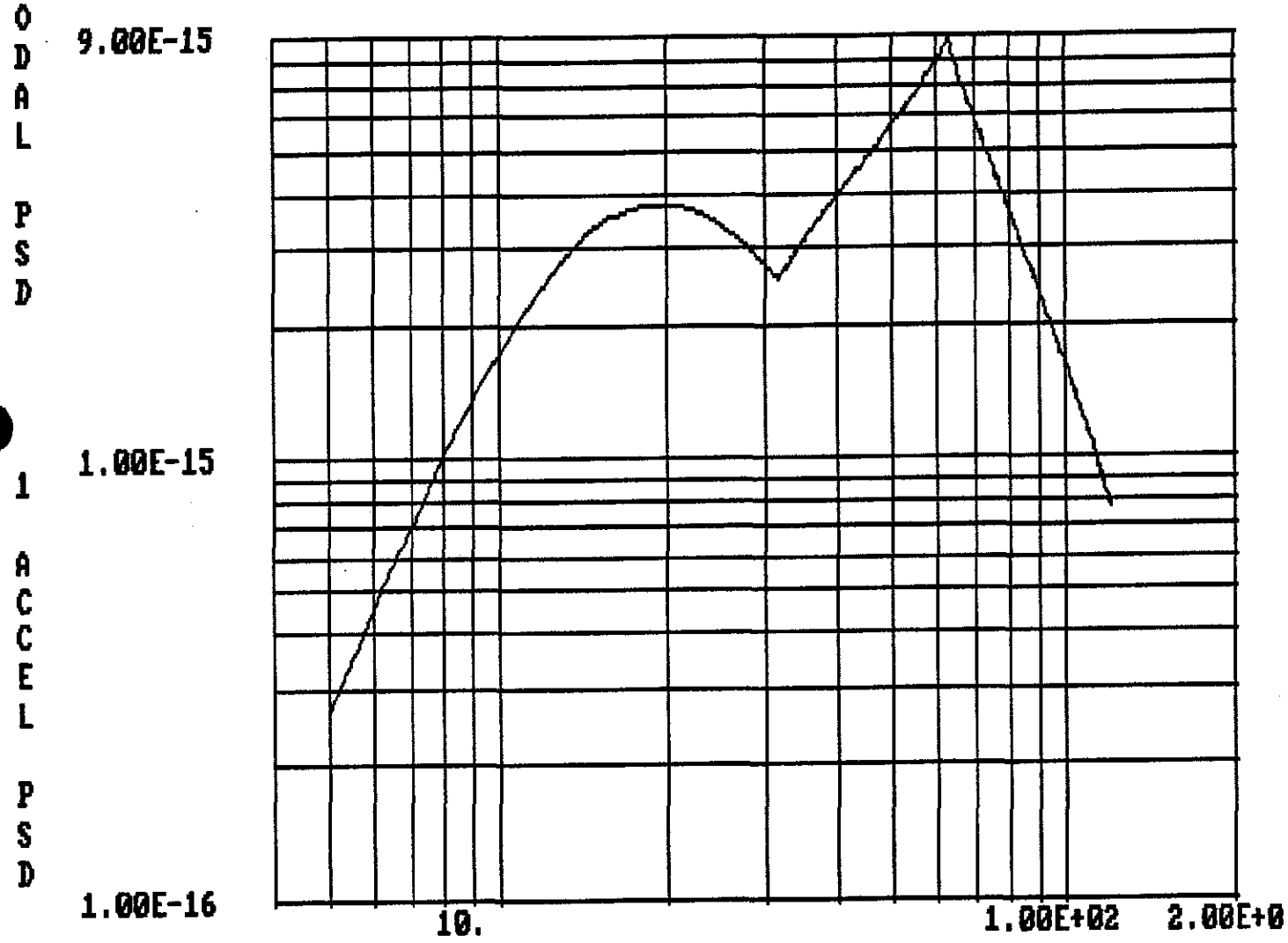
18" MIDPB1 LIGO ACOUSTIC SPECTRUM (STRAIN ENERGY DAMPIN



```
  18" MIDPB1 MARSHALL LONG'S ACOUSTIC SPECTRUM (STRAIN ENERGY DAMPING)
START3                               3          1         3.0        5.0       120.0
RMS                                                1
PRINT
         2    9    9
         2   13   13
END
MODES
           1         6          99.0
           7        70          99.0
END
PSD        1         1
NODES              150             3
END
START PSD INPUT      1
 1 3 3 2 1         1.0       2.9E-9                               -81              1
 6         1       4.0        50.0         8.0        50.0        16.0         49.0
 6        -7      31.5        48.0        63.0        58.0       125.0         49.0
ALL DONE
```

Node 150 X3

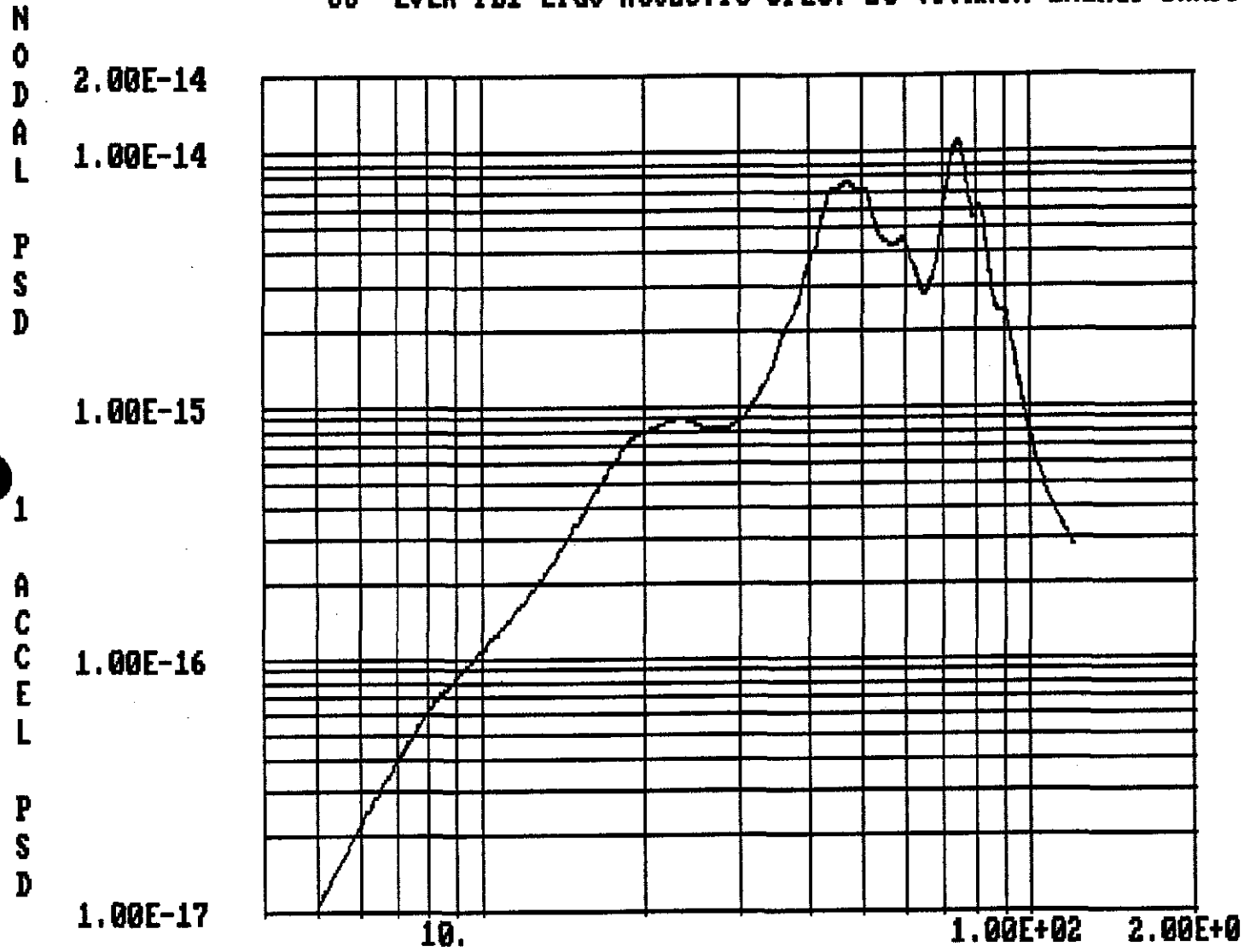
18" MIDPB1 MARSHALL LONG'S ACOUSTIC SPECTRUM (STRAIN EN



```
 68" LVEA-PB1 LIGO ACOUSTIC SPECT-UC (STRAIN ENERGY DAMPING)
START3                  3      1     3.0     5.0    120.0
RMS
PRINT
       2  230  230
       2  774  774
       2  792  792
       2 1520 1520
       2 2183 2183
END
MODES
        1     180     99.0
END
PSD      3       1
NODES           230       3     774       3     792       3
NODES          1520       3    2183       3
END
START PSD INPUT   1
 1 3 3 2 2        1.0   2.9E-9                -81          1
 6       1      4.0     50.0      8.0     57.0     16.0     61.0
 6      -7     31.5     64.0     63.0     66.0    125.0     62.0
ALL DONE
```

Node 230 X3

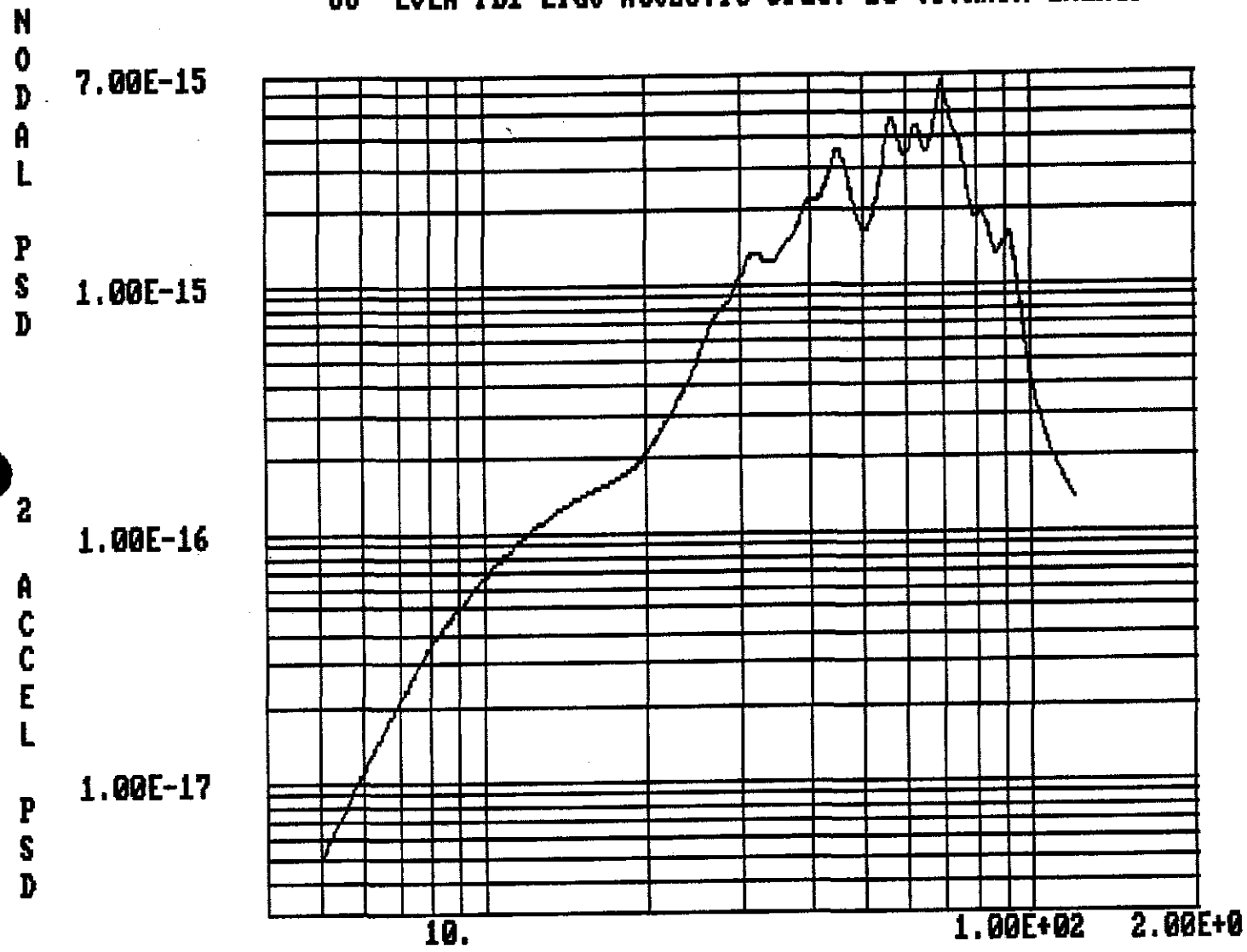
68" LVEA-PB1 LIGO ACOUSTIC SPECT-UC (STRAIN ENERGY DAMPI



FREQUENCY (HZ) PLOT NO = 1

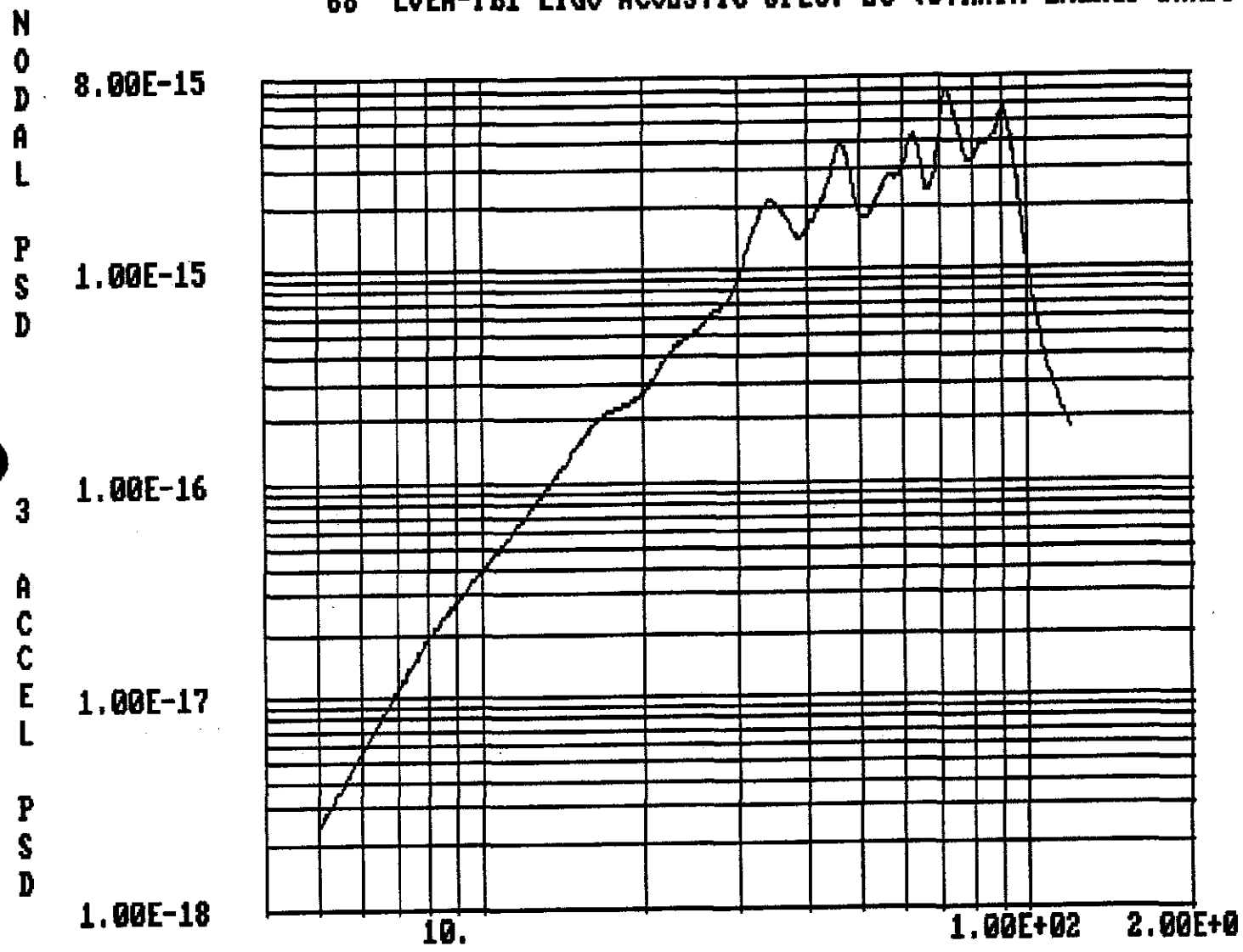
Node 774 X3

68" LVEA-PB1 LIGO ACOUSTIC SPECT-UC (STRAIN ENERGY DAMPI



Node 792 X3

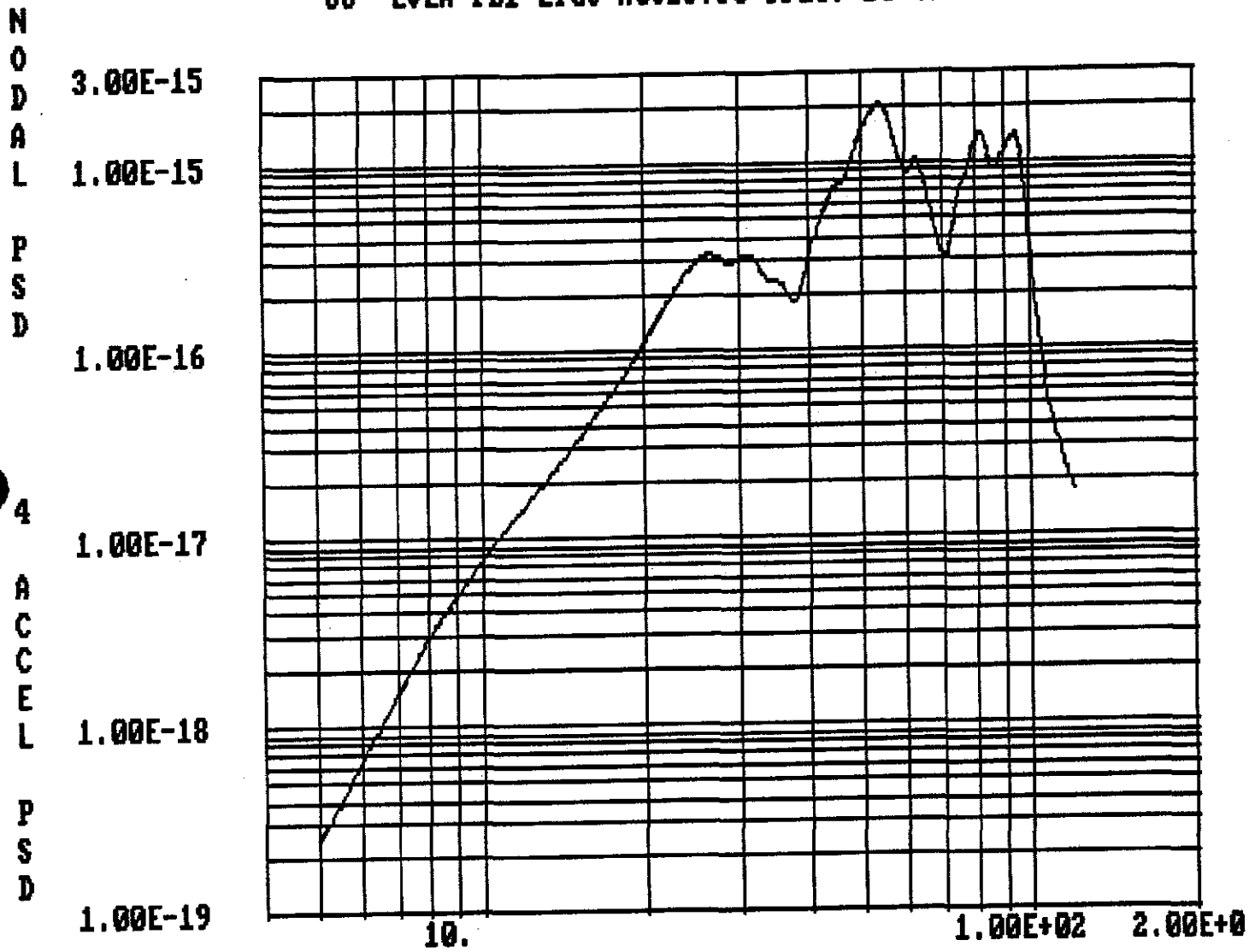
68" LVEA-PB1 LIGO ACOUSTIC SPECT-UC (STRAIN ENERGY DAMPI



FREQUENCY (HZ) PLOT NO = 3

Node 1520 X3

68" LVEA-PB1 LIGO ACOUSTIC SPECT-UC (STRAIN ENERGY DAMPI



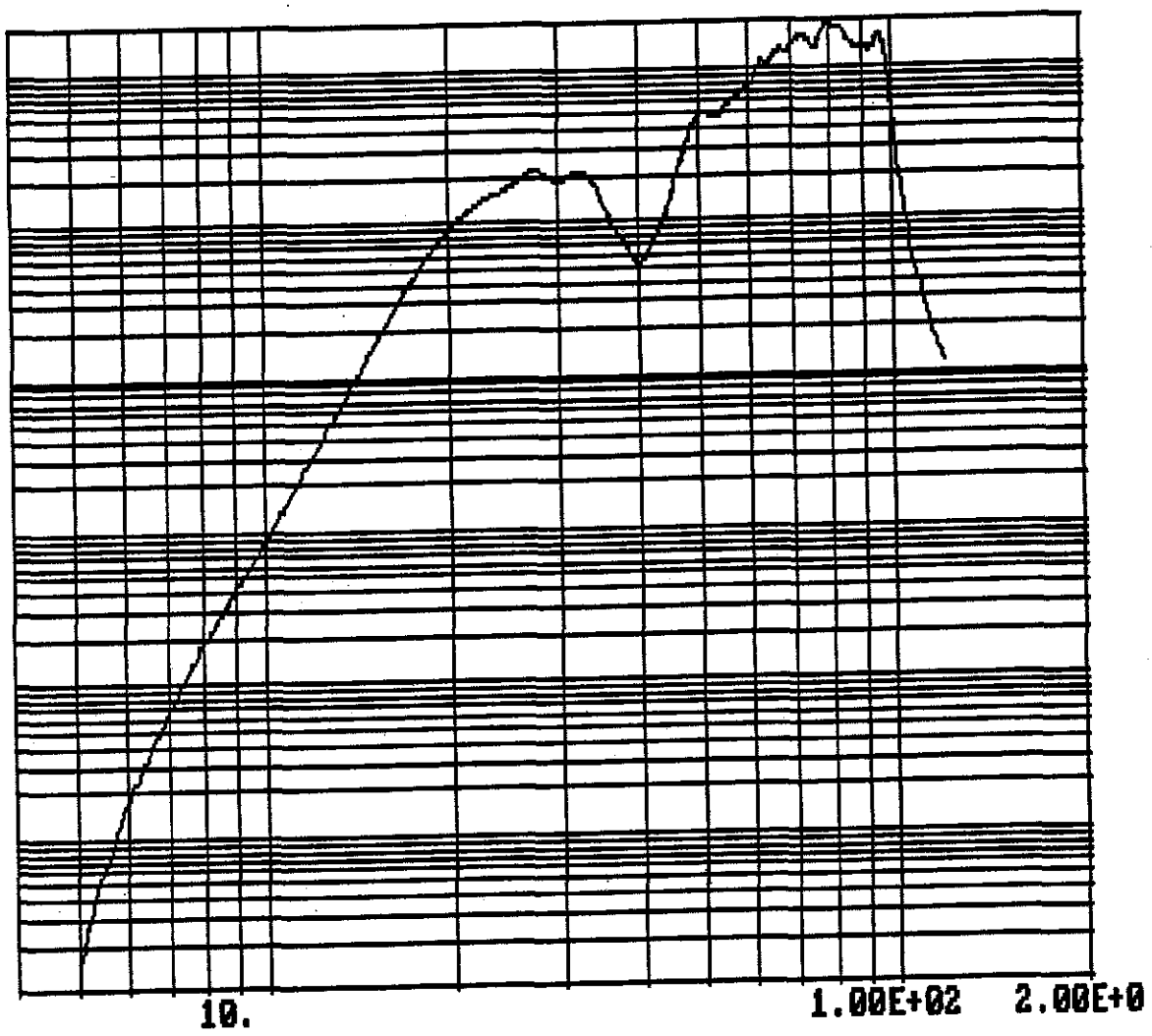
FREQUENCY (HZ)

PLOT NO = 4

&a1140V

Node 2183 X3

68" LVEA-PB1 LIGO ACOUSTIC SPECT-UC (STRAIN ENERGY DAMPI



FREQUENCY (HZ) PLOT NO = 5