GEM TN-92-219

Vessel Random Vibration Analysis

F. A. House
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October 22, 1992

Abstract:

An analysis of the GEM vacuum vessel subject to estimated random ground motion has been completed.

To: R.H. Sawicki October 22, 1992

From: F.A. House

Subject: GEM vessel random vibration analysis

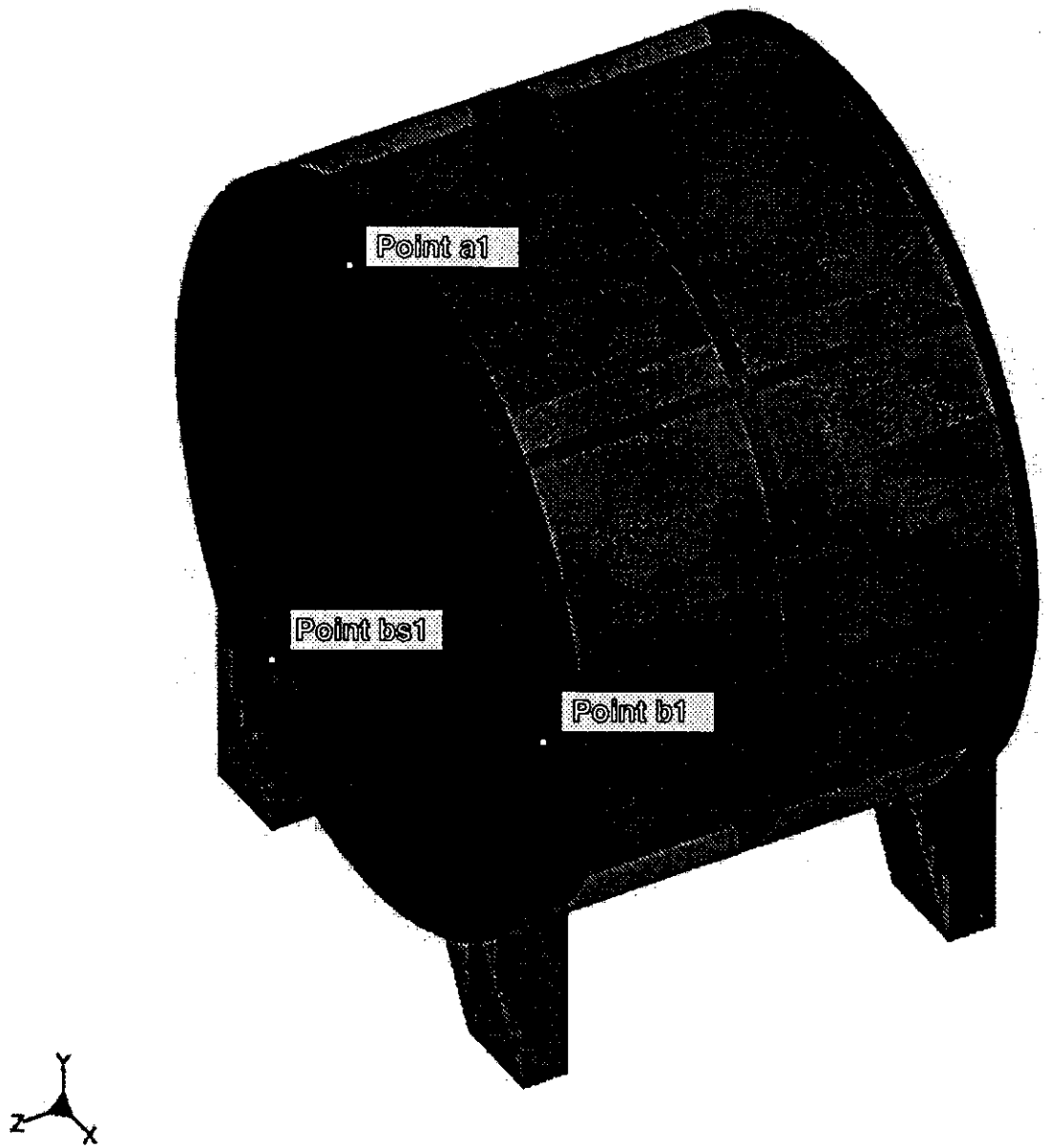
An analysis of the GEM vacuum vessel subject to estimated random ground motion has been completed. The method used is described in memo #GEM-LLNL-92-048. The finite element computer model is shown in Figure 1. The vessel is supported at the base of the legs and is free standing. The analysis included the first nine dynamic modes of the vessel. These modes are shown in Figures 2 and 3. Three input power spectral density (PSD) functions were used to excite the vessel and response values were recovered at the three points shown in Figure 1. Excitation occurred in x,y, and z axes. All input spectra were based on a $0.001g_{rms}$ acceleration level but had varying bandwidths of 4, 19, and 99 hz. Graphs of these PSD functions are shown in Figures 4-6. Resulting rms displacements of the vessel are shown in Figure 7. These values are the Square-Root-Sum-of-the-Squares of the x,y, and z response degrees of freedom. More complete results are shown in Table 1.

Note: All results are scalable to the input PSD rms level, e.g. a decrease from $0.001g_{rms}$ to $0.0001g_{rms}$ will decrease all displacements by a factor of 10.

Graphs of output displacement and acceleration spectra for all degrees of freedom at the three repsonse points on the vessel (shown in Figure 1) are included in the attachment.

Distribution

G. Deis
L. Pedrotti
J. Bowers
M. Furey
M. Gamble
C. Wuest
C. Johnson
F. Taylor
F. Nimblett
M. Harris
N. Martovetsky



GEM vessel model

Figure 1

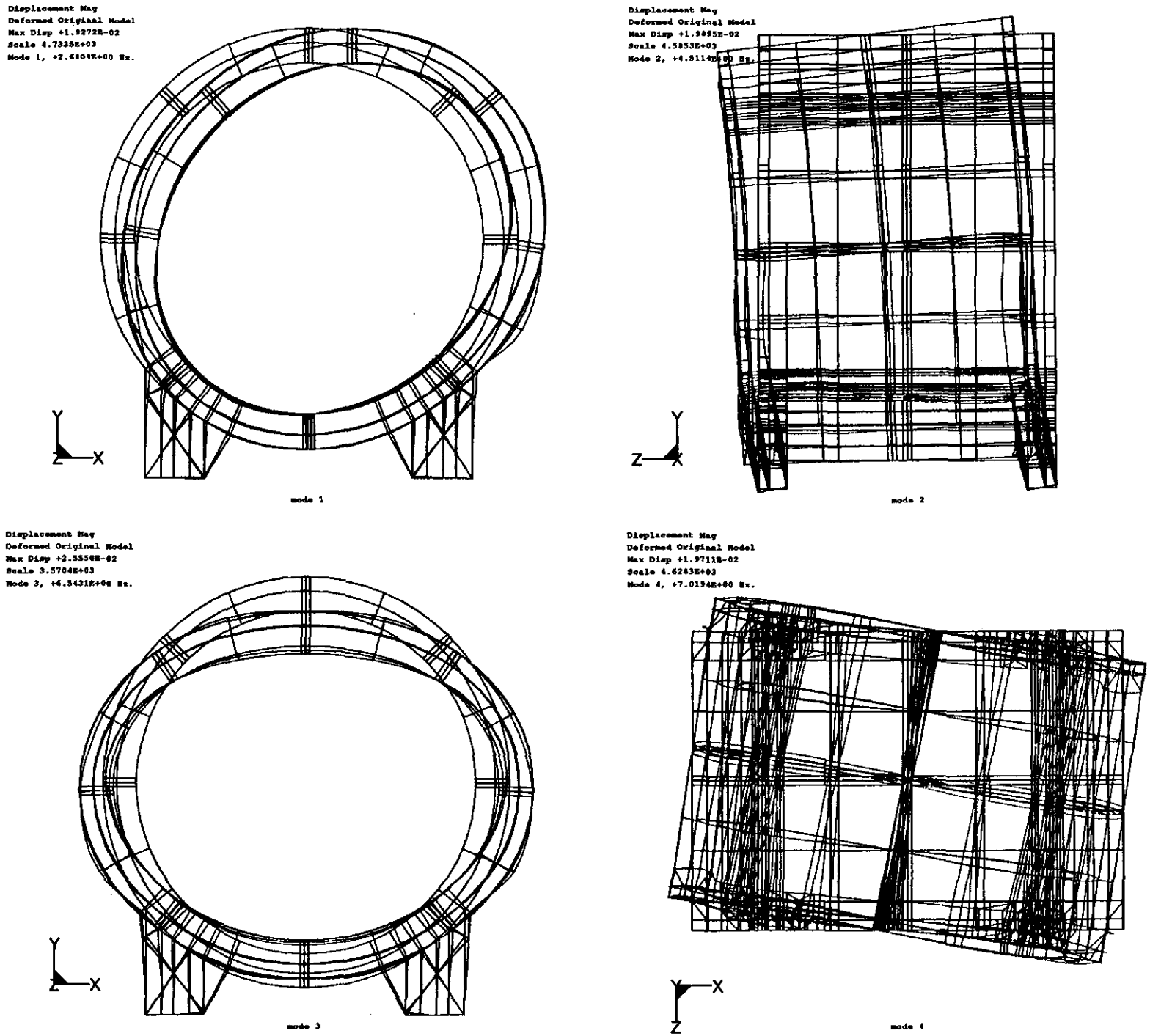

Displacement Mag
Deformed Original Model
Max Disp +1.9272E-02
Scale 4.7335E+03
Mode 1, +2.6809E+00 Hz.
Y
Z
X
mode 1
Displacement Mag
Deformed Original Model
Max Disp +1.9895E-02
Scale 4.5853E+03
Mode 2, +4.5114E+00 Hz.
Y
Z
X
mode 2
Displacement Mag
Deformed Original Model
Max Disp +2.5550E-02
Scale 3.5704E+03
Mode 3, +6.5431E+00 Hz.
Y
Z
X
mode 3
Displacement Mag
Deformed Original Model
Max Disp +1.9711E-02
Scale 4.6243E+03
Mode 4, +7.0194E+00 Hz.
Y
X
Z
mode 4

Figure 2

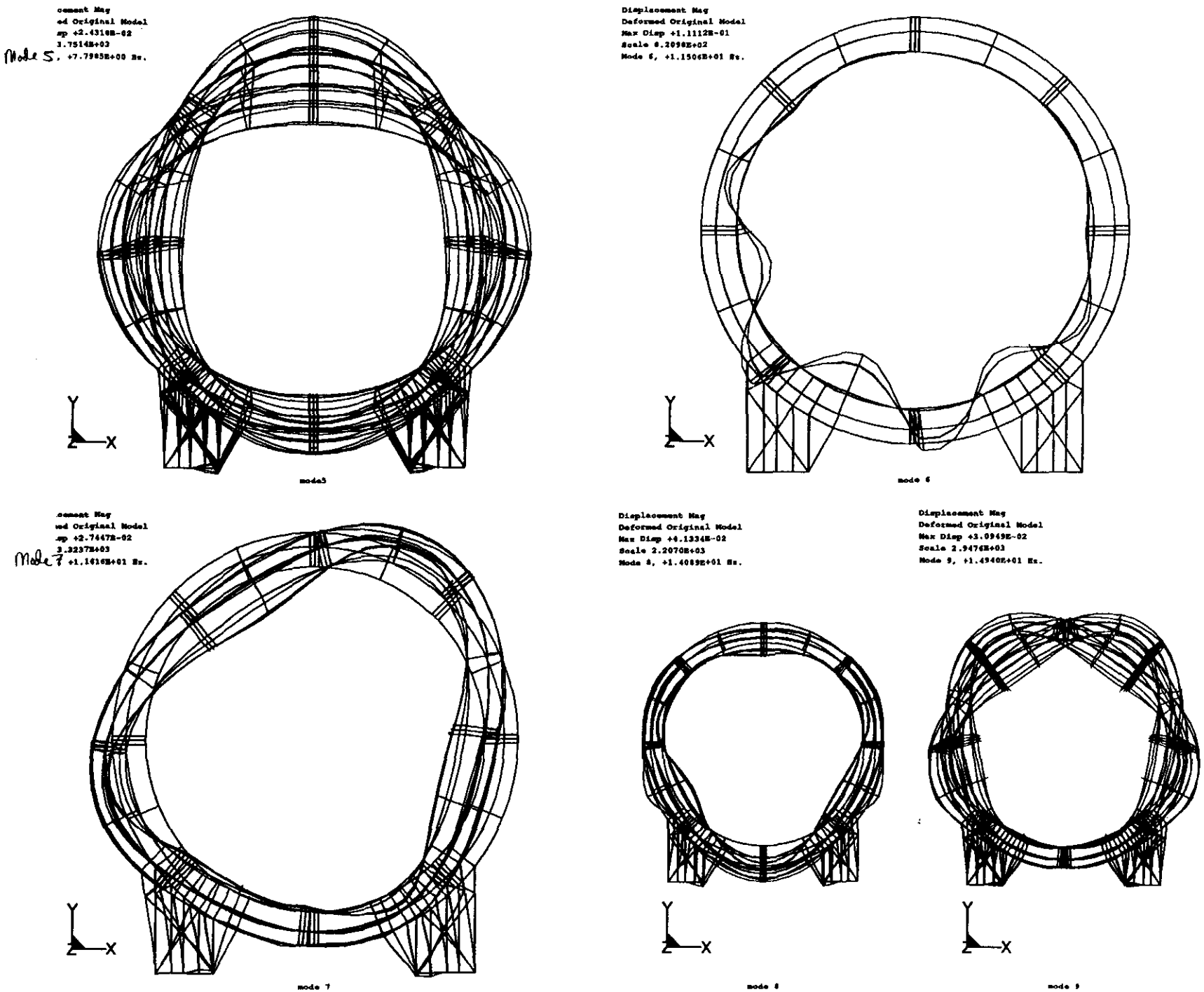

Mode 5
mode5
Displacement Mag
Deformed Original Model
Max Disp +1.1112E-01
Scale 8.2098E+02
Mode 6, +1.1506E+01 Hz.
mode 6
Mode 7
mode 7
Displacement Mag
Deformed Original Model
Max Disp +6.1334E-02
Scale 2.2070E+03
Mode 8, +1.4089E+01 Hz.
mode 8
Displacement Mag
Deformed Original Model
Max Disp +3.0949E-02
Scale 2.9476E+03
Mode 9, +1.4940E+01 Hz.
mode 9
Y
X
Z

Figure 3

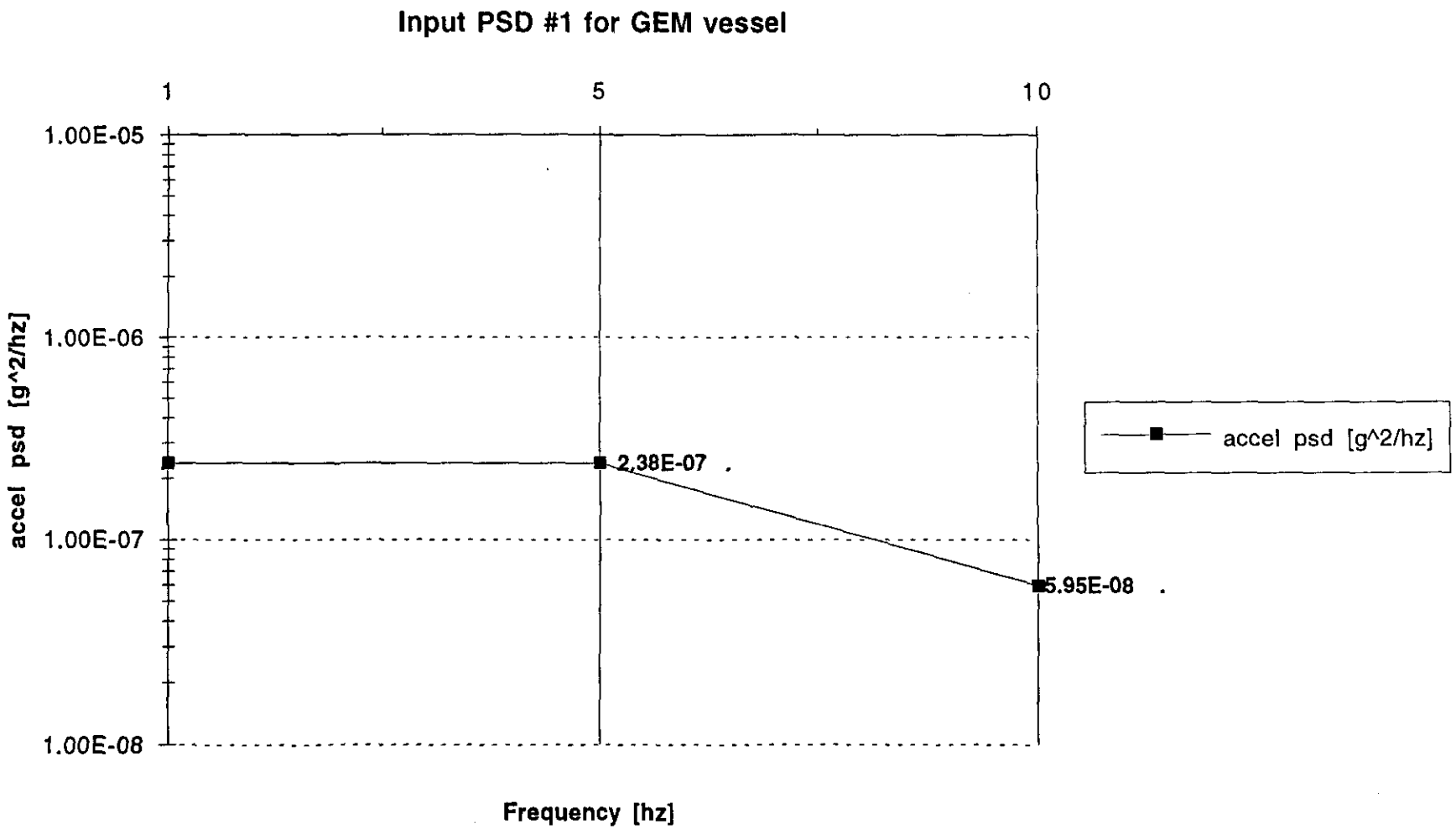

Input PSD #1 for GEM vessel
1
5
10
1.00E-05
1.00E-06
1.00E-07
1.00E-08
accel psd [g^2/hz]
2.38E-07
5.95E-08
accel psd [g^2/hz]
Frequency [hz]

Figure 4

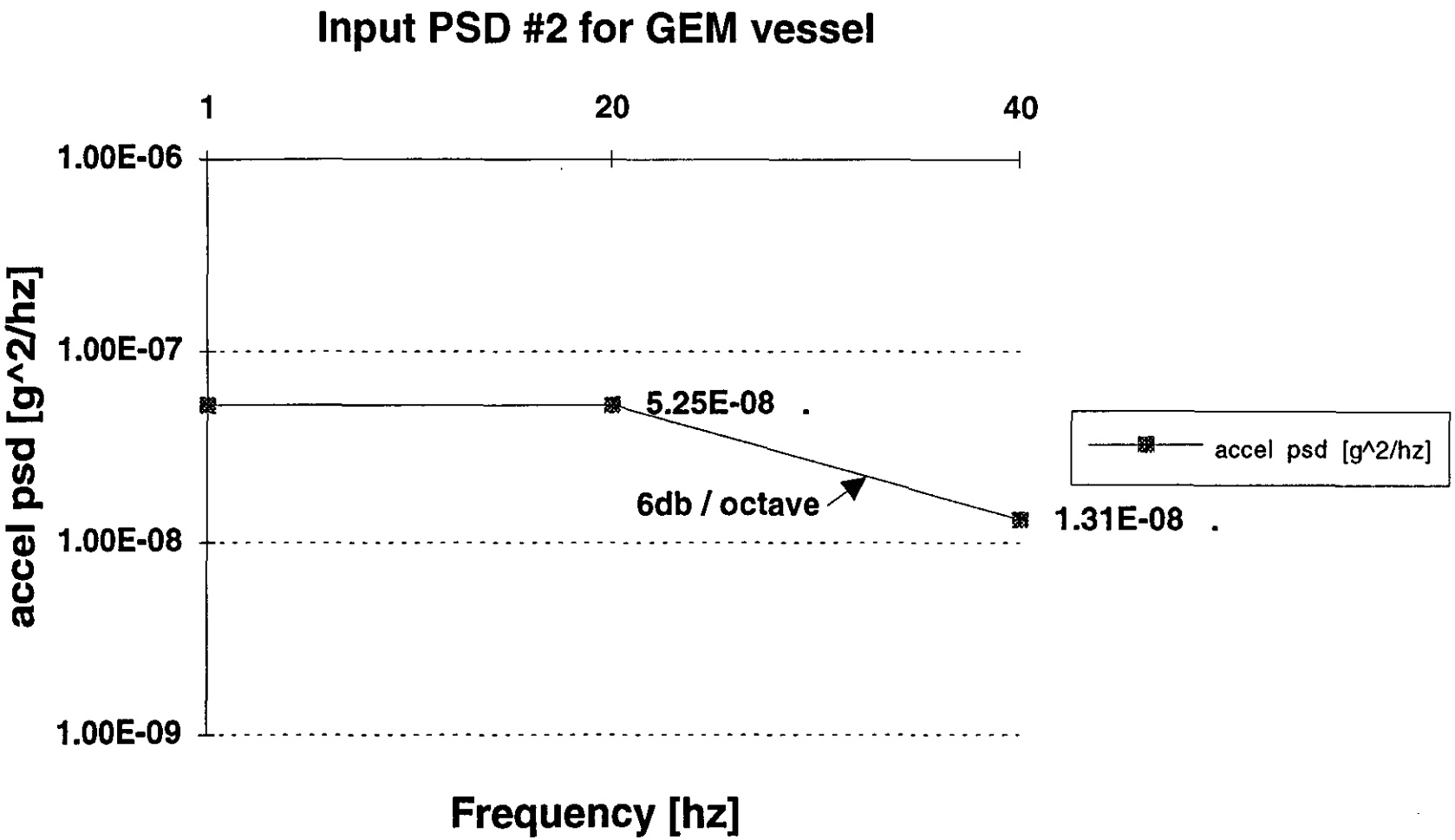

Input PSD #2 for GEM vessel
1
20
40
1.00E-06
1.00E-07
1.00E-08
1.00E-09
accel psd [g^2/hz]
5.25E-08
6db / octave
1.31E-08
accel psd [g^2/hz]
Frequency [hz]

Figure 5

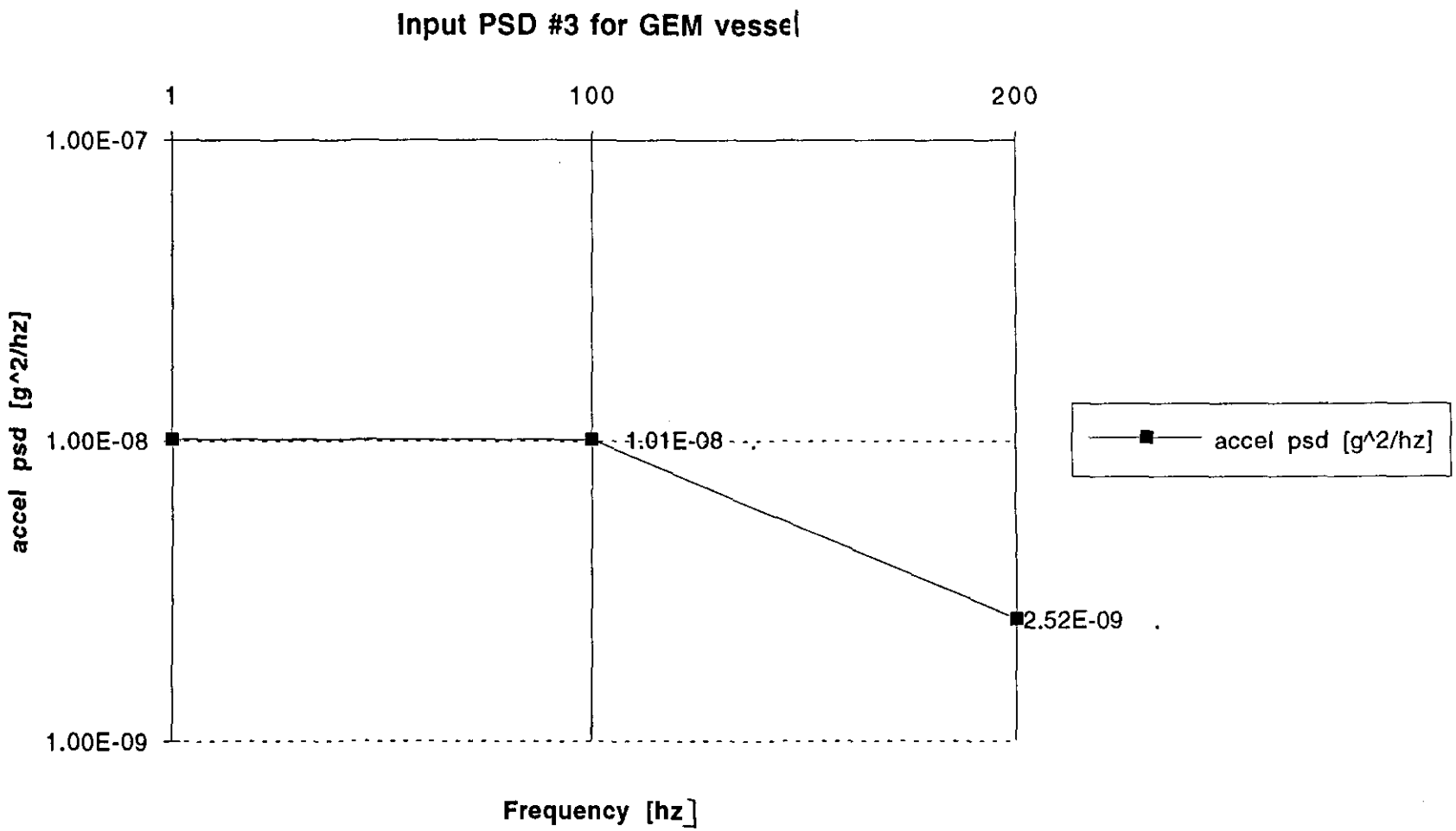

Input PSD #3 for GEM vessel
1
100
200
1.00E-07
1.00E-08
1.00E-09
1.01E-08
2.52E-09
accel psd [g^2/hz]
accel psd [g^2/hz]
Frequency [hz]

Figure 6

Vessel PSD's								
	PSD #1			PSD #2			PSD #3	
	Frequency	accel psd [g^2/hz]		Frequency	accel psd [g^2/hz]		Frequency	accel psd [g^2/hz]
	1	2.38E-07		1	5.25E-08		1	1.01E-08
	5	2.38E-07		20	5.25E-08		100	1.01E-08
	10	5.95E-08		40	1.31E-08		200	2.52E-09
	for							
	g rms = [A * (f2 - f1) + A / (f3 - f2)]^1/2							
	and							
	g rms =	0.001		g rms =	0.001		g rms =	0.001
	f1 =	1		f1 =	1		f1 =	1
	f2 =	5		f2 =	20		f2 =	100
	f3 =	10		f3 =	40		f3 =	200
	A =	2.38095E-07		A =	5.25E-08		A =	1.01E-08

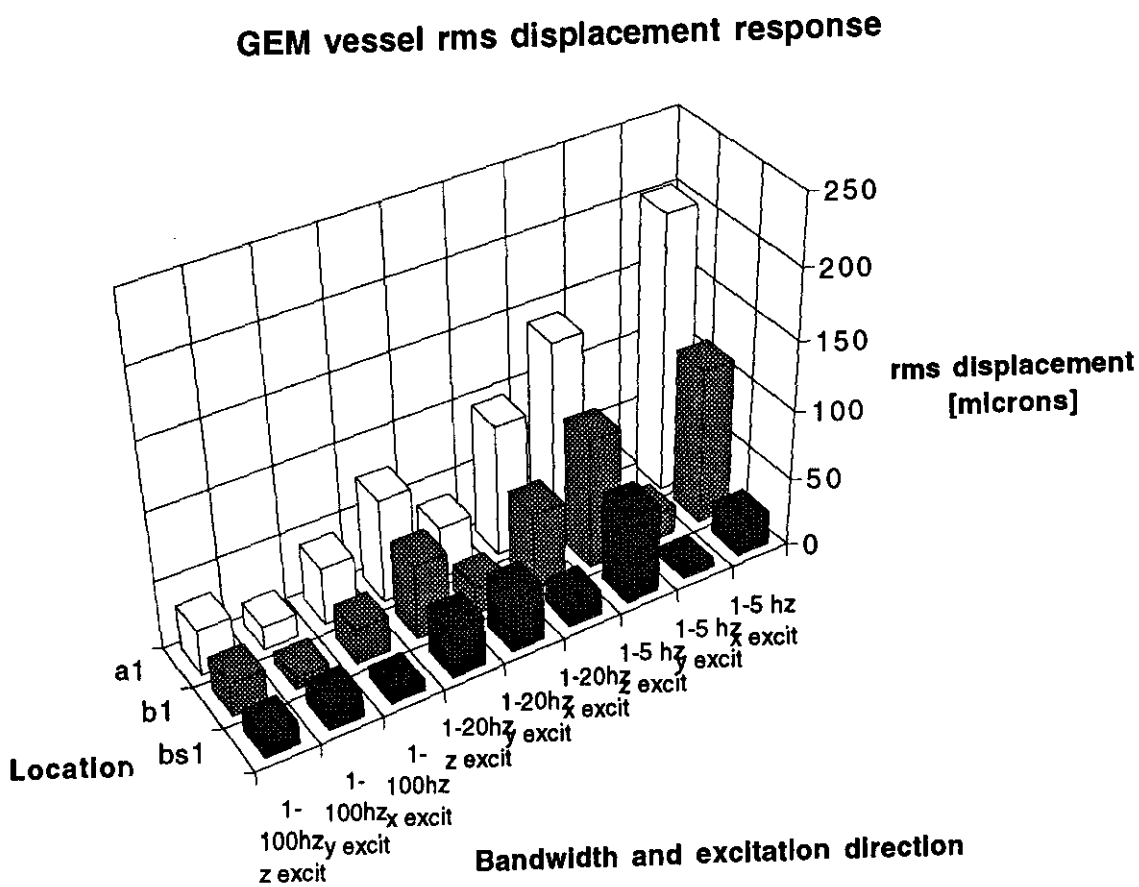
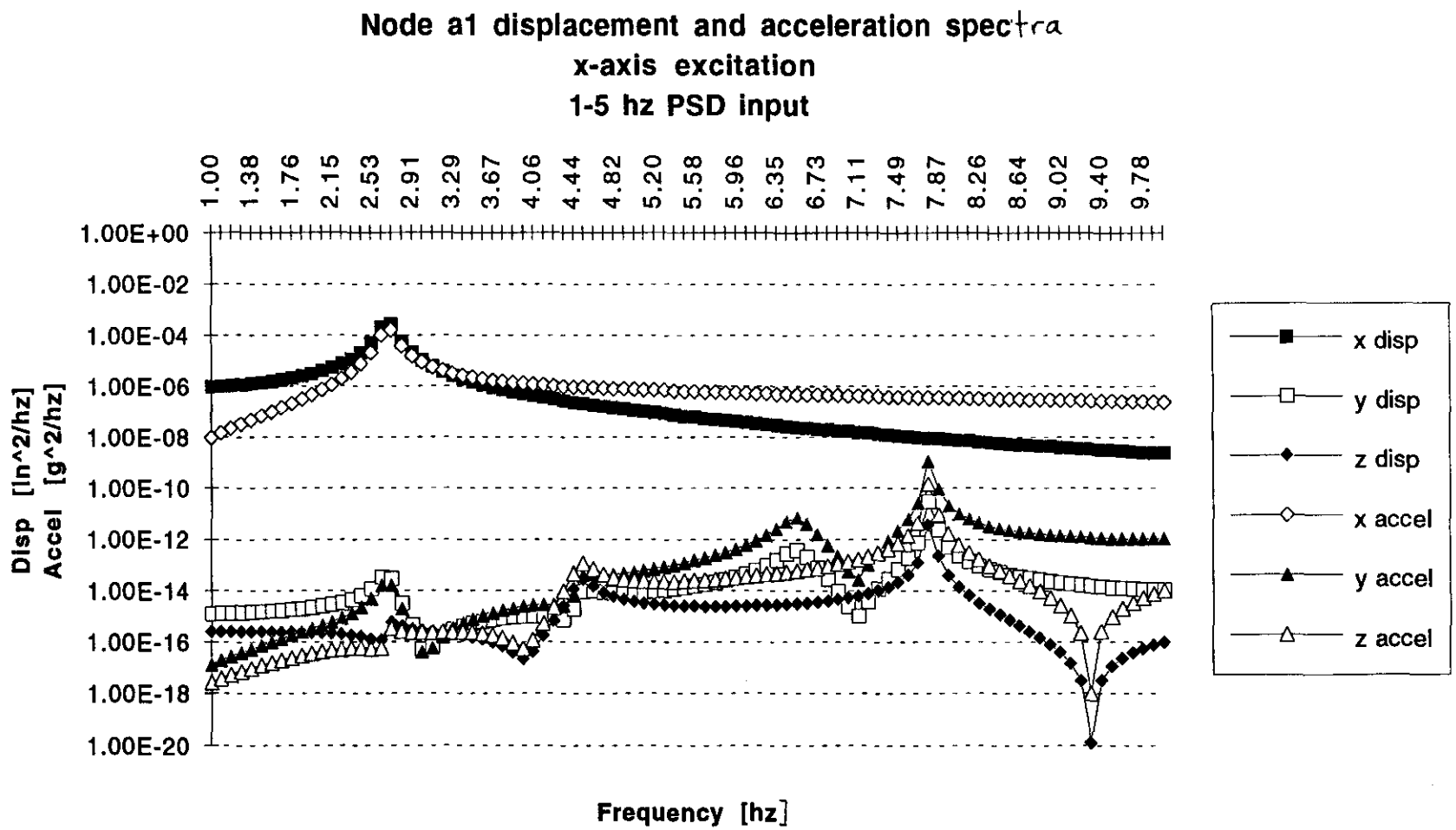
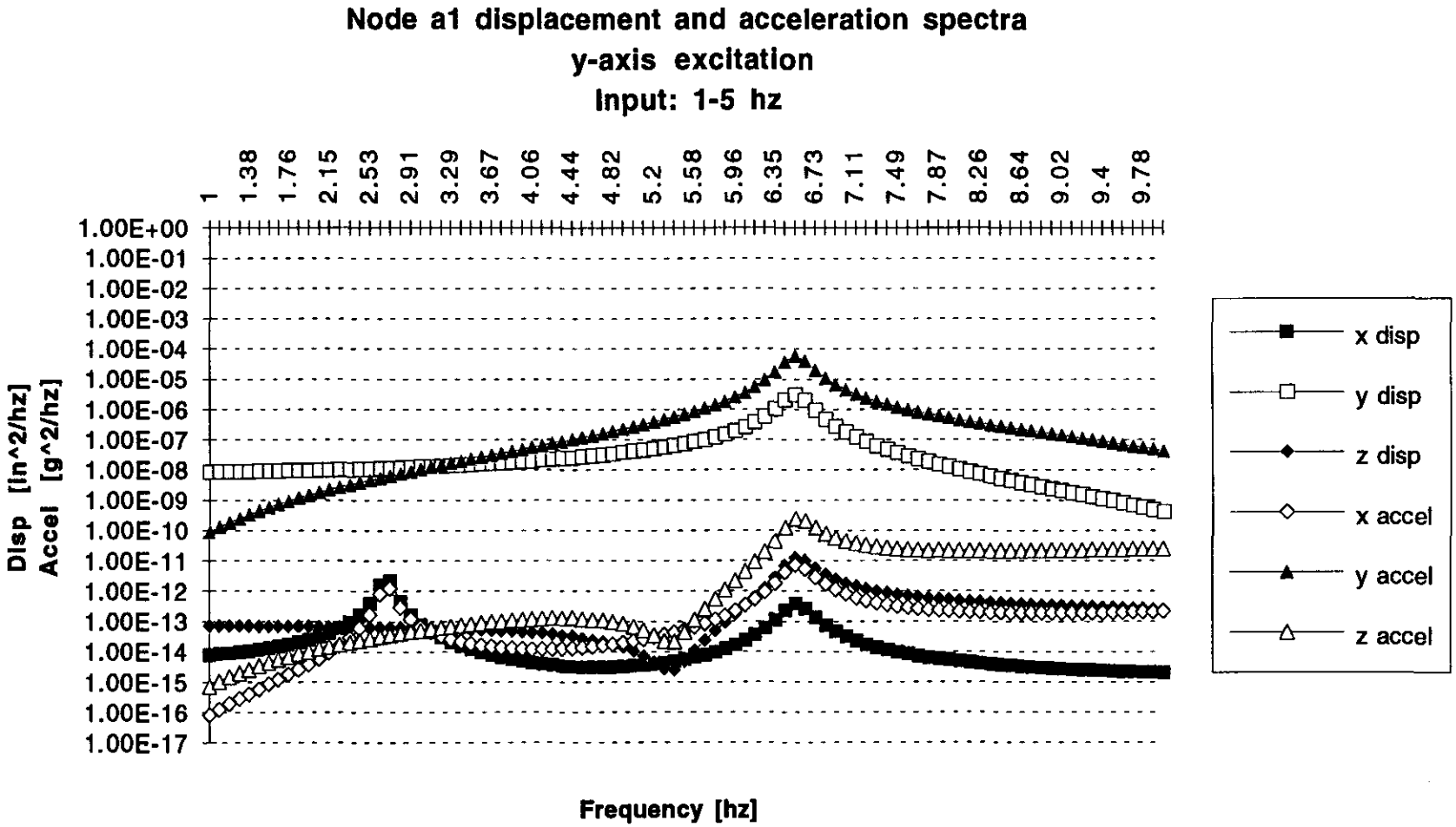

GEM vessel rms displacement response
250
200
150
100
50
0
rms displacement
[microns]
a1
b1
bs1
Location
1-
100hz
z excit
1-
100hz
y excit
1-
100hz
x excit
1-
100hz
z excit
1-20hz
y excit
1-20hz
x excit
1-20hz
z excit
1-5 hz
y excit
1-5 hz
x excit
1-5 hz
Bandwidth and excitation direction

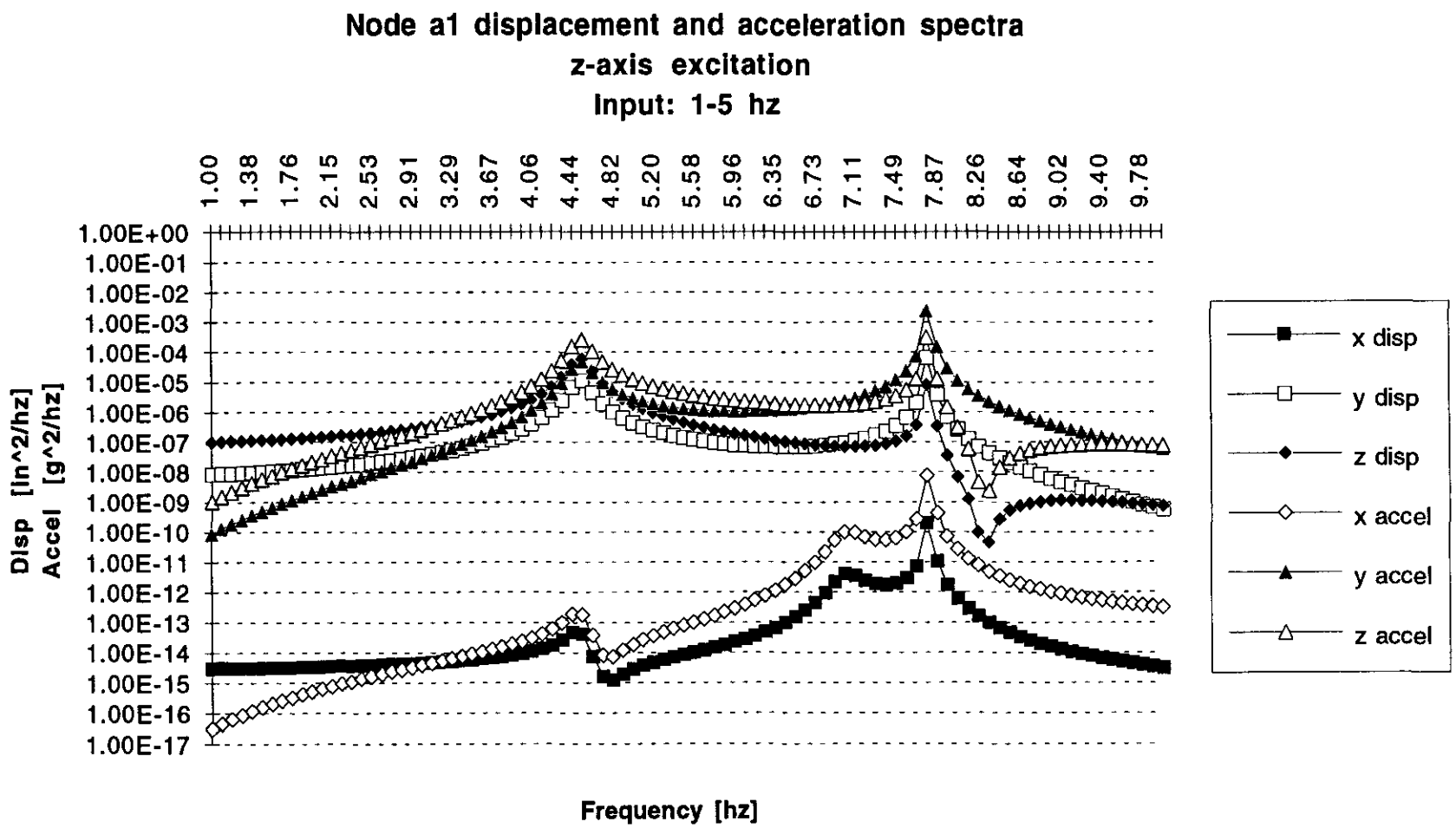
Figure 7

PSD #1 input 1-5 hz										
	RMS displacement [inches]				RMS displacement [microns]			SRSS [microns]		
node	x excit	y excit	z excit		x	y	z	x excit	y excit	z excit
a1x	7.9738E-03	8.0779E-07	5.3262E-06		202.53	0.02	0.14	203	28	141
a1y	2.0637E-06	1.1120E-03	3.4533E-03		0.05	28.24	87.71			
a1z	7.2129E-07	2.4762E-06	4.3412E-03		0.02	0.06	110.27			
b1x	4.4080E-03	7.3242E-04	2.1898E-03		111.96	18.60	55.62	113	20	94
b1y	6.6728E-04	2.4551E-04	8.9856E-04		16.95	6.24	22.82			
b1z	5.7217E-06	3.0619E-06	2.8518E-03		0.15	0.08	72.44			
bs1x	9.3559E-04	2.2649E-04	6.1634E-04		23.76	5.75	15.66	25	6	65
bs1y	2.4544E-04	5.2652E-05	4.8791E-04		6.23	1.34	12.39			
bs1z	2.0124E-05	4.0105E-06	2.4180E-03		0.51	0.10	61.42			
PSD #2 input 1-20 hz										
	RMS displacement [inches]				RMS displacement [microns]			SRSS [microns]		
node	x excit	y excit	z excit		x	y	z	x excit	y excit	z excit
a1x	3.7769E-03	2.4888E-04	6.1100E-04		95.93	6.32	15.52	96	37	75
a1y	2.3788E-06	1.4510E-03	1.9978E-03		0.06	36.86	50.74			
a1z	1.3825E-06	5.6836E-05	2.0848E-03		0.04	1.44	52.95			
b1x	2.1888E-03	7.1217E-04	1.4270E-03		55.60	18.09	36.25	57	19	54
b1y	4.6204E-04	2.1917E-04	6.0404E-04		11.74	5.57	15.34			
b1z	1.1613E-05	9.4438E-05	1.4696E-03		0.29	2.40	37.33			
bs1x	7.0128E-04	1.4951E-03	5.1294E-04		17.81	37.98	13.03	18	40	35
bs1y	1.3915E-04	4.9749E-04	2.6969E-04		3.53	12.64	6.85			
bs1z	1.8020E-05	9.2879E-05	1.2432E-03		0.46	2.36	31.58			
PSD #3 input 1-100 hz										
	RMS displacement [inches]				RMS displacement [microns]			SRSS [microns]		
node	x excit	y excit	z excit		x	y	z	x excit	y excit	z excit
a1x	1.6566E-03	1.0916E-04	2.6799E-04		42.08	2.77	6.81	42	16	33
a1y	1.0434E-06	6.3641E-04	8.7627E-04		0.03	16.16	22.26			
a1z	6.0640E-07	2.4929E-05	9.1443E-04		0.02	0.63	23.23			
b1x	9.6003E-04	3.1237E-04	6.2588E-04		24.38	7.93	15.90	25	8	24
b1y	2.0266E-04	9.6130E-05	2.6494E-04		5.15	2.44	6.73			
b1z	5.0935E-06	4.1422E-05	6.4495E-04		0.13	1.05	16.38			
bs1x	3.0759E-04	6.5576E-04	2.2498E-04		7.81	16.66	5.71	8	18	15
bs1y	6.1035E-05	2.1819E-04	1.1829E-04		1.55	5.54	3.00			
bs1z	7.9037E-06	4.0738E-05	5.4530E-04		0.20	1.03	13.85			
Notes:										
node a1 is at TDC										
node b1 is at 3 O'clock										
node bs1 is near the base of the endring where the big wheel would connect										

Table 1


Node a1 displacement and acceleration spectra
x-axis excitation
1-5 hz PSD input
1.00
1.38
1.76
2.15
2.53
2.91
3.29
3.67
4.06
4.44
4.82
5.20
5.58
5.96
6.35
6.73
7.11
7.49
7.87
8.26
8.64
9.02
9.40
9.78
1.00E+00
1.00E-02
1.00E-04
1.00E-06
1.00E-08
1.00E-10
1.00E-12
1.00E-14
1.00E-16
1.00E-18
1.00E-20
Disp [in^2/hz]
Accel [g^2/hz]
Frequency [hz]
x disp
y disp
z disp
x accel
y accel
z accel


Node a1 displacement and acceleration spectra
y-axis excitation
Input: 1-5 hz
1
1.38
1.76
2.15
2.53
2.91
3.29
3.67
4.06
4.44
4.82
5.2
5.58
5.96
6.35
6.73
7.11
7.49
7.87
8.26
8.64
9.02
9.4
9.78
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10
1.00E-11
1.00E-12
1.00E-13
1.00E-14
1.00E-15
1.00E-16
1.00E-17
Disp [in^2/hz]
Accel [g^2/hz]
Frequency [hz]
x disp
y disp
z disp
x accel
y accel
z accel


Node a1 displacement and acceleration spectra
z-axis excitation
Input: 1-5 hz
1.00
1.38
1.76
2.15
2.53
2.91
3.29
3.67
4.06
4.44
4.82
5.20
5.58
5.96
6.35
6.73
7.11
7.49
7.87
8.26
8.64
9.02
9.40
9.78
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10
1.00E-11
1.00E-12
1.00E-13
1.00E-14
1.00E-15
1.00E-16
1.00E-17
Disp [in^2/hz]
Accel [g^2/hz]
Frequency [hz]
x disp
y disp
z disp
x accel
y accel
z accel

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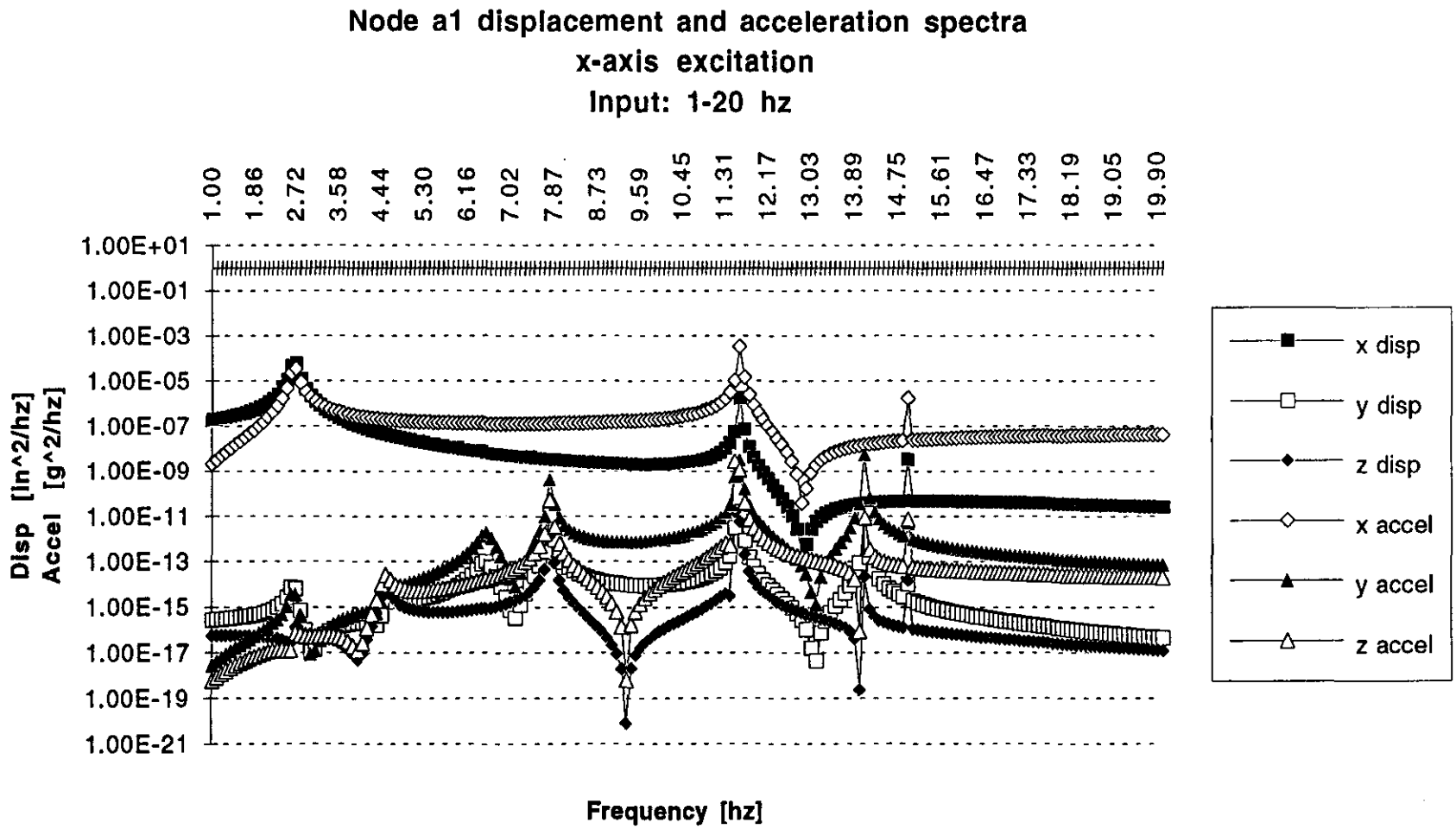
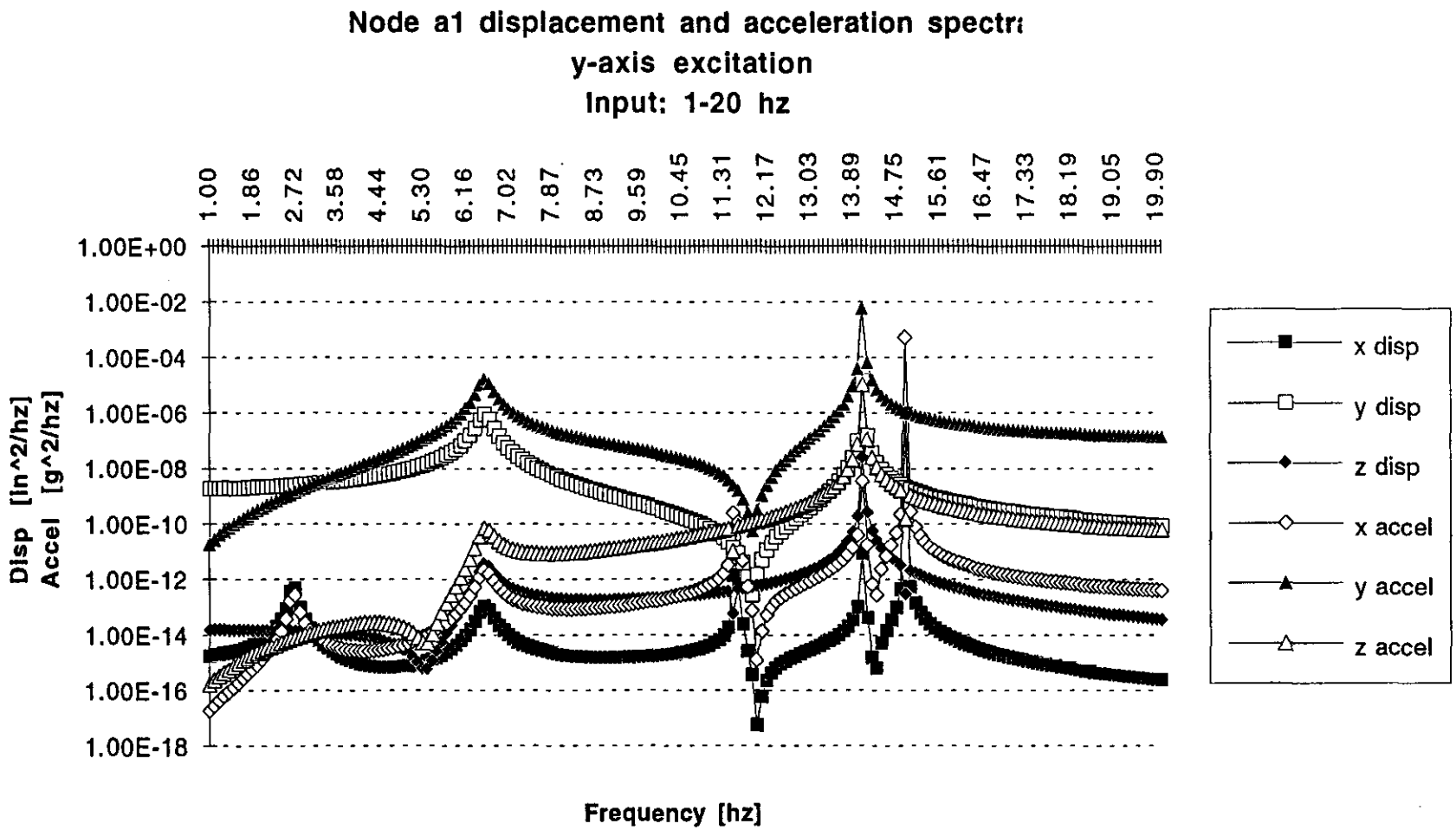
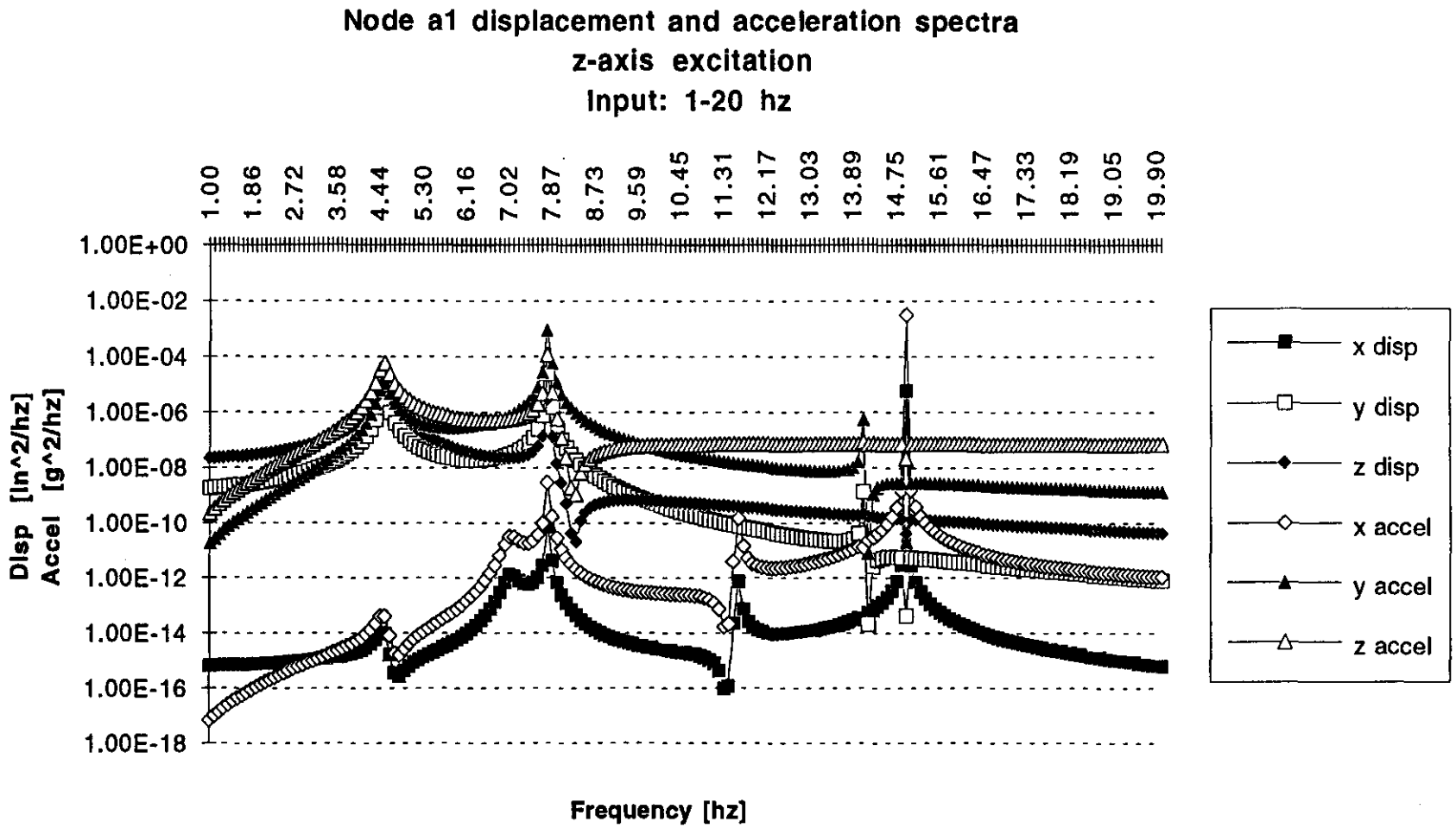

Node a1 displacement and acceleration spectra
x-axis excitation
Input: 1-20 hz
1.00
1.86
2.72
3.58
4.44
5.30
6.16
7.02
7.87
8.73
9.59
10.45
11.31
12.17
13.03
13.89
14.75
15.61
16.47
17.33
18.19
19.05
19.90
1.00E+01
1.00E-01
1.00E-03
1.00E-05
1.00E-07
1.00E-09
1.00E-11
1.00E-13
1.00E-15
1.00E-17
1.00E-19
1.00E-21
Disp [in^2/hz]
Accel [g^2/hz]
Frequency [hz]
x disp
y disp
z disp
x accel
y accel
z accel


Node a1 displacement and acceleration spectra
y-axis excitation
Input: 1-20 hz
1.00
1.86
2.72
3.58
4.44
5.30
6.16
7.02
7.87
8.73
9.59
10.45
11.31
12.17
13.03
13.89
14.75
15.61
16.47
17.33
18.19
19.05
19.90
1.00E+00
1.00E-02
1.00E-04
1.00E-06
1.00E-08
1.00E-10
1.00E-12
1.00E-14
1.00E-16
1.00E-18
Disp [in^2/hz]
Accel [g^2/hz]
Frequency [hz]
x disp
y disp
z disp
x accel
y accel
z accel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z-axis excitation
Input: 1-20 hz
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4.44
5.30
6.16
7.02
7.87
8.73
9.59
10.45
11.31
12.17
13.03
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14.75
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16.47
17.33
18.19
19.05
19.90
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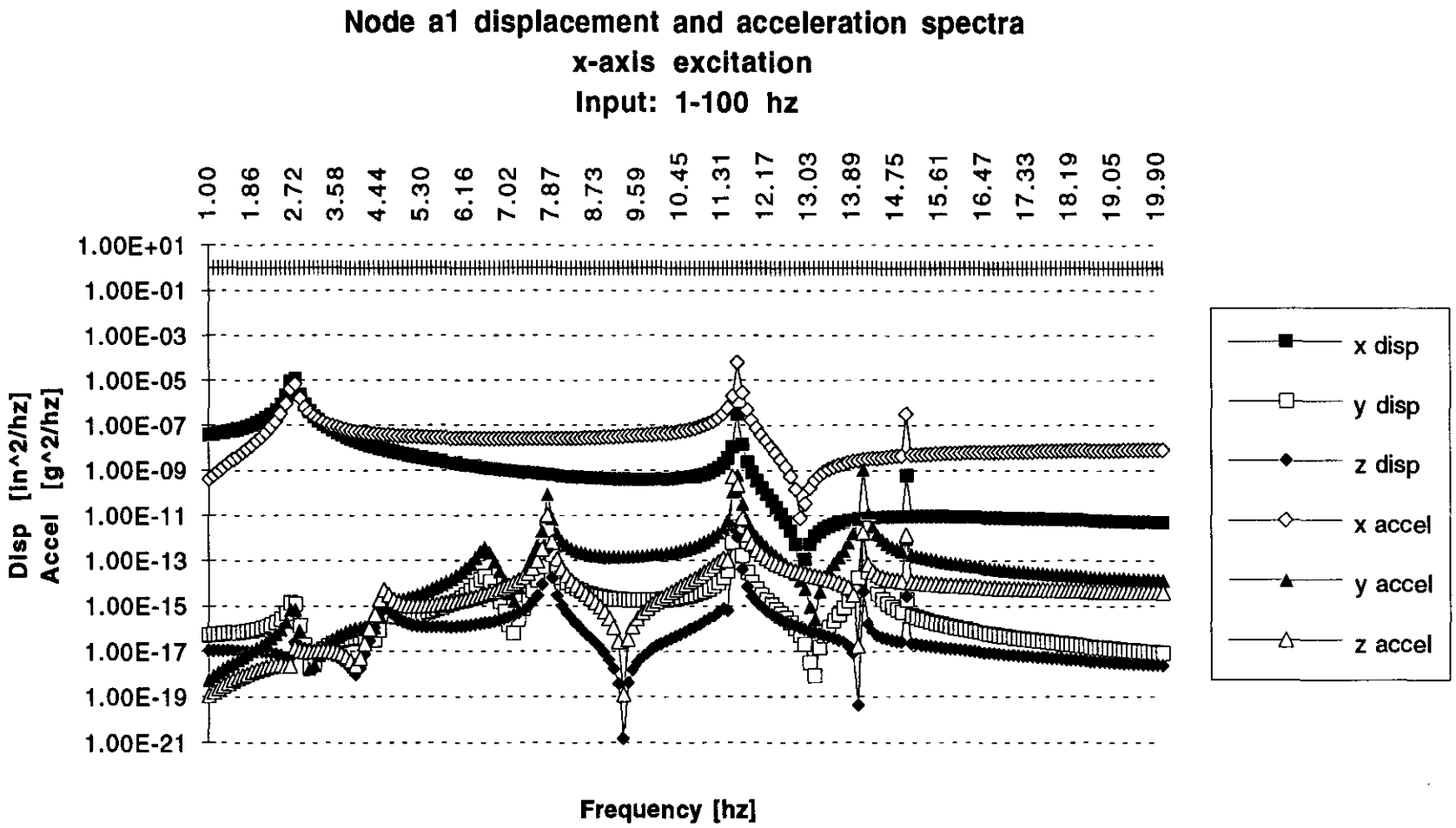
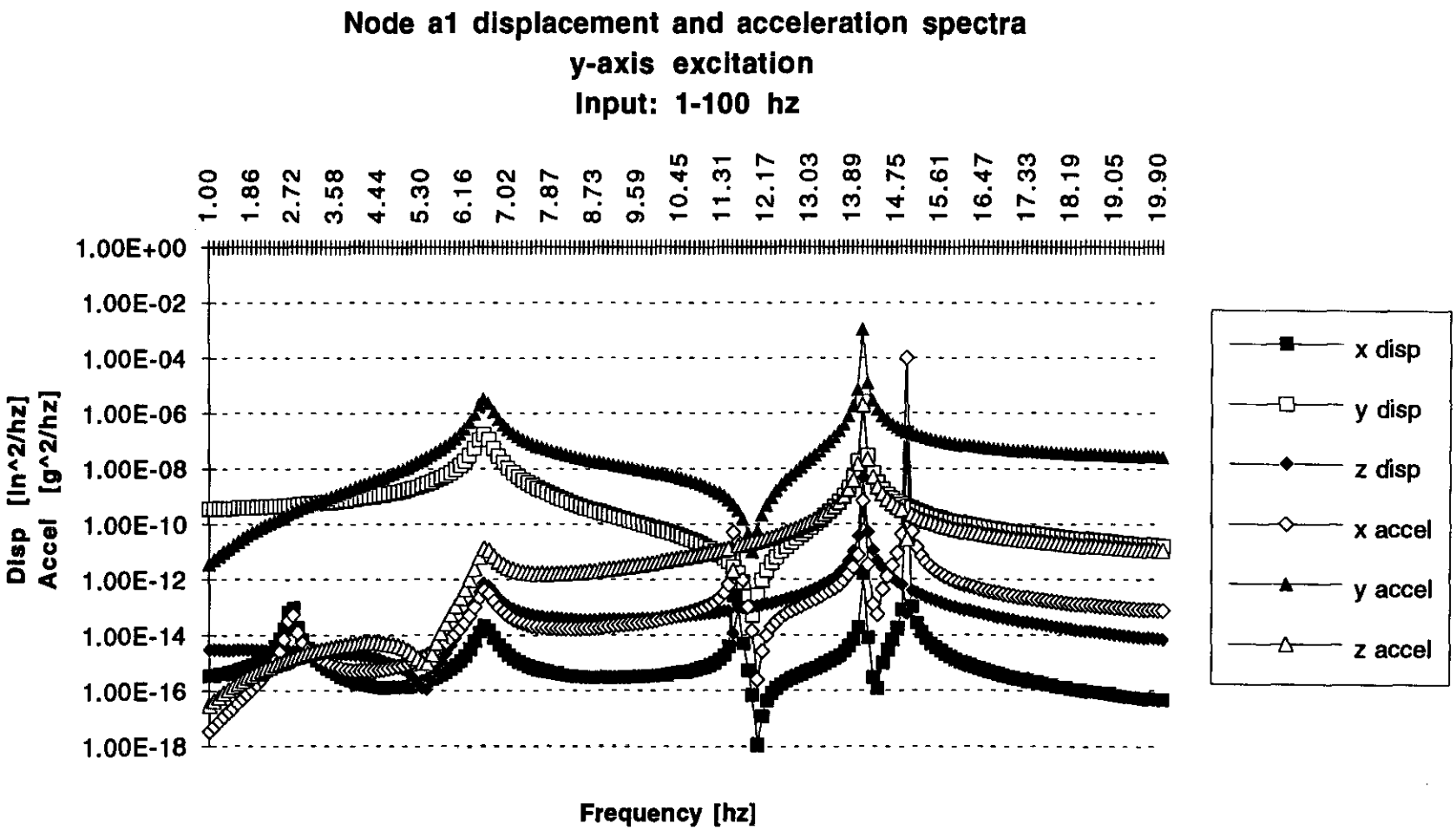
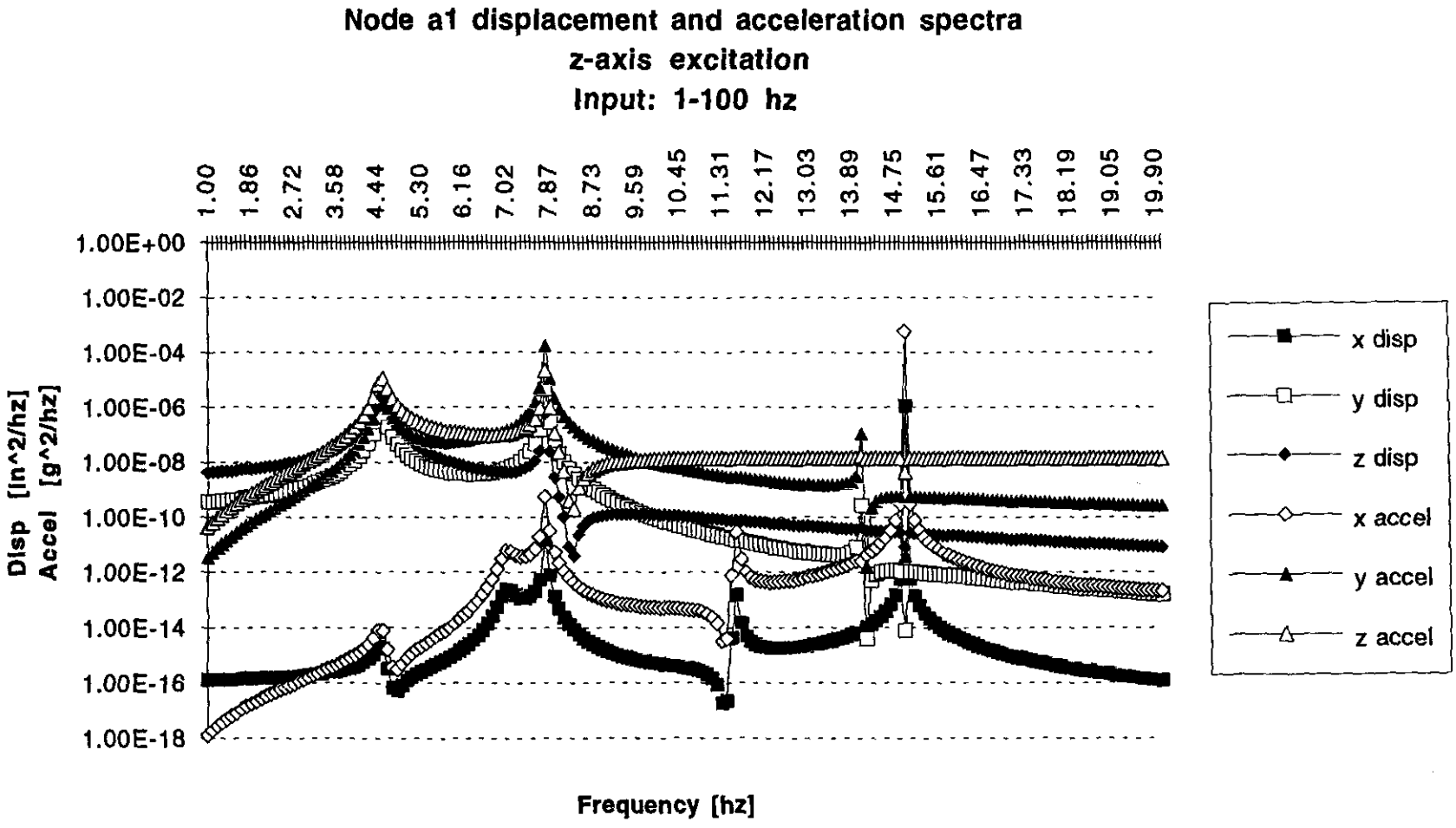
1.00E-02
1.00E-04
1.00E-06
1.00E-08
1.00E-10
1.00E-12
1.00E-14
1.00E-16
1.00E-18
Disp [in^2/hz]
Accel [g^2/hz]
Frequency [hz]
x disp
y disp
z disp
x accel
y accel
z accel


Node a1 displacement and acceleration spectra
x-axis excitation
Input: 1-100 hz
1.00
1.86
2.72
3.58
4.44
5.30
6.16
7.02
7.87
8.73
9.59
10.45
11.31
12.17
13.03
13.89
14.75
15.61
16.47
17.33
18.19
19.05
19.90
1.00E+01
1.00E-01
1.00E-03
1.00E-05
1.00E-07
1.00E-09
1.00E-11
1.00E-13
1.00E-15
1.00E-17
1.00E-19
1.00E-21
Disp [in^2/hz]
Accel [g^2/hz]
Frequency [hz]
x disp
y disp
z disp
x accel
y accel
z accel


Node a1 displacement and acceleration spectra
y-axis excitation
Input: 1-100 hz
1.00
1.86
2.72
3.58
4.44
5.30
6.16
7.02
7.87
8.73
9.59
10.45
11.31
12.17
13.03
13.89
14.75
15.61
16.47
17.33
18.19
19.05
19.90
1.00E+00
1.00E-02
1.00E-04
1.00E-06
1.00E-08
1.00E-10
1.00E-12
1.00E-14
1.00E-16
1.00E-18
Disp [in^2/hz]
Accel [g^2/hz]
Frequency [hz]
x disp
y disp
z disp
x accel
y accel
z accel


Node a1 displacement and acceleration spectra
z-axis excitation
Input: 1-100 hz
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1.86
2.72
3.58
4.44
5.30
6.16
7.02
7.87
8.73
9.59
10.45
11.31
12.17
13.03
13.89
14.75
15.61
16.47
17.33
18.19
19.05
19.90
1.00E+00
1.00E-02
1.00E-04
1.00E-06
1.00E-08
1.00E-10
1.00E-12
1.00E-14
1.00E-16
1.00E-18
Disp [in^2/hz]
Accel [g^2/hz]
Frequency [hz]
x disp
y disp
z disp
x accel
y accel
z accel

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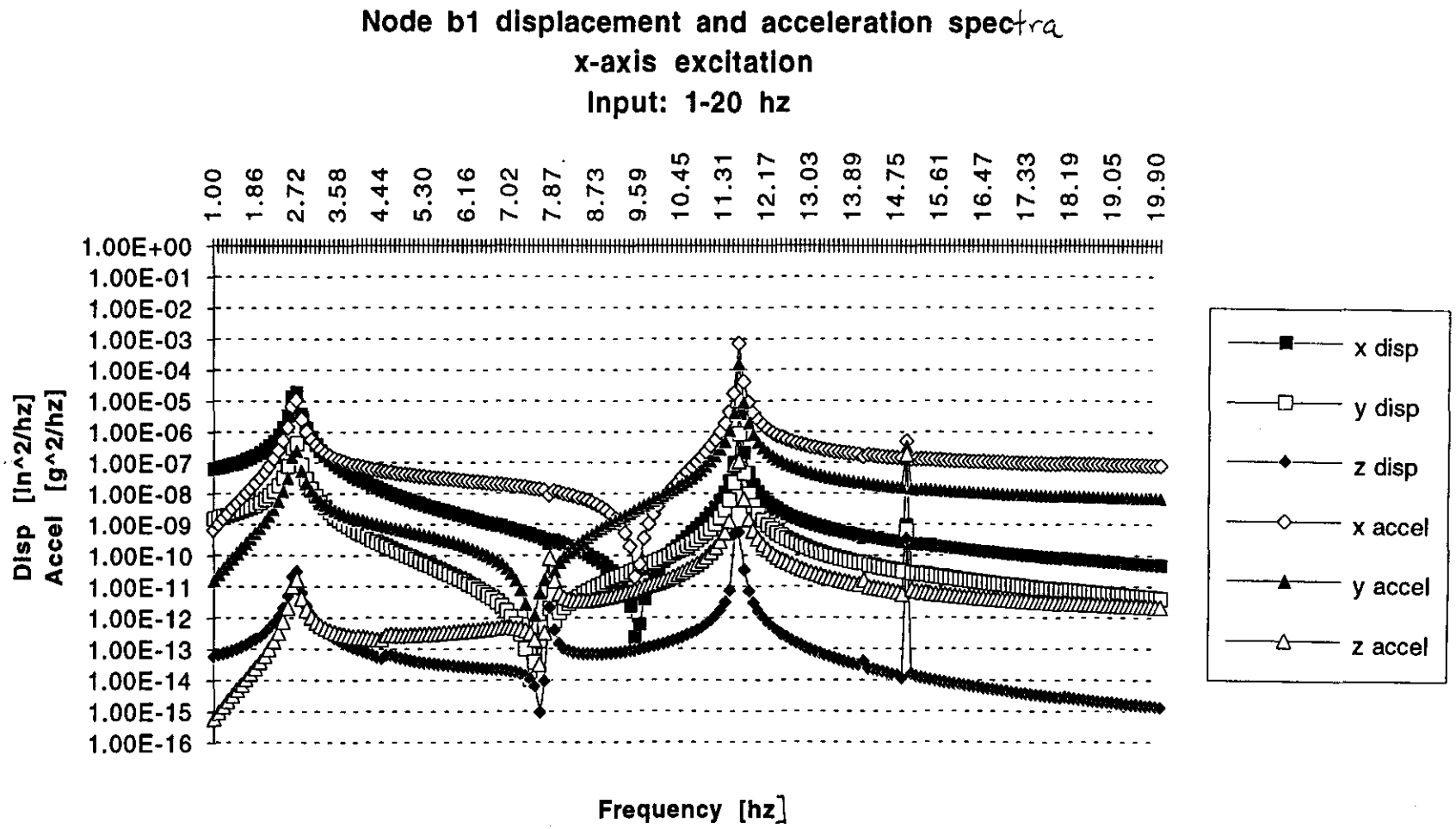
Node b1 displacement and acceleration spectra
x-axis excitation
Input: 1-20 hz
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1.86
2.72
3.58
4.44
5.30
6.16
7.02
7.87
8.73
9.59
10.45
11.31
12.17
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Frequency [hz]
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y disp
z disp
x accel
y accel
z accel

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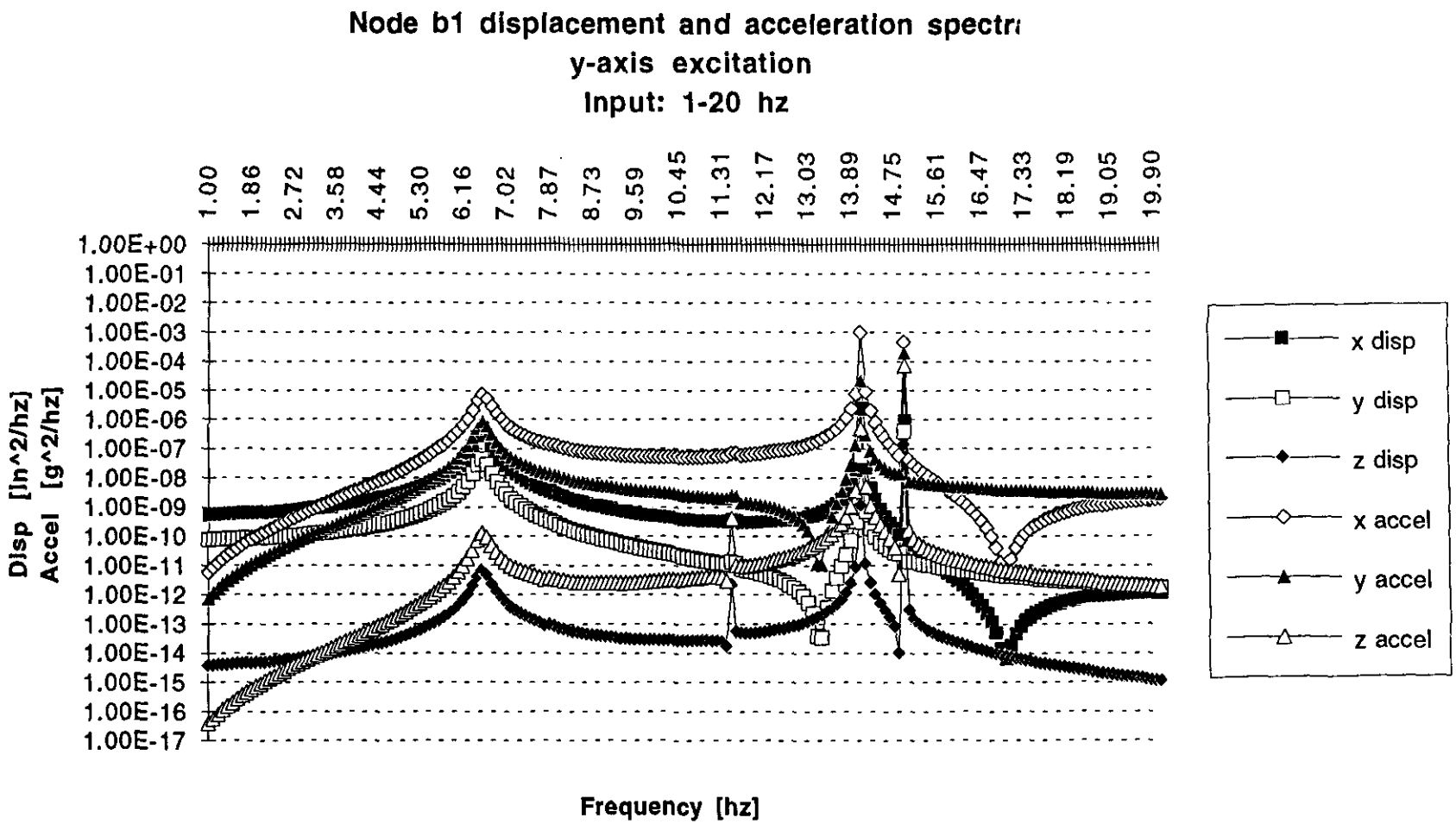
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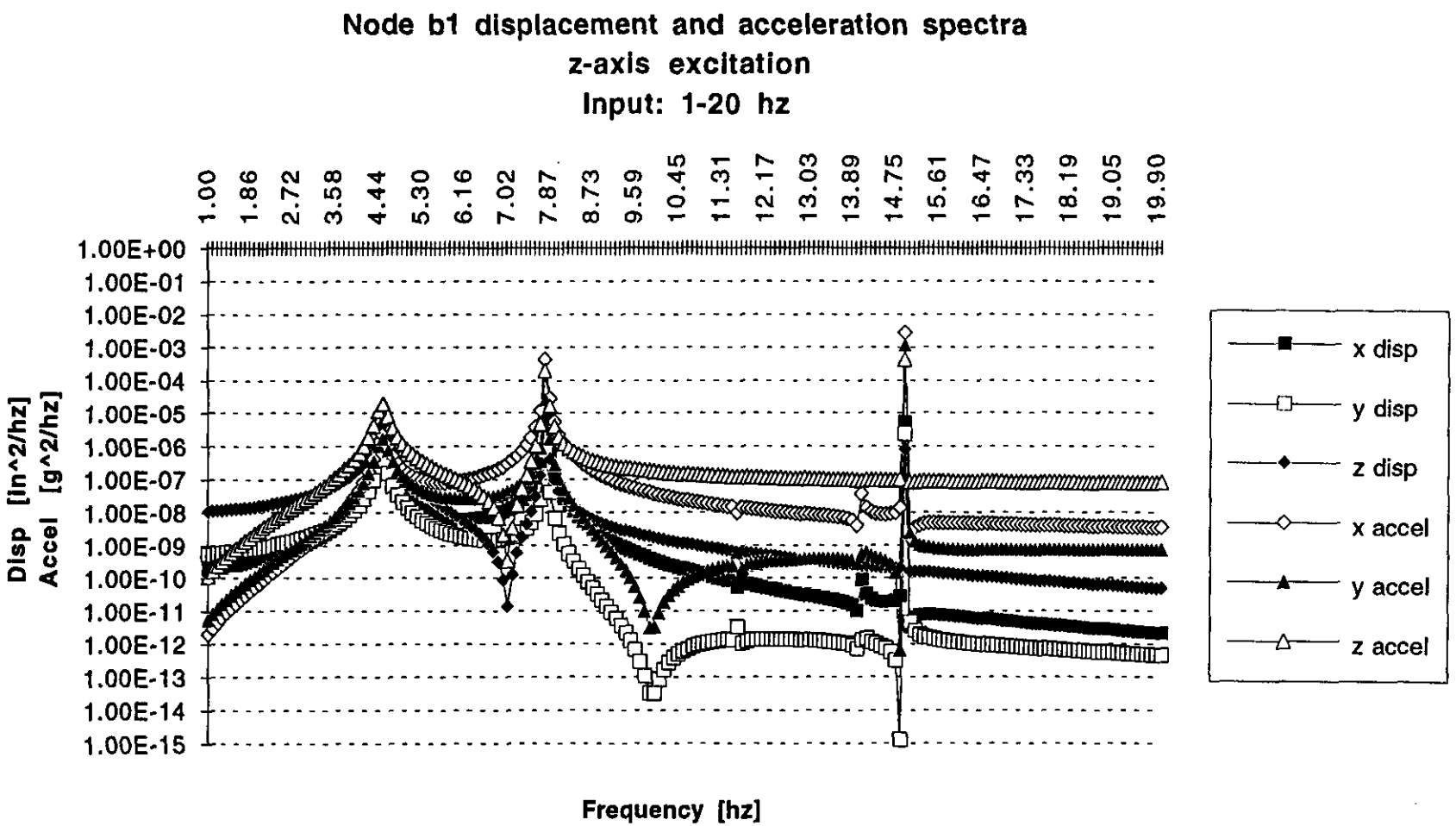
10/8/92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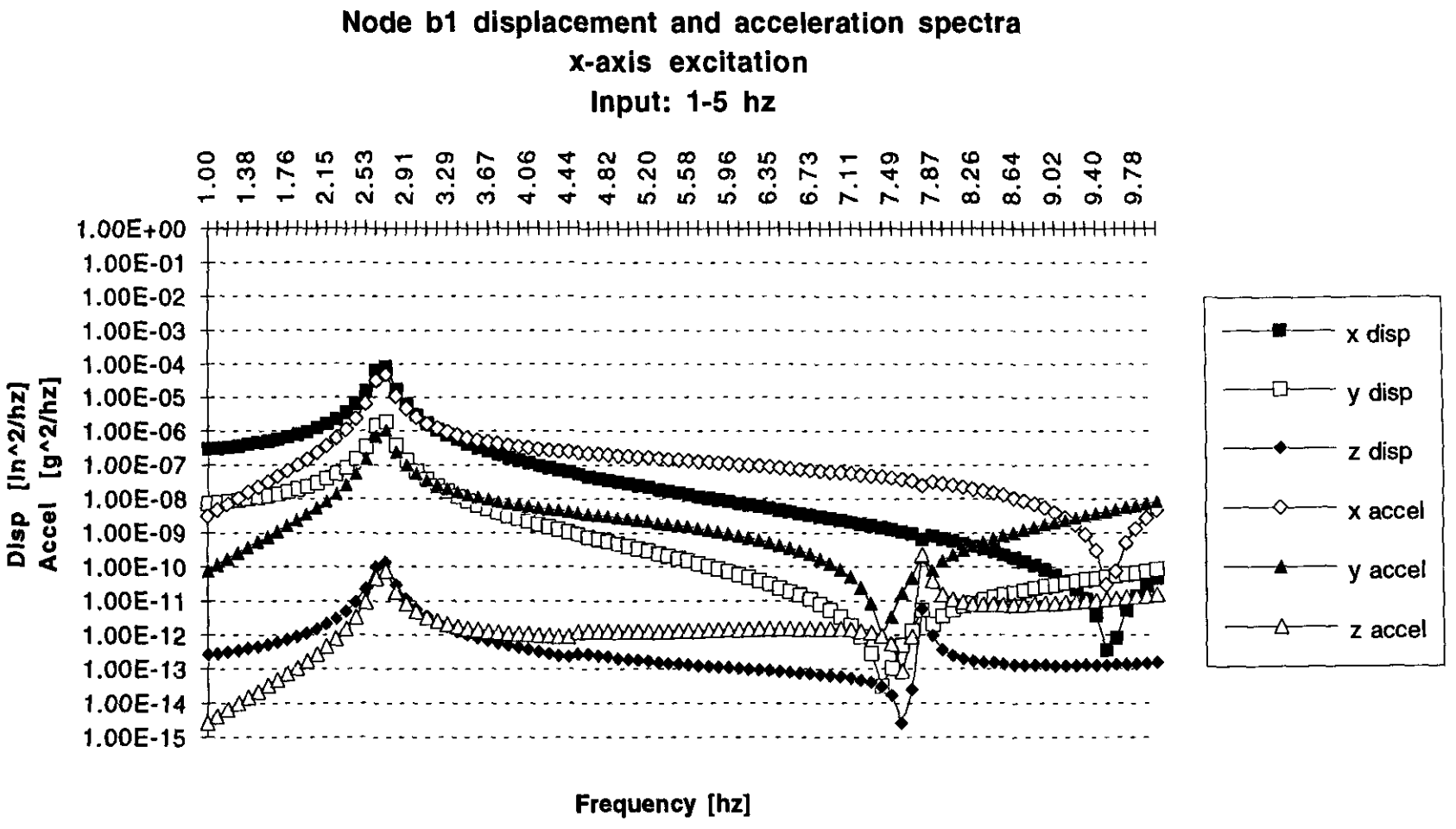
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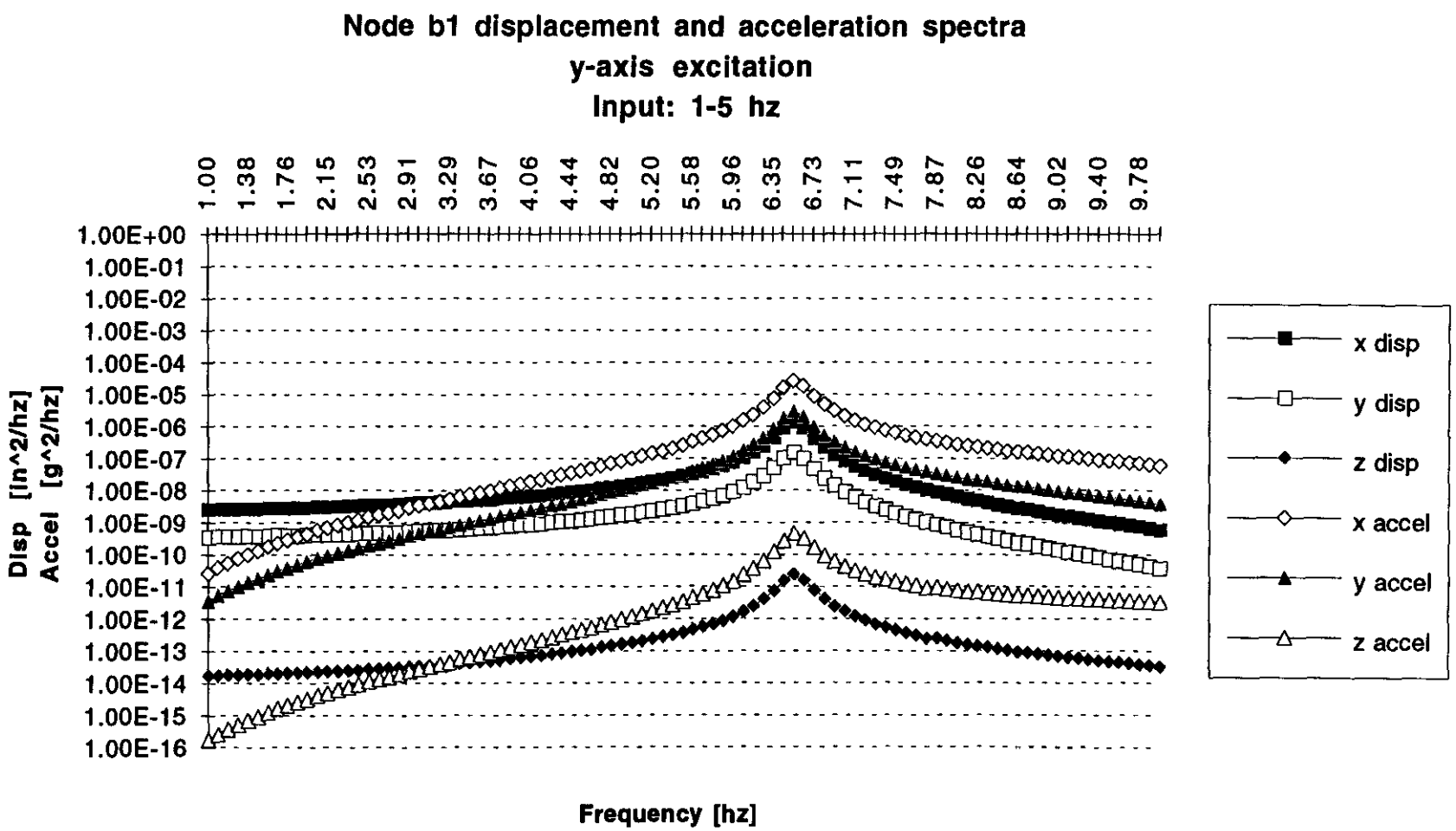
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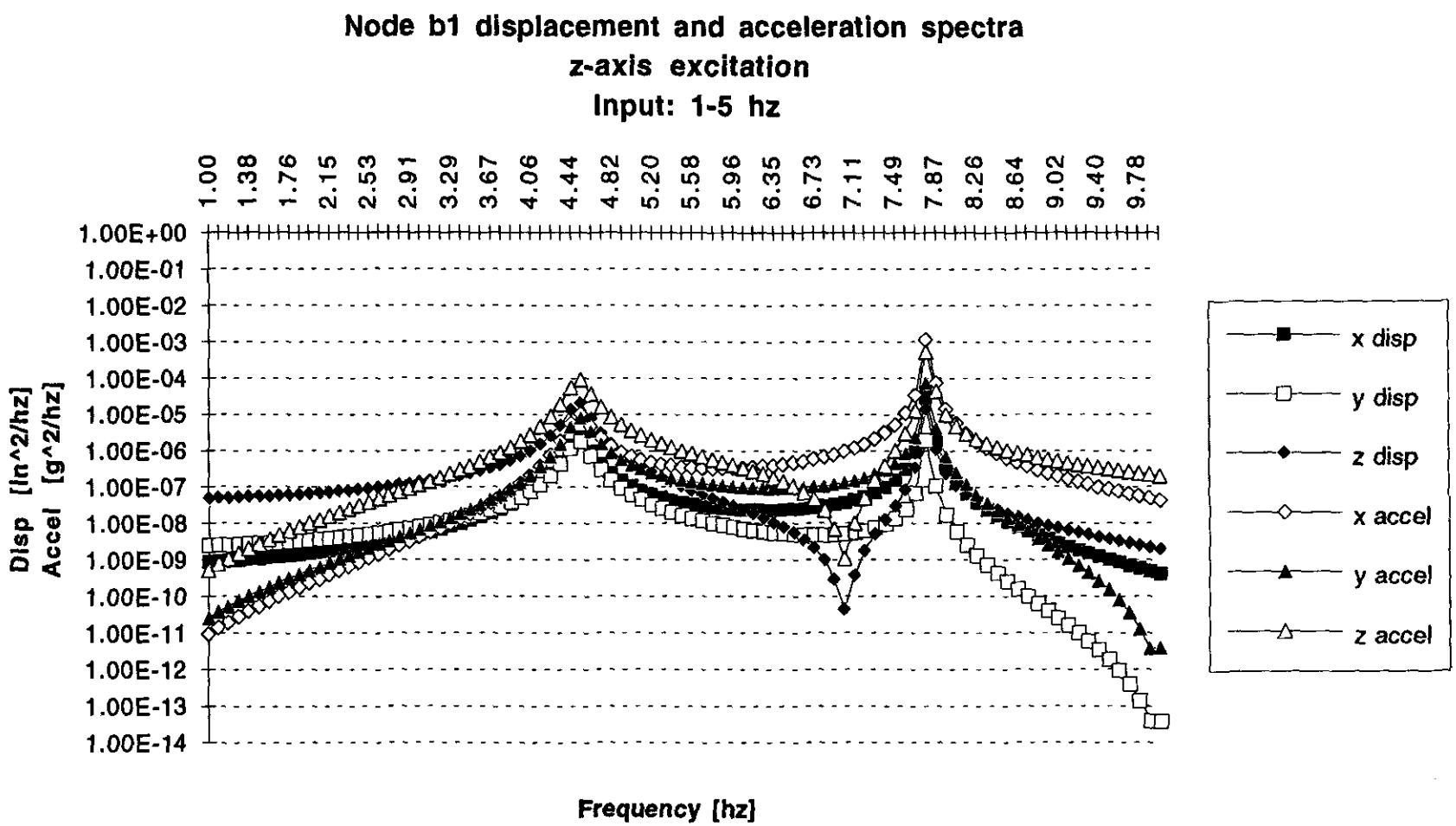
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Frequency [hz]
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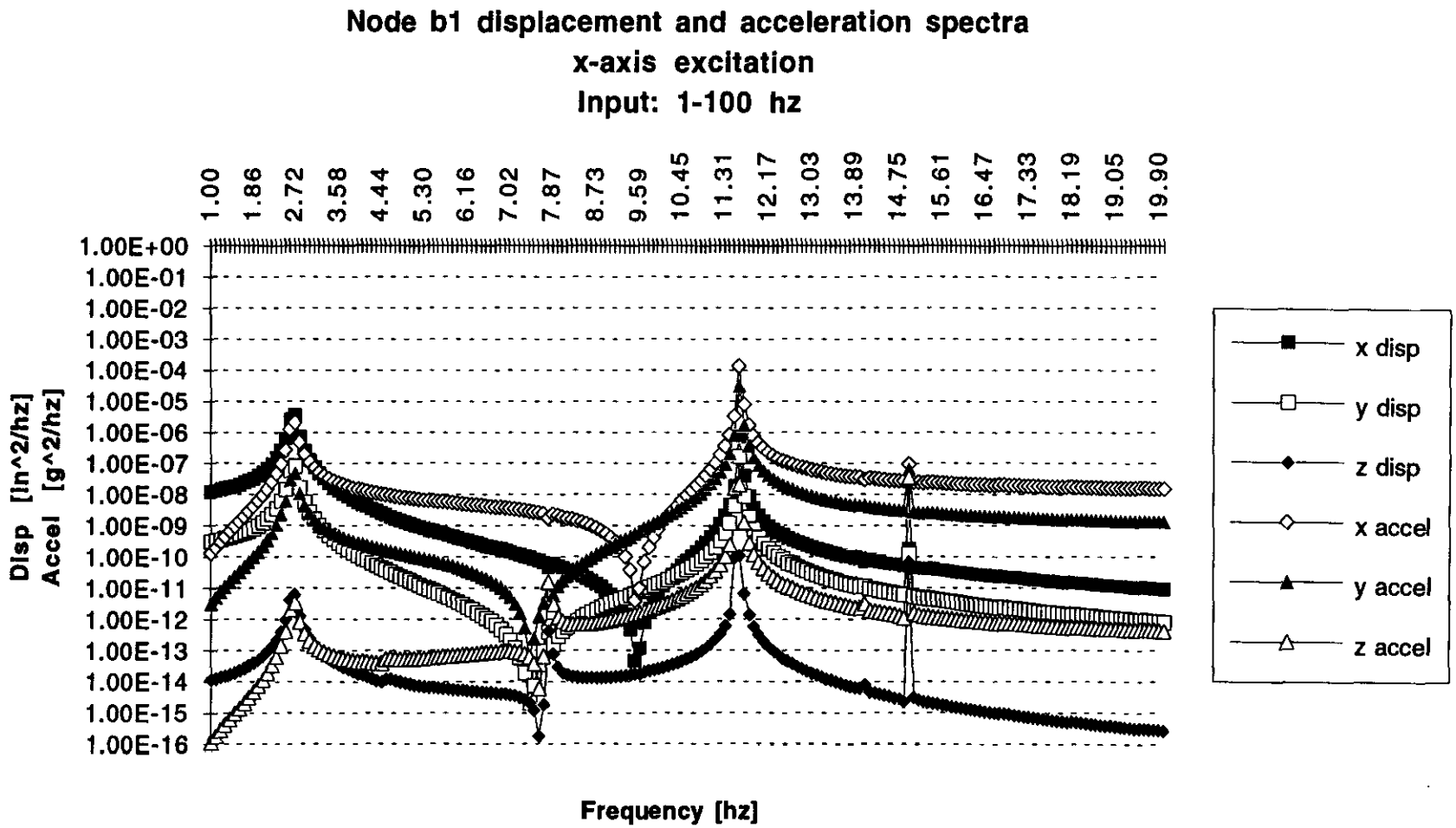
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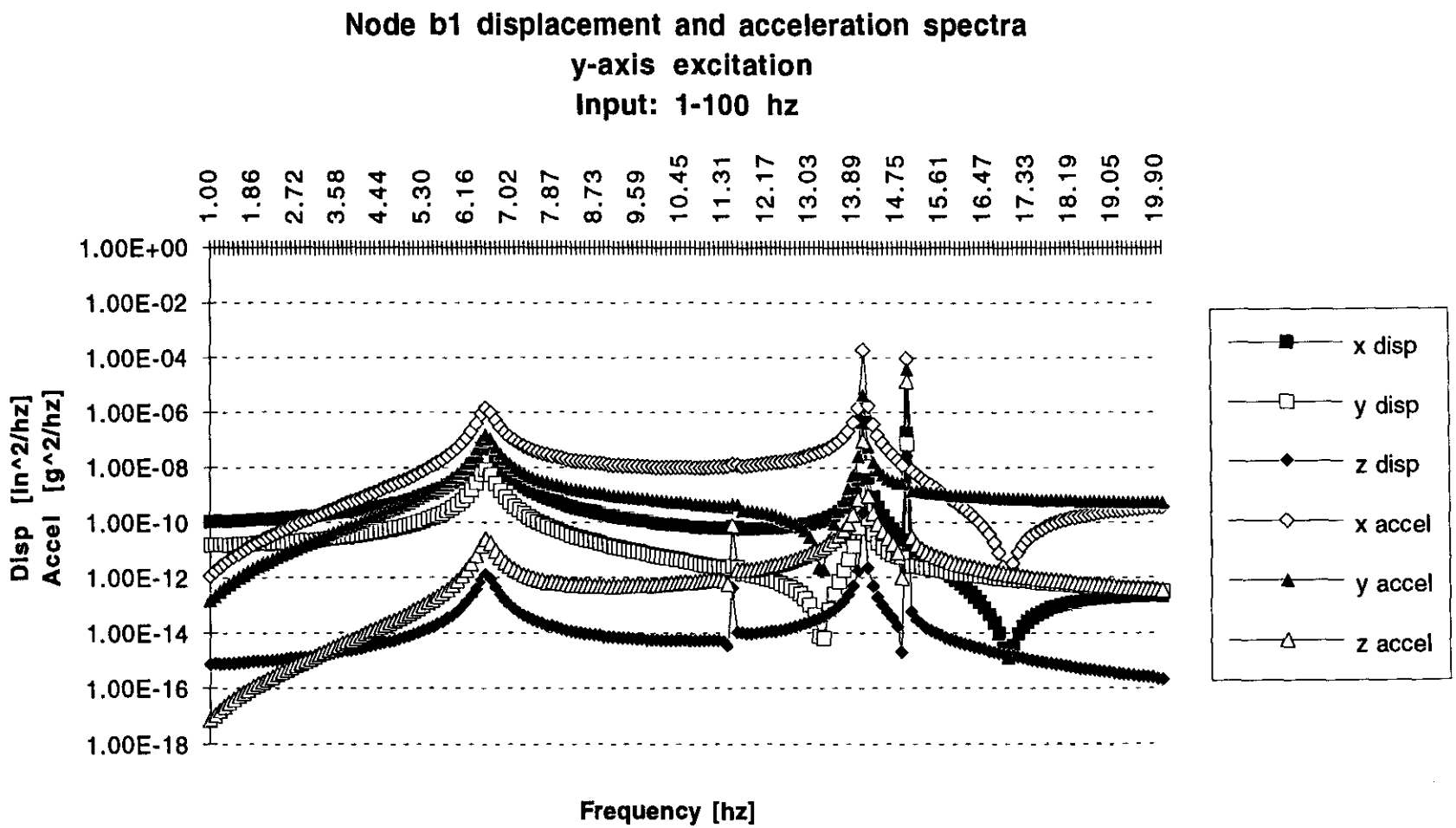
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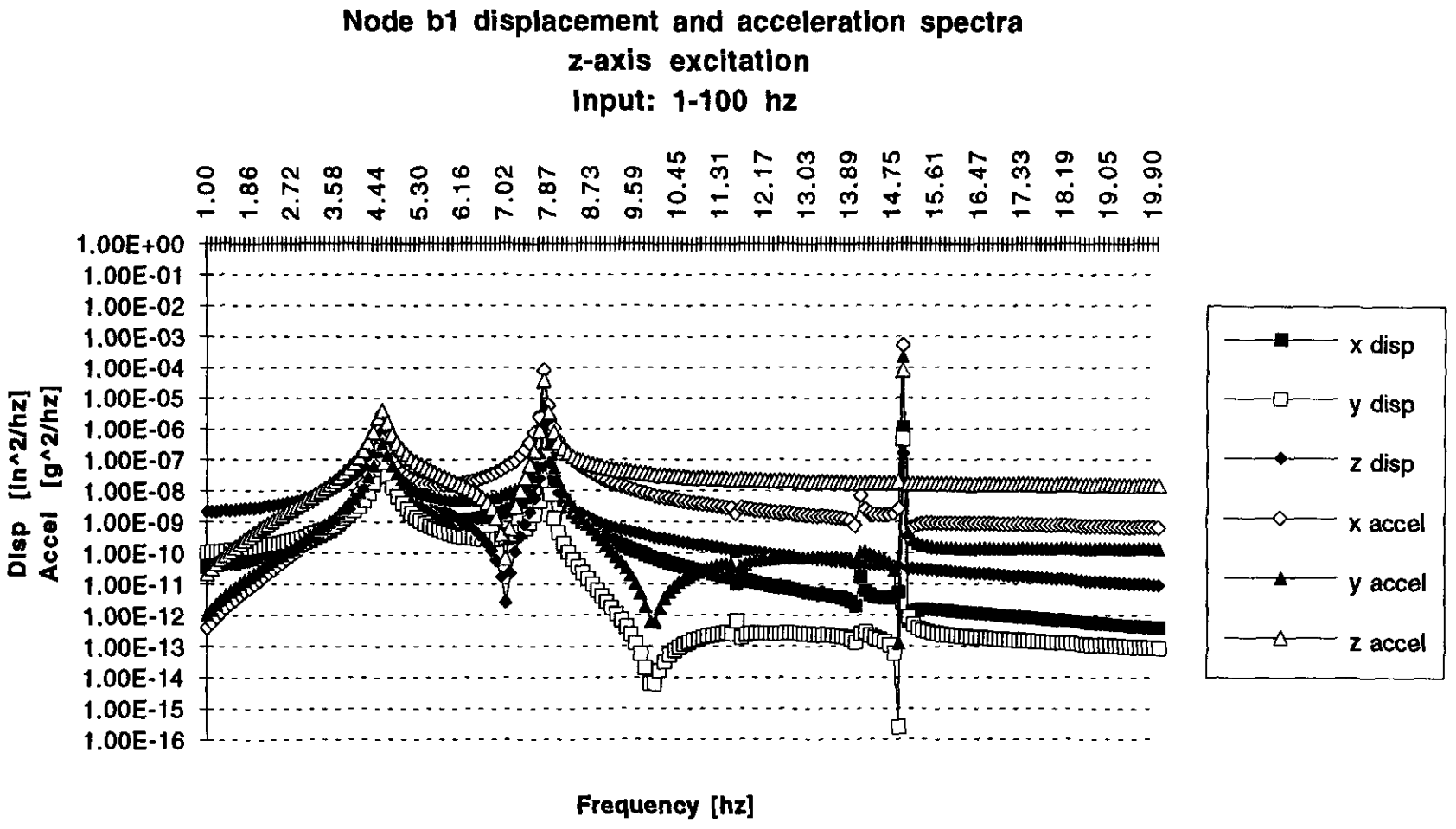
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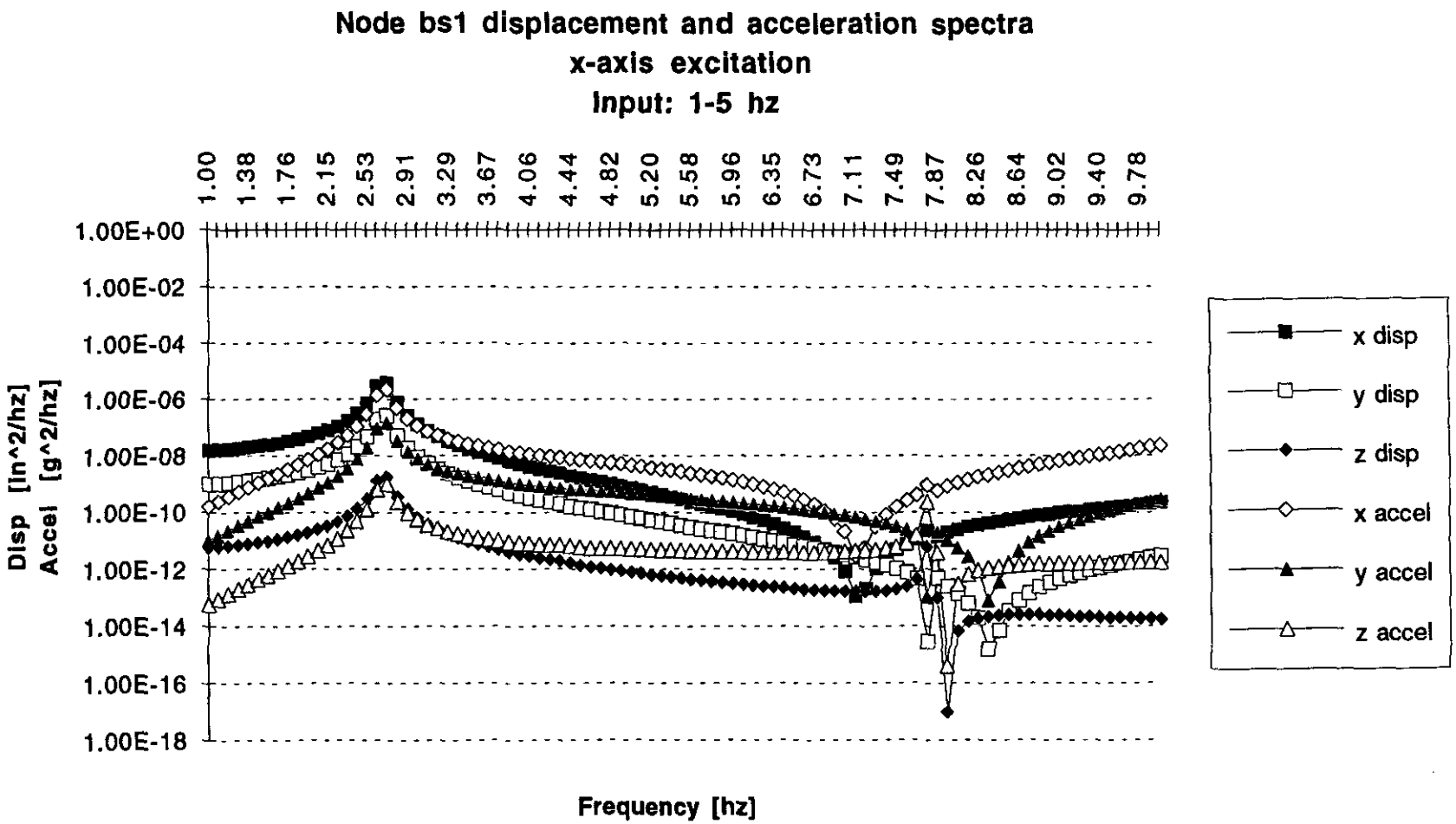
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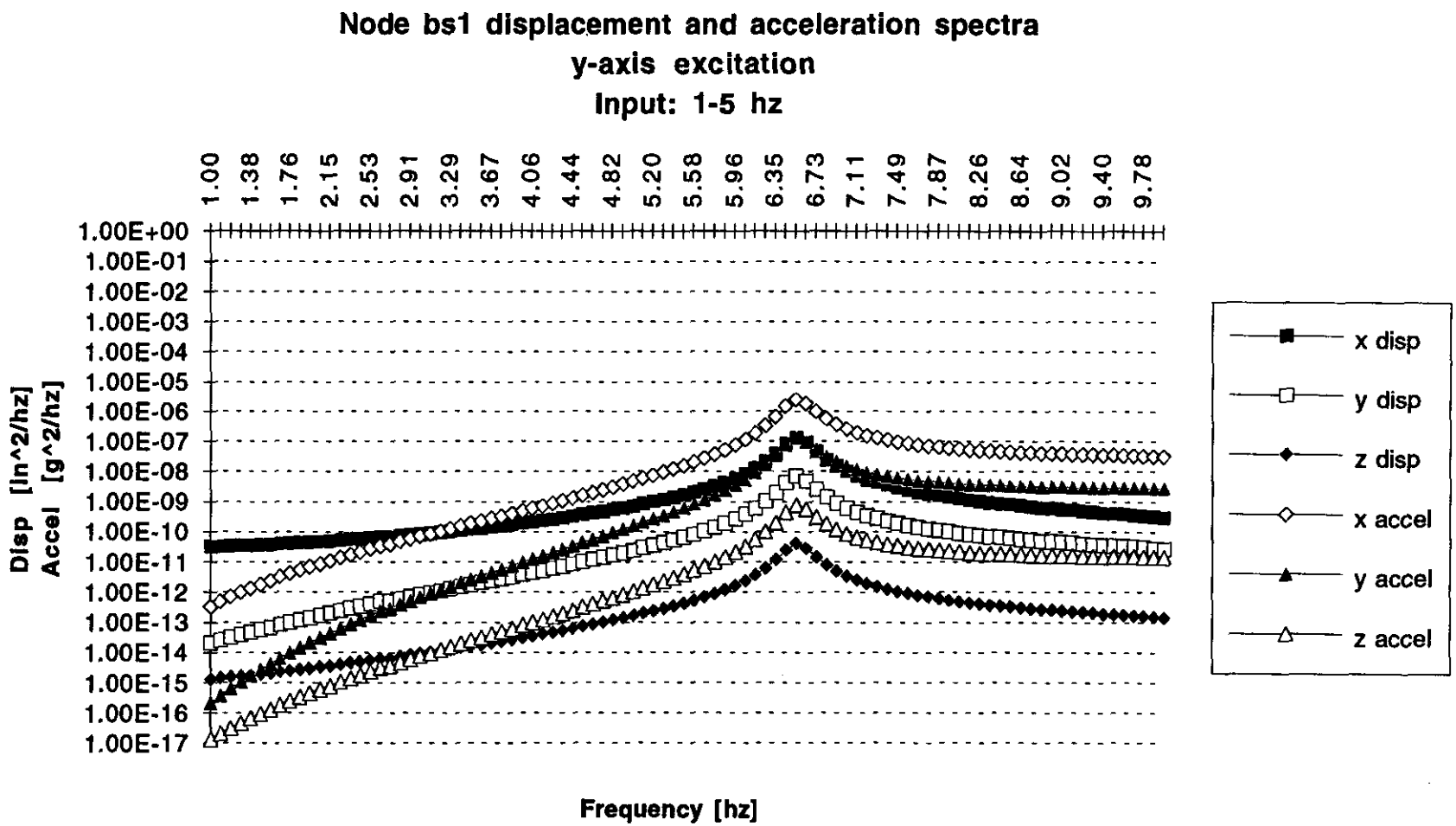
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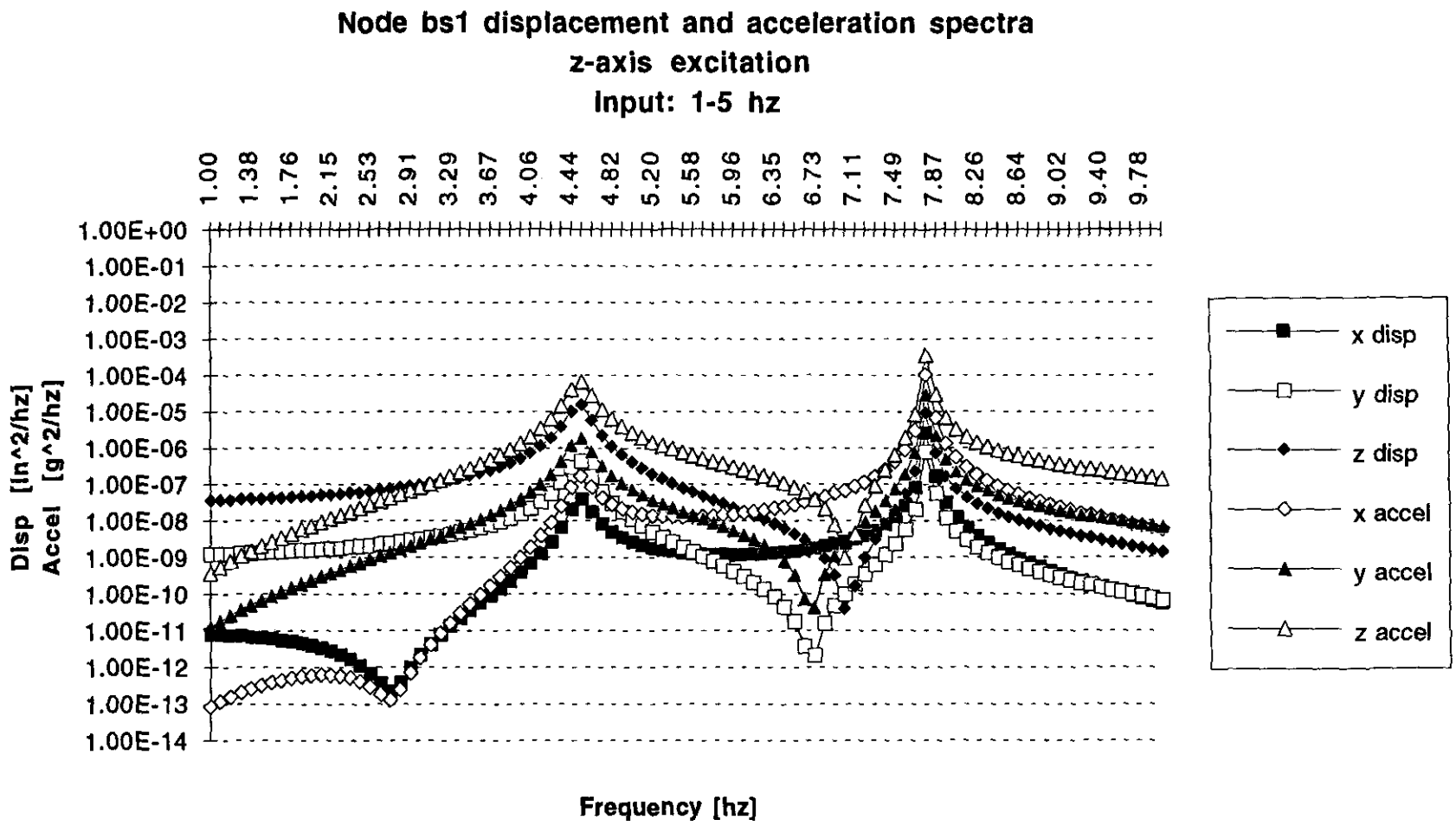
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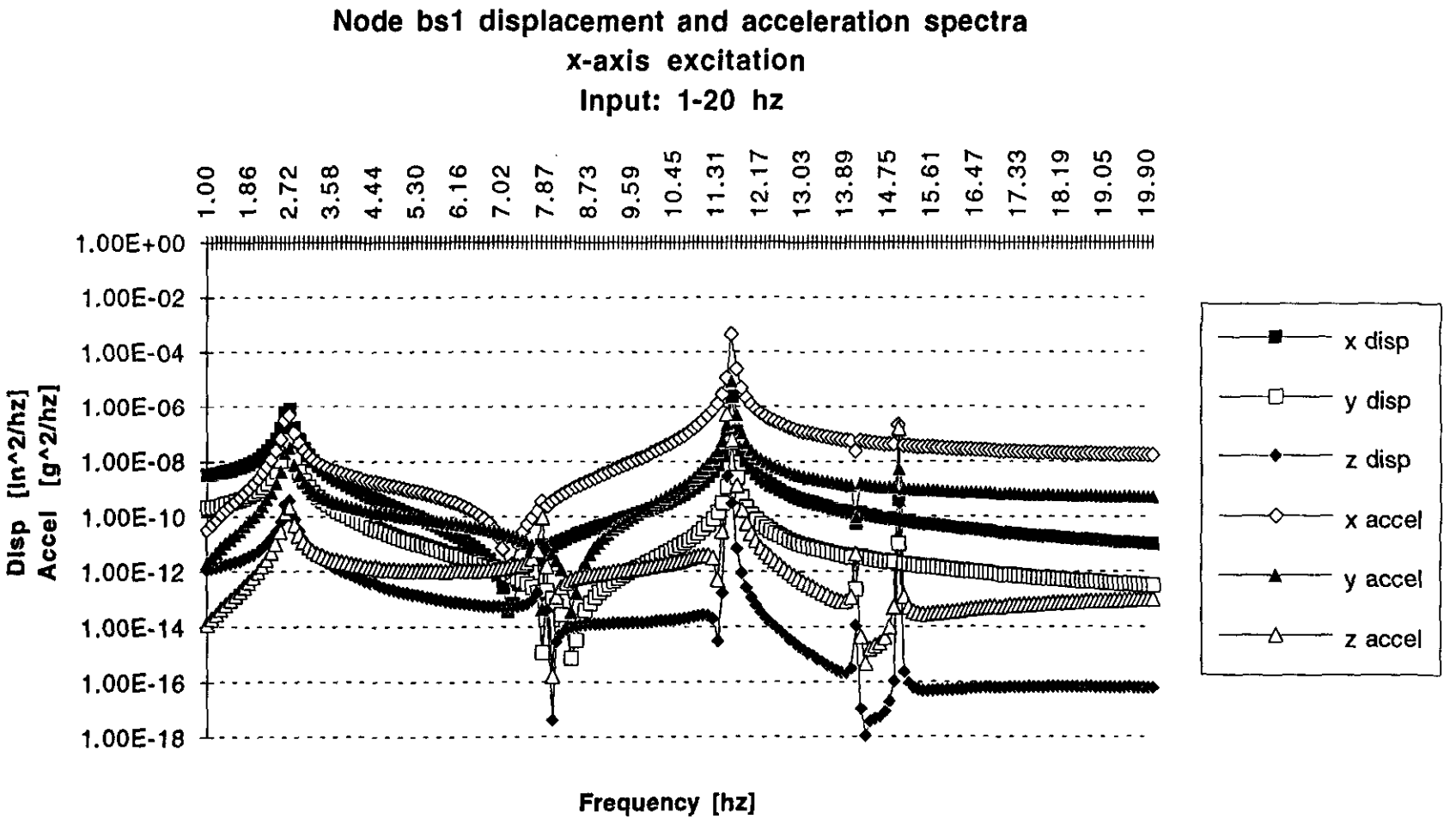
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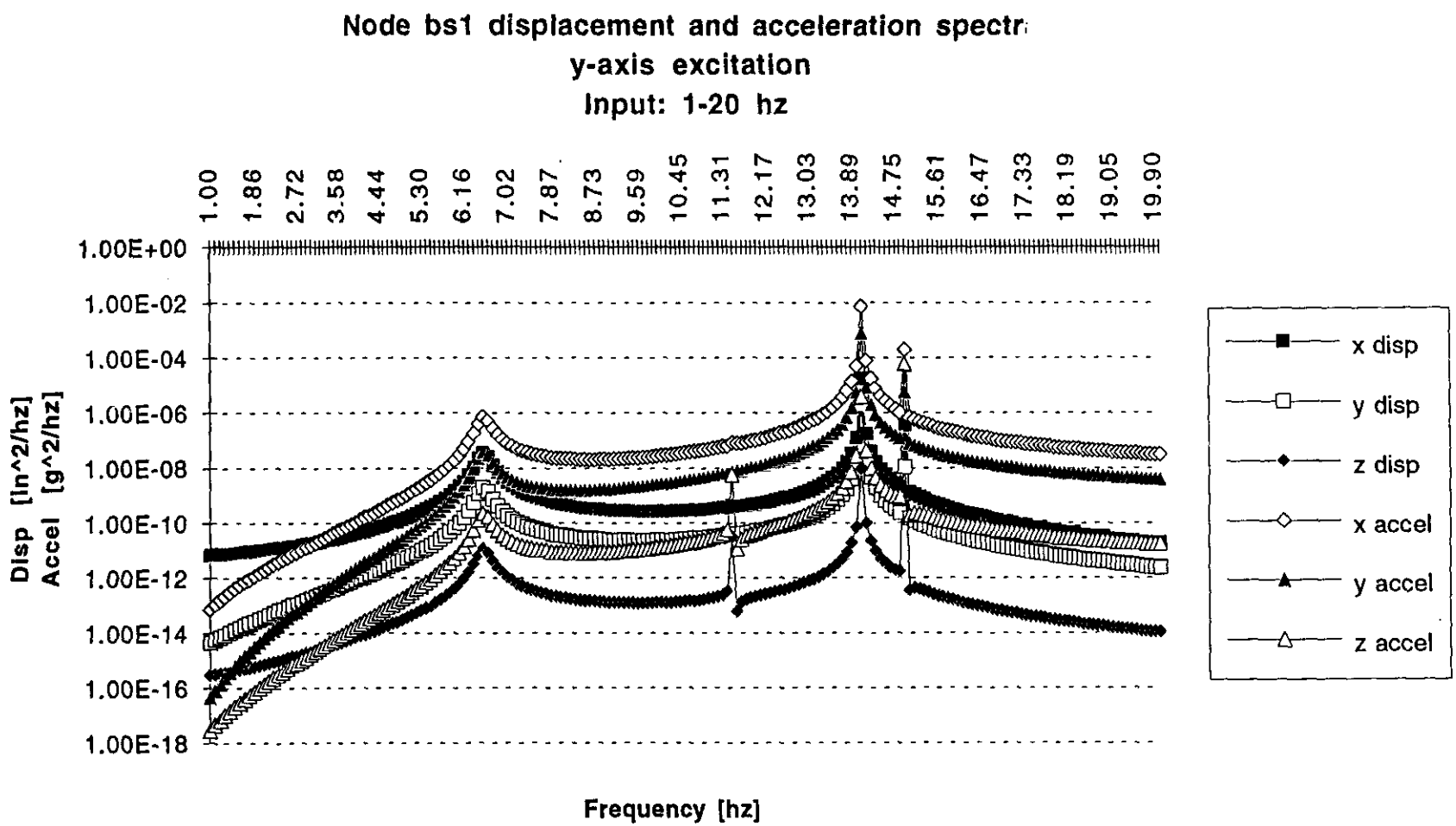
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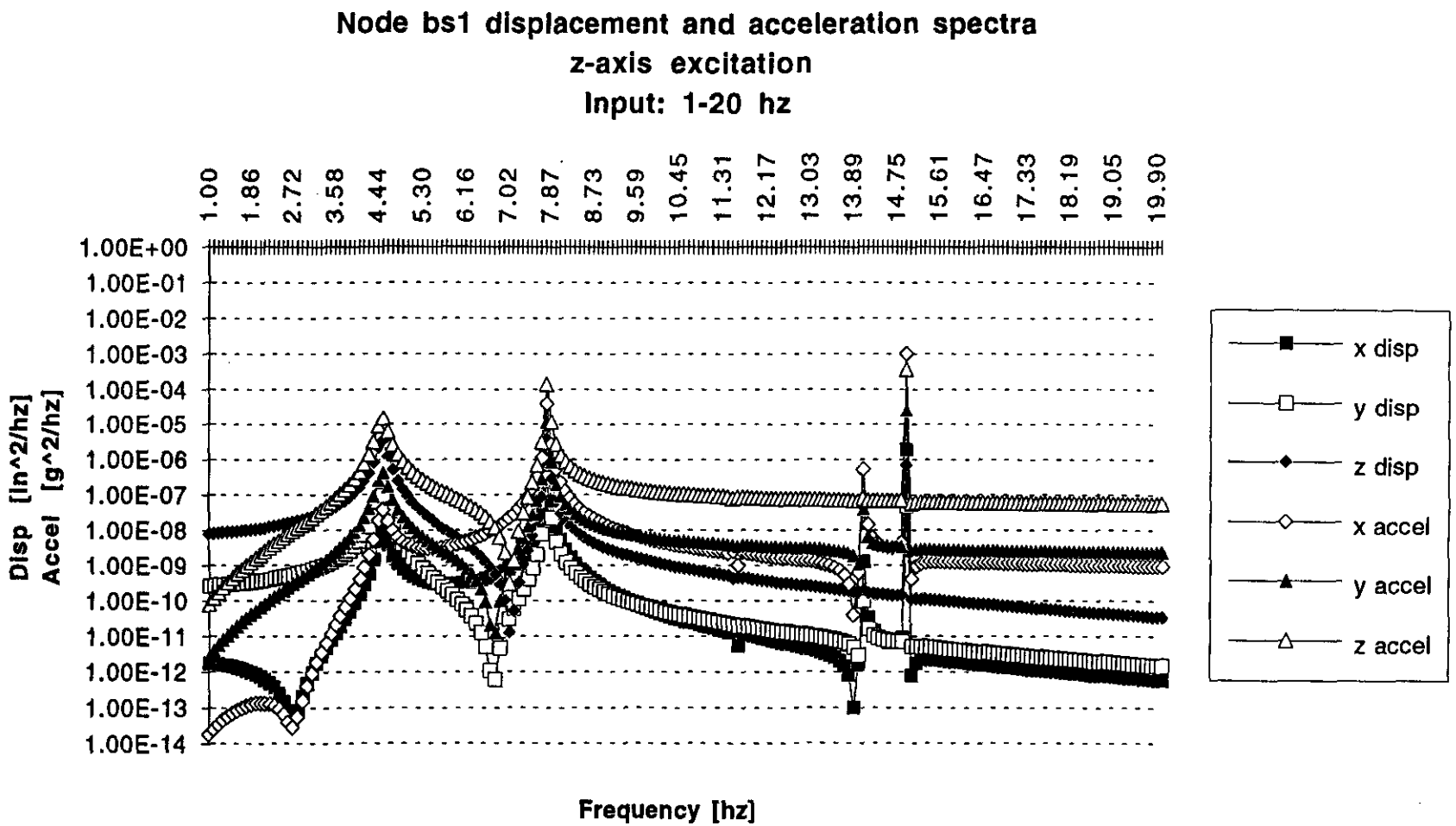
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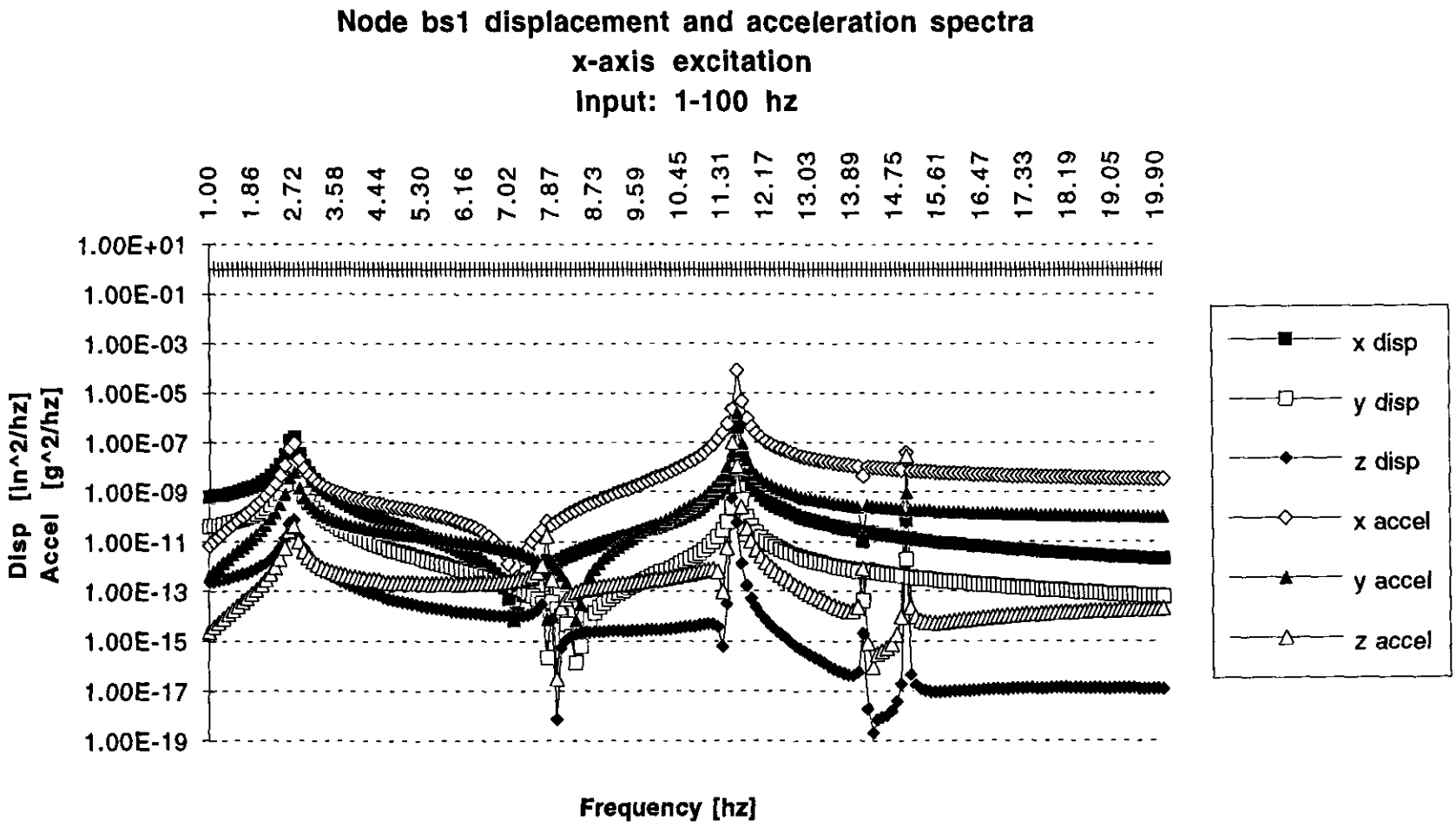
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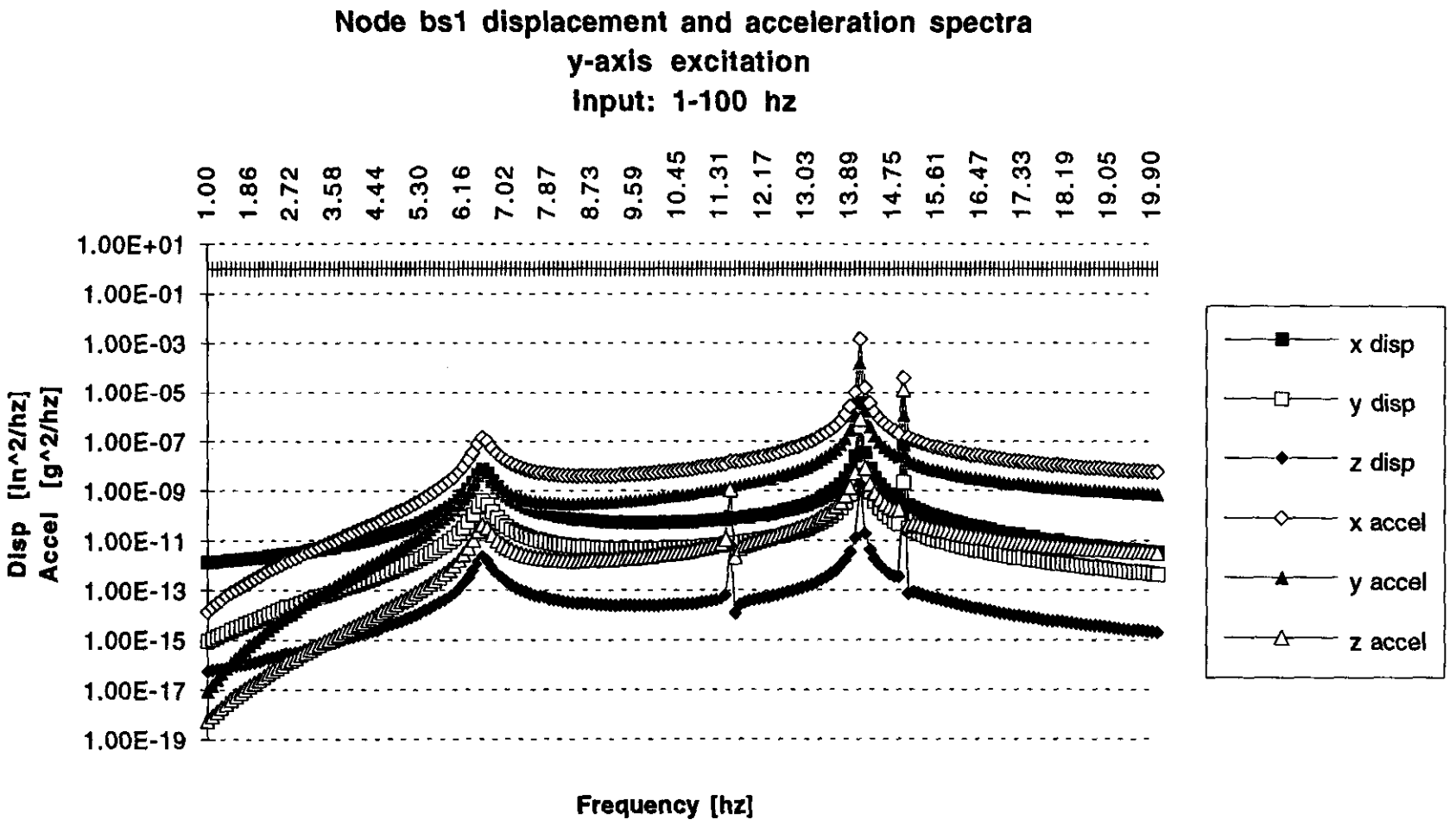
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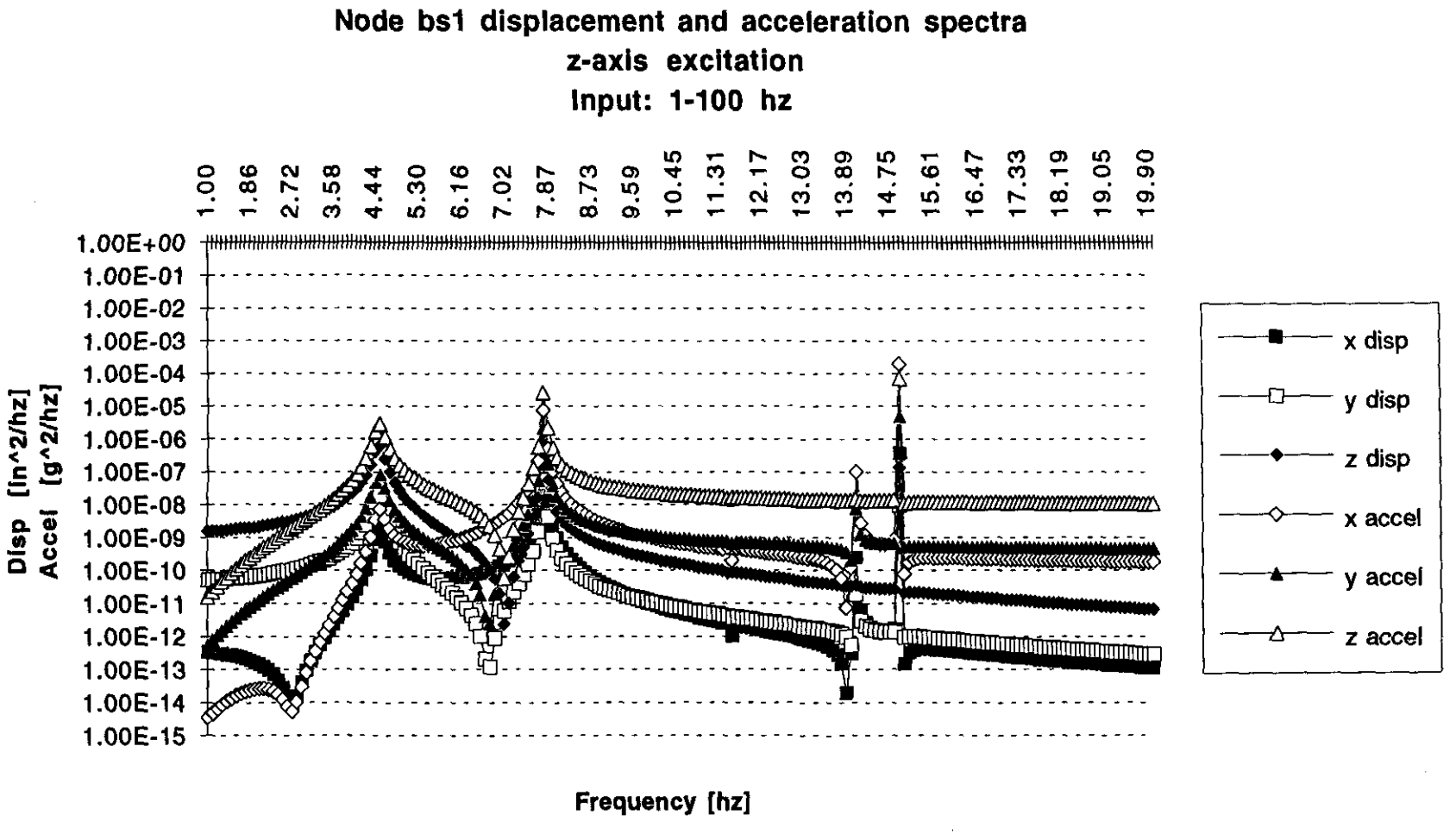
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