Quality-factor Measurement
(150728_typeB1_proto)

January 6, 2016

Note

The investigation of the mechanical Quality factors for the type-B SAS prototype without / with damping control is summarized here. The Q-factor is expressed by $Q = \frac{1}{2}\,\omega_0 T_e$, where ω_0 is a resonance frequency and T_e means $1/e$ mitigation time of its vibration. In this work, python (and gnuplot) code are used to get the fitting parameters. (In the table , Q and T_e show the measured value.)

Glossary

F0 : Top GAS Filter and Inverted Pendulums
F1 : Standard GAS Filter
F2 : Bottom GAS Filter
MD : Magnetic Damper
IR : Intermediate Recoil Mass
IM : Intermediate Mass
RM : Recoil Mass
TM : Test Mass

L : Length
T : Transverse
V : Vertical
R : Roll
P : Pitch
Y : Yaw

table 1: Model Eigen mode list of 150729typeB1proto[1]

Num.	Frequency [Hz]	Mode
#1	0.0505	**IM(Y)**, **RM(Y)**, **TM(Y)**
#2	0.0794	F0(**L**), MD(**L**), F1(**L**), F2(**L**), IR(**L**), IM(**L**), RM(**L**), TM(**L**)
#3	0.0794	F0(**T**), MD(**T**), F1(**T**), F2(**T**), IR(**T**), IM(**T**), RM(**T**), TM(**T**)
#4	0.1232	**IM(Y)**, **RM(Y)**, **TM(Y)**
#5	0.1390	**IM(Y)**, **RM(Y)**, **TM(Y)**
#6	0.1616	**IM(Y)**, **RM(Y)**, **TM(Y)**
#7	0.2494	**IM(V)**, **RM(V)**, **TM(V)**
#8	0.3021	**IM(R)**, **RM(R)**, **TM(R)**
#9	0.3418	**IM(P), RM(P), TM(P)**
#10	0.4094	**RM(T), TM**(**T**,**P**)
#11	0.4196	**TM(P)**
#12	0.5247	**IM(V), RM(V), TM(V)**
#13	0.5468	**MD(T)**
#14	0.5470	**MD(L)**
#15	0.5502	**MD(Y)**
#16	0.5740	**F2(R)**, **IR(R)**
#17	0.5787	**F2(P)**, **IR(P)**
#18	0.5889	**F1(P, R)**
#19	0.6331	**F1(P)**
#20	0.6485	**TM(T, L)**
#21	0.6571	**TM(P)**
#22	0.6580	**RM(T)**, **TM(P)**
#23	0.6863	**F1(P, R)**
#24	0.7923	**F1(V)**
#25	0.8162	**TM(P)**
#26	1.0009	**RM(Y), TM(Y)**
#27	1.0325	**IR(Y)**
#28	1.1844	**IM(T)**
#29	1.1851	**IM(L)**
#30	1.2101	**F2(R), IR(T)**
#31	1.2134	**F2(P), IR(L)**
#32	1.3798	**TM(Y)**
#33	1.4738	**IR(T)**
#34	1.4759	**IR(L)**
#35	4.8559	**IM(P, R)**
#36	11.320	**TM(V)**
#37	15.528	**TM(R)**
#38	46.957	**RM(V)**
#39	50.551	**MD(V)**
#40	51.942	**MD(P)**
#41	51.942	**MD(R)**
#42	62.748	**IM(R)**
#43	97.285	**IR(R)**
#44	100.51	**IR(P)**
#45	126.75	**IR(V)**

[1]For each mode, onyl main vibrations(whose amplitude are larger than others) are written in.

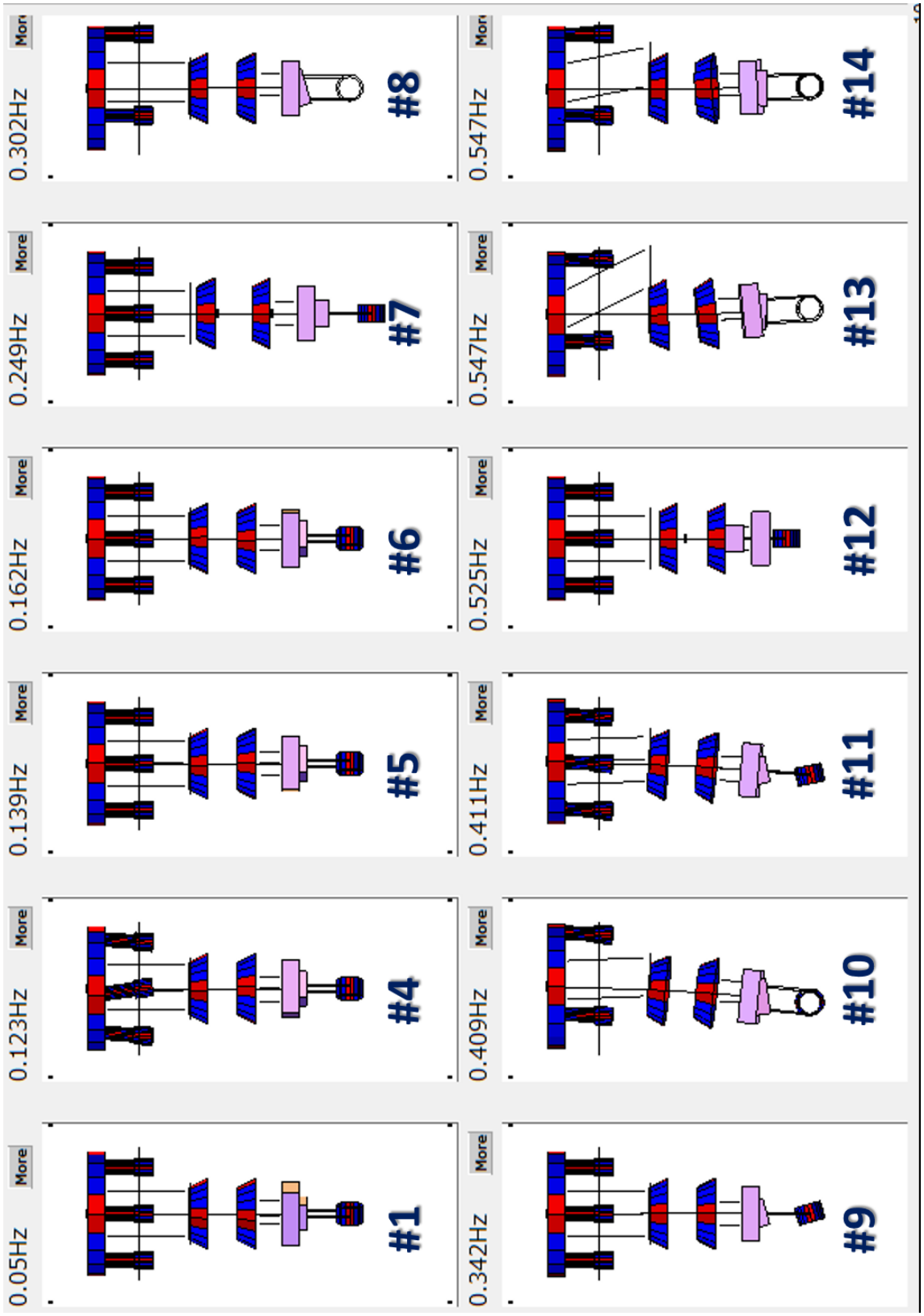

Figure 1: Eigen modes predicted by SUMCON(a)

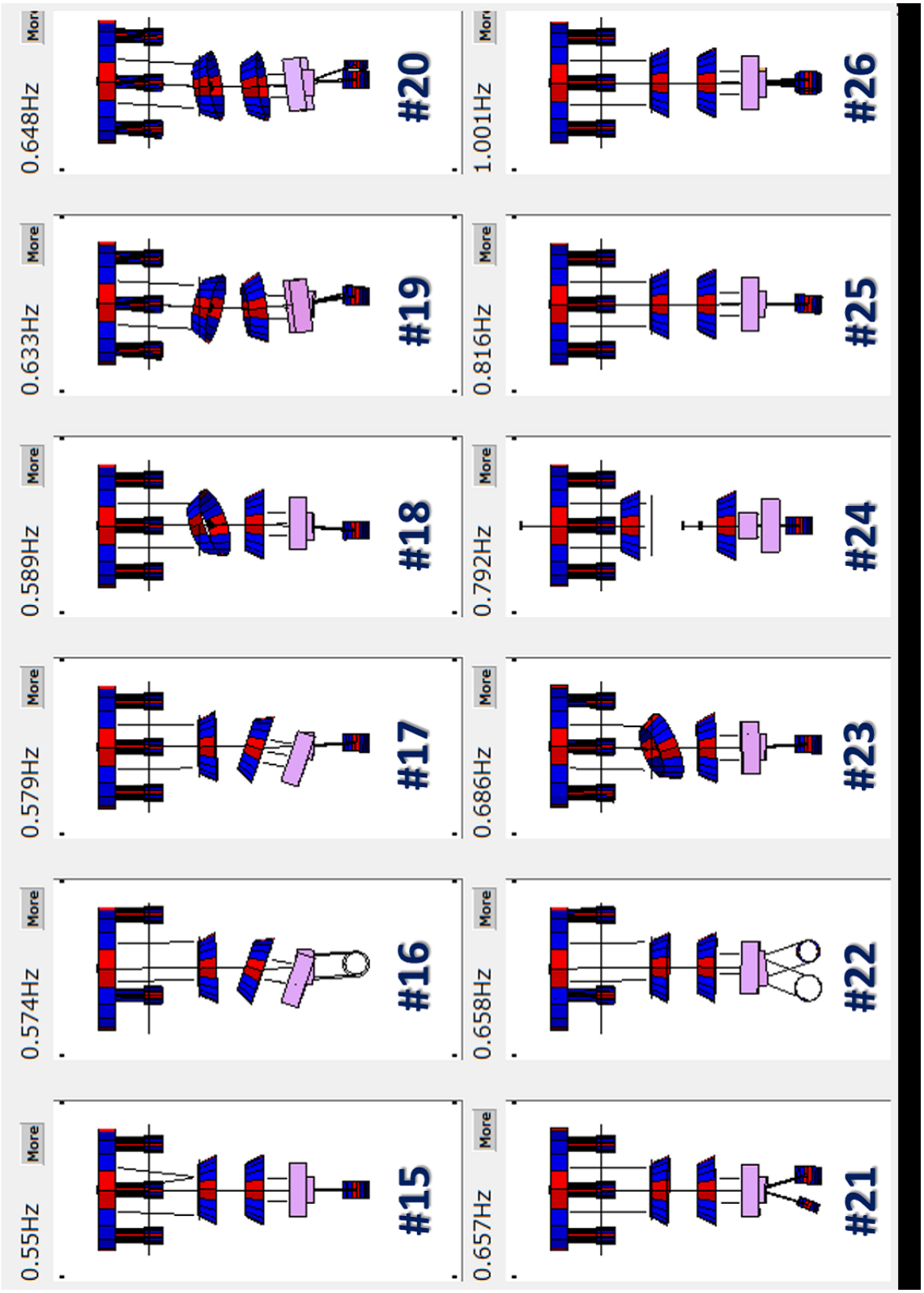

Figure 2: Eigen modes predicted by SUMCON(b)

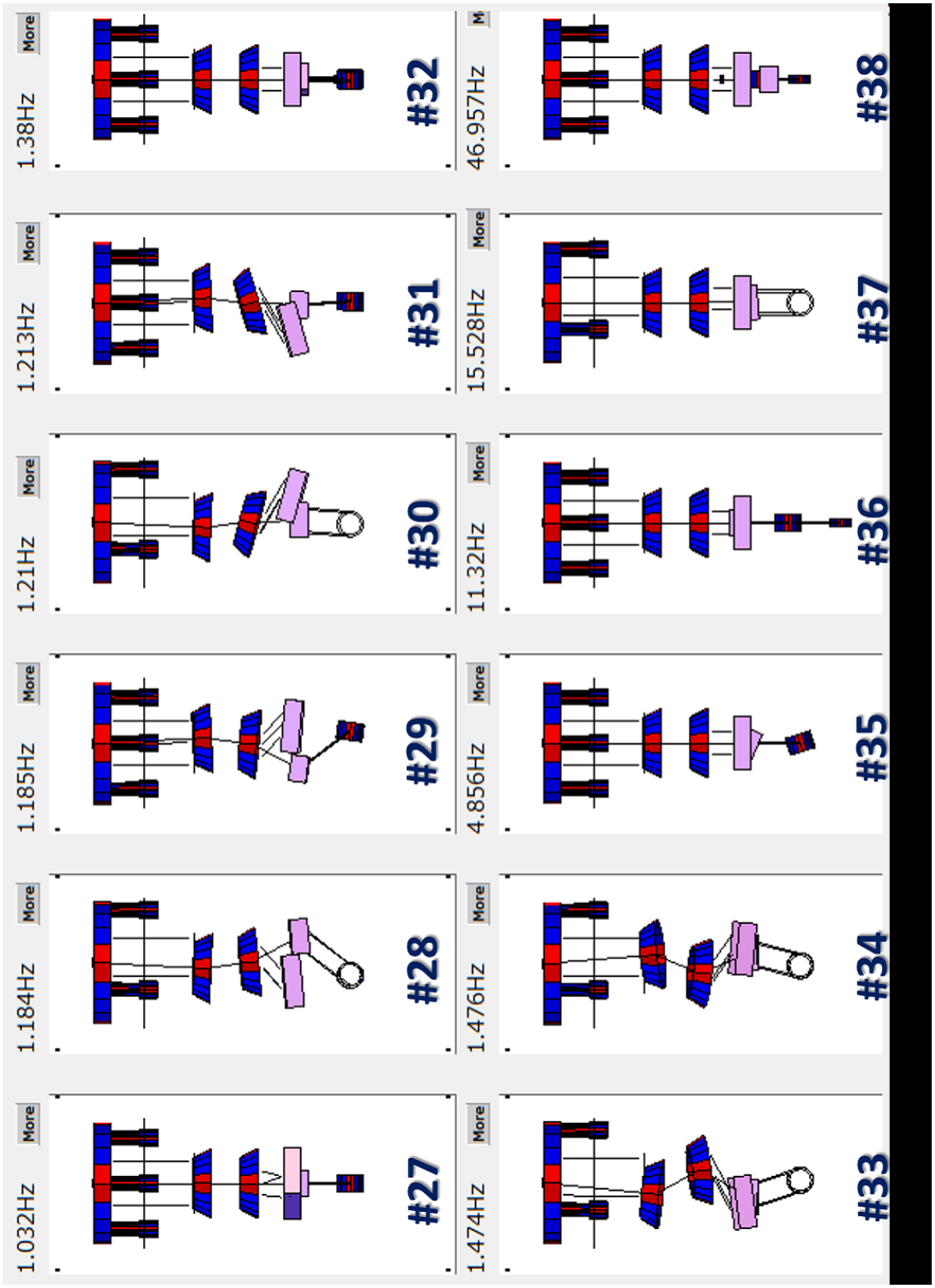

Figure 3: Eigen modes predicted by SUMCON(c)

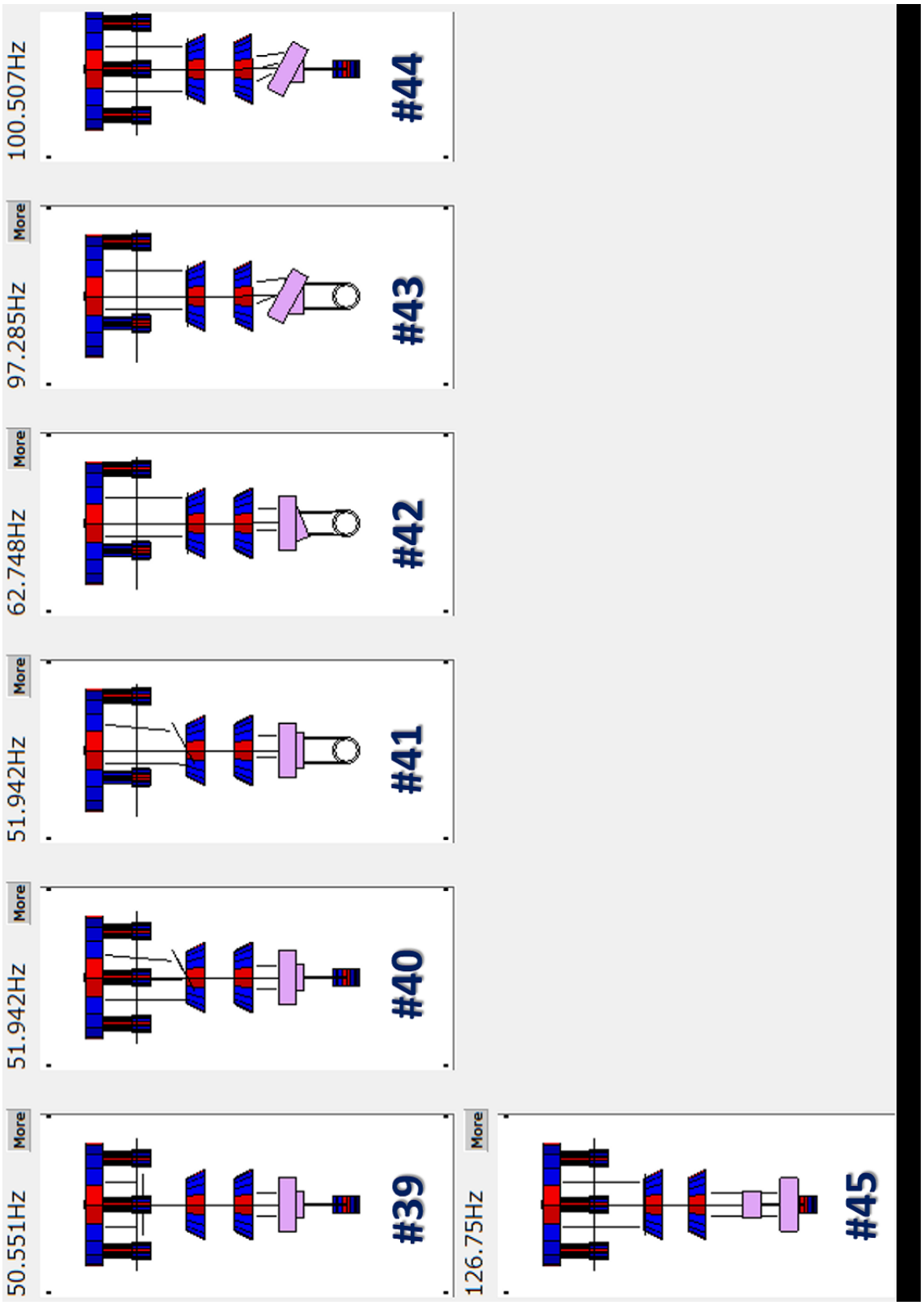

Figure 4: Eigen modes predicted by SUMCON(d)

table 2: Without damping control

Num.	Frequency [Hz] measured (simulated)	difference(%)	T_e [sec.]	Q factor	EXC. point
#1	0.061 (0.0505)	18	40	7.4	F0(Y)
#2 or 3	0.087 (0.0794)	9.6	16	4.3	F0(L)
#4	0.149 (0.1232)	20.9	6	3	F0(Y)
#5	0.150 (0.1390)	7.7	50	24	F0(Y)
#6	0.172 (0.1616)	6.2	13	7	IM(Y)
#7	0.263 (0.2494)	5.6	15	13	IM(V)
#8	0.297 (0.3021)	1.9	138	129	IM(R)
#9	0.371 (0.3418)	8.4	170	198	IM(P)
#10	0.405 (0.4094)	1.0	10	12	F0(T)
#11	0.424 (0.4196)	1.0	13	17	F0(L)
#12	0.539 (0.5247)	2.7	6	9	F0(V)
#13	X (0.5468)	X	X	X	X
#14	X (0.5470)	X	X	X	X
#15	X (0.5502)	X	X	X	X
#16	0.545 (0.5740)	0.6	71	122	IM(T)
#17	0.543 (0.5787)	0.6	79	135	IM(L)
#18	X (0.5889)	X	X	X	X
#19 or 20	0.639 (0.6331 or 0.6485)	1.1	77	154	F0(L)
#21	0.659 (0.6571)	0.7	1448	2996	TM(L)
#22	0.655 (0.6580)	0.4	442	909	F0(T)
#23	X (0.6863)	X	X	X	X
#24	0.861 (0.7923)	8.7	4	10	F0(V)
#25	0.793 (0.8162)	2.9	274	683	TM(P)
#26	1.000 (1.0009)	0.1	1295	4069	TM(Y)
#27	1.02 (1.0325)	1.2	280	895	IM(Y)
#28 or 30	1.176 (1.184 or 1.2101)	2.8	39	144	IM(T)
#28 or 30	1.198 (1.184 or 1.2101)	1.0	46	172	IM(T)
#29 or 31	1.169 (1.185 or 1.2134)	3.7	101	371	F0(L)
#29 or 31	1.178 (1.185 or 1.2134)	2.9	37	135	F0(L)
#32	1.406 (1.3798)	1.9	782	3456	TM(Y)
#33 or 34	1.456 (1.474 or 1.476)	1.0	32	143	F0(T)
#35	4.361 (4.8559)	10.2	9	119	TM(P)
#36	11.11 (11.320)	1.9	7	237	IM(V)
#37	15.25 (15.528)	1.8	5	235	IM(R)
#38	X (46.957)	X	X	X	X
#39	X (50.551)	X	X	X	X
#40	X (51.942)	X	X	X	X
#41	X (51.942)	X	X	X	X
#42	X (62.748)	X	X	X	X
#43	X (97.285)	X	X	X	X
#44	X (100.51)	X	X	X	X
#45	X (126.75)	X	X	X	X

table 3: With damping control

Num.	Frequency [Hz] w (w/o) damping	difference(%)	T_e [sec.]	Q factor	EXC. point
#1	0.065 (0.061)	5.6	43	8.6	F0(Y)
#2 or 3	0.156 (0.081)	93	4.2	2.1	F0(L)
#4	X (0.149)	X	X	X	X
#5 or 6	0.158 (0.172)	8.1	9	4.2	F0(Y)
#7	0.288 (0.263)	8.5	7.4	6.7	F0(V)
#8	0.296 (0.297)	0.3	4.7	4.4	IM(R)
#9	0.380 (0.371)	0.3	4.6	5.6	IM(P)
#10	0.384 (0.405)	5.2	3.7	4.4	F0(T)
#11	0.405 (0.424)	4.5	2.8	3.5	F0(L)
#12	0.592 (0.539)	8.9	3.8	7.0	IM(V)
#13	X	X	X	X	X
#14	X	X	X	X	X
#15	X	X	X	X	X
#16	0.548 (0.549)	0.2	5.1	8.8	IM(T)
#17	0.547 (0.545)	0.3	5.1	8.7	IM(L)
#18	X	X	X	X	
#19 or 20	0.627 (0.639)	1.8	6.5	13.0	F0(L)
#21	0.694 (0.659)	5.0	0.85	1.85	TM(L)
#22	0.654 (0.655)	0.2	242	496	F0(T)
#23	X	X	X	X	X
#24	X (0.861)	X	X	X	X
#25	0.826 (0.793)	4.0	0.45	1.2	TM(P)
#26	1.03 (1.000)	3.0	6.7	21.8	TM(Y)
#27	1.014 (1.02)	1.0	5.9	18.8	IM(Y)
#28 or 30	1.180 (1.176 or 1.198)	0.3	32.5	120	F0(T)
#29 or 31	1.180 (1.169 or 1.178)	0.3	22.5	84	F0(L)
#32	1.324 (1.406)	6.2	2.91	12	TM(Y)
#33 or 34	1.446 (1.445)	0.1	24.8	113	F0(T)
#35	4.383 (4.361)	0.5	1.9	26	TM(P)
#36	11.11 (11.11)	0.0	6.8	237	IM(V)
#37	15.30 (15.25)	0.3	5	241	IM(R)
#38	X	X	X	X	X
#39	X	X	X	X	X
#40	X	X	X	X	X
#41	X	X	X	X	X
#42	X	X	X	X	X
#43	X	X	X	X	X
#44	X	X	X	X	X
#45	X	X	X	X	X

Note

4, # 24 were damped rapidly. Thus, we couldn't get their Q factors.

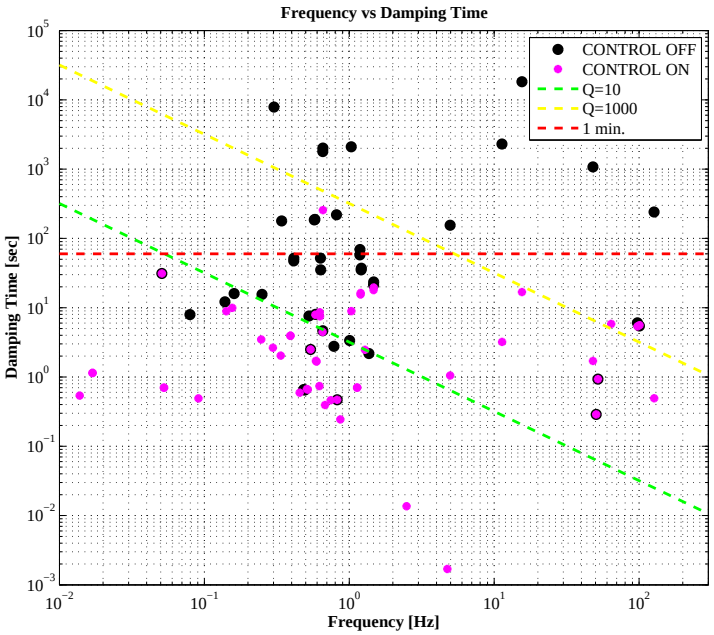

Figure 5: Simulated result

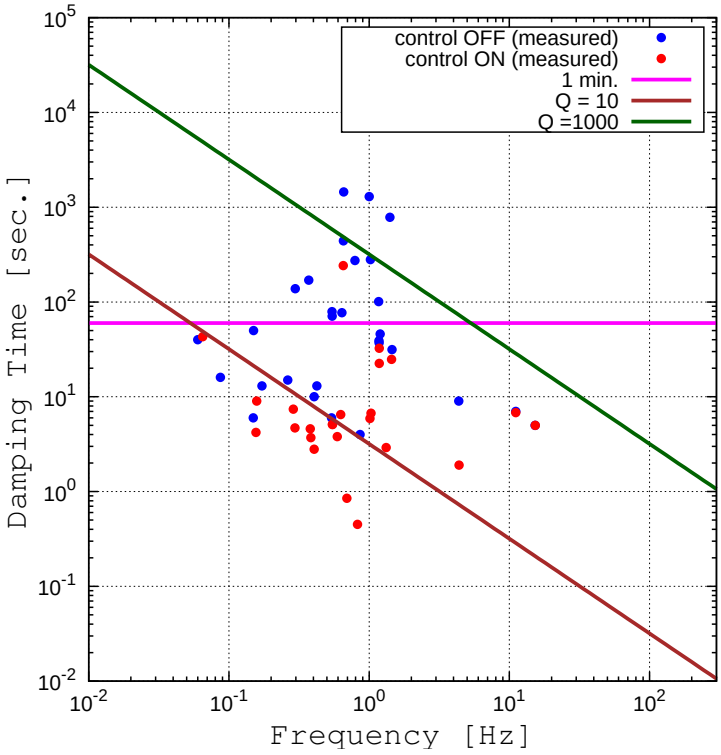

Figure 6: Measured result

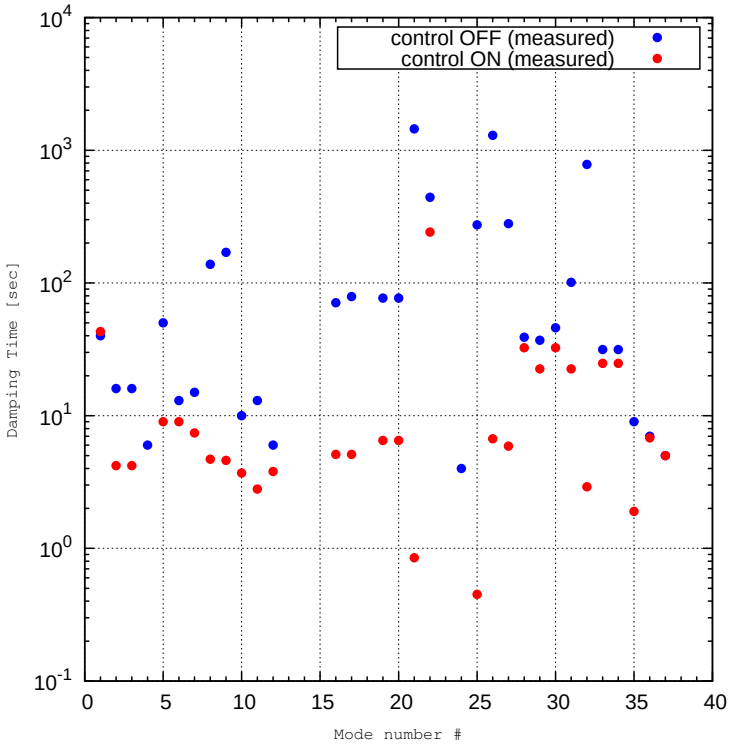

Figure 7: Measured damping time T_e with and without damping controls