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- LIGO -
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Summary of Mechanical Resonances in the LIGO Hanford Interferometers

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1 ABSTRACT

A complete understanding of mechanical resonances in the LIGO interferometers is essential to the commissioning and operations of the detectors. A summary of the resonances in the LIGO Hanford 2k and 4k interferometers is presented. Resonances expected on both theoretical grounds, and those measured experimentally, are summarized in tabular form. Theoretical and experimental Q values are included in the tables. Included as an appendix is a complete list of the resonances of the interferometers, in order of increasing frequency.

2 KEYWORDS

Resonances, Small Optics Suspensions, Large Optics Suspensions, Interferometer, Core Optics Components

3 INTRODUCTION

The following tables provide resonances associated with the Beamsplitters, Intermediate Test masses, End Test Masses, the Folding and Recycling Mirrors, HAM and BSC chambers, and the IOO system. For each optic, two (or possibly three) tables are given. The first table characterizes the internal resonances of the optic itself. The second table lists the various pendular modes the optic is capable of effecting. Lastly, a third table may list the seismic-related resonances pertaining to the mount and support structure of the optic.

For each table, six columns are shown. The first gives a description of the mode (e.g. "butterfly" mode of the large optics). The next two columns contain the frequency of the theoretical and experimentally measured resonance (f_{th} and f_{meas}, respectively). Note only a limited number of resonances have been measured, so for many resonances the "measured" fields are blank. The frequencies are followed by theoretical and experimentally measured Q values (Q_{th} and Q_{meas}). Lastly, the sixth column gives the references from which the values where taken. As there are four numbers for a given resonance (f_{th}, f_{meas}, Q_{th}, and Q_{meas}), up to four references are given. Enumerated references are given in at the end of this document.

An appendix is included, which lists all of the resonances given in the document, ordered ascending in frequency. Where there are data available on both f_{th} and f_{meas}, the resonance is ordered on the measured value.

4 BEAMSPLITTER RESONANCES

Table 1. Beamsplitter Internal Resonances

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
butterfly	3785	3733.7		$1.85x10^{6}$	1/2/-/2
	3785				1/-/-/-
drum head	5578	5477.5		$2.50x10^{4}$	1/2/-/2
3-fold radial	7975	7812	$2.6x10^{6}$	$2.65x10^{5}$	1/2/2/2
	7975				1/-/-/-
	11259	11138.7		$3.60x10^{5}$	1/2/-/2
	11259				1/-/-/-
	11332				1/-/-/-
	11334				1/-/-/-
	12674				1/-/-/-
	12677				1/-/-/-
	12760				1/-/-/-
	12760				1/-/-/-
	14629				1/-/-/-
	17283				1/-/-/-
	17283				1/-/-/-
	17388				1/-/-/-
	17388				1/-/-/-
	17958				1/-/-/-
	17958				1/-/-/-

Table 2. Beamsplitter Pendular Resonances (2k and 4k)

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
in-beam pendular	0.744	0.758			3/6/-/-
sideways pendular		0.736			-/6/-/-
pitch	0.600	0.617			3/6/-/-
yaw	0.500	0.492			3/6/-/-
vertical	~12.8	12.586			-/6/-/-
roll	~18.1	18.575			10/6/-/-
violin	223				3/-/-/-

5 INTERMEDIATE TEST MASS RESONANCES

Table 3. Intermediate Test Mass Internal Resonances (2k)

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
butterfly ITMx		6747.5	1.3×10^6	1.40×10^6	-/2/2/2
drum head ITMx		9395		6.16×10^5 (“rough est.”)	-/2/-/2
drum head ITMy		9397.5	1.3×10^6	9.98×10^5	-/2/2/2
breathing ITMx		14373.7		1.20×10^7	-/2/-/2

Table 4. Intermediate Test Mass Pendular Resonances (2k)

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
pendular	0.743				3/-/-/-
pitch	0.600				3/-/-/-
yaw	0.497				3/-/-/-
vertical	12.63				3/-/-/-
violin	341				3/-/-/-

Table 5. Intermediate Test Mass Pendular Resonances (4k)

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
pendular	0.743				3/-/-/-
pitch	0.600				3/-/-/-
yaw	0.499				3/-/-/-
vertical	12.72				3/-/-/-
violin	339				3/-/-/-

Table 6. Pathfinder Resonances with Dumbbell Standoffs

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
		9476.4		$1.3x10^6$	-/5/-/5
		22421.5		$4.6x10^5$	-/5/-/5
		25632.3		$2.6x10^6$	-/5/-/5
		29484.2		$1.1x10^6$	-/5/-/5
		29866.2		not measurable	-/5/-/5
		38763.2		$8.8x10^5$	-/5/-/5
		42758.3		$4.8x10^6$	-/5/-/5
		47332.4		$5.4x10^6$	-/5/-/5

Table 7. Resonances of the magnet/standoff assembly attached to the Pathfinder

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
		9700		130	-/5/-/5
		34600		>30	-/5/-/5

6 END TEST MASS RESONANCES

Table 8. End Test Mass Internal Resonances

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
	6595				4/-/-/-
	6595				4/-/-/-
	9206				4/-/-/-
	11217				4/-/-/-
	11217				4/-/-/-
	12056				4/-/-/-
	12057				4/-/-/-
	12941				4/-/-/-
	12943				4/-/-/-
	14475				4/-/-/-

Table 9. End Test Mass Pendular Resonances

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
pendular	0.744				3/-/-/-
pitch	0.600				3/-/-/-
yaw	0.500				3/-/-/-
vertical	12.85				3/-/-/-
violin	336	365.5			3/6/-/-

7 FOLDING MIRROR RESONANCES

Table 10. Folding Mirror Pendular Resonances

description	f_{th} (Hz)	FM(y) f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
pendular	0.744	0.766			3/9/-/-
pitch	0.600	0.633			3/9/-/-
yaw	0.500	0.477			3/9/-/-
vertical	12.85	11.68			3/9/-/-
roll		17.43, 17.875			-/9/-/-
sideways pendular		0.730			-/9/-/-
violin	336	335			3/9/-/-

8 RECYCLING MIRROR RESONANCES

Table 11. Recycling Mirror Pendular Resonances (2k)

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
pendular	0.741	0.760			3/9/-/-
pitch	0.600	0.620			3/9/-/-
yaw	0.501	0.509			3/9/-/-
vertical	12.86	11.984			3/9/-/-
roll		17.891			-/9/-/-
violin	334	335			3/-/-/-

Table 12. Recycling Mirror Pendular Resonances (4k)

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
pendular	0.741				3/-/-/-
pitch	0.600				3/-/-/-
yaw	0.501				3/-/-/-
vertical	12.86				3/-/-/-
violin	334				3/-/-/-

9 HORIZONTAL ACCESS CHAMBER (HAM) RESONANCES

Tests of a HAM chamber were performed in a spare corner of the LVEA at Hanford [8]. Minor differences between the testing and production HAM included ungrouted piers, the use of dummy components, the chamber being unevacuated, etc.

Four Bruel and Kjaer electromagnetic shakers were applied to the support table of the HAM. A displacement was provided along one of several axes, and a transfer function was obtained via a pair of 3-axis geophones. The coordinate system (U,V,W) corresponded to the in-beam direction, transverse-to-beam direction, and vertical direction, respectively.

The transfer functions indicate resonances at the frequencies recorded in tabular form below, for various actuation/transfer configurations. For instance, “vertical-vertical (W-W) transfer” corresponds to an actuation in the vertical direction, followed by transfer to displacement of the HAM stack in the vertical. Resonance peaks indicated by computer modeling are also shown as f_{th}.

Table 13. HAM Stack modes, vertical-vertical (W-W) transfer

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
	3.3	3.2			8/8/-/-
	7.8	7.8			8/8/-/-
	12.1	12.1			8/8/-/-

Table 14. HAM Stack modes, vertical-yaw transfer

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
		3.1			-/8/-/-

Table 14. HAM Stack modes, vertical-yaw transfer

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
		7.2			-/8/-/-
		8.0			-/8/-/-
		9.4			-/8/-/-
		12.1			-/8/-/-
		13.4			-/8/-/-

Table 15. HAM Stack modes, beamline (U-U) transfer

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
	1.5	1.5			8/8/-/-
	2.4	2.3			8/8/-/-
	7.2	7.2			8/8/-/-
	7.7	7.7			8/8/-/-
	9.7	10.0			8/8/-/-
	13.2	13.4			8/8/-/-

Table 16. HAM Stack modes, transverse horizontal (V-V) transfer

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
	1.8	1.6			7/7/-/-
	3.2	2.8			7/7/-/-
	7.3	7.3			7/7/-/-
	8.0	8.0			7/7/-/-
	10.0	10.3			7/7/-/-
	13.2	13.4			

Table 17: Calculated resonant mode frequencies for the HAM optical table (all modes from reference 11)

Mode	f_{th} (Hz)	*Mode*	f_{th} (Hz)
1	250	10	615

Table 17: Calculated resonant mode frequencies for the HAM optical table (all modes from reference 11)

Mode	f_{th} (Hz)	*Mode*	f_{th} (Hz)
2	342	11	622
3	397	12	622
4	457	13	623
5	474	14	628
6	559	15	639
7	584	16	643
8	584	17	645
9	596	18	654

10 BASIC SYMMETRIC CHAMBER (BSC) RESONANCES

BSC transfer functions were measured on a stack prototype at Hytec Incorporated [7]. The procedure was somewhat similar to the HAM stack tests, described above. In the tables below, resonances noted in the measured transfer functions (and computer model) are summarized. Here "horizontal-horizontal transfer" corresponds to actuation in the horizontal direction, with transfer to the BSC stacks in the same direction. Likewise, transfer to pitch of the stack was measured. Lastly, actuation in the vertical direction, and transfer to the same direction was measured.

Table 18. BSC Stack modes, horizontal-horizontal transfer

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
	1.3	1.2			7/7/-/-
	2.4	2.2			7/7/-/-
	5.5	5.5			7/7/-/-
	10.0	10.0			7/7/-/-
	13.1	13.1			7/7/-/-

Table 19. BSC Stack modes, horizontal-pitch transfer

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
	1.3	1.2			7/7/-/-
	2.4	2.2			7/7/-/-
	6.9	6.5			7/7/-/-
	11.5	11.5			7/7/-/-
	14.4	14.4			7/7/-/-

Table 20. BSC Stack modes, vertical-vertical transfer

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
	2.9	2.7			7/7/-/-
	6.5	6.4			7/7/-/-
	10.3	10.3			7/7/-/-
	13.1	13.1			7/7/-/-

Table 21. BSC Stack modes, vertical-vertical transfer

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
	2.9	2.7			7/7/-/-
	6.5	6.4			7/7/-/-
	10.3	10.3			7/7/-/-
	13.1	13.1			7/7/-/-

Table 22. BSC downtube resonances

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
	349	349 350			11/6/-/-
	355	360			11/6/-/-
	370				11/-/-/-
	371	376			11/6/-/-
	399	399			11/6/-/-

Table 22. BSC downtube resonances

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
	421	420			11/6/-/-
	441				11/-/-/-
	462				11/-/-/-
	463				11/-/-/-
	478				11/-/-/-
	556				11/-/-/-
	560				11/-/-/-
	583				11/-/-/-
	611				11/-/-/-
	615				11/-/-/-
	683				11/-/-/-
	690				11/-/-/-
	702				11/-/-/-

11 IOO SYSTEM RESONANCES

In this section we have included as many of the resonances of the components used in the IOO system as possible. These include resonances of the small optics themselves, small optics suspensions, small optics suspension support structures, the dumbbell assemblies used to hold the OSEM magnets and the periscope used to shift the beam height from the optical table to the modecleaner. The resonances of the HAM stacks and the HAM tables are listed in a preceding table.

In the following table the internal resonances for the small optics have been listed, these are the optics used for the suspended mode cleaner, the beam steering mirrors after the modecleaner and two of the mirrors used to expand the modecleaner output such that it matches into the long-arm cavity. The internal resonances for the small optics have been measured on a prototype by Hazel *et al*. [14]. We have also included some of the internal resonances of the optics used for the 2km interferometer mode cleaner, which were measured online by Haiseng Rong [13]

Table 23: Small optics internal modes

description	f_{th} (Hz)	f_{meas} (kHz)	Q_{th}	Q_{meas}	*references*
		20.15194		$4.9\ 10^{5}$	-/14/-/14
		20.18583		$2.7\ 10^{5}$	-/14/-/14
Drumhead		28.40520		$3.1\ 10^{5}$	-/14/-/14
		37.97721		$2.4\ 10^{5}$	-/14/-/14
		37.99493		$2.4\ 10^{5}$	-/14/-/14
					-/14/-/14
Drumhead MC1		28.233		$7.8\ 10^{5}$	-/13/-/13
Drumhead MC2		28.199		$3.7\ 10^{6}$	-/13/-/13
Drumhead MC3		28.233		$1.3\ 10^{6}$	-/13/-/13

Table 24. Small optics suspension system resonances

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
pendular	1.0	1.04			15/13/-/-
pitch	0.75	0.79			15/13/-/-
yaw	0.85	0.85			15/13/-/-
vertical	16.0	14.75			15/13/-/-
violin1		708.30		$2.2\ 10^{5}$	-/13/-/13
violin2		1416.34		$6.7\ 10^{5}$	-/13/-/13

Table 25: Small optics associated resonances

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
Dumbbell Assembly		9700		130	-/15/-/15

Table 25: Small optics associated resonances

description	f_{th} (Hz)	f_{meas} (Hz)	Q_{th}	Q_{meas}	*references*
Suspension Support Structure		156			-/15/-/-

Table 26: Calculated resonance frequencies of the periscope basic structure

Mode No.	*Resonance Frequencies (Hz)*	*references*
1	203	16
2	301	16
3	317	16
4	659	16
5	748	16
6	820	16

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APPENDIX 1 ORDERED LIST OF RESONANCES

This appendix includes all the resonances included in the document above. They are ordered based on ascending frequency. Included in the following table is a column named Descrip. Code, this column contains a code which describes the method in which the frequency value for a particular resonance was obtained. The codes are described in the following table:

Table 27:

Code	*Description*
OL	Measured on a component installed at LIGO Hanford
LHL	Measured at LIGO Hanford on a component prior to installation
P	Measured on a prototype structure
C	Calculated using a model

If the value of a particular resonance has been obtained in a number of different ways then only one value has been included in the look-up table (Table 28) for simplicity. The protocol for deciding which value is included is: The value that is included in Table 28 is the one obtained using the method listed closest to the top of Table 27. For example the Beam Splitter (BS) butterfly internal resonance, has been Calculated (C) and measured OnLine(OL) at LIGO Hanford, in Table 28 we have only included the value measured online at LIGO Hanford. However, the complete list of values is still included in the preceding tables.

Table 28:

Resonance Description	*Specific Mode*	*Freq (Hz)*	*Descrip. Code*
FM Pendulum	yaw	0.477	LHL
BS Pendulum	yaw	0.492	OL
ITM Pendulum (2K)	yaw	0.497	C
ITM Pendulum (4K)	yaw	0.499	C
ETM Pendulum	yaw	0.5	C
RM Pendulum (2K)	yaw	0.501	C
RM Pendulum (2K)	yaw	0.509	LHL
ETM Pendulum	pitch	0.6	C
ITM Pendulum (2K)	pitch	0.6	C
ITM Pendulum (4K)	pitch	0.6	C
RM Pendulum (2K)	pitch	0.6	C
BS Pendulum	pitch	0.617	OL
RM Pendulum (2K)	pitch	0.62	LHL
FM Pendulum	pitch	0.633	LHL
BS Pendulum	sideways pendular	0.736	OL
FM Pendulum	sideways pendular	0.73	LHL
RM Pendulum (2K)	pendular	0.741	C
ITM Pendulum (2K)	pendular	0.743	C
ITM Pendulum (4K)	pendular	0.743	C
ETM Pendulum	pendular	0.744	C
BS Pendulum	pendular	0.758	OL
RM Pendulum (2K)	pendular	0.76	LHL
FM Pendulum	pendular	0.766	LHL
SO Pendulum (2K)	pitch	0.79	LHL

Table 28:

Resonance Description	*Specific Mode*	*Freq (Hz)*	*Descrip. Code*
SO Pendulum (2K)	yaw	0.85	LHL
SO Pendulum (2K)	pendular	1.04	LHL
BSC Horizontal-Horizontal	1	1.2	P
BSC Stack Horizontal-Pitch	1	1.2	P
Ham Stack beamline (U-U)	1	1.5	LHL
BSC Horizontal-Horizontal	2	2.2	P
BSC Stack Horizontal-Pitch	2	2.2	P
Ham Stack beamline (U-U)	2	2.3	LHL
BSC Stack Vertical-Vertical	1	2.9	P
HAM Stack vertical-yaw	1	3.1	LHL
HAM Stack vertical-vertical (W-W)	1	3.2	LHL
BSC Horizontal-Horizontal	3	5.5	P
BSC Stack Horizontal-Pitch	3	6.5	P
BSC Stack Vertical-Vertical	2	6.5	P
HAM Stack vertical-yaw	2	7.2	LHL
Ham Stack beamline (U-U)	3	7.2	LHL
Ham Stack beamline (U-U)	4	7.7	LHL
HAM Stack vertical-vertical (W-W)	2	7.8	LHL
HAM Stack vertical-yaw	3	8	LHL
HAM Stack vertical-yaw	4	9.4	LHL
BSC Horizontal-Horizontal	4	10	P
Ham Stack beamline (U-U)	5	10	LHL
BSC Stack Vertical-Vertical	3	10.3	P
BS Pendulum	vertical	10.852	OL
BSC Stack Horizontal-Pitch	4	11.5	P
FM Pendulum	vertical	11.68	LHL

Table 28:

Resonance Description	*Specific Mode*	*Freq (Hz)*	*Descrip. Code*
RM Pendulum (2K)	vertical	11.984	LHL
HAM Stack vertical-vertical (W-W)	3	12.1	LHL
HAM Stack vertical-yaw	5	12.1	LHL
BS Pendulum	vertical	12.586	OL
ITM Pendulum (2K)	vertical	12.63	C
ITM Pendulum (4K)	vertical	12.72	C
ETM Pendulum	vertical	12.85	C
RM Pendulum (2K)	vertical	12.86	C
BSC Horizontal-Horizontal	5	13.1	P
BSC Stack Vertical-Vertical	4	13.1	P
HAM Stack vertical-yaw	6	13.4	LHL
Ham Stack beamline (U-U)	6	13.4	LHL
BSC Stack Horizontal-Pitch	5	14.4	P
SO Pendulum (2K)	vertical	14.75	LHL
FM Pendulum	roll	17.891	LHL
RM Pendulum (2K)	roll	17.891	LHL
BS Pendulum	roll	18.575	OL
SO Suspension Support Structure		156	P
Periscope Structure IOO	1	203	C
BS Pendulum	violin	223	C
HAM Table	1	250	C
Periscope Structure IOO	2	301	C
Periscope Structure IOO	3	317	C
RM Pendulum (2K)	violin	334	C
RM Pendulum (2K)	violin	335	LHL
ETM Pendulum	violin	336	C

Table 28:

Resonance Description	*Specific Mode*	*Freq (Hz)*	*Descrip. Code*
FM Pendulum	violin	336	LHL
ITM Pendulum (4K)	violin	339	C
ITM Pendulum (2K)	violin	341	C
HAM Table	2	342	C
BSC Down Tube	1	349	OL
BSC Down Tube	2	360	OL
BSC Down Tube	3	370	C
BSC Down Tube	4	376	OL
HAM Table	3	397	C
BSC Down Tube	5	399	OL
BSC Down Tube	6	420	OL
BSC Down Tube	7	441	C
HAM Table	4	457	C
BSC Down Tube	8	462	C
BSC Down Tube	9	463	C
HAM Table	5	474	C
BSC Down Tube	10	478	C
BSC Down Tube	11	556	C
HAM Table	6	559	C
BSC Down Tube	12	560	C
BSC Down Tube	13	583	C
HAM Table	7	584	C
HAM Table	8	584	C
HAM Table	9	596	C
BSC Down Tube	14	611	C
BSC Down Tube	15	615	C

Table 28:

Resonance Description	*Specific Mode*	*Freq (Hz)*	*Descrip. Code*
HAM Table	10	615	C
HAM Table	11	622	C
HAM Table	12	622	C
HAM Table	13	623	C
HAM Table	14	628	C
HAM Table	15	639	C
HAM Table	16	643	C
HAM Table	17	645	C
HAM Table	18	654	C
Periscope Structure IOO	4	659	C
BSC Down Tube	16	683	C
BSC Down Tube	17	690	C
BSC Down Tube	18	702	C
SO Pendulum (2K)	violin1	708.3	P
Periscope Structure IOO	5	748	C
Periscope Structure IOO	6	820	C
SO Pendulum (2K)	violin2	1416.34	P
BS Internal	Butterfly	3733.7	OL
BS Internal	Drumhead	5477.5	OL
ETM Internal	1	6595	C
ETM Internal	2	6595	C
ITM Internal (2K)	butterfly	6747.5	OL
BS Internal	3 fold radial	7812	OL
ETM Internal	3	9206	C
ITM Internal (2K)	drum head	9395	OL
ITM Internal (2K)	drum head	9397.5	OL

Table 28:

Resonance Description	*Specific Mode*	*Freq (Hz)*	*Descrip. Code*
SO Dumbbell Assembly		9700	C
ETM Internal	4	11217	C
ETM Internal	5	11217	C
BS Internal	4	11259	C
BS Internal	5	11332	C
BS Internal	6	11334	C
ETM Internal	6	12056	C
ETM Internal	7	12057	C
BS Internal	7	12674	C
BS Internal	8	12677	C
BS Internal	9	12760	C
ETM Internal	8	12941	C
ETM Internal	9	12943	C
ITM Internal (2K)	breathing	14373.7	OL
ETM Internal	10	14475	C
BS Internal	10	14629	C
BS Internal	11	17283	C
BS Internal	12	17388	C
BS Internal	13	17958	C
SO Internal (2K)	1	20151.94	P
SO Internal (2K)	2	20185.83	P
SO Internal (2K)	MC2 Drumhead	28199	OL
SO Internal (2K)	MC1 Drumhead	28233	OL

Table 28:

Resonance Description	*Specific Mode*	*Freq (Hz)*	*Descrip. Code*
SO Internal (2K)	MC3 Drumhead	28233	OL
SO Internal (2K)	3 Drumhead	28405.2	P
SO Internal (2K)	4	37977.2	P
SO Internal (2K)	5	37994.9	P