almatech | REQUEST FOR ~~WAIVER~~ / DEVIATION (~~RFW~~/RFD) | PRODUCT ASSURANCE

RFD/RFW Number:	FLX-RFD-ALM-CU-0018	Issue	1.0

Spacecraft / Project	FLORIS	Originator's Name	Marco Lai	
System / Experiment / Model	FLEX	Signature / Date	Digitally signed by Marco Lai (Qualified Signature) Date: 2019.02.01 15:24:43 +01'00'	
Sub-System		Request Type (Highlight applicable request)	~~Waiver (RFW)~~	Deviation (RFD)
Assembly	EQM/PFM	Organisation	Almatech	
Sub-Assembly	Calibration Unit	Ref. Doc. / Drwg No.	ALM-PRO-4182	
Item	-	References	-	
Serial No.	EQM, PFM			

RFW/RFD Title	Motor Power Consumption

End Items(s) Affected (Hardware, Software)

Name	CI-Number	Model(s)
Calibration Unit		EQM, PFM

Requirement / Interface Documents Affected

Specification/Drawing Title	Number	Issue	Date	App. Paragraph
FLORIS Calibration Unit URD	FLX-RS-FNM-INS-0006	6D01.1	10.07.2018	5.3.5

Description of Deviation / Discrepancy / Non-Conformance

The random level are defined in URD according to:

5.6.1.1.3 Random Vibrations

FLO-CU-URD-REQ-1330 Verification: A;T

The random loads reported in Table 7, defined in the instrument reference frame and at the interface between the CU and the instrument, shall be considered in the design.

All loads are qualification loads.

Out of Plane (Z axis)		*In Plane (XY axes)*	
f	*PSD*	*f*	*PSD*
[Hz]	*[g2/Hz]*	*[Hz]*	*[g2/Hz]*
20	0.010	20	0.006
100	1.250	100	0.750
300	1.250	300	0.750
400	0.500	400	0.500
550	0.500	550	0.500
2000	0.038	2000	0.038
GRMS	**25.2**	**GRMS**	**22.5**

Table 7 – CU Random Vibration Loads (all TBC)

Parents: FLO-TRD-REQ-1590 *

These values are demanded to be reduced according to the notch reported in FLX-RP-ALM-CU-0009 Rev 1.0 (Random Notch Proposition) also attached to this RFD.

Other Items or Requirements (Potentially) Affected
None

Need for RFW/RFD and Rationale for Acceptance
The loads are notched to quasi static loads according to ECSS handbook. The proposed notch has been used for the FLX-RP-ALM-CU-0001 Rev 3.0 (Structural Analysis Report) based on verbal agreement.

RFD/RFW Number:	FLX-RFD-ALM-CU-0018	Issue	1.0

RFW/RFD CLOSED	Name	Sign & Date	
		Approved	Rejected
Project Manager / Engineering: (Sub System)	Gianluigi Capo	Digitally signed by Gianluigi Capo (Authentication) Reason: Project Manager Date: 2019.02.01 15:43:53 +01'00'	
Engineering: (Almatech)	Marco Lai	Digitally signed by Marco Lai (Qualified Signature) Date: 2019.02.01 15:25:02 +01'00'	
Product Assurance: (Almatech)	Thomas Gandy	Digitally signed by Thomas Antoine David Gandy (Authentication) Date: 2019.02.01 15:41:07 +01'00'	
Project Manager: (Leonardo)			
Engineering: (Leonardo)			
Product Assurance: (Leonardo)			
Engineering (ESA)			
Contract Manager (ESA)			

Continuation sheet:

FLORIS Calibration Unit

Random Notch proposition

Doc :	FLX-RP-ALM-CU-0009
Issue:	1
Date :	07.09.2018
DRD Code :	--

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Approval Sheet

	Name	Date	Signature
Prepared by:	Y. Puyol		
Reviewed by:	M. Lai		
Approved by:	T. Gandy		
Released by:	G Capo	p.o.	

Distribution List

Internal reference: ALM-PRO-3889

Person	Organization	Distribution
L. Blecha	Almatech	C
G. Capo	Almatech	O
M. Lai	Almatech	C
T. Gandy	Almatech	C
M. François	ESA	C
A. Capanni	Leonardo	A

A = Approval
C = Copy
I = Information
O = Original
R = Review

Change Record

Modification	Page	Iss.	Rev.	Date
First Issue	all	1	0	07.09.2018

Contents

1 Introduction

1.1 Project Overview

The Earth Explorer - Fluorescence Explorer (FLEX) mission will map vegetation fluorescence to quantify photosynthetic activity.

The conversion of atmospheric carbon dioxide and sunlight into energy-rich carbohydrates through photosynthesis is one of the most fundamental processes on Earth – and one on which we all depend.

Information from FLEX will improve our understanding of the way carbon moves between plants and the atmosphere and how photosynthesis affects the carbon and water cycles.

In addition, information from FLEX will lead to better insight into plant health and stress. This is of particular relevance since the growing global population is placing increasing demands on the production of food and animal feed. At the moment, photosynthetic activity cannot be measured from space, but FLEX's novel sensor will observe this faint glow.

The FLEX satellite will orbit in tandem with one of the Copernicus Sentinel-3 satellites, taking advantage of its optical and thermal sensors to provide an integrated package of measurements.

Mission objectives can therefore summarized as follows:

- To assess the quality of fluorescence-derived photosynthesis data against classical optically-based methods (i.e. from fraction of absorbed photosynthetically active radiation times Light Use Efficiency).
- To address in more detail temporal and spatial scaling issues (from towers to satellite footprints).
- To identify and characterize the effects of different types of stress on fluorescence and photosynthesis (especially drought and freezing air temperatures).
- To indicate potential applications of the novel fluorescence observations.

Mission orbit:

- Orbit: Sun-synchronous
- Measurement altitude: 815 km

The FLEX Space Segment consists of a single satellite carrying the FLuORescence Imaging Spectrometer (FLORIS) push-broom instrument. This high-resolution imaging spectrometer will acquire data in the 500– 780 nm spectral range, with a sampling of 0.1 nm in the oxygen bands (759–769 nm and 686–697 nm) and 0.5–2.0 nm in the red edge, chlorophyll absorption and Photochemical Reflectance Index bands.

The monthly global maps will have an on-ground spatial resolution of 300 × 300 m2 with a swath width of 150 km.

1.2 Scope of the Document

This document presents the notch of the random levels on the quasi-static interface loads as per [AD1].

2 Applicable and Reference Documents

2.1 Applicable Documents

Ref.	Title	Reference	Iss.
AD 105	Cover Letter	FLX-LET-FNM-INS-0003	3
AD 106	Special Condition of Tender	FLX-OF-FNM-INS-0001	4
AD 100	Contract for FLEX Unit/sub-system	Draft Contract	
AD 101	Generic Statement of Work for FLEX Unit/sub-system	FLX-SOW-FNM-INS-0001	2
AD 102	Specific Statement of Work	FLX-SOW-FNM-INS-0005	2
AD 103	Floris Calibration Unit User Requirement Specification	FLX-RS-FNM-INS-0006	5
AD 201	FLORIS Radiation Environment RS	FLX-RS-FNM-INS-0016	4
AD 202	FLEX FEMM Requirements Specification	FLX-RS-FNM-INS-0023	1
AD 203	FLEX GMM &TMM Requirements Specification	FLX-RS-FNM-INS-0024	1
AD 204	FLEX CAD Model Requirements Specification	FLX-RS-FNM-INS-0025	1
AD 205	FLEX Cleanliness Requirements for Sub-contractors	FLX-RS-FNM-INS-0028	3
AD 206	FLEX Instrument General Design Interface Requirements	FLX-RS-FNM-INS-0029	3
AD 208	FLEX PA Requirements for Subcontractors	FLX-RS-FNM-INS-0021	2
AD 209	FLEX PA SW Requirements for Subcontractors	FLX-RS-FNM-INS-0022	1
AD 210	FLEX Configuration Control and Documentation Management Plan	FLX-PL-FNM-INS-0001	3
AD 211	FLEX List of Acronyms and Abbreviations	FLX-LI-FNM-INS-0003	2
AD 1	Spacecraft mechanical loads analysis handbook	ECSS-E-HB-32-26A	19.02.13

2.2 Reference Documents

Ref.	Title	Reference	Iss.	Date
[RD01]	FLORIS Calibration Unit Almatech Proposal	17-10S-225	1.0	15.06.2017
[RD02]	Leonardo Clarification Letter	FLX-LET-FNM-INS-0009	--	18.10.2017
[RD03]	Floris CU Negotiation Meeting #1 between Leonardo and Almatech	FLX-MIN-FNM-INS-0041		15.11.2017
[RD04]	Metallic Materials and Elements for Aerospace Vehicle Structures	MIL-HDBK-5J	J	31.01.2003
[RD05]	FLORIS CU Design Justification File	FLX-RP-ALM-CU-0004	3.0	27.07.2018
[RD06]	CU random notch proposition	FLX-RP-ALM-CU-0009	1.0	05.09.2018
[RD07]	Structural Analysis Report	FLX-RP-ALM-CU-0001	2.0	30.08.2018

2.3 Acronyms and Abbreviations

The abbreviations and acronyms used in this document are in accordance with [AD 211].

4 Applied Load

4.1 Quasi-Static Loads

The quasi-static loads are applied as defined in [AD103] and presented hereafter.

- Out of plane : 40g
- In-Plane: 40g

4.2 Random Nominal Loads

Random levels applied to the FEM are those defined in [AD103]. The analysis is performed with a Q factor of 25.

Table 1: Out of Plane (Z axis).

Frequency [Hz]	PSD [g^2/Hz]
20.00	0.01
100.00	1.25
300.00	1.25
400.00	0.5
550.00	0.5
2000.00	0.038
Grms	**25.22**

Table 2: In Plane XY (axes).

Frequency [Hz]	PSD [g^2/Hz]
20.00	0.006
100.00	0.75
300.00	0.75
400.00	0.5
550.00	0.5
2000.00	0.038
Grms	**22.46**

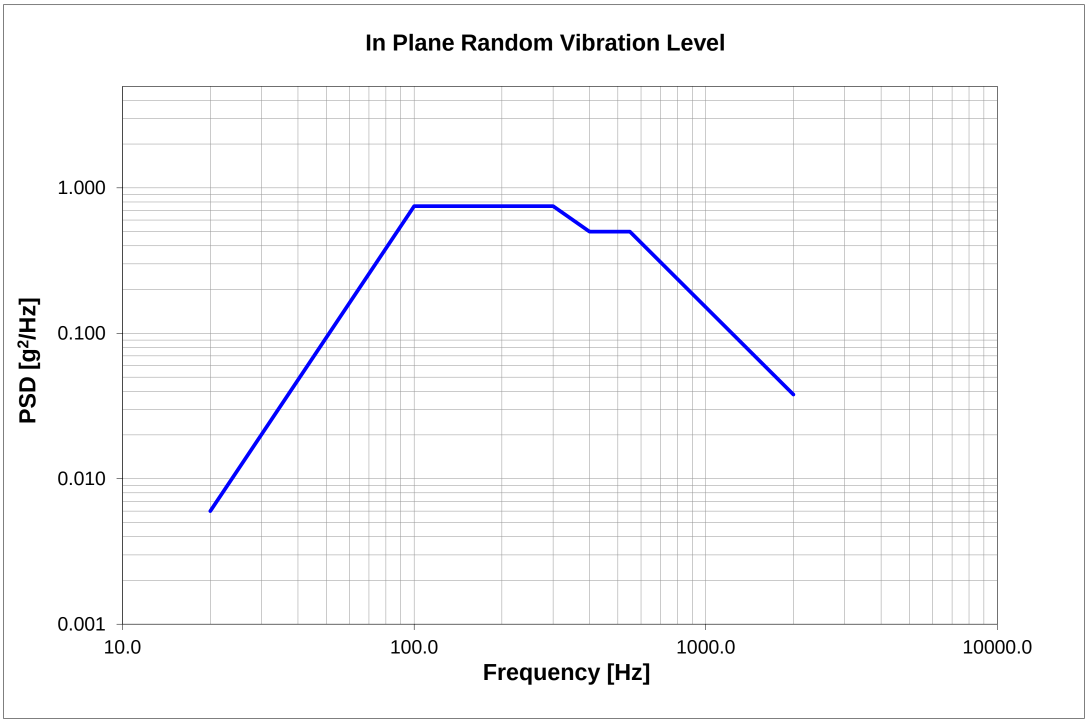

Figure 1: In Plane Random Profiles.

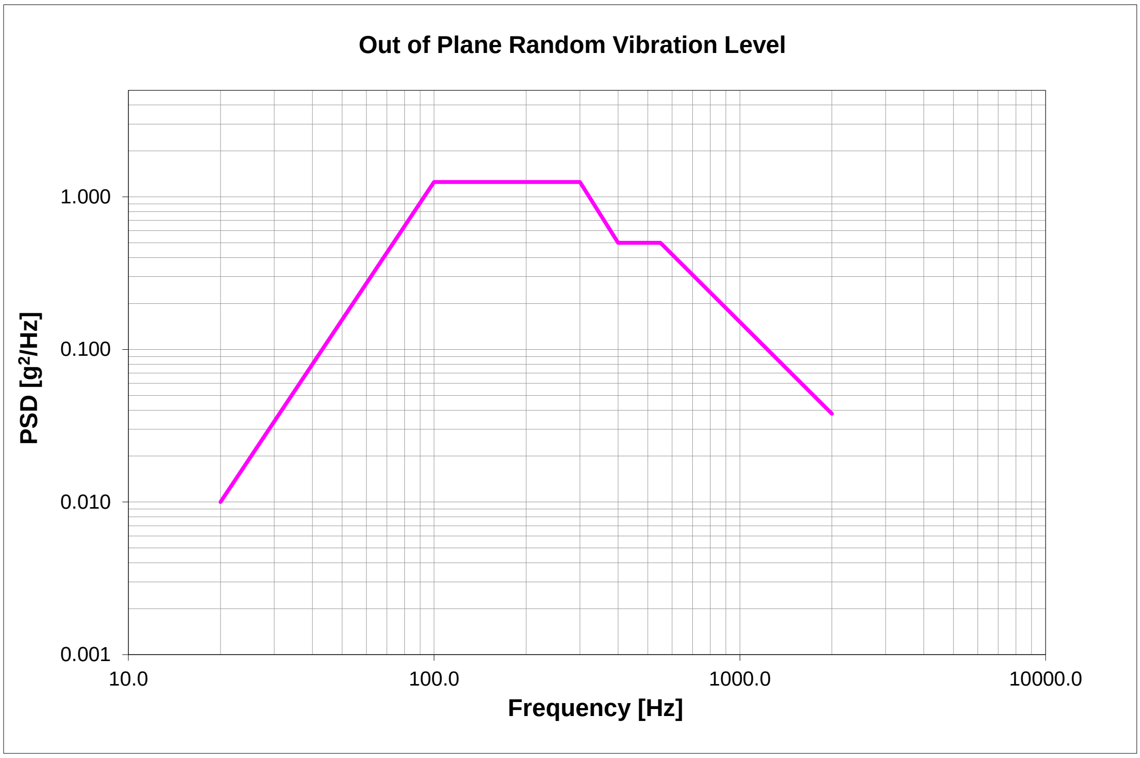

Figure 2: Out-of-Plane Random Profiles.

5 Quasi-Static Interface Loads

The quasi-static interface force criteria is 2740N (6.98kg x 9.81 x 40g) in X and Y axis.

6 Nominal Random Analysis Results

6.1 Random loads computation

Interface loads have been computed for nominal random vibration and are presented hereafter.

Table 3: Random 3σ loads at Interface

	Vibration Direction	
	X	**Y**
Interface Radial X [N]	5720	2651
Interface Radial Y [N]	2651	5641
Interface Axial Z [N]	1096	697

Bearing loads have been computed for random vibration in X, Y & Z, the 3σ force and moment results are reported in the following table.

Table 4: Random loads and moments on Bearing

	Vibration Direction	
	X	**Y**
Bearing Radial X [N]	3408	2099
Bearing Radial Y [N]	2102	3588
Bearing Axial Z [N]	667	554
Bearing Bending Moment X [Nm]	347	521
Bearing Bending Moment Y [Nm]	489	365

7 Notching on the quasi-static Interface Loads

7.1 Modal Analysis

A modal analysis has been performed to identify the mode presenting more than 10% modal effective mass. The relevant mode in X direction is at 296.8 Hz and at 265 Hz for Y direction. A complete description of the modal analysis with plots is presented in [RD07].

Mode n°	Freq. [Hz]	T1 [%]	T2 [%]	T3 [%]	R1 [%]	R2 [%]	R3 [%]	Description
1	56.3	0.0%	0.0%	0.0%	0.0%	0.0%	**21.7%**	Rotation of Rotor Assembly
2	256.1	1.1%	8.2%	0.0%	**17.0%**	2.6%	1.6%	Bending mode of the Sun Baffle in-plane
3	265.0	3.9%	**13.4%**	0.0%	**31.8%**	7.0%	5.2%	First bending mode of the rotor in-plane
4	291.9	4.8%	0.5%	3.0%	0.1%	**13.7%**	0.1%	Translation mode of the Sun Baffle in Z
5	296.8	**11.6%**	4.5%	0.1%	8.5%	**22.2%**	7.6%	Second bending mode of the rotor in-plane
6	335.3	1.6%	0.1%	4.2%	1.3%	0.3%	0.0%	Translation mode of the Sun Diffuser in Z
7	366.8	0.0%	0.2%	2.8%	2.8%	1.5%	0.3%	Translation of the Stator Housing Top in Z
8	399.6	0.2%	3.4%	0.5%	**16.6%**	0.0%	1.7%	Translation of the Stator Housing Top in Z combined with bending of the Sun Baffle
9	528.8	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	Mode of the Sun Diffuser and rotor supporting Interface
10	560.1	8.6%	0.7%	0.6%	4.6%	5.4%	3.5%	Mode of the Earth Aperture Baffle and Sun Baffle
11	564.6	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	
12	576.9	0.1%	0.1%	0.5%	0.0%	0.0%	0.0%	
13	600.3	0.1%	0.0%	0.3%	0.0%	0.0%	0.0%	
14	610.9	1.5%	0.1%	0.2%	0.4%	1.3%	0.0%	
15	613.6	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

7.2 Notching in X direction

The retained mode for notching in X direction occurs at 296.8 Hz (green line on Figure 3). The bandwidth of frequency available for notching has been derived considering a half frequency octave around the target mode. The notch can thus be performed between 250 Hz and 353 Hz (red lines on Figure 3). The RMS force is computed in this frequency bandwidth and can be reduced to the quasi-static value. In this case, the notch is limited by the frequency bandwidth considered and the RMS force computed still is higher than the quasi-static value. The blue line is retained as notched interface force in X.

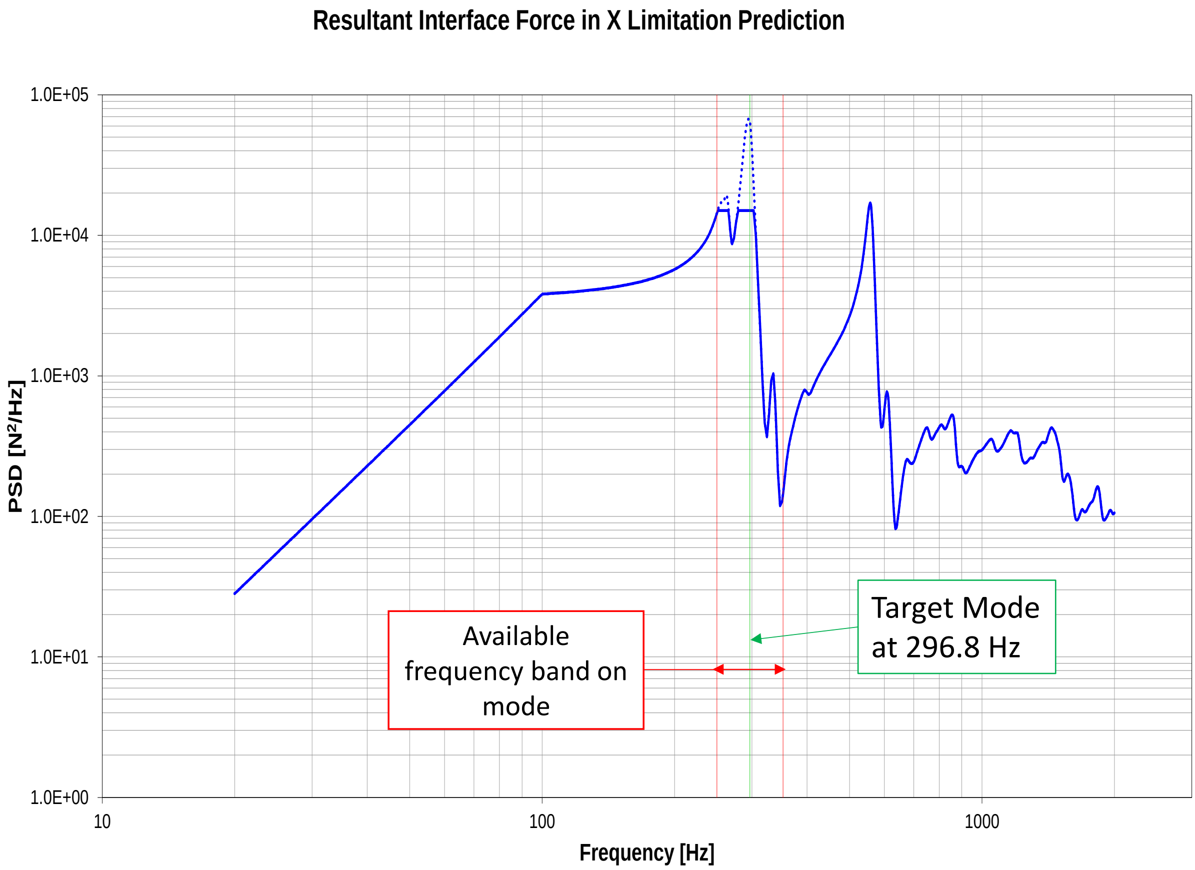

Figure 3: Resultant Interface Force Limitation Prediction in X Direction

The input corresponding to the interface force generated above is obtained with the following input PSD (dotted blue line on Figure 4). A new random input profile is derived from this notched input (black line on Figure 4). The depth of notch is obtained taking the minimum value at notch location +3 dB whereas the bandwidth of the notch is three times the frequency divided by Q. The slopes have been limited to ±25 dB/Oct.

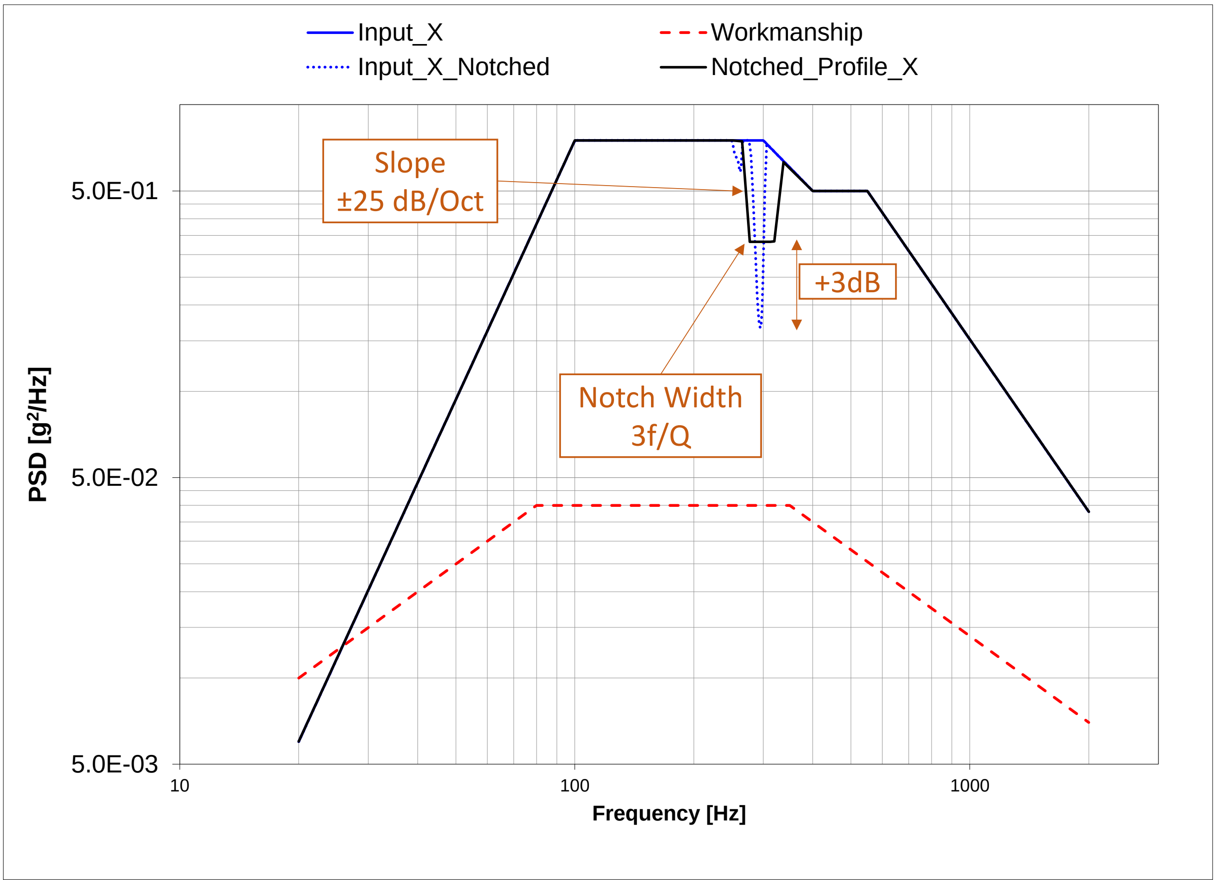

Figure 4: Notched Input Profile generation

The following table presents the notched input PSD corresponding to the black curve on Figure 4.

Table 5: Notched Input Profile in X direction

Frequency [Hz]	PSD [g^2/Hz]
20.00	0.006
100.00	0.750
251.22	0.750
277.09	0.332
312.47	0.332
337.49	0.630
400.00	0.500
550.00	0.500
2000.00	0.038
Total Grms	**21.88**

The obtained notched interface forces are the following:

Table 6: Notched Random X, 3σ loads at Interface

	Vibration Direction	
	X Notched	X Unnotched
Interface Radial X [N]	5092	5720
Interface Radial Y [N]	2024	2651
Interface Axial Z [N]	997	1096

Bearing loads have been computed for notched random vibration in X, the 3σ force and moment results are reported in the following table.

Table 7: Random loads and moments on Bearing

	Vibration Direction	
	X Notched	X Unnotched
Bearing Radial X [N]	2846	3408
Bearing Radial Y [N]	1534	2102
Bearing Axial Z [N]	598	667
Bearing Bending Moment X [Nm]	253	347
Bearing Bending Moment Y [Nm]	368	489

Plots of the bearing loads are presented on Figure 5 to Figure 9.

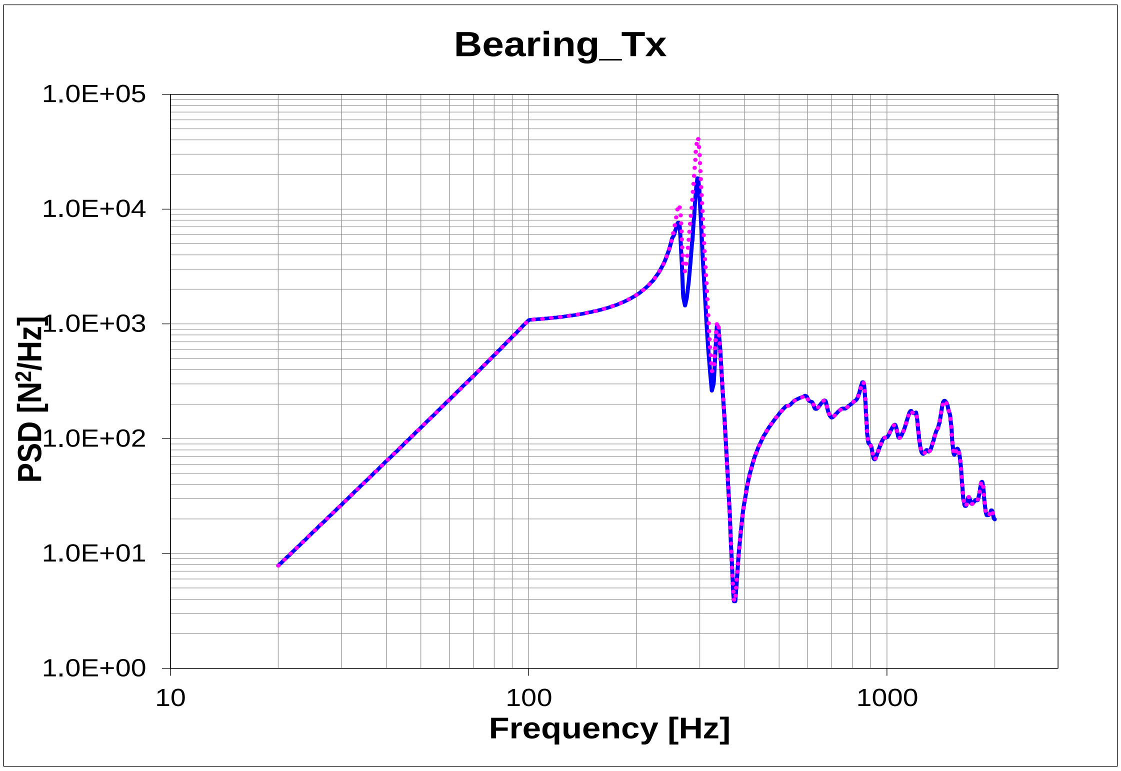

Figure 5: Random X Bearing Force X: Notched in blue, Unnotched in dotted magenta

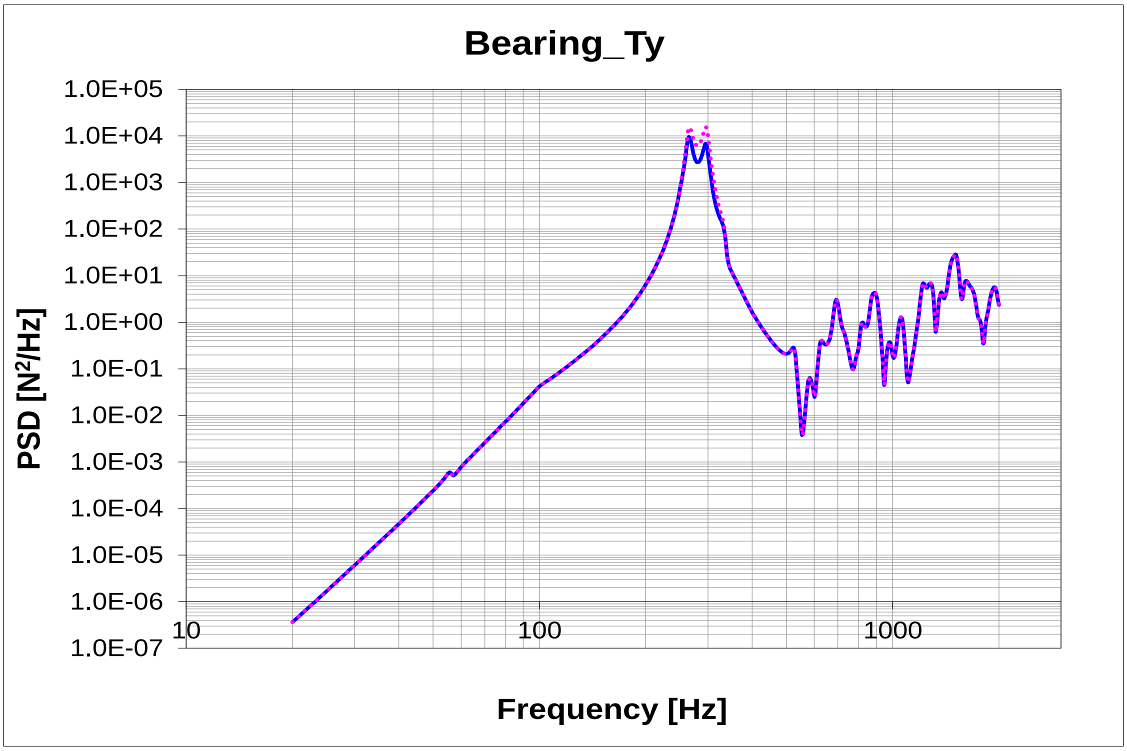

Figure 6: Random X Bearing Force Y: Notched in blue, Unnotched in dotted magenta

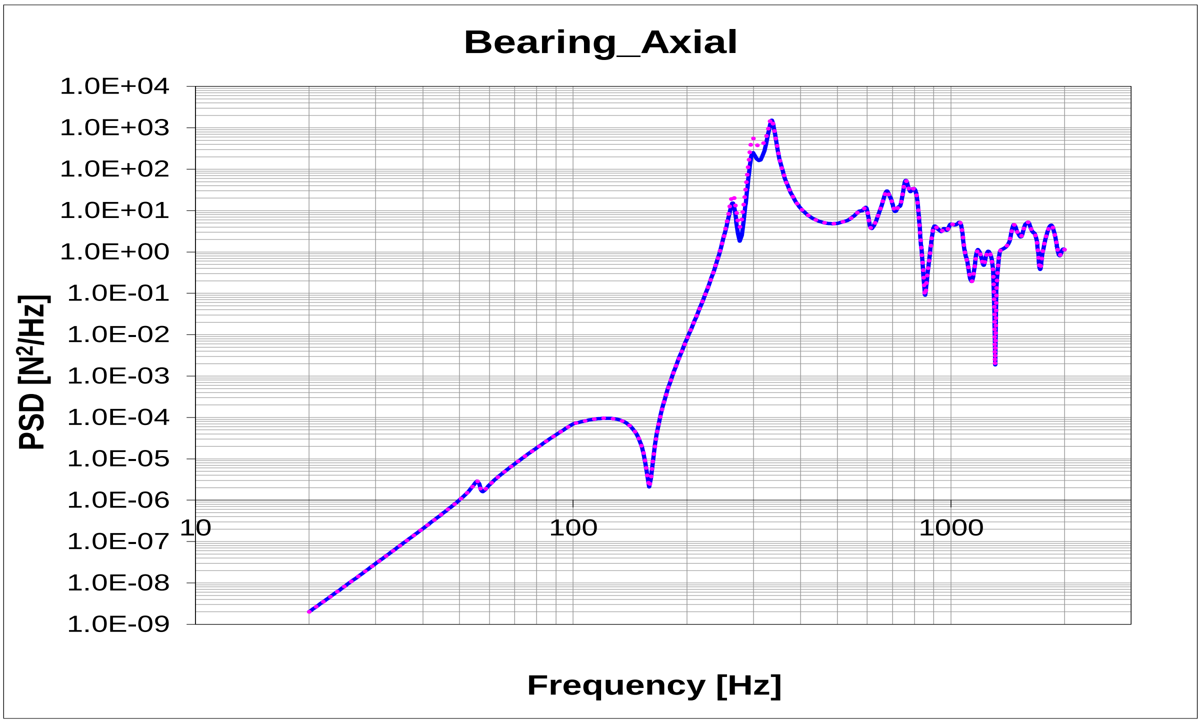

Figure 7: Random X Bearing Force Z: Notched in blue, Unnotched in dotted magenta

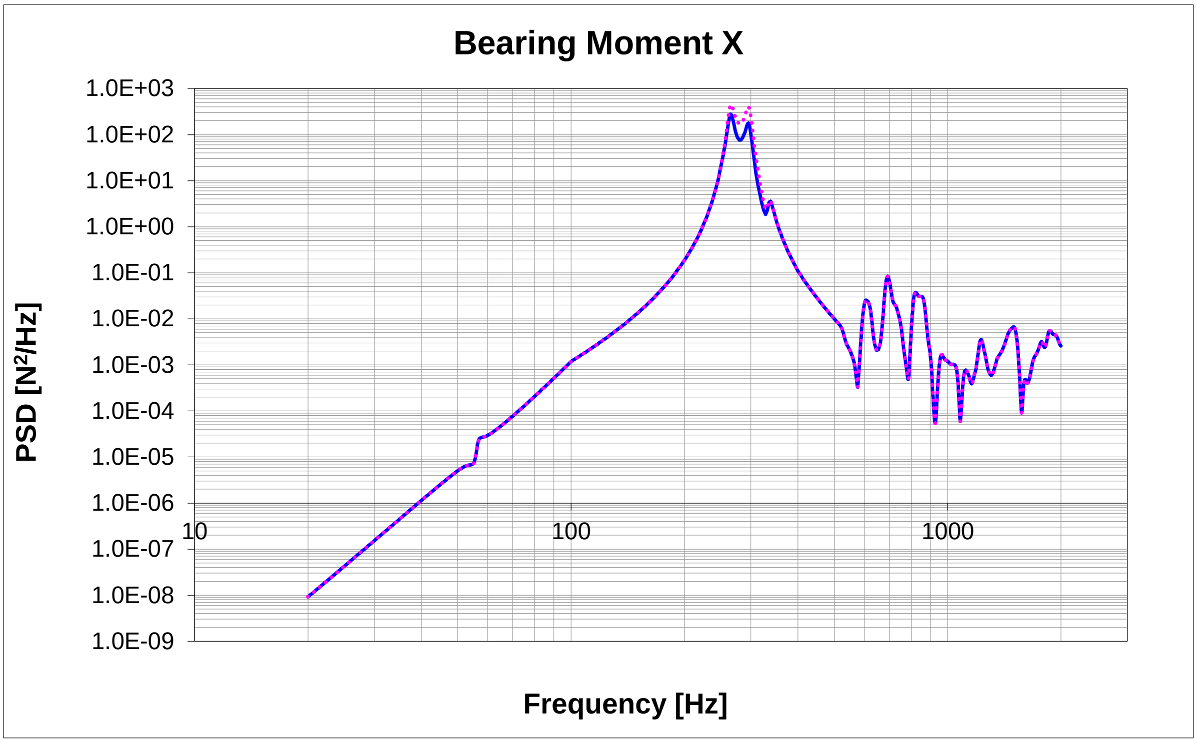

Figure 8: Random X Bearing Moment X, Notched in blue, Unnotched in dotted magenta

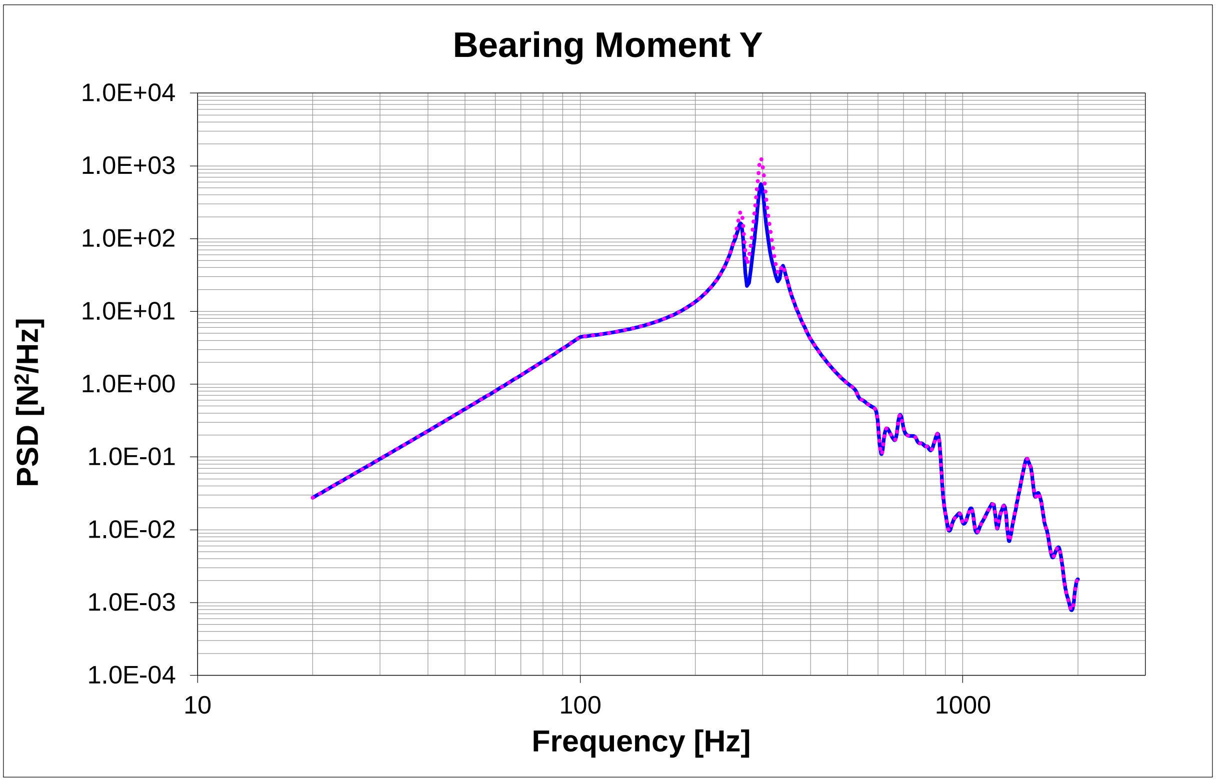

Figure 9: Random X Bearing Moment Y, Notched in blue, Unnotched in dotted magenta

7.3 Notching in Y direction

The retained mode for notching in Y direction occurs at 265 Hz (green line on Figure 10). The bandwidth of frequency available for notching has been derived considering a half frequency octave around the target mode. The notch can thus be performed between 223 Hz and 315 Hz (red lines on Figure 10). The RMS force is computed in this frequency bandwidth and can be reduced to the quasi-static value. In this case, the notch is limited by the frequency bandwidth considered and the RMS force computed still is higher than the quasi-static value. The blue line is retained as notched interface force in Y.

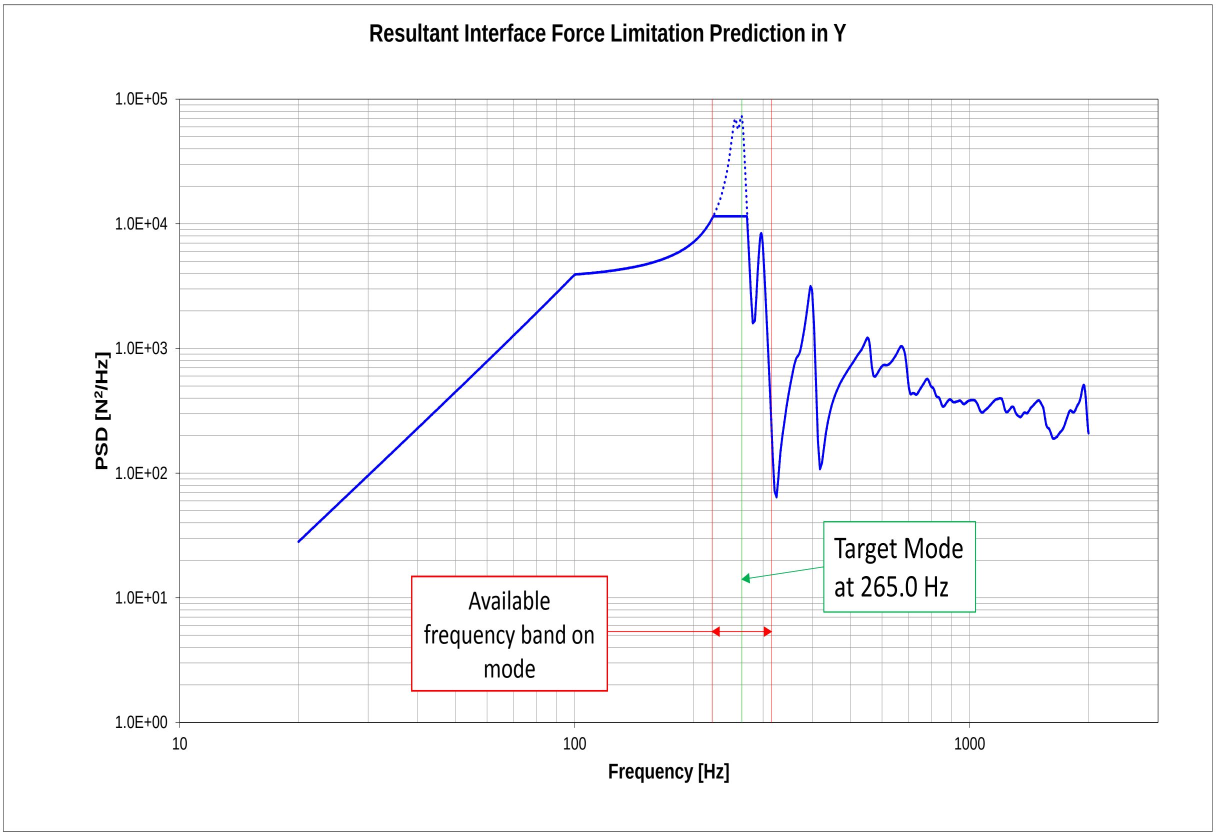

Figure 10: Resultant Interface Force Limitation Prediction in X Direction

The input corresponding to the interface force generated above is obtained with the following input PSD (dotted blue line on Figure 11). A new random input profile is derived from this notched input (black line on Figure 11). The depth of notch is obtained taking the minimum value at notch location +3 dB whereas the bandwidth of the notch is three times the frequency divided by Q. The slopes have been limited to ±25 dB/Oct.

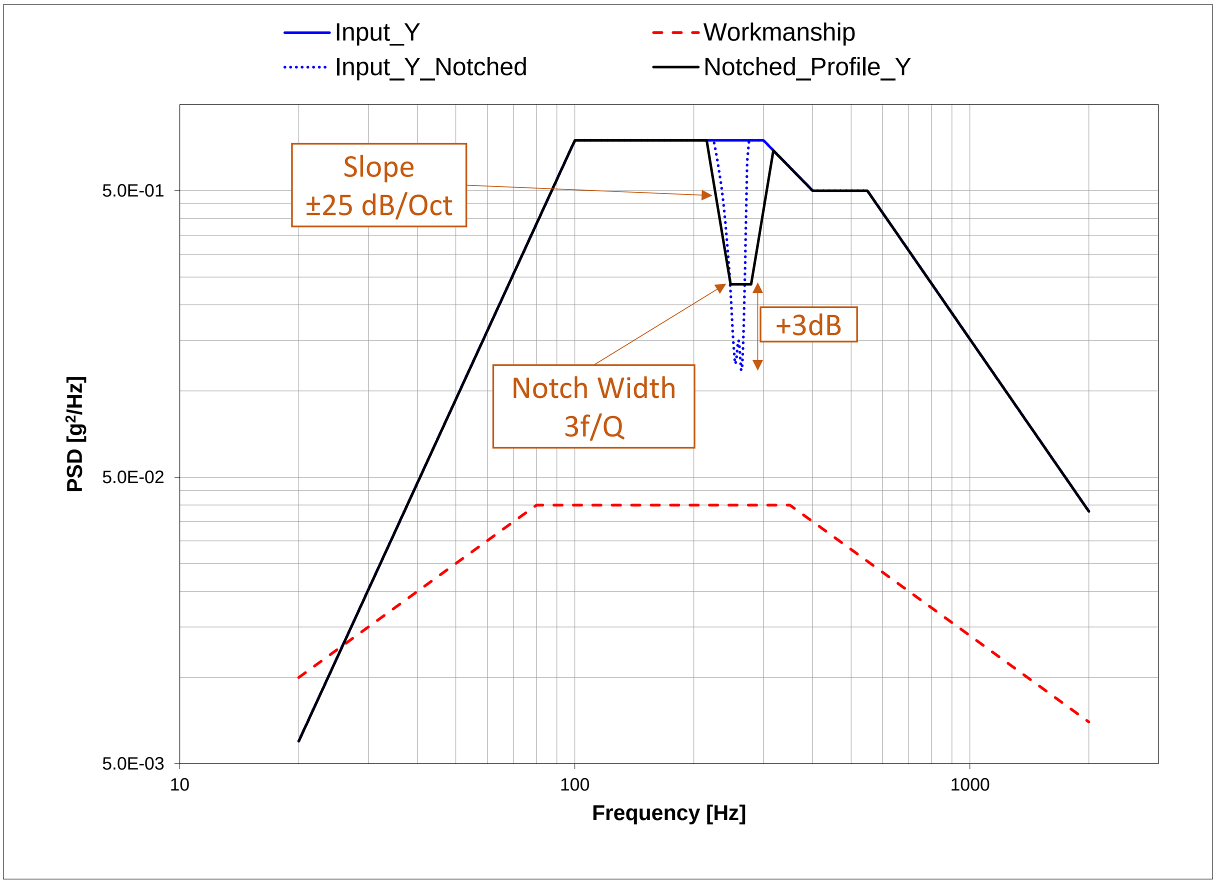

Figure 11: Notched Input Profile generation

The following table presents the notched input PSD corresponding to the black curve on Figure 11.

Table 8: Notched Input Profile in Y direction

Frequency [Hz]	PSD [g^2/Hz]
20.00	0.006
100.00	0.750
215.59	0.750
247.83	0.236
279.47	0.236
318.06	0.690
400.00	0.500
550.00	0.500
2000.00	0.038
Total Grms	**21.59**

The obtained notched interface forces are the following:

Table 9: Notched Random Y, 3σ loads at Interface

	Vibration Direction	
	Y Notched	Y Unnotched
Interface Radial X [N]	1766	2651
Interface Radial Y [N]	4493	5641
Interface Axial Z [N]	684	697

Bearing loads have been computed for notched random vibration in Y, the 3σ force and moment results are reported in the following table.

Table 10: Random loads and moments on Bearing

	Vibration Direction	
	Y Notched	Y Unnotched
Bearing Radial X [N]	1364	2099
Bearing Radial Y [N]	2654	3588
Bearing Axial Z [N]	534	554
Bearing Bending Moment X [Nm]	340	521
Bearing Bending Moment Y [Nm]	236	365

Plots of the bearing loads are presented on Figure 12 to Figure 16.

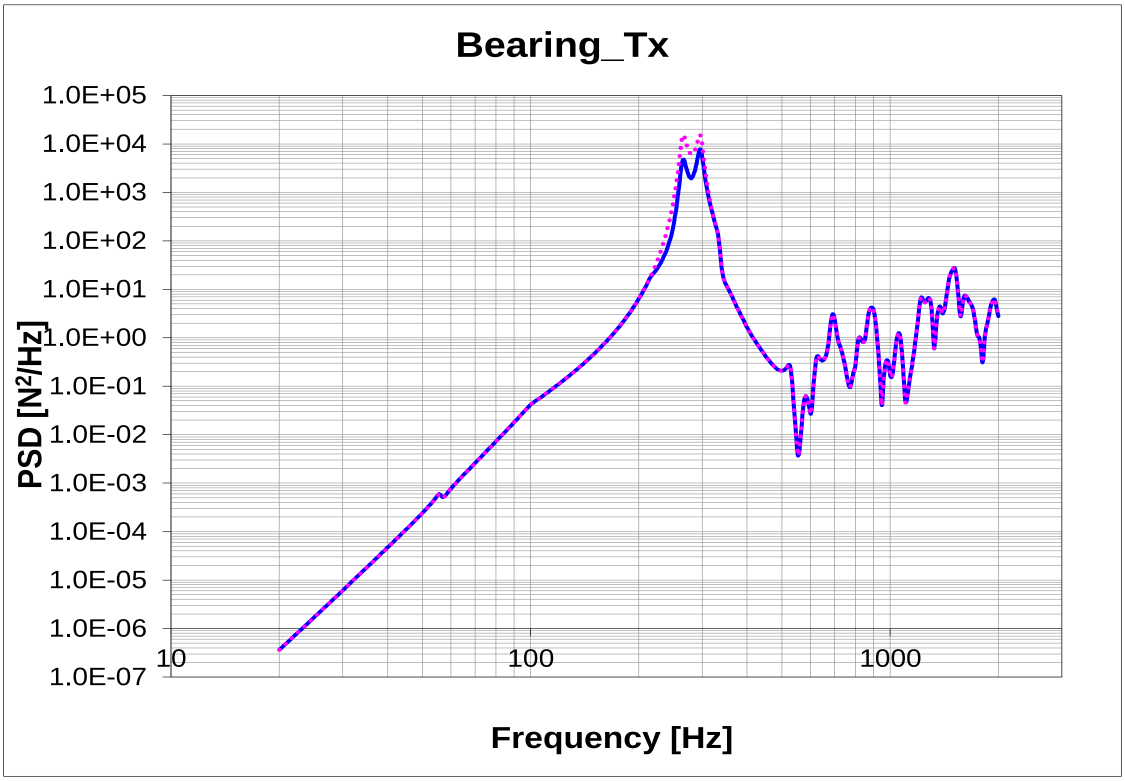

Figure 12: Random Y Bearing Force X: Notched in blue, Unnotched in dotted magenta

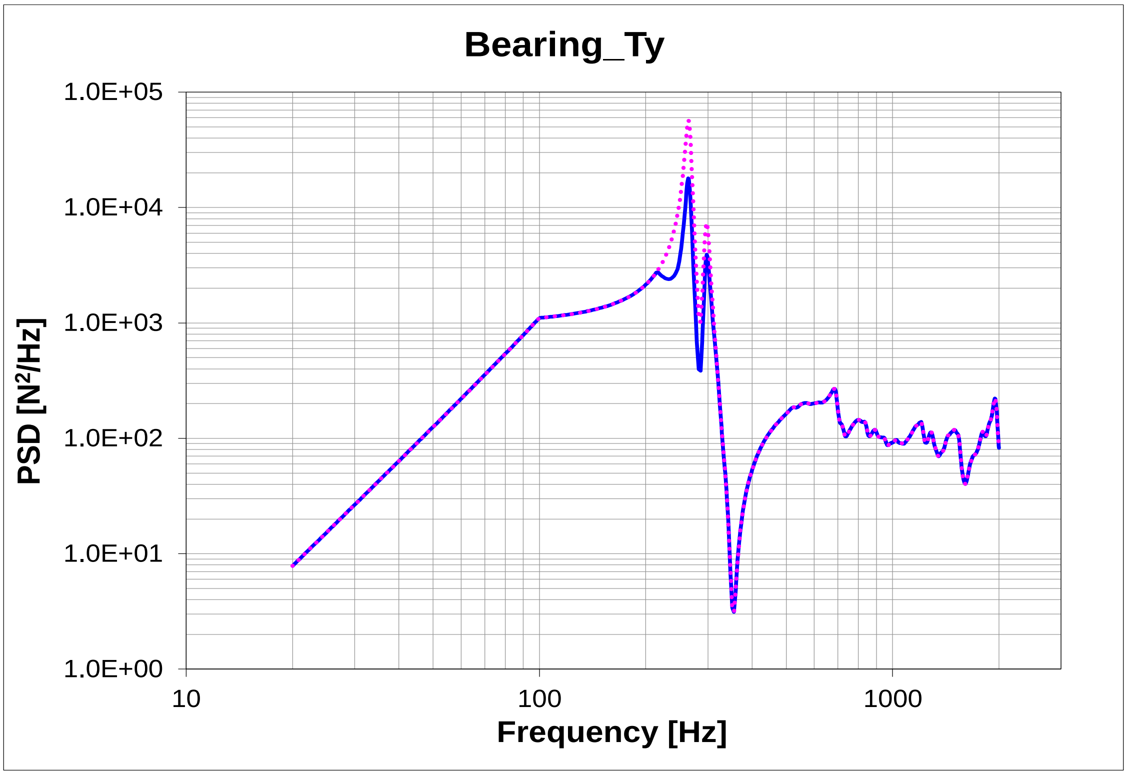

Figure 13: Random Y Bearing Force Y: Notched in blue, Unnotched in dotted magenta

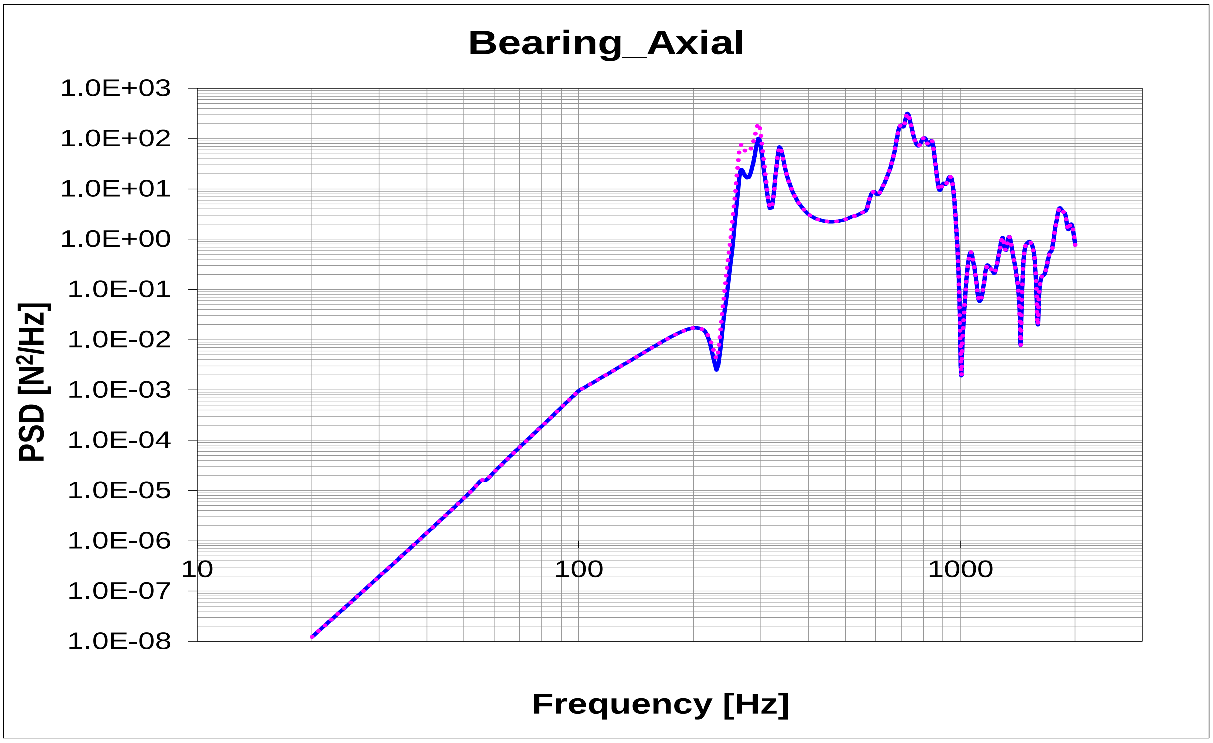

Figure 14: Random Y Bearing Force Z: Notched in blue, Unnotched in dotted magenta

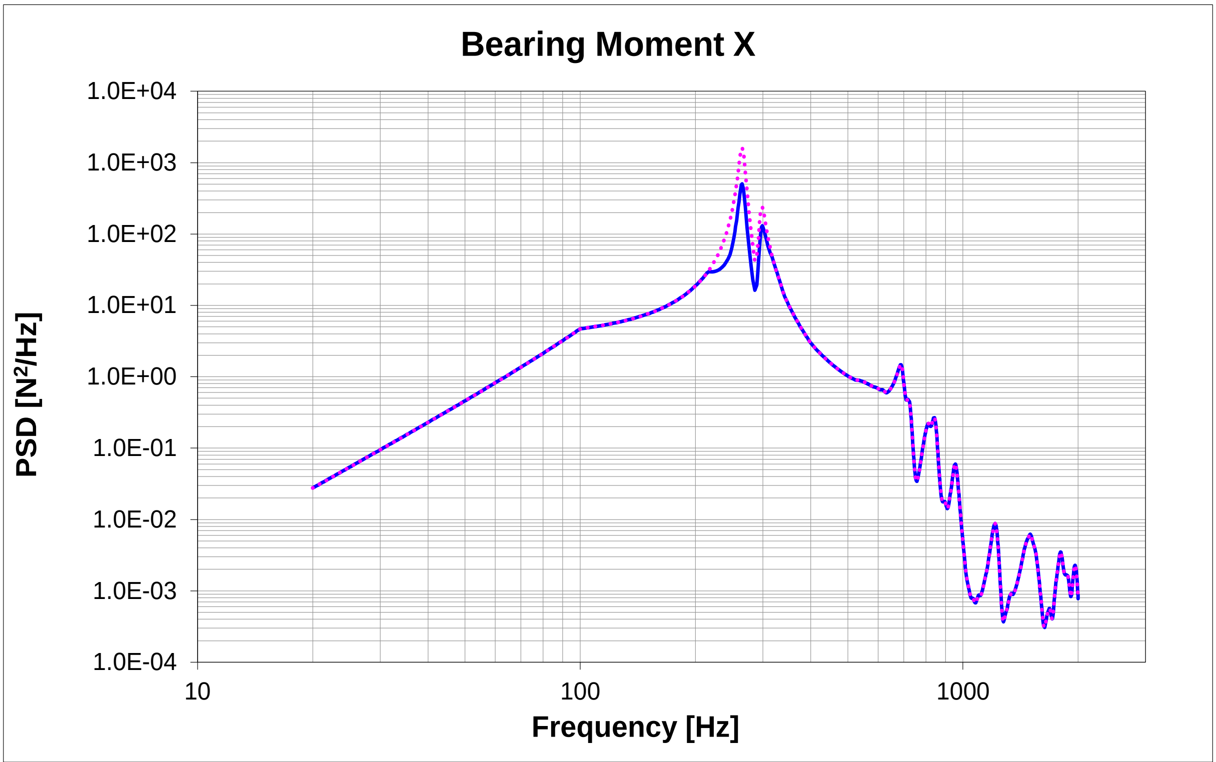

Figure 15: Random Y Bearing Moment X: Notched in blue, Unnotched in dotted magenta

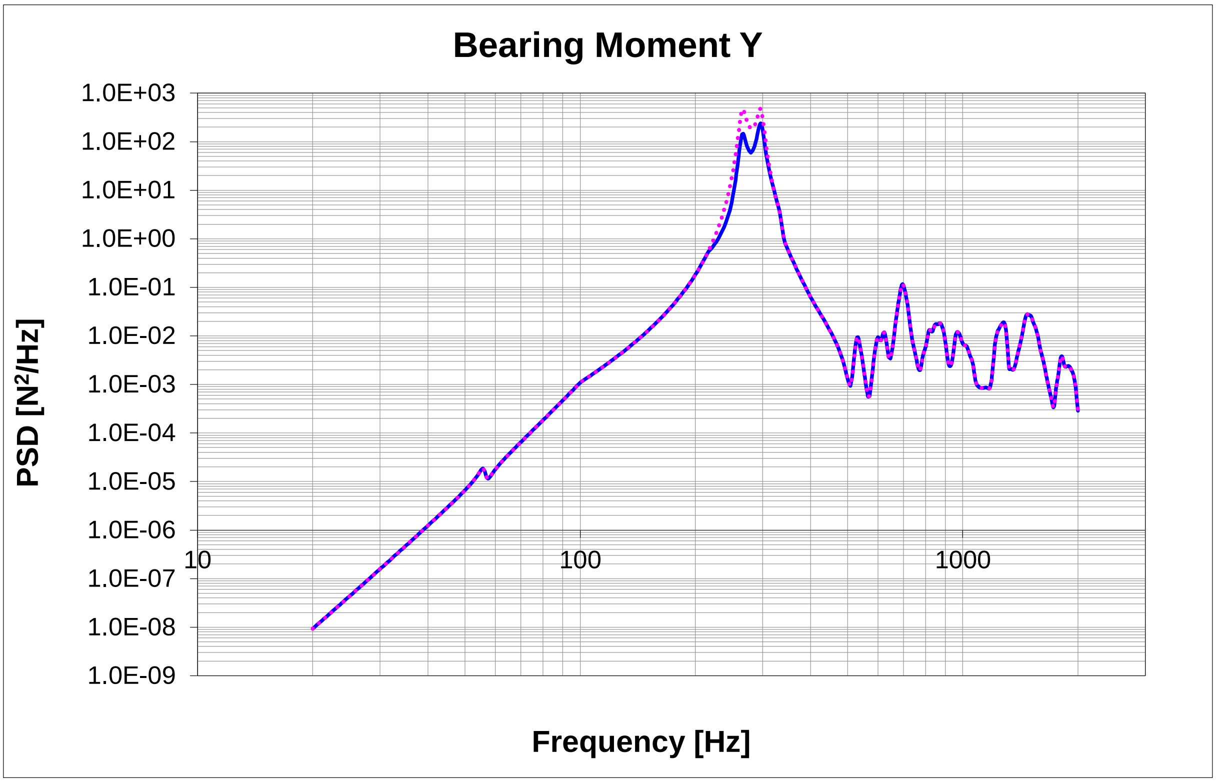

Figure 16: Random Y Bearing Moment Y: Notched in blue, Unnotched in dotted magenta