

PONTIFICIA UNIVERSIDAD CATÓLICA DEL PERÚ

FACULTAD DE CIENCIAS E INGENIERÍA



PONTIFICIA
**UNIVERSIDAD
CATÓLICA**
DEL PERÚ

IMPLEMENTACIÓN DE UN MÓDULO DE LABORATORIO PARA EL ESTUDIO DINÁMICO EN ESTRUCTURAS METÁLICAS DE EQUIPOS MECÁNICOS

ANEXOS

Tesis para optar el Título de Ingeniero Mecánico,
que presenta el bachiller:

ED FREDDY ARZAPALO BARRERA

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Lima, Octubre del 2015

ANEXOS



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Anexo A. Catálogos

A.1. Mini shaker 4810.

Vibration Exciters

All permanent magnetic exciters are versatile and can be used for a range of applications including general vibration testing, mechanical impedance and mobility measurements, modal analysis or accelerometer calibration.

Matching power amplifiers and a range of accessories are available.



Type Number		4808	4809	4810
Max. Force, Sine (peak) (without cooling)	N (lbf)	112 (25)	44.5 (10)	10 (2.25) @ 65 Hz to 4 kHz 7 (1.5) @ 65 Hz to 18 kHz
Max. Force, Sine (peak) (with air cooling)	N (lbf)	187 (42)	60 (13.5)	-
Max. Displacement, Pk-Pk	mm (in)	12.7 (0.5)	8.0 (0.32)	6.0 (0.24)
Effective Moving Mass	kg (lb)	160 (5.64)	-	18 (0.63)
Frequency Range	Hz	5 to 10000	10 to 20000	DC to 18000
Max. Bare Table Acceleration (peak)	m/s ² (g)	700 (71)	736 (75) 1000 (100) with air cooling	550 (56) @ 65 Hz to 4 kHz 383 (39) @ 65 Hz to 18 kHz
Coil Impedance	Ω	Approx. 0.8 @ 500 Hz with bare table and coils in paral- lel	Approx. 2 @ 500 Hz with bare table	3.5 @ 500 Hz
Max. Input Current	A RMS	15 with assisted air cool- ing at 25 A RMS	5 7 with forced air cool- ing	1.8
Weight	kg (lb)	35 (77.1)	8.3 (18.3)	1.1 (2.4)
Dimensions				
Diameter	mm (in)	215 (8.46)	149 (5.87)	76 (3)
Height	mm (in)	200 (7.87)	143 (5.63)	75 (2.9)
Table Diameter	mm (in)	62.5 (2.46)	29 (1.14)	14 (0.55)
Power Amplifier		Type 2719	Type 2718	Type 2718

For more information on the use of vibration exciters to calibrate accelerometers, see [Accelerometer Calibration](#).

A.2. Transductor de fuerza 8202

Product Data

With compliments
Helmut Singer Elektronik
 www.helmut-singer.de info@helmut-singer.de
 fon +49 241 155 315 fax +49 241 152 066
 Feldchen 16-24 D-52070 Aachen Germany

Force Transducers — Types 8200 and 8201

USES:

- Dynamic, short duration static and impact force measurements in machinery, buildings etc.
- Measurement of Frequency Response Functions when used together with an accelerometer

FEATURES:

- Wide force ranges

- Extremely good linearity
- High long term stability
- All welded, hermetically sealed construction
- Small size
- Wide operating temperature range
- Individually calibrated
- High resolution
- Easily mounted

These transducers are designed to measure dynamic, short duration static and impact, tensile and compressive forces in machinery and other constructions. They are mounted so that the force to be measured is transmitted through the transducer. Used with vibration exciters they can measure and control the applied force, and can be used for the measurement of Frequency Response Functions in conjunction with an accelerometer.

Type 8200 is a small, permanently pre-loaded transducer usable in the force range 1000N tensile to 5000N compressive (-225 lbf to + 1225 lbf). Its top seismic mass is low (3 grams), this feature being particularly important when measuring on low impedance structures. The transducer is mounted using the threaded spigot and tapped hole in the body.

Type 8201 is a general purpose transducer with high force measuring capability. It is supplied with pre-loading nuts for the measurement of tensile and compressive forces in the range -4000N to +16000N (-900 lbf to +3600 lbf). With the pre-loading nuts removed, compressive forces up to 20000N (+4500 lbf) are measurable. Its calibration is still valid after remounting the pre-loading nuts. The 8201 is dimensioned so that it is easily connected or built into the measuring object without the need for altering or removing existing mechanical elements.



8200
 -1000 N to +5000 N
 (-225 lbf to +1225 lbf)

8201
 -4000 N to +20000 N
 (-900 lbf to +4500 lbf)

The transducers have a rugged, all welded, hermetically sealed construction with a ceramic insulated micro-plug connector sealed with moulded glass, allowing them to be used under very severe environmental conditions. The allowable temperature operating range is -196°C to + 200°C

for the Type 8200 and -196°C to + 150°C for the Type 8201.

Sectional drawings of the two force transducers are shown in Fig.2. Both transducers work on the piezoelectric effect of quartz which, when stressed, produces an electrical charge which is proportional to the stressing force.

Specifications 8200 and 8201

	8200	8201
Force range	1000 N tensile to 5000 N compressive (-225 lbf to +1125 lbf)	4000 N tensile to 16000 N compressive (-900 lbf to +3600 lbf) with pre-loading nuts. 20000 N compressive (+4500 lbf) without pre-loading nuts
Linearity¹⁾	< ±1% of max. force	< ±2% of max. force
Reproducibility of original sensitivity with re-mounting of pre-loaded nuts	—	< ±2% of max. force
Charge Sensitivity¹⁾ (typical)	4 pC/N (17.8 pC/lbf)	4 pC/N (17.8 pC/lbf)
Capacitance (typical)	25 pF	70 pF
Leakage Resistance (at 25°C)	> 10 ⁶ MΩ	> 10 ⁶ MΩ
Stiffness	5 × 10 ⁸ N/m (2.9 × 10 ⁶ lbf/in)	7 × 10 ⁸ N/m (4 × 10 ⁶ lbf/in)
Deformation at Maximum Force	0.01 mm (0.0004 in)	0.03 mm (0.0012 in)
Resonance Frequency¹⁾ with 5 grams load mounted on top (typical)	35 kHz	20 kHz
Effective Seismic Mass:		
Above Piezoelectric Element (Top)	3 grams	With pre-loading nuts: 43 grams Without pre-loading nuts: 16 grams
Below Piezoelectric Element (Base)	18 grams	With pre-loading nuts: 69 grams Without pre-loading nuts: 43 grams
Temperature Range	-196 to +200°C (-321 to +392°F)	-196 to +150°C (-321 to +302°F)
Temperature Transient Sensitivity (typical)	0.5 N/°C (0.06 lbf/°F)	0.4 N/°C (0.05 lbf/°F)
Transverse Sensitivity²⁾ (typical)	5%	4% (with pre-loading nuts mounted)
Maximum Transverse Force for stated Transverse Sensitivity	100 N (22.5 lbf)	500 N (112 lbf)
Bending Moment Sensitivity³⁾ (typical)	100 pC/Nm (136 pC/lbf ft)	25 pC/Nm (34 pC/lbf ft) (with pre-loading nuts mounted)
Maximum Bending Moment for stated Bending Moment Sensitivity	1 Nm (0.74 lbf ft)	10 Nm (7.4 lbf ft)
Strain Sensitivity⁴⁾ (top and base)	< 0.04 N (0.009 lbf) per μStrain	< 0.004 N (0.0009 lbf) per μStrain (with pre-loading nuts mounted)
Magnetic Sensitivity⁴⁾ at 50 Hz (typical)	0.2 N/T ⁵⁾ (0.05 lbf/T)	0.9 N/T ⁵⁾ (0.2 lbf/T)
Material	Stainless steel AISI 316	Stainless steel AISI 316
Weight	21 grams (0.046 lb.)	112 grams (0.25 lb.) with pre-loading nuts 58 grams (0.13 lb.) without pre-loading nuts
Dimensions	<p>270180/1e</p>	<p>840047/2e</p>

¹⁾ Individual values given on the calibration chart

²⁾ For forces transverse to the main axis of the transducer

³⁾ The total bending moment is the sum of the resultant bending moments due to axial and transverse forces taken about the mid-point of the transducer

⁴⁾ Ref. ANSI S2.11-1969

⁵⁾ 1 Tesla = 10 kGauss

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 BP0443-15

A.3. Acelerómetro tipo 4383



PRODUCT DATA

Piezoelectric Accelerometer
Charge Accelerometer — Type 4383, 4383 S and 4383 V

USES

- General purpose
- High sensitivity
- Low-level, low-frequency measurement
- Vibration testing and analysis



Description

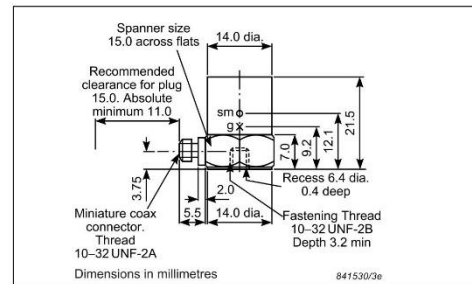
Type 4383 is a piezoelectric, DeltaShear®, Unigain® accelerometer with side connector. Type 4383 features 10–32 UNF receptacle for output connection and can be mounted on the object by means of a 10–32 UNF threaded steel stud.

Calibration

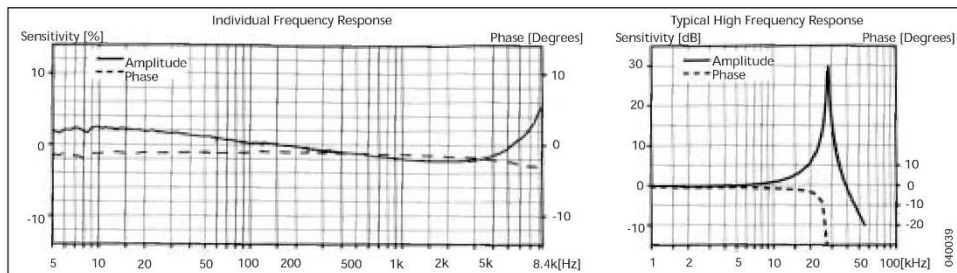
The sensitivity given in the calibration chart has been measured at 159.2 Hz and an acceleration of 10 g. For 99.9% confidence level, the accuracy of the factory calibration is ±2%.

Characteristics

This piezoelectric accelerometer may be treated as a charge source. Its sensitivity is expressed in terms of charge per unit acceleration (pC/g).



The DeltaShear design involves three piezoelectric elements and three masses arranged in a triangular configuration around a triangular centre post. The ring prestresses the piezoelectric elements to give a high degree of linearity. The charge is collected between the housing and the clamping ring. The piezoelectric element used is a PZ 23 lead zirconate titanate element. The housing material is titanium.



Specifications – Charge Accelerometer Type 4383, 4383 S and 4383 V

	Units	4383/4383 S	4383 V
Dynamic Characteristics			
Charge Sensitivity (@ 159.2 Hz)	pC/g	31 ± 2%	31 ± 15%
Frequency Response		See typical Amplitude Response	
Mounted Resonance Frequency	kHz	28	
Amplitude Response ±10% [1]	Hz	0.1 to 8400	
Transverse Sensitivity	%	<4	
Transverse Resonance Frequency	kHz	10	
Electrical Characteristics			
Min. Leakage Resistance @ 20°C	GΩ	20	
Capacitance	pF	1200	
Grounding		Signal ground connected to case	
Environmental Characteristics			
Temperature Range	°C (°F)	-74 to 250 (-101 to 482)	
Humidity		Welded, sealed	
Max. Operational Sinusoidal Vibration (peak)	g pk	2000	
Max. Operational Shock (± peak)	g pk	5000	
Base Strain Sensitivity	Equiv. g/μ strain	0.001	
Thermal Transient Sensitivity	Equiv. g/°C (g/°F)	0.01 (0.0056)	
Magnetic Sensitivity (50 Hz–0.03 Tesla)	g/T	0.3	
Physical Characteristics			
Dimensions		See outline drawing	
Weight	gram (oz.)	17 (0.6)	
Case Material		Titanium	
Connector		10–32 UNF-2A	
Mounting		10–32 UNF-2A × 4 mm threaded hole	

[1] Low-end response of the transducer is a function of its associated electronics

Ordering Information

Type 4383 includes the following accessories:

- Carrying box
- Calibration chart
- AO 0038: Low noise cable fitted with 10–32 connectors, 1.2 m
- 10–32 UNF threaded steel stud. Length 12.7 mm

Type 4383 S includes the following accessories:

- Carrying box
- Calibration chart
- AO 0038: Low noise cable fitted with 10–32 connectors, 1.2 m
- 10–32 UNF threaded steel stud. Length 12.7 mm
- UA 0078: Accessory box including:
 - Cementing stud, 10–32 UNF
 - EP610 input adaptor, TNC to 10–32 UNF microdot
 - Mounting magnet, 10–32 UNF thread
 - Case of beeswax

- Insulating disk
- Insulating stud
- Steel stud 10–32 UNF × ½"
- Tools

Type 4383 V includes the following accessories:

- Carrying box
- Calibration chart
- 10–32 UNF threaded steel stud. Length 12.7 mm

OPTIONAL ACCESSORIES

- AO 0038: 260°C Teflon® low-noise cable, 10–32 UNF, length 1.2 m (4 ft)
- AO 0122: 250°C, reinforced super low noise cable, 10–32, 3 m (10 ft)
- AO 0231: 260°C Teflon low-noise cable, 10–32 UNF/TNC, length 3 m (10 ft)
- AO 1382: Teflon low noise cable, double screened 10–32, 1.2 m (4 ft)
- DB 0544: 10–32 UNF Round tip

- JJ 0207: 2-pin TNC/10–32 UNF plug adaptor
- JP 0162: 10–32 UNF to TNC connector adaptor
- QA 0013: Hexagonal key for 10–32 UNF studs
- QA 0029: Tap for 10–32 UNF thread
- UA 0559: Mechanical filter for Accelerometer
- UA 0642: Mounting magnet and 2 insulating discs
- UA 0866: Cement stud 10–32 UNF 0.14 mm (set of 25)
- YG 0150: Steel stud 10–32/10–32 with flange
- YJ 0216: Beeswax for mounting
- YP 0080: Probe with sharp tip
- YP 0150: 10–32 UNF insulated stud. Length 12.7 mm
- YQ 2960: 0–32 UNF threaded steel stud. Length 12.7 mm
- YQ 2962: 0–32 UNF threaded steel stud. Length 7.62 mm

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Anexo A.4. Torquímetro 1 – 25 N.m

TOPTUL®

THE MARK OF PROFESSIONAL TOOLS

www.toptul.com

HOW TO USE TOPTUL TORQUE WRENCH

- UNLOCK ADJUSTABLE HANDLE.**
- SET THE REQUIRED TORQUE BY TURNING ADJUSTABLE HANDLE.**
- WHEN TORQUE VALUE IS SELECTED AND SET, LOCK ADJUSTABLE HANDLE. (TO LOCK THE HANDLE, THE ARROW MUST BE PRECISELY POINTED AT THE DIGIT/NUMBER)**
- AFTER INSTALLING SOCKET TO NUT OR BOLT, APPLY FORCE ON THE HANDLE AND THEN STOP APPLYING FORCE UNTIL HEARING "CLICK". THE TORQUE WRENCH WILL RETURN TO ZERO RESET AUTOMATICALLY.**

EXAMPLES - ANAM1205 (5-50Nm)
EXAMPLES: NEWTON SCALE (Nm) 1 ON FINE SACLE = 0.25 Nm
 A. Turn handle reach 22 Nm scale, the reading "2.00" must align with arrow.
 B. To set 40 Nm, adjust handle scale to reading "0" aligned with arrow.

A.22Nm

B.40Nm

Click-Window Scale-Type

- Large digits for exact and easy-to-read torque setting
- Torque precision of ± 3% of the preset torque value
- Large, convex display simplifies reading
- 45-tooth reversible ratchet head, fine increment movement
- Adjustable torque model for clockwise tightening
- Automatic resetting on pressure release after disengagement

5. WHEN NOT IN USE, KEEP LOWEST TORQUE SETTING IN CASE THE INTERNAL SPRING GET FATIGUED FROM A CONTINUOUS COMPRESSION.

TOPTUL® TORQUE WRENCH Calibration Certificate

Brand:	TOPTUL		
Description:	ANAM0803		
Part number:	5	=	25
Torque range:	N-m		
Tolerance + %:	+ 3.0	-	3.0
Serial number:	NA00053		

Testing machine:	S2007.01		
Serial number:	A1		
Calibration Certificate:	± 3 %		

Temp: 25 C

Setting	N-m	5.000	Abw.	15.000	Abw.	25.000	Abw.
1.Test		5.040	-0.79 %	15.006	-0.04 %	24.922	0.31 %
2.Test		5.086	-1.69 %	15.088	-0.58 %	25.109	-0.43 %
3.Test		5.113	-2.21 %	15.066	-0.44 %	25.098	-0.39 %
4.Test		5.135	-2.63 %	15.047	-0.31 %	25.073	-0.29 %
5.Test		5.144	-2.80 %	15.025	-0.17 %	25.040	-0.16 %
Average in	N-m	5.103	-2.02 %	15.046	-0.31 %	25.048	-0.19 %

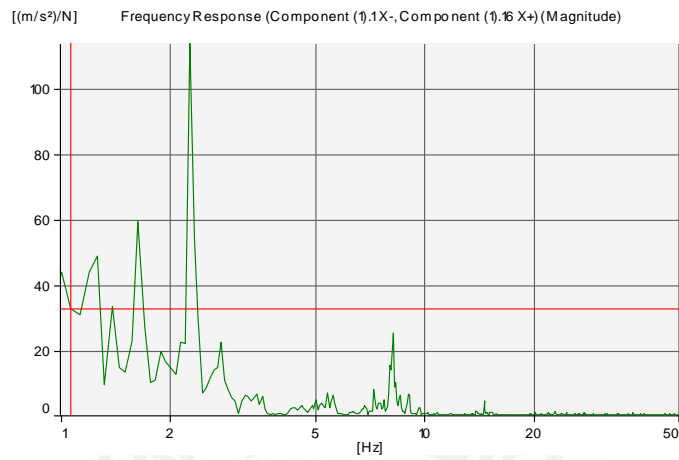
As this certificate is automatically produced, no signature is required

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Auditor: LIAN

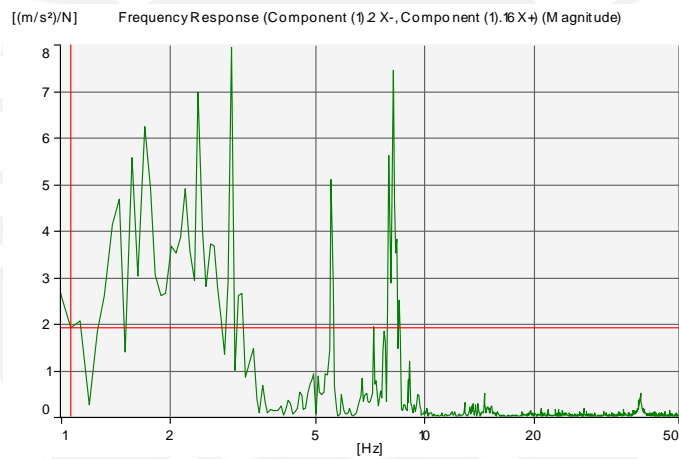
Micrometer Adjustable Torque Wrench - Window Display
 HANDBOOK No. T5-700
CERTIFICATE OF CALIBRATION

Anexo B. Gráficas Amplitud vs frecuencia

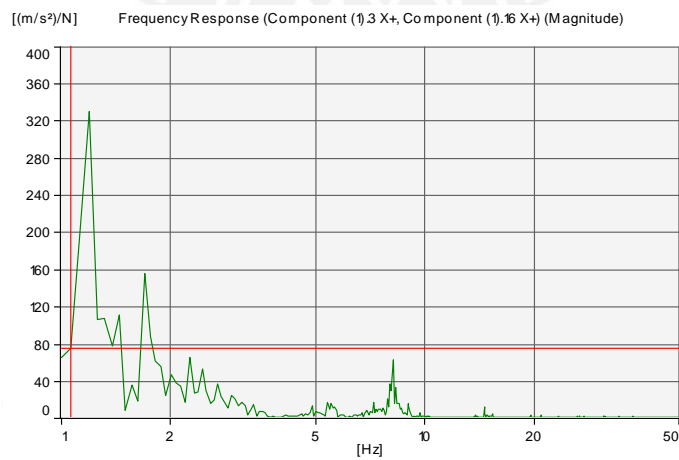
Anexo B.1. Ensayo empotrado con torque variable



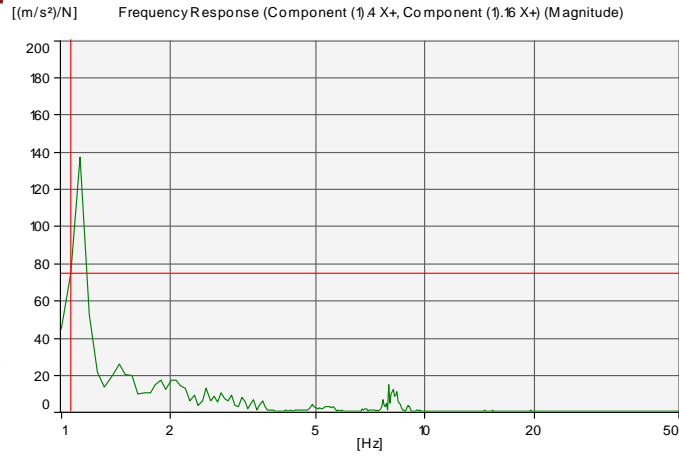
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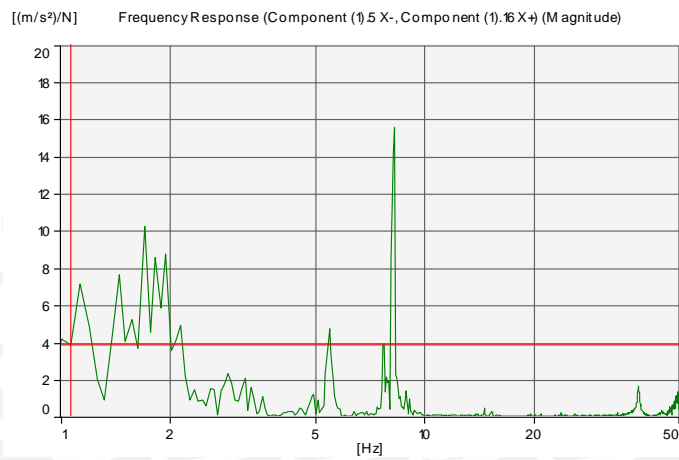
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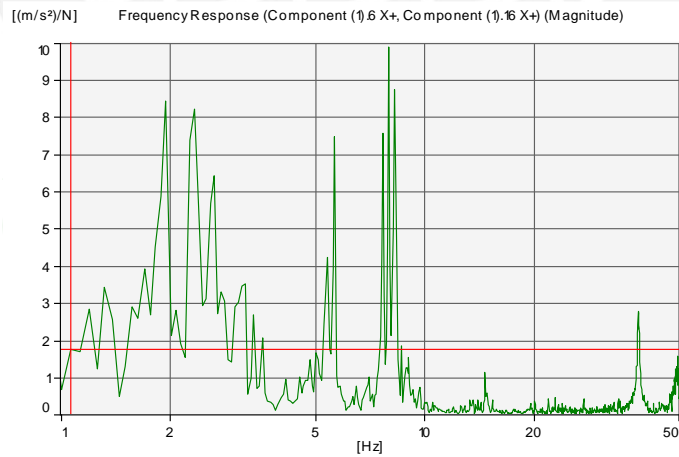
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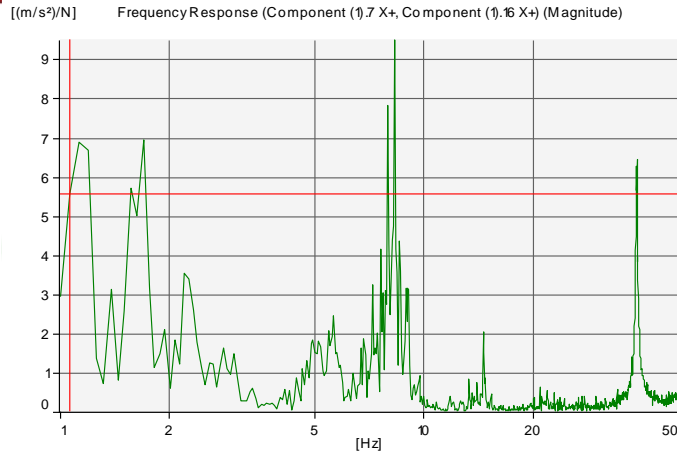
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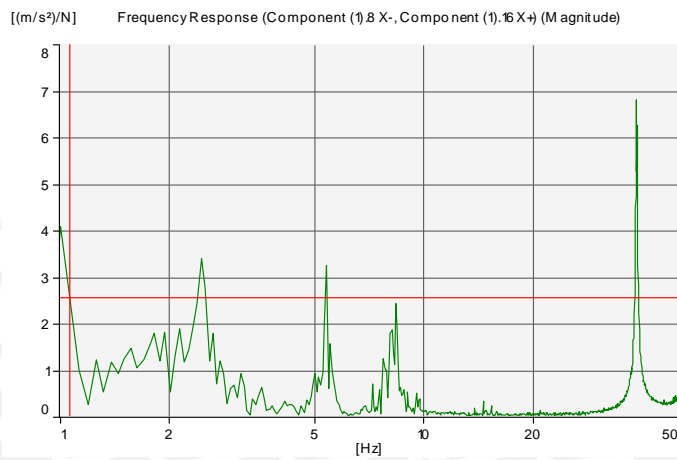
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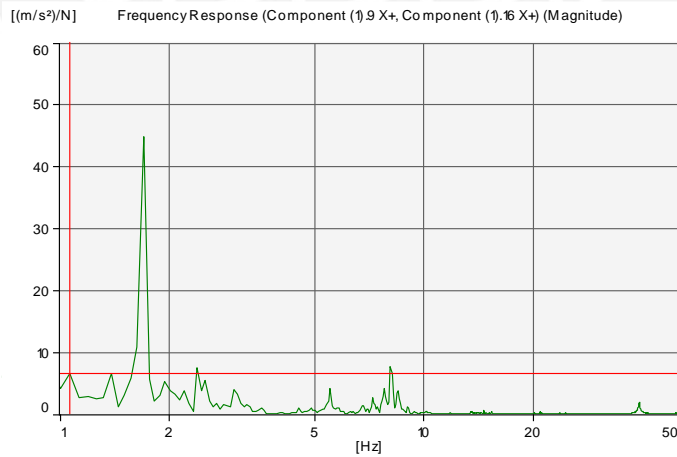
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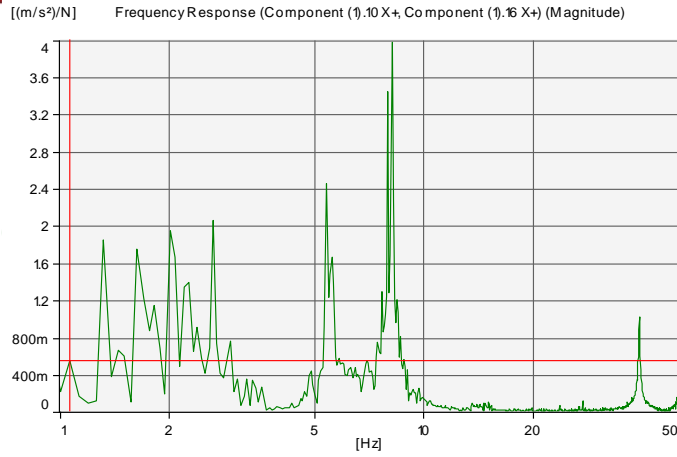
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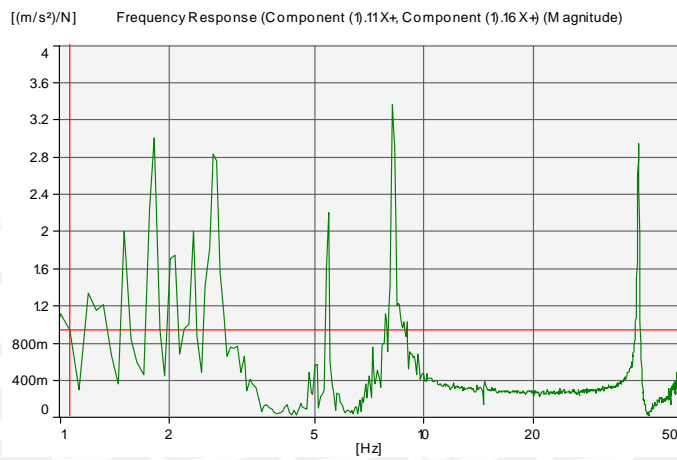
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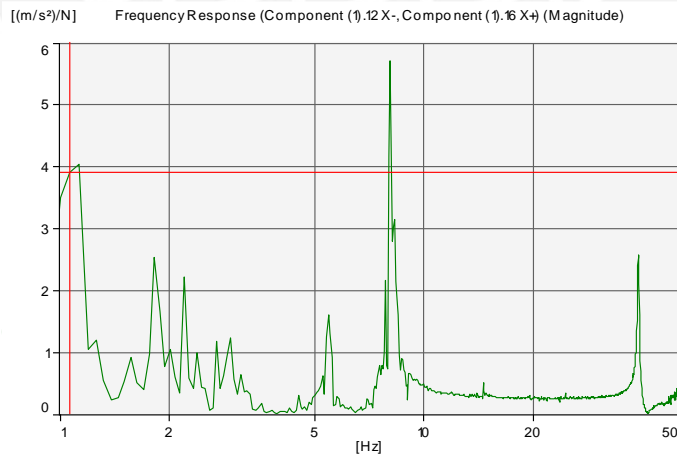
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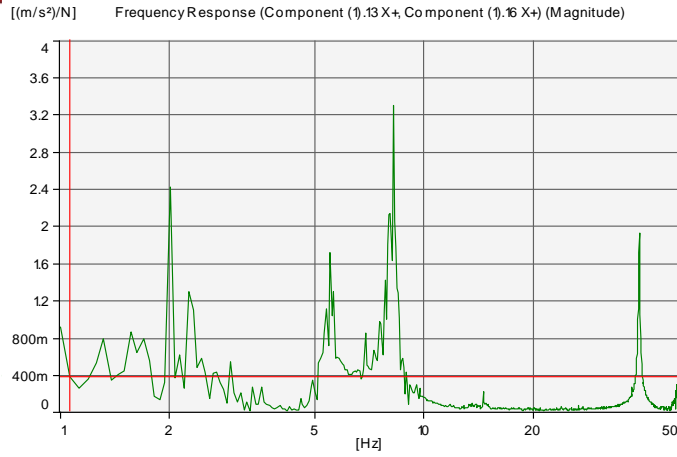
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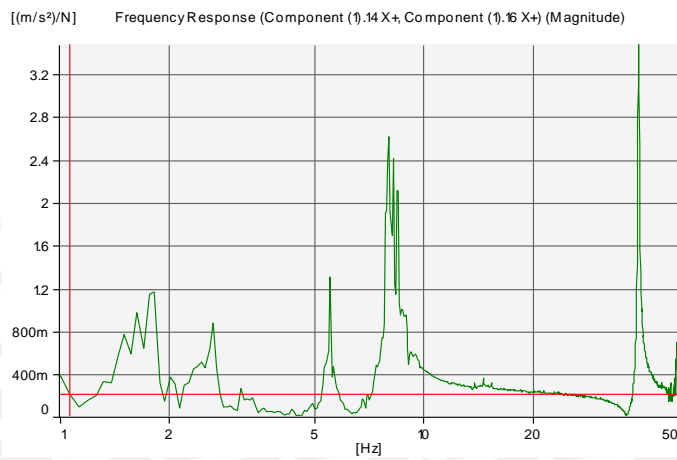
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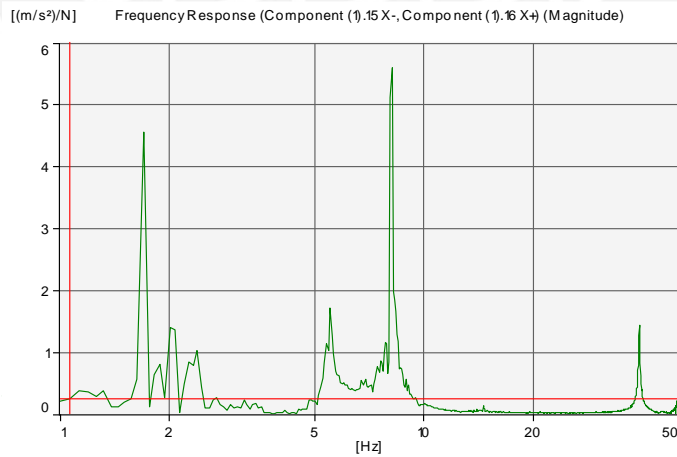
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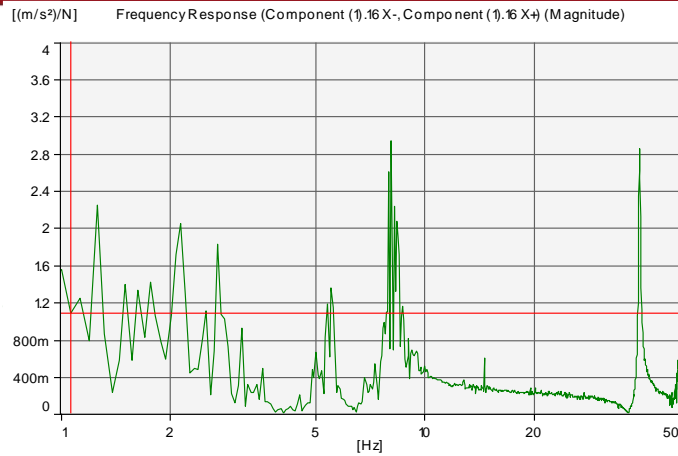
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Punto 14

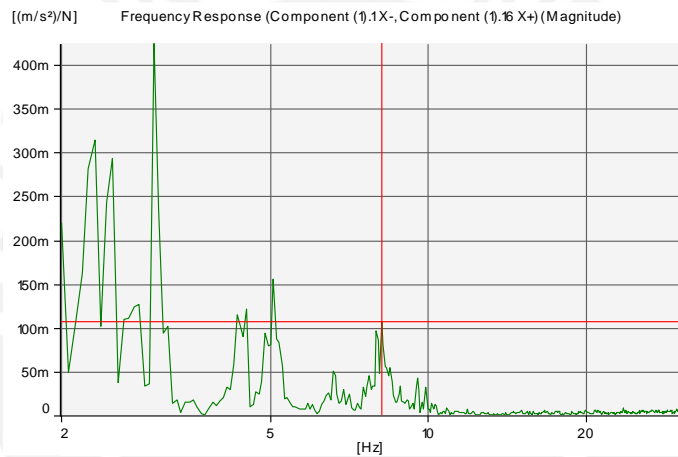


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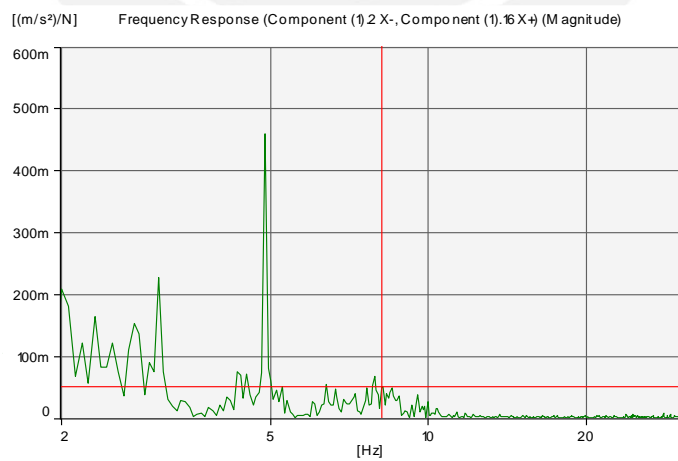


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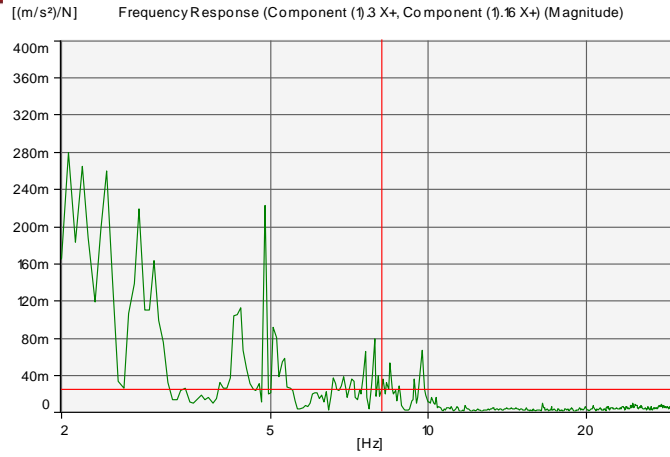
Anexo B.2. Ensayo empotrado con isotorque



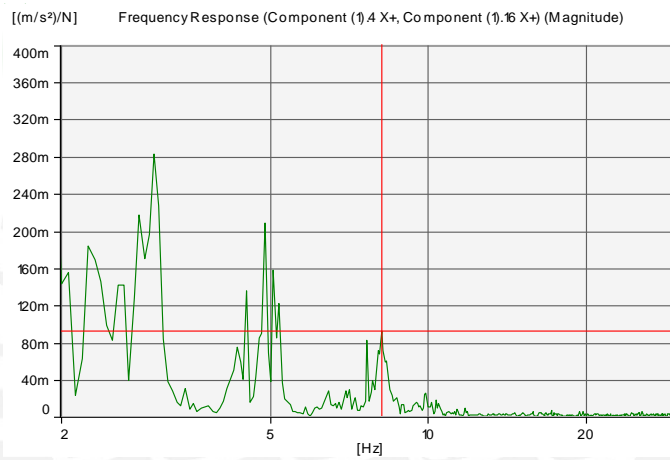
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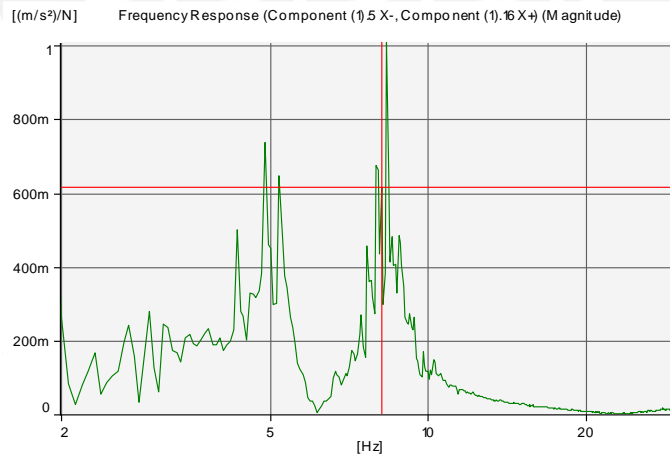
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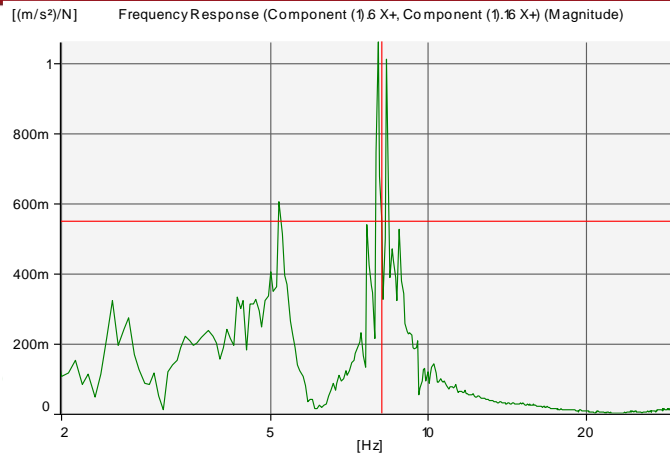
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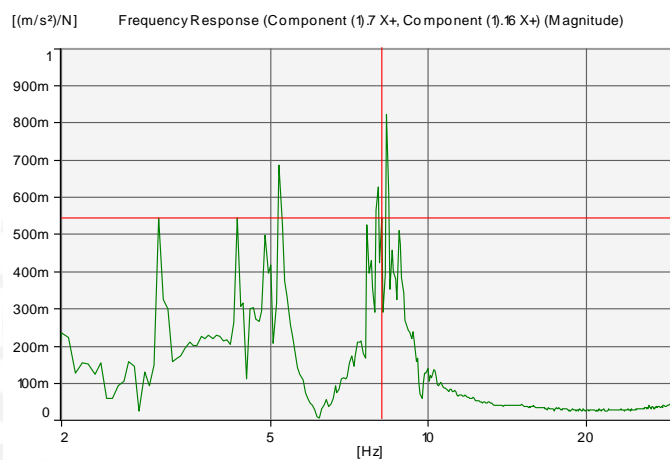
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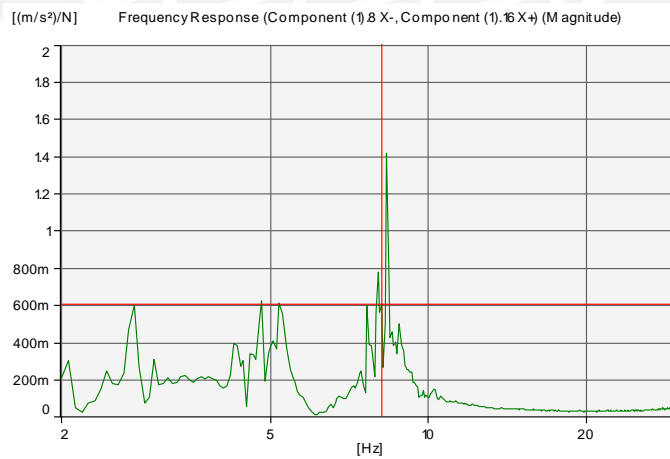
Punto 5



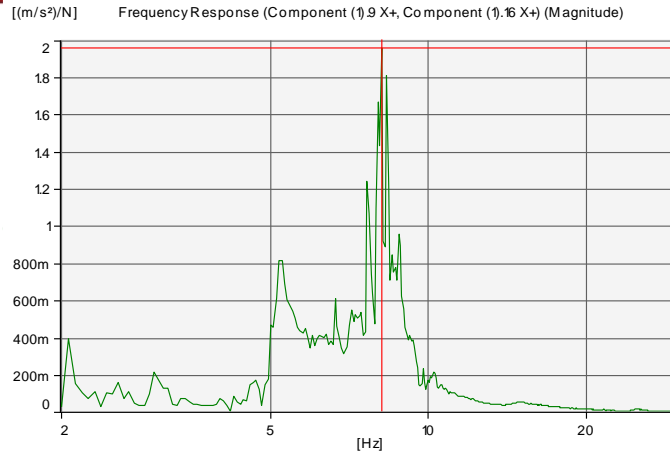
Punto 6



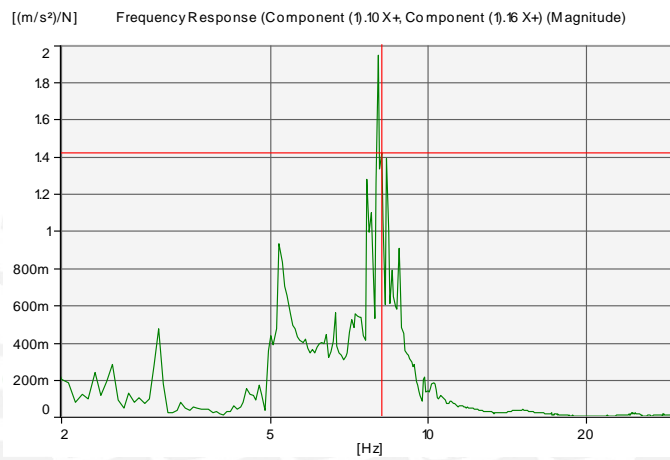
Punto 7



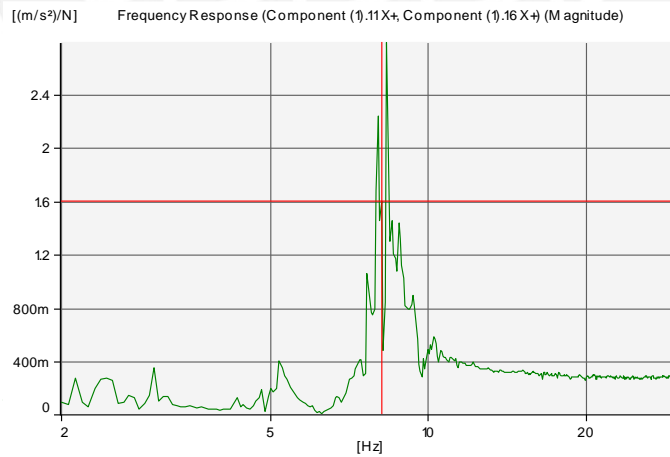
Punto 8



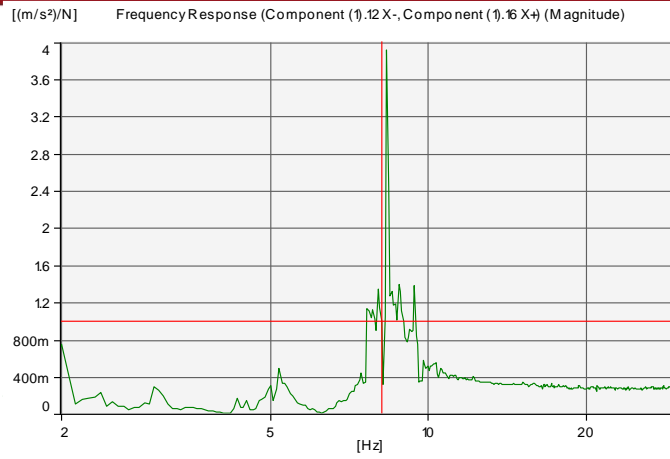
Punto 9



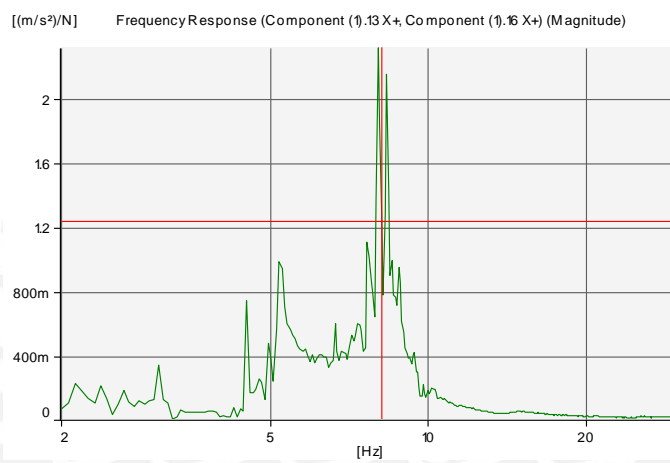
Punto 10



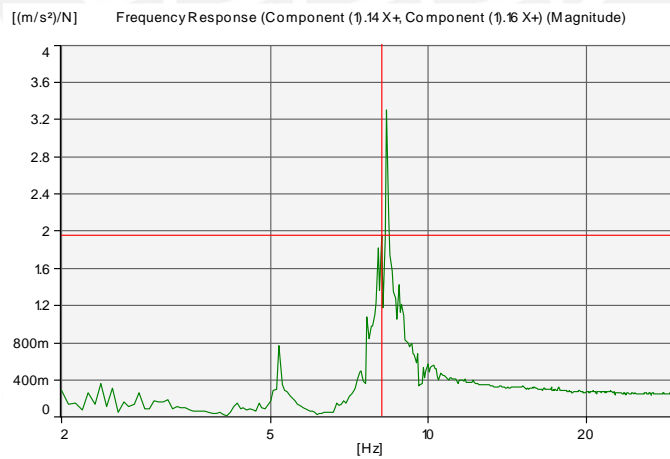
Punto 11



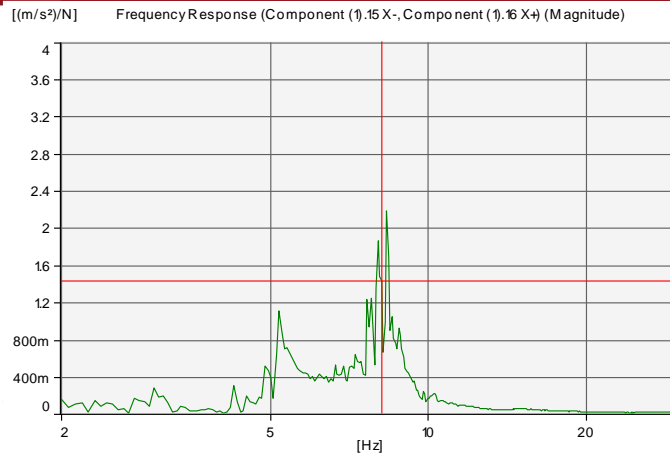
Punto 12



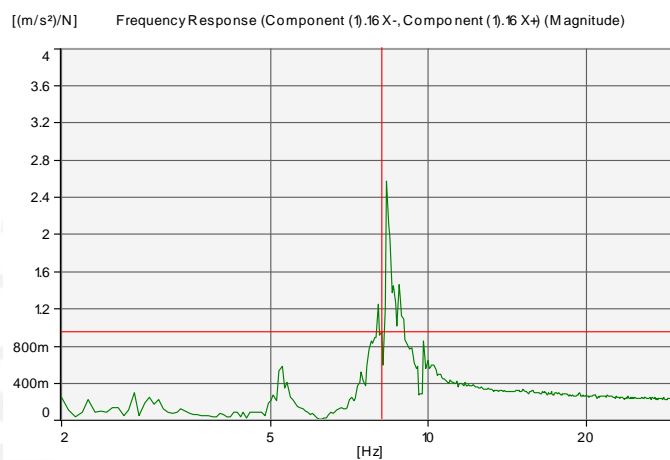
Punto 13



Punto 14

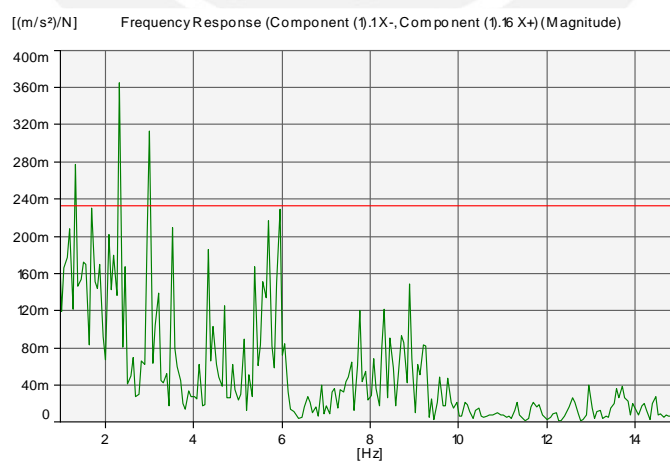


Punto 15

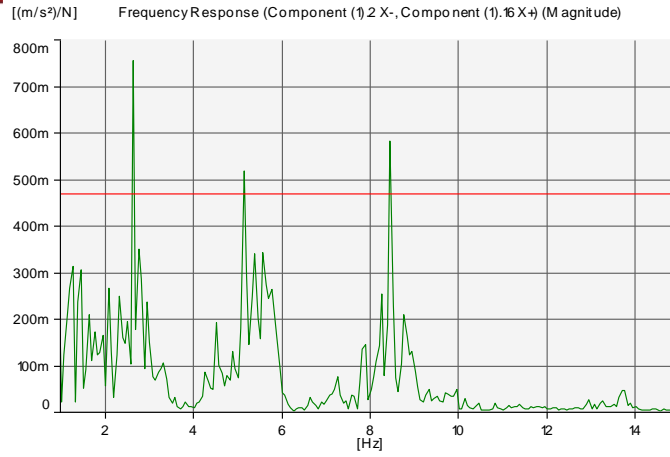


Punto 16

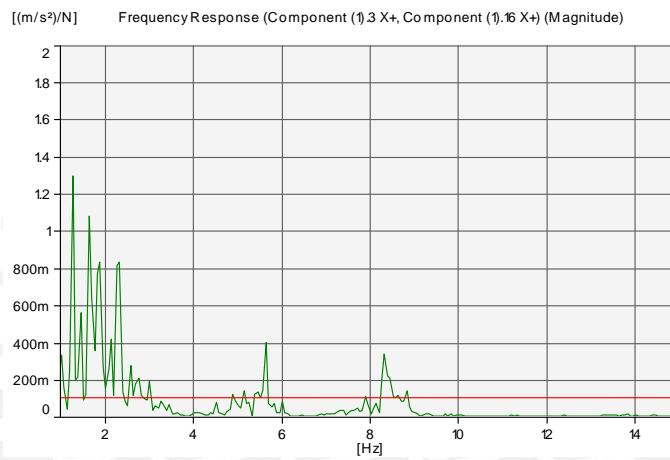
Anexo B.3. Ensayo articulado



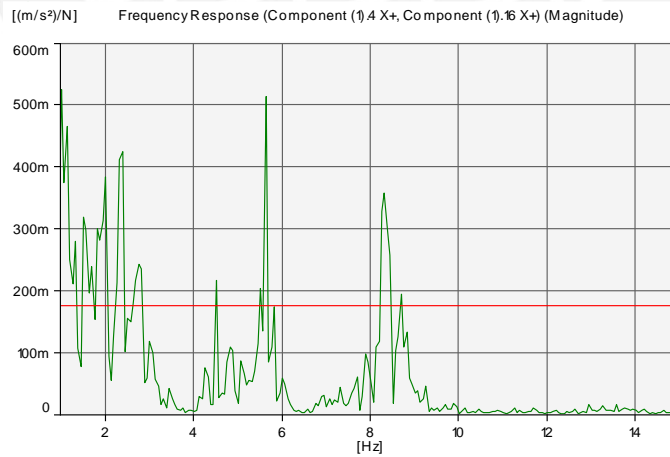
Punto 1



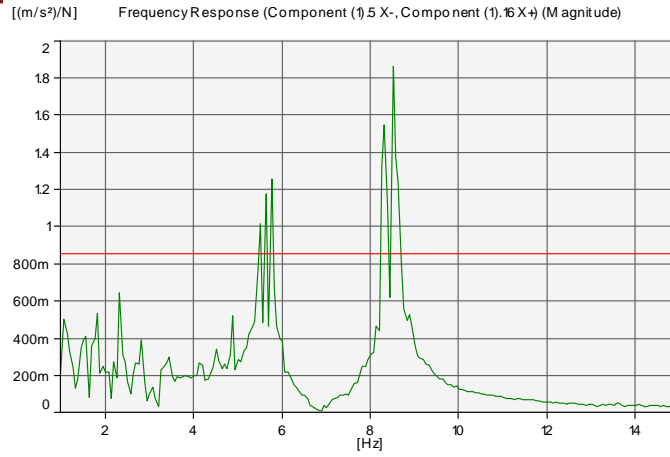
Punto 2



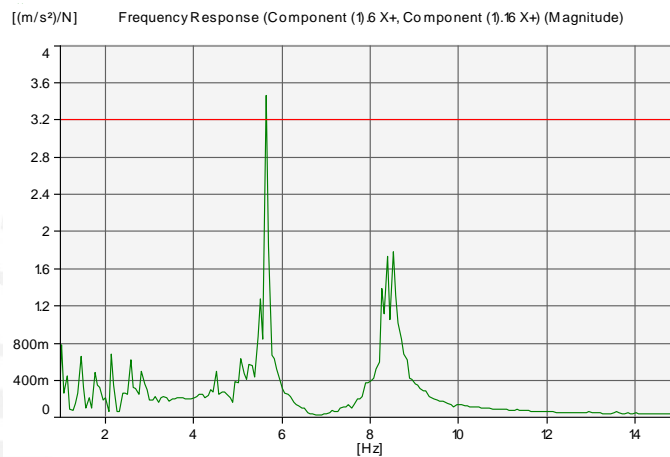
Punto 3



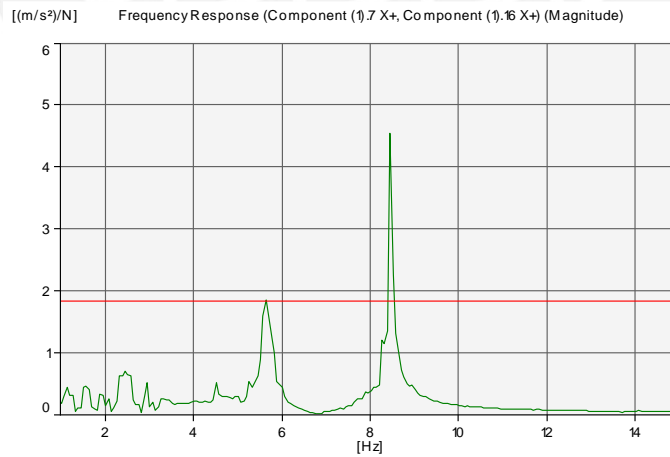
Punto 4



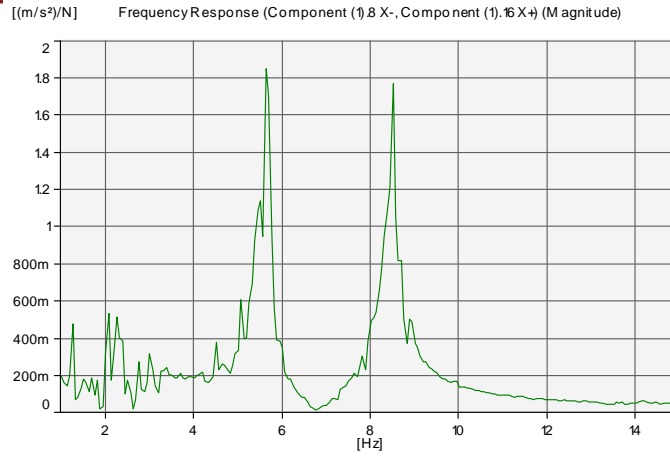
Punto 5



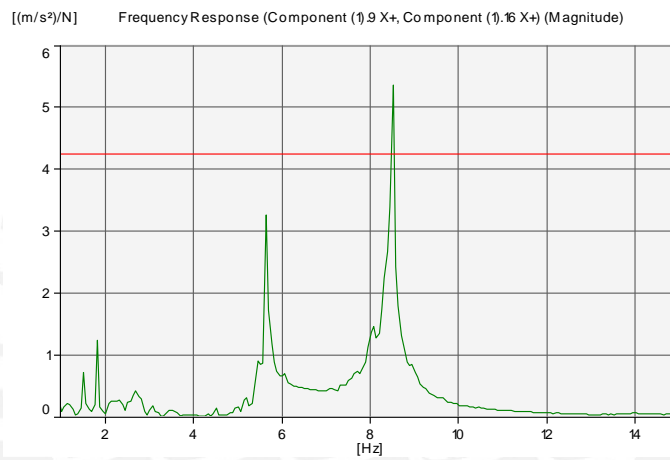
Punto 6



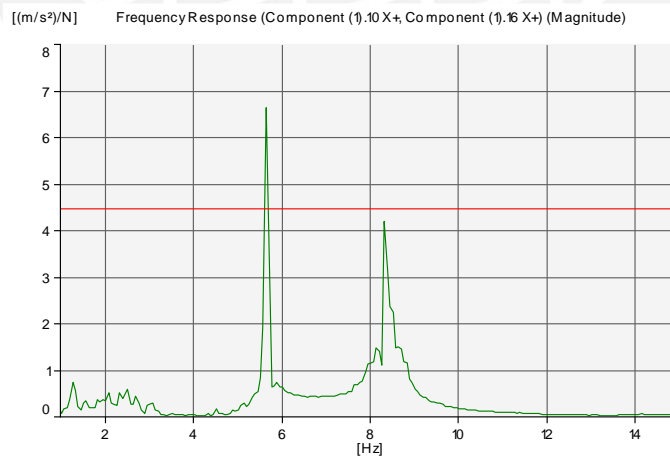
Punto 7



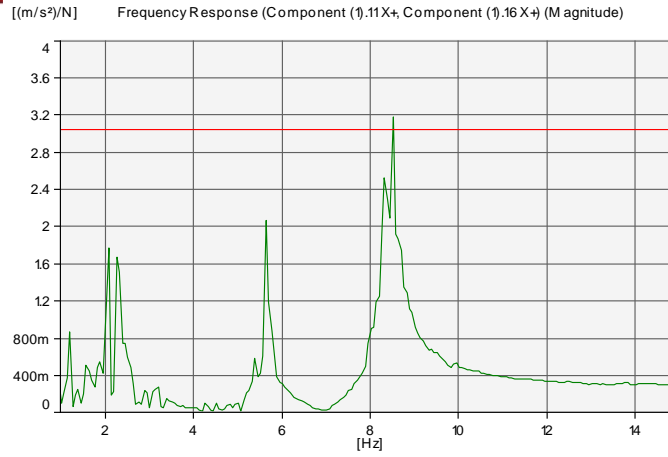
Punto 8



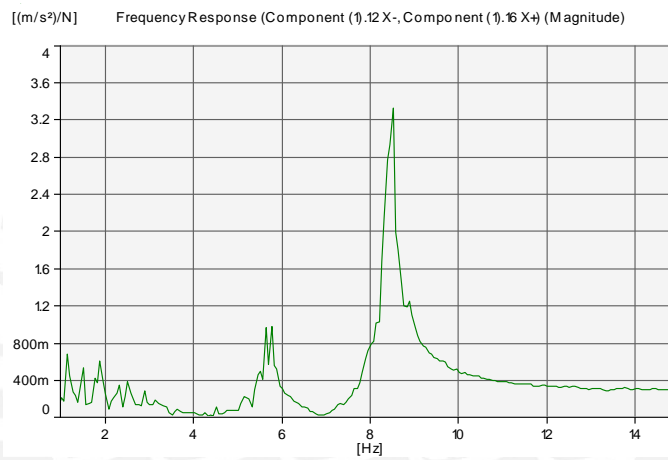
Punto 9



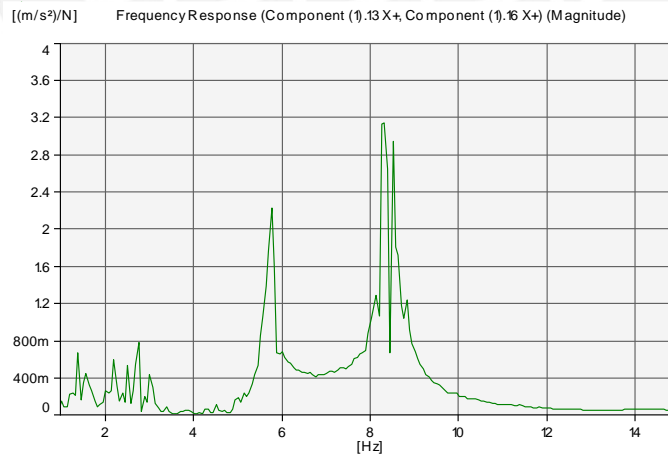
Punto 10



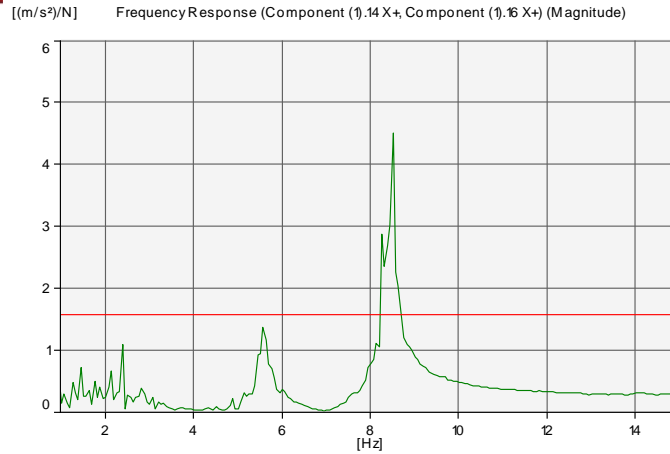
Punto 11



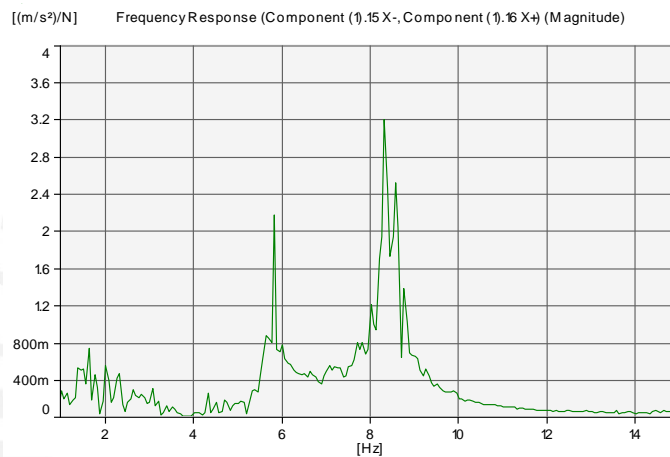
Punto 12



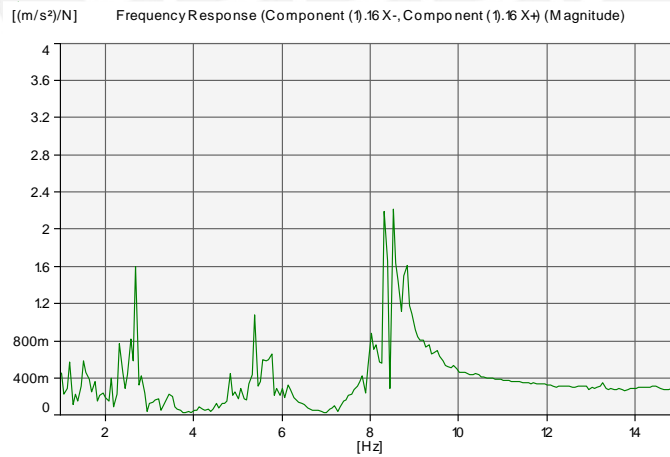
Punto 13



Punto 14

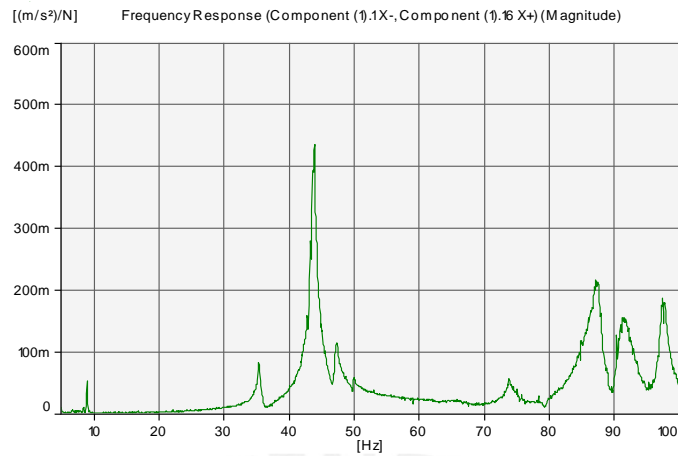


Punto 15

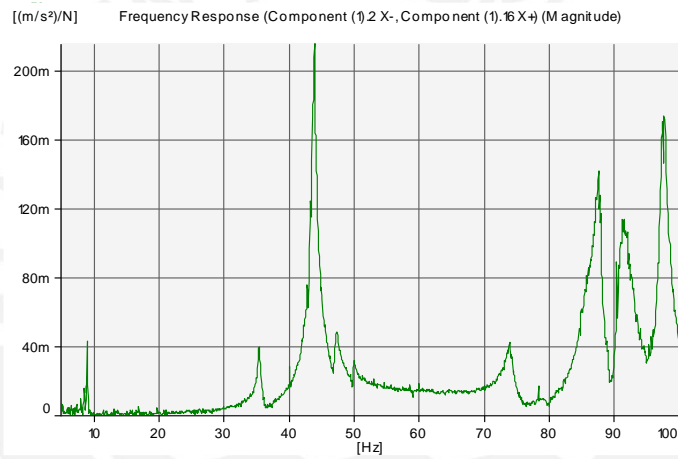


Punto 16

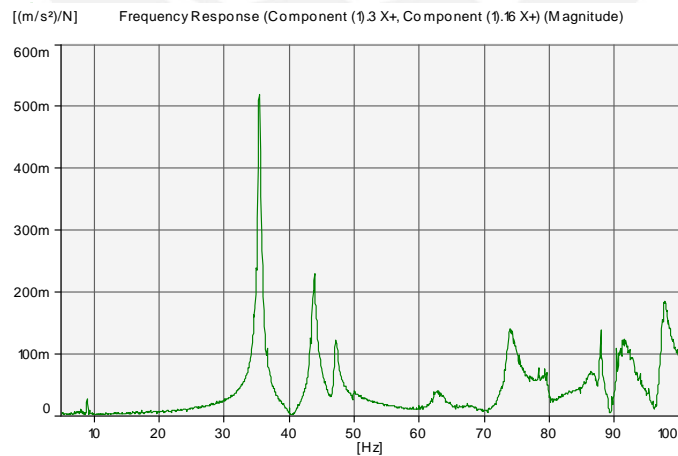
Anexo B.4. Ensayo con mayor rigidez



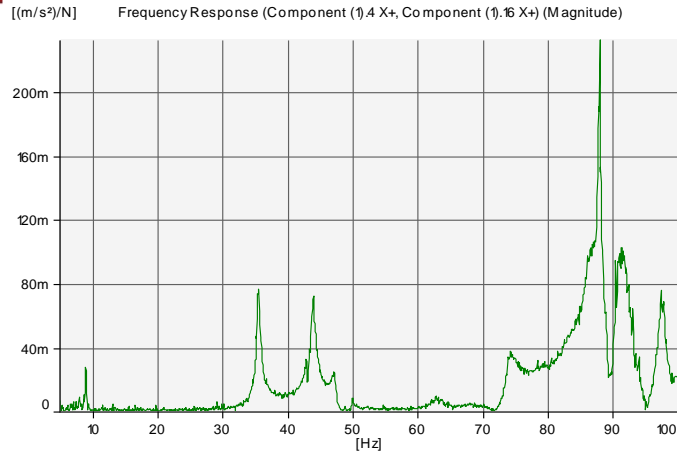
Punto 1



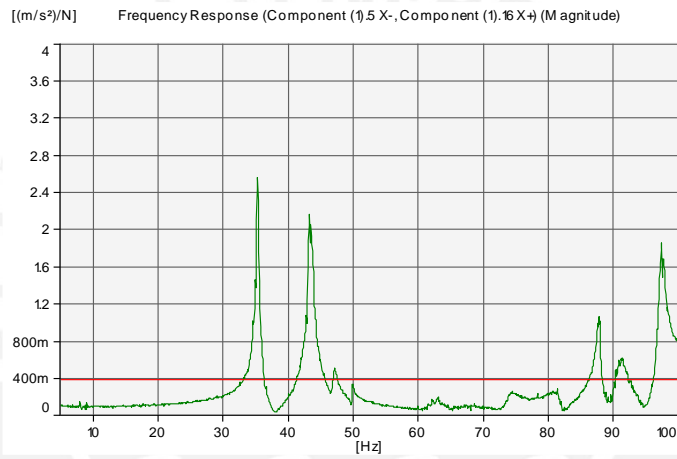
Punto 2



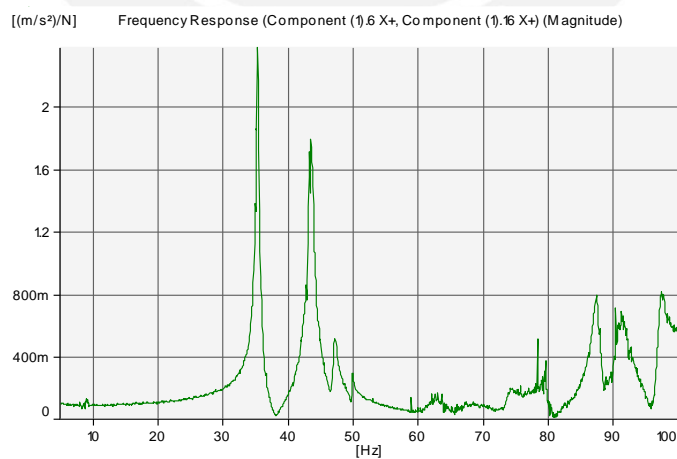
Punto 3



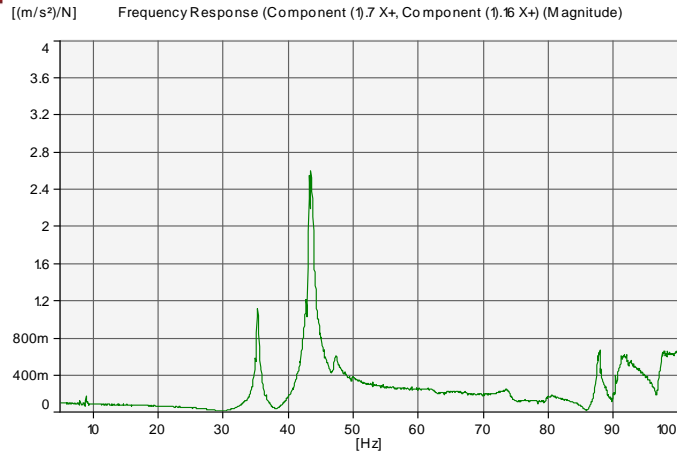
Punto 4



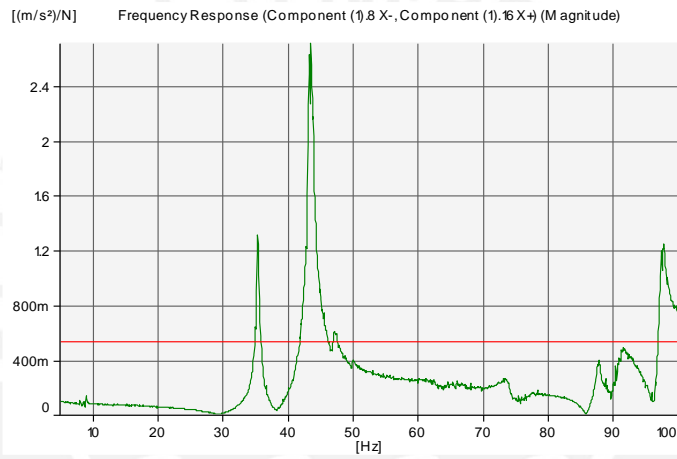
Punto 5



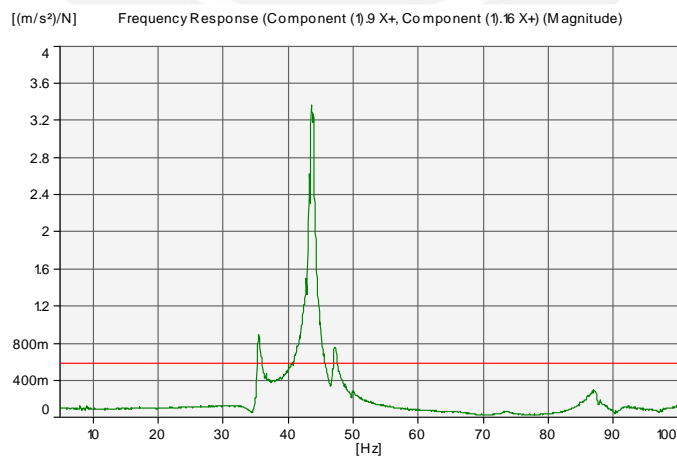
Punto 6



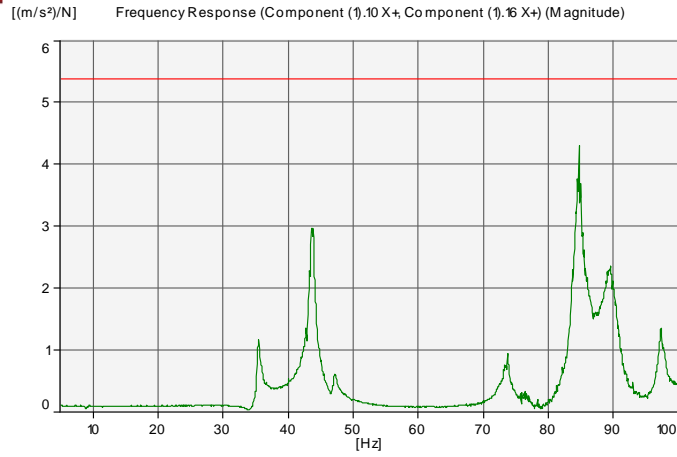
Punto 7



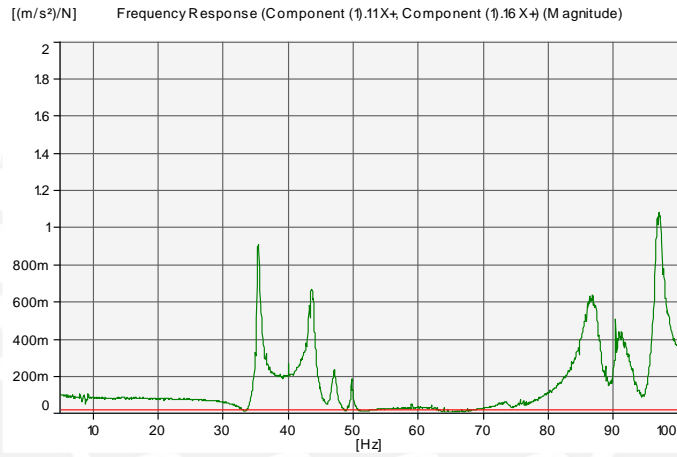
Punto 8



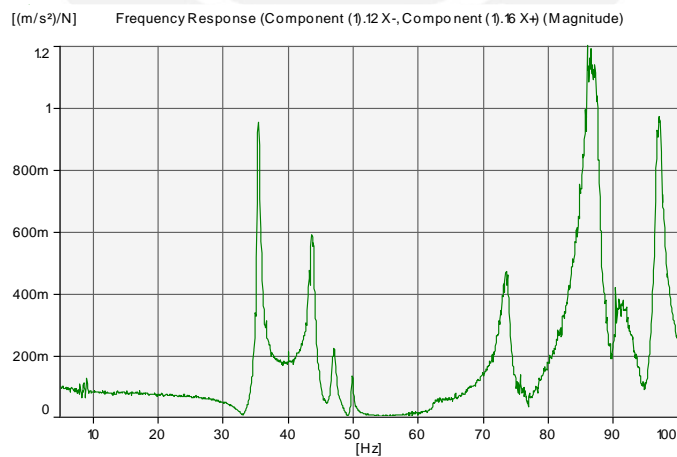
Punto 9



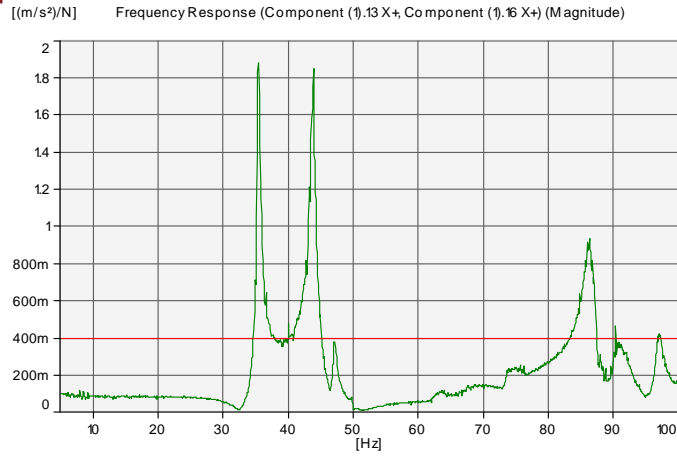
Punto 10



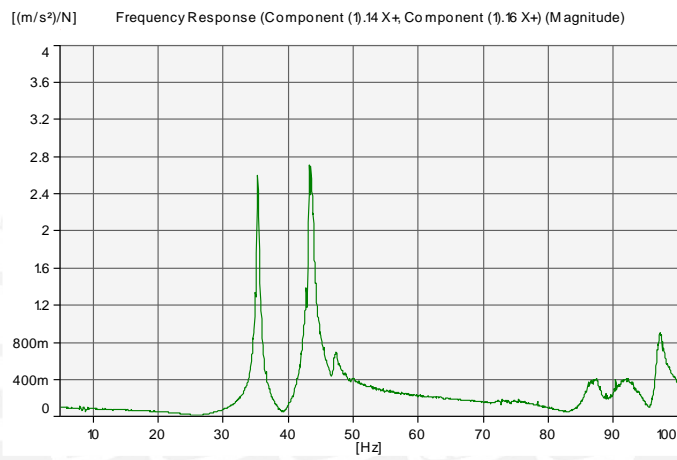
Punto 11



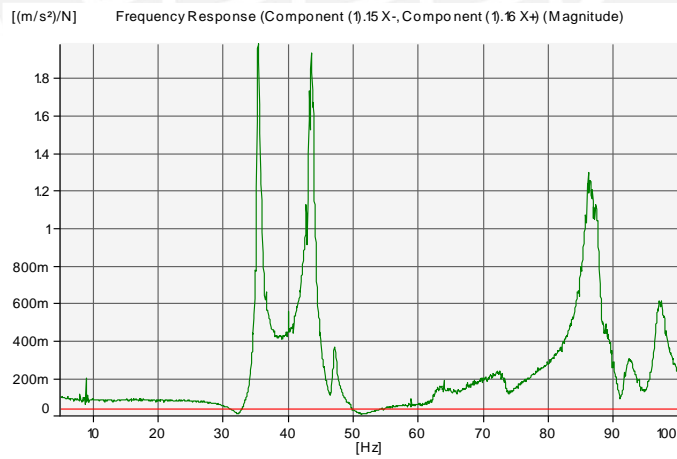
Punto 12



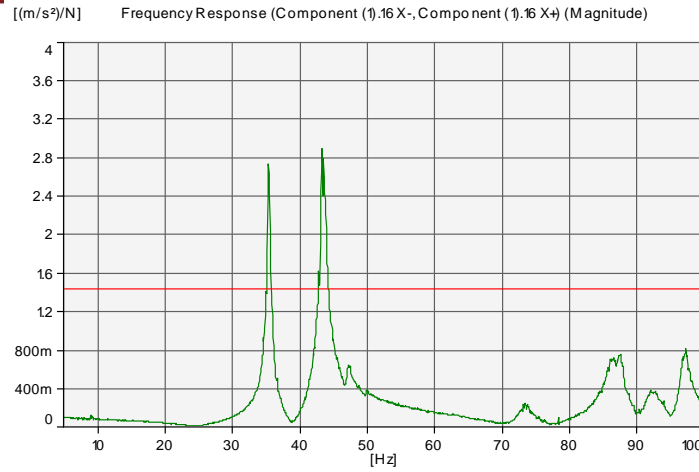
Punto 13



Punto 14



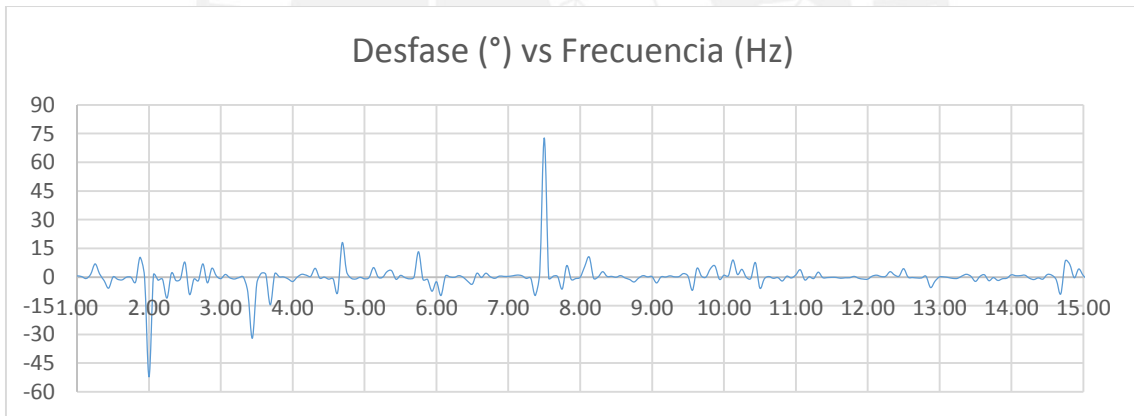
Punto15



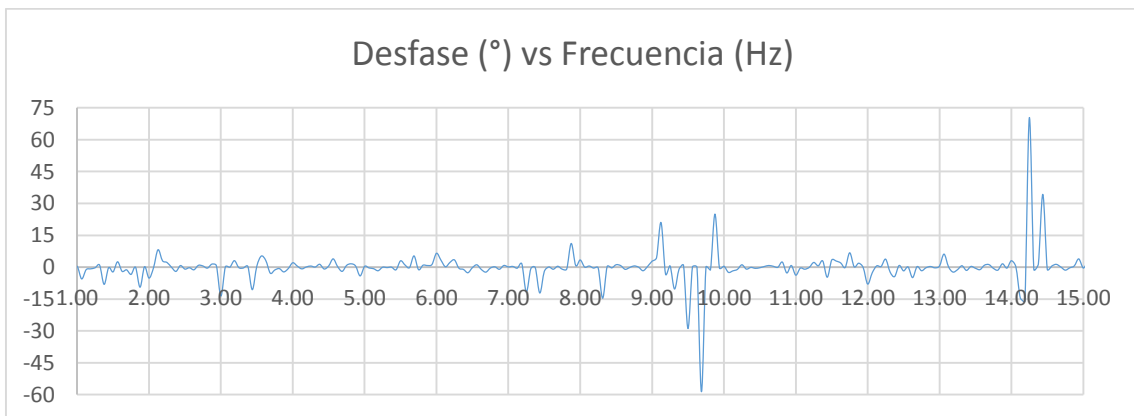
Punto 16

Anexo C. Graficas Ángulo de desfase vs Frecuencia

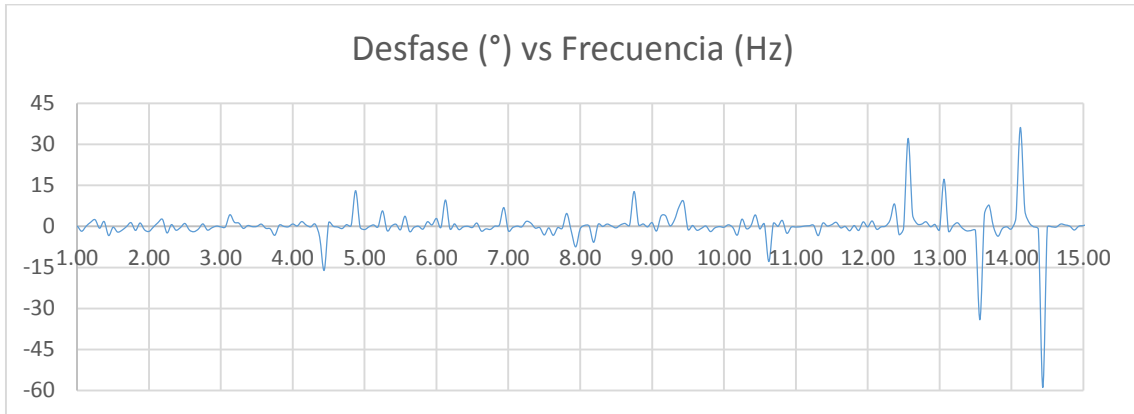
Anexo C.1. Ensayo empotrado con torque variable



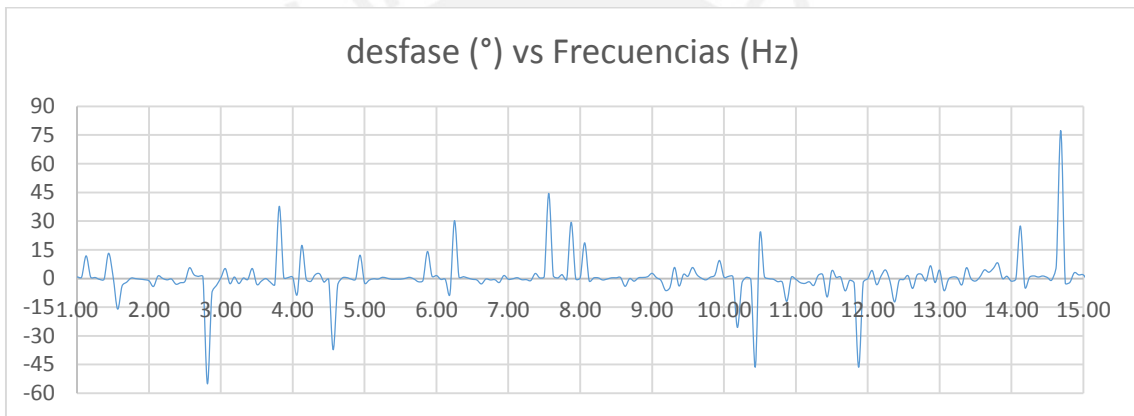
Punto 1



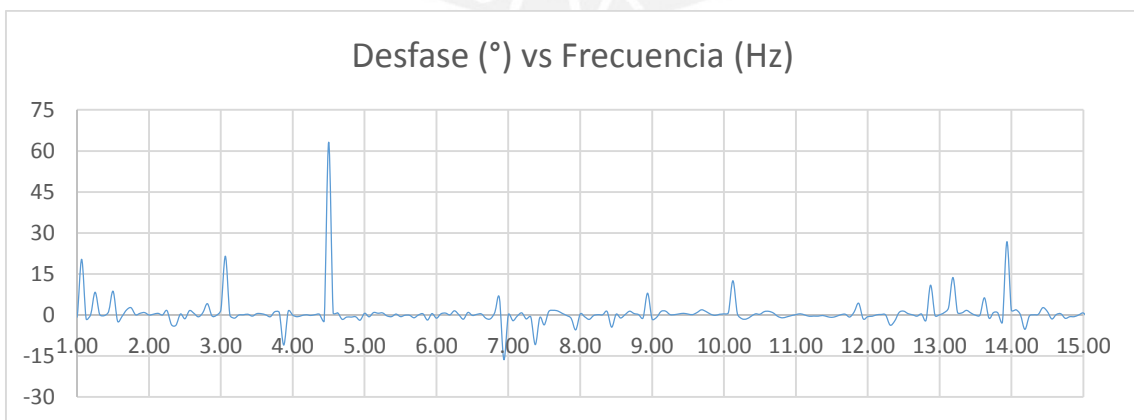
Punto 2



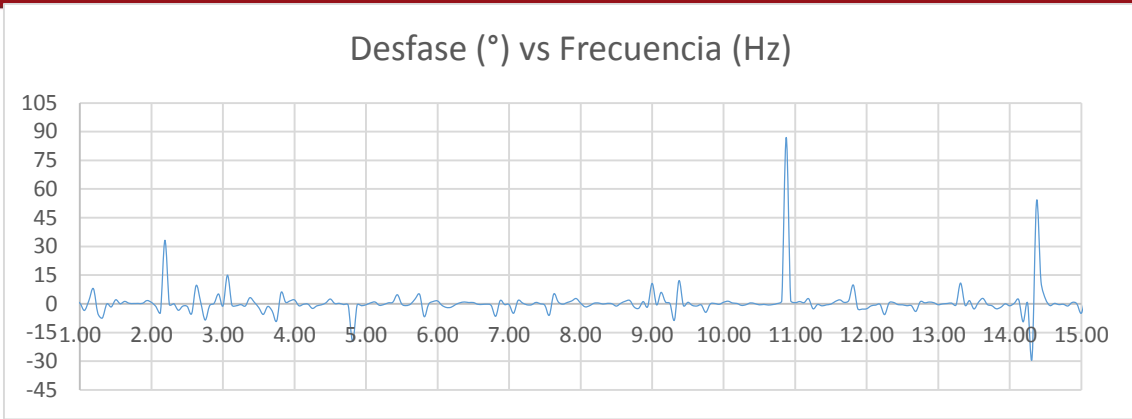
Punto 3



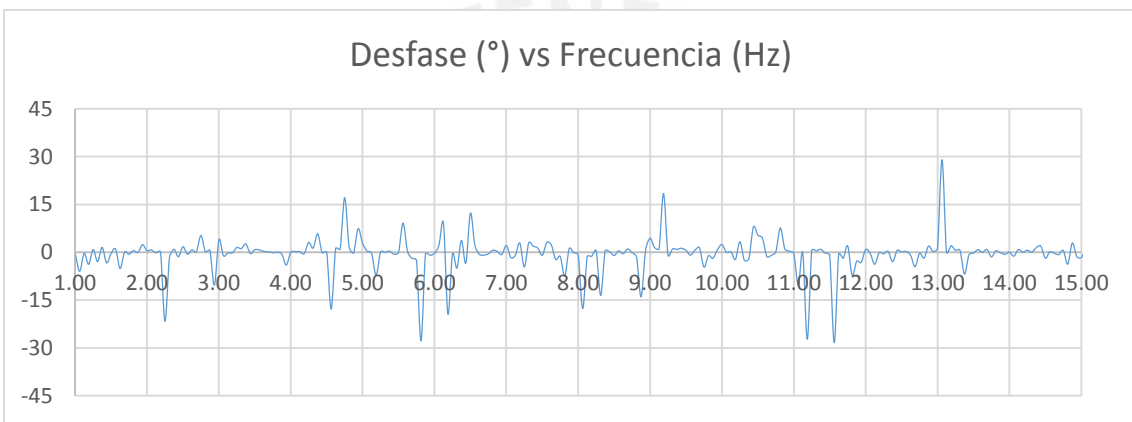
Punto 4



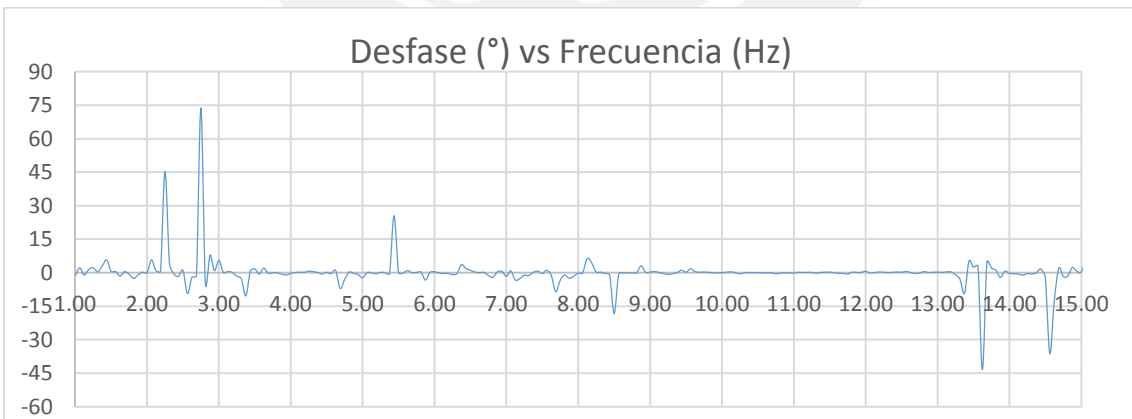
Punto 5



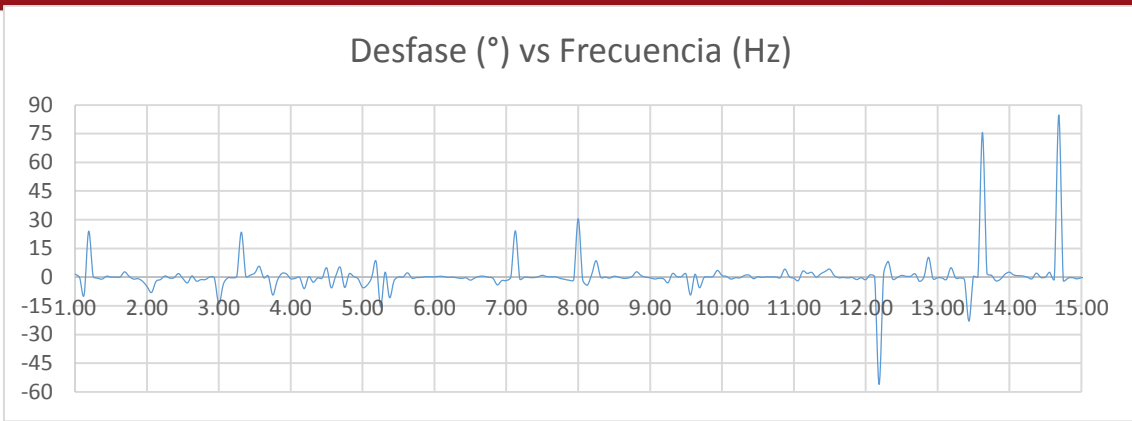
Punto 6



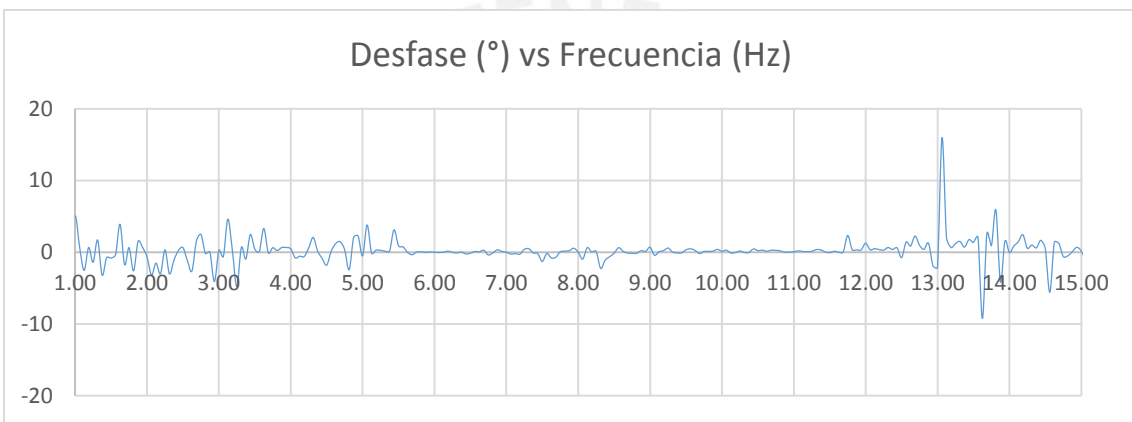
Punto 7



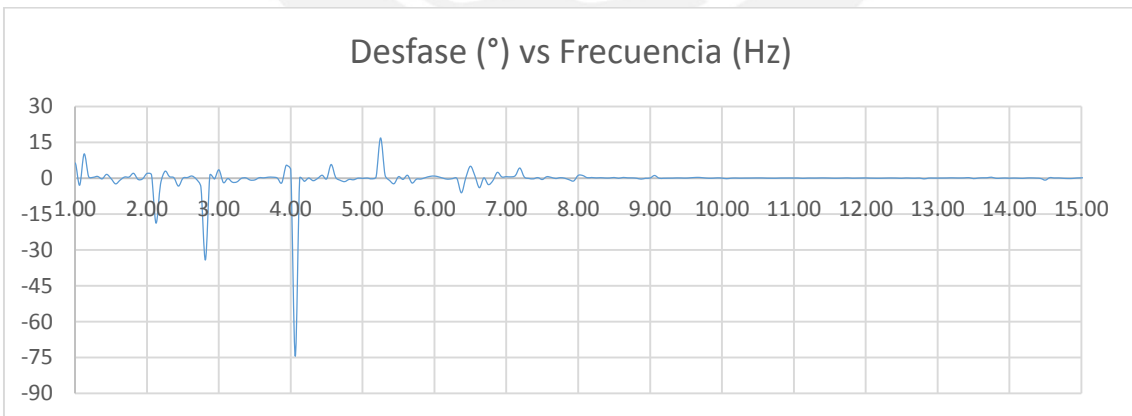
Punto 8



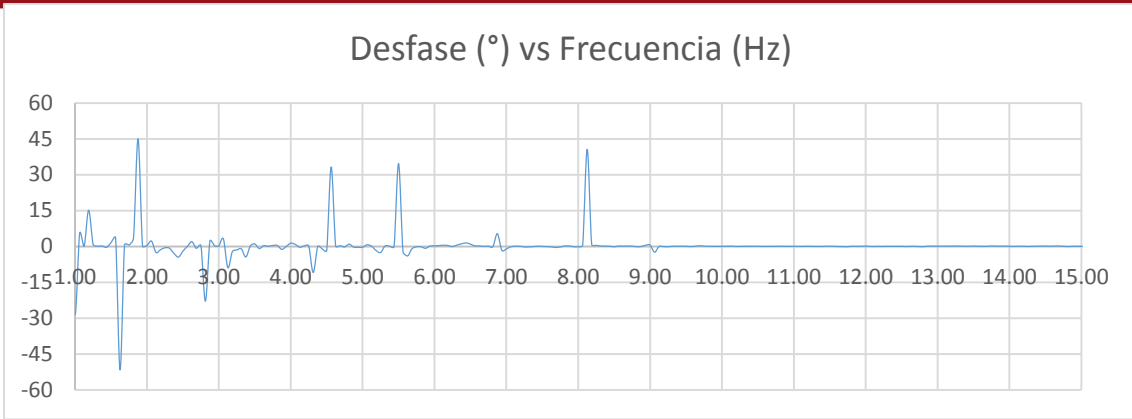
Punto 9



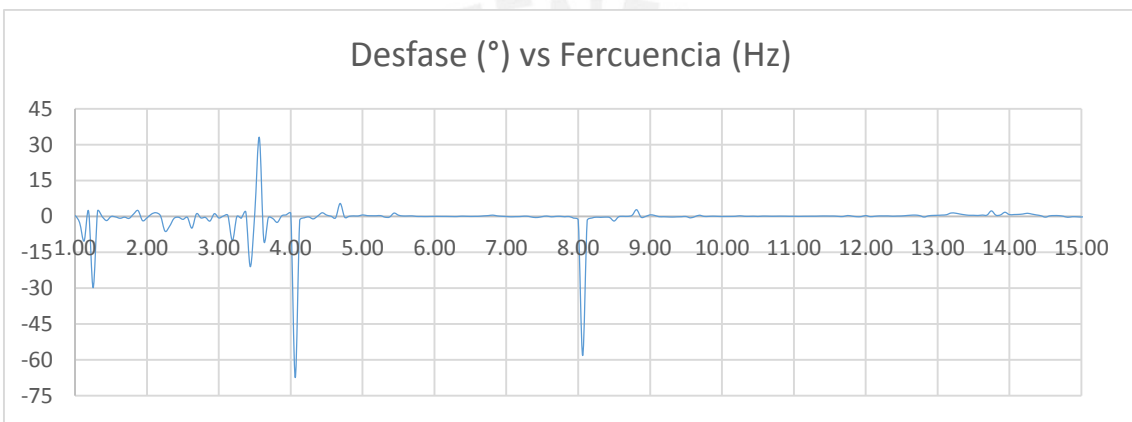
Punto 10



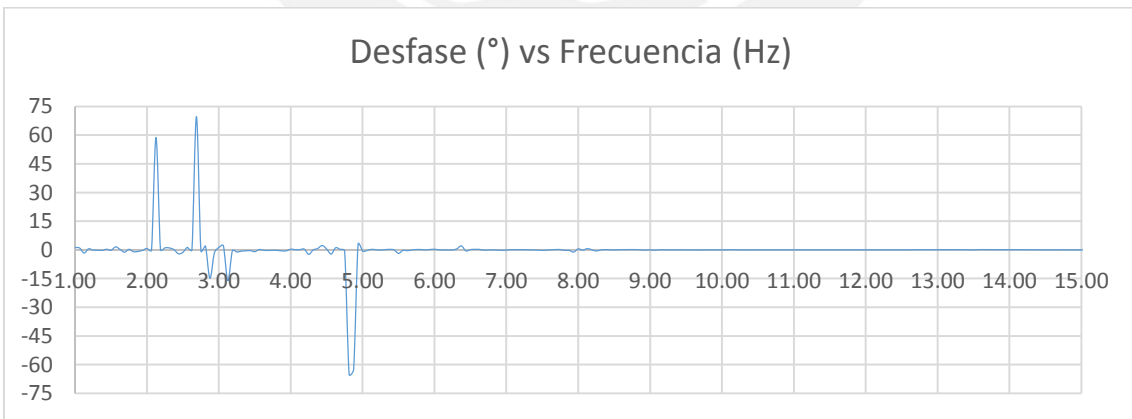
Punto 11



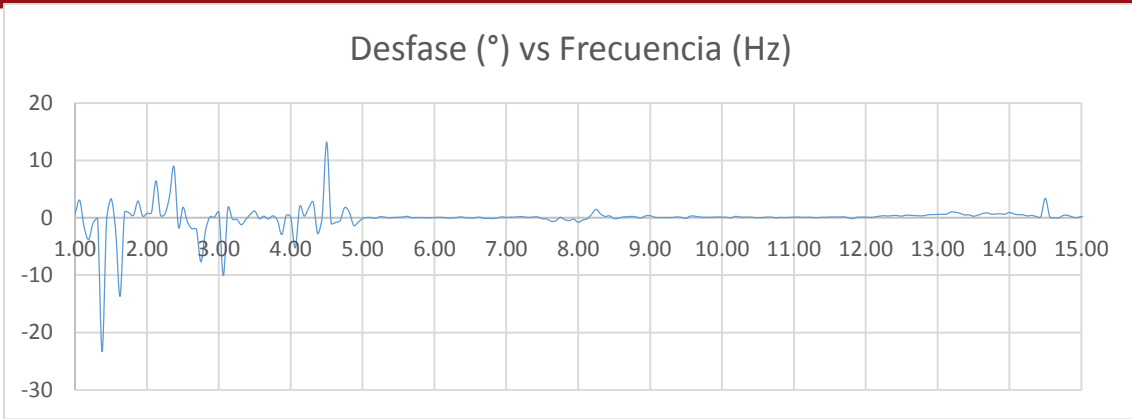
Punto 12



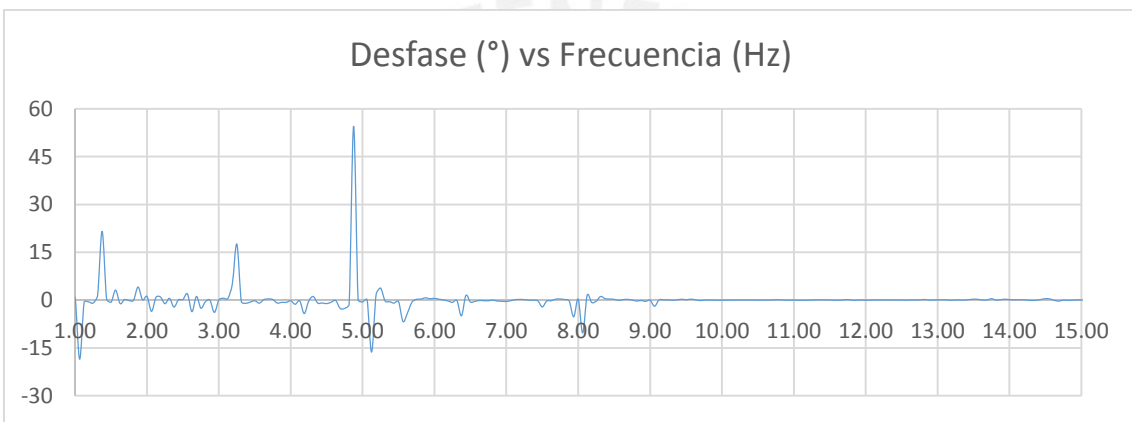
Punto 13



Punto 14

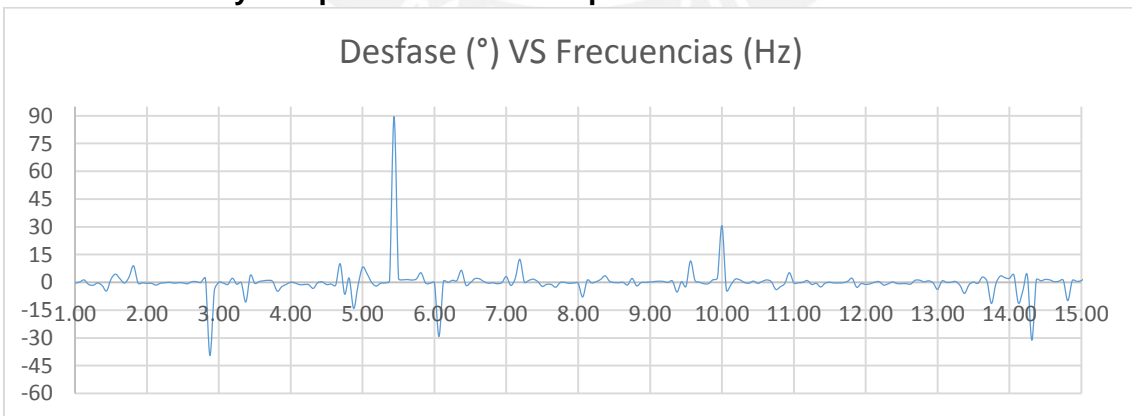


Punto 15



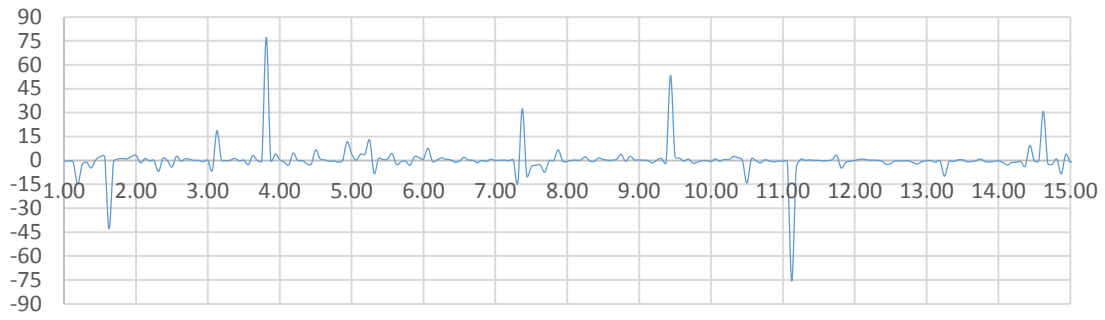
Punto 16

Anexo C.2. Ensayo empotrado con isotorque



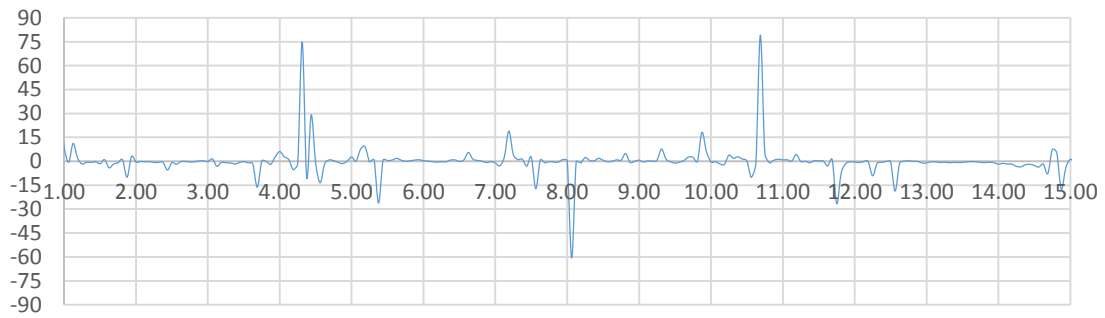
Punto 1

Desfase (°) VS Frecuencias (Hz)



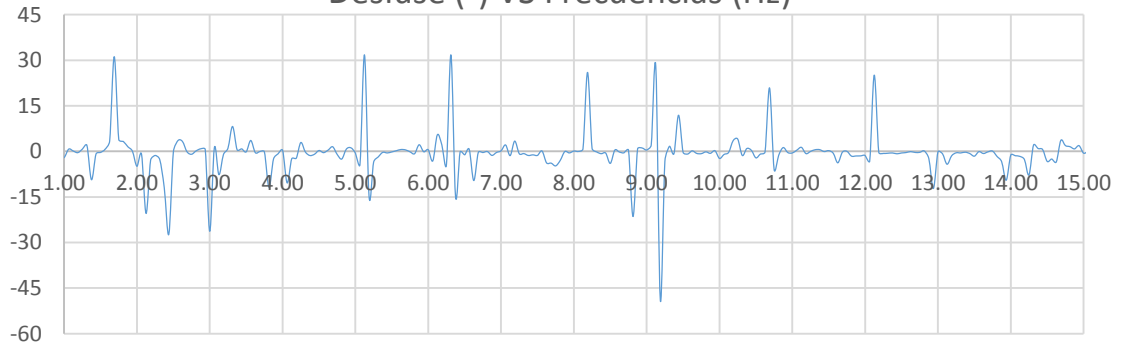
Punto 2

Desfase (°) VS Frecuencias (Hz)

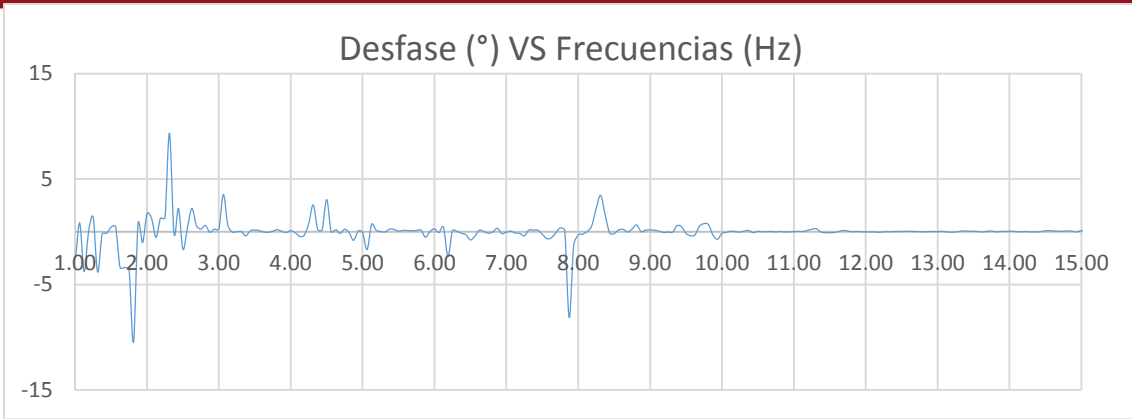


Punto 3

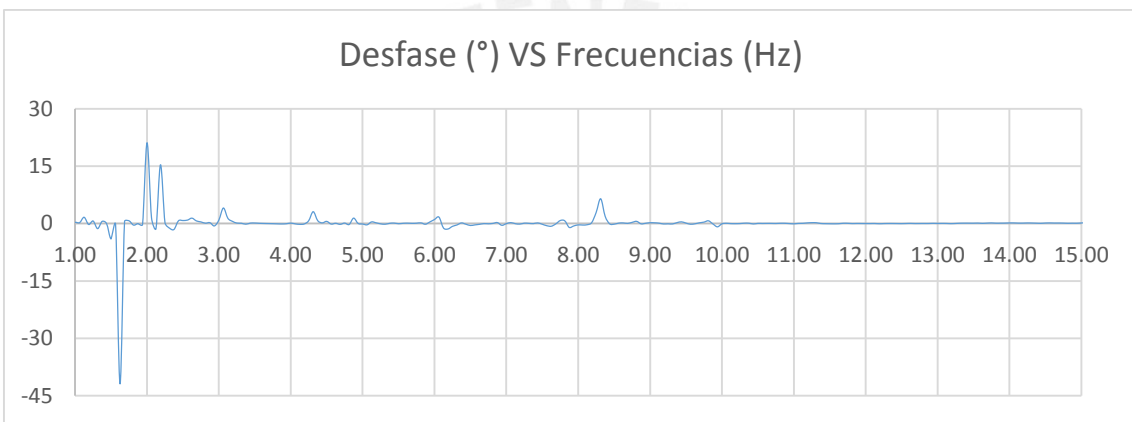
Desfase (°) VS Frecuencias (Hz)



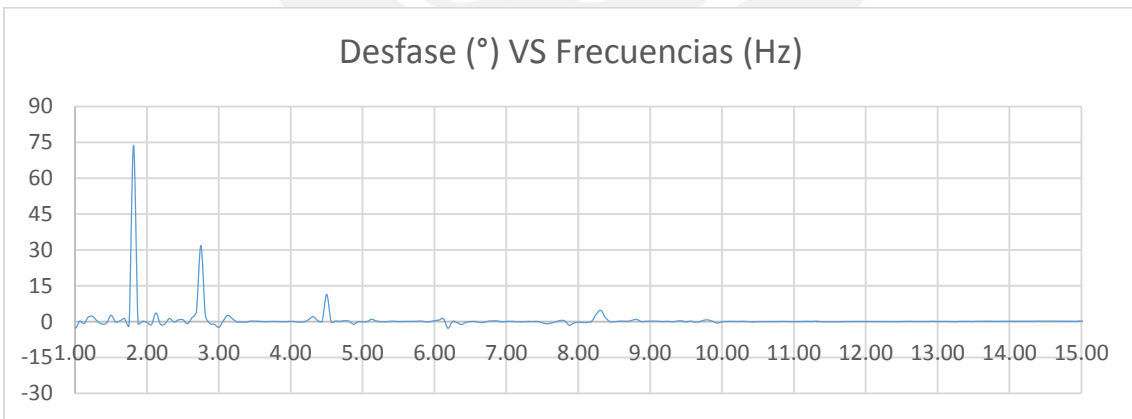
Punto 4



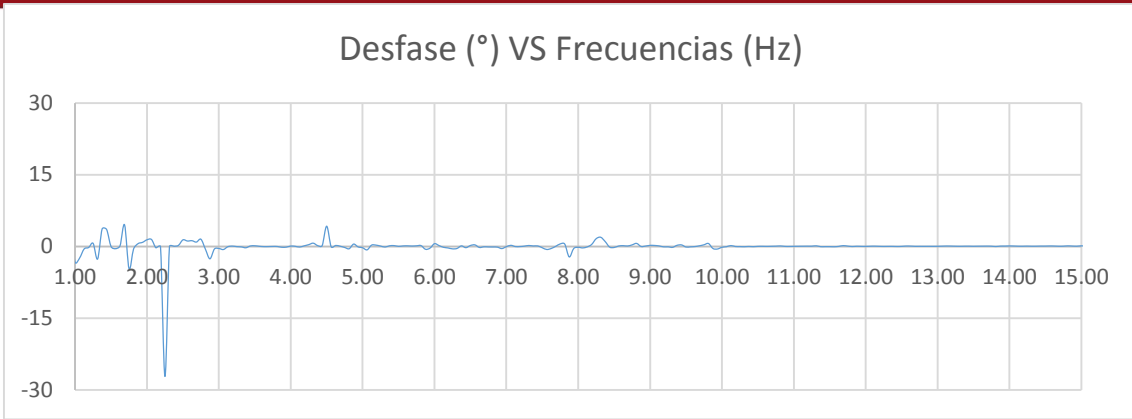
Punto 5



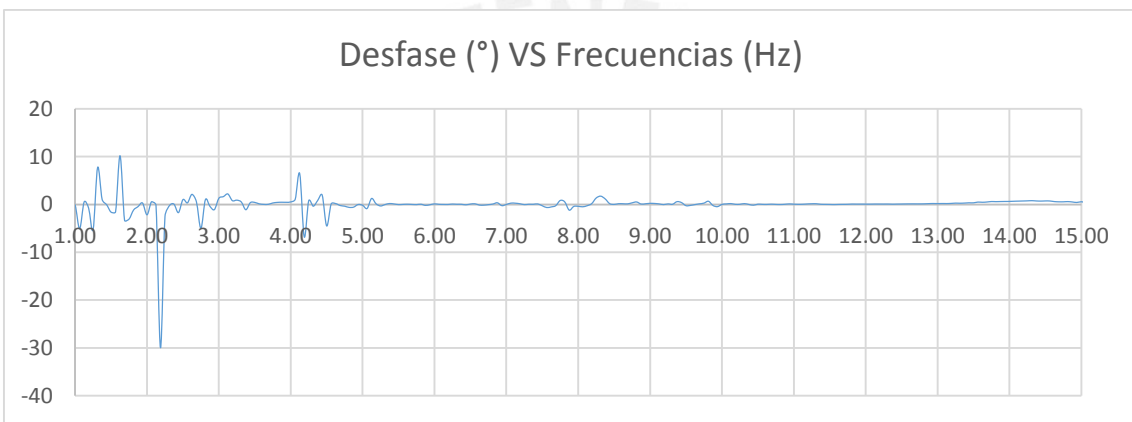
Punto 6



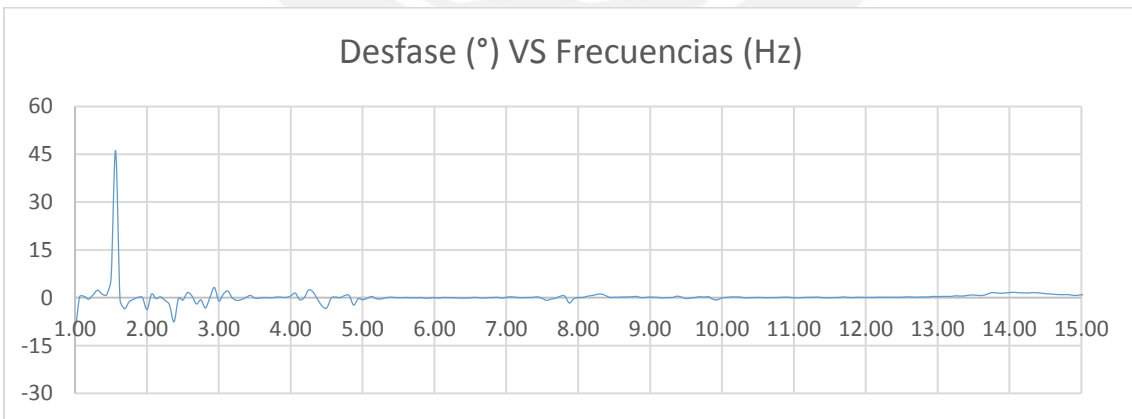
Punto 7



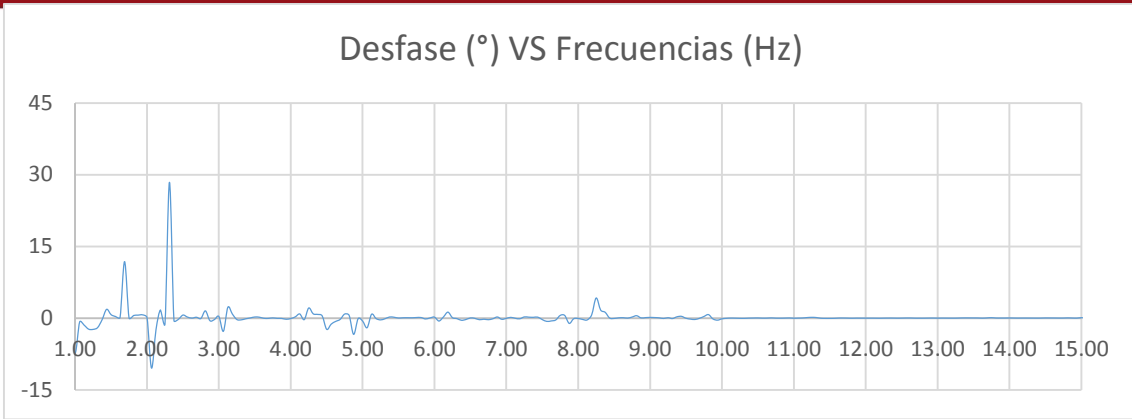
Punto 8



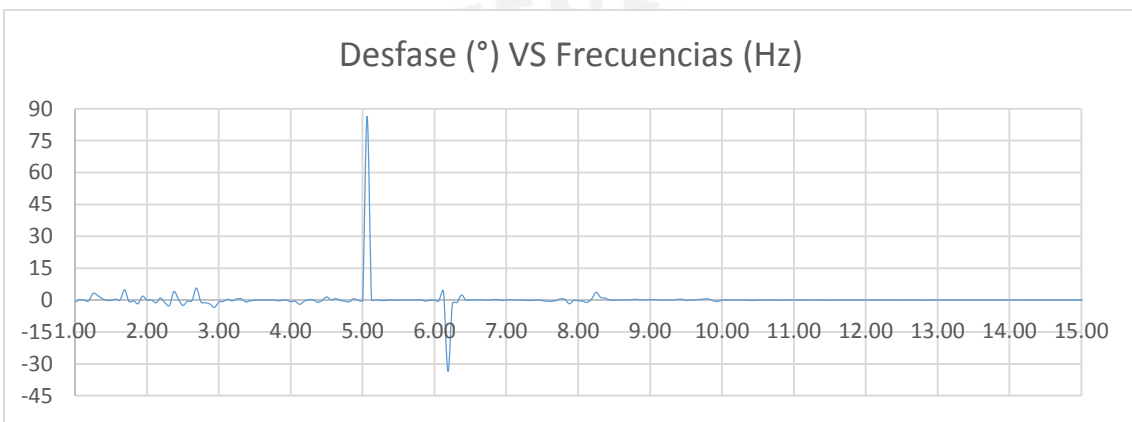
Punto 9



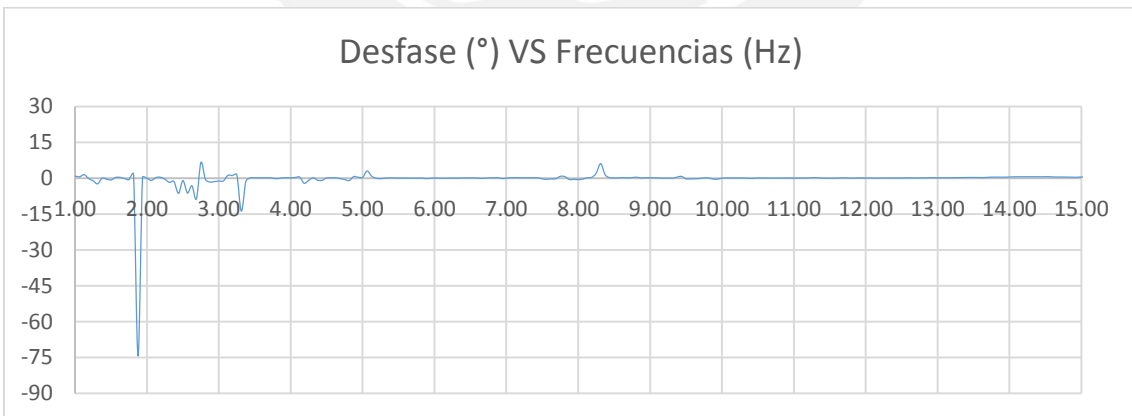
Punto 10



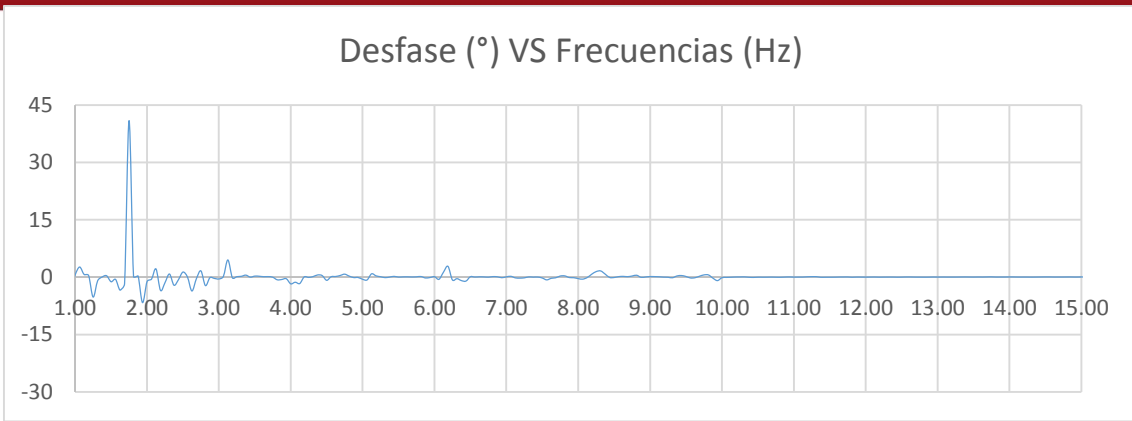
Punto 11



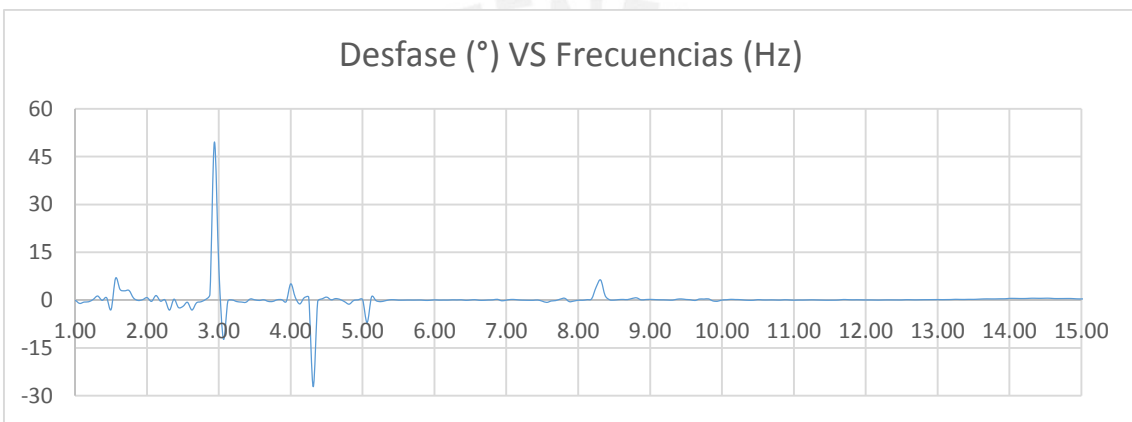
Punto 12



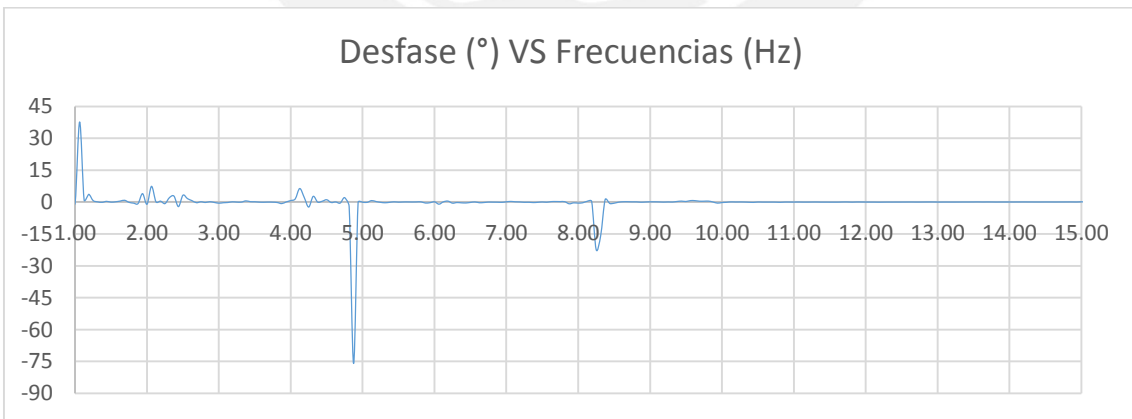
Punto 13



Punto 14

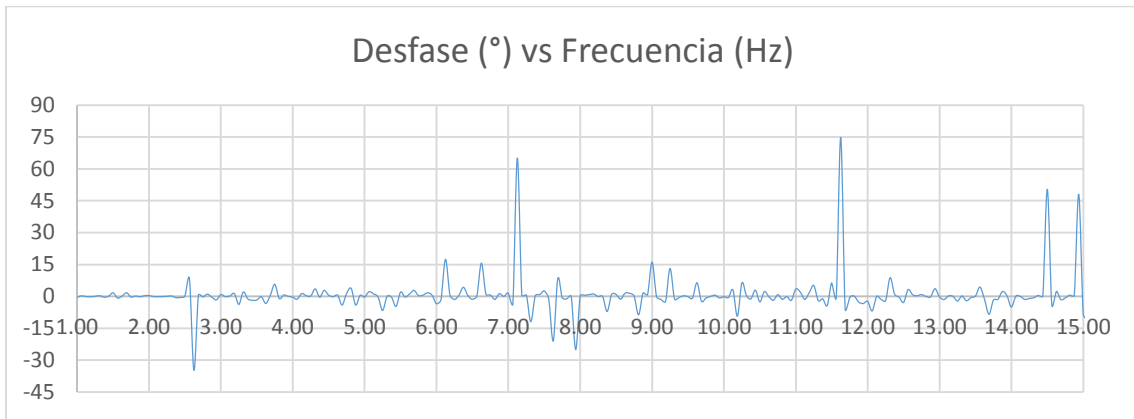


Punto 15

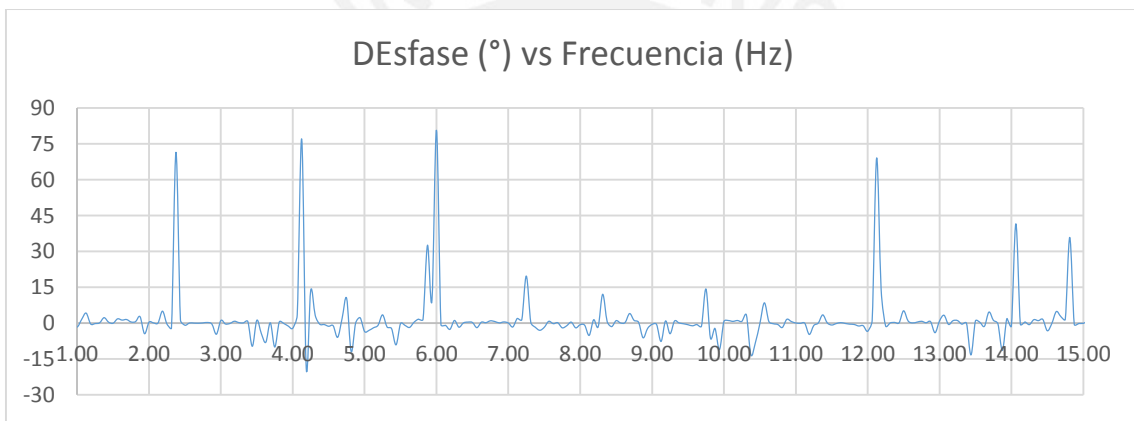


Punto 16

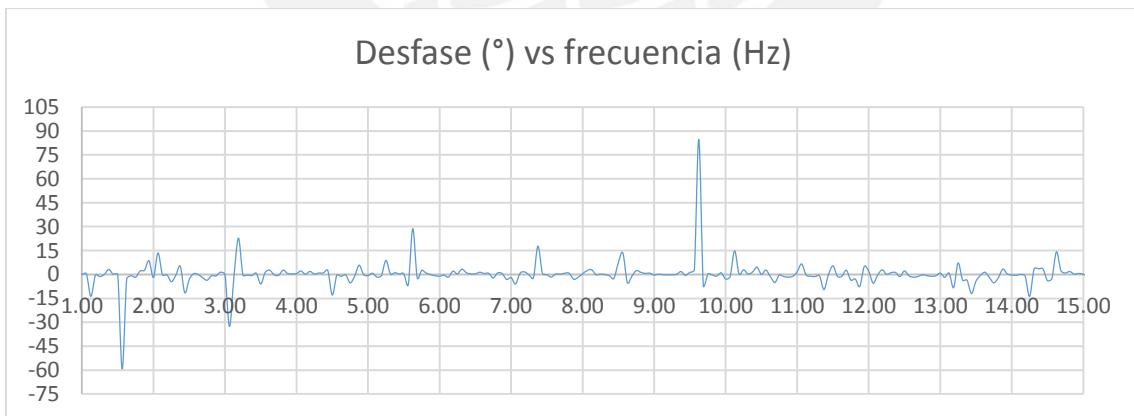
Anexo C.3. Ensayo articulado



Punto 1

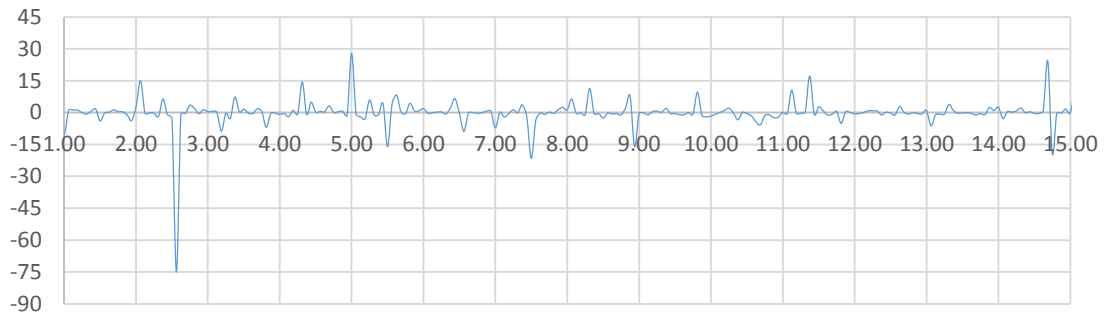


Punto 2



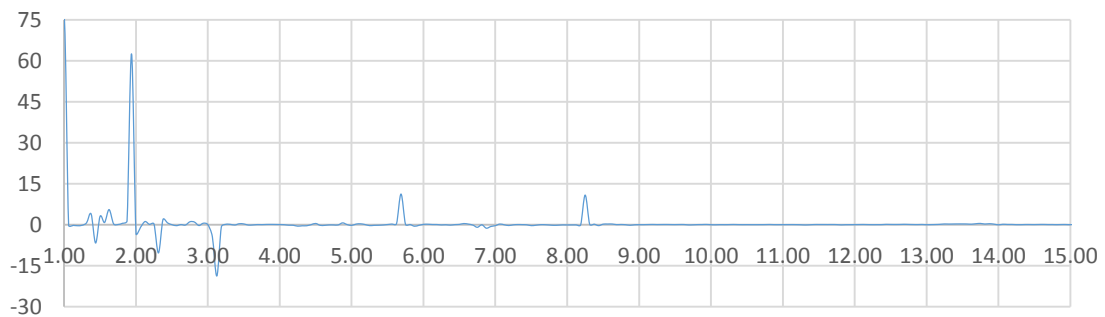
Punto 3

Desfase (°) vs Frecuencia (Hz)



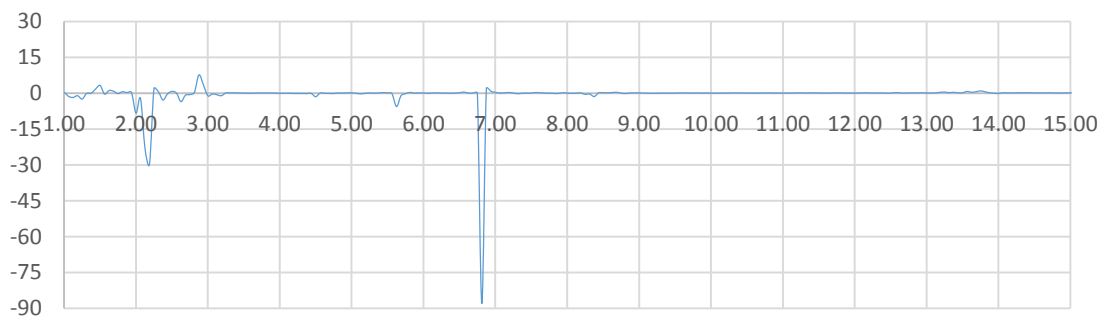
Punto 4

Desfase (°) vs Frecuencia (Hz)

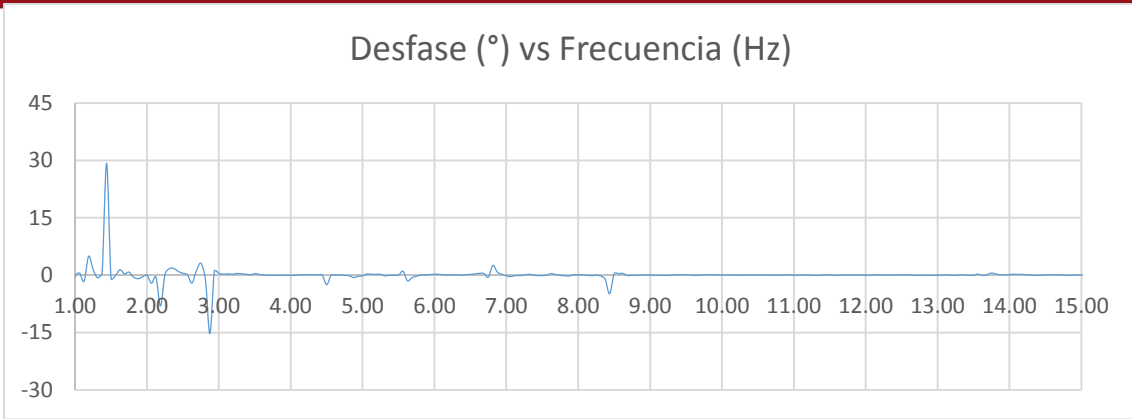


Punto 5

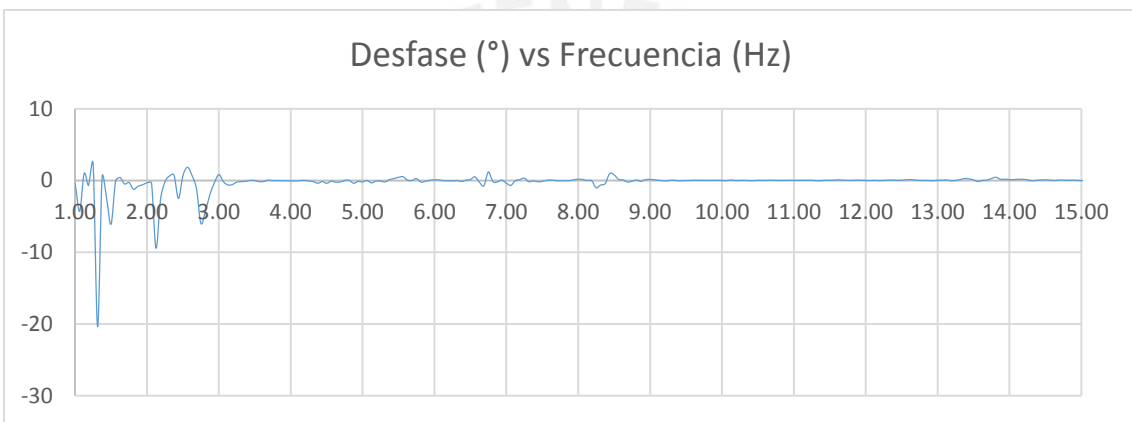
Desfase (°) vs Frecuencia (Hz)



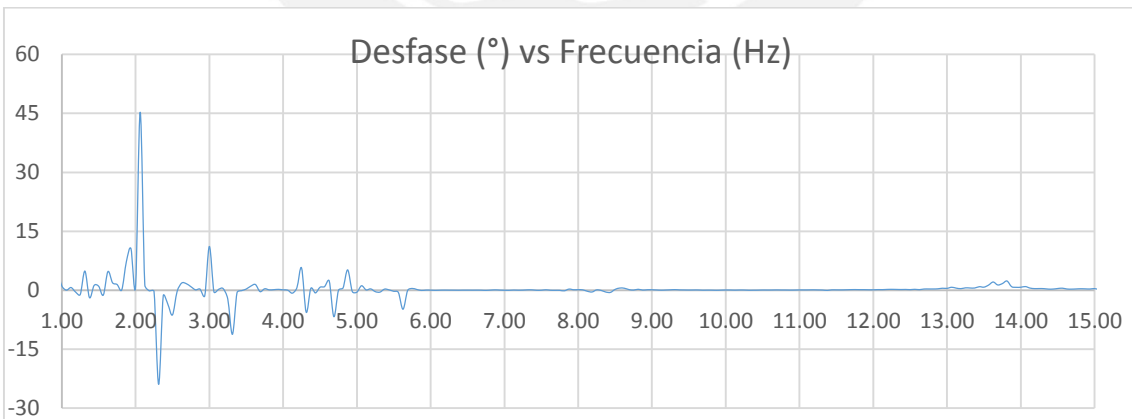
Punto 6



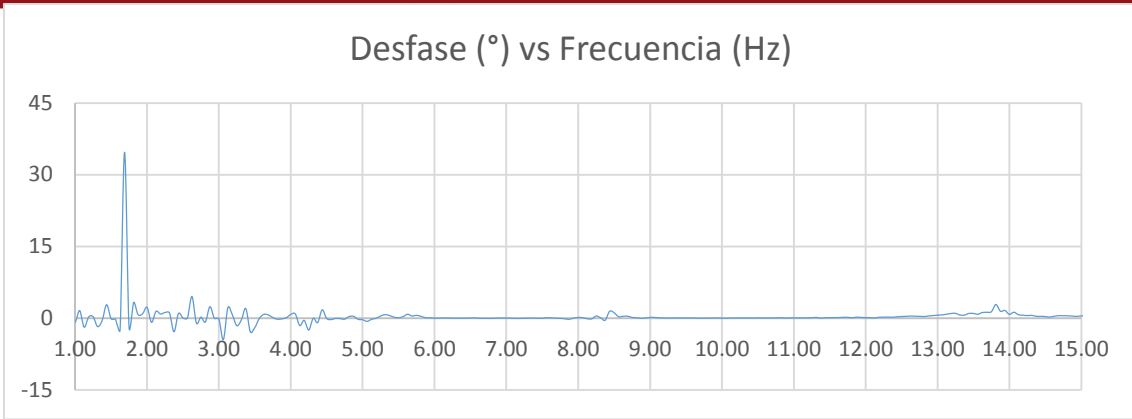
Punto 7



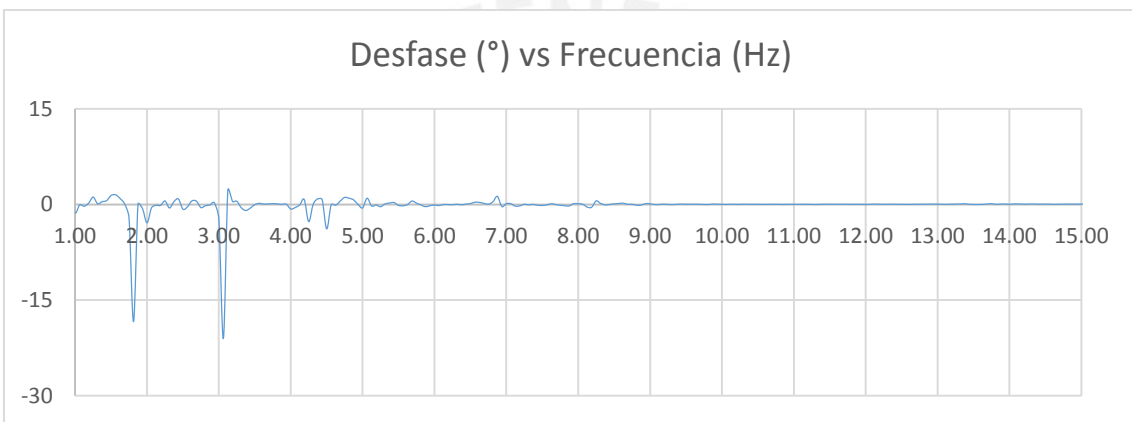
Punto 8



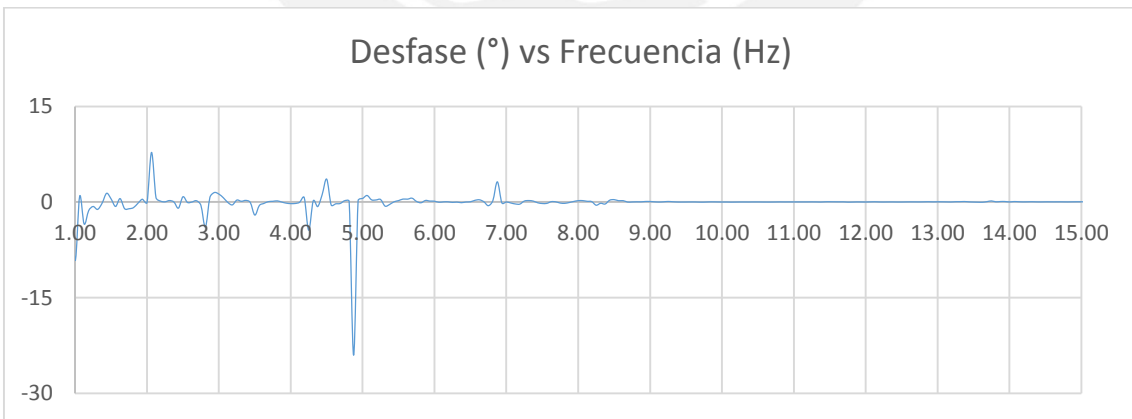
Punto 9



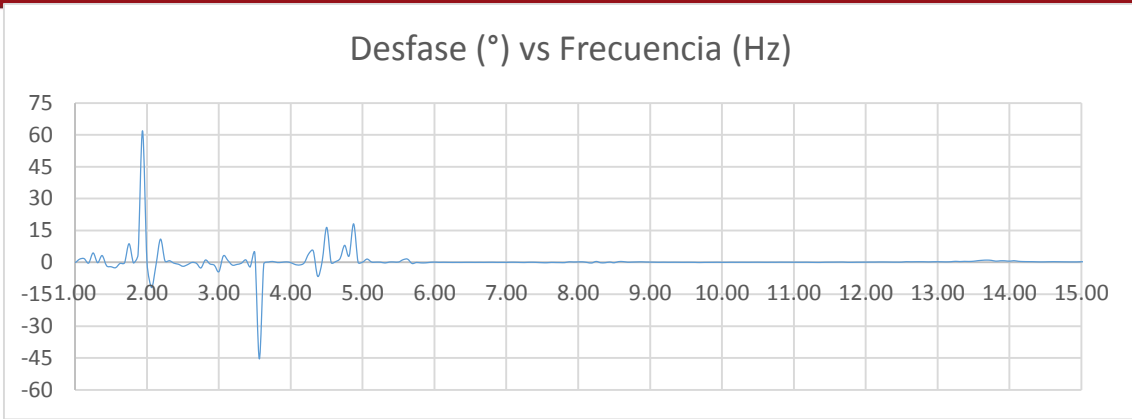
Punto 10



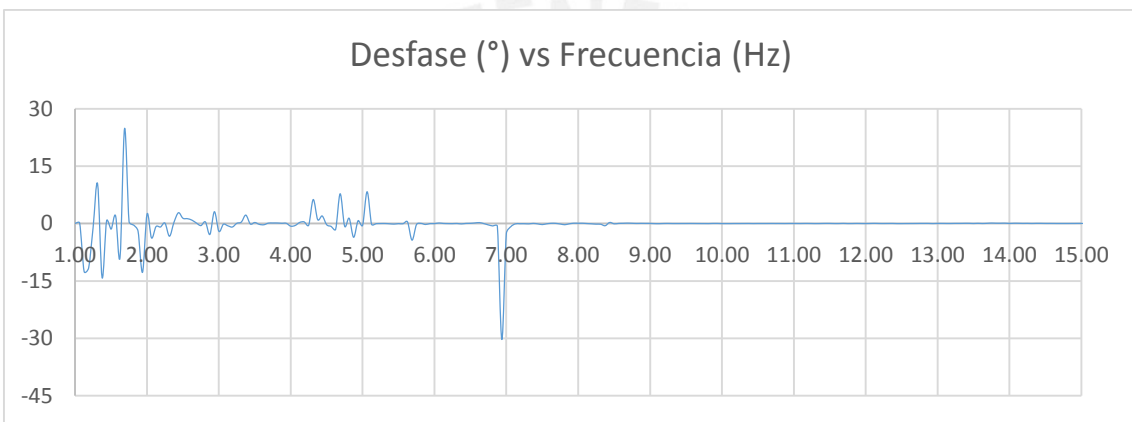
Punto 11



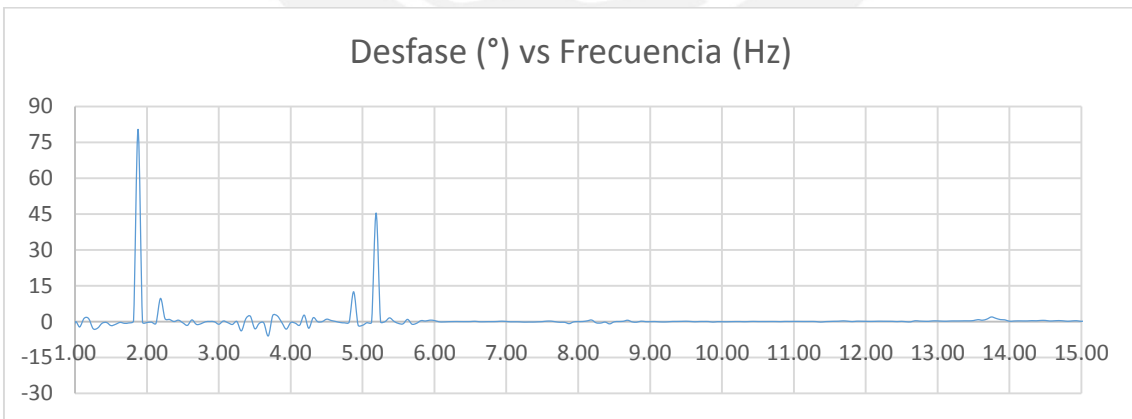
Punto 12



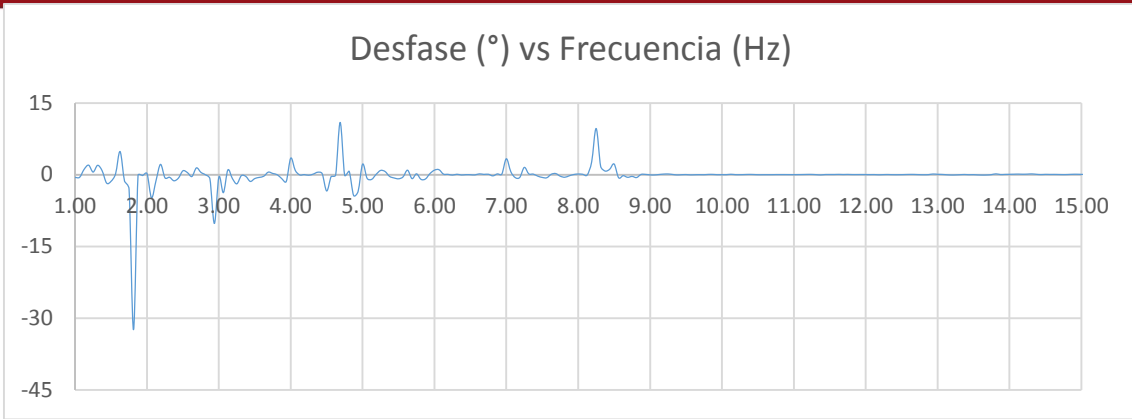
Punto 13



Punto 14

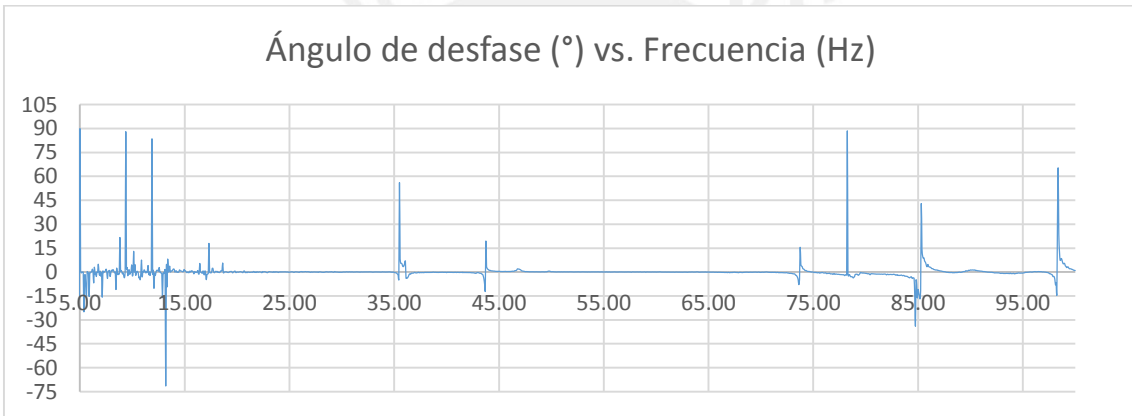


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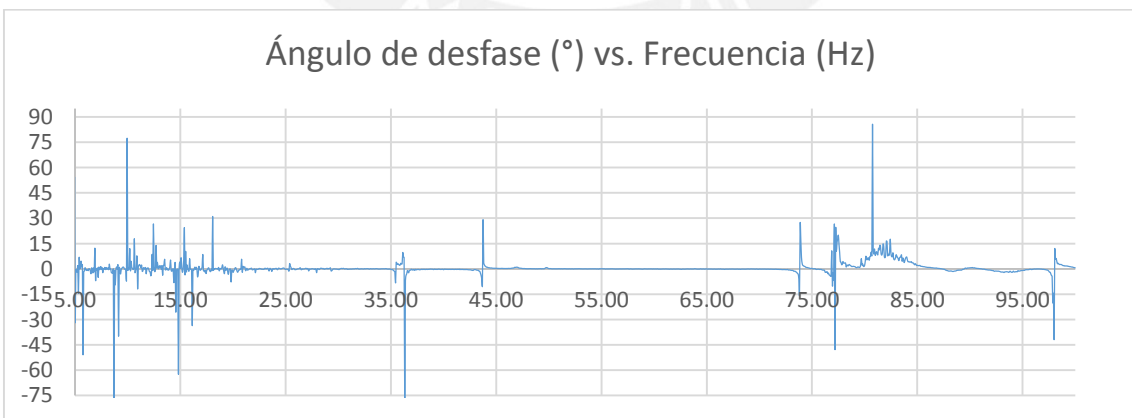


Punto 16

Anexo C.4. Ensayo con mayor rigidez

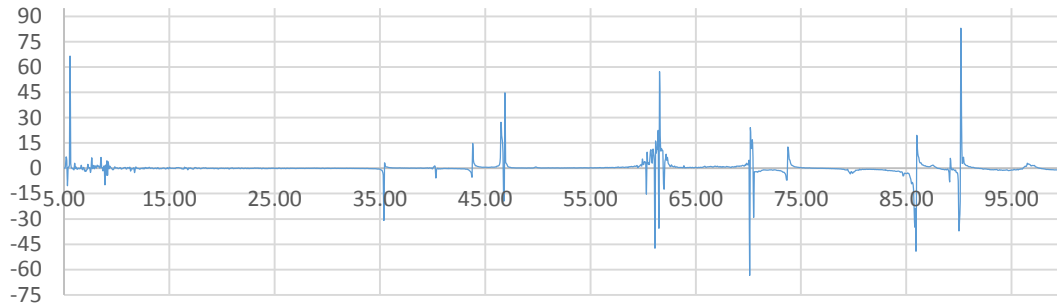


Punto 1



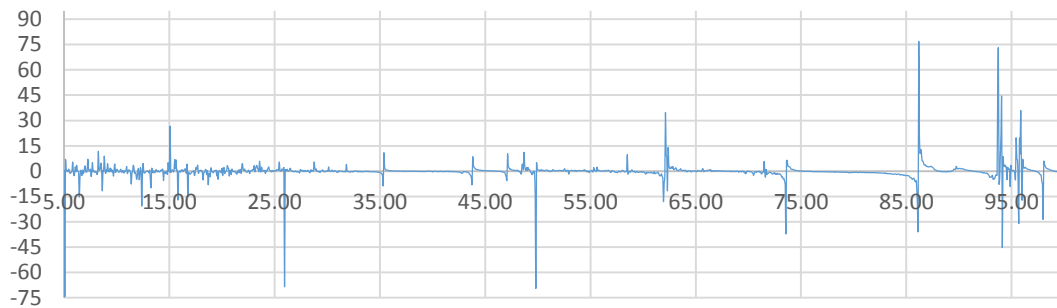
Punto 2

Ángulo de desfase (°) vs. Frecuencia (Hz)



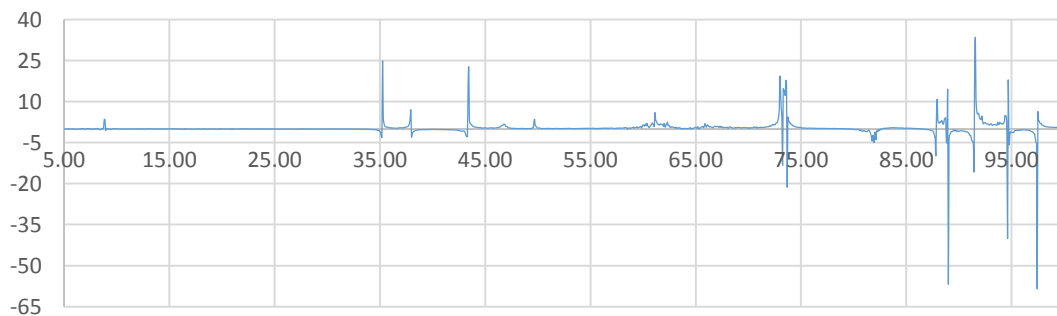
Punto 3

Ángulo de desfase (°) vs. Frecuencia (Hz)



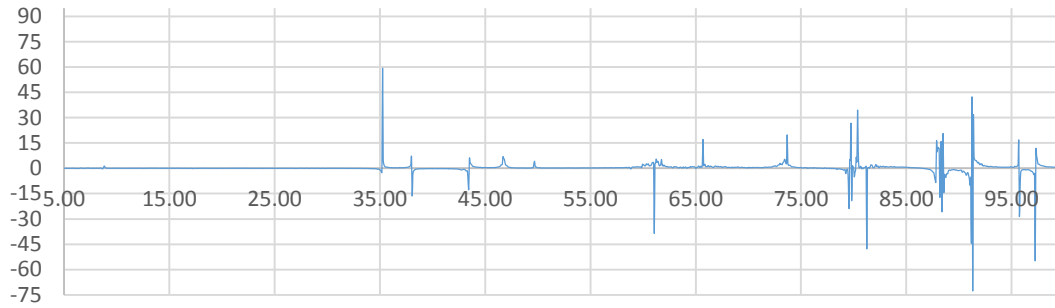
Punto 4

Ángulo de desfase (°) vs. Frecuencia (Hz)



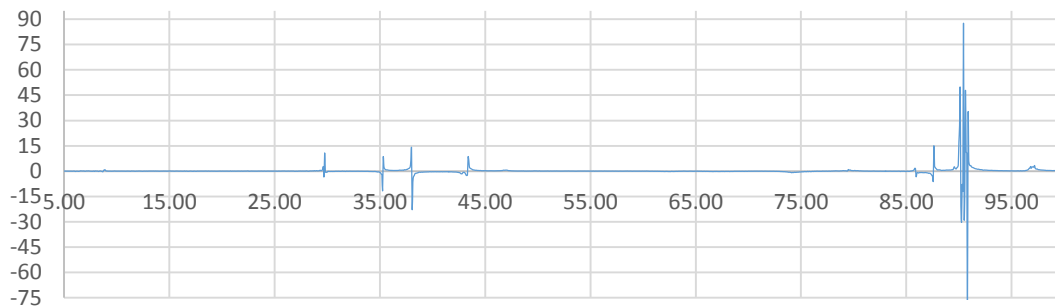
Punto 5

Ángulo de desfase (°) vs. Frecuencia (Hz)



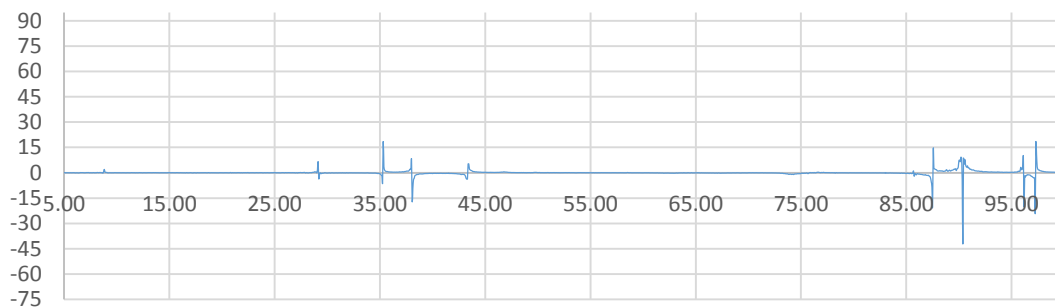
Punto 6

Ángulo de desfase (°) vs. Frecuencia (Hz)

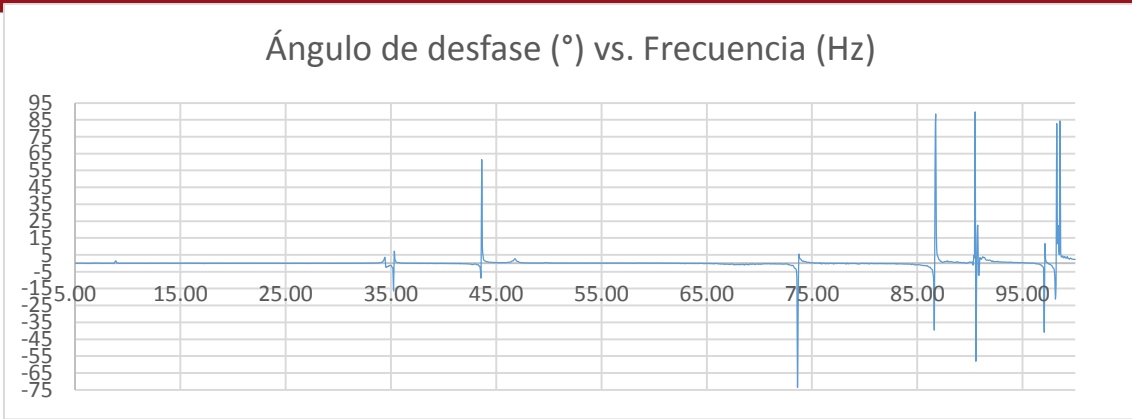


Punto 7

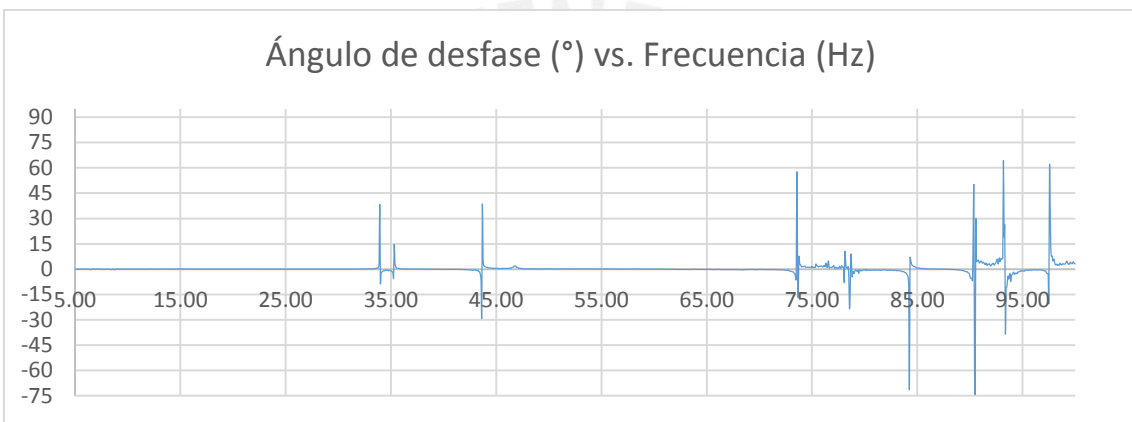
Ángulo de desfase (°) vs. Frecuencia (Hz)



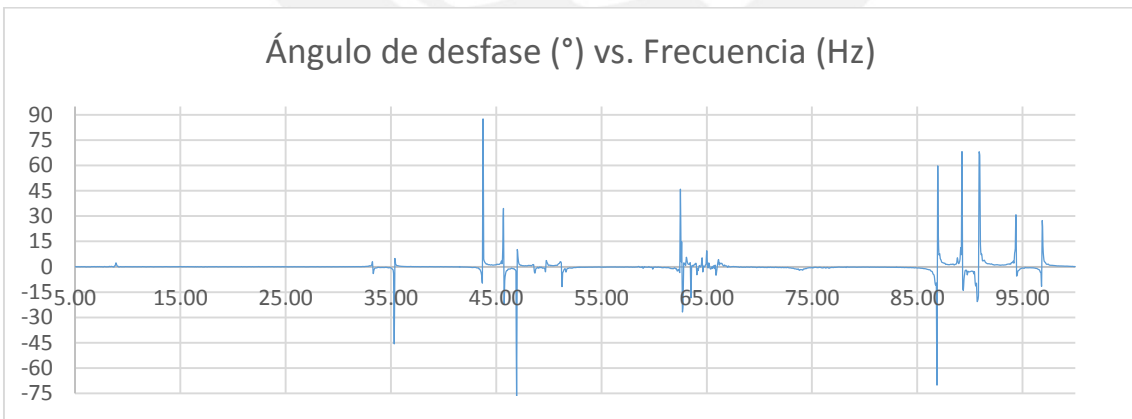
Punto 8



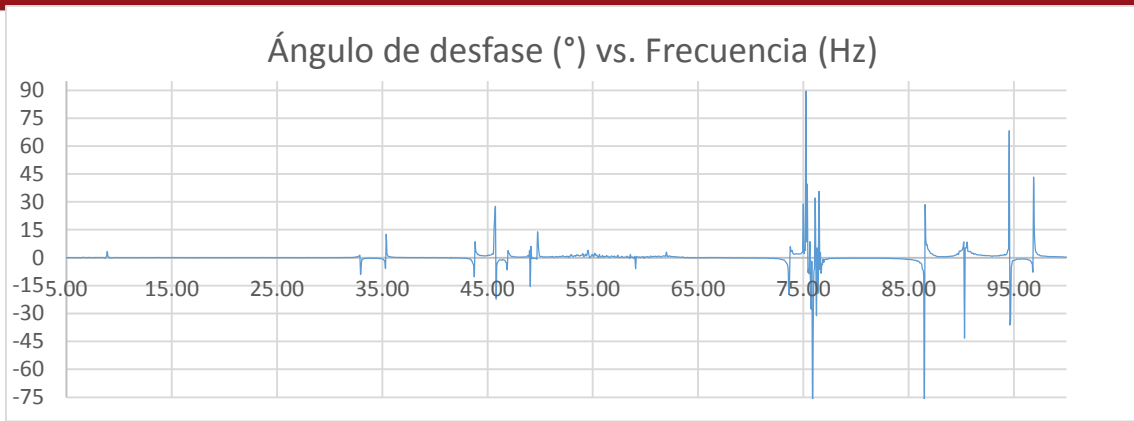
Punto 9



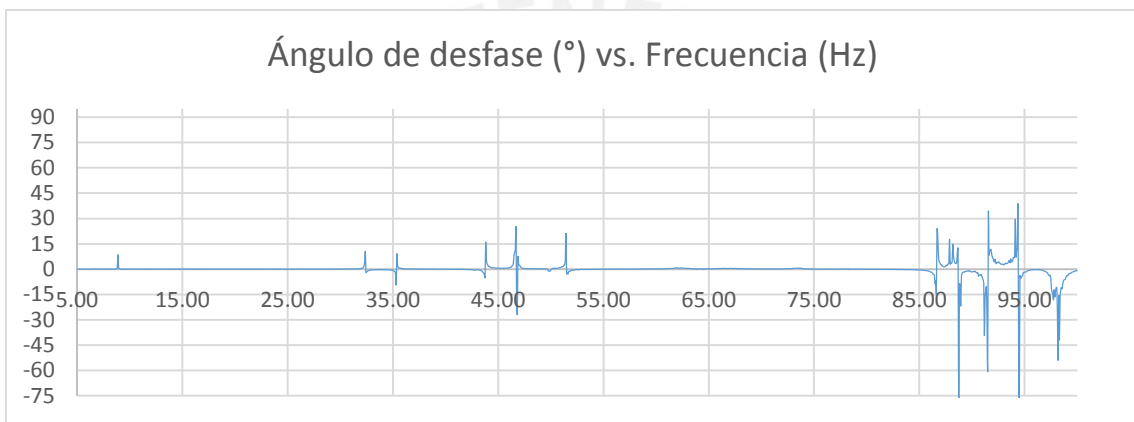
Punto 10



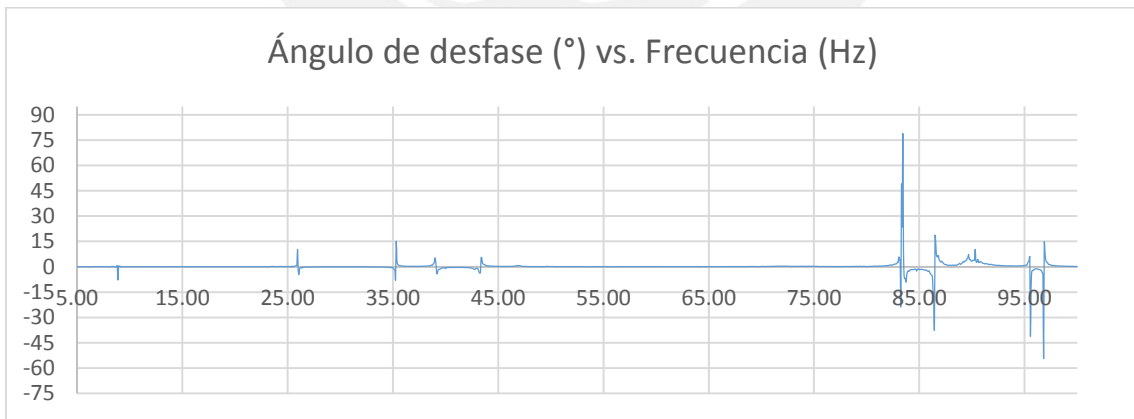
Punto 11



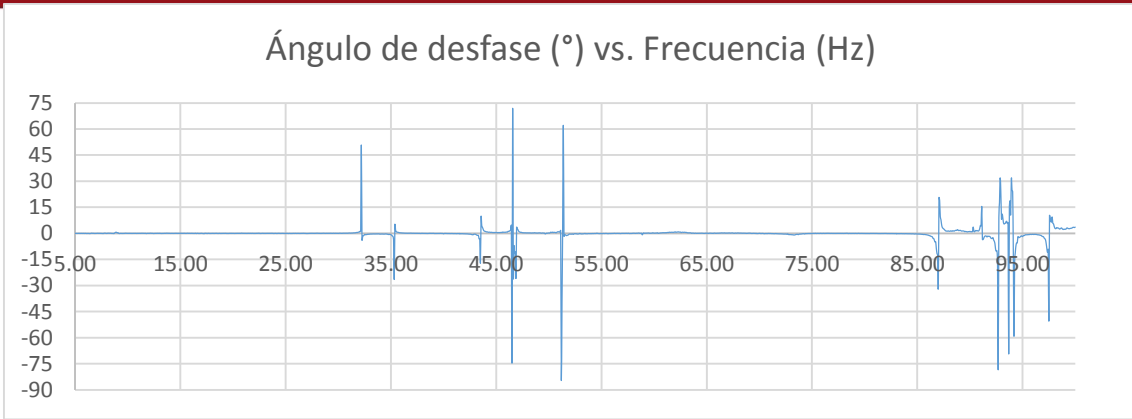
Punto 12



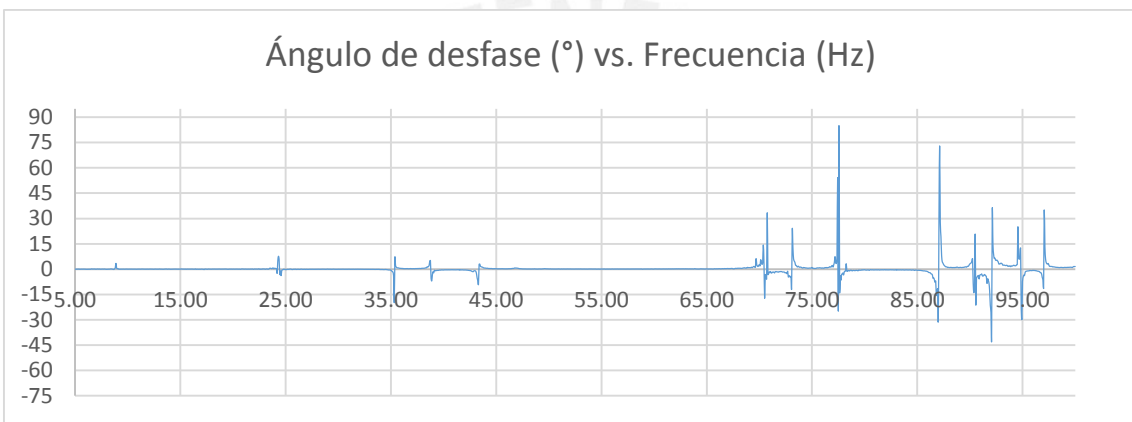
Punto 13



Punto 14



Punto 15



Punto 16

Anexo D: Tabla de ajuste de apriete.

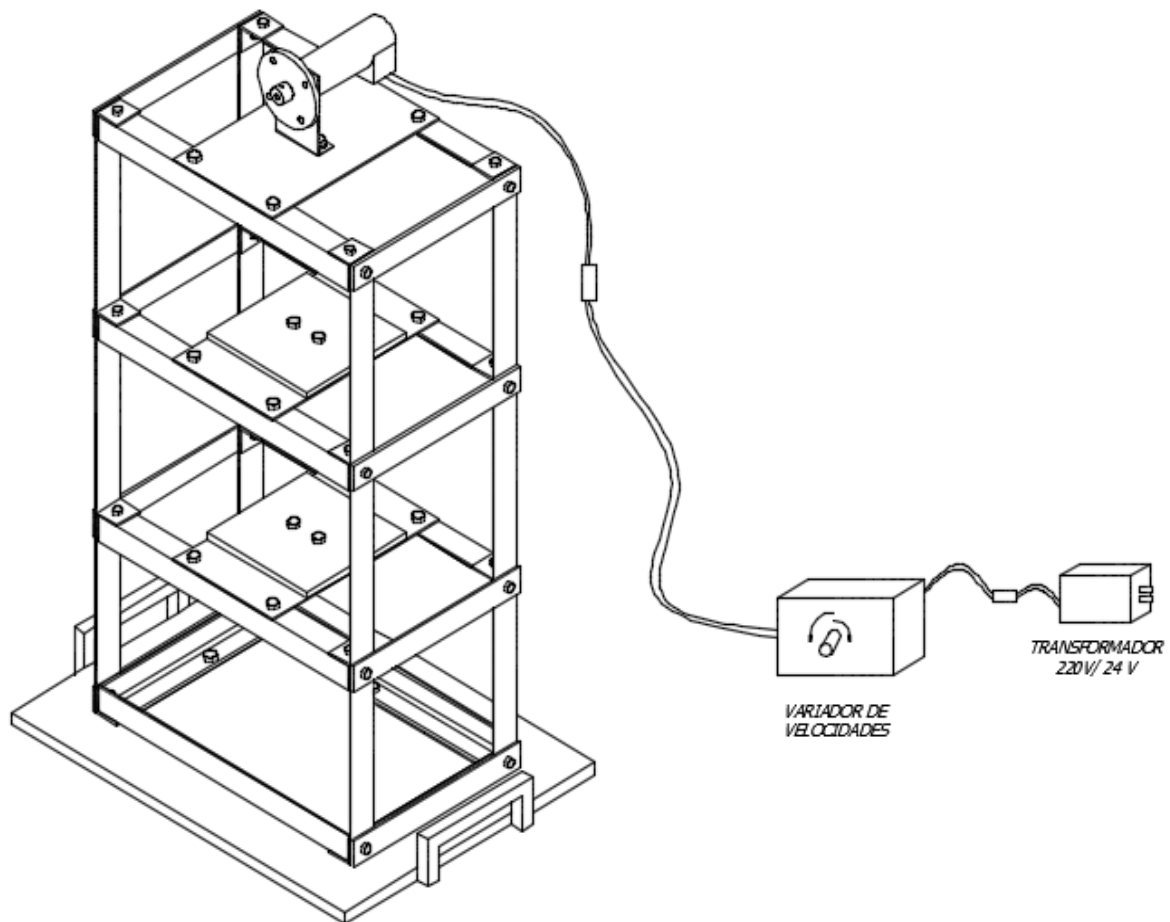
Diámetros y pasos		Aprietes en Kg/m					
		Calidad del acero					
ROSCA	PASO	3.6 (4D)	5.6 (5D)	6.9 (6G)	8.8 (8G)	10.9 (10K)	12,9 (12K)
M - 4	0,70	0,10	0,41	0,27	0,31	0,44	0,52
M - 5	0,80	0,20	0,27	0,52	0,61	0,86	1,04
M - 6	1,00	0,35	0,46	0,89	1,05	1,50	1,80
M - 7	1,00	0,57	0,76	1,45	1,75	2,50	2,90
M - 8	1,25	0,84	1,10	2,20	2,60	3,60	4,30
M - 10	1,50	1,70	2,20	4,30	5,10	7,20	8,70
M - 12	1,75	2,90	3,90	7,50	8,90	12,5	15,0
M - 14	2,00	4,60	6,20	11,9	14,1	19,8	24,0
M - 16	2,00	7,10	9,80	18,2	21,5	30,5	36,5
M - 18	2,50	9,70	13,0	25,0	29,5	42,0	50,0
M - 20	2,50	13,8	18,0	39,2	42,0	59,0	71,0
M - 22	2,50	18,6	25,0	48,0	57,0	80,0	96,0
M - 24	3,00	23,5	31,5	61,0	72,5	102	122
M - 27	3,00	35,0	47,0	90,5	107	151	181
M - 30	3,50	47,5	63,5	123	145	205	245
M - 33	3,50	64,5	86,5	166	197	277	333
M - 36	4,00	83,0	111	214	253	356	428
M - 39	4,00	108	144	277	329	462	555

Fuente: <http://www.pasaisa.com/blog/elegir-una-llave-de-impacto/>

Anexo E: Manual de funcionamiento

A continuación se presentará el manual de funcionamiento del módulo de laboratorio para estudiar el comportamiento dinámico.

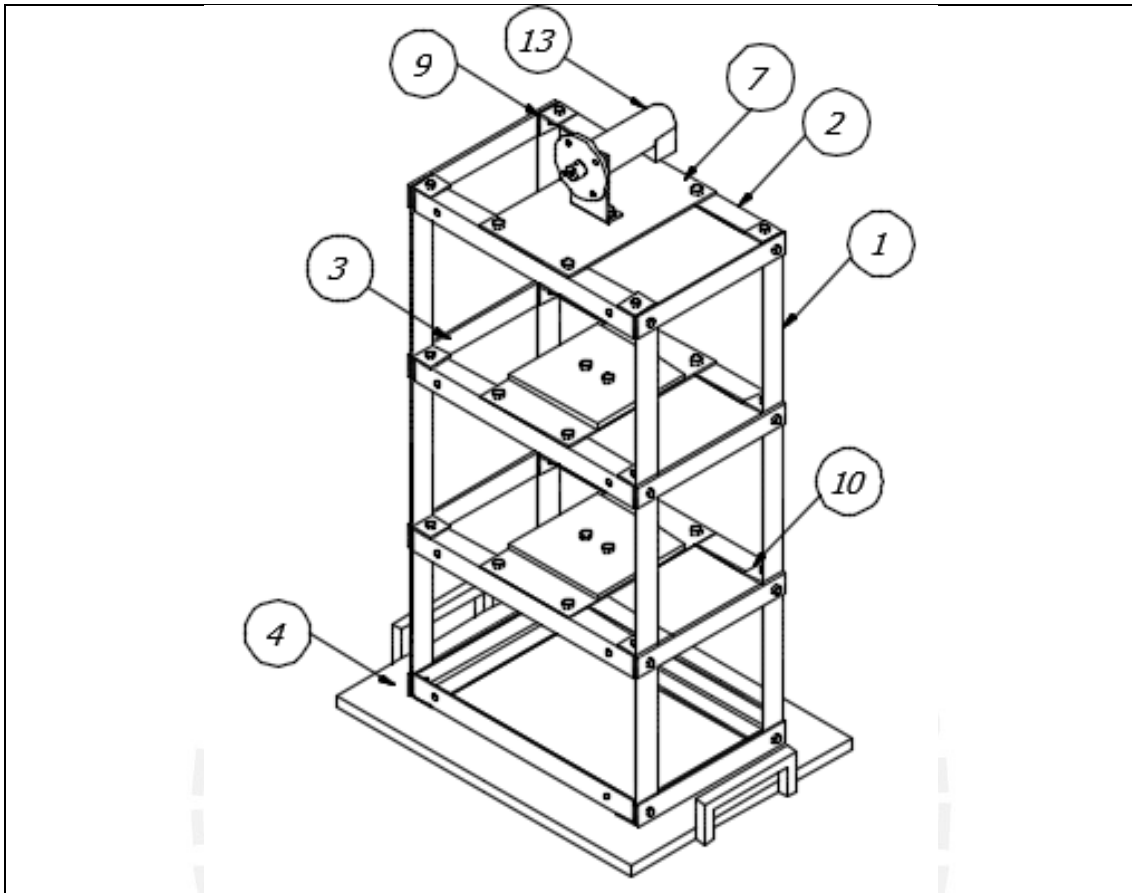
MANUAL DE FUNCIONAMIENTO DEL MODULO DE LABORATORIO

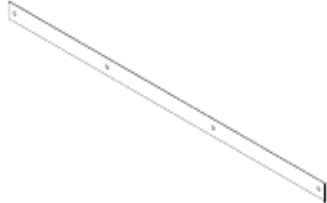
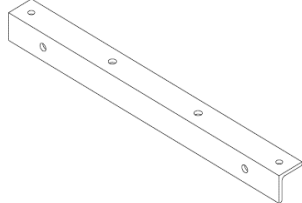
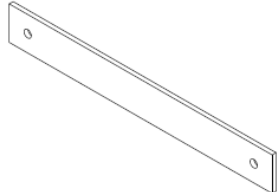
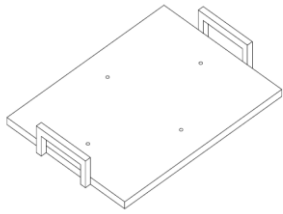
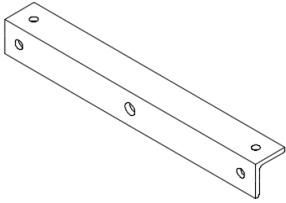
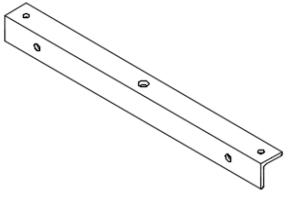


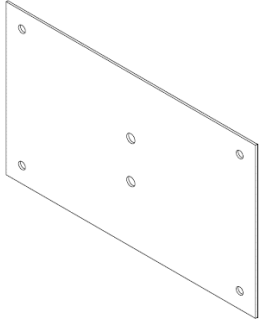
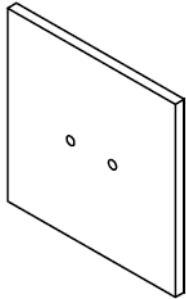
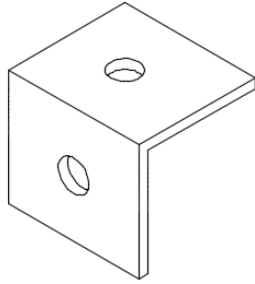
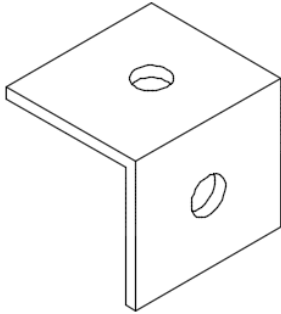

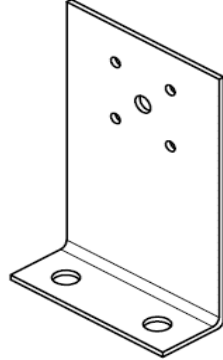
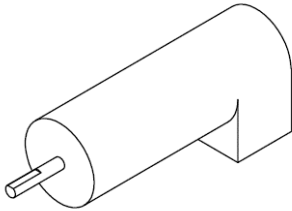
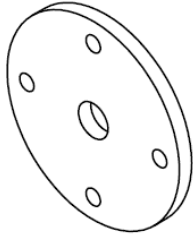
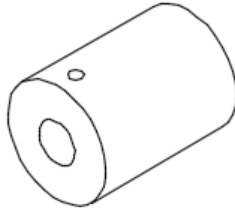
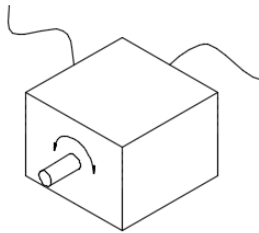
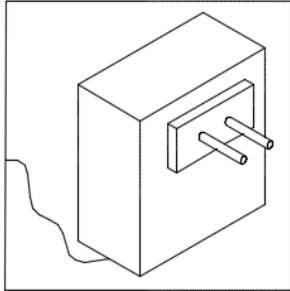
Módulo de laboratorio que permite estudiar el comportamiento dinámico de una estructura metálica que trabaja con un equipo mecánico.

IMPORTANTE: Seguir las indicaciones brindadas en este manual para el uso correcto del mismo.

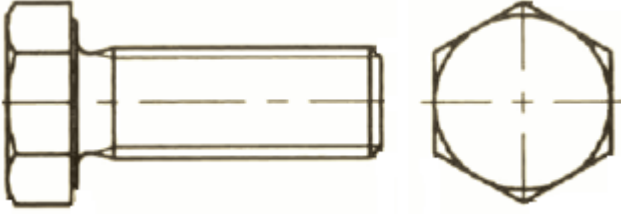




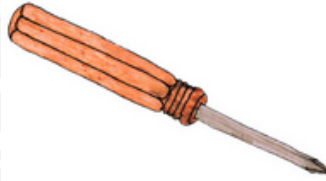

1.- LISTA DE PARTES



 <p>1.- Fleje Metálico</p>	 <p>2.- Perfil Horizontal 300 mm</p>	 <p>3.- Platina</p>
 <p>4.- Base del módulo</p>	 <p>5.- Perfil Horizontal base 200 mm</p>	 <p>6.- Perfil horizontal base 300 mm</p>

 <p>7.-Plancha de 1.5 mm de espesor</p>	 <p>8.- Plancha de 0.25 in de espesor</p>	 <p>9.- Ángulo unión izquierdo</p>
 <p>10.- Ángulo unión derecha</p>	 <p>11.- Arriostre</p>	 <p>12.- Base de motor</p>
 <p>13.- Servomotor 24 V DC</p>	 <p>14.- Volante</p>	 <p>15.- Bocina</p>
 <p>16.- Variador de Velocidad</p>	 <p>17.- Transformador de 200 V/ 24 V</p>	

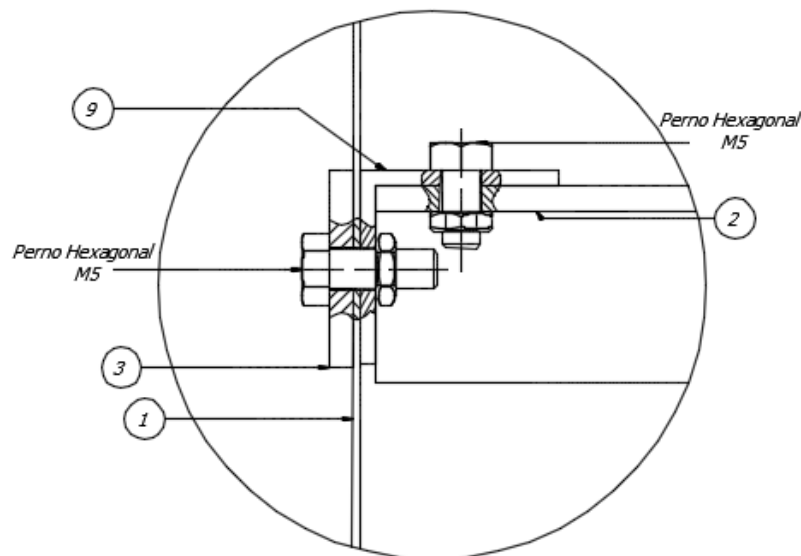
2.- PERNOS Y HERRAMIENTAS

Parte	Cantidad	Item	
A	15	Perno Hexagonal M5 x 10 mm	
B	4	Perno Hexagonal M6 x 10 mm	
C	36	Perno Hexagonal M8 x 20 mm	
D	1	Prisionero	
E	4	Tornillo M2	
F	1	Llave M5, M6 y M8	
G	1	Llave Allen	
H	1	Destornillador estrella	
I	1	Torquímetro 1 – 25 N	

3.- PROCEDIMIENTO DE ENSAMBLE

Etapa 1:

- Ensamble los perfiles horizontales (2), platinas (3) con el fleje metálico (1) con la ayuda de los ángulos de unión (9 y 10) utilizando los pernos M5 (A) con ayuda de su respectiva llave (F).
- Cada nivel cuenta con los siguientes componentes: 2 perfiles horizontales, 2 platinas, 2 ángulos de unión izquierda y 2 de tipo derecha y 4 flejes metálicos.
- Para unir una platina con dos perfiles horizontales y 2 flejes se necesitará utilizar un ángulo de unión izquierda y otro que sea derecha.
- A continuación se muestra el detalle de la unión entre estos componentes.

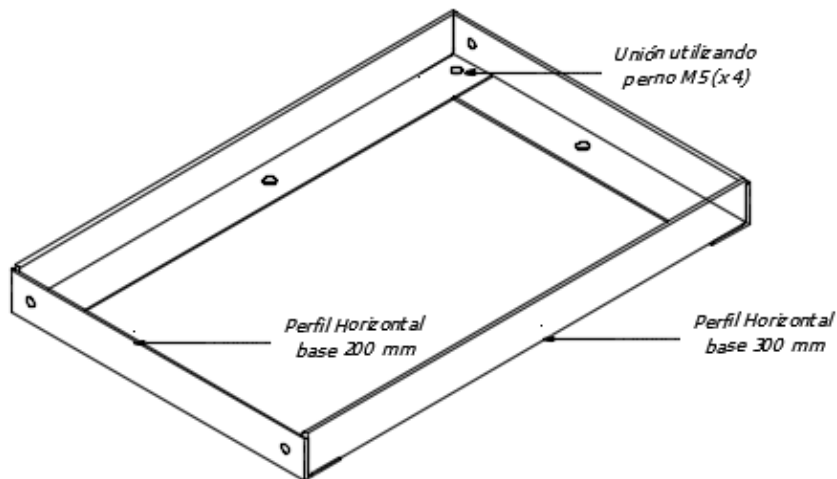


Vista de detalle utilizando un ángulo de unión derecha. Del mismo modo se procederá con el otro lado de la platina pero con diferente ángulo de unión.

Etapa 2:

Una vez armado los niveles 1, 2 y 3 del módulo de laboratorio, se procederá a ensamblar la base.

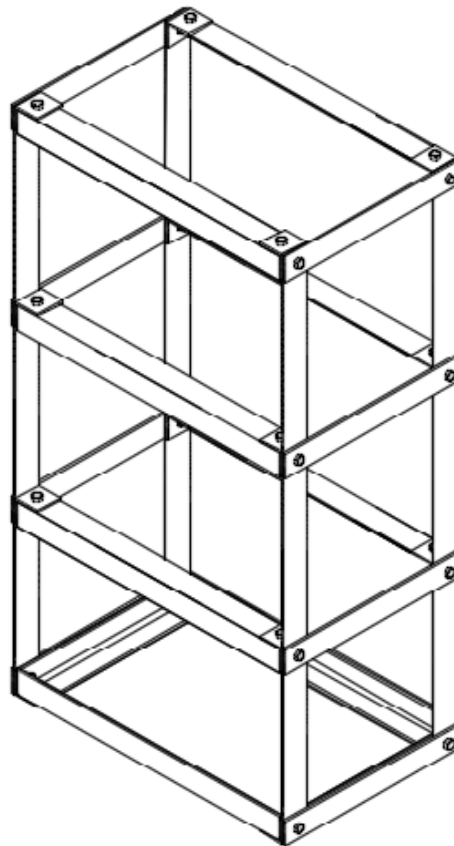
- Se deberá formar un cuadrilátero con los perfiles horizontales de la base (5 y 6), para ello se utilizará unión emperrada en las esquinas utilizando pernos M5 (A) con ayuda de su respectiva llave (F)
- Los perfiles de 300 mm estarán por encima de los perfiles de 200 mm.



Base del módulo.

- Luego se procederá a acoplar la base más 2 platinas en la parte inferior del módulo a cada lado.

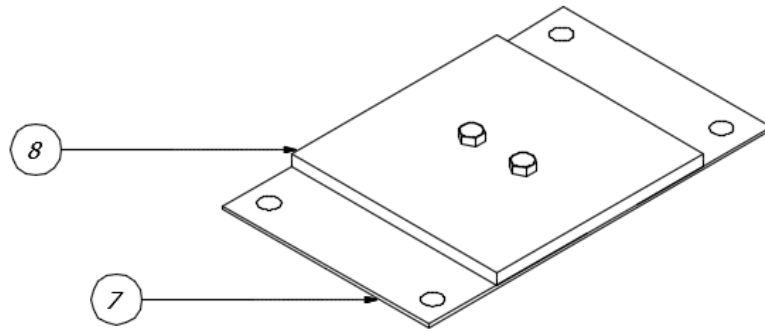
De esta forma nos quedará el siguiente avance.



Vista Isométrica de la estructura.

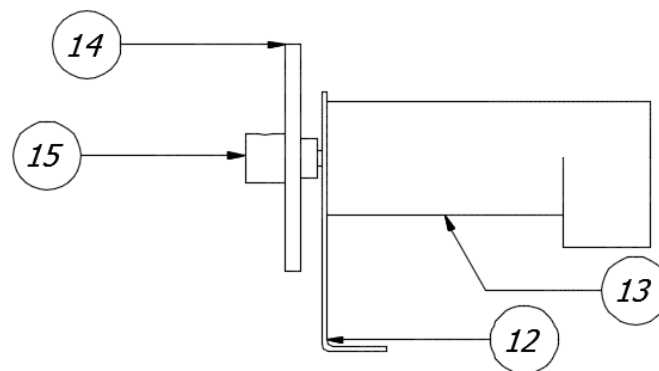
Etapa 3: Agregar planchas a los niveles 1, 2 y 3

- Primero se unirán mediante pernos las planchas de 1.5 mm de espesor (7) con las planchas de 0.25 pulgadas de espesor (8) con la ayuda de pernos M6 (B) con ayuda de su respectiva llave (F). Para los niveles 1 y 2.
- La plancha de 0.25 pulgadas de espesor (8) se colocará encima de la plancha de 1.5 mm (7).



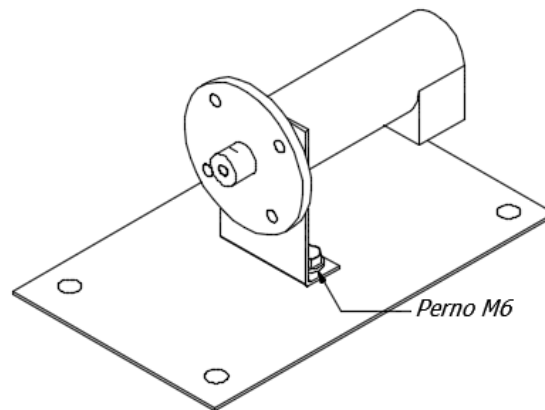
Vista Isométrica de la unión de los elementos 7 y 8.

- Para el nivel 3 se deberá unir la plancha de 1.5 mm de espesor (7) con el conjunto de la parte rotativa del módulo. La parte rotativa del módulo está compuesto por los siguientes elementos: Servomotor (13), Soporte del Servomotor (12), Volante (14), bocina (15).
- El procedimiento para este montaje empieza fijando con 4 tornillos (E) el soporte del servomotor utilizando un destornillador estrella (H) para luego colocar la volante (14) y por último fijar la bocina (15) con un prisionero (D) hacia el eje con ayuda de una llave allen (G).
- La volante presenta huecos pasantes para pernos M6 (B) y con ello poder generar una carga desbalanceada en el servomotor.



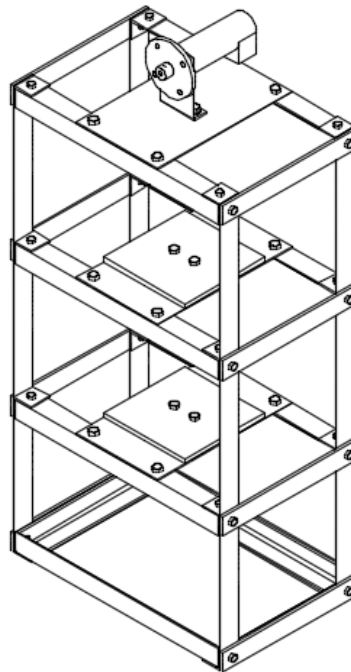
Ensamble del servomotor.

Luego se fija la plancha de 1.5 mm de espesor (7) con el conjunto del servomotor con pernos M6 (B) con ayuda de una llave (F). Tal como se muestra en la siguiente imagen.



Ensamble del servomotor a su base.

- Por último se ensambla los 3 subconjuntos en la estructura donde la plancha con el servomotor estará ubicada en el nivel 3. Para efectuar esta unión se realizará a través de las uniones empernadas entre la plancha de 1.5 mm de espesor (7) y los perfiles horizontales de 300 mm (2) de cada uno de los niveles.

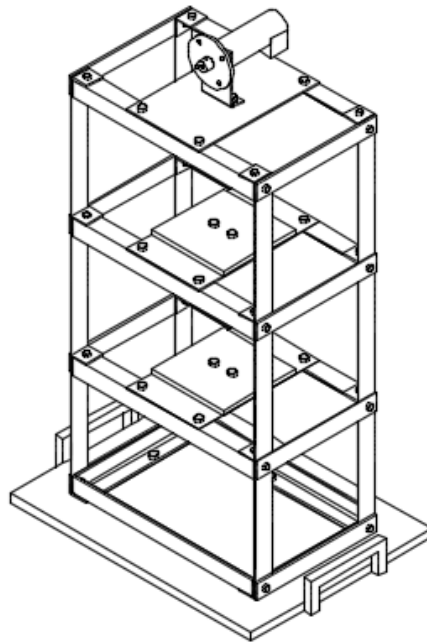


Vista Isométrica con el servomotor y masas adicionales.

Etapa 4: Ensamble de la plancha de Fe

- Una vez armado la parte estructural del módulo con el servomotor, se fijará todo el conjunto con la plancha de 1 pulgada de Hierro (4) para poder tener

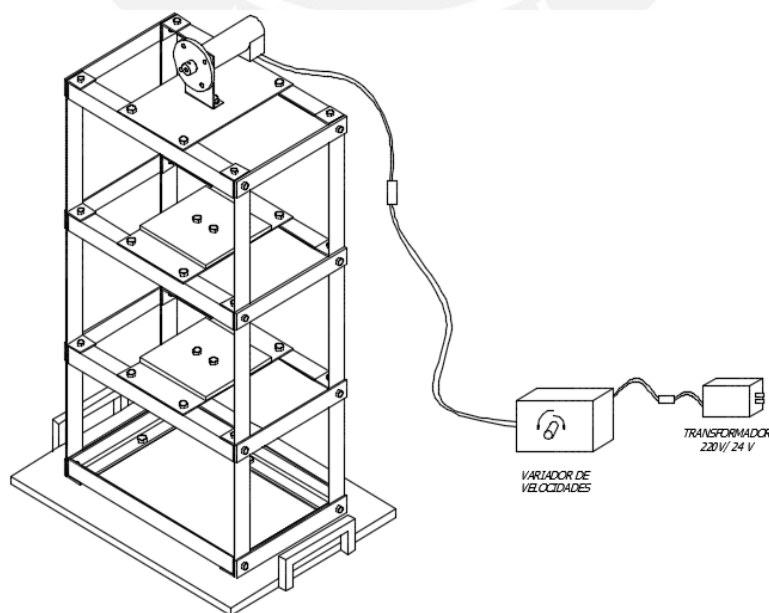
una mejor estabilidad. Para ello se utilizarán 4 pernos M8 (C) para realizar la unión con ayuda de una llave (F).



Vista Isométrica de la estructura con la plancha de Fe.

Etapa 5: Variador de velocidad y fuente de alimentación

- El sistema para alimentar el servomotor será mediante un variador de velocidades (16) y este último será conectado con un transformador de 220V / 24 V (17). La conexión entre estos elementos será de forma directa mediante el uso de borneras.



Vista Isométrica del módulo de laboratorio.

4.- FUNCIONAMIENTO

Consideraciones para la puesta en marcha

- Verificar que todas las uniones estén correctamente ajustadas y aseguradas, tanto las conexiones de la base, como el de cada ángulo que permite la adecuada estabilidad del sistema. Para ello recuerde usar el torquímetro (I) y utilizar el torque adecuado según el anexo E. Como también el uso adecuado de las demás herramientas.
- Realizar la configuración que se desee experimentar, para poder apreciar el cambio de las frecuencias y modos de vibración. Podrá retirar masas, variar el torque de ajuste de las uniones, agregar elementos rigidizadores, etc.
- Asegurarse que el variador de velocidades del servomotor este ubicado en un lugar seguro y que la conexión de alimentación este en perfectas condiciones.
- Realizar el cambio de velocidades de manera paulatina para no sobrecargar la corriente en los circuitos de la tarjeta del variador de velocidades.
- Se debe tener en cuenta que girar la perilla en sentido anti horario hará que las rpm (revoluciones por minuto) del servomotor incrementen y de manera inversa se reducirán las rpm. Cabe mencionar que el variador de velocidades está diseñado para operar con una corriente generada por 24 V. Además, el rango de frecuencias de trabajo oscila entre 1–25 Hz.
- Durante el montaje del módulo se deberá trabajar con las herramientas adecuadas y necesarias mencionadas en el capítulo 2. Para obtener los torques necesarios en los pernos, seguridad de montaje y una buena representación del modelo conceptual.