



Calibration and Test for Space Instrument II

Environmental Tests

Vibration Test

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Outline

- 振動測試的目的
- 探空火箭振動測試規範
- 衛星酬載振動測試規範
- 實驗室的測試系統介紹
- 振動系統的機台與夾具介紹
- 軟體模擬

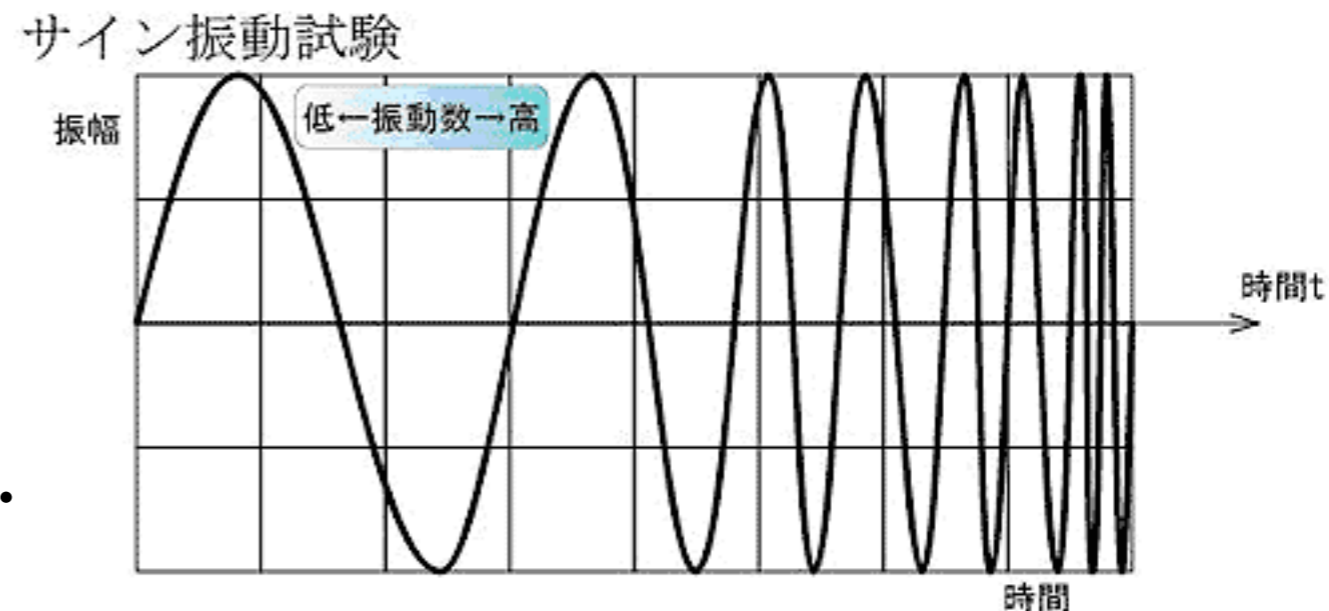
振動測試的目的

- 振動的目的是用來模擬儀器在發射過程中，火箭所產生的振動，以驗證儀器承受此振動後之功能仍正常運作。此外，並可加以找出儀器結構本身之振動頻率模式，以驗證結構之設計、分析均符合振動需求。

Sine vibration test

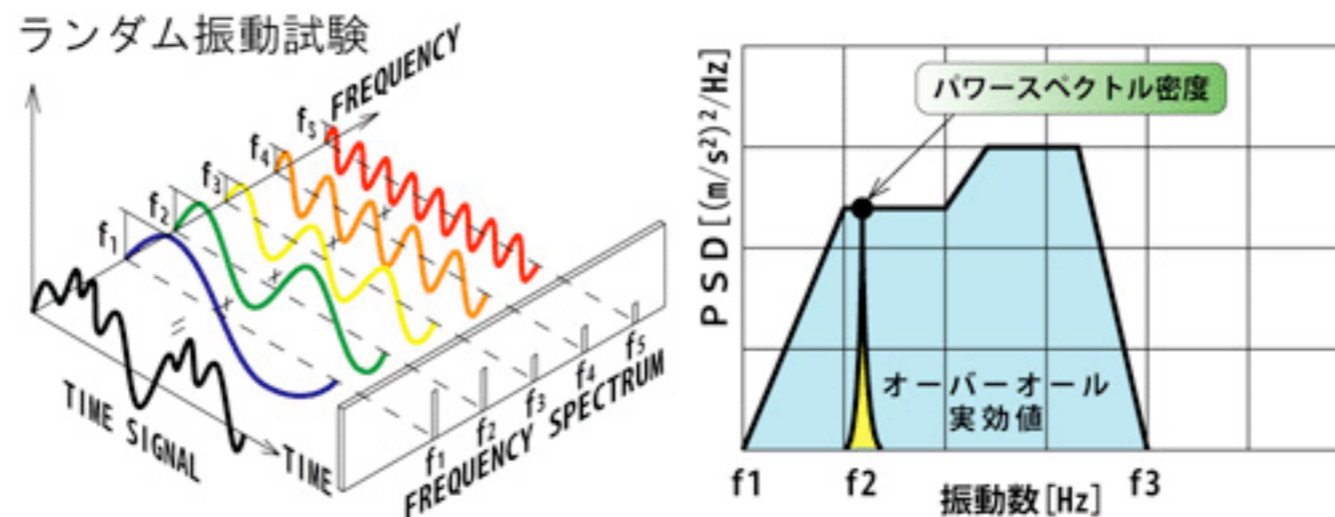
Point test (fixed frequency test): The point test is done at a frequency fixed to any given value. The aim is to evaluate the durability of a unit under test at its resonant condition or the characteristics at a specified frequency. The main parameters are **frequency** (Hz), **acceleration** (m s^{-2}), and **test time** (s).

Swept sine test: The frequency of a swept sine test changes with time continuously for the purpose of resonant search or evaluation of characteristics over any frequency range. The main parameters are **frequency** (Hz), **acceleration** (m s^{-2}), **test time** (s), and **sweep rate** (oct/min) or (Hz/s).



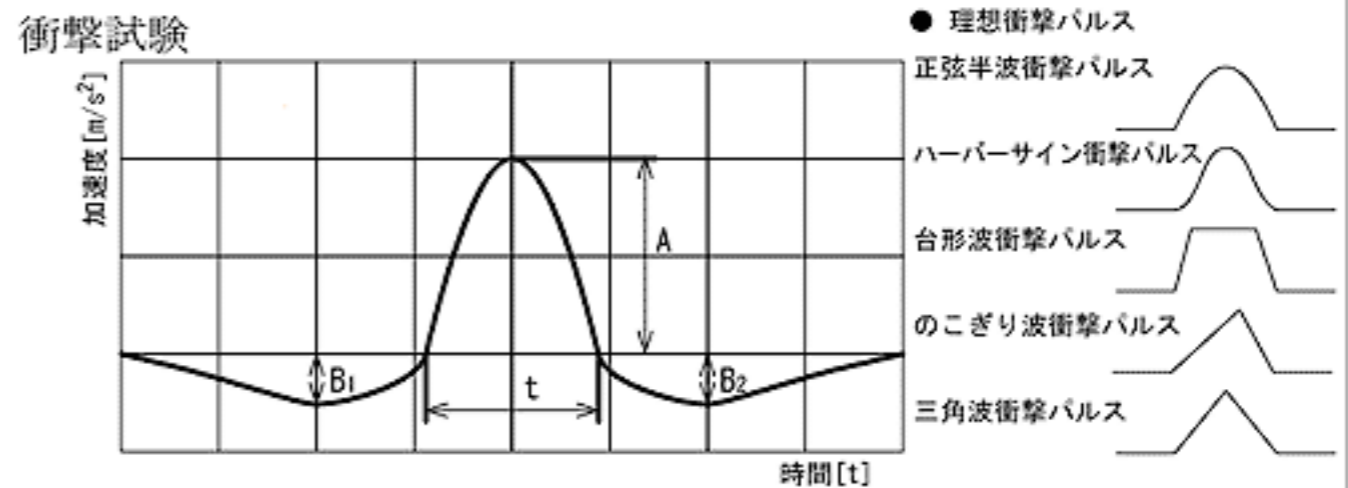
Random vibration test

A random vibration is what happens when sinusoidal waves of different frequency and phase are combined. The random vibration test permits to detect many vibrations in resonance in a short time because it can excite a test article at many different frequencies simultaneously. Also it can reproduce a vibration close to a real environment. The main parameters are overall **rms values** (rms, $m\ s^{-2}$), **power spectral density** (PSD, $(m\ s^{-2})^2/Hz$), and **test time** (s).



Shock test

The shock test is to assure that material can withstand the non-repetitive shocks and transient vibrations as well as to measure an item's fragility. The main parameters are main shock pulse, **shock pulse duration** (s) in t , **acceleration** (m s^{-2}) in A , **velocity** (m s^{-1}) in V , **pre-load** ($\% = B_1/A \times 100\%$) in P_1 , and **post-load** ($\% = B_2/A \times 100\%$) in P_2 .

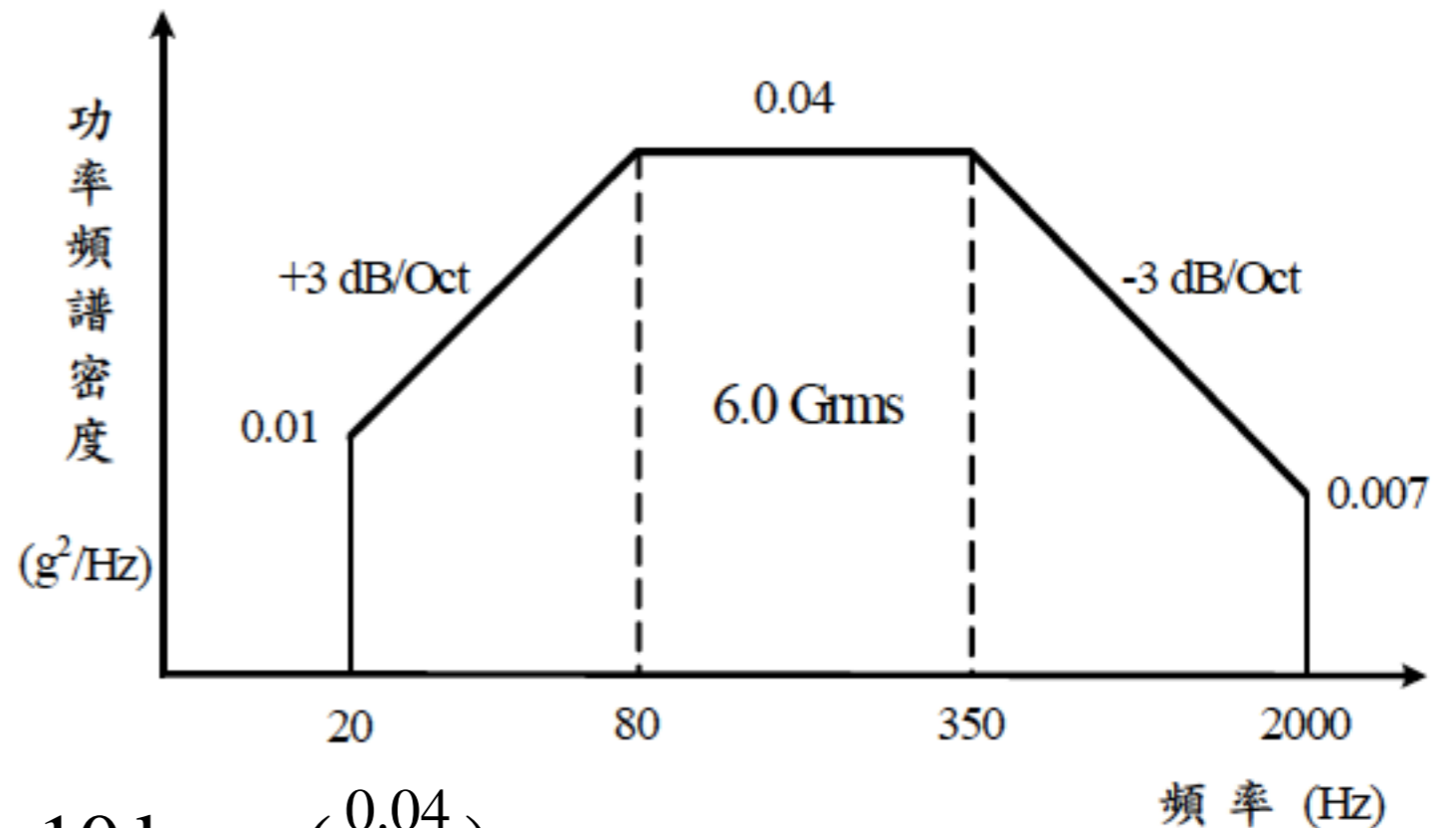


探空火箭測試規範

- 制式模組的隨機振動
- 單元的隨機振動
- 單元的衝擊測試

制式模組規範

- 隨機振動
- 3-axis
- 6 Grms
- 10min
- Power on



$$\text{dB} = 10 \log_{10} \left(\frac{P_1}{P_0} \right)$$

$$\text{Oct} = \log_2 \left(\frac{f_1}{f_0} \right)$$

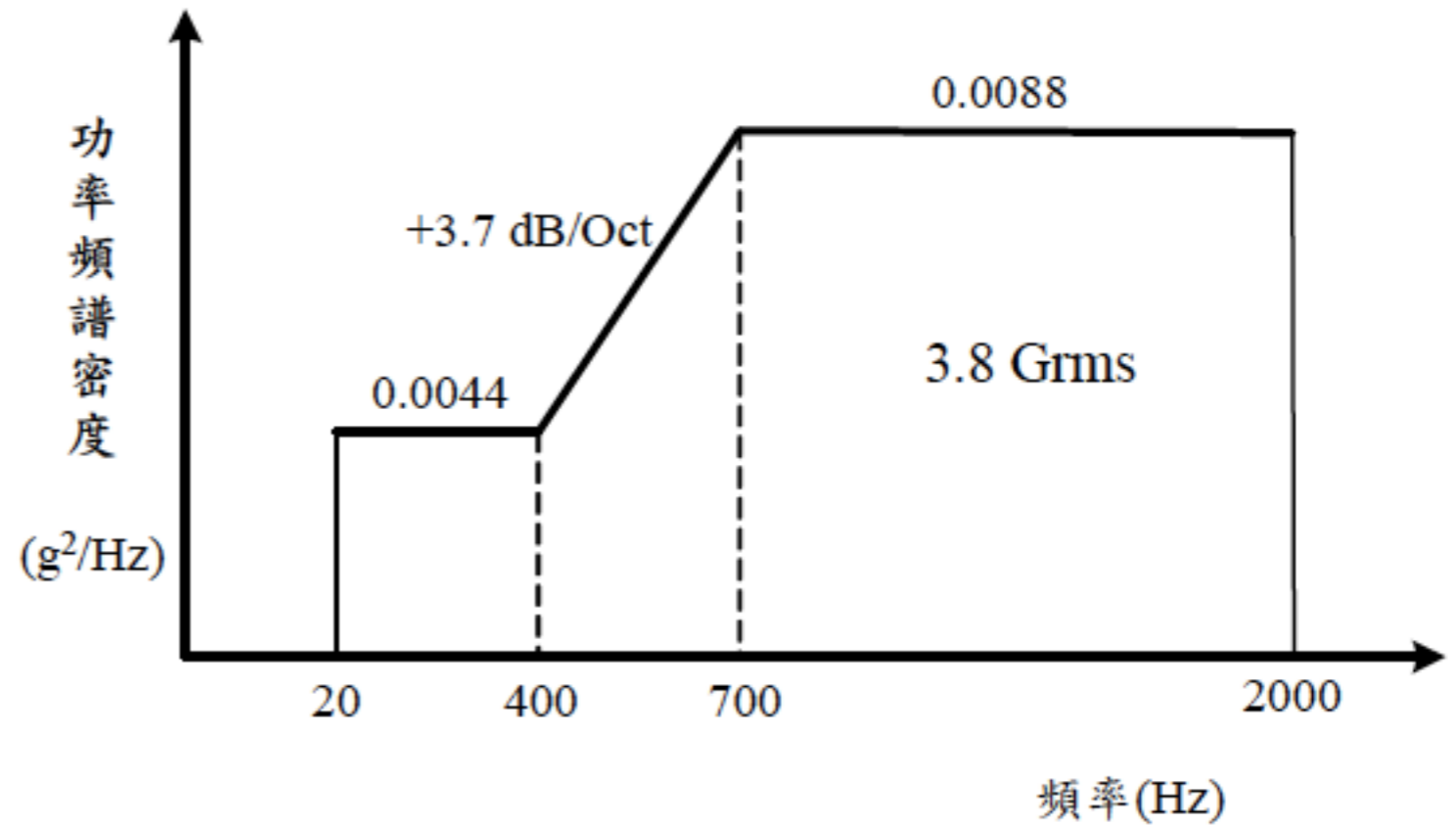
$$\text{slope} = \frac{\text{dB}}{\text{Oct}}$$

$$\text{slope} = \frac{10 \log_{10} \left(\frac{0.04}{0.01} \right)}{\log_2 \left(\frac{80}{20} \right)} = \frac{10 \times 0.6}{2} = 3 \text{ dB/Oct}$$

$$\text{slope} = \frac{10 \log_{10} \left(\frac{0.007}{0.04} \right)}{\log_2 \left(\frac{2000}{350} \right)} = \frac{10 \times (-0.757)}{2.515} = -3 \text{ dB/Oct}$$

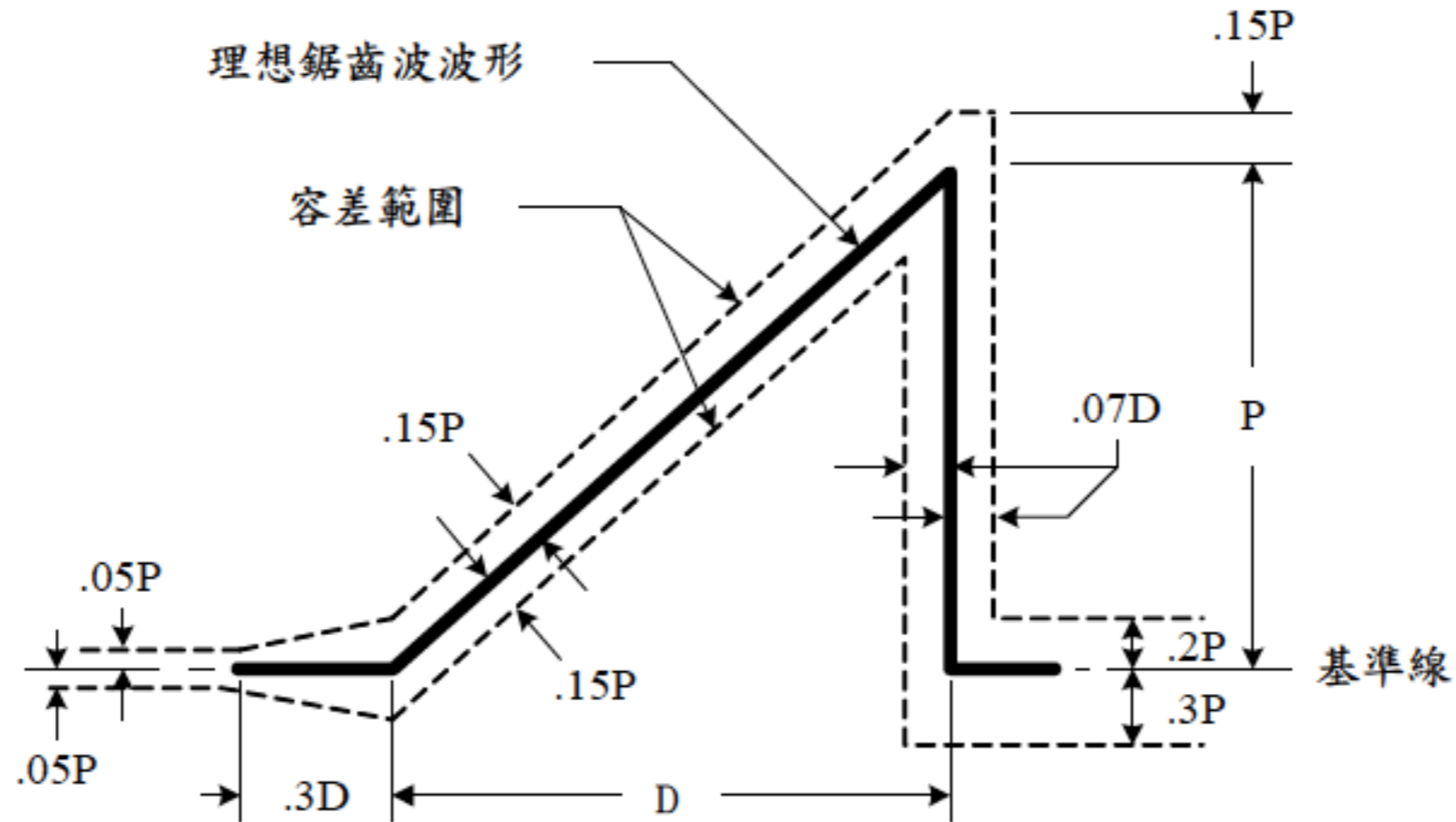
單元測試規範

- 隨機振動
- 3-axis
- 3.8 Grms
- 10 min
- Power on



$$\text{slope} = \frac{10 \log_{10}\left(\frac{0.0088}{0.0044}\right)}{\log_2\left(\frac{700}{400}\right)} = \frac{10 \times 0.3}{0.807} = 3.7 \text{ dB/Oct}$$

單元衝擊規範



軸向(X)：40g, 4ms，2 向，2 次/向

徑向(Y,Z)：30g, 4ms，2 軸 4 向，2 次/向

福衛五號測試規範

- 科學酬載的正弦振動
- 科學酬載的隨機振動 > 2 公斤
- 科學酬載的隨機振動 < 2 公斤
- 科學酬載的衝擊測試

正弦振動規範

	Proto-Flight	Qualification
5 Hz - 20 Hz	11 mm (0 – peak)	11 mm (0 – peak)
20 Hz – 60 Hz	20 g	20 g
60 Hz - 100 Hz	6 g	6 g
Test Duration	1 sweep up with 4 Oct/min	1 sweep up with 2 Oct/min

$$\text{Oct} = \log_2\left(\frac{f_1}{f_0}\right) \rightarrow \log_2\left(\frac{100}{5}\right) = 4.322$$

隨機振動 > 2kg

Frequency Range in Hz	Acceptance		Qualification	
	Out of plane	In Plane	Out of plane	In Plane
20 – 100	+ 3 dB/Oct	+ 3 dB/Oct	+ 3 dB/Oct	+ 3 dB/Oct
100 - 600	0.1 g ² /Hz	0.05 g ² /Hz	0.2 g ² /Hz	0.1 g ² /Hz
600-2,000	- 6 dB/Oct	- 6 dB/Oct	- 6 dB/Oct	- 6 dB/Oct
Test Duration	1 min	1 min	2 min	2 min
RMS in g	9.84	6.92	13.92	9.84
Protoflight testing shall be performed with qualification level with acceptance duration				

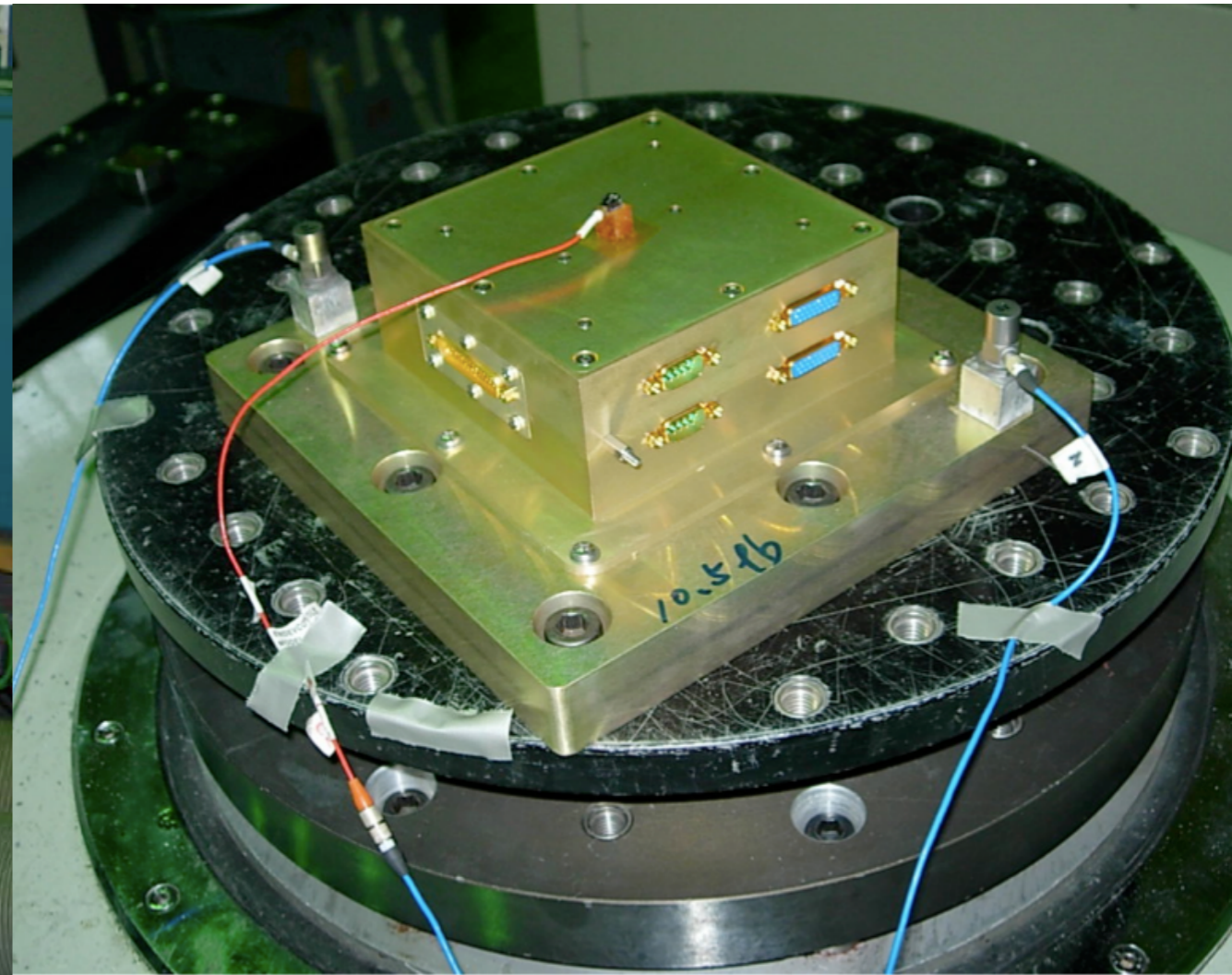
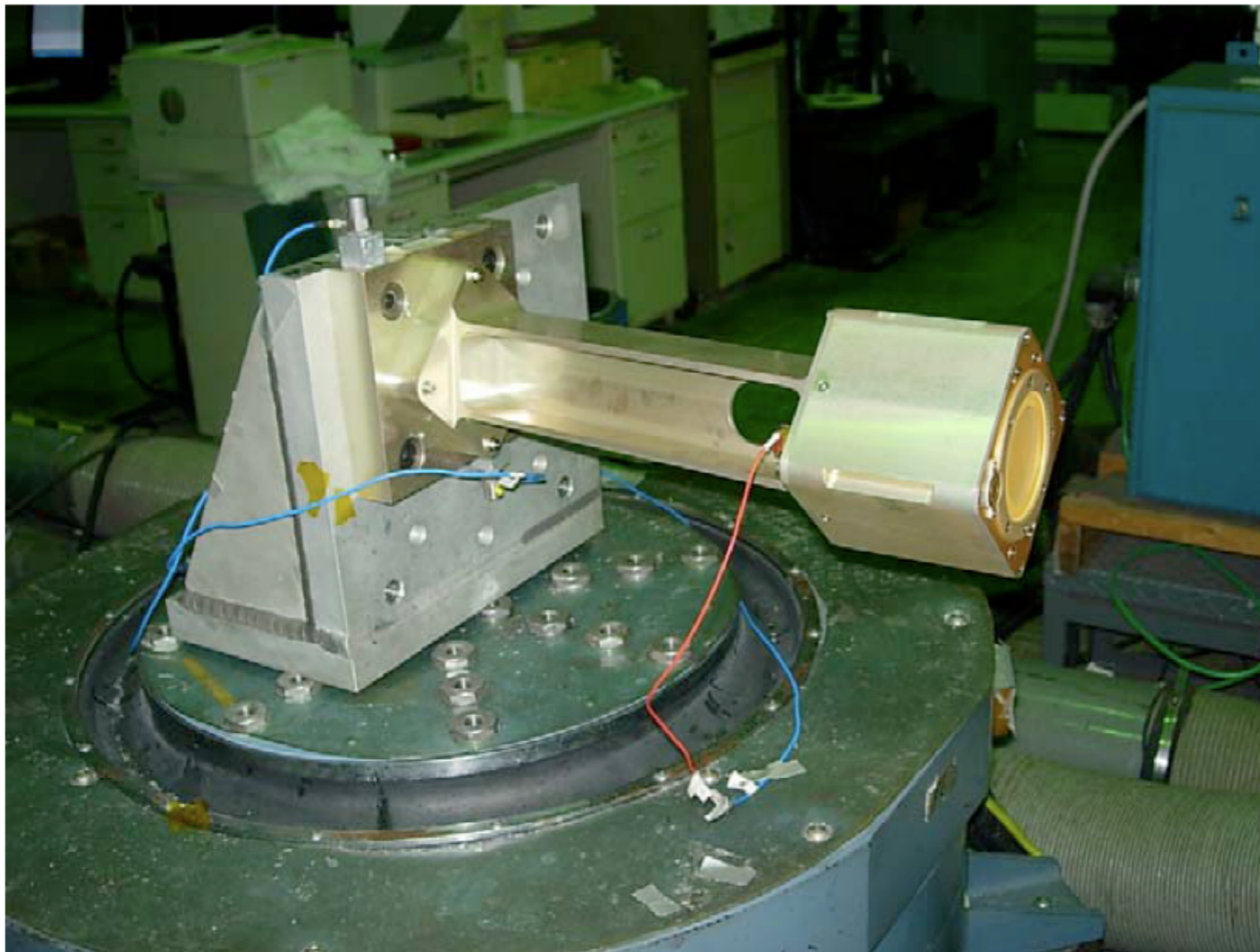
隨機振動 < 2kg

Frequency Range in Hz	Acceptance		Qualification	
	Out of plane	In Plane	Out of plane	In Plane
20 – 100	+ 3 dB/Oct	+ 3 dB/Oct	+ 3 dB/Oct	+ 3 dB/Oct
100 - 400	0.2 g ² /Hz	0.1 g ² /Hz	0.4 g ² /Hz	0.2 g ² /Hz
400-2,000	- 5 dB/Oct	- 5 dB/Oct	- 5 dB/Oct	- 5 dB/Oct
Test Duration	1 min	1 min	2 min	2 min
RMS in g	12.23	8.68	17.25	12.23
Protoflight testing shall be performed with qualification level with acceptance duration				

衝擊測試

Frequency, Hz	Peak Acceleration, g
100	40
1300	1500
10000	1500

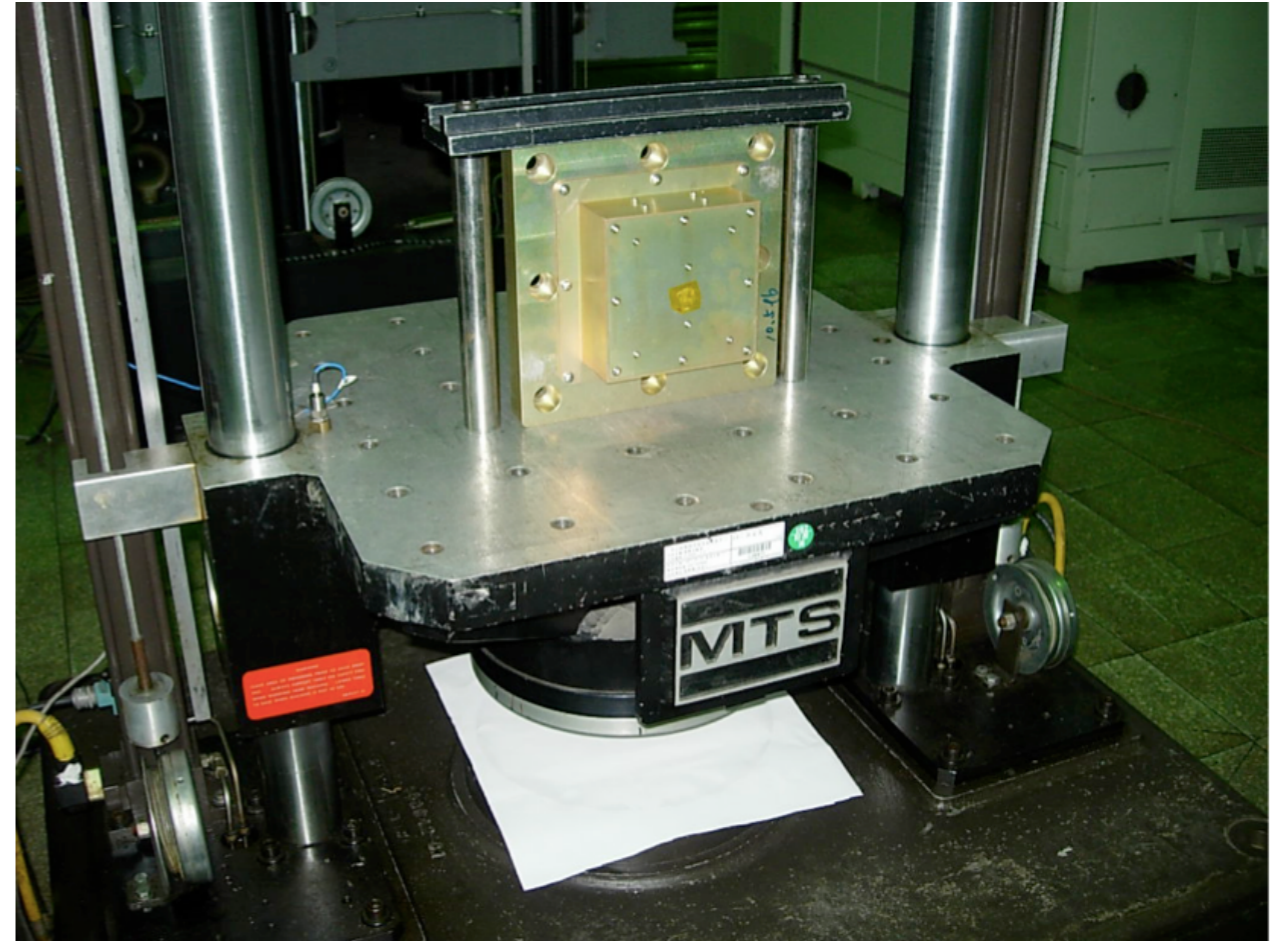
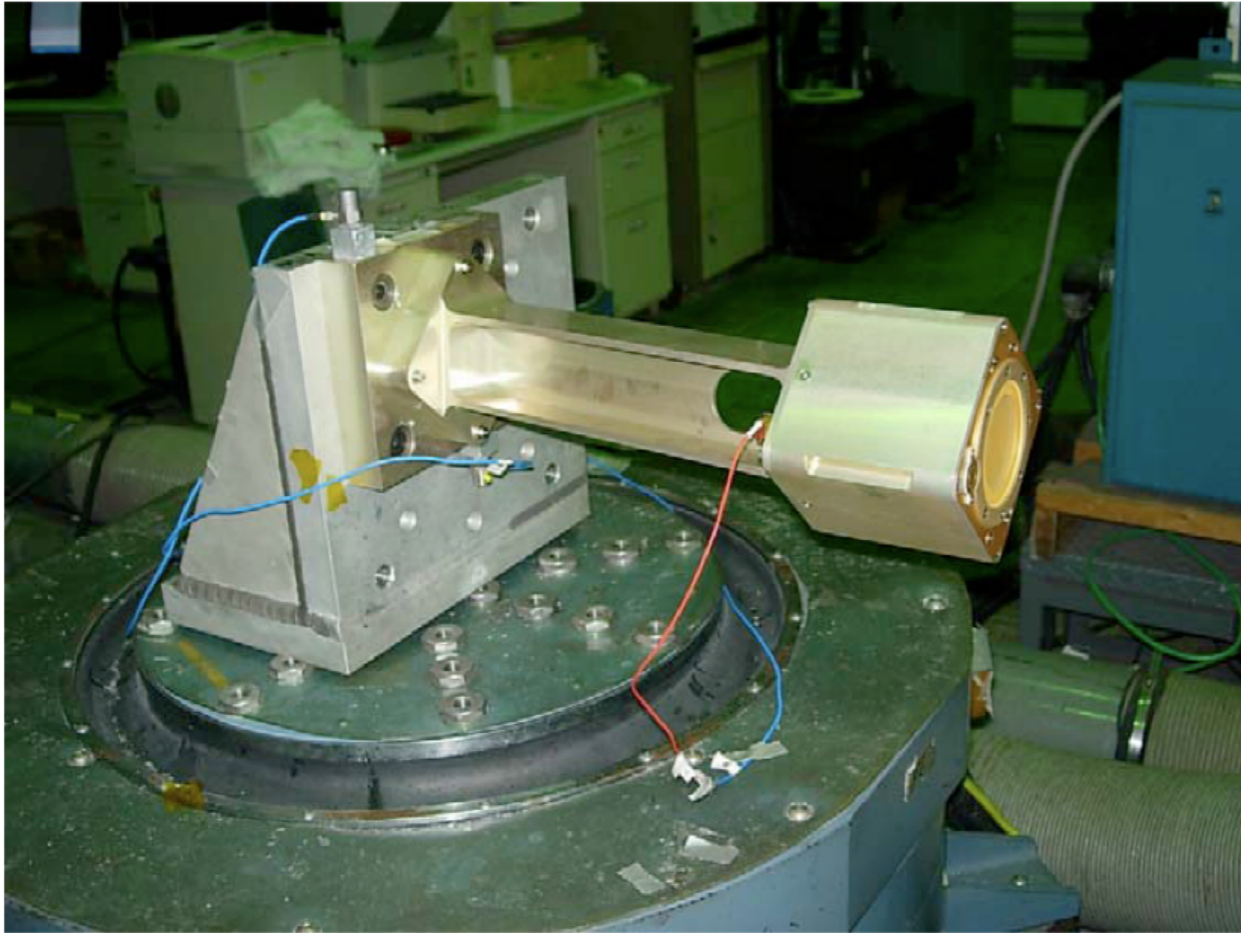
正弦與隨機振動



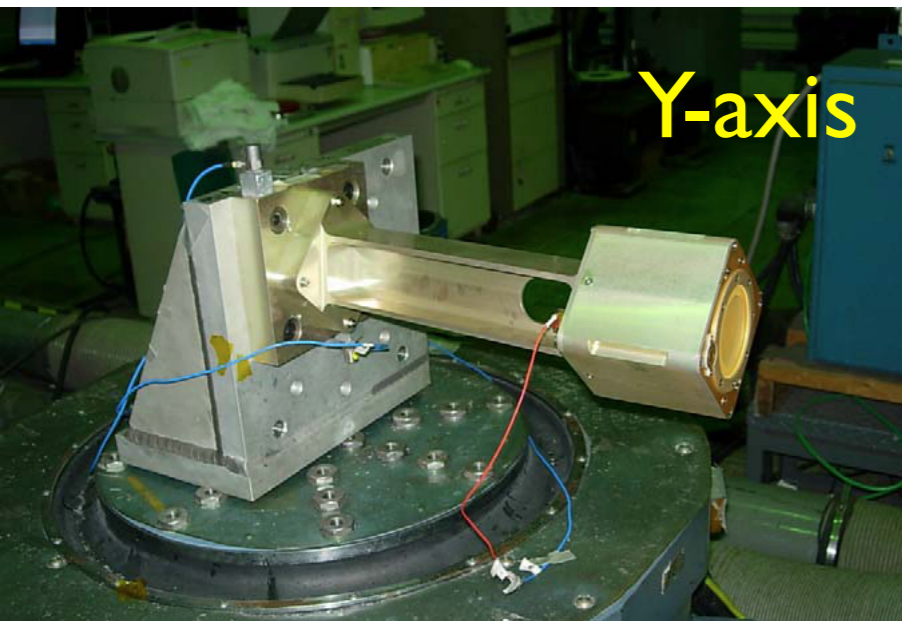
Sine vibration

步驟	內容	簽名確認
1	確認 Y 軸向振動夾具、振動控制設備與加速規。	YCM
2	將振動夾具固定至振動平台，並確認所有預先測試以及準備工作均已完成；此時確認設定符合 3.1.5 節之設定。	YCM
3	以酒精(甲醇)清潔單元與夾具表面。	YCM
4	對單元進行功能測試，確認受測前功能正常。	YCM
5	將單元固定至夾具上，並進行低位準確 (0.2 g) 正弦振動測試，掃描頻率範圍 20 至 500 Hz，以確認正試測試前單元之共振頻率 <u>128.4</u> Hz。	YCM
6	進行 3.1.5 節所規定之正弦振動需求。	YCM
7	完成測試後將圖表與加速規訊號記錄下來，並與 3.1.5 節之容差範圍比較，確認是否在容差範圍內。	YCM
8	對單元進行功能測試，確認受測後功能正常。	YCM
9	進行低位準確 (0.2 g) 正弦振動測試，掃描頻率範圍 20 至 500 Hz，以確認待測物受測後之共振頻率 <u>126.8</u> Hz。	YCM
10	將單元自夾具上移除，並置於適當容器後移至潔淨處存放。	YCM
11	將夾具以及其他物件自振動平台上移除。	YCM

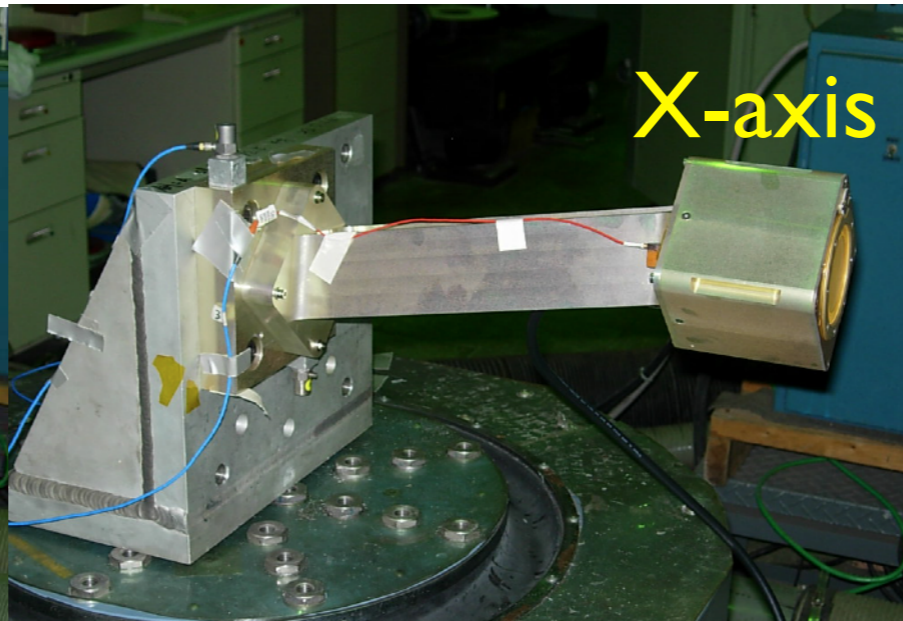
衝擊測試



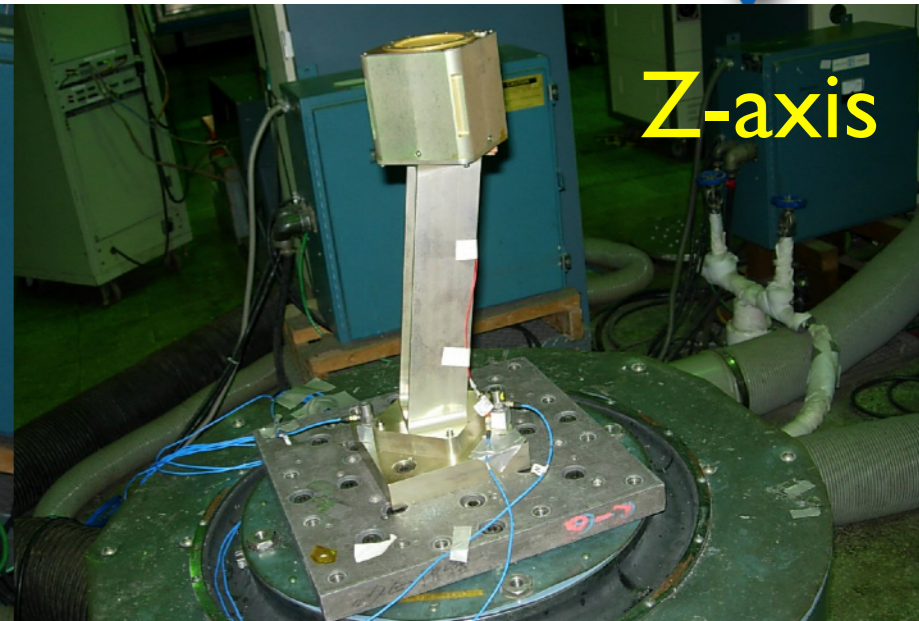
Structure measurement for sensor



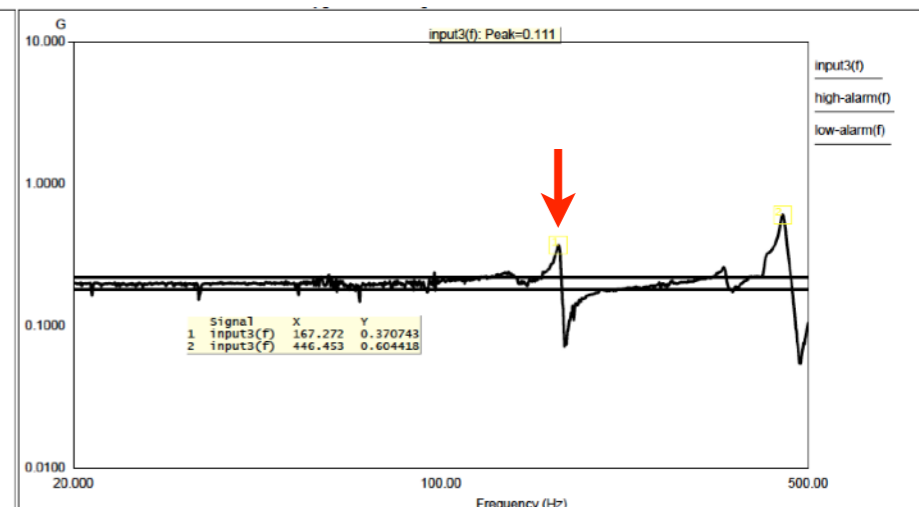
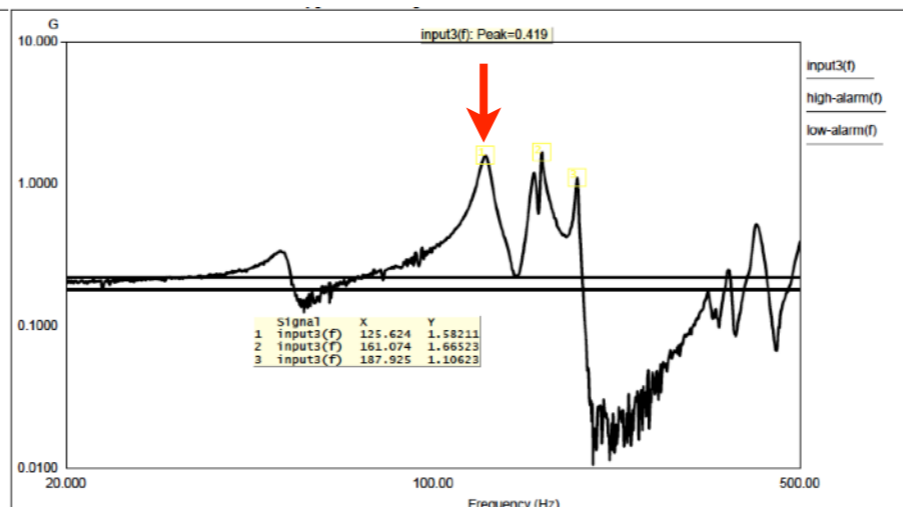
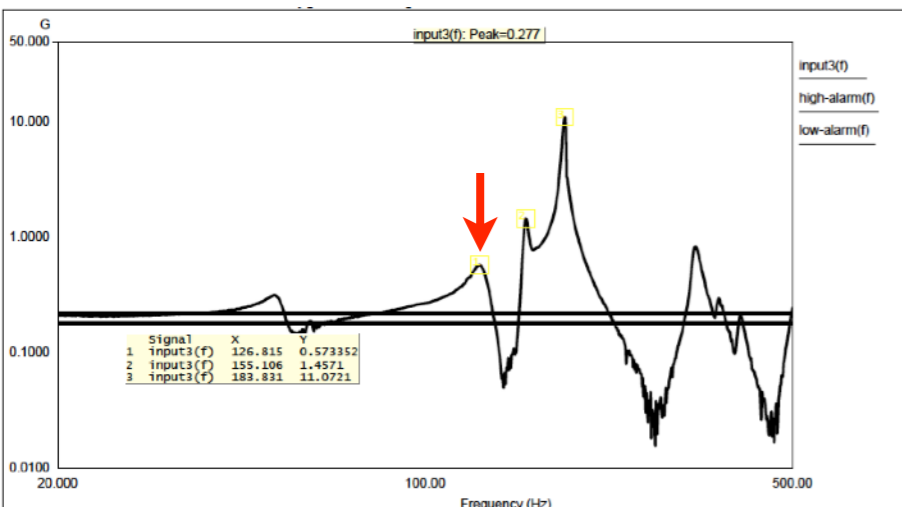
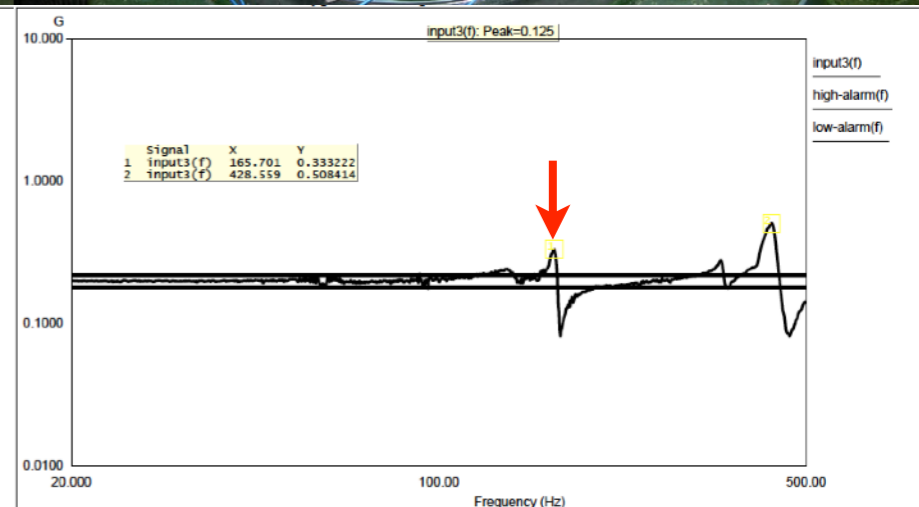
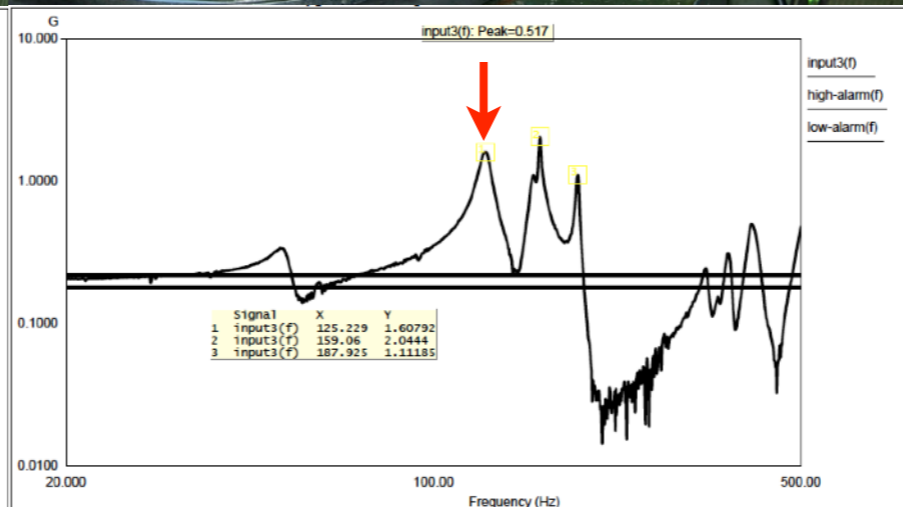
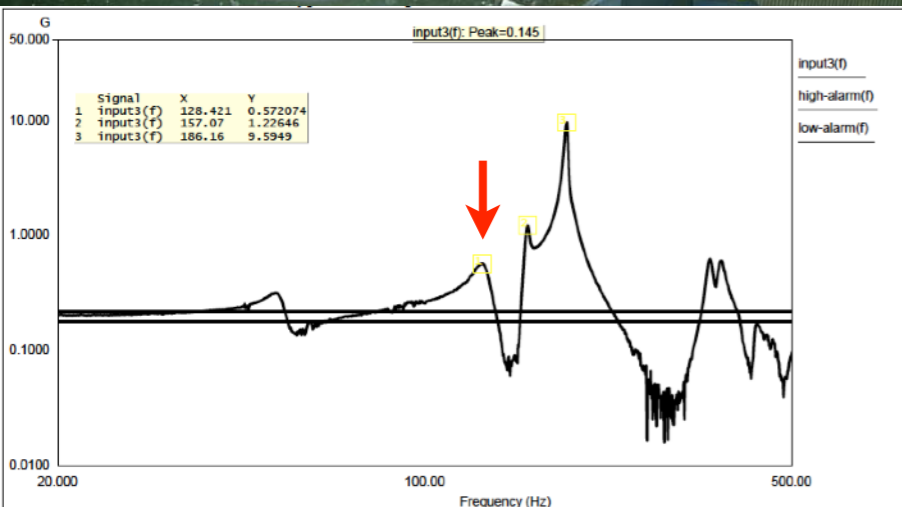
Y-axis



X-axis



Z-axis





1st mode natural frequency

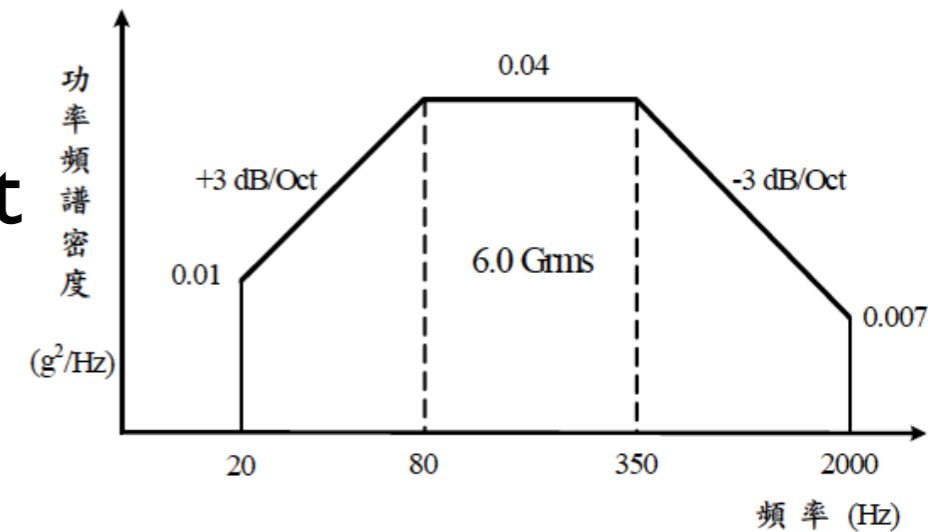
145.6 Hz estimated by SolidWorks and 136.1 Hz measured by NCU.

NCSIST	Y-axis	X-axis	Z-axis
Before	128.4 Hz (x2.71)	125.2 Hz (x8.04)	165.7 Hz (x1.67)
After	126.8 Hz (x2.87)	125.6 Hz (x7.91)	167.3 Hz (x1.85)

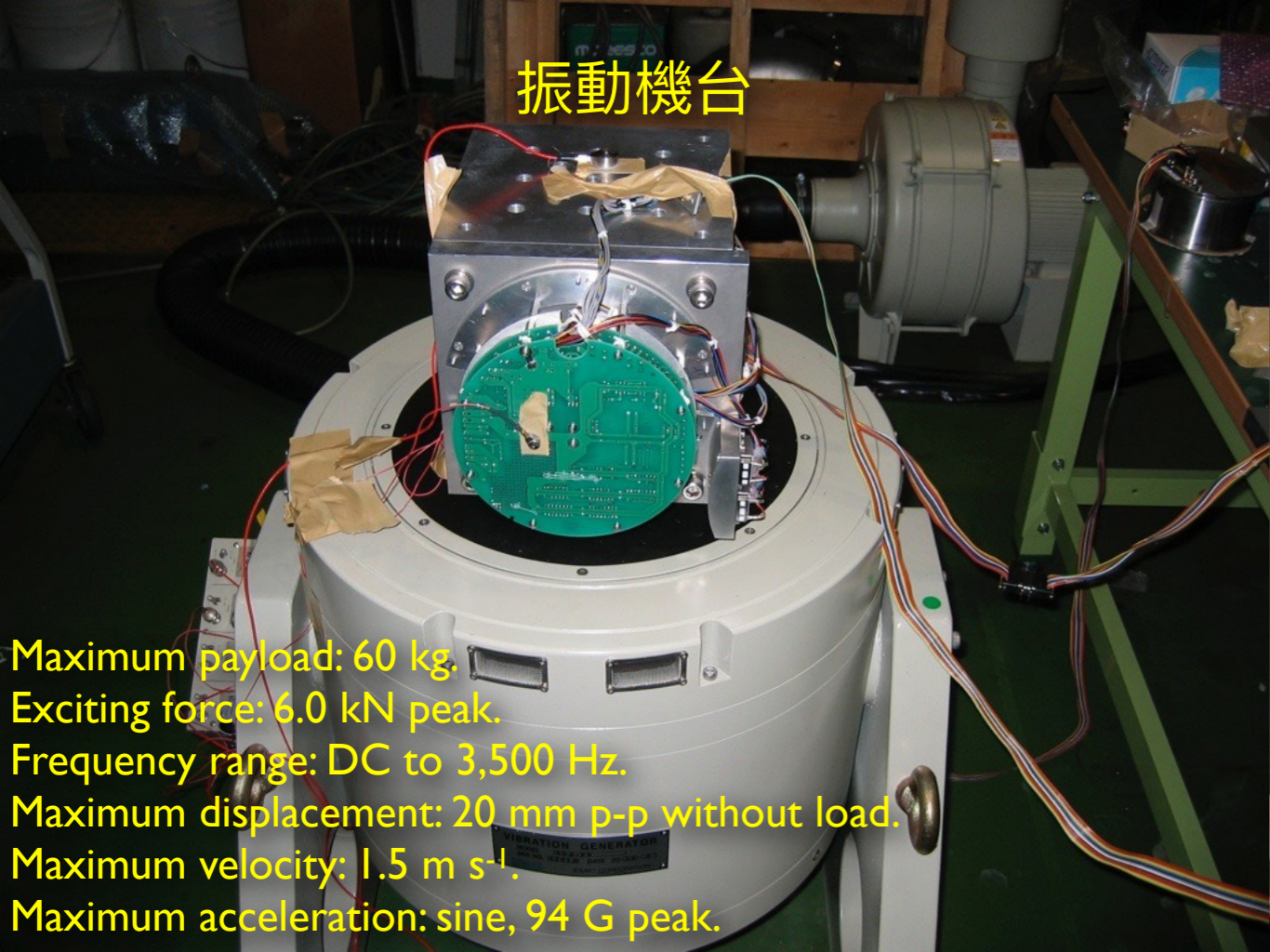
All 1st mode natural frequencies measured by NCSIST are higher than 120 Hz.

Vibration test for SR-V

- Requirements by NCSIST for module test
 - 3-axis, 6 Grms, 10 minutes
- Perform at ISAS on Aug. 8-9, 2005
 - Sinusoidal vibration along vertical direction
 - Random vibration more than 6 Grms along 3 axes for 10 minutes



振動機台



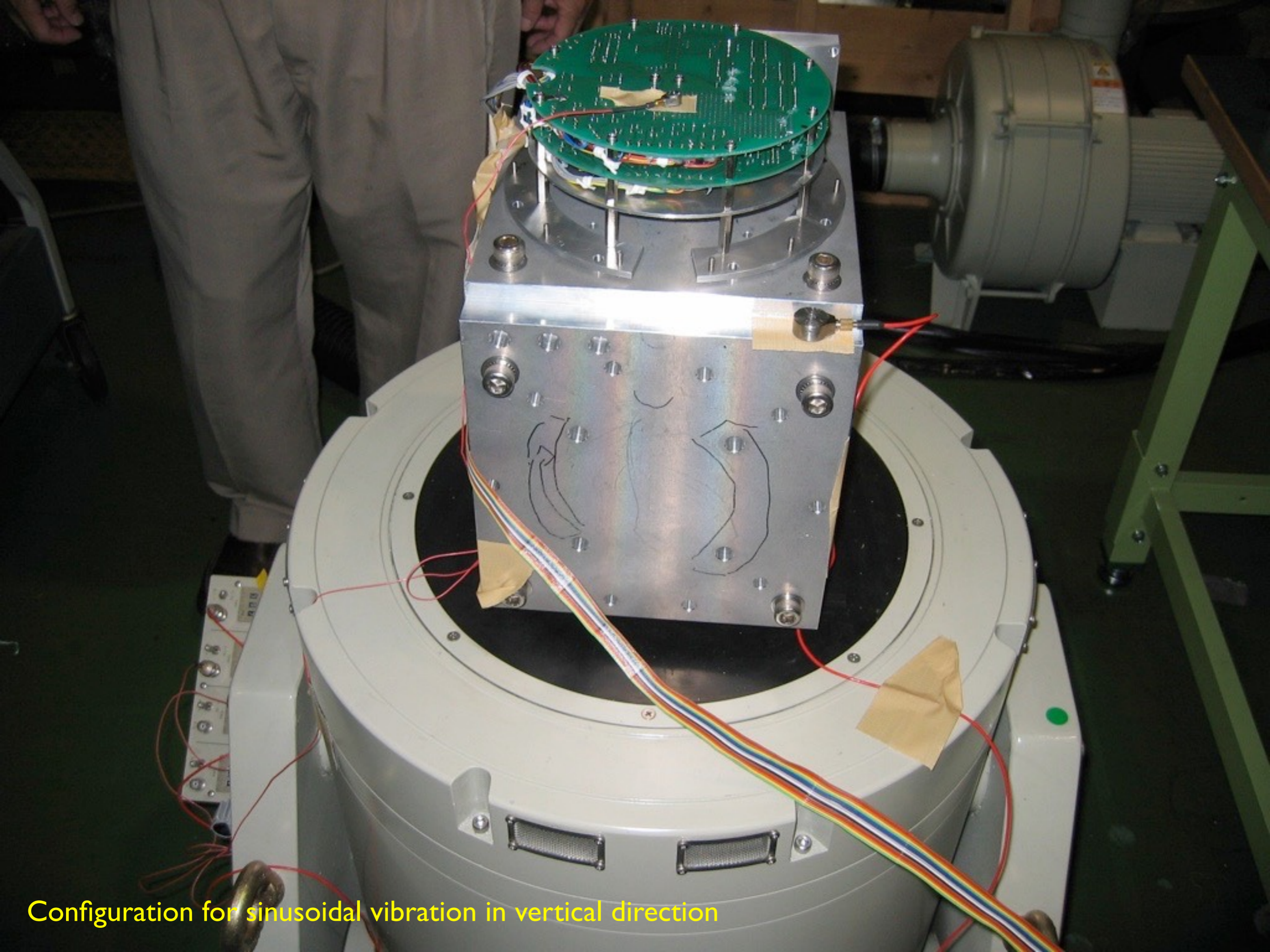
Maximum payload: 60 kg.
Exciting force: 6.0 kN peak.
Frequency range: DC to 3,500 Hz.
Maximum displacement: 20 mm p-p without load.
Maximum velocity: 1.5 m s⁻¹.
Maximum acceleration: sine, 94 G peak.



散熱風扇



控制機台



Configuration for sinusoidal vibration in vertical direction



スケジュール 555 スケジュール番号 2 / 2 試験種類 定レベル型掃引試験 オフセット なし
 タイトル 繰り返し回数 1 / 1 スケジュール繰り返し数 1 / 1

制御加速度 (m/s²) **146.722**

+0.1m/s² -0.1m/s²

加振レベル 0.0 dB 設定

出力電圧 (Volts) **1.631**

加振周波数 (Hz) **597.24**

変更 設定

経過回数 **1**

残り回数 **2**

掃引時間 **0:03:29**

掃引状態 **分(対数)** 右矢印

下降 上昇

掃引速度 **4.50**

遅く 速く

アラーム

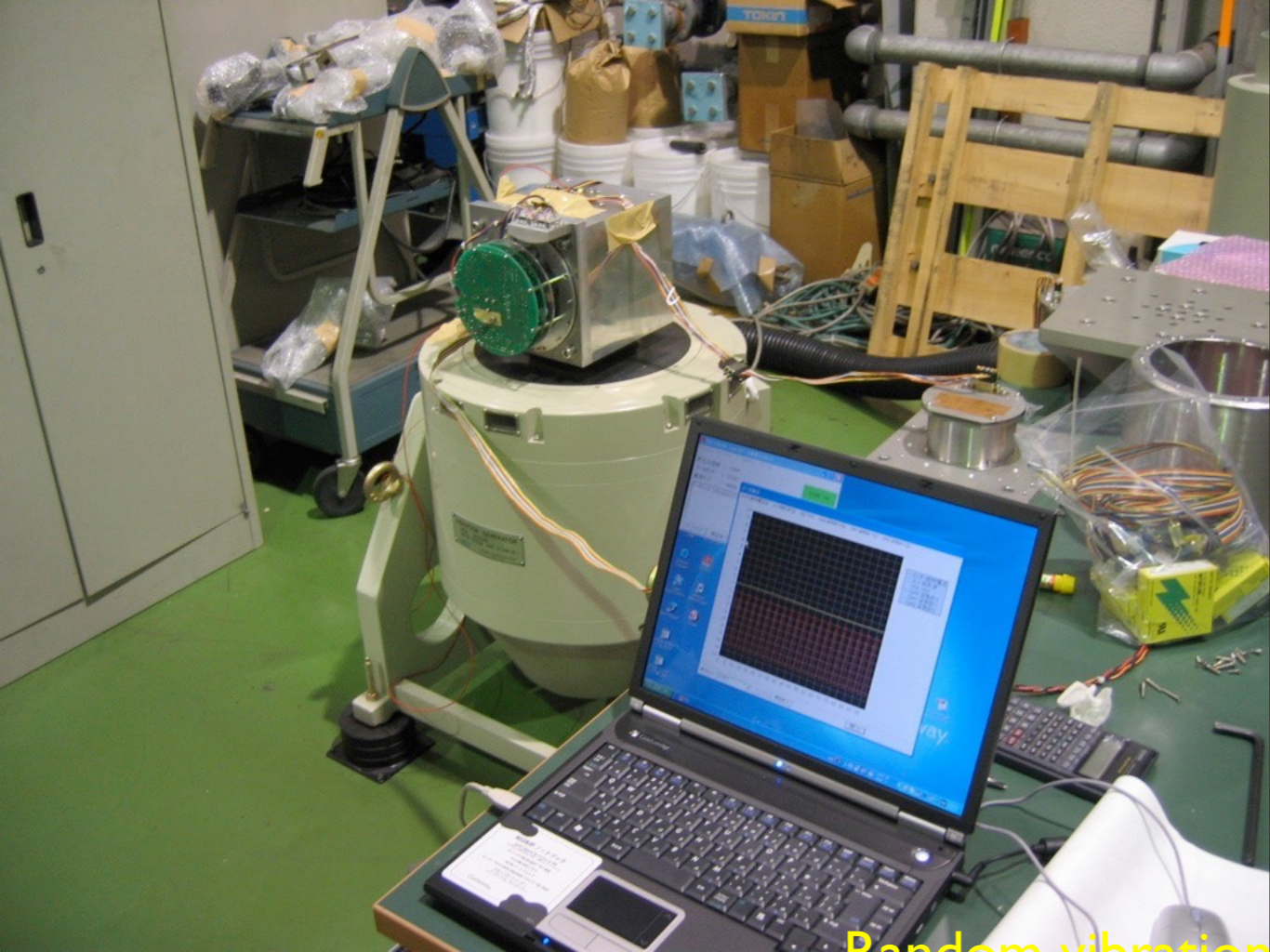
アバウト

開始

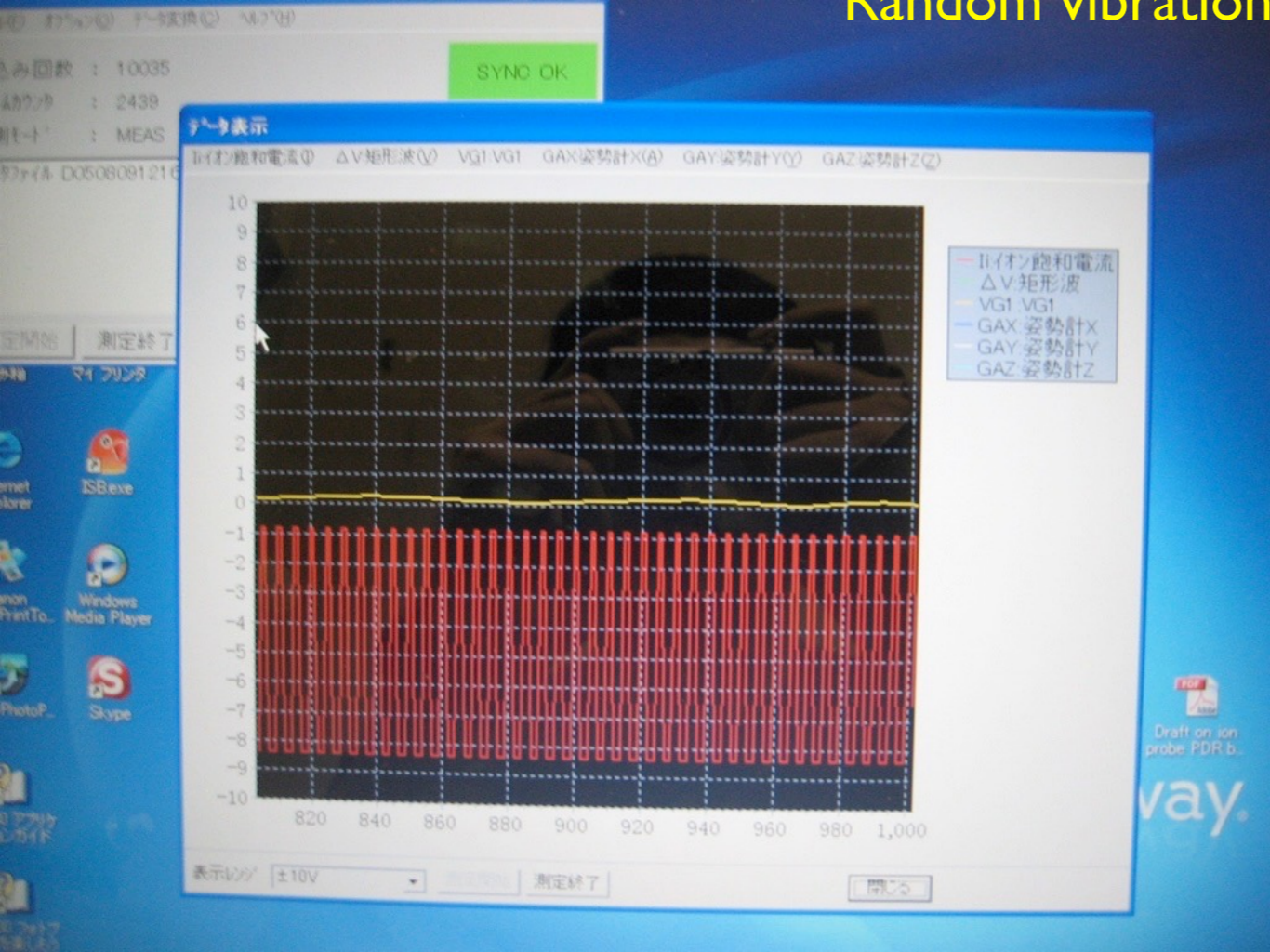
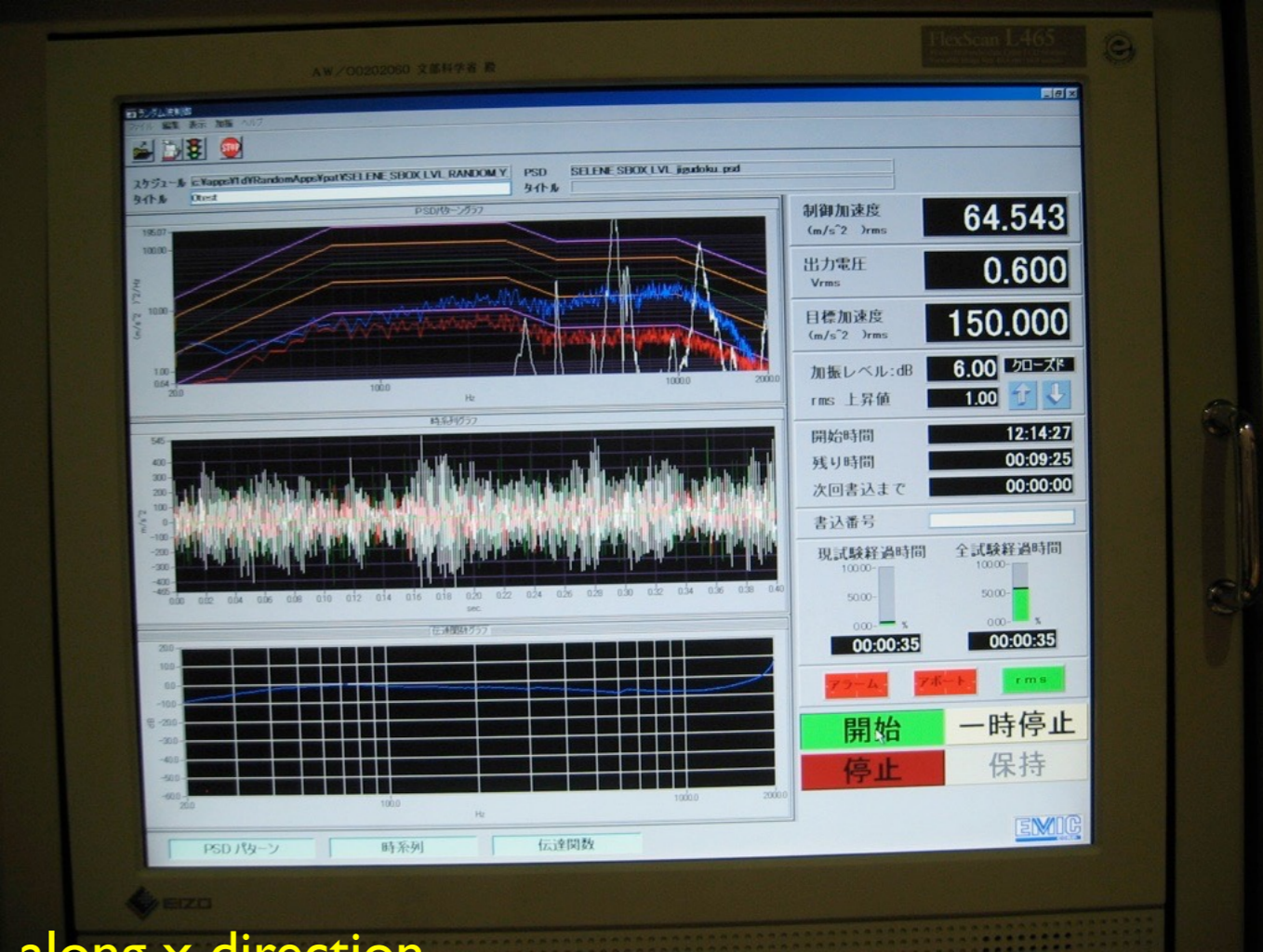
一時停止

停止

掃引停止

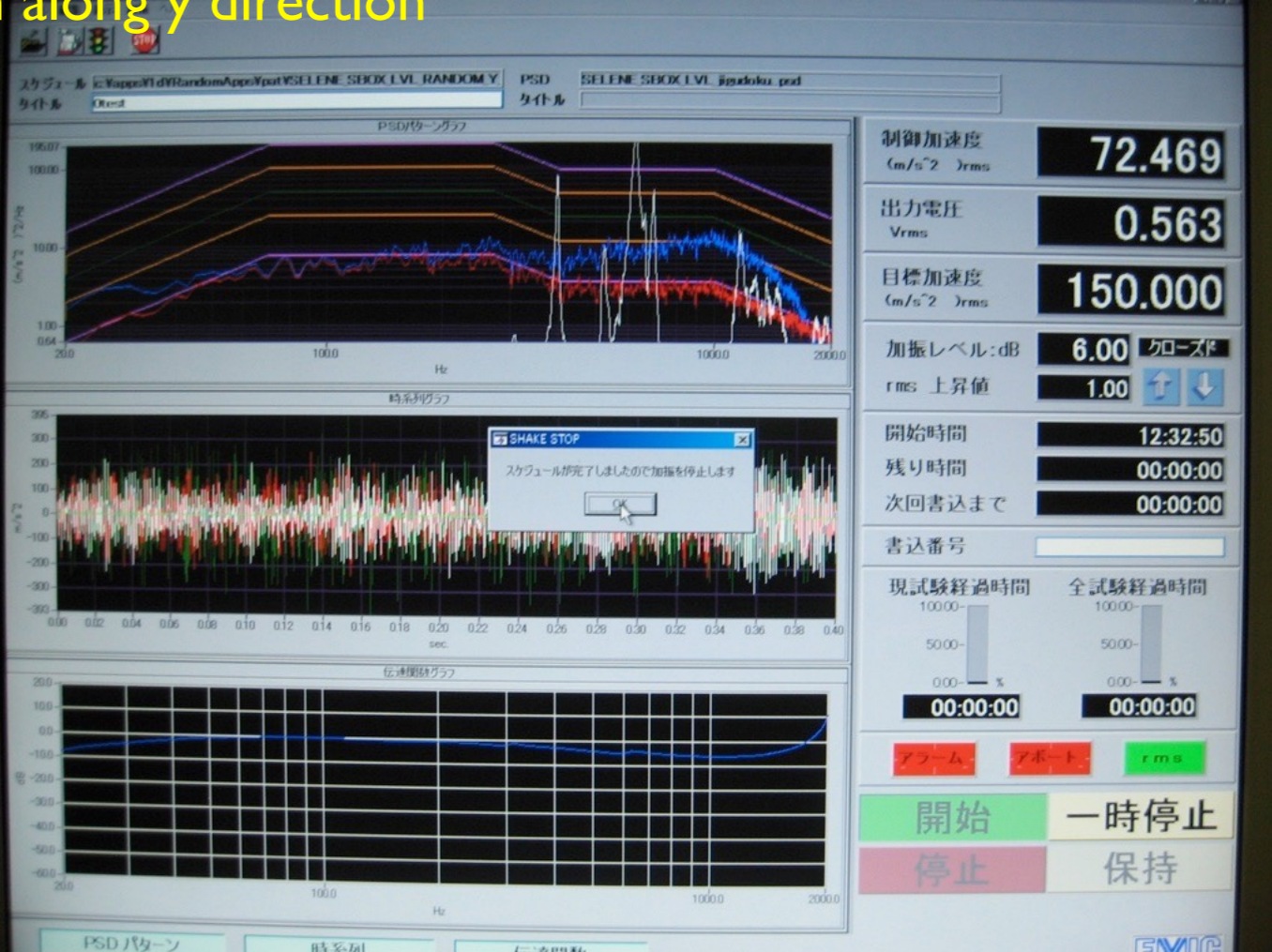
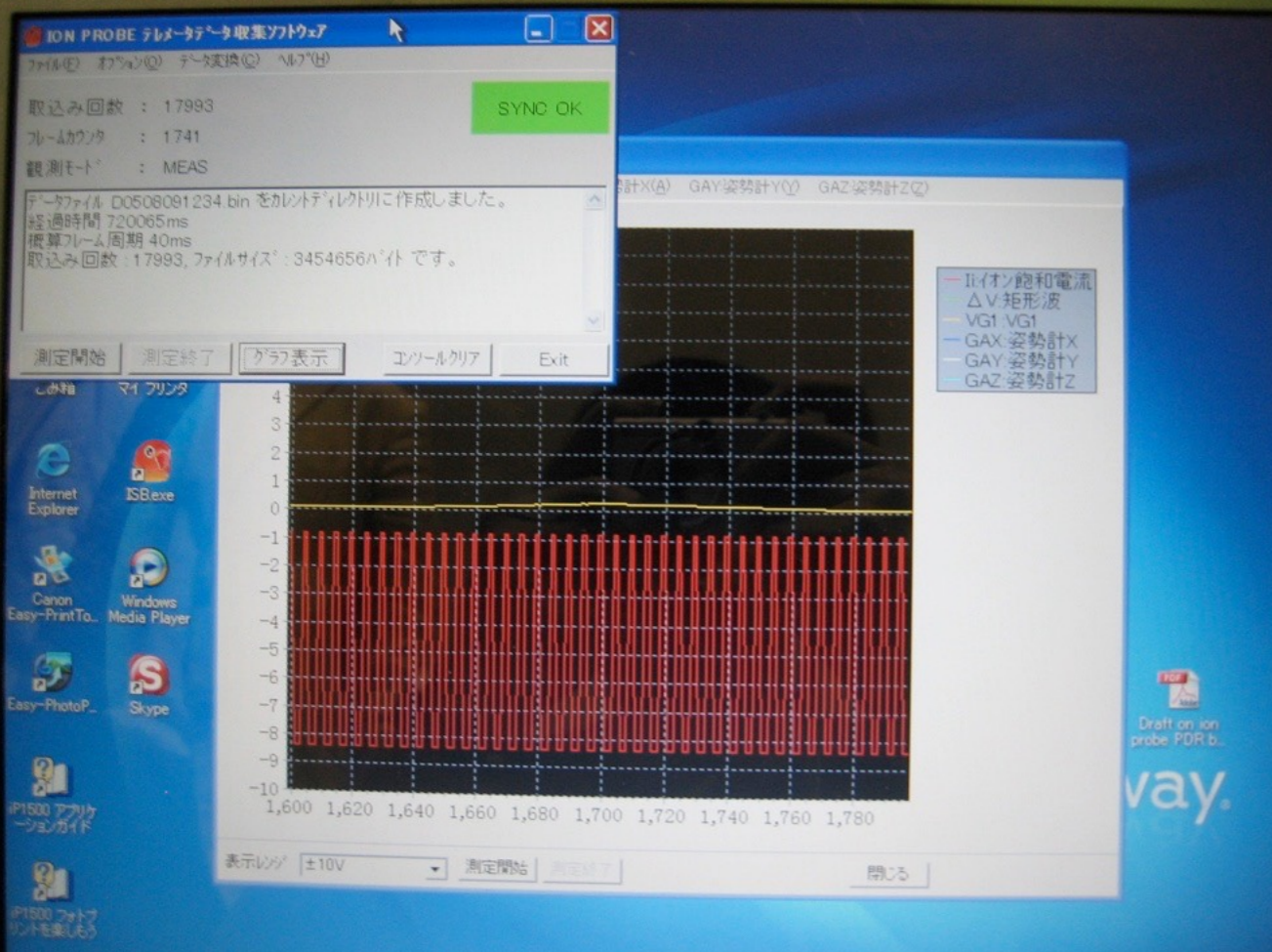


Random vibration along x direction



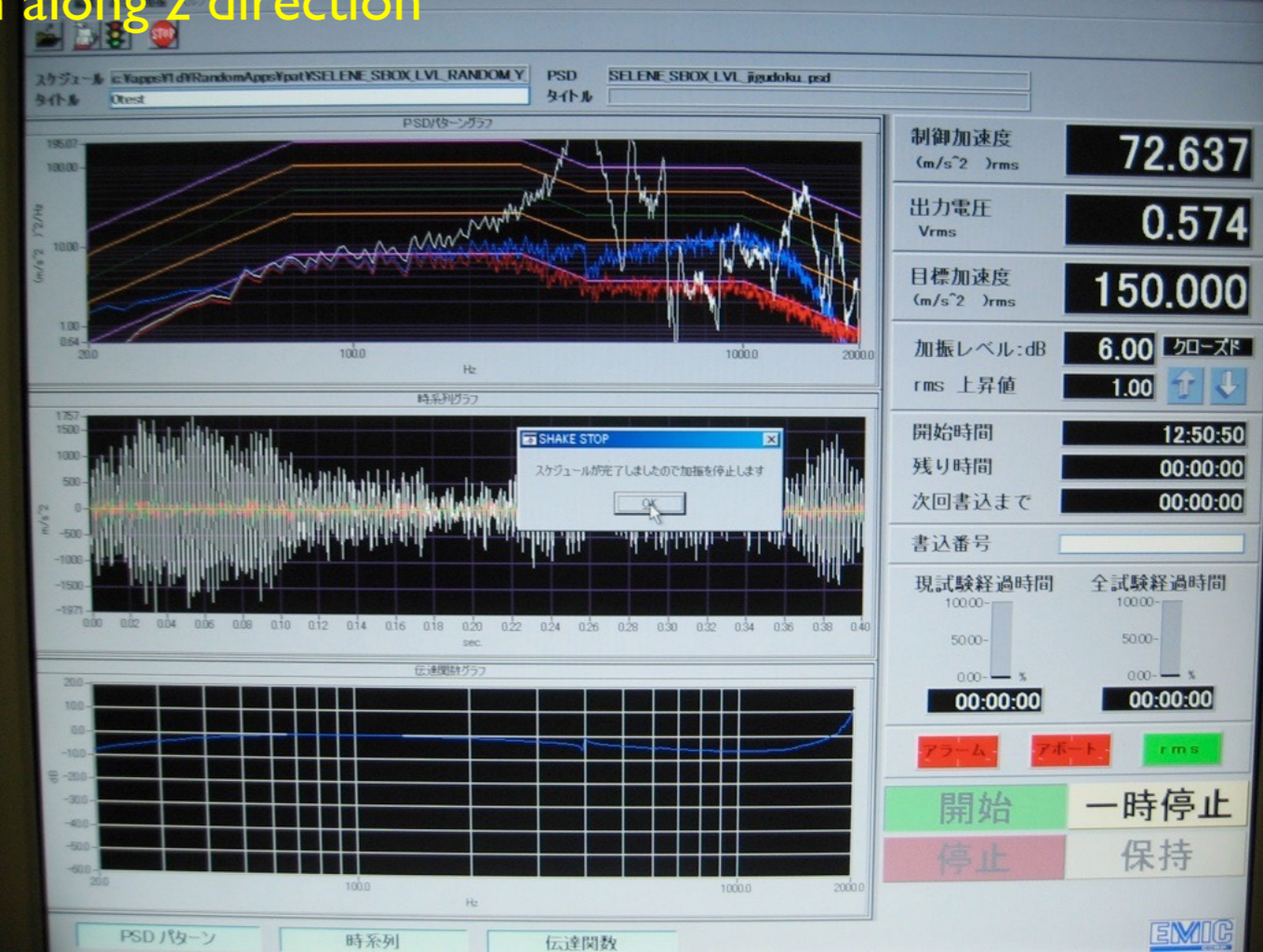
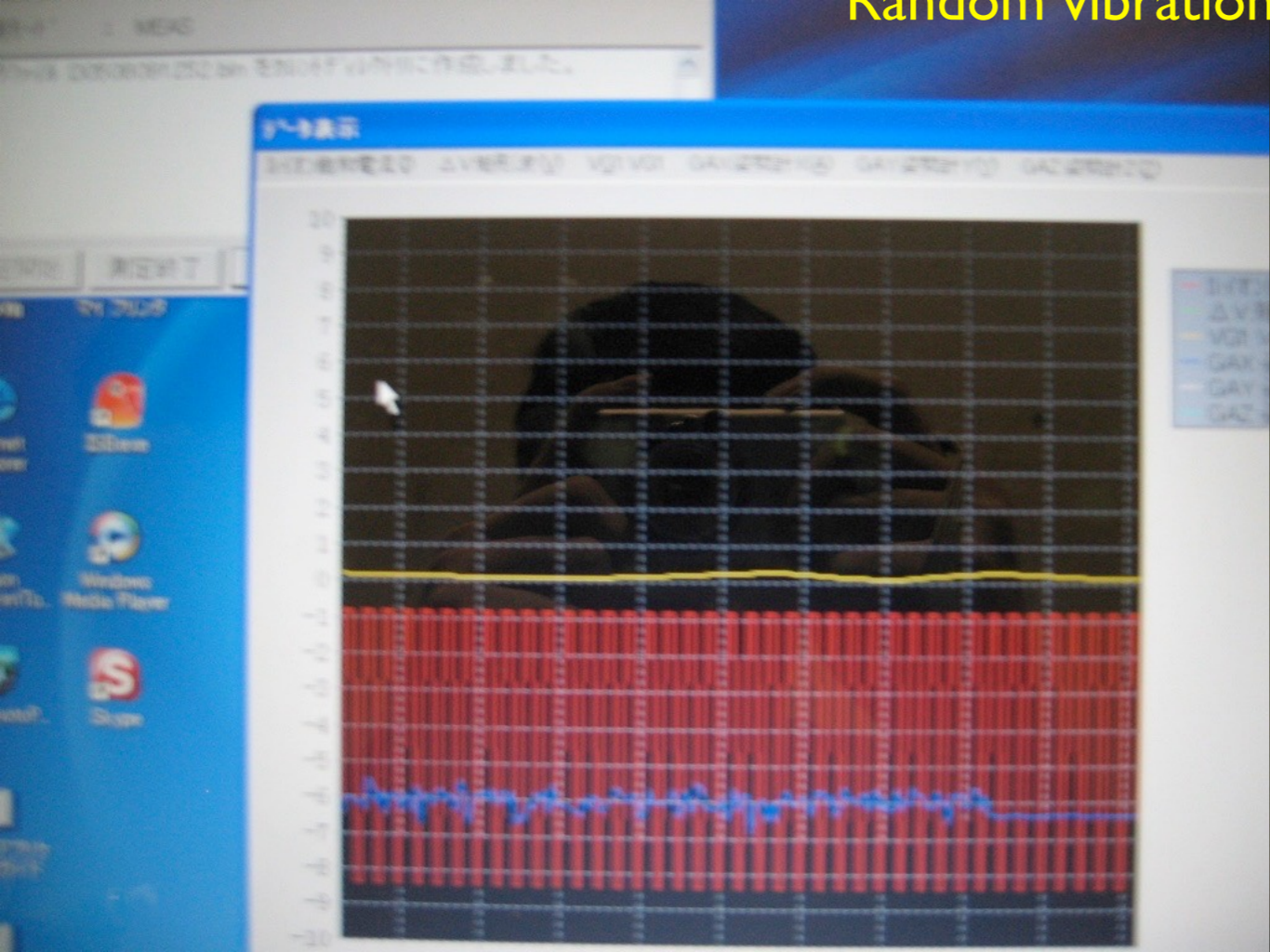


Random vibration along y direction



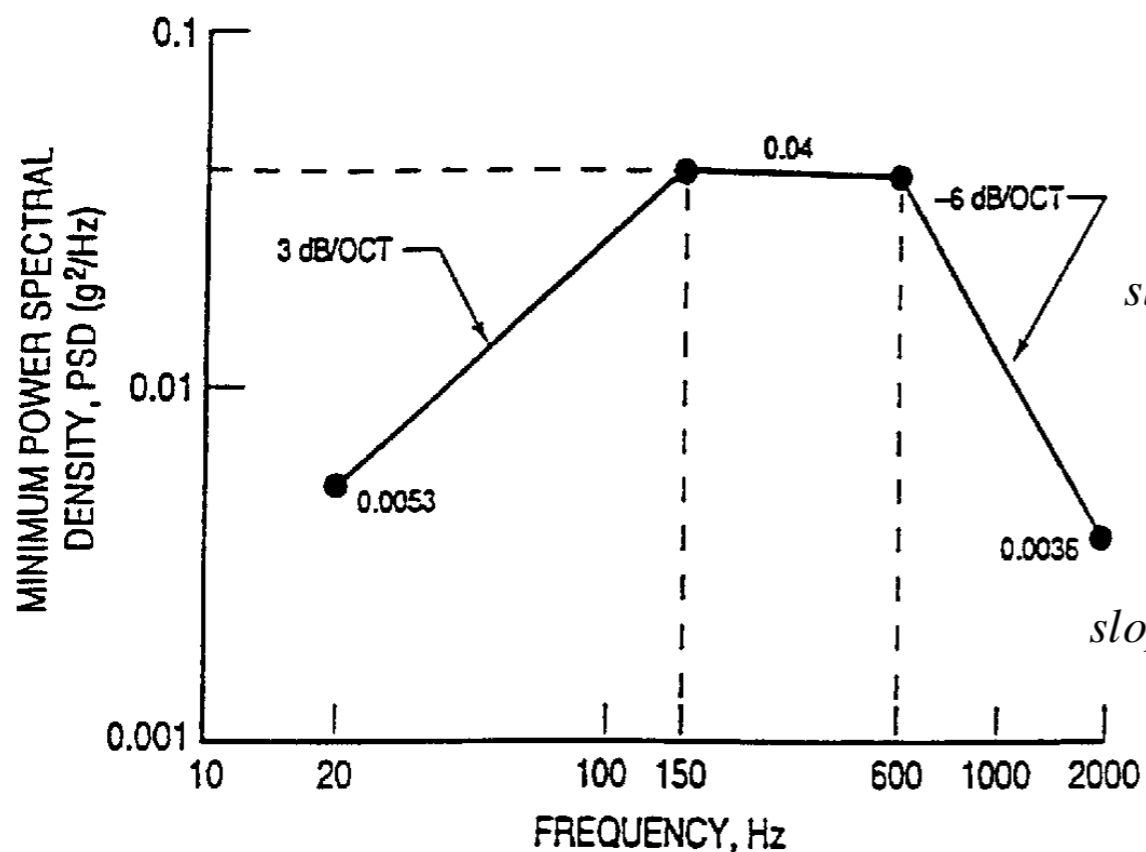


Random vibration along z direction





Minimum random vibration spectrum for unit acceptance tests



$$slope_{Up} = \frac{10 \log_{10}\left(\frac{0.04}{0.0053}\right)}{\log_2\left(\frac{150}{20}\right)} = \frac{10 \times 0.8778}{2.907} = 3.02 \text{ dB/Oct}$$

$$slope_{Down} = \frac{10 \log_{10}\left(\frac{0.0036}{0.04}\right)}{\log_2\left(\frac{2000}{600}\right)} = \frac{10 \times (-1.046)}{1.7370} = -6.02 \text{ dB/Oct}$$

Curve Values

Frequency (Hz)	Minimum PSD (g ² /Hz)
20	0.0053
20 to 150	+3 dB per octave slope
150 to 600	0.04
600 to 2000	-6 dB per octave slope
2000	0.0036

The overall acceleration level is 6.1 grms.

Note: This spectrum applies only to electrical and electronic units whose mass does not exceed 23 kilograms (50 pounds).

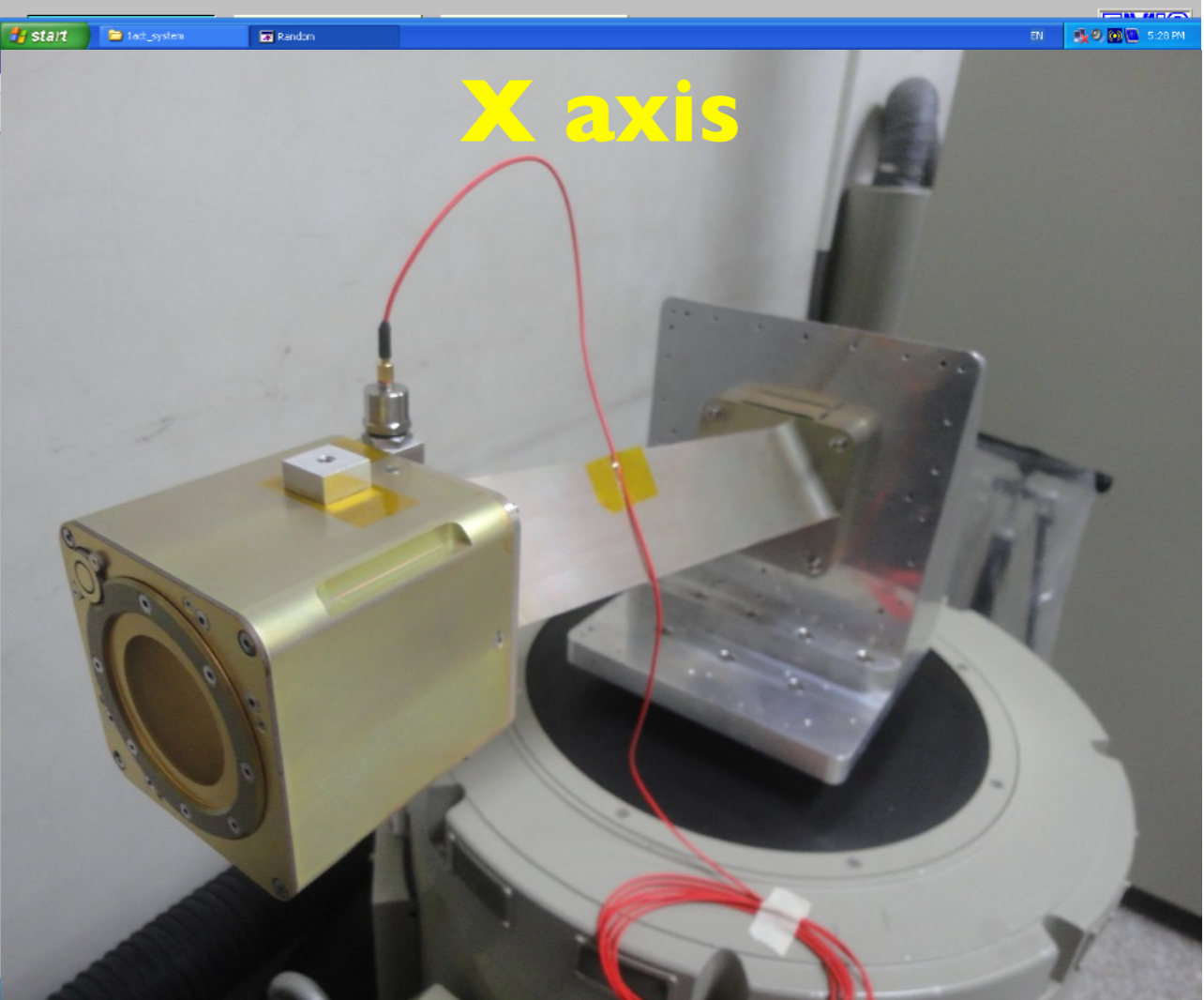
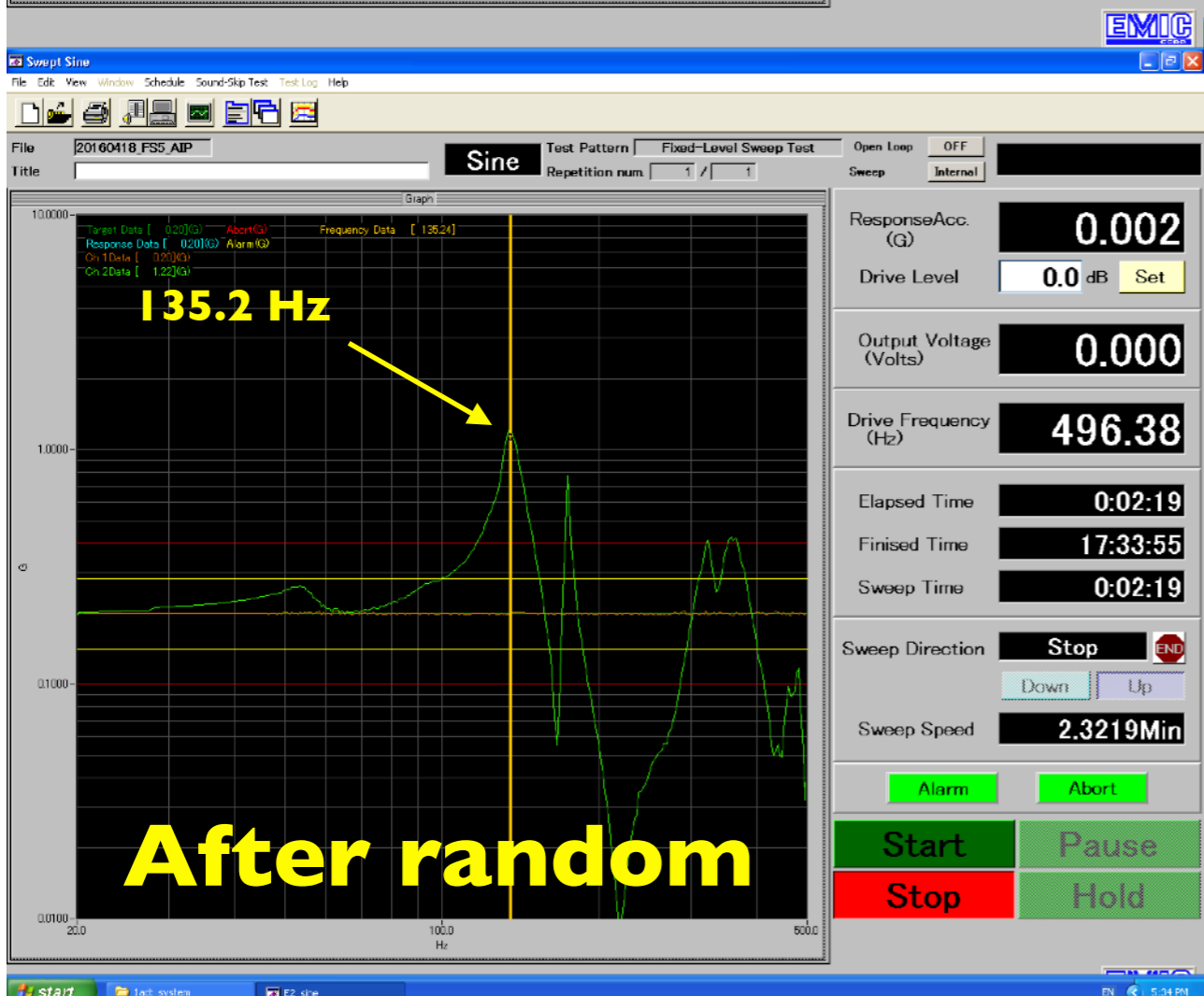
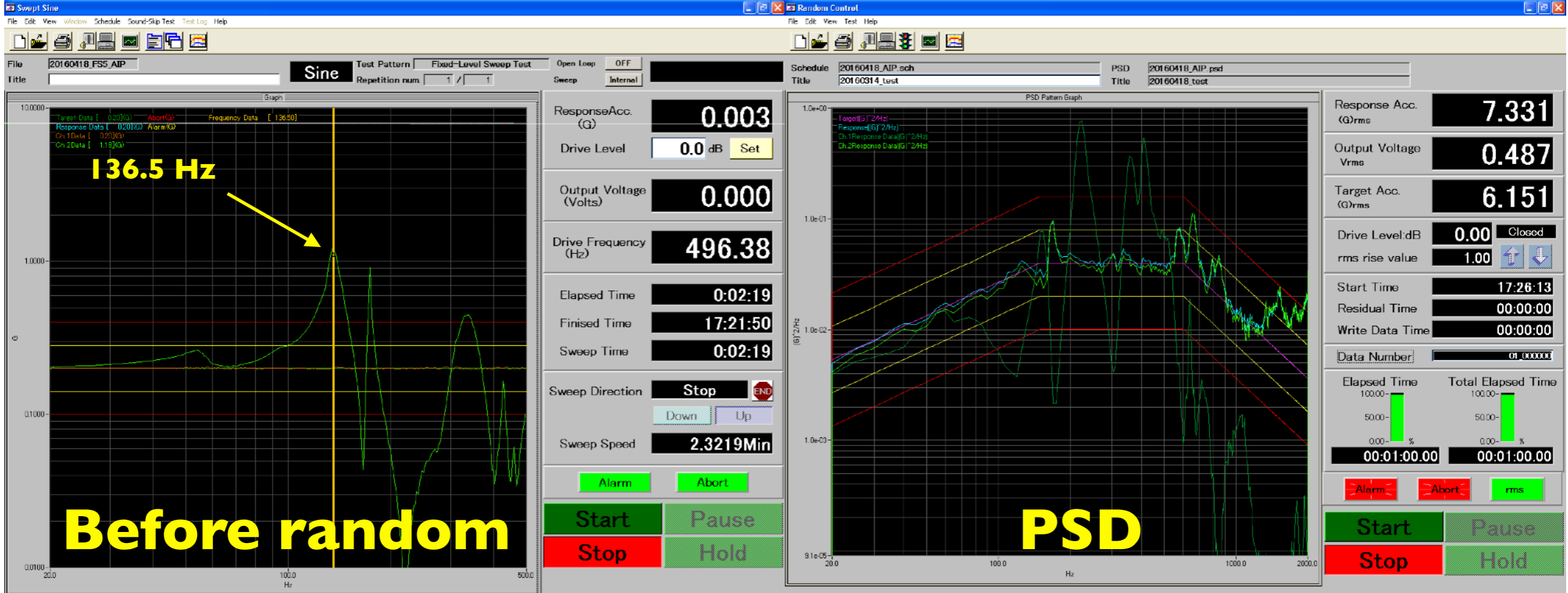
Random vibration test for workmanship verification

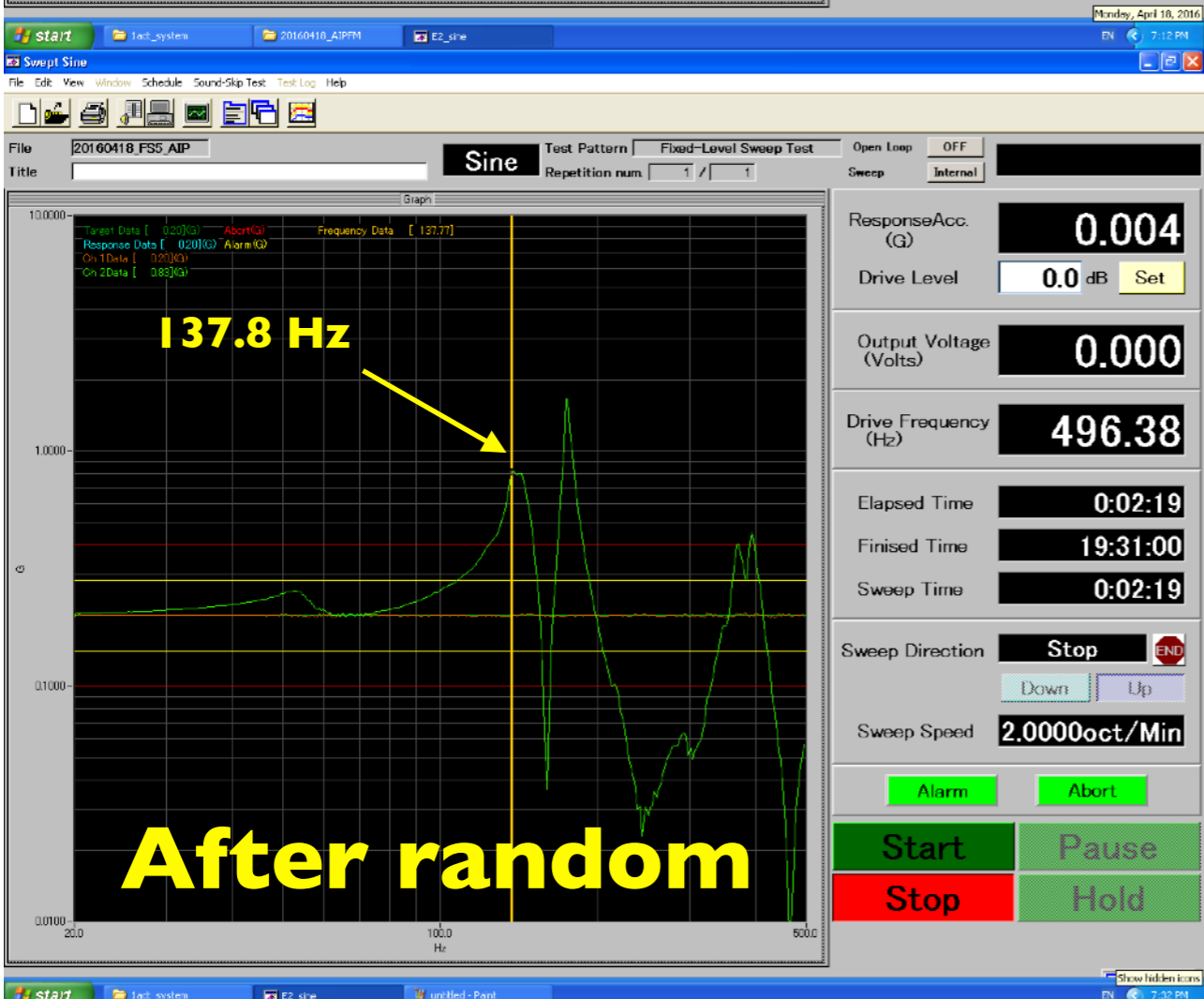
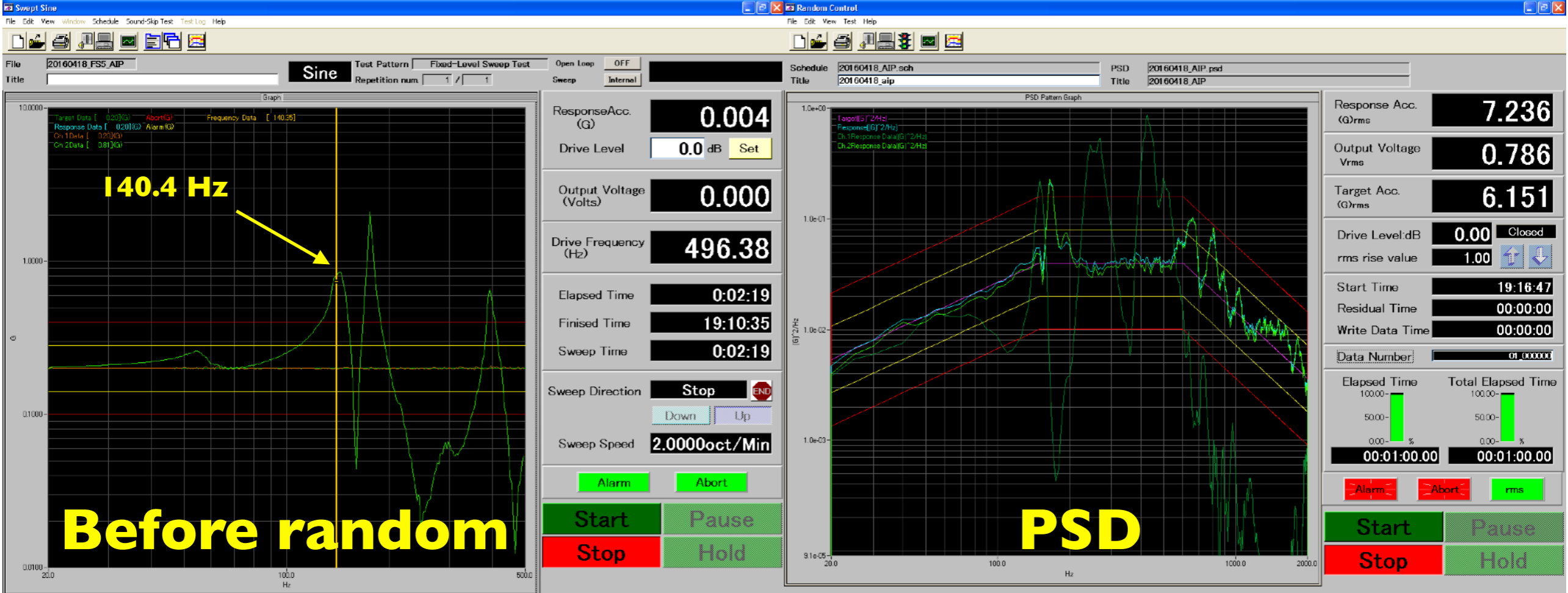


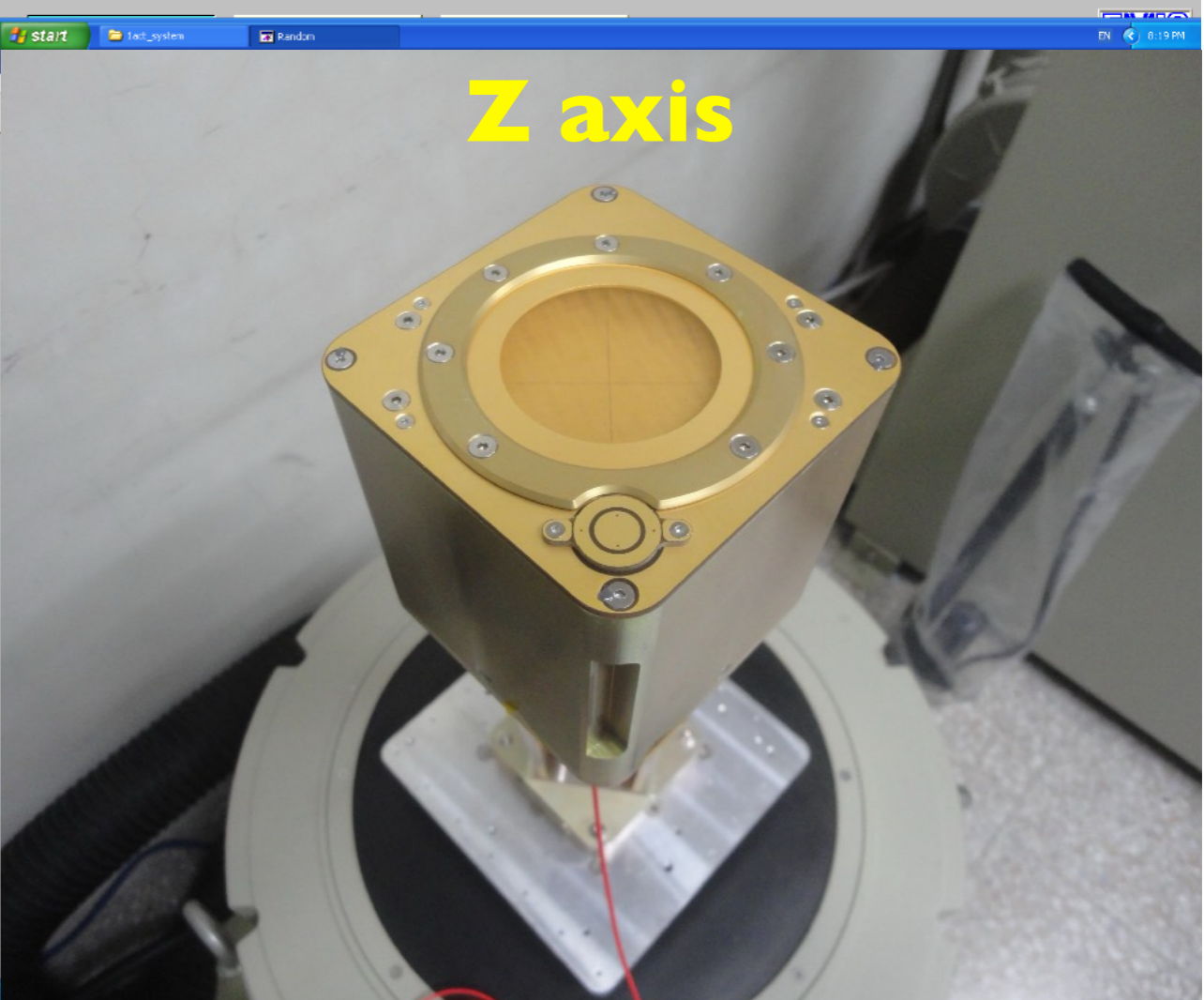
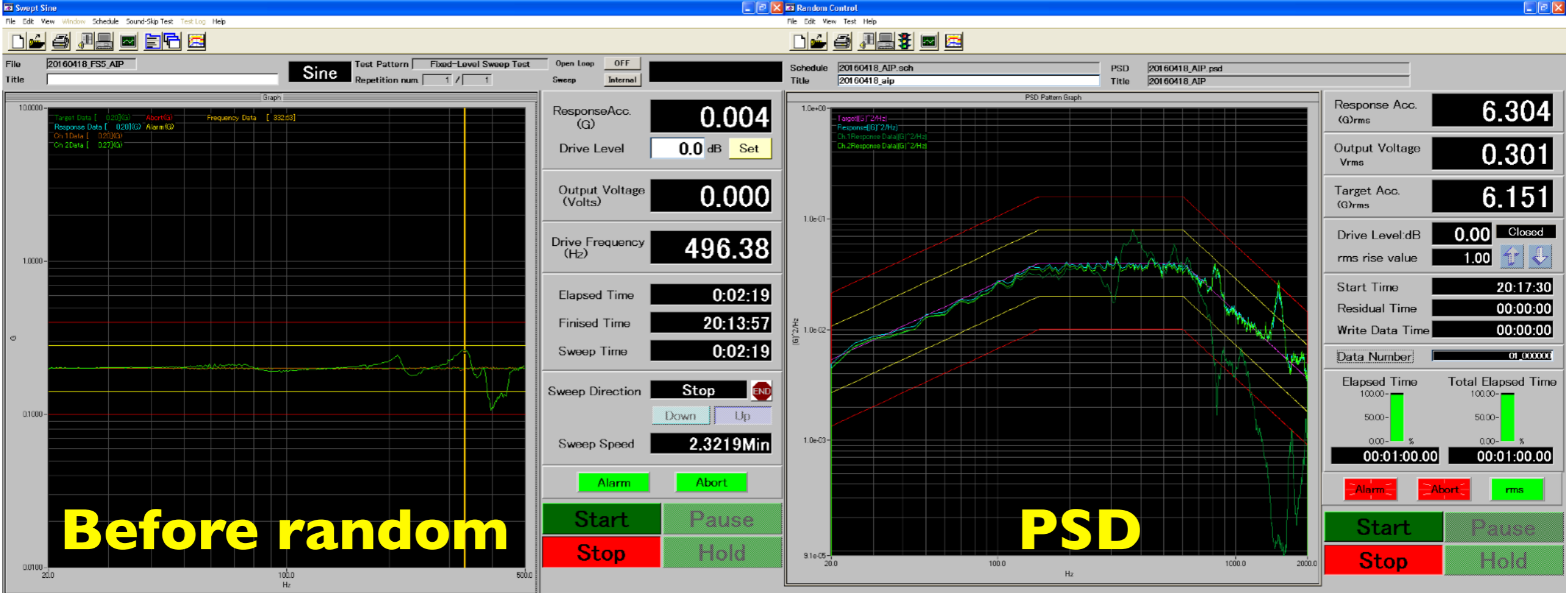
Pre-sine test with 0.2G scanning in 2 Oct/min from DC to 500 Hz.

	X-axis	Y-axis	Z-axis
Before random	136.5 Hz	140.4 Hz	NA
After random	135.2 Hz	137.8 Hz	NA

All measured 1st mode natural frequencies are higher than 120 Hz. The accelerometer at fixture is used as control in random vibration.

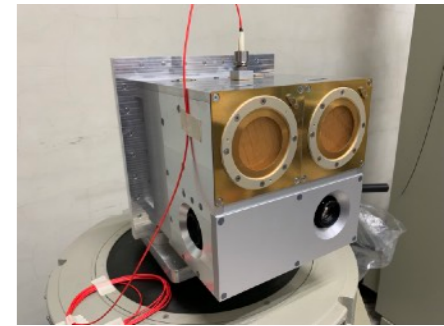






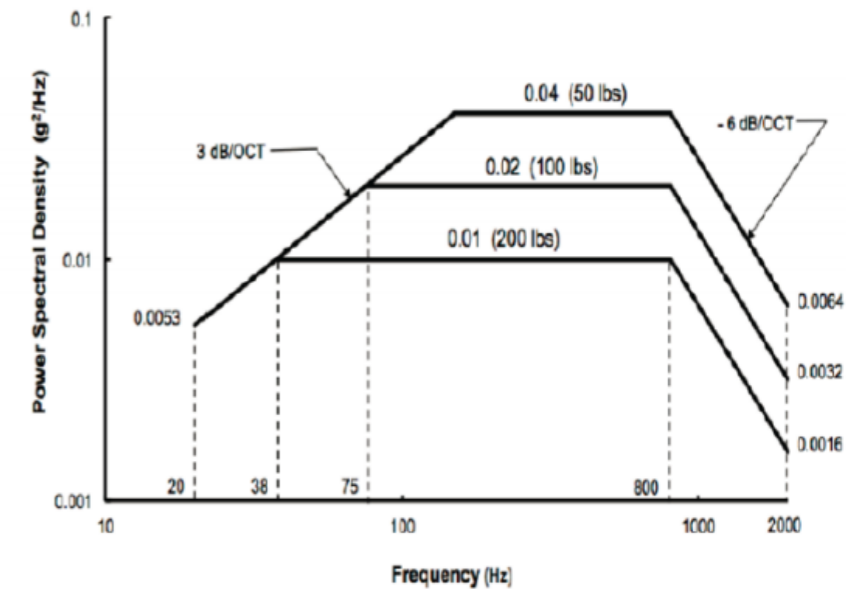


Random vibration for ISP

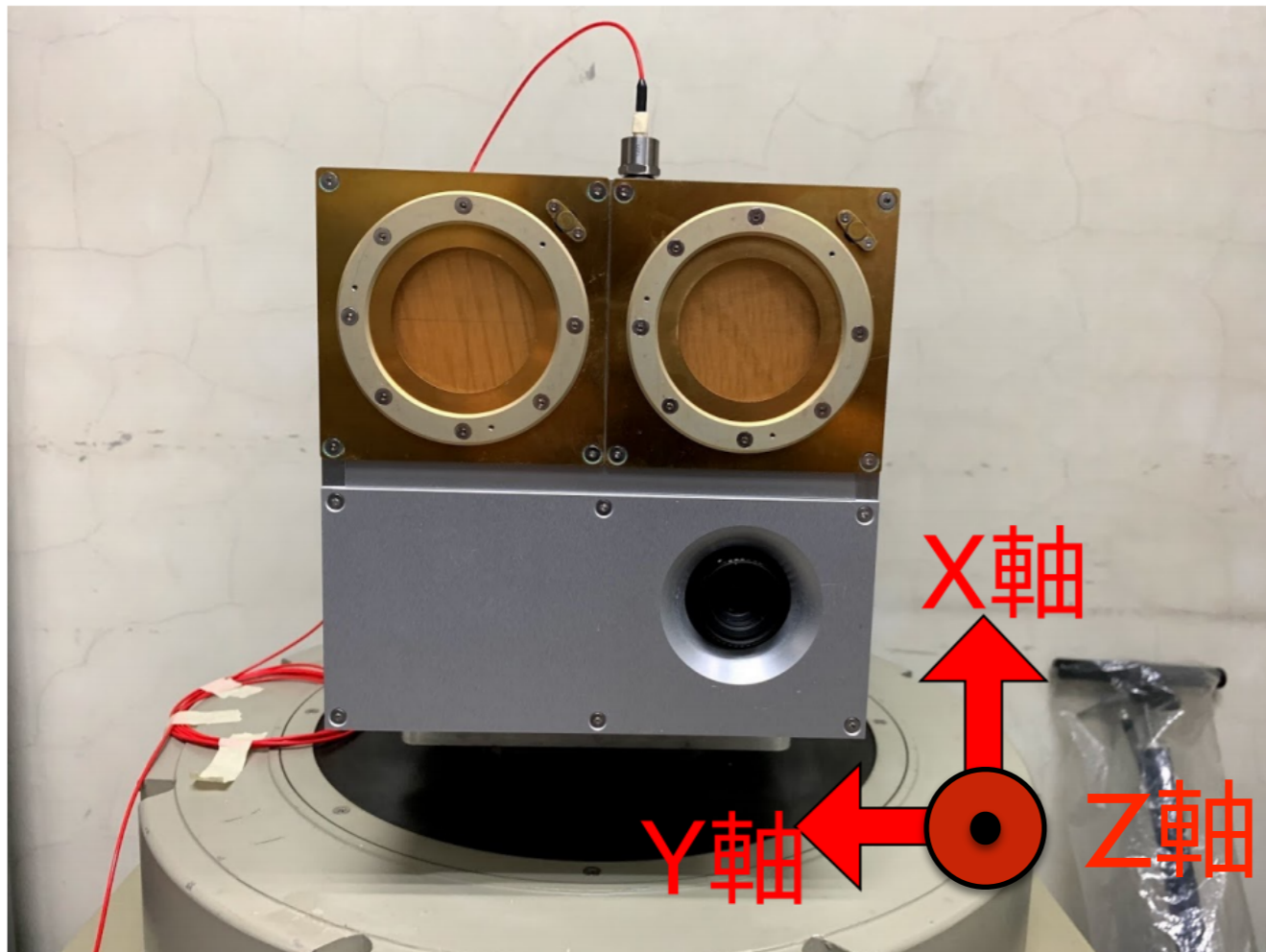


- Random Vibrations

6.9 Grms



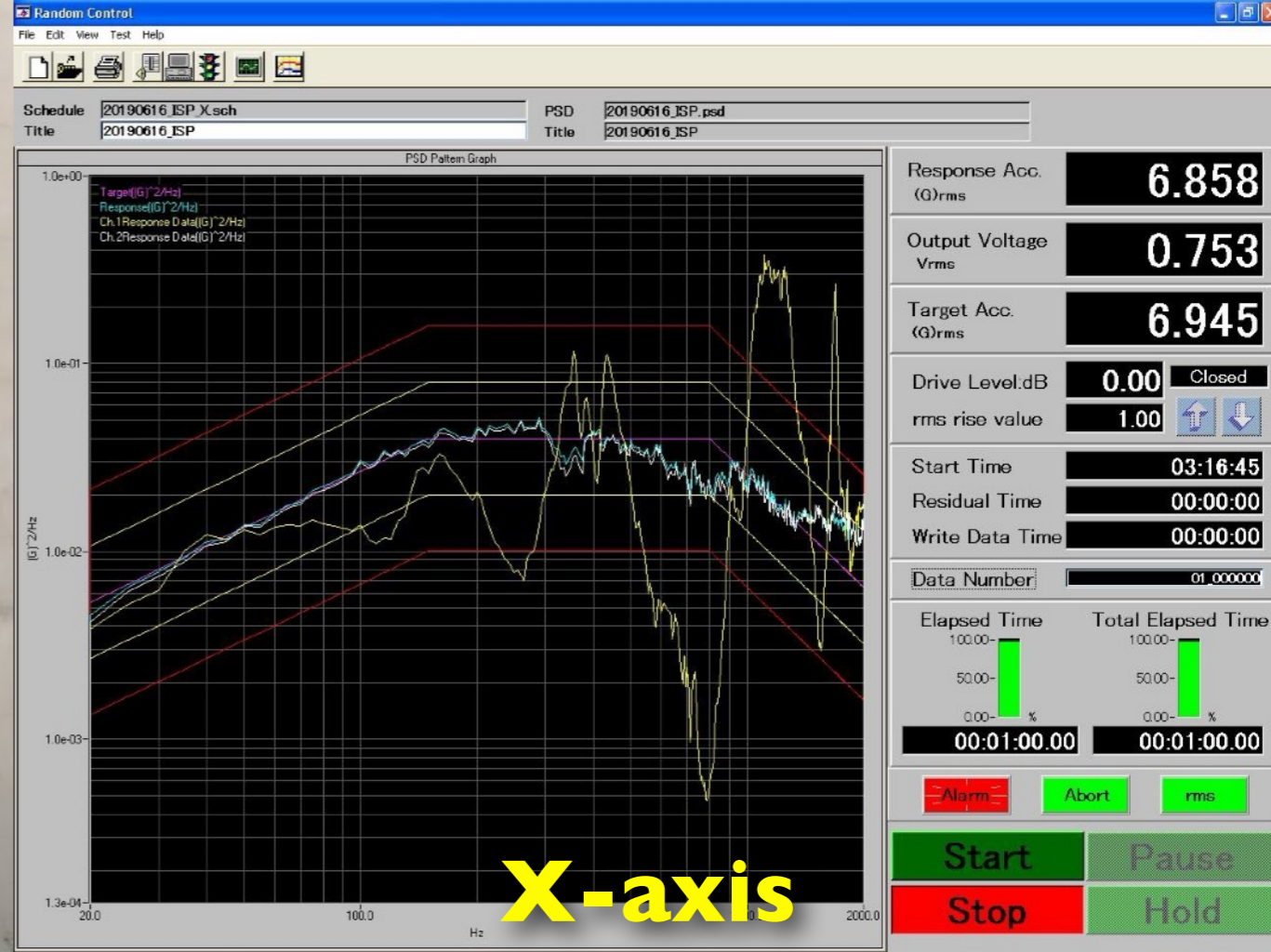
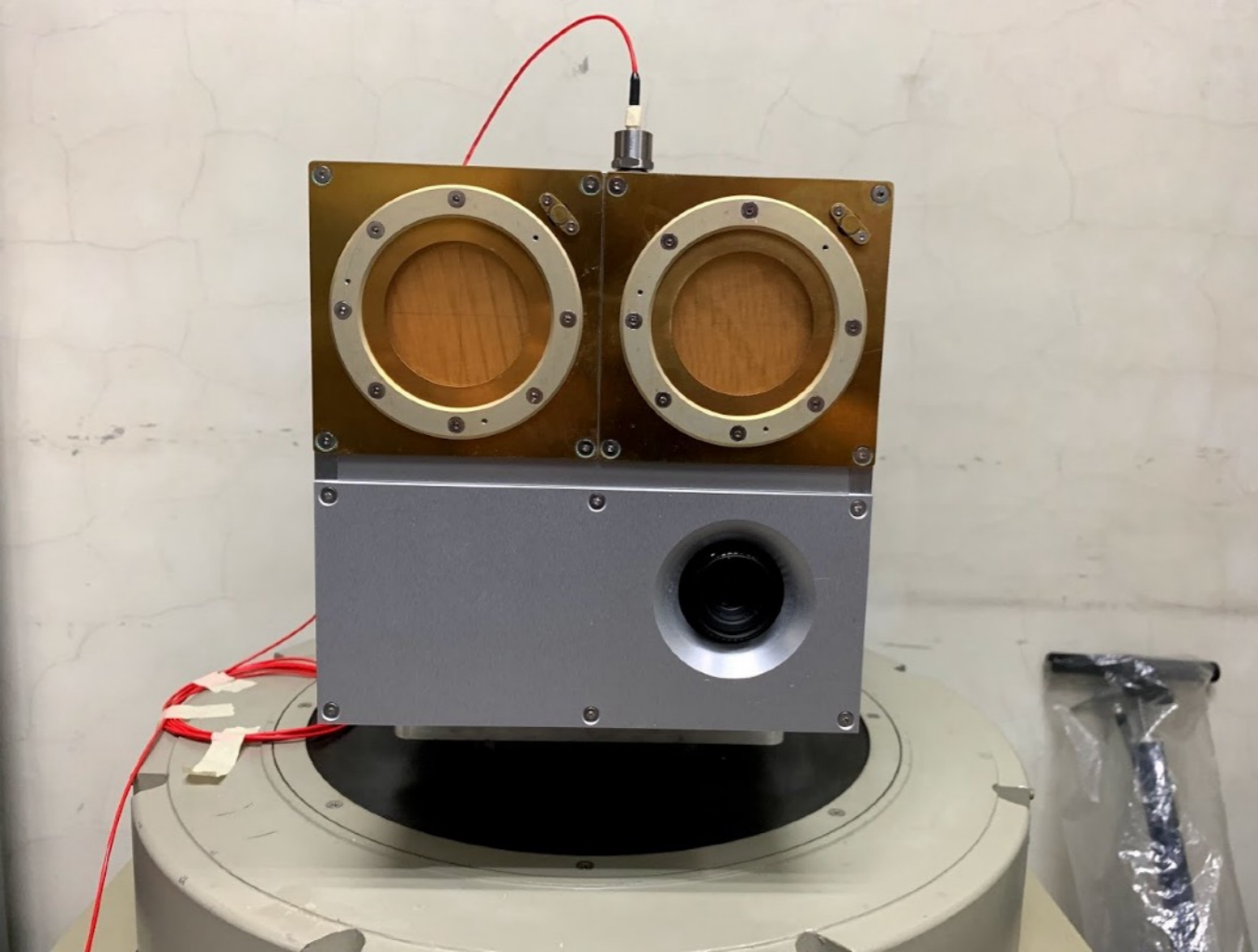
Weight (lb)	Overall Acceleration (Grms)
50	6.90
100	4.87
200	3.52



Before vibration

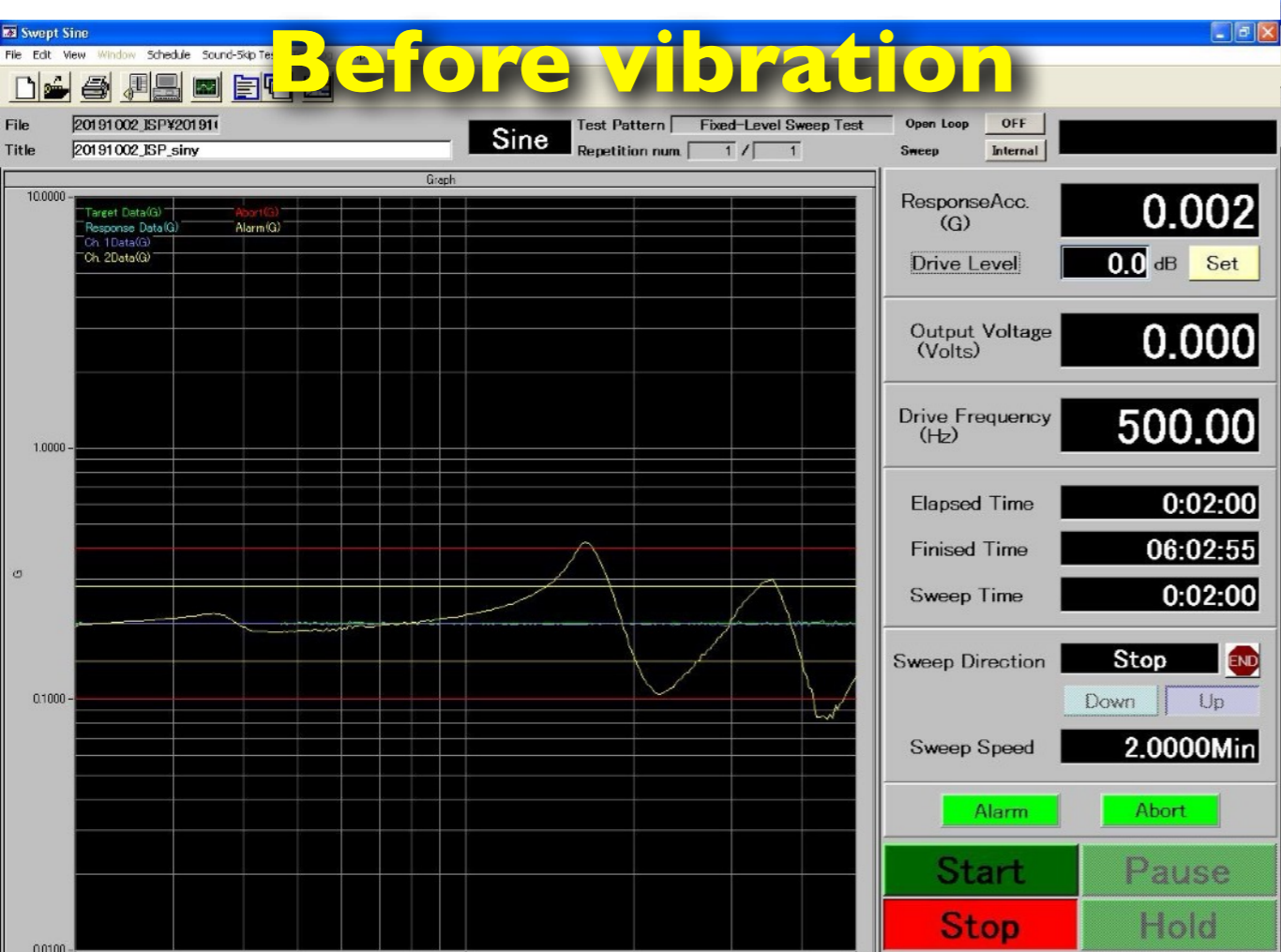


After vibration

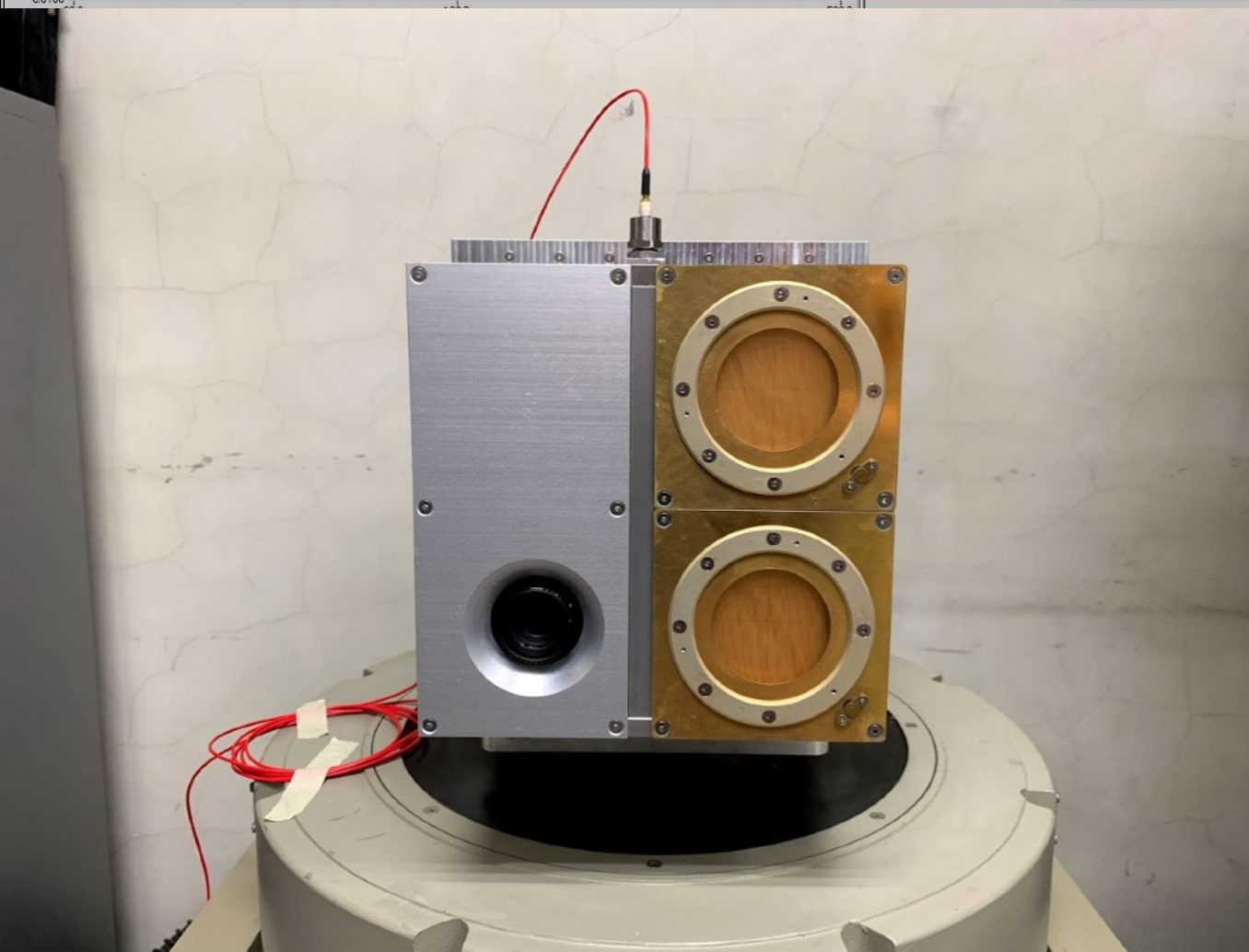
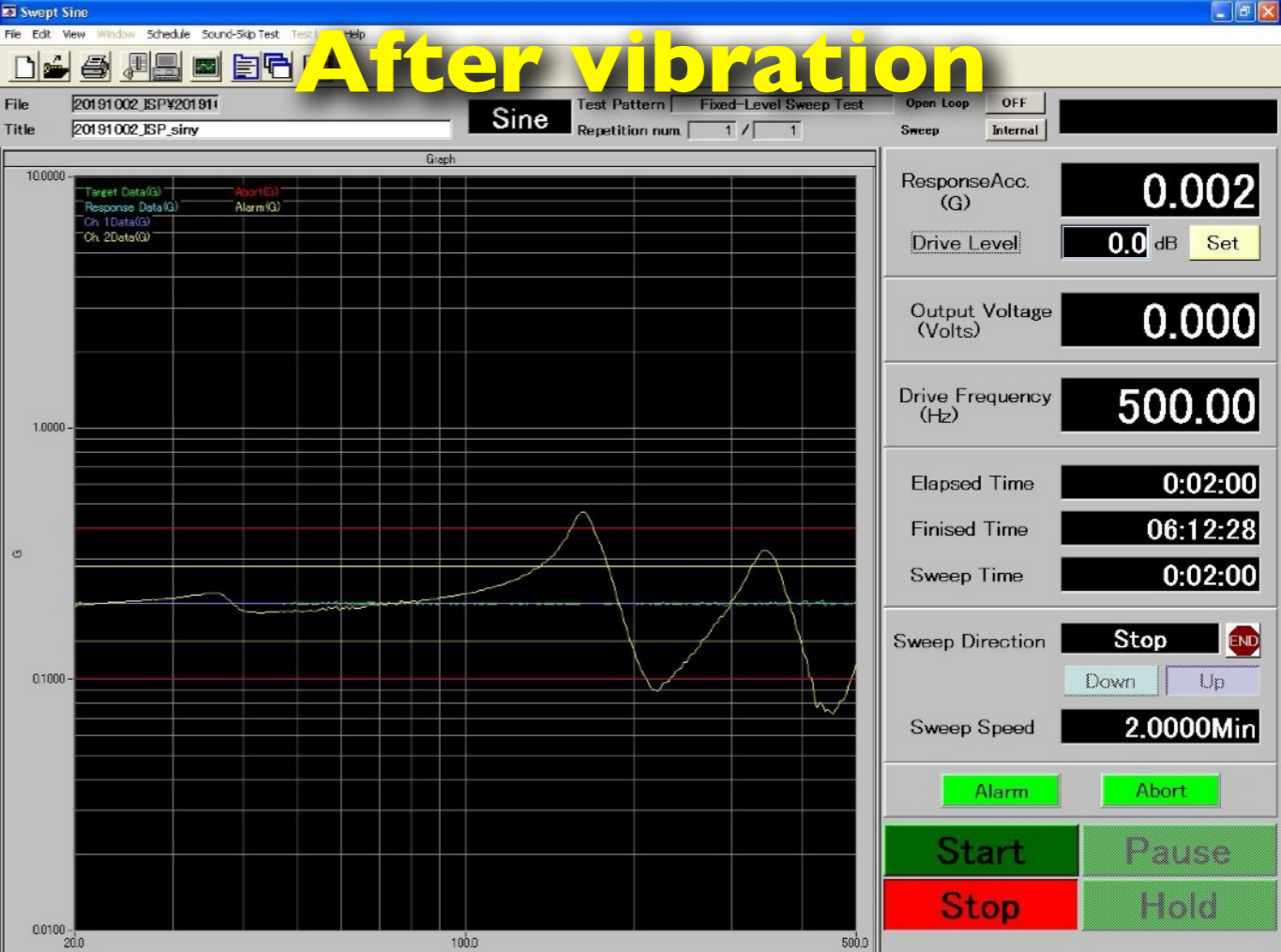


X-axis

Before vibration



After vibration



Y-axis

Before vibration

File Edit View Window Schedule Sound-Skip Test Help

File: 20191002_ISP_201911 Title: 20191002_ISP_sirz

Test Pattern: Sine Fixed-Level Sweep Test

Open Loop: OFF

Repetition num: 1 / 1

Sweep: Internal



ResponseAcc. (G): 0.002

Drive Level: 0.0 dB Set

Output Voltage (Volts): 0.000

Drive Frequency (Hz): 500.00

Elapsed Time: 0:02:00

Finised Time: 07:08:59

Sweep Time: 0:02:00

Sweep Direction: Stop

Sweep Speed: 2.0000Min

Alarm Abort

Start Pause

Stop Hold

After vibration

File Edit View Window Schedule Sound-Skip Test Help

File: PY20191002_ISP_sirz Title: 20191002_ISP_sirz

Test Pattern: Sine Fixed-Level Sweep Test

Open Loop: OFF

Repetition num: 1 / 1

Sweep: Internal



ResponseAcc. (G): 0.004

Drive Level: 0.0 dB Set

Output Voltage (Volts): 0.000

Drive Frequency (Hz): 500.00

Elapsed Time: 0:02:00

Finised Time: 07:17:22

Sweep Time: 0:02:00

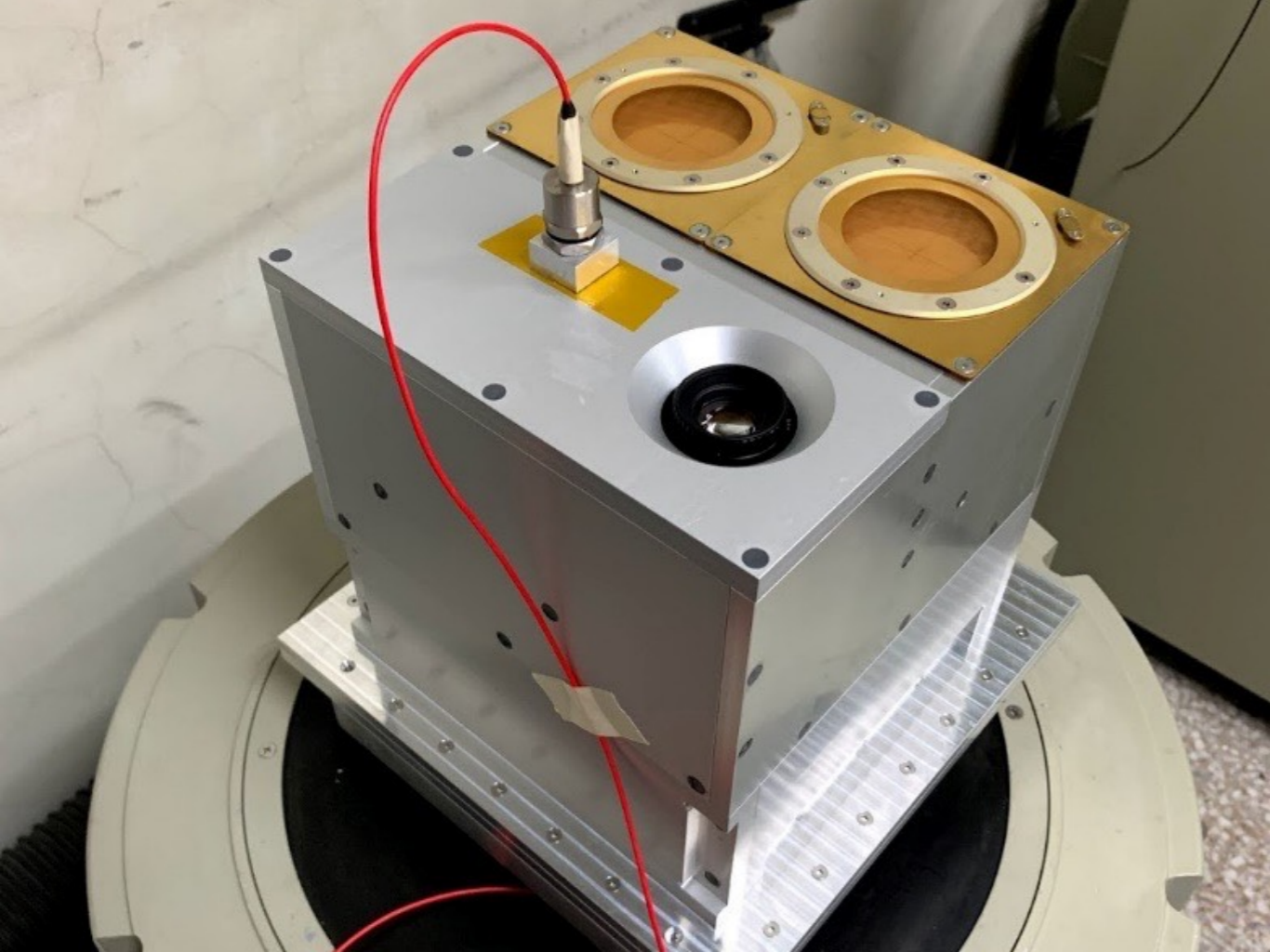
Sweep Direction: Stop

Sweep Speed: 2.0000Min

Alarm Abort

Start Pause

Stop Hold



File Edit View Test Help

Schedule: 20190616_ISP_X.sch Title: 20190616_ISP

PSD: 20190616_ISP.psd Title: 20190616_ISP

PSD Pattern Graph



Response Acc. (G)rms: 6.895

Output Voltage Vrms: 0.386

Target Acc. (G)rms: 6.945

Drive Level.dB: 0.00 Closed

rms rise value: 1.00

Start Time: 07:11:04

Residual Time: 00:00:00

Write Data Time: 00:00:00

Data Number: 01 000000

Elapsed Time: 00:01:00.00

Total Elapsed Time: 00:01:00.00

Alarm Abort rms

Start Pause

Stop Hold

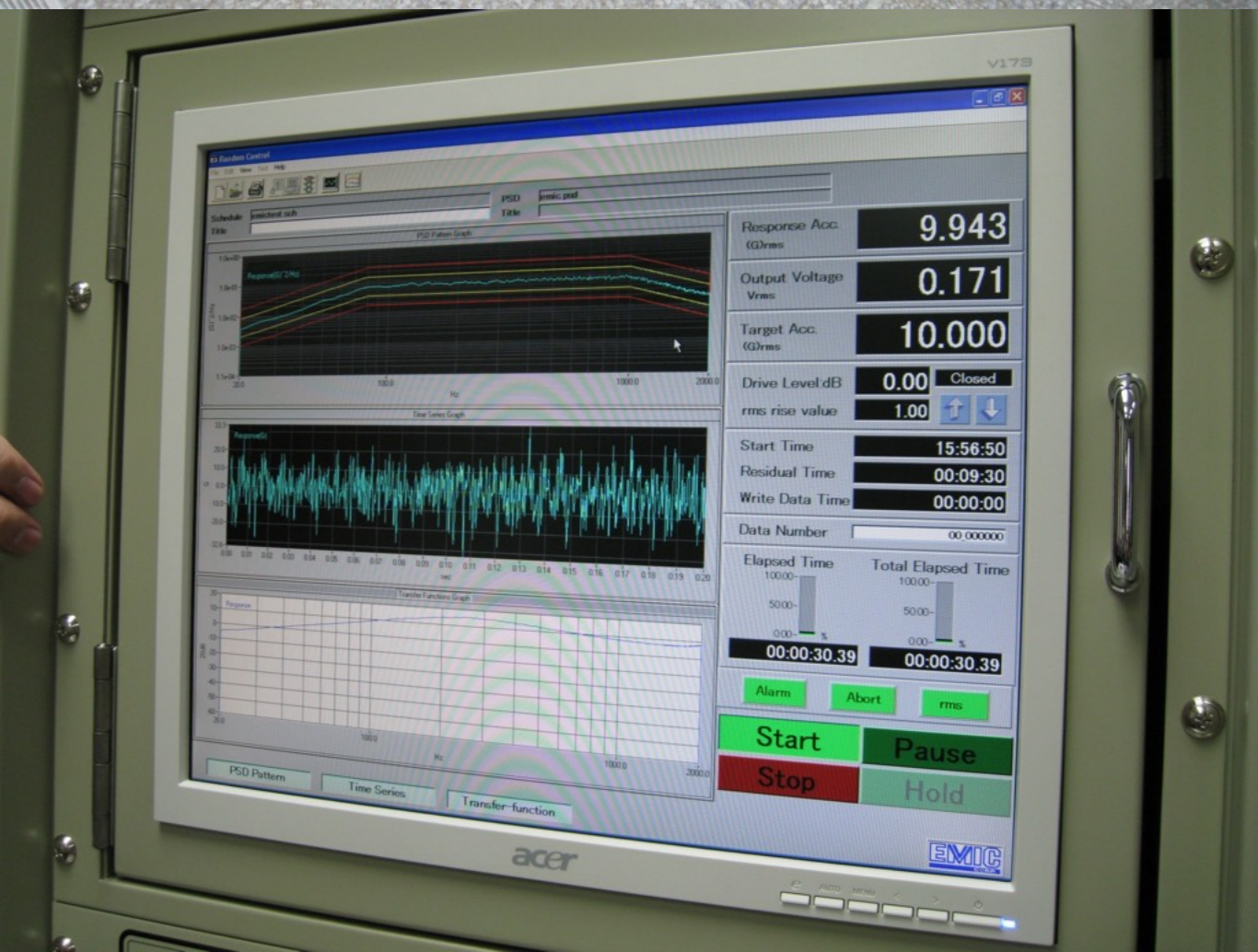
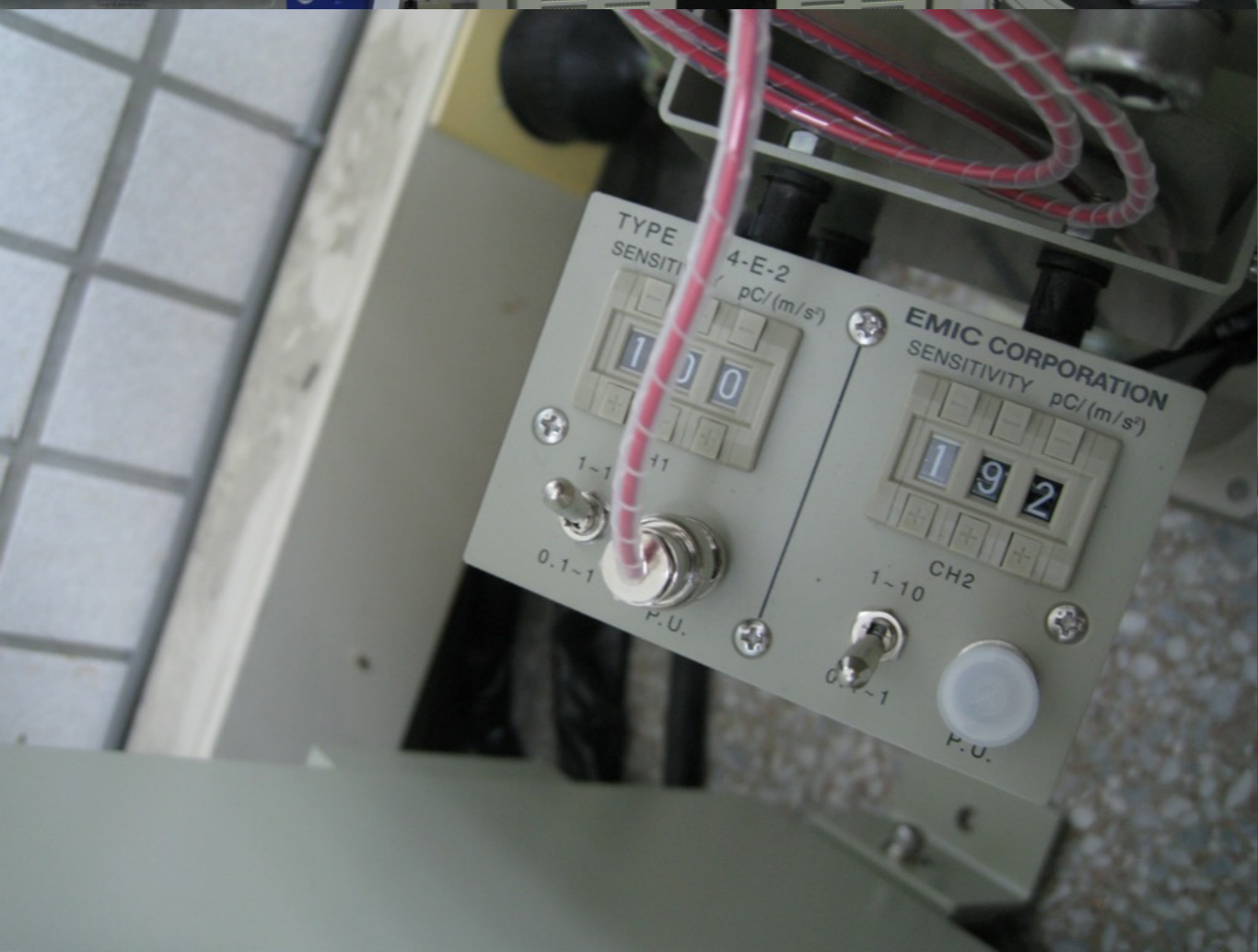
Z-axis

Vibration testing system



- Model: F-06000BM.
 - Vibration generator: 906-FN.
 - Power amplifier: 366A-0101-06.
- Console rack: CRD-2000-06.
- Digital vibration control system: DCS-98Smart.
- Pre-charge amplifier: 504-E-2
- Air cooling blower: MI-10/5.





System performance

- Model: F-06000BM.
- Exciting force: 6.0 kN_{0-p} for sine and $4.2 \text{ kN}_{\text{rms}}$ for random.
- Maximum displacement: 20 mm_{p-p} .
- Maximum velocity 1.5 m s^{-1} .
- Frequency range: DC to 3,500 Hz.
- No load maximum acceleration: $923.0 \text{ m s}^{-2}_{0-p}$ for sine.

- Maximum payload: 60 kg.
- Armature mass: 6.5 kg.
- Axial stiffness: 5.88 N/m.
- Table size: 120 mm x 120 mm.

Vibration generator

- Model: 906-FN.
- Maximum exciting force: 6.0 kN_{0-p}.
- Maximum displacement: 20 mm_{p-p}.
- No load maximum acceleration: 923.0 m s⁻²_{0-p}.
- Armature mass: 6.5 kg.
- Frequency range: DC to 3,500 Hz.
- Armature table size: 120 mm x 120 mm.



- Maximum payload: 60 kg.
- Stray magnetic field: less than 5 mT at table center.
- Magnetic structure: energized with field coils.
- Isolation: pneumatic isolator.
- Cooling: cooled by forced air using air cooling blower.
- Control accelerometer: one piezeo-electric type accelerator.
- Dimension: 720 mm (W) x 765 mm (H) x 678 mm (D).
- Weight: 500 kg.

Power amplifier



- Model: 366A-0101-06.
- Output power: 6 kVA, the maximum output can be provided to both inductive and capacitive load of power factor more than 0.2.
- Circuit: solid state.
- Distortion: less than 1% from DC to 2,000 Hz.
- Frequency response: DC to 4,000 Hz.
- S/N ratio: 70 dB below full output

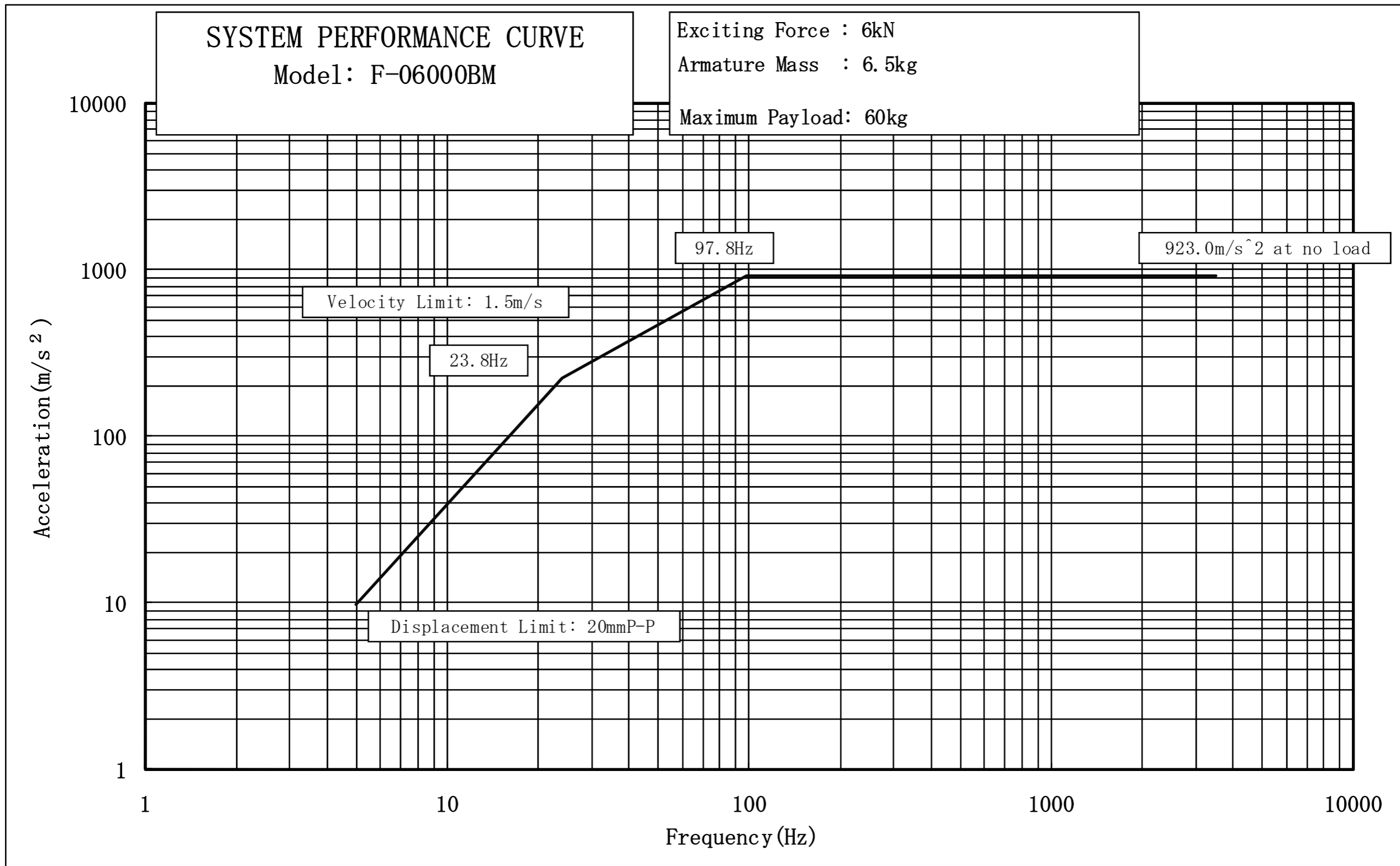
- Input impedance: 10 k Ω , any oscillator or external signal source available.
- Output impedance: matched to impedance of shaker over specified operating frequency range from DC to 500 Hz.
- Cooling method: air cooled by integral fan.
- Field power supply: 3.7 kW for DC output power.
- Dimension: 654 mm (W) x 2000 mm (H) x 1010 mm (D).
- Weight: 370 kg.

Digital vibration control system

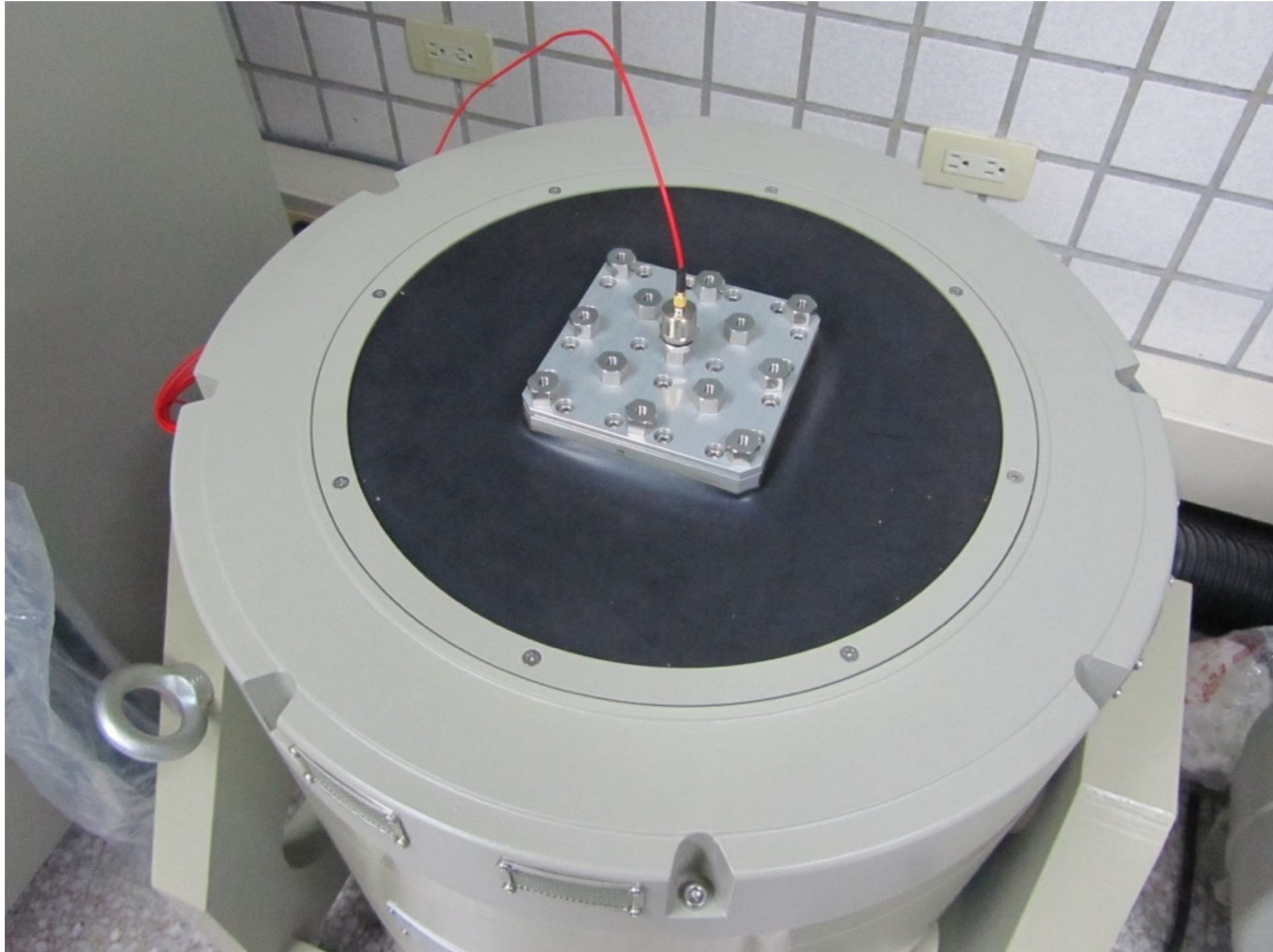
- Model: DCS-98Smart.
- Hardware:
 - Dynamic control (main DCU) for vibration control and communication.
 - Embedded computer.
- Software:
 - Random vibration control software package.
 - Sine vibration control software package.



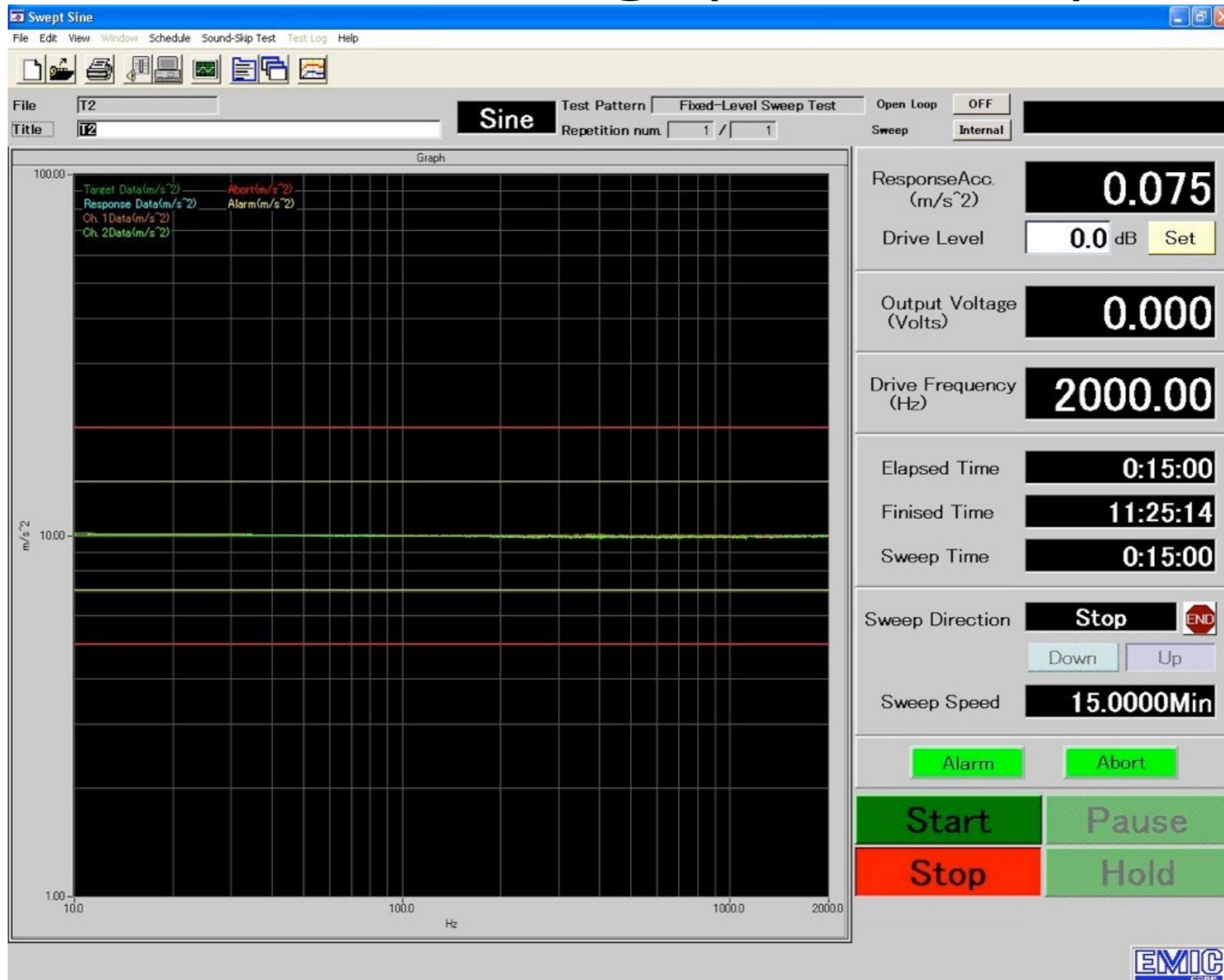
(1) Vibration Generator Alone



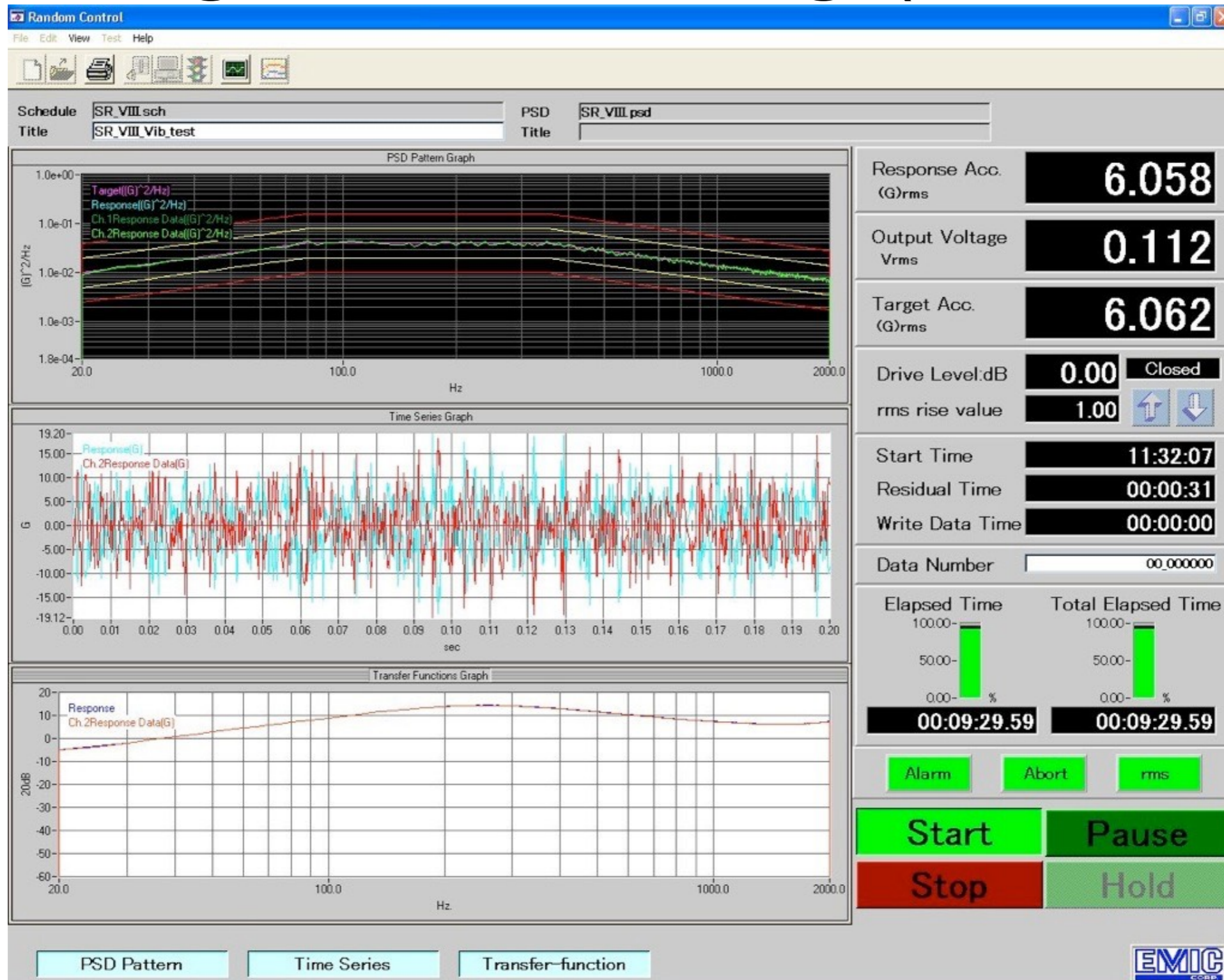
No Loading



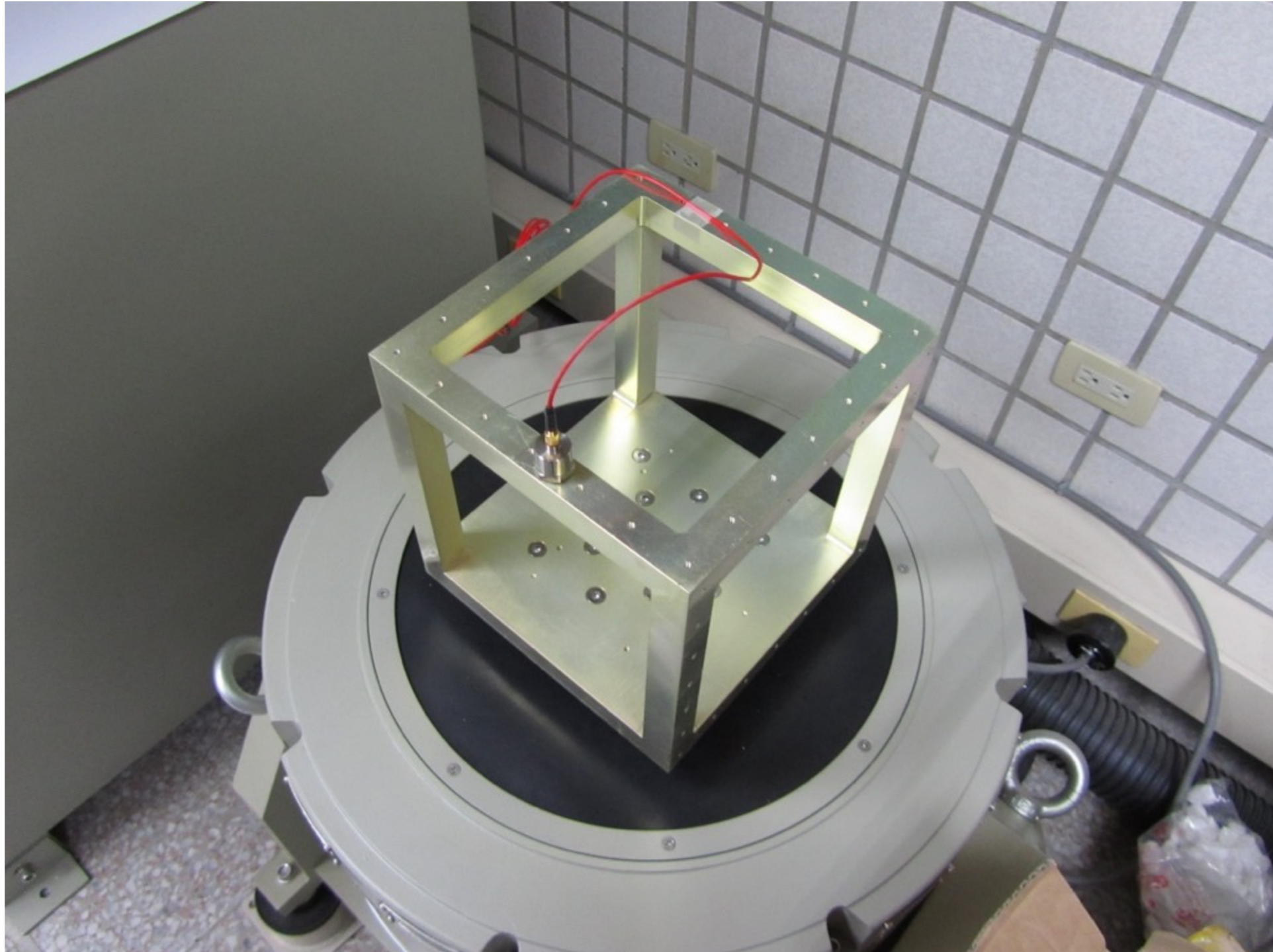
No Loading (Pre sine)



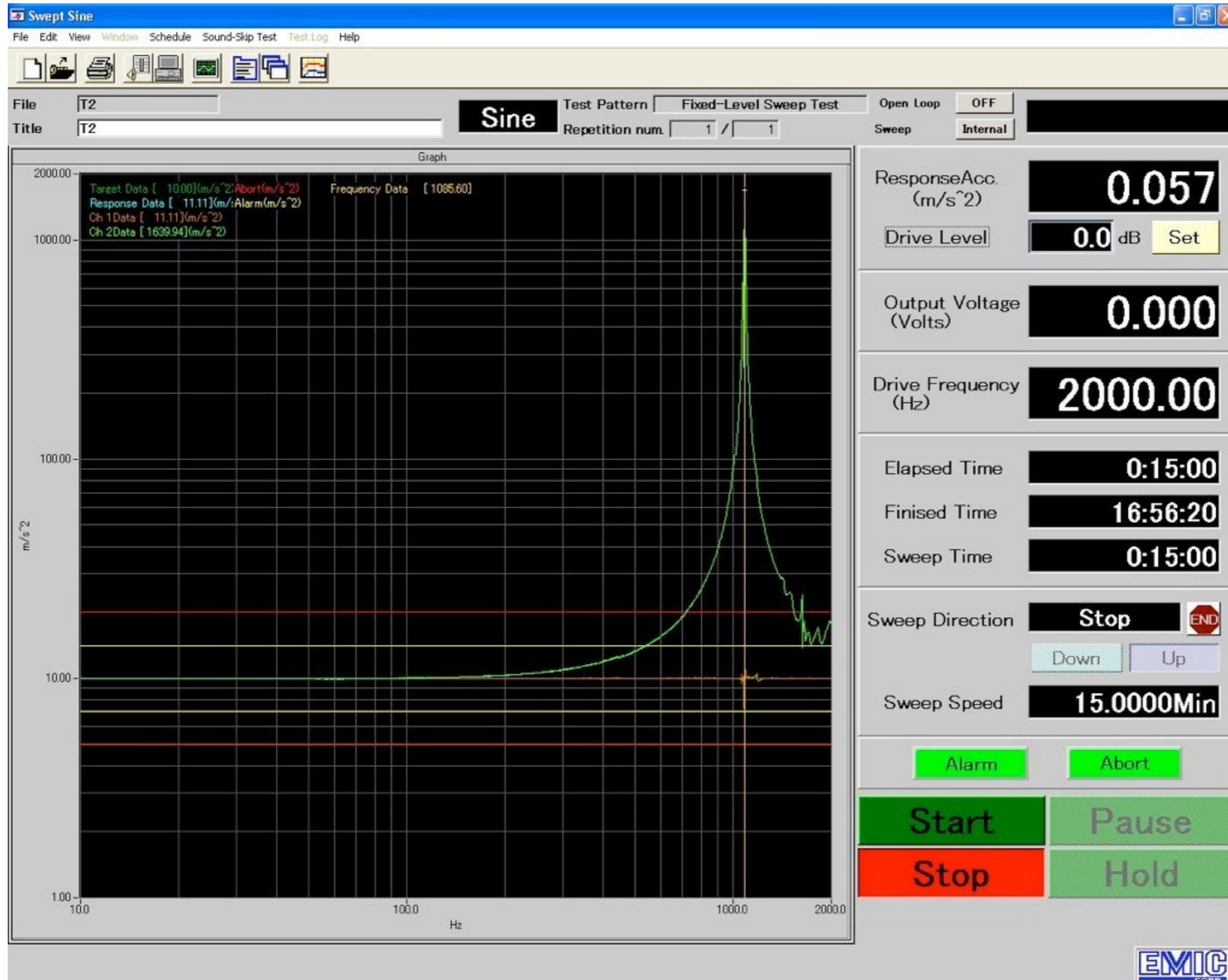
Testing - No Loading (Random)



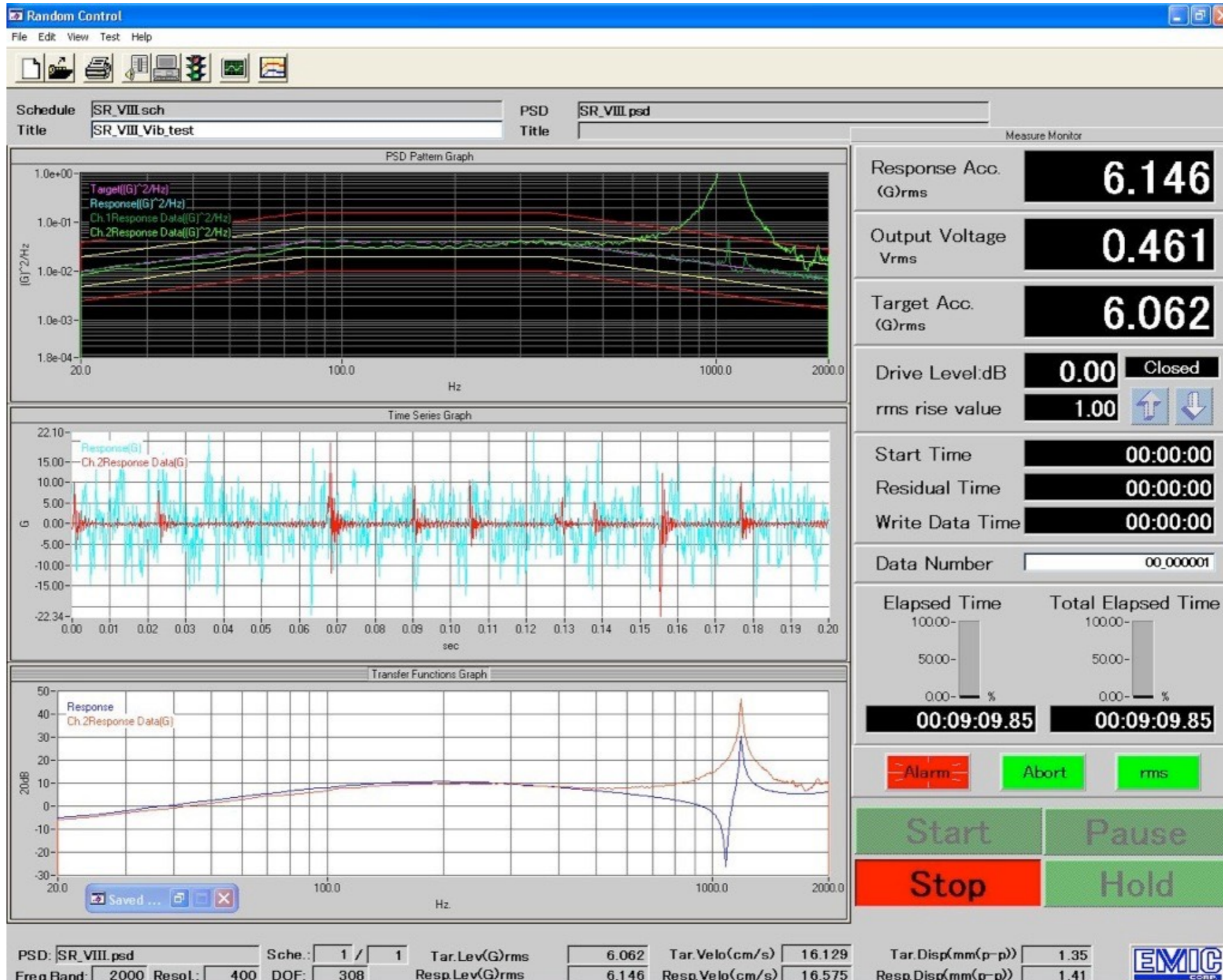
Testing - with Fixture



Testing - with Fixture (sine)



Testing - with Fixture (Random)



振動機台與夾具

- Vertical vibration system
- Slip table system
- Multiple axis vibration system
- Various vibration fixtures

Vertical vibration testing system

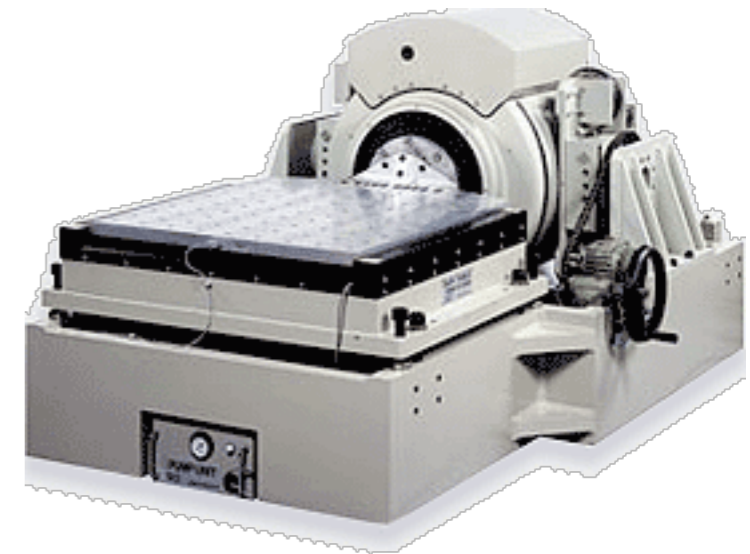
- Basic model
- High velocity
- Large displacement (100 mm_{p-p})



Slip table system for horizontal testing

The slip table system is the most familiar option to perform a vibration test. It is used for horizontal testing of a bulky unit or an article, the mounted configuration of which cannot be changed.

The slip table system incorporates oil film slip table technology of circulating oil between a marble slab and a slip table, which applies to most commonly applied operating range.



The oil circulating linear bearing strongly restrains and supports a specimen against eccentric moment. Therefore, a high center of gravity and off-center loads can be excited safely.

Multiple-axis vibration testing system

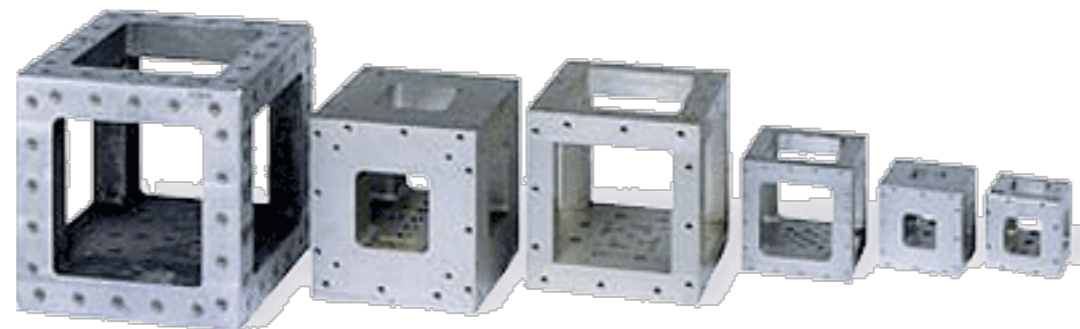
供試品を一度取り付ければ、垂直方向と水平方向を任意の組み合わせで行うことができます。（用途に適した機種を選択） 梱包製品の輸送試験、家電製品の規格試験、OA機器の規格試験などに最適な試験装置です。デジタル振動制御装置の使用によりサイン試験、ランダム試験の他、衝撃試験も可能。



- 垂直・水平方向の3軸同時加振
- X,Y,Zの3方向を切り換えて加振
- 水平の2方向を同時に、又は垂直に切り換えて加振
- 温湿度試験との複合試験も用意など多彩な振動試験が出来ます

JSA series cubic style fixture for electronic parts

The JSA series is used for exciting, up to high frequency, a relatively small and light specimen such as various sensors, electric equipment including electronic parts and PCB. The JSA has the shape of a cube providing up to 5 mutually perpendicular mounting surfaces to which an adapter plate is attached. By changing the direction of an adapter plate, it permits to test X, Y and Z axes respectively. The adapter plate is tailored to provide the optimum fitting to the specimen.

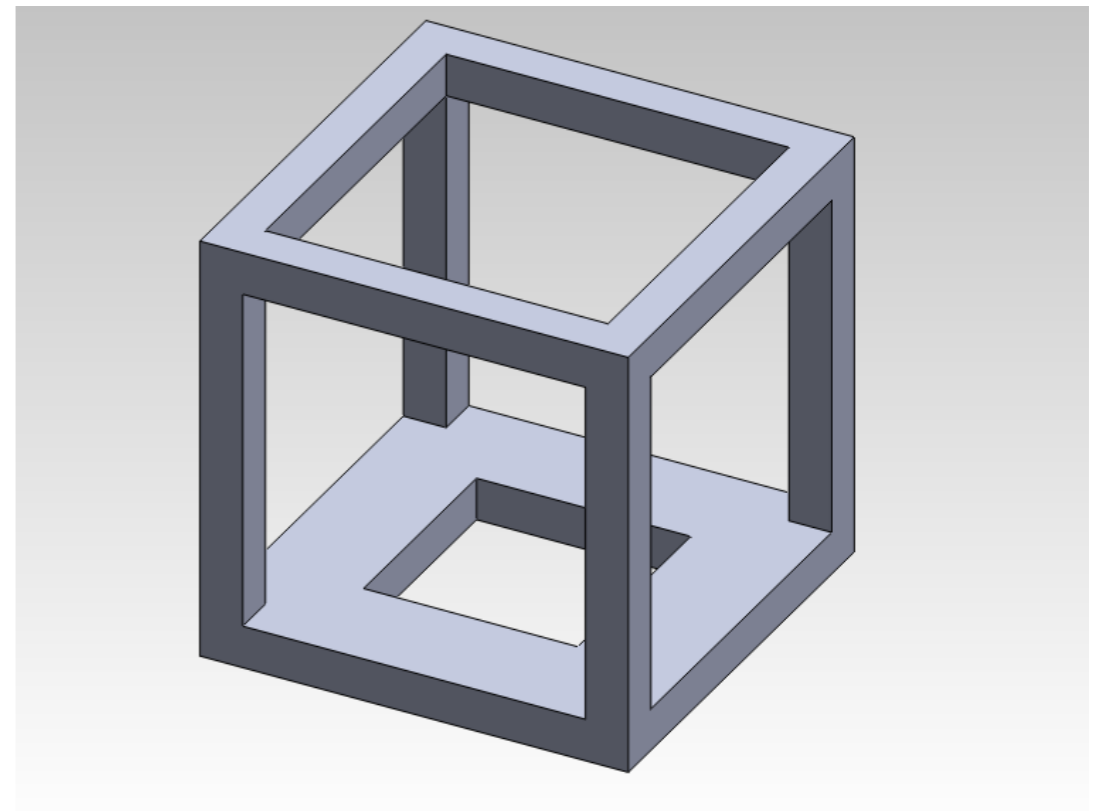




Model	JSA-100-*			JSA-150-*			JSA-200-*			JSA-300-*		
Cube Size(mm)	100 X 100 X 100			150 X 150 X 150			200 X 200 X 200			300 X 300 X 300		
Matched Shaker	514	902	903	903	906	916	906	916	926	916	926	936
Cube Mass(kg)	1.5			7			8	13	16	29	29	29
Upper Frequency(Hz)	2000			2000			500	1000	2000	500	500	500

Note: Adapter plate for X,Y and Z axes allows for tailoring of its feature to fit to your arrangement of parts. Cube mass does not include an adapter plate. Fixture is made of Aluminum. But, a fixture made of Magnesium alloy is also available.* indicates shaker code such as 16 for Model:916 series shaker, etc.

Software for Vibration Simulation



研究 ?

✓ ✗ ↵

訊息
使用頻率及模態來研究線性回應至動態負載

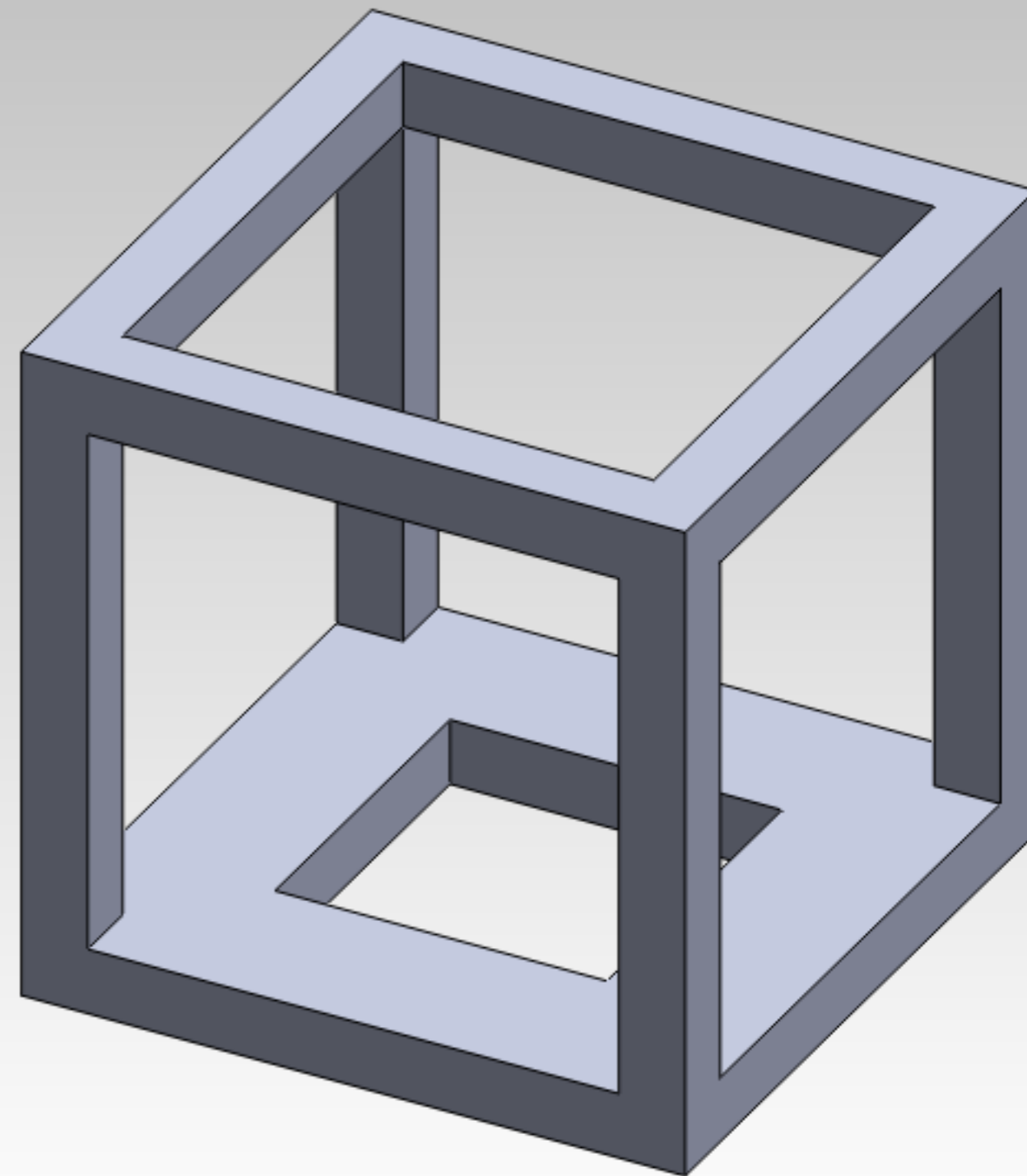
名稱
研究 4

類型

- Static
- 頻率**
- 挫曲
- 熱
- 落下測試
- 疲勞
- 非線性
- 線性動態
- 壓力容器設計

選項

零件2-2 (預設 << 預設 > 顯...



*不等角視圖

零件2-2 (預設<<預設>_顯示)

- 感測器
- 註記
- 材質 <未指定>
- 前基準面
- 上基準面
- 左基準面

研究4 (-預設)

- 零件2-2
- 連接
- 固定物
- 外部負重
- 網格
- 阻尼 (-無)
- 結果選項

執行(R)
執行頻率(F)
更新所有組成(U)
輸出(O)...

刪除(D)

詳細資料(T)

屬性(O)...

定義函數曲線(F)...

重新命名(M)

複製(C)

隨機振動

頻率選項 隨機振動選項 評論

選項

- 頻率數目(N) 5
- 計算頻率最近於(C): (頻率改變) 0 Hertz
- 頻率上限(U): 0 Hertz
- 使用軟彈力來穩定模型(I)

不相容的結合選項

- 自動
- 簡化
- 更精確 (較慢)

求解器

- 自動(A)
- 稀疏矩陣直接解法(D)
- FFEPlus(P)

結果資料夾 C:\Users\ferm\Desktop\vibration_simulation te

確定 取消 說明

隨機振動

頻率選項 隨機振動選項 評論

操作頻率限制

- 單位: Cycles/sec (Hz)
- 下限: 20
- 上限: 2000
- 頻率點數量: 4

相關性:

- 完全相關
- 完全不相關
- 部分相關

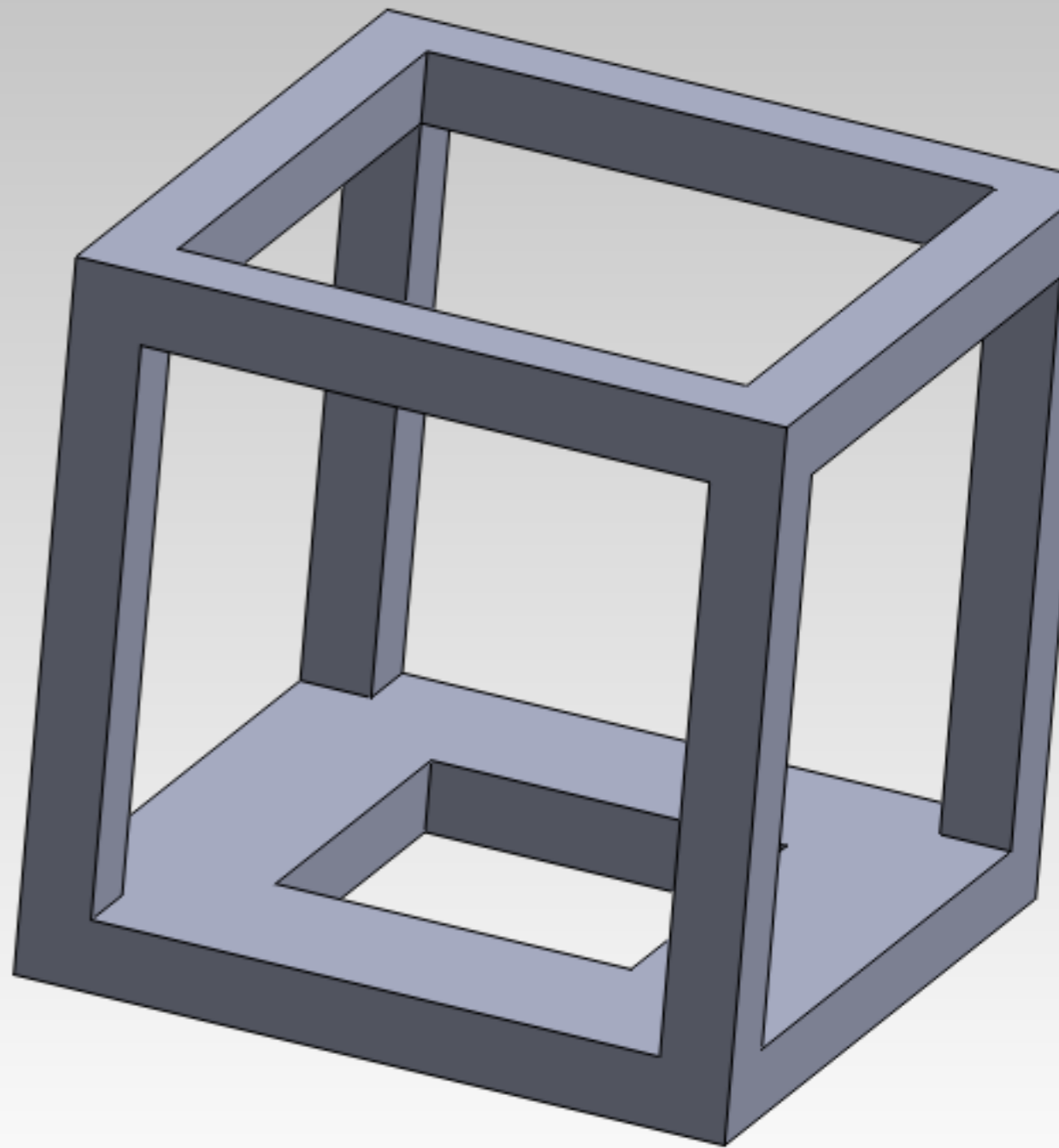
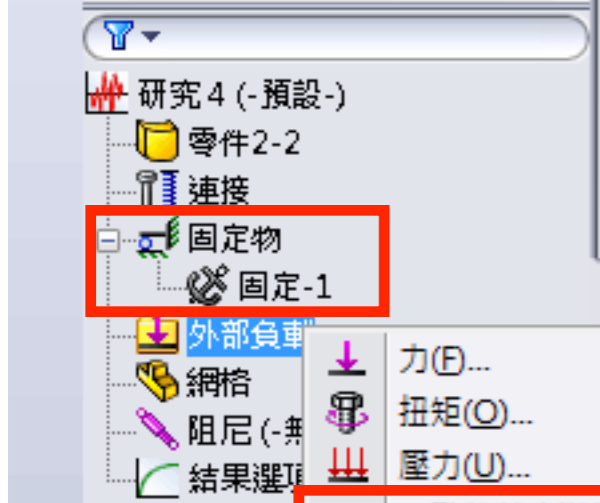
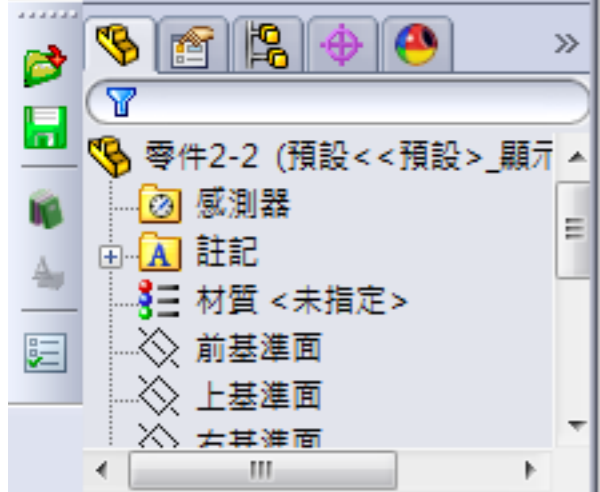
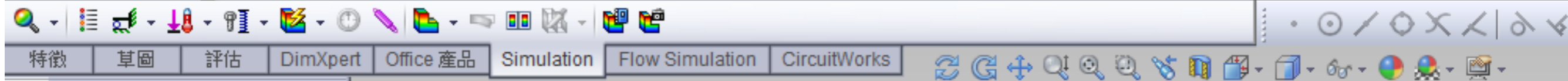
- 單位: mm
- 內側半徑: 0
- 外側半徑: 0

進階選項...

確定 取消 說明

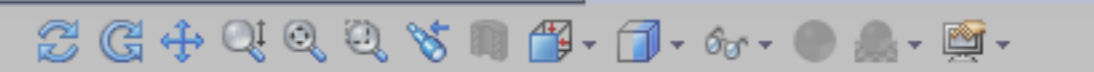


*不等角視圖





特徵 草圖 評估 DimXpert Office 產品 Simulation Flow Simulation CircuitWorks



一致的基本激振 ?

✓ ✗

訊息

激振被套用至限制於指定整體方向的所有位置。

類型

- 位移
- 速度
- 加速度

PSD 位移

mm²/Hz

0 mm²/Hz

0 mm²/Hz

0 mm²/Hz

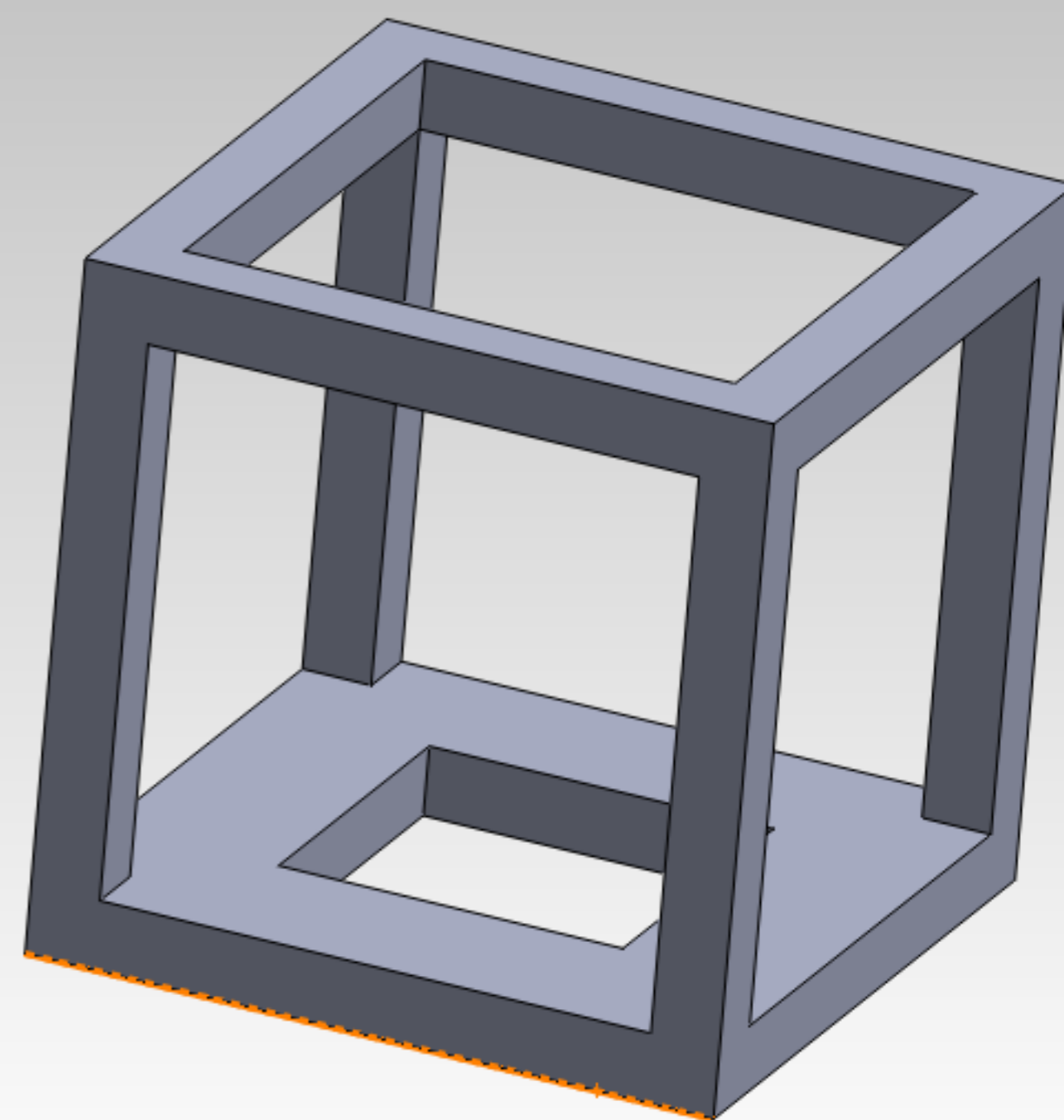
隨頻率變化

- 線性
- 曲線

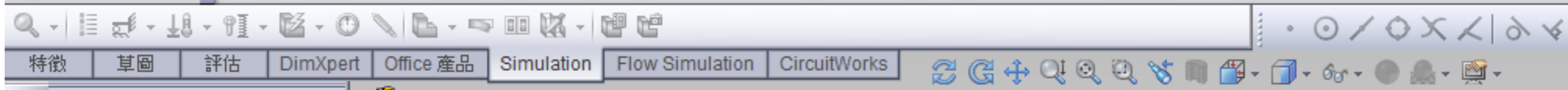
編輯... 視圖

符號設定

零件2-2 (預設 << 預設 >> 顯...



模型 動作研究 1 研究 1 研究 2 研究 3 複製 [研究 3] 研究 4



所選的基座激振 ?

✓ ✗

類型

- 位移
- 速度
- 加速度

固定-1

PSD 加速度

g^2/Hz

0 g^2/Hz

6 g^2/Hz

反轉方向

0 g^2/Hz

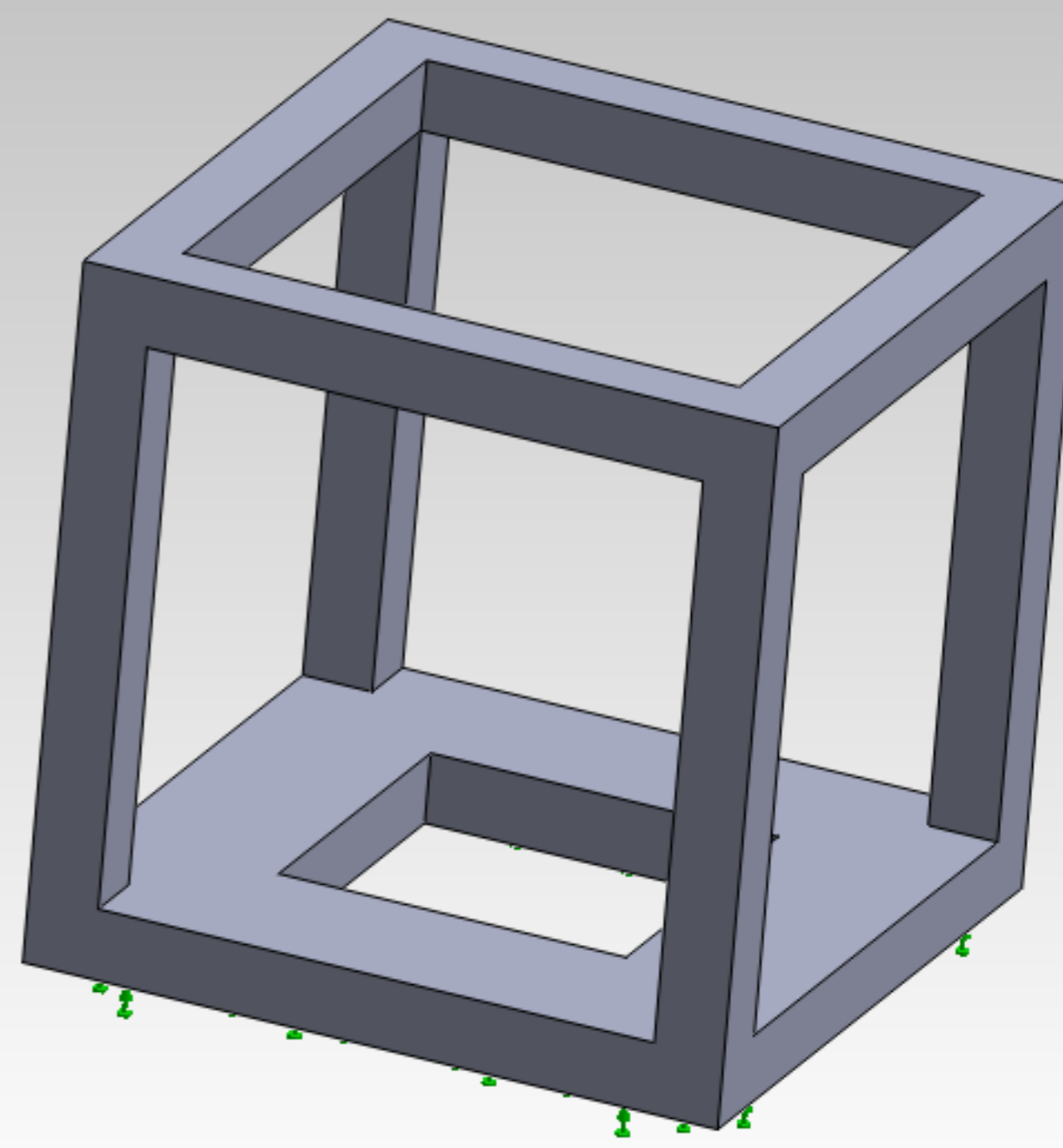
隨頻率變化

- 線性
- 曲線

編輯... 視圖

符號設定

零件2-2 (預設 << 預設 > 顯...





零件2-2 (預設 << 預設 > 顯...

頻率曲線

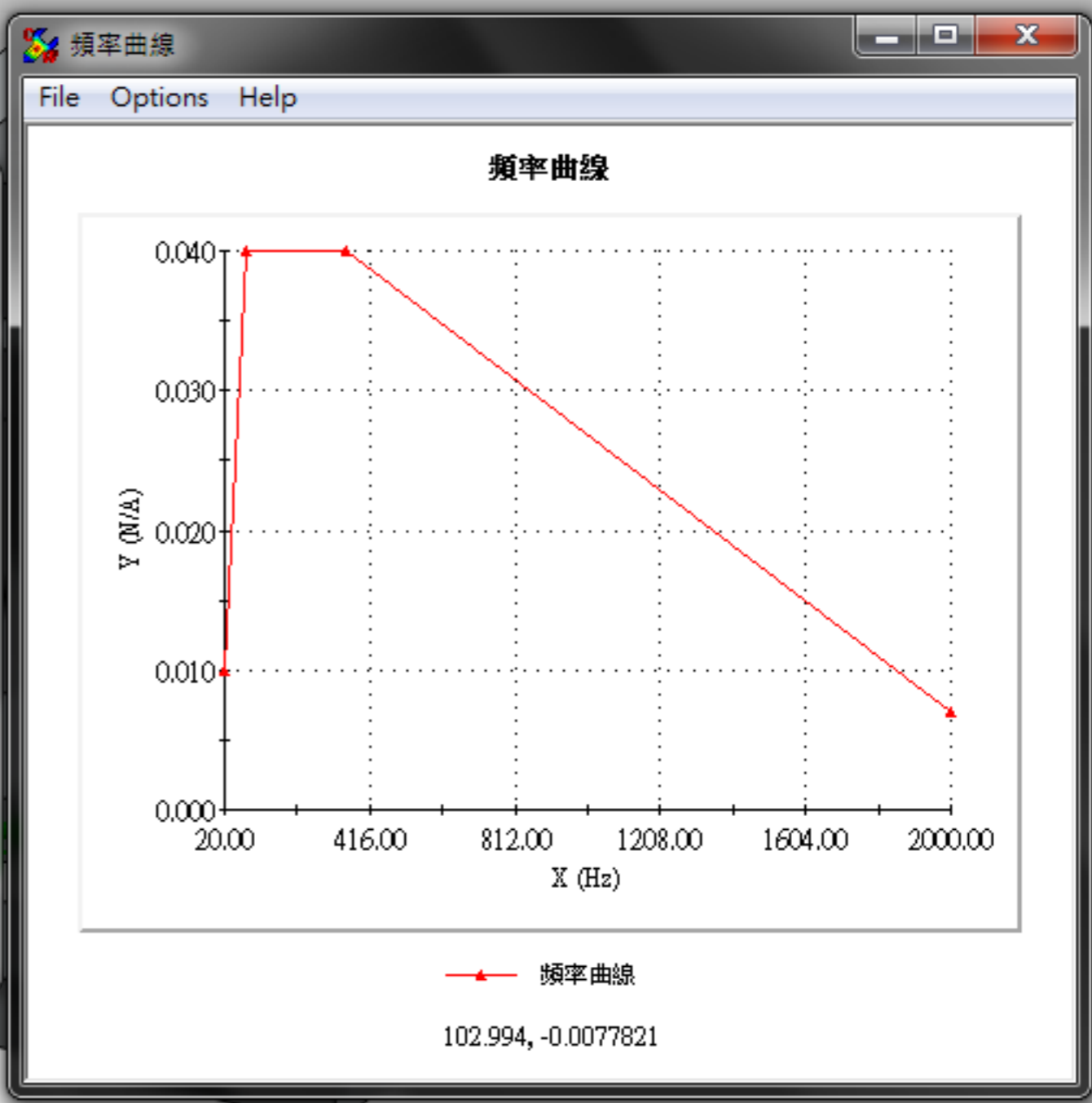
曲線資訊
 名稱(N) 頻率曲線
 形狀(S) 使用者定義

曲線資料
 單位(U) Hz N/A

點	X	Y
1	20	0.01
2	80	0.04
3	350	0.04
4	2000	0.007

取得曲線(G)...
 儲存曲線(A)...
 檢視(V)

確定 取消 說明(H)



一致的基座激振 ?

激振被套用至限制於指定整體方向的所有位置。

類型

- 位移
- 速度
- 加速度

PSD 加速度

g^2/Hz

0 g^2/Hz

6 g^2/Hz

反轉方向

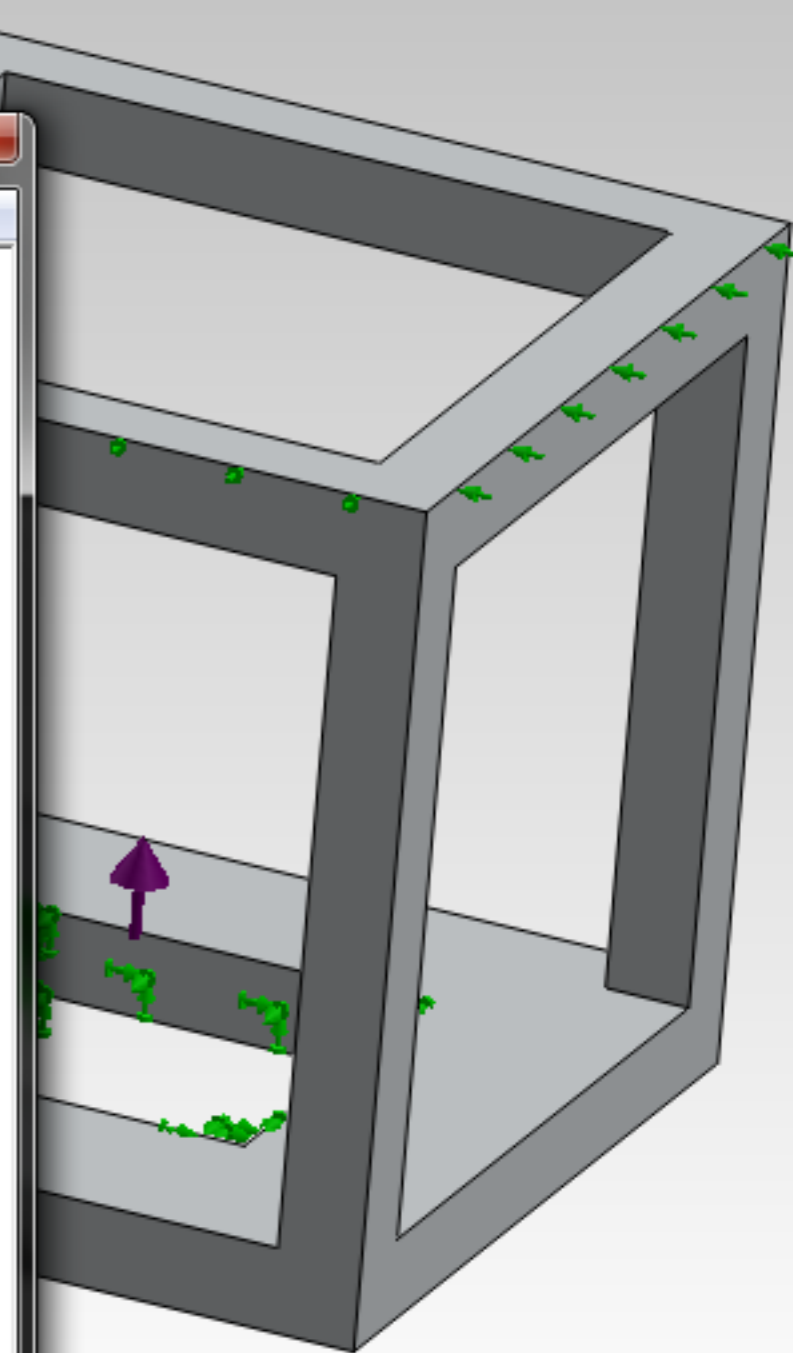
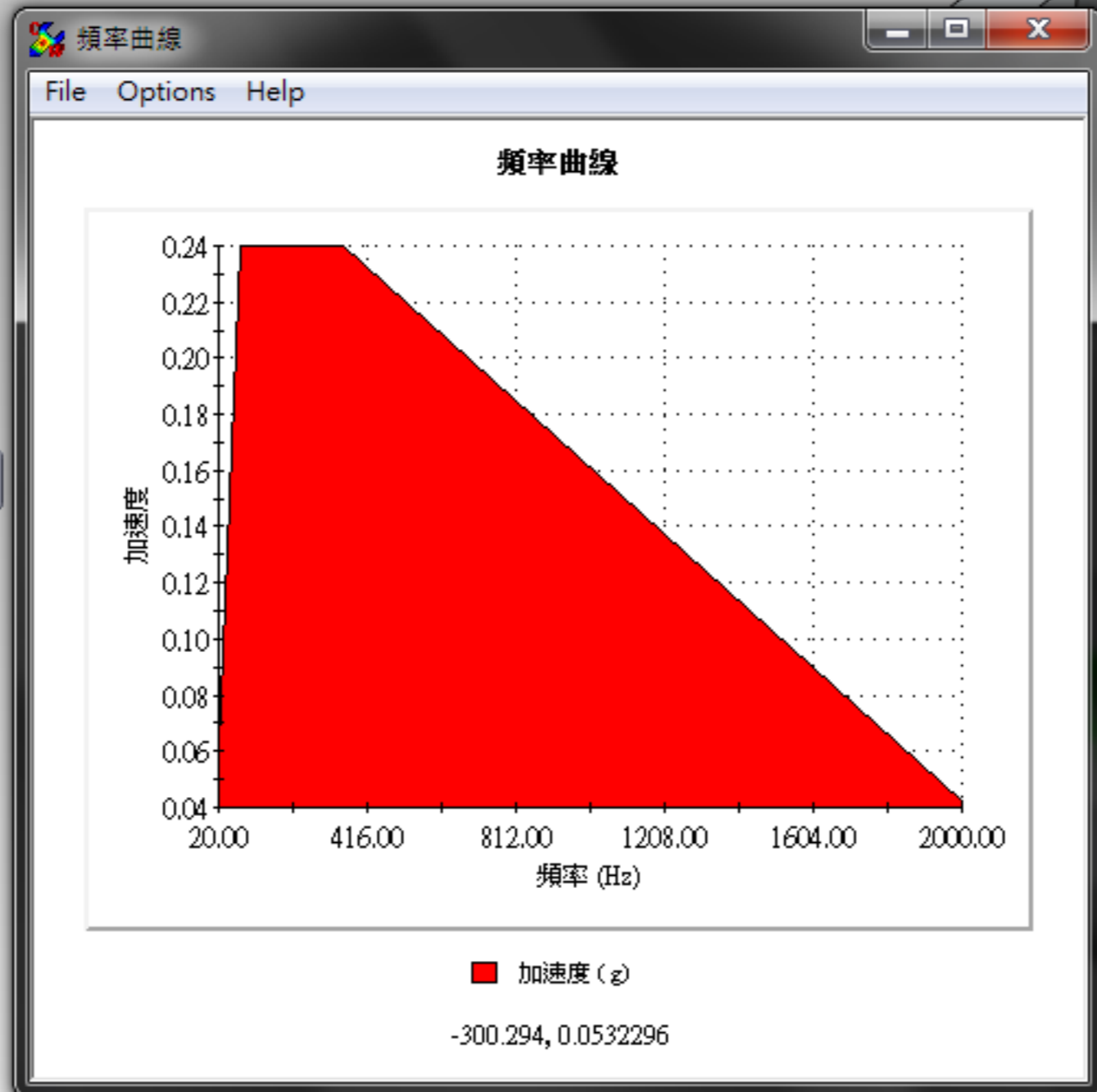
0 g^2/Hz

隨頻率變化

- 線性
- 曲線

編輯... 視圖

符號設定





特徵 草圖 評估 DimXpert Office 產品 Simulation Flow Simulation CircuitWorks

整體阻尼 ?

✓ ✗

選項

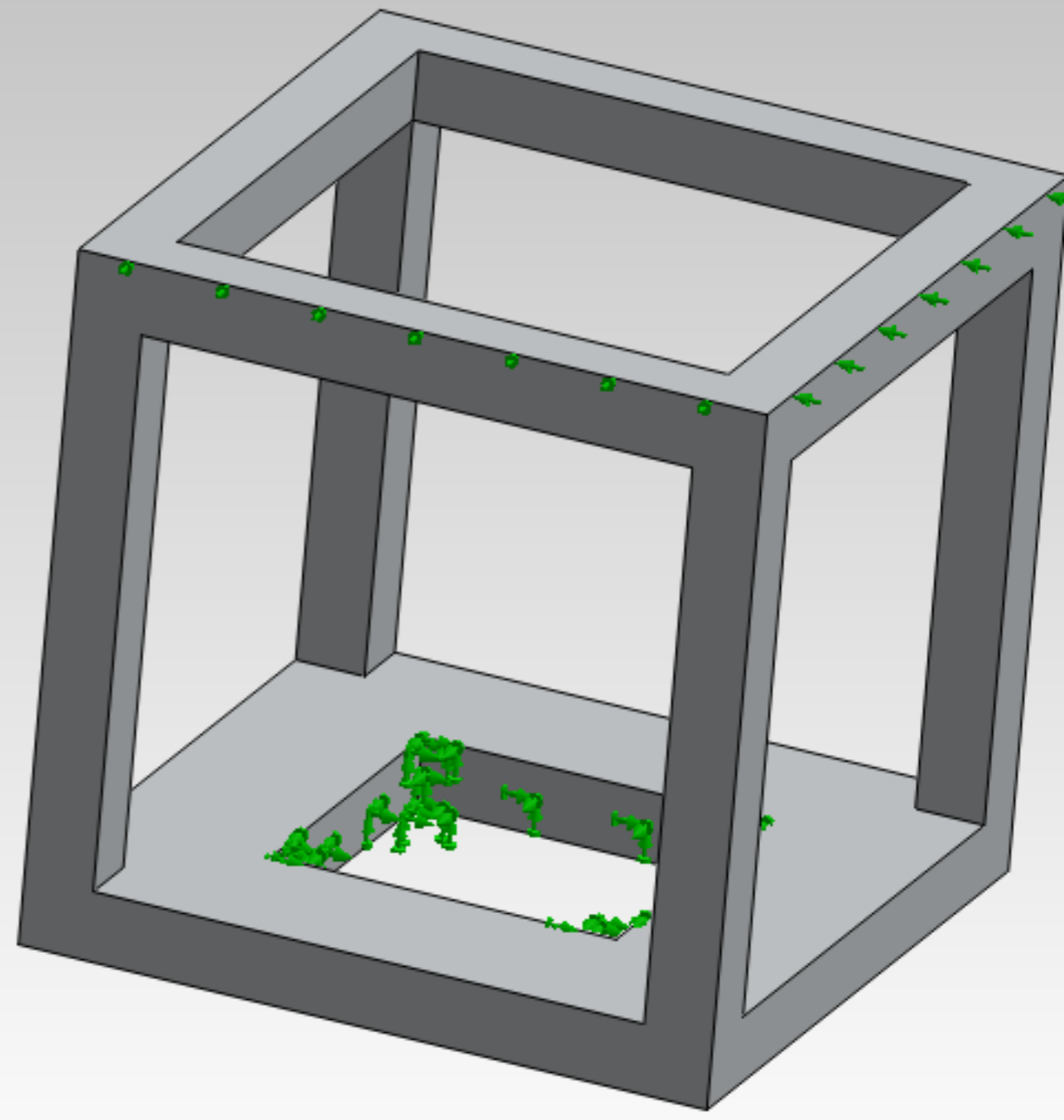
- 形式阻尼
- 從材料阻尼計算
- Rayleigh 阻尼

阻尼比例

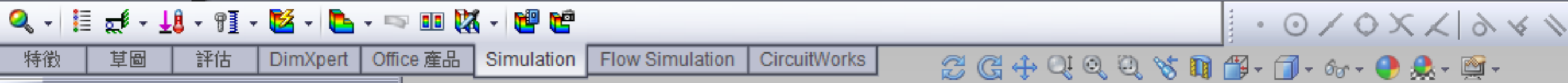
第一個模式	最後一個模式	阻尼比例
1	5	0.0001

頻率

零件2-2 (預設 << 預設 >> 顯...



模型 動作研究 1 研究 1 研究 2 研究 3 複製 研究 3 研究 4



特徵 草圖 評估 DimXpert Office 產品 Simulation Flow Simulation CircuitWorks

右基準面
 原點
 填充-伸長1
 除料-伸長1
 除料-伸長2
 除料-伸長3
 除料-伸長4

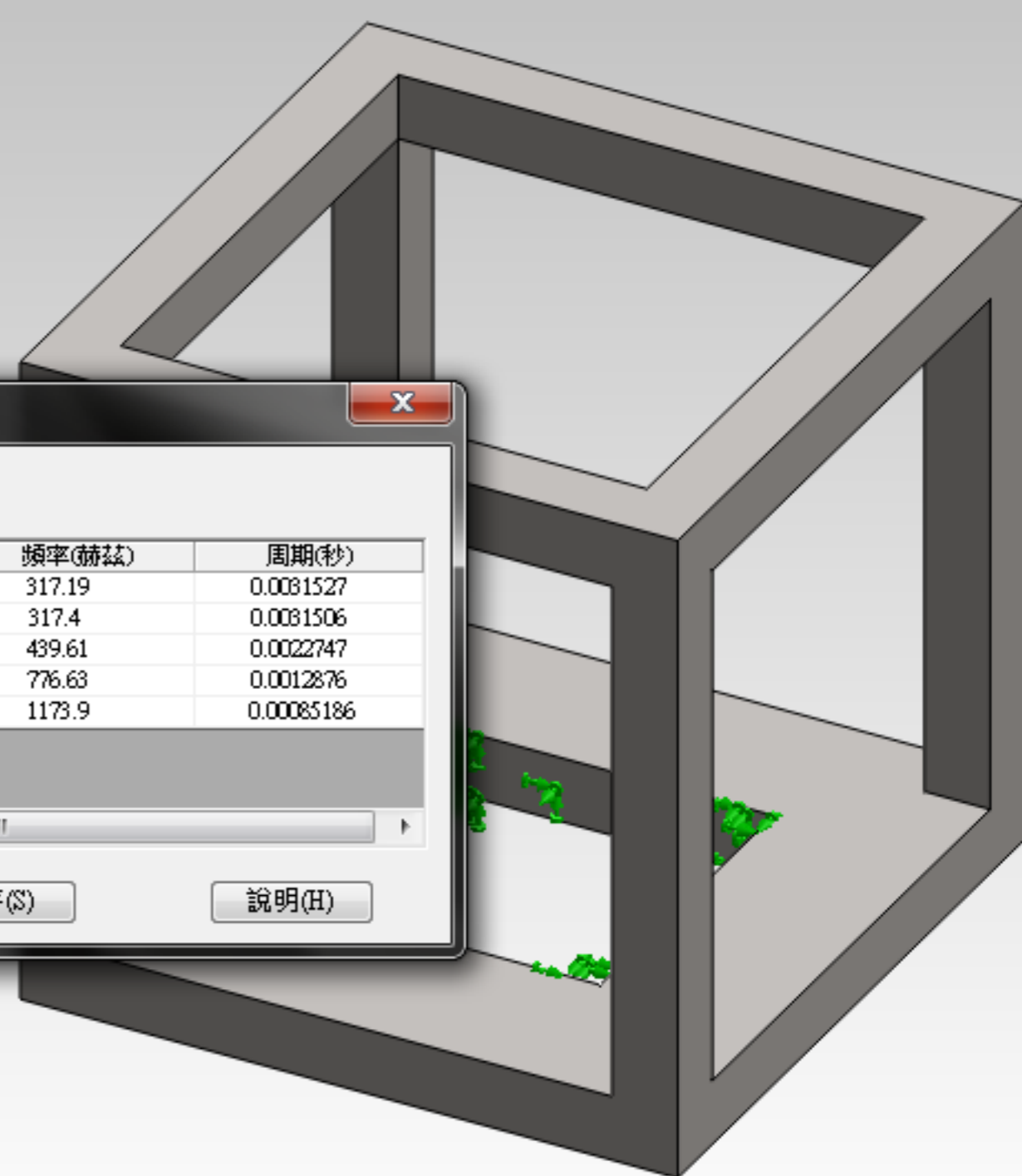
研究 3 (-預設-)
 零件2-2 (-AISI 304-)
 連接
 固定物
 固定-1
 外部負載
 網格
 結果
 位移1 (-合位移 - 模態 1-)
 位移2 (-合位移 - 模態 2-)
 位移3 (-合位移 - 模態 3-)
 位移4 (-合位移 - 模態 4-)
 位移5 (-合位移 - 模態 5-)

列出模式

研究名稱: 研究 3

模態數	頻率(弧度/秒)	頻率(赫茲)	周期(秒)
1	1992.9	317.19	0.0031527
2	1994.3	317.4	0.0031506
3	2762.2	439.61	0.0022747
4	4879.7	776.63	0.0012876
5	7375.8	1173.9	0.00085186

關閉(C) 儲存(S) 說明(H)

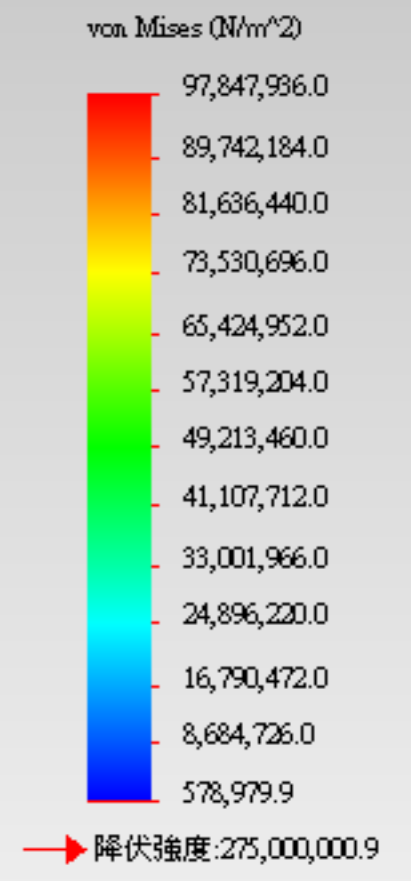
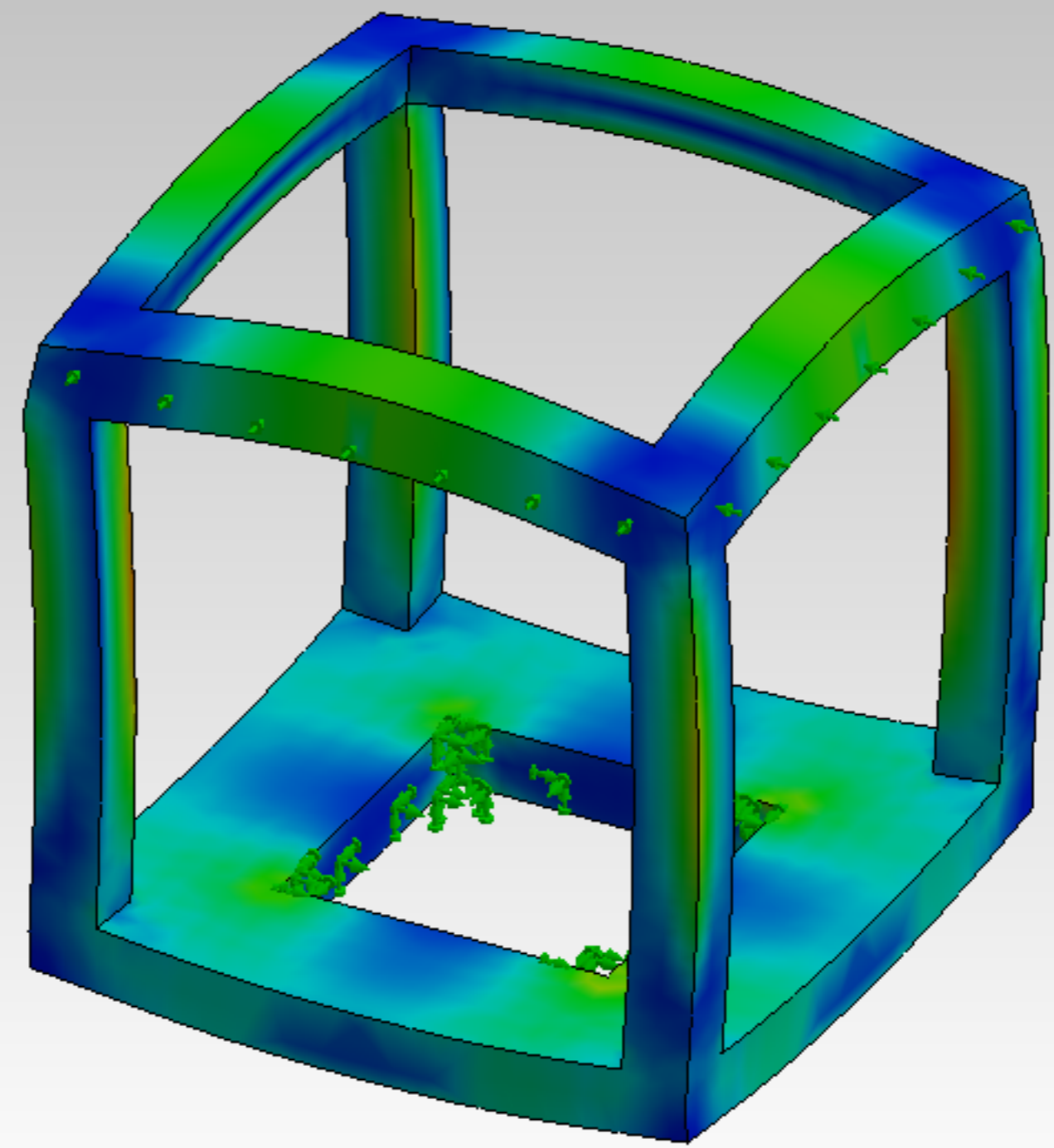


*不等角視圖



Office 產品 Simulation Flow Simulation CircuitWorks

模型名稱: 零件2-2
研究名稱: 研究 1
繪圖類型: 節點應力的 RMS 值 應力1
變形比例: 40.3583



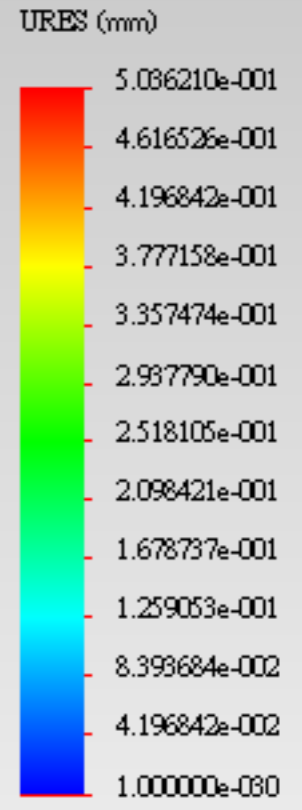
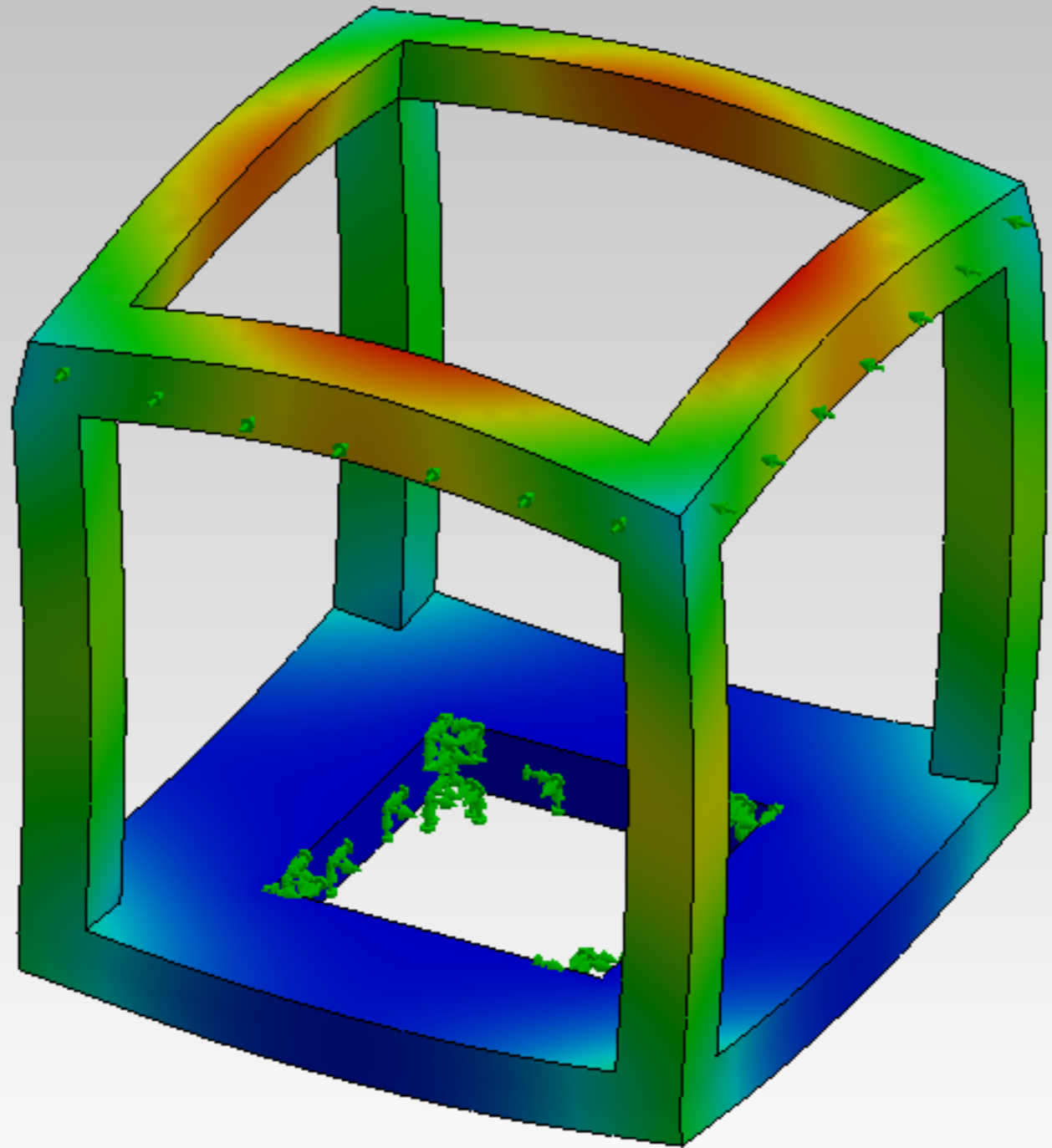
*不等角視圖

教育版。僅供教學使用



Office 產品 Simulation Flow Simulation CircuitWorks

模型名稱: 零件2-2
研究名稱: 研究 1
繪圖類型: 位移的 RMS 值 位移1
變形比例: 40.3583



*不等角視圖

教育版。僅供教學使用