時頻分析與精密機械應用研討會

Visual Signal於迴轉機械之振噪檢測

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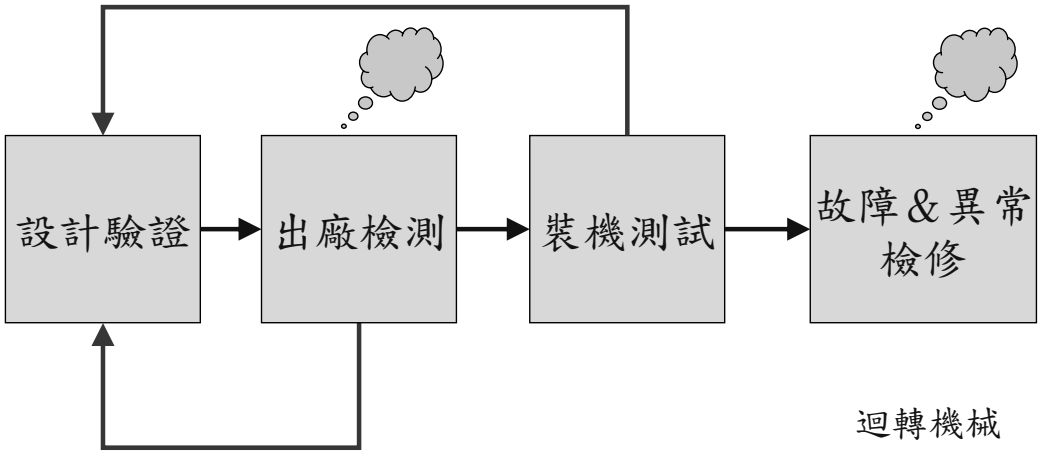
Contents

- Visual Signal
- Sound and Vibration Module (SVM)
- Time-Frequency Analysis (TFA)
- Empirical Mode Decomposition (EMD)
- Independent Component Analysis (ICA)
- Multi-Scale Entropy (MSE)
- Applications

Why振動噪音檢測？



			迴轉機械
FEM模型	生產履歷：	客戶機台	主軸
原型驗證	製造&組裝	動態特性	齒輪
參數調測	品保資料庫	操作頻率	軸承
	臨界轉速	臨界轉速	馬達

各應用層面可檢測項目

設計驗證	組裝測試	出廠檢測	裝機測試	故障檢修
◆SOP設計與驗證	◆SOP設計與驗證	◆SOP設計與驗證	◆SOP設計與驗證	◆SOP設計與驗證
◆有限元素模擬分析	◆振噪量測分析	◆振噪量測分析	◆振噪量測分析	◆振噪量測分析
◆振噪量測分析	◆動態精度檢測	◆QA/QC檢測報告	◆裝機負載檢測報告	◆故障檢測報告
◆模擬與量測比對	◆高低轉速變形效應之檢測分析	◆品保資料庫	◆整機操作頻率之測定	
		◆生產履歷	◆整機振動之來源鑑別與責任釐清	➢轉子異常檢修
➢轉子/主軸	➢轉子/主軸			➢軸承異常檢修
✓振動模態	✓動平衡測試	➢轉速倍頻激振之檢測	➢整機臨界轉速之檢測	➢馬達異常檢修
✓靜態變形剛性	✓偏心測試	➢轉子臨界轉速之檢測	➢整機共振頻段檢測	➢齒輪箱異常檢修
✓動態運轉剛性	✓對心測試	➢轉子共振頻段檢測	➢整機高低轉速之運轉振動等級檢測	
➢軸承支撐剛性分析	➢軸承	➢轉子高低轉速之運轉振動等級檢測		
✓軸承型式之選用	✓對心測試	➢熱機溫昇效應之檢測		
✓軸承位置之確認	✓軸承預壓測試			
✓軸承預壓之調測				

Why Visual Signal & SVM?

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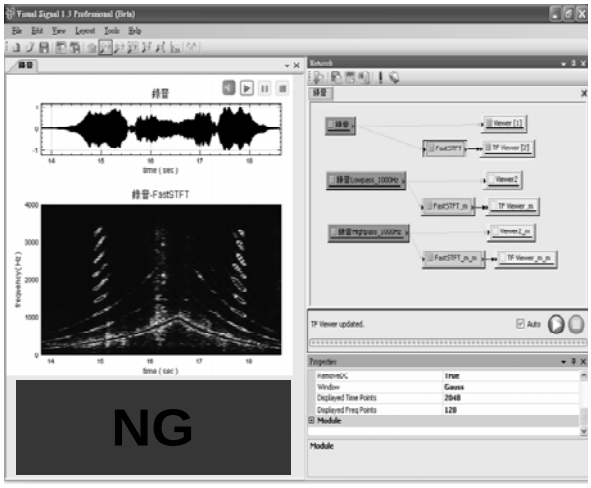
PC-based檢測系統架構➔時頻分析儀

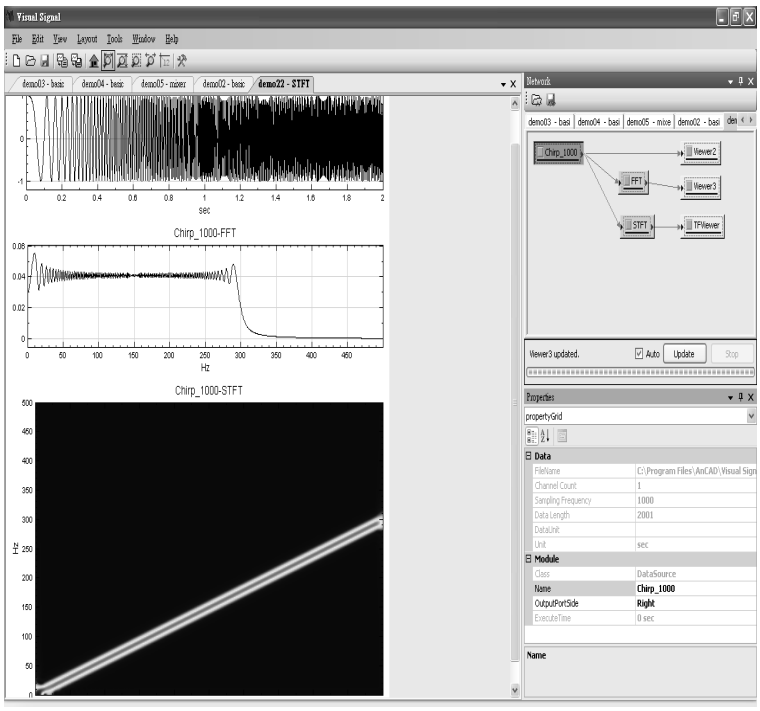
- 軟體
  - 檢測與監測操作平台(Visual Signal)
  - 資料擷取軟體(DAQ API)
  - 振動與噪音分析模組(SVM)



- 硬體
  - 資料擷取卡(NI DAQ)
  - 加速規
  - 麥克風

AnCAD

Visual Signal：軟硬體整合平台



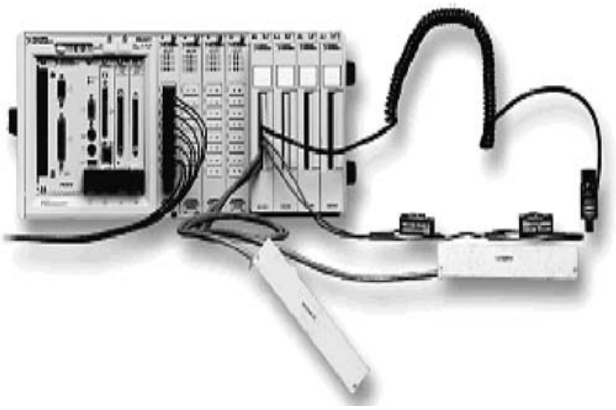
輸入
- 資料擷取硬體
- 檔案
- 使用者自建函數

分析
- 雜訊濾除
- 趨勢移除
- 時間域分析
- 頻率域分析
- 時頻分析
- 統計分析
- 矩陣與數學運算
- MATLAB, DLL

輸出
- 圖形
- 檔案
- 訊號產生器

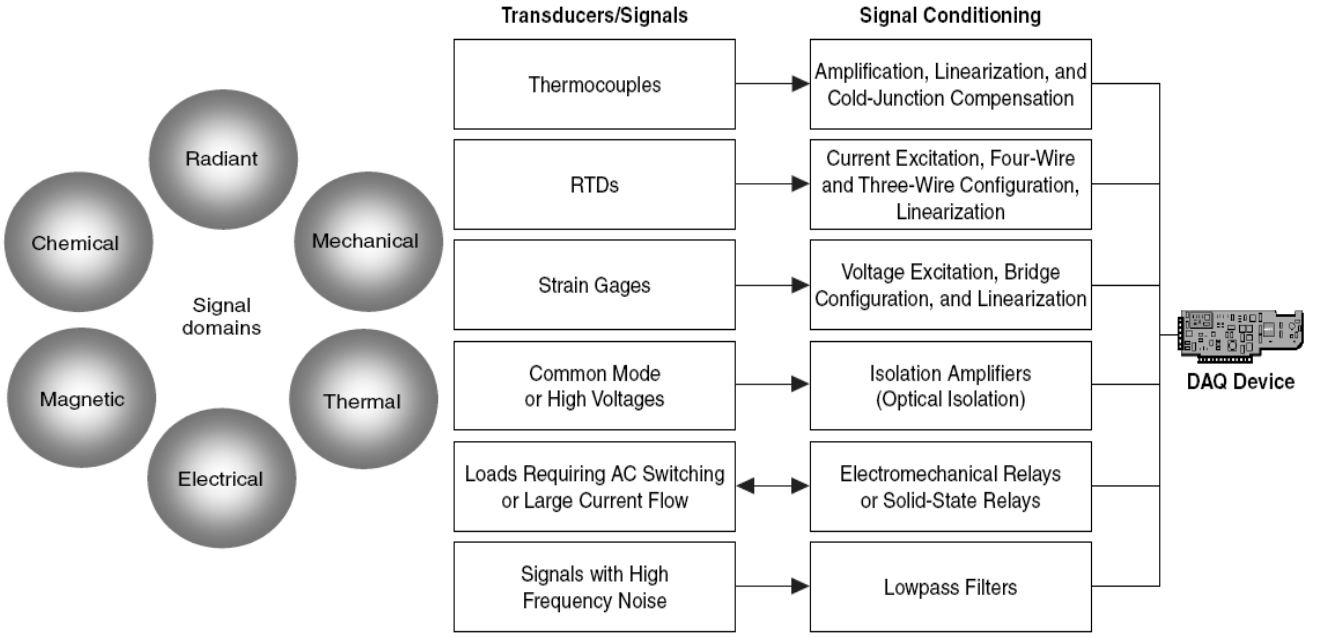
AnCAD

資料擷取卡擴充性：可攜式、工業用、分散式

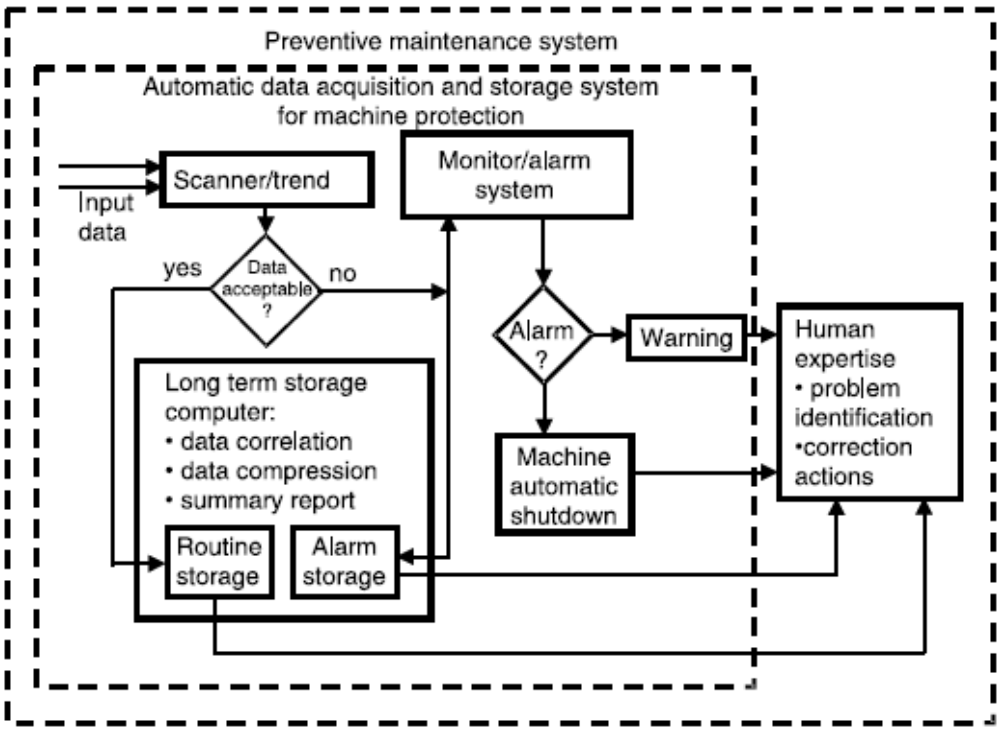


AnCAD

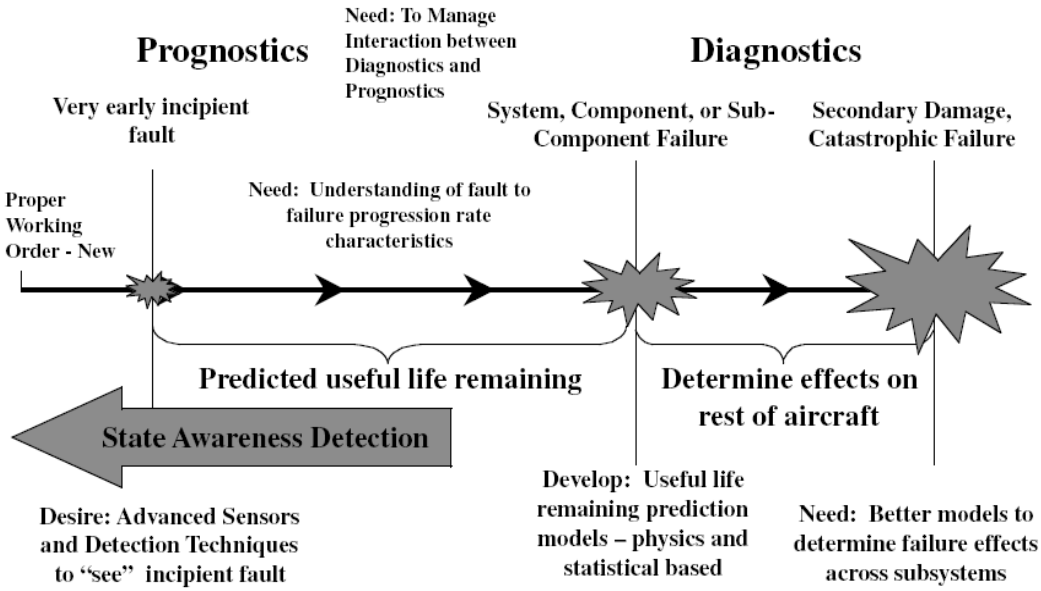
感測器擴充性：多物理場訊號擷取與整合



軟體擴充性：預防保養系統



軟體擴充性：線上故障預知與診斷系統



The Goal is To Detect "State Changes" as Far to the Left As Possible

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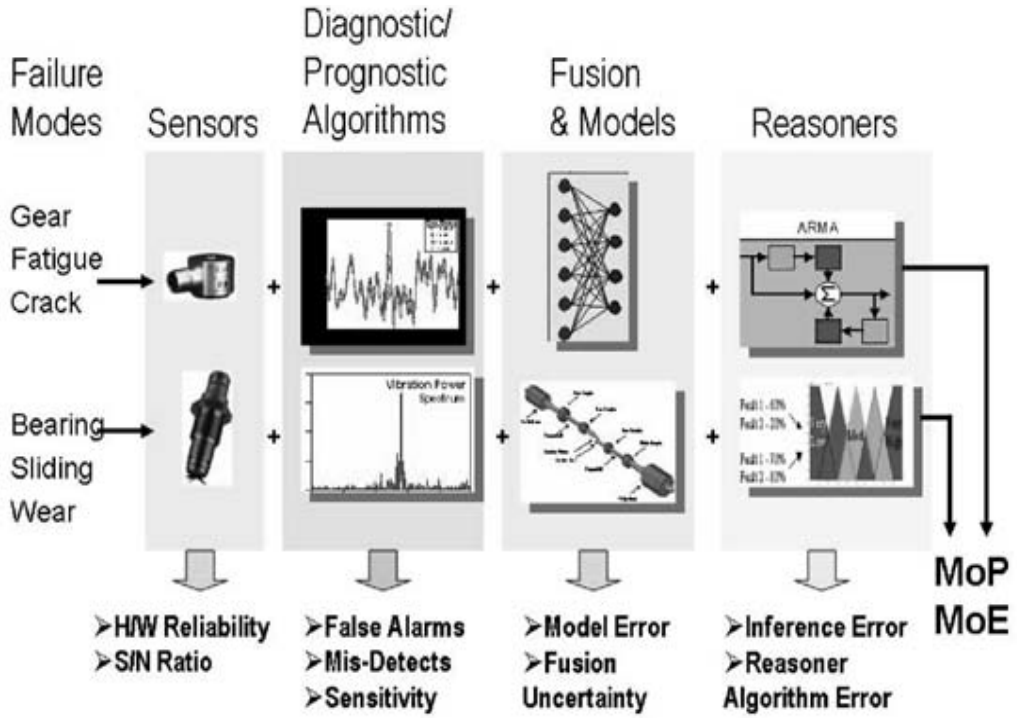
軟體擴充性：智慧型診斷系統



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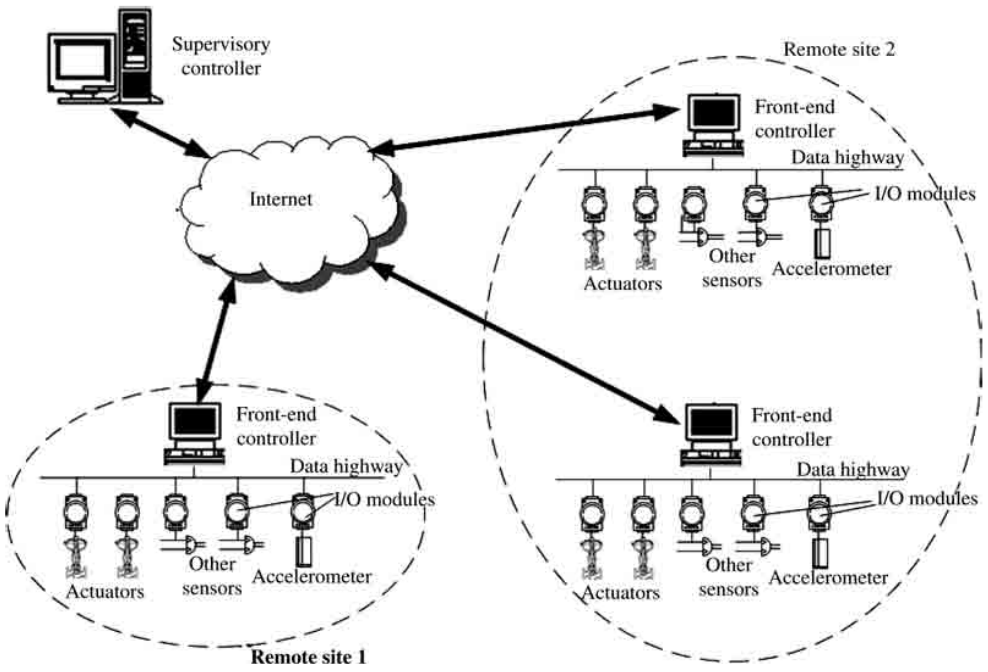
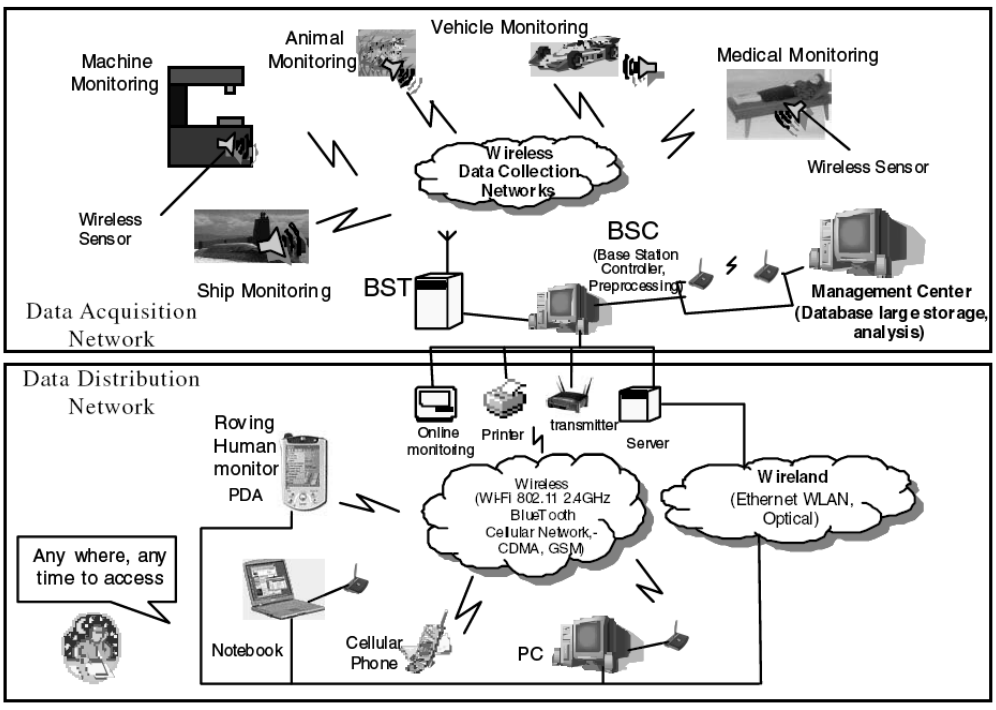
軟體擴充性：遠端監測與控制系統



軟體擴充性：資料庫建立與傳輸網路系統



Why Sound and Vibration Module?

- Vibration Level
  RMS: RMS, Peak, Peak-to-Peak
  Crest Factor
  Peak : Max, Min, True Peak, True Peak-to-Peak
- Sound Level
  A, B, and C Weighting
  Octave
- Order Tracking
  Digital Tacho
  Order Tracking by STFT
  Order Tracking by EnMorlet
- Bearing Analysis
  Bearing Defect
  Envelope Detection
- Cepstrum
- Scale…

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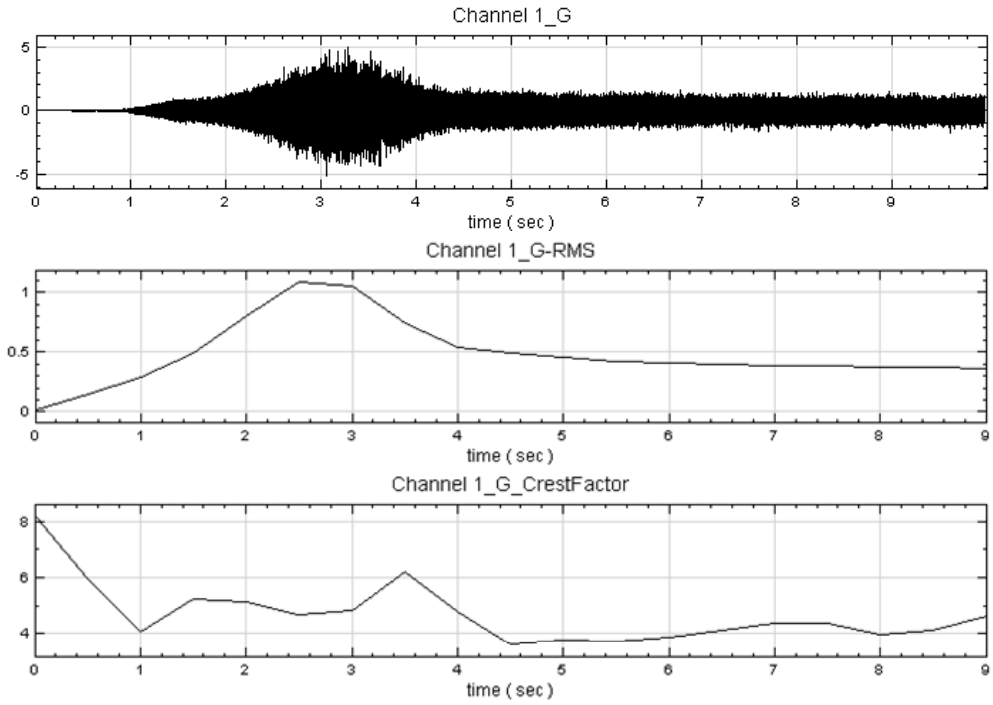
Vibration Level: RMS & Crest Factor



$$RMS = \sqrt{\frac{1}{T}\int_0^T a^2(t)\,dt}$$

$$CrestFactor = \frac{TruePeak}{RMS}$$

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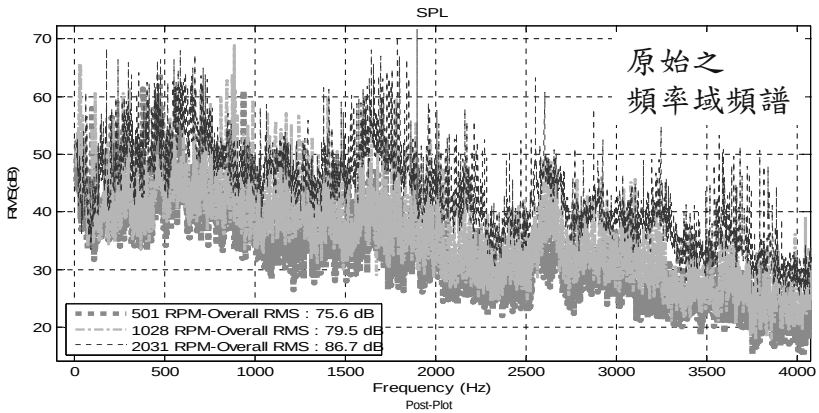
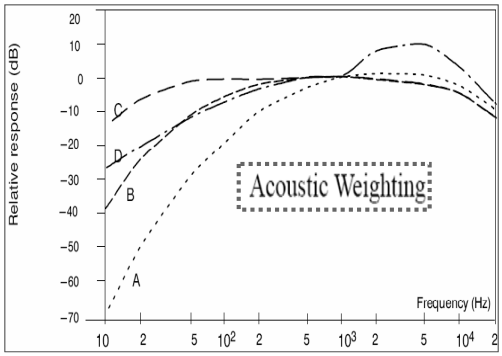
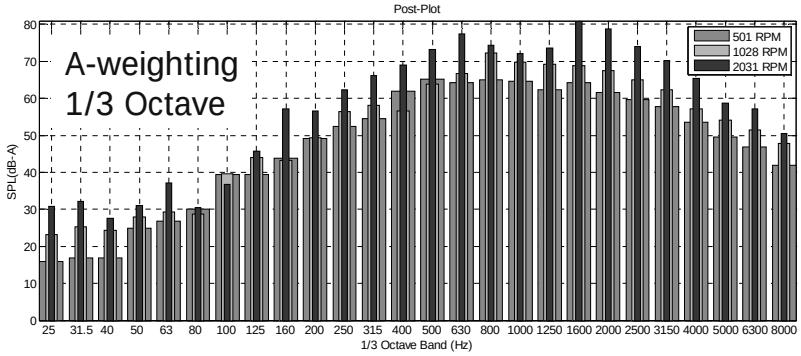
Sound Level: Weighting & Octave







ThirdOctave：$\frac{1}{3}$八度音

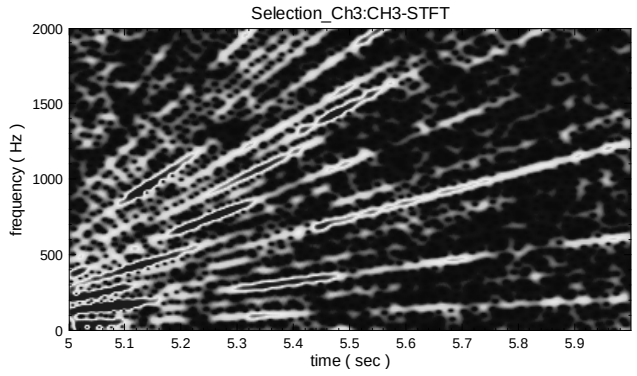
Octave：八度音

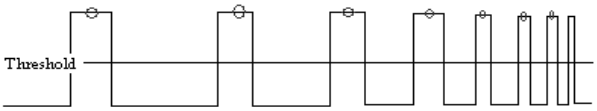
N_Octave：$\frac{1}{n}$八度音（$n=\frac{1}{1},\frac{1}{3},\frac{1}{6},\frac{1}{12},\frac{1}{24}$）

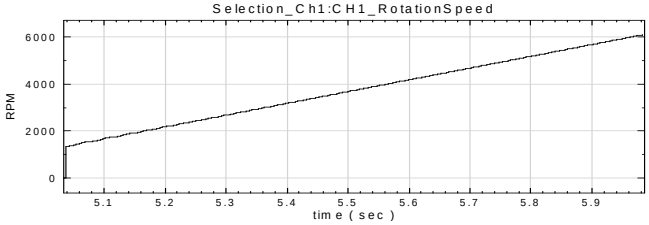
人耳效應

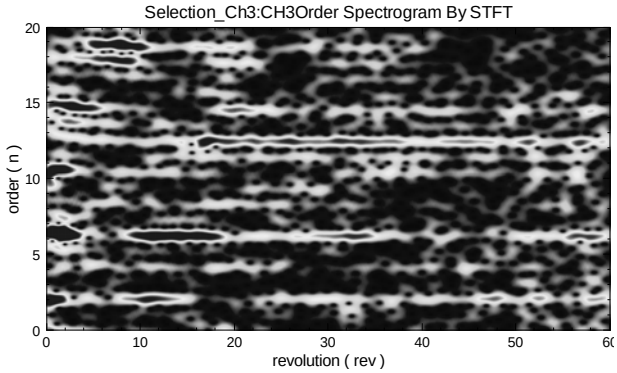
AnCAD

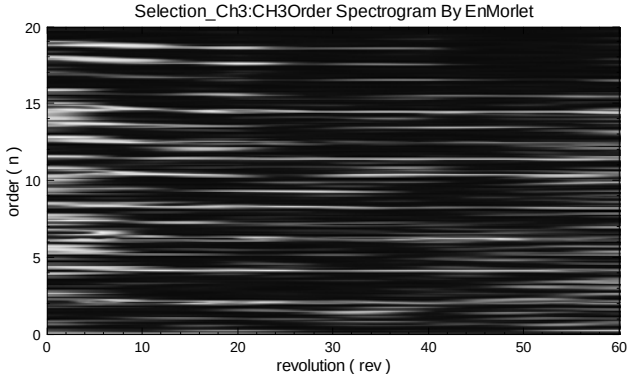
Order Tracking



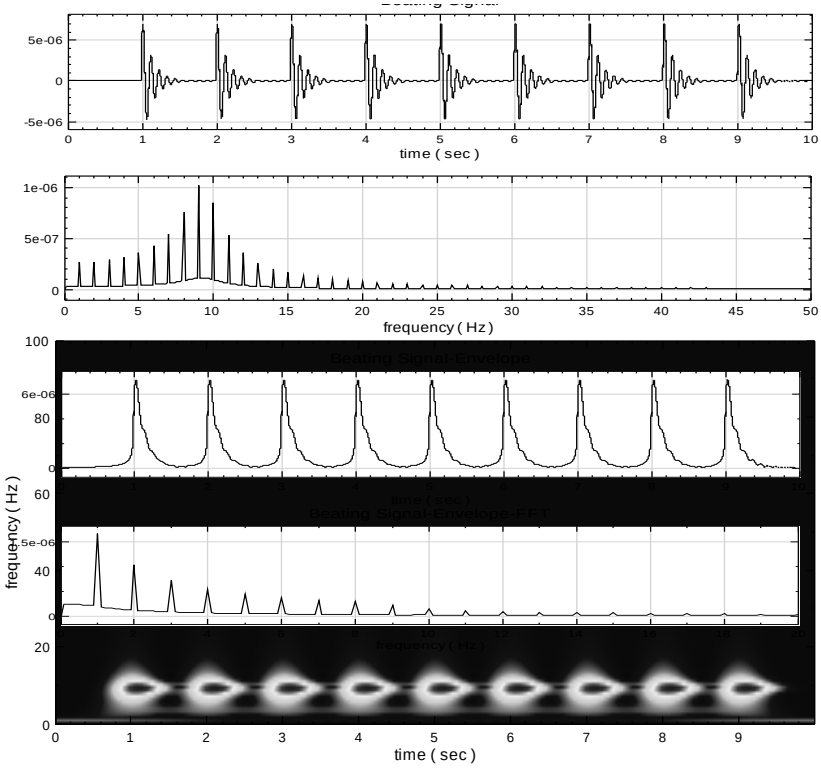


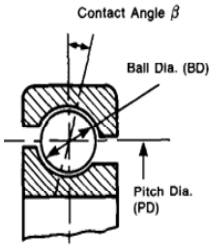






Bearing Analysis





n = number of balls or rollers
f_r = relative rev./s between inner and outer races

Impact Rates f(Hz) (assuming pure rolling motion)

For Outer Race Defect: $f(Hz) = \frac{n}{2} f_r \left(1 - \frac{BD}{PD} \cos \beta\right)$

For Inner Race Defect: $f(Hz) = \frac{n}{2} f_r \left(1 + \frac{BD}{PD} \cos \beta\right)$

For a Ball Defect: $f(Hz) = \frac{PD}{BD} f_r \left[1 - \left(\frac{BD}{PD} \cos \beta\right)^2\right]$

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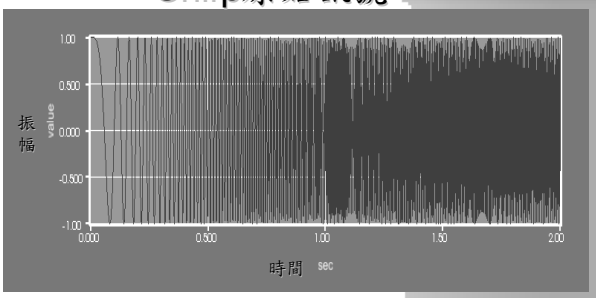
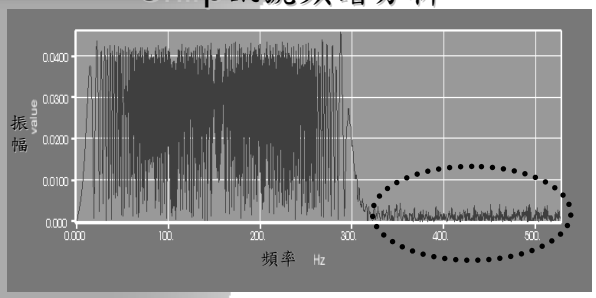
Why高解析時頻分析? ⇨ 細微異常檢出

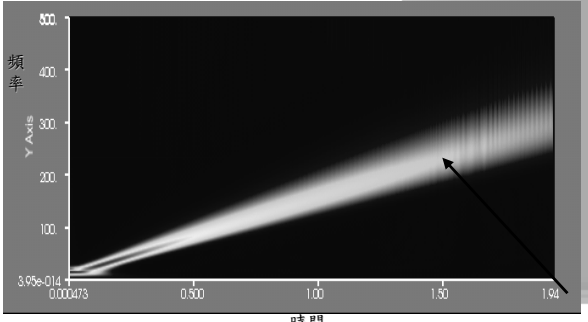
Chirp原始訊號



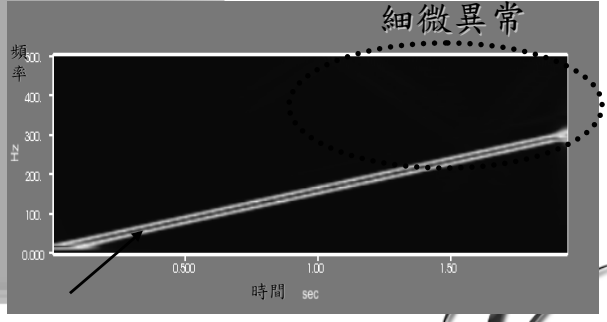
Chirp訊號頻譜分析



Morlet Transform時頻圖



Enhanced Morlet Transform



色彩表示其能量或振幅

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EMD

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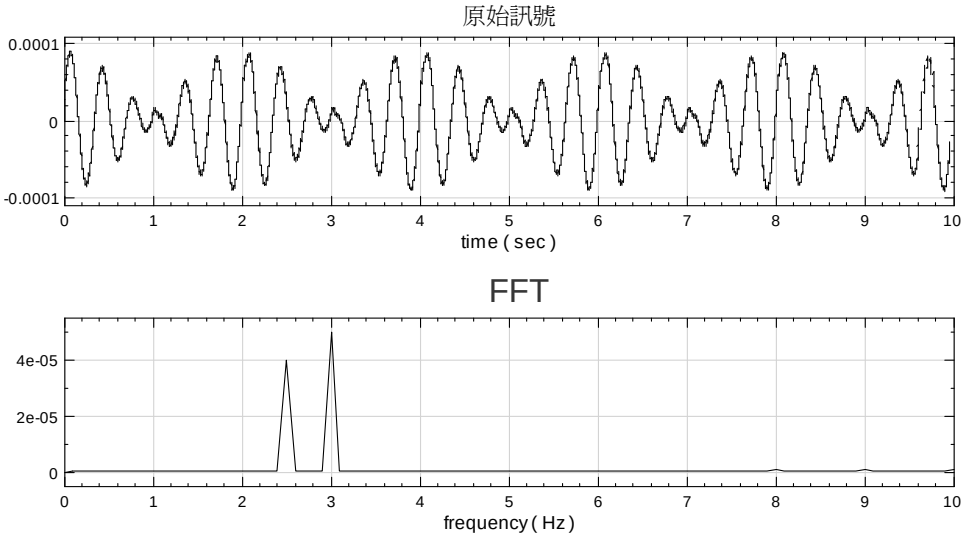
EMD 應用於微小損壞訊號偵測



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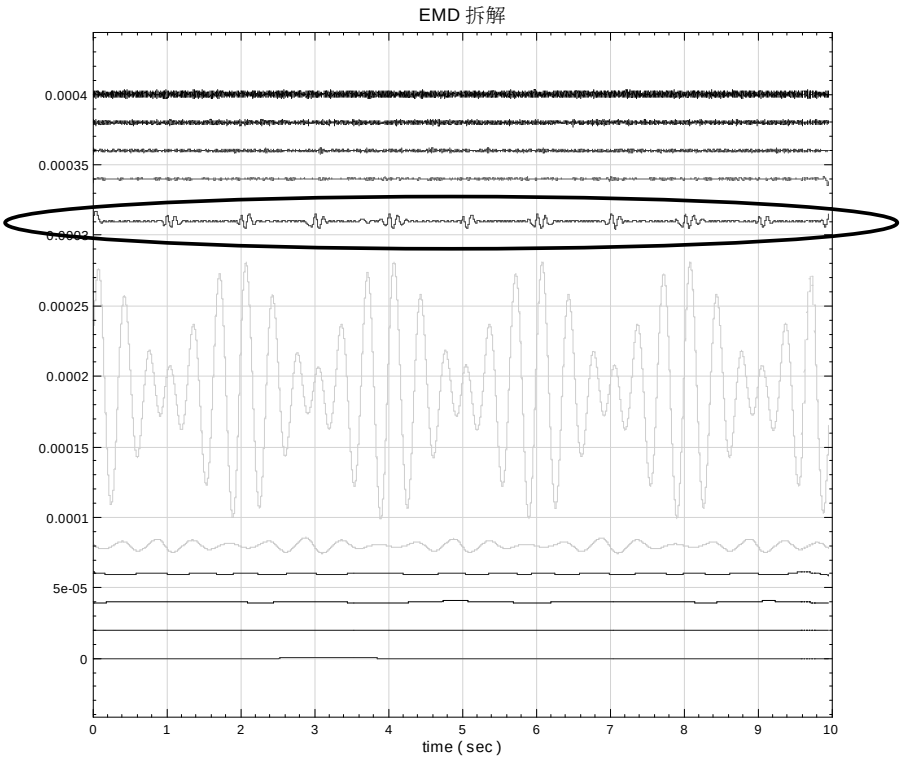
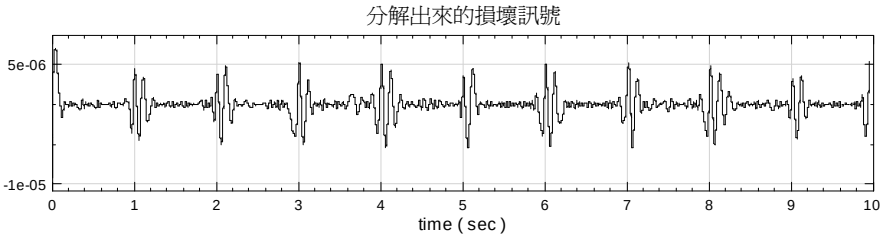
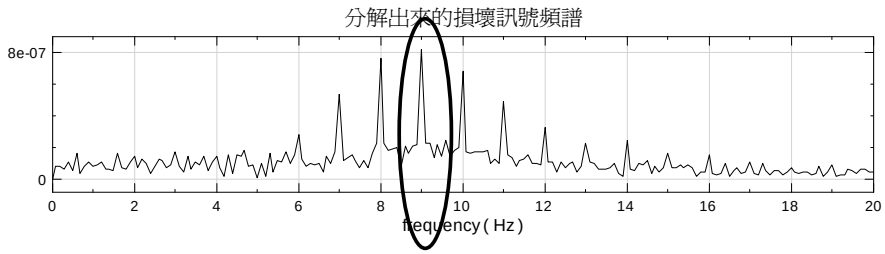
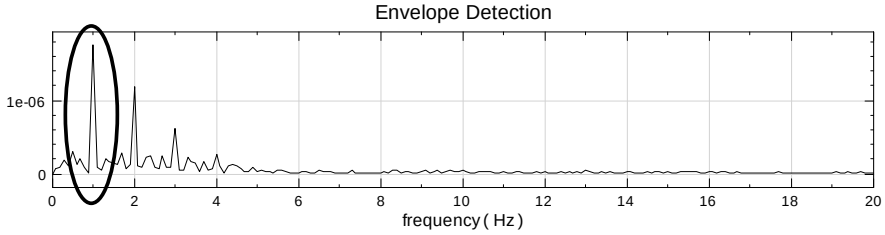
EMD 應用於微小損壞訊號偵測



EMD 應用於微小損壞訊號偵測

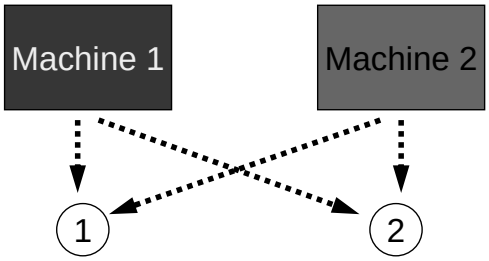


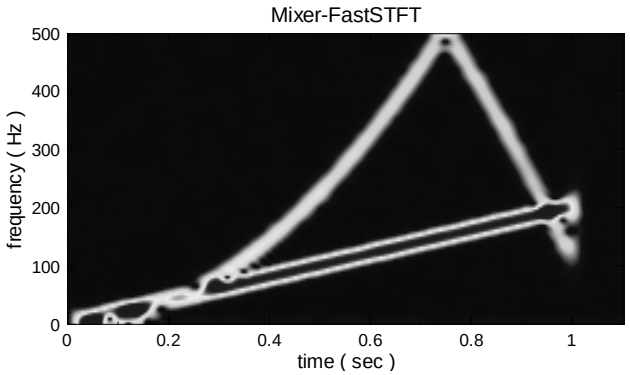




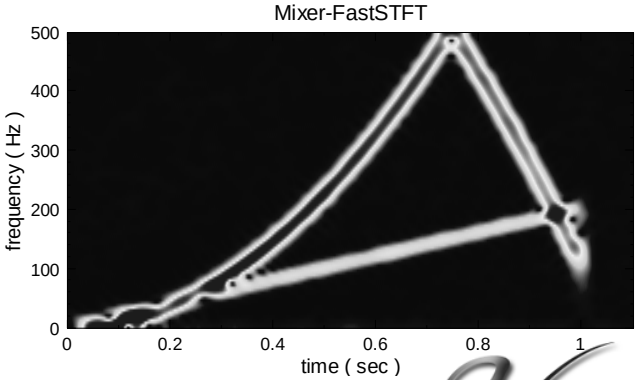
ICA

2個量測點之混合訊號





1

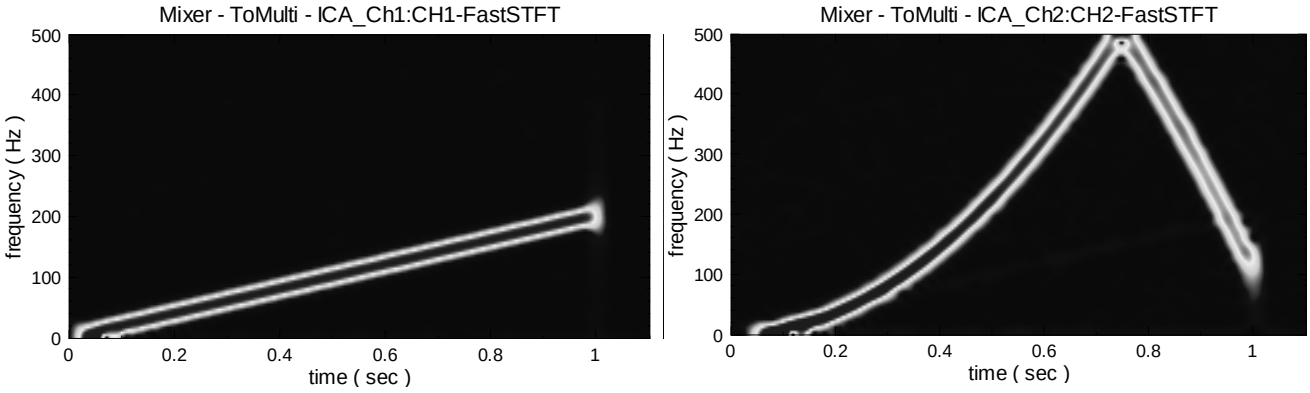


2

ICA分離 ⇨ 2個獨立振動源

Machine 1

Machine 2



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MSE

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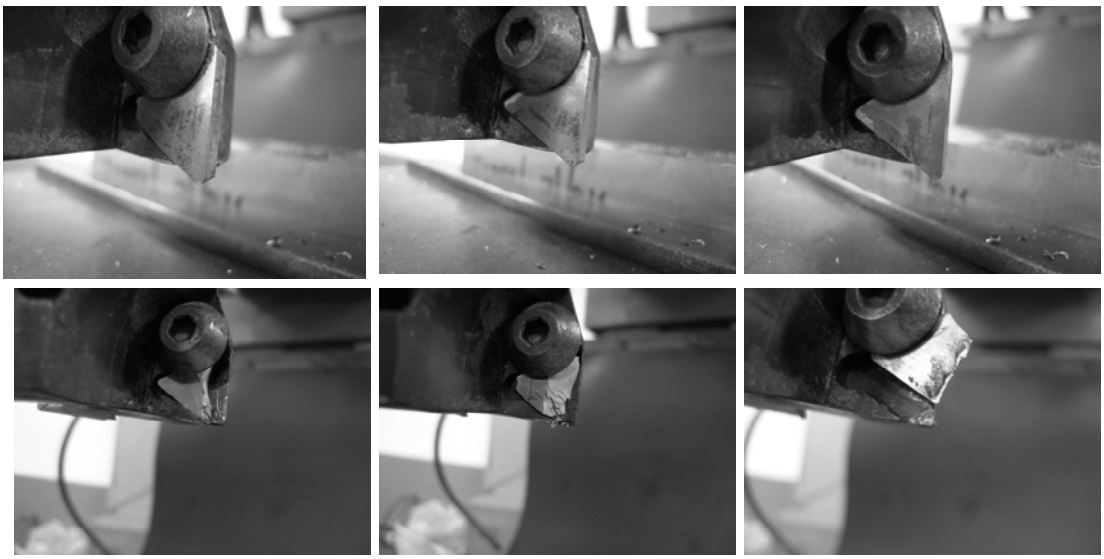
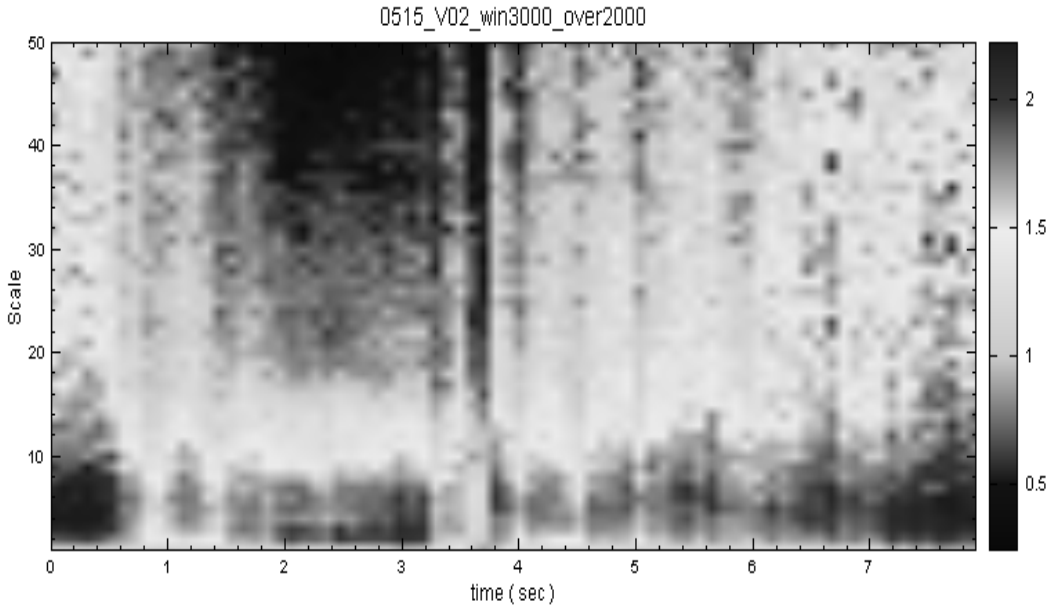
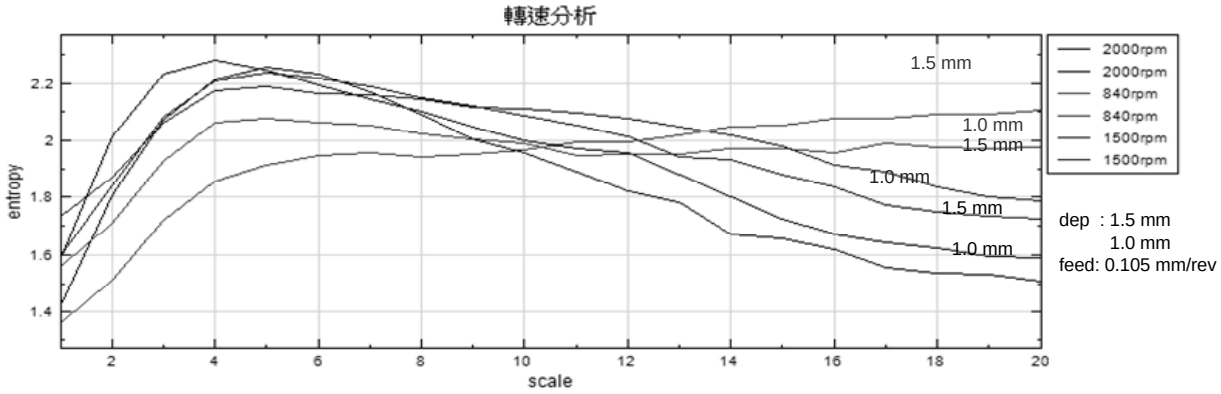
MSE：刀具損壞/加工異常檢測



MSE： Rolling MSE



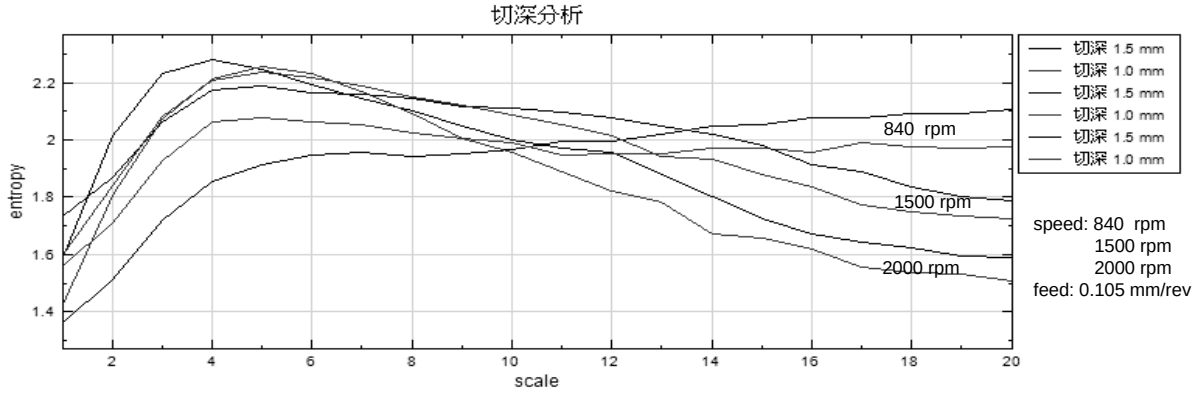
MSE：轉速分析



MSE - 轉速分析

1. 產生較明顯的變化與資料相似度。
2. 轉速在MSE上的表現明顯(決定整體趨勢線走向)。

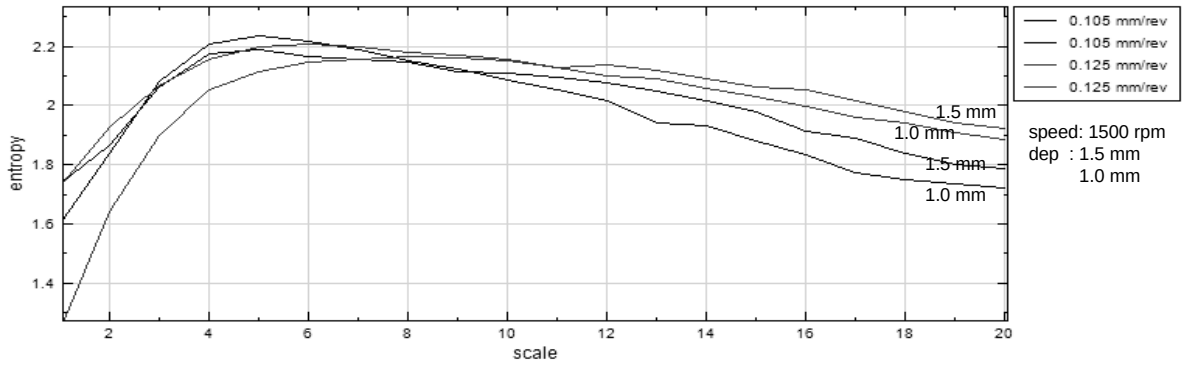
MSE：切深分析



MSE - 切深分析

1. 淺切深的趨勢線較低，穩定度相對較高。

MSE：進給分析



MSE - 進給分析

1. 進給的MSE趨勢線比轉速及切深的趨勢線不明顯。

製程參數明顯度判別: 轉速>切深>進給

Applications

應用實例：系統整合平台

應變儀

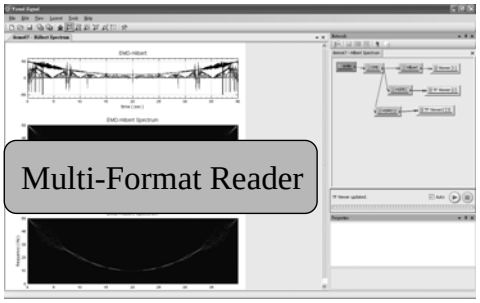
應變規
格式

振動儀

振動儀
格式

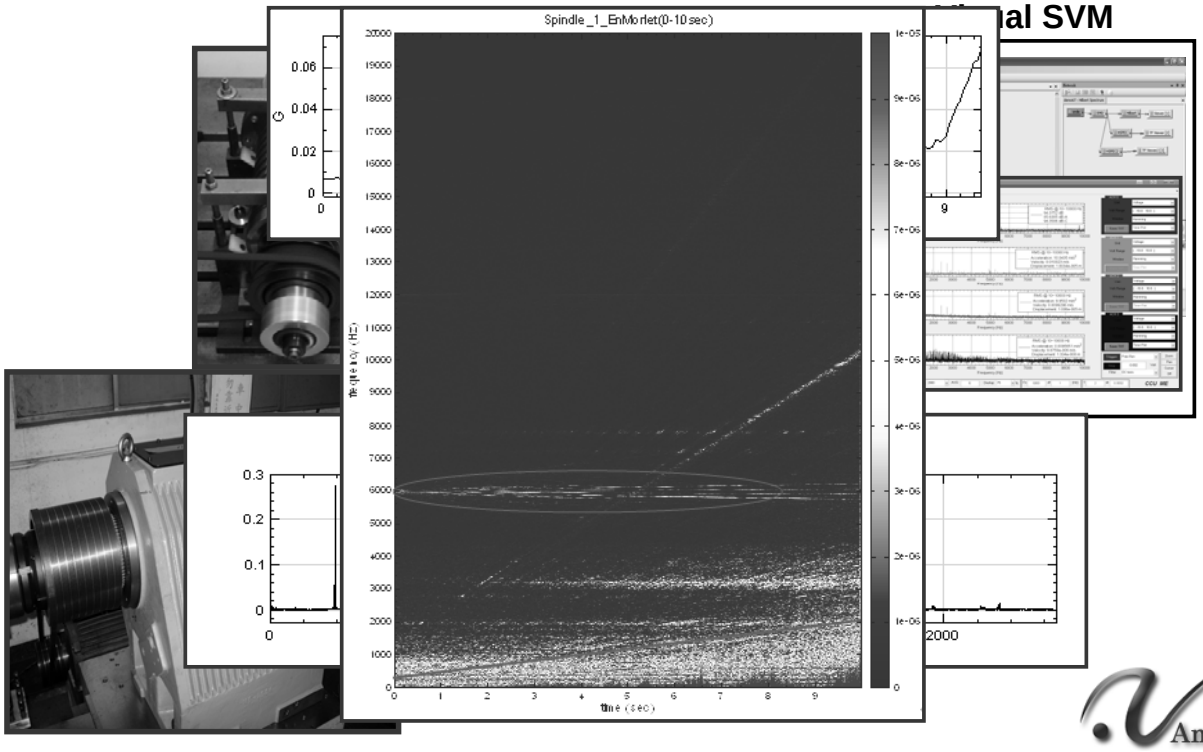
轉速計

轉速計
格式

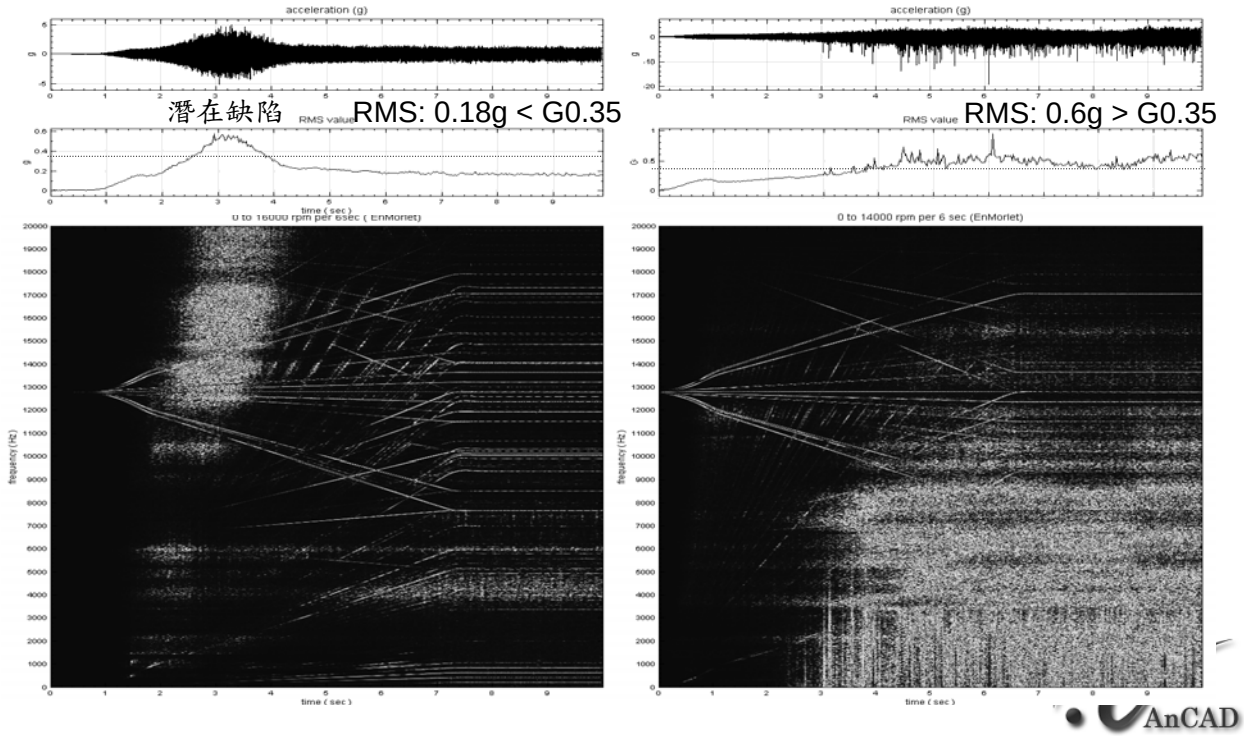


Visual Signal 分析

應用實例：主軸 QA 檢測系統



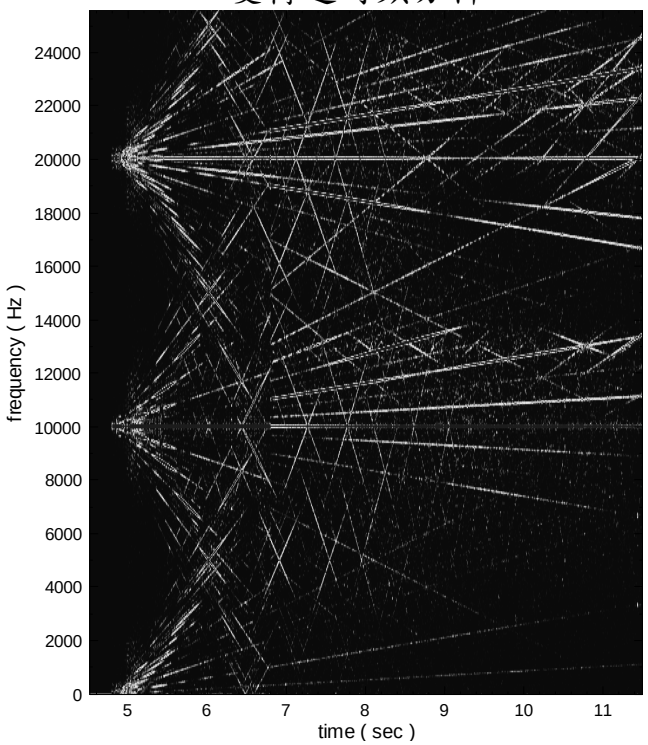
Why變轉速時頻分析? ⇨ 潛在缺陷檢出 先期故障排除



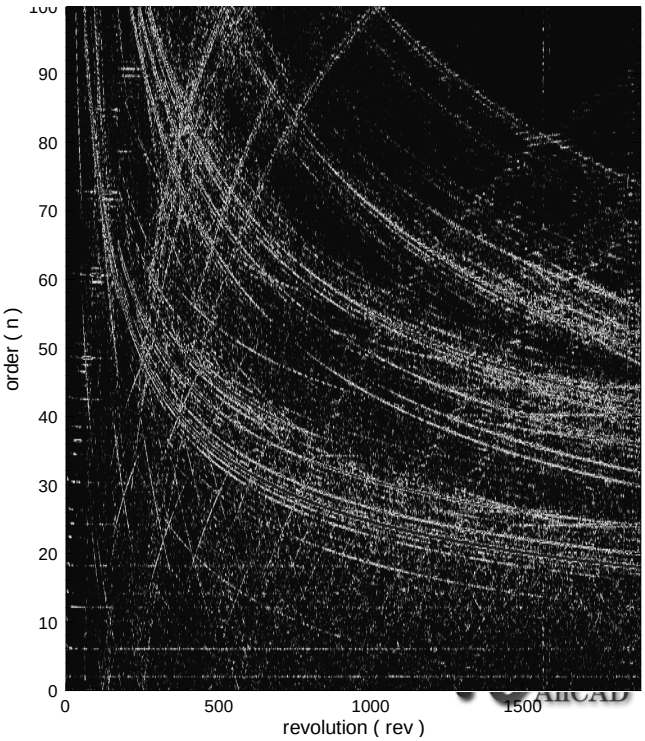
AnCAD

主軸之動態特性檢測
轉速倍頻、共振頻段、異常激振、頻率調變

變轉速時頻分析



轉速階次分析



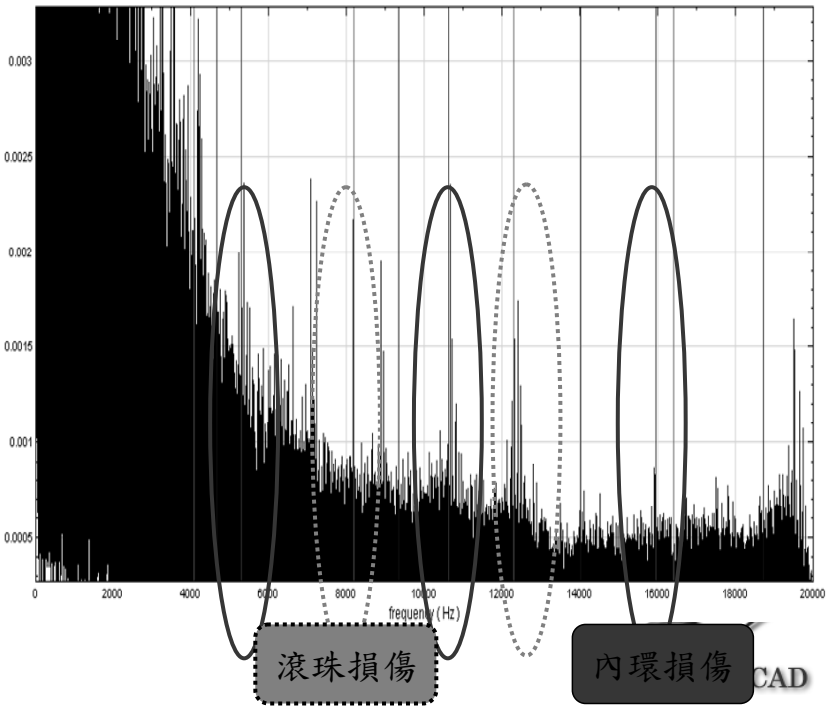
AnCAD

軸承之損壞特徵檢測
依據軸承規格自動計算內外環或滾珠損壞特徵頻率

Properties

內環損傷頻率	4889.3940246405655
外環損傷頻率	4110.6059753594345
滾珠損傷頻率	4092.8338640344609
參數	
轉速	360
軸承規格	
軸承平均直徑	100
接觸角	25
滾珠直徑	8.73
滾珠數量	25
模組	
類別	BearingDefect
名稱	Bearing Defect

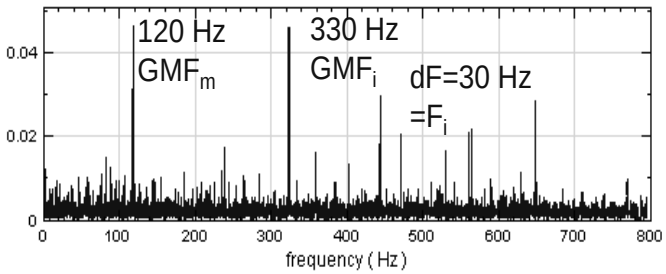
轉速
主軸每秒轉幾圈，單位爲(RPS)。



AnCAD

變速齒輪箱之嚙合異常檢測
偏心、對心、鬆脫、背隙、磨損、斷齒

正常齒輪箱之包絡線頻譜



異常之
轉速調變頻率

異常之
嚙合頻率

異常之齒輪
12齒

GMF_i=330 Hz

11齒

F_i=30 Hz

馬達輸入
1800RPM

GMF_m=120 Hz

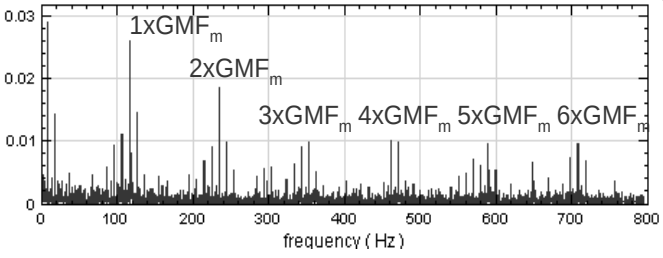
12齒

10 Hz

33齒

dF=10 Hz
=F_m

異常齒輪箱之包絡線頻譜



13齒

GMF_o=52 Hz

F_n=4 Hz

30齒

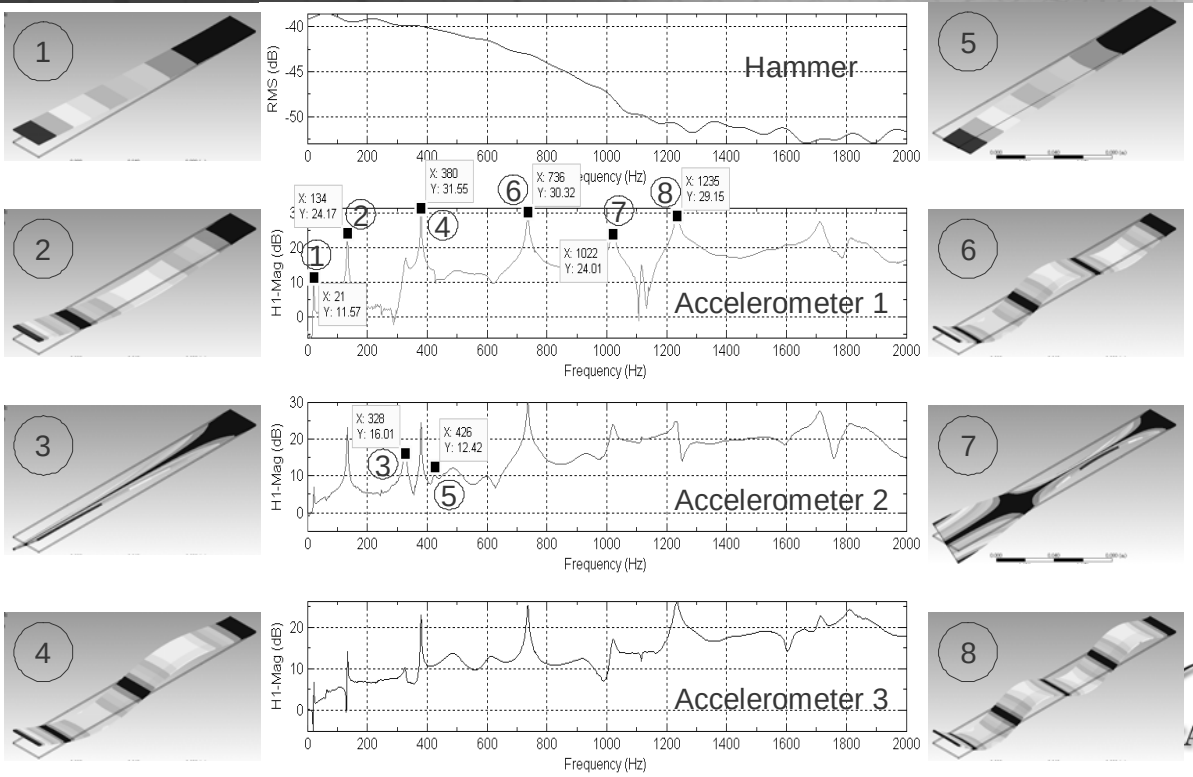
出力軸

F_o=1.67 Hz

31齒

AnCAD

結構之自然頻率檢測
利用敲擊測試之自然頻率驗證有限元素分析之正確性

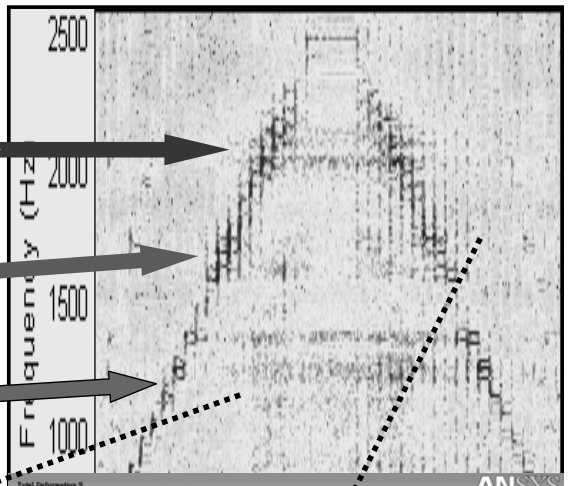


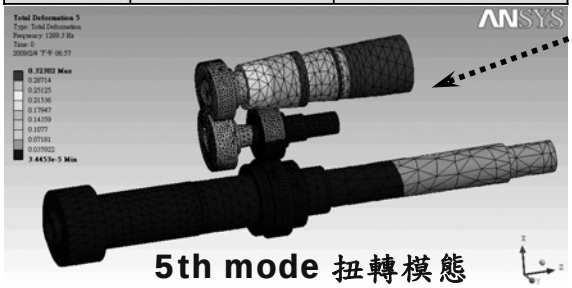
結構之自然頻率檢測
利用變轉速時頻驗證有限元素分析之正確性

FEM模擬結果：

模態	模態形式	自然頻率 (Hz)
12	Coupling	2289
11	Coupling	2176
10	Coupling	2003
9	Coupling	1784
8	Torsion	1541
7	Bending	1421
6	Bending	1415
5	Torsion	1289

量測結果：



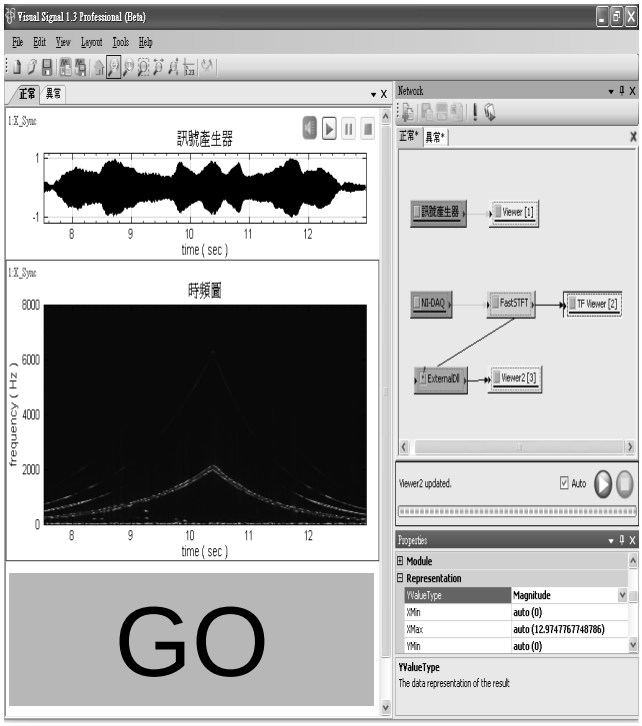


5th mode 扭轉模態

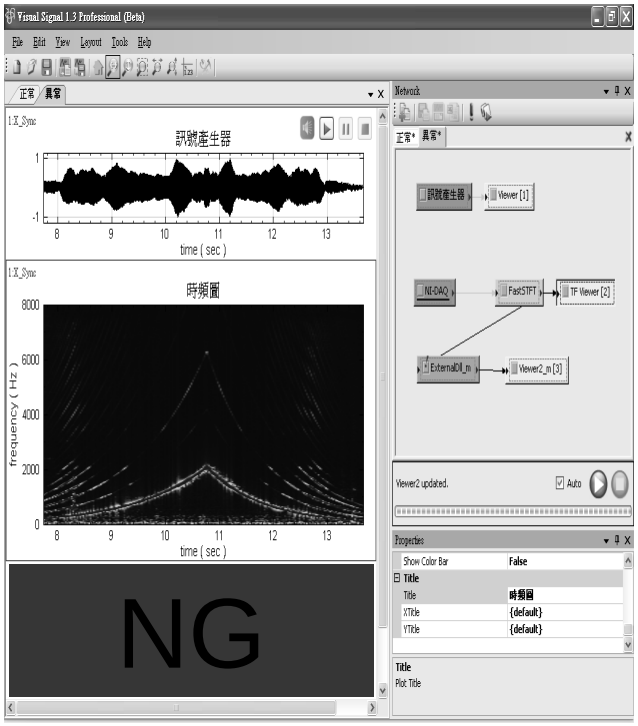
9th mode 耦合模態

出廠之振噪品管檢測
客製化自動檢測流程、訊號產生器、客製化品管介面

出廠異音檢測：合格



出廠異音檢測：不合格



Thank you