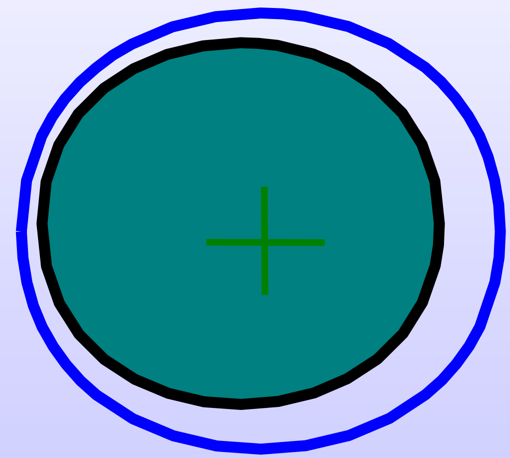
DAY 1

- Review IVT
- Maintenance Philosophy
- Time and Spectrum Domain
- ISO and Others Severity Chart
- Review Harmonics and Sideband
- Waterfall Plot
- Directional Analysis
- How to analyze by griding
- Digital and Analog Overall
- Phase Analysis

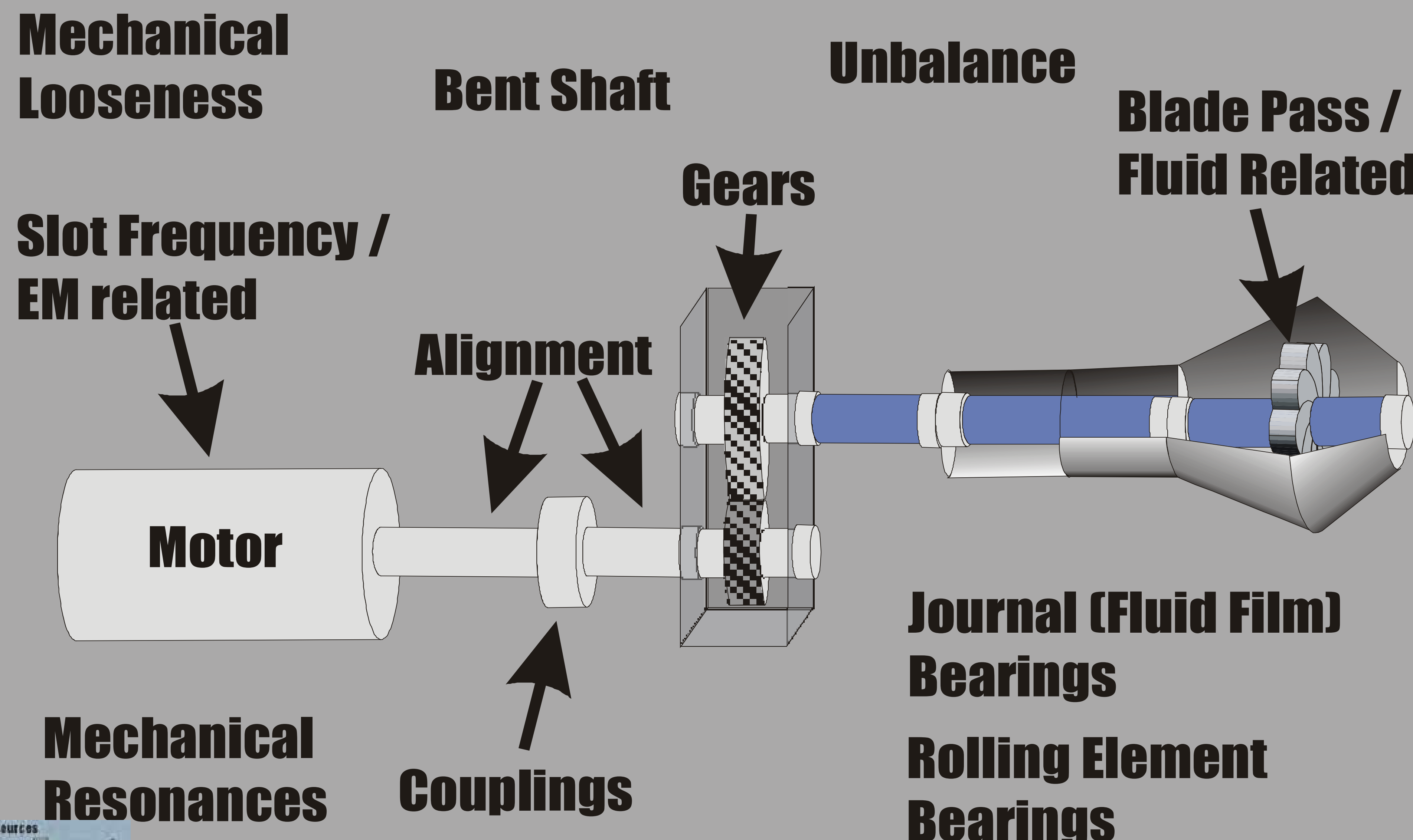
What is Vibration?

- Vibration is the motion of a body about a reference point caused by an undesirable mechanical force.

Shaft vibration caused by the shaft moving about the centerline of a journal bearing.



Vibration Excitation Sources



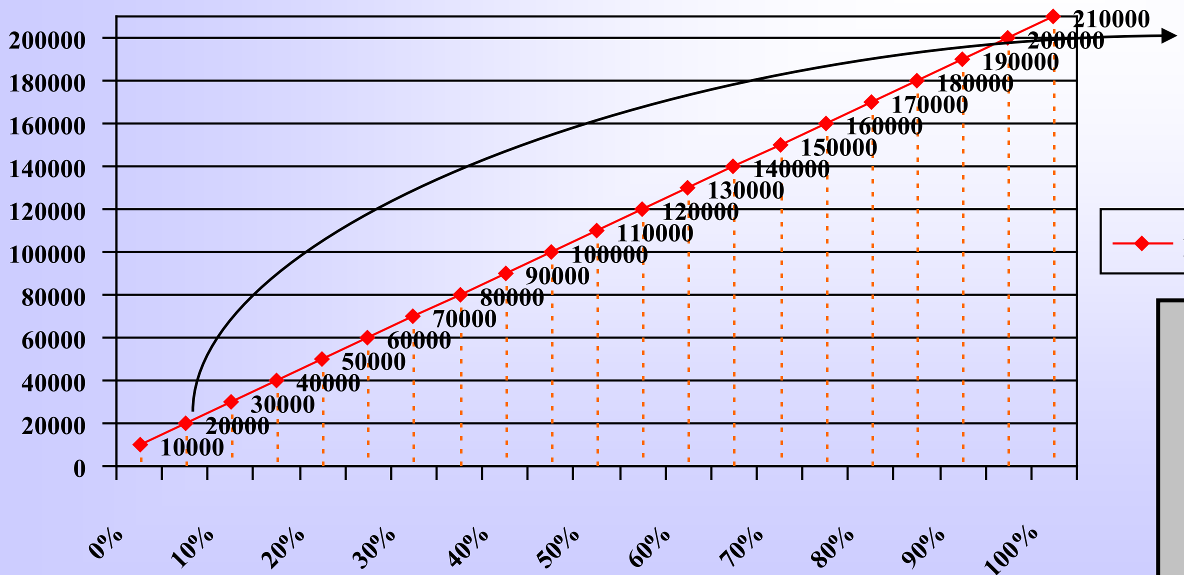
Vibration vs. Machine Life

$$L_{10}\text{ Life (Hours)} = \frac{16,666}{RPM} \times \left(\frac{Rate}{Load}\right)^3$$

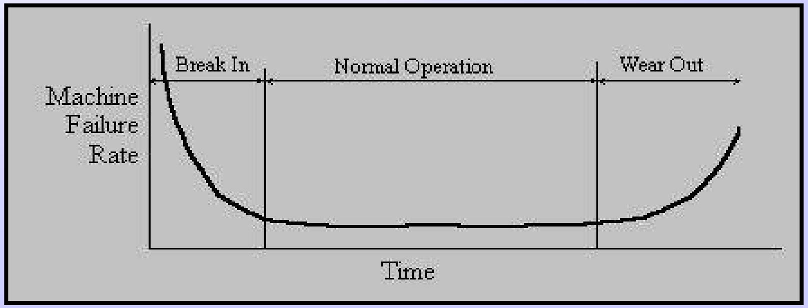
RPM = ความเร็วรอบของเครื่องจักร

Rate = Load ที่แนะนำจากผู้ผลิตลูกปืน

Load = Load ที่เกิดขึ้นจริง



L_{10} = 25,000 Hrs.



การคำนวณอายุของลูกปืน จาก Rotor Weight

$$L_{10} = \left[\frac{Rate}{Load}\right]^3 \times \left[\frac{16,666}{RPM}\right]$$

; L_{10} = Bearing Life Time in Running hours.

For Example; Centrifugal Fan Rotor

Blade Diameter = 1100 mm.

Rotor Load = 500 Kgs.

Speed = 1485 RPM

Rated Bearing Capacity = 10000 Kgs..

$$L_{10} = \left[\frac{10000}{500}\right]^3 \times \left[\frac{16,666}{1485}\right]$$

From the above Equation,
the expected life time is about 89,787 Hours

การคำนวณอายุของลูกปืน จาก Dynamic Load หรือ Vibration

Example ; เกิด Unbalance ขนาด 30 g ที่ตำแหน่งนอกสุดของเพลา

30 g at 550 mm. = 16,500 g-mm.=1,650 g-cm.

$$W = \frac{mr\omega^2}{g} = \frac{mr \times (2\pi f)^2}{9.81},$$ f = Frequency in Hz., **(next page for detail)**

$$= \frac{mr}{9.81}\left(\frac{2 \times 3.14 \times rpm}{60}\right)^2$$

$$= 0.01\ mr\ (rpm / 1000)^2$$

$$W = 0.01 \times 1,650\ (1485 / 1000)^2$$

$$= 36.38\ kg$$

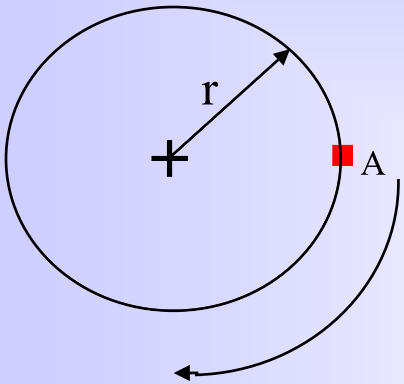
From the previous Equation

$$L_{10} = \left[\frac{\text{Rate}}{\text{Load}} \right]^3 \times \left[\frac{16{,}666}{\text{RPM}} \right]$$

$$L_{10} = \left[\frac{10000}{500+36.38} \right]^3 \times \left[\frac{16{,}666}{1485} \right]$$

the expected life time is about 72,686 Hours
= 20 % lost in Life Time

ที่มาของสูตร



ระยะทางของเส้นรอบวงจาก A มาถึง A = $2\pi r$

$$v = \omega r \,,\; a = \omega v$$

$$F = mr\omega^2 \;;\quad \omega = \frac{2\pi}{t} = 2\pi f$$

$F = ma$, F = Newton, m = kg_{Mass} , $a = m/s^2$

Force 1 N can make mass 1 kg. have acceleration 1 m/s^2

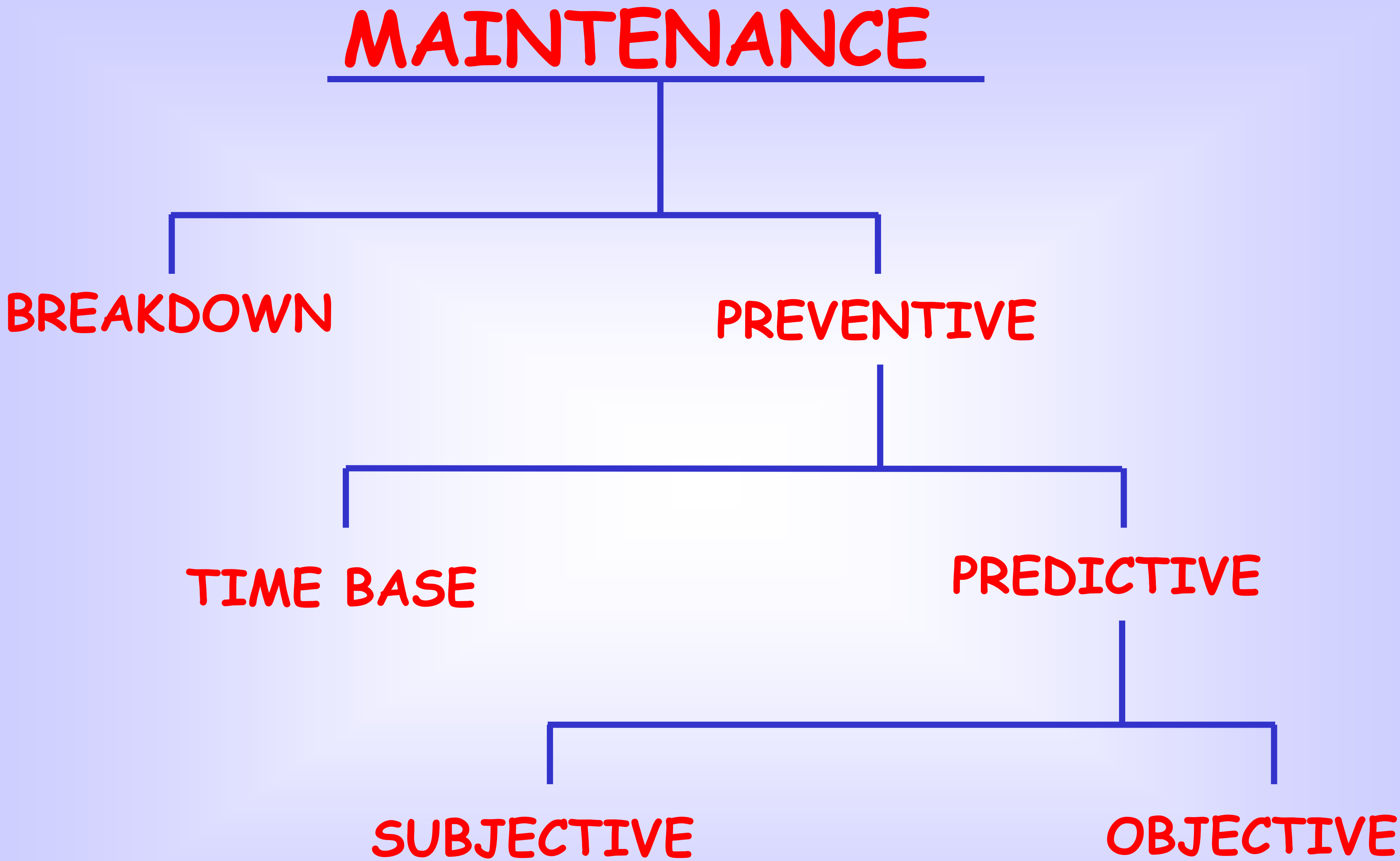
$$W = \frac{mr\omega^2}{g} \;;\quad W = \frac{2\pi}{t} = 2\pi f$$

$W = mg$, W = Kg_{Force} , m = kg_{Mass} , g = 9.81 m/s^2

Mass 1 Kg Force can make mass 1 kg. have acceleration 1 g.

CbM Program Advantages:

- Minimizes machine damage and allows scheduling of downtime, labor, materials
- Helps eliminate costly trial and error approaches to solving problems
- Allows machines in good operating condition to continue to run
- Eliminates unnecessary overhauls
- Improves safety and quality performance
- Facilitates Root Cause Analysis
- Assists in redesigns or modifications
- Increased overall knowledge for decision makers
- Properly schedules Preventive Maintenance (PM) activities


MAINTENANCE
BREAKDOWN
PREVENTIVE
TIME BASE
PREDICTIVE
SUBJECTIVE
OBJECTIVE

Example
Reduction cost for each Maintenance Philosophies

Electric Power Research Institute study on annual costs of the three philosophies

- Breakdown = $17-18 / HP
- Preventive = $11-13 / HP
- Predictive = $7-9 / HP

OBJECTIVE TOOLS

-Machinery Vibration

-Lube Oil Analysis / Wear Particle Analysis

-Ultrasonic testing

-Motor Current Analysis

-Infrared Thermography

-Bearing Temperature

-Sound Meter and etc.

Example of Ultrasonic Testing for Bearing Analysis

- Bad Bearing, Tonal Quality
- Cavitation
- Good bearing
- Oven bearing1
- Ovenbearing bad
- Squeaky Conveyor Bearing

ปัญหา Lubrication

- Good Bearing
- Bad Bearing
- Bad Bearing being greased.
- Bad Bearing 3 minutes after grease.

Vibration CbM Program

Condition Monitoring consists of four steps:

Detection

Analysis

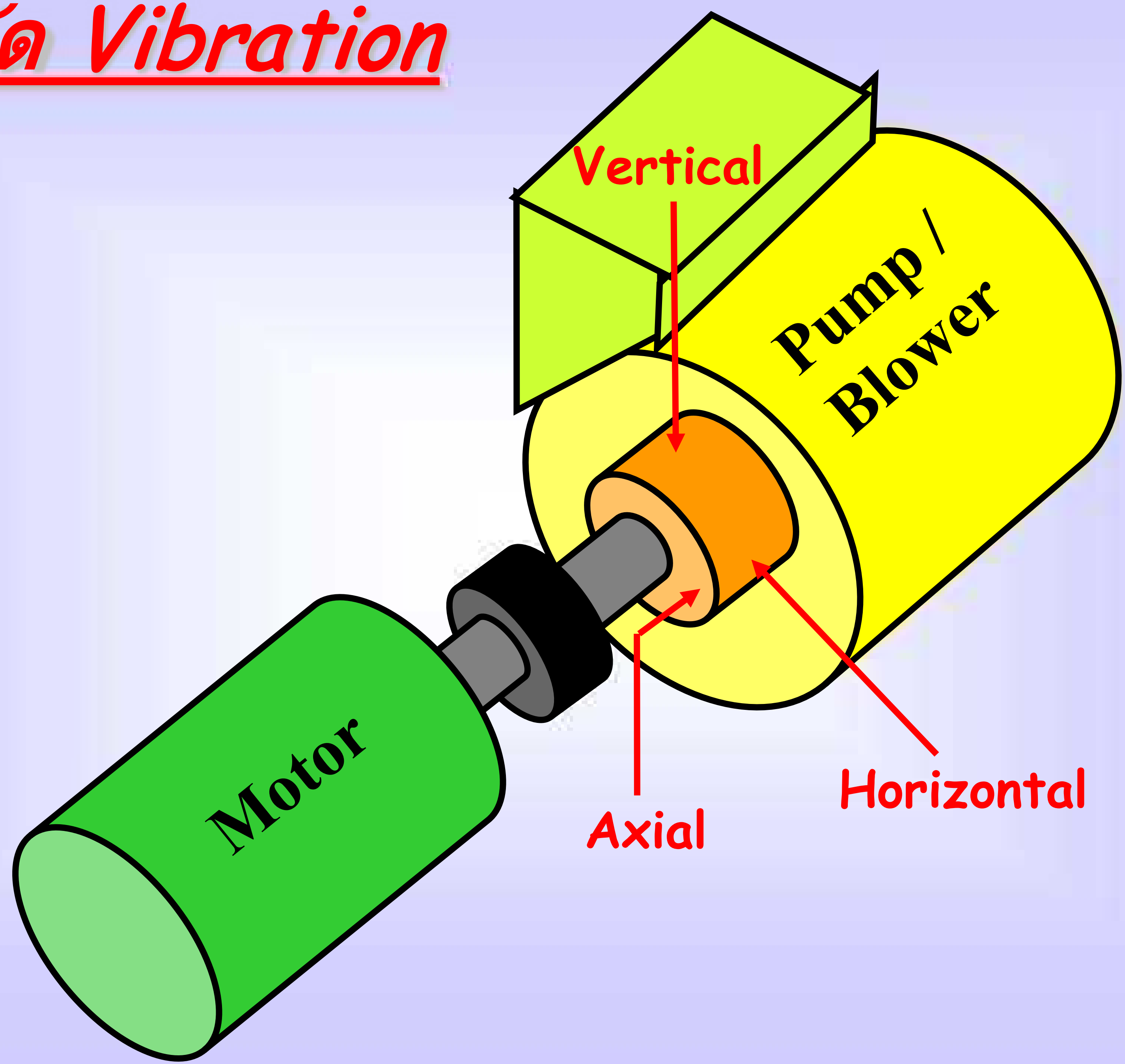
Correction

Feedback/Root Cause

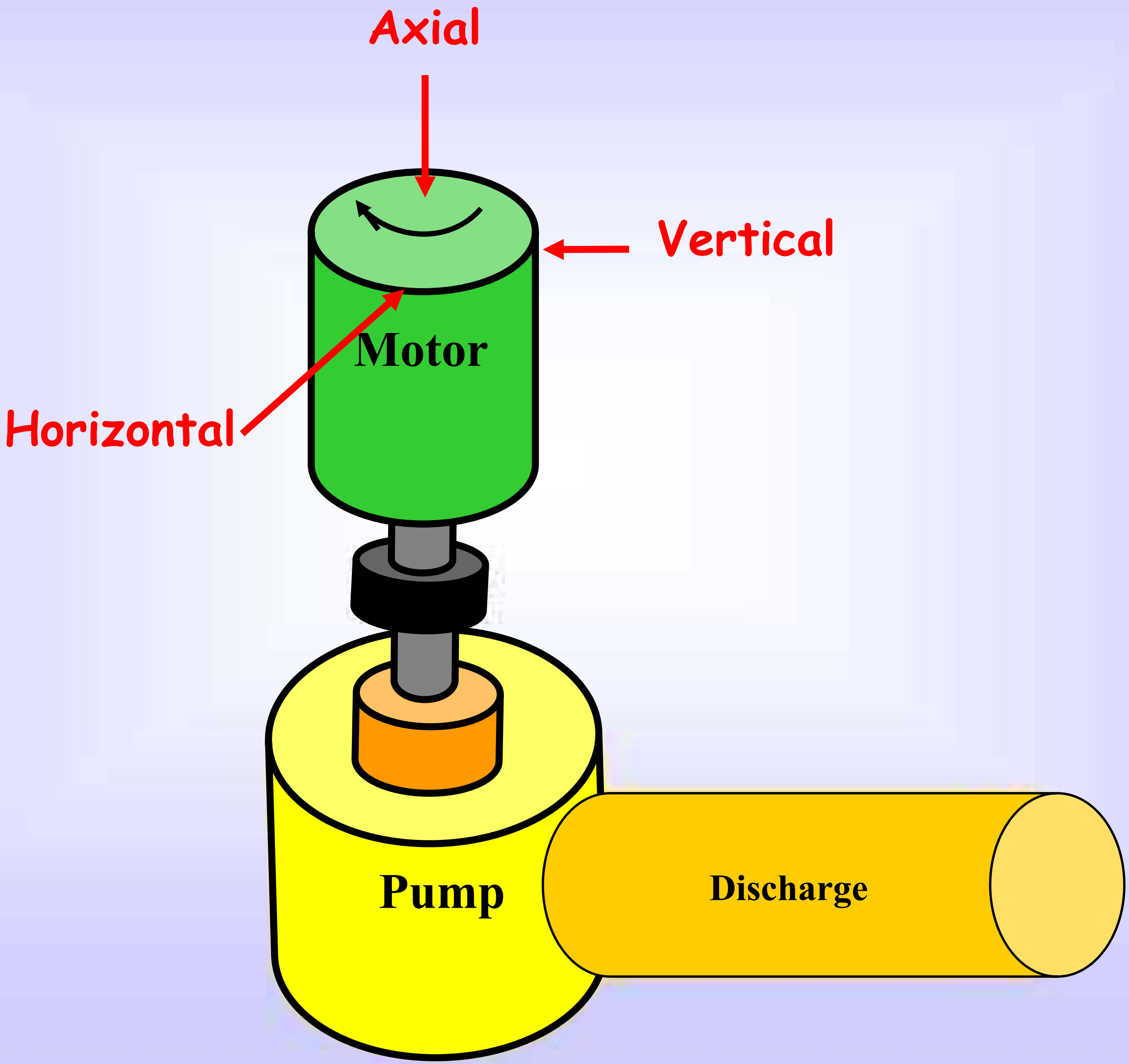
Diagnosing Machine Faults

1) Unbalance	30%
2) Misalignment	30%
3) Resonance	10%
4) Bearing defects	10%
5) Gear defects 6) Belt & Pulley problems 7) Motor analysis	15%
8) General looseness or wear 9) Soft Foot problem 10) Blade / Vane pass problem 11) ETC...	5%

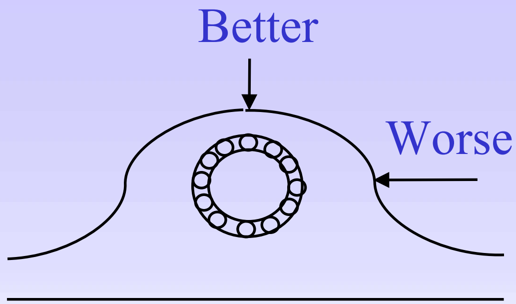
จุดวัด Vibration



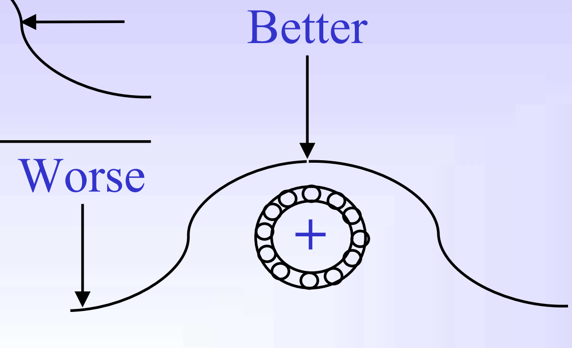
Vertical Pump Case



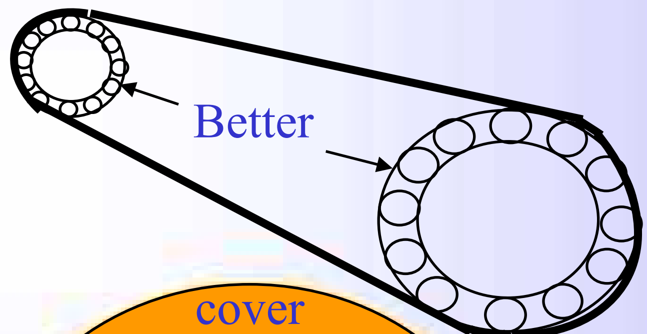
<u>จุดวัดที่เหมาะสม</u>



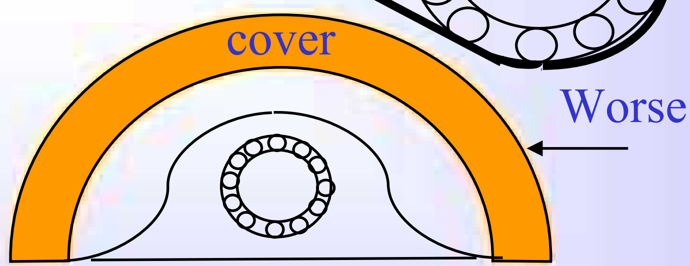
1) จุดที่ใกล้ลูกปืนมากที่สุด



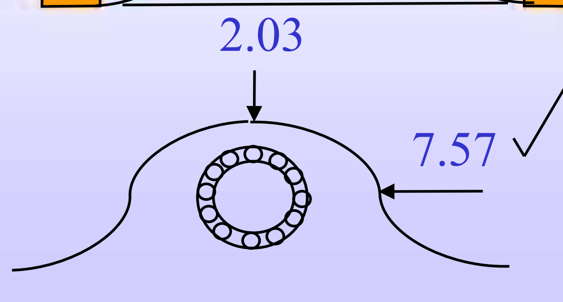
2) จุดที่ตรงเข้าสู่ศูนย์กลางลูกปืน



3) จุดที่รับภาระ (Load) มากที่สุด

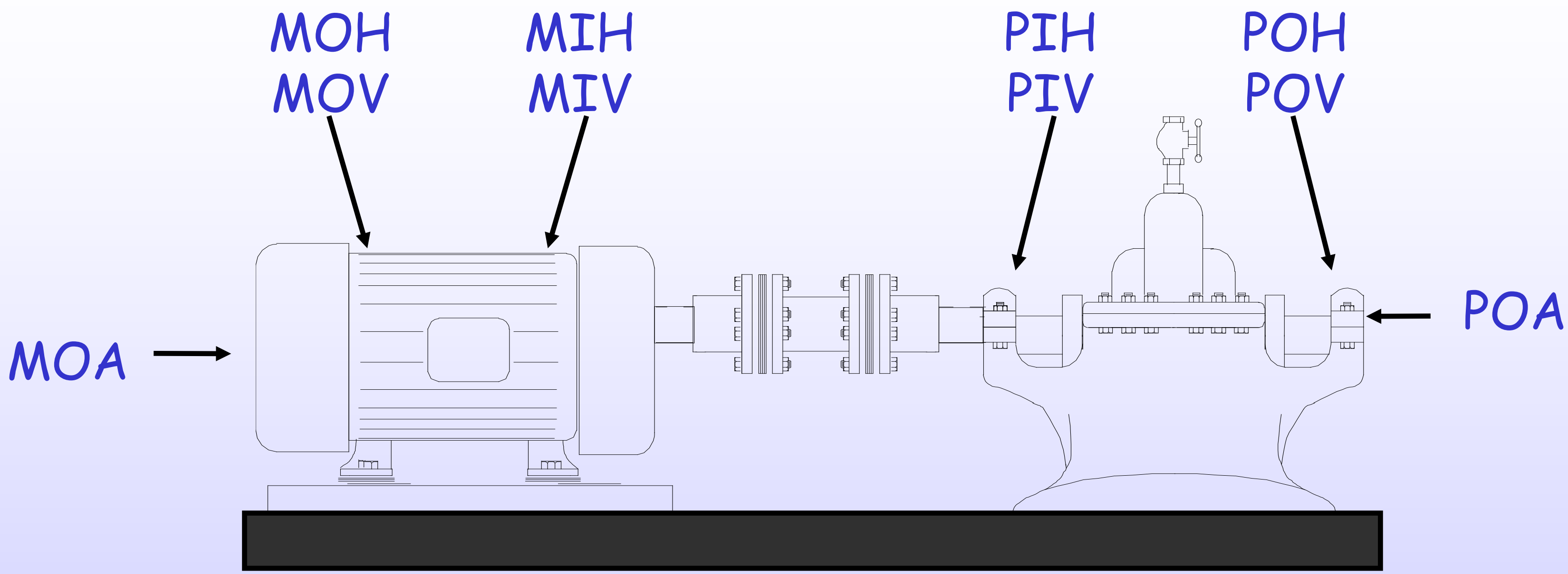


4) จุดที่เป็นเนื้อเดียวกันกับ Bearing Housing



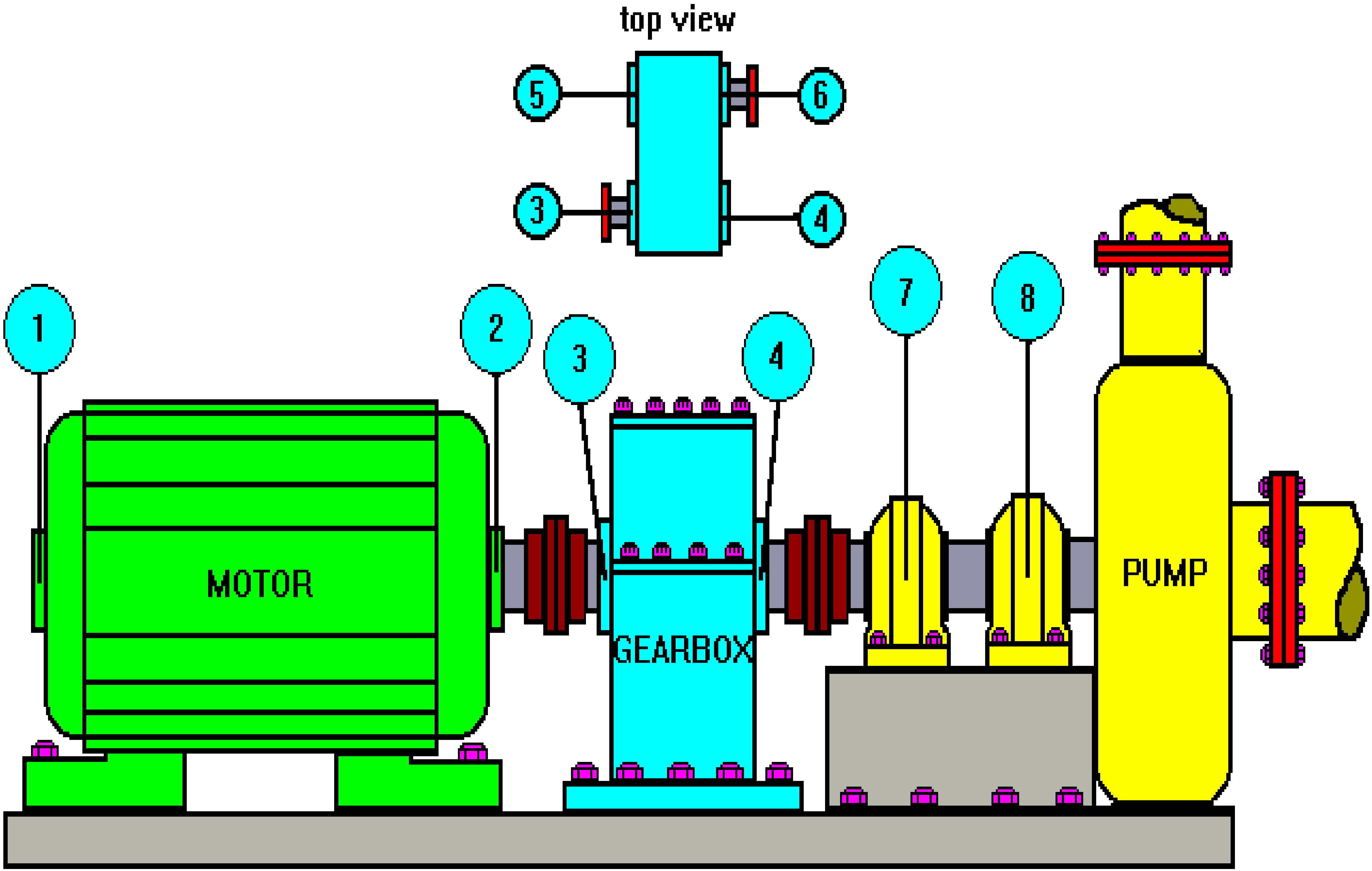
5) จุดที่ให้สัญญาณ Vibration แรงที่สุด

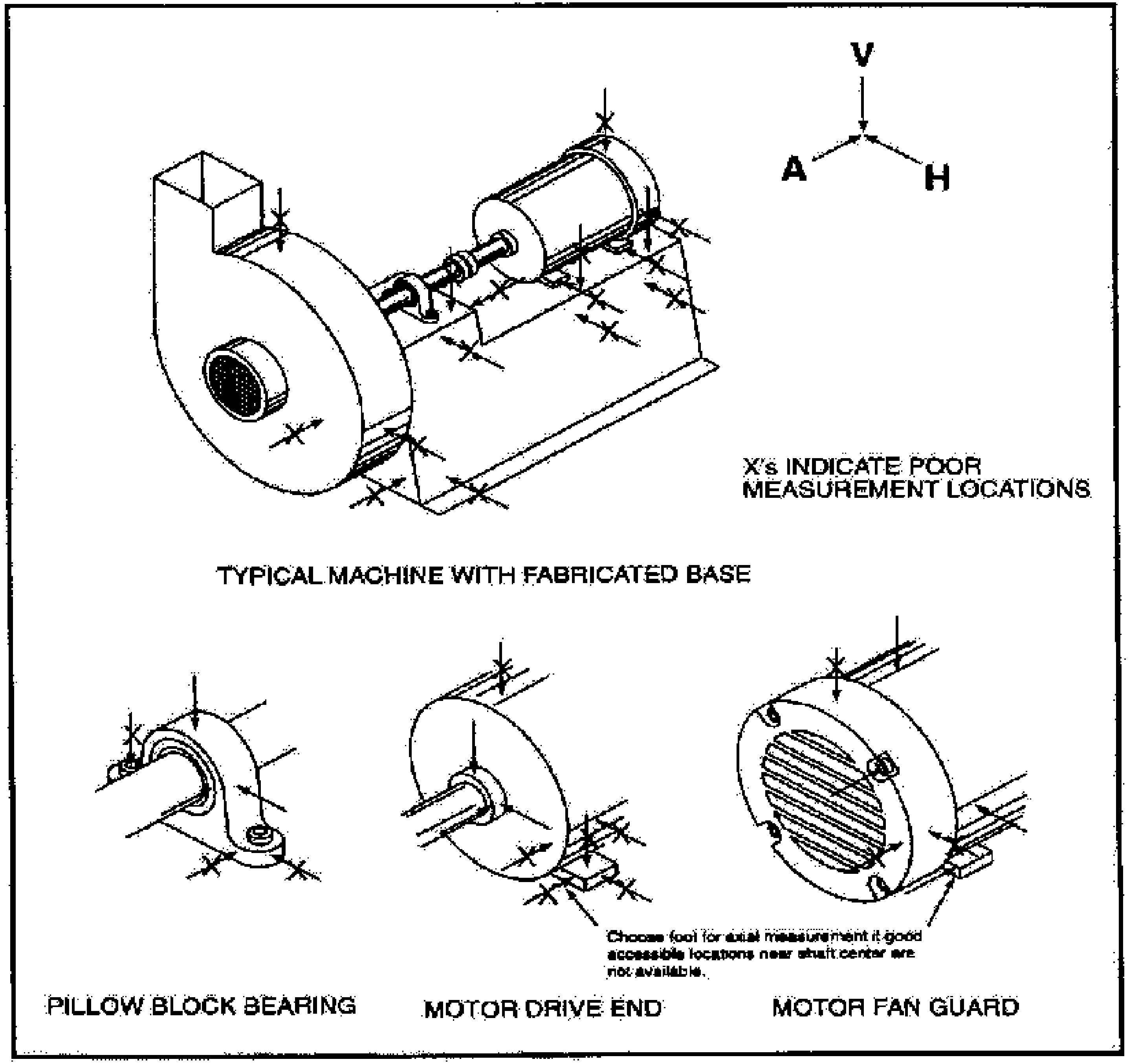
Measurement Point Locations



2 per bearing + 1 axial measurement per shaft

OB=TDS=NDE
IB=DS=DE


top view
5
6
3
4
1
2
3
4
7
8
MOTOR
GEARBOX
PUMP



ตำแหน่งและทิศทางที่เหมาะสมในการเก็บค่า **Vibration** ที่ไม่เหมือนกันเมื่อเงื่อนไขเปลี่ยนไป

การเก็บข้อมูลที่ดี

- ทิศทางเดิมเช่น H, V, A
- ตำแหน่งเดิมเช่น V ตรงจุดไหน ก็ต้อง V ตรงจุดเดิมในครั้งหน้า
- วิธีจับยึดหัววัดต้องแบบเดิม

หน่วยของการวัด Vibration

Vibration Amplitude

1) Displacement
2) Velocity
3) Acceleration
    3.1) General G
    3.2) G Spike Energy (Demodulation for Bearing Detection)

4) dB , $dB = 20 \, Log \frac{R}{R\,ref}$

R = ค่าที่อ่านได้จริง
R ref = ค่าที่นับให้เป็น Noise Vibration

Amplitude Units – What You See

Displacement

mils (0.001 inch)
μm (0.001 millimeter)

The units are all mathematically related such that…

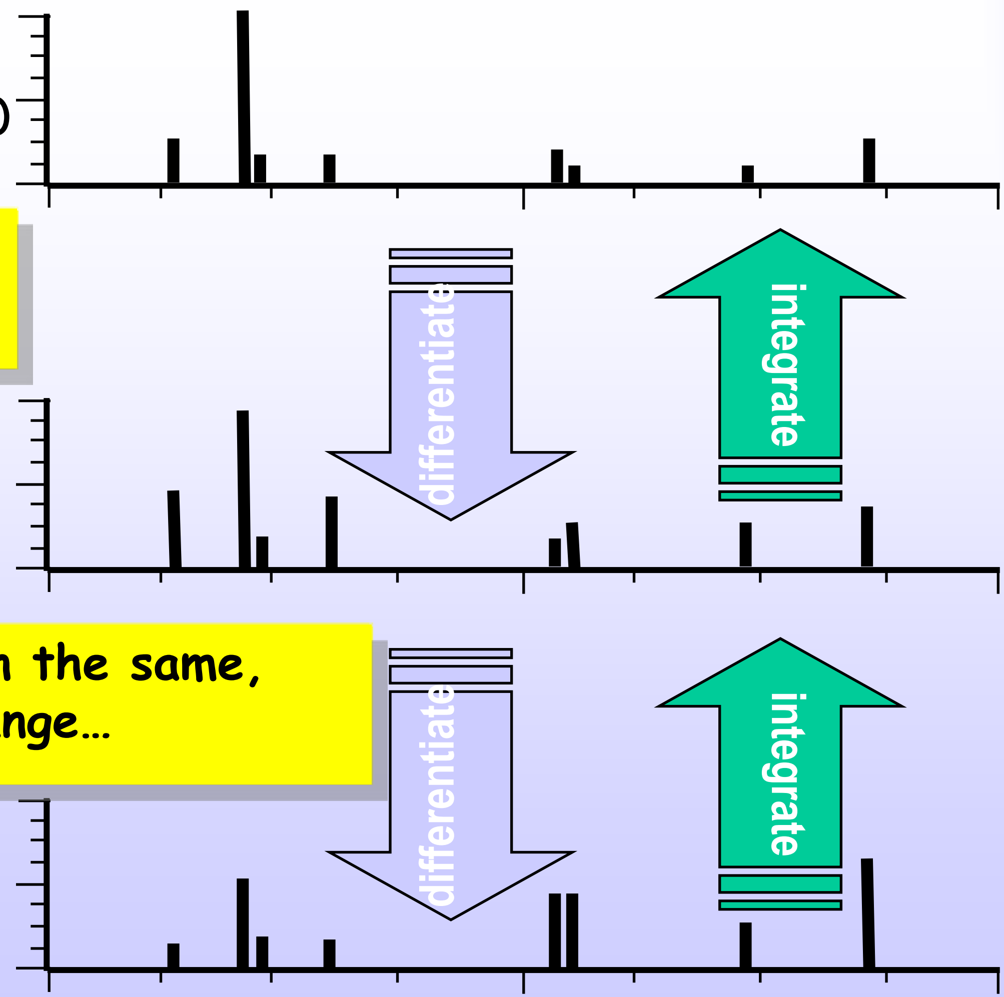
Velocity

ips (inches/sec)
mm/s (millimeters/sec)

The frequencies remain the same, but the amplitudes change…

Acceleration

g's
m/s^2(meters/sec^2)



UNIT CONVERSION

$A = 64\, fV \times 10^{-5}$

$A = 202\, f^2 D \times 10^{-8}$ G, Pk

$V = 1562 \dfrac{A}{f}$

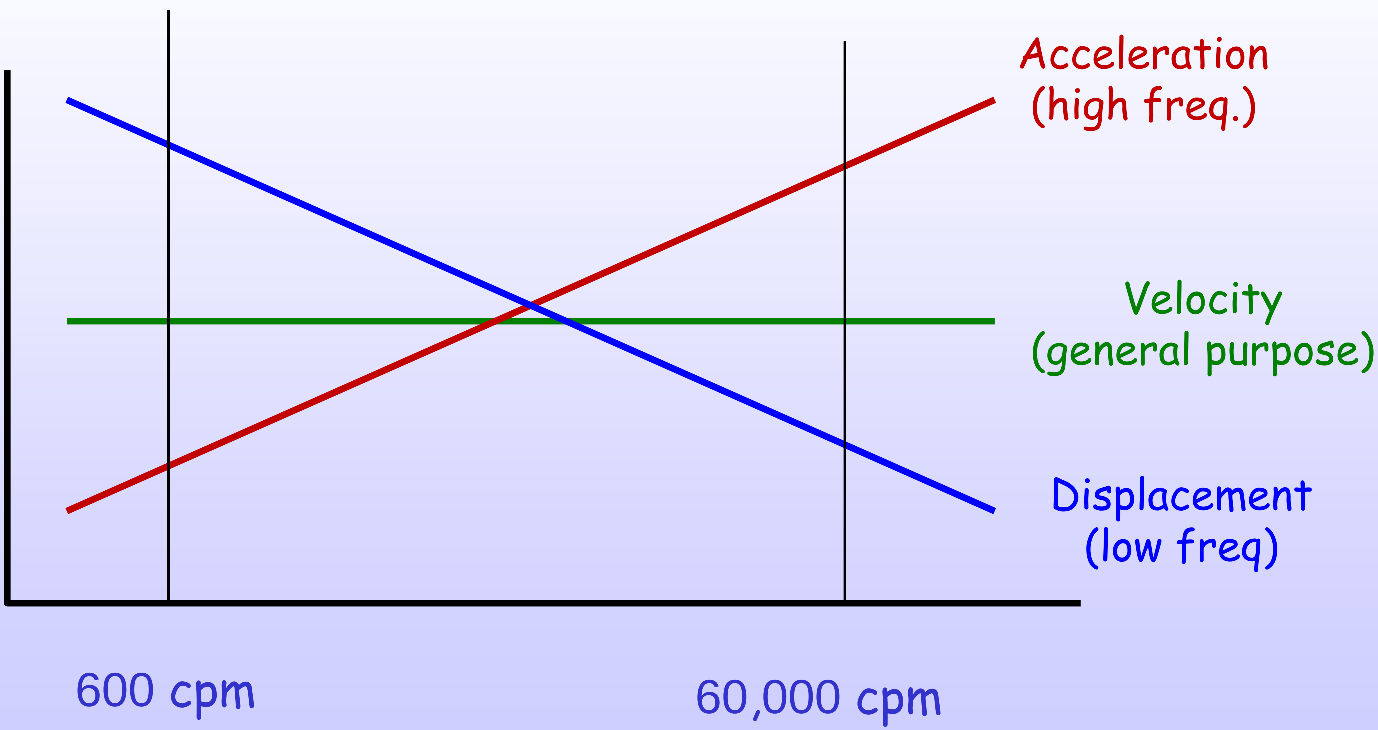
$V = 315\, f\, D \times 10^{-5}$ mm/s, Pk

$D = 495050 \dfrac{A}{f^2}$

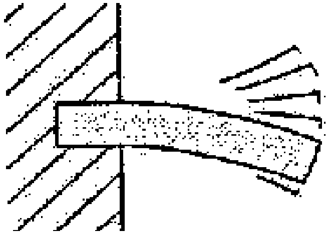
$D = 317 \dfrac{V}{f}$ Micron, Pk-Pk

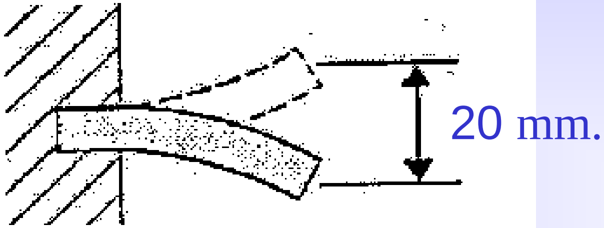
What's the difference? Acceleration,Velocity, & Displacement

- The frequency range of interest



Frequency
Hz or CPM





Displacement in mm = Machine's Stress
For Example; 20 mm. Amplitude,
What's it tell us? Just Stress

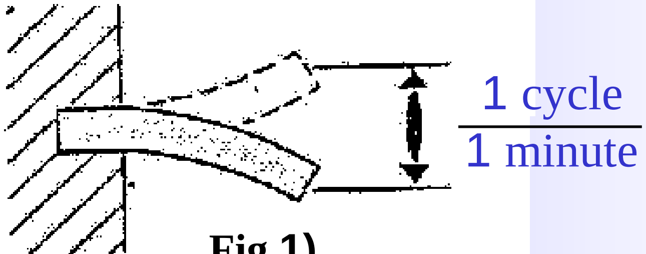


Fig 1)

Velocity in mm/s = Machine's Fatigue
For Example ; the same displacement amplitude as 20mm.
Machine can be bent as 1,000,000 times.
as Fig 1) the velocity amplitude is 20 mm/min
= 0.33 mm/s, broken in 1,000,000 min.

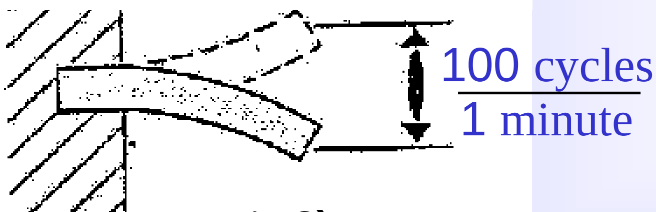
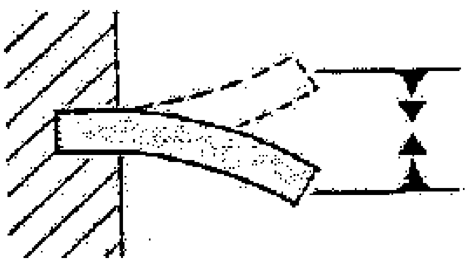


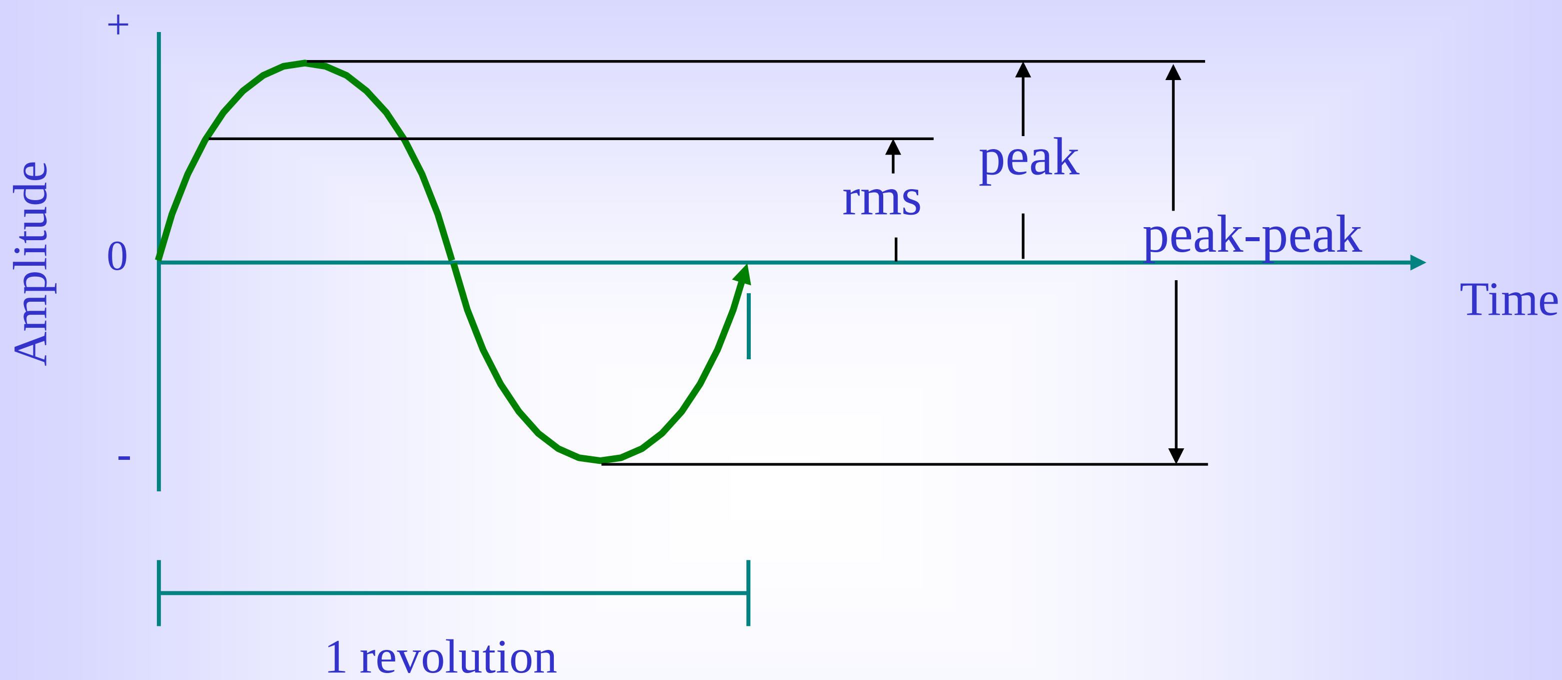
Fig 2)

as Fig 2) the velocity amplitude is 20 mm/1/100 min
= 2000 mm/min = 33.3 mm/s, broken in 10,000 min.



Acceleration in G = Impact Force from Bearing or Gear
* Rate of Change of velocity from zero to max. velocity or max. velocity to zero, if the velocity has been changed so fast, it means high G , as a hammer knock to a rigid table

Type of measurement



For Pure Sine Wave Form

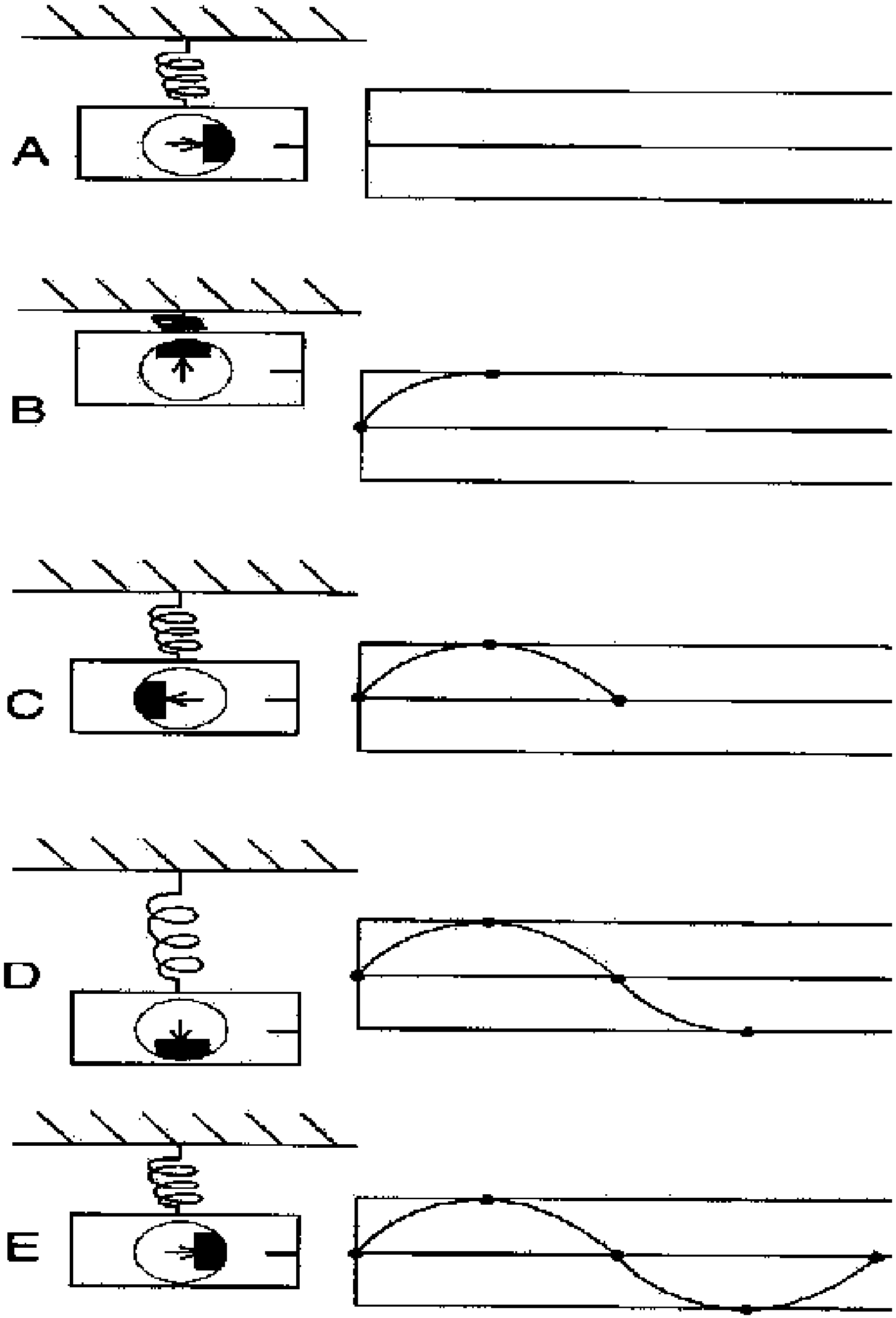
peak-peak = 2 peak
= 2 x 1.414 rms

Avg = 0.637 Peak

Vibration Analysis

"Of all the parameters that can be measured non-intrusively in industry today, the one containing the most information is the vibration signature."

Art Crawford

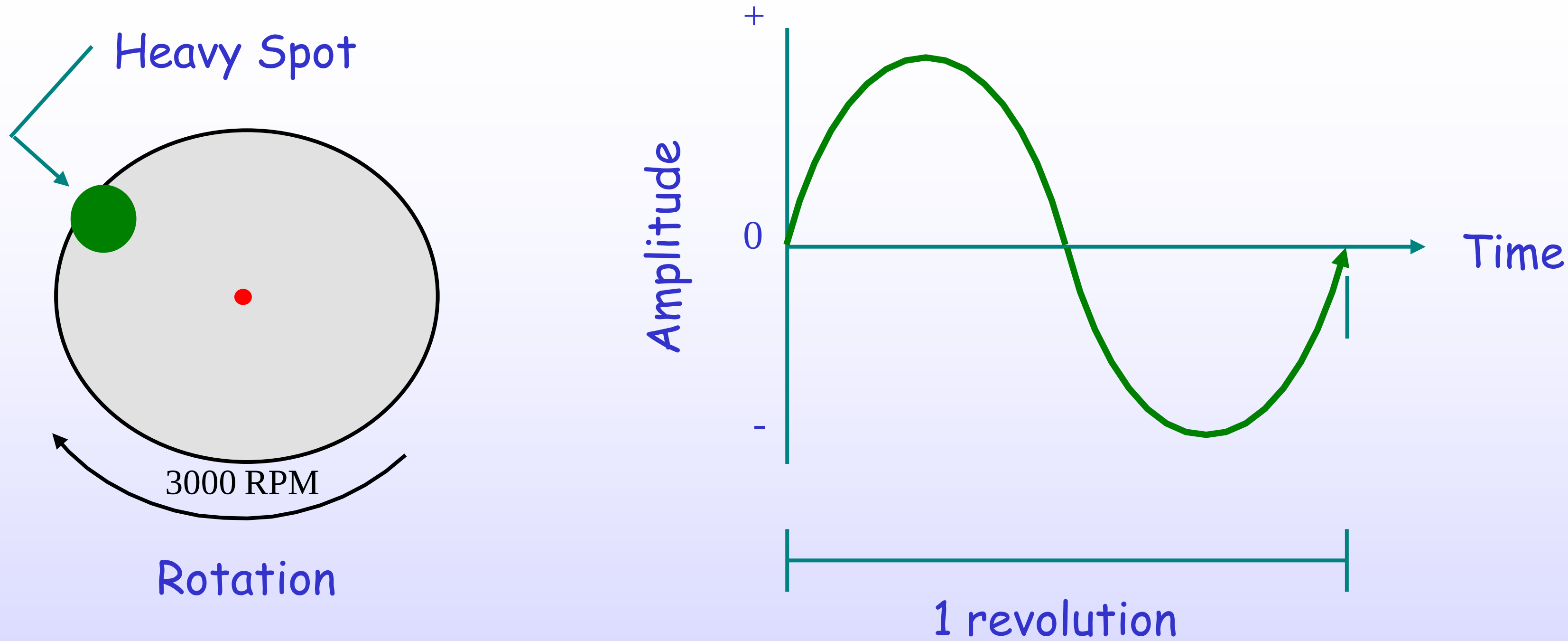


การสั่นสะเทือนในรูปแบบของ

SPRING MASS SYSTEM

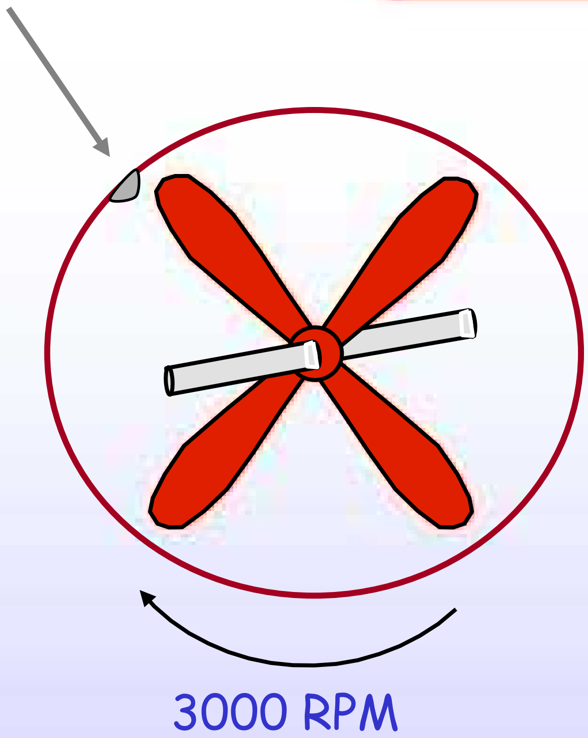
Plot ต่อหน่วยเวลา

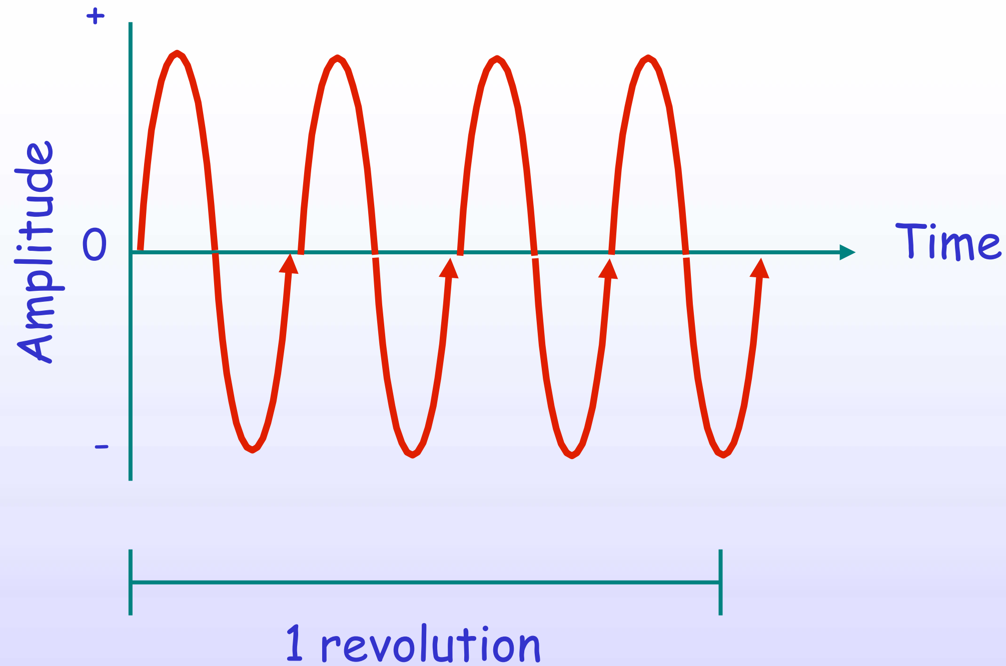
Time Waveform



3000 RPM	=	3000 cycles per minute
50 Hz	=	50 cycles per second
1 Order	=	One times turning speed

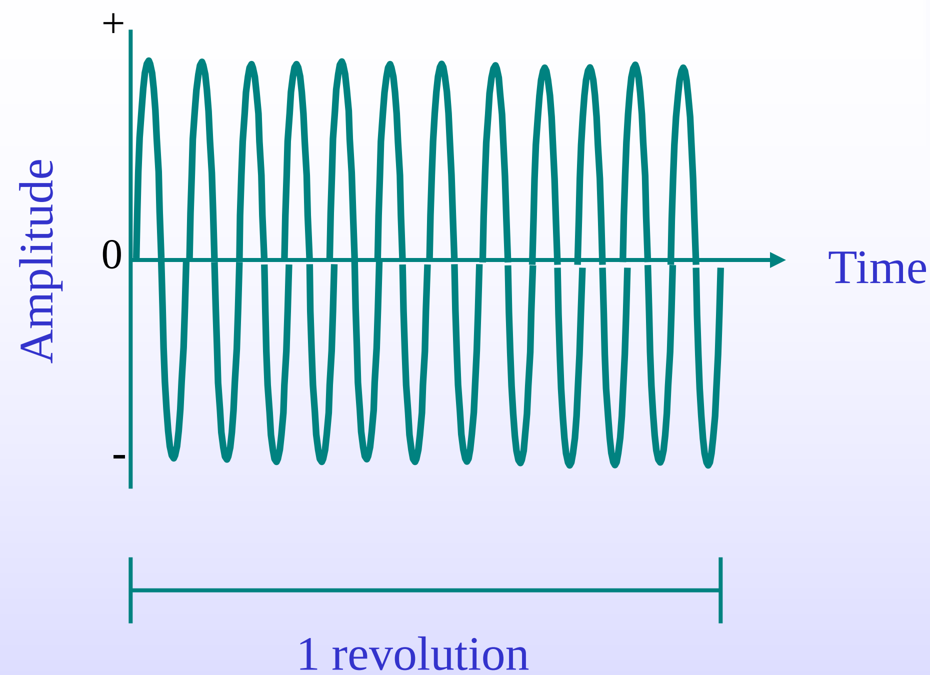
Time Waveform





4 blades	=	Vibration occurs 4 times per revolution
4 X 3000 RPM	=	Vibration occurs at 12,000 cycles per minute
	=	12,000 CPM
	=	200 Hz

Time Waveform

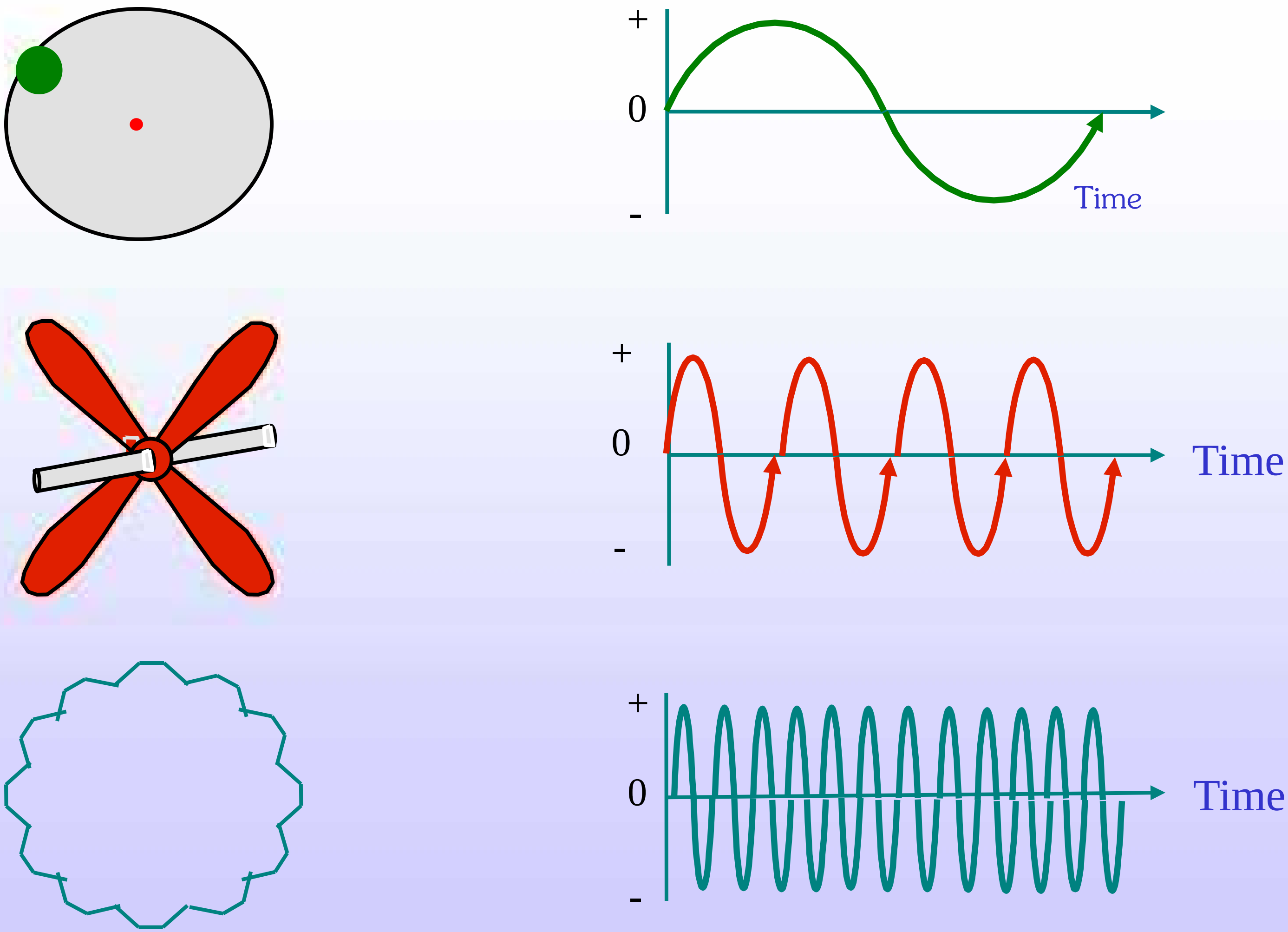


12 teeth are meshing every revolution of the gear

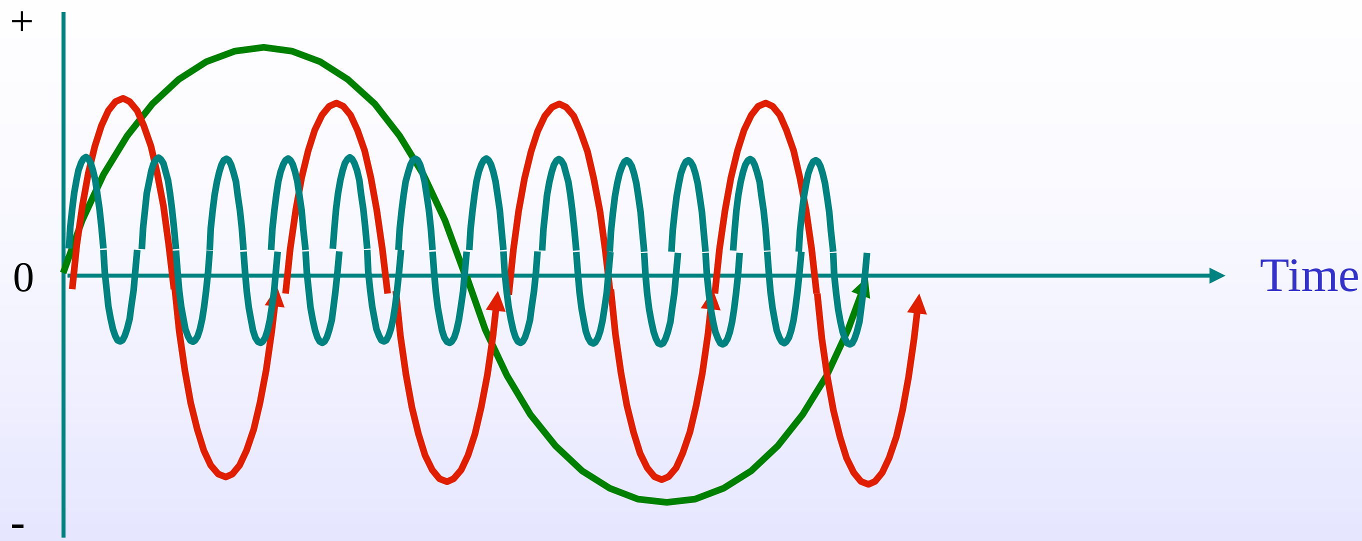
12 x 3000 RPM = vibration occurs at 36,000 cycles per minute

= 36,000 cpm = 600 Hz

Time Waveform

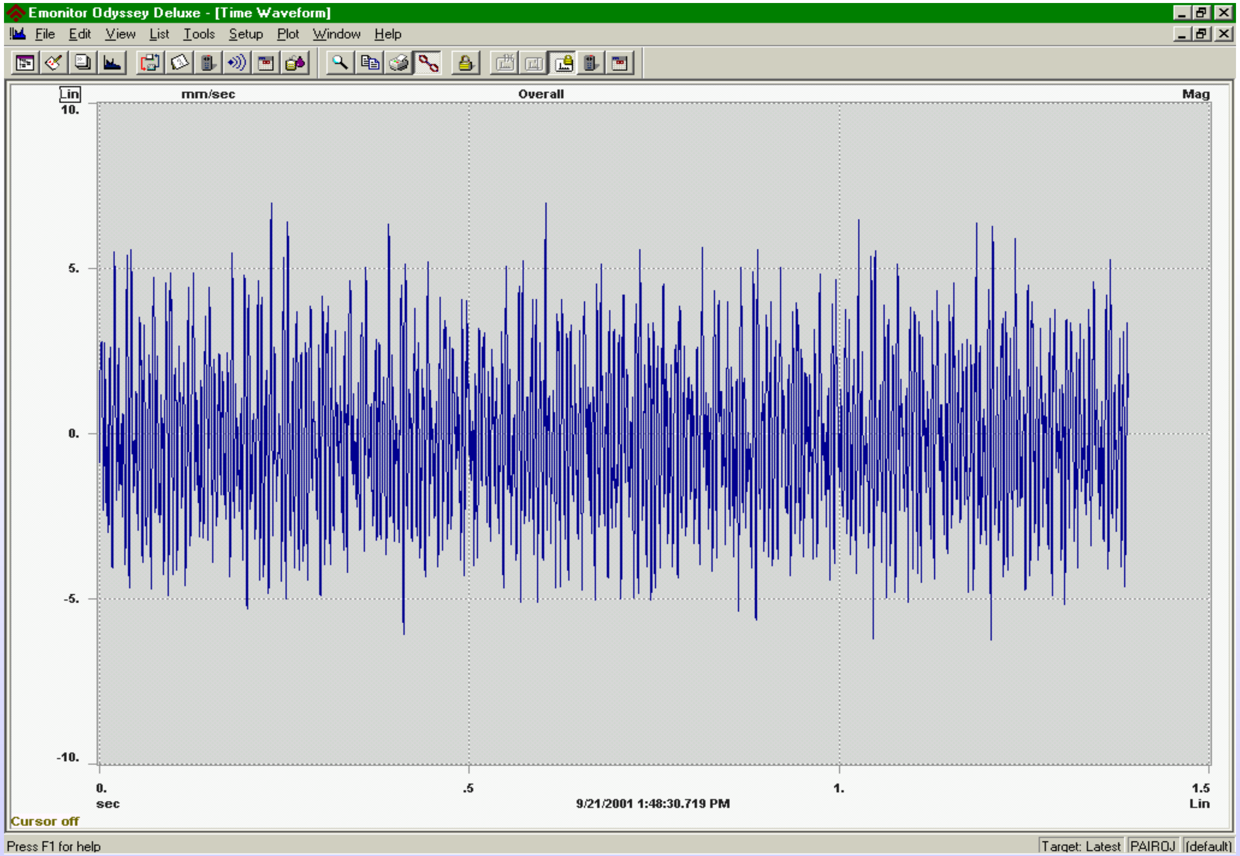


Time Waveform



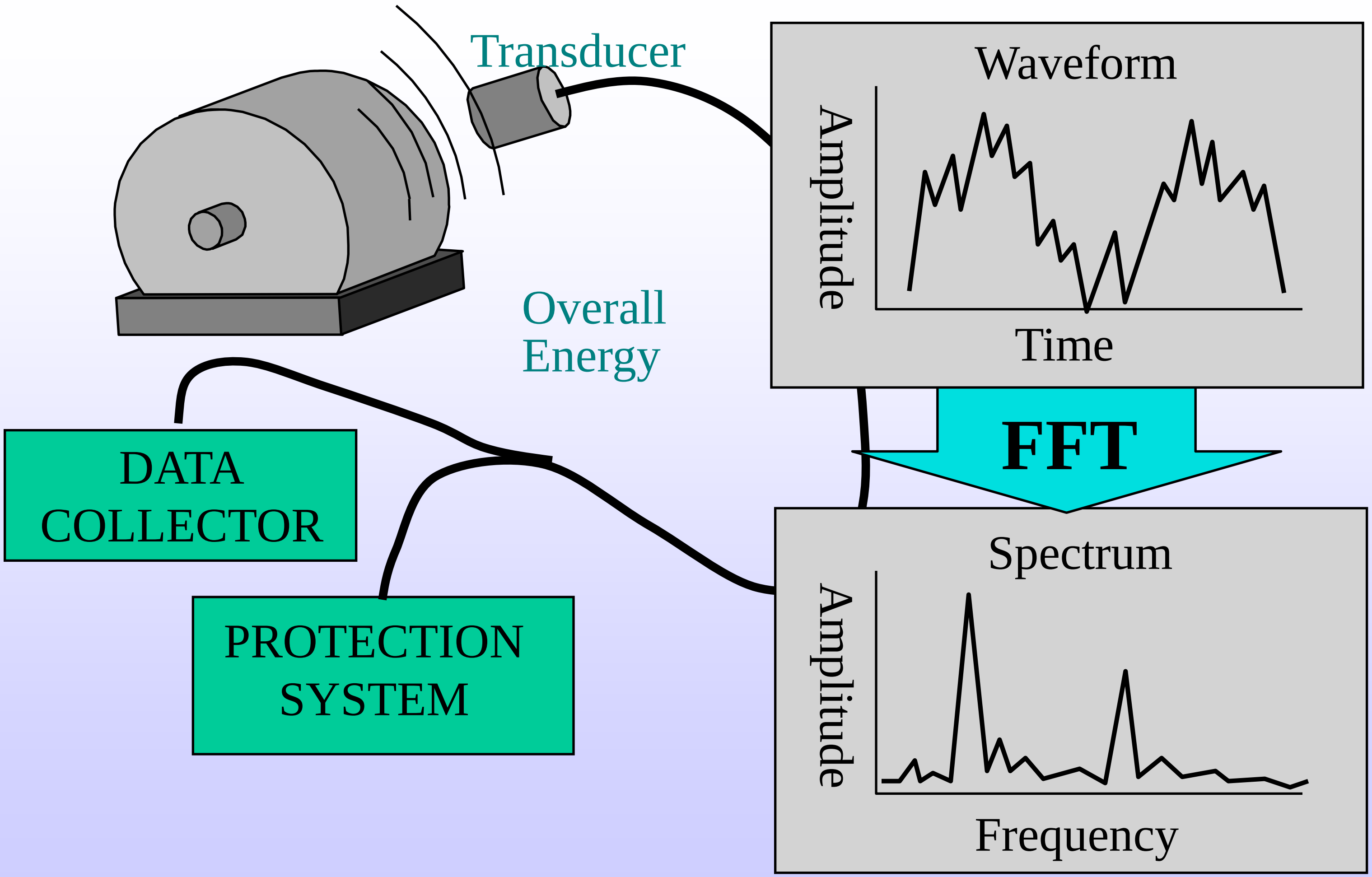
Time Waveform contains all the different frequencies mixed together.

Time Waveform

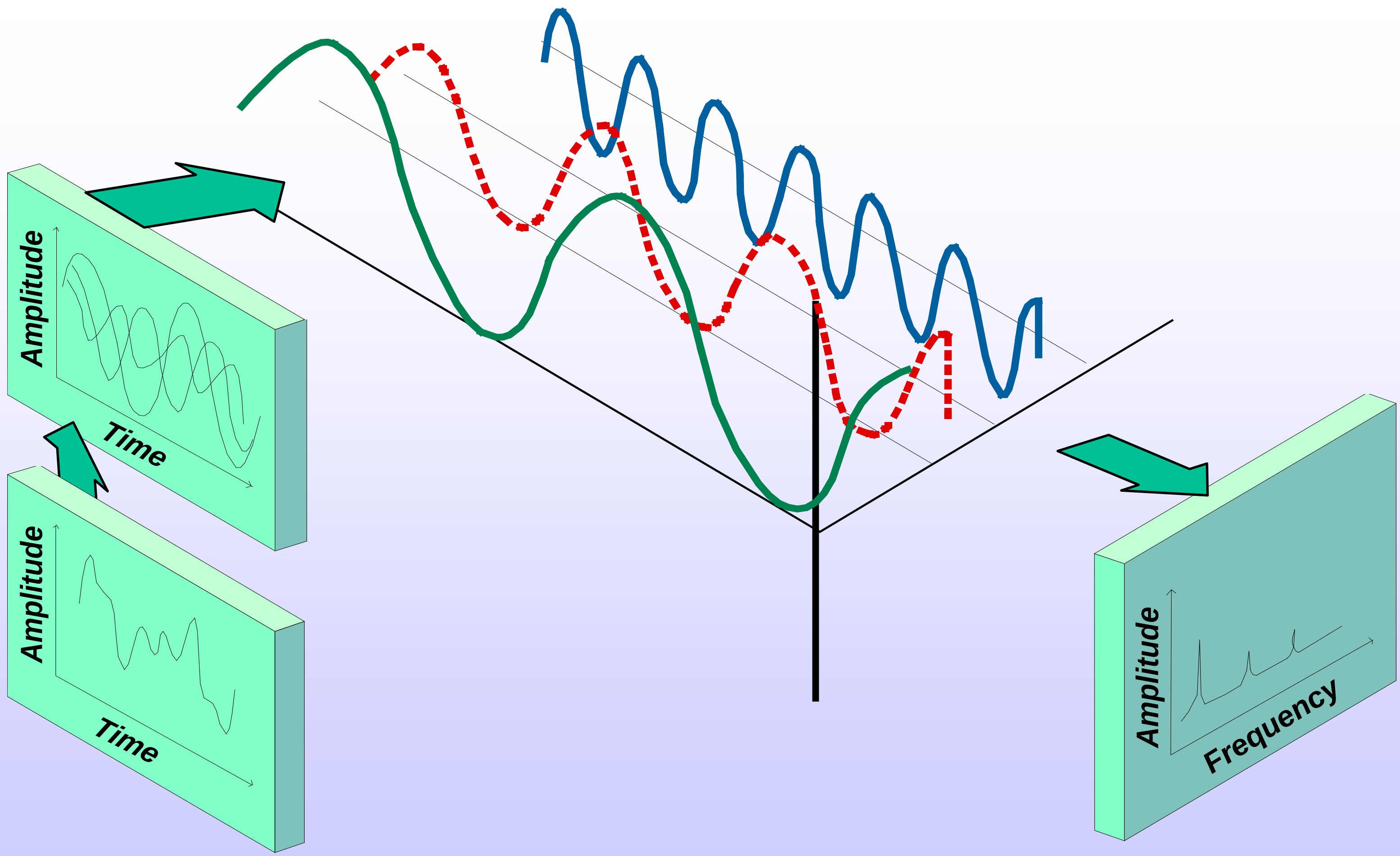


Example of a time waveform

Signal Acquisition



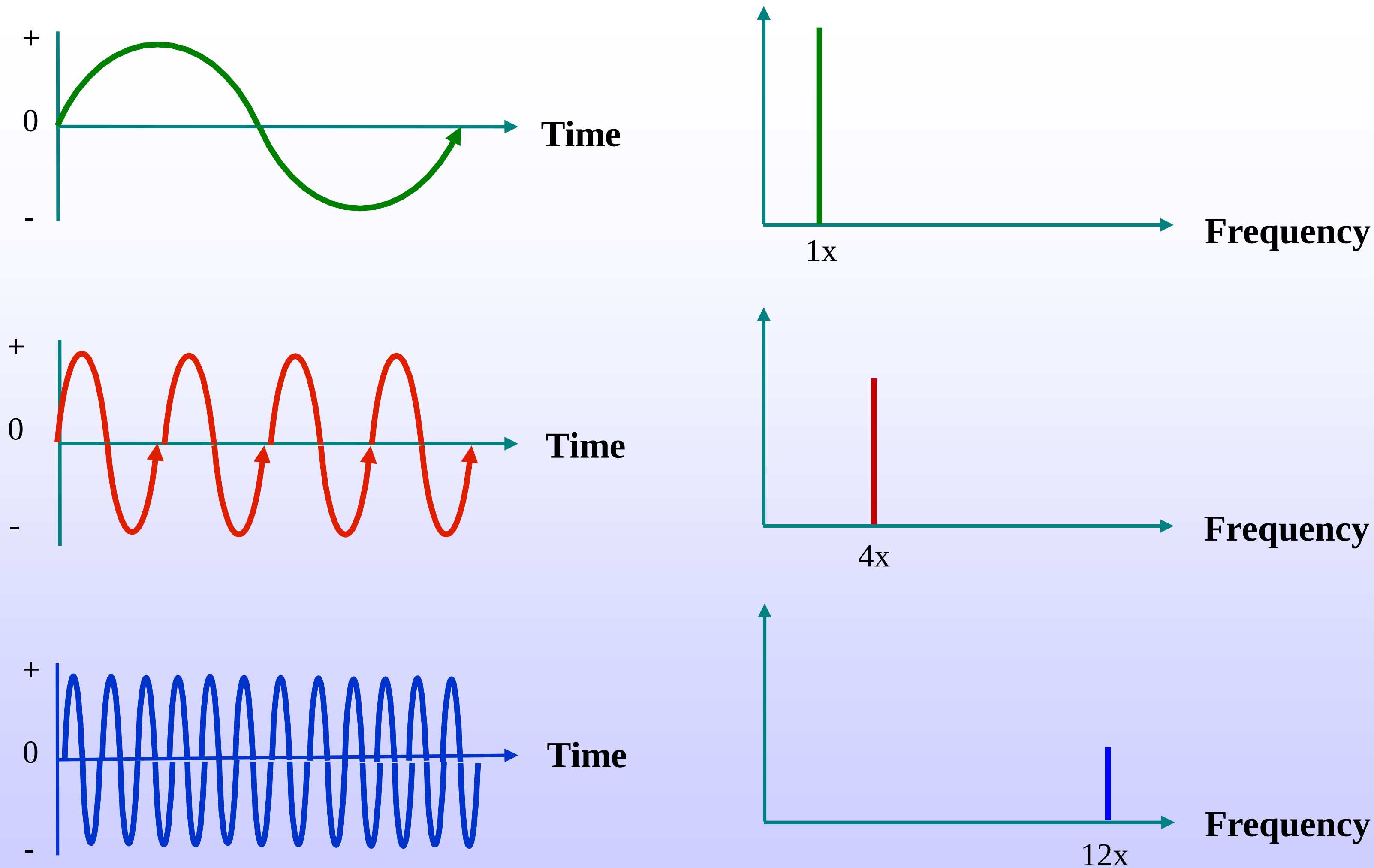
FFT Signal Processing



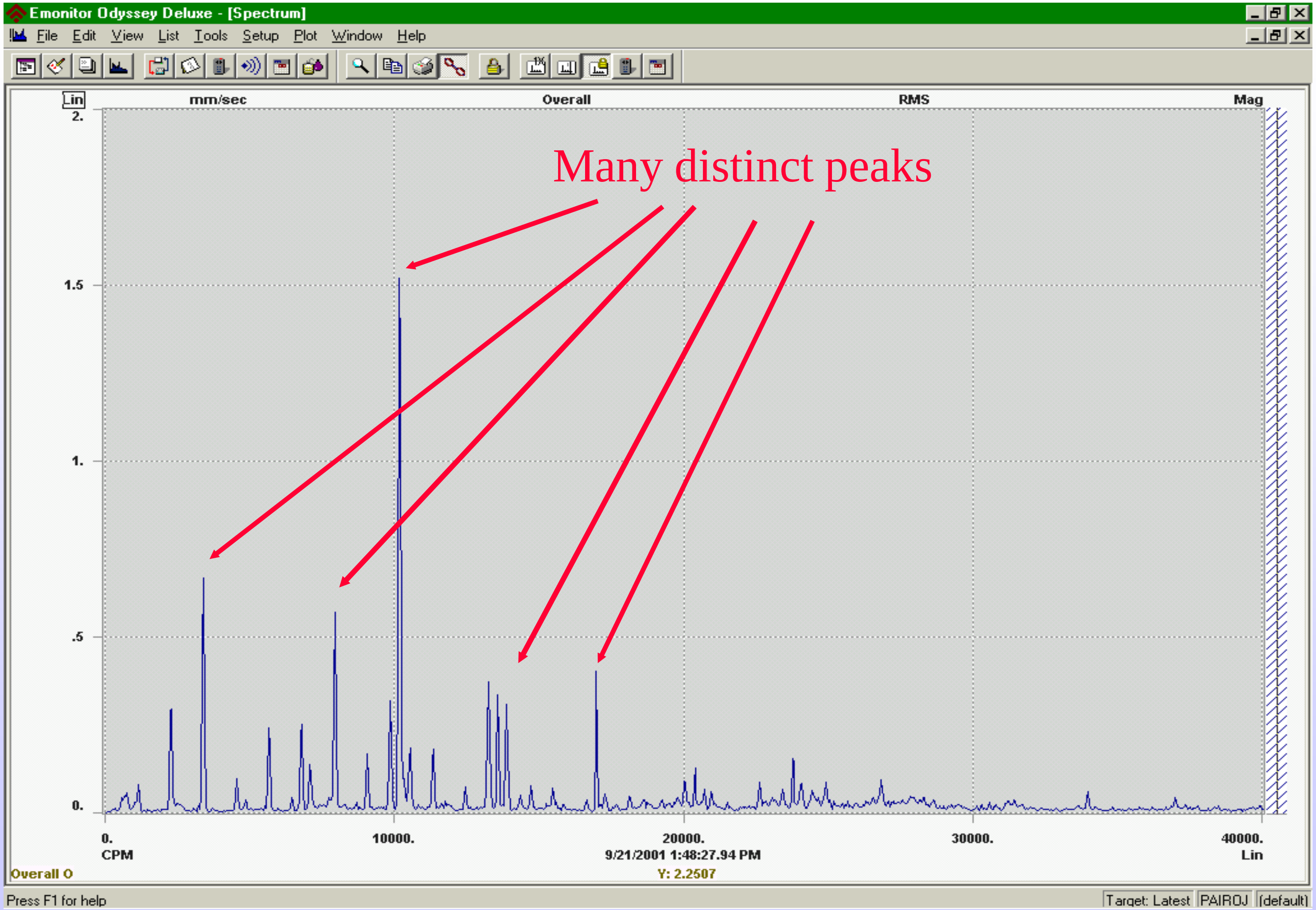
Frequency Domain

- FFT - Fast Fourier Transform
- Separates individual frequencies
- Detects how much vibration at each frequency

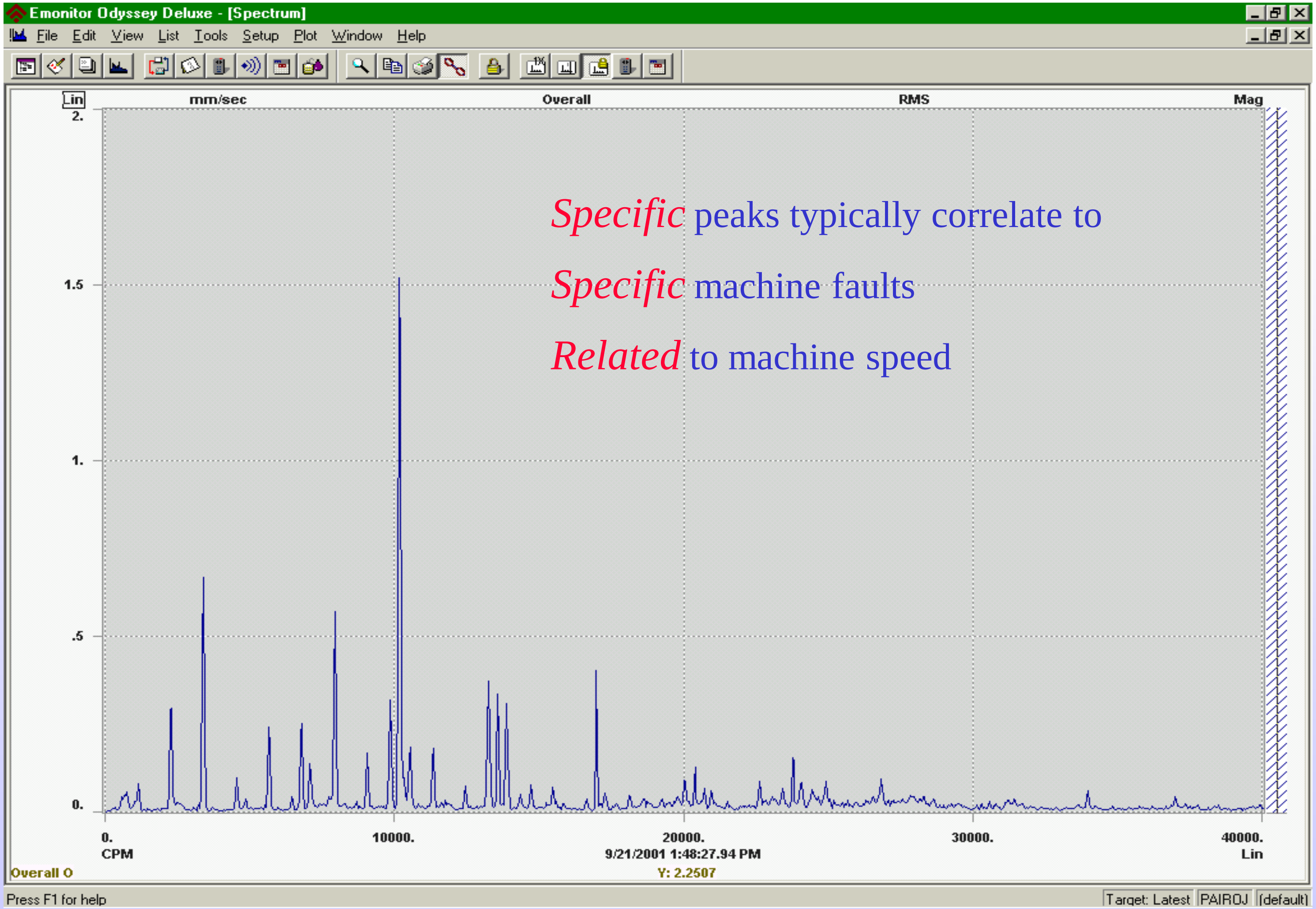
Frequency Domain



A Typical FFT Spectrum



A Typical FFT Spectrum



นิยามที่ต้องเข้าใจเกี่ยวกับการวัด วิเคราะห์ **Vibration**

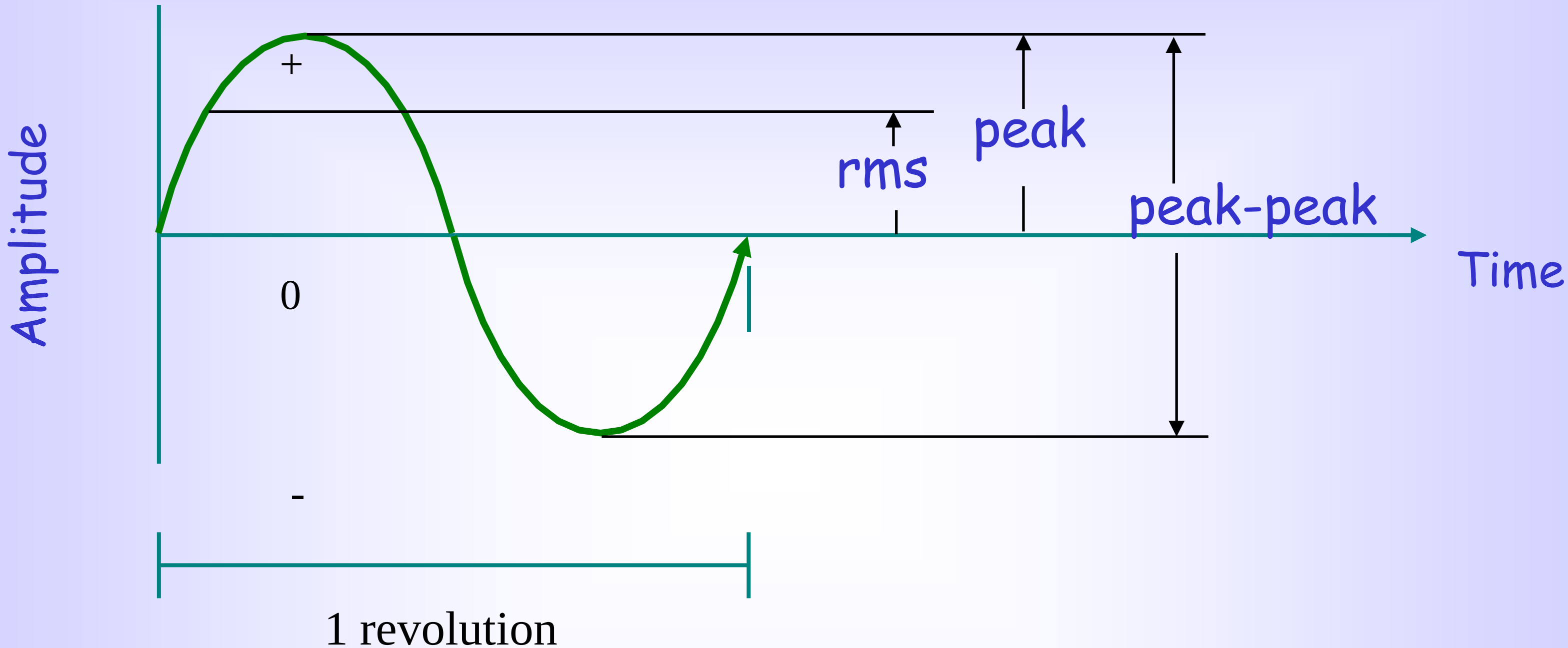
1) Frequency , CPM = Cycles Per Minute
Hertz = Cycles Per Second = CPS

2) Amplitude

3) Phase

4) Demodulation (Spike Energy)

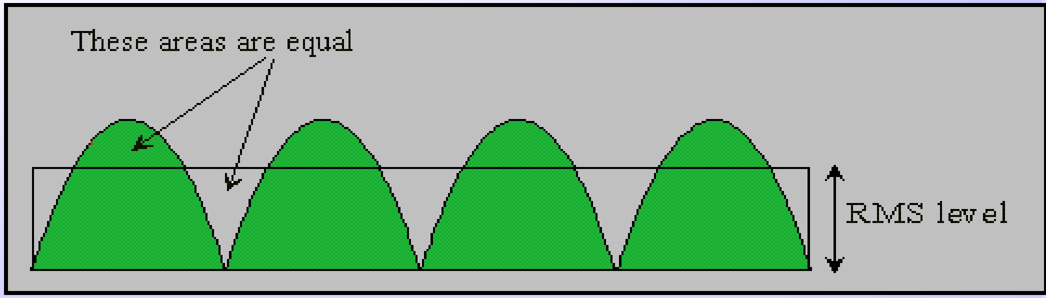
Type of measurement

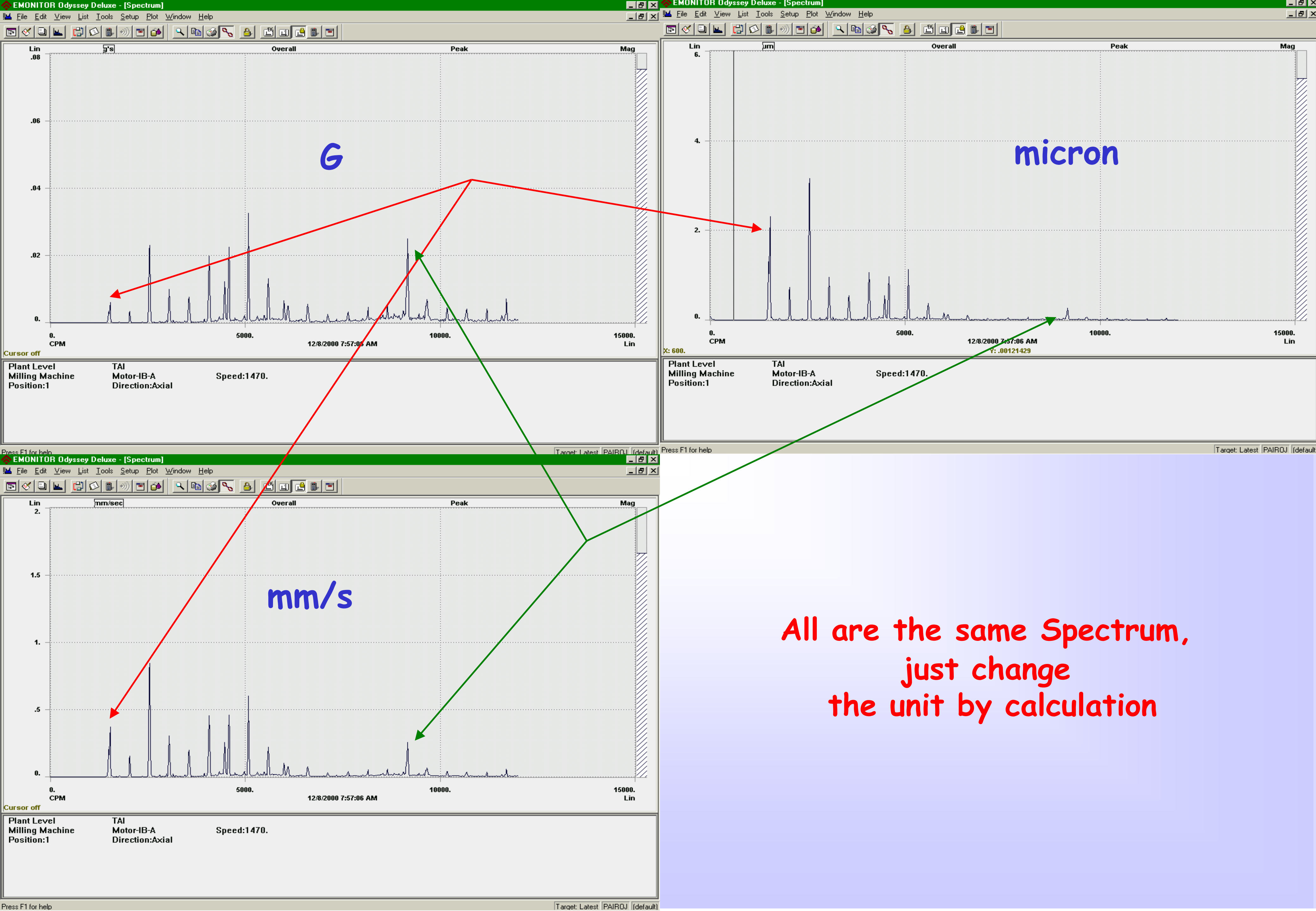


For Pure Sine Wave Form

peak-peak = 2 peak
= 2 x 1.414 rms

Avg = 0.637 Peak




EMONITOR Odyssey Deluxe - [Spectrum]
G
micron
mm/s
g's
um
mm/sec
Overall
Peak
Mag
Lin
CPM
12/8/2000 7:57:06 AM
Plant Level
Milling Machine
Position:1
TAI
Motor-IB-A
Direction:Axial
Speed:1470.
Cursor off
X: 600.
Y: .00121429
Press F1 for help
All are the same Spectrum,
just change
the unit by calculation

ค่า Vibration ที่ยอมรับได้ (Criteria Acceptance)

Definition of machine classes according to ISO 2372

The following text is a quotation from ISO 2372 (1974, E, page 6, Annex A). This ISO Recommendation has also been published as British Standard (BS 4675, part I). A similar vibration classification of industrial machinery can be found in VDI 2056.

In order to show how the recommended method of classification may be applied, examples of specific classes of machines are given below. It should be emphasized, however, that they are simply examples and it is recognized that other classifications are possible and may be substituted in accordance with the circumstances concerned. As and when circumstances permit, recommendations for acceptable levels of vibration severity for particular types of machines will be prepared. At present, experience suggests that the following classes are appropriate for most applications.

Class I

Individual parts of engines and machines, integrally connected with the complete machine in its normal operating condition. (Production electrical motors of up to 15 kW are typical examples of machines in this category.)

Class II

Medium-sized machines, (typically electrical motors with 15 to 75 kW output) without special foundations, rigidly mounted engines or machines (up to 300 kW) on special foundations.

Class III

Large prime movers and other large machines with rotating masses on rigid and heavy foundations which are relatively stiff in the direction of vibration measurement.

Class IV

Large prime movers and other large machines with rotating masses on foundations which are relatively soft in the direction of vibration measurement (for example turbogenerator sets, especially those with lightweight substructures).

Class V

Machines and mechanical drive systems with unbalanceable inertia effects (due to reciprocating parts), mounted on foundations which are relatively stiff in the direction of vibration measurement.

Class VI

Machines and mechanical drive systems with unbalanceable inertia effects (due to reciprocating parts), mounted on foundations which are relatively soft in the direction of vibration measurements; machines with rotating slackcoupled masses such as beater shafts in grinding mills; machines, like centrifugal machines, with varying unbalances capable of operating as selfcontained units without connecting components; vibrating screens, dynamic fatigue-testing machines and vibration exciters used in processing plants.

ISO 2372 Criteria

Limit, mm/s, rms	Class I	Class II	Class III	Class IV	Class V
71	D	D	D	D	D
45.0 - 71.0	D	D	D	D	D
28.0 - 45.0	D	D	D	D	D
18.0 - 28.0	D	D	D	D	C
11.2 - 18.0	D	D	D	C	C
7.1 - 11.2	D	D	C	C	B
4.5 - 7.1	D	C	C	B	B
2.8 - 4.5	C	C	B	B	A
1.8 - 2.8	C	B	B	A	A
1.12 - 1.8	B	B	A	A	A
0.71 - 1.12	B	A	A	A	A
0.3 - 0.71	A	A	A	A	A
0 - 0.3	A	A	A	A	A

Remark : 1) Amplitude in mm/s
2) Detection type in rms.
3) Band Pass Filter as 10-1000 Hz.

ISO 10816 Part 3

Industrial Machines with nominal power above 15 kW and nominal speeds between 120 rpm and 15,000 rpm when measured insitu

Velocity 10 -1000 Hz, r > 600 rpm 2 - 1000 Hz, r < 600 rpm	Pumps > 15 kW Radial , Axial, Mixed Flow				Medium Size Machines 15 kW < Power < 300 kW		Large Machines 300 kW < Power < 50 MW	
	Group 4 Integrated Driver		Group 3 External Driver		Group 2 160 mm < Motor Height < 315 mm		Group 1 315 mm < Motor Height	
Limit, mm/s, rms	**Rigid**	**Flexible**	**Rigid**	**Flexible**	**Rigid**	**Flexible**	**Rigid**	**Flexible**
> 18.0	D	D	D	D	D	D	D	D
11.0 - 18.0	D	D	D	D	D	D	D	D
7.1 - 11.0	D	D	D	C	D	D	D	C
4.5 - 7.1	D	C	C	B	D	C	C	B
3.5 - 4.5	C	B	B	B	C	B	B	B
2.8 - 3.5	C	B	B	A	C	B	B	A
2.3 - 2.8	B	B	B	A	B	B	B	A
1.4 - 2.3	B	A	A	A	B	A	A	A
0.7 - 1.4	A	A	A	A	A	A	A	A
0.0 - 0.7	A	A	A	A	A	A	A	A

Newly Commissioned

Unrestriced long-term operation

Restriced long-term operation

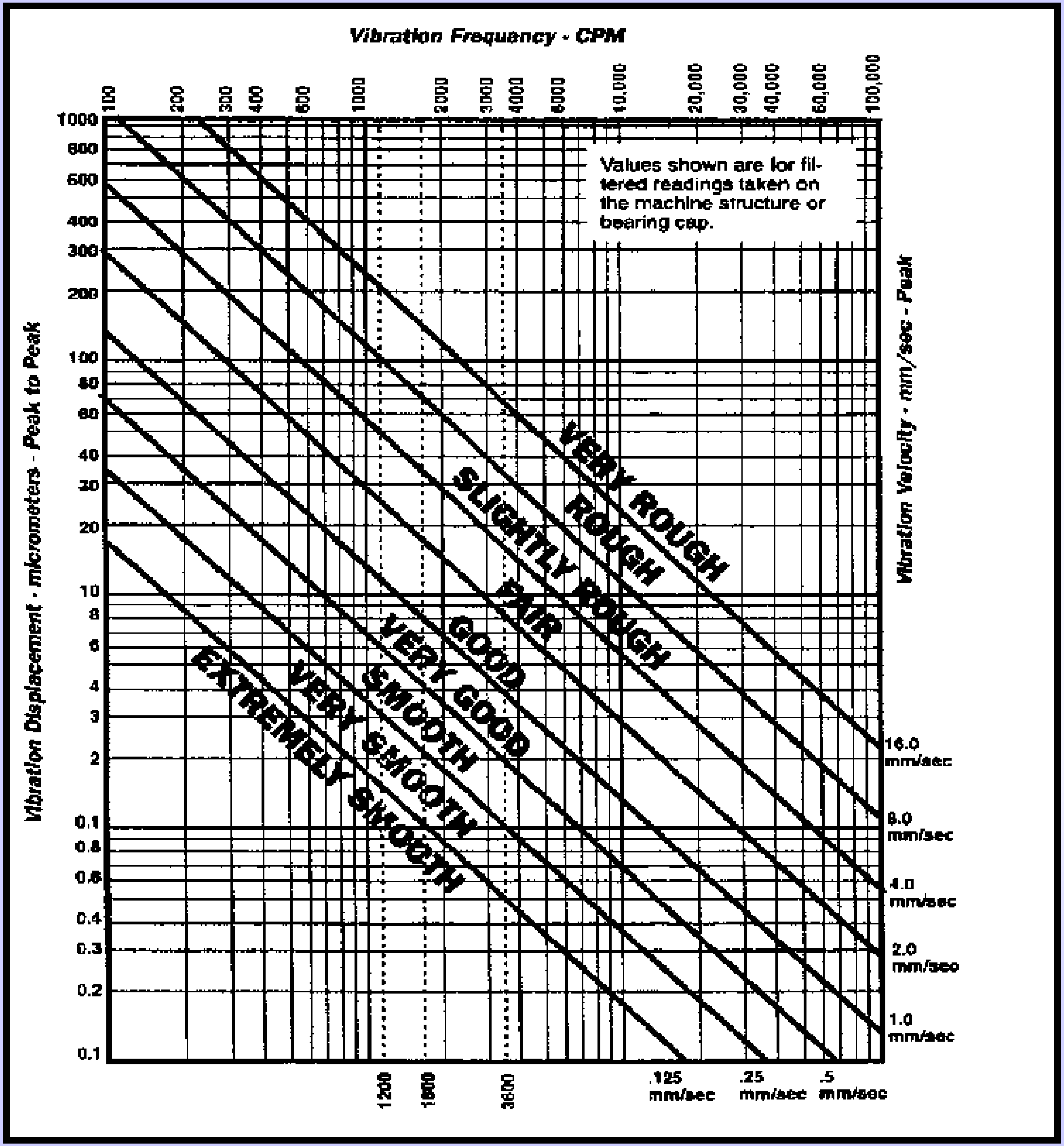
Vibration causes damage

ISO 10816 Part 3

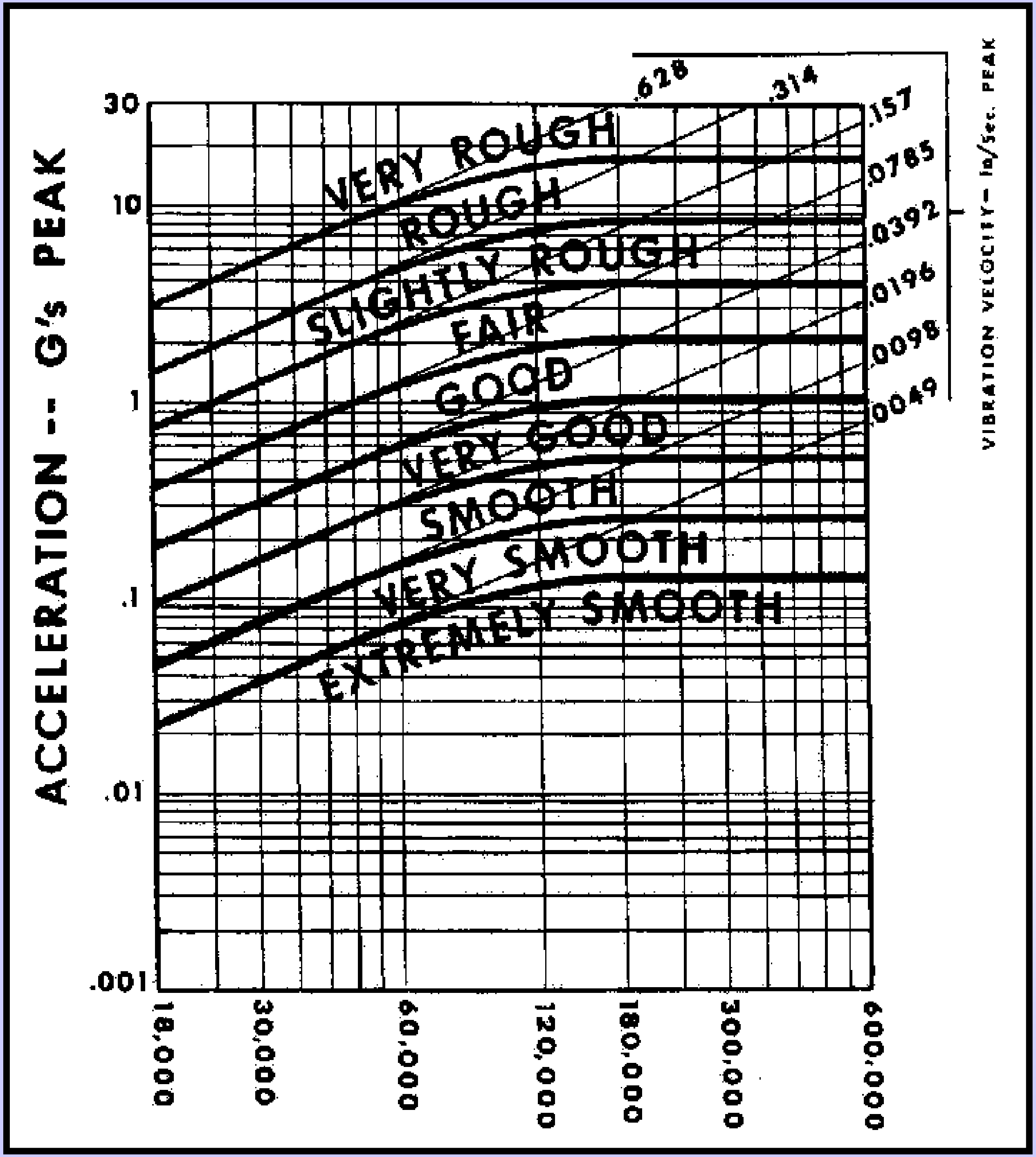
Industrial Machines with nominal power above 15 kW and nominal speeds between 120 rpm and 15,000 rpm when measured insitu

Displacement	Pumps > 15 kW				Medium Size Machines		Large Machines	
10 -1000 Hz, r > 600 rpm	Radial , Axial, Mixed Flow				15 kW < Power < 300 kW		300 kW < Power < 50 MW	
2 - 1000 Hz, r > 120 rpm	Group 4		Group 3		Group 2		Group 1	
	Integrated Driver		External Driver		160 mm < Motor Height < 315 mm		315 mm < Motor Height	
Limit, micron, rms	**Rigid**	**Flexible**	**Rigid**	**Flexible**	**Rigid**	**Flexible**	**Rigid**	**Flexible**
> 140	D	D	D	D	D	D	D	D
113 - 140	D	D	D	D	D	D	D	C
90 - 113	D	D	D	D	D	C	D	C
71 - 90	D	D	D	C	D	C	C	B
56 -71	D	D	D	C	C	B	C	B
45 -56	D	C	C	B	B	B	B	B
36 -45	D	C	C	B	B	B	B	A
28 -36	C	B	B	B	B	A	B	A
22 -28	C	B	B	A	B	A	A	A
18 -22	B	B	B	A	A	A	A	A
11 -18	B	A	A	A	A	A	A	A
0 - 11	A	A	A	A	A	A	A	A

	Newly Commissioned
	Unrestriced long-term operation
	Restriced long-term operation
	Vibration causes damage



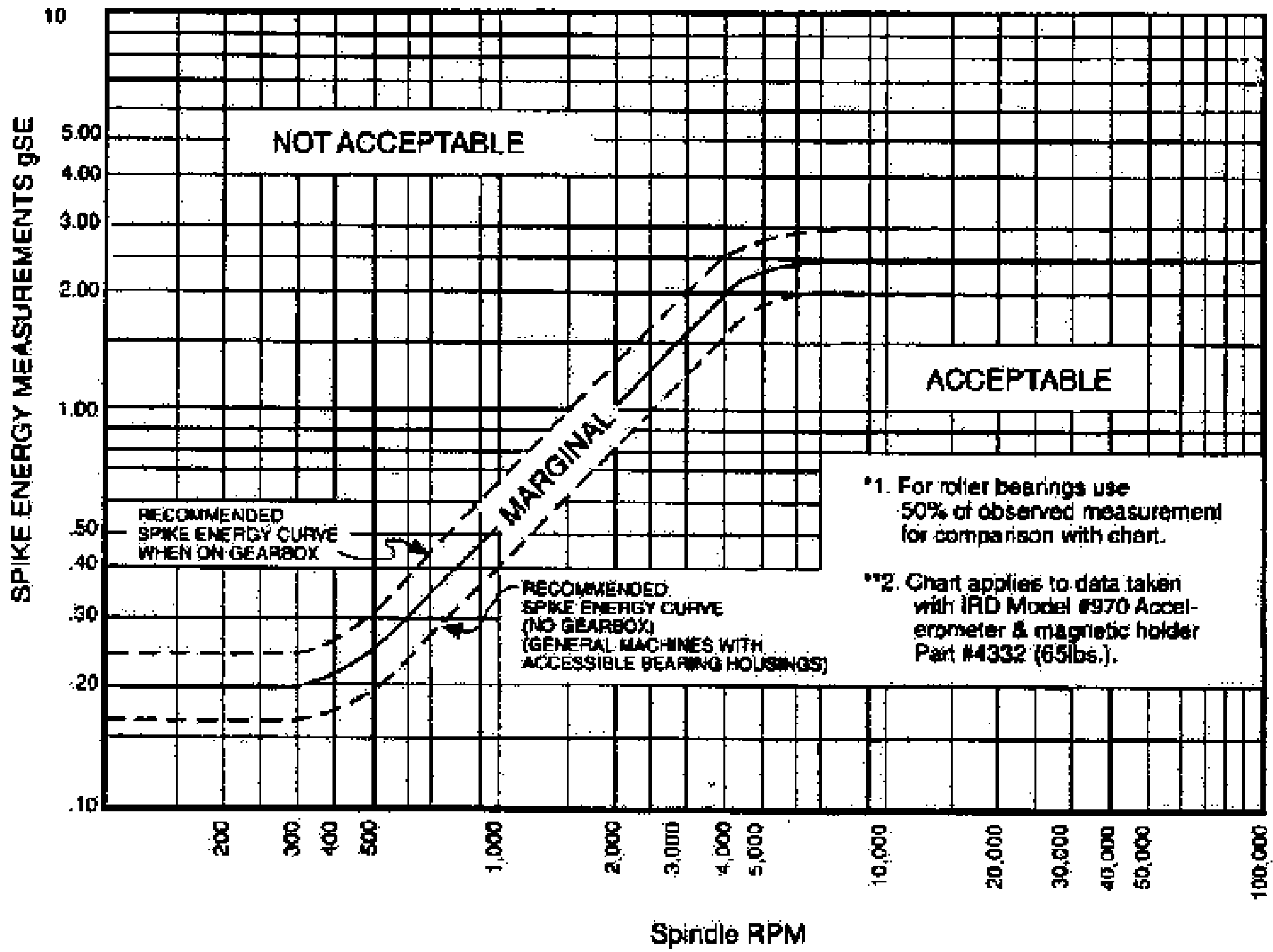
General Machinery Vibration Severity Chart



Vibration acceleration

(G's)

Severity chart



Recommended Spike Energy severity chart (IRD Spike Energy)
Severity Chart Guidelines For Ball Bearings*
Figure 1

3600 RPM = 1.4 gSE
1900 RPM = .70
1200 RPM = .50
900 RPM = .35
600 RPM = .25

Normal gSE alarms for standard RPM machs.
(IRD 970 Accelerometer & Magnet WITHOUT GEARBOX)

Vibration acceleration in Spike Energy (G'SE) Severity chart สำหรับการวัดลูกปืน

SUGGESTED OVERALL ALARMS BY MACHINE TYPE-METRIC (PEAK, OVERALL VELOCITY, MM/SEC.)

MACHINE TYPE	GOOD	FAIR	ALARM
COOLING TOWER DRIVES	0-9.5	9.5-15	15
COMPRESSORS			
Reciprocating	0-8	8-13	13
Rotary Screw	0-7	7-11	11
Centrifugal with or without External Gearbox	0-5	5-7.5	7.5
Centrifugal-Integral Gear (Axial Meas.)	0-5	5-7.5	7.5
Centrifugal-Integral Gear (Radial Meas.)	0-4	4-6.5	6.5
BLOWERS FANS			
Lobe-Type Rotary	0-7.5	7.5-11.5	11.5
Belt-Driven Blower	0-7	7-11	11
General Direct Drive Fans	0-6.5	6.5-9.5	9.5
Primary Air Fans	0-6.5	6.5+9.5	9.5
Large Forced Draft Fans	0-5	5-7.5	7.5
Large Induced Draft Fans	0-4.5	4.5-7	7
Shaft-Mounted Integral Fan	0-4.5	4.5-7	7
MOTOR/GENERATOR SETS			
Belt-Driven	0.7	7-11	11
Direct Coupled	0-5	5-7.5	7.5
CHILLERS			
Reciprocating	0-6.5	6.5-10	10
Centrifugal (Open-Air)	0-5	5-7.5	7.5
Centrifugal (Hermetic)	0-4	4-6	6
LARGE TURBINE/GENERATORS			
3600 RPM Turbine/Generators	0-6.5	6.5-9.5	9.5
3600 RPM Turbine/Generators	0-.65	6.5-9.5	9.5
1800 RPM Turbine/Generators	0-4.5	4.5-7	7

MACHINE TYPE	GOOD	FAIR	ALARM
CENTRIFUGAL PUMPS			
Vertical Pump (12" - 20")	0-9.5	9.5-15	15
Vertical Pump (8" - 12" Height)	0-8	8-13	13
Vertical Pump (5" - 8" Height)	0-6.5	6.5-10	10
Vertical Pump (0" - 5" Height)	0-5	5-7.5	7.5
General Purpose Horizontal	0-5	5-7.5	7.5
Boiler Feed Pumps	0-5	5-7.5	7.5
Hydraulic Pumps	0-3	3-5	5
MACHINE TOOLS			
Motor	0-2.5	2.5-4.5	4.5
Gearbox Input	0-4	4-6	6
Gearbox Output	0-2.5	2.5-4.5	4.5
SPINDLES			
Roughing Operations	0-2	2-3	3
Machine Finishing	0-1	1-2	2
Critical Finishing	0-0.5	0.5-1	1

CHART NOTES :

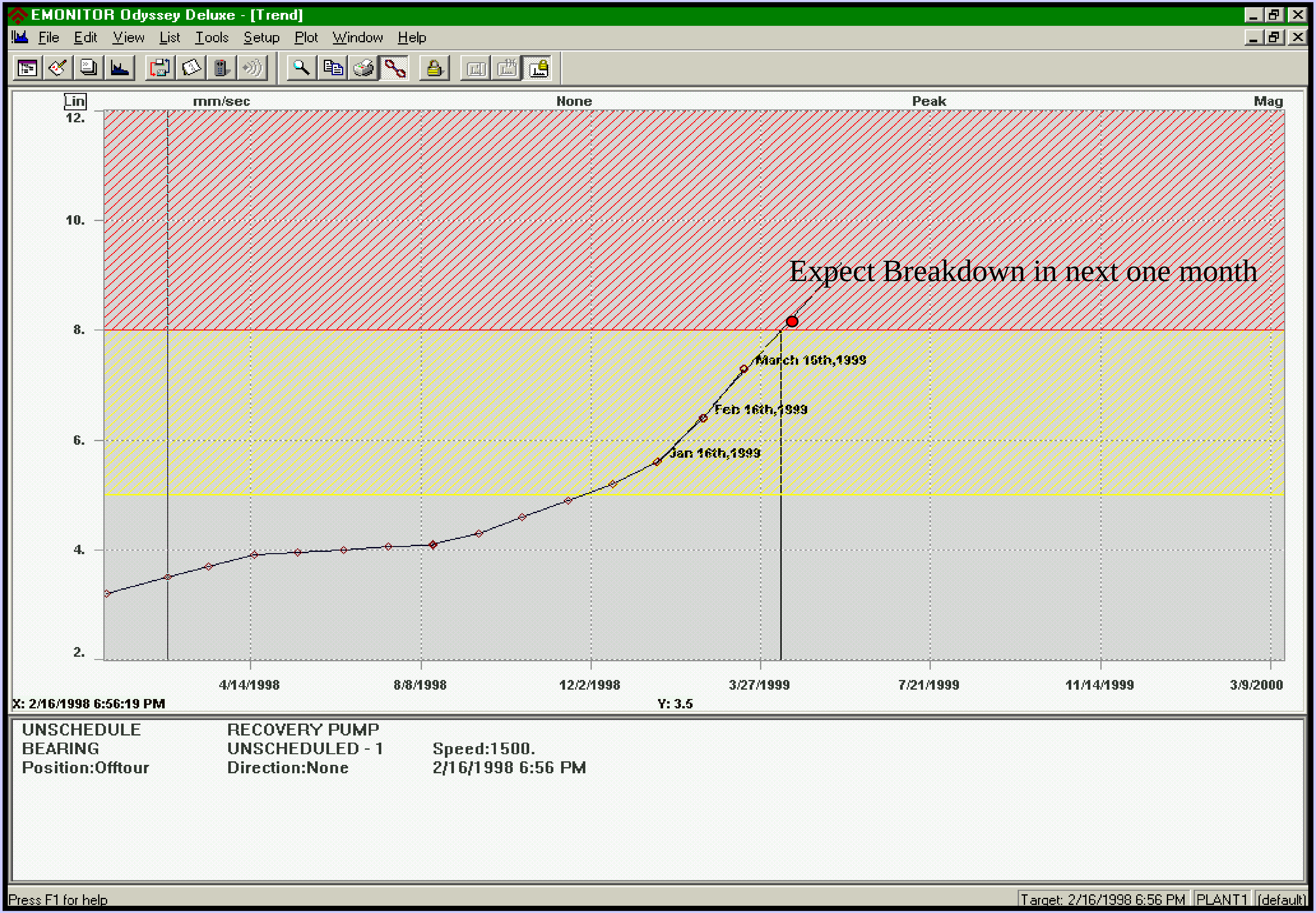
1 Assuming machine speed = 500 to 600,000 RPM

2 Assuming measurements by accelerometer or velocity pickup as close as possible to bearing housing.

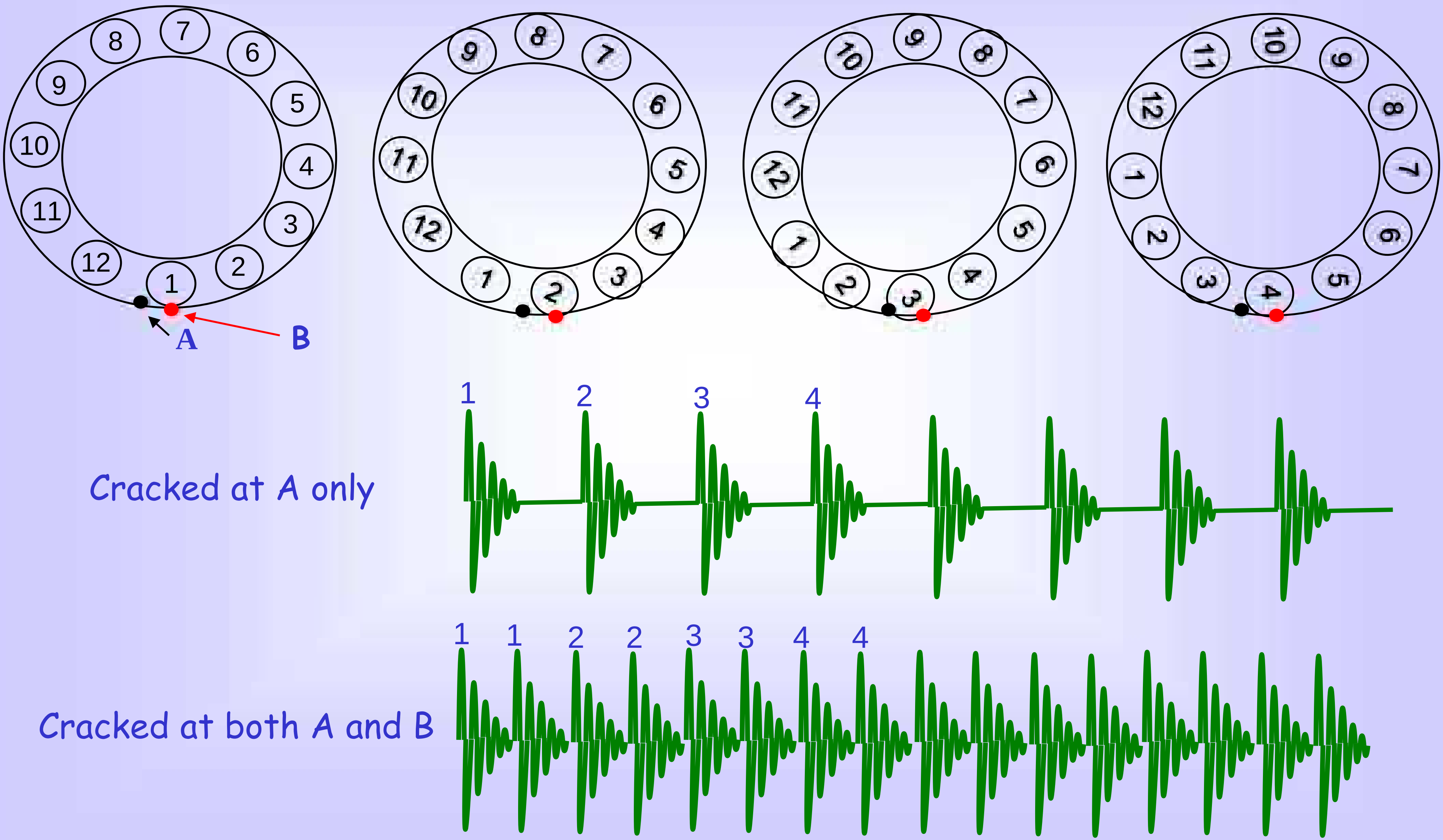
3 Assuming machine not mounted on vibration isolators (for isolated machinery-set alarm 30% to 50% higher)

4. Set motor alarms same as that for the particular machine type, unless otherwise noted.

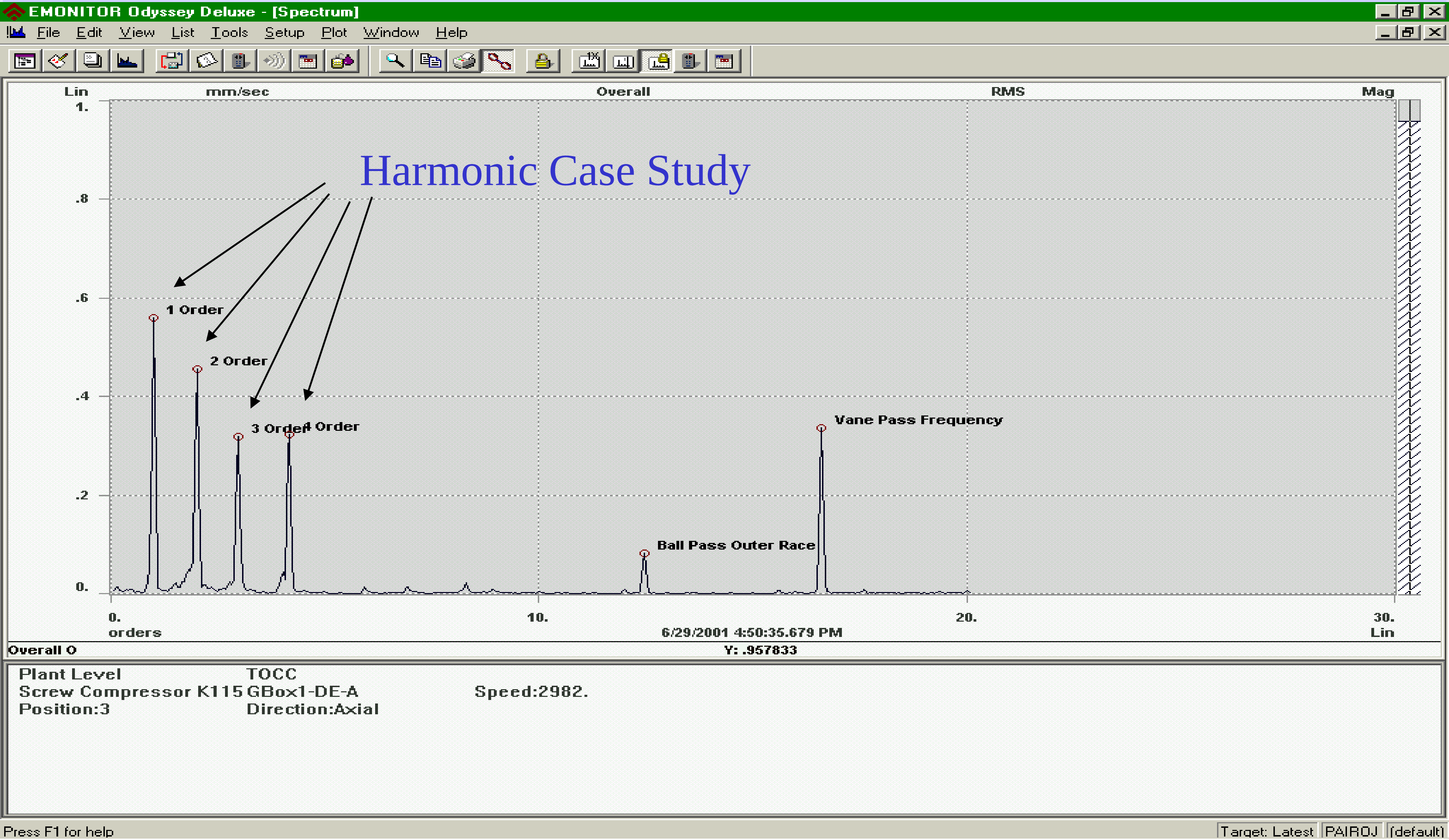
5 Set alarms on individual external gearbox 25% higher than that for a particular machine type


EMONITOR Odyssey Deluxe - [Trend]
File Edit View List Tools Setup Plot Window Help
Lin
mm/sec
None
Peak
Mag
12.
10.
8.
6.
4.
2.
Expect Breakdown in next one month
March 16th,1999
Feb 16th,1999
Jan 16th,1999
4/14/1998
8/8/1998
12/2/1998
3/27/1999
7/21/1999
11/14/1999
3/9/2000
X: 2/16/1998 6:56:19 PM
Y: 3.5
UNSCHEDULE
BEARING
Position:Offtour
RECOVERY PUMP
UNSCHEDULED - 1
Direction:None
Speed:1500.
2/16/1998 6:56 PM
Press F1 for help
Target: 2/16/1998 6:56 PM
PLANT1
(default)

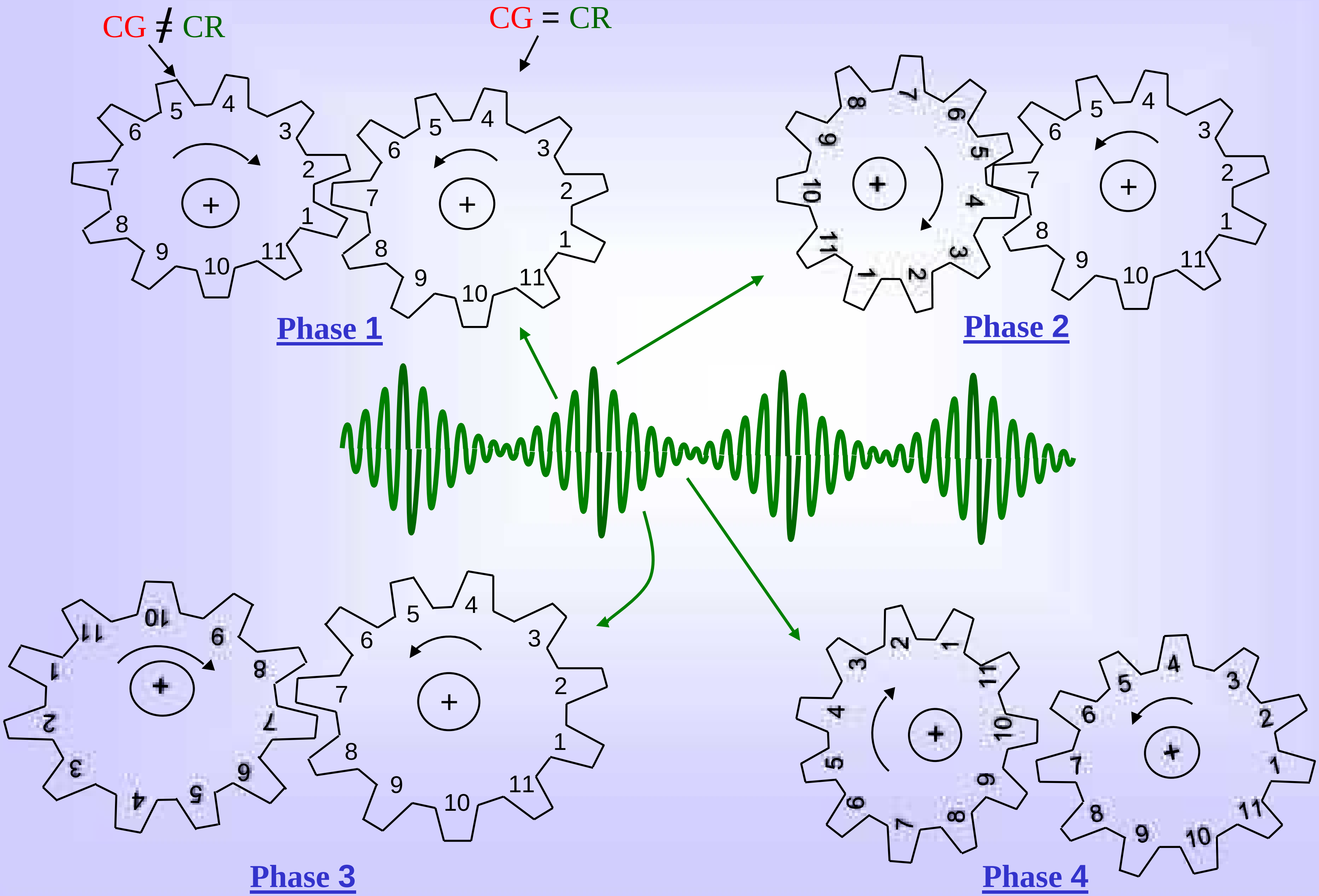
Harmonics



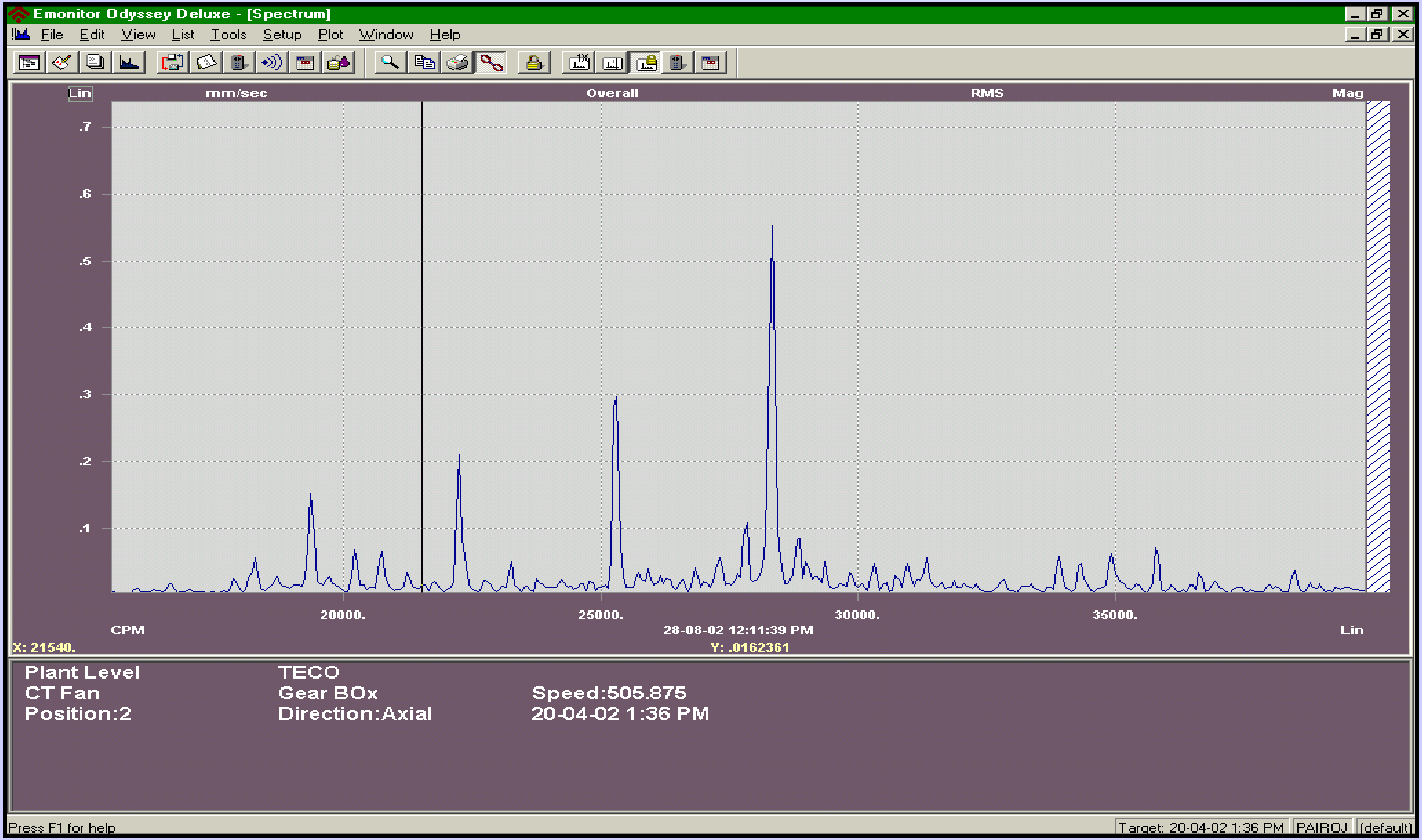
Harmonic Example



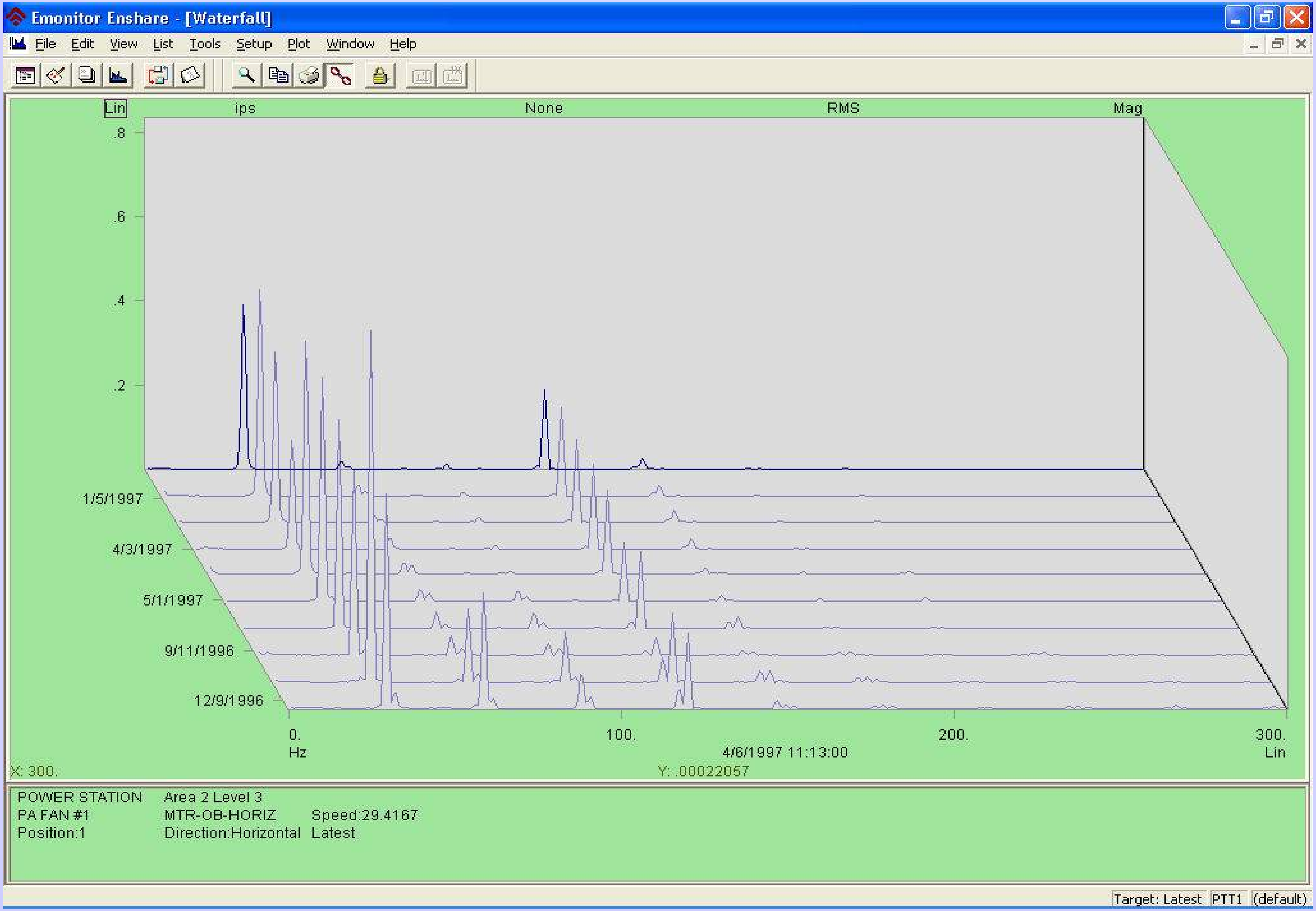
SIDE BAND



Side Band example at Gearbox of A Cooling Tower Fan with a very few of sideband frequency

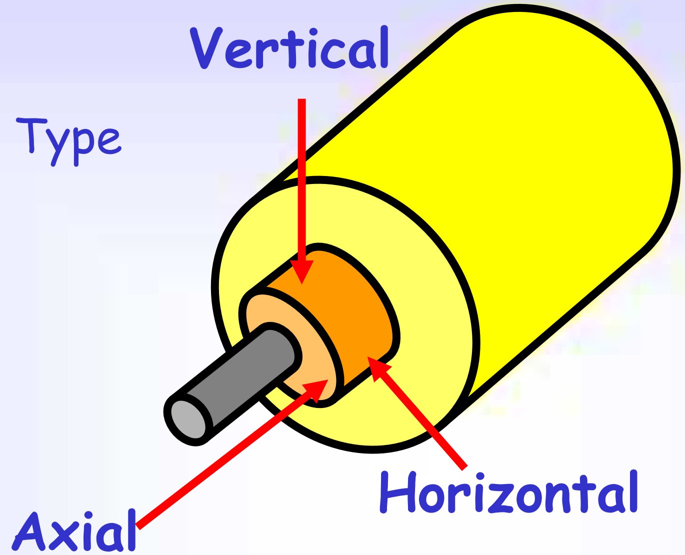


Waterfall Plot is Spectrum Trend



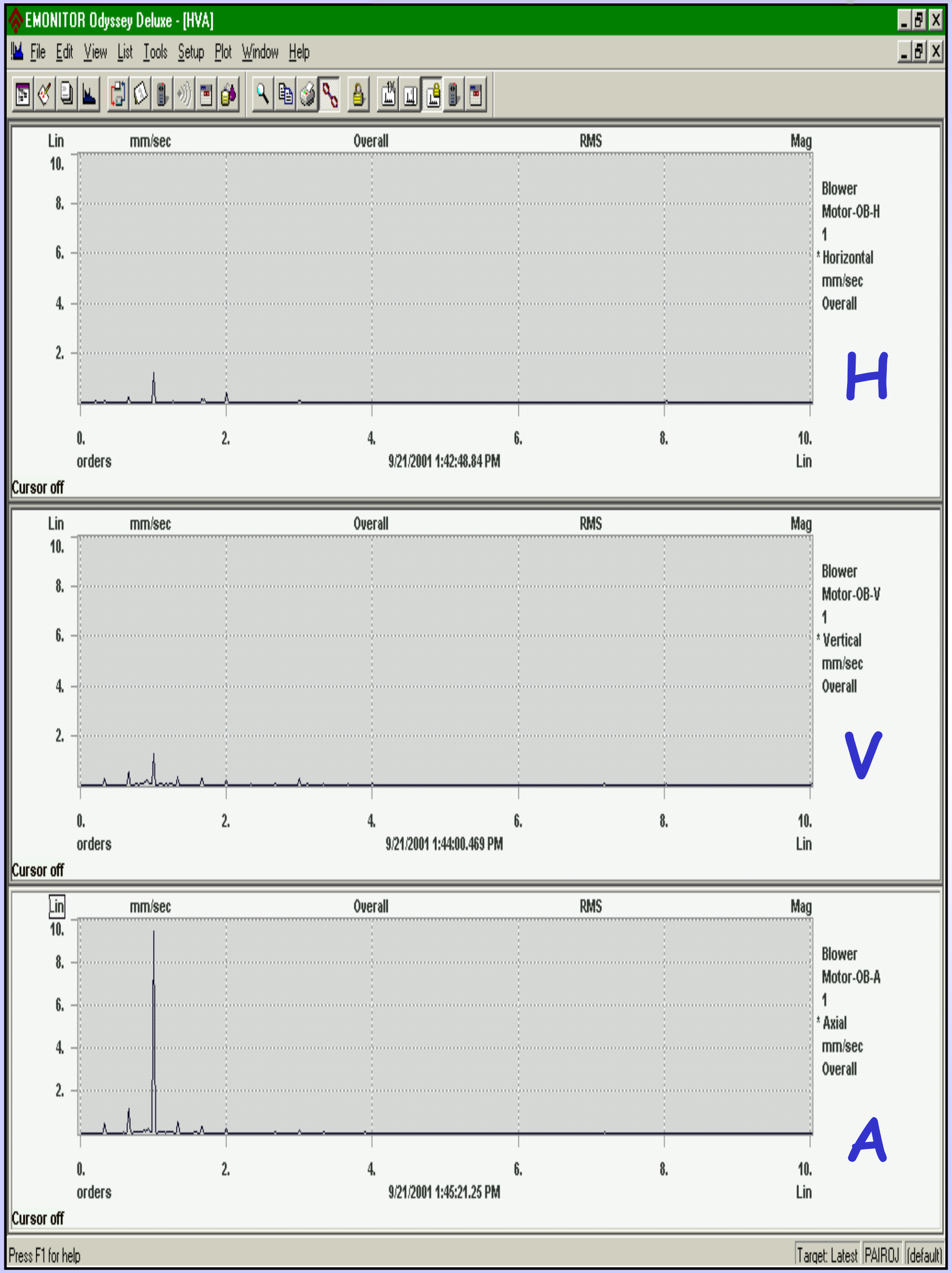
Directional Analysis for Overall value

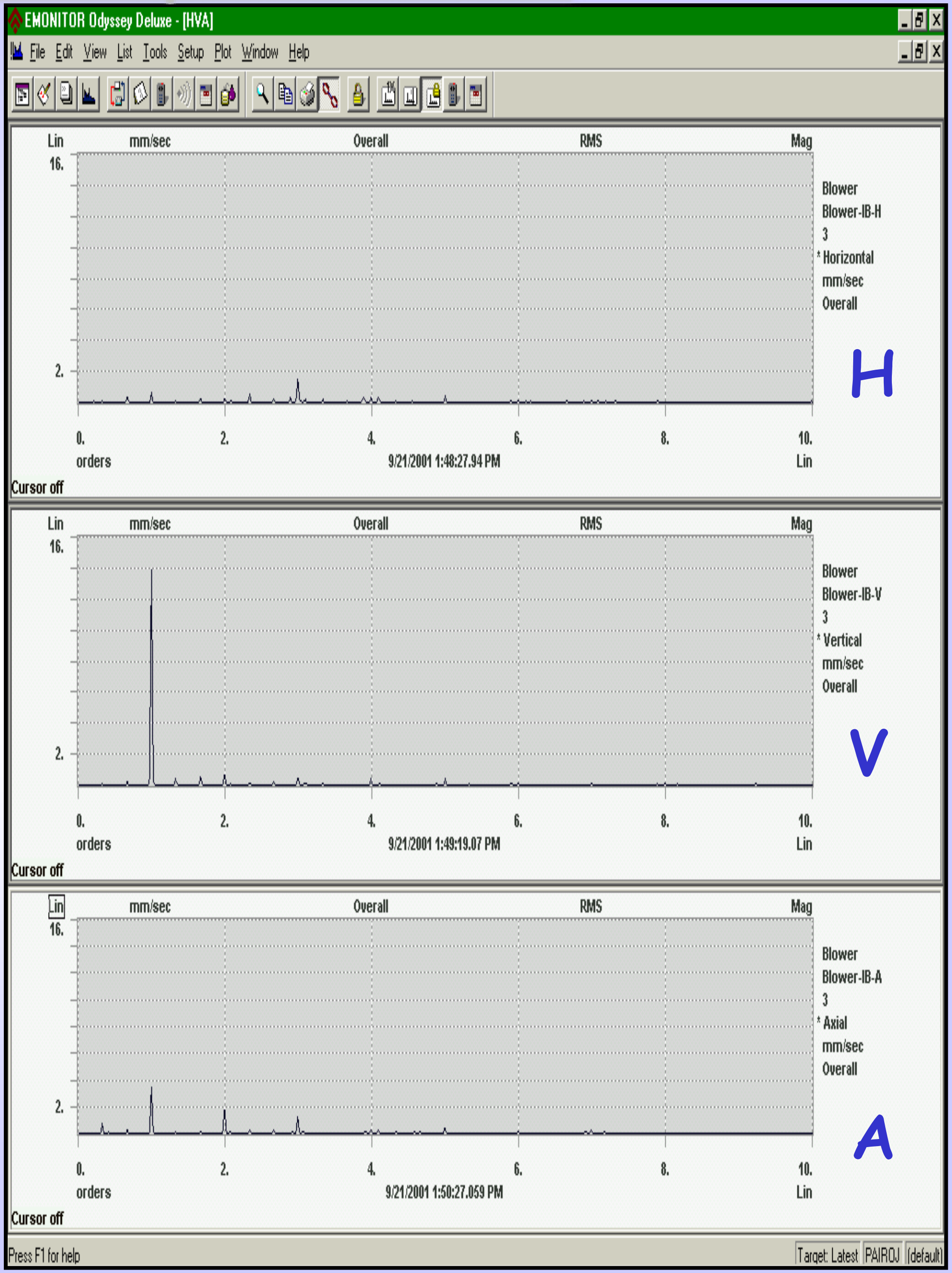
R = H or V ที่สูงที่สุด
Machine ต้องไม่เป็น Overhung Type



Unbalance		Misalignment		Resonance
Pure Unbalance	**Main Unbalance**	**Main Misalign.**	**Pure Misalignment**	
A < 0.3R	0.3R< A < 0.5R	0.5R < A < 1R	A > R	H > 4V or V > 4H

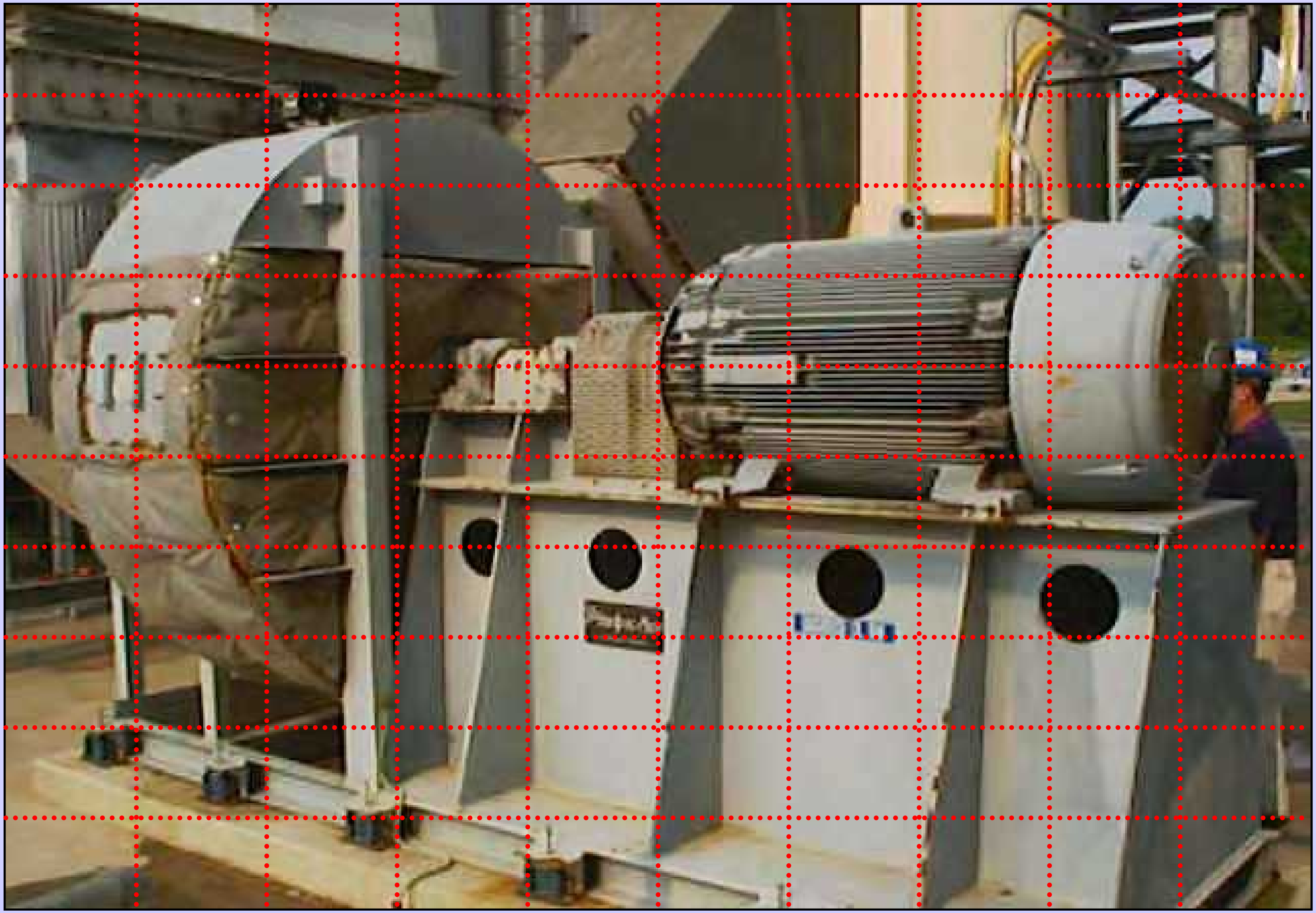
Directional Analysis for Spectrum value





VIBRATION ANALYSIS BY GRIDDING

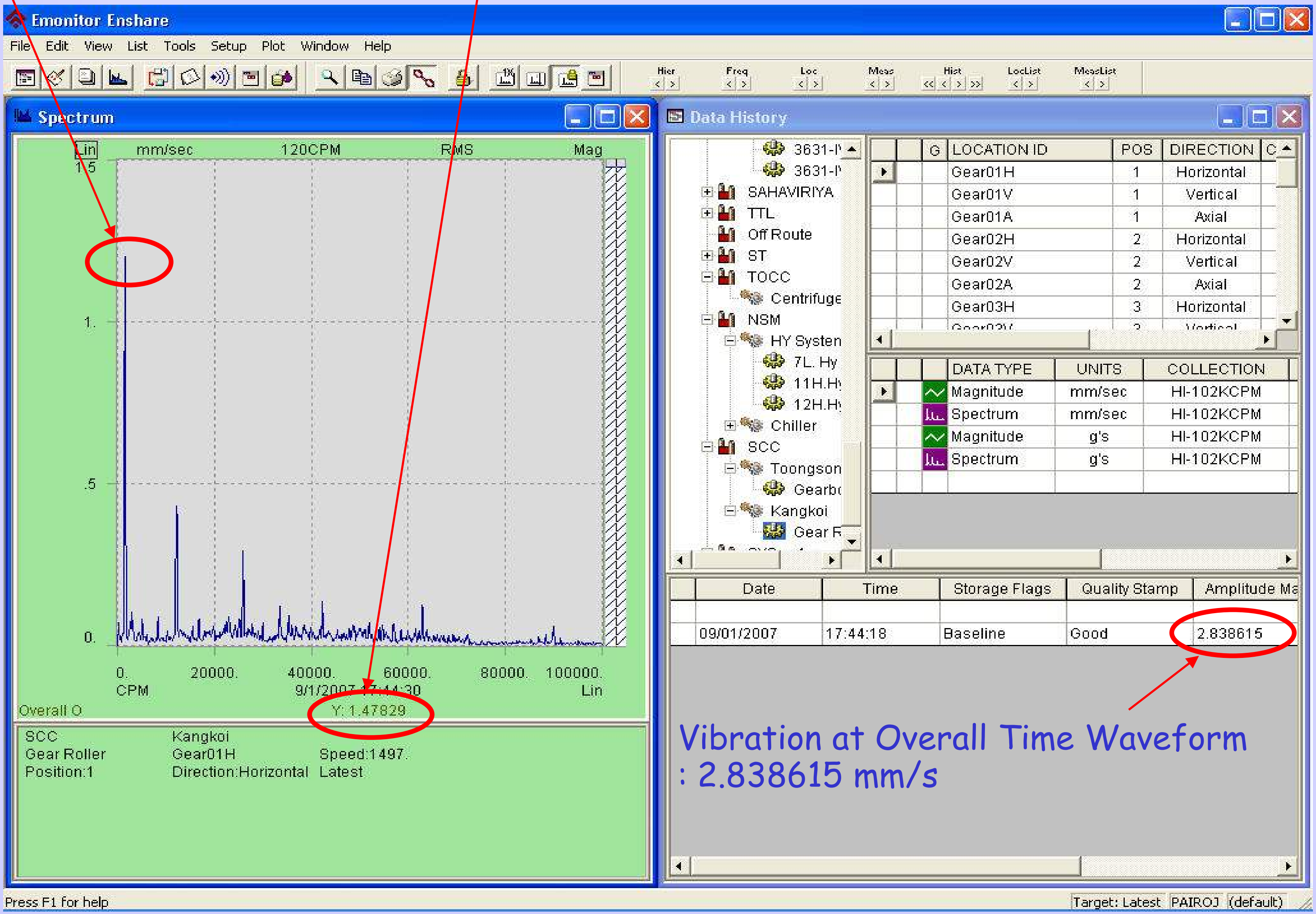
HELP TO ANALYSE THE REAL SOURCE OF THE PROBLEM WHICH MAY COMES FROM MOTOR PEDESTAL, STRUCTURE, BASEPLATE OR FOUNDATION



ANALYSE PEAK VIBRATION IN DIFFERENT WAYS.

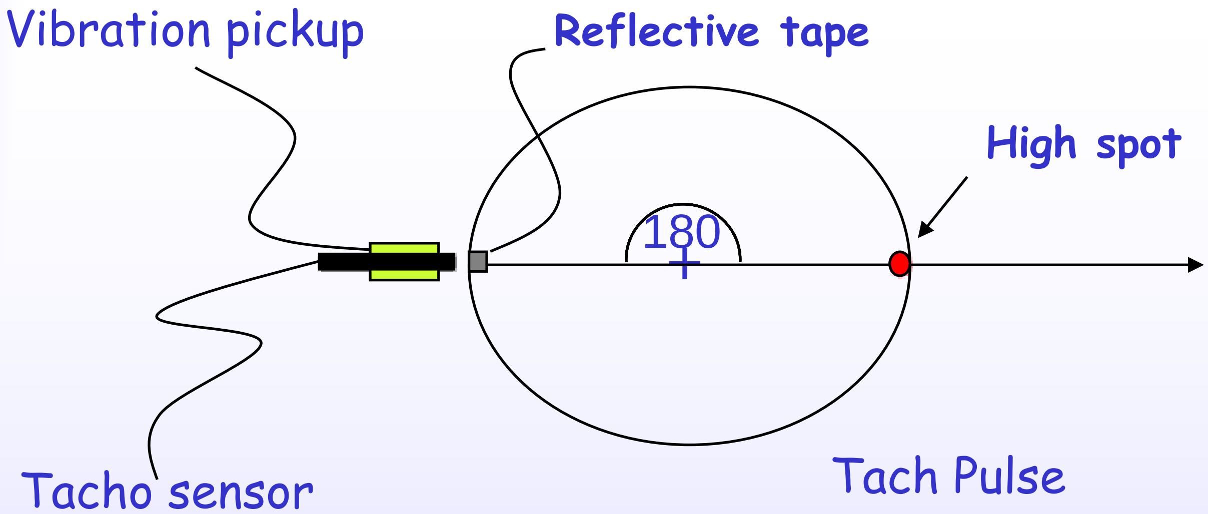
Vibration at Peak: 1.2 mm/s

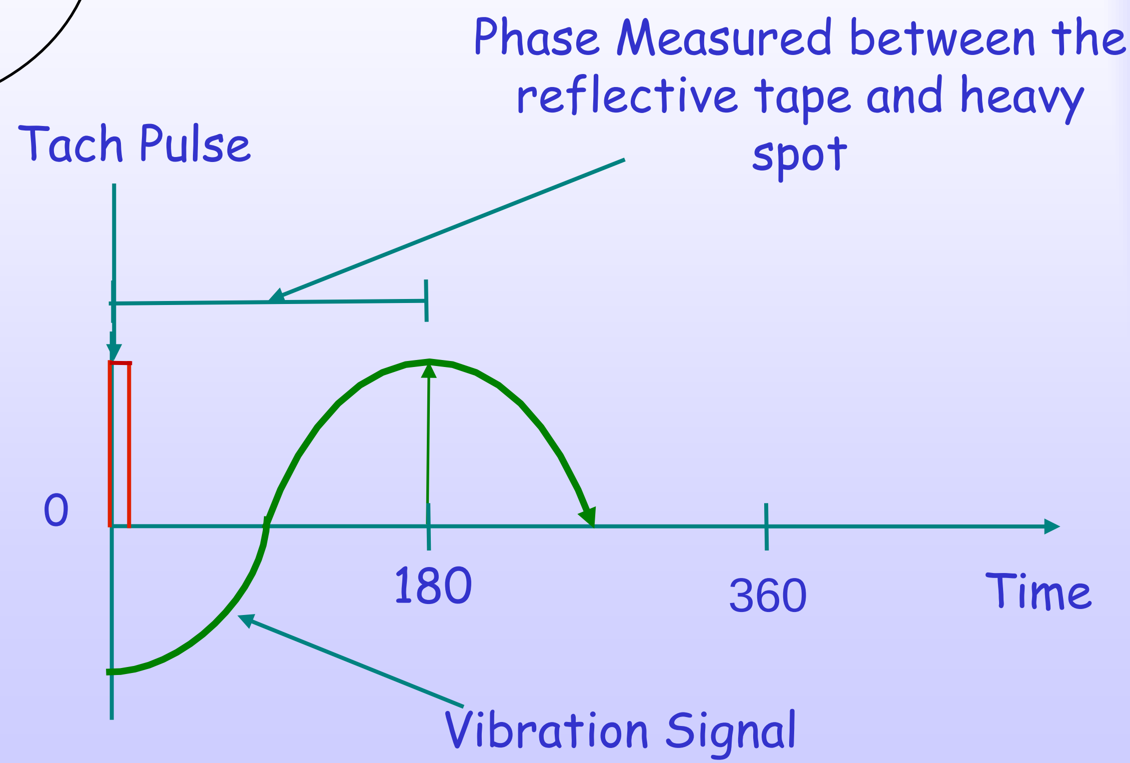
Vibration at Overall Spectrum: 1.47829 mm/s



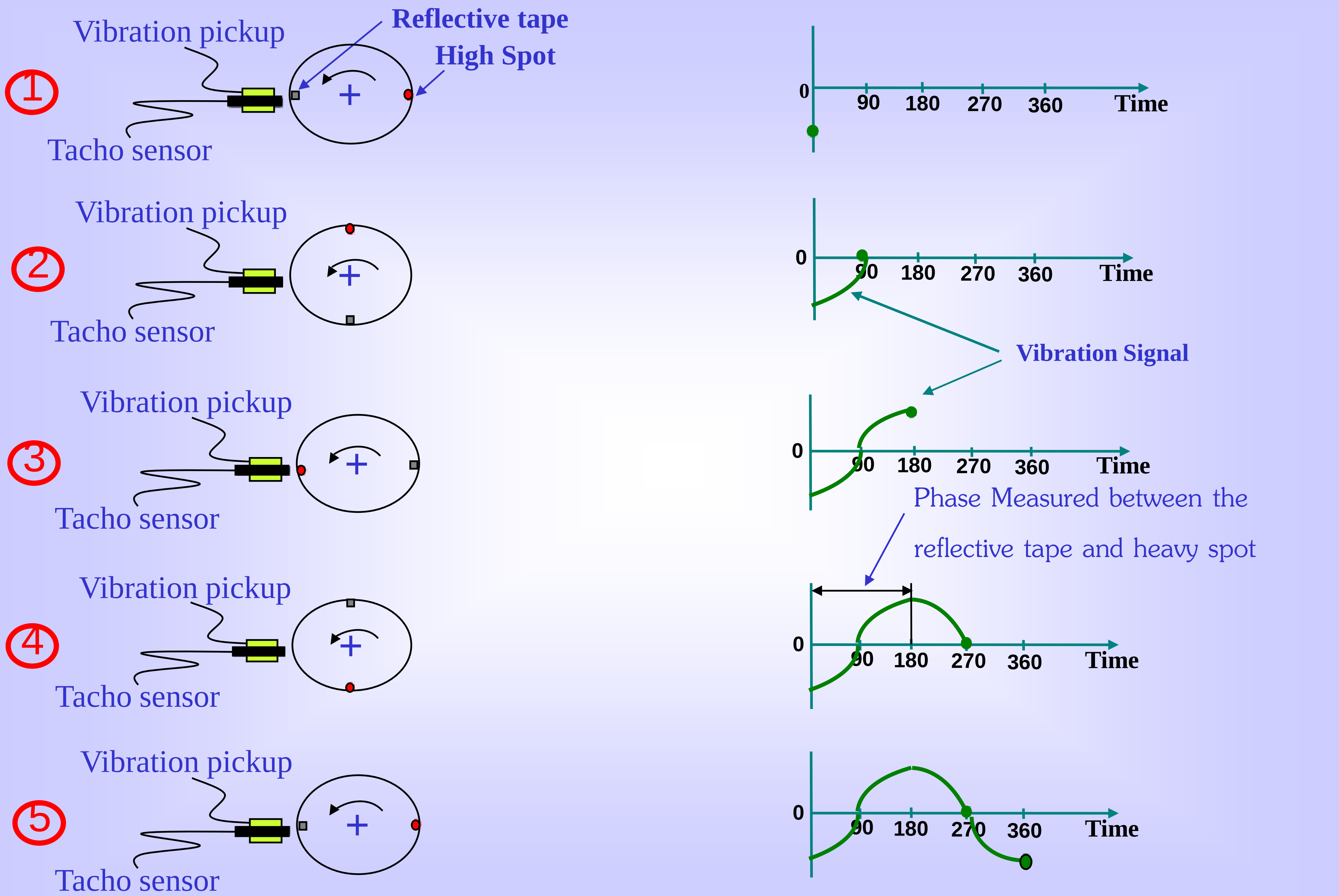
Vibration at Overall Time Waveform : 2.838615 mm/s

Phase Measurement

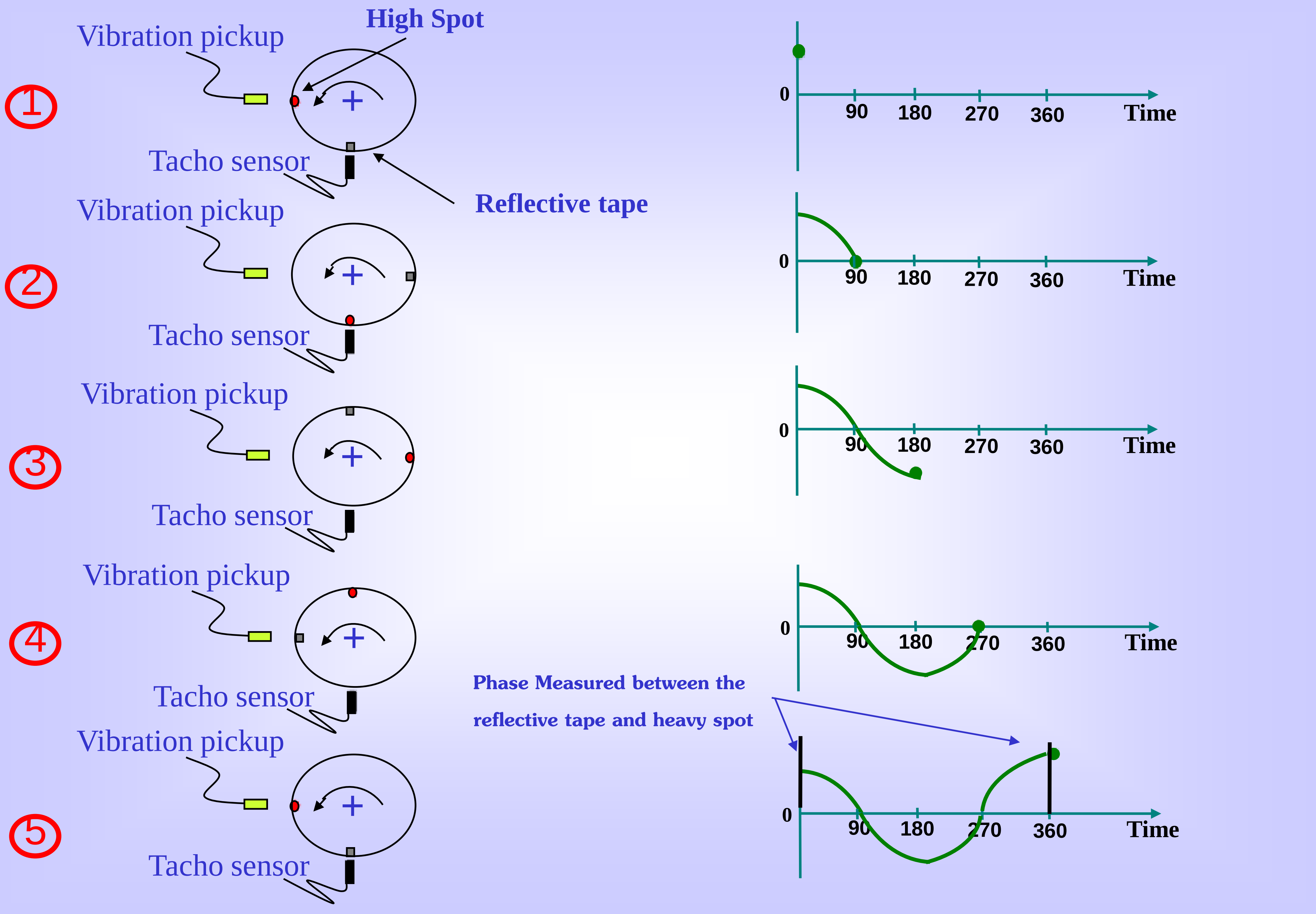




The Tacho signal get when the vibration is - Peak



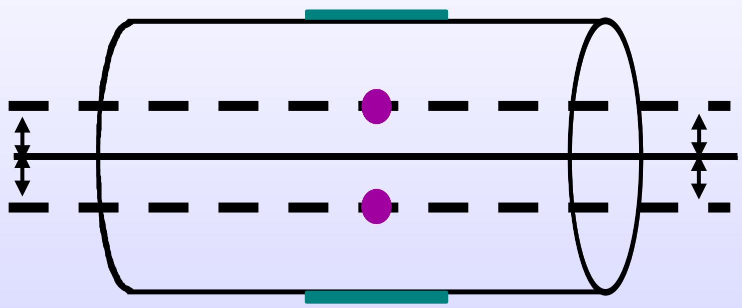
Reflective tape
High Spot
Vibration pickup
Tacho sensor
1
0
90
180
270
360
Time
2
3
4
5
Vibration Signal
Phase Measured between the
reflective tape and heavy spot



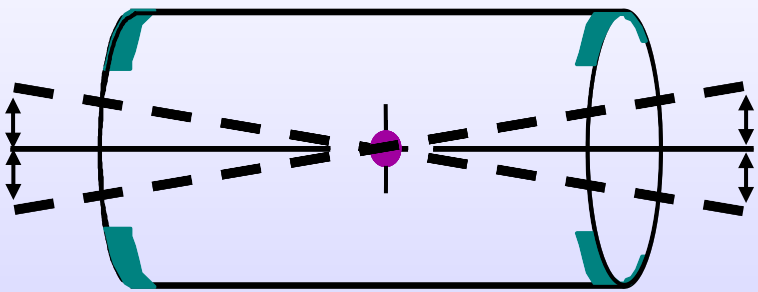
Vibration pickup
High Spot
Tacho sensor
Reflective tape
Phase Measured between the reflective tape and heavy spot
1
2
3
4
5
0
90
180
270
360
Time

Phase Comparison

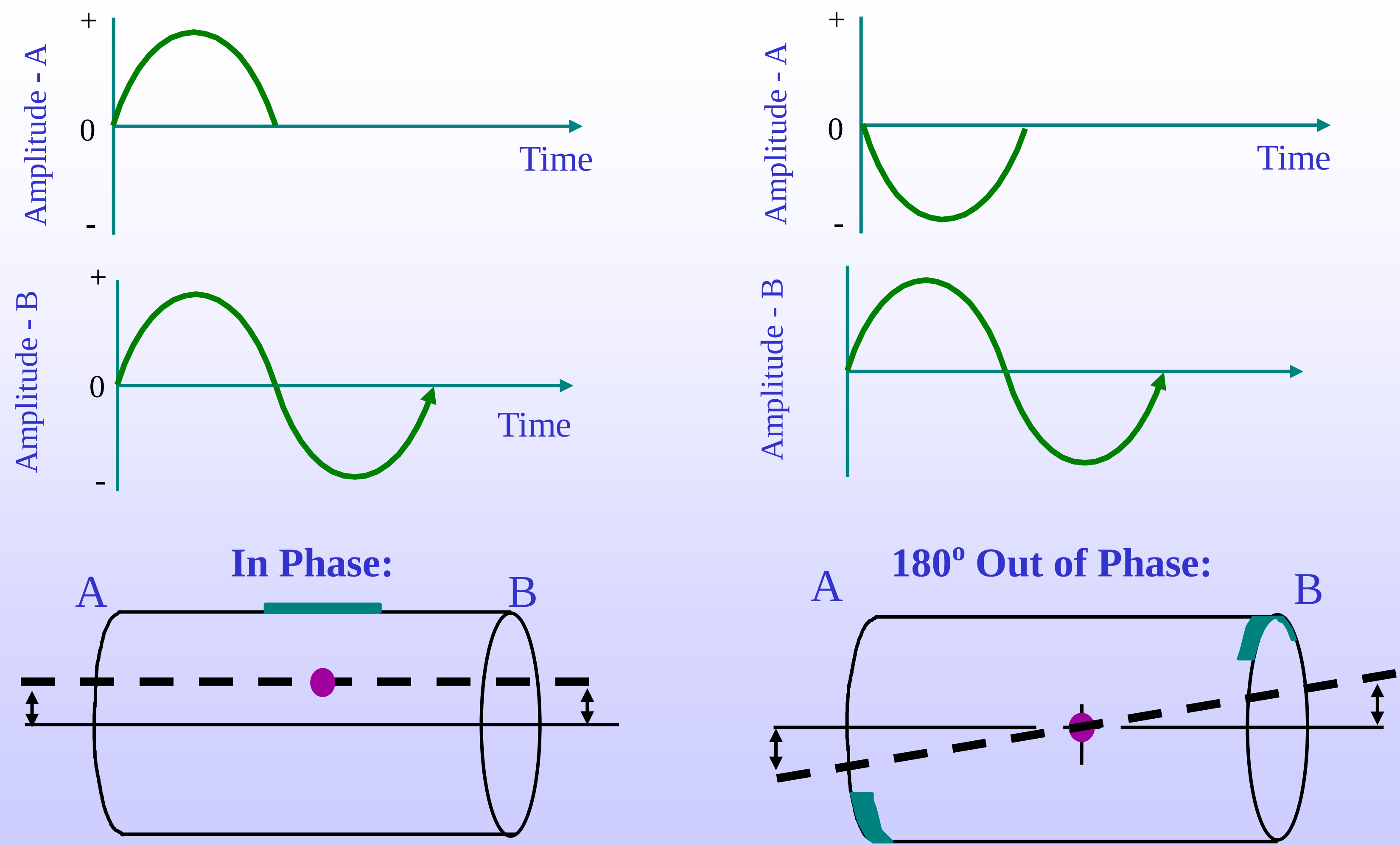
In Phase:



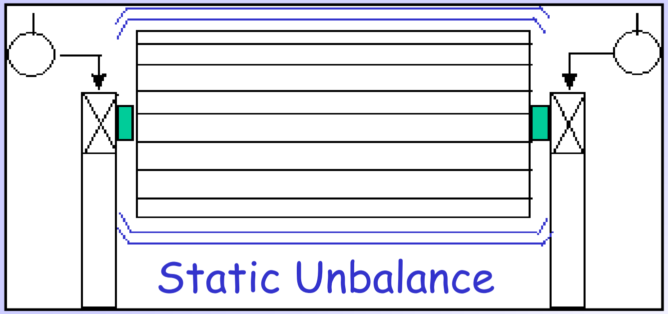
180° Out of Phase:



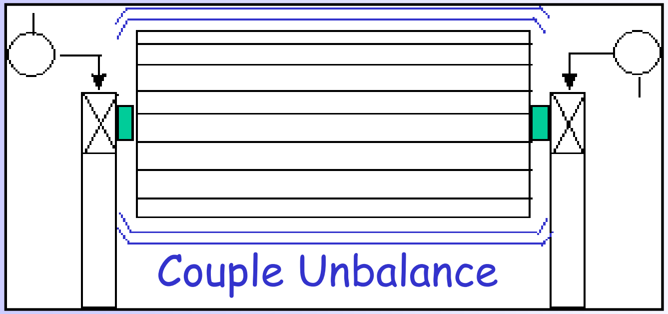
Phase Comparison



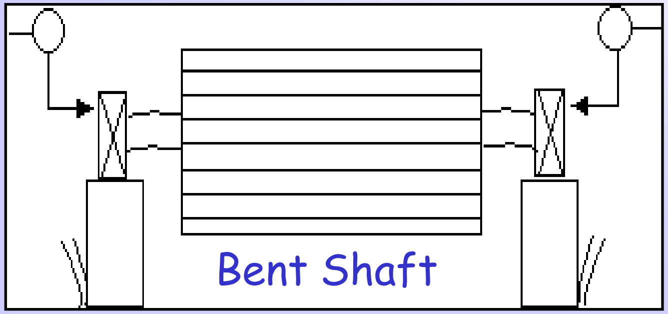
Phase Analysis



In-Phase for Static unbalance, test at radial

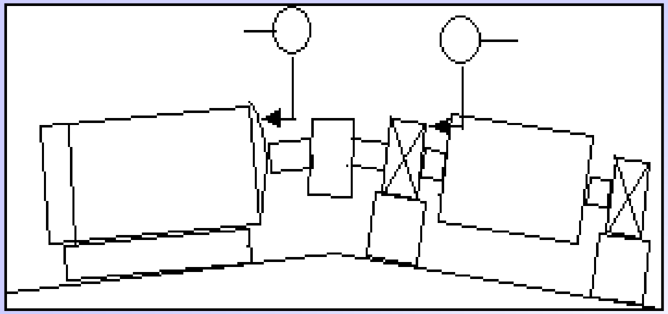


Out of Phase for Couple unbalance, test at radial.

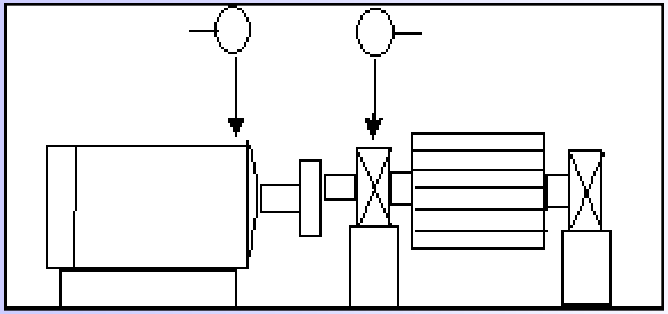


Out of Phase for Bent Shaft, test at axial.

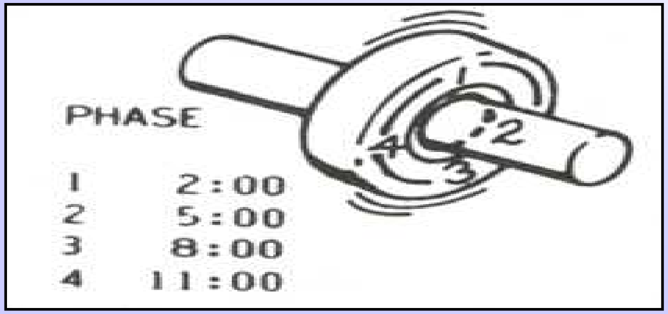
Phase Analysis



Out of Phase for Angular Misalignment, test at axial.

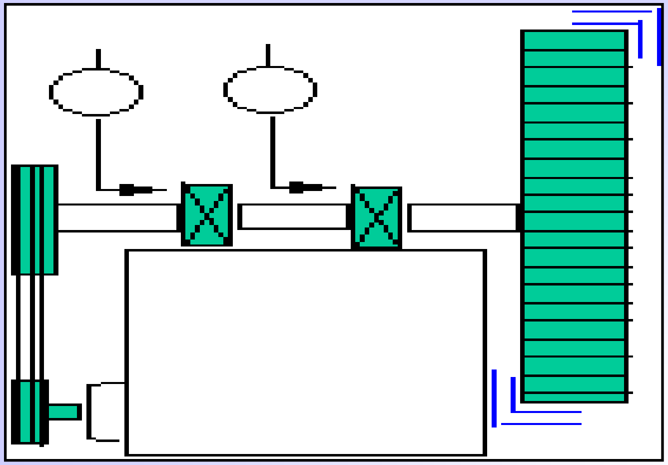


Out of Phase for Parallel Misalignment, test at radial.

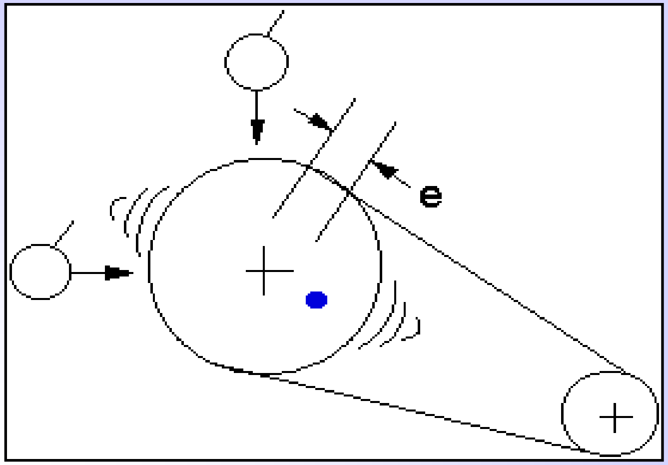


Out of Phase for Cocked Bearing, test at Circumstance of Bearing Housing.

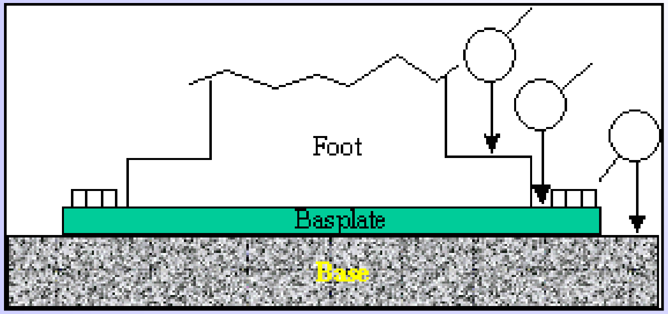
Phase Analysis



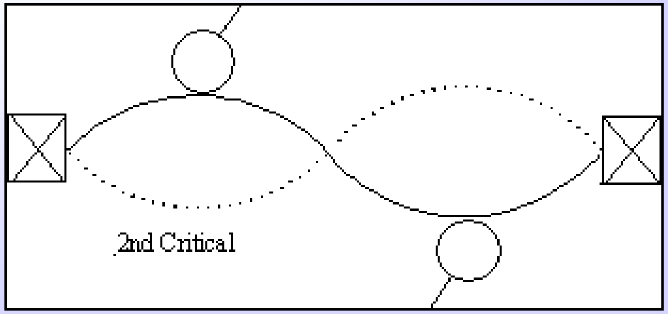
In-Phase for unbalance of Overhung Fan, test at radial



In-Phase for Eccentric Pulley, test at radial



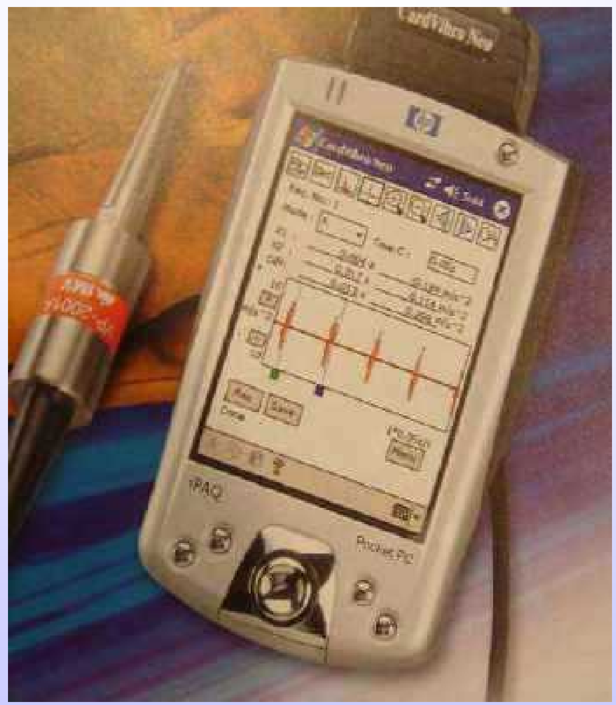
Out of Phase for Softfoot, Foundation distortion and Looseness, test at vertical



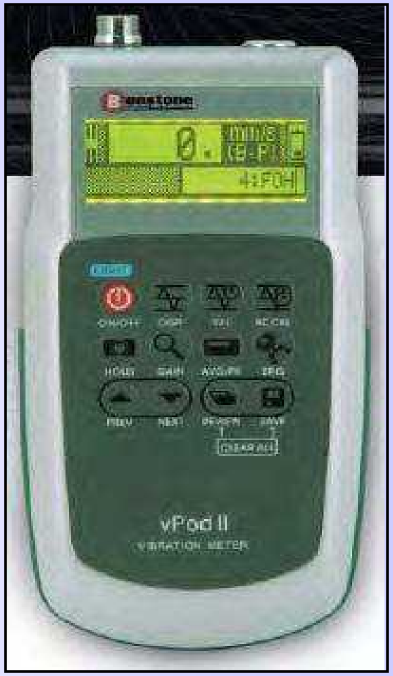
Out of Phase for Critical speed check

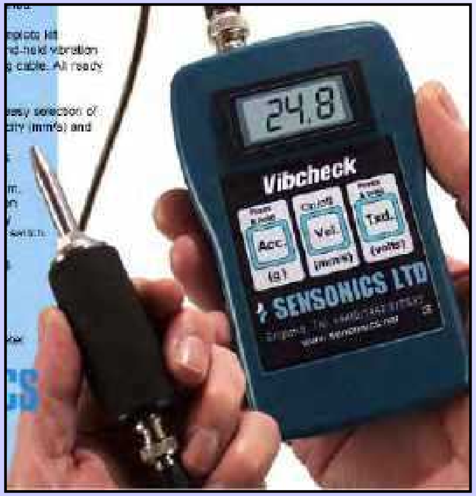
Real Time Analyzer

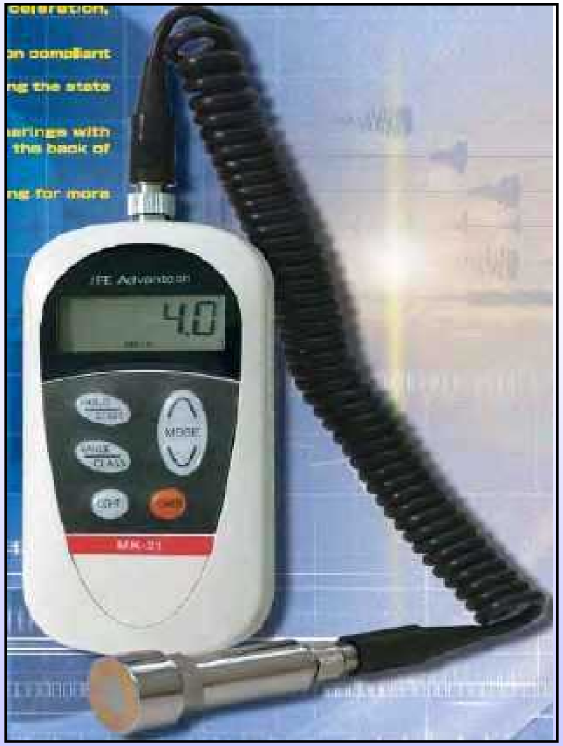
Portable Vibration Analyzer



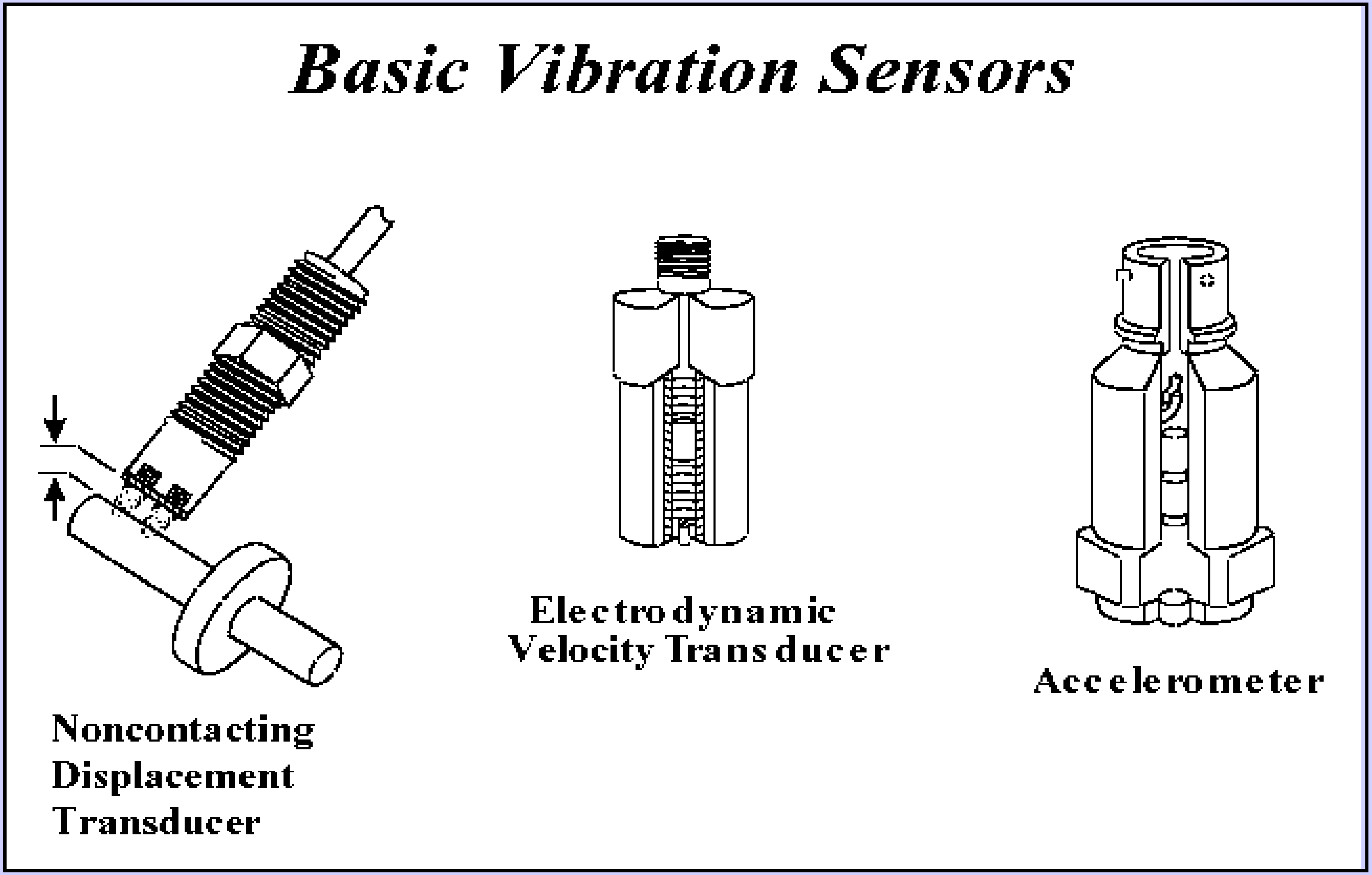
Portable Vibration Meter







ประเภทต่าง ๆ ของหัววัด Vibration



All sensors are designed to measure one of the three Sensors & Units

Displacement

mils (0.001 inch)

μm (0.001 millimeter)


Eddy Current Probes

Velocity

ips (inches/sec)

mm/s (millimeters/sec)


Velometers & Integrating Accelerometers

Acceleration

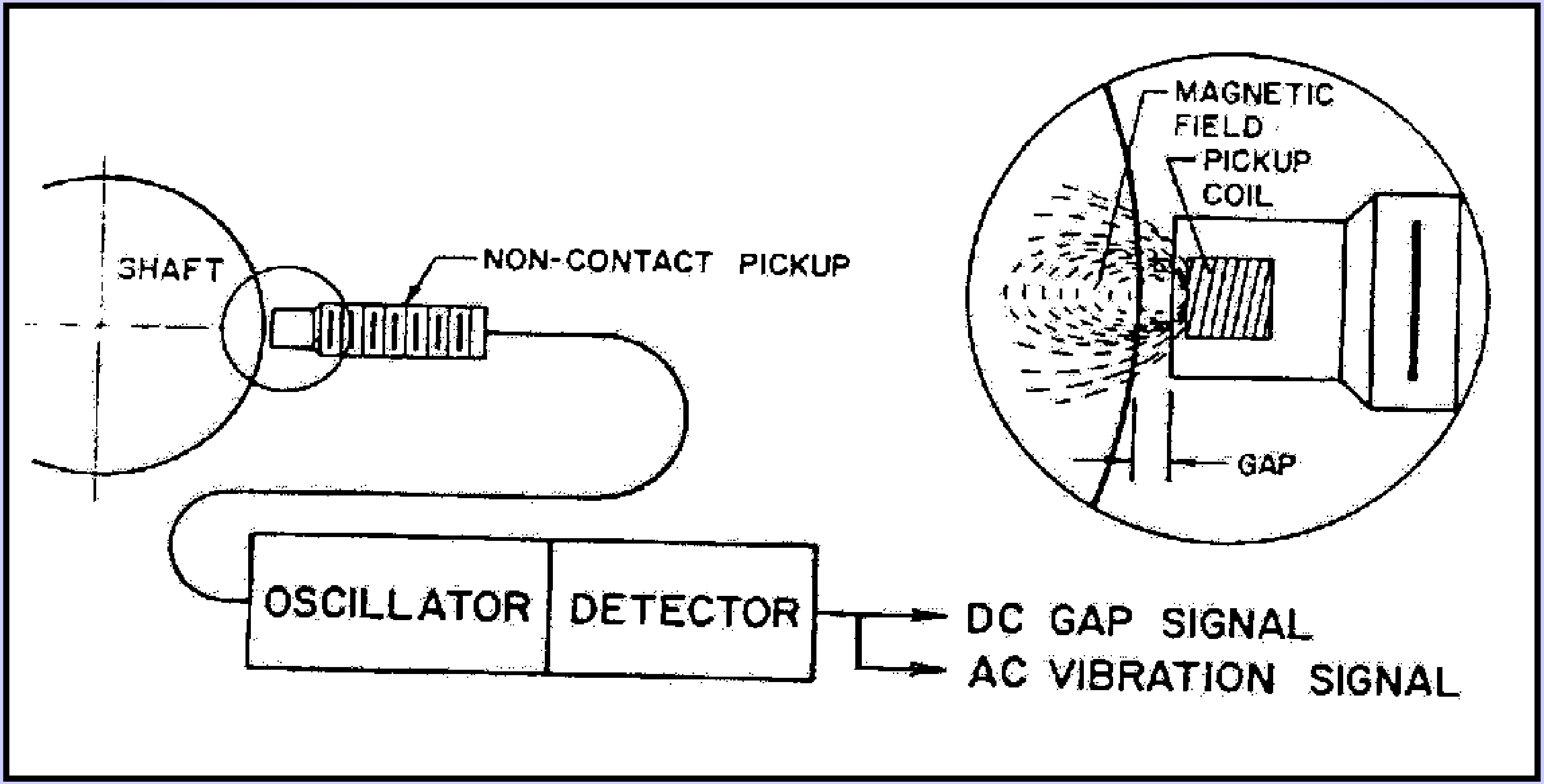
g's

m/s^2(meters/sec^2)

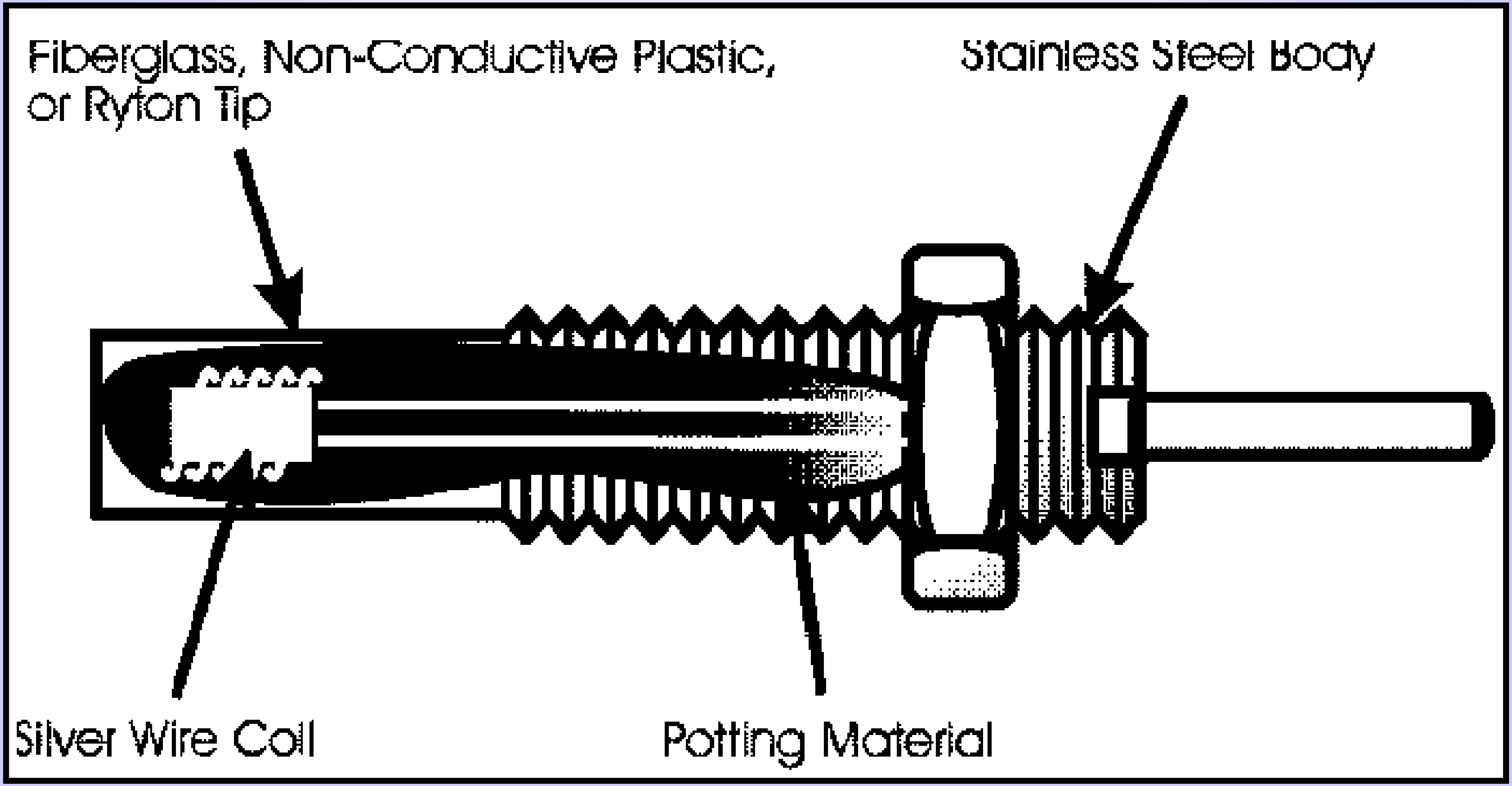
Accelerometers

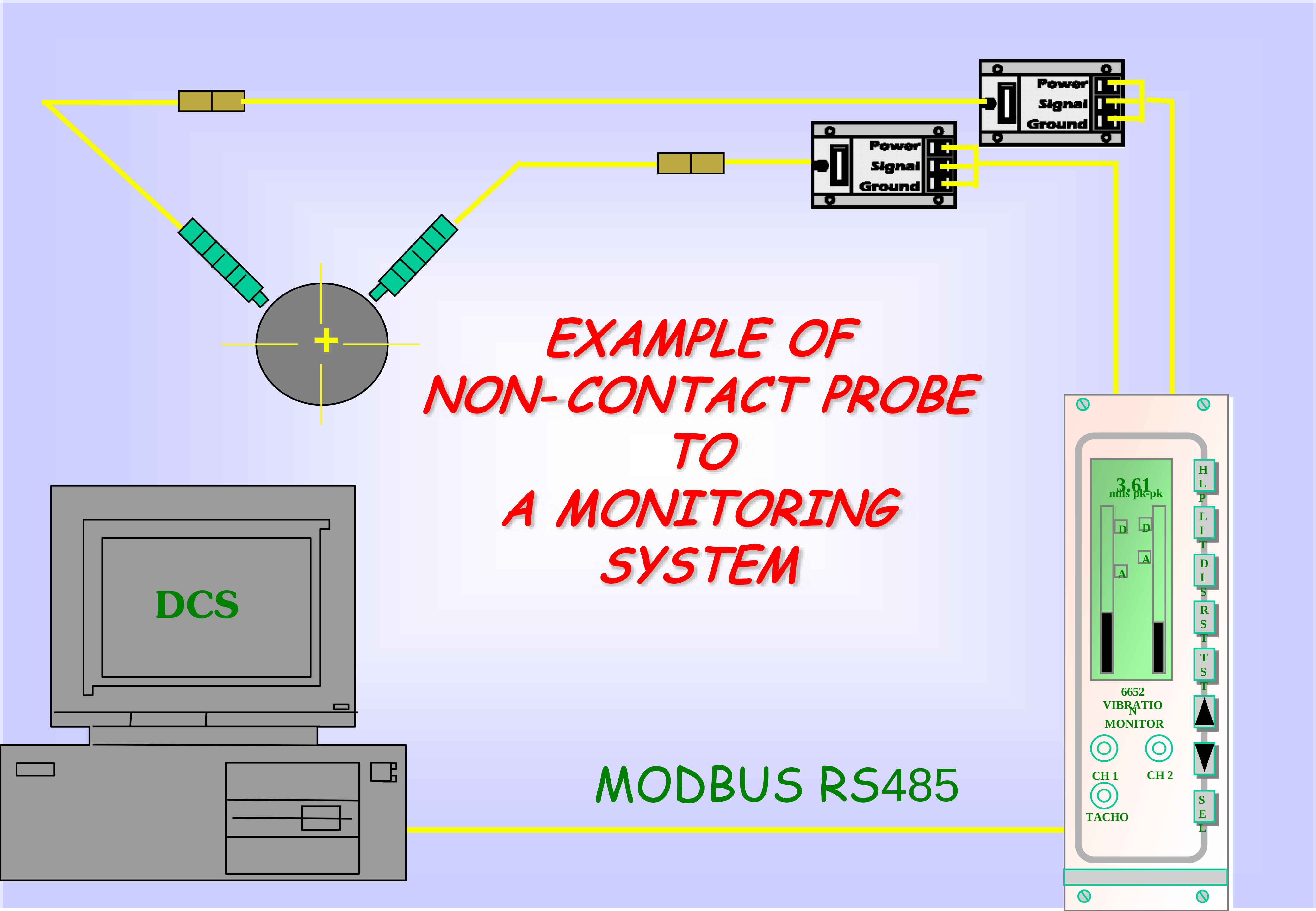
หัววัดแบบไม่สัมผัส, NCPU (Non Contact Pickup Unit) หรือ Eddy Current Probe

Displacement = The Distance the machine moved , Normal Output is 200 mV/ mil, Pk-Pk

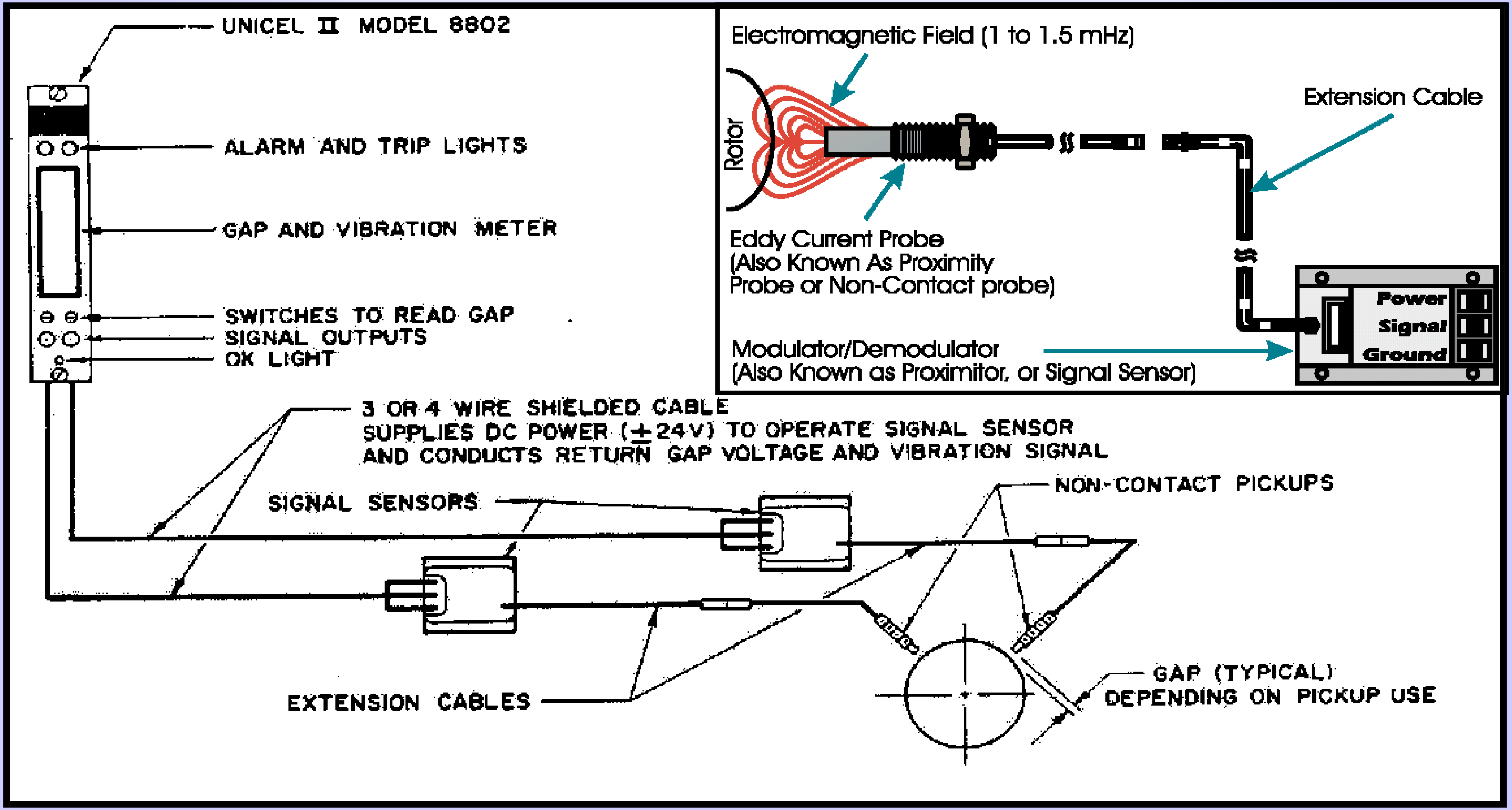


โครงสร้างภายใน Eddy Current Probe



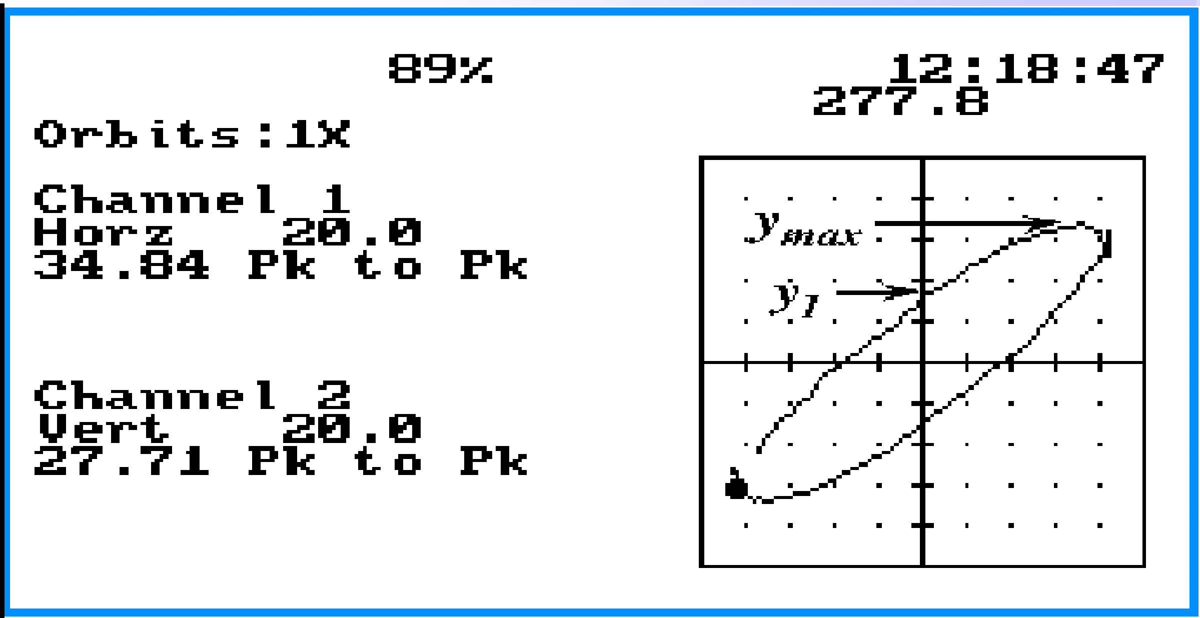

EXAMPLE OF
NON-CONTACT PROBE
TO
A MONITORING
SYSTEM
Power
Signal
Ground
Power
Signal
Ground
DCS
MODBUS RS485
3.61
mils pk-pk
D
A
D
A
6652
VIBRATION
MONITOR
CH 1
CH 2
TACHO
HLP
LIT
DIS
RST
TST
SEL

ตัวอย่างการต่อแบบครบวงจรของการ Monitor ค่าการเคลื่อนตัวของเพลาใน Turbine, Compressor, Gearbox, Pump, ฯลฯ ชนิดที่ใช้ลูกปืนแบบ Journal/Plane Bearings เพื่อวิเคราะห์หาค่าความกลม, การ Unbalance, Misalignment, Centerline, Rubbing, Looseness และอื่นๆ ของ Rotor นั้นๆ



UNIT IN RELATIVE VIBRATION

Display in Microns, 1/1000 mm. Or in Mils , 1/1000 inch.
Analyze in ORBIT or Phase analysis as Nyquist/Polar
Or Bode Plot.



Example of Certification of Calibration

Format No. 36FFB129 Rev.B

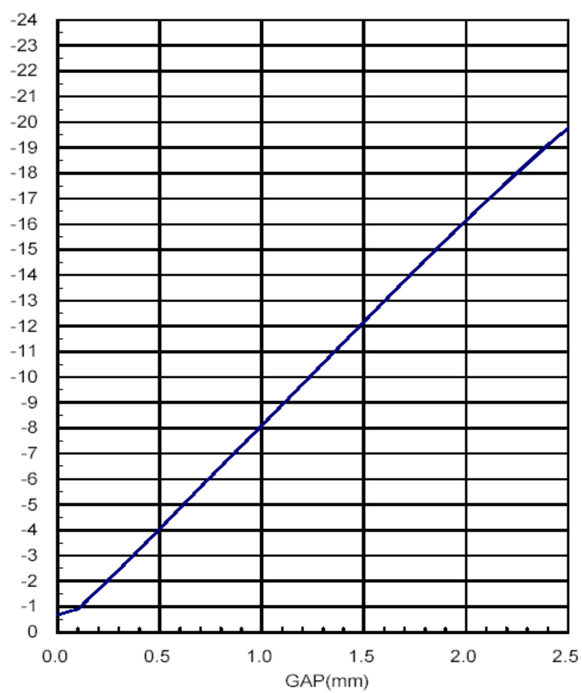
MODEL E2108 TEST DATA

Job No. 030A080 Date Nov.14,2003 Room Temp. 25 C deg.

Sensor	MODEL	E2109/30/05/1/10		SER.No.	CA08022
	TAG No.	–	ID.No.	–	
Extension cable	MODEL	STD		SER.No.	–
	TAG No.	–	ID.No.	–	
Driver	MODEL	STD		SER.No.	–
	TAG No.	–	ID.No.	–	
Target Material	JIS SCM440(AISI 4140 equivalent) FLAT				

Static characteristics data

GAP (mm)	Output (V)	SCF Error (%)
0.0	−0.671	−70.1
0.1	−0.907	−4.0
0.2	−1.663	−1.3
0.3	−2.440	1.4
0.4	−3.238	3.2
0.5	−4.050	3.9
0.6	−4.867	4.0
0.7	−5.685	3.2
0.8	−6.497	2.2
0.9	−7.301	2.2
1.0	−8.105	2.6
1.1	−8.912	3.7
1.2	−9.728	3.6
1.3	−10.543	3.2
1.4	−11.355	3.1
1.5	−12.166	3.1
1.6	−12.977	3.0
1.7	−13.787	1.7
1.8	−14.587	−0.2
1.9	−15.373	−2.2
2.0	−16.143	−3.9
2.1	−16.900	−5.4
2.2	−17.645	−6.4
2.3	−18.382	−8.2
2.4	−19.105	−17.1
2.5	−19.758	–



Static characteristics

SPECIFICATIONS	ACTUAL		RESULT
2.0mm or more within ±9% refered to Scale Factor Error Scale Factor : 0.787V/100 μm	Range 0.1mm to 2.3mm	Max. −8.2% at 2.3mm	

Overall Evaluation ______ Approved by ______ Calibrated by ______

Format No. 36FFB129 Rev.B

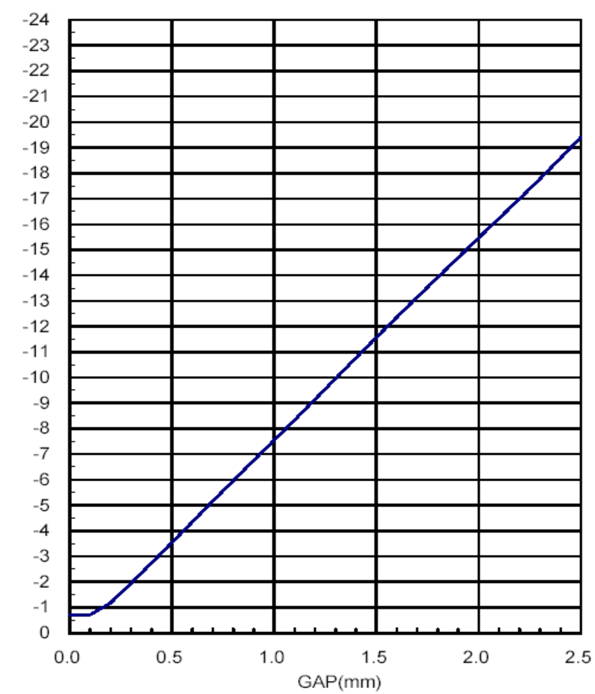
MODEL E2108 TEST DATA

Job No. 030A083 Date Nov.19,2003 Room Temp. 25 C deg.

Sensor	MODEL	STD		SER.No.	–
	TAG No.	–	ID.No.	–	
Extension cable	MODEL	STD		SER.No.	–
	TAG No.	–	ID.No.	–	
Driver	MODEL	E2108/5/001		SER.No.	CA08319
	TAG No.	–	ID.No.	–	
Target Material	JIS SCM440(AISI 4140 equivalent) FLAT				

Static characteristics data

GAP (mm)	Output (V)	SCF Error (%)
0.0	−0.712	−100.0
0.1	−0.712	−41.0
0.2	−1.177	−2.2
0.3	−1.947	0.4
0.4	−2.737	2.1
0.5	−3.540	3.0
0.6	−4.350	3.0
0.7	−5.160	2.3
0.8	−5.965	1.1
0.9	−6.760	0.2
1.0	−7.548	0.6
1.1	−8.339	2.5
1.2	−9.145	3.5
1.3	−9.959	3.2
1.4	−10.771	2.0
1.5	−11.573	0.6
1.6	−12.364	−0.4
1.7	−13.148	−1.2
1.8	−13.926	−1.8
1.9	−14.699	−2.3
2.0	−15.468	−3.0
2.1	−16.232	−2.5
2.2	−17.000	−0.6
2.3	−17.783	2.3
2.4	−18.588	3.9
2.5	−19.405	–



Static characteristics

SPECIFICATIONS	ACTUAL		RESULT
2.0mm or more within ±9% refered to Scale Factor Error Scale Factor : 0.787V/100 μm	Range 0.2mm to 2.4mm	Max. 3.9% at 2.4mm	

Overall Evaluation ______ Approved by ______ Calibrated by ______

Report Example

EDDY PROBE CALIBRATION REPORT

Machine: P201B

Date of Test: 16/09/02

Calibrated Probe P/N: 1909/30/05/1/05

Probe position: G-DEX

Calibration Equipment : TK3

Probe Resistance(Ohm) : 4.2 Ohm

Probe with Extension Cable : 12.2 Ohm

Calibrated with standard Extension Cable S/N: 8.5C

Standard Driver S/N: STDDRV_22-9.0D

System Cable Length: 9 m.

Target Material: 4140 Steel

Supply with load: -16.70 Vdc

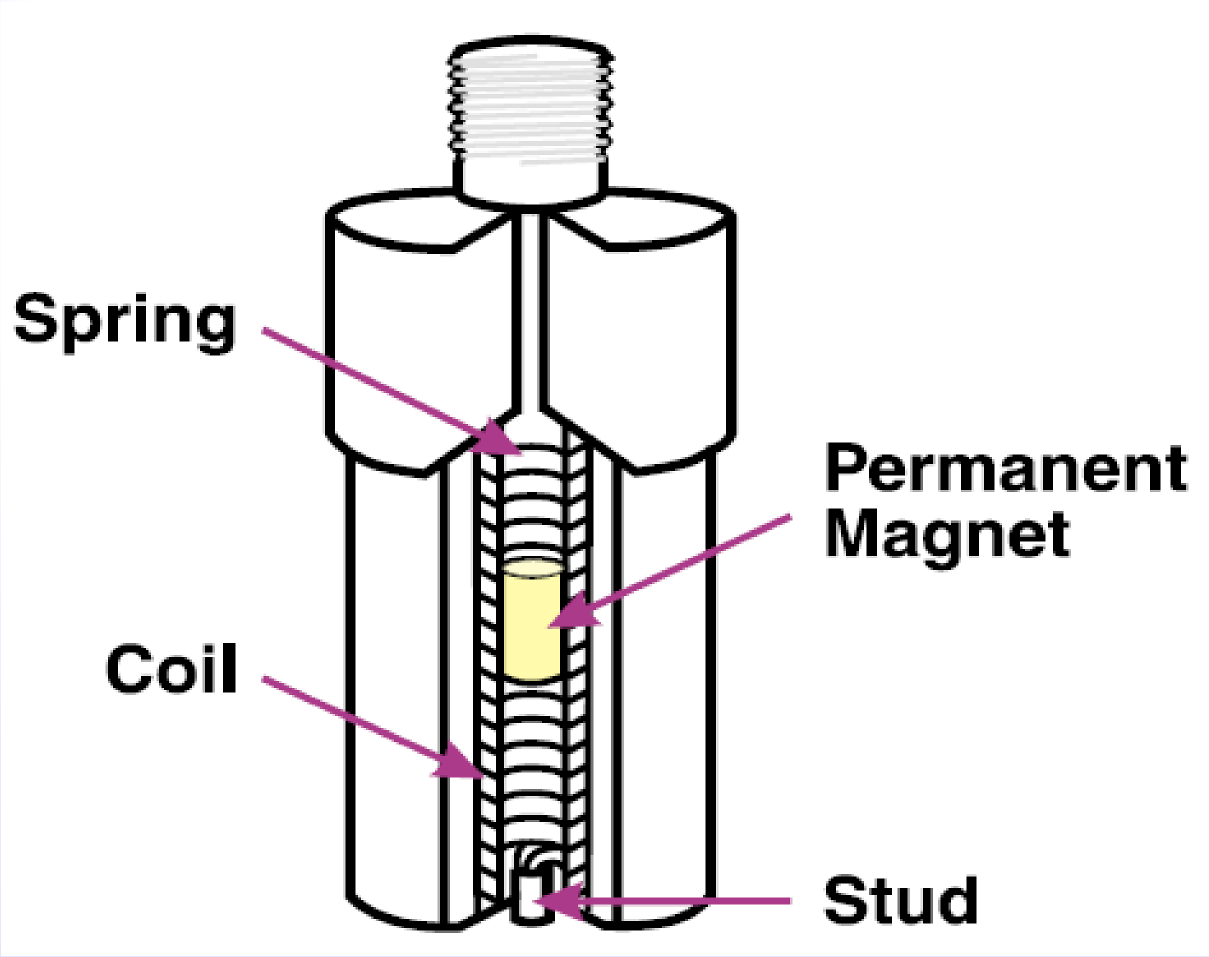
Output per one mils of Gap = 1.633 Volts

Supply without load: -19.76 Vdc

GAP (inches)	VOLTAGE	STANDARD	DEVIATION	SLOPE
0.00	0.720	2.00	1.28	N/A
0.01	0.718	2.00	1.282	N/A
0.02	2.017	3.63	1.616	129.9
0.03	3.570	5.27	1.696	155.3
0.04	5.321	6.90	1.578	175.1
0.05	7.168	8.53	1.364	184.7
0.06	8.984	10.17	1.181	181.6
0.07	10.627	11.80	1.171	164.3
0.08	12.301	13.43	1.130	167.4
0.09	13.916	15.06	1.148	161.5
0.10	15.183	16.70	1.514	126.7

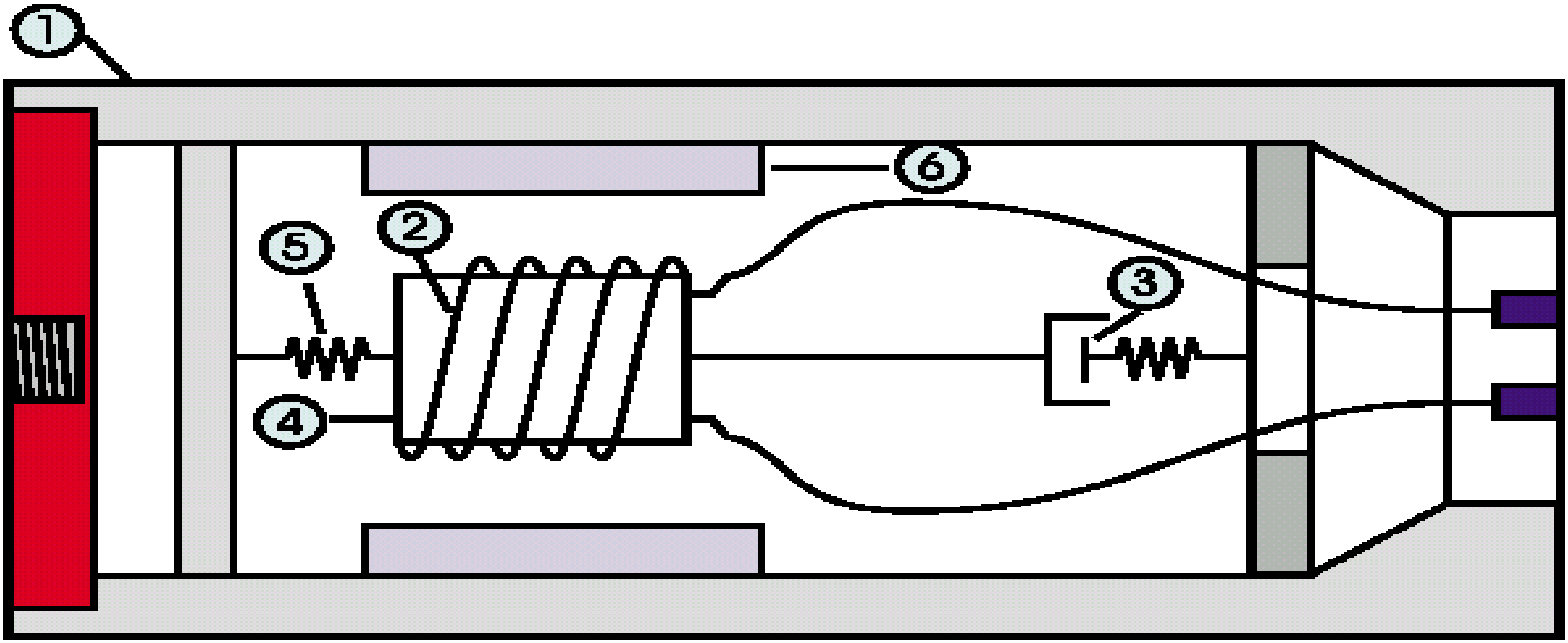
หัววัดแบบ Seismic Velocity

Velocity = The Displacement Per Time, Normal Output is 100 mV/inch/sec, Pk



ชนิดแม่เหล็กอยู่ใน Center เพื่อเป็นตัวเคลื่อน

ชนิดขดลวดอยู่ใน Center เพื่อเป็นตัวเคลื่อน

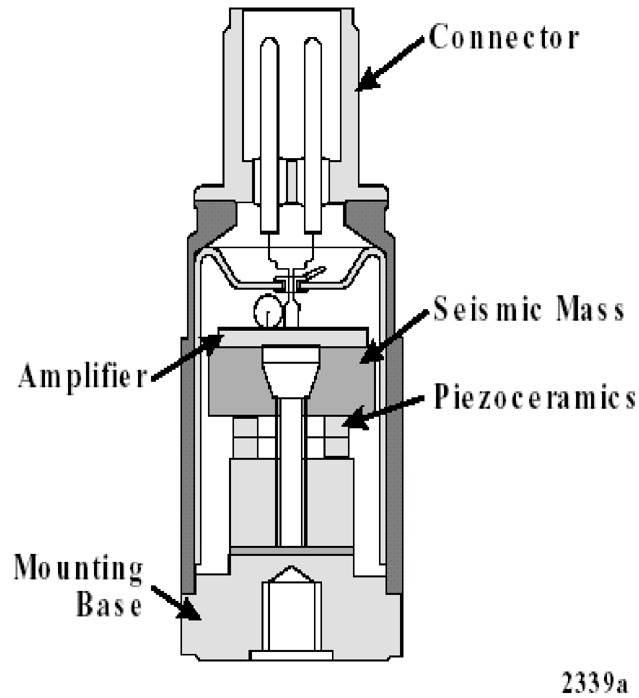


1. Pickup Case
2. Wire Coil
3. Damper
4. Mass
5. Spring
6. Magnet

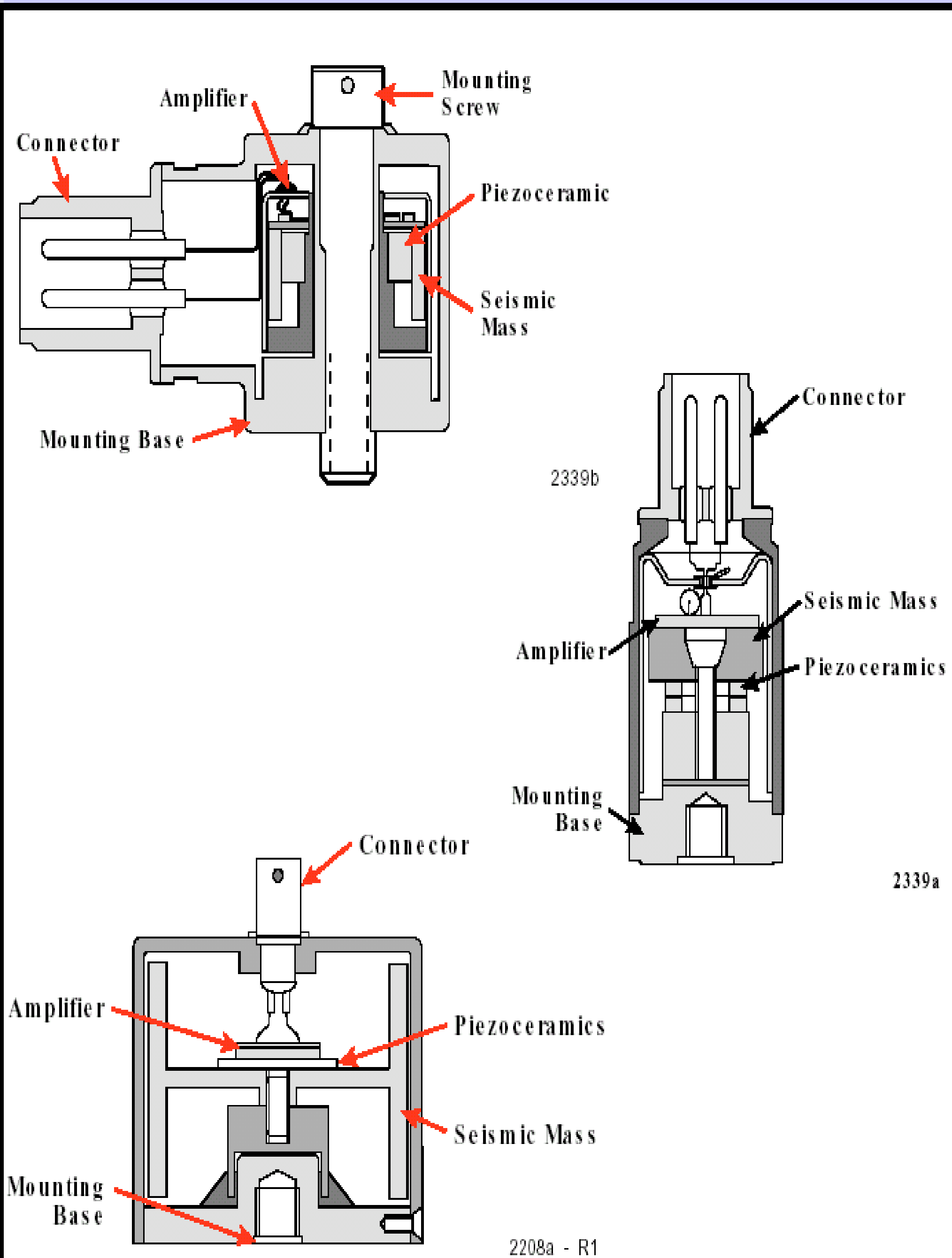
หัววัดแบบความเร่ง (Accelerometer)

Acceleration = The Rate of Change of Velocity, Normal Output is 100 mV/G, Pk

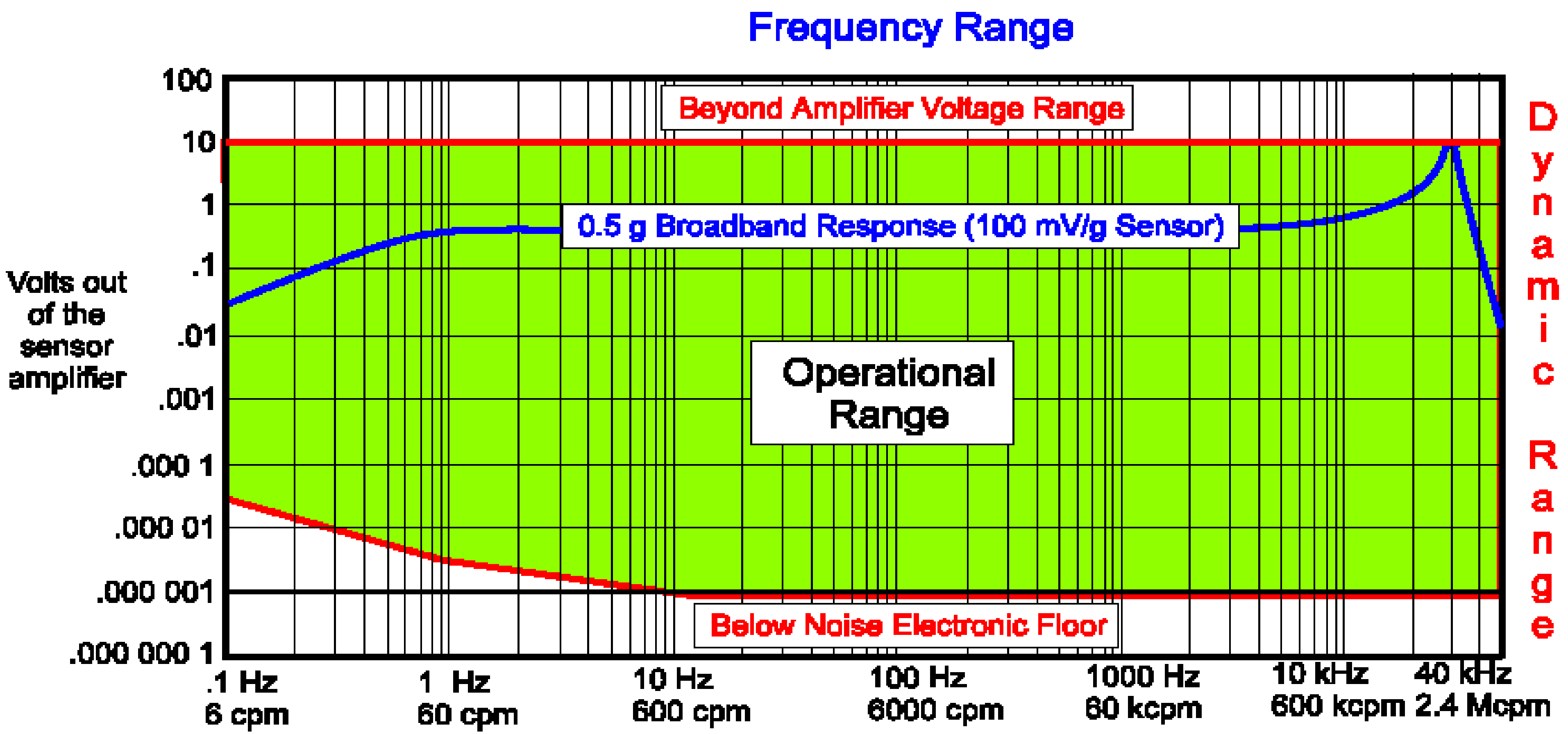
- Piezoelectric material (sensing element) is placed under load using a mass
- As 'stack' vibrates, crystal is squeezed or released
- Charge output is proportional to the force (and acceleration)
- Electronics convert charge output into voltage output



โครงสร้างภายในหัววัดความเร่ง ออกด้านบน (Top Exit), ออกด้านข้าง (Side Exit), และ Connector ต่างๆ

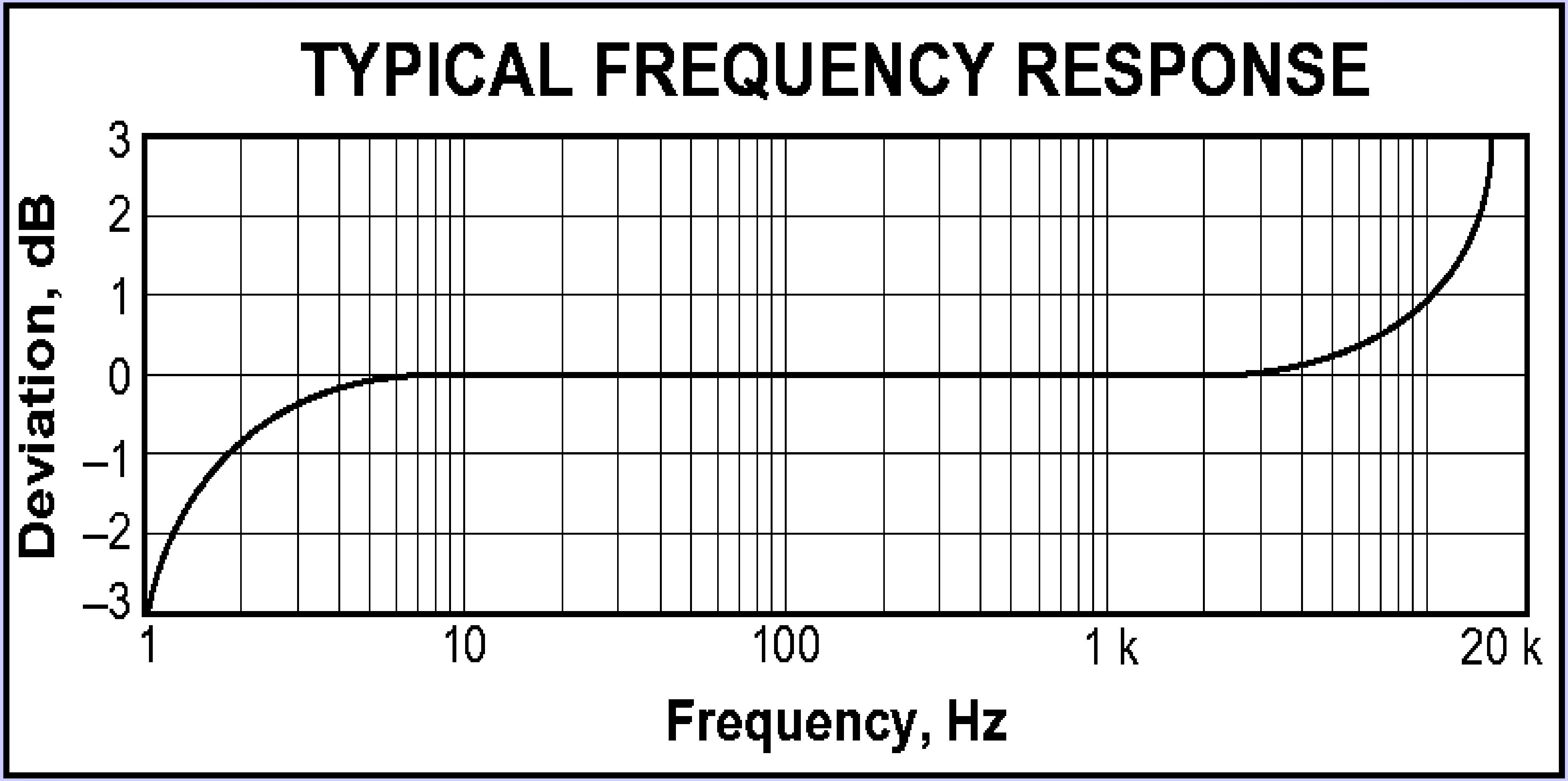


ย่านความถี่และ Amplitude ที่เหมาะสมกับการใช้งานมากที่สุดของหัววัดที่มี Amplifier หรือ หัว ICP (Integrated Circuit Powering)



Operational Range of an Accelerometer Amplifier
(Shaded Region)

Frequency Vs Amplitude accuracy example



Power supply ที่ Accelerometer ต้องการ และค่า Bias Voltage (Voltage drop ที่หัววัด) ที่แสดงค่าหัววัดที่ดี

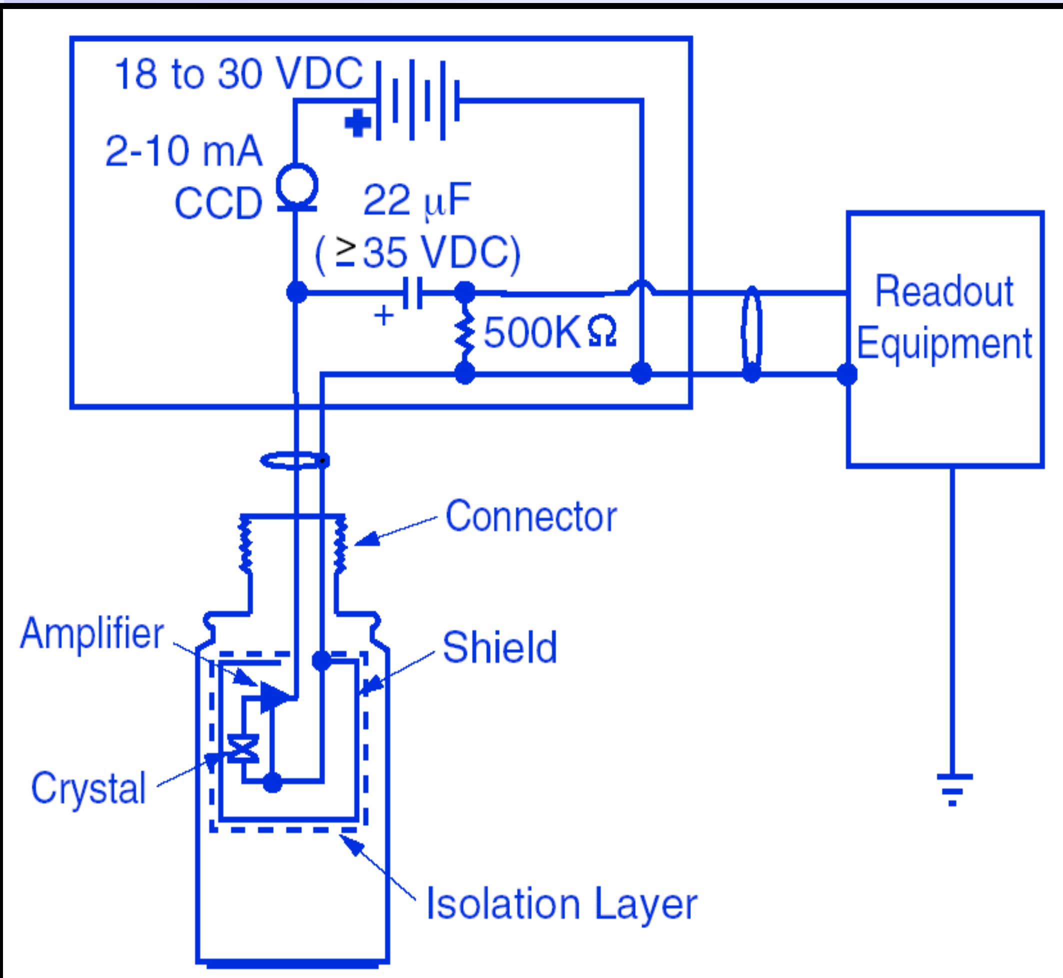
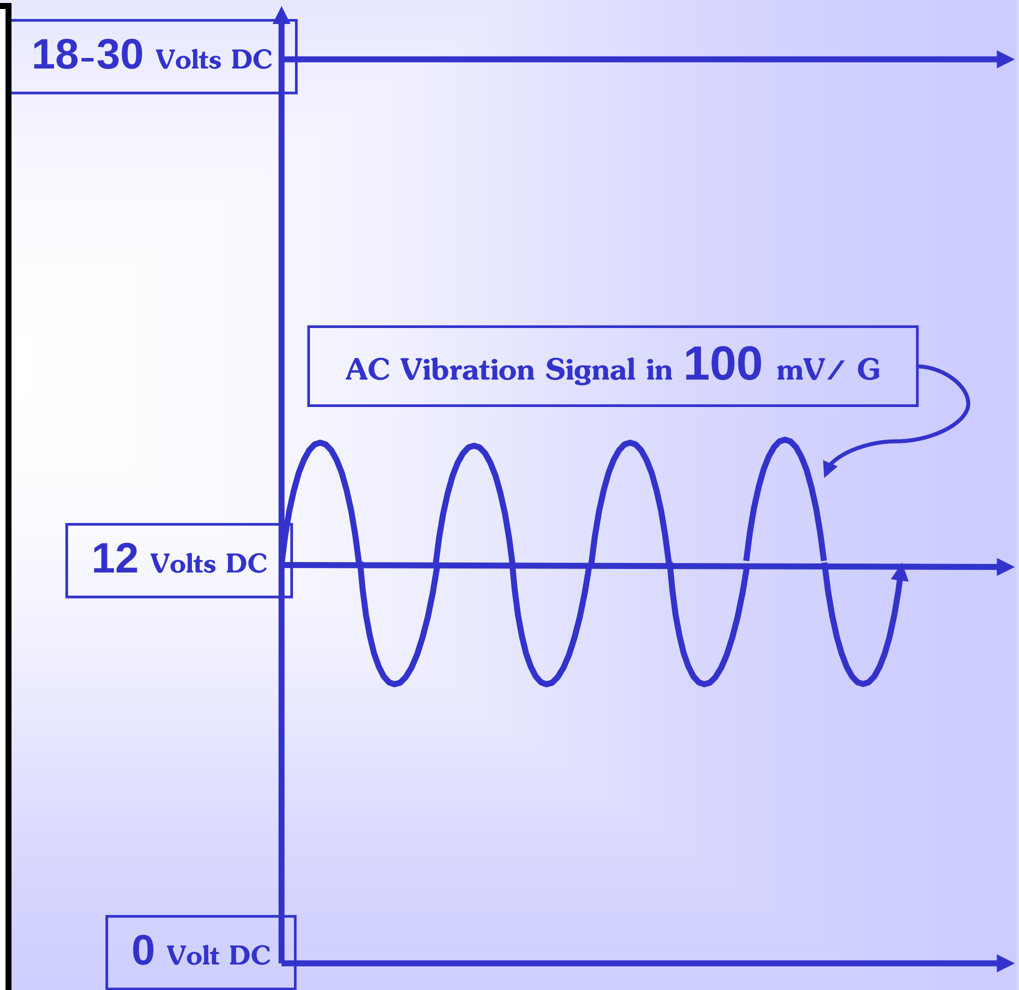


Figure 1: Powering Schematic



ย่าน Amplitude ที่เหมาะสม ที่ Accelerometer สามารถอ่านค่าได้ดี

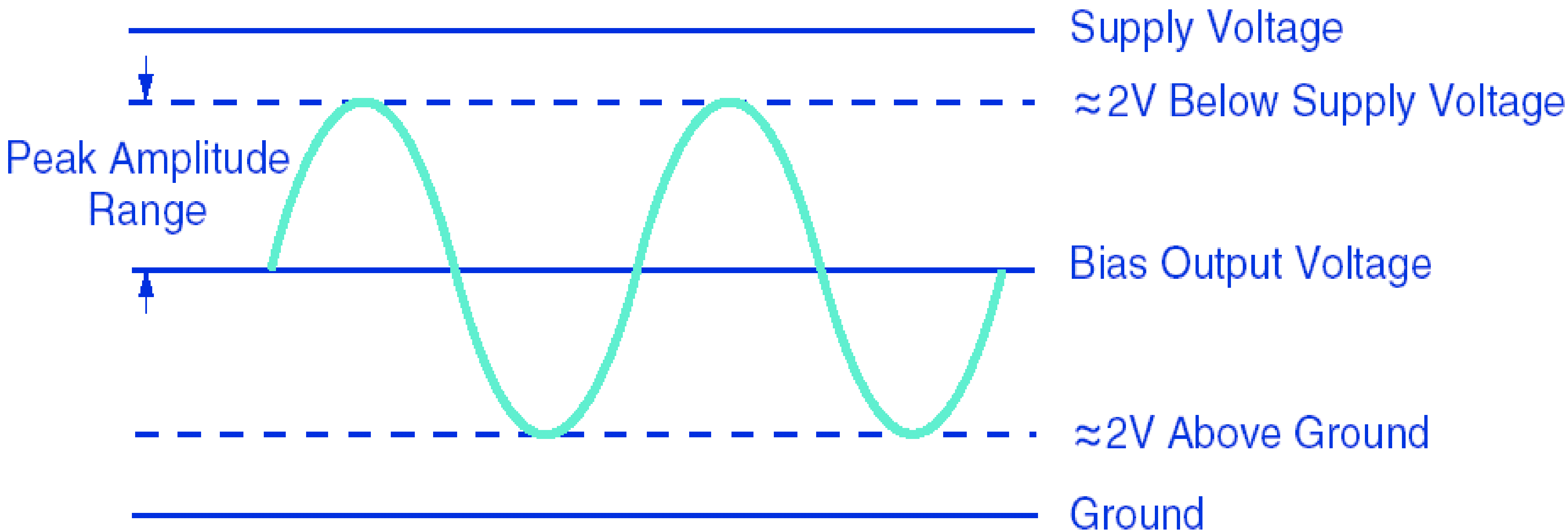


Figure 2: Range of Linear Operation

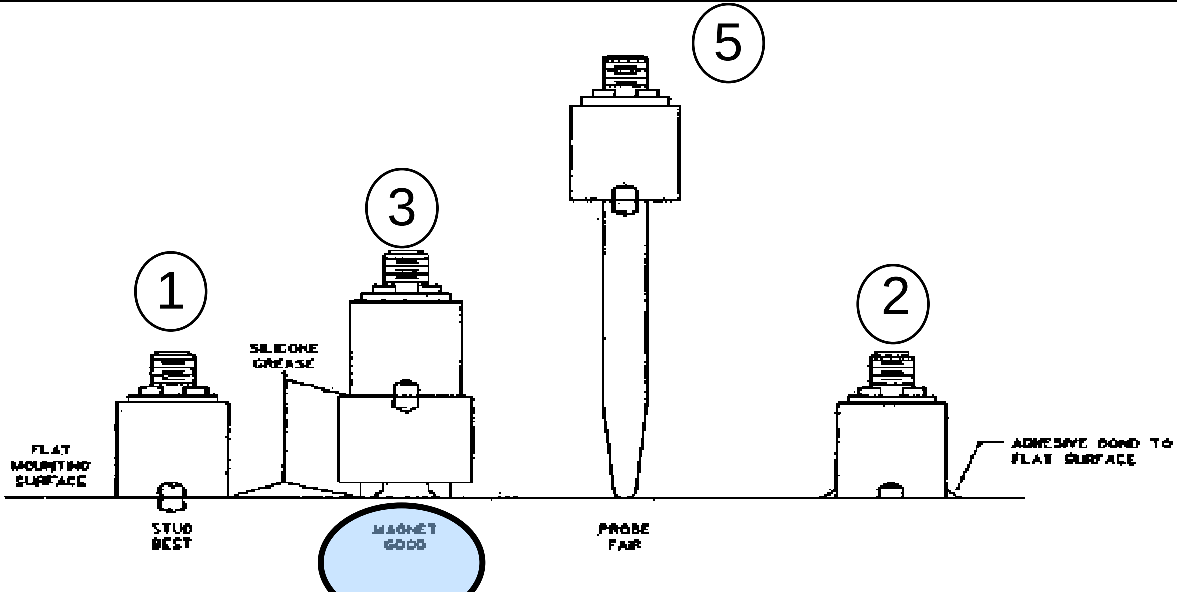


Figure 2-25. Common accelerometer (transducer) mounting methods.

ชนิดของการยึดหัววัด

Vibration

Typical Recommended maximum frequency ranges for common accelerometer mounting methods

TRANSDUCER MOUNT USABLE FREQUENCY RANGE FOR THE WILCOXON 726T (Ref. 9)

ACCELEROMETER MOUNTING	MAXIMUM ACCEPTABLE FREQUENCY (CPM)	MOUNTING NATURAL FREQUENCY (CPM)
1) Stud Mount	975,000	1,900,000
2) Adhesive Mount with Hottinger Baldwin Messtechnik X60	540,000	None Observed
3) Stud Mount on Rare Earth Magnet	450,000	724,500
4) Mounted on Quick Connect Stud Mount	360,000	609,000
5) Hand-held Mount Using a 2" Probe	48,000	88,500