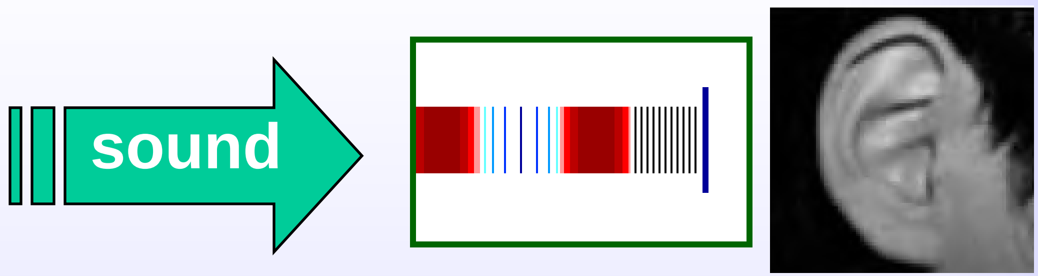
DAY 2

-Fast Fourier Transform
-Frequency Max/Min
-Resolution and Filter
-Fundamental to analyze VIBRATION
-Directional Analysis
-Harmonic, Sideband, Beating
-Amplitude Modulating/Frequency Modulating
-Basic of Vibration Problems
-4 Types of Unbalance
-Unbalance Analysis

Basic of Vibration Spectrum

Sound & Vibration

Sound waves cause vibration when they impact a surface, such as your ear drum…



Sound (pressure waves in the air) are caused by the movement (vibration) of a solid surface, such as the surface of a drum.

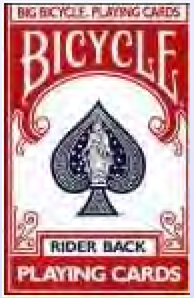
So, about that bike…

Remember that bike you had when you were 9 or 10?

It probably wasn't as cool as this one!

So You Made it Cool…

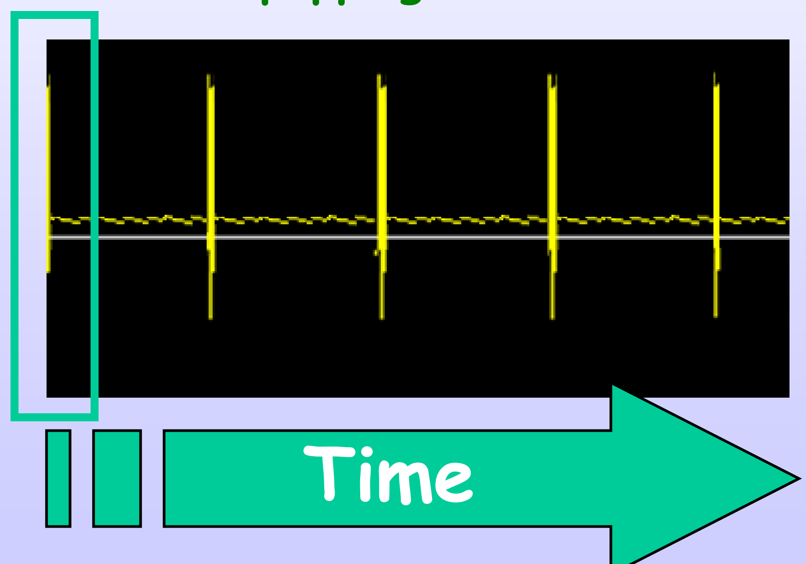
…by attaching cards, cardboard, or whatever else to the fork or spokes.



Remember the sound that it made…

…what you heard was something like…

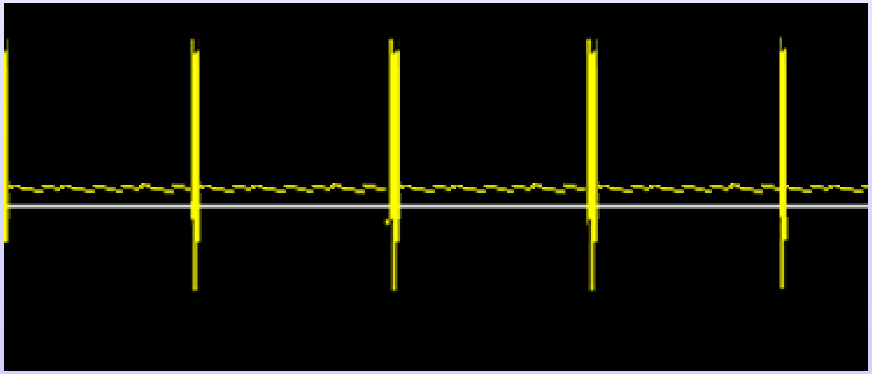
A "popping" sound…



How often did it make the sound?

If the cards were attached to **a spoke** then….

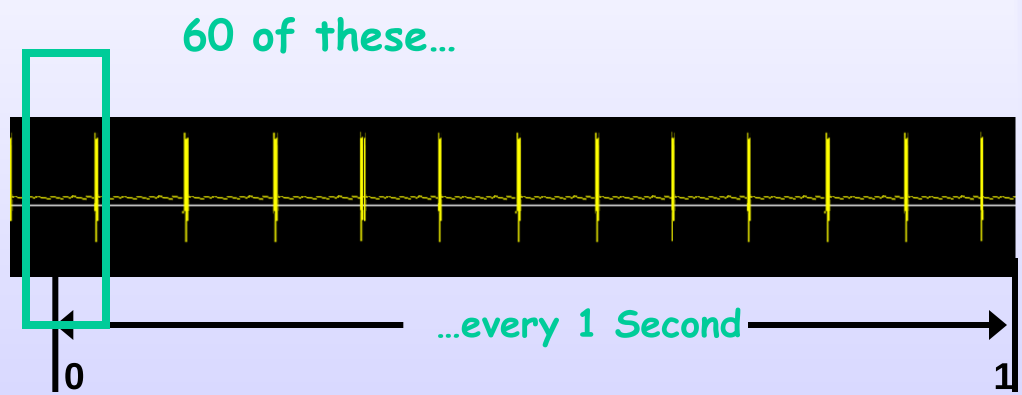
You heard the "pop" once each time the cards hit the fork, or "**ONCE PER REVOLUTION**" of the wheel.



How often did it make the sound?

…and if you pedaled fast enough that the wheel spun **60 times per second** (*tough kid!*), then….

You would hear the "pop" 60 times per second.



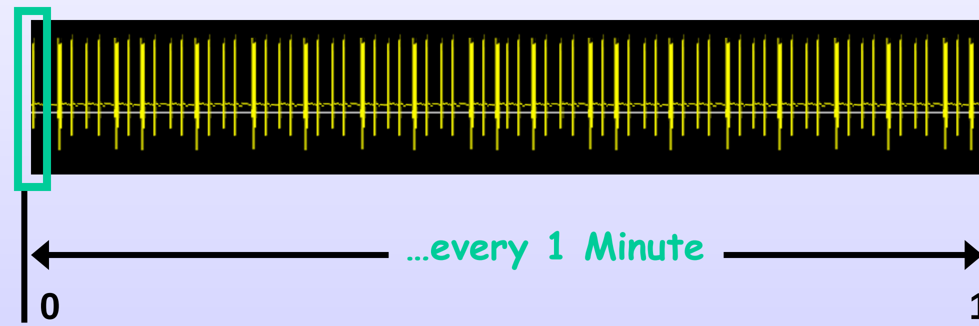
A rate of **Events Per Second** is called "**Hz**" (like the car rental folks)

And if you kept at that rate for a minute…

If you pedaled fast enough that the wheel spun **60 times per second for 1 minute** then….

You would hear the "pop" 3600 times per minute.

60/sec x 60 seconds = 3600/minute…

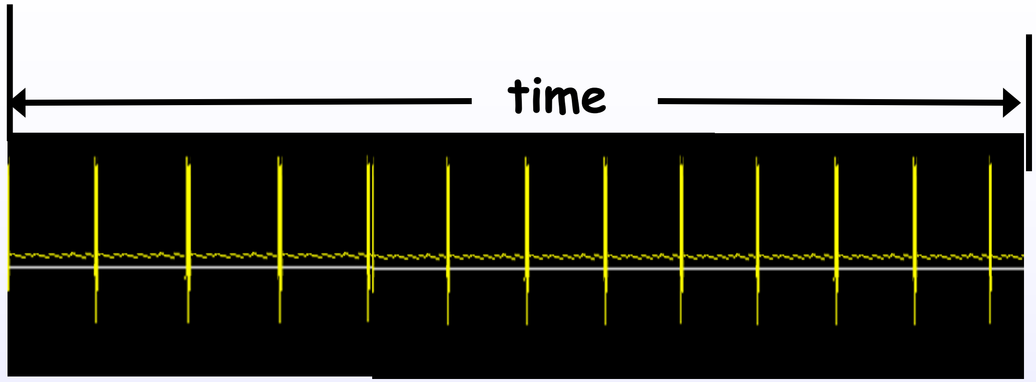


A rate of **Events Per Minute** is called **"cpm"** (Cycles Per Minute)

...really tough kid!

That's about *100 Miles Per Hour*

If you drew what you heard…



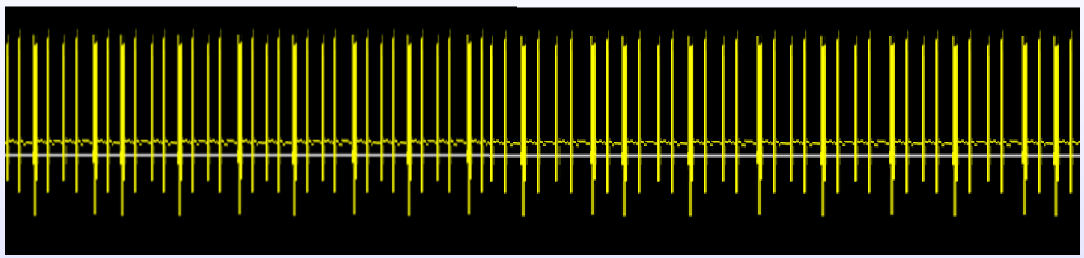
A plot of the sound over time is called a "**Time Waveform**"

In this case it's more of a "pulse" then a "wave" but we'll get to that

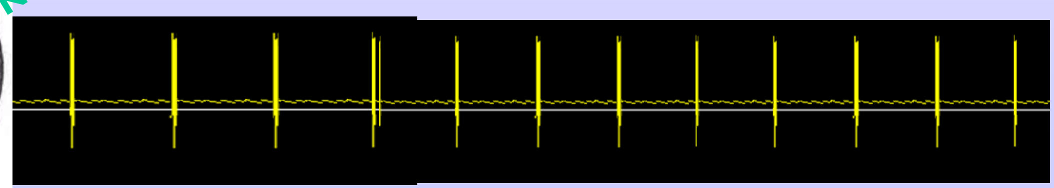
What else did you hear?

…what did you hear when you
blew past your kid brother?

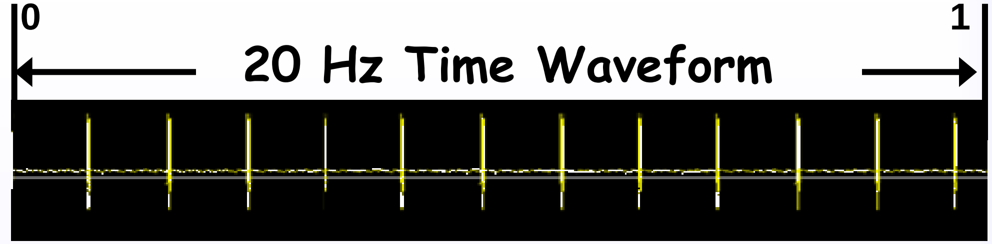
Your bike…



His bike…

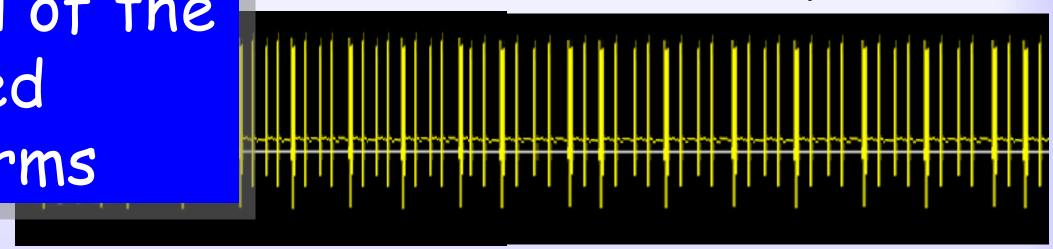


If you drew what you heard…



+

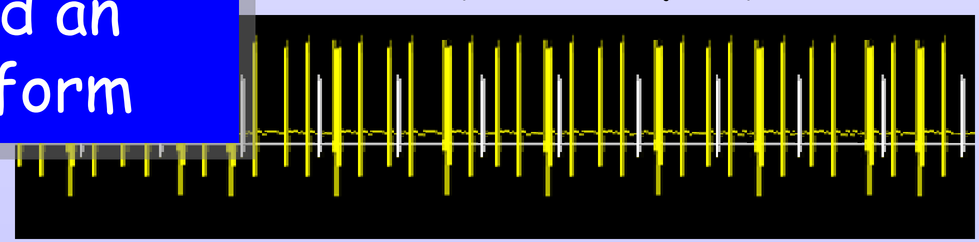
60 Hz Time Waveform



Time waveforms that include only a small subset of all of the noise out there are called "**filtered**" Time Waveforms

=

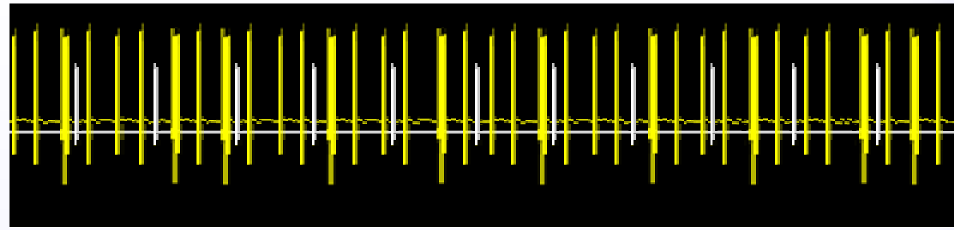
Raw Time Waveform



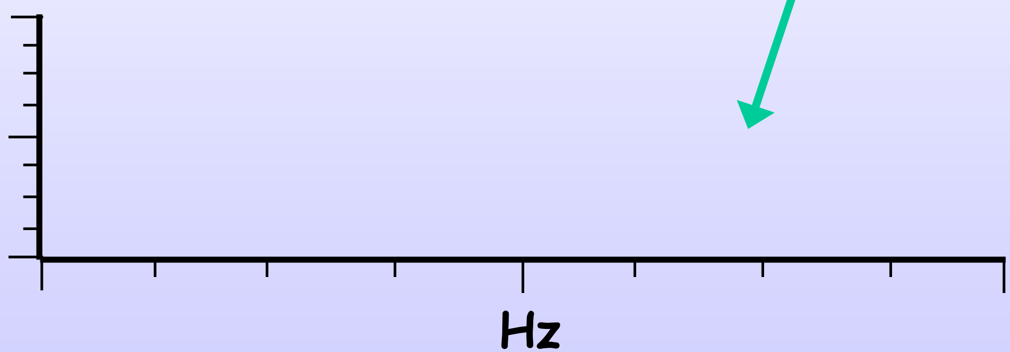
A time waveform that includes all of the sounds is called an "**unfiltered**" Time Waveform

Another way to look at it

What if I wanted to see, at a glance, what the frequency of every signal in a time waveform was?



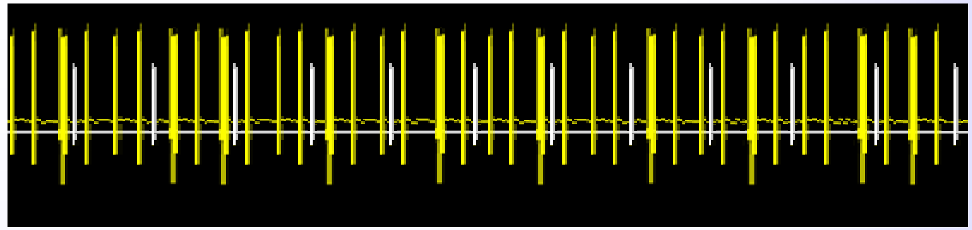
How would this be represented on this ?



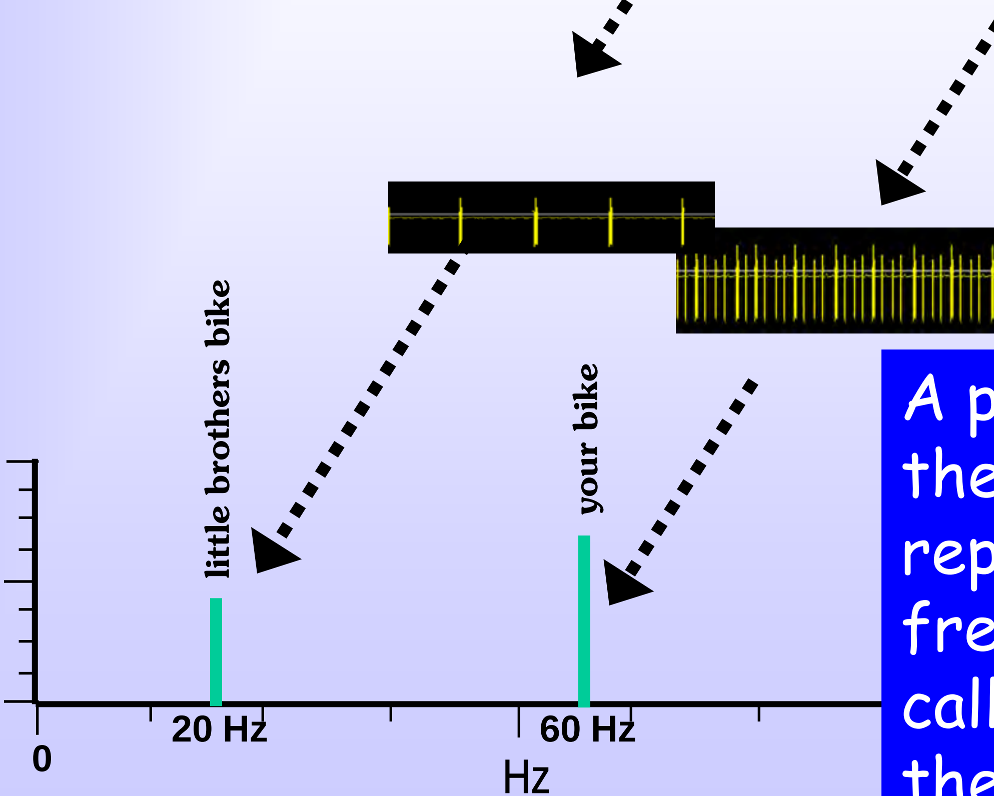
could also be "cpm"

The Spectra

Each signal (filtered time waveform) would be a line at whatever frequency that it had occurred at…



The algorithm that does this is called the **F**ast **F**ourier **T**ransform, or simply "**FFT**". Often a spectra plot is called an **FFT plot**.

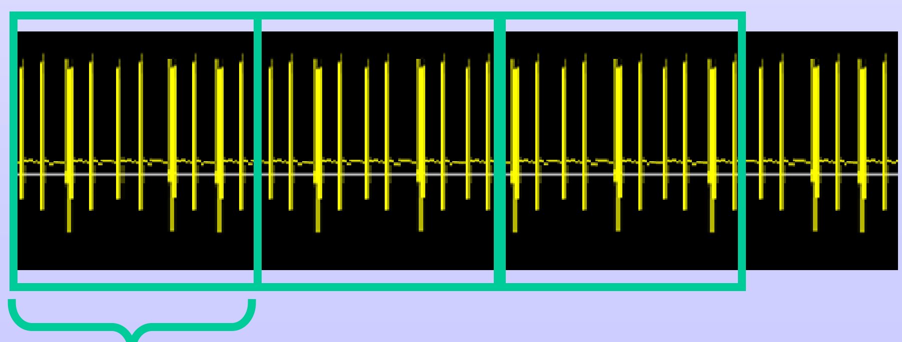


A plot that depicts all of the sounds, each represented by a line at the frequency of the sound is called a "**Spectra**" - which is the plot of a "**Spectrum**".

How often did it make the sound?

What if you had attached the cards to **the fork** rather than to a spoke?

Then you would have heard the "pop" once each time the cards hit a spoke! If there were 10 spokes then you would have heard a "pop" at a rate of "**10 TIMES PER REVOLUTION**" of the wheel.

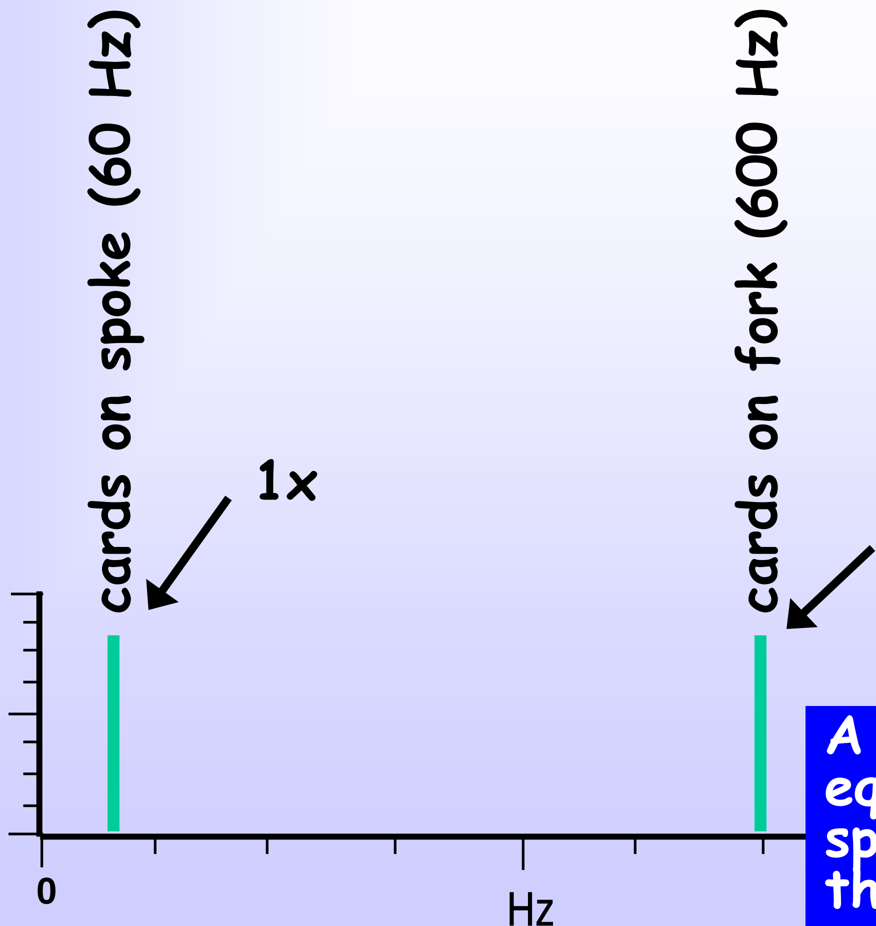


ten pulses per one revolution

Orders

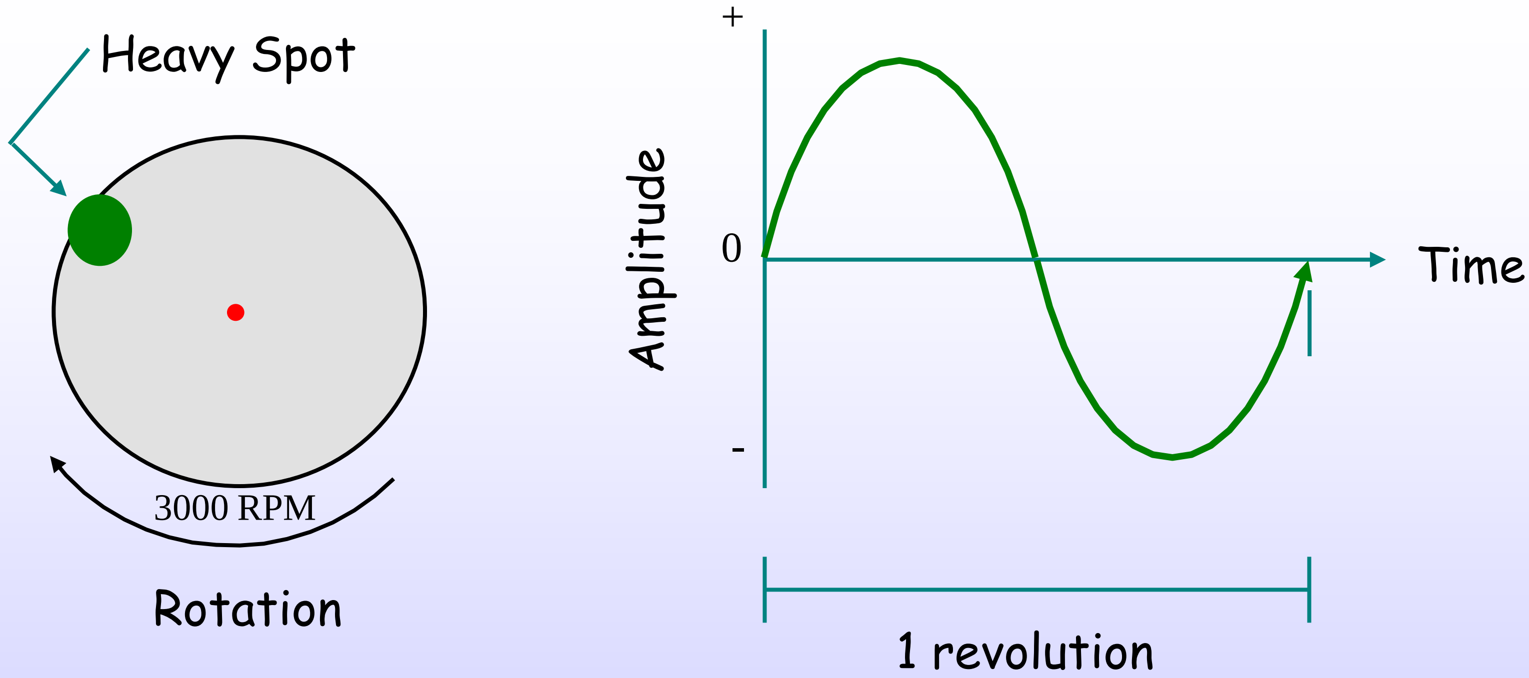
A frequency equal to the speed of shaft (wheel) is commonly called the "1x running speed" vibration, or simply…

1x



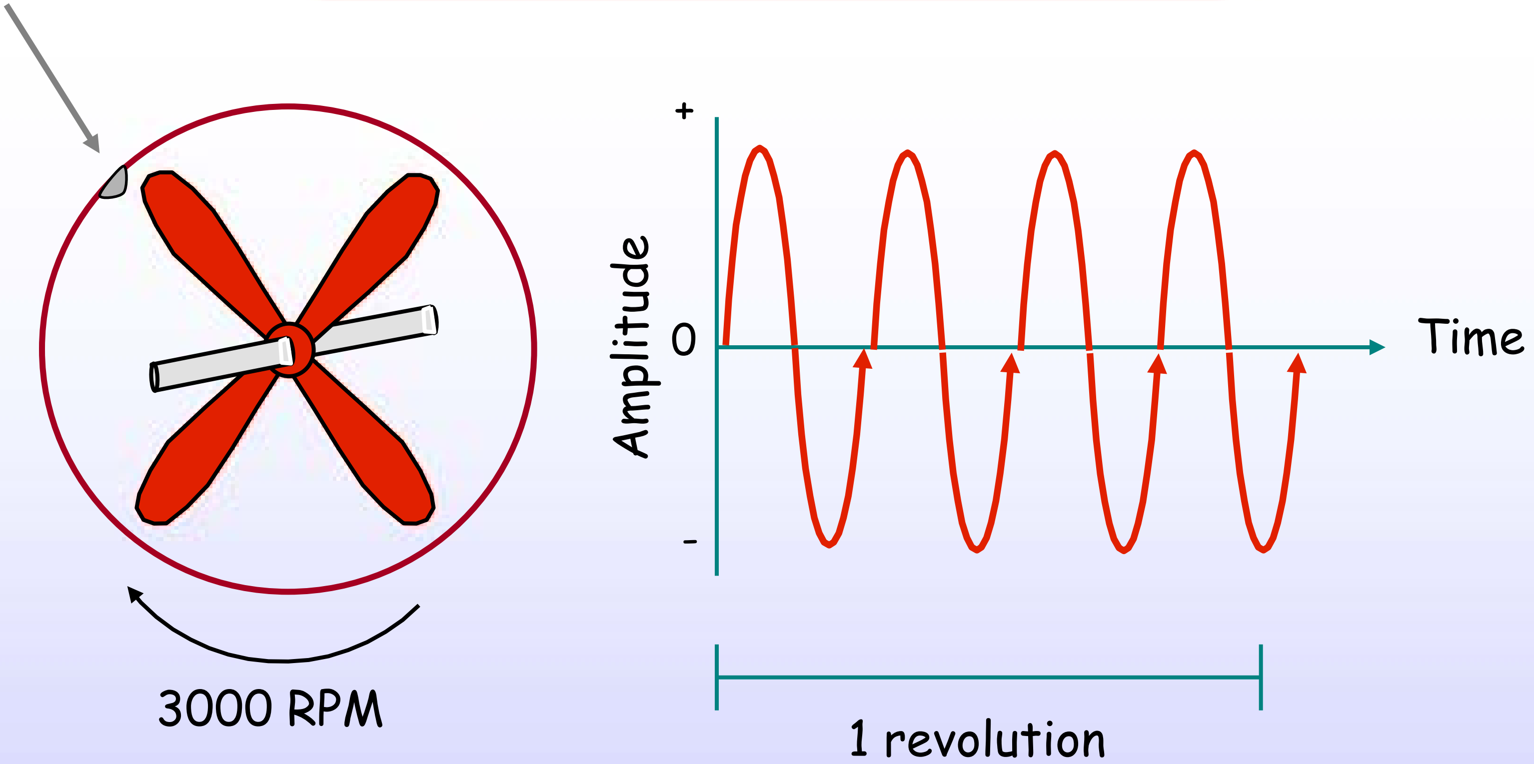
A discrete frequency that is equal to a multiple of the speed of the shaft is called the "Nx".

Time Waveform



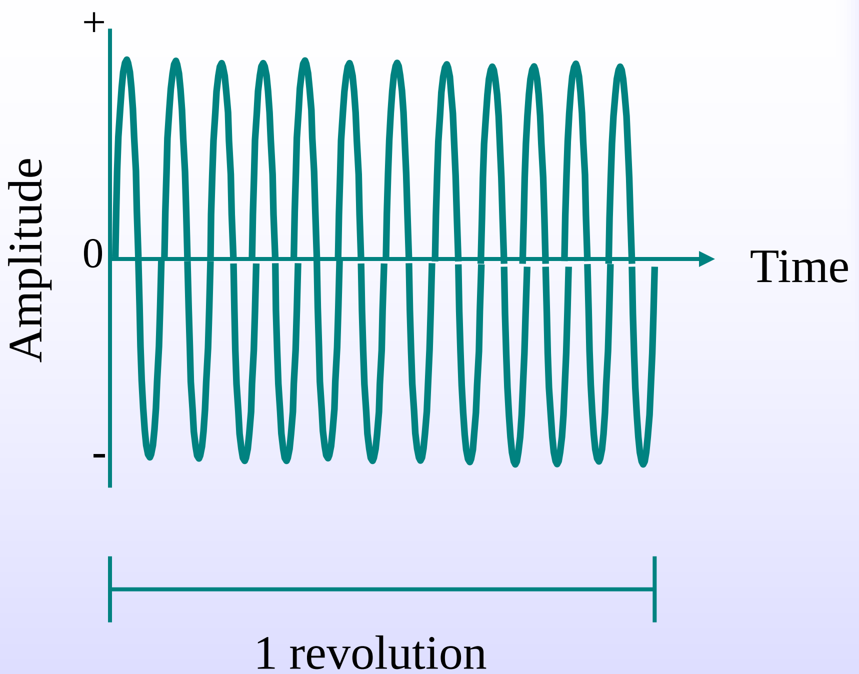
3000 RPM	=	3000 cycles per minute
50 Hz	=	50 cycles per second
1 Order	=	One times turning speed

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

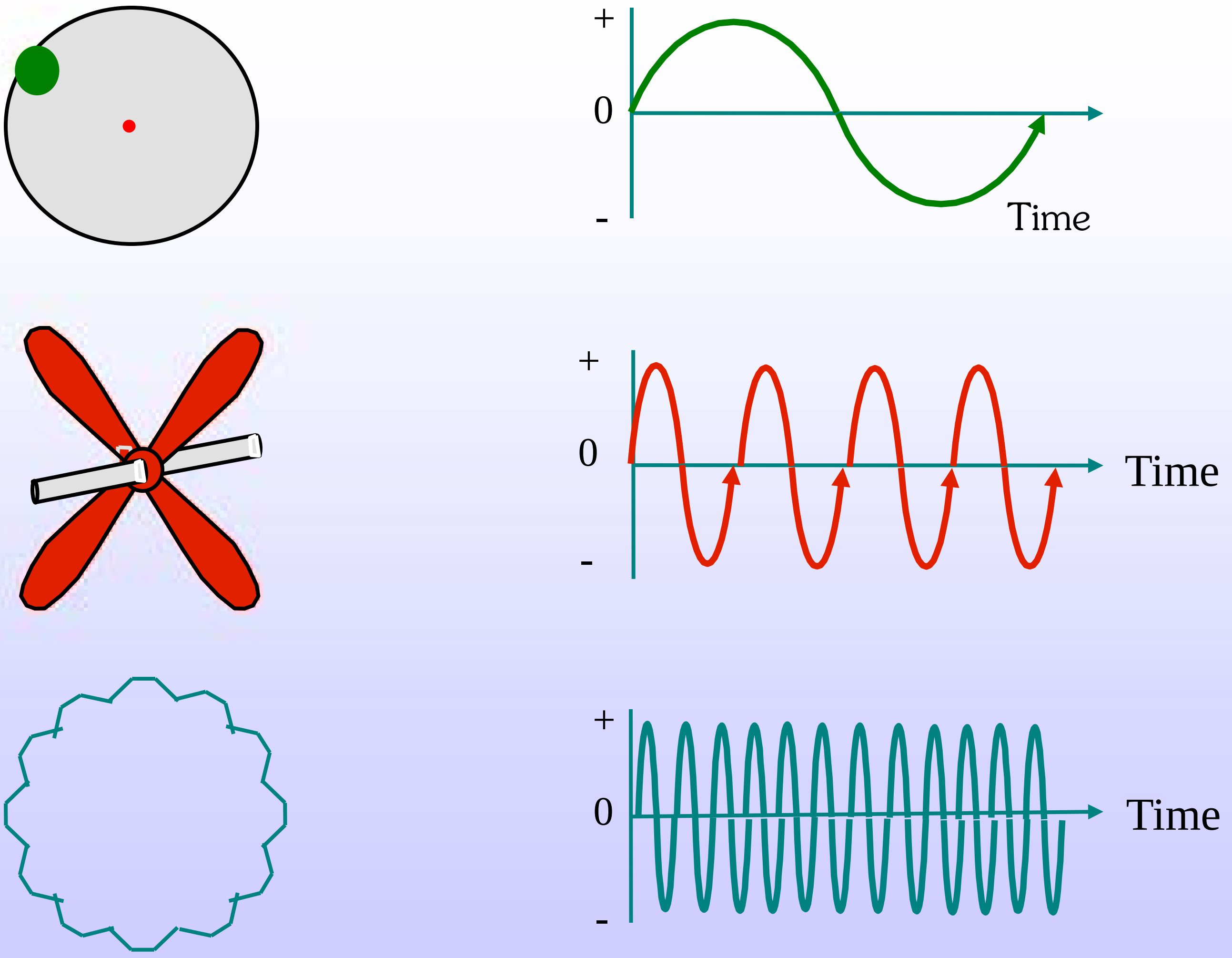


12 teeth are meshing every revolution of the gear

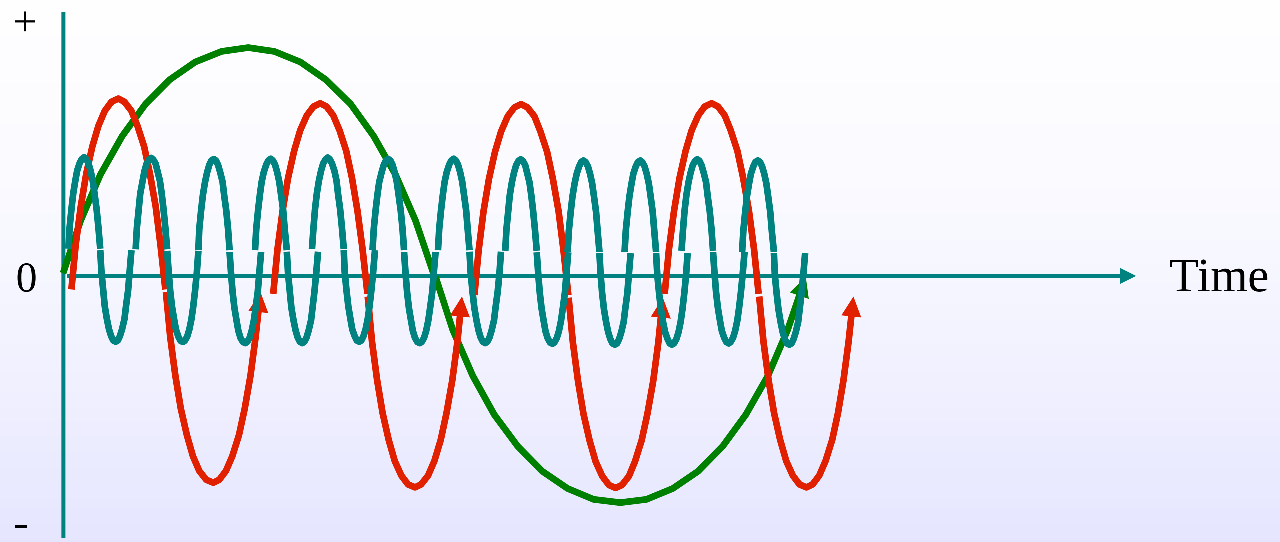
12 x 3000 RPM = vibration occurs at 36,000 cycles per minute

= 36,000 cpm = 600 Hz

Time Waveform

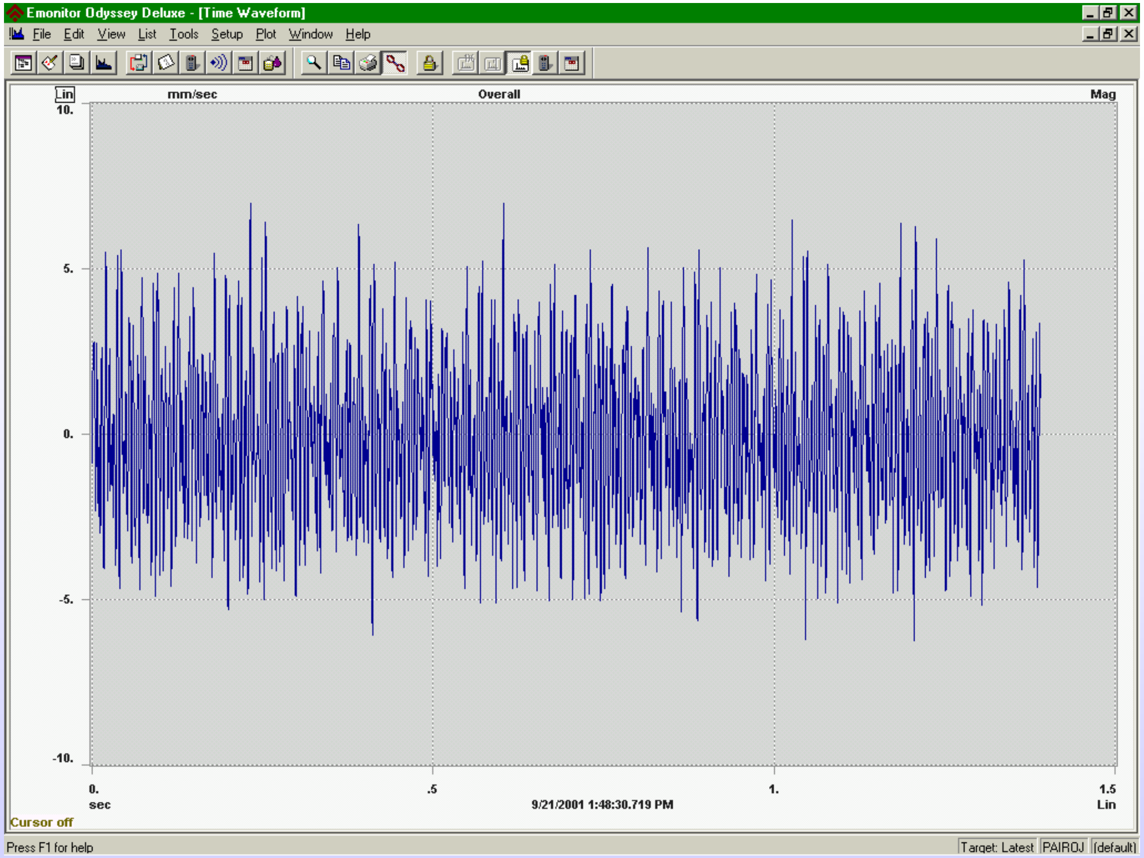


Time Waveform



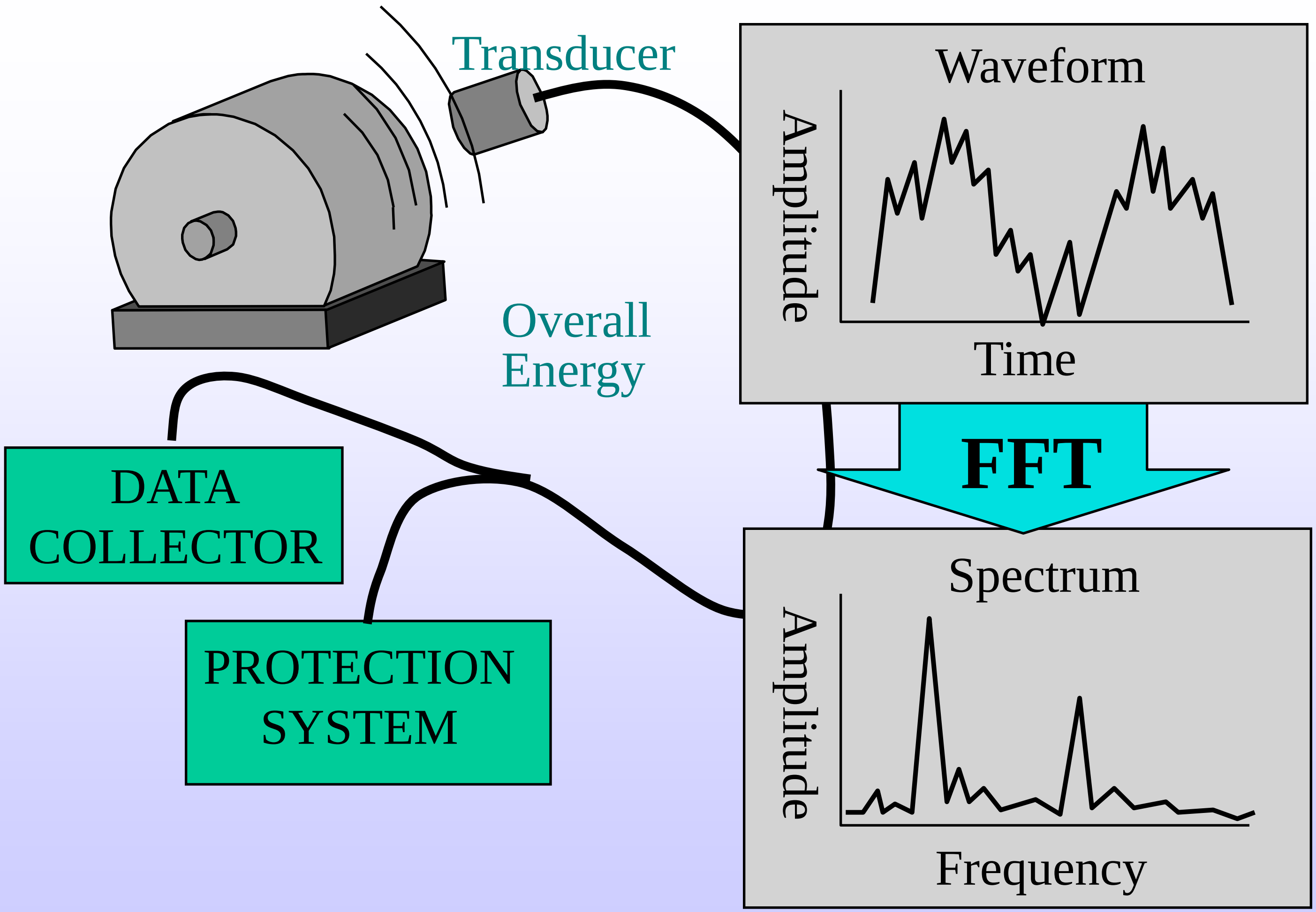
Time Waveform contains all the different frequencies mixed together.

Time Waveform

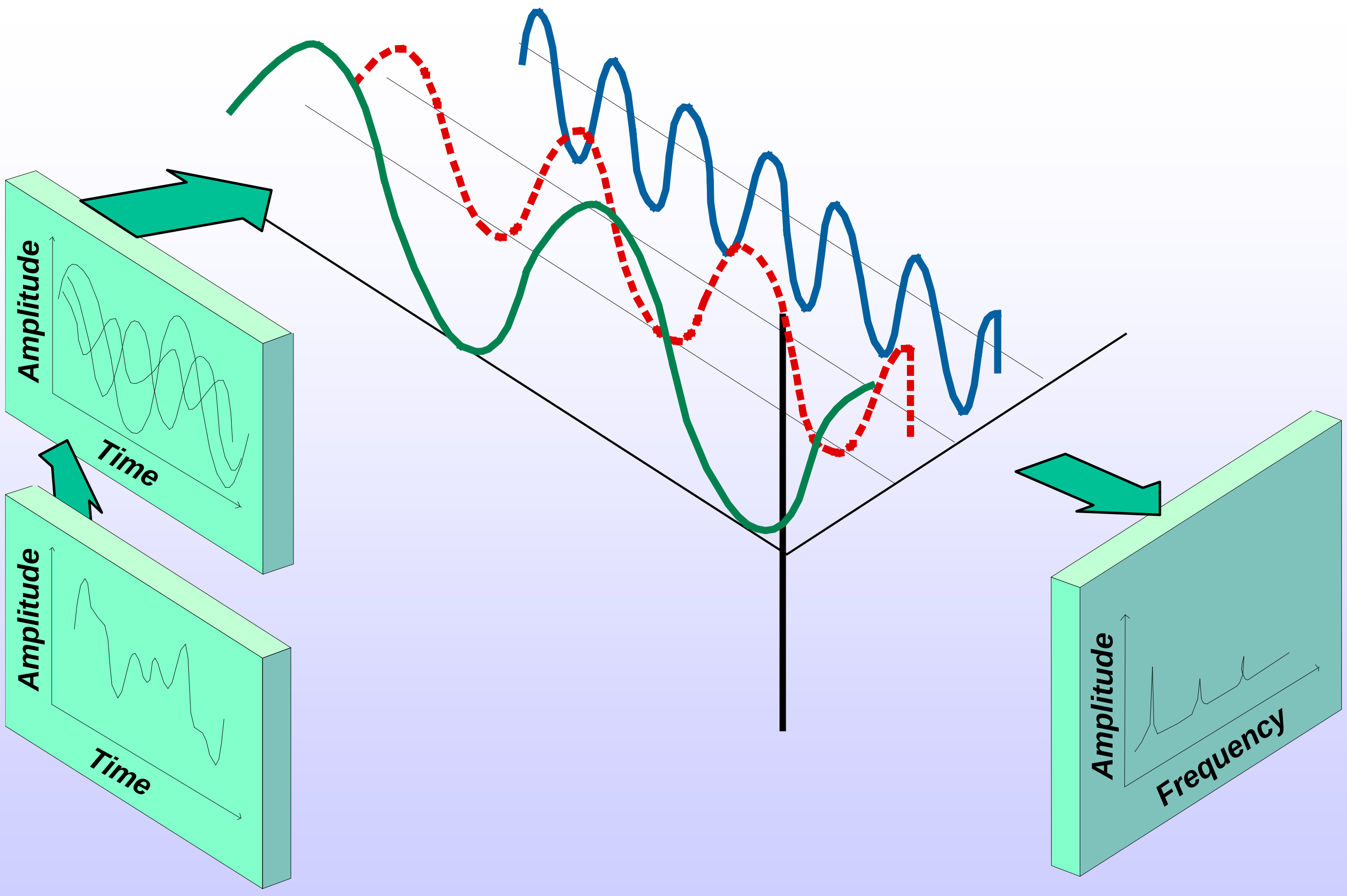


Example of a time waveform

Signal Acquisition



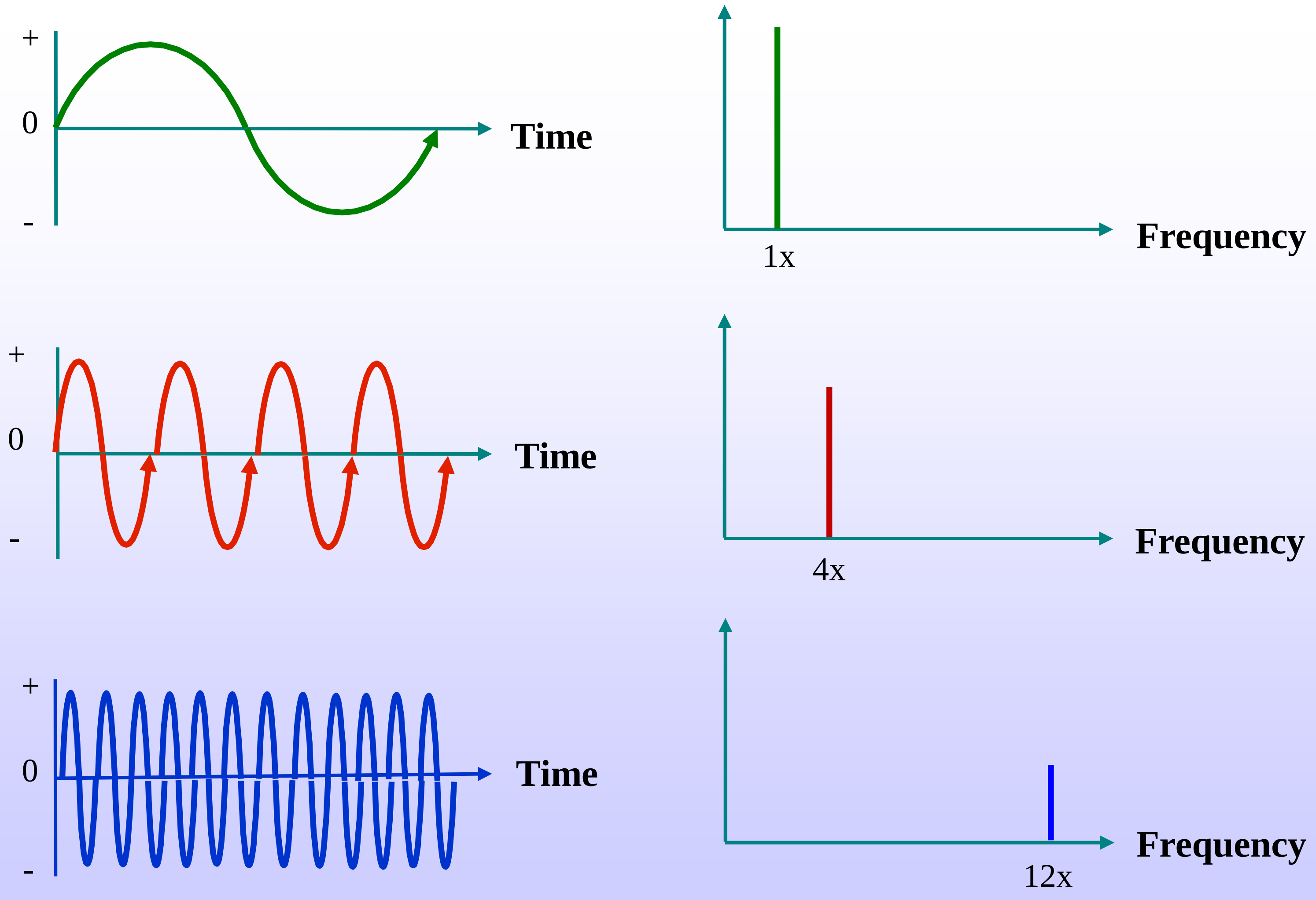
FFT Signal Processing



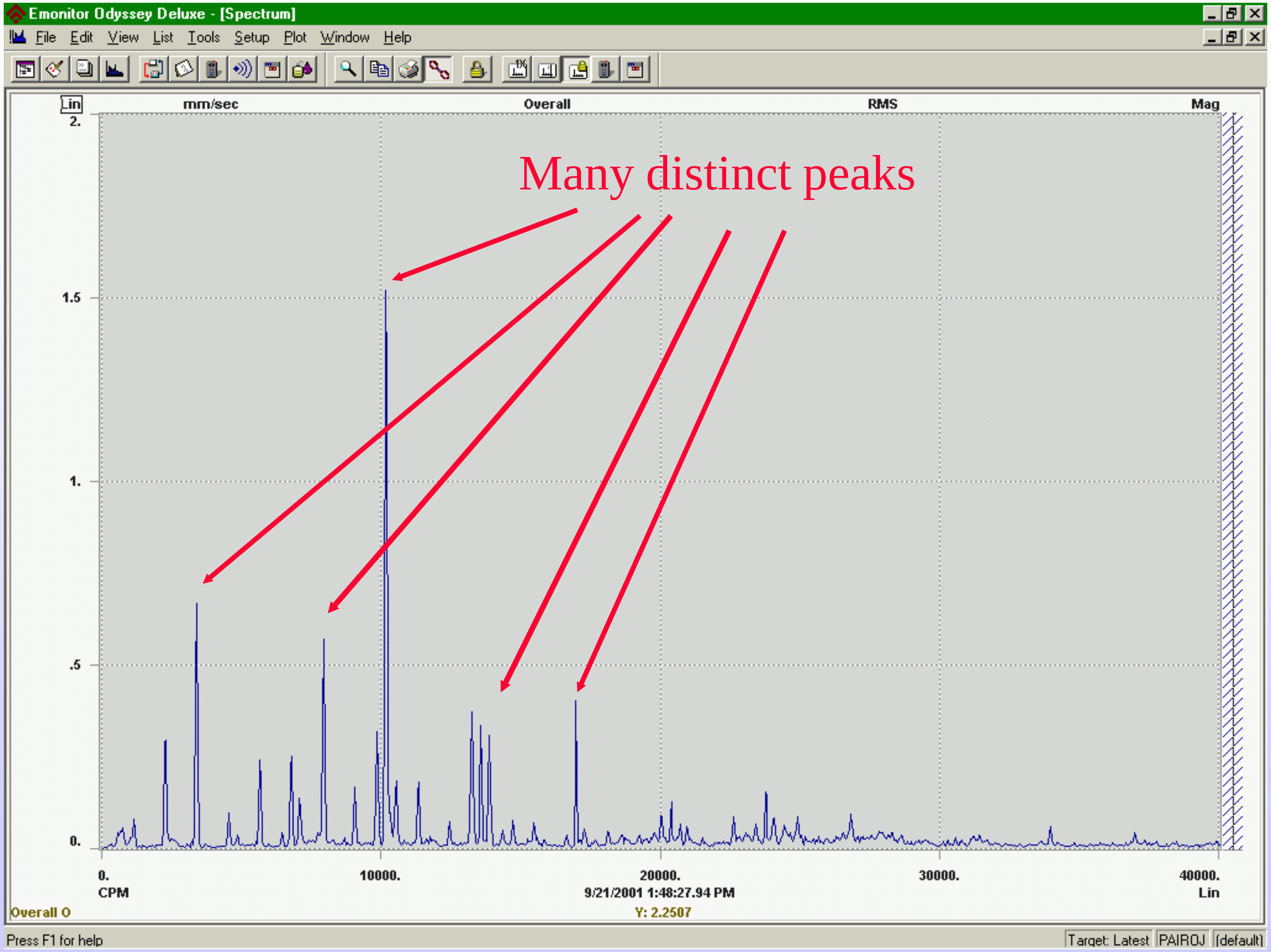
Frequency Domain

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

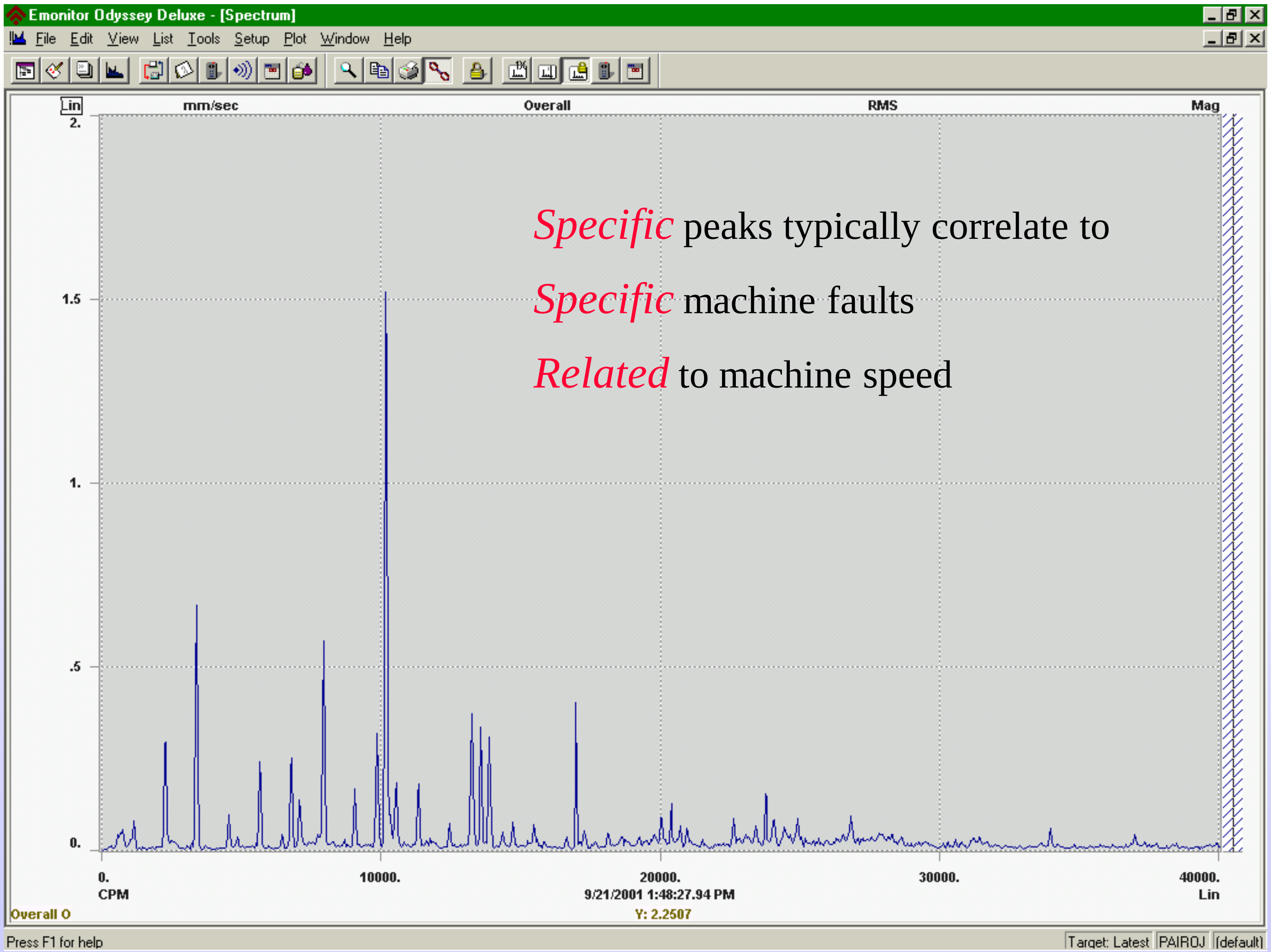
Frequency Domain



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)

Vibration Amplitude

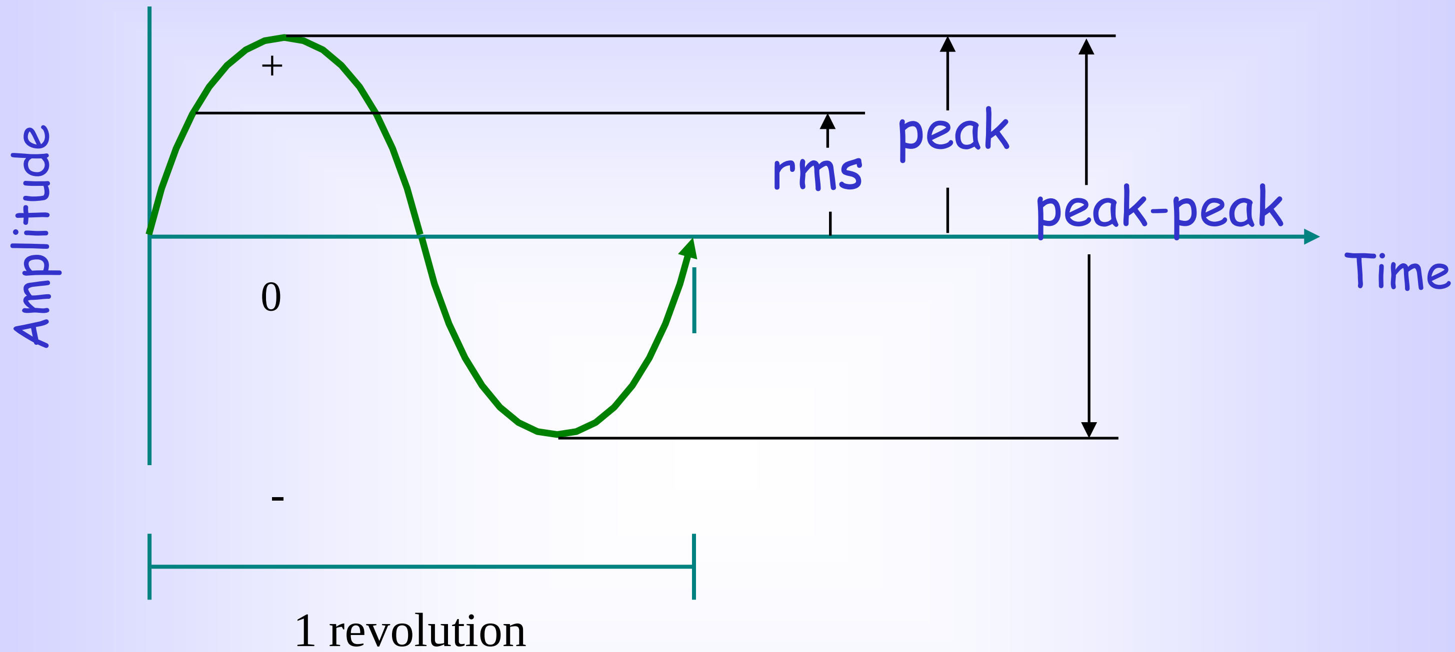
1) Displacement
2) Velocity
3) Acceleration
    3.1) General G
    3.2) G Spike Energy (Demodulation for Bearing Detection)

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

R = ค่าที่อ่านได้จริง

R ref = ค่าที่นับให้เป็น Noise Vibration

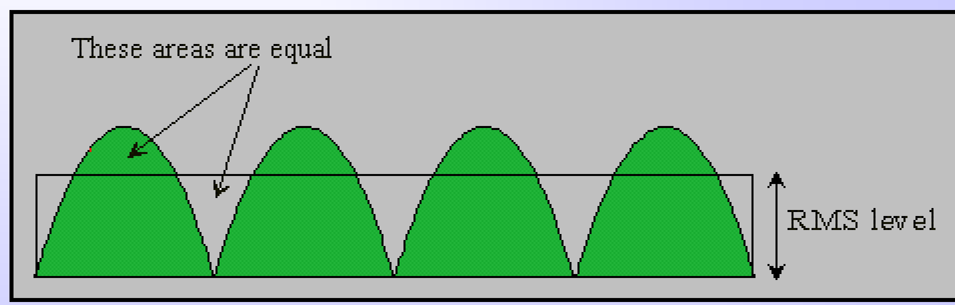
Type of measurement

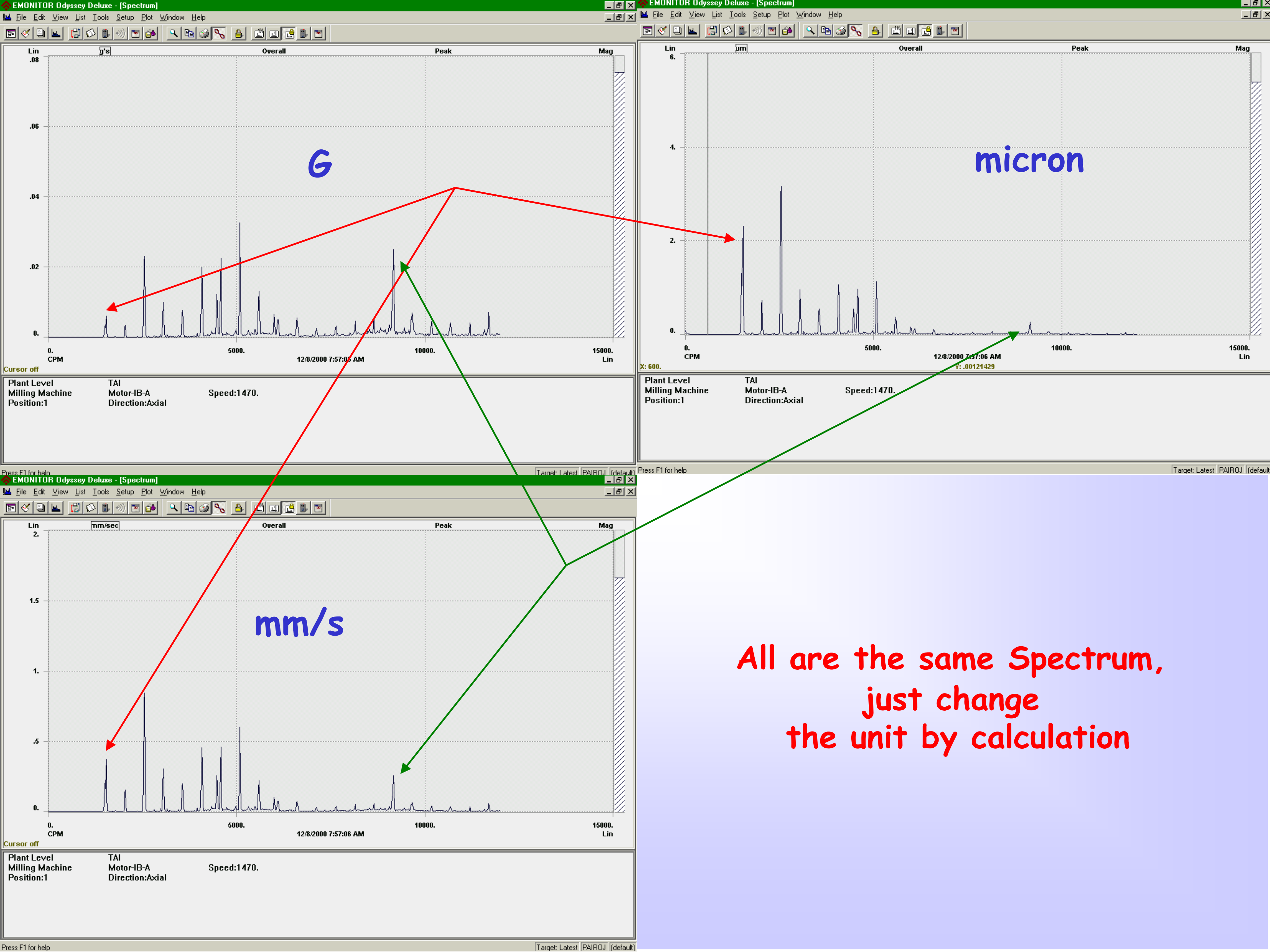


For Pure Sine Wave Form

peak-peak = 2 peak
= 2 x 1.414 rms

Avg = 0.637 Peak

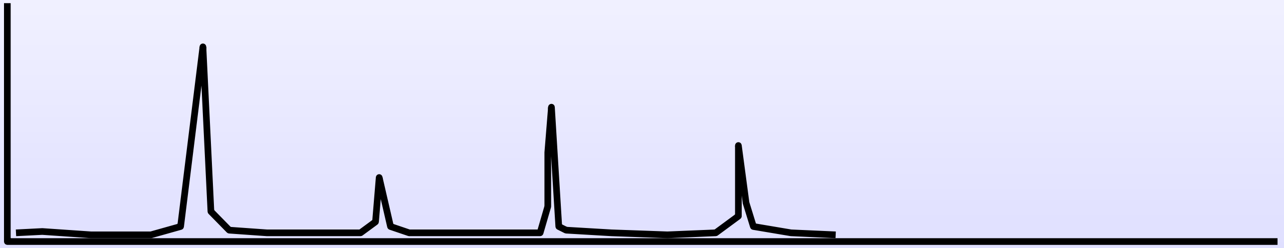




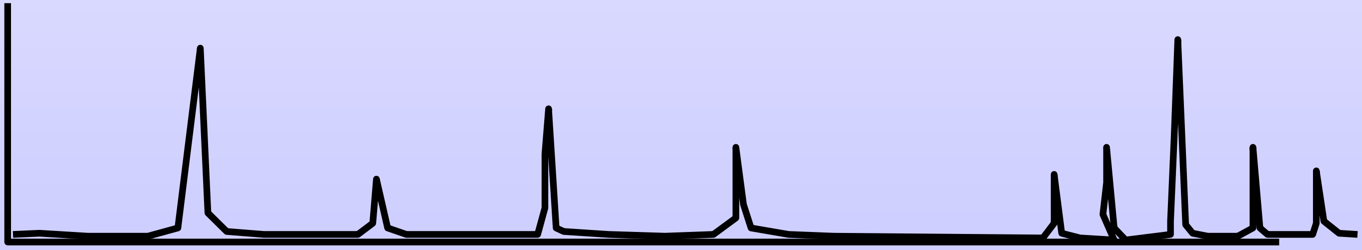
All are the same Spectrum,
just change
the unit by calculation

What's an F_{max} and Why Does It Matter?

- F_{max} is the maximum frequency of the spectrum.
- If you don't collect it, you can't analyze it.



F_{max} = low frequency



F_{max} = high frequency

What's an F_{max} and Why Does It Matter?

- F_{max} is the maximum frequency of the spectrum.
- If you don't collect it, you can't analyze it.
- Why not always collect the highest Fmax possible?
  - Limitations of the analyzer
  - Takes extra data storage space
  - Reduces the resolution of the spectrum

Fmax = 10 orders of operating speed for general analysis,
such as Unbalance, Misalignment, ...

Fmax = 20 orders of operating speed for Blade / Vane Pass analysis,
for example; Pump, Fan, Blower...

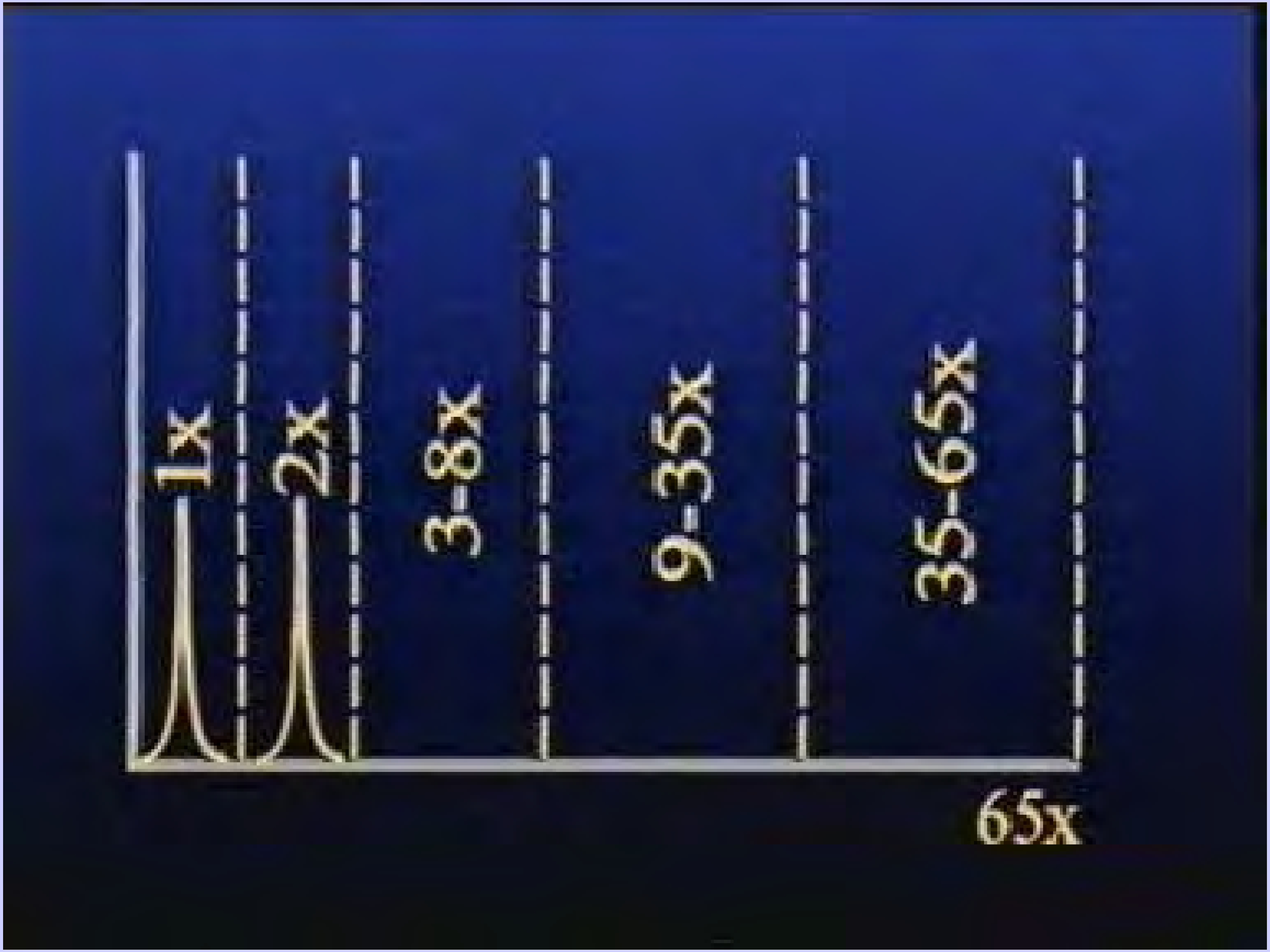
Fmax = 50 orders for Bearing analysis for Shaft diameter less than 4-6”

Fmax = 75 orders for Bearing analysis for Shaft diameter greater than 4-6”

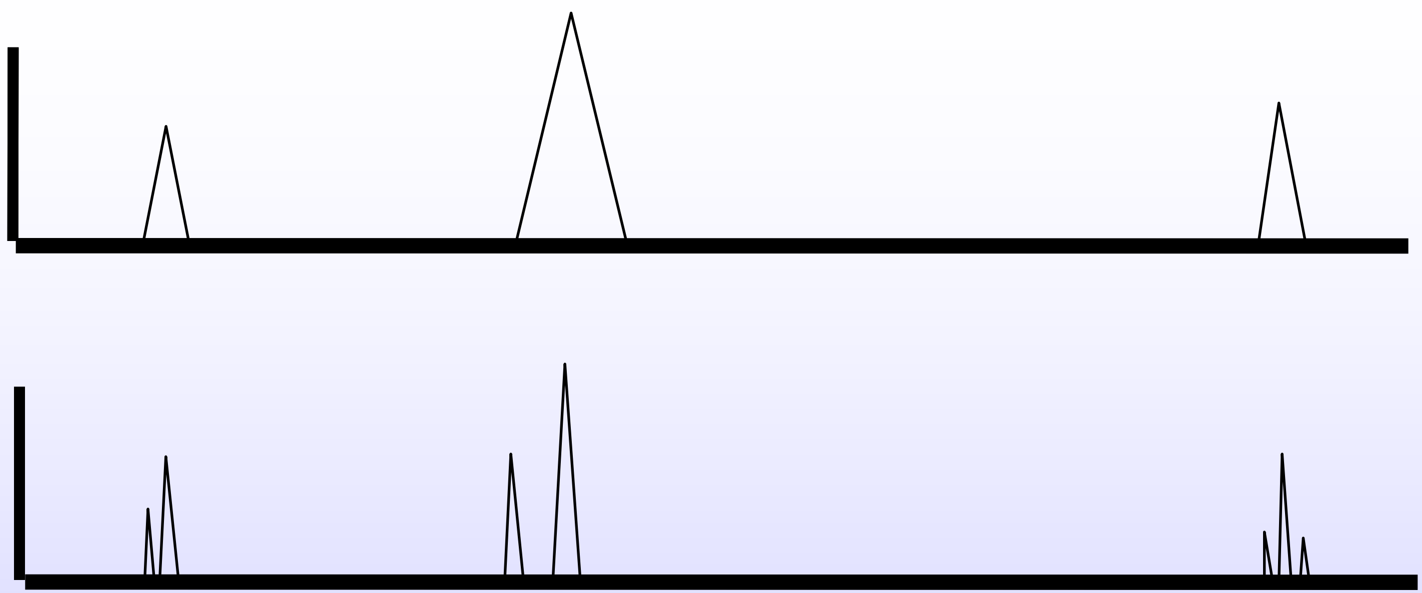
Fmax = 3.5 Times of Gear Mesh Frequency (GMF),for Gear Analysis
(GMF = Number of Gear Teeth x Shaft Running Speed of the Gear)

Fmax = 2.5 orders of Line Frequency for Electrical Eccentric Rotor/Stator,
and Electrical Phase problem

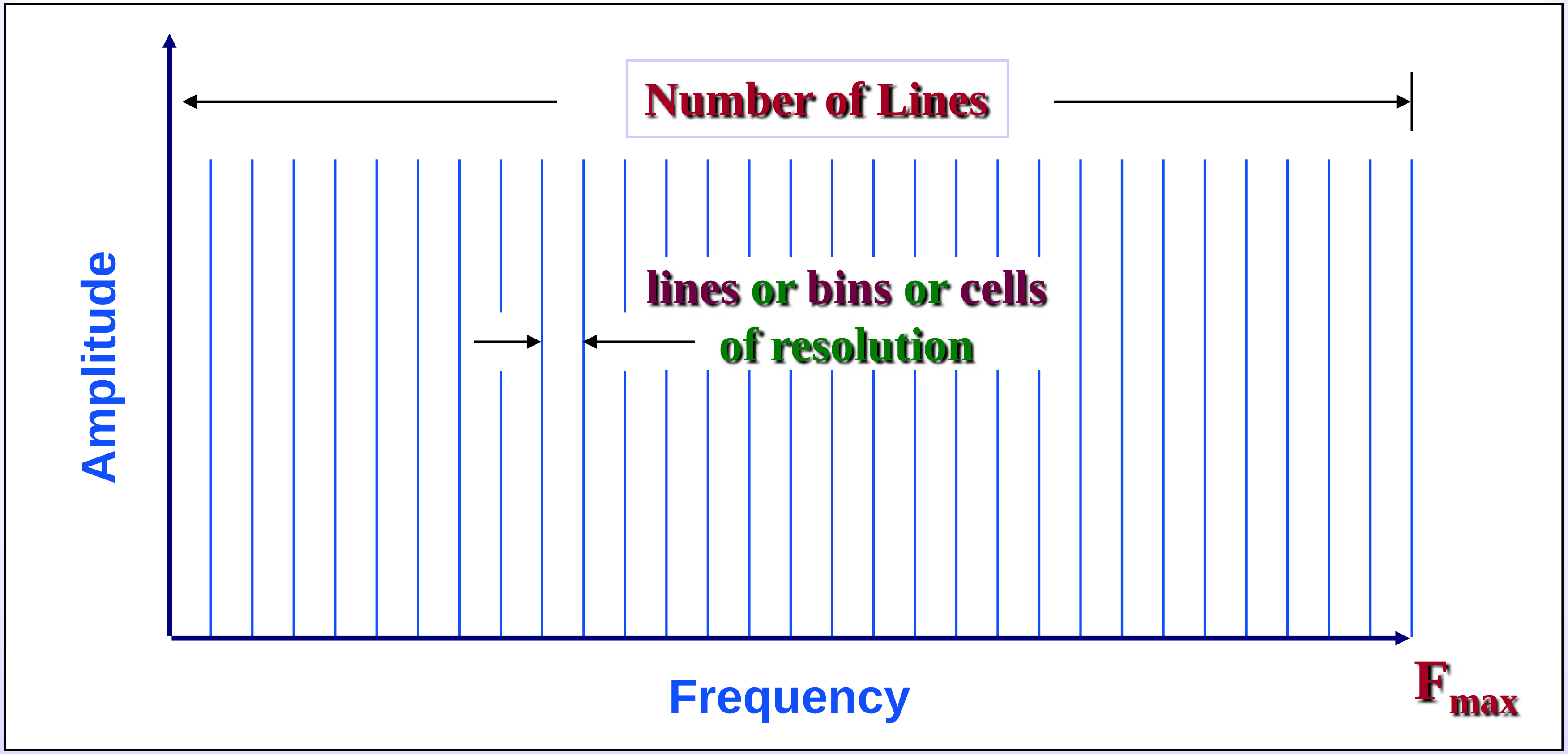
Fmax = 6KHz for Rotor Bar and Shorting Ring problem


1x
2x
3-8x
9-35x
35-65x
65x

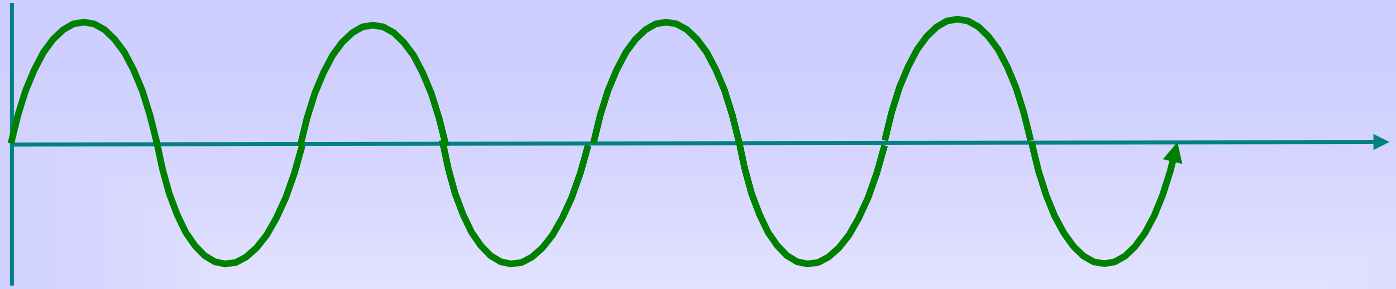
Why should I be concerned about resolution?



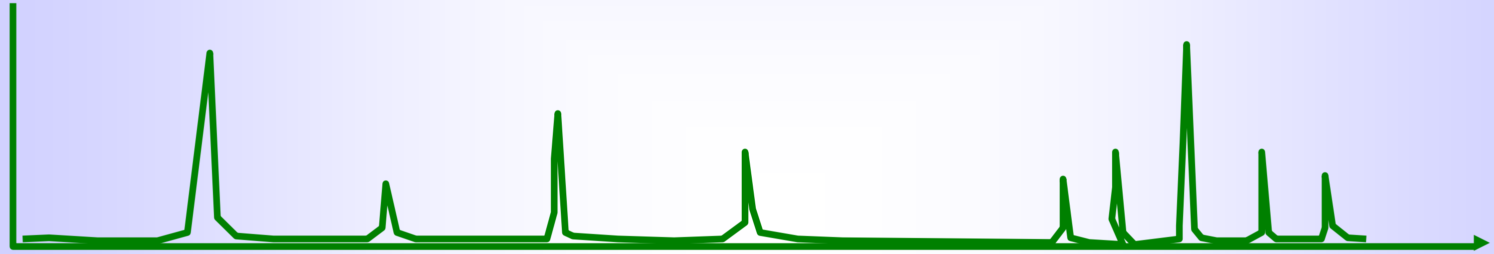
Because, if you can't see it, you can't analyze it....



$$\text{Resolution} = \frac{F_{max}}{\text{Number of Lines}}$$



Sampling Size = 256, 512, 1024, 2048, 4096, 8192, 16384, 32768



Resolution Line = 100, 200, 400, 800, 1600, 3200, 6400, 12800

Remark : 8 bits สามารถสื่อสารได้ครั้งละ 256 ค่า

Example : ต้องการเก็บค่า 100 เส้น Spectrum, ใน Time Domain ต้องเก็บอย่างน้อย 2.5 เท่าของ ค่า Spectrum

การคำนวณระยะเวลาในการเก็บข้อมูล Spectrum

$$\triangle \text{Frequency} = \frac{\text{F max.}}{\text{Resolution Line}}$$

For example : F max = 1000 Hz, Resolution Line = 400

$$\triangle \text{Frequency} = \frac{1000}{400} = 2.5 \text{ Hz.}$$

$$\triangle \text{Time} = \text{T max} = \frac{1}{2.5} = 0.4 \text{ sec.}$$

4 average = 4 x 0.4 = 1.6 sec

(More sampling data, more accuracy)

Overlap 50 % = 1.6 sec / 2 = 0.8 sec,

(Less sampling data, less accuracy)

Additional bearing spectrum = 2 x 0.8 = 1.6 sec.

Resolution Line Recommendation

400 Lines for general purpose

800 Lines for Gear and Bearing analysis

3200 Lines for Motor Analysis

The example of resolution for Bearing.

Speed > 900 rpm , Resolution = 3-5 Hz per Line

Speed < 900 rpm , Resolution = 1.5-3 Hz per Line

Filter Type

Low Pass Filter

- LP 1000 Hz. = Cut-Off Frequency more than 1000 Hz.

Band Pass Filter

- BP 10-1000 Hz. = Cut-Off Frequency less than 10 Hz. and more than 1000 Hz.

High Pass Filter

- HP 10 Hz. = Cut-Off Frequency less than 10 Hz.

สรุปการตั้งค่าที่ถูกต้องก่อนทำการวัด

1) **Amplitude Unit** : Displacement, Velocity, Acceleration

2) **Type of Detection** : RMS, Peak, Peak-Peak

3) **Fmax** : The range of vibration frequencies to be analyzed

4) **Frequency units** : CPM, Hz, Order

5) **Filtering** : The frequency to filter out (noise frequency)

6) **Resolution Lines** : The accuracy of displayed vibration frequencies

7) **Number of Averages** : How many FFT's are taken and amplitude averaged to minimize random and transient events

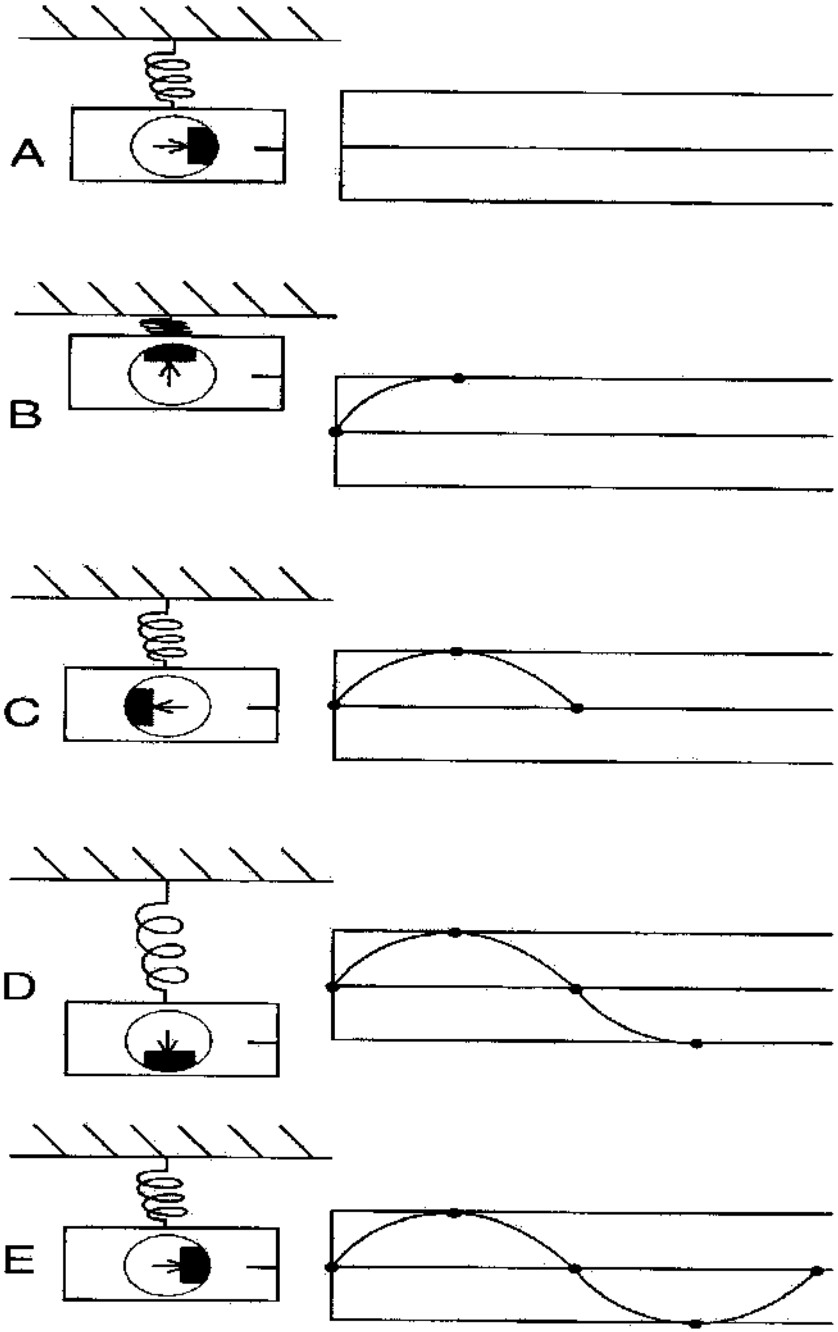
Vibration Analysis

Overall Value Part

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."

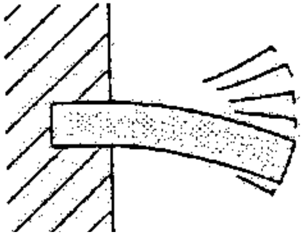
Art Crawford



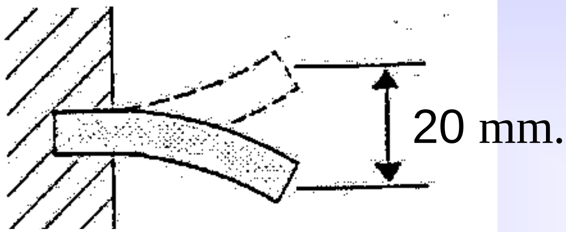
การสั่นสะเทือนในรูปแบบของ

SPRING MASS SYSTEM

Plot ต่อหน่วยเวลา



Frequency
Hz or CPM



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

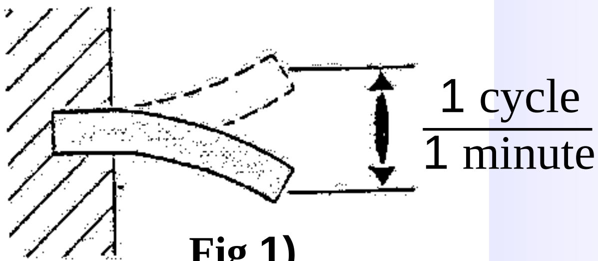


Fig 1)

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.

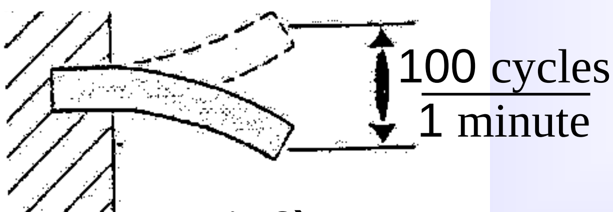
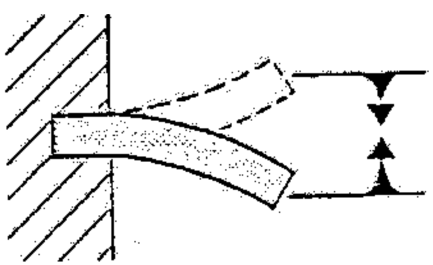


Fig 2)

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

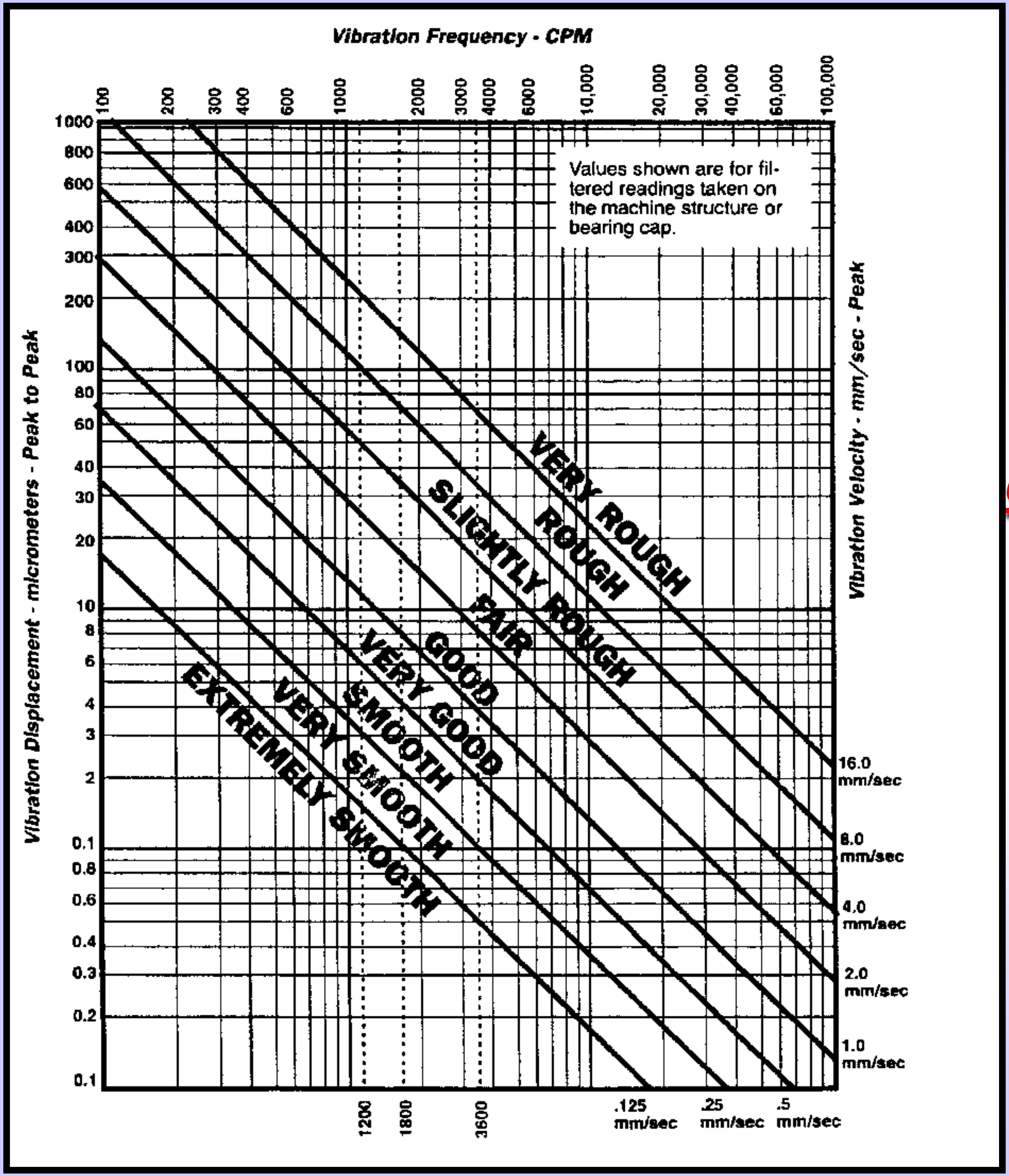


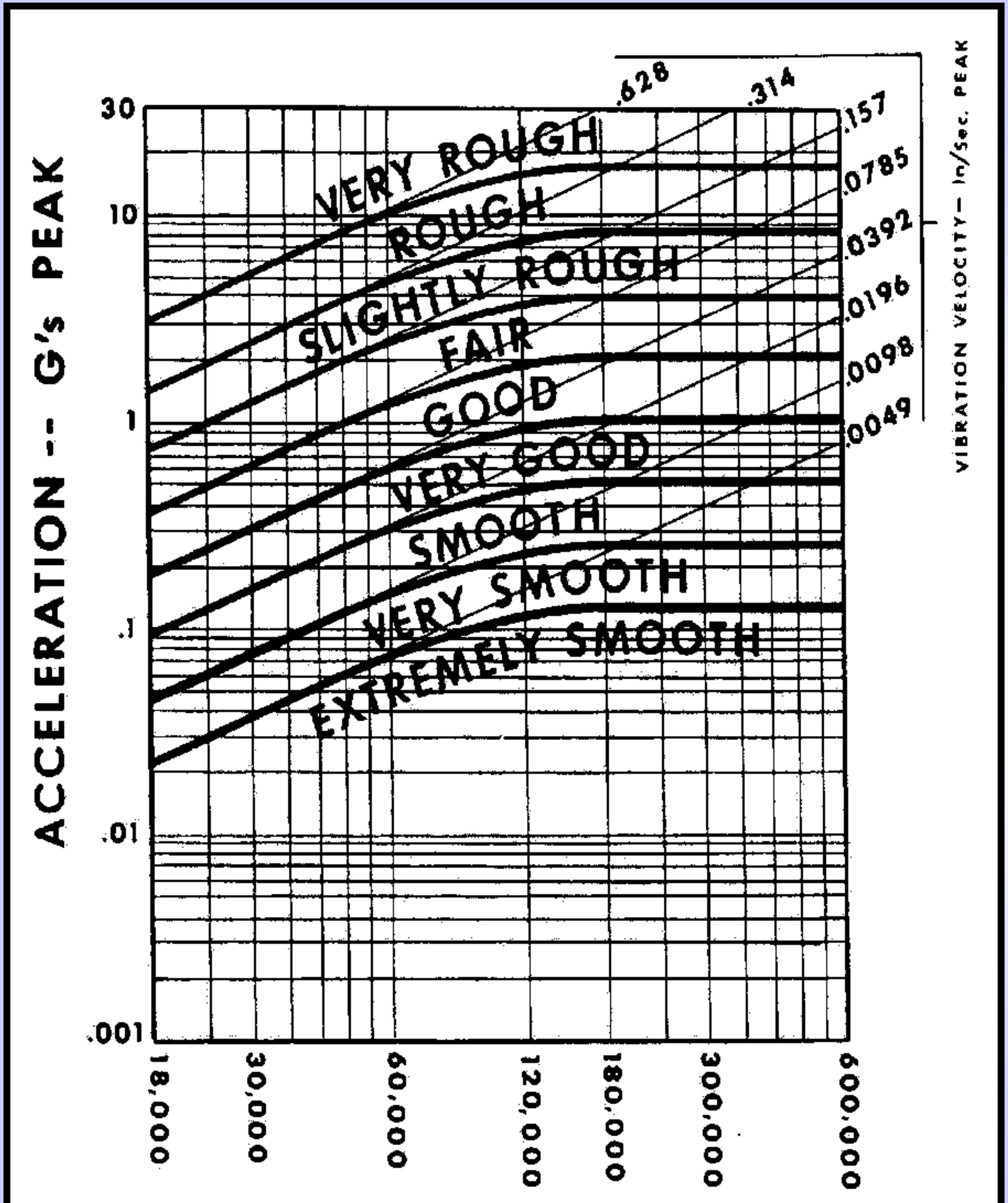
Acceleration in G = Impact Force from Bearing or Gear
* Rate of Change of velocity from zero to max. velocity
or max. velocity to zero, if the velocity has been changed
so fast, it means high G , as a hammer knock to a rigid table

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%

General Machinery Vibration Severity Chart

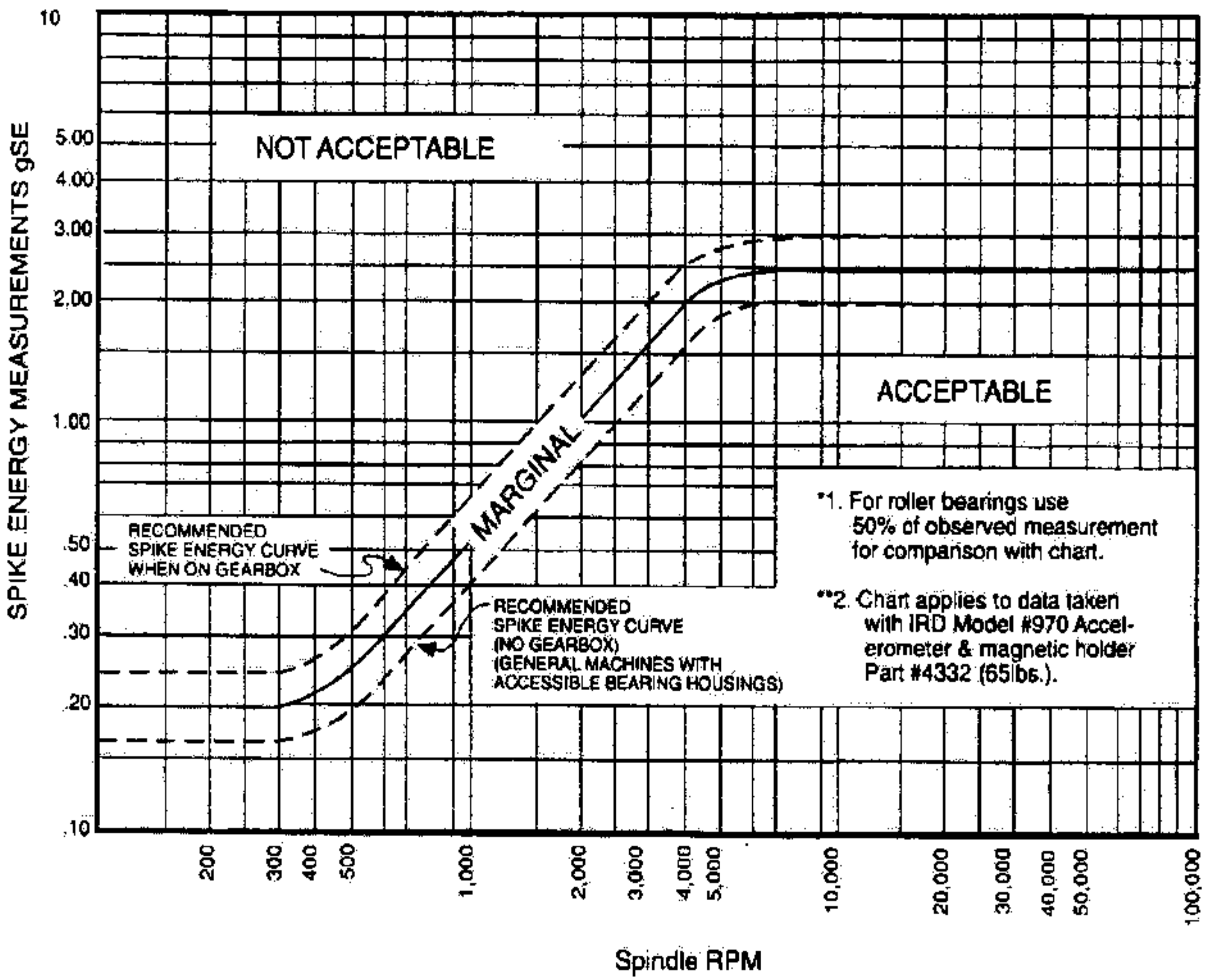




Vibration acceleration (G's) Severity chart

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

สำหรับการวัดลูกปืน



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)

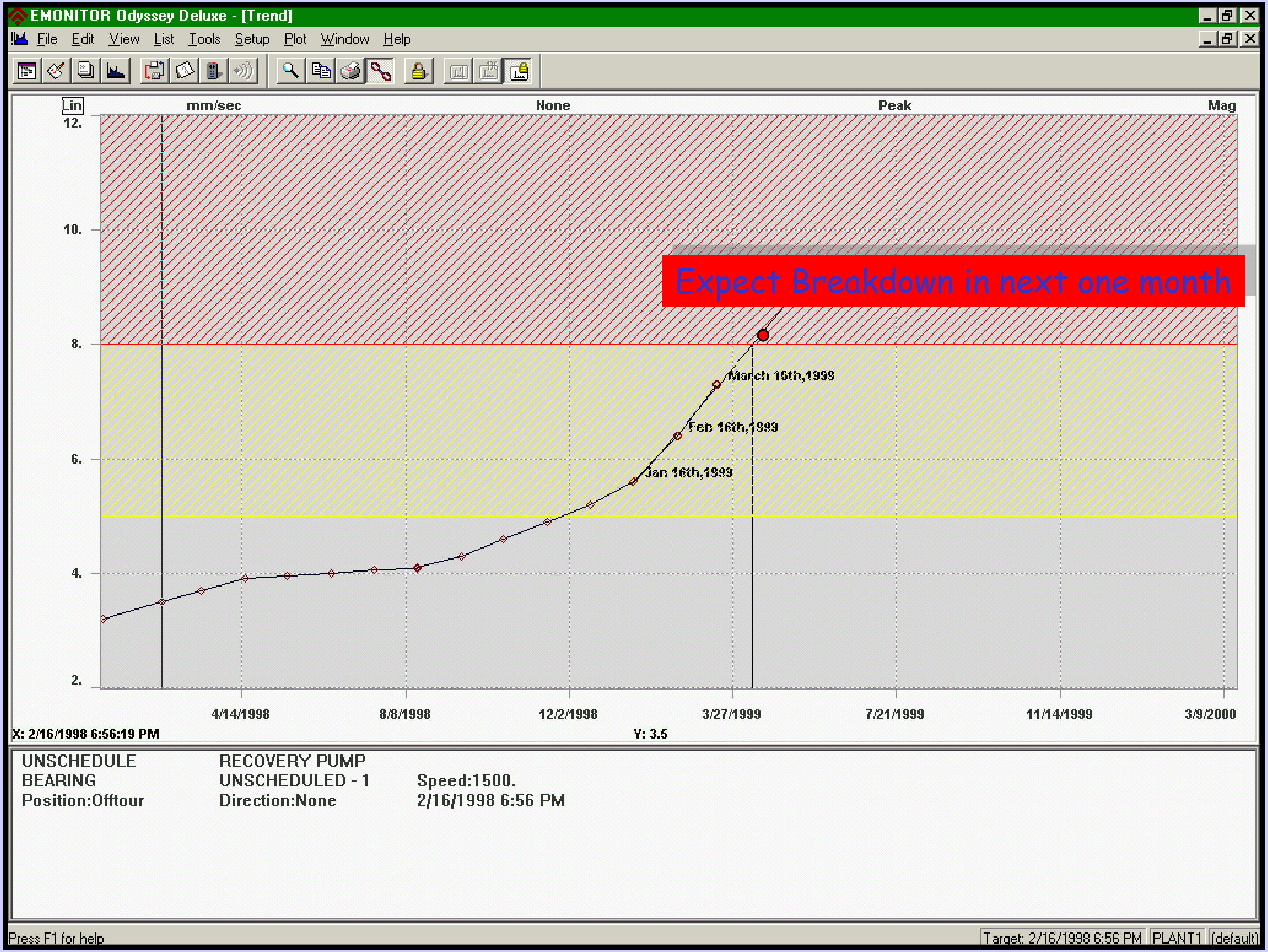
SUGGESTED OVERALL ALARMS BY MACHINE TYPE-METRIC (PEAK, OVERALL VELOCITY, MM/SEC.)

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

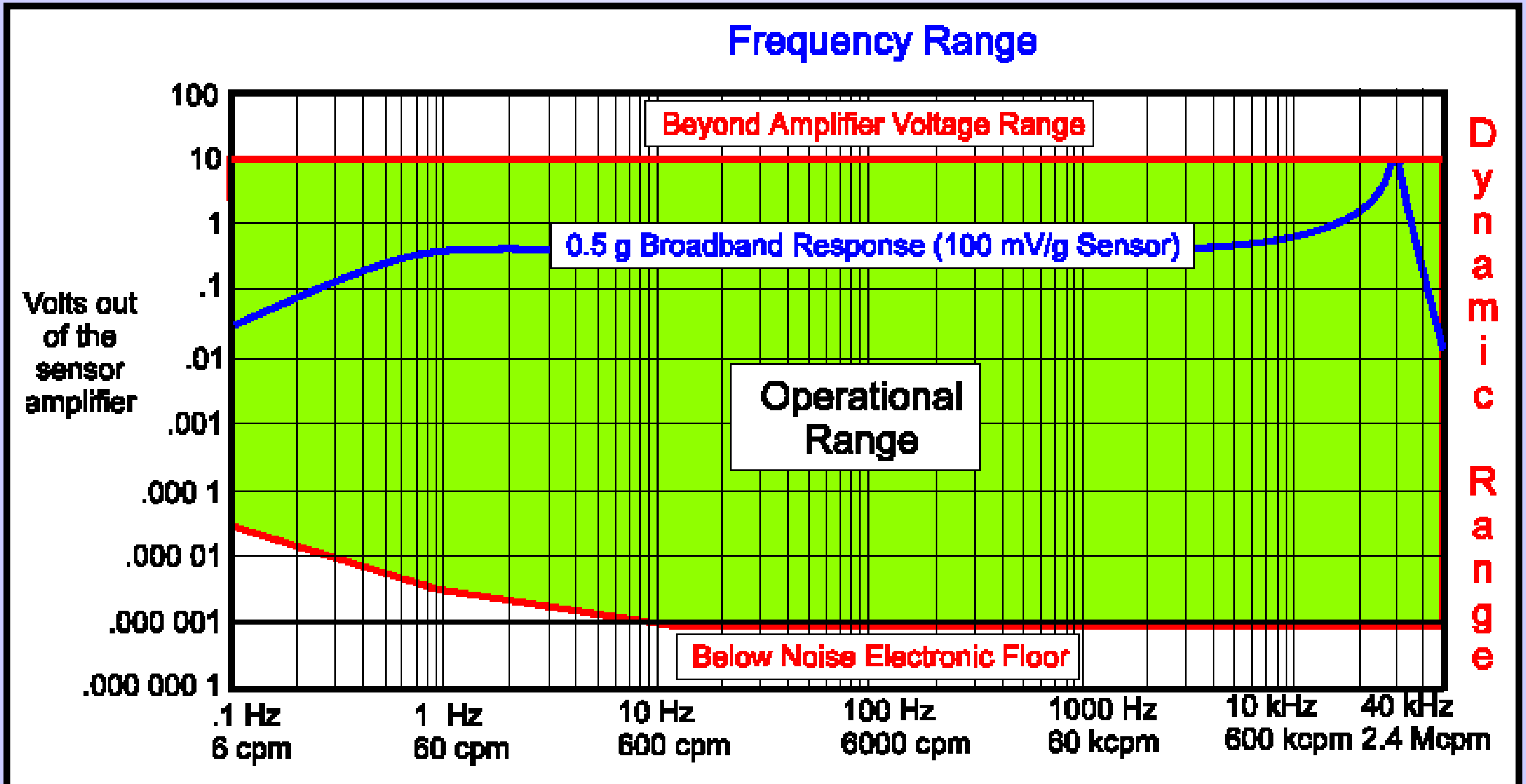
MACHINE TYPE	GOOD	FAIR	ALARM
CENTRIFUGAL PUMPS			
Vertical Pump (12" - 20")	0-9.5	9.5-15	15
Vertical Pump (8" - 12" Height)	0-8	8-13	13
Vertical Pump (5" - 8" Height)	0-6.5	6.5-10	10
Vertical Pump (0" - 5" Height)	0-5	5-7.5	7.5
General Purpose Horizontal	0-5	5-7.5	7.5
Boiler Feed Pumps	0-5	5-7.5	7.5
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.

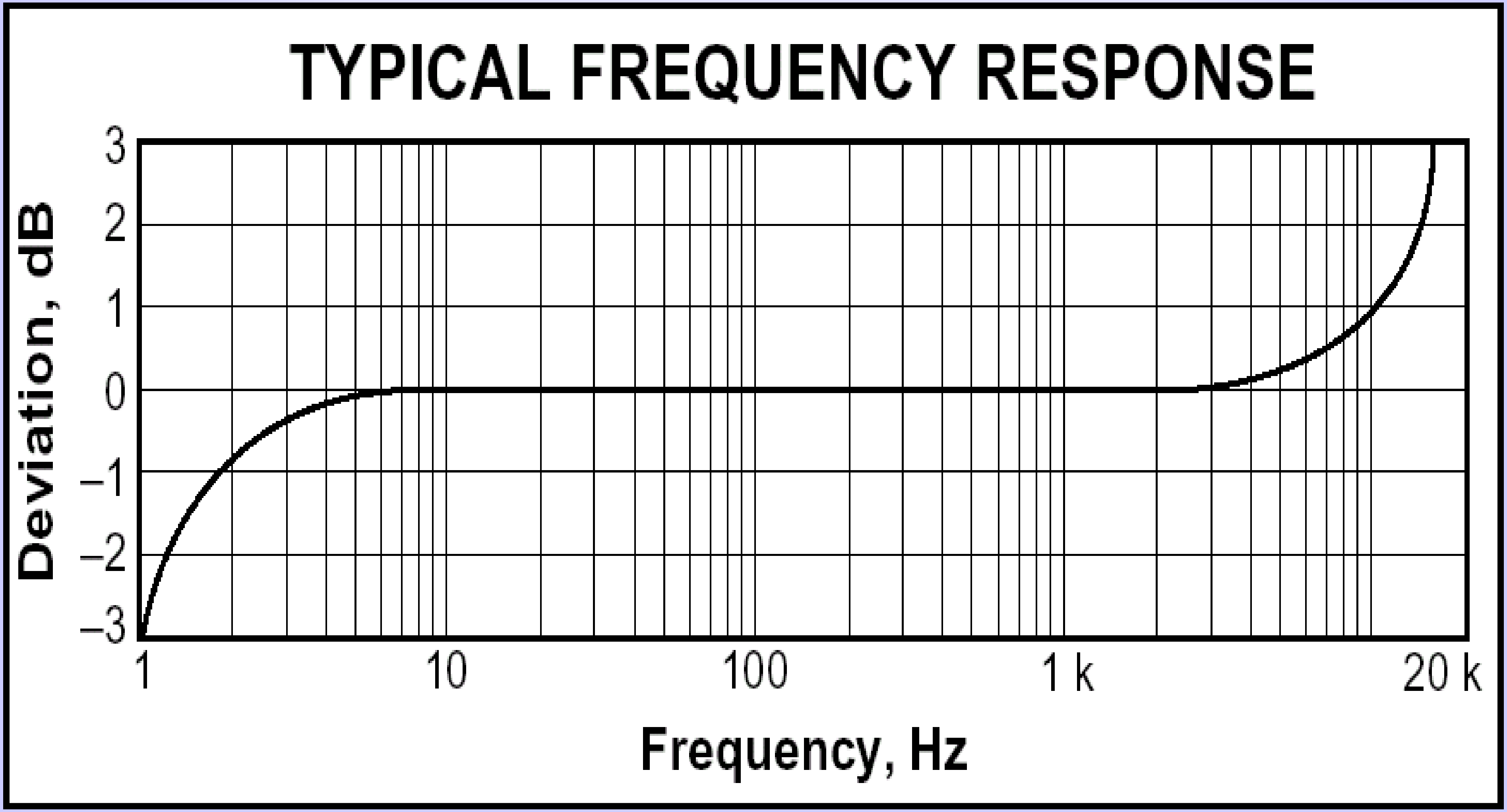

EMONITOR Odyssey Deluxe - [Trend]
File Edit View List Tools Setup Plot Window Help
Lin
mm/sec
None
Peak
Mag
12.
10.
8.
6.
4.
2.
Expect Breakdown in next one month
March 16th,1999
Feb 16th,1999
Jan 16th,1999
4/14/1998
8/8/1998
12/2/1998
3/27/1999
7/21/1999
11/14/1999
3/9/2000
X: 2/16/1998 6:56:19 PM
Y: 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)

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



Operational Range of an Accelerometer Amplifier
(Shaded Region)

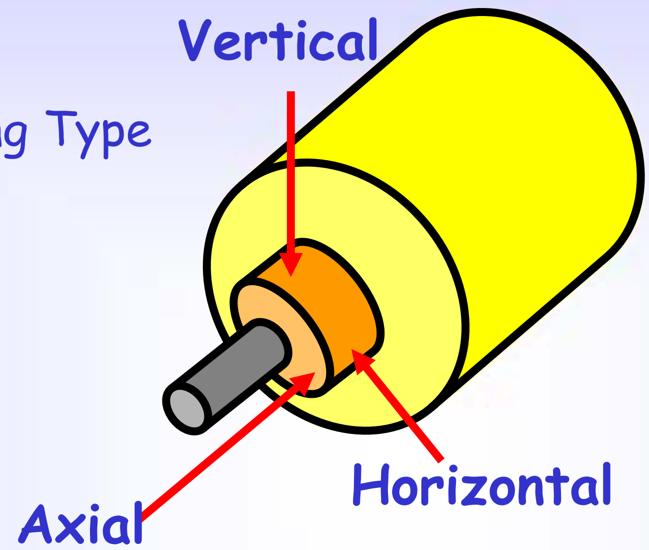
Frequency Vs Amplitude accuracy example



Directional Analysis for Overall value

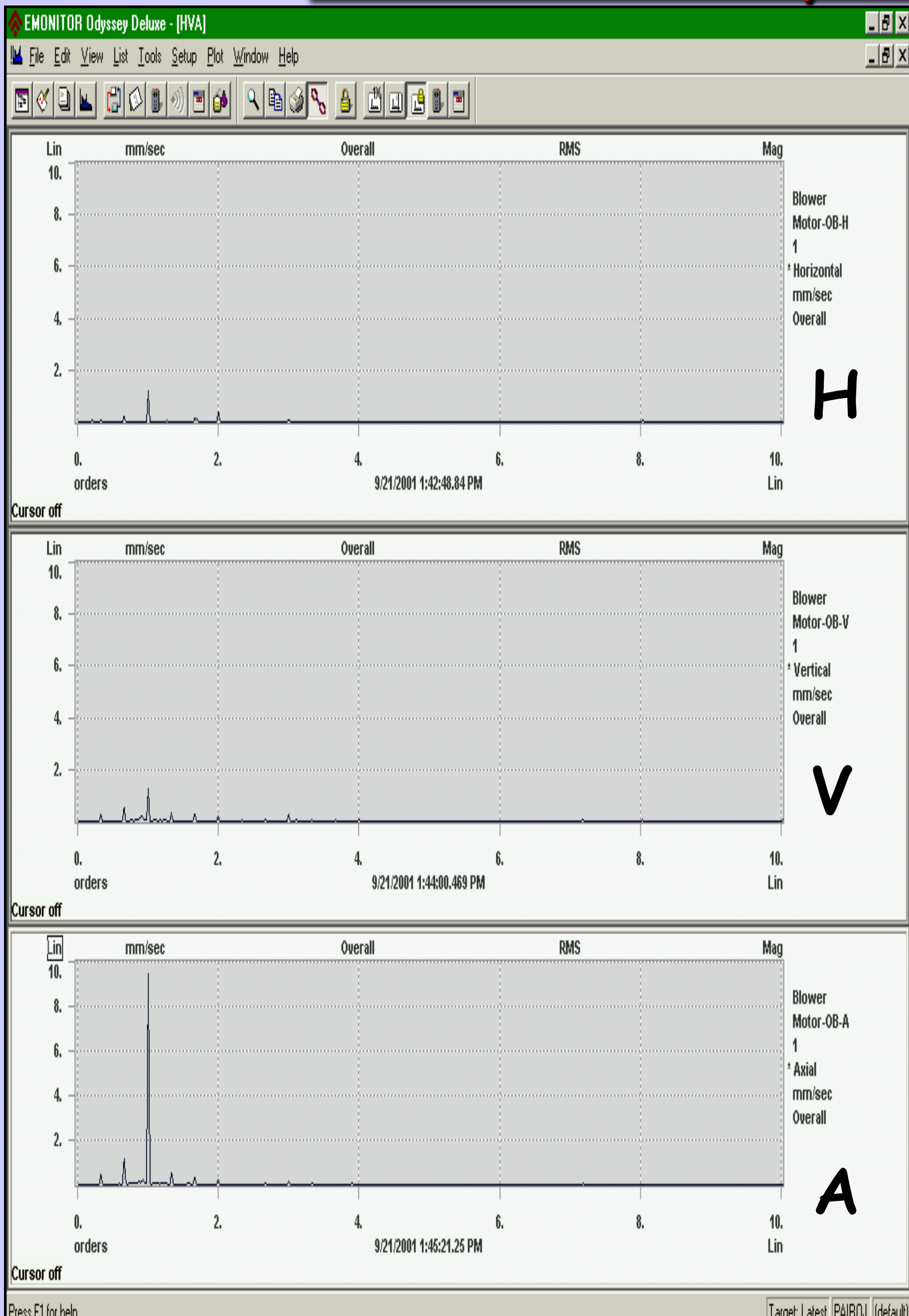
R = H or V ที่สูงที่สุด

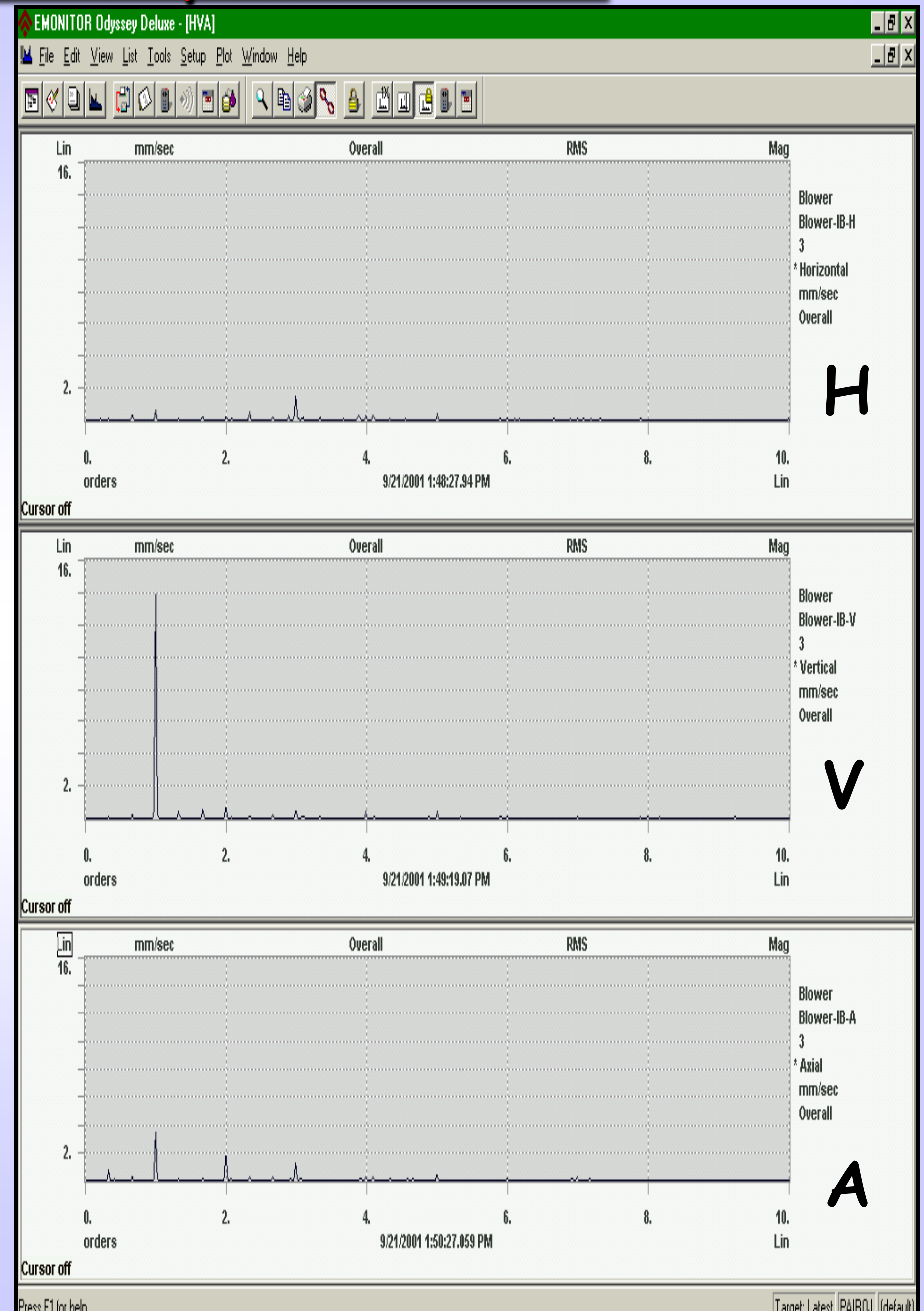
Machine ต้องไม่เป็น Overhung Type



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





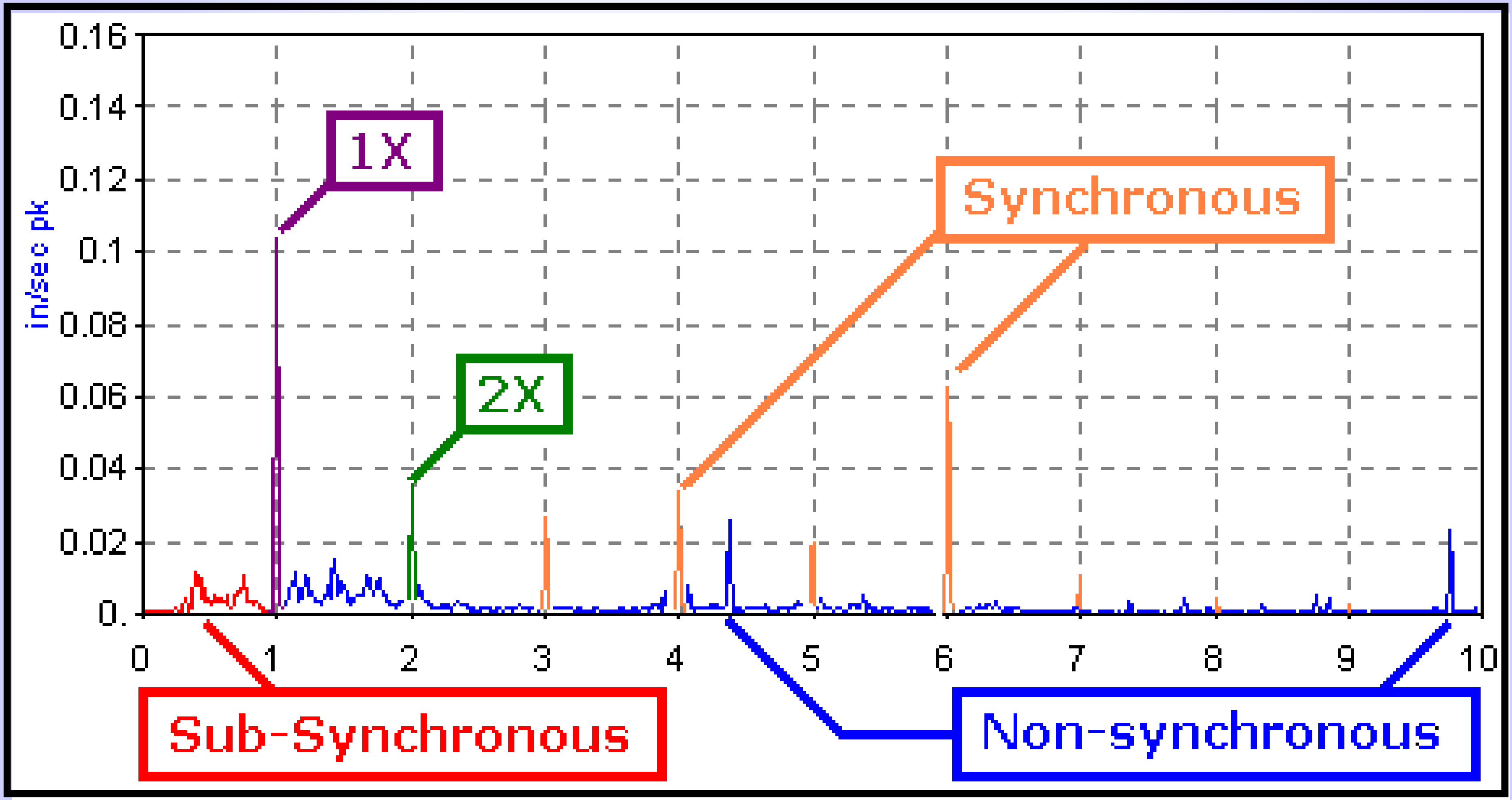
Vibration Analysis

Spectrum Analysis Part

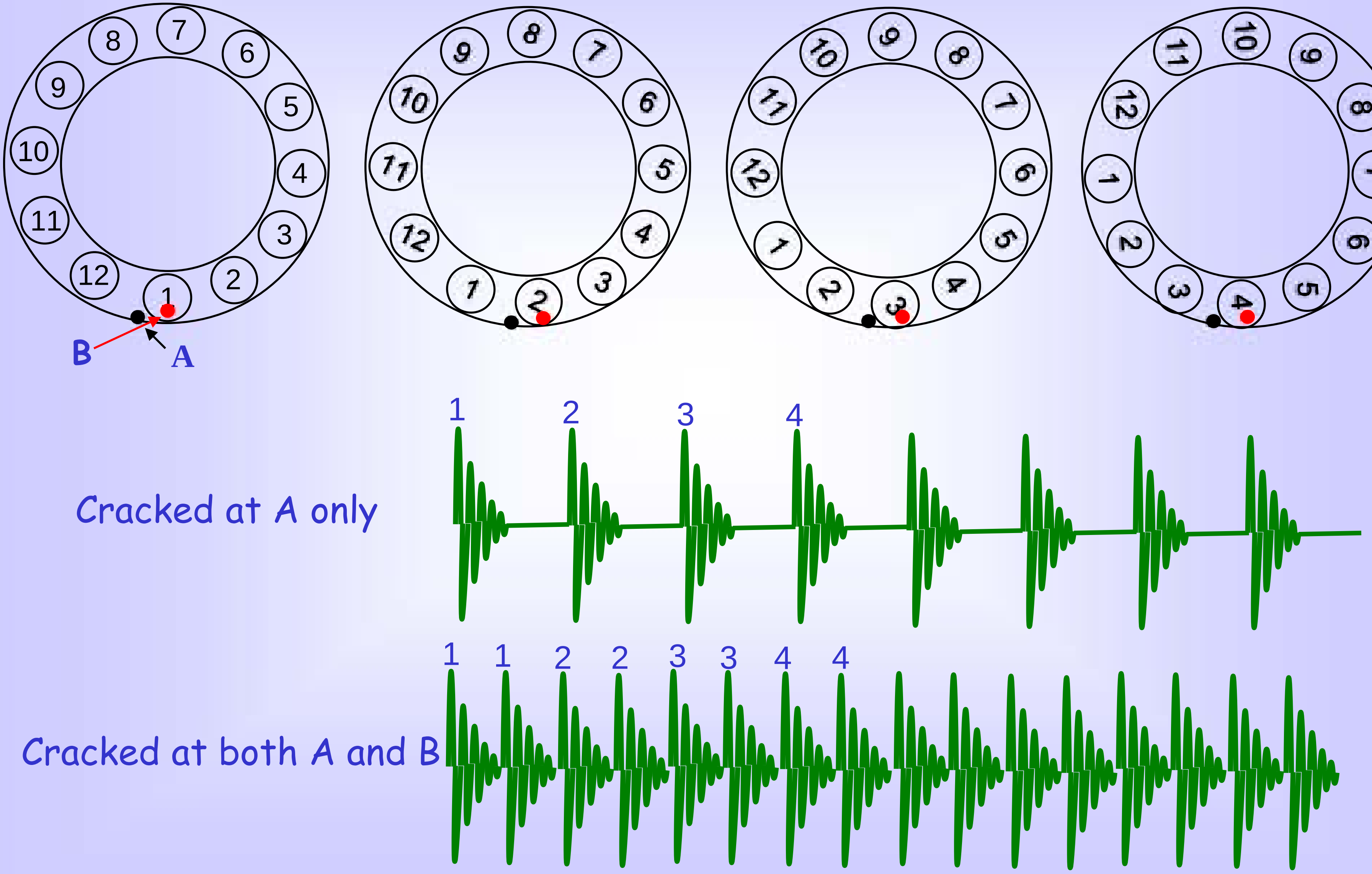
Synchronous Frequency = ความถี่ที่เท่ากับความเร็วรอบของเพลาหรือเป็นจำนวนเท่าที่ลงตัว เช่น1, 2, 3,...

Sub-Synchronous Frequency = ความถี่ที่ต่ำกว่าความเร็วรอบของเพลา

Non-Synchronous Frequency = ความถี่ที่ไม่เข้านิยามของ Synchronous และ Sub-Synchronous

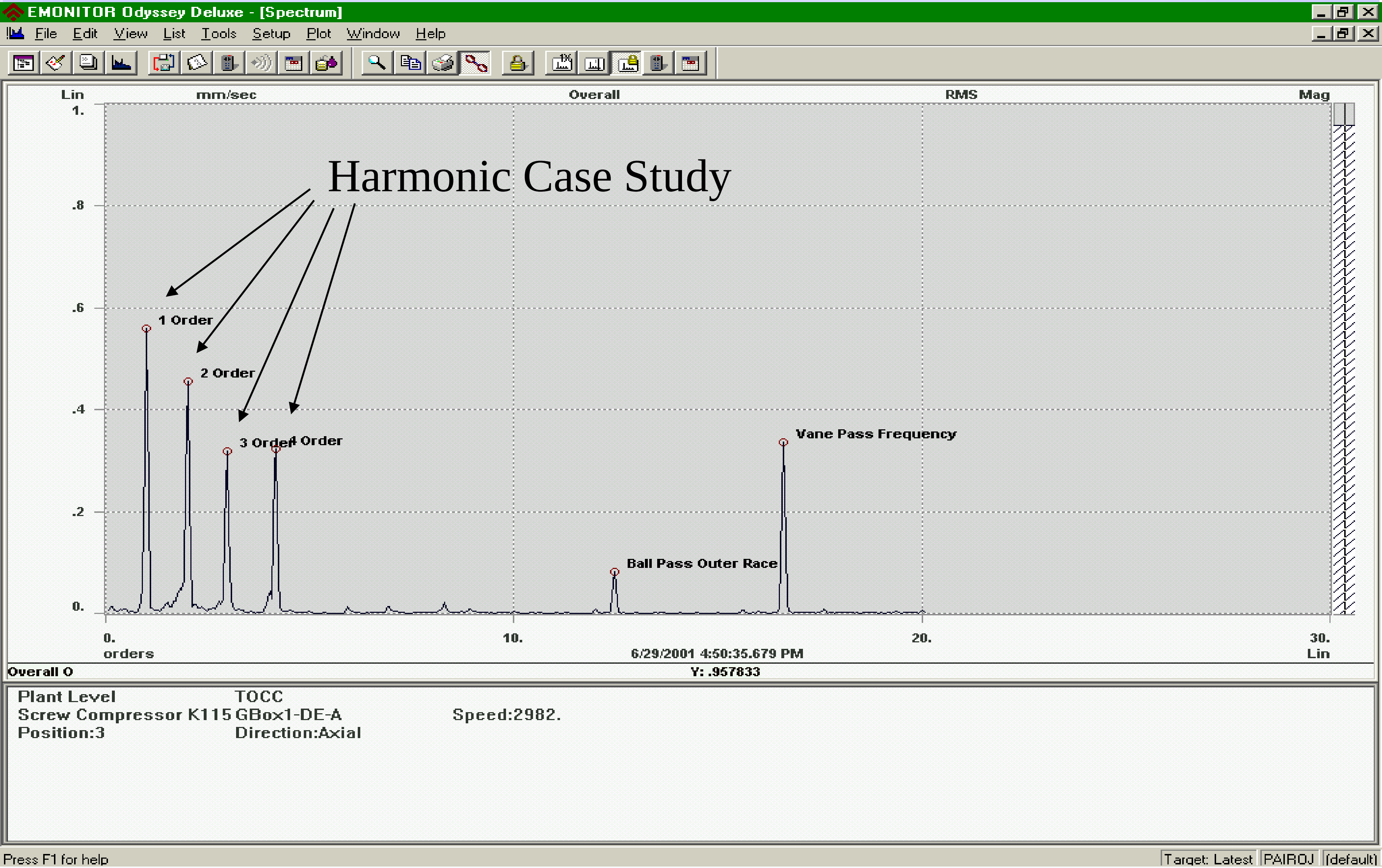


Harmonics



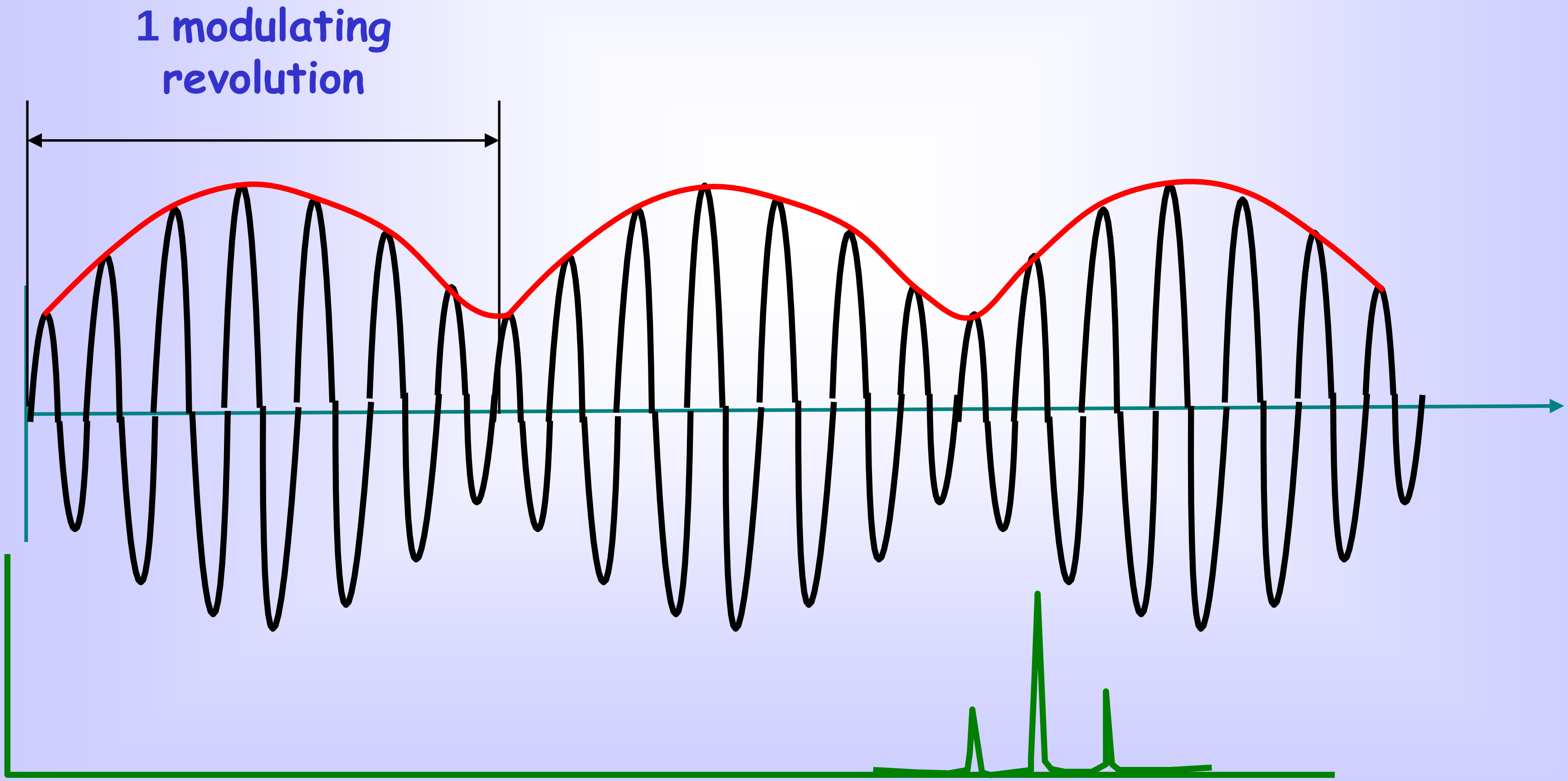
1 2 3 4 5 6 7 8 9 10 11 12
B
A
1 2 3 4
Cracked at A only
1 1 2 2 3 3 4 4
Cracked at both A and B

Harmonic Example

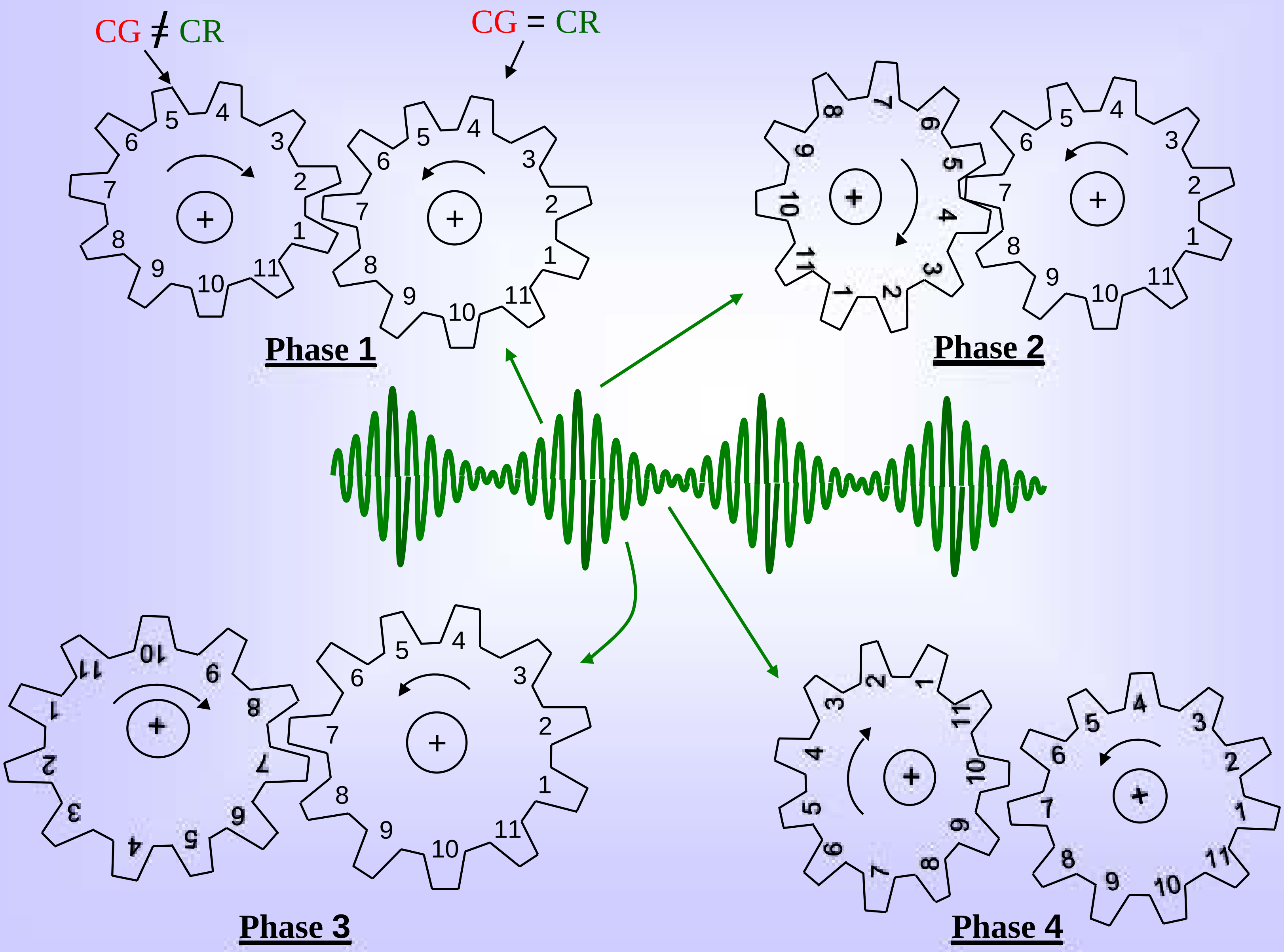


Amplitude Modulating

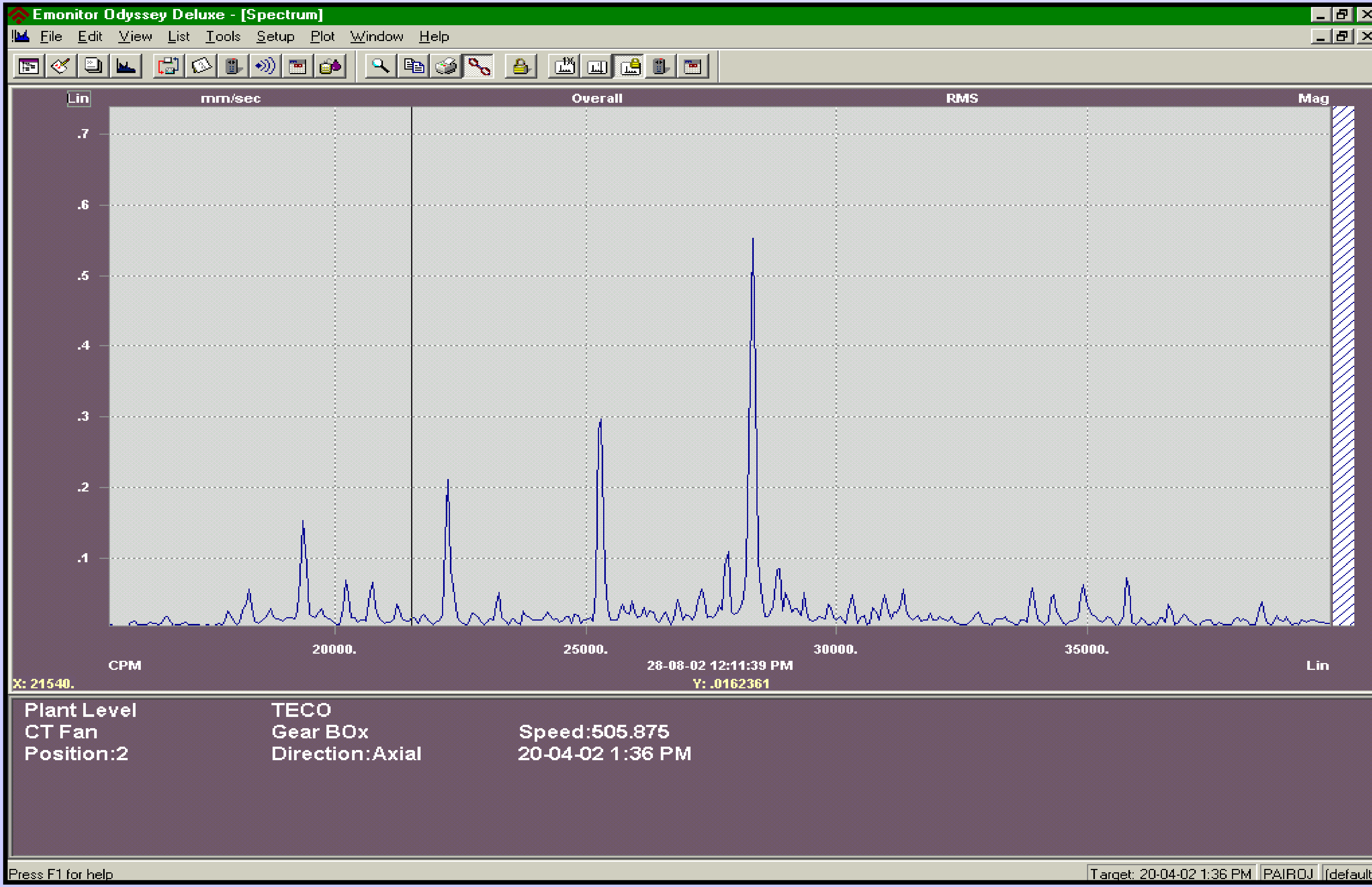
1) Occur at only one frequency which has a varied load in a specific revolution, for example,
   - Bearing frequency vary amplitude at every turning speed or FTF frequency
   - Gearmesh frequency vary load at every turning speed of Gear or Pinion
   - Rotor Eccentricity or Cracked vary load at Pole Pass Frequency (Slip Frequency x No. of Pole)
2) Will make only a few pairs of side band.



SIDE BAND

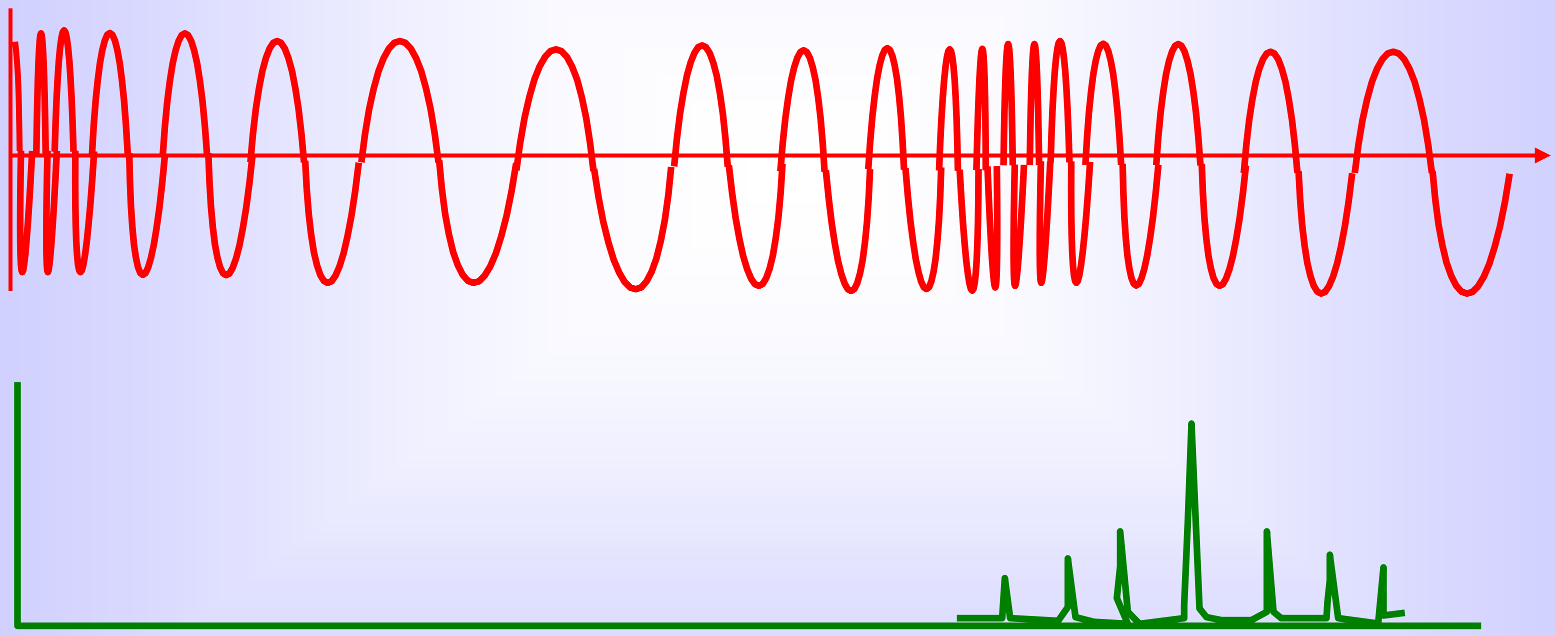


Side Band example at Gearbox of A Cooling Tower Fan with a very few of sideband frequency

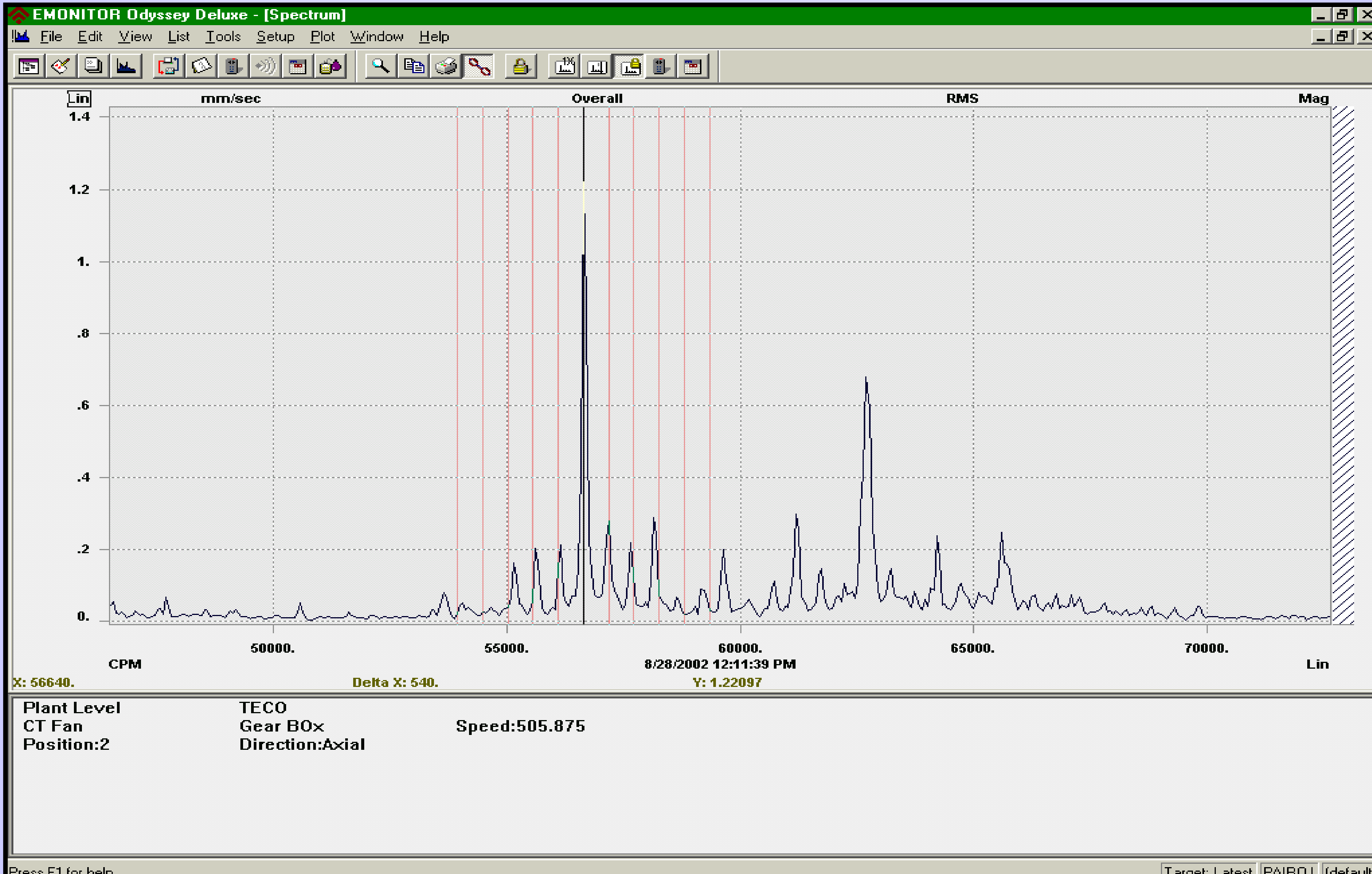


Frequency Modulating

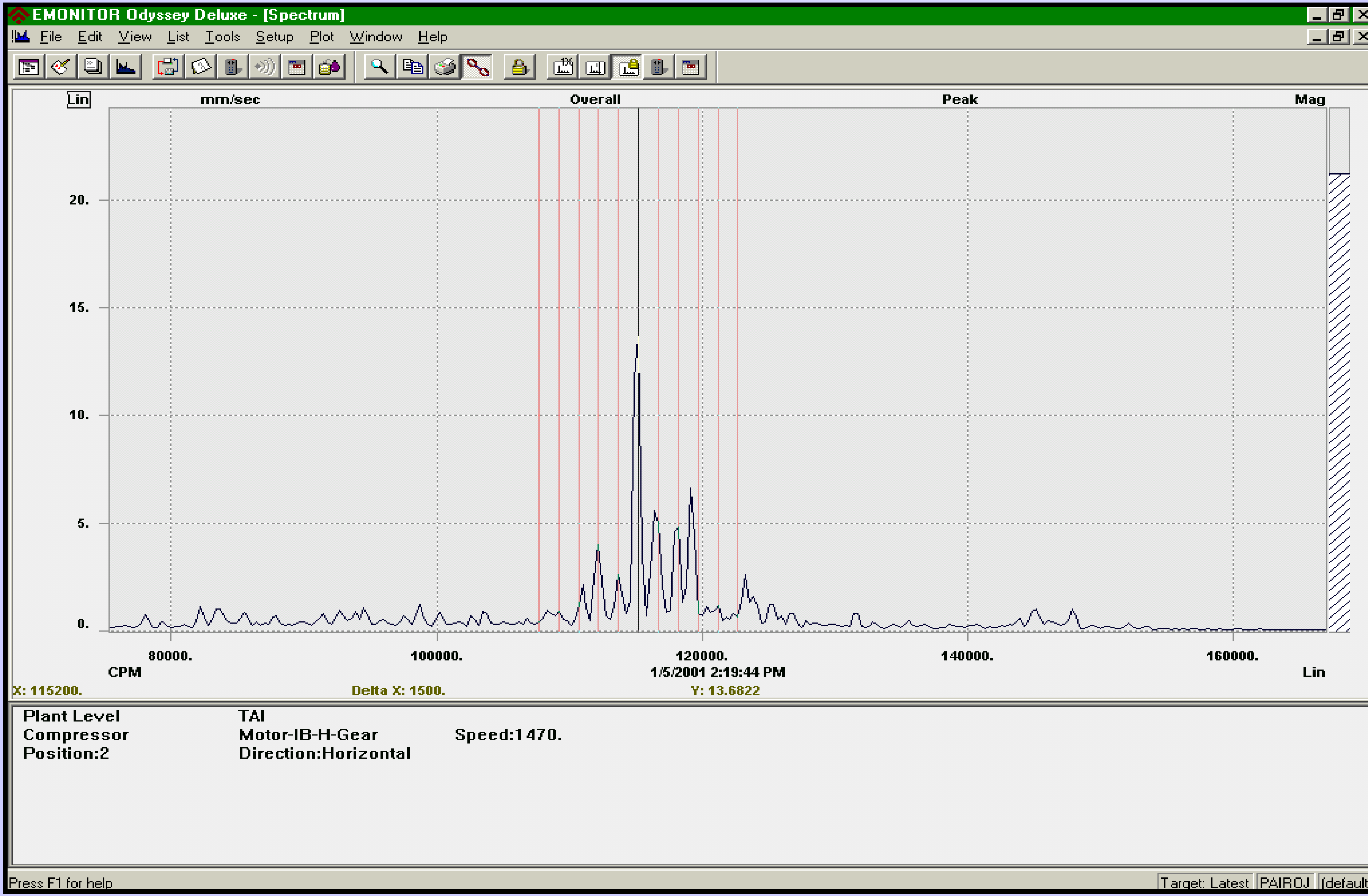
1) Occur at Eccentric , Misalign Gear which makes rotational velocity be none-linear in one revolution.
2) Will make many pairs of side band.

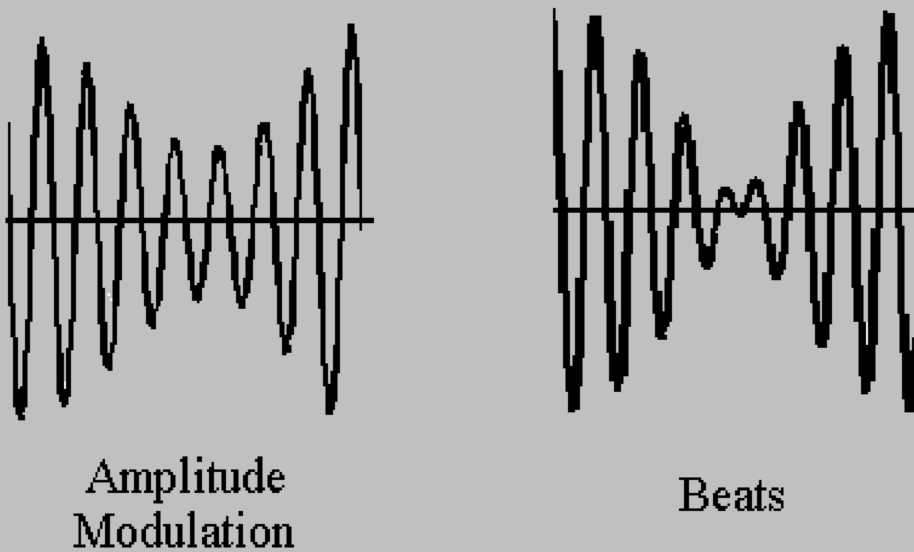


Side Band example at Gearbox of A Cooling Tower Fan with high numbers of sideband frequency

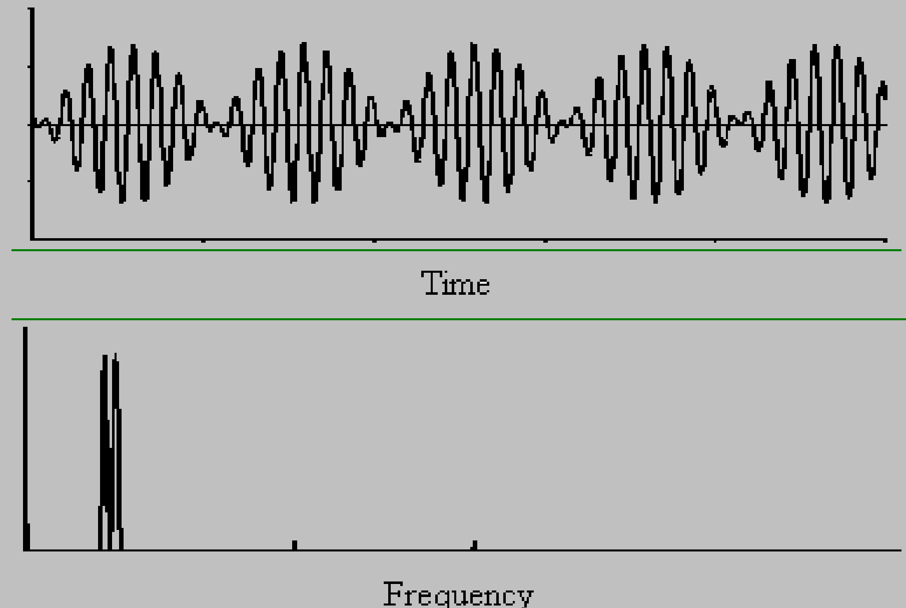


Side Band example at Gearbox of A Gas Compressor

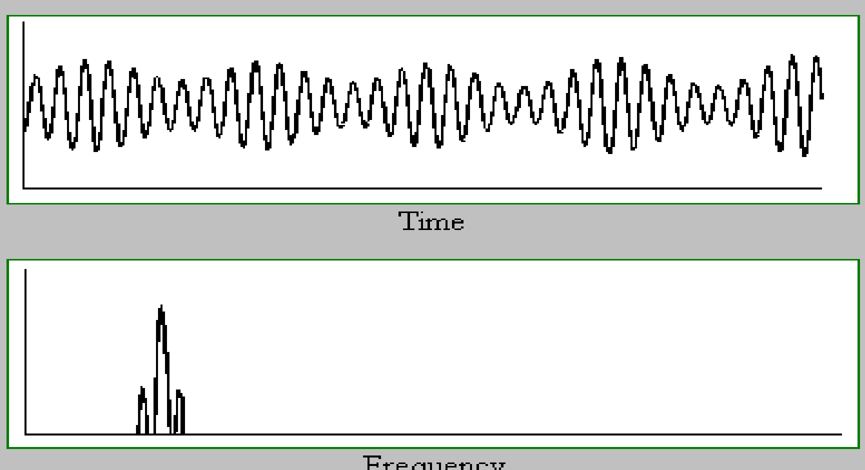




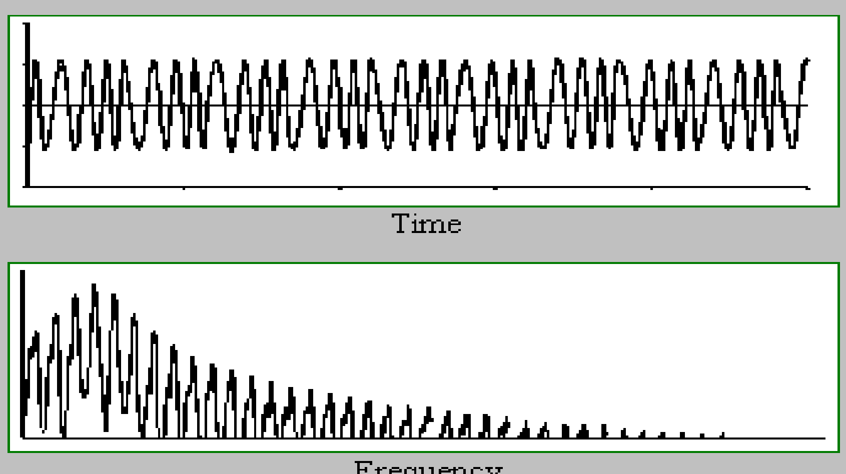
Beats vs Amplitude Modulation



Spectrum of a Beating Signal



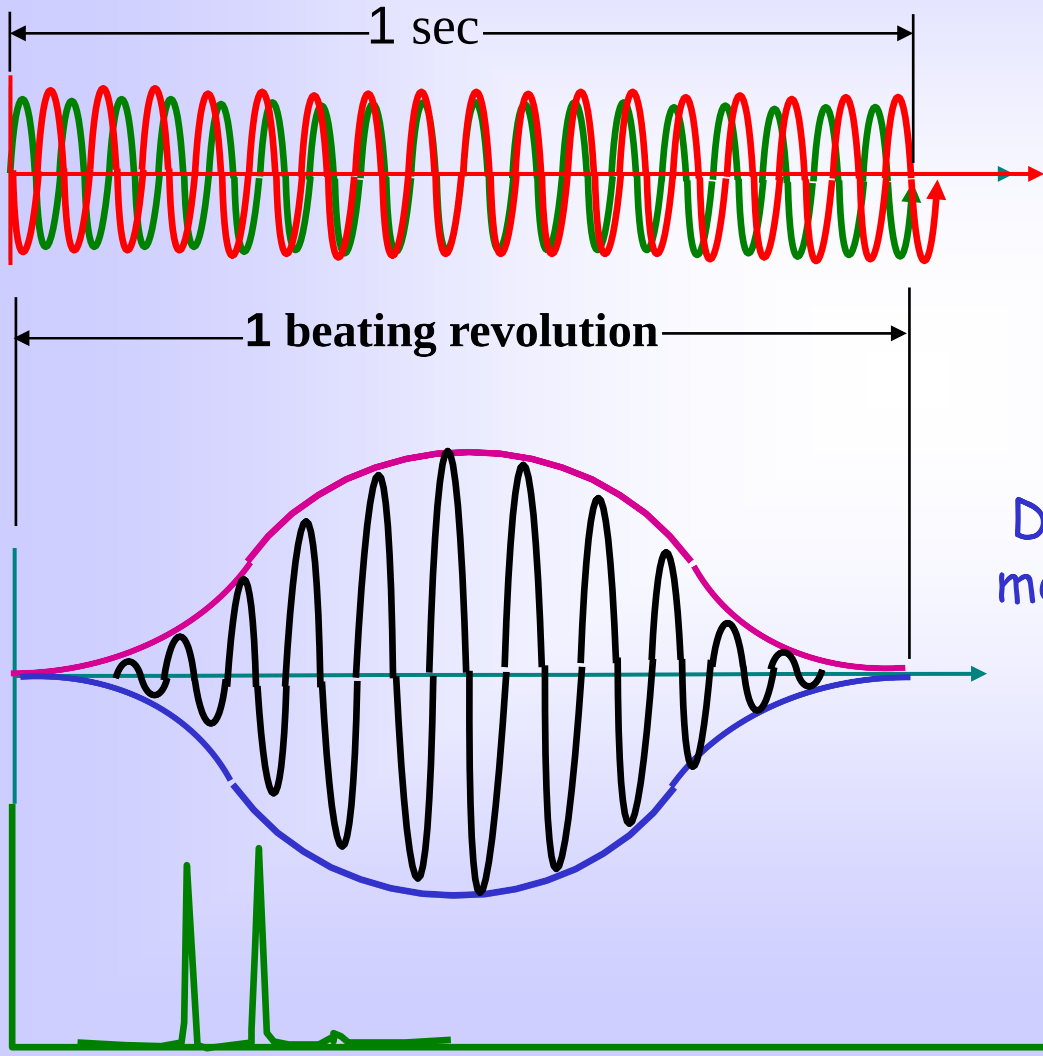
The Spectrum of an Amplitude Modulated Wave Form



The Spectrum of a Frequency Modulated Sine Wave

Beating

1) Occur at 2 frequencies have very close frequency as 5-100 cpm in normally, for example, Motor drives a fluid coupling which may have a different frequency as only lower than 100 cpm
2) Will not make a side band, just can see a two close frequencies as only 5-100 cpm which is very hard to see if the resolution is not enough.

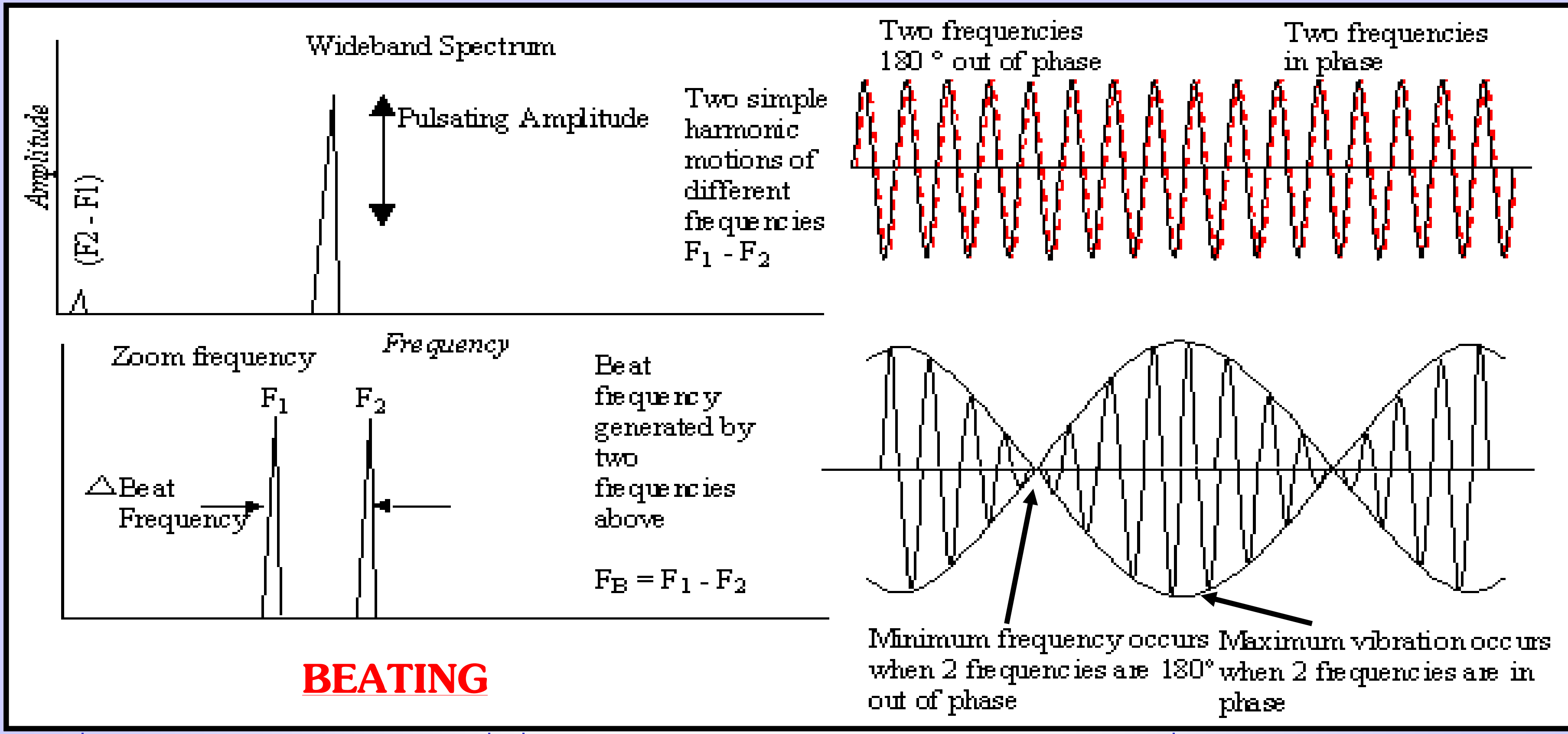


The Example

— 17 Hz = 1020 Cpm

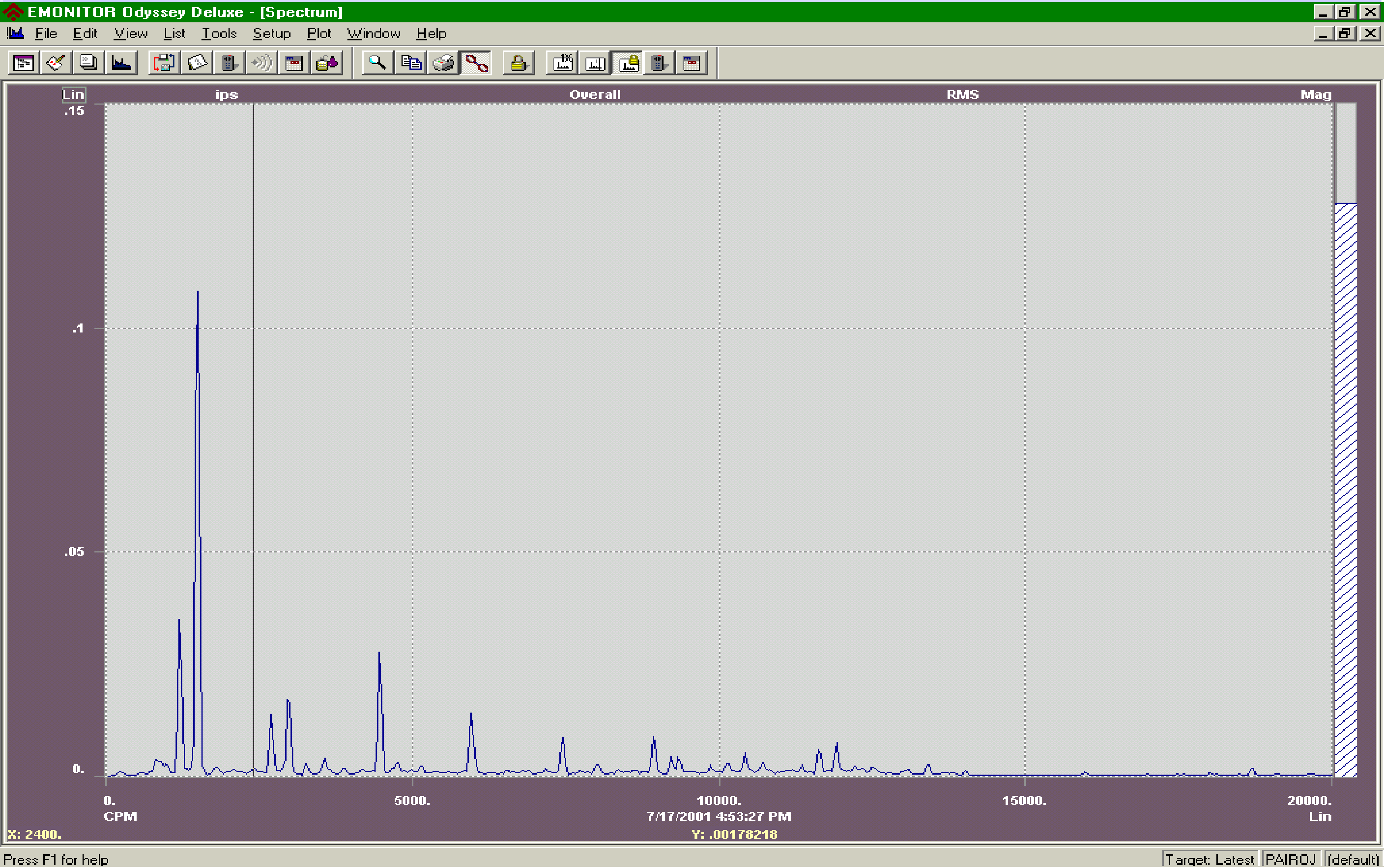
— 18 Hz = 1080 Cpm

Diff. Frequency as 60 Cpm = 1 Hz mean the beating will be occurred every 1 second

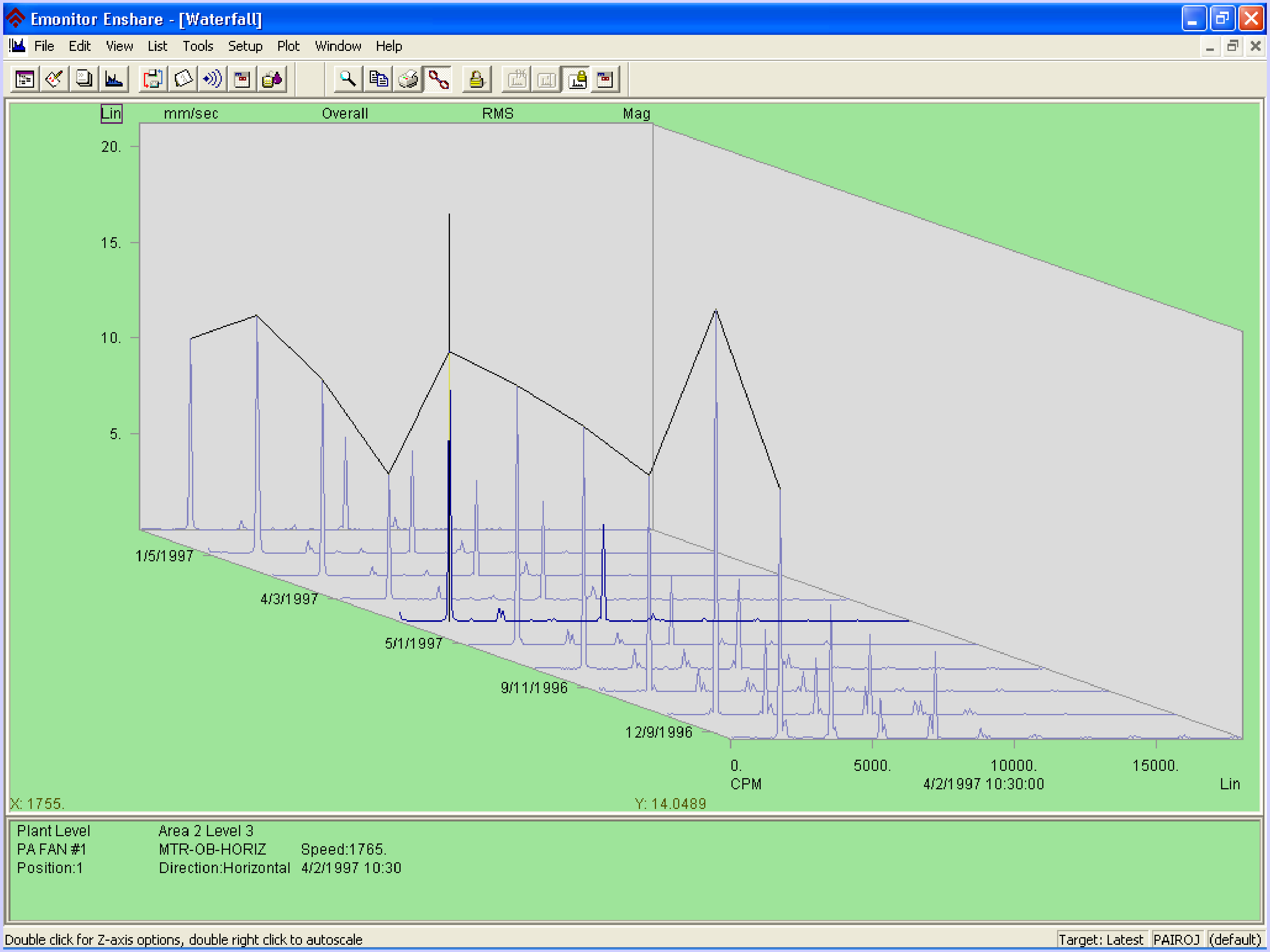


ความถี่ Beat คือผลของสองความถี่ ที่ใกล้ชิดดำเนินในแนวสอดคล้องและหักล้างซึ่งกันและกัน การวิเคราะห์แถบความถี่แบบกว้างจะแสดงการขึ้นลงเป็นจังหวะของยอดสัญญาณอันเดียว เมื่อมีการขยายเข้าไปดูในยอดสัญญาณนี้ (แถบความถี่ที่ต่ำกว่า) โดยแท้จริงจะพบยอดสัญญาณที่ใกล้กันสองยอด ความแตกต่างในสองยอดสัญญาณนี้ (F2-F1) คือ ความถี่ Beat จะไม่ถูกพบในช่วงการวัดความถี่แบบปรกติ เพราะว่ามันเกิดอยู่ในช่วงความถี่ต่ำ โดยปรกติขอบเขตจากการประมาณเพียงแค่ 5 ถึง 100 RPM ความสั่นสะเทือนสูงสุดจะเกิดเมื่อTime Waveform ที่ความถี่หนึ่ง (F1) เริ่มมีร่วมองศากับอัดความถี่หนึ่ง(F2) การสั่นสะเทือนต่ำสุดเกิดขึ้นเมื่อ Waveform ของสองความถี่นี้วางแนวต่างระดับกัน 180 องศา

Beating example at Blower with Fluid Coupling
Motor speed at 1489 , Fan speed at 1202 rpm



Waterfall Plot is Spectrum Trend



Diagnosing Machine Faults

Three Rules of Diagnosis

1) Each machine fault generates a specific vibration pattern.

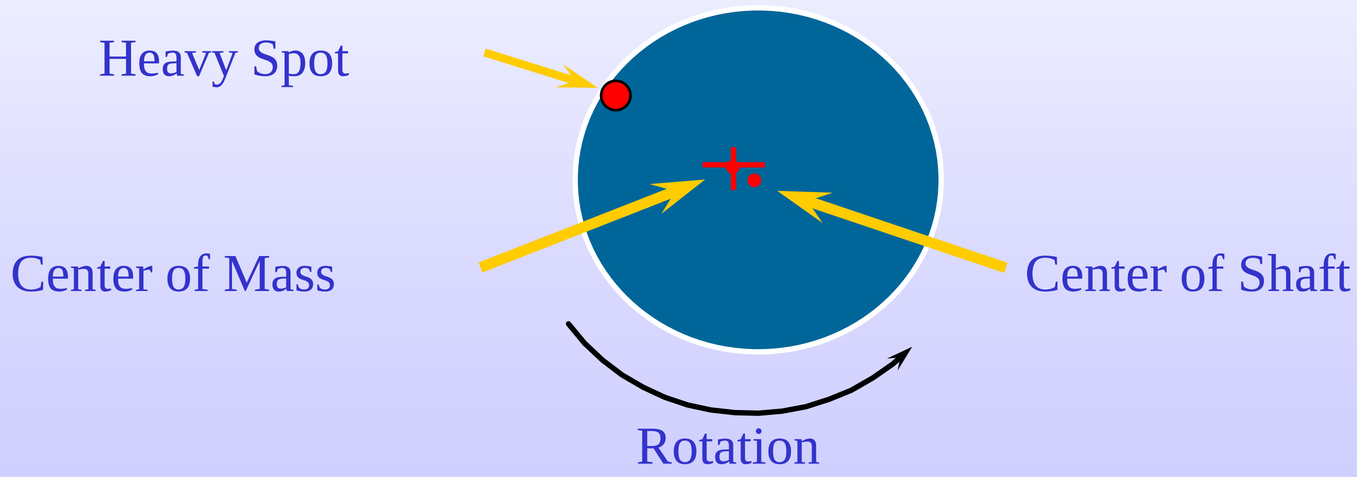
2) The frequency of the vibration is determined by the machine geometry and operating speed.

3) A single vibration measurement provides information about multiple components.

What is Unbalance?

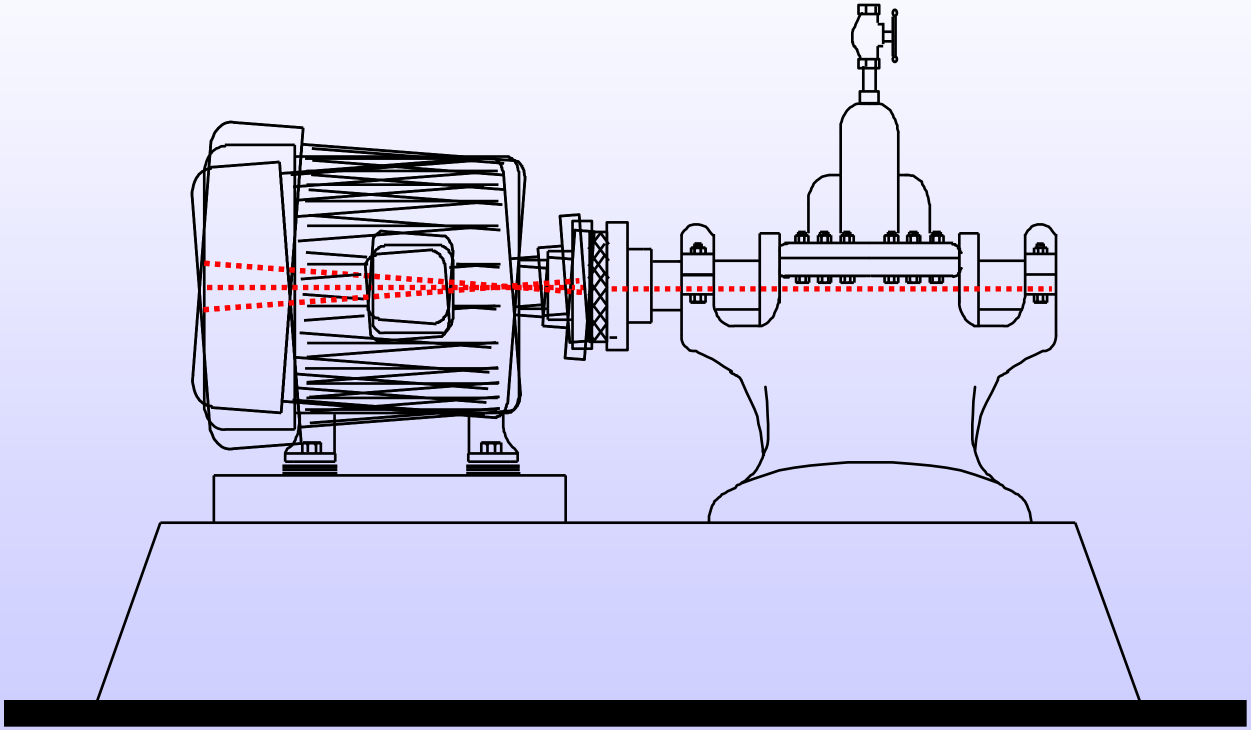
- The force created by a rotating body when its center of mass is offset from its center of rotation

Center of Mass ≠ Center of Rotation



What is Misalignment?

- Deviation from a common centerline during operation.

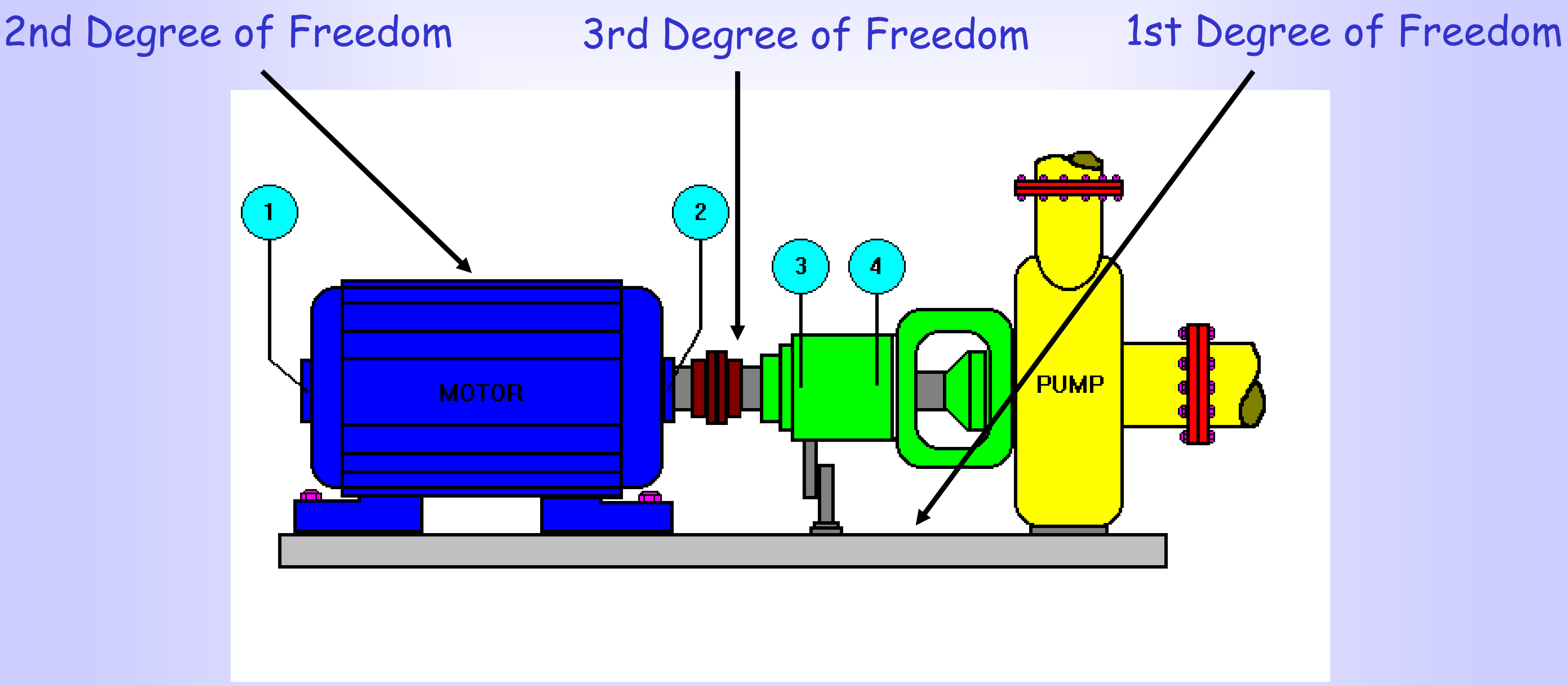


<u>Two types of Mechanical Looseness</u>

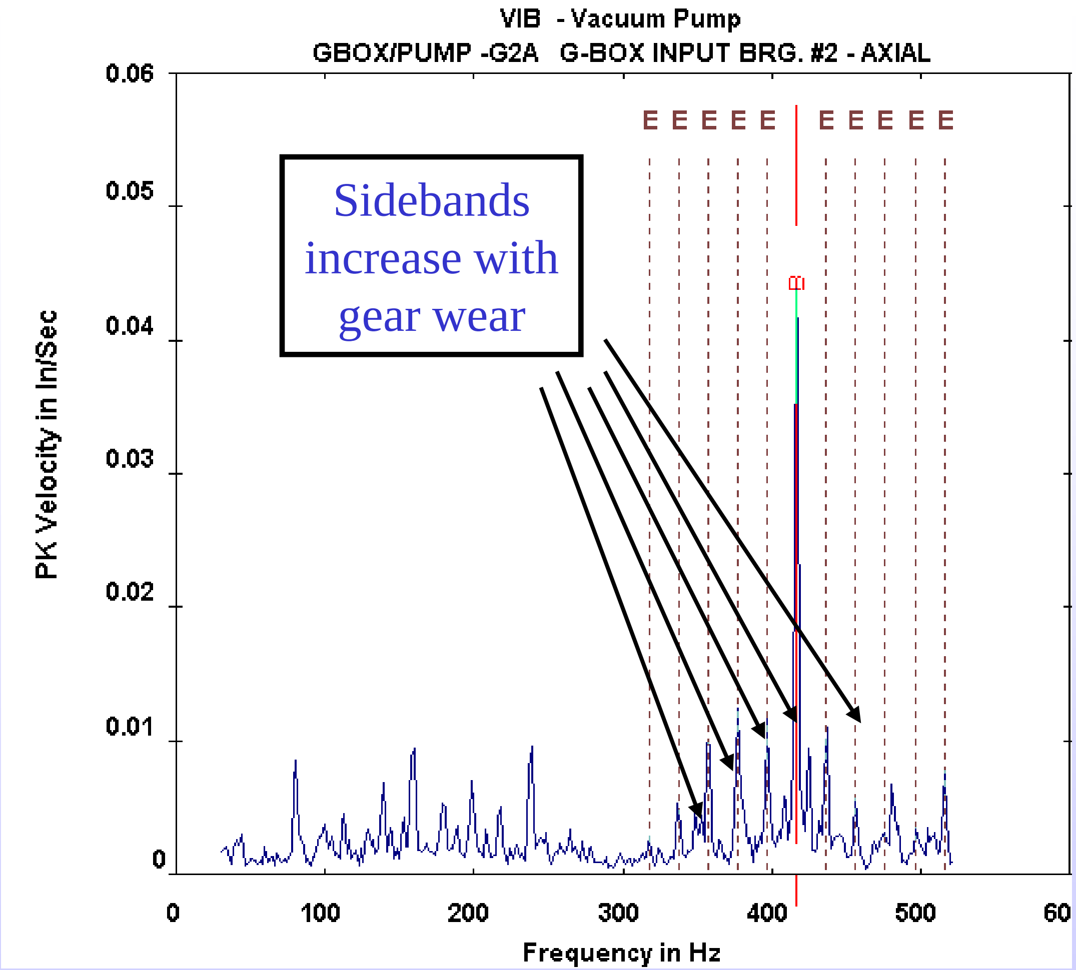
- Multiple harmonics of running speed for <u>Stationary Parts 1/3</u>, 1/2, 2/3, 1, 1-1/3, 1.5, 1-2/3, 2, 2-1/3, 2.5, 2-2/3x,...

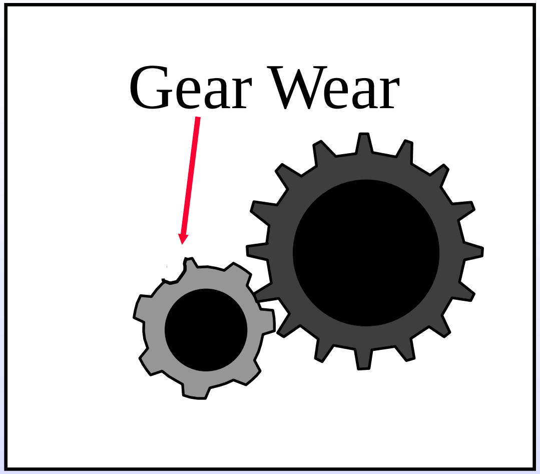
- Multiple harmonics of running speed for <u>Rotationary Parts</u> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10x

ความถี่ธรรมชาติของเครื่องจักรหนึ่งๆ จะประกอบด้วย 3 ส่วน หรือเรียกว่า 3 Degree of Freedom



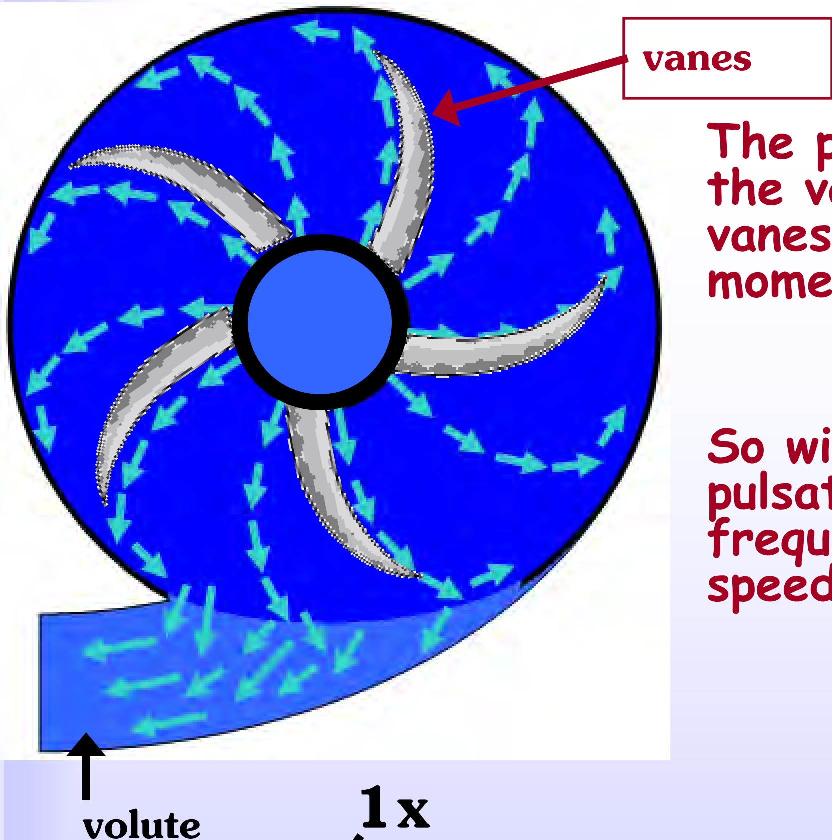
Gear Mesh Fault





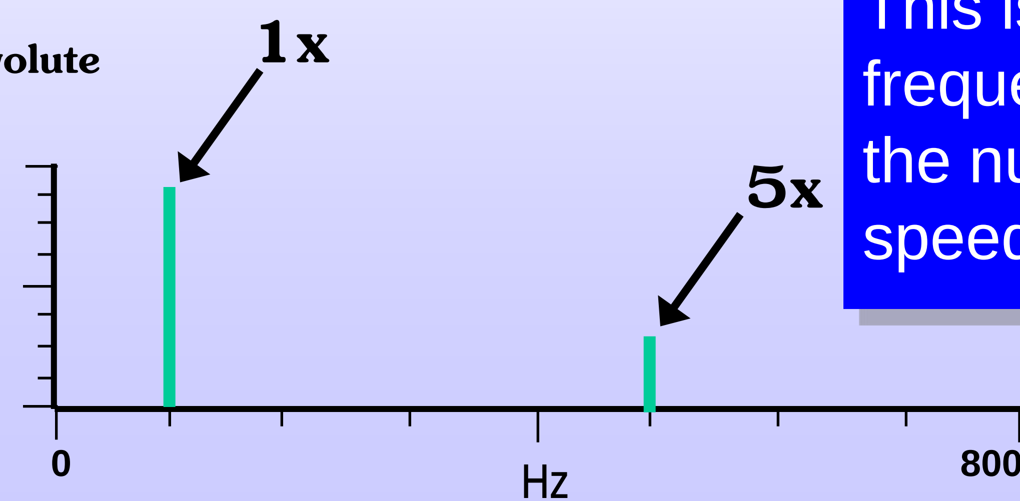
Gear Mesh Frequency = Number of Teeth X Shaft Speed

Vane Pass



The pressure output to the volute will vary as the vanes pass depending on how exactly the vanes line up with the outlet (volute) at any given moment.

So with any centrifugal pump there will be a pulsation (pressure pulse) that occurs at a frequency equal to the number of vanes times the speed of the pump.



This is called the "**Vane Pass**" frequency. It is always equal to the number of vanes times the speed of the pump.

In this case…

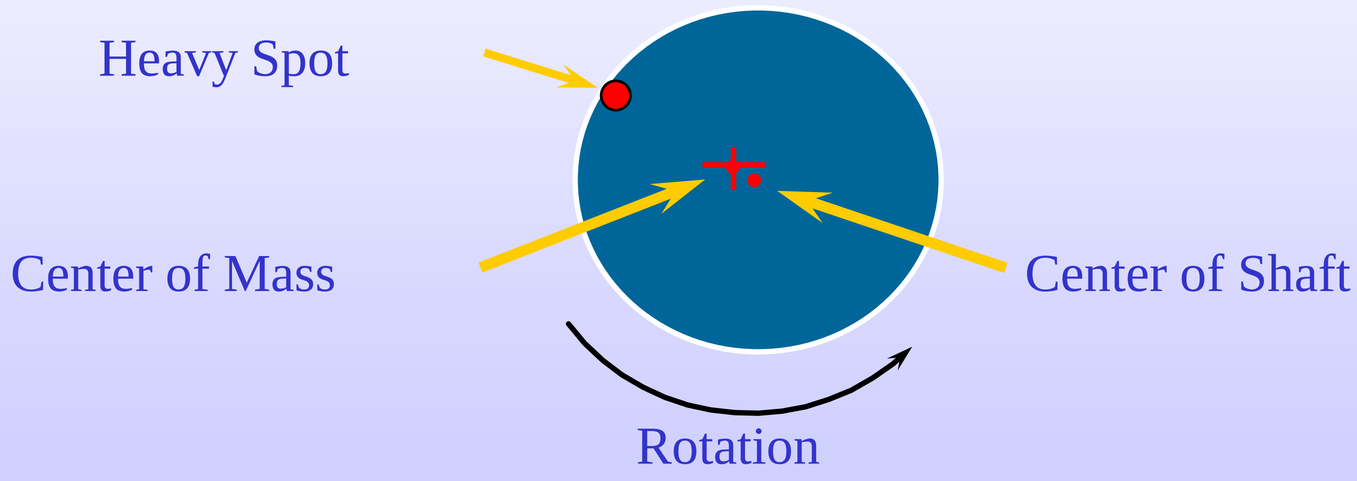
Vane Pass = 5x

Unbalance Analysis

What is Unbalance?

- The force created by a rotating body when its center of mass is offset from its center of rotation

Center of Mass ≠ Center of Rotation



4 Types of Unbalance

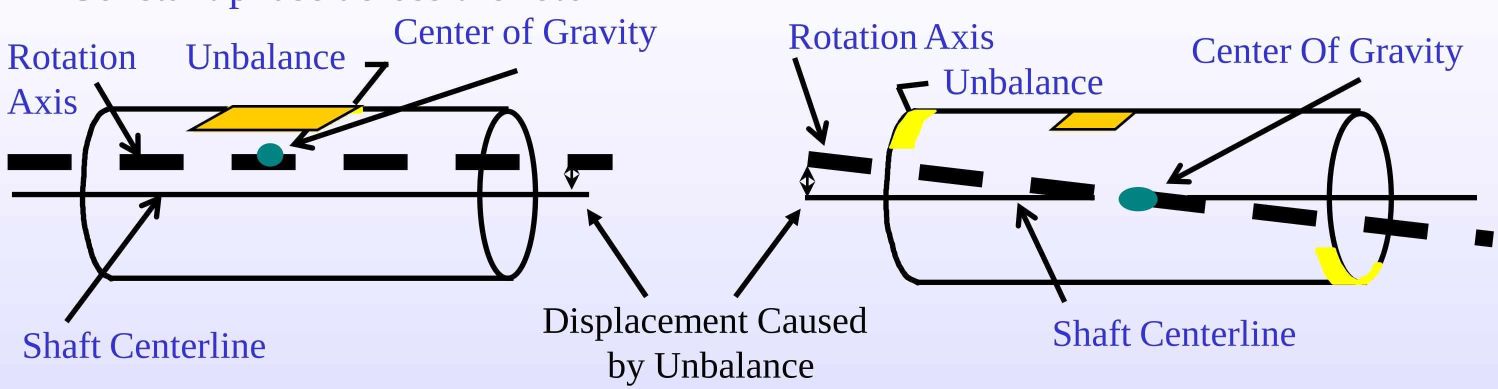
- Unbalance can be separated into 4 components:

Static Unbalance:

Constant phase across the rotor

Quasi-Static Unbalance:

180^o phase shift across the rotor

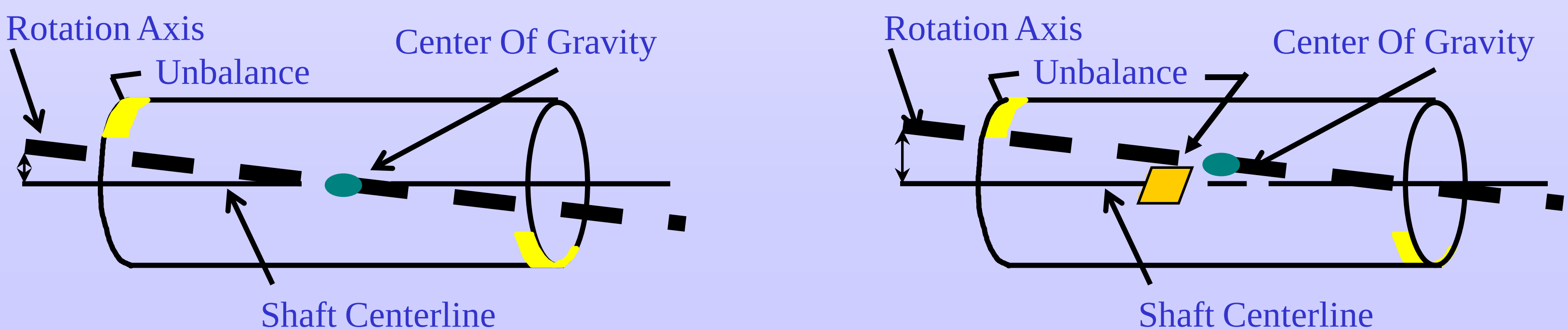


Couple Unbalance:

180^o phase shift across the rotor

Dynamic Unbalance:

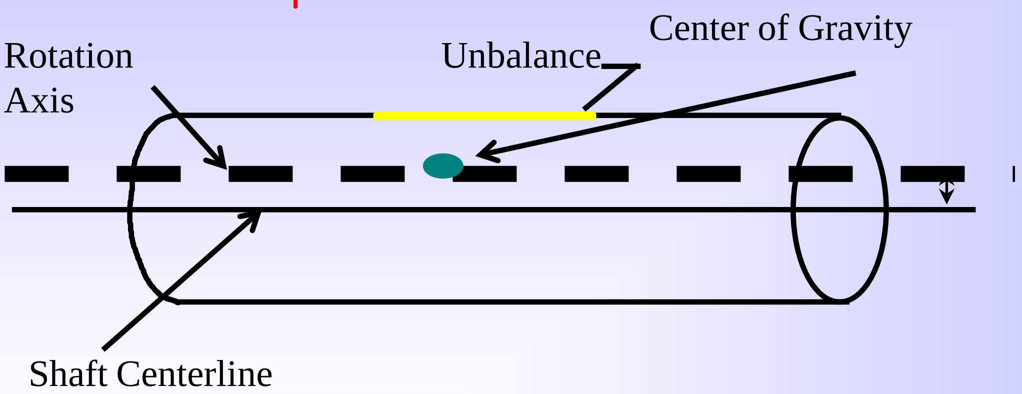
90^o phase shift across the rotor



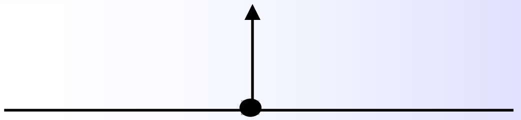
Static Unbalance:

Constant phase across the rotor

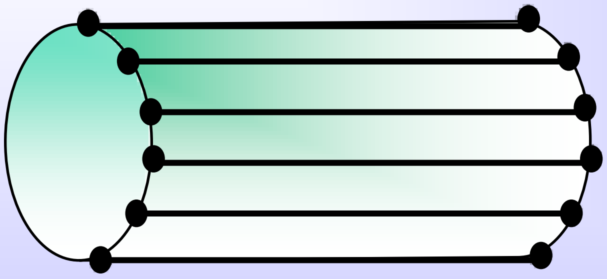
Physical Diagram



Force Diagram

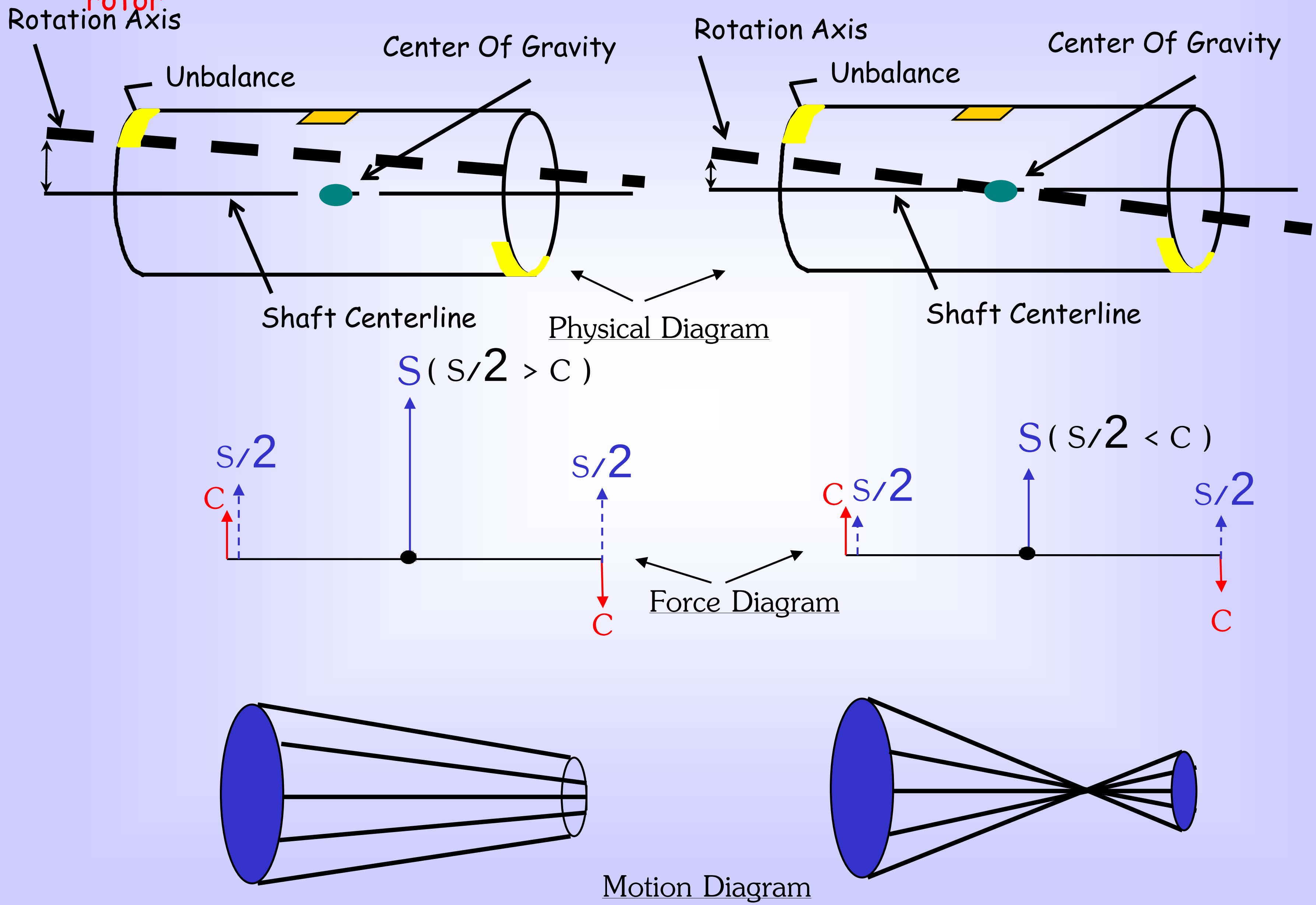


Motion Diagram



Quasi-Static Unbalance:
0° phase shift or in Phase across the rotor

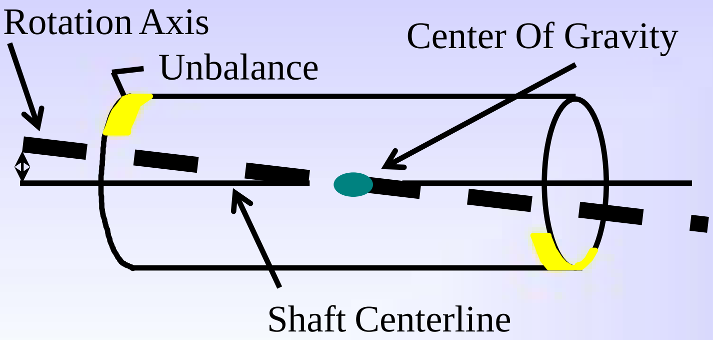
Quasi-Static Unbalance:
180° phase shift across the rotor



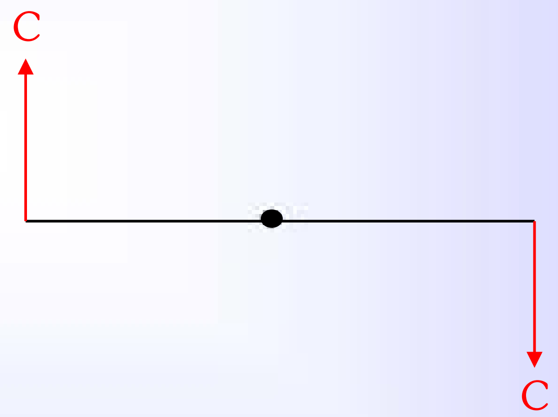
Couple Unbalance:

180° phase shift across the rotor

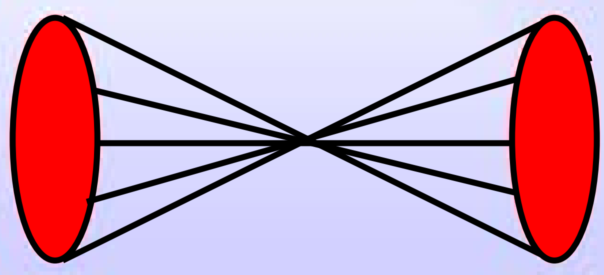
Physical Diagram



Force Diagram



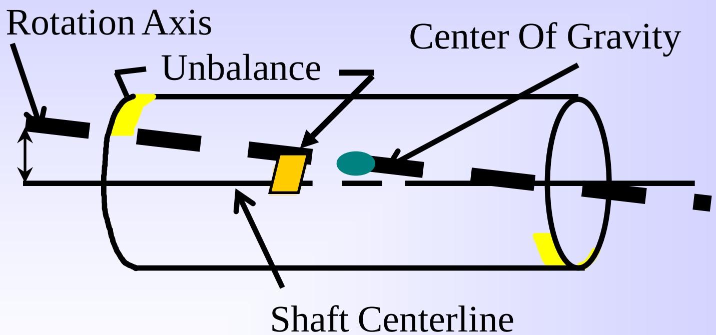
Motion Diagram



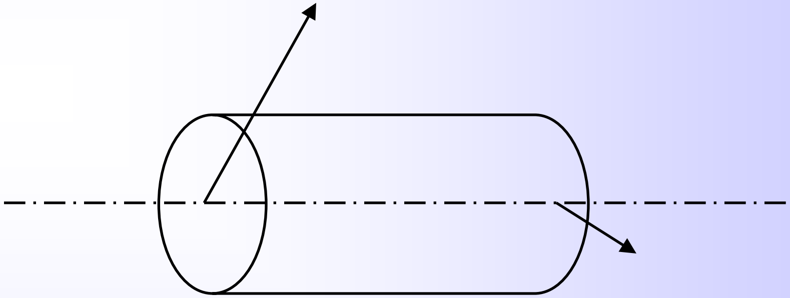
Dynamic Unbalance:

90° phase shift across the rotor

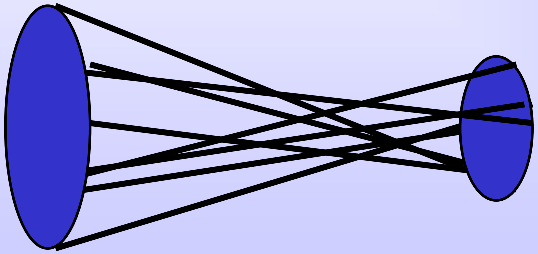
Physical Diagram



Force Diagram



Motion Diagram



Unbalance

Characteristics:

High radial peaks at 1X shaft RPM

Low axial vibration at 1X shaft RPM

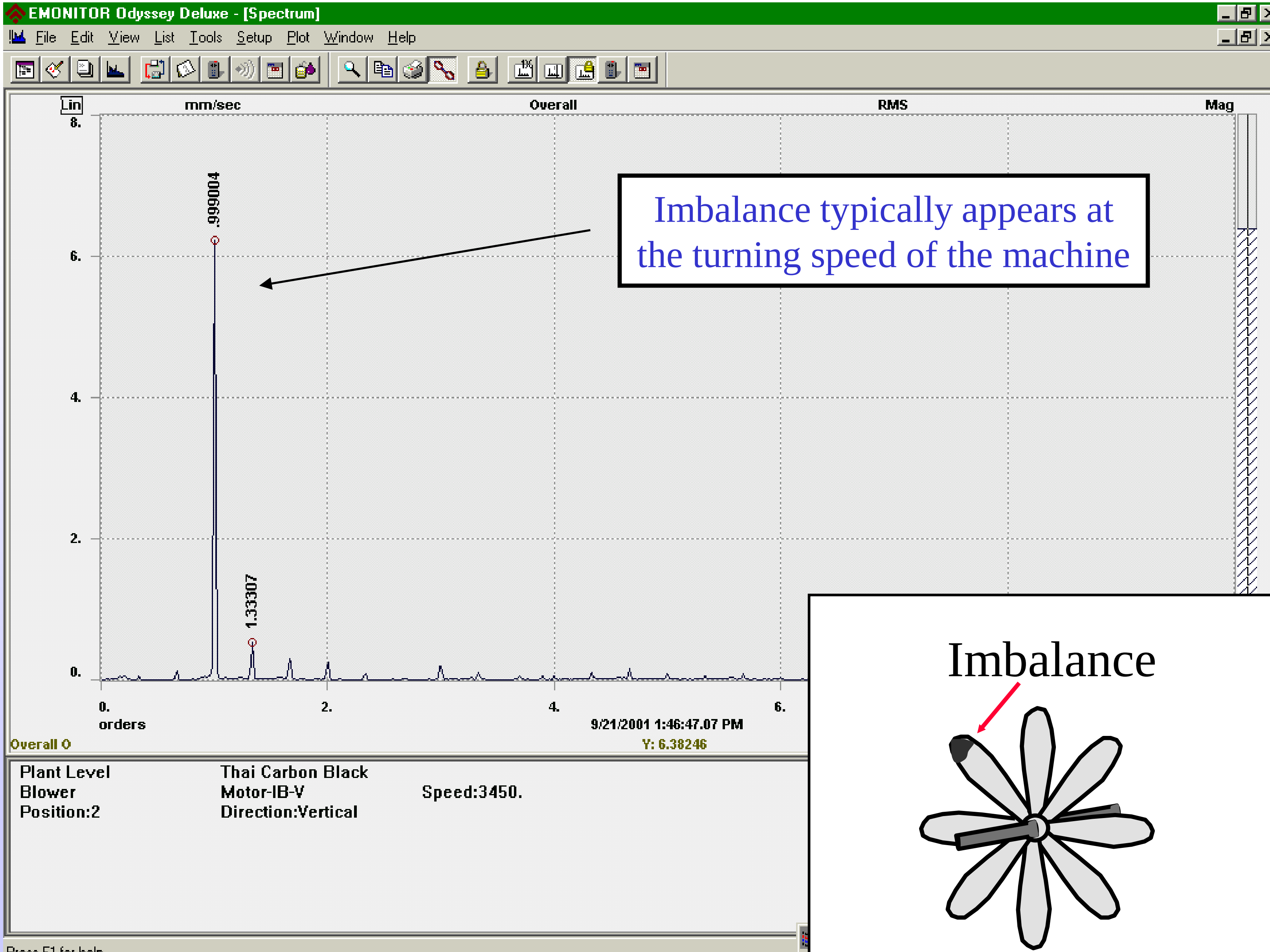
Low harmonics of shaft RPM

1X RPM sinusoidal pattern in the time waveform

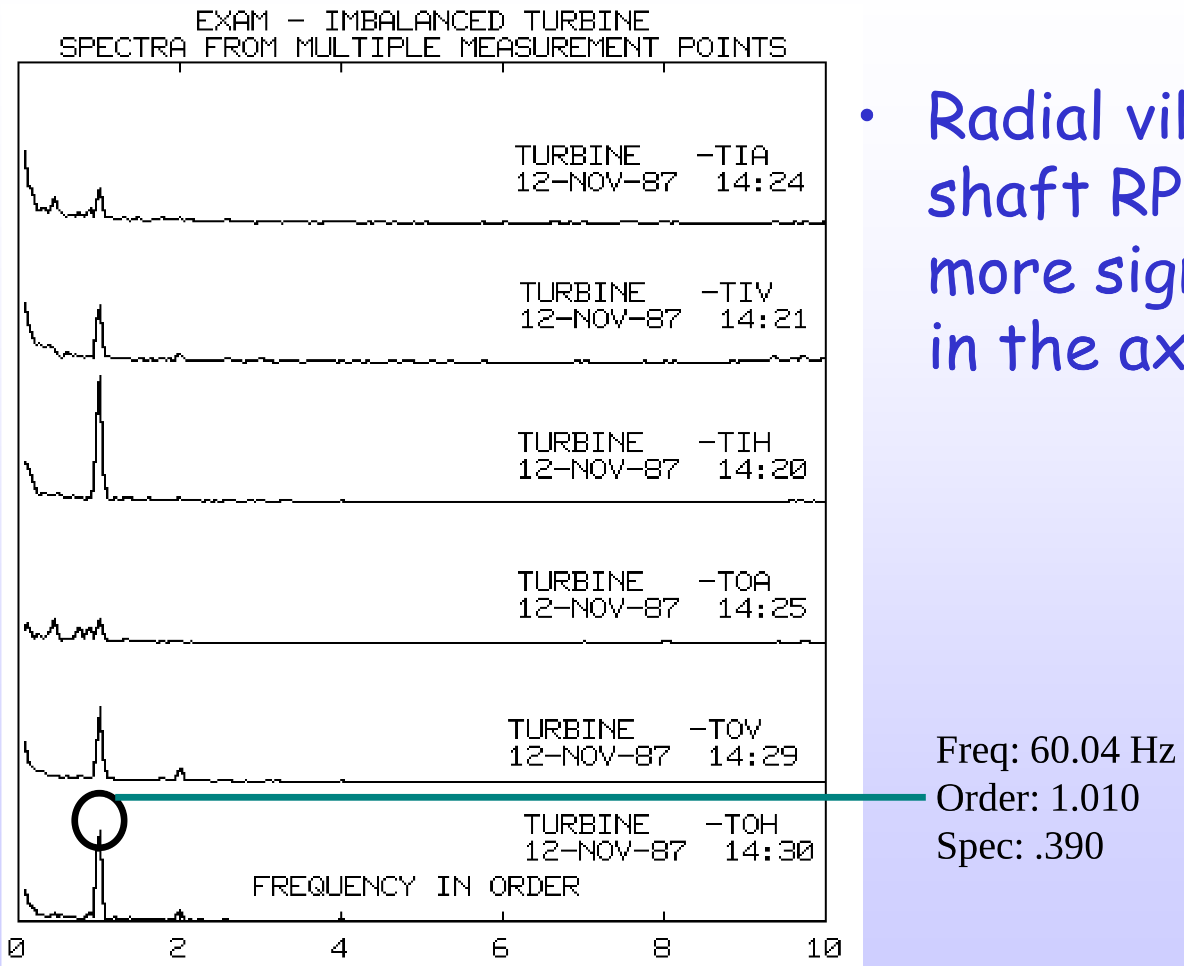
Can cause other faults to appear, especially looseness

The criteria acceptance for 1X is 90% of Overall Acceptance Value

Unbalance


EMONITOR Odyssey Deluxe - [Spectrum]
File Edit View List Tools Setup Plot Window Help
Lin
mm/sec
Overall
RMS
Mag
8.
6.
4.
2.
0.
.999004
1.33307
0.
2.
4.
6.
orders
9/21/2001 1:46:47.07 PM
Overall 0
Y: 6.38246
Imbalance typically appears at the turning speed of the machine
Plant Level
Blower
Position:2
Thai Carbon Black
Motor-IB-V
Direction:Vertical
Speed:3450.
Press F1 for help
Imbalance

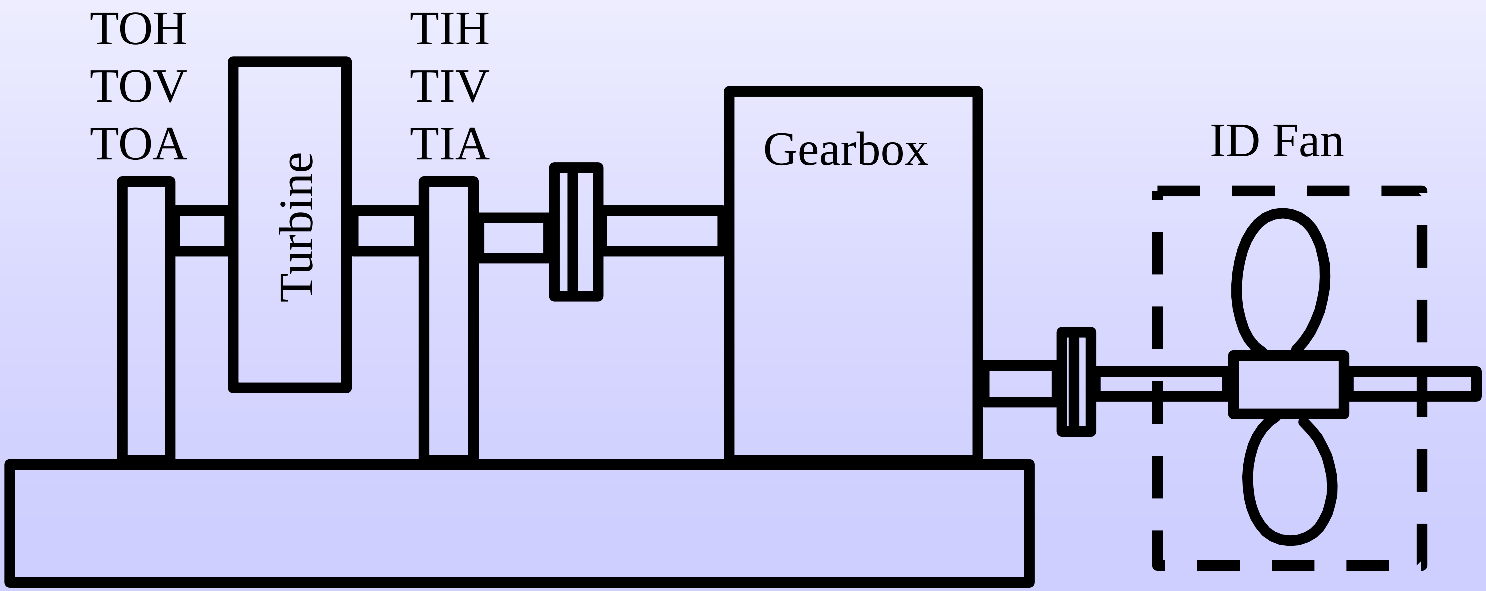
Unbalance



- Radial vibration at 1X shaft RPM is much more significant than in the axial direction

Unbalance Case History

- Turbine has thrown a blade and is out of balance.
- Speed reduced to keep vibration levels acceptable, but now turbine cannot supply enough air to boiler to generate sufficient steam for plant processes and heating.



Unbalance

IRD Mechanalysis, Inc.

Vibration and Noise

Identification Chart

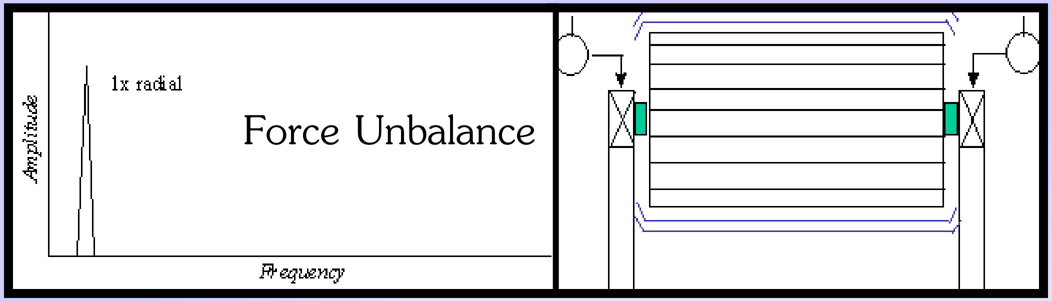
Causes of Vibration

(RELATIVE PROBABILITY RATINGS: 1 THRU 10)

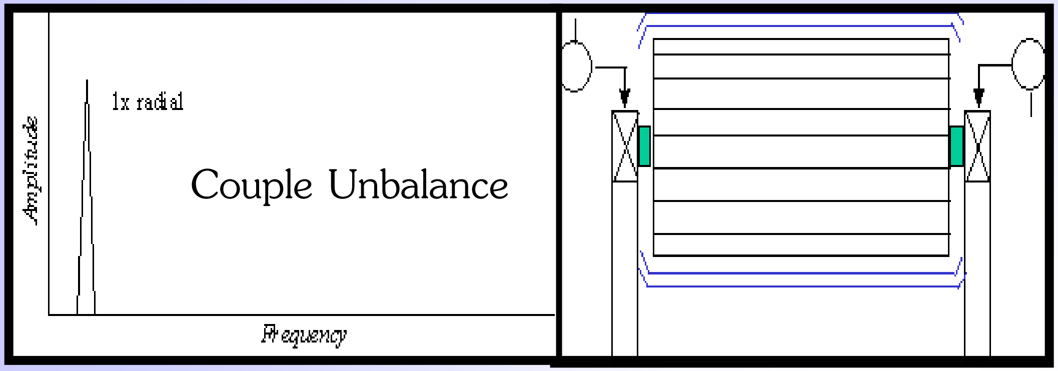
		PREDOMINANT FREQUENCIES											PREDOMINANT AMPLITUDE											PREDOMINANT NOISE							
													DIRECT			PROBABLE LOCATION															
		0-40%	40-50%	50-100%	1 X RPM	2 X RPM	Higher Multiples	1/2 RPM	1/4 RPM	Low er Multiples	Odd Frequencies	Very High Freq.	Horizontal	Vertical	Axial	rotor(shaft)	Bearings	Casing	Foundation	Piping	couplings	Phase (No of	Reference Marks)	Low Freq. "Rumble"	Loud "Roar"	"Hum"	Periodic "Beat"	High Pitch "Whine"	Very High Loud "Scre	Very High "Squeal"	Ultrasonic
UNBALANCE	Initial Unbalance				10								5	4	1	9	1					(1)			8	2					
	Shaft Bow -Lost Parts				10								5	4	1	9	1								8	2					

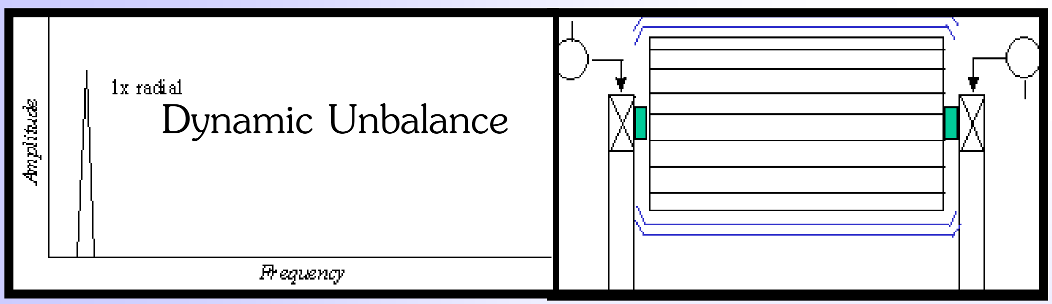
REMARKS:

- Most common cause of vibration whose amplitude is proportional to the amount of unbalance.
- May be aggravated by or may produce complications such as seal rubs, bearing failure or resonance.
- Overhung rotors may show relatively high Axial Vibration

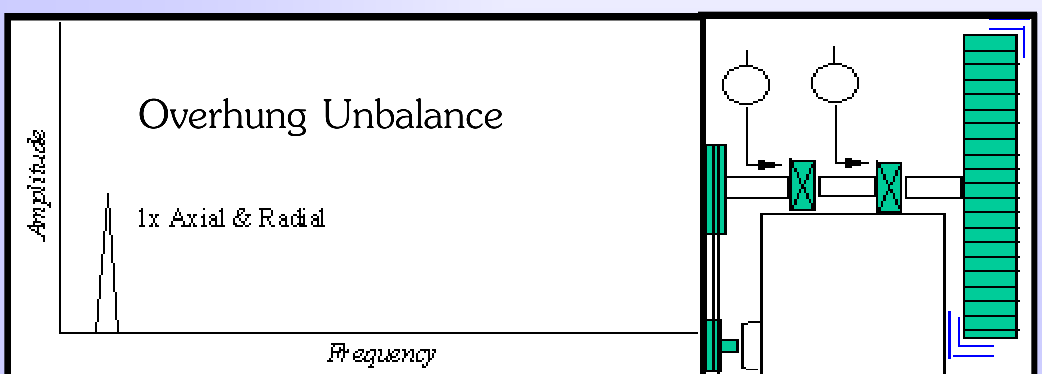


แรงไม่สมดุลย์ จะอยู่ในตำแหน่งเดียวกันคงที่ และขนาดเนื่องจากการไม่สมดุลย์จะเพิ่มขึ้นเป็นสัดส่วนกำลังสองของความเร็ว (ความเร็วเพิ่มขึ้น 3 เท่า มีผลให้การสั่นสะเทือนเพิ่มขึ้น 9 เท่า) ที่ 1 x RPM จะแสดงขึ้นบนแถบเความถี่เสมอ สามารถแก้ไขได้โดยถ่วงดุลย์ด้วยก้อนน้ำหนักที่ระนาบตรงจุดศูนย์กลางของแรงโน้มถ่วงของชิ้นงานหมุน



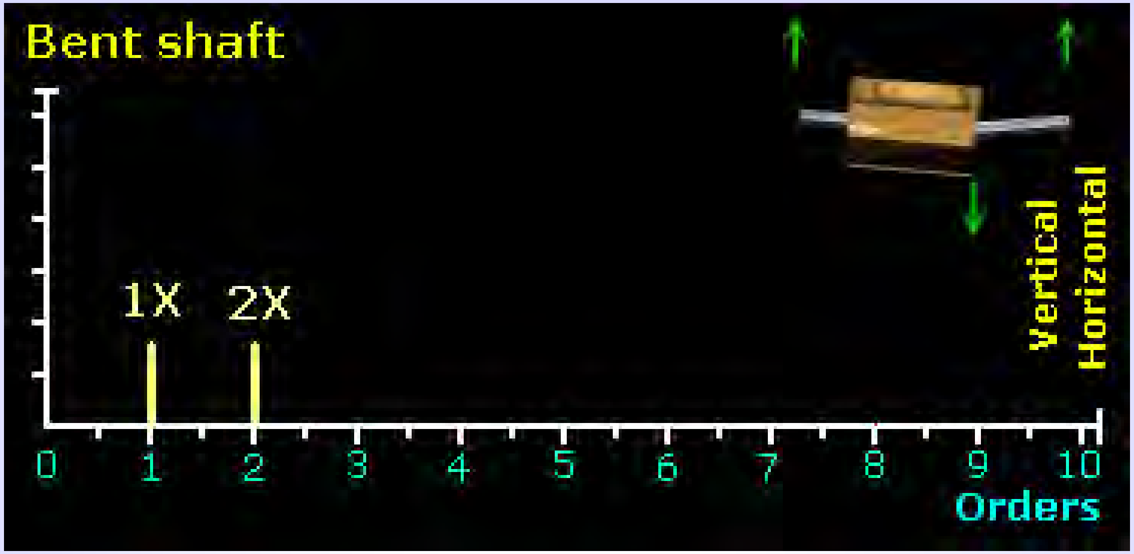


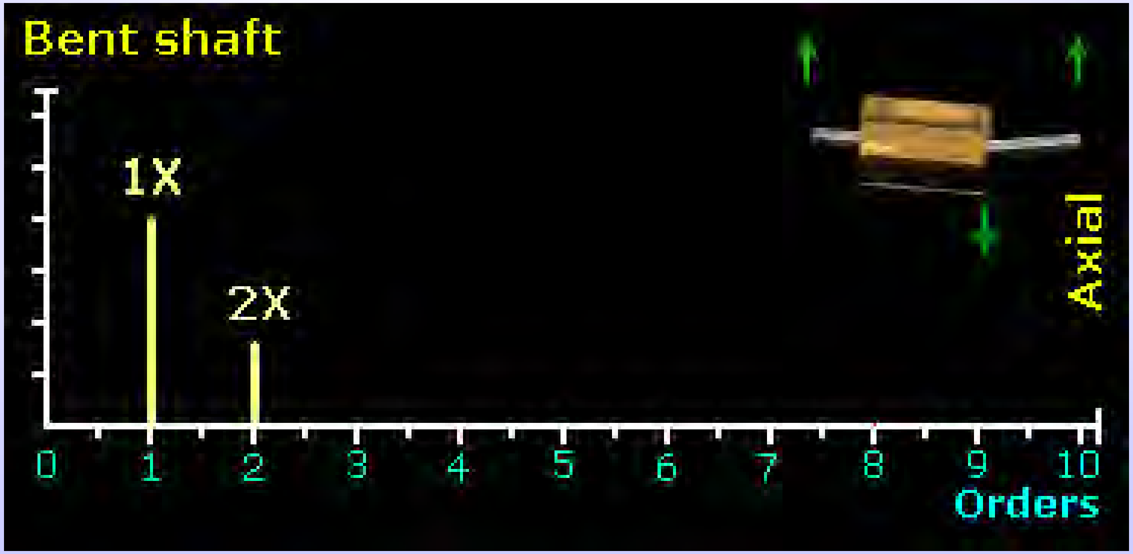
ทิศทางของแรงไม่สมดุลย์แบบคู่ควบ มีแนวโน้มต่างกัน 180องศา บนแกนเพลาเดียวกัน ที่ 1 x RPM จะแสดงขึ้นบนแถบความถี่เสมอ ขนาดเปลี่ยนแปลงขึ้นอยู่กับกำลังสองของความเร็ว อาจจะเกิดการสั่นสะเทือนตามแนวแกนสูงเช่นเดียวกันในแนวรัศมี การแก้ไขต้องถ่วงดุลย์ด้วยก้อนน้ำหนักอย่างน้อย 2 ระนาบ สังเกตุว่ามุมแตกต่างประมาณ 180 องศา จะเกิดระหว่าง OB & IB ในแนวราบเช่นเดียวกับแนวดิ่ง

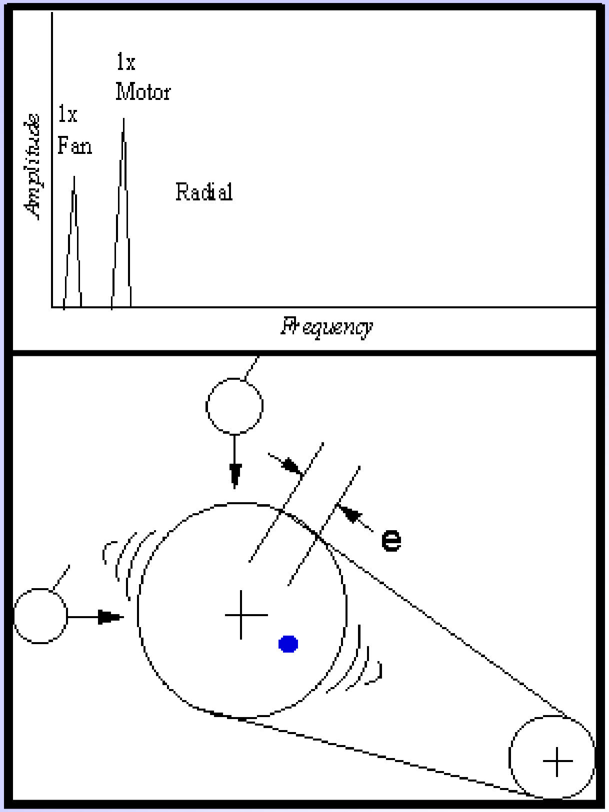


แรงไม่สมดุลย์แบบแขวนยื่นก่อให้เกิดมีค่าสูงที่ 1 x RPM ในทิศทางทั้งตามแนวแกนและแนวรัศมี ค่าที่อ่านตามแนวแกนมีแนวโน้มทิศทางเดียวกัน ขณะที่ค่าตำแหน่งที่อ่านตามแนวรัศมีอาจจะไม่นิ่ง การแขวนยื่นของชิ้นงานหมุนมักจะก่อให้เกิดทั้งแรงไม่สมดุลย์แบบสถิตย์และแบบคู่ควบ ซึ่งแต่ละปัญหาต้องการการแก้ไขเช่นเดียวกัน

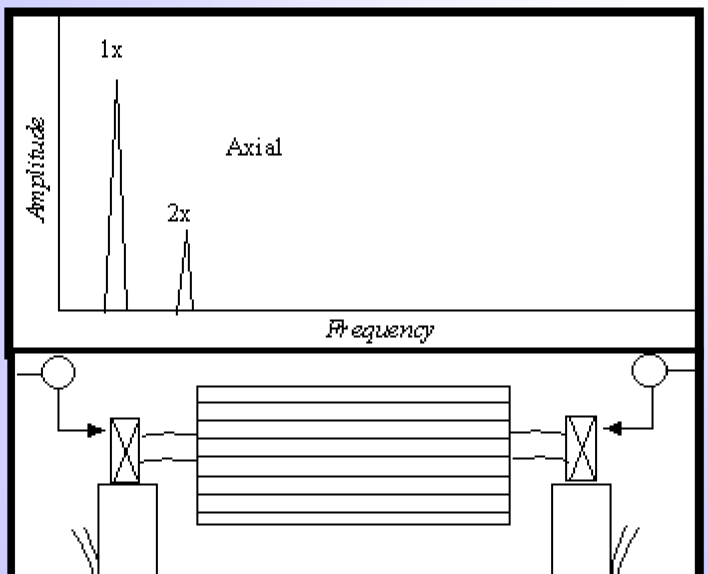
ในกรณีเพลาคด Spectrum จะออกที่ 2X ด้วยตามรูปข้างล่าง







การเยื้องศูนย์เกิดขึ้นเมื่อศูนย์กลางของการหมุนเยื้องจากศูนย์กลางของรูปทรงทางเรขาคณิตของชุดเฟือง, ลูกปืน, ขดลวดมอเตอร์ เป็นต้น ค่าการสั่นสะเทือนมากที่สุดเกิดที่ 1 x RPMของส่วนที่เยื้องศูนย์ในทิศทางลากผ่านจุดศูนย์กลางของการหมุนทั้งสองชิ้นงาน การเปรียบเทียบการอ่านในแนวราบและแนวดิ่ง ถ้าไม่ต่างกันเป็น 0 องศา ก็จะเป็น 180 องศา (แต่ละค่าการอ่านจะแสดงถึงการเคลื่อนที่ตามแนวเส้นตรงของชิ้นงานหมุน) การพยายามที่จะถ่วงดุลย์ชิ้นงานเยื้องศูนย์มักจะมีผลลดค่าการสั่นสะเทือนในทิศทางหนึ่งแต่เพิ่มขึ้นอีกทิศทางหนึ่งในแนวรัศมีเสมอ (ขึ้นอยู่กับปริมาณของการเยื้องศูนย์)



ปัญหาการคดงอของเพลา ก่อให้เกิดการสั่นสะเทือนมากตามแนวแกน ด้วยตำแหน่งการอ่านมีแนวโน้มต่างกัน 180 องศาบนชิ้นส่วนเครื่องจักรเดียวกัน โดยปกติการสั่นสะเทือนหลักจะอยู่ที่ 1 x RPM ถ้าการคดงออยู่ใกล้กับกึ่งกลางเพลา แต่จะอยู่ที่2 x RPM ถ้าคดงออยู่ใกล้จุดเชื่อมต่อหน้าแปลน (จงระวังผลจากทิศทางตัวรับสัญญาณของการวัดแต่ละแนวแกน ถ้ามีการกลับทิศตรงข้าม