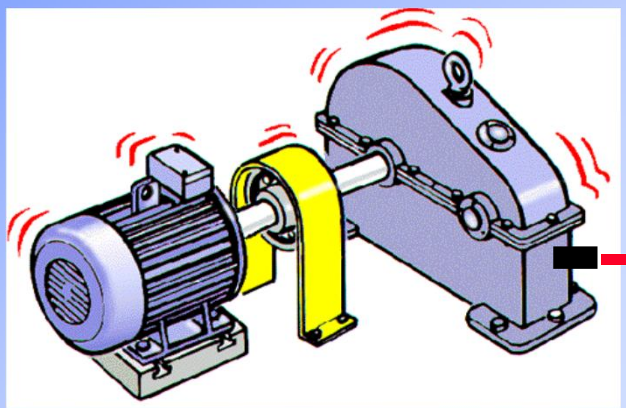
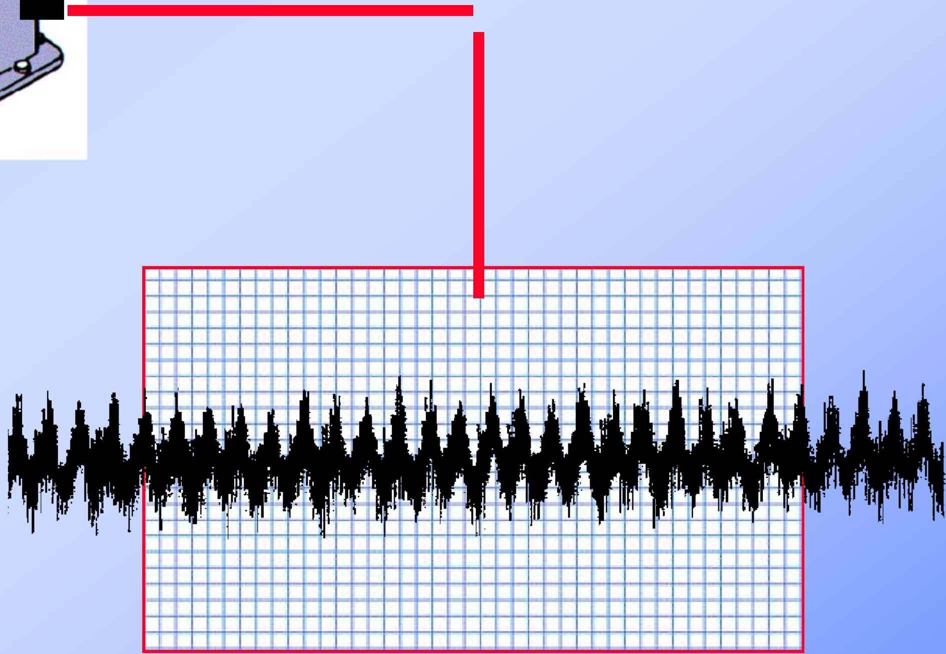
What Is Vibration?

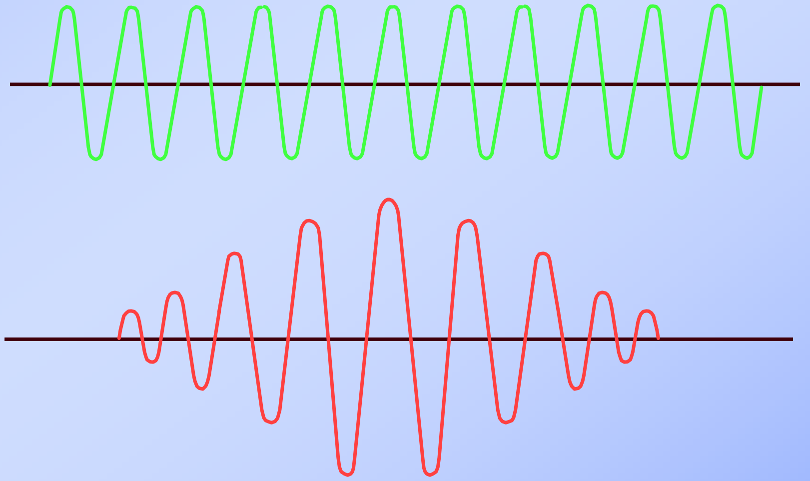
It is the response of a system to an internal or external force which causes the system to oscillate.





What Is Vibration Analysis?

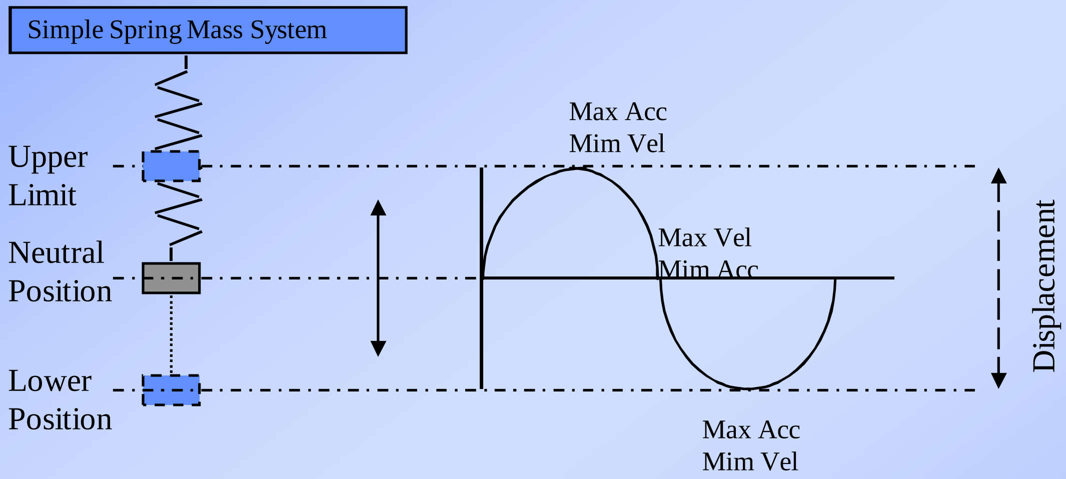
Vibration analysis is a non-destructive technique which helps early detection of machine problems by measuring vibration.



Detection By Vibration Analysis

1. Unbalance(Static, Couple, Quasi-Static),
2. Misalignment(Angular, Parallel, Combination)
3. Eccentric Rotor, Bent Shaft
4. Mechanical Looseness, Structural Weakness, Soft Foot
5. Resonance, Beat Vibration
6. Mechanical Rubbing
7. Problems Of Belt Driven Machines
8. Journal Bearing Defects
9. Antifriction Bearing Defects
   (Inner race, Outer race, Cage, Rolling Elements)
10. Problems of Hydrodynamic & Aerodynamic Machines
    (Blade Or Vane, Flow turbulence, Cavitation)
11. Gear Problems (Tooth wear, Tooth load, Gear eccentricity, Backlash, Gear misalignment, Cracked Or Broken Tooth)
12. Electrical Problems of AC & DC Motor (Variable Air Gap, Rotor Bar Defect, Problems of SCRs)

Basic Theory Of Vibration



It follows sine curve.

Frequency & Amplitude

Frequency:

How many times oscillation is occurring for a given time period?

Units: CPS(Hz), CPM

Amplitude:

It is the magnitude of vibration signal.

Units: Micron, MM/Sec, M/Sec^2

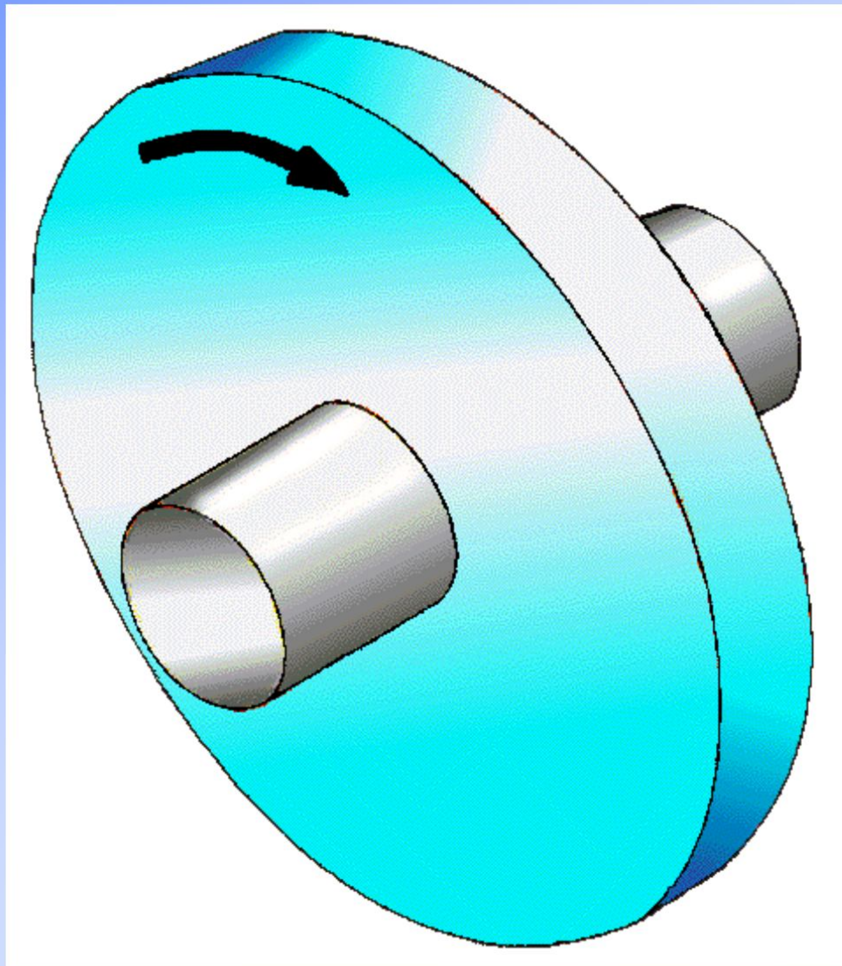
Physical Significance Of Vibration Characteristics

Frequency - What is vibrating?
Source *of the vibration.*

Amplitude - How much is it vibrating?
Size *(severity) of the problem.*

Phase Angle - How is it vibrating?
Cause *of the vibration.*

Frequency Measurement



60 RPM

= 1 Rev / s

= 1 Hz

Amplitude Measurement

1. Displacement :

Total distance traveled by the mass.

Unit : Microns

2. Velocity :

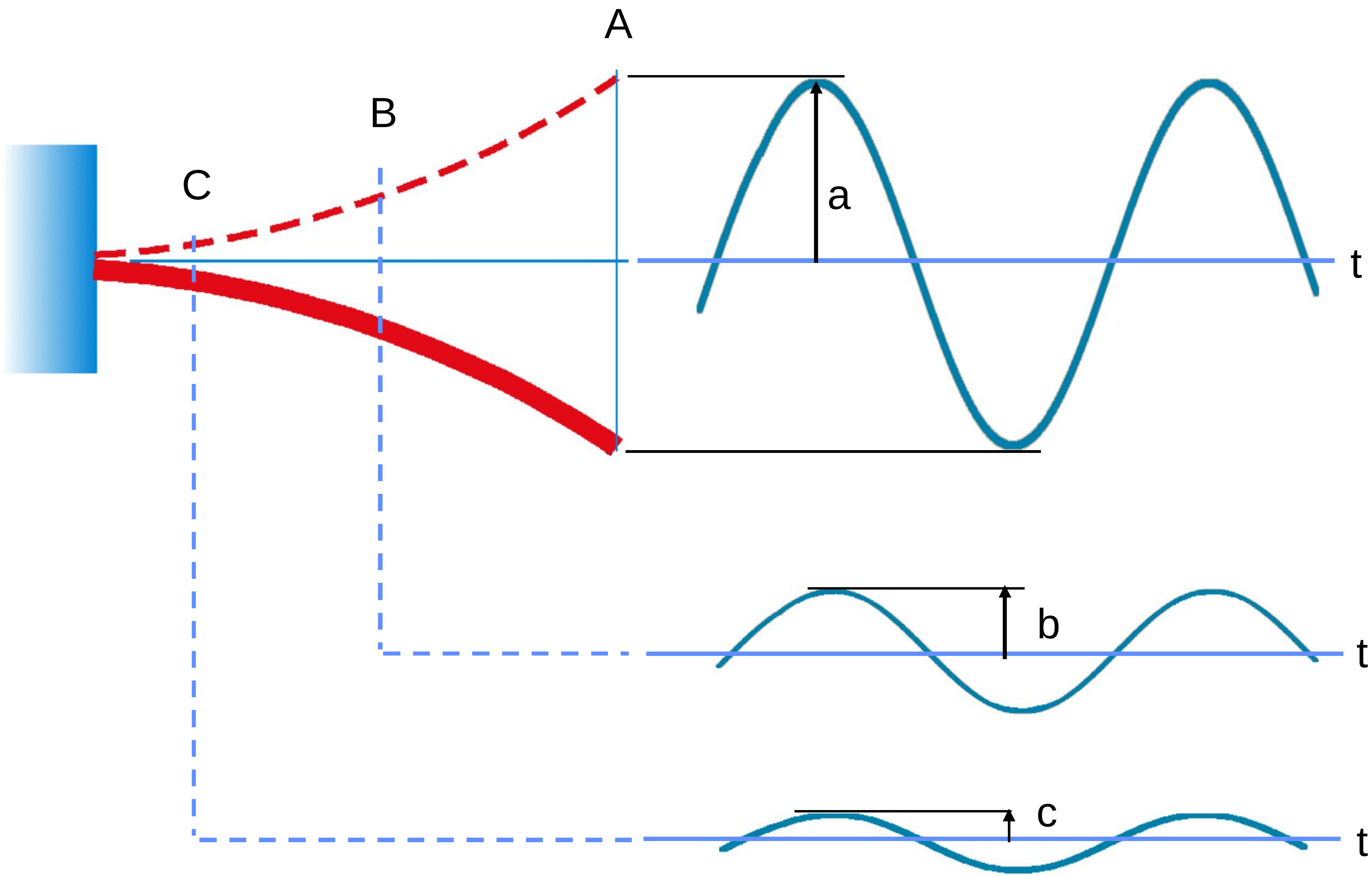
Rate of change of displacement. It is the measure of the speed at which the mass is vibrating during its oscillation.

Unit : MM/Sec, Inch/sec

3. Acceleration :

It is the rate of change of velocity. The greater the rate of change of velocity the greater the forces (P=mf) on the machines.

Unit : M/Sec^2, $Inch/sec^2$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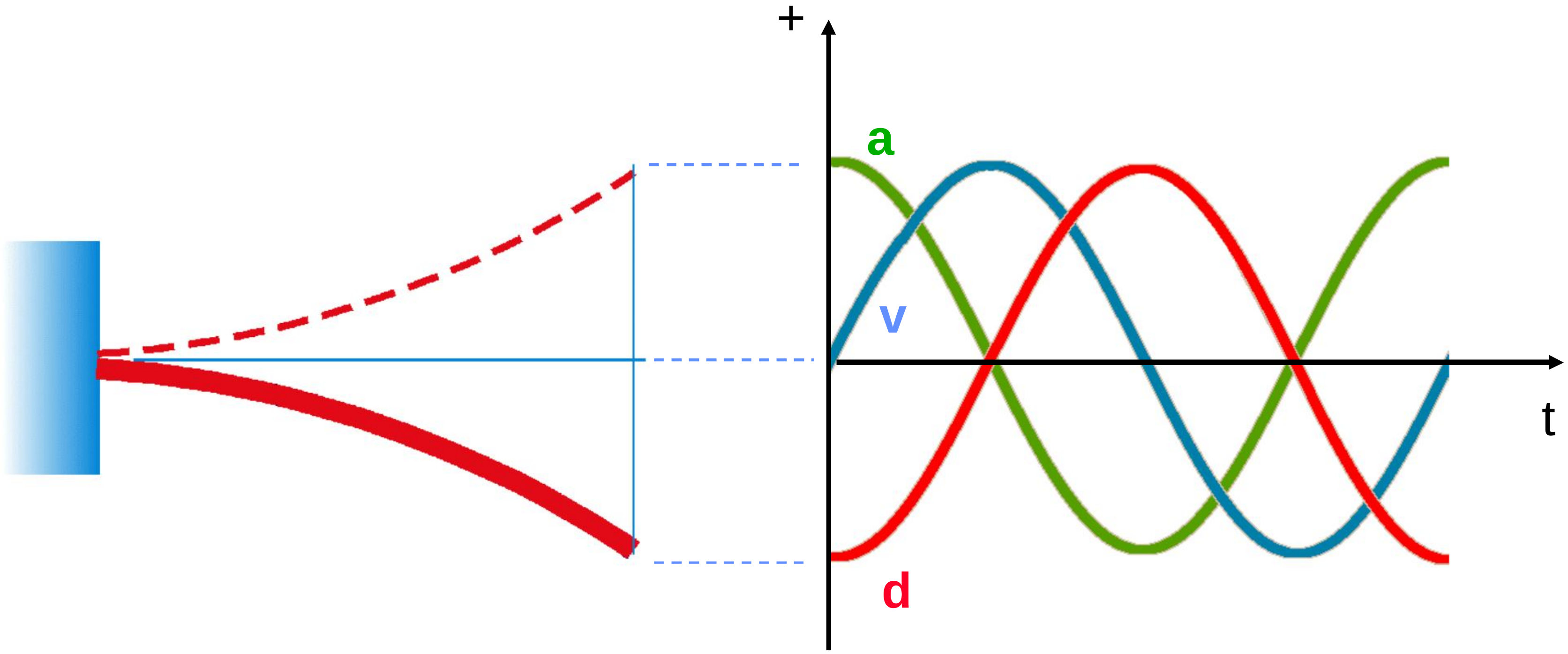
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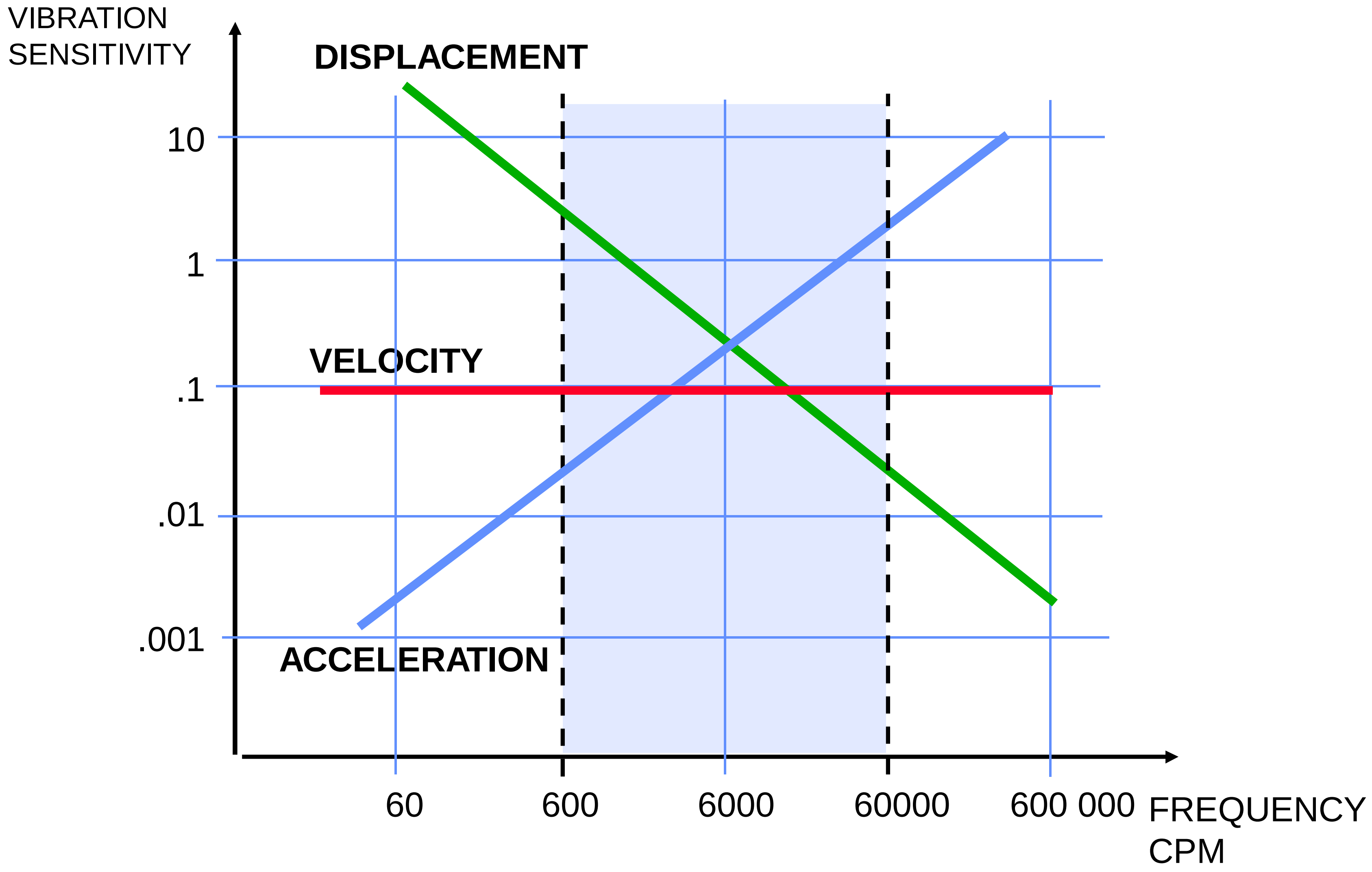
Physical Significance Of Vibration Amplitude

Displacement	:	Stress Indicator
Velocity	:	Fatigue Indicator
Acceleration	:	Force Indicator

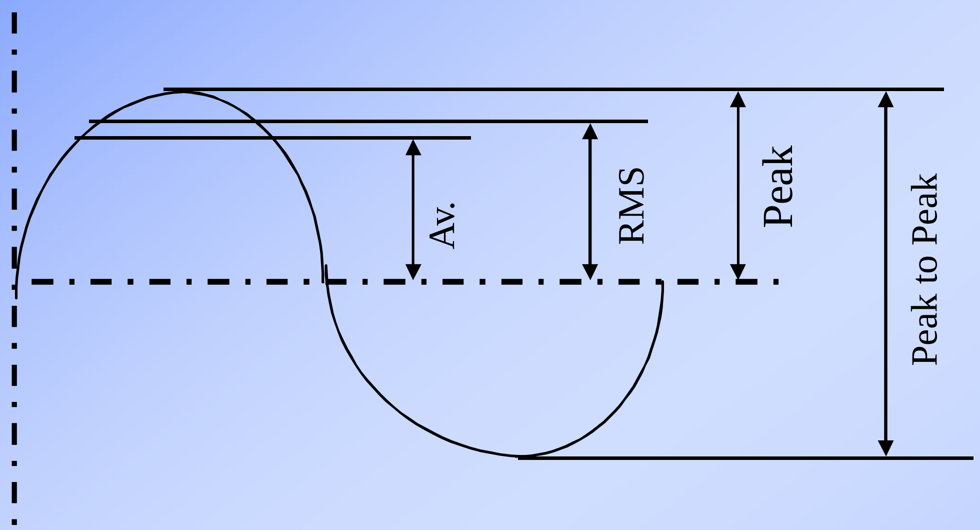
When To Use Disp., Vel. & Acc.?



What Is The Advantage Of Using Velocity?

- Flat frequency range compared to displacement & acceleration.
- Almost all machines generate fault frequency between 600CPM to 60KCPM
- Velocity indicates fatigue.
- Velocity is the best indicator of vibration severity.

Scales Of Amplitude



Peak - a

Peak to Peak - 2a

RMS - 0.707 a

Average - 0.637 a

Vibration Transducers

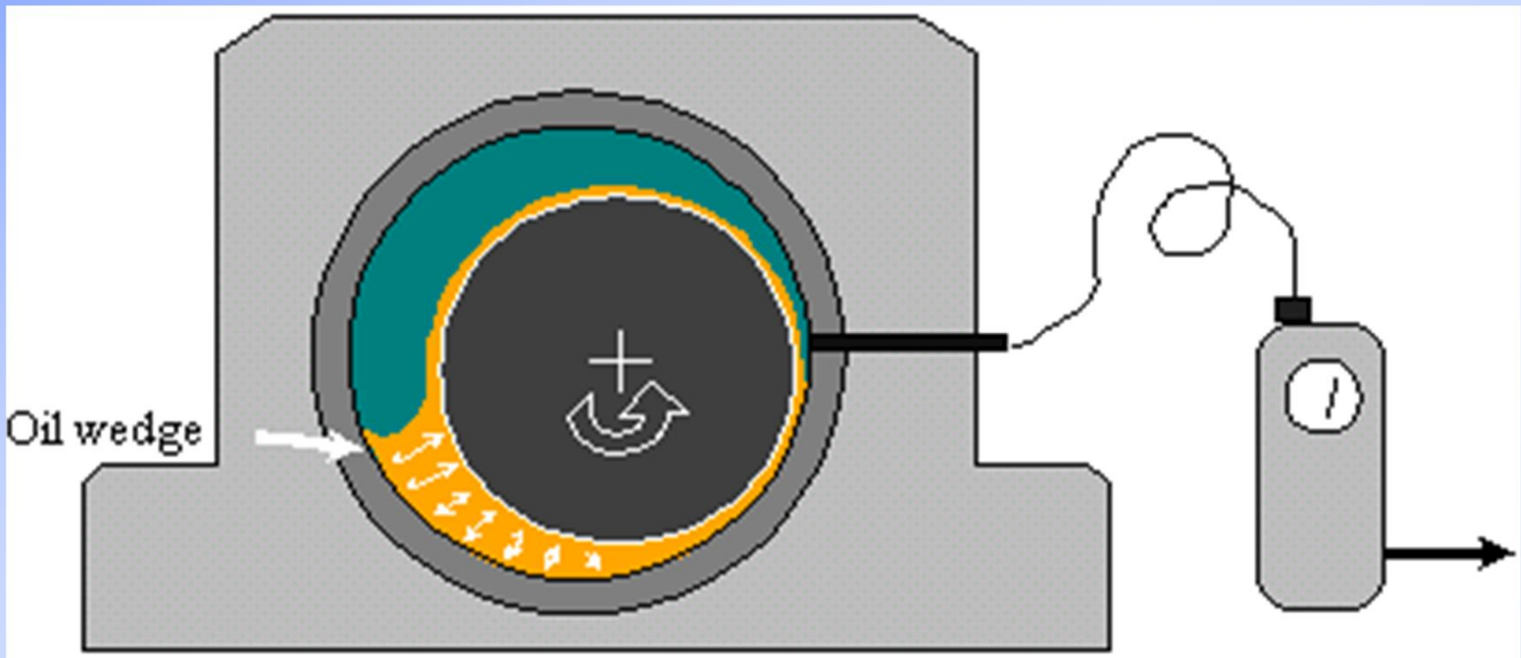
Produces electrical signal of vibratory motion

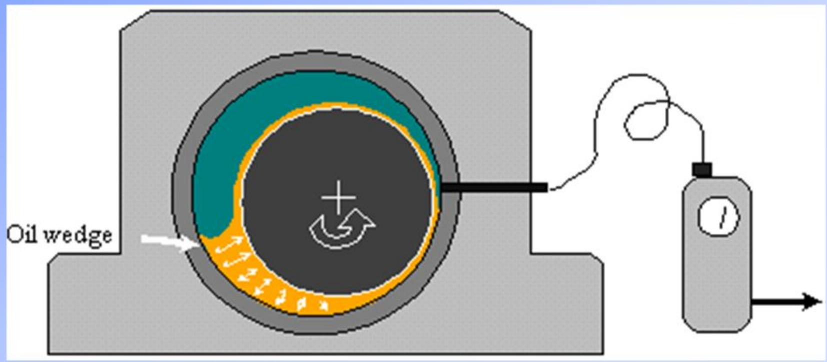
Proximity Probe - Displacement

Velocity Probe - Velocity

Accelerometer - Acceleration

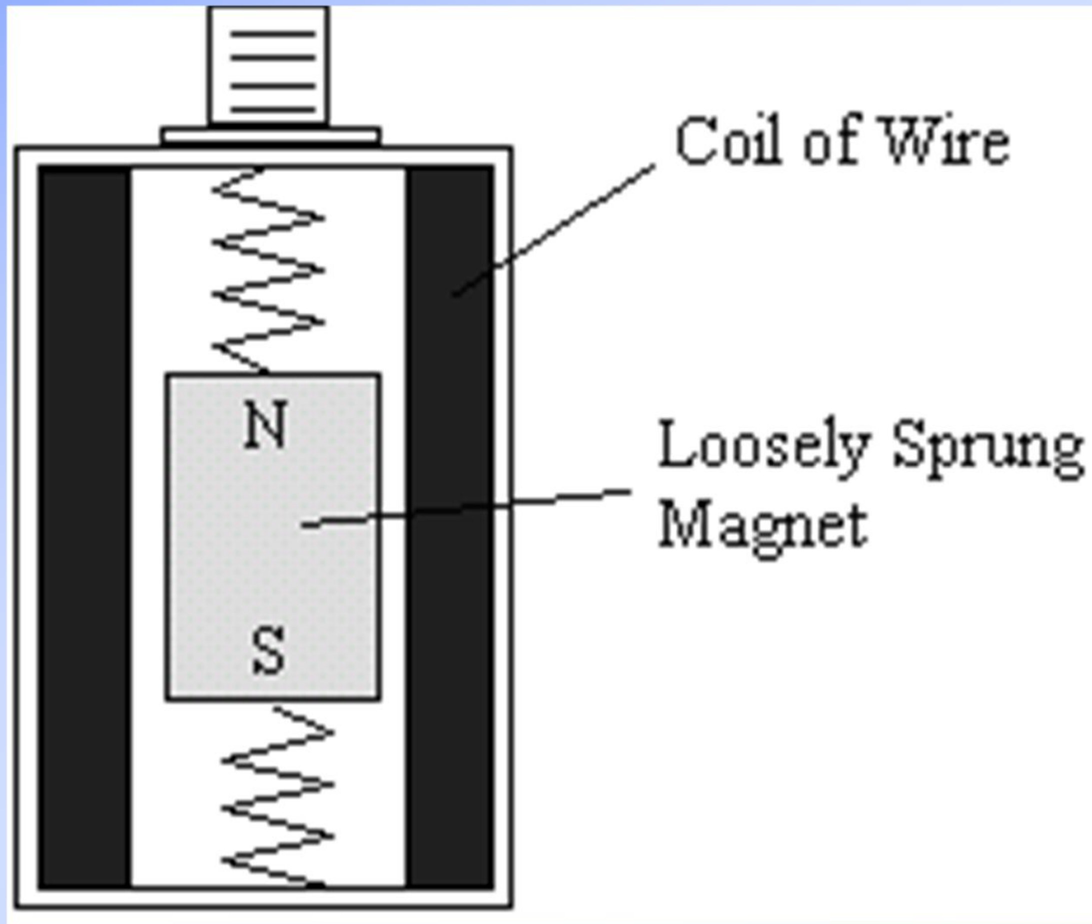
Proximity Probe

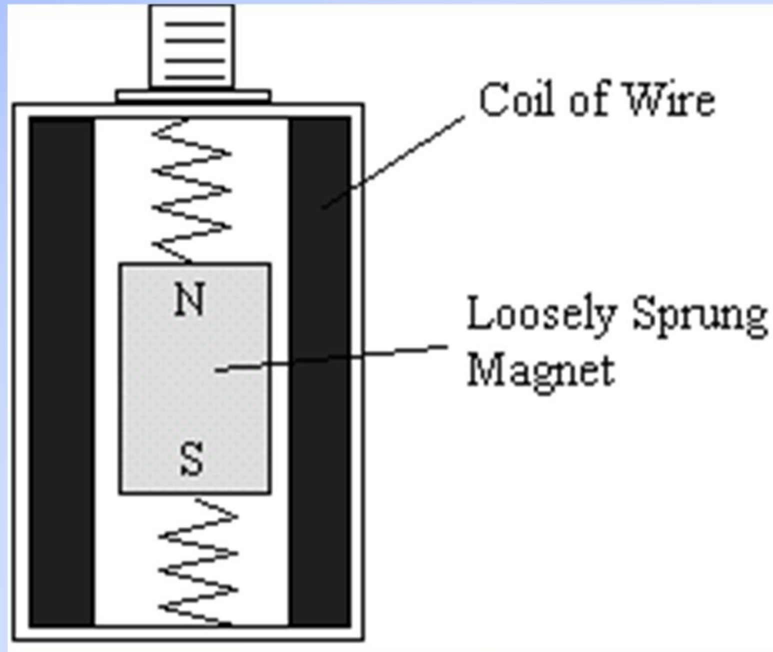




- **Permanently installed on large machines**
- **Measures relative displacement between the bearing housing and the shaft.**
- **Called Eddy Current Probe**
- **Frequency range   0 to 60,000 CPM**
- **Used 90^0 apart to display shaft orbit**

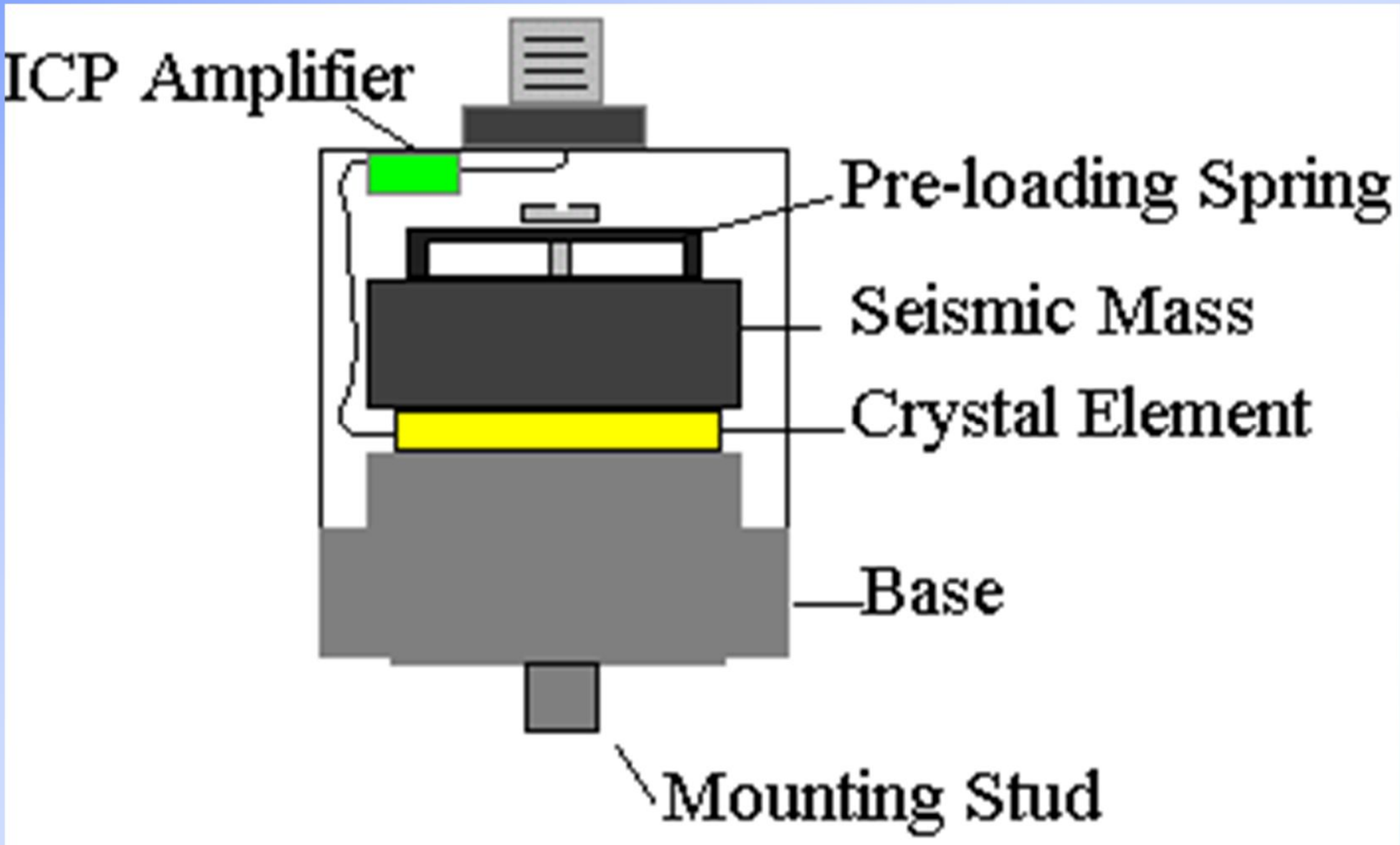
Velocity Probe

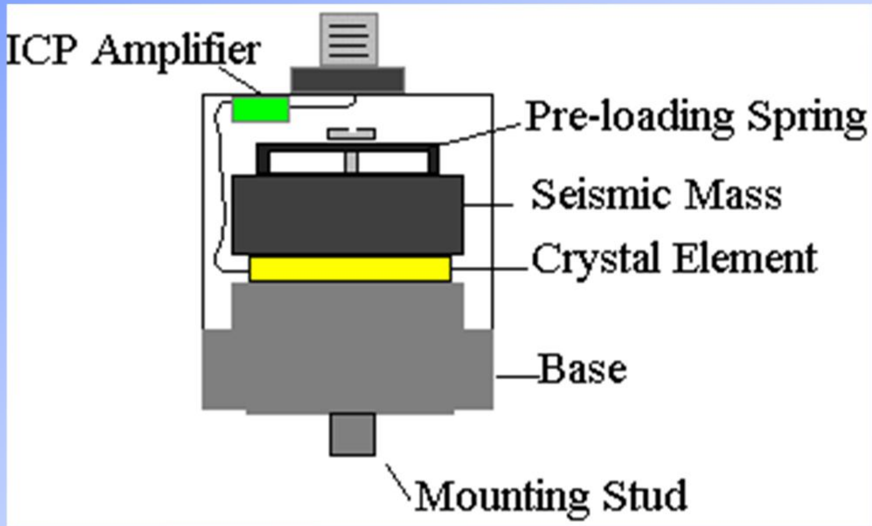




- **Oldest of all.**
- **Produces signal proportional to velocity.**
- **Self generating and needs no conditioning electronics.**
- **It is heavy, complex and expensive.**
- **Frequency response from 600CPM to 60,000CPM**
- **Temperature sensitive**

Accelerometer



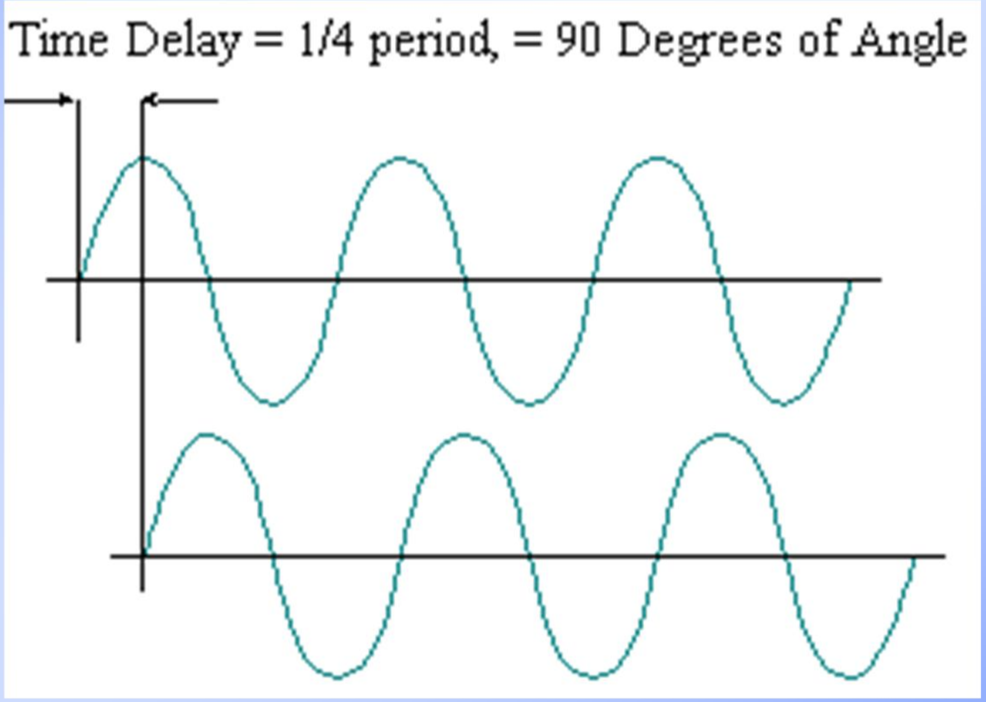


- Produces signal proportional to acceleration of seismic mass.
- Extremely linear amplitude sense.
- Large Frequency range
- Smaller in size

Phase

What Is Phase?

Phase is a measure of relative time difference between two sine waves.



Importance Of Phase

- Phase is a relative measurement.
- Provides information how one part of a machine is vibrating compared to other.
- Confirmatory tool for problems like-
  1. Unbalance(Static, Couple, Quasi-Static).
  2. Misalignment(Angular, Parallel, Combination).
  3. Eccentric Rotor, Bent Shaft.
  4. Mechanical Looseness, Structural Weakness, Soft Foot.
  5. Resonance.
  6. Cocked bearing.

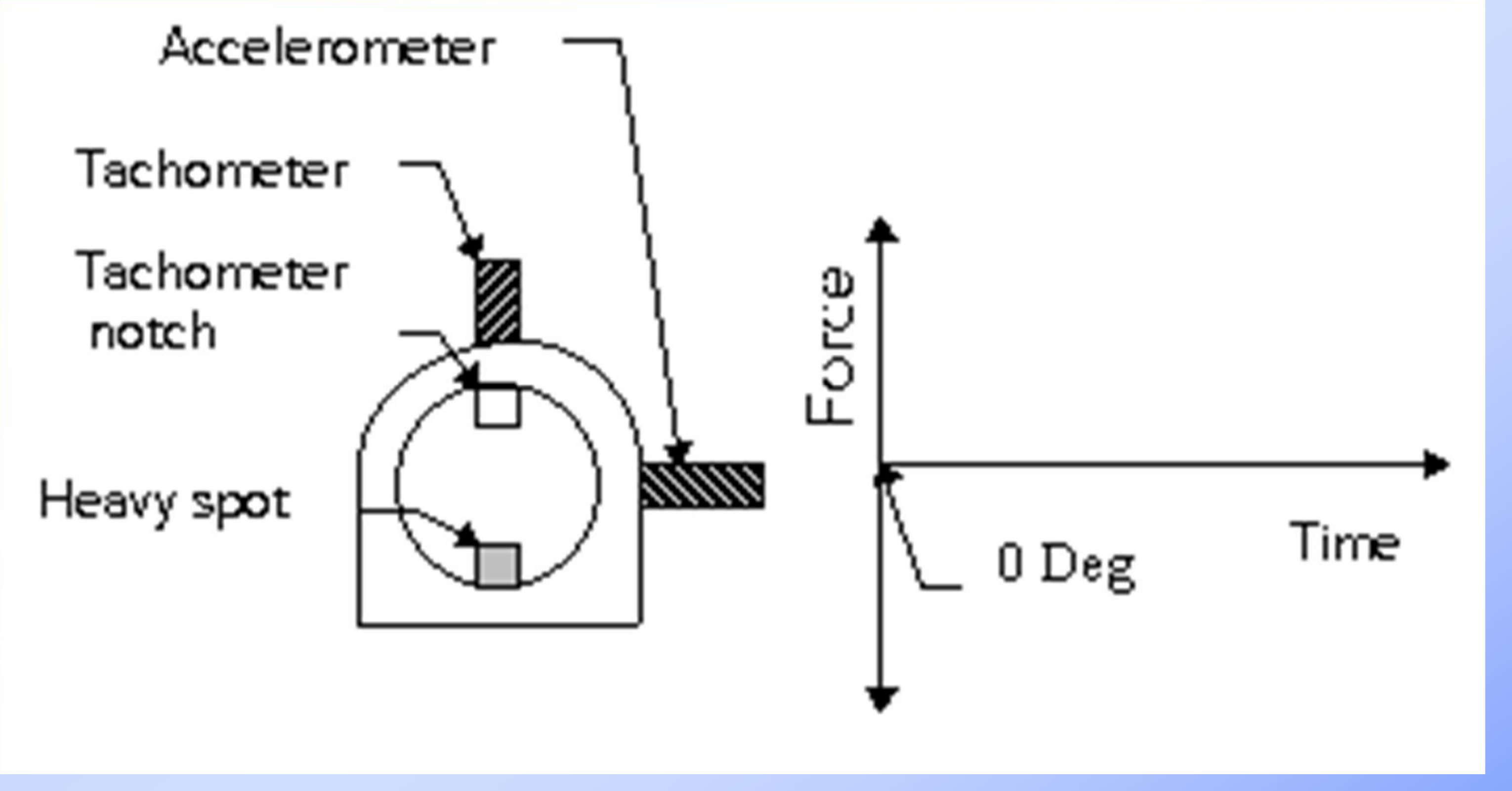
- No correlation with Bearing defects, Gear defects, Electrical motor defect.

How Phase Angle Is Measured?

The Phase Angle is the angle (in degrees) the shaft travels from the start of data collection to when the sensor experiences maximum positive force.

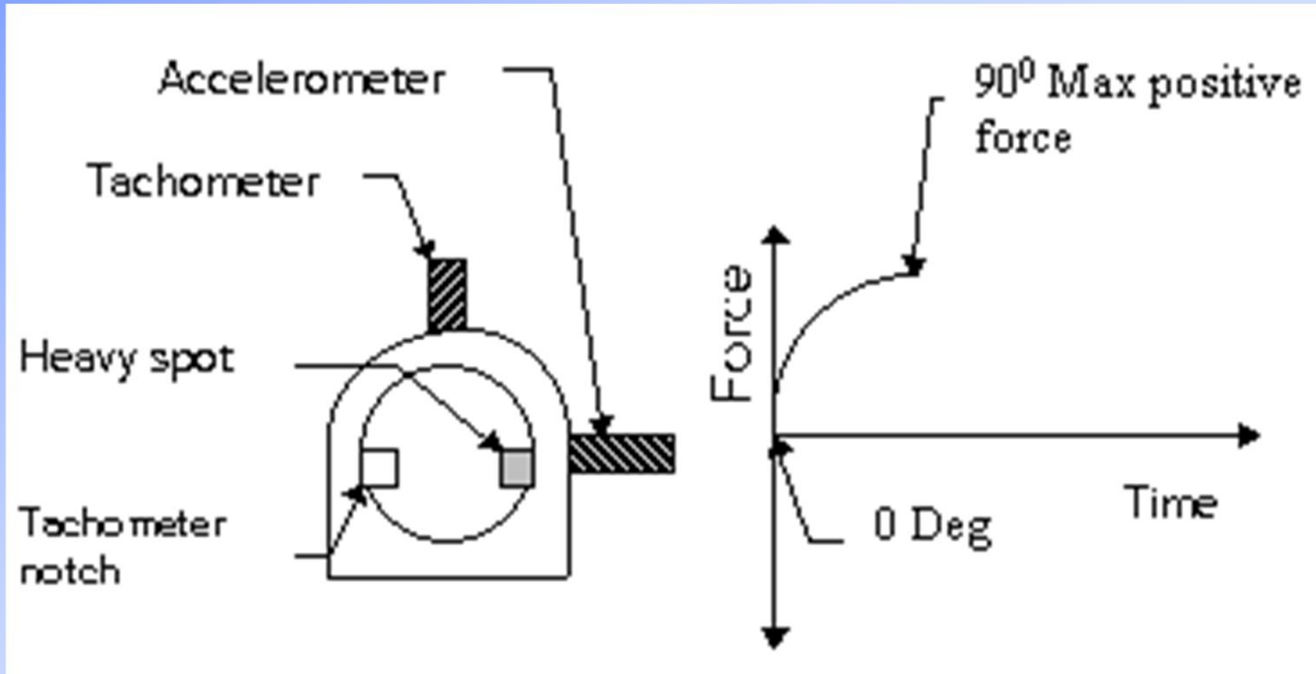
For example, the phase angle is 90° if the sensor experiences its maximum positive force at 90° after data collection was initiated by the tachometer.

Step - 1



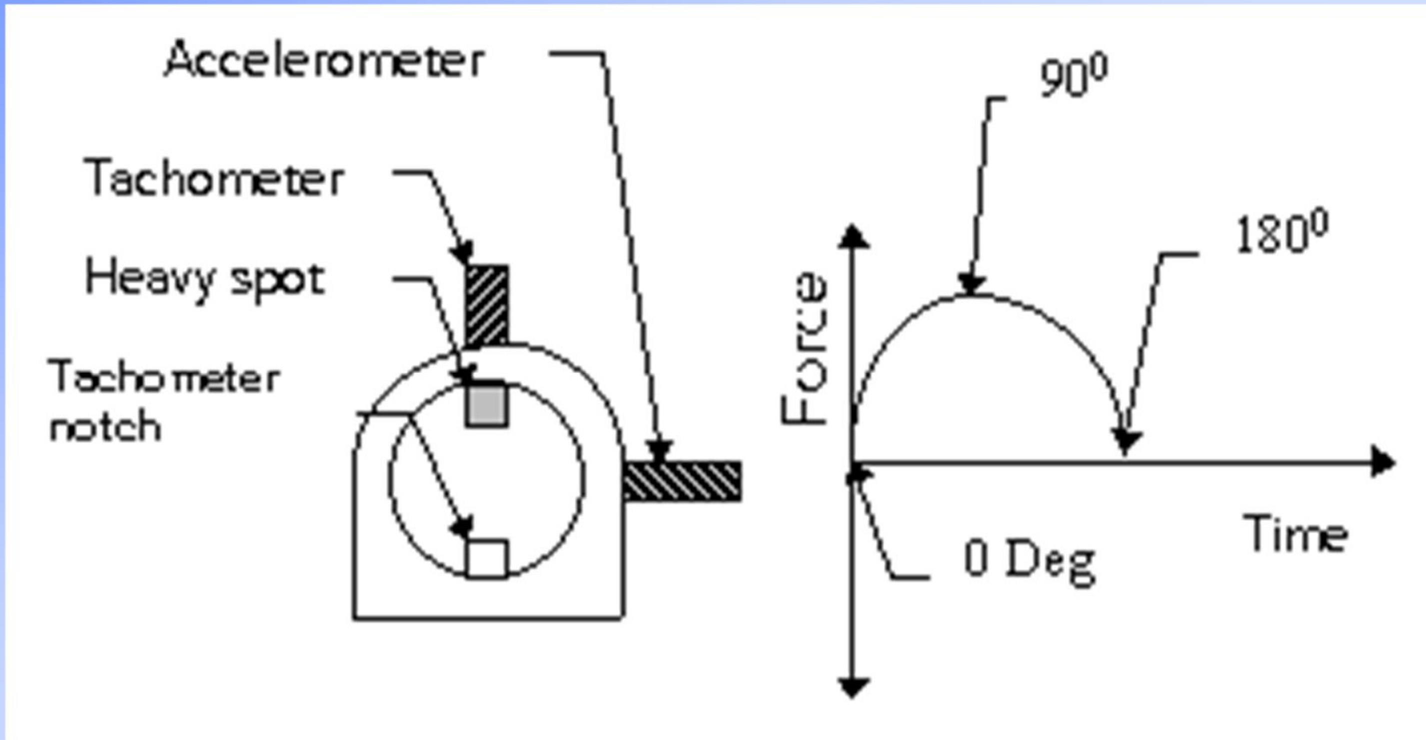
The tachometer senses the notch in the shaft and triggers data collection. At this point force equals zero.

Step - 2



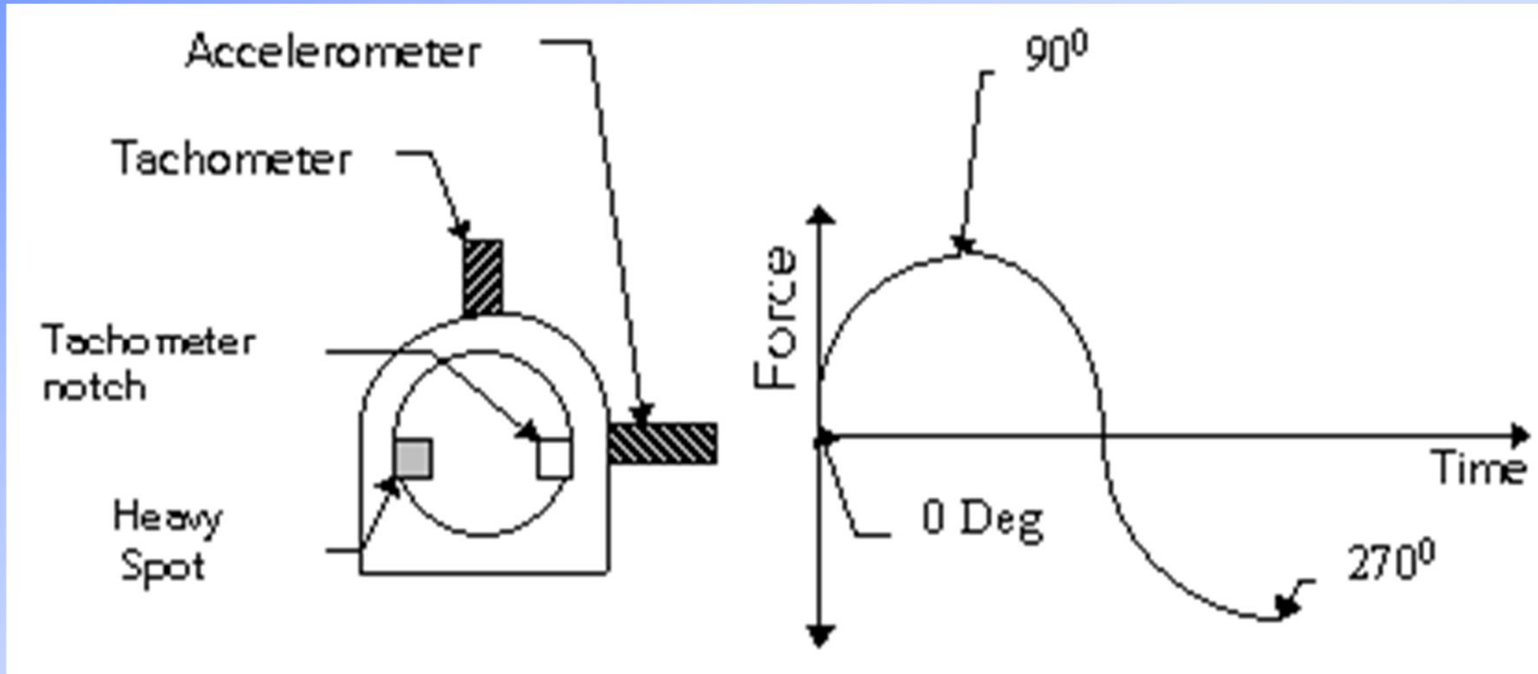
The high spot (heavy spot) rotates 90° to the sensor position. At this point the unbalance force produces the highest positive reading from the sensor.

Step - 3



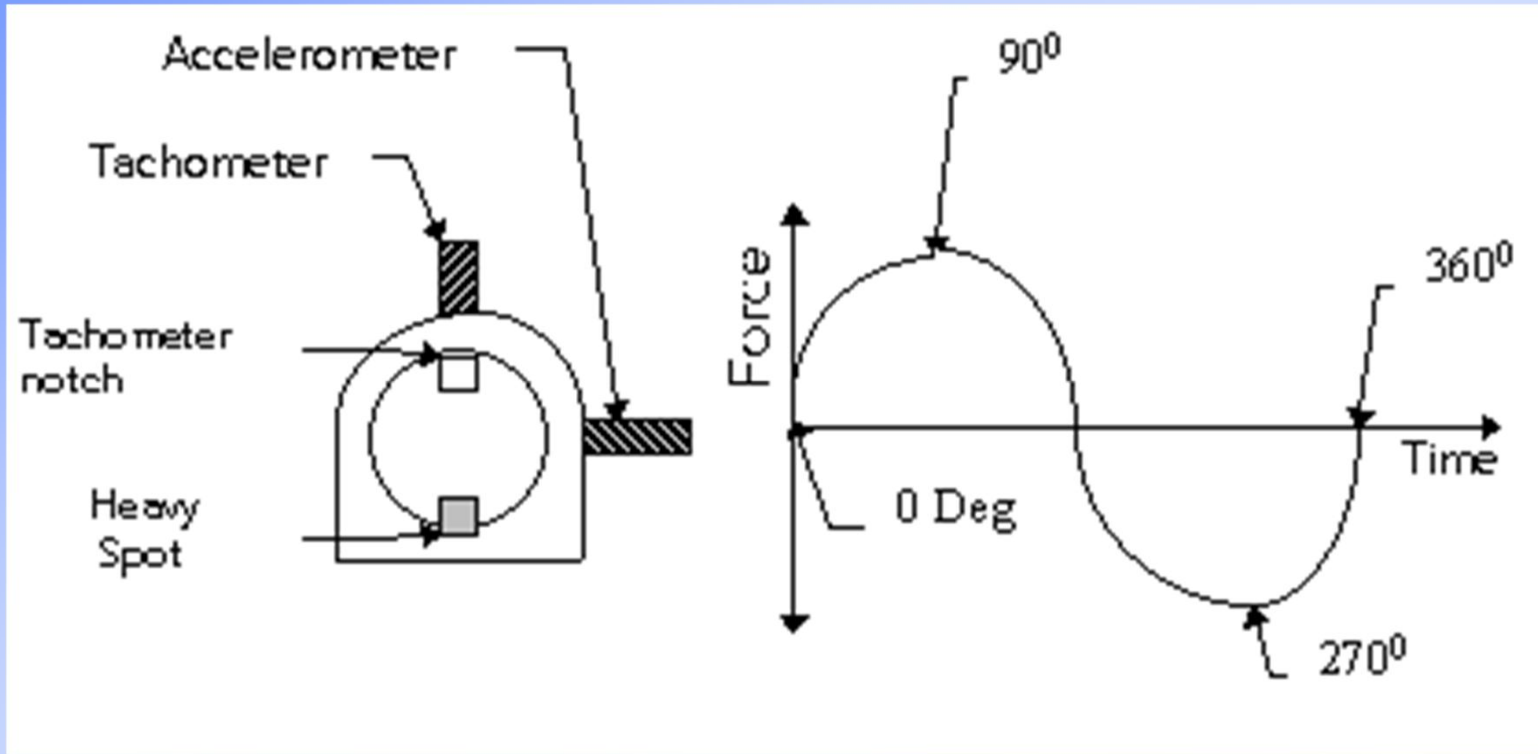
The high spot rotates 90 additional degrees, the force experience by the sensor is again zero.

Step - 4



The high spot rotates 90 additional degrees opposite the sensor position. At this point the unbalance force produces the highest negative reading from the sensor.

Step - 5



The high spot rotates 90 additional degrees to complete its 360° revolution, the force experienced by the sensor is again zero.

Phase Angle

During the 360^0 shaft rotation, the sensor experiences it's maximum positive force when the shaft's heavy spot is 90^0 from it's initial position when data collection was initiated by the tachometer.

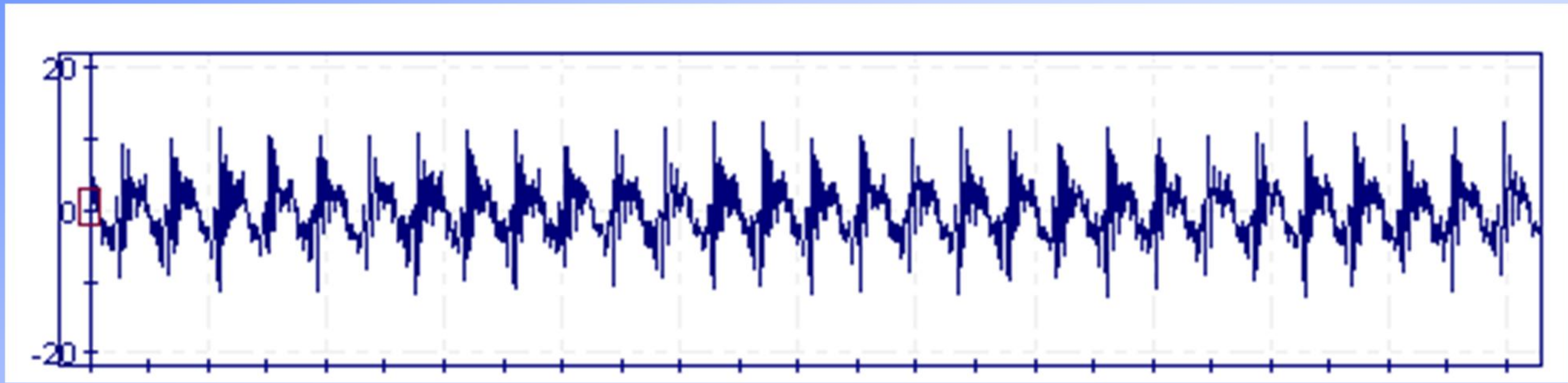
This measurement's phase angel = 90°

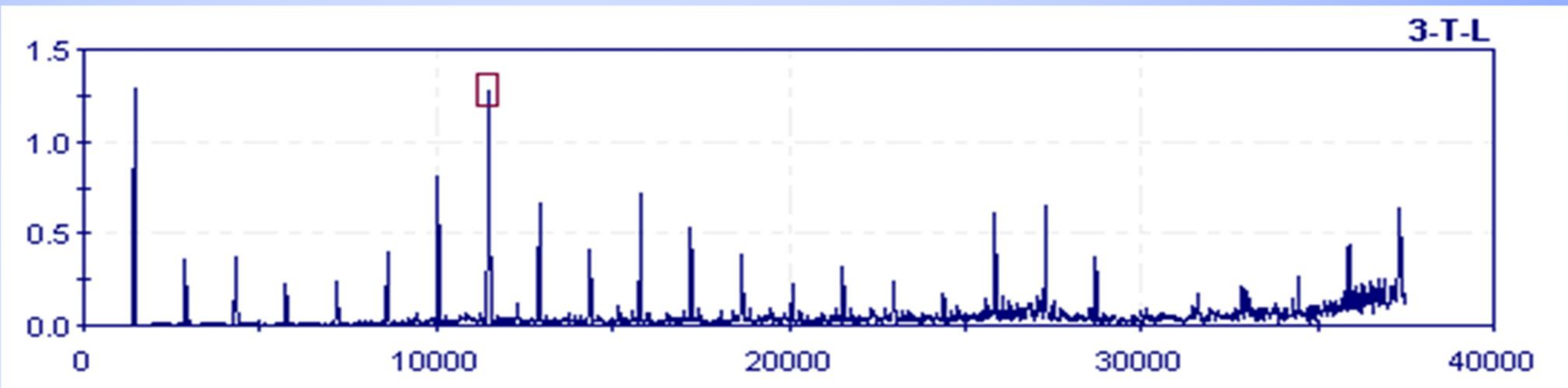
FFT Spectrum Analysis

What Is FFT?

- Known as Fast Fourier Transformation.
- Developed by J.B. Fourier in 1874.

FFT mathematically converts overall complex signal into individual amplitudes at component frequencies



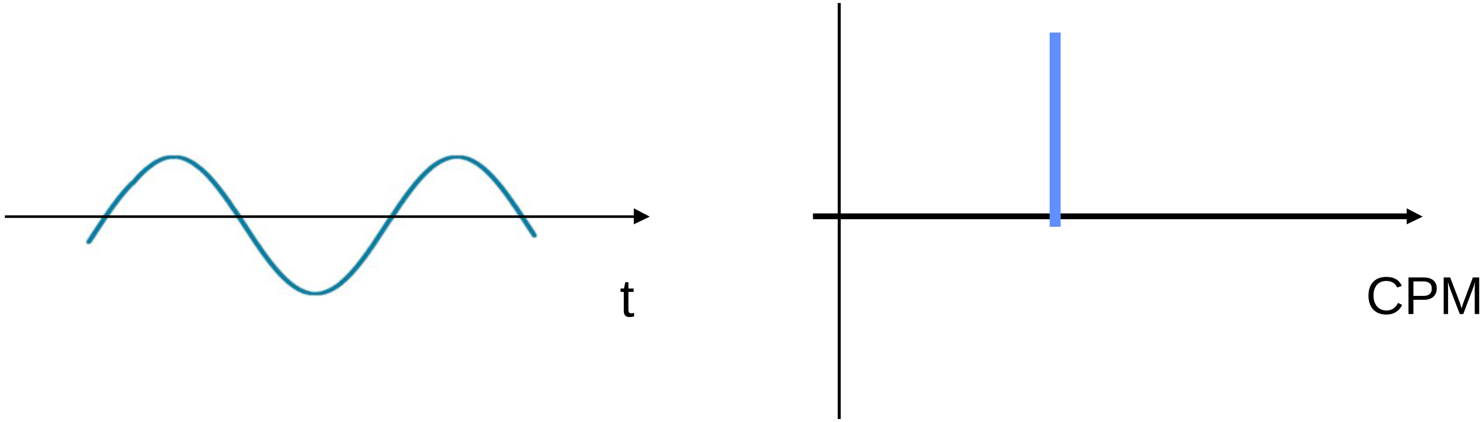


- **Different machinery problems cause vibration at different frequencies.**

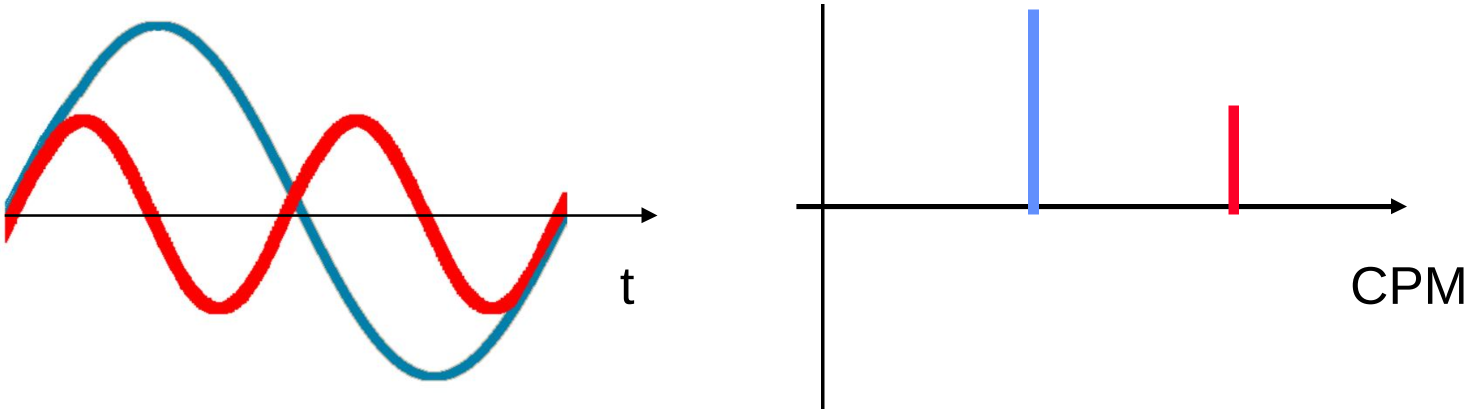
- **Overall vibration coming out from machine is combination of many vibration signals form various machine parts and it’s structure.**

- **FFT is a method of viewing the signal with respect to frequency.**

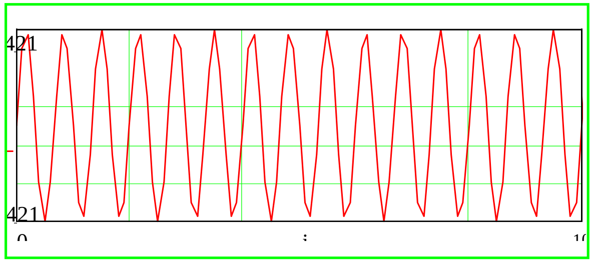
Pure sinus

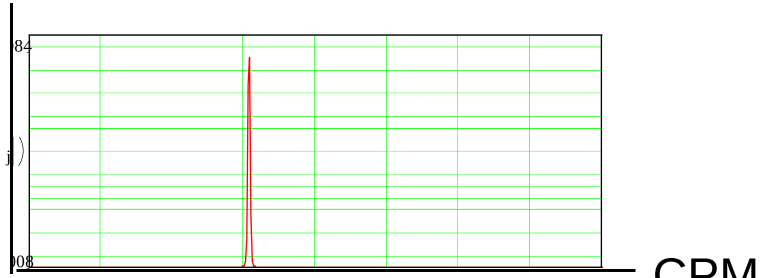


2 sine waves

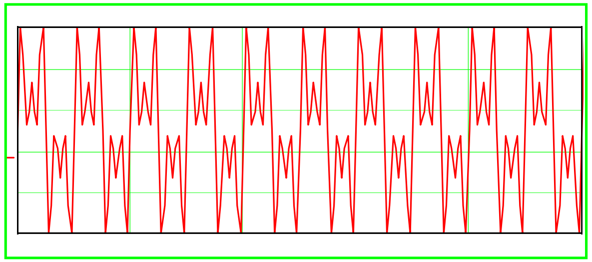


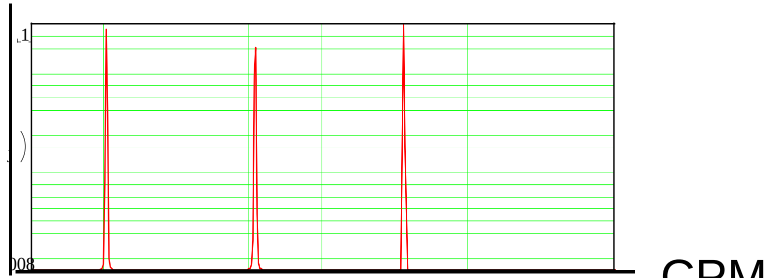
Pure sinus



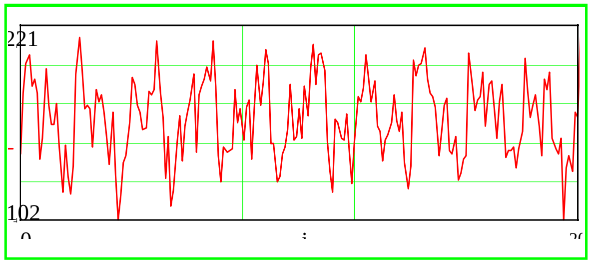


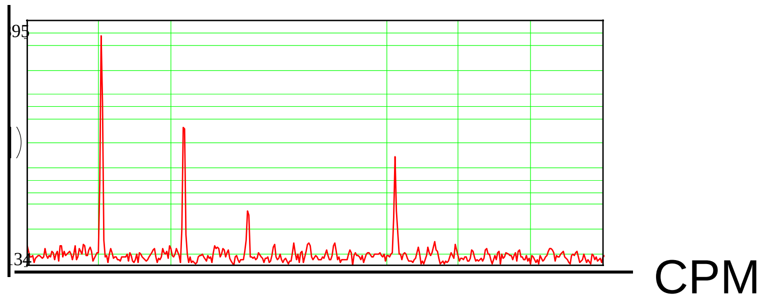
3 sine waves





Complex motion





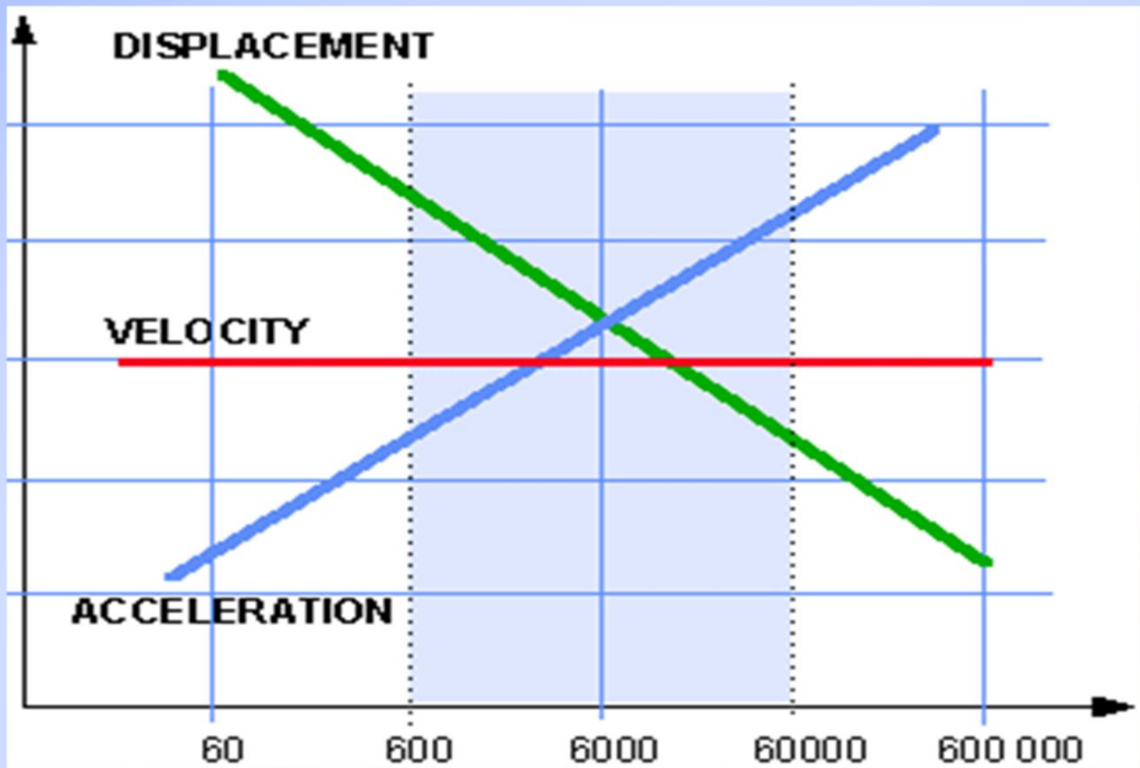
Spectrum Analysis Techniques

Step - 1
Collect useful information

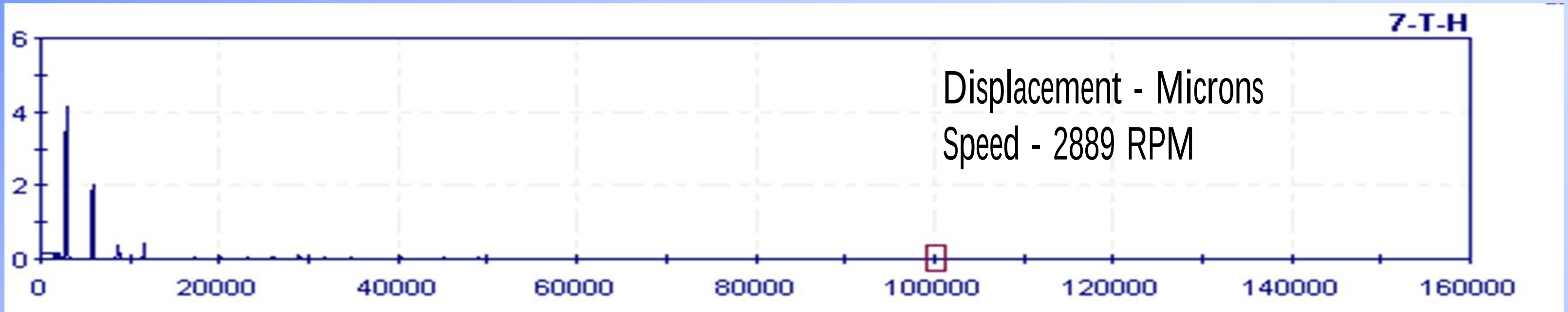
- History of machine.
- Control room data - speed, feed, temperature, pressure etc.
- Name plate details - bearing no, no of gear teeth etc.
- Design operating parameters, critical speed.

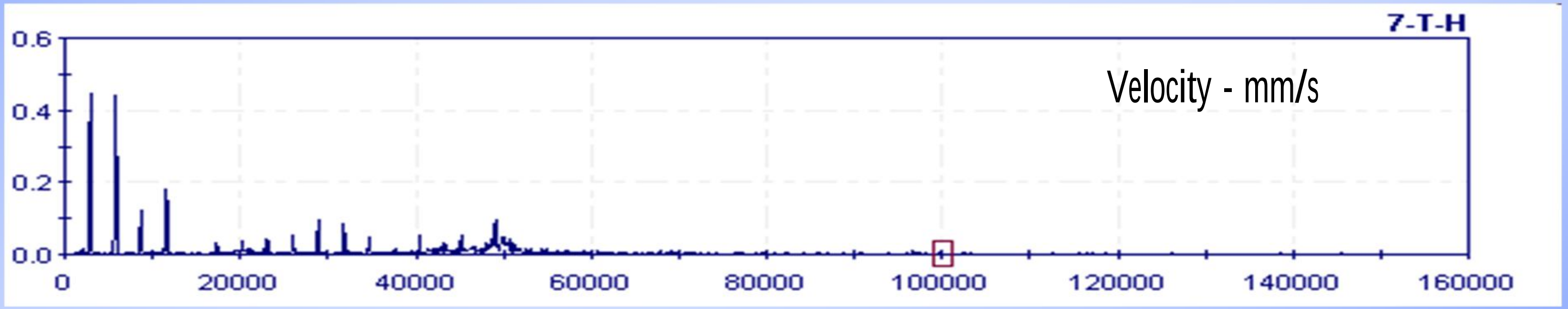
Step - 2 : Identify the type of measurement procedure:

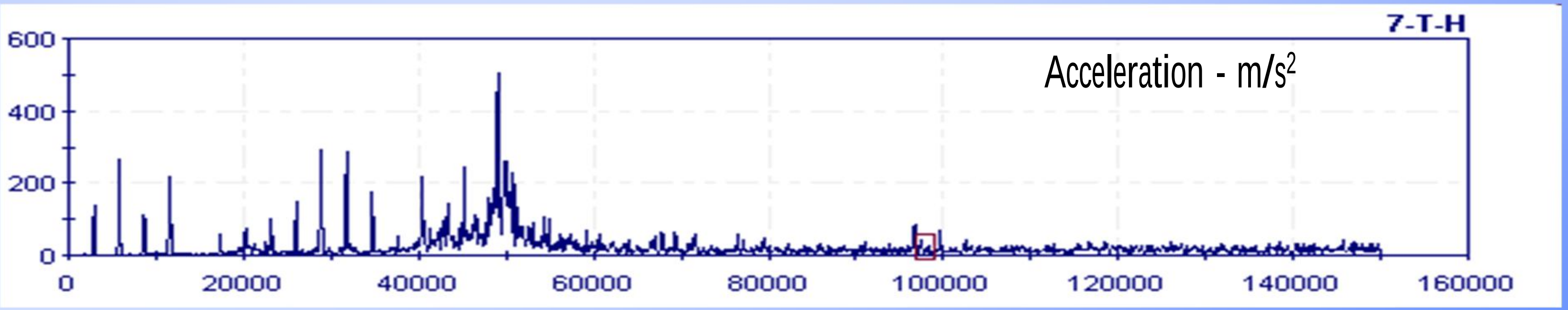
1. Identify measurement type-Disp, Vel, Acc.



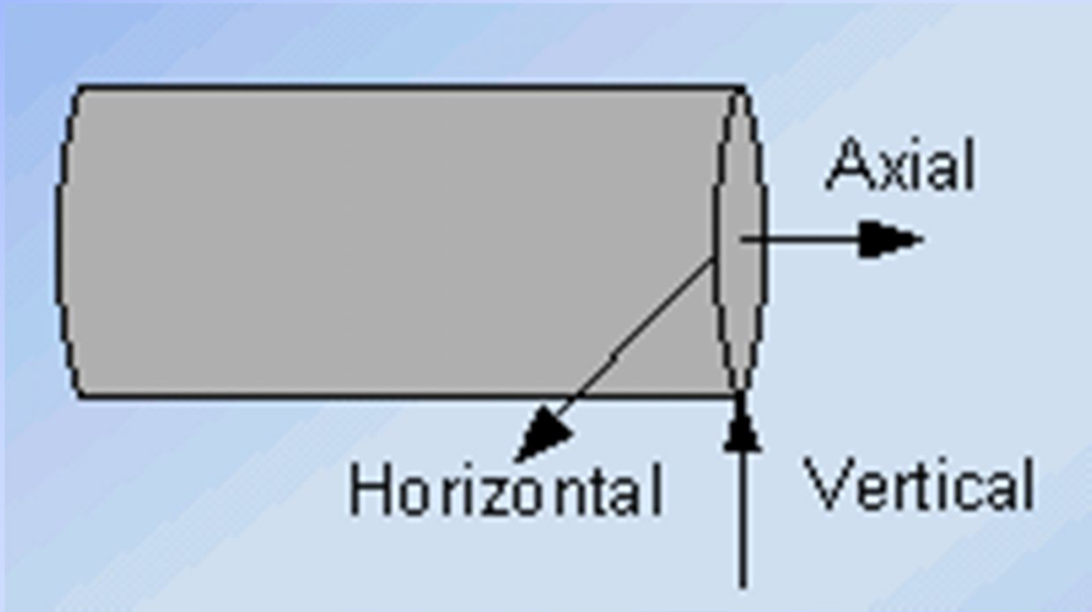
Conversion Of Spectrums

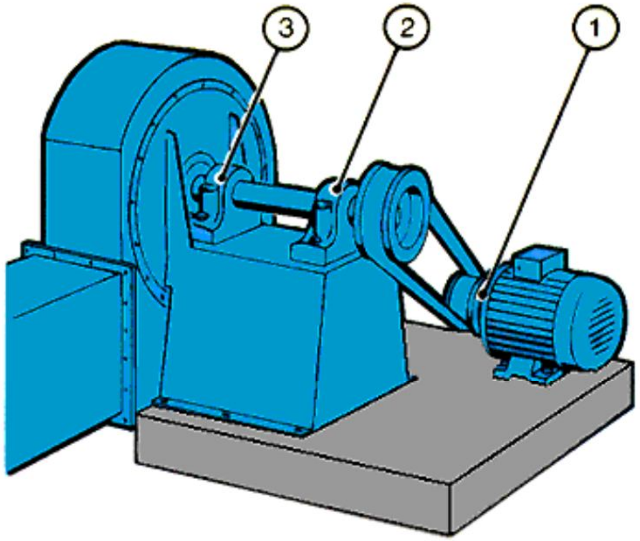






2. Measurement direction - Hori, Vert, Axial.

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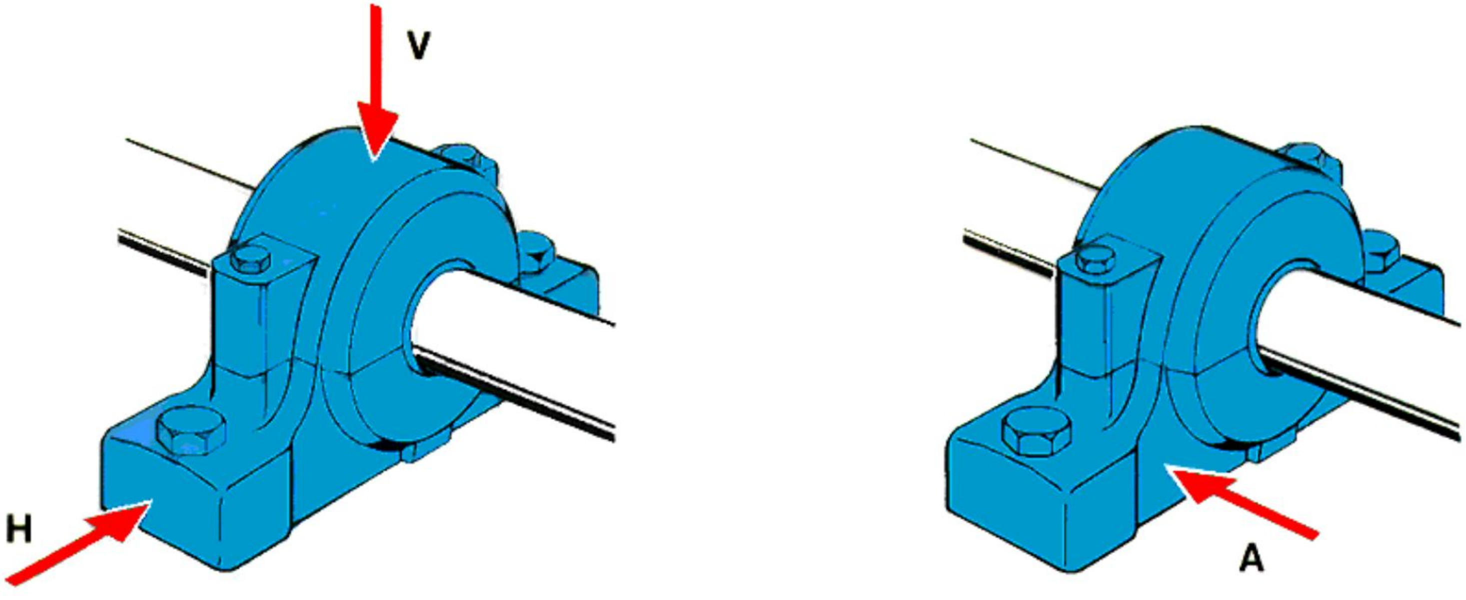
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Step - 3
Analyze:

1. Evaluate overall vibration reading of the entire machine.
   (a) Identify 1x RPM peak.
   (b) Locate highest amplitude.
   (c) What is the direction of the highest amplitude?
   (d) What is the frequency of the highest amplitude?
2. See the values of Shock pulse, HFD etc.
3. See the trend - in case of sudden increase the problem severity increases.
4. Analyze the frequency for possible defects.
5. Analyze the phase readings for confirmation if necessary.

Manual Vibration Analysis

Detection By Vibration Analysis

1. Unbalance(Static, Couple, Quasi-Static),
2. Misalignment(Angular, Parallel, Combination)
3. Eccentric Rotor, Bent Shaft
4. Mechanical Looseness, Structural Weakness, Soft Foot
5. Resonance, Beat Vibration
6. Mechanical Rubbing
7. Problems Of Belt Driven Machines
8. Journal Bearing Defects
9. Antifriction Bearing Defects
   (Inner race, Outer race, Cage, Rolling Elements)
10. Hydrodynamic & Aerodynamic Forces
    (Blade Or Vane, Flow turbulence, Cavitation)
11. Gear Problems (Tooth wear, Tooth load, Gear eccentricity, Backlash, Gear misalignment, Cracked Or Broken Tooth)
12. Electrical Problems of AC & DC Motor (Variable Air Gap, Rotor Bar Defect, Problems of SCRs)

Unbalance

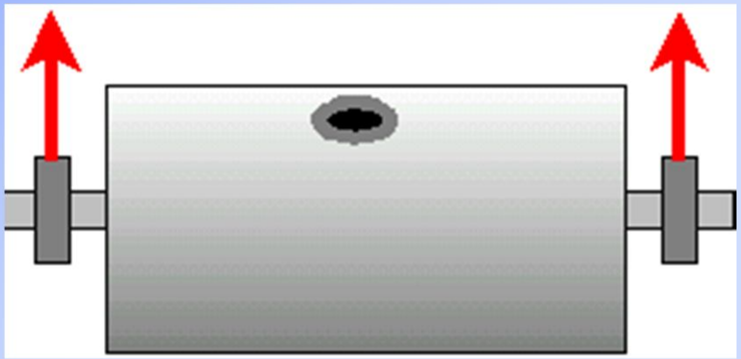
Causes Of Unbalance

- Uneven distribution of mass of rotor.
- Dirt accumulation on fan rotors.
- Rotor eccentricity
- Roller deflection, especially in paper machines
- Machining errors
- Uneven erosion and corrosion of pump impellers
- Missing balance weights

Types Of Unbalance

- **Static Unbalance**
- **Couple Unbalance**
- **Overhang Rotor Unbalance**

Static Unbalance



Detection:

- **Highest horizontal vibration**
- **Amplitude increases as square of speed.**
- **Dominant frequency at 1x rpm**
- **Horizontal to vertical phase difference 90^0 on the same bearing housing**

Correction

Can be corrected by one balance weight

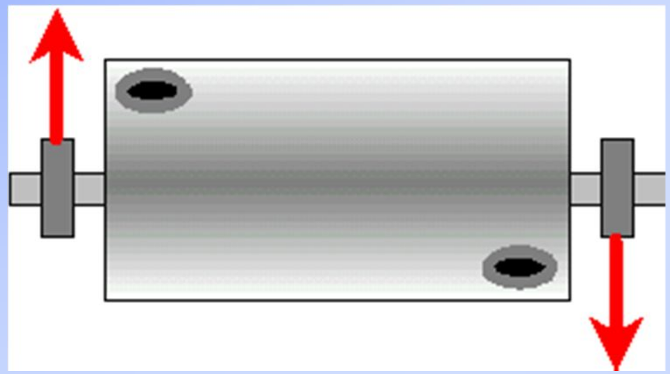
2. Vibration Phase Analysis:

Angular - 180^0 phase shift in the axial direction across the coupling.

Offset - 180^0 phase shift in the radial direction across the coupling. 0^0 to 180^0 phase shift occur as the sensor moves from horizontal to the vertical direction of the same machine.

Skew - 180^0 phase shift in the axial or radial direction across the coupling.

Couple Unbalance



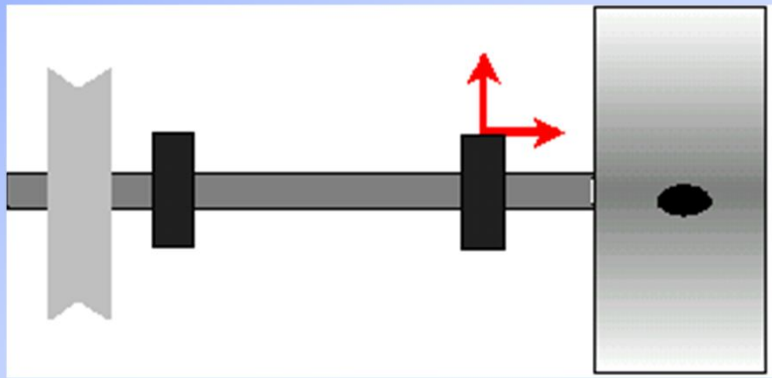
Detection:

- High horizontal & some times axial vibration
- Dominant frequency at 1x RPM
- 180^0 phase difference between both bearings horizontal as well as vertical direction.

Correction

It requires two plane balancing

Overhung Rotor Unbalance



Detection:

- High horizontal & axial vibration
- Dominant frequency at 1x RPM
- Axial readings will be in phase but radial phase readings might be unsteady.

Correction

Overhung rotors might be having both static and couple unbalance and each of which requires correction.

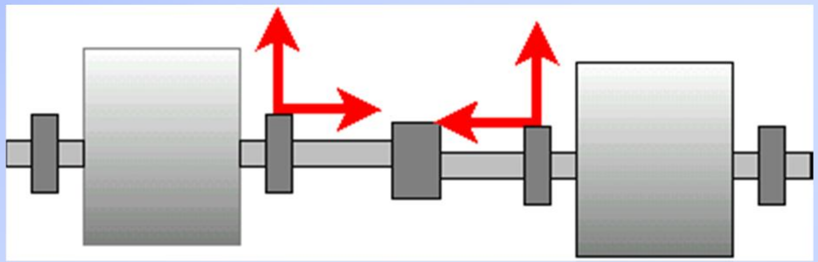
Misalignment

Causes Of Misalignment

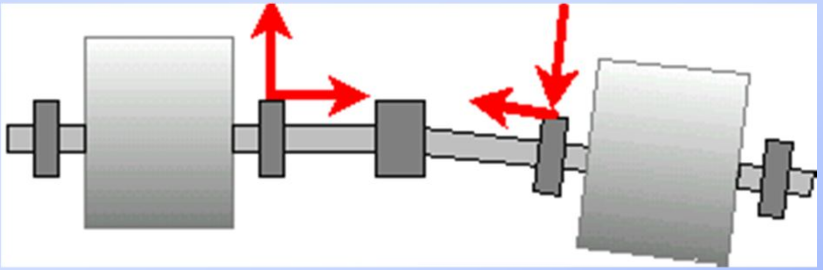
- Thermal expansion - Most machines align cold.
- Machine vibrations.
- Forces transmitted to the machine by pipe or support structure.
- Soft foot.
- Direct coupled machined are not properly aligned.
- Poor workmanship.

Types Of Misalignment

1. Off set



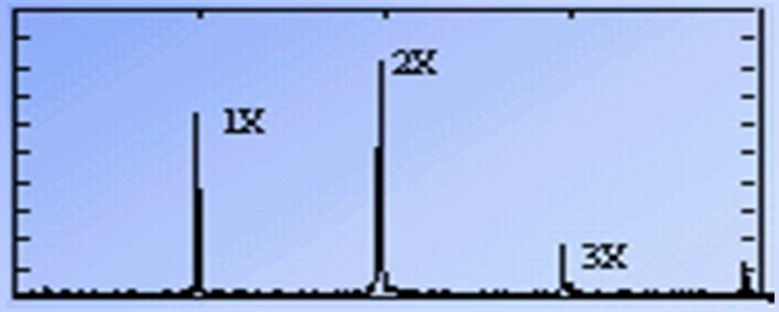
2. Angular



3. Skew - Combination of offset & angular

Diagnosis Of Misalignment

1.Vibration Spectrum Analysis:



Angular - Axial vibration at 1X RPM

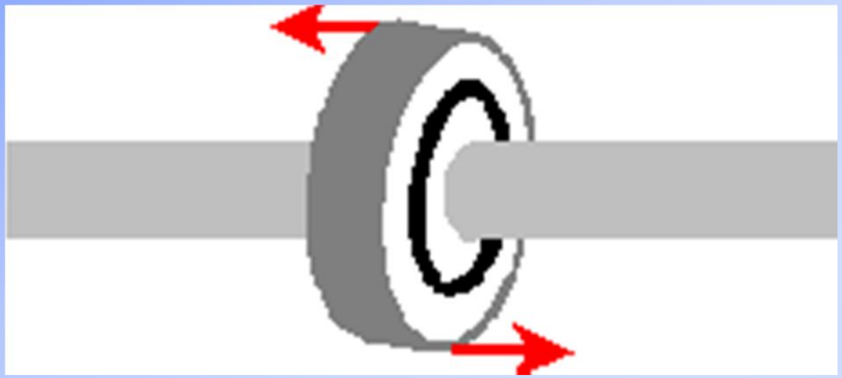
Offset - Radial vibration at 2X or 3X RPM

Harmonics (3X-10X) generates as severity increases.

If the 2X amplitude more than 50% of 1X then coupling damage starts.

If the 2X amplitude more than 150% of 1X then machine should be stopped for correction.

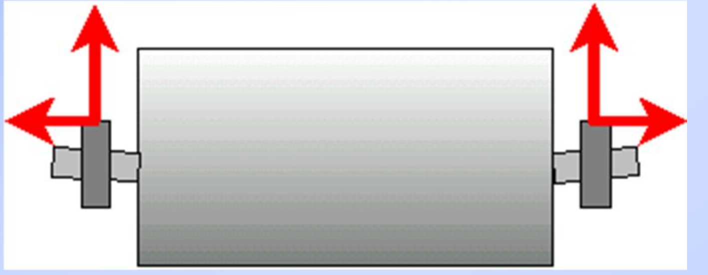
Misaligned Or Cocked Bearing



1. Predominant 1X & 2X in the axial direction.

2. 180^0 Phase shift top to bettom and/or side to side of the axial direction of the same bearing housing.

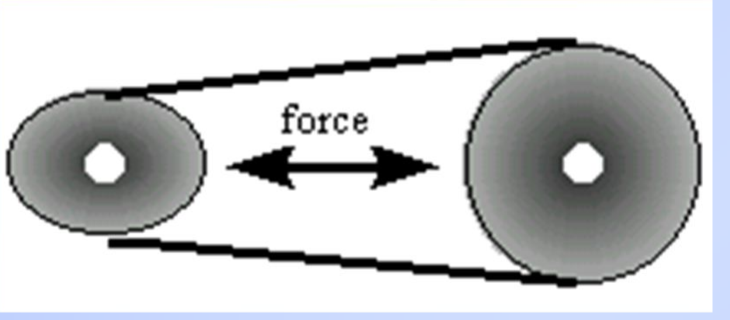
Bent Shaft



Diagnosis:

1. High 1X axial and high 1X radial if bent is near the center.
2. High 2X axial and high 2X radial if bent is near the coupling.
3. The phase of the 1X component 180^0 at opposite ends of rotor.
4. Phase difference of 180^0 between left & right hand side and also upper & lower sides of the same bearing housing in the axial direction.
5. Amplitude of 1X & 2X rpm will be steady.
6. High bearing temperature.

Eccentric Rotor



- **When center of rotation is offset from geometric center.**
- **Dominant frequency 1X.**
- **Horizontal to Vertical phase difference either 0^0 or 180^0 at the same bearing housing (Both indicate straight-line motion).**

Resonance

- Occurs when forcing frequency coincides with system natural frequency.
- Causes amplitude amplification which results catastrophic failure.
- Requires changing of natural frequency or change of operating speed.
- Bode plot is used to identify resonance.

Beat Vibration

- It is the result of two closely spaced frequencies going into and out of synchronization with one another.
- The spectrum will show one peak pulsating up and down.
- Low frequency vibration 5 to 100 CPM.
- Beat frequencies are not normally a problem when the differences exceed 150 to 200 CPM.

Mechanical Looseness

Causes

- It alone can not create vibration but in the influence of Unbalance, Misalignment, Bearing problems it amplify the amplitude.
- It should be corrected first.

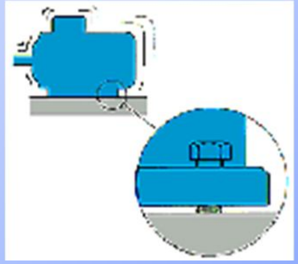
Types

1. Structural frame/base looseness (1X)
2. Cracked structure/bearing pedestal (2X)
3. Rotating looseness - Loose bearing/improper fit between component parts. (Multiple)

1. Structural frame/base looseness (1X)

Caused by-

1. **Structural looseness/weakness of machine feet, baseplate & concrete base.**
2. **Deteriorated grouting.**
3. **Deterioration of frame or base**
4. **Soft foot.**
5. **Loose holding down bolts.**



Analysis

- Dominant freq 1X. Similar to unbalance & misalignment.
- Horizontal to vertical phase diff 0^0 or 180^0 at the same bearing housing.
- 180^0 phase diff in the vertical direction between two surfaces.

2. Cracked structure/bearing pedestal (2X)

Caused by-

1. Crack in the structure or bearing pedestal.
2. Occasionally on some loose bearing housing bolts.
3. Loose bearing or improper component fit.

Analysis-

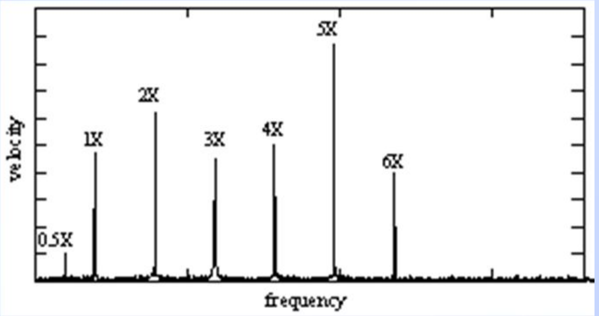
1. 2X RPM amplitude is > 150% of 1X RPM amplitude in radial direction.
2. Amplitudes are somewhat erratic.
3. 2X RPM phase somewhat erratic.

3. Rotating looseness

Caused by-

1. Loose rotor.
2. Bearing loose in the housing.
3. Bearing loose in the shaft.
4. Excessive bearing internal clearance.

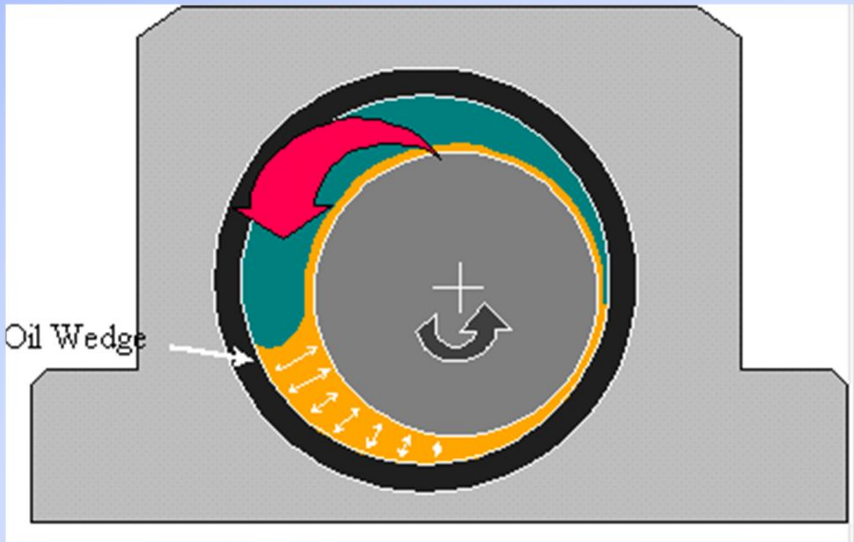
Analysis



1. Generates running speed harmonics up to 20X RPM.
2. Generates low amplitude frequencies of 1/2x (i.e. .5x, 1.5x, 2.5x…) and 1/3 x also.
3. Presence of 1/2x will indicate more advanced looseness problems like presence of rub. It indicate other problems like unbalance and misalignment.
4. Phase measurement will be *erratic*.
5. Phase for loose rotor will *vary* from one measurement to next.
6. Bearing loose on the shaft will generate *1x RPM* peak.
7. Bearing loose in the housing will generate *4x RPM* peak.

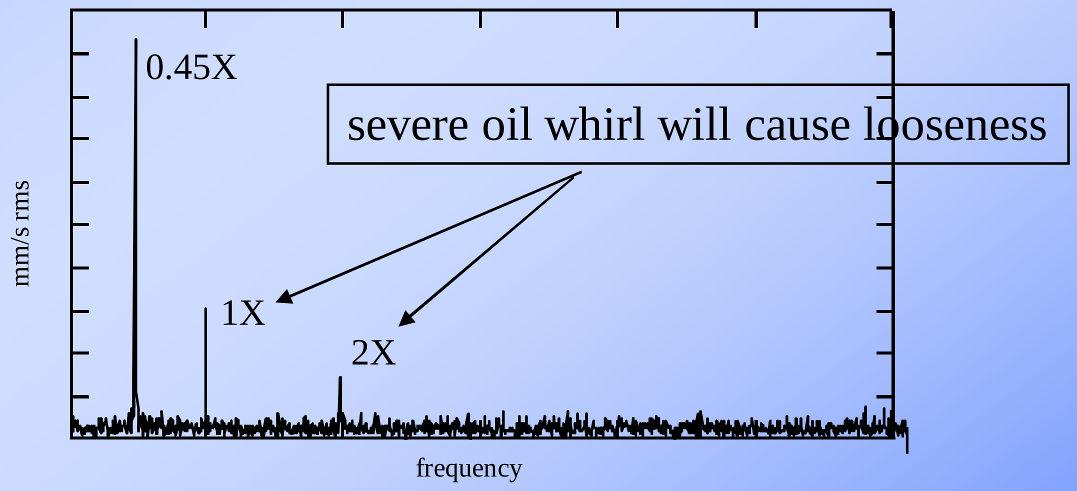
Journal Bearing

Oil Whirl

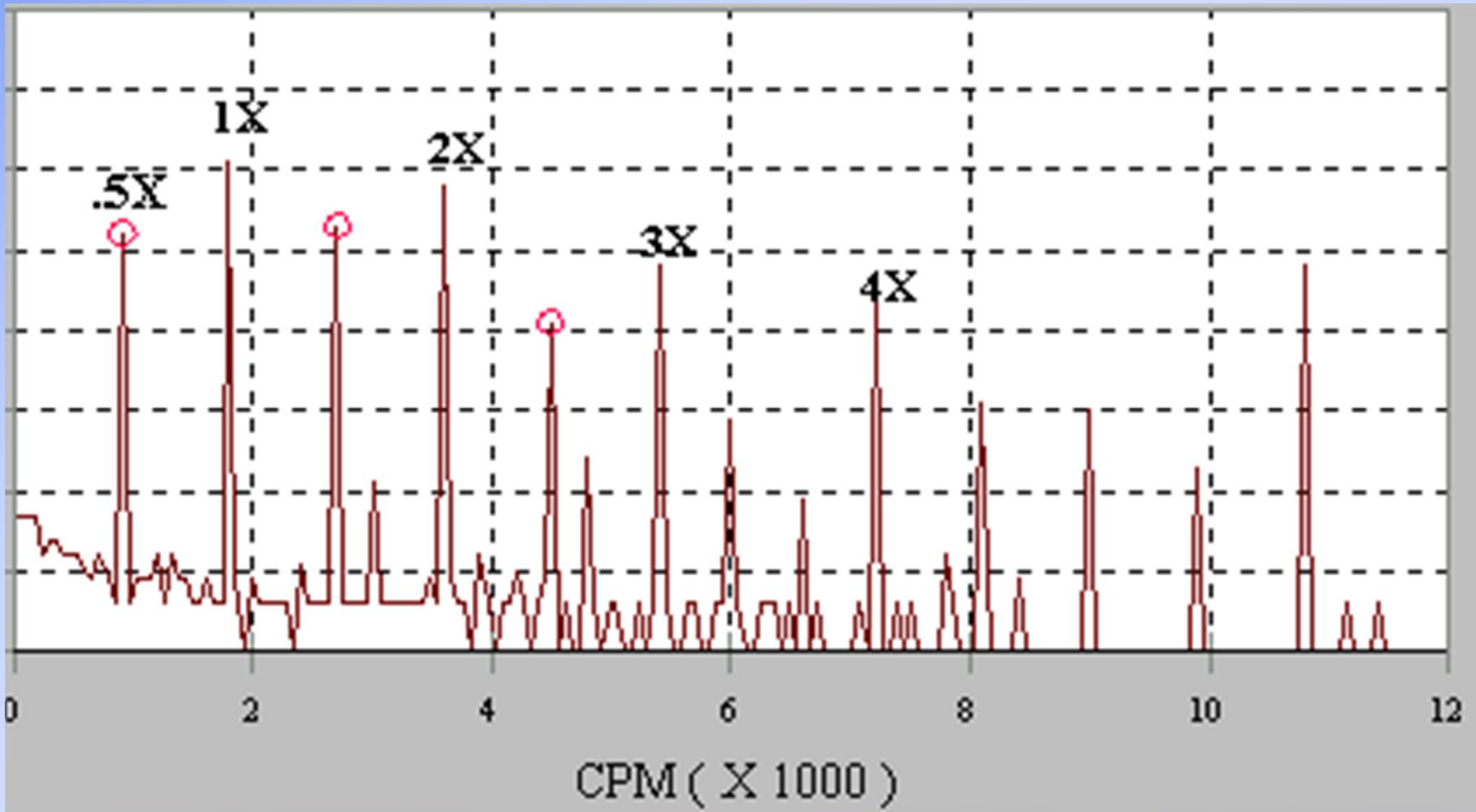


Cause: Excessive clearance and light radial loading. This results in the oil film building up and forcing the journal to migrate around in the bearing at less than one-half RPM.
Oil whirl is a serious condition and needs to be corrected. It can create metal to metal contact.

A symptom peculiar for journal bearings is oil whirl. It shows up as a vibration of approx. 0.42-0.48 X RPM. Oil whirl can be diagnosed by increasing the load which will decrease the subsyncronous vibration.



Journal Looseness (Rotating Looseness)



Rotor Rub

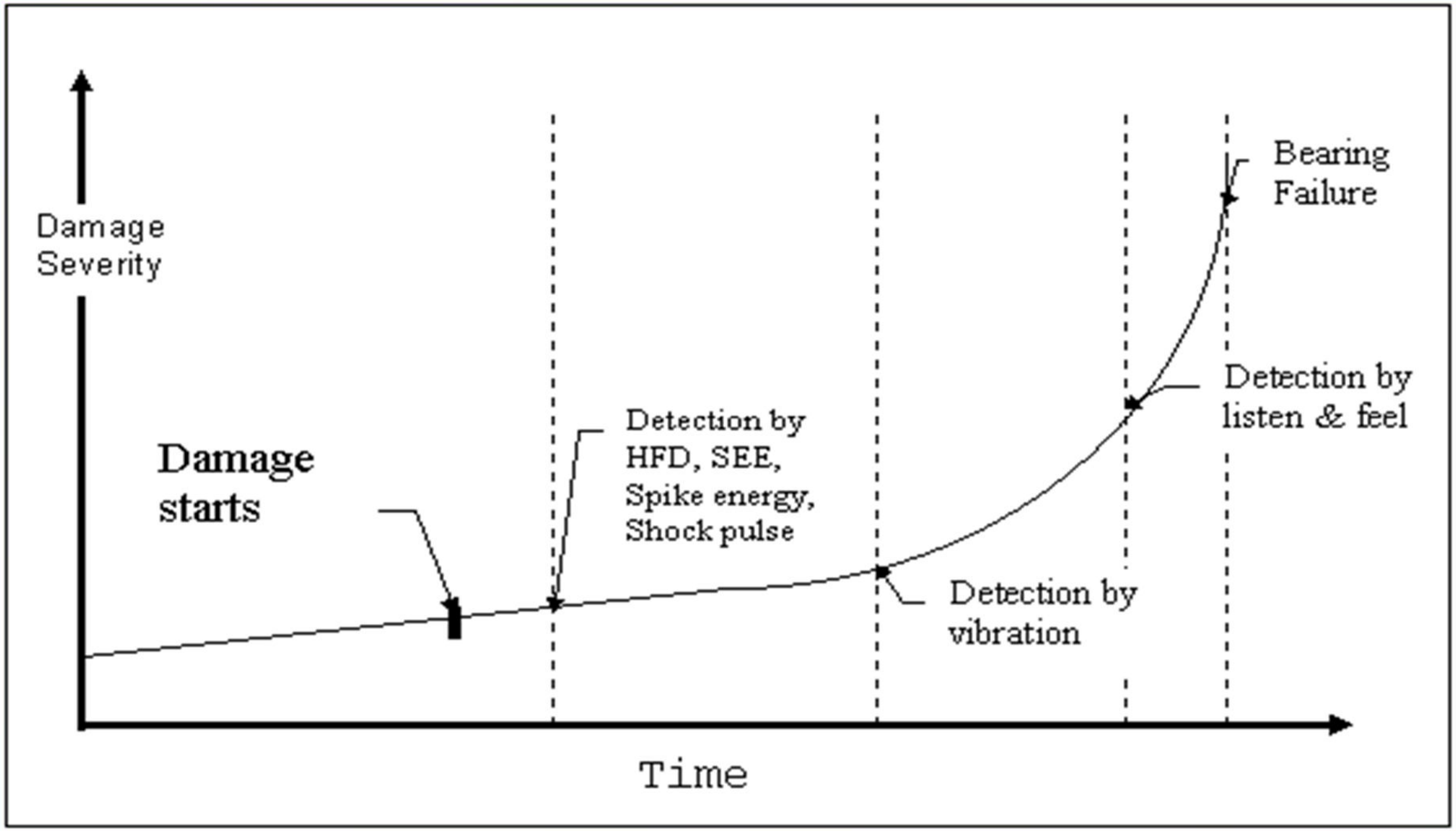
- Spectra similar to mechanical looseness.
- It may be partial or full annular rub.
- Often excites one or more resonances.
- It can excites high frequencies.
- Cascade diagram and shaft orbit are very helpful in diagnosing rubs.

Rolling Element Bearing

Why Does Bearing Fail?

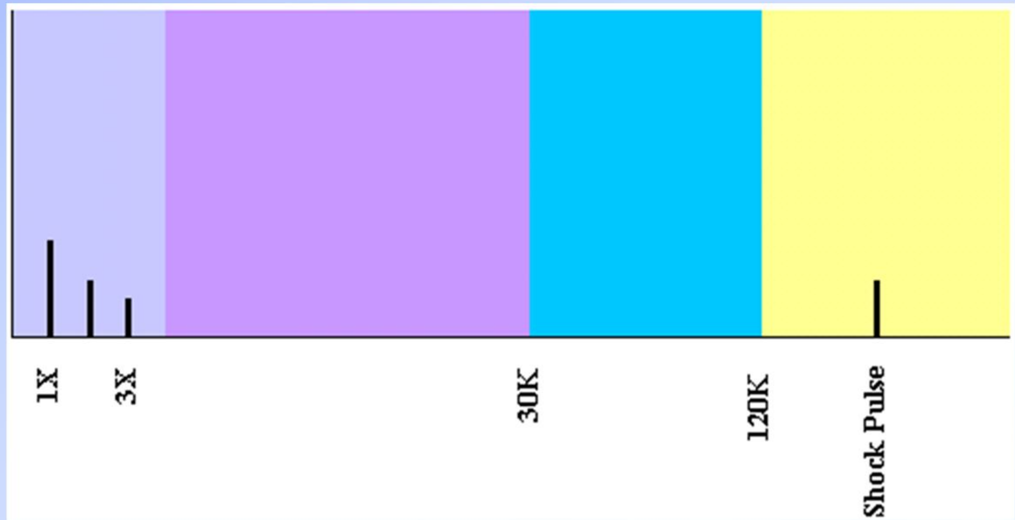
1. Improper lubrication
2. Contaminated lubrication
3. Heavier loading from unbalance, misalignment, bent shaft etc.
4. Improper handling or installation.
5. Old age (Surface fatigue) .

Bearing Failure Detection



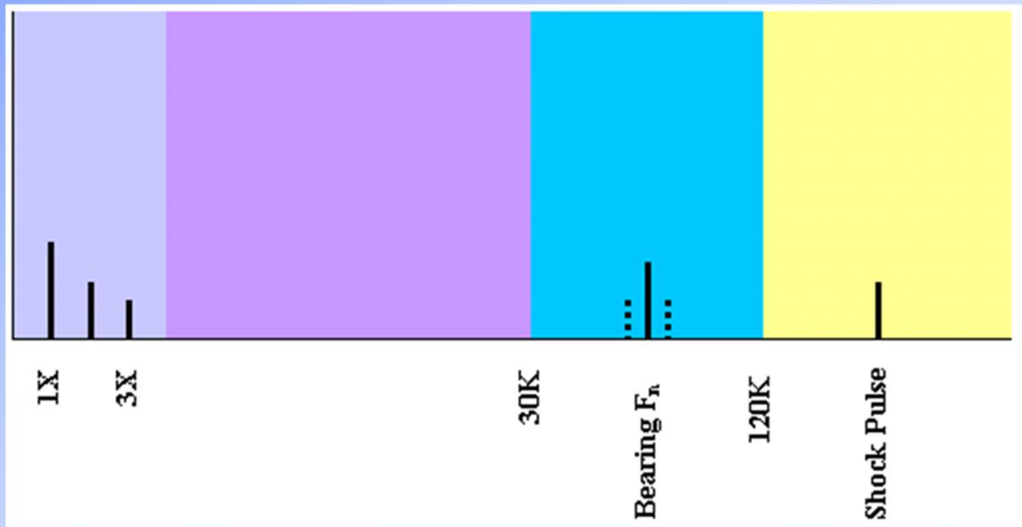
Bearing Failure Stages

Stage - 1



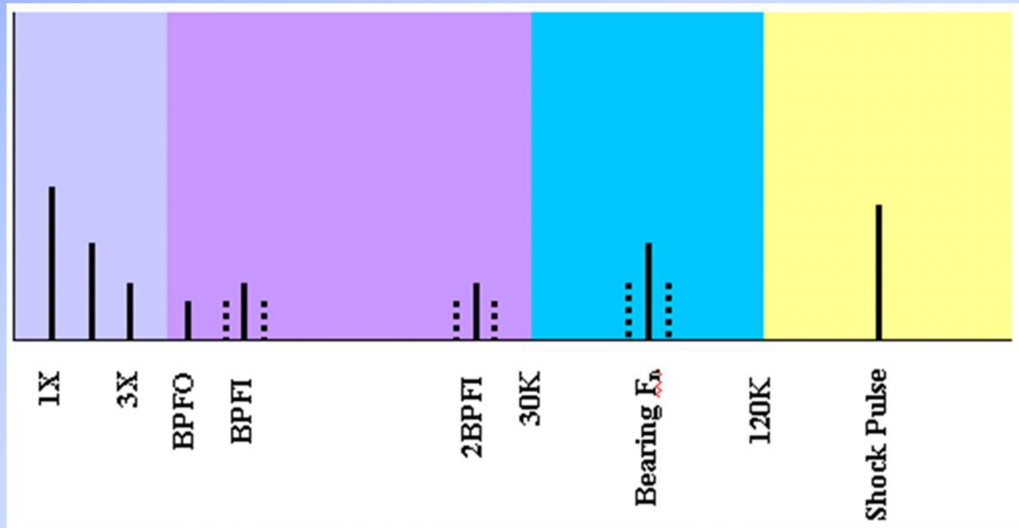
- Earliest indications of bearing problems appear in the ultrasonic frequency ranging from 1,200k to 3,600 kCPM.
- Spike Energy, HFD, and Shock Pulse evaluate these frequencies.

Stage - 2



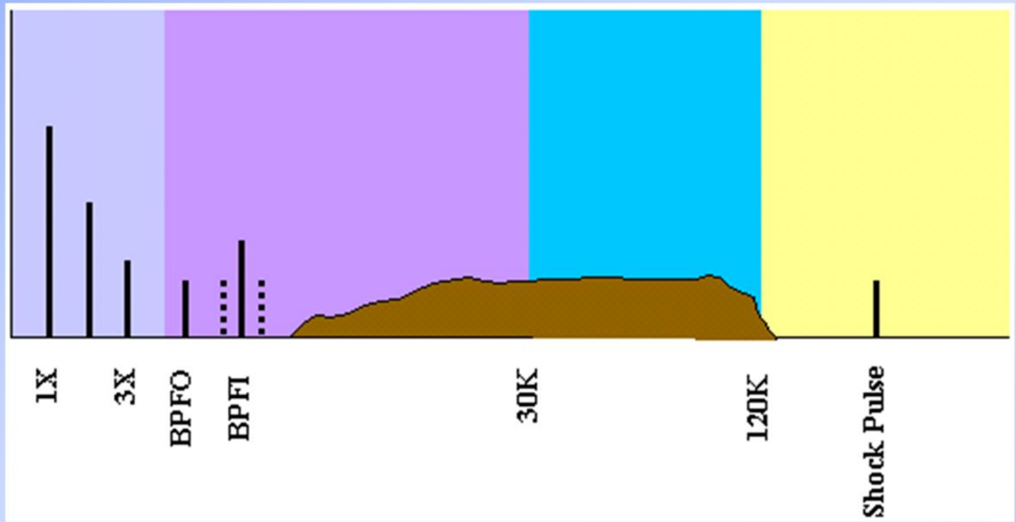
- **Slight bearing defects begin to ring bearing component natural frequencies, which predominantly occur in 30k to 120K CPM range.**
- **Sideband frequencies appear above and below natural frequency peak at the end of stage 2.**

Stage - 3



- Bearing defect frequencies and harmonics appear.
- More defect frequencies appear and nos of sidebands grow, both around these and bearing natural frequencies.
- When well-formed sidebands accompany bearing defect frequency harmonics
- Bearing has to be *replaced.*

Stage - 4



Towards the end-

- **Amplitude of 1X and other running speed harmonics will increase.**
- **Discrete bearing defect and component natural frequencies actually begin to disappear and are replaced by random, broad band high frequency noise floor.**
- **Amplitude of both high frequency noise floor and spike energy may decrease, but prior to failure, spike energy will usually grow to excessive amplitudes.**

Rolling element bearings

FTF = *Fundamental Train Frequency*
BSF = *Ball Spin Frequency*
BPFO = *Ball Pass Frequency Outer race*
BPFI = *Ball Pass Frequency Inner race*

$$FTF := \frac{1}{2}\cdot\left(1 - \frac{d}{D}\cdot\cos\Phi\right)\cdot RPM$$

$$BSF := \left(\frac{D}{2\cdot d}\right)\cdot\left[1 - \left(\frac{d}{D}\cdot\cos\Phi\right)^2\right]\cdot RPM$$

$$BPFO := N\cdot FTF$$

$$BPFI := N\cdot(RPM - FTF)$$

RPM = Shaft rotation

d = Rolling element diameter

D = Pitch diameter

N = No. of rolling elements

Φ = Contact angle

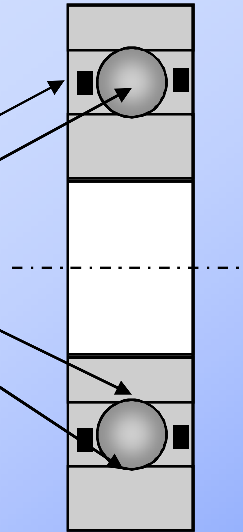
Rolling element bearings

What do the bearing frequencies mean?

If:
FTF = 0.381 * RPM
BSF = 1.981 * RPM
BPFO = 3.047 * RPM
BPFI = 4.952 * RPM

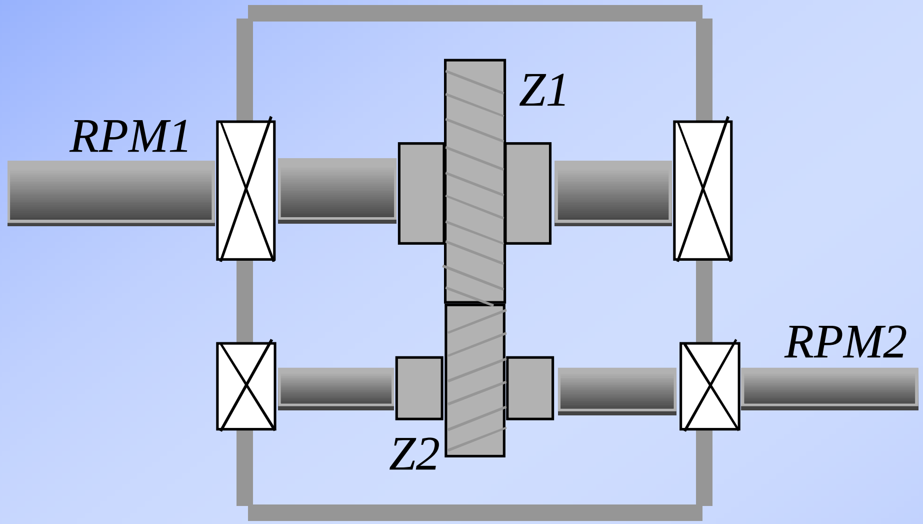
During one shaft revolution:

The cage rotates 0.381 revolutions
The ball spins 1.981 revolutions
4.952 balls pass an inner race defect
3.047 balls pass an outer race defect



Gear Box

Gear box



GMF (Gear Mesh Frequency)

Z1 ·RPM1 = Z2 ·RPM2

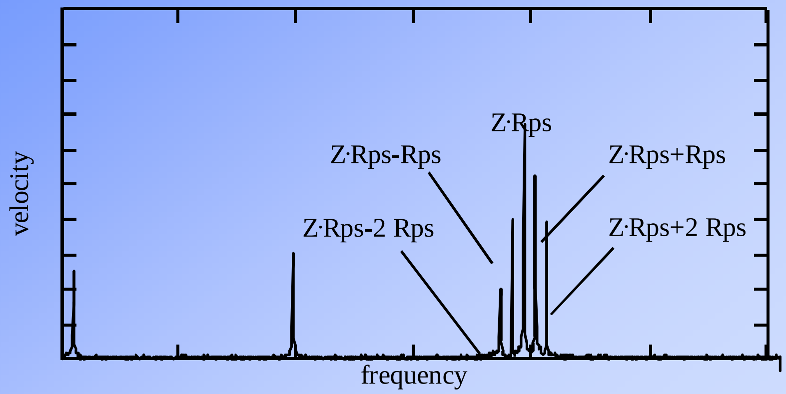
where Z = no. of teeth and RPM shaft speed

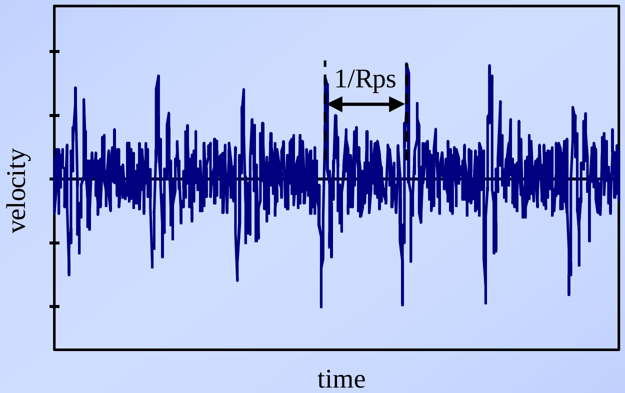
Mating gears produce only one 'Gear Mesh Frequency'

Gear Box Defects

- Tooth wear
- Gear eccentricity & backlash
- Gear misalignment
- Cracked or broken tooth
- Hunting tooth

Gear box



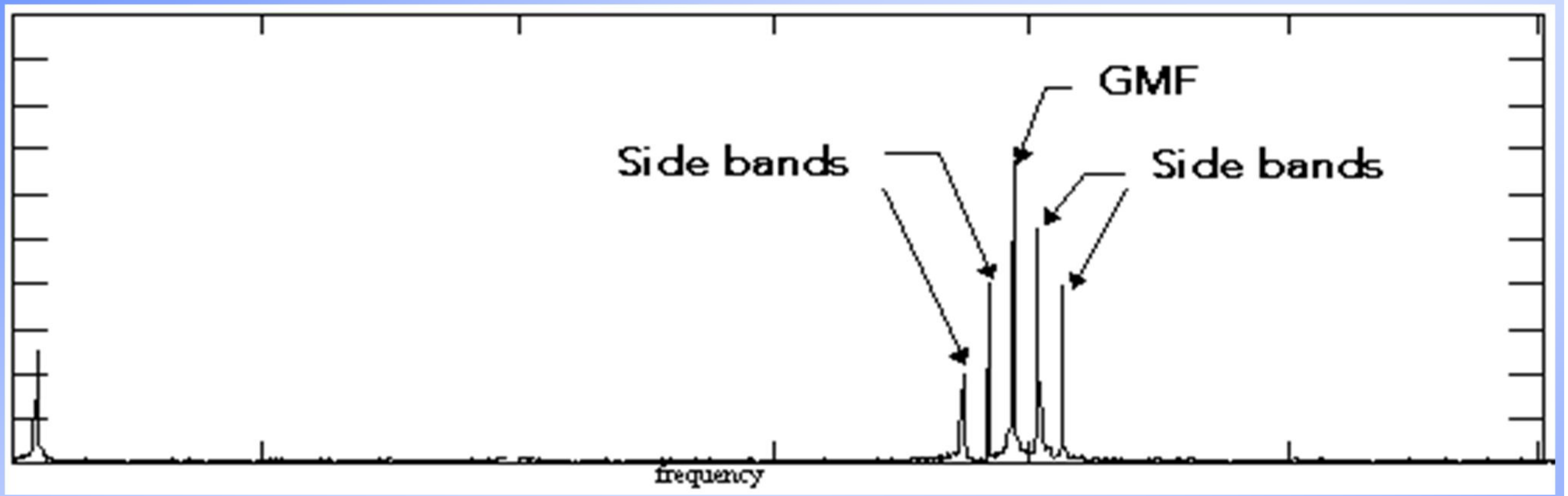


Spur gear produce vibration in radial direction and helical gear produce in radial & axial directions.

Sideband spacing reveals the defective gear or pinion.

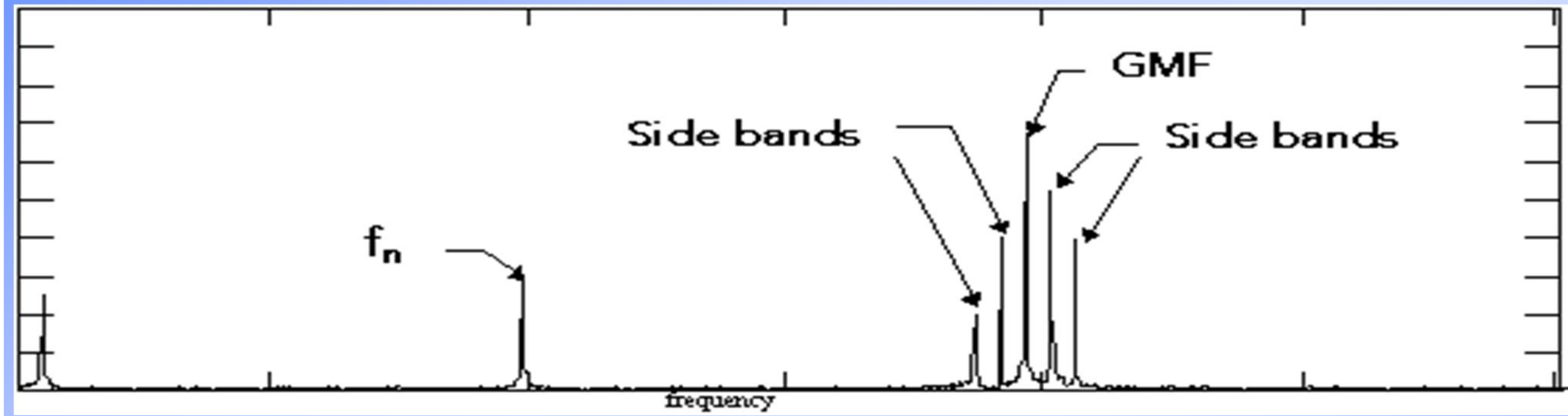
All analysis should be done at maximum load.

Normal Spectrum



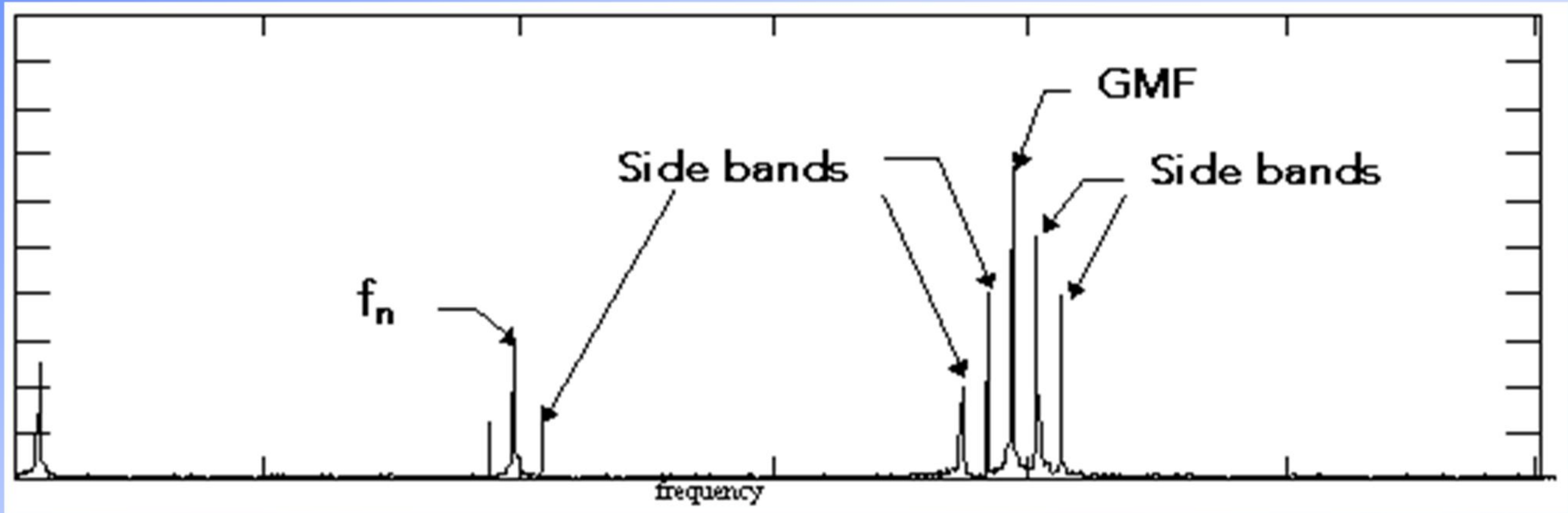
- All peaks are of low amplitudes
- No natural frequency of gear excited

Tooth Wear



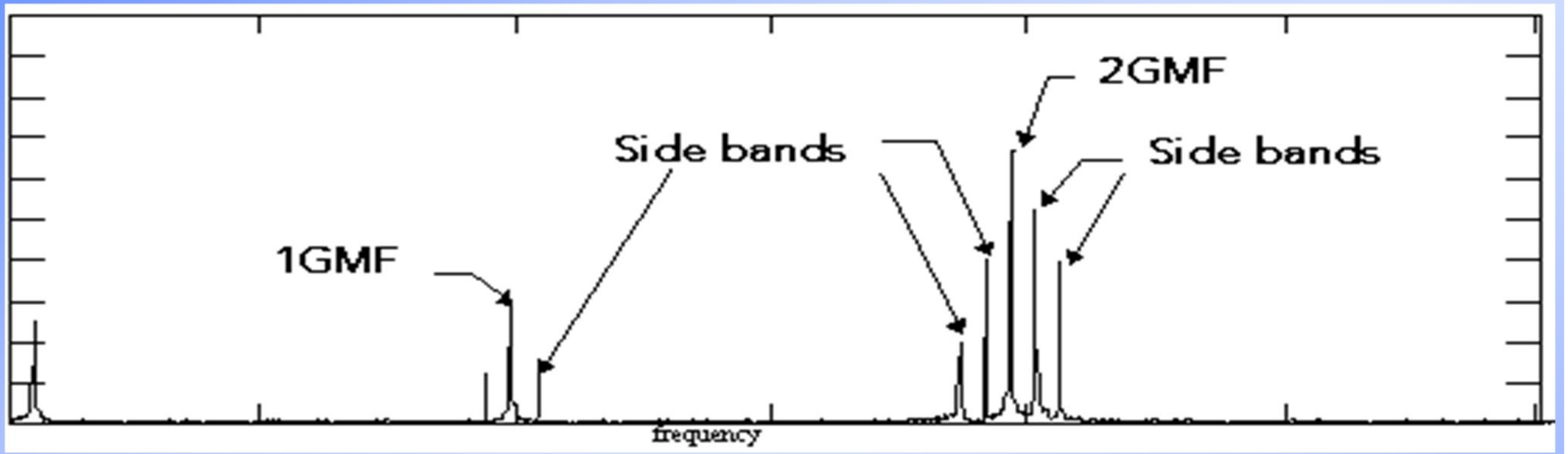
- GMF may not change
- High amplitudes of side bands
- Presence of natural frequency of gear (f_n)

Gear Eccentricity & Backlash



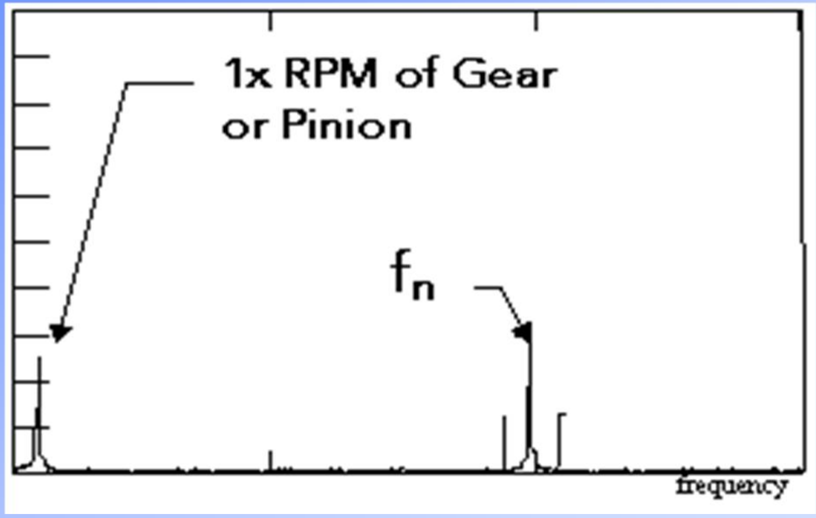
- Excites GMF, f_n & their side bands
- High amplitudes of side bands
- Sideband spacing reveals the defective gear or pinion.

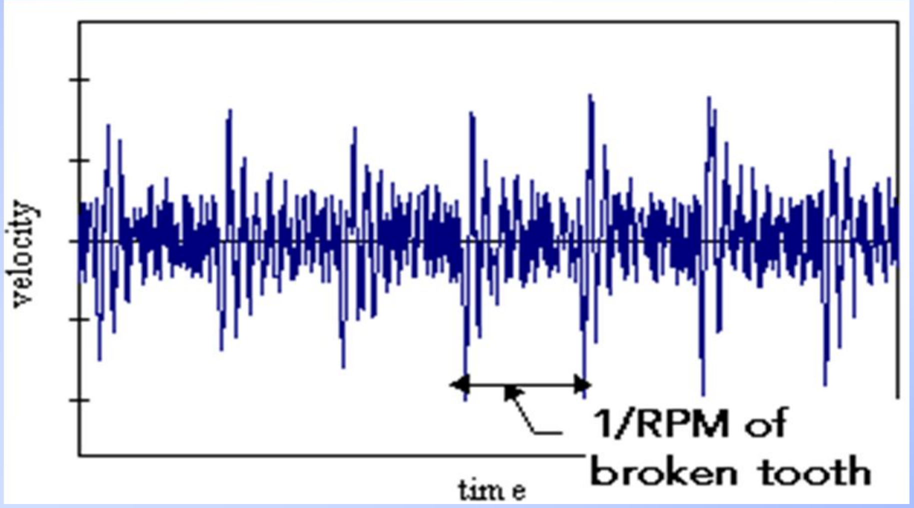
Gear Misalignment



- Excites harmonics of GMF with side bands
- Amplitudes 2GMF or 3GMF higher than 1GMF

Cracked / Broken Tooth





- High amplitudes of 1x RPM of gear or pinion
- Excites gear natural frequency.
- Time waveform indicates spikes at 1/RPM of broken or cracked tooth.
- Amplitudes of impact spikes in time waveform will be higher than that of 1xRPM in FFT.

Hunting Tooth

1. Faults on both gear & pinion occured during manufacturing.
2. Causes high vibration at low frequencies (less than 600CPM)
3. Gear set emits growling sound.

Hunting Tooth Frequency

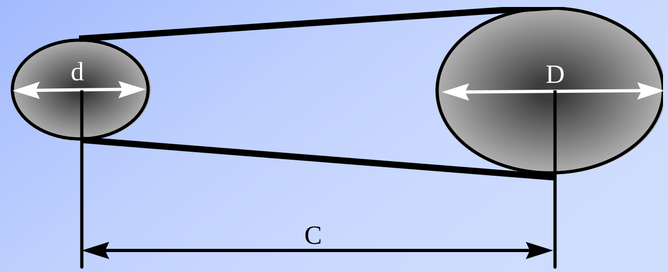
It is the rate at which a tooth in one gear mates with a particular tooth in the other gear.

For well designed gearboxes HTF is low.

HTF = GMF · (lowest common prime factor) /(Z1·Z2)

Ex:
Z1 = 63, Z2 = 12
Z1 = 63 = 7·3·3
Z2 = 12 = 3·2·2
lowest common prime factor = 3
HTF = GMF. 3 / (63.12) = GMF / 252

Belt Drive



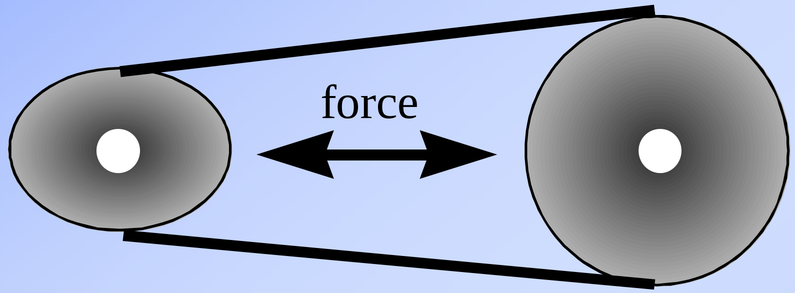
BF (Belt Frequency) = Rps·π·D / L

BF is the rotational frequency of the belt. Worn or mismatched belts will produce radial vibration at BF and its harmonics. 2·BF is often dominant with 2 sheaves in the system. BF is a subsyncronous vibration (below 1X).

$$L \approx 2C + 1.57(D+d) + \frac{(D-d)^2}{4C}$$

Belt Drive

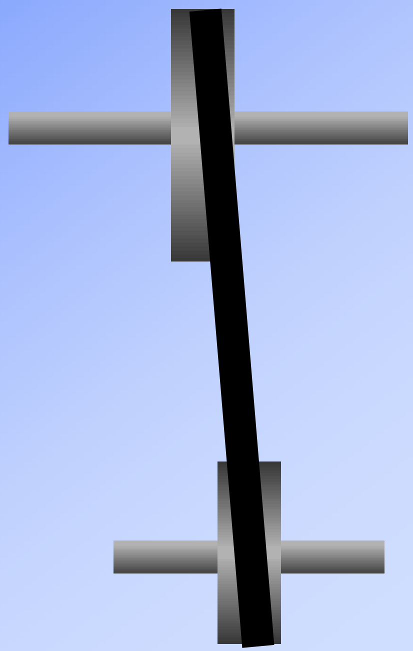
Eccentric sheaves



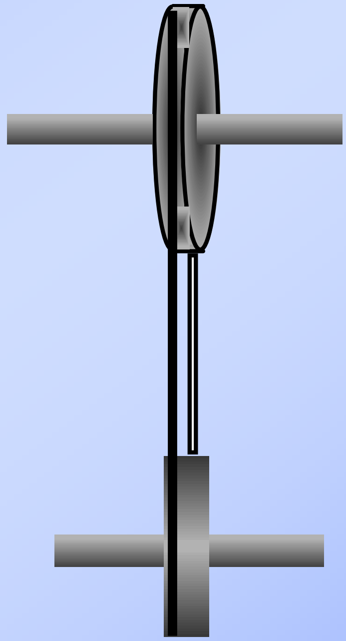
Eccentric sheaves will generate strong 1X radial components.
A common condition.
Looks like unbalance, but shows at both sheaves.

Belt Drive

Sheave misalignment



Off-set



Angular

Axial vibrations at 1X and BF with harmonics.

Fans

***Fan Blade Pass Frequency = RPM x no. of fan blades* (FBPF)**

Mainly radial vibrations

FBPF with 1X RPM sidebands.

Unbalanced horizontal or axial vibrations.

Inadequate blade clearance (at FBPF or RPM harmonics)

Uneven velocity distribution across fan inlet gives FBPF vibrations

Pumps

Vibration signature depends upon operating condition.

pressure, temperature, speed, cavitation….

☞Centrifugal pumps

at Vane Pass Frequency = RPM · no. of impeller vanes and harmonics.

☞Gear pumps

at Gear Mesh Frequency and 1X sidebands

☞Screw pumps

at thread rate = RPM · number of threads and its harmonics.

Electrical Motors

AC Motors

Asyncronous AC motors
Running speed:

$$RPM_{sync} = \frac{120}{p} \cdot f$$

where p = number of poles
f = line frequency

If no. of poles = 2.
The motor will have a sync. RPM of 3000

$$f_s = RPM_{sync} - RPM$$

where fs = slip frequency

AC Motors

☞All electrical machines vibrates at 2 · line frequency.

☞The reasons are expanding and collapsing magnetic fields.

☞This vibration is normal (to a degree).

☞The amplitude is a measure of the quality of the construction.

AC Motors

Coast Down Test

Vibration suddenly drops down after switching off the power

AC Motors

Faults possible to detect with vibration analysis:

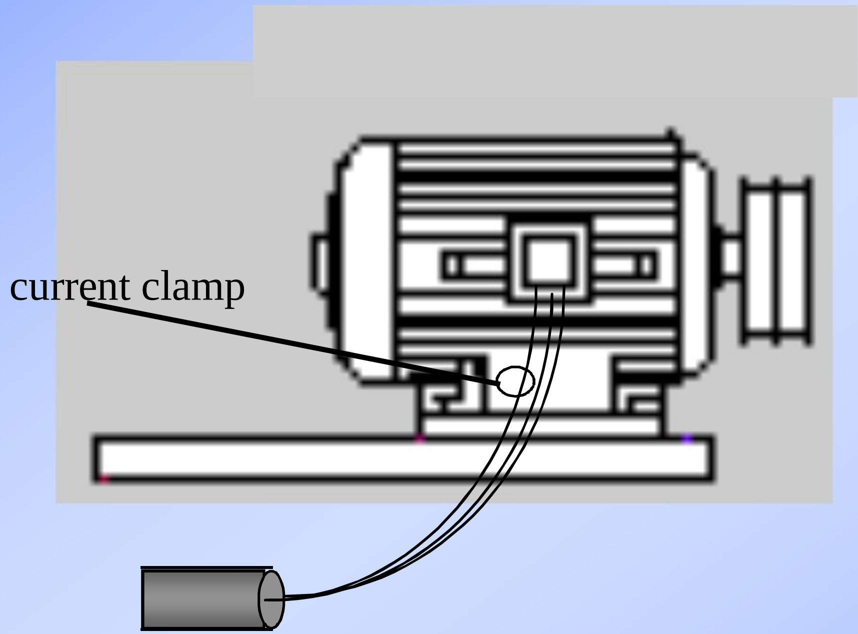
Rotor thermal bow
Air gap eccentricity
Loose rotor
Eccentric rotor
Loose windings

Necessary data:

No. of stator slots	(SPF)
No. of rotor bars	(RBPF)
Line frequency	(LF)
Slip frequency	(SF)

AC Motors

Frequency analysis of input current



In order to find 2 X slip sidebands around F_L, a analyzer with high resolution, and preferably zoom around 50 Hz is needed.

D.C. Motor

Faults possible to detect with vibration analysis:

- **Broken field winding**
- **Bad SCRs**
- **Loose connections**
- **Loose or blown fuses**
- **Shorted control cards**

Identification

For 3 phase rectified D.C. motors

- **Broken field winding, Bad SCRs, Loose connections**

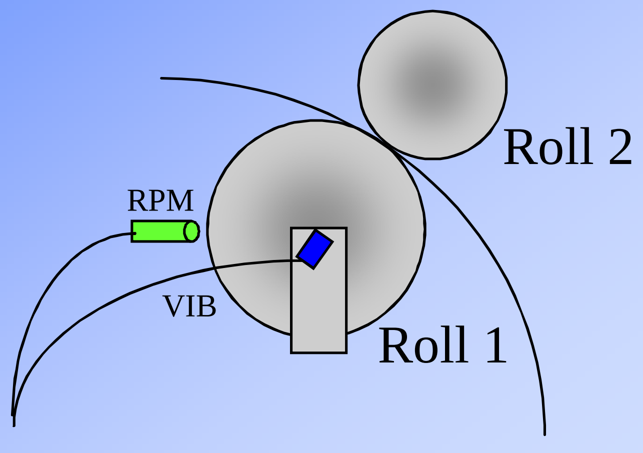
  Peaks at $6.L_F$

- **Loose or blown fuses, Shorted control cards**

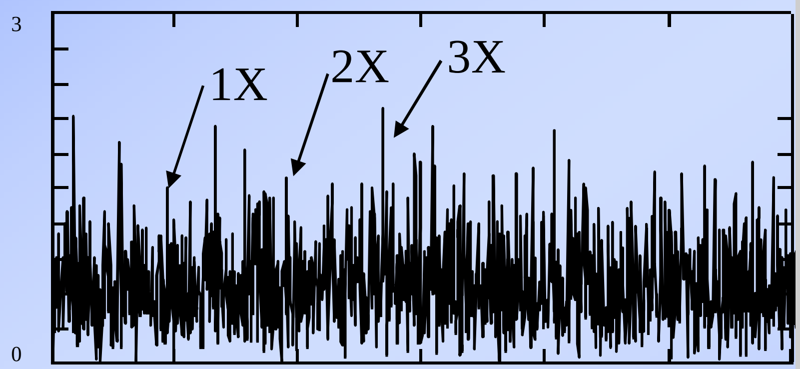
  Peaks at $1.L_F$ to $5.L_F$

Synchronous time averaging

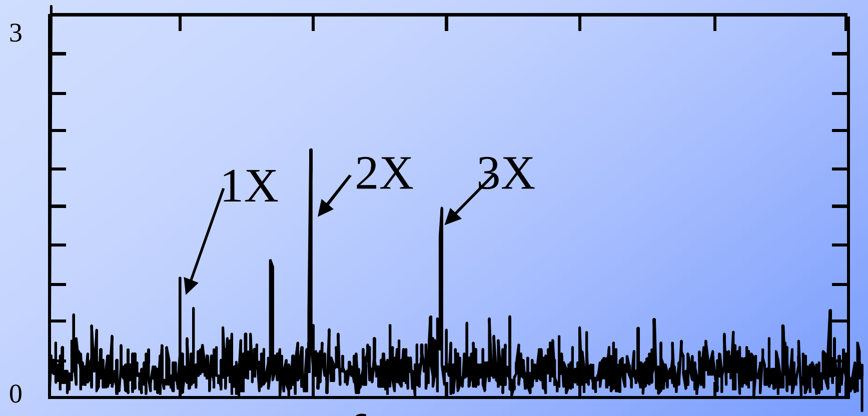
-suppresses vibrations not synchronous with the measured object.



Sampling always starts at ’tacho signal’ from roll 1.



One measurement



Average of 10 measurements

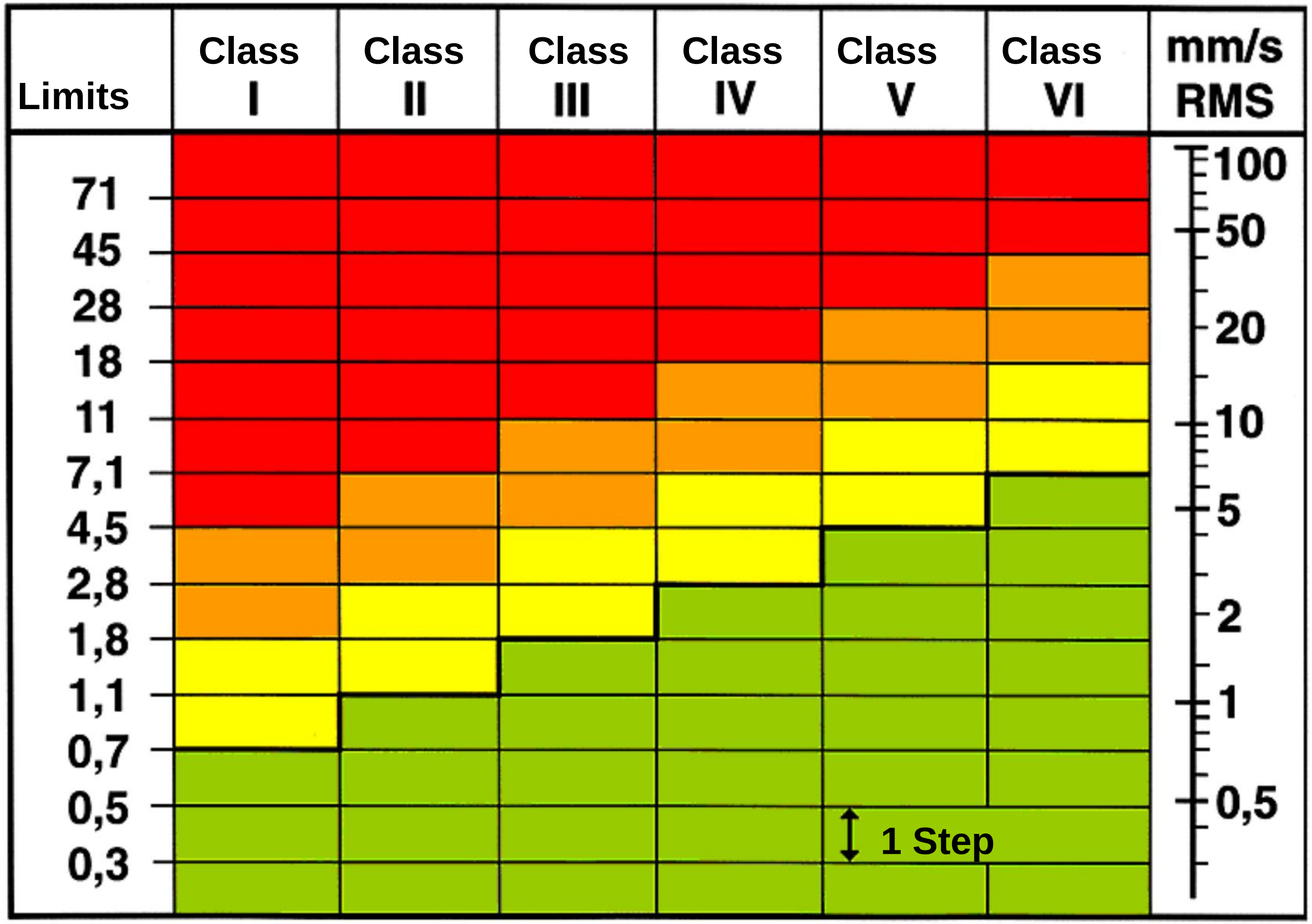
Enveloping

Detects low amplitude high frequency repetitive bearing or gear mesh defects.

These defects emit repetitive low energy impact signals that are highly pulse shaped and of very short duration. They generate harmonics in the very high frequency ranges.

These techniques filter out low frequency vibration energies and therefore isolate & emphasize specific high frequency signals.

ISO 2372


Limits
Class I
Class II
Class III
Class IV
Class V
Class VI
mm/s RMS
71
45
28
18
11
7,1
4,5
2,8
1,8
1,1
0,7
0,5
0,3
100
50
20
10
5
2
1
0,5
1 Step

Case - 1 Pump Impeller Wear

Summary

This case documents a 100 hp monitored over a period of 2 years (1500 rpm).

An increase of overall vibration levels and spectrum showed high vane pass levels of 3 x RPM.

The pump has – 3 vanes on the impeller and an internal inspection indicated impeller wears.

Impeller changed and both the overall levels of vibration and the vane pass frequency returned to normal, acceptable levels.

Analysis

Overall Vibration Levels:

Overall vibration levels were on the boarder line of being in an alarm state for several months and remained stable, it was decided to monitor closely. Then suddenly overall vibration levels jumped to 0.95 inch/sec ie 390 % change.

Vibration Spectrum :

The frequency spectrum collected from the pump inboard bearing shows a predominant peak at a frequency of 3000 rpm. The spectral plot showing the historical growth in amplitude of this predominant peak.

It is noted that the machine deterioration appears more severe on the basis of overall readings than on the basis of the frequency spectrums.

One possible explanation for the observation is that there was an increase in vibration amplitudes at frequencies beyond the range.

Theoretical Consideration:

Problems with blades and vanes are usually characterized by high vibration or near the harmonic frequency corresponding to the rotation speed X No. of blades. Blade pass frequency usually exists in normal operating machines, but harmonics usually indicates problem.

Problem Diagnosis:

The data collected pointed towards the pump impeller as the source of high vibrations because of dominant peaks at the blade pass frequency as well as growing side band harmonics.

Results

Corrective Action:

The pump impeller was removed and replaced.

Findings:

Overall vibration reading taken after repair amplitudes significantly reduced.

Conclusions

The objective of this case was to demonstrate the concept that the blade pass frequency (No. of blades x shaft speed) and surrounding harmonics gives an indication of impeller condition. This case over all vibration increases trend stopped the machine and changed impeller.

Vibration signature of the pump took on a new shape without high amplitudes at blade pass frequency and the overall vibration levels returned to acceptable levels.

