

***ON-LINE CONDITION MONITORING
OF MOTORS USING
ELECTRICAL SIGNATURE ANALYSIS***

WHAT IS ELECTRICAL SIGNATURE ANALYSIS?

Electrical Signature Analysis is the procedure of capturing a motor's current & voltage signals and analyzing them to detect various faults

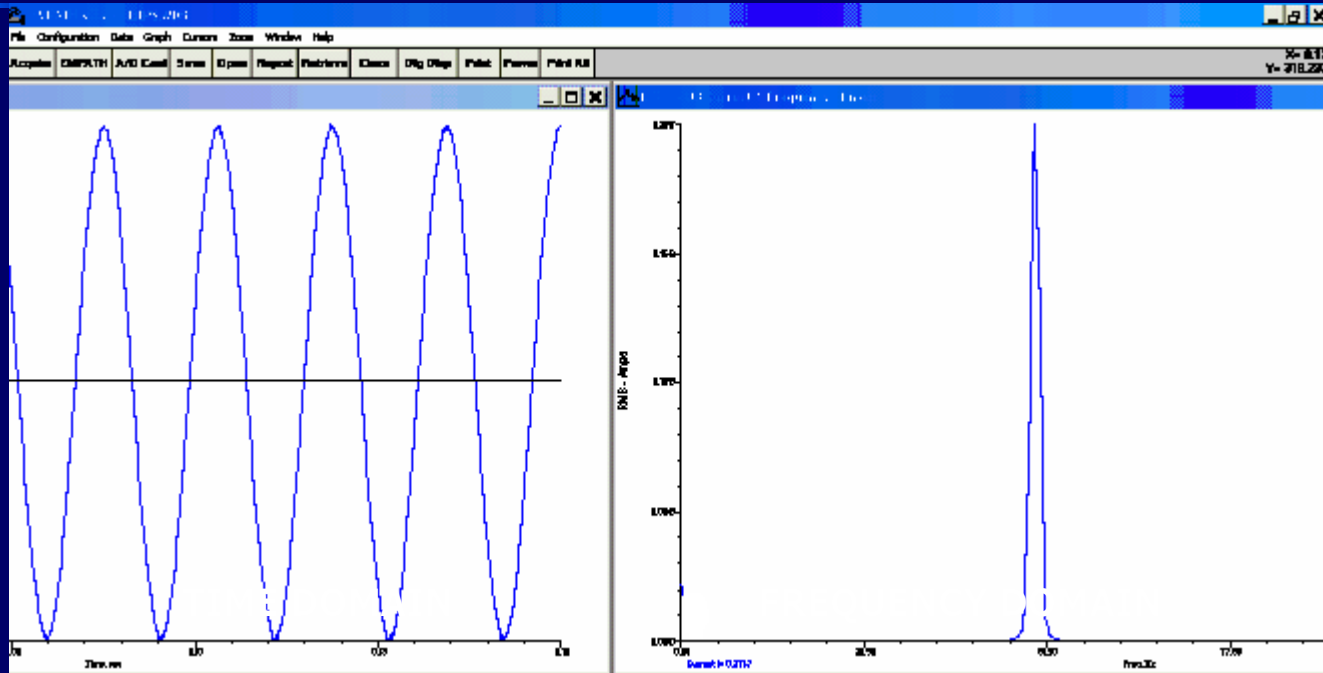
ADVANTAGES OF ELECTRICAL SIGNATURE ANALYSIS

- **On-line**, no stoppage required
- **Remote monitoring**, no need to approach the motor
- **Accurate detection** of electrical & mechanical problems
- Works with induction, synchronous & DC motors & generators as well as VFDs
- Proven technology, been **around for 20 years**
- Over **1000 motors analyzed** in India alone

What faults can electrical signature analysis detect?

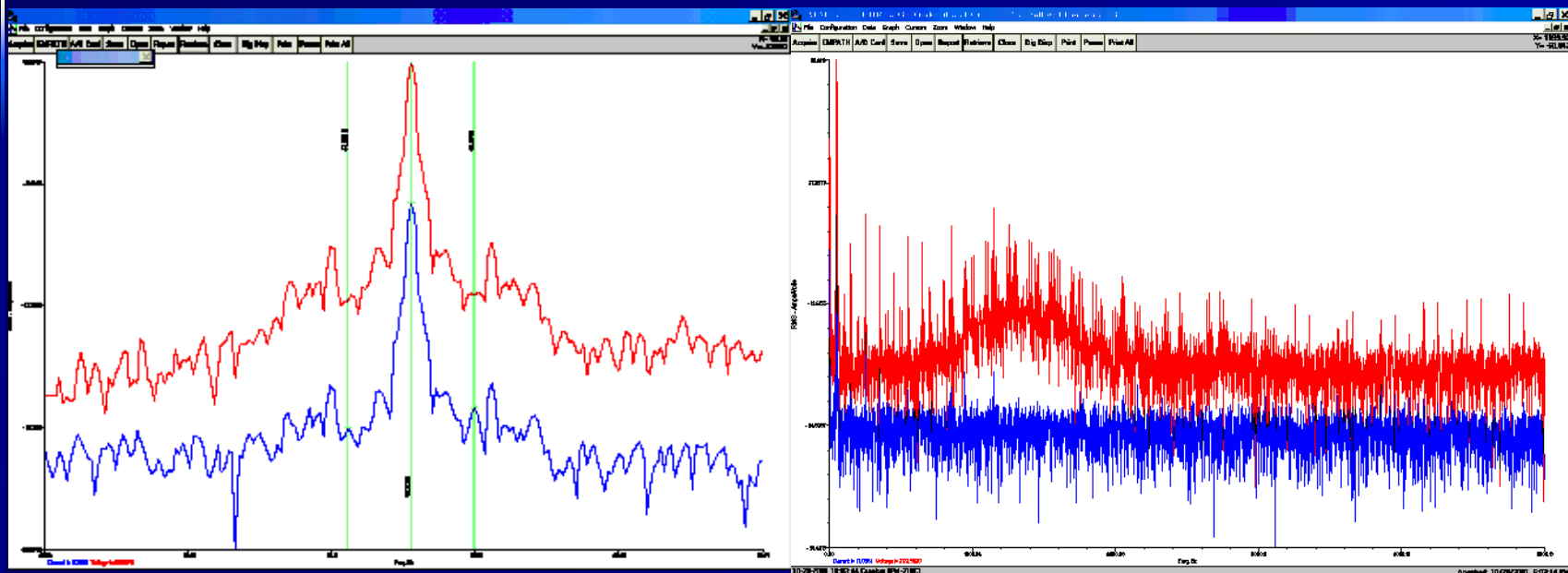
- Rotor bar damage
- Misalignment/ unbalance
- Foundation looseness
- Static eccentricity
- Dynamic eccentricity
- Stator mechanical faults
- Stator electrical faults
- Defective bearings

What is an electrical signature?



Representation of the current & voltage in the frequency domain, where $f = 1/t$

How does a healthy motor's signature appear?



Low frequency spectrum (0-200 Hz)

High frequency spectrum (0-5000 Hz)

Why are there so many peaks in the signature?

- **Power supply is not a pure sine wave, hence harmonics are present in both voltage & current**
- **Motor & load problems also generate harmonics, which show up in the current spectrum only**

How does signature analysis work?

- **The frequency spectrum enables us to see all the harmonic components of V & I**
- **All electrical & mechanical faults change the flux distribution inside the motor & hence generate harmonics in the current**
- **Superimposing the current & voltage spectra enables us to distinguish between the supply harmonics & the fault harmonics**
- **The harmonics generated by each fault will be different**
- **Thus, studying the distribution of these fault harmonics enables identification of the fault**

What are the low & high frequency spectra used for?

Low frequency

- Rotor bar degradation
- Misalignment
- Mechanical unbalance
- Foundation looseness

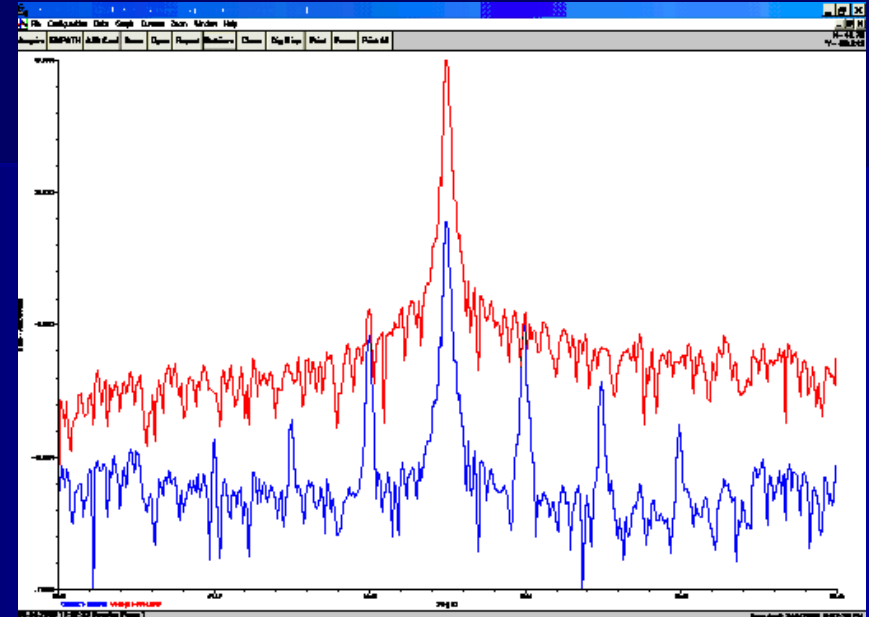
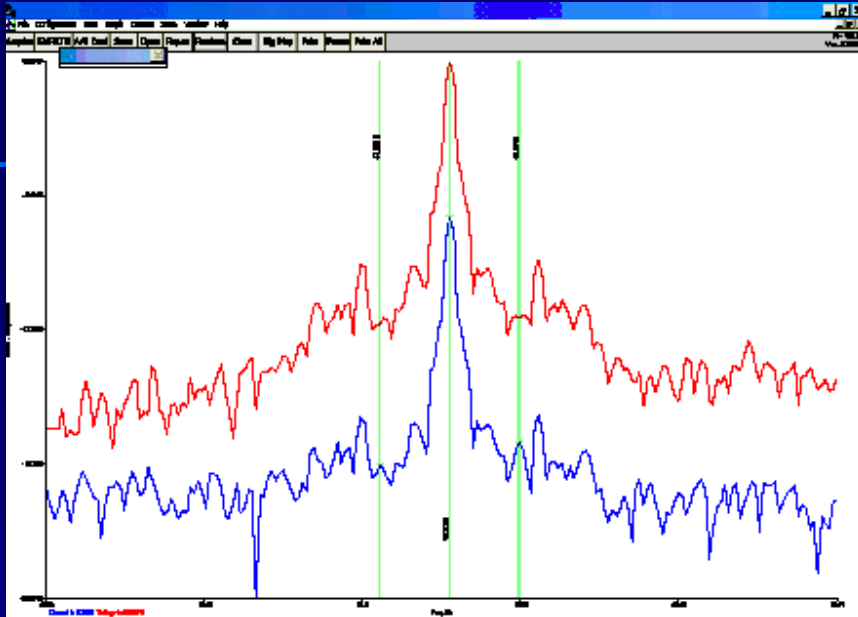
High frequency

- Static eccentricity
- Dynamic eccentricity
- Stator mechanical faults
- Stator electrical faults
- Bearing degradation

How are the current & voltage signals captured?

- **Clamp-on probes are placed around the supply cable for LT motors and around the measuring or protection CT secondary for HT motors**
- **Voltage leads are attached to the supply terminals for LT motors & at the bus PT secondary for HT motors**
- **All testing is thus done at the MCC or the motor control panel. No need to approach the motor!**

ROTOR BAR DEGRADATION

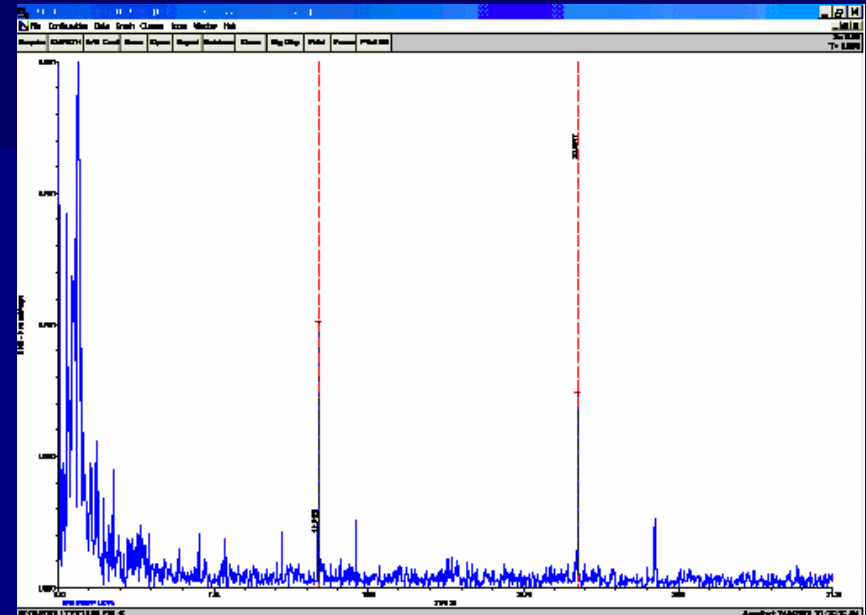
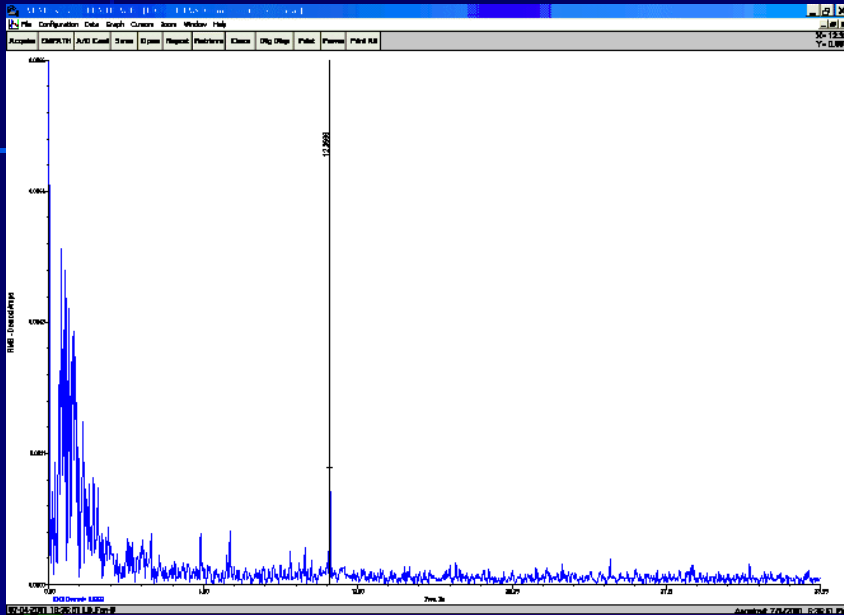


- The pole pass frequency ($PPF = \text{slip} \times \text{no. of poles}$) appears as a sideband in current
- Increase in the rotor impedance due to high resistance joints or broken bars leads to an increase in the PPF amplitude
- Difference in amplitudes of the line frequency & the PPF is an indication of the condition of the rotor

ROTOR BAR DAMAGE SEVERITY LEVELS

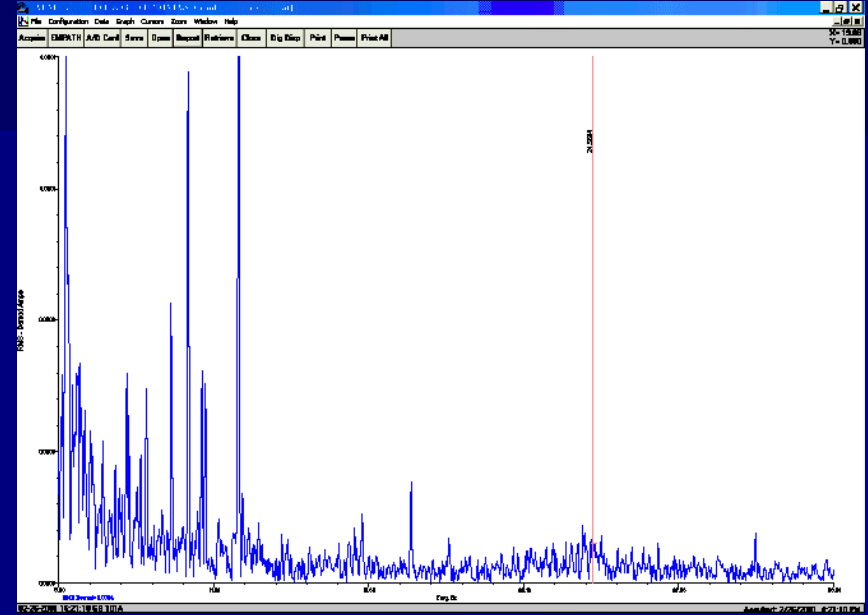
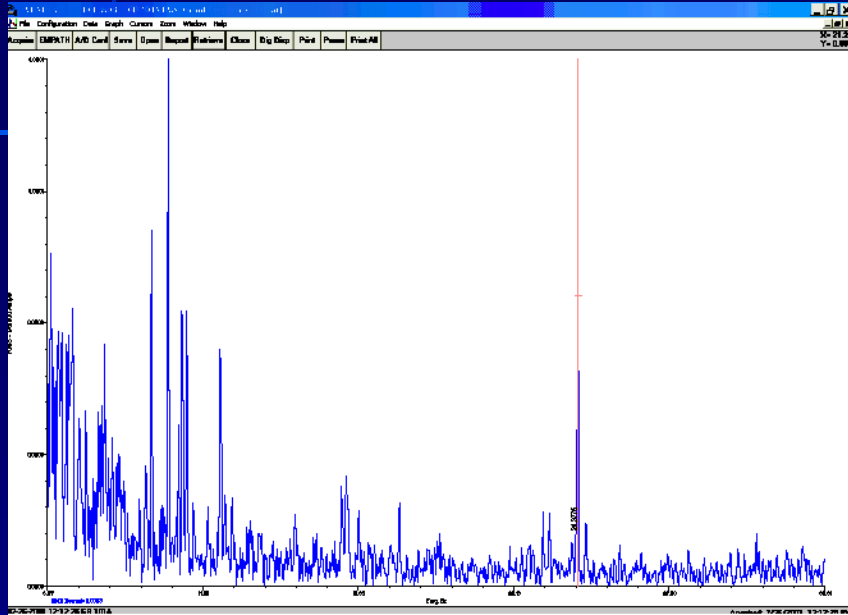
Severity level	FL / FP (dB)	FL / FP (Ratio)	FP / FL (Ratio %)	Rotor Condition Assessment	Recommended corrective action
1	>60	>1000	<0.10	Excellent	None
2	54-60	501-1000	0.10-0.20	Good	None
3	48-54	251-501	0.20-0.40	Moderate	Trend data
4	42-48	126-251	0.40-0.79	Rotor bar crack may be developing problems with high resistance joints	Increase trending frequency
5	36-42	63-126	0.79-1.58	One or two rotor bars likely cracked or broken	Perform vibration test to confirm source & severity
6	30-36	32-63	1.58-3.16	Multiple cracked or broken rotor bars	Repair ASAP
7	<30	<32	>3.16	Multiple cracked or broken rotor bars & end-rings	Repair or replace ASAP

MISALIGNMENT / UNBALANCE



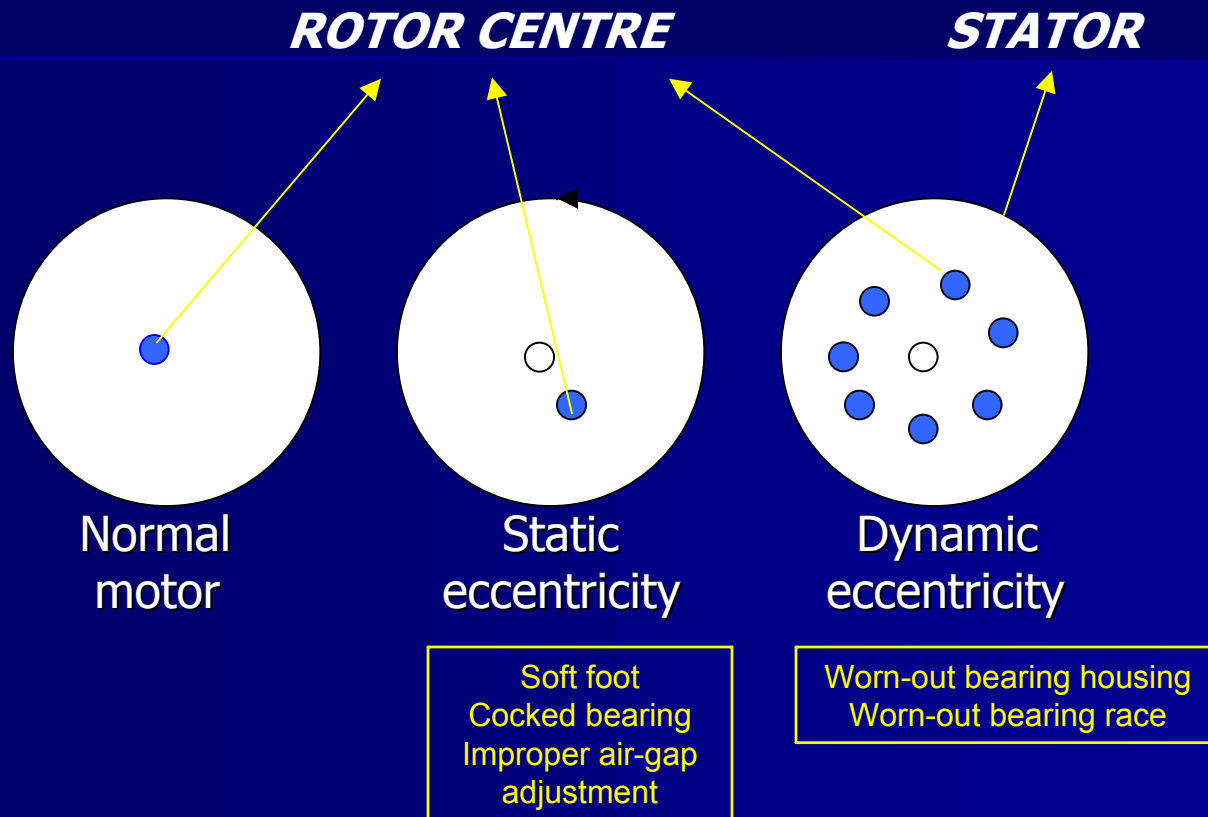
- The motor running speed (RS) is always visible as a peak in the Demodulated spectrum
- A high amplitude of the RS peak indicates misalignment or unbalance
- The RHS spectrum is of a misaligned 380 KW, 6.6 KV motor at Indian Aluminium, Hirakud

FOUNDATION LOOSENESS



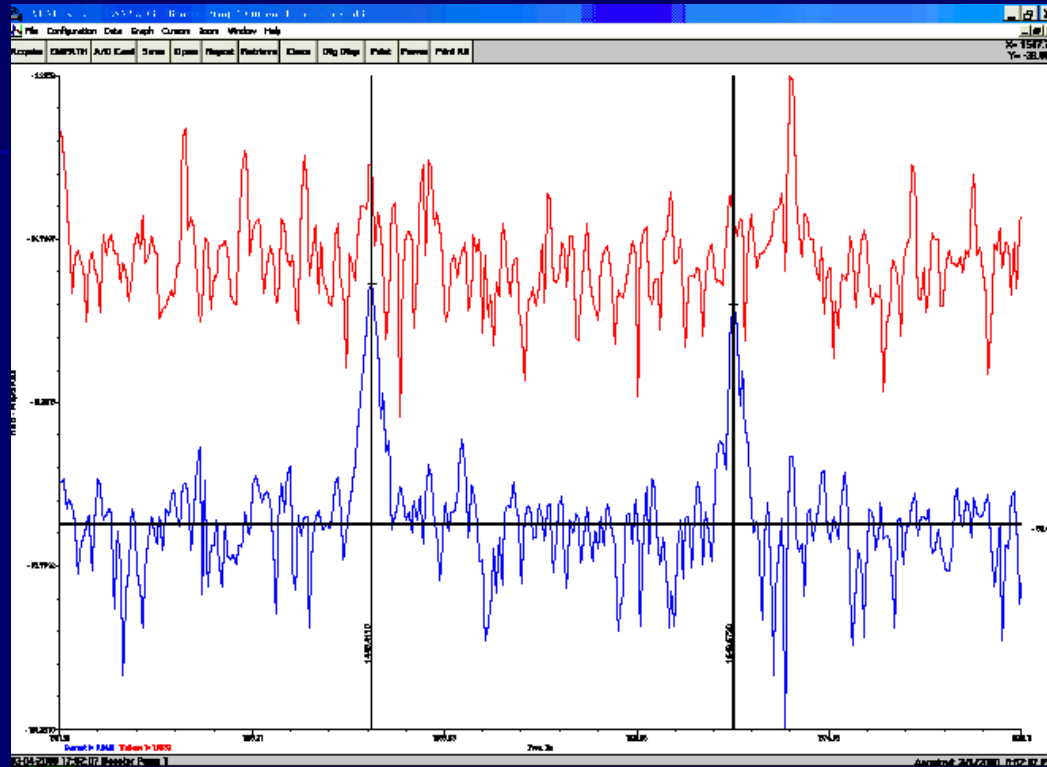
- In case of foundation looseness, a significant peak appears at $\frac{1}{2}$ the running speed of the motor
- The LHS spectrum shows a 650 KW, 3.3 KV motor at RCF, That that had severe vibration
- The RHS spectrum shows the same motor's spectrum after the foundation was tightened

ECCENTRICITY



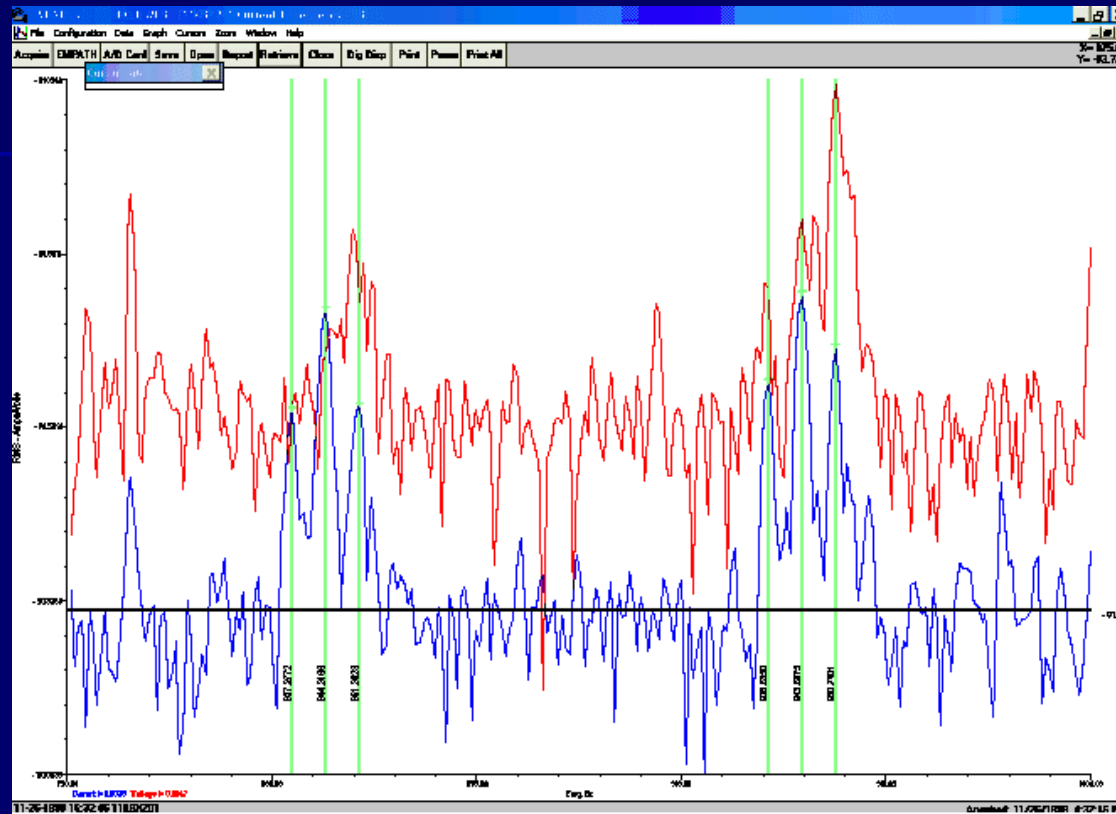
Eccentricity is the phenomenon of an uneven stator-rotor air-gap

STATOR MECHANICAL FAULTS



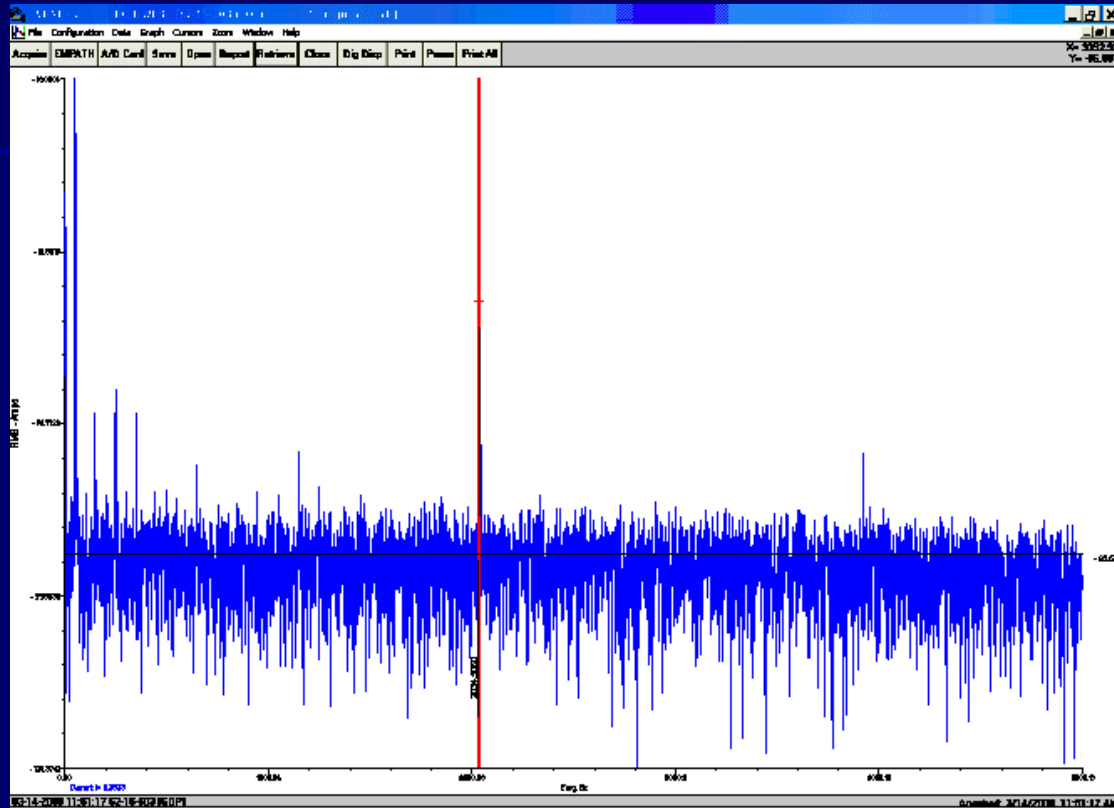
Typical spectra of a 410 KW, 6.6 KV motor with core damage (Essar Steel)

STATOR ELECTRICAL FAULTS



Typical spectra of an 1100 KW, 6.6 KV motor with degraded interturn insulation (IPCL, Baroda)

DEFECTIVE BEARINGS



Typical spectrum of an 250 KW, 6.6 KV motor with a defective bearing (IPCL, Baroda)

ADDITIONAL APPLICATIONS

GENERATORS

- Stator core degradation
- Stator winding degradation
- Rotor winding shorts

DC MOTORS

- Armature faults
- Commutator faults
- Faults in the firing circuitry

VARIABLE FREQUENCY DRIVES

- Power analysis
- Harmonic distortion
- Faults in the firing circuitry

ELECTRICAL SIGNATURE ANALYSIS SUMMARY

- On-line, non-intrusive method
- Detects all kinds of faults
- Automated diagnostic package available
- Existing service users include NPCIL, IPCL, Grasim, L & T, Reliance, Tatas, etc.

***DO NOT CONFUSE IT WITH ITS POOR COUSIN
CURRENT SIGNATURE ANALYSIS!!!!***

EMPATH

Electric Motor Performance Analyzing & Trending Hardware



A FEW WORDS ABOUT US

Integrated Predictive Maintenance Services

- Electrical Signature Analysis
- Vibration Analysis
- Acoustic Emission Analysis
- Tan Delta & Capacitance Analysis
- DC Absorption Analysis
- Interturn Surge Analysis

Condition Monitoring Instrumentation

- Electrical Signature Analyzers
- Vibration Analyzers
- Acoustic Emission Analyzers
- Motor Circuit Analyzers
- Commutator Profilers
- Vibration training software
- Valve Analyzers

Site Overhaul & Repair Services

- Motors & Generators upto 248 MVA
- DC motors upto 6000 HP
- Transformers upto 50 MVA

CONTACT US

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