# ADVANCE FAULT DIAGNOSTICS OF ELECTRICAL MACHINES

**EE901-E35**

**Credits: 4** **Year: I** **Part: II**

## Course Objectives

To develop advanced level knowledge and skills in condition monitoring, anomaly detection and fault diagnosis of electrical machines and an overview of modern fault diagnostic techniques using IoT, Artificial Intelligence and Machine Learning.

## 1 Overview of Condition Monitoring and Fault Diagnosis [6 hours]

1.1 Application of electric machines in industries and utilities such as processing industry, power plants and transports
1.2 Consequences of equipment failures
1.3 Techniques to avoid failure of machines
1.4 Breakdown versus Condition based maintenance
1.5 Condition monitoring overview and purpose
1.6 Common Condition monitoring techniques
1.7 Invasive and non-invasive methods
1.8 Sensors, data acquisition and overview of single pre- processing for condition monitoring

## 2 Common faults in Electrical Machines [6 hours]

2.1 Transformer Faults: main causes, core faults, winding faults, switching failures, tanks faults, other failures
2.2 Rotating Machine Faults- Electrical faults: Symmetrical Faults, Asymmetrical Faults, Unbalance supply voltage, Over voltage, Phase reversal, Overload stator short circuit, Broken rotor bars and End ring Faults,
2.3 Mechanical Faults: Airgap Eccentricity: Static, Elliptical, Dynamic and Mixed Eccentricity, Bearing Damage

## 3 Fault Diagnostics in Electrical Machines [12 hours]

3.1 Diagnosis and Prognosis
3.2 Importance of Early Fault Diagnostics
3.3 Common areas of Diagnostics
3.4 Non- invasive techniques, Invasive techniques, Conventional techniques- Model based diagnosis, Signal based diagnosis, Data driven diagnosis

3.5 Case example of model based (analytical/numerical) and signal-based fault diagnosis

**4 Data Acquisition Signal Analysis [12 hours]**

4.1 Data acquisition, data sampling and quantization, Aliasing and Nyquist theorem, Fault Modulation, Data Acquisition devices

4.2 Periodic and non-periodic signals, Fourier series and Transform, Fast Fourier Transform, Spectral Analysis using Fourier transform, Spectral Leakage, FFT drawbacks

4.3 Wavelet transform, Wavelet transform based features and their use in fault diagnosis

4.4 Clarke's transformation, Park's transformation, Transformation between reference frames, Compatibility for fault diagnostics, Park's Vector, Hilbert Transform, Total Harmonic Distortion

**5 Signal Based Diagnosis [13 hours]**

5.1 Current/Flux Signal: Current Signature Analysis, Flux Signature Analysis, side- bands etc; Speed Sensor less Methods (Magnetic Field Space Vector Orientation)

5.2 Temperature Signal: temperature distribution in machines, hotspots, crucial locations for temperature monitoring, simple temperature measurement techniques, case examples

5.3 Vibration Signal: measuring vibration, frequency, phase, high frequency detection systems, monitoring machine vibration, time domain, frequency domain, case examples

5.4 Fault Diagnosis simulation exercise and laboratory demonstration

**6 Advanced Diagnostic Technique [11 hours]**

6.1 Advanced Techniques in the perspective of Industry 4.0

6.2 Data driven Technique: Data generation, classification, Model training and testing; Classification Algorithm; Machine Learning: Supervised Learning, Unsupervised Learning, Deep Learning; Examples; Application if ANN in vibration and temperature monitoring

6.3 Condition monitoring using Internet of Things: Internet of Things (IoT), Remote monitoring using IoT, Cloud Implementation, Trained models

6.4 Commercial CMMS (Cloud/Computer based maintenance management system), CMMS Architecture and Interface, Use of CMMS

6.5 Fault Diagnosis simulation exercise and laboratory demonstration.

**Assignments**

**Lab Simulation Tutorials and Demonstration:**

1. Model/Signal based diagnosis of common machine faults
2. Application of ML/AI (data classification, training and testing)
3. Demonstration of application of IoT in condition monitoring and fault diagnostics

**Evaluation Schemes**

**a. Internal Evaluation**

| **Type** | **Weightage** |
|---|---|
| Minor tests | 70% |
| Assignments | 30% |

**b. Final Exam**

The questions will cover all chapters of the syllabus. The evaluation scheme will be as indicated in the table:

| **Chapter** | **Hours** | **Mark distribution*** |
|---|---|---|
| 1 | 6 | 6 |
| 2 | 6 | 6 |
| 3 | 12 | 12 |
| 4 | 12 | 12 |
| 5 | 13 | 12 |
| 6 | 11 | 12 |

*There may be minor deviation in marks distribution.

**References**


1. Rao, B. K. N. (1996). *Handbook of condition monitoring* (1st ed.). Elsevier Science.
2. Sen, P. C. (n.d.). *Principles of electrical machines and power electronics* (2nd ed.). John Wiley & Sons.

3. Latest publication on the related fields.
4. Course manual.