

Summary

Since the 20th century until today, rotatory electrical machines have been more and more relevant in a growing number and variety of applications, becoming an essential element in industry worldwide. Unscheduled outages caused by faults in electrical machine can represent a considerable economical loss. Therefore, is required detect faults in machines (in a early stage) in order to take appropriate actions.

The most commonly used diagnostic techniques are based on analysis of current (due to its non-invasive nature) through the Fast Fourier Transform FFT (with easy use and available in a great number of applications). However, its use is limited only to steady state. However, since the late 20th century until now has been developed other techniques (based on time-frequency analysis) that allows the machine diagnosis in a transient state (requiring greater computational power). On the other hand, with the evolution of computational electronic equipment (DSP, FPGAs, Microprocessors), other new lines of investigation has been focused on implement these diagnostic techniques in embedded systems, with its advantages (frequency sampling, computational power, etc.) and its main drawback: the limited memory capacity.

This thesis develops a new fault diagnostic technique valid for all possible operating states of the machine, outpacing divergences between steady-state and transient-state diagnostic techniques. It combines the advantages and properties of all techniques in a one only technique, allowing the proper fault diagnosis on all machine states (steady, transient, and also in power generation mode). The representations of the results obtained with this technique is the same regardless the machine operation state. Shows results in a diagram (similar to that obtained with the FFT) where the failure components always appear in the same position, noting the presence or absence of faults. In addition, it synthesizes all information in only 15 points thereby allowing a low memory capacity to record a machine state historic and improves the transmission of information with remote systems or systems with limited communication bandwidth.

On the other hand, an objective is to develop a technique to be implemented on electronic equipment to diagnose faults on-line mode. In this case, the first technique developed in this thesis (available for all operating states) needs more memory requirements than the available in these kind of equipment. Therefore, a new optimized

technique to diagnose faults (for steady states) that reduces memory requirements is developed. This new technique only need one point per cycle to perform an effective and consistent fault detection on machine. This technique is the startup to the development of newer diagnostic techniques availables for both operating states, with lower memory requirements.

For the validation of both techniques, an adaptative test bench has been created, with the ability to generate any operation data on all possible machine states.

- It can work the machine in motor and generator mode, with steady or transient states.
- Allows direct connection to the network or via variable speed drive (VF).
- Allows different load's states (steady, pulsing, ramps) and load's levels.

The test bench has been automated in order to reproduce the same conditions over different machine types and to perform them independently. In addition to the measurements used in diagnostic, other variables has been adquired (voltage, vibrations, etc..) and may be useful on future researchs. Also, an extensive database, with the tests data, has been created which is available and accesible over Internet for other collaborative research groups.

This doctoral thesis is structured into the following chapters:

- First (chapter 1) a brief introduction is exposed.
- On chapter 2 are shown the main objectives pursued in this work.
- On chapter 3 types of failures that can occur in rotating electrical machinery and the physical magnitudes useful for its detection are presented. On the other hand, an historical review about fault diagnostic related to rotating electrical machinery and the latest significants research performed is exposed.
- On chapter 4 the test bench design is described and the tests performed and the record and management of the database are explained.
- On chapter 5 is explained the diagnostic method valid for any operating state of machine.
- On chapter 6 is detailed the development of the diagnostic method to be implemented into a signal processing system for do failure diagnostics of machines at the moment.
- Finally in chapter 7 are exposed the conclusions and contributions of this thesis and in chapter 8 are presented some possible future researching lines opened due this work.