SUMMARY OF THE THESIS

Traditionally, the detection of faults in electric machines relies on the Fast Fourier Transform since most of the faults can be reliably diagnosed using it provided the machines are operating under steady state conditions for a reasonable period of time.

However, for applications in which machines work under fluctuating load and speed conditions (non-stationary conditions) such as windmills, traditional FFT has to be replaced with other techniques.

This thesis aims at developing a new methodology for the diagnosis of squirrel cage and wound rotor induction machines under non-stationary conditions, based on a new approach which relies on the slip-frequency domain analysis of the fault components of the currents .This approach is applied to the diagnosis of stator and rotor asymmetries and also for the mixed eccentricity.

The diagnosis of the electric machines in the slip-frequency domain provides the developed methodology an universal character since it is able to diagnose electrical machines irrespective of the features of the machine, the way in which the speed of the machine varies and its functioning mode (motor or generator).

The development of the methodology involves the following stages:

(i) Characterization of the evolutions of the fault components for stator and rotor asymmetry and also for the mixed eccentricity fault for both squirrel cage and wound rotor induction machines function of the speed (slip) and the frequency supply of the network from where the machine is fed.

(ii) Due to the importance of the signal processing, there is an introduction of a few basics of signal processing before going into the actual fault diagnosis processing.

(iii) The challenge of the extraction of the fault components is studied from three different filtering techniques such as the Discrete Wavelet Transform, Wavelet Packet Transform and with the proposal of a new filtering technique, the Spectral Filtering. The first two filtering techniques extract the fault components in the time domain whereas the new filtering technique works in the frequency domain.

(iv) The extraction of the fault components, in some cases, involves the shifting of the frequency signal components. The shifting of the frequency is carried out by two different techniques: the Frequency Displacement Theorem and the Hilbert Transform.

(v) Unlike other already developed techniques, the proposed methodology does not exclusively rely on in the computation of the energy of the fault component since it also involves the representation of the instantaneous frequency of the fault components, which is computed by two different techniques (Hilbert Transform and Teager-Kaiser Operator), vs. the slip. The representation of the instantaneous frequency vs. the slip prevents from false positive diagnosis improving the accuracy and quality of the diagnosis. Furthermore, the representation of the instantaneous frequency vs. the slip

enables the qualitative diagnosis that is fast and requires low computational resources.

(vi) Finally, due to the importance of the automation of the industrial processes and in order to avoid the divergence of criteria present in the qualitative diagnosis, three objective parameters are developed: Energy parameter, Similitude Coefficient and Regression parameters. The energy parameter quantifies the fault degree according to its value. It is computed in both the time and frequency domain (as a consequence of the extraction of the fault component in the frequency domain). The similitude coefficient and the regression parameters are objective parameters to discard false positive diagnosis giving a high reliability to the proposed methodology.

The diagnostic methodology is experimentally validated for the stator and rotor asymmetry faults and also for the mixed eccentricity fault in squirrel cage and wound rotor induction machines fed from the electric network and from variable frequency drives in non-stochastic stationary conditions.