3.3.2 Number of books and chapters in edited volumes/books published and papers published in national/ international conference proceedings per teacher during year

Academic Year	Name of the teacher	Title of the book/chapters published	Title of the paper	Title of the proceedings of the conference	Name of the conference	National / International	Affiliating Institute at the time of publication	Name of the publisher
2020-21	D. Zunaithur Rahman	Civil Engineering	Railways, Airports, Docks and Harbour Engineering				978-81-940480-3-9	Royal Book Publishers, India
	D. Zunaithur Rahman	Civil Engineering	Green Building Design				978-93-88413-90-9	Royal Book Publishers, India
	DR.N.R.Shanker	CSE		Transformer breather thermal image decomposition for fault diagnosis	Electrical Energy Systems	7th International Conference on Electrical Energy Systems (ICEES)	978-1-7281-7612-3	IEEE
	Dr. M. Amanullah	Information Technology	Machine Learning and Applications:				978-93-86923-47-9	Dipi Press OPC Pvt Limited,Chennai

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Transformer breather thermal image decomposition for fault diagnosis

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***Abstract*—Image processing techniques replace human vision in most of the applications that incur danger to human lives for maintenance purposes. As a step towards automation in condition monitoring, the proposed work involves, representing an acquired thermal image of a transformer breather showing temperature variations in the discrete domain, by transforming the image using wavelet transform. Symlet wavelet is used for transformation that captures the temporal information of the image pixels. The representative parameters of the transformed image are studied at various decomposition levels to get better insights for further analysis thereby enabling accurate condition monitoring of the transformer under study. The statistical findings of the image details at various levels of decomposition expose the variation in the distribution of temperature in and around the breather vent pipes, depending upon the transformer operating conditions. Significant differences are observed in the parameters due to transformer winding faults when compared with the parameters under normal operation. Extending the work to include various transformer faults will enable the fault diagnosis process more exhaustive.**

Keywords—Condition Monitoring, Image Processing, Breather, Wavelets

I. INTRODUCTION

The windings in the transformers are of importance since through electro-magnetic induction they can either step-up or step-down the voltage in the primary to its secondary. Various stresses influence the windings which might lead to the breakdown of insulation that isolates the inter-turns [3]. Conditions like short circuiting due to hot spot creation leads to winding failure [1]. Windings that are mostly made of copper are found to be thermal conductors and hot spots are creating in the same leading to losses and failure results. Physical or mechanical displacement in the windings due to vibrations might also cause winding failures in transformers.

One of the reasons for transformer core failure depends on the DC magnetization of winding employed for the coils that surround the core limbs [1]. Axial forces, thermal conditions cause abnormality in the core behaviour. Due to high pollution level in the transformer oil due to moisture ingress or relevant environmental factors, the distribution transformers are exposed to high failure rates [3]. Enhanced corrosion rates, loss in the dielectric characteristics of the transformer oil or failure in the transformer pressure releasing valves cause the transformer tank to fail. Monitoring and maintenance of these massive structures involves additional protective and control circuitry which needs to withstand the extreme conditions faced by the transformer. Failure of such circuitry disrupts the whole idea of preventive maintenance.

Thermal images based condition monitoring is considered to be much economical as the experimental set-up includes just the thermal imaging camera, related fixtures and a display unit. It is a non-invasive technique [9] and the acquired images are least affected by the surrounding noisy operating environment. Temperature is considered to be a principal parameter that reduces the life-time of equipment [9]. Therefore, thermal images and their analysis play a vital role in condition monitoring of machinery.

Raw signals after measurement do not provide much information for analysis. In order to extract useful data from the signals, mathematical transformations are applied. These transformations facilitate researchers to study the characteristics of the signal and thereby proposing methods to enhance the representativeness of the physical quantity that is measured using the signal. Significant features of the measured signal are embedded in its frequency components. Time-domain related processing does not exhaustively provide useful retrieval of information, rather a time-frequency based analysis would yield meaningful results [19]. On analysis with test samples, Symlet Wavelets are chosen for the purpose stated, which generate coefficients. These coefficients could be used for various purposes such as reconstruction of a received image, de-noising of the image or compression. Discrete Cosine Transform based approximation techniques have been formulated for image compression [18]. The proposed work transforms the acquired thermal image using Symlet wavelet transform which is popular for usage in image enhancement operations and the statistical parameters of the wavelet coefficients are compared after decomposing the image for the purpose of transformer fault diagnosis.

II. LITERATURE SURVEY ON TRANSFORMER FAILURES

Parameters that influence the lifetime of a transformer are identified and its performance is analysed using various diagnostic methods in the literature [10]. Failure modes effect and criticality analysis is performed due to unpredictable failure of distribution transformers by determining the reason for transformer failures and assigning a Risk Priority Number by analysing the severity of fault, its probability of occurrence and detection [1]. Lack of methodologies for early prediction of transformer failure caused due to corrosive Sulphur deposits, partial discharges, explosion or gas generation with Kraft insulation paper and

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