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Discrimination between inrush current and fault current by using wavelet transform

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Abstract: Reliable discrimination between inrush currents and internal fault currents is crucial for effective protection of transformers in power systems. Traditional methods based on harmonic content analysis often struggle due to limitations in capturing both time and frequency domain characteristics of the current signals. This paper proposes a novel approach for inrush current and fault current discrimination in transformers using wavelet transform (WT).

Wavelet transform offers a significant advantage over conventional techniques due to its ability to analyse signals simultaneously in the time and frequency domains. This allows for the extraction of features that effectively differentiate between the transient nature of inrush currents and the sustained nature of fault currents.

The proposed method involves decomposing the transformer current signal using DWT (Discrete Wavelet Transform) and extracting relevant features from the decomposed coefficients. These features can then be used to design a decision rule or train a classifier to accurately discriminate between inrush and fault events.

Keywords: Internal Fault Current, Magnetizing Inrush current, Standard Deviation, Variance, Teager Energy Operator,Signal decomposition,Power transformer.

I. INTRODUCTION

Transformers are vital components in power systems, and their reliable operation hinges on effective protection schemes. A crucial aspect of this protection is accurately distinguishing between two key current transients: inrush currents and fault currents.

Inrush currents are temporary surges that occur when a transformer is energized. These currents are non-damaging but can be high in magnitude, potentially leading to unnecessary tripping of protection relays.

Fault currents, on the other hand, arise due to internal electrical faults within the transformer. These currents can cause severe damage and require a swift response from protection relays to isolate the faulty section.

Traditional methods for discriminating between inrush and fault currents often rely on analyzing the harmonic content of the current signal. However, these methods have limitations:

They struggle to capture the dynamic nature of the current waveforms, which contain both time and frequency domain information.

Variations in transformer parameters and operating conditions can further complicate accurate discrimination.

This paper proposes a novel approach for inrush vs. fault current discrimination in transformers using wavelet transform (WT). WT offers a significant advantage over conventional techniques due to its ability to:

Simultaneously analyze signals in both time and frequency domains. This allows for a more nuanced understanding of the current's behavior during inrush and fault events.

Extract features that effectively differentiate between the transient nature of inrush currents and the sustained nature of fault currents. This enables the development of robust decision rules or classifiers for accurate discrimination.

The following sections will delve into the methodology of WT-based discrimination, discuss the expected results, and showcase the benefits of this approach for improved transformer protection.

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II. METHODOLOGY

The detailed methodology of using wavelet transform for discriminating between inrush current and internal fault current in transformers typically involves several key steps:

Data Acquisition: Gather current data from the transformer during both normal operation and fault conditions. This data will serve as the input for the discrimination algorithm.

Preprocessing: Clean the acquired data to remove noise and artefacts that may interfere with the analysis. This step may involve filtering and signal conditioning to enhance the quality of the signal.

Wavelet Transform: Apply the wavelet transform to the preprocessed current signal. The wavelet transform decomposes the signal into different frequency components at various scales. Choose an appropriate wavelet function and decomposition level based on the characteristics of the current signal.

Feature Extraction: Extract relevant features from the wavelet coefficients that capture the distinguishing characteristics of inrush and fault currents. These features may include peak amplitudes, energy distribution, frequency content, or time-frequency representations.

Feature Selection: Select the most discriminative features that effectively differentiate between inrush and fault currents. This step may involve statistical analysis or machine learning techniques to identify the most informative features.

Classification: Develop a classification algorithm to classify the current signal into inrush or fault categories based on the extracted features. This may involve training a machine learning model such as a support vector machine (SVM), neural network, or decision tree classifier using labelled data.

Validation and Optimization: Validate the discrimination algorithm using a separate dataset or through cross-validation techniques. Fine-tune the algorithm parameters and feature selection criteria to optimise performance and generalisation ability.

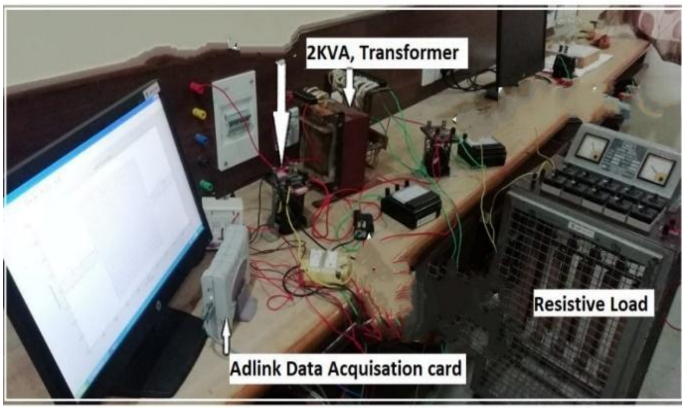
Performance Evaluation: Evaluate the performance of the discrimination algorithm in terms of accuracy, precision, recall, and other relevant metrics. Compare the results with existing techniques to assess the effectiveness of the proposed methodology.

Implementation: Implement the optimised discrimination algorithm in real-time or offline transformer protection systems. Integrate the algorithm with existing protection relays or monitoring systems to enable automatic detection and response to inrush and fault conditions.

Validation in Real-world Scenarios: Validate the performance of the implemented algorithm in real-world transformer installations under various operating conditions and fault scenarios. Monitor the system performance and gather feedback for further refinement and improvement.

By following these steps, the wavelet transform methodology can effectively discriminate between inrush and internal fault currents in transformers, thereby enhancing the reliability and efficiency of transformer protection systems.

PHOTOGRAPH OF EXPERIMENTAL SETUP DEVELOPED IN THE LABORATORY



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SAMPLE READING

	A	B	C	D	E	F	G
1	INRUSH		INTERTURN				
2							
3	-0.2059936523	-0.4531860352	-0.2059936523	0.07385253906	0.09613037109	-0.05645751953	0.09338378906
4	-0.08483886719	-0.5407714844	-0.08483886719	-0.8489990234	0.09674072266	-0.0146484375	0.08941650391
5	0.1495361328	-0.5236816406	0.1495361328	-1.620178223	0.09307861328	0.03112792969	0.06561279297
6	0.6198120117	-0.4766845703	0.6198120117	-2.346496582	0.09399414063	0.06408691406	0.02563476563
7	1.375427246	-0.4177856445	1.375427246	-2.790527344	0.06195068359	0.07141113281	-0.0146484375
8	0.6182861328	-0.3924560547	0.6182861328	-2.821655273	0.01647949219	0.07904052734	-0.05706787109
9	-0.2374267578	-0.3793334961	-0.2374267578	-2.811889648	-0.02166748047	0.08514404297	-0.07385253906
10	-0.4937744141	-0.3741455078	-0.4937744141	-2.453308105	-0.06286621094	0.09582519531	-0.07415771484
11	-0.5532836914	-0.3659057617	-0.5532836914	-1.633605957	-0.07171630859	0.09185791016	-0.08178710938
12	-0.5001831055	-0.3656005859	-0.5001831055	-0.9896850586	-0.07659912109	0.08422851563	-0.09399414063
13	-0.4309082031	-0.3741455078	-0.4309082031	-0.04791259766	-0.09429931641	0.05340576172	-0.08605957031
14	-0.3439331055	-0.3829956055	-0.3439331055	0.8480834961	-0.09765625	0.0146484375	-0.08819580078
15	-0.3009033203	-0.368347168	-0.3009033203	1.621398926	-0.09429931641	-0.02685546875	-0.06439208984
16	-0.2639770508	-0.3079223633	-0.2639770508	2.348632813	-0.08911132813	-0.05889892578	-0.03326416016
17	-0.2426147461	-0.1373291016	-0.2426147461	2.786560059	-0.06164550781	-0.06958007813	0.01556396484
18	-0.2270507813	0.1870727539	-0.2270507813	2.822875977	-0.02075195313	-0.06530761719	0.05554199219
19	-0.2081298828	0.7342529297	-0.2081298828	2.810974121	0.02166748047	-0.09002685547	0.06591796875
20	-0.2169799805	1.008911133	-0.2169799805	2.425842285	0.05920410156	-0.09185791016	0.07415771484
21	-0.2114868164	0.05798339844	-0.2114868164	1.624450684	0.06866455078	-0.09429931641	0.08239746094
22	-0.2044677734	-0.5133056641	-0.2044677734	0.9893798828	0.07415771484	-0.087890625	0.09460449219
23	-0.1846313477	-0.6506347656	-0.1846313477	0.04760742188	0.08880615234	-0.05401611328	0.09368896484

III. RESULTS

Wavelet transform can be employed to discriminate between transformer inrush current and fault current by analyzing their frequency components and time-frequency characteristics. Inrush current typically has a distinct frequency signature, often characterized by a sudden rise followed by a gradual decrease. On the other hand, fault current exhibits irregular patterns with varying frequencies depending on the fault type.

By applying wavelet transform, the transient behavior of the current signal can be analyzed in both time and frequency domains simultaneously, allowing for the extraction of unique features associated with inrush and fault currents. Wavelet coefficients can then be used as input features for machine learning algorithms or thresholding techniques to classify and differentiate between the two types of currents.

DECOMPOSTION OF INRUSH CURRENT BY WAVELET DECOMPOSITION METHOD

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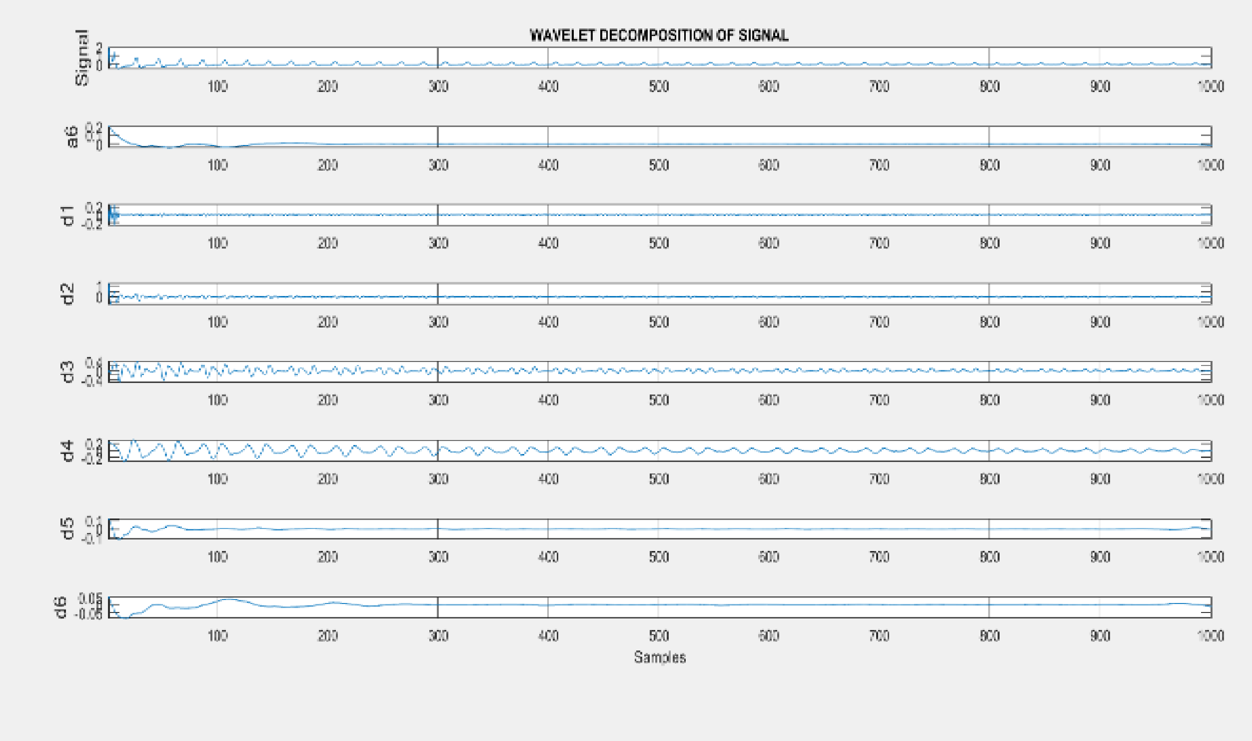
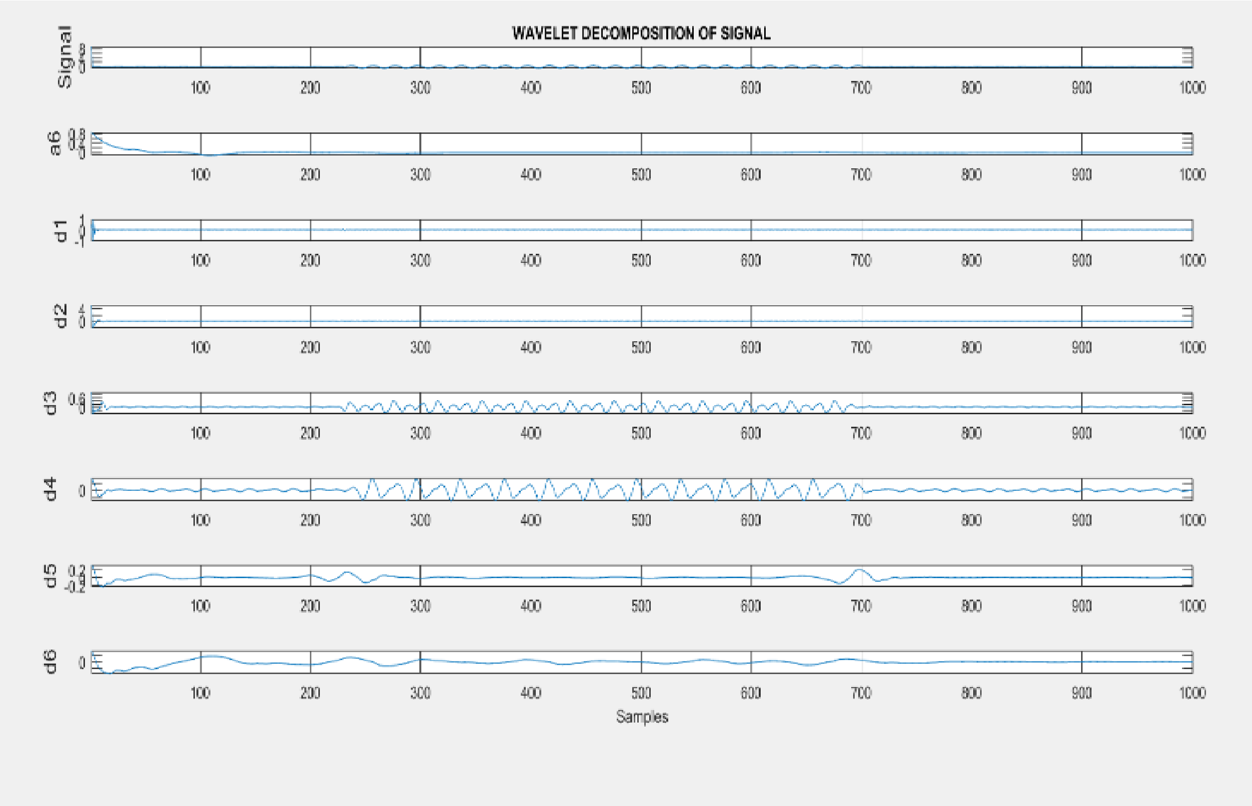


DECOMPOSTION OF INTERTURN CURRENT BY WAVELET DECOMPOSITION METHOD



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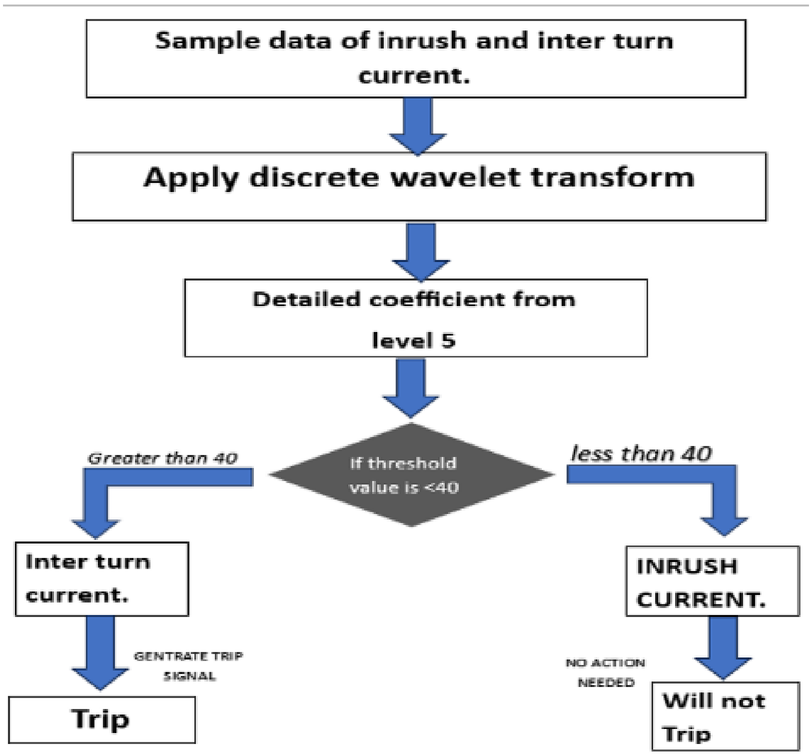
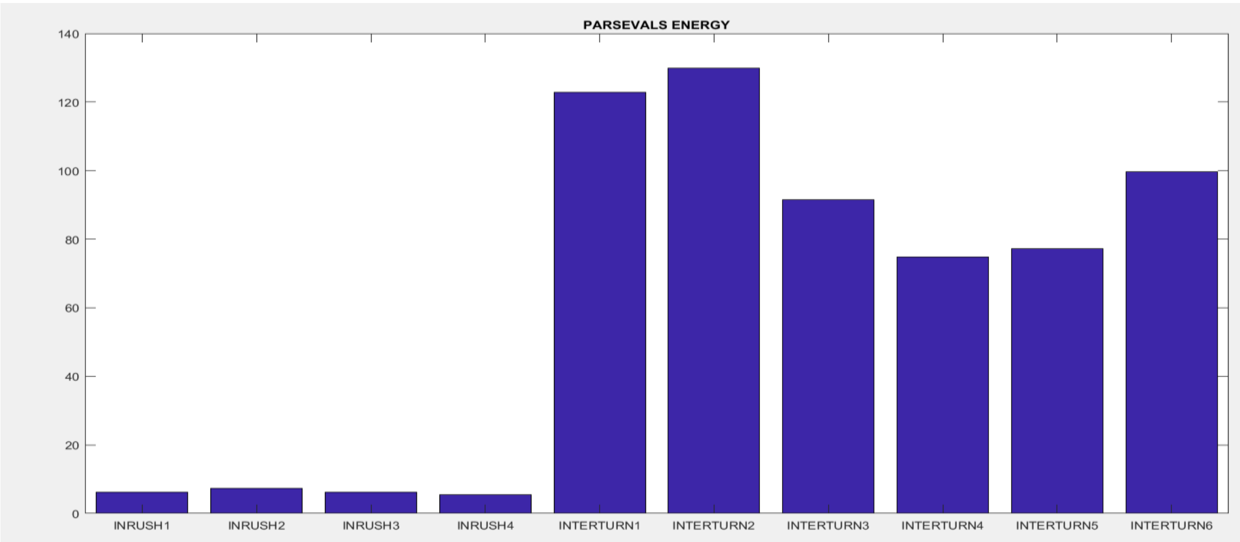
FLOWCHART



IV. CONCLUSION

In summation, the conclusions derived from discrimination between inrush and fault currents epitomize the collective ingenuity and steadfast dedication of the engineering community towards safeguarding the integrity and efficacy of electrical systems. As the discourse continues to evolve, propelled by ongoing advancements in technology and methodology, the journey towards discrimination serves as a testament to the unwavering commitment to excellence and innovation that defines the realm of electrical engineering, perpetually striving towards the realization of a safer, more reliable, and more efficient electrical infrastructure for generations to come.

VARIANCE VALUE OF INRUSH AND FAULT CURRENT TO ENERGY COMPONENT



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