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Identification of Transformer Sympathetic Inrush Based on W-DHNN

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Abstract. A new method to identify sympathetic inrush and internal fault current of transformer based on W-DHNN is put forward. Wavelet analysis can detect the abrupt change of the current signal. And extract the feature vectors of the signal. The characteristic values as the input value of discrete Hopfield neural network. Then using discrete Hopfield neural network to discriminate sympathetic inrush and internal fault current. This paper uses PSCAD/EMTDC software to model and emulates different parameters of transformer and fault types. The results show that the method is feasible.

Introduction

At present the differential protection is still one of the primary protections of transformer. Distinguish inrush and internal fault current is the key problems associated with differential protection[1-4]. Currently the main methods applied include the second harmonic restraint and intermittent angle principle[5]. But these two methods in practical engineering applications encountered some difficulties. Therefore, the imperative to explore new methods of protection.

Theoretical analysis

When transformer with no-load or the removal of external fault, due to the magnetic flux in the transformer core cannot be mutations and appear non-periodic component in the magnetic flux, remanence makes the transformer core of heavily saturated, the excitation current with a sharp increase, this current is inrush current. When a transformer switching with no-load, it will cause another adjacent parallel or series of transformer differential protection malfunction and produces sympathetic inrush. The sympathetic inrush of transformer include parallel and series sympathetic inrush. Parallel sympathetic inrush is that two transformers operating in parallel, one with no-load, another transformer will generate the current. Series sympathetic inrush is that two transformers operating in series, the end of the transformer with no-load, another will generate the current.

The principle of protection algorithm

This paper proposes to use W-DHNN to identify sympathetic inrush, inrush current and internal fault current. The paper aims to extract the energy characteristics of signal by wavelet transform. So choosing the multi-resolution analysis of different wavelet to analyze inrush current and internal fault current. Found the energy of db5 wavelet is the most concentrated, and does not produce the boundary problem. Therefore, this paper uses the db5 wavelet to extract energy eigenvalues of current signal. The db5 wavelet signal decomposition algorithm is as follows.

$$\begin{cases} C_{j+1,n} = \sum_{m \in Z} h_{m-2n+1} \bullet C_{j,m} \\ D_{j+1,n} = \sum_{m \in Z} g_{m-2n+1} \bullet D_{j,m} \end{cases} \tag{1}$$

Where C stands for the low frequency coefficient after decomposition. D stands for the high frequency coefficient after decomposition.

Discrete Hopfield network model is belong feedback neural network. It has strong computing power and good fault tolerance. And it is very suitable for nonlinear systems. This model is an ideal classifier. The model can be better combined with the wavelet technique and can improve the recognition accuracy of inrush and fault current. Therefore, this article sends the above characteristic quantity to this model to distinguish. The topology of DHNN shown in Figure 1.

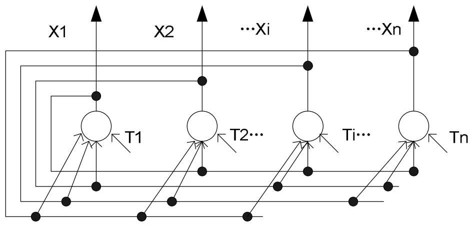


Fig.1 Discrete Hopfield neural network topology

Simulation experiment

Combine the actual conditions, and use PSCAD software to build simulation models of transformer. It includes sympathetic inrush, inrush current and internal fault current.

Sympathetic inrush and inrush current

The generated mechanism of series and parallel sympathetic inrush are similar. Therefore, this paper takes parallel sympathetic inrush as an example. Transformer using UMEC transformer model from PSCAD library. Equivalent power using R / / R-L model. The simulation model is shown in Figure 2.

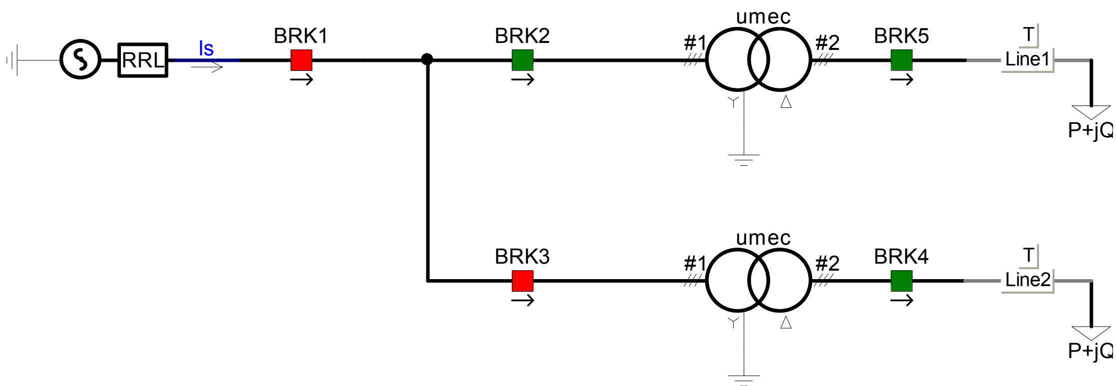


Fig.2. Three-phase transformer parallel sympathetic inrush current simulation diagram

When T2 transformer with no-load operation, T2 will appear inrush current and T1 will appear sympathetic inrush current. Discussed phase A as example. Ia1 stands for sympathetic inrush current. Ia2 stands for inrush current. Fig.3 shows that sympathetic inrush current and inrush current are all have biased timeline side characteristic, and the waveform have obvious dead angle. Based on wavelet analysis of db5, extract and reconstruct the wavelet coefficients of sympathetic inrush current and inrush current. Assuming the sampling length is 200 and decomposition scale is 4. Fig.4 and 5 shows that inrush current has distortion characteristics along with the entire decay process.

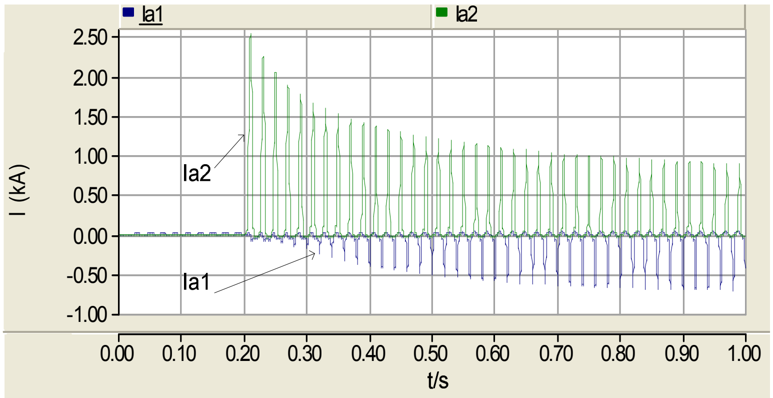
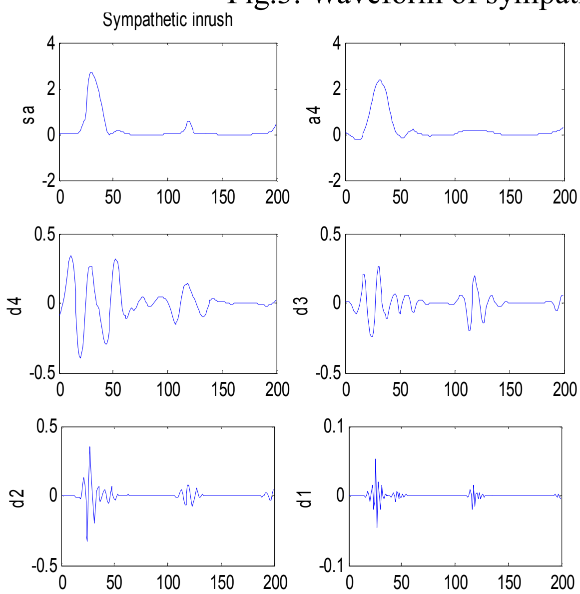


Fig.3. Waveform of sympathetic inrush current and inrush current



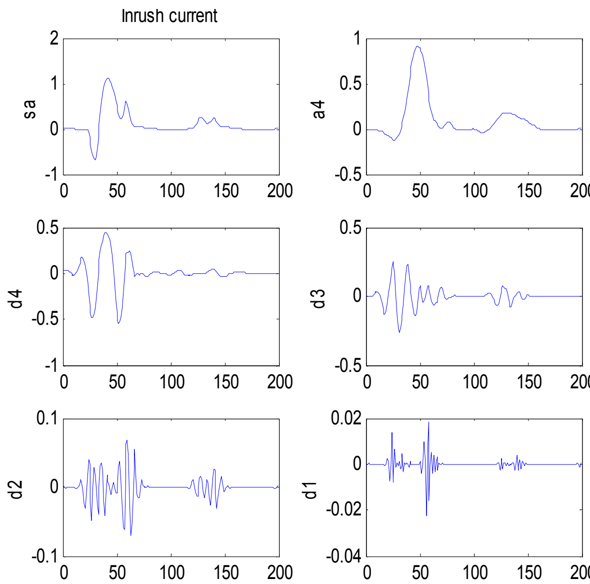


Fig.4. Waveform of wavelet reconstruction for sympathetic inrush current

Fig.5. Waveform of wavelet reconstruction for inrush current

Internal fault current

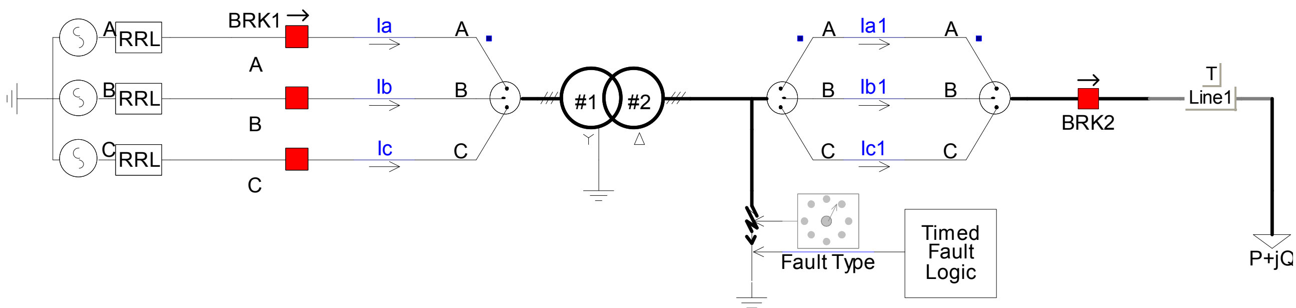


Fig.6. Three-phase transformer internal fault current simulation diagram

These types of internal fault simulations include turn-to-turn faults, single-phase grounding, two-phase short circuit, two-phase grounding, three-phase grounding. By rotary switch (Fault Type model) to control fault type. Fault time starts from 0.15 seconds, continue two seconds. As Figure 6 shows, at the moment phase A is grounding, during the fault, A-phase current increases rapidly, until the fault is removed when the return to normal. But unlike the inrush current waveform, the fault current waveform is always sine wave. And the waveform has no dead angle. Based on wavelet analysis of db5, extract the wavelet coefficients of internal fault current. Figure 7 shows that points of distortion of internal fault current are very little.

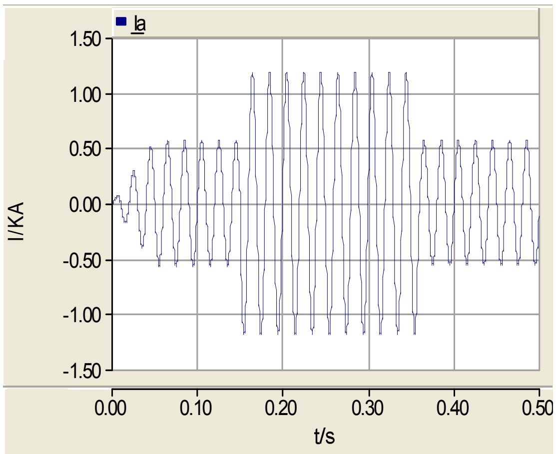


Fig.7. Waveform of phase A grounding fault current

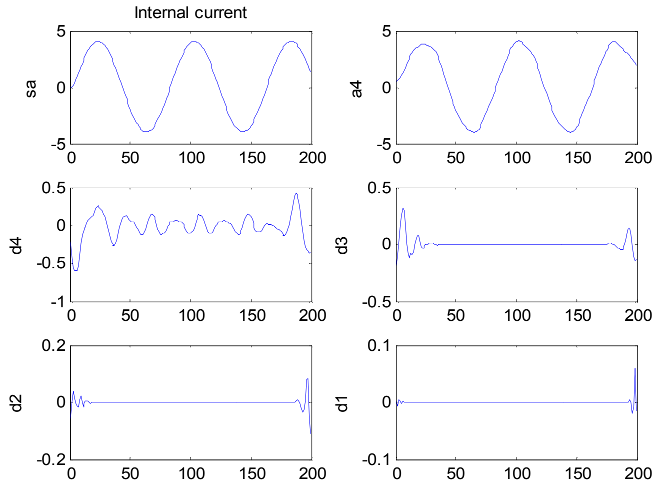


Fig.8. Waveform of wavelet reconstruction for internal current

Based on DHNN classification characteristics and theory, identification sympathetic inrush current in transformer neural networks has been built in this paper. The above eigenvalues as the training samples of DHNN. This paper takes 500 groups as training samples and 200 groups of samples taken for testing. Result shows that recognition rate up to 100%.

Table.1 Test results

Current type	Train sample	Test sample	Recognition rate %
Inrush current	300	100	100
Internal fault current	200	100	100

Conclusions

According to the differences in energy eigenvalues, a new method based on W-DHNN is proposed in the paper. A lot of simulations verify that this method can identify sympathetic inrush current and internal fault current. This method can improve the sensitivity and reliability of differential protection. It can enhance protection precision and without increasing the cost of hardware.

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