ABSTRACT

Power transformers are one of the most essential and expensive components in the operation of electric power system. When an internal fault occurs in a transformer, immediate disconnection of the faulty transformer is necessary to protect the power system. Differential protection is commonly employed for transformer protection. When an unloaded transformer is energized, high magnetizing inrush current flows only on the energised side of the transformer, it ends up as spill current and the differential relay possibly maloperates, which is not desirable. Thus, the differential relay is expected to operate only for internal faults and not for inrush current, external fault, normal and overexcitation conditions.

Fundamentally, inrush current contains second harmonic component which is atleast 15% of the fundamental component whereas the internal fault contains only negligible amount of second harmonic component when compared to the fundamental component of the differential current. Conventional transformer protection schemes use the percentage of second harmonics as criteria to discriminate internal fault from inrush current. But, due to the improvement in the core steel material, the second harmonic component has been reduced considerably to as low as 7% in inrush current and no longer harmonics based protective relays are reliable and dependable for transformer protection. Thus, discriminating internal fault from inrush current is one of the most challenging power system problems. It is revealed from the literature survey that the harmonic restraint relay takes a minimum delay of one cycle to operate and the minimum fault detection time taken for the other methods presented so far is quarter of a cycle. This research work aims to discriminate internal fault from no fault conditions i.e., inrush current, external fault, normal and overexcitation conditions accurately and minimize the fault detection time.
A standard power system model is simulated using Power Systems Computer Aided Design (PSCAD)/Electro Magnetic Transients including DC (EMTDC) and is run for different types of internal fault and no fault conditions. Simulation results show that harmonic restraint differential relay take at least one cycle to operate for internal faults and also it may maloperate during inrush. Due to the superior ability of Artificial Neural Networks (ANN) to learn and generalize from training patterns, neural network using back propagation algorithm has been implemented to train and recognize fault and no fault patterns of differential current. The first 40 samples i.e., samples in one cycle of the differential current after the occurrence of internal fault or no fault conditions are fed to the ANN and trained. The internal fault current samples are trained so that the output is ‘1’ and the no fault current samples are trained so that the output is ‘0’. ANN discriminates internal fault from no fault conditions i.e., inrush current, external fault, normal and overexcitation conditions accurately and identifies internal fault within 3ms i.e., 1/7th of a cycle from the inception of fault. Still more effective discrimination can be obtained if the high frequency components of the differential current signal are analysed. Hence, Wavelet Transformation (WT) is implemented.

WT is an efficient tool for analyzing transient signals generated during faults. On WT of the differential current, the detail 1 (d1) coefficients which are the high frequency components of the signal are obtained. The maximum value of d1 coefficient is high for internal fault current and low for no fault current. From the wavelet decomposition, it is inferred that, for internal fault, the transient spikes occur immediately at the start of the fault and decay within a cycle but for inrush current, the transient spikes take at least ten cycles to settle down. On wavelet decomposition, the number of d1 coefficients is reduced to half, which contributes to data reduction and
moreover, the d1 coefficients have valuable information about transient nature which can provide better results when given as input to ANN.

Therefore, the Wavelet Transformation combined with ANN (WNN) is been employed. Only the first five d1 coefficients i.e., samples in 1/8th of a cycle after the occurrence of a fault or no fault condition are given as input for training. Accordingly, there is a remarkable data reduction in WNN when compared to ANN. The input data reduction plays a significant role in the reduction of tripping time. WNN discriminates internal fault from no fault conditions and identifies internal fault current within 1ms i.e., 1/20th of a cycle from the inception of fault. But back propagation algorithm has certain limitations such as slow convergence, getting stuck in local minimum and difficulty in choosing the initial values of the parameters for efficient network training. This limitation is addressed by the usage of Particle Swarm Optimisation (PSO) as a training technique, which is characterised by fast convergence and global minimum.

The neural network architecture of WNN is also simplified by training the network using PSO, which is thereafter called as PSO-WNN. The accuracy of the training output has been increased to almost 100%. PSO-WNN identifies an internal fault within 1ms i.e., 1/20th of a cycle from the inception of a fault.

So far, no technique has been able to identify a fault within 1/20th of a cycle with almost 100% accurate output value. Hence, a new fast and reliable PSO-WNN based relaying is developed to identify an internal fault within 1/20th of a cycle and discriminate internal fault from no fault conditions i.e., inrush, external fault, normal and overexcitation conditions accurately.