Implementation of Simulink in Protection of Transmission Lines

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Abstract: High voltage transmission lines are used to transmit electrical energy from source to substations. If any fault and disturbance are generated in the transmission lines and not detected, located and eliminated quickly, it may cause instability in the system. To find the exact location of fault occurring in transmission lines may be calculated by some conventional methods. This paper presents the implementation of Simulink/MATLAB for finding the exact location of fault in power system.From the help of Simulink circuit diagram we will calculate the changes of voltage, current and power when the fault is occurs in phase A, phase B and phase C either with respect to ground or with respect to any two phases. Simulink results will shown in this paper.

Keywords- ANN (Artificial neural network), Simulink, High voltage transmission lines, Fault.

Introduction

Work on artificial neural networks commonly referred to as "neural networks", has been motivated right from its inception by the recognition that the human brain computers in an entirely different way from the conventional digital computers. The brain is a highly complex, nonlinear and parallel computer. It has the capability to organize its structural constituents known as neurons, so as to perform certain computations (e.g. pattern recognition, perception and motor control) many times faster than the fastest digital computer in existence today.[1]

A neural network is a massively parallel distributed processor made up of simple processing unit that has a natural propensity for storing experimental knowledge and making it available for use. It resembles the brain in two respects:
- Knowledge is acquired by the network from its environment through the learning process.
- Inter-neuron connection strengths known as synaptic weights are used to store the acquired knowledge

(i) Artificial intelligence:

Designing of intelligence computer system from characteristic associated with intelligence in human behavior [1]
Example: - 1. Neural Network 2. Fuzzy Logic 3. Expert system 4. Probabilistic reasoning.
Types: 1. Hard computing 2. Soft computing
Characteristics: - 1. Cognition 2. Logical Interface 3. Pattern Recognition
Human brain has two properties: -   Human brain is getting experienced to adapt themselves to their surrounding environments. So as a result the information processing capability of the brain is rendered, when this happen the brain becomes plastic.
1. Plastic: -   Capability to process information, capability of adding. Must preserve the information it has learn previously.
2. Stable: -   Remain stable when it is presented with irrelevant information, useless information.
*. Synapses with large area are excitatory (+Ve weights) & with small area are inhibitory (-Ve weights).

*. Synapses of the neuron are modulated as weights. (Strength of the connection)

*. Biological neuron receive all inputs through dendrites, sum them & produces an output. If the sum is greater then the threshold value, then input signals are passed to the cell body.

*. NN can mapped input patterns into output patterns.

*. NN's are robust systems. They can recall full patterns from incomplete pattern or noise channel.

*. Mc Culloh Pits neuron was centered on the idea that a neuron will fire an impulse only if the threshold value is exceed.

Total input (I) receive by the soma

$$I = \sum_{j=1}^{n} w_i . x_i$$

To generate the final output Y sum is passed through a nonlinear filter called activation filter.

(ii) Simulink Modelling Diagram:

Modern power systems are increasingly complex and the use of computers to analyze and simulate their performance is now commonplace. There are many computer packages on the market. Unfortunately, it is not all about entering data, but how the input data was arrived at. It is also important to distinguish between good and bad data. Simulink figure; is made of generators, motors, transmission lines, transformers, high speed digital relays and circuit breakers. For each of these items data is required before meaningful results can be obtained, SIMULINK is mouse-driven. The modeling of any system is carried out in the model window through identification and connection of the blocks that make up the system under consideration. Usually, it is important to model the system first on paper as to have a general knowledge of the various components that make up the system.
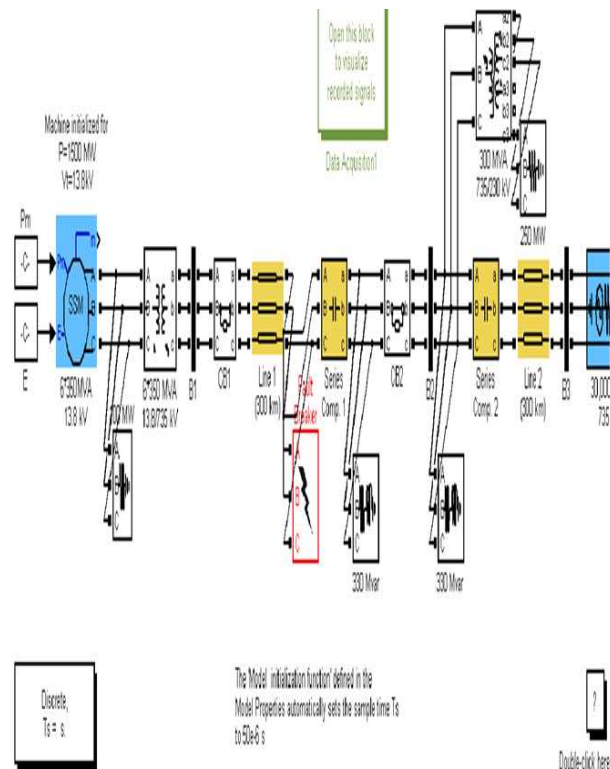
(iii) Circuit Description:-

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A three-phase, 60 Hz, 735 kV power system transmitting power from a power plant consisting of six 350 MVA generators to an equivalent network through a 600 km transmission line. The transmission line is split in two 300 km lines connected between buses B1,B2, and B3. In order to increase the transmission capacity, each line is series compensated by capacitors representing 40% of the line reactance. Both lines are also shunt compensated by a 330 Mvar shunt reactance. The shunt and series compensation equipments are located at the B2 substation where a 300 MVA 735/230 kV transformer with a 25 kV tertiary winding feeds a 230 kV, 250 MW load. The series compensation subsystems are identical for the two lines. For each line, each phase of the series compensation module contains the series capacitor , a metal oxide varistor (MOV) protecting the capacitor, and a parallel gap protecting the MOV. When the energy dissipated in the MOV exceeds a threshold level of 30 MJ, the gap simulated by a circuit breaker is fired. CB1 and CB2 are the two line circuit breakers .

The generators are simulated with a Simplified Synchronous Machine block. Universal transformer blocks (two-windings and three-windings) are used to model the two transformers. Saturation is implemented on the transformer connected at bus B2. Voltages and currents are measured in B1, B2, and B3 blocks. These blocks are Three-phase V-I Measurement blocks where voltage and current signals are sent to the Data Acquisition block through Goto blocks. Fault and Line Switching

You now study the transient performance of this circuit when a line-to-ground and three-phase-to-ground faults are applied on line 1. The fault and the two line circuit breakers CB1 and CB2 are simulated with blocks from the three-phase library. Open the dialog boxes of CB1 and CB2. See how the initial breaker status and switching times are specified. A line-to-ground fault is applied on phase A at t = 1cycle. The two circuit breakers which are initially closed are then open at t = 5 cycles, simulating a fault detection and opening time of 4 cycles. The fault is eliminated at t = 6 cycles, one cycle after line opening.

(iv) Demonstration:-

Notice that this system contains the Powergui block. In addition, when you start the system the 'power_3phseriescomp' model, the sampling time Ts = 50e-6 is automatically set in your workspace. The system is therefore be discretized using a 50 microseconds sample time.

Line-to-Ground Fault
Double click the Data Acquisition block and open the three scopes. Start the simulation. As the system has already been initialized (1500 MW generation at the 13.8 kV bus) with the Lod Flow utility of the Powergui, the simulation starts in steady state. At t = 1 cycle a line-to-ground fault is applied and the fault current reaches 10 kA . During the fault, the MOV conducts at every half cycle and the energy dissipated in the MOV builds up to 13 MJ.

At t = 5 cycles the line protection relays (not simulated) open breakers CB1 and CB2 and the energy stays constant at 13 MJ. As the maximum energy does not exceed the 30 MJ threshold level, the gap is not fired. After breaker opening the fault current drops to a small value and the line and series capacitance start to discharge through the fault and the shunt reactance. The fault current extinguishes at the first zero crossing after the opening order given to the fault breaker (t = 6 cycles). Then, the series capacitor stops discharging and its voltage oscillates around 220 kV . Three-Phase-to-Ground Fault

Change the fault type to a three-phase-to-ground fault by checking Phases A, B, and C in the Fault Breaker block. Restart the simulation. Notice that during the fault the energy dissipated in the MOV builds up faster that in the case of a line-to-ground fault. The energy reaches the 30 MJ threshold level after 3 cycles, one cycle before opening of the line breakers. As a result, the gap is fired and the capacitor voltage quickly discharges to zero through the damping circuit

(v) SIMULINK TEST RESULTS:

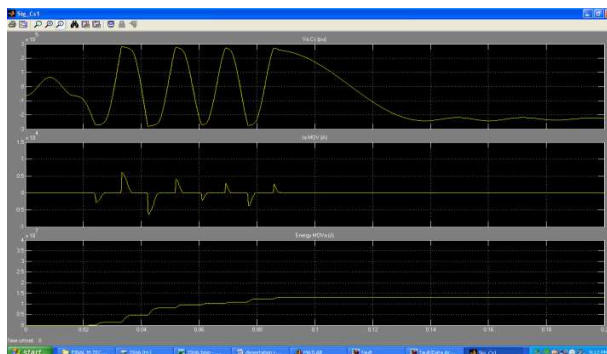**(i) Results of $V_{abc}B1$ & $I_{abc}B1$ with respect to phase A**
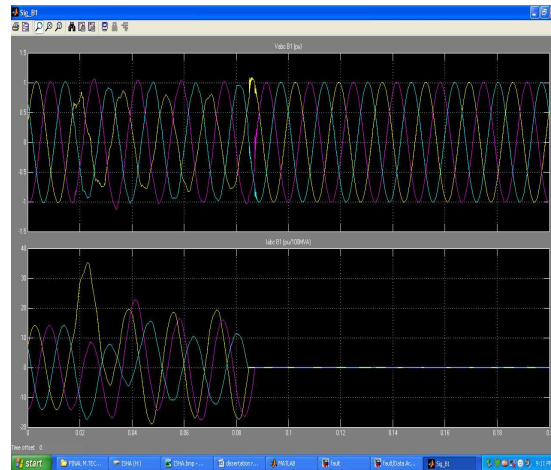
(ii) Results of VabcB2, IabcB2 & Iabc Fault with respect to phase A
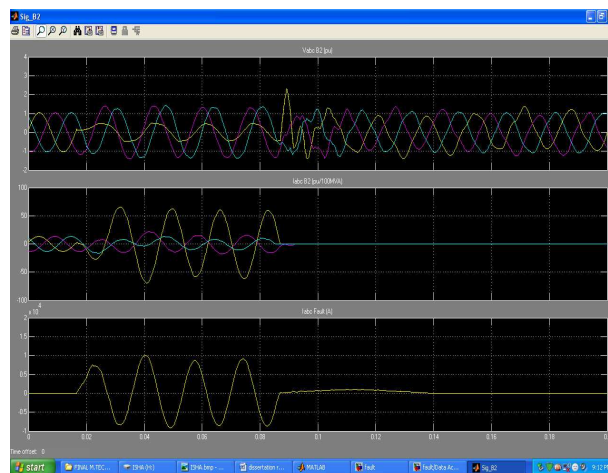
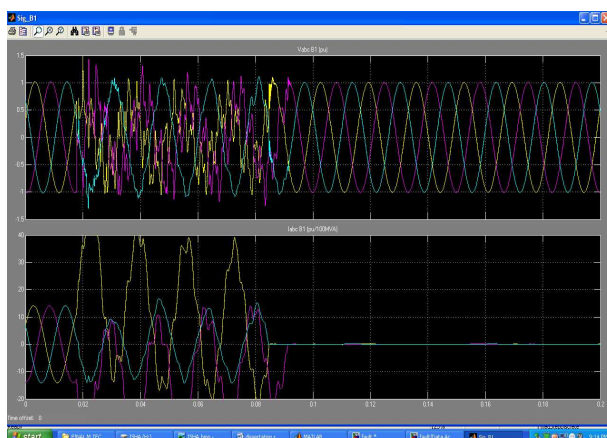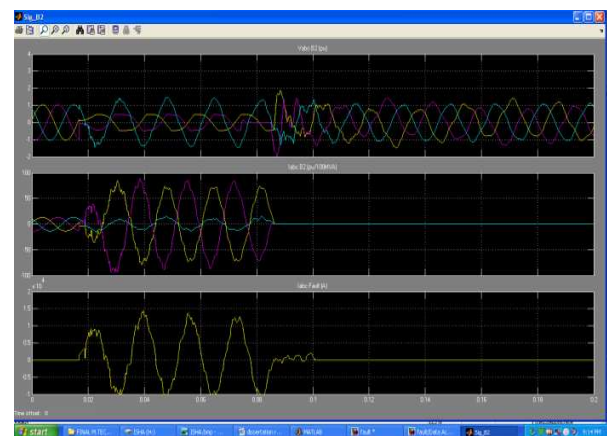**(iii) Results of Va, Ia & Energy with respect to phase A**

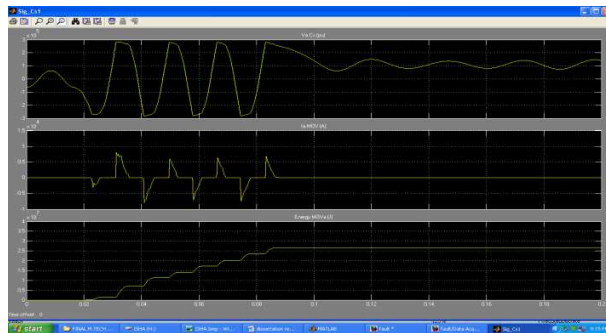**Implementation of Simulink in Protection of Transmission Lines**

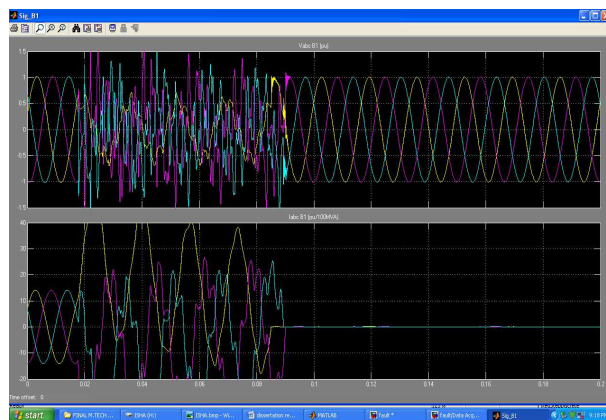

(iv) Results of VabcB1 & IabcB1 with respect to phase B

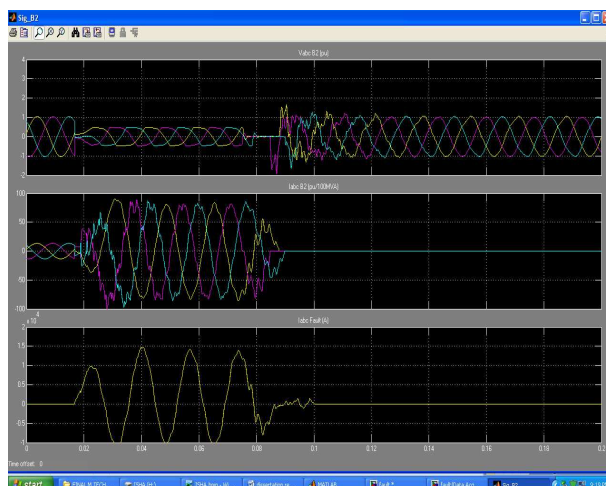**(v) Results of VabcB2, IabcB2 & IabcFault with respect to phase B**

(vi) Results of Va, Ia & Energy with respect to phase B

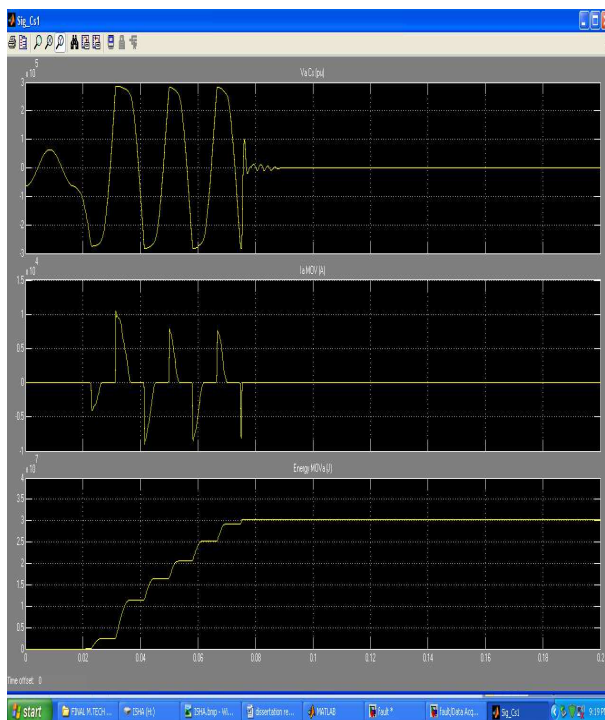**(vii) Results of VabcB1 & IabcB1 with respect to phase C**

(viii) Results of VabcB2, IabcB2 & IabcFault with respect to phase C

(ix) Results of Va, Ia & Energy with respect to phase C

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Conclusion and Recommendation

This paper reveals that protection of Transmission lines can detect, calculate location of fault by using ANN. When faults are detected and isolated faster, it minimizes damage to equipment and personnel.This saves cost of replacement of the damaged parts or equipment, save time and labour in tracing fault location by maintenance crew. The paper therefore provides an economic saving to power utility operatives.

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