Analysis and Simulations of Abnormalities for Induction Motor Using PSCAD

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Abstract – Induction motors are most important part of any network or industry because most of the industries rely on this to drive their equipment. Due to various faults that take place in the motor it interrupts the normal functioning of the motor and leads to system failure or loss. So, it is necessary to reduce this stress factors to a safer level for normal functioning of the motor and this can be done by using various types of protective devices. In this paper we have mentioned different types of abnormalities and how to analyse these abnormalities using PSCAD. By simulating we can know proper working of any system and how that system would behave if same configuration existing at that time during fault.

Keywords*-Motor, Abnormalities, PSCAD (student version)*

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I. INTRODUCTION

The three phase induction motors are the most widely used in electric motor industry. They run at essentially constant speed from no-load to full load. However, the speed is frequency dependent and consequently these motors are not easily adapted to speed control. We usually prefer DC motors when large speed variations are required. Nevertheless, the three-phase induction motors are simple, rugged, low-priced, easy to maintain and can be manufactured with characteristics suit most industrial requirements. [2]

The present paper deals with an induction motor protection unit using PSCAD/EMTDC (student version). The simulations include motor starting and protection of the motor under several abnormal conditions such as over current, over voltage, reverse phase sequence and stalling. [2]

II. PRINCIPLE OF WORKING

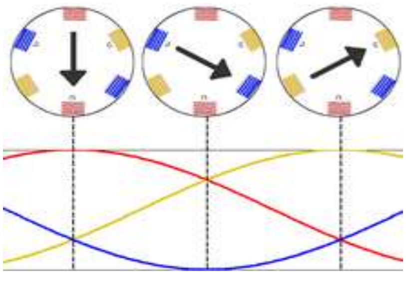

Figure 1. Undervoltage condition

The principle of operation of induction motors is when we energies 3-phase stator winding from supply a rotating magnetic field is set which sets up and rotates around stator at synchronous speed. The rotating field passes through the air gap cuts the rotor conductors and EMF is induced. The current carrying rotor conductors are placed in the magnetic field produced by the stator. Mechanical force acts on the rotor conductors and torque is produced. [2]

The fact that rotor is urged to follow the stator field can be explained by Lenz's law. According to this law, the direction of the rotor current will be such that they tend to oppose the cause producing them. [2]

III. ABNORMALITIES IN MOTOR

In plants and industry any fault in operation of electric motor will cause danger for operator and engineer dealing with it. By using various types of equipments we prevent motor against following some basic faults occurring repeatedly. They are

1. Starting current protection
2. Single phasing
3. Overcurrent
4. Under current
5. Phase reversal
6. Unbalanced
7. Locked rotor
8. Short circuit
9. Earth fault

In this paper we have shown four abnormalities from the above and designed a protection circuit using PSCAD.

IV. SIMULATIONS ON PSCAD

A. *Effect of torque on speed*

As we know that, when a motor is started, it will take some time to attain its rated speed. After some time, the motor will run at its rated speed at torque zero.

Torque and speed are inversely proportional to each other, thus when we apply a sudden torque, the speed will start decreasing gradually.

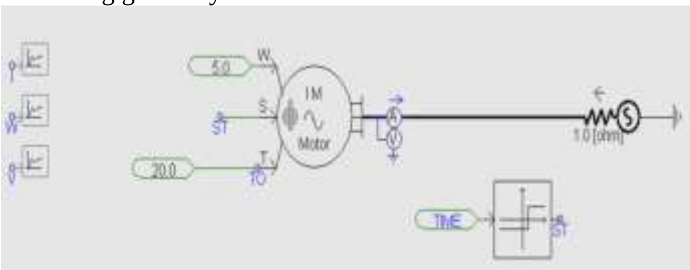

Figure 2. Overvoltage Condition

As seen from figure-2, an induction motor is connected to the three phase supply with a wattmeter connected across it. We can see that the motor has three terminals as W, S and T. That is nothing but the modes of the motor, W are for speed mode, T is for torque mode and S is a switch named switchover switch. When we give logic 1 to the S switch, the motor will run in speed mode and when S=0, it turns into torque mode.

Here, we have used a time block to change S=1 to S=0 in time t=0.1 second. At time t=0, we will have S=1 i.e. the motor is in speed mode. At time t=0.1, S=0 and motor will run at torque mode. The torque applied here is 20 N/m and speed of the motor is randomly taken as 5 rps.

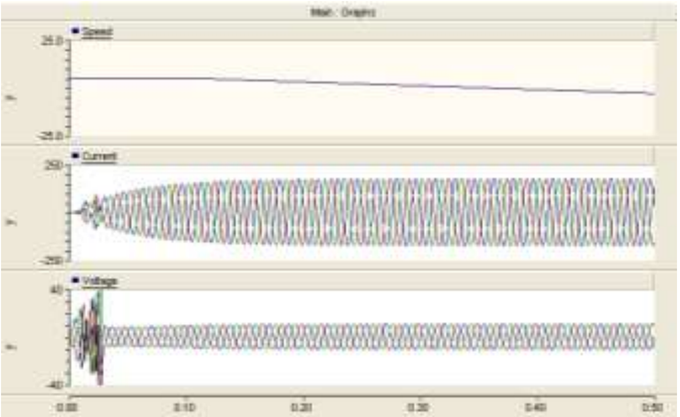

Figure 3. Unbalance current Condition

B. *Model for Overvoltage Protection*

The figure-4 shows the protection circuit for overvoltage protection. Here the motor is connected to three phase supply and an impedance relay is connected to it. At normal condition, the supply is 415 volt so the motor runs normally and the point of R+jX lies within the characteristics of impedance relay.

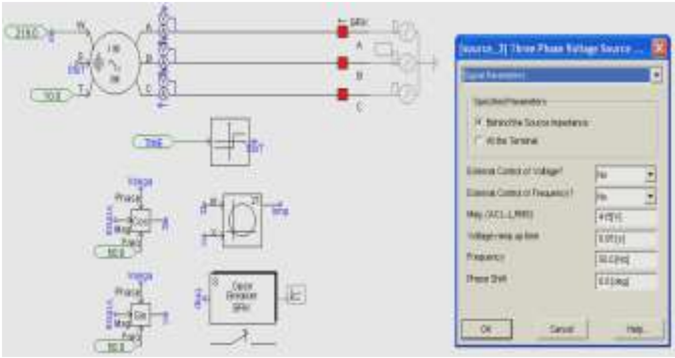

Figure 4

As seen from the figure, the breaker does not operate under the normal condition because the line to be protected is within the characteristic.

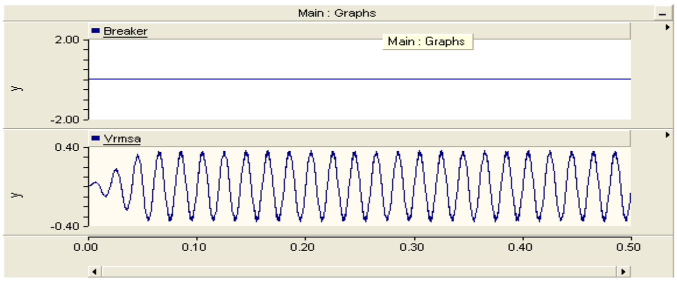

Figure 5

As seen above, the breaker does not receive any tripping signal, so the voltage is continuous which indicates that the motor is continuous receiving the supply i.e. 415 volt.

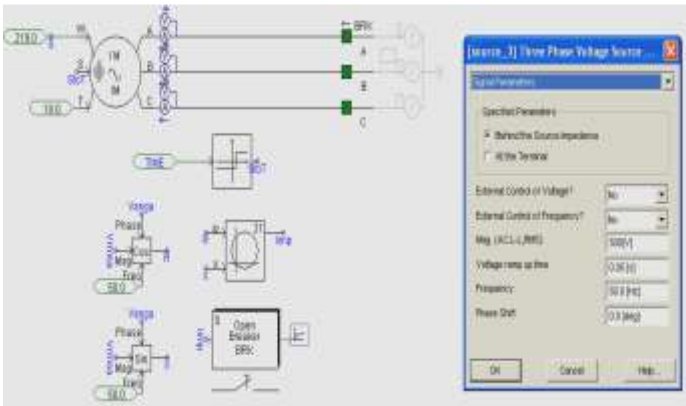

Figure 5

When we change the supply to 500 volt, as seen in the figure, the circuit breaker trips. The point R+jX lie outside the circle i.e. characteristic of impedance relay. Thus, as the point goes out of the circle, a trip signal is generated for the circuit breaker and the breaker, which was normally closed during the normal condition, trips.

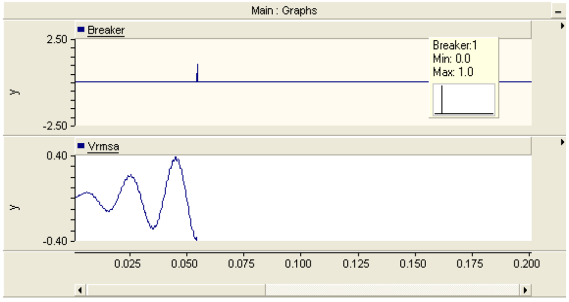

Figure 6

C. *Model for Reverse Phase Sequence*

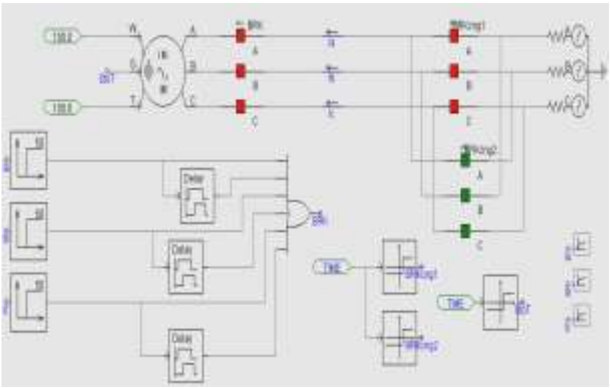

Figure 6. Normal Condition

A motor is connected with a three phase supply with three ammeters in each phase to measure currents Ia, Ib, Ic respectively. Breaker BRK is the main breaker and BRKcng1 is used to connect phases A, B, C to A, B, C of motor respectively.

Breaker BRKcng2 is used here as a switch that is used to reverse the phase sequence. i.e. initially it is A-B-C and after 0.3 seconds the phase sequence changes to B-A-C. Practically, the motor should change its direction of rotation. In this case, as we cannot sense the direction of rotation, the magnitude of current is sensed in all the phases. This is shown in the below figure.

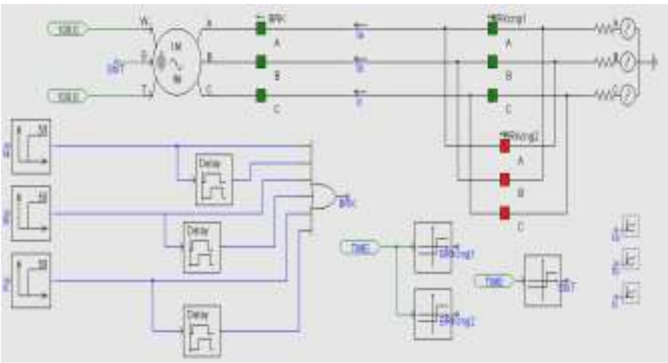

Figure 6. Faulty Condition

Logic NAND gate is used because, the relay must not get tripped if only one magnitude of current goes high, if the current in all the three phases will go high, the NAND gate will give output logic 0. Thus, as the reverse phase sequence takes place, we will get BRK=0. As soon as BRK equals to zero, the main breaker will trip and isolate the motor.

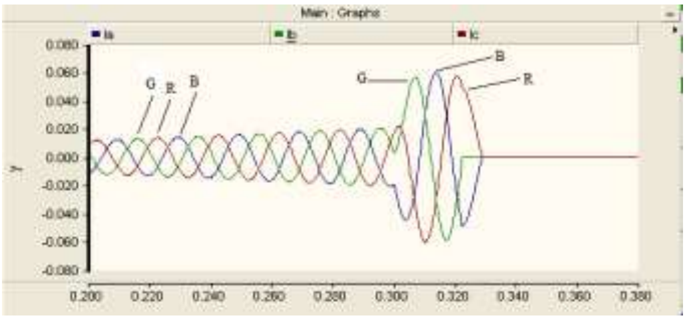

Figure 7

D. *Model for Protection against Stalling*

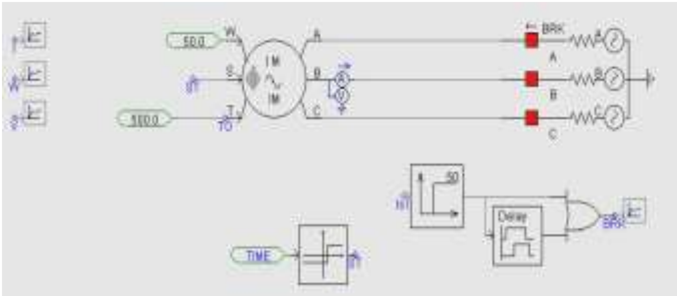

Figure 8. Normal Condition

As seen from figure-8, a three phase induction motor is connected to a three phase supply. The multimeter is connected for measurement of current in phase B. Switching to torque mode is applied after 0.2 second. Practically stalling cannot be done for practical purpose so a heavy load is suddenly applied to the motor running at its rated speed. The motor will try to run the heavy load and will demand the high current.

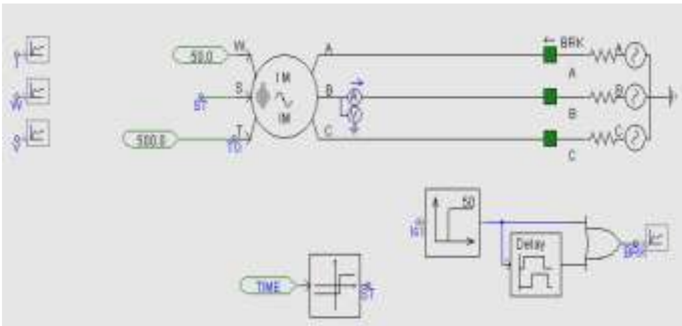

Figure 8. Faulty Condition

A heavy load is applied to the motor and as discussed earlier, the motor will draw a high current from the supply. The relay will sense the high current and will trip the circuit breaker. Is1 increases and the setting is done at some reference. If Is1>set value. It will generate a logic 1 signal which opens the circuit breaker and isolates the motor.

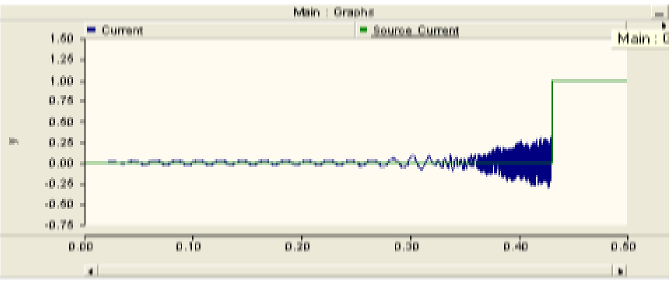

Figure 8

E.   Model for Overcurrent Protection

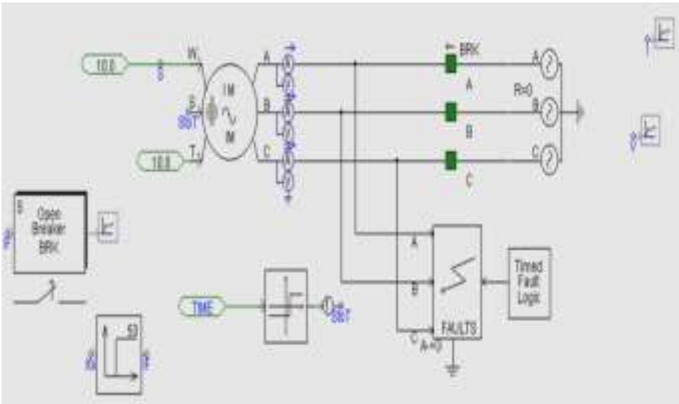

Figure 9

In this simulation, the switching from speed mode to torque mode is done at 0.2 seconds. The ratings of the motor are kept same with a 3-phase supply of 11kV at 50Hz. The fault block is used to apply a line to ground fault on line A after 0.3 seconds.

The graphs below shows that as soon as the fault is applied, a tripping signal is generated which opens the circuit breakers.

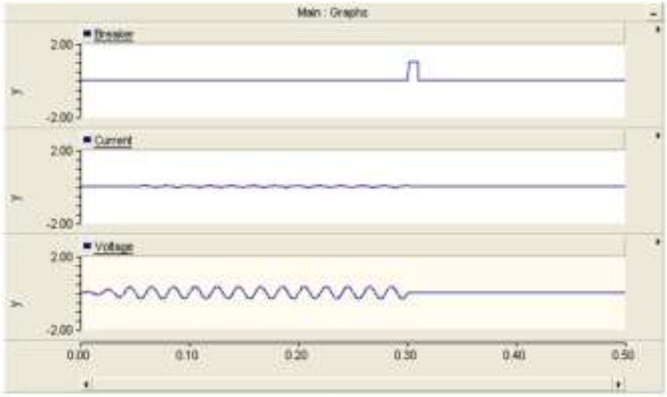

Figure 10

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