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Model reference adaptive controller based protection of Power Transformer from Various Faults

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Abstract

Power transformer is the very important element in the power systems. For successful running operation of power transmission and distribution, the transformer operation is important. The protection of power transformers is very important. Otherwise, under fault condition the complete transmission system will lead to power outage. The protection is required for power transformers i.e. mainly against inrush currents, internal faults [1].

a. Exciting inrush current will flow, when the transformer is operated without keeping load or in the voltage recovery after the fault being removed. During this fault the exciting current is as high as ten times of rated current will flow into the transformer
b. Internal faults: Most of the faults occur in the transformer are internal faults.

Conventional methods are available to protect the transformer against these faults. In conventional protection scheme, we use the current difference flowing through the difference flowing through the different terminals of the transformer so as to distinguish between different faults.
Differential Protection scheme provides satisfactory protection for both phase and ground faults. When the transformer is unearthed or via high impedance, the conventional differential protection is differential protection is difficult to detect the internal fault.
This work proposes to develop transient detection techniques using MRAS controller for all these faults. MRAS transform is a mile stone of the development of Fourier

transform and has attracted great attention and has been successfully used in many applications including the analysis and detection of electromagnetic transient, power quality assessments data compression and fault detection. The MRAS controller has an advantage of characterization of current and voltage signals. Identification of transients is very fast and accurate[8].
The research proposes to develop a new MRAS to identify inrush currents to distinguish it from power system faults. The
Proposed algorithm extract faults and inrush generated transient signals using MRAS controller.

Keywords—MRAS, MATLAB, Power transformer, Three-phase faults.

I. INTRODUCTION

Power transformer is one of the most essential elements in the power system. Power transformer functions as a node to connect two different voltage levels. Therefore, the continuity of the transformer operation is of vital importance in maintaining the reliability of power system. Any unscheduled
Maintenance, especially replacement of faulty transformer is very expensive and time consuming. In order to detect faults, high speed, highly sensitive and reliable protective relays are required [2].
For this purpose, differential protection has been employed as the primary protection for most of the power transformers. Differential protection is based on the fact that any fault within electrical equipment would cause the current entering it, to be different from that leaving it. Thus, we can compare the two currents either in magnitude or in phase or both and issue a trip output if the difference exceeds a predetermined set value. This method is very attractive when both the ends of the apparatus are physically near each other[7].
A differential scheme is supposed to respond only to internal faults and restrain from tripping on inrush currents and external faults. The differential current is small for external and normal operating conditions. The differential current becomes significant for internal faults, the relay operates if the difference exceeds a predetermined set value.
When an unloaded transformer is energized, the primary windings draw large magnetizing inrush current from the power system. As this current flow only on the primary side of the transformer, it looks like an internal fault to the differential scheme and ends up as spill current and the relay maloperates.
Distinguishing an inrush current from an internal fault current is still a challenging Power Transformer Protection problem. The inrush waveform is rich in harmonics whereas the internal fault consists of the fundamental and small amount of second harmonics[11].
Conventional transformer protection schemes use second harmonic component as the discriminator factor between an inrush and internal fault current [1].The main drawback of this approach is during CT saturation, the second harmonic component may also be generated during internal faults and the new low-loss amorphous

materials in modern Power transformers may produce low second harmonic content in inrush current [2].

II. DESIGN OF MRAC

Introduction:

To design and model adaptive controller, tune and analyze its performance using Simulink®. For this example we have used direct adaptive method called Model Reference Adaptive Controller (MRAC)[6]. There are three main elements of this model: Reference Model, Plant Model and Adaptive Controller.

1.) Reference Model: This part of the controller captures\models the desired behavior of closed-loop system. In other words, how you like your overall system to behave for a given input is modeled in this subsystem. In this example, reference behavior is modeled as a transfer function. This can also come from closed-loop system specifications described in below figure as desired Rise Time (in sec), Settling Time (in sec) and Steady State Error (0)[12].

2.) Plant Model: In this example, plant is a DC Motor. One of the many motor parameters, *Kf* – Mechanical Damping, is considered to be varying. Initial value is assumed to be 0.2. And PID controller is tuned to achieve desired response with this initial value of *Kf*. Now as motor goes through ageing and impact of other environmental conditions, *Kf* changes, this will change motor behavior. Plant output is *Yp*. Hence controller has to adapt\change its parameter values to achieve desired response (*Yp – Ym = error (e) = 0*).

III. SIMULATION MODELS

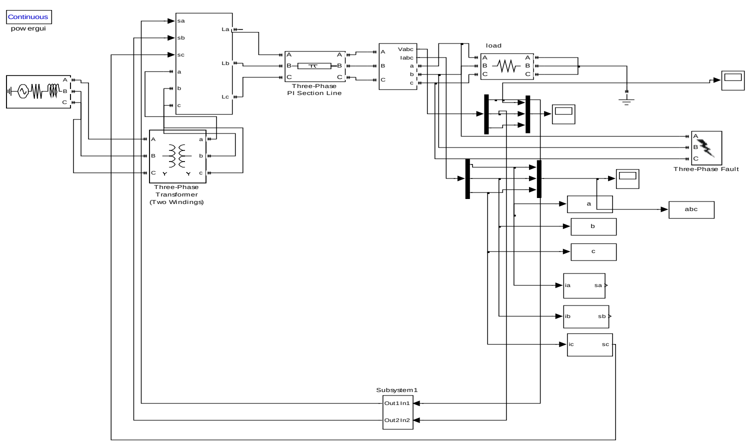

Fig 1: Simulation model with MRAS through MRAS with LG fault

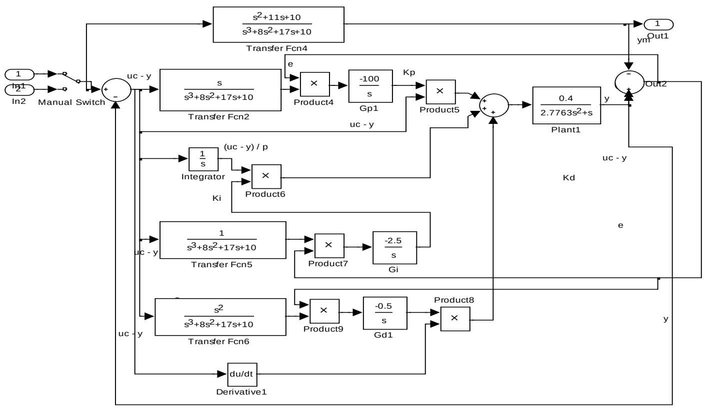

Fig 2: Sub system of MRAS

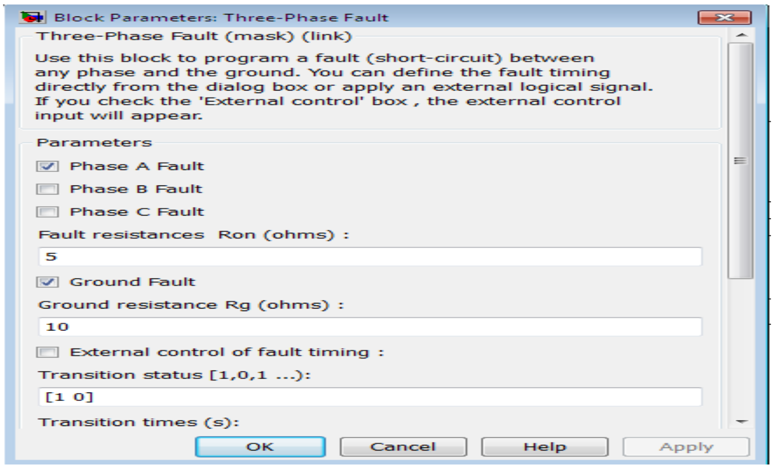

Fig 3: Three-phase fault block parameters

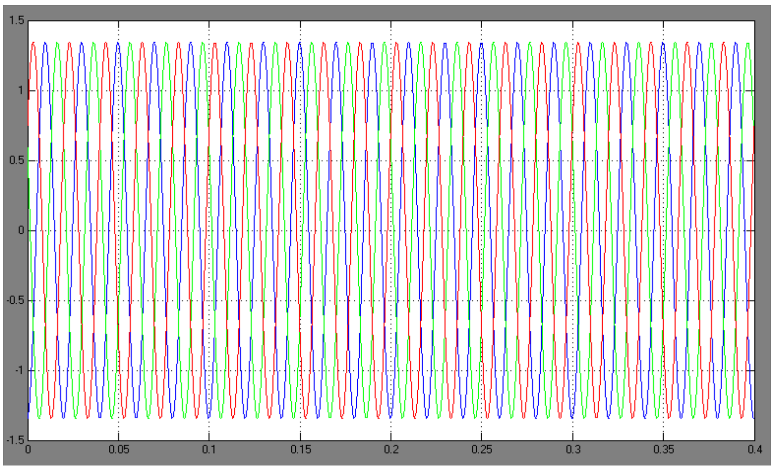

Fig 4: Three phase currents Versus time (secs) before fault

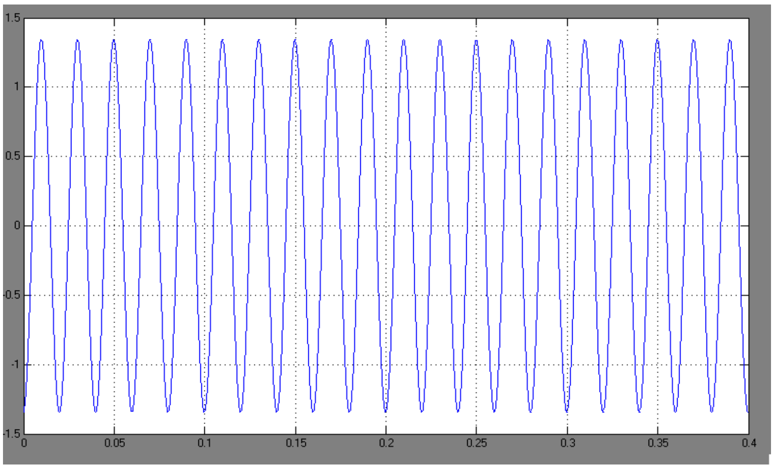

Fig 5: Single phase voltage Versus time (secs)

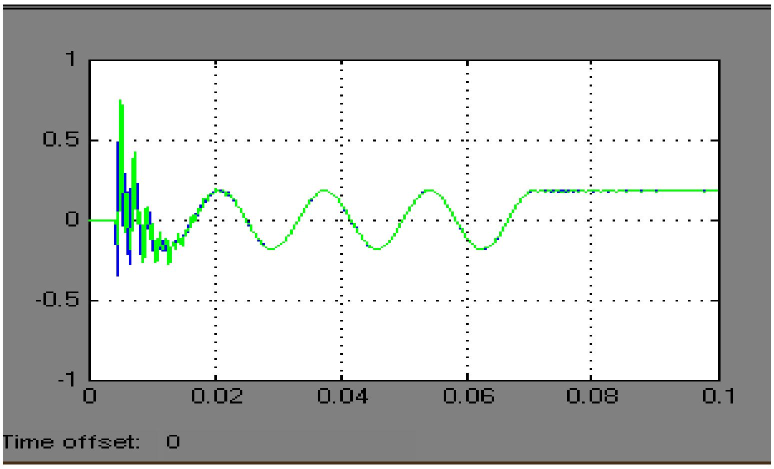

Fig 6(a) Transients in Phase a voltage versus time (secs)

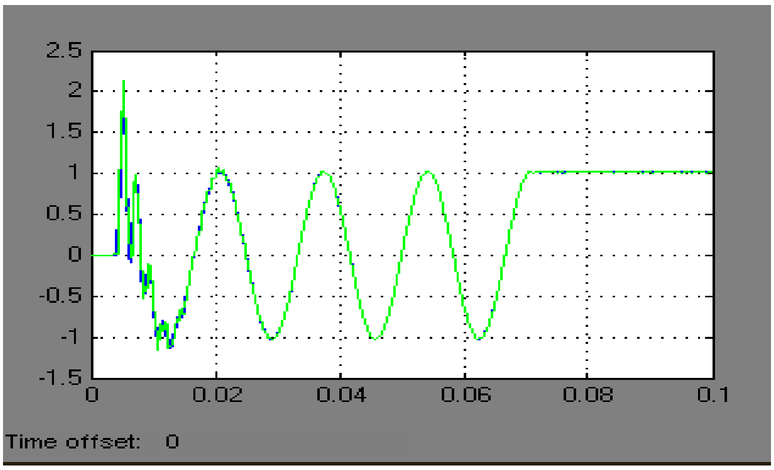

Fig 6(b) Transients in Phase b voltage versus time (secs)

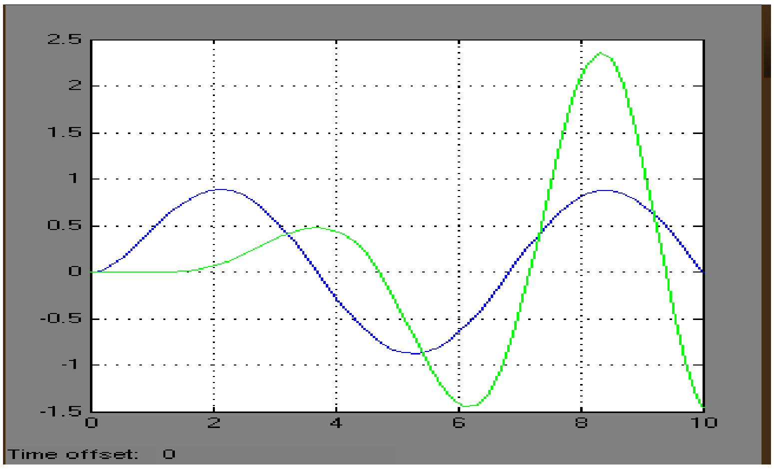

Fig 7: Error of the internal fault current after fault occurred

IV. CONCLUSION

The results clearly show that the proposed MRAS controller accurately distinguishes internal fault and magnetizing inrush currents in three phase transformers. The MRAS effectively distinguishes and gives trip signal within 1/8th of cycle which is considered to be very fast. The relay also provides high sensitivity for internal fault currents and high stability for inrush currents.

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