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Overcoming the Mal-Operation of Distance Relay in Zone-3 during Stable Power Swing:

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ABSTRACT: Distance Relays are used for the protection of transmission line. Distance relay usually operates for 3 zones. Power oscillations which are inherent to power system may result in any event such as line switching, short circuit faults, generator tripping or load shedding. If fault occurs during power swing, the distance relay should be able to detect the fault and operate correctly. The power swing caused by various transients may cause mal operation of distance relay. This paper proposes transient stability prediction based on curve fitting Polynomial and Runge kutta methodto determine the optimal tripping time for zone 3 so that the relay will block the tripping for stable power swings. Performance of the proposed scheme is evaluated on the IEEE 9 bus system using Mi Power and the results are presented in the paper.

KEYWORDS: Distance relay operation, Stable power swing, Rotor angle prediction, Blackouts

I.INTRODUCTION

Protection devices play an important role in reliability of power supply. Power system protection and stability are becoming more and more challenging due to the complex nature of the Power system. Transmission lines play an important role in transferring power to the end user. Therefore, improved dependability and security of transmission line relays are required. Finding effective means to monitor and improve distance relay operations is very important for understanding and mitigating relay operations on high voltage transmission lines. Power swing is a phenomenon of large fluctuations of power between two areas of a power system. Power swing can cause small or large impacts to the synchronous machines. During the case of large impacts, the system may lose its synchronism. The occurrence of Power swing is difficult to predict since they are quite unexpected [2]-[5]. During the occurrence of symmetrical fault, the apparent impedance at the relay location may decrease and enter into the relay tripping zone. This may cause unintended trips. During this situation, the relay needs to make proper justification either to activate the tripping signal or to block the tripping signal. The Northeast
Blackout in 2003 was caused by distance relays operation in zone 3 under the overload and power swing condition, which stressed the system and made the system collapse at the end [6].

To ensure reliability, most of the time load shedding is carried out irrespective of the type of the power swing. But during stable power swing, relay operation should be blocked and during unstable power swing relay tripping action should be activated. The procedureis easy to implement for unsymmetrical faults, since the negativeand zero sequence components do not exist during powerswing, which can be used as fault detection criterion. However, itis much more difficult to identify symmetrical fault during stablepower swing, which may delay the operation of relay [7].

This paper presents a new approach to predict the timeevolution of rotor angles of synchronous generators from a setof measurements acquired in real time after occurrence andclearing of a fault or other disturbance (i.e. immediate postfaultconditions) by using a modification of the Taylor seriesexpansion in combination with the finite difference method.The aim of the proposed approach is to alleviate thecomputational burden while maintaining satisfactory accuracy.The feasibility of the proposed work is tested on IEEE 9 bus system.

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The outline of the paper is as follows: Section II gives overview of distance relay behavior during power swing.Section III provides existing approach of Polynomial CurveFitting Method. Section IV presents case study and test resultsof the proposed approach and, Section V providesconclusions.

II. DISTANCE RELAY BEHAVIOUR DURING POWER SWING

The responses of the power system to different disturbancesdepend on both the initial operating state of the system and theseverity of the disturbances. The steady state power systemoperates at an equilibrium, which maintains the balancebetween the generated and consumed power. When systemdisturbances occur, such as faults, transmission-line switching,sudden loss of load, loss of generators, loss of excitation, etc.,the mechanical power input to the generators remains constantfor a short time under those sudden changes in power system.This will cause the oscillations in machine rotor angles andresult in power flow swings. The maximum oscillations in rotor can be up to 180^0 for a stable power swing. If this angle is exceeded, pole slipping occurs and causes unstable operation of the synchronous machines.

If there is no fault on the considered transmission line, theimpedance seen by distance relay at bus m iswhere,

$$Z_c = \frac{\dot V_m}{\dot I_{mn}} = \frac{\dot V_m}{\frac{(\dot V_m - \dot V_n)}{Z_L}} = Z_L\left(\frac{1}{1-\frac{V_n}{V_m}}\right) \rightarrow \quad (1)$$

Vm is the voltage at bus m, Imn is the current flow frombus m to bus n, ZL is
the line impedance.From (1), the apparent impedance Zc seen by the relay isdeter-mined by twovoltagesat the two ends. Since the bus voltages will oscillate duringpower swing, *Zc*will also vary accordingly. The plots of *Zc*trajectories in the R-X plane with respect to voltage magnitude ratios and angle differences are shown in fig1.

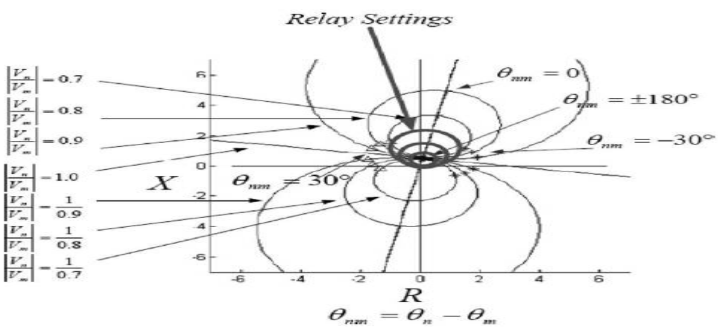

Fig.1 $Z_c$trajectory in the R-X plane.

III. POLYNOMIAL CURVE FITING METHOD (Existing work)

Mathematically, for each synchronous generator in a powersystem, the rotor angle δi (i=1,2,...*n*) is determined by theswing equation :

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$$\frac{d\,\omega_i(t)}{dt} = \frac{1}{M_i}\left[Pm_i(t) - Pe_i(t)\right] \qquad (2)$$

$$\text{where}\frac{d\omega}{dt} = \frac{d\delta_i(t)}{dt} = \omega_i(t) - \omega_0 \qquad (3)$$

where M is the moment of inertia, Pm is the mechanical power input, Pe is the electrical power output, and ω is thespeed of the generator rotor.

The basic idea behind polynomial curve fitting is to find a polynomial that best fits to a series of data points. The quality of the fit is measured by the quantity L:

$$L = \sum_{i=1}^{n} |Fi - fi|^2 \quad (4)$$

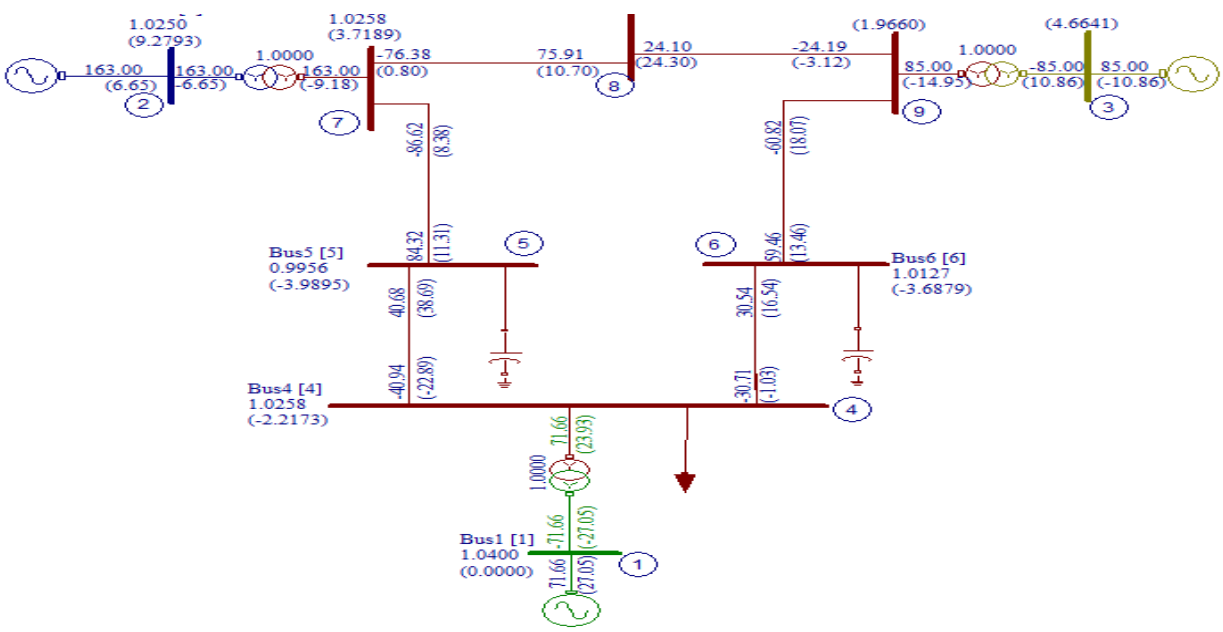
where Fi is the i-th value of data set, and fi is the value obtained from the fit. This method uses polynomial curve fitting method to determine the rotor angle of each machine to determine the stability of the synchronous machine.

IV. ANALYSING USING RUNGE KUTTA METHOD(Proposed work):

In this approach, we use Runge Kutta method to determine the rotor angles of the synchronous machines from the transient stability analysis of IEEE 9 bus system in order to obtain a better optimal tripping time in third zone for distance relay during stable power swing.

V.SIMULATION WORK

Load flow analysis for IEEE 9 bus system has been performed using Mi power. By applying 3 phase to ground fault in transmission line 7-5 near bus 7, the transient stability of the synchronous machines are studied after clearing the faults. Collecting the bus voltage at every instant, the rotor angle of the machine is estimated when the fault is cleared. By using Runga kutta method, stability of the system is determined using Matlab. The proposed work is completed up to transient stability analysis.



The remaining part of the proposed work is under progress and will be completed as soon as possible.

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VI. CONCLUSION

This paper presents a study and analysis of the performance of the IEEE 9 bus system to prevent the maloperation of the distance relay in third zone during stable power swing is achieved by setting the optimal tripping time for the distance relay operation using the RUNGA KUTTA method. From this transient stability prediction, distinction is made between the stable power swing and unstable power swing, so that the distance relay is getting blocked for stable power swing and unblocked for unstable power swing .

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