International Journal of Research and Review
www.ijrrjournal.com E-ISSN: 2349-9788; P-ISSN: 2454-2237

Original Research Article

Enhancement of CCT with Damping Control by Fuzzy Technique

B. Archana Bai[1], **R. Kalpana**[2]

[1]PG Student/EEE, [2]Assistant Professor/EEE,
PSV College of Engineering & Technology, Tamil Nadu, India.

Corresponding Author: B. Archana Bai

Received: 29/04/2015 *Revised: 15/05/2015* *Accepted: 18/05/2015*

ABSTRACT

This paper proposes an improved steady state equivalent circuit method to determine transient stability of a distribution system or a micro-grid with multiple IGs. Interaction between IGs and distribution network during a fault is investigated. The relationship between network parameters and speeds of IGs is derived using the steady-state equivalent circuits of IGs. The critical speed and critical fault clearing time (CCT) for maintaining system stability are determined using the proposed fuzzy based technique. The factors, which affect transient stability of a multi-IG distribution system, are investigated. The correctness of the proposed method is verified by dynamic simulation using MATLAB and Suppression of low-frequency oscillations increasing power transfer capability between interacting areas, Enhanced secure power flows reducing unplanned system separation or blackouts.

Index Terms: *Induction Generator (IG), Critical clearing time (CCT), Fuzzy technique, transient stability, low frequency oscillation.*

I. INTRODUCTION

More distributed generators (DGs) will be embedded in distribution networks with increasing penetration of renewable power. DGs include synchronous generators, induction generators and other power sources with the electronic interface. On the other hand, induction motors (IMs) form large part of load in industrial distribution networks. Therefore, transient stability problem appears in distribution network operation due to the connection of various DGs and IMs .Unlike doubly-fed induction generator for a large wind turbine connected to high voltage transmission network through electronic interface, most squirrel-cage conventional IGs are usually used in small and medium scale hydrous and wind farms with direct connection to sub-transmission and distribution networks as DGs due to ability to produce power at varying rotor speeds.

The squirrel-cage induction generator has received an augmented attention in distribution networks duet lower cost, smaller size, and less maintenance. When assort-circuit fault occurs, the electro-magnetic torque of an induction machine decreases significantly and rotor speed accelerates due to drop of the terminal voltage. At the same time, high reactive power consumption may cause voltage collapse of the network. An IG must be either broken emergently or disengaged if its speed exceeds the critical speed. The presence of large scale IGs in a weak network would incur serious concerns about system security and stability. Their based on the relatively mature induction motor (IM) has significant impact on voltage stability in distribution network. It is important to understand the dynamic performances of IGs under normal and fault conditions and their impacts on stability of distribution networks. Following these remarks, the aim of this paper is to study the transient stability of a multi-IG distribution network.

The stability of an IG denoted as speed stability was studied. The transient stability of a single IG has been intensively investigated using the dynamic simulation software, physical experiment and real-time simulation tool. In order to identify the instability mode, the eigenvector analysis has also been used. The critical speed and critical clearing time (CCT) of a single IG in a distribution system were investigated. The critical speed is used as the transient stability limitation. [1-3] Although the CCT of a distribution network with multiple IGs can be determined by using simulation techniques through the trying-error method, very long computation time is required. On other hand, the physical dynamic process of IGs cannot be theoretically explained and the parameters which affect system instability are not explicit. An analytical method for analyzing large-disturbance stability oaf single IG was proposed. This paper stated "Although the method can be applied to amulet-induction generator system by using aggregation techniques when such generators are installed electrically close to each other, the application to multi-induction generator systems, where the generators are installed electrically away from each other, is very difficult, if not impossible". Different kinds of topologies are applied for this investigation, but those have some drawbacks which are shown in Table-1.

II. DISTRIBUTED GENERATORS:

Distributed generation (DG) is electricity generation sited close to the load it serves, typically in the same building or complex. Ranging in capacity from a fraction of a kilowatt up to 50 MW and sometimes higher, the DG embraces a palette of technologies in varying stages of availability, from entrenched to pilot. It is sometimes called a "disruptive" technology because of its potential to upset the utility industry's apple cart. In place of building large, central station plants, DG recommends having many smaller generators, which are scattered throughout the power system. Each generator provides power to small number of consumers nearby. These units might be solar or wind turbine units, highly efficient gas turbines, small hydro, solar thermal energy storage (STES), fuel cells, small combined cycle plants etc. These units normally supply power to the local load centers but the excess power could also be exported to the regional power grid, adding to the capacity and stability of the grid system.

Table-1 Different Topologies & its drawbacks

Method	Drawbacks
Linear Quadratic Gaussian	Only distribution line considered and IG is not considered
Multi- level converter topology is used	Only DC network is analyzed in paper
Dynamic equivalent circuit model has been presented	Optimization has not been performed.
special form of the Lyapunov–Krasovskii	Only time delay is analyzed and not the control section and plant.

This paper is dedicated to study of transient stability performance of a hybrid power system, where some units are thermal type and some are renewable power-generation units. In the present study, a small hydro unit shares a part of the system load. The key to interconnection is the safety of the people who have to clear faults on the line, and protecting the DG generator from feeding into a low-impedance fault. A fault will knock DG off the system, requiring it to be resynchronized with the grid. There are various means to enhance the transient stability performance of the power systems fast valuing is one of the most effective and economic means of improving the stability of a power system under large and sudden disturbances. Fast valuing schemes involve rapid closing and opening of thermal turbine valves in a prescribed manner to reduce the generator acceleration following a severe fault. In one of the commonly used schemes, only the intercept valves are rapidly closed and then fully re-opened after a short time delay. Since the intercept valves control nearly 70% of the total unit power. This method results in a fairly significant reduction in turbine power. For maximum gains with fast valuing, the turbine driving power should be reduced as rapidly as possible. As a matter of fact, fast valuing is a technique applicable to thermal generating units only. Fast valuing techniques have been applied as early as 1929, but they have been extensively used during the decades of 1970’s and 1980’s all over the world.

In this paper, novel distributed hierarchical control architecture is proposed in order to improve the transient dynamics of a large powers system. The current primary frequency control is obtained using a droop speed control, which is easy to implement in practice, but has two major flaws. On the one hand, the steady-state frequency deviation has to be corrected by the secondary frequency control at the automatic generation control (AGC) level. On the other hand, the droop control cannot ensure sufficient oscillation damping. Presently, PSS is employed to deal with damping the generator rotor oscillations. Unfortunately, it might not provide sufficient damping when it comes to inter-area oscillations. A recent solution to smoothing out the oscillation in the power lines is the use of flexible AC transmission systems (FACTS) devices. However, their deployment on a larger scale power system could become an issue in terms of installation and cost. Therefore, in this paper, at the local level of several selected generators, robust decentralized controllers will supplement the action of the governor droop controller to enhance transient stability and restore system frequency faster after faults and disturbances have occurred in the system. At the area level, this controller is coordinated with the AGC structure to ensure that the scheduled power interchanges are met with fewer oscillations.

The proposed robust control strategy considers only the governor dynamics during design process, while the exciter dynamics effects are lumped in the electrical power and treated as disturbance. To improve the model accuracy, for the interconnected generators, a two-axis model is used, as opposed to the conventionally used one-axis flux decay model. The theoretical design of the proposed robust control is made suitable for practical implementation by restricting the controller gains, while ensuring system-wide stability.

III. POWER SYSTEM STABILIZATION CONCEPT:

Low frequency oscillations are observed when large power systems are interconnected by relatively weak tie lines. These oscillations may sustain and grow to cause system separation if no adequate damping is available with the advent of Flexible AC Transmission System (FACTS) technology, shunt FACTS devices play an important role in controlling the reactive power flow in the power network and once the system voltage fluctuations and stability.

[4-7] Series capacitive compensation was introduced decades ago to cancel a portion of the reactance line impedance and thereby increase the transmittable power. Subsequently, [8-10] with the FACTS technology initiative, variable series compensation is highly effective in both controlling power flow in the transmission line and in improving stability.

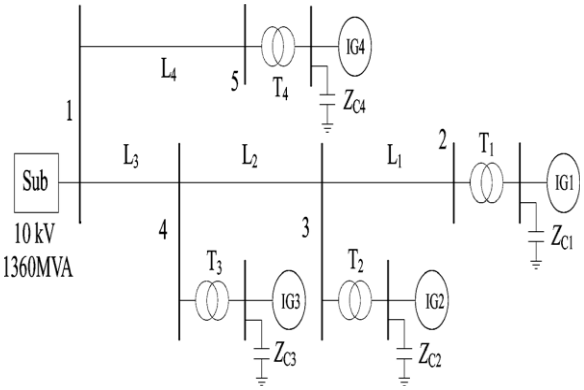


Fig.1.Single line diagram of proposed power system

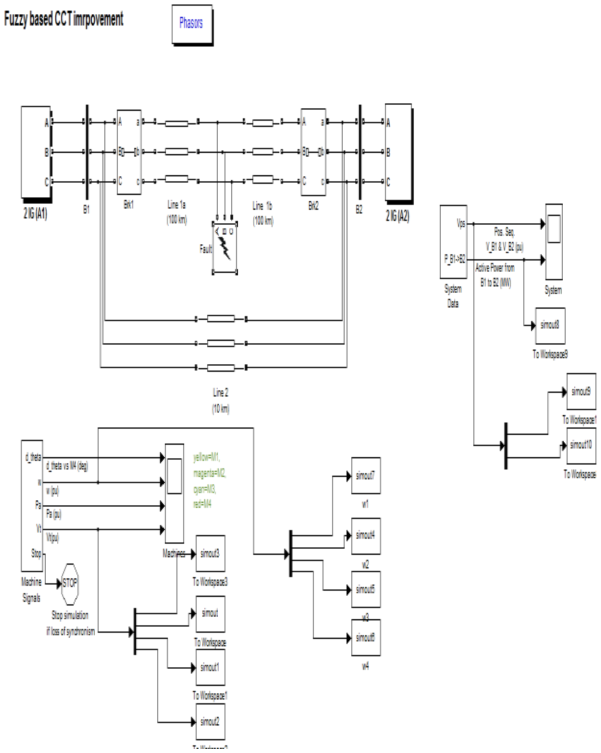


Fig.2.Fuzzy based CCT improvementEquation of CCT:

Equation of CCT is derived by using the venin’s theorem, with equivalent diagram of power system is given by,

$$\mathbf{tcrit} = \frac{\mathbf{2H}}{\mathbf{Tm}}\frac{\mathbf{1}}{\mathbf{Re^2+(Xr+Xe)^2}} \qquad (1)$$

$$\mathbf{X}\ \sqrt{\mathbf{Rr^2 / Tm^2(-4(Xe + Xr)^2Tm^2 - 4ReVe^2Tm - Ve\,{}^\wedge 4)}} \qquad (2)$$

IV. SIMULATION RESULTS:

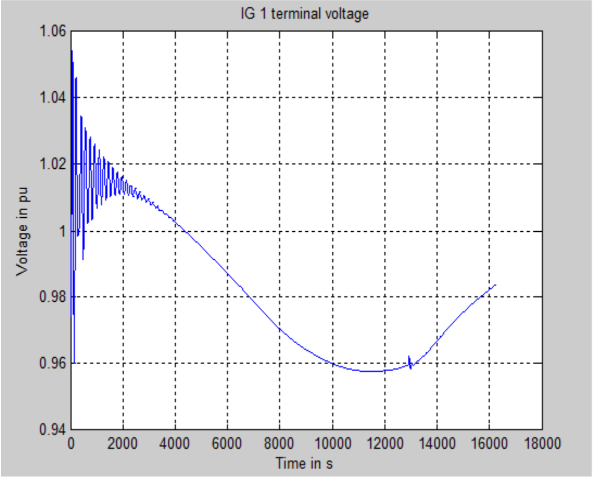
Small-signal analysis of the systems

A modal analysis of acceleration powers of the four machines shows three dominant modes:

(1) An interred-mode (FN = 0.64Hz, z = -0.026) involving the whole area 1 against area 2: this mode is clearly observable in the tie-line power displayed in "System" scope.

(2) Local mode of area 1 (FN = 1.12Hz, z = 0.08) involving this area's machines against each other

(3) Local mode of area 2 (FN = 1.16Hz, z = 0.08) involving machine M3 against M4 (i.e.: the smaller the inertia, the greater the local natural frequent.



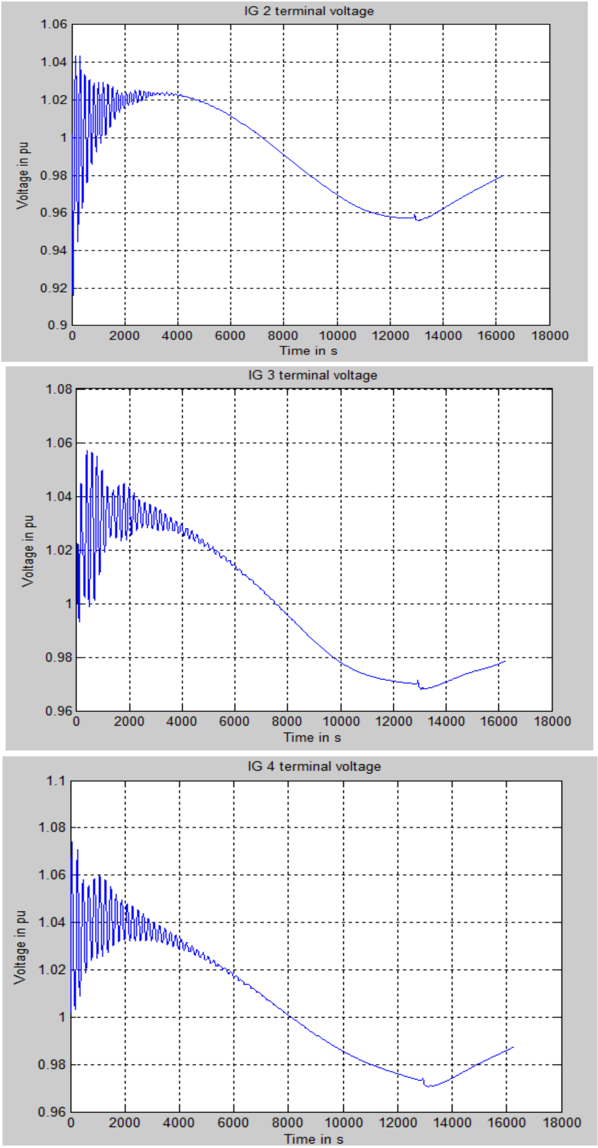
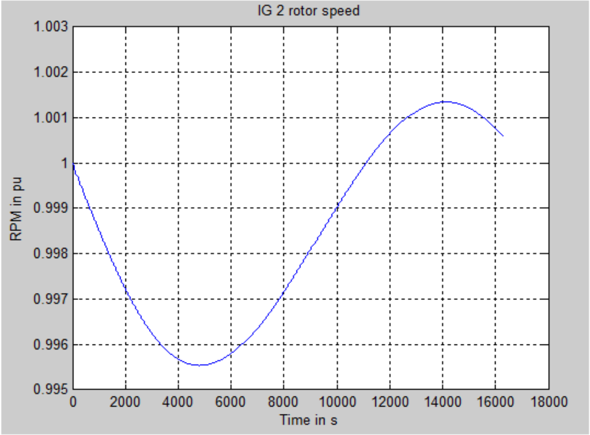


Fig.3,4,5,6. Variation of voltage at IG1,IG2,IG3,IG4 terminals



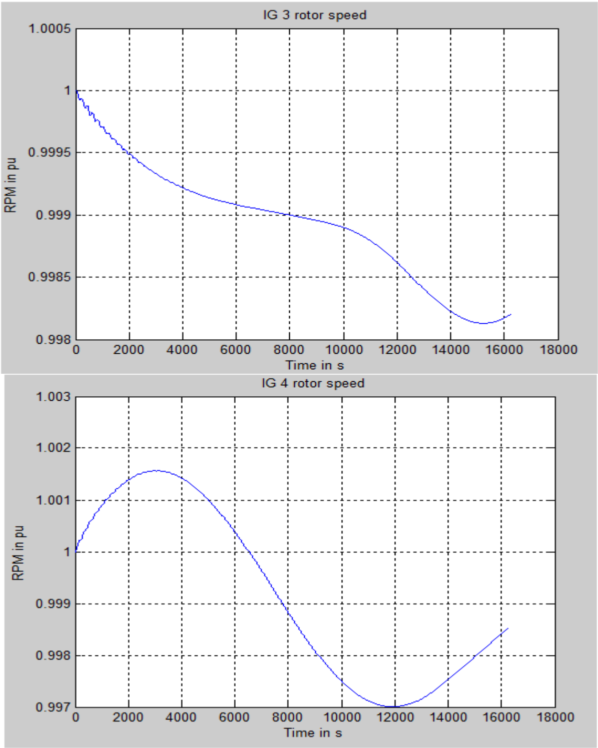


Fig.7,8,9. Rotor speed of four generators

.

The above figure shows the rotor speed variation of $\omega 4$ with respect to all other $\omega 1$, $\omega 2$, $\omega 3$ of four generators with respect to time.

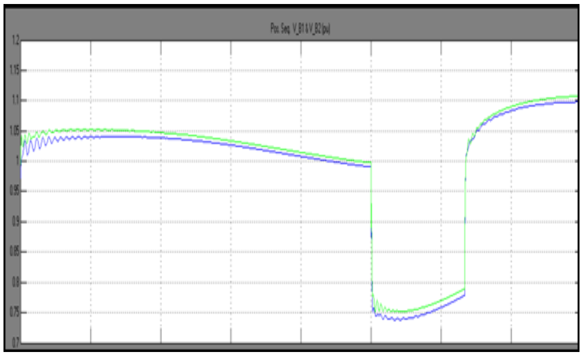


Fig.10.variation of voltage at Bus B1 and B2

Figure 10& 11 shows that, fault is created at t=0.5 with the help of a fault block from simulink. Which creates a three phase faultshorting with ground. The system restores at time t=0.64s. So total critical clearing time CCT from the graph is obtained as t=0.14s. The bus voltage resumes its steach state value within this CCT.

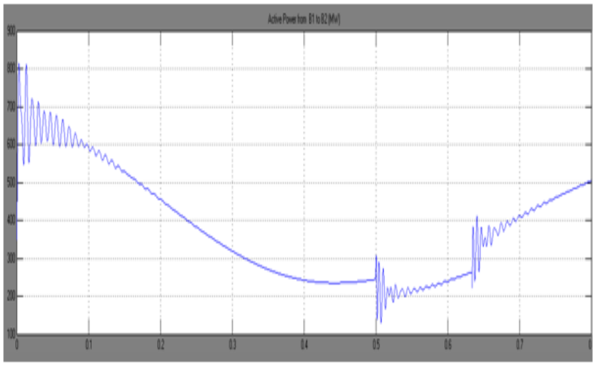


Fig.11.Variation of active power flow from Bus B1 to B2

V. CONCLUSION

This paper proposes an improved analytical method to calculate Critical speed and CCT of multi-IG systems. Transient stability interactions among IGs are investigated using the proposed technique. The proposed technique is verified using dynamic simulation. The comparisons show that the analytical results are very close to the Simulation results. The impact of fault locations and the electrical distance between IGs on system transient stability is studied. The proposed analytical technique is effective to determine the CCT and the critical speeds of multi IGs, which are very useful for transient stability analysis and protection of distribution network. In the simulation method, the CCT and the critical speeds of multi IGs is determined using a searching method from different fault durations 0<t_o<in. Therefore the simulation method needs much longer computation time to find the CCT and the critical speeds.

VI. REFERENCES

1. Z.J.Wang, X.Y.Wang, and C.Y.Chung, “An analytical method for calculating critical voltage sag clearance time of induction motors,”IEEE Trans. Power Del., vol. 27, no. 4, pp. 2412–2414, Oct. 2012.
2. J. Pedro, F. Circles, Ll. Mongo, S. Bogart, and A. Roland, “On fixed speed WT generator modelling for rotor speed stability studies,” IEEE Trans. Power Syst., vol. 27, no. 1, pp. 397–406, Feb. 2012.
3. M. H. Ali and B. Wu, “Comparison of stabilization methods for fixed speed wind generator systems,” IEEE Trans. Power Del., vol. 25, no.1, pp. 323–331, Jan. 2010.
4. H. Nikkhajoei and R. H. Lassoer, “Distributed generation interface to the CERTS micro grid,” IEEE Trans. Power Del., vol. 24, no. 3, pp. 1598–1608, Jul. 2009.
5. I. Xing, A. Ishchenko, M. Popov, and L. van deerSlues, “Transient stability analysis of a distribution network with distributed generators,” IEEE Trans. Power Syst., vol. 24, no. 2, pp. 1102–1104, May 2009.
6. O. Mohan, “Transient analysis of a grid connected wind driven induction generator using a real-time simulation platform,” Elsevier Renew. Energy, vol. 34, no. 3, pp. 801–806, Mar. 2009.
7. A. Luna, P. Rodriguez, R. Teodorescu, and F. Blaabjerg, “Low voltage ride through strategies for scig wind turbines in distributed power generation systems,” in Power Electronics Specialists Conference, 2008.PESC 2008. IEEE, june 2008, pp. 2333 -2339.
8. Kundur, Power System Stabiliy and Control. McGraw Hill, 1994.
9. A. Luna, P. Rodriguez, R. Teodorescu, and F. Blaabjerg, “Low voltage ride through strategies for SCIG wind turbines in distributed power generation systems,” in *Proc. IEEE PESC*, Jun. 2008, pp. 2333–2339.
10. J. Hu, Y. He, L. Xu, and B.Williams, “Improved control of DFIG systems during network unbalance using PIR current regulators,” *IEEE Trans. Ind.Electron.*, vol. 56, no. 2, pp. 439–451, Feb. 2009.

BIOGRAPHIES:

Mrs. B. Archana Bai received B.E(Electrical & Electronics Engineering) from PSV College Of Engg & Technology (TN), India and currently a PG student in Power Systems Engg from PSV College Of Engg & Technology (TN), India. Area of interest includes Renewable Energy Resources, Electrical machines, PSOC, FACTS.

Mrs. R. Kalpana received B.E((Electrical & Electronics Engg) from Institute of Road Transport Technology, Erode, India and M.E from Adhiyaman Engg College, TN, India. Currently pursuing Ph.D. Area of interest includes Power System operation & Control, Renewable Energy sources.

How to cite this article: Archana Bai B, Kalpana R. Enhancement of CCT with damping control by fuzzy technique. Int J Res Rev. 2015; 2(5):242-248.

****