ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2014

Power system protection issues due to wind generation farms

Sujo P George[1], Kush Khanna[2], S Ashok[3], M N Bandyopadhyay[4]

Research Scholar, Electrical Engineering Dept, National Institute of Technology Calicut, Kerala, India [1]

MTech Scholar, Electrical Engineering Dept, National Institute of Technology Calicut, Kerala, India [2]

Professor, Electrical Engineering Dept, National Institute of Technology Calicut, Kerala, India [3]

Director, National Institute of Technology, Calicut Kerala, India [4]

Abstract: The current power system is working under sustaining energy shortages. The distributed generation (DG) can be a solution for the energy shortage. Distributed generation refers to generation of power using a set of small sized generators that produces power at low voltage levels. The distributed generators are mainly designed to be connected directly to the distribution network near load centres. The distributed generation have some negative impacts in the power grid. Many of the DG sources like wind, solar etc are intermittent in nature. The source impedance is varying in nature due to these intermittencies. The fault current characteristics are changing in the presence of distributed generation. Existing relay settings will not sense these change, which leads to malperation of relays. The adaptive relaying can be a solution for the malfunction of relays. Adaptive relaying means the relay has to adapt to the changing environment. The decision making capability is to be incorporated with existing relays. The impact of increment of DG penetration in Kerala power grid is studied and adaptive relaying is suggested as the solution strategy.

Keywords: Distributed Generation (DG), Wind Power, Adaptive Relaying and Fault Current

I. INTRODUCTION

The present scenario shows that electricity sector in India is growing at rapid pace. The present peak demand is about 1, 15,000 MW and the installed capacity is 1, 52,380 MW with generation mix is thermal (63%), hydro (25%), Nuclear (9%) and renewable (9%).The projected peak demand in 2012 is about 150 GW and in 2017 is more than 200 GW. The corresponding installed capacity requirement in 2012 is about 220 GW and in 2017 is more than 300 GW.The distributed generation (DG) can be a solution for the energy shortage. Distributed generation refers to power generation at the point of consumption. Generating power on-site, rather than centrally, eliminates the cost, complexity, interdependencies, and inefficiencies. The concept of distributed generation is based on the provision of many small capacity (1kW to 30 MW) generation units situated much closer to the electricity consumers. The various types of distributed generation include wind power, solar power, biomass power generation, fuel cell, micro turbine etc.

Wind turbines are gaining great popularity among various renewable energy sources. The wind farms can be implemented at low capital cost and can be brought into service relatively quickly. The large wind farms can be connected to transmission network while smaller wind farms and individual plants can be connected directly to distribution network. A tremendous growth is experienced in the installation of wind farms in recent years in India as well as in other foreign countries. Traditional power plants are mostly based on non renewable fuels such as coal, oil and gas which are limited resource and also cause environmental pollution. Wind power has emerged as the most promising source among all other renewable energy sources for power generation and it is a viable and cost effective option for grid connected power generation. The main windy areas in the Kerala State are the eastern mountainous regions of Idukki district along the border of Tamil Nadu and elevated areas in Palakkad gap.

The effect of distributed generation on power system must be carefully studied to maintain power quality and reliability of the network. The major disadvantage associated with wind power generation is its intermittent nature shown in figure 1. The DG has to be implemented into the existing power system after the studies of complexities in operation, power quality and protection of network. The major concentration is to be given to protection of the system, because it affects the reliability of the system.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2014

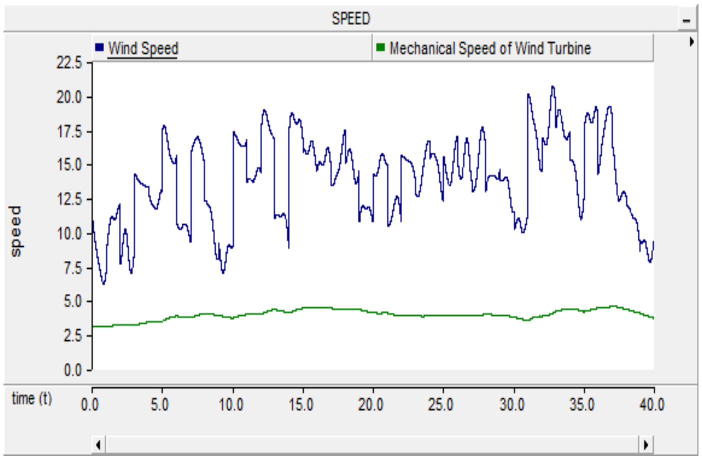

Fig. 1 Wind speed and mechanical speed of the wind turbine

II. PROBLEMS DUE TO INTERMITTENT NATURE OF DISTRIBUTED GENERATION IN PROTECTION LEVEL

The connection of a DG to a distribution network will inevitably result in some local changes to the characteristics of the network. Connecting a generator to a distribution network has the effect of increasing the fault levels in the network close to the point of connection. The connection of distributed generation to the network could cause a distribution network, which happens to be close to its fault level limit, to exceed it. The risks when fault levels are exceeded will cause damage and failure of the plant, with consequent risk of injury to personnel and interruption to supplies. The new fault current and setting should be calculated for the protection equipment in the system. Faults are eliminated in the smallest possible time, isolating the smallest part of the system containing the cause of the fault. The presence of distributed generation may cause coordination problem, such that more area will be isolated. The major problems associated with the penetration of distributed generation into existing system are given in [1] – [2]

- Increase in fault level
- Miscordination
- Reverse power flow
- Islanding
- Blinding of protection
- Sympathetic tripping

Increase in fault level: The connection of a DG to a distribution network will inevitably result in some local changes to the characteristics of the network. Connecting a generator to a distribution network has the effect of increasing the fault levels in the network close to the point of connection. The connection of distributed generation to the network could cause a distribution network, which happens to be close to its fault level limit, to exceed it. The risks when fault levels are exceeded will cause damage and failure of the plant, with consequent risk of injury to personnel and interruption to supplies. The new fault current and setting should be calculated for the protection equipment in the system.

Miscordination: Faults are eliminated in the smallest possible time, isolating the smallest part of the system containing the cause of the fault. The presence of distributed generation may cause coordination problem, such that more area will be isolated.

Reverse Power Flow: Radial distribution networks are usually designed for unidirectional power flow, form the in feed downstream to the loads. This assumption is reflected in standard protection schemes with directional over current relays. With a generation on the distribution feeder, the load flow situation may change. If the local production exceeds the local consumption, the power flow will change the direction. Reverse power flow is problematic if it is not considered in the protection system design.

Islanding: Islanding occurs when a portion of the distribution system becomes electrically isolated from the remainder the power system, yet continues to be energized by DG connected to the isolated subsystem. Distribution networks with

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2014

DG are presently not designed to operate in island mode. If unplanned islanding occurs it presents a number of hazards and thus need to be avoided.

Blinding of Protection: Blinding of protection is also called protection under reach. The distributed generation is supplying energy locally to load. As a result the fault current seen by the relay is reduced. The result is that the relay fails to trip.

Sympathetic Tripping: Sympathetic tripping is an expression given to the case at which one of the protection devices trips instead of the other. This tripping occurs due to one device detecting the fault while it is out of its local protection area and tripping before the required tripping device. The protective device operates unnecessary for faults in another protection zone. As a result of this the healthy feeder gets tripped.

III. LITERATURE REVIEW

The importance of power quality, protection and stability in micro grid is covered in [2]. It suggests three layer control using microcontroller, protection coordinator and energy manager in the operation of micro grid. The necessity of improved communication network and microprocessor for improved speed of operation is given in [3]. Protection of an islanded distribution system is an issue because of the difference in fault current when the distribution system is connected to the grid and when it is islanded. Adaptive protection, uses local information, to overcome the challenges of the over current protection in distribution systems with distributed generation. The characteristics of the relays must be updated by detecting operating states (grid connected or island) and the faulted section. Adaptive protection is an online activity that modifies the preferred protective response to a change in system conditions or requirements in a timely manner by means of externally generated signals or control action. Optimization techniques adopted for adaptive relaying is given in [4]. Time dial setting is done by linear optimization and pickup current setting is done by non linear optimization. The pickup current will be a function of load current is taken for the adaptive relay proposed in . For the differential relay, parabolic characteristic is adopted instead of conventional straight line characteristics. Over excitation is detected by monitoring the voltage and frequency and calculating the voltage to frequency ratio. Magnetizing inrush is detected by supervising the rate of rise of transformer input voltage. Compensation is provided when there is CT mismatch and variations in tap changing positions. The parabolic nature of differential relay is proposed based on this condition is given in [5]. A self adaptive percentage differential relay is proposed in [6], which can self adjust the protection characteristics has the following properties, improvement of differential relay sensitivity for slight internal fault and restraint ability under external fault. Adaptive relaying is defined as a protection philosophy which permits and seeks to make adjustments to various protection functions in order to make them more attuned to prevailing power system conditions is given in [7].

IV. TEST SYSTEM

The Kerala power grid is taken as the test system. The total installed capacity of the system is 3827.73 MW. The three wind plants are at Ramakkalmedu, Agali and Kanjikode with total installed capacity of 34.875 MW.

TABLE I
WIND FARMS IN KERALA

Sl. No	Name	No. of machines	Installed capacity
1	Kanjiokode (Palakkad)	9x0.225 MW	2.025 MW
2	Ramakkalmedu (Idukki)	19x0.750 MW	14.25 MW
3	Agali (Palakkad)	10x1.86MW	18.6MW

The Ramakkalmedu wind power generation is taken as the test system. The wind generators are connected to two feeders, feeder I and feeder II. Three wind generators are connected to feeder I and sixteen wind generators are connected to feeder II. The capacity of each wind generator is 0.75 MW with the total installed capacity of 14.25 MW. The type of generator used here is squirrel cage induction generator. The generating voltage from the wind generator is 690V. It is stepped up to 33kV, by each transformer assigned for each wind generator. The rating of the transformer is

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2014

690V/33KV, 8 KVA. It is then connected to two feeders and connected to 20MVA, 33KV/66KV transformer before connecting to the grid.

The major protection schemes for feeders are numerical distance protection and over current and earth fault protections. For transformers HV side (66kV) the following protection schemes are adopted.

1. Differential protection
2. Over current and Earth fault protection
3. Restricted Earth fault protection

For transformers LV side (33kV) the protection schemes adopted are

1. Restricted earth fault protection
2. Numerical non directional over current and earth fault protection

There are various protection issues associated with the integration of wind farm at Ramakkalmedu with Nedumkandam 66kV substation. The fault level of various buses in the substation is varied based on the availability of DG units. The results are shown in table 2, 3 and 4. It is noticed that malfunction of differential relays happens in the simulation environment. The fault level is getting increased with increase in DG penetration.

V. INCREMENT IN FAULT LEVEL

TABLE II

INCREMENT OF FAULT LEVEL IN DIFFERENT BUSES AT NEDUMKANDAM 66 KV SUBSTATION. (THREE PHASE SHORT CIRCUIT FAULT)

DG Units	**Nedumkandam 66kV**	**Nedumkandam 33kV**	**Kattappana 66kV**	**Nedumkandam 11kV**	**Kattappana 66kV**	**Feeder I 33kV**	**Feeder II 33kV**
No units	20.42	6.14	16.77	7.44	5.99	5.48	5.48
5 units	20.41	6.21	16.76	7.44	5.99	5.55	5.54
10 units	20.39	6.34	16.75	7.44	5.99	5.65	5.56
15 units	20.37	6.45	16.74	7.43	5.99	5.72	5.57
All Units	20.36	6.52	16.74	7.43	5.99	5.78	5.83

TABLE IIII

INCREMENT OF FAULT LEVEL IN DIFFERENT BUSES AT NEDUMKANDAM 66 KV SUBSTATION. (LLG FAULT)

DG Units	**Nedumkandam 66kV**	**Nedumkandam 33kV**	**Kattappana 66kV**	**Nedumkandam 11kV**	**Kattappana 66kV**	**Feeder I 33kV**	**Feeder II 33kV**
No Units	14.46	5.5	11.67	7.21	5.95	4.76	4.76
5 units	14.54	5.73	11.72	7.21	5.95	4.98	4.93
10 units	14.61	5.95	11.76	7.21	5.95	5.19	5.1
15 units	14.67	6.17	11.81	7.21	5.95	5.4	5.25
All Units	14.71	6.3	11.83	7.21	5.95	5.5	5.37

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2014

TABLE IIIV

INCREMENT OF FAULT LEVEL IN DIFFERENT BUSES AT NEDUMKANDAM 66 KV SUBSTATION. (LG FAULT)

DG Units	Nedumkandam 66kV	Nedumkandam 33kV	Kattappana 66kV	Nedumkandam 11kV	Kattappana 66kV	Feeder I 33kV	Feeder II 33kV
No Units	32.82	5.57	27.88	7.34	6.2	5.25	5.25
5 units	32.98	5.9	27.99	7.34	6.2	5.28	5.54
10 units	33.12	6.22	28.09	7.34	6.2	5.91	5.83
15 units	33.24	6.55	28.18	7.34	6.2	6.24	6.11
All Units	33.31	6.75	28.23	7.34	6.2	6.43	6.31

VI. MALFUNCTION OF DIFFERENTIAL RELAYS

The differential relay is getting malfunctioned in the presence of distributed generation. The relay setting is based on full DG capacity. When there is a variation in DG capacity the relay will not trip. In fig.2 the relay is getting tripped and in fig.3 the relay is not able to change the settings and will not trip.

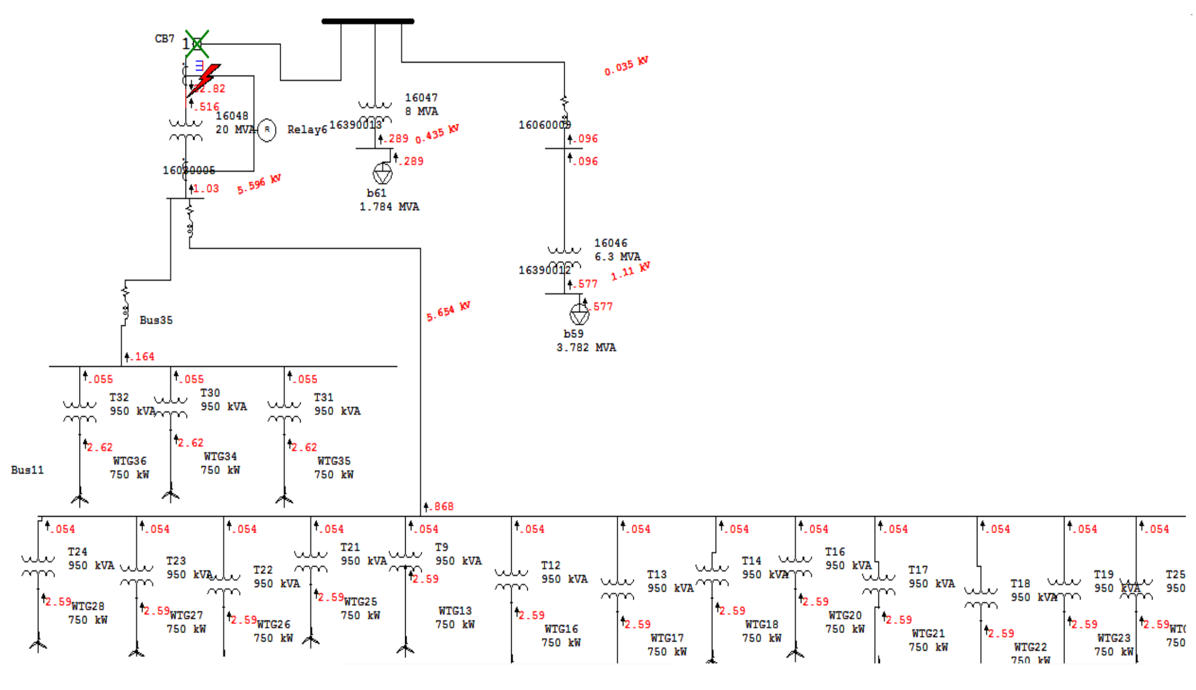

Fig.2 Differential relay get tripped when all the DG's running at its rated condition

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2014

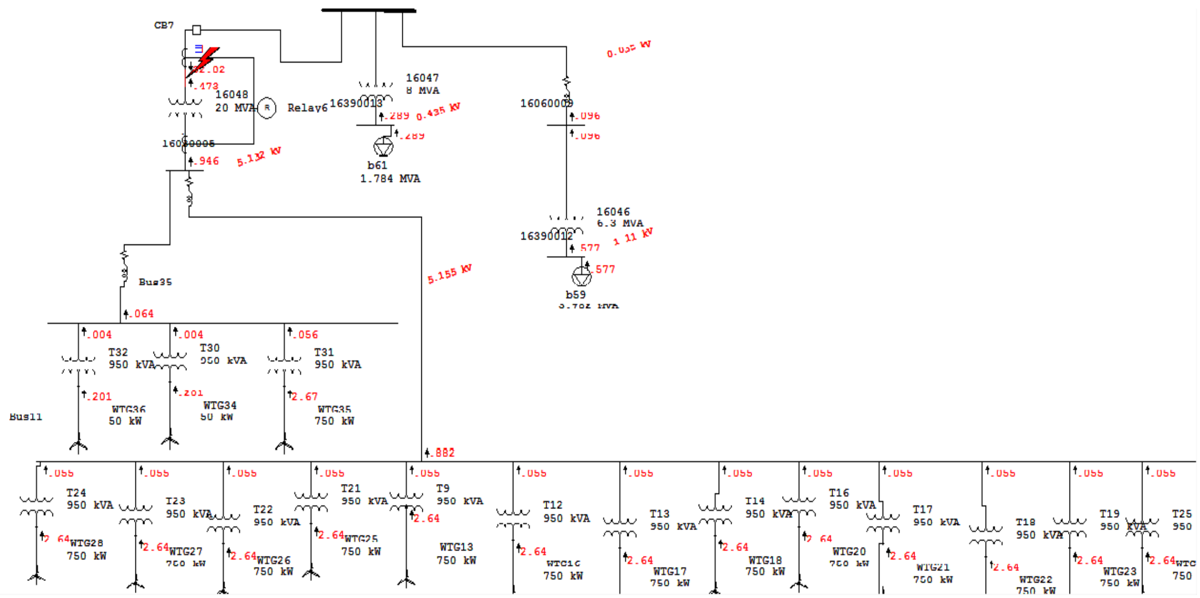

Fig.3 Differential relay not tripped when all the DG's not running at its rated condition

VII. ADAPTIVE RELAYING

An adaptive relay is a relay that can have its settings, characteristics or logic functions changed online in a timely manner by means of externally generated signals or control action. In other words, adaptive protection systems are systems which change in relay characteristics/settings due to actual system state. With respect to transformer differential protection, the change in relay settings imply that the restraint values obtained from harmonic analysis can be altered. The different step in adaptive relaying is given in [8]. The relays sample bus voltages and line currents via voltage and current transducers, auxiliary transformers, analog to digital converters and multiplexers. Each relay processes quantized samples and calculates voltage and current phasors. During normal operating conditions, each relay provides phasor measurements to its station control computer at regular intervals. The relays also check the status of local isolators and circuit breakers and provide the information to the station computers. In addition to communicating with the relays, the station computers pass on the collected information to the central computer which estimates the system state and decides whether the relay settings should be changed or not. If it decides to change the settings, it calculates them and conveys them to the relays via the station control computers. The relays implement the new settings and send confirmation messages to the central computer via the station computers. If the central computer decides not to change the settings, the decision is communicated to the relays for sharing information and confirming that communication facilities are working properly. Adaptive relaying provides lower relay operating times and maintains proper relay coordination. A change of system configuration affects the selectivity adversely unless relay settings are changed. The purpose of adaptive relaying is to change relay settings as load currents and/or expected fault currents change, and/or when the system topology changes. The another objective is to keep the minimum time delays of all relays close to a selected minimum while maintaining proper coordination margins. To implement the adaptive relaying scheme three major software packages is to be developed i.e, relaying software, coordination software and communication software. [9] - [11].

VIII. CONCLUSION

The protective relays in the power system malfunctions in the presence of distributed generation due to intermittent nature of wind power, solar power etc. The Ramakkalmedu wind generation plant in Kerala power system is taken as test system and proved that malfunction of relays takes place due to intermittent nature of distributed generation. The fault level is getting increased with increase in DG penetration. The solution method suggested is adaptive relaying and multi agent system in which relay has to adapt to the changing environment. The existing relays are to be changed into intelligent relays.

REFERENCES

[1] Hui Wan , LiK. K., Wong. K.P. ―An Adaptive Multiagent Approach to Protection relay coordination with distributed generators in industrial power distribution system‖ *IEEE Transactions on Industry Applications* Volume: 46, Issue: 5 Publication Years: 2010 , Page(s):2118-2124

[2] Prasenjit Basak, S. Chowdhury, S. Halder nee Dey, S.P. Chowdhury "A literature review on integration of distributed energy resources in the perspective of control, protection and stability of microgrid" Renewable and Sustainable Energy Reviews Volume 16, Issue 8, October 2012, Pages 5545–5556

[3] Sachit A. Gopalan, Victor Sreeram, Herbert H.C. Iu "A review of coordination strategies and protection schemes for microgrids" Renewable and Sustainable Energy Reviews, Volume 32, April 2014, Pages 222-228

[4] A.Y Abdelaziz, H.E.A Talaat, A.I Nosseir, Ammar A Hajjar "An adaptive protection scheme for optimal coordination of overcurrent relays " Electric Power Systems Research, Volume 61, Issue 1, 28 February 2002, Pages 1–9.

[5] R.P. Maheshwari, H.K. Verma "Adaptive digital differential relay with overexcitation and inrush restraint" Electric Power Systems Research Volume 41, Issue 3, June 1997, Pages 175–184

[6] Wenkui Zhang , Qian Tan , Shihong Miao , Liangsong Zhou , Pei Liu "Self-adaptive transformer differential protection" Generation, Transmission & Distribution, IET, Volume:7 , Issue: 1, Publication Year: 2013 , Page(s): 61 - 68.

[7] Jing Ma, Xi Wang, Yagang Zhang, Qixun Yang, A.G. Phadke ― "A novel adaptive current protection scheme for distribution systems with distributed generation" International Journal of Electrical Power & Energy Systems, Volume 43, Issue 1,December2012, Pages1460-1466

[8] S.H. Horowitz, A.G. Phadke and J.S. Thorp, "Adaptive Transmission System Relaying", IEEE Transactions on Power Delivery, Vol.3, no4,October 1988, pp.1436-45.

[9] Sachdev, M.S. ; Chattopadhyay, B. ; Sidhu, T.S. ― A new approach to distribution system protection-adaptive relaying Fifth International Conference on Developments in Power System Protection, 1993. Publication Year: 1993, Page(s): 165 – 168

[10] "Application of adaptive theory in distribution network protective relaying" Technical Session. International Conference on Electricity Distribution, 2008. CICED 2008. China Publication Year: 2008 , Page(s): 1- 4

[11] Hui Wan , LiK. K., Wong. K.P. ―An Multiagent Approach to Protection relay coordination with distributed generators in industrial power distribution *system Industry Applications Conference, 2005. Fortieth IAS Annual Meeting. Conference Record of the 2005,* Volume: 2, Publication Year: 2005, Page(s): 830 - 836 Vol. 2