2008년도 대한전기학회 하계학술대회 논문집 2008. 7. 16 - 18

신재생 에너지 Pilot System에서의 사고거리 판별 알고리즘 계산

김강민*, 강현구*, 문승일*
서울대*

A Modified Fault Distance Calculation in the Renewable energy Pilot System

Kang-min Kim*, Hyun-koo Kang*, Seung-Il Moon*
Seoul National University*

Abstract – In this paper, it is simulated the line fault in the renweable energy pilot system and the distance is calculated using a modified fault distance calculation algorithm and the mesurement data. The modified fault distance calculation algorithm calculate fault distance using the measurement data from power quality monitors (PQM) and the topology of the distribution networks. This algorithm is applied to PSCAD/EMTDC and the renewable energy pilot system. And these results are compared and analyzed.

1. Introduction

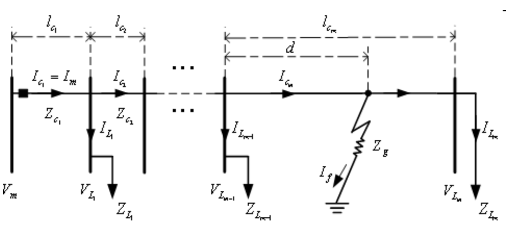
Power quality has become a important issue for both power suppliers and customers. In the past, the frequency and duration of power outages are only a matter of concern. However, those reliability issues are not sufficient in the current power systems because the loads grow more sensitive to power quality.[1]

The measurement and diagnosis of the power quality is the most important issues to manage and improve the power quality. The power quality monitors (PQM) are installed in the distribution lines for measuring of line voltage and current. If line-to-ground faults occurs, the faults in the distribution line is cleared first for the stability of overall power system. Also, when instantaneous line faults occurs, voltage sag appear. So, detecting the exact fault location is necessary for maintenance and management of power quality.[2]

In this paper, the measurement data from PQM of the renewable energy pilot system is analyzed and this mesurement data apply to a modified fault distance calculation algorithm. Also, fault distance is calculated using the mesurement data from PSCAD/EMTDC. and these calculated results are compared.

2. Fault Distance Calculation

If a line-fault-to-ground occurs in the distribution feeders, the PQ supervisor needs to know the fault location to get rid of the cause. To find the exact fault location, the PQ management system collects the measurement data of the PQMs that are scattered in the distribution systems. First of all, the PQ diagnosis system finds the closest PQM position in distribution system from the fault location by using the topological fault location method.[3] Then, the fault distance calculation mothod that is dealt with in [4] is needed for finding more accurate fault location.



<Fig 1> Equivalent circuit of generalized distribution feeder

Fig 1. shows the equivalent circuit fo the local distribution system under the PQM that is the closest to the fault position in case of a line-to-ground fault. The circuit of Fig. 1 shows one-line diagram of three phase distribution feeder line.

In Fig. 1, V_m and I_m mean the voltages and the currents measured by the PQM that is the closest to the fault. $Z_{c_1}, Z_{c_2}, Z_{c_3}$ mean the line impedances and $l_{c_1}, l_{c_2}, l_{c_3}$ are corresponding distance between each buses. $Z_{l_1}, Z_{l_2}, Z_{l_3}$ are the equivalent load impedances of each bus. d is the fault distance upon a fault occurrence with the fault impedance, Z_g.

$$I_f^0 = I_m$$

$$d^n = \frac{V_M \sin(\theta_v - \theta_{I_f^n})}{I_{fM}^n \cdot x_{c_m}} - \frac{\sum_{k=1}^{m-1} X_{c_k}}{x_{c_m}}$$

$$R_g^n = \frac{V_M}{I_{fM}^n} cos(\theta_v - \theta_{I_f^n}) - \sum_{k=1}^{m-1} R_{c_k} - d^n r_{c_m}$$

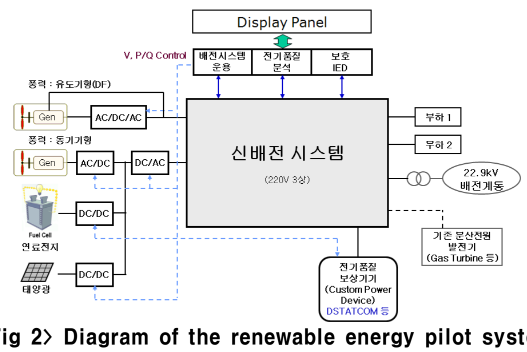
where,

$$Z_{c_k} = l_{c_k}(r_{c_k} + jx_{c_k}) = R_{c_k} + jX_{c_k}, \quad k = 1, \cdots, m$$

$$I_f^n = \frac{1/R_g^{n-1}}{\sum_{k=1}^{m} 1/Z_{L_k} + 1/R_g^{n-1}} I_f^{n-1} = I_{fM}^n(\cos\theta_{I_f^n} + j\sin\theta_{I_f^n})$$

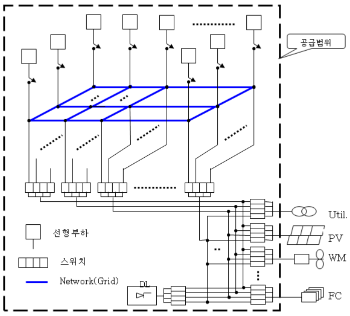
3. Renewable Energy Pilot System

Fig. 2 is diagram of the renewable energy pilot system. this is standard distribution network which can compose 220V 3-phase network. And the renewable source, power quality compensator and loads can be connected to this network and simulated. [2]



<Fig 2> Diagram of the renewable energy pilot system

As the renewable energy pilot system is high-availability systems, it is able to simulate and test the application of new distribution system, power quality analysis and coordination of the protective devices and interconnection in the real distribution network system not using the computer simulation.

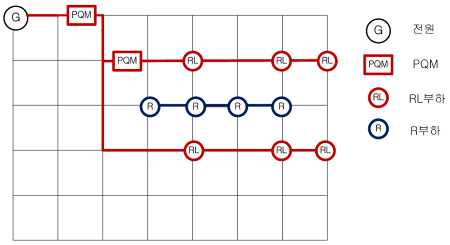


<Fig 3> New Distribution System (Distribution Network)

Fig. 3 shows the new distribution system of the renewable energy pilot system. The network(Grid) part is the distribution network, the users can choose ON/OFF and make the distribution network that they wants.

4. Test Simulation

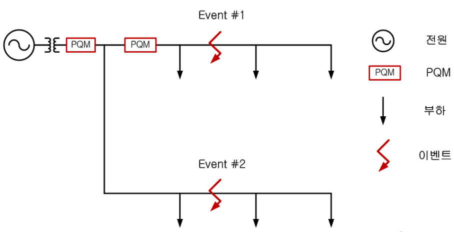
In this chpater, the algorithm of fault distance calculation is applied to the test feeder. Fig. 4 shows the test system developed using the renewable energy pilot system.



<Fig 4> Pilot System Network Topology

Though this topology is simple, it can be simulated and compared both UP events and DOWN events. And each events is simulated 3 line-to-ground fault. When 3 line-to-ground fault is simulated, the fault impedance is very small. However, the renewable energy pilot system could not simulate the line-fault event for protection of equipment and network. So, resistive load that consist of many impedance loads is connected to the fault location for fault simulation

Before simulate in the renewable pilot system, the same network is designed in PSCAD/EMTDC and the same events is simulated using PSCAD/EMTDC. Fig. 5 shows the simulation network that designed using PSCAD/EMTDC. This simulation results can be compared with the simulation results of the renewable energy pilot system.



<Fig 5> Distribution Network in PSCAD/EMTDC

<Table 1> Event Description

Event	Description	Fault distance	Fault resistance
1	3 line-to-ground fault at the first feeder	1.8kM from PQM #2	40 Ω
2	3 line-to-ground fault at the second feeder	2.4kM from PQM #1	40 Ω

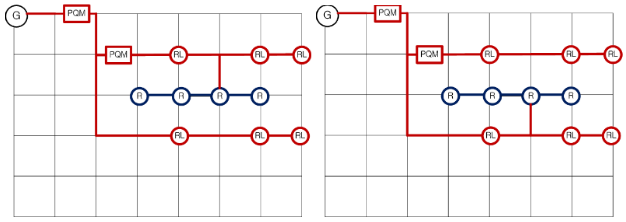
<Table 2> Calculated Distance and real Distance(PSCAD)

	Calculated(kM)	Real(kM)	Error(%)
Event #1	1.87	1.8	3.89
Event #2	2.57	2.4	7.08

<Table 3> Calculated resistance and real resistance(PSCAD)

	Calculated(kM)	Real(kM)	Error(%)
Event #1	40.5	40	1.25
Event #2	40.7	40	1.75

Fig. 6 shows how to design the network in the renewable energy pilot system. And the same events in table 1 are simulated in this network.



<Event #1> <Event #2>

<Fig 6> Simulation network in Pilot System

<Table 4> Calculated Distance and real Distance (Pilot System)

	Calculated(kM)	Real(kM)	Error(%)
Event #1	2.04	1.8	13.3
Event #2	2.60	2.4	8.3

<Table 5> Calculated resistance and real resistance (Pilot System)

	Calculated(kM)	Real(kM)	Error(%)
Event #1	40.6	40	1.5
Event #2	40.2	40	0.5

5. Conclusion

This paper has presented the fault distance calculation using PSCAD/EMTDC and the renewable energy pilot system. The simulation results in PSCAD/EMTDC is fairly accurate. However, when compared with the simulation result in PSCAD/EMTDC, the simulation result using the renewable energy pilot system has high error. The cause is the fault distance calculation method is sensitive to the measurement data and difficult to get the exact value from PQM in the the renewable energy pilot system. Though the fault location is not exact, this helps to determine the fault location.

[Reference]

[1] M.H.J. Bollen, Understanding Power Quality Problems: Voltage Sags and Interruptions, New York, IEEE Press, 2000.
[2] 신재생 에너지 발전의 계통연계 기초기술개발 연구, 산업자원부, 2007
[3] D.J. Won nad S.I Moon, "Topological Locationg of Power Quality Event Source", KIEE Inter. Trans. on Power Eng., 2005.
[4] 강현구, 정일엽, 원동준, 문승일, "전기품질 모니터링 시스템에서의 사고거리계산 알고리즘", 대한전기학회 제37회 하계학술대회, 2006.
[5] D.J. Won, I.Y. Chung, J.M. Kim, S.I. Moon, J.C. Seo, and J.W. Choe, "Development of Power Quality Monitoring System with Central Processing Scheme," in Proc. 2002 IEEE PES Summer Meeting, vol.2, pp. 915-919.