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Simulative Study on Generator Overvoltage

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1. Introduction

Power quality has been a growing concern in on-site power system. On-site power quality issues are largely because electronic equipment has been adopted in the system more than ever. In power plant however, generator excitation, switchovers, and relay coordination are also important areas to cover power quality issues.

In 2008, Okiluoto-1, a BWR unit in Finland, experienced loss of safety classified electrical equipment due to generator high voltage peak. Other than the root cause, erroneous relay coordination led the generator voltage rapid increase to 150 % of nominal voltage.

This study presents electrical simulation results of several relay coordination to deal with generator overvoltage using a domestic NPP model. This simulative study includes Okiluoto-1 like design and current design applied in Korean NPPs.

2. Methods and Results

2.1 Simulation Model

Simulation model is based on voltage analysis report of an APR-1400 type NPP. EMTP-RV simulation tool is used to modeling and simulation. EXST4B exciter model and IEEEG1 governor model are applied. Relay operations are referred from Okiluoto-1 or the APR-1400 relay coordination. Fig. 1. shows overall simulation model.

All the simulation cases start with generator overvoltage caused by exciter control malfunction and end with opening of either GCB or SWYD breaker.

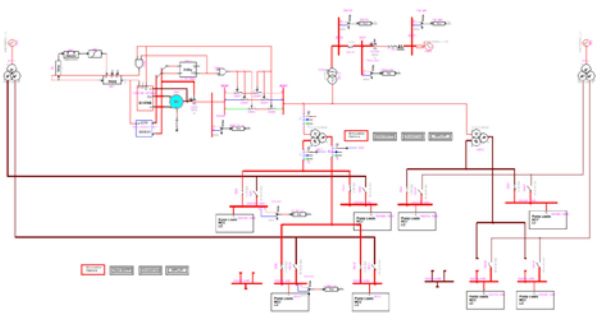

Fig. 1. EMTP-RV Simulation model overview

2.2 Case 1

After generator overvoltage occurs at 0.5 sec, SWYD breaker opens by overvoltage relay(59Ry) picked up at 115% nominal with 6 sec time delay. On-site power system remains in house load operation.

Fig. 2. shows all the bus voltage/Hz converges to certain level after the initial event and peak voltage occurs with SYWD breaker open around 8 sec.

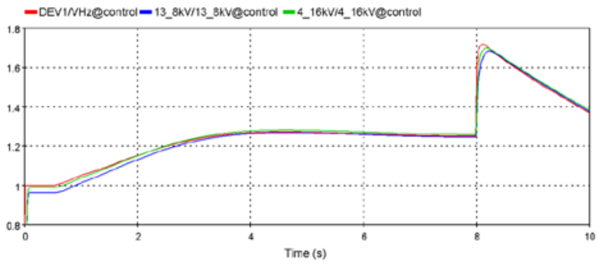

Fig. 2. V/Hz result of Case 1.

2.3 Case 2

After generator overvoltage occurs at 0.5 sec, GCB opens by V/Hz relay(25Ry) picked up at 118% nominal with 2 sec time delay. On-site power system receives power from off-site power system.

Fig. 3. shows GCB open makes safety/non-safety bus voltage/Hz stabilize with off-site power connection. Generator voltage peaked up to 200% nominal and maintained for a while. This is considered abnormal result because of modeling restraints which exclude internal circuits that eliminate remaining current in the excitation circuit.

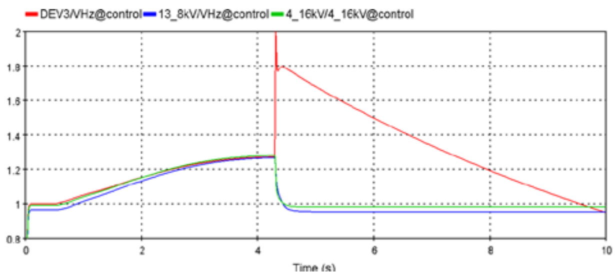

Fig. 3. V/Hz result of Case 2.

2.4 Case 3 (Okiluoto-1 case)

After generator overvoltage occurs at 0.5 sec, SWYD breaker opens by overvoltage relay(59Ry) picked up at 115% nominal with 6 sec time delay. During transfer to house load operation, GCB opens by V/Hz relay(25Ry) picked up at 118% nominal with 2 sec time delay due to transformer saturation. On-site power system receives power from off-site power system.

Fig. 4 shows maximum voltage caused by GCB operation is lower than Case 1.

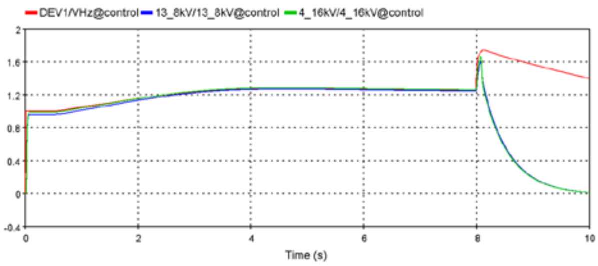

Fig. 4. V/Hz result of Case 3.

V/Hz results and Voltage results were almost identical because exciter control malfunction does not affect frequency variation.

3. Conclusions

Case simulations showed V/Hz behavior of generator bus, safety bus and non-safety bus in different relay coordination operating SWYD breaker and GCB. Case 3 which simulated Okiluoto-1 showed similar overvoltage occurred in the event. In Korea, relay coordination such as Case 1 and Case 3 are impossible in GCB installed units and practical result will be similar to Case 2 result. Even units without GCBs are expected to result in similar to Case 2 because SWYD breaker open signal is coordinated with exciter and turbine trip.

ACKNOWLEDGMENT

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