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WIDE AREA MONITORING PROTECTION AND CONTROL IN AN ELECTRICAL DISTRIBUTION NETWORK

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ABSTRACT

Wide Area Monitoring Protection and Control (WAMPAC) system in a local distribution network is presented in this paper. The WAMPAC system consist of a central unit, and a local unit at each of the six 110kv substations . it integrates the function of monitoring protection and control in the system. The protection function includes feeder protection, transformer protection ,bus bar protection and CB fail protection. The control function includes synchronous check ,auto-reclose, standby restoration, load shedding, and generations tripping. The local area distribution network has embedded generations in it .If it is islanded, the system can shed the load or trip excess generations to keep the frequency near 50 Hz to meet the synch check criteria, so that the CB of the standby supply an be auto-closed and grid supply can be restored to the islanded area quickly.

Keywords: Distribution Network, Load Shedding , Wide Area Protection and Control

I. INTRODUCTION

In China southern Power Grid,a local 110kV electricity distribution network may be supplied from a single 220kV/110kV transformer as shown in Fig.1 below. This is mainly to reduce the fault current level in the 110 kV network due to the limit of CB ratings.

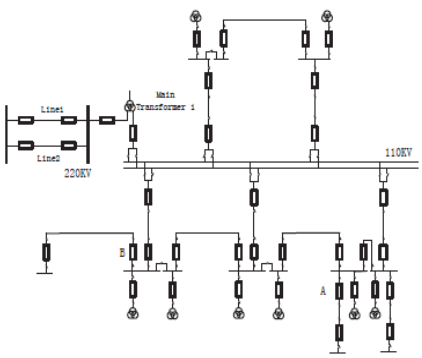

Fig.1: A local 110 kV network with embedded generations

If the two parallel 220kV circuits (line 1 and line 2 shown in Fig.1)or the 220/110kV transformer is tripped off, the local area network is then islanded. As there are embedded generations in the area(small hydro power plants connected on 10kV feeders), the voltage of the 110kV network does not reduce quickly and this will prevent the auto-close of the standby supply from point A or B as shown in Fig.1 above as currently the criteria for the auto-close is dead bus . Since the outputs of the embedded generators often do not match up with the loads in the area and the system frequency will be tripped off by their own protection . A manual restoration process can then start ,but this normally takes a long time (20 or 30 min) to restore all the generations and supplies in the area.

This paper presents a Wide Area Monitoring ,Protection and Control (WAMPAC) system developed to reduce the time of restoration of standby supply to the local area network if it is islanded also to improve the successful rate of auto-close of standby supply. The main control function of WAMPAC system is to balance the generations and loads in the area network if it is islanded ,and to restore grid supply to the islanded area quickly. In addition to the control function, protection functions of the bus bar protection ,CB fail protection ,feeder protection and transformer protection for the 110kV network are also integrated in the system. This will ensure rapid clearance of fault on bus bars and provide back --up protection for CB failures .The feeder protection will ensure a fast backup protection to the existing main protection (only one main protection on each 110 kV circuit). If any fault occurs in the 110 kV network is split after the fault clearance, the system can take the appropriate measures to keep power balance between the embedded generators and loads. The system uses multi-information exchange in the wide area to provide optimum real time control and protection functions.

II .SYSTEM ARCHITECTURE

The WAMPAC system consist of a central unit and a local unit at each substation as shown in Fig.2. The communications between central unit and local units are 2MSDH communication links. The inputs to the local units are plants status ,currents, voltages of 110 kV circuits.

The central unit receives the currents, voltages and plant status of 110 kV feeder and transformers from all the local units, and the operational data such as power and plant status of 10kV feeders from EMS. It also monitors the power exchanged between the 220kV and 110kV systems. The local unit is connected to merging units which are connected to CTs, VTs as shown in Fig.3 below. The local units also collect information of CB status, isolators of the primary plants, and send the information to the central unit so the real time topology of the local area network is known by the central unit. If a fault occurs on a 110kV feeder ,the fault can be detected by local units, and tripping commands are then issued by local units. If it is a permanent fault, the feeder will be tripped again. If part of the local area network is islanded after the tripping, the central unit can detect the islanding condition , and send the tripping commands to the local units to shed loads or trip excess generations connected at the 10kV feeders. This is to maintain the frequency near 50Hz so that the synch check condition can be met. The CB of standby supply can then be closed so that the islanded area can be connected to the grid quickly. The central unit has the information of the topology of the local area network and the control strategies are determined by the central unit.

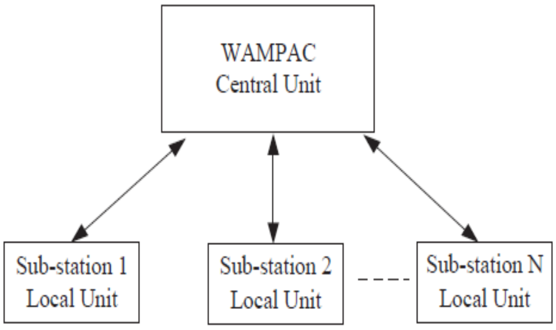

Fig.2 Architecture of the WAMPAC System

At each substation, the local unit is connected to a communicating equipment and merging units as shown in Fig.3 below.

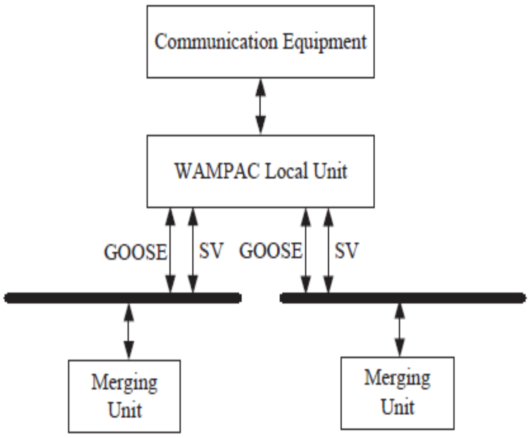

Figure 3 Connecting of WAMPAC Local Unit

III .MULTI-INFORMATION EXCHANGE

If the local 110kV area network is islanded, the WAMPAC system will shed loads or trip generators connected on 10kV feeders according to a priority order list. To obtain the real time of power of 10kV feeders, the central unit is connected to EMS to get the information of load ,generator output from the EMS. All the information exchanged has a standard format.

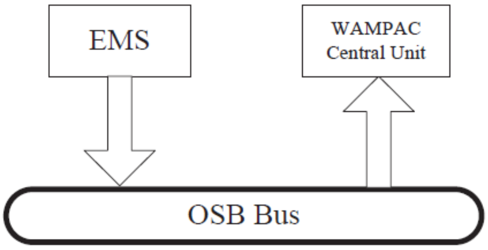

Figure 4 Data acquisition of 10kV feeders

The central unit receives the operational data from local units at each substation, and sends the load shedding or generation tripping command and auto-close command of the standby supply to the local units.

The local units get the sampled values of currents and voltages and plant status of 110kV feeders and transformers from IEC 61850 process bus as shown in Fig.3. The merging units are connected to traditional CTs and VTs and send the sampled values to the IEC61850 process bus. They also receive the tripping commands from the local unit.

To ensure the reliability of communication between central unit and local unit, the following checks are carried out :

(1) CRC Check;

(2) Address Check;

(3) Signature Check;

(4) Accumulation Sun Check.

The control commands that the central unit sends to the local unit will be checked by consecutive frames command.

IV. SYSTEM FUNCTIONS

As mentioned above, the WAMPAC system has both protection and control functions. The protection functions include 110kV feeder protection ,110/10kV transformer protection, 110 kV bus bar protection and CB fail protection. It also has the synch check and auto-reclose function.

The main control function of the WAMPAC system is to detect whether after a power system fault, there is any islanded network , such as when both line1 and line2 are tripped off, or the transformer 1 is tripped as shown in fig.5.When the islanding of an area network is detected, in order to balance the power between embedded generations and loads in the islanded area, the central unit can determine how much load or generation which needs to be tripped off based on the import/export power from/to 220kV system which is measured immediately before the islanding . It then makes a quick decision in few hundreds milliseconds to trip generation or shed loads based on a priority order list of 10kV feeders. This is to enable a successful auto-close of standby supply as the such check criteria can be met. It is expected that the whole process takes few seconds to connect the standby supply to the islanded area network . This will improve the reliability of supply to the local area network significantly.

4.1 Detection of Islanded Network

As the WAMPAC central unit knows the status of all the CBs of the 110kV lines, the 220kV lines and the 220/110kV transformer is tripped off ,the CB changes its status from closed to open position ,the central unit can then determine whether there is any islanded area based on the new topology of the area network.

For Example, as shown in fig.5 during normal operation, CB A and C are open. If the parallel circuits of line 1 and 2 are tripped ,the 110kV area network becomes islanded. If line 5 is under maintenance, when line 8 is tripped, substation 2 will become islanded.

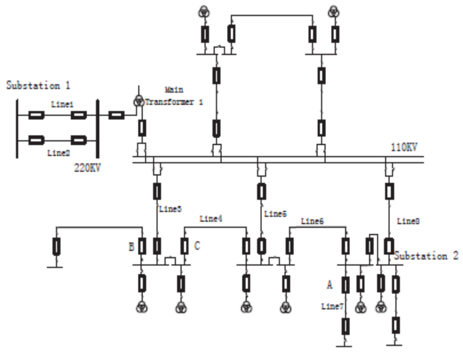

Figure 5 The area network with WAMPAC applied

4.2 Restoration of Standby Supply to the Islanded Network

After a power system fault, if part of the local area network which has embedded generations becomes islanded, the frequency of the network will change and it may not able to meet the criteria of synch check so the chance of successful auto-closing standby supply is low. This may cause a blackout of the whole islanded network if no control measure is taken.

If the 220kV parallel circuits or the 220/110kV transformer is tripped off as shown in fig.5 above ,the local distribution network is then islanded. Then control measures will be carried out to maintain the frequency to near 50Hz so that the synch check condition can be met and the CB of standby supply can be closed quickly to restore the grid supply to the islanded network. If a power system fault occurs on a 110kV circuit ,the WAMPAC system will first auto-reclose the circuit. If it is unsuccessful and part of the network is islanded, the load is unsuccessful and part of the network is islanded , the load shedding or tripping generations will be carried out to close the CB standby supply quickly.

4.3 Control Measures For Balancing the Power In Islanded Network

When the area network is islanded ,the amount of load shedding or generation tripping will be determined by the central unit according to the amount and direction of the power flow between the 220kVsystem and 110kV network immediately before the islanding .The criteria for the generation tripping or load shedding are as follows:

4.4 Tripping Generators

Prior to the islanding, assume that the power flow from the islanded network to the main network P, then :

If P<Pmkn: No tripping generation, where Pmkn is a threshold setting of tripping generation.

If P>=Pmkn : tripping generations, the amount of generation tripping is dP=P-Psetn ,where Psetn is a setting.

Tripping generation is according to a principle of minimum under tripping. For example, if 100MW generation tripping is required and there are four sets of generations available for tripping, their capacities are 30MW, 40MW ,50MW ,59MW respectively, then the two generators whose capacities are 40MW and 59MW are selected to trip.

After the above action, if the frequency of the islanded network is still above the allowed value, then further tripping of generations will be carried out. The criteria is as follows:

If f>festh1 and t>tfh1, then tripping the first setoff generations

If f>=festh2 and t>=tfh2,then tripping the second set of generations

If f>festhn and t>tfhn, then tripping the nth set of generations.

4.5 Load Shedding

Based on the amount of power of the islanded network imported from the main network ,there are three strategies for load shedding:

If the imported power is small before the islanding ,considering the spinning reserve capacity of the embedded generators, there is no need to take control measures of load shedding.

If the power shortfall of the islanded network is so large that the embedded generators are unable to maintain their stability, all the generators in the islanded network will be tripped off and then the CB of the standby supply will be closed to the islanded network quickly.

4.6 T-connection of generators to 10 kV feeders

In order to save costs some hydro generators are connected to 10 kV feeders using a T off connection. These 10kV feeders have a mixed connection of small hydro generators and loads. In The summer these feeders will export power to grid ,but in winter these feeders will import power from grid . The WAMPAC central unit will simply treat these feeders as a generator or load depending on the direction of power flow of the 10kV feeders.

V. CONCLUSION

The WAMPAC system integrates the function of protection, stability control of islanded network and fast grid supply restoration .The protection functions in the WAMPAC system provide main protection for 110kV bus bars, CB fail protection and fast backup protection for 110kV circuits and transformers. The control function in the WAMPAC system is mainly to balance the generations and loads in the islanded network to maintain the frequency near 50Hz so that the synch check condition can be met and standby grid supply can be connected to islanded network quickly. It is expected that with WAMPAC system ,the islanded network can be connected to grid in less than 10s.

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