# DECENTRALIZED CONTROL THROUGH SELF-HEALING GRIDS

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## *ABSTRACT*

*With implementation of Supervisory Control and Data Acquisition System (SCADA), all indications, status and analog signals became available with master control center along with automated controls. The level of automation to be adopted at the substation end was an outcome of various factors like the criticality of load being served, the spread of consumers affected, proximity of utility`s crew station etc. With the aid of Network planning software, automation of the substation is so planned that complete restoration and fault isolation would be possible within 10 mins. The level of automation and conversely the level of manual operations decide the restoration time .For critical customers like Hospitals, Water pumping stations, data centers the restoration has to happen in a couple of minutes if not less. This would only be possible if there is minimum or no manual intervention or essentially the system is decentralized for operations. Self-Healing Grid was thought as the best solution to be deployed for enhanced reliability of the network for critical consumers.*

## INTRODUCTION

For a Power Distribution utility it is very essential that the down time to its end consumers has to be minimal. It is therefore always the endeavor of the utility engineers to restore the interruption if any in the shortest possible time by isolating the faulty equipment and charging the healthy network. While this requires the fault isolation crew to move in the field and carry out the necessary operations, strategic network locations are automated to effect the operations from the remote control room so as to reduce the interruption time of the consumers. This is arrangement is called as Distribution Automation System (DAS). In a conventional Distribution Automation System (DAS), Feeder Remote Terminal Unit (FRTU) are installed in the Consumer Substation (CSS) for control and monitoring of the Ring Main Unit (RMU) and Fault Pass Indicators (FPI). These FRTUs are communicating with Supervisory Control & Data Acquisition System (SCADA). Information about the shutdown to the consumers is communicated by the FRTU to the operator at the Control room through a Hooter alarm. The Operator will be able to understand the suspected faulty location and with available automation in the network would isolate the faulty section and restore the remaining healthy network, which may be around 50 to 60%. This activity will take around 2 to 5 minutes. Information about the fault and restored network will be given to the Fault Duty Engineers (FDE) for restoration of the remaining network. All these activity takes around 10 to 60 minutes depends upon the traffic condition as the FDE has to physically reach each of the sites for carrying out the operations. It is a challenge for a power utility to reduce the power restoration time which has a direct impact on customer satisfaction, revenue and business.

## SELF HEALING GRID

Self-Healing Grid (SHG) is a smart application which has intellectual and self-conclusion logic. In case of fault, the system executes the best possible instruction for rapid fault isolation and restoration of supply in network. This Model eliminates manual intervention and minimizes the down time by 95% as compared to conventional restoration philosophy/methodology. SHG model facilitates Power utility to minimize down time to end consumers and no revenue loss due to un-served energy.

In SHG, Field Remote Terminal Units communicating with SCADA system are made to communicate with each other. The real-time information about condition of the network is available with all FRTUs. When there is fault in the network then all FRTUs can self-understand the faulty section and isolate the faulty section by their own and restore the power supply without any manual intervention. SHG will restore the power within 2 to 3 minutes. This is a totally de-centralized and fully automated approach towards the restoration of the power supply. As SHG is de-centralized and automated system, multiple faults can be handled without much time delay and manual interventions.

## FILED IMPLEMETATION

A Self-Healing Grid is an electrical distribution network which detects, locates and isolates a fault along with re-energisation of healthy part without any human intervention. For SHG application to work, each FRTU needs a firmware that facilitates peer to peer communication and FRTU to SCADA communication on Modbus and IEC 60870-5-104, a configuration to define the various variables and finally the embedded PLC application which performs self-healing.

SHG has been successfully implemented on Tata Power Mumbai Distribution Network jointly with M/s Schneider Electric. A particular underground ring feeder was selected for implementation. This feeder includes five Consumer Substation of 11/0.44 kV Distribution capacity. Fig.1 shows the snapshot of the network on SCADA.

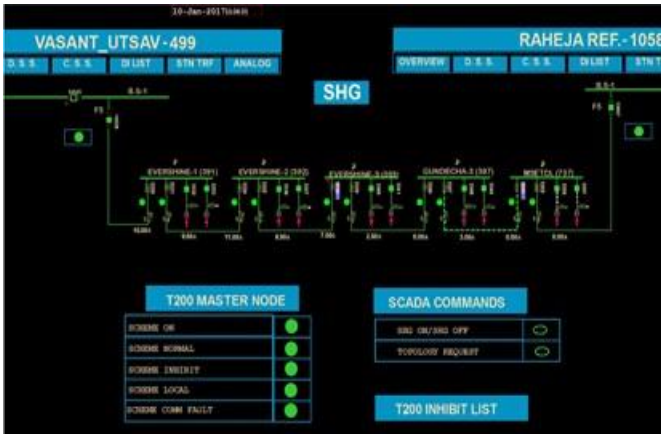


Fig:-1 Real time SCADA image of SHG Ring

## IMPLEMENTING SHG:

SHG was implemented in an already up and running system and required quite a few modifications to be done in the existing network elements:

1. **Installation of CT's for fault detection:-**

   Installation of individual CT's on existing RMU bushing`s was required to be done as earlier system only has Core Unbalance CT on the Underground Cable. Special supporting plates were fabricated in consultation with the OEM to hold the CT's on the bushing.


Fig:-2 CT holding plate installed on RMU bushing

2. **Simulation of Fault on live network:-**
   Prior to implementation of this new technology full proof testing of the Scheme was very much essential. Around 101 odd test were plan on the scheme, which required frequent operations to be carried out on the network . Simulator was developed and the same was installed on RMU while testing. Isolator on/off status simulated by operating the toggle switch on simulator.

Fig:-3 Plug Type Simulator

3. **Adoption of new operational philosophy of SHG by the field crew:-**
   Changing mind set of field crew and operation engineer from manual operation to automatic operation was required. Many queries were raised by team. Brainstorming on all the queries were carried out and finally 101 tests were carried out on the system before taking it into service.
   Few tests are listed below,

1. SHG switch on
2. SHG switch off
3. Effect of communication failure on SHG
4. Protection trip sequence
5. Single N/W faults Path A, Path B
6. Single network faults with only one switch operation failure
7. Double cable fault
8. SCADA integration test, etc.


Fig:-4 Testing of Fault

## POWER-RESTORATION ON IMPLEMENTATION OF SHG

In SHG, FRTUs communicating with SCADA system are made to communicate with each other. The real-time information about condition of the network is available with all FRTUs. When there is fault in the network then all FRTUs can self-understand the faulty section and isolate the faulty section on their own and restore the power supply without any manual intervention. SHG will restore the power within 1 to 2 minutes. This is a totally de-centralized and fully automated approach towards the restoration of the power supply. As SHG is de-centralized and automated system, multiple faults can be handled without much time delay and manual interventions. Depicted in Fig 6 is the restoration process after implementing SHG

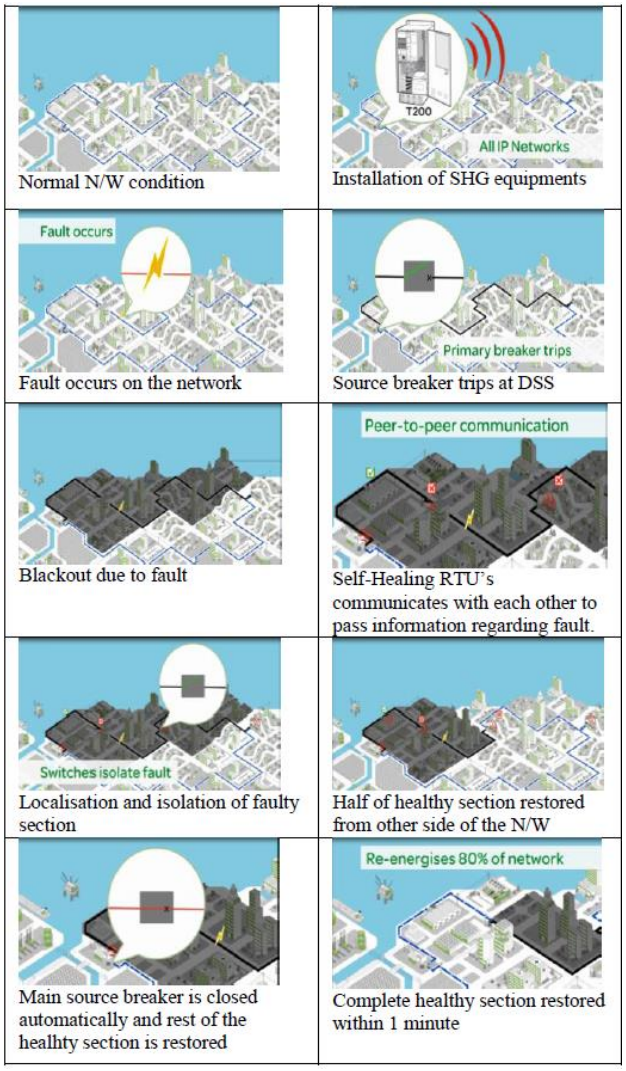


Fig:-5 Step by step process of power restoration after SHG

## BENEFITS OF SHG

### To Consumers

Fault clearance: The fault clearance is typically less than a minute while communicating via CDMA on installed RMUs. It is very useful for critical consumers like Hospitals, banks, datacenters and VIP customers etc. where the security and supply continuity is a concern.

### To The Utility

- Improvement in the reliability indices
- No operator intervention.
- Easy migration path from Switch solution to self-healing solution
- The SHG scheme en-compasses 100% automation without any manual intervention
- Life of the transformers and associated cables will increase due to full proof fault isolation process
- FPIs (Fault Passage Indicator) are inbuilt in FRTU so separate FPI's are not required.
- Pre-fabricated Cables are well structured and part of SHG and separate cables are not required between the Ring Main Unit and SHG system.
- Existing SCADA system can be used to monitor the system.
- SHG is easy for implementation due to plug and play structure.

### To the Environment

- Reduced use of transport vehicles for performing manual operations at remote substations due to complete automation and self-heal benefits.
- Greater CO2 saving in Kgs, thereby reducing carbon footprint.

## CONCLUSION

Distribution utilities can adopt a combination of fully automated and semi-automated network for achieving the best restoration time for its consumers. Deployment of SHG in the fully automated network helps in achieving a totally decentralized control on the distribution network.SHG implemented at Tata Power has been in operation for more than a year and with its satisfactory performance, it is intended to extend this to important and critical feeders in its distribution network.