Rural Digital Substation (RDS)

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SUMMARY

In the present scenario, it is essential for any Power Distribution Utility to provide an uninterrupted supply to consumers. However, it is inevitable to prevent electrical network from fault. Hence, it is a big challenge for any utility to minimize downtime whenever the fault occurs thereby increasing reliability and customer satisfaction.

As a service provider, Utility must ensure the reliability of its services to all its consumers without urban or rural discrimination. To assure the reliability to urban consumers most of the PSS (Primary Sub-station) are enabled with SAS (Substation Automation System) and can be monitored and controlled through SCADA system which helps in reduction of the power interruption time.
In the case of rural the SAS was not implemented and there is no visibility of the network condition to PSCC (Power System Control Center). Due to lack of visibility of rural PSS to remote operator, there is an increase in interruption time and decrease in consumer satisfaction. Additionally, revenue generated from the rural PSS is significantly less compared to their urban counterpart, discourages extensive capital investment for upgrading rural SAS. To make rural SAS cost efficient some innovative and cost-effective solutions were needed.

In view of the above, Rural Digital Sub-station (RDS) is a smart digital solution which helps to address the challenge. In RDS solution, every old CRP (control relay panel) needs to be replaced with a small control unit which has complete CRP functionalities and the same will be installed near outdoor CT (Current Transformer) or outdoor CB (Circuit Breaker). All these units will be communicating over IEC61850 protocol and connected in ring topology to connect to RTU (Remote Terminal Unit) using CAT6 cable. Only RTU and local HMI (Human Machine Interface) will be installed in the control room from where the operator can monitor and control the PSS. This RTU will communicate with SCADA system over IEC104 protocol. This solution eliminates the cost of CRP and provides complete SAS solution to have complete visibility to SCADA operator at almost 50% cost of conventional SAS solution. It facilitates distribution utility to minimize the revenue loss and increase the reliability index at very minimal cost.

KEYWORDS

Primary Sub-station - Substation Automation System - Supervisory Control and Data Acquisition - Power System Control Centre - Rural Digital Sub-station - Control relay panel - Current Transformer - Circuit Breaker - Remote Terminal Unit - Human Machine Interface - Aggregated technical and commercial - Bay Control Protection Unit - Digital Input/ Digital Output

1. INTRODUCTION

My utility was incorporated on 1st Jan2021 as a JV of my utility (51%) and Government (49%) on the Public-Private Partnership (PPP) model. My utility took over the licensed area which is spread approx. 48,000 sq. km and covers nine revenue districts. My utility has made a commitment to bring down AT&C Losses to 9.08% in 10 years from the present losses of 27.56%. Also committed to making the capital expenditure in the first five years to improve safety, technological and loss reduction. Besides, major improvements will affect the reliability of network and consumer services.

For a power distribution utility, to improve reliability, it is essential that the down time to its end consumers must 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 all the necessary information related to the fault should be available at the central control room to carry out the necessary operations. All PSS are automated to affect the operations from the remote-control room to reduce the interruption time of the consumers. This arrangement is called the Substation Automation System (SAS).

In conventional Substation Automation approach, control relay panels (CRP) used to be installed in control room and all control signals and CT connections connected in CRP. All BCPU's then connected to RTU and finally communicated with SCADA system.

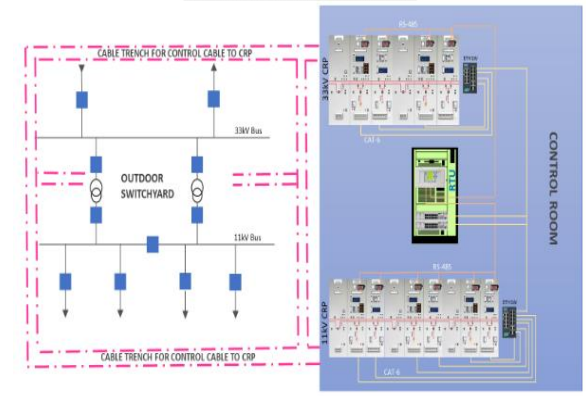

Figure 1. Conventional Substation

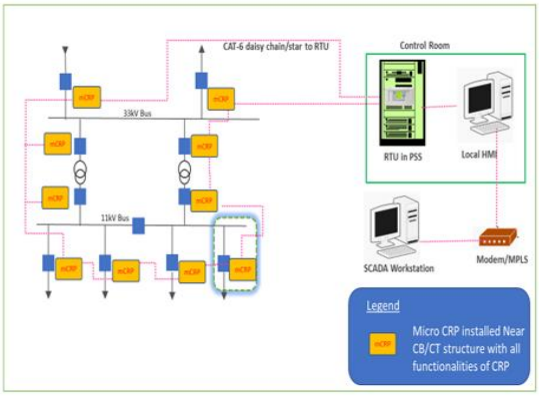

Figure 2. Rural Digital Substation

For revamping of Rural PSS, following challenges where faced,

- Huge execution time for installation of CRP and RTU Panels
- Requirement of multiple outages
- New/ Refurbishment cables for status, control, and CT circuit
- Refurbishment of cable trench
- Refurbishment of control room/construction of control room

2. RDS – RURAL DIGITAL SUBSTATION

To avoid the above challenges, it is proposed to have a digital substation approach which in turn will help to reduce costs on big CRP's, control room, outages, and so on.

Rural Digital Sub-station (RDS) is a smart digital solution for refurbishment of PSS with digital communication. In RDS solution, every old CRP needs to be replaced with small CRP which has complete CRP functionalities and the same will be installed near outdoor CT (Current Transformer) or outdoor CB (Circuit Breaker).

All these CRP's will be communicating over IEC61850 protocol and connected in ring/star topology to connect to RTU (Remote Terminal Unit) using CAT6 cable. Only RTU and local HMI (Human Machine Interface) will be installed in the control room from where the operator can monitor and control the PSS. This RTU will communicate with SCADA system over IEC104 protocol.

3. FIELD IMPLEMENTATION

My utility has taken over Government Utility to improve the reliability of power supply. If we go with conventional approach for implementation of SAS in conventional way, there will multiple outages required, and my utility might differ with their reliability goals which may lead dissatisfactions in customer. Hence, we developed innovative steps to implement RDS for Rural PSS and successfully completed pilot installation of RDS at one PSS.

4. UNIQUENESS AND DEPLOYMENT AT MASS SCALE

RDS is a unique solution which gave tremendous benefits to its customer as well as my utility. Refer below table for comparison between conventional approach Vs RDS approach.

For calculation purpose, below parameter considered,

1. 33kV/11kV PSS
2. 2 Nos. 33kV line
3. 2 Nos. 33kV HT breakers, 2 Nos. 11kV Incomer breakers
4. 4 Nos. Outgoing feeders
5. 2 Nos. PTR

Attributes	Conventional Approach			Rural Digital Substation (RDS)		
	Time in days	Approx. Cost (Lakhs)	Remarks	Time in days	Approx. Cost (Lakhs)	Remarks
Transportation of Panels from Store	3	1.5	Cost of transportation, services loading & unloading	2	1	Cost of transportation, services loading & unloading
ITC for 10 Panels	30	2.5	3 days per feeder and availability of outages	3	1	3 hours per feeder and availability of outages
Total Outages	3.3	4	4 hours per feeder	0.83	1	2 hours per feeder
CRP Feeder		21	CRP for 7 feeder protection		10.5	CRP for 7 feeder protection
CRP TRAFO.		10	CRP for 2 Transformer protection		6	CRP for 2 Transformer protection
Copper cables	5	14.4	60 meters distance from bay to CRP for CT, PT, Control, AC, DC cables	1	5.1	60 meters distance from bay to Control room for AC, DC, CAT6 cables 10 meter for control cable from CB, CT, PT to CRP
Size: Control room	90	30	3000 Sq. ft. construction	30	10	1000 Sq. ft. construction
Cable Trench	45	15	600 mt. per PSS	2	2	170 mt. HDPE Pipe/PSS
Vermin Proofing	2	0.05	For complete PSS	0	0	For complete PSS
Total (if control room is ready)	**Max 30 days**	**98.45**		**Max 3 days**	**36.6**	

* This data is calculated based on current conditions and skills of my utility; this may vary utility to utility

Table 1: Comparison between conventional approach Vs RDS approach

All over India, most of the utilities are facing similar type of challenges for grid modernization. RDS solution is a unique solution which can be deployed all over rural PSS in all utilities, which in-turn reduces copper consumption by almost 60%.

5. IMPLEMENTATING RDS

RDS was successfully implemented in an already up and running. Following are the key modifications carried to implement the same,

5.1. Installation of micro-CRP

Micro CRP is a smaller version of CRP which has all functionalities like, control, protection, metering, remote communication, remote control and so on. This micro-CRP was installed below outdoor CB.

Before | After

Figure 3. Installation of micro-CRP

5.2. Installation of RTU

Indoor wall mounted RTU panel along with RTU and switch was installed in control room.

Before | After

Figure 4. Installation of RTU

5.3. Laying of cables

- Only AC, DC and communication cable were laid from micro-CRP to control room.
- DI/DO signals were directly connected from CB to micro-CRP.
- CT and PT cable are also connected to micro-CRP.

5.4. Use of HDPE pipe

As very few cables laying was involved, the cable trench was replaced with HDEP pipe.

Figure 5. Laying of HDPE Pipe

5.5. Local HMI

Local HMI installed in control room for local monitoring and control. Local operators can view all alarms, real-time condition of all the equipment's in PSS.

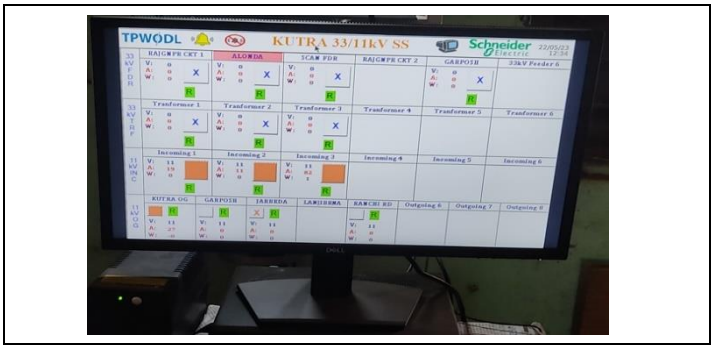

Figure 6. Local HMI

5.6. Use of plug type connectors

Prefabricated plug type connector will play plug and play role and reduced time in termination and wiring at site.

Figure 7. Plug type connector

5.7. P2P through SCADA

RTU communicated with central SCADA over IEC104, point to point testing was conducted to verify all the DI/DO status on SCADA.

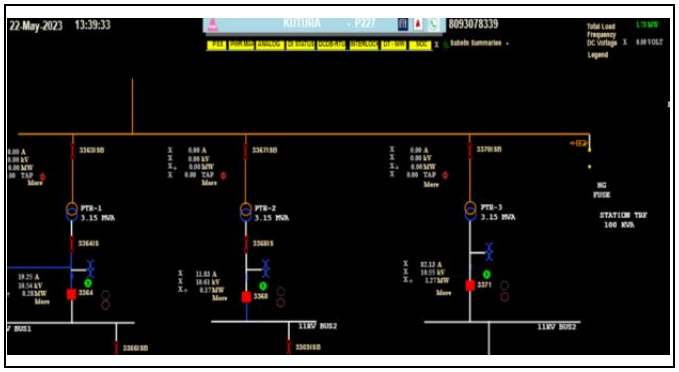

Figure 8. SLD on SCADA display

6. BENEFITS

6.1. To consumers:

Minimal Interruption Time: As RDS enables remote monitoring and control of PSS, quick response to various faults, results in reduction in interruption time by 70%.

6.2. To utility

- Improvement in the reliability indices
- The life of the transformers and associated equipment will increase due to better monitoring and control of network through PSCC.
- Prefabricated cables with plug type connection reduce huge commissioning time and provide additional safety in isolating equipment's while taking outages, also helps to reduce fictitious alarms on account of oxidation and loose connections.

6.3. To environment

- Reduced use of transport vehicles for performing manual operations at remote PSS due to better visibility of complete network in PSCC
- Greater CO2 saving in kilograms, thereby reducing carbon footprint by 80%.

Figure 9. Complete substation with micro-CRP's

CONCLUSION

Distribution utilities can adopt an RDS approach to implement SAS in rural PSS to monitor and control the network for achieving the best restoration time for its consumers. Deployment of RDS for PSS helps in modernization of grids at almost 50% less cost than conventional approach with very minimal outages. Pilot implemented at my utility has been in operation for more than three months and with its satisfactory performance, it is intended to extend this to all Rural PSS in my utility and entire Odisha distribution.

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