INTEGRATED DUAL VOLTAGE SENSORS BASED RECLOSERS IMPROVING POWER DISTRIBUTION IN DEVELOPING COUNTRIES

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ABSTRACT

In developing countries, demand for 24x7x365 availability of reliable power is on rise. On the other side distribution utilities in these countries, finds growing deployment of renewables driven distributed generation. This on one side, creates complex and challenging network topologies, but in process ensures better availability of power with integration and adoption of advanced control & automation. Under such scenario, integrated dual side voltage sensing reclosers helps distribution utilities in achieving different Fault Detection Isolation & Restoration (FDIR) schemes with smaller footprint in simple but performance efficient and cost-effective way. This paper, after brief introduction on power distribution improvement schemes, based on author experience highlights the application benefits of integrated dual voltage sensing reclosers for smart grid – FDIR initiatives.

INTRODUCTION

In developing countries, due to increased proliferation of usage of electricity in all walks of personal and professional life, demand for outage free power has assumed very high significance. Rising growth in industries and service sectors, widens the existing shortfall in capacity to supply against emerging demands. Further, 24x7 availability of uninterrupted power supply, to prevent undesirable restarts of computer/embedded electronic systems leading to loss of productive time, also has become need of the hour. On other side, with rising alarms on global warming, demand for clean energy has too become the essential need. This also has led the government authorities in developing and developed countries, in providing incentive for increased deployment of renewables. Rising uninterrupted electricity demand coupled with renewables integration thus has become basic infrastructure need for the smart city programs, which is on roll in emerging economies like India, Brazil etc. However, this also creates shift of conventional electricity generation versus consumption approach, where the generation had always been in remote with feed to the loads on downstream basis. In fact, renewables driven distributed generation introduce newer variables for utilities and thereby leads to complex distribution topologies, demanding advanced control & automation for reliable delivery of electricity.

POWER RESTORATION APPROACH IN DEVELOPING COUNTRIES

In developing countries like India, Brazil etc. even in their most urban and industrialized cities, distribution utilities have been making use of the trouble call system to detect power outages. Specifically, when a fault occurs and customer experience power outages, they call feeding substation control center and report power outage. The control center accordingly then dispatches maintenance crew to the field. Arrival of crew to the reported faulty section takes its own time due to traffic as well as local weather conditions. This in fact, can get much worse if it falls during late hours due to limited crew availability or in abnormal weather conditions arising due to rains / snow. The crew on reaching intimated location, first investigates to identify the fault trigger and post analysis followed by fault section isolation implements manual switching for power restoration on healthy section of feeder. The situation complexity increases multifold in radial distribution system where all the consumers upstream also gets affected by the power outage and their power restoration is dependent on the timeliness of the crew attending and isolating the fault [1].

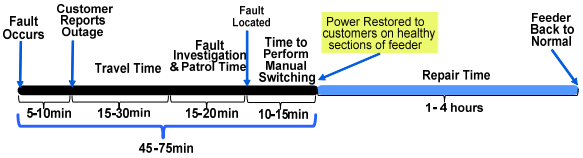

Fig. 1 Conventional power restoration scheme after fault

In recent years, at some places utilities now deploy the feeder switching devices like reclosers with intelligent electronic devices (IEDs) for protection and control applications.

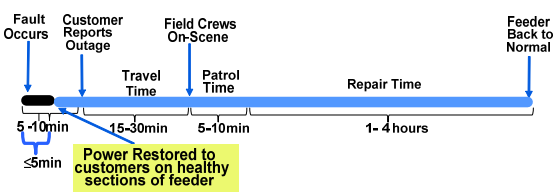

Fig. 2 Improvised power restoration scheme after fault using Reclosers

Ability of these devices for automatically re-closing on

temporary or short duration faults helps in reduction of power outage duration. It is well known that 75-80% of the outages in distribution overhead networks are temporary in their nature and these temporary faults can be effectively be addressed with basic reclosers [2].

SMART CITIES AND SMART GRID INITIATIVES

Further, especially in countries like India, with gradual reduction of solar panel cost coupled with financial subsidies getting rolled out by state governments in effort to meet global climate change targets, roof top solar installations (household as well as industrial) have increasingly becoming popular. Such solar based distributed electricity generation also leads to bi-directional power flow, creating meshed network configuration as against conventional generation, transmission, distribution and eventual consumption with Uni-directional power flow in radial configuration.

Also, it is to be noted Smart Grid, which refers to electric power systems that enhance grid reliability and efficiency by automatically anticipating and responding to system disturbances, also has been a major consideration in the smart city initiatives in these developing countries. To achieve smart grid at the power distribution level, various automatic technologies are being attempted in the areas of system metering, protection, and control. Within these technologies deployment too, automated power restoration is an important element [3]. It is also important to note, independent of budget constraint at utilities, underground distribution cable network though offering intrinsic mitigation to temporary faults sees higher cost and face continual threat of damage due to uncontrolled digging, arising due to upgrades of civic infrastructure under smart city programs for water, gas, sewage, landline communications etc. Hence, deployment & continual use of overhead networks remains inevitable.

In this backdrop, to achieve efficient renewable integration along-with distributed generation sources, use of reclosers with dual side voltage sensing can be useful choice. These reclosers also becomes an important element of various Fault Detection Isolation and Restoration (FDIR) approaches being deployed as a part of smart city & thereby smart grid network. With use of reclosers having advance intelligence-base control devices and remote connectivity, utilities can quickly identify the location of fault, isolate it and subsequently restore the power wherever possible by rerouting the flow of power on the distribution grid through unaffected paths.

FAULT DETECTION ISOLATION AND RESTORATION (FDIR) APPROACHES

Some of the FDIR related popular application configuration using reclosers are as follows:

Loop control scheme

Here, reclosers control (IED: Intelligent Electronic Device) take actions based on current/ voltage input they see on the system. This scheme is simple and does not require communication devices but offers loop control using voltage and time. Since, in this case system loading is not reviewed, here reclosers can close an un-faulted source into a faulted source under some conditions, leading to undesirable electrical stress on the distribution system.

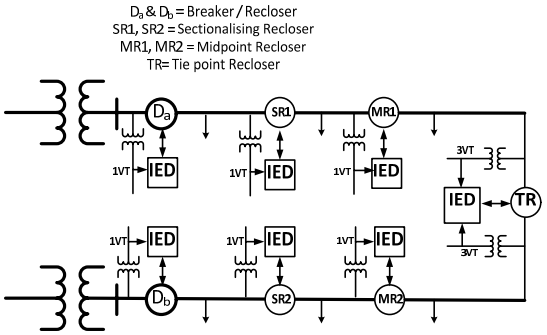

Fig. 3 Looped Network for improved Power availability using voltage sensors, timers

IEC61850 based peer to peer communication scheme

Here, also reclosers control (IED) receives current/ voltage input, as they see on the system. However, in addition reclosers communicate, using GOOSE (Generic Object Oriented Substation Events). Hence, this scheme while offering the advantages and restoration opportunity as in loop control, due to presence of communications, ensures that no closing happens for a permanent fault from another source, apart from limiting the time needed to reconfigure the network after the fault.

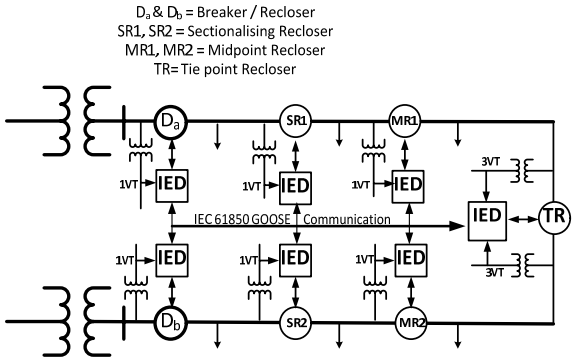

Fig. 4 Looped Network for improved Power availability using voltage sensors & IEC61850 communication

Decentralized scheme with special algorithms

Here, reclosers in certain area of distribution network are connected to substation automation device (hardware based, or cloud based) with help of communication link (preferably public mobile network). Substation Automation device, has the intelligence to analyze and arrive at the new configuration of the network post fault based on loading on the nodes, presence of distributed energy resources, numbers of customers affected etc. Special algorithms for FDIR following the operating constraints are also deployed. This scheme is the most flexible one and can be deployed for greater number of reclosers.

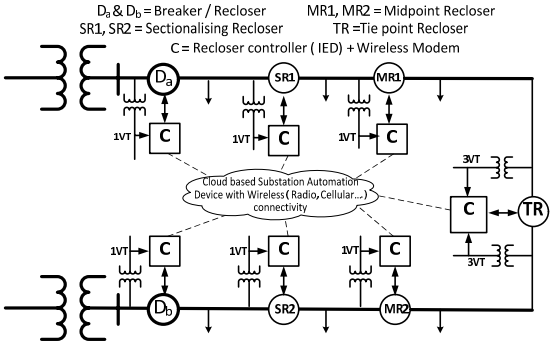

Fig. 5 Looped Network for improved Power availability using voltage sensors & Decentralised communication with Cloud based control device

Centralized communication (SCADA)

Implementing a SCADA system is though very expensive. However, with availability of dual side voltage data for recloser, current flowing in the network, along-with recloser position and remote operating control possibilities etc. for utilities having multiple feeder, SCADA approach offering fully control centrally is also followed. Network control algorithms here can be directly followed on the SCADA system. It is to be noted, with such centralized control, issues of intentional load shedding, single phasing: during power theft conditions, or switched electric supply for limited hours over radial feeder, especially for rural /agricultural / industrial zones away from urban establishments can be achieved too.

In India, private utility like torrent power Ltd. operating in Navi Mumbai region, State utilities in Assam, Himachal Pradesh have deployed such recloser schemes for improving power distribution.

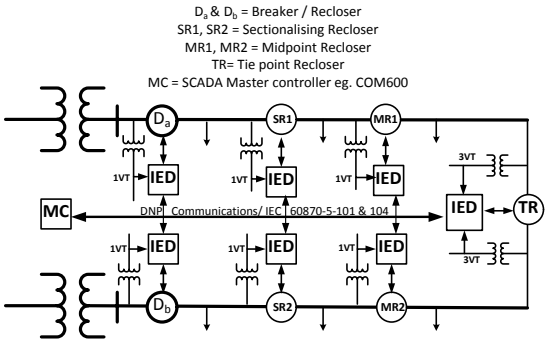

Fig. 6 Looped Network for improved power availability with voltage sensors, Substation level SCADA Communication and Master controller

DUAL SIDE VOLTAGE SENSING BY RECLOSERS

Voltage sensing on the incoming and outgoing terminals of certain reclosers forms an important element in the above schemes. Traditionally, dual voltage sensing as deployed in above schemes for reclosers installation, gets achieved by use of basic recloser with external add on voltage sensors on the incoming and outgoing side. Due to combination of different discrete objects in realizing the electrical scheme [4], the reclosers with dual side voltage sensing apart from being less safe and costly, makes the given overhead installation bulky both in terms of weight and size. This, also becomes inhibiting factor for their acceptability in installations in urban areas, considering clearance constraints due to higher density of inhabitants in proximity, apart from visually obstructive look on being mounted on poles. This, also has led to recent development and availability of medium voltage reclosers with integrated voltage and current sensors within interrupting pole(s) to facilitate altogether simplified installation.

BENEFITS OF INTEGRATED DUAL VOLTAGE SENSING

It is to be noted benefits of Integrated dual voltage sensor as a part of interrupting pole (which already carries current sensor), helps in comparatively economical, cleaner, less cluttered, compact & lightweight construction. It offers

a) installation ease with few external components, leading to simplified mounting, easier erection
b) lower commissioning efforts,
c) trouble free highly reliable operation due to minimal interconnects,
d) having smaller installation footprint in high densities areas, and
e) offering higher safety of people living in the surroundings.

On similar lines, it also helps in ensuring improved safety for the operators during any manual intervention needs.

Also, from functional application perspective apart from simplifying deployment in smart grid FDIR application, integrated voltage sensing also helps in automatic transfer applications where two independent source voltages are required to get monitored before safe transfer is affected from primary source to secondary/another source even when the communications have been lost.

Further, in the distributed generation applications where distribution grid is synchronized with backup generators, voltage sensing on either side also helps in monitoring phase angle and voltage amplitude of each phase for safe closing of recloser, when the generator is required to be connected to grid.

Similarly, for utilities deploying Conservation Voltage Reduction(CVR) strategy, to reduce the power demand, by reducing the voltage down to the lowest permissible value (e.g. 90% of nominal), Dual side accurate voltage sensing recloser can eliminate the need for having dedicated voltage sensing equipment's. In addition, for original equipment manufacturer, comparatively lower incremental cost between none, single side and dual side voltage sensing poles, can also help in standardization across production models. This, eventually creates win-win situation for both budget constrained utilities by lower recloser level cost as well as fewer spares variant management vis. a vis. optimal production volume for the manufacturer.

CONTROL AND AUTOMATION

Along with integrated voltage and current sensing at pole level, on control side advancements in sensing and computing technologies, not only helps in better accuracy & precision measurements of amplitude as well as phase of voltage & current, but also has led to realization of advanced synchronization checks, as well functions such as power quality and power flow detection with automatic change of protection group, as a part of intrinsic recloser control (IED). This eventually helps in realization of much smarter grid as against conventional over-voltage/under voltage and over current based protections and pre-defined reclosing cycles driven electricity network [5].

New generation recloser control devices further offer a variety of communication interfaces helping in ease of realization of most simple to most advanced FDIR (Fault Detection, Isolation and Restoration) solutions with power restoration time on non-faulty section ranging from few 100ms to few minutes. It is also to be noted that at the time of installation, such integrated voltage sensor based reclosers offers flexibility of achieving variety of end application configuration i.e. feeder, mid-point, tie-point, looped etc. without need for any physical changes in the installed hardware. In addition, with continuously evolving grid, which sees addition of newer generation sources, any eventual demand arising in future for reconfiguration of power flow direction can be very easily catered too. Lastly, such integrated dual voltage sensing reclosers when deployed, aids dynamic upgrades of distribution network and scaling up of functionalities. It is to be noted, this gets achieved without creating need for replacements or retrofits of existing investments for distribution utility.

SUMMARY

As highlighted in previous sections and installations experience from developing countries, integrated dual side voltage sensing for reclosers offers simple but cost efficient and effective solution. Therefore, its popularity is on rise for improving power distribution, and in developing countries various projects remain in execution. Equally well large number of projects are also in consideration under the smart city programmes running in countries like India, Brazil etc.

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