Supervisory Protection Scheme for a Wide Area 400KV Power Network

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Abstract. The Occurrences of blackout has emphasized the Engineers to enhance the protection schemes. The faulted areas are isolated and therefore the remainder of the areas are protected. During the faulted conditions like Congestion, Over/Under Voltage, Over/ Under current, Over/Under Frequency etc, the dimensions and complexity of the facility grid makes the system vulnerable. In this paper Wide area protection scheme is applied to a 400kv Network. For detection and to initiate remedial actions, SCADA alongside Phasor Measurement Unit is applied for Wide Area Protection for robustness of the facility Grid.

Keywords: Wide Area Protection, System Protection System, PMU

1. Introduction
The demand on electricity remains growing in most countries within the world. More and more renewable sources with floating in feed characteristic are installed. Transmission systems need to be more flexible to satisfy the demand. Increasing supply without improving transmission and distribution infrastructure may very well cause serious reliability issues. There are often many issues to address reliable system operation. However the first issues are typically the heavily loaded transmission. This overloading is usually at the basis of system instability problems; which successively are the first causes for blackout scenarios. Improvising protection philosophy has emerged with recent post-mortem studies of 2012 India blackouts. Blackouts prevention/mitigation and power grid security are the order of the day. Blackout--A blackout may be a total crash of the facility grid thanks to imbalance between power generation and power consumption[1]. To prevent/protect the grids from blackouts scenarios, reactive power flow analysis, including mitigation of voltage instability, should become an integral part of planning and operating studies. Implementation of wide area protection scheme for an applied electrical network is meant to supply
a security network for the electrical grid during unplanned contingency conditions or when system or operating constraints couldn't allow meeting the facility demand. The most objective of protection scheme is to stay the facility system stable by isolating only the components that are under fault conditions. The devices that are wont to protect the facility system from faults are called protection devices. Phasor Measurement Unit (PMU) represents one among the foremost advanced detector within the domain of the Wide Area Monitoring, Protection and Control (WAMPAC).

1.1 Wide Area Monitoring Protection and Control (WAMPAC)

Power Sector is that the back bone of the economy of a nation. within the day to day scenario power plays an important role and it's the essential amenity of any sector. The facility supply should be of excellent quality, highly reliable, cheap etc. Modern power grid is on the brink of the steadiness operation, because the Distributed Generations have increased widely and therefore the Power Network has been extended by laying newer Transmission Lines etc, which has eventually led to the complexity within the operation and control of the facility Network[2]. The lack of monitoring and appropriate control may cause catastrophic failure of the network referred to as blackout. It occurs thanks to a series of outage within the system. The trend within the power network sees advanced longer paths to satisfy the prevailing demand and one such trend is that the WAMPAC systems. The congestion and complexity within the network has pushed the grid to reinforce for correct monitoring and control by Wide Area Monitoring Protection and Control (WAMPAC), an enabler of the Smart Grid which may be a bidirectional network than has the power to heal itself just in case of any failure.

1.2 Phasor Measurement Unit (PMU)

Phasor Measurement Unit is taken into account to be one among the foremost important measuring instrument within the way forward for power grid protection schemes. A Phasor Measurement Unit (PMU) may be a device which measures the electrical waves on an electricity grid employing a four-four time source for synchronization [3]. generally, a PMU measures the electrical waves using Global Positioning Satellite (GPS) for time synchronization. The devices are installed at the starting also because the end of a line and send both signals to a good Area Measurement System (WAMS). The WAMS compares the signals and determines the phase difference. This provides a perfect measurement system which may protect, monitor and control an influence system. The diagram of Phasor Measurement Unit is depicted in Fig 1. In this paper Wide area protection scheme is applied to a 400kv Network.

**Figure 1.** Block diagram of PMU
2 Wide Area Protection System

Special Protection Scheme and therefore the remedial action schemes are designed to detect the abnormal system conditions for the corrective action. Depending upon the sort of the fault occurred the protective scheme are often designed. a number of the common schemes are rejection of generator and cargo, dynamic braking, VAR compensation, Stabilizers etc. supported the PMUs output the protection, emergency control are often designed. Generally in remedial action schemes the measurements and indicators are sent to an impact center for necessary action [4]. The protection scheme is meant by considering the mechanical, thermal, EMC and other environmental aspects for cover terminal. The system protection terminal comprises high speed communication interfaced to speak power grid data between the terminals. A backup protection scheme for transmission lines are often developed to spot the faulted line. After the occurrence of the fault the backup protection zone increases rapidly. the necessity for advanced dynamic tool is increased because the Distributed Generation has increased[5]. The dynamic thermal line rating of the cable is calculated in real time

3 System Protection Scheme (SPS)

The dynamic rating of the cable is taken into account because it greater than the static rating. The performance of the operational tripping scheme is improved by the mixing of the Dynamic thermal line rating in order that the likelihood of unwanted generation tripping scheme is reduced [6]. Passive fiber Bragg grating based transducers gives protection to the distributed measurement of Voltage and current. glass fiber measurement technology is established to enhance the protection schemes. FBG based sensors are used for voltage and current measurement and are integrated with Toshiba GRB 100 bus bar protection relay [7]. Adaptive Out of Step (OOS) protection in real time is proposed and uses the Extended Equal Area Criterion (EEAC) to seek out the critical clearing time and therefore the clearing angle. it’s found in real time which suits the system operating condition and is demonstrated on 16 machine 68 bus system.

A new criterion for the identification of PMU, quick detection of faults, early classification of events, time frequency based speed performance, locating the disturbance within a narrow geographical constraint are contributed which is situational awareness [8]. The synchrophasor measurements identifies the fault location and therefore the faulted line supported topology. The sum of positive sequence current increases when there's a fault. The faulted line and its location are determined by the location of PMU where the linear least square method is employed by faulted current and voltage phasor applied on WSCC 9 bus and IEEE 118 bus systems. Wide area data of WAMS and bus impedance matrix of Backup Protection Zones are utilized [9].

The component failures are quantified, and interaction matrix is framed and that they capture the patterns of the cascading failures. A high level probabilistic model is proposed to review about the interactions which are longer efficient and therefore the cascaded failures are mitigated by interaction based mitigation measures and are tested on IEEE 118 bus systems [10]. A bounded model of communication delay is considered and therefore the latency of System integrity protection schemes is investigated. Basically, the scheme is divided in to larger area and native area. the info buffering of the Phasor Data Concentrator is employed for larger area and for the local area network calculus theory is employed for offering restriction within the latency [11]. The transient stability status of the facility Network is predicted with reference to the speed N and change in voltage V. The voltage deviations are calculated by comparing the pre and post disturbances and is tested on IEEE 39 bus system[12].

The high order contingencies are identified and controlled supported optimality principle. because the system is nonlinear and sophisticated, a price based controller is meant which reduces
the control search space by model elimination method. And is tested on New-England 39 bus system[13]. The backup protection of transmission line is alerted by the WAMS for mis-operation of conventional relays. because the Wide Area copy Protection (WABP) operates at a variety of 100ms, the delays associated will face issues for a bigger system. Integer applied mathematics (ILP) is proposed to divide the system into several regions and are optimized [14]. The faulted regions are easily identified by the positive sequence measured by the digital relays. The fault condition and therefore the faulted bus are identified. The discrimination of the faulty and therefore the normal conditions are compared like Generator outages, Power Swing etc and is tested on IEEE Standard test systems [15].

The time delay and therefore the response of the disturbance is identified by the space relay. the space protection contribution degree is considered as weight and is employed to define the protection fitness function and protection fitness expectation. The fitness factor gain is calculated by dividing the protection fitness function by the protection fitness expectation function and is tested on IEEE 10 machine- 39 bus systems [16]. Wide Area Backup Protection (WABP) algorithm is framed supported the space relay. The WABP decides the position and therefore the status of the fault, the traditional relays are often simplified with WABP and is well coordinated with the traditional relays [17].

System Integrated Protection Scheme approach is proposed to enhance the safety of the facility networks. The synchronized measurements are wont to identify the faults by using two algorithms where the operating characteristic of relays in accordance with the system condition and therefore the nodes within the system are identified to scale back the load and therefore the risk is reduced and tested on New England 39 bus systems [18].
Out of Step Splitting protection is proposed to research the voltage phase angles during a frame of reference. Each bus voltages are compared with the older voltage. The buses are divided into 2 by out of step center. The voltage phase angles vary from 180 degree to 180 degree [19]. The short faults on un-transposed transmission lines are identified by sparse wide area measurements. The PMUs capture the measurement from various locations. The unbalances of the un-transposed lines and therefore the shunt capacitance of the line is considered by Optimal estimation theory and is employed to locate the fault [20]. Thanks to the rise within the distributed generation the probability of mal-operation has increased which reduces the safety of the facility system.

Adaptive nonlinear approach is employed to spot the islanding location by the voltage phase angles [21]. The explanations for blackout are Power Swings, voltage instability etc. So, the space relay got to be intelligent to spot the fault. Online intelligent techniques like online sequential extreme learning machine give an accurate result. The performances are compared with various intelligent techniques and are far from conventional techniques, [22]. The cable faults are easily identified by vector machine based fault localization supported PMU. The faulty branch and therefore the faulty bus are calculated by Fast Fourier transform analysis with reference to Equivalent Voltage Phasor Angle (EVPA) and Equivalent Current Phasor Angle (ECPA) and is validated with the Western System Coordinating Council (WSCC)-9 and IEEE 14 bus system [23].

The protection schemes related to the network clears all the faults and isolated the fault selectively. The structure of the facility System restoration is shown, during which the system is been monitored and through contingencies, it’s been controlled and therefore the load is restored. The Oscillations are damped and therefore the power flow is regulated, thereby the system is protected and secured[24]. The angular instability, or loss of synchronism, condition occurs when generators in one a part of the network accelerate while other generators elsewhere decelerate, thereby creating a situation where the system is probably going to separate into two parts. the traditional relaying approach for detecting loss of synchronism is by finding impedance at the generator terminals. It’s accepted that voltage instability is caused by the load characteristics, as against the angular instability, which is caused by the rotor dynamics of generators[25]. Voltage instability are often prevented by reactive compensation at load centers, load shedding, relays etc.

Overloads frequently occur during wide-area disturbances thanks to the increasingly high utilization of kit capability. These overloads may end in faults (such as lines sagging into trees) or equipment damage if overload protection isn’t provided. On the opposite hand, overloads sometimes end in premature removal of kit thanks to short-circuit protection relays that don’t allow the complete short-time overload capability of the equipment to be utilized. Overloads are counteracted by applying monitoring and protection equipment.

The power network modeled is shown in Fig 2 for cover using Distance relay without fuzzy controller and with fuzzy controller is shown in Fig 3 and Fig 4 respectively. The only line to ground fault is made for an equivalent and therefore the results are compared. The comparison of the response to the fault by the space relay occurred during a cable with Fuzzy and without Fuzzy is shown in Table 1 which shows that by using symbolic logic Controller the response to the fault takes less time in order that the networks are often secured.

The comparison of the response to the fault by the space relay occurred during a cable with Fuzzy and without Fuzzy is shown in Table 1 which shows that by using symbolic logic Controller the response to the fault takes less time in order that the networks are often secured. In the existing transmission, the transmission lines are subjected to several faults. Presently the faults are sensed by relays and mostly distance relays. Sometimes the space relays operate by simple unwanted faults causing disturbance to the purchasers. The faults could also be thanks to unwanted dips in voltage thanks to simple reasons. So, these are often prevented by usage of distance relays with symbolic
logic which makes a quick recovery.

**Figure 3.** Modelling of Power Network with Distance relay

**Figure 4.** Modelling of Power Network with Distance relay and Fuzzy Logic Controller
Figure 5. Output of the Power Network with distance Relay

Figure 6. Output of the Power Network with distance Relay and Fuzzy Controller

| Response time   | With Fuzzy (in seconds) | Without Fuzzy (in seconds) |
|-----------------|-------------------------|----------------------------|
|                 | 0.045                   | 0.05                       |

Table 1. Response of the Distance Relay
Now a days in advanced countries PMUs are used. The relays for cover and prevention of faults in transmission lines the symbolic logic is presented. The Impedance locus for the space relay is shown in Fig 7 during which the impedance locus shows the occurrence of fault within the space zones,

- Zone1 =80%
- Zone2 =120%

Since the fault occurs within the zones the space relay recognizes it. The results shows a really good performance within the different fault condition, the space relay convince be fast and accurate for various system conditions. Since distance relays are cheap in cost they're employed in our country universally, therefore, the symbolic logic is used alongside it, so results are going to be better and therefore the inconvenience to the subscribers are going to be reduced. The output of the facility Network with distance relay incorporated with fuzzy controller and without fuzzy controller is shown in Fig 5 and Fig 6 respectively. Also, the Impedance locus for the space Relay with symbolic logic is shown in Fig 7.

**Figure 7.** Impedance Locus for Distance Relay with Fuzzy logic

### 4 Conclusion

This paper discusses about the importance of System Protection Scheme (SPS) stressed by various authors for identifying the faults like black outs etc. Now a day’s relays like electro mechanical, static relays are widely used. we’ve proposed a digital relay method for identifying faults like generator mismatch, black outs, voltage instability, small signal stability etc. The model is simulated in MATLAB and incorporated with symbolic logic and without symbolic logic is presented. By the inclusion of the intelligent controller the system will respond at earlier time duration. the space relay gives an accurate and fast system condition when it’s in coordination with an Intelligent controller, thereby the system is more reliable.

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