REVIEW ON PMU PLACEMENT ON GRID WITH OPTIMIZATION

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Abstract- PMU helps in building system of protection so, if there arises a series of contingencies then its effect can be helped in minimising up to a controlled range. Thus, the saved can saved from entering into a blackout state. PMU data helps in providing system information at an instant common time. This information provided by PMU can be used for the analysis of dynamic real-time, which in turn may be promoted for prediction of pattern-based frequency, power profile based active-reactive etc. Security indices and margins will be identified and calculated by using real time information. This information is used for the prediction of emergency states, premier system security on the basis of monitoring and detection, and initiates restorative form of actions in order to avoid the instability of the system.

Keywords: PMU ,noise, optimization, state

I. INTRODUCTION

Estimation of different variables of power system has been an important problem which needs to be addressed. Various researchers and industries have attempted this problem over the years as it helps to estimate improve the power quality and security. The problem has gained importance further since the inception of smart grids. The concept of smart grids has drawn the attention of researchers because of their improved performance in terms of quality of power and efficient management of resources [1-4]. But along with the loads of advantages brought by smart grids, there are some inherited challenges which need to be addressed. The whole idea of making our grids smart is achieved through combining the IT sector with the Power System. This means prediction of loads and power system parameters in advance which makes accurate decision making.

1.1 Parameters in power system

The problem of load flow in power system forms an example of classic engineering problems in power system. In most of the cases of circuit analyses, the network components are limited to known value of impedances with current and voltage source [5][8-10]. But the load flow problem is different in the sense that instead of impedances, the known quantities are active and reactive powers at most network buses, because behaviour of most of the load in a lot of cases are as constant power loads, assuming that voltages applied on them remains within acceptable ranges. The set of unknowns producing power balance at all of the specified buses in the system is solved by the load flow algorithm. The power balance equation is given by equation

$$P_i^{given} + jQ_i^{given} = P_i^{comp} + jQ_i^{comp}$$

Where

$$P_i^{comp} + jQ_i^{comp} = V_i I_i^*$$

Stated otherwise, the specified power at a particular bus must be same as that of the power flowing into the system. The power which is generated is taken as positive power, which makes it consistent with KCL equation YV=I.

1.2 Need for estimation of these parameters

All the stated parameters need to be estimated in the power system in real time. One of the major parameter is the phase magnitudes which are constantly monitored by the phase measurement units. The power flow analysis techniques do provide the solution to the system but requires a prior knowledge of all the other system variables. Also they are quite computationally intensive [7, 11]. Therefore, there is a need to an alternative scheme of prediction of these variables in real time which are more accurate than the measurements of the PMU's and other sensors [12-14].

1.3 Bayesian filters

Kalman Filter has become one of the basic tools for most of the state estimation problems. In its most basic form as developed in 1960 by R.E. Kalman, it is for discrete time systems where we have a process which follows its dynamics in time domain and then we have a measurement which is used to correct the estimated obtained from the propagation of the process. The Kalman filter described above is an optimal filter for estimation problems involving linear process and measurement dynamics. Though many of the engineering problems can be approximated as linear to some extent, the ground truth is that in reality there exists no perfectly linear systems. For example, even a simple resistor follows linear Ohm's law only up to acertain range. Though the assumptions of approximating systems as linear can be valid in certain cases, it may not provide acceptable performance in many real world applications. Hence there is a high demand of non-linear estimators for many engineering applications.

II. RELATED WORK

Helder RO Rocha, et al [1] presented a new approach for designing the WAMS i.e. Wide Area Measurement Systems. An algorithm based on topological analysis in the basis of

Variable Neighbourhood Search heuristic was tested and proposed in various type of networks, that includes IEEE testing networks and the Brazilian 5804-bus transmission system. The analysis of the results have shown the effectiveness, scalability, and flexibility of the proposed framework on comparing it with presented literature-based research. Morteza, Sarailoo et al [2] was to accurately infer the isolated PMUs-based synchro phasors in order to hide the spoofing effects on the basis of real-time functions in respect to the network of PMU. As presented in the framework, a solution of deterministic form usually requires more redundant form of PMUs and lots of interconnections in the environment based on the circuits of physical transmission. Therefore, the cost (defensive) rapidly develops with increase amount of attacks based on aggressive spoofing. In order to address this kind of problem, various futurr-based directions have been considered. Zeina Al Rammal, et al [3] discussed the optimal phasor measurement placement (OPP) for reverse-based detection of power flow. A comprehensive review of literature and a comparison among a large range of already existing algorithms of optimization was done. Further, genetic algorithm (GA) was selected for solving such kind of problem. MATLAB based Global Optimization Tool was used for testing the algorithm that was proposed on IEEE-39 and IEEE-14 node-based test feeders. Saleh Almasabi, et al [4] presented an OPP based approach considering both the infrastructure of communication as well as the cost of installing the PMUs. The proposed methodology mainly used an installation of multi-stage type, where each of the stage was mainly dependent over the cost set by the system utility rather than number of PMUs used in the process. The buses with high priority can be selected under the proposed methodology. The proposed methodology was tested on the system of IEEE, and over the IEEE 118-bus, 30-bus, and 14-bus based test systems. Shahriar Amani, et al [5] was to use a new method in order to determine the optimized alterative and minimized PMU number in the network on the basis of PSO based algorithm. Considering the system from the PMUs based perspective, the process of location optimization was mainly performed on estimation mode for control and voltage variables in a distributed network with multiple loads and DG resources. The main purpose of this work was to determine the minimum number of PMUs and the voltage based differences on the basis of algorithm in the network premises. Xingzheng Zhu, et al [6] proposed the problem based on OLLP i.e. optimal PMU-communication link placement that investigated the placement of communication links (CLs) and PMUs for full power system observability. Besides the location of CLs and PMUs, in order to ensure there timely and liable PMU data transmission, the capacity of communication required on each and every CL was also captured by the problem of OPLP. The researchers have carried out the numerical-based studies on the IEEE 300-bus, 118-bus, 57-bus and 30-bus systems for the model proposed. The results have shown that on comparing with conventional optimized model of PMU placement, OPLP can help in reduction of the significant total cost of installation. MariappanSaravanan, et al [7] proposed the application of power domination integrity to an electric network of power system. A phasor measurement unit was used for analyzing and controlling the energy system by measurement of voltage phase in transmission lines and electrical nodes. For achieving this, the graph theory concept of domination was applied to energy-based networks by redefining the vertex “adjacency” as an “observed” vertex. The domination number of power helps in identifying the PMU number to be placed. The concept proposed the integrity of power domination that not only provides minimum number of PMUs but also helps in identifying the optimised locations for the placement of PMU in an electric network of power system. Emmanuel U. Oleka, et al [8] proposed various types of techniques. It evaluated various kind of major techniques and further established that the techniques available and the factors considered were not adequate for practical optimal placement of PMU. It further evaluated a method that could be applied for achieving a robust and practical solution for an effective placement of PMU for applications of synchro-phasor in a practical energy grid. Tapas Kumar Maji. et al [9] introduced a concept to solve the OPP-based problem, an algorithm of EBPSO was proposed and it was tested on distinct type of systems, like IEEE 118- bus, 57-bus, 14-bus, and practical system based on NRPG 246-bus. Due to coefficient of exponential inertia-based weight, two useful and innovative sigmoid function (SFs), two techniques based on Social Media Optimization (SMO) and logical ‘filtration’, multiple solutions are usually obtained. The coefficient based on exponential inertia weight was introduced for improving the capability based on swarm searching.

Table.1 Existing Scheduling Model

Author's Name	Year	Methodology Used	Proposed Work
MariappanSaravanan, *et al.*	2018	Phase Measurement Unit	Proposed the application of power domination integrity to an electric network of power system.
Tapas Kumar Maji. *et al.*	2017	Exponential Inertia-based Weight, Sigmoid Function (SFs)	Introduced a concept to solve the OPP-based problem, an algorithm of EBPSO was proposed and it was tested on distinct type of systems, like IEEE 118- bus, 57-bus, 14-bus, and practical system based on NRPG 246-bus.
Zeina Al Rammal, *et al.*	2018	MATLAB based Global Optimization Tool	Discussed the optimal phasor measurement placement (OPP) for reverse-based detection of power flow.
SarojKumari, *et al.*	2017	Binary Particle Swarm Optimization	Presented an optimal technique for placement of PMUs for complete power observability of the network with PMUs number as minimized as possible.
Carlos A. Lozano, *et al.*	2016	MATLAB-PSAT, PSAT: Power System Analysis Toolbox.	Presented a comparison and review of several methods for placement of PMU in power systems.
Shahriar Amani, et al	2017	PSO based algorithm	PMU number in the network on the basis of PSO based algorithm. Considering the system from the PMUs based perspective, the process of location optimization was mainly performed on estimation mode for control and voltage variables in a distributed network with multiple loads and DG resources
Xingzheng Zhu, et al	2017	PMU with OPLP	PMU data transmission, the capacity of communication required on each and every CL was also captured by the problem of OPLP. The researchers have carried out the numerical-based studies on the IEEE 300-bus, 118-bus, 57-bus and 30-bus systems for the model proposed.
MariappanSaravanan, et al	2018	controlling the energy system bymeasurement of voltage	A phasor measurement unit was used for analysing and controlling the energy system by measurement of voltage phase in transmission lines and electrical nodes. For achieving this, the graph theory concept of domination was applied to energy-based networks by redefining the vertex "adjacency" as an "observed" vertex. The domination number of power helps in identifying the PMU number to be placed. The concept proposed the integrity of power domination that not only provides minimum number of PMUs but also helps in identifying the optimised locations for the placement of PMU
Emmanuel U. Oleka, et al	2017	PMU for applications of synchro-phasor in a practical energy grid	proposed various types of techniques. It evaluated various kind of major techniques and further established that the techniques available and the factors considered were not adequate for practical

			optimal placement of PMU. It further evaluated a method that could be applied for achieving a robust and practical solution for an effective placement of PMU for applications of synchro-phasor in a practical energy grid.
Tapas Kumar Maji. et al	2017	OPP-based problem	introduced a concept to solve the OPP-based problem, an algorithm of EBPSO was proposed and it was tested on distinct type of systems, like IEEE 118- bus, 57-bus, 14-bus, and practical system based on NRPG 246-bus. Due to coefficient of exponential inertia-based weight, two useful and innovative sigmoid function (SFs), two techniques based on Social Media Optimization (SMO) and logical 'filtration', multiple solutions are usually obtained.

Nadia HanisAbd Rahman, et al [10] uses V-shaped sigmoid function and mutation strategy that improved the diversity of population, which further minimized the number of particle chances of being trapped in the region of local optima, therefore leading to a solution based on quality. For validating the effectiveness of the solution, the obtained results by the proposed methodology were compared with other existing techniques in order to demonstrate the validity and accuracy of the technique that was proposed. The IEEE 300-bus system results shows that the method proposed managed effectively to reduce the number of PMUs required. SarojKumari, et al [11] presents an optimal technique for placement of PMUs for complete power observability of the network with PMUs number as minimized as possible. Because of high cost of installation based on PMUs, it is significant to create fully observable system with minimized PMUs. A BPSO i.e. binary particle swarm optimization was mainly implemented over Puducherry 17 and standardized IEEE system bus system. The method of BPSO based on optimized placement of PMU can be applied therefore to any of the power system in order to make the system fully observable with distinct aspects of the power system. The results obtained are usually compared with existing techniques and it usually found that the Adaptive GILP, SA, GA BSA and the proposed method of BPSO was found better. Subrina Sultana Noureen, et al [12] discussed a large number of algorithms for the control and stability of power system. It further provided a platform for the experts for categorizing such type of algorithms prior to applying for the placement of PMU and to find the best possible solution. The analysis of several techniques of optimization in regard to this work helps in to mitigating the optimal placement problem (OPP) and it would help in finding the criterion based on future trends optimization criterion. Abdul Karim Mesbah, et al [13] proposed two of the distinct Integer Linear Programming method and hybrid methods for the PMU based placement in the power system of the country Afghanistan. Here, the hybrid methodology was mainly based over the combination of the Breadth First Search and Greedy algorithms. Whereas the method of integer linear programming was based on the Global Search and Binary Search algorithms. The power system of this country has been modified slightly in order to involve the sources of renewable energy. The experimental results so obtained have been further compared indicating that the results of such type of algorithms are more accurate than other form of algorithms such as Genetic Algorithm, Depth First Search, Binary Search Algorithms, and Partial Swarm Algorithms. Carlos A. Lozano, et al [14] presented a comparison and review of several methods for placement of PMU in power systems. The researchers have included a classification in accordance to the type of obtained observability and considered the method based application. Finally, a method to monitor the stability of voltage in power systems was selected and tested on IEEE39 bus system by using MATLAB-PSAT, where PSAT represents the Power System Analysis Toolbox.

IV. CONCLUSION

smart grid at its core represents the use of rising technology in order to support the energy and the cost-based efficiency. A smartly designed energy network, reads in an automatic way and reacts to the changes of supply as well as the demand. It offers a large potential for maintenance of large security of the supply system with the help of efficiency. When these are linked or coupled with the smart meter roll-out, then the possible efficiency is always larger as the customers easily adapt with their own demands on real time basis and usually increase the renewable energy integration into the grid.

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