Wide Area Monitoring System (WAMS) Application in Smart Grids

D. S. Zolin, E. N. Ryzhkova

Industrial Enterprises Power Supply and Electrical Technologies Department , Electrical Engineering and Electrification Institute, National Research University "MPEI"
111250, Russian Federation, Moscow, st. Krasnokazarmennaya, 17, dept. IEPS&ET
diffl@mail.ru

Abstract
Digital microprocessor devices are widely used in modern dispatching. The introduction of wide area measurement systems (WAMS) is one of the power systems technological development priorities globally. WAMS use a well-studied method of measuring phasor (phase vector) data in various geographically remote sections of power grid lines. With appropriate software processing, the data coming from the phasor measurement units (PMUs) allows: providing dispatch centers with data on the overall system stability; increasing the reliability of maintaining the power system operation state; obtaining cost savings by reducing or removing restrictions on power flow capacities in critical sections in real-time; maximizing the utilization of most efficient, competitive power plants, reducing the volume of consumer restrictions.

Introduction

This work contains developed methods for accelerated calculations of electrical modes in relation to the problems of emergency control within the framework of scientific research in dispatch control improving and developing field based on vector control and vector measurements. There are summarized results of the developed algorithms tests based on using Phasor Measurement Unit vector measurements in this paper.

The development and improvement of large power interconnections management on the basis of new computer and information technologies is focused on using of electrical regime parameters vector values synchronized measurements.

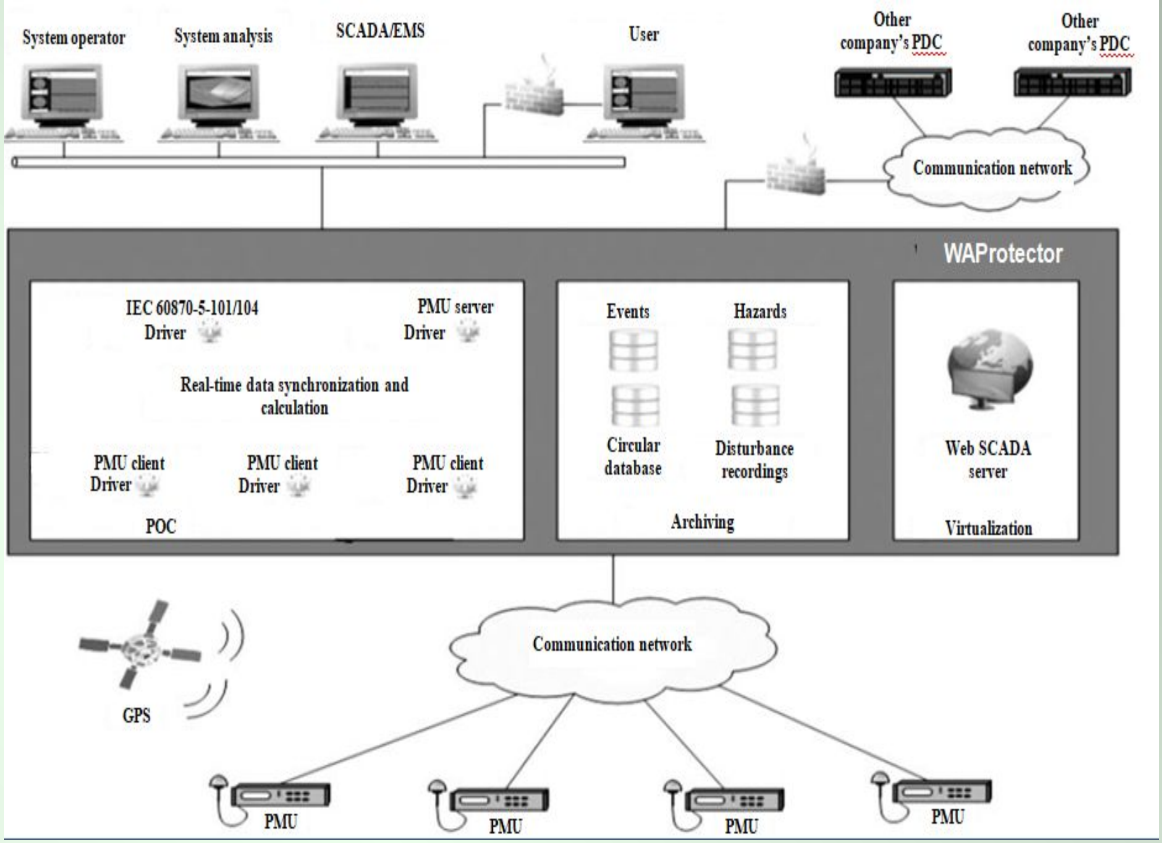

Fig. 1. WAMS configuration.

Structuring Fundamental WAMS Configuration Based on Real Power Grid Applications

The core of WAMS is a complex device consisting of three main components:

- Phasor data concentrator and real-time data analysis;
- Data archiving;
- Data visualization using Web SCADA.

Investigation of Indirect Cable Line Temperature Measurement Methods Using WAMS

One of the indirect temperature measurement methods is based on calculating the line impedance. If PMUs are installed at both ends of the line, the line active impedance can be determined using the current and voltage phasors. After that, the average temperature is calculated using the active impedance.

Described method disadvantages analisys:

- The calculation gives the average temperature of the entire line;
- Locations with high temperatures, conductor sagging and critical spans cannot be detected;
- Two PMUs must be used — one at each end of the line;

Instrument errors can significantly impact the results.

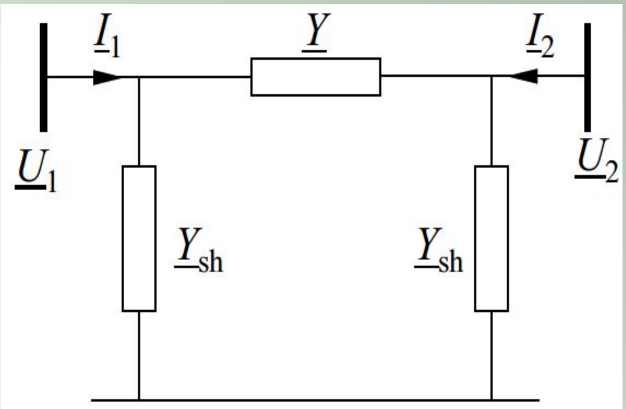

Fig. 2. U-shaped equivalent circuit of the power transmission line..

The disadvantage of indirect temperature measurement can be eliminated by using direct temperature measurement. In this case, the actual line temperature is measured at the sensor locations. The resulting solution factor in the effects of ambient temperature and wind. Temperature sensors are usually installed in critical sections of the line.

A complete EPS monitoring solution is obtained by enhancing line data in WAMS with accurate line temperature measurements.

		4	2	9	10	3	5	6	7	8	14	11	13	12
		{1}	{2}	{3}	{4}	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
8									•	•				
11					•			•				•		
12								•					•	•
13								•			•		•	•
3	[1]	•	•			•								
2	[2]	•	•			•	•							
5	[3]		•		•		•	•						
4	[4]	•	•	•		•	•		•					
7	[5]	•		•					•	•				
9	[6]	•		•	•				•		•			
10	[7]			•	•							•		
14	[8]			•							•		•	
6	[9]						•	•				•	•	•

Fig. 3. Conductivity matrix after rearranging rows and columns according to the first algorithm.

	4	6	5	2	3	7	9	11	12	13	8	10	14	1
4	•		•	•	•	•	•							
6		•	•					•	•	•				
5	•	•	•	•										•
2	•		•	•	•									•
3	•			•	•									
7	•					•	•				•			
9	•					•	•					•	•	
11		•						•				•		
12		•							•	•				
13		•							•	•			•	
8						•					•			
10							•	•				•		
14							•			•			•	
1			•	•										•

Fig. 4. Conductivity matrix Y after permutation of rows and columns according to the second algorithm.

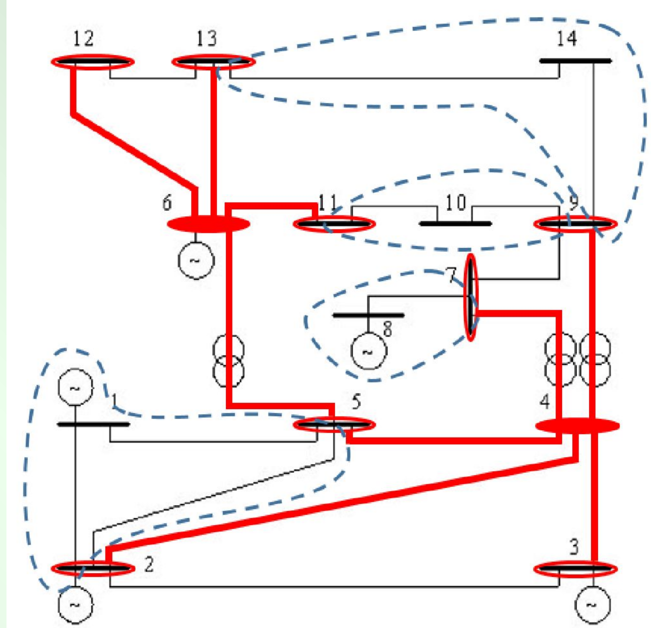

Fig. 5. IEEE – 14 network. There are 2 nodes with PMUs: 6 and 4; PP type nodes: 2, 3, 5, 7, 9, 11, 12, 13; EMI type nodes: 1, 8, 10, 14. Shown 4 local networks for an autonomous OS.

PMU DEVICES MEASUREMENT NETWORK STRUCTURING ALGORITHM

At the first stage PMU arrangement algorithm development in order to ensure EPS modes accelerated calculations, high-precision vector measurements of the node voltages - the phase and the modulus of the complex value, which the PMU can provide - were considered.

First algorithm basis was lower triangular submatrix of electrical network conductivity matrix formation, which provides nodes voltages accelerated calculation without PMU, without solving equations system, due to the sequential determination of voltages from equations with one sought variable.

The second algorithm is based on ranking of all nodes by BP_i in decreasing order, starting from the maximum. Elimination of the node with the maximum BP (this node is supposed to install a PMU) and incident nodes assigned to it as “pseudo-PMU” and denoted as PP, lower the PR and BP in the rest of the network. Vector measurements of branch currents and voltages of the beginning of power transmission allow to determine with high accuracy the complex value of the voltage of the opposite end. It is further considered as a pseudo-dimension of a PP-type node.

Conclusion

Reducing the number of nodes with PMUs for electrical network mode accelerated calculation leads to using some of the traditional active and reactive power electromagnetic measurements (EMP), and its errors are significantly higher than that provided by the PMU. Evaluation becomes an important issue. Interest in sharing information from PMU and SCADA appeared immediately with vector measurement systems WAMS appearance. The developed system is designed to control EPSs in real–time and to warn system operators if the measured or calculated values exceed the thresholds. Furthermore, the system allows to exchange measurements with other PDC and SCADA systems. WAMS potential comes from the operation of WAPS and WAMS in real-time, though widespread use of such scheme will require a more reliable communication infrastructure compared to the currently available.

Future development shall be mainly focused on the following:

- EPS WAPS, preventive and repair procedures, including control actions for tap changers and reactive shunts, division into subsystems, etc.;
- Development of an expert system to prevent system failures;
- System relay protection for conventional protection schemes;
- Complex state assessment functions.