Jean-Pierre Ngoma Sc. (Eng.), P. D. Lezhnyuk, Dr. Sc. (Eng.), Prof., A. V. Kilimchuk

AUTOMATION OF SMALL HYDRO POWER PLANTS AS MEAN OF INCREASE THE EFFICIENCY OF THEIR OPERATION IN ELECTRICAL NETWORK

The principles of creation of automated control system for small HPP are considered. It is shown, that such system should be hierarchical, formed at basic HPP and rely on lower level on local automatic systems.

***Keywords**: small HPP, automation, structure, principles.*

Introduction

Today and in the near future in power balance of all countries of the world the share of renewable energy sources (RES) grows. So the countries of European Union the possibility of increasing of this share in 2020 to 20 % is considered. Important role here is assigned to HPP, in particular to small HPP [1- 3].

With the increase of small HPP share, in energy balance of the country the development of methodical, information and engineering provision of small HPPs becomes actual [3, 4]. Important factor in this direction is integrated approach and methodological unity at decision-making level concerning improvement of service characteristics of small HPP at their operation in energy supply system. The maintenance experience of different power objects, including power plants shows the best results can be obtained by application of automated control systems (ACS).

This article is devoted to development of hierarchical ACS by small HPP which purpose is the increase of efficiency the latter while their operation in electric power system.

Features of small HPP as object of control

Operation of small HPP has a number of features, compared to traditional energy sources [5, 6]:

- small unit power of HPP (from 100 kW to 20 MW) and often low coefficient of utilization of rated capacity during a day does not allow to receive considerable profit from realization of electric power that leads to necessity of maximum possible to reduction of maintenance costs;
- to one subject of power market can submit 10 and more small HPP located in different areas and regions of the country, that essentially complicates centralization of their dispatching control, considering practical lack of industrial communication channels;
- increase of power market requirements concerning the automated systems of commercial account of electric energy (ASCAEE) regarding the efficiency of information interchange between operators and consumers requires improvement of software facilities installed at small HPP;
- productivity of small HPP greatly depends on actually unpredictable influence of the environment that leads to complexities in planning process of their operation modes;
- nonconformity of norms and rules of water resources usage in combination with human factor imposes artificial, often unreasonable, restrictions in problems of performance providing of hydroelectric plants of this class operation.

For providing of effective maintenance of small HPP the introduction of means of automation of electricity generation process is necessary. Developed automated control systems should provide the solution of the following problems:

- complete automation of information exchange between HPP and accounting-dispatching centre (in prospect by the operator of power market) for solution of problems dealing with commercial account of electric power;
- control of basic equipment state, its protection in abnormal modes of operation and providing of reliability of HPP operation as a whole;

- provision of centralized control of basic processes, maneuverability of HPP and maximal efficiency of primary energy using throughout specified period of work;
- minimization of the necessary quantity of attendants for ACS and station as a whole.

Block diagram of ACS of small HPP

For realization of the specified problems a necessary condition is assurance of possibility of centralized control over the object in real time. At the same time, specified condition cannot be provided because of spatial branching of objects and lack of reliable communication channels between them and dispatching centre. Proceeding from it, ACS with the given number of functions (fig. 1) can be created as centralized system of operational administration with decentralization of real time functions at the expense of application of local (in prospect adaptive) automatic control systems (ACS).

Considering structural and hardware complexity of the given control system, and also requirements concerning minimization of capital and maintenance costs, ACS should be built on the basic of the results of detailed technical and economic analysis. Taking into account these factors, the concept of automation of the small HPP is developed, the major principles of it are:

- substantiated sequence of development and ACS introduction provides the sequence of problems realization of automated control system;
- realization of three-level hierarchical structure with allocation of two levels of objects of control (HPP) - objects of lower level and "basic" objects - reduces capital expenditures for hardware and program realization of ACS;
- total autonomy of objects of control (HPP) of all levels in normal (planned) modes of their operation allows to provide controllability of objects and realization of the set functions by them during of certain period of time even in case of lack of communication channels with upper hierarchical level.

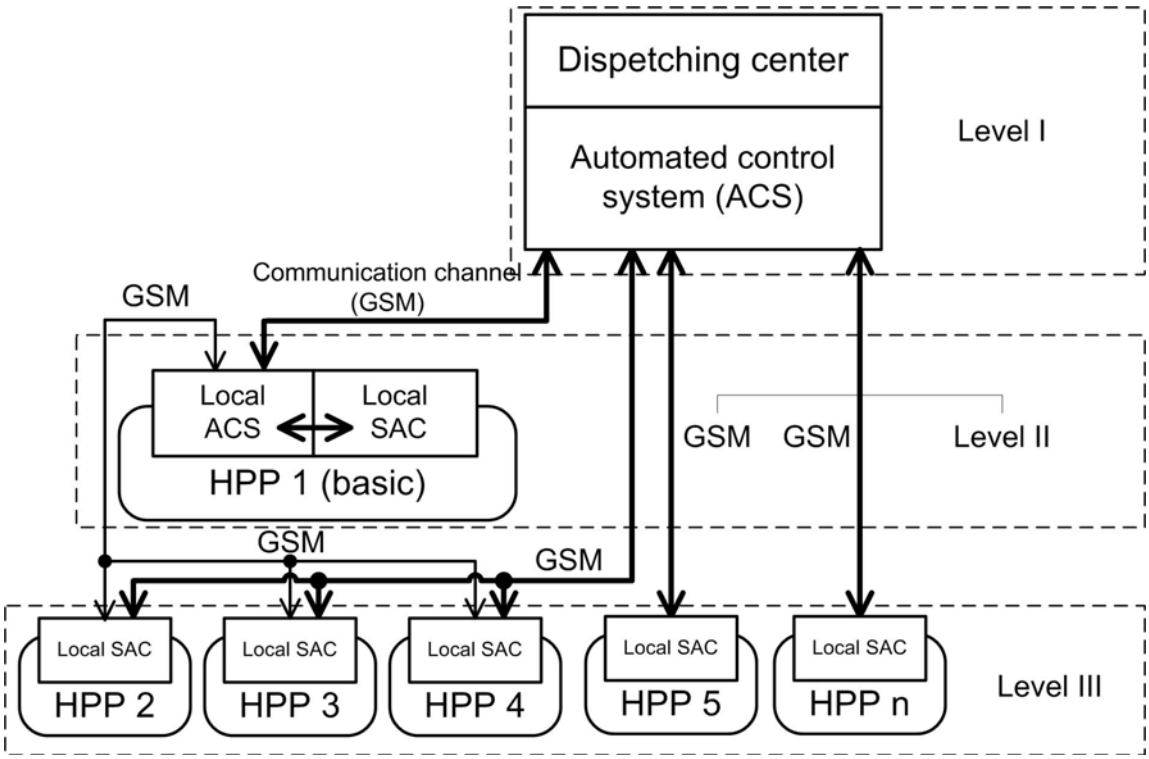

Fig. 1. Block diagram of ACS of HPP

Practical realization of ACS of small HPP

Development and introduction of automated control system over the group of small HPPs provides a number of completed stages, each of which realizes certain number of problems.

At the first stage problems of electric energy commercial account automation, as the necessary condition of HPP functioning in power market are solved. Further hardware and software for collection and transmission of data concerning half-hour schedules of electric energy supply and formation of accounting documentation in accordance with acting normative documents is developed. Additional tasks of given stage is testing of selected intellectual counters, hardware platform and communication channels, preparation of operating crew for work with new equipment.

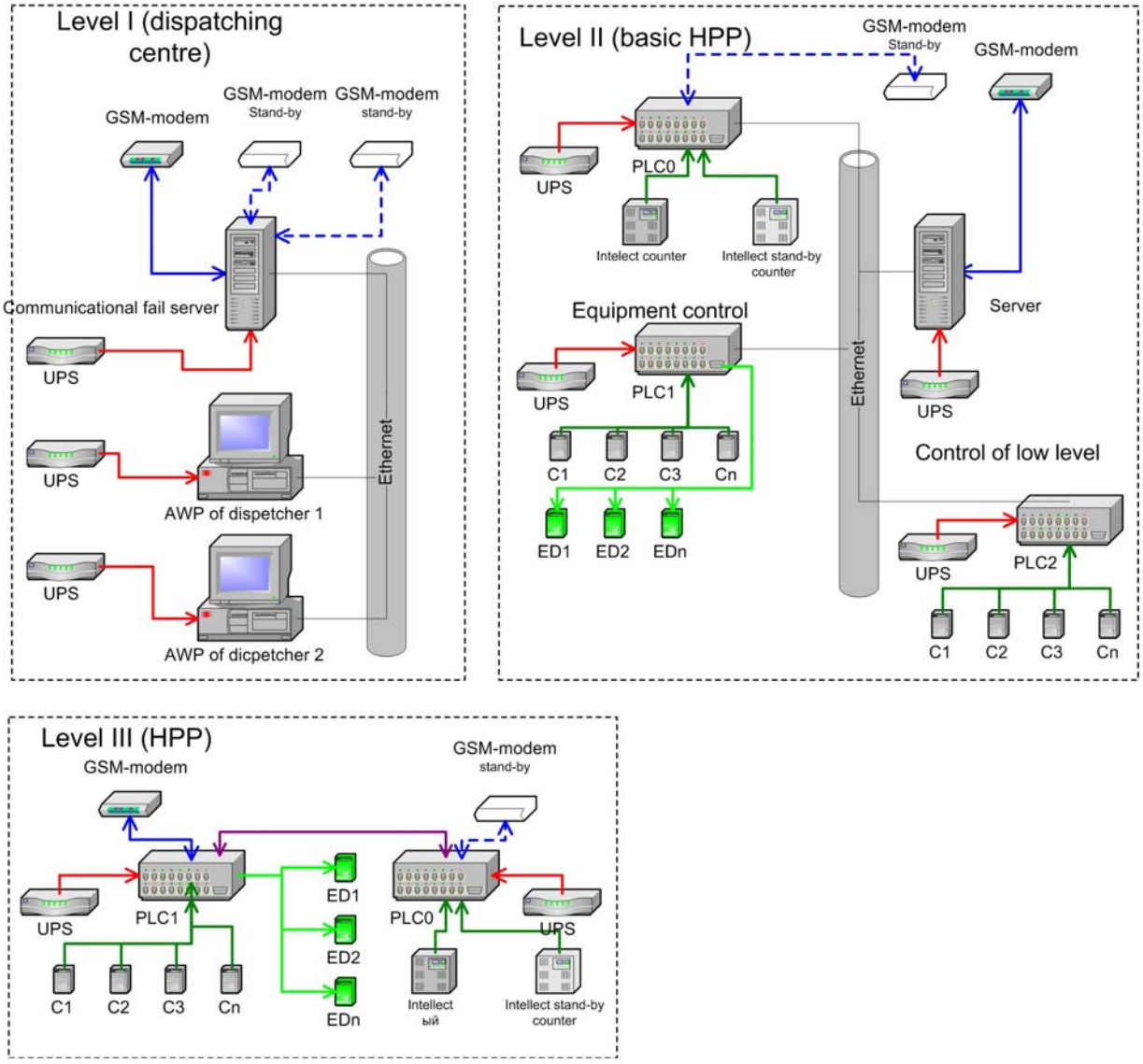

Fig. 2. Block diagram of hardware realization of HPP ACS

At the following stage of ACS realization the purpose is the automation of process of electric energy generation and maintenance of autonomy of HPP in normal (planned) modes of their work. Problems of remote maneuvering of HPP, automatic control of operability and protection of their basic equipment and reduction of necessary quantity of attendants are solved. Composition of software increases considerably as for conducting of the set remote mode of HPP with taking of elementary control decisions it is necessary:

- control water level in upper reservoir and stop units in case of minimum level achievement;

- control generators operation mode using measuring facilities of control panel and accordingly correct capacity of turbines;

- control parameters of mechanical part on HPP (bearings of generators, turbines, gears atc.) and stop units in case of achievement of limiting values of vibration and temperature;

-register accidents and preaccidents, and also presence of personnel and extraneous persons in HPP territory (including periodic video observation) informing higher hierarchical level of management (dispatching centre), and also attendants.

Solution of information provision problems of HPP mode conducting task requires expansion of hardware-software part of local control systems (fig. 2) - establishment of sensors (S) of mechanical and electric parameters control, and also executing devices (ED), united in information network of lower level, PLC-controllers for organization of performance of real time problems and data exchange between ACS subsystems etc.

The third stage of development and realization of HPP ACS begins from the allocation (by territorial sign, installed capacity, quantity and qualification of attendants) of basic HPP. At such stations the additional equipment for organization of their local automated control system and HPP connected to them of lower level is established. PLC-controllers of such objects are united in area network Ethernet that provides data exchange possibility between them and server of local ACS. The latter is provided with the software, allowing to accumulate and analyze retrospective data of own local SAC and SAC of connected HPP, to increase the efficiency of water resources usage, to predict accidents and to liquidate failures with minimum damages.

Local ACS of basic HPP are intended for independent program control of HPP modes according to changes of environmental factors, operative analyzis of operation modes of their equipment, and also for informing and the dispatching centre and duty personnel of corresponding HPP about possible accidents, analysis of tendencies of change of basic parametres (electric, mechanical), their registration and organization of full-grown information exchange between objects of control and dispatching centre.

It is obvious, that realization of the described ACS for small HPP requires besides appropriate hardware realization, elaboration of corresponding mathematical apparatus and software, which for separate HPP (especially HPP of II level) requires considerable capital expenditures and time. But economic benefit connected with improvement of controllability and maneuverability of HPP, considerable reduction of quantity of attendants, reliability enhancement of operation and efficiency of water potential usage at approximate estimates will allow to compensate all mentioned expenses throughout 3-4 years.

Conclusions

1. Modern conditions and features of operation of small HPP in energy market require increasing of automation level of the processes associated with electricity production.

2. Stage-by-stage development and realization of automated control system allows to create the system maximum adapted to the structure and parameters of small HPP which are components of separate subject of energy market.

3. Three-level hierarchy of ACS of HPP provides high reliability and system effectiveness and, at the same time, allows to reduce essentially capital expenditures for elaboration and introduction of ACS.

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Jean-Piere Ngoma – assistant of the Department of Electric Engineering ,University of Duala ,Camerun

Lezhnyuk Petro – Doct. Sc (Eng.), Head of the Department of Electric Power Stations and Systems.

Kilimchuk Anton –Master of the Department of Electric Power Stations and Systems