Interoperability Between Islands and Smart Concentrator Unit

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***Abstract*—The paper deals with the problematics of the interoperability island smart renewable sources with smart concentrator unit. These sources are built up on smart regulators and communication module. It is focused mainly on the island localities without direct electrical connection, which should be interconnected with central concentrator unit. The theory contains little bit about regulator algorithm, block diagram of both power regulation and communication part and a few about fundamentals. There is shown how should be smart concentrator unit developed and what is the important for online monitoring of these island systems. Evaluation and measured electrical, communication parameters and results follows the papers.**

***Keywords*—island renewable energy sources, GPRS communication, smart concentrator unit**

I. Introduction

Smart concentrator can be generally described as the unit where are interchanged information and data about electrical and non-electrical variables from smart grid. Based on these data different action can be processed and can be done [1]. Time to time it is necessary to have data and variables from stations which are not a subject of the grid, but these information can be suitable for any type of decision processes in the concentrator or on the upper lever in the SCADA.

A lot of these different distributed stations are implemented in our country, countryside. There are not any possibilities to establish classical electrical connection (from technical aspects) in several cases. Operating of these technologies only on batteries are not possible in the long term. For this case are suitable small and smart renewable energy sources as the photovoltaic panels or wind turbines. The combination of these resources with advanced option of online (GPRS) communication with smart concentrators brings additional benefits in terms of supervision, remote management and delivery of relevant data for upper level (decision) systems.

II. Basic technical requirements

In many cases the energy sources can be spread in a relatively large area (small weather or water management station, water tanks etc.). Information and data from these stations are not primarily intended for controlling of the grid by smart concentrators, but should be relevant for the different actions and short-term future decision processed in the smart concentrators. Due to this reason it is very advantageous to have remotely available also information about operating parameters (instantaneous power, battery voltage). Thus an operator of the system is informed about all failures and a maintenance of the system can be managed.

The proposed solution should be able both an energy harvesting from a renewable energy source and a sending information about operating parameters such as an instantaneous supplying power, an operating temperature, etc. In order to maximize the power acquired from the power source a specialized algorithm should be implemented in the solution. The solution is also required to be able to store the acquired energy into a storage medium (commonly a lead-acid battery).

Due to this two main function (the energy acquiring and the communication) the each island unit is divided into two hardware parts, a power regulator part and a communication part, see Fig. 1. Each of these parts can work independently. That means, if the communication part fails the power regulator still handles the energy acquiring.

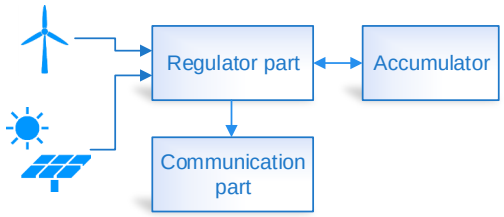

Fig. 1. The block diagram of the island unit

A. Requirements for the power regulator

The main requirement for the power regulator was ability to merge the energy acquiring from a photovoltaic panel (PV) and a wind turbine simultaneously. The energy should be stored in a 12 V lead-acid accumulator with a capacity of 75 Ah. Each of the regulator inputs (PV and wind turbine) must be able to handle the instantaneous power of 120 W.

In Fig. 2, there is shown a current-voltage characteristic of the considered PV panel used to a connection to the regulator. It must be considered that the maximum power supplied from the panel is reachable at maximum power point (MPP) shown in the figure. The regulator's goal is to maintain the power acquiring at MPP at any time of an operation. A commonly

used technique to achieve this state is a maximum power point tracking (MPPT) algorithm [2].

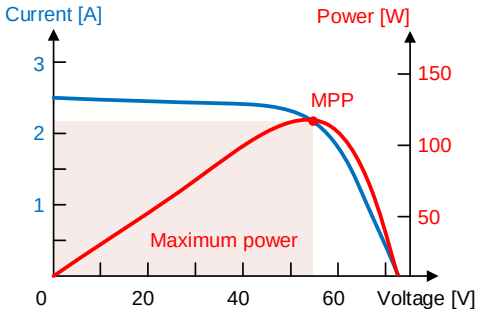

Fig. 2. The Current-Voltage characteristic of the considered PV panel

The MPPT is presented in various versions (Fixed Duty Cycle, Constant Voltage, Perturb and Observe and Modified Perturb and Observe). The presented solution implements the Perturb and Observe (P&O) algorithm. This algorithm periodically increments or decrements the PV panel output voltage (the regulator input) and compares the power in current cycle with the power reached in the previous cycle [3]. The PV panel output voltage decreasing is ensured by increasing the panel load (increasing the battery charge current). If the power increases in comparison with previous step the MPPT algorithm continues at the same direction. Otherwise the direction is opposite. A flowchart of the algorithm is shown in Fig. 3.

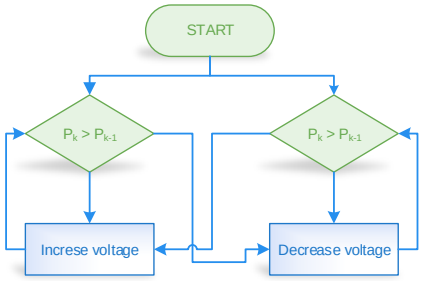

Fig. 3. The MPPT Perturb & Observe algorithm flowchart

B. Requirements for the communication part

In many cases the energy sources can be spread in a relatively large area (small weather or water management station, water tanks etc.). Information and data from these stations are not primarily intended for controlling of the grid by smart concentrators, but should be relevant for the different actions and short-term future decision processed in the smart concentrators. Due to this reason it is very advantageous to have remotely available also information about operating parameters (instantaneous power, battery voltage). Thus an operator of the system is informed about all failures and a maintenance of the system can be managed.

III. Block diagrams

On the base of the requirements described in chapter II both the power regulator and the communication part were designed. A block diagram of the power regulator part is shown in Fig. 4. A solar and a wind turbine outputs are led into the separate DC/DC converters. The converters are driven by the controller implementing the MPPT algorithm described in chapter II-A. The outputs of the converters are combined in a diode block to prevent an interaction between the converters. The diode block is directly connected to the lead-acid battery. The power regulator part is also equipped with an RS485 interface for interconnection with the communication part.

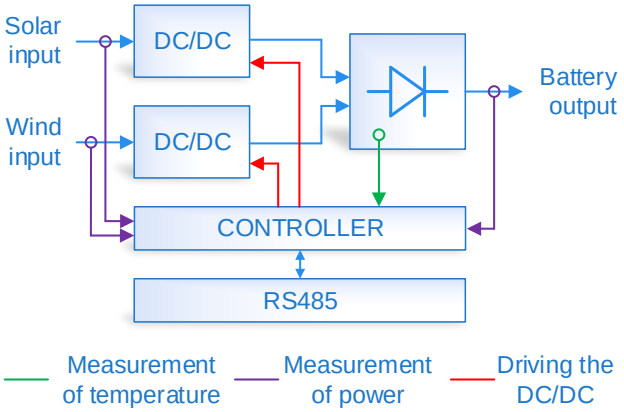

Fig. 4. The block diagram of the power regulator

A block diagram of the communication module is shown in Fig. 5. The RS485 provides the communication with the power regulator part as was stated above. The controller handles the communication with remote system via GPRS. This block must be fitted with data profile SIM card in each communication unit.

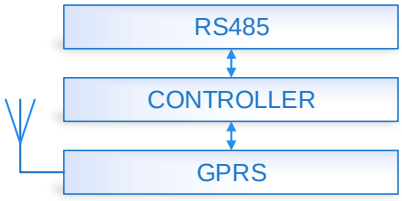

Fig. 5. The block diagram of the communication part

IV. Smart Concentrator

The smart concentrator is designed and prototyped based on the Decree of the Ministry of Economy of the Slovak Republic laying down the procedure and conditions of the deployment and operation of smart metering in electricity [4].

Smart concentrator is implemented from fundamental aspects as an embedded computer equipped with

- CPU unit based on 32-bit ARM platform,
- GPRS/GSM modem,

- Ethernet communication interface,
- built-in data storage (SD card)

and options as

- narrowband PLC communication interface,
- mesh-type RF communication interface,
- RS485 communication interface,
- M-BUS communication interface EN13757-2.

The hardware of the concentrator is developed as a base-board and a SO-DIMM 200 CPU core module. The baseboard is populated with communication interfaces, GSM modem, switching power supply and connectors. CPU module choice was the subject of research and was chosen the module containing CPU with ARM Cortex-A5 core(ARMv7 architecture), 128 MB RAM and 128 MB FLASH. ARMv7 architecture is very young, so it was expected its availability for the next 6-8 years. Figure 6 contains the outline of the concentrator hardware architecture.

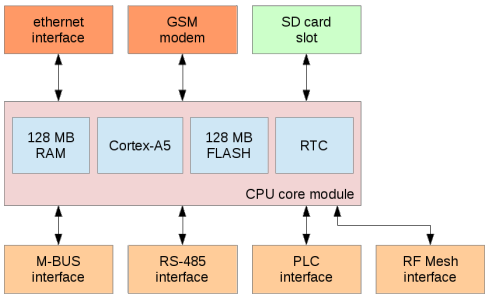

Fig. 6. Concentrator hardware architecture

V. Evaluation and Measured Parameters

To properly test and evaluate especially the power part, number of measurements must take place. Device should monitor input and output power of all connected sources and sinks (battery, powered device). Therefore measurement of instantaneous voltage and current at all input and output ports must be implemented. Heatsink temperature and ambient temperature should be measured for diagnostic purposes as well. Basic three-day test is in Fig. 7.

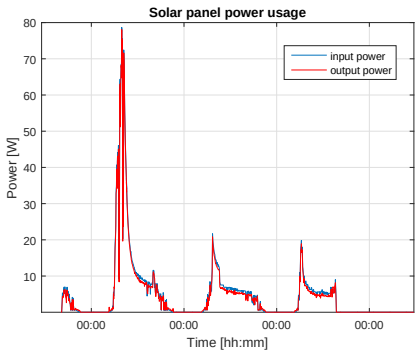

Fig. 7. Solar panel power three day test

It is clear that difference between the input and output power is at minimal value which contributes positively to the self-heating issues of power circuitry. The worst efficiency in whole power range from 0 W up to 120 W has been measured at value of $\eta = 95\ \%$. Long term test of the solar power is shown in Fig. 8.

TABLE I
Reliability test

Week Nr.	Data message count	Message reliability [%]
2016/47	672	92,7
2016/48	672	91,2
2016/49	672	93,4

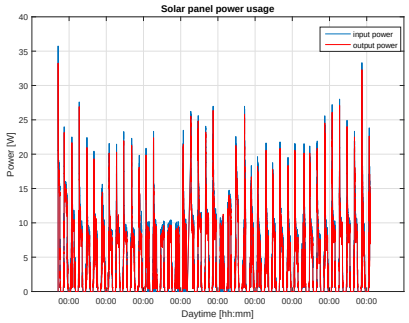

Fig. 8. Solar panel power - 45 days test

Data message count is based on the theory that firmware try to establish modem-gprs connection every 15 minutes. It is 672 messages per 7 days week. The message reliability was counted on real delivered data packets to the smart concentrator. The test result is stated in Table I.

VI. Conclusion

Interconnection intelligent MPPT regulator with GSM/GPRS communication module can enable the possibility of remote diagnostic and remote control of these island renewable power sources. The energy power from relatively small photovoltaic panel can be enough to supply small technology or system and during the maximum can be the backup battery recharged. The coverage of the GSM network in the present is well also for the countryside. Therefore simple data can be exchanged by GPRS or similar connection. The message reliability successful of the data transfer strictly depends on the GSM/GPRS aspects of the mobile networks.

Acknowledgment

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