Project Milestone Report

Microgrid Positioning

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MILESTONE M4.2.

List of Communication Requirements within Microgrid

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1. Introduction

Future power systems can require more flexible and active participants to absorb more distributed power generation of renewable energy. This requires coordinated regulatory, technical, and economic strategies for microgrid operation. These various strategies must take into account interactions between distribution system, market, renewable energy sources and microgrids. A microgrid is typically operated by a microgrid operator whose main goal is to optimize production and consumption of electricity from microgrid components. That optimization will be in accordance to price related signals and grid signals (grid conditions form the distribution system operator) that microgrid controller has received. This would mean that the microgrid operators' revenue can be maximized. Microgrid operator can also provide flexibility services to the grid using generators (e.g. voltage regulation) and loads (e.g. demand response) contained within the microgrid. To achieve an optimal solution for the microgrid operator, it is necessary to develop a microgrid controller as an information hub for the entire microgrid. Each power generator, energy storage and load will also have its own local controller that will interpret signals received from the microgrid controller and respond accordingly. For example, during peak hours when the highest market price is reached, signals will cause that loads automatically respond and decrease consumption using demand response mechanisms.

This report contains a comprehensive list of communication requirements within a microgrid. The report also describes which data type will be exchanged between the microgrid components.

2. Description of Microgrid Communication Structure

A microgrid available in the laboratory consists of a microgrid controller (NI cRIO 9004 RT controller), hydro generator with his own turbine governor (SIEMENS S315-PN/DP), battery storage (32x100 Ah – 3,2 V), PV power plant (4,8 kW), two DC electronic loads (EL 9715-40B – up to 2,4 kW), two AC loads (up to 8 kW) and 8 measuring devices (SENTRON PAC 3100), which are used for power flow measurements. Three AC/DC power converters (3x5 kW) are used to connect the AC part of the microgrid with its DC part. The microgrid controller serves as a microgrid's information hub or it can be observed as a SCADA system of that microgrid. The microgrid controller is a modular device which consists of Modbus TCP/IP communication module, Modbus RTU communication module, digital input/output module (0-10 V), analog input/output module (0-10 V). Power converters are connected to the microgrid controller through Modbus TCP/IP. SENTRON PAC 3100 measuring devices are connected to the microgrid controller through Modbus TCP/IP or Profinet. Circuit breakers (Q1-10, QE 1-3, Q AL1-4) are connected to the microgrid controller through digital signals (0-10 V). For example, digital signal status of 10 V indicates that a particular circuit breaker is activated. The controller can change the status of digital signals using digital output module and in that way can control the circuit breakers and change network topology. Controllable loads are connected to the microgrid controller through analog signals in the range from 0-10 V where 0 V represents 0% of loads rated power and 10V represents 100% of loads rated power. A list of the required microgrid hardware components with used communication protocols is provided in Table 1.

Table 1 List of required hardware with used protocols

System	Device	Type	Series	Amount	Manufacturer	Protocol
Hydro Power Plant	Hydro generator (numerical protection relay)	S80	SEPAM 80	1	Schneider	Modbus TCP/IP, IEC61850
	Hydro turbine controller	(for example CPU 315-2 PN/DP)	PLC–xxx (for example SIEMENS S7-300)	1	SIEMENS	Modbus TCP/IP, Profibus, Profinet
Microgrid Controller	Controller (microgrid controller)	cRIO	9004-RT	1	National Instruments	NI PSP (Shared Variables), OPC UA, Modbus TCP/IP
Load Controller	Controller (DC Load controller)	cRIO	9074-RT	1	National Instruments	NI PSP (Shared Variables), OPC UA, Modbus TCP/IP
-	Measuring device	SENTRON	PAC 3100	8	Siemens	Modbus TCP/IP, Profibus, Profinet
Generic component	AC/DC Inverter	-	-	3	Gulin Ltd.	Modbus TCP/IP
PV Load Battery storage	DC/DC Inverter	-	-	2	Gulin Ltd.	Modbus TCP/IP

A list of communication protocols between devices and type of data that will be exchanged between the microgrid components is provided in Table 2.

Table 2 Communication between devices

Device 1	Device 2	Protocol	Object
Numerical protection relay	Microgrid controller	Modbus TCP/IP	Hydro generator power measurements (P and Q), voltage measurement
Hydro turbine controller	Microgrid controller	Modbus TCP/IP	P-f regulation and U-Q regulation – controls the power output of hydro generator
Measuring device SENTRON	Microgrid controller	Modbus TCP/IP	Measured values of P and Q (measuring devices will be installed on 8 different places to measure power flows within microgrid)
AC/DC Inverter	Microgrid controller	Modbus TCP/IP	Power flow (P,Q) measurements between AC and DC part of microgrid, inverter regulation
DC/DC Inverter	Microgrid controller	Modbus TCP/IP	controls the power output/input of battery storage, controls the power output of PV plant, battery storage and PV plant power measurements

A list of software that will be used within this project is provided in Table 3.

Table 3 List of required software

Software Name	Developer	Function
Excel 2016	Microsoft	Data processing
Matlab R2016b	Mathworks	Algorithm modeling, data processing
General Algebraic Modeling System (GAMS) 24.7	GAMS Development Corporation	Mathematical programming - optimization model development
LabVIEW 2016	National Instruments	User interface development
NEPLAN – power system analyses	NEPLAN AG	Power system analysis

2.1. Modbus TCP/IP

Modbus TCP/IP (also Modbus-TCP) is simply the Modbus RTU protocol with a TCP interface that runs on Ethernet. The Modbus messaging structure is the application protocol that defines the rules for organizing and interpreting the data independent of the data transmission medium.

TCP/IP refers to the Transmission Control Protocol and Internet Protocol, which provides the transmission medium for Modbus TCP/IP messaging. Simply stated, TCP/IP allows blocks of binary data to be exchanged between computers. It is also a world-wide standard that serves as the foundation for the World Wide Web. The primary function of TCP is to ensure that all packets of data are received correctly, while IP makes sure that messages are correctly addressed and routed. Note that the TCP/IP combination is merely a transport protocol, and does not define what the data means or how the data is to be interpreted (this is the job of the application protocol, Modbus in this case) [1].

So in summary, Modbus TCP/IP uses TCP/IP and Ethernet to carry the data of the Modbus message structure between compatible devices. That is, Modbus TCP/IP combines a physical network (Ethernet), with a networking standard (TCP/IP), and a standard method of representing data (Modbus as the application protocol). Essentially, the Modbus TCP/IP message is simply a Modbus communication encapsulated in an Ethernet TCP/IP wrapper.

3. Graphical Presentation of Communication Requirements within Microgrid

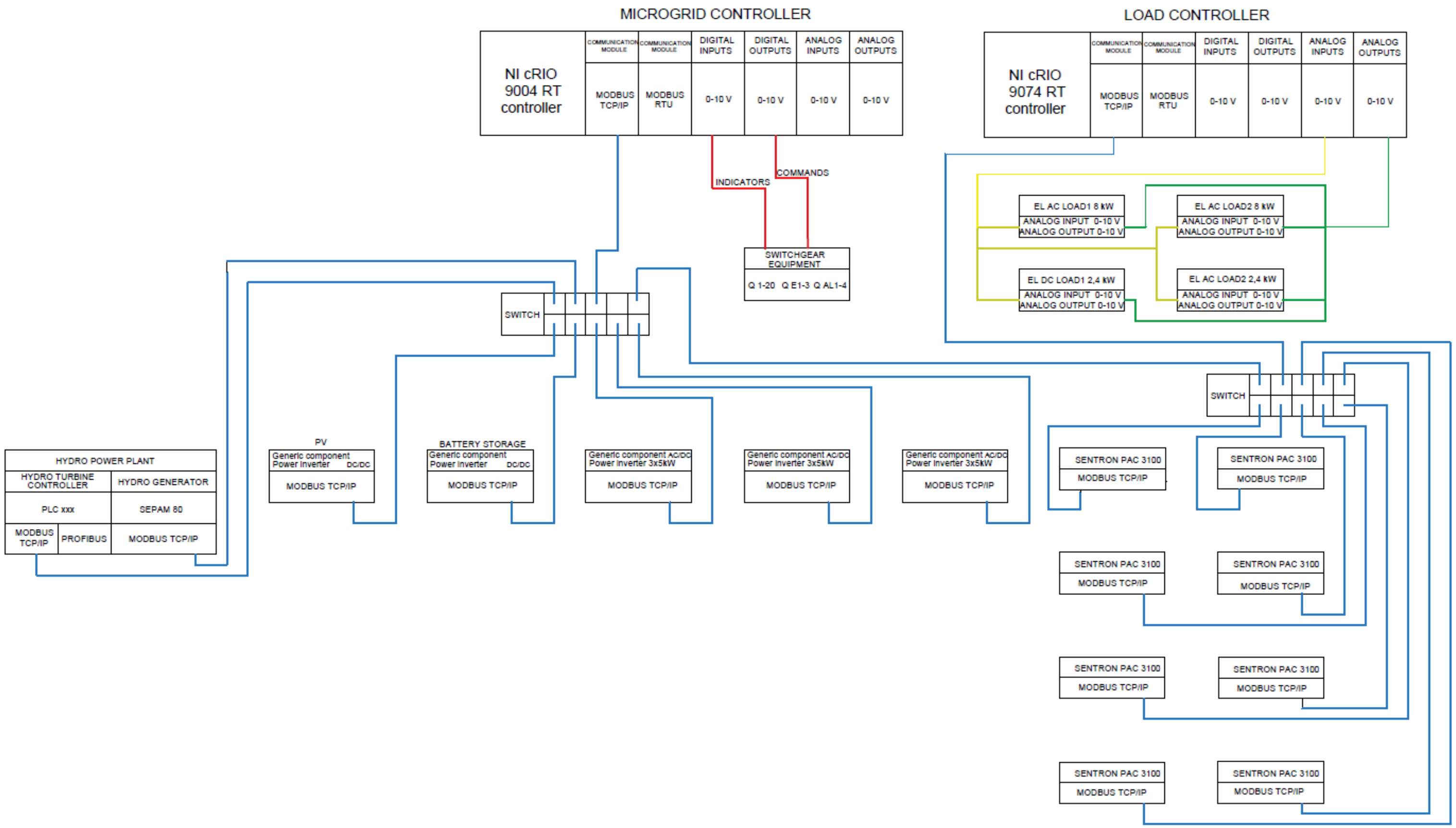

Figure 1 Microgrid communication structure

4. Conclusion

This report provides detail overview of the communication protocols that will be used for the data exchange among microgrid components. Also, this report will serve as basis for the preparation of tasks 4.2 and 4.3 of the WP4.

5. Bibliography

[1] "Introduction To Modbus Tcp / Ip." 2005.