Modelling and implementation of Single Line Diagram data in IEC61850 environment

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SAMI 2021 IEEE 19th World Symposium on Applied Machine Intelligence and Informatics
January 21-23, 2021, Herl'any, Slovakia.

I. Introduction

At the current technological level, both refurbishment and greenfield implementation, all the utility operators in the energy transport and distribution sector explicitly request automation systems with devices able to communicate and exchange information among them, thus managing a large amount of data, which represents the biggest challenge in implementing the IEC61850 standard in electric power substations. In this his paper the standard is adopted to model a 220 kV OHL (Overhead Line) performing the incoming feeder functionality following IEC 61850 standard rules defined by hierarchical level: Logical Device (LD), Logical Nodes (LN) then Data Objects (DO). The analytical model proposed in this paper was experimentally validated by using a small-size DCS (Distributed Control System), designed as in the real case with three automation levels: station, controller, and process.

II. IEC61850 Prerequisites

A) IED configuration concept

Compared to previous SCADA protocols, IEC 61850 standard has an object-oriented approach, which makes it possible for a network device (IED) to send its attributes when interrogated. The general requirements of the communication network are defined in the standard IEC 61850-3, with emphasis on quality requirements. IEC 61850 consists of the following parts, under the general title communication networks and systems in substations:

IEC61850-7-1: principle and models;
IEC61850-7-2: communication interface;
IEC61850-7-3: data objects and attributes;
IEC61850-7-4: logical node types;
IEC61850-8-x: data mapping (no sample values);
IEC61850-9-x: data mapping for sample values;
IEC61850-10: conformance testing.

B) IED information model

A DCS consist of network devices called IEDs, defined as physical devices in IEC 61850 standard. The number of logical devices per IED are not restricted by the standard but can only be housed by only one physical device. A logical device must contain a minimum three logical nodes: 1xLLN0 (Logical Node Zero) and 1xLPHD (Logical Node Physic Device) dedicated to each physical IED, containing system info, and one or more domain specific logical node (XCBR, CSWI, MMXU, etc.).

The LN contains DO which is a named instance of a common data class consisting of different Data Attributes.

Exchanging data are realized through the distributed functions located in the physical device. Each LN is linked with a function in the physical device.

C) IEC communication services

The IEC61850 standard provides four types of communication services, three connection-oriented protocols and the last one as basic service, that allow data exchange between devices connected to the same network:

1. Client – Server based on TCP/IP MMS, and Publish-Subscriber, directly on Layer 2, multicast:
2. GOOSE with a repetition mechanism, for the fast transmission of data over the network.
3. Sampled Values (SV) data stream, for the fast transmission of analogue values over the network.
4. NTP, SNMP, HTML which are not time critical.

The GOOSE and SV protocols are used for critical high-speed functions such as station interlocking, protection tripping and blocking schemes and other station-related protection devices and control functions.

III. Testing platform environment

A) Software: The IEC61850 configuration and test concept are implemented and analyzed using a small size DCS based on PACiS (Protection Automation and Control Integrated System) software platform, developed by Areva T&D France.

B) Hardware components: As shown in Figure 1, the hardware part of the testing platform is structured on 3 levels: process, controller (bay) and station levels.

C) Data mapping and communication settings of each IED: Based on XML (Extensible Markup Language), each IED should be configured with its manufacturer configurator with the scope of obtaining the standardized (SCL Substation Configuration Language) file types, that can be exchanged between configuration tools.

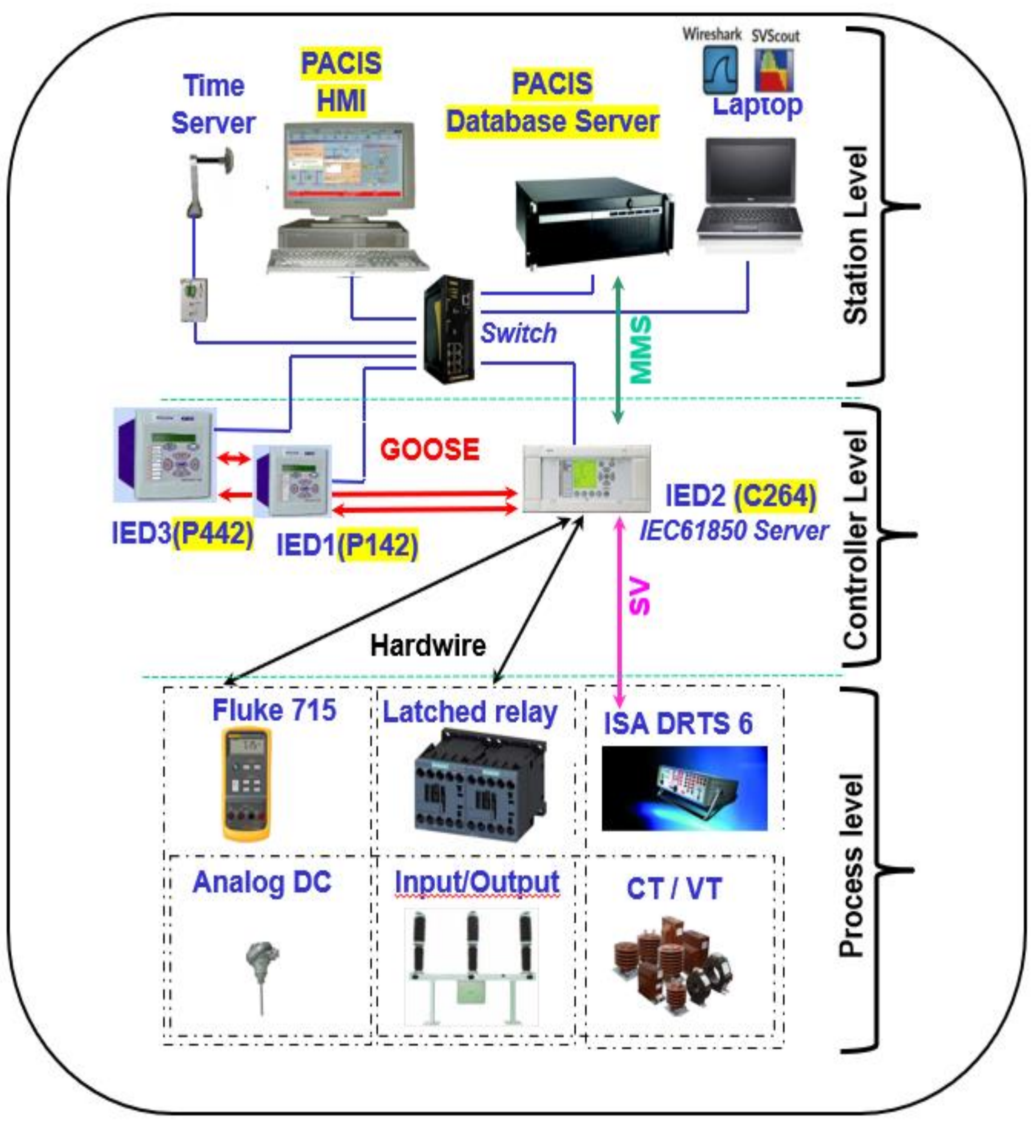

Fig.1 Study case platform framework

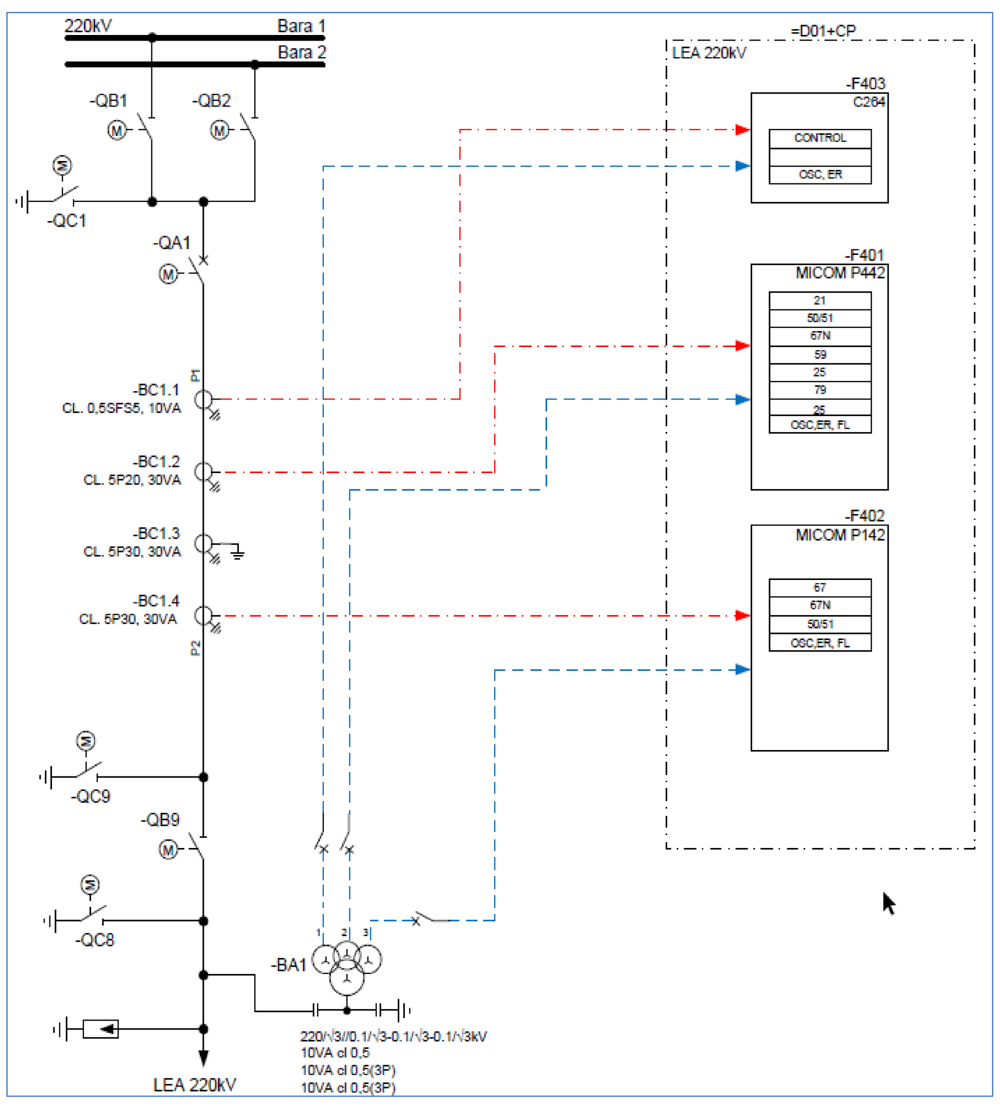

Fig.2 Single line diagram of 220kV incoming feeder

IV. Methods and key experiments

Prior conditions to translate the SLD into IE C61850 data and create a fully operational interface are: Existence of a SLD; Prepare a hardwired input/output list; Prepare the IED's Trips and Logic Matrix; Select IED's hardware; Define architecture topology and communication protocols; Define HMI symbols and color; Define different users' right access to operate from HMI; Define all the process Alarm and Events; Define the interlocks and automation functions; Define the storage and archive settings; Perform the IED parametrization; Document the application.

The present paper is focusing on a specific part of a substation, respectively a 220 kV incoming feeder with its single line diagram presented in Figure 2. The process objects are circuit breaker, disconnectors, and measurement transformers. IEC 61850 MMS applied on the presented single line diagram is achieved through three physical devices, respectively three IEDs: one BCU (Bay Control Unit) model Micom C264 for monitoring and control, and two protection relays model MiCOM P442 and MiCOM P142 performing the distance and overcurrent protection functions. The names of single line diagram objects are according to IEC81346 standard. Example:QA1=circuit breaker, QB1= Bubsbar1 disconnector, QC1=Earth switch.

Interlocking logics, to allow equipment controls, are realized using Function Block Diagram (FBD), a specific programming language that uses graphically represented logic blocks and their interactions to implement different algorithms.

The HMI interface performs the live process visualization with its screens real time updated by the system datapoints transitions but IED is still the unit that effectively control the process. Apart from the process control screens, there are dedicated screens for alarms and events.

As presented in Figure 3, the graphical interface is realized with the specific manufacturer tool and the engineering effort culminates in an Substation Configuration Description file which is the complete configuration of studied single line diagram, with standard control popup buttons, analog measurements indication, color animated alarm tags, events, and process specific objects.

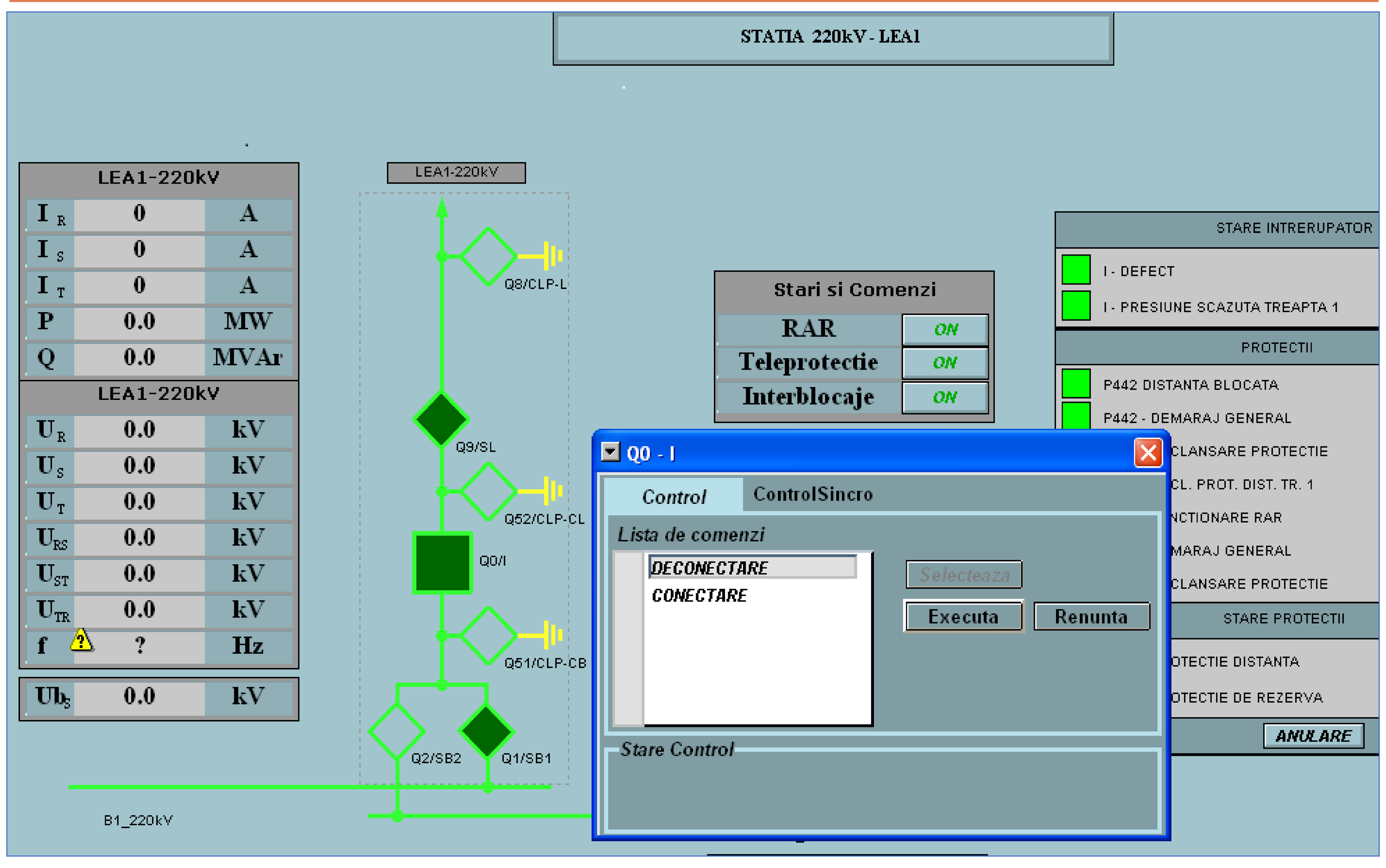

Fig.3 HMI screen from Single line diagram of 220kV incoming feeder

Conclusion

In this paper, the IEC 61850 standard was applied for a typical 220 kV incoming feeder by implementing a unified information model for a bay control unit, using a concept of complete solutions for monitoring, control, and protection.

This paper provides a simple method and technique to examine the IEC61850 based on Manufacturing Messaging Specification, Generic Object-Oriented Substation Event and Sampled Measured Values, illustrated with a typical CSWI logical node in detail.

The presented configuration of a logical device is not restricted by the IEC 61850 standard but can only be performed on a physical device while to produce the SCL files the physical device is not needed as the system engineers could use the IED's vendors templates for each type. In case of some data points are required by operator interface and those are not included in the vendor's default information report data set, those additional data are added as a new data by updating the information report data set.