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IEC 61850 Intellectual Devices Stand Tests in JSC «NIPT»

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1 INTRODUCTION

Today different Russian and foreign vendors offer a large variety of IED such as relay protection, emergency systems, digital fault recorders, bay controllers, etc. Optimization of integration of all this heterogeneous information started to be developed with the emergence of special IEC standards for substation automation. Wide Ethernet and IEC 61850 usages in substation automation allow significant reduction of wires. It is achieved by using a single bus (Ethernet) to carry all information. Using single environment for all information transmission produces special requirements for reliability since network failure can lead to system failure. Another trend in contemporary substation automation system is increasing of functions executed by IEDs and increasing of their load.

An introduction of IEC standards in substation automation requires proper IED and system testing. Different techniques of IEC 61850 system tests are being applied in Russian and foreign practice [1]:

1. Verification of IEC 61850 implementation in intelligent electronic devices (IED).
2. IED compatibility tests.
3. IED performance tests.
4. Ethernet performance tests.
5. IED redundancy tests (ethernet ports, power supply, etc.).
6. Ethernet redundancy tests.
7. High load systems tests.

2 JSC «NIPT» INTELLIGENT ELECTRONIC DEVICE TEST BENCH BASED ON IEC 61850

IEC 61850 test bench has been developed in JSC «NIPT». Main components of this test bench are:

1. DC 220 power supply for signaling wires and devices.
2. Physical model of switching devices (based on relays) used to test control operations and interlocking functions.
3. Laboratory transformer to model analogue singals.
4. RETOM-61 analogue and discrete signal simulator.
5. IEDs from different vendors.
6. LAN equipment (Hirschmann switches, optical and twisted pair cables).
7. Station controllers.

8. Automation system time synchronization (GPS receiver, SNTP server, PPS pulse source 220 VDC).
9. Substation automation server.
10. Engineer workplace.

The following IEDs have been tested according IEC 61850:

- Satec 330;
- Siemens TM 1703;
- Siemens BC 1703;
- Siemens AK 1703;
- SEL-451;
- Siemens Siprotec 7SJ64;
- Siemens Siprotec 7UT63;
- GE D60;
- Areva MiCOM P437;
- EKRA 2704V021;
- EKRA 2704V085.

The following main substation automation functions have been tested:

1. Acquisition and registration of analogue signals.
2. Acquisition and registration of discrete signals.
3. Control model.
4. Interlocking of switches and earthing switches.
5. Reading of COMRADE files.
6. Time synchronization.

While building of integrated substation automation system one of the main difficulties is creation of object database. That is why a number of tests related with configuration reading have been carried out. ICD and online configuration import have been tested for IEC 61850 IEDs. Multivendor test bench indicated that possibility of configuration import significantly reduces time needed for device integration. To automate this process IEC 61850 system configurator has been extended with the possibility to save device configuration into database. Automatic configuration import allows eliminating of errors related with addressing (addressing errors make up about 90% of all errors while connecting IEDs). Unfortunately it is not possible to fully automate this process. It is necessary to assign signal human readable names (in Russian) after configuration import. This process can be partially automated by recognition of standard identifiers from IEC 61850 7-3, 4 (analogue signal names from MMXU, “start” and “operate” signals for relay protection logical nodes) and by using of description fields “d” and “dU” in device model.

Another task that should be solved manually is device data acquisition method. It is quite difficult to automate this process and to eliminate manual work. The following methods have been tested:

1. Linking of existing Data Sets to Report Control Blocks.
2. Creation of new Data Sets.
3. Periodical polling (for energy meters).
4. Manually forced signal reading (for protection settings).

The possibility to switch between these methods has been added to IEC 61850 system configurator GUI.

At time of main substation automation functions tests all methods of analogue and discrete data transmission according to IEC 61850 have been used. To use report data transmission IED should have data sets which are linked to report control blocks. Datasets functioning differs greatly in the devices used in the lab. The following cases have been tested:

1. IED has only fixed datasets.
2. There is a possibility to create new datasets using vendor’s software.

3. There is a possibility to create permanent datasets by MMS communication (LogicalDevice/LogicalNode.DataSet).
4. There is a possibility to create temporary datasets using MMS communication (@DataSet).

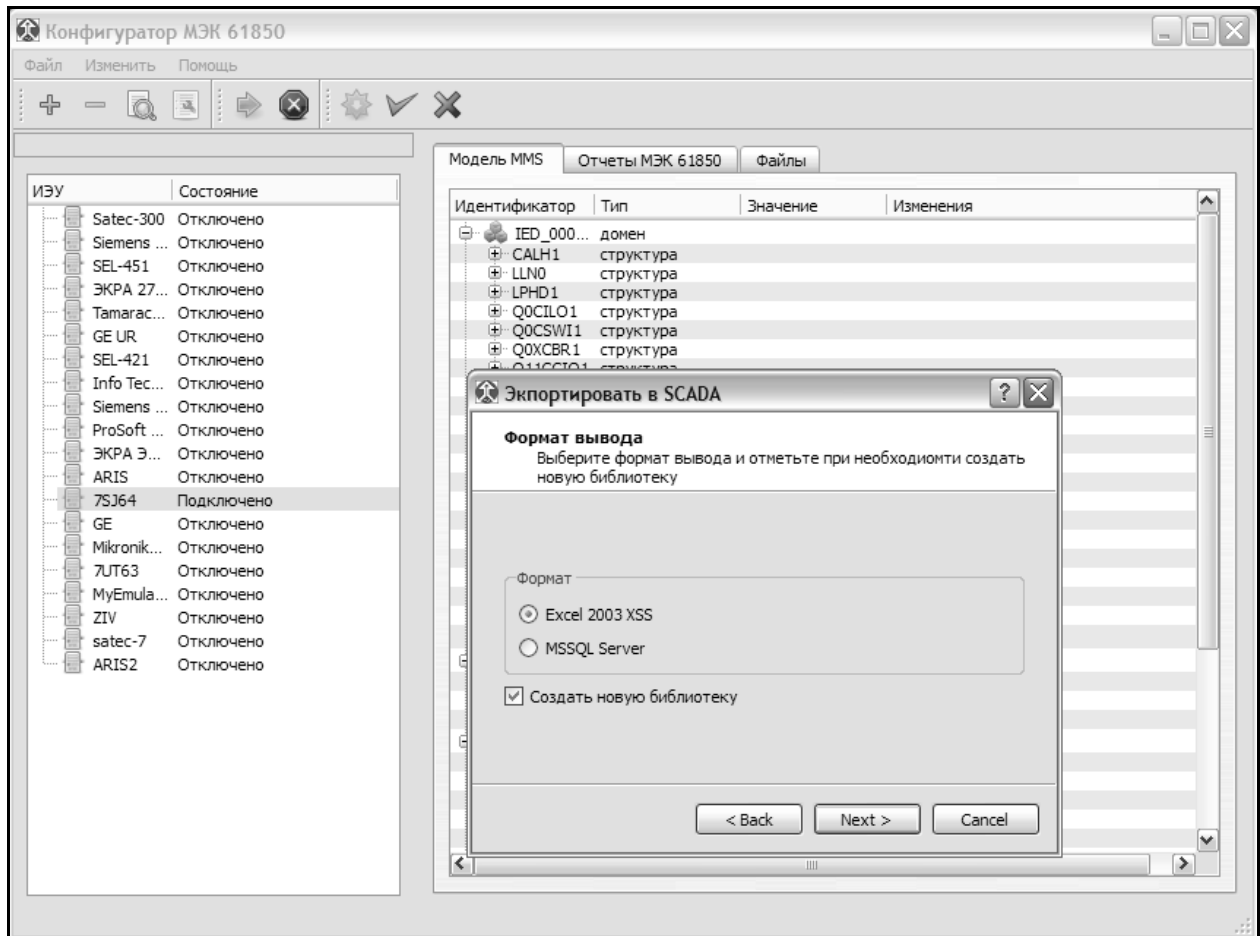


Fig. 1: Device import configuration dialog.

Different devices in the lab had different structure of report control blocks. Taking it into account it was necessary to adapt system driver. Our experience showed that IEDs which have possibility to create datasets using MMS protocol are more flexible compared to the devices with fixed datasets. Dynamic dataset creation allows substation automation system vendor to select which data should be transmitted by the device. Using periodic polling was simpler to implement because different vendors implement read request at the same way.

Control model implementation requires more flexibility from system drivers because different devices use different control model described in the standard:

1. Direct control with normal security.
2. SBO control with normal security.
3. Direct control with enhanced security.
4. SBO control with enhanced security.

IEC 61850 system driver used in the lab had all these models implemented that ensures compatibility between system and all devices.

Interlocking function of switches and earthing switches was implemented in the bay control level. GOOSE messaging was used to transmit information between bay controllers. One of the main GOOSE advantages except wire reduction is self diagnostics. To utilize this function bay controllers logic was extended to signal GOOSE message disappearance.

Test bench showed that it is not possible to provide GOOSE messaging between different devices in all the cases. Additional requirements for IEC 61850 implementations should be organized to improve compatibility between IEDs.

Fault recoders information transmission was as well tested. Fault records were transmitted using COMRADE from all IEDs. COMRADE files can be transmitted using the following ways:

1. MMS (using file transfer requests).
2. FTP.

Some devices in the lab use MMS to transfer fault records while other devices use FTP. System driver was extended to support MMS as well as FTP. IEDs that use MMS have many differences and one of the main is directory structure.

Time synchronization functions have been also tested. There are many methods of IED synchronization. Some devices use dedicated bus (PPS, IRIG-B) while other use SNTP. SNTP server was installed on station controller (which was directly connected to GPS) to support SNTP.

Besides physical device tests IEC 61850 simulators were used. IEC 61850 simulator includes:

1. MMS server;
2. GOOSE publisher and subscriber;
3. Simple programmable logic.

IEC 61850 simulator was implemented as independent module from substation automation system. It can be used in the following cases:

1. System tests in normal conditions.
2. System tests in high load conditions.

Tests were related to interaction between simulators and physical devices [2]. Information transmission from simulator to physical device and from physical device to simulator was tested. This approach allows high load testing when some part of the devices are physical while another part are simulators.

IEC 61850-9-2LE sampled value transfer was also tested. Special simulator was implemented with possibility to generate testing stream over LAN. Receiving and processing of this information was implemented on station controller. The main goal of these tests was to estimate Ethernet and device load while using IEC 61850-9-2LE.

3 CONCLUSION

Test bench allows implementing different verifications and tests of IEC 61850 equipment. Many devices from different vendors have been tested using this test bench. Tests showed differences between IEC 61850 implementations from different vendors. IEC 61850 efficient adaptation can be achieved with the additional requirements for implementation. IEC 61850 simulator efficiency was also showed in the test bench. Simulators can extend test bench possibilities in high load tests. IEC 61850-9-2 allows testing of digital substations.

REFERENCES

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