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Actual Aspects of IEC 61850 Standard Compliant Relay Protection and Automation Devices Complex Testing

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The present-day situation in the Russian power industry related to introduction of the modern microprocessor-based IEC 61850 standard compliant relay protection and automation devices (Intelligent Electronic Devices – IEDs) shows that one of the most complicated things here is testing. There is no clear comprehension of what should be tested, how and what means should be used for that. What tests are mandatory for IEDs and what can be left with automatic monitoring? IEC 61850 standard does not provide any “musts” – these problems are only discussed.

Another question with no answer yet is whether it is necessary to check Ethernet operation and how to do that. It is assumed that any time the computer network is in operation, there is no need to check it. The time of data communication via Ethernet is not limited, i.e. it can take several milliseconds up to hundreds of milliseconds depending on network loading. Therefore, the bigger is the amount of data transferred, the longer is the time delay. As the network operation is tightly bound with all components included, any changes in their operation should be followed by a complete network test, for example, after replacing a hardware device (server, router, switch), network extension, software (IEDs’ including) updating, run of complementary applications like the process control system, automated power monitoring and metering system, a workstation, etc. Obviously, the network diagnosis will be carried out more frequently than that of IEDs. Therefore, to ensure the proper operating data communication environment between all devices it is necessary to select most suitable size and topology for the physical network, data set communication configuration and the time interval, and to perform corresponding measurements. Actual data optimizes the information traffic and ensures due time of message delivery even during a fault.

IEC 61850 standard describes several control and data communication protocols. This report deals with only GOOSE- and SV-message communication, because the relay protection operation is very sensitive to their transmission time. It is less sensitive as for other protocols (TCP/IP and higher level), that is why they are not considered in this report.

The testing equipment set should include a special Ethernet-operating device that reads, processes and generates GOOSE- and SV-messages. “NPP Dinamika” proposes a switching unit RET-61850, included into RETOM-51 and RETOM-61 testing systems. The unit implements simultaneous receipt, primary processing and transmission of 16 GOOSE-messages with 64 binary signals. It has 4 RJ-45 links with up to 100 Mbit/s rate. At present, its functionality is extended due to increased number of simultaneously processed messages and signals, improved data processing rate, SV-message processing, etc.

It should be noted that in respect of the complete relay protection and automation system operation diagnosis in accordance with IEC 61850 standard not only IEDs are subject to testing, but

their interaction in the operating network as well; however, the complete diagnosis should not influence the relay protection and automation system operation.

Let's consider several solutions of this challenge and associated problems. IED1.1 is taken for example. Its software has been updated. It is necessary to check its operation, including interaction with other IEDs, e.g., IEDn.n; the rest part of relay protection system continues to function normally.

The first alternative is individual IED testing. Deactivate analog (current and voltage) and binary (input and output) signals, disconnect the IED from Ethernet, i.e. take it completely away from the protection system. Connect the testing equipment to IED analog and digital circuits (Figure 1). Connect it to local testing network and check its operation, including data communication via Ethernet.

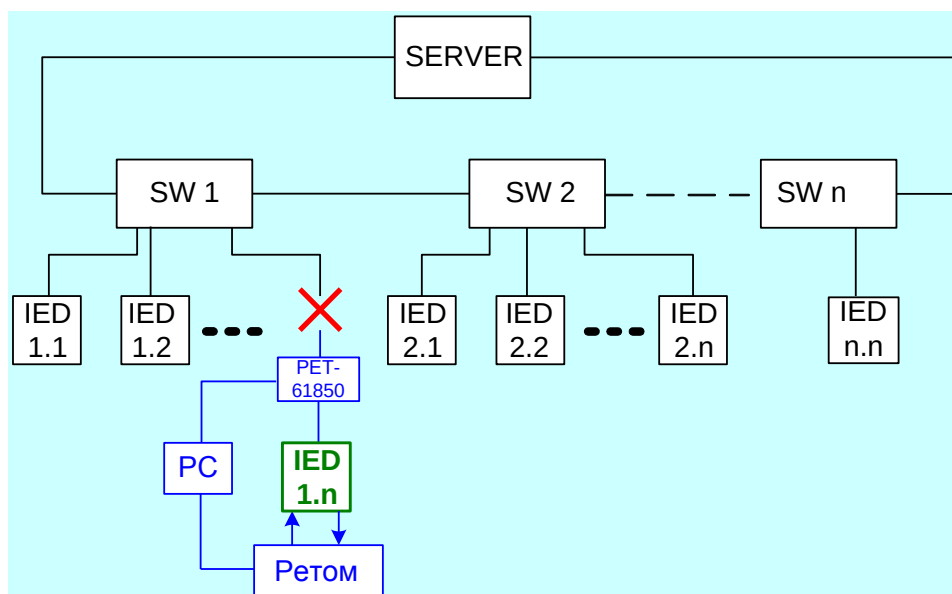


Fig. 1: Individual IED testing

This is a widely used and well-proven solution. It is safe due to no impact of the tested IED data on other IEDs' operation.

However, it has several drawbacks:

- The relay protection and automation system operation is disturbed because of one IED missing and the rest IEDs lacking its data. Therefore, before taking the IED out of operation, think whether the rest relay protection and automation system will operate correctly in conditions of no data received from one IED, and reconfigure it, if needed.
- When the IED is disconnected from Ethernet, there is no complete information about the data communication time, because one data communication device (with its time delays) is not available.
- It is impossible to estimate Ethernet network loading.

Thus, this solution does not provide comprehensive IED operation testing. After individual IED testing their interaction should be checked. Only then we can judge upon correct setup of different GOOSE-messages: data amount, priorities, time intervals, etc.

The second alternative presupposes two IED interaction diagnosis via local testing network together with individual IED testing. This local network provides comprehensive data communication monitoring between two IEDs (figure 2). IEDs should be taken out of operation and the testing equipment is connected to both; this testing equipment is simultaneously controlled from one PC. The testing program simulates different operating and fault conditions, both IEDs interact and respond to analog signals simultaneously.

This way of system operation diagnosis is common for new substation commissioning. The protection system is enhanced via sequential joining of more and more IEDs, thus providing testing of all interacting systems, preventing errors in GOOSE-messages and setup of the network.

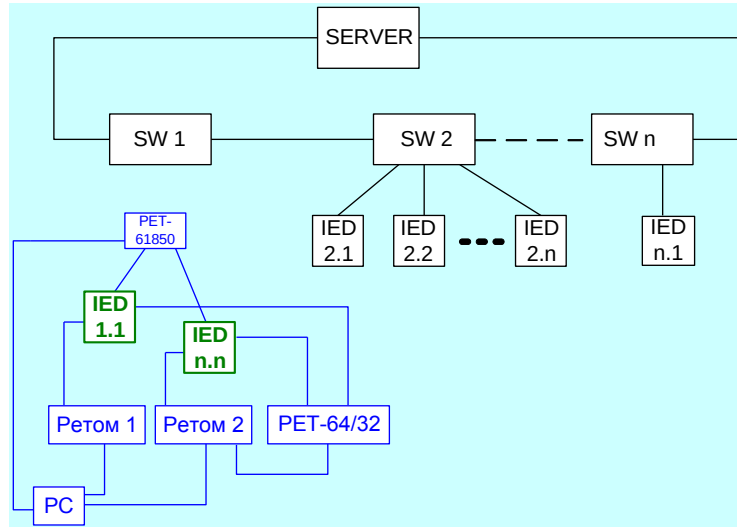


Fig. 2: Local testing network check

This diagnosis solution is safe and enables testing of the complete IED interaction functionality. However, it is also incomplete as it does not presuppose the real network operation. Therefore, it is recommended for commissioning testing.

On completion of testing following the above-mentioned alternatives it is necessary to check data communication channel operation. The diagram shown in figure 3 can be used for this purpose. By programming RET-61850 units for transmission and receipt of “dummy” GOOSE-messages, i.e. the data not involved into relay protection operation, a large number of different measurements can be performed and the network operation can be evaluated properly. Besides, it is quick and safe because:

1. IEDs are not involved into signal passing through network time estimation – therefore, there is no need to take them out of operation;

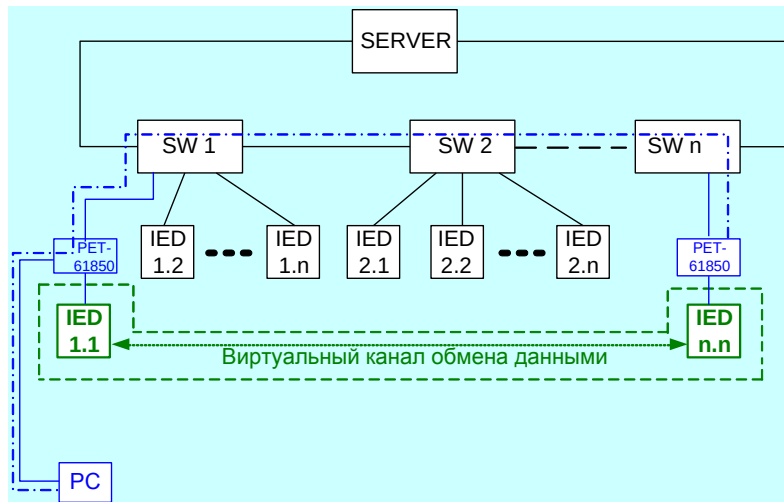


Fig. 3: Data communication channel operation check

2. “dummy” data is compiled so that it is of no interest for other IEDs, thus, preventing the risk of false tripping;
3. both units RET-61850 are controlled via the same network, i.e. everything is quickly and easily connected; there is no need to route long cables to connect the testing equipment to;
4. when connecting units in different locations it is easy to detect “bottlenecks” and take measures to improve them.

After analyzing the above-mentioned drawbacks we propose the third alternative, where the real network is used for comprehensive IED interaction testing (figure 4). Here one physical data

communication channel is divided into two non-interacting virtual channels. One is assigned for the operating system and another one – for testing. The signals coming by wires are also used, but it is important to ensure their independent application.

Thus, the complete testing system includes two diagnosis equipment sets connected to tested IEDs - IED1.1 and IEDn.n – that are simultaneously controlled from one PC. The testing program simulates different operating and fault conditions with consideration of tested IED operation peculiarities and location of assigned primary current and voltage sensors. Analog and binary signals are simultaneously applied to both IEDs.

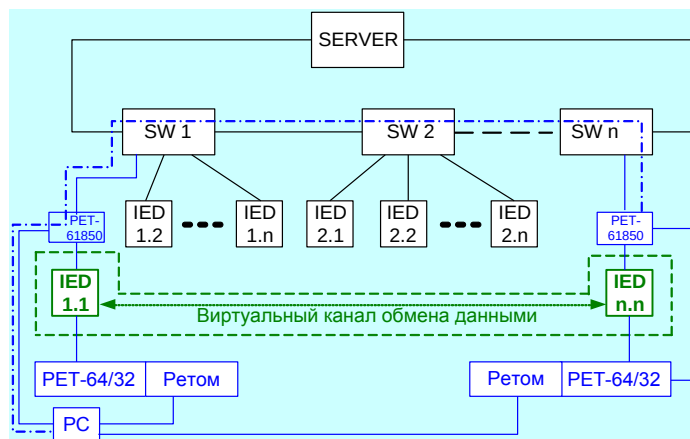


Fig. 4: Real network testing

Besides, the real network is used for safe transmission of all virtual signals required through a special adapter. Therefore, it is possible to measure the specified signal passing time, analyze the traffic for the specified network section, etc.

This alternative provides comprehensive individual IED and IED interaction testing; however, it has a drawback still – it is a very time- and labor-consuming work because all interacting IEDs shall be taken out of operation in turn.

Many aspects related to this topic are left beyond the scope of this report, e.g. testing of primary equipment generating SV-messages, etc., but still several conclusions can be made:

1. Comprehensive and complex IED testing in operating modern relay protection system is a very complicated task, and in present day situation with IEC 61850 introduction, the most convenient solution remains to test an individual IED.
2. It is necessary to develop suitable diagnosis equipment and methods that could be improved to provide the third solution (testing of IED interaction in real network conditions).
3. The operating personnel should have deep knowledge in relay protection and automation along with network technologies fields.

For the conclusion it can be said that special attention is to be paid to diagnosis aspects in IEC 61850 standard. Then the network and IED interaction testing will become quick, easy and automatic.