

## Study Committee B5

Protection & Automation

10372\_2022

# EXPERIENCE IN THE DEVELOPMENT AND IMPLEMENTATION OF AN INTELLIGENT PAC SYSTEM WITH A FLEXIBLE FUNCTIONAL ARCHITECTURE

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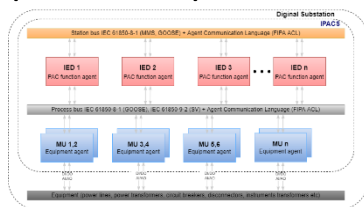
Alexander VOLOSHIN, LLC «SmartEPS»

Evgeny VOLOSHIN, LLC «SmartEPS»

## Motivation

- Overmuch increase in PACS devices for implementation of digital substations and decrease of reliability as a result
- Unjustified high CAPEX and OPEX in the implementation of PACS for digital substation
- Necessity to develop and test in practice of a new approaches for creating optimal solutions for PACS of digital substations according reliability and economic

## Experimental setup & test results



The developed solutions and algorithms allowed to implement functionality of self-adjusting, self-organization and self-recovery for PAC system in cases of failure of its elements (IED, MU, LAN)

## Method/Approach

- The way of optimal (re)allocation of PAC functions is based of multi-agent system algorithms and IEDs interaction without using a centralized device
- Optimal hardware and software architecture for a new generation of IEDs with independent of hardware PAC functionality
- Select and definition in real-time mode correct values of the necessary optimization criteria for the reallocation of the PAC functions in case of failures

## Discussion

- Recovery time for PAC functionality by failures of more than 30% of devices is about 80 ms
- Definition and application of the hybrid architecture of the intelligent PAC system:

### 110 kV and above

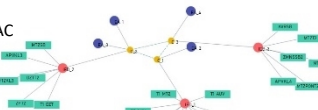
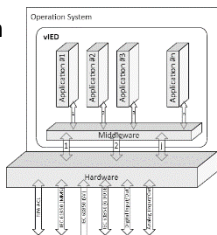
a low degree of centralization of PAC functions with the necessary reserve of processor performance for possibility of migrating technological functions between IEDs

### 35 kV and lower

a high degree of concentration of PAC functions of the busbar section bays within one hardware platform IED with reserve to ensure the protection of the adjacent busbar section

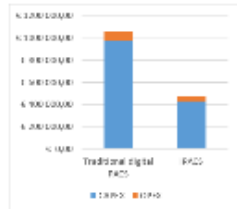
## Objects of investigation

- Hardware and software architectures of a new generation of IEDs - IPACS intelligent electronic device
- Multi-agent system for functionality reserve of PAC functions and their migration between IEDs
- Digital intelligent protection and automation system for a 110/10 kV dead-end substation - a pilot digital substation



## Conclusion

- The use of multi-agent technologies for redundant of PAC functions implementation of digital substations allows to increase their reliability and efficiency
- The approach of flexible functional implementation of reliable performance of technological functions of PAC systems without their tough binding to specific physical devices has been developed and successfully has been tested
- Internal IED architecture and the architecture of the PAC system have a mutual dependency and impact on the reliability and economic indicators of the digital system as a whole



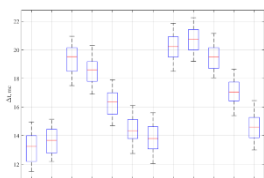
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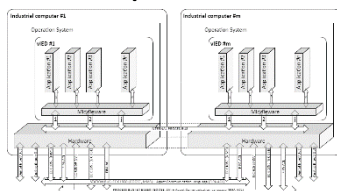
# EXPERIENCE IN THE DEVELOPMENT AND IMPLEMENTATION OF AN INTELLIGENT PAC SYSTEM WITH A FLEXIBLE FUNCTIONAL ARCHITECTURE continued

### Permissibility soft real time for PACS



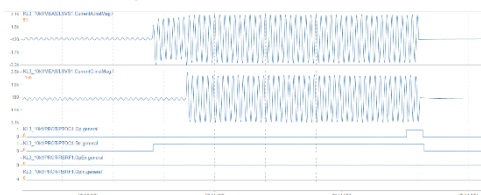
Average scatter of distance protection trip time at various values of current phase angle

### Independence PAC functions from hardware platform



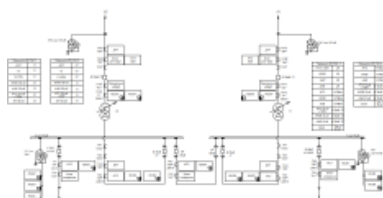
Internal architecture of developed PAC devices  
 CPU - no worse than Intel Core I5;  
 RAM - 8 GB;  
 ROM - 64 GB;  
 external communication interfaces - 1 Gbps

### In the process of pilot operation of the intelligent PAC



Oscillogram of the disturbance recorder function as part of the PTOC function VIED of the fault feeder

### Technical solution for the intelligent PAC system of pilot digital substation 110 kV



### Compact solution for SS 110 kV



### Four intelligent devices is enough



39 various protection and automation functions are implemented at the pilot substation