Study Committee B5

Protection and Automation

10154

Advantages of Full Digital Substations with Architecture Based on Process Interface Units (PIU)

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Motivation

- Process Interfaces are the bridge in between the physical and digital worlds and are critical to enable all the advantages of a full digital substation solution.
- In this work we discuss the main Process Interface and architectures to implement them into boxes (single or multiple)

Process Level Interfaces and Applications

- **Merging Unit (MU) or Stand-alone Merging Unit(SAMU):** Dedicated to the conversion of voltages and currents into Sampled Values
- **Non-Electric Interface Unit (NEIU):** Dedicated to interface non-electric sensors like gas or temperature transducers.
- **Switchgear Interface Unit (SIU):** Dedicated to interface with circuit switches and Circuit Breakers. It is usually associated to a remote I/O. SIU + NEIU is also called Switchgear Control Unit (**SCU**)

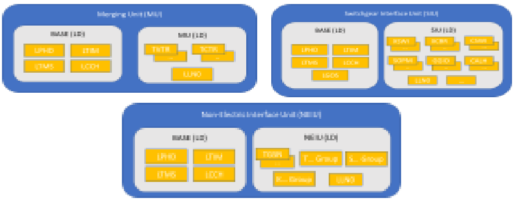

Fig 1. Generic modeling for Process Interface Devices SAMU, SIU and NEIU

Process Level Architectures: Organizing Logical Devices into Boxes

- It is considered that an IED is composed by a general infrastructure that is needed regardless the application (Comms, CPU, Power Supply) + specialized infra for specific applications

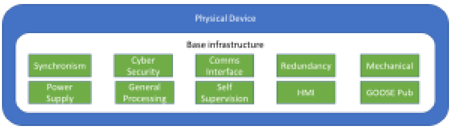

Fig 2. Diagram showing base infrastructure components for a physical device in a Digital Substation

- Two basic configurations are explored for process level: **Multiple boxes** with two different IEDs for **SAMU and SCU** applications; and a **Single box** approach with one IED for **SAMU + SCU** applications, which allows the convergence the base infrastructure.

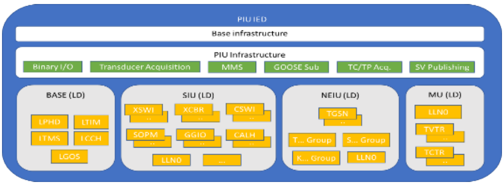

Fig 3. PIU IED modelled with logical and physical components

- Four architectures are studied:

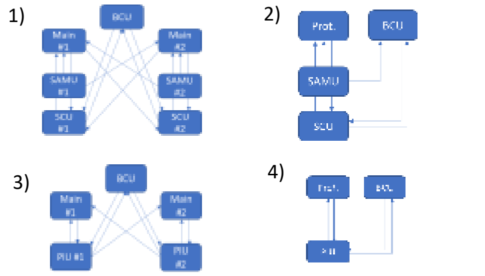

Fig 4. Process Level architectures: 1) Redundant SAMU + SCU; 2) Non-redundant SAMU + SCU; 3) Redundant PIU; 4) Non-redundant PIU

Comparison Study

- To compare the architecture against multiple criteria it were conceived hyphotetical IEDs.

IED Type	Cost (U$)	MTBF (Years)	MTTR (Hours)	Availability
SAMU	650	500	48	0,999989
SCU	700	500	48	0,999989
PIU	1000	500	48	0,999989

Tab 1. Hypothetical IED characteristics used for the comparison

- The IEDs were compared against the criteria showed in the table

	Redundant Architectures		Non-Redundant Architectures	
	Arch. 1 (2x SAMU + 2x SCU)	Arch. 3 (2x PIU)	Arch. 2 (SAMU + SCU)	Arch. 4 (1x PIU)
General Reliability	2 (99,9985%)	4 (99,99937%)	1 (99,9878%)	3 (99,9988%)
Material Costs	1 (2700 U$)	3 (2000 U$)	2 (1300 U$)	4 (1000 U$)
Commissioning	1	3	2	4
Operational Costs	1	3	2	4
Spare Management	1	3	2	4
Vendor dependency	4	2	3	1
Footprint	1	3	2	4
Complexity	1	3	2	4
Flexibility	4	2	3	1
Total	16	26	19	29

Tab 2. Comparison table with ranking of the architectures for each item analyzed

Conclusion

- **SAMU + SCU** based architecture have better results when analyzing **vendor/product dependency and flexibility** in overall
- **PIU** based architectures have higher score for the criteria: **Reliability, Cost, maintainability, footprint and simplicity** in overall
- **PIU advantages** are logical considering that each IED has a **minimum basic structure**, which **does not increase linearly** with the number of application this device will cover
- Not all criteria analyzed are quantitative and it is **not possible to elect a "best option"** for architecture. It depends on the needs and the technical and non-technical judgement in each case.
- Even with this uncertainty, **PIU based architectures** shows advantages for most of the criteria herein analyzed and points this type of architecture as a mean to simplify and **reduce the total cost ownership for full digital substations.**

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