Differences between IEC 61850-9-2, 9-2LE and IEC 61869-9

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IEC 61850-9-2 or IEC 61850-9-2 LE?

Differences between IEC 61850-9-2, 9-2LE and IEC 61869-9

- IEC 61850-9-2 is a standard
  - Definition of different ways to structure the Process bus communication.
  - Does not allow interoperability as too much open
- IEC 61850-9-2 LE is a guideline
  - Specify very few options to structure the Process bus communication:
    - “It further clarifies uncertainties with respect to the interpretation of the standards and/or to precisely define what options to choose in case the standards permit a choice of options.”
  - Does allow communication interoperability between manufacturers, ex:
    - Fiber optic transmission system 100Base-FX full duplex with ST or MTRJ,
    - Dataset as 4 I + 4 U, 80 or 256 samples per period,
    - Operation modes,
    - Synchronization, etc…
  - Does not allow interoperability as do not specify compatible contents/Data

IEC 61869-9 1/2

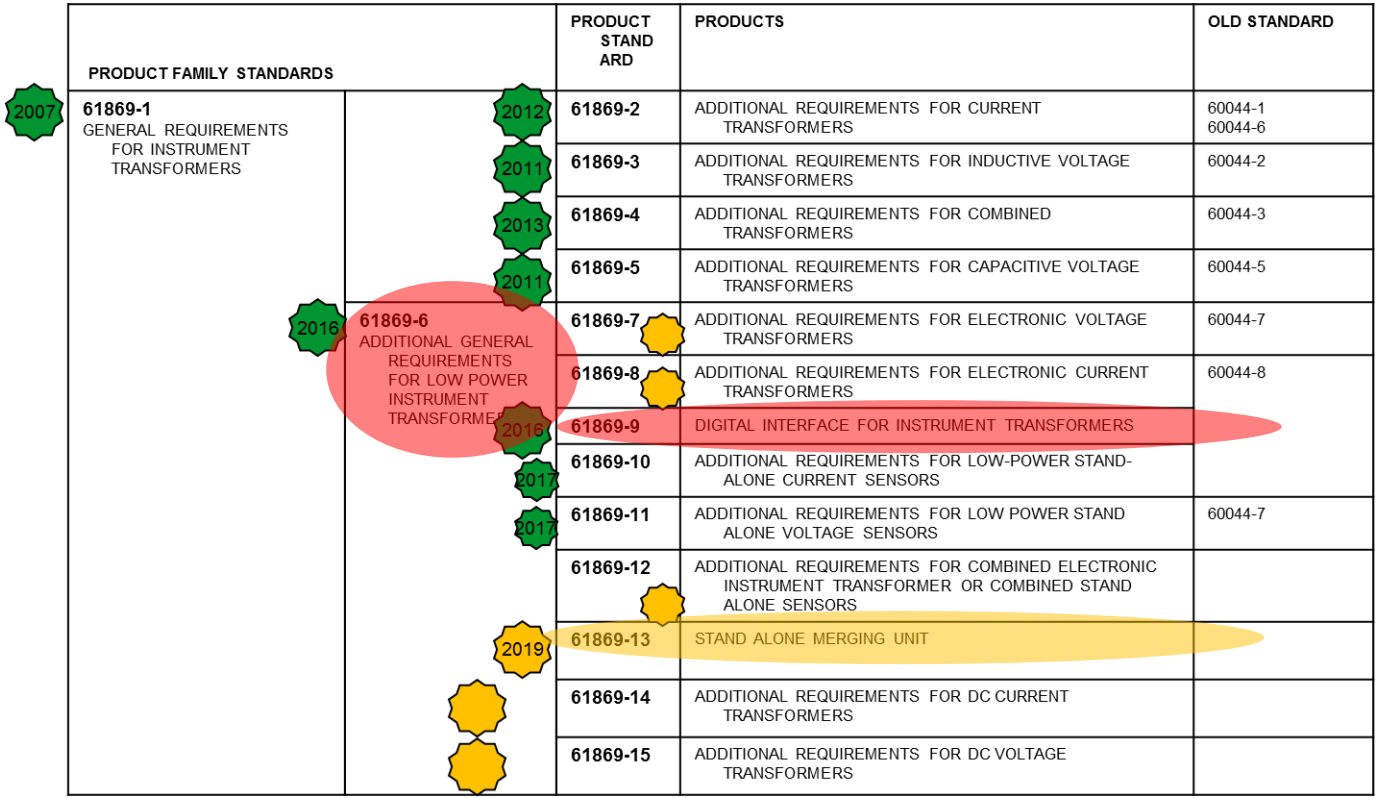
Differences between IEC 61850-9-2, 9-2LE and IEC 61869-9

The IEC 61869-9 standard:

- Replaces IEC 60044-8 digital solution.
- Provides a product standard for instrument transformers with a digital interface according to 61850.
- Includes backward compatibility for the UCA International Users Group *Implementation Guideline for Digital Interface to Instrument Transformers Using IEC 61850-9-2*.
- Uses IEC 61588 (PTP) for time synchronization, with an option for 1PPS.

IEC 61869-9 2/2

Differences between IEC 61850-9-2, 9-2LE and IEC 61869-9



PRODUCT FAMILY STANDARDS	PRODUCT STANDARD	PRODUCTS	OLD STANDARD
2007 **61869-1** GENERAL REQUIREMENTS FOR INSTRUMENT TRANSFORMERS	61869-2	ADDITIONAL REQUIREMENTS FOR CURRENT TRANSFORMERS	60044-1 60044-6
2012	61869-3	ADDITIONAL REQUIREMENTS FOR INDUCTIVE VOLTAGE TRANSFORMERS	60044-2
2011	61869-4	ADDITIONAL REQUIREMENTS FOR COMBINED TRANSFORMERS	60044-3
2013	61869-5	ADDITIONAL REQUIREMENTS FOR CAPACITIVE VOLTAGE TRANSFORMERS	60044-5
2011	61869-7	ADDITIONAL REQUIREMENTS FOR ELECTRONIC VOLTAGE TRANSFORMERS	60044-7
2016 **61869-6** ADDITIONAL GENERAL REQUIREMENTS FOR LOW POWER INSTRUMENT TRANSFORMERS	61869-8	ADDITIONAL REQUIREMENTS FOR ELECTRONIC CURRENT TRANSFORMERS	60044-8
2016	61869-9	DIGITAL INTERFACE FOR INSTRUMENT TRANSFORMERS	
2017	61869-10	ADDITIONAL REQUIREMENTS FOR LOW-POWER STAND-ALONE CURRENT SENSORS	
2017	61869-11	ADDITIONAL REQUIREMENTS FOR LOW POWER STAND ALONE VOLTAGE SENSORS	60044-7
	61869-12	ADDITIONAL REQUIREMENTS FOR COMBINED ELECTRONIC INSTRUMENT TRANSFORMER OR COMBINED STAND ALONE SENSORS	
2019	61869-13	STAND ALONE MERGING UNIT	
	61869-14	ADDITIONAL REQUIREMENTS FOR DC CURRENT TRANSFORMERS	
	61869-15	ADDITIONAL REQUIREMENTS FOR DC VOLTAGE TRANSFORMERS	

IEC 61850-9-2 LE v.s. IEC 61869-9

Differences between IEC 61850-9-2, 9-2LE and IEC 61869-9

- IEC 61869-9 is backward compatible with 9-2 LE communication

	IEC 61850-9-2 LE	IEC 61869-9
Fiber optic transmission	100Base-FX full duplex	Same (+ 1Gbit/s)
	ST or MTRJ,	Duplex LC or RJ45
Dataset	4 I + 4 U	FfSsIiUu
Protection sampling rate	80 samples per period	4800 Hz
Measurement sampling rate	256 samples per period	14400 Hz
Protection comm. ASDU	1 (≈1400 bits)	2 (≈1500 bits)*
Measurement comm. ASDU	8	6
Synchronization	1 pps	IEC 61588
Nb of “Nodes” (50% of load)	7 at 60Hz/8 at 50Hz	around 14*
Delay time* (*td*) (Protection)	none	2 ms
Delay time* (*td*) (Quality)	none	10 ms
Rated conformance*	none	a to d

*: “same” size of the frame but frames are sent twice slower thus doubles the network capability

IEC 61869-9 definitions

Definitions

- Delay time* (*t*d)
  - Delay time (*t*d) shall be measured as the difference between the time encoded by the SmpCnt and the time the message timestamp point appears at the digital output.
- Variants
  - To facilitate interoperability, only a limited variability is permitted for naming, message structure, sample rate, analogue signal content and scaling. **FfSsIiUu**
    - f is the digital output sample rate expressed in samples per second
    - s is the number of ASDUs (samples) contained in a sampled value message
    - i is the number of current quantities contained in each ASDU (max is 24*)
    - u is the number of voltage quantities contained in each ASDU (max is 24*)
  - Examples:
    - F4000S1I4U4 describes the 9-2LE MSVCB01 sampled values with 50 Hz nominal system frequency.
    - F12800S8I4U4 describes the 9-2LE MSVCB02 sampled values with 50 Hz nominal system frequency.
    - F4800S2I8U0 describes sampled values with 4800 samples per second, two ASDU (samples) per message, 8 currents, and no voltages.

*: at 100Mbit/s

IEC 61869-9 definitions

Conformance classes

- The conformance classes may be summarized as follows:
  - class a: the minimal set of services required to transmit MU data using sampled values;
  - class b: “class a” capabilities plus the minimal set of services required to support GOOSE messages;
  - class c: “class b” capabilities plus the implementation of the IEC 61850 series’ information model self-descriptive capabilities;
  - class d: “class c” capabilities plus services for file transfer and either one or more of un-buffered reporting and buffered reporting, or logging.

IEC 61869-9 definitions

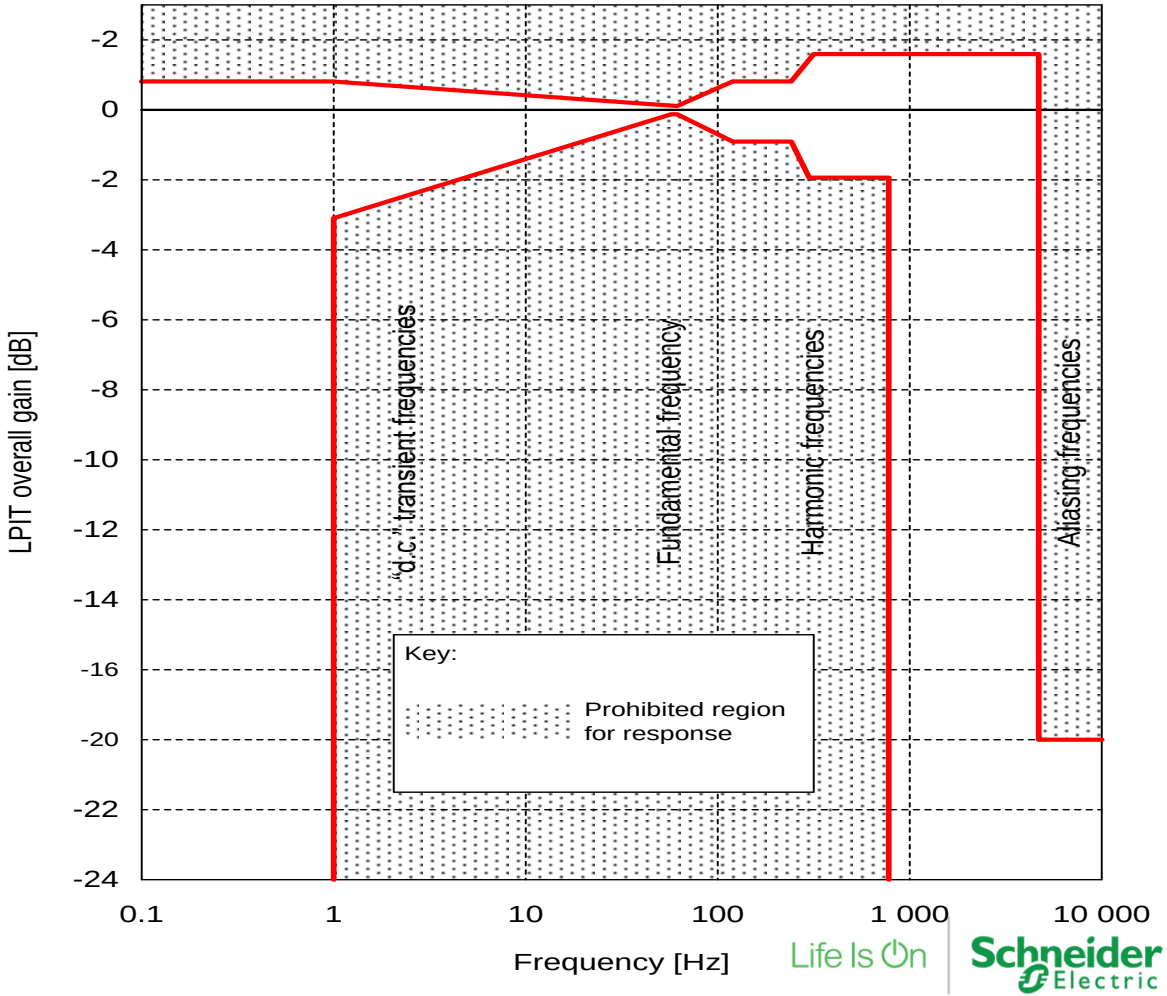
Digital Output Standard Sample Rates

Digital output sample rates [Hz]	Number of ASDUs per frame	Digital output publishing rate [frames/s]	Notes
4 000	1	4 000	Legacy, for use on 50 Hz systems.
4 800	**2**	**2 400**	**Preferred rate for general measuring and protective accuracy classes, regardless of the power system frequency**
4 800	1	4 800	Legacy, for use on 60 Hz systems, or 50 Hz systems with 96 samples per nominal system frequency cycle
5 760	1	5 760	Legacy, for applications on 60 Hz systems with 96 samples per nominal system frequency cycle
12 800	8	1 600	Deprecated, only for use on 50 Hz systems
14 400	**6**	**2 400**	**Preferred rate for quality metering accuracy class, regardless of the power system frequency**
15 360	8	1 920	Deprecated, only for use on 60 Hz systems
96 000	1	96 000	Preferred rate for HV DC applications[VS3]

IEC 61869 definitions

Frequency response

- Frequency response
  - Frequency response mask for metering accuracy class1 and SAMU
    (*fr* = 60 Hz, *f*s = 4800 Hz)



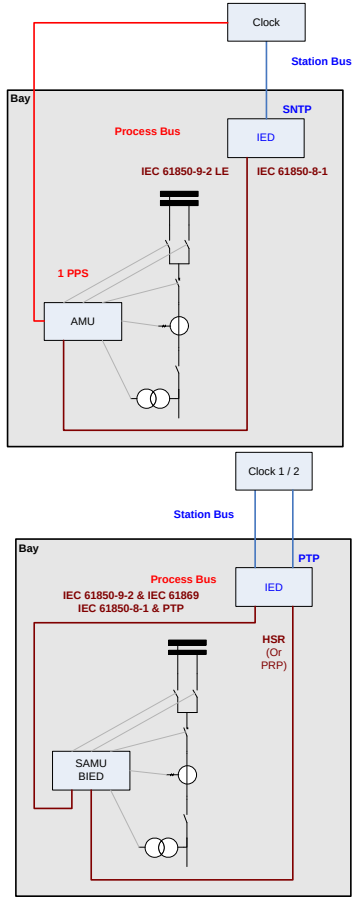
Questions?

Process Bus

Why it did not commercially work?

The **technical issues** to be solved were:

- The ~~time~~ **synchronization of measurements**:
  - 1 PPS additional link per SAMU AND from a unique clock (less availability)
  - Now solved with **doubled PTP** clocks (IEEE 1588/IEC 61588) through Eth.
- The **Ethernet communication**:
  - 1 Ethernet link per IED AND through “single” switch (decrease of availability)
  - Now solved via redundancy through IEC 62439 **PRP or HSR**
- The harmonized degree of **accuracy of the Sampled Values**
  - 9-2 LE was not standardizing the value sent (no interoperability)
  - Soon solved by **IEC 61869-13** (expected for 2019).



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Process Bus

Takeaway

1. The technical issues to be solved were:
   - The ~~time~~ synchronization of the measurements, now solved with PTP (IEC 61588)
   - The communication redundancy need, now solved by IEC 62439 PRP (or HSR)
   - The harmonized degree of accuracy of the Sampled Values soon solved by IEC 61869 full series.
2. The Process Bus is made of Ethernet networks either single or redundant, through which the following frames flow:
   - IEC 61850-9-2 Sampled Values (following IEC 61869 behavior)
   - IEC61850-8-1 GOOSE messages (mainly Binary but Analog is allowed),
   - PTP (IEC 61588) time synchronization.

Process Bus

Takeaway

3. These Ethernet networks can be either virtual or physical networks
   - But the availability, the operators understanding of the application and the maintenance provided by physical segregation is much higher than a common network supporting multiple VLANs.
4. **Time** synchronization is not an issue if SAMUs are rightly connected.
5. Except for busbar protection with more than 7 CTs per busbar, the 100Mbits/s Process Bus fits most of the applications.
6. The optimum solution would be 100Mbit/s “PRP Process Bus” or a 1Gbit/s “HSR Process Bus” to link all the feeders of a substation.

List of standards

List

1. IEC 61588 (PTP)
2. IEC 61850-8-1 and -9-2
3. IEC 61869-6 and -9 and -13
4. IEC 62271-3 (BIED/SIED)
5. IEC 62439 (PRP or HSR)

Questions?

Process Bus protocols

What is flowing through Ethernet?

- IEC 61850-9-2 (not IEC 61850-9-2 LE) for Sampled Values “SV”
  - Samples of Current measurements (CT)
  - Samples of Voltage measurements (VT)
- It is also possible to send measurements via “Analog” GOOSE
  - Example: Voltage phase angles and magnitudes for synchrocheck

- IEC 61850-8-1 “GOOSE” messaging service for Digital I/Os
  - Status position of Switch disconnector (SW)
  - Status position of Circuit Breaker (CB)
  - Trip signals from protections to CBs (Trp)
  - Commands from DCS (open, close)
  - Others (monitoring status reports, health…)

Process Bus protocols

What is flowing through Ethernet

- Precise Time Protocol (PTP) (IEEE 1588/IEC 61588) for Ethernet based time sync.
  - (Time) synchronization (to get 1us or 5us accurate time tagged samples)
  - IEC 62439 Time sync for HSR/PRP redundant networks

- IEC 62439-4 for Ethernet communication redundancy
  - PRP: Parallel Redundancy Protocol (Double star)
  - HSR: High-availability Seamless Redundancy (Ring)

- IEC 61869-9 and IEC 61869-13 for Mainly Differential protection algorithm interoperability
  - 9-2 LE described the Ethernet frame definition, not the sampled Values definition
  - 9-2 LE is already superseded by IEC 61869-9

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