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PROBLEMS FOR DIGITAL PROTECTIVE RELAYS STANDARTIZATION

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This article analyzes the urgent problems of standardizing digital protective relays and offers a Universal Basic Specification to be implemented by all manufacturers and consumers of the protective relays, as well as by the certification laboratories responsible for testing these relays.

Key words: digital protection relays, standardization, standard, technical specifications, tender

In one of my previous articles (see: "Escalated need for standardization in the design of microprocessor protection" – Energy Industry News, 2011, No. 4) I have proved the need for standardizing the design and software requirements of the digital protective relays (DPR). Without lessening the relevance and significance of such standards, it should be noted that prior to the development of such standards it is necessary to put the existing normative and technical documentation and standards for the DPRs in order.

The following basic problems of the DPR standardization are:

– Current technical documentation refers to the standards of different groups: IEC 61000 (general standards for electromagnetic compatibility), IEC 60255 (special standards for measuring relays and protection equipment) and ANSI/IEEE (Institute of Electrical and Electronics Engineers, USA), which are not fully compatible. Different manufacturers and consumers specify different standard groups in the technical and tender documents, thus significantly complicating the analysis of the relay characteristics, and usage of the technical documentation.

– Some countries still rely on outdated national standards which do not correspond to the international standards.

– The technical documentation usually refers only to the standard numbers, without specifying the category (level) and acceptance criteria; therefore it is not possible to determine the real parameters, since even in the same standard the parameters may be two- or even threefold different from each other.

–Tender and project documentation contain wrong parameters and references to nonexistent categories, levels and acceptance criteria of standards as a result of numerous subsequent copying of the parameters from the different specifications of the manufacturers.

– Some standards contain only references to other standards instead of specific numerical values.

– The potential consumer of the protection relays must know many standards and have a good understanding of complex issues out of their sphere of competence and professional activity (for example, of electromagnetic compatibility - EMC).

– The extreme complexity of the comparative evaluation of DPRs from different manufacturers stemming from reference to different groups of standards in the technical documentation, or presenting technical data in different formats.

– The extreme complexity of determining the compliance of the various types of DPRs from different manufacturers with the requirements of the tender documents due to referring to different groups of standards.

As a result, the DPR technical documentation from manufacturers often contains the data that is incomprehensibe or misleading to the consumer. Moreover, the manufacturers are not able to present clear, correct and complete test condition data to the certification centers and testing laboratories in order to make necessary tests.

Conversaly, the consumer is not able to properly formulate the technical requirements in tender documentation, compare the products from different manufacturers, whose technical parameters are shown in different forms and refer to different standards, or evaluate the compliance between the tender documentaion requirements and charactieristics of the proposed products since they have references to different standards. This problem is particularly severe if someone purchases DPRs from foreign manufacturers implementing IEC standards different from the national standards of the buyer.

This situation is a loss for both the manufacturers and the consumers of DPRs.

After analyzing dozens of DPR specifications from Russian and all the world's leading manufacturers, and the set of standards for Russian Federation, IEC and IEEE, I have developed a suggested Universal Basic Specification, which can be used by the manufacturers and the consumers of DPRs to address many of the problems mentioned above. This Specification is based on the international standards IEC 60255 for DPR implemented in most countries of the world. Since the Specification is based on the international standards, it can pull together the national and international manufacturers of DPRs and simplify the use of the DPRs from foreign manufacturers for the consumers.

Another important advantage of the international standards is that they are updated more frequently than national standards and reflect the current and actual data derived from the practice or research.

Recommended Universal Specifications on Digital Protective Relays

1. Contacts

• **Contact rating:**

IEEE St. C37.90

Tripping Output

Nominal Voltage – 250V AC/DC

Make: 30 A and carry for 0.2 s, inductive load (L/R ≤ 0.04s)

Carry: 5A continuous

Break: DC 50W resistive, 25W inductive (L/R ≤ 0.04 s)

Break AC load: 1250 VA, cos φ = 0.7

Signaling Output

Nominal Voltage – 250V AC/DC.

Make: 5A and carry for 0.2s, inductive load (L/R ≤ 0.04 s).

Carry: 3A continuous.

Break: DC 30W resistive, 15W inductive (L/R ≤ 0.04s).

Minimal contact load: 20 mA at 24 V AC/DC.

Break AC load: 500 VA, cos φ = 0.7.

Contacts for energizing logical inputs of protective relays

Nominal Voltage – 250V AC/DC.

Minimal switching current: 1 mA.

• **Durability**

Loaded contact: 10,000 operations minimum for signaling output; 1,000 operations minimum for tripping output.

Unloaded contacts: 100,000 operations minimum.

2. High voltage withstand

• **Insulation Resistance**

IEC 60255-5

>100 MOhm at 500 V, during 5 sec minimum:

- between each independent circuits and all other circuits connected together with earth terminal;

- across the open contacts of the all output relays.

• **Dielectric withstand on AC voltage at main frequency**

IEC 60255-5

- 2kV r.m.s., 50 Hz, 1 minute between each independent circuits and all other circuits connected together with earth terminal;

- 1kV r.m.s., 50 Hz, 1 minute across the open contacts of the output relays;

ANSI/IEEE St. C37.90

1.5kV r.m.s., 50 Hz, 1 minute across open contacts of tripping relays.

NOTE: For solid-state tripping relays with internal protective overvoltage elements dielectric withstand voltage applied across output terminals of the relay in OFF-condition no more than 1.5 of rated voltage.

• **High voltage impulse**

IEC 60255-5, category IV

Three positive and three negative impulses at interval of 5 sec: 5kV peak, 1.2/50μs, 0.5J between each independent circuits and all other circuits connected together with earth terminal (except communication ports).

3. Power supply

• **Operating voltage range**

176 to 264 VDC, criteria acceptance A

• **AC ripple on DC supply**

IEC 60255-11, criteria acceptance A

The protection relay will withstand without de-energizing, misoperation and losses of data 15% AC ripple (sinusoidal waveform) of rated DC value on the DC power supply.

• **Power supply (dips) interruption**

IEC 60255-11, criteria acceptance A

The protection relay must withstand such interruption in the auxiliary supply, under normal operating conditions, without de-energizing, misoperation and losses of data:

- for DC power supply: voltage dips 100% during 10 to 1000 ms (according to manufacturer choice);

- for AC power supply: voltage dips 100% during 0.5 to 25 cycles of power supply frequency (according to manufacturer choice).

• **Power-up Time**

Time to power up < 60 s

4. Electromagnetic compatibility

• **High frequency burst disturbance**

IEC 60255-22-1, level 3, criteria acceptance A:

- 2.5kV (peak), 1 MHz for common-mode test between each independent circuits and all other circuits connected together with earth terminal (except communication ports);

- 1 kV (peak), 1 MHz for differential (transverse) test across terminals of the same circuit (except communication port);

- 1 kV (peak), 1 MHz for common mode test between communication port and all other circuits connected together with earth terminal.

Test duration 2 s, 6-10 bursts per period of power supply frequency

• **Fast transient/burst immunity**

IEC 60255-22-4, level A, criteria acceptance A

Common-mode test between each independent circuits and case (earth):

- 4 kV (peak) for all circuits exclude communication port;

- 2 kV (peak) for communication ports.

Common-mode test between each independent circuits and all other circuits connected together with earth terminal.

Repetition rate during burst 5 kHz; Burst period 300 ms, Burst duration 15 ms; Test duration 1 min, each polarity.

• **Surge immunity test**

IEC 60255-22-5, level 3, criteria acceptance A

- 2 kV (peak) for common-mode test between each independent circuits and case (except communication port);

- 1 kV (peak) for differential (transverse) test across terminals of the same circuit (except communication port);

The pulse waveshape: 1.2/50 μs.

• **Immunity to radiated electromagnetic energy**

IEC 60255-22-3, level 3, criteria acceptance A:

The frequency range is swept from 80 MHz to 1000 MHZ with the signal 80% amplitude-modulated with 1 kHz sine wave, field strength 10V/m. Addition spot frequencies: 80, 160, 450 and 900 MHz.

• **Immunity to conducted radio frequency interferences**

IEC 60255-22-6, level 3, criteria acceptance A:

- 10 V (r.m.s) for frequency 150 kHz to 80 MHz with amplitude modulated by frequency 1 kHz at 80% sine wave;
- 10 V (r.m.s) for frequency 80 MHz to 2700 MHz with pulse modulation

• **Power frequency immunity**

IEC 60255-22-7, class A, criteria acceptance A:

- 300 V (r.m.s.) for common-mode test between each independent circuits and all other circuits connected together with earth terminal (except communication port);
- 150 V (r.m.s.) for differential (transverse) test across terminals of the same circuit (except communication port).

• **Power frequency magnetic field immunity**

IEC 61000-4-8, level 5, criteria acceptance A:

- 100 A/m applied continuously;
- 1000 A/m applied during 3 s.

• **Pulse magnetic field immunity**

IEC61000-4-9, Class 5, criteria acceptance A:

1000A/m, waveform 8/20 μs, 5 positive and 5 negative pulses every 10 s.

• **Damped oscillatory magnetic field immunity**

IEC61000-4-10, Class 5, criteria acceptance A:

100A/m for frequency 100 kHz and 1MHz with a burst duration of 2 s, applied in all planes.

• **Radiated immunity from digital communications**

ENV 61000-4-3, level 4, criteria acceptance A.

Test field strength 30 V/m at frequency band 800 to 960 MHz and 1.4 to 2.0 GHz with the 80% amplitude-modulated signal, 1 kHz.

• **Electrostatic discharge test (ESD)**

IEC 60255-22-2, Class 4, criteria acceptance A:

- 15 kV discharge in air to user interface, display and exposed metalwork.

IEC 60255-22-2, Class 3, criteria acceptance A:

- 6 kV discharge in air to all communication ports;
- 8 kV point contact discharge to any part of the front of the protective relay.

5. Environmental conditions (in accordance with concrete climatic zone or conditions).

• **Ambient temperature range**

IEC 60255-6

Temperature:

- operating temperature range: -10ºC to +55ºC;
- during storage: -10ºC to +65ºC
- during transportation: - 40ºC to +85ºC

Humidity:

- relative humidity (annual average) 75%;
- high-relative humidity during 30 days, 95%.

Maximal altitude above sea level 2000 m.

6. Mechanical requirements

• **Vibration**

IEC 60255-21-1, class 2:

- Vibration response (energized): sinusoidal; frequency 60 to 150 Hz; acceleration 1g; sweep rate 1 octave/min; 1 cycle in 3 orthogonal directions. Criteria acceptance A
- Vibration withstand (de-energized): sinusoidal; frequency 60 to 150 Hz; constant acceleration 2g; 40 cycles in 3 orthogonal directions.
- Vibration during transportation: 2 g in each of three mutually perpendicular axes swept over range of 10 to 500 Hz for a total of six sweeps, 15 min each sweep, without structural damage or degradation of performance.

• **Shock**

IEC 60255-21-2, level 1:

- Shock response (energized) semi-sinusoidal, 5 g acceleration, duration 11 ms, each 3 shocks in both directions of the 3 axes; criteria acceptance A
- Shock withstand (de-energized) 15g acceleration, duration 11 ms, each 3 shocks in both directions of the 3 axes.

• **Bump test**

IEC 60255-21-2, level 1

De-energized: 10g, 1000 bumps, 16 ms duration, on each direction of the 3 axes.

• **Seismic**

IEC 60255-21-3, level 2, criteria acceptance A

- X- and Y-axes: 3g, 11 mm, 1 – 50 Hz
- Z-axis: 2g, 7.5 mm, 1 - 50 Hz

NOTE: **"criteria acceptance A"** – normal performance of protection and control functions within specification limits, during and after the test, without de-energizing, misoperations and losses of stored data or transmitted data.

It is safe to assume that the implementation of the Universal Basic Specification, supplemented with the specific parameters of the certain types of DPRs by all the DPR manufacturers and the consumers will contribute to the addressing of various current problems listed above.

ПРОБЛЕМЫ СТАНДАРТИЗАЦИИ ЦИФРОВЫХ РЕЛЕ ЗАЩИТЫ

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В статье анализируются актуальные проблем стандартизации цифровых реле защиты и предлагается Универсальная базовая спецификация, предназначенная для использования всеми производителями и потребителями реле защиты, а также сертификационными лабораториями, ответственными за испытания реле.

Ключевые слова: цифровые реле защиты, стандартизация, стандарт, техническая спецификация, тендер