



PS1 – S3-09



Design Typifications for Transmission Lines Relay Protection and Automation

Valery A. EFREMOV¹, Sergei V. IVANOV¹, Dmitry V. SHABANOV²
Research Center BRESLER¹, FGC UES²
Russia
efremov_va@ic-bresler.ru

KEYWORDS

Type design, relay protection and automatics, functional protection circuit, unification of relay protection.

1 INTRODUCTION

Large-scale rearmament in the energy sector of Russia requires the establishment of regulatory documents on typing protections for substation and line equipment. The urgency of this problem lies in the fact that currently on the market of relaying there are various designs to the layout of protection at the substation, made by Russian and international design methods of relay protection and automatics (RPA).

The problem of development of technical documentation recently received considerable attention. There come out articles, speeches at various seminars, conferences, in which we are mostly talking about meeting the needs of maintenance [1]. At the same time the percentage of incorrect operation of RPA because of design errors, mainly due to the implementation of protections and diverse nature of their functional differences, is unacceptably high [2]. The use of standard designs in the design of systems RPA will significantly reduce the number of such errors, especially when using the protections on microprocessor element basis.

In recent years, “FGC UES”, JSC works on typing and unification of the protections produces standards of the organization in different directions [3, 4].

The report aims to review approaches to developing a standard for the technical designs of relay protection for power lines.

2 STANDARD FOR TYPE TECHNICAL DESIGN

Standard for type technical designs should be the basis for development of type project designs, as FGC and standard designs for manufacturers of RPA and to ensure compatibility of protection from various manufacturers on the functional saturation.

The list of problems that must be addressed when developing type designs is to ensure continuity of protection and compatibility with the protection of their previous generations. In this aspect should be considered fundamental ideological differences associated with the formation of the output signals of protection for lines with individual phase controlled switches.

The important requirement for the formation of standard designs **is allocation of functions of relay protection and automatics (RPA)** for the devices, including their combination in one device (main protections with absolute selectivity and backup multistage protections). This integration into one terminal of all the protection connections, besides the obvious economic benefits, contains a number of disadvantages associated primarily with the problems of maintenance. In table 1 it is given an example of layout in type technical design of the protection complex of lines 220-750 kV with

individual phase controlled switches. The maximum number of protection panels ranging from six for extra high voltage lines to one or two for dead-end lines or medium-voltage lines.

Panel	Name of protection assembly
Panel 1	Phase comparison line protection + backup protection (PCP+BP)
Panel 2	Differential line protection + backup protection (DLP+BP)
Panel 3	Bay control of line breaker Q1 (BC Q1)
Panel 4	Bay control of line breaker Q2 (BC Q2)

Table 1: Example of electricity box layout for RPA substation with individual controlled switches

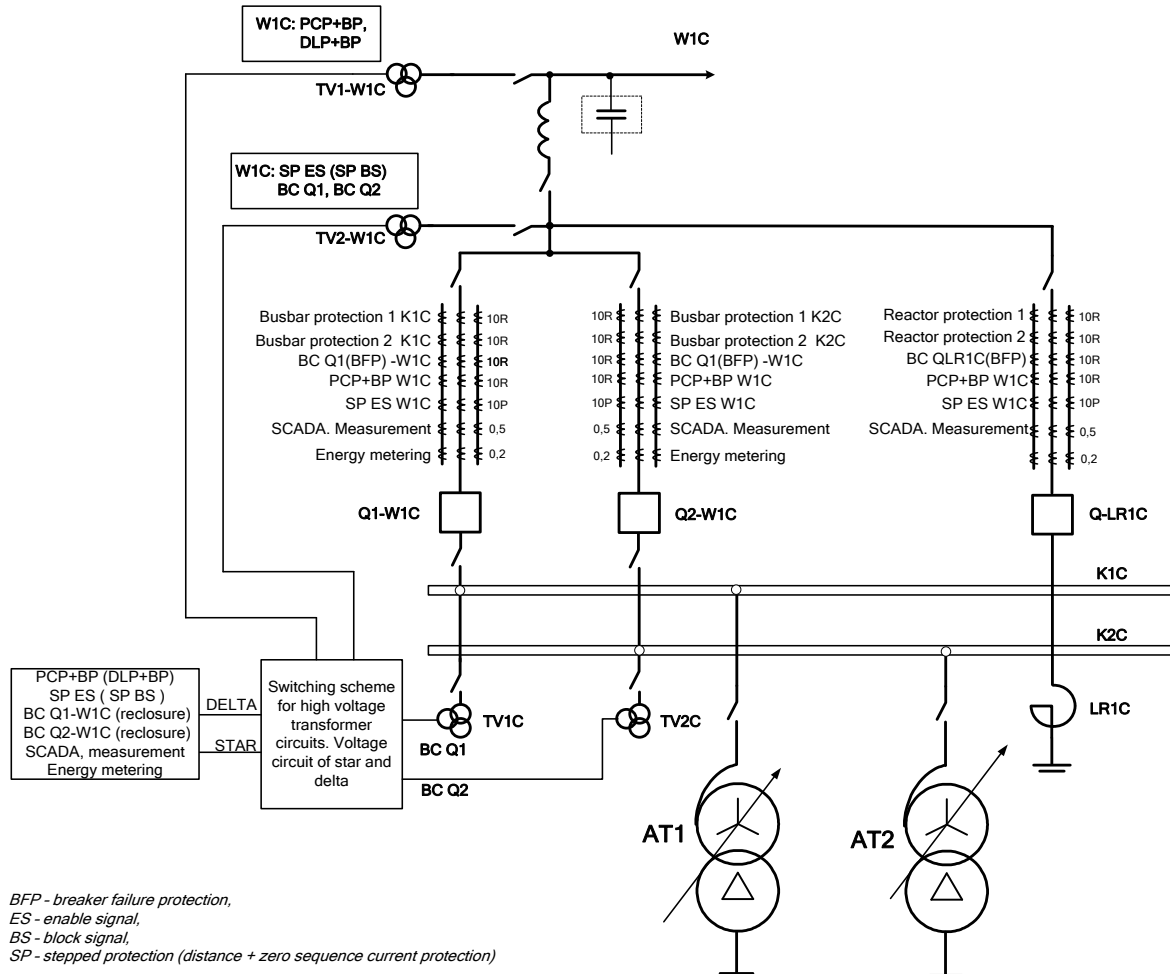


Fig. 1: Diagram of allocation of protection assembly and automatics in measuring CT and VT

In forming the **requirements for measuring current and voltage circuits** according to [4] it is taken into account that the number of current transformers (CTs), the secondary windings and their accuracy classes should provide separate connections RPA devices and measurement systems, and the main and backup protection for each circuit element should be incorporated into different secondary winding CTs, and should be provided that redundancy protection for voltage circuits with the ability to transfer them to another voltage transformer (VT).

To comply with the standard for connecting protections to measuring CT it is necessary to provide from 2 to 5 cores Class 10R (5R) - depending on the voltage class of the object, as well as 2 cores of a higher class of accuracy for connection of automated information and measuring systems of energy revenue metering, measurement and SCADA system. One of the main criteria for choosing the primary equipment should be sufficient number of secondary windings in embedded CT switches for a

separate connection of protection assembly (Fig. 1). Integration of protection in one terminal and corresponding functional saturation partially reduce tension in this part of the project.

On the lines of extra high voltage (500-750 kV) it is recommended to use two VTs, and on lines with individual phase control 220 kV and 330 kV it is allowed to use only one VT. Shifting voltage circuits from one VT to another can be performed in manual or automatic modes. Automatic shifting on exact VT is in progress almost instantly. There is a current trend to have voltage circuits connected from two VTs to a single RPA device. At the same time it carries out functional testing of all circuit voltage of the two VTs and performs automatic selection of the exactness.

The most complicated case of connecting CTs and VTs to protection for the lines of 110-220 kV circuit is a bridge circuit of double-ended substation and it concerns protection of absolute selectivity. In such protections should be provided for possible the cross-blocking of protections. Attention should be paid to the connection of the control switch automatics in breaker-and-a-half scheme to provide selective protection from shifting phases (Fig. 2).

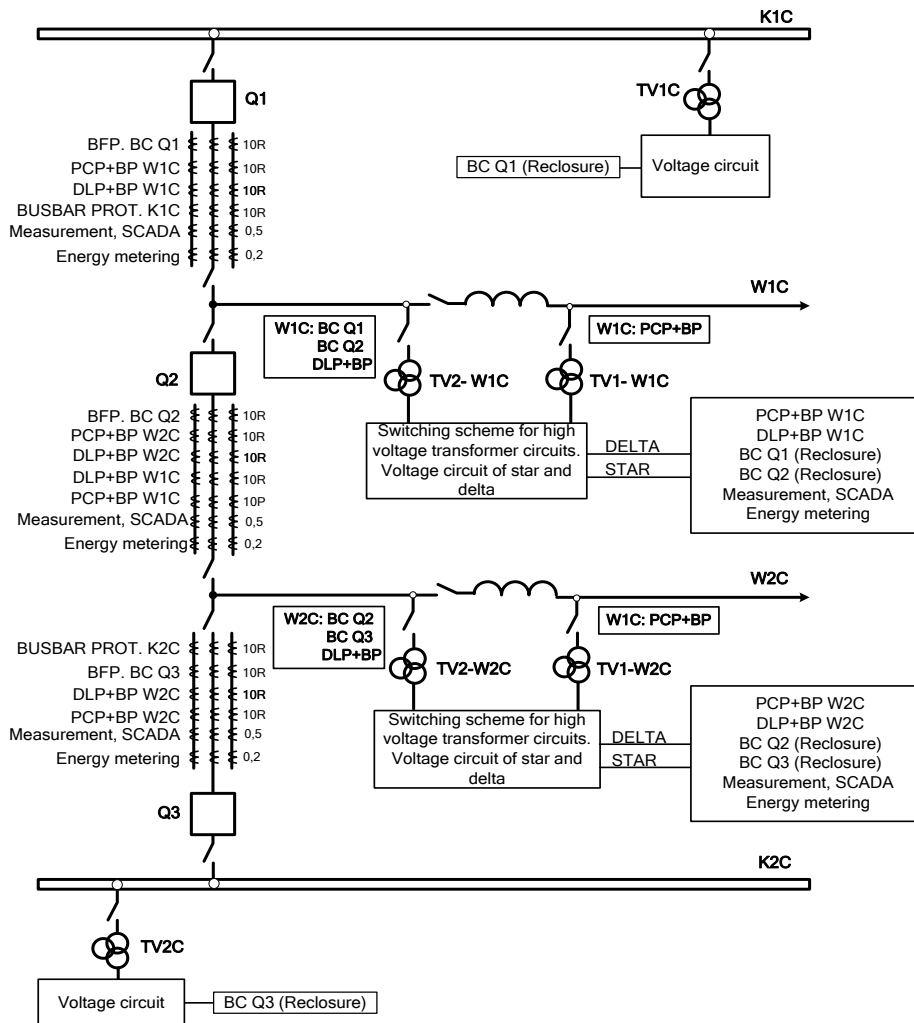


Fig. 2: Scheme of relay protection and automation connection in measuring CT and VT for breaker-and-a-half scheme

Protections functionality. The requirements on the reliability RPA systems are provided not only by performance RPA devices themselves, but also by optimally chosen amount of their functions, competent implementation of the project and other work.

Requirements for functionality of microprocessor protection (MPP) are usually performed by the manufacturers, and the absence of a functional unit can be performed by the manufacturer without significant cost and time.

In general, the functionality of the MPP includes a standard set of functions that must be defined at the stage of design work. Implementation of GIS and inserted cable on power lines requires an increase in the number of protection stages with relative selectivity equal to five. For distance

protection (DP) are recommended the following allocation stages for line voltage 110-750 kV:

- 1st stage of DP should act to shut down for all types of short circuits;
- 2nd and 3rd stages of DP are recommended for protection from $K^{(2)}$, $K^{(3)}$, $K^{(1.1)}$ and must act to shut down the three phases of a defined time delay.

To protect the cable section of the line (if any) must be provided a separate stage of DP (in the type plan it is recommended the fifth) from all types of short circuit with under-reaching coverage, providing the required sensitivity factor for back-up protection for short circuit at the end of the cable station. Stage must act to shut down three phases with the prohibition of automatic re-close and to transfer the command number 1 (three phase trip with autoreclosing block) on the opposite end of the line.

In the technical designs it is recommended for implementation function of single phase reclosing (SPR) in relay protection assembly, and its exclusion from control switch automatics. It responds to preservation of national ideology to backup SPR functions, as well as its interaction with the fault-phase selection detector and the implementation of adaptive SPR (function “control arc extinction” requires information about current of the line).

Figure 3 shows the coverage of linear protections for the case of connecting lines through two switches. With reactor on the line it should be excluded from the coverage of linear protections. From all the features of implementation of protections with absolute selectivity, we distinguish the standard requirements for line differential protection (LDP) when it is used on lines with two switches on the connection. In this case, currents of the first and second switch must be supplied to LDP with their further separate processing of channels. Galvanic current summation is unacceptable because of possible non-selective protection on saturation of one of the measuring CTs of line switches on the background of the external short circuit. Applying the LDP on lines with reactors it is allowed galvanic currents summation of a linear circuit with currents of reactor.

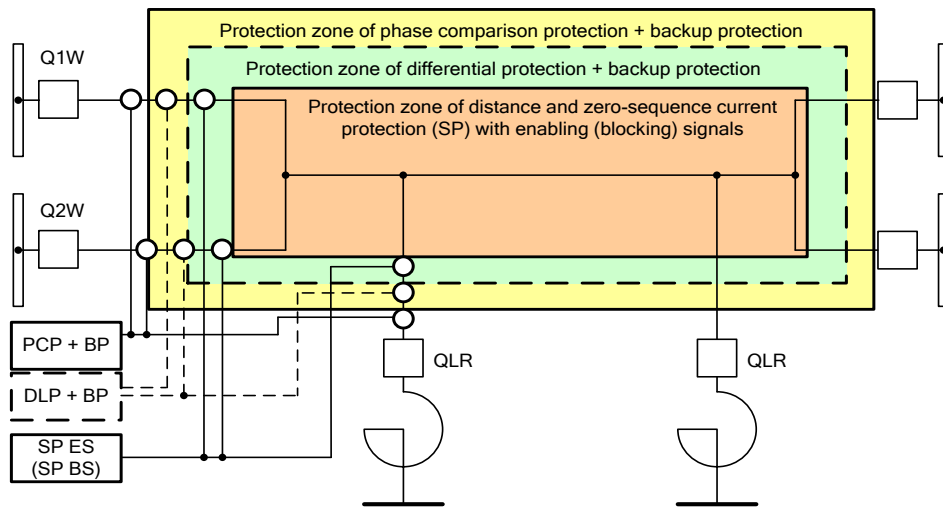


Fig. 3: Coverage of line protection

A significant part of the standard is devoted to interaction of protections at the substation, which solve the problem of optimizing the number of inter-box links in RPA system of protected power facility. For example, inserting the SPR function to all protections greatly increases the number of inter-box links due to the need of transmitting information about each disabled phase to all devices of substation. A sufficient design in such a situation would be to have SPR in not more than two devices, and other protections issue starting signals about response of fast protection stages.

The concept of a digital substation can greatly reduce or even abandon inter-box copper cable connections. However, the use of optical fiber for this purpose contains several flaws: damage of optic cable requires significant time and financial costs to recover it, and failure of the router power supply system results in a loss of inter-box connections. Given this circumstance, it is recommended to duplicate the transfer signals through copper cable cores.

Tasks of applying operational DC system, connections, etc. in the type technical designs are implemented in accordance with existing regulations [3,4], which define the list of necessary equipment and prescribe the sequence of actions.

3 CONCLUSION

Developed type technical designs are the foundation for the establishment of model design decisions on the part of RPA 10-750 kV lines, should be used by manufacturers of RPA and design organizations to determine functional saturation of protections, develop standard designs for their application, as well as for making the list of necessary RPA equipment at new construction and reconstruction.

REFERENCES

- [1] Belotelov A.K., Orlov Y.I. On sectoral regulatory and information documentation of RPA // Protection engineer. 2009. № 01. P. 64-66.
- [2] Yabuzarov M.Y., Pulyaev V.I. Directions of development and improvement of maintenance RPA systems // Electrical Networks of Russia 2010 // Materials of International Trade Show.
- [3] Systems of operational DC substations. Technical requirements. Standard of organization. Approved by Order № 191 of “FGC UES”, JSC dated 29.02.2010.
- [4] Technological design standards for AC substations with high voltage 35-750 kV. Standard of organization. Approved by Order № 187 of “FGC UES”, JSC dated 16.06.2006.
- [5] Strelkov V.M., Fokin G.G., Yakubson G.G. Basic principles of multifunction device implementation Autoreclose Overhead Transmission Line 1150 kV. In "Over-voltage, design and interference in 1150 kV power transmission". Collection of scientific papers VNIIE. Moscow: Energoatomizdat, 1984. P. 61-66.
- [6] Efremov V.A. Protection of absolute selectivity series "Bresler" // Energo-Info. 2008. № 9 (21). P. 70-73