

**SC B2 - Overhead lines
PS 2 / Enhancing overhead line performance****Development and implementation of digital line-to-cable termination points for connecting 110 kV overhead and cable lines**

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The intensive growth of urban agglomerations all over the world is associated with the infill development hence resulting into free territory shortage. One of the ways to solve this problem is to reduce the area occupied by overhead lines. This result may be achieved through the construction of cable lines. There is a tendency towards an increase in the number of overhead-and-cable lines joining the overhead sections and relatively short cable insertions. The compact and aesthetically attractive solution of transition from an overhead line into a cable one becomes one of the top-priority fields of development in the city's electric power industry. The development of information and measurement systems allows making such a transition a part of a smart grid.

Two transition arrangements from overhead lines to cable lines used worldwide are:

- above-ground transition, in which the main and auxiliary equipment is located on the ground;
- directly on an overhead line structure (lattice tower or steel pole) with the main equipment located on additional cross-arms or, occasionally, on special platforms of lattice poles.

Both of these methods have benefits, but are also associated with a number of disadvantages with regard to design and operation.

The advantages of the above-ground TP (termination points) include the fact that they enable allocating a great number of equipment, both main and auxiliary (including switching equipment up to circuit breakers) while being convenient and easily accessible for maintenance.

The following disadvantages are worth noting:

- they occupy a sufficiently great area;
- they require an arrangement of a large number of permanent foundations for structures and equipment;
- if accommodation of switching equipment is required, they may be virtually transformed into substations;
- they offer no architectural advantages.

Another problem with the incorporation of an overhead line and a cable line into one processing facility is the implementation of relay protection for the combined cable-and-overhead power transmission lines. Most accidents in overhead lines are of short-term with a self-repairable nature. Therefore, auto-reclosing (AR) is a reliable and effective way to restore functionality of an overhead line. Most accidents

occurring in a cable line are permanent, and auto-reclosing usually only develops the emergency and worsens the damage. In this case, it is necessary to determine precisely to which section the damage relates – to a cable section or to an overhead one. On the basis of this information, an instant decision should be made on the permission or prohibition of reclosing.

In Russia, we have developed and implemented a unique comprehensive technical solution – a point of transition from a 110 kV overhead line to a cable line located on a steel pole. As a result, a complex engineering facility has been created including switching, measuring, communication and other equipment placed on platforms for maintenance with a safe access. The new digital TP provides protection of equipment and people, aesthetic appearance, and efficient use of the territory. Within the project implementation, a system for the localization of damage to a cable-and-overhead power lines was developed to arrange for a selective AR.

One of the most effective and step-ahead solutions in the field of detecting and localizing a short circuit in the cable section of a combined line is an optical current sensor based on the longitudinal magneto-optical Faraday effect. Electronic fiber-optical current transformers (EFOCT) 110 kV was selected as a sensor, that can be placed directly on a current-carrying part. One electron-optical analyzer unit processes readings of all three EFOCTs located at the TP and transmits data via a fiber-optic communication line to the relay protection system of the cable-and-overhead line to permit or prohibit the AR.

The 110 kV termination point on the pole is intended for the connection of overhead lines and cable line circuits and represents a pole made of high-strength steel with two service platforms (for routine switching, cable testing, maintenance, and repairs), and structural elements to accommodate the equipment. This equipment includes the following: line disconnectors, optical current transformers, cable terminations, surge arresters, auxiliary power supplies, telemetry systems, measuring and monitoring systems.

An automated process control system (APCS) was designed to collect and transmit control signals and status signals from systems and equipment at the termination point. The APCS enables controlling the switching equipment and the security system and monitoring the status of the systems both remotely from the control centers and directly at the termination point from the control station provided on the APCS cabinet. Remote control and monitoring of the APCS status from mobile devices via GSM channels may be arranged for.

Fiber-optic communication lines are used to transmit digital signals of the APCS systems, signals of the temperature monitoring system, the cable line, other monitoring and measurement systems. The results of the measurements processing from the optical current transformers for relay protection and automatics, process and security video surveillance. Optical switching equipment is allocated at the termination point.

In general, the layout structure of the secondary equipment, communications and auxiliary systems of the termination point are such that it can be said that it is a universal platform to accommodate any other measurement, monitoring and communication system that may be required to arrange for process operations when using the 110 kV power transmission lines and the communication lines located on them and will eventually enable integrating the termination point into the branched smart grids.

The developed technical solution can be transformed for other voltage classes. The use of the digital termination point in the practical electric grid construction will have a beneficial effect on society:

- formation of a positive public opinion on electric power industry facilities due to their technological aesthetics,
- enhancement of safety of the power grid facilities through the use of explosion-proof technical solutions and provision of personnel security and the third parties,
- development of the urban environment through the freeing of territories occupied by power grid facilities.