New protection scheme based on IEC61850

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1. Abstract

The new International standard for communication networks and systems in substation, IEC61850 protocol, is expected to bring a profound evolution in electrical power systems. The new functionalities supported by an intelligent application of IEC61850 must result in a significant improvement of stability and reliability of power system.

Protection systems play a leading role in power system stability and reliability, since those depend on correct, rapid and selective disturbances elimination. IEC61850 opens the possibility of developing new protection schemes with these aims. In this paper is presented a new protection scheme performed by new IEDs based on the new features brought by IEC61850.

Key words: IEC61850, IED, Protection scheme, Reliability.

2. Introduction

IEC61850, the new International standard for substation communications, is going to involve a significant impact on the development of new devices, systems and communications schemes for power systems. In an advanced application phase of IEC61850, all devices in the substation and from remote substations, if needed from different vendors, will interchange information, such as remote sampled analogue measurements or digital signals.

Having local and remote analogue inputs available allows IEDs (Intelligent Electronic Devices) to carry out complete and precise calculations. In the same way, new algorithms and logical schemes will be developed using these measurements and digital inputs from devices of different locations of the system. This all new advantages should be used to expand the protection system solutions, resulting in a more reliable power system.

In this paper, a new protection scheme, based on IEC61850 communications is presented. The proposed scheme uses the interchange of analogue measurements and digital signals between different IEDs of a meshed network, with the aim of increasing the reliability of the system at the same time that the number of protective IEDs installed at each bay is reduced.

3. Proposed scheme

In order to illustrate the new protection scheme proposed, the network area presented in Figure 1 is used as representative example of a meshed network.

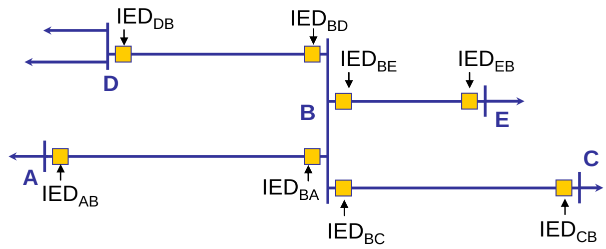

Figure 1. Meshed network scheme

Each bay of the proposed scheme is equipped with an IED, with several protective functions implemented, such as differential (87) and distance protection (21) functions.

Taking full advantage of the new possibilities provided by IEC61850, every IED could take any information involved in the Substation Automation System, whether they are measured in local or remote substations.

In the proposed solution, each IED is informed of the following analogue values:

i. Local current and voltage.
ii. Current and voltage measured at the remote end of the protected line.
iii. Current and voltage measured at both ends of adjacent lines to the remote bus of the line where the IED is installed.

Using as particular example the IED$_{AB}$ shown in Figure 1, its available analogue values are the following:

i. I_{AB}, V_{AB}.
ii. I_{BA}, V_{BA}.
iii. I_{BC}, V_{BC}; I_{CB}, V_{CB}; I_{DB}, V_{DB}; I_{BD}, V_{BD}; I_{BE}, V_{BE}; I_{EB}, V_{EB}.

Analogously, the rest of IEDs are informed of the current and voltage values of their adjacent forward lines, besides the local measurements, obviously.

In the presented scheme, every IED uses the information described above to evaluate fault conditions in its local line and, simultaneously, in the adjacent forward lines. This is called the protected area. In case of fault in any of the lines of the protected area, each IED can determine which of those lines is the faulted. In the example shown in Figure 1, if a fault occurs in line *BC*, all the IEDs looking at *B* substation (IED_{AB}, IED_{DB} and IED_{EB}) apart from local IED_{BC}, know that a fault has occurred in line *BC*.

In the proposed scheme, two different protective algorithms (differential and distance protection) work in parallel in every IED to evaluate fault conditions in the protected area:

- Differential protection: Using local and adjacent forward lines measurements each IED executes differential calculations for each line of the protected area.
- Distance protection: Using local measurements, each IED carries out fault impedance calculations and forward distance zone detection. Remote measurements from each end of the adjacent forward lines are used to execute directional comparison calculations. An overreaching zone detection combined with the directional comparison result determines which is the faulted line.

Once the faulted line is precisely located, the proposed protection scheme isolates it in a totally coordinated way ordering locally and remotely the trip of the line breakers. Each IED of the presented scheme detects when an adjacent line is faulted, as it's described above and, again using the means provided by IEC61850, sends remotely a trip signal to the corresponding breaker. In the example shown in Figure 1, if a fault occurs in line *BC*, all the IEDs looking at *B* substation detect that line *BC* is faulted and, instantaneously, cause *BC* breaker in *B* substation to trip. Analogously, all IEDs looking at *C* substation, which are not represented in Figure 1, trip *CB* breaker in *C* substation.

As can be deduced from the scheme description, although each bay is only equipped with one IED, actually each line is protected remotely by a significant number of IEDs, so back-up protection support is clearly increased respect nowadays conventional protection schemes. At present, no more than two different protective devices are installed at each end of the best protected lines.

As a particular case of example, the failure of IED_{BC} is supposed when a fault occurs in line *BC* of the meshed network shown in Figure 1. With the proposed scheme implemented the fault would be correctly and selectively isolated by IED_{AB}, IED_{DB} and IED_{EB}, as it is shown in Figure 2.

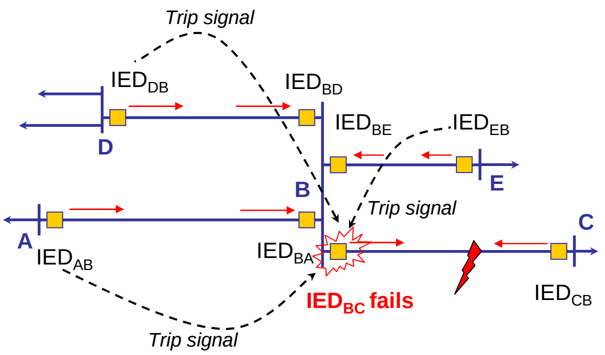

Figure 2. Scheme behaviour against fault and IED failure

In this example, each IED has three remote back-up devices, so three IEDs failures could happen and faults still would be isolated; moreover only the affected line would be isolated, which improves significantly the protection system. Another important feature of the scheme is that, under a total communication failure, the protective system would still preserve the nowadays behaviour, since distance protection functions implemented in IEDs would maintain their functionality (except communications aided schemes, obviously).

4. Modelling and simulations

The proposed scheme has been modelled and implemented in the protection simulation software CAPE. Having the system modelled in detail provide the performance of simulations which permit to evaluate the correct response of the scheme under different situations and eventual incidents.

5. Conclusion

A new protection scheme using the new features brought by IEC61850 is proposed. The main characteristics of the proposed system are the following:

1) The system reliability is remarkably increased.
2) The medium fault isolation time is decreased.
3) The isolated area in case of a back-up tripping is lower than the required in current schemes.
4) The number of IEDs required to implement the presented scheme is lower than the ones used in nowadays protection schemes, which involves significant economic saving.
5) The scheme complete functionality uses IEC61850 communications features, but if a total communications failure happens, the network would not be left unprotected: ordinary distance protection function implemented in proposed IEDs would keep active.

A meshed network and the proposed IEDs and protective logic schemes have been modelled in protection software CAPE. Simulations have been executed in CAPE, in order to evaluate and improve the logic schemes designed.

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