Reducing Outages in Distribution by Testing Recloser Controls

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Abstract

Reclosers and distribution automation solutions have been increasingly implemented into the distribution network in the utilities in East Asia and Western Pacific countries. Recloser controls nowadays offer many functions that are similar to the protection relays in the substation. This paper aims at stating the increasing need of advanced recloser control system in modern power system, and further extends the discussion to explain the importance and convenience of testing recloser controls during commissioning and maintenance in the field.

Key words: recloser control, automatic distribution restoration, test templates and plans, maintenance

Introduction

The main functions of reclosers are to reclose electricity supply network with pre-designed sequences, in order to minimize the affected area and identify the possible faulty lines. They are widely used in the distribution network especially in those areas with spread-out overhead lines. As the reliability of distribution network affects the customers' work and life, recloser and its control logic perform a vital role in maintaining power supply to hospitals, industry and even the citizens' work and life. This paper suggests the increasing need of advanced recloser control system in modern power system, and further express the importance and convenience of testing recloser controls during commissioning and maintenance.

The levels of implementation of reclosers into distribution system vary in different utilities in East Asia and Western Pacific. The industry faces increasing need in recloser. For example, some utilities are replacing fuses or manually operated switches with reclosers, while others are adding reclosers with new technologies into the networks. In this paper, several examples of reclosing and distribution restoration are explained to provide different understanding on the recloser application.

Recloser controls nowadays offer many functions that are similar to the protection relays in the substation, but working in the extreme environments. It is perhaps easily understood that the recloser control has to be tested more frequently than protection relays. Our paper briefly illustrates how recloser control tests are generally conducted and what challenges the engineers usually encounter.

In this paper, several different levels of testing solutions are explained, e.g. the simplest tests on overcurrent relay and timer, automatic tests, synchronized injection of restoration scheme and so on. The purpose of doing so is to illustrate the test on recloser control could be done easily, fast, conveniently in a reliable way.

Reclosers in Asia

Reclosers have been widely used in a lot of countries in Asia Pacific area including China, Philippines, South Korea and etc. However, the implementation of reclosers can be very different from each other. Seeing the application and implementation level of reclosers in Asia Pacific region, the following issues can be summarized into the following three aspects.

Functional Coverage

At the very beginning, it was fuse that was mainly used in distribution network. Later, the circuit breaker with the sectionalizer replaced the fuses at critical locations in order to obtain a better system reliability for the electricity users. With the increasing need on the self-healing distribution network, reclosers become more and more important.

At early stage, recloser control adopts overcurrent protection as the main function when a fault occurs on the protected distribution lines. With the increasing need for the association between each of the reclosers and advanced calculation devices, more and more recloser controls are equipped with advanced features that are similar to modern digital protection relays.

Typical advanced functions of advanced function in recloser control are voltage protection, directional overcurrent, sync check, as well as the latest application of pulse reclosing. It becomes challenging how these advanced function could be tested and commissioned, and be maintained periodically. These challenges encountered lead to the implementation levels of the recloser control which is discussed below.

Level of Implementation

Even the advanced functions is available from a lot of recloser suppliers, the implementation level of the recloser functions varies within Asian countries. Some countries are still using overcurrent, while others start adopting pulse reclosing technology. And there are reclosers in some countries which are equipped with advanced functions but only with basic overcurrent functions.

Possible explaining why these are happening can be: a) the government regulations are not yet covered; b) evaluation and simulation shows the advanced functions are not compliant to the existing network coordination; c) the difficulties on testing solutions.

Testing Solutions

Testing solution is always an immediate need associated with the recloser control functions. Advanced functions like pulse reclosing or direction overcurrent need advanced testing solutions. However, the advanced testing solutions create barriers towards the following aspects.

The maintenance work on distribution network and recloser control are usually conducted under tight time schedule. For a one-day on-site job, an engineer may need to finish the maintenance tasks on a number of reclosers meanwhile long distribution lines with several kilometers in length. If advanced functions are implemented, the time spent on each recloser will be longer and will increase the lead time of a maintenance project. Therefore, such a drawback usually makes the distribution utilities hesitate in implementing advanced functions in the recloser.

Furthermore, the advanced functions need advanced testing solutions. The goals of advanced testing solutions nowadays are generic accessibility, standardization, automation, repeatability, and complexity. In order to achieve these goals, efforts need to be spent. The next chapter will explain in detail the advanced testing solutions in order to achieve these goals.

Lastly, the testing equipment is also very important. In the past, engineers used one device for the current and voltage injection and another device for the measurement on the operations of the recloser control. Those devices were usually simple in the function and testing automation capability. It became very difficult to conduct the advanced tests. With the development of power electronics and computer technology, the testing industry on power system controls are greatly innovated. Those innovated modern testing devices are designed for test automation and standardization. With the computer-aided programmes, complex functions can easily be handled by sequence following testing steps and levels with very accurate control on magnitude, duration and rate of change.

Summary

Despite of the difficulties in implementing reclosers, it is observed that the functional coverage of the recloser are increasing with more modern recloser controls in Asian countries. Although advanced functions and features are available, not many reclosers are using complex or advanced functions to facilitate the distribution automation and self-healing network. Difficulties and barriers are discussed in terms of the workload, testing solutions as well as the testing equipment. The following chapter will discuss the readily available testing solutions from OMICRON.

Advanced Test Solutions

As a leading company in the power system testing field, recloser testing is also one of our focus application area. In this section, the advanced testing solutions suggested by OMICRON will be introduced. Three levels of tests are conducted: Level 1, manually test with connecting interfaces; Level 2, automatic test with test plans; Level 3, complex tests on automation distribution restoration (ADR) schemes.

Level 1 Test with Connecting Interfaces

Recloser control uses mainly overcurrent, voltage and frequency related protections. Therefore, the manually tests are relatively easy if the connection of the recloser control can be accessed. However, each recloser control manufacturer adopts different connecting interfaces, using various plug types, numbers of pins, as well as the functional inputs and outputs. Distribution utilities need to implement different recloser in order to keep the supply compliance, while the service providers need to handle various testing need from different distribution utilities. Needless to say, it becomes very challenging to manage and maintain such connecting interfaces within the scale of the business in utilities and service providers.

In order to overcome this difficulty, we adopt the idea of using the same testing equipment but tailor-made connection cables for different recloser control manufacturers. Figure 1 below shows a typical 14 pin recloser control cable.

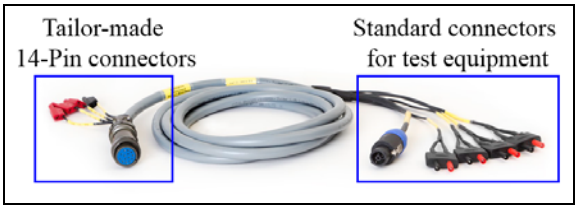

Fig. 1 Typical 14 pin recloser testing interface

On one end of the cable as shown in Figure 1 is the standard connectors for the test equipment which most of the utilities and service providers already have; on the other end, a tailor-made connecting connector for a recloser control manufacturer. In addition, Figure is available below shows how the test connection works with the test equipment. In order to conduct on-site test with the recloser control, the workers just need to disconnect the connecting cable between the control and the primary section, and then plug in the tailor-made interfacing cable from OMICRON. The remaining process is the test according to the pre-designed test plans.

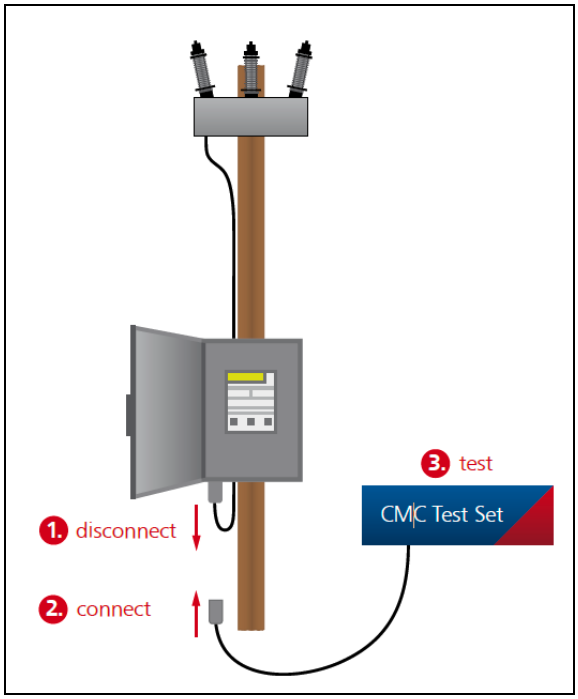

Fig. 2 On-site test with connecting interface

One main advantage of such arrangement is that the utilities and service providers can just invest on one set of test equipment with different interfacing cable. The investment is significantly reduced on training, equipment and sustainability. Moreover, the test procedures can be standardized by testing with the same test equipment as well as by maintaining the test in the way of test plans and test templates, which will be discussed in detail in the following section.

Level 2 Automatic Test with Test Plans

Both unities and service providers always want to be more professional in their work. The concept of 'professional' can be interpreted in different aspects, such as reducing redundancy, improving consistency and avoiding human-error events. To achieve these goals, automation and automatic testing is no doubt the only way.

The automatic testing on recloser control can be categorized into two groups, i.e. comprehensive test in the laboratory and on-site maintenance test. Therefore, we suggest the automatic testing with regarding to these two aspects, i.e. test templates and test plans.

Laboratorial test with test templates

The test conducted in the laboratory are more comprehensive since it is usually for the major evaluation and the time pressures are obviously less than doing on-site tests. Since the recloser control mostly involved overcurrent (50/51), directional overcurrent (67), over/under frequency (81) and over/under voltage (27 and 59), we recommend the test shall be conducted in the way and scale that are similar to protection relays. Therefore, we mainly adopt the guided workflow by using the popular test platform OMICRON Control Center.

The following Figure 3 shows a typical testing template on SEL351R. It demonstrates how a test is conducted. The control parameters need to be input (Figure 3). Those parameters can be directly obtained from the SEL351R by using the name indicated in the test template.

Settings

Stat	Name	Description	Value	Unit
✓	SYSFREQ Syst	System Frequency	60	
✓	PROT Phase R	Phase Rotation	ABC	
✓	RWM Reclose	Reclose Wear Monitor	AUTO	
✓	RTYPE Reclos	Reclose type	OIL	
✓	INTRATING Int	Interrupt rating	6000	
✓	RTLLEDS Res	Reset trip-latched LEDs on close	Y	
✓	T3PVOL True t	True three-phase voltage connected	N	
✓	PHANTV Phant	Phantom voltages from	VA	
✓	VPCONN V123	V123 Terminal Conn.	A	
✓	IPCONN I123 T	I123 Terminal Conn.	ABC	
✓	CTPOL CT Pol	CT Polarity	POS	
✓	BATAH Battery	Battery Amp-hours	8.0	
✓	PWR_AC Powe	Power-off Delay After AC Loss	180	min
✓	PWR_WU Pow	Power-off Delay After Wake-up	20	min
✓	V_LOW1 Powe	Power-off Voltage Level 1	19.2	Vdc

Fig. 3 Parameters for one typical recloser control

The workflow in the template is fully guided with detailed instructions. When operation is required, the instruction will inform the test what action shall be done at the recloser control side, as shown in Figure 4. It guarantees the minimum human error during the testing sequence.

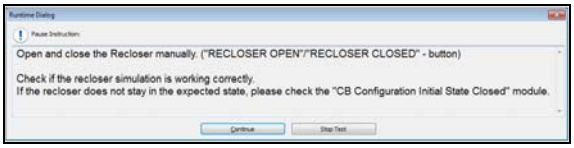

Fig. 4 Instructions on the operation of the recloser

The pre-designed tests are executed step by step, with the same manner with the protection relay tests. Below in Figure 5, is a test result on the phase overcurrent with fast curve. The curve and the verification results are clearly shown in both the test file and the test report together with other tests.

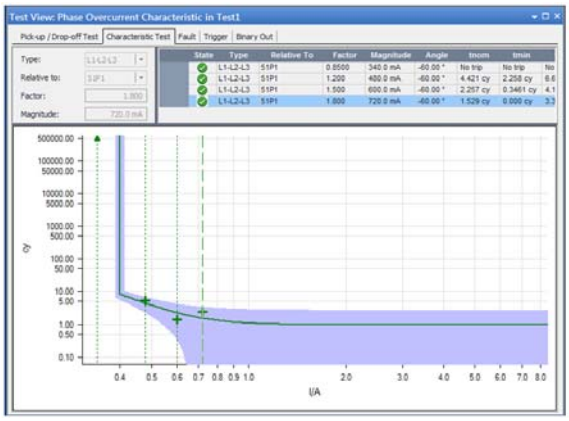

Fig. 5 Automatic executed on phase overcurrent tests with fast curve characteristic verification

On-site test with test plans

On-site test is more challenging since the test are usually conducted outdoor. The testing tasks and workers suffered from the harsh weather condition like heavy rain and strong sunlight. Meanwhile, the time pressure is always there. Therefore, we suggest to use the outdoor equipment with special designed controller with predefined testing plans to conduct the test.

The idea is that the test plan shall be created based on the parameter of the recloser control before going for on-site tests. The test plans are then loaded to the controller with straight forward user interface, as show in Figure 6 below.

Fig. 6 Test plans created on PC and loaded from PC to the controller CMControl

Figure 7 below shows that an engineer is testing the recloser control with test plan on-site. When the engineers go outside, they can just do the connection as shown in Figure 2 and go through the procedures loaded onto the controller. The efficiency is proven to be improved significantly.

Fig. 7 Engineers conduct on-site test on recloser controls with prepared test plans on CMControl

With the routine tests and maintenance easily conducted by using test plans, the engineers in the utilities and service providers can be released from the heavy workload and invest more time into other complex testing tasks, e.g. the distribution restoration scheme tests.

Level 3 Complex Tests on ADR

With the modern testing technique, the conventional tests on recloser control is no longer a challenge for the industry. However, with the implementation and the increasing needs on the Automatic Distribution Restoration (ADR), new challenges come onto engineers' the table.

To verify the scheme with one recloser, the whole sequence of logic needs to be considered in advance. Figure 8 below shows the two options of the recloser in the restoration scheme for either an N/C recloser or an N/O one.

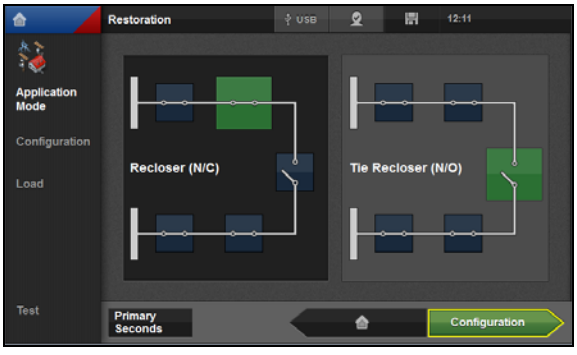

Fig. 8 Testing restoration scheme

With all the needs fulfilled according to the three levels of test on recloser controls, the commissioning and maintenance in the laboratory as well as on-site are no longer challenging. In addition, the workflow of the utilities and service providers are greatly improved and optimized.

Conclusion

It is no doubt that there is an increase trend to install reclosers in Asian countries. The advantage of recloser to the distribution automation and self-healing distribution network are widely acknowledged. The performance of the recloser affects the supply reliability.

This paper aims at raising the engineers' awareness of recloser control testing. The overview about the recloser in Asia are discussed, and several known issues and challenges against the advanced recloser functions are discussed. Furthermore, our paper suggests an advanced testing solution for modern recloser controls. The testing solution from us achieves the goals of have generic accessibility to the recloser control, standardizing testing procedures, test automation, easy repeatability for maintenance purpose, and reducing the complexity for on-site maintenance and calibration.

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About The Author

Naibo Ji was born in 1985 in People's Republic of China. He received his Master's degree in Electrical Engineering at the Hong Kong Polytechnic University. He joined OMICRON in 2011 where he worked as the regional application specialist for Asia-Pacific region with a focus on protection, power quality and recloser testing.

Stephan Geiger was born in 1987 in Austria. Graduated from HTL-Bregenz on electrical engineering, He joined OMICRON in 2008 where he worked as the product manager. With his specialized area on recloser testing, Stephan has the global vision of recloser market and trend. He also wrote many application notes on secondary testing methods.

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Reducing Outages in Distribution by Testing Recloser Controls

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Contents

Introduction Recloser

> All-in-one fault clearing system
> Improves reliability of distribution grid
  > Most faults are temporary
  > Minimize affected outage area for permanent faults
> Modern recloser control functions
  > Overcurrent (directional), load shedding etc.
  > More and more similar to protection relays
> An important component in Smart Grid
  > Automatic Distribution Restoration (ADR)
  > Self-healing grid

Reclosers in Asia

> Widely adopted in Asia
  > China, Philippines, Thailand...

> Historical development
  > Fuse → CB + Sectionalizer → Reclosers

Overcurrent

↓

Voltage protections
Directional overcurrent protections
Sync check
Frequency protections
“Pulse reclosing”

Reclosers in Asia

> Level of implementation
  > (Enabled) Overcurrent
  > (Disabled) Voltage protections
  > (Disabled) Directional overcurrent protections
  > (Disabled) Sync check
  > (Disabled) Frequency protections
  > ...

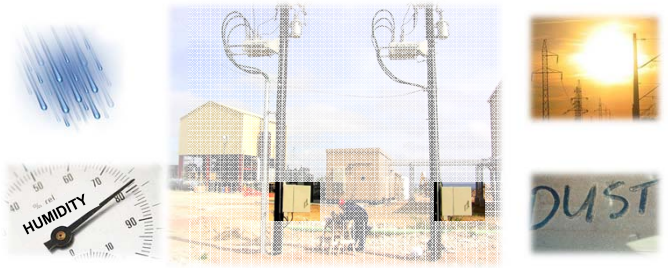
> Reasons?
  > Missing regulations in distribution grid
  > **Lack of good testing solutions**

Testing Reclosers

> Recloser controls are similar to protection relays, but exposed to nature

> Functional tests and parameter tests required

> Testing needs to be done quick and easy



Different testing stages

> Acceptance

> Commissioning

> Scheduled

Different testing requirements at different stages

Challenges during Testing

> Interfacing to the recloser control

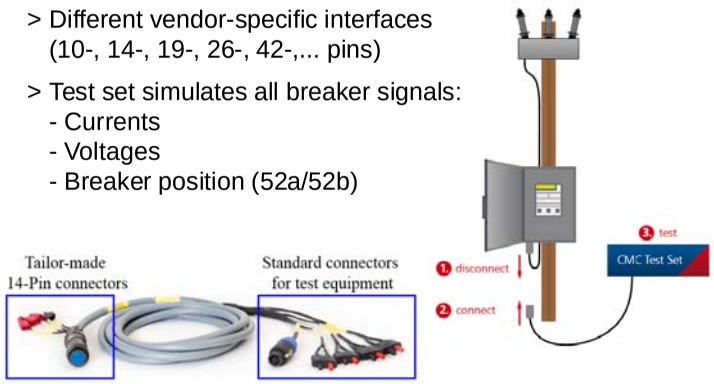
> Tight schedule

> Test equipment:
  > Ease of use
  > Breaker simulator functionality
  > Automation capability
  > Reporting

Connecting to the Controller

> Different vendor-specific interfaces (10-, 14-, 19-, 26-, 42-,... pins)

> Test set simulates all breaker signals:
- Currents
- Voltages
- Breaker position (52a/52b)



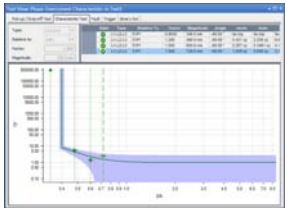
Testing in Lab

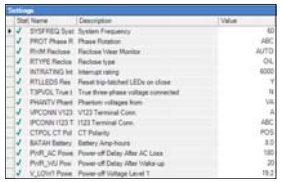
> Using PC-based Test Universe software

> Comprehensive testing

> Test plans

> Advanced test software for all kinds of tests





Field Testing

> Test plans to standardize on testing method

> Fast and easy prepared

> Save time during on-site test

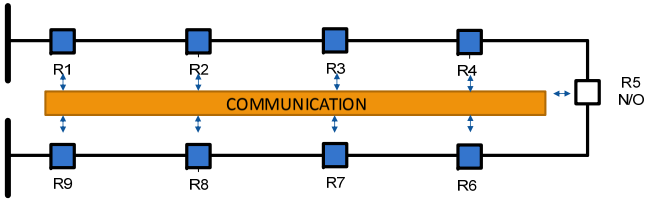
> Automatic reporting

Automatic Distribution Restoration (ADR)

> Distribution grid is becoming smarter

> Communication equipment became available at fast decreasing costs

> ADR allows faster protection and control, but is more complex

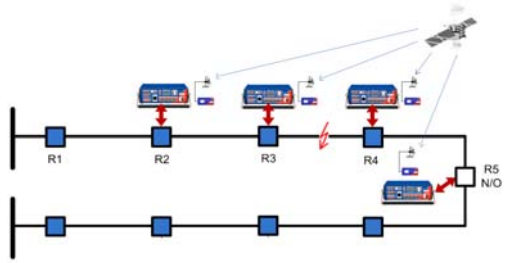


Testing ADR schemes

> Single device tests insufficient

> Test whole scheme with synchronized injection

> Verify scheme in lab and during commissioning



Conclusion

> Reclosers and Sectionalizers are widely used and need to be tested to ensure a reliable distribution grid.

> Tests on reclose controls need generic accessibility to the control device, standardizing testing procedures, test automation, easy repeatability for maintenance purpose, and reducing the complexity for on-site maintenance and calibration.

> OMICRON offers a wide range of interfacing cables to recloser controls of different manufacturers for easy testing.

> Test Universe and CMControl R provide the required testing functionality for manufacturers and utilities to increase reliability with low effort.

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Thank you for your attention!