Fault Location and Service Restoration for Electrical Distribution Systems

Jian Liu | Xinzhou Dong
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Jian Liu
Shaanxi Electric Power Research Institute, China

Xinzhou Dong
Tsinghua University, China

Xingying Chen
Hohai University, China

Xiangqian Tong
Xi'an University of Technology, China

Xiaoqing Zhang
Shaanxi Electric Power Research Institute, China

Shiming Xu
NARI Technology Development Limited Company, China

WILEY

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About the Authors

Professor, Ph.D., Liu Jian (b. 1967) is the Chief Engineer at the Shaanxi Electric Power Research Institute. He is also a Senior Member of IEEE. He has published over 100 papers and nine books on theory, analysis, automation and planning for distribution systems, some of which are used as text books or reference books for university students. Professor Liu's theory and algorithms have been applied in most of the Distribution Automation System (DAS) products and projects in China. As the head of the DAS Testing Group, Professor Liu is responsible for testing the fault processing performance of all the DAS built by the State Grid Corporation of China. He supervises all of the DAS standards of State Grid Corporation. Due to his excellent contribution in electric power engineering, Professor Liu has been awarded national and provincial levels of science and technology prizes 18 times.

Professor, Ph.D., Dong Xinzhou (b. 1963) is a Professor of Electrical Engineering at Tsinghua University. His research interests focus on relay protection for electric power transmission and distribution systems. He is one of the top scientists in traveling-wave based protection and its applications.

Professor, Ph.D., Chen Xingying (b. 1964) is a Professor of Electrical Engineering. She is also the Vice President of Hohai University. Her research interests focus on analysis and control of electric power distribution systems. She is one of the top scientists in self-healing control in China.

Professor Xu Shiming (b. 1967) is the Manager of the Distribution System Branch of the Nanri Electric Automation Corp. He has developed series automation products for electric power dispatching, substation automation, and distribution automation, which are widely used in China.

Professor Tong Xiangqian (b. 1961) is a Professor of Electrical Engineering at the Xi'an University of Technology. His research interests focus on analysis and automatic control of electric power distribution systems with Distributed Generations (DG).

Mr. Zhang Xiaoqing (b. 1970) is the Director of the Electric Power Research Center, Shaanxi Electric Power Research Institute. He is also a senior engineer and the assistant to Professor Liu.

Professor Shi Shenxing (b. 1975) is an Associate Professor of Electrical Engineering at Tsinghua University. He is assistant to Professor Dong.

Preface

This book is the English edition of *Fault Location and Service Restoration for Electrical Distribution Systems* published by the China Electric Power Press (Beijing, 2013), published in Chinese. It is revised and expanded and some of the contents of another book written by the authors, that is, *Relay Protection and Fault Processing for Distribution Systems* published by China Electric Power Press (Beijing, 2014), have been combined in this book, with particular emphasis on the contributions of the authors.

Fault location and service restoration for distribution systems is realized by Distribution Automation System (DAS). The authors are practitioners in China and they are experts in theory, technique, manufacturing, and engineering of DASs. Professors Liu and Zhang are from the research institute, one of the top teams on distribution automation technology and testing techniques. Professors Dong, Chen, and Tong are from universities that are famous for distribution system theory investigation. Professor Xu is from Nari Corp., which is the largest manufacturing enterprise of DASs in China. The contents of this book are the contributions of these authors.

After long-term engineering practice, the authors realized that the simpler the DAS, the more reliable it is. Thus, the authors proposed simple modeling, analysis, and optimization approaches for DASs, with which, not only is the problem of a lack of measuring data solved, but also the decision making time is reduced.

The authors also realized that the local intelligence based fault processing technologies are faster and more reliable; the distribution intelligence based fault processing technologies, such as coordination of reclosers and sectionalizers, are simple and cost effective; the centralized intelligence based DAS may locate the fault over a smaller area and restore the service in an optimized strategy, thus a complicated fault may be processed satisfactorily. Therefore, fault processing performance may be improved by coordination of the three types of fault processing technologies. The authors' experiences are the main contents of this book, which have been applied in DAS projects in over 70 cities in China.

The contents of this book are organized into six chapters. In Chapter 1, the progresses in fault processing for distribution grids are overviewed and the prospects are given. In Chapters 2–4, the interphase short circuit fault processing technologies based on local, distributed, and centralized intelligence are described, respectively. In Chapter 5, the single phase to ground fault processing technologies for neutral non effective grounding distribution systems are described. In Chapter 6, some practical aspects of fault processing are discussed, such as coordination of various fault processing approaches, planning of terminal units in DAS, and the testing and verification of fault processing performance.

In this book, Professor Liu translated and re-organized the contents of Chapters 1, 4, and 6. Professor Dong and Dr. Shi translated the contents of Chapter 5. Professor Tong translated and re-organized the contents of Chapter 2. Professor Chen translated and re-organized the contents of Chapter 3. The other authors of the Chinese version of this book carefully checked the translated manuscript.

The authors wish to thank many good friends and colleagues, including especially Professor Shen Bingbing, Professor Zhao Jianghe, Professor Liu Dong, Professor Song Guobing, Mr. Chen Yikai, Mr. Zhao Shuren, Mr. Zhang Zhihua, and Mr. Liu Bin for their encouragement and willing support, without which this book would never have been completed.

Liu Jian
Professor, Ph.D.

1

Progresses and Prospects for Fault Processing in Distribution Grids

Liu Jian

Abstract
Progresses in fault processing technologies for electrical power distribution grids are overviewed, including progresses in local, distributed, and centralized intelligence-based interphase short circuit fault location and isolation, and service restoration, as well as progresses in single-phase-to-ground fault processing. The prospects for fault processing technologies in electrical power distribution grids are discussed.

Keywords
distribution grids, overview, prospects, interphase short circuit fault, single-phase-to-ground fault, fault location, fault isolation, service restoration, relay protection, distribution automation system (DAS), feeder automation (FA)

1.1 Introduction

According to statistics, failures in distribution grids cause more than 85% of outages due to faults. Thus, fault processing technologies for distribution grids are of great importance in improving service reliability.

Faults can be divided into two categories: interphase short circuit faults and single-phase grounding faults. These faults can then be further divided into permanent and temporary faults.

Fault Location and Service Restoration for Electrical Distribution Systems, First Edition. Jian Liu, Xinzhou Dong, Xingying Chen, Xiangqian Tong, Xiaoqing Zhang and Shiming Xu.

As for earth-neutral systems, fault processing technologies for interphase short circuit faults and single-phase grounding faults are the same. However, for neutral ineffective grounding systems, such as those in China, systems are allowed to operate under single-phase grounding fault conditions for no more than 2 hours in order to ensure service reliability. The position of a single-phase grounding fault should be located and repaired in time to avoid causing an interphase short circuit fault. Interphase short circuit faults should be cleared immediately and as many affected healthy regions should be restored as quickly as possible.

The fault processing technologies can be classified into three types: (1) fault processing based on local intelligence, (2) fault processing based on distributed intelligence, and (3) fault processing based on centralized intelligence.

Fault processing approaches based on local intelligence were the earliest technologies in which neither a communication system nor master station is needed. The decision is made based solely on the information collected at the local position. Fault processing approaches based on local intelligence are still used today and include relay protection, automatic reclosing control, and backup automatic switching control. They have the advantage of fast speeds. However, the coordination of over-current protection is rather difficult in some cases, such as the feeder trunk in an urban area. Automatic reclosing control is suitable for feeders with overhead lines. Backup automatic switching control may switch the load to the backup power supplying route in several seconds, but it is only effective for loads with more than one power supplying route.

Feeder Automation (FA) based on recloser and voltage-delay type sectionalizers, reclosing with a fast over-current protection mode, and the fast healing approach based on neighbor communication, are three typical technologies of fault processing approaches based on distribution intelligence. FA based on recloser and voltage-delay type sectionalizers was invented by Japanese engineers in the 1970s and has been successfully used in Asia for several decades, but it needs reclosing twice. Reclosing with the fast over-current protection mode is an improved approach that only needs reclosing once, but requires circuit breakers instead of the former's load switches. Both FA based on recloser and voltage-delay type sectionalizers and reclosing with a fast over-current protection mode do not require communication systems and the whole feeder must undergo a period of outage. With the fast healing approach based on neighbor communication, the fault area can be located and isolated immediately and the healthy areas are hardly affected by the fault. However, high speed communication and reliability are both needed. Besides, the sectionalizing switches should be circuit breakers.

The typical technology of fault processing based on centralized intelligence is the Distribution Automation System (DAS), which consists of a master station, some sub-working-stations, a large number of Feeder Terminal units (FTU), and the communication system. Since global information can be collected, the fault location area of DAS can be much smaller and the service restoration schemes may be optimized. But DAS based fault processing needs a rather long time period, typically several minutes.

With the increasing of the amount of Distribution Generations (DG) in distribution grids, fault processing technologies coping with such challenges have been achieved.

In this chapter, the progress in fault processing technologies will be overviewed, and included is most of the literature written by the authors, which is also included in the following chapters of this book.

1.2 Progresses in Local Intelligence-Based Fault Processing

Although relay protection technologies have been used in electrical power systems for a long time, the coordination of relay protection is rather difficult in some distribution grids, such as short length urban feeders.

In many utilities, one over-current relay protection is coordinated with one or two fuses. Even on the output circuit breaker of a feeder in the substation only one over-current protection is installed. Coordination and setting of three-section overcurrent protection is investigated in References [1]–[4]. It is pointed out in [5] that interphase short circuit currents along the sectionalizing switches of a short length urban feeder are almost the same, thus the coordination of three-section overcurrent protection is difficult. An approach of time-delay coordination of the over-current relay protection scheme is suggested, in which outage on the trunk can be avoided in case of branch fails and outage on the branch can be avoided in the case of lateral fails. Four modes of hybrid schemes of three section overcurrent protection and time-delay over-current coordination are proposed in [4], which are commonly used in Chinese utilities. The coordination of over-current protection with FA based on recloser and voltage-delay type sectionalizers is described in [6].

Automatic reclosing control and backup automatic switching control also have a rather long history of application. Reference [7] describes a scheme suitable for switches on the branches or laterals of a feeder. Reference [8] describes a coordination scheme of backup automatic switching control with DAS for an area requiring high service reliability.

The local intelligence-based fault processing technology will be detailed in Chapter 2.

1.3 Progresses in Distributed Intelligence-Based Fault Processing

A family of switches with distributed intelligence are described in Reference [9] including FA based on recloser and voltage-delay type sectionalizers, FA based on coordination of reclosers, and FA based on recloser and over-current counting type sectionalizers.

FA based on recloser and voltage-delay type sectionalizers invented by the Toshiba Co. is the most widely used technology. Hai and Chen imported the technology from Japan to China and set up production lines for mass manufacture. The basic principle of FA based on recloser and voltage-delay type sectionalizers is described in References [10]–[12]. The appropriate setting of the recloser and voltage-delay type sectionalizers is the critical application problem, which is investigated based on a hierarchical model in Reference [13] and a program is also used to calculate the setting values for arbitrary grid topologies is developed.

Reclosing with a fast over-current protection mode is another distributed intelligence-based fault processing technology, the basic principle of which is described in Reference [14]. But the method in [14] has some limitations, such as long restoration time for temporary faults and enlargement of fault isolation area due to overload. Improvements are made in [15]. The duration time of temporary fault restoration is considerably reduced by adding a time delay mechanism to the tripping procedure of sectionalizers in the case of out-of-voltage. The drawback of enlarging the outage area due to overload is avoided by introducing an out-of-voltage lock mechanism into sectionalizers and loop switches, respectively. A linear planning approach is also proposed for optimizing the setting values in [15].

The approach of FA based on recloser and voltage-current mode switches is described in [16], which can be regarded as the combination of FA based on recloser and voltage-delay type sectionalizers and reclosing with a fast over-current protection mode.

These distributed intelligence-based fault processing approaches do not need communication systems and have played a great role, but they have some drawbacks, such as setting values should be adjusted in the field when the operation mode is changed.

Some distributed intelligence-based fault processing approaches with communication systems are published in [17]–[20]. A fast healing approach based on communication with GOOSE among the adjacent FTUs is described in [17], which is the typical scheme for distributed intelligence-based fault processing approaches with communication systems. The basic approach in [17] is improved in [18], in which both temporary fault and permanent fault can be located and isolated immediately without override tripping and it works well even in cases where a few switches fail to control. Other progresses also requiring communication systems are described in [19]–[20].

The distributed intelligence-based fault processing technology will be detailed in Chapter 3.

1.4 Progresses in Centralized Intelligence-Based Fault Processing

Centralized intelligence-based fault processing is the core technology of centralized intelligence-based distribution automation systems, which is always a hot topic of research, and there have been many achievements.

1.4.1 Fault Location

A unified matrix based algorithm for fault section detection and isolation in distribution systems is put forward in [21], which is improved in [22]. But the matrix based methods require both space and long calculation times for large scale distribution grids.

A fault location approach based on a directed graph is proposed in [23] without calculating a matrix. In [24], a large scale distribution grid is divided into many small scale connected systems consisting of some connected feeders and a fault may be processed in its corresponding connected system, thus the space and calculation time can be greatly reduced no matter how large scale the distribution grid is.

In [25] a hierarchical model based algorithm of fault section diagnosis for distribution networks is suggested. A fault location method based on pattern identification is described in [26]. A multi-objective distribution network restoration using an heuristic approach and a mixed integer programming method is proposed in [27]. A multi-agent based fault processing approach is described in [28].

In the field of robust fault location in case of insufficient information, there have been many achievements, which make the fault location program more usable in practice. In [29] and [30] a genetic algorithm is introduced into fault location to improve its robustness. A data mining approach based on the combination of a rough set with a neural network is described in [31] to solve the fault section identification problem in cases of insufficient information. A fuzzy reasoning approach for robust fault location in a distribution automation system is introduced in [32] and [33]. Uncertainty reasoning approaches based on Bayes probability theory for fault location in distribution grids are put forward in [34]–[37]. An integrated intelligent service restoration system for a distribution network with an auto-learning fuzzy expert system is described in [38].

As for the field of fault location for distribution systems with Distributed Generation (DG), many progresses have been reported. In [39] and [40], the influence of Distributed Generation (DG) on relay protection is investigated. The influence of DGs on types of synchro generator, asynchronous generator, and invertor on the short circuit current of distribution grids and the corresponding analyses are investigated in [41]–[43]. In [44], the suitable range of the traditional fault location approach based on over-current information for distribution systems with DGs is investigated, showing that the suitable range is rather wide, especially for overhead lines. In [45], an improved fault allocation process is proposed for overhead line-based feeders, in which the reclosing procedure and escaping DGs in fault situations are coordinated.

1.4.2 Fault Isolation and Service Restoration

Heuristic approaches are widely used to solve service restoration problems very quickly. In [46], a multi-objective distribution network restoration approach using an heuristic approach and mixed integer programming method is put forward. In [47], an optimal restoration algorithm of distribution systems using dynamic programming is described. In [48], the priority of customers is considered in service restoration. In [49], service restoration is improved through load curtailment of in-service customers. An approach to location and restoration of a short circuit with two phases grounded to the earth in non-effectively earthed distribution systems is described in [50].

Modern optimization methods [51]–[58], such as genetic algorithms, evolutionary algorithms, NSGA-II, expert-systems, Tabu searches, and so on, have been introduced into the service restoration field, which improve the restoration performance, but calculations are greatly increased.

To improve power supplying capacity, modeled topologies are built in many countries, such as three-sectioned and three-linked grids, three-supplying and one back-up grids and a 4 × 6 connection grids. But the advantages of modeled topologies may be realized by the corresponding service restoration schemes, which are described in [59] and [60].

Service restoration to avoid a breakdown over a large area – in cases of one or more bus loss of voltage due to a fault on the bus, substation, transmission line, or a transmission tower collapse – is also investigated. In [61], a mathematical algorithm for service restoration to avoid a large area breakdown is put forward. In [62] and [63], a Tabu search-based algorithm of restoration for large area blackout is described, which may form more complicated index and constraint conditions than the approach in [61]. A switching operation sequence management method is also suggested in [63]. A CSP-based model and algorithm of service restoration for large area distribution system blackout is introduced in [64]. An Agent-Environment-Rules (AER) model-based algorithm of service restoration for large-area distribution system blackout is described in [65].

Centralized intelligence-based fault processing technology will be detailed in Chapter 4.

1.5 Progresses in Single-Phase Grounding Fault Processing

A single-phase-to-ground fault is a kind of fault commonly happens in a power distribution system. Depending on the different types of neutral grounding in a power distribution system, the fault characteristics and effects are different, which require different solutions.

For single-phase-to-ground faults in power distribution systems with effective neutral grounding, zero-sequence over-current protection can detect the fault correctly. However, if it is a high impedance fault, which occurs frequently in power distribution systems, the fault characteristics are not obvious and over-current protection may malfunction. References [66]–[68] discuss high impedance faults in power distribution systems with effective earthing, zero-sequence inverse time over-current protection and third harmonic current based protection, which lays the foundation for high impedance fault detection.

A single-phase-to-ground fault generated zero sequence current is small in non-earthed power distribution system, which requires a protection-issued alarm signal, sometimes the trip signal. In order to compensate for the capacitive current when a single-phase-to-ground fault occurs, the Peterson coil is installed at earth, which may minimize the loss but makes it more difficult to protect the single-phase-to-ground faults in such a system.

For a single-phase-to-ground fault in power distribution systems with ineffectual earthing, reference [69] studies a single-phase-to-ground fault feeder selection using a zero-sequence current in all feeders radiating from the same bus bar and proposes a feeder selection method based on all feeders' current amplitudes and phase comparison. References [70]–[72] analyze single-phase-to-ground fault generated traveling waves in a fault superimposed network and verify that the initial traveling waves generated by single-phase-to-ground faults are independent of the method of neutral grounding, which presents a novel approach to solving the problem of single-phase-to-ground fault feeder selection in power distribution systems with poor earthing and a novel technology based on traveling waves.

Up to now, current traveling wave analysis based on single-phase-to-ground fault feeder selection in non-earthed power distribution systems have been widely used in the field. Traveling wave information during a permanent fault is recorded, which lays the foundations of research of fault prevention. References [73] and [74] propose the idea of single-phase-to-ground fault prevention based on traveling wave analysis. The idea can prevent faults based on fault precursors.

After a single-phase-to-ground fault occurs, accurate fault location can help maintenance staff to arrive at the fault point to remove the fault and recover power supply, which can improve power supply reliability but also reduce the workload for the line patrol and improve efficiency. References [75] and [76] analyze single-phase-to-ground fault generated initial traveling waves and present single-phase-to-ground fault location based on the time difference between single-phase-to-ground faults generated at the initial line module traveling wave and initial zero module traveling waves, which makes it possible to locate single-phase-to-ground faults in non-earthed power distribution systems.

Chapter 5 introduces single-phase-to-ground fault types and their protection strategies, focuses on high impendence fault in power distribution system with earthing through resistance and single-phase-to-ground faults in ineffective earthed power distribution systems, analyzes high impendence fault detection methods, and presents single-phase-to-ground fault feeder selection, and single-phase-to-ground fault protection, prevention, and location.

1.6 Prospects

Centralized intelligence, distributed intelligence, and local intelligence-based fault processing approaches have their respective advantages and limitations. Fault location and restoration approaches based on the coordination of centralized, distributed, and local intelligence are promising, in which the performance of fault isolation and restoration for distributed grids can be greatly improved. The coordination of centralized, distributed, and local will be detailed in Section 6.2.

The simpler a system, the more reliable it is. From another point of view, the fewer the terminal units, the more economical the system is. The planning approach to determine the amount of various kinds of terminal units to meet the reliability of service requirement is important, which will be detailed in Section 6.3 (Chapter 6).

Verification of fault processing performance of the centralized intelligence-based DAS, local intelligence-based relay protections, and distributed intelligence-based DAS is significant in guaranteeing the construction quality of DAS. The coal technology is the test technique, which will be detailed in Section 6.4.

2

Fault Processing Based on Local Intelligence

Tong Xiangqian and Liu Jian

Abstract
The connection of distributed generation in traditional single-ended source systems makes it possible to mesh the grid to a multi-ended source network, and the original three-section over-current protection with auto-reclosing will be no longer suitable. Various improved solutions to deal with the influence of grid-connected DG and inrush current from unloaded transformers, such as adding power direction elements and adopting multistage protection coordination, are proposed in this chapter.

Keywords
relay protection, reclosing, three-section over-current protection, multistage protection coordination, distributed generation, differential protection, magnetizing inrush current, second harmonic braking, coordination mode, setting principle

2.1 Introduction

This chapter discusses fault processing based on devices with local intelligence, including two types of automatic switch coordination methodologies: one without communication and one approach requiring high speed, reliable communication systems.

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2.2 Fault Processing Based on Local Intelligence for Distribution Networks

2.2.1 Auto-Reclosure Control

The Auto-Reclosure Device (ARD) is such an autonomous device that it automatically interrupts and recloses the circuit breaker with a preset sequence of opening and reclosure when a fault occurs in the power line. The installation of an ARD in the distribution network can greatly improve the power supply reliability and reduce outage cost.

More than 80% of faults on overhead lines are temporary faults, which are caused by insulator surface flashover due to lightning, line-to-branch discharge, and/or one line touching another due to high winds or birds. When the fault line is disconnected, the dielectric strength of the fault point will be restored and the fault will be cleared automatically. Power service will be restored if the breaker recloses automatically at this moment.

ARDs can be divided into three-phase single-shot reclosing, double-shot reclosing, and tri-shot reclosing according to the reclosing times for a fault. Statistics show that up to about 80% of faults can be successfully restored by three-phase single-shot reclosing so, in China, power lines of 35 kV and less are usually equipped with three-phase single-shot reclosing devices.

ARDs should follow the following basic principles:

1. ARDs should be put into use under normal conditions and should reclose the breaker when it trips due to the relay protection device.
2. ARDs should not reclose the breaker when the operator disconnects the breaker by the control switch or the remote control device and the operator switch onto the fault manually and then trips the breaker by relay protection device.
3. The start condition of an ARD is on the principle of discrepancy, that is, the ARD gives a reclosing operation only when the control switch is on but the breaker is actually off.
4. The operating times of ARDs should be consistent with pre-specified times (such as the single-shot reclosing device can reclose the breaker only once).
5. The operating time of ARDs should be adjustable. These times should be greater than the time needed for a fault breaker and recovery of the dielectric strength of the surrounding medium, as well as for restitution and preparation for reclosing the circuit breaker and operating mechanism once more. Usually, this time is set to 0.5~1.5 s.
6. Once the ARD recloses the breaker, it should be reset automatically and ready for the next reclose.
7. The ARD should coordinate with protection devices in the system to realize the instant accelerated protection trip or the delayed accelerated protection trip.

The operating process of an ARD is as follows: for a radial distribution network, when a fault occurs, the line breaker should be opened first by protection devices, then

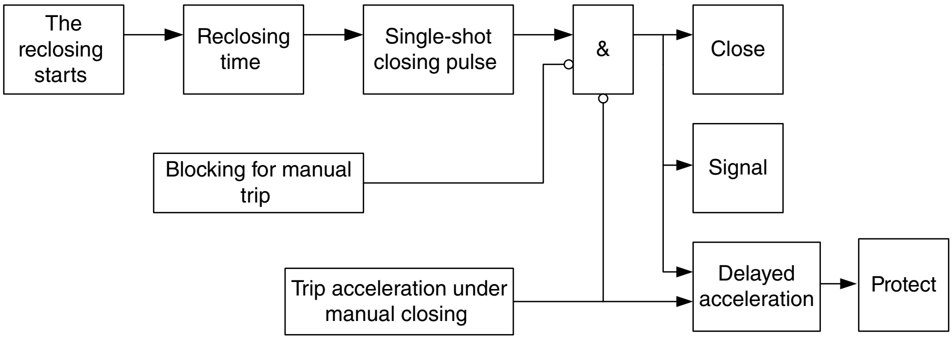

Figure 2.1 The principle diagram of three-phase single-shot reclosing

the Auto-Reclosure Device is started and recloses the circuit breaker again after a preset delay time. If the fault is temporary, reclosing will be successful and hence the power line service is restored. But if the fault is permanent, the protection system will soon let the breaker trip again after reclosure and thereafter the ARD will not reclose the breaker again.

The three-phase single-shot reclosing device is mainly composed of the starting unit, reclosing time unit, single-shot closing pulse unit, blocking device for manual trip, and trip acceleration unit under manual closure on a fault, as shown in Fig. 2.1. For a permanent fault caused by un-removed ground wire for security and unrepaired defect in the network, the re-trip of the breaker should be accelerated as much as possible to guarantee selectivity, which needs the coordinated operation of protection system and ARD.

Unlike the ARD used in the radial distribution feeder, for the ARD used in the two-source distribution network, the following two issues must be considered. (1) The ARD should reclose the breaker only after breakers on both sides of the fault point are tripped in order to extinguish the electric arc and restore the insulation strength. (2) The breaker must be closed under synchronous conditions in order to avoid electric shock at the moment of closing.

2.2.2 Automatic Backup Switching Control of the Reserve Source

The Automatic Backup Switching Control is also called as the Auto-Put-into Control. An Auto-Put-into Device of a reserve source (APD) is an automatic control device that, in the two-source system, when one source loses its voltage for some reason, it can switch the loads to another reserve-source automatically, quickly, and accurately in order to avoid interruption of the power supply and significantly improve the reliability of the electric grid.

Generally the connection of the reserve-source can be divided into standby wirings and alternate wirings, which influences the configuration of the APD, as shown in Fig. 2.2.

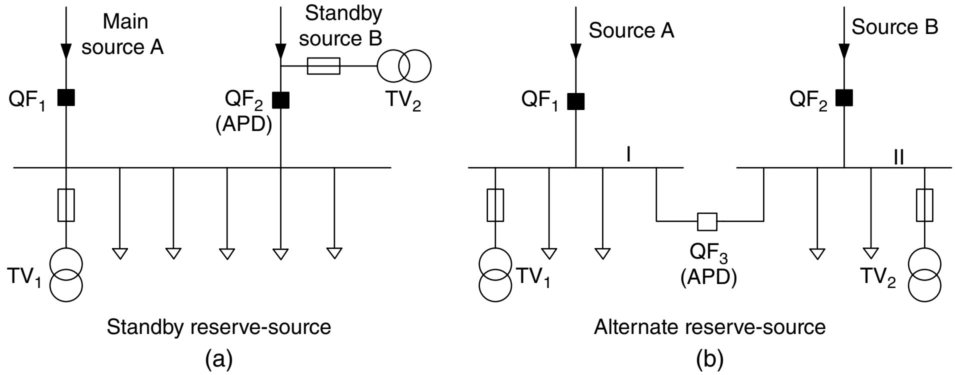

Figure 2.2 The wiring of reserve-source (a) and APD configuration (b)

There are two sources in the standby wiring; one is a main source and the other is a standby source. When the main source outage is caused by fault or maintenance, the standby source is then put to work. As shown in Fig. 2.2 (a), the APD is installed at the incoming circuit breaker QF2 of the standby source. Under normal circumstances, the bus is supplied by the main source, while the standby source is in standby state due to the breaker opening at QF2. When there is a fault in the main source, the APD will take action, the circuit breaker QF1 will be tripped, the circuit breaker QF2 will be automatically closed, and the standby source will be put to work.

There are also two sources in the alternate wirings, but they respectively provide power to their own loads under normal circumstances and mutually back each other up. When one source is out, its original load will be transferred to the other source. As shown in Fig. 2.2(b), the APD is installed at the bus-tie circuit breaker QF3. Under normal circumstances, the bus-tie breaker is in the open state, two sources supply power to the loads connecting to their own bus separately, and they are the reserve-source for each other through the breaker QF3. If bus I loses voltage due to a fault at source A, then the APD will take action, breaker QF1 will be tripped, and breaker QF3 will close automatically, thereafter the loads on bus I will be supplied by source B.

The APD of the reserve-source should comply with the following principles:

1. When one source loses its voltage, the APD should disconnect this source and then put the reserve source into service to ensure the power supply is uninterrupted.
2. The APD should not operate if a fault occurs on the load side and causes the source incoming breaker to be tripped by the protection device. The APD should not operate if the reserve source is not in service either.
3. When the working source has a planned outage, the APD shouldn't operate in order to prevent the reserve source from being put to work.
4. When the fuse of the voltage transformer is blown or the voltage transformer is disconnected by a switch, the APD should not operate.