ICS 27.100
P 62
Record No. J150—2002

DL

Electric Power Industry Standard of the People's Republic of China

P DL / T 5147 — 2001

Designing Technical Rules for Security and Automaticity Equipment of Power System

Issue Date: December 26, 2001 Implementation Date: May 1, 2002

Issued by the State Economic and Trade Commission of the People's Republic of China

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Drafted by: Northeast Electric Power Design Institute of State Power Corporation
Approved by: State Economic and Trade Commission of the People's Republic of China
Approval Document No.: No. 31 Announcement Issued by State Economic and Trade Commission of the People's Republic of China in 2001

Translation sponsored by: China Electric Power Planning & Engineering Association
Translated by: SUNTHER Consulting Co., Ltd.
Reviewed by: Northeast Electric Power Design Institute of State Power Corporation

CHINA ELECTRIC POWER PRESS
BEIJING, 2001

图书在版编目（CIP）数据

DL/T 5147—2001 电力系统安全自动装置设计技术规定：英文 / 中华人民共和国国家经济贸易委员会发布. —北京：中国电力出版社，2013.5

ISBN 978-7-5123-4404-4

Ⅰ. ①D… Ⅱ. ①中… Ⅲ. ①电力系统–安全装置–自动装置–设计规范–中国–英文 Ⅳ. ①TM774-65

中国版本图书馆 CIP 数据核字（2013）第 089398 号

中国电力出版社出版

（北京市东城区北京站西街 19 号 100005 http://www.cepp.sgcc.com.cn）

北京博图彩色印刷有限公司印刷

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2013 年 5 月第一版 2013 年 5 月北京第一次印刷

850 毫米×1168 毫米 32 开本 1 印张 21 千字

Contents

Foreword

These rules are prepared in response to the *Notice on Planned Programs of Scientific Research, Standardization and Information for Electric Power Survey and Design in 1995* issued by the Electric Power Planning and Design General Institute of State Power Corporation. They are prepared through extensive investigations, reference to similar domestic and international standards and seeking comments from the organizations and experts in the electric power industry in China.

These rules are in line with the principles specified in GB 14285—1993 *Technical Code for Relaying Protection and Security Automatic Equipment*, SD 131—1984 *Technical Guidelines for Power System (trial)* issued by the Ministry of Water Resources and Electric Power, and DL 755—2001 *Guide on Security and Stability for Power System*, and is prepared for the design of security and automaticity equipment of power system.

Appendix A to these rules is informative.

These rules are proposed by the Technical Committee on Electric Power Planning and Engineering of Standardization Administration of Power Industry.

These rules are under jurisdiction of the Technical Committee on Electric Power Planning and Engineering of Standardization Administration of Power Industry.

The drafting organization of this standard is Northeast Electric Power Design Institute of State Power Corporation.

The main drafters of these rules include Zhang You and Zuo

Changchun.

These rules are explained by the Technical Committee on Electric Power Planning and Engineering of Standardization Administration of Power Industry.

These rules are translated by SUNTHER Consulting Co., Ltd. under the authority of China Electric Power Planning & Engineering Association.

1 Scope

These rules stipulate the principled requirements on calculation and analysis of security and stability of power system, design and configuration of security and automaticity equipment during the design of power system and are applicable to the design of security and automaticity equipment of power system, the design of security and automaticity equipment necessary for connecting power plants and substations to power system as well as the study on configuration schemes of security and automaticity equipment.

2 Normative References

The following normative references contain provisions which, through reference in this text, constitute provisions of these rules for dated references, subsequent amendments to (excluding error corrections), or revisions of, any of these publications do not apply. When these rules are published, the revisions shown herein are in force. However, parties entered into agreements based on this code are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest editions thereof shall apply.

GB 14285—1993 *Technical Code for Relaying Protection and Security Automatic Devices*

DL/T 559—1994 *Code for Operation Settings of Relay Protection Equipment in 220–500 kV Power Grids*

DL 428—1991 *Technical Rules for Automatic Low Frequency Load Shedding of Power System*

DL755—2001 *Guide on Security and Stability for Power System*

SD 131—1984 *Technical Guidelines for Power System (trial)*

3 General

3.0.1 The design of security and automaticity equipment of power system shall comply with the requirements of DL 755—2001 *Guide on Security and Stability for Power System.* The security and automaticity equipment of power system can be classified into the following categories by their functional applications: equipment to automatically prevent loss of stability, equipment to automatically eliminate asynchronous operation, equipment to eliminate frequency or voltage deviations that may lead to accident evolvement or damages to equipment, and equipment to restore normal operation of power system.

The security and stability control system of power system is mainly intended to prevent loss of stability of power system and avoid the system accidents of power system, such as large-scale blackouts.

3.0.2 The security and automaticity equipment of power system should preferably employ simple, reliable, proven and effective equipment that are deployed in a distributed manner. Various equipment intended for different controlled objects shall be able to work collaboratively.

3.0.3 The hardware of power system stability control equipment shall be universal to a certain degree, while its software shall be modularized to allow for the system evolvement.

3.0.4 A proper power grid structure that meets the requirements in SD 131—1984 *Technical Guidelines for Power System* (*trial*) and DL 755—2001 *Guide on Security and Stability for Power System* provides an important physical guarantee for the safe and stable operation of power system. Under normal power grid structure conditions, the conventional measures for improving the stability are sufficient to guarantee the safe and stable operation of power system under a single fault condition. However, in order to deal with multiple faults that may give rise to detrimental cascading responses which result in a major accident across the power grid, a proper grid structure must be established, accompanied with the necessary automatic control measures for ensuring system security and stability.

3.0.5 When establishing the guiding strategy for addressing the security and stability problems of power system, it is necessary to make provisions for the most severe situations that may arise and take pre-established measures as practical as possible in order to prevent system collapse, extended large-scale blackouts and catastrophic blackouts affecting major users (including power plants where the auxiliary power is essential), reduce the power load less to the minimum and restore the system to normal operation following a severe accident. To prevent further deterioration of the system conditions, it is imperative to take actions to protect the whole system at the expense of the loss of local systems thereby avoiding the significant damage to the system.

3.0.6 As the correct operation of relay protection equipment and fast fault clearing are essential for the safe and stable operation of power system, efforts shall be made to improve the operation performance of the relay protection equipment so as to improve the stability level of power system.

3.0.7 When selecting the configuration scheme of security and automaticity equipment of power system and in order to assess the economical benefits of these equipment that are provided and put into service, one shall give more consideration to the correct functioning of these equipment which is essential for improving the stability limit of power system, increasing the power transmission capacity and guaranteeing both the social and economical benefits resulting from supplying electric power to users uninterruptedly which are to be compared with the required investment costs of these equipment.

4 Terms and Definitions

4.1

Security and Automaticity Equipment of Power System

An automatic protection device which can prevent the loss of stability of power system and avoid large-scale blackouts in power system, including auto-reclosing device on transmission lines, power system stability control device, automatic power system splitting device, low frequency load shedding devices and under voltage load shedding devices.

4.2

Stability Control Device of Power System

An integrated automatic device which can automatically protect the power system from loss of stability. The power system stability control devices can be of distributed or centralized structures. Distributed devices can process the local information and make decisions, or transmit commands via additional channels to achieve local or remote control. For centralized devices, in addition to the local information, they can collect the relevant information at other points through information channels and comprehensively process such information, make decisions, issue control commands locally or to other points via information channels.

4.3

Automatic Splitting Device of Power System

A device which can automatically disconnect the power system at predetermined suitable sites in a planned way, or automatically disconnect a power plant and its load from the main power system appropriately so as to damp out the power oscillation in the event of out-of-step oscillation, collapse of frequency or voltage of power system. Depending upon the nature of the system accidents and the application conditions and installation sites of the devices, the power system automatic splitting devices can be classified into three categories, namely, oscillation splitting device, (high/low) frequency splitting device and under voltage splitting device.

4.4

Low frequency Load Shedding Device

A device which can automatically switch off some power consuming loads to rapidly restore the frequency to be within the permissible range thereby avoiding the frequency collapse in the event that accidents occur in the power system leading to rapid and significant drop of frequency, also referred to as automatic low frequency load shedding device.

4.5

Under voltage Load Shedding Devices

A device which can automatically switch off some loads to restore the operating voltage to be within the permissible range in order to prevent voltage collapse due to insufficient reactive power compensation following accidents or when load increases to exceed the predicted value.

4.6

Auto-reclosing

An automatic operation cycle in which, after overhead lines or busbar are disconnected due to faults, the opened circuit breaker is automatically closed after a preset short-time delay to energize the de-energized power components once more; if the faults still persist, the protection devices will operate to open the circuit breaker once more. It mainly consists of three-phase reclosing, single-phase reclosing and synthetic reclosing.

4.7

Measures in Secondary System to Improve Power System Stability

A general term for all types of automation measures which are taken to improve stable operation of power system through operating the automatic devices to control and adjust the operation status of power components and equipment in the event of emergencies or accidents. These measures include fast fault clearing, generator tripping, rapid reduction of output of prime movers of thermal power units, electrical braking, quick-response excitation of generators and concentrated load shedding.

4.8

Disturbance

A sudden great and substantial change in status of power system due to short circuiting or unscheduled tripping of system components.

4.9

Connection and Power Section

Connection refers to a combination of power grid components (for example, transmission lines and transformers) that are used to connect two parts of the power system. The concept of connection may also involve intermediate power plants and key load points. A power section refers to one or more than one connection component, which, once disconnected, cause the power system to be separated into two independent parts.

5 Principle for Calculation and Analysis of Security and Stability of Power System

5.1 Operating Mode for Stability Calculation

When calculating and analyzing the stability of power system, the operating mode that is the most unfavorable to the stability shall be selected from the following three modes for checking the stability of the specific objects (for example, lines and busbar).

5.1.1 Normal Operating Mode

Normal operating mode includes normal maintenance operating mode and various possible short-time steady-state operating modes including increasing hydropower output, increasing thermal power output, operating with the maximum or minimum loads and operating with the minimum output according to the load curve and seasonal changes.

5.1.2 Post-fault Operating Mode

Post-fault operating mode refers to the short-time steady-state operating mode that occurs before the power system restores to normal operation following fault clearing.

5.1.3 Special Operating Mode

Special operating mode refers to the situation where trunk lines and large-scale interconnecting transformers are under repair or other operating modes that may severely affect the stable operation of power system.

5.2 Fault Types for Stability Calculation

5.2.1 Type I (Single Minor Faults)

1 Successful reclosing of any lines following single-phase transient ground faults;

2 In case of double circuits or multiple circuits of lines at the same voltage level, unsuccessful reclosing of any circuit following single-phase permanent ground faults and three phases' failure to reclose after being disconnected without any fault occurring;

3 Tripping or loss of excitation of any generator unit;

4 Sudden change in any large load in the system (such as impulse load or sudden switching off of a large load).

5.2.2 **Type II (Single Severe Faults)**

1 Single-circuit lines' unsuccessful reclosing following single-phase permanent ground fault and three phases' failure to reclose after being disconnected without any fault occurring;

2 Busbar faults;

3 In case of an electromagnetic loop network at two voltage levels, fault of single-circuit lines at higher voltage level or three phases' failure to reclose after being disconnected without any fault occurring;

4 In case of double circuits of lines erected on the same tower, two phases with different designations fail to reclose following simultaneous single-phase ground faults, or simultaneous tripping of double circuits;

5 Any single line accounting for a large proportion of system capacity or tripping or loss of excitation of generator units;

6 Three-phase short-circuiting of outgoing lines of power plants.

5.3 **Fault Clearing Time for Stability Calculation**

Fault clearing time consists of the time for total opening of circuit breaker and that for operation of protective relays (from the onset of fault to the issuance of tripping pulse).

5.3.1 Clearing time of line faults: in case of 500 kV lines, 0.08s for the end proximate to faults, 0.1s for the end far away from faults; in case of 220 kV, 0.1s for the end proximate to faults, 0.12s for the end far away from faults.

5.3.2 Clearing time of busbar fault: generally 0.08～0.1s; for the existing busbar, actual data is taken.

If the operation time of the existing line or busbar relay protection takes excessive time giving rise to stability problem of the power system, the operation time of quick-acting line or busbar relay protection shall be used for calculation, coupled with replacing the existing relay protection devices.

5.4 Reclosing Time for Stability Calculation

Reclosing time refers to the duration from fault clearing to reclosing of the main breaks of circuit breakers and shall be selected according to system conditions and system stability requirements.

5.4.1 Minimum Single-phase Reclosing Time Restricted by Arc Suppression and Insulator Recovery Time Following Fault Clearing

1 The reclosing time shall be selected to be no less than 0.5s for: 220 kV lines; 330 kV and 500 kV lines with a length no more than 150 km and 100 km respectively (without HV shunt reactor compensation); all 330 kV and 500 kV lines whose phase-to-phase capacitance is compensated by HV shunt reactors with small neutral reactors.

2 For 330 kV and 500 kV lines that are not provided with HV shunt reactor compensation and have a length more than 150 km and 100 km respectively, the reclosing time shall be selected with reference to the actual single-phase reclosing test results.