

两大领域前沿成果展示
国内与国外专家汇集
学术研究与技术应用兼备
来自 28 个国家和地区

国内外最新 继电保护及控制技术研究 (上册)

中国电机工程学会继电保护专业委员会 编



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要 目 录

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内 容 提 要

本书是第六届现代电力系统自动化和保护国际学术研讨会（APAP2015）论文集，收录了来自 20 个国家和地区的 174 篇论文。这些论文反映了国内外电力系统继电保护和自动化业界共同关注的问题及最新研究成果，内容涉及继电保护、变电站自动化、电网安全稳定控制、电网运行及分析、高压直流输电及电力电子设备控制保护、分布式发电、配电网保护和控制等。论文集内容丰富，实用性强，对电力系统保护和控制技术研究有较高参考价值和借鉴意义，可供相关学者、专家以及工程技术人员参考。

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前 言

中国电网是世界上发展最快的电网。大容量远距离、交直流混联电能输送，大规模可再生能源接入，以及新一代电力电子设备的应用，满足了中国经济发展在电能生产与输送方面的需求，也给继电保护、自动化和控制系统带来了许多新的问题和挑战。

现代电力系统自动化和保护国际学术研讨会（APAP）于 2004 年由韩国明知大学 Lee Seung-jae 教授发起，其目标是为电力系统继电保护和自动化领域的专家、学者搭建一个国际性的学术交流平台。同年 10 月，在韩国济州岛召开第一次会议。2007 年、2009 年在韩国济州岛召开了第二次、第三次会议。2011 年在中国北京召开了第四次会议。2013 年 10 月在韩国济州岛召开了第五次会议。

南京素有“江南佳丽地，金陵帝王州”之美称，也是中国科技最为发达的城市之一。在这座古老而又现代的城市里，聚集着大批电力自动化企业，已成为中国该领域最重要的研发和产业化基地。他山之石，可以攻玉。为借鉴国际同行的研究成果和运行经验，应对面临的问题和挑战，中国电机工程学会继电保护专业委员会决定在南京承办第六届现代电力系统自动化和保护国际学术研讨会（APAP2015），并将会议主题确定为“当前和未来电力系统中保护、自动化和控制系统面临的机遇与挑战”。相信广大与会代表能在这个平台上结识同行，分享新思想、新技术、新经验，共同推进本行业技术进步。

研讨会的征文和筹备，得到了相关各方大力支持和协助。研讨会共收到来自 22 个国家和地区的论文摘要共 268 篇。经评审，最终录用 174 篇，汇编成集。值此论文集出版之际，我们衷心感谢所有关注、支持和帮助本次研讨会的单位和个人。

中国电机工程学会继电保护专业委员会

2015 年 9 月

Foreword

Electric power system in China experienced the fastest development around the world in the past decades. Application of bulk long-distance power transmission on hybrid AC / DC transmission lines, adoption of large-scale renewable energy generation, installation of new generation power electronic equipments, meet the needs of China's economy development on electric energy generation and transmission, but also bring about many new problems and challenges to protection, automation and control system.

APAP was initiated in the year of 2004 by Professor Lee Seung-Jae from Myongji University in Korea. The goal of APAP is to build an international platform for experts, scholars and engineers to carry out academic exchanges in the field of electric power system protection, automation and control. The 1st APAP was held in October of the same year, followed by the 2nd one in 2007, and the 3rd one in 2009 in Jeju Island, Korea. The 4th one moved to Beijing, China in 2011, and the 5th one returned to Jeju Island in October 2013.

Nanjing is known as the "Beautiful place in the south of the Yangtze River and imperial state at Jinling" in the history. Now she is one of the most developed cities in high technology. With a large number of electric power automation enterprises, this ancient and modern city has become the most important research and manufacture base in this field. Wise men learn by other's mistakes. In order to learn from research results and operation experience around the world, to deal with the problems and challenges facing today, Relaying Protection Study Committee of CSEE (Chinese Society for Electrical Engineering) is pleased to organize the 6th International Conference on Advanced Power System Automation and Protection (APAP2015) in Nanjing. The theme of the conference is "Opportunities and challenges for PACS in existing and future power system". We believe that on this platform the delegates can get to know each other better, share new ideas, new technologies and new experiences, and promote progress in the industry jointly.

Strong supports from relevant parties are essential to run the conference. 268 synopses from 22 countries and regions were received, among which 174 full papers were accepted finally and published in this proceedings. We would like to thank all the bodies and individuals for your attention, support and assistance.

Relaying Protection Study Committee of CSEE

September 2015

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Appendix (973)

(1) New Development and Application of Protection

A Distinguish Method of Overload and Transmission Line Fault Based on $U \cos \varphi$ in Voltage Plane

Huangzhang Liu, Zexin Zhou, Xingguo Wang

Abstract--In allusion to the malfunction of distance protection caused by overload during large-scale blackout, a distinguish method of overload and transmission line fault based on $U \cos \varphi$ in voltage plane is proposed. Characteristics of overload and transmission line faults are analyzed in voltage plane. For overload, $U \cos \varphi$ is larger and for transmission line faults, $U \cos \varphi$ is smaller. Different $U \cos \varphi$ s are used to identify overload and transmission line faults. Simulation system is built in RTDS (Real Time Digital System), different overload and faults are simulated to verify the performance of scheme. The simulation results show that the scheme opens distance protection quickly in fault conditions and blocks it in overload conditions. The malfunction of distance protection due to the overload can be avoided.

Index Terms--Distance protection, Overload current, Transmission lined, Voltage plane, $U \cos \varphi$

I. INTRODUCTION

MALFUNCTIONS of distance protection caused by overload during large-scale blackouts in the world expand the accident scope[1]-[5]. It is important to identify line overload and fault to avoid mal-operation of distance protection in overload condition.

Normally, load limit line is used to identify transmission line fault and normal overload in impedance plane. But there are some disadvantages. Reference [6] discussed the load limit line setting calculation methods for different characteristic distance protection. References [7]-[10] propose adjusting method of load limit line according to the load current, but it will reduce the action zone of distance protection hardly and impact distance protection performance for internal faults with high resistances.

This paper proposes a new identification method of transmission line overload and faults based on $U \cos \varphi$ in voltage plane. For overload of transmission line, $U \cos \varphi$ is bigger and for faults of transmission lines, $U \cos \varphi$ is smaller. In Section II, characteristics of overload in voltage plane are analyzed. In Section III, characteristics of transmission line faults in voltage plane are analyzed. In Section IV, the protection criterion is proposed and its performance is discussed. In Section V, the protection criterion performance is

tested extensively using RTDS-generated data, the simulation verified that the proposed criterion can identify transmission fault and overload accurately. The distance protection can be avoided to mal-operate in overload.

II. THE CHARACTERISTIC OF OVERLOAD IN VOLTAGE PLANE

In normal condition, the system is shown in Fig. 1 and the relay 1 is in M side of line MN. The load current $\dot{I}_{load}$ is

$$\dot{I}_{load} = \frac{\dot{E}_M - \dot{E}_N}{Z_M + Z_{MN} + Z_N} = \frac{2E_M \sin \frac{\delta}{2}}{Z_{\Sigma}} \quad (1)$$

where δ is angle between $\dot{E}_M$ and $\dot{E}_N$.

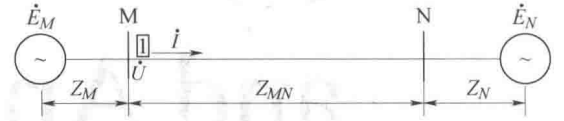


Fig. 1. The sketch of normal system

According to (1), $\dot{I}_{load}$ is proportional to δ and δ can express $\dot{I}_{load}$.

How we can get δ according to voltage and current of relay 1?

If $|E_M| = |E_N|$ and $\text{Arg} Z_M = \text{Arg} Z_N = \text{Arg} Z_{MN}$, the relation between δ and U , I is shown in Fig. 2. It can be seen from Fig. 2 that

$$E_M \cos \frac{\delta}{2} = U \cos \varphi \quad (2)$$

where $\varphi = \arg(\dot{U} / \dot{I}) + (90^\circ - \varphi_{L1})$, φ_{L1} is angle of transmission line positive sequence impedance.

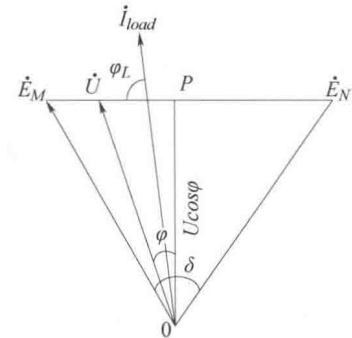


Fig. 2. Relation between U , I and δ

So we can use $U \cos \varphi$ to express δ and overload current.

For no-load of transmission lines, $\delta = 0^\circ$ and $U \cos \varphi / E_M = 1$ pu. When the system is in static power angle stability region, $\delta = 90^\circ$ and $U \cos \varphi / E_M = 0.707$ pu. For

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