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Performance of unified power flow controller (UPFC) in electric power systems

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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PERFORMANCE OF UNIFIED POWER FLOW CONTROLLER (UPFC) IN ELECTRIC POWER SYSTEMS

FOREWORD

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IEC TR 63262, which is a Technical Report, has been prepared by subcommittee 22F: Power electronics for electrical transmission and distribution systems, of IEC technical committee 22: Power electronic systems and equipment.

The text of this Technical Report is based on the following documents:

Draft TR	Report on voting
22F/521/DTR	22F/531/RVDTR

Full information on the voting for the approval of this Technical Report can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

A unified power flow controller (UPFC) adjusts both the active and reactive power of a transmission line by regulating and controlling line impedance, bus voltage and phase angle difference. When addressing a lack of power control methods and the insufficient supporting capacity of dynamic conditions, a UPFC provides an effective solution. Before 2005, there were three UPFC projects around the world: Inez UPFC project installed in 1998 in U.S.A., Kangjin UPFC project installed in 2003 in South Korea, Marcy UPFC project installed in 2004 in U.S.A. (see Annex A).

Ten years later, with relevant technology upgrades and increasing electric power demand, three more UPFC projects have been constructed and placed into service, all in China. They are the Nanjing 220 kV UPFC project installed in 2015, Shanghai 220 kV UPFC project installed in 2017 and Suzhou 500 kV UPFC project also installed in 2017. All these projects are based on the modular multilevel converter (MMC) technology which has successfully mitigated the issue of uneven power flow distribution, improved power supply capacity and the reliability of power supply in related areas. It is believed that with the further growth of electric power demand, UPFC technology will be more extensively applied in the power marketplace.

This document is based on the practical experience of UPFC projects using modular multilevel converter (MMC) which is a most perfect type of a voltage sourced converter (VSC) that can provide technical references for UPFC design, manufacture, test, commissioning, operation and maintenance.

PERFORMANCE OF UNIFIED POWER FLOW CONTROLLER (UPFC) IN ELECTRIC POWER SYSTEMS

1 Scope

This document provides guidelines for applying unified power flow controllers (UPFC) in power systems. It includes letter symbols, terms and definitions, principles and configurations, design rules, performance requirements for key equipment, control and protection, insulation co-ordination, system performance and tests. This technical report applies to the UPFC based on modular multi-level converter (MMC) technology, as well as UPFC based on three-level converter technology.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60071-1, *Insulation co-ordination – Part 1: Definitions, principles and rules*

IEC 60071-5:2014, *Insulation co-ordination – Part 5: Procedures for high-voltage direct current (HVDC) converter stations*

IEC 60076-2, *Power transformers – Part 2: Temperature rise for liquid-immersed transformers*

IEC 60076-3, *Power transformers – Part 3: Insulation levels, dielectric tests and external clearances in air*

IEC 60076-4, *Power transformers – Part 4: Guide to the lightning impulse and switching impulse testing – Power transformers and reactors*

IEC 60700-1, *Thyristor valves for high voltage direct current (HVDC) power transmission – Part 1: Electrical testing*

IEC 61954, *Static var compensators (SVC) – Testing of thyristor valves*

IEC 62501, *Voltage sourced converter (VSC) valves for high-voltage direct current (HVDC) power transmission – Electrical testing*

IEC TR 62543, *High-voltage direct current (HVDC) power transmission using voltage sourced converters (VSC)*

IEC 62751-2, *Power losses in voltage sourced converter (VSC) valves for high-voltage direct current (HVDC) systems – Part 2: Modular multilevel converters*

IEC 62823, *Thyristor valves for thyristor controlled series capacitors (TCSC) – Electrical testing*