

TECHNICAL REPORT



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

INTERNATIONAL
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CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references	8
3 Terms, definitions and symbols.....	9
3.1 Terms and definitions.....	9
3.2 Symbols.....	10
4 Principles and configurations	11
4.1 Basic principles.....	11
4.2 UPFC configurations	12
4.2.1 Basic structure.....	12
4.2.2 UPFC configuration in single transmission line	13
4.2.3 UPFC configuration in double transmission lines	13
4.2.4 UPFC configuration in multiple transmission lines	15
5 Design rules	15
5.1 Proposal selection	15
5.2 Parameter selection and coordination	15
6 Performance requirements for key equipment.....	16
6.1 General.....	16
6.2 Voltage sourced converters (VSCs)	16
6.2.1 General	16
6.2.2 Three-level converters	16
6.2.3 Modular multi-level converters (MMCs).....	17
6.3 Series transformer	18
6.3.1 General	18
6.3.2 Winding connection mode.....	18
6.3.3 Insulation level	19
6.3.4 Short circuit capability	20
6.3.5 Over-excitation tolerance.....	20
6.3.6 DC biasing.....	20
6.4 Shunt transformer	20
6.4.1 General	20
6.4.2 Winding connection	20
6.4.3 On-load voltage regulation.....	21
6.4.4 DC biasing.....	21
6.4.5 Harmonics and over-excitation tolerance	21
6.5 Fast bypass switch (FBS)	22
7 Control and protection	22
7.1 Control system of UPFC.....	22
7.1.1 Basic requirement.....	22
7.1.2 Configuration requirements.....	23
7.1.3 Functions of control system	23
7.2 Protection system of UPFC	24
7.2.1 Basic requirements	24
7.2.2 Configuration requirements.....	24
7.2.3 Functions of protection system	24

7.3	Requirements on UPFC monitoring system	25
7.4	Requirements on communication interfaces	26
8	Insulation co-ordination	26
8.1	Principles of insulation co-ordination.....	26
8.1.1	General	26
8.1.2	Insulation co-ordination procedure	26
8.1.3	Arrester protective scheme	27
8.2	Voltages and overvoltages in service	27
8.2.1	Maximum operating voltage	27
8.2.2	Sources of overvoltages	28
8.3	Determination of the required withstand voltages (U_{rw})	28
9	System performance.....	30
9.1	General.....	30
9.2	Steady-state performance	30
9.2.1	General	30
9.2.2	Steady state control requirement of transmission line power	30
9.2.3	Steady state control requirement of reactive power compensation and voltage control	30
9.2.4	Overload capacity requirement	30
9.3	Dynamic performance	30
9.4	Fault ride-through performance	31
10	Tests	31
10.1	General.....	31
10.2	Off-site tests of main components	31
10.2.1	Converter valve	31
10.2.2	Fast bypass switch (FBS)	32
10.2.3	Transformers	32
10.3	Onsite commissioning test	33
10.3.1	General	33
10.3.2	Converter energizing test.....	33
10.3.3	Energizing test of series transformer	34
10.3.4	UPFC initial operational tests	34
10.3.5	Steady-state performance test.....	34
10.3.6	Dynamic performance test	34
10.3.7	Protection trip test	34
10.3.8	Additional control function test.....	34
10.3.9	Overload test.....	34
10.3.10	Fault ride-through test of AC system.....	34
Annex A (informative)	Examples of typical UPFC projects.....	35
A.1	Inez UPFC project structure of U.S.A.	35
A.2	Kangjin UPFC project structure of South Korea.....	35
A.3	Marcy UPFC project structure of U.S.A.	36
A.4	Nanjing UPFC project structure of China.....	36
A.5	Shanghai UPFC project structure of China	37
A.6	Suzhou UPFC project structure of China	37
A.7	Other information for typical UPFC projects	38
A.8	Technical and economic evaluation for UPFC projects	38
Annex B (informative)	The difference between UPFC and other FACTS.....	39

Bibliography.....	40
Figure 1 – UPFC used in a two-terminal transmission system	11
Figure 2 –UPFC power flow schematic diagram	12
Figure 3 – UPFC control functions	12
Figure 4 – UPFC structure diagram.....	13
Figure 5 – UPFC configuration in single transmission line VSC.....	13
Figure 6 – UPFC configuration with non-common DC bus	14
Figure 7 – UPFC configuration with common DC bus	14
Figure 8 – Typical three-level converter topology	16
Figure 9 – Typical MMC topology.....	17
Figure 10 – Single-phase voltage waveform on the AC side	18
Figure 11 – Typical structure of series transformer winding.....	19
Figure 12 – Typical winding structure of the shunt transformer.....	21
Figure 13 – Typical structure of TBS	22
Figure 14 – UPFC protection function areas.....	25
Figure 15 – Example of arresters protecting areas for a MMC-UPFC	29
Figure A.1 – Main electrical circuit of Inez UPFC project.....	35
Figure A.2– Main electrical circuit of Kangjin UPFC project [1].....	35
Figure A.3 – Main electrical circuit of Marcy UPFC project [1]	36
Figure A.4– Main electrical circuit of Nanjing UPFC project [1].....	36
Figure A.5 – Main electrical circuit of Shanghai UPFC project [1].....	37
Figure A.6 – Main electrical circuit of Suzhou UPFC project [1].....	37
Table 1 – Arrester protective scheme for an MMC-UPFC	27
Table 2 – Indicative values of ratios of required impulse withstand voltage to impulse protective level	29
Table 3 – Main test items of converter valve	31
Table 4 – Main test items of TBS	32
Table 5 – Main test items of transformers	33
Table A.1 – Main parameters of typical UPFC projects [1].....	38
Table A.2 – Main parameters of transformers in Kangjin UPFC project	38
Table A.3 – Main parameters of transformers in Nanjing UPFC project	38
Table B.1 – Comparison of control parameters and application of each FACTS	39

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**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
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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*