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IEEE Guide for Technology of Unified Power Flow Controller Using Modular Multilevel Converter

Part 1: Functions

IEEE Power and Energy Society

Developed by the
Transmission and Distribution Committee

IEEE Std 2745.1™-2019

IEEE

STANDARDS

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Abstract: An approach to preparing a functional specification for a unified power flow controller (UPFC) using modular multilevel converter (MMC) is documented by this guide. This guide provides the functional requirements for UPFC project application, including UPFC system composition, function and performance requirements, primary equipment requirements, control and protection requirements, characteristic description, spares, engineering studies, testing, documentation, as well as training of UPFC projects. The intention of this document is to serve as a base specification with an informative annex provided to guide utilities, manufacturers, integrators, and other interested entities to apply a particular UPFC project.

Keywords: control and protection system, function requirements, IEEE P2745.1™, modular multilevel converter, performance requirements, primary equipment, system composition, test, unified power flow controller

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Introduction

This introduction is not part of IEEE Std 2745.1–2019, IEEE Guide for Technology of Unified Power Flow Controller Using Modular Multilevel Converter—Part 1: Functions.

As the most flexible, powerful, and comprehensive flexible ac transmission system (FACTS) device, the unified power flow controller (UPFC) can realize the bidirectional control of power flow, flexibly control voltage and reactive power, as well as improve the steady and dynamic stability of power grids. Since the 1990s to 2004, three UPFC projects were put into operation: Inez substation of AEP, Kangjin substation of KEPCO, and Marcy substation of NYPA, all of which utilized gate turn-off thyristor (GTO) devices and three-level converter technology. With increasing development of power electronics equipment and technology, modular multilevel converter (MMC) technology with insulate-gate bipolar transistor (IGBT) has been successfully applied into UPFC, such as Tiebei substation of SGCC, Yunzaobang substation of SGCC, and Mudu substation of SGCC. Compared with the GTO device and three-level multiple technology, the MMC technology is superior in expandable structure, low output waveform deviation, easy control of capacitor voltage, and desirable fault tolerance of sub-modules. Therefore, the MMC technology is the development trend of UPFC in the future. With the decreasing cost of converters, more MMC-UPFC projects may be put into commercial operation and satisfy the requirements of power flow control and system stability.

A series of documents, named the IEEE 2745™ series, is proposed to provide guides for technology of the UPFC using MMC. This guide, IEEE Std 2745.1, is the first part of the IEEE 2745 series, focusing on functions.

The purpose of this guide is to specify the functional requirements for UPFC project application, so that utilities, integrators, manufacturers, and other interested entities can benefit from this guide. This guide can specify the application conditions and system architecture of UPFC, requirements for function, performance, primary equipment, control and protection, auxiliary system, testing, spares, and training of UPFC projects. This guide aims to provide the knowledge base, experience, and opportunities for greater utilization of UPFC.

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1. Overview

1.1 Scope

This guide provides the functional requirements for unified power flow controller (UPFC) deployment, including application conditions, system architecture, function requirements, performance requirements, primary equipment requirements, control and protection requirements, auxiliary system requirements, testing, spares, and training of UPFC projects, which are suitable for UPFC in transmission power grids.

1.2 Purpose

The purpose of this guide is to specify the functional requirements for UPFC project application, allowing utilities, integrators, and other interested entities to specify the application conditions and system architecture of UPFC, and define the requirements for function, performance, primary equipment, control and protection, commissioning, and testing of UPFC projects. This guide aims to provide the knowledge base, experience, and opportunities for greater utilization of UPFC.

1.3 Application

This guide should be considered a general-purpose resource and does not include all details needed for a specific application. In addition, since UPFCs are typically designed to address a specific application, not every part of this guide may be applicable. The user of this guide should evaluate how and to what extent each clause applies to the development of a specification for a specific application.

1.4 Word usage

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[1]The use of the word *must* is deprecated and cannot be used when stating mandatory requirements, *must* is used only to describe unavoidable situations.
[2]The use of *will* is deprecated and cannot be used when stating mandatory requirements, *will* is only used in statements of fact.