

IEEE Guide for Static Var Compensator Field Tests

IEEE Power & Energy Society

Sponsored by the
Substations Committee



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IEEE Guide for Static Var Compensator Field Tests

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Substations Committee
of the
IEEE Power & Energy Society

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IEEE-SA Standards Board

Abstract: General guidelines and criteria for the field testing of static var compensators (SVCs), before they are placed in-service, for the purpose of verifying their specified performance are described. The major elements of a commissioning program are identified so that the user can formulate a specific plan that is most suited for his or her own SVC.

Keywords: IEEE 1303, mvar, static var compensator, SVC, var, field tests

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Introduction

This introduction is not part of IEEE Std 1303-2011, IEEE Guide for Static Var Compensator Field Tests.

This guide was prepared by a Task Force of Working Group I4, Static Var Compensators, of the Power Electronic Stations Subcommittee of the Substations Committee of the IEEE Power & Energy Society. The Guide was originally published in 1994. Modification of this guide began in 2005 with the purpose of updating SVC field testing guidelines for prospective or first-time users of static var compensator (SVC) systems in line with current practice.

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1. Overview

1.1 Scope

This document is a guide for field testing and commissioning of static var compensators (SVCs). As such, the document establishes general guidelines and criteria for field testing to verify the specified performance of SVC systems. Many clauses will be useful for compensator systems using gate turn-off (GTO) thyristor technology (static compensator [STATCOM]) or other semiconductor devices such as insulated gate commutated transistor (IGCT).

This guide does not

- a) Cover factory and simulator tests of SVC system components (but it assumes that such tests have been performed beforehand).
- b) Discuss the division of responsibility between user and supplier, since this division is usually defined in the contract between buyer and supplier. Most often, however, the practice is for the equipment, subsystem, and commissioning tests to be performed by the supplier, and the acceptance tests to be performed by the buyer or user.

1.2 Purpose

The purpose of this guide is to help users of SVCs carry out a field test program prior to placing an SVC into service. The major elements of a commissioning program are identified so that users can formulate a specific plan that is suited to ~~his or~~ their own SVC. Such a test program should cover the following:

- a) Equipment tests within the SVC system
- b) Tests of the various subsystems that comprise the SVC system
- c) Commissioning tests for the complete SVC system
- d) Acceptance testing of the complete SVC system

It should be recognized that there are many ways in which a particular SVC may be commissioned, and also that it is not the purpose of this guide to endorse a specific procedure to the exclusion of other methods.

Depending on the purpose of the SVC design (transmission type or smaller size used for other purposes) some tests may not be required. In particular, some control system tests may be included in the factory tests. Also, acceptance tests may be integrated into any of the categories listed above.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

~~This guide shall be used in conjunction with the following publications:~~

IEEE Std 519TM ~~1992~~, IEEE [Recommended Practices](#) and Requirements for Harmonic Control in Electric Power Systems (ANSI).^{1, 2}

~~IEEE Std 100-1992, The New IEEE Standard Dictionary of Electrical Electronics Terms (ANSI).~~

IEEE Std 693TM, IEEE Recommended Practices for Seismic Design of Substations (ANSI).

IEEE Std 1031TM, IEEE Guide for ~~a Detailed~~ the Functional Specification ~~and Application of~~ of Transmission Static VAR Compensators (ANSI).

IEEE Std C37.20.3TM, IEEE Standard for Metal-Enclosed Interrupter Switchgear (ANSI).

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3. Definitions and Acronyms

~~This clause contains definitions for key terms used in this guide. Further clarification of terminology, as needed, is provided at the appropriate points within the text of this guide.~~

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary: Glossary of Terms & Definitions* should be consulted for terms not defined in this clause.³

acceptance tests: Live tests of the complete system to demonstrate as far as possible that the installation meets the customer's specification.

as-built drawings: A complete set of drawings which, in addition to the original drawings, includes all drawings that accurately record changes made to the equipment or subsystem to indicate the final installation and commissioning.

commissioning tests: Tests of correct function of the complete system with all equipment connected and live.
databack or checkback: A system for monitoring and reporting the health of thyristors and their gate electronics.

degraded operation: Use of the system with part of the equipment out of service.

derated operation: Use of equipment or a system at a more restricted performance level than that for which the equipment or system was originally designed. Derated operation is usually implemented either to forestall failures or as a result of system component failure. See also: degraded operation.

digital fault recorder: A device which records voltage and current waveforms as well as status of relay contacts, and stores recordings of the waveforms when triggered by the change of state of any of the digital or analogue signals. Part of the stored record is prior to the triggering device operation.

digital transient recorder: A device similar to a digital fault recorder.

energization test: Any test requiring that system voltage be applied to the equipment.

equipment tests: Tests carried out on individual items of equipment before connection to other items of equipment. This forms part of pre-commissioning tests.

field test program: A set of documentation describing the installation and its tests which culminate in handover to the customer.

inspection and test plan (ITP): A summary of prerequisites, system configurations, step-by-step procedures, and evaluation criteria of the tests in one place for permanent record.

interface test: A test to check interaction among equipment through permanent interconnections.

IT product: The inductive influence expressed in terms of the product of its root-mean-square magnitude (I), in amperes, ~~times~~ multiplied by its telephone influence factor (TIF). (Source: IEEE Std 519-1992-.)

mechanically switched capacitor: A capacitor which is switched into or out of service by a circuit breaker or circuit switcher on a regular basis to control the bus voltage at the point of connection.

point of common coupling (PCC): The connection point between the SVC and the power system at which performance requirements are defined.

pre-commissioning tests: tests comprising equipment tests and subsystem tests.

real time digital simulator: A digitally based simulator, which can simulate the SVC and the system in detail and can be used for system simulations or for functional tests of the control system.

sequence of events recorder: a device which records events signaled by a change of state of a digital signal and adds a time stamp to each record.

³ The IEEE Standards Dictionary: Glossary of Terms & Definitions is available at <http://shop.ieee.org/>.

subsystem: An interconnected, interrelated group of equipment intended to serve a single basic purpose within a larger installation or facility.

subsystem tests: tests of a group of interconnected equipment, following on from equipment tests. These tests form part of pre-commissioning tests.

test coordinator: A person typically responsible for organizing and scheduling tests; deciding how, when, and where the system and its components will be tested; and determining the test equipment that is needed.

thyristor-controlled reactor (TCR): A series connection thyristor controller, typically connected between two halves of a reactor, that forms one leg of the connected circuit. The thyristor controller consists of antiparallel phase angle controlled thyristors for vernier control of the reactor susceptance (current).

thyristor-switched capacitor (TSC): A series connection of a thyristor switch, typically connected between a capacitor bank and a current limiting reactor, that forms one leg of the connected circuit. The thyristor switch consists of antiparallel thyristors that are blocked or fired for full conduction (on/off control).

thyristor-switched reactor: A series connection of a thyristor switch, typically connected between two halves of a reactor, that forms one leg of the connected circuit. The thyristor switch consists of antiparallel thyristors that are blocked or fired for full conduction (on/off control).

transient network analyzer (TNA): An analog or digital test circuit representing a scaled-down version of the pertinent power circuit components, used mainly for control response and performance testing.

transient fault recorder: A device, similar to a digital fault recorder or digital transient recorder, for recording transient quantities.

trial operation: A period during which the equipment or system is placed under service conditions and is also monitored for stable, smooth, and reliable performance.

trigger pulse converter (TPC): A device in the control system that converts the control signal to a signal that can be transmitted to the thyristor valve.

valve base electronics ~~(VBE)~~: Electronic circuitry that directs gate pulses into the thyristor valve.

valve electronics ~~(VE)~~: Electronic circuitry associated with the thyristors and mounted at thyristor level potential.

3.2 Acronyms

DFR digital fault recorder

DTR digital transient recorder

ITP ~~Acronym for~~ inspection and test plan ~~See 3.4.~~

MSC mechanically switched capacitor

RTDS real time digital simulator

SER sequence of events recorder

TCR thyristor-controlled reactor

TFR transient fault recorder

TNA transient network analyzer

TPC trigger pulse converter

TSC thyristor-switched capacitor ~~See 3.16.~~

TSR thyristor switched reactor ~~See 3.17.~~

VBE valve base electronics ~~See 3.25.~~

VE valve electronics ~~See 3.26~~

~~3.8 PCC: Acronym for point of common coupling~~

4. Preparation of a field test program

The purpose of this clause is to describe how a comprehensive field test program can be applied to SVC systems.

In general, every SVC has been designed and installed for a specific reason and purpose. This reasoning and purpose should be clearly defined for the test program and understood by the participants.

A specific set of inspection and test plans (ITPs) should be prepared for each SVC project. In the field, these ITPs will demonstrate that the specific purposes of that SVC are being met in accordance with the performance specifications.

4.1 Test program phases

A comprehensive field test program includes the following major phases:

- a) Overall test planning and organization, including the definition and line of authority for performing the tests
- b) Survey of documents and data , including contract, system study, factory test review, drawings, user's manual availability, and definition of ac system requirements or limitations.
- c) Preparation of ITPs for equipment, subsystem, commissioning, and acceptance tests of the SVC system.
- d) Review and approval of, or concurrence with, test program by user.
- e) Schedule [Preparation of](#) schedule, including coordination of installation/test schedule and coordination with system operation.
- f) [Dissemination and approval of field test results.](#)
- g) Dissemination of information, including as-built drawings.

Only phase c), the preparation of ITPs for SVC ~~equipment, subsystem, pre~~ commissioning, [commissioning](#), and acceptance tests, is discussed in this guide.

4.2 Inspection and test plans (ITPs)

It is suggested that a format be adopted that breaks down the overall test program into a series of single purpose ITPs.

4.2.1 Contents of the ITP

The ITP should contain at least the following information:

- a) Descriptive title and test number. The title should convey the purpose of the test, equipment, and subsystem or system being tested.
- b) Person (by title) responsible for directing the test and the person with whom the performance of the test is to be coordinated.
- c) List of preceding tests that should have been completed before this test can be attempted.
- d) Estimate of time required to complete the test.
- e) System configuration prior to the test. This could be in the form of a single-line diagram at the beginning of the test, a table of switch or breaker positions, or other format that describes the pretest configuration.
- f) Step-by-step description of the test execution, along with the expected results of each step [including reactive power swings](#).
- g) Description of the expected final results.
- h) Summary of the records required to document successful completion of the test.
- i) Identification and description of relevant reference information, such as industry standards, particular requirements from the specifications, or potential impact on the utility.
- j) Test equipment used, including type, serial number, calibration, etc.
- k) Test sheets with measured data (suitable for future fault diagnosis).

A sample ITP is provided in Figure 1. This ITP is for example purposes only, and should be modified to fit the circumstances of the specific project and organization.

TEST DESCRIPTION: First energization of TCR valves. (5.3.1.3 in Guide) TEST DIRECTED BY: _____ Manufacturers test coordinator PERMISSION TO PROCEED REQUIRED FROM: a) User's commissioning engineer b) Utility operating center PREREQUISITE TESTS AND CONDITIONS: a) Test 5.1 —Individual equipment tests b) Test 5.2 —Subsystem tests c) Test 5.3.1.1 —Pre-energization checks d) Test 5.3.1.2 —Low voltage energization tests ESTIMATED TIME TO PERFORM TEST: Approximately 8 hrs of actual test time. SYSTEM CONFIGURATION: a) Auxiliary power on b) Both primary and backup protection in-service c) SVC cooling in-service d) SVC controls in-service e) Filter bank switches open or in position required for start-up f) Power available to line side disconnect of main breaker TEST OPERATIONS: a) Clear valve area and reactor area of all personnel, tools, and other apparatus. b) Test coordinator to make a final inspection and confirm that areas are clear. c) Close fenced areas (if any) and lock. Remove interlock keys, safety locks, and enable main disconnect. d) Post observers at safe distance in valve hall and outside reactor yard. e) Check that all instrumentation (TFR, SER, special recorders) are operational and "ready." f) Close main disconnect. g) Carry out the following operation in 1 sec intervals, upon countdown beginning from -3 to +3 sec, as follows: -3 sec -2 sec—Manually initiate TFR and oscillograph. -1 sec 0 sec—Close main breaker. +1 sec—Open main breaker. +2 sec—Stop TFR and oscillograph. +3 sec EVALUATION: a) Check that observers saw no arcs, spitting, or other sign of electrical breakdown. b) Check that protective relaying did not operate. c) Check the TFR and special oscillograph records to confirm that all valves withstood voltage without any evidence of breakdown or thyristor gating. RECORD RETENTION: Label oscillograph record "Test IOB" and retain. CONCLUSION: At the successful conclusion of this test, the following people, witnessing the test, should acknowledge completion of the test by affixing their signature to the test document. Manufacturer's test coordinator _____ Owner's commissioning engineer _____	TEST NO. IOB
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Figure 1—Sample inspection and test plan