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IEEE Guide for the Selection of Monitoring for Circuit Breakers

IEEE Power and Energy Society

Sponsored by the
Switchgear Committee

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Abstract: Direction is provided for the selection of monitoring and for diagnostic parameters to be used with high-voltage circuit breakers (i.e., above 1000 V). Guidance on appropriate parameters to be considered for monitoring applied to various circuit breaker technologies is also provided.

Keywords: failure characteristics, failure modes and effects analysis (FMEA), failure modes, effects, and criticality analysis (FMECA), failure rate, high-voltage circuit breakers, IEEE C37.10.1™, monitoring, online condition monitoring, risk assessment

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Introduction

This introduction is not part of IEEE Std C37.10.1-2018, IEEE Guide for the Selection of Monitoring for Circuit Breakers.

The revised issue of this guide, IEEE Std C37.10.1-2018, provides guidance in the selection of monitoring for high-voltage circuit breakers. Monitoring for a particular circuit breaker is very dependent on the circuit breaker technology, age of the circuit breaker, details of the specific application, and the risks associated with the various failures possible with the circuit breaker and its many associated power, protection and control, and other support components.

This revised guide is not intended to provide guidance on the monitoring of protection and control circuits and devices used with circuit breakers, even though such circuits and devices can have a significant effect on the overall performance of circuit breaker functions.

NOTE—This guide makes no attempt to address the many possible protection and control failure modes. These failure modes are dependent on the technology of the protective devices as well as on the manner in which they are applied on the power system. IEEE Std C37.10.1-2018 does not address the subject of software used in protective, control, or monitoring devices and systems.

Several methodologies are introduced. A methodology termed failure modes and effects analysis (FMEA) is presented to assist identification of significant failure modes and their causes. The concepts of risk assessment are introduced. The subsequently derived priority and economic analysis determines when and where monitoring is warranted.

The selection of monitoring for circuit breakers should be based on logical engineering and economic principles. Appropriate monitoring can be selected by considering failure modes and their effects on the circuit breaker and on the power system, the degree of risk or criticality associated with the failure, and the economics associated with each type of failure. Monitoring can be used to reduce or replace some inspections, optimize maintenance, enhance availability of the circuit breaker, improve safety to humans and environment, and derive information on the condition of a specific circuit breaker (or information from several circuit breakers can be extrapolated to a larger population of identical circuit breakers).

Considerably more information can be gained by combining various signals than from an individual signal. More advanced monitoring systems may include diagnostic analysis using tools such as artificial intelligence. These may relate recent monitoring data to historic monitoring data and provide engineering conclusions or actions required. Systems may be further enhanced by remote access through supervisory control and data acquisition (SCADA) or use of telephone dial-up systems. Eventually, it is presumed that systems will become integral to substation automation development.

Readers of this guide are advised of ongoing standards development work now underway that will provide useful supplementary guidance.

The IEEE Substations Committee is in the draft stages of developing a Draft Standard for Substation Integrated Protection, Control, and Data Acquisition Communications. The communication requirement for devices used to monitor substation equipment is a rapidly changing area.

The IEC is in the draft stages of producing IEC 60300, Dependability Management—Part 3-13: Application guide—Project risk management.

The IEEE Transformer Committee is developing similar guidance for selecting monitoring for transformers.

Monitoring of predominant failure causes and remedying them may also significantly reduce minor failure causes from occurring. Many of the techniques discussed in this guide could have application with many other types of components.

Contents

IEEE Guide for the Selection of Monitoring for Circuit Breakers

1. Scope

This guide provides direction for the selection of monitoring and for diagnostic parameters to be used with high-voltage circuit breakers (i.e., above 1000 V ac). It provides guidance on appropriate parameters to be considered for monitoring applied to various circuit breaker technologies.

This guide will lead a user through an analysis of circuit breaker performance and application expectations. The analysis includes a failure modes and effects analysis (FMEA) of the circuit breaker and associated components, an analysis of the risks associated with failure of the specific application, and a discussion of the items to be considered in a cost-benefit study to justify application of monitoring in its many forms. Monitoring is dependent on the technology of the circuit breaker and monitoring available at the time of application. FMEA, as well as failure modes, effects, and criticality analysis (FMECA), are methods of reliability analysis intended to identify failures that have significant consequences affecting the system performance in the considered application.

NOTE—The examples shown are for illustrative purposes only. Numeric and financial values shown are solely for the purpose of showing that values can be assigned if so chosen. Actual circumstances will dictate values, costs, and expenses to be used in the quantifying of risk, economic evaluation and justification, and the ultimate selection of monitoring. The specific circuit breaker technology employed will also either restrict or broaden opportunities for monitoring.[1]

This guide provides advice on what parameters can be monitored to derive information about the condition of a circuit breaker. Use of techniques, such as those in CEA Project No. 485T1049 (1997), provides more information on combining appropriate signals to derive greater information than either signal alone would provide.[2]

Circuits associated with the operation of the circuit breaker, which might include auxiliary contacts, X and Y relays, lockout switches, and so on, are included in this guide. External control circuits are not included in the scope of this guide. This guide is not intended to provide guidance on the monitoring of protection and control circuits, although they can have a significant effect on the overall circuit breaker functions.

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

[1]Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.
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