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IEEE Guide for Protective Relay Applications to Power System Buses

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Foreword

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This publication was prepared by the Transformer and Bus Protection Subcommittee of the IEEE Power System Relaying Committee. The Subcommittee expresses its gratitude to past and present members, members of the Power System Relaying Committee, Liaison Committees and Groups who have contributed their time and knowledge in preparing this guide.

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IEEE Guide for Protective Relay Applications to Power System Buses

1. Introduction

1.1 Purpose and Scope

This guide has been prepared to assist the reader in the effective application of relays for protection of power system electrical buses. The bus protection described refers only to protection at the bus location, independent of equipment at remote locations. Common bus arrangements and some special arrangements used in the United States are covered. Not all bus protection systems or all possible bus arrangements are included.

1.2 Factors Which Determine the Need and Type of Bus Protection

A bus is a critical element of a power system, as it is the point of convergence of many circuits — transmission, generation, or loads. The effect of a single bus fault is equivalent to many simultaneous faults and usually, due to the concentration of supply circuits, involves high current magnitudes. High-speed bus protection is often provided to limit the damaging effects on equipment or system stability or to maintain service to as much load as possible. Without bus protection, the remote terminals of lines connected to a faulted bus must be tripped. This will result in the loss of load tapped to these lines. Inadequate bus protection can result in catastrophic failures and present serious personnel hazards.

Factors such as bus configuration, relay input sources, operating time, sensitivity, and existing facilities are important in selecting the type of bus protection system. Existing stations may not have the required relay input sources for bus protection. Technical and economic considerations determine whether additional facilities are to be installed. If a common scheme cannot be used, consideration may be given to special bus protection methods.

1.3 Basic Principles of Bus Protection Operation

Several methods of bus protection are available. Probably the most sensitive method employs the differential principle, in which the phasor summation of all the measured current entering and leaving the bus must be zero unless there is a fault within the protected zone. For a fault not in the protected zone the instantaneous direction of at least one current is opposite to the others.

Other bus protection schemes such as partial differential, directional comparison, and the fault-bus methods use either or both the magnitude and direction of fault current and are described in Section 3.

2. Relay Input Sources

(Current Transformers and Linear Couplers)

2.1 General Background

Historically, the major problem in a bus protection system has been unequal core saturation of the current transformers (ct) used in the system. This unequal core saturation is due to the possible large variation of current magnitude and residual flux in the individual current transformer used in the system. The basic requirement is that the total scheme will provide the degree of selectivity necessary to restrain from operating on the most severe external fault and yet have the required sensitivity to operate on the minimum expected internal fault. In an existing installation, this usually requires selecting a scheme compatible with the existing current transformer, unless it is feasible to change or add current transformers. In a new installation, relay input sources can usually be selected which are compatible with the preferred scheme.

2.2 Types of Current Transformers

2.2.1 Bushing Current Transformers

The bushing current transformer is the most widely used for relaying because the installed cost is less than for other types of current transformers. It is generally applicable in most bus protective systems. It consists of a tapped secondary winding on an annular magnetic core and is referred to as a multiratio bushing current transformer. The core encircles a high-voltage insulating bushing used on circuit breakers, power transformers, generators, and switchgear, through which a power conductor passes to form the primary turn.

The secondary turns of a bushing current transformer should be distributed to minimize leakage reactance. Physically, this is accomplished by distributing each section of the tapped secondary winding completely around the circumference of the core [31].¹

2.2.2 Window-Type Current Transformers

The window-type current transformer, which is used at medium and lower voltages, has a magnetic core with a center opening through which a power conductor passes to form the primary turn. The secondary is wound on the core, and in some styles the entire assembly is encased in molded insulating material. The core may be annular in shape with a uniformly distributed secondary winding, similar to a bushing current transformer, or rectangular in shape with the secondary winding either distributed or wound on only two legs.

2.2.3 Wound-Type Current Transformers

A wound-type current transformer has a primary winding of one or more turns and a secondary winding on a common core, similar to a power transformer.

2.2.4 Auxiliary Current Transformers

Auxiliary current transformers are sometimes used in the secondary circuit of other types of current transformers to change either or both the ratio and phase angle of the secondary current. The auxiliary current transformers should be selected to make sure theft characteristics do not adversely affect the performance of the selected bus protection scheme.

¹Numbers in brackets correspond to those of the Bibliography, Section 6. of this guide.