

# Selection of Current Transformers and Wire Sizing in Substations

Sethuraman Ganesan, ABB Inc.

**Abstract**— While retrofitting protections and meters in substations, the older equipment get replaced with newer ones with the rest of the installation such as Current Transformer (CT) and lead remaining undisturbed. Utilities have standardized on their older current transformers and want to maintain the same current transformer specifications throughout their system even in their newer installation. An extension of the above approach is that even the cable leads and panel wiring sizes are over-specified resulting in totally unjustified cost of installations as well as difficulty in terminating such wires in the modern panels and equipment. On the other end of the spectrum, in rare cases, the existing CT sizes and lead sizes of electromechanical relays may not be adequate for the latest protective relays which might demand a different current transformer performance. This paper systematically lists and analyses such requirements for various modern protective relays.

**Index Terms**—Power system protection, Protective relaying, Short circuit currents, Power transmission, Current Transformers, Substations, Substation Measurements

## I. INTRODUCTION

THE foremost interface device between the power system and the protective relaying is the ubiquitous current transformer. The standard current transformer secondary winding is rated at 5A as per ANSI standards. Other rated currents such as 1A exist elsewhere. The main purpose of a current transformer is to translate the primary current in a high voltage power system to a signal level that can be handled by delicate electromechanical or electronic devices. The secondary connected devices could be indicating or energy integrating instruments, protective relays, transducers etc. Since the applications are so varied, it is natural that the CT be properly specified, depending on the exact application to which it is applied. To this extent, it is necessary to understand some of the fundamental ways the CTs behave. This paper makes an attempt to present the basics to understand the behavior and application of the CTs. The bibliography at the end of the paper provides more detailed analysis and application data.

## II. CHARACTERISTICS OF CT

The current transformer primary is connected in series with the device in which the current is to be measured. Since

Current Transformer is fundamentally a transformer, it translates the current from the Primary to the Secondary side, inversely proportional to the turns so as to maintain the relationship,

$$I_p = n I_s$$

where,  $n$  is the turns ratio of turns between the secondary and primary winding. Mostly, the primary of a CT is a straight-through bar, meaning the number of turns on the primary is just 1. Hence  $n$  is often the number of turns of the secondary.

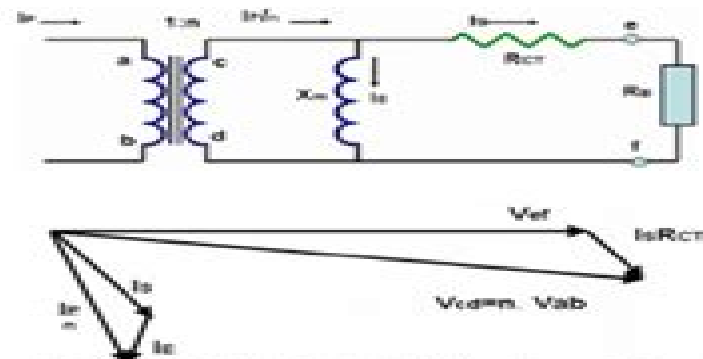


Fig. 1. Simplified equivalent circuit and phasor diagram of a Current Transformer

The relationship above is assuming an ideal current transformer without any losses and negligible magnetizing current. In actual practice, the CTs draw a current to keep the iron core excited and drop a voltage proportional to the current transformed because of the inherent resistance of its windings. An equivalent circuit of a CT is represented by Figure 1, where  $X_m$  represents the magnetizing reactance and  $R_{CT}$  represents the internal winding resistance. The current transformer is expected to deliver about 5A, or lower under healthy load conditions. The current goes to a high value if a fault occurs. As per ANSI, the CT ratio shall be chosen so that the maximum symmetrical fault current on the CT secondary is limited to 100A. Since it is very difficult to meet the high accuracy requirement for billing purposes near rated current as well as maintain an acceptable linearity for protection at current levels of 100A, it is usual to separate the functions to two different sets of CT cores.

S. Ganesan is with ABB Inc, Substation Automation and Protection Division, Allentown, PA18106 USA (e-mail: sethuraman.ganesan@us.abb.com).

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*AC Circuits and Power Systems in Practice* Graeme Vertigan, 2017-09-28 The essential guide that combines power system fundamentals with the practical aspects of equipment design and operation in modern power systems Written by an experienced power engineer *AC Circuits and Power Systems in Practice* offers a comprehensive guide that reviews power system fundamentals and network theorems while exploring the practical aspects of equipment design and application The author covers a wide range of topics including basic circuit theorems phasor diagrams per unit quantities and symmetrical component theory as well as active and reactive power and their effects on network stability voltage support and voltage collapse Magnetic circuits reactor and transformer design are analyzed as is the operation of step voltage regulators In addition detailed introductions are provided to earthing systems in LV and MV networks the adverse effects of harmonics on power equipment and power system protection Finally European and American engineering standards are presented where appropriate throughout the text to familiarize the reader with their use and application This book is written as a practical power engineering text for engineering students and recent graduates It contains more than 400 illustrations and is designed to provide the reader with a broad introduction to the subject and to facilitate further study Many of the examples included come from industry and are not normally covered in undergraduate syllabi They are provided to assist in bridging the gap between tertiary study and industrial practice and to assist the professional development of recent graduates The material presented is easy to follow and includes both mathematical and visual representations using phasor diagrams Problems included at the end of most chapters are designed to walk the reader through practical applications of the associated theory

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