

# 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 analyzes 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.

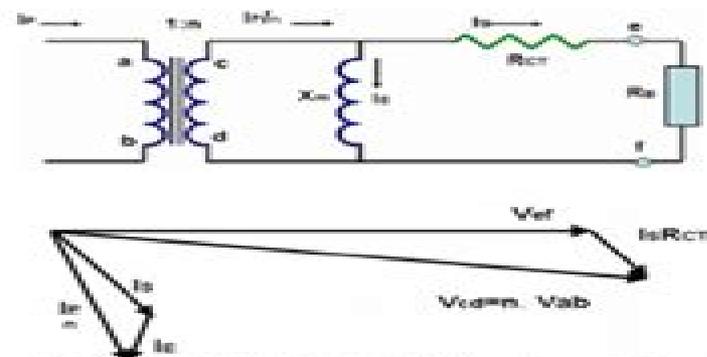


Fig. 1. Simplified equivalent circuit and phasor diagram of a Current Transformer

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 current 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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