World Academy of Science, Engineering and Technology
International Journal of Electrical and Computer Engineering
Vol:8, No:9, 2014

Analyzing Current Transformer's Transient and Steady State Behavior for Different Burden's Using LabVIEW Data Acquisition Tool

D. Subedi, D. Sharma

***Abstract*—**Current transformers (CTs) are used to transform large primary currents to a small secondary current. Since most standard equipment's are not designed to handle large primary currents the CTs have an important part in any electrical system for the purpose of Metering and Protection both of which are integral in Power system. Now a days due to advancement in solid state technology, the operation times of the protective relays have come to a few cycles from few seconds. Thus, in such a scenario it becomes important to study the transient response of the current transformers as it will play a vital role in the operating of the protective devices.

This paper shows the steady state and transient behavior of current transformers and how it changes with change in connected burden. The transient and steady state response will be captured using the data acquisition software LabVIEW. Analysis is done on the real time data gathered using LabVIEW. Variation of current transformer characteristics with changes in burden will be discussed.

Keywords—Accuracy, Accuracy limiting factor, Burden, Current Transformer, Instrument Security factor.

I. Introduction

CURRENT transformers (CT's) are the most basic part of any power system as it is required for all the protection and metering functions. With advancement in solid state technology the reliability and accuracy of the devices have increased. Although the advancement has brought about great advantages but it has also made the devices more susceptible to the transient responses of the current transformers. Hence it becomes essential to study these transient responses adequately so that we will be able to protect the measuring and protection IED's [1].

The behavior of the Current Transformers with different connected loads on a steady primary current and the response of the CT with change in current will have a direct impact on the measuring and protection device. Huge variation in the secondary transformed current may lead to erroneous measurement and maloperation of protection.

II. LabVIEW

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a system-design platform and development environment for a visual programming language from National Instruments. It is used here as a data acquisition and recording tool to gather current transformer input and output current values [4].

The programming done is just for data gathering and no scaling or any other changes have been made to the raw data in LabVIEW.

A. Set Up

Input modules of LabVIEW have been connected in series with the primary and secondary of the CT respectively. Real time data is stored in the computer via input modules. The CT secondary is also connected with a variable resistor for variable burden [3], [5], [6].

A variable current source is connected to CT primary. The CT secondary is connected to a variable resistor and the LabVIEW data acquisition tool.

Class 3 with 30VA CT is used for this setup. The CT ratio is 5:1 Amperes.

4-Channel Current Input C Series Module is used to gather current signals. It is designed to measure 5 Arms nominal and up to 14 A peak on each channel with channel-to-channel isolation [4].

III. Transformation Accuracy and Burden

By inherent nature of CT's, errors are introduced during of transformation. These errors are kept as low as possible depending upon the usage. The manufacturers provide the % transformation error [6] that is to be expected of the CT in its nameplate. However the manufacturers are required to guarantee the accuracy for only 25 to 100% of the nameplate burden [6]-[7].

The transformation error has been plotted for different connected burdens to verify to response of the CT to its nameplate specification. It can be seen from Fig. 1 that the errors are not constant. The % error changes with changes in connected burden for different % of rated current.

The % error specified in the nameplate should hold true for up to 100% of rated burden but we can observe that is not so. The CT's show the highest accuracy for midrange current for different connected burdens. Also the highest error is shown when the connected burden in 75% of rated burden and the current is 100%.

For lower burdens the error is negative as seen in Fig. 1.

D. Subedi and D. Sharma are with the Centre of Excellence for Control and Protection, Druk Green Power Corporation Ltd., Chukha, Bhutan (e-mail: hdilson@gmail.com, deepen.sharma@gmail.com).

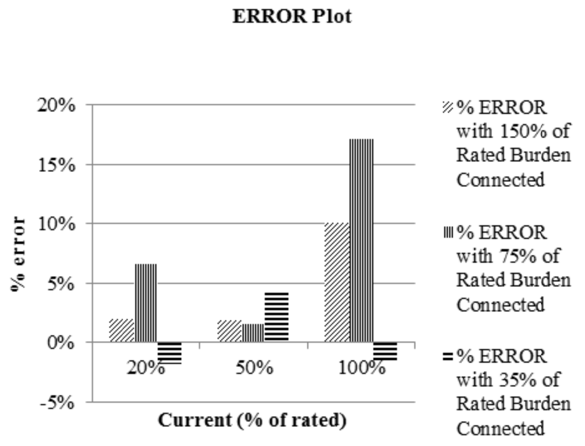

Fig. 1 % Transformation Error for different connected burden

IV. Current Transformation for Different Burden

Secondary current for different burden have been plotted in figures below. Fig. 2 shows the secondary current waveform when 20% of rated current is injected in the primary for different burdens. Similarly, Figs. 3 and 4 show secondary current waveform when 50% and 100% of rated primary current is injected respectively.

The secondary peak to peak current is different when the burden is different even when the primary current is same. From the figures we can effectively conclude that as the burden increases the secondary peak to peak value for the same injected primary current decreases. This may be due to the change in the CT parameters like Accuracy Limiting Factor (ALF)/ Instrument Security Factor (ISF) with the change in burden. Also with increase in resistance the current flow decreases as the potential drop across the resistance is more.

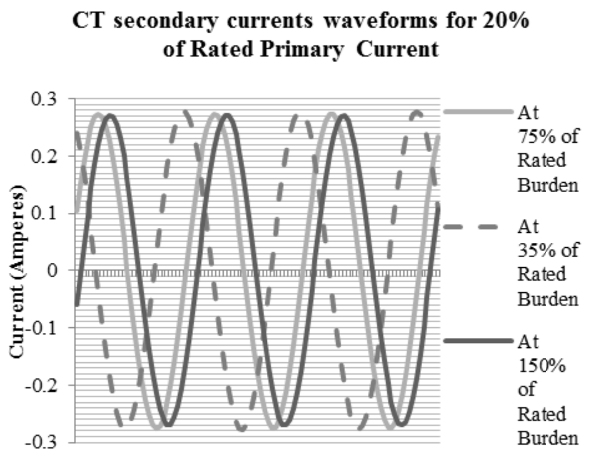

Fig. 2 CT secondary Current waveform when 20% of rated current is injected for different burden

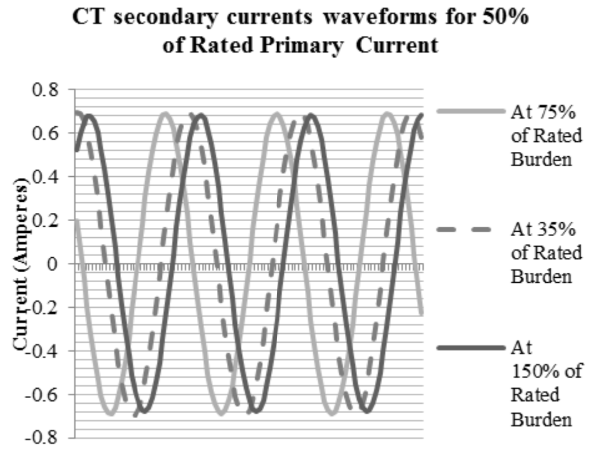

Fig. 3 CT secondary Current waveform when 50% of rated current is injected for different burden

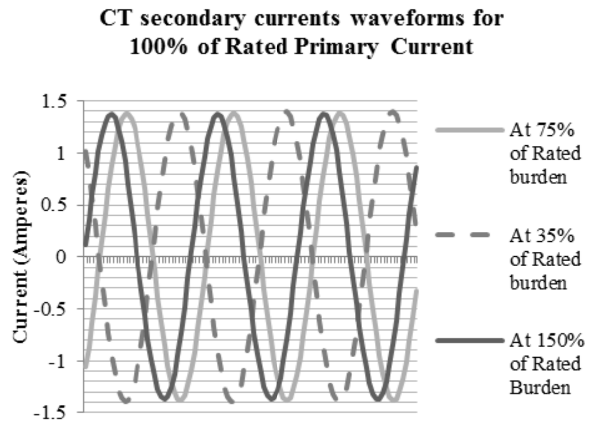

Fig. 4 CT secondary Current waveform when 100% of rated current is injected for different burden

V. Waveform Distortion

The shape of the waveform during increase of input current from 20% to 50% and 50% to 100% of rated current are shown in Figs. 5 and 6 respectively.

During change in current the current waveform gets distorted during current transformation. This distortion also varies with secondary connected burden as seen in the graph. High distortion is observed when the connected burden is either very low or very high when compared to the rated burden. There is less distortion when the connected burden is around 75% of rated burden as seen in Figs. 5 and 6.

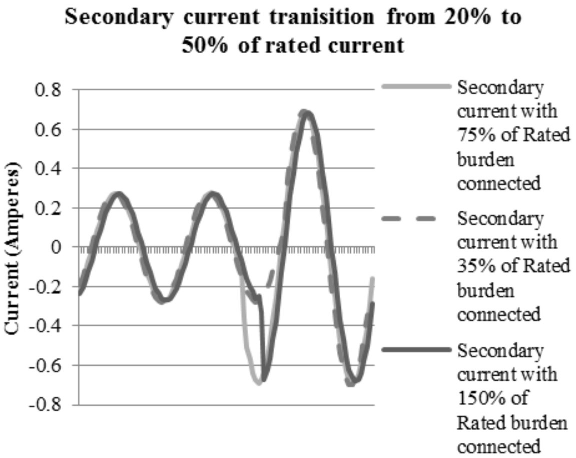

Fig. 5 CT secondary Current waveform during transition from 20% to 50% of rated current

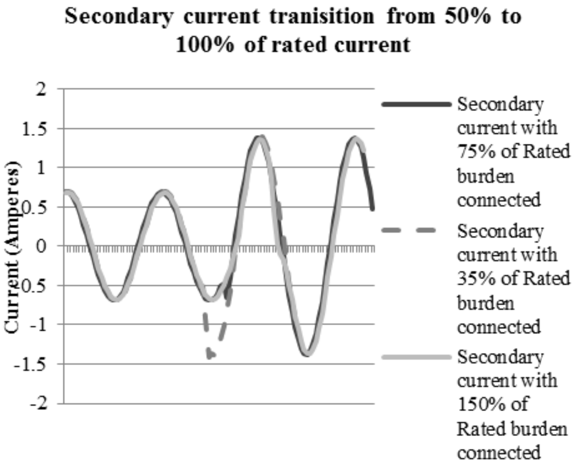

Fig. 6 CT secondary Current waveform during transition from 50% to 100% of rated current

VI. Burden and CT Saturation

CT saturation current is directly related to the connected burden. If the connected burden is different than the rated burden then the CT saturates at a varied current than that given in the nameplate. The over current factor which specifies the current till which the CT does not saturate is dependent on the connected burden as shown below. If a low burden is connected to a CT, then the over current factor (*Ksccn*) will not be valid for that circuit as it is dependent on the burden connected [2]. The new operational overcurrent factor (*Kscco*) can be calculated as:

$$Vknee = Ksccn \times Ifs,max \times (Rct + Rbn) = Kscco \times Ifs,max \times (Rct + Rbo) \quad (1)$$

where;

Vknee= CT Knee point voltage
Ifs, max= Maximum secondary fault current
Rct= CT secondary resistance
Rbn= Rated CT burden in ohms
Rbo= Connected burden in ohms

Since knee point voltage *Vknee* will remain same on different connected burden.

Simplifying we get

$$Kscco = Ksccn \times \frac{Rct+Rbn}{Rct+Rbo} \quad (2)$$

The above equation shows that the new overcurrent factor varies proportionately to the connected burden. Therefore the connected burden should be verified for proper CT saturation in case of overcurrent [1]-[2].

VII. Conclusion

The CT secondary burden affects the CT performance and should be studied before putting the CT in service. If proper studies are not carried out it could lead to erroneous measurement and have adverse effect on the equipment connected.

References

[1] Jaeger et al. D.T. 2008. Instrument Transformer Dimensioning: Past and Future. 4th GCC CIGRE International Conference, Manama (Bahrain)
[2] Ibrahim et al. D.T. 2006. Saturation of current transformers and its impact on digital over current relays. 2006 IEEE PES transmission and distribution conference and exposition, Latin America, Venezuela.
[3] David Topolánek, Doctoral Degree Programme (1), FEEC BUT, current-transformer testing with cpc 100.
[4] LabVIEW user manual. National Instruments
[5] CMC 356 user manual. Omicron.
[6] ANSI/IEEE C57.13.1-1981, IEEE guide for field testing of relaying current transformers
[7] IEC 60044-1, Edition 1.2 -2003, Instrument Transformers Part 1- Current Transformers.