Application Note

Principles of Measurement Transformer Accuracy

Measuring instruments, such as ammeters, voltmeters, kilowatt□hour meters, etc , whether electromechanical or electronic, meet insuperable design problems if faced with the high voltages or high currents commonly used in power systems. Furthermore, the range of currents employed throughout is such that it would not be practical to manufacture instruments on a mass production scale to meet the wide variety of current ranges required.
Current transformers are therefore used with the measuring instruments to:

(a) Isolate the instruments from the power circuits.
(b) Standardise the instruments, usually at 5 amps or 1 amp.
(The scale of the instrument (according to the CT ratio), then becomes the only non□standard feature of the instrument)

Accuracy classes for various types of measurement are set out in the relevant IEEE(ANSI), CAN/CSA, AS or in our case BSEN /IEC 60044-1.

It will be seen that the class designation is an approximate measure of the accuracy, e g , Class 1 current transformers have ratio error within 1% of rated current. Phase difference is important when power measurements are involved, i.e. when using wattmeter's, kilowatt□hour meters, VAr meters and Power Factor meters.

Accuracy Class	% current (ratio) error at % of rated current shown below				Phase displacement (minutes) at % of rated current shown below				Application
	5	20	100	120	5	20	100	120	
0.1	0.4	0.2	0.1	0.1	15	8	5	5	Precision Test & Measurement
0.2	0.75	0.35	0.2	0.2	30	15	10	10	Precision Grade Meters
0.5	1.5	0.75	0.5	0.5	90	45	30	30	Tariff kWh Metering
1.0	3.0	1.5	1.0	1.0	180	90	60	60	Commercial kWh Metering

The table below details limits of error for current transformers for special applications and having a secondary current of 5A

Accuracy Class	% current (ratio) error at % of rated current shown below					Phase displacement (minutes) at % of rated current shown below				
0.2s	0.75	0.35	0.2	0.2	0.2	30	15	10	10	10
0.5s	1.5	0.75	0.5	0.5	0.5	90	45	30	30	30

Design Considerations

As in all transformers, errors arise due to a proportion of the primary input current being used to magnetise the core and not transferred to the secondary winding. The proportion of the primary current used for this purpose determines the amount of error.

The essence of good design of measuring current transformers is to ensure that the magnetising current is low enough to ensure that the error specified for the accuracy class is not exceeded. This is achieved by selecting suitable core materials and the appropriate cross-sectional area of core. Frequently in measuring currents of 50A and upwards, it is convenient and technically sound for the primary winding of a CT to have ***one turn only***.

In these most common cases the CT is supplied with a secondary winding only, the primary being the cable or busbar of the main conductor which is passed through the CT aperture in the case of ring CTs (i .e. single primary turn) it should be noted that the lower the rated primary current the more difficult it is (and the more expensive it is) to achieve a given accuracy. Considering a core of certain fixed dimensions and magnetic materials with a secondary winding of say 200 turns (current ratio 200/1 turns ratio 1/200) and say it takes 2 amperes of the 200A primary current to magnetise the core, the error is therefore only 1% approximately. However considering a 50/1 CT with 50 secondary turns on the same core it still takes 2 amperes to magnetise to core. The error is then 4% approximately, to obtain a 1% accuracy on the 50/1 ring CT a much larger core and/or expensive core material is required.

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