The Basics of Current Transformers

Current Transformers (CTs) can be used for monitoring current or for transforming primary current into reduced secondary current used for meters, relays, control equipment and other instruments. CTs that transform current isolate the high voltage primary, permit grounding of the secondary, and step-down the magnitude of the measured current to a standard value that can be safely handled by the instrument. To determine which CT is appropriate for a particular application, it is important to understand the following characteristics that are used to classify current transformers.

Ratio

The CT ratio is the ratio of primary current input to secondary current output at full load. For example, a CT with a ratio of 300:5 is rated for 300 primary amps at full load and will produce 5 amps of secondary current when 300 amps flow through the primary. If the primary current changes the secondary current output will change proportionally. For example, if 150 amps flow through the 300 amp rated primary the secondary current output will be 2.5 amps (150:300 = 2.5:5).

Polarity

The polarity of a CT is determined by the direction the coils are wound around the core of the CT (clockwise or counter-clockwise) and by the way the leads, if any, are brought out of the transformer case.

All current transformers are subtractive polarity and will have the following designations to guide proper installation:

(H1) primary current, line facing direction; (H2) primary current, load facing direction; and (X1) secondary current.

Taking care to observe proper polarity is important when installing and connecting current transformers to power metering and protective relays.

Accuracy Class

Accuracy Class describes the performance characteristics of a CT and the maximum burden allowable on the CTs secondary. Figure 1 shows typical accuracy classes. Depending on their Accuracy Class, CTs are divided into Metering Accuracy CTs or Relaying Accuracy CTs (Protection CTs). A CT can have ratings for both groups.

Metering Accuracy CTs are rated for specified standard burdens and designed to be highly accurate from very low current to the maximum current rating of the CT. Because of their high degree of accuracy, these CTs are typically used by utility companies for measuring usage for billing purposes.

Relaying Accuracy CTs are not as accurate as Metering Accuracy CTs. They are designed to perform with a reasonable degree of accuracy over a wider range of current. These CTs are typically used for supplying current to protective relays. The wider range of current allows the protective relay to operate at different fault levels.

The CT Accuracy Class is listed on the label or the nameplate of the CT and is comprised of three parts: rated ratio accuracy rating, class rating, and maximum burden (Figure 2).

Rated Ratio Accuracy Rating is a number which is the rated ratio expressed as a percent. For example, a CT with an accuracy class of 0.3 is certified by the manufacturer to be accurate to within 0.3 percent of its rated ratio value for a primary current of 100 percent of rated ratio.

Correction Factor Limits for CTs				
Accuracy	100% Rated Current		10% Rated Current	
Class	Min	Max	Min	Max
1.2	0.998	1.012	0.976	1.024
0.6	0.994	1.006	0.988	1.012
0.3	0.997	1.003	0.994	1.006
0.5	0.995	1.005	0.995	1.005

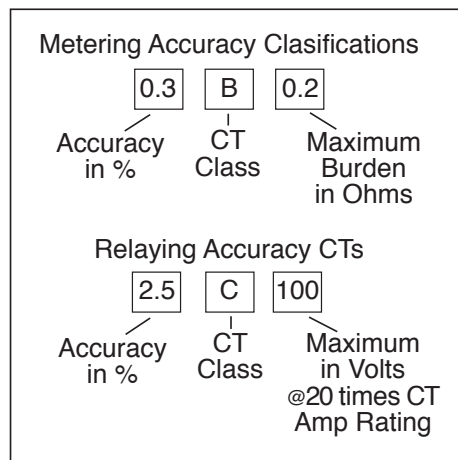Figure 1: Typical Accuracy Classes and Correction Factors

Figure 2: Examples of Accuracy Classifications for Metering CTs and Relaying (Protection) CTs.

CT Class Rating is a letter that designates the application for which the CT is rated. Metering CTs are designated with the letter B. Relaying CTs have several different letter designations:

C: The CT has low leakage flux. (Accuracy can be calculated before manufacturing.)

T: The CT can have significant leakage flux. (Accuracy must be determined by testing at the factory.)

H: The CT accuracy is applicable within the entire range of secondary currents from 5 to 20 times the nominal CT rating. (Typically wound primary CTs.)

L: The CT accuracy applies at the maximum rated secondary burden at 20 time the rated current. The ratio accuracy can be up to four times greater than the listed value, depending on connected burden and fault current. (Typically window, busing, or bar-type CTs.)

The third part of the CT Accuracy Class is the maximum burden allowed for the CT. This is the load that may be imposed on a transformer secondary without causing an error greater than the stated accuracy classification. For Metering Class CTs burden is expressed as ohms impedance. For Protection-class CTs burden is express as volt-amperes (VA). Protection-class CT burdens are displayed as the maximum secondary volts allowable if 20 times the CT rating were to flow through the secondary circuit (100 amperes with a five-ampere nominal CT secondary).

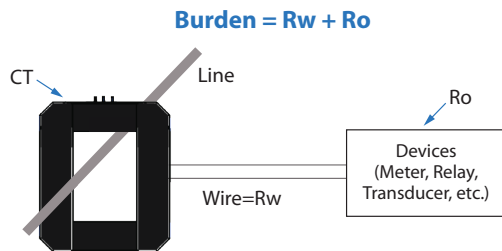Calculating CT Burden (Figure 3):

Burden = Rw + Ro

Figure 3: Calculating CT Burden

1. Determine the burden of the device connected to the CT in VA or ohms impedance. (Stated on the data sheet for the device.)

2. Add impedance of the secondary wire run. Measure the length of the wire between the current transformer and the burden (i.e. meter, relay, etc.). Refer to the table at the right to determine the resistance, in ohms or VA, of the wires that connect the secondary of the current transformer to the device.

3. Make sure the total burden does not exceed the specified limits for the CT.

Examples of Burden Calculations:

Metering CT: The ratio of a 0.3B0.1 rated Metering CT is accurate to 0.3 percent if the connected secondary burden if impedance does not exceed 0.1 ohms. A 0.6B8 rated metering-class CT will operate within 0.6 percent accuracy if the secondary burden does not exceed 8.0 ohms.

Relaying (Protection) CT: A 2.5C100 Relaying CT is accurate within 2.5 percent if the secondary burden is less than 1.0 ohm (100 volts/100 amperes).

If the CT has a stated burden of 8VA, the total connected secondary load cannot exceed 0.32 ohms. This includes the resistance of the secondary wire leads and the connected load (panel meter or power monitor). Using 18 AWG wire for the secondary means that the current transformer must be less than 18.95 feet from the connected load (37.9 feet divided by two, The maximum distance from CT out to the load and back to the current transformer). This table is based on 5 amp secondary current transformer types.

Allowable Burden Expressed As[1]		Allowable Lead Length in Feet for Copper AWG Wire[2]					
VA	Ohms[3]	18	16	14	12	10	8
1	0.04	4.7	7.6	12.3	19.5	31.0	49.4
1.5	0.06	7.1	11.3	18.4	29.3	46.5	74.2
2	0.08	9.5	15.1	24.5	39.0	62.0	98.9
3	0.12	14.2	22.7	36.8	58.5	93.0	148.3
4	0.16	18.9	30.2	49.1	78.0	124.0	197.8
5	0.20	23.7	37.8	61.3	97.6	155.0	247.2
6	0.24	28.4	45.4	73.6	117.1	186.0	296.7
7	0.28	33.1	52.9	85.9	136.6	217.1	346.1
8	0.32	37.9	60.5	98.2	156.1	248.1	395.6
9	0.36	42.6	68.1	110.4	175.6	279.1	445.0
10	0.40	47.3	75.6	122.7	195.1	310.1	494.4
12	0.48	56.8	90.7	147.2	234.1	392.1	593.3
14	0.56	66.3	105.9	171.8	273.2	434.1	692.2
16	0.64	75.7	121.0	196.3	312.2	496.1	791.1
18	0.72	85.2	136.1	220.9	351.2	558.1	890.0
20	0.80	94.7	151.2	245.4	390.2	620.2	988.9
25	1.00	118.3	189.0	306.7	487.8	775.2	1,236.1
30	1.20	142.0	226.8	368.1	585.4	930.2	1483.3
35	1.40	165.7	264.7	429.4	682.9	1,085.3	1,730.5
40	1.60	189.3	302.5	490.8	780.5	1,240.3	1,977.8
45	1.80	213.0	340.3	552.1	878.0	1,395.3	2,225.0
50	2.00	236.7	378.1	613.5	975.6	1,550.4	2,472.2

[1] See the NK Technologies' Product Catalog for Allowable Burden. Add any other resistance such as terminations, etc.
[2] Lead length is the total wire run (out and back). Divide by two to get the lead distance.
[3] Resistance for 5 Amp output CTs.

Current Transformer Shorting

CTs should remain shorted during installation until secondary wiring is complete. Figure 4 shows the termination of a multi-ratio CT on a shorting terminal strip.

A shorting screw inserted through the shorting bar ties isolated terminal strip points together. Any shorting winding effectively shorts the entire CT.
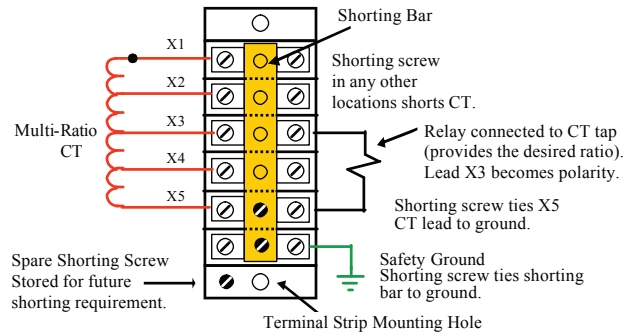

Figure 4: Termination of a CT on a shorting terminal strip.

Use Caution When Installing a Current Transformer

➤ Inspect the physical and mechanical condition of the CT before installation.

➤ Check the connection of the transformer requirments for the instrument or the system requirements before connecting the CT.

➤ Inspect the space between the CT phases, ground and secondary conductor for adequate clearance between the primary and secondary circuity wiring.

➤ Verify that the shorting device on the CT is properly connected until the CT is ready to be installed. The secondary of the CT must always have a burden (load) connected when not in use. NOTE: A dangerously high secondary voltage can develop with an open-circiuited secondary.

Current Transformer Model Option

There are many methods of measuring electrical current, but when the requirement is to replicate the primary current wave shape, toroid based current transformers are the most common and least expensive method available. Current transformers are available in solid-core or split-core designs A split-core case allows the transformer to be installed after the conductors are in place. Pull the top bar off the sensing ring and set the transformer underneath the wires or bars. There are also CTs with larger sensing windows that will easily accommodate the conductors. Multiple wires per phase will pass through the aperture without extra efforts.

CT-MS & CT-LS current transformers feature larger sensing windows for easy installation around larger conductors and multiple wires.

ProteCT™ current transformers eliminate the need for a shorting block and produce only a very low voltage when they are in an open secondary condition, a safety feature inherent in the product design. The drawback is that the power monitor or panel meter must be designed to accept the low voltage input. The need to calculate burden is eliminated, as the output signal can be read at a long distance from the measuring location with very little added error. The secondary leads from the ProteCT™ to the connected load should be a twisted pair, with shielding optional but highly recommended.

ProteCT™ current transformers eliminate the need for a shorting block.

A current transformer can also be used as an input to a current relay or transmitter, or to reduce the current so that a current switch or transducer can be utilized. Simply short the secondary of the CT through the sensing window of the sensor. A trip point between 1 and 5 amps can be established with a current switch. Use a current transducer with a range of 0–5 amps, or if the CT secondary is looped through the sensor twice, a transducer with a range of 0–10 amps can be used.