

# CURRENT TRANSFORMERS THE BASICS

**Current Transformers (CT's)** can be used for monitoring current or for transforming primary current into reduced secondary current used for meters, relays, control equipment and other instruments. CT's 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 accordingly. 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 for the CT (clockwise or counterclockwise) and by the way the leads are brought out of the transformer case (Figure 1). 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 CT's secondary. Figure 2 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 3).

**Rated Ratio Accuracy Rating** –The first part of the CT Accuracy Class 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.

**CT Class Rating**–The second part of the CT Accuracy Class 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 CTs.)
- L** – The CT accuracy applies at the maximum rated secondary burden at 20 time rated only. 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.)



Figure 1: On subtractive polarity transformers the H1 primary lead and the X1 secondary lead are on the same side of the transformer.

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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 2: Typical Accuracy Classes and Correction Factors

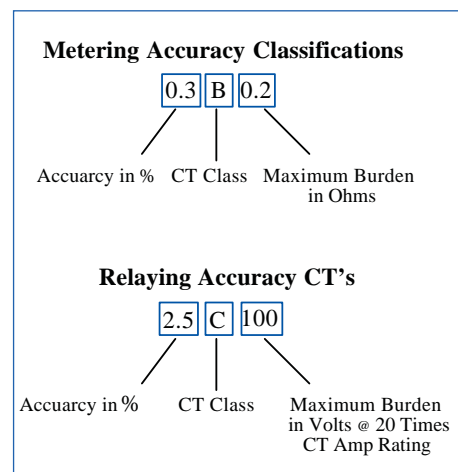


Figure 3: Examples of Accuracy Classifications for Metering CTs and Relaying (Protection) CTs.

## Burden

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 expressed 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 4):

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 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).

Allowable Burden Expressed As*		Allowable Lead Length in Feet for Copper AWG Wire**					
VA	Ohms***	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

Note: \* See Catalog for Allowable Burden. Add any other resistance such as terminations, etc.  
 \*\* Lead length is the total wire run (out and back). Divide by two to get the lead distance.  
 \*\*\* Resistance for 5 Amp output CTs.

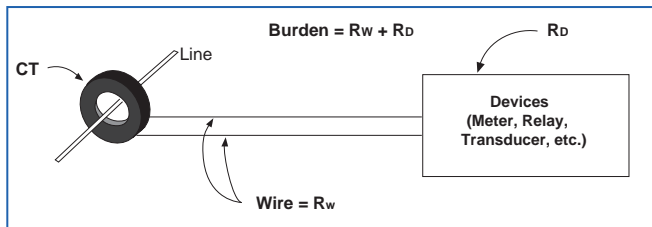


Figure 3: Calculating CT Burden

## CT 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.

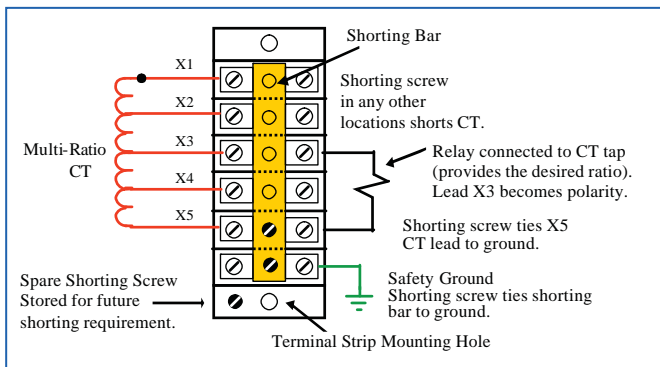


Figure 4: Termination of a multi-ratio CT on a shorting strip.

## Cautions

- ⚠ Inspect the physical and mechanical condition of the CT before installation.
- ⚠ Check the connection of the transformer requirements 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 circuitry 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-circuited secondary.