SQUARE D
Product Data Bulletin

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MOST OFTEN ASKED QUESTIONS ABOUT CURRENT AND VOLTAGE TRANSFORMERS (CTs AND VTs)

1. **What CT window size is needed to accommodate the customer's conductors?**
   Table 1 shows the suggested minimum window diameter to accommodate the following 600V wire types: RH, XHHW, RH with outer covering, RHW with outer covering, THW, RUH, RUW, THHN, TW, and THWN.

Table 1: Minimum Current Transformer Window Diameter

Wire Size	Number of Conductors Through Window						Cable Diameter
	1	2	3	4	5	6	
#12 AWG							0.221
#10 AWG							0.242
#8 AWG						1-1/8	0.328
#6 AWG	Fits in 1-1/8 in. CTs				1-1/8	1-5/16	0.397
#4 AWG				1-1/8	1-5/16	1-9/16	0.452
#3 AWG				1-5/16	1-5/16	1-9/16	0.481
#2 AWG		1-1/8	1-1/8	1-5/16	1-9/16	1-9/16	0.513
#1 AWG		1-5/16	1-5/16	1-9/16	1-15/16	1-15/16	0.588
#1/0 AWG		1-5/16	1-5/16	1-9/16	1-15/16	1-15/16	0.629
#2/0 AWG		1-9/16	1-9/16	1-15/16	1-15/16	2-11/32	0.675
#3/0 AWG		1-9/16	1-9/16	1-15/16	2-11/32	2-11/32	0.727
#4/0 AWG		1-9/16	1-9/16	1-15/16	2-11/32	2-11/32	0.785
250 kcmil		1-15/16	1-15/16	2-11/32	2-1/2	2-1/2	0.868
300 kcmil		1-15/16	2-11/32	2-11/32	2-1/2	4	0.933
350 kcmil		1-15/16	2-11/32	2-1/2	4	4	0.985
400 kcmil		2-11/32	2-11/32	2-1/2	4	4	1.032
500 kcmil	1-1/8	2-11/32	2-1/2	4	4	4	1.119
600 kcmil	1-5/16	2-1/2	4	4	4	4	1.233
700 kcmil	1-5/16	4	4	4	4	4	1.304
750 kcmil	1-9/16	4	4	4	4	4	1.339
800 kcmil	1-9/16	4	4	4	4	4-1/4	1.372
900 kcmil	1-9/16	4	4	4	4	4-1/4	1.435
1000 kcmil	1-9/16	4	4	4	4-1/4	5-3/4	1.494

For cable diameters other than those shown in Table 1, use the following formula to determine the minimum window diameter:

Window Diameter = F × Cable Diameter

Where "F" = factor for number of cables through the window, determined from the following table:

No. of Cables through Window	3	4	5	6	7	8	9
"F"	2.165	2.414	2.704	3.000	3.000	3.730	3.830

2. **Does the position of the conductor in the CT window matter?** No, not for toroidal design CTs.

3. **What does "R" in 64R stand for?** UL component recognition per classification XODW2.

4. **Does polarity matter?** Polarity is *not* important when connecting to ammeters and voltmeters. Polarity *is* important only when connecting to watt meters, watthour meters, varmeters, and induction-type relays. To maintain polarity, the "H1" side of the CT must be toward the source of power; then the "X1" secondary terminal is the polarity connection.

5. **Why can't a control power transformer be used in place of a VT?** Control power transformers provide acceptable voltage regulation for power needs; however, their ratio and phase angle performance are not as accurate as VTs for metering application.

6. **How are primary amperes determined if only a motor horsepower rating is known, and what CT ratios are applicable to these current levels?** Table 2 shows the motor full load amperes. *Use this table only when the motor full load current is not known.*

Table 2: Primary Amperes for Motor Horsepower Ratings

Motor Horsepower	Motor Full Load Current (FLC) in Amperes ac				
	Three Phase			Single Phase	
	230V	460V	575V	115V	230V
1/3	1.32	0.66	0.053	5.47	2.74
1/2	1.80	0.90	0.72	7.45	3.73
3/4	2.50	1.25	1.00	10.1	5.07
1	3.20	1.60	1.28	12.6	6.31
1-1/2	4.50	2.25	1.80	17.2	8.59
2	5.80	2.90	2.32	21.4	10.7
3	8.40	4.20	3.36	29.1	14.5
5	13.4	6.68	5.35	42.9	21.4
7-1/2	19.6	9.82	7.86	58.4	29.2
10	25.8	12.9	10.3	–	36.3
15	38.0	19.0	15.2	–	49.4
20	49.9	24.9	20.0	–	–
25	61.7	30.8	24.7	–	–
30	73.3	36.7	29.3	–	–
40	96.4	48.2	38.5	–	–
50	119	59.6	47.6	–	–
60	142	70.8	56.6	–	–
75	175	87.6	70.0	–	–
100	230	115	92.0	–	–
125	284	142	114	–	–
150	338	169	135	–	–
200	445	222	178	–	–

Note: These currents should not be used for selection of fuses, circuit breakers, or wire sizes. See National Electric Code (NEC) Tables 430-148 through 430-150. For motors rated 208 to 220 volts, use 230V column. For motors rated 440 to 550 volts use 460V and 575V columns respectively.

Table 3: Current Transformer Ratios for Motor Load Applications [1]

Motor Full Load Current (FLC) in Amperes ac	Current Transformer Ratio
10–18	25:5[2]
18–37	50:5[2]
32–55	75:5[2]
50–74	100:5
65–110	150:5
100–150	200:5
130–190	250:5
180–225	300:5
200–300	400:5
290–375	500:5
350–450	600:5
400–550	750:5
500–750	1000:5

[1] Because of in-rush current effect on meter movements, leaving a sizeable safety margin between Motor FLC and CT ratio is recommended.

[2] Adding primary turns may be necessary to obtain these low ratios.

7. **Can the CTs and the VTs in the Class 4210 catalog be used for *utility* revenue billing?** No. Utilities require units of a specific size and design, and require certified test reports submitted with each unit. Indoor units are not supplied with certified test reports.

8. **What are the hazards of having the CT secondary open-circuited?** The hazard of electric shock, burn, or explosion exists on an open-circuited CT. Death, severe personal injury, or equipment damage can result if the leads are touched when the CT is open-circuited. As much as 4000V on the secondary has been measured on large core CTs with an open-circuited secondary. CTs must *always* be shorted *or* connected to a burden such as a meter or relay. Open-circuiting may also damage the CT insulation. Once a CT has been open-circuited, it must be demagnetized or accuracy may be reduced. For information on how to demagnetize a CT, ask your Square D representative.

9. **What CT should be used on a meter with specific full-scale marking and a specific meter movement?** The CT ratio must be the same as the full-scale marking on the meter to its meter movement.

      Example: Meter Scale = 0–50A ac
                     Meter Movement = 0–5A ac
      Answer: CT ratio must equal 50:5

With 50A flowing in the primary conductor, the CT secondary reading is 5A. Five amperes into the meter gives *full*-scale deflection. Thus, the meter reading is correct.

10. **What are some common mistakes made with CTs?**
    1) For a meter with a 0 to 100A scale and 5A movement, the user selects an improper ratio such as 50:5, 30:5, or 200:5. Solution: only a 100:5 CT ratio will read correctly in this situation.
    2) Use of small size CTs (2NR or 5NR) connected to meter more than 100 feet away. The meter will read incorrectly because the small CT is unable to support the burden (ohms). This is due to the long run of wire. Solution: use a larger CT (one with more core steel), or if the distance is too far, use a current transducer and change to a milliamperes (dc) meter with a linear ac scale that is the same as the CT ratio at full load.

11. **What is the difference between potential transformers and voltage transformers?** Potential transformers (PTs) and voltage transformers (VTs) are the same. "VT" describes the voltage quantity measured and complies with the latest national standard.

12. **Can the CTs and VTs in the Class 4210 catalog be used outdoors?** No. Class 4210 transformers are for indoor use only.

13. **Can 600V window-type CTs be used at voltages above 600V?** A common misconception is that 600V window-type CTs may be applied only on circuits of 600V or less. If a conductor is fully insulated and shielded for the voltage, then a 600V CT may be properly applied over the shielding on higher voltage systems. However, 600V CTs listed in our catalog should not be applied to circuits having a phase-to-phase voltage greater than 600V, unless adequate additional insulation is applied between the primary and secondary windings. Square D assumes no responsibility for personal injury or equipment damage from the use of transformers on circuits above their published ratings.

14. **What is Thermal Rating Factor?** Frequently, CTs are designed to continuously carry a current exceeding the nameplate rating. This overcurrent factor is know as the *Continuous Thermal Current Rating Factor*, frequently abbreviated to *Rating Factor* or *RF*. The maximum current at which a CT can operate continuously, without exceeding the thermal limits of its insulation, is the nameplate rating times the rating factor. For example, a CT with a nameplate rating of 500:5 and a RF of 1.5, could operate continuously at 750:7.5 amperes. A transformer with a RF of 1.0 could not be operated continuously above its nameplate rating without the risk of overheating and subsequent damage to the insulation.

15. **What is accuracy?** CT accuracy is a percent of metering error at a given volt ampere (VA) or ohms burden. The accuracy of Models 2NR and 5NR are from ±1% to ±2%, depending on the model and ratio at a specific VA. These VAs are a maximum value. At a greater VA, the error is greater than stated; at less VA, the accuracy is at least as good as stated, maybe better. The relationship between CT burden (given as VA) and impedance is expressed as:

$$VA \times \cos\theta(PF) = P = I^2R$$
$$VA \times \sin\theta = Q = I^2X$$

This relationship can be approximated by finding the sum of the impedance values, similar to adding resistance. Then, VA and ohms impedance can be easily converted using the formula:

$$VA = I^2Z$$

Where "Z" is the total secondary impedance in the circuit, which is the sum of the resistance of the wiring and connected devices. The rated secondary current "I" for CTs is 5A.

To convert from VA to ohms resistance, let's use the Catalog #2NR-101 as an example: If 2NR-101 accuracy = ±1% at burden of 2.0VA (60Hz), then:

$$2.0VA = I^2Z = (5)^2(Z)$$
$$Z = 0.08 \text{ ohm}$$

So the maximum burden or resistance that this CT can operate at is 0.08 ohm and still maintain a ±1% accuracy.

VT accuracy is also a percent of error at a given volt ampere (VA) burden. With a ±0.3% accuracy, the secondary voltage output is within ±0.3% of rated voltage at the stated burdens. VT burdens are listed in VAs, which is designated by industry standards as a letter, as shown below:

Volts Amperes (VA)	12.5	25	35	75	200	400
Burden Designation	W	X	M	Y	Z	ZZ

Accuracy and burden are normally listed as follows:
CTs = 0.3 B1.8 is ±0.3% accuracy at a burden not greater than 1.8 ohm
VTs = 0.3 W, X is ±0.3% accuracy at burdens "W" (12.5 VA@0.1PF) and "X" (25VA@0.1PF)

16. **How do I select transformer accuracy?** All instrument transformers operate within a measurable margin of error. The metering accuracy is divided into three classes as shown in Table 4.

Table 4: Metering Accuracy of Current Transformers

Accuracy Class	Current Transformer Max. Error at Secondary Amperes		Voltage Transformer Max. Error 90–110% Volts
	5.0 Ampere	0.5 Ampere	
0.3	± 0.3%	± 0.6%	± 0.3%
0.6	± 0.6%	± 1.2%	± 0.6%
1.2	± 1.2%	± 2.4%	± 1.2%

Table 5 shows recommended accuracy classes for metering and control relaying. Switchboard meters are normally rated at 1% accuracy and panelboard meters are rated 2% or 3%.

Table 5: Determining Accuracy

Accuracy Class of Meter	1%	2%	3%
Accuracy Class of CT or VT	0.3%	0.6%	1.2%
Accuracy Class of CT or VT for Wattmeter, Watthour meters, Varmeters, Transducers, etc.	0.3%		
Accuracy Class of CT or VT for Control Relay Use	1.2%		

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