



- Ring type current transformer.
- Tough resilient flame retardant.
- Temperature range -20°C to 70°C
- Protection class 5P5, 5P10, 5P20 etc.
- Test voltage 4Kv 50Hz. 1min.
- IEC44-1, IEC185, BS3938, DIN42600
- Tropicalised design with Insulation Class A and thermal 105°C
- Totally enclosed in tough with self extinguishing.
- Operating voltage 0.66 KV

Introduction

Protective Current Transformers are designed to measure the actual currents in power systems and to produce proportional currents in their secondary windings which are isolated from the main power circuit. These replica currents are used as inputs to protective relays which will automatically isolate part of a power circuit in the event of an abnormal or fault condition therein, yet permit other parts of the plant to continue in operation.

Satisfactory operation of protective relays can depend on accurate representation of currents ranging from small leakage currents to very high overcurrents, requiring the protective current transformer to be linear, and therefore below magnetic saturation, at values up to perhaps 30 times full load current. This wide operating range means that protective current transformer require to be constructed with larger cross-sections and heavier cores than equivalent current transformers used for measuring duties only. For space and economy reasons, equipment designers should however, avoid over-specifying protective current transformers. To specifying protective CT's and require some or all of the following information:

- (a) Protected equipment and type of protection.
- (b) Maximum fault level for stability.
- (c) Sensitivity required.
- (d) Type of relay and likely setting.
- (e) Pilot wire resistance, or length of run and pilot wire used.
- (f) Primary conductor diameter or busbar dimensions.

CAUTION:
RELAY MANUFACTURER'S RECOMMENDATIONS SHOULD ALWAYS BE FOLLOWED

Accuracy

Accuracy Limit Factor is defined as the multiple of rated primary current up to the transformer will comply with the requirements of 'Composite Error'.

Composite Error is the deviation from an ideal CT (as in Current Error), but takes account of harmonics in the secondary current caused by non-linear magnetic conditions through the cycle at higher flux densities

Standard Accuracy Limit Factors are 5, 10, 15, 20 and 30.

The electrical requirements of protection current transformer can therefore be defined as:

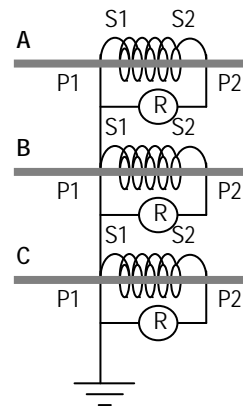
Ratio / VA Burden / Accuracy Class / Accuracy Limit Factor.

Class 5P and 10P protective current transformers are generally used in overcurrent and unrestricted earth leakage protection.

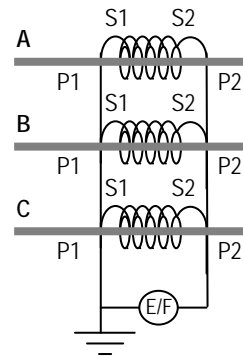
With the exception of simple trip relays, the protective device usually has an intentional time delay, thereby ensuring that the severe effect of transients has passed before the relay is called to operate. Protection Current Transformers used for such applications are normally working under steady state conditions. Three examples of such protection is shown.

In some systems it may sufficient to simply detect a fault and isolate that circuit. However, in more discriminating schemes, it is necessary to ensure that a phase-to-phase fault does not operate the earth fault relay.

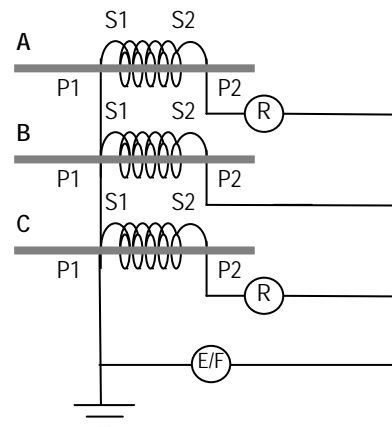
Three Phase Overcurrent Protection.



Unrestricted Earth Fault Protection (Detects earth faults on the load side of CT)



Combined 3Phase & Unrestricted Earth Fault Protection



Phase Fault Stability

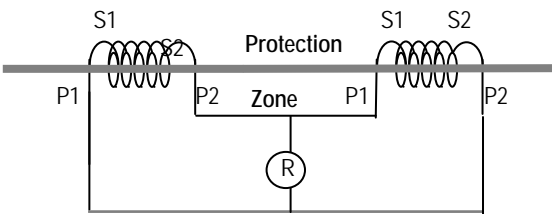
Current transformers which are well matched and operating below saturation, will deliver no current to the earth fault relay, since 3-phase currents sum to zero. If however, the transformers are badly matched, a spill current will arise which will trip the relay. Similarly, current transformers must operate below the saturation region, since, in a 3-phase system, third harmonics in the secondary are additive through the relay, thereby creating instability and erroneously tripping the earth fault relay .

Balanced Protection

In balanced systems of protection, electrical power is monitored by the protective CTs at two points in the system as shown. The protected zone is between the two CTs. If the power out differs from the power in, then a fault has developed within the protected zone and the protection relay will operate.

A 'Through Fault' is one outside the protected zone. Should such a fault occur, the relay protecting the protected zone will not trip, since the power out will still equal the power in.

Numerous different types of balanced systems exist and advice may often have to be obtained from the relay manufacturer. However, in all cases Sensitivity and Stability must be considered.



Transient Effects

Balanced protective systems may use time lag or high speed armature relays. Where high speed relays are used, operation of the relay occurs in the transient region of fault current, which includes the d.c. asymmetrical component. The build up of magnetic flux may therefore be high enough to preclude the possibility of avoiding the saturation region.

The resulting transient instability can fortunately be overcome using some of the following techniques:

- (a) Relays incorporating capacitors to block the dc asymmetrical component.
- (b) Biassed relays, where dc asymmetrical currents are compensated by anti-phase coils
- (c) Stabilising resistors in series with current operated relays, or in parallel with voltage-operated relays. These limit the spill current (or voltage) to a maximum value below the setting value. For series resistors in current operated armature relays.

$$R_s = \frac{V_{kp} - VA}{\frac{2}{I_r}}$$

Where R_s = value of stabilising resistor in ohms
 V_{kp} = CT knee point voltage
 VA = relay burden (typically 3VA)
 I_r = relay setting current

Note

The value of R_s varies with each fault setting. An adjustable resistors is therefore required for optimum results. Often a fixed resistor suitable for mid-setting will suffice.

Sensitivity

Sensitivity is defined as the lowest value of primary fault current, within the protected zone, which will cause the relay to operate. To provide fast operation on an in-zone fault, the current transformer should have a 'Knee-Point Voltage' at least twice the setting voltage of the relay.

The 'Knee-Point Voltage' (V_{kp}) is defined as the secondary voltage at which an increase of 10% produces an increase in magnetising current of 50%. It is the secondary voltage above which the CT is in magnetic saturation.

Differential relays may be set to a required sensitivity but will operate at some higher value depending on the magnetising currents of the CTs, for example: The diagram shows a restricted earth fault system with the relay fed from 400/5 CTs. The relay may be set at 10%, but, it requires more than 40A to operate the relay, since the CT in the faulty phase, has to deliver its own magnetising current and that of the other CTs in addition to the relay operating current.

Where

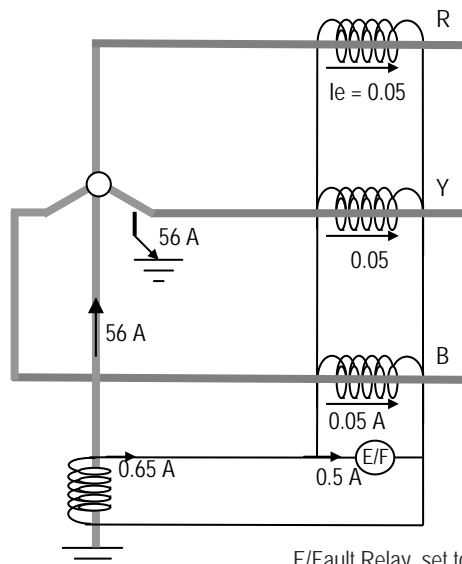
Primary Operating Current (P.O.C.) = $K(I_r + nI_e)$

K = CT Ratio

I_r = Relay set current

I_e = CT magnetising current

n = Number of CTs in parallel.



Neutral CT Supplies Relay+ Mag. Current Of four CT's

E/Fault Relay, set to trip at 10% ie. 40A Pri. Fault, will not trip until fault is 56A.

Stability

That quality whereby a protective system remains in-operative under all conditions other than those for which it is designed to operate, i.e., an in-zone fault. Stability is defined as ratio of the maximum through fault current at which the system is stable to nominal full load current.

Good quality current transformers will produce linear output up to the defined knee-point voltage (V_{kp}).

Typically,

$V_{kp} = 21f (R_s + R_p)$ for stability, where

I_f = max. through fault secondary current at stability limit
 R_s = CT secondary winding resistance
 R_p = loop lead resistance from CT to Relay

LIMITS OF ERROR FOR ACCURACY CLASS 5P and 10P

According to BS3938 (1973) and IEC 185(1966) protective current transformers are specified as follows:

Rated Output: The burden including relay and pilot wires. Standard burdens are 2.5, 5, 7.5, 10, 15 and 30VA.

Accuracy Class: Accuracy classes are defined as 5P or 10P with limits according to the following table extracted from IEC 185.

| General Type of Relay | Protective System | Phase Displacement at Rated Primary Current | | Composite Error at Rated Accuracy Limit Primary Current |
|-----------------------|-------------------|---|--------------|---|
| | | Mins | Centiradians | Accuracy Limit Factor |
| 5P | ±1 | ±60 | ±1.8 | 5 |
| 10P | ±3 | | | 10 |

The designing of a protective system, of which the current transformer is a vital part, can be a complex recommendation, the following is a guide to those systems that occur frequently. This suggestion should be treated with caution as they may be subject to variation due to relay characteristics or the other components.

Typical Example of Current Transformer.

Time lags on relays are set in such a way that a fault in a sub-section will isolate that section of the distribution only. Accurate time grading of relays can be adversely affected by inaccuracy or saturation in the associated current transformer. The following table is intended to show typical examples of CT applications. However, in all cases, manufacturers recommendations must be followed.

Recommendation For Protective Current Transformers

| General Type Relay | Protective Systems | TYPICAL CT REQUIREMENT | | |
|--|---|------------------------|-------|---|
| | | VA | Class | Accuracy Limit |
| Magnetic Trips | Over current | 2.5-5 | 10P | 5 |
| Magnetic O/L with dash pot | Motor Over current with Time relay | 5 | 10P | 5 -10 |
| Low consumption Thermal Type | Motor Over current with Time delay | 2.5 | 10P | 10 - 15 |
| Thermal | Motor Over current | 7.5 | 10P | 10 - 15 |
| Thermal relays requiring saturating CTs to protect heater elements | Motor Over current with Time delay | relay VA + pilot VA | 10P | 1.5 Saturating CTs also used to avoid spurious tripping on slow start |
| Inverse Definite Min. Time Relays(I.D.M.T.) | Over current | 15 | 10P | 10 or 15 |
| I.D.M.T. Earth fault Relays | Unrestricted earth fault & approx. time grading | 15 | 10P | 10 |
| I.D.M.T. Earth fault Relays | Unrestricted earth fault where phase fault stability or accurate time grading required. | 15 | 5P | 10 |

Please note:

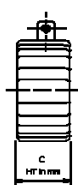
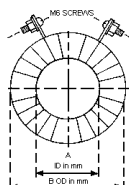
1. Add lead burden if more than 1.5VA. (Refer to next page table for CSA cable calculation on Burden).
2. The standard accuracy limit factors are 5-10-15-20-30.

VA For "Go And Return" Cable Per Meter On The Length For Single Lead Run

| Cable CSA | VA / METER | | | | | | | |
|-----------|------------|----------|----------|----------|----------|----------|----------|----------|
| | 20°C | | | | 35°C | | | |
| | Ratio/5A | Ratio/5A | Ratio/5A | Ratio/5A | Ratio/1A | Ratio/1A | Ratio/1A | Ratio/1A |
| 1 | 1.08 | 1.14 | 1.22 | 1.32 | 0.040 | 0.044 | 0.048 | 0.132 |
| 1.5 | 0.72 | 0.64 | 0.82 | 0.88 | 0.028 | 0.030 | 0.032 | 0.034 |
| 2.5 | 0.44 | 0.46 | 0.50 | 0.52 | 0.018 | 0.018 | 0.020 | 0.020 |
| 4 | 0.26 | 0.28 | 0.03 | 0.32 | 0.010 | 0.011 | 0.012 | 0.013 |
| 6 | 0.18 | 0.20 | 0.16 | 0.22 | 0.072 | 0.008 | 0.008 | 0.008 |
| 10 | 0.11 | 0.11 | 0.12 | 0.13 | 0.004 | 0.004 | 0.004 | 0.005 |
| 16 | 0.03 | 0.032 | 0.034 | 0.37 | 0.0001 | 0.00012 | 0.00014 | 0.00014 |

- Note:
- 1) For Leads On Unequal Length Use VA/METER Shown X Total Lead Length (Meter)
 - 2) VA shown is calculated at 25% over current to match the error limits of measurement current transformers.
 - 3) The temperature selected should be the maximum temperature expected where the leads run, plus any temperature rise in the cable due to the secondary current. The temperature rise is usually negligible. Check temperature rise at 1.25 x rated current in doubt.
 - 4) No allowance has been made for VA used in the connections of leads between the CT and driven device. It is particularly important to keep these resistance very low for 5 Amps CTs because 0.02 Ohms is 0.5VA.

Current Transformer Ring Type



- 1) Ratio : Standard Ratio as listed
- 2) Class : 5P10, 5P5 etc
- 3) Burden : Standard Ratio as listed or specify
- 4) Type : PR1, PR2 etc.

Example
100/5A, Class 5P10, 5VA, Type PR1

| Type | Ratio | ID (mm.) | OD (mm.) | BURDEN OF CLASS 5P5 | | | | | | BURDEN OF CLASS 5P10 | | | | | BURDEN OF CLASS 5P20 | | | |
|------|---------|----------|----------|---------------------|-----|----|-----|-----|-----|----------------------|-----|-----|-----|-----|----------------------|-----|-----|-----|
| | | | | 5 | 7.5 | 10 | 15 | 20 | 30 | 5 | 7.5 | 10 | 15 | 20 | 5 | 7.5 | 10 | 15 |
| PR1 | 100/5 | 32 | 95 | HT Thickness (mm.) | | | | | | HT Thickness (mm.) | | | | | HT Thickness (mm.) | | | |
| | 120/5 | 32 | 95 | 50 | 60 | 70 | 100 | 120 | - | 80 | 105 | - | - | - | - | - | - | - |
| | 150/5 | 32 | 95 | 40 | 50 | 60 | 80 | 110 | - | 70 | 90 | 110 | - | - | - | - | - | - |
| | 200/5 | 32 | 95 | 40 | 40 | 40 | 55 | 65 | - | 50 | 65 | 75 | - | - | - | - | - | - |
| PR2 | 150/5 | 35 | 100 | 50 | 60 | 70 | 85 | 100 | - | 80 | 100 | 110 | 120 | - | - | - | - | - |
| | 200/5 | 35 | 100 | 40 | 40 | 50 | 65 | 75 | 110 | 55 | 70 | 85 | 115 | - | - | - | - | - |
| | 250/5 | 35 | 100 | 40 | 40 | 50 | 60 | 75 | - | 50 | 70 | 85 | 110 | - | 75 | 100 | - | - |
| | 300/5 | 35 | 100 | 35 | 40 | 40 | 60 | 65 | 90 | 50 | 60 | 70 | 100 | - | 70 | 85 | 110 | - |
| PR3 | 200/5 | 45 | 95 | 40 | 55 | 65 | 80 | 100 | 115 | 75 | 95 | 115 | - | - | - | - | - | - |
| | 250/5 | 45 | 95 | 40 | 50 | 60 | 70 | 85 | 110 | 60 | 85 | 90 | 115 | - | 85 | 110 | - | - |
| | 300/5 | 45 | 95 | 35 | 40 | 40 | 60 | 70 | 95 | 50 | 65 | 85 | 100 | - | 70 | 95 | - | - |
| | 400/5 | 45 | 95 | 35 | 40 | 40 | 60 | 60 | 85 | 60 | 60 | 70 | 90 | - | 65 | 80 | 100 | - |
| PR4 | 400/5 | 60 | 95 | 35 | 40 | 50 | 60 | 70 | 95 | 60 | 70 | 80 | 105 | - | 75 | 95 | 115 | - |
| | 500/5 | 60 | 95 | 35 | 40 | 40 | 60 | 60 | 80 | 50 | 60 | 70 | 90 | 110 | 70 | 85 | 100 | - |
| | 600/5 | 60 | 95 | 30 | 35 | 40 | 50 | 60 | 70 | 50 | 55 | 60 | 80 | 95 | 65 | 75 | 90 | 110 |
| | 800/5 | 60 | 95 | 30 | 30 | 35 | 40 | 50 | 60 | 40 | 50 | 55 | 65 | 80 | 55 | 65 | 75 | 95 |
| PR5 | 600/5 | 70 | 110 | 35 | 35 | 40 | 50 | 55 | 70 | 50 | 55 | 65 | 80 | 100 | 70 | 80 | 90 | 115 |
| | 800/5 | 70 | 110 | 35 | 35 | 35 | 40 | 45 | 55 | 40 | 50 | 50 | 60 | 75 | 50 | 60 | 70 | 85 |
| | 1000/5 | 70 | 110 | 35 | 35 | 35 | 35 | 40 | 50 | 40 | 40 | 50 | 55 | 65 | 50 | 60 | 70 | 80 |
| | 1200/5 | 70 | 110 | 35 | 35 | 35 | 35 | 40 | 40 | 35 | 40 | 40 | 50 | 60 | 40 | 50 | 60 | 70 |
| PR6 | 800/5 | 85 | 125 | 35 | 35 | 35 | 40 | 50 | 60 | 40 | 50 | 55 | 65 | 85 | 60 | 70 | 80 | 95 |
| | 1000/5 | 85 | 125 | 35 | 35 | 40 | 40 | 40 | 60 | 40 | 50 | 50 | 65 | 75 | 50 | 60 | 70 | 85 |
| | 1200/5 | 85 | 125 | 35 | 35 | 35 | 35 | 45 | 40 | 35 | 35 | 40 | 45 | 60 | 40 | 50 | 60 | 65 |
| | 1600/5 | 85 | 125 | 35 | 35 | 35 | 35 | 35 | 40 | 35 | 35 | 35 | 40 | 50 | 40 | 50 | 50 | 65 |
| PR7 | 1200/5 | 110 | 150 | 35 | 35 | 35 | 35 | 40 | 50 | 40 | 35 | 50 | 45 | 65 | 50 | 60 | 65 | 80 |
| | 1600/5 | 110 | 150 | 35 | 35 | 35 | 35 | 35 | 40 | 35 | 35 | 40 | 40 | 50 | 35 | 50 | 50 | 60 |
| | 2000/5 | 110 | 150 | 30 | 30 | 30 | 30 | 30 | 40 | 35 | 35 | 35 | 40 | 40 | 35 | 40 | 50 | 50 |
| | 2500/5 | 110 | 150 | 30 | 30 | 30 | 30 | 30 | 35 | 35 | 35 | 35 | 40 | 40 | 35 | 40 | 40 | 50 |
| PR8 | 1600/5 | 120 | 160 | 35 | 35 | 35 | 35 | 40 | 40 | 35 | 40 | 40 | 45 | 60 | 50 | 50 | 60 | 70 |
| | 2000/5 | 120 | 160 | 35 | 35 | 35 | 35 | 35 | 40 | 35 | 35 | 40 | 40 | 45 | 40 | 40 | 50 | 55 |
| | 2500/5 | 120 | 160 | 35 | 35 | 35 | 35 | 35 | 40 | 35 | 35 | 35 | 40 | 35 | 40 | 40 | 50 | 50 |
| | 3000/5 | 120 | 160 | 35 | 35 | 35 | 35 | 35 | 40 | 35 | 35 | 35 | 40 | 35 | 40 | 40 | 40 | 50 |
| PR9 | 2000/5 | 130 | 170 | 35 | 35 | 35 | 35 | 35 | 40 | 35 | 35 | 40 | 40 | 50 | 40 | 50 | 50 | 60 |
| | 2500/5 | 130 | 170 | 35 | 35 | 35 | 35 | 35 | 40 | 35 | 35 | 40 | 40 | 40 | 40 | 40 | 50 | 55 |
| | 3000/5 | 130 | 170 | 35 | 35 | 35 | 35 | 35 | 40 | 35 | 35 | 35 | 40 | 40 | 35 | 40 | 40 | 50 |
| | 3500/5 | 130 | 170 | 35 | 35 | 35 | 35 | 35 | 40 | 35 | 35 | 35 | 40 | 40 | 35 | 40 | 40 | 40 |
| PR10 | 2000/5 | 140 | 175 | 35 | 35 | 35 | 40 | 40 | 40 | 35 | 35 | 40 | 40 | 50 | 40 | 40 | 55 | 60 |
| | 2500/5 | 140 | 175 | 35 | 35 | 35 | 40 | 40 | 40 | 35 | 35 | 40 | 40 | 50 | 40 | 40 | 55 | 60 |
| | 3000/5 | 140 | 175 | 35 | 35 | 35 | 35 | 35 | 40 | 35 | 35 | 35 | 40 | 40 | 35 | 40 | 40 | 50 |
| | 3500/5 | 140 | 175 | 35 | 35 | 35 | 35 | 35 | 40 | 35 | 35 | 35 | 40 | 40 | 35 | 40 | 40 | 40 |
| PR11 | 4000/5 | 170 | 210 | - | - | 40 | - | - | - | - | - | 40 | - | - | - | - | 40 | - |
| | 5000/5 | 170 | 210 | - | - | 40 | - | - | - | - | - | 40 | - | - | - | - | 40 | - |
| | 6000/5 | 170 | 210 | - | - | 40 | - | - | - | - | - | 40 | - | - | - | - | 40 | - |
| PR12 | 4000/5 | 190 | 230 | - | - | 45 | - | - | - | - | - | 45 | - | - | - | - | 45 | - |
| | 5000/5 | 190 | 230 | - | - | 45 | - | - | - | - | - | 45 | - | - | - | - | 45 | - |
| | 6000/5 | 190 | 230 | - | - | 45 | - | - | - | - | - | 45 | - | - | - | - | 45 | - |
| PR13 | 4000/5 | 220 | 260 | - | - | 50 | - | - | - | - | - | 50 | - | - | - | - | 50 | - |
| | 5000/5 | 220 | 260 | - | - | 50 | - | - | - | - | - | 50 | - | - | - | - | 50 | - |
| | 6000/5 | 220 | 260 | - | - | 50 | - | - | - | - | - | 50 | - | - | - | - | 50 | - |
| PR14 | 4000/5 | 250 | 290 | - | - | 50 | - | - | - | - | - | 50 | - | - | - | - | 50 | - |
| | 5000/5 | 250 | 290 | - | - | 50 | - | - | - | - | - | 50 | - | - | - | - | 50 | - |
| | 6000/5 | 250 | 290 | - | - | 50 | - | - | - | - | - | 50 | - | - | - | - | 50 | - |
| | 8000/5 | 250 | 290 | - | - | 50 | - | - | - | - | - | 50 | - | - | - | - | 50 | - |
| PR15 | 4000/5 | 270 | 310 | - | - | 50 | - | - | - | - | - | 50 | - | - | - | - | 50 | - |
| | 5000/5 | 270 | 310 | - | - | 50 | - | - | - | - | - | 50 | - | - | - | - | 50 | - |
| | 6000/5 | 270 | 310 | - | - | 50 | - | - | - | - | - | 50 | - | - | - | - | 50 | - |
| | 8000/5 | 270 | 310 | - | - | 50 | - | - | - | - | - | 50 | - | - | - | - | 50 | - |
| PR16 | 4000/5 | 270 | 340 | - | - | 50 | - | - | - | - | - | 50 | - | - | - | - | 50 | - |
| | 5000/5 | 270 | 340 | - | - | 50 | - | - | - | - | - | 50 | - | - | - | - | 50 | - |
| | 6000/5 | 270 | 340 | - | - | 50 | - | - | - | - | - | 50 | - | - | - | - | 50 | - |
| | 8000/5 | 270 | 340 | - | - | 50 | - | - | - | - | - | 50 | - | - | - | - | 50 | - |
| | 10000/5 | 270 | 340 | - | - | 50 | - | - | - | - | - | 50 | - | - | - | - | 50 | - |