CURRENT TRANSFORMERS
INSTALLATION GUIDE

IMPORTANT SAFETY INFORMATION

Current transformers (CTs) must be installed by trained electricians or technicians. Only Instrument-type CTs with a low Safety Factor may be used with PRI metering. Protection-type CTs with a high Safety Factor must NOT be used.

Dangerous voltages are likely to be present in the vicinity of current transformers. The primary terminals (**P1** and **P2**) of wound-primary CTs are at mains potential.

Provision should be made for shorting the current transformers and isolating the meter from the voltage supplies to enable maintenance or removal of the meter.

Under no circumstances may the secondary circuit of a CT be opened when current is flowing in the primary circuit. The voltage generated in the primary winding is stepped up by the turns-ratio of the CT (typically by a factor of several hundred). The voltage in the primary winding can reach several thousand volts in a fraction of a second if the secondaries are made open-circuit while current is flowing in the circuit being metered. Such high voltages can be dangerous to personnel and can cause serious damage to to the transformer or equipment connected to it. Such damage may not be immediately obvious, but will certainly lead to incorrect operation of the equipment.

In LV (low-voltage) installations it is recommended that the current transformer secondary leads (**S2**) are grounded as protection against static voltages or insulation failure. Only one connection to ground is necessary and it is general practice to make this at the transformer. In HV (high-voltage) installations the current transformers must be grounded.

SECTION A: INTRODUCTION

For low voltage circuits carrying up to around 100 A it is possible to fit ‘direct-connected’ or ‘whole current’ metering that does not require additional current sensors. For low voltage circuits carrying more than 100 A, and for all high voltage circuits, current transformers are used to feed into the meter a signal proportional to the current flowing through the load. Current transformers (CTs) are necessary for metering high currents, or currents at high voltage levels, because it would be impractical to design and manufacture electricity meters with sufficient current capacity and with adequate insulation levels to measure the current directly.

SECTION B: PRINCIPLES & CONFIGURATION

A current transformer produces a small output signal directly proportional to the magnitude of the current flowing in the conductor around which it is placed. The output signal from the current transformer is then presented as an input to the meter which in turn uses it to determine current flow in the circuit. It is general practice for the meter to 'scale up' the signal it receives from the current transformer to reflect the current flowing through the load. However, it is also acceptable in some applications for the current input to be metered at the 'secondary level' and for an external multiplier to be applied to the values determined by the meter.

A current transformer is required for each metered circuit, so a three-phase four-wire installation requires three current transformers, whereas a three-phase three-wire installation needs only two.

Polarity must be observed when fitting current transformers. If a current transformer is fitted the wrong way round the meter will incorrectly interpret its output as indicating a consuming circuit as generating and vice-versa.

There are four main types of instrument current transformers:

1. Ring type: can be circular or rectangular. The conductor has to be dismantled at one end to fit the CT.
2. Split-core: the CT splits into two pieces so that it can be fitted around the conductor.
3. Summation: can be in a rectangular box or in a ring. Used to add together the outputs from several CTs.
4. Wound-primary: the conductor is wired into the CT rather than passing through it.

SECTION C: TRANSFORMER RATIO AND METROLOGICAL ACCURACY

Current transformers are marked with the ratio between the maximum primary current and the maximum secondary current. For example a '600:5A' CT produces a 5 A output signal when 600 A is flowing through the load. The primary rating must always be at least as large as the maximum current of the circuit to be monitored. This is usually determined by the size of switchgear and fusing arrangements. It is best to match the CT primary as closely as possible to the maximum current in order to maintain metrological accuracy. This is because CTs are less accurate at low loads than they are at full load.

SECTION D: POLARITY

Current transformers are polarised and must be fitted the correct way round. CTs are marked with **P1** and **P2** to indicate which way they should be fitted around the cable or buss-bar. The side marked **P1** must point towards the generator, and **P2** must point towards the load. If an arrow is printed on the CT it must point towards the load.

The CT outputs - 'secondaries' - must be connected to the meter the correct way round. All current transformers are supplied with secondary terminals marked **S1** and **S2** which must be connected to the correct terminals on the meter. The meter will not register correctly if any of the CTs are connected incorrectly.

The **S1** terminal must be connected to the 'current in' terminal for the appropriate phase on the meter. On PRI meters the 'current in' terminals are the left-hand ones in each pair of current terminals. The **S2** terminal should be connected to the 'current out' terminal for the appropriate phase on the meter. On PRI meters the 'current out' terminals are the right-hand ones in each pair of current terminals. (*See Figure 1 right*). The CTs must be connected to the correct phase inputs on the meter. The meter will not register correctly if the CT for L1 is connected to the inputs for L3 current, for example.

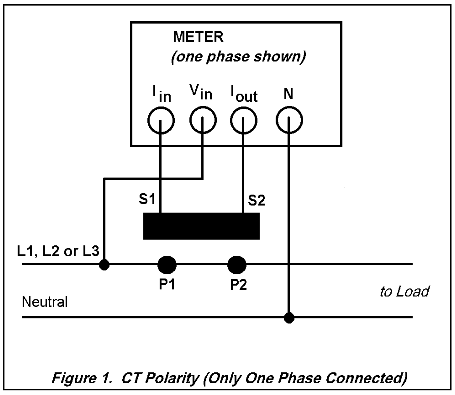


Figure 1. CT Polarity (Only One Phase Connected)

For wound-primary CTs the section of the conductor nearest the generator is connected to the **P1** terminal. The **P2** terminal takes the section of the conductor leading to the load. Note that these terminals are at mains potential.

SECTION E: BURDENS - METERING

In response to the flow of current in the CT primary, a current flows in the secondary leads and the meter, and a voltage is developed across the secondary terminals of the CT. The impedance of the metering circuitry and the secondary leads from the CT therefore present a load or 'burden' on the CT secondary wiring.

Current transformers are marked with a burden capacity which is the maximum burden that can be supported whilst maintaining metrological accuracy. The burden is expressed in volt-amperes (VA). The combined burden of the meter and the cabling must be taken into account before installation. The burden for a meter is fixed, but the burden for cabling increases with length and decreases as cable size is increased.

The following table shows the burden figures for a range of PRI meters:

Meter Type	Burden per Secondary Circuit at Full Load
Premier with 1 A Secondary Input	0.05 VA
Premier with 5 A Secondary Input	0.3 VA
Encore/Elite with 1 A Secondary Input	0.02 VA
Encore/Elite with 5 A Secondary Input	0.3 VA
CALMU3+ with 1 A Secondary Input	0.1 VA
CALMU3+ with 5 A Secondary Input	0.6 VA
CALMU3 with 1 A Secondary Input	0.1 VA
CALMU3 with 5 A Secondary Input	0.5 VA
Prime 500 with 1 A Secondary Input	0.2 VA
Prime 500 with 5 A Secondary Input	1.2 VA

SECTION F: BURDENS - CABLING

To determine the acceptable distance between the current transformer and the meter the CT burden for the meter should be added to the burden for the cabling. The total cable distance from the CT to the meter and back should be used, i.e. the total length of the circuit. The combined figure for cabling and meter must not exceed the VA rating for the CT. The charts below show typical burdens for common sizes of single-core, PVC insulated, copper conductors. Note that CTs with 1 A secondaries can drive much greater lengths of cable than CTs with 5 A secondaries.

Figure 2. Cable Burden for 1 A Meter Applications

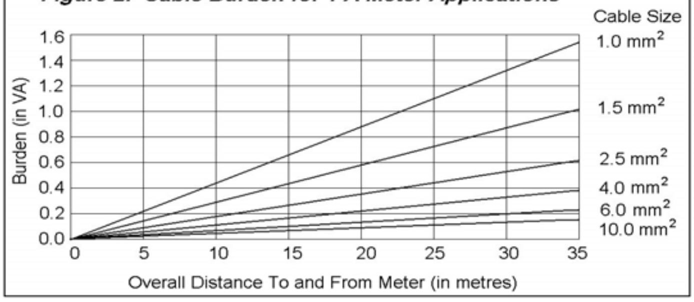
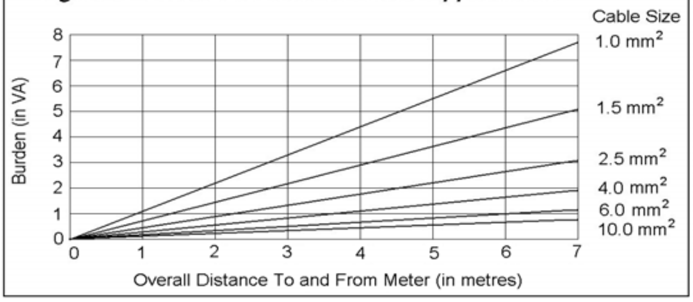


Figure 3. Cable Burden for 5 A Meter Applications

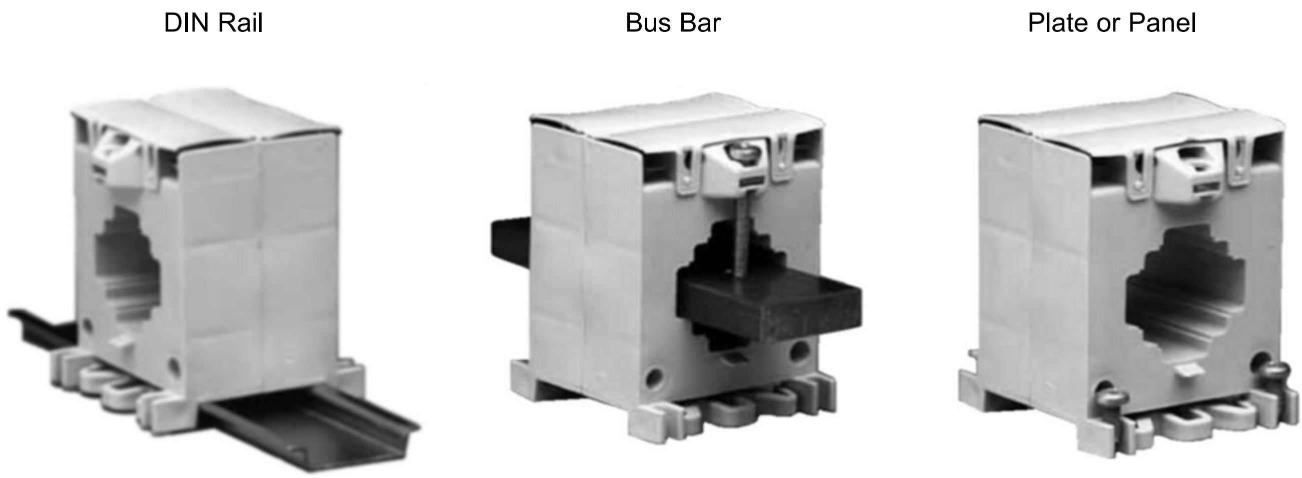


SECTION G: MOULDED-CASE CTs

Moulded-case CTs are suitable for general purpose use in many applications. The only limitation is that installation requires the bus bar or cable to be fed through the CT during installation (ring-type) or wired into the CT (wound-primary).

PRI moulded-case CTs are designed for mounting in the following ways: clipped on to a DIN rail, screwed down on to a bus bar or screwed down on a base plate or back panel.

Figure 4. Mounting Arrangements for Moulded Case CTs



PRI's moulded-case CTs are designed primarily for new installations but can used in any application where it is possible to disconnect the feeder cable or bus bar at one end.

Ring-type CTs are fitted over the cable or bus bar, whereas wound-primary CTs are wired into the circuit. In both cases the correct polarity must be observed. Ring-type CTs are marked with an arrow showing the direction of conventional current flow; from the generator to the load. On wound-primary CTs the cable coming from the generator must be connected to the terminal marked **P1**; the cable going out to the load must be connected to the terminal marked **P2**.

For both CT types the secondary terminals are located under hinged flaps or a detachable insulated cover. The **S1** terminal must be connected to 'current in' on the meter, and the **S2** terminal must be connected to 'current out' as shown in Figure 5 below.

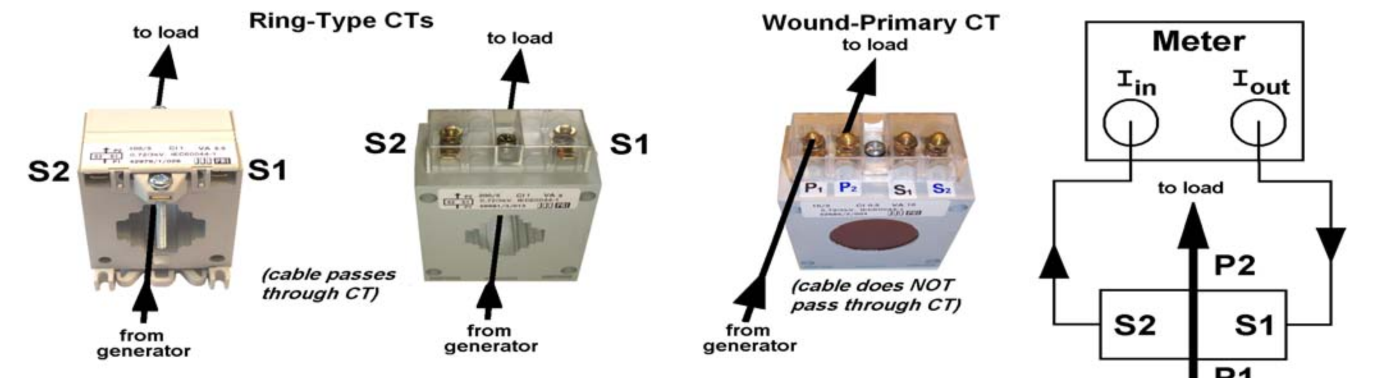


Figure 5. Moulded-Case CT Connections

SECTION H: SPLIT-CORE CTs

Split-core CTs are designed for use in existing installations in which it is not possible to disconnect one end of the cable or bus bar. A split-core CT has two main segments that are normally held together with a clip.

It is essential that the CT is fitted the right way around the feeder cable or bus bar, and also that the core segments are fitted together tightly and in the correct orientation.

The process for fitting a split-core CT is as follows:

1. Undo the clip and separate the two core segments.
2. Fit the main segment around the cable or bus bar. The side labelled **P1** must point towards the supply.
3. Fit the small segment around the cable and up against the main segment, taking care that it is the correct way round. The side labelled **P1** must point towards the supply. The **P1** labels must both be on the same side of the CT (see Fig. 6 right).
4. Make sure that no insulation or any other material is trapped between the mating surfaces of the core segments.
5. Fit the clip around both core segments.
6. Tighten the clip, ensuring that the core segments are held firmly against each other.

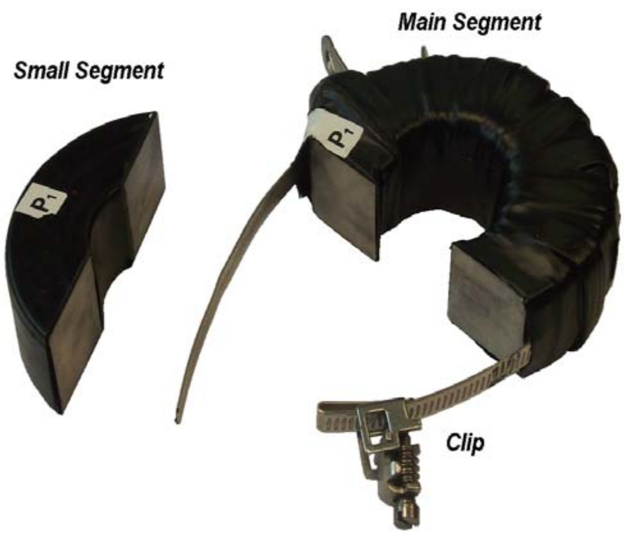


Figure 6. Split-Core CT Dismantled

The secondary terminals are located around the edge of the CT. The **S1** terminal must be connected to 'current in' on the meter, and the **S2** terminal must be connected to 'current out' as shown in Figure 5 above.

SECTION I: CONNECTIONS

Current transformers must be connected in accordance with all relevant safety procedures. This hand book is intended only to provide guidance in certain specific areas and is not exhaustive; reference should also be made to relevant documents such as IEE Wiring Regulations.

Wound-Primary CTs

CTs with low turns-ratios (e.g. 20/5 A) are usually made in wound-primary format. These CTs are not fitted around the cable or bus bar in the conventional way. The live cable has to be cut where the CT is fitted. The side nearest the incoming supply (the generator) is connected to the terminal **P1** and the side leading to the load is connected to terminal **P2**.

Common Secondary Leads

For a polyphase circuit where two or three current transformers are used it is common practice to use one wire as the common secondary lead for all the CTs. This saves time and material and simplifies the wiring. The connections required depend on the type of supply being metered. Figure 7 (*right*) shows connections for a three-phase, four-wire, low voltage installation.

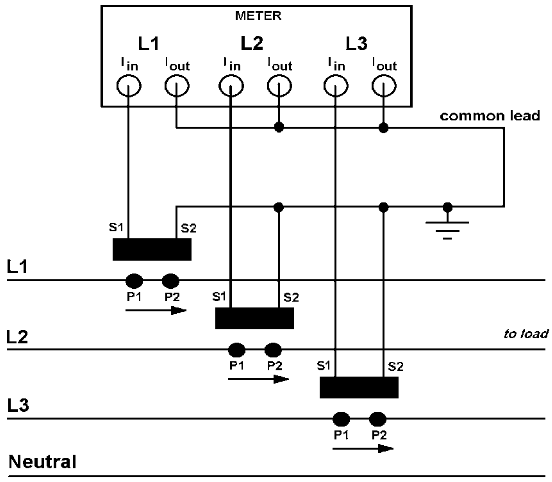


Figure 7. Common CT Secondary Leads

Grounding

It is common practice in low voltage (LV) installations (circuits below 1000 V) to ground the current transformer secondary **S2** leads. This is a safety precaution to protect against static voltages or insulation failure. There only needs to be one ground on the secondary circuit, and this is usually made at the transformer end (see diagram above). In polyphase installations where a common secondary lead is used the grounding can be taken from the common lead.

Note: Current transformers *must* be grounded in HV (high voltage) installations (circuits above 1000 V)

SECTION J: SUMMATION CTs

Summation current transformers enable a single electricity meter to monitor the total load across a number of supplies. Each supply is fitted with ordinary current transformers, and the secondary leads are then connected to a summation transformer. The secondary terminals of the summation transformer are then connected to the meter. The meter is thus presented with a signal which represents the total for all the circuits connected to the summation transformer.

When summation transformers are used it is not possible to determine the individual contribution from each supply. A separate summation transformer is required for each phase. For single-phase installations it is permissible to use one summation transformer so long as all the circuits are connected to the same phase. (*See Figure 8 right*).

Summation transformers can be manufactured with between two and ten input circuits. It is not good practice to use a summation transformer with more inputs than the number of circuits to be metered. This is because unused circuits can introduce stray signals and can also reduce the dynamic range available to circuits that are connected. If an input to a summation transformer needs to be temporarily disconnected (during fault-finding, for example) the relevant **P1** and **P2** connections should be shorted together.

All the input circuits must have the same ratio. The output from a summation CT with mismatched inputs (e.g. 200 + 300 + 250 : 5A) would be unpredictable and therefore unsuitable for metering.

The secondary leads (**S1** and **S2**) from the CTs from L1 on each circuit to be summated are connected to one summation transformer, whose outputs are connected to the L1 current inputs on the meter. This process is repeated for L2 and L3.

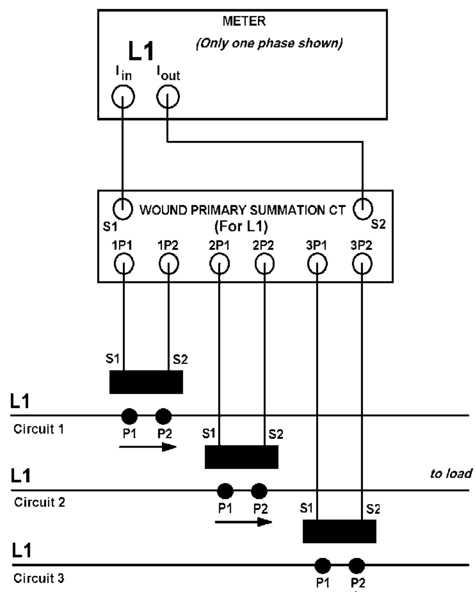


Figure 8. Summation CT Connections (one phase)

The meter should be scaled to reflect the total summated capacity of the circuits. For example a system summating three circuits each fitted with 300:5 A CTs, connected to a (5+5+5):5 A summation CT, would need a meter with 5 A inputs scaled for 900:5 A operation.

It should be noted that summating circuits in this manner reduces the overall system accuracy.

Particular care must be taken when connecting multiple circuits to ensure correct polarity for each circuit; it may be possible for incorrect connection of one or more CTs to pass unnoticed as the individual contribution to the summated load may be small.

SECTION K: DIAGNOSTIC CHECKS

For correct operation it is essential that the CTs are connected the right way round and that the phase relationships are maintained between the meter and the CTs.

The following must be checked during installation of the meter and CTs:

1. Orientation of each CT around the conductor. (**P1** towards the generator, **P2** towards the load, or arrow pointing from the generator towards the load).

2. Output orientation from CT. (**S1** to ‘current in’, **S2** to ‘current out’).

3. CT assignment. (CT around L1 conductor connected to the L1 current inputs on the meter, and so on).

PRI meters support diagnostic checks for correct connection of CTs. All PRI meters have an LED ‘activity indicator’ that flashes at a rate proportional to the instantaneous active (kW) power. On Encore, Elite, Sprint and Premier meters the LED flashes for imported and exported active (kW) power. On CALMU3+ meters the LED flashes for imported active (kW) power only.

Encore and Elite meters have a diagnostic mode that checks for the missing voltage connections, reversed CTs and incorrect phase angles on power-up. Detected faults are shown on the LCD on the front panel (see Encore and Elite handbooks for details).

Sprint and Premier meters support displays that can be used to help determine incorrect connection of voltage or current inputs. Displays are provided for each voltage input and each current input. Models supplied after March 2001 support additional displays showing active current for each input and also a high-resolution energy register that shows fractions of units.

CALMU3+ meters do not have displays for current or voltage, but they do support a display for instantaneous three phase power factor. The activity indicator LED flashes only for imported power, so it is possible to determine CT polarity. In combination with the power factor display it is possible to check that the CTs are fitted around the correct phases.

It is best to check each connection in turn as errors can be difficult to isolate, particularly if circuits are being summated.

1. Check that all the voltage inputs are displayed on the meter, by observing the individual phase voltage displays, or by examining the ‘phase presence’ display.

2. Check that each current input is shown as ‘positive’ for circuits known to be consuming. On CALMU3+ meters apply the currents one at a time and check that the activity LED flashes. (Disconnect the other CT inputs after shorting them together)

3. Check that the energy display advances when current and voltage are applied together.

4. Check that the power factor indicated by the meter agrees with the expected value.

For complex systems it can be helpful to apply current inputs one at a time when checking polarity. Short all other current inputs at the CT and then disconnect them from the meter to remove their contribution to the energy advance.