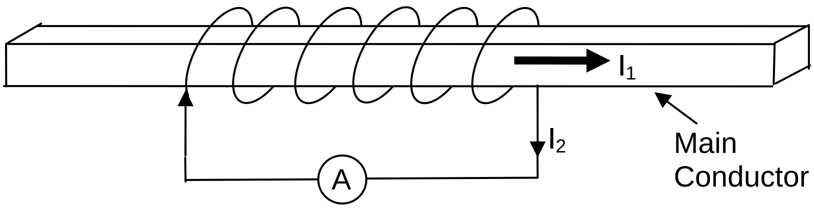
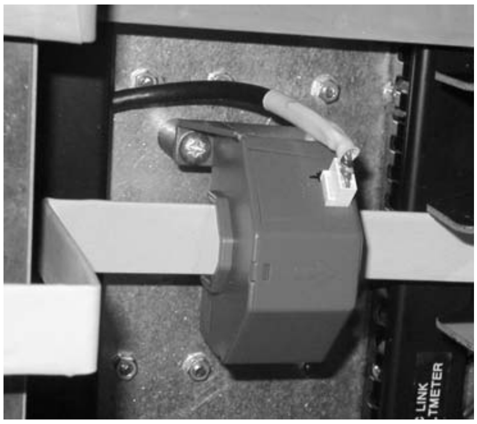
# Current Transformers (CTs)

CTs are used for monitoring very high currents (eg 100 – 10000A). Ammeters in series with the circuit which are capable of measuring such levels are extremely difficult to construct. In practice busbars (thick copper bars), rather than cables, are used to carry such high currents which makes it difficult to route conductors to a control room which may be remote from the process it is trying to control.

Current transformers are used to step down the high currents to more manageable ones (typically 5A fsd – full scale deflection).

They also provide electrical isolation between the primary winding (busbar) and the secondary winding.



This is equivalent to a transformer with a single turn primary winding ($N_1$ = 1). The turns ratio is calculated using the formula:

$$\frac{I_1}{I_2} = \frac{N_2}{N_1}$$

where $I_1$ is the maximum busbar current and $I_2$ = 5A (typically).

Usually current transformers are selected to provide a given output ( eg 5A) for a specified maximum primary current. If for example the maximum current through the busbar was 10000A then a suitable coil would have:

$$N_2 = \frac{10000}{5} = 2000 \text{ turns}$$

In practice the secondary coil is wound on an iron toroidal shaped former and the primary conductor is passed through the centre of it.

When in use a current transformer MUST be loaded with an ammeter (or short circuit). It must NEVER be operated without a load otherwise the induced secondary emfs become very high – typically hundreds or thousands of volts if the core does not saturate.

***Current transformers must have a load (or 'burden') in the form of an ammeter or short circuit connected across them whenever a current is flowing through the primary conductor.***

In normal operation the mmf of the primary is balanced by that of the secondary. In other words the secondary current $I_2$ itself produces a 'back' flux to oppose the 'forward' flux (Lenz's law) and the two are almost equal. If the ammeter is removed, there is no 'back' flux produced since $I_2 = 0$, therefore the current through the busbar produces the 'forward', unopposed flux. This cuts the secondary windings and the high flux value and (often) the high number of turns on the secondary produce very high induced voltages.

<u>Example</u>

Consider a 5A current transformer monitoring a busbar carrying a maximum current of 10000A. Calculate typical emfs produced if the load on the secondary coil is removed. Assume the reluctance of the core is $10^5$ $H^{-1}$.

The turns ratio is given by:

$$\frac{N_1}{N_2} = \frac{I_2}{I_1} = \frac{1}{10000}$$

If we assume:

$$I_1 = 10000 \sin \omega t$$

then:

$$\phi_{1CORE} = \frac{mmf}{reluctance} = \frac{N_1 I_1}{S_{CORE}} = \frac{10000 \sin \omega t}{10^5}$$

If there is no secondary load, then there is no 'back' flux to oppose this and the emf in the secondary is calculated from:

$$V_2 = N_2 \frac{d\phi}{dt} = \frac{2000 \times \omega \times 10000 \sin \omega t}{10^5} = \frac{2000 \times 2\pi \times 50 \times 10000 \sin \omega t}{10^5}$$

ie a maximum induced emf of 63kV.