Introduction to

Current Transformer (CT)

Substation Secondary Design Course | Eng Ahmed Metwally

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Agenda

01 Introduction

02 Types

03 Key Manufacturers

04 Parameters

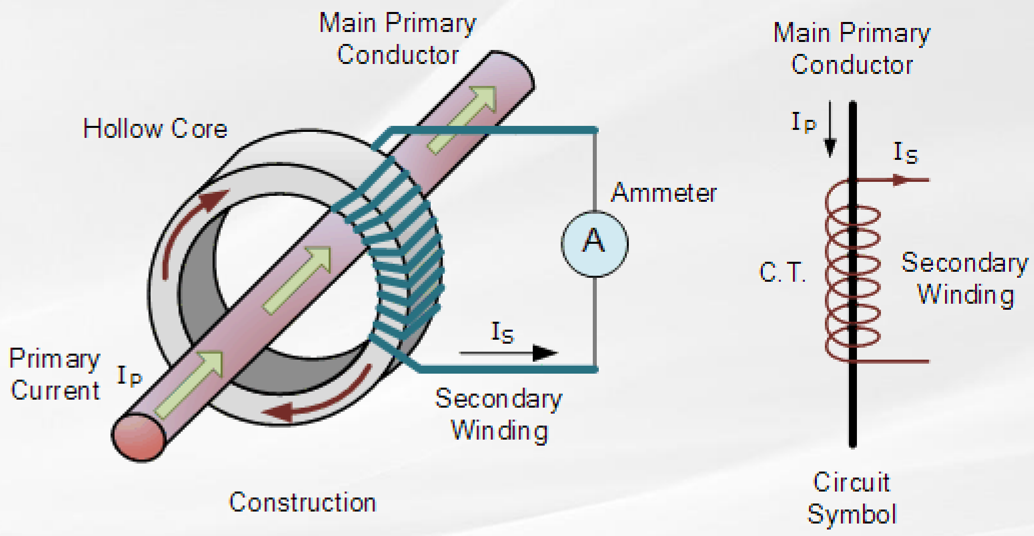
05 Notes

Introduction & Description

How current transformers work

Electromagnetic Induction:

- When an alternating current flows through the primary winding (the conductor), it generates a magnetic field around the conductor.
- This changing magnetic field induces a current in the secondary winding according to Faraday's Law of Electromagnetic Induction, which states that a change in magnetic flux through a circuit induces an electromotive force (EMF) in that circuit.



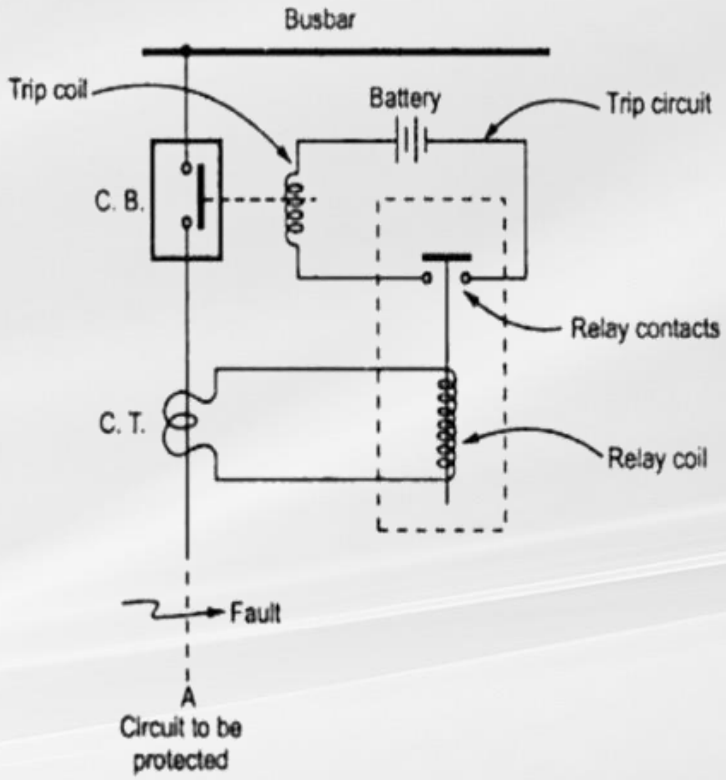
Introduction & Description

How current transformers work

They are defined by:

- ratio
- burden
- accuracy class

- A CT requires **good accuracy** around the nominal current value.
- The **metering** instruments do not need to withstand currents as high as the protection relays
- Current transformers are used **to supply information** to the protective relays



Introduction & Description

How current transformers work

Current Transformation:

The relationship between the primary current (I_p) and the secondary current (I_s) is defined by the turns ratio (N) of the transformer:

$$\frac{I_p}{I_s} = \frac{N_s}{N_p}$$

N_S: number of turns in the **secondary** winding
N_P: number of turns in the **primary** winding.

For example, in a 1000:1 CT, 1000 A in the primary results in 1 A in the secondary.

Introduction & Description

How current transformers work

Single-ratio CTs

Standard single-ratio CTs that are manufactured in the United States are as listed:

SINGLE RATIO CTS			
10:5	100:5	800:5	4000:5
15:5	200:5	1200:5	5000:5
25:5	300:5	1500:5	6000:5
40:5	400:5	2000:5	8000:5
50:5	600:5	3000:5	12000:5
75:5			

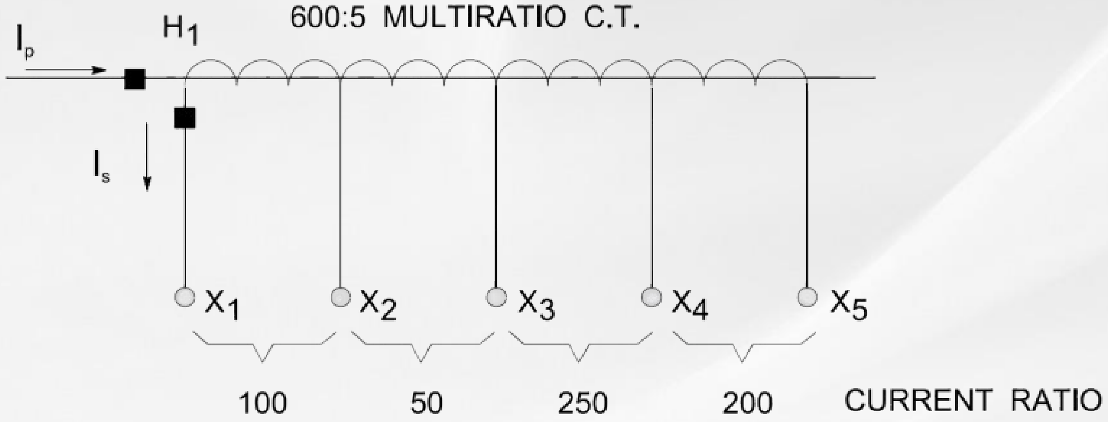
Source: C57-13

Introduction & Description

How current transformers work

Multi-ratio CTs

- Single primary winding and a **tapped** secondary winding as shown:



- The standard multi-ratio CTs that are are listed:

MULTIRATIO CTS					
Current Rating	Secondary Taps	Current Rating	Secondary Taps	Current Ratings	Secondary Taps
600:5		2000:5		4000:5	
50:5	X2-X3	300:5	X3-X4	500:5	X1-X2
100:5	X1-X2	400:5	X1-X2	1000:5	X3-X4
150:5	X1-X3	500:5	X4-X5	1500:5	X2-X3
200:5	X4-X5	800:5	X2-X3	2000:5	X1-X3
250:5	X3-X4	1100:5	X2-X4	2500:5	X2-X4
300:5	X2-X4	1200:5	X2-X5	3000:5	X1-X4
400:5	X1-X4	1500:5	X1-X4	3500:5	X2-X5
450:5	X3-X5	1600:5	X2-X5	4000:5	X1-X5
500:5	X2-X5	2000:5	X1-X5		
600:6	X1-X5				
1200:5		3000:5		5000:5	
100:5	X2-X3	300:5	X3-X4	500:5	X2-X3
200:5	X1-X2	500:5	X4-X5	1000:5	X4-X5
300:5	X1-X3	800:5	X3-X5	1500:5	X1-X2
400:5	X4-X5	1000:5	X1-X2	2000:5	X3-X4
500:5	X3-X4	1200:5	X2-X3	2500:5	X2-X4
600:5	X2-X4	1500:5	X2-X4	3000:5	X3-X5
800:5	X1-X4	2000:5	X2-X5	3500:5	X2-X5
900:5	X3-X5	2200:5	X1-X3	4000:5	X1-X4
1000:5	X2-X5	2500:5	X1-X4	5000:5	X1-X5
1200:5	X1-X5	3000:5	X1-X5		

Source: C57.13

Components

Key components

Core:

1) Material: laminated silicon steel to reduce eddy current losses, or ferrite for high-frequency applications.

2) Types:
   a) Toroidal Core: Circular shape, used for high accuracy and low burden.
   b) Bar Core: Used for large conductors, where the bar passes through the core.

2. Windings:

1) Primary Winding: Usually consists of a <u>single turn</u> (the conductor itself) or a few turns for higher current applications

2) Secondary Winding: <u>Multiple</u> turns are wound around the core to step down the current

Components

Key components

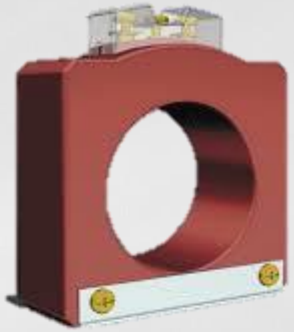
3. Insulation:

1) Materials:
   a) Resin: Used in encapsulated CTs for moisture resistance.
   b) Oil: Provides cooling and insulation in larger CTs.

2) Housing:

   Purpose: Protects the internal components from environmental factors.

   Mounting Options: CTs can be mounted on switchgear, busbars, or distribution panels.



Types & Uses

Uses

1 Measurement

- Energy Meters
- Power Quality Monitoring

2 Protection

- Provides information to the protection relay

Examples

Used in all substation in the HV and MV switchgears

Types & Uses

Types

Current transformers (CTs) are categorized based on their design, application, and construction. Each type serves specific purposes in electrical systems, particularly in measurement and protection, tailored for specific applications and installation requirements.

They are extensively used in protective relaying, energy measurement, and monitoring within power systems, ensuring the safe and accurate assessment of electrical currents in high-voltage environments.

Types & Uses

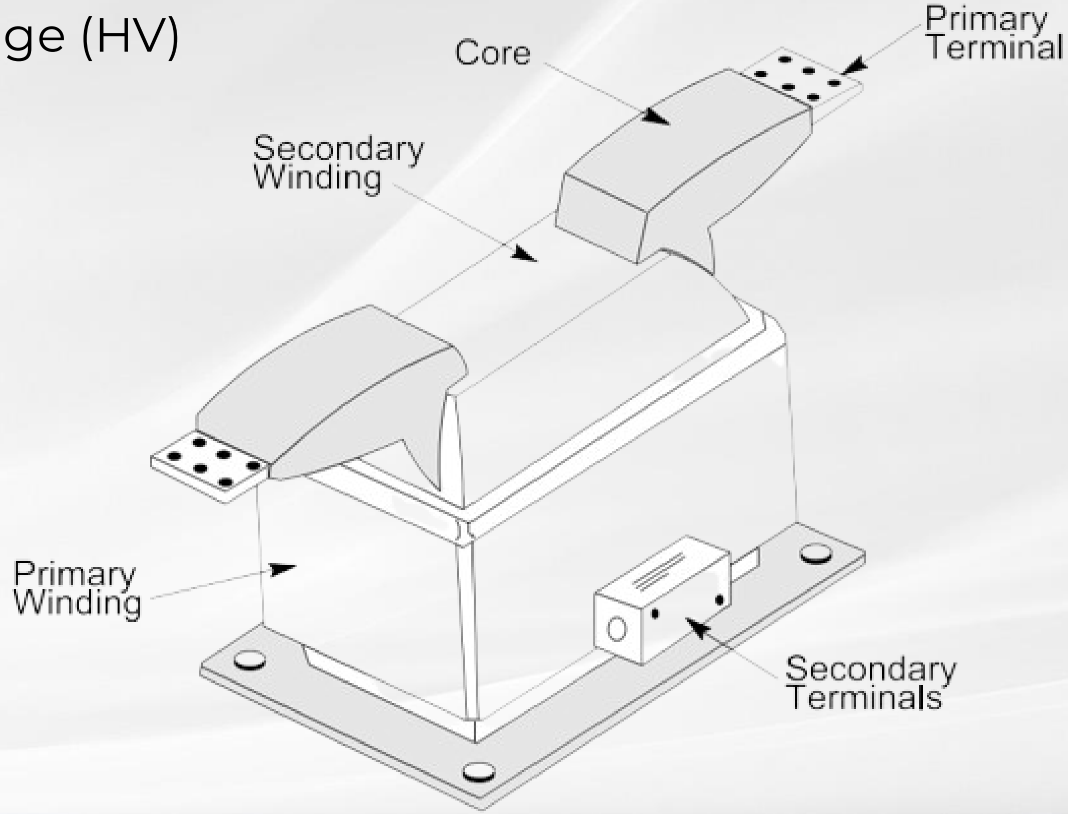
Types

1. Wound Current Transformer

A CT that has a primary winding consisting of one or more turns mechanically encircling the core or cores. The primary and secondary windings are insulated from each other and from the cores and are assembled as an integral structure (C57.13).

Voltage level: High Voltage (HV)

Usage: Indoor



Types & Uses

Types

1. Wound Current Transformer

•**Description**: A wound current transformer is a transformer with separate primary and secondary windings wrapped around a laminated core. It’s located on the high-voltage side of substations. The primary winding consists of one or more turns of large cross-section wire connected in series with the circuit to be measured.

•**Application**: Commonly used in applications where high accuracy is required, such as in metering and protection in substations.

•**Characteristics**:

- **Accuracy**: High accuracy over a wide range of currents.
- **Voltage Rating**: Can handle high voltages, making them suitable for high-power applications.

Types & Uses

Types

2. Toroidal (or Ring) Current Transformer

•**Description**: A toroidal CT features a doughnut-shaped core through which the primary conductor passes. The secondary winding is wound around the core.

•**Application**: Often used in energy monitoring systems and industrial applications due to their compact design.

•**Characteristics**:

- **Ease of Installation**.
- **Compact Size**: Smaller and lighter compared to other types.
- **Noise**: Produces less noise.
- **Power Efficiency & Electromagnetic Shielding.**

Voltage level: Medium Voltage (MV) and Low Voltage (LV)

Usage: Indoor or Outdoor

Types & Uses

Types

3. Split-Core Current Transformer

•**Description**: A unique design that allows the core to be opened and closed around a conductor without interrupting the circuit.

•**Application**: Widely used in energy auditing, monitoring, and retrofitting applications.

•**Characteristics**:

- **Flexibility**: Ideal for applications where access to conductors is limited.
- **Portability**: Lightweight and easy to transport.

Voltage level: Medium Voltage (MV) and Low Voltage (LV)

Usage: **Indoor** (typically)

Types & Uses

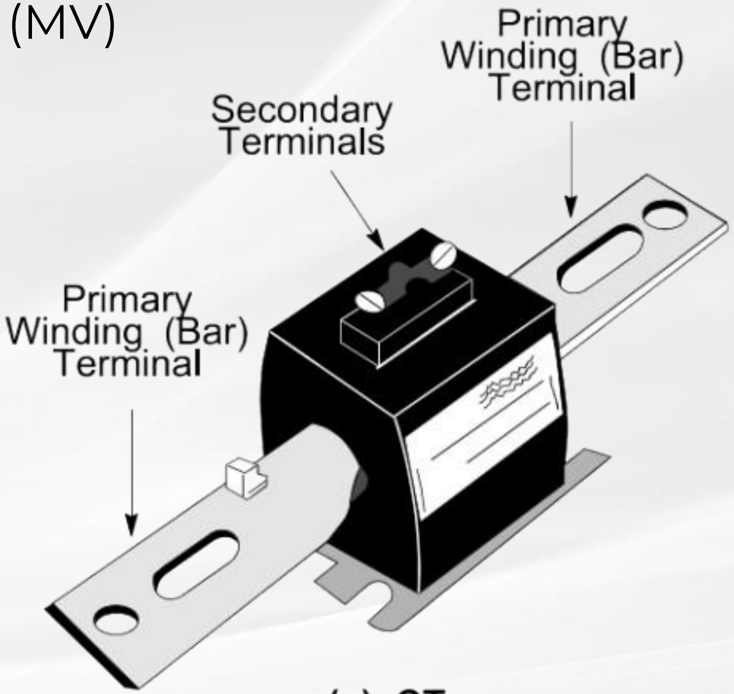
Types

4. Bar-Type Current Transformer

It's a special type of window current transformer with a solid bar placed permanently through the window. It has a fixed, insulated straight conductor in the form of a bar, rod, or tube that is a single primary turn passing through the magnetic circuit and that is assembled to the secondary, core, and winding (C57.13)

Voltage level: Medium Voltage (MV)

Usage: Indoor



(a) CT

Types & Uses

Types

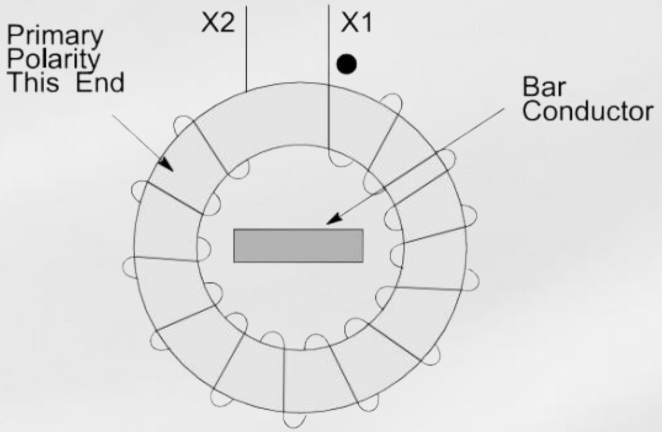
4. Bar-Type Current Transformer

•**Description**: The primary conductor is integrated into the transformer design , while the secondary part consists of windings wound on a circular core surrounding the primary bar conductor. It’s typically used in switchgear.

•**Application**: Commonly found in high-current applications, such as in substations and industrial distribution boards.

•**Characteristics**:

- **High Current Handling**: Can withstand stresses of heavy overcurrent.
- **Cost**: Costly compared to the wound-type counterparts but give extremely accurate results.



(b) Diagram

Types & Uses

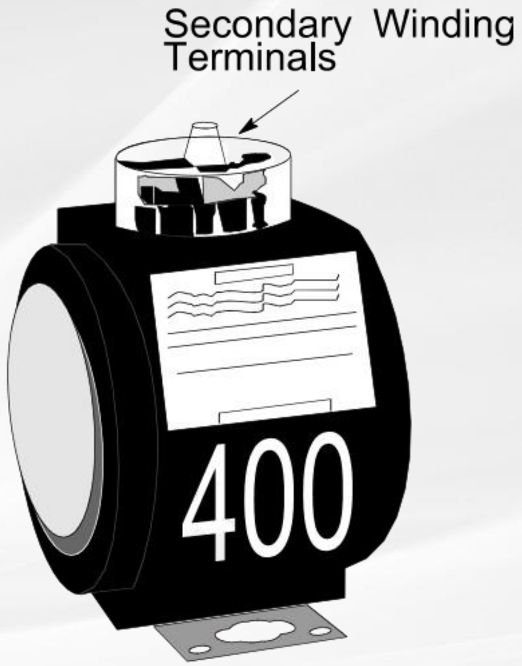
Types

5. Window-Type Current Transformer

A CT that features an open window through which a single conductor passes. The magnetic field generated by the conductor induces current in the secondary winding. It's very similar to a bushing type CT.

Voltage level: Medium Voltage (MV) and Low Voltage (LV)

Usage: Indoors or Outdoors



(a) CT

Types & Uses

Types

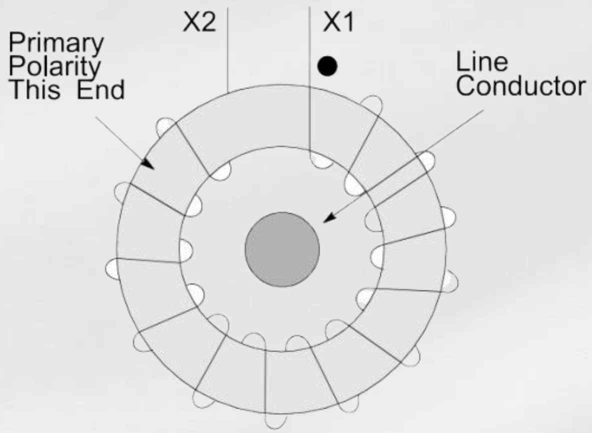
5. Window-Type Current Transformer

•**Description**: It has a secondary winding insulated from and permanently assembled on the core but has no primary winding as an integral part of the structure.

•**Application**: Suitable for retrofitting and monitoring existing installations.

•**Characteristics**:

- **Ease of Use**: Simple to install without modifying the existing circuitry.
- **Versatility**: Compatible with various conductor sizes.



(b) Diagram

Types & Uses

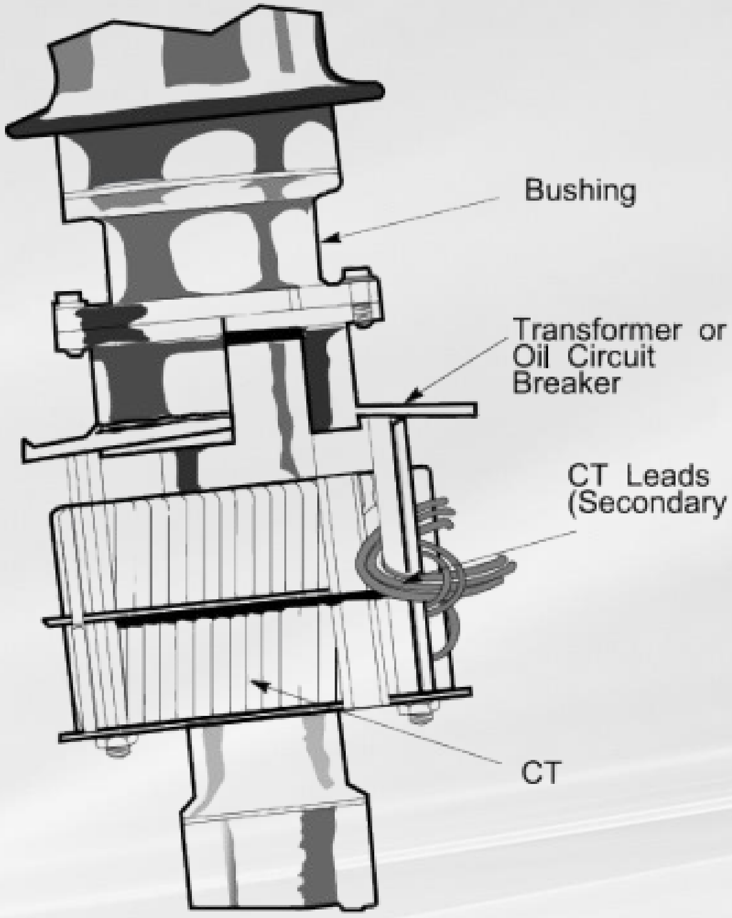
Types

6. Bushing Current Transformer

A BCT is a window-type current transformer mounted around the bushing's flange. It may be inside the main tank of an oil circuit breaker or mounted externally. It consists only of a toroidal-shaped core with a secondary winding. The bushing's center conductor forms the single turn primary of the BCT (doesn't have a traditional primary winding).

Voltage level: High Voltage (HV)

Usage: Outdoor



(a) CT

Types & Uses

Types

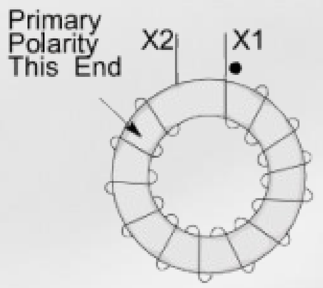
6. Bushing Current Transformer

•**Description**: Integrated within the bushing of high-voltage equipment, such as transformers and circuit breakers. It features a primary winding around the conductor passing through the bushing and a secondary winding encapsulated within the bushing.

•**Application**: Used in substations and high-voltage systems for current measurement and protection.

•**Characteristics**:

- **Compact Design**: Space-efficient and seamlessly integrates with existing equipment.
- **High Voltage Capability**: Designed to handle high-voltage levels.
- **Durability**: Built to withstand harsh environmental conditions.
- **Safety**: Provides electrical isolation for safe operation.



(b) Diagram

Types & Uses

Types

7. Optical Current Transformer (OCT)

- **Principle**: Optical current transformers (OCTs) use fiber optic technology to measure current based on the Faraday effect for current measurement.

- **Advantages**:
  - **Electromagnetic Interference Immunity**: Making them ideal for high-voltage environments where noise can affect accuracy.
  - **High Electrical Isolation**: For safety in high-voltage applications.
  - **High Speed Measurements**
  - **Wide Bandwidth**: For accurate high-frequency signal measurement.
  - **Lightweight and Easier to Install**: Compared to traditional CTs.

Types & Uses

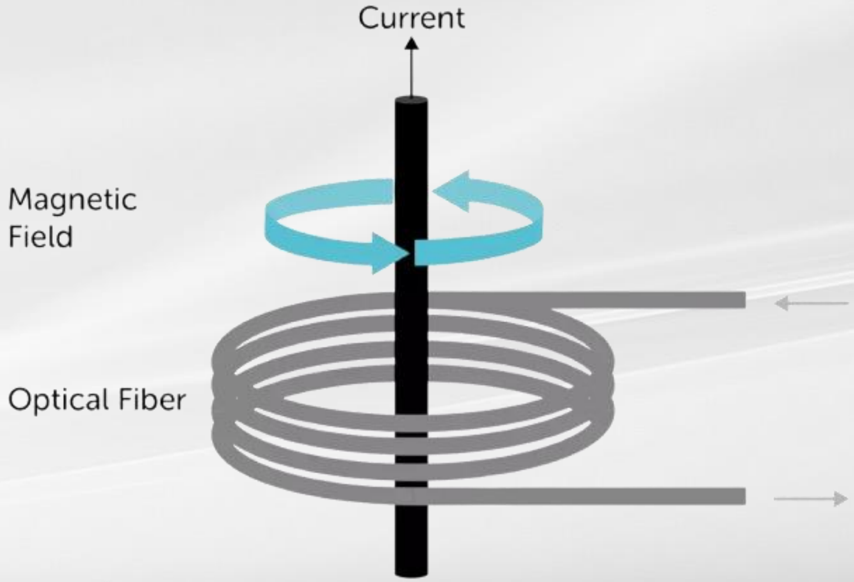
Types

7. Optical Current Transformer (OCT)

- **Applications**: Ideal for substations, renewable energy systems, and smart grids.
- **Limitations**: Generally, more expensive and may require specialized handling.
- **Standards**: Governed by IEC and IEEE standards to ensure safety and performance.

Voltage level: High Voltage (HV) and Medium Voltage (MV)

Usage: Outdoor (typically)



Types & Uses

Broader category

Current sensors

- **Definition**: This broader category includes various devices that measure current, including but not limited to CTs. Current sensors are devices that measure the flow of electric current in a conductor. They can provide information about both alternating current (AC) and direct current (DC) levels.

Relationship Between Current Sensors and Current Transformers

- **Subset**: CT is a specific type of current sensor designed primarily for AC measurements, particularly in high-power applications, and external power supply isn't needed. Whereas current sensor is a generalized concept, that can detect both AC and DC (transforms AC into DC or DC into DC) and external power supply is needed.

- **Measurement Principle**: CTs rely on electromagnetic induction, while other current sensors may use different principles such as the Hall effect or resistive measurements.

- **Applications**: Both CTs and other current sensors can be used in similar applications, such as energy monitoring, protection, and metering.

Key Manufacturers

Top Manufacturers

1. **ABB**

- **Overview:** A global leader in power and automation technologies with a diverse portfolio.

- **Products:**
  1. **Types of CTs:** Indoor and outdoor CTs, metering CTs, protection CTs.
  2. **Notable Product:** ABB's "Transformer Protection CT", designed for high accuracy in protection applications.

- **Location:** Zurich, Switzerland.

CT30/250, Split-core current transformer used to transform primary currents to 5A

Key Manufacturers

Top Manufacturers

2. Siemens:

- **Overview:** A major player in electrical engineering with a focus on innovation.
- **Products:**
  1. **Types of CTs:** Ring core CTs, encapsulated CTs for harsh environments.
  2. **Notable Product:** Siemens' "SENTRON".
- **Location:** Munich, Germany.

SENTRON CT 1200/5 A 10 VA CL 0.5, Bushing-type cuurent transformer

Key Manufacturers

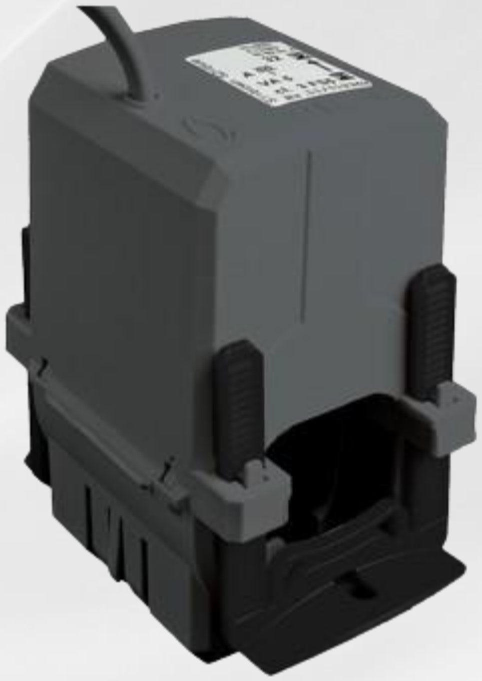
Top Manufacturers

3. Schneider Electric

- **Overview:** Focuses on smart and sustainable energy solutions.

- **Products:**
  1. **Types of CTs:** Smart CTs integrated with IoT technology for remote monitoring.
  2. **Notable Product:** Schneider’s "PowerLogic" series for energy management.

- **Location:** Rueil-Malmaison, France.



PowerLogic CT 150/5A, Split-core current transformer

Key Manufacturers

Top Manufacturers

4. General Electric (GE)

- **Overview:** Known for high-quality electrical equipment and advanced technology.
- **Products:**
  1. **Types of CTs:** Protective CTs, measuring CTs for different voltage levels.
  2. **Notable Product:** GE “OSKF" CTs designed for grid solutions.
- **Location:** Boston, Massachusetts, USA.

Oil-Insulated Current Transformers
72.5 kV to 800 kV, up to 5000A

Key Manufacturers

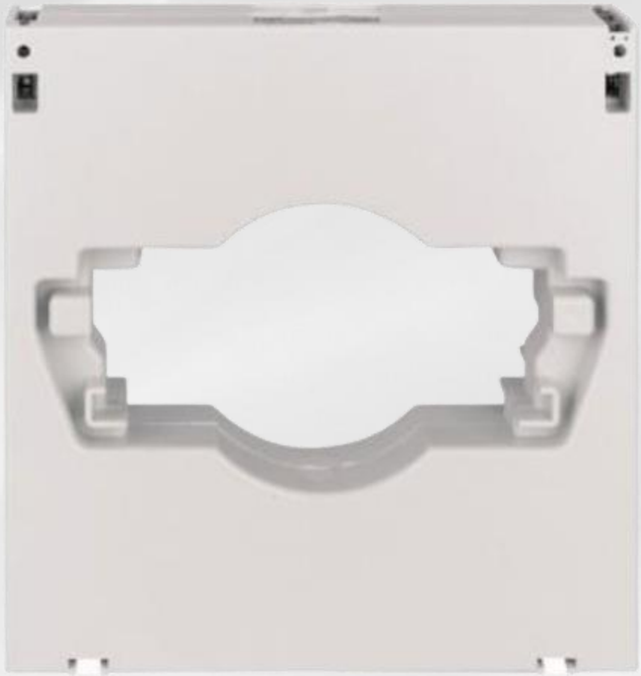
Top Manufacturers

5. Eaton

- **Overview:** Provides power management solutions across various sectors.

- **Products:**
  1. **Types of CTs:** Precision CTs for metering and protective applications.
  2. **Notable Product:** Eaton's "T-Line" CTs known for excellent performance.

- **Location:** Dublin, Ireland.



T-Line, Current transformer HF8A, 2500A/5A, Class 0.2S

Parameters

Rated Primary Current I_{pr}

Shall be selected according to the load current and to make sure CT do not reach <u>saturation</u>

Rated Secondary Current I_{sr}

Typically, 1A or 5A this is according to:

- CT burden
- Distance between relay and CT

Burden

Impedance of secondary circuit usually expressed in VA ($I_{sr}^2 R_b$) at specific power factor

R_b: rated resistive burden

R_{ct}: secondary winding resistance

Parameters

Extended Current Rating (%)

Expressed as a percentage of the rated current (e.g., 120%, 150%, 200%), elucidates the CT’s ability to handle higher currents while maintaining temperature limits

Parameters

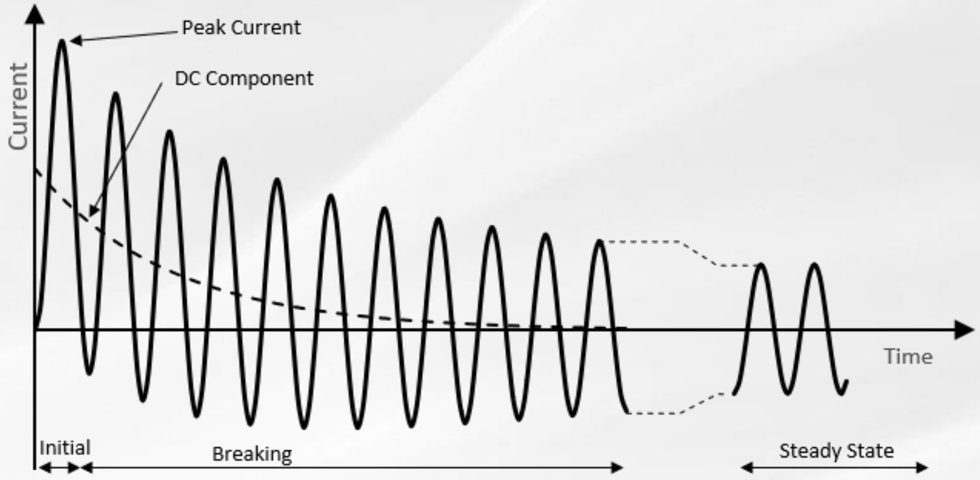
Rated Short-time Thermal Current I_{th}

Maximum current the CT shall withstand for a specific short time typically 1-3 seconds

Rated Dynamic Current I_{dyn}

Maximum peak value the CT shall withstand without being mechanically damaged

Used to address the electromagnetic forces resulting from a short circuit



Parameters

Highest voltage for equipment U_m (r.m.s.)

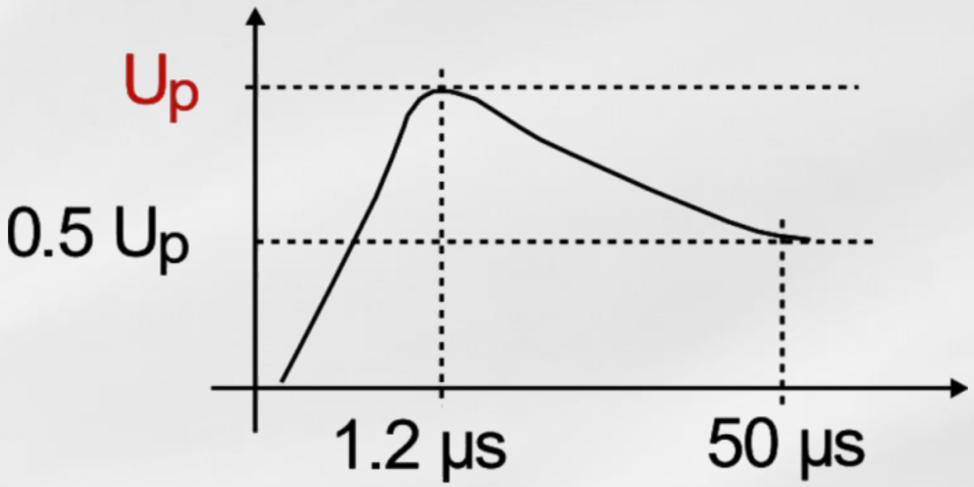
Highest voltage during normal operation and shall be at least equal to the system voltage

Rated power-frequency withstand voltage U_d (r.m.s.)

A typical 50/60Hz waveform for 60 seconds

Rated lightning impulse withstand voltage U_p (peak)

A standard high voltage testing waveform characterized by a fast-rising edge



$$U_m < U_d < U_p$$

Parameters

IEC 61869-1

Table 2 – Rated primary terminal insulation levels for instrument transformers

Highest voltage for equipment U_m (r.m.s.) kV	Rated power-frequency withstand voltage (r.m.s.) kV	Rated lightning impulse withstand voltage (peak) kV	Rated switching withstand voltage (peak) kV
0,72	3	---	
1,2	6	---	
3,6	10	20 40	
7,2	20	40 60	
12	28	60 75	
17,5	38	75 95	
24	50	95 125	
36	70	145 170	
52	95	250	
72,5	140	325	

Parameters

Protection Cores

Example: **5P20**

P: Accuracy class designation

5: Composite error, ±5%

20: Accuracy limit factor (ALF) this means that up to x20 the rated current, the composite error will be sustained, and the core will not saturate

There are other types of classes used for distance and differential protection and transient performance

Parameters

Metering Cores

Examples: 0.1 – 0.2 – 0.2s – 0.5 – 0.5s – 1 – 3 – 5

The number above is ratio error

At these values burden can be 25-100% of rated output

For 3 and 5 burden is 50-100%

Instrument Security Factor (ISF)
Examples FS5 and FS10

A multiple value of the primary current at which the CT will saturate to prevent damage

Accuracy class	Ratio error ± %			
	at current (% of rated)			
	5	20	100	120
0,1	0,4	0,2	0,1	0,1
0,2	0,75	0,35	0,2	0,2
0,5	1,5	0,75	0,5	0,5
1	3,0	1,5	1,0	1,0

Accuracy class	Ratio error ± %				
	at current (% of rated)				
	1	5	20	100	120
0,2 S	0,75	0,35	0,2	0,2	0,2
0,5 S	1,5	0,75	0,5	0,5	0,5

Class	Ratio error ± %	
	at current (% of rated)	
	50	120
3	3	3
5	5	5

Parameters

Insulation Classes

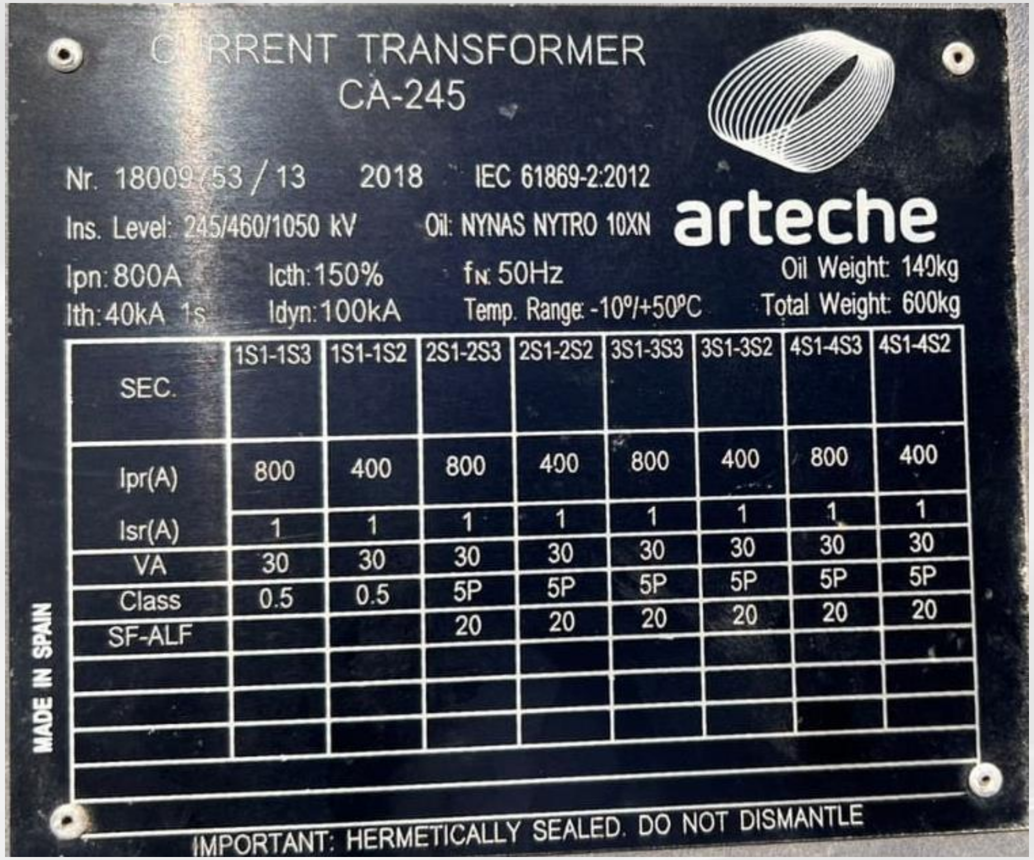
Maximum continuous use temperature in degrees Celsius

Letter Designation	Thermal Class °C
Y	90
A	105
E	120
B	130
F	155
H	180
N	200
R	220

IEC 60085-2007 Table 1 – Thermal class assignment

Parameters

Nameplate Example



IEEE Std C57.13-2016

Table 8—Standard accuracy class for metering service and corresponding limits of transformer correction factor and ratio correction factor [0.6 to 1.0 power factor (lagging) of metered load][c]

Metering accuracy class	Voltage transformers (at 90% to 110% rated voltage)		Current transformers					
			At 100% rated current[a]		At 10% rated current		At 5% rated current	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
0.15S[b]	—	—	0.9985	1.0015	—	—	0.9985	1.0015
0.15[b]	0.9985	1.0015	0.9985	1.0015	—	—	0.9970	1.0030
0.15N	—	—	0.9985	1.0015	0.9970	1.0030	—	—
0.3S	—	—	0.9970	1.0030	—	—	0.9970	1.0030
0.3	0.9970	1.0030	0.9970	1.0030	0.9940	1.0060	—	—
0.6	0.9940	1.0060	0.9940	1.0060	0.9880	1.0120	—	—
1.2	0.9880	1.0120	0.9880	1.0120	0.9760	1.0240	—	—

[a] For current transformers, the 100% rated current limit also applies to the current corresponding to the continuous thermal current rating factor.
[b] Previously defined in IEEE Std C57.13.6.
[c] Other accuracy requirements may be specified and should be included on the nameplate.

Accuracy class mean at 100% rated current the error=0.3% and at 10% rated current error =0.6% (double).
Example: 0.3B-0.9

IEEE Std C57.13-2016 cont..

Table 10 —Standard metering burdens for current transformers with 5 A secondary windings[a]

Burdens	Burden designation[b]	Resistance (Ω)	Inductance (mH)	Impedance (Ω)[c]	Total Power (VA at 5 A)	Total Power (VA at 1 A)	Power factor
Electronic burdens	E0.04	0.04	0	0.04	1.0	0.04	1.0
	E0.2	0.2	0	0.2	5.0	0.2	
Metering burdens	B-0.1	0.09	0.116	0.1	2.5	0.1	0.9
	B-0.2	0.18	0.232	0.2	5.0	0.2	
	B-0.5	0.45	0.580	0.5	12.5	0.5	
	B-0.9	0.81	1.040	0.9	22.5	0.9	
	B-1.8	1.62	2.080	1.8	45.0	1.8	

[a] If a current transformer secondary winding is rated at other than 5 A, the impedance, the power factor, and the burden designation remain the same while the VA at rated current shall be adjusted by [5/(ampere rating)].[2]
[b] These standard burden designations have no significance at frequencies other than 60 Hz.
[c] The impedance tolerance is +5% and –0%.

Table 13—Standard relaying burdens for current transformers with 5 A secondary windings

Burdens	Burden designation[b]	Resistance (Ω)	Inductance (mH)	Impedance (Ω)[c]	Total Power (VA at 5 A)	Power Factor	Terminal Voltage
Relaying burdens	B-0.1	0.09	0.116	0.1	2.5	0.9	10
	B-0.2	0.18	0.232	0.2	5.0	0.9	20
	B-0.5	0.45	0.580	0.5	12.5	0.9	50
	B-1.0	0.50	2.300	1.0	25.0	0.5	100
	B-2.0	1.00	4.600	2.0	50.0	0.5	200
	B-4.0	2.00	9.200	4.0	100.0	0.5	400
	B-8.0	4.00	18.400	8.0	200.0	0.5	800

[a] If a current transformer secondary winding is rated at other than 5 A, the equivalent burden shall be derived by dividing the secondary terminal voltage by (I_S × 20). For example, if the rated secondary current is 1 A and the relay class is C100, then the corresponding burden to develop the secondary terminal voltage would be 100 V / (1 A × 20) = 5 Ω.
[b] These standard burden designations have no significance at frequencies other than 60 Hz.
[c] The impedance tolerance is +5% and –0%.

Metering class related to burden impedance.

The accuracy class is the description of how much voltage the transformer can supply to the output circuit(burden),without the CT core going into saturation. C200,C400

What Is Knee Point According To IEEE Std C57.13-2016

IEEE Std C57.13-2016
IEEE Standard for Requirements for Instrument Transformers

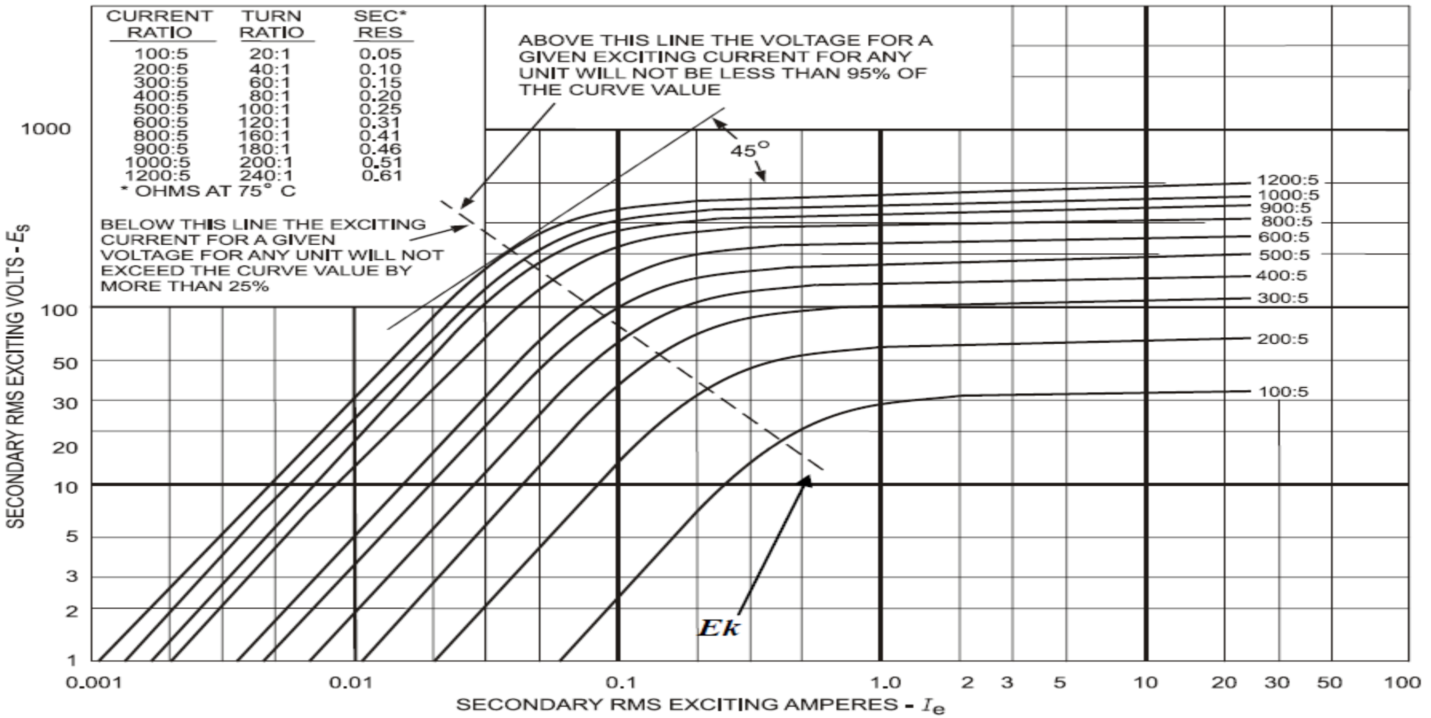


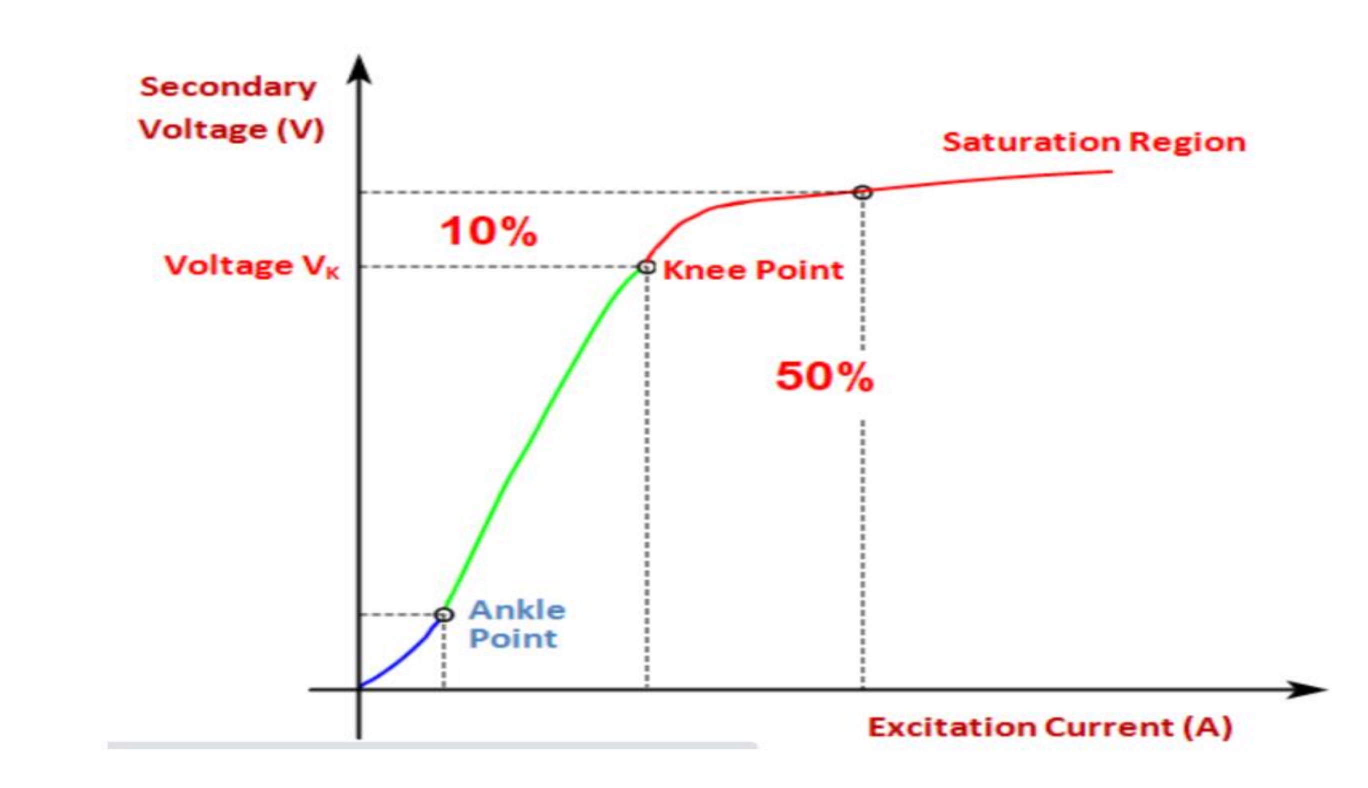
Figure 6 —Typical excitation curves for multiratio C class current transformers with nongapped cores

Curves shall also show the knee of the curve. For current transformers with nongapped cores, the knee is defined as the point where the tangent is at 45° to the abscissa. For current transformers conforming to this standard, it shall be possible to draw the above tangents to the excitation curves. The maximum tolerance of excitation values above and below the knee shall be as shown (see Figure 6).

1. CT secondary voltage depend on the primary current.
2. When the secondary voltage

exceed the knee voltage the CT become saturated which means there is no current produce in secondary winding or there is distorted current that lead to malfunction operation of protective relay.

What Is Knee Point According To IEC 61869-2



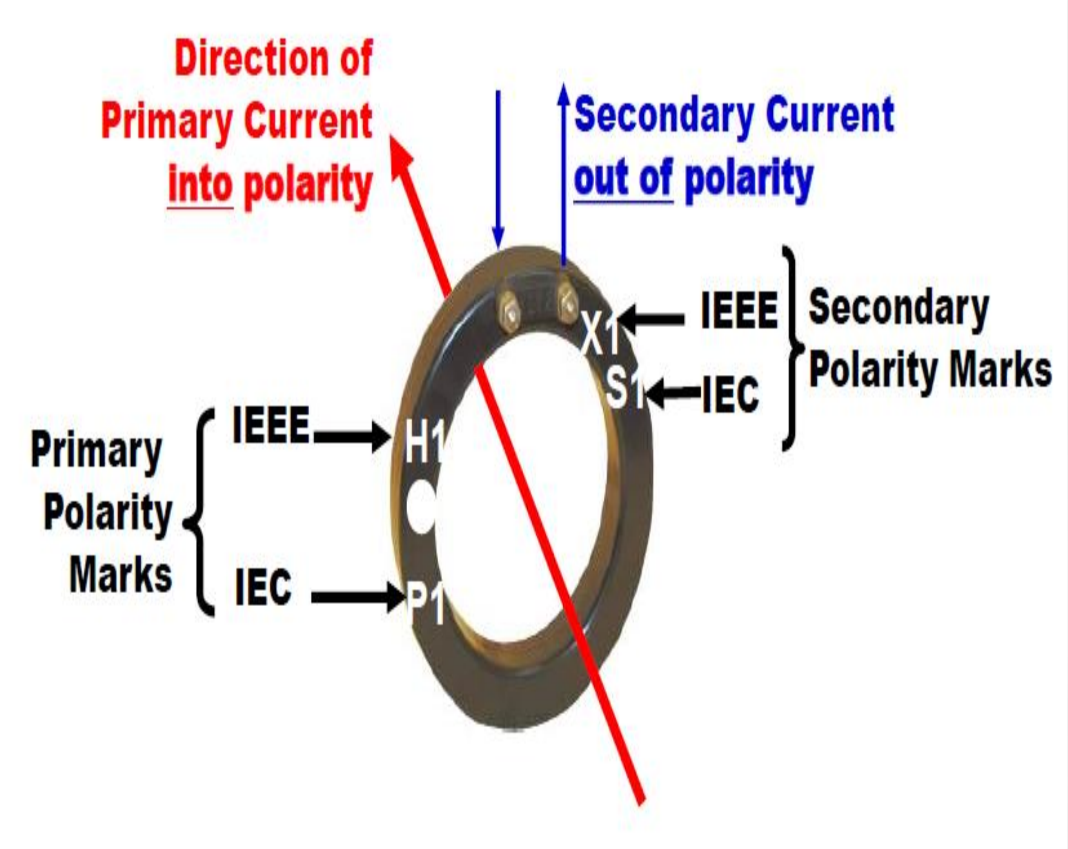
3.4.216
knee point e.m.f.
e.m.f. of a current transformer at rated frequency, which, when increased by 10 %, causes the r.m.s. value of the exciting current to increase by 50 %

-IEC value is higher than IEEE, IEEE is more conservative

Compare between IEEE & IEC Standard.

Secondary terminal voltage (V_B)	Burden Designation	Impedance Z_B (Ohms) @ 5A	IEEE relay accuracy	Equivalent IEC protective accuracy
10	B 0.1	0.1	C 10	2.5VA – 5P20
20	B 0.2	0.2	C 20	5.0VA – 5P20
50	B 0.5	0.5	C 50	12.5VA – 5P20
100	B 1.0	1.0	C 100	25.0VA – 5P20
200	B 2.0	2.0	C 200	50VA – 5P20
400	B 4.0	4.0	C 400	100VA – 5P20
800	B 8.0	8.0	C 800	200VA – 5P20

Compare between IEEE & IEC class.



Compare between IEC &IEEE polarity symbol.

Saudi Electricity Company standard (SEC Standard)

TSP: Transmission Service Provider

TES: Transmission Engineering Standard.

TMSS: Transmission Material Standards and Specification.

CT Class From TES-P-119.28

Table 1.0 Limits of Error for Protective Current Transformers

Accuracy class	Current error at rated primary current %	Phase displacement at rated primary current		Composite error at rated accuracy limit primary current %
		minutes	centi-radians	
5P	±1	±60	±1.8	5
10P	±3	-	-	10

5.5 Current Transformer Classes for Protection Devices as per IEEE C 57.13 the CT protection relaying accuracy class is determined by letter designation and secondary terminal voltage rating.

CT bushing type Class C and Class K shall be used for protection relaying purposes.

5.6 Current Transformer for measuring devices

The accuracy class of metering CT depends on the load currents. For measuring current transformers, the accuracy class is designated by the highest permissible percentage current error at rated current prescribed for the accuracy class concerned. Current Transformer for metering by IEC designation are to be identified by the code letter "M" preceded by the accuracy class and followed by the multiplier for the maximum primary current.

As a general guide, the following are the typical class of accuracy adopted in SEC system:

CT class 0.1 to 0.2 is generally adapted for precision measurements
CT class 0.5 is for high grade kilowatt hour meters.
CT class 3 to 5 is for approximate measurements.

Note: if class PX is specify it shall be preferred over class P

measuring current transformers, the accuracy class is designated by the highest permissible percentage of the ratio error (ε) at rated primary current and rated output.

Design Parameter & Equation From TES-P-119.28

5.7.1 Design Parameters

The value of resistance for CT winding and lead wires used for the terminal connections of the current transformers, relay and meters and auxiliary CTs is generally based on reference temperature of 20ºC.

A twenty (20%) percent margin on calculated knee-point voltage is to be considered for the CT not to be saturated.

A twenty-five (25%) percent margin on the calculated CT burden of the connected load is considered to give enough safety factors and prevent CT to be saturated under all condition.

5.7.4.2 Inverse Time Function connection

$V_{KP} \geq 20 \times I_{set} \times (R_{CT} + R_L + R_R)$,

Wherein;
I_{set} is the current set value of the relay connected
R_R is the burden resistance of the relay

5.7.4.3 Instantaneous Function

$V_{KP} \geq I_{sc} \times (R_{CT} + R_L + R_R)$,

Where in,
I_{sc} is the maximum short circuit current related to the secondary side of CT connected; also it is equal to the maximum fault current level divided by CT ratio.

Core & Insulation Material From 50-TMSS-01

4.2 Construction

4.2.1 General

a. Current transformers shall be of ring type (with continuous ring or split core), bushing type or freestanding type as specified in data schedule.

b. All CTs shall be of low leakage construction.

c. Cores of protection CTs shall be high grade grain-oriented, silicon steel with non-gapped construction.

d. Cores of metering CTs shall be of nickel alloy type to provide low losses, high accuracy and low saturation levels.

Table- I

Nominal Voltage	Installation Indoor/Outdoor	Type of CT Insulation
11kV or 13.8kV	Indoor(Bushing or Ring Type)	Cast Resin
33kV & 34.5kV	Indoor(Bushing or Ring Type)	Cast Resin
33kV & 34.5kV	Outdoor	Mineral Oil Filled
69kV	Indoor	Cast resin/Silicone Liquid Filled
69kV, 110kV,115kV & 132kV	Outdoor	Mineral Oil Filled
230kV & 380kV	Outdoor	Mineral Oil Filled

Specification From Egyptian Distribution Material Specification (EDMS).

Technical specifications:

- Highest voltage for equipment U_m (R.M.S) (kV) 12 – 24
- Number of secondary windings 1-2 (3 if required)
- Service voltage (KV) 11 - 22
- Secondary current (A) 5 (1 if required)
- Rated primary current (A) **As Required**
- Rated continuous current 1.2 I rated primary current
- Accuracy class :
  - Measuring 0.5S
  - Protection 5P10- 5P20
    Class PX(if required)
- Rated burden:
  - Measuring (VA) ≥ 10
  - Protection (VA) ≥ 15
- Accuracy Limiting Factor
  - Protection P10 – P20
  - Measuring FS5 – FS10
- Creepage distance ≥ 2 Cm/KV
- Rated short time "thermal" withstand current (RMS) (KA)

	1 sec winding 11KV	1 sec winding 22 KV	2 sec windings 11 KV	2 sec windings 22 KV
Time	1 sec	1 sec	3 sec	3 sec
Value of SC (KA)	25	20	31.5or 25 (1)	25

(1) Please choose only one value.

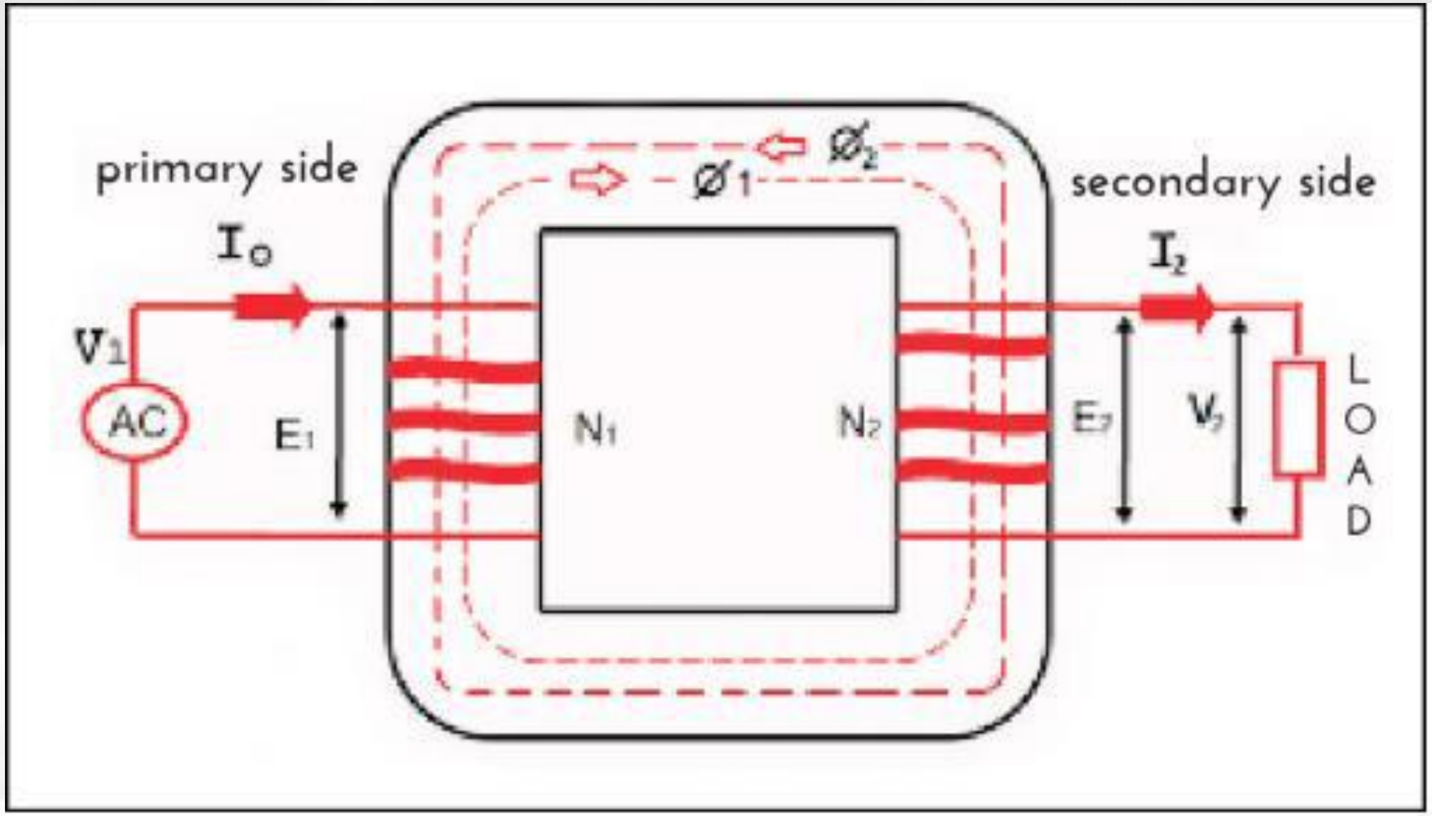
Notes

- **Why Should the CT Secondary Never be Opened?**

counter balancing flux.
$\varnothing = \varnothing 1 - \varnothing 2$,is the flux that flows through the core.

Its value is relatively small
If compared to $\varnothing 1$.

This flux maintains
linear relationship between secondary
and primary current depending on
the core material when secondary
connected with Load.



Notes

High Voltage Risk: potentially harmful voltages that can cause electric shock or damage equipment.

Insulation Breakdown: high voltage produced can exceed the insulation ratings of the transformer leading to insulation breakdown & possible arcing,fire hazards.

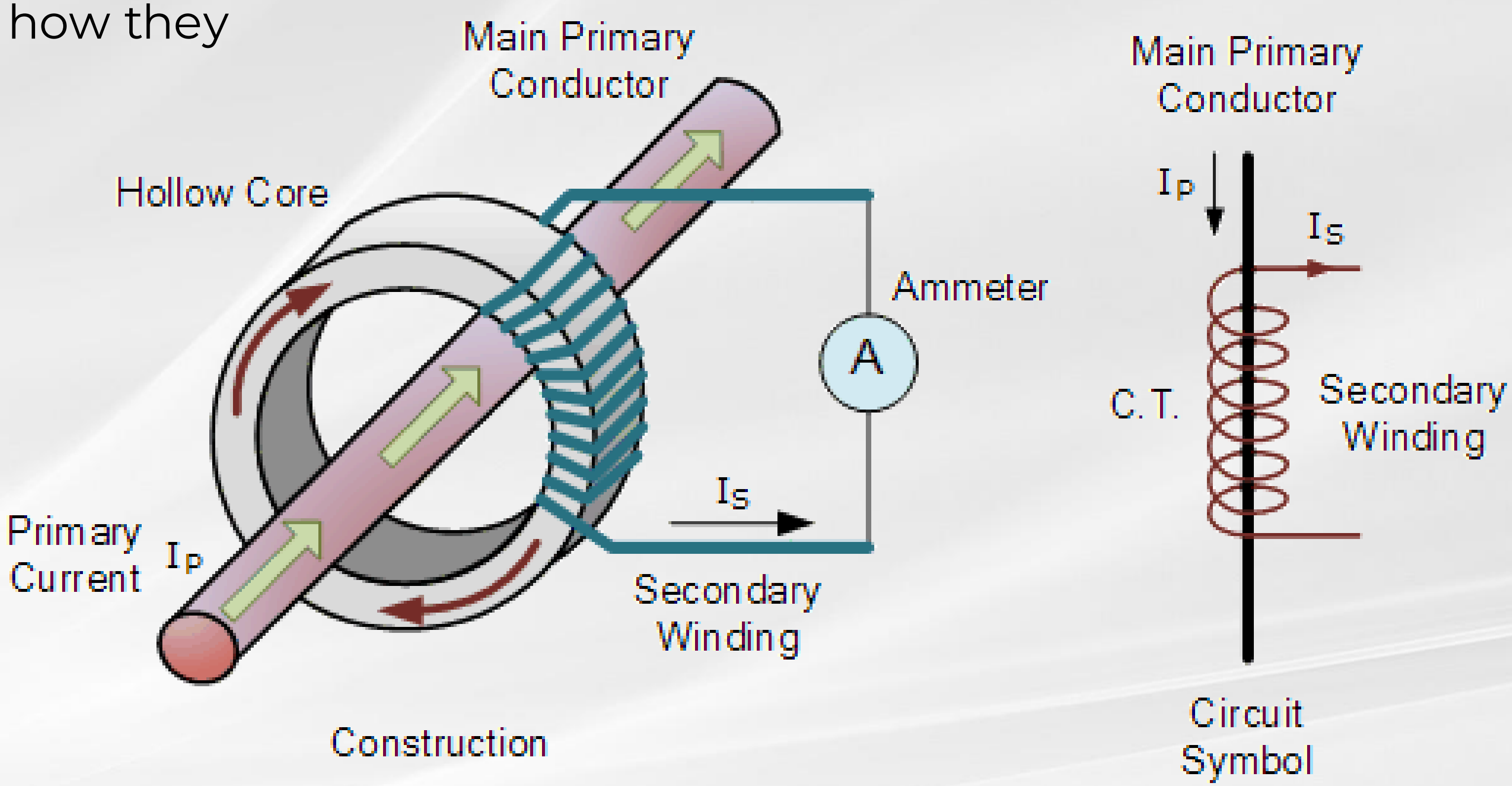
Equipment Damage: The excessive voltage can damage the CT itself and any connected devices, such as meters or relays.

Safety Hazards: If someone is working on the system &inadvertently opens the secondary circuit, they may be exposed to dangerous conditions. Protective measures that rely on the CT's proper functioning may fail.

Notes

- **Why is the polarity of a current transformer (CT) is crucial?**

High voltage current transformer (HVCT) polarity refers to the orientation of the transformer's primary and secondary windings and how they relate to the direction of current flow.



Notes

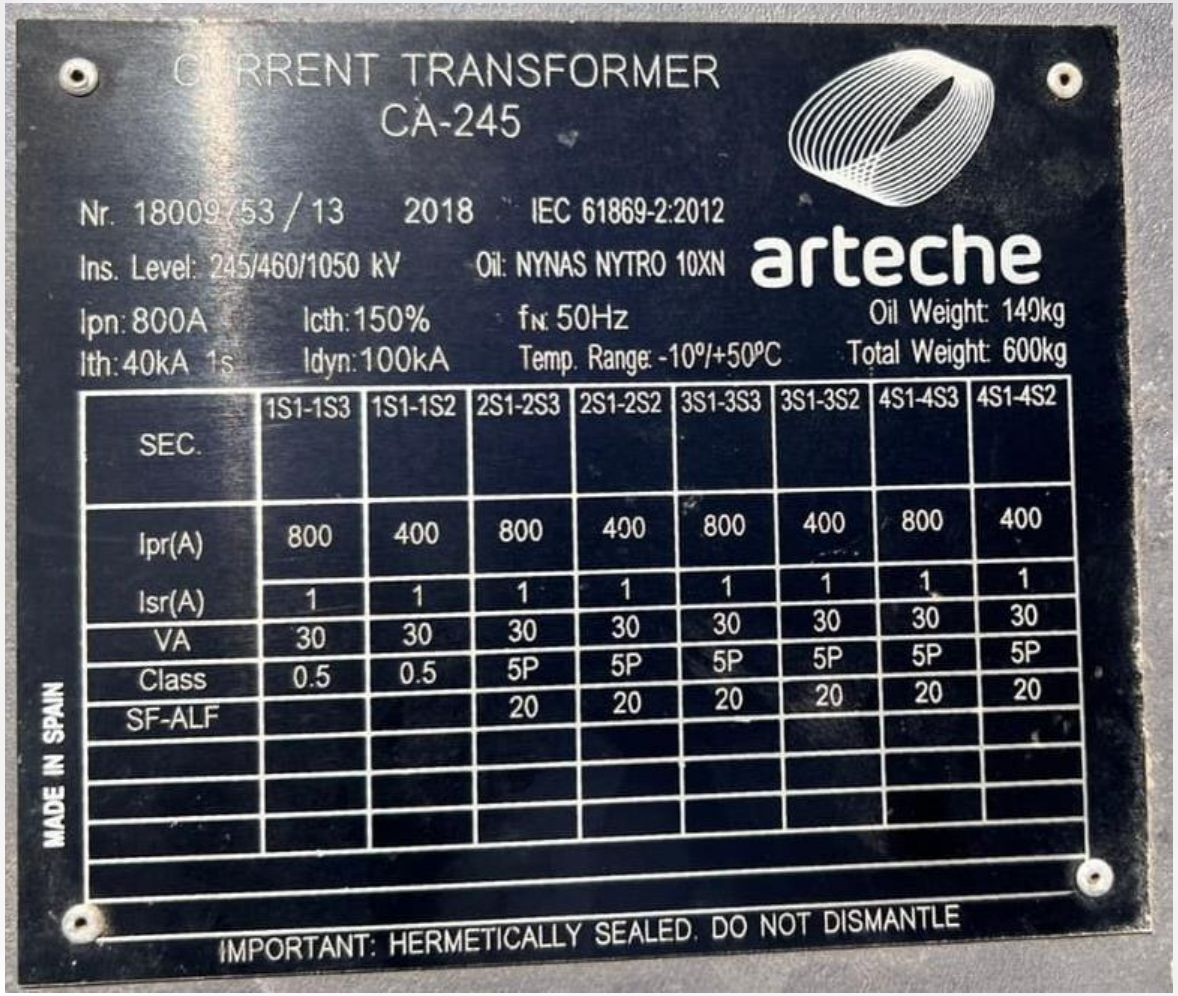
- **Why is the polarity of a current transformer (CT) is crucial?**

Notes

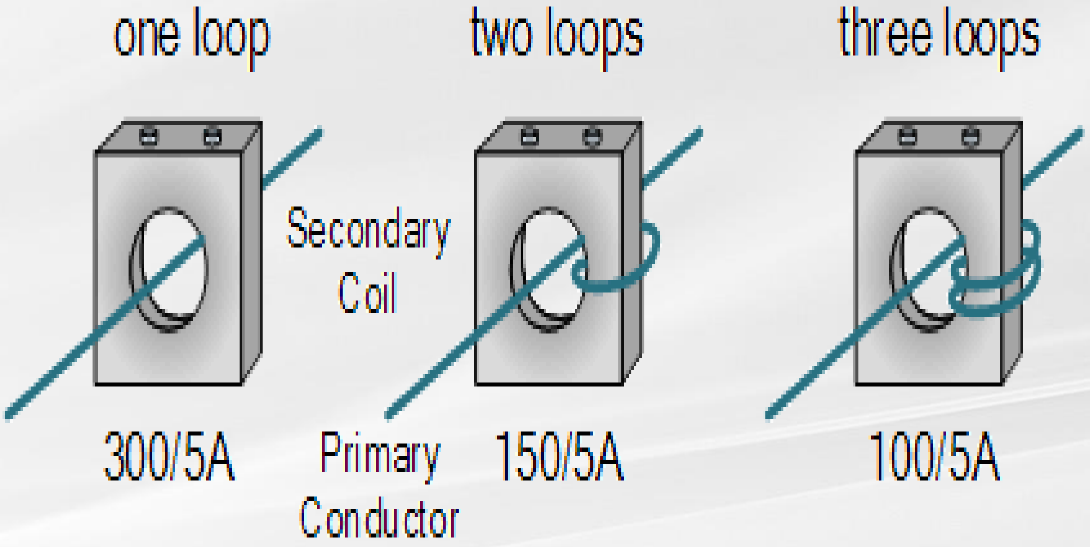
- **Why is the polarity of a current transformer (CT) is crucial?**
- **Accurate Measurement:** If the CT is connected with the wrong polarity, the readings can be reversed or inaccurate, leading to erroneous data.
- **Protection Systems:** Incorrect polarity can cause relays to trip when they shouldn't or fail to trip when needed, compromising system safety.
- **System Coordination:** In multi-CT setups, maintaining proper polarity ensures that all devices operate in harmony. This is vital for coordination between different protection devices and ensuring that faults are accurately detected and isolated.
- **Phase Relationships:** Accurate phase alignment is important for power quality and system performance.
- **Safety:** Incorrectly connected CTs can lead to dangerous situations, such as those involving high voltage surges when the secondary circuit is open.

Notes

What is the Dual Ratio Current Transformer ?



Current transformers having a center tapped secondary. it is necessary to have available two ratios of primary to secondary current from the same secondary winding of the CT.



Notes

- **What is the Dual Ratio Current Transformer ?**
- The ratio obtained by the tap is usually one-half the ratio obtained by the full secondary winding.
- With 200 amperes flowing in the primary, CT. They are used in applications where a connection 1S1 – 1S2 will produce 5 amperes out of the secondary.
- Then as the load grows to 400 amperes, the secondary circuit will be reconnected to 1S1 – 1S3 to produce 5 amperes in the secondary.
- It is not recommended to reconnect while the unit is energized, the secondary terminals must be short circuited so as not to induce high voltage in the secondary circuit.
- On a dual ratio tapped secondary CT, both the full winding and the tapped winding cannot be operated simultaneously.

- **Another design of CT commonly used is the double secondary CT. Where the CT has two cores, two secondary windings and one common primary winding.**