CT & VT Testing

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Agenda

- Introduction to CTs and VTs
- Standard Tests for CTs and VTs
- Testing Mythology
- MRCT (Reveal)

Current Transformers

Applications , Identification , Classification

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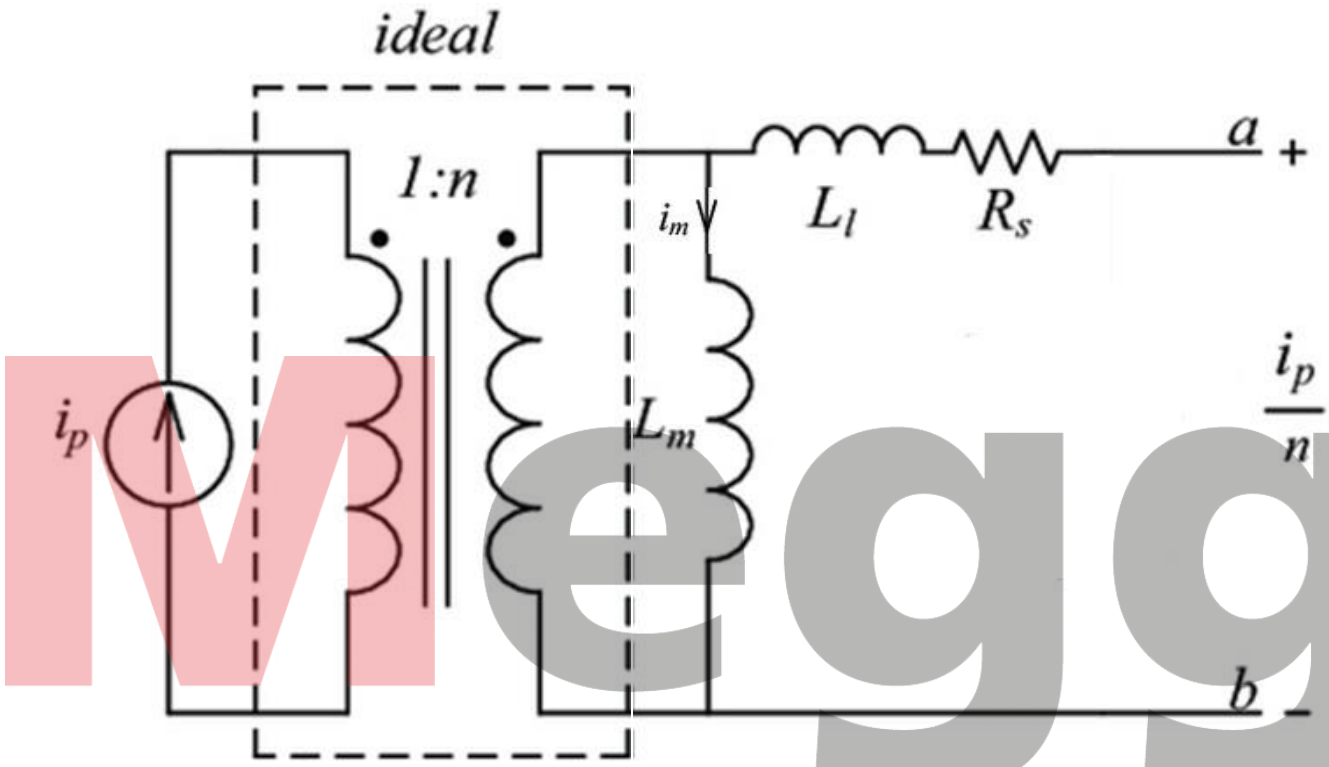
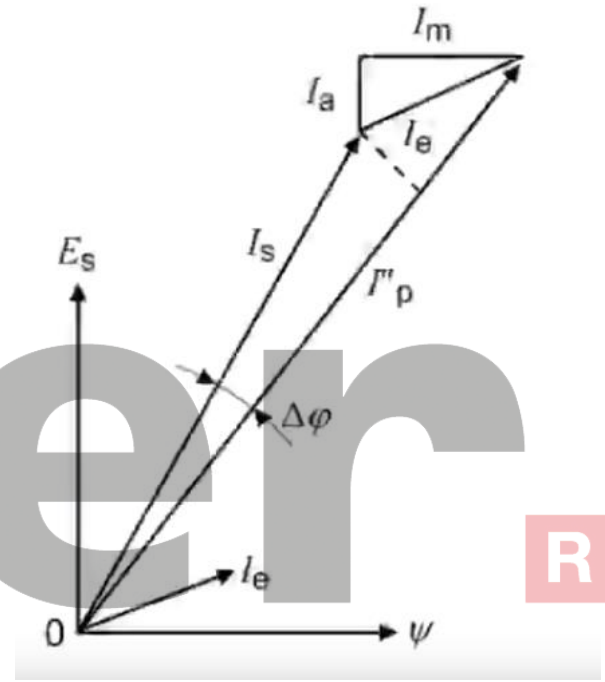
Power on

Current Transformer





Ideal CT

$$I_s = \frac{N1}{N2} \times I1$$

Real CT

$$I_1 I_s = \frac{N1}{N2} \times I1 - Ie$$

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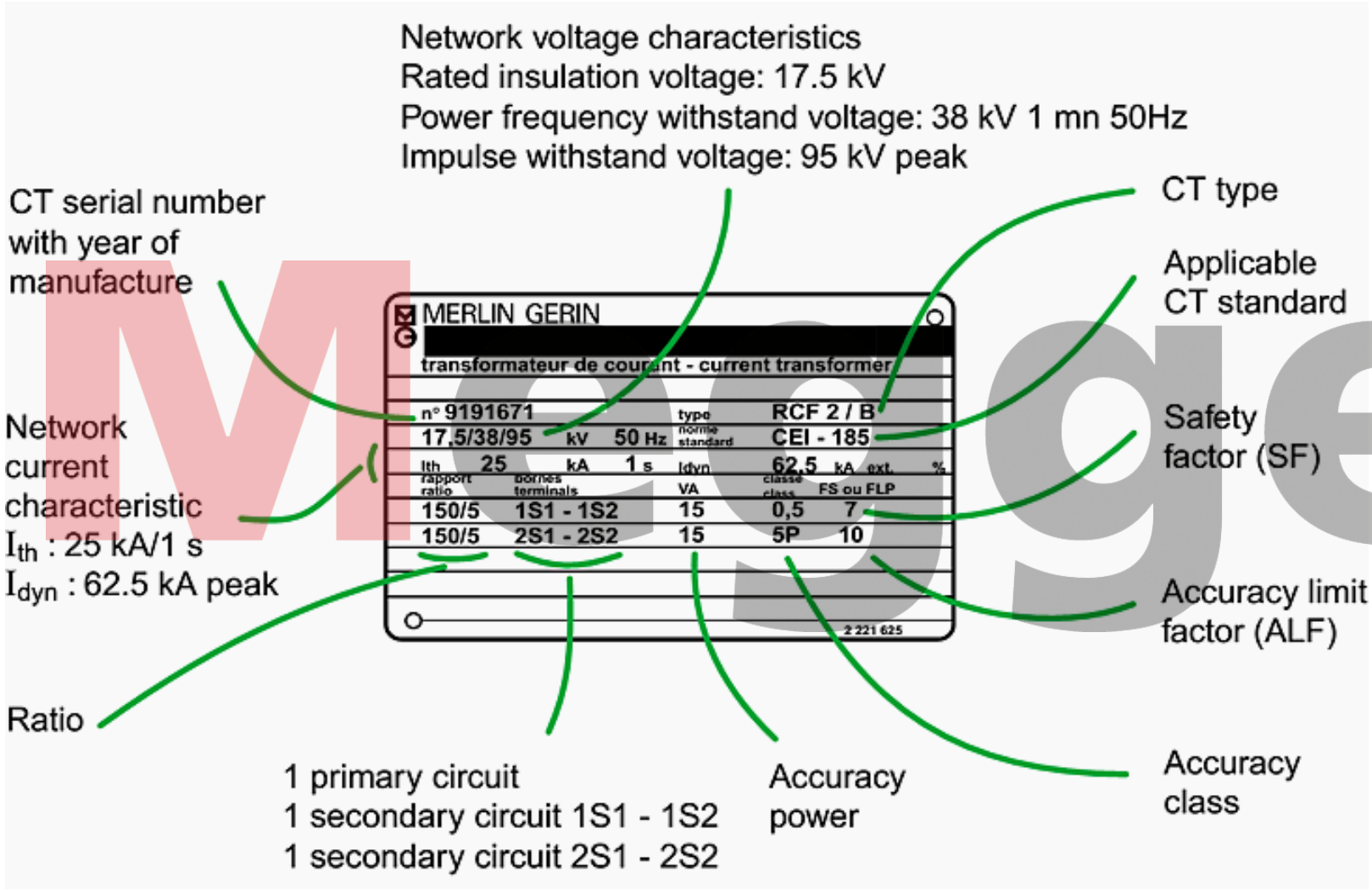
Current Transformers in Applications

- Metering
- Protection

Standard Definition

- IEC 61869-2 – 2012
  - IEC 60044-1
  - IEC 60044-6
- IEEE C37.110 – 2007

Name Plate



Most Important Ratings :

1- Ratio (150/5)

2-Burden (15 VA)

3- Classification

a- Accuracy

b-Factor

Source : Electrical-Engineering-Portal.com

Metering CT – IEC 61869-2

The Ratio Error and Phase displacement at rated frequency shall not exceed the values given in the standard

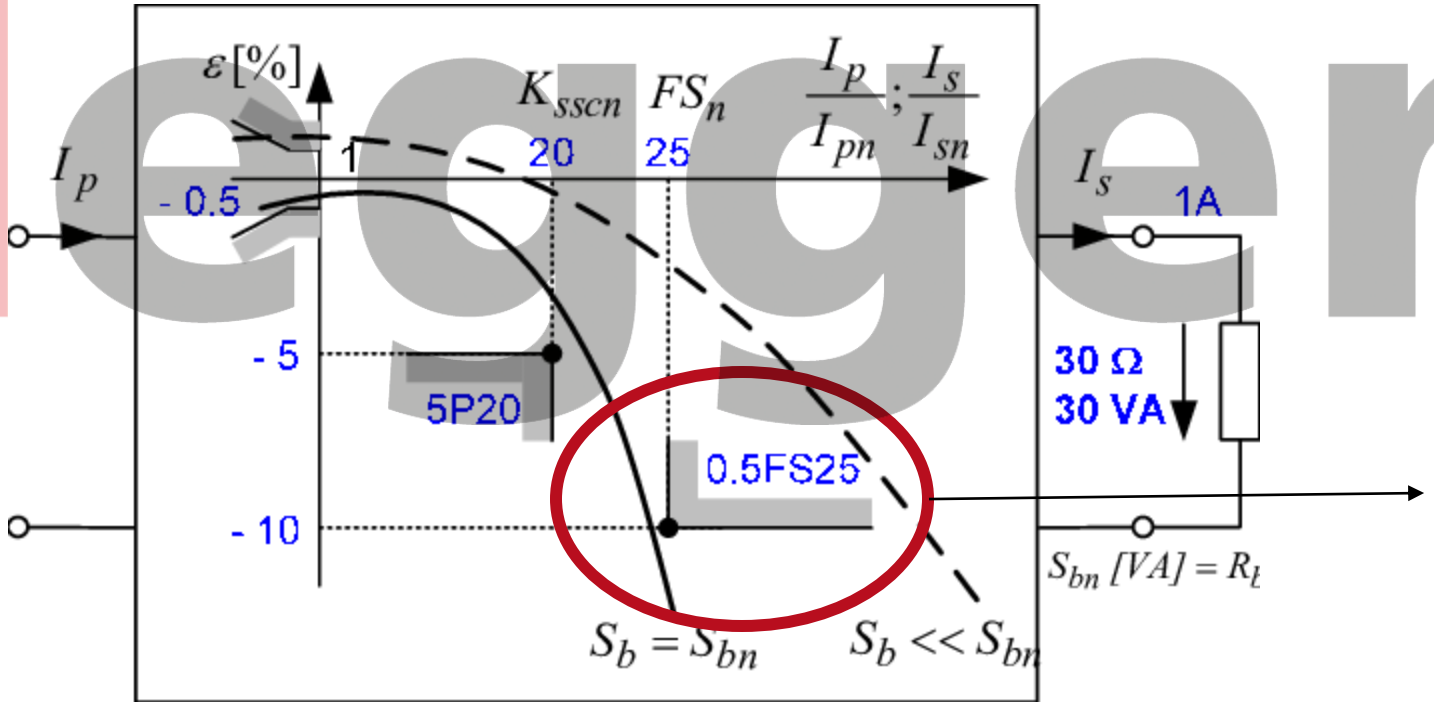
The Burden can assume any value from 25% to 100% of the rated output

Accuracy Classification – IEC

Accuracy Class	Precentage current (Ratio Error at Precentage of Rated Current)					Phase Displacement at Percentage of Rated Current									
						Minutes					Cent radians				
	1	5	20	100	120	1	5	20	100	120	1	5	20	100	120
0.1	N/A	0.4	0.2	0.1	0.1	N/A	15	8	5	5	N/A	0.45	0.24	0.15	0.15
0.2	N/A	0.75	0.35	0.2	0.2	N/A	30	15	10	10	N/A	0.9	0.45	0.3	0.3
0.5	N/A	1.5	0.75	0.5	0.5	N/A	90	45	30	30	N/A	2.7	1.35	0.9	0.9
1.0	N/A	3.0	1.5	1.0	1.0	N/A	180	90	60	60	N/A	5.4	2.7	1.8	1.8
0.2S	0.75	0.35	0.2	0.2	0.2	30	15	10	10	10	0.9	0.45	0.3	0.3	0.3
0.5S	1.5	0.75	0.5	0.5	0.5	90	45	30	30	30	2.7	1.35	0.9	0.9	0.9

Metering (FS) Security Factor

- Factor that should not be exceeded by Metering CT , to protect the Connected Meter from high Fault currents



Safety Factor (FS)

Source: www.researchgate.net

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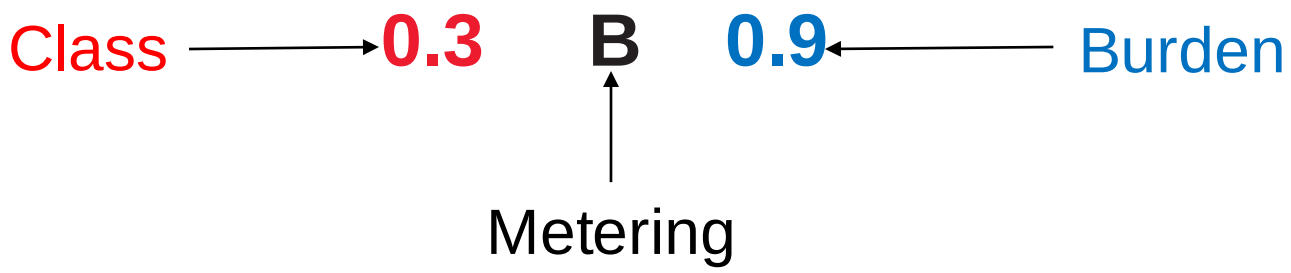
Metering CT - IEEE

- High degree of accuracy at the specified standard burden at 10% and 100% of the rated primary current
- Revenue metering requirement
  - The Transformer correction factor (TCF) of the CT shall be within the specified limits when the PF (lagging) if the metered load (burden) has any value from 0.6 to 1.0
- The Identifier



Metering CT - IEEE

Standard accuracy class for metering CTs	Limits of transformer correction factor			
	@ 100% rated current		@ 10% rated current	
	Min	Max	Min	Max
0.3	0.997	1.003	0.994	1.006
0.6	0.994	1.006	0.988	1.012
1.2	0.988	1.012	0.976	1.024

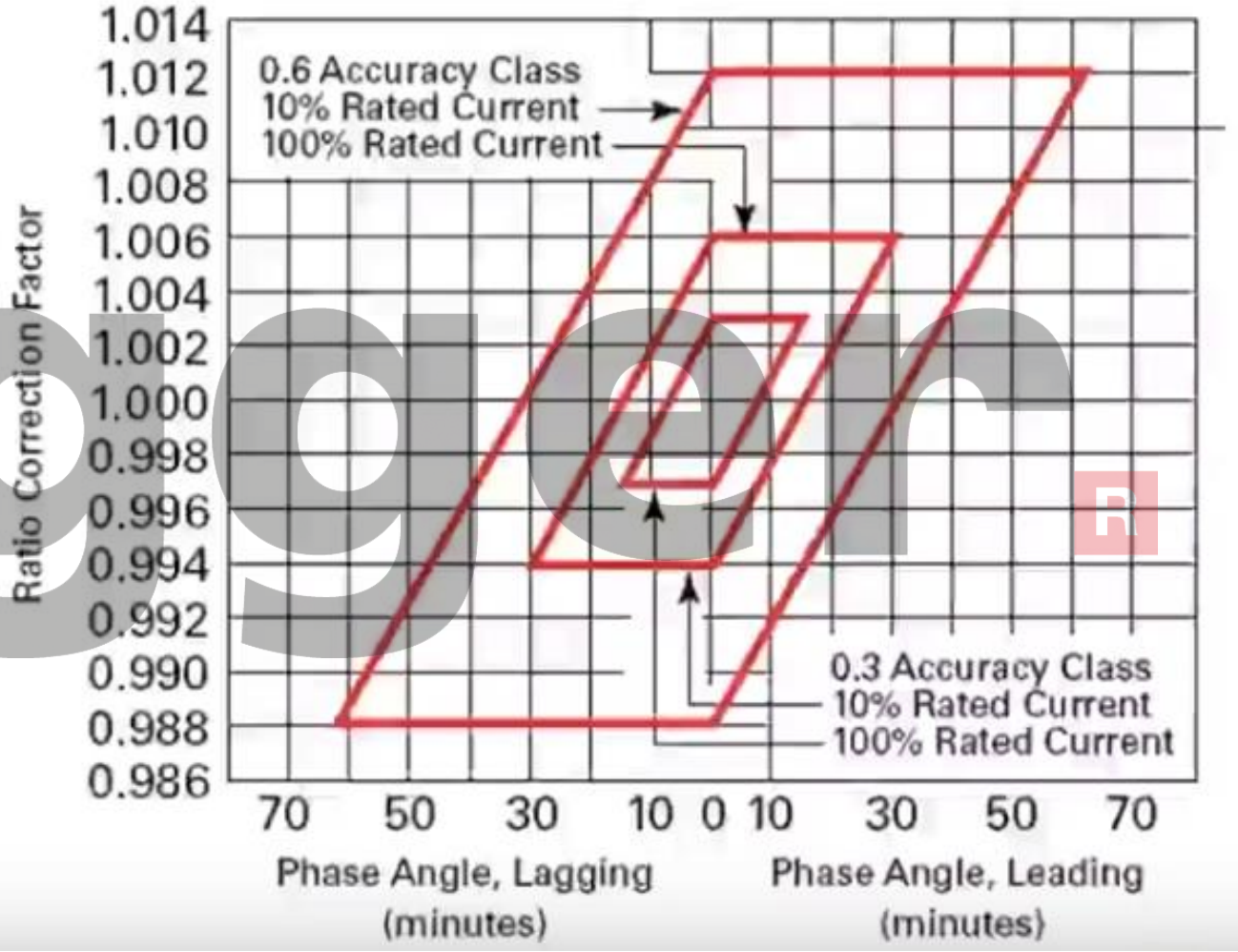
Standard accuracy class for metering CTs	Limits of Transformer correction factor					
	@ 100% rated current		@ 15% rated current		@ 5% rated current	
	Min	Max	Min	Max	Min	Max
0.15	0.9985	1.0015	-		0.997	1.003
0.15S	0.9985	1.0015	0.9985	1.0015	-	

Accuracy Class Tolerances for Metering CTs - IEEE

$$RCF = \frac{\text{Actual CT Ratio}}{\text{Nameplate Ratio}}$$

Actual Ratio = Nameplate Ratio * RCF

$$Cos(53.13° - \Delta\varphi) = 0.6 \cdot \frac{RCF}{TCF}$$



Metering CT- Burden

Burden Designation	Resistance (Ω)	Inductance (mH)	Impedance (Ω)	Volt amperes (@ 5 A)	PF
B-0.1	0.09	0.116	0.1	2.5	0.9
B-0.2	0.18	0.232	0.2	5.0	0.9
B-0.5	0.45	0.580	0.5	12.5	0.9
B-0.9	0.81	1.040	0.9	22.5	0.9
B-1.8	1.62	2.080	1.8	45.0	0.9

Burden Designation = Impedance = $Z = R + j\omega L$

$VA = V \times I_s = I_s^2 \times Z$, $I_s = 5$ A

$PF = R / Z$

Protection Classes- IEC61869-2

Protection (P) Class CTs – IEC

- IEC 61869-2 Specifies that , the ratio error , phase displacement and composite error shall not exceed the limits specified in the standard
- To maintain the Specified Class connected burden my stay within the rated burden
- ALF (Accuracy limit Factor)

Accuracy Class	Percent error for the Nominal Primary current	Offset for Primary Rated Current		Compound Error Limit for Primary current Accuracy in %
		Minutes	Centi-radians	
5 P ALF	+/- 1	+/- 60	+/- 1.8	5
10 P ALF	+/- 3	-	-	10

Example :10P20 = not more than +/-10% error at 20 times rated current

Class PX

Purpose: Special-purpose CT for differential/distance protection as per **IEC 61869-2**.

Defining Feature: No fixed accuracy class; performance defined by **excitation curve**.

Parameters:

Knee Point Voltage (Vk): Determines linearity.
Excitation Current (Ie): Current at Vk.
Secondary Winding Resistance (Rs): Affects CT performance.
Turns Ratio (N): Ensures relay accuracy.

Application: High-accuracy differential protection (transformer, line, generator) to prevent CT saturation.

Low remanence Type CT (PR Class)

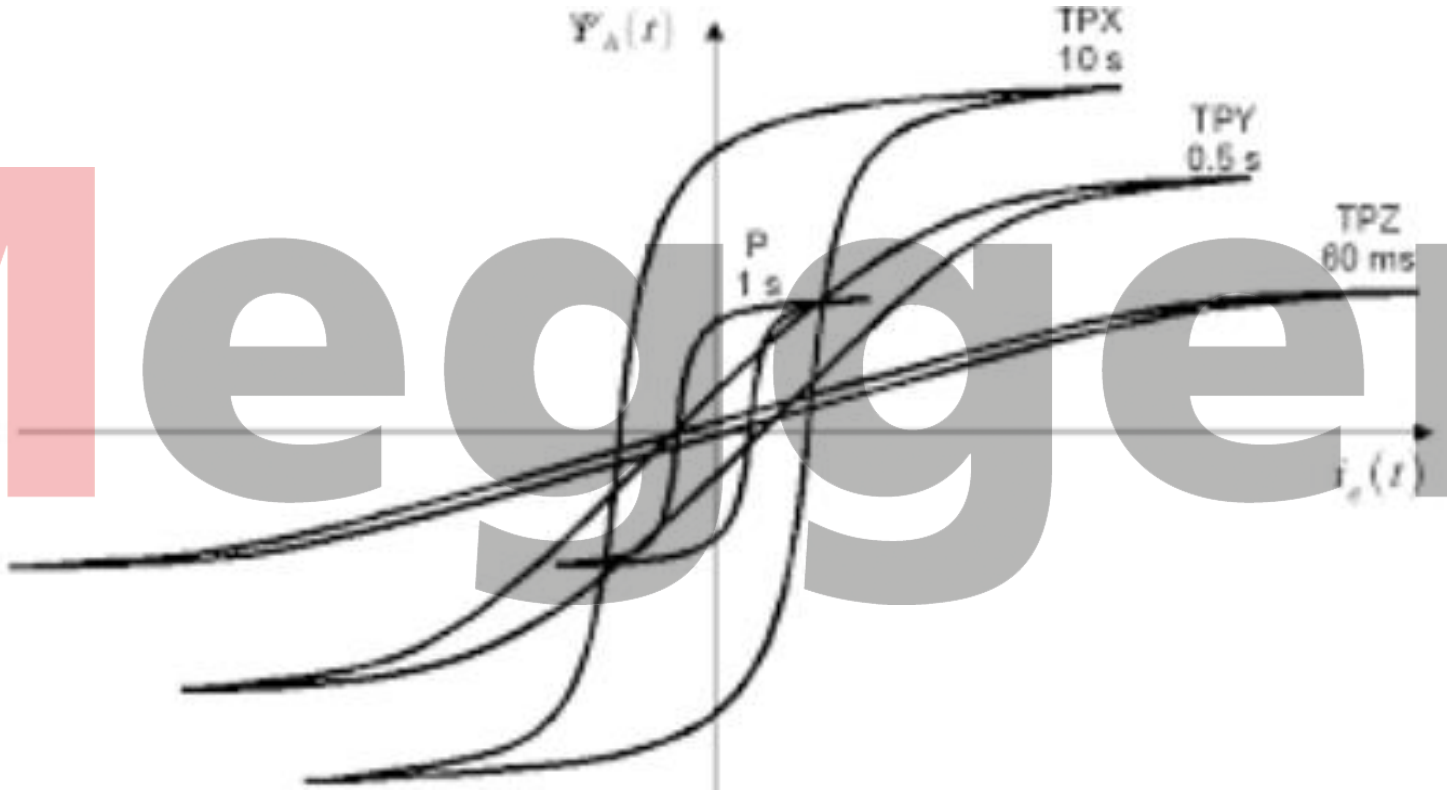
- Low remanence Type CT (PR Class)
  - E.g. 5PRX , X = ALF (accuracy limiting Factor)
  - Where the remanence shall not Exceed 10%
  - Usually contains air Gaps to achieved that

Example :10PR20 = not more than +/-10% error at 20 times rated current
Shall not exceed more than 10% Remanence

TP Classes(Transient conditions)

- IEC 61689-2 defines the accuracy classes TPX, TPY and TPZ. The cores designed for transient current including AC and DC with Specified Duty Cycles
- TPX have no air gaps. High remanence CT.
- TPY with small air gaps. Low remanence CT.
- TPZ the air gaps will be large. Non remanence CT.

Characteristics Transient Classes



Source : IEEEXplore.ieee.org

Protection CT - IEEE

- Protective Relaying
  - Protection Class CTs provide input information for the protection of a power system
  - IEEE C57.13.1 – 2006 specifies that protection CTs must maintain a ratio error of no more than +/- 10% in a range from 1 to 20 times rated secondary current at the specified load

Protection CT – Classification IEEE

Class T

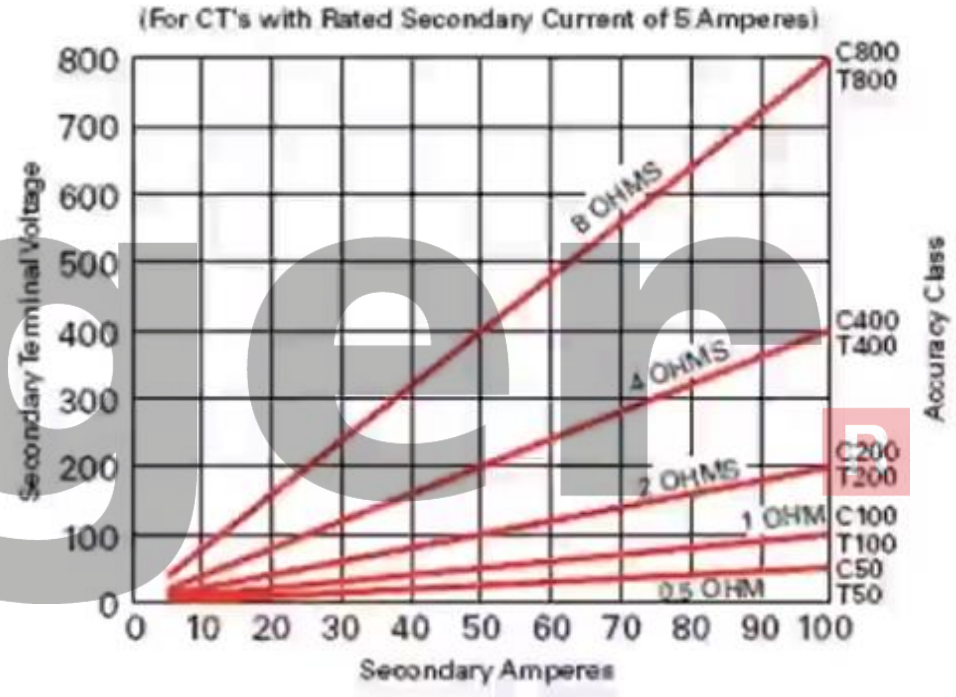
- Covers the CTs where the leakage flux in the core creates a 1% difference between the actual ratio correction and the calculated ratio correction within the current and burden limits , in this case the ratio must be **T**ested (name **T** come from)

Class C

- Widely use , Covers the CTs that leakage flux in the core has a **negligible** effect on the ratio within the limits of current and burden , so that ratio can be **C**alculated (name Class **C** comes from)

Protection CTs – Standard Burden IEEE

Burden	R (Ω)	L (mH)	Z (Ω)	VA (at 5A)	PF
B – 1	0.50	2.30	1.0	25	0.5
B – 2	1.00	4.60	2.0	50	0.5
B – 4	2.00	9.20	4.0	100	0.5
B – 8	4.00	18.40	8.0	200	0.5



Voltage Transformer (VT) Testing

Applications , Identification , Classification

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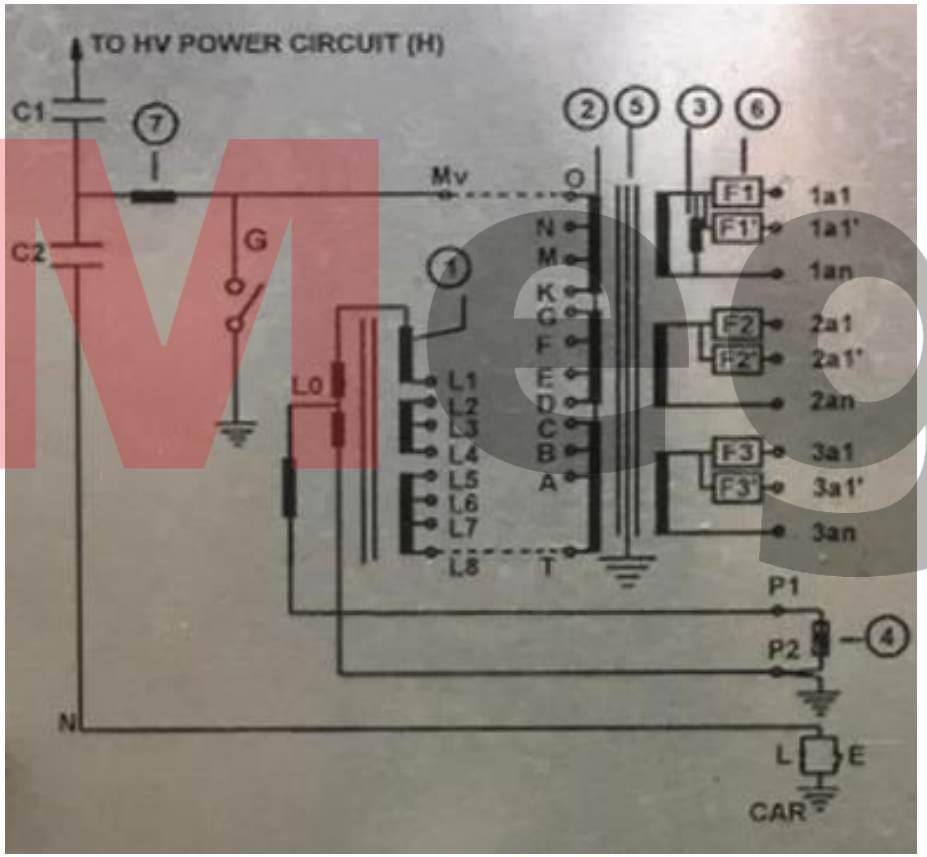
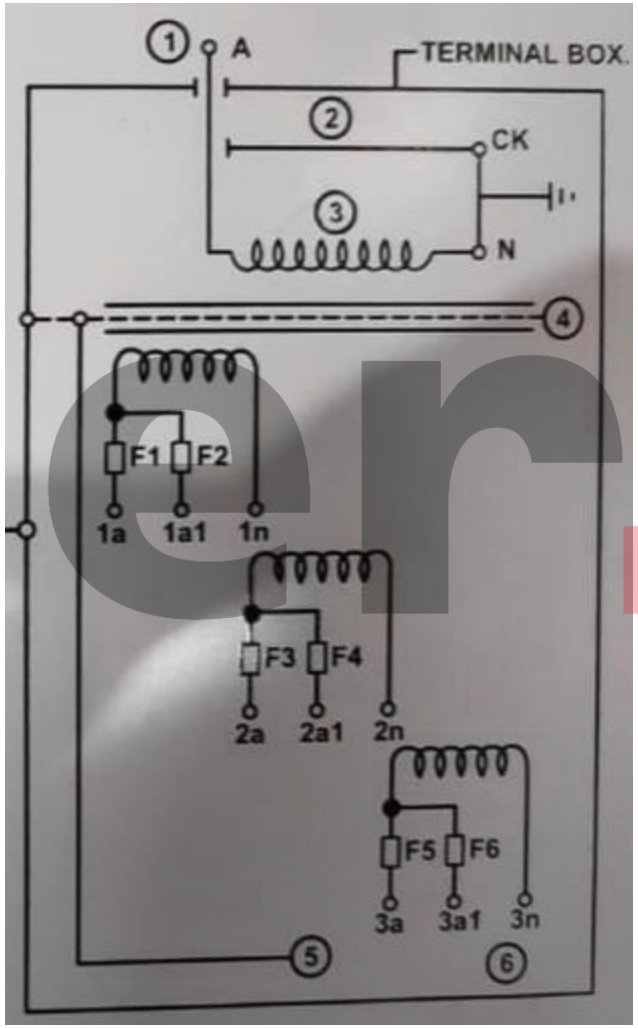
Inductive (IVT) and Capacitive (CVT)



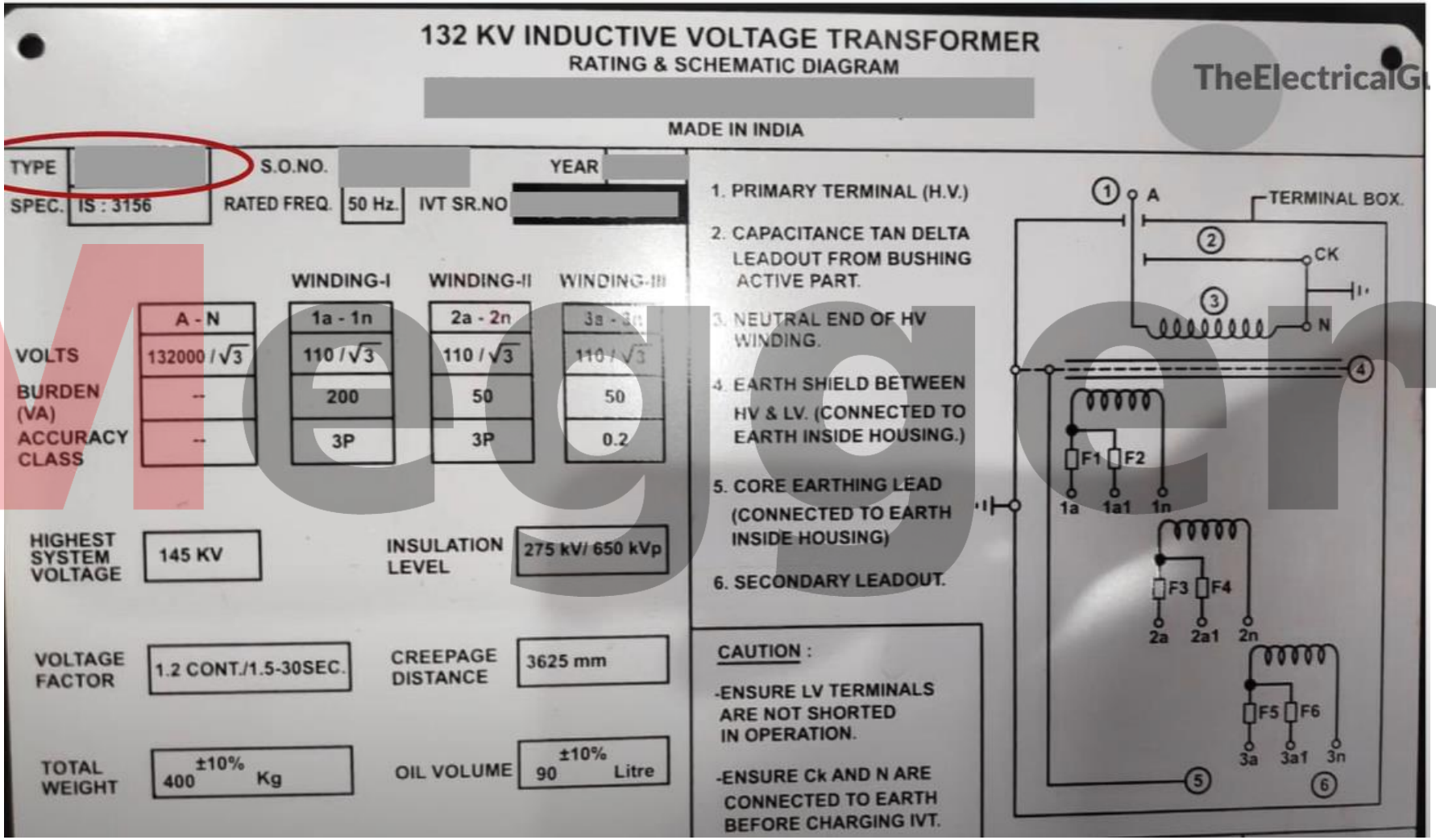


Standard Definitions

- IEC 61869-3 – *Instrument transformers – Part 3: Additional requirements for inductive voltage transformers*
  - IEC 60044-2 are withdrawn voltage transformer standards
- IEC-61869-5- Additional requirements for capacitor voltage transformers

- IEEE Std C57.13 – *IEEE Standard Requirements for Instrument Transformers*

IVT Nameplate



https://www.theelectricalguy.in

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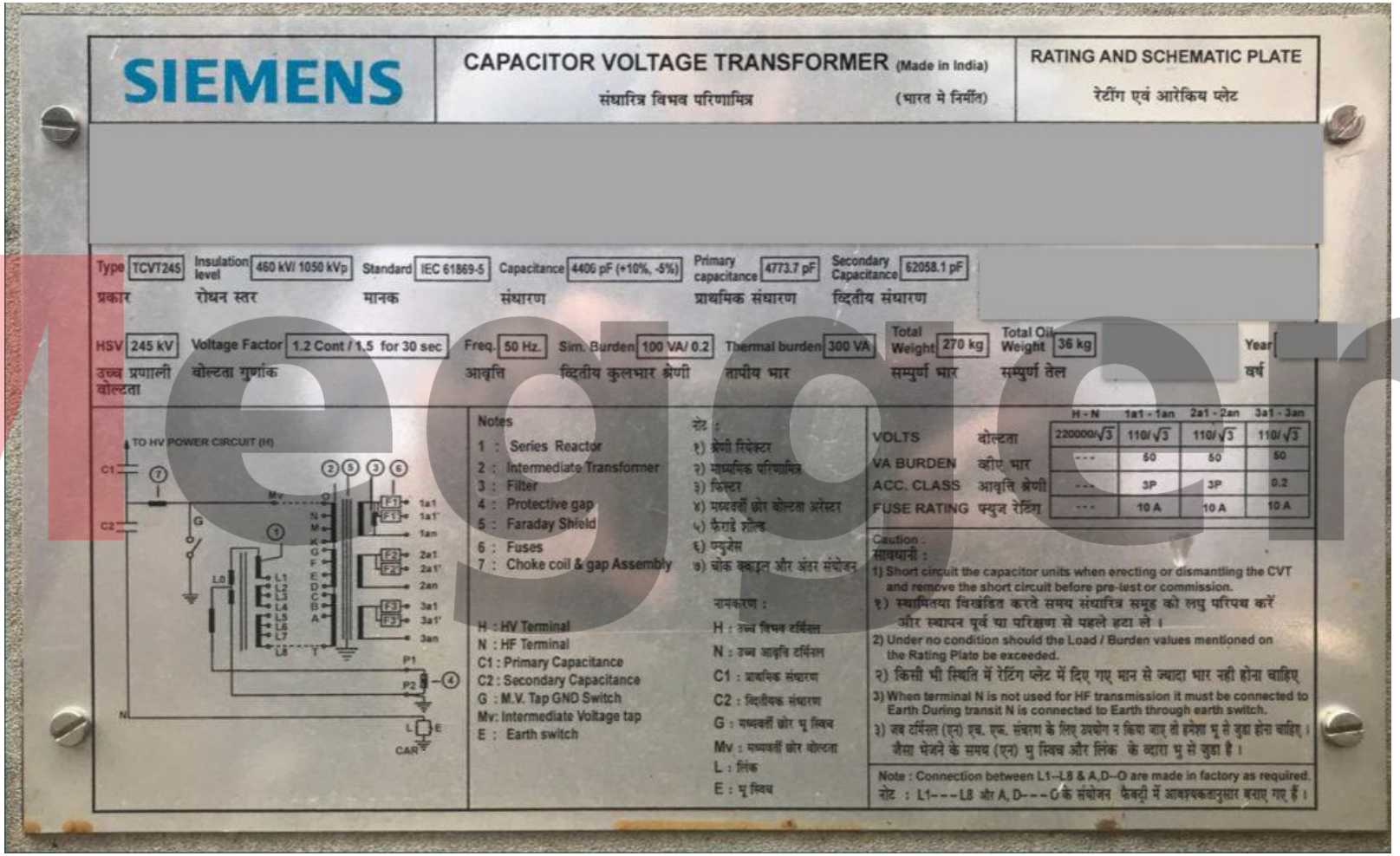
CVT Nameplate



https://www.theelectricalguy.in/tutorials/nameplate-details-of-capacitive-voltage-transformer-explained/

Voltage Transformers in Applications

- Metering
- Protection

IEC61869 – Classes

- Metering Classes
  - 0.1
  - 0.2
  - 0.5
  - 1
  - 3
- Defined Accuracy from 80%-120%

- Protection Classes
  - 3P
  - 6P
- Defined Accuracy from 5%-120%

IEC61869 Burdens

10 VA	15 VA
25 VA	30 VA
50 VA	75 VA
100 VA	150 VA
200 VA	300 VA
400 VA	500 VA

IEEE Std Classes

- Metering Classes
  - 0.15
  - 0.3
  - 0.6
  - 1.2

IEEE Std Burdens

M	–	35 VA,	pf = 0.2
W	–	12.5 VA,	pf = 0.1
X	–	25 VA,	pf = 0.7
Y	–	75 VA,	pf = 0.85
Z	–	200 VA,	pf = 0.85
ZZ	–	400 VA,	pf = 0.85

CT and VT Tests

Power on

Standard Field Electrical Tests for CTs

- Insulation Resistance
- Winding Resistance
  - Demagnetization of Ct
- Excitation / Saturation (Knee point)
- Ratio and phase deviation
- Polarity
- Burden

- Typical Tests
  - Insulation Resistance
  - Winding Resistance
    - Demagnetization of VT
  - Ratio and phase deviation
  - Knee-point (Saturation Test)
  - Short-Circuit (impedance) Test

- Additional Tests(Depends)
  - Tan-Delta Test (Power Factor)
  - DFR (Dielectric Frequency response)
  - Partial Discharge

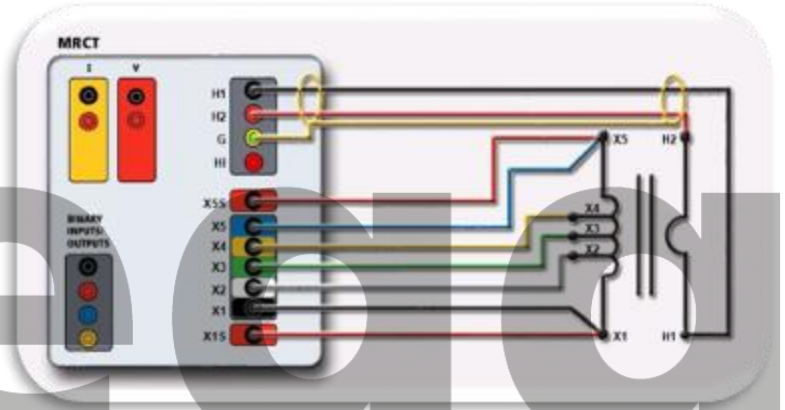
Testing methodology

Primary Current Injection

Pros :
-Direct Actual Values

Cons :
Difficult setup
Not possible to automate
Limited to Source
No full assessment

Hybrid (Primary – Secondary)



Pros:
-Direct Actual Values
-Easy Setup
-Automate Testing (one click)
-Assessment

Secondary Voltage Injection

Pros :
-Easy Setup
-Automate Testing (one click)
-Assessment

Cons :
Not Actual Values
Indirect Results
Lower Voltages

Megger MRCT

The Hybrid Primary and Secondary Injection

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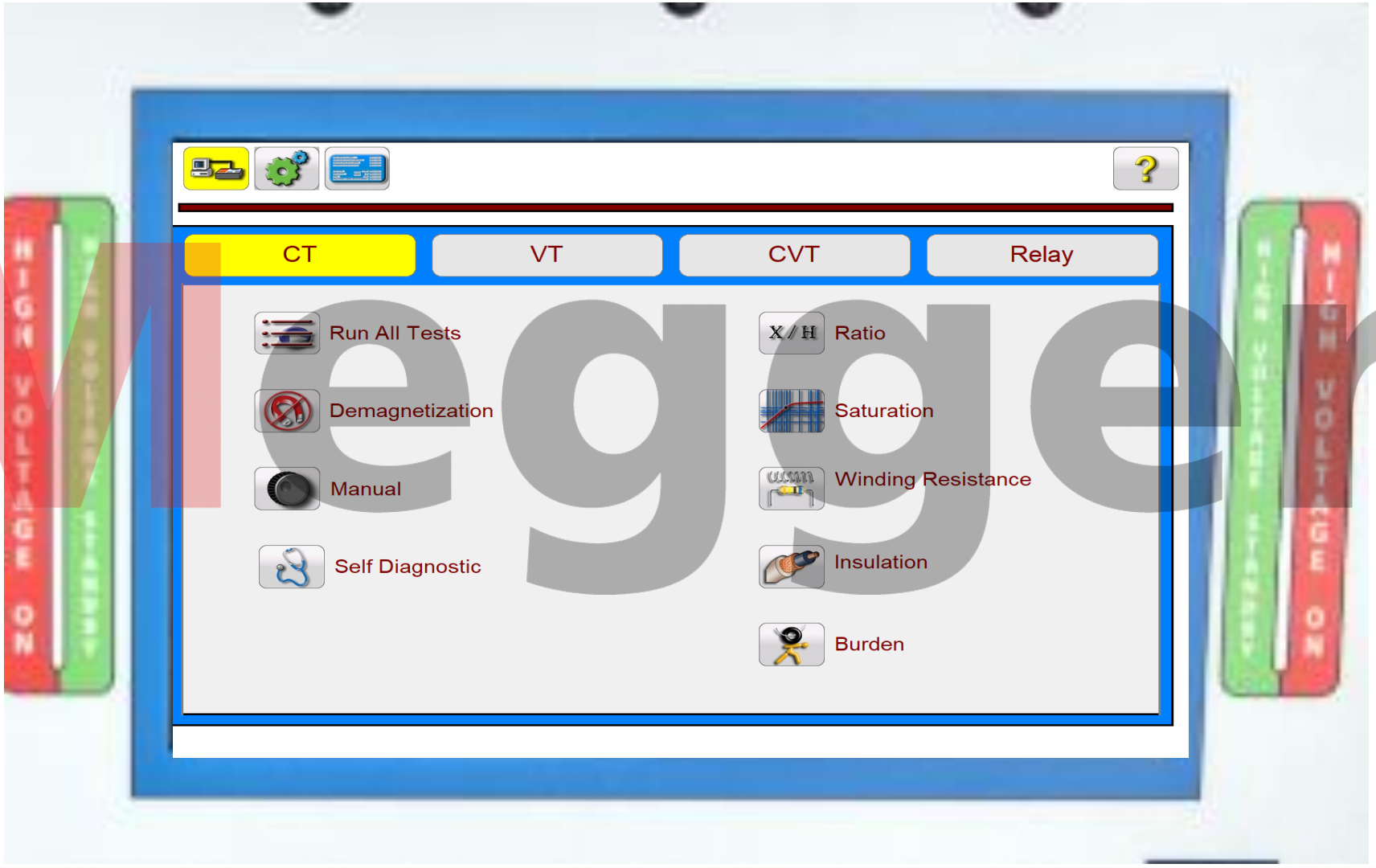
MRCT – Megger Voltage and Current Transformer Tester

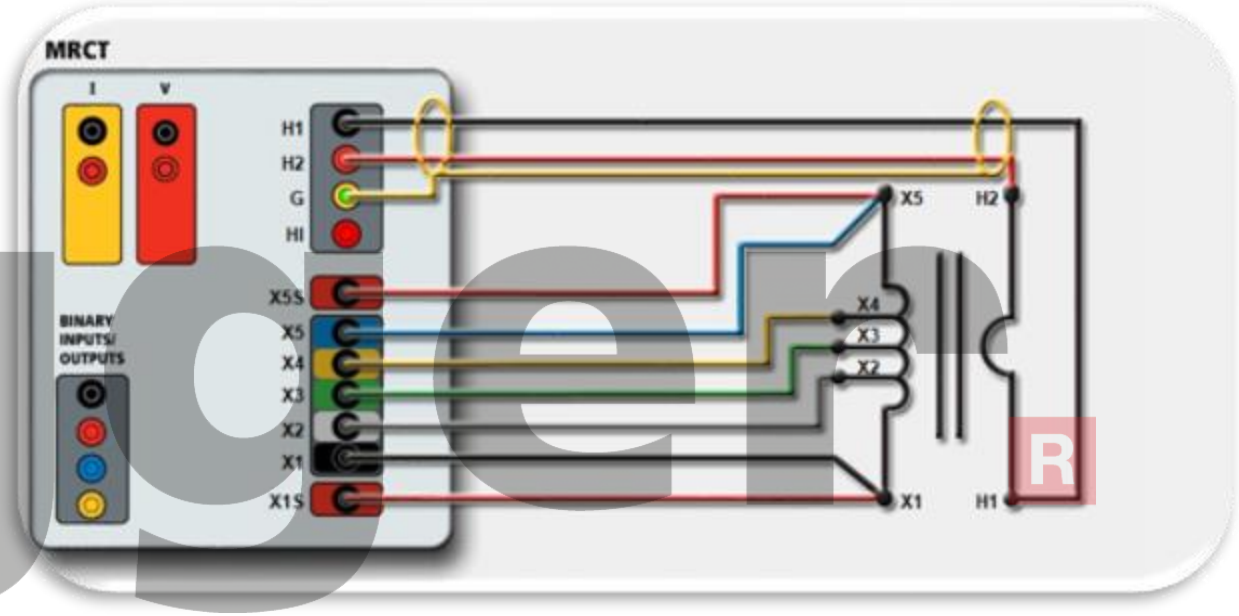
- Dedicated CT & VT and CVT Tester
- Small and lightweight
- Performs all usual CT test in Single Connection
  - Winding Resistance
  - Ratio
  - Knee-point
  - Burden measurement
- Perform 5 taps Testing Simultaneously
- Can perform Insulation resistance test (1 kV)
- 2Kv Source for VT and CVT testing

Operated by built-in touchscreen



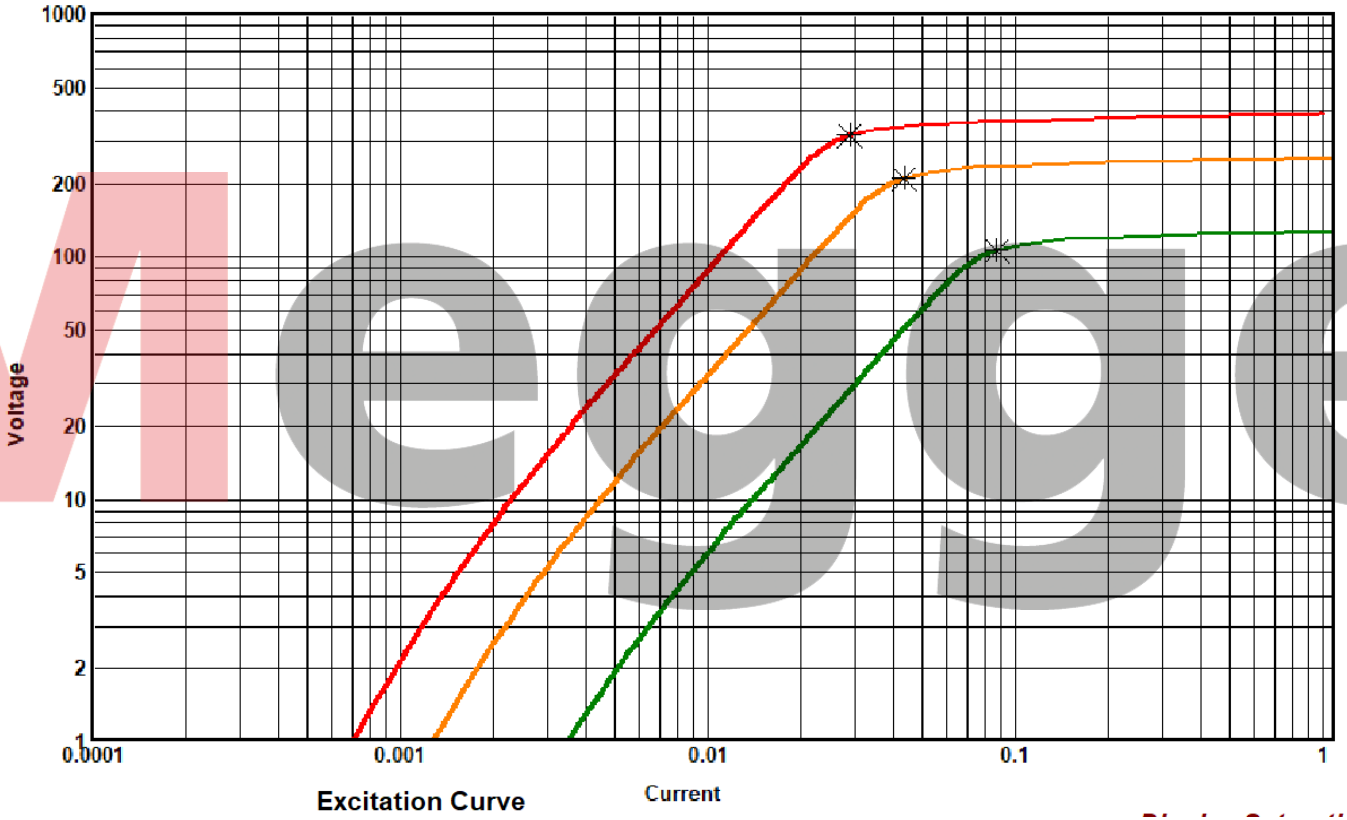
Simultaneous Tap measurement

- Patented Concurrent method for testing up to 5 taps simultaneously and in one connection
- No switchbox or internal switching needed!
  – All taps are tested at the same time



Kneepoint measurement

- Measures CT kneepoints upto 2kV – using AC voltage injection method
- Uses DC method to measure knee points up to 30kV

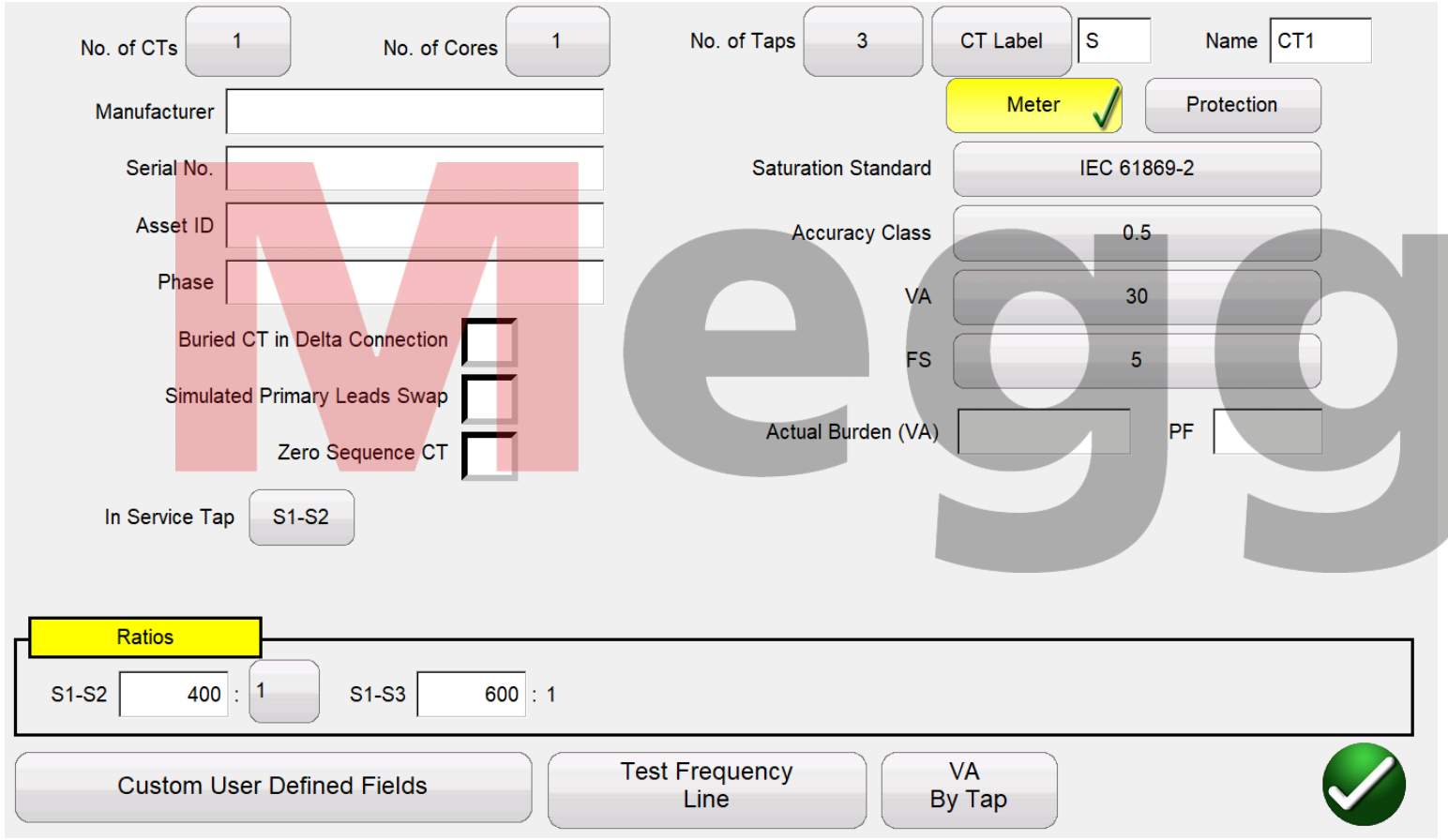


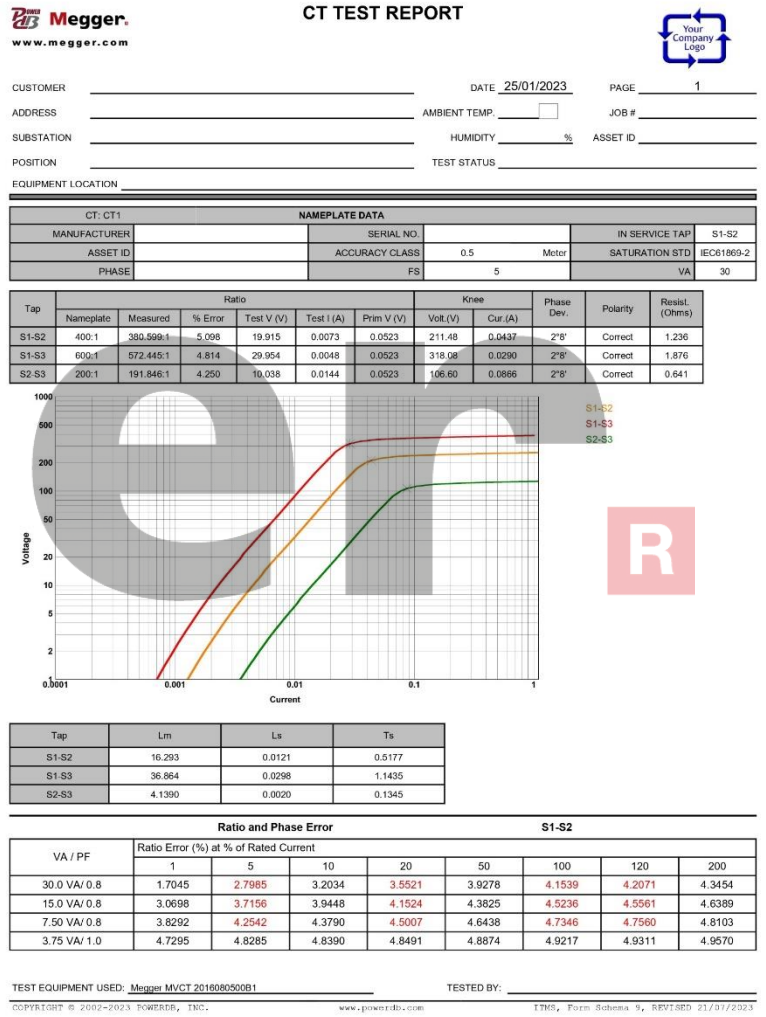
- Supports for both IEC and ANSI standards for kneepoint measurement

Test Transformer Bushing CTs

- Ability to tests CTs mounted on power transformers bushings

Fully automated testing, assessment and reporting





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www.megger.com

CT TEST REPORT

Your Company Logo

CUSTOMER
ADDRESS
SUBSTATION
POSITION
EQUIPMENT LOCATION
DATE 25/01/2023
AMBIENT TEMP.
HUMIDITY %
TEST STATUS
PAGE 1
JOB #
ASSET ID

CT: CT1	NAMEPLATE DATA				
MANUFACTURER		SERIAL NO.		IN SERVICE TAP	S1-S2
ASSET ID		ACCURACY CLASS	0.5 Meter	SATURATION STD	IEC61869-2
PHASE		FS	5	VA	30

Tap	Ratio						Knee		Phase Dev.	Polarity	Resist. (Ohms)
	Nameplate	Measured	% Error	Test V (V)	Test I (A)	Prim V (V)	Volt.(V)	Cur.(A)			
S1-S2	400:1	380.599:1	5.098	19.915	0.0073	0.0523	211.48	0.0437	2°8'	Correct	1.236
S1-S3	600:1	572.445:1	4.814	29.954	0.0048	0.0523	318.08	0.0290	2°8'	Correct	1.876
S2-S3	200:1	191.846:1	4.250	10.038	0.0144	0.0523	106.60	0.0866	2°8'	Correct	0.641

Tap	Lm	Ls	Ts
S1-S2	16.293	0.0121	0.5177
S1-S3	36.864	0.0298	1.1435
S2-S3	4.1390	0.0020	0.1345

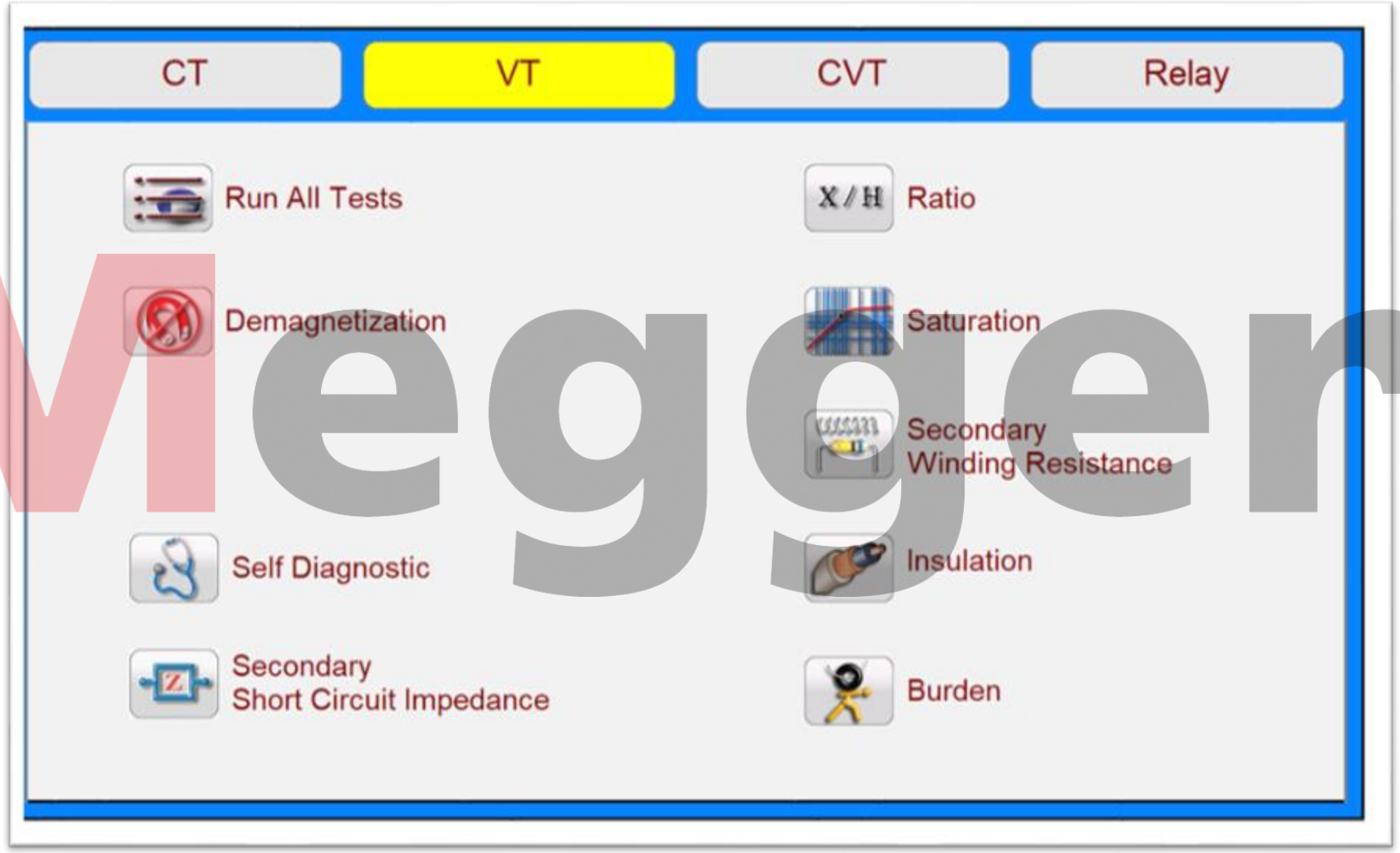
Ratio and Phase Error — S1-S2

VA / PF	Ratio Error (%) at % of Rated Current							
	1	5	10	20	50	100	120	200
30.0 VA/ 0.8	1.7045	2.7985	3.2034	3.5521	3.9278	4.1539	4.2071	4.3454
15.0 VA/ 0.8	3.0698	3.7156	3.9448	4.1524	4.3825	4.5236	4.5561	4.6389
7.50 VA/ 0.8	3.8292	4.2542	4.3790	4.5007	4.6438	4.7346	4.7560	4.8103
3.75 VA/ 1.0	4.7295	4.8285	4.8390	4.8491	4.8874	4.9217	4.9311	4.9570

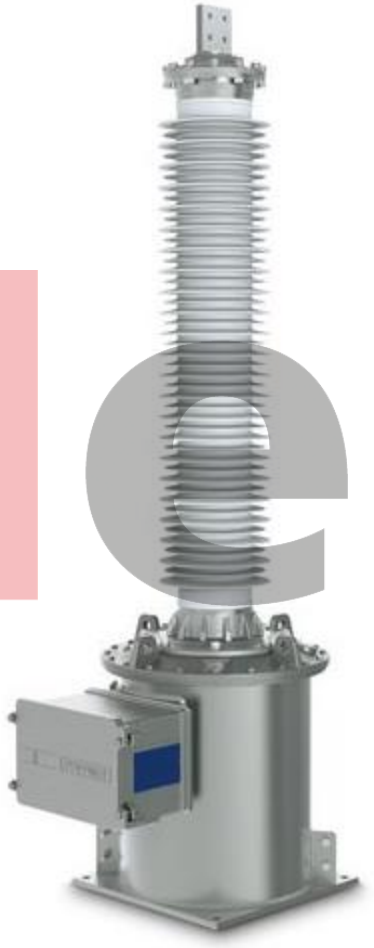
TEST EQUIPMENT USED: Megger MVCT 2016080500B1
TESTED BY:

www.powerdb.com
TTMS, Form Schema 9, REVISED 21/07/2023

VT Testing



MRCT – Megger Relay and CT Tester



Capacitive Voltage Transformer

Any Questions?

Thank you very much for your Attention

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Power on

Appendix

- For Your info , additional information in the slides below

Essential VT Tests

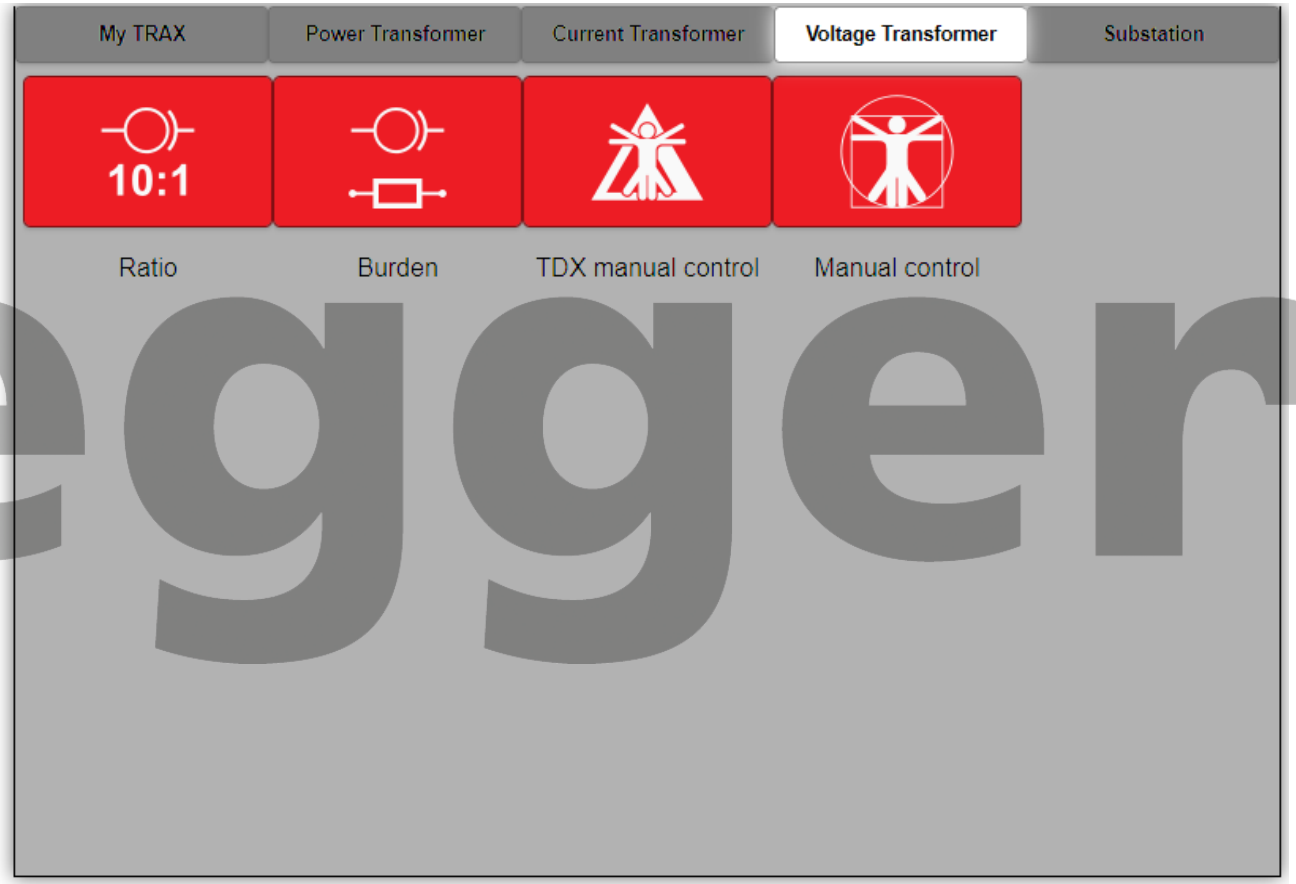
Power on

TRAX

Multifunction transformer and substation test system

TRAX - Multifunction Transformer and Substation Test System

TDX120 Tan-Delta unit



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Test Transformer Bushing CTs

- Ability to tests CTs mounted on power transformers bushings

DELTA4000 (Tan-Delta)

- Power factor test set
- Automatic and manual operation
- Accurate and repeatable measurement results with high noise suppression
- Lightweight, rugged two-piece design
- New built-in intelligent temperature correction (patent pending)
- New automatic voltage dependence detection (patent pending)

Megger
Power on

Dialectic Frequency Response

IDAX300

IDAX350

IDAX322