

# Importance of Correctly Specifying Measurement Instrument Transformers

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# Importance of Correctly Specifying Measurement Instrument Transformers

## Definition of Instrument transformer (IEC61869 -1, 2007)

- Transformer intended to transmit an **information signal** to measuring instruments, meters and protective or control devices or similar apparatus

## Why correctly specifying?

- To reduce loss of revenue
- To avoid disputes with customers
- Manage equipment cost (total cost of ownership)
- Accurate measurement (PQ, etc)

# Important Parameters when Specifying Instrument Transformers



## Current Transformers

- Accuracy class
- Ratio
- Burden
- Number of cores
- Security factor

## Voltage Transformers

- Accuracy class
- Ratio
- Burden
- Number of windings/loaded windings
- Voltage factor

# Overview of IEC61869-2 Requirements

## (Current transformer requirements)



<b>Standard Accuracy class</b>	<p>The standard accuracy classes for measuring current transformers are: 0,1 – 0,2 – 0,2S – 0,5 – 0,5S – 1 – 3 – 5</p> <p>For Class 0,1 – 0,2 – 0,2S – 0,5 – 0,5S – 1: Ratio error and phase displacement at rated frequency valid in the range 25 % to 100 % of the rated Burden.</p>
<b>Standard Rated Burden</b>	<p>The standard values of rated output: 2.5 – 5.0 – 10 – 15 and 30 VA. Values above 30 VA may be selected to match the application.</p>
<b>Security Factor, FS</b>	<p>Standard Values : FS5 &amp; FS10</p> <p>For preventing secondary device from damage, the core should go into saturation in case of an overcurrent. Saturation of the core is indicated through a deviation of the rated secondary current of at least 10 %. The initial overcurrent value is described through the security factor FS, i.e. <math>\text{overcurrent} \geq \text{FS} * \text{rated primary current}</math>.</p>

# Ratio Error Comparison (0.2 vs 0.2S class)



Accuracy class	Ratio Error				
	% of rated current				
	1	5	20	100	120
0.2	NA	0.75	0.35	0.2	0.2
0.2S	0.75	0.35	0.2	0.2	0.2

Consider a 33kV three phase variable load/source operating between 40MW and 500kW. Minimum load current = 8.75A, Max load current = 699.82A, CTR = 700/1

- At 500kW, the load current is 1.25% of the CT rated current ( $(8.75/700) \times 100\%$ ), If 0.2 class is used, then measurement errors are not guaranteed. Class 0.2S guarantee measurement error of 0.75% in this case.
- At 10MW, 0.2 class CT gives 0.35% measurement error vs  $\leq 0.2\%$  error from 0.2S

# Ratio Error Comparison (Continue...)



- 10MW at 0.35% error vs 10MW at 0.2% error over a life span of the installation (25 years) at N\$1.80/kWh for 10hrs a day produces a loss of N\$2 463 750.00 (excluding price escalation)
- If yearly price adjustment of 4% is considered, then the losses incurred will be N\$ 4 102 204.00. (Assuming all other requirements are met and the VTs measurement errors are within limits).

# Overview of IEC61869-3 Requirements

## (Voltage Transformer requirements)



<b>Standard Accuracy Class</b>	The standard accuracy classes for single-phase inductive measuring voltage transformers are: 0,1 – 0,2 – 0,5 – 1,0 – 3,0
<b>Standard Rated Output</b>	Two Burden ranges are defined: <ul style="list-style-type: none"><li>○ Burden range I: 1.0 – 2.5 – 5.0 - 10VA - defined at power factor of 1.</li><li>○ Burden range II: 10 - 25 - 50 - 100 VA - defined at a power factor of 0.8 lagging.</li></ul>

### Limits of voltage error and phase displacement

- 80 -120% of rate Voltage
- For Burden range I : 0 -100% of rated burden, at unity pf
- For Burden range II: 25 -100% of rated burden at pf = 0.8 lagging

Ensure that the limits above are observed during FAT and SAT for correct assessment of test results.

# Overview of IEC61869-3 Requirements (Continue...)



Accuracy class	Voltage(ratio) error  ±%	Phase displacement	
		±Minutes	±Centiradians
<b>0.1</b>	0.1	5	0.15
<b>0.2</b>	0.2	10	0.3
<b>0.5</b>	0.5	20	0.6
<b>1.0</b>	1.0	40	1.2
<b>3.0</b>	3.0	Not specified	Not specified



# Operating vs Rated Burden



- As discussed above, Accuracy for burden range II voltage transformers is defined at 25 -100% of rated burden. Meaning operating burden must fall within the defined range to guarantee accurate measurement.
- A pass test result  $\neq$  Accurate measurement during operation .For example: Consider a class 0.2 winding with 100VA rated burden , supplying a 5VA load (metering circuit). Pass test results obtained at 25 & 100% of the rated burden. However, this can result in high measurement errors and incorrect billing due to too low operating burden.
- Always consider expected operating burden when specifying voltage transformers rated burden
- Also confirm accuracy at low burden during FAT and SAT i.e at 2 – 25 % of rated burden, especially for stock equipment.

# Operating vs Rated Burden (Continue...)



Model		VT		Type		XXXXXXXXXX						
Rated primary voltage [V]		33000/v3		Serial number		XXXXXXXXXX						
Applied standard		IEC 61869-3		Measurement saving time		2024-03-19, 13:44:11 AM						
Rated frequency [Hz]		50.00		Firmware version		2.31 SR 1 (1165) 2023-06-16 13:43						
Fv		1.2										
Winding	Rated sec. voltage [V]		Class		M-Class	Nom. Burden [VA]/cosφ		Auto assessment				
1a-1n	110/v3		3P		0.2	100/0.8		Failed				
2a-2n	110/v3				0.2	100/0.8		Failed				
<b>Overview of ratio errors and phase displacements</b>												
			<b>Burden</b>									
Winding	Upr [V]	Usr [V]	S1 [VA]	S2 [VA]	S3 [VA]	S4 [VA]	S5 [VA]	U [%]		Ratio error [%]	Phase error [min]	
1a-1n	33/v3	110/v3	100/0.8					80%		0.1552	-1.32	
								100%		0.1464	-1.15	
								120%		0.0822	0.02	
			80%						0.3530	-0.80		
			100%						0.3441	-0.63		
			120%						0.2790	0.55		
	25/0.8			100/0.8	100/0.8				80%		-0.0086	-3.16
									100%		-0.0172	-3.00
									120%		-0.0802	-1.85
									80%		0.1887	-2.64
									100%		0.1800	-2.48
									120%		0.1161	-1.32
25/0.8			100/0.8	100/0.8				80%		0.1552	-1.32	
								100%		0.1464	-1.15	
								120%		0.0822	0.02	
								80%		0.3530	-0.80	
								100%		0.3441	-0.63	
								120%		0.2790	0.55	

# Challenges

- Variable loads/generation
- Inverter based resources.



# Conclusion



- Burden is important. Always calculate the expected operating burden and ensure that it is falling within the recommended range of the rated burden for accuracy.
- A pass test result  $\neq$  Accurate measurement during operation . Always confirm the accuracy at expected operating burden.
- Reduce revenue loss and avoid disputes with customers by correctly specifying measuring instrument transformers
- Find a balance between equipment cost/capital investment and cost of ownership



**Thank you!**

