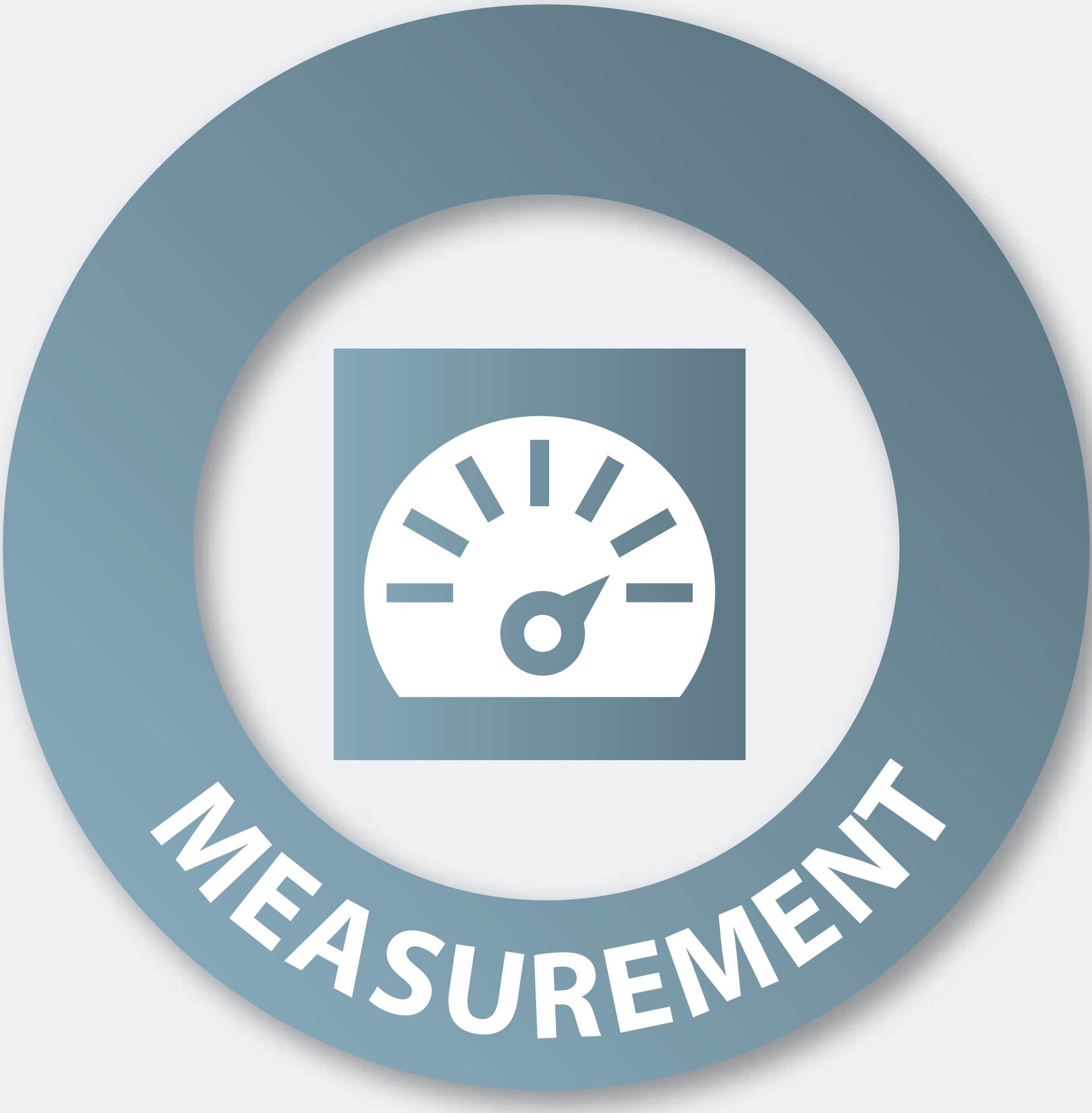
TECHNICAL NOTE

Overall accuracy

Energy Efficiency



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Introduction

SITE 607 A

Measurement is crucial to reducing power consumption. But all too often, when faced with a choice of measurement solutions, the user focuses on the accuracy of the measuring device (PMD*), forgetting to take into account the accuracy of its sensors. But the accuracy of measurement is inextricably linked to the accuracy of the overall chain, i.e. the PMD and its associated sensors. This is especially important in an Energy Efficiency project, the success of which relies on the ability to provide relevant analysis of the electrical system measurement data.

** PMD: Performance Measuring and monitoring Device.*

Contents

Benchmarks

• IEC 61557-12: performance measuring and monitoring devices (PMD*).
• IEC 61869-2 (previously IEC 60044-1): specifications for current transformers.

** PMD: Performance Measuring and monitoring Device.*

Defining a sensor's accuracy class

The product standard relating to current transformers is IEC 61869-2.
The voltage is directly measured for three-phase networks.
If you are using a step-down voltage transformer, its accuracy must also be taken into account.
The nominal values of the secondary current are 1 A and 5 A.
The accuracy classes of current transformers are as follows: **0.1 - 0.2 - 0.2S - 0.5 - 0.5S - 1 - 3 - 5.**

Extract from standard IEC 61869-2 for "standard" class current transformers

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)	
	50	120
3	3	3
5	5	5

This standard requires an accuracy ratio equivalent only to the accuracy class from:
• 100 to 120 % In for classes 0.1 to 1 (e.g. 0.5 % for a 0.5 class),
• 50 to 120 % In for classes 3 and 5.

Extract from the standard IEC 61869-2 for S-class current transformers:

Accuracy class	**Ratio error ±%**				
	at current (% of rated)				
	1	5	20	100	120
0.2S	0.75	0.35	0.2	0.2	0.2
0.5S	1.5	0.75	0.5	0.5	0.5

For S-class transformers, the standard requires an accuracy equivalent to the accuracy class from 20 % to 120 % of the primary rating.

Difference between a “standard”-class transformer and an S-class transformer.

Example of transformers from class 0.5 and class 0.5S:

Current measured	0.5-class transformer	0.5S-class transformer
1 % In < I < 5 % In	-	1.5 %
5 % In < I < 20 % In	1.5 %	0.75 %
20 % In < I < 100 % In	0.75 %	0.5 %
100 % In < I < 120 % In	0.5 %	0.5 %

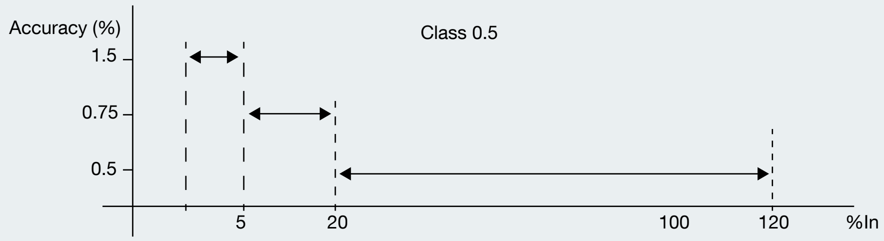

Fig. 1 - Difference between a standard and a s-class transformer.

“Standard” current transformers only guarantee an accuracy equivalent to the 100 % to 120 % In class.

In practice this accuracy is rarely achieved, with the operating current of the loads actually being closer to 30 %-40 % of the rated current In.

To ensure a measurement accuracy over a wide current range, you should therefore use an S-class transformer. However, these transformers are more expensive because of the magnetic material used.

Defining the accuracy class of the power and active energy of a measuring device (PMD)

The product standard relating to measuring devices is IEC 61557-12.

Extract from the standard:

Specified measuring range		Power factor[d]	Intrinsic uncertainty limits for PMD of function performance class C [abc]		Unit
Value of current for Direct connected PMD Dx	Value of current for Sensor operated PMD Sx		For C < 1	For C ≥ 1	
$2\% I_b \le I < 10\% I_b$	$1\% I_n \le I < 5\% I_n$	1	±2.0 x C	No requirement	%
$5\% I_b \le I < 10\% I_b$	$1\% I_n \le I < 5\% I_n$	1	No requirement	±(1.0 x C + 0.5)	%
$10\% I_b \le I \le I_{max}$	$5\% I_n \le I \le I_{max}$	1	±1.0 x C	±1.0 x C	%
$5\% I_b \le I\, 20\% I_b$	$2\% I_n \le I < 10\% I_n$	0.5 inductive 0.8 capacitive	±(1.7 x C + 0.15) ±(1.7 x C + 0.15)	No requirement No requirement	%
$10\% I_b \le I\, 20\% I_b$	$5\% I_n \le I < 10\% I_n$	0.5 inductive 0.8 capacitive	No requirement No requirement	±(1.0 x C + 0.5) ±(1.0 x C + 0.5)	%
$20\% I_b \le I \le I_{max}$	$10\% I_n \le I \le I_{max}$	0.5 inductive 0.8 capacitive	±(1.0 x C + 0.1) ±(1.0 x C + 0.1)	±1.0 x C ±1.0 x C	%

Fig. 2 - Extract from the IEC 61557-12.

Summary table with an external current sensor:

Measurement range Value of the current for PMDs with external current sensor (PMD Sx)	Power factor	Restrictions to intrinsic uncertainty for PMDs of operating performance class C	Unit
1 % In ≤ I < 5 % In	1	±2 x C	%
5 % In ≤ I ≤ 120 % In	1	±1 x C	%
2 % In ≤ I < 10 % In	0.5 inductive 0.8 capacitive	±(1.7 x C + 0.15) ±(1.7 x C + 0.15)	%
10 % In ≤ I ≤ 120 % In	0.5 inductive 0.8 capacitive	±(1 x C + 0.1) ±(1 x C + 0.1)	%

C = PMD accuracy class with C < 1. Imax = 120 % In.

Fig. 3 - Summary table with an external current sensor.

Example of a 0.5-class measuring device with a power factor = 1 and Imax = 120 % In.

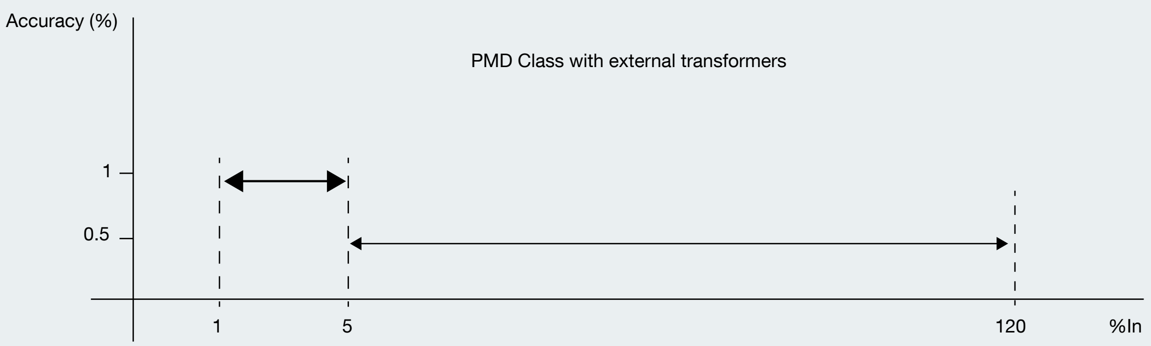

Fig. 4 - PMD Class with external transformers.

Definition of the overall performance class

The accuracy of the overall measuring chain results from adding the measurement accuracy of each element within that chain:

Fig. 5 - Measurement chain.

To obtain the overall accuracy of the measurement chain, you have to consider the accuracy of each element: PMD, current transformer, voltage transformer and cables.

How do you calculate the overall performance class of a measuring chain ?

The overall accuracy of the measurement chain comes from the overall performance class. To calculate this, you have to consider the accuracy of each element.
The calculation is based on the formula given in Appendix D of IEC 61557-12 “Overall system performance class”, taking into account the PMD, voltage sensor and current sensor that make up the measurement chain.

Overall performance class =

$$1{,}15 \times \sqrt{\text{Class (current\_sensor)}^2 + \text{Class (voltage\_sensor)}^2 + \text{Performance class (PMD SS)}^2}$$

The overall performance class of the system is rounded to the nearest normalised default value:

0.2	0.3	0.5	0.75	1	1.5	2	2.5	3	5	7,5	10	15	20

Warnings
This formula is only valid for a power factor equal to 1 and does not take account phase errors (see Section 6). In addition, the formula only has statistical value and does not absolutely guarantee accuracy.

Notes:
The voltage sensor is not present for most low-voltage applications.
In a three-phase network, the class of the three sensors is the same as the class of a sensor, on the condition that all three sensors have the same class.

Examples

The PMD is class 0.5 and the current transformer class 0.5. The rated current is 100A. Applying the

- 100 to 120 % In
  PMD Accuracy = 0,5 % ; CT = 0,5 %
  Overall accuracy of the measuring chain = 1,15x $\sqrt{(0{,}5^2+0{,}5^2)}$ 0, 81 %
- 20 to 100 % In
  PMD Accuracy = 0,5 % ; CT = 0,75 %
  Overall accuracy of the measuring chain = 1,15x $\sqrt{(0{,}5^2+0{,}75^2)}$ 1,04 %
- 5 to 20 % In
  PMD Accuracy = 0,5 % ; CT = 1,5 %
  Overall accuracy of the measuring chain = 1,15x $\sqrt{(0{,}5^2+1{,}5^2)}$ 1,82 %
- 1 to 5 % In
  PMD Accuracy = 1 % ; TC = undefined
  Overall accuracy of the measuring chain → undefined

Percentage of rated current	Current	PMC accuracy 	Current transformer accuracy 	Overall accuracy 
1 %	1 A	1 %	-	-
5 %	5 A	0.5 %	1.5 %	1.82 %
20 %	20 A	0.5 %	0.75 %	1.04 %
100 %	100 A	0.5 %	0.5 %	0.81 %
120 %	120 A	0.5 %	0.5 %	0.81 %

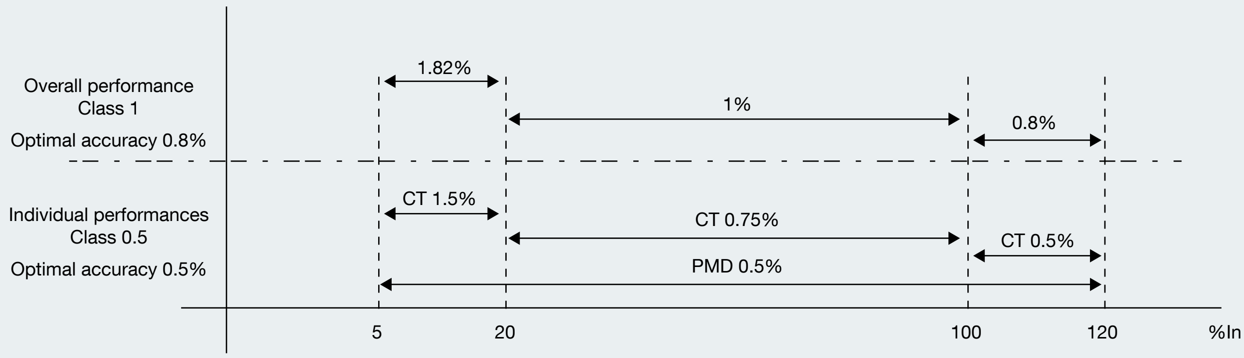

Fig. 6 - Overall accuracy of the measurement chain.

**The current transformer's accuracy range and performances are restricted compared to those of the PMD.
Even if the accuracy of each element is 0.5 %, the overall accuracy will never reach 0.5 %.
The system's overall performance class is equivalent to 1 with a restricted optimal accuracy range compared to the PMD alone (20 % instead of 5 % In).**

Impact of the accuracy class on an electrical system's consumption error

Calculating the impact of the sensors' accuracy class on power consumption.

Example:
• a power source supplies a three-phase 4-wire network (3 x 230/400 Vac) with a power factor (PF) equal to 1,
• the measurement is done with a PMD of class 0.5 and current transformers of class 0, 5 or 1,
• multiple loads are measured with rated currents of 1000 A, 600 A and 250 A,
• the average kWh cost is €0.04 on a green tariff.

Consumption measurement errors over 1 year based on the accuracies of the PMD and its current transformers for each load:

Nominal current (A)	PMD Class	CT Class	Global accuracy at In	Active power (kW)	Active energy cumulated on 1 year (kWh)	Error annual consumption (kWh)	Enregy cost
1000	0.5	0.5	0.81	690	6 044 400	49 151	1 966 €
600	0.5	0.5	0.81	414	3 626 640	29 491	1 180 €
250	0.5	0.5	0.81	173	1 511 100	12 288	492 €
250	0.5	1	1.29	173	1 511 100	19 429	777 €

Multiple points are highlighted here:
• the higher the rated current the more of an impact the measurement error has,
• the error rate significantly increases when the CT's accuracy class goes down.

Accuracy classes and nominal current have a direct impact on the consumption measurement error rate.

Influence of the phase error of current sensors

The phase error compared to the measured current, however minimal, introduced by the current sensor, directly affects the power and energy measurements if the power factor is less than 1.
To minimise the phase error, we recommend using 0.2S and 0,5S-class sensors.

Example:
The power factor (PF) is 0.5 but the phase error of the current sensor is 0.3°.
PF = 0.5 corresponds to φ = 60° for a sinusoidal system, which means an error of 0.3° corresponds to a PF = 0.495 (cos [60°+0.3°]).
The active power is linked directly to the PF by the formula:

Pa (active power) = PF (power factor) x S (apparent power)

→ Additional error in the power measurement: $\frac{\text{Ptrue-Pmeasured}}{\text{Ptrue}} = \frac{0.5 - 0.495}{0.5} = 1\,\%$

The same calculation with an error of 1° would lead to a measurement error of 3%.
For example, if we take an engine with a low load, the phase error increases as the cos φ drops and can expose the system up to major measurement errors.

The sensor's phase error affects power and energy measurements if the power factor is not 1.
For example, a phase error of 20 minutes for a PF = 0.5 adds 1% error to the active power measurement and 3% to a 1° phase error.

Influence of cable length

When defining the power of the current sensor required for the overall measuring chain to function and deliver properly, we also need to take into account the burden of cables.

Current sensor output power (VA) > PMD input power (VA) + cable losses (VA)

Losses in the cables are expressed by the following formula:

$$\textbf{Losses in VA} = \frac{I^2\,(A) \times 2}{S\,(mm^2) \times 56} \times L\,(m)$$

I: current to the CT secondary.
L: distance between the CT and the PMD.
S: section of cable.

Example:
- the current sensor delivers 5 A to the secondary terminals,
- the length of the cable between the PMD and the sensor is 1 m and the section of cable is 2.5 mm^2,
- the PMD inputs consume 0.1 VA.

By applying the formula, the losses in the cable will be 0,36VA and the output power required for the current sensor must be greater than 0,46 VA. A lower output power would not damage the current sensor but would reduce the measurement accuracy.

We must take into account cable consumption when choosing a current sensor, so as not to diminish the accuracy of the overall measuring chain.

New approach of DIRIS Digiware ranges

For Energy Efficiency projects, we need to measure a number of loads on an installation to be able to assess its behaviour.
To this end, Socomec has developed a comprehensive solution called DIRIS Digiware, comprising a multipoint measurement system with a range of associated current sensors.
The DIRIS Digiware measurement system consists of interconnected modules:

• a DIRIS Digiware U module dedicated to measuring voltage,
• DIRIS Digiware I modules dedicated to measuring current.

Several types of modules are available depending on the number of loads to measure.
Data from voltage measurement U is transmitted digitally to the current measurement I modules to calculate power and energy.

The current sensors use a specific connection type RJ12, allowing:

• a fast connection without wiring errors,
• detection of current sensors,
• the guarantee of a 0.5 % overall accuracy in the power and energy measurement chain.

Example of a connection between the DIRIS Digiware I-30 with its assigned TE current sensors:

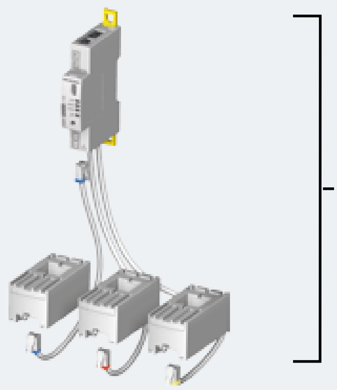

Fig. 7 - Digiware Accuracy Class.

Classification of the DIRIS Digiware solution according to the standard IEC 61557-12

With this approach we can classify the DIRIS Digiware solution and its current sensors in the direct connection PMDs (PMD DD) section according to the standard IEC 61557-12.
For a PMD of a C < 1 accuracy class and taking into account Ib = In and Imax = 120 % In, the table of IEC 61557-12 (Section 3) is as follows:

Measurement range Value of the current for directly PMDs (PMD Dx)	Power factor	Restrictions to intrinsic uncertainity for PMDs of operating performance class C	Unit
2 % In ≤ I < 10 % In	1	±2 x C	%
10 % In ≤ I ≤ 120 % In	1	±1 x C	%
5 % In ≤ I ≤ 20 % In	0.5 inductive 0.8 capacitive	±(1.7 x C + 0.15) ±(1.7 x C + 0.15)	%
20 % In ≤ I ≤ 120 % In	0.5 inductive 0.8 capacitive	±(1 x C + 0.1) ±(1 x C + 0.1)	%

Comparison between a “standard” PMD+CT product and the DIRIS Digiware solution

- “Standard” product: Class 0.5 measuring device (PMD) assigned to class 0.5 current transformers (CT) → **Class 1 calculated** (See Section 5).
- Digiware solution using TE current sensors → Class 0.5 guaranteed.

Curent measured	Accuracy of DIRIS Digiware	Accuracy of class 0.5 PMD+CT
2 % In < I < 5 % In	1 %	-
5 % In < I < 10 % In	1 %	1.82 %
10 % In < I < 20 % In	0.5 %	1.82 %
20 % In < I < 100 % In	0.5 %	1.04 %
100 % In < I < 120 % In	0.5 %	0.81 %

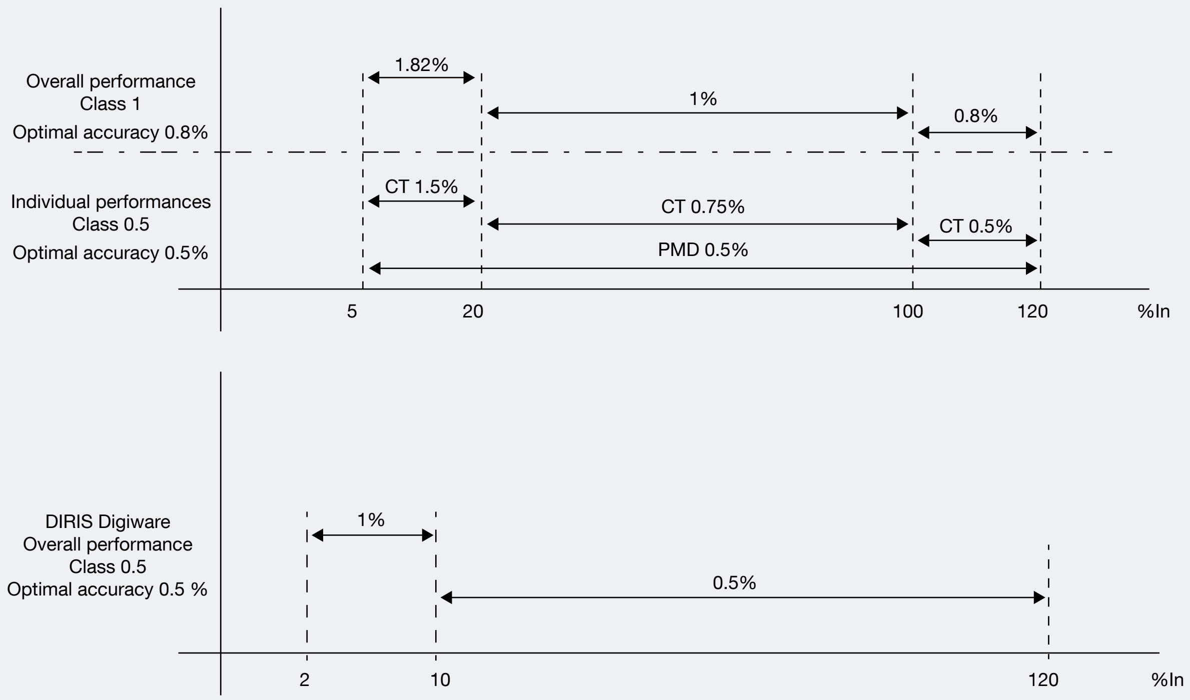

Fig. 8 - Comparison between a standard PMD+CT product and the DIRIS Digiware solution.

Thanks to its innovative technology, with DIRIS Digiware we canguarantee with between 2 and 120 % In a 0.5 overall performance classin power and energy.
By comparison, with a 0.5-class measurement device assigned to 0.5-class current transformers, you will only reach an overall performanceclass of 1.
The overall accuracy class formula (Section 5) just has one statisticalvalue while the DIRIS Digiware guarantees the accuracy of the overallmeasuring chain.
The measuring range and performances offered by DIRIS Digiware surpasses the PMD+CT conventional solutions offered on the market.

Range of rated current In

Current sensors assigned to the DIRIS Digiware are no longer distinguished by a rated current value but a rated current range.

TE sensor - Closed sensor

	TE-18	TE-18	TE-25	TE-35	TE-45	TE-55
Range of rated curren In	5 to 20 A	25 to 63 A	40 to 160 A	63 to 250 A	160 to 630 A	400 to 1000 A

TR sensor - Open sensor

	TR-10	TR-16	TR-24	TR-36
Range of rated curren In	25 to 75 A	32 to 100 A	63 to 200 A	200 to 600 A

TF sensor - Flexible sensor

	TF-55	TF-120	TF-300
Range of rated curren In	150 to 600 A	500 to 2000 A	1600 to 6000 A

Fig. 9 - Range of rated current In according sensor type.

This property brings two major advantages:
- Expanding the measurement range: a sensor with a rated current defined over a range rather than a single value means you can extend its low current usage.
  For example, with the TE-35 you can work at a rated current range of 63 A (2 to 120 %) to 250 A (2 to 120 %), with the covered current range as follows:
  - 2 % of the minimum rated current ➜ 2 % of 63 A = 1.26 A
  - to 120 % of the maximum rated current ➜ 120 % of 250 A
    = 300 A
    ➜ guaranteed accuracy of the current range: 1.26 to 300 A.
- Reducing the number of sensors required to cover a current range: DIRIS Digiware sensors cover a wide range of rated currents compared to a single rated currentvalue for standard current transformers.

For example, to cover a range of 100 to 250 A, you need at least 5 references from conventional sensors of the same type compared to a single TE-35 for DIRIS Digiware.

Comparing the accuracy achieved by DIRIS Digiware and PMD+CT

Based on the above, the following table definitively illustrates the accuracy for power and energy obtained by DIRIS Digiware compared to that obtained with a 0.5-class PMD linked to 0.5-class current transformers covering the range of rated currents from 100 to 250 A.

Precision = DIRIS Digiware + TE-35
IEC 61557-12
0.5 global accuracy
1 CT from 63 to 250 A
from 2 to 120 % of In

Precision = PMD 0.5 class + CT 0.5 class
IEC 61557-12
Global accuracy (cable not included) =
1.15 x √(PMD² class + CT² class)
Cable not included
from 5 to 120 % of In

Precision = CT alone
IEC 61869-2
0.5 class
5 CT from 100 to 250 A
from 5 to 120 % of In

		Terminal In	In (PMD+CT)					In (CT alone)				
A	**Precision %**	**63 to 250 A**	**100 A**	**125 A**	**150 A**	**200 A**	**250 A**	**100 A**	**125 A**	**150 A**	**200 A**	**250 A**
2		1.00 %										
5		1.00 %	1.82 %					1.50 %				
6.3		0.50 %	1.82 %	1.82 %				1.50 %	1.50 %			
7.5		0.50 %	1.82 %	1.82 %	1.82 %			1.50 %	1.50 %	1.50 %		
10		0.50 %	1.82 %	1.82 %	1.82 %	1.82 %		1.50 %	1.50 %	1.50 %	1.50 %	
12.5		0.50 %	1.82 %	1.82 %	1.82 %	1.82 %	1.82 %	1.50 %	1.50 %	1.50 %	1.50 %	1.50 %
20		0.50 %	1.04 %	1.82 %	1.82 %	1.82 %	1.82 %	0.75 %	1.50 %	1.50 %	1.50 %	1.50 %
25		0.50 %	1.04 %	1.04 %	1.82 %	1.82 %	1.82 %	0.75 %	0.75 %	1.50 %	1.50 %	1.50 %
30		0.50 %	1.04 %	1.04 %	1.04 %	1.82 %	1.82 %	0.75 %	0.75 %	0.75 %	1.50 %	1.50 %
40		0.50 %	1.04 %	1.04 %	1.04 %	1.04 %	1.82 %	0.75 %	0.75 %	0.75 %	0.75 %	1.50 %
50		0.50 %	1.04 %	1.04 %	1.04 %	1.04 %	1.04 %	0.75 %	0.75 %	0.75 %	0.75 %	0.75 %
100		0.50 %	0.81 %	1.04 %	1.04 %	1.04 %	1.04 %	0.50 %	0.75 %	0.75 %	0.75 %	0.75 %
125		0.50 %		0.81 %	1.04 %	1.04 %	1.04 %		0.50 %	0.75 %	0.75 %	0.75 %
150		0.50 %			0.81 %	1.04 %	1.04 %			0.50 %	0.75 %	0.75 %
200		0.50 %				0.81 %	1.04 %				0.50 %	0.75 %
250		0.50 %					0.81 %					0.50 %
300												

Fig. 10 - Comparing the accuracy achieved by DIRIS Digiware and PMD+CT.

The DIRIS Digiware solution proves it has a number of advantages:

- **an extended current range with excellent accuracy (0.5 %) of 6.3 to 300 A,**
- **the accuracy of a conventional PMD+CT system is always much worse,**
- **the maximum accuracy (0.81 %) of the PMD+CT system only applies to currents above In,**
- **you only need a single current sensor (TE-35) assigned to the DIRIS Digiware to cover the rated current range of 63 to 250 A,**
- **you need 5 sensors in the PMD+CT system to cover the same current range as DIRIS Digiware.**

Accuracy comparison - DIRIS Digiware vs. PMD+CT

Based on the same principle, the tables below detail all the comparisons between the DIRIS Digiware range and conventional PMD + current transformers solutions:

Range 25 to 63 A (on the market, CT standards are Class 1)

Precision = DIRIS Digiware + TE-18
IEC 61557-12
0.5 global accuracy
1 CT from 25 to 63 A
from 2 to 120 % of In

Precision = PMD 0.5 class + CT class 1
IEC 61557-12
Global accuracy (cable not included) =
1.15 x √(PMD² class + CT² class)
Cable not included
from 5 to 120 % of In

Precision = CT alone
IEC 61869-2
Class 1
3 TC from 40 to 60 A
from 5 to 120 % of In

		Terminal In	In (PMD+CT)			In (CT alone)		
A	**Precision %**	**25 to 63 A**	**40 A**	**50 A**	**60 A**	**40 A**	**50 A**	**60 A**
0.5		1.00 %						
2		1.00 %	3.50 %			3.00 %		
2.5		0.50 %	3.50 %	3.50 %		3.00 %	3.00 %	
3		0.50 %	3.50 %	3.50 %	3.50 %	3.00 %	3.00 %	3.00 %
8		0.50 %	1.82 %	3.50 %	3.50 %	1.50 %	3.00 %	3.00 %
10		0.50 %	1.82 %	1.82 %	3.50 %	1.50 %	1.50 %	3.00 %
12		0.50 %	1.82 %	1.82 %	1.82 %	1.50 %	1.50 %	1.50 %
40		0.50 %	1.29 %	1.82 %	1.82 %	1.00 %	1.50 %	1.50 %
48		0.50 %		1.29 %	1.82 %		1.00 %	1.50 %
50		0.50 %			1.29 %			1.00 %
60		0.50 %						
72								

Fig. 11 - Comparing the accuracy achieved by DIRIS Digiware and PMD+CT from 25 to 63 A.

Range 40 to 160 A

	Precision = DIRIS Digiware + TE-25 IEC 61557-12 **0.5 global accuracy** 1 CT from 40 to 160 A from 2 to 120 % of In	Precision = PMD 0.5 class + CT 0.5 class IEC 61557-12 **Global accuracy (cable not included) =** **1.15 x √(PMD² class + CT² class)** Cable not included from 5 to 120 % of In					Precision = CT alone IEC 61869-2 **0.5 class** 5 CT from 50 to 150 A from 5 to 120 % of In				
	Terminal In	**In**					**In**				
A	**40 to 160 A**	**60 A**	**80 A**	**100 A**	**125 A**	**150 A**	**60 A**	**80 A**	**100 A**	**125 A**	**150 A**
0.8	1.00%										
2	1.00 %										
2.5	1.00 %										
3	1.00 %	1.82%					1.50%				
4	0.50 %	1.82 %	1.82 %				1.50 %	1.50 %			
5	0.50 %	1.82 %	1.82 %	2.07 %			1.50 %	1.50 %	1.50 %		
6.25	0.50 %	1.82 %	1.82 %	1.82 %	1.82 %		1.50 %	1.50 %	1.50 %	1.50 %	
8	0.50 %	1.82 %	1.82 %	1.82 %	1.82 %	1.82 %	1.50 %	1.50 %	1.50 %	1.50 %	1.50 %
10	0.50 %	1.82 %	1.82 %	1.82 %	1.82 %	1.82 %	1.50 %	1.50 %	1.50 %	1.50 %	1.50 %
12	0.50 %	1.04 %	1.82 %	1.82 %	1.82 %	1.82 %	0.75 %	1.50 %	1.50 %	1.50 %	1.50 %
15	0.50 %	1.04 %	1.04 %	1.82 %	1.82 %	1.82 %	0.75 %	0.75 %	1.50 %	1.50 %	1.50 %
20	0.50 %	1.04 %	1.04 %	1.04 %	1.82 %	1.82 %	0.75 %	0.75 %	0.75 %	1.50 %	1.50 %
25	0.50 %	1.04 %	1.04 %	1.04 %	1.04 %	1.82 %	0.75 %	0.75 %	0.75 %	0.75 %	1.50 %
30	0.50 %	1.04 %	1.04 %	1.04 %	1.04 %	1.04 %	0.75 %	0.75 %	0.75 %	0.75 %	0.75 %
40	0.50 %	1.04 %	1.04 %	1.04 %	1.04 %	1.04 %	0.75 %	0.75 %	0.75 %	0.75 %	0.75 %
50	0.50 %	1.04 %	1.04 %	1.04 %	1.04 %	1.04 %	0.75 %	0.75 %	0.75 %	0.75 %	0.75 %
60	0.50 %	0.81 %	1.04 %	1.04 %	1.04 %	1.04 %	0.50 %	0.75 %	0.75 %	0.75 %	0.75 %
75	0.50 %		0.81 %	1.04 %	1.04 %	1.04 %		0.75 %	0.75 %	0.75 %	0.75 %
80	0.50 %			0.81 %	1.04 %	1.04 %		0.50 %	0.75 %	0.75 %	0.75 %
100	0.50 %				0.81 %	1.04 %			0.50 %	0.75 %	0.75 %
125	0.50 %					0.81 %				0.50 %	0.75 %
150	0.50 %										0.50 %
160	0.50 %										
180	0.50 %										
192											

Precision %

Fig. 12 - Comparing the accuracy achieved by DIRIS Digiware and PMD+CT from 40 to 160 A.

Range 160 to 630 A

	Precision = DIRIS Digiware + TE-45 IEC 61557-12 **0.5 global accuracy** 1 CT from 160 to 630 A from 2 to 120 % of In	Precision = PMD 0.5 class + CT 0.5 class IEC 61557-12 **Global accuracy (cable not included) =** **1.15 x √(PMD² class + CT² class)** Cable not included from 5 to 120 % of In						Precision = CT alone IEC 61869-2 **0.5 class** 6 CT from 200 to 630 A from 5 to 120 % of In					
	Terminal In	**In**						**In**					
A	**160 to 630 A**	**200 A**	**250 A**	**300 A**	**400 A**	**500 A**	**600 A**	**200 A**	**250 A**	**300 A**	**400 A**	**500 A**	**600 A**
3.2	1.00%												
8	1.00 %												
10	1.00 %	1.82%						1.50%					
12.5	1.00 %	1.82 %	1.82 %					1.50 %	1.50 %				
16	0.50 %	1.82 %	1.82 %	1.82 %	2.07 %			1.50 %	1.50 %	1.50 %	1.50 %		
20	0.50 %	1.82 %	1.82 %	1.82 %	1.82 %	2.07 %		1.50 %	1.50 %	1.50 %	1.50 %	1.50 %	
25	0.50 %	1.82 %	1.82 %	1.82 %	1.82 %	1.82 %	2.07 %	1.50 %	1.50 %	1.50 %	1.50 %	1.50 %	1.50 %
30	0.50 %	1.82 %	1.82 %	1.82 %	1.82 %	1.82 %	1.82 %	1.50 %	1.50 %	1.50 %	1.50 %	1.50 %	1.50 %
32	0.50 %	1.82 %	1.82 %	1.82 %	1.82 %	1.82 %	1.82 %	1.50 %	1.50 %	1.50 %	1.50 %	1.50 %	1.50 %
40	0.50 %	1.04 %	1.82 %	1.82 %	1.82 %	1.82 %	1.82 %	0.75 %	1.50 %	1.50 %	1.50 %	1.50 %	1.50 %
50	0.50 %	1.04 %	1.04 %	1.82 %	1.82 %	1.82 %	1.82 %	0.75 %	0.75 %	1.50 %	1.50 %	1.50 %	1.50 %
60	0.50 %	1.04 %	1.04 %	1.04 %	1.82 %	1.82 %	1.82 %	0.75 %	0.75 %	0.75 %	1.50 %	1.50 %	1.50 %
80	0.50 %	1.04 %	1.04 %	1.04 %	1.04 %	1.82 %	1.82 %	0.75 %	0.75 %	0.75 %	0.75 %	1.50 %	1.50 %
100	0.50 %	1.04 %	1.04 %	1.04 %	1.04 %	1.04 %	1.82 %	0.75 %	0.75 %	0.75 %	0.75 %	0.75 %	1.50 %
120	0.50 %	1.04 %	1.04 %	1.04 %	1.04 %	1.04 %	1.04 %	0.75 %	0.75 %	0.75 %	0.75 %	0.75 %	0.75 %
160	0.50 %	1.04 %	1.04 %	1.04 %	1.04 %	1.04 %	1.04 %	0.75 %	0.75 %	0.75 %	0.75 %	0.75 %	0.75 %
200	0.50 %	0.81 %	1.04 %	1.04 %	1.04 %	1.04 %	1.04 %	0.50 %	0.75 %	0.75 %	0.75 %	0.75 %	0.75 %
250	0.50 %		0.81 %	1.04 %	1.04 %	1.04 %	1.04 %		0.50 %	0.75 %	0.75 %	0.75 %	0.75 %
300	0.50 %			0.81 %	0.81 %	1.04 %	1.04 %			0.50 %	0.75 %	0.75 %	0.75 %
360	0.50 %				1.04 %	1.04 %	1.04 %				0.75 %	0.75 %	0.75 %
400	0.50 %				0.81 %	1.04 %	1.04 %				0.50 %	0.75 %	0.75 %
500	0.50 %					0.81 %	1.04 %					0.50 %	0.75 %
600							0.81 %						0.50 %
756													

Precision %

Fig. 13 - Comparing the accuracy achieved by DIRIS Digiware and PMD+CT from 160 to 630 A.

Range 400 to 1000 A

A	Terminal In: 400 to 1000 A	In: 400 A	In: 500 A	In: 600 A	In: 800 A	In: 1000 A	In: 400 A	In: 500 A	In: 600 A	In: 800 A	In: 1000 A
	Precision = DIRIS Digiware + TE-55 IEC 61557-12 **0.5 global accuracy** 1 CT from 400 to 1000 A from 2 to 120 % of In	**Precision = PMD 0.5 class + CT 0.5 class** IEC 61557-12 **Global accuracy (cable not included) = 1.15 x √(PMD² class + CT² class)** Cable not included from 5 to 120 % of In					**Precision = CT alone** IEC 61869-2 **0.5 class** 5 CT from 400 to 1000 A from 5 to 120 % of In				
8	1.00 %										
10	1.00 %										
12.5	1.00 %										
15	1.00 %										
20	0.50 %	1.82 %					1.50 %				
25	0.50 %	1.82 %	1.82 %				1.50 %	1.50 %			
30	0.50 %	1.82 %	1.82 %	1.82 %			1.50 %	1.50 %	1.50 %		
37.5	0.50 %	1.82 %	1.82 %	1.82 %			1.50 %	1.50 %	1.50 %		
40	0.50 %	1.82 %	1.82 %	1.82 %	1.82 %		1.50 %	1.50 %	1.50 %	1.50 %	
50	0.50 %	1.82 %	1.82 %	1.82 %	1.82 %	1.82 %	1.50 %	1.50 %	1.50 %	1.50 %	1.50 %
80	0.50 %	1.04 %	1.82 %	1.82 %	1.82 %	1.82 %	0.75 %	1.50 %	1.50 %	1.50 %	1.50 %
100	0.50 %	1.04 %	1.04 %	1.82 %	1.82 %	1.82 %	0.75 %	0.75 %	1.50 %	1.50 %	1.50 %
120	0.50 %	1.04 %	1.04 %	1.04 %	1.82 %	1.82 %	0.75 %	0.75 %	0.75 %	1.50 %	1.50 %
160	0.50 %	1.04 %	1.04 %	1.04 %	1.04 %	1.82 %	0.75 %	0.75 %	0.75 %	0.75 %	1.50 %
200	0.50 %	1.04 %	1.04 %	1.04 %	1.04 %	1.04 %	0.75 %	0.75 %	0.75 %	0.75 %	0.75 %
400	0.50 %	0.81 %	1.04 %	1.04 %	1.04 %	1.04 %	0.50 %	0.75 %	0.75 %	0.75 %	0.75 %
500	0.50 %		0.81 %	1.04 %	1.04 %	1.04 %		0.50 %	0.75 %	0.75 %	0.75 %
600	0.50 %			0.81 %	0.81 %	1.04 %			0.50 %	0.75 %	0.75 %
750	0.50 %				1.04 %	1.04 %				0.75 %	0.75 %
800	0.50 %				0.81 %	1.04 %				0.50 %	0.75 %
900	0.50 %				0.81 %	1.04 %				0.50 %	0.75 %
1000	0.50 %					0.81 %					0.50 %
1200											

Precision %

Fig. 14 - Comparing the accuracy achieved by DIRIS Digiware and PMD+CT from 400 to 1000 A.

Comparing consumption measurement errors between DIRIS Digiware solutions and conventional PMD+CT solutions

Taking the example above (Section 6) with a load rate of 35 %, we get the following measurement errors.

Three-phase networks (3 x 230/400V) PF = 1			DIRIS Digiware			PMD Cl 0.5 + CT			
Nominal current (A)	**Load rate (% In)**	**Cumulated active energy in 1 year (kWh)**	**Overall accuracy**	**Annual consumption error (kWh)**	**Associated energy cost**	**CT class**	**Overall accuracy of In**	**Annual consumption error (kWh)**	**Associated energy cost**
1000	35	2 115 540	0.50	10 578	423 €	0.5	1.04	21 930	877 €
600	35	1 269 324	0.50	6 374	254 €	0.5	1.04	13 158	526 €
250	35	528 885	0.50	2 644	106 €	0.5	1.04	5 482	219 €
250	35	528 885	0.50	2 644	106 €	1	1.82	9 617	385 €

Fig. 15 - Comparing the accuracy achieved by DIRIS Digiware and PMD+CT.

Summary:
- the accuracy of the DIRIS Digiware solution leads to fewer errors in measuring consumption, every time: errors are at least halved,
- the drop in the CT's accuracy class (in this example, from 0.5 to 1) leads to a significant increase in the consumption measurement error (from 5482 to 9617 kWh),
- the wide accuracy range delivered by DIRIS Digiware helps maintain a high level of accuracy even with a low load rate (in this example, 35 %),
- this allows for fewer errors in consumption measurements as well as giving a reliable assessment of your energy bills.

Thanks to its increased accuracy, with DIRIS Digiware you can reduce errors in consumption measurements so you can validate your energy bill.

Summary

With a conventional PMD solution + current transformer, the accuracy of the measurement, the power and the energy, but also other electrical parameters, must take the following into account:
• the class and range of accuracy of the measuring device (PMD),
• the class and range of accuracy of the sensors (PMD),
• the class and accuracy class of the overall measuring chain,
• the influence of the phase error,
• the influence of cable length.

These parameters have a direct impact on the power consumption measurement error.
With the DIRIS Digiware solution, the user does not have to worry about any of the above: the accuracy of the overall measuring chain is guaranteed over an extensive current range.

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