

Power Transformer Testing Using - Infratek 108A-6 Power Analyzer

General

The 108A High Precision Power Analyzer is an ideal tool to test single and three phase Power Transformers. The 108A is using very linear input amplifiers to preserve the transformer wave forms. The 108A current amplifiers are equipped with broad band current shunts that exhibit a typical phase error of 0.001° at 50/60Hz. The overall accuracy for very low power factor 0 to 0.05 is 0.01% of reading + 0.01% of range. The following table shows three phase power measurements at power factors 0.08 and 0.008 at 50Hz using the current inputs In1A and In5A. Measurements were performed by ELCAL Swiss Calibration Service.

50W, range (100V / 500mA; In1A)

Reference input	PF	phase 1	phase 2	phase 3	% Tolerance ph1 / ph2 / ph3
4.0000W \pm 1.8mW	0.08	4.003W	4.004W	4.005W	12 / 18 / 23
0.4000W \pm 1.8mW	0.008	0.401W	0.403W	0.404W	28 / 66 / 70

150W Range (300V / 500mA; In1A)

9.2000W \pm 3.8mW	0.08	9.2065W	9.2100W	9.2119W	10 / 16 / 19
0.9200W \pm 3.9mW	0.008	0.9253W	0.9272W	0.9297W	35 / 47 / 64

150W Range (100V / 1.5A; In5A)

12.000W \pm 2.3mW	0.08	12.000W	12.003W	12.005W	0 / 5 / 8
1.2000W \pm 2.7mW	0.008	1.195W	1.200W	1.200W	30 / 2 / 2

450W Range (230V / 1.5A; In5A)

27.600W \pm 25mW	0.08	27.607W	27.603W	27.612W	4 / 1 / 6
2.7600W \pm 19mW	0.008	2.752W	2.764W	2.757W	19 / 8 / 7

Standard	L1 30A As 500V 10A	L2 30A As 500V 10A	L3 30A As 500V 10A	L4 30A As 500V 10A	PAGE 1
Arms	51.815m	50.748m	46.360m	45.323m	IN 30A
Vrms	282.13m	239.23m	189.45m	203.50m	10A
Watt	-7.4301m	-4.8215m	-1.2593m	-1.9440m	300V
VA	14.618m	12.140m	8.7831m	9.2236m	Sync A
Vrect	229.71m	203.24m	154.00m	174.24m	1s
PF	-508.26m	-397.14m	-143.38m	-210.76m	WAVE
T1 T2 T3	255.13m	-6.6854m	-1.6943	0.0000	Standard
T4 T5 T6	-2.7674	4.6891	847.94m	0.0000	
HOLD	AC+DC	L3 - L6	FFT Table	Reset Wh	SETUP



108A front with Vrect / W / VA / PF and transformer values

108A six-phase rear panel



Irreversible losses in a Power Transformer are due to hysteresis, eddy currents, and winding resistance. The hysteresis loss is proportional to the applied frequency and is dependent on magnetic flux density B_m , on leakage flux, and on the ferromagnetic material.

A Power Transformer, once installed, operates day and night for many years. Low losses are paramount to avoid waste of energy.

The 108A-6 six phase high Precision Power Analyzer performs all required measurements to precisely determine power loss of single- and three-phase power transformers. Per phase there are four different current inputs: 0-1A, 0-7A, 0-40A, and a shunt voltage input from external coaxial shunts.

Very high precision (0.005% accuracy, very low phase error) 40A to 700A broad band current transformers are available. Their output is connected to the 0-1A rear panel input. Use built in scaling to obtain actual currents.



Sensors 0-700A

For medium size transformer the 0-40A direct current input is available. Small size transformers are connected to the 0-7A current input.

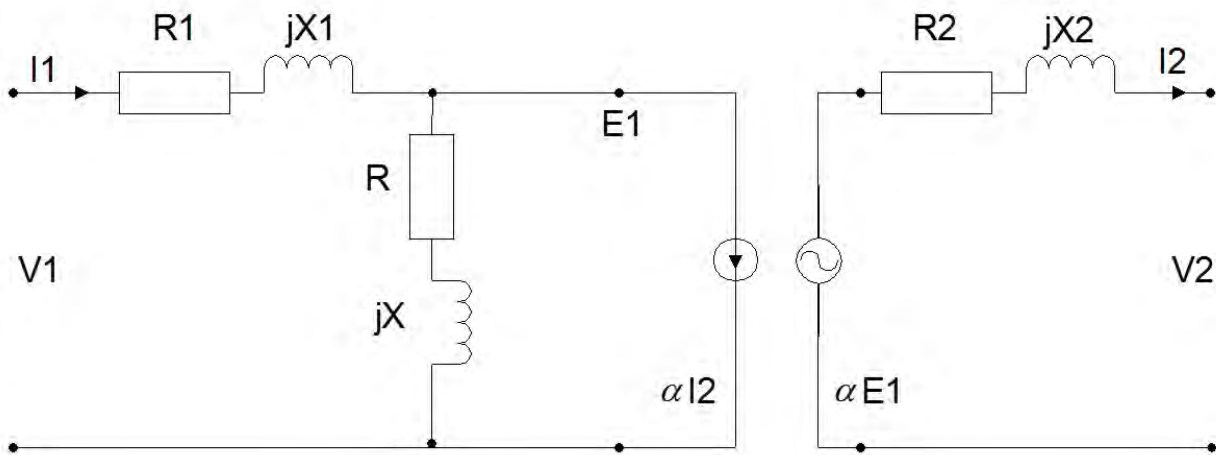
On all current inputs the 108A shows excellent performance at low power factors. The screen shut below summarizes the measurements at a lagging phase angle of -89.35 degrees (power factor = 0.0113).

150W Range (100V/1.5A) :							
301	150	150.062W	150.0000W	50H_Cos=1	0.041 %	52	18mW
302	150	106.110W	106.0660W	50H_Cos=0.707	0.041 %	43	13mW
303	150	120.044W	120.0000W	50H_Cos=0.8	0.037 %	41	16mW
304	150	12.005W	12.0000W	50H_Cos=0.08	0.042 %	8	2.9mW
305	150	1.200W	1.2000W	50H_Cos=0.008	0.027 %	2	2.7mW
450W Range (230V/1.5A) :							
306	450	345.146W	345.0000W	50H_Cos=1	0.042 %	46	40mW
307	450	244.046W	243.9520W	50H_Cos=0.707	0.039 %	34	25mW
308	450	276.124W	276.0000W	50H_Cos=0.8	0.045 %	43	21mW
309	450	27.612W	27.6000W	50H_Cos=0.08	0.043 %	6	14mW
310	450	2.757W	2.7600W	50H_Cos=0.008	-0.119 %	7	11mW



Testing single- and three phase Power Transformers

The 108A Power Analyzer measures on phase 1 the transformer input and on phase 2 the transformer output. The calculations are based on the linear circuit model shown below.



On one display line the three transformer values T1, T2, and T3 and on a second display line T4, T5, and T6 can be displayed.

- T1: $V_{corrected} = 1.1107 \cdot V_{rectified\ mean}$
 T2: $P_{corrected} = P_{act1} / (0.5 + 0.5 V_{rms} / V_{corrected})$
 T3: Loss factor $= \tan X/R$. No load measurement $R1, X1 \ll R, X$
 $Z = IZ011 / \Phi01 \rightarrow R + jX = R + j\omega L$. $IZ011$ and $\Phi01$ can be displayed on two display lines.
 T4: $R2 = P_{act1} / I_{rms}^2$ } short circuit test at rated current
 T5: $X2 = P_{reactive} / I_{rms}^2$ } $R1, x1$ set to 0
 T6: $\alpha = N2 / N1 = V_{rms2} / V_{rms1}$ at no load

At varying loads, the transformer efficiency is determined from:

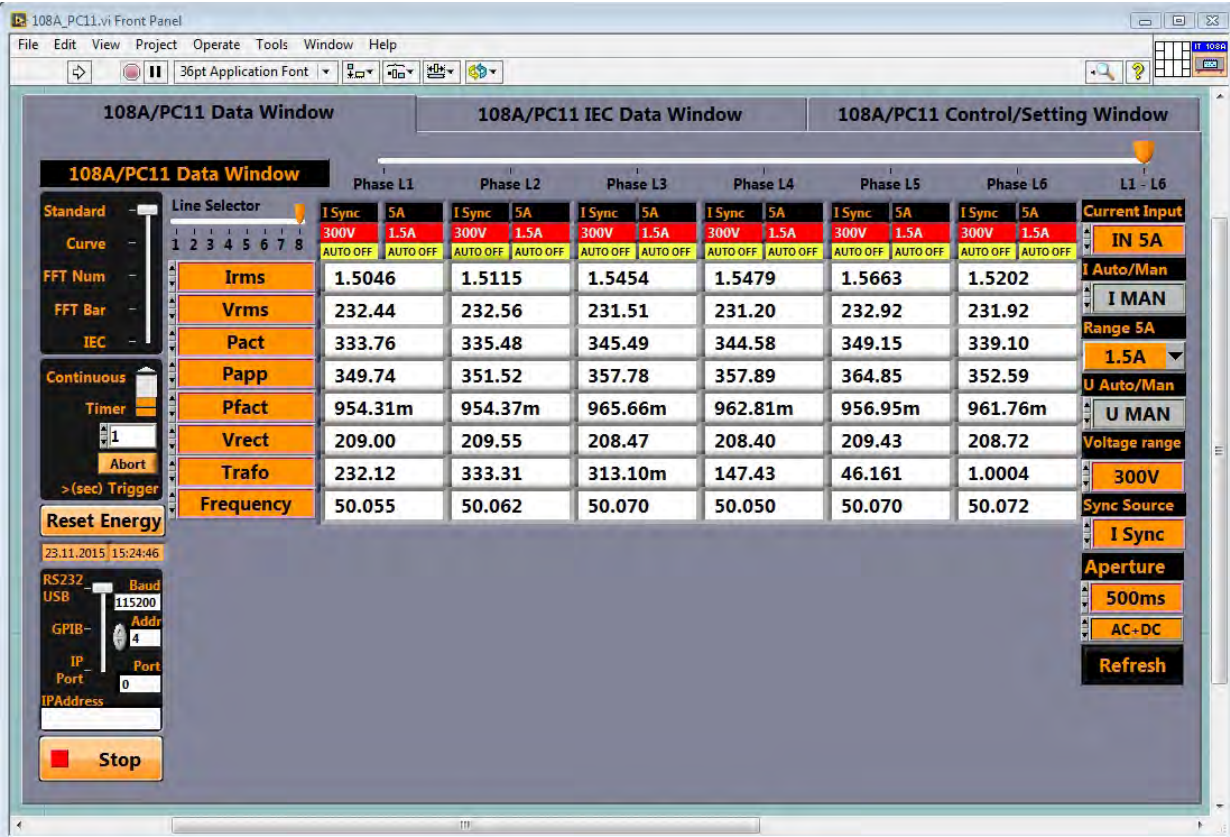
Efficiency = Output P_{act2} / Input P_{act1} . Display $R1 | R2 | R3$ on a display line. $R3$, the third value, is the desired efficiency P_{act2} / P_{act1} .

An approximate value for $R1$ and $R2$ can be obtained by applying a DC current on the primary side $R1 = P_{act1} / I_{rms1}^2$, and applying a DC current on the secondary side $R2 = P_{act2} / I_{rms2}^2$.



Caution: Transformers can store a large amount of energy. In case of emergency this energy must be discharged by external elements.
 Although, the 108A inputs are protected against voltage $>\pm 2500V$ with respect to ground, protection elements may fail in case of large energies.

Use of 108A Operating Software for Transformer-Testing



The screenshot displays the '108A/PC11 Data Window' with a table of measurements for six phases (L1 to L6). The table includes columns for 'I Sync', '5A', and 'AUTO OFF' for each phase, followed by various electrical parameters.

	Phase L1	Phase L2	Phase L3	Phase L4	Phase L5	Phase L6	L1 - L6
I Sync	300V	300V	300V	300V	300V	300V	Current Input
5A	1.5A	1.5A	1.5A	1.5A	1.5A	1.5A	IN 5A
AUTO OFF	AUTO OFF	AUTO OFF	AUTO OFF	AUTO OFF	AUTO OFF	AUTO OFF	I Auto/Man
Irms	1.5046	1.5115	1.5454	1.5479	1.5663	1.5202	I MAN
Vrms	232.44	232.56	231.51	231.20	232.92	231.92	Range 5A
Pact	333.76	335.48	345.49	344.58	349.15	339.10	1.5A
Papp	349.74	351.52	357.78	357.89	364.85	352.59	U Auto/Man
Pfact	954.31m	954.37m	965.66m	962.81m	956.95m	961.76m	U MAN
Vrect	209.00	209.55	208.47	208.40	209.43	208.72	Voltage range
Trafo	232.12	333.31	313.10m	147.43	46.161	1.0004	300V
Frequency	50.055	50.062	50.070	50.050	50.070	50.072	Sync Source

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