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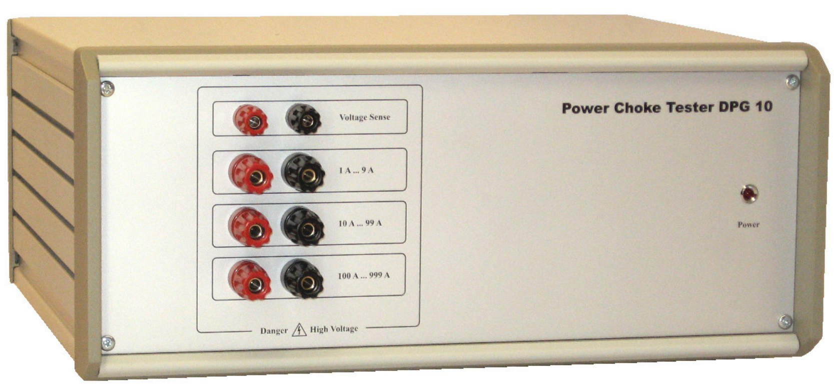
electronics development

POWER CHOKE TESTER DPG10

Description & Technical Specifications



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Product Description

1. Application areas

The Power Choke Tester DPG10 is an instrument for measuring inductance in all kinds of power inductors. This includes measuring inductance *subject to pre-magnetisation*, which also means *saturation characteristics* can be determined.

The innovative large-signal impulse measuring method provides a complete current-dependent inductance curve L(I). The use of this measuring method means that major errors can be avoided in comparison to other measuring processes, which will be influenced by the non-linear hysteresis characteristics of most core materials.

Due to it's wide current range all inductors with rated currents from 0.5A to 1500A are covered by this measuring instrument. Additionally, the Power Choke Tester DPG10 also measures the DC resistance of the test component.

This makes this instrument suitable for use in development and production of all kinds of power inductors, i.e.

- Filter inductors for switch mode power supplies, DC/DC converters etc.
- Filter inductors for uninterruptible power supplies, inverters etc.
- Power chokes for PFC etc. and commutation inductors
- Suppression chokes
- Current compensated chokes
- Solenoids, coils of valves
- And much, much more

2. Measuring principle

The DPG10 works on the principle that a constant DC voltage is applied to the test inductor, which corresponds to the inductor's real operational conditions. This will result in a current ramp in the test component, whose dt/di slew rate is subject to inductance.

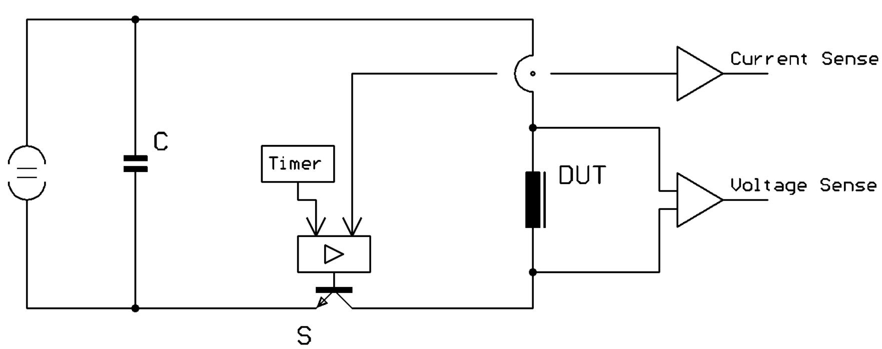


Fig 1: Principle circuit diagram

By making calculations based on the profile of the di/dt slew rate of the measurement current, a complete inductance curve (which displays the DC pre-magnetisation dependent inductance profile) for the test component can be produced by taking a single measurement*.

* Sometimes it is named as incremental inductance in the technical literature

If the pre-set maximum current limit is reached, the measurement impulse is cut off.

Principle advantages of the di/dt measuring principle:

Compared with the inductance measurement with 50/60Hz lines currents the di/dt measuring principle provides much more informations. The measurement with lines currents results in an averaged inductance (over a period) at a certain RMS value. But due to the extremely non-linear hysteresis characteristics of most core materials the inductor behaves different at each momentary value of the current. Non-linear behavior will not be pointed out adequately.
Due to the non-linear behavior the currents and the voltages will be non-sinusoidal with significant harmonic content. Therefore the RMS calculations and the application of the common alternating current theory ($L = U / \omega * I$ with $\omega = 2*pi*50Hz$) is questionable.

Another advantage of impulse measuring lies in the fact that average dissipated power remains low. The DC voltage source, which is connected to the test component via the switch S, is provided by a suitable capacitor bank. In this way, the measuring instrument remains small and relatively cheap despite supplying very high measuring currents of up to 1500A. Corresponding measuring systems for small-signal sinusoidal voltage measurements require expensive DC power supplies to magnetise the test components. Therefore they are restricted to low currents (20 ... 100A) and they are very expensive.

An important advantage of the measuring principle lies in the fact that *the measuring conditions correspond to the operational conditions of the inductive components in real applications,* because in many applications (i.e. smoothing inductors for switch mode power supply, filter inductors for uninterruptible power supply and IGBT inverters etc.) a rectangular voltage form (similar to the measuring impulse of the DPG10) is applied to the inductor. A measuring process that applies a continuous DC current to the test component and superimposes a fixed frequency small-signal measurement is not realistic and always produces results which are considerable dependent on frequency. The impulse measuring method of the Power Choke Tester DPG10 eliminates this dependance on frequency.

Operating & Properties

1. Measuring range

1.1. Measuring current

The maximum level of current, which when exceeded causes the measuring interval to be terminated, is adjustable from 1A to 1000A (special models adjustable up to 1500A and 100A can be supplied). For this reason there are three measuring ranges (1 to 9A, 10 to 99A and 100 to 1000A). This measuring instrument is also suitable for measuring very large power inductors, thanks to its very high maximum current level.

1.2. Measuring voltage

The voltage applied to the test component can be adjusted within the range of 10V to 400V.

1.3. Measurement impulse duration

The maximum duration of measuring impulses can be pre-set within a wide range of approximately 3µs to 70ms when needed.

2. Operating the instrument

A PC is used to operate and display results from the DPG10 via a simple and user-friendly graphical interface, which runs under Excel©. The measuring instrument must be connected with a suitable cable to the serial port (RS232) of the PC. Installing the software is very easy.

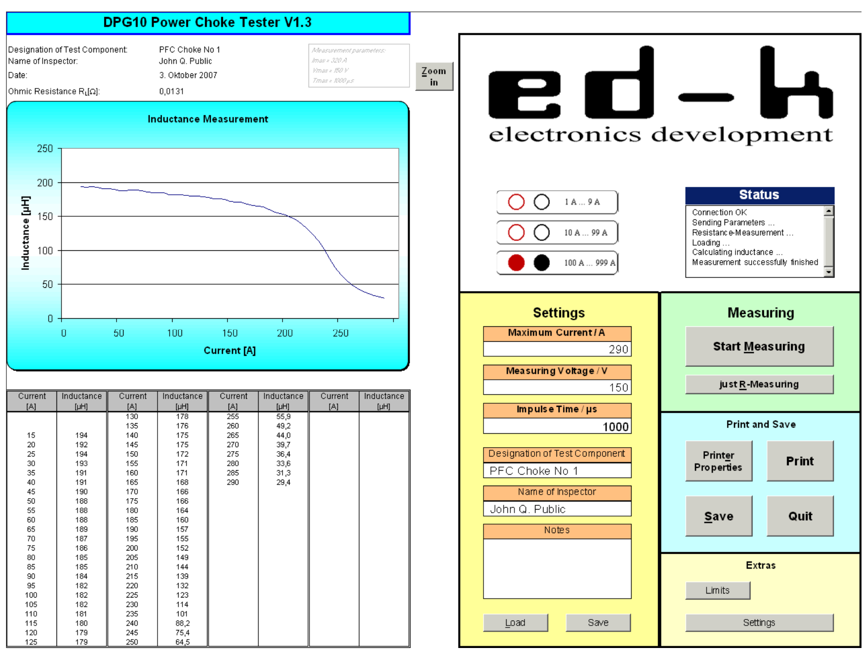


Fig 2: The graphical user interface of the DPG10

2.1. Settings

The following parameters can be set before measuring inductance:

- Maximum current:

  The measuring impulse is terminated when this value is reached, so long as the pre-set maximum duration of the measuring impulse has not been reached before.

- Maximum duration of the measuring impulse:

  The measuring impulse is terminated when this value is reached, so long as the maximum current level is not reached before.

- Measuring impulse voltage:

  A value should be entered here that corresponds to the test component's voltage levels during normal operating conditions.

In addition to this, a designation for the test component and the name of the tester can also be entered. These will appear in the measuring protocol. There is a 'Notes' field, which can be used to records all kinds of information / notes, i.e. test component parameters and, if required, entered in the measuring protocol and printed out.

All settings can be saved and reloaded when required. This considerably eases conducting a series of measurements for quality control checks during production.

2.2. Using the measuring instrument

A resistance test is automatically carried out before every inductance measurement is undertaken because the ohmic portion of the inductor must be considered in the calculation of the inductance curve. A resistance test can also be carried out separately. The status display shows which action is being currently executed.

After the measurements are complete, the results are displayed in the form of both a diagram and in a table.

Alternatively in some cases it could be useful to display the inductance as a function of the voltage-time-integral $\int U(t)dt$ applied to the inductor. The display mode is togglable.

If the instrument is incorrectly used (i.e. incorrectly connected or setup), then detailed error warnings help to quickly solve any problems.

2.3. Limit curves

To make routine testing easier during production, minimum and maximum limit curves can be defined. If the measured inductance curve falls within the range created by these two limit curves, then the test component is passed, if not then it is failed.

2.4. Saving measuring diagrams and exporting data

Measuring diagrams including all measuring parameters and other data can be saved in Excel format (.xls). This means that they can be easily forwarded and be viewed on every PC, which has MS Excel© installed.

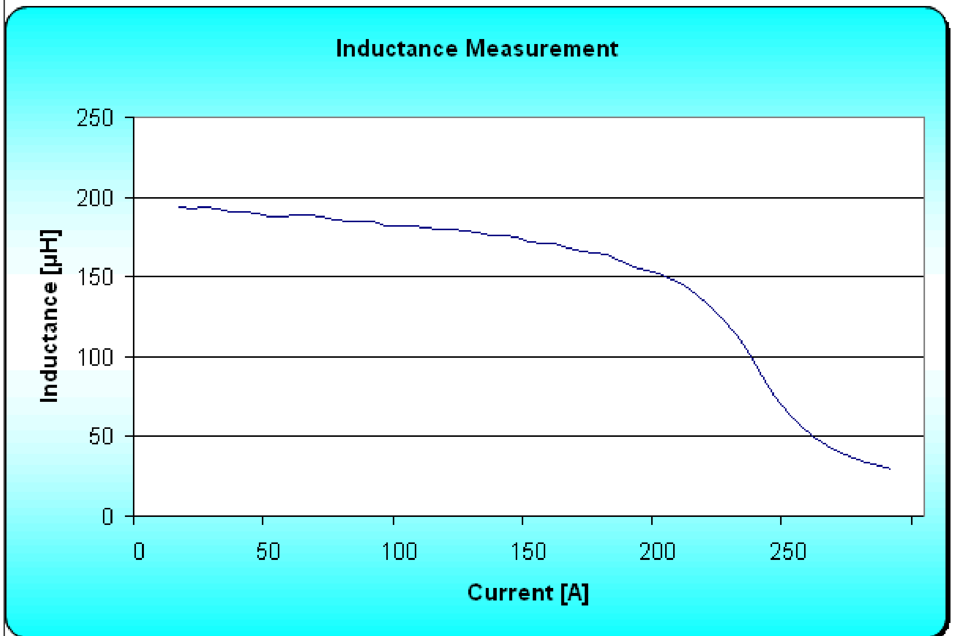
On top of this, it is also possible to export data in .csv format, so that the data can be processed in another location.

For routine testing there are special functions. Either a measurement report in table form with selectable reading points in Excel format or a .csv file with complete measurement data sets for electronical storage can be created.

DPG10 Power Choke Tester V1.3

Designation of Test Component:	PFC Choke No 1
Name of Inspector:	John Q. Public
Date:	3. Oktober 2007
Ohmic Resistance $R_L[\Omega]$:	0,0131

Measurement parameters:
Imax = 320 A
Vmax = 150 V
Tmax = 1000 µs



Current [A]	Inductance [µH]	Current [A]	Inductance [µH]	Current [A]	Inductance [µH]	Current [A]	Inductance [µH]
		130	178	255	55,9		
		135	176	260	49,2		
15	194	140	175	265	44,0		
20	192	145	175	270	39,7		
25	194	150	172	275	36,4		
30	193	155	171	280	33,6		
35	191	160	171	285	31,3		
40	191	165	168	290	29,4		
45	190	170	166				
50	188	175	166				
55	188	180	164				
60	188	185	160				
65	189	190	157				
70	187	195	155				
75	186	200	152				
80	185	205	149				
85	185	210	144				
90	184	215	139				
95	182	220	132				
100	182	225	123				
105	182	230	114				
110	181	235	101				
115	180	240	88,2				
120	179	245	75,4				
125	179	250	64,5				

Fig 3: Measuring protocol of an inductor with an amorphous ribbon core, $I_{nom} = 125A_{rms}$

Sample Applications

With the exception of air-core coils, all power inductors posses certain saturation characteristics. That means inductance decreases with increasing levels of current. This is due to the various core materials, which start to lose their permeability more or less strongly after a certain induction level B is reached and in extreme cases take on the characteristics of air. The saturation characteristics of an inductor can be influenced by:

- the type of core material,
- core geometry,
- the number of turns,
- and the air gap.

However, deviations often exist between the calculated inductance at a certain current level (i.e. rated current) and the real inductance, because:

- the inductor geometry causes a non-homogenous field distribution
- the core's spec sheet entries are inaccurate or incomplete
- production spread of the core is available
- manufacturing tolerances
- Thermal influences.

For this reason it is important to measure saturation characteristics during the development phase and quality inspection of power inductors.

1. Filter choke with ferrite core E32

In this case, the test component is a filter choke for a switch mode power supply with an output voltage of 5V and a power of 100W. The E-core consists of standard ferrite material N27 and is fitted with an air gap.

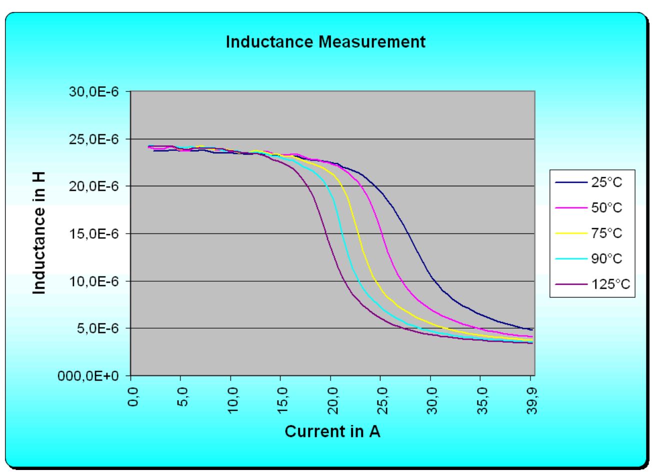


Fig 4: Measuring protocol of a filter choke with E32 ferrite core

In this example, occurrences of saturation are clearly linked to temperature. Inductance decreases by 25°C at 24A with 20µH. At 125°C, this threshold is reached at only 17.5A. Other core materials quite often demonstrate much less susceptibility to temperature.

Inductors from the standard product range of manufacturers are particularly unsuited to or completely unrated with regard to inductance at higher temperatures. In this case, only taking saturation characteristic measurements yourself can do any good.

2. Balance choke with ribbon core

This balance choke is installed in a 12 pulse rectifier and is made up of a SU39 silicon iron ribbon core with an air gap. The rated current is 25A per coil. For the most part, the current flow is compensated by the circuit's topology. The rest of the uncompensated current lies at around 2 x 6A (max.).

A small-signal measurement shows an inductance of 1.31mH at 1kHz and 1.33mH at 100Hz. In this example it is clear to see, that the initial inductance which is measurable by a small-signal measuring device lies considerably under the real inductance level (1.9mH) present during operations.

Power inductors with iron based cores cannot be usefully measured using a small-signal AC measuring process, due to their extremely non-linear characteristics! Only a large signal measurement as used by the Power Choke Tester DPG10, can deliver the correct results.

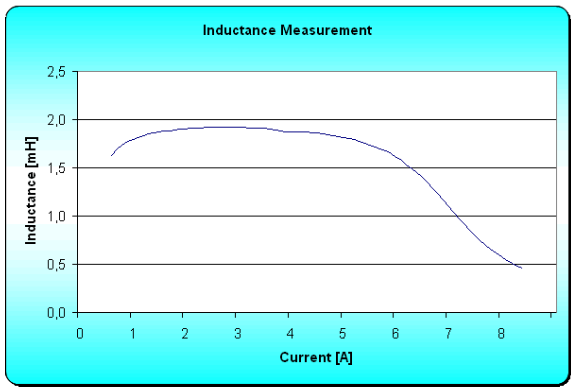


Fig 5: Measurement protocol of a balance choke with a SU39 ribbon core

3. Filter choke with high flux core

This inductor has an initial inductance of 4.5µH and consists of three ring cores (high flux core material) with an outer diameter of 58mm. This is normally used in a switch mode power supply of 48V / 300A .

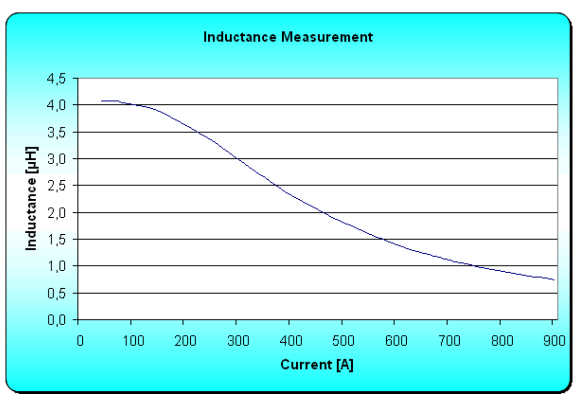


Fig 6: Measurement protocol of a filter choke with high flux core (3x R58)

The typical slope of the saturation profile of this core is very easy to discern. However, because this core material is very expensive, an optimal economic solution requires that the operational point at rated current lies beneath the level of initial inductance.

Technical Specifications

1. General data

Power outputs:

Standard model:	
Output current-Measuring range 1	Maximum value is adjustable 1 to 9A
Output current-Measuring range 2	Maximum value is adjustable 10 to 99A
Output current-Measuring range 3	Maximum value is adjustable 100...1000A
Special model 1500A:	
Output current-Measuring range 1	Maximum value is adjustable 1 to 9A
Output current-Measuring range 2	Maximum value is adjustable 10 to 99A
Output current-Measuring range 3	Maximum value is adjustable 100...1500A
Special model 100A:	
Output current-Measuring range 1	Maximum value is adjustable 0,1...0,9A
Output current-Measuring range 2	Maximum value is adjustable 1,0...9,9A
Output current-Measuring range 3	Maximum value is adjustable 10,0...100,0A
All models:	
Max. Output voltage	Adjustable from 10 to 400V
Max. impulse duration	Adjustable from 3µs to 70ms
Max. Impulse energy	900J
RS232 port:	
Parameters	115200, N, 8, 1
Galvanical insulation	Yes, completely floating
Connector	D-Sub-9 pole (female)
Voltage supply:	
Mains voltage	207 to 253 VAC
Frequency	50 to 60 Hz
Power consumption	100 VA max. (80 W max.)
Environmental conditions:	
In operation	0 to 50°C, no moisture condensation
Storage, transport	-20 to 75°C, no moisture condensation
Weight, dimensions:	
Weight	approx. 7.2 kg
Dimensions	320 (L) x 370 (W) x 167 (H) mm^3

2. Accuracy[*]

Measuring range 1:

$I_{measmax} \leq 3$ A	± (1.0% + 3 / $I_{measmax}$ * 0.9%)
$I_{measmax} \geq 4$ A	± (1.0% + 10 / $I_{measmax}$ * 0.9%)
Measuring range 2:	
$I_{measmax} \leq 30$ A	± (1.0% + 30 / $I_{measmax}$ * 0.9%)
$I_{measmax} \geq 31$ A	± (1.0% + 100 / $I_{measmax}$ * 0.9%)
Measuring range 3:	
$I_{measmax} \leq 309$ A	± (1.0% + 300 / $I_{measmax}$ * 0.9%)
$I_{measmax} \geq 310$ A	± (1.0% + 1000 / $I_{measmax}$ * 0.9%)
Measuring range 3 (Special model 1500A):	
$I_{measmax} \leq 499$ A	± (1.0% + 500 / $I_{measmax}$ * 0.9%)
$I_{measmax} \geq 500$ A	± (1.0% + 1500 / $I_{measmax}$ * 0.9%)
Impulse time-measurement	± (0.02 % + 2 µs)
Resistance measurement	±(0.5% + 0.8 mΩ) from 0.0 to 300 mΩ
	±(0.5% + 8 mΩ) from 300 to 3000 mΩ

Special model 100A:

Measuring range 1:

$I_{messmax} \leq 0{,}3$ A	± (1,0% + 0,3 / $I_{messmax}$ * 0,9%)
$I_{messmax} \geq 0{,}4$ A	± (1,0% + 1 / $I_{messmax}$ * 0,9%)
Measuring range 2:	
$I_{messmax} \leq 3{,}0$ A	± (1,0% + 3 / $I_{messmax}$ * 0,9%)
$I_{messmax} \geq 3{,}1$ A	± (1,0% + 10 / $I_{messmax}$ * 0,9%)
Measuring range 3:	
$I_{messmax} \leq 30{,}9$ A	± (1,0% + 30 / $I_{messmax}$ * 0,9%)
$I_{messmax} \geq 31{,}0$ A	± (1,0% + 100 / $I_{messmax}$ * 0,9%)
Impulse time-measurement	± (0,02 % + 2 µs)
Resistance measurement	±(0,5% + 8 mΩ) von 0 … 3 Ω
	±(0,5% + 80 mΩ) von 3 … 30 Ω

Please note:

These values are valid for impulse times > 10 µs and inductance > 10 µH as well as low parasitic inductive coupling between Force lines and Sense lines. See instruction manual chapter "Operation" paragraph 2 "Connecting the Test Component".

The impulse time can be roughly estimated as follows: $T = L_{average} * I_{max} / V_{meas}$

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[*] Accuracy values remain valid up to one year after calibration. Accuracy values do not take account of effects caused by core losses or AC resistance considerably larger than the DC resistance. These effects are however negligible with most inductive components.