

## **Production Testing of Transformers and Chokes**

### **with High Current DC Bias**

This application note introduces and discusses methods of testing transformers, inductors and chokes that operate with DC current present.

General test principles are presented as well as several innovative and unique Voltech solutions.

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## Introduction

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Transformers and chokes are components that are essential to the proper function of most electronic power converters. In products ranging from tablet computer chargers to large wind turbines, transformers are used to transform or filter AC voltage and are often required to do so with DC current present in a winding at the same time. The DC current is the smoothed load current that will be delivered to the load. See Appendix C for an example.

This application note describes methods to test transformers and chokes designed to operate with high levels of DC current present, from 1A up to 250A and 1000A.

## Why test with high DC current bias?

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If the final product is to operate correctly and to specification the transformer or choke must have the expected value of inductance with the DC current flowing through it. If, during product test, the inductance is not measured with the expected DC bias current present then the following manufacturing faults may not be detected:

- Wrong core material
  - Incorrect grade of ferrite or steel purchased or issued from stock
- Cores not assembled properly
  - Wrong gap
  - Dirty or contaminated core surfaces
- Bad wire termination
  - Poor crimping or soldering

These faults may not be detected by inductance measurement alone. This is because the magnetic core of the part operates in a completely different area when the DC bias current is present. (For information on Transformer Theory, please request Voltech application note 104-039 “Transformer Basics”).

If faulty transformers are shipped and fitted inside the final product then the result is expensive re-work or scrap.

## Typical Applications:

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### Production Testing

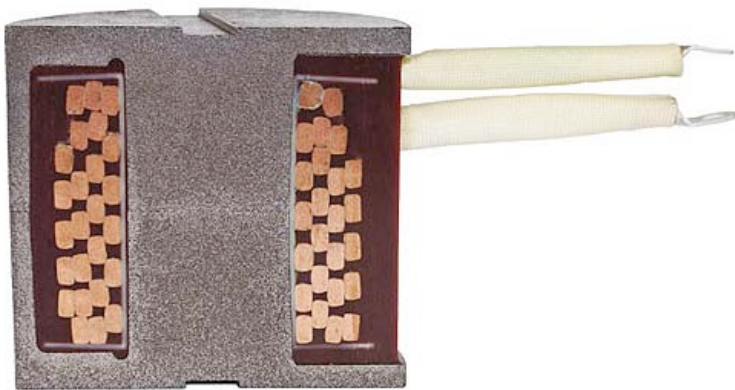
- Test every part produced with DC bias current to guarantee quality

### Design Verification

- Check operating performance
- Assess power loss and voltage drop.
- Design margin (by using DC Bias current in excess of the specification requirement)

Testing transformers, chokes and inductors used in:

- Power Supplies and DC-DC convertors.
  - Forward converter transformer / choke
  - Simple L-C DC output filters
- Wind Turbines
  - DC Link Choke in full-conversion type
- UPS
  - Filter component in the DC link
- PV Inverter



*Section through a 200A PV Inverter Choke*



*50A DC – DC Converter Filter Inductor*

## Equipment Required

To test the transformer or choke thoroughly a combination of different pieces of equipment may be necessary.

Test	Typical Bench or Design Equipment	Voltech Production Equipment
DC Resistance	DVM or Continuity Tester	ATi or AT3600
Inductance, L	LCR meter	ATi or AT3600
Quality Factor, Q	LCR or Impedance Meter	ATi or AT3600
Turns Ratio	Dual Input LCR or Impedance meter. OR Signal generator and DVM	ATi or AT3600
Insulation Resistance	LCR meter or Insulation Tester	ATi or AT3600
DC Bias Current 0-250A	DC1000	DC1000

In all cases a special type of power supply is required to provide the DC Bias current. This DC current bias supply is specially constructed not to interfere with the precision AC measurements made by the LCR meter or Voltech AT Series Tester. (See Appendix E).

### DC1000 25A DC Current Bias Supply

The Voltech DC1000 25A dc current supply will seamlessly integrate into the AT3600 or ATi test environment to provide up to 250A (10x DC1000 in parallel) of smooth, programmable dc bias current with minimal effect on the ac inductance measurement.

1. 25A programmable dc current per DC1000.
2. Operate in parallel to 500+ Amps.
3. Works seamlessly with AT3600 or ATi
4. Unique “electronic inductor” design minimizes effect on the ac inductance measurement (See Appendix F).
5. Can be used on almost any LCR meter. Alternative for Agilent, Wayne Kerr and Chroma types.

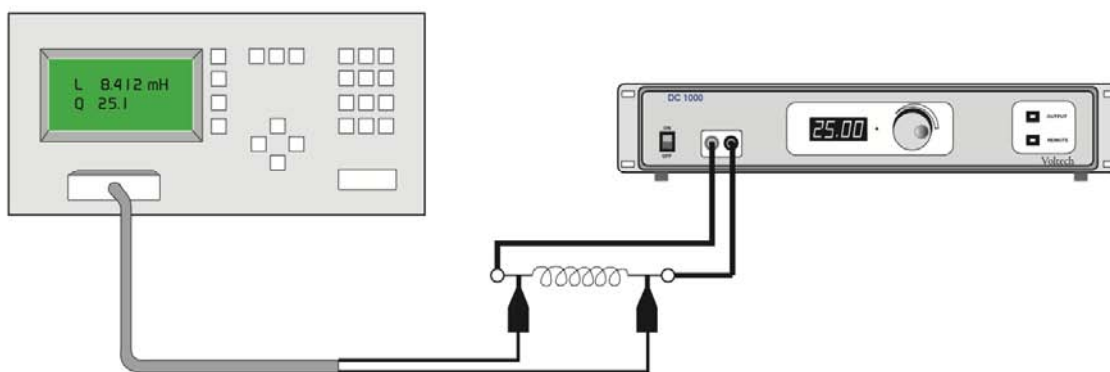


## Manual Testing with an LCR Meter

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### Up to 25A DC Bias Current

1. Simply connect the DC1000 to the part under test in parallel with the LCR meter.  
The DC1000 is supplied with 25A safety leads and alligator clips.
2. Adjust the DC Bias current using the front-panel rotary control of the DC1000.  
10mA resolution is available.
3. Set the LCR meter to measure as normal – for example inductance at 50kHz and 100mV.
4. Take the LCR meter measurements as normal.



### Compensation

For precise measurements at high frequencies it is always required to compensate the LCR measurements against the effects of stray connection impedances. A good quality LCR meter will already have Kelvin 4-wire connections to eliminate contact impedance but will have a compensation facility for offsetting stray inductance and capacitance.

To compensate when using a DC1000:

- Have the DC1000 connected as above and switched on but with its output set to 0.00A.
- Compensate the LCR meter as normal. (It's not necessary to have the DC1000 connected for short-circuit compensation).

See also Appendix D for safety and protection instructions.

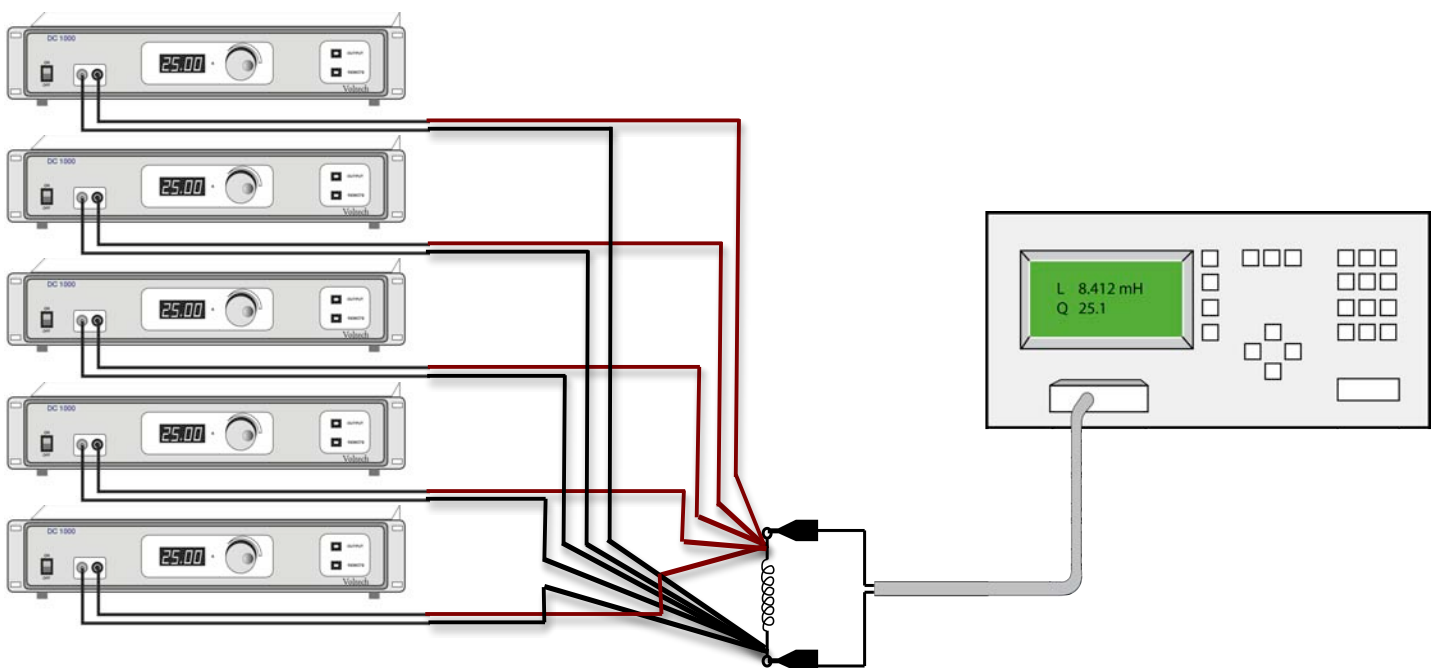
## 25 to 500A DC Bias Current.

Each DC1000 can supply up to 25A of smooth and programmable DC current. To increase the test current, simply connect multiple DC1000 in parallel as required. For example, to test with 250A bias current 10 DC1000 will be required.

Each DC1000 will supply the DC current that is programmed on its front panel or remotely. For example, to supply 250A use 10 DC1000 and set 25A on each.

The number of DC1000 that could be used in parallel is theoretically unlimited but testing to 500A with 20 DC1000 is known to work well.

The use the standard 25A current leads as supplied, the output of each DC1000 must be taken to a common connection or 'star' point.



*5x DC1000 Connected in Parallel for 125A Testing with an LCR Meter*

Operation and compensation is as described for 25A above.

## Connecting to the Part Under Test

The connections to the transformer or inductor under test will depend on the terminations provided by the part. Connections must be suitable for the current provided by the DC1000 bias supplies:

- Clean  
It may be necessary to clean the transformer terminations.
- Use the maximum surface area provided
- Use pressure to secure the transformer termination to the chosen connector
- Remember to bring the DC1000 output cables to a star point first, but as close as possible to the connection.

Connectors used for earthing / grounding or welding may be useful and many examples are available.



Use bus bar terminal strips to bring the DC1000 connections to a common or 'star' point.



Grounding clamps can provide a good and secure connection to the part under test.



This is an example of a grounding connector used in electric welding.

*Courtesy Deep Recycling Industries*  
*[www.deepri.com](http://www.deepri.com)*

## Automatic Testing

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In production, it is convenient to automate testing.

- Consistent set up.  
Quick to set up.  
Test with exactly the same environment every time.
- Automatically save results
- Fast test.

There are two ways to operate the DC1000 automatically:

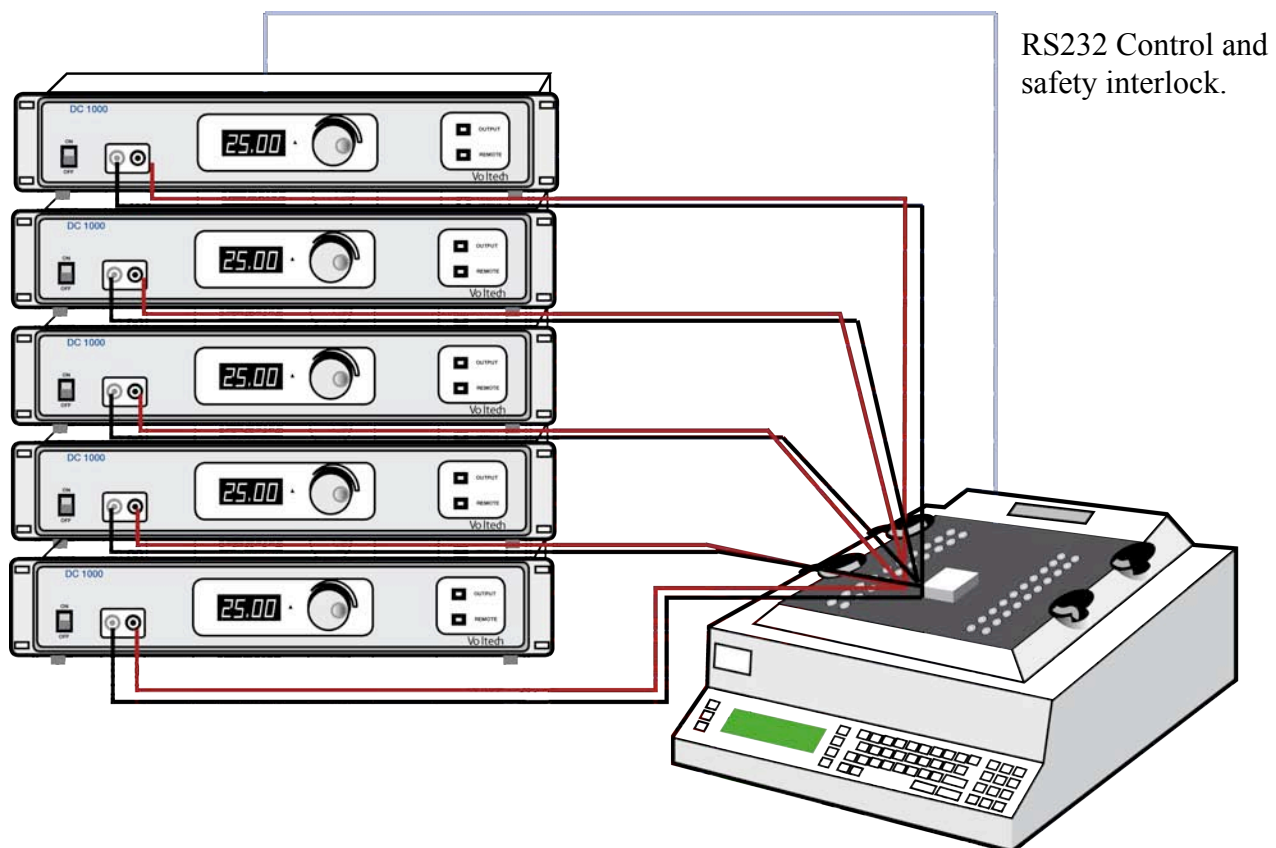
1. With custom PC Software control over RS232
2. Using the fully automatic and integrated environment of the AT Series testers.  
No programming is required.  
Fully automatic and seamless testing along with all other parameters.



## Testing Automatically with a Voltech AT Series Tester

When used with a Voltech AT Series Tester the DC1000 DC Bias Supply:

- Provides the requested current on demand when required by the AT tester
- Is fully automatic via RS232 in series “daisy-chain” for up to 10x DC1000
- Is fully integrated with the AT3600 safety interlock system for operator safety.



*Up to 10 DC1000 for 250A with a Voltech AT3600 or ATi Automatic Transformer Tester*

**Further information.**

- Technical Advice
- Free trial of Voltech Equipment
- Check of DC1000 compatibility with LCR meters

Please visit:

[www.voltech.com](http://www.voltech.com)

## Appendix A - Voltech DC1000 and Production Tests for the AT Series

Power transformers and chokes that carry a high dc current are common in power supplies and inverters. Testing these parts at their rated dc current provides complete confidence that the parts have been correctly wound, assembled and terminated.

The Voltech DC1000 25A dc current supply will seamlessly integrate into the AT3600 or ATi test environment to provide up to 250A (10x DC1000 in parallel) of smooth, programmable dc bias current with minimal effect on the ac inductance measurement.

- 25A programmable dc current
- 250A with 10x DC1000
- Works seamlessly with AT3600 or ATi
- Unique “electronic inductor” design minimizes effect on the ac inductance measurement
- Can be used on almost any LCR meter. Alternative for Agilent, Wayne Kerr and Chroma types.



### Tests for the DC1000 and AT3600 / ATi

<b>LSBX</b>	Inductance with External Bias (Series)	1nH	to	1MH	1mV	to	5V	20Hz	to	3MHz	0.05%
<b>LPBX</b>	Inductance with External Bias (Parallel)	1nH	to	1MH	1mV	to	5V	20Hz	to	3MHz	0.05%
<b>ZBX</b>	Impedance with external bias	1mΩ	to	1MΩ	1mV	to	5V	20Hz	to	3MHz	0.2%

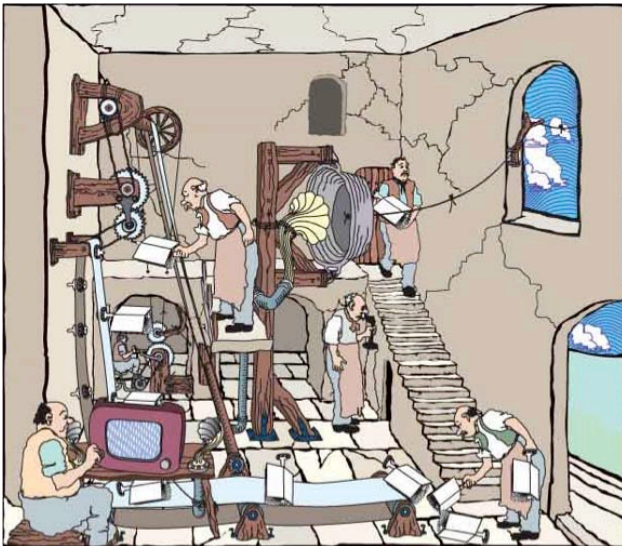
## **Appendix B - Voltech Automatic Transformer Testers.**

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The unique AT3600 and ATi automatic transformer testers combine the features of a precision LCR meter, ac source, HiPot tester and 20-way kelvin switching matrix to provide fast and accurate testing of all parameters on most kinds of small transformers and chokes.

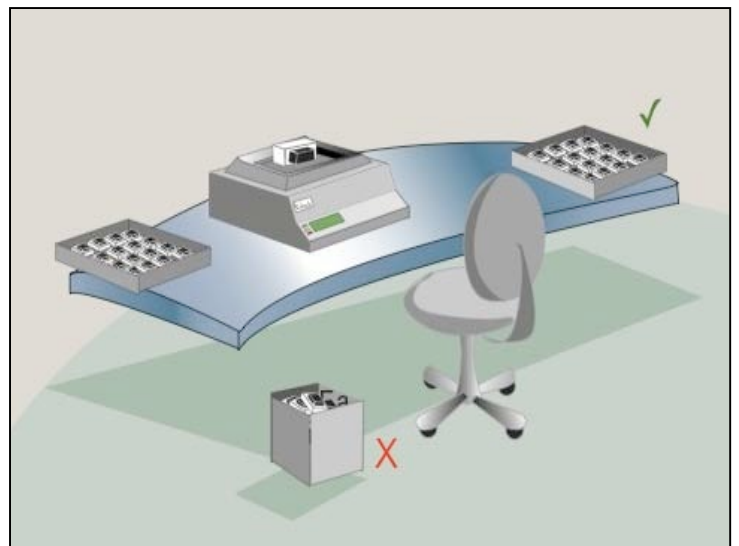
The cost and quality benefits of the AT Series testers are well known to our customers and this technical note describes the latest extended features of the AT3600 and ATi.

### ***Before Voltech***



Special skills were required to design, maintain, program and operate transformer testing equipment.

### ***With Voltech***



All tests in one station, up to 10 different tests per second with automatic connection to different windings.

### ***Voltech AT Series testers.***

***- going from strength to strength -***

## Essential Capability

The testers have the built-in capability described below.



### AT3600

### ATi

Capability:	AT3600	ATi
20 way switching matrix	✓	✓
PC test editor and results server	✓	✓
Quick-change Fixture System	✓	✓
Test fixture system	✓	✓
Small signal tests (e.g. inductance, capacitance, turns ratio)	✓	✓
Telecomms. tests (e.g. return loss, longitudinal balance)	✓	✓
Insulation resistance	7000V	500V
Hi-pot (AC)	5500V	
Hi-pot (DC)	7000V	
Magnetizing current and open circuit voltage	270V, 2A	
Watts, Stress Watts	40W	
Leakage Current	2A	

To make use of this capability, the testers may be fitted with a number of different tests such as inductance, ac resistance, turns ratio, watts or ac hipot.

Tests are sold in packages such as ‘Standard’ or ‘Gold’ or may be purchased individually and fitted by the user via firmware upgrade.

The complete list of available tests is shown at the end of this document.

## Updating an AT3600 or ATi

Any AT3600 or ATi less than 10 yers old may be upgraded to include the lalest tests or accessories available. Most tests may be fitted by upgrading the firmware using the

Voltech PC Editor. Contact your local supplier for the costs and availability of fitting new tests via firmware upgrade.

If your AT3600 or ATi is over 10 years old we will either offer to re-furbish it at our factory or offer you a trade-in value against the purchase of a new Voltech tester.

## Test Descriptions

Test	Description	Main Application	Winding Tested	Reason for Test
CTY	Continuity	All transformers		Properly installed fixture
R	DC Resistance	All transformers	All windings	Properly installed fixture Correct wire used Integrity of terminations
LS	Inductance (Series circuit)	Most transformers But usually not line frequency transformers	One winding usually the primary	Correct primary turns Right grade of core material Core correctly assembled
LP	Inductance (Parallel circuit)			
QL	Quality Factor			
RLS	Equivalent Series Resistance			Right grade of core material Core correctly assembled Check for shorted turns
RLP	Equivalent Parallel Resistance			
D	Dissipation Factor			
LL	Leakage Inductance	SMPS transformers	Selected windings	Check windings have been installed in the correct position relative to the core
LLO		Communication transformers Others as applicable		
C	Interwinding Capacitance	High frequency transformers Isolating transformers		Check winding positioning Check insulation thickness between windings
TR	Turns Ratio and Phasing	Most transformers, but usually not line frequency transformers	All windings	Check windings have correct turns and phasing
TRL	Turns Ratio by Inductance	As with Turns Ratio but used where there is poor flux linkage between windings.	All windings	Check windings have correct turns and phasing
MAGI	Magnetising Current	Usually line frequency transformers	One winding, usually the primary	Correct primary turns Correct core material properly assembled
MAGX	MAGI (External Source)			
VOC	Open Circuit Voltage		All other windings	Correct secondary turns Correct phasing
VOCX	VOCX (External Source)			
LVOC	Low Voltage Open Circuit			
IR	Insulation Resistance	All transformers	Between selected windings	Winding isolation check where safety is not involved
HPDC	Hi-Pot (DC)	All transformers especially those used for safety insulation	Between selected windings usually primary to secondary, screens and core	High voltage safety insulation
HPAC	Hi-Pot (AC)			
LSB	Inductance with Bias Current (Series Circuit)	Transformers for use in applications where passing significant (dc) bias current is part of the normal operation	One winding	Correct number of turns Right grade of core material Core correctly assembled
LPB	Inductance with Bias Current (Parallel Circuit)			
WATT	Wattage	50Hz Iron core transformers	One winding	Correct core material Properly assembled
WATX	WATT (External Source)			

Test	Description	Main Application	Winding Tested	Reason for Test
SURG	Surge Stress Test	All transformers, especially those using fine wire	Selected windings	To identify shorted turns
TRIM	Trimming Adjustment	Transformers with variable / trimmable components		To adjust transformer to give specific measured values
OUT	Output To User Port			Allows the AT to perform external switching as part of the test program.
R2	DC Resistance Match	SMPS, audio & telecom	All windings	Checks matching between windings
L2	Inductance Match	SMPS, audio & telecom transformers	All windings	Checks matching between windings
C2	Capacitance Match	SMPS, audio & telecom transformers	All Windings	Checks correct winding position on bobbin
GBAL	General Longitudinal Balance	Audio & telecom transformers	Selected Windings	Checks common mode rejection ratio
LBAL	Longitudinal Balance	Audio & telecom transformers	Selected Windings	Checks common mode rejection ratio
ILOS	Insertion Loss	Audio & telecom transformers	Selected Windings	Checks losses within the transformer
RESP	Frequency Response	Audio & telecom transformers	Selected Windings	Checks losses over a range of frequencies
RLOS	Return Loss	Audio & telecom transformers	Selected Windings	Checks losses returned by a transformer
Z	Impedance	Audio & telecom transformers	Selected Windings	Checks impedance at a given frequency
ZB	Impedance + bias	Audio & telecom transformers	Selected Windings	Checks impedance at a given frequency
STRW	Stress Wattage	Line frequency & High Frequency Transformers	One Winding (Usually the primary)	Checks integrity of inter-turn insulation, the magnetic material and joints
STRX	STRW (External Source)			
ANGL	Impedance Phase Angle	Audio & telecom transformers	Selected Windings	Finds phase shift between Voltage and Current on a winding.
PHAS	Interwinding Phase Test	Audio & telecom transformers	Selected Windings	Measures phase shift between a pair of windings
ILK	Leakage Current Test	Medical applications	Between Primary and Secondary Windings	Checks for a common mode current due to capacitance
LSBX	Inductance with External Bias (Series Circuit)	Wound components that usually carry a significant DC Bias current in normal operation.	Selected Windings	Checks number of turns, right grade of correctly assembled core material, where bias current is greater than LSB test can handle.
LPBX	Inductance with External Bias (Parallel Circuit)	Wound components that usually carry a significant DC Bias current in normal operation.	Select Windings	Checks number of turns, right grade of correctly assembled core material, where bias current is greater than LPB test can handle.
ZBX	Impedance with External Bias	Audio & Telecom	Selected Windings	Checks impedance at a given frequency, while applying a greater bias current than is possible with ZB test.
ACRT	Hi-Pot Ramp (AC)	All transformers especially those used for safety insulation	Between selected windings usually primary to secondary, screens and core	High voltage safety insulation
DCRT	Hi-Pot Ramp (DC)			
ACVB	Voltage Breakdown (AC)	Transformers with MOV fitted	Between selected windings usually primary to secondary, screens and core	High voltage safety insulation
DCVB	Voltage Breakdown (DC)			



## Test Specifications

Test		User Entered Test Data									A <sub>R</sub> <sup>(1)</sup>
		Measurement Range			Test Signal			Test Frequency <sup>(4)</sup>			
CTY	Continuity	10kΩ	to	10MΩ	n/a			n/a			n/a
R	DC Resistance	10μΩ	to	10MΩ	n/a			n/a			0.1%
LS	Inductance (series circuit)	1nH	to	1MH	1mV	to	5V	20Hz	to	3MHz	0.05%
LP	Inductance (parallel circuit)	1nH	to	1MH	1mV	to	5V	20Hz	to	3MHz	0.05%
QL	Quality Factor	0.001	to	1000	1mV	to	5V	20Hz	to	3MHz	0.5%
D	Dissipation Factor	0.001	to	1000	1mV	to	5V	20Hz	to	3MHz	0.5%
RLS	Equivalent Series Resistance	10μΩ	to	10MΩ	1mV	to	5V	20Hz	to	3MHz	0.05%
RLP	Equivalent Parallel Resistance	10μΩ	to	10MΩ	1V	to	5V	20Hz	to	3MHz	0.05%
LL	Leakage Inductance	1nH	to	1kH	20μA	to	100mA	20Hz	to	3MHz	0.1%
LL0	Leakage Inductance with user offset	1nH	to	1kH	20μA	to	100mA	20Hz	to	3MHz	0.1%
C	Inter-winding Capacitance	100fF	to	1mF	1mV	to	5V	20Hz	to	3MHz	0.1%
TR	Turns Ratio and Phasing	1:100k	to	100k:1	1mV	to	5V	20Hz	to	3MHz	0.1%
TRL	Turns Ratio by Inductance	30:1	to	1:30	1mV	to	5V	20Hz	to	3MHz	0.1%
MAGI	Magnetizing Current	1μA	to	2A	1V	to	270V	20Hz	to	1500Hz	0.1%
MAGX	Magnetizing Current (External Source)	50mA	to	10A	5V	to	600V	20Hz	to	5kHz <sup>(2)</sup>	0.1%
VOC	Open Circuit Voltage	100μV	to	650V <sup>(3)</sup>	1V	to	270V	20Hz	to	1500Hz	0.1%
VOCX	O/C Voltage (External Source)	100μV	to	650V <sup>(3)</sup>	1V	to	600V	20Hz	to	5kHz <sup>(2)</sup>	0.1%
LVOC	Low Voltage Open Circuit	100μV	to	650V <sup>(3)</sup>	1mV	to	5V	20Hz	to	3MHz	0.1%
IR	Insulation Resistance	1MΩ	to	100GΩ	100V	to	7KV	n/a			1%
HPDC	Hi-Pot (DC)	1μA	to	3mA	100V	to	7KV	n/a			3.2%
HPAC	Hi-Pot (AC)	10μA	to	30mA <sup>(4)</sup>	100V	to	5KV	50Hz	to	1kHz	3.0%
LSB	Inductance with Bias (Series) DC Bias	1nH	to	1MH	1mV	to	5V	20Hz	to	3MHz	0.05%
					1mA	to	400mA				
LPB	Inductance with Bias (Parallel) DC Bias	1nH	to	1MH	1mV	to	5V	20Hz	to	3MHz	0.05%
					1mA	to	400mA				

User Entered Test Data											
Test		Measurement Range			Test Signal			Test Frequency <sup>(5)</sup>			A <sub>R</sub> <sup>(1)</sup>
WATT	Wattage	1mW	to	40W	1V	to	270V	20Hz	to	1500Hz	0.3%
WATX	Wattage (External Source)	1mW	to	6kW	5V	to	600V	20Hz	to	5kHz <sup>(2)</sup>	0.3%
SURG	Surge Stress	1mVs	to	1kVs	100V	to	5kV		n/a		3.0%
TRIM	Trimming Adjustment		n/a			n/a			n/a		n/a
STRW	Stress Wattage	1mW	to	40W	1V	to	270V	20Hz	to	1500Hz	1%
STRX	Stress Wattage (External Source)	1mW	to	6kW	5V	to	600V	20Hz	to	5kHz <sup>(2)</sup>	1%
R2	DC Resistance Match	1:1000	to	1000:1		n/a			n/a		0.2%
L2	Inductance Match	1:10000	to	10000:1	1mV	to	5V	20Hz	to	3MHz	0.1%
C2	Inter-winding Capacitance Match	1:1000	to	1000:1	1mV	to	5V	20Hz	to	3MHz	0.2%
GBAL	General Longitudinal Balance	0dB	to	100dB	1mV	to	5V	20Hz	to	3MHz	0.5dB
LBAL	Longitudinal Balance	0dB	To	100dB	1mV	to	5V	20Hz	to	3MHz	0.5dB
ILOS	Insertion Loss	-100dB	to	100dB	1mV	to	5V	20Hz	to	3MHz	0.5dB
RESP	Frequency Response	-100dB	to	100dB	1mV	to	5V	20Hz	to	3MHz	1.0dB
RLOS	Return Loss	-100dB	to	100dB	1mV	to	5V	20Hz	to	3MHz	0.2%
Z, ZB	Impedance, Impedance + bias	1mΩ	to	1MΩ	1mV	to	5V	20Hz	to	3MHz	0.2%
OUT	Output to User Port		n/a			n/a			n/a		n/a
ANGL	Impedance Phase Angle	-360°	to	360°	1mV	to	5V	20Hz	to	3MHz	0.05°
PHAS	Inter-winding Phase Test	-360°	to	360°	1mV	to	5V	20Hz	to	3MHz	0.05°
ILK	Leakage Current Test	1μA	to	10mA	1V	to	270V	20Hz	to	1kHz	0.5%
ACRT	Hi-Pot Ramp (AC)	10μA	to	5mA <sup>(4)</sup>	100V	to	5.5KV	50Hz	to	1kHz	3.0%
DCRT	Hi-Pot Ramp (DC)	1μA	to	3mA	100V	to	7KV		n/a		3.2%
ACVB	Voltage Break down (AC)	10μA	to	5mA <sup>(4)</sup>	100V	to	5.0KV	50Hz	to	1kHz	3.0%
DCVB	Voltage Break down (DC)	10μA	to	3mA	100V	to	7KV		n/a		3.2%

Yellow Shade AT3600 Only

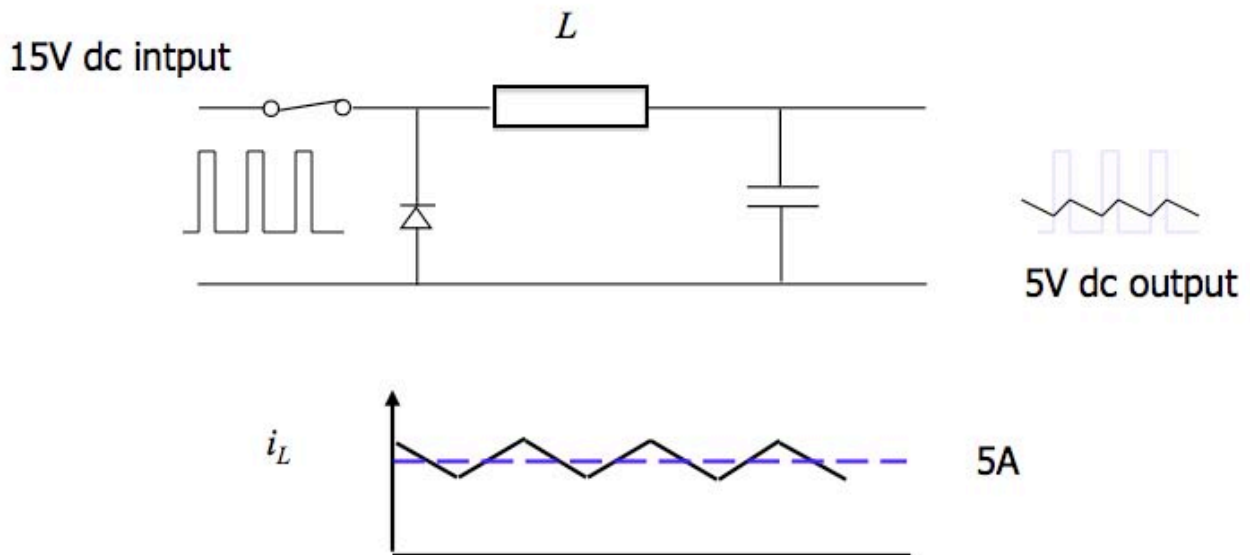
Notes:

1.  $A_R$  = The basic relative accuracy (see the user manual for the full specification).
2. Depends on external source type.
3. 650Vrms for AC measurements, or 1000V for DC measurements.
4. Peak value.
5. 1MHz may be the maximum bandwidth for some testers manufactured before 1999. Consult your supplier for details.
6. Where used, the bias current accuracy is  $\pm 10\%$  of the requested value.
7. Test Frequency Accuracy
  - a.  $F \leq 16\text{kHz}$ , error is  $\pm 0.25\text{Hz} \pm 0.01\%$  of requested frequency
  - b.  $F > 16\text{kHz}$  and  $\leq 250\text{kHz}$ , error is  $\pm 4\text{Hz} \pm 0.01\%$  of requested frequency
  - c.  $F > 250\text{kHz}$ , error is  $\pm 64\text{Hz} \pm 0.01\%$  of requested frequency

## Appendix C - Simple Circuit Example

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A simple and very common example of an inductor that filters AC voltage while carrying DC current at the same time is the output storage choke of a switching power supply.



The choke,  $L$ :

- Must have the correct inductance to form the L-C filter necessary to produce a DC output
- Simultaneously carry the DC load current  $i_L$

To guarantee long life and high efficiency of the converter it is necessary to perform realistic tests on each transformer during its manufacture.

## **Appendix D - Operator Safety and Protection for the LCR meter.**

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When DC current is applied to any inductor there is always the possibility of large and potentially dangerous voltage being produced if the DC Current is suddenly removed. This is because the inductor opposes the change in current by producing a “Back-EMF”.

In normal operation the DC1000 will ramp up and down the current and also act as a sink for any excess energy and no dangerous voltage will be produced by the inductance under test.

If the DC1000 current connection is removed abruptly *during a test*, then there will be the possibility that dangerous voltage will be present across the inductor.

To protect against this:

- Operators must be clear about the safety instructions supplied with the DC1000.
  - Use good quality connectors with a strong grip to avoid accidental misconnection
  - Always turn the DC1000 output off when making connections
  - Consider physical barriers for un-trained operators.
- (The DC1000 provides a safety interlock system).

To protect the LCR meter:

- Connect the LCR meter to the DC1000 such first such that if the inductor is disconnected accidentally then the DC1000 and LCR meter remain connected together.
- Protect the LCR meter with diodes or Metal-Oxide Varistors (MOV) to absorb energy in case of excess voltage. The protection must not operate within the normal output range of the LCR meter.

In all cases refer to the product manuals for safety instructions and follow procedures for risk assessment and protection as determined by local regulations.

## Appendix E - Compliance Voltage

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The compliance voltage is the maximum voltage that a constant current power supply can produce.

The compliance voltage of a DC1000 is 5.0V.

The maximum resistive impedance of the inductor under test is thus  $5V / \text{test current}$  (Ohm's law).

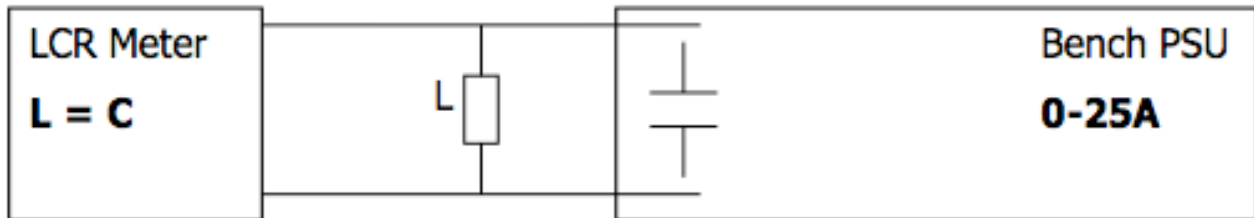
This is 2 ohms at 2.5A, 200 milli-ohms at 25A and 20 milli-ohms at 250A.

The impedance of the part must be less then this for the DC1000 to operate. For normal applications in power conversion this is always true since higher impedances would generate significant heat during operation and have poor efficiency.

## Appendix F - Why a Special DC Bias Supply is Required.

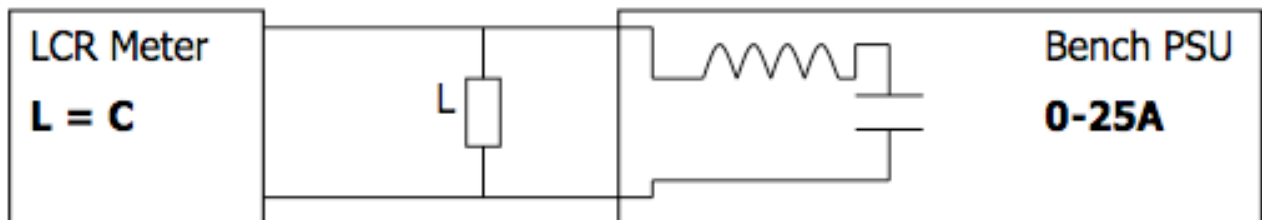
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A typical bench power supply has large smoothing capacitors at its output. This presents a low impedance  $X_C$  to the LCR meter:



*Bench PSU Capacitor short-circuits L.*

One solution to the problem of the large output capacitance is to use large inductors to keep the dc impedance low, but to present a large ac impedance to the LCR meter. This inductor is fitted inside the DC Bias Supply.



*Typical solution to the problem used by LCR meter manufacturers is to add a large inductor.*

The inductor solution has a number of problems:

- Big and heavy
- Different value inductors are required at different frequencies
  - Relay switched (unreliable)
  - Must route LCR meter to the DC Bias supply (inconvenient)
- DC bias supply matched to a particular manufacturers LCR meter.

The Voltech DC1000 DC current bias supply is a modern bias supply that has none of the problems of the previous solutions. It has a very low (and well specified) impact on the LCR measurement and may be used with most types of LCR meters.