AT3600
Transformer
Tester
User Manual

Voltech™

AT3600

Automatic Transformer Tester

User Manual

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VOLTECH AT3600 USER MANUAL

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VOLTECH AT3600 USER MANUAL

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CHAPTER 1 - INTRODUCTION

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This chapter will provide an introduction into the setup and use of your AT3600 Tester.

1. INTRODUCTION

1.1. HOW TO USE THIS MANUAL

Welcome to the Voltech AT3600 wound component tester. Please study this introductory chapter of the manual carefully. It will help you to setup your tester quickly and safely. By using your instrument to its full potential, you will increase the quality and reduce the cost of your transformers and inductors.

The following symbol conventions are used throughout:

Important safety information. To ensure operator safety, all safety information must be read and understood.

Important information that explains a general principle or refers to other sections of the manual.

The contents of this manual are believed to be accurate at the time of printing. Voltech reserves the right, however, to change the operation or specification of the AT3600 tester without notice. No liability is accepted for the inappropriate, negligent, or incorrect set-up of the AT3600 tester by the user, by either manual or automated means.

The Voltech AT3600 is protected by the following patents:

USA:	US 5500598
UK:	2261957B
Europe:	0621953B

1.2. GENERAL SAFETY INSTRUCTIONS

DANGER OF ELECTRIC SHOCK

Only qualified personnel should install this equipment, after reading and understanding this users manual. If in doubt, consult your supplier.

WARNING: The AT tester must be connected to a safety ground (earth). Only insert the power lead into a socket with a protective ground contact. Ensure that the power lead is in good condition and free from damage before use.
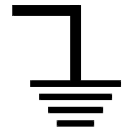
Replace the fuse only with the same type and rating: 3.15AT

Refer servicing only to qualified personnel who understand the danger of shock hazards.

WARNING: The AT3600 wound component tester can generate voltages that may be LETHAL. The safety interlock is designed to ensure the safety of operators when used with a Voltech approved safety system. To ensure operator safety, this interlock must always be properly connected to a Voltech approved safety system.

DANGER OF ELECTRIC SHOCK

Only qualified personnel should install this equipment, after reading and understanding this user manual. If in doubt, consult your supplier.

RISQUE D'ELECTROCUTION

L'installation de cet équipement ne doit être confiée qu'à un personnel qualifié ayant lu et compris le présent manuel d'utilisation. Dans le doute, s'adresser au fournisseur.

GEFAHR VON ELEKTRISCHEM SCHOCK

Nur entsprechend ausgebildetes Personal ist berechtigt, diese Ausrüstung nach dem Lesen und Verständnis dieses Anwendungshandbuches zu installieren. Falls Sie Zweifel haben sollten, wenden Sie sich bitte an Ihren Lieferanten.

RISCHIO DI SCARICHE ELETTRICHE

Solo personale qualificato può installare questo strumento, dopo la lettura e la comprensione di questo manuale. Se esistono dubbi consultate il vostro rivenditore.

1.3. PACKAGE CONTENTS

The following items are supplied in the packing case along with this manual:

1. AT3600 transformer tester.

2. Power cord.

3. CD-ROM inside the cover of this manual, which contains the Editor and Server installation files and other important information.

4. 9pin'D' – 9pin'D' F-F Cable.

5. 9pin'D' – 25pin'D' F-F Cable.

6. 25pin'D' – 25pin'D' F-F Cable.

7. This AT Series user manual.

8. Calibration certificate.

9. A Voltech product registration card.

Please report any missing items to your Voltech supplier. Returning your product registration card will ensure that you continue to receive the latest product and application information.

1.4. AT3600 AND ATI

The AT3600 is one of a family of automatic testers from Voltech that share the same fixture construction and PC editor and server software. ATi's and AT3600's can share the same server application, simultaneously recalling test programs and recording test results.

AT3600   ATi

Features:	ATi	AT3600
20 way switching matrix	✓	✓
PC test editor and results server	✓	✓
Test fixture system	✓	✓
Small signal tests (e.g. inductance, capacitance, turns	✓	✓
Telecomms. tests (e.g. return loss, longitudinal	✓	✓
Insulation resistance	500V	7000V
Hi-pot (AC)		5500V
Hi-pot (DC)		7000V
Surge testing		5000V
Magnetizing current and open circuit voltage		270V
Watts, Stress Watts		✓
Leakage Current		✓
Hi-pot Ramp (AC)		5500V
Hi-pot Ramp (DC)		7000V

Also available for the AT3600, the Voltech **'AC Source Interface**' extends the possible test range of the AT3600 test signal generators up **600V, 10A** when used with a suitable external supply.

Over 35 different tests are available for the AT3600. Check our website at **www.voltech.com** for details of new tests. Most can be installed within a few minutes by purchasing a software upgrade.

To determine which options were installed on your tester during manufacture, check the list attached to the calibration certificate inserted in the pocket on the inside front cover of this manual.

2. AT3600 FEATURES SUMMARY

Your AT3600 tester is designed for fast, accurate and reliable testing of transformers and other wound components in a production or goods inwards environment.

However, it is a complex instrument with many ways in which it can be set up and used.

Therefore, it is important that you take the time to read this section and the Overview in the following section, in order to understand the product capabilities, and enable you to make the best use of your AT3600 in your particular environment.

TYPICAL INSTALLATION

Editor PC - used when creating or editing test programs.

Server PC - for handling detailed results and large numbers of test programs.

Untested

transformers

PASS   **FAIL**

Tested transformers
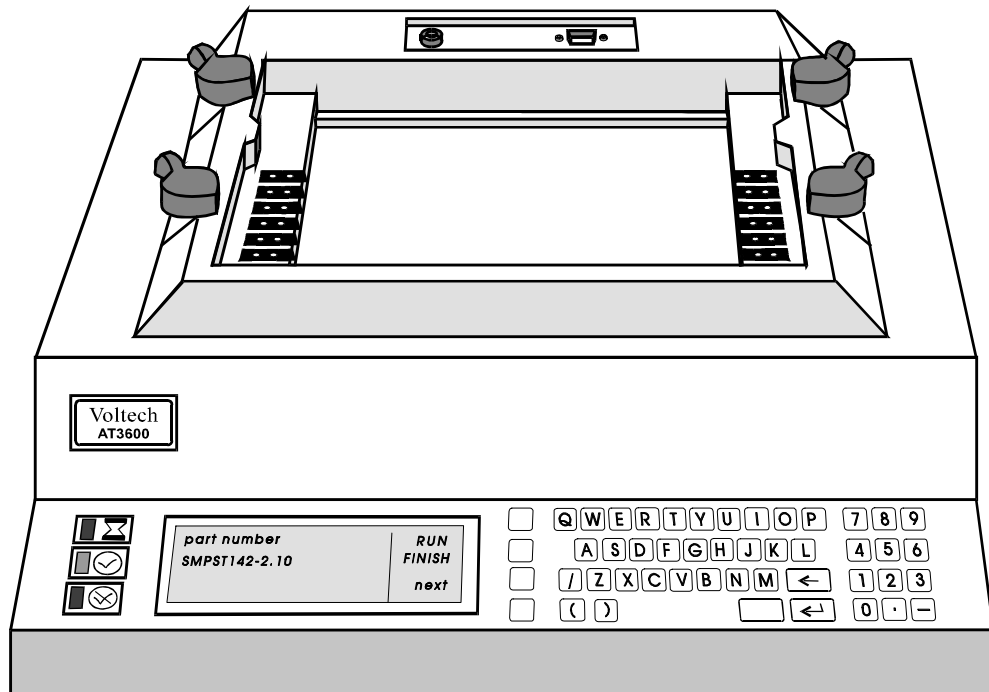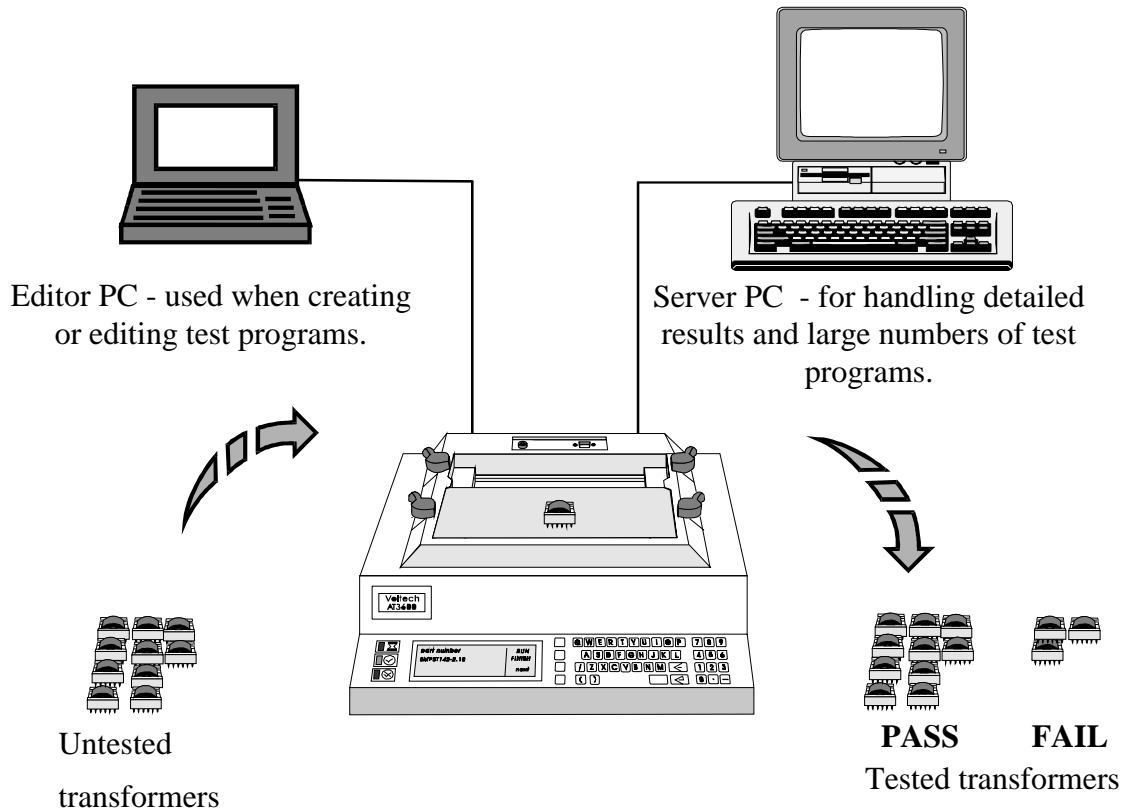
TEST PROGRAM CREATION

- Simple, easy to use, Windows based Editor for creating test programs. (Chapter 3.)

- Requires no software programming skills or expertise.

- Test conditions may be entered manually, or chosen automatically by measuring a sample transformer.

PROGRAM ARCHIVE MANAGEMENT

- Windows based Server software for easy management of all test programs. (Chapter 4.)

- Optionally, programs may be resident in the AT3600 Tester for stand-alone operation.

OPERATION

- Manual or robotic operation

- Barcode input

- Footswitch input

- Simple PASS / FAIL operation by an unskilled operator

- Safe – Light barrier controlled power isolation prevents operator injury from high voltages. (Chapters 8 & 10.)

RESULTS

- Direct printing from the AT Series Tester.

- Results archiving to disk using the Server application.

- Results for analysis can be easily exported to other Windows applications.

AT MEASUREMENTS

Versatile – Many different types of test are all performed automatically. The range of tests available is being constantly expanded, but common test types include:

- Continuity

- DC Resistance

- Primary Inductance (Series or Parallel)

- Q Factor

- Equivalent Resistance (Series or Parallel)

- Leakage Inductance

- Capacitance

- Turns Ratio and Phasing

- Inductance with Bias Current (Series or Parallel)

- Insulation Resistance

- Magnetizing Current

- Open Circuit Voltage

- Hi-Pot (DC)

- Hi-Pot (AC)

- Surge Stress Test

- Hi-Pot Ramp (AC)

- Hi-Pot Ramp (DC)

- Modular Upgrades - Each individual test is independent of the others, therefore only the tests required need to be purchased for each tester. Additional tests may be added as required via a firmware upgrade, see chap 7 section 1.1 for the tests currently available.

- Fast - Achieving an average of 10 tests per second *including switching of the relay matrix.*

- Accurate - Fully programmable signal sources and high-resolution 'intelligent' digital measurements.

- Reliable - Totally integrated signal sources, switching matrix and measurement circuits under microprocessor control ensure low stress on all circuits.

OVERVIEW

The next section gives a more detailed overview of your AT3600 Tester and how to use it. It is recommended that you read this section before attempting to use your tester.

AT3600 OVERVIEW

TOPICS COVERED IN THIS OVERVIEW

- The features and functionality of the AT3600 tester.

- Internal functionality.

- How the tester executes each test.

- What appears in a test program.

- How programs are created, archived and then used in actual test.

- Test fixtures.

- Typical manual and robotic test situations.

- Safety systems.

Note: This overview is intended as an introduction to each of the above topics, so that you may quickly understand what may be possible. If further details are required on any topic, they can be found in later chapters of this manual.

BEHIND THE FRONT PANEL

The internal functionality of the AT3600 tester is summarized in the following figure:

```
                    ┌─────────────────────────┐
                    │       Test Nodes        │
                    └─────────────────────────┘
                              ↕
                    ┌─────────────────────────┐
                    │  Relay Switching Matrix  │
                    └─────────────────────────┘
                        ↕              ↕
        ┌──────────────────┐   ┌──────────────────────┐
        │   Test Sources   │   │ Measurement Circuits │
        └──────────────────┘   └──────────────────────┘
                        ↕              ↕
                    ┌─────────────────────────┐
                    │       Processors        │
                    └─────────────────────────┘
                        ↕              ↕
        ┌──────────────────┐   ┌──────────────────────┐
        │ Keyboard & Display │   │     Interfaces      │
        └──────────────────┘   └──────────────────────┘
```
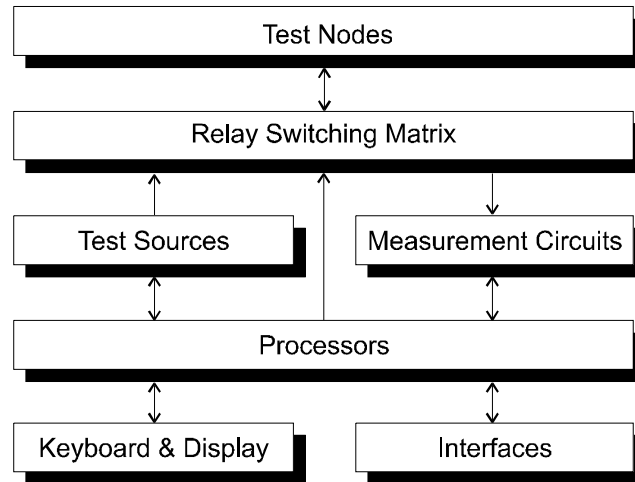
You do not need to know how each block functions in order to use the tester. The following explanation is included for readers who wish to know more.

Test Nodes

These are the spring-loaded ATE pins that can be seen on the top surface of the tester.

Each node is made up of two contacts - a 'power' pin, and a 'sense' pin - forming a Kelvin pair.

Relay Switching Matrix

The purpose of the relay-switching matrix is to connect the selected test source and measurement circuits to the particular nodes required in the test.

The matrix is a crucial component in the performance of the AT Series tester. It is made up of very advanced, high speed, high voltage reed relays, capable both of holding off the 7000V test voltages used in Hi Pot tests, and of accurately switching the very small voltages and currents encountered in other tests. (Lower voltage rating relays are used on the AT1600).

The switching of the relays is carefully controlled by the processors so that there is no arcing across the contacts. This means that the life of the relays can be guaranteed to last for many millions of switching operations.
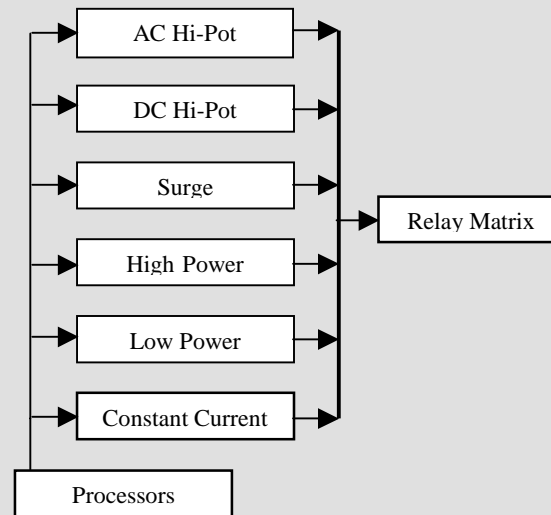
Processors

The AT Series Testers are based on a two-processor design:

A standard microprocessor which acts as controller, and also drives the relay matrix, the keyboard and display, and the various interfaces.

A fast digital signal processor that controls the test sources and performs the measurements.

Test Sources

```
           ┌──────────────┐
     ┌────▶│   AC Hi-Pot  │────▶
     │     └──────────────┘
     │     ┌──────────────┐
     ├────▶│   DC Hi-Pot  │────▶
     │     └──────────────┘
     │     ┌──────────────┐              ┌──────────────┐
     ├────▶│    Surge     │────▶  ┌─────▶│ Relay Matrix │
     │     └──────────────┘       │      └──────────────┘
     │     ┌──────────────┐       │
     ├────▶│  High Power  │────▶
     │     └──────────────┘
     │     ┌──────────────┐
     ├────▶│   Low Power  │────▶
     │     └──────────────┘
     │     ┌──────────────┐
     ├────▶│Constant Current│────▶
     │     └──────────────┘
     │     ┌──────────────┐
     └─────│  Processors  │
           └──────────────┘
```

There are six different test sources within the AT3600.

The processors select which one is to be connected to the relay matrix, as each test is executed.

Measurement Circuits

The AT3600 tester contains a variety of circuits, capable of performing all the following measurements:

- Voltages from less than 1mV to greater than 7000V,
- Currents from nano-amps to amps,
- DC and harmonic analysis,
- RMS, mean-sense, wattage and VA analysis,
- Transient capture,

and more.

Again, the processors select which is appropriate for each test as it is executed.

Keyboard & Display

The front-panel of the tester contains an LCD graphics panel display, three LED's, and a membrane type alpha-numeric keyboard.

To give the greatest versatility and ease of use, the front panel ergonomics are based around four 'soft-keys', which are situated to the right of the display. During operation, the display provides titles for these keys, allowing them to change with the context, so that the operator is presented with only the key choices that are relevant at that point in time.

Interfaces

These include the Remote, Bar Code, Auxiliary and Server Ports located on the rear panel, and the User Port that is at the rear of the top surface.

HOW DOES THE AT3600 TESTER RUN A TEST?

Because the programming of each test is done at a high level, it is not strictly necessary for you to know the details of how tests are executed within the tester. However, for some users this subject may be of interest, therefore a brief explanation has been included here.

When the test program is loaded into the tester, each individual test is assembled into a sequence of operations involving the components in the functional block diagram shown previously. The sequence is different for each test, and in some cases, it depends on which are the preceding and following tests in the program; but in all cases, it is optimized to give the best measurement speed and accuracy.

As an example, the sequence for measuring inductance may be summarized as follows:
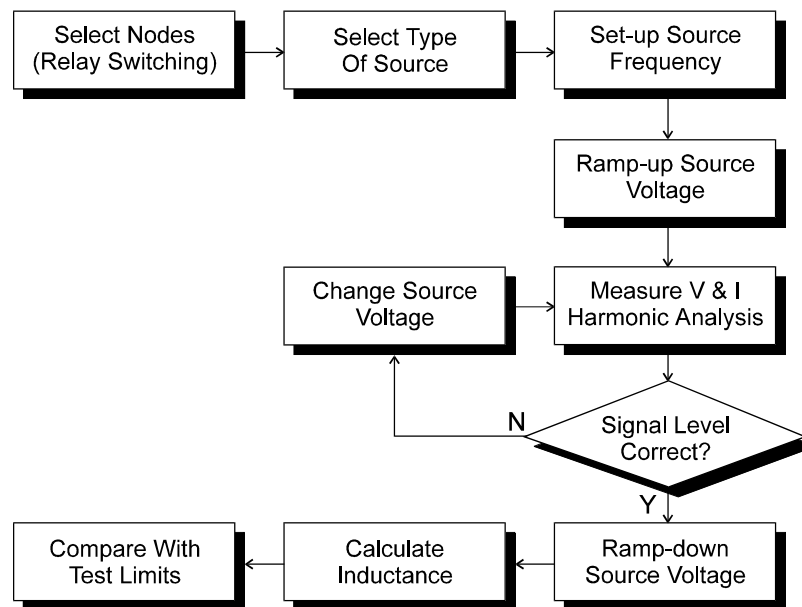
For other tests, the sequence may be more complicated.

Notes: All the relay switching is completed before the test source is energized; this will ensure that there can be no arcing, and prolong the life of the relays.

In contrast to some LCR bridges, the AT Series testers trim the test source to give the user programmed test conditions. This will guarantee that the same test conditions are applied to all transformers that use the same test program.
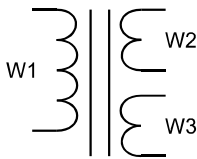
At the end of the test, the source is safely ramped down, so that the relay switching for any subsequent test will always occur with the source removed.

CREATING PROGRAMS - THE EDITOR

The test program is simply the list of tests that you wish to apply to your transformer.

Clearly individual transformers will each have their own program, but as an example, a typical program for a three winding switch-mode power supply transformer could be as follows:

Program:

```
Resistance    W1
Resistance    W2
Resistance    W3
Inductance    W1
Turns Ratio   W1 to W2
Turns Ratio   W2 to W3
Hi-Pot        W1 to W2 + W3
```

Part Number: SMPSE42-A

The Test Program Editor supplied with your tester allows you to create such a program simply and easily without any need for software programming skills. Each test required for the program is selected from a list of 'available tests' by clicking with the mouse. The test details (such as the transformer terminals, test conditions, and pass / fail limits) are then entered into a form fill dialogue box.
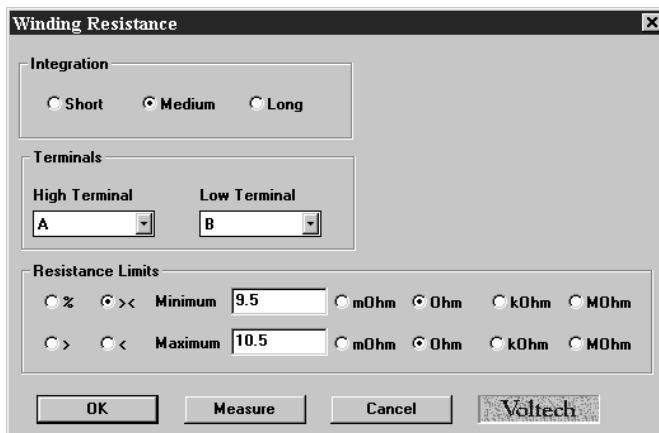
Normally, the Editor is used with the Auxiliary Port of the Tester connected to a spare Com-Port on the PC:

Auxiliary port

PC running the
Editor software
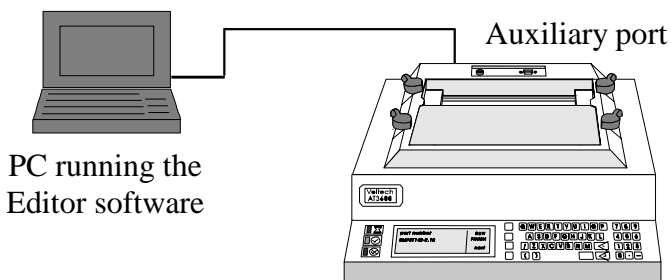
Pull-down menus in the Editor would then allow you to download the program to the tester, so that it may be run for the purposes of evaluation and modification.

STORING PROGRAMS AND RESULTS - THE SERVER

The Editor software previously described, allows you to create and evaluate each individual test program. It is not intended to manage the large numbers of test programs that may be required on a daily basis once they are in 'production' use. This is the function of a second PC program supplied with your AT3600.

Usually, the Server would be installed on a PC with access to a large disk, which could be attached to the PC itself, or connected via a network. The Server (and disk) could then be optionally used for either or both of two purposes:

- To provide the master archive for test programs

- To archive test results

The tester has a separate 'Server' port on its rear panel for connecting to the Server.

TRANSFERRING PROGRAMS BETWEEN EDITOR AND SERVER

Within your establishment, there are several possible ways in which the Server and Editor may be installed and used, depending on how many separate PC's are available.

The standard installation uses separate PC's for the Editor and Server:

Programs

Auxiliary Port   Server Port
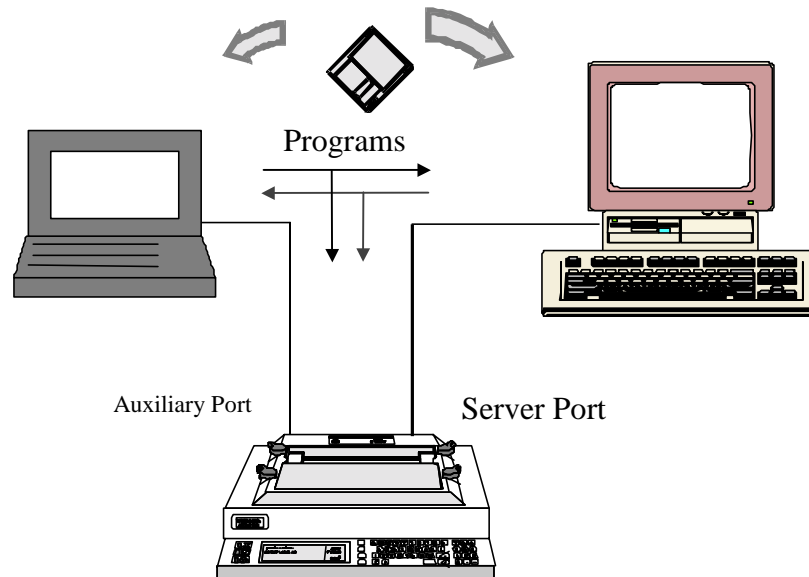
Transferring a new test program from the Editor to the Server archive can be done in any of three ways:

- Via the tester

- Directly from PC to PC via a floppy disk

- Via a network connection between the PC's using 'Save As' in the Editor to transfer the program to the directory used by the Server for programs.

With both Server and Editor installed on the same PC

Auxiliary port

(Connected when
using the Editor)

Server Port
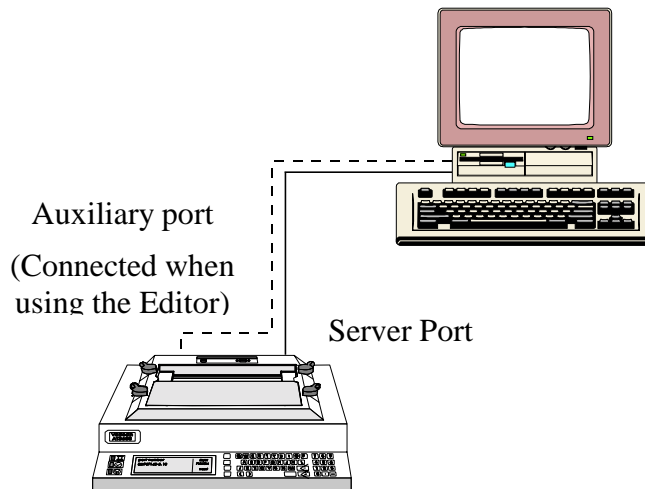
Transferring a new test program from the Editor to the Server archive can be done in
either of two ways:

- Via the tester (if the Auxiliary Port connection is made)

- Directly from the Editor using 'Save As' to the directory used by the Server
  for programs

EXECUTING PROGRAMS

Within your establishment, there are many ways in which an AT3600 and Server may
be installed and used.

Large Production Facility

The standard installation in a large production facility could use several testers,
together with a Server PC for test program and results archive:

Results

Programs

Server port
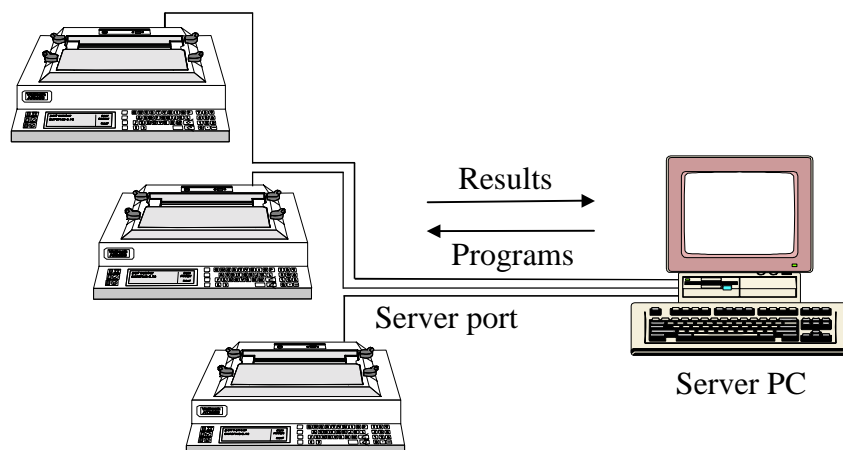
Server PC

Advantages

- Convenient storage and management of large numbers of test programs (e.g. >1000).

- Easy storage and management of test results.

- Importing results into other Windows applications for analysis.

- The Server PC could be located away from the test area, for example in a supervisor's office, allowing results analysis to be performed where it is required.

- Up to 8 AT Series testers may be connected to each Server PC

Limitations

- Requires the Server PC to be permanently connected. This is to allow the tester uninterrupted access to the server, for the purposes of accessing programs and storing results.

- Usually requires an additional PC (which could be a portable) to be attached locally to (the Auxiliary Port of) one of the testers when a new program needs to be developed and evaluated.

Small Production Facility

At the other extreme, possibly more suitable for a small production facility with a single AT Series tester and limited or temporary access to a PC:

- Connect the AT to the PC (running both Editor and Server software) as shown above when developing the test programs.

- Download a group of programs from the Server to the AT, where they will be held in the internal non-volatile memory.

- Remove the PC, and run all the production test programs from the AT internal memory.
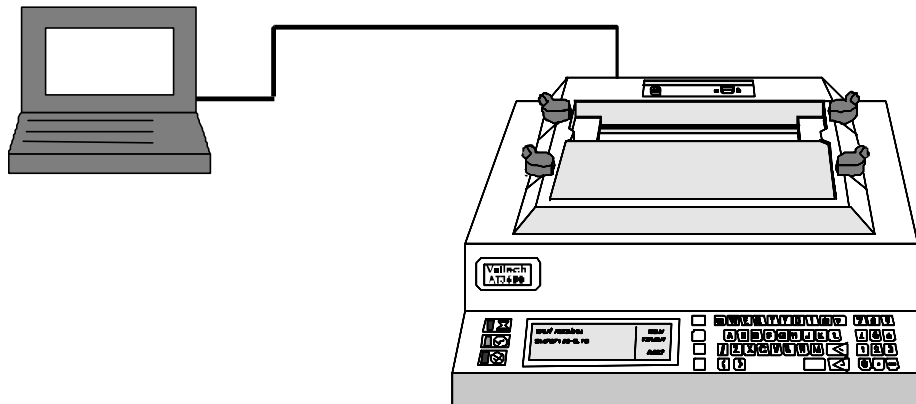
Advantages

- Requires only occasional use of a PC (which could be a portable) to develop test programs and load them into the AT.

- Test programs can be executed by the AT without the PC attached, which may be of advantage if the working space is limited.

Limitations

- Suitable for small numbers of test programs (e.g. <50).

- Test results cannot be archived to disk, or analyzed by other Windows based applications.

TEST FIXTURES

When running the test program in production, how do you connect your transformer with its own arrangement of terminals to the test nodes of the AT Series tester?

The AT Series has been designed with its own test fixture system to answer just this question:

- Fixtures are constructed on a standard 'fixture board' which fits into the top surface of the tester.

- The fixture system uses Kelvin connections to give the best possible measurements when testing wound components.

- The fixture system will accommodate different types of connectors suitable for both PCB mounting and flying lead transformers.

- A single test fixture can be used for all transformers wound on the same bobbin.
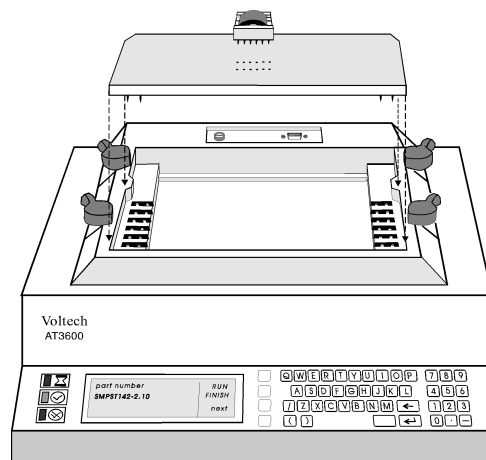
OPERATING THE AT SERIES TESTERS IN PRODUCTION TEST

The AT3600 has been designed to work in both manual and robotic production situations.

Manual Use

In manual use, the tester is simply placed on a work surface in front of the operator.

The tester may be connected to a Server PC, or used stand-alone as described previously.

The operator instructions are very simple:

- At the start of a batch, enter the name of the test program together with any additional information required, for example the batch number.

    Data entry may be via the keyboard, or via a bar-code reader connected to the Bar Code Port on the tester.

    The list of additional data entries is stored in each test program, and may be different for each program.

- Fit the required test fixture, if it is not the same as used for the previous batch.

    This may not always be necessary as several transformers can all use the same test fixture.

    Fixtures are easily changed in a matter of seconds.

- Insert the first transformer into the test fixture, and press RUN.

    The 'RUN switch' can be a front-panel key or an auxiliary switch, for example, a foot-switch connected to the Remote Port on the rear panel of the tester.

- At the end of the test, remove the transformer and place it in the 'Pass' or 'Fail' bins as indicated by the tester's display.

    Optionally, the tester may be attached to a printer, allowing a printed copy of the test results to be either retained for archive, or attached to each tested component.

    The printout may be configured for all test data, or only following a 'fail'.

- Continue in this way for the remaining transformers in the batch.
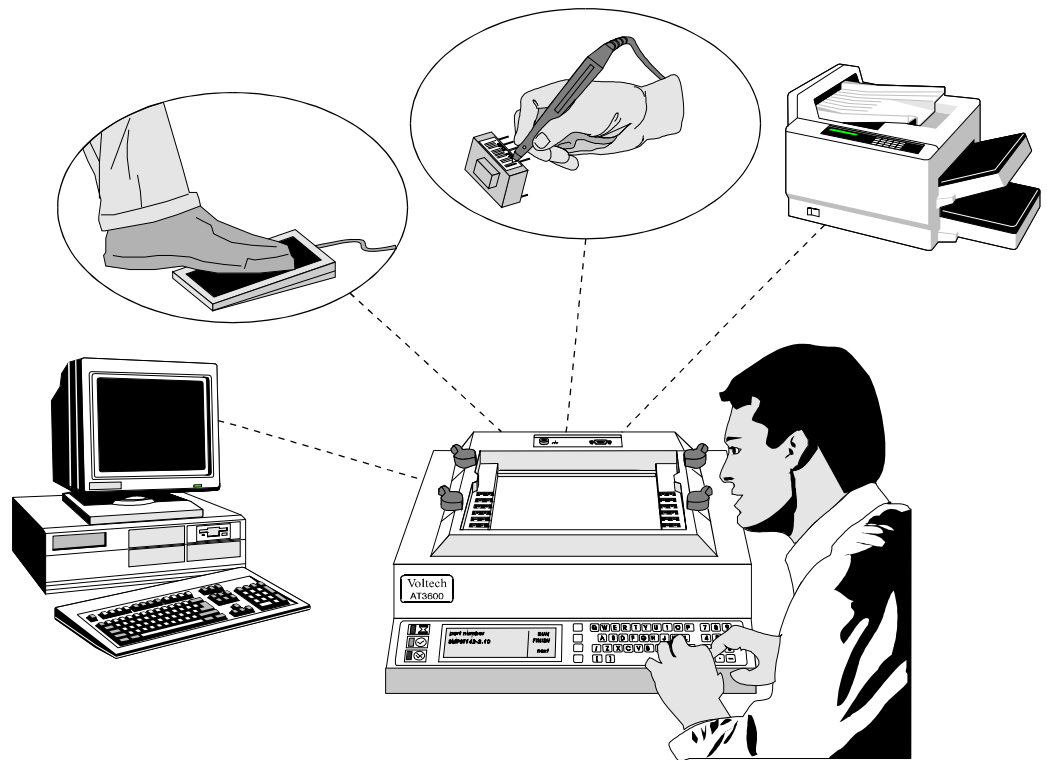
Robotic Situations

In robotic situations, the tester's Remote Port provides the following signals for connecting into your system:

RUN	input	PASS	output
STOP	input	FAIL	output
BUSY	output	BEEPER	output
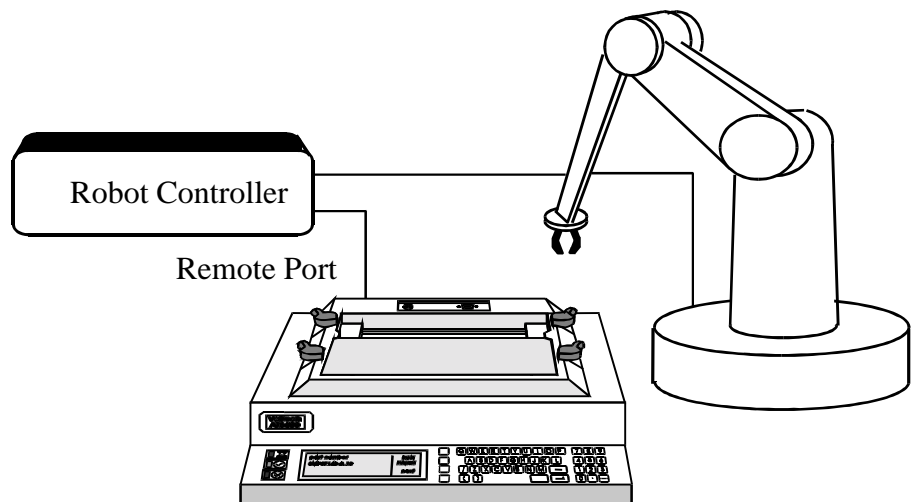
Again the tester may be connected to a Server PC, or used stand-alone as described above.

OPERATOR SAFETY

The AT3600 is capable of generating high voltage test signals that could cause operator injury.

The AT3600 design includes a Safety Interlock connector on the rear panel. The safety interlocks must be properly connected before any high voltage test is allowed to execute.

1. For a test situation that only uses low voltage tests, the tester will operate satisfactorily without any safety interlocks. Low voltage tests include:

   - Continuity

   - Winding Resistance

   - Winding Inductance (Series or Parallel)

   - Q Factor

   - Equivalent Resistance (Series or Parallel)

   - Leakage Inductance

   - Interwinding Capacitance

   - Turns Ratio

2. For manual operation, if high voltage tests are required, the Voltech safety system is recommended. This is based around the use of Infra Red light beams to provide a safety curtain, and has the advantage of not slowing test throughput.

   The following are some of the tests which will not function without a safety system:

   - Insulation Resistance

   - Magnetizing Current

   - Open Circuit Voltage

   - Hi-Pot (DC) & (AC)

   - Hi-Pot Ramp (DC) & (AC)
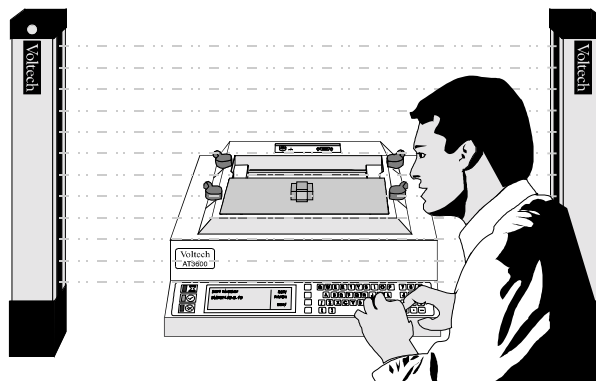
3. Alternatively, you may construct your own safety system based on a mechanical barrier fitted with safety switches.

   In a robotic situation, this could take the form of a walled off area with the interlocks in the door.
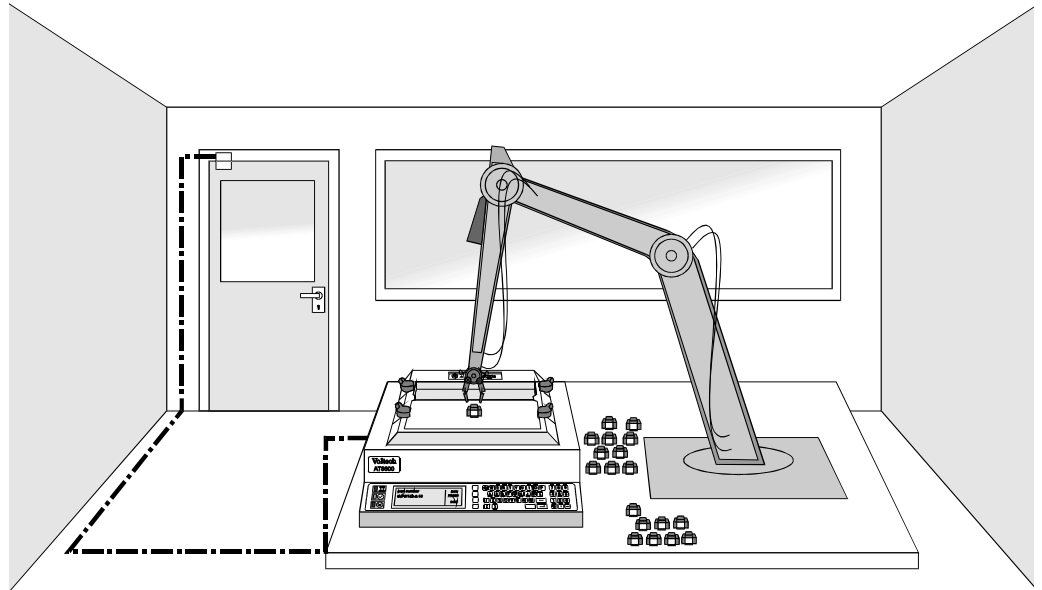
GETTING STARTED

The quick start tutorial of Chapter 2 will take you through many of the AT3600 features using a step by step approach to creating and using a program.

CHAPTER 2 – GETTING STARTED

TABLE OF CONTENTS

This chapter will guide you through the process of setting up and becoming accustomed to basic aspects of the AT3600 tester and its associated software.

1. INTRODUCTION

Welcome to the Voltech AT3600 transformer tester, and its associated editor and server software packages.

Once installed:

- The AT3600 will enable you to rapidly, accurately and reliably test wound components in your production or goods inwards environment.

- The editor will enable you to quickly and easily create test programs for your tester, without any specialized knowledge of computer programming.

- The server will provide a storage system for archiving both the test programs and the test results.

In this chapter, you will learn:

- How to install the tester.

- How to setup the editor and server software.

- How to create and run a simple test program.

- How to upgrade your AT series tester's firmware

2. INSTALLING THE AT3600 TESTER

2.1. PACKAGE CONTENTS

The following items are supplied in the packing case along with this manual:

1. AT3600 transformer tester.
2. Power cord.
3. CD-ROM inside the cover of this manual, which contains the Editor and Server installation files and other important information.
4. 9pin'D' – 9pin'D' F-F Cable.
5. 9pin'D' – 25pin'D' F-F Cable.
6. 25pin'D' – 25pin'D' F-F Cable.
7. This AT3600 user manual.
8. Calibration certificate.
9. A Voltech product registration card.

Please report any missing items to your Voltech supplier.

Returning your product registration card will ensure that you continue to receive the latest product and application information.

2.2. INSTALLING THE TESTER

- Place the tester on a suitable work surface in the position where it is to be used.

  Before deciding on the exact location, it may be useful to refer to Chapter 10 of this manual which describes a safety system to protect operators from the high voltages which may be present on the components under test.

- Connect the tester's auxiliary port to a spare COM port on the PC as shown.

Auxiliary Port
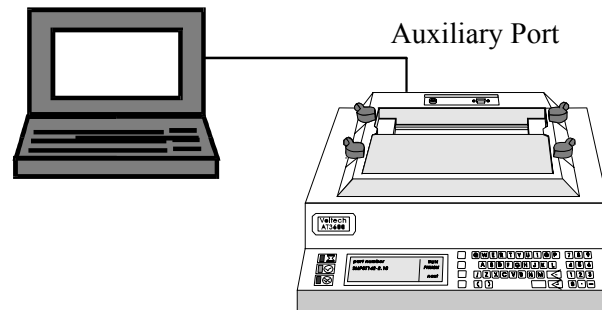
- Switch on the supplies to the PC.

- Ensure that the top surface of the tester is not fitted with any test fixture and nothing is touching any of the test nodes. Connect the tester's line input to the available supply, and switch on.

You must connect the power lead to a socket with a safety ground contact.

Do not try to connect the safety interlocks at this stage. They are for your protection and prevent the AT3600 from producing harmful voltages.

For full operation of the testers with high voltage tests, the safety interlocks must be properly connected to a Voltech approved safety system - see Chapters 8 and 10 of this manual.

2.3. INSTALLING THE EDITOR SOFTWARE

Connect the tester's auxiliary port to a spare COM port on the PC as shown. The cable that is used will be determined by the type of PC connector. For most PC's this will be a 9-pin female (PC) to 9-pin female (AT3600).

Switch on the power supply to the PC

Before attempting to install the Editor, check that your PC satisfies the following hardware requirements:

PC Processor	486 or better
Memory	4MB minimum
Hard Disk Space	2MB minimum
Operating system	Windows 95 or newer
Supported screen resolutions	640 x 480, 800 x 600
	1024 x 768, 1280 x 1024

To install the Editor software, place the AT series CD-ROM supplied with your tester into the CD-ROM drive of the computer and follow the on-screen instructions.

The set-up program will suggest a directory in which to place the Editor files:

c:\Program Files\Voltech Instruments\Voltech AT Editor

This directory will be created if it does not already exist. If you want to place the files elsewhere, browse to another directory.

If you have a previous version of the Editor software already installed on your PC, the procedure outlined above may also be used to install a new version. None of your program files will be lost. The same Editor program is used for all AT Series testers (excluding the discontinued AT3500 and AT1000).

PC COM PORT CONFIGURATION

When the installation of the Editor has been completed, you will see the Editor icon in the program group 'Voltech Software'. Double-click with the left mouse button on the Editor icon to start the program.

Initially configure the Editor to use the chosen COM Port:

1. From the Top Level '**Setup**' menu, select '**Communications**'.
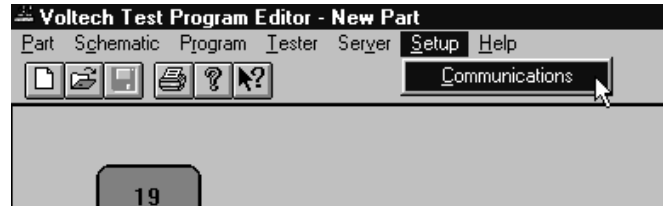
2. In the dialogue box shown here; select the PC communications port which is connected to the tester.
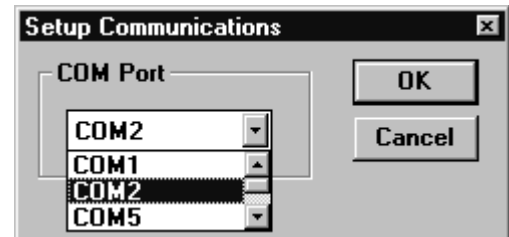
> **WARNING: If the chosen 'COM' port is reserved by another Windows application, an error message will appear. You should select another port.**

2.4. INSTALLING THE SERVER SOFTWARE

Check that your PC satisfies the following hardware requirements:

PC Processor	486 or better
Memory	4MB minimum
Hard Disk Space	3MB minimum

(Note: 3MB does not include disk space required for storing programs or test results)

Operating system	Windows 95 or later

To install the Server software, follow the same basic instructions as for the Editor. The Server is often installed on a different PC to that which will be used for the Editor, depending on your production needs. A Server PC needs to be permanently connected to the AT600 only if you wish to store test results or use a central program store rather than the AT3600's own memory.

2.5. SERVER HARDWARE CONNECTIONS

In some applications, you may wish to position the Server PC some distance away from the tester, which will require a cable longer than the one supplied. The AT Series Server Port connector details are shown in Chapter 8 to enable you to make up a cable of the length you require.

To use more than one AT Series Tester with the same Server host PC, an intelligent COM Port expansion card will be required. The Server application supports the DIGIBOARD XE, eight channel device.
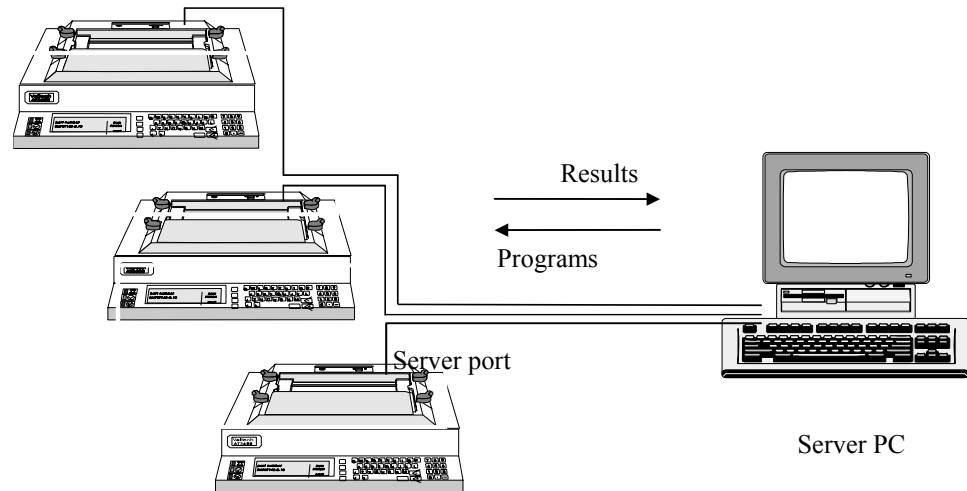
Before installing an expansion card, ensure that the PC is switched off and that you follow all of the manufacturers instructions. All supporting software must also be installed before attempting to configure the Server application.

PC COM PORT CONFIGURATION

Before proceeding any further, check within the MS Windows Control Panel to ensure that the desired COM Port(s) are recognized by Windows.
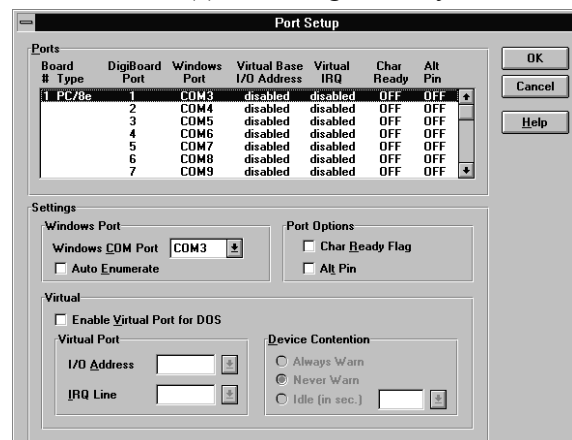
Example of setup for DIGIBOARD XE

2.6. SERVER SOFTWARE SET UP

When the installation of the Server has been completed, you will see the Server icon in the program group 'Voltech Software'. Double-click with the left mouse button on the Server icon to start the program.

Before you can use the Server, the PC communication channels must be assigned for each tester connected.

When the Server is executed for the first time, the following dialogue will be displayed:
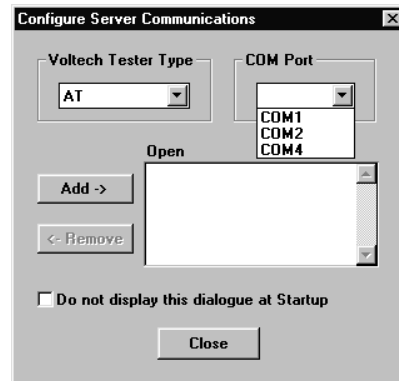
A check box 'Do not display this dialogue at Startup' exists to prevent it from being displayed each time the Server application is launched. When this option is activated, this dialogue box can be accessed via the 'Setup', 'Communications...' menu.
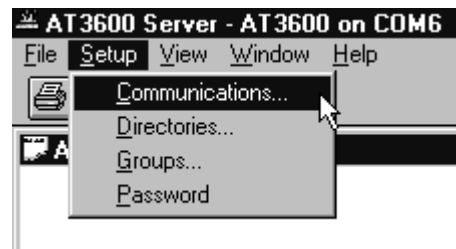
To assign a particular AT Series Tester to a COM Port:

1. Select the communication port to which your tester is connected from the COM PORT selection box.

2. Click on the ADD button to append your connection to the current connection list.

3. To remove a current connection select it from the list and then click on the REMOVE button.

IMPORTANT:
You must have at least one AT Series Tester connection to use the program transfer or real time results functions of the Server application.

The final stage of setting up the server involves specifying the file location paths.

The directory setup dialogue will prompt you with the current directory. Change these settings if you wish to nominate your own program and results storage directories.

```
Set Default Directories                                    ☒

Program Directory :   C:\AT3600\SERVER

Results Directory :   C:\AT3600\SERVER

              [    OK    ]          [   Cancel   ]
```
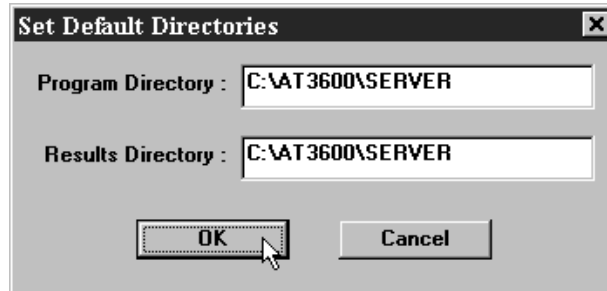
The setting of storage path directories may be altered at any time. The directory setup dialogue may be found under the SETUP section of the menu bar.

IMPORTANT:
If you change the factory default settings, remember that the Server will only look in the directories specified for test programs or results.

3. QUICK START TUTORIAL

2.3.1 QUICK START TUTORIAL

After you have installed the AT3600, together with the editor and server software packages as described in the previous section you may wish to follow through this tutorial before trying to create any programs for actual use.

The purpose of this tutorial is to familiarize you with the process of creating a schematic and a test program using the editor. The program you will create will only run if your tester has been installed with the tests used.

CREATING A SCHEMATIC OF A 2-WINDING, 4-TERMINAL SAMPLE TRANSFORMER

This tutorial describes a method of setting up the tester to test a two winding transformer with the following specification:

Resistance of winding AB   (59 to 73Ω)

Resistance of winding CD   (59 to 73Ω)

Inductance of winding AB   (>3H)

Turns ratio AB to CD   (1:1 ± 2%)
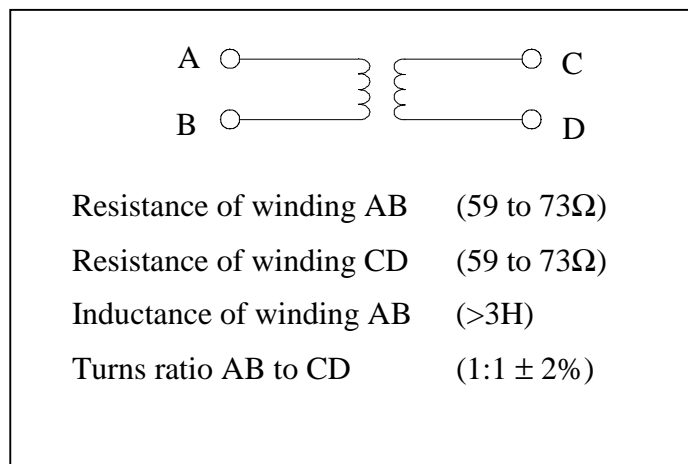
Before proceeding ensure that the tester is connected to the editor PC as described in chapter 2.2.

Having started the editor program by double-clicking with the left mouse button on the editor icon, the first thing to do is to 'draw' a schematic of the transformer to be tested.

Using the left mouse button, click on 'Schematic' on the Top Level menu bar, and select 'Add Winding' from the menu.
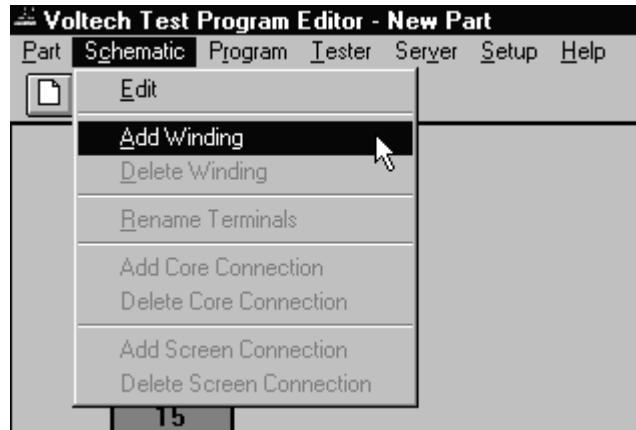
You will now see a winding with two terminals, floating below the mouse pointer.

Place the winding on the left hand side of the screen and press the left mouse button.

A dialogue box will ask you to name the terminals of the winding; the cursor will be in the box for Terminal 1.

Type the name of the Terminal 1 (e.g. 'A').

Press TAB to move to the Terminal 2 box, and type the name of the second terminal (e.g. 'B') in that box. Then click OK or press [Enter].

Repeat steps 1-3 to create a second winding.

This time place the winding on the right hand side of the screen, a mirror image of the first winding, and use different terminal names (e.g. 'C' and 'D'). The screen should then look like this:
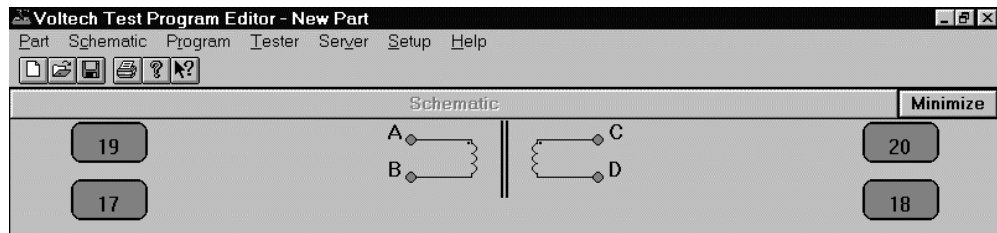
Now you must connect the windings to the test nodes of the tester:

Place the mouse pointer over terminal A; press and hold the <u>right</u> mouse button. Continue holding this mouse button down and drag the mouse pointer to test node 9. Release the button. A wire will now connect terminal A to test node 9.Repeat this procedure to connect the other three terminals, B, C and D to nodes 7, 10 and 8. The screen should now look like this:
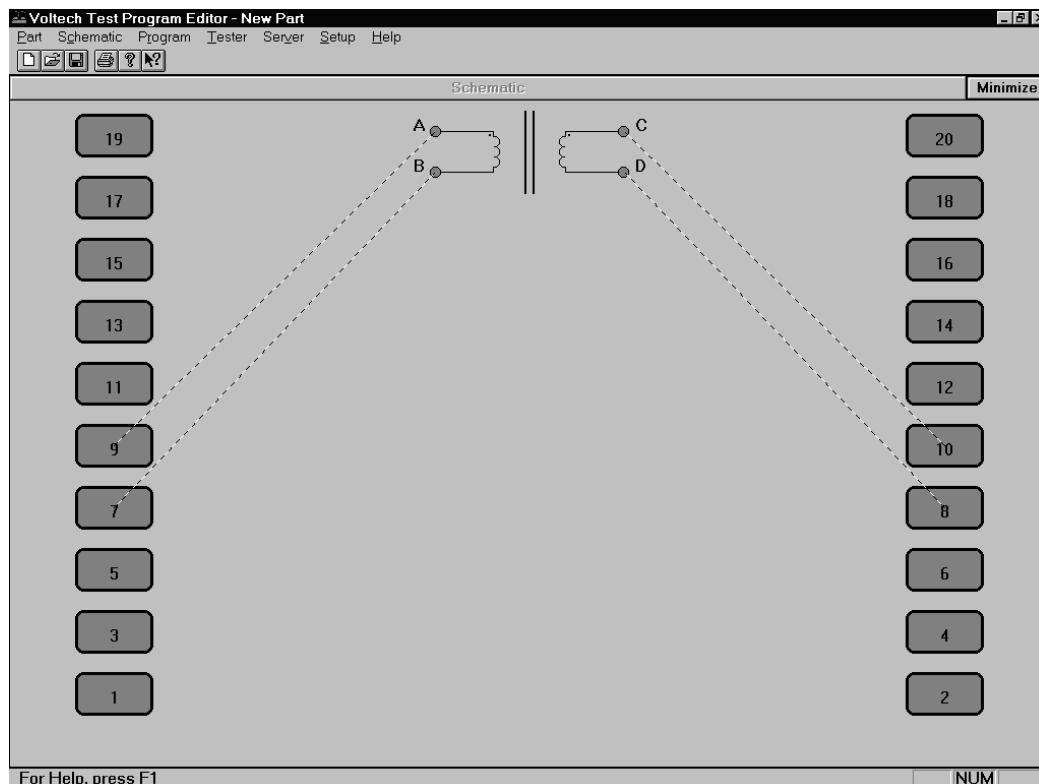
You have now created a schematic layout of a four terminal transformer.

CREATING THE TEST PROGRAM

After creating the transformer schematic, you may now create an example program, containing the following four tests:

Resistance of winding AB	(59 to 73Ω)
Resistance of winding CD	(59 to 73Ω)
Inductance of winding AB	(>3H)
Turns ratio AB to CD	(1:1 $\pm$ 2%)

(It is probable that the actual program used to test such a transformer in production would be the same four tests, plus an additional insulation resistance (or Hi-Pot) test to check for winding to winding isolation. This last test has not been included in this tutorial as it would require the use of safety interlocks.)

Initially set up the program options:

From the top level menu bar select:

Program
Options

The following dialogue box will appear:
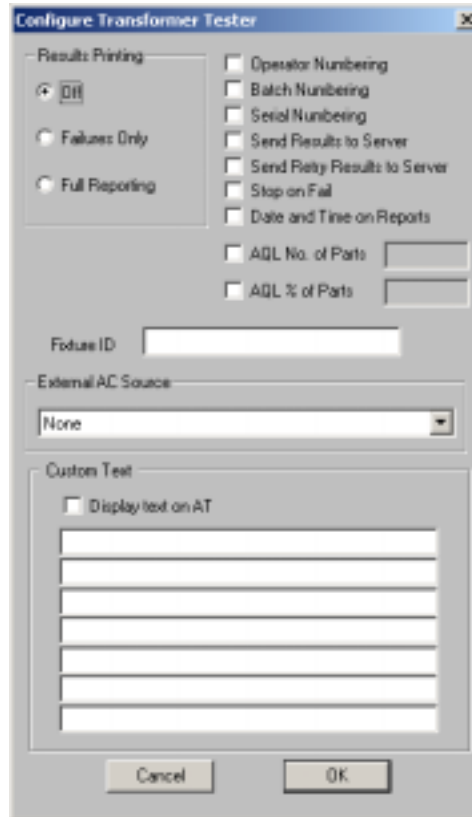
By clicking with the mouse, enable the following option

'Send Results to Server'

In the Fixture ID box, enter the name:

'UNIVERSAL'

Click on 'OK' or press [Return] to accept and close the dialogue box.

You can now move on to create the program:

From the Top Level 'Program' menu, select 'Edit'.

The screen will now be made up of three Windows:

Top left: The schematic window showing the two windings.

Right: The available tests window listing all the tests available on your AT3600. (If the tester is connected all unavailable tests will be greyed out).

Lower left: The Program window displaying the tests programmed so far.

By double clicking the left mouse button, select 'R Winding Resistance' from the 'Available Tests' window.

The following dialogue box will appear.

Initially enter the terminal names. Input 'A' as the high terminal and 'B' as the low terminal, moving between the fill-in boxes using the TAB key.

Now enter the resistance limits. This can be done in four ways:

%   Click on this button to enter a nominal value with a percentage tolerance (for example, 66Ω with 10% tolerance),

><   Click on this button to enter minimum and maximum values (for example, 59Ω and 73Ω),

>   Click on this button to enter just a minimum value (for example, > 59Ω),

<   Click on this button to enter just a maximum value (for example < 73Ω).

In this example, >< limits will be used:
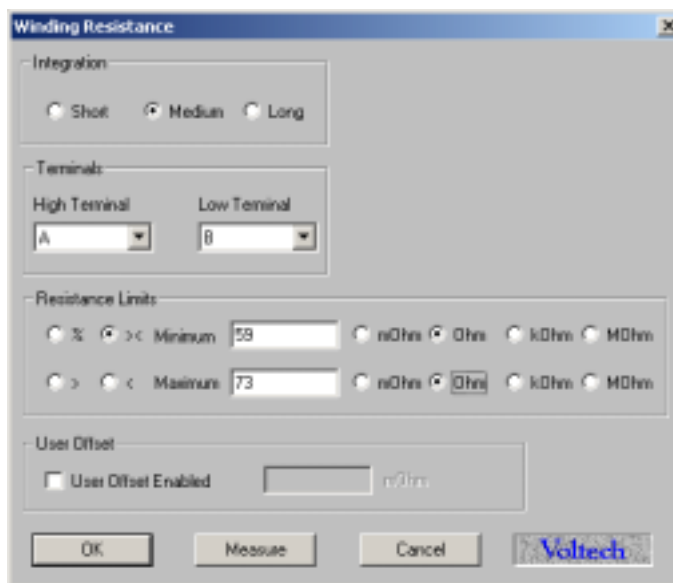
(The 'Ohm' units button is selected by clicking with the mouse.)

If the "User Offset Enabled" check box is checked, a value can be entered into the edit box. The value entered (in the units shown) is then added to any results returned from the AT tester. This function can be used to adjust for measurement fixture effects that cannot be compensated for or to compensate the fixture manually so a compensation stage is not required to obtain the correct readings.

Click on the 'OK' button. The test and its parameters will now appear in the 'Program' window.

```
1.      Winding Resistance
        Integration:  Medium
        High Terminal: A                    Low Terminal: B
        User Offset: 0.0000 Ohms
        Minimum Value: 59.000 Ohms          Maximum Value: 73.000 Ohms
```

Again by double clicking the left mouse button, select 'R Winding Resistance' from the 'Available Tests' window.

At the dialogue box, enter the data as before; this time for the second winding:

Integration	**(Leave as the default - Medium)**
High terminal	**C**
Low terminal	**D**
Minimum	**59Ω**
Maximum	**73Ω**

Click on the 'OK' button. Again the test and its parameters will appear in the 'Program' window.

Now, by double clicking the left mouse button, select 'LS Inductance (Series Circuit)' from the 'Available Tests' window.

At the dialogue box, enter the data required for the inductance test:

Signal	**1V (again choose the V units button by clicking with the mouse)**
Frequency	**50Hz**
Integration	**(Leave as the default - Medium)**
High terminal	**A**
Low terminal	**B**

Click on the ' > ' button to select a minimum limit only, and enter:

Minimum   3   H

The "User Offset Enabled" check box has the same function as before but in units of inductance.

Click on the 'OK' button. Again the test and its parameters will appear in the 'Program' window.

Finally, by double clicking the left mouse button, select 'TR Turns Ratio' from the 'Available Tests' window.

At the dialogue box, enter the data required for the turns ratio test:

> **Voltage**   **1 V**
>
> **Frequency**   **50 Hz**
>
> **Integration**   **(Leave as the default - Medium)**

The AT measures the turns ratio between 'primary' and 'secondary' windings; and allows the possibility of applying the test voltage to a third 'energized' winding. For this example, the primary and energized windings are the same:

> **Energized high terminal   A**
>
> **Energized low terminal B**
>
> **Primary high terminal   A**
>
> **Primary low terminal   B**
>
> **Secondary high terminal   C**
>
> **Secondary low terminal D**

Using the default ' % ' type of limits, enter:

> **Primary : Secondary   1:1**
>
> **Neg   2%**
>
> **Pos   2%**

The "User Offset Enabled" check box has the same function as before but in units of turns ratio.

Click on the 'OK' button. Again the test and its parameters will appear in the 'Program' window.

The lower left window should now contain the complete program. The scroll bars in this window enable you to view each test in the program in turn to check that it is correct.

The editor will not allow a program to be run in the AT unless it has previously been saved:
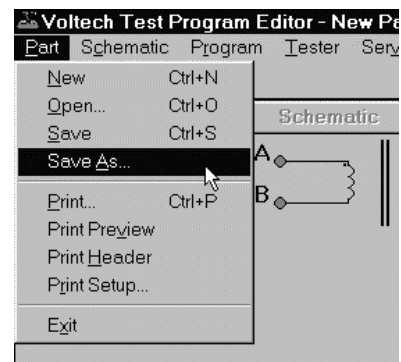
> From the top level
>
> menu bar, select
>
> > **Part >**
> >
> > **Save As**

At the dialogue box, type in

> **TUTORIAL**

as the part name
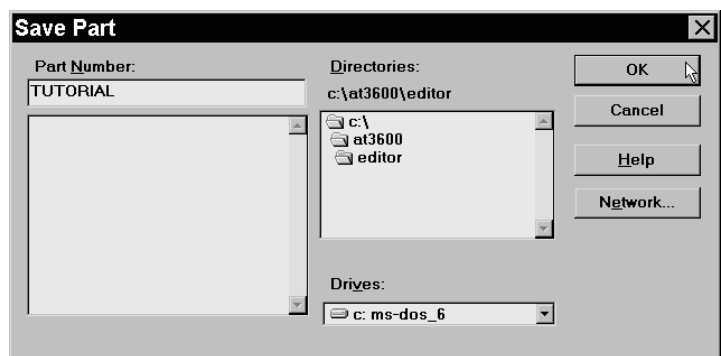
Click on the OK button

to close the dialogue box and save the test program in the editor default directory.

RUNNING THE PROGRAM FROM THE EDITOR

The following section describes how to run a test program from the Editor. To do this you must first create a program which includes only the test options installed in your tester. You will not be able to include any of the following tests until you have fitted your safety interlock system: AC-Hipot, DC-Hipot, Insulation Resistance, Surge, Watts Loss, Induced Voltage (STRW), Magnetizing Current, Open Circuit Voltage.

Having created both the transformer schematic and the test program, the program is now ready to run on your AT3600 tester under the control of the Editor.

Before proceeding further, make sure that the interface cable between the tester's Auxiliary Port and the selected PC COM port is correctly fitted, and that the COM Port is correctly configured in the editor (see page 2.2.5).

Ensure that the tester has been powered on as described in the previous section (page 2.2.2), and the front panel display is showing:

```
Power On Test                        EXECUTE
          PASS                       MEASURE
                                     PROGRAM
                                     SELF-TEST
```
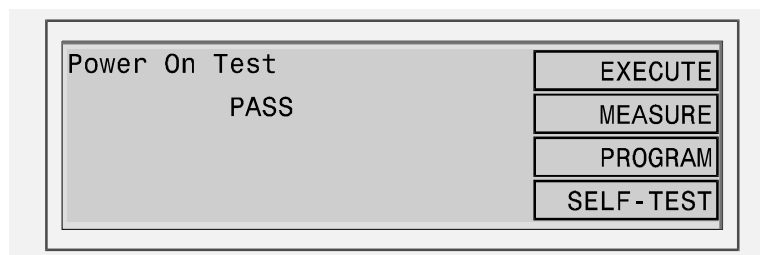
To run the program:

1. From the Top Level menu bar, select

       Tester
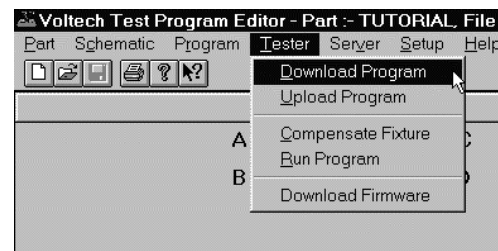
       Download Program

The editor will now download the test program to the AT3600. After a few seconds, you should see a message to say that the download was successful.

If you see a message indicating that the download has failed, check your cable/COM Port connections and try again. If the download continues to fail, reboot your PC and try again.

The front panel of the AT will now display:

```
SAVE PROGRAM                          CONTINUE
Saving this program to the
local store will overwrite
an existing program group.            LOCAL SAVE
```
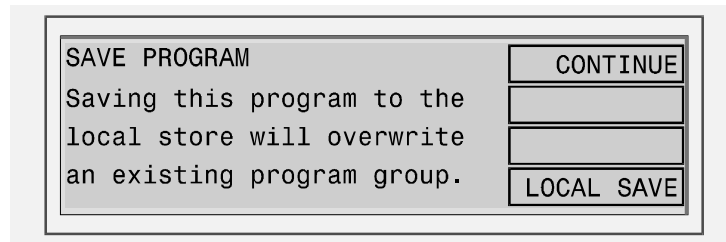
This allows the program to be stored on the AT by pressing the soft key next to 'LOCAL SAVE'. See section 2.3.4. for a description of running the program on the transformer tester.

For now, run the program from the editor software and ignore the AT display:

2. Again, from the top level menu bar, select

Tester

Run Program

The test program will now begin execution.

When it is finished, you will see a dialogue box containing the results of the test.

If the transformer had been connected up as in the schematic to nodes 7, 8, 9, and 10 then the results might be:

```
Test Results                                                    ×

  1   R      65.571 Ohm      PASS   0000
  2   R      65.358 Ohm      PASS   0000
  3   LS     3.7752 H        PASS   0000
  4   TR     1.0151          PASS   0000

RUN TIME   977 msec




            Print          Re-Run Test          Close
```
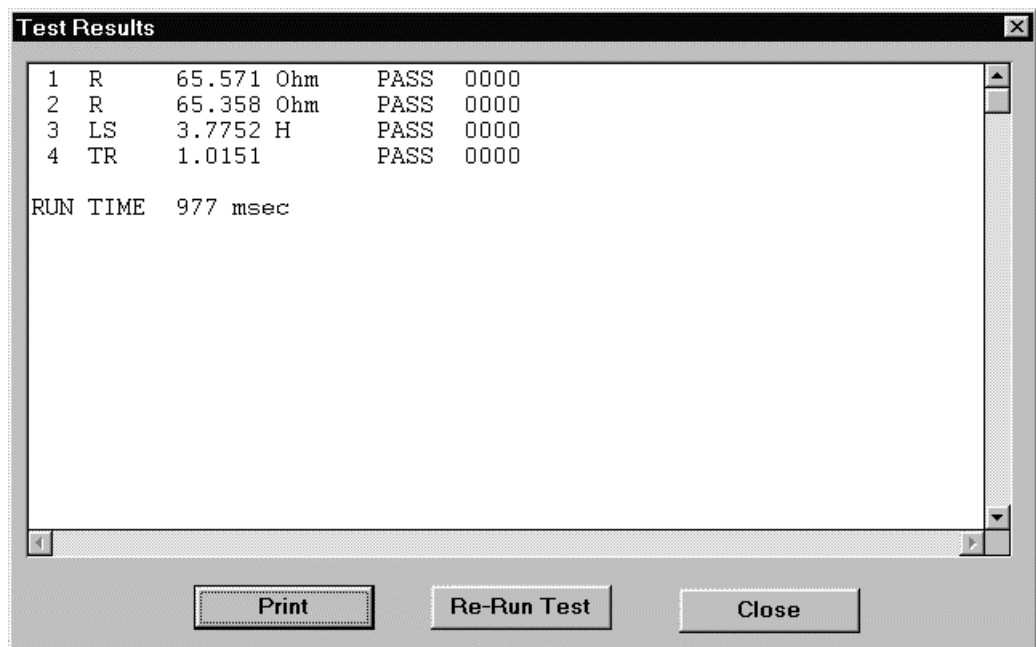
If no transformer is fitted, the results will have no meaning, but **you have now successfully installed the AT3600 and the Voltech AT editor software.**

The results window will give you the options to:

1.   Print the test results.

2.   Re-run the test program.

3.   Close the window.

Closing the window will return you to the top level menu.

2.3.2 QUICK START TUTORIAL – THE SERVER

TRANSFERRING THE PROGRAM TO THE SERVER

The Voltech Server software is supplied with every AT3600. The use of the Server software is required for handling and storage of test results and is recommended for handling large numbers of different test programs.

Having created, saved and tested the program TUTORIAL using the Editor, you are now in a position to run it again on your AT Series Tester, but this time using the Server. The procedure for transferring the program to the Server archive will depend on where you have installed the Editor and Server programs.

EDITOR AND SERVER ON SEPARATE PC'S

In many situations the Editor and Server would be installed on separate PC's (as shown in the illustration on page 2.2.2). In this situation, the AT3600 is used to perform the transfer.

Before proceeding further, make sure that all the following have been set up:

• The interface cable between the tester's Auxiliary Port and the selected COM Port on the Editor PC is correctly fitted, and that the COM Port is correctly configured in the Editor software (see page 2.2.5).

• The interface cable between the tester's Server Port and the selected COM port on the Server PC is correctly fitted, and that the COM Port is correctly configured in the Server software (see page 2.2.8.)

• Both the Editor and the Server software packages are running.

• The tester is still powered on as described above.

To transfer the program, from the Top Level menu bar, select

    Server

    Download Program

The Editor will now down-load the test program to the Server using the AT3600.
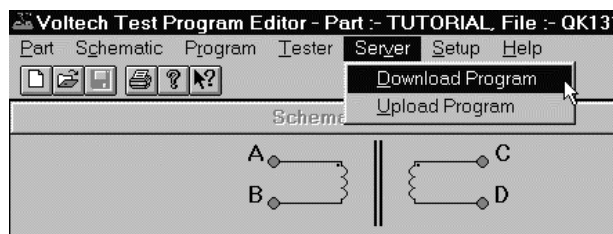
After a few seconds, you should see a message to say that the Download was successful.

If you see a message indicating that the download has failed, check your cable/COM Port connections and try again. If the download continues to fail, reboot both PC's and try again.

EDITOR AND SERVER BOTH ON A SINGLE PC

If the Server and Editor are installed on the same PC, the easiest way to transfer the test program to the Server is to use the Save As menu in the Editor:

From the Top Level menu bar, select

Part >

Save As
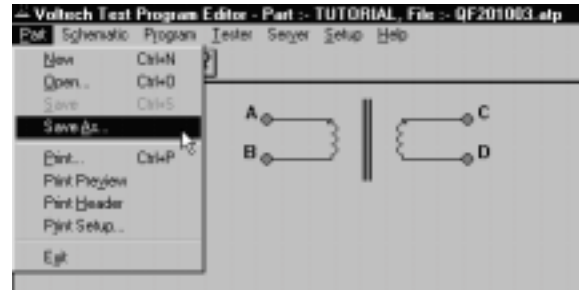
At the dialogue box, type in the part name

TUTORIAL

as before, and change the directory to the one selected for program storage

e.g. C:\AT3600\SERVER
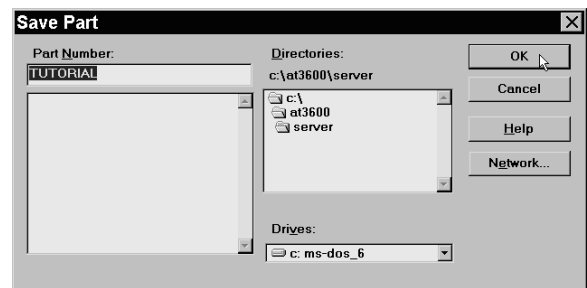
when the Server was installed (page 2.2.6.).

Click on the OK button to close the dialogue box and save the test program in the Server program directory.

The next section of the Tutorial demonstrates running the program on the AT3600 tester from the archive on the Server. Before proceeding to that section, if the Server and Editor are using the same COM-Port on the single PC, re-allocate the COM-Port from the Editor to the Server:

- Close down the Editor by clicking on

  Part >

  Exit

  in the Top Level menu.

- Start the Server by double clicking on its Windows icon.

- Configure the COM-Port as shown on page 2.2.8.

- Remove the cable between the AT Auxiliary Port and the PC COM-Port.

- Connect the cable between the AT Server Port and the PC COM-Port

2.3.3 RUNNING A PROGRAM ON THE TESTER

Having stored the program in the server archive, it is now possible to run the program on your AT3600 in the same way that you would use in production test. (If you do not intend to use the server see also section 2.3.4 - Additional topics to investigate).

Before proceeding further, it may be worth pointing out the main features of the tester's front panel, which will be used in running the program:
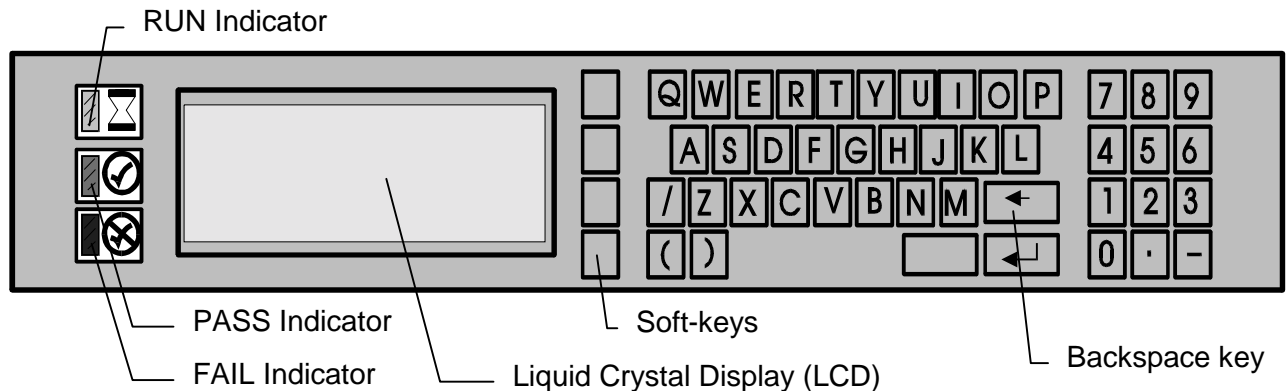
- The LCD display prompts for and provides relevant information.

- The alphanumeric keypad allows you to enter text data such as the part number (i.e. test program name) of the transformer to be tested.

- The 'Backspace' key allows you to correct typing errors during data entry.

- The four 'soft-keys' adjacent to the LCD are provided for functions which vary with different aspects of the tester's operation. The function for each soft-key at any given time is shown in the text boxes at the right hand side of the LCD.

  (Also before proceeding further make sure that the Server is running, with the interface cable correctly fitted between the tester's Server Port and the selected Server PC COM Port, and the COM Port correctly configured in the Server software (see page 2.2.8.).

At this point the AT3600 Tester should be still powered on, the display should still show a 'last transformer' message, produced when the test program was run from the Editor. It will be similar to the following:
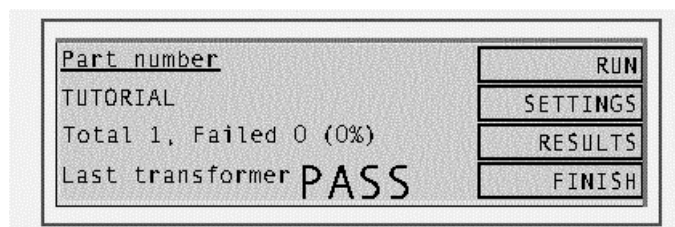
Before running any new test program, return the tester to the top-level menu by pressing the FINISH soft-key (i.e. the 2nd soft-key from the top).

```
                          ┌──────────────┐
                          │     EXECUTE  │
                          │     MEASURE  │
                          │     PROGRAM  │
                          │   SELF-TEST  │
                          └──────────────┘
```
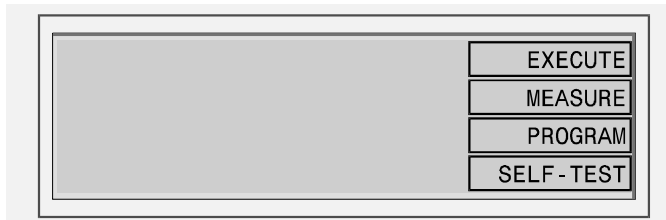
Use the following sequence of key-presses to ensure that the AT is configured to use the Server as the source for test programs:

• Press the soft-key PROGRAM to change to the following display:

```
  Program Mode              ┌──────────┐
                            │   GROUPS │
                            │   SET-UP │
                            │          │
                            │     EXIT │
                            └──────────┘
```
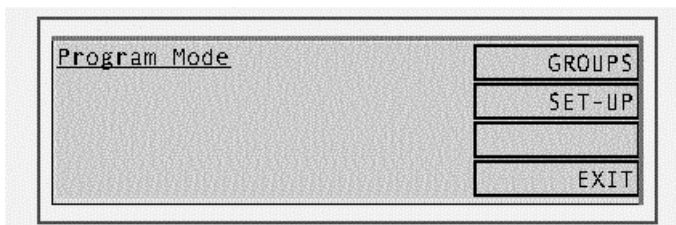
• Press the soft-key SET-UP, and at the following display:

```
  Set-Up                    ┌──────────┐
                            │          │
                            │       ↓  │
  Fail Beeper: SHORT        │CONTINUOUS│
  Pass Beeper: OFF          │     EXIT │
                            └──────────┘
```
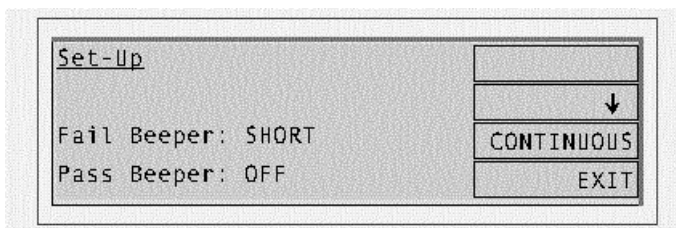
• Press the ↓ soft-key until the third line shows the words 'Program Store':

```
  Set-Up                    ┌──────────┐
  Clock: 2002 May 03 10:09  │       ↑  │
                            │          │
  Program Store: INTERNAL   │   SERVER │
                            │     EXIT │
                            └──────────┘
```
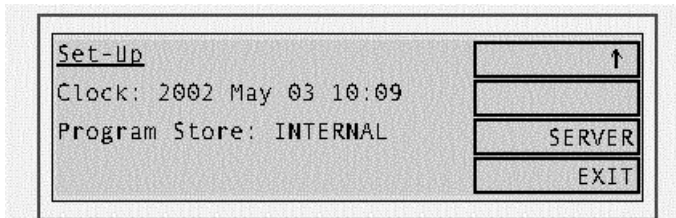
• If, as shown above, the origin is INTERNAL, then press the soft-key SERVER, so the third line reads as follows:

```
  Set-Up                    ┌──────────┐
  Clock: 2002 May 03 10:09  │       ↑  │
                            │          │
  Program Store: SERVER     │ INTERNAL │
                            │     EXIT │
                            └──────────┘
```
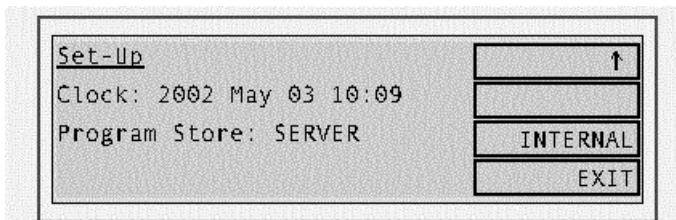
• Press the soft-key EXIT to return to the 'Program Mode' display shown above.

• At the 'Program Mode' display, again press the EXIT soft key, this time to return to the top-level (EXECUTE-MEASURE) display.

```
                                    EXECUTE
                                    MEASURE
                                    PROGRAM
                                  SELF-TEST
```
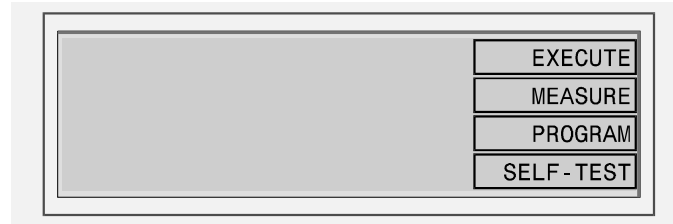
Then, use the following sequence of key-presses to run the test program for the part 'TUTORIAL':

• Press the soft-key EXECUTE to display:
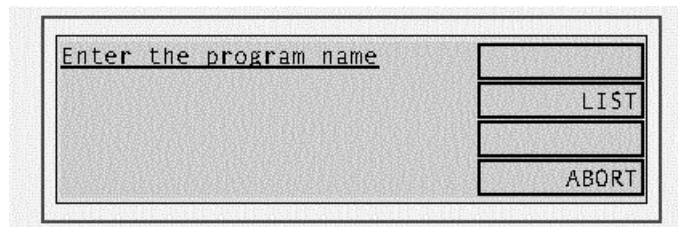
```
Enter the program name
                                         LIST

                                        ABORT
```

• The program name can now be typed at the keyboard, entered by swiping a barcode, or chosen from a list. Press the soft-key LIST to see a list of the programs available on the PC server.

```
Enter the program name               ENTER
Tutorial                               ↑
Program 1                              ↓
Program 2                            ABORT
```
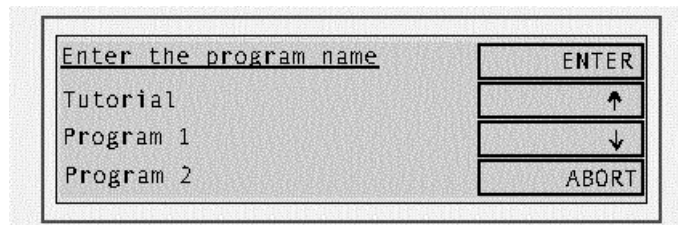
If the list of programs fails to appear after a few seconds, check that the server is running and that the COM port and file folder are correctly configured. Is the cable from the AT3600's server port to the PC fitted correctly?

Use the ↑ and ↓ keys to select the program and press the enter key [↵] or the enter soft-key.

• When the download has been successfully completed, you will see a message to fit the fixture similar to the following:

```
Fit the fixture                 COMPENSATE
UNIVERSAL
with short circuit links
and press COMPENSATE              NO COMP
```
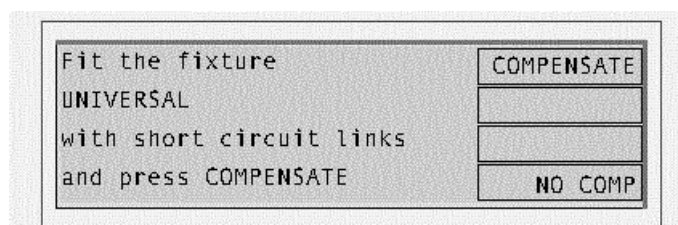
- As the fixture is already fitted, and compensation is not required with the example transformer, simply press the NO COMP. soft-key to move on to the RUN-FINISH display:

```
Part number                    RUN
TUTORIAL                   SETTINGS

                            FINISH
```
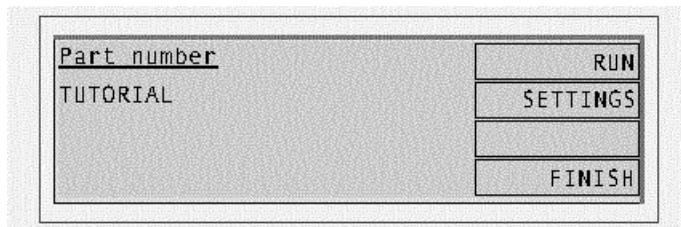
- Press the RUN soft-key to start program execution.

    As the program is running, the RUN indicator (the yellow LED to the left of the display) will be illuminated, and the display will indicate the test currently being executed:

```
Part number
TUTORIAL


Executing test 1               STOP
```
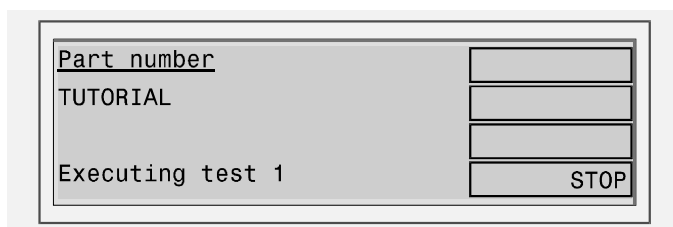
    At the end of program execution, the PASS indicator (the green LED to the left of the display) should be illuminated, and the display should show:

```
Part number                    RUN
TUTORIAL                   SETTINGS
Total 1, Failed 0 (0%)      RESULTS
Last transformer PASS       FINISH
```
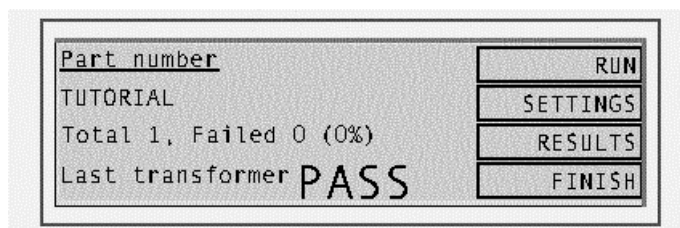
- Press the RUN soft-key several times to repeat the program execution.

    On each run of the program, the test results will be passed back to the Server, where they may be viewed in the 'On-line Monitor' window.

```
AT3600 on COM1                              _ □ ×
1  R      65.569 Ohm     PASS   0000
2  R      65.348 Ohm     PASS   0000
3  LS     3.7441 H       PASS   0000
4  TR     1.0151         PASS   0000
```
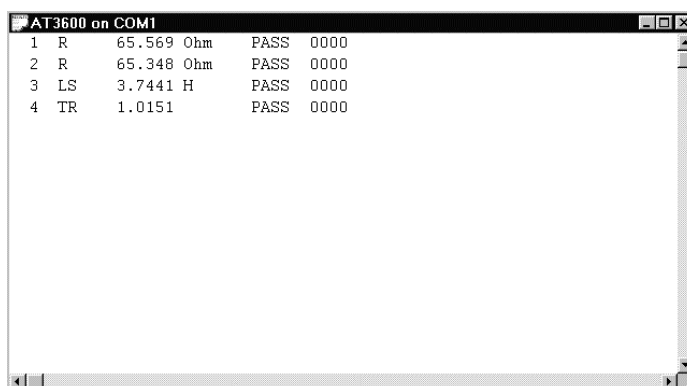
Test results may also be reviewed at any time via the tester's front-panel results listing screen, which is accessible from the RUN-FINISH display by pressing the RESULTS soft-key.

```
#   Type    Result     Status │              │
                              │           ↓  │
1   CTY     0.0000  FAIL  0001 │       PRINT  │
2   LS    -1.196H FAIL  0000 │          OK  │
```

The results listing screen displays all completed tests giving test number, type, result in both value and pass or fail, and status error (for a description of status error codes, see chapter 3). The listing may be printed in the same style as the standard results by pressing the PRINT soft-key.

• After several program runs, press the FINISH soft-key to return the tester to the top-level display.

This is the end of the step-by-step tutorial, which forms only a very brief introduction to the features available on your AT3600. Please study and browse through the rest of this manual (or the on-line help for the Windows software) to get the best from your transformer tester.

The next section lists more features of the tester that you may wish to investigate yourself at this point, before you try to create 'real' programs for production use.

2.3.4 ADDITIONAL TOPICS TO INVESTIGATE

1. STORING PROGRAMS INSIDE THE TESTER

The AT3600 contains memory for the storage of test programs. The programs are stored even when the tester is switched off. Once a program is stored, the tester may be used without PC editor or server software.

To operate the tester in this way, the <u>origin</u> of the tester's programs must be set to the <u>local</u> program store.

- On the tester, at the 'Program mode' display, under the soft-key SET-UP, change the 'Origin' to 'LOCAL'.

This is described in section 2.3.3

WORKING WITHOUT A SERVER

A single program may be stored in the AT3600 using the PC editor.

Once a program has been entered using the editor and downloaded to the tester,

The tester will display:

```
SAVE PROGRAM                        ┌──────────┐
                                    │ CONTINUE │
Saving this program to the          ├──────────┤
                                    │          │
local store will overwrite          ├──────────┤
                                    │          │
an existing program group.          ├──────────┤
                                    │LOCAL SAVE│
                                    └──────────┘
```
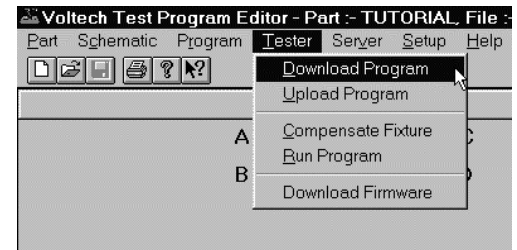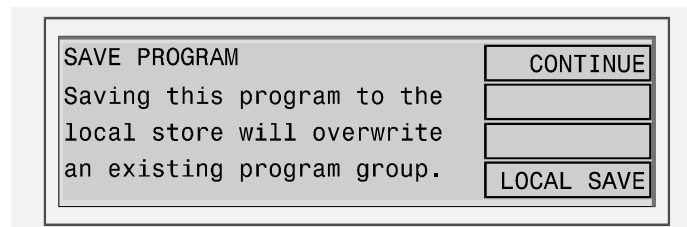
Press LOCAL SAVE and the program that has been downloaded from the PC editor will be saved in the tester's local program store. Note that any programs previously stored in the tester will be lost.

All PC connections to the tester may be now be removed.

To run the program at any time, return the tester to the top level display, press EXECUTE at the top level display:

```
┌─────────────────────────────────────────────┐
│ ┌─────────────────────────────────────────┐ │
│ │                              ┌─────────┐ │ │
│ │                              │ EXECUTE │ │ │
│ │                              ├─────────┤ │ │
│ │                              │ MEASURE │ │ │
│ │                              ├─────────┤ │ │
│ │                              │ PROGRAM │ │ │
│ │                              ├─────────┤ │ │
│ │                              │SELF-TEST│ │ │
│ │                              └─────────┘ │ │
│ └─────────────────────────────────────────┘ │
└─────────────────────────────────────────────┘
```
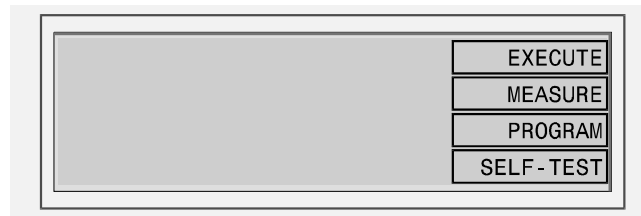
Then press LIST to choose the program and press the RUN key and continue as before.

GROUP DOWNLOAD USING THE SERVER

Rather than deal simply with individual programs, the server is able to create program groups. A group of programs can be downloaded to a tester which can then use individual programs using its local facilities.

Having executed programs loaded from the Server connected to the tester, you may wish to download a group of programs so that the tester may be used in a stand-alone situation:

- Use the Server menus to create a named group of programs. (It is possible to create a group containing only the program TUTORIAL created above.)

- Ensure that the Server is still running and connected to the tester as above.

- On the tester, at the 'Program mode' display, use the soft-key PROGRAMS, and enter the name of the group to be downloaded.

- At this point, unless you wish to archive measured results on the Server, the Server connection may be removed.

- At the tester's Top-Level display, press EXECUTE, and enter the name of a program in the group, and continue as normal.

2. RESULTS ANALYSIS

You may wish to use another application for further analysis of test results sent back to the Server:

- Close down the Server so that you may have full access to the results file

  The results will be stored in the directory chosen for results when the Server was installed (see page 2.2.6), in a file with a name similar to

  C2311096.ATR

  where the 'C2311096' is a coded version of the date, and '.ATR' is the file extension used by the Server for results files.

- As an example, use the procedure outlined on page 4.3.13. to import the results into an Excel spreadsheet.

4. FIRMWARE UPGRADES

The firmware of the AT3600 controls how tests are carried out, which tests are available and how the interfaces (including the front panel) function. New versions of the firmware are made available periodically and electronic copies are available free of charge. To maximize the performance and longevity of your AT3600, you should install these upgrades as they become available. Contact your local supplier or see the Voltech website at **http://www.voltech.com** for details. Upgrade firmware is distributed in a file called '**AT36.ABS**'**.**

If you have purchased new tests, you will be supplied with a file called '**CUSTAT36.ABS**' which contains the tests you have requested as well as the latest version of firmware. Save the file to a local or network directory (normally 'C:\Program Files\Voltech Instruments\Voltech AT Editor\'.

You may also be supplied with a file called 'BOOTAT36.ABS'. You must save this file in the same directory. To upgrade, locate the '**.ABS**' file and double click on it. Then select:

Tester >

Download Firmware

The firmware upgrade will now commence, and the editor screen will show a series of dialogue boxes to identify each stage in the process. The download should take approximately 30 minutes.

In the unlikely event that the editor display shows an 'ERROR' dialogue box, before the download is complete, then try repeating the entire procedure. Should the error persist, then contact your Voltech distributor.

At the end of the download, the tester will reset itself. You may then carry on using your tester as normal, with the benefits offered by the new firmware being available immediately.

If you were supplied with a '**BOOTAT36.ABS'** file, the tester will now check the boot code version already inside the AT and upgrade this automatically if required.

WARNING: You must __NOT__ switch off the AT or interrupt the communications during the 7 minutes required for this part of the upgrade.

CHAPTER 3 - TEST PROGRAM EDITOR

TABLE OF CONTENTS

This chapter will guide you through the operation and functional aspects of the test program editor.

TABLE OF CONTENTS - CONTINUED

1. INTRODUCTION

Welcome to the Voltech test program editor.

Using the editor enables you to quickly and easily create test programs for your AT series tester without any specialized knowledge of computer programming.

The editor will guide you through the programming of the tests you wish to carry out, helping you ensure that programming errors are eliminated.

The features of the test program editor include :

- Full MS Windows application compatibility, providing many visual aids for tailoring the test parameters to your needs.

- Schematic diagrams of the transformer under test showing pin to node connections. These form the basis of your test program.

- Form fill-in dialogue boxes to guide you through the programming of each test.

- A test program under development may be executed and the test results viewed on screen.

- Test programs and results may be stored in a PC running the AT series server.

- Transfer of test programs to specified paths or floppy disk for backup.

- A full context sensitive and menu driven help system.

An additional function available through the test program editor is upgrading the firmware of your AT series tester. See the 'Firmware Upgrades' section in chapter 2 for details.

2. SCHEMATIC EDITING

The Voltech AT series schematic editor allows you to recreate the configuration of the transformer on the fixture as a schematic diagram on the screen. Using the schematic as a visual reference, you may create your test program.

This chapter describes how to create a transformer schematic using the AT series schematic editor.

This chapter covers the following operations:

How To:

- Create or add a transformer winding

- Connect the winding terminals to test nodes

- Delete a winding

- Rename a terminal

- Add a terminal

- Delete a terminal

- Add a core connection

- Delete a core connection

- Add a screen connection
- Delete a screen connection

2.1. ADDING A TRANSFORMER WINDING

To add a transformer winding onto the screen:

1.   Select 'Add Winding' from the Schematic menu on the menu bar.

2.   Place the winding on the screen:

A selected winding will now be displayed attached to the mouse pointer on the screen. You must decide which half of the screen to place the winding. On crossing the mid-point of the screen, the winding is mirrored to face the nearest test nodes. Click the left mouse button to place the winding.

3.   Name the winding terminals:

When the winding is placed, a dialogue box appears prompting you to name both of the winding's two terminals.
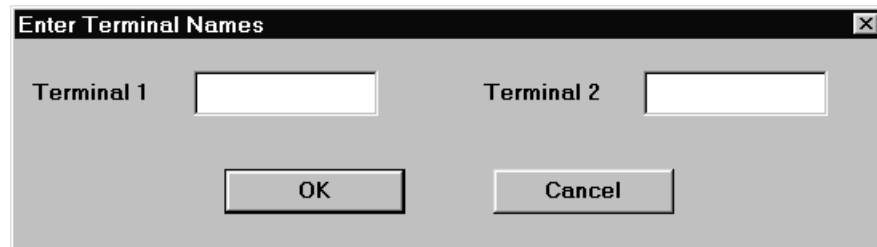
You may move the cursor focus between the fill-in boxes by using the TAB key or by pointing and clicking with the mouse.

When both terminals have been named, you should press ENTER on the keyboard or click on OK with the mouse in the dialogue box.

4.   To make a winding with more than two terminals, see *Adding a terminal to an Existing Winding*, in section 2.5 of this chapter.

NOTE: Terminal names may be between 1 and 6 characters in length, and may contain any upper case letter or AT Series keyboard character excluding SPACE.

2.2. CONNECTING THE WINDING TERMINALS TO NODES

To connect the winding terminals to test nodes:

1.   Select a terminal to connect with the RIGHT mouse button.

2.   Keeping the right button pressed, drag the wire to the selected test node.

When the mouse pointer is over the test node, release the mouse button.

The connection may also be made in reverse by first selecting the test node and then connecting it to the winding terminal.
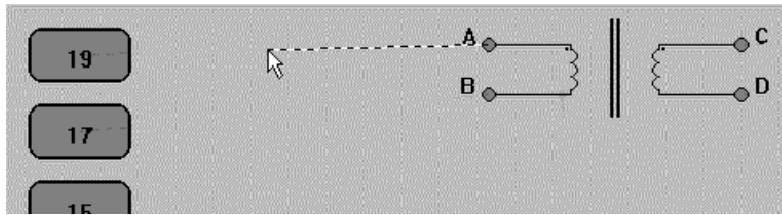
To change a connection, simply use the right button to pick it up and move it to either another test node or to another transformer terminal.

To delete a connection, again use the right mouse button to pick up the connection, but this time release it when it is not over either a node or a terminal.

2.3. DELETING A WINDING

To delete a winding:

1.   Select a winding by pointing at it with the mouse pointer and clicking the left mouse button once. A selected winding will be indicated by a box surrounding the winding.

2.   Choose 'Delete Winding' from the 'Schematic' menu.
       The selection will be removed from the screen.
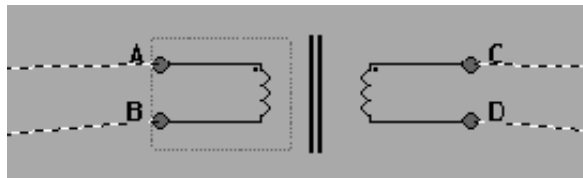
2.4. RENAMING A TERMINAL

To rename a terminal either:

1.   Select the winding containing the terminal to rename by using the mouse pointer and clicking the left mouse button.

2.   Choose 'Rename Terminals' from the 'Schematic' menu.

OR   **MOUSE SHORTCUT:** Double-click on the chosen winding.

A fill in dialogue box will appear. Each fill-in box will contain the current names of the winding terminals.

You may change a name by:

1. Selecting the appropriate terminal box with the mouse, or by moving between the boxes with the TAB key on the keyboard and then typing the new name.

2. Pressing ENTER or clicking the mouse pointer on OK

The dialogue box will be removed and the corrections will be displayed on the screen.

2.5. ADDING A TERMINAL TO AN EXISTING WINDING

To add a terminal to a transformer winding:

1. Select 'Add Winding' from the 'Schematic' menu on the menu bar to create a second two terminal winding.

2. Now place the new winding on the same side of the schematic as the winding which requires the additional terminal.
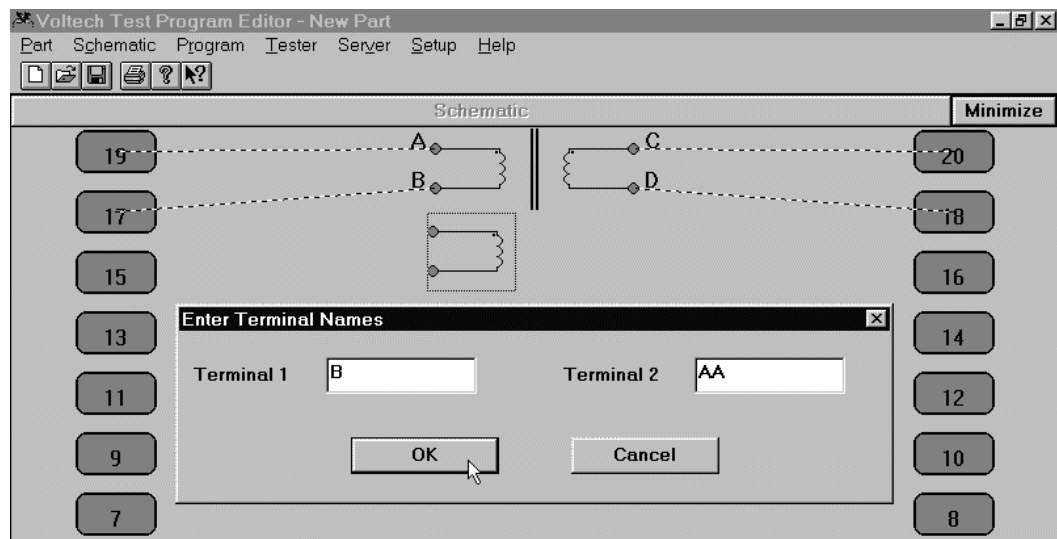
Upon clicking the left mouse button, a form fill-in dialogue box will appear on the screen with prompts to insert the terminal names of the new winding.

3. Name the terminals of the second winding, giving one terminal the same name as a terminal of the previous winding.

4. Press ENTER or click on OK.

The dialogue box will be removed, and the schematic will show the two windings joined at the common terminal.
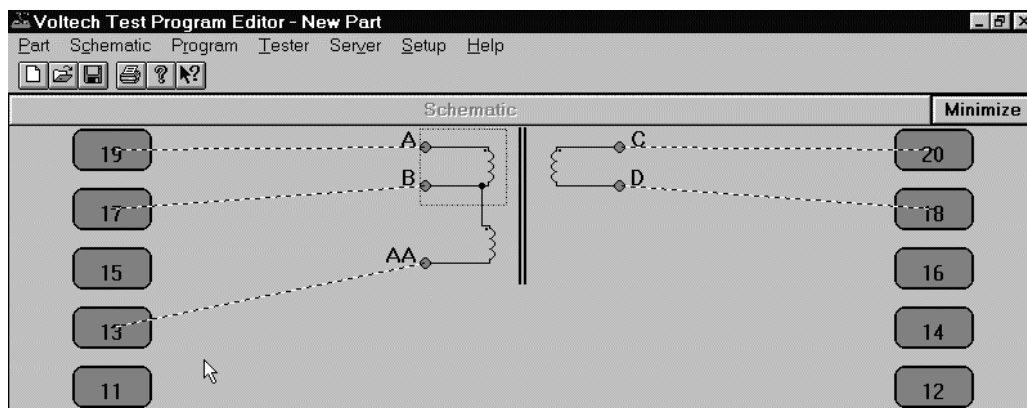
2.6. DELETING A TERMINAL FROM AN EXISTING WINDING

To remove a terminal from a transformer winding:

1. Select the terminal which you would like to be removed by using the mouse pointer and clicking the left mouse button once.

2. Choose 'Delete Winding' from the 'Schematic' menu on the menu bar.

The bottom terminal of the winding will be removed from the screen, together with any connections to that terminal which are present.

2.7. ADDING A CORE CONNECTION

To add a core connection:

1. Choose 'Add Core Connection' from the 'Schematic' menu.
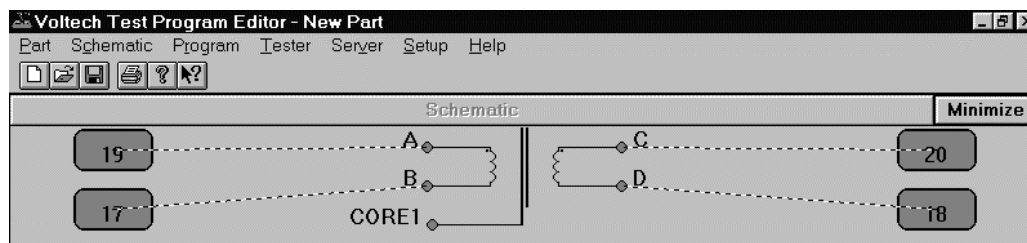
A connection from the core will appear on the screen. You may now add a core-to-node connection.

2.8. DELETING A CORE CONNECTION

To delete a core connection:

1. Choose 'Delete Core Connection' from the 'Schematic' menu.

The connection from the core will be removed from the schematic.

2.9. ADDING A SCREEN CONNECTION

To add a screen connection:

1. Choose 'Add Screen Connection' from the 'Schematic' menu.
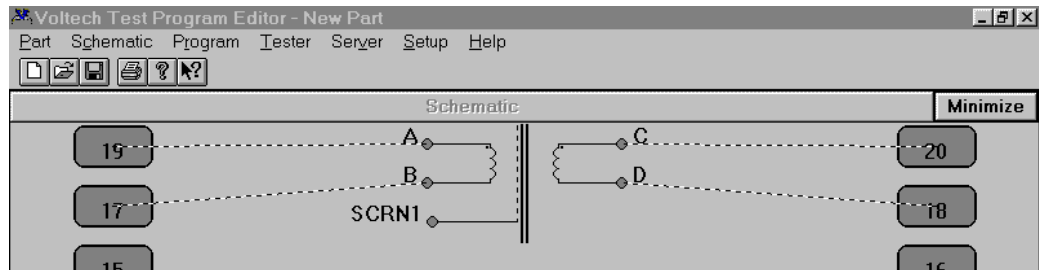
A connection from the screen will appear on the schematic. You may now add a screen-to-node connection.

2.10. DELETING A SCREEN CONNECTION

To delete a screen connection:

1. Select the connection you wish to delete by pointing at it with the mouse prompt and pressing the left mouse button.

2. Choose 'Delete Screen Connection' from the 'Schematic' menu.

The screen connection will be removed from the schematic.

3. CREATING THE PROGRAM

Section 3 describes the procedures used when creating the test program with the AT Series Test Program Editor.

By the end of this chapter you will be able to:

- Set up the program options
- Add a test to the program
- Insert a test in the program
- Modify an existing test in the program
- Delete a test
- Use the measure button to create test parameters
- Verify the program - including fixture compensation

3.1. SETTING THE PROGRAM OPTIONS

3.1.1. OVERVIEW

After you have created the program schematic, before starting to insert any tests in the program, you should set up which program options you would like to use.

From the Top Level menu bar, select:

**Program >
Options**
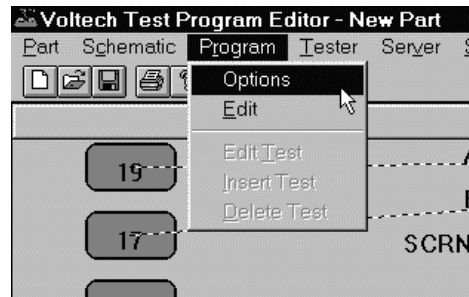
You will then see the following dialogue box:
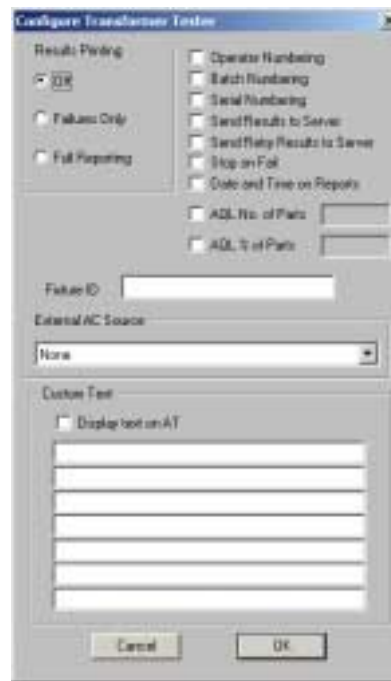
You may now set up any of the following options by simply clicking with the left button of the mouse:

*Results Printing

Printed reports may be obtained from the printer port of the tester as follows:

Off	There will be no results printed out during the test execution.
Failures Only	The results of the tests producing a 'fail' result will be printed.
Full Reporting	The results for all the tests in the program will be printed out for each transformer tested.

Operator Numbering	During program execution, the operator will be prompted to enter his or her identity code. All results will then be tagged with this code.
Batch Numbering	During program execution, the operator will be prompted to enter a batch number, which will be attached to the test results.
Serial Numbering	During program execution, the operator will be prompted to enter a serial number for each transformer. The number will then be attached to the results for the next transformer tested.
*Send Results to Server	Select this option if you wish to have the tester send all the measurement results back to the Server PC for archive or analysis.
*Send Retry Results to Server	Enable this function if you wish the Server Archive to contain the results from the additional measurements associated with re-running a program, for example after execution has been halted by the STOP ON FAIL program option.
Stop on Fail	Select this option to give the fastest test throughput. During program execution, only transformers which produce a 'pass' result will be fully tested; failures will be rejected at the earliest opportunity.
Date and Time on Reports	Select this option to have the reports date and time tagged.

AQL (Acceptable Quality Level)

Settings for production test are defined here. AQL is the level of test failures in a batch that are acceptable. Exceeding the AQL is an indication that there is a problem with the quality of the production process or the quality of materials that are being used. AQL monitoring is an optional feature of the Voltech PC Server, which displays live summary results from multiple AT testers. When the AQL set here is reached or exceeded, the Server will display a warning. Both types of AQL limits may be used at the same time. Reaching any one limit will cause a warning to be displayed on the Server.

For further details, see the AT Server section of this manual.

AQL No. of Parts	This is the number of failures in the batch at which a warning will be displayed on the Server. This is most often used when the batch size is always similar, or zero / very small numbers of defects are expected.

AQL % of Parts	This is the percentage level of failures at which a warning will be displayed on the Server. Note that this AQL is only applied after sufficient parts have been tested to make the percentage meaningful. When setting AQL % of Parts to be 1%, for example, a warning will only be displayed after 100/1 = 100 parts have been tested.
Fixture ID	Finally, you should enter a fixture name.

The Fixture Name can be up to 20 characters long. You may use any of the characters which appear on the tester's keyboard:

> A .. Z (upper case only)
>
> 0 1 2 3 4 5 6 7 8 9 . - / ( ) and 'space'

When the test program is run on the AT Series Tester, the operator will be prompted to fit the fixture with this name. This will help to make sure that the correct fixture is used.

Note that the fixture name does not have to be the same as the program (part) name. This makes it possible to have one fixture common to a number of transformers which may, for example, have the same arrangement of pins, but have different windings requiring different test programs.

External AC Source	It is possible to use an external ac source to generate the test signal for testing. Using an external source extends the power and voltage range available. The source must be coupled to the tester via a Voltech AC Source Interface (contact your supplier for details). This option allows you to choose and configure the type of external source you will be using; see the External AC Source Interface user manual for details.
	If you are not using an external source, it is IMPORTANT that the source type is set to 'None'.
Custom Text	In the Editor, you may now enter up to 7 lines of text. This text may then be displayed on an AT when a program is first loaded from the front panel.

When you have selected all the required options, click on the OK button to return to the top-level menu.

3.1.2. STOP ON FAIL

With this function enabled, the tester will stop program execution whenever a fail is detected, rather than carrying out all the tests in the test program and reporting the passes and fails at the end.

This enables the user to quickly identify a faulty transformer and replace it with another before all the tests have been carried out, thus speeding up the test process.

When a fail is encountered, the tester will display a warning screen and stop the program. The display will inform the user of a test failure, and indicate which limits have been exceeded.

An example of this display for an inductance test is shown below.

1	Part name / number.
2	Failing test number.
3	Qualification of the failure showing the value measured with respect to the range of legal values, where: Box – Represents the user programmable limits for the test Vertical bar – Represents the value measured
4	Value measured, with appropriate units.
5	Available softkey functions.

From this display, after you have pressed the CONTINUE soft-key, the tester will execute the remaining tests in the program, and the transformer will be recorded as a fail. (If any further tests fail, then there will be another display similar to the one above for each failing test.)

If you simply wish to throw away the failing transformer at the earliest opportunity, then press the ABORT soft-key to terminate this program run, and return to the RUN-FINISH display, from where you can start the program again for the next transformer in the batch.

Alternatively, you may use the RE-RUN soft-key if, for example, the failure is due to the fact that the transformer is not correctly inserted in the test fixture. In this case, program execution starts again, and the transformer will receive a 'pass', if the only fault was that it had been wrongly inserted at the first attempt.

After you have pressed the RE-RUN soft-key, the tester will then be executing a 'retry'. When results are sent to the Server, unless you have enabled the program option 'Send Retry Results to Server', then no result will be sent to the Server Results

File except those for the final execution run, i.e. the one that produces the pass or fail front panel display.

If you wish to see the measured results from each retry in your Server Results File, then you should enable the program option 'Send Retry Results to Server' when the program is created in the Editor. This option could provide data, for example, which allows you to improve your production process and yield.

Notes:

1. The third line showing the graphical comparison of the measured value and user programmable limits has a logarithmic scale. The measured value may be represented by either a vertical bar (as shown) when it lies within the range that can be displayed on the LCD, or by an arrowhead ($<$ or $>$) at the end of the horizontal bar when it lies outside the range that can be displayed on the LCD.

2. Should the tester be returning results to a PC running the editor software, then the editor software will 'freeze' when this screen is displayed until the appropriate softkey (Re-run, Continue or Abort) is pressed.

3.2. PROGRAM EDIT

After you have created the program schematic, and selected the program options, you may then start creating the actual program of tests.

To edit the test program, you must first switch to the Program Editor.

From the Top Level menu bar, select:

Program > Edit
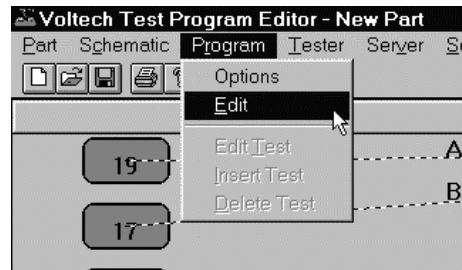
You will now see a display with three separate
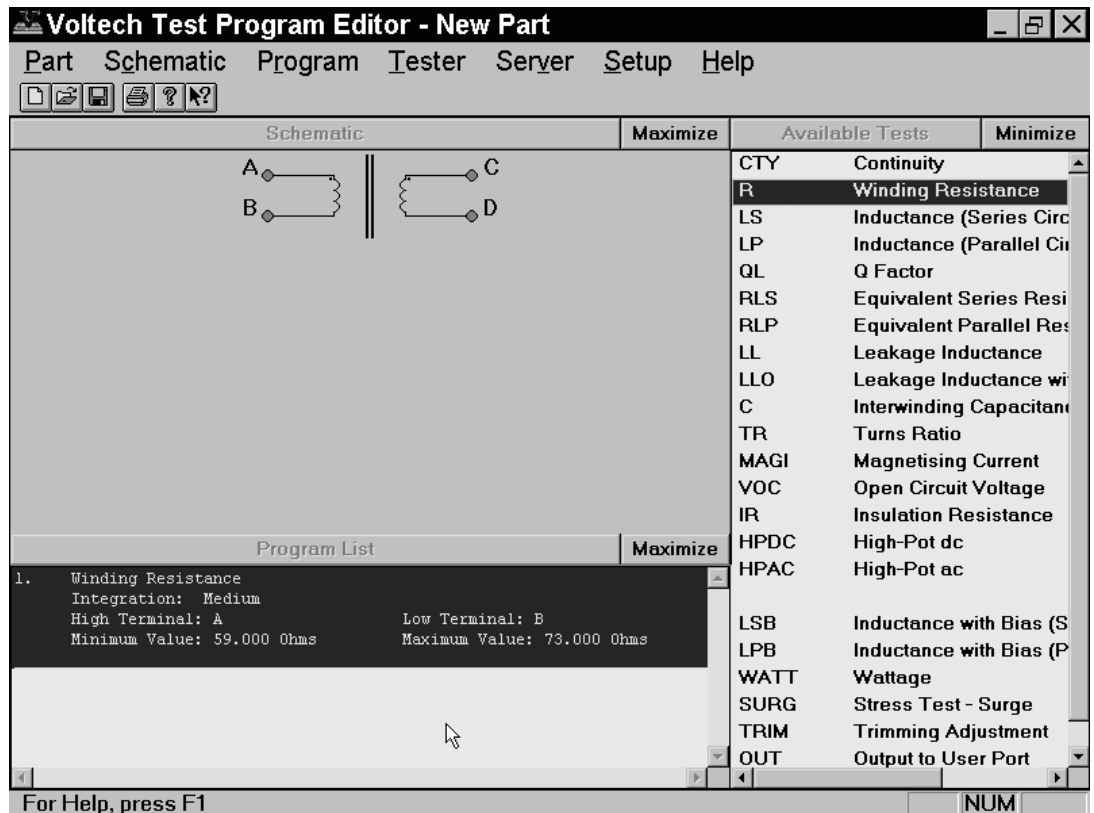
windows:

Top Left: A simplified view of the transformer schematic omitting the wiring to the nodes.

This is a passive window intended to be used as a memory aid; it cannot be used to change the schematic. (If you need to alter the schematic at any time, simply click on 'Schematic' then 'Edit' in the Top Level menu.)

Bottom Left: The Program Window.

This is the list of tests which currently make up the test program.

Normally, for a new program, this window would initially be empty. The display above shows the program of one resistance test created in the Quick Start Tutorial.

Right: The Available Tests Window.

This is the list of tests which are available to be used in creating or modifying the test program.

From this display, you may now create the test program suitable for your transformer by adding tests to the Program from the Available Tests list. The following sections describe how to do this.

3.3. ADDING TESTS

A test program is a list of tests chosen from the Available Tests list. To create a new program, you simply add tests to the list.

To add a test, use the mouse to select the test you require from the Available Tests list, and double click on that test with the left button.

This will open the dialogue box particular to that test. You simply fill in all the fields of the dialogue box, and then click on the OK button. The test will be added at the end of the Program.

As an example, if you wish to add another 'R Winding Resistance' to the program:

    Double click on the 'R Winding Resistance' test in Available Test list.

    Fill in the fields of the dialogue box.
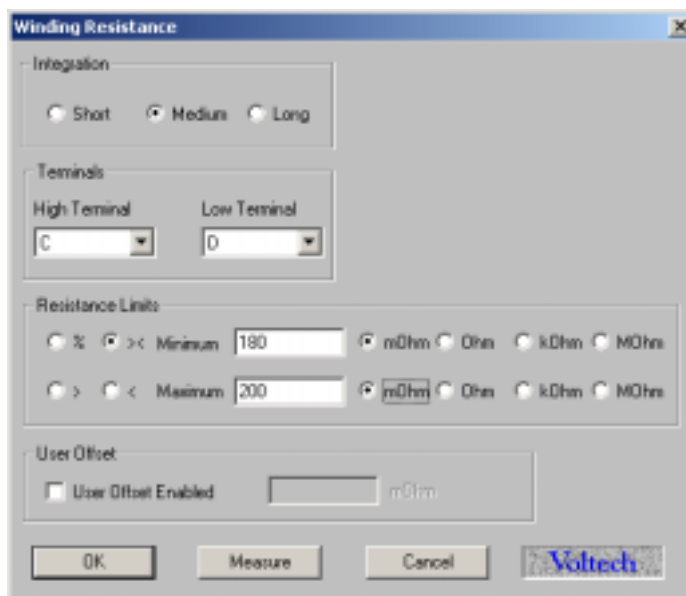
    Click on the OK button.

You will now see this test added to the Program:
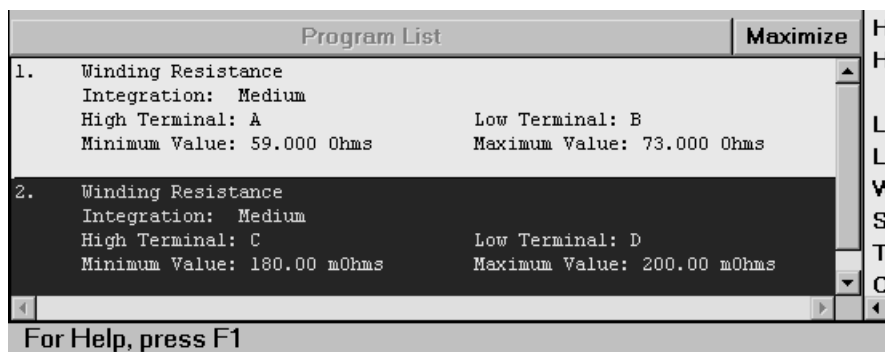
3.4. INSERTING TESTS

Normally, if you are creating a new test program, you would add the tests in the correct order of execution, as described in the previous section. You would also use this procedure for modifying an existing program, if you needed to append further tests at the end.

However, if you wish to add an extra test somewhere in the middle of an existing program, a different procedure is required:

1. In the Available Tests window, click with the left button of the mouse to highlight the test you wish to insert.

2. In the Program window, click with the left mouse button to highlight one of the existing tests in the list. This will become the point of insertion; the new test will be inserted in front of the one you have selected.

3. From the Top Level menu bar, select:

   Program, Insert Test
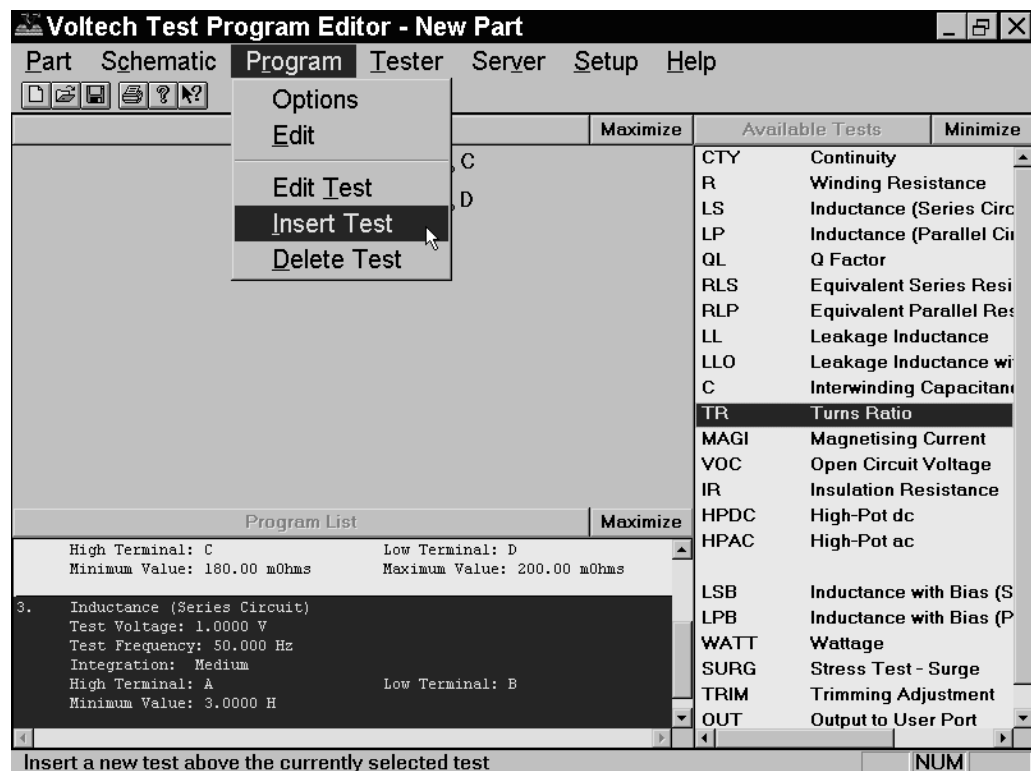
In this example, a Turns Ratio test will be inserted before the Inductance test 3 in the Program.

You will now see the dialogue box for the test you wish to insert.

4. Enter the appropriate test data in the fields of the dialogue box, and click on OK.

You will now see the new test inserted into the Program.

```
2.    Winding Resistance
      Integration:  Medium
      High Terminal: C                    Low Terminal: D
      Minimum Value: 180.00 mOhms         Maximum Value: 200.00 mOhms

3.    Turns Ratio
      Test Voltage: 1.0000 V
      Test Frequency: 50.000 Hz
      Integration:  Medium
      Terminals:
        Energised High: A                 Energised Low: B
        Primary High: A                   Primary Low: B
        Secondary High: C                 Secondary Low: D
      Turns Ratio: 1:1
      Minimum Error: -01.00%              Maximum Error: 01.00%

4.    Inductance (Series Circuit)
      Test Voltage: 1.0000 V
      Test Frequency: 50.000 Hz
      Integration:  Medium
      High Terminal: A                    Low Terminal: B
      Minimum Value: 3.0000 H
```

3.5. MODIFYING TESTS

As part of creating a new test program, you would normally experiment by running it with a sample batch of transformers. At this point, you may find that some tests need to be modified, a typical example being that you need to change the test limits.

With the Editor software, modifying a test is very simple.
1. In the Program window, double-click with the left mouse button on the test you wish to modify.
   This will re-open the dialogue box for that particular test.
2. Make any changes you require to the test data in the fields of the dialogue box, and click on OK.
   You will now see the test with the modified data in the Program window.

3.6. DELETING TESTS

To delete a test from the Program, with the Editor software is very simple.

1.   In the Program window, click with the left mouse button to highlight the test
     you wish to delete.

     NOTE: Take care to correctly select the test to be deleted, as the Editor software
     will permanently delete the test.

2.   From the Top Level menu bar, select:

         Program, Delete Test

You will now see the test has been removed from the list in the Program window.

3.7. TEST PARAMETERS

Some tests such as the R-Winding Resistance test (as used in the quick start tutorial – chapter 3) are relatively simple to program because you do not have to set up any test conditions. This is not the normal case.

The LS - Winding Inductance (Series Circuit) - test is more typical, requiring the test parameters 'Signal' and 'Frequency' to be specified

For many tests, including the LS test, you may enter the Test Parameters in two ways: either by simply keying in the numbers you require, or by using the Measure button.

Clearly, you would type in the test parameters if, for example, they have been specified by the designer of the transformer. If you are not sure what values to use, some guidance is given in chapter 7 (Tests & Test Conditions) later in this manual.

If you are using the Measure button to enter limit values, as described in section 3.9 later in this chapter, you may also at the same time have the AT Series Tester enter the recommended test parameter values.

To do this in the case of the LS test, you simply leave the Signal and Frequency edit boxes empty at the time you click on the Measure button. If you choose either the 'mV' or 'V' units button before clicking the Measure button, the test signal determined by the tester will be entered as a voltage; alternatively if you choose the 'mA' units button before clicking the Measure button, the test signal determined by the tester will be entered as a current.

Note that not all tests allow the test parameters to be chosen by the tester; MAGI - Magnetizing Current - being a clear example of a test which does not make sense unless you specify both the test voltage and frequency at which the current should be measured.

The programming details for each test in section 4 (Programming Tests) of this chapter specify which tests allow the Measure button to enter the test parameter values.

3.8. TEST LIMITS

In the Quick Start Tutorial (section 3 of chapter 2), it was stated that for the R - Winding Resistance - test the limits could be entered in four different ways. The R test is not unique in this respect. In fact, most tests have several ways in which the limits may be entered, allowing you greater flexibility in configuring each test to match your production testing requirements.

The four types of limits for the R- Winding Resistance - test are:

%:   The limits are entered as positive and negative percentages about a nominal value.

> <:   The limits are entered as minimum and maximum values.

>:   There is only a minimum limit.

<:   There is only a maximum limit.

The corresponding dialogue boxes are as follows:
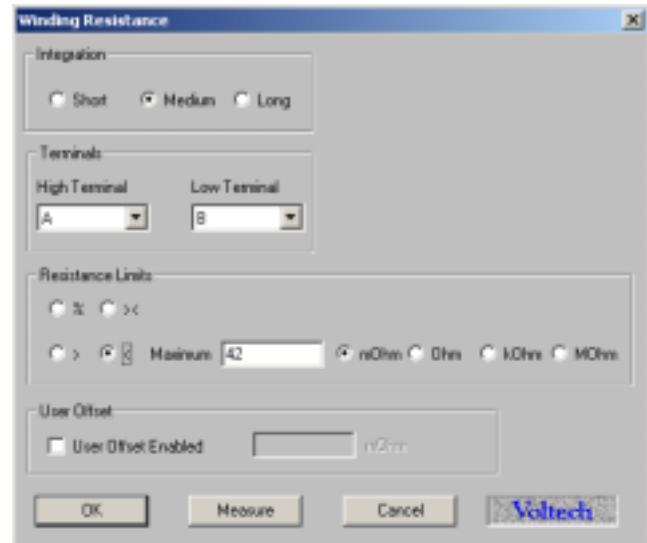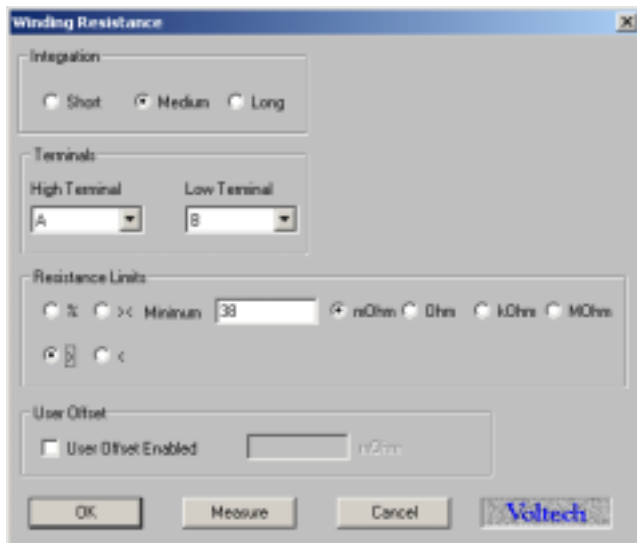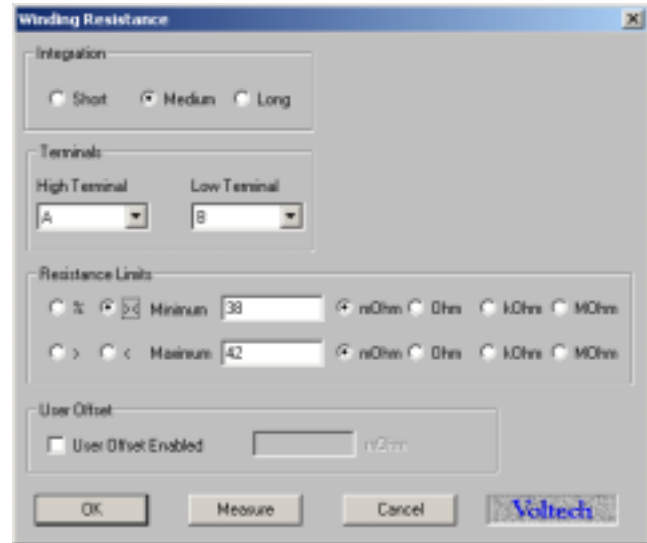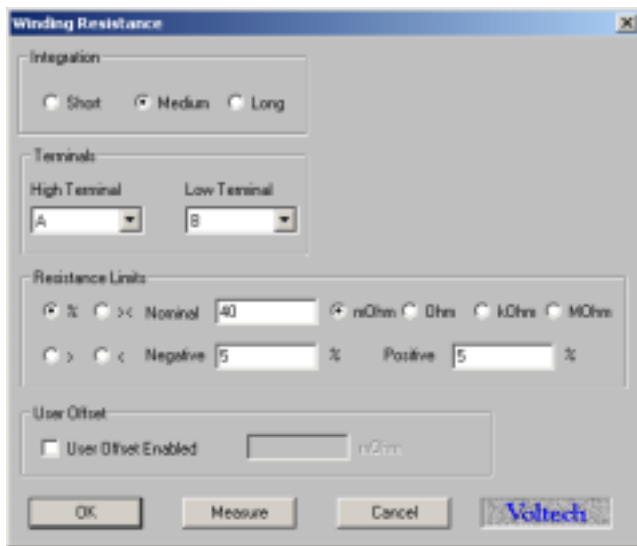
Many of the tests available for the AT Series have all four limit types. There are obviously some tests where it is not sensible to have four limits, IR - Insulation Resistance - being a clear example where only a minimum limit is applicable, as the perfect insulation between windings has no upper limit to its resistance.

To choose which type of limit you wish to use, simply use the mouse to click on one of the buttons % , > < , > or < .

After you have entered the limits in one form, you may change to another form of limits by clicking with the mouse on another of the buttons.

When you change from one limit type to another, the tester will convert any limits you have previously entered to match the new type as shown in the following tables:

CONVERSION BETWEEN LIMIT TYPES FOR TESTS OTHER THAN TR AND TRL

	Conversion	Previous
%	nom $\leftarrow$ (max + min) / 2	> <
	|neg%| $\leftarrow$ (nom - min) / nom	
	pos% $\leftarrow$ (max - nom) / nom	
	nom $\leftarrow$ low + 0.01%	>
	|neg%| $\leftarrow$ 0.01%	
	pos% $\leftarrow$ 0.01%	
	nom $\leftarrow$ upp - 0.01%	<
	|neg%| $\leftarrow$ 0.01%	
	pos% $\leftarrow$ 0.01%	
dB +/-	nom dB $\leftarrow$ (max dB + min dB) / 2	> <
	|neg dB| $\leftarrow$ nom dB – min dB	
	pos dB $\leftarrow$ max dB – nom dB	
	nom dB $\leftarrow$ low + 0.01 dB	>
	|neg dB| $\leftarrow$ 0.01 dB	
	pos dB $\leftarrow$ 0.01 dB	
	nom dB $\leftarrow$ upp - 0.01 dB	<
	|neg dB| $\leftarrow$ 0.01 dB	
	pos dB $\leftarrow$ 0.01 dB	
> <	min $\leftarrow$ nom - |neg%|	%
	max $\leftarrow$ nom + pos%	
	min $\leftarrow$ nom dB – neg dB	dB +/-
	max $\leftarrow$ nom dB + pos dB	
	min $\leftarrow$ low	>
	max $\leftarrow$ low + 0.02%	
	min $\leftarrow$ upp - 0.02%	<
	max $\leftarrow$ upp	
>	low $\leftarrow$ nom - |neg%|	%

	low	$\leftarrow$ nom dB – neg dB	dB +/-
	low	$\leftarrow$ min	$><$
	low	$\leftarrow$ upp	$<$
$<$	upp	$\leftarrow$ nom + pos%	%
	upp	$\leftarrow$ nom dB – neg dB	dB
	upp	$\leftarrow$ max	$><$
	upp	$\leftarrow$ low	$>$

Where:

nom dB	=	the nominal value for the [dB] limits
neg dB	=	the negative error for the [dB] limits
pos dB	=	the positive error for the [dB] limits
nom	=	the nominal value for the [%] limits
neg%	=	the negative percentage error for the [%] limits
pos%	=	the positive percentage error for the [%] limits
min	=	the minimum value for the [><] limits
max	=	the maximum value for the [><] limits
low	=	the minimum value for the [>] limit
upp	=	the maximum value for the [<] limit

CONVERSION BETWEEN LIMIT TYPES FOR THE TESTS TR AND TRL

New	Conversion			Previous
% neg% pos%	pri sec	← ← ← ←	#np #ns (δnp / #np + δns / #ns) (δnp / #np + δns / #ns)	#
# δnp δns	#np #ns	← ← ← ←	pri ∗ K sec ∗ K #np ∗ (|neg%| + pos%) / 4 #ns ∗ (|neg%| + pos%) / 4	%

where

pri	=	the primary ratio number for the [%] limits
sec	=	the secondary ratio number for the [%] limits
neg%	=	the negative percentage error for the [%] limits
pos%	=	the positive percentage error for the [%] limits
#np	=	the number of primary turns for the [#] limits
#ns	=	the number of secondary turns for the [#] limits
δnp	=	the ± error number of primary turns for the [#] limits
δns	=	the ± error number of secondary turns for the [#] limits
K	=	a factor to make #np and #ns whole numbers in the range 1 to 99999

Notes

1. The conversions in the above tables are written in a form to make it easier for you to understand the conversion process; they are not intended to be exact mathematical formulae.

2. Some changes in the tables above are not reversible.
   For example, after you have changed from a >< limit which has two values to a > limit which has only one, changing back will not give the original values again.

This is because the Editor only holds the latest limit values, and therefore when you have changed to a minimum only limit, any previous maximum value will be lost.

3. When a single value limit (such as >) is converted to a multiple value limit (such as > <), the conversion process has in essence to use the previous single value as both the minimum and maximum new values.
    As it is not logical to have a minimum and a maximum exactly the same, the two values are made different, but only by a small amount.

3.9. USING THE MEASURE BUTTON

While working through the Quick Start Tutorial (section 3, chapter 2), you may have noticed that the dialogue box for the test R - Winding Resistance - contained a button labeled 'Measure'.

In fact, most tests have a Measure button within the dialogue box. It is included there to allow you to fill in various fields in the dialogue box by using the AT3600 to measure the value from a sample transformer.

All tests with a Measure button will allow you to enter a value into the test limits section of the dialogue box.

In addition, some tests can also make use of the Measure button to select the test conditions. The programming details for each test in section 4 (Programming Tests) later in this chapter, specify which tests allow the Measure button to enter the test parameter values.

HARDWARE CONNECTIONS FOR USING THE MEASURE BUTTON

Before attempting to use the Measure button:

1. Make sure you have connected your tester's Auxiliary Port (on the rear panel) to a suitable Comm Port on your PC. (This may be Comm Port 2 if your mouse is already using Comm Port 1.)
2. Set up the Comm Port on the PC.
    From the Top Level menu, select

        Setup>
        Communications

    In the dialogue box,

    select the PC communications port which is connected to the transformer tester.
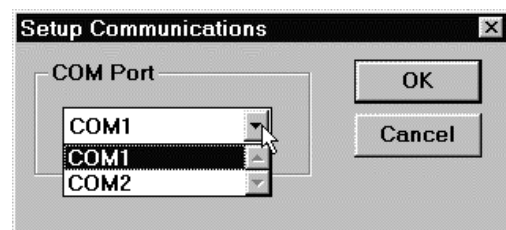
WARNING: If the chosen 'COM' port is reserved by another Windows application, an error message will appear. You should select another port.

3. Fit the appropriate fixture to the tester.

4. Have available both a sample transformer, and possibly a shorting header if you wish to add tests to the program for which you will be applying short-circuit compensation.

EXAMPLE OF USING THE MEASURE BUTTON WITH THE LS TEST

LS - Winding Inductance (Series Circuit) - is one of the tests where both the test voltage and frequency, and the actual measurement may be obtained by using the Measure button. The following example assumes that this is what you wish to do.

Initially select the LS test in the normal way by double-clicking with the mouse in the Available Tests list.

In the LS test dialogue box:

Enter the terminal names in the normal way.

Select the integration you require if different from the default setting of Medium.

In the Test Parameters section, leave both the Signal and the Frequency edit boxes blank.

The default units button for the Signal is 'mV'. With this setting, the Editor will enter the test voltage chosen by the tester, changing as appropriate to the 'V' button if the signal is large. Alternatively, if you wish the test signal to be determined as a current, click on the 'mA' units button.

Finally, in the lower section of the dialogue box, select the desired limits type.

At this point, the dialogue box should be as follows:
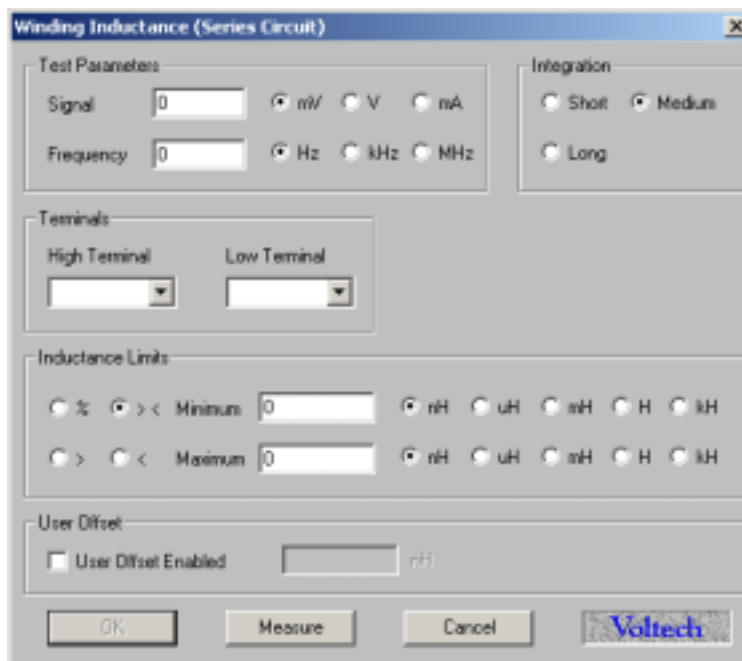
Now, using the mouse, click on the Measure button.

Because the LS test is one where short-circuit fixture compensation could be applied, you will then see the following message:

Measure

     ◉   **Measure without Fixture Compensation**

     ○   **Compensate Fixture**

                  [**OK**]

If the value of inductance is high, then compensation may not be needed, and you may click on 'OK' with 'Measure without Fixture Compensation' selected.

If you click on 'OK' with 'Compensate Fixture' selected, then there will be an additional message, which in general depends on whether the test requires short- or open-circuit compensation. In this case, the LS test requires short-circuit compensation, so the following dialogue box will be shown:

Editor Windows Application

    (**i**)   Short-Circuit Fixture Compensation
             will be applied to this test

             Fit a short-circuit link in place of each winding.

                [OK]
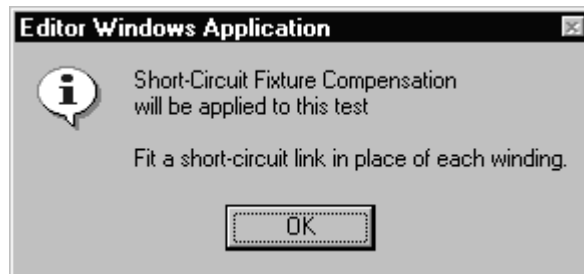
Fit the required short-circuit header, and click on 'OK'.

The Editor will now command the tester to perform the Fixture Compensation for the required test (in this case LS). The tester will then store the 'zero' value, and subtract it from the next result returned for the test.

If the short-circuit links are not correctly fitted, you may see an error message which allows you to try again, or to cancel the compensation.

Assuming no errors, when the tester has finished the compensation measurement, you will be prompted to remove the shorting links, and fit the sample transformer:

Editor Windows Application

    (**i**)   Fixture Compensation Finished

             Re-connect the transformer
             to measure the test parameters

                [OK]
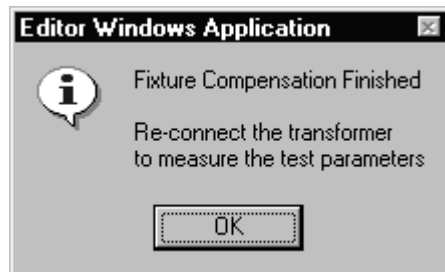
After you have clicked on the 'OK' button, the tester will be commanded to make its measurements, and you will see the following message:

AT3600 Program Editor

    (V)   **Attempting to perform the measure.**
            Please wait.
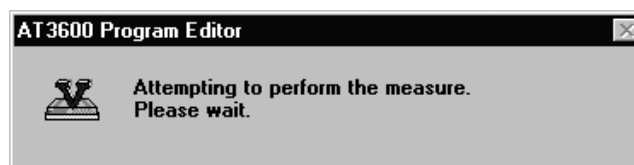
When the measurements have finished, the display will return to the dialogue box for the LS test, with values entered for the test signal, the frequency and the nominal inductance:
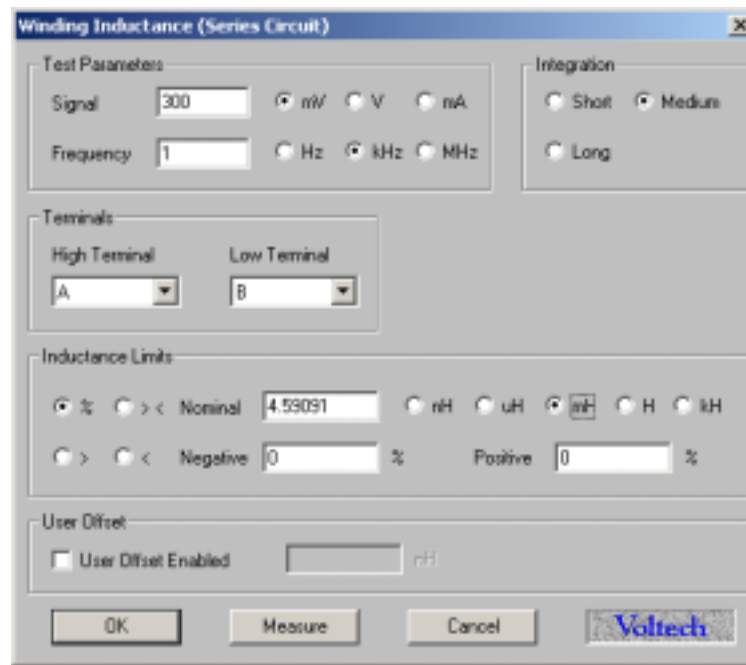
From this point, it is very easy for you to complete the dialogue box by simply entering the values you require for the Negative and Positive percentage limits.

If you have chosen fixed voltage, current or frequency conditions it may not be possible for the tester to make a measurement. For example, if the AC impedance of the winding under test is only 0.1Ω at the specified frequency and you have specified a 5V test signal, then the AT would have to supply $5V / 0.1\Omega = 50$ Amps!

You will then see a warning similar to this:
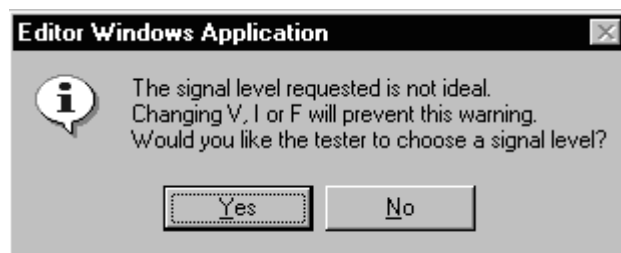
Check first that the winding is properly connected to the right nodes.

Choose 'Yes' and the AT will choose suitable voltage conditions for you and enter them into the test dialogue. Choose 'No' and no conditions will be chosen. See Chapter 7 – Tests and test conditions for suitable values.

RESTRICTIONS FOR AUTOMATICALLY OBTAINING THE TEST PARAMETERS

As shown above, the LS - Winding Inductance (Series Circuit) - test is one where both the test voltage (or current) and frequency may be obtained automatically by using the Measure button.

Alternatively, you may wish to specify yourself either one or both of the parameters before using the Measure button. In this case, the tester will attempt to make use of the parameter(s) that you have specified, and enter a value only for parameters that you have not specified.

In general, all tests have restrictions on which test parameters may be (or have to be) specified, and which may be chosen automatically. In the case of the LS - Winding Inductance (Series Circuit) - test, the valid combinations are summarized in the following table:

Signal	Specified voltage	Specified current	Auto	Auto
Frequency	Specified	Specified	Specified	Auto

(The combination that is not allowed, is to specify the voltage (or current), and ask the AT to find the frequency.)

If you have entered a non-permitted combination, the Editor will display a warning message when you click on the Measure button, and there will be no measurement until you correct the error.

WHAT HAPPENS WITH DIFFERENT TYPES OF LIMIT?

In the example shown above, percentage limits were chosen before clicking on the Measure button. In this case, the measured result from the tester is inserted as the nominal value, allowing you to set the limits for the test as a percentage either side of this nominal value.

If you choose one of the other possible limit types before clicking on the Measure button, the following table shows the way in which the measured result will be converted to edit box values:

Limit Type	Conversion		
%	nom	$\leftarrow$	result
	|neg%|	$\leftarrow$	no change
	pos%	$\leftarrow$	no change
dB	nom dB	$\leftarrow$	result
	|neg dB|	$\leftarrow$	no change
	pos dB	$\leftarrow$	no change
$><$	min	$\leftarrow$	result - 0.01%
	max	$\leftarrow$	result + 0.01%
$>$	low	$\leftarrow$	result
$<$	upp	$\leftarrow$	result
% for TR or TRL	pri	$\leftarrow$	result
	sec	$\leftarrow$	1
	|neg%|	$\leftarrow$	no change
	pos%	$\leftarrow$	no change
# for TR or TRL	#np	$\leftarrow$	result * K
	#ns	$\leftarrow$	K
		$\leftarrow$	no change
		$\leftarrow$	no change

Where, as before:

nom	=	the nominal value for the [%] limits
neg% (pos%)	=	the negative (positive) percentage error for the [%] limits
min (max)	=	the minimum (maximum) value for the [$><$] limits
low	=	the minimum value for the [$>$] limit
upp	=	the maximum value for the [$<$] limit
pri, (sec)	=	the primary (secondary) ratio number for the [%] limits - TR or TRL test

And for the TR or TRL test:

neg% (pos%)	=	the negative (positive) percentage error for the [%] limits
#np (#ns)	=	the number of primary (secondary) turns for the [#] limits

| δnp (δns) | = | the ± error number of primary (secondary) turns for the [#] limits |
| K | = | a factor to make #np and #ns whole numbers in the range 1 to 99999 |

Notes:

1. The conversions in the above table are written in a form to make it easier to understand the conversion process; they are not intended to be exact mathematical formulae.

2. Where possible the measured result is used as the nominal or central value.

   For the $>$ and $<$ limits where only one value is required, the measured result simply becomes that value.

   For the $><$ limit where two values are required, the conversion process is in essence to use the single measured result as both the minimum and maximum values. Again, as stated previously for the conversions between the different limit types, because it is not logical to have a minimum and a maximum exactly the same, the two values are made different, but only by a small amount.

If you prefer to use the $><$ limit, but would like the minimum and maximum values to cover a larger range (for example ±5%), a possible approach is as follows:

   Initially choose the % limits before clicking on the Measure button.

   After the result has been returned, set the Negative and Positive limits to 5%.

   Then change to the $><$ type of limit, to view the limits in your preferred way.

Another possibility, which you may also choose, is to use this last procedure simply to find approximate values for the minimum and maximum which are 5% from the measured value. You may then enter the actual test limits by rounding up or down to your nearest preferred values.

3.10. VERIFYING YOUR PROGRAM

Typically in production use, your program would be downloaded to AT Series Tester from the Server, which is a PC resident software package, described in detail in Chapter 4. However, before you transfer your program to the Server archive, you should always verify it by running it on an actual transformer.

The Editor software will enable you to download a program directly to the tester, and to execute it from the PC keyboard.

Before you attempt to run the program:

1. Make sure you have connected your tester's Auxiliary Port (on the rear panel) to a suitable Comm Port on your PC. (This may be Comm Port 2 if your mouse is already using Comm Port 1.)

2. Set up the Comm Port on the PC.

    From the Top Level menu, select

    > Setup>
    > Communications

    In the dialogue box,

    select the PC communications port which is connected to the tester.
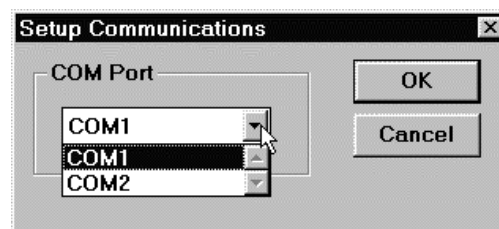
WARNING: If the chosen 'COM' port is reserved by another Windows application, an error message will appear. You should select another port.

3. Fit the appropriate fixture to the tester and plug in the specimen transformer.

    You are now ready to download and run your test program.

4. From the Top Level menu bar, select:

    > Tester>
    > Download Program
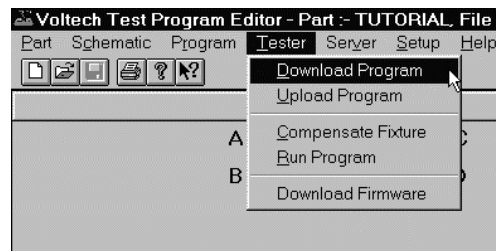
    The Editor will now down-load the test program to the tester. After a few seconds, you should see a message to say that the Download was successful.

5. Again, from the Top Level menu bar, select:

    > Tester>
    > Run Program

    The test program will now begin execution.

When it is finished, you will see a dialogue box containing the results of the test.

```
Test Results                                          ☒
┌─────────────────────────────────────────────────┐ ▲
│ 1   R       13.747 mOhm    PASS   0000            │
│ 2   LS      10.448 uH      PASS   0000            │
│                                                   │
│ RUN TIME   517 msec                               │
│                                                   │
│                                                   │
│                                                   │
│                                                   │
│                                                   │
│                                                   │
│                                                   │ ▼
│ ◄                                               ► │
└─────────────────────────────────────────────────┘
        [ Print ]      [ Re-Run Test ]      [ Close ]
```
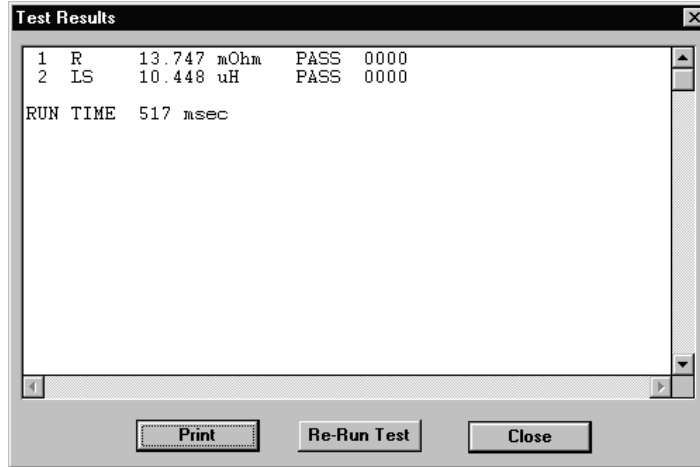
From the results, you should be able to see any tests where there may be problems. Return to the Program Editor to make the necessary changes, then download the program again, and run the corrected version.

Continue in this way until you are satisfied that the program is correct, before archiving it for use in production.

The code at the end of each result line should normally be zero; any other code signifies that an error occurred in the measurement.

At this point, you may want to protect your test program by setting an AT password. To do this, select:

Tester > Set Password

The resulting dialogue (see below) allows the AT password to be set. If a password is set, this password will need to be entered into the AT whenever a test program is changed or deleted.

```
Part :- TUTORIAL, File :- TUTORIAL.atp - Voltech
Part  Schematic  Program  Tester  Server  Setup  Help
 ┌─┬─┬─┐ ┌─┬─┬─┐        Download Program
 │ │ │ │ │ │ │ │        Upload Program
 └─┴─┴─┘ └─┴─┴─┘
                        Compensate Fixture
                        Run Program
    ┌──────────┐
    │    19    │        Download Firmware
    └──────────┘
                        Set Password
    ┌──────────┐
    │    17    │
```

```
Set AT Password                                     ☒
┌──────────────────────────────────────────────────┐
│  Only the following characters can be used in the │
│        password (max 25 characters) :             │
│                                                    │
│        ABCDEFGHIJKLMNOPQRSTUVWXYZ                  │
│        1234567890 / ( ) . - [SPACE]                │
│                                                    │
│                                                    │
│   New Password      ┌────────────────────────┐    │
│                     │                        │    │
│                     └────────────────────────┘    │
│                                                    │
│   Verify Password   ┌────────────────────────┐    │
│                     │                        │    │
│                     └────────────────────────┘    │
│                                                    │
│      ┌──────────┐              ┌──────────┐        │
│      │    OK    │              │  Cancel  │        │
│      └──────────┘              └──────────┘        │
└──────────────────────────────────────────────────┘
```

Note that this Editor dialogue also allows the password to be reset. The old password is not required to do this. All that is required is for the new password to be entered and verified.

3.11 ERROR CODES

Voltech AT Series testers provide the operator with two types of error detection:

- An electrically sound hardware integrity test, called self-test, with the provision of error codes, should an electrical fault be detected.

- Return of an error code during transformer testing to assist in diagnosing whether incorrect test parameters have been used or poor connections have caused the fault.

During normal component or transformer testing and/or while running self-test, voltage and current signals are constantly being generated, stabilized, measured and dissipated. Should a problem occur during one of these four stages, a unique error code is produced and displayed by the AT Series tester. The error code consists of a DSP (digital signal processor) status error code and a reason for DSP status error code.

The DSP status error code is a four-digit number that indicates that something has gone wrong. Each error code translates into an effect (a short description of the fault), such as a current or voltage overload, that can help the operator diagnose the cause of the problem. The DSP status error code is seen on self-test failures and on the Editors results screen.

The reason for DSP status error code is a one or two-digit number, displayed in parentheses, that explains the reason for the four-digit DSP status error code. These reason for DSP status error code translates into why a status error was displayed. This, again, can help the operator diagnose the cause of the problem. The reason for DSP status error code is only seen on self-test failures.

For the operator, the DSP status error codes can assist in determining if the fault is due to a poor fixture or an incorrectly seated part, or it could prompt an investigation into the appropriate test parameters being used. For the more serious faults, the user can contact their local Voltech technical support group and by explaining the application along with the DSP status error code can speed up and help the technical support engineer investigate the cause of the fault.

FRONT-PANEL ERROR CODES

When a fault is detected, the first DSP error code seen is a four-digit hexadecimal number, called the DSP status error code; the second is a one or a two-digit hexadecimal number in parentheses, called the reason for DSP status error code. This one or two digit code is only displayed with self-test failures.

Status error codes can be seen after a self-test failure. To view the error code, at the 'FAIL' display, press the 'Details' softkey. The following display will show the two status error codes: the first four digits being the DSP status error code and the second single or two-digit number in parentheses being the reason for DSP status error code.

Important Note:

Should self-test fail for any reason, contact Voltech technical support immediately, providing the following information:

- Serial number of the instrument
- Status error codes (the four-digit number and the one or two-digit number in parentheses on the display)

EDITOR ERROR CODES

Status error codes are also shown when using the Editor software in download and run mode. They are shown at the end of each test result. Only the first four-digit error code is displayed when using the Editor.
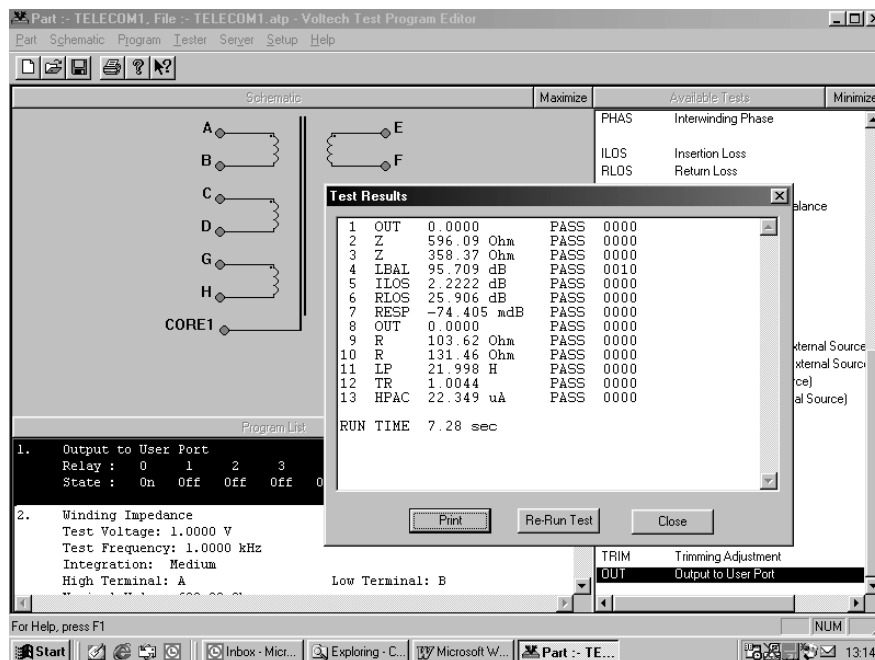
If you look at the test results screen shown above, you will see that test 4 (LBAL) contains a status error code of 0010. This error code indicates that "The measurement had not settled in time". Although this test passed, it indicates that a problem existed during the test sequence. In this particular example, the fault was due to a poor connection to the core of the transformer.

The following table gives the error codes that can appear when using the run facility in the Editor or when viewing on-line results with the Server. These error codes can give specific help in modifying the test program, depending on the tests used.

The error code is a 16-bit binary code, which is shown in hexadecimal notation in the table below. The error codes indicate one single bit of the 16-bit code, and therefore one or more errors could occur at the same time, which will be shown as a full, 4-digit hexadecimal code. For example, if a voltage over-range (xxx1) and a current over-range (xxx2) have occurred at the same time during test, then the error code is *0003* (i.e., both bits 0 and 1 set in the 16 bit binary error code).

If a test has failed due to an interrupt, then an additional code is attached to bits 12-15 of the error code as the table details further.

Hex Code	Error
0000	Test passed with no errors.
xxx1	Voltage over-range occurred.
xxx2	Current over-range occurred.
xxx4	Ramp-up process has been aborted; too much load.
xx2x	The test parameters could not be trimmed to required value; incorrect test parameters for the load.
xx4x	An error occurred after ramp-down; current did not decay away in time.
x1xx	Current limit fail (hi-pot tests only); test current exceeded pre-programmed limit (AT3600 only).
x2xx	Voltage present (Vpres) did not go away in time; something on the fixture is staying charged (AT3600 only).
#4xx	The test has failed due to an interrupt (see table below).

Where # = reason for interrupt fail.

1	The safety interlock interrupt has terminated the test; a break has occurred from the safety interlock port (AT3600 only).
3	A hi-pot trip interrupt has terminated the test; a flashover has occurred or the current has exceeded the AT's current capabilities (can occur on HPAC, HPDC, ACRT, DCRT and IR) (AT3600 only).
4	A STOP interrupt has terminated the test from the STOP flag of the remote port.
5	An 8kV interrupt has terminated the test - voltage > 8kV (AT3600 only).
7	An over-temperature interrupt has terminated the test; unit has become too hot (AT3600 only).
8	An auxiliary trip interrupt has terminated the test; this can be created by an attached device to the peripherals port.

3.12 FIXTURE COMPENSATION

Often when measuring small values of resistance, inductance or capacitance, the effects of the fixture can add significant errors to the results. To allow you to make more accurate measurements, the AT Series Testers have built-in firmware to compensate for the fixture parasitics.

If fixture compensation is required, follow steps 1, 2 and 4 of the procedure in section 3.10 of this chapter, so that the tester is connected and the program is downloaded.

Then from the top-level menu bar, select:

   Tester
   Compensate Fixture

If your program does not contain any tests where compensation can be applied, you will see the following message:

When you click on 'OK' to return to the top level menu, the tester will not make any measurements.

Most programs will contain at least one test where fixture compensation can be applied. In this case, you will then see one of two messages:
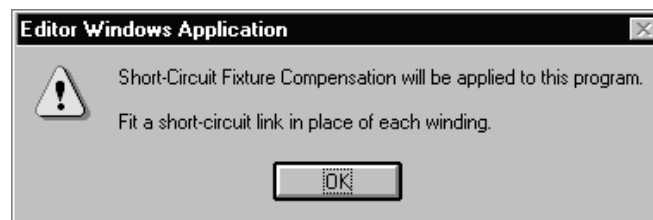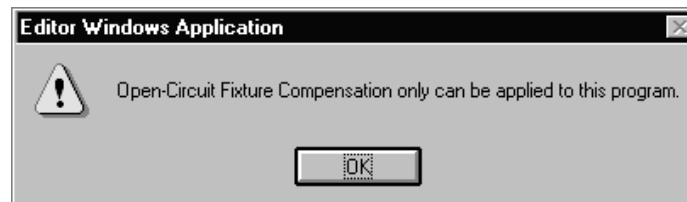
At this point you should ensure that the appropriate fixture has been placed on the tester. With the first message, it is possible to leave the fixture empty.

The second message will be displayed when the program contains at least one test for which short-circuit compensation is applicable. As the program may also contain tests requiring open-circuit compensation, you should ideally plug a dummy header into the fixture, where all the transformer windings are replaced by short-circuit links.

After you have clicked on the 'OK' button at either of the messages, the tester will be commanded to make the compensation measurements for your test program.

If errors are encountered, such as a shorting link is not fitted, the editor will display the appropriate warning message, and allow you either to try again, or to cancel the compensation.

When the compensation measurements have been successfully completed, the compensation values for each test in the program will be stored inside the tester. Any subsequent measurements (started as described above by clicking on Tester - Run Program) will return compensated results to the Editor.

If you are not sure whether to compensate or not, simply try it. If any of the results change significantly, then it should be done.

REMEMBER: Whenever you make changes to the program, the compensation results in the tester will no longer be valid.

Make sure to compensate again each time you download a test program to an AT Series Tester, whether the program has changed or not.

3.13. PROGRAMMING HINTS AND TIPS

The following is a list of points that should be remembered when you are creating your test programs.

1.   Create your schematic first.

When you are creating your test programs, you should work in the following order:

       a. Initially, create the schematic.

       b. Then, set up the program options.

       c. Finally, create the list of tests that make up the program.

Note: If you make any changes to the schematic after you have created the list of tests, then some tests may be inadvertently deleted. Examples where this may happen are: deleting a winding or a terminal, and renaming a terminal.

2.   Use the recommended order for the tests in the program.

The actual tests used in the program are of course dependent on the type of transformer to be tested, and the number of parameters you have chosen to test.

However, it is recommended that you generally do the tests in the following order:

a. Continuity.

To detect a transformer not correctly plugged into the test fixture, and any open circuit windings.

b. Primary inductance or magnetizing current

To detect faulty core material, and the wrong number of primary turns.

c. Turns ratios or open circuit voltages

To detect any windings with the wrong number of turns.

d. Isolation tests such as Insulation Resistance

To detect poor interwinding isolation where safety is not an issue, for example between two secondary windings.

e. Safety tests such as Hi-Pot

To detect poor interwinding isolation; but this time where safety is an issue, for example, from a primary winding to a secondary winding on a mains isolation transformer.

In the above list, items b and c will depend on the type of transformer:

For ferrite cored transformers operating at frequencies higher than 1kHz, it is preferable to measure the primary inductance and the turns ratios between windings.

For iron cored transformers operating at the 50 or 60Hz line frequency, where normal operation extends to the point of core saturation, magnetizing current and open circuit voltage measurement are normally the preferred tests.

3.   Use test limits which are as wide as possible.

For example, if you are testing the turns ratio between windings where the actual number of turns on one of the windings is only 10, specify limits of ± 5% (which is equivalent to half a turn).

4.   Make use of the Measure button.

For many tests, the dialogue box for the test contains a button labeled 'Measure'.

If, when you are creating your test program, you have a tester connected to your PC, fitted with the appropriate test fixture containing a specimen transformer, clicking on the Measure button will signal the tester to measure the actual parameter of the test. The result will be returned to the PC, and the Editor will insert it as the 'nominal value' in the limits section of the test dialogue box.

This is often the best way to find the value for some of the parameters which you may wish to test, but which do not appear on the actual transformer design documents.

5.   User Offset.
Under most circumstances, performing compensation as described earlier will compensate all measurements for the effects of stray parallel and series impedances, providing accurate measurements upon the part under test.
If compensation cannot be performed conveniently or an offset is required in the measurement is required for other reasons, then enable 'User Offset' and enter the value to add to the result.
Enter a negative value to subtract from the measured result.
The adjusted result (including any offset) is the result that will be used to provide PASS / FAIL judgments, and is the result that will be printed and / or stored by the server.

6.   Finally, download and run the program from the Editor, to make sure the results are what you expect, before you use it in production.

4. PROGRAMMING TESTS

This section describes in more detail how to fill in the data for the dialogue boxes for each of the tests available for your AT3600.

By the end of this chapter you will be able to program any of the following tests :

Test Type	Test Type
Continuity	Inter Winding Phase Angle
Resistance (dc)	Trimming Adjustment
Resistance (ac), series or parallel	Output To User Port
Inductance, series or parallel	Insulation Resistance
Inductance with Internal Bias	Hi-Pot (DC)
Quality Factor	Hi-Pot (AC)
Dissipation factor	Surge (Impulse)
Leakage Inductance	Wattage
Inter-winding Capacitance	Wattage (External Source)
Turns Ratio	Stress Wattage
Turns Ratio By Inductance	Stress Watts (External Source)
Impedance	Magnetizing Current
Impedance with Internal Bias	Mag. Current (External Source)
Inductance Match	Voltage Open Circuit
Capacitance Match	Voltage O/C (External Source)
General Longitudinal Balance	Low Voltage Open Circuit
Longitudinal Balance	Leakage Current
Insertion Loss	Inductance with External Bias
Frequency Response	Impedance with External Bias
Return Loss	Hi-Pot Ramp (AC)
Impedance Phase Angle	Hi-Pot Ramp (DC)

SEE ALSO:

Chapter 7 - 'Test Conditions' for help with selecting the tests and test signal conditions that you need.

AND:

The tester's measure mode can also be used to determine the nominal values of a new part. See section 3.9 of this chapter.

4.1. CTY - CONTINUITY

The continuity test can be placed as the first test in the program to check that the transformer has been inserted correctly into the test fixture. The test checks that every winding has a resistance less than a user specified limit, the same limit being applied to all windings.

The CTY test is an alternative to using an R (Winding Resistance) test on each winding separately. The CTY test has the advantage of speed of execution; but with the R test, individual limits can be applied to each winding, to give confidence, for example, that the correct wire gauge has been used.

On selecting 'CTY - Continuity' from the available tests window, the following dialogue box will be displayed:
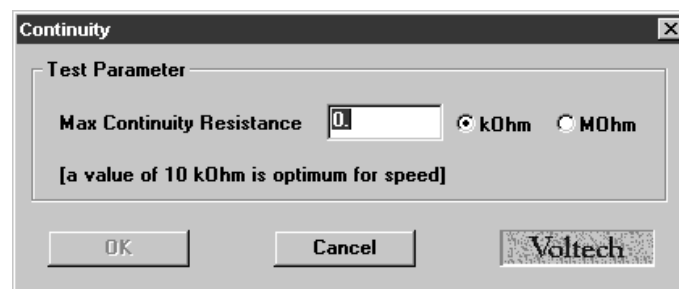
To program the test:

1. Enter the maximum resistance limit.

    Remember that there is only one limit, and the same value will be applied to all windings.

    If all the windings on your transformer have small resistance values, then choose the value of 10kΩ, to give the quickest test execution.

    If any winding has a resistance greater than 10kΩ, then choose a value bigger than that expected for the winding with the largest resistance.

2. Select OK. The test specification will then be displayed in the program window.

4.2. R - WINDING RESISTANCE

To check that the resistance of a winding is correct, the AT3600 applies a dc test signal to the selected winding. It then measures both the current through and the voltage across the winding, and calculates the resistance.

On selecting 'R Winding Resistance' from the available tests window, a dialogue box will be displayed.
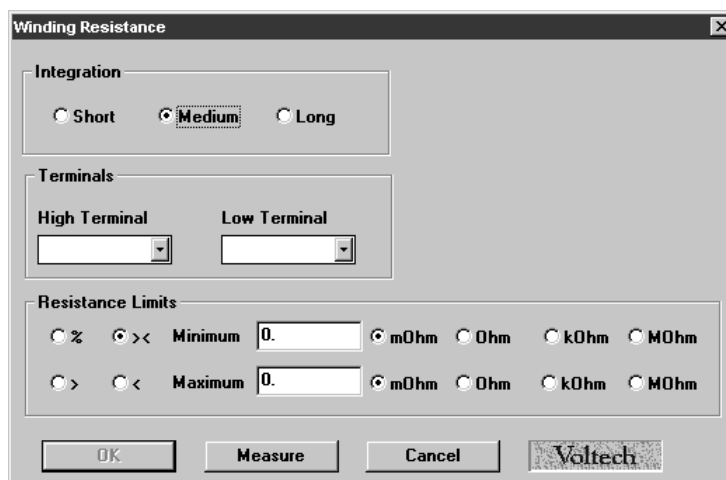
To program the test:

1. Select (mouse click the button) the integration time you require.

    'medium' is the default setting. 'long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'short' will test at the maximum speed, but may give a slightly noisier reading.

2. Enter the terminal names between which the resistance is to be measured.

    Pull down (mouse click the down arrow) the list of available terminal names and click the terminal name you require.

3. Select (mouse click the button) the type of limits you require and enter the values.

    %   Enter a nominal value and then the limits as negative and positive percentage values.

    ><   Enter minimum and maximum values.

    >   Enter just a minimum value.

    <   Enter just a maximum value.

    Note that the measure button may be used here as outlined in section 3.9.

4. Select OK. The test specification will then be displayed in the program window.

4.3. RLS OR RLP - EQUIVALENT SERIES OR PARALLEL RESISTANCE

The equivalent series or parallel resistance is obtained from a measurement of the complex impedance. An ac voltage is applied across the selected winding. The voltage across and current through the winding are then measured using harmonic analysis. The measured voltage is divided by the current to obtain a complex impedance and the equivalent series or parallel resistance calculated.

Select either 'RLS Equivalent Series Resistance' or 'RLP Equivalent Parallel Resistance' from the Available Tests window, to display:

or:

To program the test :

1.   Enter the signal and frequency required for the test.

Note that the signal is normally entered as a voltage by selecting the 'mV' or 'V' button; but you may optionally enter it as a current by selecting the 'mA' button.

(If in doubt, refer to Chapter 7 - 'Test Conditions', which lists recommended test conditions based on the values of winding inductance.)

Note also that the Measure button may be used here as outlined in section 3.9, with the combinations of test parameter specification shown in the following table:

Signal	Specified voltage	Specified current	Auto
Frequency	Specified	Specified	Specified

Normally, the equivalent resistance test would follow an inductance test on the same winding. Using the same test conditions for both tests will speed the execution of the program.

2. Select (mouse click the button) the integration time you require.

    'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Enter the terminal names for the selected winding. By pulling down the menu along side the fill-in box, you may select the high and low terminals for the test.

4. Select (mouse click the button) the type of limits you require and enter the values.

    %   Enter a nominal value and then the limits as negative and positive percentage values.

    ><   Enter minimum and maximum values.

    >   Enter just a minimum value.

    <   Enter just a maximum value.

    Note that the Measure button may be used here as outlined in section 3.9.

5. Select OK. The test specification will then be displayed in the program window.

4.4. LS OR LP – WINDING INDUCTANCE (SERIES OR PARALLEL CIRCUIT)

The inductance of a transformer winding may be tested using series or parallel equivalent circuit models. An ac voltage is applied across the selected winding. The voltage across and current through the winding are then measured using harmonic analysis. The measured voltage is divided by the current to obtain a complex impedance and the inductance is calculated.

On selecting 'LS Inductance (series cct)' or 'LP Inductance (parallel cct)' from the Available Tests window, a dialogue box will be displayed.

or:

To program the test:

1.   Enter the signal and frequency required for the test.

     Note that the signal is normally entered as a voltage by selecting the 'mV' or 'V' button; but you may optionally enter it as a current by selecting the 'mA' button.

(If in doubt, refer to Chapter 7 - 'Test Conditions', which lists recommended test conditions for different values of inductance.)

Note also that the Measure button may be used here as outlined in section 3.9, with the combinations of test parameter specification shown in the following table:

Signal	Specified voltage	Specified current	Auto	Auto
Frequency	Specified	Specified	Specified	Auto

2. Select (mouse click the button) the integration time you require.

    'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Enter the terminal names between which the inductance will be measured. By pulling down the menu along side the fill-in box, you may select the high and low terminals for the test.

4. Select (mouse click the button) the type of limits you require and enter the values.

    %   Enter a nominal value and then the limits as negative and positive percentage values,

    ><   Enter minimum and maximum values.

    >   Enter just a minimum value.

    <   Enter just a maximum value.

    Note that the Measure button may be used here as outlined in section 3.9.

5. Select OK. The test specification will then be displayed in the program window.

4.5. LSB OR LPB - INDUCTANCE WITH BIAS (SERIES OR PARALLEL CIRCUIT)

The inductance of a transformer winding when a bias current is flowing may be tested using series or parallel equivalent circuit models. Initially the (dc) bias current is set up and allowed to stabilize. An ac voltage is applied across the selected winding; the voltage across and current through the winding are then measured using harmonic analysis. The measured voltage is divided by the current to obtain a complex impedance and the inductance is calculated .

On selecting 'LSB Inductance with Bias (Series cct)' or 'LPB Inductance with Bias (Parallel cct)' from the Available Tests window, a dialogue box will be displayed.

or:

To program the test:

1. Enter the signal, frequency and bias current required for the test.

Note that the signal is normally entered as a voltage by selecting the 'mV' or 'V' button; but you may optionally enter it as a current by selecting the 'mA' button.

(If in doubt, refer to Chapter 7 - 'Test Conditions', which lists recommended test conditions for different values of inductance.)

Note also that the Measure button may be used here as outlined in section 3.9, with the combinations of test parameter specification shown in the following table:

Signal	Specified voltage	Specified current	Auto	Auto
Frequency	Specified	Specified	Specified	Auto
Bias	Specified	Specified	Specified	Specified

2. Select (mouse click the button) the integration time you require.

    'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Enter the terminal names between which the inductance will be measured. By pulling down the menu along side the fill-in box, you may select the high and low terminals for the test.

4. Select (mouse click the button) the type of limits you require and enter the values.

    %   Enter a nominal value and then the limits as negative and positive percentage values.

    ><   Enter minimum and maximum values.

    >   Enter just a minimum value.

    <   Enter just a maximum value.

    Note that the Measure button may be used here as outlined in section 3.9.

5. Select OK. The test specification will then be displayed in the program window.

4.6. QL - QUALITY FACTOR

To test for Q factor, an ac voltage is applied across the selected winding. The voltage across and current through the winding are then measured using harmonic analysis. The measured voltage is divided by the current to obtain a complex impedance, from which the Q factor is calculated.

On selecting 'QL Q Factor' from the Available Tests window, a dialogue box will be displayed.

To program the test :

1. Enter the signal and frequency required for the test.

    Note that the signal is normally entered as a voltage by selecting the 'mV' or 'V' button; but you may optionally enter it as a current by selecting the 'mA' button.

    (If in doubt, refer to Chapter 7 - 'Test Conditions', which lists recommended test conditions based on the values of winding inductance.)

    Note also that the Measure button may be used here as outlined in section 3.9, with the combinations of test parameter specification shown in the following table:

Signal	Specified voltage	Specified current	Auto
Frequency	Specified	Specified	Specified

    Normally, the Q factor test would follow an inductance test on the same winding. Using the same test conditions for both tests will speed the execution of the program.

2. Select (mouse click the button) the integration time you require.

    'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Enter the high and low terminal names. Use the mouse to pull down the menu along side the fill-in box, and double click to select the terminal.

4. Select (mouse click the button) the type of limits you require and enter the values.

    %   Enter a nominal value and then the limits as negative and positive percentage values.

    ><   Enter minimum and maximum values.

    >   Enter just a minimum value.

    <   Enter just a maximum value.

    Note that the Measure button may be used here as outlined in section 3.9.

5. Select OK. The test specification will then be displayed in the program window.

4.7. D – DISSIPATION FACTOR OR TANδ

To measure dissipation factor, the tester applies an AC voltage across the selected winding, and measures the voltage across and the current through the winding. Using harmonic analysis, the measured voltage is divided by the current to obtain a complex impedance from which the dissipation factor is obtained.

Choosing the test signal

For optimum accuracy and performance, use the test conditions chosen for capacitance in a later section of this chapter.

The test conditions can also be determined automatically by the AT3600 according to this table:

Signal	Specified voltage	Specified current	Auto
Frequency	Specified	Specified	Specified

Note that a 'fixed' signal cannot be used with an 'auto' frequency.

To program the test using the PC Test Editor:

Choose the integration period (normally 'Medium') and enter the terminals to be measured.

Use the Editor's 'measure' button (together with a sample part) if you are unsure of how to choose the test conditions.

Choosing the test limits

The test limits can be:

%	A nominal value together with + and – percentage limits.
><	Minimum and maximum values
>	A minimum value only
<	A maximum value only

Use the PC Editor's 'measure' button (together with a sample part) if you are unsure of the nominal value.

Typically, D is tested against a maximum value. A typical film dielectric capacitor may have a $D < 0.01$. Because D is a ratio of two impedances it has no units.

4.8. LL OR LLO - LEAKAGE INDUCTANCE

The Leakage Inductance for a particular transformer is tested by measuring the inductance of a 'primary' winding when one or more 'secondary' windings have short-circuits applied.

Select either 'LL Leakage Inductance' or 'LLO Leakage Inductance with Offset' from the available tests window, to display one of the following form fill-in dialogue boxes as appropriate.

LL (Leakage Inductance)   LLO (Leakage Inductance with Offset)

To program the test :

1. Enter the signal and frequency required for the test.

    Note that the signal is normally entered as a current by selecting the 'uA' or 'mA' button; but you may optionally enter it as a voltage by selecting the 'mV' button.

    (Refer to Chapter 7 - 'Test Conditions', if you are unsure of the voltage and frequency to use.)

    Note also that the Measure button may be used here as outlined in section 3.9, with the combinations of test parameter specification shown in the following table:

Signal	Specified current	Specified voltage	Auto	Auto
Frequency	Specified	Specified	Specified	Auto

2. Select (mouse click the button) the integration time you require.

    'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Select the high and low terminals of the coil to be energized (primary terminals). By clicking on the arrow to the right of the fill-in box, you will be provided with a choice of possible terminals. Double-click on the name of the required terminal.

4. Select the secondary high and low terminals.

   These terminals will be shorted out during the test. As the short-circuit applied via the relay matrix in the tester cannot be perfect, additional measurements will be made to these terminals to compensate.

5. Select the additional low terminals.

   These terminals are also shorted out during the test, but they are not used in the compensation measurements.

   If only one secondary winding is to be shorted, then there will be no additional low terminals. If several windings are to be shorted, then the Secondary Terminals should be on the winding with the largest number of turns, and Additional Low terminals should be used for the rest.

6. Select (mouse click the button) the type of limits you require and enter the values.

   %   Enter a nominal value and then the limits as negative and positive percentage values.

   ><   Enter minimum and maximum values.

   >   Enter just a minimum value.

   <   Enter just a maximum value.

   Note that the Measure button may be used here as outlined in section 3.9.

7. Select whether a user offset is required (LLO test only) and enter its value if applicable. This value will be added to the measured value to give the returned result.

   Normally a user offset would not be required. However for small values of leakage inductance ($<1\mu$H) when there are a number of additional low terminals, it is not always possible during fixture compensation for the tester to remove all of the parasitic errors of the test fixture. In this case, the user offset may be required to fully remove the errors. The LLO test provides this additional feature.

8. Select OK. The test specification will then be displayed in the program window.

4.9. C - INTERWINDING CAPACITANCE

Your AT3600 can test the capacitance present between windings, screens and core.

Select 'C Interwinding Capacitance' from the list of available tests, to give the following dialogue box:

To program the test :

1. Enter the voltage and frequency required for the test.

    (Refer to Chapter 7 - 'Test Conditions', which lists recommended test conditions for different values of capacitance.)

    Note also that the Measure button may be used here as outlined in section 3.9, with the combinations of test parameter specification shown in the following table:

Voltage	Specified	Auto	Auto
Frequency	Specified	Specified	Auto

2. Select (mouse click the button) the limit integration time you require.

    'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Enter the terminal names for the High and Low Terminals.

    Click with the mouse to select a terminal from the Available list; then click the 'Add >' button to transfer it to the Used list.

4. Select (mouse click the button) the type of limits you require and enter the values.

   %   Enter a nominal value and then the limits as negative and positive percentage values.

   ><   Enter minimum and maximum values.

   >   Enter just a minimum value.

   <   Enter just a maximum value.

Note that the Measure button may be used here as outlined in section 3.9.

5. Select OK. The test specification will then be displayed in the program window.

4.10. TR - TURNS RATIO

You may program the AT3600 Tester to test the turns ratio between one winding and any other.

To measure turns ratio, a test source voltage is applied to one winding, the energized winding, and the voltages across two other windings (one of which may also be the energized winding) are measured using harmonic analysis. The turns ratio is measured by dividing one measured voltage by the other, and making a compensation for the effects of winding resistance.

On selecting 'TR Turns Ratio' from the available tests window, a dialogue box will be displayed.

To program the test :

1. In the fields provided, insert the voltage and frequency you require for the test (see chapter 7 - 'Test Conditions').

Note also that the Measure button may be used here as outlined in section 3.9, with the combinations of test parameter specification shown in the following table:

Voltage	Specified	Auto	Auto
Frequency	Specified	Specified	Auto

2. Select (mouse click the button) the integration time you require.

'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Select the high and low terminals of the coil to be energized. (Click on the arrow to the right of the fill-in box and you will be provided with a choice of the available terminals. Click the required terminal.)

    Normally, choose the energized winding to be the one with the highest number of turns. An exception to this rule can be made in the case when there are three separate windings, and you wish to check that two windings with the same number of turns are accurately 1:1; in this case it is preferable to energize the third winding, even if it has fewer turns.

4. Similarly, select the high and low terminals of the primary and secondary windings.

    In the case of a two winding transformer, choose both the primary winding and the energized winding to be the one with the highest number of turns.

5. Select (mouse click the button) Ratio (%), or Turns (#) limits.

    Enter the required limits:

    Ratio (%)

    Enter the nominal Primary to Secondary ratio, together with the limits as positive and negative percentage values.

    Turns(#)

    In turns mode you may set upper and lower limits on the primary and secondary windings. The transformer tester will then set limits on the turns ratio which are equal to the sum of these two errors, e.g.:

primary	100 turns	$\pm$ 2 turns
secondary	100 turns	$\pm$ 2 turns

    the tester will set the following limits on the ratio:

    upper limit =   104/100   lower limit = 96/100.

    If you wish to set limits on only one winding, you must enter zero (0) as the limit for the other winding.

    Note that the Measure button may be used here as outlined in section 3.9.

6. If required, the polarity of the test can be checked. Click on the expected polarity of the transformer turns, otherwise disable the test by selecting 'No Test'.

7. Select OK. The test specification will be displayed in the program window on the screen.

Choosing the test limits

The limits may be entered as :

1. A nominal value together a percentage tolerance.(%)

Enter the nominal Primary to Secondary ratio, together with the limits as positive and negative percentage values.

2. An absolute number of turns(#)

When limits are set as +/- an absolute number of turns, the tester converts these limits to the % type in the following way:

$$= +/- \left(\frac{\text{Pri Limit}}{\text{Pri Turns}} + \frac{\text{Sec Limit}}{\text{Sec Turns}} \right) \times 100\%$$

(You can see the exact result of this conversion by clicking on % limits in the Editor dialogue once the absolute, # , limits have bee entered.)

For example, take a typical Switched Mode Power Supply transformer with windings in the ratio of **200:10.**

Typically, a prior measurement of inductance will have confirmed the correct number of primary turns have been fitted with the correct cores. Setting absolute limits of **0 on the primary and 1 on the secondary** will result in limits of;

Nominal Ratio: 200/10   =20

Ratio + 1 sec turn   =18.18

Ratio –1 sec turn   = 22.22

Limits calculated by tester = (0/200 + 1/10) x 100%= +/- 10%

The equivalent ratio limits used by tester are:

Upper limit = 22. Lower Limit = 18

Which equates to the actual ratios with a one turn error on the secondary.

In general, the voltages obtained during any voltage turns ratio test will not equate exactly to the theoretical calculation of Np / Ns, because, for example, of the relative positions of the windings with respect to each other and the core.

General Rule

When setting turns ratio limits in absolute terms, use a limit of **½ turn less** than the number of turns you want to detect. In this case set a limit of 0 (pri) and ½(sec). This will result in equivalent limits of 19 and 21. Ideal for detecting an errors of 1 turn or more.

What happens if I set both absolute limits for both primary and secondary windings?

If you want to detect up to a 10 turn error on the primary and 1 turn on the secondary in the above example, set **9 1/2 (pri) and 1/2 (sec)**. The tester uses the equivalent ratio limits: 21.95 and 18.05. **Setting both limits WIDENS the limit to allow for an error of 10 Turn on the primary SIMULTANEOUSLY with 1 turn on the secondary**.

i.e. to allow 190:11 (17.27) and 210:9 (23.33).

Notice that these limits will NOT detect just a 1 turn error on the secondary because you have now chosen limits to allow for errors on both primary and secondary, resulting in a broader tolerance on the absolute ratio.

How so I set limits that will detect a 1 turn error in either the primary or secondary winding?

To do this you must set limits that will detect the smallest possible error. This will be due to the 1 turn error being on the winding with the largest number of turns.

In the above example then, set absolute limits of ½turn (pri) and 0 turn (sec). (Remember to use the n-1/2 rule).

The equivalent limits used by the tester will be:

20.05 and 19.95

This will certainly detect a 1 turn error in the primary, but because of the physical errors already described these limits may be too severe for a normal good part. This is why a **combination** of inductance and turns ratio tests are normally used to confirm the correct assembly of transformers.

The polarity test may be selected as (+)ve, (-)ve or no test. To measure the exact interwinding phase angle use the PHAS test.

Use the PC Editor's 'measure' button (together with a sample part) if you are unsure of the nominal value.

4.11. TRL - TURNS RATIO (BY INDUCTANCE)

The TRL test measures the turns ratio between a pair of windings by comparing their inductance. This is different from the TR test, which compares the voltage used to energize one winding, with the voltage induced on a second. The TRL test is preferable to the TR test when the coupling between the primary and secondary windings is poor.

An alternating voltage is applied to each winding in turn. The alternating currents that flow and the applied voltage at the transformer are measured. From these measured currents and voltages a complex-impedance is derived, and the inductance is then calculated. The turns ratio is computed by dividing the square root of the primary inductance by the square root of the secondary inductance.

On selecting 'TRL Turns Ratio (from inductance)' from the available tests window, a dialogue box will be displayed.

To program the test :

1. In the fields provided, insert the voltage and frequency you require for the test (see chapter 7 - 'Test Conditions').

    Note also that the Measure button may be used here as outlined in section 3.9 of this chapter, with the combinations of test parameter specification shown in the following table:

Voltage	Specified	Auto	Auto
Frequency	Specified	Specified	Auto

2. Select (mouse click the button) the integration time you require.

    'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Select the high and low terminals of the primary winding. (Click on the arrow to the right of the fill-in box and you will be provided with a choice of the available terminals. Click the required terminal.)

    Select the high and low terminals of the secondary winding.

4. Select (mouse click the button) Ratio (%), or Turns (#) limits.

    Enter the required limits:

    Ratio (%)

    Enter the nominal Primary to Secondary ratio, together with the limits as positive and negative percentage values.

    Turns(#)

    In turns mode you may set upper and lower limits on the primary and secondary windings. The transformer tester will then set limits on the turns ratio which are equal to the sum of these two errors, e.g.:

    Primary   100 turns $\pm$ 2 turns

    secondary   100 turns $\pm$ 2 turns

    the tester will set the following limits on the ratio:

    upper limit =   104/100   lower limit = 96/100.

    If you wish to set limits on only one winding, you must enter zero (0) as the limit for the other winding.

    Note that the Measure button may be used here as outlined in section 3.9.

5. If required, the polarity of the test can be checked. Click on the expected polarity of the transformer turns, otherwise disable the test by selecting 'No Test'.

6. Select OK. The test specification will be displayed in the program window on the screen.

4.12. Z, ZB – IMPEDANCE

The Winding Impedance test measures the impedance of a selected winding using specified voltage (or current) and frequency conditions. An AC voltage is applied across the winding under test and the complex impedance is determined from measurement of the test voltage and the flowing current. The Z result is the magnitude of this impedance.

This test is normally used for audio & telecommunication transformers to check the impedance presented to the transformers input and output.

On selecting "Z Winding Impedance" from the 'available tests' window, the following dialog box is displayed:

To program the test:

1. Enter the value of voltage (or current) for the signal and the required frequency of the test. (If in doubt, refer to Chapter 7 - 'Test Conditions', which lists recommended test conditions.)

Note also that the Measure button may be used here as outlined in section 3.9.

2. Select the integration time required. 'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Enter the terminal names between which the impedance is to be measured. See terminal selection.

4. Set the impedance limits.

+/-   Enter a nominal value and then the limits as negative and positive values.

><   Enter minimum and maximum values.

>   Enter just a minimum value.

<   Enter just a maximum value.

5. For the impedance with bias test, you may also select a DC bias current

6. Select OK. The test specification will then be displayed in the program window.

4.13. L2 - INDUCTANCE MATCH

The inductance match test calculates the ratio between two inductance's on two windings. An equivalent series inductance measurement is performed on each winding by measuring the complex impedance.

This test is suitable for switched mode power supply transformers, and audio & telecommunication transformers. It checks matching between windings.

On selecting 'L2 Inductance Match a dialogue box will be displayed.

To program the test:

1. Enter the required values of frequency and current or voltage for the X and Y windings

    (If in doubt, refer to Chapter 7 - 'Test Conditions', which lists recommended test conditions.)

    Note also that the Measure button may be used here as outlined in section 3.9.

2. Select (mouse click the button) the integration time you require.

    'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Enter the terminal names between which the X inductance is to be measured.

4. Enter the terminal names between which the Y inductance is to be measured.

5. Set the inductance ratio limits

6. Select OK. The test specification will then be displayed in the program window

4.14. C2 – CAPACITANCE MATCH

The Interwinding capacitance match test calculates the ratio between two capacitance measurements on two groups of windings. It is measured by applying a specified ac voltage between two separate windings and the voltage across and current flow between the two windings is measured to obtain a complex impedance. This is performed to the two groups in turn.

This test is suitable for switched mode power supply, audio and telecommunication transformers. It checks that the windings are installed in the correct positions on the bobbin.

On selecting "C2 Interwinding Capacitance Match" from the available tests window, a dialogue box will be displayed.
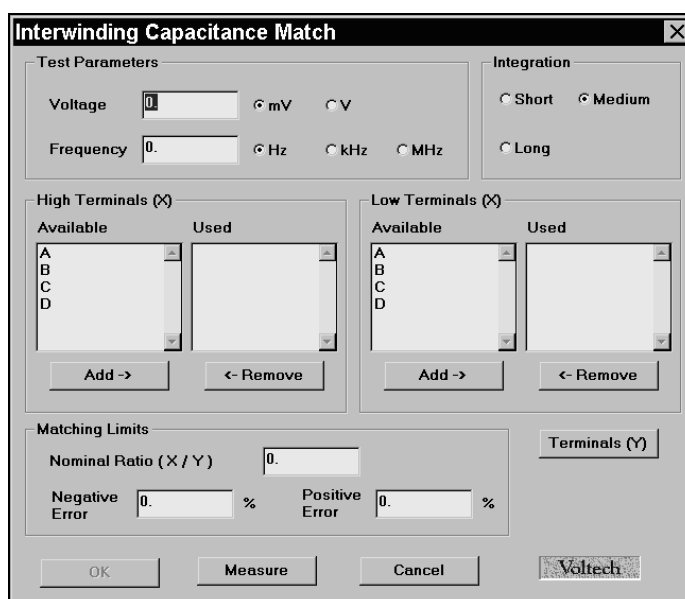
To program the test:

1. Enter the voltage and frequency required for the test.

    (Refer to Chapter 7 - 'Test Conditions', which lists recommended test conditions for different values of capacitance.)

2. Select the integration time you require.

    'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Select the terminals to be included for both high and low X test terminals.

4. Selecting Terminals [Y] prompts a second dialogue box allowing the second set of windings to be configured for the test.

5. Set the capacitance limits.

6. Select OK. The test specification will then be displayed in the program window.

4.15. GBAL – GENERAL LONGITUDINAL BALANCE

The general longitudinal balance test is intended to measure what is effectively the Common Mode Rejection Ratio of a transformer designed to connect to a balanced line. Two measurements are performed each by applying a voltage to the transformer and measuring the resulting voltage to calculate the CMRR. To overcome the differences of three standard methods of measuring the CMRR the GBAL dialogue box has a separate group of terminals X and Y for the first and second measurements respectively. The preferred method of measurement is the LBAL test for which Voltech provide a separate test specifically for this measurement.

This test is suitable for audio & telecommunication transformers and checks the effective common mode rejection ratio of the transformer.

On selecting "GBAL General Longitudinal Balance" from the available tests window, a dialogue box will be displayed:

To program the test:

1.   Enter the voltage and frequency parameters of the test signal.

     (If in doubt, refer to Chapter 7 - 'Test Conditions', which lists recommended test conditions).

     Note also that the Measure button may be used here as outlined in section 3.9.

2.   Select the integration time you require

     'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Enter the names for the energised and measured terminals for the X measurement.

4. Similarly configure Y terminals.

5. When required the "Optional 2nd Energised Hi" allows an additional terminal connection to the energised high node.

6. Set (X/Y) limits.

    +/-   Enter a nominal value and then the limits as negative and positive values.

    ><   Enter minimum and maximum values.

    >   Enter just a minimum value.

7. Since components on the test fixture may scale measured readings the "Compensate for Test Fixture Scaling" allows the test to account for this.

8. Select OK. The test specification will then be displayed in the program window.

4.16. LBAL – LONGITUDINAL BALANCE

The longitudinal balance test is Voltech's preferred method to measure what is effectively the Common Mode Rejection Ratio of a transformer designed to connect to a balanced line. Two measurements are performed each by applying a voltage to the transformer and measuring the resulting voltage to calculate the CMRR.

This test is suitable for audio & telecommunication transformers and checks the effective common mode rejection ratio of the transformer.

On selecting "LBAL Longitudinal Balance" from the available tests window, a dialogue box will be displayed:

To program the test:

1. Enter the voltage and frequency parameters of the test signal.

    (If in doubt, refer to Chapter 7 - 'Test Conditions', which lists recommended test conditions.)

    Note also that the Measure button may be used here as outlined in section 3.9.

2. Select the integration time you require.

    'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Enter the names of the Hi and Lo input terminals and Common Terminal.

4. Enter the names of the Hi and Lo output terminals.

5.   Set the longitudinal balance limits.

+/-   Enter a nominal value and then the limits as negative and positive values.

><   Enter minimum and maximum values.

>   Enter just a minimum value.

6.   Select OK. The test specification will then be displayed in the program window.

4.17. ILOS – INSERTION LOSS

The Insertion loss test measures the output power delivered by a transformer to a load, relative to the maximum power theoretically available. A voltage is applied to the input winding and the input/output voltages are measured to calculate the loss. This test is suitable for audio & telecommunication transformers and checks the effective losses in the transformer when used for its application.

On selecting "ILOS Insertion Loss" from the available tests window, a dialogue box will be displayed.

To program the test:

1. Enter the voltage and frequency parameters of the test signal.

   (If in doubt, refer to Chapter 7 - 'Test Conditions', which lists recommended test conditions.)

   Note also that the Measure button may be used here as outlined in section 3.9.

2. Select the integration time you require.

   'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Enter the names of the Hi and Lo input terminals and value of source resistance.

4. Enter the names of the Hi and Lo output terminals and value of load resistance.

5. Set the insertion loss limits.

   +/-   Enter a nominal value and then the limits as negative and positive values.

   ><   Enter minimum and maximum values.

   >   Enter just a minimum value.

6. Select OK. The test specification will then be displayed in the program window.

4.18. RESP – FREQUENCY RESPONSE

The frequency response test, RESP, may be used to check that the variation in power loss of a telecommunications or audio transformer over a specified frequency range is less than specified limits.

The RESP test consists of a number of Insertion Loss (ILOS) tests repeated at different frequencies.

To program the test:

1.   Enter the voltage and frequency parameters of the reference test signal. (If in doubt, refer to Chapter 7 - 'Test Conditions', which lists recommended test conditions.)

2.   Select the integration time required. 'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3.   Enter the names of the Hi and Lo input terminals.

4.   Enter the names of the Hi and Lo output terminals.

5.   Add test frequencies as required by entering the frequency and clicking 'add'. See Chapter 7.

6.   Set the frequency response limits. See Setting Limits

7.   Select OK. The test specification will then be displayed in the program window.

4.19. RLOS – RETURN LOSS

The Return loss test measures the impedance mismatch between the transformer and a transmission line of a specified impedance. RLOS is calculated from a measurement of the complex impedance and the specified impedance

This test is suitable for audio & telecommunication transformers and checks the effective input impedance of the transformer in the application.

On selecting "RLOS Return Loss" from the available tests window, the following dialogue box is displayed:

To program the test:

1. Enter the voltage and frequency parameters of the test signal.

    (If in doubt, refer to Chapter 7 - 'Test Conditions', which lists recommended test conditions.)

    Note also that the Measure button may be used here as outlined in section 3.9.

2. Select the integration time you require.

    'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Enter the names of the Hi and Lo input terminals and value of source resistance.

4. Set the return loss limits.

    +/-   Enter a nominal value and then the limits as negative and positive values.

    ><   Enter minimum and maximum values.

    >   Enter just a minimum value.

5. Select OK. The test specification will then be displayed in the program window.

4.20. ANGL – IMPEDANCE PHASE ANGLE

The Impedance Phase Angle test can measure the impedance of a selected winding using specified voltage (or current) and frequency conditions, and then reports the equivalent impedance phase. An AC voltage is applied across the winding under test and the complex impedance is determined from measurements of the voltage across the winding and the current flowing through it. The ANGL result is the phase of this complex impedance, it is the phase angle between the voltage and current.

This test is normally used for audio & telecommunication transformers along with the Z (impedance) test to check the complex impedance presented to the transformers input and output.

On selecting "ANGL Impedance Phase Angle" from the 'available tests' window, the following dialogue box will be displayed:

To program the test:

1. Enter the value of voltage (or current) for the signal and the required frequency of the test. (If in doubt, refer to Chapter 7 - 'Test Conditions', which lists recommended test conditions.)

Note also that the Measure button may be used here as outlined in section 3.9. Note: you must specify the frequency when using the 'Measure' button in the ANGL test.

2. Select the integration time required. 'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Enter the terminal names between which the impedance is to be measured. See terminal selection.

4. Enter the phase limits.

For phase tests, the convention of the result returned by the AT depends on the minimum limit requested. If this limit is >0 the result returned is between 0^0 and 360^0. If the minimum limit is $>-180^0$, the result returned is between -180^0 and 180^0, otherwise the result returned is between -360^0 and 0^0. This is done to ensure continuity of results and ease of setting limits irrespective of where the phasor diagram is being checked.

5. Select 'OK'. The test specification will then be displayed in the program window.

4.21. PHAS – INTERWINDING PHASE TEST

The interwinding phase may be tested between one winding and another. A test source voltage is applied to one winding, and the voltages across two other windings (one of which may be the driven winding) are measured. The interwinding phase is measured by finding the phase difference between the voltages measured on the primary and secondary windings.

This test is suitable for most types of transformers although unusual with line frequency transformers, it tests the windings for the correct phasing. It is most useful for determining the effect of audio and telecommunications transformers when placed in a transmission line.

On selecting "PHAS Interwinding Phase" from the 'available tests' window, the following dialog box is displayed:

To program the test:

1. Enter the value of voltage for the signal and the required frequency of the test. (If in doubt, refer to Chapter 7 - 'Test Conditions', which lists recommended test conditions.)

   Note also that the Measure button may be used here as outlined in section 3.9.

2. Select the integration time required. 'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Enter the terminal names of the winding to be energized. Enter the terminal names of the primary and secondary windings on which the PHAS test is to be performed. Note: either of these windings can be the energized winding.

4. Set the phase limits:

   For phase tests, the convention of the result returned by the AT depends on the minimum limit requested. If this limit is >0 the result returned is between 0^0 and 360^0. If the minimum limit is $>-180^0$, the result returned is between -180^0 and 180^0, otherwise the result returned is between -360^0 and 0^0. This is done to ensure continuity of results and ease of setting limits irrespective of where the phasor diagram is being checked.

5. Select 'OK'. The test specification will then be displayed in the program window.

4.22. TRIM - TRIMMING ADJUSTMENT TEST

This test allows the operator to make adjustments to the transformer under test, at selected points in the test program.

The TRIM test is inserted immediately following the test for the property that may need to be adjusted. If the result for the previous test is a 'PASS', the trim test will do nothing, and program execution will continue in the normal way. However, if the previous test fails, the TRIM test calls up the Measure Mode for the previous test, and lets the operator make the required adjustments to bring the parameter into specification. Following the adjustments, the program must be re-run from the beginning to produce a 'PASS' result for the transformer.

In a program, only tests from the following list are allowed to precede a Trim test:

R, LS, LP, QL, RLS, RLP, LL, C, LSB, or LPB

On selecting 'TRIM - Trimming Adjustment' from the Available Tests Window, the following dialogue box will be displayed:
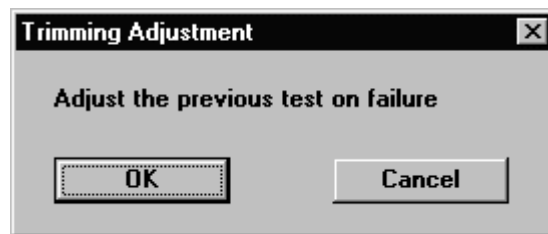
To program the test:

1.   Select OK. The test will then be displayed in the program window.

4.23. OUT – OUTPUT TO USER PORT

The User Port on the AT3600 has 6 'Relay Driver' outputs associated with it. The OUT test allows programming of the User Port relay driver outputs to perform additional relay switching as part of the test program.

An example of this would be an application where a transformer has two separate primary windings. An OUT test could be used to connect them in series, allowing them to be tested as a single primary with twice the working voltage.

A second example is the switching of additional resistors mounted on the test fixture allowing tests to be included in a program on a transformer with a loaded secondary winding.

Each of the relay driver outputs can be set to on or off (closed or open respectively) as shown:
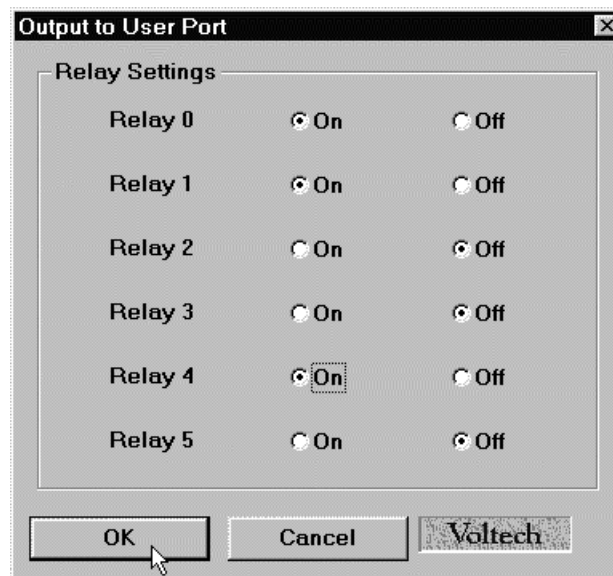
Once the settings are correct click on OK to accept them.

Note:

The relay drivers are only set as and when the tester encounters an OUT test. The settings given will remain in place until another OUT test is encountered. Therefore if the settings are required for one part of the test program only, two OUT tests will be required, the first to turn the appropriate relay drivers on and the second to turn them back off.

See the Specification for details of the relay driver configuration.

4.24. IR - INSULATION RESISTANCE

The insulation resistance may be measured between any number of windings. A dc voltage is applied across two groups of windings, with the windings in each group being shorted together. The voltage and current are measured; dividing the voltage by the current gives the insulation resistance.

On selecting 'IR - Insulation Resistance' from the available tests window, a form fill-in dialogue box will be displayed:

To program the test :

1.   Enter the test voltage.

   Note that the Measure button **cannot** be used to determine the required Test Voltage.

2.   Select (mouse click the button) the integration time you require.

   'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3.   Enter the terminal names for the High and Low Terminals.

   Click with the mouse to select a terminal from the Available list; then click the 'Add >' button to transfer it to the Used list.

   (To correct a mistake, click with the mouse to select a terminal from the Used list; then click the '< Remove' button to transfer it back to the Available list.)

4.   Enter the minimum insulation resistance value in the bottom section.

Note: The combination of test voltage and minimum resistance must be equivalent to a test current less than 1 mA.

The Measure button may be used here as outlined in section 3.9.

5.   Select OK. The test specification will then be displayed in the program window.

4.25. HPDC - DC HI-POT (EHT)

The dc high-pot (or EHT) test is used to check for safety isolation between windings, or between windings and the core or screens.

During the test, a dc voltage is applied across two groups of windings with the windings in each group being shorted together. The voltage and current are monitored throughout the dwell time; if either the test voltage cannot be maintained, or the current is too large, then a failure will be recorded.

On selecting 'HPDC High-Pot dc' from the Available Tests window, a dialogue box will be displayed:
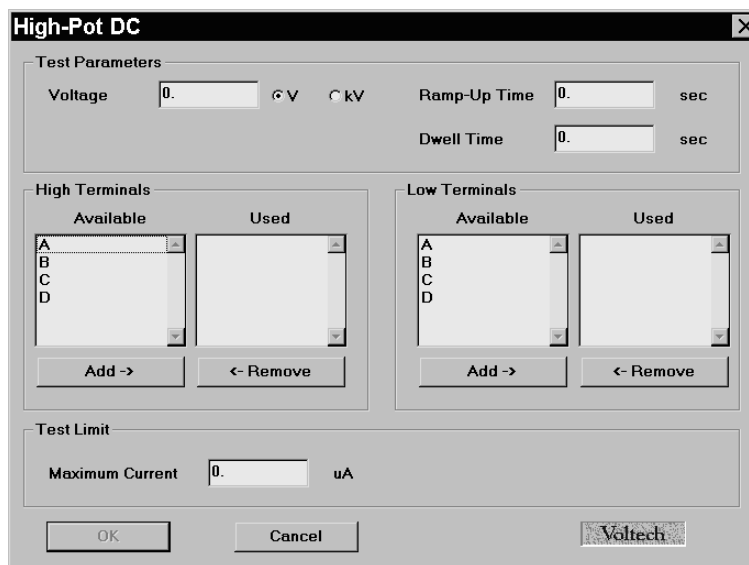
To program the test :

1. Enter the test voltage, and the ramp-up and dwell times.

2. Enter the terminal names for the High and Low Terminals.

   Click with the mouse to select a terminal from the Available list; then click the 'Add >' button to transfer it to the Used list.

   (To correct a mistake, click with the mouse to select a terminal from the Used list; then click the '< Remove' button to transfer it back to the Available list.)

3. Enter the maximum current value in the bottom section.

4. Select OK. The test specification will then be displayed in the program window.

4.26. HPAC - AC HI-POT (EHT)

The ac high-pot (or EHT) test is used to check for safety isolation between windings, or between windings and the core or screens.

During the test, an ac voltage is applied across two groups of windings with the windings in each group being shorted together. The voltage and current are monitored throughout the dwell time; if either the test voltage cannot be maintained, or the current is too large, then a failure will be recorded.

On selecting 'HPAC High-Pot ac' from the Available Tests window, a dialogue box will be displayed:

To program the test :

1. Enter the test voltage, the test frequency, and the ramp-up and dwell times.

2. Enter the terminal names for the High and Low Terminals.

    Click with the mouse to select a terminal from the Available list; then click the 'Add >' button to transfer it to the Used list.

    (To correct a mistake, click with the mouse to select a terminal from the Used list; then click the '< Remove' button to transfer it back to the Available list.)

3. Enter the maximum current value in the bottom section.

    Note that the current is the peak value, not an rms.

4. Select OK. The test specification will then be displayed in the program window.

4.27. SURG - SURGE STRESS TEST

WARNING
UNDER NO CIRCUMSTANCES SHOULD THE SURGE BE APPLIED TO THE INPUT WINDING OF A STEP UP TRANSFORMER SUCH THAT ITS OUTPUT IS BIGGER THAN 7KV

The purpose of this test is to detect an inter-turn short by applying a number of high voltage impulses (or surges) to the selected winding.

Each impulse produces a sinusoidal transient which eventually decays to zero.

During the test, the tester measures the area (in Volt - seconds) under each transient. The decay is much shorter in a faulty winding, and is detected as a smaller value for the measured area.

On selecting 'SURG Stress Test - Surge' from the Available Tests window, the following form-fill dialogue box will be displayed:

To program the test :

1. Enter the desired test voltage.

2. Enter either a nominal winding inductance or select AUTO mode.

    When a fixed inductance is entered, the AT3600 uses this value to estimate the frequency and duration of the transient waveform and thus determine the digital waveform sampling rate that is used.

In AUTO mode, the tester automatically determines the ideal sample rate and duration after testing the first sample in a batch. AUTO mode is recommended for new test programs. If you are converting an existing test program from fixed to AUTO surge testing mode, beware that under some conditions the measured result may change.

Note that the Inductance value may also be entered from a measurement on the specimen by using the Measure button.

3. Enter the number of impulses.

    You may choose only to have one impulse; the test will be quicker to execute, but there will be less chance of promoting a failure in a transformer where the inter-turn insulation is damaged and weakened, but not yet causing a complete short. More impulses give a greater chance of detecting damaged insulation.

4. Enter the high and low terminal names. Use the mouse to pull down the menu along side the fill-in box, and double click to select the terminal.

5. Select (mouse click the button) the type of limits you require and enter the values.

    %   Enter a nominal value and then the limits as negative and positive percentage values.

    ><   Enter minimum and maximum values.

    >   Enter just a minimum value.

    It is very difficult to predict the minimum and maximum areas from theory. A practical approach is to use the Measure Button (see section 3.9 of this chapter):

    Measure the area on a known good transformer; let this result be area A_G.

    Wrap an additional single turn round the core, short the two ends together, and re-measure the area; let this result be area A_F.

    Set the limits as follows:

    $$\text{Max Area} = 3A_G/2$$

    $$\text{Min Area} = (A_G + A_F)/2$$

    Remember that these limits are taken from only one transformer, and may need to be revised after more have been tested.

6. Select OK. The test specification will then be displayed in the program window.

4.28 WATT - WATTAGE

The Wattage test is a measure of the input power required to energize a transformer at no load.

During the test, a constant, user specified ac voltage is applied across the winding in question; the power is then measured. All other windings are held open circuit during this test.

On selecting the WATT test the following dialogue box will be displayed:

To program the test :

1.   Enter the test voltage and frequency.

2.   Select which are to be the high & low terminals.

     For each terminal; click with the mouse cursor positioned over the desired terminal name.

3.   Enter the maximum wattage value in the bottom section.

4.   Select OK. The test specification will then be displayed in the program window.

Note: The measure button may be used as outlined in section 3.9 to 'Auto-Specify' the wattage test parameters.

4.29. WATX – WATTAGE (EXTERNAL SOURCE)

The Wattage (External Source) test measures the power needed to energize a particular winding, usually the primary, with the remaining windings open circuit. It is usual to configure the test signal to the normal operating conditions of the transformer to determine the power needed to energize the transformer. This test uses an external source to provide the test signal which must be coupled to the tester via a Voltech AC Source Interface (contact your supplier for details). See the AC Source Interface user manual or the Editor help system for details of how to configure external ac sources for use with an AT3600.

See also the WATT test which uses the AT3600s internal generator which can provide up to 270V ac at 40W.

On selecting "WATX Wattage (External Source)" from the 'available tests' window, the following dialog box will be displayed.

To program the test:

1. Enter the voltage and frequency parameters of the test signal.

2. Select the integration time required.

3. Enter the terminal names of the winding to be measured.

4. Enter the limits for power to test against. Either use max. -Min. (><) limit or test against just maximum (<) limits if required.

5. Select OK. The test specification will then be displayed in the program window.

Note: The measure button may be used to determine typical test results.

4.30. STRW – STRESS WATTAGE

The Stress Wattage test tests the transformer for breakdown of insulation by measurement of the energizing power of a winding, usually the primary, with the remaining windings open circuit. This test applies the voltage, usually twice the normal operating voltage, and continually measures the power to determine any breakdown by changes in the measurement.

This test is suitable for subminiature line frequency, large line frequency bobbin wound and some HF transformers. It checks the integrity of interturn insulation, the magnetic material and joints.

On selecting "STRW Stress wattage" from the available tests window, a form fill-in dialogue box will be displayed:

To program the test:

1. Enter the voltage and frequency parameters of the test signal.

    (If in doubt, refer to Chapter 7 - 'Test Conditions', which lists recommended test conditions for different values of inductance.)

2. Select the Dwell time you require.

3. Enter the names of the Hi and Lo terminals.

4. Set maximum power limit.

5. Select OK. The test specification will then be displayed in the program window.

4.31. STRX - STRESS WATTS (EXTERNAL SOURCE)

The Stress Watts (External Source) test tests the transformer for breakdown of winding insulation by measurement of the energizing power of a winding, usually the primary, with the remaining windings open circuit. This test applies the voltage from an external ac source (usually at twice the normal operating voltage and frequency), and measures the power drawn.

This test uses an external source to provide the test signal which must be coupled to the tester via a Voltech AC Source Interface (contact your supplier for details). See the AC Source Interface user manual or the Editor help system for details of how to configure external ac sources for use with an AT3600.

On selecting "STRX Stress Wattage (External Source)" from the available tests window, the following dialogue box is displayed:

To program the test:

1. Enter the voltage and frequency parameters of the test signal.

2. Enter the dwell time for the test signal.

3. Enter the terminal names of the winding to energize.

4. Enter the power limit to test against. Either use max. - Min. (><) limit or test against just a maximum (<) limit if required.

5. Select OK. The test specification will then be displayed in the program window.

4.32. MAGI - MAGNETIZING CURRENT

Magnetizing current is measured by applying an ac test voltage to the selected winding, and measuring the resulting current.

You may program the test to use either an rms, or a mean-sense (rms scaled) type of measurement to obtain a value for the current. Normally, an rms measurement is preferred, but the mean-sense measurement is also available as it is used by some low cost multi-meters.

On selecting 'MAGI Magnetizing Current' from the available tests window, a form fill-in dialogue box will be displayed:

To program the test :

1. Enter the voltage and frequency limits (refer to Chapter 7 - 'Test Conditions' which lists recommended test conditions if required).

    Note that the Measure button **cannot** be used to determine any of the required test parameters.

2. Select (mouse click the button) the type of measurement you require - RMS or Mean sense. If in doubt, see chapter 7 for more information.

3. Select (mouse click the button) the integration time you require.

    'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

4. Enter the terminal names for the High and Low Terminals.

    Click on the arrow to the right of the fill-in box and you will be provided with a choice of the available terminals. Click the required terminal.

5. Select (mouse click the button) the type of limits you require and enter the values.

 ≻≺   Enter minimum and maximum values.

 <   Enter just a maximum value.

Note that the Measure button may be used here as outlined in section 3.9.

6. Select OK. The test specification will then be displayed in the program window.

4.33. MAGX - MAG. CURRENT (EXTERNAL SOURCE)

The Magnetizing Current within a winding may be tested. An AC voltage (from an external source) is applied across the winding under test and the current flowing through the winding is measured.

This test uses an external source to provide the test signal which must be coupled to the tester via a Voltech AC Source Interface (contact your supplier for details). See the AC Source Interface user manual or the Editor help system for details of how to configure external ac sources for use with an AT3600.

On selecting "MAGX Magnetizing Current (External Source)" from the available tests window, a dialog box will be displayed.

To program the test :

1. Enter the test voltage and frequency at which the test is to be carried out. This is usually at the highest working voltage at the lowest operating frequency. Note that the Measure button **cannot** be used to determine any of the required test parameters.

2. Select the integration time required.
   'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Enter the terminal names across which the voltage is to be applied and through which the magnetizing current will be measured.

4. Enter the expected range of magnetizing current. Either use max. - Min. (><) limit or test against just maximum (<) limits if required.

5. Select OK. The test specification will be displayed in the program window on the screen.

Note: The measure button may be used to determine typical test results.

4.34. VOC - OPEN CIRCUIT VOLTAGE

Open circuit voltage is measured by applying an ac test voltage to a selected winding (usually a primary winding), and measuring the resulting voltage produced on another winding.

You may program the test to use either the normal ac measurement, or a dc measurement, which could be used, for example, when testing transformers fitted with a rectifying diode.

If there are several windings to be tested, the program will execute more quickly if the following points are observed:

Place all the open circuit voltage (VOC) tests consecutively at the same point in the program.

Use the same energized winding, with the same test voltage and frequency for each test.

If there is a magnetizing current (MAGI) test which has the same energized winding and the same test voltage and frequency, place this immediately before the first open circuit voltage test.

On selecting 'VOC Open Circuit Voltage' from the available tests window, the following form-fill dialogue box will be displayed:

To program the test :

1. Enter the test voltage and test frequency.

   Note that the Measure button **cannot** be used to determine any of the required test parameters.

2. Select either AC Voltage, DC Voltage or Mean sense, RMS scaled measurement by clicking on the relevant button.

3. Select (mouse click the button) the integration time you require.

    'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

4. Enter the terminal names for the Energized High and Low Terminals.

    Click on the arrow to the right of the fill-in box, and you will be provided with a choice of available terminals; double-click on the one required.

5. Similarly, enter the names for the Measured Terminals.

6. Select (mouse click the button) the type of limits you require and enter the values.

    %   Enter a nominal value and then the limits as negative and positive percentage values.

    ><   Enter minimum and maximum values.

    >   Enter just a minimum value.

    <   Enter just a maximum value.

    Note that the Measure button may be used here as outlined in section 3.9.

7. Click on the appropriate button to choose the polarity, or choose the 'No Test' button. (For ac measurements, use the positive polarity when the measured winding has the same phase as the energized winding, use the negative polarity when they have opposite phases.)

    Select OK. The test specification will then be displayed in the program window.

4.35. VOCX – O/C VOLTAGE (EXTERNAL SOURCE)

The Open Circuit Voltage across a winding may be tested. An AC voltage (from an external source) is applied across the primary winding and the resulting voltage across the chosen secondary winding is measured.

This test uses an external source to provide the test signal which must be coupled to the tester via a Voltech AC Source Interface (contact your supplier for details). See the AC Source Interface user manual or the Editor help system for details of how to configure external ac sources for use with an AT3600.

On selecting "VOCX Open Circuit Voltage (External Source)" from the available tests window, a form fill-in dialog box will be displayed:

To program the test :

1. Enter the test voltage and frequency at which the test is to be carried out.
    Note that the Measure button **cannot** be used to determine any of the required test parameters.

2. Select either AC Voltage, DC Voltage or Mean sense, RMS scaled measurement by clicking on the relevant button.

3. Select the integration time required.
    'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

4. Enter the terminal names for the Energized High and Low Terminals.

Click on the arrow to the right of the fill-in box, and you will be provided with a choice of available terminals; double-click on the one required.

Similarly, enter the names for the Measured Terminals.

5. Set the voltage limits.

%   Enter a nominal value and then the limits as negative and positive percentage values.

><   Enter minimum and maximum values.

>   Enter just a minimum value.

<   Enter just a maximum value.

Note that the Measure button may be used here as outlined in section 3.9.

6. Polarity testing can be included in the test by selecting either positive or negative radio buttons to test against. Here the polarity test will produce either Pass or Fail results. Polarity testing is not possible if the source type is 'Manual Source / Line Supply'. (For ac measurements, use the positive polarity when the measured winding has the same phase as the energized winding, use the negative polarity when they have opposite phases.)

7. Select OK. The test specification will be displayed in the program window on the screen.

4.36. LVOC – LOW VOLTAGE OPEN CIRCUIT

Applying an ac voltage to the primary of the transformer will produce an ac voltage in the secondary. Low Voltage Open Circuit measures the 'open circuit' voltage produced when the specified test signal is applied.

The secondary voltage may be in phase with the primary voltage or it may be anti-phase depending on the winding and the termination of the windings.

To program the test:

1. Enter the required test signal.

2. Choose the integration period (normally 'medium').

3. Enter the terminals to be used.

4. Energized terminals: The terminals where the test signal will be applied. This is normally the winding with the greatest number of turns.

5. Primary terminals 'High' and 'Low': The zero phase reference terminals which are often the same as the energized terminals.

6. Secondary terminals 'High' and 'Low': The turns ratio and polarity measurement will be made between the primary and secondary terminals.

7. Choosing the test limits.

The test limits can be:

%   A nominal value together with + and – percentage limits.

><   Minimum and maximum values

>   A minimum value only

<   A maximum value only

Use the Editor's 'measure' button (together with a sample part) if you are unsure of the nominal value.

Remember to click on the units of limits (mV or V) when entering absolute values as limits.

Test limits should be set as close as possible to the nominal value in order to detect faults. A typical tolerance would be ± 5%

4.37. ILK – LEAKAGE CURRENT TEST

A leakage current test is needed for transformers used in certain applications, mainly medical, where it is an additional safety requirement.

The leakage current to be measured is that which flows between primary windings and secondary windings under normal operating conditions due to interwinding capacitance. In a switching power supply, the primary circuits could be connected directly to the power line supply, and could experience the normal line voltage as a common signal with respect to ground. This AC signal could cause a significant leakage current to flow through the transformer to grounded secondaries.

This test is typically carried out by applying the test voltage between all the primary terminals shorted together and all the secondary terminals and screen shorted together.

On selecting "ILK Leakage Current" from the 'available tests' window, the following dialog box is displayed:

To program the test:

1. Enter the value of voltage for the signal and the required frequency of the test.

   Note also that the Measure button may be used here as outlined in section 3.9.

2. Select the integration time required. 'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of an increased test time, and 'Short' will test at the maximum speed, but may give a slightly noisier reading.

3. Select the terminals to be included for both high and low terminals. For both high and low terminals, select each terminal in turn and click on the 'Add' button at the bottom of the list. Terminals can be removed from the used list by selecting them and clicking on the 'Remove' button.

4. Select the current limit. There is only a maximum limit for this test. Note, you may use the measure button to find the current which flows and set your limits based on that, however in most cases the current limit will be determined by the safety standard to which you are working.

5. Select 'OK'. The test specification will then be displayed in the program window.

4.38. LSBX – Inductance with External Bias (Series Circuit)

DC Bias	Measure Range	Test Voltage	Test Frequency	Basic Accuracy
0.1A to 250A	1nH 1MH	1mV to 5V	20Hz to 3MHz	0.2% @ Q>10

This test requires the use of one or more Voltech DC1000 Precision DC Bias Current Sources. Contact your Voltech sales office for details.

The inductance of a transformer winding while an external bias current is flowing through it may be tested using series or parallel equivalent circuit models. Initially the DC bias current is set up and allowed to stabilize. An AC voltage is applied across the selected winding; the voltage across and current through the winding is then measured using harmonic analysis. The measured voltage is divided by the current to obtain a complex impedance and the inductance is calculated.

On selecting 'LSBX Inductance with External Bias (Series Circuit)' from the 'Available Tests' window, a dialogue box will be displayed.

To program the test:

1.   Enter the signal, frequency and bias current required for the test.

Note that the signal is normally entered as a voltage by selecting the 'mV' or 'V' button; but you may optionally enter it as a current by selecting the 'mA' button. (If in doubt refer to the 'Test Conditions' chapter of your AT user manual.

Note also that the measure button may be used here, as outlined in your AT user manual, with the combinations of test parameter specification shown in the following table:

	Option 1	**Option 2**	**Option 3**	**Option 4**
Signal	Specified voltage	Specified current	Auto	Auto
Frequency	Specified	Specified	Specified	Auto
Bias	Specified	Specified	Specified	Specified

2.   Select (mouse click the button) the integration time you require.

'Medium' is the default setting. 'Long' will give you more stable readings (for tighter limits) at the expense of test time, and 'Short' will test at the maximum speed, but may give slightly noisier readings.

3.   Enter the terminal names between which the inductance will be measured. By pulling down the menu along side the fill-in box, you may select the high and low terminals for each test.

4.   Select (mouse click the button) the type of limits you require, and enter the values.

%   Enter a nominal value and then the limits as negative and positive values.

><   Enter minimum and maximum values.

>   Enter just a minimum value.

<   Enter just a maximum value.

5.   Select OK. The test specification will then be displayed in the program window.

4.39. LPBX – Inductance with External Bias (Parallel Circuit)

DC Bias	Measure Range	Test Voltage	Test Frequency	Basic Accuracy
0.1A to 250A	1nH 1MH	1mV to 5V	20Hz to 3MHz	0.2% @ Q>10

This test requires the use of one or more Voltech DC1000 Precision DC Bias Current Sources. Contact your Voltech sales office for details.

The inductance of a transformer winding while an external bias current is flowing through it may be tested using series or parallel equivalent circuit models. Initially the DC bias current is set up and allowed to stabilize. An AC voltage is applied across the selected winding; the voltage across and current through the winding are then measured using harmonic analysis. The measured voltage is divided by the current to obtain a complex impedance and the inductance is calculated.

On selecting 'LPBX Inductance with External Bias (Parallel Circuit) from the 'Available Tests' window, a dialogue box will be displayed.

To program the test:

1. Enter the signal, frequency and bias current required for the test.

Note that the signal is normally entered as a voltage by selecting the 'mV' or 'V' button; but you may optionally enter it as a current by selecting the 'mA' button. (If in doubt refer to the 'Test Conditions' chapter of your AT user manual.

Note also that the measure button may be used here, as outlined in your AT user manual, with the combinations of test parameter specification shown in the following table:

	Option 1	**Option 2**	**Option 3**	**Option 4**
Signal	Specified voltage	Specified current	Auto	Auto
Frequency	Specified	Specified	Specified	Auto
Bias	Specified	Specified	Specified	Specified

2. Select (mouse click the button) the integration time you require.

'Medium' is the default setting. 'Long' will give you more stable readings (for tighter limits) at the expense of test time, and 'Short' will test at the maximum speed, but may give slightly noisier readings.

3. Enter the terminal names between which the inductance will be measured. By pulling down the menu along side the fill-in box, you may select the high and low terminals for each test.

4. Select (mouse click the button) the type of limits you require, and enter the values.

%   Enter a nominal value and then the limits as negative and positive values.

><   Enter minimum and maximum values.

>   Enter just a minimum value.

<   Enter just a maximum value.

5. Select OK. The test specification will then be displayed in the program window.

4.40. ZBX - Impedance with External Bias

DC Bias	Measurement Range	Test Voltage	Test Frequency	Basic Accuracy
0.1A to 250A	1mΩ to 1MΩ	1mV to 5V	20Hz to 3MHz	0.2%

This test requires the use of one or more Voltech DC1000 Precision DC Bias Current Sources. Contact your Voltech sales office for details.

The Winding Impedance with External Bias test measures the impedance of a selected winding while applying a DC current from the DC1000 through the winding. An AC voltage is also applied across the winding from the AT.

This test can be used with inductors to measure the change in impedance with a bias current.

On selecting "ZBX Impedance with External Bias" from the 'available tests' window, the following dialog box is displayed:

To program the test:

1. Enter the value of a voltage (or current) for the signal and the required frequency of the test.

   Also enter the bias current you would like to apply.

   Please note that the **Measure** button may be used here. For information, refer to the 'Test Program Editor' of your AT manual.

2. Select the integration time required. 'Medium' is the default setting. 'Long' will give more stable readings (for tighter limits) at the expense of time, and 'Short' will test at the maximum speed, but may give slightly noisier readings.

3. Enter the terminal names between which the impedance is to be measured.

4. Set the impedance limits.

+/-   Enter a nominal value and then the limits as negative and positive values.

   ><   Enter minimum and maximum values.

   >   Enter just a minimum value.

            <   Enter just a maximum value.

5. Select OK. The test specification will then be displayed in the program window.

4.41. ACRT - AC HI-POT RAMP

The ac high-pot Ramp test is used to check for safety isolation between windings, or between windings and the core or screens.

During the test, an ac target voltage is applied across two groups of windings with the windings in each group being shorted together. The voltage is ramped and the current is monitored throughout the ramp time; if either the test voltage cannot be maintained, or the current is too large, then a failure will be recorded.

On selecting 'ACRT High-Pot Ramp' from the Available Tests window, a dialogue box will be displayed:

To program the test :

1. Enter the target voltage, the test frequency, and the ramp-up time.

2. Enter the terminal names for the High and Low Terminals.

    Click with the mouse to select a terminal from the Available list; then click the 'Add >' button to transfer it to the Used list.

    (To correct a mistake, click with the mouse to select a terminal from the Used list; then click the '< Remove' button to transfer it back to the Available list.)

3. Enter the maximum current value in the bottom section.

    Note that the current is the peak value, not an rms.

4. Select the user offset enabled, if required and enter the voltage value.

5. Select OK. The test specification will then be displayed in the program window.

4.42. DCRT - DC Hɪ-Poᴛ Rᴀᴍᴘ

The dc high-pot Ramp test is used to check for safety isolation between windings, or between windings and the core or screens.

During the test, an ac target voltage is applied across two groups of windings with the windings in each group being shorted together. The voltage is ramped and the current is monitored throughout the ramp time; if either the test voltage cannot be maintained, or the current is too large, then a failure will be recorded.

On selecting 'DCRT High-Pot Ramp' from the Available Tests window, a dialogue box will be displayed:

To program the test :

1. Enter the target voltage, the test frequency, and the ramp-up time.

2. Enter the terminal names for the High and Low Terminals.

    Click with the mouse to select a terminal from the Available list; then click the 'Add >' button to transfer it to the Used list.

    (To correct a mistake, click with the mouse to select a terminal from the Used list; then click the '< Remove' button to transfer it back to the Available list.)

3. Enter the maximum current value in the bottom section.

4. Select the user offset enabled, if required and enter the voltage value.

5. Select OK. The test specification will then be displayed in the program window.

CHAPTER 4 - USING THE SERVER

TABLE OF CONTENTS

This chapter will guide you through the operation and functional aspects of the server application.

1. INTRODUCTION

The server program supplied with your AT series tester may be considered as an on-line storage system.

The server will handle two types of data:

 - TEST PROGRAMS

 - TEST RESULTS

Test programs that are created using the editor application may be uploaded into the server central file store. All testers connected to the server then have access to the central store. Programs are called up from the server, sent to and then executed within the tester.

The features of the server include:

- MS Windows application style dialogues and tools

- Storage of all previously created test programs

- Transfer of test programs to the tester on request

- Viewing of test programs outside the test program editor environment

- Test results may be received and stored in a database ready format for easy off -line analysis

- OLE 2 support allowing real-time analysis of your production test system

Test programs may be stored on floppy disk for back-up or inter-site transfer

Installation and setup of the server program is explained in Chapter 2.

2. TEST PROGRAM HANDLING

2.1. STORING TEST PROGRAMS

After a test program has been created using the program editor application it will be ready for use with your AT series tester. The diagram below shows a potential connection scheme for use with a single tester and two PCs.

Before program requests or uploads may be completed, the tester must be configured for server mode. See Chapter 2, section 2.3.3.
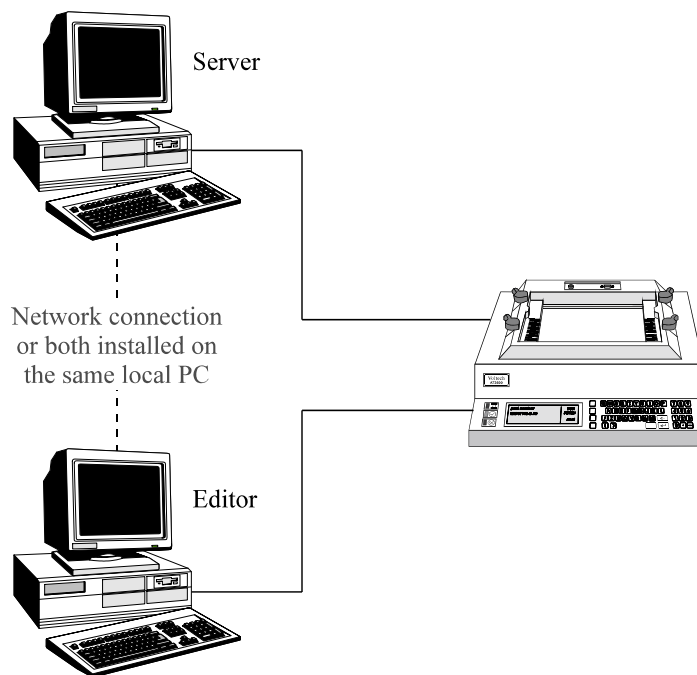
There are two ways that you may transfer test programs into the server file store:

1.   By selecting 'Upload Program' from the editor 'Tester' menu .
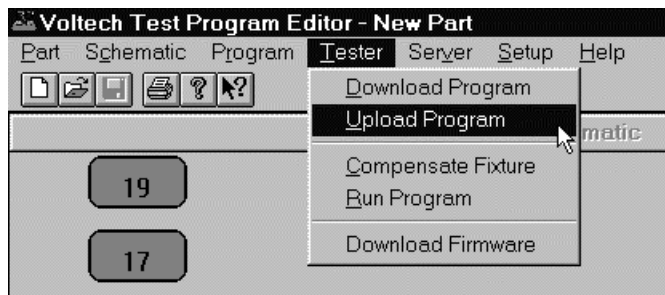
This will transfer the current program from the editor to the server. The program will be sent via the tester's serial link if present, by direct file transfer if both applications are resident on the same PC or by network file transfer if a network link is present and is identified to the server.

2.   By floppy disk or direct network transfer.

You may copy program files directly into the program directory used by the server application.

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IMPORTANT: When a program file is copied to the server and a file with the same name is already resident within the server, the incoming file will replace the previous file.

2.2. VIEWING A TEST PROGRAM

Each test program has a part name. To view a particular test program you will need to know its part name. Select FILE, PART and then OPEN from the menu bar. You may select the part to open from the list displayed, or change the path and drive to search for other parts.
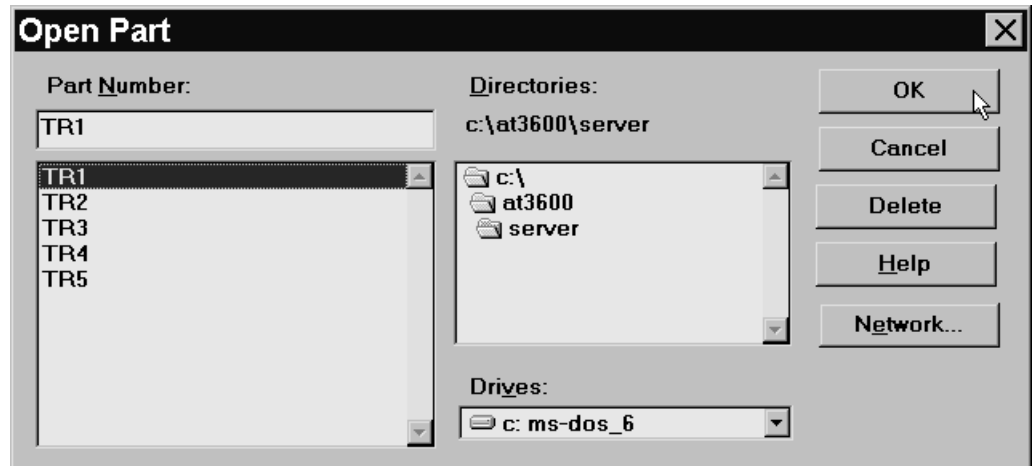
When you have selected the correct part to open, click on the OK button.

You will now be able to view the text listing of the test program chosen.
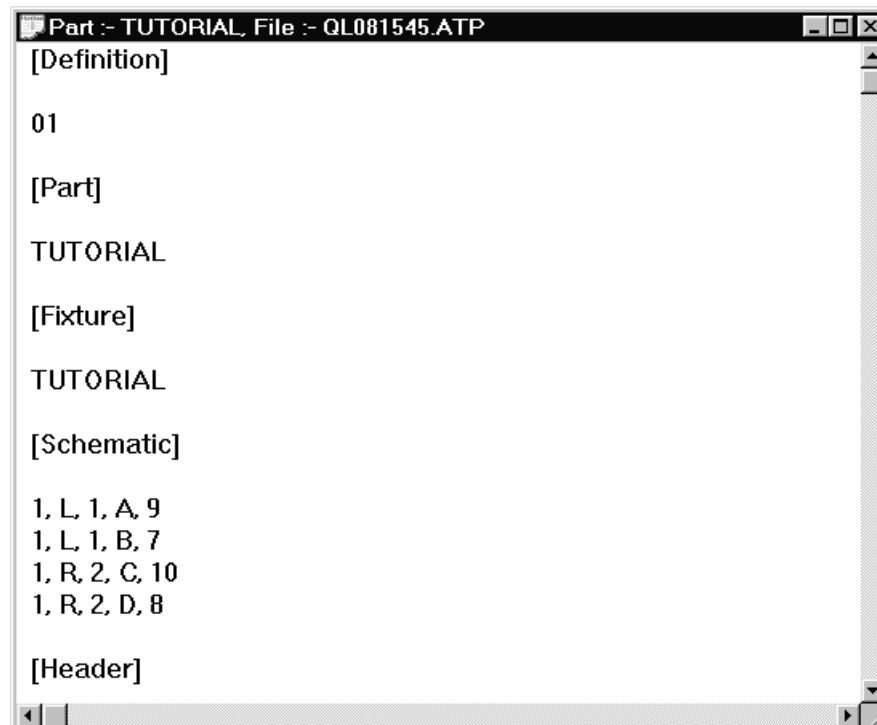
2.3. SAVING A NEW COPY OF A PART

Using the SAVE AS function under the PART menu you are able to save a new copy of the same test program under a new part name.

1. Open the part required and select SAVE AS.

2. Enter the new part name and select the appropriate file path.

3. Click on the OK button.

A new copy of the test program will now be saved with the new part name as specified.

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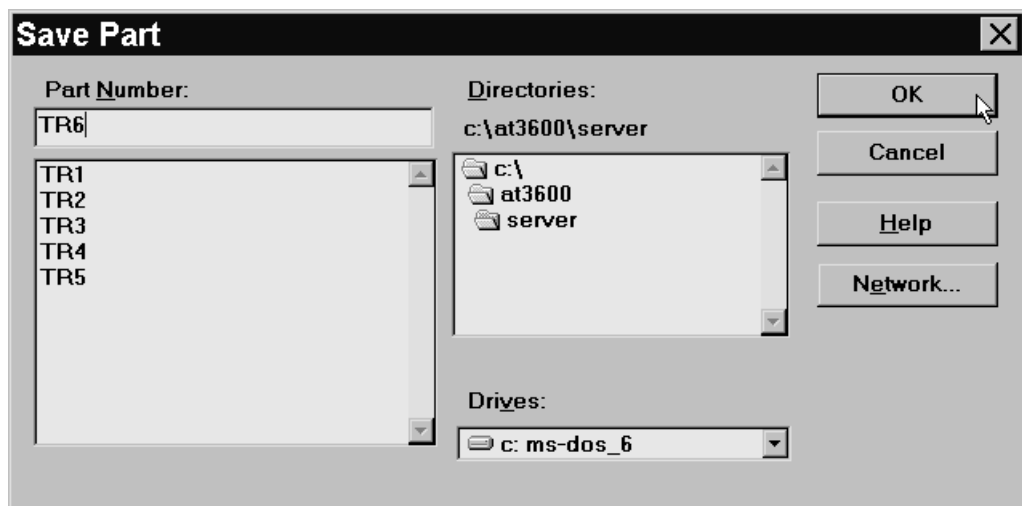
IMPORTANT: When using the SAVE AS function you must be aware that it is not a 'RENAME' function. The previous copy of the test program with the original part name will remain in your program directory.

2.4. DELETING A TEST PROGRAM

When the Server stores the test program on your PC hard disk, the DOS filename used differs from the part name specified. The Server uses an algorithm to encode a unique filename for each part.

When you open a part, you are shown the part name, not the filename. For this reason if you use MS Windows File manager to view the Server program directory, you will not see any meaningful part names.

If you need to remove a part from the Server program directory, a button has been provided within the PART, OPEN dialogue.

Select the part to be deleted and press the DELETE button.

You will then be prompted to enter the password (as defined when installing the server software) to allow the part to be deleted.

The program will then be removed from the directory.
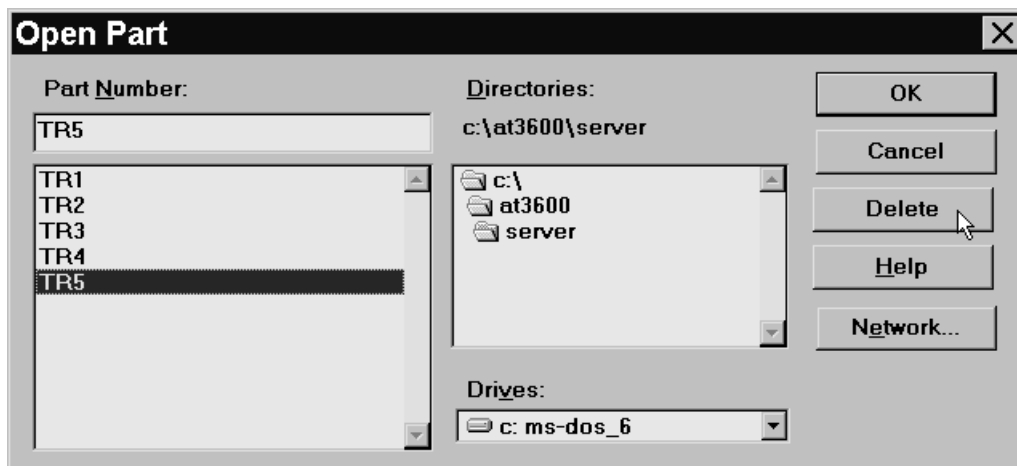
IMPORTANT: Once a part has been deleted it may not be recovered. Before deleting a part it is advisable to open and view to ensure you are deleting the correct test program.		

2.5. GROUPING TEST PROGRAMS

Programs that are used on the transformer tester at similar times may be grouped for convenience. For example, a number of transformers all based on the same bobbin may be tested at the same time.

When a program group has been defined it may be downloaded to the tester. Each of the parts within the group will then be available for 'local' use. The parts will be stored in non-volatile RAM. No programs are lost after power-down.

The following dialogue is used to configure groups and may be located under the Setup menu in the Server:
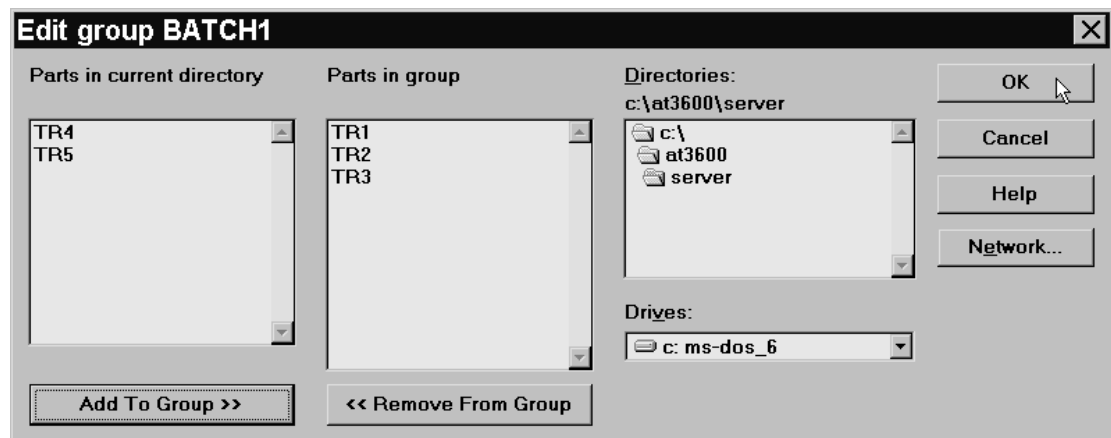
Double-clicking on any part in the left hand list will add it to the right hand, grouped list.

When you have completed editing a group you will see it added to the available group list. To transfer the group to the tester it must be requested by the tester. See Chapter 2 of the manual for details.

IMPORTANT: The group function does not store a new copy of each part when a group is defined. Only reference is made to the part being in a group. DO NOT delete a part after including it in a group other wise the part will be lost, and the group rendered invalid.

3. TEST RESULTS HANDLING

3.1. RECEIVING TEST RESULTS

By default, the AT series tester does not automatically send test results back to the server. Results will only be sent back for test programs that have been set up with the 'Send Results to Server' option enabled (see chapter 2, section 2.3.1).

The server receives test results from the tester via the same serial connection used for transferring test programs to the tester. Results handling is a separate function of the server program, and is not part of program transfer. Where more than one tester is connected to your server PC, the one server program handles all the transformer tester results as well as acting as the central server.

All results sent by one tester's channel during one day, are collected together and formed into one large file. This file is known as the batch results file.

One batch results file will be generated per open channel, per day. Batch files are stored under the specified results directory; see chapter 2, section 2.2.6.

The DOS filename of the batch results file is generated as follows;

> **c<n><dd><mm><yy>.atr**

where:

> **n**   **channel number**
>
> **dd**   **day number**
>
> **mm**   **month number**
>
> **yy**   **year number**

example:

> **c1250297.atr**   (Channel 1, 25-02-1997)

'**atr**' is the reserved file extension used by the server to indicate a stored test result file.

What follows is an example of the first part of a batch result file.

Note the DOS file name (c6200697.atr) and the part name ("Part #" "2") are both listed within the file.

```
"VOLTECH AT3600 RESULTS FILE"
"Server Program Version: 2.1"
"Communication Channel: 6"
"AT3600 ID: 0571"
"AT3600 Software Version: 2.2"
"File name: C6200697.atr"
"Test Date: 20 Jun 1997"


"Part #","2"
"Fixture ID","TEST"
"Operator"
"Batch #"
"No Fixture Compensation"



"Result #","Serial #","Time","Pass/Fail","","001   R","","","","002
"","","","","","Minimum","Maximum","Reading","","Minimum","Maximum","R

1,"","10:44:20","Pass","",59,73,6.776850E+01,"Pass",3,,3.223899E+00,"P
2,"","10:44:23","Pass","",59,73,6.776832E+01,"Pass",3,,3.110549E+00,"P
3,"","10:44:24","Pass","",59,73,6.776363E+01,"Pass",3,,3.125640E+00,"P
4,"","10:44:26","Pass","",59,73,6.777967E+01,"Pass",3,,3.135034E+00,"P
5,"","10:44:27","Pass","",59,73,6.777842E+01,"Pass",3,,3.185198E+00,"P
6,"","10:44:29","Pass","",59,73,6.778374E+01,"Pass",3,,3.152627E+00,"P
```

...and so forth for each result until a change of batch or part. If a result window is closed, the connection to the transformer tester will be lost. A warning is issued before connections are removed.

3.2. RESULT DISPLAY AND ANALYSIS

Four approaches have been provided to allow observation of your test result data:

- On-Line monitoring

- On-Line analysis via a Database

- On-Line analysis via OLE

- Off-Line analysis

3.2.1. ON-LINE MONITORING

Each time a COM to AT series tester connection is opened using the SETUP, COMMUNICATION menu, an accompanying result monitoring window will be created.

One result monitoring window will be present for each open channel.

When results are sent from the tester they will be displayed in the monitoring window before passing to the batch result file. The most recent result for each channel will be visible in the window.

An open result window may be minimised at any time and subsequently maximized using the icons indicated. (Windows 95 and 98)
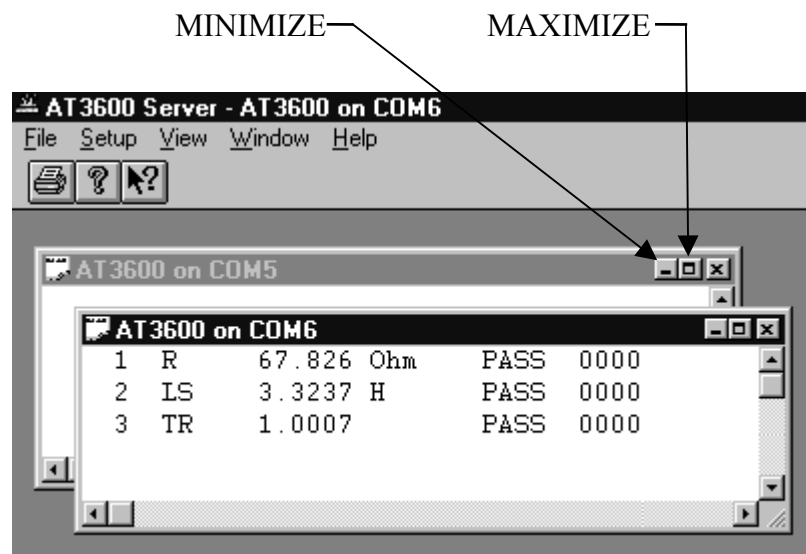
3.2.2. BATCH STATISTICS ON-LINE ANALYSIS

Setting Up Batch Statistics

From the 'Set-up' menu, select 'Results' to see the following dialogue:
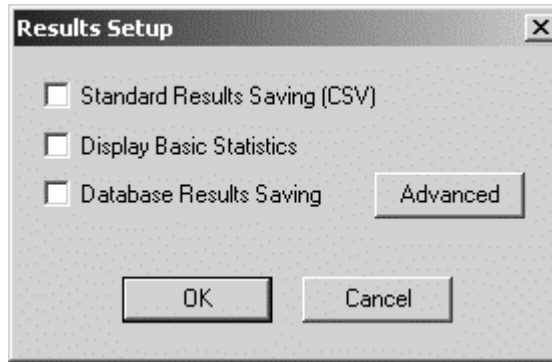
Select 'Display Basic Statistics' to save results to a database. For this feature to operate a licence for use must first be obtained from your Voltech supplier.

All results formats can be saved simultaneously.

Basic statistics displays, on-line, a summary of the results for the current batch of transformers that is being tested on every AT connected to the Server. Results for previous batches can also be opened and the statistics displayed and printed.

The batch statistics window display is automatically shown once this feature is enabled. For each AT connected to the Server the following information is displayed:

The type of AT and its serial number, and the part name, operator and batch.

PASS or FAIL for the last part tested, the total tested so far and the serial number of the last part tested.

The number that have passed and failed, and the AQL<+> (Acceptable Quality Level) of the transformer.

The number of re-tries that have been attempted, the percentage of failures so far and the number of transformers that failed out of the last 10 tested.

For each test in the program, the test limits, the last result and the accumulated number of fails for each test.

Results may also be exported or printed using the normal options found under the file menu.

AQL

AQL (Acceptable Quality Level) settings for production test are defined for each program using the Editor. AQL is the level of test failures in a batch that are acceptable. Exceeding the AQL is an indication that there is problem with the quality of the production process or the quality of materials used. AQL monitoring is an optional feature of the Voltech PC Server which displays live summary results from multiple AT testers. When the AQL level set here is reached or exceeded, the Server will display a warning.

'AQL No. of Parts' is the number of failures in the batch at which a warning will be displayed on the Server. This is most often used when the batch size is always similar, or zero / very small numbers of defects are expected.

'AQL % of Parts' is the percentage level of failures at which a warning will be displayed on the Server. Note that this AQL is only applied after sufficient parts have been tested to make the percentage meaningful. When setting AQL % of Parts to be 1% for example, a warning will only be displayed after $100/1 = 100$ parts have been tested.

Both types of limit may be used at the same time. Reaching any one limit will cause a warning to be displayed on the Server.

When an AQL level is reached or exceeded the Server will display a warning:
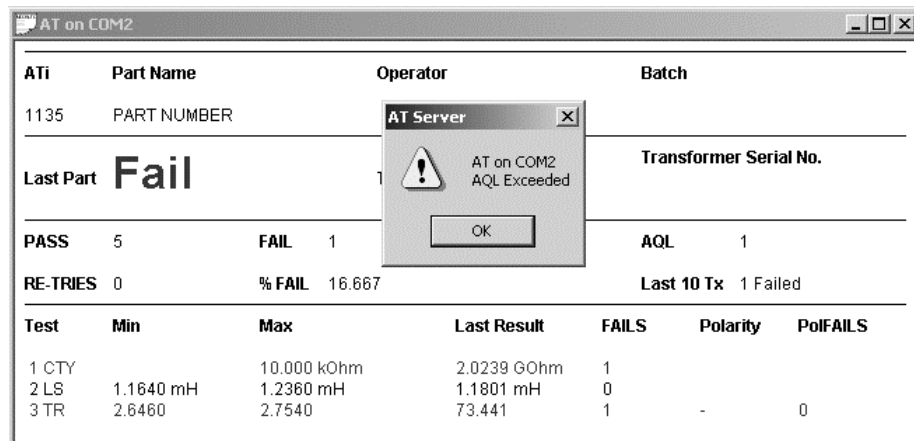
Click on 'OK' to acknowledge the warning. You will be given the option to disable the warning for further parts in the batch. Normally, you would select 'No' to leave the AQL checking active for the rest of the batch. When a new batch is started, the AQL level is reset according to the level entered for the part using the Voltech AT Editor.

3.2.3. ON-LINE ANALYSIS VIA A DATABASE

The AT Server software can store test results in an electronic database. This provides a very powerful and versatile method of recording and analysing test results historically or on-line. The Server uses standard Windows methods (including OLE DB and ODBC) to connect to a variety of databases that conform to these specifications.

Once stored in a database the data may then be analysed using tools available in the database application or tools provided by specialist software packages such as those available for SPC (Statistical Process Control). One example of this is to monitor in real time the trend in a winding resistance to identify a defective drum of copper. You would then be able to rectify the fault during production rather than producing a large stock of QA failed transformers all wound with the defective wire.

SETTING UP DATABASE RESULTS STORAGE

From the 'Setup' menu, select 'Results' to see the following dialogue:
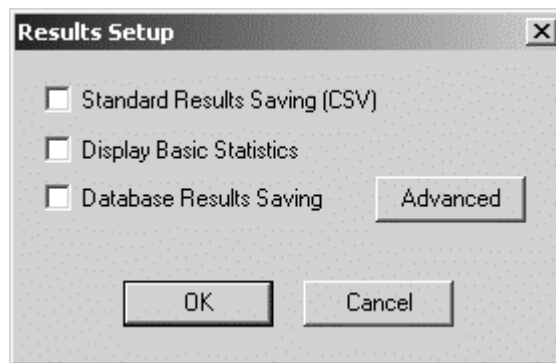
Select 'Standard Results Saving' (CSV) to save all results to a spreadsheet compatible file. See 3.2.4.

Select 'Database Results Saving' to save results to a database. For this feature to operate properly, a connection to the database must be set up first.

CSV and database format results can be saved simultaneously.

Click on 'Advanced' to set up your database connection:
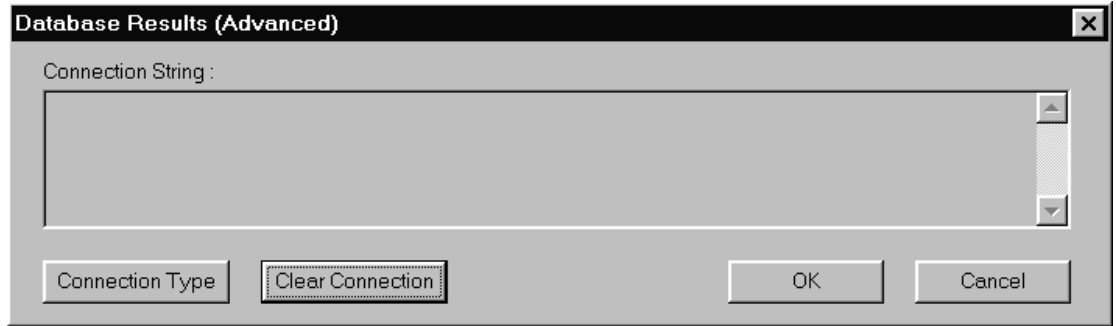
To connect to your database, the Server software uses a connection string that contains (amongst other things) the name of a provider, the name and location of the database and a valid database user name and password (if required). You may need to consult with the database or network administrator to obtain this information.

If a connection has already been established you will see the connection string in the window inside this dialogue. If you wish to remove an existing connection string, click on 'Clear Connection'.

To establish a new connection click on 'Connection Type'.
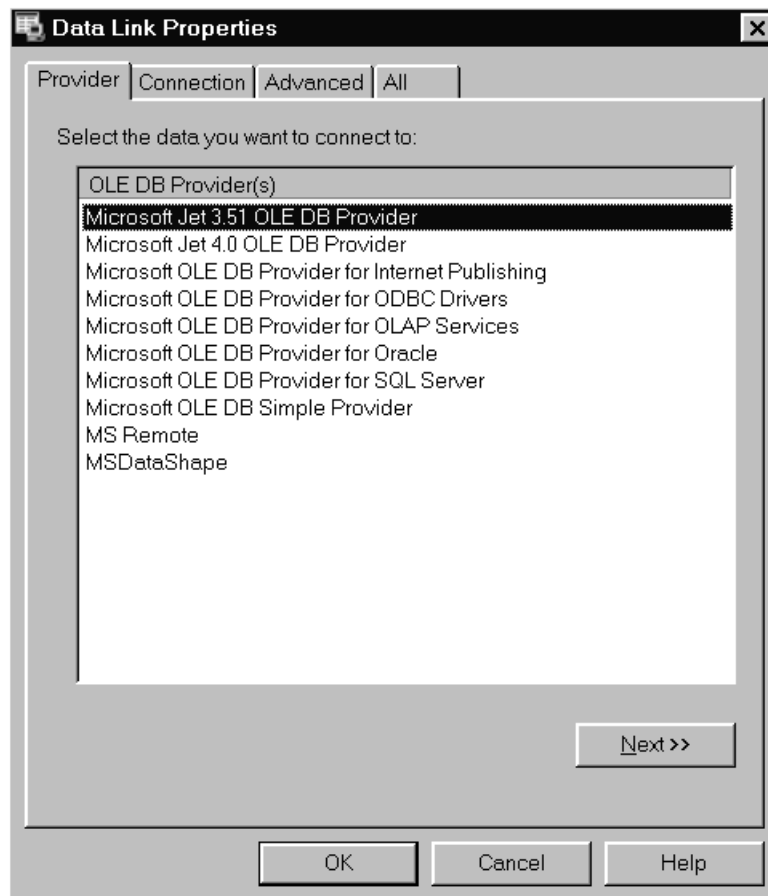
The 'Data Link Properties' dialogue is a standard one that is supplied by Windows. You should choose the provider that will provide the connection to the type of database that you are using.

Several different types of provider are installed along with the Server software, others may be available if you have a database application installed on the same PC as the Server. If the provider you need is not available and the database is installed on another PC, ask the database administrator for the database client tools for the Server PC.

Typical provider types are:

Database	Provider
Microsoft Access 97	Microsoft Jet 3.51
Microsoft Access 2000	Microsoft Jet 4.0
Oracle	Microsoft OLE DB Provider for Oracle
SQL Server	Microsoft OLE DB Provider for SQL Server

In addition it is possible to connect to ODBC compliant databases (including Microsoft Access) using the Microsoft OLE DB Provider for ODBC Drivers.

Click on 'Next' when you have chosen the correct provider.

Select the database name that you will be using by clicking on 'Select'. If you wish to create a new database for AT Server results, do so now using your database program.

The default user name 'Admin' with no password may be adequate. Consult your database administrator if you need a specific user name and password.

When you click on 'Test Connection' you should see something similar to:
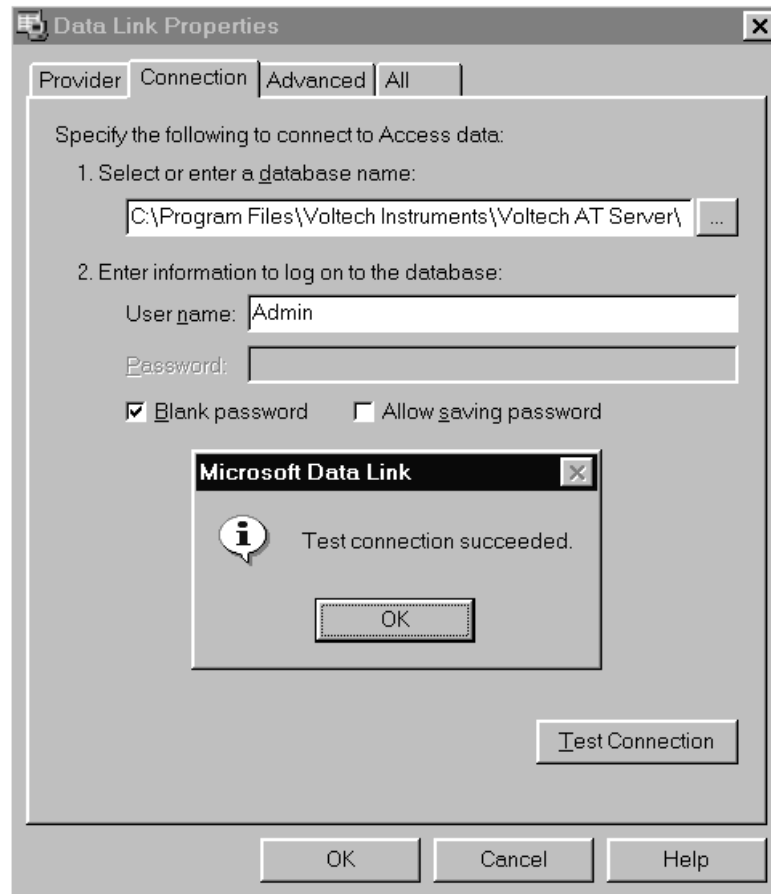
Next, click on 'OK' of the 'Test connection succeeded' dialogue and select the 'Advanced' tab.
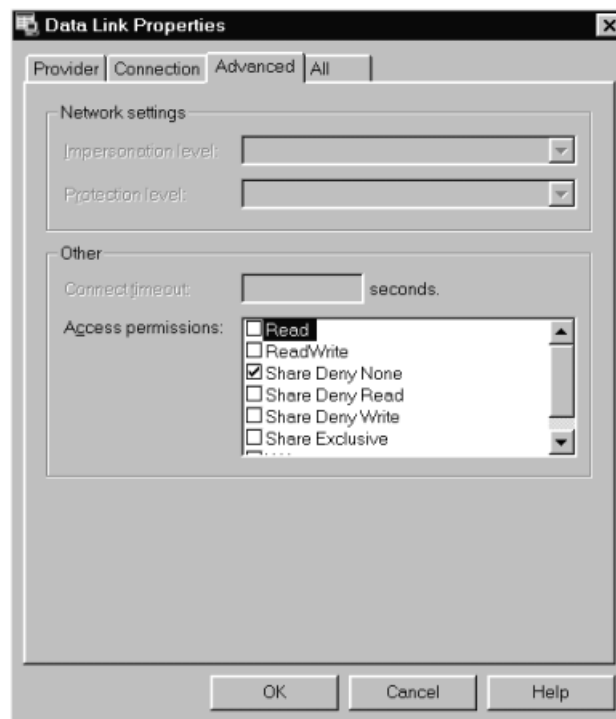
Check that the 'Access permissions' for the database are as required. 'Share Deny None' is the default and is usually the most suitable setting.

Under the 'All' tab all of the individual settings can be reviewed and adjusted if necessary.
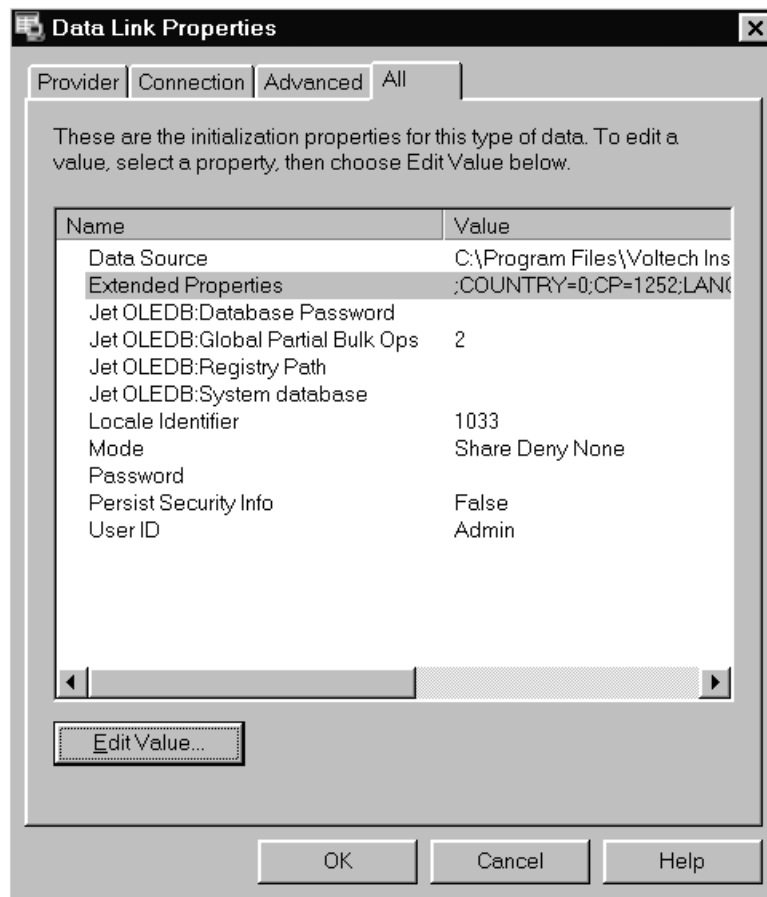
Click on OK to complete the setting of the data link properties. A typical AT Server advanced database results dialogue would be:

Click on OK to return to the results dialogue. At this point the AT Server will automatically create the required database tables if they do not already exist.

Ensure that 'Database Results Saving' is checked and click on 'OK'. Whenever a results window is open, the results will now be stored in the selected database.

DATABASE TABLES

The server software automatically creates the following tables in the selected database (if they do not already exist) and stores data within the tables using the structure defined here.

The tables store all the information that is available concerning the results (including time, date, limits, operator etc.) in a very compact and efficient structure.

Note that new data is not necessarily appended to the end of a table; it may appear anywhere within.

Table:	tblVoltechATUnitID	
Field	*Format*	*Notes*
ATUnitID	Text (25)	Index ID
UnitType	Text (10)	AT3600, AT1600, ATi
UnitID	Text (10)	Unit Serial Number
FirmwareID	Text (10)	Unit Firmware Version

Table:	tblVoltechResults	
Field	*Format*	*Notes*
ResultID	Text (25)	Index ID
RunID	Text (25)	As tblVoltechRunID.RunID
TestID	Text (25)	As tblVoltechTestID.TestID
TestNo	Number (Long Integer)	Test number as in test program
OC_Comp	Text (5)	YES , NO , N/A Open Circuit Compensation status
SC_Comp	Text (5)	YES , NO , N/A Short Circuit Compensation status
Load_Comp	Text (5)	YES , NO , N/A Load Compensation (future development)
Result	Number (Single)	Actual test result
TestStatus	Text (5)	DSP Status for test
PassFail	Text (5)	PASS/FAIL Individual test pass or fail result

Table:	tblVoltechRunID	
Field	*Format*	*Notes*
RunID	Text (25)	Index ID
Date	Date/Time (Short Date)	Date of Test Run
Time	Date/Time (Long Time)	Time of Test Run
ATUnitID	Text (25)	As tblVoltechATUnitID.ATUnitID
PartID	Text (25)	Part name
FixtureID	Text (25)	Fixture name
OperatorID	Text (25)	Operator name
BatchID	Text (25)	Batch name
TransformerSerialNo	Text (25)	Transformer serial number
OverallResult	Text (10)	PASS/FAIL/RE-RUN/ABORT Overall test pass or fail result and Re-Run result.

Table:	tblVoltechTestID	
Field	*Format*	*Notes*
TestID	Text (25)	Index ID
TestMnemonic	Text (10)	Individual test mnemonic
TestUnits	Text (10)	Individual test units
CheckType	Text (5)	NONE/MIN/MAX/DIFF/POL Type of test limits (see *)
MinLimit	Number (Single)	Minimum limit for test (see *)
MaxLimit	Number (Single)	Maximum limit for test (see *)

* Notes:

(CheckType = NONE)   If there are no Min or Max limits, MinLimit = 0 and MaxLimit = 0

(CheckType = MIN)   If there is a Min limit only, MaxLimit = 0

(CheckType = MAX)   If there is a Max limit only, MinLimit = 0

(CheckType = DIFF)   If there is a Min and Max limit

(CheckType = POL)   Polarity test
                     If Positive Polarity test, MinLimit = 0 and MaxLimit = 1
                     If Negative Polarity test, MinLimit = -1 and MaxLimit = 0

CHARTING AND ANALYSIS USING SPC/SQC SOFTWARE

Once an AT Server to database connection has been made, it is possible to connect third party analysis software to the same database for live on-line (or offline) data analysis. The example reports presented here were created using PQ Systems ChartRunner, but many other charting and analysis programs are available. Voltech does not recommend one package more than any other. You should choose to use the one that best meets your needs.
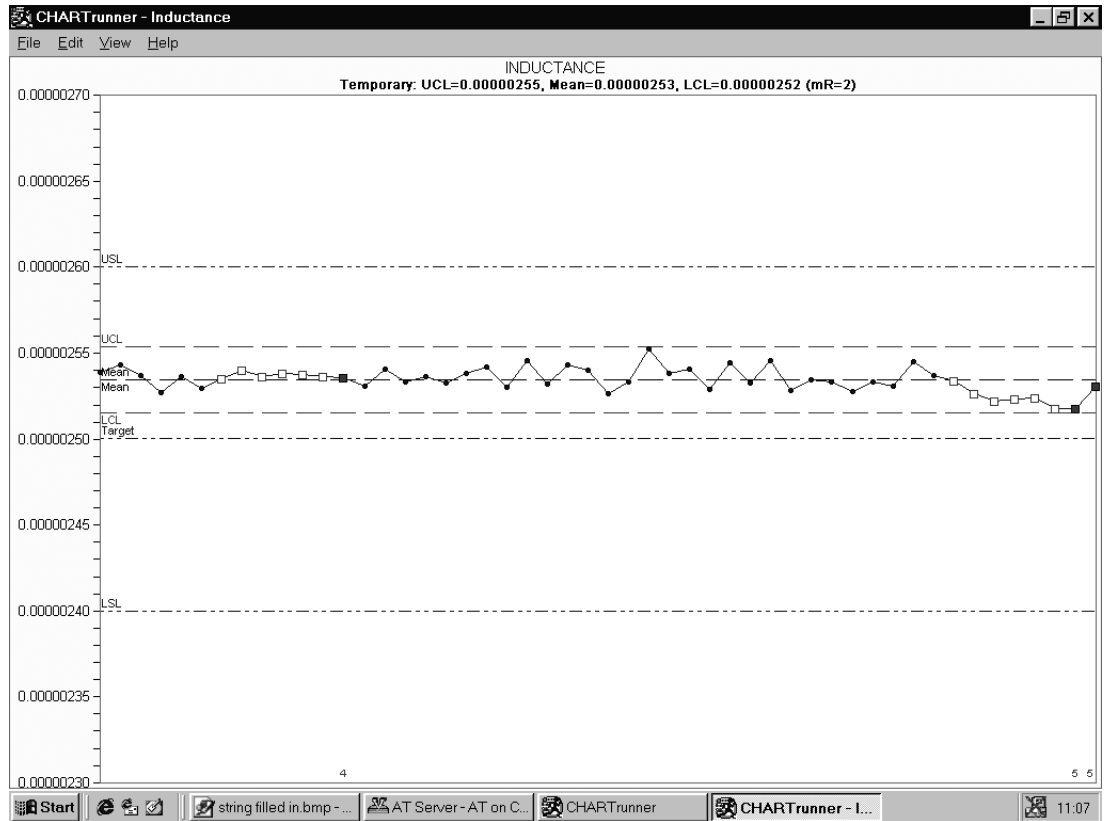
Inductance Trend Analysis
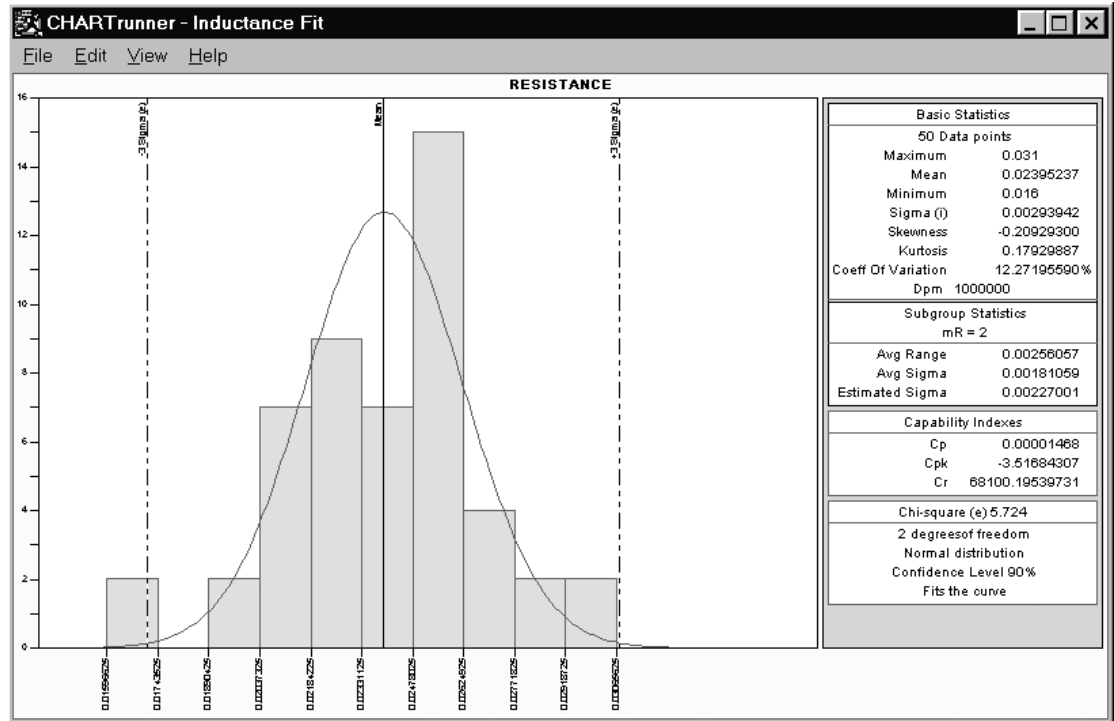
Resistance Distribution Analysis
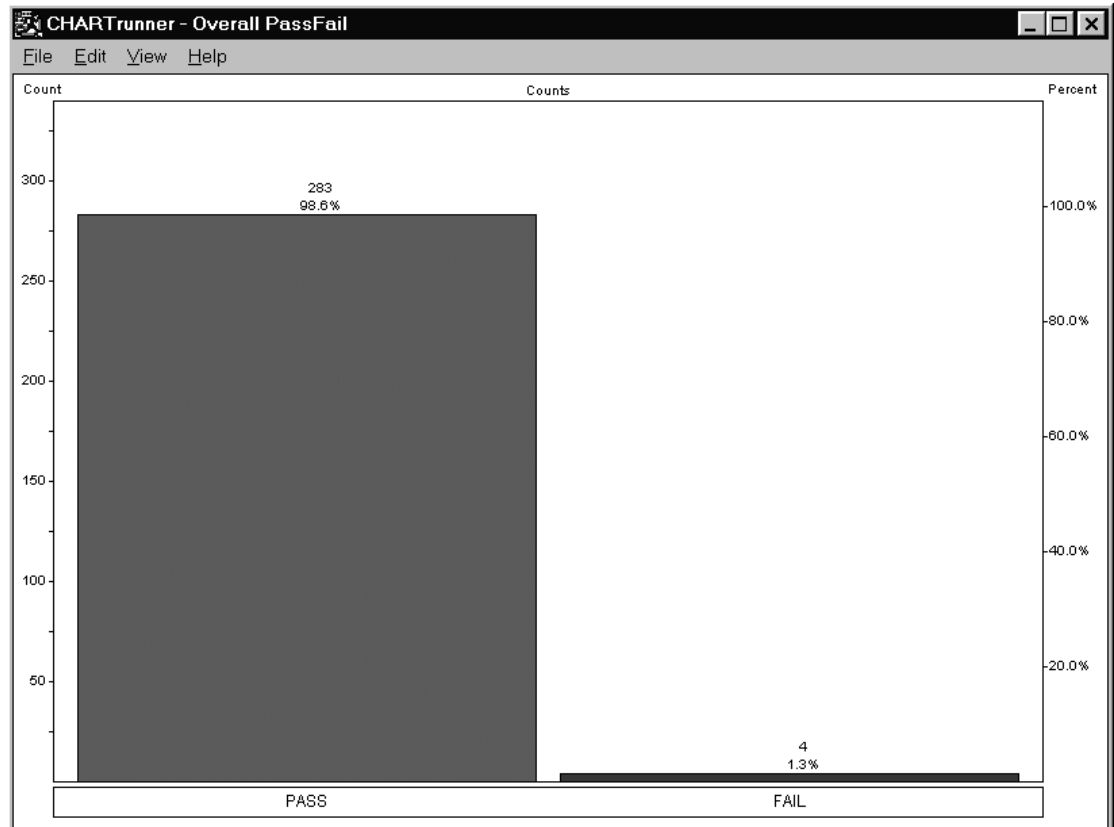
Overall Pass/Fail Analysis

ChartRunner Example Database Connection

The chart will show the trend of inductance measurements over time - an 'Individuals' chart type. See the ChartRunner help system for how to set up control limits, change the display appearance or set up any of the other available chart types.

In the ChartRunner software, create a new chart.

Enter a chart type, the refresh rate (for on-line analysis) and the chart type.

Click on the 'Data Source' tab to choose the results database:
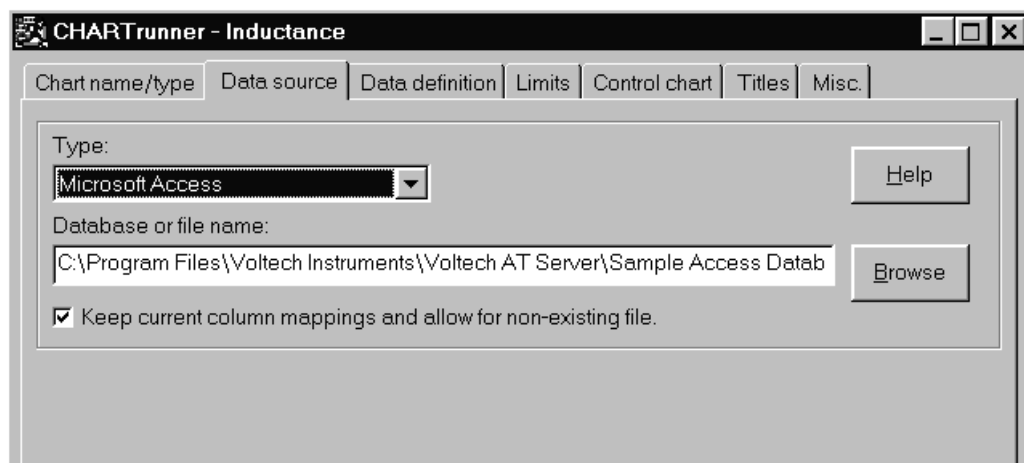
Under the 'Data Definition' tab:

Select the table of the database that holds the data that you want to chart. (You may also select a query that has been written in the database or write a 'Custom Query').

In this case the database table 'tblVoltechresults' has been chosen and the column 'Result' flagged as a measurement. (To do this, click on the 'Treat as' column of the 'Result' row and select 'Measurement' from the drop down list).

Next, click on 'Filtering' and filter the data for 'TestNo' = 2.

Filter for selecting rows from data table	☒

Select data where the date/time in THIS column:

Is Between: and: ☑ Inclusive

AND (

TestNo ▾   = ▾   2

▾

▾   ▾

▾

▾   ▾

) ▾ (Additional Conditions)

See WHERE clause

Additional Conditions:

| Help | Clear all | | OK | Cancel |

This selects only the results for test number 2 of the AT test program (which is an inductance test).

Next click on the 'Limits' tab and enter appropriate specification limits which will appear on the chart. The ChartRunner software can automatically select appropriate control limits from the data. This is the default and recommended setting.
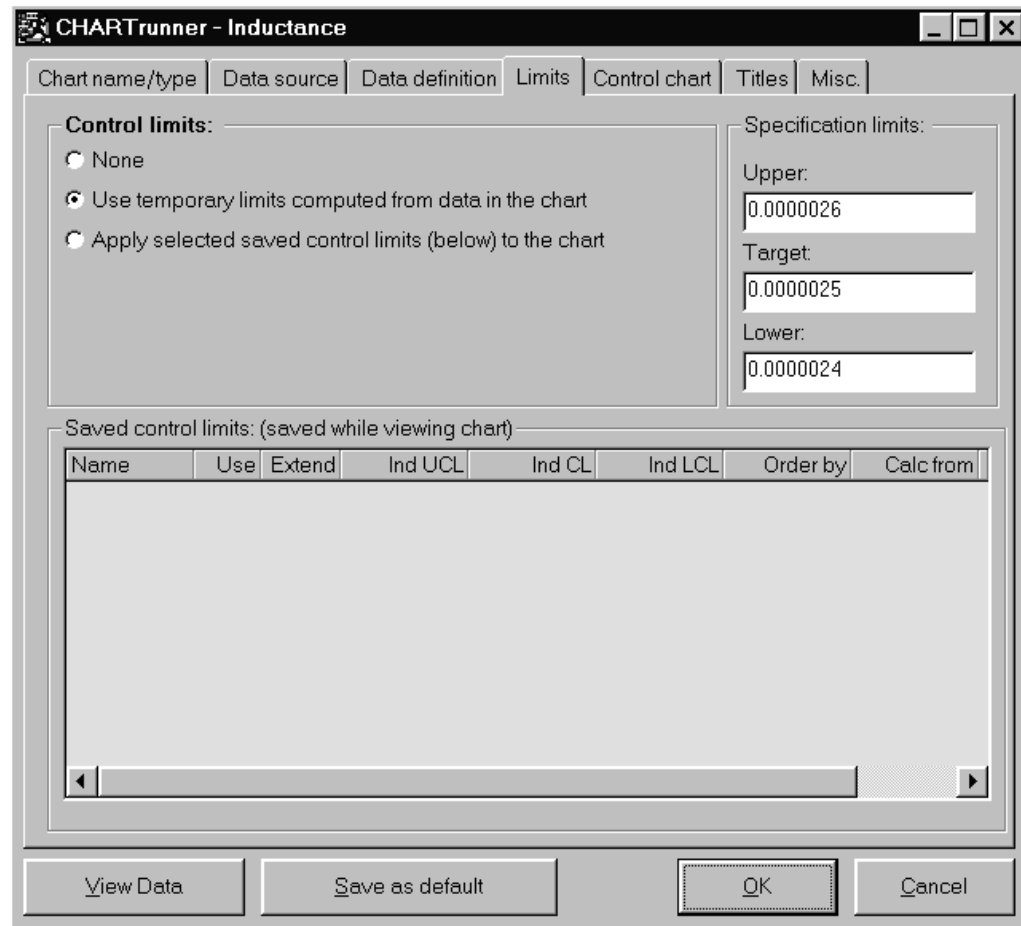
Under the 'Control Chart' tab, display options (including axis scaling) can be altered.
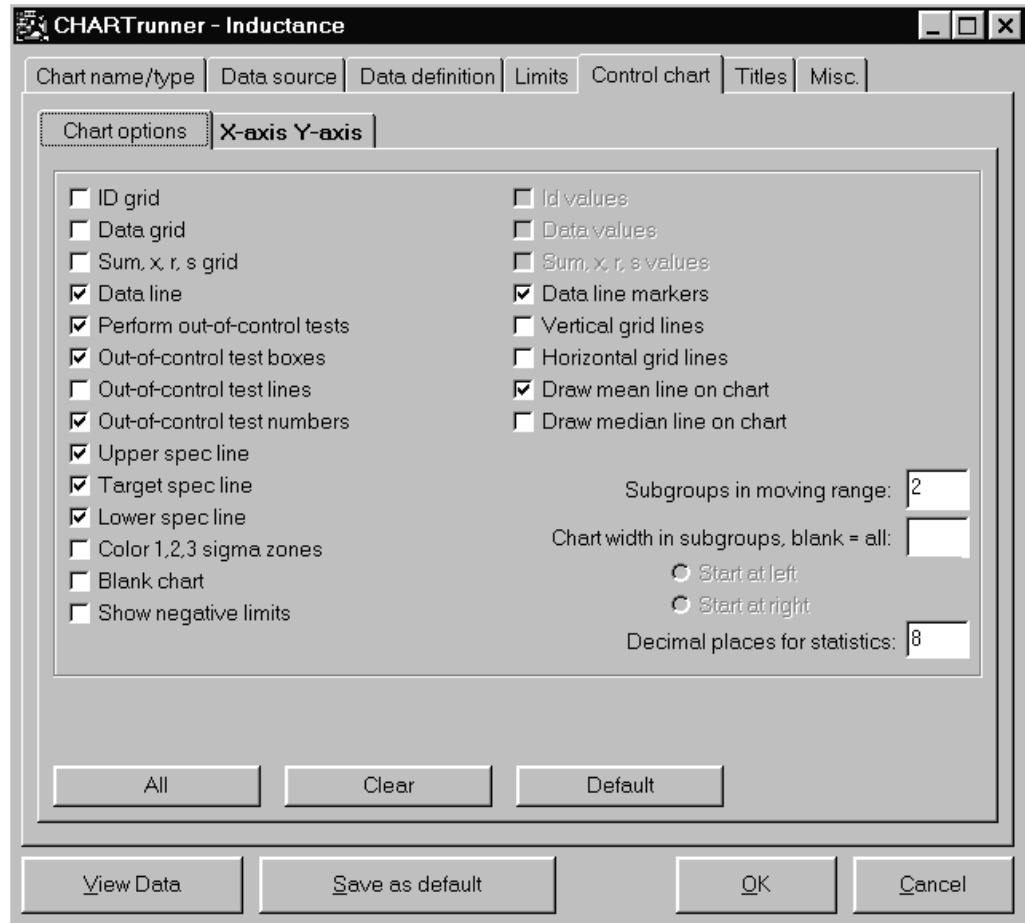
Other options including chart titles and size can be altered by selecting the 'Titles' and 'Misc.' tabs.

Click on 'OK' when finished. Double click on the chart definition to display the chart.

Please refer to the help system of the analysis software you are using for further advice and information on chart types, connectivity, options and statistical analysis in general.

Free trial versions of ChartRunner are available from PQSystems at www.pqsystems.com or any of their regional offices.

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PQ Systems Inc. Corporate Headquarters

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E-mail: sales@pqsystems.com.au

3.2.4. ON-LINE ANALYSIS VIA OLE

The MS Windows environment provides a system of transferring data between active applications in real-time known as Object Link Embedding (OLE). OLE2 is the latest version of the transfer standard and is fully supported by the Server application.

Embedded data links allow test results received by the server to automatically pass into a second application, which may be your own custom software or a spreadsheet such as Microsoft Excel. Server OLE commands also allow you to load and execute test programs. OLE is the analysis and control method preferred by users who wish to operate the AT under software control.

OLE is already configured ready-to-go within the Server application. Your client application will need to be setup to request data from the Server. Refer to your own application handbook for details of OLE setup.

IMPORTANT: Attempting to make more than ten data requests per second may result in data loss or corruption.

NOTES:

1. The automation object is called '**Server**.**Results**'

2. The exposed OLE automation methods are:

    GetVariantResult (LPCSTR ComPort, short TestNumber)

    where: LPCSTR ComPort is a pointer to a string ComPort

             ComPort   =   "COM2"... "COM9"

                        =   the port connected to the AT Series Tester which gives the required result

             TestNumber =   Integer number for test within program

The number returned is a float representing the value of the result measured or a zero if no result was available.

This call returns a result on success or a failure string:

"INVALID COM PORT"   no valid com port found

"COM PORT IS NOT OPEN"   com port requested not connected to an
                                AT Series Tester

"INVALID RESULT NUMBER"   the requested result number is out of range

"NO RESULT"   no updated result data available

Further Voltech Server OLE functions are described below. They use the same format and failure strings as 'GetVariant Result'. Only function specific responses and return values are shown.

NewDataAvailable (LPCSTR ComPort)

Returns TRUE or FALSE (Boolean 1 or 0 as variant) depending on whether new data is available. If this function returns true it means that new data can be read back via the OLE. If false then no new data has come in since the last read

GetPartID (LPCSTR ComPort)

Returns the part name on success or a failure string:

"NO PART ID"   no valid part name found

GetFixtureID (LPCSTR ComPort)

This call returns the fixture name on success or a failure string:

"NO FIXTURE ID"   no valid fixture name found

GetOperatorID (LPCSTR ComPort)

This call returns the operator name on success or a failure string:

"NO OPERATOR ID"   no valid operator name found

GetBatchID (LPCSTR ComPort)

This call returns the batch number on success or a failure string:

"NO BATCH ID"   no valid batch number found

GetFirmwareID (LPCSTR ComPort)

This call returns the firmware version number on success or a failure string:

"NO FIRMWARE ID"   no valid firmware version found

GetUnitID (LPCSTR ComPort)

This call returns the tester serial number on success or a failure string:

 "NO UNIT ID"   no valid AT serial number found

GetTransformerSerialNo (LPCSTR ComPort)

This call returns the transformer serial number on success or a failure string:

 "NO SERIAL NO"   no valid transformer serial number found

GetResultsFilename (LPCSTR ComPort)

This call returns the results file filename on success or a failure string:

 "NO RESULTS FILE"   no valid filename found. (No results yet?)

GetResultPolarity (LPCSTR ComPort, short TestNumber)

 "NO POLARITY"   Test has no polarity result

 "+"   Polarity is positive

 "-"   Polarity is negative

GetPolarityPass (LPCSTR ComPort, short TestNumber)

 "NO POLARITY"   Test number has no polarity result

 "PASS"   Polarity result has passed

 "FAIL"   Polarity result has failed

GetTestPass (LPCSTR ComPort, short TestNumber)

 "PASS"   Test result has passed

 "FAIL"   Test result has failed

GetOverallPass (LPCSTR ComPort)

 "PASS"   All tests have passed

 "FAIL"   One or more tests have failed

GetNumberOfTests (LPCSTR ComPort)

Returns a short integer variant type giving the number of tests in the program. Use for possible determination of the maximum value for TestNumber in other functions.

GetMinLimit (LPCSTR ComPort, short TestNumber)

Float value giving the minimum limit for the test TestNumber.

"NO LIMIT"   This test has no minimum limit.

GetMaxLimit (LPCSTR ComPort, short TestNumber)

Float value giving the maximum limit for the test TestNumber.

"NO LIMIT"   This test has no maximum limit.

GetTestStatus (LPCSTR ComPort, short TestNumber)

Returns four digit hex string ("####") giving the test status as seen on editor results screen.

GetTestMnemonic (LPCSTR ComPort, short TestNumber)

Returns the test mnemonic as a string, i.e. "LBAL".

GetTestUnits (LPCSTR ComPort, short TestNumber)

Returns the test units as a string, i.e. "Ohm".

GetCompensationStatus (LPCSTR ComPort)

"NO COMPENSATION STATUS"	No status received yet.
"No Fixture Compensation"	Program has not been compensated.
"Fixture Compensation: successful"	Compensation all OK.
"Fixture Compensation: fail" + ExtraString	Compensation has failed.

GetUnitType(LPCSTR ComPort)

Returns "AT3600", "AT1600" or "ATi" depending on the type of instrument connected to the ComPort.

GetResult (LPCSTR ComPort, short TestNumber)

The number returned is a float representing the value of the result measured or a zero if no result was available.

This function is included for compatibility with older versions of the Voltech AT Server. It is not recommended for new applications.

This section shows available functions for controlling an attached instrument via the server. This is to allow basic instrument control in applications where the AT is being used entirely remotely. The functions available allow a program to be loaded into an AT, and give the ability to run and stop it.

Variant LoadProgramToAT (LPCSTR ComPort, LPCSTR ProgName)

"PROGRAM DOES NOT EXIST"	Program is not in the servers program folder.
"INVALID PROGRAM"	Program fails AT test program validation.
"LOADING"	Returned when command is first sent to server, and every subsequent time it is sent until loading finishes.
"LOADED"	The program has been successfully loaded, this will continue to be returned, and the program will not load until either StopAT() is called or the server receives results on that COM port.

Variant RunProgramInAT (LPCSTR ComPort)

"NO PROGRAM"	The AT has no program to run.
"SENT"	Returned when the program has started to run and every subsequent time the function is called until the server receives results.
"DONE"	The program has finished running, results will be available. If the function is called after it has returned this value it will cause the program to be run again.

Variant StopAT (LPCSTR ComPort)

"STOPPED"	The AT must stop whatever test it is running

EXAMPLE OF ON-LINE ANALYSIS

This section contains a simple example to illustrate how you may use OLE to transfer the measured results into a spreadsheet as they happen in real-time.

The spreadsheet used in the example is Microsoft Excel 97, and the module of code illustrated is written in the Visual Basic supplied with the spreadsheet.

Before attempting to create the spreadsheet, set up the AT and server:

- Use the editor to create a program containing 5 tests, where test number 3 measures a winding resistance.

- Ensure that the program option 'Send Results to Server' is set to 'On'.

- Transfer the program to the directory being used by the server for storing programs.

- Ensure that the server program is running, and that the COM Port to be used has been enabled.

- Connect the AT to the server PC, and use the PROGRAM - SET-UP menu to set the origin to SERVER.

- At the AT Top Level menu, press the EXECUTE soft-key, and type in the name of the program.

- Run the program and check that the correct results are displayed in the on-line monitoring window.

Leave the Server program running, and on the same PC, start Microsoft Excel 97. A new (empty) spreadsheet will be created.

From the Excel top level menu bar, select:

> Tools
>
> Macro
>
> Macros

Enter the name 'OLE_Demo' and then create.

Excel will then bring up a module sheet labeled 'Module 1'. Type the following code into this module sheet:

```
'*****************************************************************
'OLE_Demo Sub
'
'Procedure to demonstrate linking AT results into an Excel spreadsheet
'in real time using OLE.
'
'The procedure will read the third test in the program and put the result
'into a cell on the third row of the spreadsheet.
```

```
'
'The procedure will do this for a total of 3 program runs, and then exit.

Sub OLE_Demo()

  Dim objServerResult As Object
  Dim vntResult(1 To 99) As Variant

  Set objServerResult = CreateObject("Server.Results")

  nTest = 3
  nNumRuns = 3
  sComPort = "COM2"

                            'Dummy read to clear any previous result
  vntResult(nTest) = objServerResult.GetVariantResult(sComPort, nTest)

  MsgBox ("Press the RUN soft-key on the AT3600")

  For nRun = 1 To nNumRuns                       'Get the results

    Do
      vntResult(nTest) = objServerResult.GetVariantResult(sComPort, nTest)
    Loop Until (vntResult(nTest) <> "NO RESULT") And _
            (vntResult(nTest) <> "INVALID RESULT NUMBER")

    Cells(3, 5 + nRun) = vntResult(nTest)      'Put result in spreadsheet

  Next nRun

  MsgBox ("Done")

End Sub
```

When you have finished typing the code, return to the 'Sheet 1' of the spreadsheet.

To run the code, again from the Excel top-level menu bar, select:

Tools > Macro

At the dialog box, select the name of the macro 'OLE_Demo', and click on the RUN button.

The code will now start to run, and after a few seconds, you will see the first message box defined in the code:

Click on the OK button. When you have pressed the RUN soft-key and the first result has been read, the message box will disappear, and you will then see the first result entered into cell F3 of the spreadsheet.

Continue pressing the RUN soft-key until the second message box is seen.

Click on the OK button to finish running the code.

ADDITIONAL NOTES FOR THE ABOVE EXAMPLE

If there appear to be any problems while the code is running, press the escape key. This will halt the execution, and bring up a dialog box to allow you to either exit from the code execution, or to debug your code, for example by single-stepping through it.

Once the results have been placed into cells in the spreadsheet, standard Excel functions may be used to perform further analysis on the data, or to present the data in different ways. As an example, you may wish to use the Excel Chart Wizard to produce a graph of the results. Alternatively, you may wish to add further code to the example shown above, as another way of extending the functionality. For guidance of what may be possible, please refer to the Microsoft Excel user manuals.

In the code example shown above, it is worth noting the following points:

- vntResult(1 To 99) is declared as a variant type because the GetVariantResult method can return either a numerical value corresponding to a valid result, or a string corresponding to an error message.

- The line

```
Set objServerResult = CreateObject("Server.Results")
```

creates the server.Results automation object within Visual Basic.

When trying to read the result with

```
Do
  vntResult(nTest) = objServerResult.GetVariantResult(sComPort, nTest)
Loop Until (vntResult(nTest) <> "NO RESULT") And _
           (vntResult(nTest) <> "INVALID RESULT NUMBER")
```

two tests for 'No Result' and 'Invalid Result Number' are included.

The GetVariant method will normally read back 'No Result', until a measurement has occurred. The next time it is executed after a new result has been sent to the server, GetVariant will read back the actual result value. The act of doing this will set a flag in the Server to say that the data has been read, so that any further executions of the GetVariant statement before another result has been transferred to the server will then return the 'No Result' reply.

Although the test number is fixed (= 3) in this example, the 'Invalid Result Number' test is also included. This is because the GetVariant method can be activated at exactly the same time as the results are being transferred from the AT to the server. Depending on the speed and other parameters of your PC, there may be a small time during the transfer when the result number requested can be read as invalid. Including this test in the loop will trap out this error.

Instead of using the GetVariantResult function itself to determine if new data is available, the NewDataAvailable function can be used. This function is recommended for use when more than one item of data is to be read after new data is available. For example, the NewDataAvailable function can be read in the do loop until it returns true, after which any other OLE function can be called to gather their return values knowing that all the data will be valid. Using the NewDataAvailable function also means that checking for 'INVALID RESULT NUMBER' and 'NO RESULT' return values is no longer necessary.

3.2.5. OFF-LINE ANALYSIS

If you have no requirement for real-time analysis but are interested in post test analysis of test results, off-line data analysis should be adopted. An example of this would be to view the results file created the previous day.

As described in section one of this chapter, the batch result file is stored in a text based Comma Separated Variable format (CSV).

A spreadsheet is an ideal environment to analyze and manage your test data. Almost all spreadsheet applications are able to import a CSV file.

Once imported test results may be graphed, calculated, edited and printed like any other data. Using a package such as Microsoft Excel, macros may be setup to sort and extract the appropriate result sections, calculate and compile reports and finally produce a printout for records.

Refer to your own application handbook for details of importing and manipulating data.

EXAMPLE OF OFF-LINE ANALYSIS

The spreadsheet used in the example is Microsoft Excel 97.

From the Excel top level menu bar, select:

File > Open
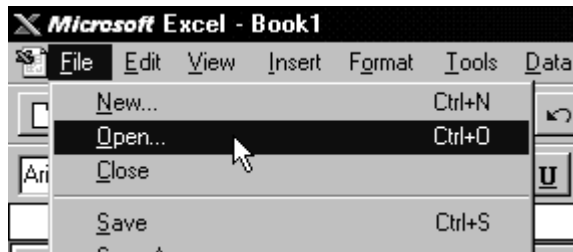
Excel will then bring up the 'Open File' dialogue box. Select the results file you wish to view and click on 'Open'.
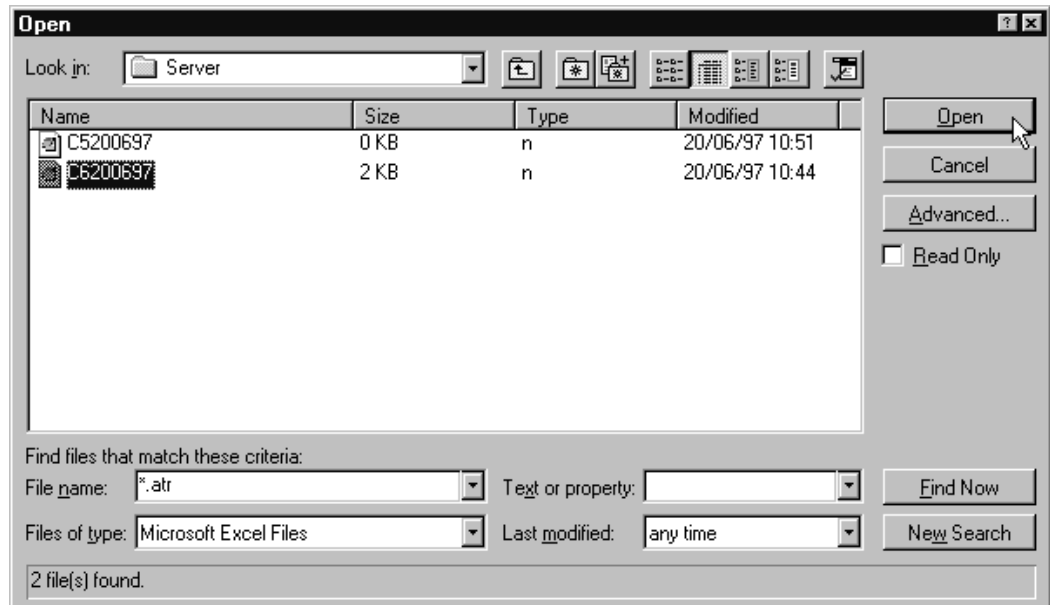
After clicking 'Open', the Text Import Wizard dialog box will appear:
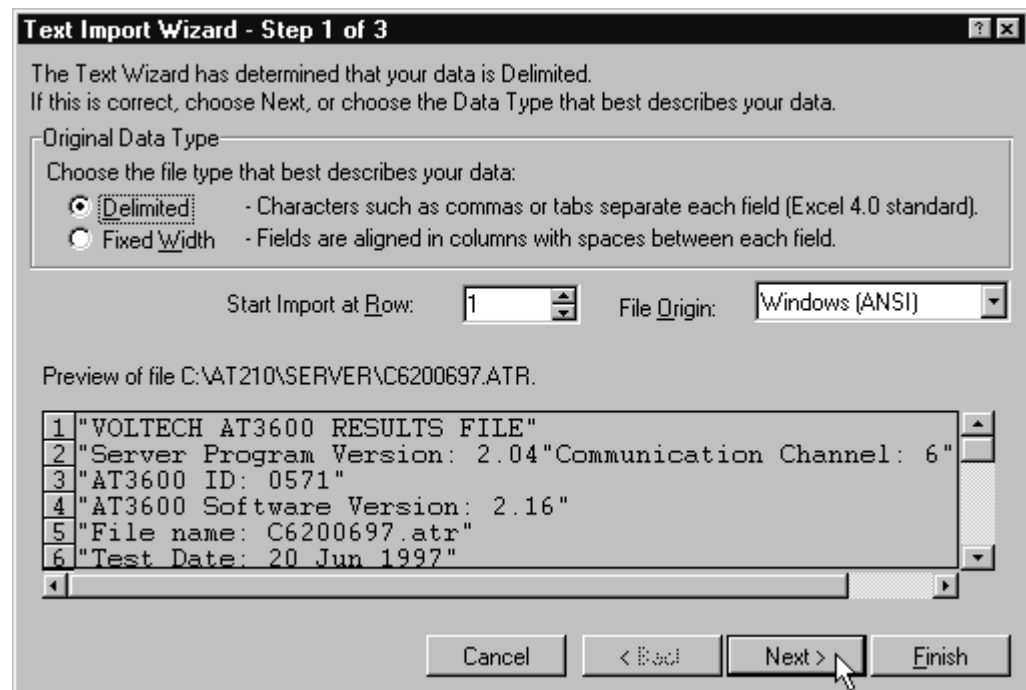
Ensure that the 'Delimited' option is checked and click on 'Next >' to move to step two.
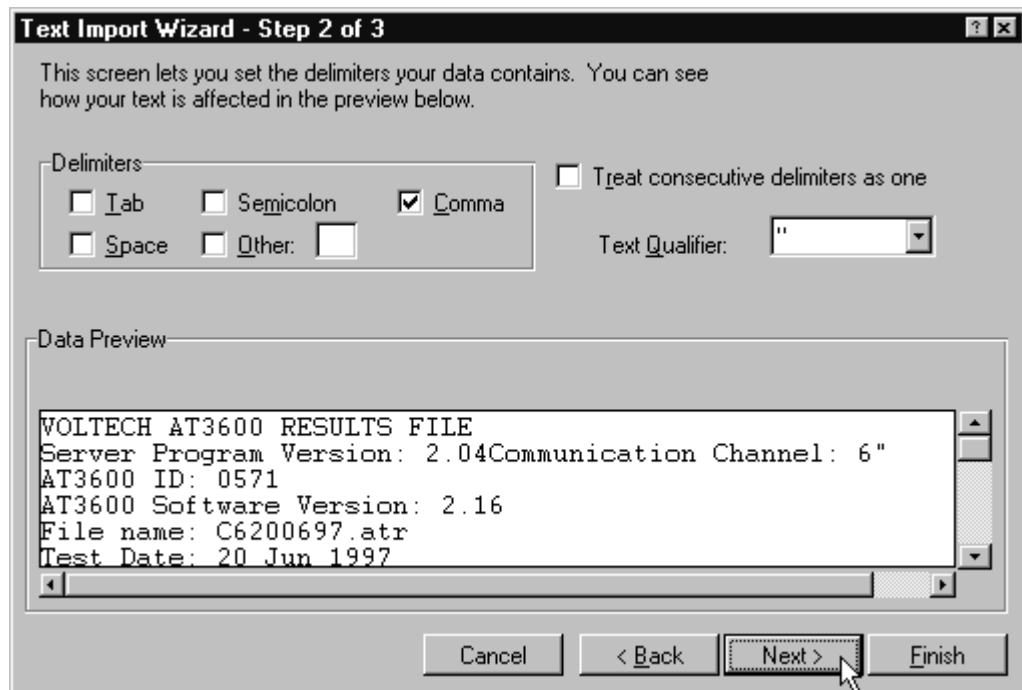
In the 'Delimiters' section of this screen, ensure that only the 'Comma' option is checked. Click on 'Next >' and proceed to step three:
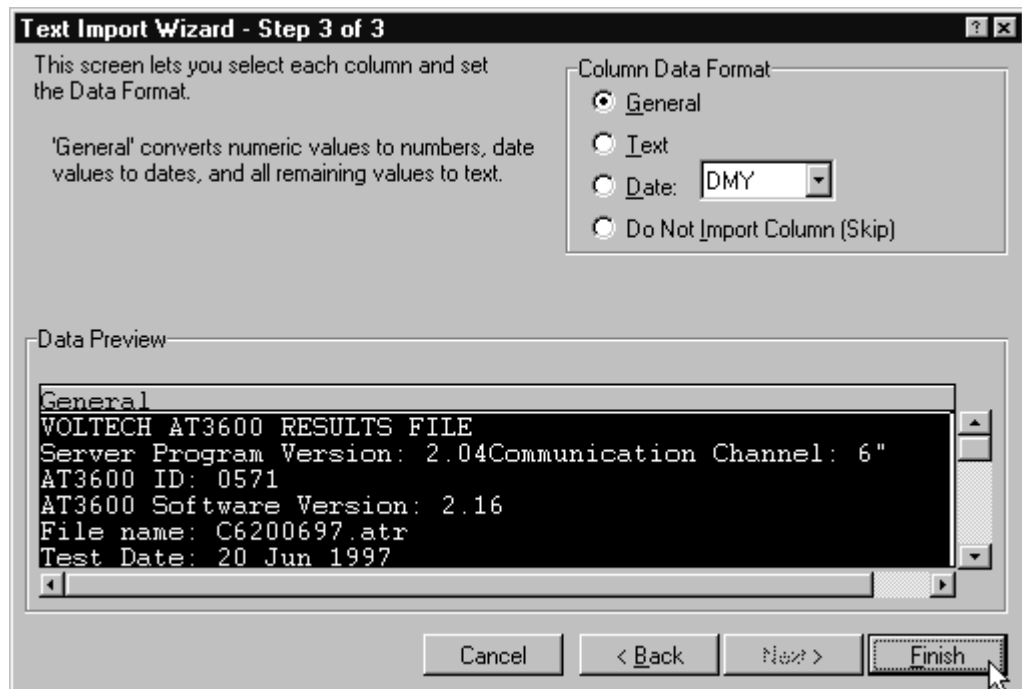
Check that the 'Column Data Format' option is checked as 'General' and click on finish.

The results will now be displayed as shown below:

You may need to adjust the Cell number format of the spreadsheet, and the width of the columns, in order to display the required number of decimal places.

Using functions built into the spreadsheet, the data obtained may now be used to create graphs and barcharts for a visual representation of your results. As an example, to produce a graph, select a group of results from one column; then click the Chart Wizard button and use this to create the graph you require in the normal way. For additional help on what may be possible, please refer to your spreadsheet user manuals.

CHAPTER 5 - FIXTURES

TABLE OF CONTENTS

This chapter will guide you through the fixture system designed for use with the at series testers. Detailed and comprehensive instructions and applications guidance for the construction of your own custom fixtures are supplied with every custom fixture kit.

1. INTRODUCTION

The AT Series Testers are able to perform an extremely comprehensive series of tests on a wide variety of transformers. To utilize this capability fully it is recommended that test fixtures are constructed to suit each particular type of transformer to be tested.

Test fixtures are based on a fixture board containing connection pins. They provide the interface to the tester via the tester node pins, allowing transformers to be quickly inserted and removed in a reliable manner taking full advantage of the high speed testing capability of the tester.
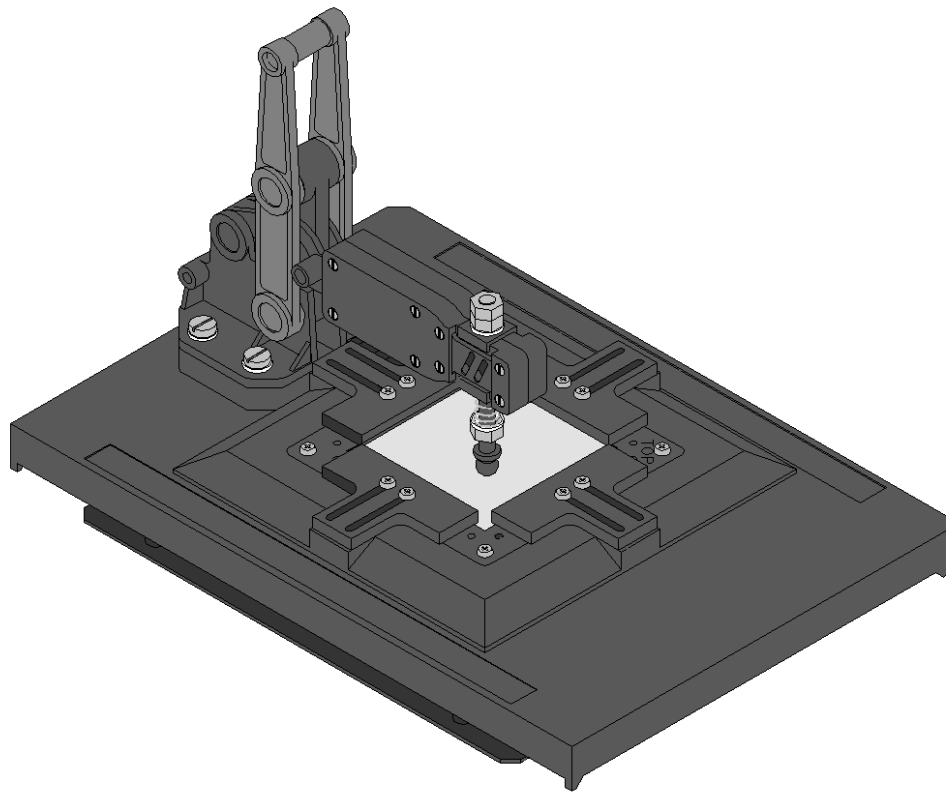
Voltech recognize the importance of well constructed test fixtures. These benefits include minimizing operator fatigue, ensuring optimum repeatability, preventing unnecessary rejects and increasing throughput of the AT Series testers.

2. DESCRIPTION OF THE FIXTURE SYSTEM

2.1 DESCRIPTION

The Voltech AT Series fixture system allows you freedom and flexibility when considering your fixturing needs.

All fixtures are mounted on fixture boards, which are available as a blank fixture plate and also as fixture kit which contains parts to help you.
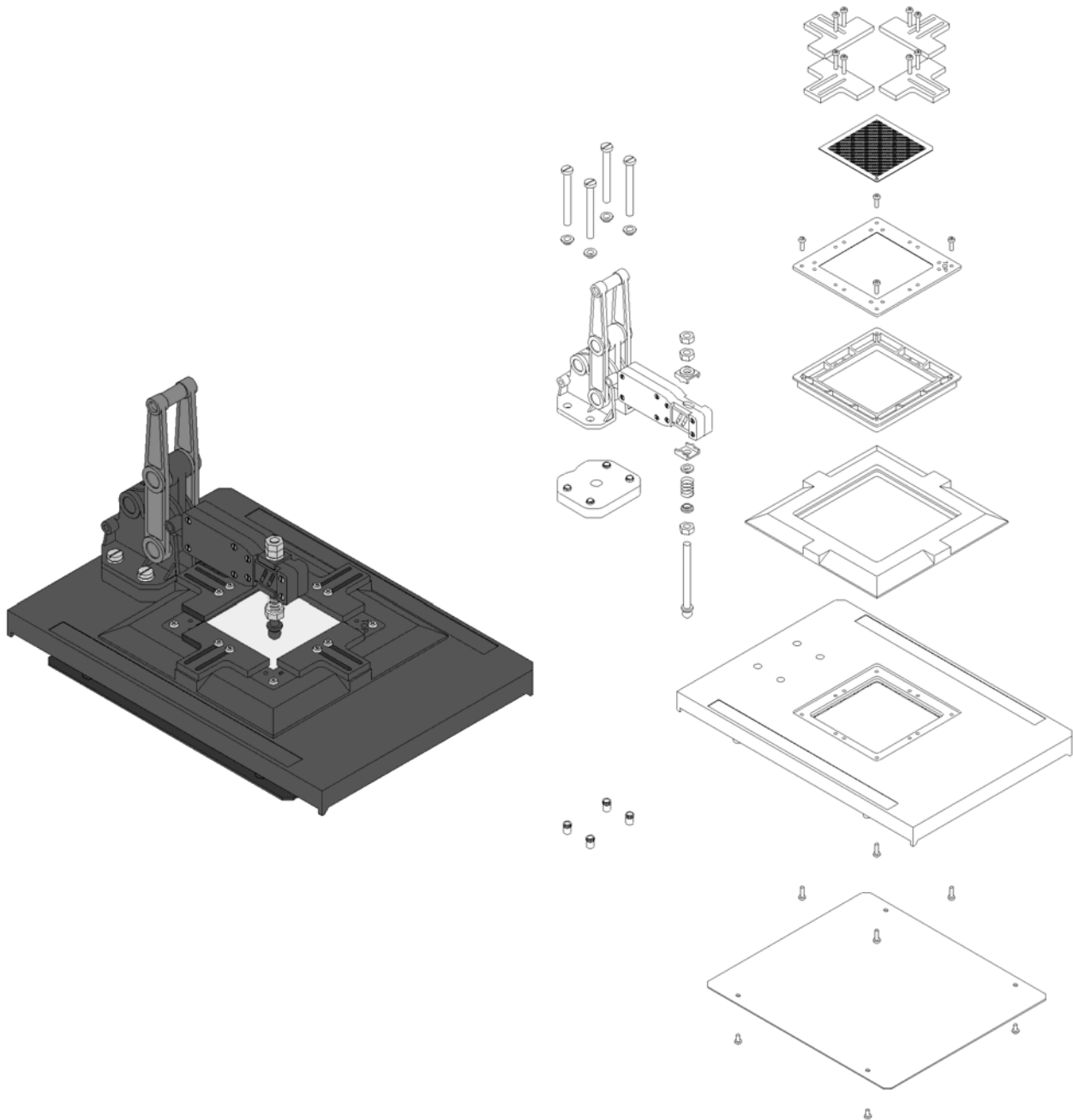
APPLICATION

The fixture is designed to connect to wound components with the following characteristics:

Size:

A footprint of up to 63.5mm square

A height of up to 63.5mm

A connection matrix up to 60mm square

Connection Types:

Surface mount.

Pin connection.

Blade connection.

Flying leads

Pitches of: -

1.27mm

1.962mm(0.156")

2.00mm

2.5mm

2.54mm (0.1")

3.81mm (0.15")

There are some application limitations to the above, for example, the minimum pitch of the blade type that can be connected to is determined by the minimum pitch that the necessary connector can be put on.

Also though a 1.27mm pitch is available it is only anticipated that component connections will be on multiples of this pitch and there will not be two connections only 1.27mm apart.

COMPATIBLE CONNECTION TYPES

Kelvin clips

Kelvin blades (Automech type)

4mm sockets

ATE pin types

Rotary point

Castellated

Point

Cup

Crown

A list of known suitable ATE pin types is available from Voltech.

THE COMPONENTS
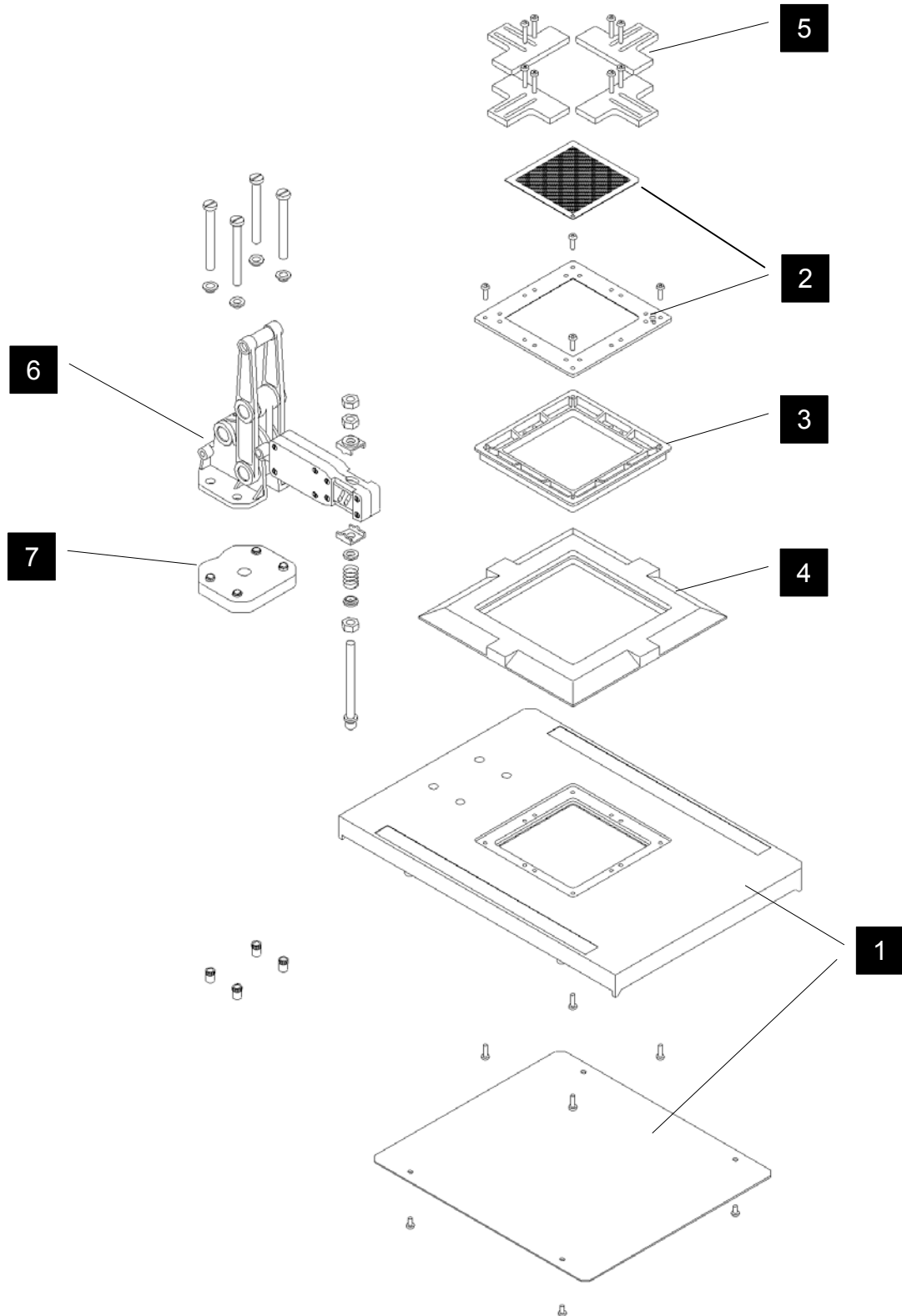
1. BASE PLATE

This fits into the top of the transformer tester and has the following features:

- Fitted with 40 node contacts which connect to the 40 test node pins on the top of the tester.

- Moulded indents on the bottom surface to act as drill guide marks for ease of drilling to fit:
    4mm safety sockets as a universal or for specific applications.
    Termination posts

- Provision for drilling through and fitting inserts for the attachment of a clamp in either the left or right hand position.

- Slots moulded into the base to support wiring to the connection points from the nodes.

- Four mounting pillars to hold the cover plate (supplied). The cover plate fits on to the underside of the fixture by four snap rivets to protect the wiring from accidental damage. It locates into moulded sockets in the Fixture Board by a simple press-fit action.

The fixture parts are made using a high-pressure injection moulding process in a material that is suitable for soldering temperatures and the high voltage that will exist during use.

2. INTERFACE PLATE

The interface plate is a glass fibre board with an injected plastic trim and fits into the bezel in close alignment with the Probe Housing box. The interface plate supports the body of the test piece during testing.

The bezel has 4 groups of 2 x M3 inserts for the attachment of the guides. The plate can accommodate a test piece of up to 63.5mm square, and can be drilled for probes over an area of 60mm square when using the drilling plates.

3. PROBE HOUSING BOX

The housing box fits into the bezel and base plate. This box has a base thickness of 9mm so that it can be drilled to accommodate a range of ATE probes and Kelvin pins.

The housing box is fastened into position by 4*M3 screws which also lock the Bezel into place.

4. BEZEL

This provides an accurate location for the probe housing box and the test piece interface plate. The design also includes support areas for the rear of the guides.

5. GUIDES

The guides help to locate the test piece into the fixture quickly and accurately.

They are adjustable to suit the test piece plan size and can be stacked or reversed if required.

The guides are capable of having sections cut off to enable them to be used down to small footprints. Four pairs are shown in the sketch.

6. CLAMP

A clamping mechanism may be purchased to hold the test piece in place for testing.

The clamp head has a sliding guide which allows the vertical clamping rod to move horizontally relative to the clamp head. This minimises the possibility of side movement to the test piece during the clamping action.

The clamp head is also designed to accommodate springs of force ratings of 2.9N/mm, 4.5N/mm and 5.4N/mm to allow for the differing types of probes used for wound component connections.

.

7. HEIGHT BLOCKS

Height adjustment blocks are capable of being stacked in order to clamp a UUT of up to 70mm in height in 10mm steps.

8. TOOLING

To enable the probe housing box and the test piece interface plate be drilled to the accuracy required, drilling templates are available in the following grid pitches:

    1.27mm

    2.00mm

    2.50mm

    2.54mm

    3.81mm

To hold the drilling templates in place for drilling, clips are provided to hold the drilling templates in place. They clip into holes provided at the corners of the interface plate and the probe housing box.

You can also make use of the free area behind the fixture, allowing you to mount other clamps, handling accessories, ink jet spray printers or even a scanning bar code reader close to the point of test.

ASSEMBLY AND WIRING

i	**A comprehensive guide to the construction of your own custom fixtures is supplied with each custom fixture plate kit (see section 2.2 of this chapter).**

2.2 FIXTURE PARTS AVAILABLE FROM VOLTECH

1. FIXTURE PLATE

Designed for mounting existing fixtures to an AT series tester the fixture plate comprises:

- Item 1, Base plate (including contact pins) with cover.

- Item 2, Test piece interface plate.

- Fixings for above.

2. CUSTOM FIXTURE KIT

A kit of parts for constructing your own fixtures. Interconnecting wire, test probes or clips and a drilling template will also be required. The custom fixture kit comprises:

- Item 1, Base plate (including contact pins) with cover.

- Item 2, Test piece interface plate.

- Item 3, Probe housing box.

- Item 4, Bezel.

- Item 5, Guides (12 off)

- Fixings for above.

3. 40 SOCKET FIXTURE

A fixture board fitted with 40 4mm sockets. 20 red (power) and 20 black (sense). The sockets are wired to the 40 contacts which align with the tester's 40 nodes.

This fixture may be used for convenient wiring to existing fixtures or as a means of connecting flying leads and clips for use in developing test programs or testing parts in a design laboratory.

4. CLAMP

The hand clamp is supplied with 7 height blocks and fixings.

5. TOOLING

Drilling templates are available in a variety of sizes as described on page 5.2.5.

3. KELVIN CONNECTIONS

In testing many transformer parameters, such as winding resistance or inductance, it is necessary to measure electrical impedance.

The normal method of measuring impedance is to pass a test current through the unknown component, and to measure the resulting voltage produced across it. Dividing the voltage by the current gives the required value of impedance.

In making such measurements, great care must be taken not to include the impedance of the measuring leads in the result. A connection system that avoids such problems is shown below; it uses four wires and is often referred to as a Kelvin connection.
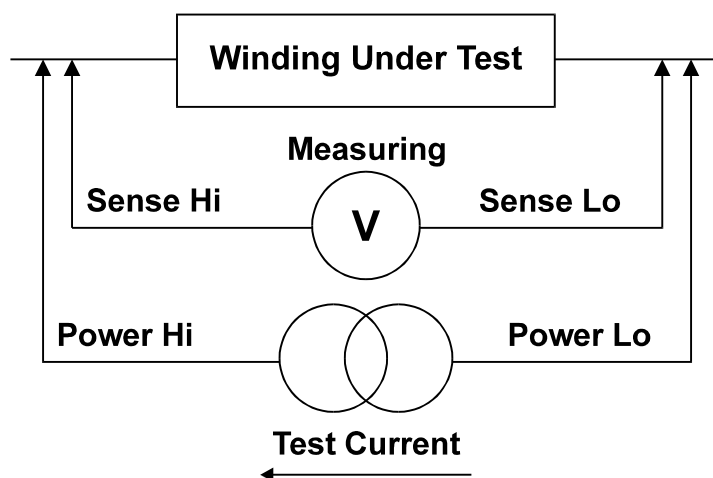
In this arrangement, the test current passes through the two 'power' leads, and the voltage is measured using the two 'sense' leads.

Provided that the sense leads are connected as close as possible to the body of the device under test, any additional voltage drop produced by the test current flowing through the impedance of the power leads is not measured.

The Kelvin connection therefore provides the most accurate means of sensing the voltage, and hence the impedance of the winding.

Ideally, all impedance measurements would be made using Kelvin connections. However, many terminals do not permit the use of four wires all the way to the body of the component under test.

In such cases, separate power and sense leads are used up to the base of the terminal, and the length of 'common' lead (from the junction of the power and sense leads, through the terminal and the component lead to the body of the component) should be kept to a minimum.

The 'common' lead length is shown as AA' and BB' in the diagram below.
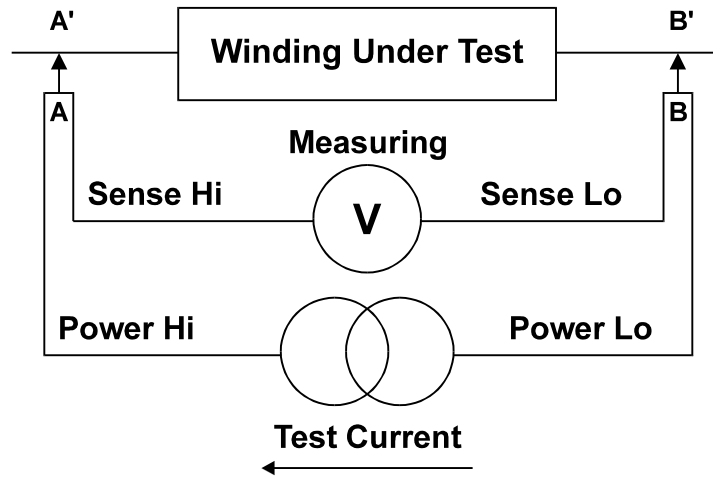
The AT series testers provide all the connections required to take advantage of Kelvin measurements.

A test node may be considered to be a pair of connections consisting of one power and one sense terminal.

The following diagram indicates how to identify the node terminal function;

Power   Sense
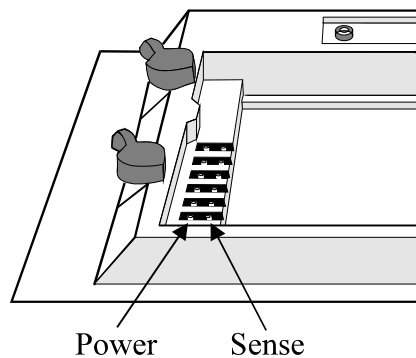
POWER terminals are all on the outside of the fixture area.

SENSE terminals are all on the inside of the fixture area.

IMPORTANT: Kelvin four terminal connections are generally advised to be used in all test fixtures; they are essential for transformers whose winding resistance's are less then 1Ω.

4. GENERAL NOTES

The following general notes should be considered when constructing or modifying fixtures.

4.1. BEWARE OF HIGH VOLTAGES

The AT3600 can apply AC voltages up to 5000 Vrms during the course of a test. This must be kept in mind when constructing test fixtures.

If possible, always design the fixture with the nodes that experience the same high voltages grouped together.

> An example of this is the common situation of performing hi-pot tests between the primary windings as a group, and the secondary windings as a group.

> The best layout for the test pins in this case (assuming this is not prohibited for other reasons) is to have all the primary windings connected to test nodes on one side of the fixture board (say the left-hand side using nodes 1, 3, 5, 7, etc.), and to have all the secondary windings connected to test nodes on the opposite side (for example, nodes 2, 4 and 6).

> If, in addition, you need to test the isolation between two secondary windings, use the low-numbered nodes (say 2, 4 and 6) for one winding and a well separated group of high-numbered nodes (say 14, 16 and 18) for the other.

For PCB mounting transformers, clearly the spacing between the pins is determined by the transformer itself. If necessary, place pieces of high-voltage insulation between each Kelvin blade and its nearest neighbors, to prevent any high voltage flashover.

When separate terminals are used for transformers with flying leads, you should ensure that there is a generous separation between individual terminals to allow for the high voltages in your program. Consider both the exposed (high-voltage) metal parts of the terminal itself, and the free ends of the transformer lead, which may be carelessly inserted and may bend round to touch an adjacent terminal. Ensure that there is a separation of at least 3mm per kV between any sharp points in an air gap, assuming that the air is dry. Increase the separation still further for conditions of high humidity.

All leads between the terminals, or crocodile clips, and the contact pins on the AT3600 fixture plate should be covered with insulation capable of withstanding the test voltages you are using in your programs. They should be kept as short as possible, and the leads from one power-sense pair should not touch any bare metal associated with another power-sense pair.

Terminals or interconnections, which have exposed (high voltage) metal in contact with the surface of the fixture board, should be avoided where possible, as there may be creepage along the surface. If such a terminal is necessary, you must ensure that there are no sharp points or corners on the metal pieces, that the surface between them is scrupulously clean, and that a separation of at least 3mm per kV is used.

4.2. KELVIN CONNECTIONS

Always use Kelvin connections (e.g. separate power and sense leads) between each socket pin and the corresponding power and sense Contact Pins on the Fixture Board.

In addition, when measuring very low transformer impedances; make sure that the Kelvin connections are continued through the terminal to the transformer leads.

4.3. MECHANICAL PROBLEMS

Always use terminals, sockets or probes that are mechanically robust. Poor mechanical connections can affect the measurements, and hence your throughput and quality of product.

In use, clean the fixtures and connectors regularly, to avoid any build-up of dirt and transformer varnish. Dirty fixtures give poor contacts and poor insulation resistance between contacts, and could reduce the quality of your product.

Use a separate fixture for each type of wound component, as this can improve the testing throughput.

Design the fixture so that the connections to the component under test can be made quickly and easily. One example is to use guides to ensure that the component cannot be put on to the fixture the wrong way round.

4.4. WIRE STRIPPING

It is most important that when removing insulation from single core wire that the conductor does not get marked or damaged when stripping as this will fracture in time when in use.

CHAPTER 6 – FRONT PANEL OPERATION

TABLE OF CONTENTS

This chapter will guide you through the operation of your tester via the integral keyboard and display.

1. INTRODUCTION

1.1. THE AT SERIES FRONT PANEL

RUN Indicator

PASS Indicator   Soft-keys
                                                                        Backspace key
FAIL Indicator   Liquid Crystal Display (LCD)
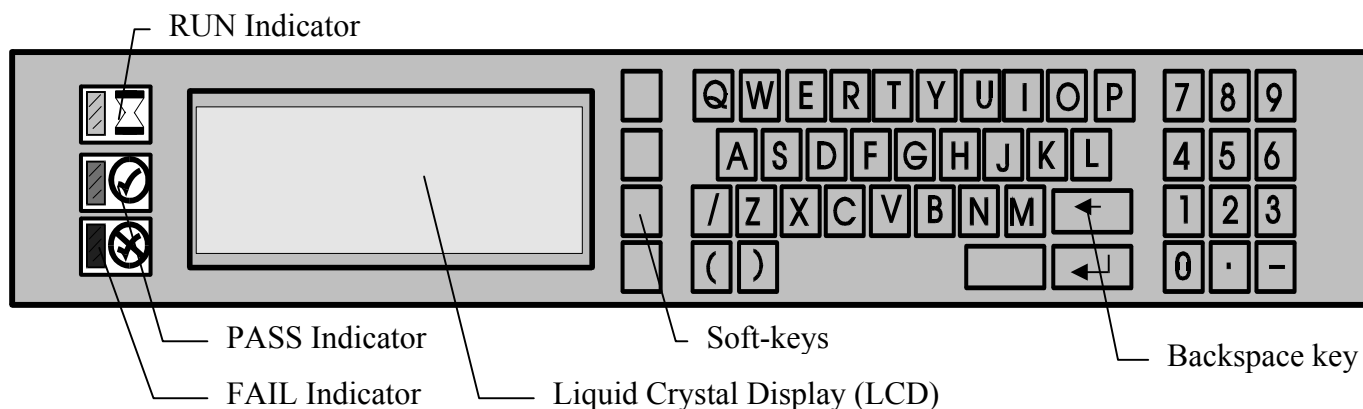
The front panel of the AT Series testers is designed with a membrane type keyboard and liquid crystal display. The main features are as follows:

Liquid Crystal Display	The Liquid Crystal Display (LCD) is a graphics panel that is normally organised as four lines of text. It is used both to display test results, and to provide prompts for data entry within the menu structure.
RUN Indicator	The RUN indicator is a yellow LED. This is illuminated when the tester is busy, for example when running a test program.
PASS Indicator	The PASS indicator is a green LED. This is illuminated after running a test program, when the result is 'Pass'.
FAIL Indicator	The FAIL indicator is a red LED. This is illuminated after running a test program, when the result is 'Fail'.
Alpha-numeric Keypad	The alpha-numeric keypad allows you to enter text data such as the part number (i.e. test program name) of the transformer to be tested.
Backspace Key	The 'Backspace' key allows you to correct typing errors during data entry
Soft-Keys	The four 'soft-keys' adjacent to the LCD are provided for functions which vary with different aspects of the tester's operation. The function for each soft-key at any given time is shown in the text boxes at the right hand side of the LCD.

Note: The only characters that the tester will accept either via the front panel or remotely are those shown on the keypad above. All alpha characters are upper case.

1.2. OTHER DATA INPUTS

To give you the greatest ergonomic flexibility, at certain points in the tester's menu system, as well as the keyboard, other methods of entering data are possible:

FOOTSWITCH

The 'Run' input of the 'Remote Port' on the tester's rear panel can be optionally connected to a footswitch.

At both the Top Level menu and in Execute Mode (see below), the footswitch may be used as an alternative to pressing the first (uppermost) soft-key.

BARCODE INPUT

A barcode reader connected to the 'Barcode Port' on the tester's rear panel can optionally be used to input text data, such the name of the test program, or the transformer batch or serial number.

1.3. POWER ON

When the AT3600 tester is switched on it performs a self-test which lasts for about 10 seconds.

After power on you should see the following display:

```
┌─────────────────────────────────────────────┐
│ ┌─────────────────────────────────────────┐ │
│ │ Power On Test              ┌──────────┐ │ │
│ │                            │ EXECUTE  │ │ │
│ │         PASS               ├──────────┤ │ │
│ │                            │ MEASURE  │ │ │
│ │                            ├──────────┤ │ │
│ │                            │ PROGRAM  │ │ │
│ │                            ├──────────┤ │ │
│ │                            │SELF-TEST │ │ │
│ │                            └──────────┘ │ │
│ └─────────────────────────────────────────┘ │
└─────────────────────────────────────────────┘
```
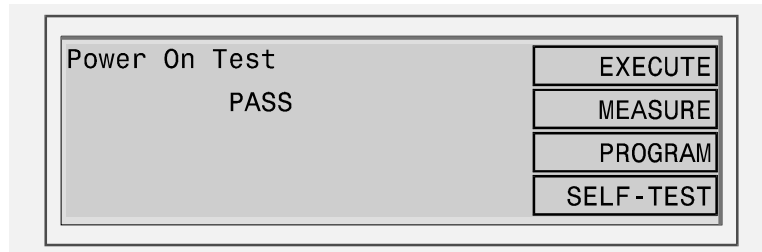
The tester is now at the Top Level menu, and the soft-keys allow you to select which of the four main functions you require:

EXECUTE   is used when running the programs in production test.

MEASURE   enables the tester to behave like a component analyzer, continuously updating front panel readings for one type of test only.

PROGRAM   is used to 'group download' programs from a server PC to the tester's permanent store, and to 'Set-Up' the options within the tester.

SELF-TEST   is used to perform a thorough self-test.

Each of these options are described in the following sections.

2. SELF-TEST

Self-test is a sequence of checks made by the tester to ensure the unit is functioning correctly.

You may run Self-test at any time by pressing the SELF-TEST soft-key in the Top Level menu.

```
Remove any test fixture          CONTINUE


then press the soft-key
CONTINUE                             ABORT
```
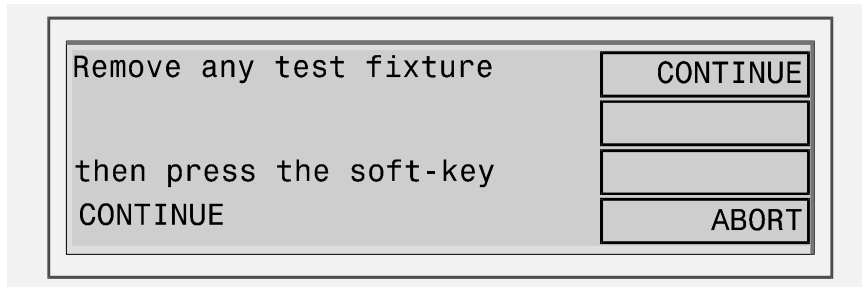
⚠ **Before commencing self-test, please ensure that there is nothing touching any of the test nodes on the top surface of the tester. In particular, remove all test fixtures and transformers.**

As the self-test is running, the front panel display will indicate progress using a horizontal bar:

```
Self Test




                                    STOP
```
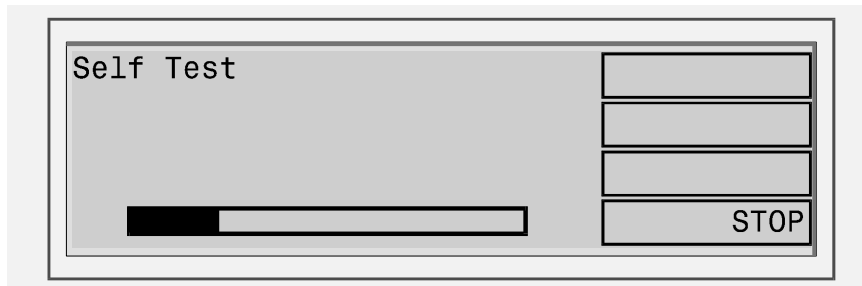
⚠ **CAUTION:- If the connections have been correctly made to the Safety Interlock, then a complete test will be executed, including high voltage testing up to 7000V. These voltages will be present on all the test nodes on the top surface of the tester.**

At the end of the self-test, you should see the following screen:

```
Self Test                              ┌──────────┐
                                       │ EXECUTE  │
         PASS                          ├──────────┤
                                       │ MEASURE  │
                                       ├──────────┤
                                       │ PROGRAM  │
                                       ├──────────┤
                                       │SELF-TEST │
                                       └──────────┘
```

To ensure operator safety, the high voltage sources are not checked until about 10 seconds after the start of self-test.

If the safety interlocks are not 'made' before the end of this period, high voltages will not be generated or checked, and at the end of the test, you will see the following message:

```
Low voltage self test                  ┌──────────┐
                                       │ EXECUTE  │
         PASS                          ├──────────┤
                                       │ MEASURE  │
                                       ├──────────┤
                                       │ PROGRAM  │
                                       ├──────────┤
                                       │SELF-TEST │
                                       └──────────┘
```
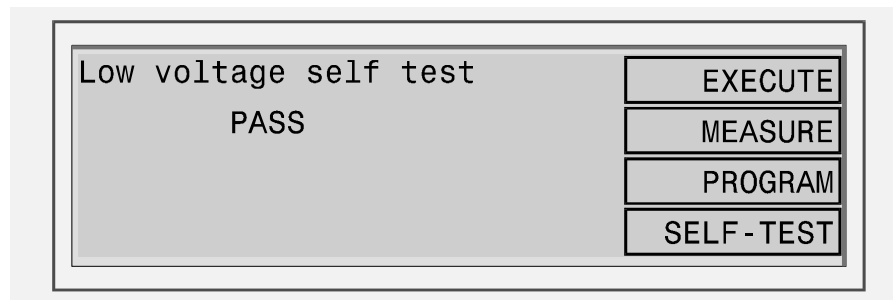
Without a safety interlock system the unit cannot perform any high voltage self tests, hence the high voltage sources are disabled.

If there is a failure at any point in the self-test, you will see a display similar to the following:

```
Self Test                              ┌──────────┐
                                       │ EXECUTE  │
          FAIL                         ├──────────┤
                                       │ MEASURE  │
[Failure message]                      ├──────────┤
                                       │ PROGRAM  │
                                       ├──────────┤
                                       │SELF-TEST │
                                       └──────────┘
```
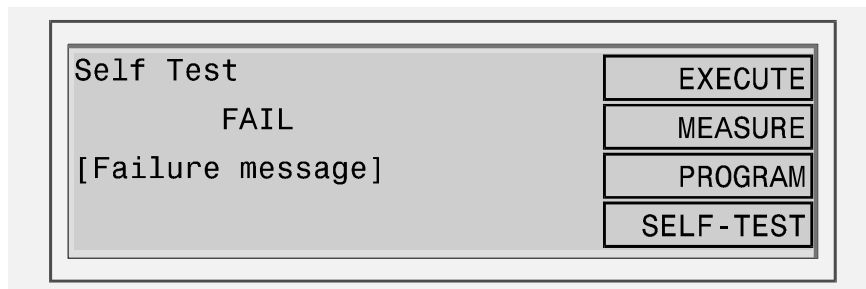
The message shown on the lower two display lines will depend on what caused the failure.

In the unlikely event that your tester continues to fail, please make a note of the failure message and contact your Voltech supplier for service.

3. EXECUTE MODE

This is the normal operating mode of the AT3600 when used for production testing of transformers.

Before you try to use the tester in EXECUTE MODE, make sure that all the following have been carried out:

- Test programs have been created for the transformers you wish to test.

- Either

  The programs are archived in the server, which is connected to the tester and running, and the tester has been set up to use the Server as the Program Store,

  or

  The programs have been downloaded into the tester, which has been set up to use its internal memory as the Program Store.

  For a reminder of how to set up the tester for operation with a LOCAL or PROGRAM store, see chapter 2, section 2.3.3 of the quick start tutorial.

- Fixtures have been created for the transformers you wish to test.

Note: If you have a foot switch fitted to the remote port on the tester, usually in EXECUTE Mode, pressing it will take the same action as pressing the upper soft key.

For text entry (such as the name of the program, or the serial number of the transformer under test), you may optionally use a bar-code reader connected to the tester's rear panel Bar-Code Port.

3.1. EXECUTE MODE WITH NO OPTIONS ENABLED

For simple test programs (where none of the following options are enabled: Batch Number, Operator Number or Serial Number), the following flow diagram summarises EXECUTE MODE operation:
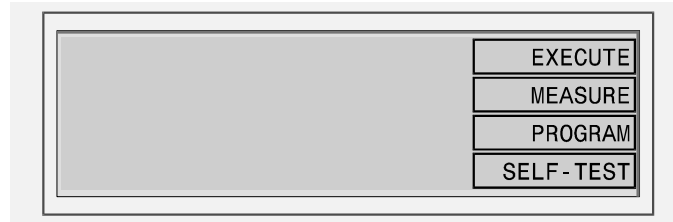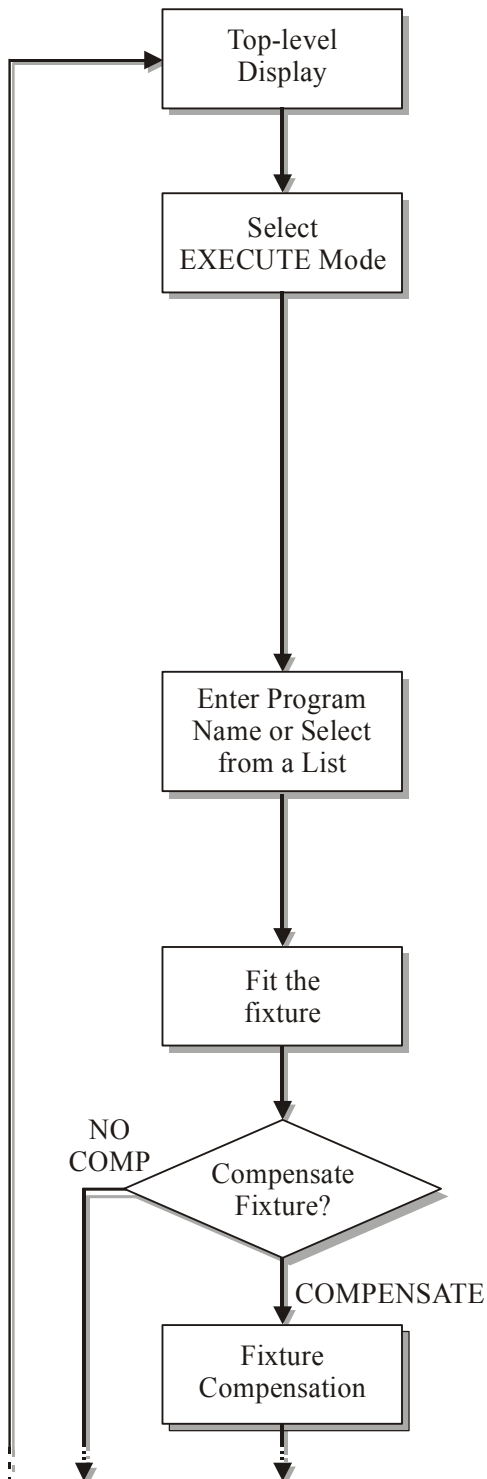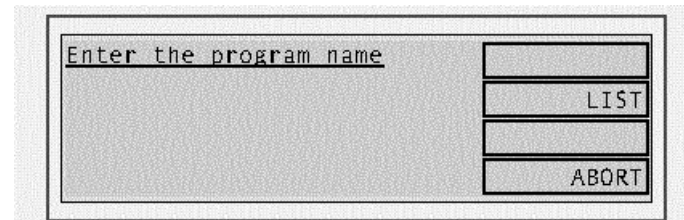
| EXECUTE |
| MEASURE |
| PROGRAM |
| SELF-TEST |

At the top-level display, press EXECUTE.

```
Enter the program name
                                    LIST

                                    ABORT
```

The program name can now be typed at the keyboard, entered by swiping a barcode or chosen from a list. Press the soft-key LIST to see a list of the programs available on the PC server or in the AT3600's own memory (see section 6.6.2)
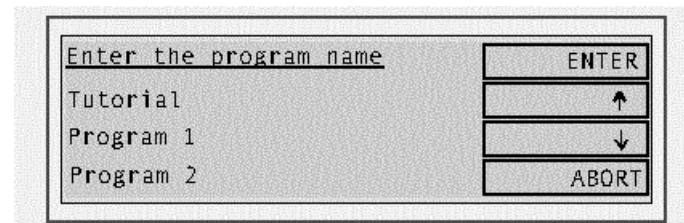
```
Enter the program name       ENTER
Tutorial                       ↑
Program 1                      ↓
Program 2                    ABORT
```

Use the ↑ and ↓ keys to select the program and press the enter key [↵] or the enter soft-key.

```
Fit the fixture           COMPENSATE
UNIVERSAL
with short circuit links
and press COMPENSATE       NO COMP
```
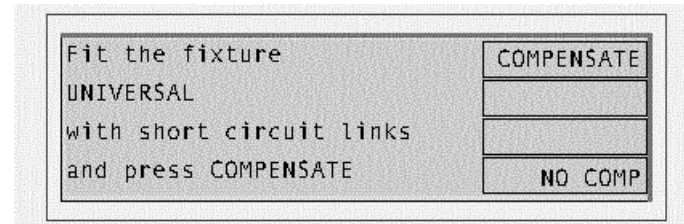
UNIVERSAL is the name given as the 'Fixture ID' in the Editor software 'Program options' dialogue (see Chapter 3).

Press COMPENSATE or NO COMP as required.

Note: For fixture compensation, connect a short circuit in place of each winding of the transformer under test.

Flow diagram (left column):

Top-level Display → Select EXECUTE Mode → Enter Program Name or Select from a List → Fit the fixture → Compensate Fixture? → (NO COMP / COMPENSATE) → Fixture Compensation
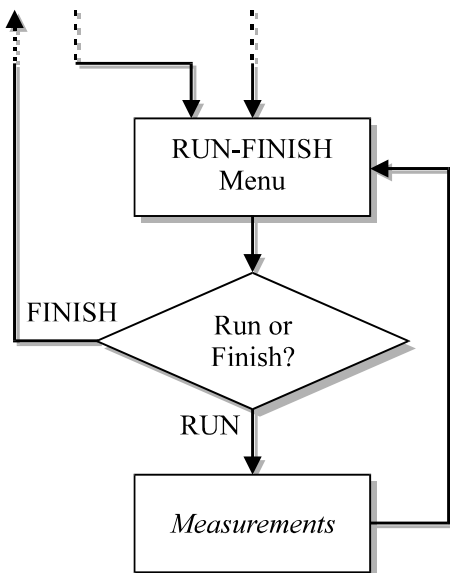
Fail Indication

If the FAIL indicator illuminates at this point this indicates a problem with the compensation procedure, check the fixture and short-circuit header connection, then re-try the fixture compensation.

Pass Indication

Illumination of the PASS indicator represents a successful compensation. Remove the short circuit links and continue.

```
Part number                                    RUN
TUTORIAL                                   SETTINGS

                                             FINISH
```
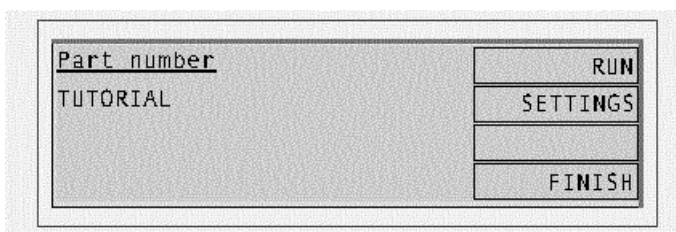
Place the component to be tested in the fixture and press the RUN soft-key, or the footswitch.

After the measurement, remove the component and place it in the 'Pass' or 'Fail' bin as appropriate.

Continue in this way until each component in the batch has been tested, then press FINISH.

NOTES:

1.   ERROR MESSAGES WHEN ENTERING THE PART NUMBER

a)   Server program store (see section 6.2 in this chapter)

```
ERROR REPORT



Server not responding

                                          CONTINUE
```
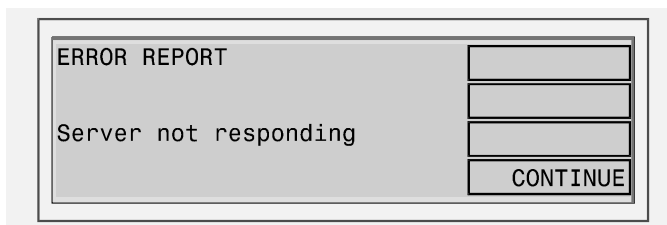
Possible causes:

Faulty Cable: The cable from the AT server port to the server PC has a broken wire, or is not plugged in correctly.

COM-Port: The COM Port has not been set up in the server application.

Server not running: Either the server PC is not powered on, or the server application is not running.

Or
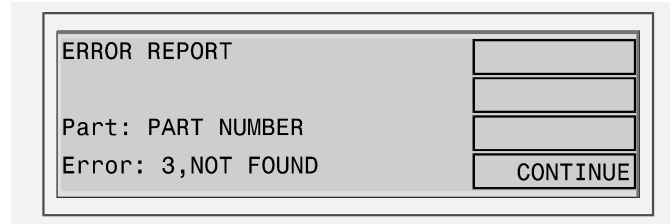
```
┌─────────────────────────────────────────┐
│  ┌────────────────────────┬──────────┐   │
│  │ ERROR REPORT           │          │   │
│  │                        ├──────────┤   │
│  │                        │          │   │
│  │ Part: PART NUMBER      ├──────────┤   │
│  │                        │          │   │
│  │ Error: 3,NOT FOUND     ├──────────┤   │
│  │                        │ CONTINUE │   │
│  └────────────────────────┴──────────┘   │
└─────────────────────────────────────────┘
```

Cause:

The directory set-up in the server application as the location of test programs does not contain a test program file with the requested part name.

b)   Local program store (see chapter 2, section 2.3.4)

```
┌─────────────────────────────────────────┐
│  ┌────────────────────────┬──────────┐   │
│  │ ERROR REPORT           │          │   │
│  │                        ├──────────┤   │
│  │                        │          │   │
│  │ Part not found         ├──────────┤   │
│  │                        │          │   │
│  │ in local group         ├──────────┤   │
│  │                        │ CONTINUE │   │
│  └────────────────────────┴──────────┘   │
└─────────────────────────────────────────┘
```
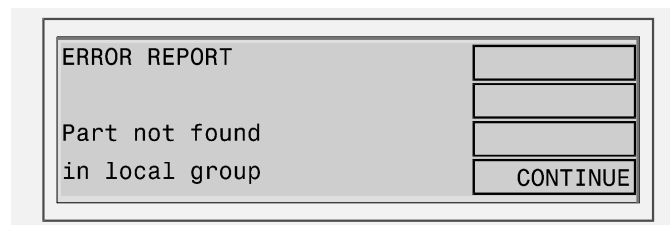
Cause:

The requested part number is not resident in the group of programs that have been downloaded into the AT.

At all the above displays, pressing the CONTINUE soft key will take you back to the top level display.

2.   INDICATIONS DISPLAYED WHILE TESTS ARE RUNNING

a)

```
┌──────────┐     ┌────────────────────────┬──────────┐
│      ⧗   │     │ Part number            │          │
│          │     │ TUTORIAL               ├──────────┤
│          │     │                        │          │
└──────────┘     │                        ├──────────┤
                 │ Executing test 1       ├──────────┤
                 │                        │   STOP   │
                 └────────────────────────┴──────────┘
```
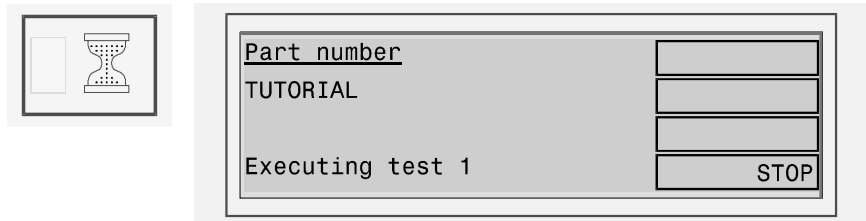
Where 1 represents the position of the test within the test program.

The operator may terminate the measurements at any time by pressing the STOP soft-key. Alternatively, you may use the STOP input signal on the tester's remote port, which may be connected, for example, to an emergency stop switch.

As the measurements proceed, the test number will be incremented, and for the Hi-Pot and Stress Watts tests, the measured test voltage will also be displayed on the lower line.

b)
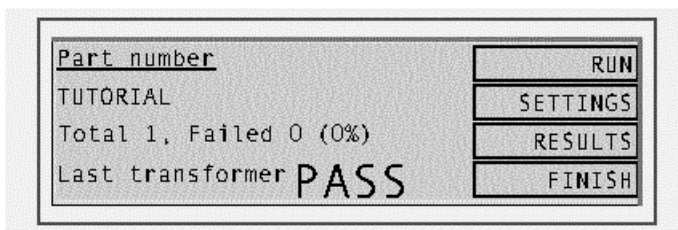
OR
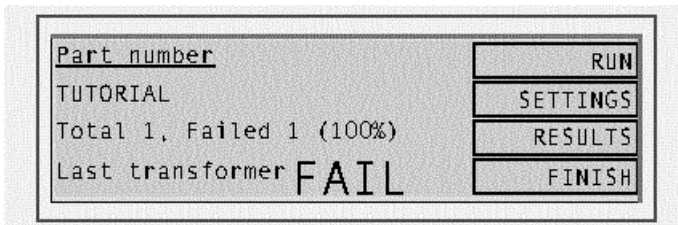
The RUN-FINISH displays seen after a previous component has been tested.

Both the front panel LED's (green = 'Pass' and red = 'Fail') and output lines of the remote port indicate the test result of the previous transformer, so that it may be placed in the appropriate 'Pass' or 'Fail' bin.

If enabled, the appropriate test result is now sent back to the Server, and all previous test results may be reviewed on the results listing screen, which is accessible directly on the front panel via the RESULTS soft-key (see below).

Results listing screen

c)
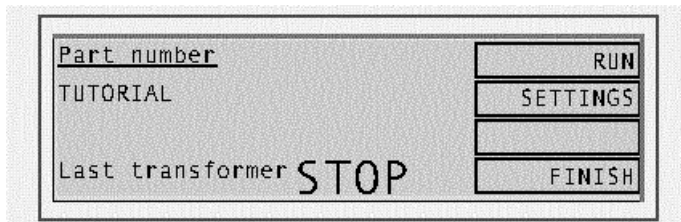
The RUN-FINISH display seen after measurement of the previous component was halted using the STOP soft-key, or the STOP input of the remote port.

At this display, all LED's will be off, and no results will be reported back to the server.

3.   RE-MEASURING THE FIXTURE COMPENSATION

```
Part number                              RUN
TUTORIAL                            SETTINGS
Total 1, Failed 1 (100%)            RESULTS
Last transformer FAIL                 FINISH
```
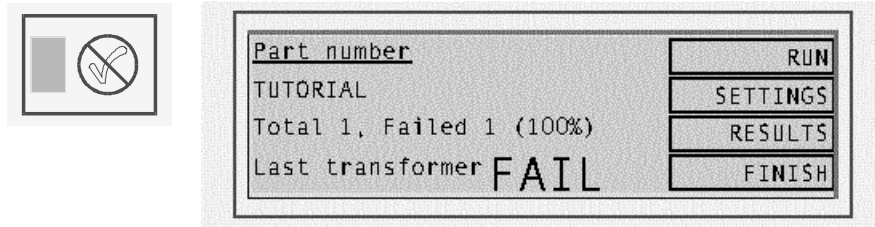
If you think that fixture compensation needs to be re-measured at any time, at the RUN-FINISH display, press the 'SEETINGS' soft-key to reveal:

```
Part number                        COMPENSATE
TUTORIAL
Total 1, Failed 1 (100%)
Last transformer FAIL                   Back
```
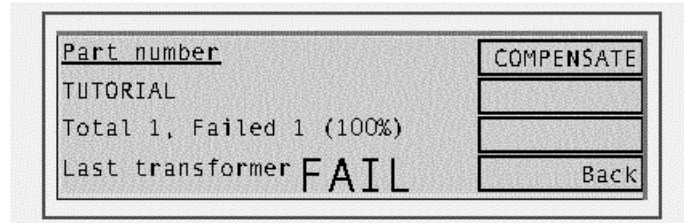
Press COMPENSATE to repeat the fixture compensation measurements, or 'Back' to return to the RUN-FINISH display without re-compensating.

3.2. EXECUTE MODE WITH OPTIONS ENABLED

As stated in Chapter 3 'The test program editor', programs may be created with the following three options enabled or disabled:

   Operator name

   Batch numbers

   Serial numbers

In each case, if the option is enabled, the data entered by the operator for that option is included with the results which are sent back to the server. This additional data is then available to be used as you wish; for example, it may be included your production reports.

Note that these options are part of the program, not global settings for the AT, allowing you to enable different options for each transformer as required.

When running programs where any of the above options are enabled, after the 'Fit the Fixture' display, there will be additional displays (depending on which options are enabled), before the RUN-FINISH display.

The following flow diagram summarizes the possibilities:

```
                              ┌──────────────────┐
                              │ Top-Level Display │
                              └──────────────────┘
                                       │
                              ┌──────────────────┐
                              │     Select       │
                              │  EXECUTE Mode    │
                              └──────────────────┘
                                       │
                              ┌──────────────────┐
                              │ Enter Part Number │
                              │ or Select from List │
                              └──────────────────┘
                                       │
                              ┌──────────────────┐
                              │     FIT and      │
                              │   COMPENSATE     │
                              │   the Fixture    │
                              └──────────────────┘
                                       │
                                       │        ┌──────────────────┐
                                       │        │     Enter        │
                                       │        │  Operator Name   │
                                       │        └──────────────────┘
                                       │
                                       │        ┌──────────────────┐
                                       │        │     Enter        │
                                       │        │  Batch Number    │
                                       │        └──────────────────┘
                                       │
                                       │        ┌──────────────────┐
                                       │        │     Enter        │
                                       │        │  Serial Number   │
                                       │        └──────────────────┘
                                       │
                              ┌──────────────────┐  ── New BATCH ──
                              │   RUN-FINISH     │  ── New Operator ──
                              │     Menu         │  ── Re COMPENSATE ──
                              └──────────────────┘
                                  │         ──── FINISH ────
                                 RUN
                              ┌──────────────────┐
                              │   Measurements   │
                              └──────────────────┘
                                       │
                              ┌──────────────────┐
                              │   Enter New      │
                              │  Serial Number   │
                              └──────────────────┘
```
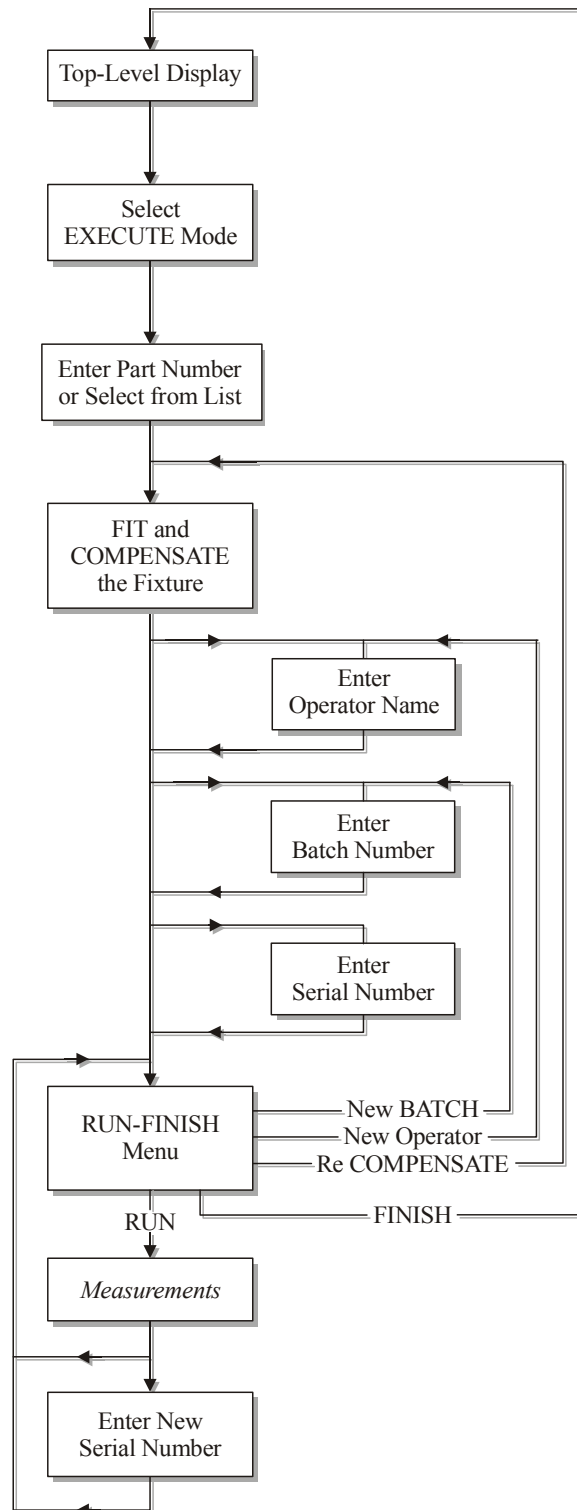
NOTES:

1.   ADDITIONAL DISPLAYS AFTER ENTERING THE PART NUMBER

```
Enter operator name                    ENTER
OPERATOR NAME_
                                         ←
                                       ABORT
```

```
Enter the batch number                 ENTER
BATCH NUMBER_
                                         ←
                                       ABORT
```

```
Enter the serial number                ENTER
SERIAL NUMBER_
                                         ←
                                       ABORT
```

As when entering the part number:

- Use either the keyboard or a barcode reader to type in the operator/batch/serial number, then press the ENTER key, the ENTER soft-key or a footswitch.

- Cursor soft-keys (← →) appear in context, and may be used with the backspace key (←) to correct mistakes.

2.   SERIAL NUMBER ENTRY AFTER THE FIRST TRANSFORMER

When the serial number option is enabled, after the measurements for each transformer have been completed, the following display will be seen (with the fourth line indicating 'Pass', 'Fail' or 'Stop' as appropriate):

```
┌─────────────────────────────────────────┐
│  Enter the new serial number    ┌────────┐│
│                                 │LAST + 1││
│                                 ├────────┤│
│                                 │        ││
│                                 ├────────┤│
│                                 │        ││
│  Last transformer PASS          ├────────┤│
│                                 │  ABORT ││
│                                 └────────┘│
└─────────────────────────────────────────┘
```
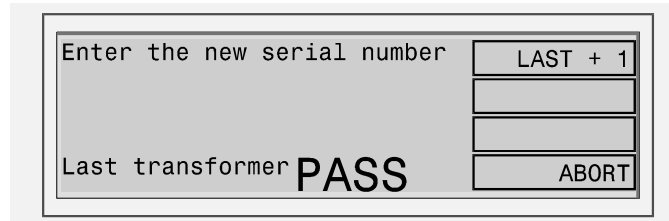
If the next serial to be used simply follows on in sequence after the previous one, then press the LAST + 1 soft-key (or the footswitch). This will enter the next serial number automatically and return the display to the RUN-FINISH selection.

Note: LAST+1 will be displayed only if the serial number is of the form:

xxxAnnnn

where 'xxx' is a field containing any characters, A is a non-numeric character, and 'nnnn' is a field of all numeric characters.

Both 'xxx' and 'nnnn' can be of any length, provided that the total serial number is not more than 20 characters.

When 'nnnn' is all 9's (for example 99), the next number will show 'nnnn' as all 0's (for example 00); the characters 'xxxA' will not be changed).

Alternatively, if the next serial number does not follow from the previous one in sequence, you may use the keyboard (or the barcode reader) to type in a new number. After typing, the display will be:

```
┌─────────────────────────────────────────┐
│  Enter the new serial number    ┌────────┐│
│  SERIAL NUMBER_                  │ ENTER  ││
│                                 ├────────┤│
│                                 │        ││
│                                 ├────────┤│
│                                 │   ←    ││
│                                 ├────────┤│
│                                 │  ABORT ││
│                                 └────────┘│
└─────────────────────────────────────────┘
```
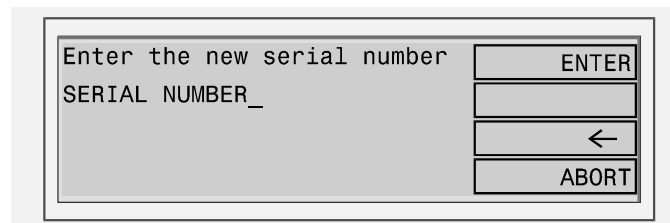
After typing the new number, press the ENTER key, the ENTER soft-key or the footswitch to return to the RUN finish display.

(Again cursor soft-keys (← →) appear in context, and may be used with the backspace key (←) to correct mistakes.)

Note that pressing the ABORT soft-key will also take you back to the RUN-FINISH display, but with no serial number having been entered. This would be the correct action if the next soft-key you wish to press is FINISH. (subsequently pressing RUN would merely return you to the 'Enter the serial number' display.)

3.   RE-INPUTTING THE OPTIONS

When options are enabled, the SETTINGS soft-key on the RUN-FINISH display enables you to change program options such as compensation, batch number or operator name without having to re-enter the test program name.

To change the batch number, for example, at the RUN-FINISH display, press SETTINGS, then NEW BATCH:
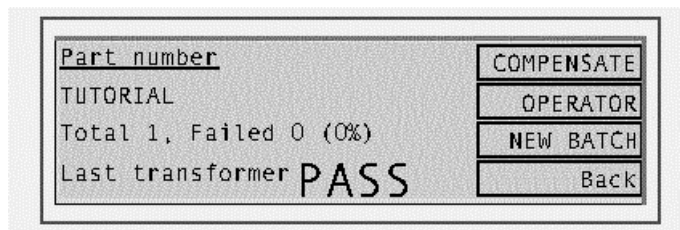
To change the operator name, press the OPERATOR soft-key.

3.3. STOP ON FAIL

'Stop on Fail' is another program option that is either enabled or disabled when the program is created (see Chapter 3 - 'The Test Program Editor').

When enabled, it will cause the measurements to be terminated after each test which has produced a 'Fail' result. A display similar to one of the following will then be seen:

```
PART NUMBER                    RE-RUN
FAIL at test n                CONTINUE

   ←      ▭

      68.4588 Ω               ABORT
```

```
1 ─  PART NUMBER                    RE-RUN
2 ─  FAIL at test n                CONTINUE
3 ─       ├─ ▭                            ─ 5
4 ─       3.9150 H               ABORT
```

1	Part name / number.
2	Failing test number.
3	Graphical qualification of the failure showing the value measured with respect to the range of legal values, where: Box – Represents the legal limits for the test Vertical bar – Represents the value measured. (Replaced by an arrowhead to represent higher or lower, when the measured value is significantly outside of the legal range – see notes below.)
4	Value measured, with appropriate units.
5	Available soft-key functions.

Note:

The third line showing the graphical comparison of the measured value and test limits has a logarithmic scale. The measured value may be represented by either a vertical bar (as shown) when it lies within the range that can be displayed on the LCD, or by an arrowhead (< or >) at the end of the horizontal bar when it lies outside the range that can be displayed on the LCD.

Pressing the ABORT soft-key stops the program and allows the operator to discard the failing component at the earliest opportunity to minimise test times. (The ABORT is also reported to the server when the program option 'Send retry results to server' is enabled and printed out, when a results printing option is set.)

After pressing the CONTINUE soft-key, the remaining tests in the program will be executed. 'Stop on Fail' will remain active, and any subsequent test that also fails will produce a similar display. At the end of the measurement, the component will be classed as a 'Fail'.

Pressing the RE-RUN soft-key will re-start the test sequence from the beginning.

Note: You would normally press RE-RUN if the failure was caused by the component being incorrectly inserted into the fixture. Unless the option 'Send retry results to server' is enabled, at this point there will be no data sent back to the server. Therefore, after you have corrected the mistake, following the re-run, good transformers will be reported as 'Pass'.

3.4. TRIM

If the TRIM test is included in a program, the behaviour in EXECUTE Mode is similar to the 'Stop on Fail' option described above:

If the test before the TRIM test produces a 'Pass' result, then the program proceeds directly to the next test after the TRIM test.

If the test before the TRIM test produces a 'Fail' result, then the front panel display will be similar to the following:

```
PART NUMBER                          RE-RUN

TRIM at test n                       CONTINUE

   ←———————[====]———————

              68.4508 mH             ABORT
```

```
PART NUMBER                          RE-RUN

TRIM at test n                       CONTINUE

   ——|————[====]————————

              3.5215 H               ABORT
```
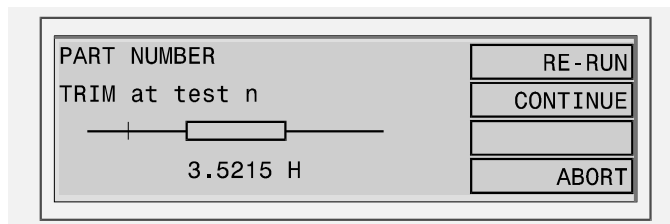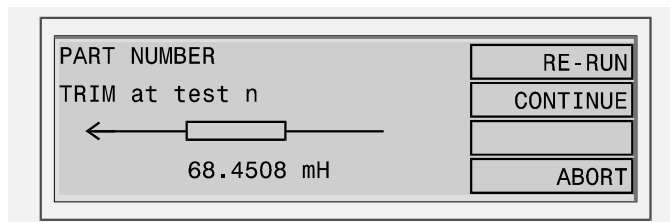
The main difference between this and the 'Stop on fail' display is that the reading on the fourth line will be continuously updated, allowing adjustments to be made to bring the test result within limits.

Pressing the ABORT soft-key again stops the program and allows the operator to throw away a transformer that cannot be adjusted to give a 'Pass' result.

After pressing the CONTINUE soft-key, the remaining tests in the program will be executed, and at the end of the measurement, the component will be classed as a 'Fail'.

Pressing the RE-RUN soft-key will re-start the test sequence from the beginning.

Note:	After making the necessary adjustments, you must press RE-RUN to enable the component to be recorded as a 'Pass'.

If further adjustment is necessary, you may re-run from the start as many times as you like. Unless the option 'Send Retry Results to Server' is enabled, there will be no data sent back to the Server until the measurements for all tests in the program have been completed.

As TRIM can only be applied to a test that uses a low voltage generator, the safety interlocks will not be in operation while adjustments are being made.

All transformers are capable of generating voltages much higher than the test voltage.

When making adjustments, take care not to touch any transformer terminals, the transformer body, or any exposed metal on the test fixture. Ideally, make sure that you use trimming tool with a well insulated handle.

When applying a test signal to a winding, always be mindful of the turns ratio of the transformer you are testing. Very high voltages can be generated on the other windings of the transformer, if these voltages exceed 7kV the tester may be permanently damaged.

4. FIXTURE COMPENSATION

AT3600 tester fixture compensation is equivalent to short-circuit and open-circuit correction on a component analyzer. It eliminates errors due to stray parasitic components on the fixture board itself. These are usually a combination of parallel capacitance between adjacent wires and sockets or pins, and series resistance and inductance along the lengths of wires.

Not all test programs require fixture compensation; and for some programs containing only high power tests, fixture compensation is not possible. As suggested in Chapter 3, it is best to try fixture compensation when performing trial runs on the program as it is being developed. If fixture compensation changes the test results, then it should be applied whenever the program is run in a production situation.

In production test, for optimum accuracy, fixture compensation measurements should be made :-

1. Whenever the test fixture is changed.

2. At the beginning of each day or work period.

3. Whenever a new test program is loaded into the AT for execution

After you have pressed the COMPENSATE soft-key on the front panel, the tester will automatically perform all the compensation measurements and retain the results in internal memory. The compensation factors will then be applied to each transformer as it is tested.

For compensation, first make up a transformer bobbin with shorting links in place of the windings:

To make a shorting bobbin, solder short pieces of wire across the relevant pins of an otherwise blank bobbin. Do not use a bobbin that contains any transformer windings to make up a compensation test part, since this would invalidate the open circuit measurements.

Ensure that DC Bias current is switched off before connecting and disconnecting component under test.
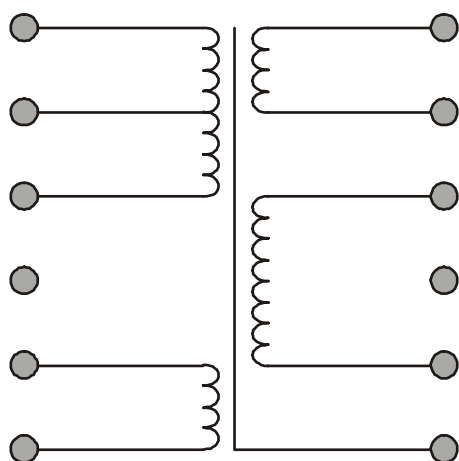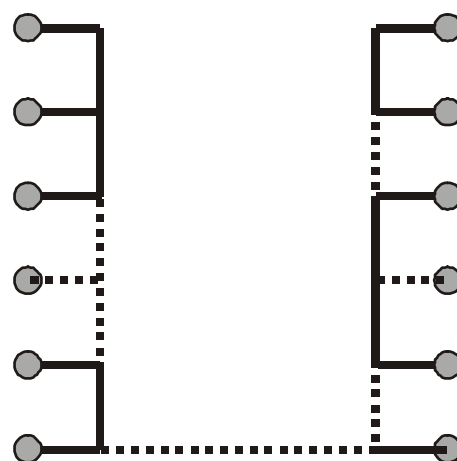
Transformer   *Shorting Bobbin for compensation*

OPERATOR INSTRUCTIONS

After you have entered the name of a program where compensation can be applied, at the next display:

```
Fit the fixture              COMPENSATE
UNIVERSAL
with short circuit links
and press COMPENSATE           NO COMP
```
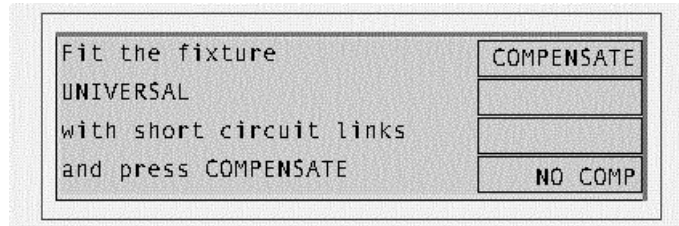
- Fit the shorting bobbin into the test fixture on the tester.

- Press the COMPENSATE soft-key.

The tester will perform the short and open circuit compensation.

As the compensation measurements are being made, the display will briefly show:

```
Compensating fixture
UNIVERSAL
```
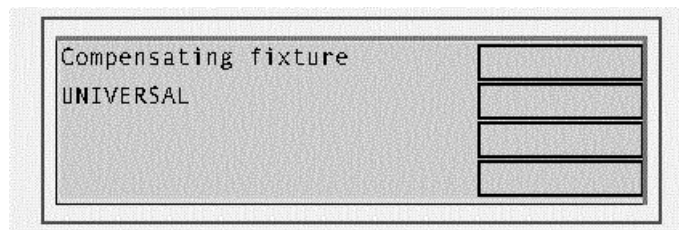
The tester will then show:

COMPENSATION PASS AND FAIL INDICATIONS

PASS   OR   FAIL
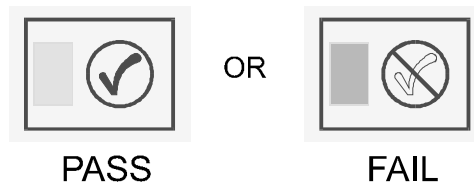
In the event of a failure check the following:

- The short circuit connections (if applicable)

- The fixture integrity.

And then retry the compensation.

If desired the test programs can be run without fixture compensation being performed, however this may affect the accuracy of the results, depending upon the type of transformer being tested and the fixture design.

5. MEASURE MODE

5.1. MEASURE MODE OPERATION

In MEASURE Mode, the AT3600 tester is set up to operate like a component bridge. It repeatedly makes measurements for one selected test, and continuously updates the front panel display with results.

To access MEASURE mode, press the MEASURE soft key at the top-level display:

```
┌──────────────────────────────────┐
│                       ┌─────────┐ │
│                       │ EXECUTE │ │
│                       ├─────────┤ │
│                       │ MEASURE │ │
│                       ├─────────┤ │
│                       │ PROGRAM │ │
│                       ├─────────┤ │
│                       │SELF-TEST│ │
│                       └─────────┘ │
└──────────────────────────────────┘
```
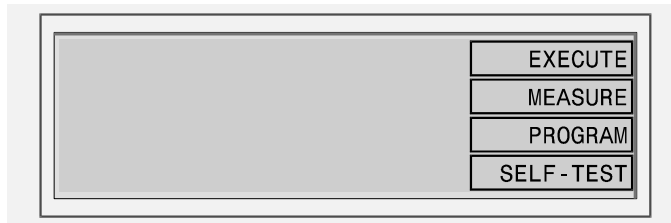
the following display lists the tests that are available for your tester in MEASURE mode.

```
┌──────────────────────────────────┐
│ Select measurement    ┌─────────┐ │
│                       │         │ │
│                       ├─────────┤ │
│                       │    ↓    │ │
│ R    Winding Resistance├────────┤ │
│                       │  ENTER  │ │
│ LS   Series Inductance├─────────┤ │
│                       │  ABORT  │ │
│                       └─────────┘ │
└──────────────────────────────────┘
```
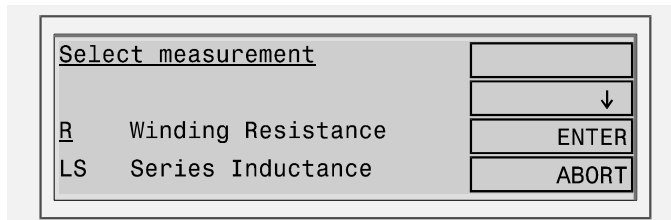
By using the soft-key cursors (↑ and ↓) or by typing the initial letter of a test, you may select the test you require. The cursors are displayed only when they are valid, hence the↑ cursor is not visible when the screen is displaying the top line of the list of tests.

The ABORT soft-key may be used to return the tester to the top level menu.

Having selected the test, for example 'C Capacitance',

```
┌──────────────────────────────────┐
│ Select measurement    ┌─────────┐ │
│ LL   Leakage Inductance│   ↑    │ │
│                       ├─────────┤ │
│ C    Capacitance      │   ↓    │ │
│                       ├─────────┤ │
│ TR   Turns Ratio      │  ENTER  │ │
│                       ├─────────┤ │
│                       │  ABORT  │ │
│                       └─────────┘ │
└──────────────────────────────────┘
```
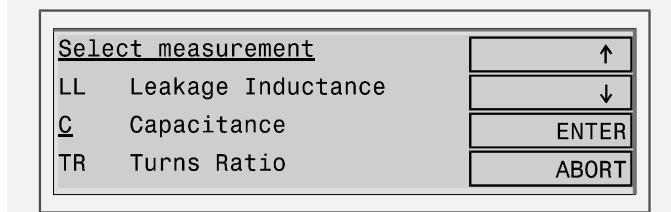
pressing ENTER takes you to the relevant set up display:

```
Set up C                                    ┌──────────┐
                                            ├──────────┤
                                            │        ↓ │
Test voltage (V): _                         │     AUTO │
Test frequency (Hz):                        │     EXIT │
                                            └──────────┘
```
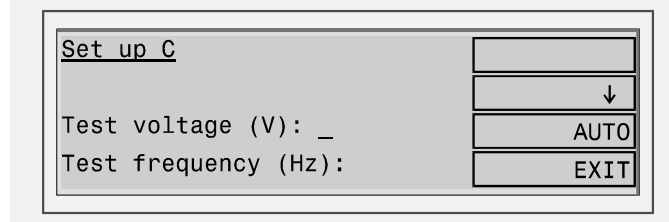
The details of the set up display will vary depending on which test you have selected. For the capacitance test, the list of parameters to enter is: Test voltage, Test frequency, Integration, Hi node(s), and Lo node(s). For Winding Resistance, the list is simply: Integration, Hi node, and Lo node.

Some tests, such as Winding Inductance and Capacitance, will require you to set up the measurement conditions - the test voltage and frequency. If these are known, you can enter the values you require.

Alternatively, the tester allows a choice of AUTO for the measurement conditions for some tests. Choose this if you are unsure of what voltage and / or frequency to program.

Note that there are sometimes restrictions on which combinations of parameters can be AUTO and SPECIFIED. In the 'C Capacitance' test, the valid combinations are as follows:

Voltage	Auto	Auto	Specified
Frequency	Auto	Specified	Specified

In the set up list, it is always the parameter on the third line that is active, for example 'Test voltage' in the display above.

Parameter data is either typed in via the keyboard (if the data to be entered is for example a number of volts), or selected by pressing the third soft-key. Examples of using the third soft-key are: selecting between AUTO and SPECIFIED for the 'Test voltage'; and selecting the 'Integration':

```
Set up C                                    ┌──────────┐
Test Frequency                              │        ↑ │
                                            │        ↓ │
Integration: MEDIUM _                       │     LONG │
Hi node:                                    │     EXIT │
                                            └──────────┘
```
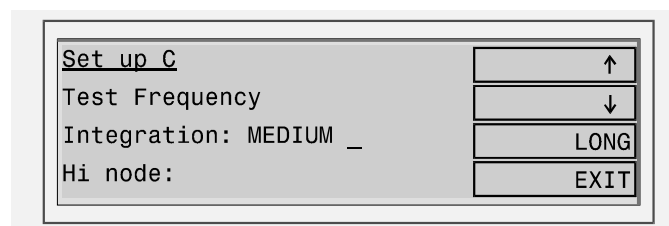
In this particular case, the Integration is set to MEDIUM, and the next available choice is LONG. Pressing the third soft-key repeatedly will cycle the parameter setting through all the available choices:

```
Set up C                              ↑
Test Frequency                        ↓
Integration: LONG_                 SHORT
Hi node:                            EXIT
```

```
Set up C                              ↑
Test Frequency                        ↓
Integration: SHORT_               MEDIUM
Hi node:                            EXIT
```
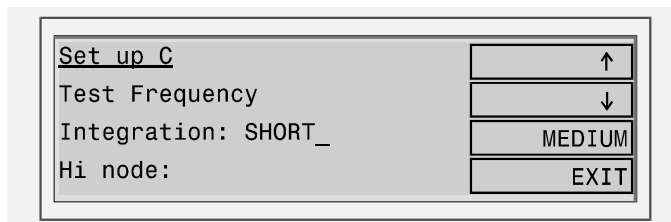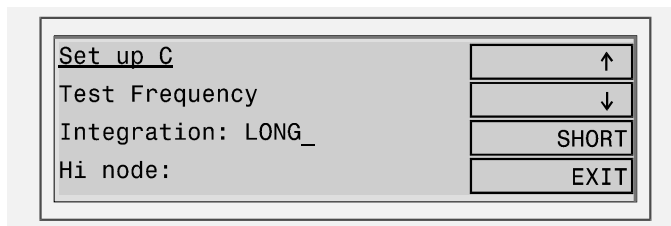
Because node numbers (1 to 20) are used in the MEASURE Mode, the test nodes are entered using the keyboard number pad. After each node number has been typed, proceed to the next by using the cursor (↑ or ↓) soft-keys, or by using the ENTER key (↵).

If you have have purchased an AT1600 without the optional nodes 11 to 20 fitted, the display will show node 10 if you try to enter 11 to 20.

For simple tests such as Winding Resistance, there is only one Hi (or Lo) node value to enter. However, for the 'C Capacitance' test, there may be several values for both Hi and Lo nodes.After you have entered the first Hi node, the display will show:

```
Set up C                              ↑
Hi node: 17                           ↓
Hi node: _
Lo node:                            EXIT
```
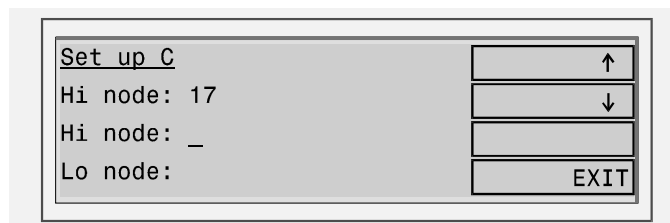
As you enter more numbers, these will be added to the list of Hi nodes. When you press the Enter key, or the ↓ soft-key with no new number (for example at the display above), then the group of Hi nodes will be terminated, and the display will move to the Lo nodes:

```
Set up C                              ↑
Hi node: 17                           ↓
Lo node: 18_
                                    EXIT
```
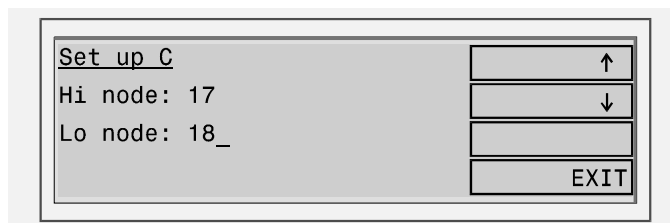
When you have entered values for each parameter in the set up list, press the EXIT soft-key.

The next display will depend on the particular test. For the 'C Capacitance' test, it is:

```
Measure C                          MEASURE
                                  COMPENSATE

(With compensate use

empty fixture)                       ABORT
```
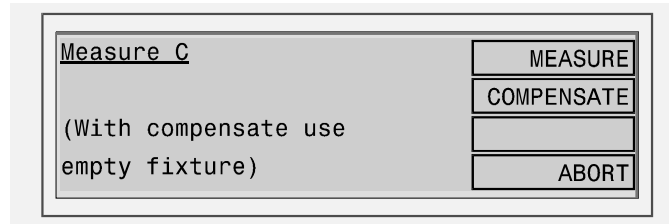
If you wish to apply Fixture Compensation to the measurements, ensure that the fixture is empty, and press the COMPENSATE soft-key. When the Compensation is finished, the display will return to one similar to the one above, but with the COMPENSATE soft-key and message omitted. (For some tests there is no COMPENSATE option, and for others compensation requires the fixture to be fitted with short-circuit links.)

Pressing the MEASURE soft-key will start the measurements.

```
Measuring C                     NEW MEASURE
Nodes: 17 , 18                  NEW SET UP
At 5V 100Hz

      35.337pF                     FINISH
```
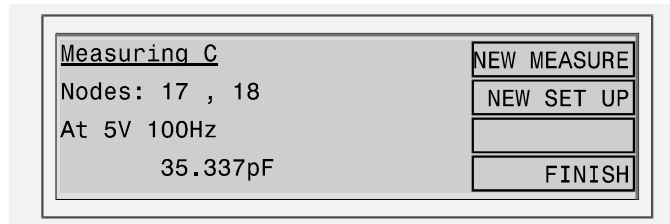
and the measurements will be continually updated until a key is pressed.

The results are shown with 5 significant figures, in normal engineering notation, with symbols for the units (Ω, F, H etc.), and with the normal multipliers covering 10^{-18} to 10^{+18} (a, f, p, n, μ, m, K, M, G, T, P and E).

Pressing NEW MEASURE takes the operator back to the 'Select measurement' display above. You should do this if you wish to measure a different parameter.

If you wish to simply change the test conditions for the existing measurement, then press the soft-key NEW SET UP to return to the set up list for the current test.

Pressing FINISH goes back to the top-level display.

Please study chapter 7. 'Tests and test conditions' for help with selecting MEASURE Mode test parameters.

5.2 FRONT-PANEL MEASURE MODE ERROR MESSAGES

The measurement conditions displayed on the front panel are the actual values of the voltage/current and frequency sensed at the AT3600's nodes. If voltage or current and frequency test conditions have been specified it may not be possible for the AT to maintain these conditions. For example, if the AC impedance of the winding under test is only 0.1Ω at the specified frequency and you have specified a 5V test signal, then the AT would have to supply 5V / 0.1Ω = 50 Amps!

You will then see a warning similar to this:

```
 ┌───────────────────────────────────────────────────┐
 │  Measuring LS                        ┌───────────┐ │
 │                                      │NEW MEASURE│ │
 │  Warning : Signal not trimmed        ├───────────┤ │
 │                                      │NEW SET UP │ │
 │  At : 3.1462V, 100Hz                 ├───────────┤ │
 │                                      │   AUTO V  │ │
 │            36.193nF                  ├───────────┤ │
 │                                      │    FINISH │ │
 │                                      └───────────┘ │
 └───────────────────────────────────────────────────┘
```
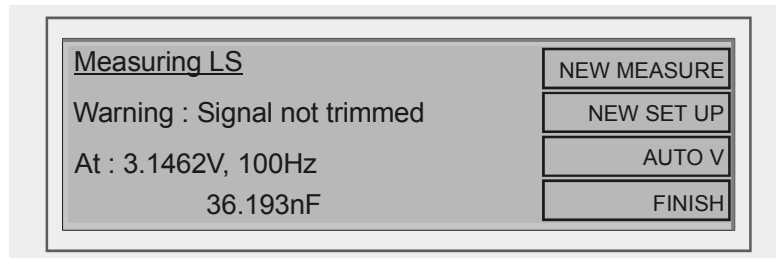
The AT will continue to measure accurately, but you can also allow the tester to automatically choose a test voltage or current based on the programmed frequency by selecting AUTO V.

For the leakage inductance test only, AUTO A may be displayed.

Some tests energize more than one winding (e.g. TRL), and in this case, the display will show voltage from the first energized node unless the error is only on the second, when that voltage will be displayed.

For over-range errors you may also see an error message similar to this:

```
 ┌───────────────────────────────────────────────────┐
 │  Measuring C                         ┌───────────┐ │
 │                                      │NEW MEASURE│ │
 │  Nodes : 1  2                        ├───────────┤ │
 │                                      │NEW SET UP │ │
 │  Overload : adjust V, I  or  f       ├───────────┤ │
 │                                      │           │ │
 │            0.0000pF                  ├───────────┤ │
 │                                      │    FINISH │ │
 │                                      └───────────┘ │
 └───────────────────────────────────────────────────┘
```
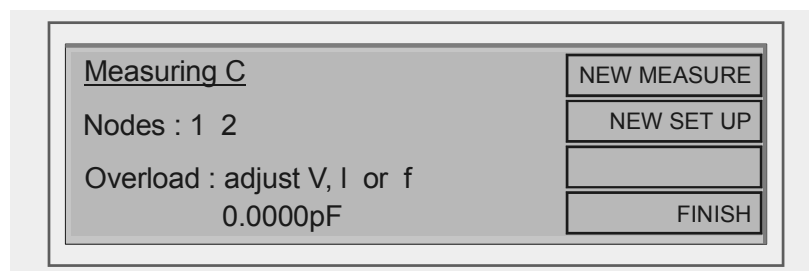
In this case, choose AUTO conditions where possible in a NEW SET UP and consult Chapter 7, Tests and Test Conditions. For low voltage / low power tests only, the tester will continue to try making measurements.

For low power tests that include dc bias you may see the following message:


```
Measuring LSB                    NEW MEASURE

Nodes : 1  2                     NEW SET UP

Overload : reduce bias
          0.0000pF                   FINISH
```
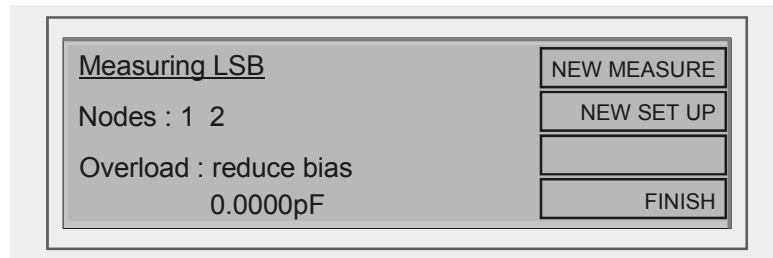
In which case, you should reduce the dc bias level until this message no longer appears.

6. PROGRAM MODE

PROGRAM mode has two main functions:

- To change the tester's set up options (including setting up for server operation).

- To download a group of programs from the server PC to the tester's internal memory.

```
┌──────────────────────────────────┐
│ ┌──────────────────────────────┐ │
│ │                  ┌──────────┐ │ │
│ │                  │ EXECUTE  │ │ │
│ │                  ├──────────┤ │ │
│ │                  │ MEASURE  │ │ │
│ │                  ├──────────┤ │ │
│ │                  │ PROGRAM  │ │ │
│ │                  ├──────────┤ │ │
│ │                  │ SELF-TEST│ │ │
│ │                  └──────────┘ │ │
│ └──────────────────────────────┘ │
└──────────────────────────────────┘
```
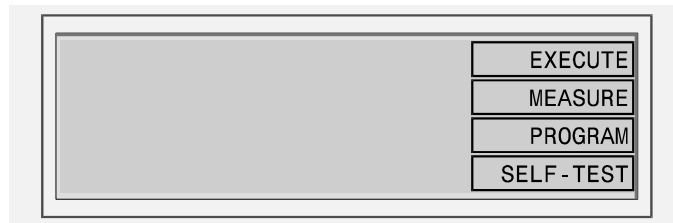
To access PROGRAM Mode, from the top level menu, press the soft-key PROGRAM to change to the following display:

```
┌──────────────────────────────────┐
│ ┌──────────────────────────────┐ │
│ │ Program Mode     ┌──────────┐ │ │
│ │                  │  GROUPS  │ │ │
│ │                  ├──────────┤ │ │
│ │                  │  SET-UP  │ │ │
│ │                  ├──────────┤ │ │
│ │                  │          │ │ │
│ │                  ├──────────┤ │ │
│ │                  │   EXIT   │ │ │
│ │                  └──────────┘ │ │
│ └──────────────────────────────┘ │
└──────────────────────────────────┘
```
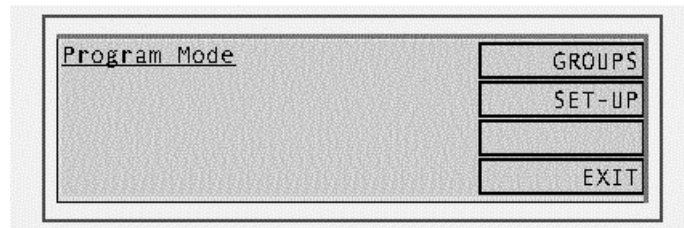
The two main functions of PROGRAM mode each have their own soft-keys at this display. Press the GROUPS soft-key to download a group of test programs from the server to the tester's internal memory or press the SET-UP soft-key to change any of the set-up options.

Pressing EXIT at this point will return the tester to the top level display.

6.1 SET UP

Pressing the soft-key SET-UP at the 'Program Mode' display above will reveal:

```
Set-Up                              │              │
                                    │          ↓   │
Fail Beeper: SHORT                  │ CONTINUOUS   │
Pass Beeper: OFF                    │        EXIT  │
```
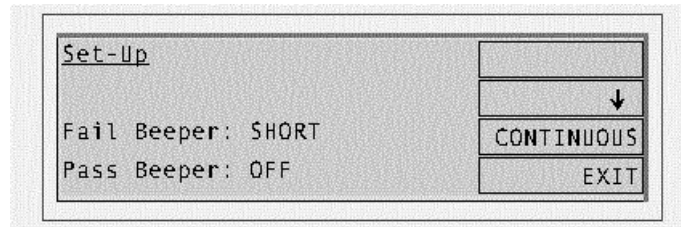
This display is the start of a list of options under the title 'Set-Up'.

To modify an option:

- Press the cursor soft-keys (↑ and ↓ which appear in context) to scroll up and down the list, so that the option you wish to modify is positioned on the third line ('Fail Beeper' in the above example).

- For most options, press the third soft-key to cycle round the available settings for that option. In the example of 'Fail Beeper', this will be:

```
Set-Up                              │              │
                                    │          ↓   │
Fail Beeper: CONTINUOUS             │        OFF   │
Pass Beeper: OFF                    │        EXIT  │
```
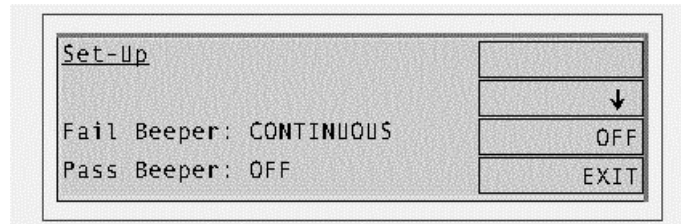
The full list of options is shown below:

Fail Beeper	SHORT	CONTINUOUS	OFF
Pass Beeper	SHORT	OFF	
Key Response	CLICK	BEEP	
Beeper Volume	CHANGE		
Display Contrast	CHANGE		
Clock: yyyy mmm dd hh:mm	+		
Program Store	SERVER	INTERNAL	

Three of the options require more than just pressing the third soft-key.

For 'Beeper Volume', pressing the soft-key CHANGE brings up an additional display:

```
Beeper Volume                                    ↑

                                                 ↓
Press ↑ and ↓ to adjust
then EXIT                                      EXIT
```
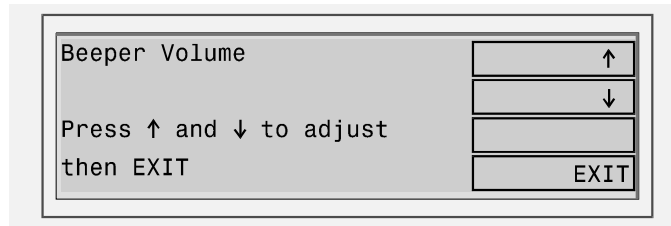
- Press the ↑ and ↓ soft-keys until the beeper makes the level of sound you require, then press the EXIT soft-key to return to the Set-Up list.

For 'Display Contrast', the additional display is very similar, again with ↑ and ↓ soft-keys, which this time adjust the display contrast.

For the 'Clock' option, there are five fields to set up:

- Initially the cursor will be in the first field - 'yyyy' - which is the year. Type the number you require using the keyboard, and press either the ENTER key (↵), or the → soft-key to move to the next field.

- For the second field - 'mmm' - which is the month, the soft-keys change to give the names of each month. Press the appropriate soft-key to select which month.

- The remaining fields - 'dd', 'hh' and 'mm' (day, hour and minute) are changed in the same way as the year, using the number pad.

To reset the set-up options to the factory defaults:

Press the decimal point (".") on the instrument keypad during boot-up at the general information screen. This will reset all tester options to the factory defaults, including screen contrast and beep volume, excluding the real-time clock.

The factory default settings are:

Option	Default Setting
FAIL Beeper	OFF
PASS Beeper	OFF
Key Response	CLICK
Beeper Volume	6
Display Contrast	8
Program Store	INTERNAL

6.2. PROGRAMS
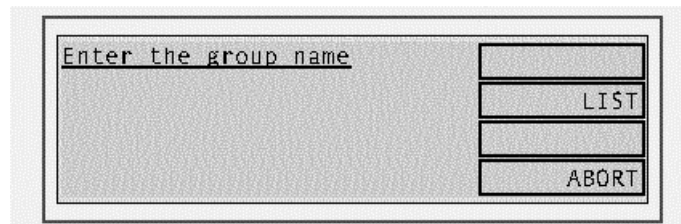
When the tester is set up to use the LOCAL program store, and after you have entered the part name, it will search for that name in the programs that are stored in its own non-volatile RAM. To store these programs you must use either the 'group download' or 'tester download' features described here.

GROUP DOWNLOAD USING THE SERVER

Before attempting to download a group of programs:
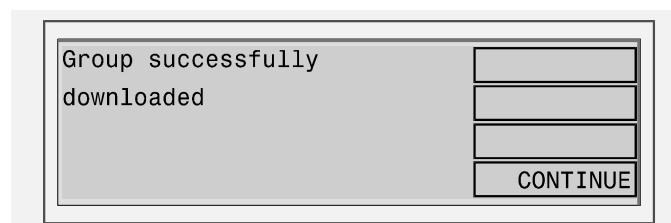
- Ensure that the server software is running on its PC, that the lead is connected from the tester's server port to the server PC, and that COM port is correctly set up in the server.

- Also ensure that the group you wish to use has been created within the server. (From the server top level menu, select 'Setup', 'Groups' etc - as explained in chapter 4).

To download a group of programs, at the tester's top-level display, press the PROGRAM soft-key; and then at the 'Program Mode' display, press the soft-key GROUPS. The next display will then prompt you for the name of the program group you wish to use:

```
┌─────────────────────────────────────┐
│  ┌─────────────────────────────┐     │
│  │ Enter the group name    ┌───────┐ │
│  │                         └───────┘ │
│  │                         ┌───────┐ │
│  │                         │  LIST │ │
│  │                         └───────┘ │
│  │                         ┌───────┐ │
│  │                         └───────┘ │
│  │                         ┌───────┐ │
│  │                         │ ABORT │ │
│  └─────────────────────────└───────┘ │
└─────────────────────────────────────┘
```

As with other names, the group name can be typed in from the keyboard, entered using a bar-code reader connected to the tester's bar-code port or chosen from a list of available groups.

After choosing the group to be downloaded, pressing the ENTER soft-key (or ↵ key) will commence the download and, after a few seconds you will see the following display:

```
┌─────────────────────────────────────┐
│  ┌─────────────────────────────┐     │
│  │ Group successfully      ┌───────┐ │
│  │ downloaded              └───────┘ │
│  │                         ┌───────┐ │
│  │                         └───────┘ │
│  │                         ┌───────┐ │
│  │                         └───────┘ │
│  │                         ┌──────────┐│
│  │                         │ CONTINUE ││
│  └─────────────────────────└──────────┘│
└─────────────────────────────────────┘
```

Press 'CONTINUE' to return to the top level display. Your program group has now been loaded into the tester's internal store and the server PC may be disconnected. These programs will be stored during power off, and will only be overwritten by another group download.

ERROR MESSAGES

The following is a list of possible error messages, which may occur if there is a fault in the group download process, together with suggestions for the possible cause.

a)

```
ERROR REPORT                          ┌──────────┐
                                      ├──────────┤
                                      ├──────────┤
Server not responding                 ├──────────┤
                                      │ CONTINUE │
                                      └──────────┘
```
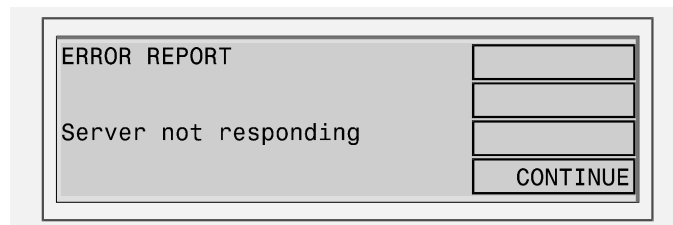
Possible causes:

Faulty cable: The cable from the tester's server port to the server PC has a broken wire, or is not plugged in correctly.

COM port: The COM port has not been set up in the server application.

Server not running: Either the server PC is not powered on, or the server application is not running.

b)
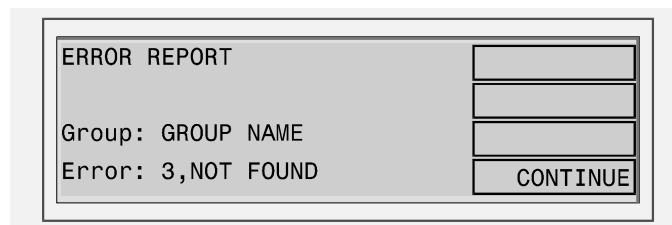
```
ERROR REPORT                          ┌──────────┐
                                      ├──────────┤
                                      ├──────────┤
Group: GROUP NAME                     ├──────────┤
Error: 3,NOT FOUND                    │ CONTINUE │
                                      └──────────┘
```

Cause:

The directory set up in the server application as the location of test programs does not contain a group with the requested name.

At all the above displays, pressing the CONTINUE soft key will take you back to the top level display.

TESTER DOWNLOAD USING THE EDITOR

A single program may be stored in the AT3600 using the PC editor.

Once a program has been entered using the editor and downloaded to the tester, the tester will display:

```
SAVE PROGRAM                         CONTINUE
Saving this program to the
local store will overwrite
an existing program group.          LOCAL SAVE
```
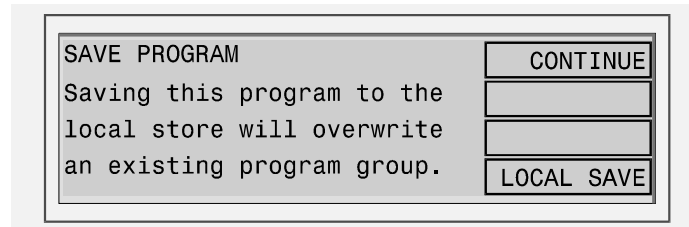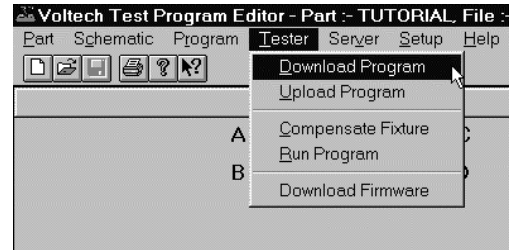
Press LOCAL SAVE and the program that has been downloaded from the PC editor will be saved in the tester's local program store. Note that any programs previously stored in the tester will be lost.

All PC connections to the tester may be now be removed.

1. TRANSFORMER TESTS

1.1. APPLICATION OF TESTS

The following table summarizes the tests available for the AT3600 and indicates where they might be used:

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			Right grade of core material Core correctly assembled Check for shorted turns
RLS	Equivalent Series Resistance			
RLP	Equivalent Parallel Resistance			
D	Dissipation Factor			
LL	Leakage Inductance	SMPS transformers Communication transformers Others as applicable	Selected windings	Check windings have been installed in the correct position relative to the core
LLO				
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)			

* These tests require the use of one or more Voltech **DC1000** Precision DC Bias Current Sources. Contact your Voltech sales office for details.

SELF RESONANT FREQUENCY

Practical inductive components are not perfect inductors; they have stray resistances and capacitances associated with them. For certain components, especially those with a low inductance value, the impedance of the stray capacitance can become significant when compared to that of the inductance.

$$X_L = 2\pi f_L \quad X_C = \frac{1}{2}\pi f_C$$

At a sufficiently high frequency, the capacitive impedance can dominate, making a measurement of the inductance impossible. Under these circumstances, any measurement instrument may report negative inductance values and measurement errors. Should these symptoms be observed, reduce the test frequency to avoid problems.

The frequency at which the inductive impedance equals the capacitive impedance ($X_L = X_C$) is known as the self resonant frequency (SRF) of the component. At this point, the phase angle of the impedance (which can be measured using the ANGL test) is zero. At test conditions where the frequency is low enough for problems with capacitive impedance to be negligible, the phase angle will be positive and close to 90 degrees. Therefore an ANGL test can be used during program development to confirm if measurement problems are due to the chosen test frequency approaching the SRF of the part under test. If the angle is significantly less than 90 degrees, consider reducing the test frequency.

Note that stray fixture capacitance will add to the capacitance of the component and reduce the SRF. Performing compensation will remove the effect of stray fixture capacitance on the measurement of capacitance, but cannot remove its effect on SRF.

1.2. CTY - CONTINUITY

WHERE USED

The continuity test is available to be placed as the first test in the program to check that the transformer has been inserted correctly into the test fixture. The test checks that every winding has a resistance less than a user specified limit, with the same limit being applied to all windings.

The CTY test is an alternative to using an R (Winding Resistance) test on each winding separately. The CTY test has the advantage of speed of execution; but with the R test, individual limits can be applied to each winding, and manufacturing faults such as the use of the wrong wire gauge can be identified.

If you choose to use it, the continuity test will be quicker to execute than a series of resistance tests applied to each winding.

SPECIFYING THE TEST LIMIT

When specifying the test limit, remember that the same limit is applied to each winding, so you must choose a value higher than the resistance of the biggest winding. For most transformers, where the winding resistances are less than 1kΩ, a test limit of 10kΩ should be used, as this will give the quickest test execution.

1.3. R - WINDING RESISTANCE

WHERE USED

The measurement of the resistance of all windings should generally be the first group of tests carried out for any type of transformer. It checks that the wire is of the correct diameter, and has not been over-tensioned during winding.

The measurement also confirms that the connections between the test fixture and the transformer have been made properly. This is particularly important when Kelvin connections are required, perhaps for a test to follow, as a resistance measurement will confirm that both the power lead and sense lead are making good electrical contact.

To check that the resistance of a winding is correct, the tester applies a constant current (dc) to the selected winding. Both the current through and the voltage across the winding are measured; dividing the voltage by the current gives the value of the resistance.
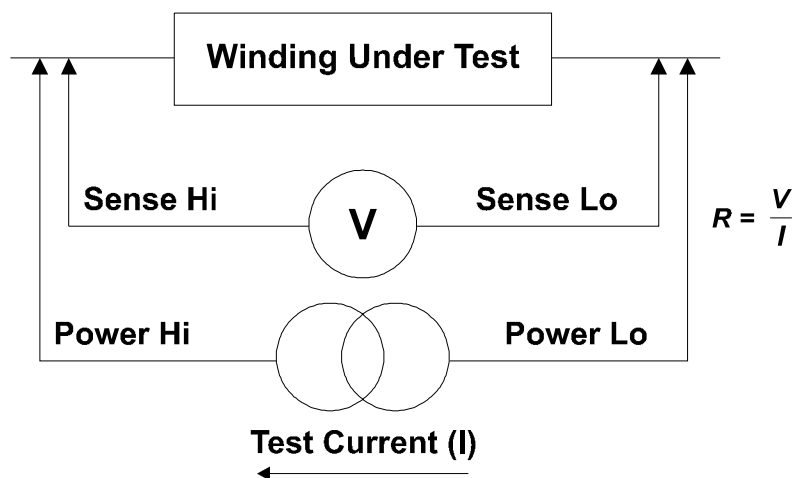
SPECIFYING THE TEST LIMITS

Maximum Value -   Specify limit as tightly as possible to ensure that correct wire has been used.

Minimum Value   Not usually so critical - can be set to any value that ensures that there is no solder splash causing a short circuit between pins.

TEST CURRENT

The test current is set according to the value specified as maximum in the test limits:-

Maximum Resistance	<0.1Ω	<1Ω	<10Ω	<100Ω	<1kΩ	<10kΩ
Test current	400mA	200mA	100mA	30mA	3mA	300μA

NOTE: Above 10kΩ, a constant voltage source of 8.0V is used.

1.4. RLS OR RLP - EQUIVALENT SERIES OR PARALLEL RESISTANCE

WHERE USED

The equivalent series or parallel resistance measurements are alternatives to a Q factor measurement to follow the inductance test in the program.

As with the Q factor measurement, an equivalent series or parallel resistance test would normally be used for signal, pulse and switched mode power transformers, where the normal operating conditions require only small excursions of the B-H curve, never extending beyond the linear regions.

An equivalent resistance test is also one way of highlighting shorted turns within the transformer.

MEASUREMENT CONDITIONS

As with measuring inductance and Q factor, to measure an equivalent series or parallel resistance, the tester applies an ac voltage across the selected winding. It then measures the voltage across and current through the winding using harmonic analysis. The measured voltage is divided by the current to obtain a complex impedance and the equivalent series or parallel resistance calculated.

If, in the program, the RLS or RLP test follows either an LS or LP test which has the same test conditions (voltage and frequency), and is applied to the same winding, then the measurement results from the previous inductance test can be re-used, saving program execution time.

The test signal can have a frequency in the range 20Hz to 1MHz, and an amplitude from 1mV to 5V.

Normally when following an inductance test, you would choose the same test conditions for the RLS or RLP test. If the RLS or RLP test does not have an associated inductance test, then choose the test conditions as detailed in the Table on page 7.1.8, base on the value of the inductance of the winding under test.

1.5. LS OR LP - INDUCTANCE
(SERIES OR PARALLEL CIRCUIT)

WHERE USED

The AT3600 offers two basic alternative ways to confirm that the transformer has been assembled properly, with the appropriate number of primary and secondary turns, the right grade of magnetic material for the core, and the correct air gap if required.

When testing signal, pulse and switched mode power transformers, where the normal operating conditions require only small excursions of the B-H curve, never extending beyond the linear regions, a measurement of primary inductance, together with a turns ratio test is used.

(For line frequency transformers, designed to operate over the full extent of the B-H curve, including the non-linear regions, the preferred method is to use a magnetising current test applied to a primary winding, followed by an open-circuit voltage test for every other winding.)

MEASUREMENT CONDITIONS

To measure inductance, the tester applies an ac voltage across the selected winding; it then measures the voltage across and the current through the winding using harmonic analysis. The measured voltage is divided by the current to obtain a complex impedance and the inductance is calculated.

The test signal can have a frequency in the range 20Hz to 1MHz, and an amplitude from 1mV to 5V.

Generally, it is not necessary to measure the inductance at the normal operating conditions of the transformer, which could involve, for example, voltage levels of hundreds of volts. This is because the B-H curve can normally be assumed to be linear in the operating region, and the inductance measured at a low level represents the inductance that will appear in use.

Also, it can usually be assumed that the inductance value does not vary significantly with frequency. Therefore, although high frequencies are available with the tester, measurement frequencies above a few hundred kilohertz should be used with caution. This is because the errors caused by the stray inductance and capacitance of your fixture may become much more significant at these frequencies. Compensation can be used to eliminate these errors.

The following table suggests suitable test conditions for different values of expected primary inductance:

Inductance range			Preferred test signal	
			Frequency	Voltage
100nH	$\rightarrow$	1uH	300KHz	10mV
1uH	$\rightarrow$	10uH	100KHz	30mV
10uH	$\rightarrow$	100uH	30KHz	50mV
100uH	$\rightarrow$	1mH	10KHz	100mV
1mH	$\rightarrow$	10mH	1KHz	100mV
10mH	$\rightarrow$	100mH	100Hz	100mV
100mH	$\rightarrow$	1H	100Hz	300mV
1H	$\rightarrow$	10H	50Hz	1V
10H	$\rightarrow$	100H	50Hz	5V
100H	$\rightarrow$	1KH	50Hz	5V
1kH	$\rightarrow$	10KH	20Hz	5V

The Test Conditions for Inductance Measurement

Wherever possible, this table should be used for all inductance tests. The inductance range should be chosen based on minimum value of inductance expected.

When choosing the test conditions, the following potential problems should be considered:

A)   CURRENT LEVELS

The upper voltage limits should be chosen to give a maximum current level of about 50mA rms. for the lowest inductance expected. In some cases, this current may cause core saturation, and a lower voltage should be used. The minimum voltage level must be chosen so that the test current does not become so low that it cannot be sensibly measured. The lower voltage limits in the table above always give test currents higher than $3\mu A$ rms.

B)   SELF-RESONANT FREQUENCY

At lower frequencies, the capacitance of the windings can normally be ignored because its impedance is much higher than that of the inductance. However, at very high frequencies, this is not so, the capacitance dominates and inductance cannot be measured. The self-resonant frequency of the transformer is the change-over point between these two regions.

Normally to get a good measurement of inductance, the test frequency should be less than 20% of the resonant frequency of the transformer.

In general high values of inductance will have a high inter-turn capacitance and hence a low resonant frequency. Where there is a choice of test frequencies always use the lower value, to minimise any problems due to self-resonance.

C)   NON-LINEAR INDUCTANCE

Normally inductance measurements should be used for transformers where the B-H characteristics are linear.

However, if inductance measurements are attempted for instance with line frequency transformers where the core material is non-linear even at low signal levels, the measured results can be highly dependant on the applied test signal.

This can be a problem when trying to compare measurements made on commercially available impedance bridges, or component testers, with measurements made using the AT3600. The test signal in such bridges is usually determined within the instrument, and is often at a fixed frequency and at a voltage level which is not guaranteed to be constant for all value of inductance.

Usually, if the actual test conditions of the bridge can be determined, and the tester is then programmed to deliver the same test conditions across the inductance the results will then agree. (See also the comments below on differences caused by the choice of equivalent circuit)

D)   EQUIVALENT CIRCUIT

Inductance is always measured as part of a complex impedance, the result being expressed in terms of either a series or parallel equivalent circuit. Note that, for any given winding, the inductance values for the two circuits are not necessarily the same. This should be born in mind when specifying the test limits.

1.6. LSB OR LPB-INDUCTANCE WITH BIAS CURRENT (SERIES OR PARALLEL CIRCUIT)

WHERE USED

With the LSB and LPB tests, the AT3600 offers two further ways to confirm that the transformer has been assembled properly, with the appropriate number of turns, the right grade of magnetic material for the core, and the correct air gap if required.

These tests would normally be used for transformers designed to be used in applications where a large dc current is flowing through one or more of the windings.

MEASUREMENT CONDITIONS

To measure inductance with bias, the tester firstly applies the programmed bias current to the winding under test. When this has stabilised, it then applies an ac voltage across the selected winding, and measures the voltage across and the current through the winding using harmonic analysis. The measured voltage is divided by the harmonic current to obtain a complex impedance and the inductance is calculated.

The bias current can be programmed in the range 10mA to 400mA. The (ac) test signal can have a frequency between 20Hz and 1MHz, and an amplitude from 1mV to 5V.

Usually, the signal frequency and voltage are chosen so that, with the expected inductance, the resulting signal current is less than 20% of the bias current.

Recommended test signals generally would be the same as given in section 7.1.8 for the normal inductance test. However, if the recommended levels correspond to too high a signal current, then use a corresponding smaller test voltage.

It is not normally recommended that the test frequency be increased in an attempt to reduce the signal current, as this may lead to other problems, such as those caused by parasitic inductance and capacitance of the test fixture, and the self-resonant frequency of the transformer itself.

1.7. QL - QUALITY FACTOR

WHERE USED

The Q factor measurement would normally follow a measurement of the inductance of the primary winding in the test program.

As with an inductance measurement, the Q factor test would normally be used for signal, pulse and switched mode power transformers, where the normal operating conditions require only small excursions of the B-H curve, never extending beyond the linear regions.

A Q factor test is one way of highlighting shorted turns within the transformer.

MEASUREMENT CONDITIONS

To measure Q factor, the tester performs exactly the same steps that would be used to measure inductance. The only difference is in the calculation at the end of the test: the measured voltage is divided by the current to obtain a complex impedance from which the Q factor is calculated.

The test signal can have a frequency in the range 20Hz to 1MHz, and an amplitude from 1mV to 5V.

Normally when following an inductance test, you would choose the same test conditions for the QL test. If the QL test does not have an associated inductance test, then choose the test conditions as detailed in the Table on page 7.1.8, base on the value of the inductance of the winding under test.

1.8. D – DISSIPATION FACTOR OR TANδ

Measurement Range	Test Voltage	Test Frequency	Basic Accuracy
0.001 to 1000	1mV to 5V	20Hz to 3MHz	0.5%
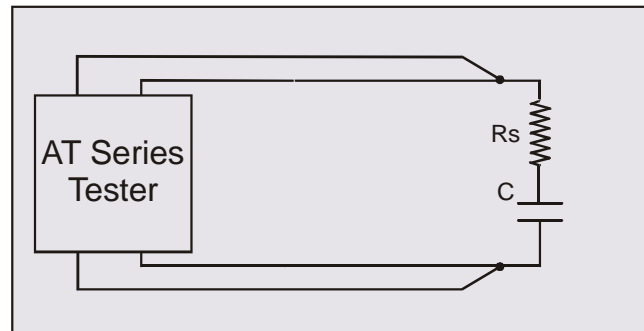
The parameter 'D' is most often used as a measurement of the losses in a capacitor. It is analogous to Q for a transformer winding.

For this equivalent circuit the Dissipation Factor D is defined as:

$$D = \frac{Rs}{1/\omega Cs} \qquad (\text{where } \omega = 2\pi f)$$

For a given capacitance, the lower the equivalent series resistance, the lower is the value of the dissipation factor or tanδ, i.e. the 'better' the capacitor.

Where used

The dissipation factor test would normally be used for capacitors of all types. A D factor test will help to determine that the capacitor has been manufactured correctly.

Measurement conditions

To measure Dissipation Factor, the tester applies an ac voltage across the selected winding, and measures the voltage across and the current through the winding. Using harmonic analysis, the measured voltage is divided by the current to obtain a complex impedance from which the Dissipation Factor is obtained.

Choosing the test signal

For optimum accuracy and performance, use the test conditions chosen for capacitance in a later section of this chapter.

The test conditions can also be determined automatically by the AT3600 according to this table:

Signal Frequency	Specified voltage Specified	Specified current Specified	Auto Specified

Note that a 'fixed' signal cannot be used with an 'Auto' frequency.

1.9. LL OR LLO- LEAKAGE INDUCTANCE

WHERE USED

Leakage inductance is important in many applications. One example is flyback designs for high frequency switched mode power supplies, where the leakage inductance must be less than a specified critical value for proper operation.

MEASUREMENT CONDITIONS

Leakage inductance is tested by measuring the inductance of a 'primary' winding when one or more 'secondary' windings are shorted out. In performing the calculation at the end of the test to extract the inductance value from the measured winding impedance, the tester uses a series equivalent circuit.

In making the measurement, the tester automatically compensates for the impedance of the wiring, the connections and the relays in the shorting path.

Leakage inductance can be measured using a test current in the range 20µA to 100mA at a frequency of 20Hz to 1MHz.

You may choose a suitable test current and frequency based on the expected value of the leakage inductance using the following table:

Leakage Inductance range			Preferred test signal	
			Frequency	Current
100nH	$\rightarrow$	1uH	300kHz	50mA
1uH	$\rightarrow$	10uH	100kHz	20mA
10uH	$\rightarrow$	100uH	30kHz	10mA
100uH	$\rightarrow$	1mH	10kHz	5mA
1mH	$\rightarrow$	10mH	1kHz	5mA
10mH	$\rightarrow$	100mH	100Hz	5mA
100mH	$\rightarrow$	1H	100Hz	1mA
1H	$\rightarrow$	10H	50Hz	500µA

The Test Conditions for Leakage Inductance Measurement

NOTE: Because leakage inductance is measured with a secondary winding shorted out, be careful to choose a test signal that will not cause excessive currents to flow. This is particularly significant in transformers where the turns ratio is very high and the shorted winding has only a few turns.

> If, for example, the primary winding has 300 turns, and the secondary 3 turns, a test current of 10mA flowing through the leakage inductance on the primary side will give rise to a current of 1 Amp flowing in the shorted secondary winding.

In order to protect transformer windings, the test current when measuring leakage inductance is limited in the table to 50mA maximum.

In addition, the problem of self-resonant frequency listed under the primary inductance test also applies when measuring leakage inductance, so always use the lower of the available band of frequencies.

User Offset (LLO test only)

This is used to offset the result returned by the AT by a user defined amount.

i.e.

Result returned = Measured result + User offset

Normally a user offset would not be required. However for small values of leakage inductance (<1μH) when there are a number of additional low terminals, it is not always possible during fixture compensation for the tester to remove all of the parasitic errors of the test fixture. In this case, the user offset may be required to fully remove the errors. The LLO test provides this additional feature.

1.10. C - INTERWINDING CAPACITANCE

WHERE USED

Capacitance occurs in transformers due to the physical proximity of, and electrostatic coupling between, different turns of wire. In general, the capacitance is distributed between the different layers within a winding, and between the outside layer of one winding and the inside layer of the next.

Although the capacitance is distributed, it is usually represented by a simple equivalent circuit showing a single capacitance from one winding to the next.
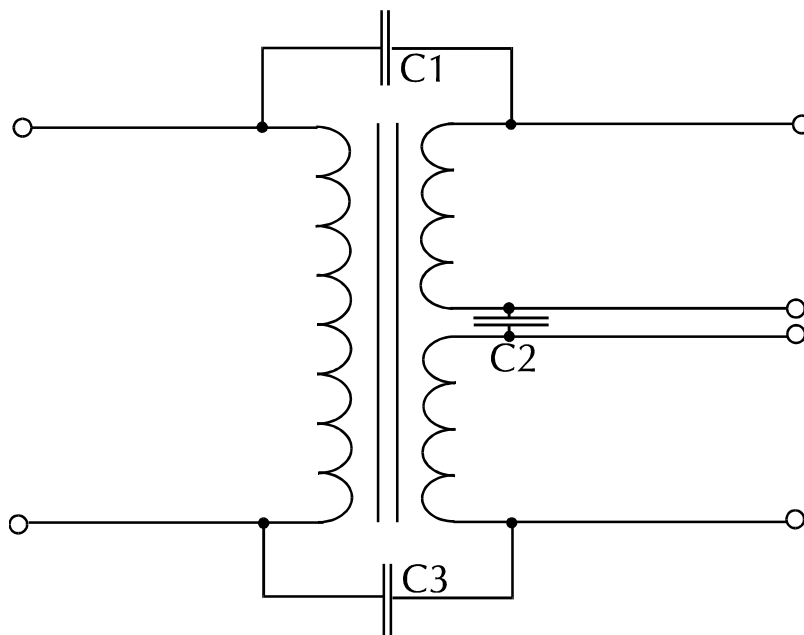
Inter-winding capacitance may be of interest in transformers used in audio, medical and instrumentation applications, where isolation between primary and secondary windings is important. It can also play an important part in the circuit operation of switch-mode transformers where, for example, too large a capacitance may give rise to a large amount of noise at the switching frequency being coupled into sensitive circuits connected to the secondary windings.

MEASUREMENT CONDITIONS

To measure capacitance, the tester applies an ac voltage between the windings to be tested, usually with all taps on each winding shorted together. It then measures the voltage between the windings, and the resulting current using harmonic analysis. Dividing the voltage by the current gives the inter-winding impedance, from which the capacitance may be calculated.

The test voltage can be in the range of 1mV to 5V at a frequency of 20Hz to 1MHz.

The table below gives the recommended test conditions for different values of capacitance:

Capacitance range			Preferred test signal	
			Frequency	Voltage
1pF	$\rightarrow$	10pF	100KHz	5V
10pF	$\rightarrow$	100pF	100KHz	5V
100pF	$\rightarrow$	1nF	10KHz	5V
1nF	$\rightarrow$	10nF	1KHz	5V
10nF	$\rightarrow$	100nF	100Hz	5V

The Test Conditions for Capacitance Measurement

When choosing the test conditions, the following potential problems should be considered:

A)   CURRENT LEVELS

For larger capacitance, particularly at higher frequencies, the current flowing during the measurement can be very high, and similarly the measured current could also be very small for small capacitance at lower frequencies and voltages.

Where possible, you should use the recommended test signal levels in the table above to ensure that the currents which flow can be measured accurately.

B)   NON-LINEAR CAPACITANCE

Normally non-linearities in the stray capacitance of transformers are not a problem, and therefore capacitance is measured with as large a voltage as possible.

c)   EQUIVALENT CIRCUIT

As with inductance, capacitance is actually measured as a complex impedance, and therefore the result can be expressed in terms of either a series or a parallel equivalent circuit.

It was explained in section 1.5 of this chapter that parallel and series equivalent inductance do not necessarily have the same values. The same is true for capacitance; parallel and series equivalents can also be different.

The tester always uses a parallel equivalent circuit for capacitance measurements.

1.11. TR - TURNS RATIO

WHERE USED

The AT3600 offer two basic alternative ways to confirm that the transformer has been assembled properly, with the appropriate number of primary and secondary turns.

Turns ratio is the preferred test for signal, pulse and switched mode power transformers, where the normal operating conditions require only small excursions of the B-H curve, never extending beyond the linear regions.

(For line frequency transformers, designed to operate over the full extent of the B-H curve, including the non-linear regions, the preferred method is to use an open - circuit voltage test to check for the correct numbers of turns on each winding.)

Clearly a turns ratio test cannot tell you the actual number of turns on a winding, only the ratio between one winding and the next. You should therefore have at least one inductance test in your program to give confidence that the absolute number of turns is correct as well as the ratio.

MEASUREMENT CONDITIONS

To measure turns ratio, a test source voltage is applied to one winding, the energised winding, and the voltages across two other windings (one of which may also be the energised winding) are measured using harmonic analysis. The turns ratio is measured by dividing one measured voltage by the other, and making a compensation for the effects of winding resistance.

It is recommended that you choose the winding with the highest number of turns as the one to be energised. A possible exception to this rule is when you wish to measure the ratio between two windings which should be accurately matched at 1:1. In this case it may be better to energise a third winding with a lower number of turns, to ensure that any measurement errors apply equally to the two windings under test.

You can specify the signal to be applied to the energised winding to have a frequency in the range 20Hz to 1MHz, and an amplitude from 1mV to 5V.

The recommended test conditions depend on the inductance of the energised winding; they are given in the table below assuming that the energised winding is the one with the highest number of turns:

Inductance of the Energised Winding			Preferred test signal	
			Frequency	Voltage
100nH	→	1uH	300KHz	10mV
1uH	→	10uH	100KHz	30mV
10uH	→	100uH	30KHz	50mV
100uH	→	1mH	10KHz	100mV
1mH	→	10mH	1KHz	100mV
10mH	→	100mH	100Hz	100mV
100mH	→	1H	100Hz	300mV
1H	→	10H	50Hz	1V
10H	→	100H	50Hz	5V
100H	→	1KH	50Hz	5V
1KH	→	10KH	20Hz	5V

The Test Conditions for Turns Ratio Measurement

Notes: The signal is applied to the primary winding, or the winding which has the largest number of turns.

However, if by doing this, the expected voltage on the winding with the smallest number of turns falls below 1mV, then the test voltage should be increased.

This may also require an increase in the test frequency so that the current taken by the driven winding does not become too large, but in general this frequency increase should be kept as small as possible to avoid problems caused by stray capacitance at high frequencies.

WHERE MATCHING IN GROUPS IS IMPORTANT:

In some transformer designs, the turns ratio between a primary winding and a secondary winding is not as important as the ratio between different primaries or different secondaries.

To make the most accurate measurements in such cases apply the test signal to the primary winding and measure the turns-ratio from primary to one of the secondaries.

Then, leaving the primary energised as above, measure the turns ratio between the secondaries.

Next, energise a secondary winding (possibly at a different voltage and / or frequency depending on its inductance) and measure the turns ratio between the various primaries.

In this way windings which should be matched are treated equally during the test.

SPECIFYING THE TEST LIMITS

When specifying turns ratio tests, it is preferable to avoid limits which are unnecessarily tight, and which may therefore lead to measurement difficulties.

For example, if two equal secondary windings should have 10 turns each, the ratio should be 1:1. One turn in error would produce a ratio error of 10% or -10% (i.e. 11:10 or 10:11), and therefore limits of +5% and -5% would be suitable to detect the error.

1.12. TRL - TURNS RATIO BY INDUCTANCE

WHERE USED

The AT3600 offers two basic alternative ways to confirm that the transformer has been assembled properly, with the appropriate number of primary and secondary turns.

Turns ratio is the preferred test for signal, pulse and switched mode power transformers, where the normal operating conditions require only small excursions of the B-H curve, never extending beyond the linear regions.

Where the magnetic coupling between the primary and secondary is poor, it is preferable to measure the turns ratio by inductance. This test measures the inductance of both the primary and secondary and calculates the turns ratio from these measured values.

(For line frequency transformers, designed to operate over the full extent of the B-H curve, including the non-linear regions, the preferred method is to use an open - circuit voltage test to check for the correct number of turns on each winding.)

Clearly a turns ratio test cannot tell you the actual number of turns on a winding, only the ratio between one winding and the next. You should therefore have at least one inductance test in your program to give confidence that the absolute number of turns is correct as well as the ratio.

MEASUREMENT CONDITIONS

The inductance of a winding can often depend upon the flux density in the core/windings. Since during measurement, the flux density will depend upon the signal energising the winding, it is important that both windings are energized at the same level. This will ensure that both inductances are measured along the same region of the B/H curve of the core, to give a true ratio.

SETTING THE TEST PARAMETERS

The simplest method of setting the test parameters is to use the 'Measure' button, to do this you have to program the test from a computer which is connected to the Auxiliary port of the tester. There are two other methods of inputting the test parameters, one is to set the primary voltage and frequency and let the editor set the secondary voltage, and the second is to set both voltages manually.

USING THE MEASURE BUTTON TO SET TEST PARAMETERS

To do this you must be programming the test from a computer that is connected to the tester's auxiliary port. Select the integration period you require, enter the primary and secondary terminals, then click on the measure button. The editor will then enter the test signal and show the measured turns ratio. Set percentage limits on this ratio and click 'OK' (you may select a polarity test before clicking 'OK').

USING THE AUTO BUTTON TO SET SECONDARY VOLTAGE

To do this you must know the primary inductance.

Select the test voltage and frequency for the primary from the table below and enter them in the TRL dialogue box. Enter the turns ratio, then press the 'Auto' button next to the secondary voltage parameter, the tester will automatically select the appropriate test voltage for the secondary winding when the program is running.

SETTING THE PRIMARY AND SECONDARY PARAMETERS MANUALLY

To do this you will need to know the inductance of the primary and secondary windings.

The optimum test conditions are chosen for an inductance value that is between the primary and secondary (L_m).

$$L_m = \sqrt{L_p \times L_s}$$

Look up the recommended test signal for this inductance.

Enter the recommended frequency for this inductance as the test frequency.

The primary and secondary voltages can be calculated from the following:

$$V_s = V_m \sqrt{\frac{N_s}{N_p}} \qquad V_p = V_m \sqrt{\frac{N_p}{N_s}}$$

Where:

L_m = Intermediate inductance

L_p = Primary inductance

L_s = Secondary inductance

V_p = Primary voltage

V_s = Secondary voltage

V_m = Intermediate voltage

N_p = Primary turns

N_s = Secondary turns

If you calculate V_s or V_p to be greater than 5V, you should set 5V as your test signal. If you calculate V_s or V_p to be less than 1mV, you should set 1mV as your test signal.

Intermediate Inductance (L_m)			Preferred test signal	
			Frequency	**Voltage (V_m)**
100nH	$\rightarrow$	1uH	300KHz	10mV
1uH	$\rightarrow$	10uH	100KHz	30mV
10uH	$\rightarrow$	100uH	30KHz	50mV
100uH	$\rightarrow$	1mH	10KHz	100mV
1mH	$\rightarrow$	10mH	1KHz	100mV
10mH	$\rightarrow$	100mH	100Hz	100mV
100mH	$\rightarrow$	1H	100Hz	300mV
1H	$\rightarrow$	10H	50Hz	1V
10H	$\rightarrow$	100H	50Hz	5V
100H	$\rightarrow$	1KH	50Hz	5V
1KH	$\rightarrow$	10KH	20Hz	5V

The Test Conditions for Turns Ratio by Inductance Measurement

SPECIFYING THE TEST LIMITS

When specifying turns ratio tests, it is preferable to avoid limits which are unnecessarily tight, and which may therefore lead to measurement difficulties.

For example, if two equal secondary windings should have 10 turns each, the ratio should be 1:1. One turn in error would produce a ratio error of 10% or -10% (i.e. 11:10 or 10:11), and therefore limits of +5% and -5% would be suitable to detect the error.

1.13. Z, ZB – IMPEDANCE, IMPEDANCE WITH BIAS

WHERE USED

The impedance test measures the impedance of a transformer winding by applying a specified voltage and frequency and by measuring the current that flows, calculating the magnitude of the complex impedance.

MEASUREMENT CONDITIONS
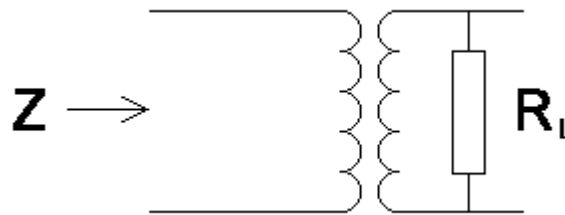
The load resistor is assumed to be on the fixture, but not shown on the Editor schematic. It is switched in circuit using an OUT test that must be inserted in the program before the Z test. (The relay patterns associated with inserting and removing fixture resistors have deliberately not been included in the Z test dialogue for two reasons: a) it would make the dialogue too complicated, and b) it is not always necessary - e.g. in the case of a fixture where the resistor is permanently fitted in circuit).

The test voltage is applied to the input winding, and the voltage and current measured. From the measured results the impedance is calculated.
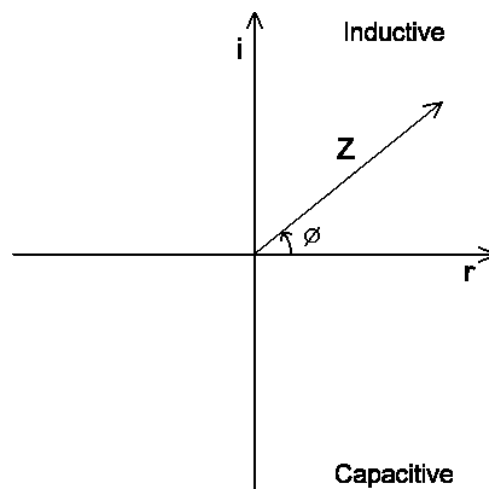
1.14. R2 – DC RESISTANCE MATCH

WHERE USED

The DC resistance match test – as opposed to an ordinary DC resistance measurement (R) - is used on audio and telecommunications transformers, where it is important that the resistance of different pairs of windings is controlled and matched to a specified ratio. The absolute value of the resistances may be of less importance to the performance of the transformer than the match between two resistances.

MEASUREMENT CONDITIONS

To measure DC resistance match, the tester makes two DC resistance measurements (see the R test) and compares the two results. Limits for the match of the two measured resistances may be set in terms of the ratio between them (e.g. 1:1 ± 5%).

By adding further DC resistance match tests to the test program, any number of DC resistances can be tested for match.

CHOOSING TEST CONDITIONS

For optimum accuracy and performance, use the test conditions shown in the DC resistance section of this chapter for each of the two windings.

PROGRAMMING THE TEST USING THE PC TEST EDITOR

- Select the integration time required.

- Enter the terminal names between which the X resistance is to be measured.

- Enter the terminal names between which the Y resistance is to be measured.

- Set the specific resistance for both X and Y terminals, and then set the negative and positive percentage (%) limits.

- Select OK. The test specification will now be displayed in the program window.

Use the PC Editor's 'Measure' button (together with a sample part) if you are unsure of how to choose the test conditions.

CHOOSING TEST LIMITS

The test limits are the specific resistances for both X and Y terminals together with + and – percentage limits.

Use the PC Editor's 'Measure' button (together with a sample part) if you are unsure of the resistance values.

1.15. L2 – INDUCTANCE MATCH

WHERE USED

The inductance match test calculates the ratio between two inductances on two windings. An equivalent series inductance measurement is performed on each winding by measuring the complex impedance.

This test is suitable for switched mode power supply transformers, and audio & telecommunication transformers. It checks matching between windings.

MEASUREMENT CONDITIONS

When calculating inductance match the tester performs two inductance measurements. Firstly the unit applies an ac voltage across the first winding; it then measures the voltage across and the current through the winding using harmonic analysis. The measured voltage is divided by the current to obtain a complex impedance and the inductance is calculated. This is then repeated for the second winding. The inductance match is the ratio of first to second winding inductance.

The test signal can have a frequency in the range 20Hz to 1MHz, and an amplitude from 1mV to 5V.

Generally, it is not necessary to measure the inductance at the normal operating conditions of the transformer, which could involve, for example, voltage levels of hundreds of volts. This is because the B-H curve can normally be assumed to be linear in the operating region, and the inductance measured at a low level represents the inductance that will appear in use.

Also, it can usually be assumed that the inductance value does not vary significantly with frequency. Therefore, although high frequencies are available with the tester, measurement frequencies above a few hundred kilohertz should be used with caution. This is because the errors caused by the stray inductance and capacitance of your fixture may become much more significant at these frequencies. Compensation can be used to eliminate these errors.

The following table suggests suitable test conditions for different values of expected average inductance:

Average Inductance (Geometric Mean)			Preferred test signal	
			Frequency	Voltage
100nH	→	1uH	300KHz	10mV
1uH	→	10uH	100KHz	30mV
10uH	→	100uH	30KHz	50mV
100uH	→	1mH	10KHz	100mV
1mH	→	10mH	1KHz	100mV
10mH	→	100mH	100Hz	100mV
100mH	→	1H	100Hz	300mV
1H	→	10H	50Hz	1V
10H	→	100H	50Hz	5V
100H	→	1KH	50Hz	5V
1kH	→	10KH	20Hz	5V

Test Conditions for Inductance Match Measurement

Wherever possible, this table should be used for all inductance tests. The inductance range should be chosen based on minimum value of inductance expected.

When choosing the test conditions, the following potential problems should be considered:

A)   CURRENT LEVELS

The upper voltage limits should be chosen to give a maximum current level of about 100mArms. for the lowest inductance expected. In some cases, this current may cause core saturation, and a lower voltage should be used. The minimum voltage level must be chosen so that the test current does not become so low that it cannot be sensibly measured. The lower voltage limits in the table above always give test currents higher than $3\mu A$ rms.

B)   SELF-RESONANT FREQUENCY

At lower frequencies, the capacitance of the windings can normally be ignored because its impedance is much higher than that of the inductance. However, at very high frequencies, this is not so, the capacitance dominates and inductance cannot be measured. The self-resonant frequency of the transformer is the change-over point between these two regions.

Normally to get a good measurement of inductance, the test frequency should be less than 20% of the resonant frequency of the transformer.

In general high values of inductance will have a high inter-turn capacitance and hence a low resonant frequency. Where there is a choice of test frequencies always use the lower value, to minimise any problems due to self-resonance.

C)   NON-LINEAR INDUCTANCE

Normally inductance measurements should be used for transformers where the B-H characteristics are linear.

However, if inductance measurements are attempted for instance with line frequency transformers where the core material is non-linear even at low signal levels, the measured results can be highly dependant on the applied test signal.

This can be a problem when trying to compare measurements made on commercially available impedance bridges, or component testers, with measurements made using the AT Series testers. The test signal in such bridges is usually determined within the instrument, and is often at a fixed frequency and at a voltage level which is not guaranteed to be constant for all value of inductance.

Usually, if the actual test conditions of the bridge can be determined, and the tester is then programmed to deliver the same test conditions across the inductance the results will then agree. (See also the comments below on differences caused by the choice of equivalent circuit)

D)   EQUIVALENT CIRCUIT

Inductance is always measured as part of a complex impedance, the result being expressed in terms of either a series or parallel equivalent circuit. Note that, for any given winding, the inductance values for two circuits are not necessarily the same; this should be born in mind when specifying the test limits.

1.16. C2 – CAPACITANCE MATCH

WHERE USED

The interwinding capacitance match test calculates the ratio between two capacitance measurements on two groups of windings. It is measured by applying a specified ac voltage between two separate windings and the voltage across and current flow between the two windings is measured to obtain a complex impedance. This is performed to the two groups in turn.

This test is suitable for switched mode power supply, audio and telecommunication transformers. It checks that the windings are installed in the correct positions on the bobbin.

MEASUREMENT CONDITIONS

When calculating capacitance match the tester performs 2 capacitance measurements. Firstly the tester applies an ac voltage between first group of windings to be tested, usually with all taps on each winding shorted together. It then measures the voltage between the windings, and the resulting current using harmonic analysis. Dividing the voltage by the current gives the inter-winding impedance, from which the capacitance may be calculated. This is then repeated for the second winding group. The capacitance match is the ratio of first to second winding group capacitances.

The test voltage can be in the range of 1mV to 5V at a frequency of 20Hz to 1MHz.

The table below gives the recommended test conditions for different values of average capacitance:

Average Capacitance (Geometric Mean)			Preferred test signal	
			Frequency	Voltage
1pF	$\rightarrow$	10pF	100KHz	5V
10pF	$\rightarrow$	100pF	100KHz	5V
100pF	$\rightarrow$	1nF	10KHz	5V
1nF	$\rightarrow$	10nF	1KHz	5V
10nF	$\rightarrow$	100nF	100Hz	5V

The Test Conditions for Capacitance Match Measurement

When choosing the test conditions, the following potential problems should be considered:

A)   CURRENT LEVELS

For larger capacitances, particularly at higher frequencies, the current flowing during the measurement can be very high, and similarly the measured current could also be very small for small capacitances at lower frequencies and voltages.

Where possible, you should use the recommended test signal levels in the table above to ensure that the currents which flow can be measured accurately.

B)   NON-LINEAR CAPACITANCE

Normally non-linearities in the stray capacitance of transformers are not a problem, and therefore capacitance is measured with as large a voltage as possible.

C)   EQUIVALENT CIRCUIT

As with inductance, capacitance is actually measured as a complex impedance, and therefore the result can be expressed in terms of either a series or a parallel equivalent circuit.

It was explained in section 1.5. of this chapter, that parallel and series equivalent inductance do not necessarily have the same values. The same is true for capacitance; parallel and series equivalents can also be different.

The tester uses a parallel equivalent circuit for capacitance measurements, and does not give you a choice of a series equivalent.

Generally, this will present no problems, as on the majority of transformers the difference between the two values is usually negligible, and can be ignored.

1.17. GBAL – GENERAL LONGITUDINAL BALANCE

WHERE USED

The general longitudinal balance test is intended to measure what is effectively the Common Mode Rejection Ratio of a transformer designed to connect to a balanced line. Two measurements are performed each by applying a voltage to the transformer and measuring the resulting voltage to calculate the CMRR. To overcome the differences of three standard methods of measuring the CMRR the GBAL dialogue box has a separate group of terminals X and Y for the first and second measurements respectively. The preferred method of measurement is the LBAL test for which Voltech provide a separate test specifically for this measurement.

This test is suitable for audio & telecommunication transformers and checks the effective common mode rejection ratio of the transformer.

MEASUREMENT CONDITIONS AND TYPES

Unfortunately, there are several published specifications for measuring longitudinal balance. These are all different, and potentially give different results for the same transformer.

To allow each user the freedom to test to his preferred method, the GBAL test has been configured with the greatest flexibility. It therefore consists of two separate measurements which the user can program, and the result is the ratio between the two expressed in dB.

OPERATION

For the reasons outlined above, the test consists of two separate user programmed measurements, each with its own 'energised' and 'measured' terminals. This approach is illustrated below with reference to three standard methods:

1. Preferred method (the method of the LBAL test, used by many transformer manufacturers)
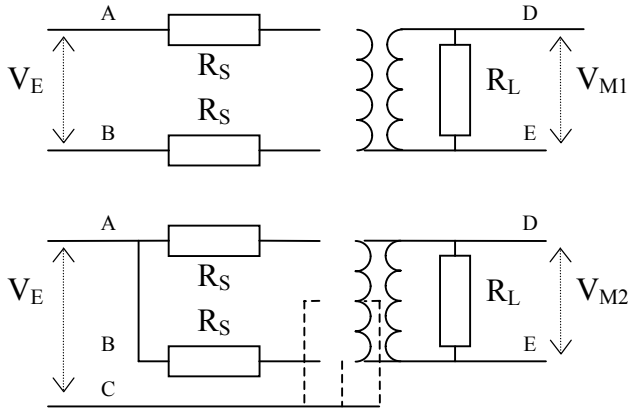
Measurement				
	Energised		Measured	
	Hi	Lo	Hi	Lo
1	A	B	D	E
2	A+B	C	D	E

2. IEEE 455 method (used in Canada, Europe and ROW)

Fixture
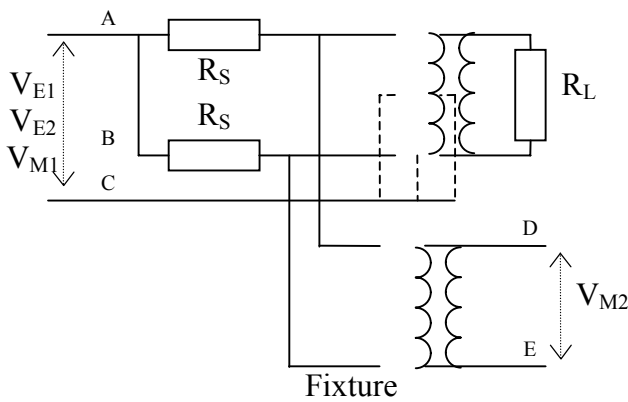
Measurement				
	Energised		Measured	
	Hi	Lo	Hi	Lo
1	A+B	C	A	C
2	A+B	C	D	E

3. FCC 68.310 method (used in USA)

Fixture   Transformer
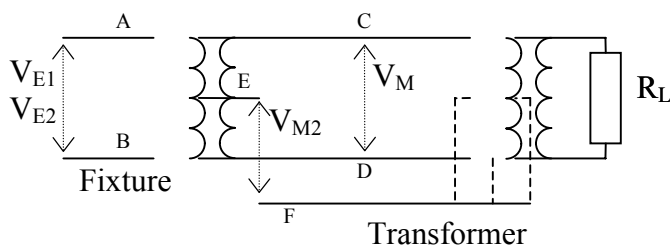
Measurement				
	Energised		Measured	
	Hi	Lo	Hi	Lo
1	A	B	C	D
2	A	B	E	F

The source and load resistors (and the fixture transformer for the IEEE and FCC methods) are assumed to be on the fixture, but are not shown on the Editor schematic. They are switched in circuit using an OUT test that must be inserted in the program before the GBAL test. (The relay patterns associated with inserting and removing fixture resistors have deliberately not been included in the GBAL test dialogue for two reasons: a) it would make the dialogue too complicated, and b) it is not always necessary - e.g. in the case of a fixture where the resistors are permanently fitted in circuit).

After the two measurements have been taken, the longitudinal balance is calculated from the ratio of the two outputs:

$$GBAL = 20 \log | V_{M1} / V_{M2} |$$

$$+ \text{(optionally) compensation for test fixture scaling}$$

1.18. LBAL – LONGITUDINAL BALANCE

WHERE USED

The longitudinal balance test is Voltech's preferred method to measure what is effectively the Common Mode Rejection Ratio of a transformer designed to connect to a balanced line. Two measurements are performed each by applying a voltage to the transformer and measuring the resulting voltage to calculate the CMRR. This test is suitable for audio & telecommunication transformers and checks the effective common mode rejection ratio of the transformer.

MEASUREMENT CONDITIONS

$$LBAL = 20 \log | V_{O2} / V_{O1} |$$

The source and load resistors are assumed to be on the fixture, but are not shown on the editor schematic. They are switched in circuit using an OUT test that must be inserted in the program before the LBAL test. (the relay patterns associated with inserting and removing fixture resistors have deliberately not been included in the LBAL test dialogue for two reasons: a) it would make the dialogue too complicated, and b) it is not always necessary - e.g. in the case of a fixture where the resistors are permanently fitted in circuit).

The test consists of two measurements: a) with the input applied as a common mode voltage relative to a common lo point, which could be the centre tap of the primary winding, the centre tap of the secondary winding, the transformer core or an interwinding screen, and b) with the same input applied as a differential signal. In each case the output is measured, and the longitudinal balance is calculated from the ratio of the two outputs.

1.19. ILOS – INSERTION LOSS

WHERE USED

The Insertion loss test measures the output power delivered by a transformer to a load, relative to the maximum power theoretically available. A voltage is applied to the input winding and the input/output voltages are measured to calculate the loss.

This test is suitable for audio & telecommunication transformers and checks the effective losses in the transformer when used for its application.

MEASUREMENT CONDITIONS
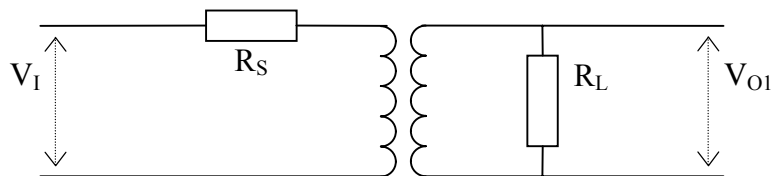
$$ILOS = 10 \log (V_I^2 R_L / 4 V_O^2 R_S)$$

The source and load resistors are assumed to be on the fixture, but are not shown on the Editor schematic. They are switched in circuit using an OUT test that must be inserted in the program before the ILOS test. (the relay patterns associated with inserting and removing fixture resistors have deliberately not been included in the ILOS test dialogue for two reasons: a) it would make the dialogue too complicated, and b) it is not always necessary - e.g. in the case of a fixture where the resistors are permanently fitted in circuit).

The test voltage is applied to the input winding, and the voltages measured on the input and output windings. From the ratio of input and output voltages, and the resistance values (specified by the user in the test dialogue), the insertion loss is calculated.

1.20. RESP – FREQUENCY RESPONSE

WHERE USED

The frequency response test, RESP, may be used to check that the variation in power loss of a telecommunications or audio transformer over a specified frequency range is less than specified limits.

MEASUREMENT CONDITIONS
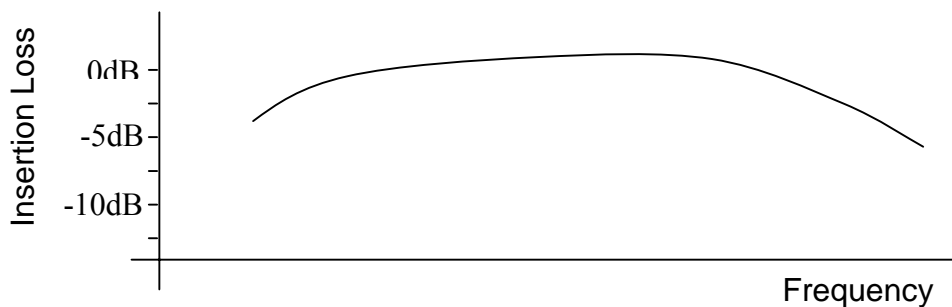
The RESP test consists of a number of Insertion Loss (ILOS) tests repeated at different frequencies.
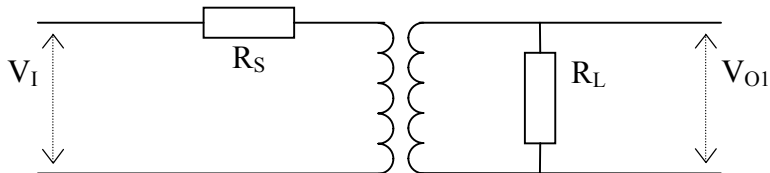
The resistors shown are fitted to the test fixture and should be switched out of circuit when making other measurements such as resistance and inductance. This can be done by fitting relays to the fixture and switching them at appropriate points in the test program using OUT tests.

The first ILOS test is made at a reference frequency that is usually near the middle of the band of frequencies of interest. The result of this test is the 0dB reference level. Further ILOS tests are then carried out at user selected frequencies and the results referred to the reference dB level.

If all the referred ILOS results are at or inside the specified limits, the result of a RESP test is the referred ILOS result that is closest to the limit. If any of the referred ILOS results are outside the specified limits, the RESP result is the referred ILOS result that is furthest away from the limit.

1.21. RLOS – RETURN LOSS

WHERE USED

The Return loss test measures the impedance mismatch between the transformer and a transmission line of a specified impedance. RLOS is calculated from a measurement of the complex impedance and the specified impedance. This test is suitable for audio & telecommunication transformers and checks the effective input impedance of the transformer in the application.

MEASUREMENT CONDITIONS

$$RLOS = 20 \log (\, | \, Z_R + Z_\ell \, | \, / \, | \, Z_R - Z_\ell \, | \,)$$

The load resistor is assumed to be on the fixture, but not shown on the Editor schematic. It is switched in circuit using an OUT test that must be inserted in the program before the RLOS test. (The relay patterns associated with inserting and removing fixture resistors have deliberately not been included in the RLOS test dialogue for two reasons: a) it would make the dialogue too complicated, and b) it is not always necessary - e.g. in the case of a fixture where the resistor is permanently fitted in circuit).

The test voltage is applied to the input winding, and the voltage and current measured. From the measured results, and the reference impedance value (specified by the user in the test dialogue), the return loss is calculated.

The impedances used are complex, where:

$$Z_R = R_R + j \, X_R$$

$$Z_\ell = R_\ell + j \, X_\ell$$

1.22. ANGL – IMPEDANCE PHASE ANGLE

WHERE USED
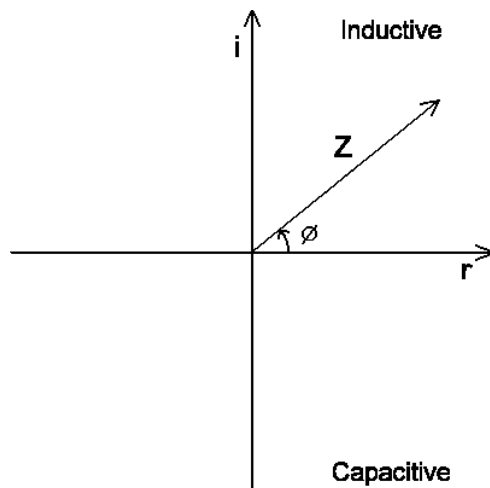
The impedance phase angle test measures the angle $\varnothing$ of the impedance vector Z, as shown in the phasor diagram. It represents the phase difference between the fundamental current flowing through a winding and the fundamental voltage across it. This test is normally used for audio and telecommunication transformers along with the Z test to check the complex impedance presented to the transformers input and output.

MEASUREMENT CONDITIONS

An AC voltage is applied across the winding under test, the complex impedance is determined from measurement of the test voltage and current flowing.

To set the test voltage or current you will need to know the expected impedance of the winding at the test frequency. You can measure this using the 'Z' (Impedance) test.

Select the test voltage or current from the table below; find the correct impedance range for your winding and read off the test voltage or current.

Impedance Range			Test Voltage	Test Current
1MΩ	→	100kΩ	5V	-
100kΩ	→	10kΩ	5V	30μA
10kΩ	→	1kΩ	5V	300μA
1kΩ	→	100Ω	3V	3mA
100Ω	→	10Ω	0.5V	10mA
10Ω	→	1Ω	100mV	50mA
1Ω	→	100mΩ	10mV	50mA
100mΩ	→	10mΩ	1mV	50mA
10mΩ	→	1mΩ	-	50mA

1.23. PHAS – INTERWINDING PHASE TEST

WHERE USED
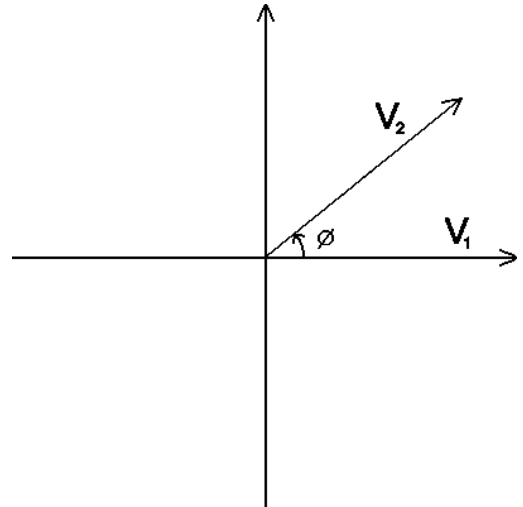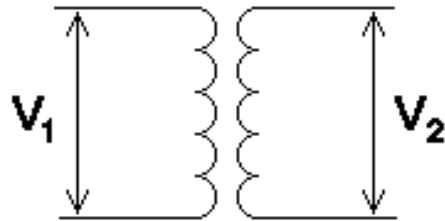
This test is useful for most types of transformer, although unusual with line frequency transformers and tests for the phase angle between windings. It is most useful for determining the phase effect of audio and telecommunications transformers when placed in a transmission line.

MEASUREMENT CONDITIONS

If you are programming the test from a computer that is connected to the auxiliary port of the tester, you may enter the test conditions in the following way. Select the test terminals, enter the test frequency, click on the measure button and the editor will select the correct voltage and display the measured phase angle. You can then use this measured angle as a basis for setting your limits.

If your computer is not connected to the tester, you can choose the test voltage from the following table.

N.B.   **When selecting your energised winding, check that your transformer does not have a large step-up turns ratio between this winding and any other windings as this may cause high voltages to be present during the test. Energise the winding with the most turns if this is the case.**

Impedance of Energised Winding			Test Voltage
$1M\Omega$	$\rightarrow$	$100k\Omega$	5V
$100k\Omega$	$\rightarrow$	$10k\Omega$	5V
$10k\Omega$	$\rightarrow$	$1k\Omega$	5V
$1k\Omega$	$\rightarrow$	100Ω	3V
100Ω	$\rightarrow$	10Ω	0.5V
10Ω	$\rightarrow$	1Ω	100mV
1Ω	$\rightarrow$	$100m\Omega$	10mV
$100m\Omega$	$\rightarrow$	$10m\Omega$	1mV

1.24. TRIM - TRIMMING ADJUSTMENT

WHERE USED

TRIM is used on transformers with adjustable or variable components where it is desirable to adjust the transformer at various points within the test program to give specific measured values.

The Trimming Adjustment is placed within the program immediately after a test for the value to be adjusted. It is only actioned if the transformer fails that particular test.

e.g. To trim the inductance of a particular transformer to a specific value, then include TRIM test immediately following an inductance test.

Trimming adjustment can be used with any small signal test such as resistance, inductance and capacitance.

There is no trimming facility for high voltage tests such as MAGI and HIPOT.

TEST LIMITS

Although the TRIM test itself does not have any user specified limits, the Trimming adjustment is carried out using the same test limits as set for the preceding test.

1.25. OUT – OUTPUT TO USER PORT

WHERE USED

OUT is used where additional switching (other than performed by the nodes of the AT) is required for parts of the test program.

The User Port on the tester has associated with it 6 'Relay Driver' outputs. The OUT test allows programming of the User Port relay driver outputs to perform additional relay switching as part of the test program.

An example of this would be an application where a transformer has two separate primary windings. An OUT test could be used to connect them in series, allowing them to be tested as a single primary with twice the working voltage.

A second example is the switching of additional resistors mounted on the test fixture allowing tests to be included in a program on a transformer with a loaded secondary winding.

SPECIFYING TEST CONDITIONS

Relay Driver Outputs

Each of the relay driver outputs (numbered $0 – 5$) is an open collector output which can be set to **On** or **Off** as desired:

> **On = Connected to Gnd (0V)**
>
> **Off = Open circuit (Floating)**

Note:
> The relay drivers are set as and when the tester encounters an OUT test. The settings given will latch until another OUT test is encountered. Therefore if the settings are required for one part of the test program only, 2 OUT tests will be required, 1 to turn the appropriate relay drivers on and 1 to turn them back off.

12 Volt Supply Pin

The user port also provides a 12V output to supply the power to the relays on your test fixture.

For more information see Chapter 8 – Specification.

1.26. IR - INSULATION RESISTANCE

WHERE USED

An Insulation Resistance check is recommended as good practice for most transformers to check the integrity of the insulation between separate windings, or between a winding and a screen.

It is used where winding isolation is a part of the functionality of the transformer, but not part of a safety requirement, for which a Hi-Pot (EHT) test is preferred.

It would therefore be used, for example, between two primary windings, or between two secondary windings.

MEASUREMENT CONDITIONS

To measure insulation resistance, the tester applies a dc voltage between two groups of windings, with the windings in each group being shorted together. Each group may contain as many windings as you wish.

The voltage and current are measured; dividing the voltage by the current gives the insulation resistance.

You can also command the tester to perform a compensation measurement on the empty fixture at the start of a test run. This is recommended as it will allow the tester to subtract the errors due to the fixture from subsequent measurements, to give more accurate results.

The test voltage may be chosen in the range from 100V to 7kV. (500V AT1600)

Normally however, you would perform the test with a voltage just greater than twice the highest possible peak working voltage on the winding. Therefore, for example, to check the isolation between the two primary windings of a line frequency transformer, which could be connected in series and operated at 240V, 800V would be a suitable test signal.

SPECIFYING THE TEST LIMITS

Although the tester is capable of measuring insulation resistance values greater than 1GΩ, there is no need to specify so high a value to check that windings are isolated.

In many cases, specifying a lower value will speed up the execution of the test. A value of 100MΩ is generally suitable for most applications.

1.27. HPDC - DC HI-POT (EHT)

WHERE USED

Hi-Pot or EHT testing (to check for insulation breakdown between windings or between windings and the screen or core) is often specified for power line transformers or for switched mode power transformers in applications where safety is important.

It is typically performed between all primary windings connected together, and all secondary windings plus the screen connected together.

SPECIFYING THE MEASUREMENT

During the test, a dc voltage is applied across two groups of windings with the windings in each group being shorted together. The voltage and current are monitored throughout the dwell time; if either the test voltage cannot be maintained, or the current is too large, then a failure will be recorded.

In programming the tester you may select the voltage (from 100V to 7KVdc), the current trip level (1μA to 1mA), and the ramp up and dwell times, all to suit the specification of the transformer under test.

Many transformer specifications require Hi-Pot testing to be carried out with a dwell time of 60 seconds. Although the transformer must be designed and constructed to meet this, it is common practice to reduce the dwell time for production testing.

This is recognised by IEC 742, which permits a dwell time of 2 seconds for production testing. Although not required by IEC 742, it is good practice to increase the test voltage by, for example, 10% when performing reduced-time testing, to provide additional security for the test.

IEC742 has been replaced by IEC61558, which specifies 1 second for production testing. Details are available on the IEC web-site (http://www.iec.ch).

1.28. HPAC - AC HI-POT (EHT)

WHERE USED

Hi-Pot or EHT testing (to check for insulation breakdown between windings or between windings and the screen or core) is often specified for power line transformers or for switched mode power transformers in applications where safety is important.

It is typically performed between all primary windings connected together, and all secondary windings plus the screen connected together.

SPECIFYING THE MEASUREMENT

During the test, an ac voltage is applied across two groups of windings with the windings in each group being shorted together. The voltage and current are monitored throughout the dwell time; if either the test voltage cannot be maintained, or the current is too large, then a failure will be recorded.

In programming the AT3600 you may select the voltage (from 100V to 5kVrms), the frequency (50Hz / 60Hz at the full voltage, or up to 1kHz at reduced voltage), the current trip level (300µA to 30mApeak), and the ramp up and dwell times, all to suit the specification of the transformer under test.

Many transformer specifications require Hi-Pot testing to be carried out with a dwell time of 60 seconds. Although the transformer must be designed and constructed to meet this, it is common practice to reduce the dwell time for production testing.

This is recognised by IEC 742, which permits a dwell time of 2 seconds for production testing. Although not required by IEC 742, it is good practice to increase the test voltage by say 10% when performing reduced-time testing, to provide additional security for the test.

IEC742 has been replaced by IEC61558, which specifies 1 second for production testing. Details are available on the IEC web-site (http://www.iec.ch).

During a Hi-Pot test, the Wattage is continuously monitored and adjusted to provide the correct output. If the programmed output voltage cannot be maintained, the tester will automatically display 'FAIL', illuminate the red indicator, return a 'FAIL' to the server (if used) and sound a warning buzzer (if enabled). This method complies with the production requirements of EN61558-1 (1998), UL1411, 5th Edition and others.

Special Notes:

Under certain test conditions the measured current will be higher than the allowed minimum limit due to parasitic effects on the AT3600 and any connected fixture system. The maximum parasitic effect created by the AT3600 with every node being used on an HPAC test can be calculated by:

$$I_p = V*(4.614*10^{-10} + 9.1*10^{-11}*f) \text{ where } V = \text{Test voltage and } f = \text{test frequency.}$$

This works out to be 12.5uA **at** 2.5KV @ 50Hz**.**

1.29. SURG - SURGE STRESS TEST

WHERE USED

This test may be used to highlight a short-circuit between adjacent turns in a winding. It is applicable to any transformer, but is particularly suitable for transformers with a large number of turns using very fine wire.

For such wire, the enamel coating is very thin, and there is a danger that it will be scratched, giving rise to exposed copper. In some cases, the scratch does not immediately cause a shorted turn, but will leave a weak spot which may eventually fail.

By applying a higher than normal voltage across the winding, any weakness in wire insulation will be encouraged to fail.

MEASUREMENT METHOD

Each SURG test can be programmed to consist of a number of impulses.

For each impulse, the AT3600 will charge an internal capacitor to the high voltage specified. This stored charge will then be suddenly discharged into the winding-under-test, and the resulting transient voltage will be analysed.

The product from the discharge will be a sinusoidal wave with decaying amplitude.
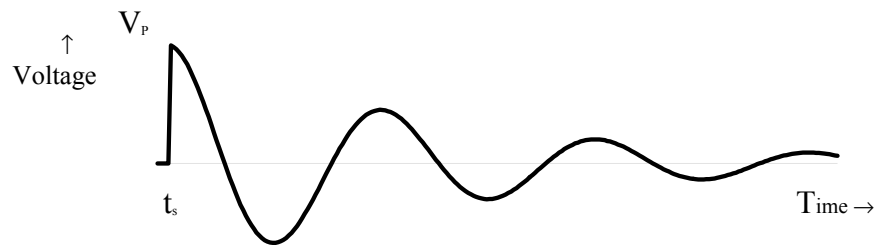
Where t_s =   The time of releasing the impulse

V_P =   The peak voltage just after switch-on

At the start of the surge test, the AT3600 performs an initial run to compensate for the effect of the capacitance of the transformer winding. Without this compensation, the peak voltage would be reduced by charge sharing between the winding capacitance and the reservoir capacitance within the AT3600, and would not be the value you require.

Therefore, the full test sequence is a follows:

Preliminary Impulse: The value of V_P is measured, and the starting conditions changed to compensate for the charge sharing effects.

Impulse #1: The value of V_P is again checked. If it is as specified for the test, this becomes the first impulse of the sequence, and the transient is analysed. (If not it is treated as a second preliminary impulse, and impulse #1 is repeated.)

...: Repeated impulses, up to the number programmed for the test.

Impulse #n: The value of V_P is re-checked, and the transient analysed on each impulse of the sequence.

TRANSIENT ANALYSIS

During the decay phase after the impulse has been fired, the AT3600 measures both the voltage amplitude along the transient, and the time of decay.

A good transformer will have a clean and sustained transient, with a long decay period. A transformer with a shorted turn will have a heavily damped response, with a shorter decay period.

The calculation performed is to calculate the 'area' underneath the graphical plot of the decaying transient. (For the calculation used, both negative peaks and positive peaks add to the total area.) The area, measured in Volts-seconds, is much smaller for the faulty winding with a shorted turn.

SPECIFYING THE TEST LIMITS

It is very difficult to predict the Volts-seconds 'area' under the curve from theoretical calculations.

The recommended method is to use the Measure Mode (see Chapters 3 & 6) to obtain some values. The procedure is as follows:

Measure the area on a known good transformer; let this result be area A_G.

Wrap an additional single turn round the core, short the two ends together, and re-measure the area; let this result be area A_F.

Set the limits as follows:

Max Area $= 3A_G/2$

Min Area $= (A_G + A_F)/2$

Remember that these limits are taken from only one transformer, and may need to be revised after more have been tested.

1.30. WATT - WATTAGE

WHERE USED

The Wattage test is a measure of the input power required to energize a transformer at no load.

A Wattage test is an excellent check on the magnetic quality of the iron core and the magnetic joints and would typically be used with iron core transformers with an operating frequency of around 50Hz.

MEASUREMENT CONDITIONS

During the Wattage test, a constant, user specified ac voltage is applied across the winding in question. All other windings are held open circuit during this test.

The AT3600 measures the voltage across and current through the winding. The Wattage is the product of the in phase components of the current and voltage.

If, in the program, the WATT test follows either a VOC or MAGI test which has the same test conditions (voltage and frequency), and is applied to the same winding, then the measurement results from the previous tests can be re-used, saving program execution time.

The test signal can have a frequency in the range 20Hz to 1.5KHz, and an amplitude from 1V to 270V.

1.31. WATX - WATTAGE (EXTERNAL SOURCE)

WHERE USED

The Wattage test measures the power needed to energise a particular winding, usually the primary, with the remaining windings open circuit. It is usual to configure the test signal to the normal operating conditions of the transformer to determine the power needed to energise the transformer.

This test uses an external source to provide the test signal which must be coupled to the tester via a Voltech AC Source Interface (contact your supplier for details). See the AC Source Interface user manual or the Editor help system for details of how to configure external ac sources for use with an AT3600.

This test is suitable for line frequency transformers (25-400Hz) and checks the no load losses in the transformer.

MEASUREMENT CONDITIONS

During the Wattage (External Source) test, a constant, user specified ac voltage from an external source is applied across the winding in question. All other windings are held open circuit during this test.

The AT3600 measures the voltage across and current through the winding. The Wattage is the product of the in phase components of the current and voltage.

If, in the program, the WATX test follows either a VOCX or MAGX test which has the same test conditions (voltage and frequency), and is applied to the same winding, then the measurement results from the previous tests can be re-used, saving program execution time.

The test signal can have a frequency in the range 20Hz to 5KHz, and an amplitude from 5V to 600V depending on the type of external source used. The current rating of a single AC Source Interface is 10A rms. See also the WATT test which uses the AT3600s internal generator which can provide up to 270V ac at 40W.

1.32. STRW – STRESS WATTS

WHERE USED

The Stress Wattage test tests the transformer for breakdown of insulation by measurement of the energising power of a winding, usually the primary, with the remaining windings open circuit. This test applies the voltage, usually twice the normal operating voltage, and continually measures the power to determine any breakdown by changes in the measurement.

This test is suitable for sub-miniature line frequency, large line frequency bobbin wound and some HF transformers. It checks the integrity of interturn insulation, the magnetic material and joints.

MEASUREMENT CONDITIONS

A constant voltage source is applied to the winding under test. Both the rms voltage and the power are measured. If necessary, the voltage can is trimmed to the user specified value, and the measurement repeated. The measurement is repeated many times until the dwell time has elapsed. The result given is the measured power.

Usually, the energization is at twice the working voltage and frequency, and has the purpose of trying to create an inter-turn breakdown at a point of potential weakness in the wire enamel. This breakdown is detected by an increase in the measured power.

1.33. STRX – STRESS WATTS (EXTERNAL SOURCE)

WHERE USED

The Stress Watts (External Source) test tests the transformer for breakdown of winding insulation by measurement of the energising power of a winding, usually the primary, with the remaining windings open circuit. This test applies the voltage from an external ac source (usually at twice the normal operating voltage and frequency), and measures the power drawn.

This test uses an external source to provide the test signal which must be coupled to the tester via a Voltech AC Source Interface (contact your supplier for details). See the AC Source Interface user manual or the Editor help system for details of how to configure external ac sources for use with an AT3600.

This test is suitable for large line frequency bobbin wound and some HF transformers. It checks the integrity of inter-turn insulation, the magnetic material and joints at higher than the normal operating voltage.

MEASUREMENTS CONDITIONS

A constant voltage (supplied by an external source) is applied to the winding under test. Both the rms voltage and the power are measured. If necessary (and depending on the source type used), the voltage can be trimmed to the user specified value, and the measurement repeated. The measurement is repeated many times until the dwell time has elapsed. The result given is the measured power.

The test can detect winding insulation defects in the following way:

1. The winding insulation is stressed by the use of the increased voltage (increased volts per turn).

2. Increasing the frequency in proportion to the voltage increase ensures that the magnetic core of the transformer is exercised over the same area as it would be at the normal operating voltage and frequency. - The core losses remain the same.

3. A significant increase in the power drawn when tested at increased voltage and frequency indicates a failure of the winding insulation that would not be detected at normal operating conditions.

The test signal can have a frequency in the range 20Hz to 5KHz, and an amplitude from 5V to 600V depending on the type of external source used. The current rating of a single AC Source Interface is 10A rms. See also the STRW test which uses the AT3600s internal generator which can provide up to 270V ac at 40W.

1.34. MAGI - MAGNETIZING CURRENT

WHERE USED

The AT3600 offers two basic alternative ways to confirm that the transformer has been assembled properly, with the appropriate number of primary and secondary turns, the right grade of magnetic material for the core, and the correct air gap if required.

Magnetising current and open circuit voltage are the preferred tests for line frequency transformers, designed to operate over the full extent of the B-H curve, including the non-linear regions.

(For other transformers, such as pulse transformers and those used in switched mode power supplies, inductance and turns ratio are the preferred tests.)

MEASUREMENT CONDITIONS

When measuring magnetising current, you should normally program the test to apply the highest working voltage at the lowest working frequency to the primary winding.

In the case of a transformer with a split primary, the test can be conducted equally well by energising just one of the primary windings, as opposed to the two in series. The expected current will be greater for the single winding, rising in proportion to the turns ratio:

$$I_A = I_{AB} \; x \; (N_{AB} / N_A)$$

where

I_A = The current to be specified when testing with winding A

I_{AB} = The current for windings A and B in series

N_A = The number of turns on winding A

N_{AB} = The number of turns on A and B in series

(As an alternative, the formula above can be written using the voltage ratio between the two windings, rather than the turns ratio.)

In principle, you may measure the magnetising current using any winding, or any series combination of windings, with the current limit adjusted according to the formula above, because the Ampere-turns required to magnetise a transformer to a given flux level is independent of which winding is used.

In practice, the magnetising current waveform may have a transient component following the switch-on of the test voltage. To give you repeatable accurate results, the measurement does not start until any transient has settled. In addition, to give you the quickest test execution time, the AT3600 uses a switch-on sequence which minimises such transient effects.

SPECIFYING THE TEST LIMITS

The AT3600 offers you two ways to specify the test limits:

Using a true rms measurement

Using a mean-sense measurement, which is scaled to rms for sinewaves.

Generally the rms value would be used.

However, you may wish to use the second method if, for example, your test limits have been established by a previous measurement on a low cost multimeter which uses this technique.

1.35. MAGX - MAGNETIZING CURRENT (EXTERNAL SOURCE)

WHERE USED

The AT3600 offers two basic alternative ways to confirm that the transformer has been assembled properly, with the appropriate number of primary and secondary turns, the right grade of magnetic material for the core, and the correct air gap if required.

Magnetising current and open circuit voltage are the preferred tests for line frequency transformers, designed to operate over the full extent of the B-H curve, including the non-linear regions.

(For other transformers, such as pulse transformers and those used in switched mode power supplies, inductance and turns ratio are the preferred tests.)

This version of the MAGI test uses an external source to provide the test signal which must be coupled to the tester via a Voltech AC Source Interface (contact your supplier for details). See the AC Source Interface user manual or the Editor help system for details of how to configure external ac sources for use with an AT3600.

MEASUREMENT CONDITIONS

When measuring magnetising current, you should normally program the test to apply the highest working voltage at the lowest working frequency to the primary winding.

In the case of a transformer with a split primary, the test can be conducted equally well by energising just one of the primary windings, as opposed to the two in series. The expected current will be greater for the single winding, rising in proportion to the turns ratio:

$$I_A = I_{AB} \times (N_{AB} / N_A)$$

where

I_A = The current to be specified when testing with winding A

I_{AB} = The current for windings A and B in series

N_A = The number of turns on winding A

N_{AB} = The number of turns on A and B in series

(As an alternative, the formula above can be written using the voltage ratio between the two windings, rather than the turns ratio.)

In principle, you may measure the magnetising current using any winding, or any series combination of windings, with the current limit adjusted according to the formula above, because the Ampere-turns required to magnetise a transformer to a given flux level is independent of which winding is used.

In practice, the magnetising current waveform may have a transient component following the switch-on of the test voltage. To give you repeatable accurate results, the measurement does not start until any transient has settled.

The test signal can have a frequency in the range 20Hz to 5KHz, and an amplitude from 5V to 600V depending on the type of external source used. The current rating of a single AC Source Interface is 10A rms. See also the MAGI test which uses the AT3600s internal generator which can provide up to 270V ac at 40W.

1.36. VOC - OPEN CIRCUIT VOLTAGE

WHERE USED

The AT3600 offers two basic alternative ways to confirm that the transformer has been assembled properly, with the appropriate number of primary and secondary turns.

Open circuit voltage measurements are the preferred tests for line frequency transformers, designed to operate over the full extent of the B-H curve, including the non-linear regions.

(For other transformers, such as pulse transformers and those used in switched mode power supplies, a measurement of turns ratio is the preferred test.)

Clearly an open circuit voltage test cannot tell you the actual number of turns on a winding, only the ratio between one winding and the next. You should therefore also include a magnetising current test in your program, to give confidence that the absolute number of turns is correct as well as the ratio.

MEASUREMENT CONDITIONS

Open circuit voltage is measured by applying an ac test voltage to a selected winding (usually a primary winding), and measuring the resulting voltage produced on another winding.

If, there are several windings to be tested, the program will execute more quickly if the following points are observed:

Place all the open circuit voltage (VOC) tests consecutively at the same point in the program.

Use the same energised winding, with the same test voltage and frequency for each test.

If there is a magnetising current (MAGI) test which has the same energised winding and the same test voltage and frequency, place this immediately before the first open circuit voltage test.

SPECIFYING THE TEST LIMITS

The AT3600 offers you three ways to specify the test limits:

Using a normal AC (rms) measurement.

Using a rectified (mean) measurement.

Using a DC (mean) measurement.

Generally, the AC (rms) value would be used, but you could use the rectified (mean) or DC (mean) measurements if, for example, you are testing transformers fitted with a rectifying diode.

To give the best accuracy, the DC measurement is averaged over the period of the energization frequency.

In addition, the VOC test can be used to test the polarity (or phasing) of the windings, if this is required.

1.37. VOCX - O/C VOLTAGE (EXTERNAL SOURCE)

WHERE USED

The AT3600 offers two basic alternative ways to confirm that the transformer has been assembled properly, with the appropriate number of primary and secondary turns.

Open circuit voltage measurements are the preferred tests for line frequency transformers, designed to operate over the full extent of the B-H curve, including the non-linear regions.

(For other transformers, such as pulse transformers and those used in switched mode power supplies, a measurement of turns ratio is the preferred test.)

Clearly an open circuit voltage test cannot tell you the actual number of turns on a winding, only the ratio between one winding and the next. You should therefore also include a magnetising current test (MAGI or MAGX) in your program, to give confidence that the absolute number of turns is correct as well as the ratio.

This version of the VOC test uses an external source to provide the test signal which must be coupled to the tester via a Voltech AC Source Interface (contact your supplier for details). See the AC Source Interface user manual or the Editor help system for details of how to configure external ac sources for use with an AT3600.

MEASUREMENT CONDITIONS

Open circuit voltage is measured by applying an ac test voltage (supplied by an external source) to a selected winding (usually a primary winding), and measuring the resulting voltage produced on another winding.

If, there are several windings to be tested, the program will execute more quickly if the following points are observed:

Place all the open circuit voltage (VOCX) tests consecutively at the same point in the program.

Use the same energised winding, with the same test voltage and frequency for each test.

If there is a magnetising current (MAGX) test which has the same energised winding and the same test voltage and frequency, place this immediately before the first open circuit voltage test.

The test signal can have a frequency in the range 20Hz to 5KHz, and an amplitude from 5V to 600V depending on the type of external source used. The current rating of a single AC Source Interface is 10A rms. See also the MAGI test which uses the AT3600s internal generator which can provide up to 270V ac at 40W.

SPECIFYING THE TEST LIMITS

The AT3600 offers you three ways to specify the test limits:

Using a normal AC (rms) measurement.

Using a rectified (mean) measurement.

Using a DC (mean) measurement.

Generally, the AC (rms) value would be used, but you could use the rectified (mean) or DC (mean) measurements if, for example, you are testing transformers fitted with a rectifying diode.

To give the best accuracy, the dc measurement is averaged over the period of the energization frequency.

In addition, the VOCX test can be used to test the polarity (or phasing) of the windings, if this is required. This is not available when some types of external source.

1.38. LVOC – LOW VOLTAGE OPEN CIRCUIT

Measurement Range	Test Voltage	Test Frequency	Basic Accuracy
100μV to 650V	1mV to 5V	20Hz to 3MHz	0.1%
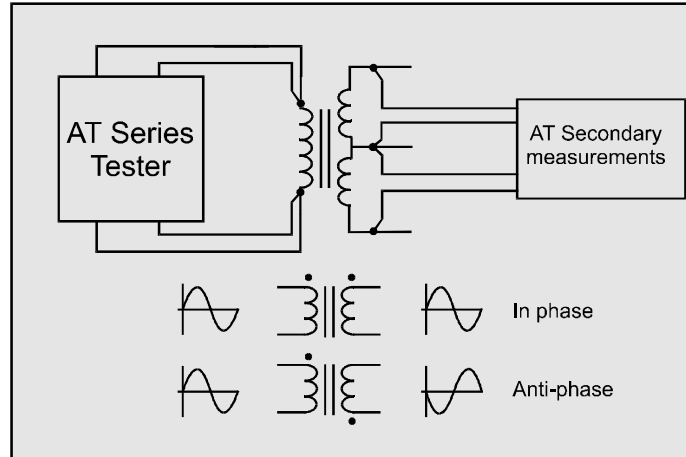
Where used

The low voltage open circuit test is used to confirm that windings have the correct ratio of turns between them, and that the phasing of the windings is correct. This test is used for signal, pulse and switched mode power transformers where the normal operating conditions require only small excursions of the B-H curve, never extending beyond the linear region. On the AT3600 only, a high voltage open circuit test is available for testing line frequency transformers at their operating point (up to 270V, 1kHz and 2A). See also the test TR – turns ratio.

Measurement conditions

To measure low voltage open circuit, the test signal is applied to one winding called the energized winding. The voltages across another winding (or the same, energized winding) is measured. The low voltage open circuit measurement is the rms value of the voltage measured and can be an ac or a dc voltage.

It is recommended that you choose the winding with the highest number of turns as the one to be energised.

Choosing test conditions

The recommended test conditions depend on the inductance of the energised winding; they are given in the table below assuming that the energised winding is the one with the highest number of turns:

Inductance of the Energised Winding			Preferred test signal	
			Frequency	Voltage
100nH	→	1μH	300kHz	10mV
1uH	→	10μH	100kHz	30mV
10uH	→	100μH	30kHz	50mV
100uH	→	1mH	10kHz	100mV
1mH	→	10mH	1kHz	100mV
10mH	→	100mH	100Hz	100mV
100mH	→	1H	100Hz	300mV
1H	→	10H	50Hz	1V
10H	→	100H	50Hz	5V
100H	→	1kH	50Hz	5V
1kH	→	10kH	20Hz	5V

The test conditions can also be determined automatically by the AT3600 according to this table:

Voltage	Specified	Auto	Auto
Frequency	Specified	Specified	Auto

Note that a 'fixed' voltage signal cannot be used with an 'Auto' frequency.

1.39. ILK – LEAKAGE CURRENT TEST

WHERE USED

The leakage current test is needed for transformers used in certain applications, mainly medical, where it is an additional safety requirement.

MEASUREMENT CONDITIONS

The test is typically carried out by applying the test voltage between all the primary terminals shorted together, and all the secondary terminals and screen shorted together.

The voltage and frequency applied are normally the operating voltage and frequency of the transformer.

1.40. LSBX – Inductance with External Bias (Series Circuit)

DC Bias	Measure Range	Test Voltage	Test Frequency	Basic Accuracy
0.1A to 250A	1nH 1MH	1mV to 5V	20Hz to 3MHz	0.2% @ Q>10

This test requires the use of one or more Voltech DC1000 Precision DC Bias Current Sources. Contact your Voltech sales office for details.

The inductance of a transformer winding while an external bias current is flowing through it may be tested using series or parallel equivalent circuit models. Initially the DC bias current is set up and allowed to stabilize. An AC voltage is applied across the selected winding; the voltage across and current through the winding is then measured using harmonic analysis. The measured voltage is divided by the current to obtain a complex impedance and the inductance is calculated.

1.41. LPBX – Inductance with External Bias (Parallel Circuit)

DC Bias	Measure Range	Test Voltage	Test Frequency	Basic Accuracy
0.1A to 250A	1nH 1MH	1mV to 5V	20Hz to 3MHz	0.2% @ Q>10

This test requires the use of one or more Voltech DC1000 Precision DC Bias Current Sources. Contact your Voltech sales office for details.

The inductance of a transformer winding while an external bias current is flowing through it may be tested using series or parallel equivalent circuit models. Initially the DC bias current is set up and allowed to stabilize. An AC voltage is applied across the selected winding; the voltage across and current through the winding are then measured using harmonic analysis. The measured voltage is divided by the current to obtain a complex impedance and the inductance is calculated.

1.42. ZBX - Impedance with External Bias

DC Bias	Measurement Range	Test Voltage	Test Frequency	Basic Accuracy
0.1A to 250A	1mΩ to 1MΩ	1mV to 5V	20Hz to 3MHz	0.2%

This test requires the use of one or more Voltech DC1000 Precision DC Bias Current Sources. Contact your Voltech sales office for details.

The Winding Impedance with External Bias test measures the impedance of a selected winding while applying a DC current from the DC1000 through the winding. An AC voltage is also applied across the winding from the AT.

This test can be used with inductors to measure the change in impedance with a bias current.

1.43. ACRT - AC HI-POT RAMP

WHERE USED

Hi-Pot Ramp testing (to check for insulation breakdown between windings or between windings and the screen or core) is often specified for power line transformers or for switched mode power transformers in applications where safety is important.

It is typically performed between all primary windings connected together, and all secondary windings plus the screen connected together.

SPECIFYING THE MEASUREMENT

During the test, an ac target voltage is applied across two groups of windings with the windings in each group being shorted together. The voltage and current are monitored throughout the ramp time.

In programming the AT3600 you may select the voltage (from 100V to 5.5kVrms), the frequency (50Hz / 60Hz at the full voltage, or up to 1kHz at reduced voltage), the current trip level (10µA to 5mApeak), and the ramp up times (1 to 30sec), all to suit the specification of the transformer under test.

The purpose is to check the safety isolation between windings, windings and core, or windings and screens, measuring the voltage at which a user specified current is exceeded, by ramping to a maximum user specified voltage at a user specified frequency.

The operation is to ramp up the test voltage while measuring the voltage across the selected terminals and continually monitor the current to check it is below the test limit.

If target voltage is reached before and the maximum monitored current is met the test has "Passed".

If the maximum monitored current is met before the target voltage is reached the test has "Failed".

1.44. DCAT - DC HI-POT RAMP

WHERE USED

Hi-Pot Ramp testing (to check for insulation breakdown between windings or between windings and the screen or core) is often specified for power line transformers or for switched mode power transformers in applications where safety is important.

It is typically performed between all primary windings connected together, and all secondary windings plus the screen connected together.
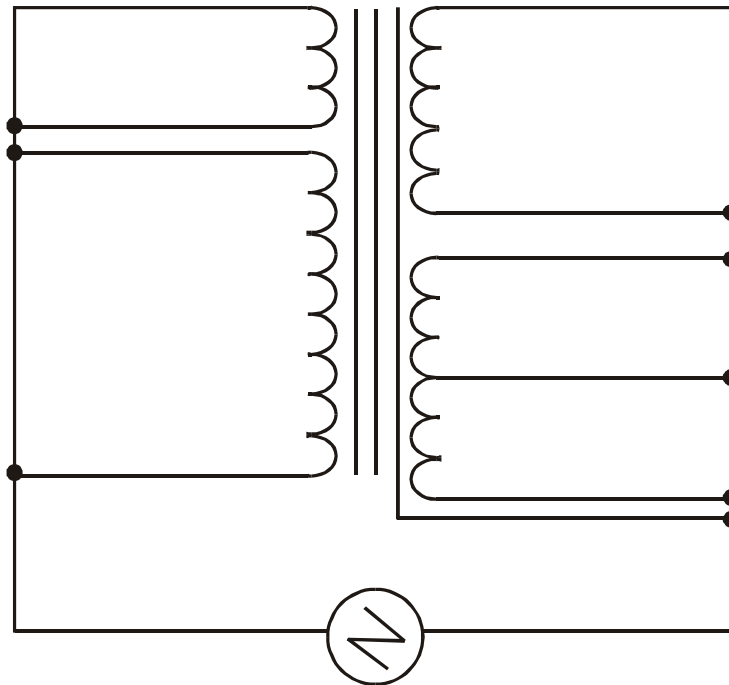
SPECIFYING THE MEASUREMENT

During the test, a dc target voltage is applied across two groups of windings with the windings in each group being shorted together. The voltage and current are monitored throughout the ramp time.

In programming the tester you may select the voltage (from 100V to 7KVdc), the current trip level (1μA to 3mA), and the ramp up times (1 to 2sec), all to suit the specification of the transformer under test.

The purpose is to check the safety isolation between windings, windings and core, or windings and screens, measuring the voltage at which a user specified current is exceeded, by ramping to a maximum user specified voltage at a user specified frequency.

The operation is to ramp up the test voltage while measuring the voltage across the selected terminals and continually monitor the current to check it is below the test limit.

If target voltage is reached before and the maximum monitored current is met the test has "Passed".

If the maximum monitored current is met before the target voltage is reached the test has "Failed".

CHAPTER 8 - SPECIFICATION

TABLE OF CONTENTS

This chapter will provide all specification and technical details for your AT3600 tester.

1. SPECIFICATION

1.1. SPECIFICATION SUMMARY - AVAILABLE TESTS

Test		User Entered Test Data								$A_R^{(1)}$
		Measurement Range			Test Signal			Test Frequency[4]		
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[2]	0.1%
VOC	Open Circuit Voltage	100μV	to	650V[3]	1V	to	270V	20Hz	to 1500Hz	0.1%
VOCX	O/C Voltage (External Source)	100μV	to	650V[3]	1V	to	600V	20Hz	to 5kHz[2]	0.1%
LVOC	Low Voltage Open Circuit	100μV	to	650V[3]	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	10mA[4]	100V	to	5KV	50Hz	to 1kHz	3.0%
LSB	Inductance with Bias (Series)	1nH	to	1MH	1mV	to	5V	20Hz	to 3MHz	0.05%
	DC Bias				1mA	to	400mA			
LPB	Inductance with Bias (Parallel)	1nH	to	1MH	1mV	to	5V	20Hz	to 3MHz	0.05%
	DC Bias				1mA	to	400mA			

Specification summary continued over.

| Test | | User Entered Test Data | | | | | | | | $A_R^{(1)}$ |
		Measurement Range			Test Signal			Test Frequency[5]		
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[2]	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[2]	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%
LSBX	Inductance with External Bias (Series) DC Bias	1nH	to	1MH	1mV 1mA	to to	5V 400mA	20Hz	to	3MHz	0.05%
LPBX	Inductance with External Bias (Parallel) DC Bias	1nH	to	1MH	1mV 1mA	to to	5V 400mA	20Hz	to	3MHz	0.05%
ZBX	Impedance, Impedance +External bias	1mΩ	to	1MΩ	1mV	to	5V	20Hz	to	3MHz	0.2%
ACRT	Hi-Pot Ranp (AC)	10μA	to	5mA[4]	100V	to	5.5KV	50Hz	to	1kHz	3.0%
DCRT	Hi-Pot Ramp (DC)	1μA	to	3mA	100V	to	7KV		n/a		3.2%

Notes:

1. A_R = The basic relative accuracy (see over 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 +/-10% of the requested value.

1.2. ACCURACY SPECIFICATIONS – AVAILABLE TESTS

R TEST

The accuracy is based on the test conditions chosen to measure the winding resistance, and is given as:

$$A_T = A_R + A_C + A_V + A_I$$

where

A_T is the total accuracy (%)
A_R is the basic relative accuracy (%)
A_C is the calibration accuracy (%)
A_V is the correction for voltage level (%)
A_I is the correction for current level (%)

The value of A_R is given in the table in section 1.1 of this chapter.

The values of the other factors are given below.

$$A_C = 0.2\%$$
$$A_V = 0.03\% + (0.01\% / V_M)$$
$$A_I = 0.03\% + (0.01\% / I_M)$$

where

V_M is the measured voltage (V)
I_M is the measured current (A)

LS, LP, RLS, RLP, LL, LLO AND C TESTS

The accuracy is based on the test conditions chosen to measure the impedance of the parameter under test, and is given as:

$$A_T = A_R + A_C + A_V + A_I + A_Q$$

where

A_T is the total accuracy (%)
A_R is the basic relative accuracy (%)
A_C is the calibration accuracy (%)
A_V is the correction for voltage level (%)
A_I is the correction for current level (%)
A_Q is the correction for Q factor (%)

The value of A_R is given in the table in section 1.1 of this chapter.

The values of the other factors are given below.

$$A_C = 0.08\% + (0.00001\% \times F_M)$$

$$A_V = 0.08\% + (0.001\% / V_M)$$

$$A_I = 0.08\% + (0.0001\% / I_M)$$

$$A_Q = 0.08\% + (2\% / Q_M) \quad \text{(LS, LP, LL and C)}$$

$$A_Q = 0.08\% + (2\% \times Q_M) \quad \text{(RLS and RLP)}$$

where

F_M is the measurement frequency (Hz)
V_M is the measured voltage (V)
I_M is the measured current (A)
Q_M is the Q factor of the measured impedance

QL AND D TESTS

The accuracy of measuring Q factor and D factor is given as:

$$A_T = A_R + A_I + A_{QD}$$

where

A_T	is the basic total accuracy (%)
A_R	is the basic relative accuracy (%)
A_I	is the correction for current level (%)
A_{QD}	is the correction for Q or D factor (%)

The value of A_R is given in the table in section 1.1 of this chapter.
The values of the other factors are given below:

A_I	$= 0.08\% + (0.0001\%/Im)$	
A_{QD}	$= 0.2\% \times (Q_M + (1/Q_M))$	(Q factor)
A_{QD}	$= 0.2\% \times (D_M + (1/D_M))$	(D factor)

where:

Q_M	is the Q factor of the measured impedance
D_M	is the D factor of the measurement impedance
I_M	is the measured current (A)

TR TEST

The accuracy is based on the test conditions chosen to measure the turns ratio, and is given as:

$$A_T \quad = A_R + A_C + A_{PV} + A_{SV} + A_N$$

where

A_T is the total accuracy (%)
A_R is the basic relative accuracy (%)
A_C is the calibration accuracy (%)
A_{PV} is the correction for primary voltage level (%)
A_{PS} is the correction for secondary voltage level (%)
A_N is the correction for the turns ratio value (%)

The value of A_R is given in the table in section 1.1. of this chapter.

The values of the other factors are given below.

$A_C \quad = 0.1\% + (0.00003\% \text{ x } F_M)$
$A_{PV} = 0.1\% + (0.01\% / V_{PM})$
$A_{SV} = 0.1\% + (0.01\% / V_{SM})$
$A_N \quad = 0.1\% + (0.1 / N_M)$

where

F_M is the measurement frequency (Hz)
V_{PM} is the measured primary voltage (V)
V_{SM} is the measured secondary voltage (V)
N_M is the measured turns ratio (primary / secondary)

TRL TEST

The accuracy for the test is given as:

$$A_T \quad = \quad A_P + A_S$$

where:

A_T is the total accuracy (%).
A_P is the accuracy of the primary winding measurement (%).
A_S is the accuracy of the secondary winding measurement (%).

To determine the values of A_P and A_S use the accuracy specification for series inductance.

MAGI TEST

The accuracy for the test voltage is given by:

$$A(V_{TEST}) = 1\%$$

The accuracy for measuring magnetizing current is given as:

$$A_T \quad = A_R + A_C + A_I$$

where

A_T is the total accuracy (%)
A_R is the basic relative accuracy (%)
A_C is the calibration accuracy (%)
A_I is the correction for current level (%)

The value of A_R is given in the table in section 1.1 of this chapter.

The values of the other factors are given below.

$$A_C \quad = 0.03\% + (0.001\% \times F_M)$$

$$A_I \quad = 0.03\% + (0.0001\% / I_M) + (2\% \times I_M)$$

where

F_M is the measurement frequency (Hz)
I_M is the measured current (A)

MAGX TEST (EXTERNAL SOURCE)

The accuracy for measuring magnetising current using an external source is:

$$A_T = A_R + A_C + A_I + A_{OFF} + A_{ESI} + A_{SRCE}$$

Where

A_T is the total accuracy (%)
A_R is the basic relative accuracy (%)
A_C is the calibration accuracy (%)
A_I is the correction for the current level (%)
A_{OFF} is the error in the compensation measurement (%)
A_{ESI} is the error in the current measurement from the source interface (%)
A_{SRCE} is the correction for the external source type (%)

The value of A_R is given in the table in section 1.1 of this chapter

A_C $= 0.03\% + (0.001 * F_M)$
A_I $= 0.03\% + (0.0001 / I_M) + (2 * I_M)$
A_{OFF} $= (0.76\% + (0.001 * F_M)) * (0.3 / I_M)$
A_{ESI} $= 0.5\%$
A_{SRCE} $= 0.5\%$ for manual / line supply
           $= 0.0\%$ for analogue / amplifier and AT output transformer

F_M is the test frequency (Hz)
I_M is the measured current (A)

During a MAGX test, the AT3600 automatically applies the test voltage to the part under test and checks that the voltage has stabilised before recording measurements. The time that the voltage takes to stabilise will vary with the source type used and the nature of the part under test.

In general (and especially for source types 'Programmable' and 'AT Output Transformer'), the AT3600 will record a measurement very quickly, (typically in less than 0.5 seconds) which is desirable in a production test environment.

If the measurement were to be recorded after a longer period of time under power, slightly different readings may be obtained due to self-heating effects in the part under test. This effect may be noticed when comparing results taken using different source types or with slower measurement systems.

VOC TEST

The accuracy for measuring open circuit voltage is given as:

$$A_T = A_R + A_C + A_V$$

where

A_T is the total accuracy (%)
A_R is the basic relative accuracy (%)
A_C is the calibration accuracy (%)
A_V is the correction for voltage level (%)

The value of A_R is given in the table in section 1.1 of this chapter

The values of the other factors are given below.

$$A_C = 0.03\% + (0.001\% \ \times \ F_M)$$
$$A_V = 0.03\% + (0.001\% \ / \ V_M)$$

where

F_M is the measurement frequency (Hz)
V_M is the measured voltage (V)

VOCX TEST (EXTERNAL SOURCE)

The accuracy for measuring open circuit voltage is given as:

$$A_T = A_R + A_C + A_V + A_{SRCE}$$

where

A_T	is the total accuracy (%)
A_R	is the basic relative accuracy (%)
A_C	is the calibration accuracy (%)
A_V	is the correction for voltage level (%)
A_{SRCE}	is the correction for the external source type (%)

The value of A_R is given in the table in section 1.1 of this chapter

The values of the other factors are given below.

$$A_C = 0.03\% + (0.001\% \times F_M)$$
$$A_V = 0.03\% + (0.001\% / V_M)$$
$$A_{SRCE} = 0.5\% \text{ for manual / line supply}$$
$$= 0.0\% \text{ for analogue / amplifier and AT output transformer}$$

where

F_M	is the measurement frequency (Hz)
V_M	is the measured voltage (V)

During a VOCX test, the AT3600 automatically applies the test voltage to the part under test and checks that the voltage has stabilised before recording measurements. The time that the voltage takes to stabilise will vary with the source type used and the nature of the part under test.
In general (and especially for source types 'Programmable' and 'AT Output Transformer'), the AT3600 will record a measurement very quickly, (typically in less than 0.5 seconds) which is desirable in a production test environment.
If the measurement were to be recorded after a longer period of time under power, slightly different readings may be obtained due to self-heating effects in the part under test. This effect may be noticed when comparing results taken using different source types or with slower measurement systems.

LVOC TEST

The accuracy for measuring open circuit voltage is given as:

$$A_T = A_R + A_C + A_V$$

where

A_T is the total accuracy (%)

A_R is the basic relative accuracy (%)

A_C is the calibration accuracy (%)

A_V is the correction for voltage level (%)

The value of A_R is given in the section 1.1 of this chapter.

The values of the other factors are given below.

$$A_C = 0.03\% + 0.001\% \times F_M$$

$$A_V = 0.03\% + 0.001\% \big/ V_M$$

where

F_M is the measurement frequency (Hz)

V_M is the measured voltage (V)

IR TEST

The accuracy is based on the test conditions chosen to measure the insulation resistance, and is given as:

$$A_T = A_R + A_C + A_I + A_Z$$

where

A_T	is the total accuracy (%)
A_R	is the basic relative accuracy (%)
A_C	is the calibration accuracy (%)
A_I	is the correction for current level (%)
A_Z	is the correction for impedance level (%)

The value of A_R is given in the table in section 1.1 of this chapter.

The values of the other factors are given below.

$$A_C = 0.03\%$$

$$A_I = 3.2\% + (0.000002\% / I_M)$$

$$A_Z = 0.5\% + (0.001\% \times Z_M)$$

where

I_M	is the measured current (A)
Z_M	is the measured IR value (MΩ)

HPDC TEST

The accuracy for the test voltage is given by:

$$A(V_{TEST}) = 3\%$$

The accuracy for the peak current detection is given by:

$$A_T = A_R + A_C + A_I$$

where

    A_R is the basic relative accuracy (%)
    A_T is the total accuracy (%)
    A_C is the calibration accuracy (%)
    A_I is the correction for current level (%)

$$A_C = 0.03\%$$

$$A_I = 0.00006\% / I_M$$

where

    I_M is the measured current (A)

HPAC TEST

The accuracy for the test voltage is given by:

$$A(V_{TEST}) = 3\%$$

The accuracy for the peak current detection is given by:

$$A_T = A_R + A_C + A_I$$

where

    A_R is the basic relative accuracy (%)
    A_T is the total accuracy (%)
    A_C is the calibration accuracy (%)
    A_I is the correction for current level (%)

$$A_C = 0.03\%$$

$$A_I = 0.003\% / I_M$$

where

    I_M is the measured current (A)

Special Notes:

Under certain test conditions the measured current will be higher than the allowed minimum limit due to parasitic effects on the AT3600 and any connected fixture system. The maximum parasitic effect created by the AT3600 with every node being used on an HPAC test can be calculated by:

$$I_p = V*(4.614*10^{-10} + 9.1*10^{-11}*f) \text{ where } V = \text{Test voltage and } f = \text{test frequency.}$$

This works out to be 12.5uA at 2.5KV @ 50Hz.

LSB AND LPB TESTS

The accuracy for measuring inductance with bias is given as:
The accuracy is based on the test conditions chosen to measure the impedance of the parameter under test, and is given as:

$$A_T = A_R + A_C + A_V + A_I + A_Q$$

where

A_T	is the total accuracy (%)
A_R	is the basic relative accuracy (%)
A_C	is the calibration accuracy (%)
A_V	is the correction for voltage level (%)
A_I	is the correction for current level (%)
A_Q	is the correction for Q factor (%)

The value of A_R is given in the table in section 1.1. of this chapter.

The values of the other factors are given below.

$$A_C = 0.08\% + (0.00001\% \times F_M)$$

$$A_V = 0.08\% + (0.001\% / V_M)$$

$$A_I = 0.08\% + (0.0001\% / I_M) + (0.03\% \times (I_B / I_M))$$

$$A_Q = 0.08\% + (2\% / Q_M)$$

where

F_M	is the measurement frequency (Hz)
V_M	is the measured voltage (V)
I_M	is the measured current (A)
Q_M	is the Q factor of the measured impedance
I_B	is the bias current (A)

WATT AND STRW TESTS

The accuracy for the test voltage is given by:

$$A(V_{TEST}) = 2\%$$

The accuracy for the wattage measurement is given by:

$$A_T = A_R + A_C + A_V + A_I + A_P$$

where

A_R is the basic relative accuracy (%)
A_T is the total accuracy (%)
A_C is the calibration accuracy (%)
A_V is the correction for voltage level (%)
A_I is the correction for current level (%)
A_P is the correction for power factor (%)

$$A_C = 0.01\% \ / \ (F_M + 0.01)$$

$$A_V = 0.05\% \ + (0.0001\% \ / \ V_M)$$

$$A_I = 0.05\% \ + (0.000002\% \ / \ I_M)$$

$$A_P = 1\% \times \left(\sqrt{(1 - PF^2)} \ / \ PF \right)$$

where

F_M is the test frequency (kHz)
V_M is the measured voltage (V)
I_M is the measured current (A)
PF is the power factor of the load

$$PF = W \ / \ VA$$

where

W   is the measured wattage (W)
VA   is the product of the test voltage and magnetising current

WATX AND STRX TESTS (EXTERNAL SOURCE)

The accuracy for the measurement is given by:

$$A_T = A_{MAGX} + A_{VOCX} + A_P$$

Where:

A_T	is the total accuracy (%)
A_{MAGX}	is the accuracy for the current measurement (see MAGX specification) (%)
A_{VOCX}	is the accuracy for the voltage measurement (see VOCX specification) (%)
A_P	is the correction for the power factor (%)

and

$$A_P = (1 + 0.0007 * F_M) * (\sqrt{(1 - PF^2)} / PF)$$

where

PF	is the power factor of the load. (PF = W / VA)
F_M	is the measurement frequency (Hz)

When performing either of the above tests, the AT3600 automatically applies the test voltage to the part under test and checks that the voltage has stabilised before recording measurements. The time that the voltage takes to stabilise will vary with the source type used and the nature of the part under test.

In general (and especially for source types 'Programmable' and 'AT Output Transformer'), the AT3600 will record a measurement very quickly, (typically in less than 0.5 seconds) which is desirable in a production test environment.

If the measurement were to be recorded after a longer period of time under power, slightly different readings may be obtained due to self-heating effects in the part under test. This effect may be noticed when comparing results taken using different source types or with slower measurement systems.

SURG TEST

The accuracy of the Volts-seconds 'area' under the curve of the decaying transient curve is based on the chosen test conditions, and is given as:

$$A_T \quad = A_R + A_C + A_V$$

where

A_R is the basic relative accuracy (%)
A_T is the total accuracy (%)
A_C is the calibration accuracy (%)
A_V is the correction for voltage level (%)

The values of the factors are given below.

$$A_C \quad = 3\%$$

$$A_V \quad = 2\% + (250\% \ / \ V_P) + (0.001\% \ \times V_P)$$

where

V_P is the peak voltage of the transient (V)

L2, C2 AND R2 TESTS

The accuracy is dependant on the accuracy of the two inductance or capacitance measurements made, and is given as:

$$A_T \quad = A_X + A_Y$$

where

A_T is the total accuracy (%)
A_X is the accuracy of the X measurement (%)
A_Y is the accuracy of the Y measurement (%)

Refer to the accuracy specifications for the LS, C and R tests to determine the accuracy of the X and Y measurements.

GBAL TEST

The accuracy is based on the test conditions chosen to measure the longitudinal balance of the transformer under test, and is given as:

$$A_T = A_R + 0.87(A_C + A_{VX} + A_{VY})$$

where

A_T	is the total accuracy (dB)
A_R	is the basic relative accuracy (dB)
A_C	is the correction for calibration
A_{VX}	is the correction for the X measurement voltage level
A_{VY}	is the correction for the Y measurement voltage level

The value of A_R is given in the table in section 1.1 of this chapter

The values of the other factors are given below.

$$A_C = 0.1 + (0.0000001\% \times F_M)$$

$$A_{VX} = (0.001 + \Delta V_{CMNX}) / V_{MX}$$

$$A_{VY} = (0.001 + \Delta V_{CMNY}) / V_{MY}$$

where

F_M	is the measurement frequency (Hz)
V_{MX}	is the measured voltage for the X measurement (V)
V_{MY}	is the measured voltage for the Y measurement (V)
ΔV_{CMNX}	is the error due to the common mode voltage in the X measurement
ΔV_{CMNY}	is the error due to the common mode voltage in the Y measurement

The error due to the common mode voltage in the measurement (ΔV_{CMNX} and ΔV_{CMNY}) is given as

$$\Delta V_{CMN} = \left(V_{CMN} * \sqrt{1 + 0.00000001 \times F_M{}^2} \right) / 398$$

where

V_{CMN} is the common mode voltage measured

LBAL AND ILOS TESTS

The accuracy is given as:

$$A_T = A_R + 0.87\,(A_C + A_{VI} + A_{VO})$$

where

A_T is the total accuracy (dB)
A_R is the basic relative accuracy (dB)
A_C is the correction for calibration
A_{VI} is the correction for the input voltage level
A_{VO} is the correction for the output voltage level

The value of A_R is given in the table in section 1.1 of this chapter.

The values of the other factors are given below.

$$A_C = 0.1 + (0.0000001\% \times F_M)$$

$$A_{VI} = 0.001\,/\,V_{MI}$$

$$A_{VO} = 0.001\,/\,V_{MO}$$

where

F_M is the measurement frequency (Hz)
V_{MI} is the measured input voltage (V)
V_{MO} is the measured output voltage (V)

RESP TEST

The accuracy is given as:

$$A_T \quad = A_R + 1.74 \, (A_C + A_{VI} + A_{VO})$$

where

A_T is the total accuracy (dB)
A_R is the basic relative accuracy (dB)
A_C is the correction for calibration
A_{VI} is the correction for the input voltage level
A_{VO} is the correction for the output voltage level

The value of A_R is given in the table in section 1.1 of this chapter.

The values of the other factors are given below.

$$A_C \quad = 0.1 + (0.0000001\% \times F_M)$$

$$A_{VI} = 0.001 \, / \, V_{MI}$$

$$A_{VO} = 0.001 \, / \, V_{MO}$$

where

F_M is the measurement frequency (Hz)
V_{MI} is the measured input voltage (V)
V_{MO} is the measured output voltage (V)

RLOS TEST

The accuracy is given as:

$$A_T \quad = 0.174 \times \frac{(Z_R \times Z)}{(Z_R^2 \times Z^2)} \times A_Z$$

where

A_T is the total accuracy (dB)
A_Z is the total accuracy for the Z test (%)
Z is V_M / I_M
Z_R is $\sqrt{ Z_{real}^2 + Z_{imag}^2 }$

where

V_M is the measured voltage (V)
I_M is the measured current (A)
Z_{real} is the real part of the reference impedance (Ω)
Z_{imag} is the imaginary part of the reference impedance (Ω)

Z AND ZB TEST

The accuracy is given as:

$$A_T = A_R + A_C + A_V + A_I$$

where

A_T	is the total accuracy (%)
A_R	is the basic relative accuracy (%)
A_C	is the calibration accuracy (%)
A_V	is the correction for voltage level (%)
A_I	is the correction for current level (%)

The value of A_R is given in the table in section 1.1. of this chapter.

The values of the other factors are given below.

A_C	$= 0.08\% + (0.0000001\% \times F_M)$
A_V	$= 0.08\% + (0.000003\% / V_M)$
A_I	$= 0.08\% + (0.0000003\% / I_M) + (0.03\% \times I_B / I_M)$

where

F_M	is the measurement frequency (Hz)
V_M	is the measured voltage (V)
I_M	is the measured current (A)
I_B	is the bias current (A).

ANGL TEST

The accuracy is given as:

$$A_T = A_R + A_C + A_V + A_I$$

where

A_T is the total accuracy (°)
A_R is the basic relative accuracy (°)
A_C is the calibration accuracy (°)
A_V is the correction for voltage level (°)
A_I is the correction for current level (°)

The value of A_R is given in the table in section 1.1 of this chapter.

The values of the other factors are given below.

$$A_C = 0.03 + (0.0000005\% \times F_M)$$
$$A_V = 0.03 + (0.000003\% \ / \ V_M)$$
$$A_I = 0.03 + (0.0000003\% \ / \ I_M)$$

where

F_M is the measurement frequency (Hz)
V_M is the measured voltage (V)
I_M is the measured current (A)

PHAS TEST

The accuracy is given as:

$$A_T = A_R + A_C + A_V + A_N$$

where
- A_T is the total accuracy (°)
- A_R is the basic relative accuracy (°)
- A_C is the calibration accuracy (°)
- A_V is the correction for voltage level (°)
- A_N is the correction for turns ratio (°)

The value of A_R is given in the table in section 1.1 of this chapter.

The values of the other factors are given below.

$$A_C = 0.000005\% \text{ x } F_M$$
$$A_V = 0.002 \left((1 / V_P) + (TR / V_P) \right)$$
$$A_N = 0.05 \left(| V_P - (V_P / TR) | \right)$$

where
- F_M is the measurement frequency (Hz)
- V_P is the measured voltage across the primary winding (V)
- TR is the turns ratio between the primary and secondary windings

ILK TEST

The accuracy is given as:

$$A_T = A_R + A_C + A_I$$

where

A_T is the total accuracy (%)
A_R is the basic relative accuracy (%)
A_C is the calibration accuracy (%)
A_I is the correction for current level (%)

The value of A_R is given in the table in section 1.1. of this chapter.

The values of the other factors are given below.

$$A_C = 0.1\% + (0.0005\% \times F_M)$$
$$A_I = 0.1\% + (0.0000001\% / I_M)$$

where

F_M is the measurement frequency (Hz)
I_M is the measured current (A)

LSBX AND LPBX TESTS

The accuracy for measuring inductance with bias is given as:
The accuracy is based on the test conditions chosen to measure the impedance of the parameter under test, and is given as:

$$A_T = A_R + A_C + A_V + A_I + A_Q$$

where

A_T is the total accuracy (%)
A_R is the basic relative accuracy (%)
A_C is the calibration accuracy (%)
A_V is the correction for voltage level (%)
A_I is the correction for current level (%)
A_Q is the correction for Q factor (%)

The value of A_R is given in the table in section 1.1. of this chapter.

The values of the other factors are given below.

$$A_C = 0.08\% + (0.00001\% \times F_M)$$

$$A_V = 0.08\% + (0.001\% / V_M)$$

$$A_I = 0.08\% + (0.0001\% / I_M) + (0.03\% \times (I_B / I_M))$$

$$A_Q = 0.08\% + (2\% / Q_M)$$

where

F_M is the measurement frequency (Hz)
V_M is the measured voltage (V)
I_M is the measured current (A)
Q_M is the Q factor of the measured impedance
I_B is the bias current (A)

ZBX TEST

The accuracy is given as:

$$A_T = A_R + A_C + A_V + A_I$$

where

A_T is the total accuracy (%)

A_R is the basic relative accuracy (%)

A_C is the calibration accuracy (%)

A_V is the correction for voltage level (%)

A_I is the correction for current level (%)

The value of A_R is given in the table in section 1.1. of this chapter.

The values of the other factors are given below.

A_C $= 0.08\% + (0.0000001\% \times F_M)$

A_V $= 0.08\% + (0.000003\% / V_M)$

A_I $= 0.08\% + (0.0000003\% / I_M) + (0.03\% \times I_B / I_M)$

where

F_M is the measurement frequency (Hz)

V_M is the measured voltage (V)

I_M is the measured current (A)

I_B is the bias current (A).

ACRT TEST

The accuracy for the test voltage is given by:

$$A_T = A_R + A_V + A_C + A_I + A_{RNG}$$

where

A_T is the total accuracy (%)
A_C is the calibration accuracy (%)
A_I is the correction for current level (%)
$A_V = 3\% + 10/V_M \%$
$A_C = 0.03\%$
$A_I = 0.003\% / I_M$
$A_{RNG} = Range/V_M \%$

where

I_M is the maximum test current (A (rms.))
V_M is the actual voltage (V(rms.))

Range is the voltage range used for the measurement that will be the lowest possible of the following ranges:

333V
1000V
3000V
10000V

The value of A_R is given in the table in section 1.1. of this chapter.

SPECIAL NOTES:

Under certain test conditions the measured current will be higher than the allowed minimum limit due to parasitic effects on the AT3600 and any connected fixture system. The maximum parasitic effect created by the AT3600 with every node being used on an ACRT test can be calculated by:
$I_p = V*(4.614*10^{-10} + 9.1*10^{-11}*f)$ where V = Test voltage and f = test frequency.
This works out to be 12.5uA at 2.5KV@50Hz.

DCRT TEST

The accuracy for the test voltage is given by:

$$A_T = A_R + A_V + A_C + A_I + A_{RNG}$$

where

A_T is the total accuracy (%)

A_C is the calibration accuracy (%)

A_I is the correction for current level (%)

$A_V = 3\% + 10/V_M \%$

$A_C = 0.03\%$

$A_I = 0.00006\% / I_M$

$A_{RNG} = Range/V_M \%$

where

I_M is the maximum test current (A)

V_M is the actual voltage (V)

Range is the voltage range used for the measurement that will be the lowest possible of the following ranges:

333V

1000V

3000V

10000V

The value of A_R is given in the table in section 1.1. of this chapter.

2. INTERFACE DETAILS
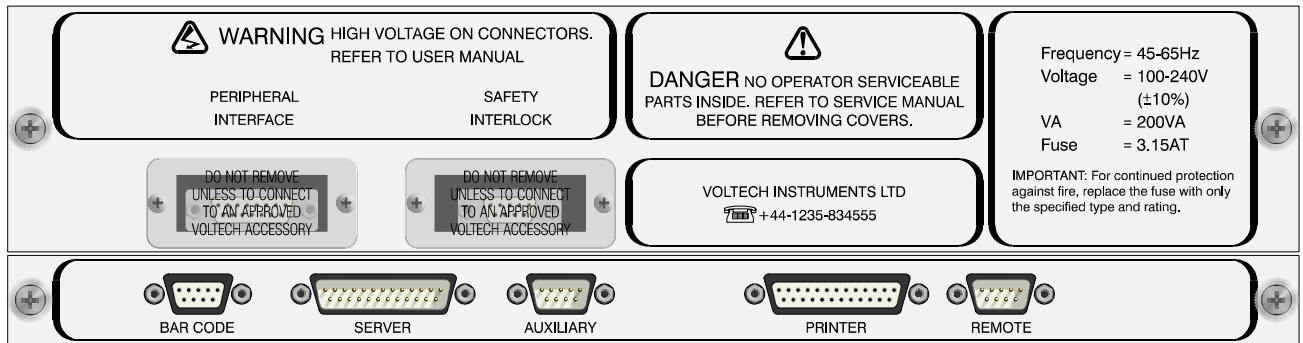
The following is a description of each of the ports to be found on the rear panel of the AT3600:

2.1. BARCODE PORT

RS232 interface for barcode entry.
9-pin female D-type connector.
Baud rate: 19 200
Parity: None
Stop bits: 1

Pin		Signal name	Pin	Signal name
1		No connection	6	No connection
2	i/p	RX	7	0V
3	o/p	TX	8	No connection
4		No connection	9	+5V
5		No connection		

The recommended barcode reader for the AT3600 is the 'Smart Wand' Barcode Reader from Hewlett Packard, available from Farnell Electronic Components

Hewlett-Packard List No: HBSW-8300

The HP 'Smart Wand' reader connects directly to the AT3600's barcode port; no extra interfacing is required to configure the HBSW-8300. Plug the barcode reader into the port and switch the AT3600 on. The barcode reader is configured by simply scanning the three barcodes printed below:

19 200 Baud

0's Parity (none)

1 Stop bit

2.2. SERVER PORT

RS232 interface for connection to a PC server running the Voltech server software.

25-pin male D-type connector.

Pin		Signal name	Pin	Signal name
1		Ground (Earth)	6	No connection
2	i/p	RX	7	0V
3	o/p	TX	8	No connection
4	i/p	CTS	...	
5	o/p	RTS	25	No connection

2.3. AUXILIARY PORT

RS232 interface for connection to a PC running the Voltech editor software.

9-pin male D-type connector.

Pin		Signal name	Pin		Signal name
1		No connection	6		No connection
2	o/p	TX	7	i/p	CTS
3	i/p	RX	8	o/p	RTS
4		No connection	9		No connection
5		0V			

2.4. PRINTER PORT

Standard parallel printer interface.

25-pin female D-type connector.

Pin		Signal name	Pin		Signal name
1	o/p	!STROBE	11	i/p	BUSY
2	o/p	D0	12	i/p	PE
3	o/p	D1	13		No connection
4	o/p	D2	14	o/p	!AUTOFD
5	o/p	D3	15	i/p	!ERROR
6	o/p	D4	16	o/p	!INIT
7	o/p	D5	17	o/p	!SLCTIN
8	o/p	D6	18		0V
9	o/p	D7	...		
10	i/p	!ACKNLG	25		0V

Signals with a name starting with ! are active Lo.

2.5. REMOTE PORT

TTL compatible interface for operation with various peripherals including foot switch, remote controller and monitor output.

9-pin male D-type connector.

Pin		Signal name	Pin		Signal name
1	o/p	BEEP	6	o/p	!BUSY / Bin0
2	o/p	!PASS / Bin1	7		0V
3	i/p	!RUN	8		0V
4	o/p	!FAIL / BinStrb	9	i/p	!STOP
5		+5V			

Signals with a name starting with ! are active Lo.

!RUN Input (Pin 3)

The !RUN input is an active Lo input with an internal pull-up resistor.

In the execution of programs, it is equivalent to pressing the RUN key on the front panel.

To use this with a foot-switch, wire the switch between this input and 0V.

!STOP Input (Pin 9)

The !STOP input is an active Lo input with an internal pull-up resistor.

The active-going edge of this input halts all Tester activity, turning off all signal sources.

To use this with an 'emergency stop' switch, wire the switch between this input and 0V.

Status Outputs (Pins 2, 4 and 6)

The status outputs are standard 5Volt logic signals.

In the standard set-up, the three status outputs are active Lo signals which duplicate the three LED's on the front panel - Busy, Pass and Fail. They could, for example, be connected as status inputs to a robot controller, or a bin selector.

Beep Output (Pin 1)

This is an active Hi output which copies the internal beeper.

It is configured in the test program header (see the Test Editor section of this manual).

All the outputs (pins 1, 2, 4 and 6) are fitted with 1kΩ protection resistors, and therefore they cannot directly drive external high current loads such as indicators, or bin-select relays. Minimum input resistance of devices connected to these outputs to be 10kΩ.

2.6. PERIPHERAL INTERFACE

For connection to a Voltech accessory only.

2.7. SAFETY INTERLOCK

The AT Series safety interlock has been designed to be used with the Voltech Safety System, which is based on the use of a light curtain. Details of this accessory are available from your Voltech distributor.

Alternatively, it may be connected into your own safety system as described in the following pages.

DANGER OF ELECTRIC SHOCK

Once the interlock has been connected, the AT Series Tester may produce high voltages that should be considered lethal.

It is always the responsibility of the user to ensure adequate safety measures are taken in accordance with local regulations.

Contact your Voltech supplier for details of approved safety systems, if in any doubt.

CONNECTOR DETAILS

9-pin female D-type connector.*

Pin		Signal name	Pin		Signal name
1		No connection	6		0V
2		+18V	7	i/p	HVIP
3	o/p	HVOP	8	o/p	LID1
4	o/p	LID0	9	i/p	LB1
5	i/p	!LB0			

There are 3 active circuits on the safety interlock connector. Two are digital control circuits, and the third is a high voltage analog circuit.

ALL three circuits must be correctly made before the AT Series Tester will generate accessible dangerous voltages.

If any of the circuits are 'broken' during use, dangerous voltages, which could be applied to the transformer under test, are actively reduced and quickly made safe.

*NOTE: A slim connector shell is required to fit the AT3600 aperture. Example type: McMurdo 51218-1

HVOP and HVIP (Pins 3 and 7)

DANGEROUS VOLTAGE

The HVOP is an analog voltage output which can be as high as 400V.

The HVIP is a corresponding input voltage. All the high voltage test signals used by the AT Series Testers are derived from this input.

In the 'safe' condition, HVOP is linked back into HVIP.

LB0 and LB1 (Pins 5 and 9)

These are the two digital control signals.

In the 'safe' condition, !LB0 is linked to 0v, and LB1 is driven to a voltage between +4.5V and +5V.

LID0 and LID1 (Pins 4 and 8)

These are two further digital control outputs used by the Voltech Safety System.

INTERFACE DETAILS

Connection to Your Safety System

The following diagram shows the principles of how to construct your own safety system based on the signals available on the Safety Interlock connector.

SAFETY COVER   USER SAFETY SYSTEM
                      EG. DOOR SWITCHES
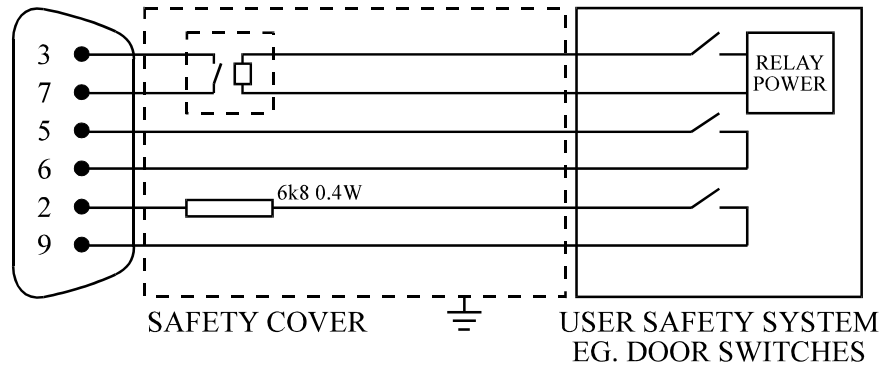
NOTES: Your safety system <u>must</u> contain all three switches, as shown in the diagram. If any switch is in the open position (as shown), the Tester will not produce any voltages greater than 20V peak, at the test nodes on the top face. The connection between pins 3 and 7 must be made with a relay rated at 400V 2ARMS. The relay must be situated no more than 1.5metres from the Tester's safety interlock connector. Timing requirements of any safety system must conform to the spec section of chapter 10.

**DO NOT ROUTE OVER LONG DISTANCES.
DO NOT ATTEMPT TO ROUTE LINE POWER (230/110V)
THROUGH THESE INTERLOCKS.**

2.8. USER PORT

The User Port is positioned on the top moulding of the AT Series Testers, at the rear behind the fixture board recess.
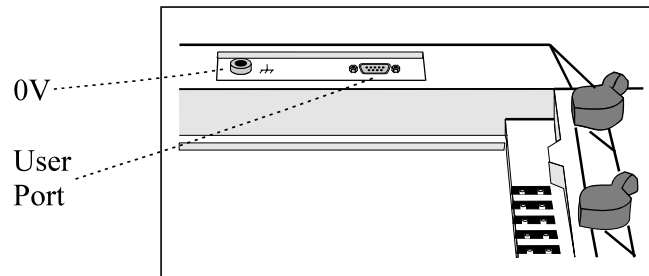
The port contains six open-collector relay drive outputs, and two HC MOS compatible inputs.

The relay drives are switched on and off by certain optional tests (e.g. the OUT test) inserted into your test program. This will enable you, for example, to switch a dummy load on to the secondary winding of the transformer under test, so that subsequent tests are performed on the loaded transformer.
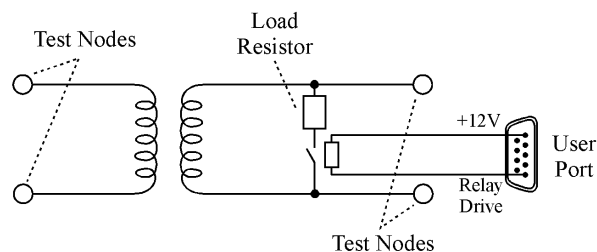
BEWARE OF HIGH VOLTAGES

Remember when designing relays into your fixture that the AT3600 is capable of producing very high voltages.

It is the responsibility of the user to ensure that both the relays themselves, and the associated wiring are able to withstand any high voltage produced in the test program.

It is particularly important that YOU ensure that there is never a flash-over from a high voltage test signal to a relay coil driven from the User Port. Such a flash-over would cause extensive damage to the circuits inside the Tester.

If in any doubt, contact your Voltech supplier for advice on which relay to use in your application.

CONNECTOR DETAILS

9-pin female D-type connector.
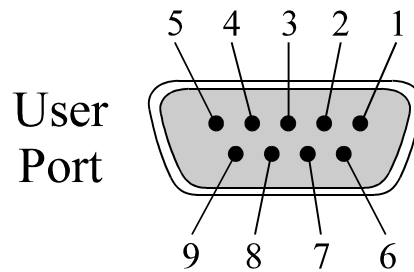
Pin		Signal name	Pin		Signal name
1	o/p	User Relay Drive 0	6	o/p	User Relay Drive 1
2	o/p	User Relay Drive 2	7	o/p	User Relay Drive 3
3	o/p	User Relay Drive 4	8	o/p	User Relay Drive 5
4	i/p	User Input 0	9	i/p	User Input 1
5	o/p	+12V			

USER RELAY DRIVE OUTPUTS (PINS 1, 2, 3, 6, 7 AND 8)

All the User Relay Drive Outputs have the following equivalent circuit:
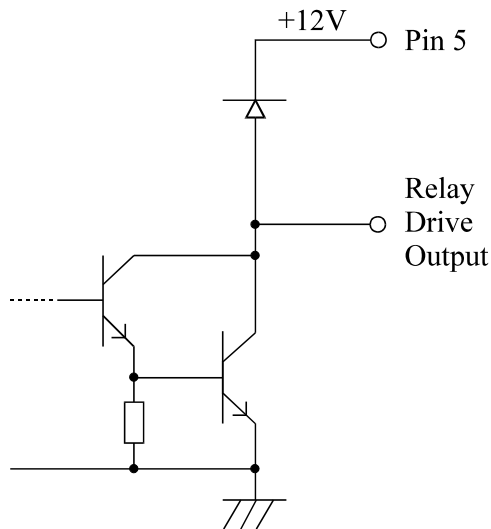
Specification:

Relay coil resistance: $> 150\Omega$

Maximum output current: 80mA per output

USER INPUTS (PINS 4 AND 9)

The User Inputs have the following equivalent circuit:
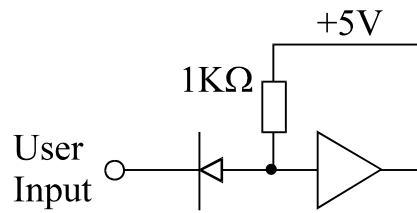
Specification:

       Maximum input voltage: +5V

       Minimum input voltage: 0V

       Minimum logic 1 input: 4V

       Maximum logic 0 input: 0.25V

The zero reference voltage for these inputs is the 0V(ground) 4mm socket situated to the left of the User Port.

3. ENVIRONMENTAL CONDITIONS

LINE INPUT
IEC 3-pin socket
90 to 265V ac 50 or 60Hz @200VA
Fuse 3.15AT

DIELECTRIC STRENGTH
2kV ac 50Hz for 1 minute, line input to case.
Storage Temperature
-40° to +70°C

OPERATING TEMPERATURE
0° to 40°C

HUMIDITY
10 to 90% RH non-condensing

MECHANICAL
Weight: Approx. 23kg
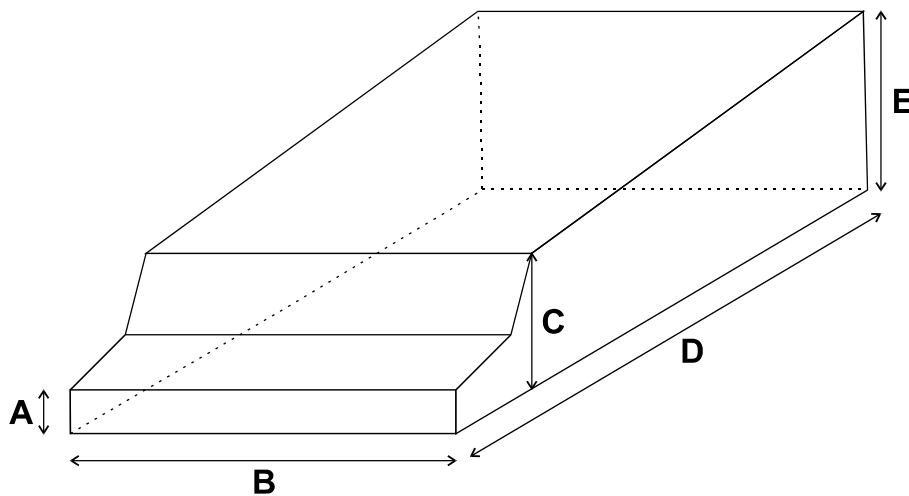
A =   50mm   Height of front edge

B =   442mm   Full width

C =   155mm   Front height

D =   545mm   Full length

E =   210mm   Rear height

4.   EMC COMPLIANCE

4.1. DECLARATIONS OF CONFORMITY

<div align="center">

DECLARATION OF CONFORMITY

</div>

Manufacturer's Name   Voltech Instruments Ltd

Manufacturer's Address   65 Milton Park
                                 Abingdon, Oxon
                                 United Kingdom

declares, that the product

    Product Name: Transformer Tester

    Model Number: AT3600

conforms to the following Product Specifications

    Safety: BS EN 61010 (1993)

    EMC: BS EN 55022 (1995): Class A
                                 BS EN 50082-2 (1992)

Supplementary Information: The product herewith complies with the requirements of
                                 the EMC Directives 89/336/EEC and 92/31/EEC and the
                                 Low Voltage Directive 73/23/EEC

Signed for on behalf of Voltech Instruments Ltd

                                    Martin Whitley, Quality Manager

Abingdon, United Kingdom, December 16, 1996

4.2. EMC PRECAUTIONS

CONDUCTED AND RADIATED EMISSIONS

The AT3600 complies with the limits of BS EN 55022 Class A.

IMMUNITY

The AT3600 may be susceptible to Fast Electrical Transients on the power line and Electrostatic Discharges, which can disrupt the operation of the unit.

In the event of such an occurrence, to return the AT3600 to normal operation:

1) Switch off the power
2) Wait 5 seconds
3) Switch on again

CHAPTER 9 - WARRANTY AND SERVICE

TABLE OF CONTENTS

This chapter of the manual will introduce the terms of warranty, service and calibration for the AT3600 transformer tester.

1. WARRANTY INFORMATION

1. WARRANTY INFORMATION

1.1. POST SALE WARRANTY AGREEMENT

The AT3600 from Voltech are warranted against defects in materials and workmanship for a period of twelve (12) months from the date of shipment OR ten million (*10,000,000*) wound component tests, which ever occurs first.

The electrical switching relays are warranted against defects in materials and workmanship for a period of twenty four (24) months OR ten million (*10,000,000*) transformer tests, which ever occurs first..

In the event of failure of a customer unit during this period, Voltech will:

1. At Voltech's discretion, repair or replace the faulty unit free-of-charge for a unit returned to an authorized service center. Shipment from the customer address will be the responsibility of the customer.

    Voltech reserve the right to waive this benefit in any event where it is clear upon inspection that the cause of the failure is due to customer misuse.

    Voltech will be the sole arbiter in this circumstance.

2. Pay all return shipment charges from the Voltech service center to the customer.

3. Re-calibrate the customer unit before dispatch. A certificate of calibration will be issued as a matter of course.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from unauthorized modification or misuse, or operation outside specification of instrument. No other warranty is expressed or implied.

Whilst every care has been taken in compiling the information in this publication Voltech Instruments Ltd cannot accept legal liability for any inaccuracies contained herein Voltech Instruments Ltd has an intensive programme of design and development which may well alter product specification, and reserve the right to alter specification without notice and whenever necessary to ensure optimum performance from its product range.

Because software is inherently complex and may not be completely free of errors, you are advised to verify your work. In no event will Voltech be liable for direct, indirect, special, incidental or consequential damages arising out of the use of or inability to use software or documentation, even if advised of the possibility of such damage. In particular, Voltech is not responsible for any lost profits or revenue, loss of use of software, loss of data, cost of substitute software, claims by third parties, or for other similar costs. In no case shall Voltech's liability exceed the amount of the license fee.

1.2. SERVICE AND CALIBRATION

To confirm the accuracy of your AT3600 tester, a calibration check should be carried out every 12 months.

Calibration is carried out using a special fixture as described in the next section. The calibration can be performed by an authorized Voltech service center or at your own facility if you have the required equipment

For details of calibration facilities and any other service request, please contact your supplier. Voltech strongly recommends that you discuss your service requirements with your supplier before service is needed. Extended warranty and full service agreements are available.

1.3. VOLTECH AT CALIBRATION SYSTEM

- Calibrates AT3600
- Mimimises production down time – return to service centre not required.
- Calibrates tester to full specification - including high voltage tests.
- Precision circuits and components built-in for reliable, error-free calibration.
- Semi or fully-automatic calibration process controlled by easy-to-use PC software.

Voltech recommends that the AT3600 is calibrated every 12 months to ensure optimum measurement accuracy. The calibration system is designed for use by owners of Voltech AT testers and third party calibration companies who regularly calibrate testers or who wish to avoid the production downtime of returning a tester to a Voltech service center.

- Complete record of results stored on PC.
- Prints formal calibration certificate showing verification results.

- Calibration verified by making precise measurements on built-in sample R, L and C (Verification may be performed at any time).
- Verification L and C may be calibrated separately for external traceability.

THE COMPLETE CALIBRATION SYSTEM:

- The calibration fixture that fits into the normal position at the top of the tester (pictured).
- PC Software disk to run on a PC (386 or better with 4MB RAM). PC not supplied.
- A precision digital multi-meter (not supplied).
- An optional IEEE488 interface for the PC for fully automatic calibration (not supplied).

Fully Automatic Calibration	Semi–Automatic Calibration.
Less than 30 minutes	About 45 minutes
No manual readings	About 30 readings read from the meter and entered into the PC
IEEE488 Interface required *NI PCII/IIA, IoTech GP488 and CEC suitable*	Normal PC Serial 'COM' interface required
HP3458A 8½ digit DMM essential	HP 3458A DMM or similar required

DMM SPECIFICATION FOR SEMI-AUTOMATIC USE

The Voltech calibration system relies on the accuracy of the DMM used to achieve the published specification of the tester. The meter must measure:

AC Volts to 0.04% @100Hz and 3% @1MHz

DC Volts to 0.003% @2V and 0.005% @600V

DC resistance using a four terminal connection to 0.05% for 500mΩ and 0.01% for 750Ω.

Keithly 2002 and Datron Wavetek 1271 (with high accuracy AC option) DMMs are suitable alternative meters.

CALIBRATION ENVIRONMENT

Calibration should be carried out at 23°C ±5°C, relative humidity 10 to 90% non-condensing.

CHAPTER 10 – SAFETY SYSTEMS

TABLE OF CONTENTS

This chapter describes the recommended safety enclosure for the AT3600.

1. SAFETY SYSTEMS

1.1. INTRODUCTION

Many of the tests available with the AT series testers are capable of generating dangerously high voltages, which could cause operator injury unless proper safety precautions are taken.

With this in mind, the rear panel of the AT3600 and some AT accessories have been designed with a safety interlock connector, which is described in the user manual of those products.

Unless the three safety interlock signals on this connector are properly made, the tester will not generate any dangerous voltages.

It is possible for you to use your tester without connecting the safety interlocks; but you will then be restricted to only 'low voltage' tests. If you wish to make full use of your tester and use any test that can generate high voltages, including

- Magnetizing Current

- Open Circuit Voltage

- Insulation Resistance

- Hi-Pot (DC)

- Wattage

- Hi-Pot (AC)

- Surge Stress Test

- Hi-Pot Ramp (AC)

- Hi-Pot Ramp (DC)

then you must have a safety system operating the safety interlocks.

Note: Dangerous voltages may also be produced when testing transformers and inductors in the presence of a dc bias current. Sudden removal of the dc current will generate high voltages across the part under test.

The details of any particular safety system installation could vary depending on where the tester is being used. In a robotic production line, for example, the tester could be located in an enclosed area, and the safety switches could be mounted in the door.

With manual production, the safety system could be based on a physical barrier, for example, a 'lid' fitted with safety interlock switches. However, the requirement to open and close such a barrier will give a slower speed of test, and often the reduced production throughput that follows from this may not be acceptable.

1.2. RECOMMENDED SAFETY SYSTEM.

For optimum safety, ease of use and test speed, Voltech recommends the use of a safety light curtain with the AT3600 and other Voltech products that can generate dangerous voltages during routine production testing. This provides a 'light curtain' of infrared beams positioned in front of the tester.

Once the operator has placed a transformer on the test fixture, and removed his or her hand, the light curtain can signal that the situation is safe within a few tens of milliseconds. However, if the operator tries to touch the transformer during program execution, the safety system will open the safety interlocks (also within a few tens of milliseconds), so that the tests with dangerously high voltages will not be run.

The Safety Interlock Cable is an accessory that makes connection between the AT3600 and a safety light curtain as safe and easy as possible. The cable has been optimised for use with the 'Banner' safety light curtain described below, but safety light curtains from other manufacturers may also be suitable.

To construct a complete safety system you will need:

- Voltech Safety Interlock Cable
  (See next section)

- Banner 'Micro-Screen' safety light curtain

  - 1 off USCD-1T2 Metal Box Controller

  - 1 off USE2424YI Yellow Emitter 610mm high with 150mm to 9m range.

  - 1 off USR2424YI Yellow Receiver 610mm high with 150mm to 9m range.

    Source: www.banner.com

- Methods to restrict access to the back of the working area

NOTE: The Banner part numbers were correct in 2004. You are strongly advised to consult with your safety system supplier before making purchase decisions. Similar safety systems are available from many other manufacturers and may be suitable.

1.3. VOLTECH SAFETY INTERLOCK CABLE

The Safety Interlock Cable is a robust and convenient way of connecting the AT3600 and other Voltech products to a safety interlock system. Although other safety systems may be suitable, the cable has been optimised for direct and quick connection to the Banner product described in the previous section.

Length	1.75 metres
Construction	High-quality shielded cable and terminations.
AT3600 Termination	Slimline 9-way d-type plug
Safety System Termination	Color-coded wires with bootlace ferrules. 20mm cable gland to secure the cable to the light curtain control box case.
Voltech Part Number	250-022

Principle of Operation

The cable carries 3 pairs of color-coded wires. Each pair must be linked together by the safety system before the AT3600 will operate a high voltage test. If any one of the three pairs is becomes un-linked during a test, the AT3600 very quickly switches off any high voltage that is being produced.

There are three pairs of wires in order to provide the multiple redundancy required by various international safety standards.

Cable Schematic.

Function	AT3600 9-pin d-type		Safety Light Curtain	Connection to safety system.
Primary power to the high voltage generators is passed through pins 3 and 7	3	—	Yellow	Main power-breaking relays (Final Switching Device) of the safety system. The black link is used to series 2 relays, if present.
	7	—	Blue	
	No Connection		Black	
	No Connection		Black	
Secondary control logic.	5	—	Green	Monitoring or auxiliary relay.
	6	—	Black	
Secondary switching device. (A 6k8 resistor is fitted in series with pin 2).	2	—	Red	Secondary Control Element.
	9	—	White	
Screen	Screen		No Connection	

For full details of the Voltech Safety Interlock cable, request a copy of the Safety Interlock Cable Installation Guide, Voltech part number 98-078.

2. SAFETY NOTICES

2.1. OPERATOR SAFETY

It is the responsibility of the user's organization to ensure that the AT3600 and its associated safety systems are installed, maintained, and operated in accordance with all safety guidance and legislation that may be in force locally. The Banner Micr- Screen (light curtain) will provide only part of the complete safety function that is required. The AT3600 and light curtain must be installed by a designated, qualified safety person who will conduct an overall assessment of the risks involved and provide operator training, safety notices, and further safety equipment as well as install the AT3600 and light curtain in accordance with local regulations.

When conducting a risk assessment and providing operator training and notices, it should be noted that the first safety feature of the AT3600 is the yellow indicating light on its front panel. This light will be lit when the AT3600 is running a test and may be generating dangerous voltages. (External indicating devices can also be used to show that the AT3600 is in a hazardous condition. See the 'Remote Port' description in the AT3600 user manual.) The operator should not attempt to touch the part under test or enter the safety enclosure when the yellow light is illuminated. The light curtain then provides supplementary safety protection against accidental entry into the safety enclosure by the operator.

2.2. THE SAFETY ENCLOSURE

Clearly, any safety system should be thought of providing a total 'safety enclosure' which prevents access from all sides to the dangerous voltages on the transformer under test. It is also clear that the infrared safety system can only provide one side of this safety enclosure - that which faces the operator.

If there is a danger that an operator or any other person could touch the transformer under test from either the side or the rear of the tester, then you must also take steps to prevent this, either by installing suitable physical barriers, or for example, by positioning the tester in the corner of the room so that existing walls prevent access to the transformer from the side and rear. The two vertical columns of the IR safety system would then normally be placed touching the physical barriers, which form the side-walls of the safety enclosure.

If there is any danger that the operator could touch the transformer under test from above, then further precautions should be taken to provide physical barriers to guard against this.

3. TYPICAL INSTALLATION

The safety system is based on the use of an infrared light curtain as a barrier between the operator and the dangerously high voltages present on the transformer under test.

A typical system is shown below:
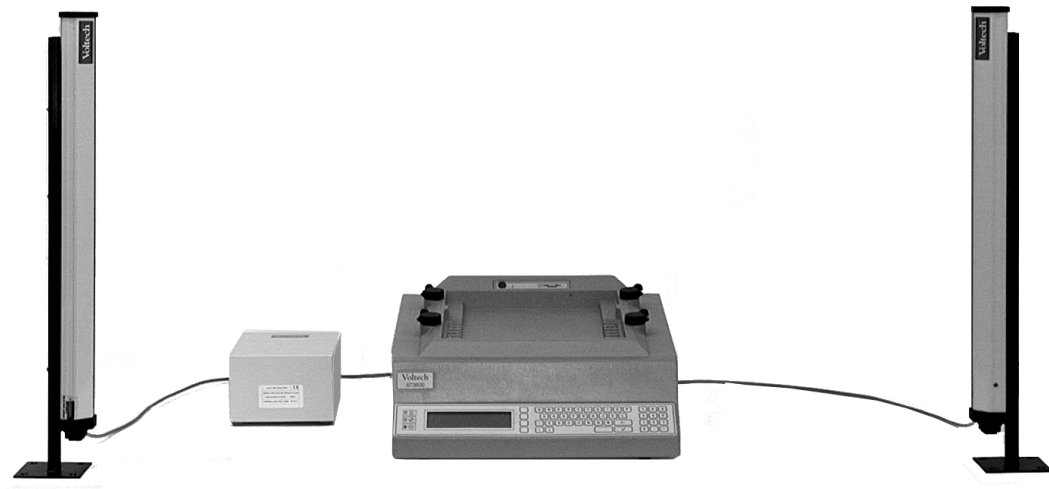
The light curtain is positioned in front of the tester. It extends well beyond the width of the tester so that the operator is not impeded when he/she has to load and unload the transformer under test.

The infrared safety system is housed in three separate modules:

1. A vertical column of transmitters and/or receivers, which form the left-hand edge of the light curtain.
2. A vertical column of transmitters and/or receivers, which form the right-hand edge of the light curtain.
3. A control box, containing the power supply circuits, the switching electronics and the interface to the tester.

The interconnection between each of the modules is via simple multi-way cables, which are easy to install.

The following show plan and side views of a typical installation:
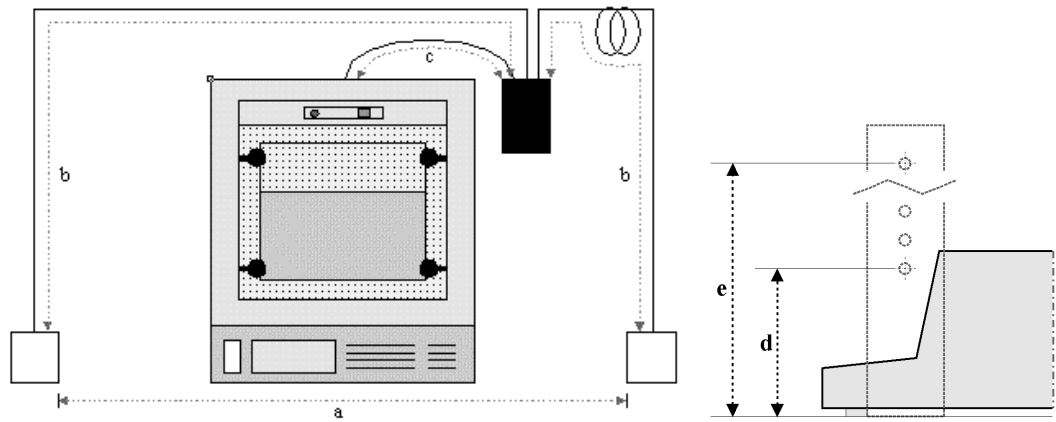
The dimensions are as follows:

a.   Width of the light curtain: 1.8m to 2.0m

b.   Cable length from control box

                                            to vertical columns: 2m

c.   Cable length from control box

                                            to tester: 1.5m

d.   Lowest beam in light curtain: 60mm
maximum above the work surface

e.   Highest beam in light curtain: 630mm
minimum above the work surface

f.   Maximum object resolution: 18mm

4. OPERATION WITH AN IR SAFETY SYSTEM

Note:

This section describes the various operating and warning messages that may be observed on the AT3600 when it is being used with a safety light curtain. Please consult the documentation supplied with your safety system for its operating instructions.

The tester has four distinct points in its operation when it may check the condition of the safety interlock:

1. Running a high voltage test during program execution

2. Performing the fixture compensation for a high voltage test within a program

3. Running a high voltage test in measure mode

4. Performing the fixture compensation prior to running a high voltage test in measure mode

As indicated in the previous section entitled 'Testing the Safety System', the safety checks are made both before and during the measurement.

If the safety system indicates that the light curtain is broken before the start of the measurement, the tester will display one of four 'suspended' messages on the front panel, depending on which of the four operations listed above you were trying to perform:

(a)

```
Part number
PART NUMBER
Safety interlock open
Suspended at test n                    STOP
```
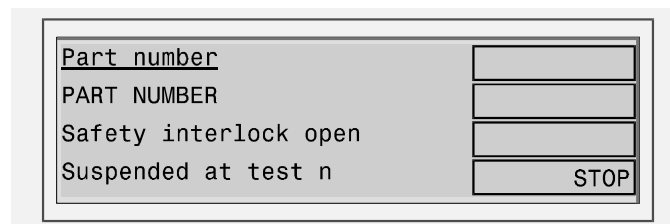
Where 'n' is the number of the test with the dangerous source.

(b)

```
Part number
PART NUMBER
Safety interlock open
Compensation suspended                 STOP
```

(c)

```
┌──────────────────────────────────────────┐
│  ┌────────────────────────────┬────────┐  │
│  │ Measurement                │        │  │
│  │                            ├────────┤  │
│  │                            │        │  │
│  │ Safety interlock open      ├────────┤  │
│  │                            │        │  │
│  │ Suspended                  ├────────┤  │
│  │                            │   STOP │  │
│  └────────────────────────────┴────────┘  │
└──────────────────────────────────────────┘
```

(d)

```
┌──────────────────────────────────────────┐
│  ┌────────────────────────────┬────────┐  │
│  │ Measuring XXXX             │        │  │
│  │                            ├────────┤  │
│  │                            │        │  │
│  │ Safety interlock open      ├────────┤  │
│  │                            │        │  │
│  │ Compensation suspended     ├────────┤  │
│  │                            │   STOP │  │
│  └────────────────────────────┴────────┘  │
└──────────────────────────────────────────┘
```
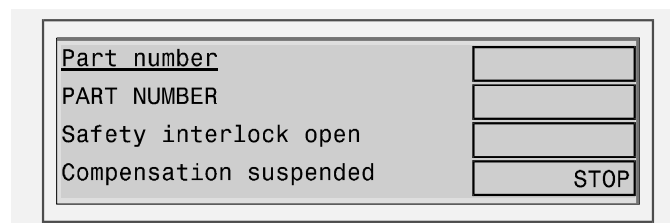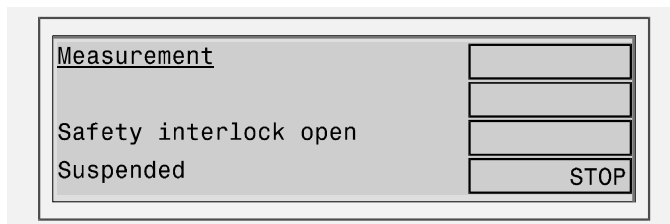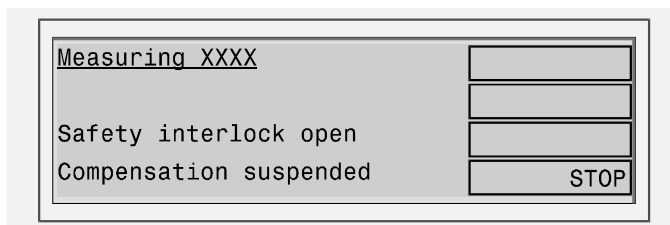
Where 'XXXX' is the appropriate test mnemonic.

Operation will remain suspended at this point until the safety system indicates that it is safe to proceed, after which test execution will carry on as normal. If you do not wish to continue from this point, pressing the STOP soft-key will halt the test execution and return the display to the appropriate higher level menu selection.

If the light curtain is broken after the measurement has started, then the test will be stopped, and the high voltage source shut down. The front panel of the tester will show a message containing the word 'STOP', again with the exact text varying depending upon the operation that you were trying to perform. Examples are as follows:

(a)

```
┌──────────────────────────────────────────┐
│  ┌────────────────────────────┬────────┐  │
│  │ Part number                │    RUN │  │
│  │ PART NUMBER                ├────────┤  │
│  │                            │ FINISH │  │
│  │ Safety interlock open      ├────────┤  │
│  │                            │        │  │
│  │ Last transformer STOP      ├────────┤  │
│  │                            │        │  │
│  └────────────────────────────┴────────┘  │
└──────────────────────────────────────────┘
```
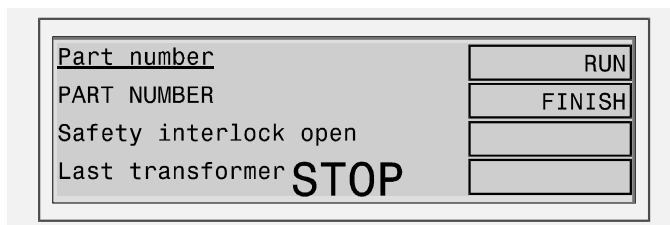
(b)

```
┌─────────────────────────────────────────┐
│ ┌─────────────────────────────────────┐ │
│ │ Part number              ┌─────────┐ │ │
│ │                          │     RUN │ │ │
│ │ PART NUMBER              ├─────────┤ │ │
│ │                          │  FINISH │ │ │
│ │ Safety interlock open    ├─────────┤ │ │
│ │                          │         │ │ │
│ │ Compensation    STOP     ├─────────┤ │ │
│ │                          │         │ │ │
│ │                          └─────────┘ │ │
│ └─────────────────────────────────────┘ │
└─────────────────────────────────────────┘
```

(c)

```
┌─────────────────────────────────────────┐
│ ┌─────────────────────────────────────┐ │
│ │ Measurement              ┌─────────┐ │ │
│ │                          │ EXECUTE │ │ │
│ │            STOP          ├─────────┤ │ │
│ │                          │ MEASURE │ │ │
│ │ Safety interlock open    ├─────────┤ │ │
│ │                          │ PROGRAM │ │ │
│ │                          ├─────────┤ │ │
│ │                          │SELF-TEST│ │ │
│ │                          └─────────┘ │ │
│ └─────────────────────────────────────┘ │
└─────────────────────────────────────────┘
```

(d)

```
┌─────────────────────────────────────────┐
│ ┌─────────────────────────────────────┐ │
│ │ Measure XXXX             ┌─────────┐ │ │
│ │                          │         │ │ │
│ │                          ├─────────┤ │ │
│ │                          │         │ │ │
│ │ Safety interlock open    ├─────────┤ │ │
│ │                          │         │ │ │
│ │ Compensation    STOP     ├─────────┤ │ │
│ │                          │   ABORT │ │ │
│ │                          └─────────┘ │ │
│ └─────────────────────────────────────┘ │
└─────────────────────────────────────────┘
```

There is no way that the measurement can be recovered from this point. For program execution, this means that the entire program has to be re-run from the first test; and for measure mode, the test has to be re-entered. In the case of fixture compensation, either the compensation for the entire program must be re-run, or (in measure mode) the compensation for the required test.

Note that during the normal operation of changing transformers, the indicator on the slave column can show a red light. This merely indicates that the light curtain has been broken; it should automatically reset and return to the green indicator when the operator removes their hand.

When program execution has finished, and the front panel LED changes to either red (fail) or green (pass), then it is safe for the operator to change to the next transformer to be tested.

5. CONSTRUCTING SAFE FIXTURES

As described in the previous section, when the light curtain of the safety system is broken, the tester will stop the execution of a high voltage test, and remove the dangerous voltages, to protect the operator from the dangers of electric shock.

This may sound a simple operation, but in fact it is not. Firstly, there has to be a certain amount of signal processing within the vertical columns to detect that the IR beams have been broken; secondly, the control box has to signal this to the tester; and thirdly, the tester has to ramp-down the test source. This final operation has to be done carefully, because if there is current flowing through the inductance of a winding and it is suddenly switched off, rather than creating a safe situation, it could produce a dangerously high 'back emf'.

Clearly this means that, after the light curtain has been broken, there has to be a finite amount of time to switch off and safely ramp down the potentially dangerous voltage. With the IR Safety System, this time could be as long as 50msec.

This time has to be born in mind when you are designing your test fixtures. It is essential that any high voltage point on the transformer under test is set far enough back from the light curtain so that it cannot be touched by the operators hand within 75msec of breaking the beams.

Note that the high voltage points on the transformer could include the body or core (as well as terminals) if your program contains Hi Pot tests for core isolation.

The normally assumed value for the speed of an operator's hand is 2m/sec. This speed implies that the distance from the beams of the light curtain to the dangerous point on the transformer should be at least 150mm.