



ALL-TEST *PRO*[®] 5

User Manual

Version 1.4



Tester and Analyzer for Electrical Motors, Generators and Transformers

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INTRODUCTION

Congratulations on your purchase of the new patented **ALL-TEST PRO® 5** Motor Circuit Analyzer (AT5) from **ALL-TEST Pro, LLC (ATP)**. The AT5 is a new hand-held Test Instrument on motors, generators and transformers from ALL-TEST Pro.

The AT5 offers a complete motor testing system solution for stand-alone troubleshooting/fault localization, quality control of stored or incoming new/repared motors, as well as data collection and trending for early fault detection when combined with the comprehensive MCA-Basic or MCA-PRO computer software.

The ALL-TEST PRO 5 performs Motor Circuit Analysis (MCA) through a series of low voltage tests to identify faults inside an electric motor. It detects winding contamination, stator faults such as turn-to-turn and coil-to-coil shorts, open connections, ground faults, and broken/fractured rotor bars. Experience has proven that the ALL-TEST PRO series of Motor Test Instruments are the most powerful and easiest to use diagnostic tools available for de-energized testing of motors in today's industry.

The AT5 is designed to be used as a stand-alone unit in the field or workshop with or without the software. MCA-Basic and MCA-PRO software provides for further analysis, reporting, trending and database management. MCA-Basic comes standard with the AT5 and is used for single and three phase AC motor analysis, trending, and reporting. MCA-PRO adds DC motor and transformer analysis, plus unique rotor grading method along with route based testing.

The ALL-TEST PRO 5 has a built-in real time clock and large memory for storage of test and reference data. The instruments are built to exacting standards and rugged to handle the daily use in tough industrial environments. The rechargeable Lithium batteries support eight hours or more testing and data collection*.

** Assumes most testing is phase to phase. Performing insulation to ground testing in applications where there are long cable running will increase the drain on the battery. Therefore, user may not get 8 hours of use between battery charges.*

Training

Continuing Education Accredited Training Courses are held at various locations throughout the world. In addition, all of the ALL-TEST Pro training courses can be customized and brought to your plant site. Contact ALL-TEST Pro training department at www.alltestpro.com for further information.

Warranty

One year limited warranty. See ALL-TEST Pro Terms and Conditions for details.



ALL-TEST *PRO*® 5 User Manual

Contact Information

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SAFETY



SAFETY WARNINGS

- **The Device Under Test (DUT) must be fully de-energized before AT5 instrument can be connected for any test**
- **Please do not touch any test leads during any on-going tests**

Introduction

Safety Warnings and Precautions must be understood and observed when the instrument is being used. Follow all safety rules of your company and OSHA (or country equivalent) for off-line testing methods, including wearing appropriate Personal Protective Equipment (PPE). *To ensure proper and safe operation of the ALL-TEST PRO® 5 is the sole responsibility of the user.*

The ALL-TEST PRO® 5 is only to be used on de-energized motors. Connecting the instrument to live voltage will destroy the unit and void the warranty. Always verify the motor circuit is de-energized before connecting the ALL-TEST PRO® 5. Ensure that all power has been removed from the circuit being tested, including static power stored in capacitors. Discharge all capacitors involved in the motor circuitry. During testing, ensure that one terminal of any power factor correction capacitor or lightning arrestor that is in the test circuit is disconnected to avoid erroneous test results.

During MCA testing, the ALL-TEST PRO® 5 sends out a low voltage, low frequency test signal not harmful to the human being or most electronic equipment (variable frequency drives and soft starters). However, electronic equipment and personnel must observe appropriate safety considerations (disconnect electronic equipment) when performing the insulation to ground resistance test (Meg-Ohm test).

Test leads including crocodile clips must be in good shape, clean and have no broken or cracked insulation.

Safety Symbols

The following is summary of the safety symbols and corresponding meanings.

Symbols used on the instrument:

	Important information; see user manual !
	WARNING: risk of electric shock !
	Equipment complies with EU regulations and directives regarding safety and electromagnetic compatibility
	Do not dispose of this product as unsorted municipal waste
	Lead free equipment, complies with EU RoHS directive regarding restriction of hazardous substances

ALL-TEST PRO® 5 TEST KIT

- ALL-TEST PRO 5 with back-lit graphic LCD screen (128x128 pixel)
- 3x Test leads with custom Kelvin Clips
- 1x Test lead with 4mm safety plug and “Dolphin” clip
- Battery charging adapter
- Attaché type hard case with pre-cut foam liner
- User Manual on CD (Under unit)
- Windows (XP/7) based software for database storage, further analysis, reporting and trending
- USB cable 1m (for PC communication)

AVAILABLE ACCESSORIES

- MCA-PRO software for DC motor and transformer analysis, rotor grading, and route based testing.
- Soft carrying pouch for instrument and test leads
- Battery pack and DC charger

Test Lead Connections

The ALL-TEST PRO 5 uses specially designed test leads and clips to provide accurate measurement of the low resistance values typically associated with coil windings. The test leads are also shielded to prevent “hum” or other electrical interference that can result in erratic readings for DF and C.

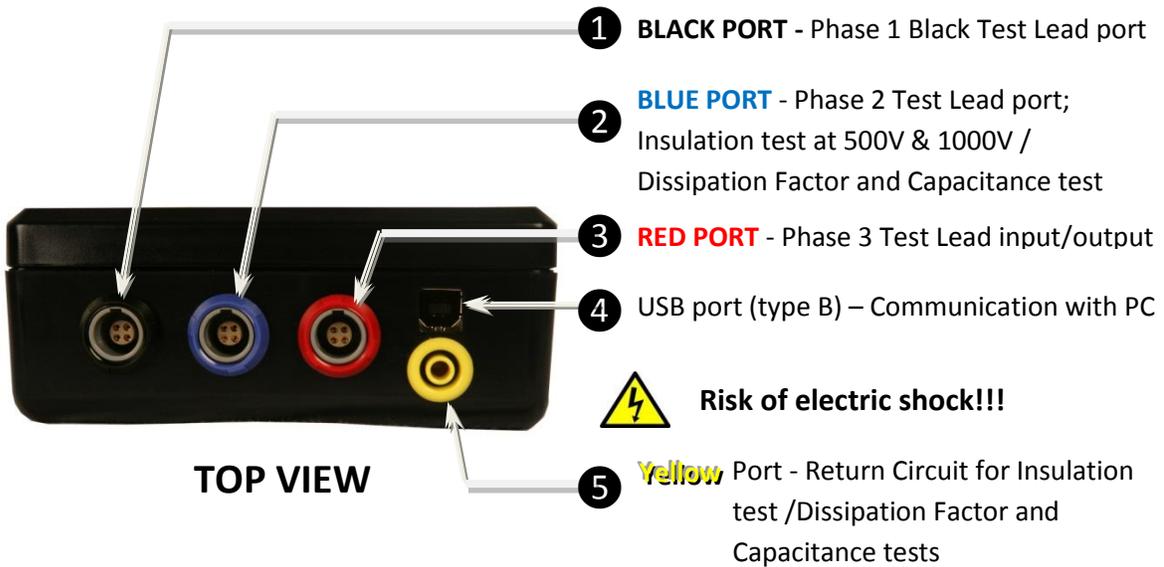
(See specifications section for measurement ranges and accuracies)

Instrument Layout

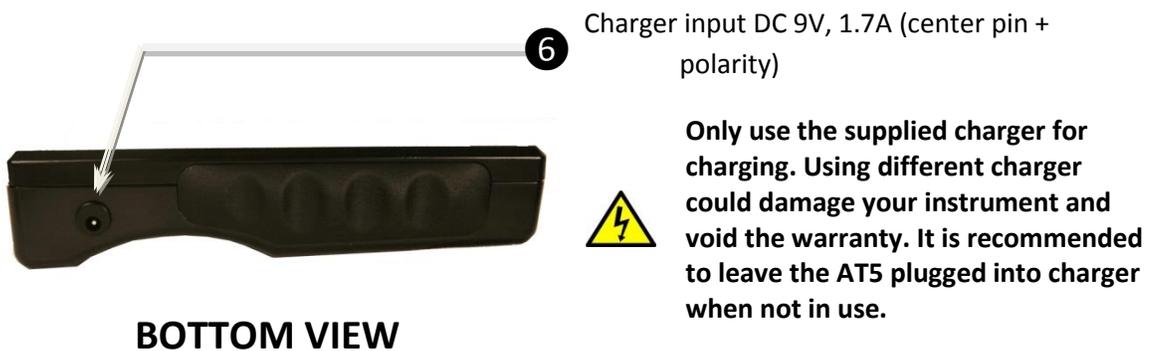
The instrument has three sections:

- Input/output ports
- LED display
- Control Keypad & Function LED's

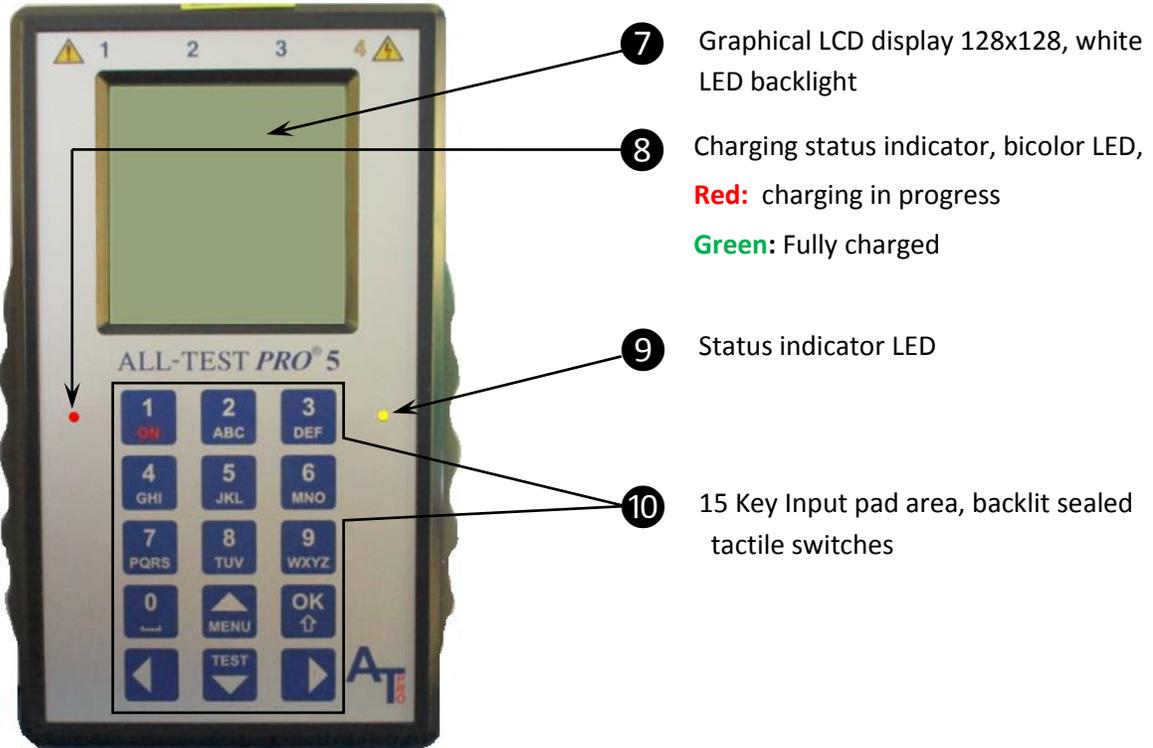
Input/Output Ports



Battery Charging Port



Front Panel Layout



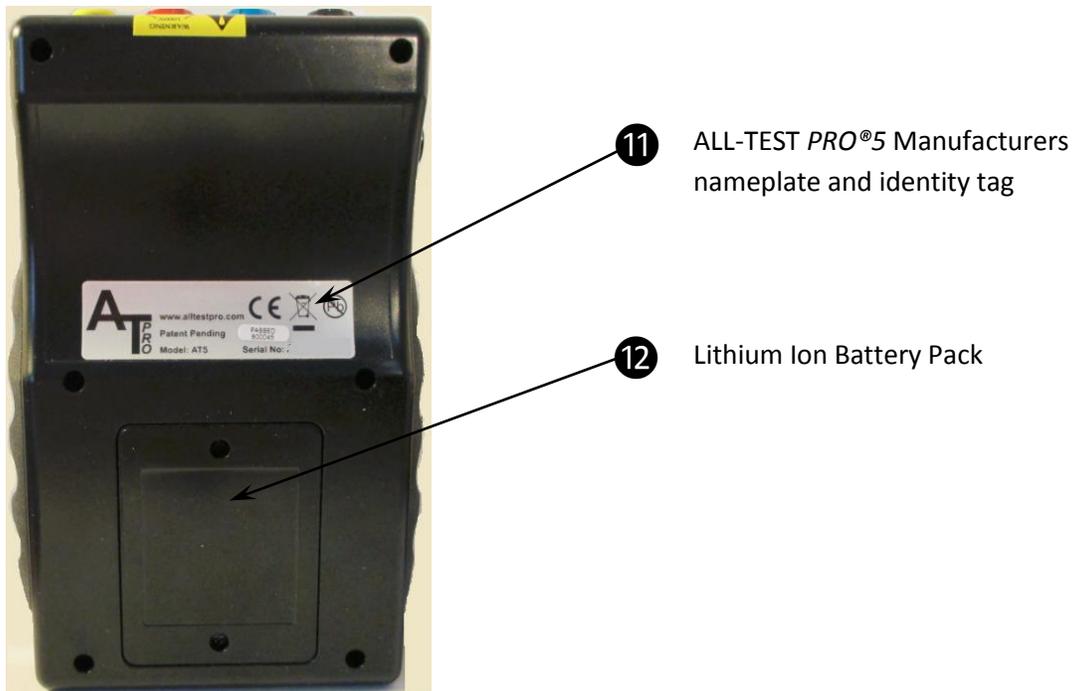
7 Graphical LCD display 128x128, white LED backlight

8 Charging status indicator, bicolor LED,
Red: charging in progress
Green: Fully charged

9 Status indicator LED

10 15 Key Input pad area, backlit sealed tactile switches

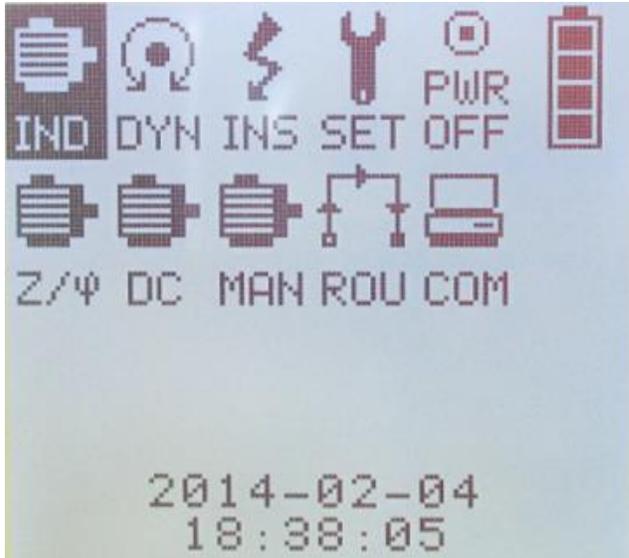
Rear View



11 ALL-TEST PRO®5 Manufacturers nameplate and identity tag

12 Lithium Ion Battery Pack

MAIN MENU



The main menu provides the icons to access the various tests and other functions of the ALL-TEST Pro 5.

The LCD display provides the screens, instructions and displays necessary to perform de-energized tests on:

- Induction Motors
- Synchronous Motors
- Permanent Magnet
- DC Motors
- Shunt
- Transformers
- Squirrel Cage
- Wound Rotor
- Self-Excited
- Series
- Compound
- Generators

Figure 1 Main Menu



IND – Performs tests on AC three phase squirrel cage induction motors with rated voltage less than 1000 V. It performs the Static, Dynamic, Insulation resistance to ground, DF & capacitance of winding tests.



DYN – Directly accesses the dynamic tests on AC three phase squirrel cage induction motors with supply voltage less than 1000 V. This test requires manually rotating the shaft. This test should only be performed directly on the motor.



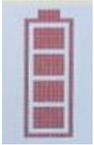
INS – Directly accesses the Insulation resistance to ground test.



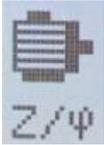
SET- provides direct access to view or delete previously stored test data, set the date and time of the instrument or make manual measurement of R, L, & ϕ .



PWR OFF – Provides the selection to turn the AT 5 off. If the instrument idles for 5 minutes or longer, the AT 5 will power off automatically.



Battery Charge Indicator – Provides indication of the status of the battery charge. See the Battery section for further information about battery care.



Z/ψ – Performs de-energized winding tests, insulation resistance to ground, DF & capacitance of winding to ground tests on all types of AC 3 phase motors, transformers or generators.



DC – Performs de-energized winding tests and insulation to ground tests on various types of DC motors.



MAN – Two test options. "1-Phase" test accesses DF and capacitance of winding to ground, insulation resistance to ground and other physical quantities on any single phase motor. "Rotor test" provides convenient way of performing rotor test for rotor problem diagnostics for 3-phase motors.



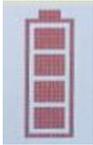
ROU – Directly accesses the test screens to perform motor testing using predetermined routes setup downloaded from the MCA software.



COM – Sets up the instrument into the communication mode to communicate with the MCA software on a computer.

BATTERY

Battery Meter



Battery Charge Indicator is located on the right top corner of the main screen. It provides indication of the status of the battery charge. When battery charge is low, it could possibly lead to inaccurate measurements. Therefore, it is always recommended to make measurements only when there are 3 bars at minimum. Users are suggested to keep the instrument charged when it is not being used.

Battery Charging



Only use the supplied charger for charging. Using the wrong charger can damage your instrument.

The battery typically takes 2.5 hours to fully charge.

Charging status is indicated by bi-color LED to the left of keyboard:

Red = Battery conditioning and charging

Green = Charge complete

OFF = Charger not connected





The ALL-TEST *PRO* 5 is powered by 2 rechargeable Lithium-Ion batteries. The battery pack is easily replaceable and comes as a complete unit. The battery capacity can support eight hours of normal testing.

Li-Ion Battery Care

Lithium-ion batteries have significant advantages over many other types of batteries in both performance and capacity. Following the guidelines below will help maintain both performance of your batteries and maximize the lifetime.

Li-ion batteries do not develop memory and don't require full discharge before charging. To increase the usage lifetime of Li-ion batteries it is recommended to perform more frequent partial discharges instead of complete discharges. Li-ion batteries will last longer using partial discharge cycles and try to avoid full discharge cycles.

Li-ion batteries will discharge while setting idle. It is recommended to recharge the ALL-TEST 5 prior to use if it has been setting idle for an extended period.

Battery voltage is independently monitored and indicated in the main menu, as one of four possible levels or will show the word "LOW".

When the charger is plugged into line power the charging circuit automatically resumes charging when the battery voltage falls below the preset threshold.

The Li-ION batteries have built in over-discharge protection circuits, activated if the cell voltage falls below a threshold that will disconnect the cell resulting in no power! The solution is to recharge the batteries.

The battery charge light is the best indicator for when the battery is fully charged.

INSTRUMENT OPERATION

Turning the instrument ON

Press the "ON" key **1** to turn on the instrument.

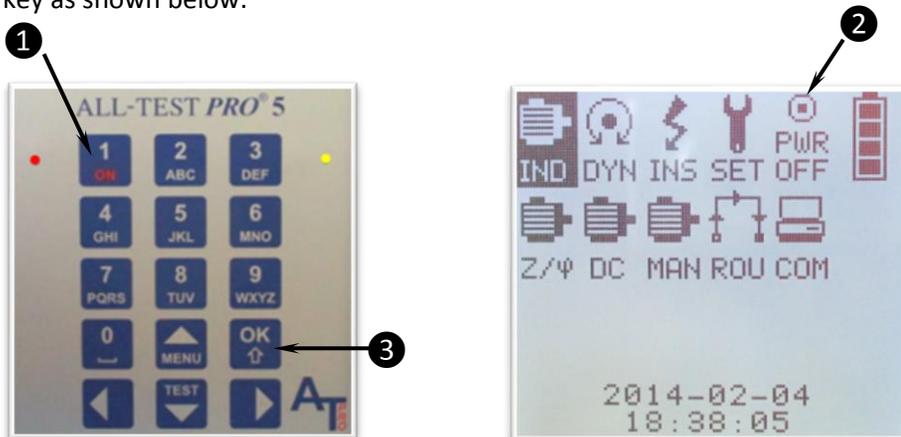
Note: If the instrument does not turn on, try to hold the "ON" key for a little longer. If it still does not turn on, the most likely cause would be that the Li-ION batteries built-in over discharge protection circuits have switched off. In such scenario, please try the following in the order those steps are listed:

1. Try pressing left and right arrow keys simultaneously for a few times to see if the instrument can be turned one
2. Leave the instrument alone for 5 minutes, try to turn it on again. If it does not turn on, try #1 above again.
3. If neither of above works, connect the charger until the instrument is fully charged, then try it again.
4. The last option would be to open the battery cover, disconnect and reconnect battery pack back to the circuit. The battery pack is labeled as **12** in Section "Rear View".

Now the instrument can be turned on normally.

Turning the instrument OFF

Select the "PWR OFF" icon **2** in the main menu with the arrow keys and then press "OK" **3** key as shown below.



Reset the instrument

Simultaneously press the left and right arrow keys and then release. This performs a forced hardware & firmware reset and will return the display back to the main menu

Automatic OFF

Without any operation, the instrument will turn off after idling for approximately 5 minutes.

However, if the instrument is set in Communication mode, the feature is disabled. If left unattended, eventually the instrument battery will drain out completely.

To exit the communication mode:

1. If the MCA software on a computer perform any operation, e.g. upload data, download data, upload route etc, the instrument will be discharged once the operation is completed.
2. To manual is to use Left arrow and Right arrow simultaneously to reset the instrument. See Section

Reset the instrument.

IND/DYN/INS – AC INDUCTION MOTOR TEST

The new Patented & Patent Pending analysis methods and measuring technologies are divided into two main testing types: “**STATIC**” and “**DYNAMIC**”.

After completing a test “path” the AT5 will automatically “ANALYZE” the test result of each parameter and presents the result in a user friendly format. Analysis results include one of three possible levels: “**OK**”, “**WARN**” or “**BAD**” based on the preset rules. The user always has the option to compare the new results with already preloaded or saved record in the memory, or to save the current test as a baseline reference test.

Saved test records can be uploaded to the optional PC software for further analysis, trending, data base management and report generation.



The three icons are used for **STATIC** and **DYNAMIC** test. They are located on the very first three positions on the 1st line of icons of main menu, as shown in the main menu below.



IND – Performs tests on AC three phase squirrel cage induction motors with rated voltage less than 1000 V. It performs the Static, Dynamic, Insulation resistance to ground, DF & capacitance of winding tests.

DYN – “DYN” means dynamic test and is a part of the “IND” test and “Z/φ” test. This menu provides a convenient direct access for dynamic test.

INS – “IND” means insulation resistance to ground test and is part of the “IND” test and “Z/φ” test. This menu provides a convenient direct access for insulation test.

Before going into the details on how to perform the test, the general testing theory is presented first below.

Electrical Winding Testing Theory

Studies have shown that a leading cause for motor failure is deterioration of the insulation. There are two different insulation systems. The motor conductors that make up the coils are individually coated with resin or varnish that acts as insulation to keep the current flowing through the designed path of the entire winding; this insulation system is called turn or winding insulation.

The second insulation system is referred to as the ground wall insulation and is located between the windings and the motor core or stator, this system separates the conductors from the motor core or frame.

Since current takes the path of least resistance; any weaknesses or faults in the insulation system will allow flow of the current through the insulations and will allow the current to bypass or “short circuit” designed flow path. This “short circuiting” will further degrade the operation of the motor and potentially result in catastrophic failure. Additionally, weaknesses in the ground wall insulation system will not only degrade motor operation but will lead to increased electrical shock potential to personnel or plant safety.

Insulation failures can be caused by thermal, electrical, mechanical, and environmental stresses. Electrical surges, voltage unbalance, incorrect voltage, excessive current or mechanical vibration are common reasons that cause the insulation to wear and breakdown. Other typical insulation failures include excessive moisture, contamination, and metallic dust. Some faults are due to poor manufacturing or assembly of the motor.

Electrical Motor Winding Testing has historically been limited to measuring the DC resistance of the conductors in Ohms as well as DC resistance of the insulation in Mega-Ohms. These tests are very common due to the availability of electrical test instruments. The purpose of these instruments has a multitude functions to make generalized electrical measurements and do provide some valuable information. In many cases faults that affect these measurements have been identified.

Hipot tests are designed to look for any weaknesses in the system by applying high voltage and may result in complete insulation failure by overstressing it. Many of these tests are destructive and result in a complete failure of the winding as well as additional damage to the stator or rotor core. Most of these tests are Go - No Go and will only locate existing significant weaknesses in the insulation system but fail to provide any indication of early degradation of the insulation system. Therefore, early-stage insulation faults or developing faults that these tests cannot identify may be present and will damage the motor in a certain period depending on the deteriorating speed.

For over 30 years the ALL-TEST *Pro* line of motor testers have been the leaders in the industry in providing easy-to-use hand held instruments specifically designed to test motors. It injects a series of low voltage signals into the winding system to exercise the effects of the conductors as well, as the interaction with the insulation system. These instruments allow the technician to

not only identify faults within the winding or insulation system but also identify small changes that provide early warning or other changes in the system.

Static Testing

The static tests refer to the de-energized motor winding tests performed with the motor rotor in a stationary “static” position. It uses ALL-TEST Pro’s proven testing methods to measure the windings in all three phases at various pre-determined test frequencies. The results of these tests are used to calculate the **Test Value Static (TVS)** Test Value Static (TVS) and **Reference Value Static (RVS) (Patented)**.

Contamination: Measures the Dissipation Factor (DF) and the capacitance between motor frame–stator windings.

Resistance: 0-999Ω, resolution 0.01mΩ. True 4-wire Kelvin measurement for accurate low resistance results (includes automatic compensation for thermoelectric offset voltages).

Insulation Resistance: 0 – 999MΩ @1000V, 0 – 500MΩ @500V

Note: Static tests (*except for DF and Capacitance*) can be performed directly at the motor or from the starter or motor drive. However, testing from the starter or motor drive can introduce external sources of interference that can influence the test results. User should repeat any test from the starter/drive to verify measurements are repeatable.

Test Value Static (TVS)

The TVS is a single value which is calculated using a proprietary algorithm that defines the symmetry of the three phase winding system. This value is calculated from measurements made at several different frequencies through the motor stator windings. Any change in the winding insulations systems condition will be reflected in the TVS.

Reference Value Static (RVS)

When a test record is saved as reference type in the instrument, the TVS is called RVS. Each RVS corresponds to a specific machine and serves as baseline test data for diagnostic purpose. Any measured TVS can be trended over time or compared to its RVS, or the RVs of another motor that is known to be in good condition and is exactly the same motor.

Capacitance (C)

The insulation between the winding conductors and the machines frame form a natural capacitor. Capacitance is a measure of a systems ability to store electrical charges. The magnitude of capacitance in a system is determined by:

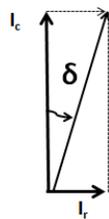
- Effective surface area or conductors in the case of a motor.
- Distance between the conductors

- Contamination, moisture, chemical changes or any build up

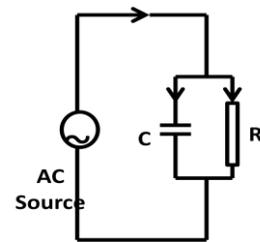
The actual capacitance for each motor is unique to that motor and will differ from any other motor, even motors of the same size and type. However, when the insulation system becomes coated with foreign matter, such as grease, cement dust, carbon dust or any other material, it will cause changes in capacitance. By measuring this value on a new motor and trending it over time provides indication of debris buildup or contamination, moisture absorption, chemical reaction or thermal degradation of the insulation system.

Dissipation Factor (DF)

Since the insulation material forms a capacitor, an AC voltage applied



across the insulation will cause the system to react as a capacitive circuit. Ideally the electrical equivalent circuit would be a simple capacitive circuit, and all of the current through the circuit would be capacitive. However, in real life the equivalent electrical circuit will be a parallel RC circuit. Some of the current will be capacitive I_c while



some of the circuit will be resistive I_r . The two currents have a phase difference of 90° . The DF is the ratio of the resistive current to the capacitive current. $DF = I_r / I_c$. It is also referred to as the $\tan \delta$.

DF testing is widely used on electrical equipment such as power transformers, circuit breakers, generators and cables. Also, DF values, trended over time, can help in detecting problems like contamination, high moisture content and the presence of voids in insulation.

When the insulation system begins to degrade or becomes contaminated, the DF will increase. In addition, the DF is temperature dependent. Measuring DF at too high or too low temperature can introduce errors, and the IEEE recommends performing DF tests at or near 68°F (20°C).

INS - Insulation Resistance to Ground (IRG)

IRG is the most common electrical test performed on electrical systems. The IRG test is performed by applying a high dc voltage between de-energized current-carrying conductors, (windings) and the machine casing or earth.

According to IEEE Std 43, the insulation resistance is measured after applying DC high voltage for 1 minute. The motor should be above dew point temperature before testing if possible. It is important to correct values to a reference temperature (typically 40°C) so that trends and changes in insulation resistance can be readily detected. Contamination, humidity, temperature, and other factors affect insulation resistance values.

The standard recommends choosing test voltages for insulation resistance testing:

Winding rated voltage (V) ^a	Insulation resistance test direct voltage (V)
<1000	500
1000–2500	500–1000
2501–5000	1000–2500
5001–12 000	2500–5000
>12 000	5000–10 000

^aRated line-to-line voltage for three-phase ac machines, line-to-ground voltage for single-phase machines, and rated direct voltage for dc machines or field windings.

The AT5 instrument offers two voltages: 500V and 1kV. For windings rated over 5kV, an additional megger tester with higher voltage will be needed according to the guidelines above.

The standard also recommends minimum insulation resistance value at 40 °C as shown below. “kV” is the rated line to line rms voltage of 3 phase motor, line to ground voltage of single phase motor, or rated DC motor voltage.

Minimum insulation resistance (megohms)	Test specimen
$IR_{1\min} = kV + 1$	For most windings made before about 1970, all field windings, and others not described below
$IR_{1\min} = 100$	For most ac windings built after about 1970 (form wound coils)
$IR_{1\min} = 5$	For most machines with random-wound stator coils and form-wound coils rated below 1 kV and dc armatures

Note: The IEEE guidelines above provide the recommended voltages and Minimum Insulation Resistance to ground values. If these procedures or values differ from your equipment manufactures’ recommendations, follow their guideline.

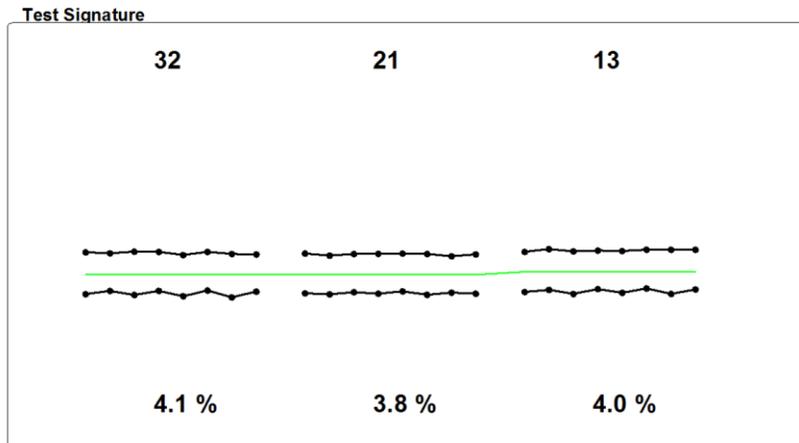
Dynamic Testing - DYN

Dynamic tests are patented test methods that refer to the de-energized motor tests which are performed while the squirrel cage rotor of an induction motor is manually rotated. The dynamic test sequentially performs tests on all three phases of the stator windings and develops a “Test Signature” of both the rotor and the stator which are then analyzed to provide immediate results as to the condition of the rotor and the stator of three phase squirrel cage induction motors.



Dynamic tests need to be performed directly at the motor. Testing from the starter or motor drive can introduce external sources of interference that can adversely influence the test results.

“Test Signature” (patented): Measures, in real time during manual rotation, a number of parameters in all three phases which together forms the “Test Signature” for the rotor and stator. The “Test Signature” is then automatically analyzed in the AT5 and gives the user immediate results for Stator and Rotor status. The “Test Signature” can also be uploaded to the optional PC software and evaluated further by a trained technician.



An example of dynamic test signatures is shown above. The six dotted lines, each of which consisting of 8 data points represent the rotor signatures. When one of the six signatures does not have significant variations, chances are the rotor is good.

However, visual look only provides a means to give users some clues on the nature of the test signatures. However, diagnostic conclusions cannot be drawn based on the visual look only. Always refer to the analysis from the instrument and software.

Recommended Testing Practice

Prior to the motor installation in the field, a DF/C + Insulation + Static + Dynamic test should be performed directly at the motor leads and then saved as a reference test.

After the motor is installed then an Insulation + Static test should be performed from the starter/drive and then saved as another reference test. This test should be repeated to verify stable results are achieved.

Subsequent Insulation + Static testing can be done for trouble-shooting or other purposes. If a change in either the Insulation or Static test is observed then both tests should be performed at the motor with incoming leads removed from the motor.

This new Insulation + Static test at the motor terminals should now be compared to the initial reference static test that is mentioned in item 1.

If the values have not changed from the initial static test then likely the problem is related to cables/connections between starter/drive and motor.

If values have changed from initial static test then the user will need to perform a complete DF/C + Insulation + Static + Dynamic to determine the root cause for this change.

Contamination DF & Capacitance Test Practice



The Dissipation Factor test (DF) & Capacitance test (C) of the AT5 is a low voltage method to measure the Dissipation Factor [also known as tan delta (loss angle)] and the Capacitive system inside the motor formed by the motor frame and the stator windings. Due to the inherently high impedance nature of the DF & C test the AT5 connection is designed to form a shielded test setup together with the motor object under test.

All DF & Capacitance testing should be performed directly on the motor terminals as instructed and pictured in this Manual.

Only the supplied (shielded) test leads and clips should be used. The use of any additional cable(s) between the test clips and motor terminals can introduce hum and/or other interference that can result in erratic readings for DF and C. In addition, longer cable lengths can also add the influence of the cable itself.

In order to get the highest possible accuracy for the DF test, the instrument should be allowed to have a warm up time of approximately 10 seconds after powering “ON” (this allows time for the DC and offset levels to stabilize). Note that the specification for DF and Capacitance is based on battery powered operation. The USB communication cable cannot be connected to a computer during the DF (or Contamination) test described below.

Test Steps

Before starting this test, verify that you have a good ground. To do so, entering into "INS" menu, connect the blue test lead and yellow lead to the instrument. Clip the connectors onto ground test lead and motor frame ground. Press the button to do the insulation test. If it shows a value close to 0 Ω , it means the ground test lead is good. Otherwise, please check to make sure the ground test lead is really grounded. The steps are described in the Section “Verifying Proper Ground Connections”.

To start the static and dynamic tests, select the “IND” icon in the Main Menu and press the OK key.

DF/C Test

Connect the test leads according to instructions in the message screen.

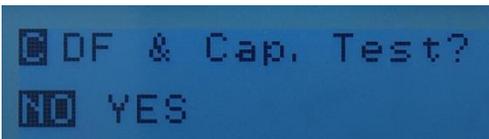
“Connect BLUE clip to Phase 2 and YELLOW to Frame, OK to continue....”



This connection will prepare the instrument for the DF, Capacitance and Insulation tests.

A message screen during the DF and Capacitance measurements will appear displaying:

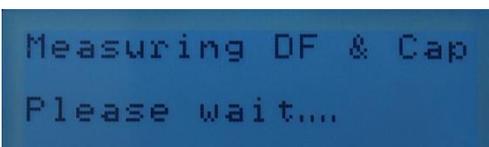
“DF & Cap. Test?”. Press NO to skip or YES to continue.



If NO is selected then the display will sequence to the Insulation to Ground Test

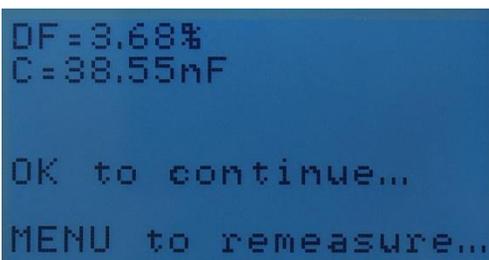
If YES is pressed then a message screen during the DF and Capacitance measurements will appear displaying:

“Measuring DF & Cap, Please wait....”



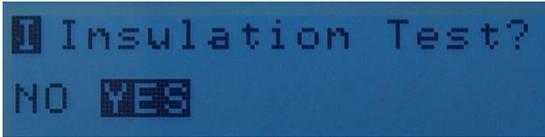
After the DF and Capacitance test is complete then the display will show the measured values.

Press “OK to continue... or MENU to remeasure...”



Insulation Resistance Test (MΩ)

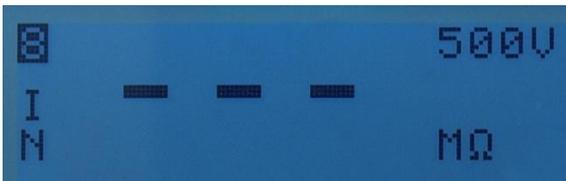
Next step is the selection of “Insulation Test?” Select “NO” or “YES” and press OK.



If “YES” is selected “---” will be displayed indicating an empty start value for MΩ.

Select the desired test voltage by pressing the right arrow key, which will toggle between the two available selections: 500V or 1000V.

NOTE: See Section “INS - Insulation Resistance to Ground (IRG)” for guidelines on performing the test and interpreting data.



WARNING: Risk of electric shock!



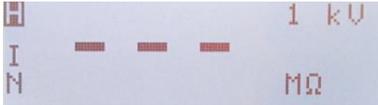
Pressing the TEST key will output the selected test voltage of 500V or 1000V on the yellow output port and illuminate orange status LED.

To perform Insulation Resistance to Ground (IRG) test:

Press “TEST” key until the MΩ value becomes stable or >500MΩ is displayed, and then OK to continue.



Verifying Proper Ground Connections

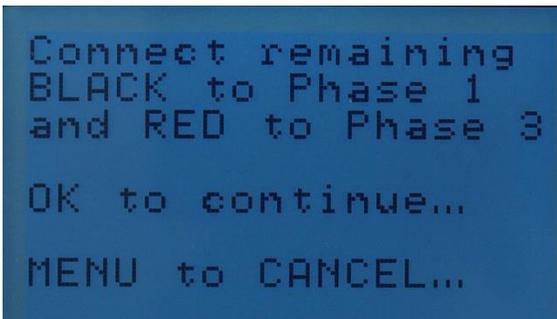
- 1) From the main menu press the **▶** key to highlight the **INS** function. 
- 2) Connect Blue Test lead to a ground or earth location, and the Yellow test lead to a separate ground or earth location.
- 3) Press the **OK** key, the screen will display 3 - - -, this indicates that no measurements have been taken. 
- 4) Press and Hold the **TEST** key until a value very close to 0 is displayed. If any other value is displayed one or the other of the test leads are not properly connected to ground.
- 5) To Clear value displayed press the **OK** key

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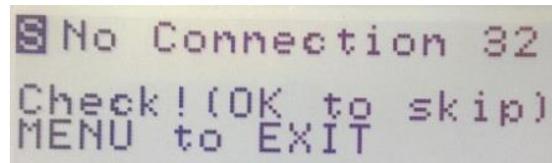
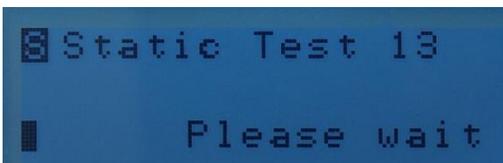
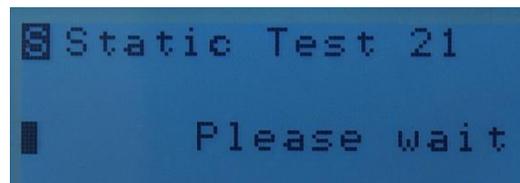
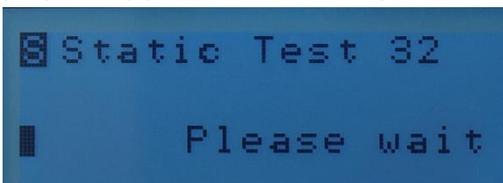
- 6) Verify the Connection of the blue lead has a good path to ground, or earth
- 7) To retest press and hold the **TEST** key until 0.00 is displayed. If any other value is displayed one or the other of the test leads are not properly connected to ground.
- 8) Verify the Connection of the Yellow lead has a good path to ground, or earth,
- 9) To retest press and hold the **TEST** key until 0.00 is displayed. If any other value is displayed one or the other of the test leads are not properly connected to ground.
- 10) Continue to retest until both test leads have a good path to ground

Resistance and “Test Value Static” Test (R, TVS)

Connect the remaining test leads according to instructions in the message screen to prepare the instrument for the remaining “STATIC” & “DYNAMIC” tests.

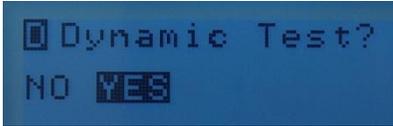


The AT 5 will now start the automatic “STATIC” series tests, starting between phases 3-2 displaying: “STATIC Test 32, Please wait” (with progression bar) and continuing with subsequent testing between phases 2-1 and 1-3. This test includes measuring a number of parameters between the three phases at all available test frequencies such as: Resistance (R), Inductance (L), Impedance (Z), Current/Frequency Response (I/F) and Phase Angle (φ), together with other proprietary parameters to finally calculate TVS, the “Test Value Static”.



NOTE: If “No Connection” is detected by the AT 5 will display the warning message listed above. If your connection to the motor is correct then you can force it to sequence to the next phase by pressing OK.

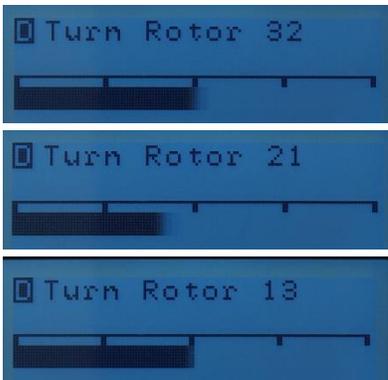
Dynamic Test



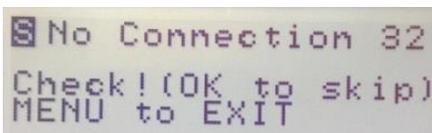
The next step provides the option to select a “Dynamic Test?”. Select “NO” or “YES” and press OK. If “NO” is selected then the instrument will skip the Dynamic Test and go directly to the “Result Menu Screen”. Selecting “YES” will start the Dynamic test



Start by turning the Rotor as smoothly as possible by using the bar graph as a visual feedback aid. Continue turning/rotating the rotor while the AT5 automatically switches to the next “phase to phase” connection displayed in the following order:



NOTE: When performing a Dynamic test it is important to watch the AT 5 display screen while turning the motor shaft. The bar will move horizontally across the screen while you are rotating the motor shaft. If little (or no) movement occurs then it is possible it will not sequence to the next phase during the dynamic test. You can force the AT5 to sequence to the next phase by pressing OK. This does not mean that the motor is necessarily bad, but instead may relate to the design/construction of the motor. *It’s always recommended to practice the dynamic test using the “DYN” menu to find the optimized turning speed.*



NOTE: If “No Connection” is detected by the instrument you will see the warning message listed above. If your connection to the motor is correct then you can force it to sequence to the next phase by pressing OK.

Rotation Speed Guidelines

Start by turning the Rotor slowly and as smoothly as possible by using the bar graph as a visual feedback aid.

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Maximum recommended rotor shaft rotational speed for 2-pole motor = 100 RPM

Maximum recommended rotor shaft rotational speed for 4-pole motor = 50 RPM

Maximum recommended rotor shaft rotational speed for 6-pole motor = 33 RPM

Maximum recommended rotor shaft rotational speed for 8-pole motor = 25 RPM

Maximum recommended rotor shaft rotational speed for 10-pole motor = 20 RPM

Maximum recommended rotor shaft rotational speed for 12-pole motor = 17 RPM

Resistance	NoR
Stator	OK
Rotor	Warn
Contamination	NoR
Insulation	NoR

SAVE
EXIT/Upload TEST
REMEASURE

Viewing Test Results

After the STATIC and DYNAMIC tests are done, the instrument will automatically analyze, calculate and display the result menu screen, reporting **OK**, **WARN**, **BAD** or **NoR** = No Reading. The following is summary of the alarms on different parameters:

RESISTANCE deviation	Displayed Result
< 3 %	OK
≥ 3% < 5 %	WARN
≥ 5 %	BAD
No Reading	NoR

STATOR signature dev	Displayed Result
< 1.1%	OK
≥ 1.1% < 3 %	WARN
≥ 3 %	BAD
Only STATIC test done	use REF (TVS)
Concentric Windings	CC

ROTOR signature dev.	Displayed Result
< 10 %	OK
≥ 10 % < 15 %	WARN
≥ 15 %	BAD
Only STATIC test done	use REF (TVS)
Small Signature Variation With < 2 % variation	< 2

Note: Rotor analyze is a proprietary patented method

CONTAMINATION DF%	Displayed Result	INSULATION MΩ	Displayed Result
≤ 6 %	OK	≥ 100 MΩ	OK
> 6 % ≤ 10 %	WARN	≥ 5 MΩ < 100 MΩ	WARN
> 10 %	BAD	< 5 MΩ	BAD
No Reading	NoR	No Reading	NoR

The Result screen has selectable submenus to display test result details, including Rotor and Stator graphic “Test Signature” Pattern if a Dynamic test was done. If only a STATIC test was done the Rotor and Stator fields will display “use REF” and subsequent sub-menu will show the TVS = “Test Value Static” value.

1. Use UP & DOWN arrow keys to select item then press OK to enter the sub-menu and view details.
2. Press **OK** or **MENU** to return when done.

The following is an example of reviewing resistance test results submenu.

<pre> R32 R21 R13 18.0Ω 18.0Ω 18.0Ω Rdev Rdev Rdev +0.1% -0.1% +0.0%</pre>	<p>The Resistance Submenu will display actual R values and % deviation. % deviation is calculated by comparing each phase to the average of the three-phases.</p>
---	--

The **Contamination Submenu** will display DF in % and Capacitance in nF. If C is less than 1% it will display <1.

<pre> DF = 3.68% C = 38.55nF</pre>

The **Insulation** submenu will display Insulation resistance in MΩ or >999MΩ or --- MΩ (if NoR)

<pre> INS Test Result: >999MΩ @500V</pre>
--

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The following is the example of the test results display when dynamic test is not performed. The right screen below is the submenu after OK key is pressed to select “Rotor” on the left screen.

```

Resistance      OK
Stator         use REF
Rotor          use REF
Contamination  OK
Insulation     OK

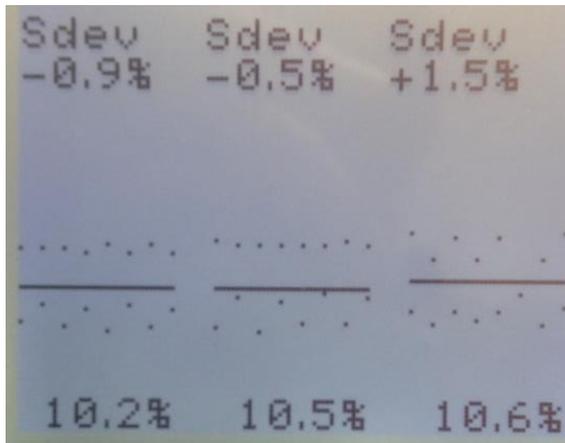
SAVE/REF
EXIT/Upload TEST
REMEASURE
  
```

```

Static Test Mode.
Test Signature not
available! use REF

TVS=672.56
  
```

The **Stator** submenu will display the “Test Signature Pattern” if a DYNAMIC test was done. If only STATIC tests were done then the TVS=“Test Value Static” (dimensionless) will be displayed. The following is an example when dynamic test is performed and **Stator** is selected.



The center solid line in the graph is the Stator signature and Sdev represents the deviation of the stator signature. Evidently, for the last measurement of Phase 1-3, the stator signature is higher than the other two measurements which will provide a WARN alarm since 1.5% exceeds the WARN limit.

The six black dotted lines represent the Rotor Signature and include an upper and lower signature. This represents the deviation of the peak values during rotation. As the output of the instrument is sinusoidal and the response of the motor will be sinusoidal, there will be peak values both positive and negative. There are 8 dots for each phase and if this were an 8-pole

motor then this represents 1 full revolution of the motor shaft. If this were a 2-pole motor then it represents 4 revolutions of the motor shaft. If this were a 12-pole motor then it represents $\frac{3}{4}$ of a revolution of the motor shaft. With this Rotor signature there is a slight variation in the distribution of the peak values, but as they are within our limit, this rotor is in good condition.

The % change displayed on the bottom represents the change in impedance during rotation of the shaft.

Test Save and Reference Comparison

After viewing the test data, if the user wants to save the test, highlight the “SAVE/REF” and then press “OK” key.

```
Resistance      OK
Stator          OK
Rotor           OK
Contamination  OK
Insulation      OK

SAVE/REF
EXIT/Upload TEST
REMEASURE
```

There are four options available.

```
Select function:
QUICK SAVE
SAVE
SAVE as REF
Compare to REF

CANCEL
```

Letter and Number Input

Before exploring all SAVE options, the method to input the letter or number is described below.

Alpha Characters

The highlighted section in the upper left hand corner indicates if the key pad is using the alpha characters or the numeric characters. To switch between Alpha and Numeric keys, press the OK key while the highlight is in the data entry field variable bar is highlighted.

Alpha characters will be entered when ABC is displayed in the upper left hand corner of the save screen. To enter Alpha characters press the keypad with the desired Alpha character. The first character of the three or four characters on each key will be entered with the first press of the button, immediately repressing the button will select the second alpha character, as well as the third and the fourth. Momentarily pausing after a key stroke will cause the cursor to automatically move to the next blank space. And the new or different Alpha character can now be entered in that space.

Numeric Characters

Numbers will be entered when 123 is displayed in the upper left hand corner of the save screen. To enter numbers simply press the key with the desired number. The selected number will be entered and the highlight will automatically move to the next available space.

Move to Different Screens

To complete any entry, press the Upward or Downward arrow keys. This will highlight the NEXT button, and then press OK. This will either display the next selection or move to the next screen.

The function of the three buttons:

PREV: Goes back to the previous steps so that you can modify the information input

NEXT: Goes to next step

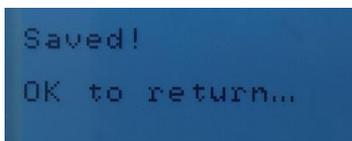
CANCEL: Goes back to the test results screen. You still have the chance to save the test data.

QUICK SAVE

QUICK SAVE provides a quick and easy way to save the test data in just a couple of steps.



Input the Motor ID or serial number, then use Upward or Downward key to highlight “NEXT”, pressing “OK” key.



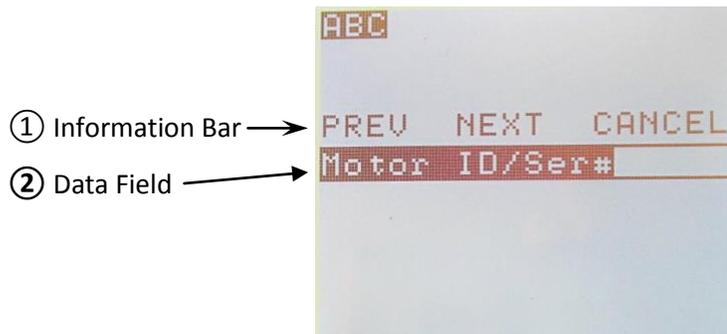
It shows the test has been saved in the memory. Press “OK” key to return to the test results screen.

SAVE / SAVE as REF

If you want to save the test data with some specific information about the motor, **SAVE** or **SAVE as REF** is the option to choose. You will go through the same saving steps for either option. The only difference between **SAVE** and **SAVE as REF** is the type of data saved in the AT5 memory. If you choose **SAVE as REF**, the test will saved as reference type and can be compared to when

In the **SAVE** or **SAVE as REF** screens additional machine information can be entered into any current data test set using the AT5 Keypad. The following additional information can be entered into the test data set from the keypad. Most of the additional machine information is self-explanatory, but a brief description is provided below for each entry.

Note: There is no mandatory entry that the users are required to input. However, it is always encouraged that the user fill in Motor/ID/Ser# at minimum.



Company: The Company name where the motor is located. Any combination of alpha-numeric characters or underscores, maximum 18 characters

Location: Machine Location. This can be the machine train that motor is driving. Any combination of alpha-numeric characters or underscores, maximum 18 characters

Motor/ID/Ser#: Unique ID for the motor; Each motor should have its own ID that remains with the motor; Any combination of alpha-numeric characters or underscores, maximum 18 characters

Motor Type: For the static or dynamic test this must be 3 phase squirrel cage induction motors only; Any combination of alpha-numeric characters or underscores, maximum 18 characters

Manufacturer: Motor Manufacturer; Any combination of alpha-numeric characters or underscores, maximum 18 characters

Motor Size(kW): Name plate motor Power rating in kilowatts; Numbers & decimals, maximum 18 characters

Motor Size (HP): Nameplate motor power rating in HP: Numbers & decimals, maximum 18 characters

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Motor Speed (RPM): Nameplate Speed: Numbers & decimals, maximum 18 characters

Current (A): Nameplate full load Current; Numbers & decimals, maximum 18 characters

Voltage (V): Nameplate voltage; Numbers & decimals, maximum 18 characters

PF/Cosφ: Nameplate power factor rating; Numbers & decimals, maximum 18 characters

Insulation Class: A letter designation specifying the thermal tolerance, or ability to survive a specified temperature for a specified period of time, of the motor windings. IES motors use five different insulation classes: Any combination of alpha-numeric characters or underscores, maximum 8 characters

IEC winding insulation classes parallel those of NEMA and in all but very rare cases use the same letter designations.

Class A 105° C (221° F)

Class E 120° C (248° F)

Class B 130° C (266° F)

Class F 155° C (311° F)

Class H 180° C (356° F)

Continue? This allows for entry of additional information. This information about the condition of the motor is selectable from drop down menus.

Select Connection: Indicates how the winding connections are configured. This is for information only, it doesn't affect the evaluation of the windings or rotor.

NEXT: Skips this menu and goes to next menu

Delta EU: Indicates that the 3 phase motor connections are connected in a delta arrangement following the European IEC nomenclature and guidelines.

Delta US: Indicates that the 3 phase motor connections are connected in a delta arrangement following the United States NEMA nomenclature and guidelines.

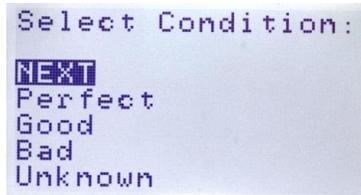
Star EU: Indicates that the 3 phase motor connections are connected in a arrangement following the European IEC nomenclature and guidelines.

Star US: Indicates that the 3 phase motor connections are connected in a Wye or Star arrangement following the United States NEMA nomenclature and guidelines.

Select Condition: Provides the ability to add a personal or "corporate" self assessment of the motors condition at the time of collection of the motor data test set.

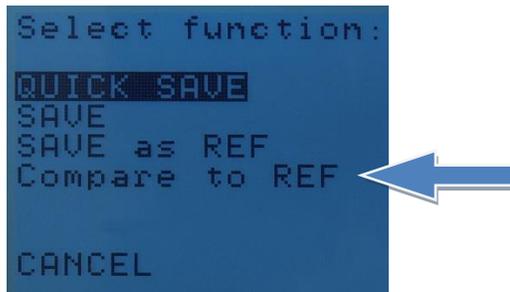


NEXT skips this menu and goes to next menu.



The entire list of “additional information” must be entered or skipped before the motor data test set can be saved in the SAVE or SAVE as REF mode.

COMPARE to REF



COMPARE to REF: Allows the current Motor data test data TVS to be compared to any of the Reference Test TVS, or RVS saved in the instrument.

The AT5 will display the deviation of the present TVS compared to the saved TVS in percentage. In addition it will also display one of these findings: **OK, WARN, or BAD** according to preset guidelines:

TVS deviation	Displayed Result
< 3 %	OK
≥ 3% < 5 %	WARN
≥ 5 %	BAD

To compare current test to Reference test:

1. From the results screen repeatedly press the **TEST** key to highlight the **SAVE/REF** button.
2. Press the **OK** key. This will display the save function screen.
3. Highlight **COMPARE to REF**
4. Press the **OK** key.

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This will display the **Find REF:** screen:

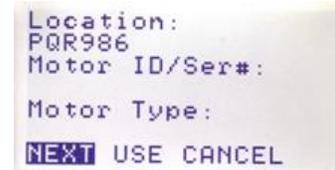
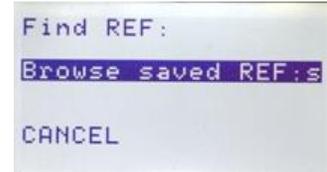
5. Select **Browse saved REF:s**
6. Press the **OK** key.

AT 5 will display REF:

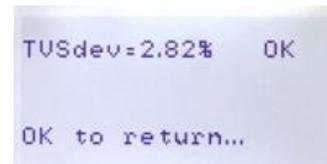
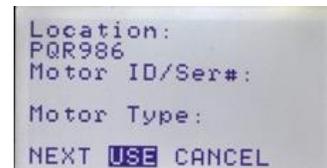
Location

Motor ID/Ser.#

Motor Type

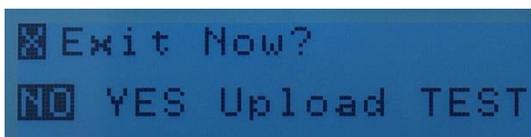


7. Press the **NEXT** function, the AT5 will display the first stored REF record one by one. Once the desired test is found, highlight the **USE** function.
8. To view additional REF tests press the key.
9. Press the **OK** key until the desired REF test is displayed.
10. Press the **>** key and highlight the **USE** function
11. This will display Motors Condition as compared to its RVS
12. Press **OK** key to return to Results screen
13. Any time to discard the comparison and return to the test results screen, highlight **CANCEL:** and press OK key.



Exit the Results Screen

The **EXIT/Upload TEST** function provides the options to exit the results screen and returns to the main menu, upload the test data to a PC using the USB serial port.



Note: The EXIT function doesn't save the Motor data test set. To save the teste data set in the AT5, the user has to use the **SAVE/REF** function prior to exiting this screen, as explained in Section Test Save and Reference Comparison.

- 1) To **Upload** the test data: Highlight the **Upload TEST** function, then press OK key
- 2) To **EXIT** the results screen: Highlight **YES**, then the screen returns to the main menu



REMEASURE

The user also has the option to do the same measurements again from the beginning by pressing “REMEASURE”.

Z/φ TEST

Z/φ test provides capability of testing broader range of 3 Phase AC equipment for various applications including transformer and generators. As shown below, Z/φ menu is located right below “IND” menu on the main menu

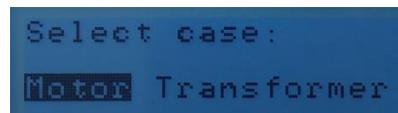


Z/φ provides same functionality as IND in that the tests of contamination, insulation, resistance and proprietary TVS are all performed, however, there are also significant differences. The IND adopts proprietary dynamic tests which is not available in Z/φ menu. On the other hand, Z/φ menu can be implemented on most of the 3 Phase AC equipment without the limit of less than 1kV rated voltage. It also makes tests and analysis on multiple measurements including impedance, inductance, phase angle and I/F.

Since both “IND” and “Z/φ” tests provides TVS, both types of test can be saved as reference record – refer to Section “Reference Value Static (RVS)”. Therefore, either test result can be compared to RVS.

Motor and Transformer Test

When open the Z/φ menu, there are two type of equipment to be selected: Motor or Transformer.



The operation steps are the same for Motor and Transformer and the displayed results are also similar, however, the transformer adopts a different alarm analysis algorithm from motor based on characteristics of transformer windings.

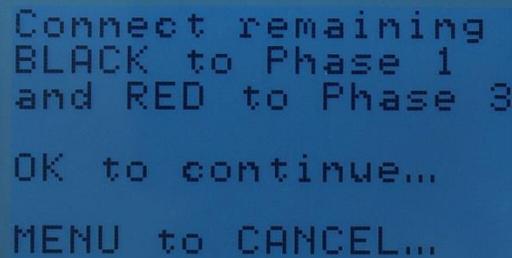
In addition, the SAVE menu operation is also same as IND test result.

Please refer to the Section “Test Steps” under Chapter “ind/dyn/ins – ac INDuction motor test”.

Rotor Compensated Test

When the parameter of impedance, inductance, phase angle and I/F are given alarms, the way to determine whether the fault comes from stator or rotor is to apply rotor compensated test which requires both AT31 and AT5 instruments.

1. Find rotor positions of maximum impedance corresponding to every two phases.
 - a. Connect AT31 to two phases, e.g. Phase 32, then turn shaft until the maximum impedance value is obtained.
 - b. Mark the rotor position.
 - c. In the same way, mark the rotor positions for Phase 21 and Phase 13 where maximum impedance occurs.
2. Start Z/φ test. Skip the DF/C test and insulation test. The yellow test lead do not have to be connected.
3. Go directly to the 3 phase static test, i.e. the test screen will be displayed as shown below.



```

Connect remaining
BLACK to Phase 1
and RED to Phase 3

OK to continue...
MENU to CANCEL...
  
```

4. Do not follow the instructions on the display. Instead, do the following
 - a. Connect Kelvin test leads 32 from AT5 to the Phase 3 and Phase 2 terminals on the motor.
 - b. Leave Test lead 1 open, i.e. not connected to anything
 - c. Turn the rotor to the marked position of maximum impedance for Phase 32
 - d. After the measurement of Phase 32, AT5 will start beeping due to test lead 1 not connected
 - e. Ignore the beeping, turn the rotor to the position of maximum impedance for Phase 21. Keep test lead 2 connected, disconnect test lead 3 (do not connect it to anything), connect test lead 1.
 - f. AT5 stops beeping and starts the measurement. Once it's completed, AT5 will start beeping again.
 - g. Ignore the beeping, turn the rotor to the position of maximum impedance for Phase 13. Keep test lead 1 connected, disconnect test lead 2 (do not connect it to anything), connect test lead 3.
 - h. AT5 stops beeping and start the measurement.
 - i. Then the rotor compensated test is completed. Save the test results in the same way as described in Section "Test Save and Reference Comparison".
 - j. Run MCA software to upload the test data and perform the 3 Phase AC individual analysis. If no WARN or BAD alarm shows up on the parameters of impedance, inductance, phase angle and I/F, it means the motor is in good condition.

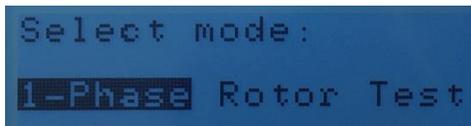
Note: the time interval between every two measurements, i.e. the time AT5 keeps beeping should be limited less than 5 minutes.

MAN MENU – 1 PHASE AC TEST AND ROTOR TEST

The “MAN” menu is located in the middle of the 2nd line of icons on the main screen as shown below.

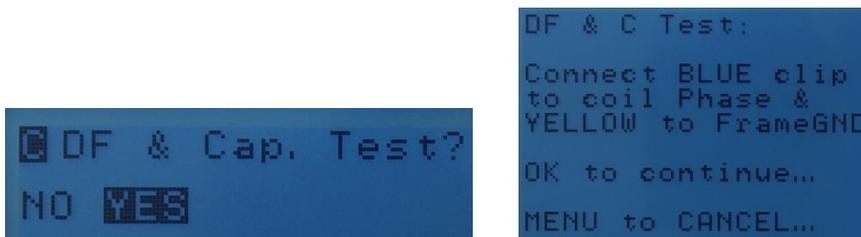


Press on “MAN” menu, the following screen pops up. The 1st option “1-Phase” is used for test on 1 Phase AC motor. The 2nd option “Rotor Test” is used for diagnose problems with rotor after the stator is determined to be good.

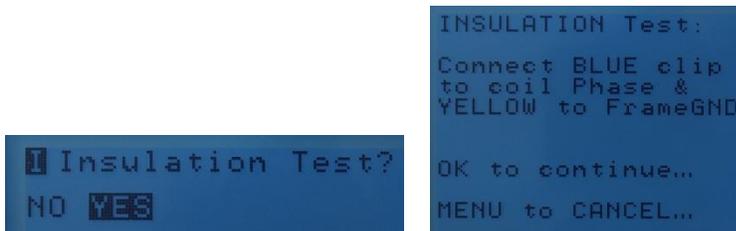


1 - Phase AC Test

- 1-Phase AC test starts with DF/C test as shown below.



- Choose to perform insulation test.



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3. Connect red test lead to the other terminal of the 1 Phase winding.

```

STATIC Test:
Connect BLUE & RED
clips to COIL

OK to continue...
MENU to CANCEL...
  
```

4. The user has the option to choose the test frequency. It's recommended to choose "A", i.e. the instrument will determine the optimized frequency for measurements.

```

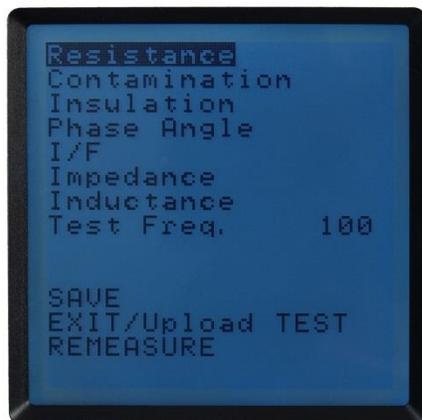
Select Frequency:
[5] 50 100 200 400
A=Auto frequency
(Recommended)

OK to continue...
MENU to CANCEL...
  
```

5. The results will be displayed as below. Press on any parameter will show the measurement value. Refer to Section "Viewing Test Results" in Chapter "ind/dyn/ins – ac INDuction motor test".

Note: For 1 – Phase AC test, no diagnostic analysis will be provided on instrument. Please refer to MCA software manual for the analysis performed in MCA software.

6. For the operations to save the test, exit or remeasure, refer to the Section "Test Save and Reference Comparison" in Chapter "ind/dyn/ins – ac INDuction motor test".



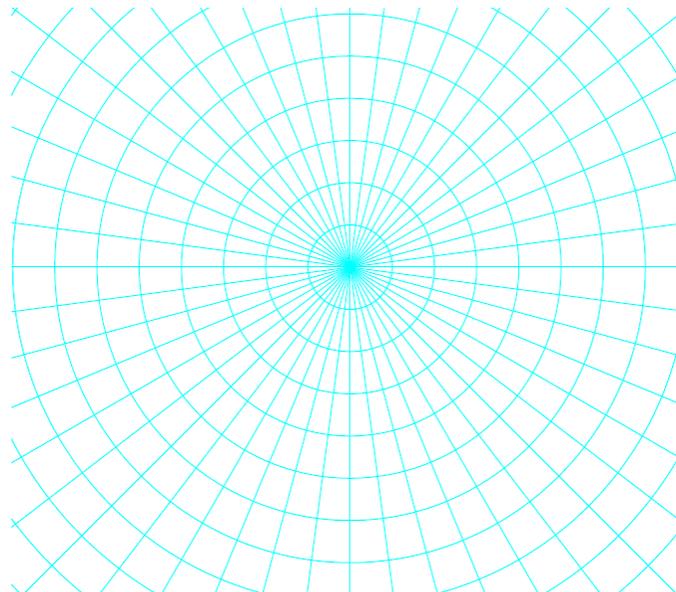
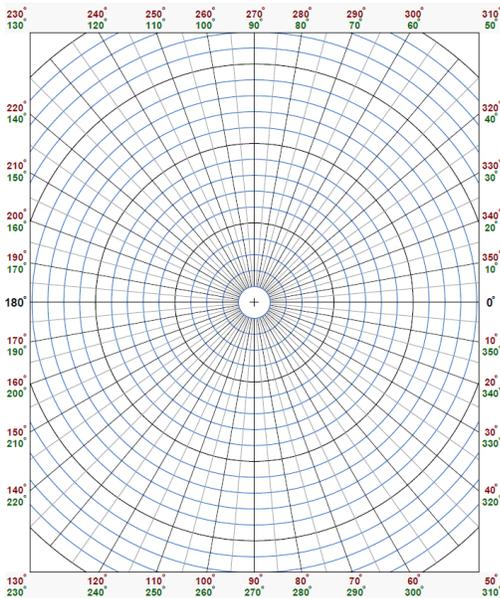
Rotor Test

Rotor test is only performed on 3 Phase AC motor after stator is determined to be fault-free. For motors with pole number 4 or less, 48 tests at minimum have to be performed on 48 different positions for one cycle. In other words, one test has to be performed every 7.5° around 360° . For motors with pole number of 6 or more, 72 tests have to be performed at minimum, i.e. one test every 5° .

To precisely determine every test position, an angle gauge can be attached to the rotor to determine to rotation angle step. Or the users can find polar graph online and print it and attach it to the motor frame with rotor shaft going through the center. An example is provided below.



Examples of polar graph: left- 5° interval, right – 7.5° interval.



Rotor Test steps

1. Select Rotor Test option, then connect the three test leads to the motor's three phases

```
Connect:
BLACK,BLUE,RED
clips to Phases
1,2,3

OK to continue...
MENU to CANCEL...
```

2. The instrument starts the measurement, then will show the frequency determined. The users can either use this frequency or select another frequency at their discretion.

Note: the frequency can be changed any time. However, to make a round of rotor tests, one frequency has to be used. So whenever the users decide to change the frequency, it means the rotor test has to restart.

```
Select Frequency:
50 100 200 400
Accept Auto freq.
cursor selection
or select manually

OK to test...
MENU to CANCEL...
```

3. Each time, the test is performed on three phases with results displayed as shown below.
 - a. When the rotor is turned to the next position, press the "REMEASURE", it will do another measurements. Each measurement has to be recorded on MCA software or another way, e.g. manual writing it down on a paper or on spreadsheet.
 - b. To change frequency, choose "fHz", highlight the desired frequency, then press "OK" key.
 - c. When all rotor tests are completed, choose "EXIT".

```
L32=347mH
L21=375mH
L13=370mH
Test Freq.=100Hz
REMEASURE fHz EXIT
```

DC MOTOR TEST



DC motor de-energized testing provides specific challenges since multiple duplicate coils are not easily accessible for comparative analysis. Additionally DC motors offer a variety of winding configurations, depending on the type of DC motor.

The motor tests made with the AT 5 are done with all of the motor windings connected. If a change is identified, then it is necessary to individually test the coils to identify the faulty coil. More detailed analysis procedures are available in the ALL-TEST *Pro* MCA analysis manual.

To identify developing faults in DC motors it is necessary to:

- 1) **Baseline:** Develop a baseline Motor data set on a DC motor in good condition as a baseline for future comparison.
- 2) **Trend:** Trend 2 or more motor data sets taken at different times to identify any changes in the winding condition over time.
- 3) **Comparison:** establish an average of several like motors and filed windings and compare the current measurements with the average for that coil. It is necessary to compare shunt coils with shunt coils, series coils with series coils, interpole coils with interpole coils.

New or Rebuilt Motors (Baseline Testing)

- 1) Take a complete set of motor data directly at the motor for a baseline data set following the guidelines for the specific type of DC Motor
- 2) Install the motor, take a complete set of motor data from the DC motor drive for a baseline motor data set, following the guidelines for the specific type of DC motor
- 3) Periodically monitor the DC motor from the controller, compare current motor data to the baseline from the drive.
- 4) If a significant change has occurred, disconnect the motor and test at the motor directly
- 5) Compare the current motor data taken directly at the motor to the baseline motor data previously taken directly at the motor.

If a change from the baseline motor data, test each coil individually and compare the data from like coils to all of the other like coils. All of the data from like coils should be the same. Any coil that deviates from the average values of the other coils should be suspect.

Used Motors (Trending)

- 1) Take a complete set of motor data directly at the motor, (this will not be a true baseline, since the condition of the motor is unknown) this motor data set will be the first data set for trending. Follow the testing guidelines for the specific type of DC Motor
- 2) Install the motor, take a complete set of motor data from the DC motor drive (this will not be a true baseline, since the condition of the motor is unknown) this motor data set will be the first data set for trending. Follow the testing guidelines for the specific type of DC motor.
- 3) Periodically monitor the DC motor from the controller, and trend the data over time beginning with the first motor data set taken on that particular machine, compare like coils to like coils. If a significant change has occurred, disconnect the motor and test at the motor directly
- 4) Compare the current motor data taken directly at the motor to the first data set taken directly at the motor.
- 5) If a change from the first motor data, test each coil individually and compare the data from like coils to all of the other like coils. All of the data from like coils should be the same. Any coil that deviates from the average values of the other coils should be suspect.

Like Motors (Average)

- 1) Take a complete set of motor data directly at the motor from 3 or more identical motors in both size and type. Follow the testing guidelines for the specific type of DC Motor. Take the average of the motor winding by winding type. All shunt coils should be averaged with shunt coils, series coils averaged with series coils, etc.
Note: Even if some motors look similar, they are actually different. This can be proved when there is significant difference among the measurements on the similar coils.
- 2) Install the motor, take a complete set of motor data from the drive from 3 or more identical motors; (both size and type) follow the testing guidelines for the specific type of DC Motor. Take the average of the motor winding by winding type. All shunt coils should be averaged with shunt coils, series coils averaged with series coils, etc.
- 3) Periodically monitor the DC motor from the controller, and compare the new average data to previously data. If a change has occurred, disconnect the motor and test at the motor directly.
- 4) Compare the current motor data taken directly at the motor to the baseline average data set previously taken directly at the motor for those machines.

- 5) If a change from the average motor data is identified, test each coil individually and compare the data from like coils to all of the other like coils. All of the data from like coils should be the same. Any coil that deviates from the average values of the other coils should be suspect.

To ease the process for DC motor testing, AT5 provides the capability to test several different DC motor types. DC motors can be tested remotely from the DC drive or directly at the motor.

DC Motor Leads Labeling

The motor leads connected to the brushes that provide power to the armature are labeled A1 & A2. The series field leads are normally labeled S1 & S2, shunt field leads are labeled F1 & F2. Some motors such as dual voltage motors have additional shunt field windings which are normally labeled as F3 & F4.

Note: One of the most common maintenance problems associated with DC motors is carbon build up in the armature windings. AT5 readings identify these problems with inconsistent results in back to back measurements. It is good practice to always re-measure any readings that include the armature coils. If back to back measurements are made and the AT5 readings change between tests, then carbon build-up is likely the cause.

DC Motor Testing from the Motor Drive

Due to the ease of accessibility of the motor leads, it is recommended to test DC motors from motor drive for predictive maintenance testing or initial troubleshooting motor or drive faults. This coincides with the main purpose of the detection phase of the predictive maintenance process, which is to identify “bad” motors by observing changes in the motors condition. To do this, it is recommended to survey as many motors as possible and test as much of the machine as rapidly as possible. Testing from the DC motor drive actually tests multiple coils at the same time. It tests not only the motor leads but also the motor systems cabling and other components and connections of the motor circuit. On the other hand, the DF and capacitance measurements must be taken directly at the motor.

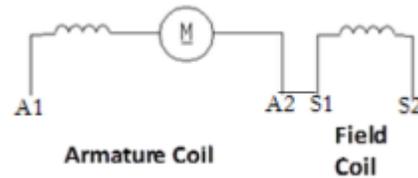
If a change in the motors condition is “detected” during the motor drive test it is then recommended to perform the test directly at the motor.

The following is a list of configurations for tests from DC drive.

DC Series Motors

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DC series motors have the field and armature windings connected in series. When testing DC series motors from the drive both the field and armature windings are tested at the same time.



The armature leads are normally labeled A1 & A2; the field leads are normally labeled S1 & S2. For the windings to be in series, A2 & S1, or S2 & A1 are connected. Test the windings by connecting the AT 5 test leads to free- end on the armature lead and the free end of the field coil.

Since the armature and field windings are connected in series it is enough to only measure the insulation resistance for one time from the DC motor drive.

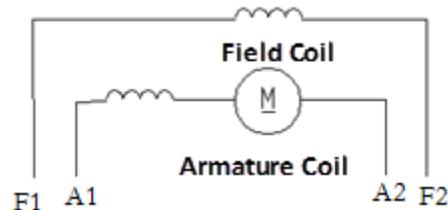
INS1 = field windings & armature windings to ground

STATIC readings for DC Series Motors

DC1 = Series & Armature Coil

DC Shunt Motors Single Voltage

DC shunt motors have the field winding and the armature winding in parallel. For testing DC shunt motors the field windings and armature winding are tested separately.



The armature leads are normally labeled A1 & A2, the field leads are normally labeled F1 & F2. It is recommended to take the field windings first and the armature winding second. **Note:** Always re-measure the armature windings to look for carbon build up. Test the windings by connecting to F1 & F1, for DC1, then A1 & A2 for DC2.

Since the Field leads are parallel to the armature windings, separate IRG to ground are taken from the field coils to Ground or the frame and the armature coils to ground or frame. In the AT5 IRG1 are the measurements for the field windings and IRG2 are for the armature windings.

Since the Field leads are parallel to the armature windings, separate IRG to ground are taken from the field coils to Ground or the frame and the armature coils to ground or frame. In the AT5 IRG1 are the measurements for the field windings and IRG2 are for the armature windings.

INS1 = field windings to ground

INS2 = armature windings to ground

INS3 = field winding to armature winding

STATIC readings for DC Compound Single Voltage Motors

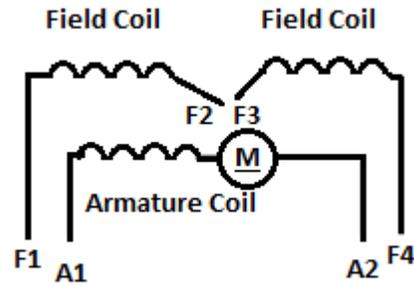
DC1 = Field Coils

DC2 = Armature Coils

DC Shunt Dual Voltage Motors

DC shunt dual voltage motors normally have 2 separate field windings which are in parallel with the armature windings. For testing DC dual voltage shunt motors the 2 field windings and armature winding are each tested separately.

The armature leads are normally labeled A1 & A2, the field coil leads for the first field coil are normally labeled F1 & F2, the field coil leads for the second field coil are normally labeled F3 & F4. It is recommended to take the shunt field winding 1 first, the shunt field winding 2 second and the armature winding third.



Note: Always re-measure the armature windings to look for carbon build up.

Test the windings by connecting to F1 & F2, for DC1, then F3 & F4 for DC2 A1 & A2 for DC3.

Since the Field leads are parallel to the armature windings, separate IRG to ground are taken from the field coils to Ground or the frame and the armature coils to ground or frame a third Insulation resistance measurement is taken from the field coil to the armature coil.

INS1 = field windings to ground

INS2 = armature windings to ground

INS3 = field winding to armature winding

STATIC readings for DC Shunt Dual Voltage Motors

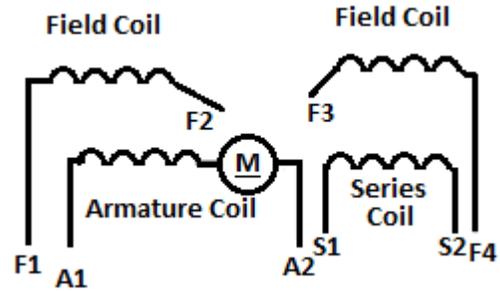
DC1 = Field Coil 1

DC2 = Field Coil 2

DC3 = Armature Coil

DC Compound Single Voltage Motors

DC Compound single voltage motors normally have 2 separate field windings. 1 shunt field which is in parallel with the armature windings and 1 series field, which is in series with the armature winding. For testing DC compound motors the shunt field winding is tested by itself. The series and armature winding are each tested together as in a DC series motor.



The armature leads are normally labeled A1 & A2, the field coil leads for the shunt field coil are normally labeled F1 & F2, and the field coil leads for the series field coil are normally labeled S1 & S2. For the windings to be in series, A2 & S1, or S2 & A1 are connected. Test the series and armature windings by connecting the AT 5 test leads to free- end on the armature lead and the free end of the field coil.

It is recommended to take the shunt field winding first, the series field and armature winding 2 second.

Note: Always re-measure the armature windings to look for carbon build up.

Since the Field leads are parallel to the armature windings, separate IRG to ground are taken from the field coils to Ground or the frame and the armature coils to ground or frame a third Insulation resistance measurement is taken from the field coil to the armature coil.

INS1 = field windings to ground

INS2 = armature windings to ground

INS3 = field winding to armature winding

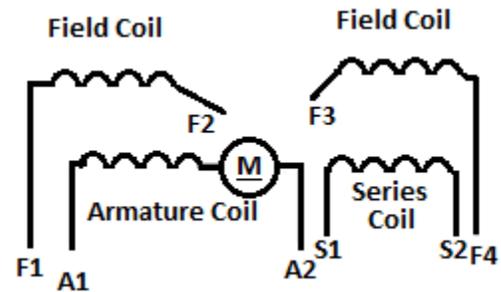
STATIC readings for DC Compound Single Voltage Motors

DC1 = Series & Armature Coil

DC2 = Field Coil

DC Compound Dual Voltage Motors

Compound dual voltage motors normally have 2 separate shunt fields, which are in parallel with the armature field and 1 series field, which is in series with the armature field. For testing DC compound dual voltage motors the shunt field windings are tested individually by themselves. The series and armature winding are each tested together as in a DC series motor.



The armature leads are normally labeled A1 & A2, the field coil leads for the shunt field 1 coil are normally labeled F1 & F2, the field coil leads for the shunt field coil 2 are normally labeled F3 & F4, and the field coil leads for the series field coil are normally labeled S1 & S2. For the windings to be in series, A2 & S1, or S2 & A1 are connected. Test the series and armature windings by connecting the AT 5 test leads to free- end on the armature lead and the free end of the field coil.

It is recommended to take the shunt field winding 1 first, the shunt field winding 2 second and the armature winding and series winding third.

Note: Always remeasure the armature windings to look for carbon build up.

Since the Field leads are parallel to the armature windings, separate IRG measurements are taken from the field coils to Ground or the frame and the armature coils to ground or frame a third Insulation resistance measurement is taken from the field coil to the armature coil.

INS1 = field windings to ground

INS2 = armature windings to ground

INS3 = field winding to armature winding

STATIC readings for DC Shunt Dual Voltage Motors

DC1 = Series & Armature Coil

DC2 = Field Coil 1

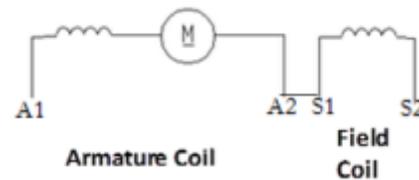
DC3 = Field Coil 2

DC Motor Testing from the Motor

The AT 5 offers the following configurations for testing DC motors directly at the DC Motor. Testing directly from motor provides a more detailed and in-depth analysis, since the different motor fields can be measured at the motor and a DF & Cap tests can be performed at the motor. The following configurations for testing directly at the DC motor are available:

DC Series Motors

DC series motors have the field and armature windings connected in series. When testing DC series motors at the motor series field windings and armature windings can be measured separately.



The armature leads are normally labeled A1 & A2; the field leads are normally labeled S1 & S2.

Note: Always remeasure the armature windings to look for carbon build up.

Testing the DC motor locally provides the option of performing a DF & Cap to ground test. Additionally it is also possible to take IRG measurements on the individual field and armature windings.

INS1 = field windings to ground

INS2 = armature windings to ground

STATIC readings for DC Series Motors

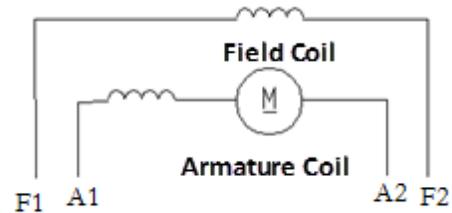
DC1 = Series Field Coil

DC2 = Armature Coil

DC Shunt Motors Single Voltage

DC shunt motors have the field windings and the armature winding in parallel. For testing DC shunt motors the field windings and armature winding are tested separately.

The armature leads are normally labeled A1 & A2, the field leads are normally labeled F1 & F2. It is recommended to take the field windings first and the armature winding second.



Note: Always remeasure the armature windings to look for carbon build up.

Test the windings by connecting field windings F1 & F2, for DC1, then armature windings A1 & A2 for DC2.

Testing the DC motor locally provides the option of performing a DF & Cap to ground test. Additionally it is also possible to take IRG measurements on the individual field and armature windings.

Since the Field leads are parallel to the armature windings, separate IRG to ground are taken from the field coils to Ground or the frame and the armature coils to ground or frame. In the AT5 IRG1 are the measurements for the field windings and IRG2 are for the armature windings.

INS1 = field windings to ground

INS2 = armature windings to ground

INS3 = field winding to armature winding

STATIC readings for DC Compound Single Voltage Motors

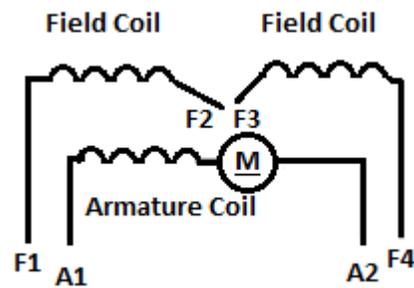
DC1 =Shunt Field Coil

DC2 Armature Coils

DC Shunt Dual Voltage Motors

DC shunt dual voltage motors normally have 2 separate field windings which are in parallel with the armature windings. For testing DC dual voltage shunt motors the 2 field windings and armature winding are each tested separately.

The armature leads are normally labeled A1 & A2, the field coil leads for the first field coil are normally labeled F1 & F2, and the field coil leads for the second field coil are normally labeled F3 & F4. It is recommended to take the shunt field winding 1 first, the shunt field winding 2 second and the armature winding third.



Note: Always remeasure the armature windings to look for carbon build up.

Test the windings by connecting to F1 & F2, for DC1, then F3 & F4 for DC2 A1 & A2 for DC3.

Testing the DC motor locally provides the option of performing a DF & Cap to ground test. Additionally it is also possible to take IRG measurements on the individual field and armature windings.

Since the Field leads are parallel to the armature windings, separate IRG to ground are taken from the field coils to Ground or the frame and the armature coils to ground or frame a third Insulation resistance measurement is taken from the field coil to the armature coil.

INS1 = field windings to ground

INS2 = armature windings to ground

INS3 = field winding to armature winding

STATIC readings for DC Shunt Dual Voltage Motors

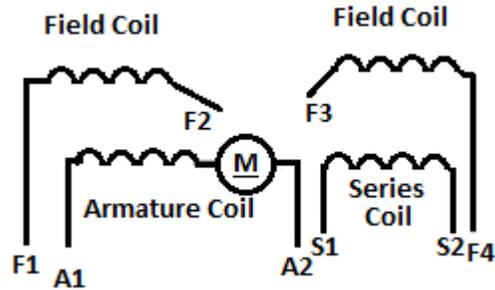
DC1 = Field Coil 1

DC2 = Field Coil 2

DC3 = Armature Coil

DC Compound Single Voltage Motors

DC Compound single voltage motors normally have 2 separate field windings. 1 shunt field which is in parallel with the armature windings and 1 series field, which is in series with the armature winding. For testing DC compound motors at the motor each of the windings can be tested separately.



The armature leads are normally labeled A1 & A2, the leads for the shunt field coil are normally labeled F1 & F2, and the leads for the series field coil are normally labeled S1 & S2.

It is recommended to take the shunt field winding first F1 & F2 for DC1, the series field winding second S1 & S2 for DC2 and armature winding last for DC3.

Note: Always remeasure the armature windings to look for carbon build up.

Since the Field leads are parallel to the armature windings, separate IRG to ground are taken from the field coils to Ground or the frame and the armature coils to ground or frame a third Insulation resistance measurement is taken from the field coil to the armature coil.

INS1 = field windings to ground

INS2 = armature windings to ground

INS3 = field winding to armature winding

STATIC readings for DC Compound Single Voltage Motors

DC1 =Series

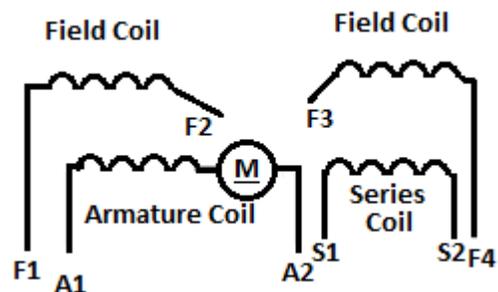
DC2 = Shunt Field1 Coil

DC3 = Armature Coil

DC Compound Dual Voltage Motors

DC Compound dual voltage motors normally have 2 separate shunt fields, which are in parallel with the armature field and 1 series field, which is in series with the armature field. For testing DC compound dual voltage motors at the motor each of the coils can be tested by themselves.

The armature leads are normally labeled A1 & A2, the field coil leads for the shunt field 1 coil are normally labeled F1 & F2, the field coil leads for the shunt field coil 2 are normally labeled F3 & F4, and the field coil leads for the series field coil are normally labeled S1 & S2.



It is recommended to take the shunt field winding 1 first F1 & F2 for DC1, the shunt field winding 2 second F3 & F4 for DC2, the series winding third S1 & S2 for DC3 and the armature winding last A1 & A2 for DC4.

Note: Always remeasure the armature windings to look for carbon build up.

Since the Field leads are parallel to the armature windings, separate IRG measurements are taken from the field coils to Ground or the frame and the armature coils to ground or frame a third Insulation resistance measurement is taken from the field coil to the armature coil.

INS1 = field windings to ground

INS2 = armature windings to ground

INS3 = field winding to armature winding

STATIC readings for DC Shunt Dual Voltage Motors

DC1 = Series coil

DC2 = Field Coil 1

DC3 = Field Coil 2

DC4 = Armature Coil

Individual Coil Testing

The coil test option is located under DC menu. Each motor field will have at least 2 coils per field. 1 coil is a north pole and 1 is a south pole. When a change has been detected in a set of field coils, during the detection phase, it is recommended to separate the individual coils in field winding and measure each coil individually.

The AT5 offers the ability to individually measure up to 4 identical DC motor coils for one group at one test to identify faulty coils within a set of coils. The users actually can test as many coils as needed by use of the trending function in MCA software to compare coils in different groups.

One DF & Capacitance of winding and one insulation Resistance measurement are available under Coil Test option. The MCA software will provide diagnostic conclusions for DF (Dissipation Factor) and insulation resistance. If there are over 1 group of coils, the users can connect the coils under one group and measure the DF & C as well as insulation resistance so that different group of coils can be compared using Trend function.

INS = Individual coil to ground

STATIC readings for DC Shunt Dual Voltage Motors

DC1 = Individual Coil 1

DC2 = Individual Coil 2

DC3 = Individual Coil 3

DC4 = Individual Coil 4

Rule of Performing Coil Tests

1. Up to 4 coils can be tested and compared for each group of coils test. The users have the option to test 1 coil, 2 coils, 3 coils or 4 coils.
2. If there are more 4 coils, the coils should be divided into several groups. Each group has to have the same number of coils, and the coils should be tested per the order of coils listed. For example, if the 1st group has 2 coils tested and saved, the 2nd group should also have 2 coils tested and saved. For both groups, the 2 coils have to be tested as 1st coil and 2nd coil in the COIL TEST menu instead of using other combinations, e.g. 1st coil and 3rd coil.

This is required for trending purpose in MCA software, which essentially compare coils in different groups instead of trending over time. For coil individual analysis, this is not required. Please refer to MCA software manual for details.

ROUTE

Route function provides a convenient way to manage multiple equipment with corresponding tests. A route can be created in MCA Pro software containing up to 100 equipment e.g. AC motor, DC motor, transformer, generator, coils etc. The route includes the information of each equipment so that the testers know which equipment to test. At one time only one route exists in the AT5 instrument. On the other side, with a route uploaded in the memory, any regular tests not included in route can still be performed and saved in AT5.

During the route testing in AT5, the users can choose to make the test, or skip the test and make the test later, save the test to route, or save the test separate from route in the way a regular test saved. A route can contain up to 100 equipment.

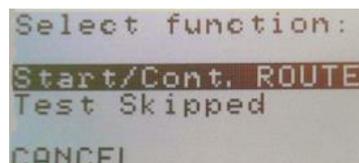
When a route is done, whether or not all tests are performed and saved, the users can upload all data in MCA software and handle them in the way as the regular test data. For details, please refer to the user manual of MCA software.

Route Operation

1. First download a route from MCA Pro software into the AT5 memory.
Note: all other test records will be cleared when the route is downloaded from a computer to the AT5. Upload all test data before route downloading.
2. From the main screen highlight the **ROU** icon.



3. Press the **OK** key to access the Route Screen.

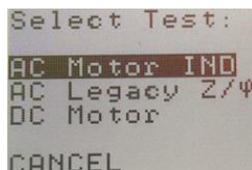


4. Three options available:

- a. Press “Start/Cont. Route” to start a new route testing or continue the route from the last test performed in the route
 - b. Press “Test Skipped” to perform the test which has been skipped during previous route testing.
 - c. Press “CANCEL” to return to the main menu:
5. The ALL-TEST Pro 5 screen will momentarily display “Checking Route; Please wait...”, then the screen displays the 1st available route test:

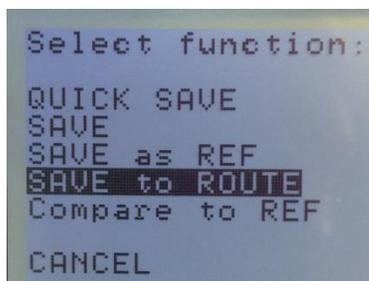


6. There are three options:
- a. Pressing “TEST” to begin the motor test on the displayed machine
 - b. Pressing “SKIP” to skip the displayed equipment
 - c. Pressing “CANCEL” will exit to the main screen. Next time when starting the route, this test will be the 1st one to be available.
7. If “TEST” is chosen, the following menu shows up so that the users can choose the type of test desired



Note: the transformer test is included in the 2nd test listed

8. Whichever test is chosen, the users can perform it the way as the corresponding regular test is done.
9. Once the test is completed, the users have the SAVE options. The “SAVE to ROUTE” provides a convenient way to save the test into the route as it does not need any additional input. For other save options, please refer to Section “Test Save and Reference Comparison” in Chapter “ind/dyn/ins – ac INDuction motor test”.



COMMUNICATION

The ALL-TEST PRO® 5 operates with the MCA-Basic and MCA-PRO software to upload, analyze and trend tests data of motor, generator, transformer tests saved in the instrument. The software also download route and TVS data to the instrument. For all of these cases the communication has to be established between AT5 instrument and PC software. Therefore, the AT5 has to be set up in Communication mode.

Note: the AT5 cannot be automatically turned off if it stays in Communication mode. Please refer to Section “Automatic OFF”.

ALL-TEST Pro 5 Communications Set-up

1. From the Main Menu use the **TEST**  and the **>** keys to highlight **COM** icon:



2. Press the **OK** Key to place the ALL-TEST Pro 5 in the communications mode, the screen will display:

Ready, waiting...

Now the AT5 instrument is set in communication mode. For communication operations, please check the MCA software user manual.

SETUP

SET- provides direct access to view or delete previously stored test data, set the date and time of the instrument or to make manual measurement of Resistance (R), Inductance (L), & Phase Angle (φ).



Pressing “OK” key when “SET” is highlighted will show up the following screen:

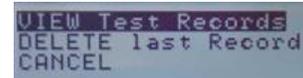


VIEW/DELETE Record

Viewing Saved Test Data

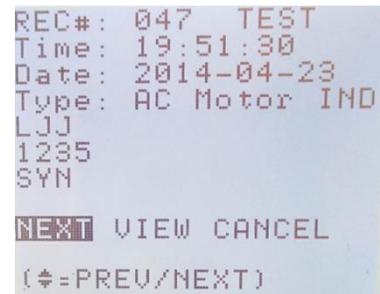
To view any data stored in the AT5:

1. From the Main Menu; press **▶** key 3 times to highlight the **SET** function
2. Press the **OK** key, this will display the Setup Menu
3. Highlight **VIEW/DELETE** record
4. Press **OK** key, this will display VIEW Test Records Display screen
5. Highlight **VIEW Test Records**
6. Press **OK** key, this will display the last Motor data test set stored in AT 5 Memory



This displays the REC #, and identifies the Motor data test as a **TEST** or **REF** data set

- **Time:** Time the Motor Test was performed
- **Date:** Date the Motor Test was performed
- **Type:** Type of Motor data set



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Blank fields: Motor ID, Serial Number, Type of Motor

1. Press the **>** key to highlight the **VIEW** function
2. Press **OK** key to display the condition of the Motor data for the current displayed record.
This will display the results screen for the selected Motor data test set.
3. Press the **TEST** **v** key to view the previous test record.
4. Press the **MENU** **^** key to view the next test record.

Exiting Test Records Screen

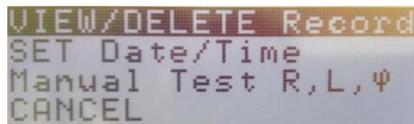
1. Press the **>** key 2 times to highlight **CANCEL**
2. Press **OK** key to return to will display the VIEW Test Records screen

Deleting Test Records

This function is the only method of deleting test records on AT5. Note, it deletes the last Motor test only for each operation.

The MCA software provides additional capability for handling test records, e.g. it can clear the whole memory at one time.

1. From the Main Menu; press **>** key 3 times to highlight the **SET** function.
2. Press the **OK** key, this will display the Setup Menu.



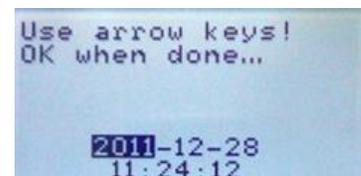
3. Highlight **VIEW/DELETE** record.
4. Press **OK** key, this will display **VIEW/DELETE** Test Records Display screen .
5. Press **TEST** **v** key to highlight **DELETE last Record**
6. Press the **>**key to highlight **DELETE**
7. Press the **OK** key this will delete the last motor test record.
stored in the AT 5 and return to the **VIEW/DELETE** Test Records Display screen
8. To delete another test record repeat steps 5,6,& 7
9. From the **VIEW/DELETE** Test Records Display screen Highlight **CANCEL** to return to Main Menu



Set Up Date/Time

From the Main Menu:

1. Press **>** key 3 times to highlight the **SET** function.
2. Press the **OK** key, this will display the Setup Menu.
Press **TEST** **v** key to highlight **SET Date/Time** .



4. Press **OK** key to display the **Date/Time Set** screen.
5. Use **<**; **>** keys to move left to right from one selection to another.
6. Press the **MENU ^** key to increase the value of the highlighted variable.
7. Press the **TEST v** key to decrease the value of the highlighted variable.
8. Use **<**; **>** keys to move another selection.
9. Repeat steps 6, 7 & 8, until correct date and time are set.
10. Press **OK** key when current Date/Time is set, this will return the display to the **Main Menu**.

Manual Test

The AT5 can make manual measurements of a coil's winding resistance, inductance and/or phase angle ϕ in the manual mode. In the manual measurement mode the AT5 does not save the results of the test in internal memory. Manually record the test data if necessary. The manual test option provides a convenient way for some quick check test as well as instrument calibration purpose.

To make manual measurements:

1. From the Main Menu:
2. Press the **>** key 3 times to highlight the **SET** function
3. Press the **OK** key, this will display the Setup Menu
4. Press **TEST v** key 2 times to highlight **Manual Test R,L, ψ**
5. Press the **OK** key, this will display the **Select Leads** Menu
6. Press **>** key to highlight the motor leads which correspond to the phase of the winding measurement to be made, **32**; **21**; or **13**
7. Press the **OK** key, this will display the **Select Test** screen
8. Press the **>** key to highlight which measurement to make: **R** for Resistance, **L** for Inductance or **ϕ** for Phase Angle.
9. Press the **OK** key to display the Test Leads connection screen

Use the table below as a guide to make the connections to AT5 for manual measurements

Motor Leads	Instrument Leads
3-2	RED & BLUE
2-1	BLUE & BLACK
1-3	BLACK & RED

10. Press the **OK** key to continue with the measurement, the screen will display **Manual Test** **please wait**. When the measurement is complete the screen will display the results of the manual measurement.
11. Press the **OK** key to return to the **Select Leads** Menu

12. To re-measure the same phase again: Press the key to highlight **REMEASURE**; then press the key, this will perform the same measurement and display the measured value.
13. To exit the Setup Menu and return to the Main Menu press the **TEST** key to highlight **CANCEL** then press the **OK** key.

Firmware Version Number

On the bottom of the “SET” menu, the instrument firmware version is displayed. For the example below, the version number is “AT5140612A4”.



```
VIEW/DELETE Record
SET Date/Time
Manual Test R,L,ψ
CANCEL

Ver. AT5140612A4
```

Note: Whenever a problem is reported to tech support, always include the firmware version number in the communication.

SPECIFICATIONS

Test Frequencies

50, 100, 200, 400, 800 Hz

Test Value Static / Reference Value Static

0.01 – 10000 ±1%, (Dimensionless calculated value)

Stator Test Dynamic

Repeatability ±1%, (of measured data and calculated deviations)

Rotor Test Dynamic

Repeatability ±2%, (of measured data and calculated deviations)

Resistance

0.01 – 999 Ω measurement range

0.01 – 99.9 Ω ±1%, Max Resolution: 0.01 mΩ

100 Ω - 500 Ω ±1.5%, displayed as whole numbers

501 Ω - 999 Ω ±2.5%, displayed as whole numbers

Relative Accuracy “Phase to Phase” ± 0.1%

True 4-wire Kelvin measurement. (Compensation for thermoelectric offset voltages)

Impedance

0.1-999 Ω ±2%, Max Resolution: 0.01 Ω

Relative Accuracy “Phase to Phase” ± 0.2%

Inductance

1 – 999mH measurement range

1 – 200mH ±2%, all other values ±3%

Relative Accuracy “Phase to Phase” ± 0.2%

Phase Angle φ

1– 90° ±1°, Max Resolution: 0.1°

Relative Accuracy “Phase to Phase” ± 0.1°

I/F (current/frequency)

-50% ~ +99% ±1%, Max Resolution: 0.1 %

Relative Accuracy “Phase to Phase” ± 0.1%

Dissipation Factor - DF (frame – stator)

1 – 100% measurement range (expressed as a percentage)

1 – 10% ±0.75% (C = 10 – 1000 nF) ±1.0% (all other values of C within range 2-2000 nF)

10 – 30% ±1.0

(This specification is based on battery operation and USB not connected to PC)

Capacitance (frame – stator)

2 – 2000 nF measurement range

10 – 2000 nF ±5%

(This specification is based on battery operation and USB not connected to PC)

Insulation Resistance

0 – 999 MΩ @500V or 1000V

1 – 100 MΩ ±3%, all other values ±5%

Connections

3 x Motor input/output - push-pull connectors 4-pole

High Voltage output - Ø 4mm safety jack

PC communication: USB type B connector

Charger input - 2.5mm diameter center pin DC-jack

Keyboard

Sealed tactile switches with backlight overlay

Display

Graphic LCD, monochrome 128 x 128 pixels (3.8”), white LED backlight.

Temperature Range (Storage)

-20 °C to +55 °C (-4 °F to +131 °F)

Temperature Range (Operating)

-20 °C to +50 °C (-4 °F to +122 °F)

Humidity

0-80% relative humidity, non-condensing

Certification

CE

Safety

IEC 61010-1 Ed. 3.0

EMC

Emission: EN61000-6-4

Immunity: EN61000-6-2, EN1000-4-2, EN61000-4-3

Calibration Certificate

Optional (contact nearest distributor for more information)

Batteries

2 x Li-ION cells with ≥ 2100 mAH capacity, UL 1642 (Safety)

Enclosure

126 x 218 x 51 mm (5" x 8.6" x 2") (W x L x H)

(basic enclosure size without minor protrusions)

Material - Polycarbonate, UL94-V2 (Flammability)

Weight: 0.7 kg (1.55 lb)

Accessories (included)

3x Test Leads with heavy-duty custom Kelvin Clips and push-pull connectors

1x Test Lead with 4mm safety plug and MC "Dolphin" clip

Charging adapter, Universal input type 85-260VAC, output 9VDC @ 1.7A

MCA Basic™ Software (Windows 7/8, 32/64 bit)

1xUSB cable 1m

Durable and rugged hard case with pre-cut foam liner

User Manual on CD

Accessories NOT included

Soft carrying pouch for instrument and test leads; MCA PRO™ Software; Training Demo Motor, Test Leads: 3X with Kelvin clips and push-pull connectors and 1x with 4mm safety plug

Specifications subject to change without notice.

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