ALL-TEST PRO 7™ (AT7™)

ALL-TEST PRO 7™ PROFESSIONAL (AT7P)

Instrument User Manual

Version 1.0

MCA™ Tester and Analyzer for Electrical Motors, Generators and Transformers

REV 06/20/2019

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Specifications are subject to change without notice

INTRODUCTION

Congratulations on your purchase of the new patented **ALL-TEST PRO 7™ PROFESSIONAL** (AT7P) or **ALL-TEST PRO 7™** (AT7™) Motor Circuit Analysis™ (MCA™) instrument from **ALL-TEST Pro, LLC (ATP)**.

The AT7 series offers a complete motor testing system solution for stand-alone troubleshooting/fault localization, quality control of stored or incoming new/repaired motors, as well as data collection and trending for early fault detection when combined with the comprehensive MCA Basic™, MCA PRO™, or MCA PRO™ Enterprise computer software.

The AT7 series performs 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 MCA instruments are the most powerful and easiest to use diagnostic tools available for deenergized testing of motors in today's industry.

The AT7 series 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 AT7 and is used for single and three phase AC motor analysis, trending, and reporting. MCA PRO comes standard with AT7P which includes DC motor and transformer analysis, plus unique rotor grading method along with route-based testing.

The AT7 series 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 cables 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 available either at your plant or are held at various locations throughout the world. Contact ALL-TEST Pro training department at ce@alltestpro.com for further information.

Warranty

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

Contact Information

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SAFETY

SAFETY WARNINGS

- **The Device Under Test (DUT) must be fully deenergized before AT7™ series instruments can be connected for any test.**
- **Please do not touch 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 deenergized (off-line) testing methods, including wearing appropriate Personal Protective Equipment (PPE). *To ensure proper and safe operation of the AT7 series instruments is the sole responsibility of the user.*

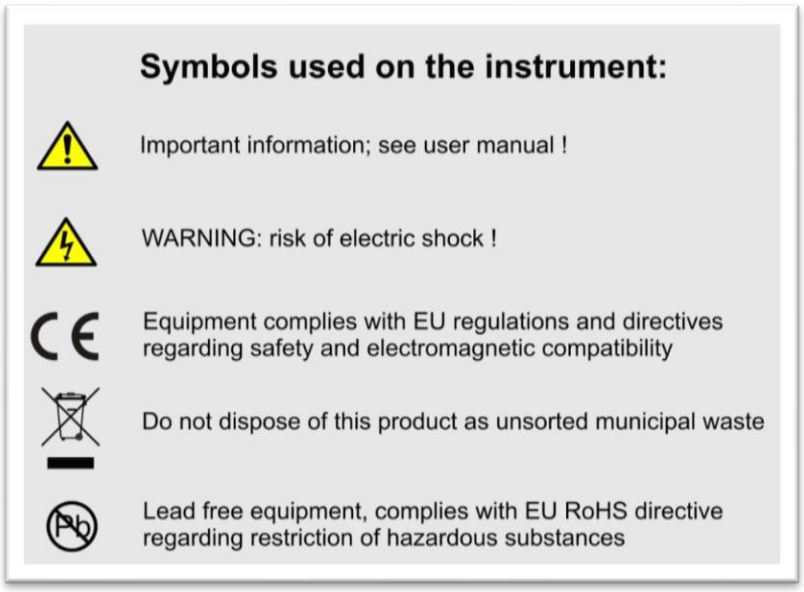
The AT7 series instruments are only to be used on deenergized motors. Connecting the instrument to live voltage will destroy the unit and void the warranty. Always verify the motor circuit is deenergized before connecting the instruments. Ensure that all power has been removed from the circuit being tested, including static power stored in capacitors. Discharge all capacitors involved in the motor circuity. 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 instrument 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.



ALL-TEST PRO 7™ SERIES TEST KIT

- 3x Test Leads with heavy duty Kelvin Clips and push-pull connectors
- 1x Test Lead with 4mm safety plug and MC “Dolphin” clip
- Charging adapter, Universal input type 100-240VAC, output 9VDC @ 1.7A
- Software download certificate (dongle if AT7P has been purchased)
- 1x USB cable 1m
- Durable and rugged hard case with pre-cut foam liner
- User Manual
- Warranty: 1 year limited; Optional 2 years available with calibration

AVAILABLE ACCESSORIES

- Soft carrying pouch for instrument and test leads
- Optional smaller sized Kelvin Clips

Test Lead Connections

The AT7 series instruments use 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.

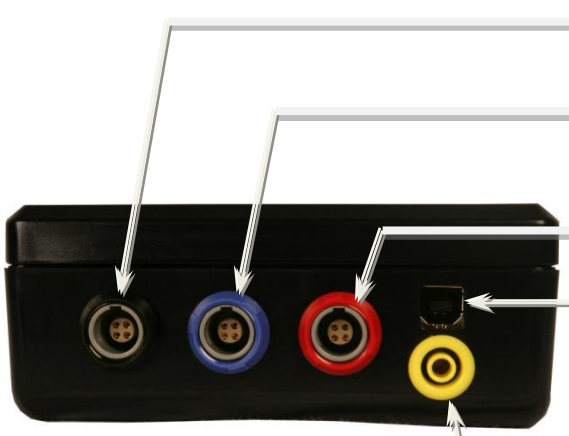
(See specifications section for measurement ranges and accuracies)

Instrument Layout

The instrument has three sections:

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

Input/Output Ports



TOP VIEW

1. **BLACK PORT -** Phase 1 Black Test Lead port
2. **BLUE PORT** - Phase 2 Test Lead port; Insulation test at 500V & 1000V / Dissipation Factor and Capacitance test
3. **RED PORT** - Phase 3 Test Lead input/output
4. USB port (type B) – Communication with PC

Risk of electric shock!!!

5. **Yellow** Port - Return Circuit for Insulation test /Dissipation Factor and Capacitance tests

Battery Charging Port

SIDE VIEW

6. Charger input DC 9V, 1.7A (center pin + polarity)

Only use the supplied charger for charging. Using different charger could damage your instrument and void the warranty. It is recommended to leave the instrument plugged into charger when not in use.

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 7 series manufacturers nameplate and identity tag

12. Lithium Ion Battery Pack

MAIN MENU

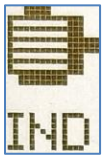
Figure 1 Main Menu

The main menu provides the icons to access the various tests and other functions of the ALL-TEST PRO 7™ instruments.

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

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

**ALL-TEST PRO 7 PROFESSIONAL REQUIRED*



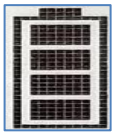
IND – Performs tests on AC three phase squirrel cage induction motors with rated voltage less than 1000 V. It performs the Static, Dynamic, Insulation resistance to ground, DF & capacitance of winding tests.

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.

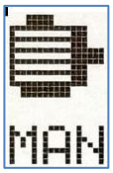
PWR OFF – Provides the selection to turn the AT7 off. If the instrument idles for 5 minutes or longer, it will power off automatically.



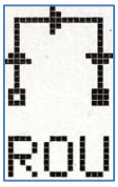
Battery Charge Indicator – Provides indication of the status of the battery charge. See the Battery section for further information about battery care.

Z/φ – Performs deenergized winding tests, insulation resistance to ground, DF & capacitance of winding to ground tests on all types of AC 3 phase motors, generators, and rotor compensation test. **Transformers only available with ALL-TEST PRO 7 PROFESSIONAL.*

DC – Performs deenergized winding tests and insulation to ground tests on various types of DC motors. **DC motors and coil test only available with ALL-TEST PRO 7 PROFESSIONAL.*



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. **Rotor test only available with ALL-TEST PRO 7 PROFESSIONAL.*

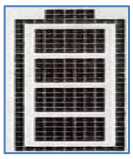


ROU – Directly accesses the test screens to perform motor testing using predetermined routes setup downloaded from the MCA PRO software. **Route based testing standard with ALL-TEST PRO 7 PROFESSIONAL.*

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 AT7 series instruments are 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 instruments 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 ❶ 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.

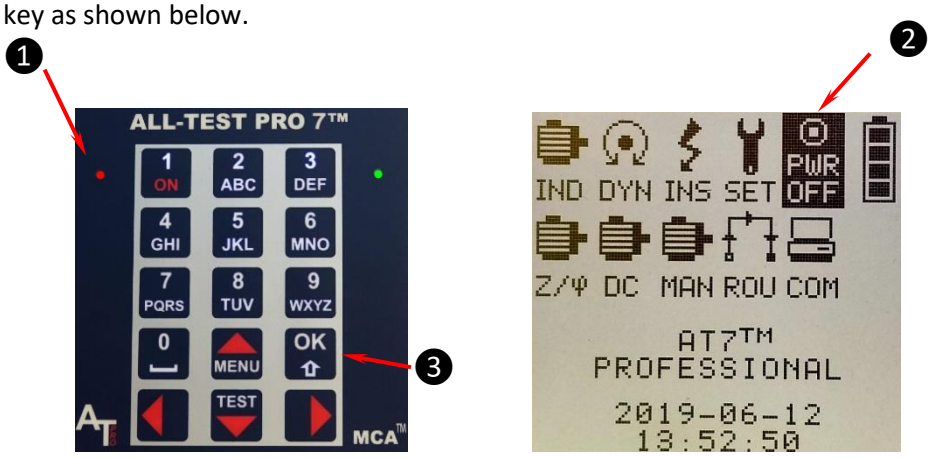
If neither of above works, connect the charger until the instrument is fully charged, then try it again.

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 ⓬ in Section “Rear View”.

Now the instrument can be turned on normally.

Turning the instrument OFF

Select the "PWR OFF" icon ❷ in the main menu with the arrow keys and then press "OK" ❸ 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:

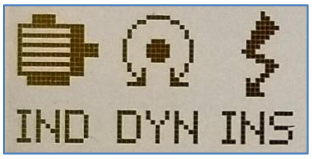
1. If the MCA software on a computer perform any operation, e.g. upload data, download data, upload route etc., the instrument will be discharged once the operation is completed.
2. To manual is to use Left arrow and Right arrow simultaneously to reset the instrument. See Section

IND/DYN/INS – AC INDUCTION MOTOR TEST

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

After completing a test "path" the instrument 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 computer 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 handheld 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 deenergized 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 patented **Test Value Static (TVS)** and **Reference Test Value Static** (REF TVS) **(REF TVS)**.

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

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

Insulation Resistance: 0 – 5000 Meg Ω @1000V, 0 – 5000 Meg Ω @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 Test Value Static (REF TVS)

When a test record is saved as reference type in the instrument, the TVS is called REF TVS. Each REF TVS 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 REF, or the REF value of another motor that is known to be in good condition and is exactly the same motor.

Capacitance (C)

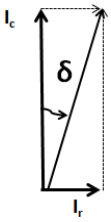
The insulation between the winding conductors and the machines frame form a natural capacitor. Capacitance is a measure of a systems ability to store electrical charges. The magnitude of capacitance in a system is determined by:

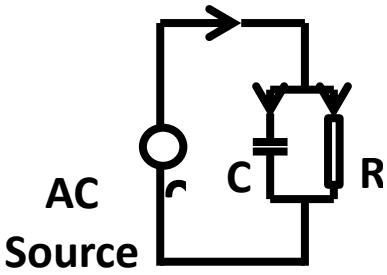
- Effective surface area or conductors in the case of a motor.
- Distance between the conductors

- 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 90^0. 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 **δ.**

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 ^{0}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

[a]Rated 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 instruments offer 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

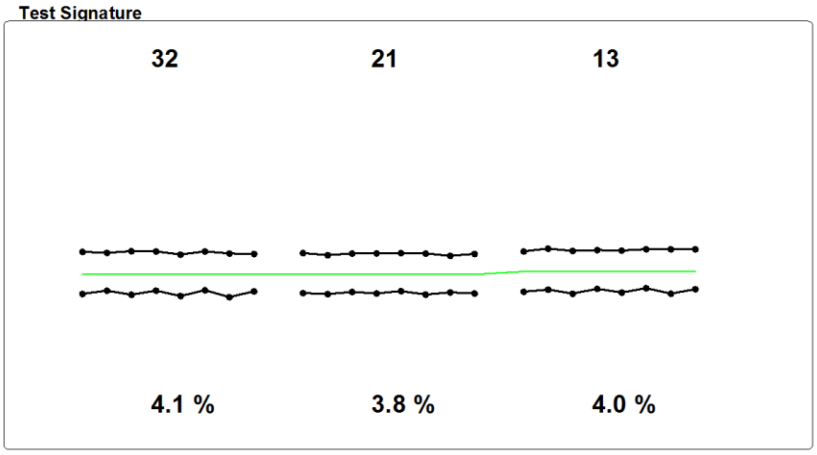
***Note**: The IEEE guidelines above provide the recommended voltages and Minimum Insulation Resistance to ground values. If these procedures or values differ from your equipment manufactures' recommendations, follow their guideline.*

Dynamic Testing - DYN

Dynamic tests are patented test methods that refer to the deenergized 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.

"Dynamic and Stator Signatures™" (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 instrument 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.



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. For further information review the Motor Circuit Analysis Manual provided with your instrument.

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 instruments 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 instruments 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 warmup 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

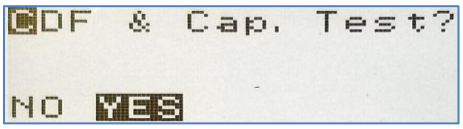
Connect the test leads according to instructions in the message screen.

"**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:

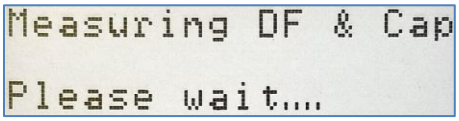
"**DF & Cap. Test?"** Press NO to skip or YES to continue.



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

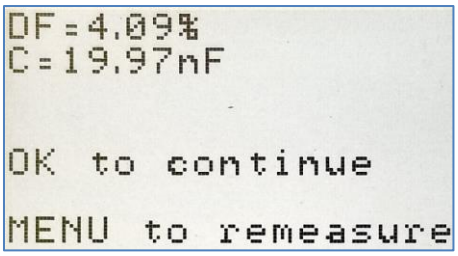
If YES is pressed, then a message screen during the DF and Capacitance measurements will appear displaying:

"**Measuring DF & Cap, Please wait….**"



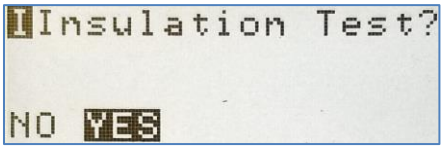
After the DF and Capacitance test is complete then the display will show the measured values.

Press "**OK to continue…** or **MENU to remeasure**…"



Insulation Resistance Test (MΩ)

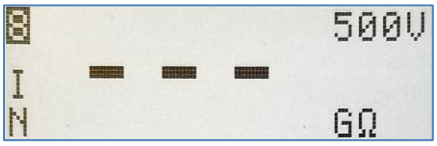
Next step is the selection of "Insulation Test?" Select "NO" or "YES" and press OK.



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!

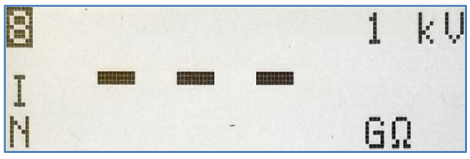
Pressing the TEST key will output the selected test voltage of 500V or 1000V on the yellow output port and illuminate orange status LED.

To perform Insulation Resistance to Ground (IRG)test:

Press "TEST" key until the GΩ value becomes stable or >5GΩ is displayed, and then OK to continue.

Verifying Proper Ground Connections

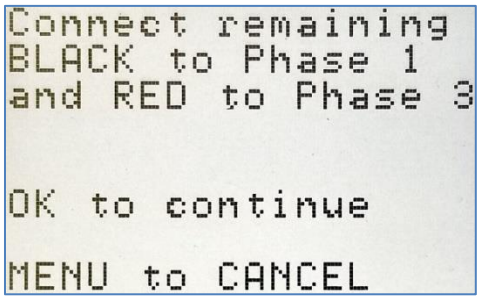
1) From the main menu press the > key to highlight the INS function. Connect Blue Test lead to a ground or earth location, and the Yellow test lead to a separate ground or earth location.
2) Press the OK key, the screen will display 3 - - -, this indicates that no measurements have been taken.
3) Press 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.



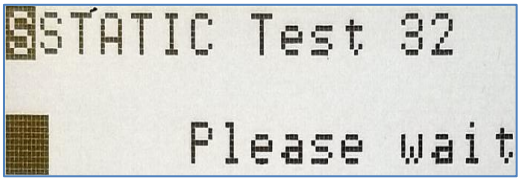
4) To Clear value displayed press the OK key
5) Verify the Connection of the blue lead has a good path to ground, or earth
6) To retest press and hold the TEST ˅ key until 0.00 is displayed. If any other value is displayed one or the other of the test leads are not properly connected to ground.
7) Verify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

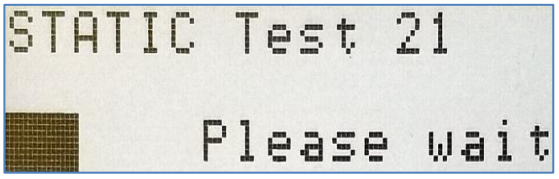
Resistance and "Test Value Static" Test (R, TVS)

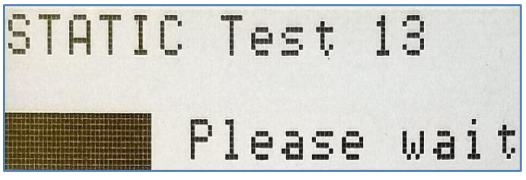
Connect the remaining test leads according to instructions in the message screen to prepare the instrument for the remaining "STATIC" & "DYNAMIC" tests.

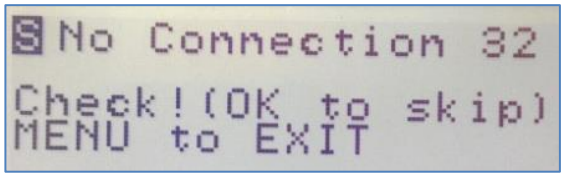


The instrument will now start the automatic "STATIC" series tests, starting between phases 3-2 displaying: "STATIC Test 32, Please wait" (with progression bar) and continuing with subsequent testing between phases 2-1 and 1-3. This test includes measuring a number of parameters between the three phases 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".



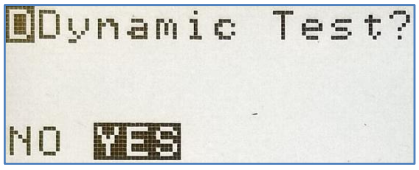






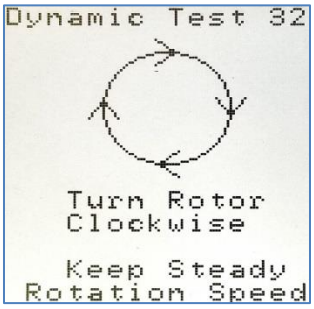
NOTE: If "No Connection" is detected by the instrument it will display the warning message listed above. If your connection to the motor is correct, then you can force it to sequence to the next phase by pressing OK.

Dynamic Test



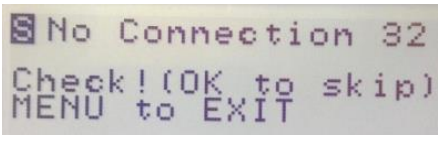
The next step provides the option to select a "Dynamic Test?". Select "NO" or "YES" and press OK. If "NO" is selected, then the instrument will skip the Dynamic Test and go directly to the "Result Menu Screen". Selecting "YES" will start the Dynamic test. The first phases are 3 to 2 (32) and the instrument's display will guide you through the testing process. Use the same starting position for each phase. Press the OK key to test phases 32.

Start by turning the Rotor as <u>smoothly as possible</u> and the instrument will emit a "beep" tone to help the user turn the shaft at the proper speed. 4 beeps per revolution = 15 RPM. 8 beeps per revolution = 7.5 RPM. We suggest using a "shaft strap" as shown in this picture. Continue turning/rotating the rotor while the instrument automatically switches to the next "phase to phase" connection displayed in the following order:



After phases 32 finishes it will then sequence to the next phases (21). Press the OK key to start the test and use the "beeps" to set the rotation speed. Phases 13 follows after phases 21.

NOTE: 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 instrument 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 in the same direction using a shaft strap.

Maximum recommended rotor shaft rotational speed for 2 & 4-pole motors = 15 RPM

Maximum recommended rotor shaft rotational speed for 6-pole motors or higher = 7.5 RPM

Viewing Results Upon Test Completion

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 analysis is a proprietary patented method

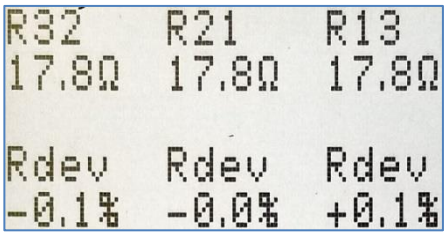
INSULATION MΩ	*Displayed Result*
≥ 100 MΩ	*OK*
≥ 5 MΩ < 100 MΩ	*WARN*
< 5 MΩ	*BAD*
No Reading	*NoR*

CONTAMINATION DF%	*Displayed Result*
≤ 6 %	*OK*
> 6 % ≤ 10 %	*WARN*
> 10 %	*BAD*
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.

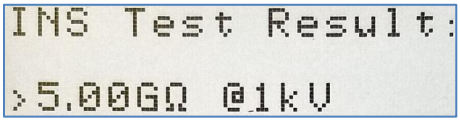
The following is an example of reviewing resistance test results submenu.



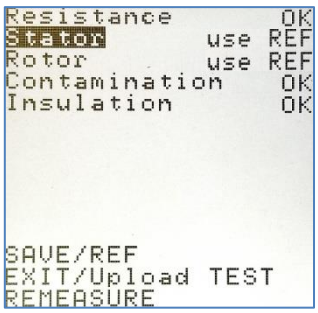
The **Resistance** Submenu will display actual R values and % deviation. % deviation is calculated by comparing each phase to the average of the three-phases.

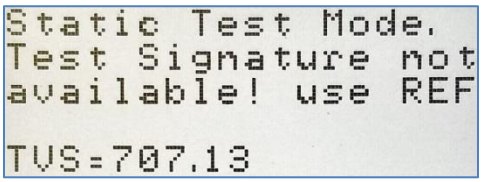
The **Contamination Submenu** will display DF in % and Capacitance in nF. If C is less than 1nF it will display <1.

The **Insulation** submenu will display Insulation resistance in MΩ or >5GΩ or --- MΩ (if NoR)

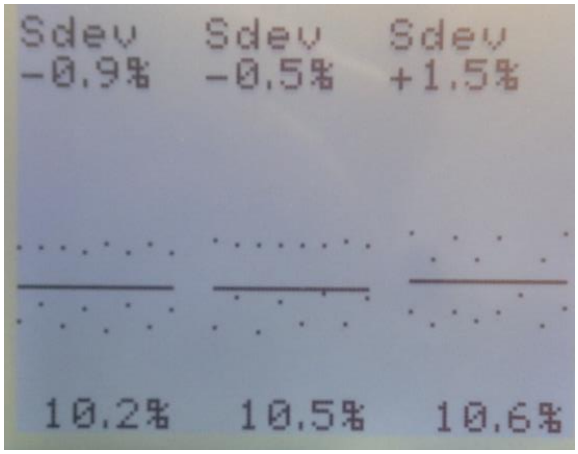


The following is the example of the test results display when dynamic test is not performed. The right screen below is the submenu after OK key is pressed to select "Stator" on the left screen. The **Stator** submenu will display the "Test Signature Pattern" if a DYNAMIC test was done. If only STATIC tests were done, then the TVS=**"**Test Value Static" (dimensionless) will be displayed.





The following is an example whey 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 provides a WARN alarm since 1.5% exceeds the WARN limit.



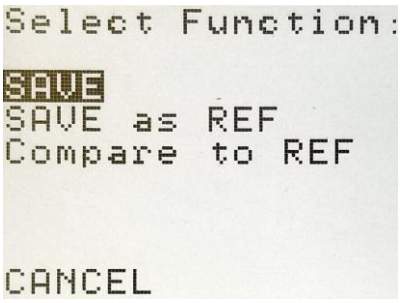
The six black dotted lines represent the Rotor Signature and include an upper and lower signature. This represents the deviation of the peak values during rotation. As the output of the instrument is sinusoidal and the response of the motor will be sinusoidal, there will be peak values both positive 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 ¾ 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.

There are three options available.



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 keypad 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 curser 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:

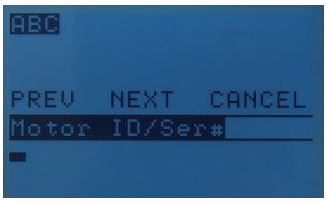
PREV: Goes back to the previous steps so that you can modify the information input

NEXT: Goes to next step

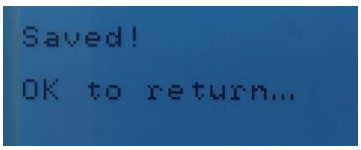
CANCEL: Goes back to the test results screen. You still have the chance to save the test data.

SAVE

SAVE provides a quick and easy way to save the test data in just a couple of steps. **It is strongly recommended to use SAVE right after a test.**



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.

To view the test results after exiting the test menu, please refer to Section “Viewing Saved Test Data”.

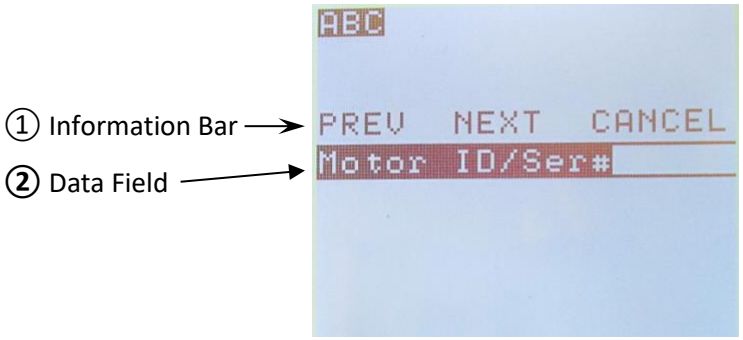
SAVE as REF

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 instrument

memory. If you choose **SAVE as REF**, the test will save as a reference type and can be compared to in the instrument.

In the **SAVE** or **SAVE as REF** screen the MOTOR ID/Ser# must be entered. To view the test results after exiting the test menu, please refer to Section "Viewing Saved Test Data".

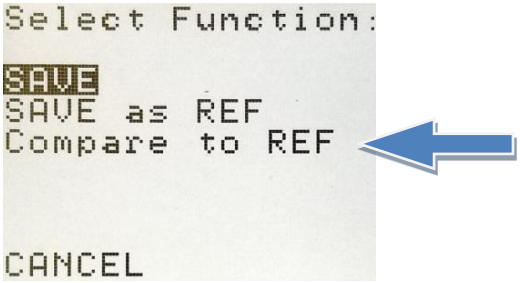
Note: There is no mandatory entry that the users are required to input. However, it is always encouraged that the user fills in the Motor/ID/Ser# at minimum.



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

NEXT skips this menu and goes to next menu.

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 REF TVS saved in the instrument.

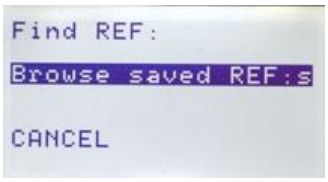
The instruments will display the deviation of the present TVS compared to the saved TVS in percentage. In addition, it will also display one of these findings: **OK, WARN, or BAD** according to preset guidelines:

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

To compare current test to Reference test:

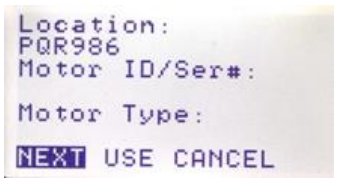
1. From the results screen repeatedly press the **TEST ˅** key to highlight the **SAVE/REF** button.
2. Press the **OK** key. This will display the save function screen.
3. Highlight **COMPARE to REF**
4. Press the **OK** key.

This will display the Find REF: screen:



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

The instruments will display REF:

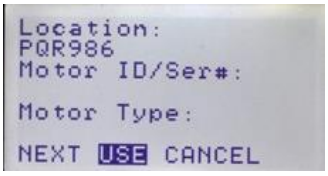


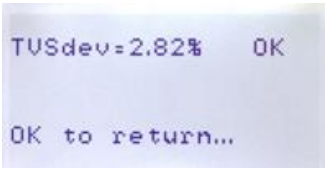
Location

Motor ID/Ser.#

Motor Type

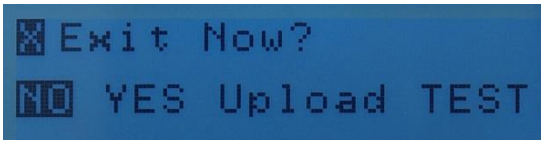
7. Press the **NEXT** function, the instruments will display the first stored REF record one by one. Once the desired test is found, highlight the **USE** function.
8. To view additional REF tests, press the key.
9. Press the **OK** key until the desired REF test is displayed.
10. Press the **>** key 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 instrument, 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

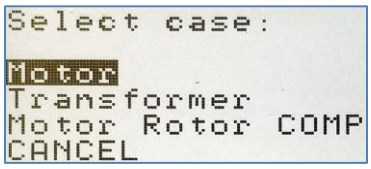
Z/φ test provides capability of testing broader range of 3 Phase AC equipment for various applications including transformer and generators. As shown below, Z/φ menu is located right below "IND" menu on the main menu

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 provide TVS, both types of test can be saved as reference record – refer to Section "Reference Test Value Static (REF TVS)". Therefore, either test result can be compared to RVS.

Motor, Transformer, Motor Rotor COMP Test

When open the Z/φ menu, there are three that can be selected: Motor, Transformer, or Motor Rotor COMP. **Transformer test only available in ALL-TEST PRO 7 PROFFESIONAL.*



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.

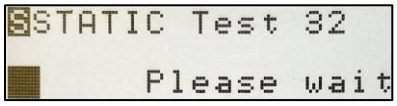
In addition, the SAVE menu operation is also same as IND test result.

Please refer to the Section "Test Steps" under Chapter "ind/dyn/ins – ac INDuction motor test".
Please refer to the next Section "Rotor Compensated Test" for "Motor Rotor COMP" procedure.

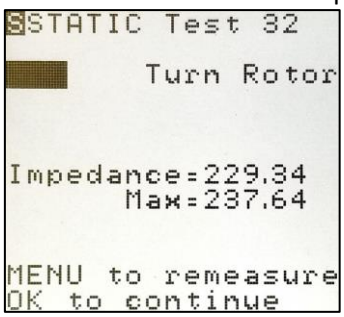
Rotor Compensated Test

When the parameter of impedance, inductance, phase angle and I/F are in alarm(s), one way to determine whether the fault comes from stator or rotor is to apply rotor compensated test which requires an AT7 series instrument. NOTE: If testing an AC induction squirrel-cage rotor motor <1000V and you have access to turn the motor shaft, perform the DYN test.

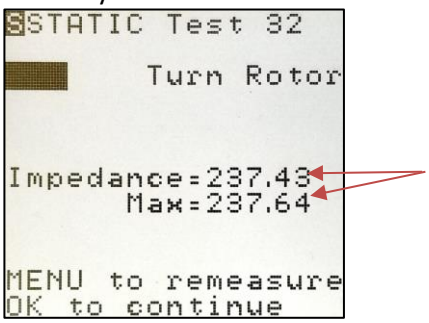
1. Performing a rotor compensated winding test.
    a. If only a rotor comp test is required select NO for DF/C and INS test.
    b. Connect all three test leads when prompted and select “OK”
    c. A static test between winding 3-2 will automatically begin.



    d. The instrument will then display the actual impedance value and MAX.



    e. Slowly rotate the rotor a minimum of one full revolution. During this rotation the maximum (MAX) value will automatically display on the instrument screen. Continue to slowly rotate the motor shaft until the Impedance = maximum value.



    e. Press “OK” to continue. The instrument will sequence to winding 2-1.
    f. Repeat step d and e for winding 2-1, press OK.
    g. Repeat step d and e for winding 3-1, press OK.
2. The rotor compensated test is complete. Save the test results in the same way as described in Section “Test Save and Reference Comparison”.
    f. 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.

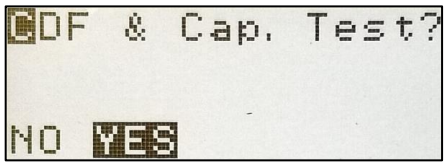
MAN MENU – 1 PHASE AC TEST AND ROTOR TEST

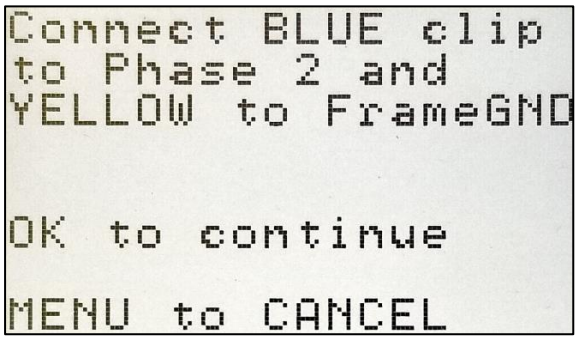
The "MAN" menu is located in the middle of the 2nd line of icons on the main screen as shown below.

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 diagnosing problems with rotor after the stator is determined to be good.

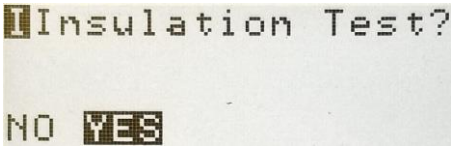
1 - Phase AC Test

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

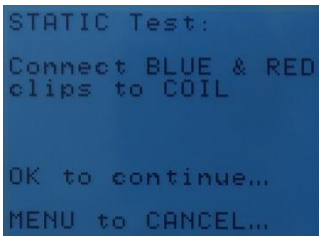




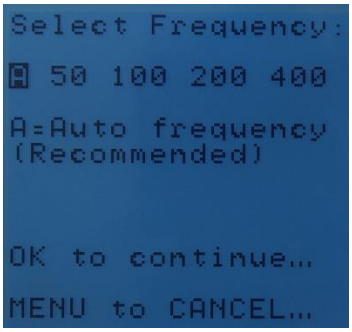
2. Choose to perform insulation test.



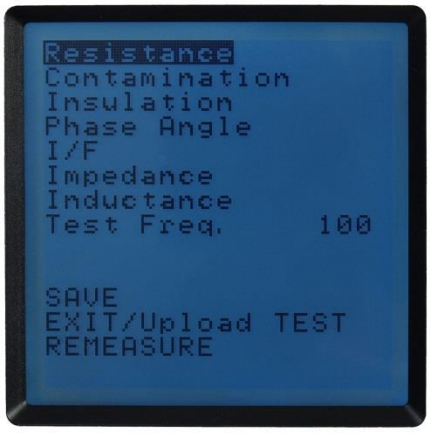
3. Connect red test lead to the other terminal of the 1 Phase winding.



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.



5. The results will be displayed as below. Press on any parameter will show the measurement value. Refer to Section "Viewing 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".

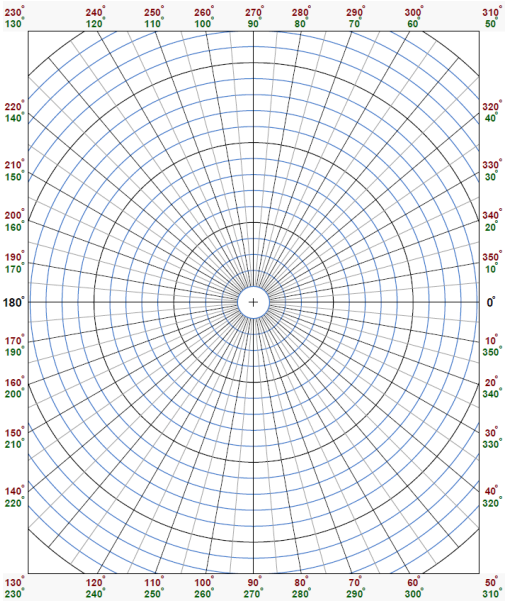


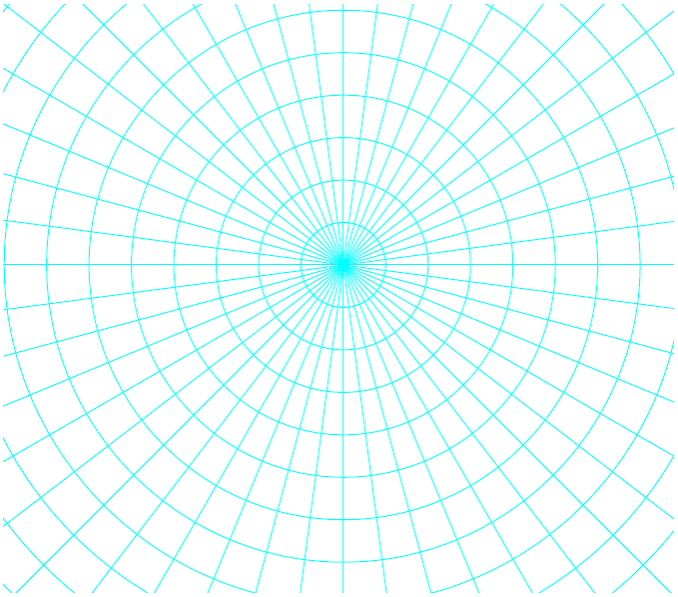
Rotor Test

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.

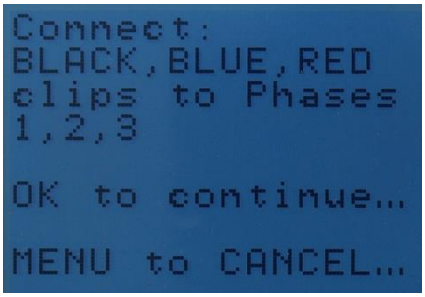
Examples of polar graph: left- 5° interval, right – 7.5° interval.





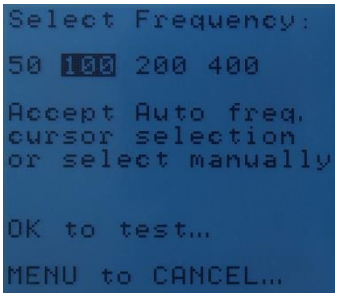
Rotor Test steps

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

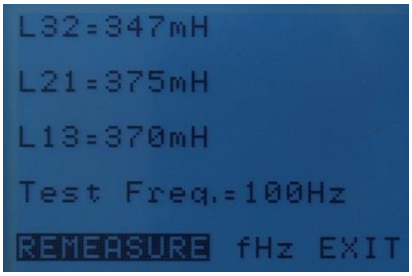


2. The instrument starts the measurement, then will show the frequency determined. The users can either use this frequency or select another frequency at their discretion.

   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.



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 measurement. 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".



DC MOTOR TEST (*ALL-TEST PRO 7 PROFESSIONAL)

DC motor deenergized 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 AT7 PROFESSIONAL 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, AT7P 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. AT7P 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 AT7P readings change between tests, then carbon build-up is likely the cause.

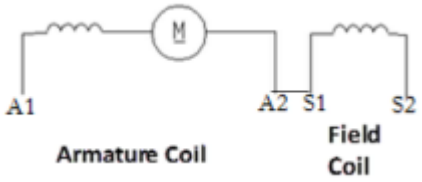
DC Motor Testing from the Motor Drive

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



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 AT5™ test leads to free- end on the armature lead and the free end of the field coil.

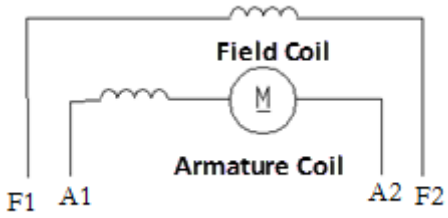
Since the armature and field windings are connected in series it is enough to only measure the insulation resistance for one time from the DC motor drive.

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.

INS1 = field windings to ground

INS2 = armature windings to ground

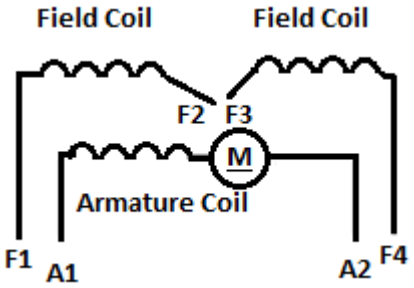
INS3 = field winding to armature winding

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

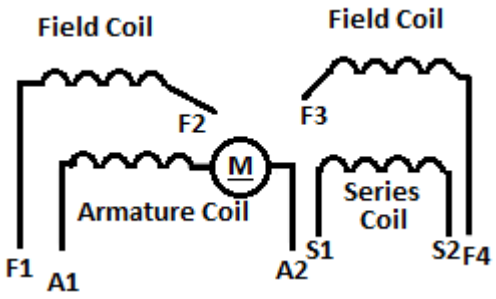
DC1 = Field Coil 1

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 AT5™ 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

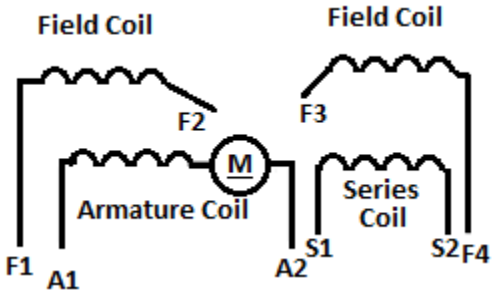
STATIC readings for DC Compound Single Voltage Motors

DC1 = Series & Armature Coil

DC2 = **F**ield 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 AT5™ 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 = **F**ield Coil 1

DC3 = Field Coil 2

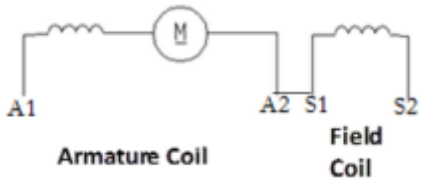
DC Motor Testing from the Motor

The AT7P 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 filed 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

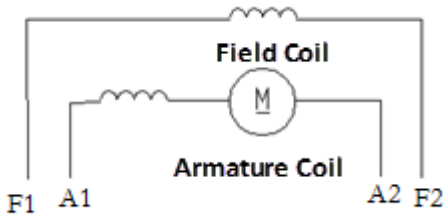
STATIC readings for DC Series Motors

DC1 = Series **F**ield 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 filed 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

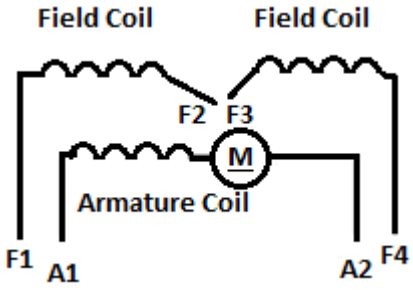
INS3 = field winding to armature winding

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

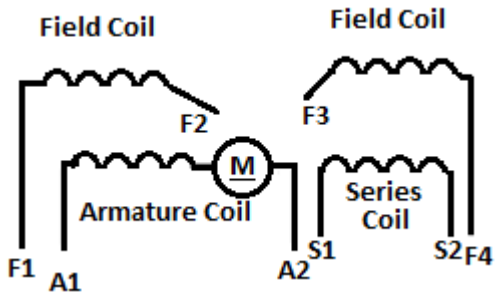
DC1 = Field Coil 1

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

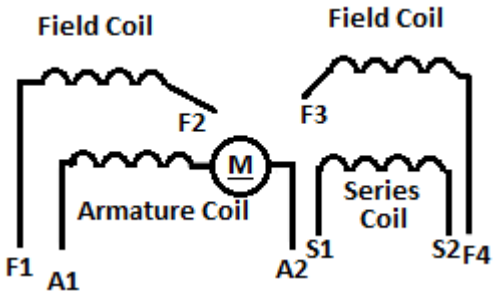
DC1 =Series

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 = **F**ield 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 AT7P 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 PRO 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 AT7P 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 AT7P instruments.

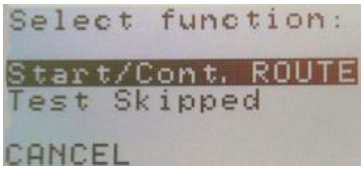
During the route testing in AT7P instrument, the users can choose to make the test, or skip the test and make the test later, save the test to route, or save the test separate from route in the way a regular test saved. A route can contain up to 100 equipment.

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 AT7P instrument memory. *Note: all other test records will be cleared when the route is downloaded from a computer to the instrument. Upload all test data before route downloading.*
2. From the main screen highlight the **ROU** icon.

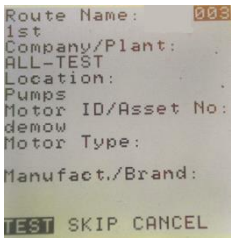
3. Press the **OK** key to access the Route Screen.



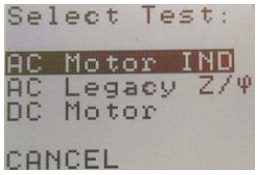
4. Three options available:

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 instrument screen will momentarily display “Checking Route; Please wait….”, then the screen displays the 1st available route test:

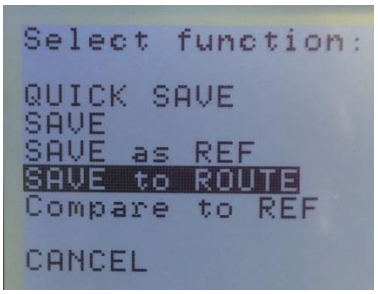


6. There are three options:
   a. Pressing “TEST” to begin the motor test on the displayed machine
   b. Pressing “SKIP” to skip the displayed equipment
   c. Pressing “CANCEL” will exit to the main screen. Next time when starting the route, this test will be the 1st one to be available.
7. If “TEST” 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 AT7 operates with MCA Basic to upload, analyze and trend tests data for single and three phase motors. AT7P operates with the MCA PRO software to upload, analyze and trend tests data of motors, generators, transformers, and 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 instrument and PC software. Therefore, the instrument has to be set up in Communication mode.

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

ALL-TEST PRO Instrument 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 instrument in the communications mode, the screen will display:

Now the 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).

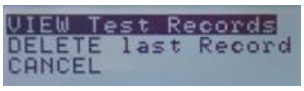
Pressing "OK" key when "SET" is highlighted will show up the following screen:

VIEW/DELETE Record

Viewing Saved Test Data

To view any data stored in the instrument:

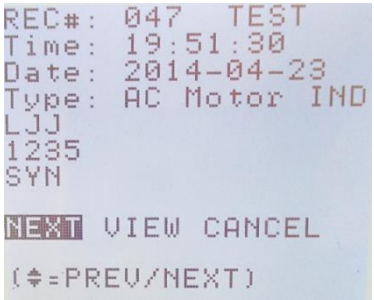
1. From the Main Menu; press > key 3 times to highlight the SET function
2. Press the OK key, this will display the Setup Menu
3. Highlight VIEW/DELETE record
4. Press OK key, this will display VIEW Test Records Display screen



5. Highlight VIEW Test Records
6. Press OK key, this will display the last Motor data test set stored in the instrument 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



If a test is saved by choosing “SAVE” upon its completion, then Location, Motor ID and Type of Motor will be displayed. If the test is saved by “QUICK SAVE”, then only the Motor ID will be shown.

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 ˅ 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

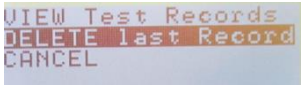
Deleting Test Records

This function is the only method of deleting test records in the instrument. 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.

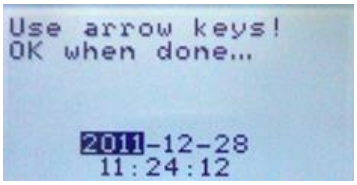
3. Highlight **VIEW/DELETE** record.
4. Press OK key, this will display **VIEW/DELETE** Test Records Display screen.
5. Press TEST ˅ key to highlight **DELETE last Record**
6. Press the >key to highlight **DELETE**
7. Press the OK key this will delete the last motor test record. stored in the instrument 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 ˅ 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 ˅** 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 AT7 series instruments 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 instrument 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 ˅ 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 instrument 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 "AT7P190610D".

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 – 10,000 ±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 total measurement range

0.01 – 99.9 Ω ±1%, Max Resolution: 0.01 mΩ or one count (whichever is greater)

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 or one count (whichever is greater)

Relative Accuracy “Phase to Phase” ± 0.2%

Inductance

1 – 999mH total 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 – 2,000 nF measurement range

10 – 2,000 nF ±5%

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

Insulation Resistance

0 – 5000 MΩ @500V or 1000V

1 – 999 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)

-10 °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 Kelvin Clips and push-pull connectors

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

Charging adapter, Universal input type 100 - 240VAC, output 9VDC @ 1.7A

Refer to software specification sheet

ALL-TEST PRO 7™ - MCA Basic™ Software

ALL-TEST PRO 7™ PROFESSIONAL - MCA PRO™ Software

1x USB 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™ Enterprise Software; Training Demo Motor, Test Leads: 3X with small Kelvin clips and push-pull connectors and 1x with 4mm safety plug

Specifications subject to change without notice.

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