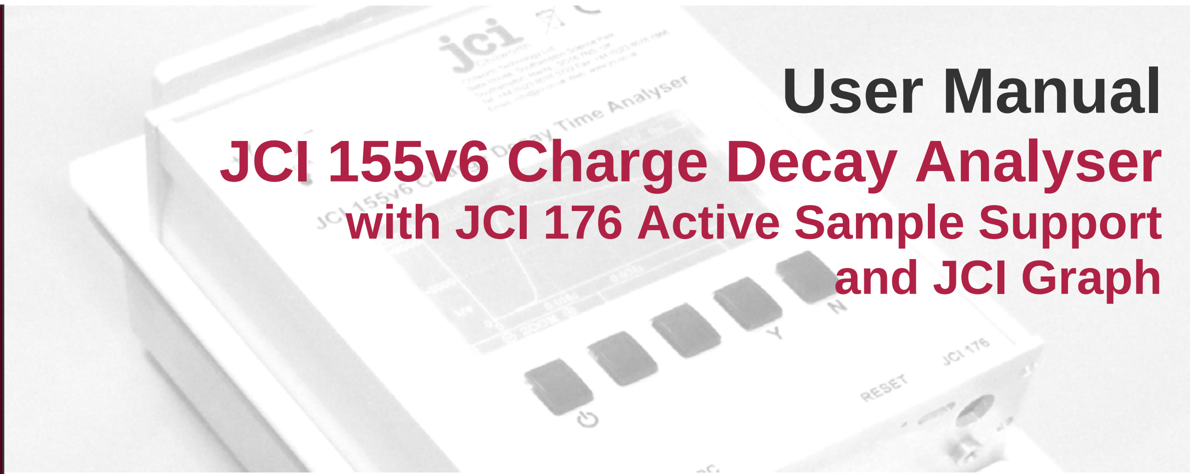
jci Chilworth



User Manual

JCI 155v6 Charge Decay Analyser

with JCI 176 Active Sample Support and JCI Graph

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Declaration of CE conformance

Chilworth Technology Ltd, Beta House, Southampton Science Park, Southampton, SO16 7NS, UK declares, as designer and manufacturer of the JCI 155v6 Charge decay Analyser and JCI 176 Active Sample Support, that the design and construction of these instruments conform to the requirements of the EC Directive on Electromagnetic Compatibility (EMC) 89/336/EEC to Standards EN 50081-1:1992 and EN 50082-1: 1992. These instruments also conform to the requirements of the Electrical Equipment (Safety) Regulations 1994 (S.I. 1994/3260).

Dr Stephen Rowe, for and on behalf of Chilworth Technology Ltd.

RoHS and WEEE Directives

JCI Chilworth electrostatic measuring instruments are not required to conform to the RoHS Directive because they come within Category 9 exemption.

To comply with the requirements of the EC WEEE (Waste Electrical & Electronic Equipment) Directive all JCI Chilworth instruments, at the end of their useful life, should be returned to Chilworth Technology Ltd for disposal or recycling in an environmentally appropriate way. Chilworth Technology Ltd is a member of the Producer Compliance Scheme ECONO-WEEE Ltd registration number WEE/KB1414VU.

Safety Warning

Of necessity the JCI 155v6 uses a high voltage power supply and if misused (i.e. used in ways other than described in this manual) it is possible that the user, or others in the immediate vicinity, could be exposed to live high voltage electrodes. Although contact with these electrodes could result in an uncomfortable electric shock, the current capability is such that it would not normally be deemed hazardous in its own right. However, the involuntary reaction to such a shock could expose the recipient to other hazards not associated with the instrument, or result damage to delicate parts of the instrument. Hence, it is important that the instructions in this manual are understood and adhered to.

PRODUCT WARRANTY

All test instrumentation supplied by Chilworth Technology Ltd., is manufactured to the highest specification, and as such Chilworth Technology Ltd., warrants the product against defects in materials and workmanship for a period of twelve (12) months or up to 8000 test-runs (whichever is sooner) from the date of receipt at the Customer premises, on a return to base policy.

It is a necessary requirement of the warranty conditions that the instructions given in the user manual are read, understood and adhered to before putting the instrumentation into first use. If any doubt exists, please consult the manufacturer for further assistance. In such cases where the product is returned to Chilworth Technology Ltd., we will inspect the product on receipt to diagnose the fault, and will issue the Customer with an inspection and condition report.

If the product proves defective during the warranty period, Chilworth Technology Ltd., at its option, will repair the product at our facilities in Southampton, UK.

Provided the product has been used in accordance with the manufacturers guidelines and that the fault is due to a manufacturing defect or component failure and is not due to expected wear and tear caused by the operating environment in which it is used, this warranty covers all parts and labour, but specifically excludes any consumable parts supplied with the product and any shipping costs to Chilworth Technology Ltd.

Chilworth Technology Ltd. shall not be obliged under this warranty:

a) to repair damage resulting from attempts by personnel other than Chilworth Technology Ltd. representatives to install, repair or service the product unless directed by a Chilworth Technology Ltd. representative,
b) to repair damage, malfunction, or degradation of performance resulting from improper use or connection to incompatible equipment or memory,
c) to repair damage, malfunction, or degradation of performance caused by the use of non Chilworth Technology Ltd. supplies or consumables or the use of Chilworth Technology Ltd. supplies not specified for use with the product,
d) to repair an item that has been modified or integrated with other products when the effect of such modification or integration increases the time or difficulty of servicing the product or degrades performance or reliability,
e) to perform user maintenance or cleaning or to repair damage, malfunction, or degradation of performance resulting from failure to perform user maintenance and cleaning as prescribed in published instruction/user manual,
f) to repair damage, malfunction, or degradation of performance resulting from use of the product in an environment not meeting the operating specifications set forth in the instruction/user manual,
g) to repair damage, malfunction, or degradation of performance resulting from failure to properly prepare and transport the product as prescribed in published product materials
h) to replace items that have been refilled, are used up, abused, misused, or tampered with in any way;
i) to support software not supplied by Chilworth Technology Ltd.;
j) to provide software or firmware updates or upgrades.

In the maintenance of the product, Chilworth Technology Ltd. may use new or equivalent to new parts, assemblies or products for equal or improved quality. All defective parts, assemblies, and products become the property of Chilworth Technology Ltd..

Any additional service identified and provided by Chilworth Technology Ltd. at the Customer's request shall be invoiced to Customer at Chilworth Technology Ltd.'s current rates for parts, labour and travel.

User Manual

JCI 155v6 Charge Decay Analyser

with JCI 176 Active Sample Support and JCI Graph

The JCI 155v6 is a compact instrument for the quick, easy and direct measurement of the ability of materials to dissipate static electricity and, with the JCI 176, to assess whether significant voltages will arise from practical amounts of acquired charge.

1. INTRODUCTION

Many materials easily become electrostatically charged when rubbed against other materials. In some cases such triboelectric charging may be positively encouraged for beneficial use - for example, in photocopying, electrostatic clamping and the retention of powder in electrostatic precipitation and surface coating applications. However, where charge generation is unintentional it frequently causes problems and hazards across many areas of industry. It can cause ignition of flammable gases, vapours and powders. It can make thin films difficult to handle and light fabrics cling. It causes attraction of airborne dust and debris which can affect product quality where scrupulous cleanliness is necessary, or simply lead to unsightly surface contamination during storage. Where high quality printing or coating is required, charge on the surface can lead to a reduction in quality. Static charge can damage semiconductor devices and upset the operation of microelectronic equipment. It also results in shocks to personnel, which although rarely hazardous in their own right, can become very annoying and distracting. In addition, the largely involuntary reaction to receiving a shock can result in exposure to other hazards – for example falls when working at heights or injury through contact with nearby machinery.

Most of the uses, problems and hazards of static electricity relate to the influence of charge retained on surfaces, not just the magnitude of the charge. The "suitability" of materials for particular applications therefore needs to be judged in relation to the longevity of charge retained on surfaces *and* a measure of the effect of the retained charge.

The way to assess the charge retention performance of materials is to measure the charge decay time - how quickly any charge acquired by the material dissipates over and through it to earth [1]. To avoid hazards and problems it is necessary to ensure that static charge can dissipate more quickly than charge is generated. For normal manual handling and body motion activities this means the charge decay time needs to be ¼ second or less, although for high speed processing much shorter charge decay times may be required. On the other hand, if charge is to be used beneficially, it may have to be retained almost undiminished for the entire duration of a process step. Either way, charge decay time is a much more informative measurement than resistivity for two reasons. First, the interpretation of charge decay time is immediately and intuitively understandable even by those who are unfamiliar with the field of electrostatics. Second, charge decay time reflects exactly how charge will be lost in reality, which for many materials includes the effect of a continuously changing resistivity as charge decay proceeds. This latter effect is impossible to predict from a single resistivity measurement and will often lead to charge actually being retained far longer than a simple resistivity determination would predict.

The effect of retained charge can be assessed by measurement of capacitance loading – made possible by combining the JCI 155v6 Charge Decay Analyser with the JCI 176 Active

Sample Support. Capacitance loading takes account of both the thickness of a material and its relative permittivity, such that if static charge is acquired by a material with high capacitance loading, only low surface voltages will be observed. And if the voltage is kept low, most problems and hazards will be reduced despite the presence of charge, and in some cases simply will not arise [3, 4].

The simplest way to test the charge retention capability of materials is to put some charge on the material and see how quickly this charge disappears. In the JCI 155v6 Charge Decay Analyser a high voltage corona discharge is used to deposit a patch of charge on the surface of the material to be tested. A fast response electrostatic fieldmeter observes the voltage generated by this charge and continually monitors it as the charge migrates away [1]. The general arrangement is shown in Figure 1.

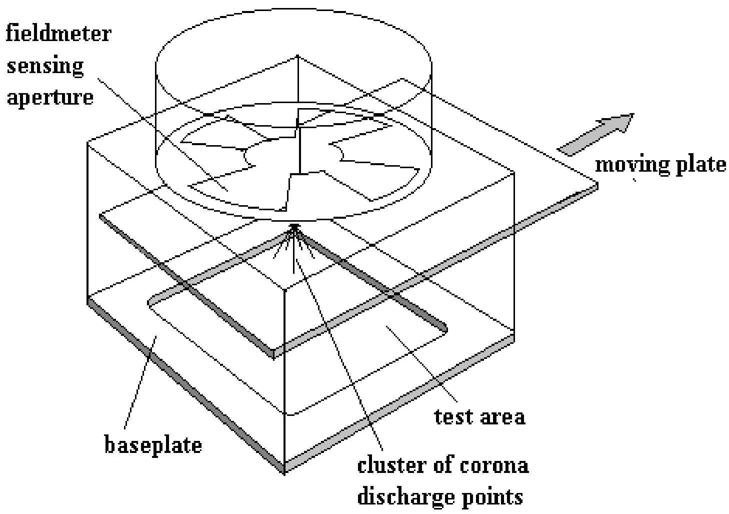


Figure 1: Basic Concept of Charge Decay Analyser

Corona charge deposition is a simple way to simulate practical charging events. It allows control of initial surface voltage and charge polarity and is applicable for all types of surfaces - whether homogeneous or with localised conducting features. It can also be used with liquids and powders. Studies have shown that charge decay time derived from a corona-charged material provides good agreement with charge decay time from the same material following the practical situation of tribocharging [2, 3, 4]. It also gives consistent and reproducible results that are not affected by corona exposure.

Studies have also confirmed that the measurement of capacitance loading is a useful additional feature for assessing risks from static electricity [3, 4, 8, 9]. A high capacitance loading means that only a low surface voltage arises per unit of charge. When the JCI 155v6 is used with the JCI 176 Active Sample Support, capacitance loading is automatically determined.

The JCI 155v6 Charge Decay Analyser is the latest development of the well-respected and long-standing range of charge decay instruments given the JCI 155 designation. It includes a wealth of new enhancements and features, the most immediately obvious of which are the large on-instrument LCD display, the user-friendly interface using 5 variable-function buttons, and the driverless USB interface to computers.

Observations, and information on test conditions, are stored in the on-board memory for subsequent transfer to any computer with a USB port. In addition, when the JCI 155v6 is

connected to a computer running Windows XP, Windows Vista or Windows 7, remote operation, data transfer, analysis and display of results, and preparation of summary test data, can all be undertaken from the latest version of JCI Graph.
The upgradeable integral software in the JCI 155v6 provides full versatility for user setting of instrument operation and measurement parameters. Values that are considered to be the most commonly appropriate are factory-set as default values, which can be recalled at any time by the user. Settable parameters include the corona voltage and duration (polarity is also selectable), the criterion for terminating a test, the speed of corona electrode retraction (slow retraction should be used when testing light powders), and the delay time after corona charging before the analysis is begun.

Charge decay time, and to a lesser extent capacitance loading, often vary with temperature and humidity. For good consistent and reliable measurements it is necessary that materials are conditioned for an adequate time (for example 24 hours) and tested in stable and defined conditions of temperature and humidity. This is particularly important where materials have an “antistat” treatment, as the performance of this relies upon adsorption of atmospheric moisture. For this reason, the JCI 155v6 includes sensors for measuring and recording temperature and humidity conditions in the immediate vicinity of the sample within the test region of the instrument. To minimise differences between local ambient conditions and those within the JCI 155v6 it is important to keep heat dissipation within the instrument to a low level. This is best achieved by making measurements with the instrument running on battery power alone, having disconnected the mains power supply at least half an hour before beginning testing (this allows the battery that may have become warm during charging to cool). As a fully charged battery will typically run the instrument for more than 8 hours, running from the battery is unlikely to present a problem.

2. OPERATIONAL AND FEATURES OVERVIEW

2.1 Operation

The JCI 155v6 operations and data analyses are all carried out by the instrument's own computer and upgradeable, installed software. The user interface is via the unit's five multi-function buttons.

Observations and results are stored in the internal memory and can be easily transferred to any computer with a USB port for long-term archiving.

When connected to a computer via the driverless USB connection, the JCI 155v6 can be controlled using the supplied JCI Graph software. JCI Graph also allows results to be displayed on the computer screen and for easy comparison produces a spreadsheet summarising all results obtained in a series of test runs. Results from JCI Graph can be inserted into Word documents, making the preparation of reports using data from the JCI 155v6 as simple as copying and pasting.

2.2 Power Supplies

The JCI 155v6 operates from its own internal rechargeable battery. When fully charged this will provide around 8 hours of battery powered operation. When the instrument is connected to its external mains power supply fast charging of the battery will begin. If the instrument is switched on this will be indicated by the animated battery symbol towards the top right of the screen. Otherwise, the presence of the mains power supply is simply indicated by the red LED near the external 18 V connector and battery charging will proceed in the same way as when the unit is switched on. Once the fast charging regime is completed, if the mains power supply remains connected the battery will be kept fully charged by a trickle charging regime.

<u>Warning: Repeated disconnection and reconnection of the mains power supply will force repeated fast charging, even if the battery is already fully charged. When combined with exceptionally high ambient temperatures this could lead to battery overheating, ultimately leading to the opening of a non-resettable thermal fuse and possibly permanent battery damage. In any case, to enable the unit to be used again it will have to be returned to the manufacturer. It is therefore recommended that the unit should not be left unattended and connected to the mains power supply if there is a significant risk of mains power failures.</u>

2.3 Test Area

The JCI 155v6 has a 45 mm x 54 mm test aperture in the instrument base-plate. This can rest directly on the test surface. Contact with the surface around the test aperture provides a return route for outwardly migrating charge and high local capacitance to trap such charge. With short duration corona charging (e.g. 20 ms) the presence and position of the outer earth boundary is not important.

Measurements can be made on surfaces smaller than the test aperture area.

2.4 Charging

The test surface is charged by a high voltage corona discharge (0 – 9.9 kV) from the tips of a small cluster of fine wires mounted on the underside of a light moveable plate (see Figure 1). This plate is moved between the fieldmeter sensing aperture and the material surface exposed through the instrument base-plate. Corona is usually generated as a brief pulse (typically 20 ms) immediately before the plate is moved away. In fast plate retraction mode the plate is fully retracted within 20 ms.

The moving plate and instrument construction shield the fieldmeter from high voltage connections, so reliable measurements can be made down to quite low surface voltages. An “air dam” is mounted on the trailing edge of the moving plate, which sweeps away residual ions still present in the space between the corona electrode and the sample surface. This ensures that residual ions contribute no more than about 10 V to the indicated surface voltage. Nevertheless, to avoid air ions affecting the measurements it is recommended that wherever possible test results should only be used where the initial peak voltage is at least 100 V.

The moving plate carrying the corona electrode is advanced against return tension springs by a snail cam, and held in place by a latch. At the end of corona charge deposition the latch is released (within 3 ms) by the action of a magnetic solenoid and the plate moves to the fully retracted (open) position within 20 ms.

2.5 Fieldmeter

A proprietary fast response “field mill” electrostatic fieldmeter [5, 6] gives fast, sensitive and stable measurement of surface potential. The response time is below 10 ms and charge decay times can be measured from less than 50 ms to many days, though in practice few measurements would warrant running for more than a few hours. Immediately before each test the JCI 155v6 instrument software automatically sets the fieldmeter zero.

It is not easy to measure decay times with signals where noise is significant in comparison to the signals or the signal differences to be measured. This is relevant to materials that dissipate charge either so quickly that the initial peak voltage is very low (10 – 50 V) or for materials that dissipate charge so slowly that small differences in signal levels need to be measured to get results within modest periods of observation. A special feature of the JCI 155v6 is that it uses a proprietary algorithm referred to as “stutter timing” to overcome this problem. This provides an excellent way of identifying average values of a noisy signal without slowing down response time.

2.6 Sample Support

Measurements are normally made both with the material freely supported with an open backing and also resting against an earthed conductive backing. These two arrangements represent the extremes of possible situations in practice. The longer of the two charge decay times is used for assessment of the suitability of the material.

The JCI 155v6 is designed such that it can be placed directly on a plane sample surface with no additional equipment. However, the JCI 166 Sample Support provides a simple arrangement for providing both the open and closed backing while locating the sample and the JCI 155v6 in just the right places relative to one another.

The JCI 155v6 will normally have been supplied with a JCI 176 Active sample Support (unless a specific request was received to deliver the JCI 155v6 alone). In normal operation the two are linked by an 8w to 8w mini DIN cable. The JCI 176 provides the benefits of the JCI 166 and also measures the total amount of charge delivered to the sample during corona charge transfer from the JCI 155v6. By combining the total charge and the peak measured voltage, the JCI 155v6 is then able to calculate and display capacitance loading for the sample [3, 4, 9].

Whichever type of sample support is used, special sample containers are available for measuring powder and liquid samples. For the normal situation of the JCI 155v6 and JCI 176 combination, the relevant sample holder for powders and liquids is the JCI 173. The sample holder is mounted in the JCI 176 much like any other sample, but incorporates a recess to hold the powder or liquid.

2.7 Test Conditions

Charge decay characteristics are usually susceptible to adsorption of surface moisture from the atmosphere, so measurements are very likely to depend on humidity. Temperature can also have an effect on both charge decay time and capacitance loading, though for the most part this will be secondary to the effect of humidity on charge decay time. It is therefore desirable to at least record the temperature and relative humidity at which tests are undertaken, and preferably to carry out tests under controlled conditions. More preferably, materials will be tested under at least two different temperature and humidity conditions (after a suitable conditioning period) so an indication of the magnitude of the effects can be seen. If a controlled environment laboratory is not available, the JCI 191C Controlled Humidity Test Chamber provides the means for doing this in a bench-top enclosure. The JCI 155v6 includes sensors to measure both temperature and humidity within the test region of the instrument. These measurements are stored along with all the other test data.

For critical measurements under defined environmental conditions it is recommended that the instrument should be operated from its battery, without a mains power supply connected. This is because when the battery is being charged it dissipates some heat, which could affect the temperature within the instrument, and hence the relative humidity at the sample surface, even if the instrument itself is within a controlled humidity environment.

The charge decay and capacitance loading characteristics of many materials (for example some clean-room garment fabrics) can also vary with the quantity of charge deposited. In such cases it is desirable to make measurements using quantities of charge comparable to those applicable in the practical situation. The charge deposited is measured by the JCI 176 Active Sample Support and made available through the JCI Graph software, which helps to make this feasible as part of a practical test protocol.

2.8 Test Criteria

Where the issue is one of problems or hazards due to static, and materials must be shown to be suitably dissipative, a simple acceptance criterion would be that the charge decay time (the time between the initial peak voltage and the surface voltage passing through 1/e of the initial peak) should be less than half a second. Alternatively, the maximum acceptable time to 10 % of the initial peak could be set to 2 seconds. Further information regarding formal arrangements for assessing the electrostatic suitability of materials has been published by Chubb [9].

Experience is that despite the general appearance of the form of most charge decay curves, they are usually not true exponential decays [1]. It is therefore also useful to record how the rate of charge decay varies as the decay proceeds to see whether significant levels of charge may be retained for long times. It is sometimes observed that charge decay curves may plateau after an initial, perhaps fairly rapid, decay. In this situation it may be argued that the better acceptance criterion would be the time to 10% of the initial peak voltage as this would ensure testing continued to a low residual surface voltage. Ideally, though, measurements to both 1/e and to 10% of the initial peak are recommended. Where this is not practical, for instance because charge decay times are significantly longer than 1 hour, it is possible to predict the charge decay times to 1/e or to 10% using a correlation between local charge decay time and time using data from JCI Graph [11].

2.9 Decay Timing

Charge decay times are measured using a proprietary algorithm called stutter timing. This approach very effectively overcomes problems with signal noise at low signal levels. It is therefore very helpful with very slow charge decay times and with very low initial peak voltages (for example 10 – 50 V). Stutter timing works by running and stopping the timing clock according to whether the instantaneous fieldmeter signal is above or below the voltage of interest and is used both for finding the initial peak and for determining when the end criteria have been achieved. It is also used for determining the values used to calculate each local charge decay time as the charge decay test proceeds.

2.10 Calibration

Where the results of measurements may be used with contractual, legal or otherwise critical implications then it is necessary for the JCI 155v6 to be within formal calibration [7, 10] and for measurements to be made using appropriate test procedures [8, 9].

Instrument performance can be formally calibrated to British Standard BS 7506: Part 2: 1996 [7] using measurements whose accuracy is traceable to National Standards by returning the unit to the manufacturer. Annual calibration is normally recommended. For users who need ongoing confirmation of the calibration status of the instrument a JCI 255 Calibrator Unit is recommended.

3. GETTING STARTED WITH THE JCI 155v6 AND JCI 176

Throughout this section it may be helpful to refer to the labelled photograph in Figure 2, below.

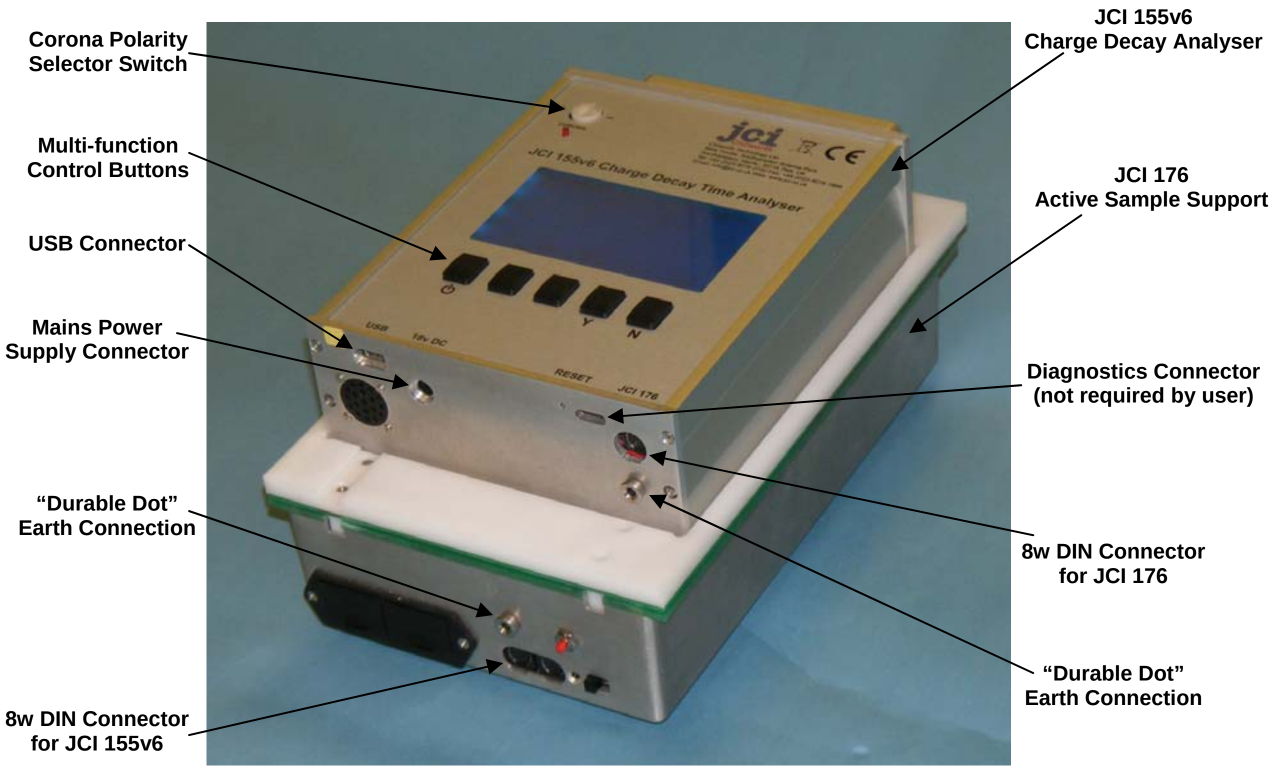


Figure 2: JCI 155v6 Charge Decay Analyser and JCI 176 Active Sample Support (cables omitted for clarity)

3.1 Setting Up

The JCI 155v6 can be operated with the mains power supply connected. In that case the output from the separate mains power supply should be plugged into the instrument's 18 V Mains Power Supply Connector. The input to the mains power supply should be connected to a mains outlet and the power switched on. _Warning: There are rare circumstances in which failure to correctly earth the JCI 155v6 could result in internal damage to the unit or to the mains power supply. Hence, when powered from the mains, only use a three-terminal mains outlet which includes an earth terminal._

However, as discussed in Section 2.7, where critical measurements requiring closely defined environmental conditions are being carried out it is preferable that the unit should be operated from its own internal battery. Hence, it is recommended that prior to use the unit will have been fully charged, which will take no more than 2 hours, and the mains power supply disconnected at least 30 minutes before the critical tests are started. This will ensure the battery is cool.

The JCI 155v6 should be connected to a known good earth using the "Durable Dot" earth connection. _Warning: There are rare circumstances in which failure to correctly earth the JCI 155v6 could result in internal damage to the unit or to the mains power supply (when_ *connected). A good earth connection should therefore always be provided at the "Durable Dot" connector.*

Where the material to be tested is very large and/or installed (e.g. floor tiles), the JCI 155v6 can now be placed directly on the material. If necessary, the area to be tested should be aligned with the sensing aperture in the JCI 155v6 base-plate, though care must be taken to ensure the sample does not protrude into the sensing aperture.

Where possible, smaller samples should be prepared and used in conjunction with a specially designed sample support (JCI 166 or JCI 176). This makes the selection of open or closed backing particularly easy and ensures the sample is placed in just the right location with respect to the JCI 155v6. At this stage the JCI 155v6 can be located on top of the sample support (as seen in Figure 2). To do this the JCI 176 should be placed in front of the user with the top plate handle furthest away. The far end of the JCI 155v6 (the opposite end from the connectors) should then be placed in the JCI 176 top frame, and pushed against the rubber buffer at the far end. Using two thumbs the connector end of the JCI 155v6 can then be pushed down into the JCI 176 frame as the rubber buffer is compressed (see also Section 7.2). This arrangement ensures that in use movement of the JCI 155v6 relative to the JCI 176 is minimal.

The sample support should then be cross bonded to the JCI 155v6 and earthed. This will be most easily achieved by connecting the "Durable Dot" earthing points on the sample support and the JCI 155v6 using a short cable with a stackable plug at one end to facilitate onward connection to a known good earth.

Where the sample support is a JCI 176 (normally supplied as standard with the JCI 155v6) the two units should also be connected using the short 8w to 8w mini DIN cable. It does not matter which of the two 8w mini DIN connectors is used on the JCI 176. When the JCI 176 is used for normal testing with the JCI 155v6 the second 8w mini DIN connector, the slide switch, the momentary press-button switch and the batteries are not required. (These are mainly present for use with a much earlier charge decay tester).

For much of the rest of this manual it will be assumed that the JCI 155v6 will be used with the JCI 176 Active Sample Support. If this is not the case the operation of the JCI 155v6 will be exactly the same and it will be a simple matter to ignore those instructions clearly relating to the Active Sample Support. The stored data and instrument display will also make it clear that the Active Sample Support was not present and therefore that charge transfer was not measured and capacitance loading not determined.

3.2 Installing the Sample

The JCI 176 is designed such that for most samples it easy to open the top plate single-handed, with the JCI 155v6 in place, place the sample over the aperture in the JCI 176 bottom plate, and then lower the top plate (and Charge Decay Analyser) back into position.

If this proves too difficult the JCI 155v6 can be lifted off and placed to one side of the JCI 176 while the sample is installed, and then returned to its position on the Active Sample Support.

Although sufficiently robust for a typical laboratory environment, the JCI 155v6 has many delicate parts, and it is therefore important that it should not be dropped or jarred when replacing it whether or not it remains on the Sample Support top plate during sample installation.

The JCI 176 top plate hinge is an expanding type and can therefore accommodate samples up to 25 mm thick.

3.3 Basic Controls

The JCI 155v6 is entirely operated using 5 multi-function buttons (keys). For the most part the function of these keys changes as indicated on the instrument's screen display and depending upon what else is on the screen at the time. However, three keys also have fixed markings against them on the main instrument case.

The far left button (when the cable connections are closest to the user) turns the unit on when it switched off. In addition, when the unit is running, as an additional security measure some commands required confirmation that it is the user's intention to carry out the command. This is done by opening a small window on the main screen requesting "Yes / No" confirmation or rejection of the command. To respond to this query the right hand button (marked "N") should be pressed if the response is "No", and the next button along (marked "Y") pressed if the response is "Yes".

3.4 Basic Testing

The JCI 155v6 allows a wide range of test parameters and data analysis settings to be set by the user to ensure the most appropriate tests are carried out for a particular type of assessment of a particular type of sample. Some experimentation to establish the best test settings is therefore recommended. Full details of the menu system, and hence how to make the adjustments necessary for such experimentation, are given in Section 6.

However, the JCI 155v6 comes with the most commonly useful values already pre-set, with easy reversion to the factory-set values available at any time. Hence, the instrument can be used to carry out a test as soon as the instructions in Sections 3.1 and 3.2 have been carried out. This section is therefore aimed at starting simple testing as quickly as possible.

If a simple practice sample is required, a sheet of ordinary paper is ideal, as its charge decay time test will usually be completed in seconds, yet it is slow enough to be able to pick out a good deal of detail. In any case, the sample should preferably (but not necessarily) be cut to a roughly 100 mm to 150 mm square and have been installed as described in Section 3.2.

Once the instrument is set up (Section 3.1) and the test sample is in place (Section 3.2), a test can be carried out as indicated in the following sub-sections.

3.4.1 Turning the JCI 155v6 On

If not already done, turn the JCI 155v6 on by pressing the left hand button. A full description of what can then be seen is given below. Alternatively, to continue the quick test, go directly to Section 3.4.2.

Having turned the JCI 155v6 on, a start-up screen will be seen for a short period. This shows the instrument's serial number and the software version number before being replaced by the Home screen. The Home screen can be seen in Figure 3.

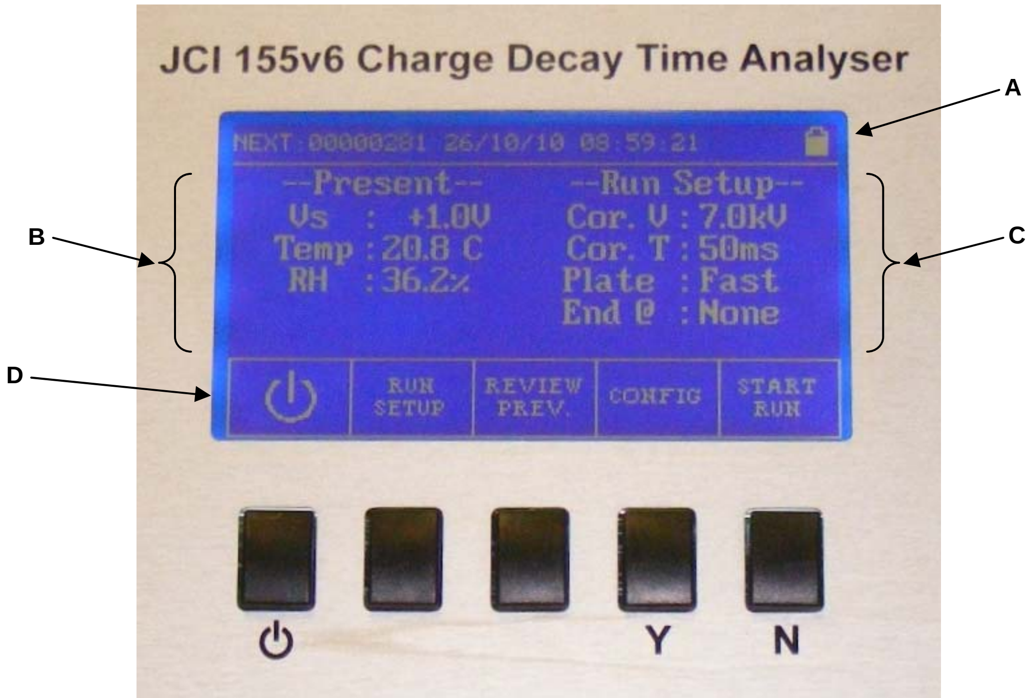


Figure 3: JCI 155v6 Home Screen

Referring to Figure 3 the various parts of the Home screen can be identified as follows:

A: Header - from left to right the header contains:

- The file number that will be used to store data from the next test. As this number is incremented by one with each test, it also indicates the total number of tests carried out by the instrument.
- Current date and time.

- Between the time and the battery symbol the number “176” would indicate a JCI 176 Active Sample Support is connected to the instrument. The blank space in Figure 3 indicates no JCI 176 is connected.
- The battery symbol indicates the current level of battery charge, and would be animated if the mains power supply had been recently connected and the battery charger operating in fast charge mode.

B: Current measured conditions – reading down:

- “Vs” is the surface voltage currently being measured on the sample.
- “Temp” is the temperature currently being measured near the sample.
- “RH” is the relative humidity currently being measured near the sample.

C: Currently set test parameters – reading down:

- “Cor. V” is the voltage that will be applied to the corona electrodes during charging of the sample.
- “Cor. T” is the time for which the corona electrodes will be energised for charging of the sample.

- “Plate” indicates whether or not plate retraction after charging will be fast (as in Figure 3) or slow. Fast retraction gives better resolution of the charge decay curve immediately after charging, but slow retraction must be used for powders to avoid contamination of the sensing aperture.
- “End @” indicates the criterion used for ending the test run. This could be when the surface voltage passes through 1/e of the peak voltage, when the surface voltage passes through a set percentage of the peak voltage, or it could be when the test duration exceeds a set time. The illustrated indication “none” shows that no end criterion has been set and the test will have to be terminated manually.

D: Current function of each button – reading left to right:

- Off – initiates powering the instrument down.
- “Run Setup” opens a new screen from which the test parameters can be set. Details will be found in Section 6.2.2.
- “Review Prev.” opens a new screen through which data from previous tests can be reviewed. Details will be found in Section 6.2.3.
- “Config” opens a new screen for configuring the instrument. Details will be found in Section 6.2.4.
- “Start Run” initiates a test run using the current settings.

3.4.2 Starting the Test

Press the right hand “Start Run” button to initiate the test run. A full description of what can then be seen is given below. Alternatively, to continue the quick test and see the charge decay presented graphically, go directly to Section 3.4.3.

As the run starts the plate carrying the corona electrode will be heard to advance. The LED next to the Corona Polarity Selector Switch (see Figure 2) may be seen to flash briefly as corona charging occurs. Almost immediately the plate will be heard to retract very quickly, allowing surface voltage measurements to begin.

The screen will briefly show some text as self-checks proceed, after which the Running screen will appear. A typical Running screen can be seen in Figure 4.

Figure 4: JCI 155v6 Typical Running Screen

Referring to Figure 4 the various parts of the Running screen can be identified as follows:

A: Header contains:

- The file number that will be used to store the data.

B: Ongoing run information – from left to right contains:

- The current surface voltage on the sample.
- The elapsed time since the test started.
- The current surface voltage expressed as a percentage of the initial peak voltage – in Figure 4 this has been blanked as the surface voltage has already decayed below the likely noise threshold and therefore can no longer give meaningful percentage information.

C: "Pause Point" information. Pause Points are so called because in earlier JCI 155 versions the less sophisticated display paused to allow the user to see information relating to key parts of the decay curve as it proceeded. On the JCI 155v6 Pause Point information can be selectively displayed at any time from the Running screen by using the left-hand button (see D below).

Pause Points which may be viewed (see D below) are as follows:

- Pre-test conditions.
- Initial Peak: conditions at the time the initial peak voltage is detected.
- T=0: conditions at the analysis start time – a user-settable time after the run started.
- 1/e: conditions as the surface voltage passes through 1/e (approximately 37%) of the analysis start time voltage.
- %: conditions as the surface voltage passes through the user-settable % of the analysis start time voltage (illustrated in Figure 4).

NB. If the selected Pause Point has not yet been reached, which is often possible for longer charge decay times, the key data values will be blanked (the field filled with "#" characters).

D: Current function of each button – reading left to right:

- "⇨(P.P)": repeated pressing of this button steps through the various Pause Points (see C above).
- "Text / Graph": pressing this button changes the screen to a quasi real time graphical display of the charge decay as it proceeds (See 3.4.3 below).
- Blank: this button is not used from the Running screen.
- Blank: this button is not used from the Running screen.
- "Stop (Save)": initiates manual termination of the test, which also results in the test data being saved to internal memory. Yes / No confirmation will be required (using the keys marked "Y" or "N") before the test is actually terminated. See also Section 3.4.5 below.

3.4.3 Viewing the Graph

Press the "Text / Graph" key to view the quasi real time graphical display of the charge decay. A full description of what can then be seen is given below. Alternatively, to continue the quick test, go directly to Section 3.4.4.

Having pressed the "Text / Graph" button, the instrument will show a graph display, an example of which can be seen in Figure 5, below.

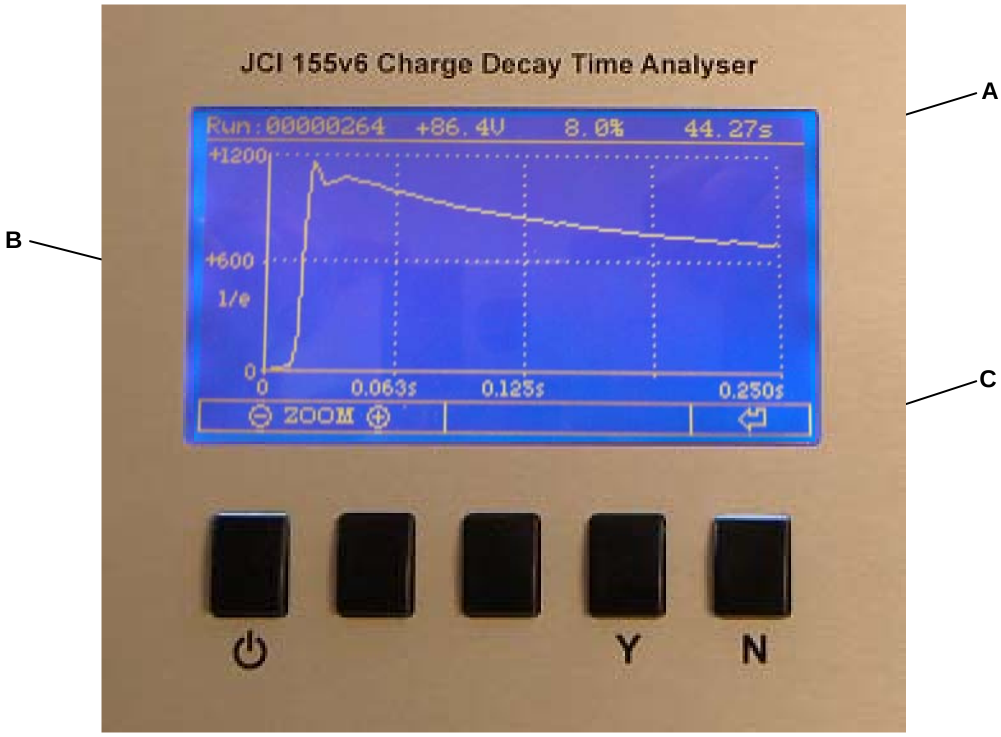


Figure 5: JCI 155v6 Typical Charge Decay Graph

Referring to Figure 5 the various parts of the Graph screen can be identified as follows:

A: Header contains:

- The file number that will be used to store the data.
- The current surface voltage.
- The current surface voltage as a percentage of the analysis start voltage.
- The current elapsed time since the start of the run.

B: The charge decay curve presented as surface voltage plotted against time since the start of the test.

In Figure 5 a small disturbance can be seen near the start of the decay part of the curve. This sometimes occurs in "Fast Plate" mode (see Section 6.2.2 B) as a result of instrument shake due to the very fast retraction of the plate carrying the corona electrodes. This disturbance will sometimes have a different form from that shown or may not occur at all. However, it will not continue beyond 50 ms from the start of the test. Detailed studies of this part of the curve must therefore be treated with caution.

C: Current function of each button – reading left to right:

- "Zoom –": zooms out to reveal more of the time axis.
- "Zoom +": zooms in to expand the time axis close to the origin. The graph in Figure 5 has clearly been expanded since the maximum time shown on the time axis is 0.25 s, whereas the elapsed time (in the header) is 44.27 s.
- Blank: this button is not used from the Running Charge Decay Graph screen.
- Blank: this button is not used from the Running Charge Decay Graph screen.

- “⏎ ”: returns to the Running screen (as in Figure 4).

3.4.4 Returning to the Test Running Screen

From the Graph screen press the “⏎ ” button to return to the Running screen (as seen in Figure 4).

3.4.5 Terminating the Test

From the Running screen (as in Figure 4) press the right hand “Stop (Save)” button to terminate the run. A small window will open in the display asking for confirmation. Press the right hand (“N”) button to abort the run termination and return to the Running screen, or the “Y” button to terminate the run and save the data.

On termination of the run the display will show the Home screen (as in Figure 3).

3.4.3 Turning the JCI 155v6 OFF

If testing has been completed, from the Home screen (as in Figure 3) press the left hand button to turn off the JCI 155v6. Confirmation using the “Y” button will be required. Pressing the “N” button will return the Home screen.

4. JCI GRAPH

This section provides abbreviated instructions for JCI Graph in order to begin using it with the JCI 155v6 Charge Decay Analyser. For fully detailed instructions the separate JCI Graph manual should be consulted.

4.1 Introduction

JCI Graph v3.1 is proprietary Windows-based software for the display of graphs, numerical results and test details of corona charge decay and capacitance loading studies made using JCI 155v6 (and JCI 155v5) Charge Decay Analyser and JCI 176 Active Sample Support. It is supplied as standard with the instrumentation and is compatible with computers running Windows XP, Windows Vista and Windows 7 operating systems.

Special features of JCI-Graph are:

- Use of a computer to remotely initiate, monitor and terminate tests with the JCI 155v6 Charge Decay Analyser. This is particularly useful when studies are conducted in a controlled environment chamber with limited access to the instrument controls and display.
- Ability to present up to 4 selected charge decay graphs and associated test data together for direct comparison.
- Selection and scaling of decay graph sections.
- Copying of graphs and test data directly to other Windows applications, such as Word documents, for ease of reporting.
- Displaying of the variation in local charge decay time as the decay proceeds, allowing early prediction of final results for very slow charge decays [12].
- Creation of an Excel loadable file giving a summary of all numerical values of test conditions and measurements, providing an easy way to compare various samples.
- Creation of an Excel loadable file of charge decay observations, calculated local decay time constants and all the recorded test condition data.
- Means of extracting test observations direct from JCI 155v6 instruments (and from JCI 155v5 memory cards).

Charge decay time measurements within JCI Graph use the same proprietary stutter timing method [13] as is used by the JCI 155v6 Charge Decay Analyser. This method of time measurement minimises the influence of noise when working with low level signals and long charge decay times. In this approach, as the signal falls below the target level of voltage the timing clock is stopped and is then restarted as it rises back above. Thus as a noisy signal gradually falls through a target voltage level the clock may stop and start many times until the signal level no longer rises up to the level at which it can restart the clock. Modelling studies have shown this to be an excellent way to find the time at which noisy signals cross set voltage levels.

4.2 Software Installation

Installation of JCI Graph follows usual Windows practice and will usually start automatically after loading the software disc into the CD drive. If installation does not start automatically it may be initiated via the usual Windows routes using the ‘Start’ button and ‘Run’ or using Windows Explorer to find and run the Setup file on the CD. Basic operational features are described in the ‘Readme’ file on the installation disc.

On starting JCI Graph the initial screen as shown in Figure 6 will be seen. The working area can be entered by clicking the left mouse button, or simply waiting for a few seconds. If a JCI 155v6 Charge Decay Analyser is already switched on and connected to a USB port the windows seen in Figure 7 will appear.

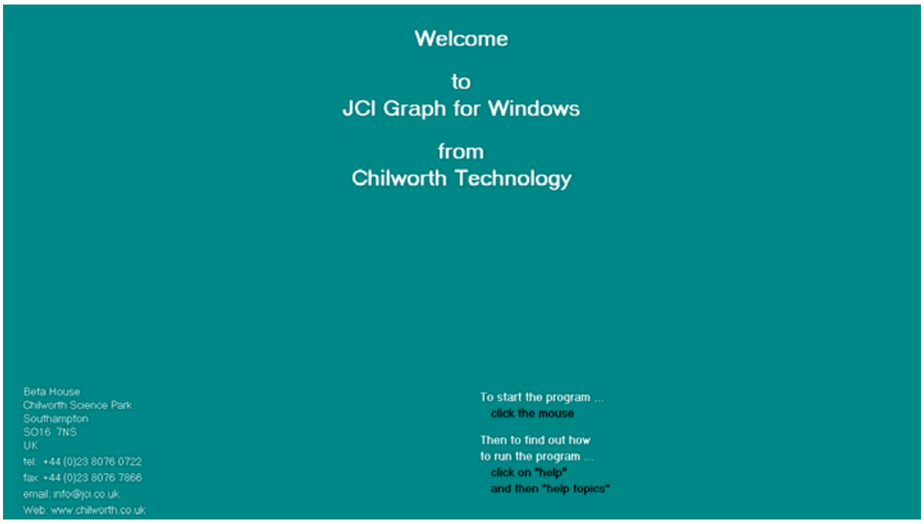


Figure 6: JCI Graph Opening Screen

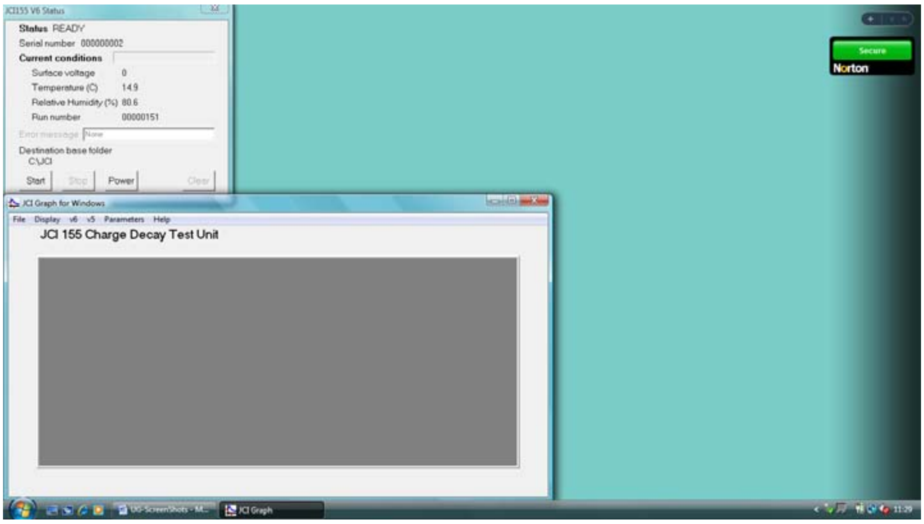


Figure 7: Initial Working Area Screen With JCI 155v6 Connected

In Figure 7 the main window of interest is the largely empty JCI Graph window seen in the bottom left of the screen. This includes a menu bar with the following menu items: File, Display, v6, v5, Parameters and Help.

The ‘Help’ menu has two options. The first, ‘About JCI Graph’, gives background information about JCI Graph (including the version number). The second, ‘Help topics’, opens the help facility in a new window, which provides access to descriptions of all the main operational features of the software, in more detail than could easily be given in a printed manual.

Other menu items, and further details of working with JCI Graph are given in a separate manual. However, abbreviated instructions relating directly to the operation of the JCI 155v6 Charge Decay Analyser are presented in the next few subsections.

4.3 Connecting the JCI 155v6

At first connection of an operating JCI 155v6 to a computer running Windows, the instrument will be recognised as a remote hard drive (possibly E:\) and a window will be shown with the contents. This window is a natural part of the Windows operating system and may be closed immediately by clicking the top right hand X marker.

The first action with a new installation of JCI Graph is to set the base folder for v6 files, via the File menu item, as indicated below.

<u>Menu: File / Set v6 base folder for extraction</u>
Clicking this menu item allows the folder used by JCI Graph to be defined. The folder defined might conveniently be, say, “JCI-Graph data” on the C:\ drive. Once set this will be reused at all subsequent uses of JCI Graph unless manually changed by further use of the “Set v6 base folder for extraction” menu item. If it is required to separate data according to, say, material types, a number of different folders equivalent to “JCI-Graph data” could be defined, and the appropriate one selected as required.

4.4 Remote Operation of the JCI 155v6

The “JCI155v6 Status” window which appears on starting JCI Graph (see Figure 7) includes a display of the current measurement of surface voltage on the sample. This enables a judgement to be made as to whether the surface voltage is adequately low for a test run to be started [14, 9].

When conditions are ready click the “Start” button in the “JCI 155v6 Status” window to initiate a test. After a few seconds the charge decay curve will be displayed in the graph area in real time. This will show the surface voltage plotted against time, and will also show a series of horizontal lines which when viewed against the right hand axis can be seen as locally calculated charge decay times, changing as the decay proceeds. A screen showing this can be seen in Figure 8.

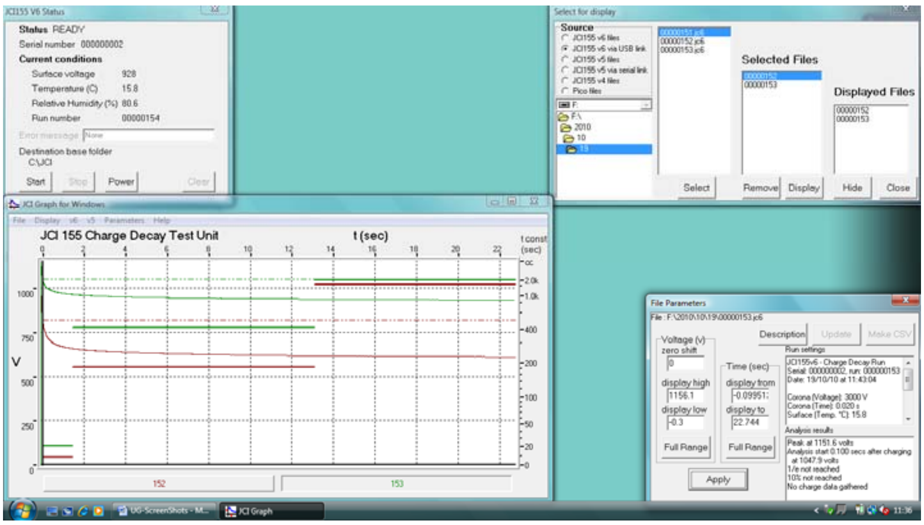


Figure 8: Typical Screen When Running A JCI 155v6 Test

In Figure 8 two decay curves can be seen on the graph window. Up to four can be displayed at any time, after which as a new run is initiated the earliest curve will be removed. Additional data can be displayed by clicking on the run number tab beneath the decay graph, and this can be seen in the bottom right hand corner of the screen in Figure 8.

In the top right hand corner of the screen in Figure 8 is the "Select for Display" window. This shows the source of curves shown on the graph window, and allows the possibility of removing graphs from the display and adding others that were saved earlier.

At any time part of the decay graph can be expanded to fill the space available simply by drawing a rectangle over the area to be expanded. This is done by taking the mouse pointer to the top left of the rectangle and the holding the left button down while the pointer is moved to the bottom right of the rectangle. To revert to the full graph use the menu items: Display / View full range.

The test may be terminated manually at any time by clicking on the 'Stop' button in the JCI 155v6 Status window.

4.4 Transferring Results to Other Windows Programs

The graphs and text boxes containing numerical data for tests currently displayed in JCI Graph can be copied to Windows programs. Copying to Word documents is especially helpful for preparing reports.

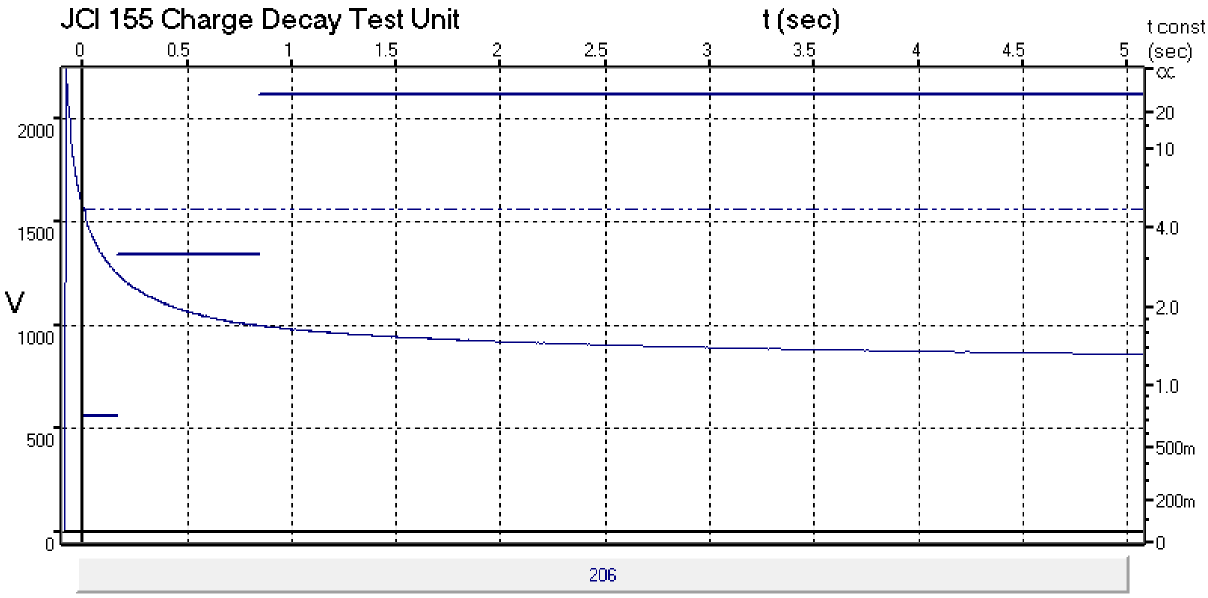
If only part of the graph is required, this should first be expanded as detailed in Section 4.3. Then, to initiate the copy process, the following menu item should be selected from the JCI Graph window: Display / Copy to document. A new window will open which states that the Word document (or other Windows application) to which the results are to be copied can now be selected, following which a paste command (or <Ctrl> v) will insert the graph into the document, just as it appeared in JCI Graph. Then return to JCI Graph to click the 'Done' button in the 'Copy to Document' window. A new window will again open, with instructions to repeat the process for the text data.

Examples of results copied in this way have been inserted into this document at the top of the next page. These data indicate the data file is located on the C:\ drive, in a folder whose details have been deleted here for clarity, in a subfolder tree with successive levels indicating the instrument's serial number, the year, the month, the day, and the unique file name (with .jc6 extension).

All other data is self explanatory, though it might be noted that the test was clearly stopped before either 1/e or 10% of the peak voltage was reached. Also, the final line "No charge data gathered" indicates that a JCI 176 Active Sample Support was not connected for this test. Had it been, both the transferred charge and capacitance loading would have been shown.

4.5 Closing JCI Graph

Clicking on the 'X' in the top right hand corner of the JCI Graph window will close all the JCI Graph windows and the program.



1 : C:\... …\000000002\2010\10\19\00000206.jc6

Serial: 000000002, run: 000000206
Date: 19/10/10 at 16:15:31
Corona (Voltage): 9000 V
Corona (Time): 0.050 s
Surface (Temp. °C): 24.3
Surface (% R.H.): 41.1
Pretest (Voltage): -48 V
Peak at 2224.6 volts
Analysis start 0.100 secs after charging
at 1562.6 volts
1/e not reached
10% not reached
No charge data gathered

5. CHARGE DECAY AND CAPACITANCE LOADING TESTING

5.1 Introduction

The following procedure is suggested as likely to be suitable for general assessment of the ability of materials and surfaces to dissipate electrostatic charge and for measurement of capacitance loading [8]. Alternative procedures may prove to be more appropriate for particular materials or items. Where the results of measurements may be used with contractual, legal or other critical implications then it is necessary for the JCI 155v6 to be within formal calibration [7] and for measurements to be made using appropriate, defined and documented test procedures [8].

The charge decay performance of materials is conveniently represented by the time from the initial peak voltage to 1/e (about 37%) and/or to 10% of the peak voltage. Display and inspection of the actual decay curve data provides a better insight into the character of the material performance. Display of the variation of surface voltage during the progress of charge decay is provided on the JCI 155v6, and can also be seen on a computer connected to the instrument and running JCI Graph. JCI Graph also provides an easy means for transferring test data to a Word report, as seen in Section 4. (Fully detailed instructions for the use of JCI Graph can be found in a separate manual).

5.2 Equipment

The JCI 155v6 can be used as a stand-alone instrument to obtain charge decay time testing. However, for full and detailed assessment of materials the following equipment would ideally be available:

- JCI 155v6 Charge Decay Analyser.
- JCI 176 Active Sample Support. Other sample support arrangements may suit some applications but the JCI 176 is essential if capacitance loading measurements are to be made (see also Section 2.6).
- JCI 173 for use with the JCI 176 where the assessment of liquids or powders is required (see also Section 2.6).
- JCI Graph software on a computer running Windows XP, Vista or 7 (see also Section 4).
- Humidity controlled laboratory or test chamber (e.g. the JCI 191C controlled humidity chamber)

5.3 Test Samples

The easiest materials to test are in sheet, film or layer form. These should lie flat under the test aperture without rucks, bulges or parts that might project into the test aperture. Other surface forms can be studied whether larger than the test aperture (45 mm x 54 mm) or smaller. However, attention is drawn to the following:

a) The surface area tested is that close to the middle of the test aperture (about 15 mm diameter).
b) Material projecting into the test aperture may foul the air dam on the moving plate, possibly leading to significant damage to the instrument.

Special care must also be taken when testing powders or materials that may have loose surface fibres, as material ingested into the test aperture is likely to adversely affect operation of the instrument. In particular, insulating powder particles or fibres on surfaces in and near the fieldmeter sensing aperture are likely to cause appreciable zero offsets and drift. For this reason it is strongly recommended that the "Slow" plate release option is used when powders are being tested. Ensuring the powder surface is well away from the sensing aperture, possibly by underfilling the powder sample container, may also be appropriate.

5.3 Test Environmental Conditions

The charge decay properties of many materials vary with adsorption of atmospheric water and hence relative humidity. Temperature also has an effect, albeit to a lesser extent. It is hence very important that the values of these parameters in the test environment are known, and preferably that they are controlled to agreed values for standardised measurements. The JCI 155v6 includes sensors to measure temperature and humidity within the instrument and to record these values along with other test data. Current temperature and humidity values can easily be seen on the instrument display.

For critical measurements and to ensure environmental conditions within the instrument match those of the surroundings in which samples have been conditioned, it is best that the JCI 155v6 is operated from its internal battery, with the mains power supply disconnected. This will ensure heat naturally generated during battery charging is not dissipated within the instrument. It is also best to leave the JCI 155v6 with its test aperture in the same environment as the samples being conditioned. As a consequence of the above, attention is also drawn to the following:

a) The JCI 155v6 battery should be fully recharged before a period of measurements. This should take no more than 2 hours, during which time the instrument should not be placed on the sample to be tested or on the JCI 176 Active Sample Support.
b) A period of at least ½ hour should be allowed between disconnecting the mains power supply (stopping battery charging) and beginning measurements.

When handling samples contact should only be with parts that are well away from the area of the surface to be tested. For preference gloves would be worn and tweezers used for small samples. Breathing in the direction of the sample should be avoided as far as is possible, since the moisture content of exhaled air is very high.

For measurements in practical situations (such as installed flooring) the ambient temperature and relative humidity should be recorded. This is automatically achieved with the JCI 155v6 instrument and its internal thermometer and hygrometer. For laboratory measurements samples should be conditioned in the selected environmental condition for at least 12 hours, though anything up to 48 hours may be required on occasions. Unless agreed otherwise it is recommended that testing is carried out under the following two conditions after a suitable period of conditioning [7, 8].

	Temperature (°C)	Relative humidity (%)
High relative humidity	23 ± 2	50 ± 3
Low relative humidity	23 ± 2	12 ± 3

If materials are known to have never been exposed to normal atmospheric conditions, it is recommended that the low humidity condition is tested first. In that case, care must be taken to ensure the sample is never exposed to a higher humidity before conditioning.

The surface of the material tested should be clean and free of loose dust. Remove any loose dust by gentle brushing or blowing with clean, dry air. If the surface is obviously contaminated either an alternative area or sample should be tested or measurements made with the contamination present and the condition of the sample reported to be “as received”.

As a general rule solvent or chemical cleaning is not recommended as this may change surface conditions or characteristics.

For measurements in practical or installed applications, the materials should be tested without any “special” cleaning. However, if cleaning is part of normal usage, for example washing of garments or floors, measurements should be taken before and after cleaning wherever practical.

If samples are cleaned prior to testing the materials and methods used to clean should be reported.

5.5 Placement of JCI 155v6

5.5.1 Introduction

The JCI 155v6 must be placed on the sample in a way that ensures it will remain stable and steady in position throughout the period of charge decay measurement. This is easily achieved when using the JCI 176 Active Sample Support, which is designed to ensure relative movement is virtually eliminated in normal use. If the instrument is allowed to move relative to the sample during testing, two effects may occur. First the sample may experience some tribocharging as a result of the movement, which may affect the results. In addition, simply moving the JCI 155v6 so that it is suddenly measuring another part of the surface will lead to a discontinuity in the decay curve, again affecting the overall results.

Where non-homogeneous samples contain conducting elements (such as some types of static dissipative fabric) it is important that any part overhanging the JCI 176 plates is not allowed to touch anything else. If it does, a discontinuity in the decay curve could occur, leading to disruption of the results.

5.5.2 Pre-charged Sample Surfaces

For quality tests it is recommended that no measurements are attempted by putting corona charge on to an already well-charged surface or material. Therefore, when a sample is presented for testing the initial surface voltage on the material should be observed before beginning. If it is more than 50 V the sample should be left in place under the instrument until the surface voltage has fallen to below 20 V. For some materials even handling them to place the sample in the JCI 176 can lead to significant charge generation, in which case careful handling may be sufficient to avoid the problem.

In any case, if appreciable initial charge is observed there are two main options:

a) Wait until the pre-charge has dissipated. This means waiting for the initial surface voltage to fall to say 10 V – 50 V, depending on the quality of observations required.

b) Make a study on the self-decay of the pre-charge without adding any corona. This can be done by initiating a test with the corona switched off. How to do this is described in Section 6.2.2.

There are other ways other of apparently removing charge from a surface (such as charge neutralisation), though to employ such methods may also affect the very property that is to be measured or simply mask the problem. Hence, these should only ever be a last resort and are not presented in detail here as general recommendations.

In the context of charging other than by the corona used for the normal charge decay test, the following two points are also worth noting:

a) If the air dam on the trailing edge of the moving plate touches the sample surface then tribocharging may occur during plate movement. This could arise when testing light fabrics. Such surfaces should therefore be stretched flat under the test aperture, though even then it may be difficult to void. If necessary, raising the JCI 155v6 base-plate away from the sample may provide the answer.

b) For some materials a very short (1 ms – 2 ms) transient peak voltage is observed before the real charge decay curve begins. It is thought this is due to vertical charge separation between front and back surfaces of the sample as the sample flexes. Precautions are in place to prevent such events upsetting the charge decay analysis.

5.6 Sample Mounting – Open and Earthed Backing

With an installed material the test aperture in the base-plate of the instrument should be placed directly on its surface.

Sheet or flexible materials should preferably be tested by placing them against the test aperture with both ‘open backing’ (i.e. no backing where the sample crosses the test aperture) and ‘earthed backing’. These two arrangements represent the extreme conditions encountered in practical applications. For both arrangements the longer of the two charge decay times should be taken for comparison with the acceptance criteria for the sample.

Note - In practical terms, ‘earthed backing’ represents a material in intimate contact with an earthed surface, for example a garment fitted close to the body of the wearer, or a work surface on top of a metal bench. ‘Open backing’ measurements represent the other practical extreme where materials are separated from earthed surfaces, for example the bottom edge of a coat or smock which hangs away from the body of the wearer.

For testing of material with ‘open backing’ the material should be supported against the base-plate of the instrument by an earthed metal aperture aligned with the instrument test aperture and with the sample extending at least 5 mm outside the test aperture. Parts of the support structure behind the sample should be earthed and at least 25 mm away from any part of the test area.

For testing of materials against an ‘earthed backing’ the material should be mounted between the base-plate and a flat earthed metal plate.

Note - If charge moves more readily through the bulk test material than across its surface, then placing an earthed metal plate immediately behind the test area may decrease the charge decay time. On the other hand, if charge moves more readily across the surface of the test material, then charge decay time may be increased due to increased capacitive loading.

Powders and liquids may be tested while supported in an earthed metal cup beneath the test aperture. An insulating cup should not be used.

The JCI 176 Active Sample Support, together with the JCI 173 powder / liquid holder accessory where required, provides a ready means of presenting samples to the JCI 155v6 in the ways described above.

5.7 Corona Charge Deposition

Corona charging provides a rapid and repeatable non-contact means of depositing charge with controllable magnitude and polarity.

Corona charging is achieved using a number of discharge points on an approximately 10 mm diameter circle 10 mm above the middle of the test area. The exact size and distribution of charge deposited on the material is not well defined, particularly with the more conductive surfaces, but the arrangement provides a consistent pattern of deposited charge for decay time measurement.

For the most part a corona voltage of around 7 kV, with a charge deposition time of about 20 ms has been found to be appropriate, although different voltages and times may be used if needed to achieve an adequate initial peak voltage. Initial peak voltages in the range 50 V to 1000 V are suitable.
Materials should preferably be tested with both positive and negative polarity, although very similar results would normally be expected.

Charge decay and capacitance loading characteristics of materials can vary with the quantity of charge deposited. It is therefore wise to make tests with quantities of charge comparable to those likely to arise in the practical situation or, if this is not known, over a range of quantities of charge. Tribocharging by rubbing may involve quantities of charge in the range 10 nC to 20 nC. For layer, fabric and film materials the JCI 176 Active Sample Support provides the most convenient way to measure the quantity of charge transferred.

It is preferable that measurements are repeated at the same location to check consistency of behaviour for particular positions on a sample. However, it is also necessary to check that characteristics have not been affected by corona exposure. The best way to check this is to start and finish at low corona charge levels and to include changes in test position.

On completion of charging the corona electrode and fieldmeter shield plate move fully away from the test region in around 20 ms.

5.8 Measurement of Surface Voltage

A “field mill” type of electrostatic fieldmeter is used to measure the surface voltage of the sample. The proprietary design of the fieldmeter used has been described in published papers [4, 5]. These should be consulted to gain understanding of instrument principles and operation. The dynamic noise level corresponds to surface voltage variation of no more than 2 V p-p. The influence of noise on surface voltage measurement is decreased progressively during the progress of studies by averaging an increasing number of observations.

During corona charge deposition and charge decay time measurement the sensing aperture of the fieldmeter is well shielded from any connections or surfaces associated with the corona and its high voltage supply. There are no insulating materials in or around the region of the instrument between the fieldmeter and the test aperture that can retain charge and would contribute to fieldmeter observations.

The upper surface of the moving plate carrying the corona discharge points is gold plated. When this surface is moved forward in front of the fieldmeter it is used as a zero reference. This zero check is made at the start of each test run.

For measurements with materials having initial peak surface voltages less than 200 V it is necessary to remove residual air ionisation left by the corona discharge when the plate carrying the corona discharge points is moved away. An air dam is mounted on the trailing edge of the moving plate which removes the air ions from the region between the moving plate and the test aperture. In this way residual ions contribute less than 10 V to the measurement of surface voltage. This can be confirmed by running a test on a fully conducting sample.

5.9 Measurement of Charge Decay Times

Experience has shown that charge decay curves usually do not follow a true exponential form, despite the general appearance. With some materials the curve may plateau at a non-zero value as the decay progresses. Nevertheless, it is often observed that the form of decay curve is in practice little affected by the precise level of the initial peak voltage. Hence, it is appropriate to routinely normalise decay time measurements in relation to the initial peak voltage observed. The time to decay from the initial peak voltage, V_i, to a lower end voltage, V_e, at 1/e (about 37%) of the initial peak is therefore a convenient measurement for comparison of samples. In addition, measurement of the decay time to 10% of the initial peak is desirable as this often better includes any tendency to plateau as the decay proceeds.

Signal noise makes decay time measurements difficult with low level signals. This problem has been overcome by the use of the proprietary “stutter timing” approach in which the timing clock is started and stopped as the surface voltage fluctuates around the target voltage level as a result of noise.

The peak voltage (and hence the start of timing) is determined by comparing the median of the most recent four surface voltage measurements with the maximum median value. Clearly, this will reveal a peak just after the actual maximum voltage, though this is appropriate as selection of an initial voltage and the start of timing needs to relate to the beginning of the falling part of the decay curve rather than the instant at which the signal reaches a maximum as the plate fully retracts. The analysis ‘Time zero’ is determined by stutter timing from this start point.

Experience from manual tribocharging studies [2, 3] indicates that it takes about 100 ms after the end of charging for the rubbing surfaces to separate and for the surface voltage to reach a peak value and hence be available to influence items nearby. In the light of this it is appropriate to use a similar time after the end of corona charging for selecting the initial voltage on which analysis of decay curves is based. The form of decay curves before this time may well still be of interest but is not directly relevant to using corona studies to predict the performance of materials in practice

5.10 Measurement of Quantity of Charge Deposited on the Sample Surface

Measurement of the quantity of corona charge transferred to a sample is made using the JCI 176 Active Sample Support. A JCI 155v6 in its normal test position on a JCI 176 can be seen in Figure 2.

The total charge transferred, Q_{tot}, is determined by a combination of conduction and induction signals [8]. The conduction charge signal, Q_c, relates to charge deposited but already transferred by conduction to the virtual earth frame in which the sample is clamped. This can be measured directly and precisely. The induction charge signal, Q_i, relates to charge induced on an electrode behind, but some distance away from, the open backing test aperture. Clearly, the actual amount of charge remaining in the test area will be related to the induced charge signal by some function of the electrode and sample geometries. Hence, the total charge may be expressed as:

$$Q_{tot} = Q_c + f\left(Q_i\right) \tag{1}$$

With simple dissipative or relatively insulating samples, such as paper or "cling film", it is observed that nearly all the initial observations are associated with induction charge, and that as this decreases the conduction signal increases. The total corona charge deposited is of course constant, hence the fall of the induction signal, $Q_{i,}$ must match the increase in the conduction signal Q_c. A simple multiplier can therefore be found to approximate the function relating the induction charge signal to charge on the open backing area of the sample. The geometry of the induction electrode in the JCI 176 was designed to give a multiplier of about 2 for a thin sample, and experience shows the actual value to be close to 2.2.

Where it is required to change the quantity of charge transferred to the sample, this is most effectively achieved by changing the corona voltage, though experimenting with the duration of corona charging may also be helpful. Experience shows that charge decay measurements may be made with corona voltages as low as 2.5 – 3 kV, and corona times can be adjusted from 2 ms to 50 ms.

Further details of the JCI 176 are given in Section 7.

5.11 Measurement of Capacitance Loading

Although the longevity of electrostatic charge is very important (hence the need to know charge decay time) the effect of any charge that is on materials depends on the voltage created. The ratio of charge to voltage, which is therefore of particular interest, is effectively a capacitance. If this capacitance is large then only low surface voltages will arise from the quantities of charge likely to result from practical tribocharging events. Many materials, notably materials like cleanroom garment fabrics with conductive threads, show high values of capacitance so even if their charge decay times are long there may be little risk of causing problems since surface voltages will remain low in practical situations [3, 4, 8].

Measurement of the quantity of corona charge transferred to a sample is conveniently made using a JCI 176, and was discussed in the previous sub-section. Surface voltage as measured by the JCI 155v6 is calibrated in terms of a voltage applied to a conducting plane across the whole test aperture area, whereas the area over which corona charge is deposited is much smaller. Hence, the highest local peak voltage will be rather higher than the value determined by the fieldmeter measurements. For this and other similar reasons, rather than trying to calculate a true capacitance, a dimensionless value relating to capacitance and referred to as "capacitance loading" has been defined [3, 4, 8]. This is the effective capacitance determined for the test material divided by the effective capacitance obtained for a very thin dielectric layer, such as "cling film". A simple check of the continuing accuracy of the JCI 155v6 and JCI 176 combination can therefore be made by carrying out a test using a thin insulator such as "cling film". The capacitance loading obtained should then be close to 1.

5.12 Results

At least 3 decay time and capacitance loading measurements should be made in testing any material under any set of test conditions. These measurements should be made at different positions on the material and/or with different samples of the same material. Where possible such measurements should be made with both “open” backing and “earthed” backing.

Experience is that very similar results are obtained with positive and negative corona polarity, however it is considered wise to check that this is the case when new materials are being tested.

Ideally, repeatability of results for a test sample would confirmed by making, say, 4 measurements at one location (with adequate time for the surface voltage to fall to below 5% of the initial peak value before the next test) and then moving on to, say, 3 further measurement positions over the sample, followed by repeat sets of measurements on the first 2 areas. However, it is clear that such extensive testing would only be practical for relatively short charge decay times (say, less than 100 s), and in any case may only be required to gain an initial understanding of the characteristics of a new material.

5.13 Test Report

It is recommended that the following information, much of which is available from JCI Graph, should be recorded in a test report:

a) Data file reference.
b) The serial number of the instrument used for testing and its calibration status.
c) Date of measurements.
d) Description and identification of test material and location of test area.
e) History (if any) of test sample (e.g. number of washes of fabrics).
f) Temperature and relative humidity.
g) Test conditions (corona charging voltage, duration, polarity; open or earthed backing).
h) Individual values of initial peak voltage and voltage at analysis start time if different.
i) The time from the analysis start time voltage to 1/e of the start time voltage (and to other notable decay points as required e.g. 10% of initial peak, or a defined value).
j) The charge received by the sample and the calculated capacitance loading.
k) The charge decay curve, including the changing calculated charge decay times

6. JCI 155v6 REFERENCE

This section presents full details of the JCI 155v6 control button operations and the transfer of stored data. The way it is set out is based on the menu tree beneath each button, and summarised in Figure 9, below.

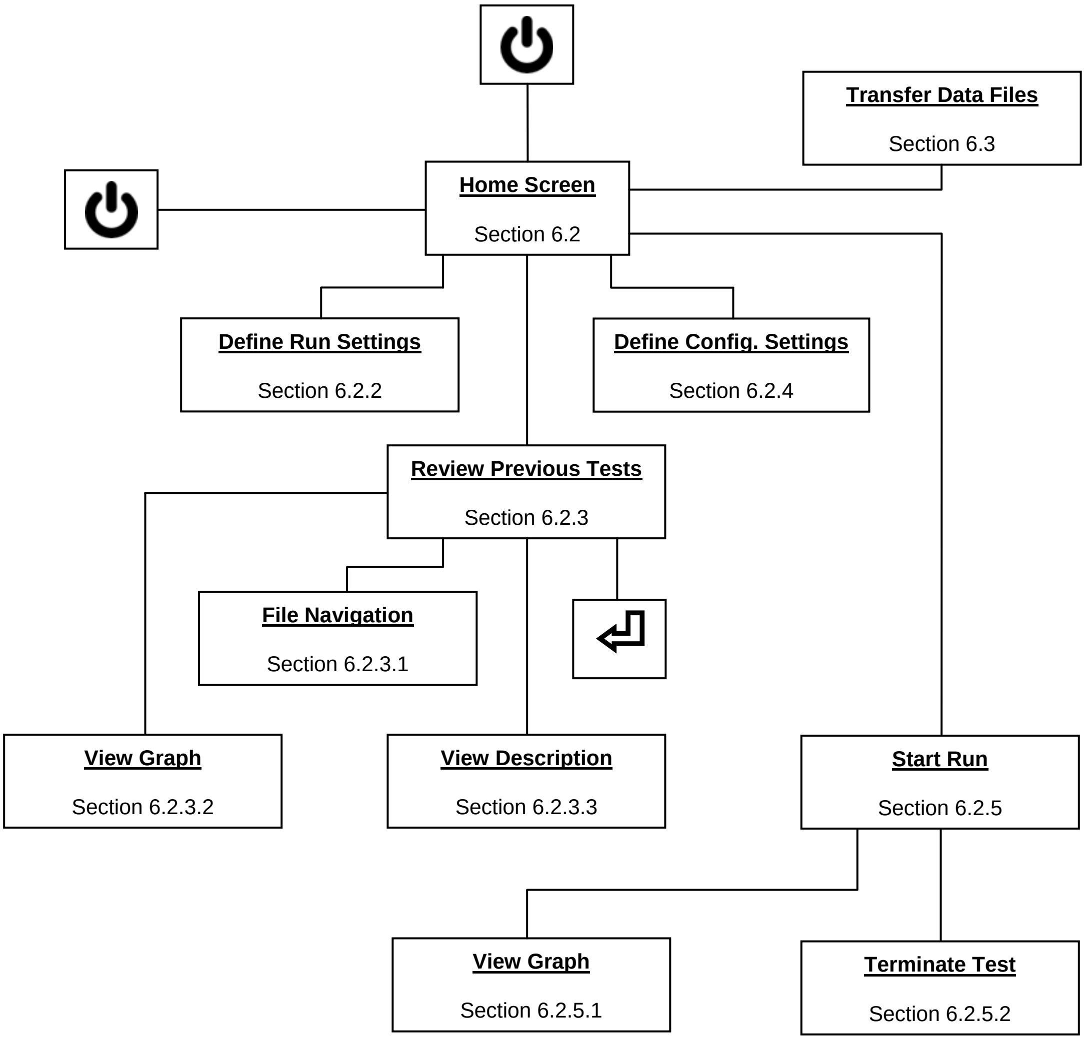


Figure 9: JCI 155v6 Outline Menu Tree

6.1 From Off

6.1.1 "⏻" Button

When the JCI 155v6 is switched off, the only button that normally has any effect is the left hand button, marked "⏻" on the case. Pressing this button will switch the unit on, initiating a start-up sequence of tests before stopping on the "Home" window.

6.2 From the “Home” Window

The “Home” Window can be seen in Figure 10, which is a repeat of Figure 3.

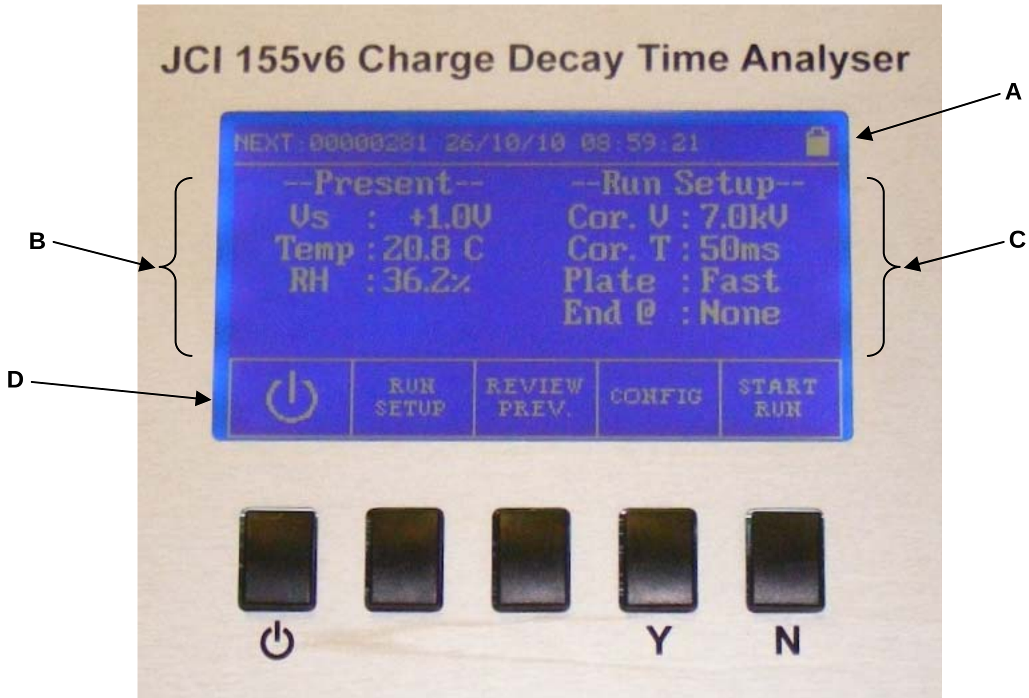


Figure 10: JCI 155v6 Home Screen

Referring to Figure 10, the various parts of the Home screen can be identified as follows:

A: Header - from left to right the header contains:

- The file number that will be used to store data from the next test. As this number is incremented by one with each test, it also indicates the total number of tests carried out by the instrument.
- Current date and time.
- Between the time and the battery symbol the number “176” would indicate a JCI 176 Active Sample Support is connected to the instrument. The blank space in Figure 10 indicates no JCI 176 is connected.
- The battery symbol indicates the current level of battery charge, and would be animated if the mains power supply had been recently connected and the battery charger operating in fast charge mode.

B: Current measured conditions – reading down:

- “Vs” is the surface voltage currently being measured on the sample.
- “Temp” is the temperature currently being measured near the sample.
- “RH” is the relative humidity currently being measured near the sample.

C: Currently set test parameters – reading down:

- “Cor. V” is the voltage that will be applied to the corona electrodes during charging of the sample.

- "Cor. T" is the time for which the corona electrodes will be energised for charging of the sample.
- "Plate" indicates whether or not plate retraction after charging will be fast (as in Figure 10) or slow. Fast retraction gives better resolution of the charge decay curve immediately after charging, but slow retraction must be used for powders to avoid contamination of the sensing aperture.
- "End @" indicates the criterion used for ending the test run. This could be when the surface voltage passes through 1/e of the peak voltage, when the surface voltage passes through a set percentage of the peak voltage, or it could be when the tests duration exceeds a set time. The illustrated indication "none" shows that no end criterion has been set and the test will have to be terminated manually.

D: Current function of each button – reading left to right:

- "⏻" initiates powering the instrument down.
- "Run Setup" opens a new screen from which the test parameters can be set. Details will be found in Section 6.2.2.
- "Review Prev." opens a new screen through which data from previous tests can be reviewed. Details will be found in Section 6.2.3.
- "Config" opens a new screen for configuring the instrument. Details will be found in Section 6.2.4.
- "Start Run" initiates a test run using the current settings.

6.2.1 '⏻' Button

The left hand **'⏻'** button is used to turn off the JCI 155v6. Confirmation using the "Y" button will be required. Pressing the "N" button will return the Home screen.

6.2.2 Run Setup

The Run Setup button opens a new screen from which various parameters relating to the test can be set. The Run Setup screen is shown in Figure 11.

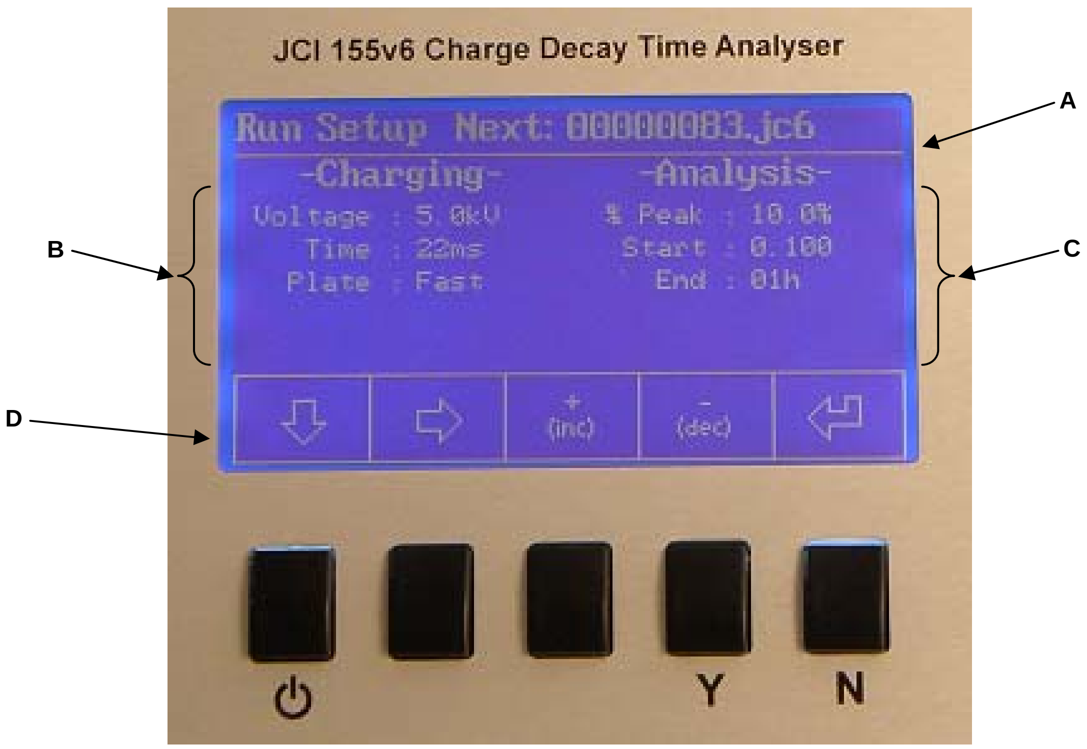


Figure 11: JCI 155v6 Run Setup Screen

Referring to Figure 11, the various parts of the Run Setup screen can be identified as follows:

A: Header - from left to right the header contains:

- The screen name (Run Setup)
- The file number that will be used to store data from the next test.

B: Current corona charging conditions – reading down:

- "Voltage" is the voltage that will be applied to the corona electrode during charging. This is user settable from 0 – 9.9 kV (factory set default value = 7.0 kV). Setting 0 V is one way of running without corona charge.
  <u>NB: corona polarity is set using the rotary switch on the main instrument case above and to the left of the display screen.</u>
- "Time" is the time for which the high voltage is applied to the corona electrode. This is user settable from 0 – 50 ms in 2 ms steps (factory set default value = 20 ms). Setting 0 ms is one way of running without corona charge.
- "Plate" refers to the speed of retraction of the plate after corona charging. It is user selectable as "Fast" (retracts in around 20 ms) or "Slow" (retracts in 0.75 s). "Slow should be used wherever possible when light powders are being tested, as otherwise there is a significant risk of readings being disrupted by the presence of powder ingested into the fieldmeter sensing aperture. (The factory set default condition is "Fast").

C: Currently set analysis parameters – reading down:

- "% Peak". The time between the analysis start time and the surface voltage passing through the given percentage of the analysis peak voltage will be recorded. The "% Peak" is user settable from 10% - 99% (the factory set default value is 10%).
- "Start" is the time after completion of corona charging that is used as the analysis start time. This is user settable from 0 – 100 ms in 10 ms steps. However, irrespective of the set "Start" time, the actual analysis start time will never be before the peak voltage had been detected. Hence, if the "Start" time is set at 20 ms, but the peak voltage is detected 30 ms after completion of corona charging, the analysis start time actually used will be 30 ms. The factory set default "Start" time is 100 ms.

- "End" sets the criterion (if any) used to automatically stop a test. This is user settable from the Configuration screen as:

  a) Low Voltage: the test will stop if the surface voltage drops below 2 V (positive or negative).
  b) Analysis Done: the test will stop when the surface voltage drops below 1/e of the peak voltage and the user settable percentage of the peak voltage.
  c) End Time (as seen in Figure 10): the test will stop when the user settable end time has been reached. This can be up to 99 hours.

d) None: the test must be stopped manually by the user.

The factory set default “End” setting is “None”.

D: Current function of each button – reading left to right:

- “⇩“: allows the user to navigate through the list of user settable test and analysis settings until the one to be modified has been reached. Once the bottom of the list of corona charging settings has been reached, a further press of the button will highlight the top of the analysis parameter list.
- “⇨”:once the desired corona setting or analysis parameter has been highlighted using the “⇩“ button, the “⇨” button allows the user to navigate to the digit to be changed (where relevant).
- “+ (inc)” / “- (dec)”: these buttons are used to increment or decrement the variables, or change non-numerical settings, that have been highlighted using the two navigation buttons.
- “⏎”: once all the settings are as required, this button returns the user to the Home screen.

6.2.3 Review Prev.

The Review Previous button (see Figure 10) opens a new screen from which previous test data can be reviewed. A typical Review Previous screen is shown in Figure 12.

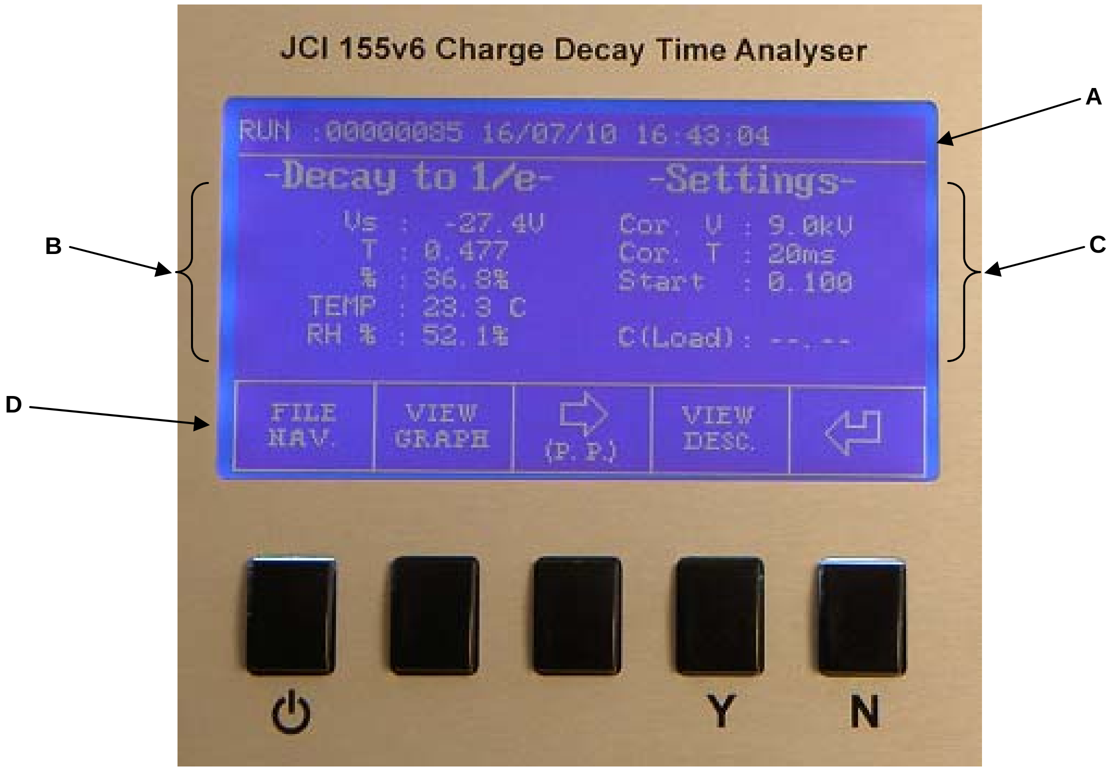


Figure 12: JCI 155v6 Review Previous Screen

Referring to Figure 12, the various parts of the Review Previous screen can be identified as follows:

A: Header - from left to right the header contains:

- The test run number (and file name in which the data is stored) for the data being shown.
- The date and time that the test being viewed was undertaken.

B: "Pause Point" information. Pause Points are so called because in earlier JCI 155 versions the less sophisticated display paused to allow the user to see information relating to key parts of the decay curve as it proceeded. On the JCI 155v6 the term Pause Point is simply used to identify key moments in the progression of a decay curve, five of which are defined, as follows:

- Pre-test conditions.
- Initial Peak: conditions at the time the initial peak voltage is detected.
- T=0: conditions at the analysis start time – a user-settable time after completion of corona charging.
- 1/e: conditions as the surface voltage passes through 1/e (approximately 37%) of the analysis start time voltage (illustrated in Figure 12).
- %: conditions as the surface voltage passes through the user-settable % of the analysis start time voltage.

In Figure 12, the heading in this section indicates that the displayed Pause Point is the time to 1/e of the peak voltage. Reading down, the following data were recorded at the 1/e Pause Point:

a) Vs: the surface voltage (1/e of the voltage at the analysis start time).
b) T: the time elapsed since the analysis start time (which may be quoted s charge decay time).
c) Temp: the temperature.
d) RH %: the relative humidity.

NB. If the selected Pause Point was not reached, which is possible for longer charge decay times which were manually stopped, relevant data values will be blanked (the field filled with "#" characters).

C: Settings used for the test – reading down:

- "Cor. V": the corona voltage used.
- "Cor. T": the duration of corona charging used.
- "Start": the time from completion of charging to the analysis start time.

Also located at the bottom of this column is the Capacitance Loading value, though in Figure 12 this was not measured because the JCI 176 Active Sample Support was not connected.

D: Current function of each button. Reading left to right, these will be discussed in detail in the following sub-sections.

6.2.3.1 "File Nav."

The "File Nav." button is used to navigate through previously saved data files. Pressing "File Nav." alters the button functions to give the File Navigation screen, as seen in Figure 13.

From the File Navigation screen, the "⇦ File" and "⇨ File" buttons should be repeatedly pressed to step through the saved data files until the desired file has been reached. This also makes for easy comparison of the displayed data for each run.

At any time the “⇦ P.P.” and “⇨ P.P.” buttons can be pressed to step through the displayed Pause Points (see, for example, B in Section 6.2.3 for Pause Point details).

Pressing the right hand ↵” button will return the user to the Review Previous screen.

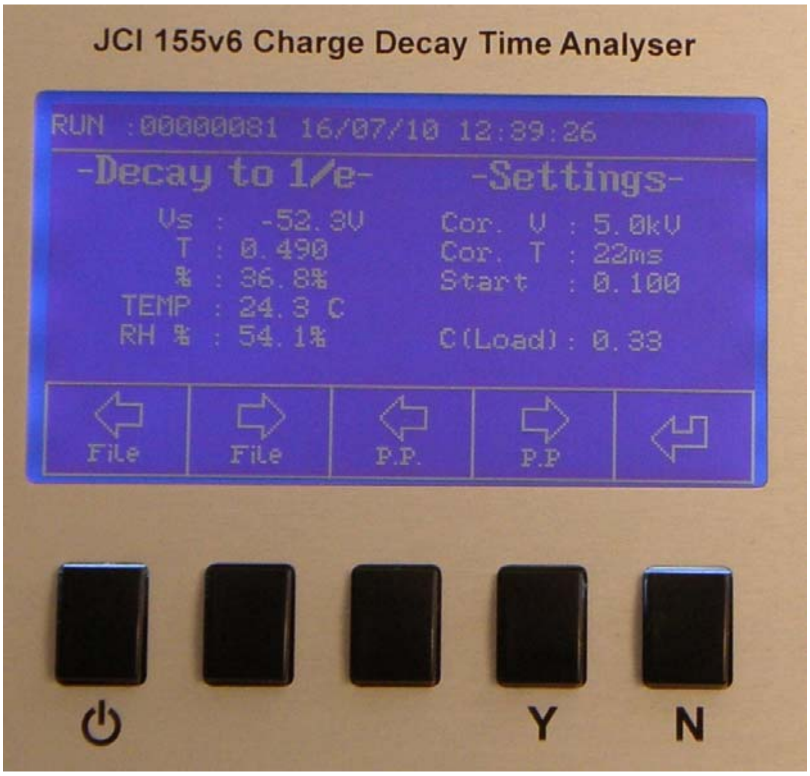


Figure 13: JCI 155v6 File Navigation Screen

6.2.3.2 “View Graph”

The “View Graph” button (on the Review Previous screen seen in Figure 12) opens a new screen displaying the charge decay curve for the currently open test file. An example can be seen in Figure 14.

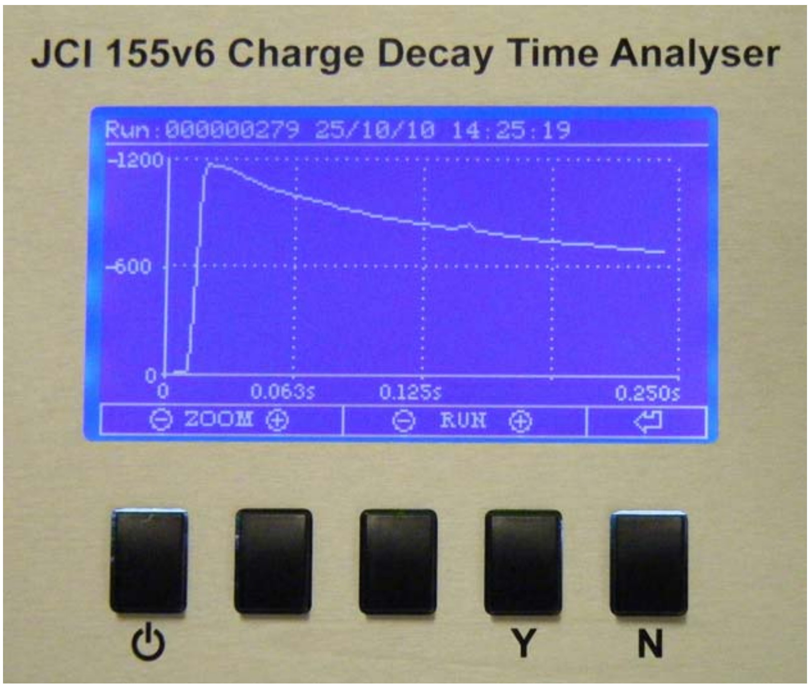


Figure 14: JCI 155v6 View Previous Graph Screen

Referring to Figure 14, on the View Previous Graph screen the following buttons are available:

a) “Zoom –“ and “Zoom +”: zooms in or out on the time axis.
b) “Run -” and “Run +”: steps through the different run numbers for instant comparison between decay curves.
c) “⏎ ”: returns to the Review Previous screen (as in Figure 12).

6.2.3.3 “View Desc.”

The “View Desc.” Button (on the Review Previous screen seen in Figure 12) opens a new screen displaying a written Run Description, which may have been added using JCI Graph (see separate manual). Figure 15 is an example of the Run Description screen, albeit one for which no run description has been saved.

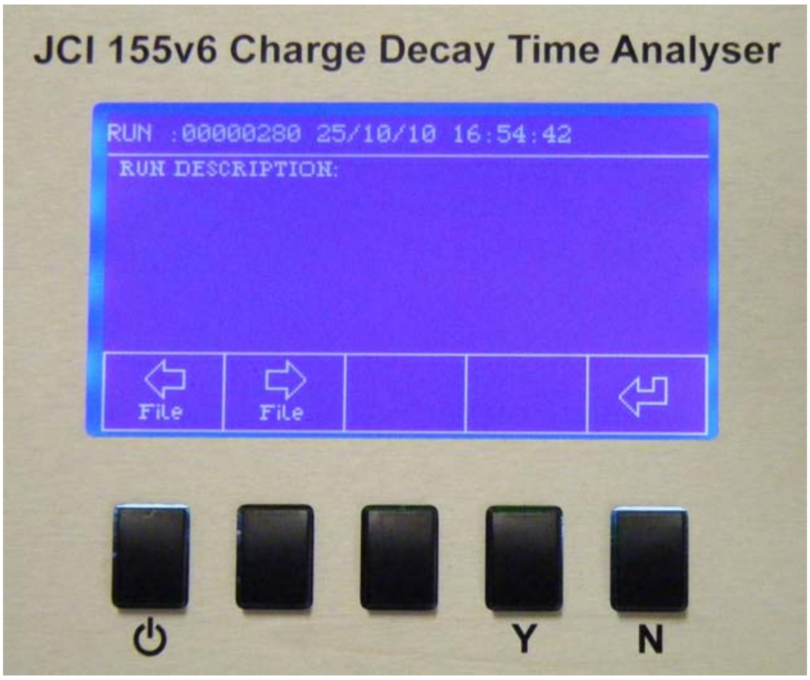


Figure 15: JCI 155v6 Previous Run Description Screen

Referring to Figure 15, from the Previous Run Description screen the “⇦ File” and “⇨ File” buttons should be repeatedly pressed to step through the saved data files. This makes quickly identifying the required file using the Run Description very easy.

Pressing the right hand “⏎” button will return the user to the Review Previous screen.

6.2.3.4 “⏎ ”

The “⏎” Button (on the Review Previous screen seen in Figure 12) returns the user to the Home screen, as seen in Figure 10.

6.2.4 Config.

The Config. button (on the Home screen seen in Figure 10) opens a new screen from which instrument configuration variables can be set. A typical Configuration screen is shown in Figure 16.

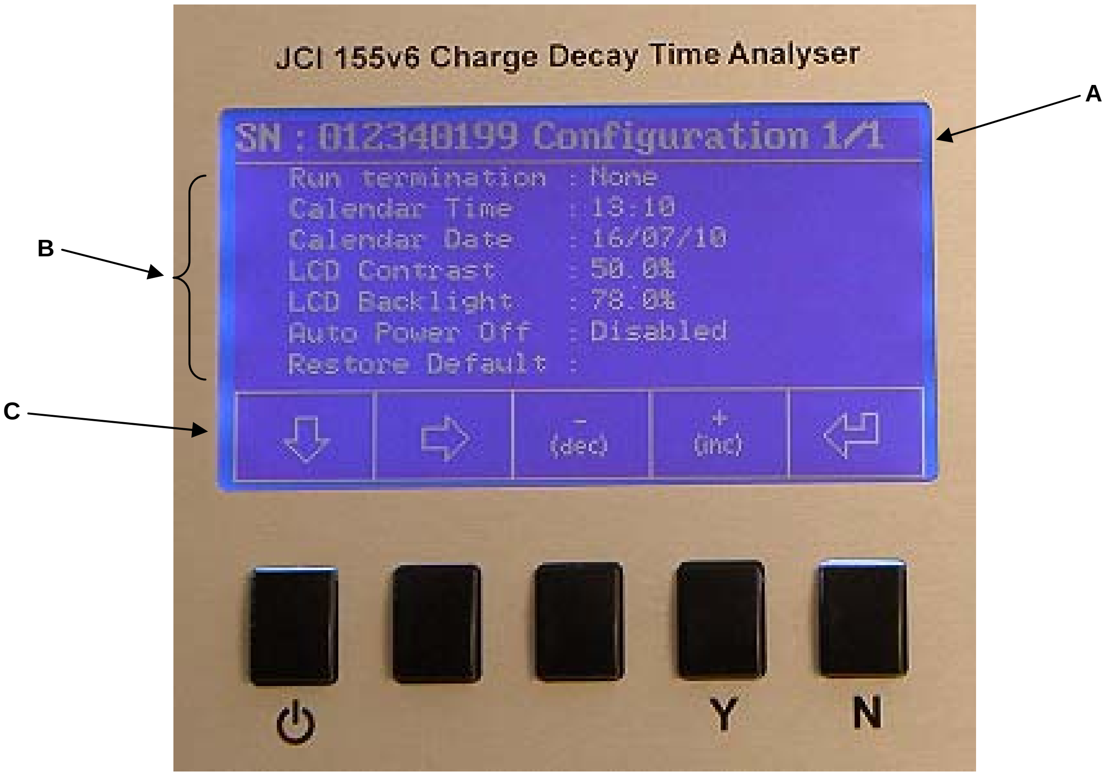


Figure 16: JCI 155v6 Configuration Screen

Referring to Figure 16, the various parts of the Configuration screen can be identified as follows:

A: Header - from left to right the header contains:

- The instrument serial number.
- The Configuration screen page number (currently there is only one configuration page).

B: Current configuration details – reading down:

- “Run Termination” shows the criterion set for terminating a test. This can be set as:

a) Low Voltage: tests will stop if the surface voltage drops below 2 V (positive or negative).
b) Analysis Done: tests will stop when the surface voltage drops below 1/e of the peak voltage and the user settable percentage of the peak voltage.
c) End Time: tests will stop when the user settable end time has been reached.
d) None: the test must be stopped manually by the user (as seen in Figure 16)

- "Calendar Time" - the current time (hh:mm).
- "Calendar Date" – the current date (dd/mm/yy).
- "LCD Contrast" – the display contrast setting.
- "LCD Backlight" – the display brightness.
- "Auto Power Off" – indicates whether or the Auto Power Off mode is enabled or disabled. When enabled, the unit does not switch off, but the display dims to the point that at first glance it may appear off. The fact that the unit is still switched on is shown by the flashing LED embedded in the "⏻" button of the production units but not seen in the photographs in this manual. Restoring the display to full brightness is achieved by pressing any of the buttons, which will have no other effect.
- "Restore Default" – is the means of restoring all the default (factory set) run settings.

C: Current function of each button – reading left to right:

- "⇩": allows the user to navigate through the list of configuration details until the one to be modified has been reached.
- "⇨": once the desired configuration detail has been highlighted using the "⇩" button, the "⇨" button allows the user to navigate to the digit to be changed (where relevant).
- "+ (inc)" / "- (dec)": these buttons are used to increment or decrement numerical values, or change non-numerical settings that have been highlighted using the two navigation buttons.
- "⏎": once the configuration details are as required, this button returns the user to the Home screen.

6.2.5 Start Run

The Start Run button (on the Home screen seen in Figure 10) initiates a test run.

As the run starts the plate carrying the corona electrode will be heard to advance. The LED next to the Corona Polarity Selector Switch (see Figure 2) may be seen to flash briefly as corona charging occurs. Almost immediately the plate will be heard to retract very quickly, allowing surface voltage measurements to begin.

The screen will briefly show some text as self-checks proceed, after which the Running screen will appear. A typical Running screen can be seen in Figure 17.

Referring to Figure 17 the various parts of the Running screen can be identified as follows:

A: Header contains:

- The file number that will be used to store the data.

B: Ongoing run information – from left to right contains:

- The current surface voltage on the sample.
- The elapsed time since the test started.

- The current surface voltage expressed as a percentage of the initial peak voltage – in Figure 17 this has been blanked as the surface voltage has already decayed below the likely noise threshold and therefore can no longer give meaningful percentage information.

Figure 17: JCI 155v6 Typical Running Screen

C: “Pause Point” information. Pause Points are so called because in earlier JCI 155 versions the less sophisticated display paused to allow the user to see information relating to key parts of the decay curve as it proceeded. On the JCI 155v6 Pause Point information can be selectively displayed at any time from the Running screen by using the left-hand button (see D below).

Pause Points which may be viewed are as follows:

- Pre-test conditions.
- Initial Peak: conditions at the time the initial peak voltage is detected.
- T=0: conditions at the analysis start time – a user-settable time after the run started.
- 1/e: conditions as the surface voltage passes through 1/e (approximately 37%) of the analysis start time voltage.
- %: conditions as the surface voltage passes through the user-settable % of the analysis start time voltage (illustrated in Figure 17).

NB. If the selected Pause Point has not yet been reached, which is often possible for longer charge decay times, the key data values will be blanked (the field filled with “#” characters).

D: Current function of each button – reading left to right:

- "⇨(P.P)": repeated pressing of this button steps through the various Pause Points (see, for example, C above).
- "Text / Graph": pressing this button changes the screen to a quasi real time graphical display of the charge decay as it proceeds (See Section 6.2.5.1 below).
- Blank: this button is not used from the Running screen.
- Blank: this button is not used from the Running screen.
- "Stop (Save)": initiates manual termination of the test, which also results in the test data being saved to internal memory. Yes / No confirmation will be required (using the keys marked "Y" or "N") before the test is actually terminated. See also Section 6.2.5.2 below.

6.2.5.1 Viewing the Graph

Press the "Text / Graph" key in the Running screen (Figure 17) to view the quasi real time graphical display of the charge decay. This will open a new Charge decay Graph display, an example of which can be seen in Figure 18, below.

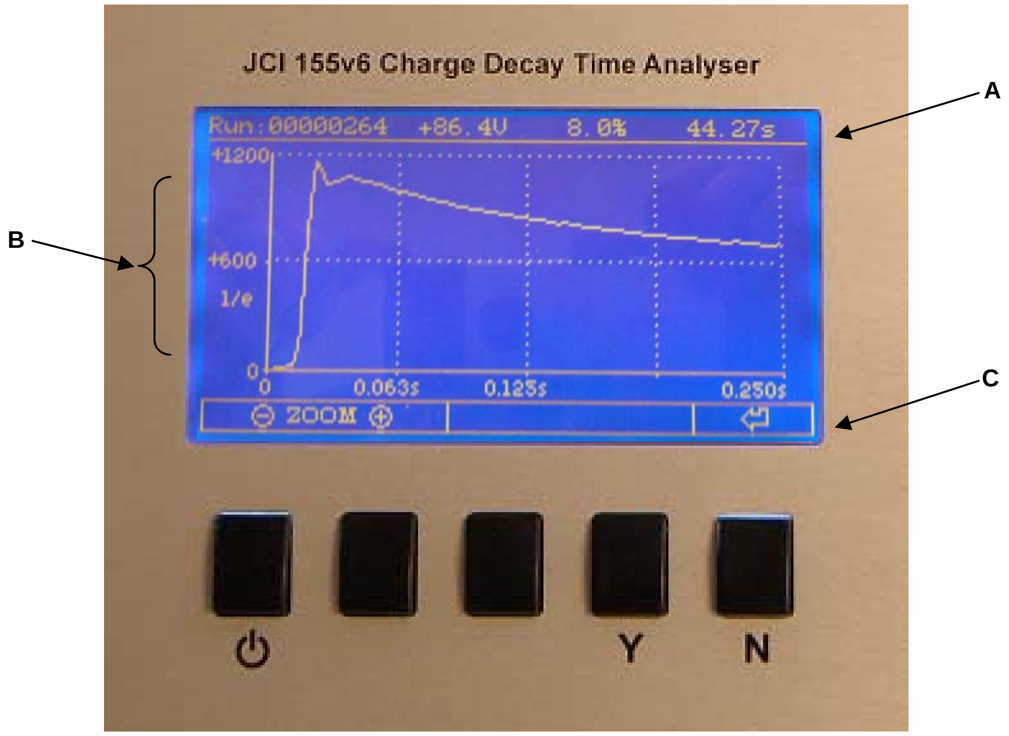


Figure 18: JCI 155v6 Typical Charge Decay Graph

Referring to Figure 18 the various parts of the Graph screen can be identified as follows:

A: Header contains:

- The file number that will be used to store the data.
- The current surface voltage.
- The current surface voltage as a percentage of the analysis start voltage.
- The current elapsed time since the start of the run.

B: The charge decay curve presented as surface voltage plotted against time since the start of the test.

In Figure 18 a small disturbance can be seen near the start of the decay part of the curve. This sometimes occurs in “Fast Plate” mode (see Section 6.2.2 B) as a result of instrument shake due to the very fast retraction of the plate carrying the corona electrodes. This disturbance will sometimes have a different form from that shown or may not occur at all. However, it will not continue beyond 50 ms from the start of the test. Detailed studies of this part of the curve must therefore be treated with caution.

C: Current function of each button – reading left to right:

- “Zoom –“: zooms out to reveal more of the time axis.
- “Zoom +”: zooms in to expand the time axis close to the origin. The graph in Figure 17 has clearly been expanded since the maximum time shown on the time axis is 0.125 s, whereas the elapsed time (in the header) is 42 s.
- Blank: this button is not used from the Running Charge Decay Graph screen.
- Blank: this button is not used from the Running Charge Decay Graph screen.
- “⏎ ”: returns to the Running screen (as in Figure 17).

6.2.5.2 Terminating the Test

From the Running screen (as in Figure 17) press the right hand “Stop (Save)” button to manually terminate the run. A small window will open in the display asking for confirmation. Press the right hand (“N”) button to abort the run termination and return to the Running screen, or the “Y” button to terminate the run and save the data.

On termination of the run the display will show the Home screen (as in Figure 10).

6.3 Transferring Stored Data

With the JCI 155v6 switched on and showing its Home screen, connecting a USB memory stick using the supplied adaptor cable (mini USB plug to USB socket) will initiate a self explanatory sequence of questions and answers via the display which will permit transfer of data files from internal memory to the memory stick. Files can then be transferred to any computer with a USB port for long-term secure storage, as required.

To ensure continued fast operation of the JCI 155v6 Charge Decay Analyser, it is recommended that the internal memory is cleared every 100 runs or so.

7. JCI 176 REFERENCE

7.1 Introduction

The JCI 176 Active Sample Support provides a convenient means of presenting samples to the JCI 155v6 Charge Decay Analyser, as well as allowing measurement of the corona charge transferred. This allows measurements on different samples to be made under comparable test conditions and enables measurement of the capacitance loading of samples. Combining capacitance loading with charge decay time provides excellent criteria for the suitability of materials to avoid problems from static electricity [2-4, 7, 14, 15] or to maximise any beneficial effect.

The basic arrangement for measuring the corona charge transferred to the test surface during charge decay measurements is shown diagrammatically in Figure 19, with the practical embodiment shown in Figure 2.

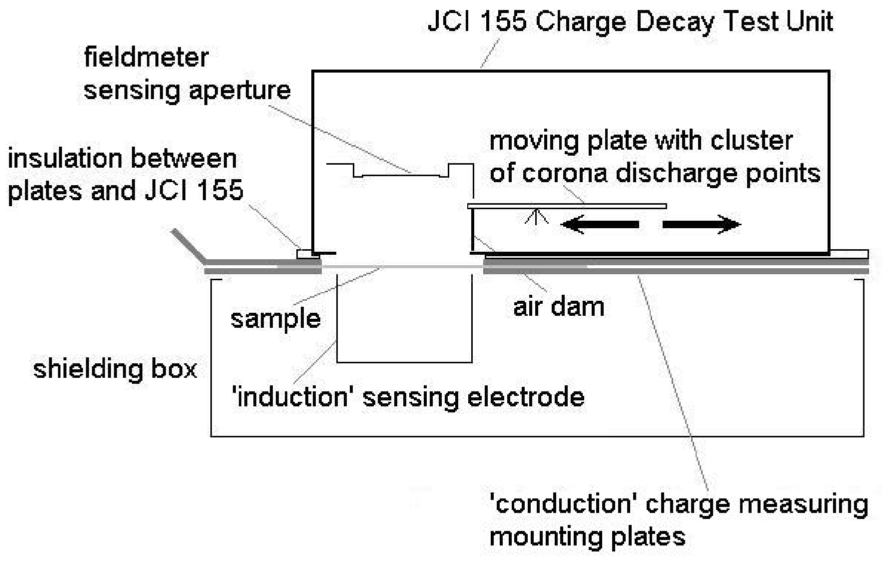


Figure 19: JCI 155v6 Charge Decay Analyser on JCI 176 Active Sample Support

The total charge transferred, Q_{tot}, is determined by a combination of conduction and induction signals [8]. The conduction charge signal, Q_c, relates to charge deposited but already transferred by conduction to the virtual earth frame in which the sample is clamped. This can be measured directly and precisely. The induction charge signal, Q_i, relates to charge induced on an electrode behind, but some distance away from, the open backing test aperture. Clearly, the actual amount of charge remaining in the test area will be related to the induced charge signal by some function of the electrode and sample geometries. Hence, the total charge may be expressed as:

$$Q_{tot} = Q_c + f(Q_i) \tag{1}$$

In practice it is found that a simple multiplier can be found to approximate the function relating induction charge signal to charge on the open backing area of the sample; the factor being about 2.2.

The quantities of conduction and induction charge are measured using virtual earth charge sensitive amplifier circuits. These provide the capability to measure quantities of charge respectively up to ±4000 nC and ±400 nC.

Layer and fabric samples are easily mounted in the JCI 176 between the two hinged plates which have apertures to expose a rather larger area of the sample than the 45 mm x 54 mm test aperture of the JCI 155v6. It has been shown that in normal testing there is negligible direct coupling to these plates from the high voltage pulse applied to the corona discharge electrodes or by leakage corona current flow. Powder and liquid samples may be mounted in a JCI 173 Sample Support Plate. This is located into the aperture of the lower conduction charge measurement plate with the long extension directed towards the hinge (see Figure 20). Care needs to be taken to avoid spillage of powders and liquids and, as discussed elsewhere in this manual, ingestion into the mechanics of the JCI 155v6.

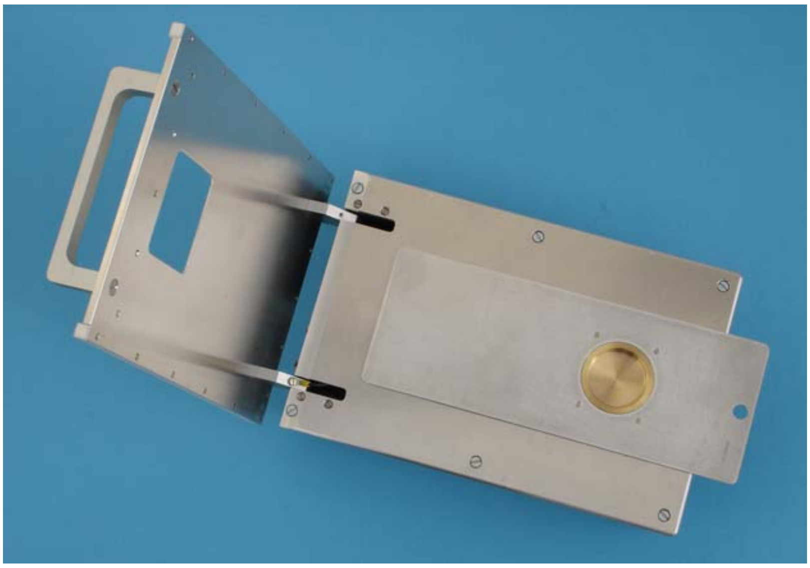
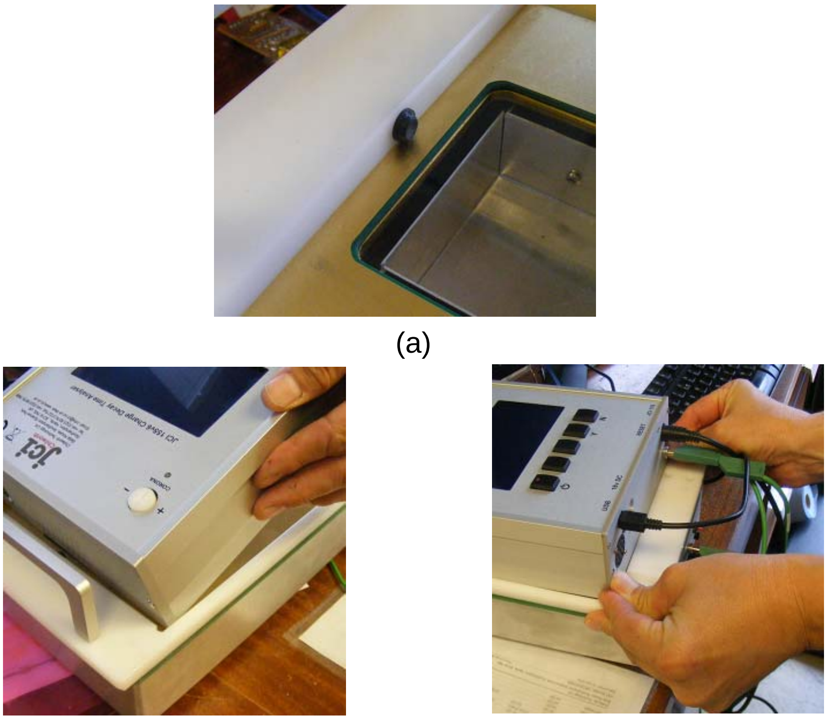


Figure 20: JCI 176 Active Sample Support and JCI 173 Liquid / Powder Sample Holder

7.2 Operation of the JCI 176

In use, the JCI 155v6 Charge Decay Analyser is mounted on top of the JCI 176 Active Sample Support, as seen in Figure 2. A small rubber buffer is mounted within the locating frame for the JCI 155v6 to minimise the detrimental effect of small movements of the Charge Decay Analyser on the charge decay measurements. This can be seen in Figure 21a, and requires that the front of the JCI 155v6 must be inserted first and the back eased into place as the buffer is compressed, as shown in Figures 21b and 21c. Care should be taken to avoid damaging the buffer.



(a)

(b) (c)

Figure 21: Locating the JCI 155v6 Charge Decay Analyser on the JCI 176

The JCI 155v6 should be connected to the JCI 176 using the supplied 8w to 8w mini DIN cable. It does not matter which of the two JCI 176 mini Din connectors is used. The JCI 155v6 and JCI 176 should also be bonded together via the Durable Dot connectors, and earthed. This is most convenient using a short 4 mm to 4mm plug cable, in which at least one of the plugs is stackable. A second cable also with a 4 mm plug can then be used to connect one end to a known good earth. Power for the JCI 176 is provided by the JCI 155v6, and neither the batteries nor the switches on the JCI 176 are required, as these were mainly for earlier versions of the JCI 155.

The top plate of the JCI 176 can be swung up on its hinges at the back so samples can be placed between the plates over the aperture area. It is important to make sure that samples lie as flat as possible and without wrinkles. The top surface of the sample should be free of loose dust, particles and fibres and without projections that could extend into the test aperture of the JCI 155v6. The top plate of the JCI 176 can usually be lifted sufficiently to place samples in position without removing the JCI 155v6, though if this does prove necessary the connecting leads should be long enough to place Charge Decay Analyser to one side while inserting the sample.

The sample mounting plates are part of the active charge measurement circuits. It is therefore important that these plates do not contact anything earthed or which may be charged. This also means that when working with samples which include high conductivity components (e.g. some types of static protective fabrics), the sample should be cut so as not to extend much beyond the mounting plates and risk contacting something.

7.3 Calibration of the JCI 176

The sensitivity of conduction and induction charge measurements may be calibrated by transferring a known quantity of charge to the sensors using a JCI 256 Charge Calibrator. This provides calibration capability for quantities of charge from 1 – 999 nC with an accuracy better than 1%. The JCI 256 Charge Calibrator can itself be formally calibrated with measurements whose accuracies are traceable to National Standards.

The sensitivities of the conduction and induction charge sensing amplifiers have been chosen to allow measurements over the range of charge transfers likely to occur in tribocharging events – from around 1 nC up to about 4000 nC. This allows direct comparison of the characteristics of materials using corona charging with those obtained in tribocharging work [2, 4, 15].

The induction signal sensing surface is designed to be broadly symmetrical beneath a thin sample with the sensing region of the JCI 155v6 above the sample (see Figure 19). In principle, therefore, for a thin sample the quantity of charge on the induction electrode should be about half the total charge retained at the open backing aperture. The actual value can be established using, for example, paper or cling film as a test sample.

An oscilloscope recording of induction and conduction signals during corona charge transfer can be made via the spare 8w connector on the JCI 176 (see Section 7.4 for connection details). The quantity of charge initially measured only on the induction circuit transfers to become the conduction signal as the decay proceeds. Hence, the original induced charge can be deduced from the final conduction charge measurement. Knowing the indicated induction charge measurement means the factor discussed in Section 7.1 can be determined.

7.4 JCI 176 Connections

Connections at each of the two 8w mini DIN sockets on the JCI 176 are listed below. The 8w DIN sockets are connected in parallel so it is possible to monitor the output from the JCI 176 at the same time as undertaking tests using the JCI 155v6.

Pin No.	Signal	JCI Cable Colour Code
1	Conduction charge signal x1	Black
2	Induction charge signal x1	White
3	Conduction charge signal x8	Red
4	Induction charge signal x8	Yellow
5	Initial zeroing to earth	Violet
6	Ground	Blue
7	+5V supply input	Green
8	-5V supply input	Brown

Table 1: JCI 176 8w Mini DIN Connections

The x1 and x8 signals are available simultaneously. The conduction and induction charge signals may be displayed and recorded on a digital storage oscilloscope and/or displayed on digital multimeters. It is important to either pre-select or record the sensitivity ranges at the same time. In addition the JCI 176 may be directly connected to a JCI 155v6 Charge Decay Test Unit. This both provides power supplies for operation of the JCI 176, and permits recording of induction and conduction charge components at x1 and x8 sensitivity levels. The JCI 155v6 controls zeroing of the JCI 176 in appropriate relation to deposition of corona charge.

The sensitivity of the signal outputs is 1 mV per nC (and 8 mV per nC) for the conduction charge signal, and 10 mV per nC (and 80 mV per nC) for the induction charge signal.

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