OWNER'S MANUAL

MODEL 1656

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MODEL 1657

BATTERY ELEMENT TESTER

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1656/1657 Owner's Manual

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CERTIFICATION

STS INSRUMENTS CERTIFIES THAT THIS INSTRUMENT WAS THOROUGHLY TESTED AND INSPECTED AND FOUND TO MEET OR EXCEED ITS PUBLISHED SPECIFICATIONS WHEN IT WAS SHIPPED FROM THE FACTORY.

LIMITED WARRANTY

All products are covered by our standard limited warranty: Your new instrument is warranted to be free from defects in workmanship and material for a period of (1) year from date of shipment and we will repair or replace any such product we find to be so defective upon its prepaid return to us. This warranty is void if the product has been tampered with, or subjected to gross misuse, and is exclusive of all others, expressed or implied. In case products of other manufacturers are specified as a part of the above quotation, the warranty of that manufacturer will apply to such items, and our responsibility is limited to assisting the customer in filing warranty claims with the manufacturer responsible. In the event that the prepaid return of a system to our Irvine, California plant is impractical and the customer desires on-site warranty, we expect payment for the actual incurred travel and out-of-factory expense of our factory representative.

The customer must prepay transportation costs for the return of instrument for warranty service. The return method will be at the discretion of STS Instruments.

Except as provided herein, STS Instruments makes no warranties to the purchaser of this instrument and all other warranties, expressed or implied (including, without limitation, merchantability or fitness for a particular purpose) are hereby excluded, disclaimed and waived.

Any non-authorized modifications, tampering or physical damage will void your warranty. Elimination of any connections in the earth grounding system or bypassing any safety systems will void this warranty. This warranty does not cover batteries or accessories not of STS Instruments manufacture. Parts used must be parts that are recommended by STS Instruments as an acceptable specified part. Use of non-authorized parts in the repair of this instrument will void the warranty.

CALIBRATION

STS Instruments certifies that this instrument was calibrated using standards that are traceable to the National Institute of Standards and Technology (NIST). We recommend that your instrument be calibrated on a twelve-month cycle.

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of this manual before installing or operating this equipment.

WARNING

IF THIS EQUIPMENT IS NOT INSTALLED AND/OR USED IN A MANNER SPECIFIED BY THE MANUFACTURER, THE PROTECTION PROVIDED BY THE EQUIPMENT MAY BE IMPAIRED

1 Introduction

1.1 Manuals

This manual covers all aspects of the STS Instrument models 1656 and 1657 Battery Element Testers. This includes setup, programming, use, specifications, and principle of operation, maintenance and calibration. An Operator Manual (P/N 201749) is supplied with the instrument as well which only contains information on actual use of the tester. This Operator manual contains only sections of the Owners' manual that are relevant to the operator. This Owner's Manual should not be given to operators of the unit.

The 1657 model is identical in function and specifications to the rack mountable model 1656 but has a narrower and taller chassis similar to the discontinued Model 1652. It is offered in selected markets where space is not available for the wider but lower 1656 rack mountable unit.

1.2 Background

For over 30 years, the STS Instruments Battery Element Testers have been the de-facto benchmark for Battery Cell quality testing. The new 1656 and 1657 models build on this legacy of reliable, high volume testing using a state-of-the-art digital design made possible by advanced microcontrollers (MCUs) and high resolution, fast Analog to Digital conversion (ADC) of voltage and current test signals. This advanced and modern digital design is complemented by a convenient operator interface using a large LED backlight, color graphic LCD screen that displays settings that results in large, easy to read operator information.

The Model 1656 and 1657 Digital Battery Element Testers are designed to test the dielectric strength of separators in lead-acid battery cells. The high level of digital processing used in the 1656 design provides enhanced resolution of defective separators with reduced false rejects due to moisture in damp process plates.

Test voltage is adjustable to 3000 volts peak and is measured and indicated on the large color LCD. The Model 1656 and 1657 testers produce high voltage, high-current pulses of very short time duration. These pulses repeat at a programmable rate. Duration of each pulse is approximately 120 microseconds. Although the instantaneous energy in each pulse is high, the short duration of the pulses results in a low average energy level. Therefore, the high voltage stress required to obtain a good test is produced without the problem of producing excessive heat within the test object as is the case for other test methods.

The high speed digitizing metering circuits of the 1656 monitor the loading of the tester by the unit under test. This measurement is indicated in quantitative units, on a scale of 0 to 750 (with Sensitivity set to one. For higher sensitivity settings, scale is multiplied by sensitivity setting value).

The Model 1656 and 1657 Battery Element Testers (BET) are equipped with a Modular Line Cord Assembly and a universal AC input supply that allows the tester to operate on a nominal 90Vac through 264Vac input at 50 or 60 Hz.

Standard USB and optional RS232 or RS485 control interfaces and a Programmable Logic Controller interface are available on the rear panel to facility factory automation and data collection for quality control purposes.

2 Technical Specifications

This section includes performance specifications for the 1656/1657 Battery Element Testers. All specifications are valid over the stated temperature. Calibration is performed at 23°C ± 5°.

2.1 Output

Parameter	Specification	Notes
Channels	1	
Test Voltage		
Range	300 – 3000 V peak	
Resolution	10 V	
Accuracy	±2.0% F.S.	
Shape	Pulse	
Duration	120 µsec (typical)	
Test Interval	Programmable from 30[1] to 5000 msec	
High Voltage Connections		
Front Panel Sockets	Amphenol / Alden	
Rear Panel Sockets	Amphenol / Alden	-RPC Option

2.2 Measurements

Parameter	Specification	Notes
Channels	1	
Voltage Measurement		
Range	0 – 3000 Vpk	
Resolution	1 V	
Accuracy	± 2.0% F.S.	
Quality Measurement		
Range	10 - 3750	
Resolution	1	
Accuracy	± 2.0% F.S.	

2.3 AC Input

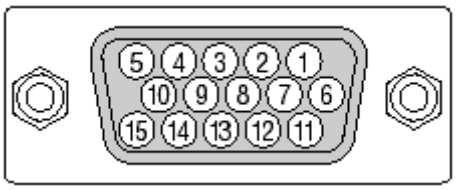
Parameter	Specification	Notes
AC Input Voltage		
Type	Universal Input	
Range	100Vac – 240Vac ±10%	RMS
Frequency	47 – 63 Hz	
AC Input Current		
Max.	500 mA	
Input Power Factor		
Typical	0.98	

[1] Note: For 1656/1657 hardware rev. AB or older, Test Voltage Setting 300V-1790V Tmin = 30 msec, Test Voltage Setting 1800-2190V Tmin = 65 msec, Test Voltage Setting 2200V-3000V, Tmin = 500 msec. For 1656/1657 hardware rev. AC and higher, Test Voltage Setting 300V-2490V Tmin = 30 msec, Test Voltage Setting 2200V-3000V, Tmin = 65 msec.

Parameter	Specification	Notes
Input Fuse		
Type	250V, 0.5A, Slow Blow	
Dimension	5 x 20 mm / 0.20" x 0.80"	
On/Off Switch		
Type	Rocker Type, Front Panel. Press O to turn Off	
Line Cord		
Type	IEC 60329, C13, Detachable	
AC Input Connector		
Type	IEC 60320, C14	

2.4 Remote Interface Options

Parameter	Specification	Notes
USB		
USB Rev.	2.0	
Virtual COM Baud Rate	115200 (Fixed)	
Connector	Device, Type B, Rear Panel, Female	
UBS Connector Pins	Pin 1: +5Vdc Pin 2: TxD Pin 3: RxD Pin4: Signal Gnd	
RS232 (Option –RS232) – NOTE: Mutually exclusive with –RS485 option		
Baud Rate	115200 (Fixed)	
Data Bits	8	
Start Bits	1	
Stop Bits	1	
Connector	D-Sub, 9 pin, Rear Panel, Female	
RS232 Connector Pins	Pin 1: Signal Gnd Pin 2: Vcc Pin 3: TxD Pin4: RxD Pins 5, 6: Con Pins 7, 8, 9: n/c	

Parameter	Specification	Notes
RS485 (Option –RS485) – NOTE: Mutually exclusive with –RS232 option		
Baud Rate	9600 (Fixed)	
Data Bits	8	
Start Bits	1	
Stop Bits	1	
Connector	D-Sub, 9 pin, Rear Panel, Female	
RS485 Connector Pins	Pin 1: Signal Gnd Pin 2: Vcc Pin 3: A+ Pin4: B- Pins 5,6, 7, 8, 9: n/c	
PLC (Option)		
Type	Digital I/O	
Connector	HD DE-Sub, 15 pin, Rear Panel, Female  Pin #'s - View from the back of the unit	
Signals	See next Table	

2.4.1 PLC Connector Pins

Pin	Direction	Signal	Description
1	Relay Output	**FAIL** result	Latches low on FAIL till a new test is started
2	Relay Output	**PASS** result	Latches low on PASS till a new test is started
3	RLY Common	Relay Common	Common for all Relay Outputs
4	Digital Output	Reserved for Auto-line Option	Do not connect
5	Ground	Analog/Digital Signal Ground	Signal Ground for non-Relay Outputs
6	n/c	Reserved	Do not connect
7	Relay Output	Processing	Low when test is running
8	Relay Output	Bell	Low on FAIL, High on PASS
9	Digital Output	Reserved for Auto-line Option	Do not connect
10	Power	DC power supply output	Power out: +5Vdc, 1.5Adc max
11	n/c		Not connected
12	Digital Input	Remote Test	Short to signal ground and release to remotely trigger a test (positive edge triggered)
13	Digital Input	Remote Reset	Short to signal ground and release to remotely stop a test (positive edge triggered)
14	Analog Input	Reserved	Do not connect
15	Digital Output	Reserved for Auto-line Option	Do not connect

Table 2-1: PLC Connector Pin-out

Note: Do NOT use VGA monitor cables to connect to the PLC interface as one or more pins on these cables are shorted to ground. Instead, use a straight-through HD DE15 to HD DE15 cable. Example L-Com model CHD15MF-5 male/female cable or equivalent.

2.4.2 PLC Signal Levels

Output voltage levels and current capability for each output are shown in the table below. Do not exceed these rating or damage to the instrument may occur.

Relay Outputs	Resistive Load	Inductive Load
Rated Load	AC: 125V, 0.5A	AC: 125V, 0.3A
	DC: 30V, 2A	DC: 30V, 1A
Maximum Current	3A	
Contact Voltage Max.	AC: 250V, DC: 220V	
Contact Current Max.	2A	1A
Analog Input		
Analog Level	Input Range = 0.0Vdc to 3.3Vdc	
Digital Outputs		
Voltage Level	low = 0Vdc, high = 5Vdc	
Current Max.	6 mA	
Power Supply Output		
Pin 10: Voltage	5 Vdc	
Pin 10: Current Max	1.5 Adc	
Pin 5	Return Power / Ground	

Table 2-2: PLC Option Signals - Maximum Ratings

2.5 System Functions

Parameter	Specification	Notes
Display		
Type	High Contrast Graphical Color TFT LCD	
Size	4.2" diagonal	
Resolution	480 x 272 (HVGA)	
Backlight	White LED	
Shuttle		
Type	Rotary Digital Encoder	
Keypad		
Type	Momentary Push Buttons	
Reset Button	Illuminated Push Button, Green	
Check Button	Illuminated Push Button, Red	

2.6 Environmental

Parameter	Specification	Notes
Temperature		
Operating	32 to 104° F/ 0 to 40°C	
Storage	-2 to 158° F / -20 to 70° C	
Cooling	Convection	
Humidity		

Parameter	Specification	Notes
Operating	5% to 95% non-condensing	
Altitude		
Operating	6000 ft. / 2000 meters	

2.7 Mechanical

2.7.1 Rack Mount Model 1656

Figure 2-1: 1656 Front Panel

Figure 2-2: 1656 Rear Panel (shown with PLC and optional RS232 interface)

Parameter	Specification	Notes
Dimensions		
Width	19" / 483 mm 16.7" / 425 mm	Incl. rack ears No rack ears.
Height	3.5" / 89 mm (2U)	Excluding rubber feet.
Depth	9.9" / 252 mm	Excluding terminals
Shipping		
Width	21.7" / 550 mm	
Height	8.8" / 224 mm	
Depth	16.3" / 415 mm	
Rack Mount		
Method	Removable Handles with Rack Ears	
Weight		
Net	15.4 lbs. / 7 Kg	
Shipping	20 lbs. / 9 Kg	

2.7.2 Bench Model 1657

Figure 2-3: 1657-Front Panel

Figure 2-4: 1657- Front Panel – Shown with –PLC, RS232 and –RPC options

Parameter	Specification	Notes
Dimensions		
Width	13.4" / 340 mm	
Height	5.5" / 140 mm	Excluding rubber feet
Depth	13.2" / 336 mm	Excluding terminals
Shipping		
Width	18.5" / 470 mm	
Height	10.8" / 275 mm	
Depth	19.6" / 497 mm	
Weight		
Net	14.8 lbs. / 6.7 Kg	
Shipping	18 lbs. / 8.2 Kg	

2.8 Regulatory Compliance

Parameter	Specification	Notes
CE Mark		
EMC	IEC61326-1:2013	
Safety	IEC61010-1:2010	

2.9 Available Options

The following options may be specified at the time of order.

Part Number	Description	Notes
-PLC	Programmable Logic Controller Interface, Analog/Digital I/O and Relay Functions	HD15 Connector
-RS232	RS232 Serial Interface Remote Control	DB9 Connector
-RS485	RS485 Multi-drop Serial Interface Remote Control	DB9 Connector
-RPC	Rear Panel High Voltage Probe Connections	HV Connectors
TT1652	The -TT1652 Test Input Trigger Mode changes the mode of operation of the Test Trigger input on the 1656-PLC and 1657-PLC battery element testers to operate like the previous generation 1652 models.	Requires PLC Interface

2.10 Available Accessories

Part Number	Description	Notes
Probes		
102-050-919	Set of Safety Retracting Probe, Red & Black w/ 6 ft. leads	
200025	Safety Retracting Probe, Red w/ 6 ft. lead	
200386	Safety Retracting Probe, Red w/ 10 ft. lead	
200026	Safety Retracting Probe, Black w/ 6 ft. lead	
200387	Safety Retracting Probe, Black w/ 10 ft. lead	
Adapters		
Type 070	Battery Element Tester Adapter Module Type 070 for use with Models 1656 or 1657 Battery Element Tester. P/N 995-0017-907B	

3 Installation and Safety

This chapter describes required installation provisions and precautions necessary to deploy this equipment effectively and above all safely. Please ensure anyone that will be assigned to operate this equipment is fully qualified and trained to operate this equipment in a safe manner.

WARNING

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3.1 Unpacking and Ship Kit

Before removing the 1656 or 1657 from its container, carefully inspect the shipping carton for any signs of damage or signs of dropping during transit. If no damage is evident, carefully remove the 1656 or 1657, documentation and accessories from the shipping carton. Check the 1656 main unit for any visible sign of damage before proceeding with any installation.

If damage is evident, keep the original carton and file an insurance claim with the carrier.

Check all content of the 1656 or 1657 shipping carton to make sure you have received all items that make up the 1656 or 1657 product. The table below lists the included items.

Part Number	Description	Notes
Unit		
Model: 1656 P/N: 201178-AA	Battery Element Tester, Main Unit	
OR		
Model: 1656-PLC P/N: 201734-AA	Battery Element Tester, Main Unit, with PLC I/F	
OR		
Model: 1657 P/N: 201678-AB	Battery Element Tester Bench, Main Unit	
AC Line Cord		
	AC Line Cord	

Part Number	Description	Notes
Probes		
200025	Safety Retracting Probe, Red w/ 6 ft. lead	
200026	Safety Retracting Probe, Black w/ 6 ft. lead	
Documentation		
201749	1656 & 1657 Owners' Manual	
201353	1656 & 1657 Operator Manual	
	Certificate of Conformance	
	Calibration Certificate	

3.1 Operator Training

One of the more important ways to promote safety is through operator training. Benefits of training are twofold. First, thorough training promotes safety, which may significantly reduce injuries on the job. Second, it ensures adequate testing of the product which helps increase product reliability.

Generally, commercial high voltage test equipment in itself is not hazardous. The hazards come about when the equipment is improperly used. These testers, when used properly and in a safe manner, can greatly contribute to the quality and reliability of your product. If used incorrectly and without proper consideration for safety, they represent a hazard for both operating personnel and casual bystanders. We strongly recommend proper training for all personnel involved in testing.

3.2 Ergonomics

An additional consideration in any test station is operator comfort. This is affected by the operator's position, which includes the chair, table, test equipment, the object under test and the test procedure itself. The chair and work bench or table should be **non-conductive** and the table or work surface as large as possible to allow sufficient room for the test equipment and the object under test. Studies should be made of the test requirements and work habits and steps taken to ensure that any unusual or unnatural motion is not required and to eliminate any repetitive motions that may produce injuries over time such as carpel tunnel syndrome.

3.3 Important Safety Precautions

CAUTION

ALWAYS FOLLOW RECOMMENDED SAFETY PRACTIVES WHEN OPERATING THIS EQUIPMENT

After the equipment has been installed, a careful study should be made of the test station to determine what, if any, safeguards are needed. It is suggested that any electrical test station involving voltages in excess of 42.4 volts peak (approximately 30 volts RMS) should be equipped with safeguards. These should operate both for the protection of the operating personnel and for the protection of casual bystanders. At the minimum, safeguards should prevent the operating personnel or casual bystanders from coming into contact with the test circuit. In the event electrical interlocks of any sort are required, either to insure that guards are in place, or to insure that the operator's hands are in a safe location, we will be happy to provide suggestions and schematics for safety interlocking our test equipment.

The test procedure should be well thought out to ensure that it adequately tests the product to the desired criteria but that the procedure does not require the operator to perform tasks that are unsafe. The product should never be touched during a test.

Good safety practice dictates labeling of hazards properly. Since high voltage testing can be hazardous, the work station should be labeled. Naturally, the location of the label should be carefully selected so that it can be placed in a location that will do the most good.

In some cases, this may be on the test instrument itself, and in others, it may be in a location directly in front of the operator, somewhat removed from the instrument.

3.4 Initial Setup Procedure

Setup adjustments should be made with no load connected to the test leads. Proceed as follows:

1. Insert the AC line cord into a suitable AC outlet. The 1656 and 1657 have a universal input and will operate from any voltage between 100Vac RMS L-N and 240Vac RMS L-N.
2. Install the supplied test leads on the front panel sockets. The test leads are color coded to match the positive and negative terminals on the 1656 or 1657 front panel.
3. Turn the unit ON using the front panel toggle switch.
4. Adjust voltage setting to desired Peak Volts reading using one of the VOLTn buttons.
5. The Quality readout with no battery cell connected to the test leads should be zero (Q =).
6. To check the unit, set the lower trip level to 10 and the upper trip level to 1000.

7. Battery impedance is complex in nature and composed mainly of capacitive leakage combined with resistive and inductive leakage. Because the open circuit reading on the Quality Meter is 'balanced' to zero (0) against an internal load that is primarily inductive and resistive, we do not assign a scalar value to the Quality meter reading. It is used to indicate a change from this balance condition and to allow you to determine your product's relative impedance.

   To determine your product's relative impedance:

   a. Adjust the test voltage to the desired level, e.g. 1500V.
   b. Adjust the Lower Trip level to 10 and the upper trip level to 1000.
   c. Test 10 to 12 known good battery cells.
   d. Note down the Quality Meter reading of each.

   For example:

   You test 10 known good batteries and record readings of 650, 653, 680, 675, 701, 645, 665, 663, 688, and 660. Since your 'average' reading calculated to 668, you would set your Trip Level limits for production test use to 668 ± 10% or larger 601 for low limit and 735 for high limit. (601 / 735).

   Actual settings can be as "tight" as you like but, you should allow for normal product variation and the effect of humidity on the moisture content of the plates. If you perform your setup under low humidity conditions you would expect the readings to slightly higher during high humidity conditions.

8. Apply the test probes to battery to be tested. The reject visual and audible signals operate if quality meter is outside the trip level setting range. The reject signals cancel automatically when the probes are lifted from the battery.
9. Even on good parts, a slight spark will be noticed when the tester probe is touched to the part under test. This is normal, since charging current flows as a result of the inherent capacity of the part under test.

4 Theory of Operation

This section provides background information on the test methodology used by the 1656/1657 Battery Element Tester.

4.1 Test Pulse Generation

The 1656/1657 generates a short duration, high voltage spike at its output by quickly discharging a charged capacitor that has been pre-charged. This capacitor is charged to the set test voltage level using a half wave rectified DC supply operating from a high voltage step-up transformer. The digital controller sets the primary voltage level of this transformer using a DAC based on the user's programmed set point. This provides an accurate and repeatable test voltage waveform at the output of the 1656/1657test leads.

The discharge capacitors are charged on the negative half cycles of the AC line input. On the alternate half cycles, a Silicon Controller Rectifier (SCR) is triggered by the digital controller so that the capacitor is discharged into the load while the main charging circuit is in a non-conducting condition. The digital measurement system uses precision Analog to Digital converters (ADC's) to digitize the resulting output voltage waveform. This data is processed by the microcontroller (MCU) to verify the applied test voltage is correct.

An internal bleed load-switching coil is connected across the output terminals of the unit to produce a fixed load condition while the unit is operating under standby (no load) conditions.

4.2 Back EMF Measurement

Under normal conditions, discharge of the capacitors into the internal coil creates a strong magnetic field in the core of this inductor load. When the forward pulse dies off, this magnetic field collapses producing a back Electro Magnetic Force (EMF) which is captured by the digital controller's measurement read back circuits. An average peak voltage read back value is obtained over a number of successively applied test pulses.

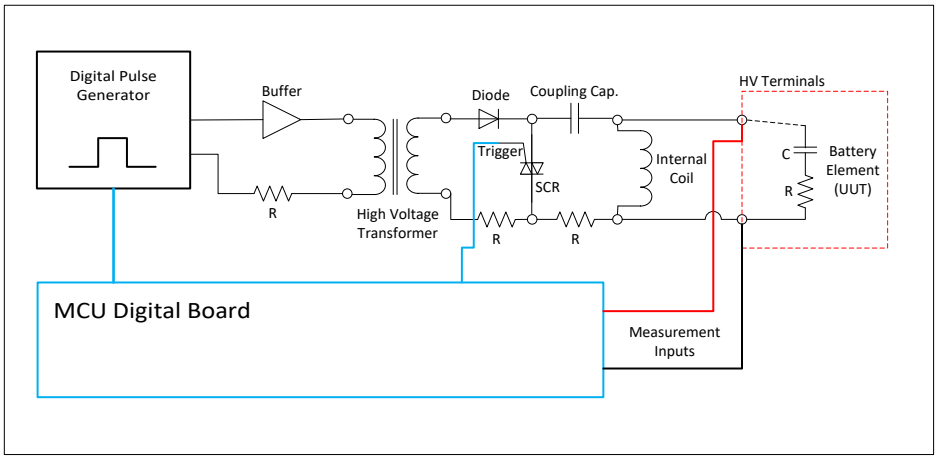


Figure 4-1: Equivalent Battery Element Tester Schematic

Any external load, such as a battery cell under test, is effectively in shunt with the internal bleed load coil (as shown in Figure 4-1) and therefore, will reduce the back EMF signal, resulting in a

lower peak voltage reading. The reading will of course, depend on the amount of reduction in back EMF caused by the battery cell being tested. Refer to Figure 4-2 for reference.

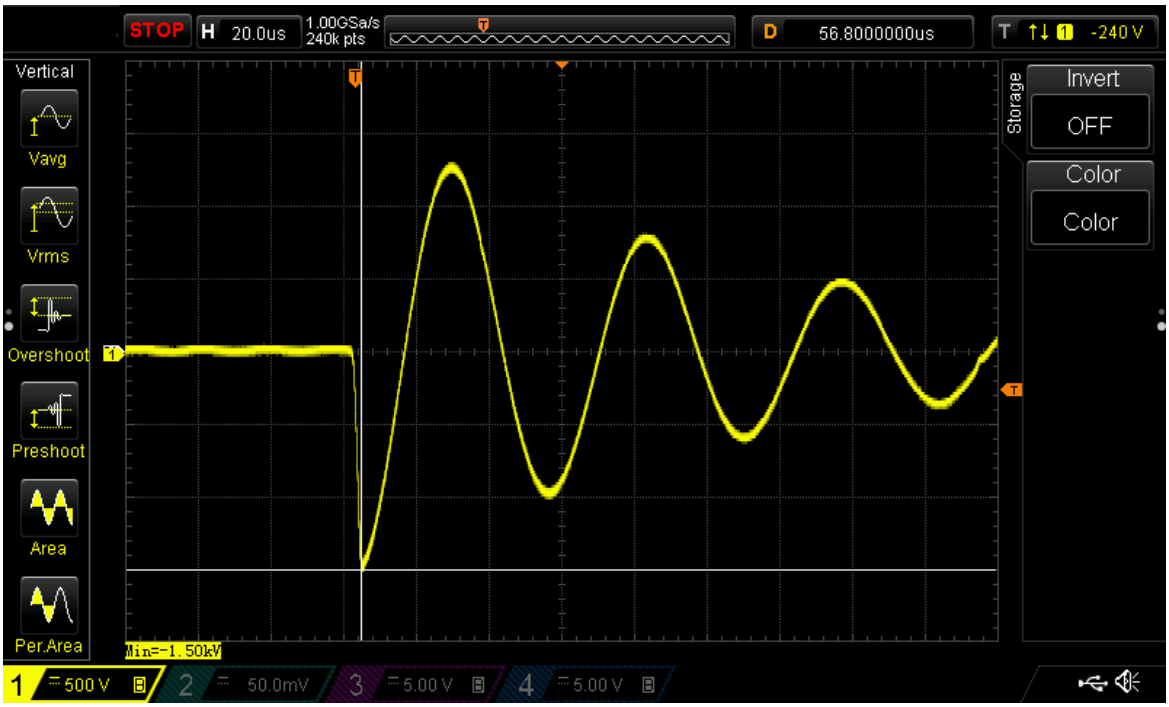


Figure 4-2: Battery Element Test Waveform

4.3 No Load Conditions

To ensure sufficient test voltage levels are available for an actual unit under test, a certain amount of over-voltage is to be expected during idle conditions (no load). It is not recommended that this unit be left set to its maximum voltage output during idle conditions for extended periods of time such as breaks, lunch hour, etc. The high over-voltage levels may damage the internal switching coil or the SCR.

4.4 Model 1651 and 1652 Readings versus 1656 and 1657

Operators familiar with prior generation Battery Element Tester, specifically models 1651 and 1652 should familiarize themselves with the enhanced 1656/1657 measurement results as displayed on the 1656/1657 screen. Unlike the relative Q factor reading obtained from the analog measurement systems used in older BET's, the 1656/1657 is capable of accurately reporting the reflected EMF pulse amplitude resulting from the unit under test connection. This makes it unnecessary to have a balance adjustment and impedance preset switch for 100 Ohm or 250 Ohm expected impedance of the EUT, as was the case on the analog models.

Figure 4-3: Controls no longer required

Rather than a relative "down-scale" negative Q reading as used on older models, the 1656/1657 will display actual absolute peak voltage value information (positive number). Thus, values displayed on older BET models and the 1656/1657 are **not directly comparable**. Instead, new upper and lower limit acceptance test levels should be established empirically for any given type battery cell to be tested.

5 Operation

Figure 5-1: 1656 Front Panel View

This chapter describes the various front panel controls, menu's, settings and readouts that are used to interface with the operator. It is strongly recommended that the user familiarizes him / her with the contents of this chapter before attempting to operate this equipment. Front panel operation of the 1656 and 1657 models is identical so only the 1656 is used in this section. The 1657 use the same controls and menus.

5.1 Controls, Indicators and Connectors

Functions of the various controls and indicators found on the front panel of the 1656 Battery Element Tester are explained in the table below. Figure 5-2 shows call-outs to the various controls and indicators to help familiarize the operator with the front panel layout.

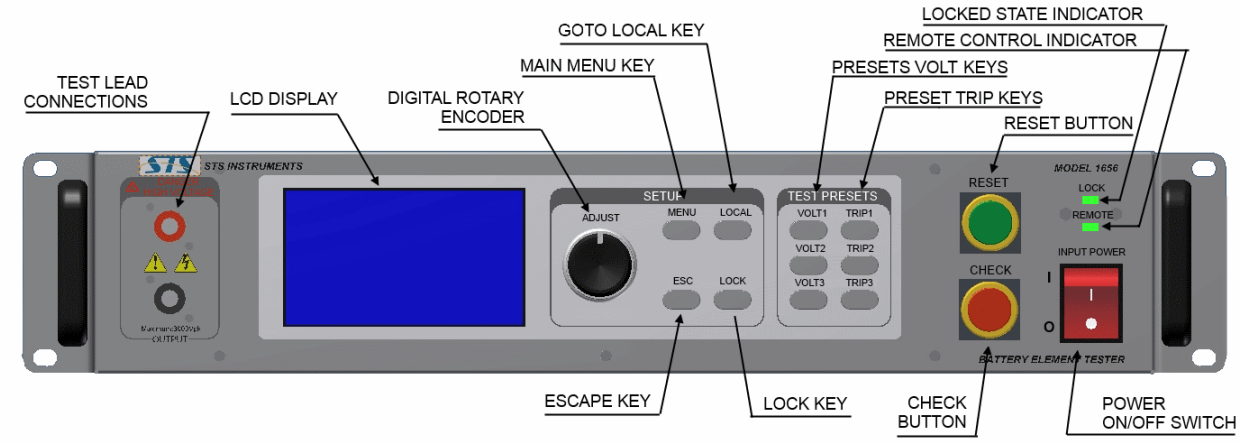


Figure 5-2: Control and Indicator Locations

Controls	Description
POWER ON/OFF SWITCH	The Power On/Off rocker switch is used to turn the instrument on or off. Press the switch bottom (O symbol) to turn the unit OFF. Press the switch top half (I symbol) to turn the unit ON.

Controls	Description
ADJUST	The rotary knob in the center of the front panel is used to adjust settings and values as displayed on the LCD screen whenever the selected field is in EDIT mode. EDIT mode is indicated by a blinking field. To Enter/Exit EDIT mode, push in the knob till a click is felt and heard. To adjust a value, turn the knob to the right (increment) or the left (decrement.) When not in EDIT mode, the same knob is used to scroll from field to field in any menu screen. A selected field is indicated by a reversal of the text and background color of the field.
SETUP KEYS	
MENU	The MENU key brings up the MAIN MENU screen. From this screens, all settings can be accessed and changes as needed using the ADJUST knob to scroll through fields. Some fields will bring up nested MENU's below the MAIN MENU.
LOCAL	The LOCAL key may be used to change the state of the instrument from LOCK (no front panel control) to LOCAL. NOTE that this key may be disabled through the remote control interface.
ESC	The ESC (Escape) key exits any menu field and backs up to the previous state of the selected field.
LOCK	The LOCK key may be used to put the instrument in a LOCKed state. In this state, no changes to any settings can be made. To unlock the instruments, a password must be entered. Refer to section 5.10.
TEST PRESET KEYS	
VOLT1, VOLT2, VOLT3	These 3 keys allow for quick setting of the voltage test level for 1000V (VOLT1), 2000V (VOLT2) or 3000V (VOLT3)
TRIP1, TRIP2, TRIP3	These 3 keys allow quick setting of the following trip levels: TRIP1 = 200/250 TRIP2 = 400/500 TRIP3 = 600/750
BUTTON / INDICATORS	
CHECK BUTTON	The red CHECK Button is START a test. The test will be run for the number to counts set or indefinitely is set to "CONT." If this, case the RESET button must be used to terminate a test. During a test, the CHECK button will blink ON at the programmed test interval rate. The green RESET light will be OFF during a test.
RESET BUTTON	The green RESET Button may be used to stop a test in progress. When the green light is ON, the red CHECK light will be off. When a battery cell fails the test, the red CHECK light will blink at a lower rate and the alarm will be ON. Once the operator removes the probes from the defective cell, the alarm will turn off.

Indicators	Description
LCD DISPLAY	This is the main display area of the instruments. All settings and readings are displayed on the main LCD screen uses a variety of menus and measurement/test screens.
REJECT INDICATOR	The 1656 has two Reject Indications; an Audible Tone and a 15-pin HD D-sub PLC interface connector on the rear panel which provides a Dry Contact Closure when a reject occurs.
CHECK BUTTON	See Controls Table
LOCK LED	Indicates instrument is in LOCKED state (Controls are Locked out). A password entry is required to unlock the front panel. Refer to section 5.10, "Password Information" for details.
REMOTE LED	Indicate instruments in being controlled remotely over one of its digital control interfaces.

Connectors	Description
HIGH VOLTAGE CONNECTORS	Two (2) High Voltage connectors are provided on the front panel. Polarity should be observed when connecting the leads. The black socket is referenced to ground.
OUTPUT HIGH	Test Lead High Voltage Mating Connector, RED
OUTPUT LOW	Test Lead High Voltage Mating Connector, BLACK
-RPC Option	The –RPC option adds rear panel High Voltage connectors to the 1656 unit.

5.2 Rear Panel Connectors

The available connectors located on the rear panel of the 1656 Battery Element Tester are shown in the Figure below.

Figure 5-3: Rear Panel Connector Locations (shown with PLC Interface and -RS232 option)

5.3 Menu Operation Information

Setting changes are made by navigating through a series of on screen menus and data screens. Each menu may have one or more fields containing the set values of parameters such as test voltage, trip level, Interface selection, LCD contrast settings etc. Some sub menus are used to drill down into specific setups that may need more parameters than what is shown on at the top level menu.

MENU SCREEN: A menu screen consists of a simple list of choices that can be selected by turning the shuttle to the right (scroll down) or to the left (scroll up). Once you reach the end of a list, the selection bar wraps around to the top or bottom as illustrated in the screen below.

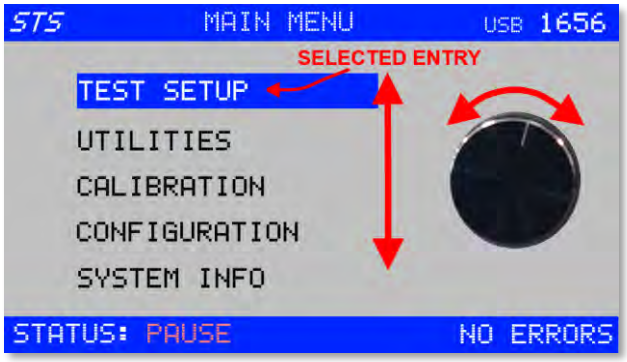


Figure 5-4: Navigating through a Menu Screen

TEST RESULT SCREEN: A data display screen is used to provide feedback to the operator on test results for the unit under test. This screen also contains reference information of test settings and a pass or fail indication.

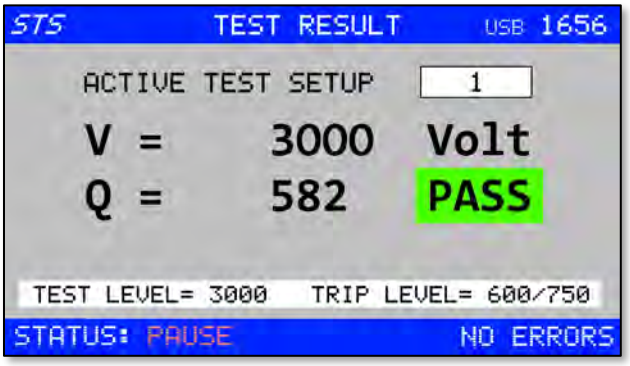


Figure 5-5: Test Result Screen Example

5.3.1 Menu Hierarchy

The Menu tree shows the hierarchy of the available menus and display screens. Use it to familiarize yourself with the various menu entries and setting options.

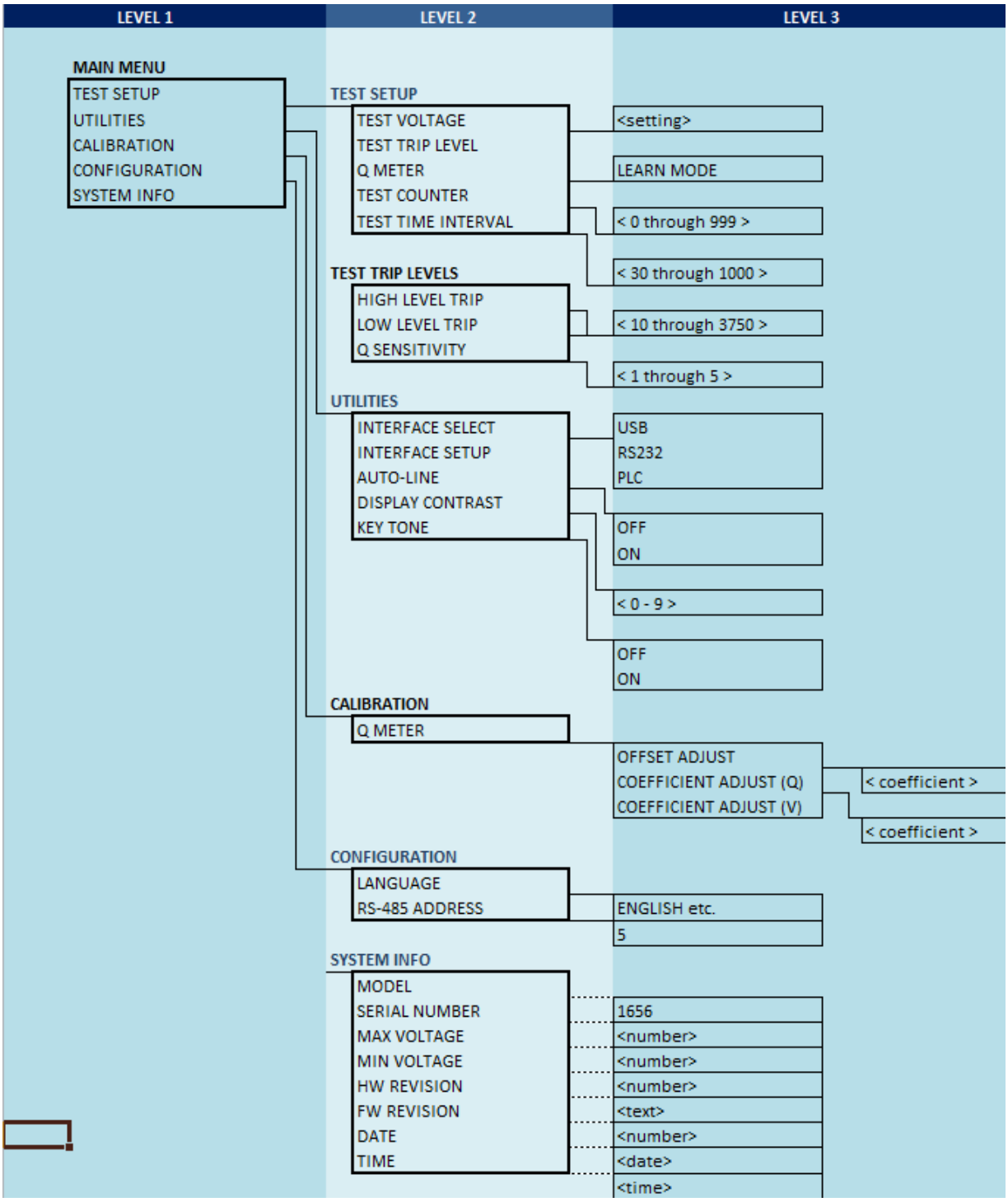


Figure 5-6: Menu Structure Tree

To back up to previous MENU level, press the **ESC** key.

5.3.2 Test Result Data Display

This is the default screen that comes up after power on once the initialization of the tester has been completed. The STS Instruments logo will disappear and the normal test data display window will be shown.

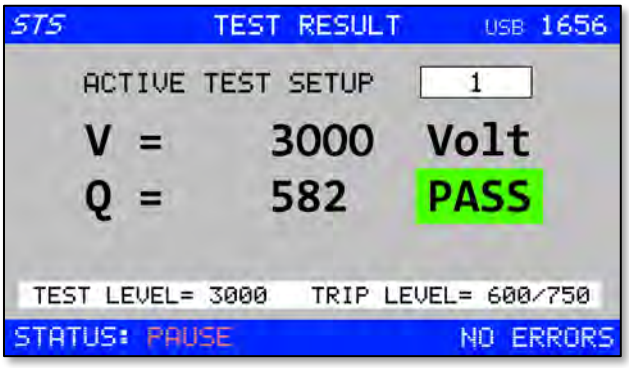


Figure 5-7: Test Results Screen

Note that there are 9 possible setups (1 through 9) that are stored in non-volatile memory. The first three of these setups (1 through 3) are directly available using the VOLT n and TRIP n front panel keys.

Figure 5-8: TEST PRESET keys for Test Setups 1 through 3

This screen also allows selection of the ACTIVE SETUP. The number of the Test Setup to use is shown in the parameter field in the top right corner. In this example, Test Setup number 4 is selected. The Shuttle can be used to scroll through available setup numbers 1 through 9. Push the Shuttle (ENTER) to make your selection.

5.3.3 EDIT Mode

Parameters and data value can be changed by using the EDIT MODE. To enter EDIT MODE, make sure the selector bar (BLUE Highlight) is position on a parameter field (White Background).

Press the Shuttle to enter into EDIT MODE. This mode is indicated by a blinking cursor block to the right of the selected parameter.

While in EDIT MODE, the selected parameter value can be incremented or decremented using the Shuttle. To accept the new value and exit EDIT MODE, press the Shuttle again (ENTER).

5.3.4 Menu Field Types

Several types of fields can be contained in a single menu screen. Not all fields are of the same type. Depending on the nature of the field, some fields are editable, other are not.

The non-editable fields are either used to display information only or to show an available menu entry for a lower level menu (sub-menu).

The following field types exist:

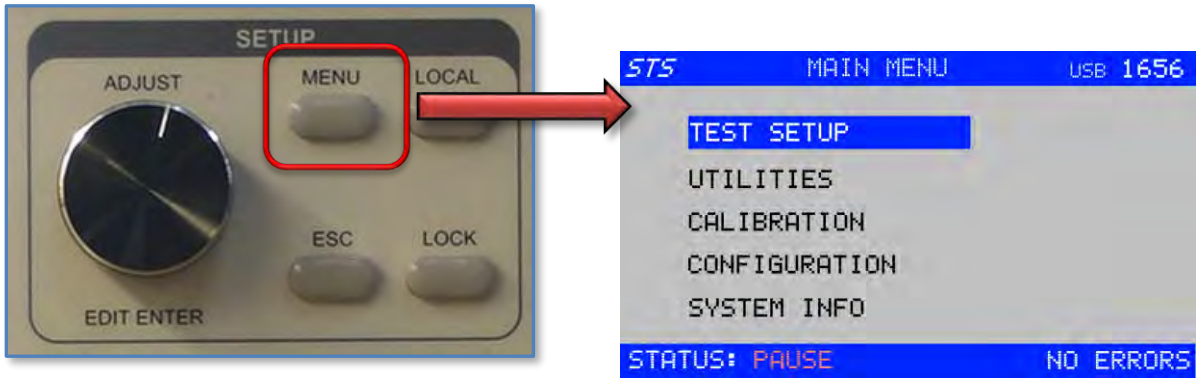
FIELD TYPE	EDITABLE	DESCRIPTION
Menu	No	Allows selection of a sub-menu by pushing in the Shuttle knob (ENTER) while the Menu item is selected (BLUE SELECTION BAR).
Display	No	Displays a value or condition. This if for information to the user only. Display fields cannot be selected using the SELECTION BAR nor can they be edited/changed by the user.
Action	No	Performs the indicated action when the Shuttle is pressed.
Parameter	Yes	Display current setting of indicated parameter and allows value to be changed using EDIT mode. Parameter fields allow a numeric value to be set by scrolling the shuttle while in EDIT mode.
List	Yes	Display current setting of indicated parameter and allows value to be changed using EDIT mode. . List fields allow a non-numeric value to be set by scrolling the shuttle while in EDIT mode. Examples of non-numeric values are "ON", "OFF", "USB" etc.

Table 5-1: Available Menu Field Types

5.4 Main Menu

The main menu is at the top of the menu tree. From here, all other lower level menus can be accessed by scrolling the selection bar to one of the available entries using the shuttle and pressing on it (ENTER) key.

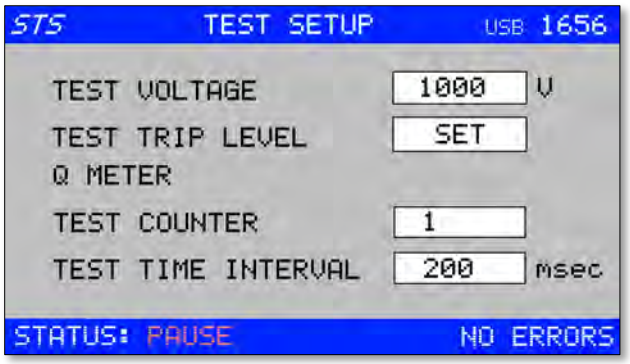
To display the main menu, press the **MENU** button on the front panel. All lower level menus are accessed through on screen selection of a menu entry item using the Shuttle.



MAIN MENU		
Entry	Type	Description
TEST SETUP	Menu	Selects the main Test Setup Screen.
UTILITIES	Menu	Selects the Utilities menu. In this menu you will find LCD contrast control and Buzzer settings.
CALIBRATION	Menu	Selects the Calibration Menu. This menu is only needed if you have to perform a routine calibration of the Battery Element Tester.
CONFIGURATION	Menu	Sets Language selection and RS-485 address
SYSTEM INFO	Menu	Selects an information screen showing, model, serial number, hardware and software revision and the Real Time Clock settings. The only user changeable information in the SYSTEM INFO screen is the date and time for the real-time clock. All other data is for information purposes only.

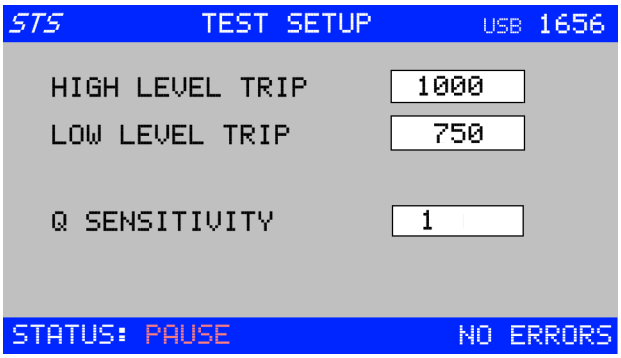
5.5 Test Setup Menu

The Test Setup menu is used to program the 9 pre-stored test level and trip level settings for the tester. This allows up to nine battery types or models to be preprogrammed for immediate recall.



The screen shown above displays settings for setup number 1. To select a different setup number, press the ESC key to return to the Test Result screen and change the active test setup selection to the desired number.

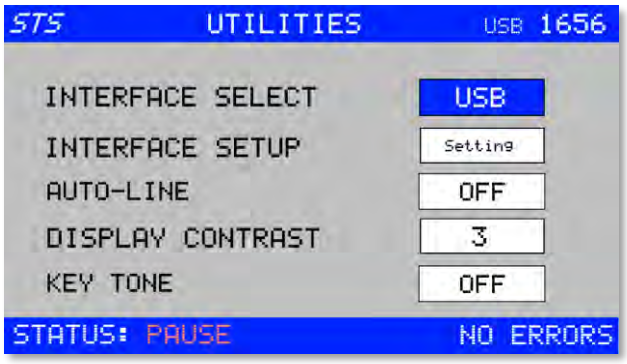
TEST SETUP <n> MENU		
Entry	**Type**	**Description**
TEST VOLTAGE	Parameter	Sets the test voltage level for the selected test setup. For most battery types, a test voltage between 1500 V and 2000 V should be sufficient. Setting the test voltage too low may not allow possible defects to be found. Setting it too high could result in damage to the unit under test. To change the voltage level, mode the selector bar to the Voltage field and press the Shuttle to enter the EDIT mode. The Edit mode is indicated by a flashing cursor in the selected parameter box. Once in edit mode, turn the shuttle left or right to decrement or increment the test level. Once the desired level is displayed, press the Shuttle again (ENTER) to accept the new value. This accepts the new value and exits out of the EDIT mode. The selector bar can now be move to the next parameter field or menu entry using the Shuttle.

TEST SETUP <n> MENU		
Entry	**Type**	**Description**
TEST TRIP LEVEL	**UPPER** **LOWER**	 Sets the pass/fail upper and lower trip levels. The appropriate trip level varies by battery separator type and construction. It may require testing on several batteries to come up with suitable upper and lower trip levels. This process of empirically establishing the trip level for a specific make/model battery can be accomplished using the LEARN MODE. (See next) Note that the TRIP1, TRIP2 and TRIP3 buttons can be used to quickly set both levels at once. They can then be adjusted up or down using the shuttle.
	Q SENSITIVITY	The Q sensitivity setting combines up to five Q readings and compares them against the same multiple of the pass/fail limit values. Changes the Q sensitivity value automatically adjust the trip level settings.
Q METER	List	Opens the learn mode screen which allows the user to test multiple batteries by running repeated tests on a given battery while observing the Q read back value. This procedure may be required to determine the optimal pass/fail limits for a specific battery type.
TEST COUNTER	List	Number of times the test voltage is applied and a reading is taken. For continuous test mode until stopped by the operator, set to zero. The rate at which tests are applied to the unit under test in this mode is determined by the TEST TIME INTERVAL setting. (See next).

TEST SETUP <n> MENU		
Entry	**Type**	**Description**
TEST TIME INTERVAL	Parameter	This setting determines the time between repeated applications of the test voltage to the unit under test. Minimum test interval programmable is a function of the 1656/1657 hardware revision and test voltage set per the table below. Hardware revisions AB and lower: Test Voltage Range — Min. Test Time Interval 300 V – 1790 V — 30 msec 1800 V – 2190 V — 65 msec 2200 V – 3000 V — 500 msec Hardware revisions AC or higher: Test Voltage Range — Min. Test Time Interval 300 V – 2490 V — 30 msec 2500 V – 3000 V — 65 msec Maximum test interval is 5000 msec for all revisions.

5.6 Utilities Menu

The Utilities menu combines several system level controls and parameters into a single menu. It typically is used infrequently only to set general operating functions and settings like the selected remote control interface (if any), the contrast level of the LCD display and the Buzzer function.

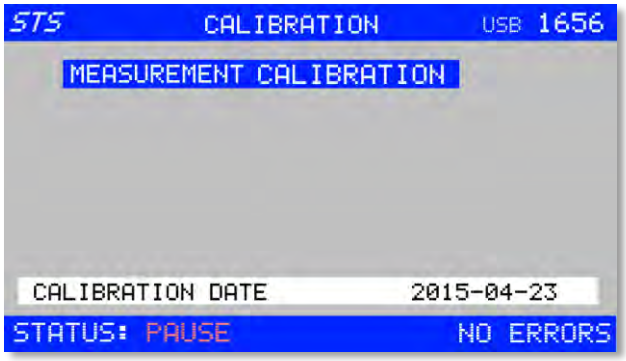


UTILITIES MENU		
Entry	Type	Description
INTERFACE SELECT	List	Selects between available digital remote control interfaces. The Model 1656/1657 offers interfaces such as USB, RS232, RS485 or PLC. Interface parameters such as baud rate are fixed for USB, RS232 and RS485. The RS485 address can be set from the settings menu. If no Interface is installed, "---" will be displayed to indicate that no interfaces are available.
INTERFACE SETUP	Label only	Use the CONGIFURATION menu to set the RS485 address
AUTO-LINE	Boolean	If the AUTO-LINE option is connected, this setting is used to enable (ON) or disable it (OFF)
DISPLAY CONTRAST	Parameter	Sets the LCD contrast and viewing angle for best visibility. This setting ranges from 1 through 9. Depending on ambient lighting and operator viewing angle, adjust this parameter using the EDIT MODE for optimal viewing.
KEY TONE	Boolean	The Audible key tone can be disabled (OFF) or enabled (ON). Use the EDIT MODE to toggle through the various Buzzer options.

5.7 Calibration Menu

The Calibration menu is used to access the Q measurement calibration coefficient data. Calibration coefficients are stored in non-volatile FLASH memory. Note that output test voltage calibration requires a special automated calibration software program that calculates and stores the required output calibration coefficients in FLASH based on an external reference measurement. It is not recommended that the end-user performs this test voltage calibration.

See Section 11 – "Calibration" for more details.



CALIBRATION MENU		
Entry	Type	Description
MEASUREMENT CALIBRATION	Menu	Enters Quality Measurement calibration mode. A 4 digit key code will have to be entered to enter calibration mode. This prevents unauthorized calibration access.
CALIBRATION DATE	Display	This field is not user accessible or editable and only serves to display the last calibration date. It is set to the current date and time when ever calibration coefficients are saved. **Note:** Approximately 11 months after the last calibration date, a reminded message will appear on screen at power-on reminding the operator the unit is coming up on its calibration interval. This reminder can be disabled if desired.

5.7.1 Q Meter Calibration Menu

The Q Meter Calibration menu is used to adjust the Q read back measurement value. There are two coefficients for this purpose:

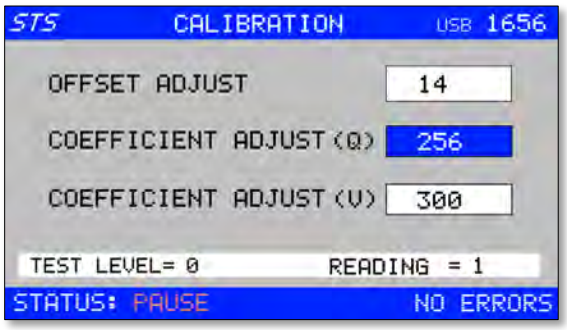
- Offset adjustment performed with no test voltage output
- Full scale adjustment, performed at a specific test voltage

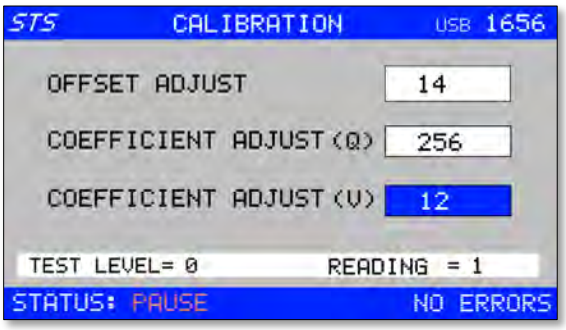
Offset Adjustment

The offset calibration is used to zero out any DC offset from the measurement circuits of the battery element tester.

Full Scale Adjustment

The full scale adjustment allows the Q reading at the programmed test voltage to be adjusted to a known good EUT reading. This known good value should be determined using a sample of good EUT's as a reference.



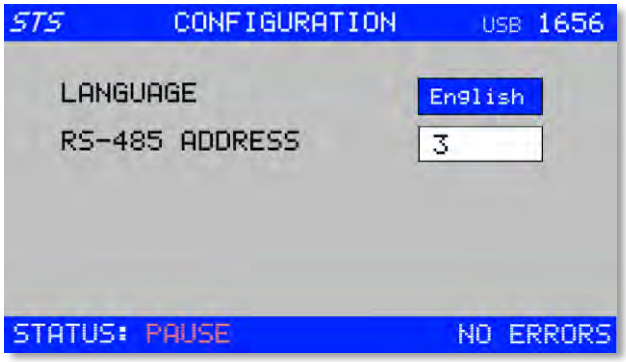


Q METER CAL MENU		
Entry	Type	Description
OFFSET ADJUST	Parameter	With no load connected to the BET, adjust this coefficient in EDIT Mode using the shuttle until the Q readout in the lower right corner of the screen reads zero.
COEFFICIENT ADJUST (Q)	Parameter	With a known load connected to the instrument, adjust this coefficient in EDIT Mode using the shuttle until the Q readout in the lower right corner of the screen reads the desired target value.
COEFFICIENT ADJUST (V)	Parameter	With **NO** load connected to the instrument, adjust this coefficient in EDIT Mode using the shuttle until the Voltage readout in the lower right corner of the screen reads the desired target value. Repeat this for 1000V, 2000V and 3000V settings. You can use the VOLT1, VOLT2, VOLT3.

5.8 Configuration Menu

The CONFIGURATION menu is used to configure certain capabilities and features of the tester. At this time, this consists of two items:

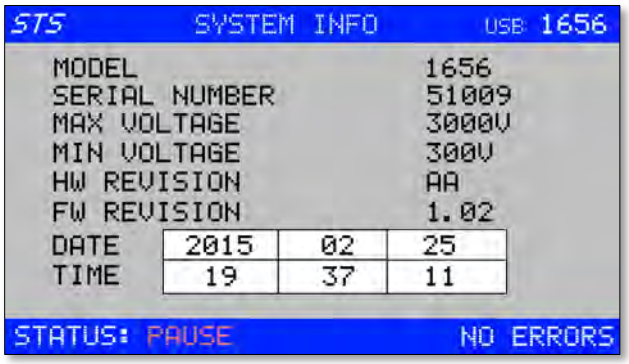
- LANGUAGE selection
- RS-485 Interface Address



Q METER CAL MENU		
Entry	Type	Description
LANGUAGE	List	Available language selections are: *English, Chinese(simplified), Chinese(traditional), Thai, Vietnamese, Indonesian, Japanese, Korean*
RS-485 ADDRESS	Integer	Allows setting of the RS-485 address. Option -485 has to be installed for this field to be active.

5.9 System Info

The System Info screen is a primarily a display screen. It contains basic information about the instrument. The only editable fields are those used to set the Real-time Clock. The date and time are saved in battery backed memory and may have to be set to the correct date and local time. This is possible using the EDIT mode.



Q METER CAL MENU		
Entry	Type	Description
MODEL	Display	Displays the BET Model Number
SERIAL NUMBER	Display	Displays the serial number. This number should match the serial number on the type tag. If not, contact STS Instruments customer service.
MAX VOLTAGE	Display	Displays the maximum supported test voltage.
MIN VOLTAGE	Display	Displays the minimum supported test voltage.
HW REVISION	Display	Displays the hardware build revision.
FW REVISION	Display	Displays the installed firmware revision. For firmware update information, visit the STS Instruments website at www.stsinstruments.com.
DATE	Parameter	Displays the current date as YYYY – MM – DD. This date may be change by selecting any of the date fields and using the Shuttle to enter EDIT mode.
TIME	Parameter	Displays the current time as HH:MM:SS. This time may be change by selecting any of the time fields and using the Shuttle to enter EDIT mode.

5.10 Password Information

To place the instrument in LOCAL mode after the LOCK key has been pushed, the user will be prompted to a password. This four digit password prevents unauthorized access to setups and calibration functions.

Only authorized personal should be given this password information.

The password for a given unit consists of the last four digits of the serial number that can be seen in the System screen. (See previous section).

6 Options

The following options can be ordered with the 1656 or 1657 Battery Element Testers. The operation of these options is covered in this section.

6.1 Remote Test Input Option TT1652

The TT1652 Test Input Trigger Mode changes the mode of operation of the Test Trigger input on the 1656-PLC and 1657-PLC battery element testers to operate like the previous generation 1652 models.

The following features are provided by this option:

- Changes Test Trigger Input on PLC interface from Edge Triggered to Level Triggered
- Test Mode is engaged as long as Test input is low or shorted to digital common

This option allows 1656 and 1657 Battery Element Testers with PLC to interface to battery production lines that were set up for previous generation 1652/070 BET model AC Input and Output Controls.

6.1.1 TEST and RESET Inputs Modes

Without this option, the 1656/1657 uses a TEST input to remotely trigger a programmed test duration and a RESET input to abort if a continuous test duration is programmed.

By adding this option, the remote TEST Trigger input becomes level triggered instead of edge triggered as illustrated in the diagram below. The normal mode of operation using TEST and RESET inputs is shown on the left. The operation with the TT1652 option installed is on the right.

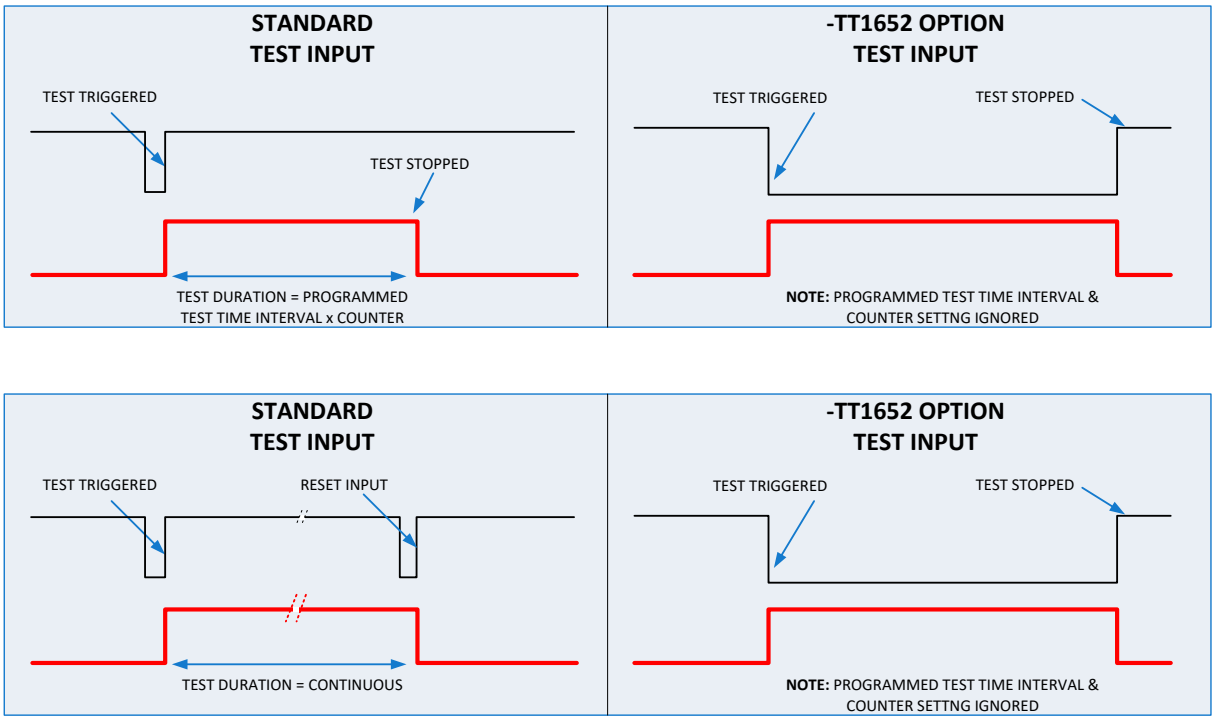


Figure 6-1: Effect of TT1652 Option on Test Input control vs normal remote operation

Note that in 1652 Mode, the test is ended by raising the TEST input high or opening the TEST contacts.

6.1.2 Functional Comparison

The differences between the previous generation Model 1652 and the new 1656/1567 without and with the TT1652 option are shown in the table below.

Test Condition	Model 1652	Standard 1656/1657-PLC	1656/1657-PLC-TT
Start Test	Short Pins 3 & 5 on Test Connector	Momentary Short on PLC pin 12 to Common	Short PLC Pins 12 & 5
Stop Test	Open Pins 3 & 5 on Test Connector	Momentary Short on PLC pin 13 to Common (RESET)	Open PLC Pins 12 & 5
Programmed Test Duration	N/A	Test Duration = Test Interval x Test Counter or Cont.	Test Duration Setting Ignored

Table 6-1: Differences between various BET Models TEST Input operation

6.1.3 Model Configurations with TT1652 Option.

MODEL	DESCRIPTION	PART NUMBER	NOTES
1656-PLC-TT **1657-PLC-TT**	BET with 1652 Test Trigger Level Sense Mode	TT1652	The -PLC interface is required.
			Must be specified at time of order. For field upgrades, contact customer service.
			Included with 070 Adapter Module unless otherwise specified. Refer to Type 070 section for details

Table 6-2: Model Configurations with TT1652 Option

7 Accessories

The following accessories can be used in conjunction with the 1656 or 1657 Battery Element Testers. The operation of these accessories is covered in this section.

7.1 Type 070 Adapter Module

The STS Instruments Type 070 I/O adapter allows the 1656 and 1657 Battery Element Testers to interface with battery production lines that were set up for previous generation 1652/070 BET model Input and Output Controls.

This adapter converts 115Vac control signaling to isolated low level signal input appropriate for the 1656 and 1657.

Using this Adapter module, the following features can be added to the newer STS 1656/1657 model testers:

- Elimination of the modular AC line cord
- Operation on 115Vac input only
- Adds 3/4 inch hole for wire-harness feed-through
- Internal 6 Position Input/Output terminal strip

Figure 7-1: Type 070 Adapter Module

7.1.1 Operation

The 070 Type BET Adapter Module P/N 995-017-907B is designed for use with the standard 1656 and 1657 model Battery Element testers and replaces the Model 1652 BET based adaptor. Note that the Adapter Module provides remote Input / Output control of the BET using AC voltages by interfacing to the 1656/1657 PLC option interface.

Note: **To use this Adapter Module,** the 1656 or 1657 -PLC option and the –TT1652 Option are required on the Battery Element Tester used.

7.1.2 Connections to Model 1656-PLC

The 070 Adapter provides two cables that connect to the 1656 Rear Panel

1. An IEC60320 C13 Modular Female power cord that plugs into the C14 power inlet of the tester.
2. An HD15 PLC cable that connects to the PLC Connector of the 1656

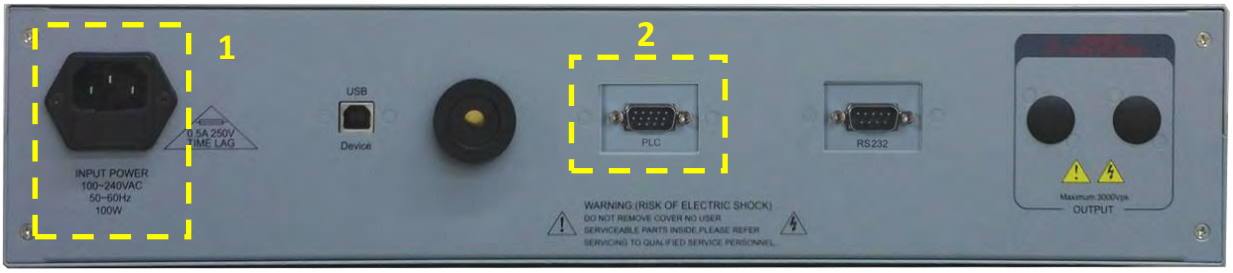


Figure 7-2: 070 Adaptor Connections to Model 1656

7.1.3 Connections to Model 1657-PLC

The 070 Adapter provides two cables that connect to the 1657 Rear Panel

1. An IEC60320 C13 Modular Female power cord that plugs into the C14 power inlet of the tester.

An HD15 PLC cable that connects to the PLC C

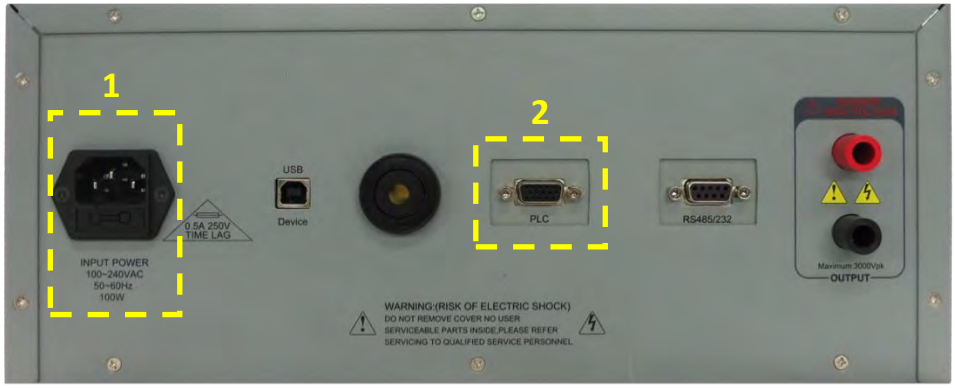


Figure 7-3: 070 Adaptor Connections to Model 1657

7.1.4 Connections to Battery Element Tester

The required interconnects between the Battery Element Tester and the 070 Adaptor box are shown in the image below.

Figure 7-4: Typical Connection of the 995-017-907B Adaptor to the 1656

7.1.5 AC Input Power

AC input power is routed through the adaptor to the 1656/1657 Tester. This is required to provide 115Vac power to both the tester and the adapter. An AC line cord with 115V plug and spade lugs terminations (**not included with the adaptor**) must be used to provide AC power and Ground to the Adapter using the internal terminal block.

WARNING

When used with the '070' Module, ONLY 115Vac input voltage (typical for the US) can be used to power the Battery Element tester. Although the 1656 and 1657 can operate over a wider AC input voltage range, the 070 adapter is rated for 115Vac use ONLY.

7.1.6 Internal 070 Adaptor Connections

To connect AC power, Test Input and Reject Output wires to the 995-017-907B Adaptor module, the top cover must be removed. This can be done by removing the four screws in each cover using a Phillip screwdriver.

WARNING

NEVER operate the 070 Adapter with the top cover removed as potential dangerous 115Vac Voltage is present on energized circuits

The following inputs and outputs are provided on the six position compression terminal strip located on the left hand side of the adapter module.

1	2	3	4	5	6
AC High INPUT (LINE)	**Common (AC low) INPUT (NEUTRAL)**	**Ground (GROUND)**	**Test AC High INPUT**	**Reject AC High OUTPUT**	**No Connection**

Table 7-1: 995-017-907B Adaptor Terminal Block Connections

The following connections must be made to the 070 internal terminal strip:

- **AC Input Voltage:** Nominal 115 volt 50/60 Hz input power is required on Terminal 1 (A.C. High Input) and Terminal 2 (A.C. Low or Common Input).
- **Ground:** Terminal 3 is Ground.
- **Test Input AC:** An application of a nominal 115 volt (A.C. High Input) to Terminal 4 will initiate and maintain the test voltage.
- **Reject Output AC:** A nominal 115 volt (A.C. High Output) Reject Signal will appear at Terminal 5 whenever the tester is indicating a reject.
- No Connection: Terminal 6 is not used.

When all connections have been made, the **top cover must be re-installed**. The adaptor module is now ready for use.

7.1.7 Technical Specifications

PARAMETER	SPECIFICATION
REMOTE I/O CONTROLS	
Test Input	115Vac applied will initiate and maintain test voltage
Reject Output	115VAC Line Derived
AC INPUT	
Input Voltage	115V ± 10 % variation; 47 – 63 Hz
CONNECTION	Terminal Strip, Pin 1 (Line) and Pin 2 (Neutral)
TESTER REQUIREMENTS	
TT1652 Option	The use of this adapter requires the TT1652 Option on the 1656 or 1657 Battery Element Tester. This is a factory configured option. See section 6.1 for details.

Table 7-2: Type 070 Adapter Module Specifications

TERMINAL STRIP POSITION	SIGNAL
PIN 1	AC Line Input (Line)
PIN 2	AC Line Input (Neutral)
PIN 3	Ground
PIN 4	AC Test Input (High)
PIN 5	AC Reject Output (High)
PIN 6	No Connection

Table 7-3: Type 070 Adapter Terminal Strip Positons

8 Remote Programming

This section describes remote control functions of the battery element test over the serial or USB Remote Interface. To select the proper commands for accurate setup and control of the unit, a thorough understanding of the tester's capabilities and operation is required. It is strongly recommended that the user read to become familiar with the STS 1656 & 1657 battery element testers.

8.1 Introduction to SCPI

SCPI stands for "Standard Commands for Programmable Instruments". This industry standard has been widely adopted by manufactures of test equipment since its inception in 1999. The objective of the standard is to create a uniform and easily human-readable command syntax between test instruments and computers that is transferable between instrument types and brands.

The SCPI Standard is built on the foundation of IEEE-488.2, Standard Codes and Formats. It requires conformance to IEEE-488.2, but is pure software standard. SCPI syntax is ASCII text, and therefore can be attached to any computer test language, such as BASIC, C, or C++. It can also be used with Test Application Environments such as LabWindows/CVI, LabVIEW, MATLAB, Microsoft Visual Studio, or Agilent VEE. SCPI is hardware-independent. SCPI strings can be sent over any instrument interface. It works equally well over RS-232 or LAN networks.

The standard was originally created by an industry standards group (SCPI Consortium) and has since been transferred for management to the IVI foundation (www.ivifoundation.org). A copy of the SPCI standard is available from the IVI Foundation but not required to use this manual.

For more details about these underlying IEEE standards, refer to the ANSI/IEEE-488.1 2003 and ANSI/IEEE-488.2 1992 standards. These standards can be purchased at www.ieee.com but are not required to use this manual.

Note that the battery element tester does not offer and GPIB interface but as noted, the SCPI syntax is independent from the physical transport layer.

8.2 SCPI Command Syntax

The following notations are used in this manual to define the SCPI command syntax used:

1. COMMANDS are shown in the left hand column in BOLD, beginning with an asterisk (*) or colon (:) text with NO underline.
2. Command DESCRIPTIONS appear in the right hand column.
3. Some SCPI keywords are optional, and are ignored by the device. Optional keywords are enclosed in square brackets [ ].
4. Lowercase letters of commands shown are also optional.
5. The SCPI standard requires uppercase text in all SCPI commands (start with :), however, the battery element tester is not case sensitive and will accept commands sent in lower case. It is recommended that programming formats follow the SCPI standard.
6. All SCPI commands have query command counterparts unless noted. A query command consists of the command immediately appended with a question mark (?). Values

cannot be sent with a query. IEEE-488.2 commands do not have query counterparts unless explicitly shown with a question mark appended.

7. Parameters for a command must be separated from the command itself using a **<space> character (0h20).**
8. IEEE-488.2 commands start with an asterisk (*) and are not case sensitive.
9. All numerical values are ASCII encoded decimal strings consisting of 1 or more ASCII digits. 8 and 16 bit register values are binary weighted values represented by an ASCII string of 1 or more decimal digits.
10. Multiple Commands and Queries as part of the same program message string are **NOT** supported. The term 'program message' refers to a continuous string.
11. Multiple data parameter names and values must be separated by commas.
12. 'Multiple key word' messages may be sent without duplicating the first level SCPI keyword (i.e., OUTPut).
    e.g., OUTPut:COUNt_20;TINTerval_200 (space shown as "_")
13. A keyword is a single word beginning with a colon (:).
14. Program Messages MUST be terminated with a Line Feed (0Ahex, 10dec) or a Carriage Return (0h0D, 13dec) character. This is referred to as an end-of-string <eos>. Further SCPI commands shall begin with a first level keyword (i.e.,:SOURce:).
15. All values shown in angle brackets <> are examples of real values used with commands but labels are sometimes used to indicate a variable which is not known until actual time of use.
16. Units shown after the angle bracketed value are not to be included inside the value, but are shown as a reference to the units. The angle brackets are not part of the value.
17. Command strings may contain spaces.
18. The battery element tester interface accepts IEEE-488.2 NR1, NR2 and NR3 numeric formats. Most query responses are NR1 or NR2 types. i.e., NR1=120, NR2=120.0, NR3=1.2E+02.

8.3 SCPI Commands Summary

Following table lists all available programming commands. Details for each command follow in subsequent paragraphs.

Command	Type	Notes
CALIBRATION Commands		
CALibration:MEASure:VOLTage:LOW<space><n>	Command	n = 1 - 900
CALibration:MEASure:VOLTage:LOW?	Query	
CALibration:MEASure:VOLTage:MEDium<space><n>	Command	n = 1 - 900
CALibration:MEASure:VOLTage: MEDium?	Query	
CALibration:MEASure:VOLTage:HIGH<space><n>	Command	n = 1 - 900
CALibration:MEASure:VOLTage: HIGH?	Query	
MEASURE Commands		
MEASure:VOLTage:AC? <space><n>	Query	Returns n Q readings
MEASure:VOLTage:PEAK? <space><n>	Query	Returns n peak voltage readings
OUTPUT Commands		
OUTPut < 0 | 1 >	Command	
OUTPut?	Query	
OUTPut:COUNt <space><n>	Command	n = 0 ~ 999 (0 = continuous)
OUTPut:COUNt?	Query	
OUTPut:TINTerval <space><n>	Command	n = 30 ~ 5000 (msec)
OUTPut:TINTerval?	Query	
SOURCE Commands		
[SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <n>	Command	
[SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude]?	Query	
[SOURce:]VOLTage[:LEVel]:TRIGgered <min>, <max>	Command	
[SOURce:]VOLTage[:LEVel]:TRIGgered?	Query	
STATUS Commands		
STATus:OPERation:CONDition?	Query	
STATus:QUEStionable:CONDition?	Query	
STATus:OPERation:ENABle<space> <n>	Command	
STATus:OPERation:ENABle?	Command	
STATus:QUEStionable:ENABle <space><n>	Command	
STATus:QUEStionable:ENABle?	Query	
STATus:OPERation:EVENt?	Query	
STATus:QUEStionable:EVENt?	Query	
SYSTEM Commands		
SYSTem:CALibration:DATE?	Query	
SYSTem:VERSion?	Query	
SYSTem:SERialnumber?	Query	
SYSTem:ERRor?	Query	
SYSTem:DATE <space><yyyy>, <mm>, <dd>	Command	
SYSTem:DATE?	Query	
SYSTem:TIME <space><hh>, <mm>, <ss>	Command	24 hour format
SYSTem:TIME?	Query	24 hour format
SYSTem:BEEPer:MODE <space><off | high>	Command	

Table 8-1: STS 1656 & 1657 SCPI Command Summary Table

8.4 SCPI Command Details

Instrument specific commands conform to the SCPI standard where the standard provides guidance on the type of function that is being controlled.

8.4.1 CALIBRATION Commands

Calibration commands allow writing and reading measurement calibration coefficients to and from the instrument.

CALibration:MEASure:VOLTage:LOW<space><n>

Command Syntax:	CALibration:MEASure:VOLTage:LOW<space><n>
Purpose:	Sets the calibration coefficients for adjusting the voltage measurement for the tested voltage range from 300 – 1000V. Available coefficients range is 1 to 999.
Description:	Sets or queries the calibration coefficients for adjusting the voltage measurement read-back for the tested voltage range from 300 – 1000V.
Parameter:	1 - 999
Query Format:	CALibration:MEASure:VOLTage:LOW?
Returns:	<NR1>

CALibration:MEASure:VOLTage:MEDium<space><n>

Command Syntax:	CALibration:MEASure:VOLTage:MEDium<space><n>
Purpose:	Sets the calibration coefficients for adjusting the voltage measurement read-back for the tested voltage range from 1001 – 2000V. Available coefficients range is 1 to 999.
Description:	Sets or queries the calibration coefficients for adjusting the voltage measurement read-back for the tested voltage range from 1001 – 2000V.
Parameter:	1 - 999
Query Format:	CALibration:MEASure:VOLTage:MEDium?
Returns:	<NR1>

CALibration:MEASure:VOLTage:HIGH<space><n>

Command Syntax:	CALibration:MEASure:VOLTage:HIGH<space><n>
Purpose:	Sets the calibration coefficients for adjusting the voltage measurement read-back for the tested voltage range from 2001 – 3000V. Available coefficients range is 1 to 999.
Description:	Sets or queries the calibration coefficients for adjusting the voltage measurement read-back for the tested voltage range from 2001 – 3000V.
Parameter:	1 - 999
Query Format:	CALibration:MEASure:VOLTage:HIGH?
Returns:	<NR1>

CALibration:SAVe

Command Syntax:	CALibration:SAVe
Purpose:	Saves all three voltage measurement calibration coefficients in non-volatile memory.
Description:	All saved measurement coefficients can be retrieved using CALIBRATION Commands.

8.4.2 MEASURE Commands

Measurement commands allow measurement data to be retrieved.

MEASure:VOLTage:AC?

Query Format: MEASure:VOLTage:AC**<space>**<n>

Purpose: Measures the reflected peak voltage of the reflected voltage waveform for specified number of times <n>. This is the Q meter value shown on the Test result screen. The <n> parameter determines how many measurements will be taken and returned. For n=1, only a single measurement is taken. For n >1, the response will contain <n> values separated by commas. The maximum value for n = 100.

Description: Reads the digitized peak voltage of the reflected voltage waveform. The engineering unit is Voltage (V).

Returns: <NR1>, <NR1>, <NR1>, <NR1> etc.

MEASure:VOLTage:PEAK?

Query Format: MEASure:VOLTage:PEAK**<space>**<n>

Purpose: Measures the peak of the test voltage applied to the unit under test for the specified number of times <n>. The <n> parameter determines how many measurements should be taken. For n=1, only a single measurement is taken. For n >1, the response will contain <n> values separated by commas. The maximum value for n = 100.

Description: Reads the digitized peak voltage of the voltage waveform. The engineering unit is Voltage (V).

Returns: <NR1>, <NR1>, <NR1>, <NR1> etc.

8.4.3 OUTPUT Commands

Output commands control the test application and output voltage being applied to the unit under test.

OUTPut

Command Syntax: OUTPut **<space>**<n>

Purpose: Applies test voltage to the unit under test.

Description: Applies output test voltage. The query format returns the state of the output as either on (1) or off (0).

Parameter: 0 | 1

Query Format: OUTPut?

Returns: 0 | 1

OUTPut:COUNt

Command Syntax: OUTPut:COUNt **<space>**<n>

Purpose: Sets the number of test repetitions to be applied to the unit under test. Tests will run at the test interval programmed. See OUTP:TINT command.

Description: Applies output test voltage repeatedly at pre-set time interval. When set to zero (0), testing is continuous testing until aborted by operator or program.

Parameter: 0 - 999

Query Format: OUTPut:COUNt?

Returns: <NR1>

OUTPut:TINTerval

Command Syntax: OUTPut:TINTerval **<space>**<n>

Purpose: This setting determines the time delay between repeated applications of the test voltage to the UUT.

Description: Sets test time interval in milliseconds. See section 5.5, page 34.

Parameter: 30 or 65 – 5000

Query Format: OUTPut:TINTerval?

Returns: <NR1>

8.4.4 SOURCE Commands

Source voltage commands control the test voltage being applied to the unit under test and the fault detection level for each test.

[SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude]

Command Syntax:	**[**SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <n>
Purpose:	Sets the test voltage level.
Description:	This command sets the test voltage level. Available range is from 300 to 3000.
Query Format:	[SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude]?
Returns:	<NR1> Test voltage setting.

[SOURce:]VOLTage[:LEVel]:TRIGgered

Command Syntax:	**[**SOURce:]VOLTage[:LEVel]:TRIGgered <min>, <max>
Purpose:	Sets the fault detection lower (min) and upper (max) voltage trip level.
Description:	This command sets lower and upper trip voltage levels for detection of a separator fault on the unit under test. Available range for <min> and <max> value is from 0 to 4096.
Query Format:	**[**SOURce:]VOLTage[:LEVel]:TRIGgered?
Returns:	<NR1>,<NR1> Fault detection voltage, min and max trip level settings.

8.4.5 STATUS Commands

Status commands control and return settings for status and error reporting.

STATus:OPERation:CONDition?

Command Syntax: STATus:OPERation:CONDition?

Purpose: Returns the content of the Status Operation Condition register.

Description: This command returns the bit values of the Status Operation Condition register. This is a query only format command.

Query Format: STATus:OPERation:CONDition?

Returns: <NR1>

STATus:QUEStionable:CONDition?

Command Syntax: STATus:QUEStionable:CONDition?

Purpose: Returns the content of the Questionable Status Condition register.

Description: This command returns the bit values of the Questionable Status Condition register. This is a query only format command.

Query Format: STATus: QUEStionable:CONDition?

Returns: <NR1>

STATus:OPERation:ENABle <n>

Command Syntax: STATus:OPERation:ENABle <n>

Purpose: Sets the content of the Status Operation Enable register.

Description: This command sets the bit values of the Status Operation Enable register.

Parameter: 0 - 255

Query Format: STATus:OPERation:ENABle?

Returns: <NR1>

STATus:QUEStionable:ENABle <n>

Command Syntax: STATus:QUEStionable:ENABle <n>

Purpose: Sets the content of the Questionable Status Enable register.

Description: This command sets the bit values of the Questionable Status Enable register.

Parameter: 0 - 255

Query Format: STATus:QUEStionable:ENABle?

Returns: <NR1>

STATus:OPERation:EVENt?

Command Syntax: STATus:OPERation:EVENt?

Purpose: Sets the content of the Status Operation Event register.

Description: This command returns the bit values of the Status Operation Event register. This is a query only format command.

Query Format: STATus:OPERation:EVENt?

Returns: <NR1>

STATus:QUEStionable:EVENt?

Command Syntax: STATus:QUEStionable:EVENt?

Purpose: Sets the content of the Status Questionable Event register.

Description: This command returns the bit values of the Status Questionable Event register. This is a query only format command.

Query Format: STATus:QUEStionable:EVENt?

Returns: <NR1>

8.4.6 SYSTEM Commands

System commands control general features and setting at the system level of the instrument.

SYSTem:VERSion?

Command Syntax: SYSTem:VERSion?

Purpose: Returns SCPI version in NR2 format YYYY.V where YYYY represents the year and V represents an approved revision number or 0 if no revision exists. Eg. <1999.0> SCPI standard revision.

Description: Only the query version of this command is supported.

Returns: <NR2> SCPI version.

SYSTem:SERialnumber?

Command Syntax: SYSTem:SERialnumber?

Purpose: Returns serial number of the instrument. The same information can be obtained using the *IDN? Command but the SYST:SER? command only returns the serial number.

Description: Only the query version of this command is supported.

Returns: <NR1> Serial number of the instrument.

SYSTem:ERRor?

Command Syntax: SYSTem:ERRor?

Purpose: Returns next available entry from error queue and removes it from the queue. The error/event queue contains items that include a numerical and textual description of the error or event. The <Error/event_number> is a unique integer in the range [-32768, 32767]. All positive numbers are instrument-dependent. All negative numbers are reserved by the SCPI standard with certain standard error/event codes described in this document. The value, zero, is also reserved to indicate that no error or event has occurred.

Description: Only the query version of this command is supported.

Returns: Error message.

Available Error messages are shown in the table below.

Error Message	Description
100, "Test Failed"	Test performed returned FAIL result If the number of measurements taken is 5 (MEAS:VOLT:AC? 5) and reading #1 fails while readings 2, 3, 4 and 5 pass, the tester will still report a FAIL result. This test failed flag is latched until the message is read at which time it is cleared. For the Auto-Line option, when performing a measurement

Error Message	Description
	(MEAS:VOLT:AC? 1) and cell #1 and #3 happen to fail, the message queue will contain a 100 error message for each cell number that failed.
100, "Test Failed n,n,n,n,n,n"	Test performed in Auto Line mode returned at least one FAIL result For the Auto-Line option, when performing a measurement (MEAS:VOLT:AC? 1) and cell #1 and #3 happen to fail, the error message will contain PASS or FAIL indications for each cell. Example: 100, "Test Failed FAIL, PASS, FAIL, PASS, PASS, PASS
0, "No error"	No error detected
-102, "Command error"	Indicates invalid command or query received
-200, "Execution error"	Indicates can't execute command with parameters received
-300, "Device-specific error"	Indicates instrument not properly configured
-350, "Query overflow"	A specific code entered into the queue in lieu of the code that caused the error. This code indicates that there is no room in the queue and an error occurred but was not recorded
-400, "Query error"	Indicates query aborted

SYSTem:BEEPer:MODE

Command Syntax: SYSTem:BEEPer:MODe<space> < off | low | high >

Purpose: Sets the loudness level of the internal buzzer used to indicate a key press on the front panel.

Description: Three levels are available: off, low or high. For loud factory environment, the high setting is recommended.

SYSTem:MANufacturer?

Command Syntax: SYSTem:MANufacturer?

Purpose: Returns the name of the instrument manufacturer.

Description: This command returns the manufacturer of the instrument as a character string. This is a query format command only.

SYSTem:DATE

Command Syntax: SYSTem:DATE <space><yyyy>, <mm>, <dd>

Purpose: Sets the Real Time clock's date to the value passed. Date format is YYYY,MM,DD. All fields are NR1 (integer)

Description: This command sets the system date. Numeric values representing Year (2001-2099), Month (1-12), Day (1-31). Year parameter must be 4 digits.

Query Format: SYSTem:DATE?

Returns: <yyyy>, <mm>, <dd>. All fields separated by commas.

SYSTem:CALibration:DATE?

Command Syntax: SYSTem:CALibration:DATe?

Purpose: Queries the Calibration Date. Date format is YYYY,MM,DD. All fields are NR1 (integer)

Description: This command queries the calibration date. Numeric values representing Year (2001-2099), Month (1-12), Day (1-31). Year parameter must be 4 digits.

Returns: <yyyy>, <mm>, <dd>. All fields separated by commas.

SYSTem:TIME

Command Syntax: SYSTem:TIME **<space>**<hh>, <mm>, <ss>

Purpose: Sets the Real Time clock's time to the value passed. Time format is hours, minutes, seconds (HH,MM,SS). All fields are NR1 (integer)

Description: Numeric values representing Hours (00-23), Minutes (00-59), Seconds (0-60). Note: 60 is accepted for seconds to allow for rounding on non-integer values. Any rounded value resulting in 60 shall be set to 0.

Query Format: SYSTem:TIME?

Returns: <hh>, <mm>, <ss>. All fields separated by commas.

8.5 IEEE488.2 Common (*) Commands

The IEEE488.2 common commands are often referred to as 'star' commands as they all start with a "*" character. The battery element tester supports the common command shown in the table below. Details for each command are shown in next section.

Command	Type	Notes
IEEE488.2 Common Commands		
*CLS	Command	Clear status registers
*ESE <n>	Command	Standard Event Status Enable. n = 0 | 1
*ESE?	Query	Standard Event Status Enable query
*ESR?	Query	Standard Event Status Register query
*GTL	Command	Sets the instrument in local mode
*IDN?	Query	Returns manufacturer, model, hardware version, firmware version, interface types and serial number.
*LLO	Command	Sets the instrument in Local Lock-Out mode
*OPC	Command	Operation Complete
*OPC?	Query	Operation Complete query
*RCL <n>	Command	Recall Setup Register <n>. n = 1 ~ 10
*RST	Command	Reset all
*SAV <n>	Command	Save Setup to Register <n>. n = 1 ~ 10
*SRE <n>	Command	Status Byte Register bits enable. n = 0 | 1
*SRE?	Query	Status Byte Register Enable query
*STB?	Query	Status Byte Register query
*TST?	Command	Execute Self-Test and return result. Zero result equals pass
*WAI	Command	Hold GPIB bus till execution of all commands is completed

8.6 Registers, Events and Status Reporting

Events and device Status may be queried by the through the following registers and queues. Query commands are explicitly shown in this section for clarity. The following status and event registers are supported.

8.6.1 STATUS BYTE REGISTER (STB)

STATUS conditions reported by the STATUS BYTE may be queried using the *STB? command. The *CLS command clears the ESR and the STB. The Status Byte Register contains the following bits.

BIT	NAME	WEIGHT	DEFINITION
7	SOS	128	:STATus:OPERation register bit summary. See STATus:OPERation:ENABle for more.
6	MSS/RQS	64	MASTER SUMMARY. Summarizes all STATUS BYTE bits (except bit 6) for *STB?, or *SRE for more. REQUEST SERVICE: indicates this device requested service when a Serial Poll was performed.
5	ESB	32	STANDARD EVENT STATUS REGISTER bit summary. See the *ESE command for more.
4	MAV	16	MESSAGE AVAILABLE indicates Query response data is available
3	SQS	8	:STATus:QUEStionable register bit summary. See STATus:QUEStionable:ENABle for more.
2	EEQ	4	ERROR/EVENT QUEUE indicates an SCPI Error/Event message is available. Use the SYSTem:ERRor? Command to query any messages from the Error Queue.
1	BUSY	2	Indicates instrument is busy.
0	SHUTDOWN	1	Indicates hard failure or unrecoverable error condition.

Setting a SERVICE REQUEST ENABLE (SRE) bit true unmasks the STATUS bit in the STB. Bit 6 of the SRE is not applicable as the MASTER SUMMARY bit of the STB cannot be masked. The STB, SRE, ESR and ESE registers are 8 bits each.

8.6.2 STANDARD EVENT STATUS REGISTER (ESR)

Events reported by the STANDARD EVENT STATUS register may be queried via the ***ESR?** command. Reading the ESR register clears it. The EVENT STATUS summary bit in the STATUS BYTE (STB) will be set when an unmasked EVENT STATUS bit goes true.

The Standard Event Status Register contains the following bits.

BIT	NAME	WEIGHT	DEFINITION
7	PON	128	POWER ON indicates Input power was just applied
6	URQ	64	USER REQUEST indicates "LOCAL" key was just pressed
5	CME	32	COMMAND ERROR indicates invalid command or query received
4	EXE	16	EXECUTION ERROR indicates can't execute command with data received

BIT	NAME	WEIGHT	DEFINITION
3	DDE	8	DEVICE DEPENDANT ERROR indicates instrument not properly configured
2	QYE	4	QUERY ERROR indicates cannot respond with data
1	RQC	2	REQUEST CONTROL - not used
0	OPC	1	OPERATION COMPLETE indicates previous operation complete

Setting an EVENT STATUS ENABLE (ESE) bit true unmasks the EVENT bit in the ESR. Also see **:SYSTem:ERRor?** query for corresponding information.

8.6.3 Status Reporting

The following lists the SCPI Commands for **Status Reporting** from the instrument. Refer to the SCPI 1999 standard for more information. Query commands are explicitly shown in this section for clarity.

SYSTem:ERRor? Query: system error

Returns one of the following types of messages, with details appended to it if possible. A maximum of 256 characters may be sent as a response to this query. Negative error messages (< 0) are defined in the SCPI Standard. Positive error message (> 0) are instrument specific.

The table below indicates the error query responses that are be supported.

Error Message	Description
100, "Test Failed"	Test performed returned FAIL result If the number of measurements taken is 5 (MEAS:VOLT:AC? 5) and reading #1 fails while readings 2, 3, 4 and 5 pass, the tester will still report a FAIL result. This test failed flag is latched until the message is read at which time it is cleared. For the Auto-Line option, when performing a measurement (MEAS:VOLT:AC? 1) and cell #1 and #3 happen to fail, the message queue will contain a 100 error message for each cell number that failed.
100, "Test Failed n,n,n,n,n,n"	Test performed in Auto Line mode returned at least one FAIL result For the Auto-Line option, when performing a measurement (MEAS:VOLT:AC? 1) and cell #1 and #3 happen to fail, the error message will contain PASS or FAIL indications for each cell. Example: 100, "Test Failed FAIL, PASS, FAIL, PASS, PASS, PASS
0, "No error"	No error detected
-102, "Command error"	Indicates invalid command or query received
-200, "Execution error"	Indicates can't execute command with parameters received
-300, "Device-specific error"	Indicates instrument not properly configured
-350, "Query overflow"	A specific code entered into the queue in lieu of the code that

Error Message	Description
	caused the error. This code indicates that there is no room in the queue and an error occurred but was not recorded
-400, "Query error"	Indicates query aborted

Table 8-2: SYSTEM:ERROR? Query Responses Table

8.7 IEEE488.2 Common Command Details

This section provides details on syntax and operation of the supported IEEE488.2 common commands.

8.7.1 *CLS

Command Syntax: ***CLS**

Purpose: Clears the event status register.

Description: This command clears all bits in the event status registers and any fault conditions.

8.7.2 *ESE <n>

Command Syntax: ***ESE<space><n>**

Purpose: Enables or disables specific bits in the Standard Event Status register.

Description: The value passed as a parameter <n> with the *ESE command determines which bits are enabled or not. Enabled bit conditions can generate a status request.

8.7.3 *ESE?

Command Syntax: ***ESE<space><n>**

Purpose: Queries the bits positions in the Standard Event Status register that are enabled.

Description: This query format of the *ESE command returns the value of the enabled bit position as a decimal value.

Query response: Returns the decimal value of the ESR enabled bits.

8.7.4 *ESR?

Command Syntax: ***ESR?**

Purpose: The *ESR? Query command returns the value of the Standard Event Status register.

Description: This query only format command returns the value of the Standard Event Status register as a decimal value. It also clears all bits in this register that are set.

Query response: Returns the decimal value of the ESR register. See section 8.6.2.

8.7.5 *GTL

Command Syntax: ***GTL**

Purpose: The *GTL command releases the bus and sets the instrument in local mode.

Description: This command sets the instrument for front panel operation.

8.7.6 *IDN?

Command Syntax: ***IDN?**

Purpose: Returns the instrument's Identity string.

Description: This query only command returns the response in a SCPI compliant format. The query response contains four fields separated by a comma.

Query response: Manufacturer, model number, hardware revision, firmware revision, interface types and serial number. The interfaces types are encoded as follows
bit 0 = RS232 weight = 1
bit 1 = RS485 weight = 2
bit 2 = USB weight = 4
bit 3 = PLC weight = 8

Example: STS, 1656, 1, 1, 5, 12345
This example indicated hardware = 1.0, firmware = 1.0, Interface are RS232 and USB (1 + 4)

8.7.7 *LLO

Command Syntax: ***LLO**

Purpose: The *LLO command locks the instrument front panel.

Description: This command locks the instrument from accessing control through the front panel.

8.7.8 *OPC

Command Syntax: ***OPC**

Purpose: This command instructs the instrument to set the operation complete status bit.

Description: The operation complete command allows commands that take a long time to execute to signal busy status by returning a "1" to any *OPC? query that follows. On the STS 1656/1657, all command execute immediate so the *OPC command is not required and is ignored when issued.

8.7.9 *OPC?

Command Syntax: ***OPC?**

Purpose: This query format of the *OPC command returns a 0 when the previously issued command has completed execution.

Description: The STS 1656/1657 executes all commands immediately so the *OPC? query always returns a "0".

8.7.10 *RCL <n>

Command Syntax: ***RCL<space><n>**

Purpose: Recalls instrument setup from non-volatile register n.

Description: The *RCL command may be used to recall setups from non-volatile memory. There are 10 setup registers available, numbered 1 through 10. (n = 1 ~ 10). Any active setup can be saved to a register using the *SAV <n> command.

8.7.11 *RST

Command Syntax: ***RST**

Purpose: Resets instrument to power on conditions.

Description: The *RST command resets the instrument to a known default state. The following settings will take affect after execution of a *RST command.

Parameter	Reset State
INITIAL VOLTAGE	300
CONTINUOUS MODE	OFF
TRIP LEVELS	0, 500
KEYBOARD LOCK	OFF
MAX VOLTAGE	3000 V
MIN VOLTAGE	300 V
MODE	MANUAL
TEST TIME INTERVAL	1.000 SEC
OUTPUT	DISABLED
OUTPUT TESTS VOLTAGE(S)	300

8.7.12 *SAV <n>

Command Syntax: ***SAV<space><n>**

Purpose: Saves instrument setup to non-volatile setup register n.

Description: The *SAV command may be used to store setups in non-volatile memory for future recall. There are 10 setup registers available, numbered 1 through 10. (n = 1 ~ 10).
All setups can be recalled using the *RCL <n> command.

8.7.13 *SRE <n>

Command Syntax: ***SRE<space><n>**

Purpose: Enables or disables specific bits in the Status Byte register.

Description: The value passed as a parameter <n> with the *SRE command determines which bits are enabled or not. Enabled bit conditions can generate a status request.

8.7.14 *SRE?

Command Syntax: ***SRE?**

Purpose: Queries the bits positions in the Status Byte register that are enabled.

Description: This query format of the *SRE command returns the value of the enabled bit position as a decimal value.

Query response: Returns the decimal value of the STB enabled bits.

8.7.15 *STB?

Command Syntax: ***STB?**

Purpose: The *STB? query command return the value of the Status Byte register.

Description: This query only format command returns the value of the Status Byte register as a decimal value. It also clears all bits in this register that are set.

Query response: Returns the decimal value of the STB register. See section 8.6.1.

8.7.16 *TST?

Command Syntax: ***TST**

Purpose: The *TST? Query command performs an instrument self-test and returns a zero result if the self-test passes.

Description: This command is not supported on the STS1656/1657. It will be accepted and return a zero result but is otherwise ignored (No operation).

8.7.17 *WAI

Command Syntax: ***WAI**

Purpose: The *WAI command holds the bus until the previously received command is completed.

Description: This command is not supported on the STS1656/1657. It will be accepted without generating a command error but is otherwise ignored (No operation).

8.8 RS232 Serial Interface Operation

Operation over RS232 serial interface is similar to using USB but a serial port on the controller or computer is required. Note that most PC's no longer offer a standard COM port. In that case, it is suggested to use the USB interface instead.

For serial operation, a straight through DB9 to DB9 male-female cable is needed to connect the 1656/1657 to a COM port. If the controller has a 25 pin RS232 connector, a DB9 to DB25 adapter is required.

Baud rate, start bits, data bits and stop bits setting on the PC or controller and the 1656/1657 must match in order for the serial interface to work. The RS232 parameters on the battery testers are fixed to 115200, 1, 8, 1. All command strings send must be terminated by a LF or CR. The command syntax is the same SPCI syntax as for all other interface types.

8.9 RS485 Serial Interface Operation

In contrast to RS232, RS485 is a multi-drop serial interface which means that multiple devices can be connected to the same controller. The signal levels differ as well so do not attempt to use an RS232 COM port on a PC to control the 1656/1657 over its RS485 interface.

The RS485 parameters on the battery testers are fixed to 115200, 1, 8, 1. Since RS485 is a multi-drop interface, device addressing is required so all commands must have an address. It also means the 1656/1657 must have its RS486 device address set in the SETTINGS menu in the UTILITIES menu.

Data sent over RS485 connections is packetized as an eight byte packet and includes a checksum as its last byte to allow the receiving device to verify correct receipt of the packet content. This requires more a correct CRC to be calculated and appended to every packet sent.

Formatted packet

8.9.1 Formatted Packet of data for RS485 interface (ASCII Code):

The required packet format for RS485 communication is as follows:

Order	Type	Content
data(0)=2	(RS485 Address)	
data(1)=1	(Communication code)	
data(2)=5	(Length of command, example "*IDN?"=5)	
data(3)=42	(*)	Command ASCII char
data(4)=73	(I)	Command ASCII char
data(5)=68	(D)	Command ASCII char
data(6)=78	(N)	Command ASCII char
data(7)=63	(?)	Command ASCII char
data(8)=180	(checksum of byte array of data(0) – data(7))	Checksum

Table 8-3: RS485 Communication Packet Format

8.9.2 Calculating Checksum Visual Basic NET Example

The following two code samples illustrates how to communicate with the Battery Element Tester using the RS485 protocol.

CalcCheckSum Call

```
Private Sub btnCalcCheckSum_Click(ByVal sender As System.Object, ByVal e As System.EventArgs)
Handles Button16.Click
Dim str1 As String
        Dim str2 As String
        Dim str3 As String
        Dim checksum1, checksum, i As Integer
Try
                txtLengthCmd.Text = txtActualCmd.TextLength
                str1 = ChrW(txtRS485Addr.Text) & ChrW(txtComm01.Text) &
ChrW(txtLengthCmd.Text)
                str2 = txtActualCmd.Text
                str3 = str1 & str2
                checksum = 0
                checksum1 = 0
                For i = 0 To str3.Length - 1
                        checksum += AscW(str3.Substring(i, 1))
                Next
                checksum1 = checksum And &HFF
                checksum = (&H100 - checksum1) And &HFF
                str3 = ChrW(checksum)
                txtCheckSum.Text = str3
        Catch exp As Exception
MessageBox.Show("Please verify entries are properly entered", "Calulating Checksum",
MessageBoxButtons.OK, MessageBoxIcon.Warning)
        End Try
End Sub
```

WriteQuery Routine

```
Private Sub btnWriteQuery_Click(ByVal sender As System.Object, ByVal e As System.EventArgs)
Handles btnWriteQuery.Click
        Dim transfer_data(100) As Byte
 Dim str1 As String
        Dim str2 As String
        Try
        If txtCheckSum.Text = "" Then
MessageBox.Show("Please select 'Calculating Checksum' button to calculate checksum", "Missing
Checksum Code", MessageBoxButtons.OK, MessageBoxIcon.Warning)
                ElseIf btnConnect1656.Enabled = True Then
MessageBox.Show("Please establish connection to STS1656", "Connection Error",
MessageBoxButtons.OK, MessageBoxIcon.Warning)
                Else
str1 = ChrW(txtRS485Addr.Text) & ChrW(txtComm01.Text) & ChrW(txtLengthCmd.Text) &
txtActualCmd.Text & txtCheckSum.Text
                        For i = 0 To str1.Length - 1
                                transfer_data(i) = AscW(str1.Substring(i, 1))
                        Next
                        SerialPort1.Write(transfer_data, 0, str1.Length)
                        If str1.IndexOf("?") > 0 Then
                                str2 = SerialPort1.ReadLine
                                RichTextBox1.Text += str2 & vbCrLf
                        End If
                End If
        Catch exp As Exception
MessageBox.Show("Please verify command syntax is entered correctly", "Syntax Error",
MessageBoxButtons.OK, MessageBoxIcon.Warning)
        End Try
End Sub
```

9 Application Notes

This section contains remarks and comments on practical matters that apply to testing battery elements using high voltage testers like the 1656 and 1657.

1. This unit is solid state High-Voltage Pulse type leakage and breakdown Tester with digital meters. Essentially, it subjects the battery elements to a high peak voltage that appears between all plates and across all separators.
2. If everything is normal – if there are no defects in the separators, no runs, trees, etcetera, the battery element will withstand the test voltage, and the instrument will register a "normal" quality meter reading.
3. This normal quality meter reading is due to the electrostatic capacity between the plates, and should not vary except in relation to the moisture content of the separators.
4. If separators are defective, or if for any reason opposite polarity spacing within the battery element are abnormally close, the high voltage applied will jump this gap, and a rejection will be indicated.
5. The user best establishes exact test voltage for any particular battery element. It is suggested that a representative group be checked at successively higher voltages until the voltage that will reject good assemblies is established. The voltage should then be "backed off" 200 to 500 volts for routine testing of high quality assemblies, and somewhat more for lower grade elements.

   When a capacitive load (the battery) is coupled to an inductor (internal load of the tester) the voltage developed across the inductor and the capacitor will be higher at resonance. The outgoing voltage pulse of the battery tester is composed of an extremely wide range of frequencies so resonance can occur. The battery's capacitance will determine the resonance frequency for a particular battery line. The firing characteristics of the SCR produce different output wave shapes that affect the frequency of the output and consequently resonance.
6. The most difficult defects to detect are pinholes and splits or tears in separators. With present day separators a voltage in the 2000 to 2500 volt range may be required. If some defects are acceptable, the test voltage can be dropped as low as 1500, and practically all defects except pinholes, hairline splits, and tears will be detected. Holes in the insulation are normally detected by arcing. The suggested procedure is to use sufficient voltage to initiate an arc if the insulation has a hole or is missing. The insulation will prevent arcing. If there is a hole or the insulation is missing, the tester will arc across and find the fault (no insulation).
7. Battery elements are sometimes tested in a "formed" (the paste in the lattice is conductive) or an "un-formed" (the past in the lattice is non-conductive) condition. If the battery element is un-formed when the test is conducted, faults are much, much harder to detect because a fault must be located in an area between the conductive lead lattices of the positive and negative plates. If the fault is located in a non-conductive area, an arc will generally not occur and the fault will be un-detected.
8. The tester does not determine that an element is reversed in a cell. The tester sees only the potential between the positive and the negative plate.

9. Users may construct a STANDARD BATTERY PROXY. This is a 0.002 microfarad capacitor in parallel with two ½ inch steel balls separated by gap of 0.013 inch / 0.33 mm. This 'standard' can be constructed by anyone and allows a repeatable comparison of testers.

10 Maintenance

Routine maintenance should include the following:

10.1 Functional Check

At least once per shift verify correct operation by the methods described in paragraph 3.4, "Initial Setup Procedure" on page 21.

10.2 Safety Inspection

A. **Daily** – Check test leads for damage. Retracting probes should be inspected for contamination or burning inside barrel by bringing the tips together in the retracted position at full voltage. Clip type probes should be inspected for tears in the protective boot. Leads should be inspected for cracks or deterioration. Front panel receptacle should be inspected for excessive wear, cracks or loose components.

B. **Monthly** – Check line cord on tester for damage, deterioration and ground lead integrity. Check line receptacle for ground integrity.

10.3 Annual Maintenance

Recommended Calibration interval for the 1656 and 1657 is one year. Contact STS Instruments to request a calibration quotation.

Individual fuses are used to protect the different sections of the equipment. Failure of any of the fuses is evidence either of fuse aging, abnormal line surges, or trouble in the unit.

The main AC line input fuse is on the rear panel. If a fuse is blown, replace with one of the same type and rating. If the replacement holds, the original failure is probably due to aging or line surges. If the replacement immediately blows, something is wrong and repairs are indicated. Under no circumstances should oversize fuses be used in this equipment.

10.4 Test Probes

High Voltage test probes as used by the 1656 and 1657 testers are prone to wear and tear over extended periods of use. Based on inspection results per paragraph 10.2 (Safety Inspection), replacement may be needed.

10.5 Replacement Parts

Replacement test probes assemblies and fuses can be obtained by ordering the following:

Part Number	Description	Notes
102-050-919	Test Probe Assembly Kit	Set of Safety Retracting Red/Black Probes with 1.8 m /6 ft. leads
200025	Test Probe Assembly, Red	Safety Retracting Probe, Red with 1.8 m / 6 ft. lead
200026	Test Probe Assembly, Black	Safety Retracting Probe, Black with 1.8 m / 6 ft. lead
200386	Test Probe Assembly, Red	Safety Retracting Probe, Red with 3 m / 10 ft. lead
200387	Test Probe Assembly, Black	Safety Retracting Probe, Black with 3 m / 10 ft. lead

10.6 Model Configurations and Manufacturer Part Numbers

10.6.1 1656 Models

Part Number	Description	Notes
201178-AA	Model 1656 Digital Battery Element Tester (base version)	
201734-AA	Model 1656-PLC Digital Battery Element Tester with PLC Interface	Standard for US market
201777-AA	Model 1656-PLC-RS232	PLC+RS232
201778-AA	Model 1656-PLC-RS485	PLC+RS485
201779-AA	Model 1656PLC-RPC	PLC+RPC
201780-AA	Model 1656-PLC-PRC-RS232	PLC+RPC+RS232
201781-AA	Model 1656-PLC-PRC-RS485	PLC+RPC+RS485
201782-AA	Model 1656-RPC	Base+Rear Panel Conn.
201783-AA	Model 1656-RPC-RS232	Base+ Rear Panel Conn.+RS232
201784-AA	Model 1656-RPC-RS485	Base+ Rear Panel Conn..+RS485

***Note**: Revision designation post-fix not shown on part number*

10.6.2 1657 Models

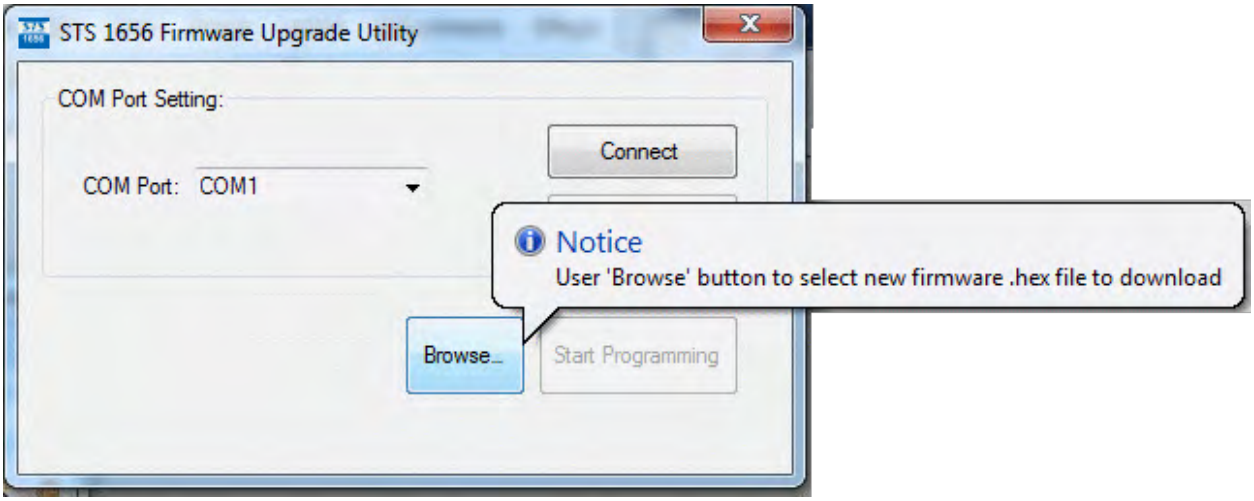
10.7 Updating Instrument Firmware Revision

The firmware revision of the 1656/1657 Battery Element Tester can be updated by re-flashing the main processors Flash Memory over the USB interface. This requires the use of a Windows Flash Loader utility which is available free of charge through STS Instruments' website. (www.stsinstruments.com)

To update from your existing revision, a binary file (HEX file) with the latest firmware binary image is required. These firmware files are available from STS Instruments by request. Contact STS Instruments Customer Service to obtain the most current revision. See Section 12, "Service".

10.7.1 Downloading and Installing Flash Uploader

To perform a firmware upgrade of the 1656 or 1657, you will need to download the Flash loader utility program for Windows. This utility communicates with the 1656/1657 using either the USB or RS232 interface and performs the transfer of the upgrade firmware HEX file to the processor Flash memory.



This utility can be downloaded free of charge from the STS Instruments website in the Technical Resources section at:

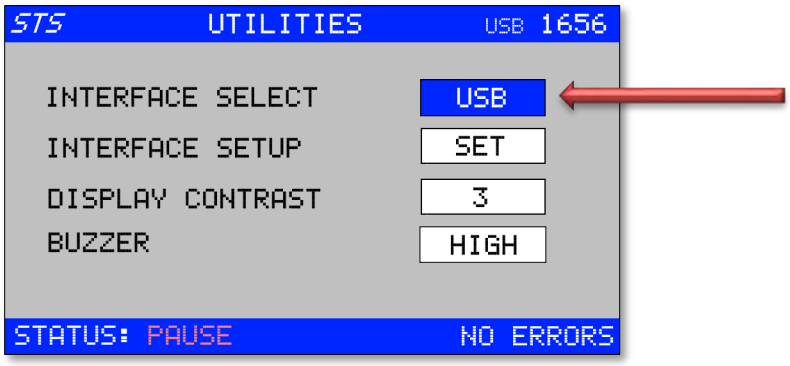
http://www.stsinstruments.com/lang-en/resources

Download the STS1656_FlashLoader_Setup.zip file from the STS website and unzip the setup program. Run the setup program to install the utility on a Windows PC equipped with either a RS232 or a USB interface. Once installed, launch the Flash Loader utility.

10.7.2 Installing New Firmware

To download new firmware, you must establish a communication connection with the instruments. Select the COM port that the 1656 or 1657 is connected to. This can be Com1 through Com4 if the PC you are using has a native RS232 port. If you are using the virtual com port (VCP) driver to connect to a USB port on the PC, locate the correct COM number from the list. If you are not sure what com port number was assigned to the USB port, use the Windows Device manager to locate the correct virtual com port number.

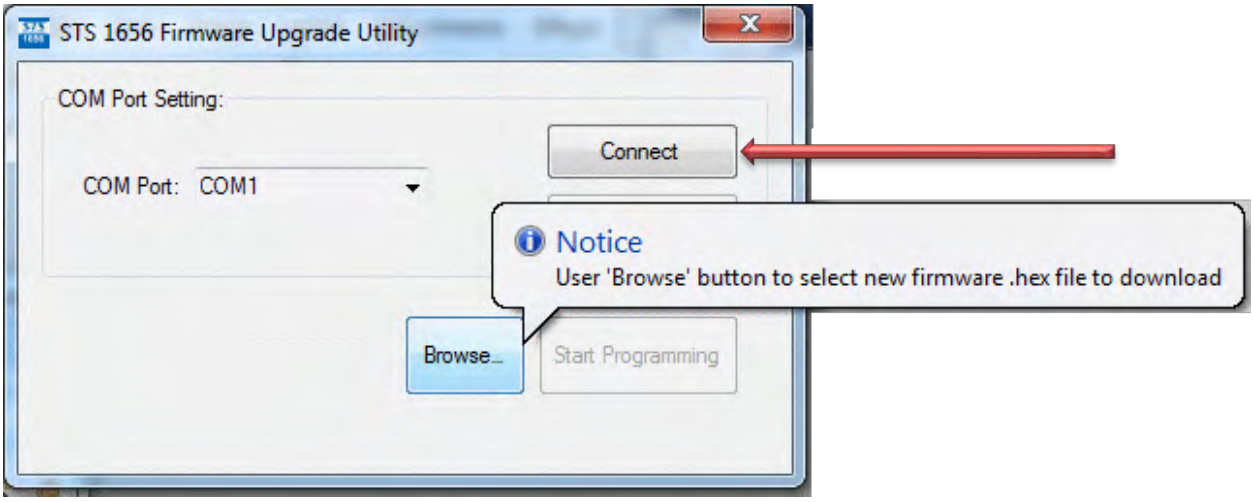
On the 1656 or 1657 instrument itself, make sure the corresponding interface type (USB or RS232) is selected correctly in the UTILITIES menu.



Once the required interface type is set, turn off the 1656/1657 unit. To enter flash download mode, depress the Shuttle knob while turning the 1656/1657on at the power switch. This will cause the unit to boot up in Flash loader mode. This is indicated by the fact that the RESET and CHECK buttons are both lit. (on).

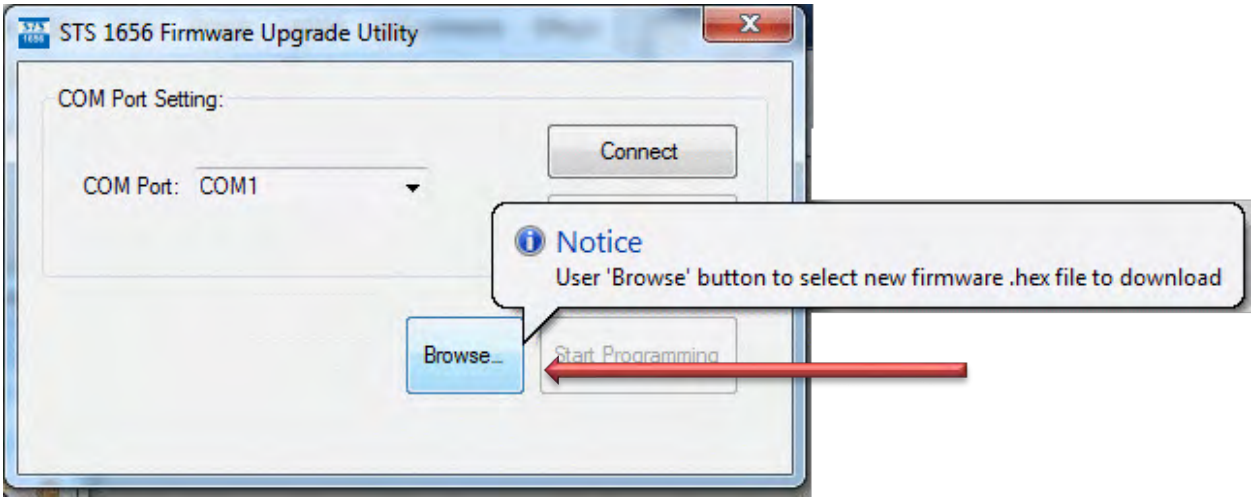
You are now ready to start the firmware download.

Once selected, press the "**Connect**" button to establish the connection to the instrument. If the connection is not successful, check your cabling and the com port selection and re-try if needed.



From the flash loader main screen, press the "**Browse**" button to locate the firmware HEX file you received or downloaded for your instruments. The file must have the extension ".hex".

NOTE: Do not alter or modify the firmware HEX file in any way or it will be corrupted and could render your instrument inoperative.



Clicking on the "**Browse**" button will display the Windows File Open dialog box. Use this dialog to locate the correct firmware hex file and click on the "**Open**" button.

Once the correct firmware hex file has been selected, the "**Start Firmware Upgrade**" button will be enabled. Click this button to start the download.

Note that the download may take several minutes to complete. Watch for any error messages reported by the Flash downloader utility program. If the download is successful, the 1656/1657 will reboot and display the normal start up screen.

If for some reason the firmware download is not successful, turn the unit off and back on in Flash loader mode as described above.

11 Calibration

This section provides direction on periodic calibration of the 1656 and 1657 Battery Element Testers.). We recommend that your instrument be calibrated on a twelve-month cycle by returning it to the manufacturer for factory calibration. Refer to Section 12, "Service" for instructions to return a unit for calibration.

NOTE: It is not recommend to attempt to calibrate the STS 1656 or 1657 yourself or to use a third party calibration lab which is not familiar with this type of instrument.

11.1 Equipment List

The following equipment may be used to calibrate this instrument.

Equipment	Description	Suggested Makes & Models
Digital Oscilloscope	2 Channel Scope, 300MHz	Tektronix DPO4054, Rigol DS2302A Series or equivalent
High Voltage Probe	Scope Prove, 1000x, 20KV	SAPPHIRE KC-9010, Beckman PR-55 10kV Probe, Tektronix P6015A, Probemaster 4234 High Voltage Isolation probe or equivalent
STS Auto-Calibration Software	Automated STS1656/1657 Calibration Windows Software	STS Instruments

Since all calibrations involve dangerous voltage levels, customers are advised to return units to STS Instrument for calibration.

11.2 Calibration Report

All factory calibrations are performed with traceable equipment and supplied with a calibration report.

12 Service

This equipment is rather complex. Field repairs, other than routine replacement test probe assemblies and fuses are not recommended due to the risk of high voltage shock. It is recommended that defective equipment be returned to the factory for repair where complete calibration and repair services are offered at any of our Authorized Service Facilities listed below.

Calibrations are to original factory specifications and are traceable to National Standards. A certificate of conformance accompanies each repaired tester.

A Return Material Authorization (RMA) number must be obtained before returning any instrument for repair and calibration. Please contact your nearest service center location as indicated below or email info@stsinstruments.com for assistance and instructions.

Transportation costs for the return of the instrument to STS Instruments must be prepaid by the customer. Tester sent for repair should be shipped prepaid and insured to the address show below.

NORTH AMERICA	***EUROPE***	***ASIA***
STS Instruments *Attn: Customer Service* *17711 Mitchell North* *Irvine, CA 92614 USA* ***Phone:****+1-580-223-4773* ***Fax****: +-1-580-226-5757*	***STS Instruments*** *Attn: Customer Service* *4 Riverside Business Centre* *Walnut Tree Close Guildford,* *United Kingdom GU14UG* ***Phone:*** *+44(0)1483-302-700* ***Fax:*** *+44(0)1483-300-562*	***STS Instruments*** *Attn: Customer Service* *4 floors , building 2, No. 2185 Lai Fang Road, Jiu Ting Town, Song Jiang District, Shanghai 201615* *China* ***Phone:*** *+86-21-6763-9223* ***Fax:*** *+86-21-5763-824*

Inside the container with the instrument, put the name and telephone number of someone to contact if the Service Department has any questions regarding the repair and someone to advise of billing. Please indicate your 'ship to' address – no PO boxes, please.

Subject to weight restrictions, testers are normally returned to the customer via UPS ground with the actual shipping charges prepaid and added to the invoice. Premium shipping and alternate carriers can be provided upon customer request. Freight charges will vary according to the method/carrier specified.

Factory service is based upon an hourly rate with a one hour minimum charge per tester. Parts needed to bring the tester back to factory specifications are extra. Altered testers cannot be certified. All non-STS Instruments parts will be removed and the customer charged to bring the tester back to original factory specifications before calibration will be attempted.

Non-warranty repairs carry a limited warranty of 90 days on services and replacement parts only. Defects in our repair work or any parts replaced will be corrected at no charge if the defect occurs within 90 days from shipment from our factory.

If difficulty arises during the 90-day period that is due to a secondary defect, which could not normally be detected during the original service procedure, it will be repaired and a charge made only for parts used.

13 CE MARK Declaration of Conformity

The manufacturer hereby declares that the product

Product Name: STS Models 1656 and 1657
Description: BATTERY ELEMENT TESTER

Conforms to the following stands or other normative documents:

RoHS (DIRECTIVE 2011/65/EU)
Standard applied EN 50581: 2012

SAFETY:
Standard applied EN 61010-1:2010

EMC:
Standard applied EN 61326-1:2013

ELECTROMAGNETIC EMISSIONS:

Radiated Emissions (at Enclosure)
CISPR 11 Group 1 CLASS A **

30 MHz-230MHz	50dB(µV/m) QP at 3m SAC
230 MHz-1000MHz	57dB(µV/m) QP at 3m SAC

Conducted Emissions (at Mains Terminals)
CISPR 11 Group 1 CLASS A **

150 kHz-0,5MHz	79dB(µV/m) QP 66dB(µV/m) AV
0,5 MHz-5,0MHz	73dB(µV/m) QP 60dB(µV/m) AV
5 MHz-30MHz	73dB(µV/m) QP 60dB(µV/m) AV

** GROUP 1: designates General Purpose Applications for this device. CLASS A: designates the device is not suitable for installation in a domestic building.

Voltage Fluctuations and Flicker IEC 61000-3-3:2008 (Section 5)

ELECTROMAGNETIC IMMUNITY:

Electrostatic Discharge (Enclosure Port)	IEC 61000-4-2:2008
RF Electromagnetic Field (Enclosure Port)	IEC 61000-4-3:2006+A1:2007+A2:2010
Electrical Fast Transient/Burst (Input AC Power port; Signal port)	IEC 61000-4-4:2004+A1:2010
Surge (Input AC Power port)	IEC 61000-4-5:2005
Conducted Disturbances (Input AC Power port; Signal port)	IEC61000-4-6:2008
Voltage Dips and Short Interruptions (Input AC Power port)	IEC 61000-4-11:2004
Power frequency magnetic fields (Enclosure Port)	IEC 61000-4-8:2009

Supplemental Information:

When and Where Issued: August 11, 2014
Shanghai, China

Authorized Signatory
Jerome Wang
Quality Assurance Inspector
PPST Shanghai, Co, Ltd.

Mark of Compliance:

CE

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