THERMAL TRANSIENT TEST SET
MODEL 730

INSTALLATION AND OPERATION MANUAL

MODEL 730 - THERMAL TRANSIENT TEST SET
SPECIFICATIONS

BRIDGEWIRE RESISTANCE RANGE: 0.10 to 10.50 ohms (19-volt maximum DUT voltage)

TEST CURRENT: 10 to 2000 milliamps

CURRENT RESOLUTION: 38 μamps constant current power supply resolution (set in 1 milliamp increments)

CURRENT ACCURACY: Less than 0.5% $\pm$190 μamps error over operating temperature

TEST PULSE DURATION: 4 to 250 milliseconds

DATA CAPTURE RESOLUTION: 32-bit resolution over 5-volt full scale range with variable data acquisition input gains ranging from 0.2x to 104x

GAIN DETERMINATION CURRENT (PRE-PULSE CURRENT): <5 milliamps

DATA CAPTURE RATE: 15,625 kSPS (one sample every 64 microseconds)

COLD RESISTANCE ACCURACY: Less than 1% $\pm$190 μohms error over operating temperature

TOTAL NOISE: Less than 3 millivolts p-p at output at minimum gain. Less than 100 μvolts p-p at higher gains.

ANALOG OUTPUT RESOLUTION: 16-bit resolution over full scale of -3.0 volts to 3.0 volts

ANALOG OUTPUT GAIN: 0 to 500x (May be set to other values via software user interface)

TEST START TRIGGER: Command input from user to start test. TTL level pulse, 15 milliseconds minimum, via a BNC connector or software triggered via software user interface.

SYNC OUT (SWEEP START TRIGGER): TTL output, nominal 1 millisecond, via a BNC connector to trigger oscilloscope sweep prior to start of EED characteristic pulse.

INPUT POWER:	105 to 125 VAC, 50-60 Hz, 10 Amps (max) 210 to 250 VAC, 50-60 Hz, 5 Amps (max) (option)
TEMPERATURE:	Operating: 15C to +35C Storage: -40C to +70C
COOLING:	Fan
DIMENSIONS:	11.23"W x 8.54"H x 7.93"D.
WEIGHT:	18 lbs (approx) net. 34 lbs (approx) shipping
ACCESSORIES:	AC power cord, EED Training cable, EED Test cable, Reference bridgewire RB101, Installation, Operation, and Maintenance Manuals

A word about safety . . . . .

Thermal transient testing involves the application of precise, controlled test signals to the device under test. The nondestructive aspects of the test, and the safety implied, are closely related to the magnitude of the test signals and the characteristics of the test item.

As in any test involving potentially hazardous material, an element of danger is present when an EED is subjected to an electrical test signal. In the interest of safety, it is recommended that those using the equipment described herein thoroughly familiarize themselves with the contents of this manual prior to testing hazardous devices. In addition, hazardous test items should be placed in appropriate fixtures and protective enclosures (test chamber, barrier, etc.) during the time test signals are being applied.

PASADENA SCIENTIFIC INDUSTRIES

WARRANTY

Model 730 Thermal Transient Test Set is warranted against defects in materials and workmanship for one year from date of shipment. Our obligation is limited to repairing or replacing parts which prove to be defective during the warranty period. No other warranty is expressed or implied. We are not liable for consequential damages.

How to contact PSI

You may phone us at 717-227-1220 or FAX us at 717-227-2129.

https://www.pasadenascientific.com/contact-us

You may also send a letter detailing your comments to:

Pasadena Scientific LLC
1418 Gunston Road
Bel Air, Maryland 21015, USA

Please include a daytime and an evening phone number in case we need to call you for more information.

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SECTION I

THERMAL TRANSIENT TEST

1.1 Introduction

The use of electro-explosive devices (EED's) in military, aerospace, and many commercial applications necessitates a high degree of reliability at a high level of confidence in each item. Commonly employed testing techniques rely heavily on destructive techniques. The thermal transient test is a nondestructive technique for inspection of the critical bridgewire -explosive interface. In essence, the test allows one to "look" inside the EED nondestructively and determine if certain failure conditions and/or abnormalities are present.

In addition to the nondestructive testing aspects, the thermal transient test offers unique and significant advantages for EED characterization. The test is particularly well-suited for quality assurance, development, and production control applications.

1.2 Test Concept

Application of a current to a hot bridgewire type EED causes the bridgewire temperature to increase. Some of this energy is dissipated from the bridgewire to surrounding explosive material. The temperature rise is accompanied by a corresponding increase in the resistance of the bridgewire material (it is important that the bridgewire material have a reasonable temperature coefficient of resistance [TCR]). By carefully controlling and limiting the amplitude and duration of the current pulse, so that no chemical change of the explosive material occurs, the EED will return to ambient temperature at the end of the pulse with no discernible permanent change. The pulse magnitude is selected to stress the bridgewire-explosive interface to the extent that its latent thermal characteristics become responsive. Pulse duration is chosen to produce thermal equilibrium at the interface. The rate at which the bridgewire changes, and the maximum value of change, are determined by the interface characteristics. The signals generated by the changes are displayed on an oscilloscope for observation and analysis.

1.3 Test Capabilities

EED nondestructive test and measurement[2] capabilities include:

(a) Bridgewire weld quality
(b) Loading density
(c) Interface air gaps
(d) Explosive contamination
(e) Gas inclusion along bridgewire
(f) Thermal time constant
(g) Thermal capacity
(h) Bridgewire resistance
(i) Bridgewire temperature

SECTION II

DESCRIPTION – MODEL 730

2.1 General

The Model 730 is designed to facilitate thermal transient testing of EEDs across a wide range of test parameters, catering to the entirety of the EED market. It boasts industry-leading current capacity, load resistance range, data capture resolution, and minimal noise levels.

As the successor to the 630 Thermal Transient Test Set, the 730 not only surpasses the performance and specifications of the 630 but also enhances the user experience by introducing a touch screen interface, USB and network logging, and incorporating functionality for saving and loading test configurations.

2.2 Physical Description

The 730 Thermal Transient Test Set measures 11.23 inches wide by 8.54 inches tall by 7.93 inches deep. The test set can run as a stand-alone unit or be integrated into a production line via easy-to-use external IO trigger and feedback line. The front panel contains a 10.1” industrial touch screen display and one USB 3.0 port. Power and other cable connections are on the back panel.

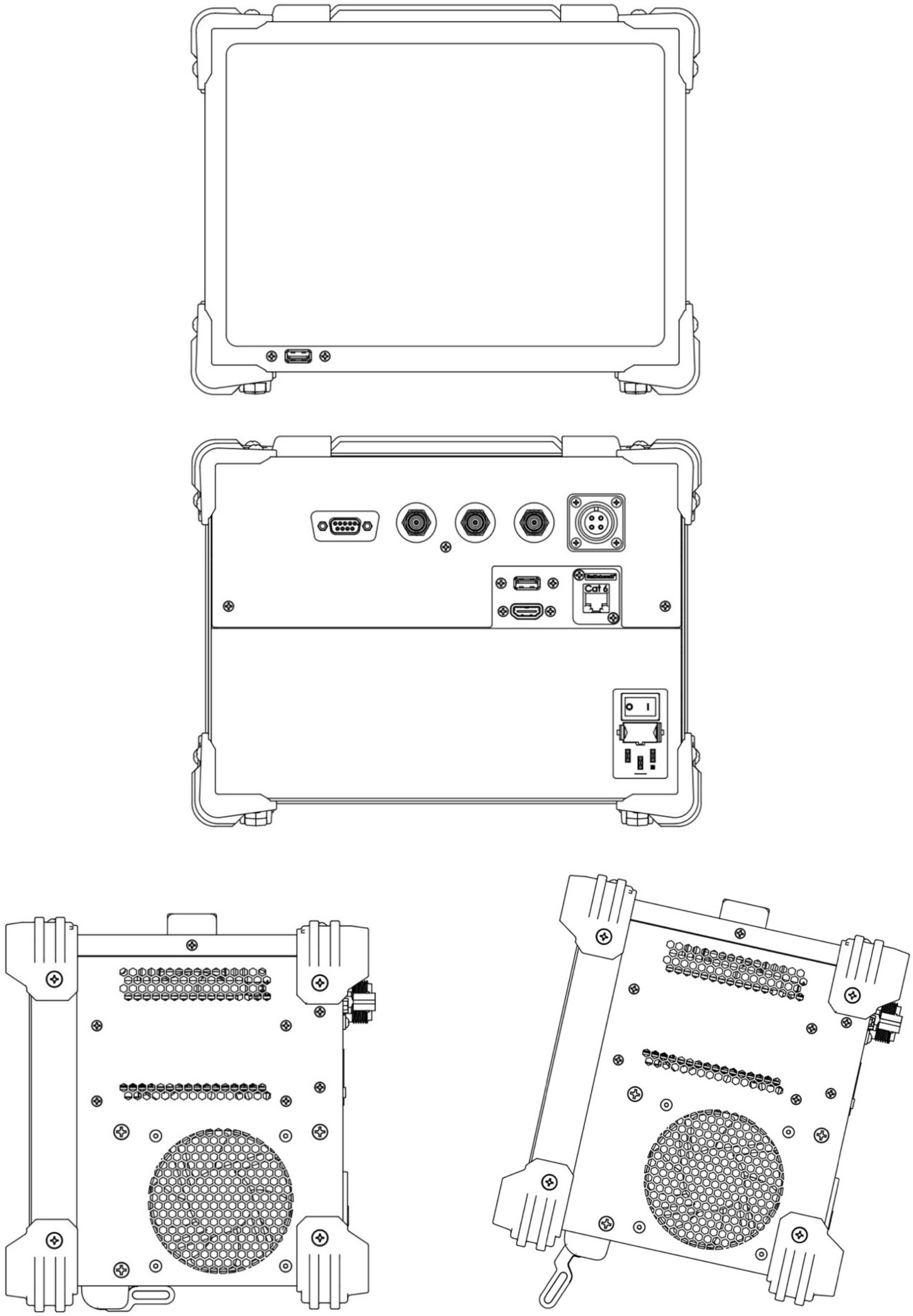

Figure 1 - Appearance of Model 730

2.3 Functional Description

The Model 730 Auto Nulling Thermal Transient Test Set is a digitally controlled measurement system designed to produce a high-quality, digitized waveform representing the change in resistance of a bridgewire device as it heats during a constant current pulse. This waveform is displayed on the main screen and a scaled Digital-to-Analog Converter (DAC) recreation of the waveform is accessible through an output BNC connector on the back panel.

When a trigger command is received, a test sequence is initiated comprising of several constant current pulses: the pre-pulses and the test pulse. The pre-pulses are used to determine a coarse measurement of the cold resistance of the Device Under Test (DUT). This measurement is crucial for determining a gain value for the test pulse, allowing for the full utilization of the dynamic range of the Analog-to-Digital Converter (ADC). The cold resistance measurement obtained from the pre-pulses is considered coarse due to the low amplitude of the pre-pulses and the conservative ADC gain value required to measure across the entire resistance range of the 730.

The pre-pulse actually consists of two ultra-low amplitude current pulses. The Pre-Pulse Currents are one milliamp and two milliamps, which should induce no measurable heating (resistance change) within typical DUTs. Each of the two pre-pulses has a duration of 20 milliseconds, enabling the digitization of a 16.7-millisecond dataset that is then averaged, canceling any ambient or bleed-through 60Hz noise.

Furthermore, the cold resistance is checked against the Test Resistance and Test Resistance Tolerance to ensure that the test pulse is not applied to DUTs outside the expected resistance value range.

Once the gain value is selected, the test pulse (of the desired test current and duration) is initiated and digitized. The digitized data contains both the thermal transient and isothermal response of the DUT. The isothermal response is equal to the cold resistance multiplied by the Test Current, so a high-resolution cold resistance is determined by extrapolation of the initial slope of the waveform. This cold resistance is then utilized to nullify the isothermal response, revealing the thermal transient characteristic response.

The characteristic response is further processed to ascertain the properties of the EED and is evaluated against the pass/fail criteria. The waveform and calculated results are then displayed on the screen, logged, and recreated via the analog output DAC. Finally, the external IO are pulsed indicating the status of the test.

2.4 Simplified System Schematic

A simplified system schematic for the 730 test circuit is shown below.

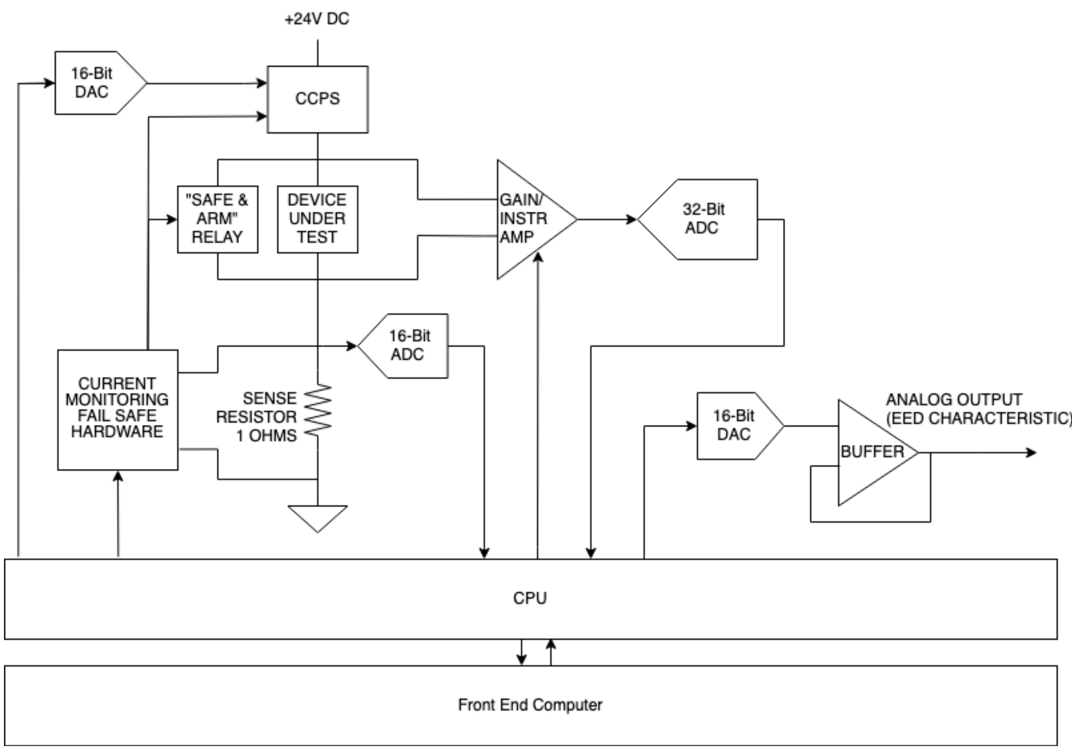

Figure 2 - Simplified 730 Test System Schematic

2.5 Hardware Safety Features

The 730 is equipped with robust hardware safety features, including an EED-shorting "Safe and Arm" relay, current feedback fail-safe, and overvoltage protection for the acquisition system.

The "TO EED" connector terminals are effectively shorted by a normally closed "Safe and Arm" relay. This relay eliminates any potential difference between the EED terminals outside of the test sequence, with the short momentarily lifted during the application of pre-pulse and test currents.

The current feedback fail-safe introduces an additional layer of protection through the integration of a dedicated 16-bit DAC. This component serves the specific purpose of establishing a "high current" threshold. Set slightly above the desired current across the CCPS sense resistor, the dynamic threshold is continually compared against the actual voltage across the CCPS sense resistors. If the sense resistor voltage surpasses the fail-safe DAC setting, the EED relay is promptly shorted, and the CCPS DAC is deactivated.

This hardware-based safety mechanism operates independently of software, ensuring that the desired test current is never significantly exceeded once set.

The data acquisition overvoltage protection circuitry is designed to safeguard the (low voltage) data acquisition system, regardless of the gain or voltage across the EED. This protection is crucial, particularly in scenarios where no EED is connected during test initiation, in the presence of extreme thermal transient rise, or incorrectly set Expected Thermal Transient Rise.

SECTION III

INSTALLATION

3.1 General

The 730 is designed for both bench/table top use as well as automated production line use. The 730 is capable of testing up to one device per second. Installation consists of placing the instrument at a suitable operating position and making the cable interconnections to the AC power source and the device under test (including user-supplied test fixtures).

Optional additional connections include:

- USB Storage for logging
- Ethernet Cable for network logging
- Keyboard and Mouse
- HDMI Cable for external display (replaces touch screen)
- A control device for automated testing
- Oscilloscope or other data capture hardware

3.2 Cable Connections

Figure 3 – Rear panel Overview

1. 115V 60HZ POWER Connector - Three-pin connector (J1) for AC power cord.

2. EED Connector - The device under test is connected to the 730 Test Set through the EED cable at the "TO EED" connector (J2) on the back panel. Both cable shields must be electrically insulated from each other and from ground. The EED terminals are normally shorted by relay (K202) on the CCPS board as a safety measure. The short circuit is removed when either the null or test current circuit is activated.

3. EED CHARACTERISTIC OUT Connector - BNC type coaxial connector (J5), on the rear panel connects to an oscilloscope or other capture hardware by means of BNC coaxial cable assembly.

4. SYNC OUTPUT Connector - BNC type coaxial connector (J6) on the rear panel connects the 730 to the trigger input of an oscilloscope or other capture hardware by means of a BNC coaxial cable assembly.

5. COMMAND TRIGGER INPUT Connector - BNC type coaxial connector (J4) on the rear panel provides a means for applying the Command Trigger to the test set.

6. TEST COMPLETE OUTPUT Connector - BNC type coaxial connector (J3) on the rear panel provides access to the Test Complete pulse.

7. TEST FAIL OUTPUT Connector - BNC type coaxial connector (J3) on the rear panel provides access to the Test Fail pulse.

8. PART FAIL OUTPUT Connector - BNC type coaxial connector (J3) on the rear panel provides access to the Part Fail Output signal.

9. PART PASS OUTPUT Connector - BNC type coaxial connector (J3) on the rear panel provides access to the Part Pass Output signal.

10. HDMI Connector – Standard HDMI output is supported, however the 730 must be power cycled in order to switch between the primary touch screen and HDMI input. A USB mouse need to be used in leu of the Touch while using an external display.

11. USB 3.0 (2X) – Two USB 3.0 ports are conveniently located on the front and rear of the 730 for connecting USB storage devices for log and configuration files. The USB ports can also be used for connecting a keyboard and mouse. If additional USB ports are required, USB hub connection is supported, however it is not advised to connect high power USB devices or connection of non-test related devices (such as charging of mobile phones).

12. Ethernet – standard networking is supported via the ethernet port for network logging. NOTE: Although network security precautions have been taken in the design of the 730, connection of this device to the internet could pose a security threat to sensitive

networks. It is recommended that an IT professional be involved when setting up the Ethernet related functionalities of this product.

3.3 Test Fixtures

User-fabricated or sourced test fixtures designed to accommodate the particular test components will usually improve the efficiency and safety of the test procedure.

AS A SAFETY MEASURE WE STRONGLY RECOMMEND THAT TEST ITEMS BE PLACED IN A SUITABLE TEST CHAMBER DURING TESTS.

User-supplied test fixtures should include provisions for electrically disconnecting the device under test from the 730 "TO EED" connector terminals and shorting, and grounding, the bridgewire leads except during the application of balancing and test currents. It should be repeated that the 730 "TO EED" connector terminals are shorted by "Safe and Arm" relay of the CCPS; the short is removed during the time the pre-pulse and test currents are applied.

3.4 730 EED Cable

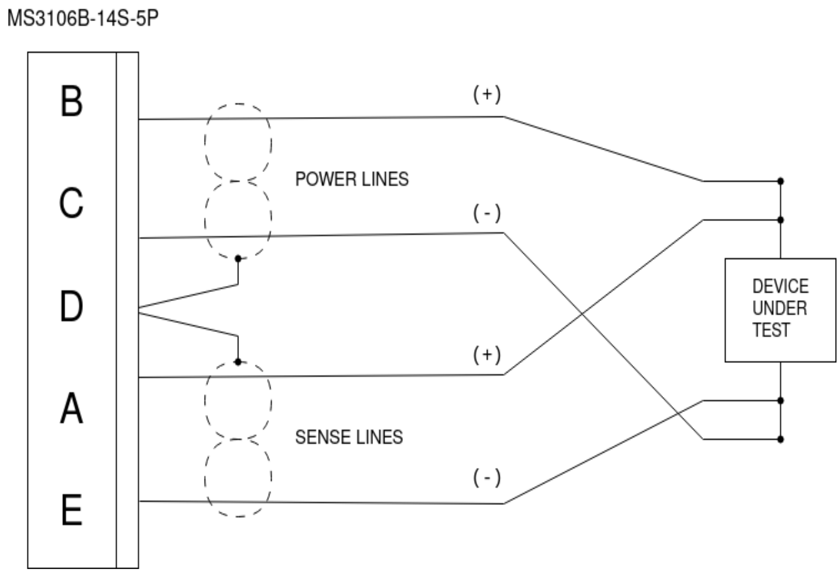

Figure 4 - EED Cable

The test involves relatively low level and high impedance signals (on the order of a few millivolts in some cases). Electrical noise from external sources will seriously degrade the data waveforms. In order to minimize stray noise entering the system via the cable connecting the 730 and the DUT, careful attention must be given to the cable details. It is required that a high-quality 4-wire Kelvin connection is made to the DUT in order for the 730 to perform to the datasheet specifications. Test lead resistance for 2-wire measurements and contact resistance from poorly made connections will add significant error to the 730 measurements.

The 730 is supplied with a two EED cables, a fully terminated Training Cable and a partially terminated EED Cable. It is highly recommended that a custom cable is made by terminating the provided EED cable (as per Figure 4) with a high-quality connection that is custom to your process. High quality binding posts, terminals, switches, etc., are essential for low-noise test signals. Alligator clips and similar devices should be avoided. The provided EED cable has operated extremely well over distances in excess of 10 feet. Cable installations meeting these general requirements should work satisfactorily. Shields should be allowed to float at the EED end of the cable.

The Training Cable enables the 730 to be used immediately out of the box, however care must be taken when using the training cable to ensure that the 4-wire Kelvin measurement is preserved. This can be accomplished by separating the two connectors at the end of the training cable and attaching extension leads such that the Sense and Power lines (+) and (-) pairs connect properly as close to the DUT as possible.

SECTION IV

OPERATING INSTRUCTIONS

4.1 QUICKSTART

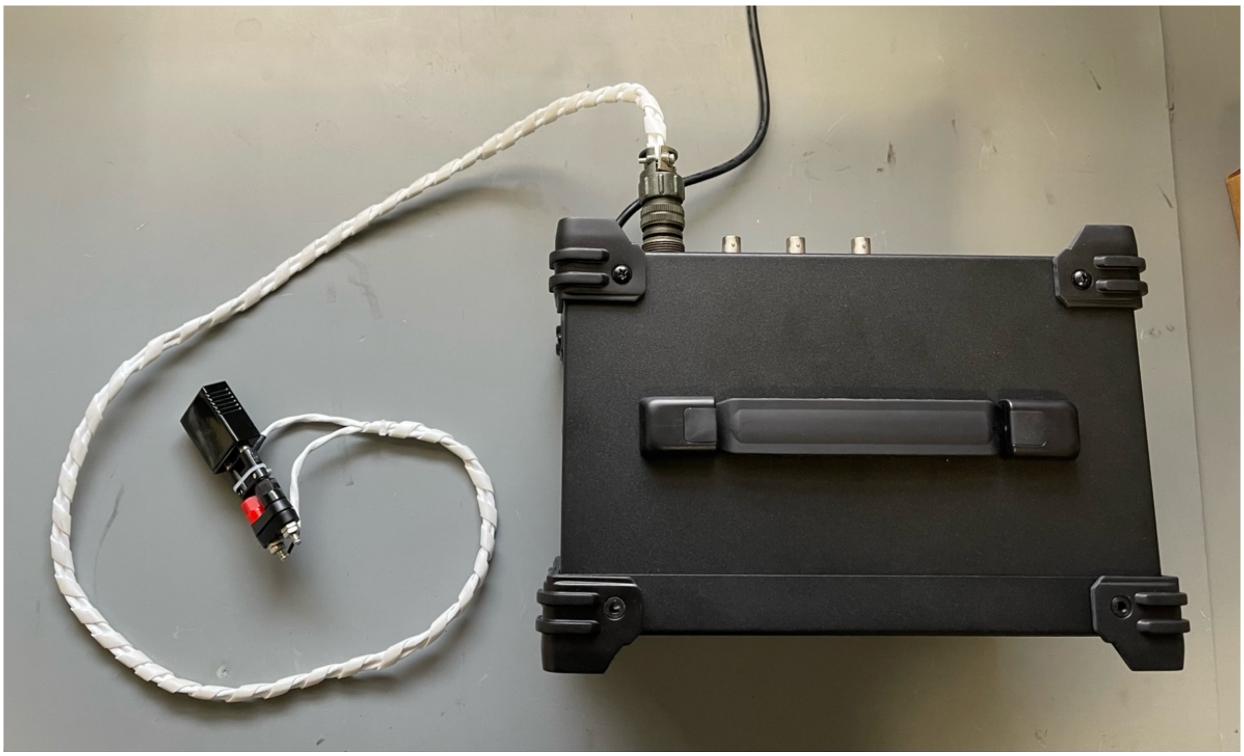

Figure 5 – RB101 Quickstart Connections

For indoctrination purposes Reference Bridgewire RB101 can be used as the device under test and connected via the included EED Training Cable. The RB101 is a thermally responsive resistor network whose electrothermal behavior is comparable to typical EED's. A full description of the RB101 will be found in Appendix A.

A QuickStart test can be performed by connecting RB101 via the EED Training Cable, loading the 730 Default Parameters, and pressing “Test” on the Home screen. Note that your results may vary slightly from Figure 6 as there is part to part variation across RB101s.

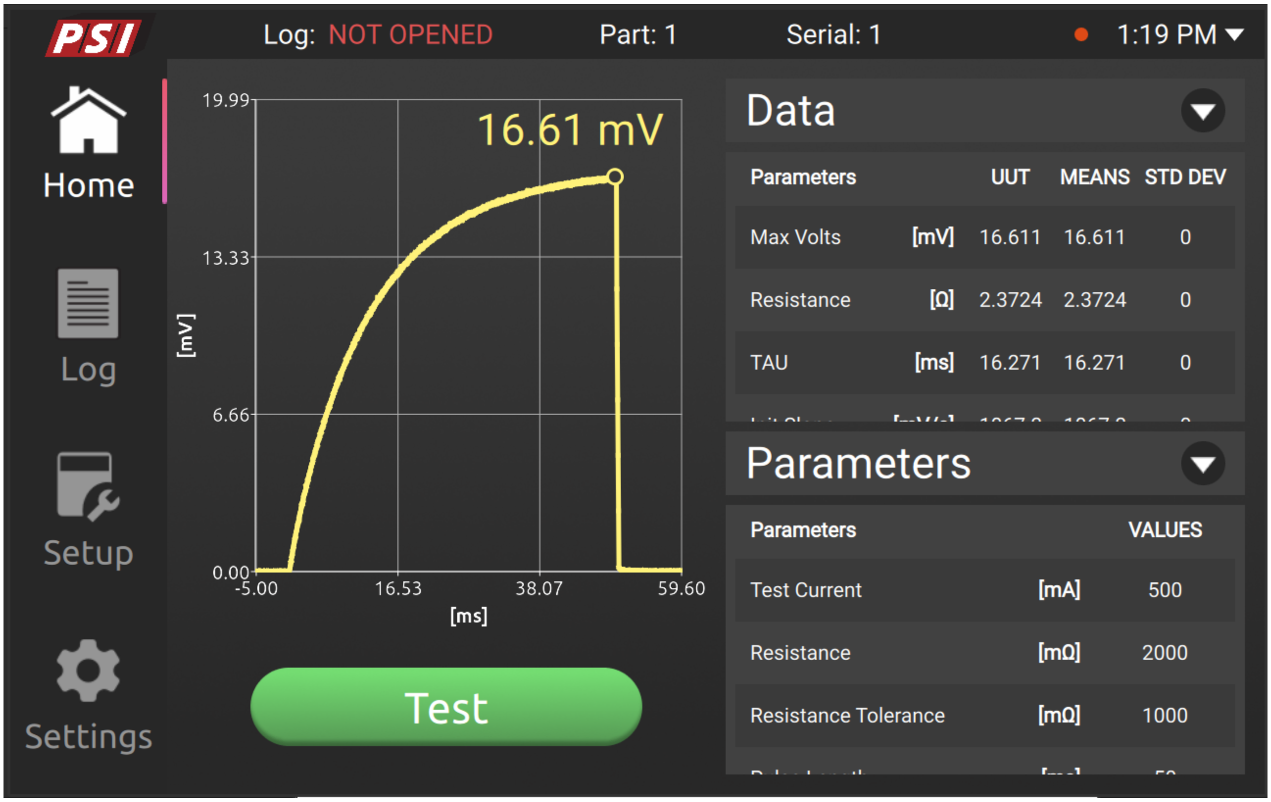

Figure 6 - RB101 Tested Under Default Parameters

4.2 Description of Signal Interface

INPUTS -

COMMAND TRIGGER

The primary method to initiate a test is through the "TEST" button on the touchscreen display. Alternatively, a positive TTL level pulse can be applied to the "COMMAND INPUT TRIGGER" BNC (J4), with a minimum pulse width of 15 milliseconds. The COMMAND INPUT TRIGGER undergoes software-based debouncing and must return to a Low Logic State before subsequent tests can be initiated.

It's important to note that the COMMAND INPUT TRIGGER is a "soft" request, and it will not trigger a test unless the GUI software is in a "Ready" state. For users preferring a mechanical Test Start button, Pasadena Scientific offers an External Trigger Box (available for separate purchase).

OUTPUTS -

TEST COMPLETE (J3 - Pins 9 and 4)

Opto-Isolated (ILQ74) gate used for external interfacing. Gate closes for 50 milliseconds immediately after a successful test.

TEST FAIL (J3 - Pins 8 and 3)

Opto-Isolated (ILQ74) gate used for external interfacing. Gate closes for 50 milliseconds follows immediately after a test sequence that has encountered an error. Possible causes include:

Resistance Out of Range/Tolerance
ADC Saturation
No EED Installed
Some types of squib anomalies

PART PASS OUTPUT (J3 - Pins 7 and 2)

Opto-Isolated (ILQ74) gate used for external interfacing. Gate closes for 50 milliseconds (synchronized with TEST COMPLETE) when Pass/Fail analysis is enabled and the part just tested has passed all enabled evaluation criteria.

PART FAIL OUTPUT (J3 - Pins 6 and 1)

Opto-Isolated (ILQ74) gate used for external interfacing. Gate closes for 50 milliseconds (synchronized with TEST COMPLETE) when Pass/Fail analysis is enabled and the part just tested has failed one or more enabled evaluation criteria.

SYNC OUTPUT (J6)

A positive-going TTL level pulse, one millisecond in width, is accessible for initiating the oscilloscope sweep or opening the data capture window. This pulse precedes the onset of the Characteristic Pulse by 5 milliseconds.

NOTE: The BNC shell (SYNC OUTPUT ground) is electrically connected to the 730 chassis and, consequently, to the earth ground. During the period when SYNC OUTPUT is actively transmitting a signal, an internal relay is activated to connect the chassis ground with the analog ground. This design feature ensures precise grounding alignment and stability between the 730 and the external data capture system while the SYNC OUTPUT is active. It also effectively isolates the 730's sensitive electronics during the test procedure and system setup, contributing to overall system reliability.

CHARACTERISTIC OUTPUT (J5)

Analog representation of the heating of the squib bridgewire during the test pulse (when enabled). Width equals width of test pulse. 16-bit resolution over amplitude range of -3.0v to 3.0v. The default gain value is set at 100x, and users have the flexibility to adjust the gain value through the GUI Settings Tab.

NOTE: The BNC shell (CHARACTERISTIC OUTPUT ground) is electrically connected to the 730 chassis and, consequently, to the earth ground. During the period when CHARACTERISTIC OUTPUT is actively transmitting a signal, an internal relay is activated to connect the chassis ground with the analog ground. This design feature ensures precise grounding alignment and stability between the 730 and the external data capture system while the CHARACTERISTIC OUTPUT is active. It also effectively isolates the 730's sensitive electronics during the test procedure and system setup, contributing to overall system reliability.

4.3 Parameter Selection

This screen depicts the 'Parameters' table, which is visible on the Home page. Users can modify values for each parameter by selecting the 'Value' column in the corresponding row.

For instance, selecting the value field for 'Test Current' prompts the appearance of a dialog (refer to Figure 8). In this dialog, users can enter the 'Test Current' value within the specified range provided below the text field.

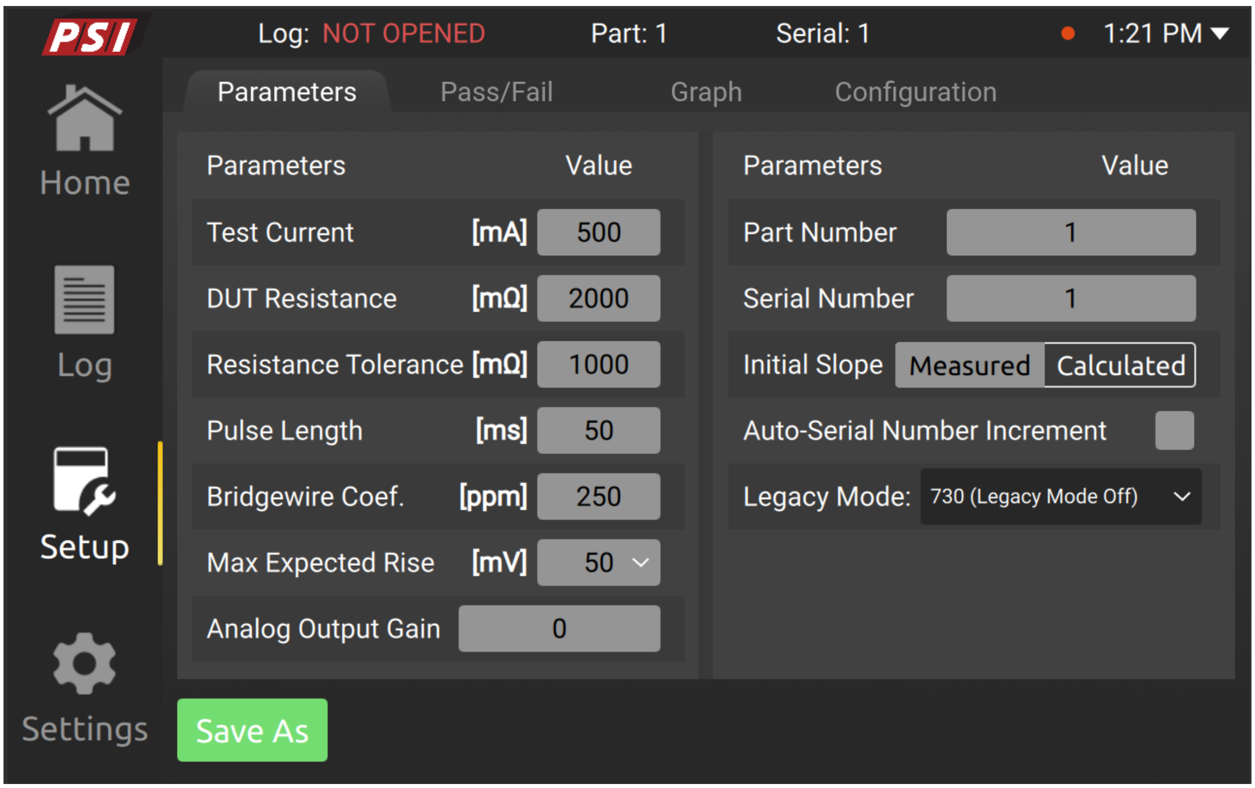

Figure 7 – Parameters tab of the Setup page

All settings can be reset to their default values in the 'Settings' tab, see Section 5.3.1 General.

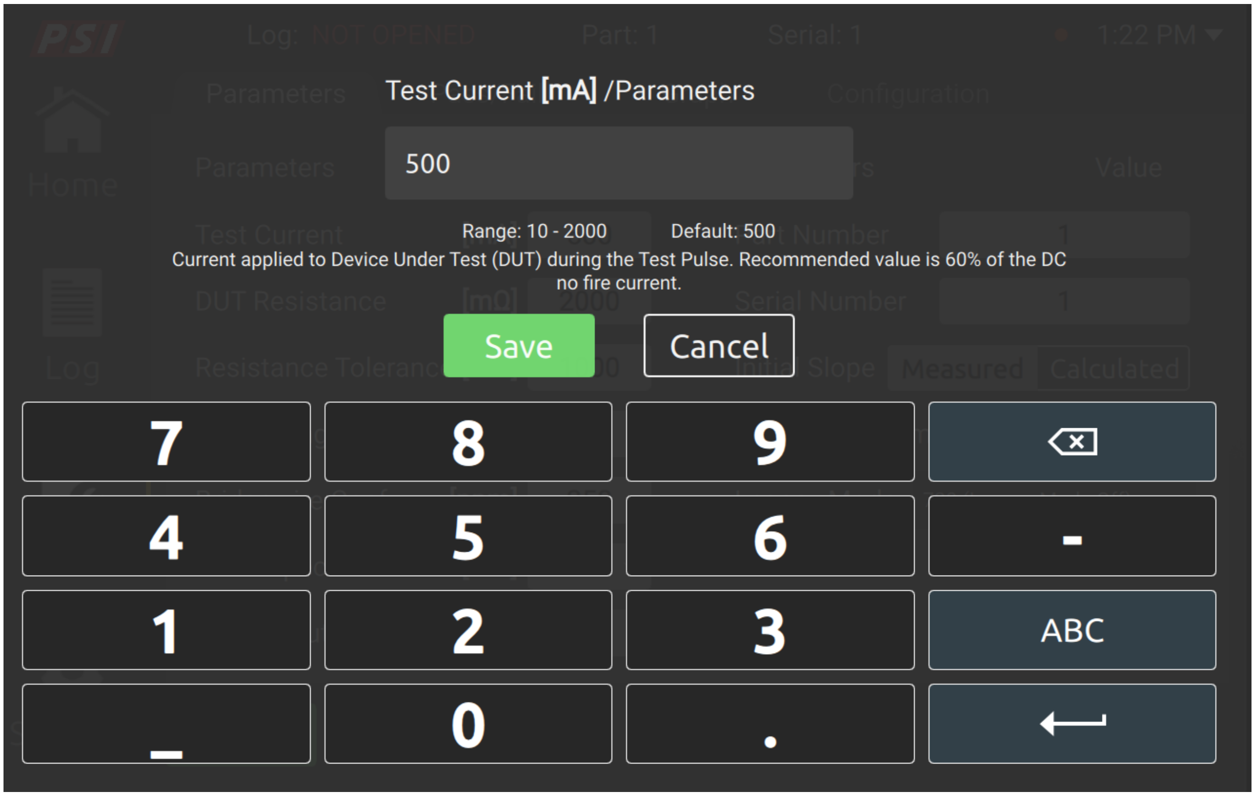

Figure 8 – Illustration of Adjust Parameters screen

4.3.1 Test Current/EED Resistance

The 730 is capable of providing 2,000 milliampere (maximum) constant current test pulses to a load of 0.10 to 10.50 ohms. Loads in the range of 9.0 to 10.5 ohms require reduced maximum test current in order to maintain a maximum EED voltage equal to or less than 19v.

4.3.2 Selection of Test Current Level

The nondestructive aspects of the thermal transient test, and the safety implied, are related to the magnitude of the test current. Since bridgewire temperature is a function of bridgewire current (and time), limiting the current to a safe magnitude is of utmost importance. Obviously, the bridgewire temperature must be held to a value less than the ignition temperature of the explosive mixture. In practice, it is customary to limit the temperature rise at the bridgewire-explosive interface to a maximum of 100C above ambient during the thermal transient test. Either of two approaches may be used in holding the temperature to a safe level.

If the DC no-fire current value of a given design has been established (via functional destructive testing), one approach is to limit the thermal transient test current to approximately 60% of the DC no-fire current.

Another approach may be used if the DC no-fire current level has not been established. This method involves calculating bridgewire temperature based on the signal developed across the bridgewire when the bridgewire is pulsed with a known current, and the Temperature Coefficient of Resistivity of the bridgewire material is also known. (See Application Note 3 (Theory Book) "Calculation of Electrothermal Parameters"). In this instance the test current level is limited to a value resulting in a temperature rise of 100C, maximum.

The thermal transient test concept requires that the bridgewire material have a “reasonable” Temperature Coefficient of Resistivity (TCR), and that the TCR be known in order to generate a useful signal. Bridgewire materials having TCR's greater than about 50 parts per million/C generally yield satisfactory signals at acceptable bridgewire temperatures. TCR's much less than 50 ppm/EC probably will require dangerously high bridgewire temperatures (above the 100C figure) in order to generate a meaningful response.

4.3.3 Selection of Test Pulse Duration

Test current is generally applied to the device-under-test for a period of time sufficient for the bridgewire-explosive interface to reach thermal equilibrium. This usually requires several time constants. (Refer to Application Note 3 (Theory Book) for Time Constant calculation). The 730 series Thermal Transient Test Sets are capable of generating current pulses of less than 4 milliseconds to 250 milliseconds. Time constants of aerospace and military devices are typically in the range of 3 to 20 milliseconds, with low energy devices under 3 milliseconds. If the current pulse is too short (terminated before thermal equilibrium is reached) valuable thermal information may be missed since thermally induced abnormalities (bridgewire movement, air gaps, etc.) usually occur late in the thermal response cycle.

4.3.4 Selection of Resistance Tolerance

The Resistance Tolerance is a non-essential but safety-critical parameter utilized to preemptively halt a test sequence in the event the EED resistance is determined to be outside of the specified tolerance by the Pre-Pulse measurement. This precautionary measure prevents the application of the larger Test Current across an EED that falls outside the specified resistance tolerance.

4.3.5 Selection of Bridgewire Coefficient

The Bridgewire Coefficient setting is set to the temperature coefficient of resistance (TCR) of the bridgewire, a material property necessary for calculating Thermal Capacitance, Temperature Rise, and Heat Loss results. This value is typically found on the bridgewire material datasheet or can be obtained by contacting the material supplier.

In cases where the TCR is unknown, users can select the "Unknown" checkbox, resulting in the exclusion of Thermal Capacitance, Temperature Rise, and Heat Loss Calculations.

The thermal transient test concept requires that the bridgewire material have a “reasonable” Temperature Coefficient of Resistivity (TCR), and that the TCR be known in order to generate a useful signal. Bridgewire materials having TCR's greater than about 50 parts per million/C generally yield satisfactory signals at acceptable bridgewire temperatures. TCR's much less than 50 ppm/EC probably will require dangerously high bridgewire temperatures (above the 100C figure) in order to generate a meaningful response.

4.3.6 Selection of Maximum Expected Rise

The Maximum Expected Rise setting is crucial during the gain selection of the data acquisition system to ensure ample headroom for the otherwise unknown thermal rise. For example, a higher gain can be selected for low-energy devices, given a low expected resistive change, resulting in improved noise suppression.

If the expected thermal transient rise is unknown, it is recommended to set this value to the maximum setting for the first test. Then, reduce the Maximum Expected Rise setting to a value just above your measured Max Volts and retest the device. Note that the 730 software adds an additional 5% overhead to the Maximum Expected Rise value when calculating the acquisition gain.

Setting the Maximum Expected Rise to a value less than the actual thermal transient rise may result in ADC saturation. This will cause the test to be aborted but is otherwise not an issue.

4.3.7 Selection of Legacy Mode

"Legacy Modes" enable the 730 to replicate the results of previous generation test sets. This can be useful for comparative testing against legacy models or continuing testing with thresholds and standards established around these older models. All of the features of the 730 are still available while in Legacy Mode, which brings a huge benefit in the event one of these modes is used for more than just initial 730 comparison. A title above the graph on the home screen will indicate if the displayed results are legacy mode results. This field is also present in the log files.

4.3.8 Selection of Analog Output Gain

The Analog Output Gain is the scaling factor for the thermal transient analog output. The analog output is a Digital to Analog Converter (DAC) recreation of only the EED characteristic waveform. This feature preserves the analog output functionality of Pasadena Scientific's previous thermal transient test sets. The gain value set by this variable will scale the analog output in order to better utilize the full scale range of the DAC and the data capture system or oscilloscope reading the analog output. The DAC has a full scale output of -3.0V to 3.0V.

The gain value can be set to any decimal value between 0 and 500 with up to two digits of precision. The DAC and analog ground of the 730 are completely disconnected from the external BNC connector outside of the data transition window to avoid ground loops and protect the internal circuitry. This connection/disconnection is made by an internal relay and a slight audible chirp can be heard when the relay is closed.

The Analog Output Gain can be set to a value of "0" when the analog output is not in use. This will turn off the analog output completely, eliminating the chirp and shortening the test procedure cycle time.

4.4 PASS/FAIL Setup

4.4.1 General Pass/Fail Setup

The Pass/Fail tab enables users to specify evaluation criteria for Pass/Fail determination. Upon initiating a test, only the selected parameters will be assessed. A green mark is assigned to parameters within the allowed range in the Data table on the Home screen, while a red mark indicates that a parameter falls outside the specified range.

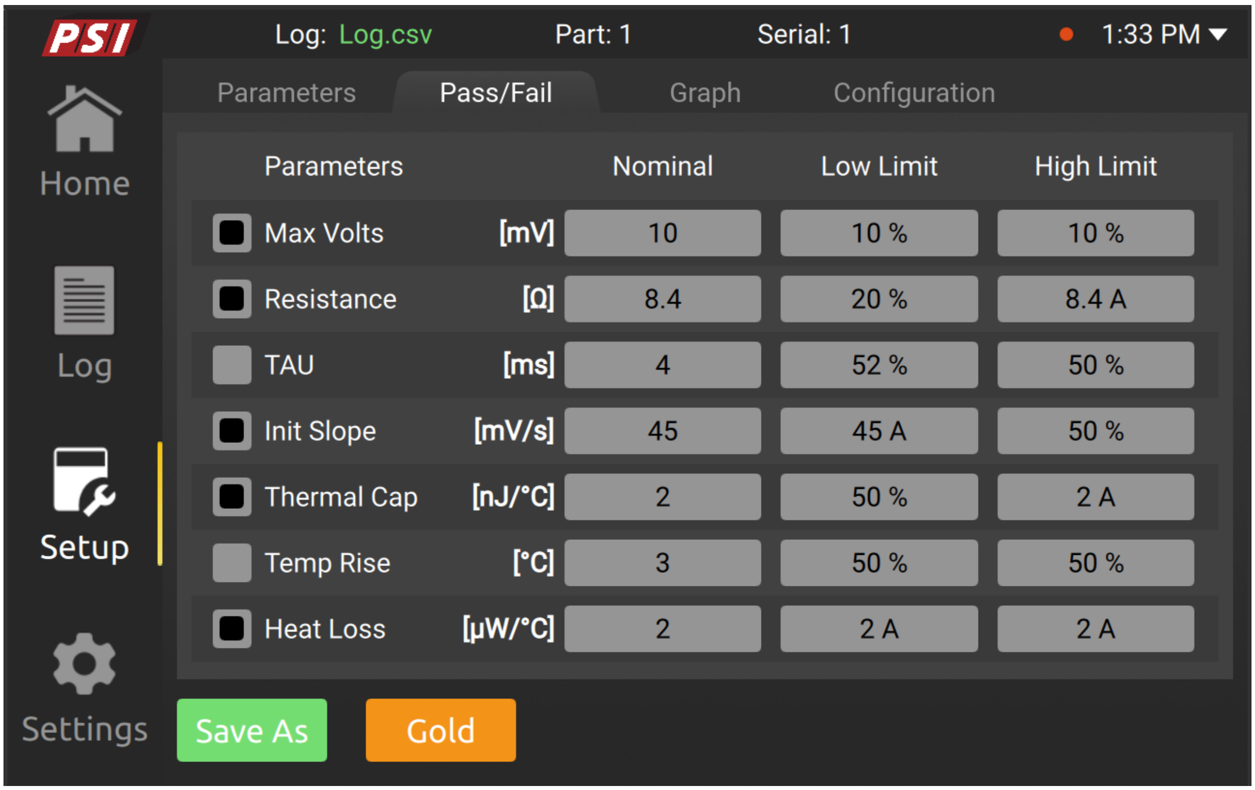

Figure 9 – Illustration of the Pass/Fail tab

Values within this tab can be configured as follows:

- **Clicking a value in the table**: Opens a dialog featuring a virtual keyboard and a predefined range for the respective value, allowing users to set the desired value. Notably, a drop-down menu allows users to choose between an absolute value or a percentage limit for the parameter under consideration.

In Figure 9, the Low and High limit columns denote either 'A' (for absolute values) or '%' (for percentage limits). The Nominal column is exclusively relevant when a percentage limit is selected in the corresponding Low/High limit column. For instance, if the high and low limits for a given parameter are set at 10%, the test will pass if the obtained value, falls within 10% higher or lower than the nominal value. The Nominal value is ignored in the case that both high and low limits are set to absolute values.

The 'Gold' button provides the option to import a Gold Standard file. When clicked, and a USB flash drive is detected, it triggers a popup displaying the contents of the USB (refer to Figure 10). Gold Standard files are simply user made log files containing test results of parts that are known to be good. Upon loading a Gold Standard, the nominal column is populated, and concurrently, data is also presented in the 'Graph' tab. The populated nominal values are an average of all tests within the loaded Gold Standard file.

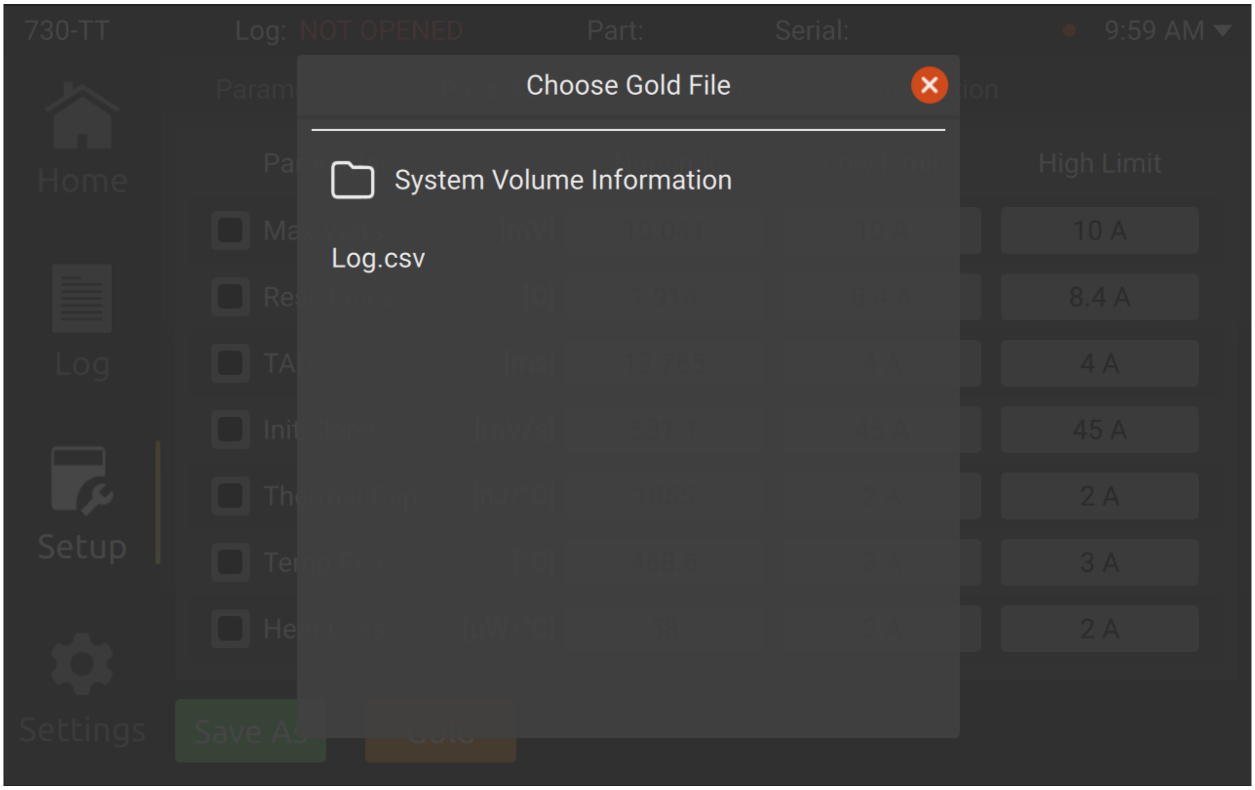

Figure 10 – Illustration of the popup for importing a Gold file

4.4.2 Pass/Fail Graph

The ‘Graph’ tab found on the Setup page allows the user to set Low and High waveform limits based on a nominal waveform loaded from a Gold Standard file. Users can load a Gold Standard waveform by clicking the 'Gold' button and selecting the desired file from the inserted USB flash drive. Once a Gold Standard file is opened, the yellow line will represent a point for point average of all waveforms within the Gold Standard file. The upper and lower limits will be plotted in green and offset be the specified percentage from the nominal yellow line. These green lines will also be added to the home screen graph and will change to red in the event that the line is crossed by a given test result.

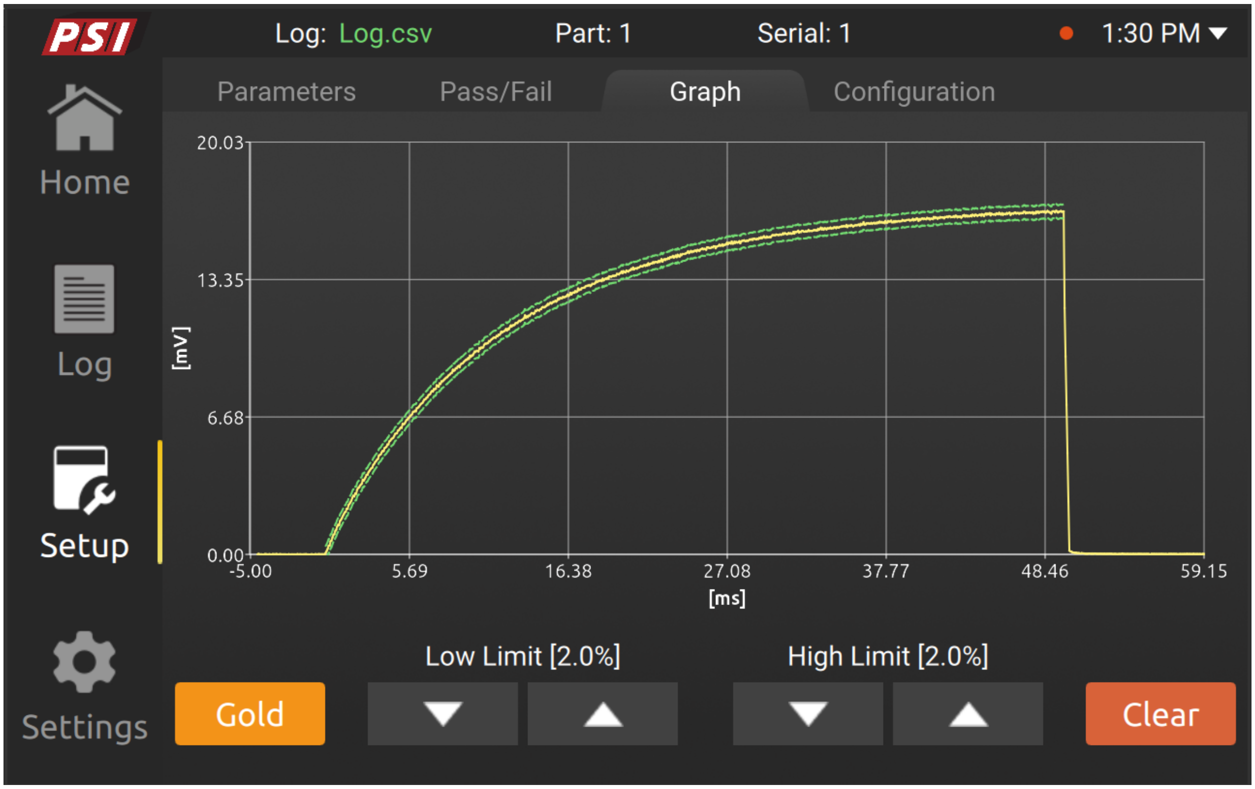

Figure 11 – Illustration of the Graph screen with imported Gold file

4.5 Configuration Files

A configuration file serves as a means for defined test parameters and pass/fail criteria to be save and loaded at a later time. This functionality enables users to quickly switch between previously defined tests to drastically shorten downtime when switching between DUT models. The configuration file contains key parameters such that all of the test inputs and pass/fail criteria at a given time can be easily recalled.

Figure 12 provides a visual representation of the Configuration tab within the Setup page.

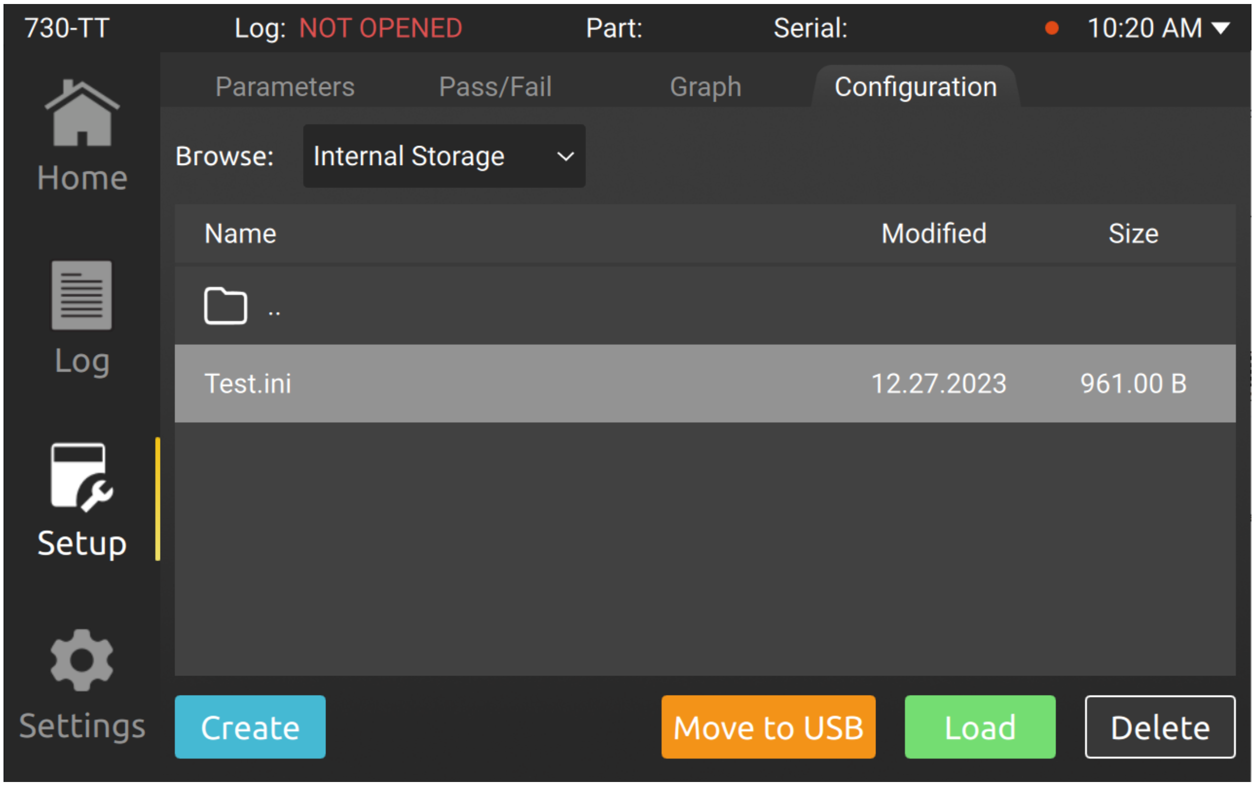

Figure 12 – Illustration of the Configuration tab with Internal Storage selected

This screen comprises the following elements:

- **'Browse' drop-down** – Allows users to choose between 'Internal Storage' and 'USB', depending on the location of the file for Move/Load/Delete operations.
- **'Create' button** – Initiates a popup window with a text field for naming new files.
- **'Load' button** – Loads the selected configuration file, applying it to every segment of the application, including the aforementioned tabs within the Setup menu.
- '**Delete' button** – Triggers a confirmation popup to confirm the deletion of the selected file.
- **'Move to USB' button** – Opens a popup displaying data from the USB, enabling users to select a location for moving the file (refer to Figure 13).

When 'USB' is selected in the 'Browse' drop-down, the 'Move to USB' button is replaced with a button labeled 'Move to Internal' (refer to Figure 12).

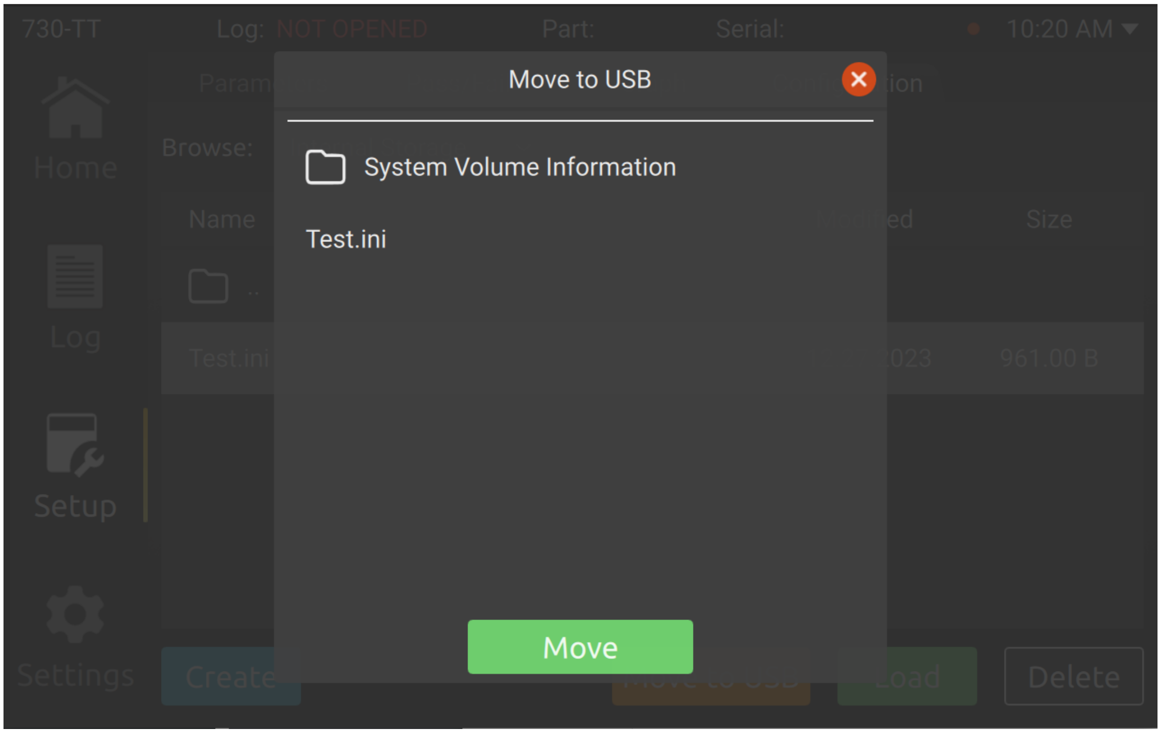

Figure 13 – Illustration of the popup for moving data to USB

- **'Save As'** – If parameters are updated on any of the Setup tabs, the updates can be saved by clicking on the 'Save As' button on the Parameters or Pass/fail tabs. Clicking this button opens the popup depicted in Figure 14, allowing users to select a location for saving the log file.

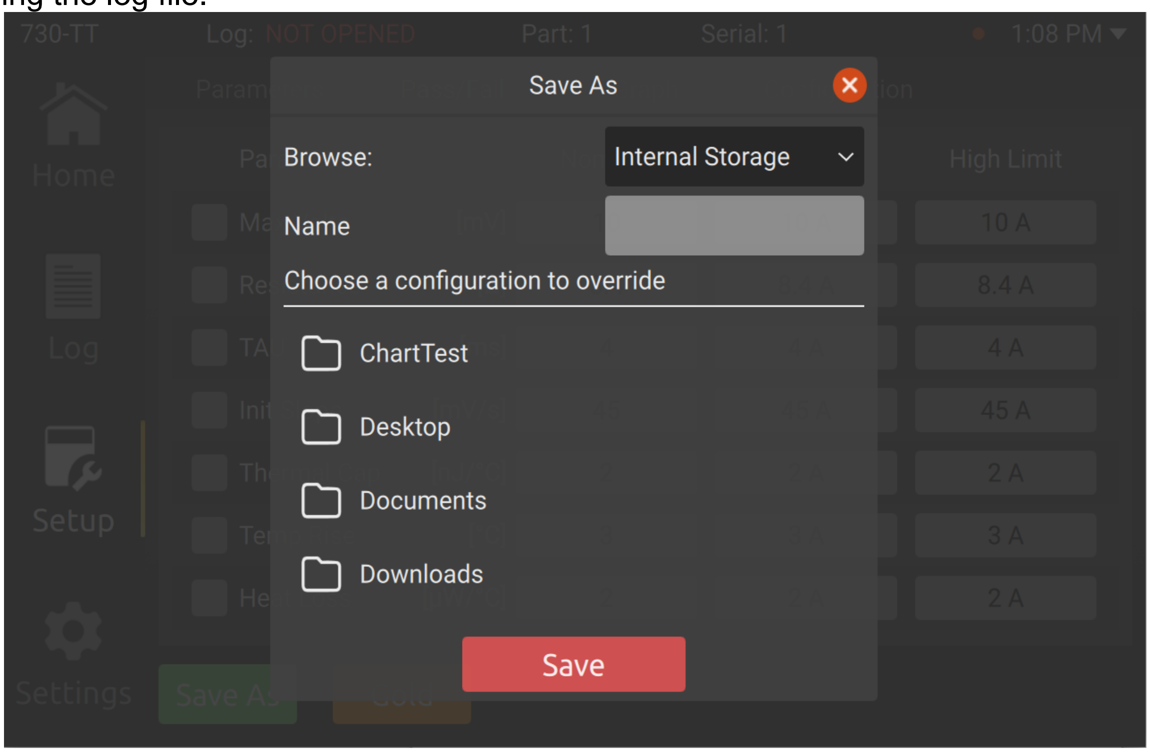

Figure 14 – Illustration of the popup for saving the Config file

4.6 Home screen

To be able to perform a test, the user must be familiar with the Home screen of the application:

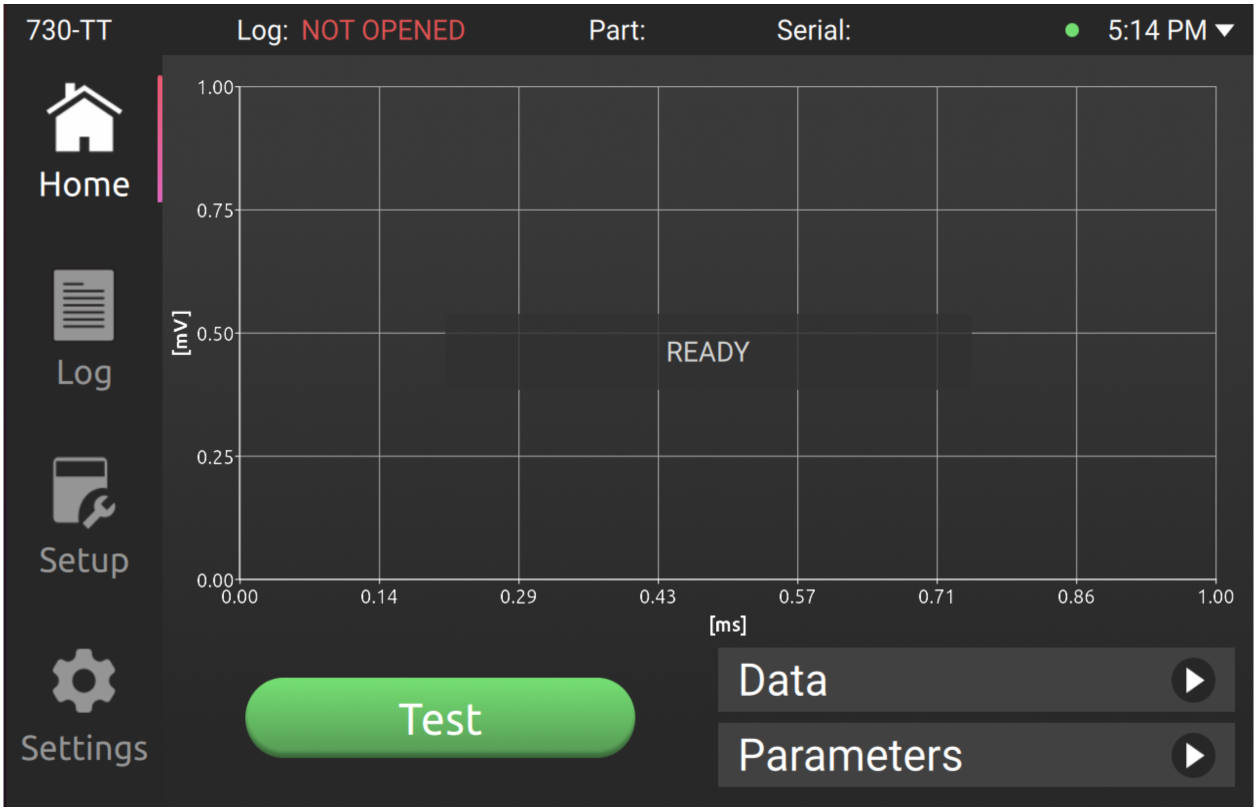

Figure 15 – Illustration of Home Screen – "Ready" state

The page features several key elements:

- **Graph** – This is a visual representation from the data acquired during the last test with units in millivolts vs milliseconds.
  - The graph can be navigated through using standard touch gestures – pinch to zoom and swipe to pan.
  - By tapping the ends of the axes a new screen will appear that allows precise values to be entered for the graph limits. (refer to Figure 16)
- **"Test" button** – By clicking this button, users can initiate a test.
- **"Data" and "Parameters" headers** – These headers serve as navigational elements for distinct tables. Clicking either header displays the corresponding table to the right of the screen, causing the graph to resize to the left.

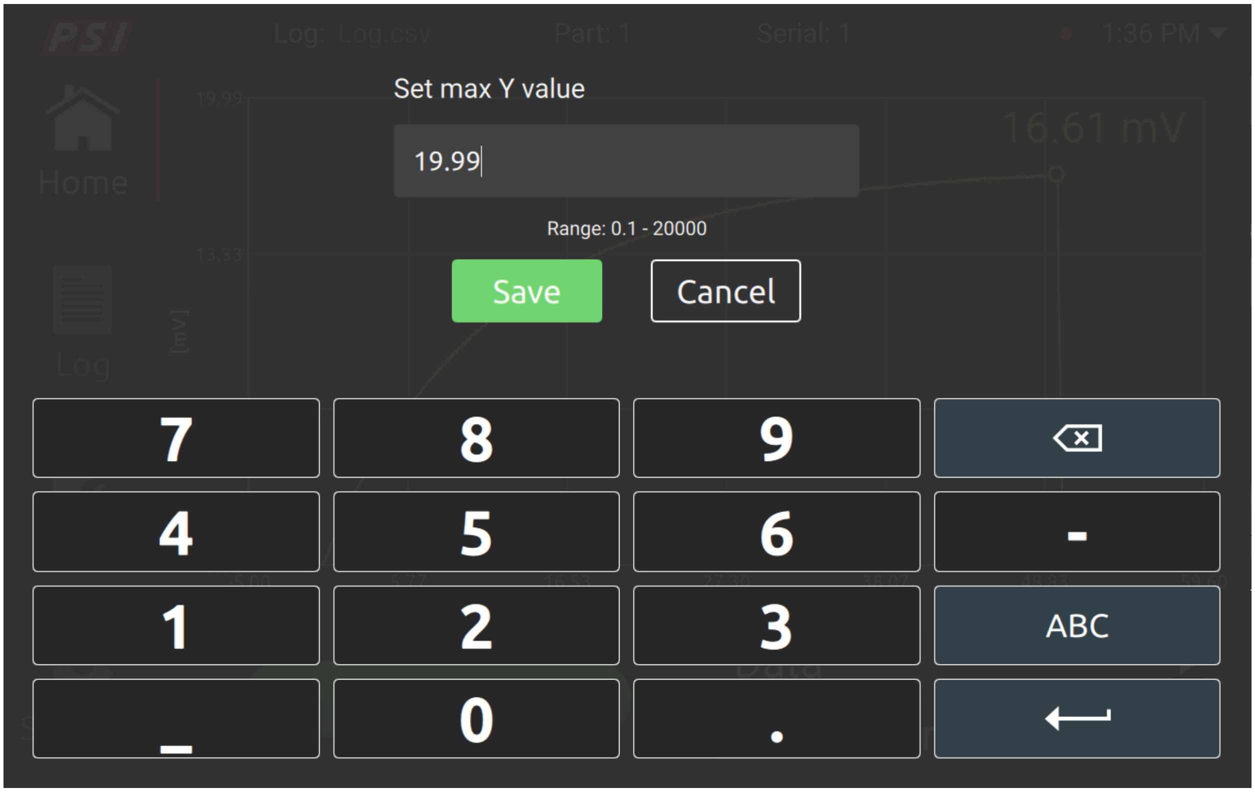

Figure 16 – Setting the graph limits

In the center of the screen, a popup message conveys the current system state, which can be one of the following:

- **"Ready"** – Signifying a successful connection to the MCU (refer to Figure 15).
- **"Internal communication error"** – Indicating a complication encountered while attempting to establish communication with the MCU (refer to Figure 18)."

In the 'Ready' state, users have the capability to press the 'Test' button. Subsequently, the test results are promptly displayed on the graph, providing a visual representation of the acquired data.

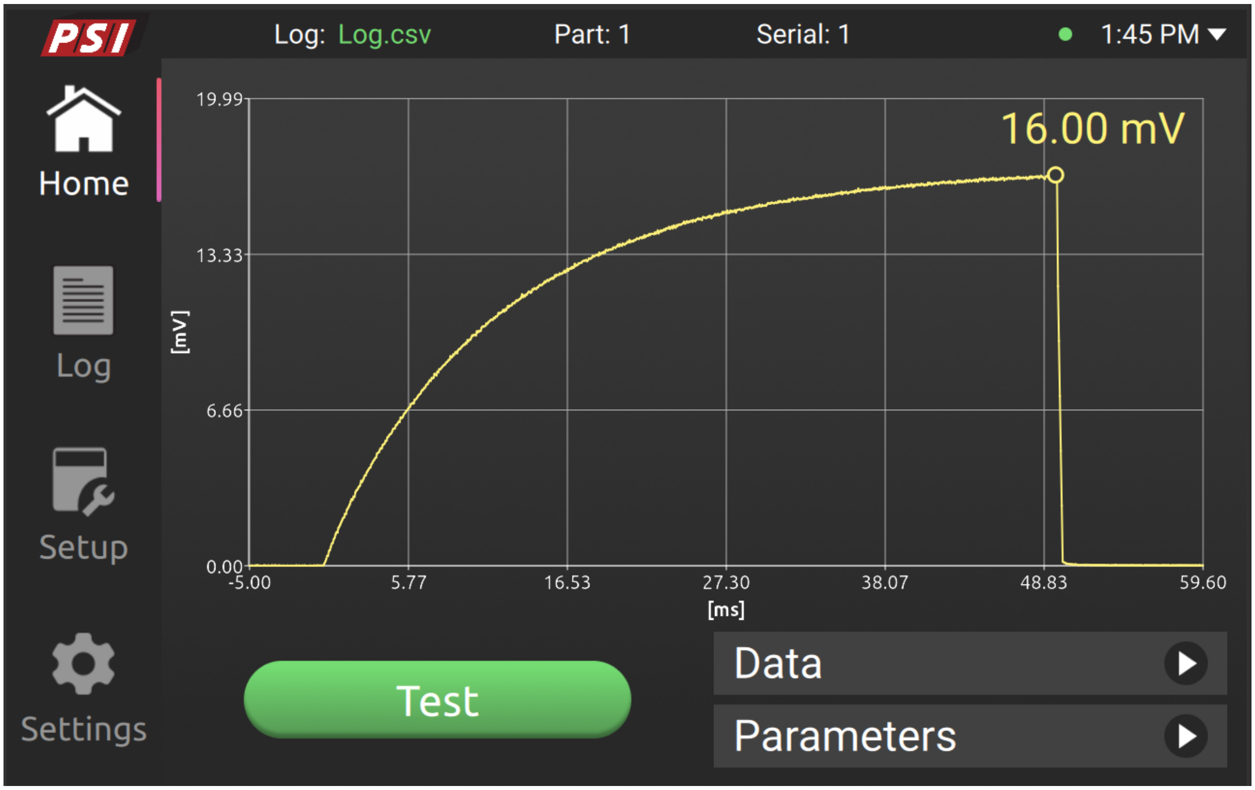

Figure 17 – Illustration of the Home screen, after performing a test

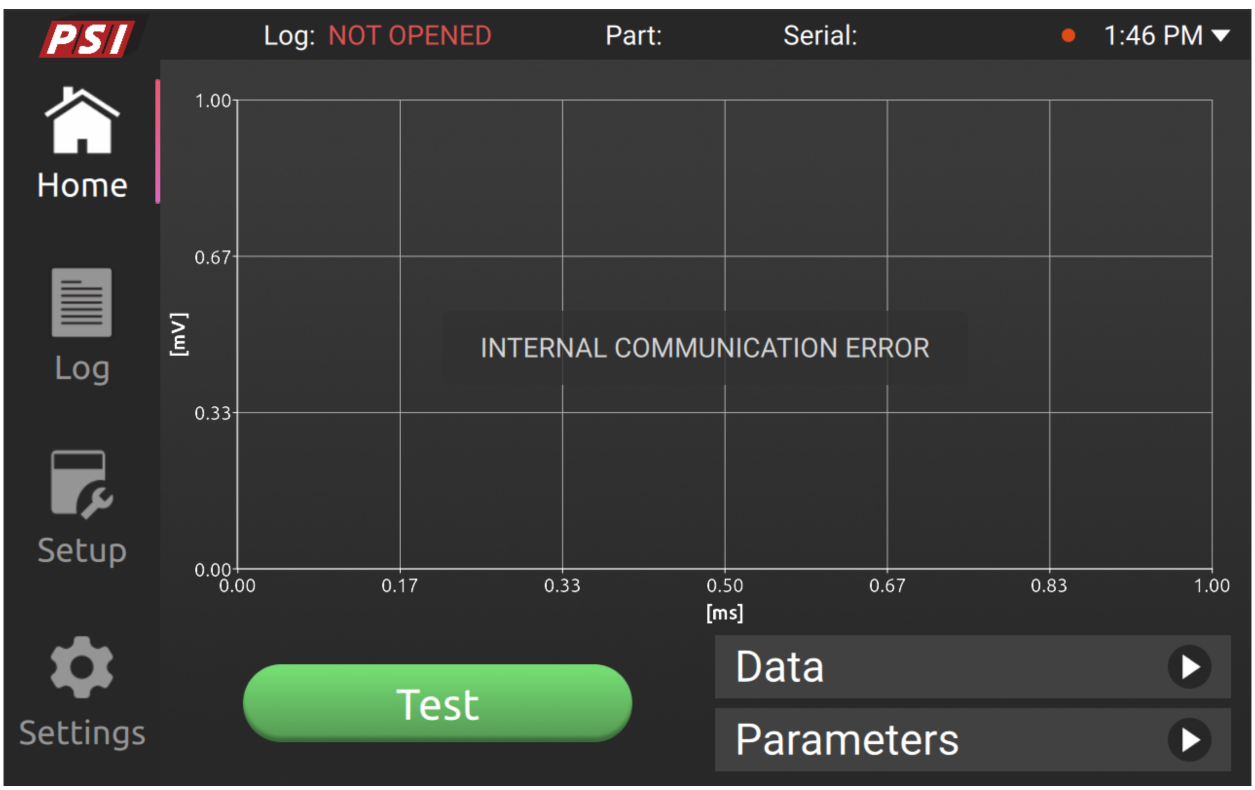

Figure 18 – Illustration of the Home screen – “Internal communication error” state

Refer to the accompanying image of the Home screen, where both the Data and Parameters tables have been extended for enhanced visibility:

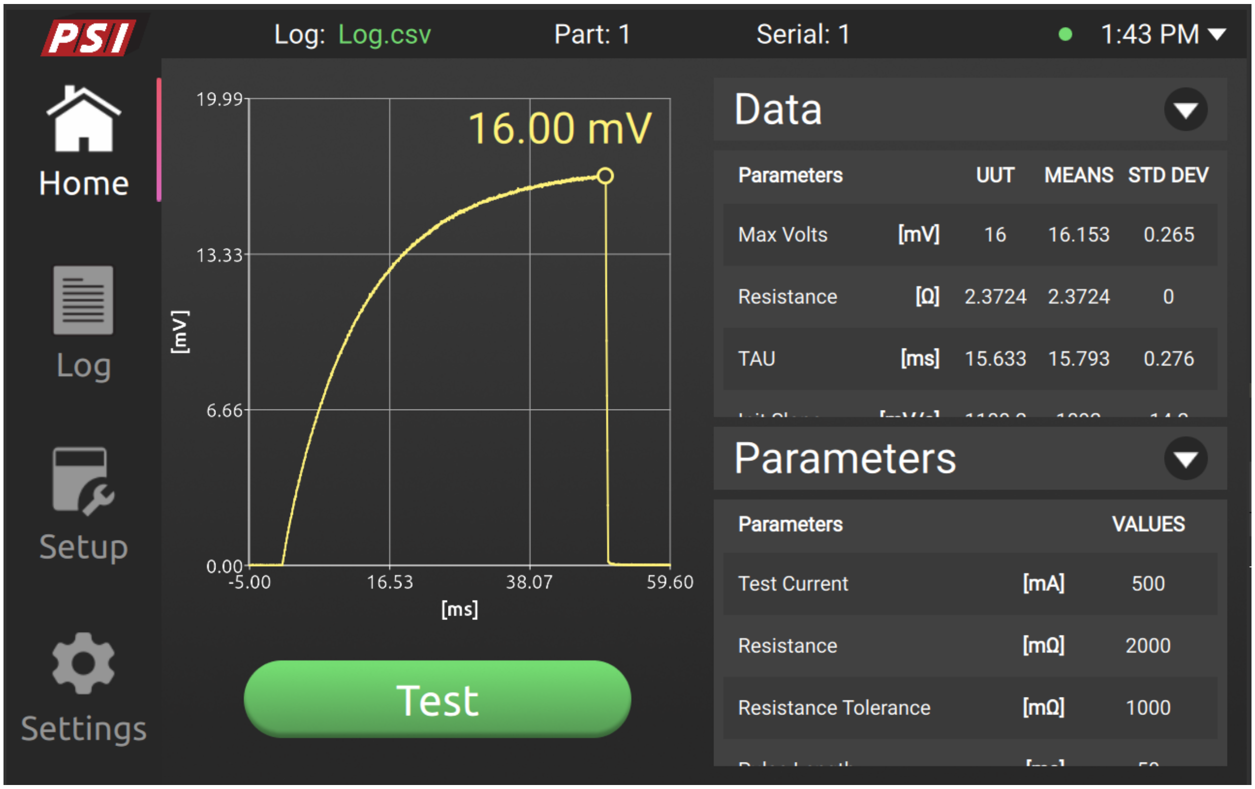

Figure 19 – Illustration of the Home screen with Data and Parameters displayed

SECTION V

GENERAL TESTER SETTINGS

5.1 Log Files

The log files, saved in .csv format, comprehensively capture information including input parameters, pass/fail status, test results, and thermal transient waveform data. The initial two columns within the logging file are date and time that the test occurred. The next column is the 730 Test Set Serial Number, the following two columns contain Part Serial Number and Part/SKU Number, both configurable within the Parameters tab on the Setup screen. In cases where the Serial Number is not specified, it defaults to a sequential numbering from 1 to the total number of tests.

The subsequent six columns correspond to essential test input parameters, encompassing Test Current, Resistance, Tolerance, Pulse Length, Bridgewire Coefficient and Legacy Mode. Following these, the subsequent nine columns pertain to the Pass/Fail results. The first column, Pass/Fail, indicates the overall test outcome, while the subsequent columns provide pass/fail information specific to individual parameters, including Resistance, Max Voltage, Tau, Init Slope, Temp Rise, Heat Loss, Thermal Cap, and waveform (graph). If any of these parameters are unchecked in the Pass/Fail table, the respective field is populated with a slash ('/'). Similarly, the Gold Standard column is populated with a slash ('/') if a waveform is not imported.

The subsequent seven columns encapsulate the test results, mirroring the Data table visible on the Home Screen. Following this, we have ten columns of unlabeled data passed from the Microcontroller Unit (MCU). This unlabeled data can be used by Pasadena Scientific to back into the original (un-nulled) waveform data and also contains status flags and debugging information. Lastly, the Waveform column denotes the start of the waveform raw data.

5.1.1 Log Files Screen

For simplicity of data transfer, Log files have been limited to only USB flash drives (internal storage of log files is not supported). USB devices should be formatted as FAT32, however other formats may be compatible. When a USB flash drive is detected, the screen will display the data from the USB, enabling users to seamlessly create, delete, and load log files.

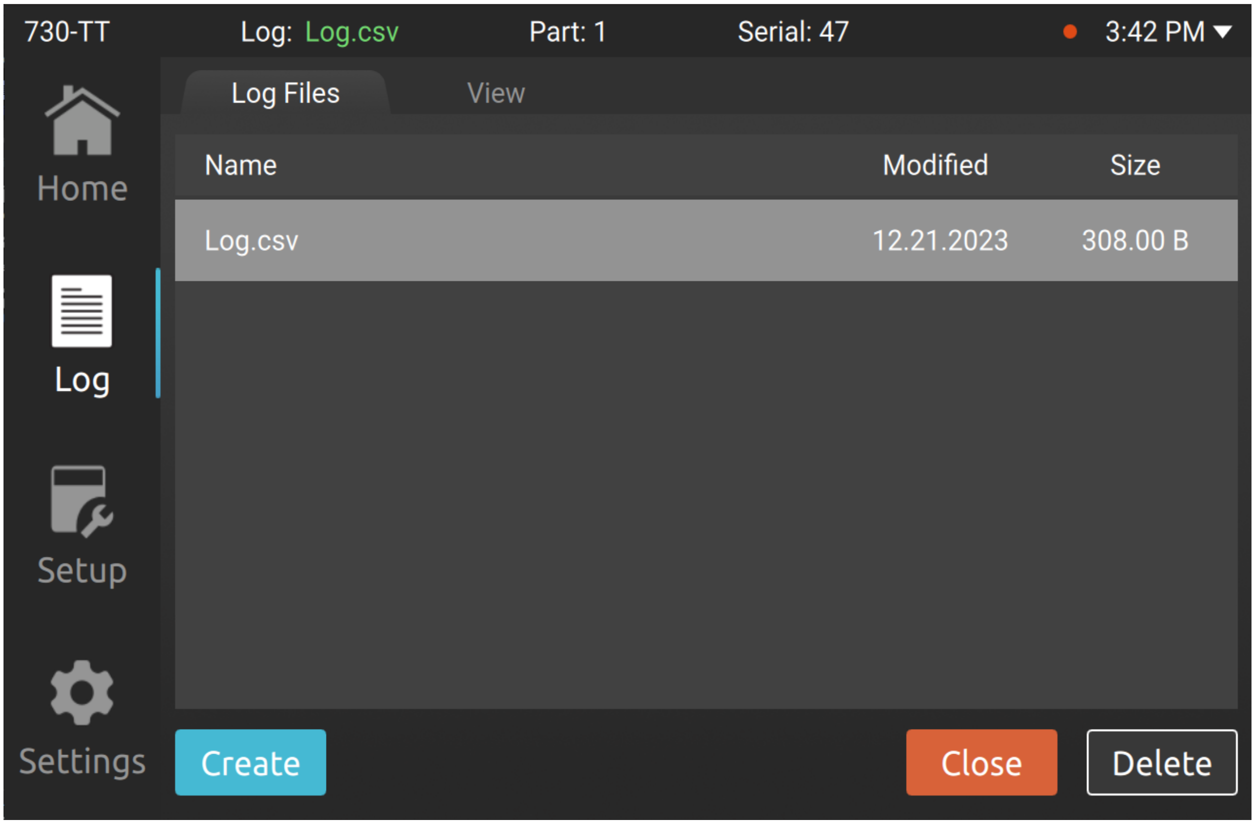

Figure 20 - Log Files tab displaying data from USB

5.1.2 View screen

The 'View' tab is only enabled while a log file is open. Once activated, this tab provides the functionality to view all test entries in the log file, as illustrated in Figure 21.

- 'Serial Number' field - displays the serial number of the part test being viewed. The 'View' tab seamlessly handles repeated entries of the same serial number by appending a bracketed number to the end of the serial number in the event of repeat serial numbers. By clicking on the 'Serial Number' field, a dropdown menu can be accessed to quickly navigate to a desired serial number.
- 'Next' and 'Previous' – step through sequential tests contained within the log file.
- 'Parameters' tab – displays the test input of the selected test.
- 'Data' tab – displays the test results of the selected test.

The same graph controls can be used here as on the Home screen.

- The graph can be navigated through using standard touch gestures – pinch to zoom and swipe to pan.
- By tapping the ends of the axes a new screen will appear that allows precise values to be entered for the graph limits.

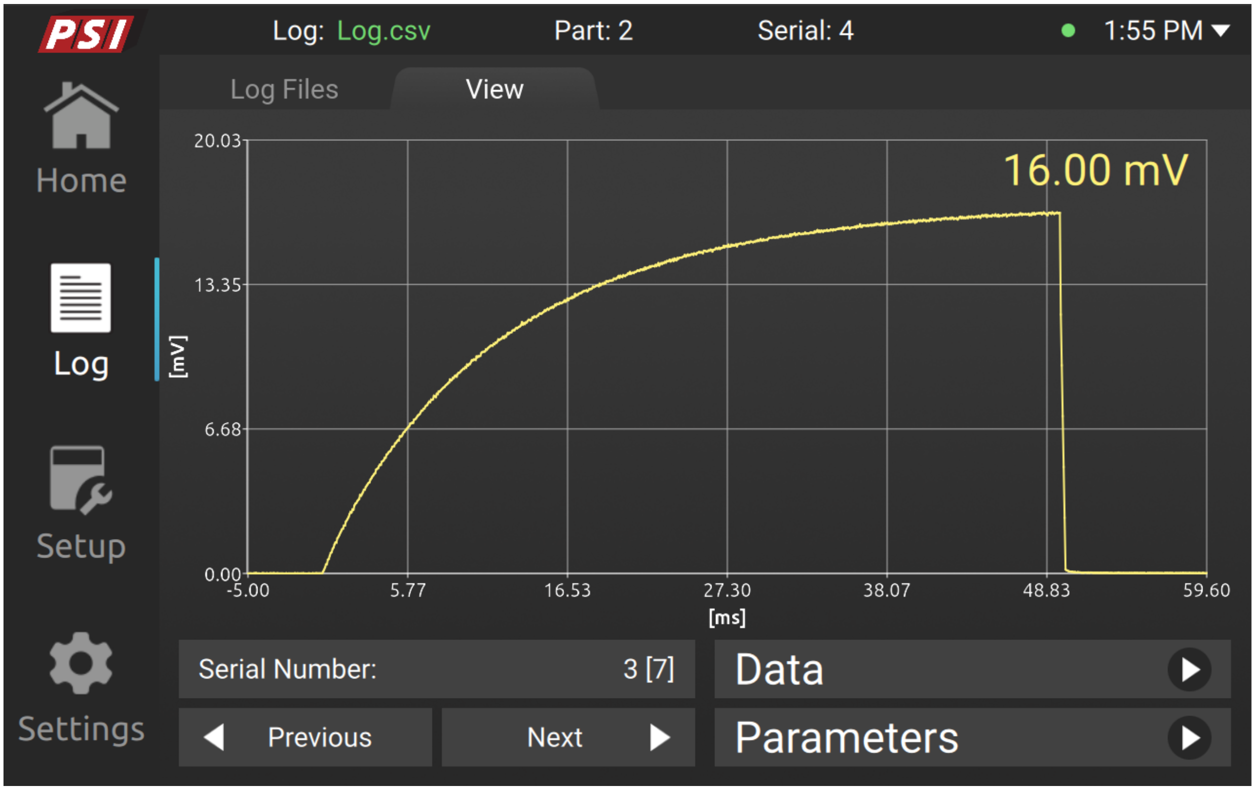

Figure 21 - View tab displaying data from imported log file

5.2 Network Logging

The Network Logging feature offers an advanced capability to ensure test data is not only saved locally but also transmitted to a designated server for further analysis, storage, or monitoring. This section provides a comprehensive guide to enabling, configuring, and utilizing the Network Logging function effectively. The Network Logging functionality is built around the Syslog protocol.

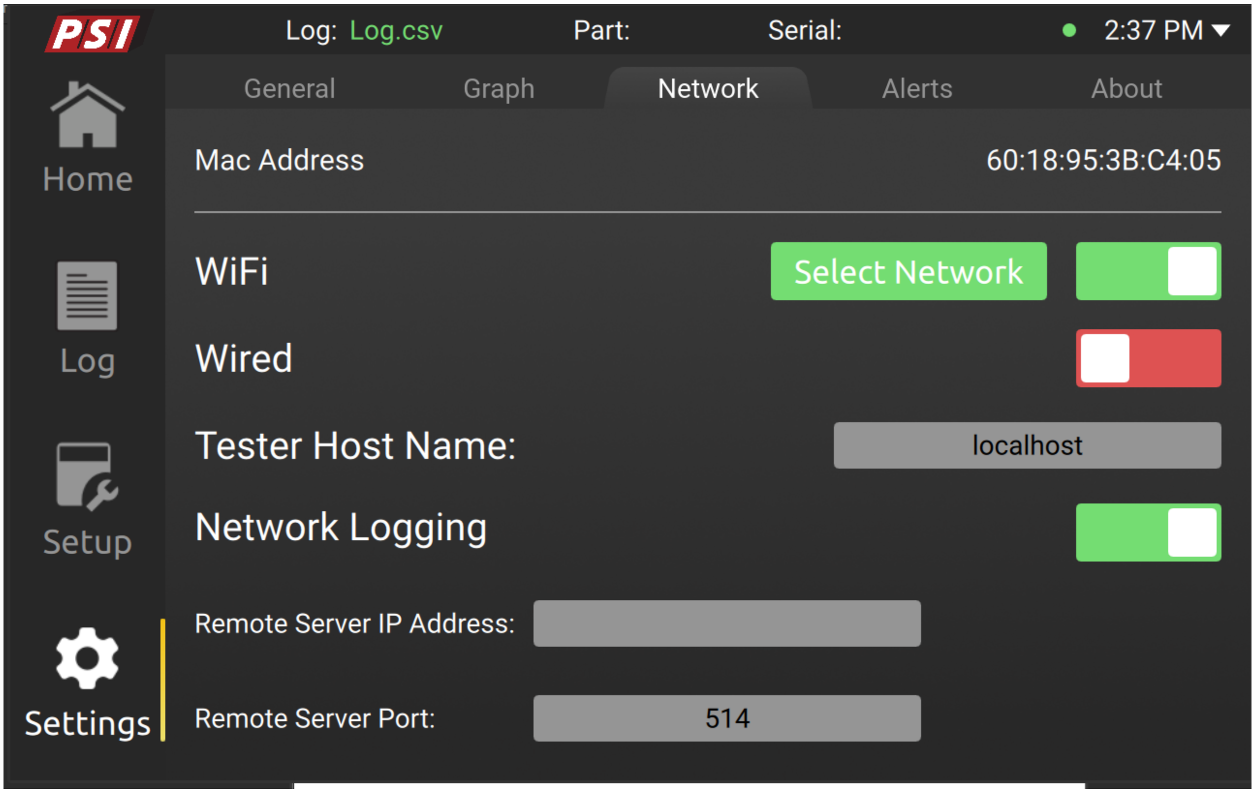

Figure 22 – Network Logging Settings

5.2.1 Enabling Network Logging

To activate Network Logging, navigate to the Network Tab of the Settings menu and locate the "Network Logging" button. Upon activation, enter the two crucial pieces of information:

- **Server IP Address**: The unique IP address of the server where the log files will be sent.
- **Server Port**: The port on the server designated to receive the log files.

Please ensure that the server IP address and port are correctly configured to enable successful log file transmission.

5.2.2 Working Mechanism

When Network Logging is enabled and a data log file is open, the 730 continuously monitors the log file for any changes. Each time new test data is appended to the log file this new data is sent to the configured server using the Syslog protocol.

5.2.3 Syslog Protocol

Syslog is a standard for message logging that allows for the separation of the software that generates messages, the system that stores them, and the software that reports and analyzes them. For Network Logging, Syslog ensures that log data is transmitted swiftly and efficiently to the designated server. However, users should be aware that Syslog does not guarantee delivery; thus, if the server is unreachable, the data packets will be dropped. Additionally note that the file monitoring by Syslog is periodic and data transmission may not be immediate. Lastly, it is important to note that Syslog is configured to operate in a manner where, if the server does not receive the sent data (for reasons such as network issues or server unavailability), the data packets are dropped. This means they are not queued or resent. However, users can be assured that all test data remains intact in the local log file on the 730.

5.2.4 Server Configuration and Data Handling

The responsibility of setting up and configuring the receiving server falls on the user. This includes ensuring the server is correctly configured to receive Syslog messages on the specified IP address and port. Additionally, users are tasked with processing and managing the data once it is received on the server.

The log files transmitted are in CSV (Comma-Separated Values) format, which facilitates easy data manipulation and integration into databases or data analysis tools.

5.2.5 Best Practices and Recommendations

- Ensure the receiving server is always operational and capable of receiving data to avoid data packet loss.
- Regularly verify the integrity and availability of the network connection between the benchtop test equipment and the server.
- Familiarize yourself with the fields and structure of the CSV log files for effective data processing and utilization.
- Consider implementing additional data integrity checks or backup mechanisms on the receiving server to safeguard against data loss or corruption.

5.3 Settings tabs

The Settings screen is organized into the following tabs:
- General (Figure 22)
- Graph (Figure 24)
- Network (Figure 25)
- Alerts (Figure 26)
- About (Figure 27)

5.3.1 General

Illustration of the General tab from the Settings page is provided below:

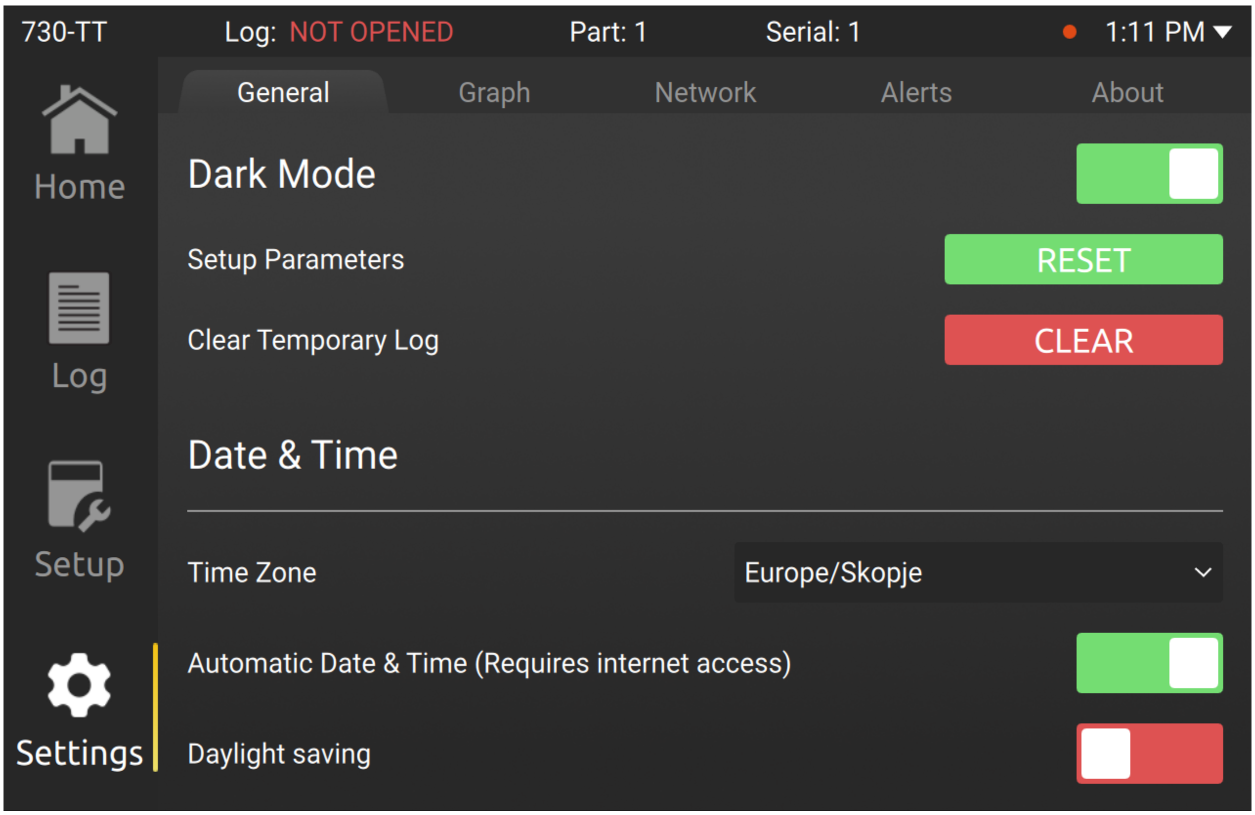

Figure 23 – General tab of the Settings page

The General tab on the settings page encompasses the following features:
- **'Dark mode' switch** – Allows users to toggle between Dark and Light modes.
- **'Reset' button** – Initiates a confirmation popup and resets all parameters in the 'Setup' menu to default upon confirmation.
- **'Clear Temporary Log' button** – Opens a confirmation popup and clears the temporary log upon confirmation. When a log file is not open, the temporary log contains the statistical data of all tests performed in the current work session (since the tester was last turned on). Clearing the Temporary Log clears out the statistics of the current working session. Alternatively, the 730 can be rebooted to clear the Temporary Log.

- **'Time Zone' drop-down** – Enables users to select their specific time zone.
- **'Automatic Date & Time' switch –** When connected to the internet, users can activate this switch for automatic detection of Date & Time.
- **"Daylight saving" switch** – When activated, calculates daylight saving for the selected time zone.

If Automatic Date & Time switch is not activated, an additional field will appear, allowing the users to manually input the date and time (refer to Figure 23). The 730 internal computer has a real time clock and CMOS battery in order to keep track of time and date, even when turned off and disconnected from power/internet.

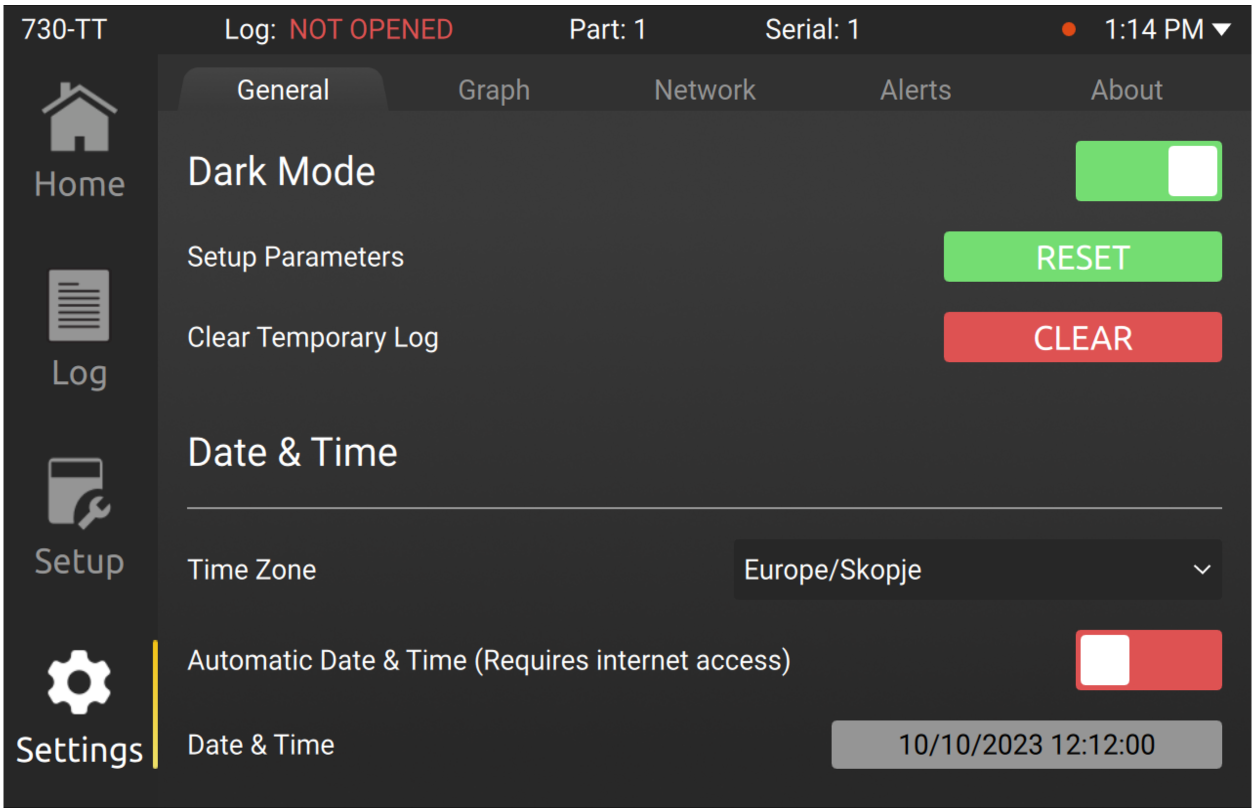

Figure 24 – Illustration of the General tab with Automatic Date & Time off

5.3.2 Graph

Users can manually adjust the Graph settings by opening the Graph tab from the Settings page (refer to Figure 24).

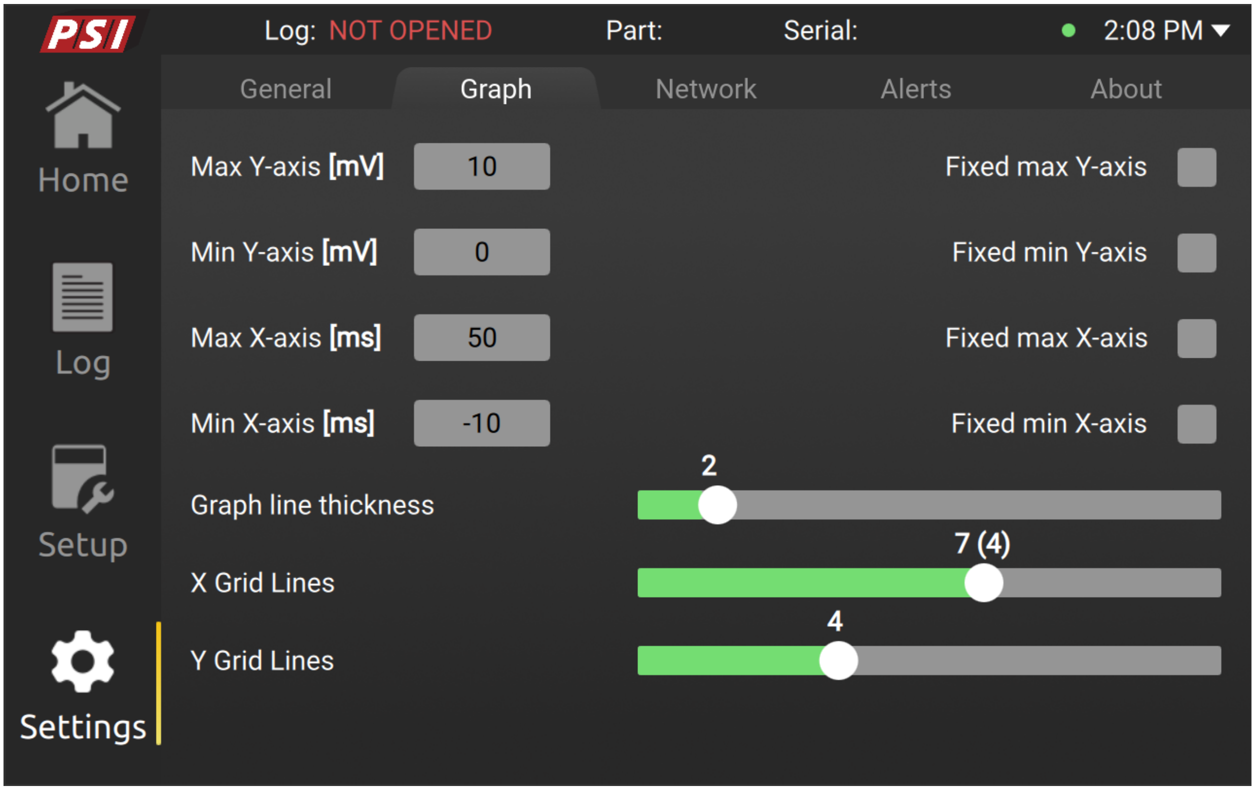

Figure 25 – Graph tab of the Settings page

On the Graph screen the following elements are visible:

- **'Max/Min Y-axis[mV]' text field** – Enables users to fix the Y- axis values for the graph. Clicking this field opens a dialog with a virtual keyboard, facilitating the adjustment of the desired value. The axis will not become fixed unless the check box is checked.
- **'Max/Min X-axis[mV]' text field** – Enables users to fix the X-axis values for the graph. Clicking this field opens a dialog with a virtual keyboard, facilitating the adjustment of the desired value. The axis will not become fixed unless the check box is checked.
- **'Fixed Y-axis' checkbox** – When selected, ensures fixed value for the Y axis.
- **'Fixed X-axis' checkbox** – When selected, ensures fixed value for the X axis.
- **'Graph line thickness' slider** – Allows users to adjust the thickness of the graph line by sliding.
- **'X Grid Lines' slider** – Enables users to set the number of X-axis grid lines by sliding left or right.
- **'Y Grid Lines' slider** - Facilitates the adjustment of the number of Y-axis grid lines by sliding left or right.

5.3.3 Network

Figure 25 is an illustration of the Network tab containing different possibilities for setting up a network connection.

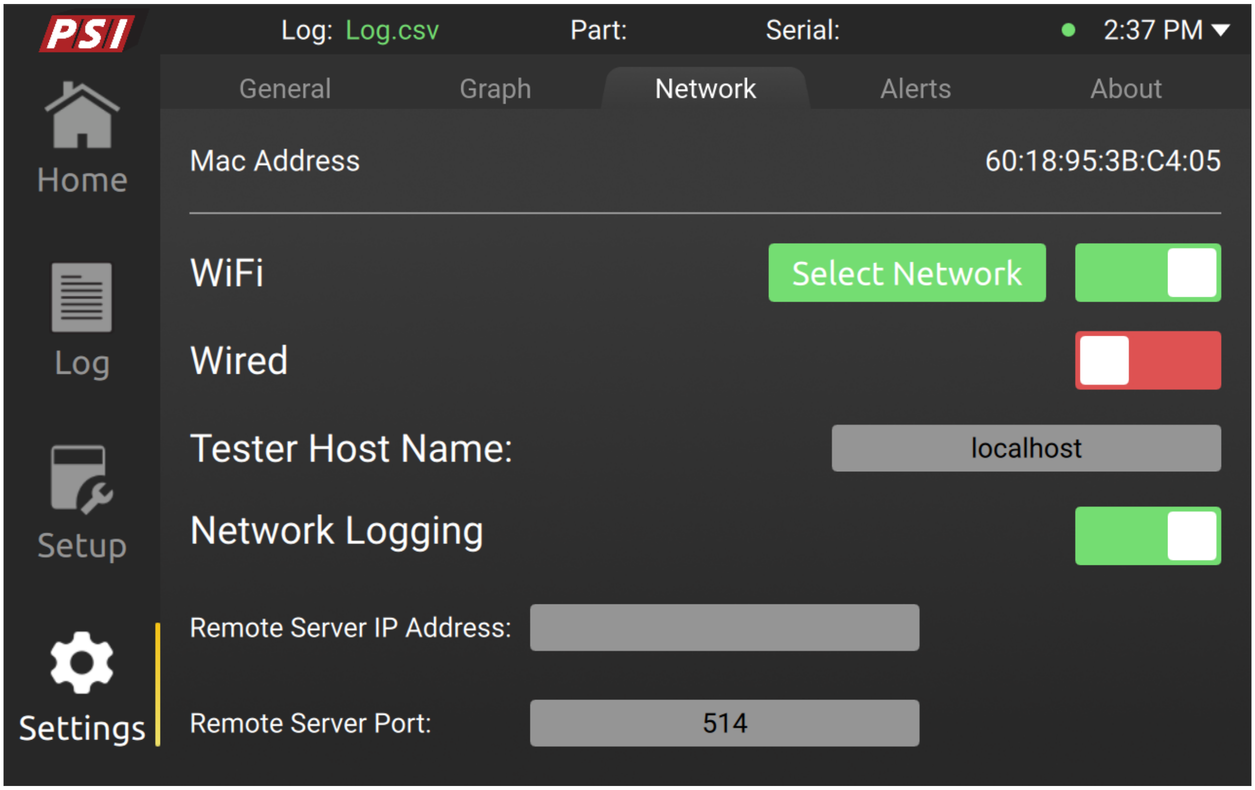

Figure 26 – Network tab of the Settings page

The Network screen contains the following elements:

- **'WiFi' switch** – Allows users to enable or disable the WiFi connection. When activated, additional field appears:
    - **'Select Network' text field** – Clicking this field opens a popup displaying a list of all available WiFi connections.
- **'Wired' switch –** Enables users to activate a wired network connection, automatically switching off the WiFi connection.
- **'Tester Host Name' text field –** Users can input the host name here.
- **'Network Logging' switch –** When activated, additional fields become visible for manual network setup:
    - **'Remote Server IP Address' text field –** The Remote Server IP Address should be entered in this field.
    - **'Remote Server Port' text field –** Users should enter the Remote Server Port in this field.

5.3.4 Alerts

Alerts is the screen where the user is able to keep track of all the alerts/notifications that occurred while using the software. The screen is illustrated on Figure 26.

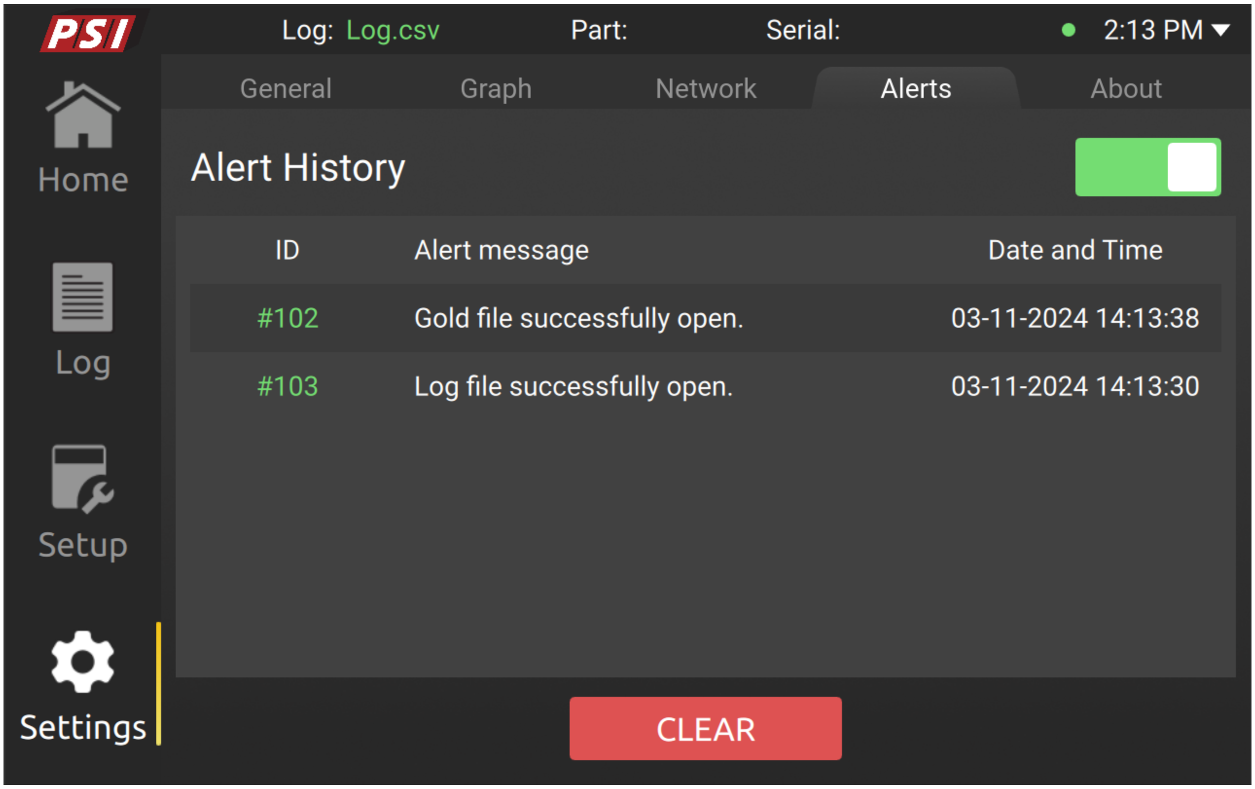

Figure 27 – Alerts tab from the Settings page

The Alerts screen comprises the following elements:

- **'Alert History' switch** – Allows users to toggle the display of alert/notification history. When turned OFF, historical alerts and notifications will not be shown.
- **'Clear' button** – When clicked, this button clears all existing alerts and notifications.

5.3.5 About

The About tab on the Settings page displays essential information, including 730 serial number, the software version, date of last calibration, and manufacturer contact info.

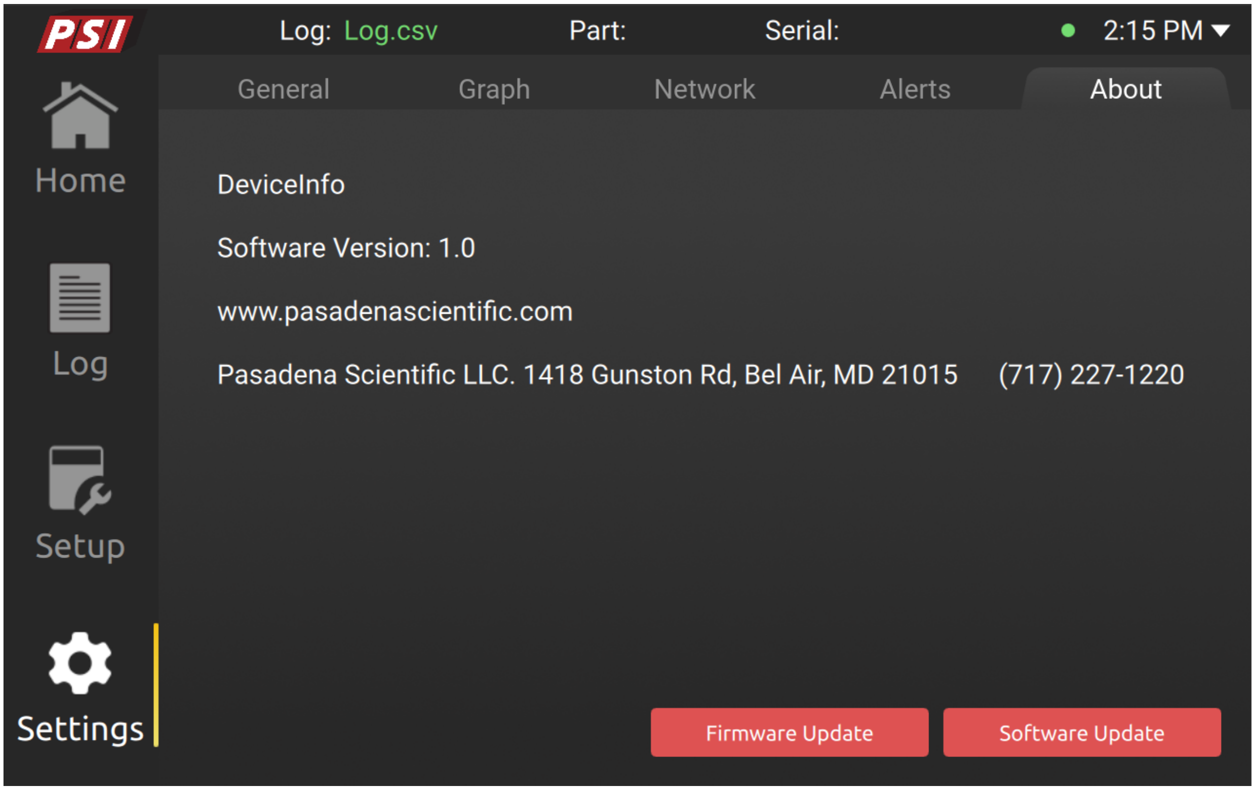

Figure 28 - About tab of the Settings page

On this page the users have two buttons available for updating the software on their own: "Firmware Update" and "Software Update"

5.4 Updating the Software

Before initiating the update process, the user should ensure that the manufacturer-provided correct file is copied onto a USB drive. Once the USB drive is mounted on the device, a brief 10-second loading process ensues. Then the corresponding button can be pressed to initiate the update.

5.4.1 Firmware Update

Updates the firmware of the MCU.

For this update the USB drive needs to contain the file ‘psi-730-firmware-update.bin’ provided by the manufacturer. After successfully updating the firmware a message will appear (Figure 28) and the system requires a full power cycle, meaning it should be completely powered off and then powered on again.

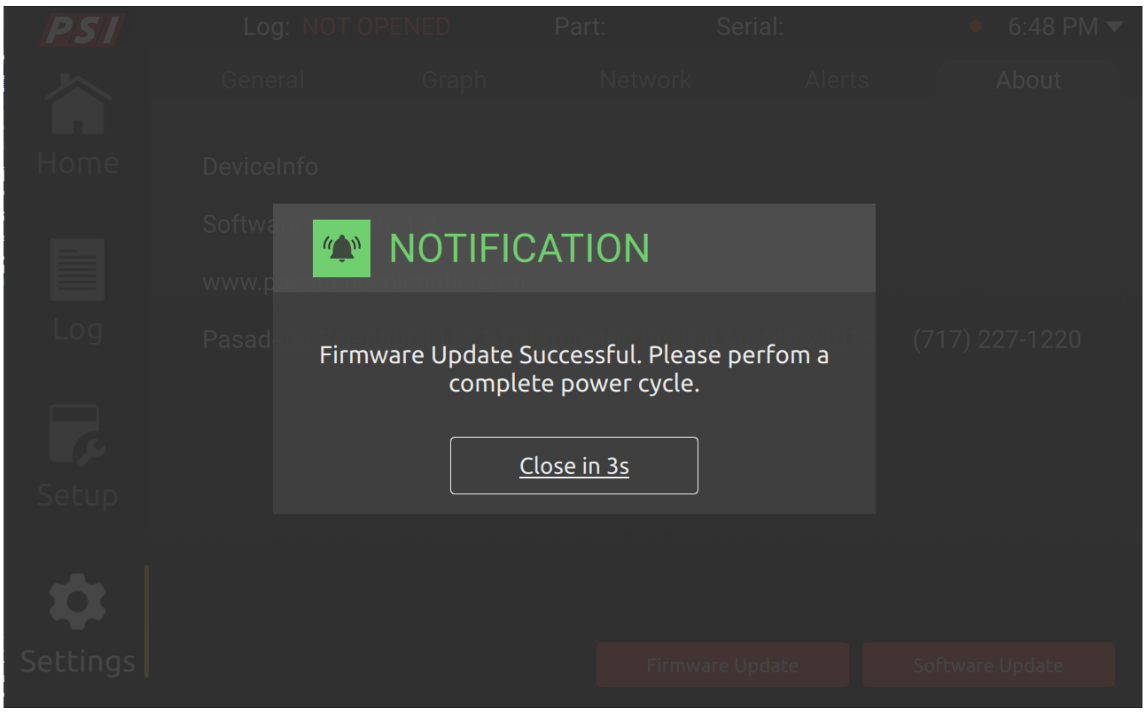

Figure 29 – Firmware Update Successful Alert

5.4.2 Software Update

Updates the software of the device.

For this update the USB drive needs to contain Application executable file provided by the manufacturer. After successfully updating the software, a message will appear (Figure 29) and the system will reboot automatically.

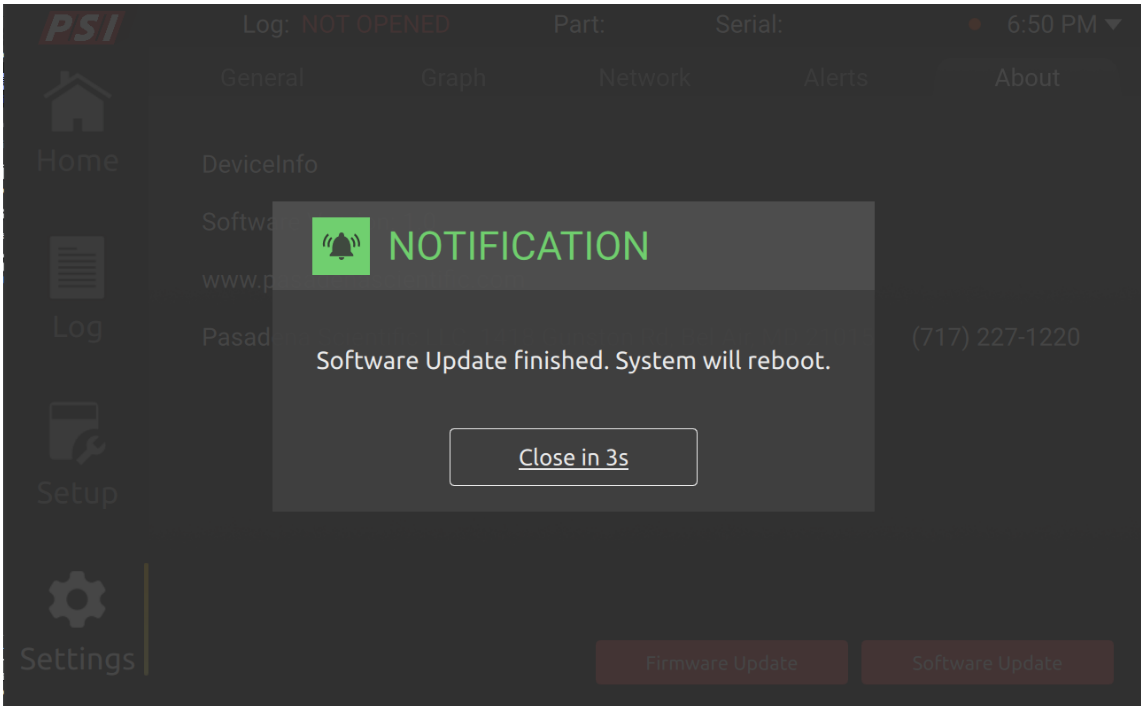

Figure 30 – Software Update finished Alert

CAUTION:

Do not remove the USB drive or power off the system until "Update finished" or "Update failed" message appears. The updating time can take up to 30 seconds.

APPENDIX A

REFERENCE BRIDGEWIRE RB101

Reference Bridgewire RB101 is a thermally responsive resistor for use in checking the operation and performance of Series 730 Thermal Transient Test Sets. It also finds use as a training aid during 730 indoctrination and familiarization. In effect, the RB101 is a simulated bridgewire whose electrothermal response to test signals is similar to that of an operational bridgewire.

Components of the device include a #112 standard incandescent lamp in a two-resistor network, shown below. Cold resistance (RE) is in the range of 2.00 to 2.50 ohms. Maximum test current (I_{max}) is approximately 600 milliamperes. The device plugs into the 730 EED cable.

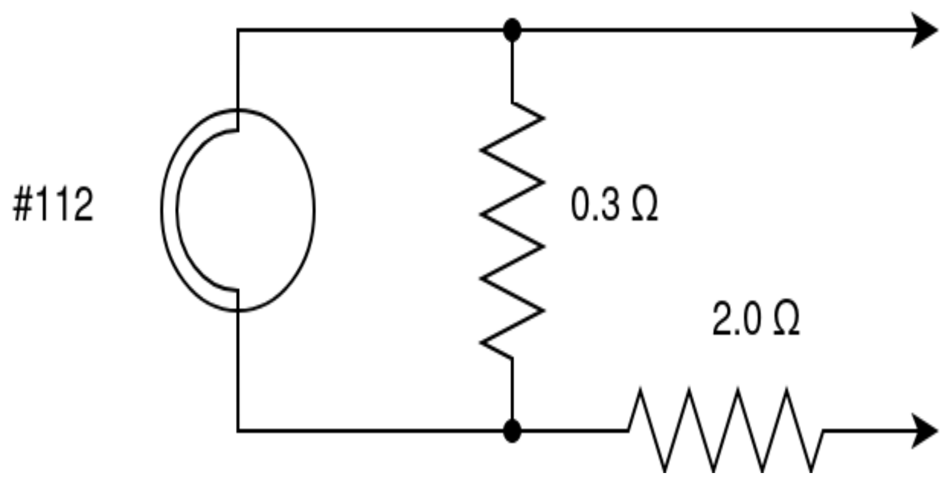

Figure 31 - Reference Bridgewire RB101

Figure 31 is a multiple exposure image of <u>typical</u> Reference Bridgewire RB101 thermal response curves at several test current levels.* Amplitude and slope of the curves of a particular RB101 may vary from the examples because of lamp filament material TCR and manufacturing tolerances.

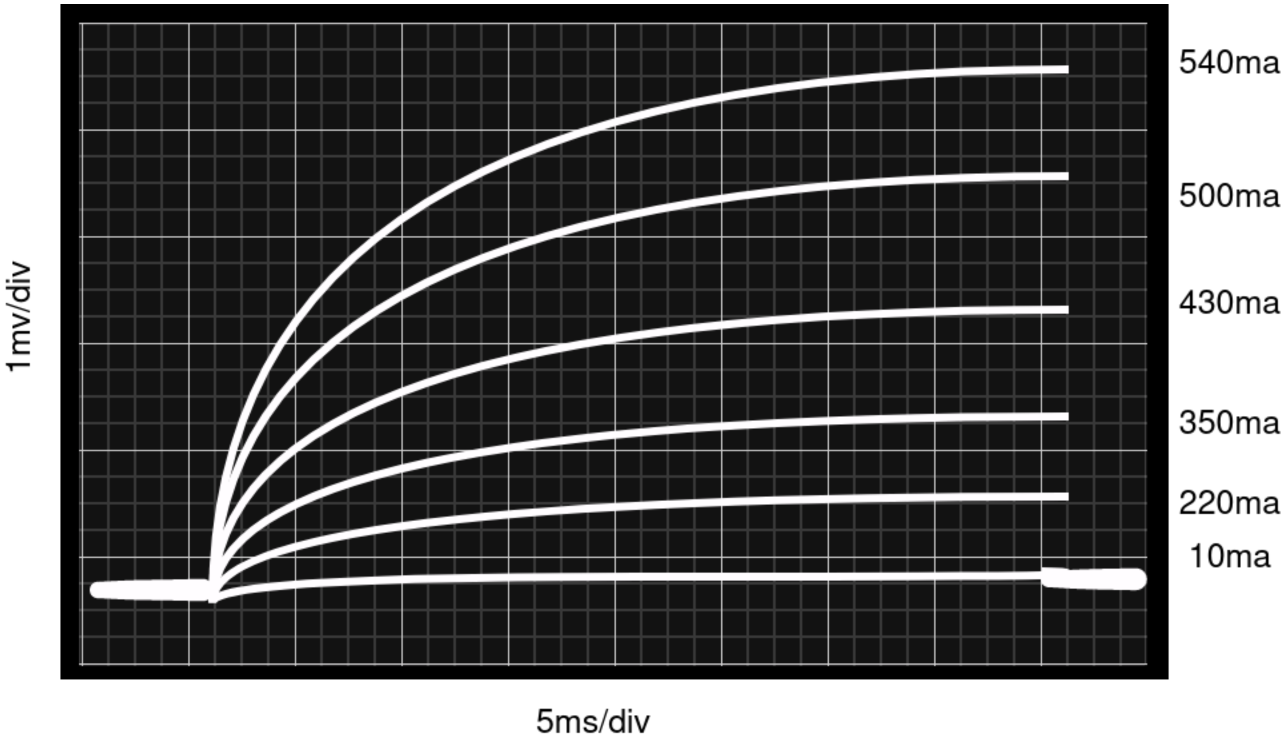

Figure 32 - RB101 Thermal Response Curves

*Curves of different RB101 units may vary (i.e., slope, amplitude, etc.) because of lamp filament TCR differences.

CAUTION

OBSERVE APPROPRIATE SAFETY PRACTICES
WHILE PERFORMING THESE TESTS