

UHPC HARDWARE MANUAL



## **Safety Precautions**

#### These safety precautions must be read and understood before using any of the products described herein.

Regardless of whether this equipment is to be used to generate and measure non-hazardous voltages, stored energy may be present in battery cells and other hazardous conditions may be present.

Ensure that all users of this system are qualified professionals, trained to recognize shock hazards and familiar with the risks and precautions necessary when working with chemical and electrical energy.

Use this hardware in the manner specified only.

Follow all installation and operation information provided.

Do not exceed the maximum signals specified. Refer to the product-specific specifications sheets where necessary.

Do not defeat or otherwise circumvent built-in hardware or software safety limits (see Safety Limits).

Use all equipment as delivered. Do not use 3<sup>rd</sup> party software or firmware to control NOVONIXsupplied equipment.

Regardless of operating environment, it is a good safety practice to assume that all unknown cells contain hazardous levels of stored energy prior to measuring.

Observe the specific power supply requirements for each UHPC Channel Module. Note that the 10A and 20A Channel Module must be powered via a NOVONIX-supplied Power Module only and not directly connected to building-supplied power.

Where fuses are present, replace with the same type and rating only. Do not attempt to replace a damaged breaker or power switch.

Keep Thermal Chamber doors closed while power is applied, or testing is underway.

Do not physically disconnect cell holders without first ensuring there is no test is running.

If using stripped wire connectors, alligator clip connectors or otherwise "floating" connectors, ensure that unused connectors are electrically isolated to eliminate the risk of a short circuit developing.

This equipment is intended to be used in a location having equipotential bonding (such as a telecommunication centre, a dedicated computer room or a restricted access area) and has installation instructions that require verification of the protective earthing connection of the socketoutlet by a skilled person.

Where this symbol is present, connect that point to earth ground directly using the appropriate wire.



- The symbol in the documentation indicates that a surface may be hot.
  - The symbol indicates a safety warning specific for its context in the documentation
- The symbol indicates a NOVONIX recommendation or tip to help ensure the best practice when using the equipment



# **Acronyms**

AC	Alternating Current	
BS	British Standards	
CEE	Consortium for Energy Efficiency	
CE	Coulombic Efficiency	
DC	Direct Current	
I/O	Input / Output	
IEC	International Electrotechnical Commission	
LED	Light Emitting Diode	
NEMA	National Electrical Manufacturers Association	
PCC	Peltier Cooled Chamber	
ppm	Parts per million	
RTD	Resistance Temperature Detector	
UHPC	Ultra High Precision Coulometry	
UPS	Uninterruptible Power Supply	
VA	Volt-Amps	
VAC	Volts Alternating Current	
VDC	Volts Direct Current	
WRC	Wide Range Chamber	



# **UHPC Hardware Manual**

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## **UHPC System Introduction**

NOVONIX's Ultra High Precision Coulometry (UHPC) battery testing systems offer industry leading accuracy and precision for battery test electronics.

Each testing channel can operate in constant current or constant voltage charge or discharge mode across the full 0–5V load window.

Systems typically come with integrated Thermal Chambers to ensure the temperature stability of the cell., In UHPC experiments, this is critical for minimizing noise and ensuring consistency in data collected. Each channel has integrated local and remote (i.e., cell-level) temperature sensing to monitor room and cell temperature.

When used under appropriate environmental conditions and with quality cells, each channel can measure Coulombic Efficiency to better than 20 ppm precision and better than 50 ppm accuracy.

The NOVONIX software suite allows users to build and run test protocols with live monitoring of each channel. Output data is stored as text and can be examined using the powerful NOVONIX plotting software provided or exported in various formats for data analysis and understanding of cell performance.

Read and understand all Safety Precautions prior to first use. The system supplied is designed to be used for testing of electrochemical cells within the known limits between 0-5 Volts in different operation modes (constant current charge/discharge, constant voltage charge/discharge or open circuit storage). This includes, but is not limited to, such devices as rechargeable batteries (Lithium-ion or other) and supercapacitors.



# **1. System Modules**

## 1.1 Control Module (EMA-HXX-99-56)

The Control Module houses the communication board for connections between control software running on a lab PC, and up to 8 UHPC Channel Modules.



Figure 1: Front and rear panels of Control Module

Note that the USB-B port and the Serial interface are used only by NOVONIX for setup and debugging and are not intended to be connected to by users. The serial number of the Control module can be found on the rear of the unit near the C14 power socket.



The USB-B port and the Serial interface are used only by NOVONIX for setup and debug and are not intended to be connected to by users

The connections on the rear of the Control module are highlighted in Figure 2, below.

**PC Communications**. Use a standard straight-through Cat6 shielded Ethernet cable to connect the Control Module's "Computer" port to the Ethernet connection of your lab PC.

**Channel Module Communications** Use a standard straight-through Cat6 shielded cable to connect to each Channel Module. A Channel Module connected to Port 1 will appear on the PC's UHPC-Control software as Channels 1-8 (or Channels 1-4 in the case of a 20A Channel Module), and so on.



The Control Module ports will function **only** with standard, straight-through Ethernet cables. Crossover style cables, which are less common, will <u>not</u> work

**AC Power**. The Control Module accepts 90 - 240VAC power (50/60Hz, 12VA) via a C14 socket. Each module ensures that the switch or breaker is in the OFF position. Use the NOVONIX-supplied C13/C14 cable to connect the module to AC power.





Figure 2: Control module rear panel connection scheme

To power on the Control module for the first time, verify that the switch is OFF.

Connect the provided power cable to your UPS and the C14 socket on the rear of the Control module. Turn the switch ON.

Once powered, the RESET switch on the front panel illuminates. The RESET functions to reboot the module. Use this if there is a loss of communication or during troubleshooting.



Do not reset the Control Module while tests are running on any channels! Always stop any running tests via the software before performing a reset of the Control Module

Control Modules use a single breaker switch, but some legacy units may use a 6.3A Time Delay fuse. See Appendix B: for more information.

Communication between the software and all channels will need to be re-established after performing a reset or otherwise cycling power to the unit. The Control Module can take up to 30s to initialize. Please wait this time before starting Channel Modules and/or starting the control software.



#### 1.2 Power Module (PMA-XXX-99-56)

The UHPC Power Module (PMA-XXX-99-56) is the DC power supply to all NOVONIX 10A or 20A Channel Modules. 2A Channel Modules do not require a Power Module.

A single Power Module can provide power to any of a single 10A Channel Module, a single 20A



Channel Module, two 20A Channel Modules, two 10A Channel Modules OR a 10A and 20A Module combination.



Figure 4: Power Module, rear

#### **AC Input**

The Power Module accepts 120 – 240 VAC input (50/60Hz, 3000VA Max). All AC power is delivered via a C20 socket, and all cables are supplied by NOVONIX. The power input socket is protected by a 30A breaker.



Use only the correctly rated, NOVONIX-supplied cable to connect the Power Module to mains power. Reset the breaker by flipping the switch if tripped. Do not power on until all DC Outputs are connected.

## DC Output

All DC output is located on the rear of the Power Module.

**Connect current outputs**. Use Group 1 I-1to I-4 to connect the corresponding connectors on your first 10A or 20A module (Figure 6, above). Only use Group 2 if connecting a second module.

Connected Channel Modules do not have to be identical, i.e. if a 10A Channel Module is connected to Group 1, a 20A may be subsequently connected to Group 2.





If connecting a single module, use **only** the Group 1 I-1 – I-4 current outputs. Mixing current output groups can cause serious damage.

**Connect voltage outputs**. Only one voltage output is required per Channel Module. Use the appropriately labelled output for your Channel Module.

**Connect fan power**. Only one fan power connection is required per Channel Module.



Connect all I/O **before** powering on the power module.



#### 1.3 Channel Modules (CMA-XXX-99-56)

## 2A Channel Module (CMA-HDX-99-56)

The 2A Channel Module provides 8 numbered channels, each with a maximum current of 2A and 5 ranges for measurement: 2A, 200mA, 20mA, 2mA and 200µA.

Based on the current requested by the control software, the 2A Channel Module selects the best range available automatically.



Figure 5: 2A Channel Module, front (left) and rear (right)

The front panel is equipped with an LED indicator and a 9-pin output connector (front panel) for each channel, as well as a RESET switch. The serial number of the Channel Module is located on the rear of the unit near the power entry.

The rear panel houses a C14 socket for AC power supply, a power switch and an RJ45 comms connection that accepts a standard, straight through Cat6 shielded Ethernet cable.



Figure 6: 2A Channel Module front and rear panel I/O scheme

**Channel Module Communications** Use a standard, straight through Ethernet cable to connect to a Control Module. Ensure the Channel Module is connected to its Control Module before powering on. A Channel Module connected to Port 1 of a Control Module will appear on the PC's UHPC-Control software as Channels 1-8, Port 2 as 9-16 etc.

AC Power The 2A Channel Module accepts 100 – 230VAC power (50/60Hz, 320VA) via a C14 socket.



2A Channel Modules use a 15A breaker switch, but some legacy units may use a 6.3A Time Delay fuse.

To power on the Channel Module for the first time, verify that the switch is OFF. Connect the green NOVONIX Communication cable from the Channel Module to a spare port on a Control Module.



Connect the provided power cable to your UPS and the C14 socket on the rear panel of the Channel Module. Turn the switch ON.

Once powered, the RESET switch on the front panel illuminates. The RESET functions to reboot the module. Use this if there is a loss of communication or during troubleshooting.



Do not reset a Channel Module while tests are running on any channels! Always stop any running tests via the software before performing a reset of a Channel Module

Note that the Status Indicator LEDs for each channel will not illuminate until communication is established with the Control Module and the software. The LED code reference is as follows:

Colour	Status
Red	Charging Step (normal operation)
Green	Discharging Step (normal operation)
Yellow Paused/Suspended Step (normal operation) OR Error, abnormal operation – check log	

Each channel on the 2A charger module has the capabilities described in its specification sheet, with current/voltage source across the 0–5V operating window, voltage sense, local (electronics) RTD temperature sensing and RTD temperature sensing from the remote RTD included on NOVONIX-built cell holders (See 2.2 Cell Holders)



## 10A Channel Module (CMA-HEX-99-56)

The 10A Channel Module provides 8 independent channels, each with a maximum current of 10A and 6 ranges for measurement: 10A, 1A, 100mA, 10mA, 1mA and 100µA.

Based on the current requested by the control software, the 10A Channel Module selects the best range available automatically.



Figure 7: 10A Channel Module front (left) and rear (right)

The front panel is equipped with an LED indicator and a 9-pin output connector for each channel, as well as a RESET switch. The serial number is located on the rear of the unit.

The rear panel houses a 4 DC Current inputs, a DC Voltage input and a Fan Power input. Each of these inputs is provided by a corresponding output on the Power Module (required). An RJ45 comms connection for standard, straight-through Ethernet cables is located in the left corner of the panel.



This module does <u>not</u> connect to AC power! It accepts **DC Power** from a NOVONIX Power Module across 6 cables (4 current, 1 voltage, 1 fan power).



Figure 8: 10A Channel Module front and rear panel I/O scheme

**Channel Module Communications** Use a standard, straight through Ethernet cable to connect to a Control Module. Ensure the Channel Module is connected to its Control Module before powering on. A Channel Module connected to Port 1 of a Control Module will appear on the PC's UHPC-Control software as Channels 1-4, Port 2 as 9-12 etc.



**DC Power** As noted above, this device accepts DC power supplied by the Power Module (required). Ensure that the communications cable has been connected and that the Power Module is OFF prior to connecting cables.

**Connect Current Inputs**. See 1.2 Power Module in this manual. If this is the first module connected to the Power Module, use Group 1 I-1 to I-4 outputs to connect the corresponding DC Current In connectors on the 20A module. Only use Group 2 if you are connecting your second Channel Module. Connect all four I-1 to I-4 inputs.

**Connect Voltage Inputs**. Only one input is required per Channel Module. Connect a voltage cable from a 20A output on the Power Module.

**Connect Fan Power**. Only one fan power connection is required per Channel Module. Connect a fan power cable from a Fan Power output on the Power Module.

Power on your Power Module to begin delivering power to the 10A Channel Module



Only power on the Power Module *after* all current, voltage and fan power connections have been made on both. Verify the Ethernet comms cable is connected before powering on.

Once powered, the RESET switch on the front panel illuminates. The RESET functions to reboot the module. Use this if there is a loss of communication or during troubleshooting.



Do not reset the Channel Module while tests are running on any channels! Always stop any running tests via the software before performing a reset of a Channel Module

Note that the Status Indicator LEDs for each channel will not illuminate until communication is established with the Control Module and the software. The LED code reference is as follows:

Colour	Status
Red	Charging Step (normal operation)
Green Discharging Step (normal operation)	
Yellow Paused/Suspended Step (normal operation) OR Error, abnormal operation – check log	

Each channel on the 10A Channel Module has the capabilities described in its specification sheet, with current/voltage source across the 0–5V operating window, voltage sense, local (electronics) RTD temperature sensing and RTD temperature sensing from an external RTD attached to a cell holder (See 2.2 Cell Holders).



#### 20A Channel Module (CMA-HFX-99-56)

The 20A Channel Module provides 4 numbered channels, each with a maximum current of 20A and 2 ranges for measurement: 20A and 2A.

Based on the current requested by the control software, the 20A Channel Module selects the best range available automatically.



Figure 9: 20A Channel Module front (left) and rear (right)

The front panel is equipped with an LED indicator and a 10-pin output connector for each channel, as well as a RESET switch. The serial number is located on the rear of the unit.

The rear panel houses a 4 DC Current inputs, a DC Voltage input and a Fan Power input. Each of these inputs is provided by a corresponding output on the Power Module (required). An RJ45 comms connection for a custom green NOVONIX communications cable is located in the center of the panel.



This module does <u>not</u> connect to AC power! It accepts **DC Power** from a NOVONIX Power Module across 6 cables (4 current, 1 voltage, 1 fan power).



Figure 10: 20A Channel Module front and rear panel I/O scheme

**Channel Module Communications** Use a standard, straight through Ethernet cable to connect to a Control Module. Ensure the Channel Module is connected to its Control Module before powering on. A Channel Module connected to Port 1 of a Control Module will appear on the PC's UHPC-Control software as Channels 1-4, Port 2 as 9-12 etc.



**DC Power** As noted above, this device accepts DC power supplied by the Power Module (required). Ensure that the communications cable has been connected and that the Power Module is OFF prior to connecting cables.

**Connect Current Inputs**. See 1.2 Power Module in this manual. If this is the first module connected to the Power Module, use Group 1 I-1 to I-4 outputs to connect the corresponding DC Current In connectors on the 20A module. Only use Group 2 if you are connecting your second Channel Module. Connect all four I-1 to I-4 inputs.

**Connect Voltage Inputs**. Only one input is required per Channel Module. Connect a voltage cable from a 20A output on the Power Module.

**Connect Fan Power**. Only one fan power connection is required per Channel Module. Connect a fan power cable from a Fan Power output on the Power Module.

Power on your Power Module to begin delivering power to the 20A Channel Module



Only power on the Power Module *after* all current, voltage and fan power connections have been made on both. Verify the green NOVONIX comms cable is connected before powering on.

Once powered, the RESET switch on the front panel illuminates. The RESET functions to reboot the module. Use this if there is a loss of communication or during troubleshooting.



Do not reset the Channel Module while tests are running on any channels! Always stop any running tests via the software before performing a reset of a Channel Module

Note that the Status Indicator LEDs for each channel will not illuminate until communication is established with the Control Module and the software. The LED code reference is as follows:

Colour	Status
Red	Charging Step (normal operation)
Green	Discharging Step (normal operation)
Yellow Paused/Suspended Step (normal operation) OR Error, abnormal operation – check log	

Each channel on the 20A Channel Module has the capabilities described in its specification sheet, with current/voltage source across the 0–5V operating window, voltage sense, local (electronics) RTD temperature sensing and RTD temperature sensing from an external RTD attached to a cell holder (See 2.2 Cell Holders).



## 1.4 Thermal Chambers (TCA-XXX-XX-XX)

NOVONIX Thermal Chambers are broadly divided into two categories, distinguished by the cooling technology employed.

**Peltier Thermal Chambers** use a Peltier-effect thermoelectric cooler, alongside resistive heat, to hold a specified temperature. Peltier-cooled chambers can maintain a temperature typically only about 10°C below the ambient room temperature but are much better at maintaining fixed temperatures close to ordinary room temperatures.

**Wide Range Thermal Chambers (WRC)** use a traditional compressor-evaporator cooling loop alongside resistive heat to meet the setpoint temperature. This design allows for much colder temperatures to be reached and maintained. Due to the mechanical nature of the cooling system, WRCs are much larger and heavier than their Peltier counterparts. Additionally, they are not as efficient as Peltier chambers when operating at temperatures at or around the ambient environment temperature.

Both styles of Thermal Chambers may be designed to accommodate between 4 and 16 cell holders (depending on the model) on individual channels.

The serial number for the Thermal Chamber is located on the rear of the unit, near the power socket.



If your application calls for consistently low temperatures (more than 10°C below ambient), use a WRC. In other cases, Peltier Chambers are more reliable and efficient devices, due to their solid-state cooling.

#### **Peltier Thermal Chamber**



10°C to 60°C*
100-120VAC 50/60Hz 5A <u>or</u> 220VAC 50/60Hz, 3A
15A, 250VAC
85°C

\*Cooling capability is approx. 10°C below ambient room temperature

#### Wide Range Chamber (WRC)

Temperature Range	-20°C to 60°C*
Input Power	100-120VAC 50/60Hz 5A <u>or</u> 220VAC 50/60Hz, 5.5A
Circuit Breaker	20A, 250VAC
Thermal Auto-Off	85°C





The power configuration is specified on the rear of the Thermal Chamber adjacent to the power socket. Ensure only the appropriate input voltage is used to power the chamber.



Figure 11: Front Panel I/O Scheme, Thermal Chamber



Figure 12: Internal I/O Scheme, Thermal Chamber

**Channel Module Communications.** Each Thermal Chamber connects directly to a Channel Module via a proprietary NOVONIX Interconnect Cable (See '2.1 Interconnect Cables').

In the example shown above, in Figure 11, the front panel Thermal Chamber connections should be directly connected to the front panel connections on a Channel Module.



Each channel on the Thermal Chamber is individually mapped and isolated, so connections can be made with any correctly rated channels from any combination of UHPC Channel Modules.

Front Panel connections are labelled and mapped 1:1 to their respective internal Cell Holder Connectors.



Always use caution when working inside thermal chambers. Inner walls may be hot during operation. Human skin can sustain first-degree burns at temperatures as low as 50°C.



The Thermal Chamber contains internal fans for air circulation as well as a 4-wire RTD, which provides closed-loop feedback to the temperature controlled.

For safety, thermal auto-shutoff is integrated inline with the resistive heaters; if the temperature inside the chamber exceeds the thermal cut-off temperature of 85°C, power is cut to the heater until the temperature before resuming operation.



The auto-shutoff should never be triggered in normal operation; if this occurs, power off the Thermal Chamber immediately and contact NOVONIX customer support.

**AC Power.** NOVONIX Thermal Chambers accept 100–230VAC power (50/60Hz) via a C14 socket. To power on the Channel Module for the first time, verify that the switch is OFF. Connect the provided power cable to your UPS and the C14 socket on the rear panel of the Channel Module. Turn the switch ON. Once powered, the RESET switch on the front panel illuminates. The RESET functions to reboot the temperature controller and temperature relays. Use this as required during troubleshooting.

**Temperature Controller.** The Thermal Chamber temperature is controlled by a Watlow EZ-Zone integrated temperature controller, accessed on the front panel. Some older Thermal Chamber models used an Omega controller, now legacy (See 9 Appendix B: Omega Controllers (Legacy)). Both models provide similar levels of accuracy and response.

Temperature setpoints must be entered directly on the device. Software-controlled programming of the setpoint is not supported at this time.

#### Set Temperature Setpoint - Watlow

Selecting your temperature setpoint is straightforward:

- 1. Power on Thermal Chamber.
- 2. Enter desired setpoint using (and (

#### **Troubleshooting - Watlow**

If the Thermal Chamber does not reach the desired set-point after more than 1 hour or the autoshutoff is triggered, please <u>contact us</u> for advice.

Symptom	Cause	Solution	
Controller displays Limit Error, Low or High Li.E1, Li.L1, Li.h1	Chamber temperature sensor damaged, or wiring damaged	Do not attempt to repair a damaged temperature sensor or wire. <u>Contact us.</u>	
No Display	Controller is not receiving power	Check that device is plugged in and that UPS is able to supply sufficient power. Check that breakers are not tripped, or fuses are not blown (where applicable)	



Chamber does not reach setpoint or is unstable	Tuning incorrect or setpoint not entered	Verify that setpoint is correct. Follow the programming steps in 8 Appendix A: Programming Watlow Controllers or <u>contact us</u>
Condensation forming on inside of chamber walls when operating at colder temperatures	Significant humidity in ambient air while operating chamber below ambient	This is normal; NOVONIX Thermal Chambers are not sealed environments, and air is passively exchanged with the ambient air during operation. Dry with a lint- free cloth or open doors and allow to dry naturally. Operate the chamber in a low, stable humidity (<60%RH) environment where possible.



## 1.5 Uninterruptible Power Supply (UPS)

NOVONIX UHPC systems use an uninterruptible power supply (UPS) to power and protect equipment. The UPS provides a brief battery backup in the event of a power loss. This backup is not meant to provide extended power through a prolonged power outage, but rather to allow a user to stop all tests and shutdown the system safely.



In the event of a power loss, where possible, stop any running tests via the software safely, save data and snapshots, and shut down each module in your system at its switch. The UPS is not intended or designed to run the system through a prolonged loss of mains power.



Using a UPS is critical for protecting the sensitive electronics found in NOVONIX equipment. If you are a user who has purchased a partial system or individual components, ensure that you have discussed a UPS implementation strategy with your NOVONIX Sales rep.

The UPS NOVONIX provides come from APC Canada, and the precise model depends on the configuration of original system provided. All UPS units will input/output either 100, 120 or 220 VAC at 50/60 Hz, configured for input based on country. Replacement battery styles and OEM documentation for your UPS will be provided



In the event of a UPS failure or error, contact the APC Canada customer care team at **1-800-800-4272**. APC will complete diagnostics and replace the unit if required.



## 1.6 Rack Enclosure

All modules are housed in a standard 19" equipment rack. This rack is equipped with secondary uprights to support the charger modules and Thermal Chambers as well as a smaller set of rear rails to provide rear support for the UPS.

The rack and chassis of all components within the rack must be connected to earth ground via the UPS.

Ensure that when the rack is positioned for final use, all panels are accessible, and doors swing freely.



The rack is equipped with an additional ground wire from the rear earth point that must be connected to earth ground. See the 'Getting started with UHPC: Uncrating and power on' guide for more information.



# **2. System Peripherals**

2.1 Interconnect Cables (ICA-XXX-00-00)



Figure 13: Channel Module to Thermal Chamber interconnect cable

Interconnect cables connect each channel on the front panel of a Channel Module to each channel of a Thermal Chamber.

Cables will be labeled on both ends to indicate which channel they are connected to and are all varying length. In general, these cables never need to be disconnected from their Channel Module host but may be relocated on a Thermal Chamber(s) depending on experimental needs.

Interconnect cables are 9-pin configuration for the current source (+/-), cell voltage sense (+/-), RTD current drive (+/-), RTD voltage sense (+/-) and cable shield.

20A and 10A Interconnect cables are interchangeable, while 2A cables use a different pin configuration and will not physically mate with a 10A or 20A chamber or Channel Module.



#### 2.2 Cell Holders (CHA-XXX-00-00)

NOVONIX offers different cell holders, broadly split between Standard Format and Large Format configurations. NOVONIX sales will help you select cell holders appropriate for your application. In some cases, customers with specific needs will opt not to use NOVONIX-built Environmental Chambers. In these cases, NOVONIX supports customers by providing custom connections on a case-by-case basis.

#### Standard Format Cell Holders.

16-position Thermal Chambers can take advantage of NOVONIX's Standard Format cell holders. These cell holders carry a circuit board hosting an on-board RTD temperature sensor as well as an interface to connect an external RTD (optional). External RTDs are often used if a temperature even closer to the testing cell is desired.

NOVONIX offers two styles of Standard Format Cell Holder.

**2A/10A Capable Holders:** These connectors use a magnetic latching mechanism and use a pokayoke design to ensure only one orientation is possible, Cell holders with these connectors are rated for up to 10A of current at 5V and can safely be used with NOVONIX 2A and 10A Channel Modules. To disconnect these cell holders once attached, pull gently backwards to overcome the magnetic mating force.



Figure 14: Standard Format Cell Holders with magnetic coupler

To use an external RTD with these connectors, disconnect the 4-pin RTD header (brown, white, grey and blue wires) from the circuit board, and connect your RTD. Otherwise, the onboard RTD will be used for temperature measurements.





## Large Format Cell Holders.

NOVONIX Large Format Cell Holders are typically made to order and feature custom lead lengths and terminations to accommodate various pouch cell sizes. These connectors may be connected directly to a 10A or 20A Channel Module or to a compatible Thermal Chamber.



Figure 15: Large format cell holders, designed for higher current loads, can be configured in a number of ways, with pouch clips, stripped wire, ring terminals, alligator clips etc.

These Cell Holders come wired to accept a separate, external 4-wire RTD, as no on-board RTD is provided.

NOVONIX often provides custom cell holders of all styles. Instructions regarding their use is not covered in this manual.



## 2.3 Communication Cables

Communications cables are used to connect a Control Module to Channel Modules, and to a lab PC running NOVONIX software.



Figure 16: NOVONIX provides custom length cables for new systems to simplify cable management

Each Control Module can connect up to any 8 Channel Modules simultaneously, provided that they are of the same type (2A, 10A <u>or</u> 20A). Channel Modules do not support connecting to mixed Channel Modules at this time.



One Control Module per type of Channel Module! Control Modules do **not** currently support connecting to multiple types of Channel Modules (2A, 10A or 20A) at this time.

All communications cables use an RJ45 connector, with a straight-through Ethernet configuration. Standard, off the shelf Cat6 shielded cables will work. Crossover style Ethernet cables, which are less common, will <u>not</u> work. Ensure the cables you are using are straight-through Ethernet, available from most computer or office supply stores.



Use straight-through Ethernet cables only! Crossover cables will not work and may damage your system.

NOVONIX supplies all necessary cables with new systems cut to a custom length and labeled. Channel Module cables are coloured **green**, while the PC cable is **black**. Some legacy communications cables are **blue**.



# 3. Safety Limits

NOVONIX UHPC channels have several safety limits in place to minimize the risk of over-charge or over-discharge of cells.

The Protocol Designer software package, UHPC-Protocol, includes operating and emergency limits, global settings for a given protocol and the option of individual settings for each step in the protocol. A channel will shut down if these limits are exceeded. These limits can be based on channel current, cell voltage, cell temperature or run time. These safety limits are stored locally with each saved protocol, with default values stored locally on the control PC.

The Control Software, UHPC-Control also uses built-in safety limits. If a user attempts to run a protocol that contains values that exceed UHPC-Control's default limits, it will throw an error and prevent the protocol file from being loaded.

During operation, the software continuously monitors the data returned from each channel and compares this to both the system limits and the limits contained in the protocol file. These limits are integrated in the control software.

The channel boards, located in all UHPC Channel Modules, employ hard current and voltage limits that will prevent these values exceeding the system limits. These limits are inherent to the board and cannot be changed. In the case of constant current testing, channels' voltage limits are slightly above (charge) or below (discharge) the step voltage limit.

Finally, all channel boards employ a hardware timeout; all current is cut if no heartbeat signal is received after a certain period of time. The default value is 60s but can be changed via software settings to a minimum of 10s. See the Software Manual for further information.



# 4.Software

Three software programs are supplied with each system:

**UHPC Control**: this program starts and runs tests dictated by protocol files. It controls the Control Module, its communication with connected channels and controlling charge/discharge profiles etc.

**UHPC Protocol**: this program is used to generate the test sequence protocol files that dictate how a charger channel will operate for a given cell. It allows the user to configure currents, voltage limits, data collection intervals etc.

**UHPC Plot**: this program allows the user to analyze data files generated by the UHPC Control software. It provides both a graphical interface for viewing of data and a data export section that allows the user to export simple text files for subsequent graphing and further analysis





If there is an issue with an existing installation, each piece of software may be removed using the native Windows "Add or remove programs" in System settings.

Remove the problematic installation and reinstall by downloading the latest version from the NOVONIX Customer Area, extracting the folder and running the Setup application.

A Software Manual that covers detailed use of the UHPC Software suite is available in the <u>NOVONIX UHPC Software</u> and is outside the scope of this document.



# 5. Appendix A: Programming NOVONIX Chamber Controllers

More detailed instruction on use of the temperature controller is provided in the hardware manual for your specific controller - <u>Watlow PM PLUS controller</u>.

#### Basic NOVONIX Chamber controller operation:

#### **Control Mode**

- 1. From Home, tap the forward arrow to go to Operations.
- 2. Scroll to and select Setup.
- 3. Scroll to and select Control Loop.
- 4. Scroll to and select Control Mode.
- Select Off, Auto, or Manual.
  Auto: loop adjusts output, so process matches set point.
  Manual: user sets control loop output in percent power. Off: no control loop output

#### **Control Loop Set Point**

- 1. Press the **Home** button to return to the home screen.
- 2. Use the numeric slider or the +/-keys to choose the set point.

#### Autotune

- 1. From Setup, scroll to and select **Control Loop**.
- 2. Scroll to and select Autotune.
- 3. Select Yes.

#### Temperature Control with UHPC Software:

• Temperature can be controlled remotely via NOVONIX UHPC Software (see software manual, Appendix A).







# 6. Appendix B: Cable connections of a UHPC system

The cable connection of an example 2A UHPC system is shown below.



#### ✓ To set up or check cable connection

 Make sure interconnect cables are correctly installed between the Channel Module and the Thermal Chamber. Identify the <u>Channel Module</u> end by looking for additional RF shielding on the cable (see image below).



Make sure a **standard, straight-through Ethernet cable** connects Control Module "computer" port to your PC. Additionally, **standard, straight-through Ethernet cables** should connect Control Module to Channel Modules. Verify that crossover style cables are not being used.

- Power cables of all modules should be connected via a UPS. Please refer to the specific device's <u>specification sheet</u> for power draw information if using a 3<sup>rd</sup> party UPS or have another power solution.
- Make sure that all cables are connected and seated securely.



## ✓ Plug type

The plug requirements by region and by product can be found in the table below.

Thermal Chamber Voltage	Plug	
100-120V	NEMA 5-15p	
220-240V	IEC 320 C14	

UPS Model #	UK	Rest of Europe	North America (Low Voltage)	North America (High Voltage)
SMT3000RM2UC			NEMA L5-30P	
SMX3000RMHV2U	BS 1363A	CEE 7/7		IEC 60320 C20
SRT5KRMXLT-IEC				NEMA L6-30





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