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1. Safety Notices

1.1 Warnings

The following warning and cautions are applicable to this device:

GROUNDING - The control system must be connected to AC (mains) power using a three-wire power cord with a protective ground contact. Always use a three-prong outlet that is properly grounded. Do not operate the device with any two-conductor outlet or extension cord. If using an extension cord, use a three-conductor version.

LINE FUSE - Only use line fuses with the required rated current and voltage, and the specified type (normal blow, time delay, etc.). Do not use repaired fuses or short-circuited fuse holders; to do so could cause a shock or fire hazard.

INTERNAL ADJUSTMENTS - Internal adjustments should be made only by trained service personnel. When performing internal adjustments, use adequate safety precautions to prevent the risk of electric shock. *High voltages from the AC (mains) power line will be present!*

LINE VOLTAGE SELECTION – The control system can operate from an AC (mains) power source with a voltage between 90 and 132 V\(_{AC}\) (100 – 120 V nominal) or between 180 and 264 V\(_{AC}\) (200 – 240 V nominal), and a line frequency between 47 and 63 Hz. There is no line voltage selection switch - the internal power supply will automatically adjust its operation for the applied line voltage.
1.2 SYMBOLS

The following symbols are used in this manual:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>!</td>
<td>Caution! – Risk of electric shock</td>
</tr>
<tr>
<td>!</td>
<td>Caution! – Risk of damage to equipment</td>
</tr>
<tr>
<td>⬇️</td>
<td>Earth Ground</td>
</tr>
<tr>
<td>⬇️</td>
<td>Reference Ground (not necessarily connected to earth ground)</td>
</tr>
<tr>
<td>⫸</td>
<td>Voltage Source</td>
</tr>
<tr>
<td>⫸</td>
<td>Amplifiers (op-amp, line driver, receiver, etc.)</td>
</tr>
<tr>
<td>⫸</td>
<td>Resistor or General Impedance</td>
</tr>
<tr>
<td>⫸</td>
<td>Twisted-Pair Cable</td>
</tr>
</tbody>
</table>
1.3 PACKAGE CONTENTS

Upon receiving the control system, inspect the packaging for damage. If the packaging shows signs of damage or excessive shock, notify the shipping company and then contact ColdQuanta. Keep packing materials, per the instructions of the shipping company.

The shipment should contain the following items:

- Computer control system
- PCIe host card with optional low-profile bracket
- 18-pin TDP cable
- 6-foot analog output cables with three-pin LEMO plugs, quantity = 10
- Additional three-pin LEMO plugs, quantity = 6
- Additional 50 feet of shielded, twisted-pair cable
- AC power cord
- User’s manual (this document)

If any of these items are missing, please contact ColdQuanta to obtain replacements.
## 2. Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANALOG OUTPUTS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage Range</td>
<td></td>
<td></td>
<td>±10</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Current Drive</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Output Impedance</td>
<td>$Z_o$</td>
<td>$f &lt; 100$ kHz</td>
<td></td>
<td></td>
<td>10</td>
<td>Ω</td>
</tr>
<tr>
<td>Capacitive Drive</td>
<td></td>
<td></td>
<td>1.5</td>
<td></td>
<td></td>
<td>nF</td>
</tr>
<tr>
<td>Update Time</td>
<td></td>
<td></td>
<td>12</td>
<td></td>
<td></td>
<td>μs</td>
</tr>
<tr>
<td><strong>DIGITAL OUTPUTS</strong>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Voltage</td>
<td>$V_{OH}$</td>
<td>Sourcing 100 μA</td>
<td>4.75</td>
<td>5.2</td>
<td>5.2</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sourcing 2 mA</td>
<td>4</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Low Voltage</td>
<td>$V_{OL}$</td>
<td>Sinking 100 μA</td>
<td>0.1</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sinking 2 mA</td>
<td>0.26</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Update Time</td>
<td></td>
<td></td>
<td>8</td>
<td></td>
<td></td>
<td>μs</td>
</tr>
<tr>
<td><strong>AC Power Requirements</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage</td>
<td></td>
<td>100 – 120 VAC nominal</td>
<td>90</td>
<td>132</td>
<td>132</td>
<td>VAC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>200 – 240 VAC nominal</td>
<td>180</td>
<td>264</td>
<td>264</td>
<td>VAC</td>
</tr>
<tr>
<td>Frequency</td>
<td></td>
<td>All voltage ranges</td>
<td>47</td>
<td>63</td>
<td>63</td>
<td>Hz</td>
</tr>
<tr>
<td><strong>Physical Dimensions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$l \times w \times h$</td>
<td>16.69 $\times$ 10 $\times$ 5.25</td>
<td>inches</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$l \times w \times h$</td>
<td>42.4 $\times$ 25.4 $\times$ 13.3</td>
<td>cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>14.8</td>
<td></td>
<td></td>
<td>lbs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6.7</td>
<td></td>
<td></td>
<td>kg</td>
</tr>
</tbody>
</table>

1 Includes digital outputs on the 25-pin DDS programming connector and the 1394 shutter connectors.
3. Description

3.1 Overview

ColdQuanta’s computer control system is a single-box solution for providing analog and digital control signals to a variety of laboratory instruments. The system provides 20 analog outputs, 24 digital TTL outputs, a 25-pin output for programming ColdQuanta’s DDS-based frequency synthesizer, and three 1394 TTL outputs for directly driving mechanical shutters. All of the outputs are controlled via an internal FPGA that allows for real-time programming and synchronization.

The computer control system is designed to work with other ColdQuanta products for laboratory-based experiments. The system can be programmed with ColdQuanta’s control software. In addition, the analog outputs of the control system are configured for direct integration with ColdQuanta’s chip and coil drivers. The control software and system also provide seamless programming of ColdQuanta’s DDS-based frequency synthesizer.

3.2 Power Requirements

The control system is powered with a standard three-prong power cord that inserts into the AC Power Module on the rear panel (see Figure 2). The unit can operate with an input voltage of 90-132 or 180-264 VAC and a line frequency between 47 and 63 Hz. The AC power module contains the line fuse, which is a fast-blow type rated at 1 A / 250 V and measuring 5 × 20 mm.

**HIGH VOLTAGE WARNING!**

The control system must be connected to AC (mains) power using a three-wire power cord with a protective ground contact. Always use a three-prong outlet that is properly grounded. Do not operate the device with any two-conductor outlet or extension cord. If using an extension cord, use a three-conductor version.

**HIGH VOLTAGE WARNING!**

Only use line fuses with the required rated current and voltage, and the specified type (normal blow, time delay, etc.). Do not use repaired fuses or short-circuited fuse holders; to do so could cause a shock or fire hazard.
Figure 1: Front panel layout of the computer control system.

Figure 2: Rear panel layout of the computer control system.
4. Connecting to a Computer

The control system interfaces to a computer using a PCIe host card. The card can be installed in any PC with a x1 PCIe slot. The connection between the host card and control system is made with the supplied TDP cable.

4.1 Unpacking the PCIe Host Card

CAUTION!

The PCIe host card is shipped in an antistatic package to prevent electrostatic discharge (ESD) to the device. ESD can damage several components on the device.

Never touch exposed pins on the PCIe card. Doing so may risk damage to the device.

To avoid ESD damage when handling this device, take the following precautions:

- Ground yourself using a grounding strap or by holding a grounded object.
- Touch the antistatic package to a metal part of the computer chassis before removing the device from the package.

Remove the PCIe host card from the package and inspect the device for loose components or any sign of damage. Notify ColdQuanta if the host card appears damaged in any way. Do NOT install a damaged host card into a computer.

Store the host card in the antistatic envelope when not in use.
4.2 INSTALLING THE PCIe HOST CARD

Complete the following steps to install the PCIe host card in your computer.

Note: to install the host card in a computer that requires a low-profile height card, the front bracket must be replaced with the included low-profile bracket.

(1) Power off your computer.

(2) Remove the top cover or access port to the PCIe expansion slots.

(3) Touch the metal part of the power supply case inside the computer to discharge any static electricity on your clothes and/or body.

(4) Unplug the computer from the wall power outlet and wait 30 seconds for the energy stored in the computer’s power supply to fully dissipate.

(5) Select any available PCI slot (x1 or wider) for the host card.

(6) Locate the metal bracket that covers the cut-out in the back panel of the computer for the slot you selected. Remove and save the bracket-retaining screw and the bracket cover.

(7) Line up the host card with the slot in the back panel and slowly push down on the top of the card until its card-edge connector is resting on the expansion slot receptacle. Using slow, evenly distributed pressure, press the host card straight down until it seats in the expansion slot.

(8) Reinstall the bracket-retaining screw and secure the host card to the back panel rail.

(9) Replace the computer cover.

(10) Plug the computer back in.

Note: the BIOS or motherboard may not support the host card in a slot intended for a graphics card.

CAUTION!

To protect both yourself and the computer from electrical hazards, your computer should remain off and unplugged until you have finished installed all hardware.
4.3 CONNECTING THE CABLE

Connect the control system to the PCIe host card using the 18-pin TDP cable. The cable plugs into the jack labeled “PCI Interface” on the right side of the control system’s rear panel (see Figure 2).

4.4 POWERING THE CONTROL SYSTEM ON AND OFF

Power on the control system _BEFORE_ powering on the host computer. The control system will appear as a PCI device connected to the host computer through a PCI-PCI bridge. BIOSes and operating systems make the assumption all PCI devices will be available as soon as code execution begins at power-up. This means that the control system must be turned on _BEFORE_ the host computer in order for the BIOS and OS to configure the control system.

Similarly, operating systems and drivers assume that PCI devices will be available until power-down. Therefore, it is important that you turn off the control system _AFTER_ the host PC. Powering off the control system before the host PC can cause crashes or hangs.
5. Outputs

The table below lists the control system’s outputs. More details about the different types of outputs, including pin designations, are provided throughout this section.

<table>
<thead>
<tr>
<th>Description</th>
<th>Output</th>
<th>Quantity</th>
<th>Connector</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog</td>
<td>±10 V</td>
<td>16</td>
<td>LEMO</td>
<td>Rear</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>BNC</td>
<td>Front</td>
</tr>
<tr>
<td>Digital</td>
<td>5 V TTL</td>
<td>20</td>
<td>BNC</td>
<td>Rear</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>BNC</td>
<td>Front</td>
</tr>
<tr>
<td>DDS</td>
<td>5 V TTL (x24)</td>
<td>1</td>
<td>DB25</td>
<td>Rear</td>
</tr>
<tr>
<td>Shutter</td>
<td>5 V TTL +4.5 VDC</td>
<td>3</td>
<td>IEEE-1394 6-pin alpha</td>
<td>Rear</td>
</tr>
</tbody>
</table>

5.1 Analog Voltage Outputs

The control system comes with 20 digital-to-analog converters (DACs) that can be programmed to output analog voltages between -10 and +10 V. The DACs have a resolution of 16 bits and an update rate of 100 kS/s, and they can source/sink a maximum current of ±1 mA.

5.1.1 Pin Connections

The 16 analog outputs on the rear panel of the control system are connected to three-pin LEMO jacks. The pin configuration of these jacks is shown in Figure 3. The analog voltage (+) is applied to pin 2, and the common (-) is applied to pin 3. Pin 1 should be connected to the shield of the output cable.

The four analog outputs on the front panel of the control system are connected to BNC jacks.

![Figure 3: Pin diagram for the rear-panel analog output connectors. Pin 1 is closest to the red notch. SH = shield.](image-url)
5.1.2 Grounding

The analog voltage outputs are derived from four-channel digital-to-analog (D/A) converter modules that are floating. To provide the greatest flexibility for grounding, switches on the rear panel of the control system can be used to ground the D/A modules to AC earth ground. The configuration of a single module is shown in Figure 4. The four analog channels above each switch are referenced to the same internal common. The four analog outputs on the front panel of the control system are internally referenced to AC earth ground.

Figure 4: The analog voltage outputs are derived from four-channel digital-to-analog (D/A) modules that are floating. For the rear-panel outputs, switches can be used to tie the module common to AC earth ground. Note that the four outputs from the same module are all referenced to the same ground.
5.1.3 Balanced Outputs

To reject ground noise and electromagnetic interference, each of the 16 analog outputs on the rear panel of the control system is configured as a balanced transmitter. When connected to a balanced receiver with high common-mode input impedances, excellent common-mode rejection can be achieved. This topology is particularly useful for rejecting pick-up at 50/60 Hz.

To better understand how balanced circuitry provides common-mode rejection, Figure 5 shows a schematic of a voltage source connected to a balanced receiver. Here, a line driver outputs a differential signal onto two lines labeled HI and LO. These lines have (common-mode) source impedances $Z_{01}$ and $Z_{02}$, and a differential source impedance of $Z_{01} + Z_{02}$. At the receiver, the common-mode load impedances are $Z_{CM1}$ and $Z_{CM2}$, and the differential load impedance is $Z_I$. For the control system, the HI line corresponds to the + output (pin 2) of the LEMO jacks while the LO line is applied to the – output (pin 3) of the LEMO jacks.

The receiver is a differential amplifier that produces an output in response to the voltage difference across its inputs. As a result, common-mode signals (i.e. signals that appear identically on both of the inputs) are suppressed via subtraction. Assume that the receiver is referenced to a ground that has a noise voltage superimposed on it, as measured with respect to the receiver’s ground. The voltage at each of the receiver’s inputs, again measured with respect to the receiver’s ground, is the sum of the desired transmitted signal and the unwanted ground noise voltage. The ground noise will appear identically on both of the inputs, and therefore will be removed by the receiver upon subtraction.

Note that the voltage on the HI line will be reduced by the voltage divider formed by $Z_{01}$ and $Z_{CM1}$. Similarly, the voltage on the LO line will be reduced by the voltage divider formed by $Z_{02}$ and $Z_{CM2}$. For optimal common-mode rejection, these voltage dividers should be matched as well as possible. Given the limitations imposed by the 1% tolerance of typical resistors, the mismatch between the voltage dividers can be minimized by reducing the source impedances and increasing the load impedances, i.e. $Z_0 \ll Z_{CM}$. For example, with $Z_0 = 100 \, \Omega$ and $Z_{CM} = 10 \, \text{M}\Omega$, the voltage on each line will be reduced by $10 \, \text{M}\Omega / (100 \, \Omega + 10 \, \text{M}\Omega) \approx 0.99999$. Assuming that source and load impedances are matched to 1%, the voltage dividers will be matched to 1 part in $10^7$, corresponding to a limit for the common-mode rejection ratio (CMRR) of $20 \log 10^7 = -140 \, \text{dB}$. The actual CMRR will be limited by the performance of the receiver.

Figure 5: The rear-panel analog outputs are configured as balanced transmitters. When used with balanced receivers with high common-mode input impedances, the topology provides excellent common-mode rejection of ground noise and electromagnetic interference.
5.1.4 Proper Wiring of the Analog Outputs

To maximize common-mode rejection of ground noise and electromagnetic interference, the use of shielded, twisted-pair cables is strongly recommended. A cable’s shield should be tied to the reference voltage at the source, not the load. To create electrically and mechanically reliable connections to the cable’s shield, a cable with a drain wire is recommended, and the drain wire should be soldered to pin 1 of the LEMO plug. As described in more detail in the next section, the cable shield should never be connected to the metal housing of the LEMO plug.

The control system is shipped with ten analog output cables. On one end of each cable, the HI and LO wires have been soldered to pins 2 and 3, respectively, of a LEMO plug that mates with the jacks on the control system. The cable drain wire has been soldered to pin 1 of the LEMO plug. In addition, the cable shield has not been connected to the metal housing of the LEMO plug. The other end of the cable has not been connectorized.

Figure 6 shows how an analog output is configured as a balanced line driver with a shielded, twisted-pair cable. When the D/A module is floating, large common-mode voltages can appear on the analog outputs. Although a common-mode voltage will be rejected by a balanced receiver, the input voltage range of the receiver may be exceeded. To reduce the common-mode voltage, the D/A module should be tied to earth ground using the ground switch on the rear panel.

The analog outputs can be used as single-ended voltage sources. However, common-mode rejection may be compromised depending on how the HI and LO lines are terminated at the receiver. When the LO line is connected to earth ground at the receiver (see the dashed gray line in Figure 6), the entire D/A module will be earth-grounded. This will create a ground loop if the D/A module is also earth-grounded at the control system. To break this ground loop, the D/A module should be floating.

Figure 6: The analog outputs can be configured as balanced or single-ended line drivers. When the LO signal (blue) is earth-grounded at the receiver (gray dashed line), a ground-loop will form if the D/A module is earth-grounded at the control system. To break this ground loop, the D/A module should be floating.
5.1.5 Improper Wiring of the Analog Outputs

Figure 7 shows three improper techniques for wiring the analog outputs: a cable shield grounded at both ends, a cable shield connected to the metal housing of the cable plug, and a cable shield unconnected at the line driver. The problems that arise from these connections are described below.

5.1.5.1 Shield Directly Grounded at Two Points

As indicated by the purple line in Figure 7a, a cable shield earth-grounded at both of its ends creates a ground loop. Due to this loop, voltage noise on the earth ground will drive a noise current through the cable shield. Imperfections in cable manufacturing give rise to imbalances in magnetic and capacitive couplings between the cable’s shield and two signal lines. As a result, currents flowing along the shield will couple differentially into the signal lines. The coupled noise will appear as normal-mode to the receiver, and will therefore not be rejected. This effect is known as shield current induced noise, or SCIN.

5.1.5.2 Unconnected Cable Shield at Line Driver

As mentioned in the previous section, imperfections in cable manufacturing give rise to an imbalance in capacitive coupling between the cable’s shield and each of two signal lines. These cable capacitances interact with the line driver’s common-mode output impedances to form low-pass filters. If the shield is connected only at the coil driver input, as shown in Figure 7b, then voltage noise on the earth-ground will be filtered differently on each of the two signal lines. The result is a degradation of common-mode rejection of this ground noise. The problem can be mitigated by tying the cable shield only to the reference voltage of the analog output.

5.1.5.3 Cable Shield Connected to Housing of Input or Output Jack

The LEMO plugs that connect to the analog outputs have metal housings that can be internally tied to the cable shield. When this connection is made, the cable shield is directly tied to earth ground through the control system’s metal enclosure, bypassing the grounding switch (see Figure 7c). To prevent this bypass, the cable shield should never be tied to the metal housing of the LEMO plug.
Figure 7: Improper wiring of the analog outputs.
5.2 **Digital Outputs**

The computer control system provides 24 digital outputs, all of which are accessed via BNC jacks. Twenty of these outputs are on the rear panel, with an additional four on the front panel. The outputs are single-ended +5V TTL signals that can source/sink up to ±2 mA. All of the outputs are referenced to the same ground.

5.3 **DDS Control Output**

A 25-pin D-sub connector on the rear panel provides digital TTL lines for programming ColdQuanta’s DDS-based frequency synthesizer. Please refer to the synthesizer user’s manual for more information about the pin configuration and synthesizer programming.

5.4 **Shutter Outputs**

On the rear panel of the control system are three IEEE-1394 jacks (6-pin alpha) for driving mechanical shutter heads from Stanford Research Systems (models SR475 and SR476). The pin diagram for these jacks is shown in Figure 8. Alternatively, these jacks can be used with any device that requires a TTL control signal along with a DC power source.

To work with the SR475/476 shutter heads, ground must be provided on pin 2 with the 1394 cable shield connected to chassis ground. Note that standard IEEE-1394 cables are crossover cables that reverse the signals of pins (3,5) and of (4,6) at the two ends.

![Pin Diagram](image)

**Figure 8**: Pin diagram for the 1394 shutter control outputs.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+12 VDC</td>
</tr>
<tr>
<td>2</td>
<td>Ground</td>
</tr>
<tr>
<td>3</td>
<td>NC</td>
</tr>
<tr>
<td>4</td>
<td>NC</td>
</tr>
<tr>
<td>5</td>
<td>+4.5 VDC</td>
</tr>
<tr>
<td>6</td>
<td>TTL Signal</td>
</tr>
</tbody>
</table>
6. Troubleshooting

<table>
<thead>
<tr>
<th>Description</th>
<th>Solution</th>
</tr>
</thead>
</table>
| “Main Power” indicator does not illuminate when button is depressed. | The unit is not receiving power from the input AC (mains) line:  
  - Check that the power cord is properly inserted into a three-prong protective-grounded power output.  
  - Check that the power cord is properly plugged into the input power module on the back of the device.  
  - Check that the correct fuse has been inserted into the fuse holder on the back of the device. If the fuse is blown, replace with a fuse of the same current rating, voltage rating, and type (i.e. slo-blo, fast blo, etc.). |
7. Limited Warranty

1. Definitions
a) “Delivery” means standard ColdQuanta shipping to and arrival at the receiving area at the “Ship To” address specified in Customer’s Order.
b) “Exhibits” means attachments that describe or otherwise apply to the sale of Products.
c) “Products” means hardware, documentation, accessories, supplies, parts and upgrades that are determined by ColdQuanta to be available from ColdQuanta upon receipt of Customer’s Order. “Custom Products” means Products modified, designed or manufactured to meet Customer requirements.
d) “Specifications” means specific technical information about ColdQuanta Products that has been delivered by ColdQuanta to the Customer with Customer’s Order.
e) “Support” means hardware maintenance and repair; training; and other standard support services provided by ColdQuanta. “Custom Support” means any agreed nonstandard support, including consulting and custom project services.

2. Limited Warranty
a) ColdQuanta warrants ColdQuanta hardware Products against defects in materials and workmanship for a period of one year from the delivery date.
b) ColdQuanta does not warrant that the operation of Products will be uninterrupted or error free.
c) If ColdQuanta receives notice of defects, ColdQuanta will, at its option, repair or replace the affected Products. If ColdQuanta is unable, within a reasonable time, to repair, replace or correct a defect or non-conformance in a Product to a condition as warranted, Customer will be entitled to a prorated refund of the purchase price upon prompt return of the Product to ColdQuanta. Such refunded amount will be prorated based on a four-year straight line depreciation schedule. Customer will pay expenses for return of such Products to ColdQuanta. ColdQuanta will pay expenses for shipment of repaired or replacement Products.
d) ColdQuanta warrants that ColdQuanta Support will be provided in a professional and workmanlike manner. Some newly manufactured ColdQuanta Products may contain and ColdQuanta Support may use remanufactured parts that are equivalent to new in performance.
e) The above warranties do not apply to defects resulting from:
   (i) improper or inadequate maintenance by Customer;
   (ii) customer or third party supplies;
   (iii) unauthorized modification;
   (iv) improper use or operation outside of the Specifications for the Product;
   (v) abuse, negligence, accident, loss or damage in transit;
   (vi) improper site preparation; or
   (vii) unauthorized maintenance or repair.

f) THE ABOVE WARRANTIES ARE EXCLUSIVE AND NO OTHER WARRANTY, WHETHER WRITTEN OR ORAL, IS EXPRESSED OR IMPLIED. TO THE EXTENT PERMITTED BY LAW, COLDQUANTA SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, TITLE, AND NONINFRINGEMENT.