ICI

Interlock Control Interface

for Particle Therapy Systems

User Manual

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1 Table of Contents

2 Figures

3 Safety Information

3.1 Standards

This unit is designed for compliance with harmonized electrical safety standard EN61010−1:2000. It must be used in accordance with its specifications and operating instructions. Operators of the unit are expected to be qualified personnel who are aware of electrical safety issues. The customer's Responsible Body, as defined in the standard, must ensure that operators are provided with the appropriate equipment and training.

3.2 Power and Grounding

The unit is designed to operate from +24 VDC power, with a typical current requirement of 600 mA. A suitably rated power supply module is available as standard and is strongly recommended. Customers who make their own 24 V power provision should ensure that the supply cannot source more than 4200 mA, that it has the correct connector type, that it is rated for use in the environment, that it provides overcurrent and short circuit shutdown and that it has all necessary regulatory approvals.

A safety ground must be securely connected to the ground lug on the case of the ICI.

3.3 Safety considerations for the intended application

The ICI is a component of an overall safety system for a proton therapy system. By itself, it cannot ensure safe delivery of dose. It must be connected to relevant signals and interlock systems, the configuration must be subjected to risk analysis, and the connections must be checked and tested. If there is any reason to suspect the features are not working as described, the proton therapy system must not be used for medical treatments until the problem is identified and resolved.

3.3.1 Signal passthrough

The unit is equipped with a signal passthrough loop. Critical accelerator control signals, such as originating from a Pyramid Accelerator Control Interface (ACI) can be gated via this passthrough feature. In particular the Beam Enable, and Current Command signals can be interrupted so that they are included in a safety interlock system.

3.3.2 Safety Relays

The ICI uses RF1V−4A2B−D24 IDEC force guided safety relays to constitute two interlock chains, referred to as the hard and room (or soft) interlock chains. The relays are used in redundant pairs.

These safety relays are generally used in safety circuits because they permit secure detection of failures such as contact welding and damage to the contact spring. Contacts of a force guided relay are forced to open and close by a guide connected to the armature. Due to requirements of standard EN50205, a force guided relay has independent NO and NC contacts. If a NO

contact welds, a NC contact will not close even when the relay coil is turned off (de−energized) and must maintain a gap of at least 0.5 mm. Furthermore, if a NC contact welds, a NO contact will not close when the relay is turned on (energized) and must maintain a gap of at least 0.5 mm.

In the ICI circuit, the safety relays have an “open” time of under 5 msec. In order to provide a faster initial response redundant pairs of fast Coto Technology Reed fast relays in the through lines allocated for Beam Enable and Current Command are included that open in under 25 µsec.

3.4 Symbols

Some of the following symbols may be displayed on the unit and have the indicated meanings.


Direct current


Earth (ground) terminal


Protective conductor terminal


Frame or chassis terminal


Equipotentiality

Supply ON


Supply OFF


CAUTION − RISK OF ELECTRIC SHOCK


CAUTION − RISK OF DANGER − REFER TO MANUAL

4 Models

ICI–G	ICI interlock control interface.

5 Scope of Supply

ICI−G model.

PSU24−40−1R 24 VDC 40−watt power supply with Redel locking connector, rated for medical use.

Mating connectors for rear panel headers (six).

USB memory stick containing:

- ICI User manual
- ICI Datasheet
- Manufacturing test results

OEM customers will receive only components relevant to their application.

6 Optional Items and Related Products

6.1 Power Supplies

PSU24−40−1R +24 VDC 40W PSU (universal voltage input, 50/60 Hz, plug receptacle for standard IEC C14 three−pin socket) with output lead terminated in two−pin Redel PAG connector.

CAB−LR−3−REDEL Cable Switchcraft LR 2.1mm jack to Redel PAG connector, 3 feet long.

PD−8 Eight output +24 VDC power supply unit, 19” rack mounting.

6.2 Data Cables

CAB−RJ45−xxx−RJ45 Ethernet CAT5, xxx feet long.

7 Intended Use and Key Features

7.1 Intended Use

The Interlock Control Unit (ICI) is intended to provide dose safety interlocks for a particle therapy control system. It provides enable signals to a beam production system provided that all relevant incoming interlocks are good. The ICI should must be connected so that beam current delivered from a particle accelerator and beam transfer line is stopped with very high reliability when its output relays are opened. The relay contacts are normally open type so that the ICI must be operating with all relevant inputs good before the output relays will be energized to allow beam.

The ICI was designed in association with the Pyramid Accelerator Control Interface (ACI) and includes features that exploit the relationship. The ICI may be used in other contexts provided that its specifications and functions are fully understood. Consult Pyramid Technical Consultants for further advice in this case.

The ICI receives interlock signals from external devices, such as from the Pyramid Scan/Dose nozzle systems. These signals are processed in the ICI using hardware−only logic, and the resultant interlocks sent to an output connector for further interlock use. The ICI also allows gating of beam enable and beam current command signals routed out the ACI, via the ICI and back into the ACI. The ICI includes monitoring of the state of the various signals it handles via a computer interface, but this function does not have any control influence on the hardware logic.

The ICI is not intended to provide a general purpose facility interlock capability. It is not designed to manage controlled area access, area monitoring, fire or flood monitoring for example. It includes two uncommitted interlock inputs (in addition to inputs nominally allocated to treatment rooms) that can be used for any signal that the user wishes to have as a beam enable condition.

It is possible to place ICIs in series in order to provide more inputs, for example having one in each treatment room feeding one at the accelerator interface level.

CAUTION

The ICI alone cannot ensure patient or user safety in the presence of therapeutic particle beams. All particle therapy systems must be subjected to risk analysis according to ISO 14971 to assess hazards and harms and judge whether safety systems and procedures are sufficient to mitigate risks to acceptable levels.

7.2 Key Features

The ICI is designed to address certain requirements of IEC 60601−2−64:2014 as it relates to delivery of therapeutic beam.

All interlock logic is implemented only in hardware.

All inputs and outputs implemented as redundant series pairs for reliability of the disable response.

High level of electrical isolation for electromagnetic immunity.

Compatible with Pyramid Accelerator Control Interface (ACI)

Supports two independent interlock chains referred to as the soft (room−centric) and hard (facility−wide) interlocks.

Any hard interlock input going bad will cause the hard output relay to open to disable the beam.

The soft interlock input for the selected treatment room going bad will cause the soft output relay to open to disable the beam.

Six hard interlock inputs.

Four room (soft) interlock inputs.

A signal passthrough system that allows the interlocks to additionally gate two accelerator control signals such as beam enable and analog current command at high speed.

Illuminated LCD display to view device status.

Interlock status LEDs.

Built−in self−diagnostics.

Ethernet connectivity via EPICS interface to report interlock states to remote computers.

Web browser interface.

8 Specification

Interlocks		
	Room (soft) interlock inputs	Four opto−coupled inputs (5 to 24 VDC operation, two 1 kohm loads in parallel per input for 500 ohm total per input). Two inputs to each of two connectors. Each input drives a redundant pair of parallel signal paths in the ICI, both of which must pass a good condition before the output can be good. The combined hold current for the redundant opto−coupler pair on each input is 44 mA typical at 24 VDC and 10 mA typical at 5 VDC. Only the state of a selected room is passed to subsequent circuitry in the ICI. This allows patient setup activities in inactive rooms that might otherwise cause an unwanted beam shutdown.
	Soft interlock output relay	Potential−free safety−rated relay contact. Two relays in series. Maximum switched current rating 6 A and maximum switched voltage 250 VAC or 30 VDC. Maximum switched resistive load 1500 VA (AC), 180 W (DC). Output opens in response to a loss of 24 V logic signal on the input within 5 msec.
	Hard interlock input relays	Six relay coil inputs, 24 VDC operation. Two inputs to each of three connectors to receive interlock inputs from each of four rooms and from two additional sources. Each input drives a redundant pair of relays in series, both of which must pass a good condition across all the hard inputs before the output can be good. The combined hold current for the redundant relay pair on each input is 42 mA typical. The ICI forms the logical AND of the good state of all six hard interlock inputs. No treatment room gating.
	Hard interlock output relay	Potential−free safety−rated relay contact pair. Maximum switched current rating 6 A and maximum switched voltage 250 VAC or 30 VDC. Maximum switched resistive load 1500 VA (AC), 180 W (DC). The output opens in response to a loss of 24 V logic signal on an input within 10 msec.
	Signal passthrough	Interrupts the critical accelerator control signals such as from an external device such as the ACI based on the states of the soft and hard interlocks.

		A selected room (soft) interlock input going bad will interrupt the Beam Enable and CurrentCommand passthroughs in less than 25 µsec. A hard interlock input going bad will interrupt the Beam Enable and CurrentCommand passthroughs in less than 10 msec.
Processor		
	Type	TI Sitara AM335x (ARM Cortex A8) 1 GHz with dual PRU.
	Operating system	QNX.
	Safety logic	No ICI safety logic is handled by the processor, which performs monitoring functions only.
Self−test		
	Automated self−test (POST)	Automated tests of r RAM and flash memory, Ethernet connection. Host system can see if POST fails and may take system out of clinical operation mode if desired.
Connectivity		
	Ethernet	Ethernet 10/100/1000 Mbps. Auto MDIX. Embedded EPICS channel access server allows client software to monitor and control device function.
	USB	USB port for device setup and diagnostics (qualified service technician operation requiring internal access). Connecting to the USB port creates a virtual network to a host system and appears at static IP address 192.168.7.2.
	Serial debug port	Serial connection to internal processor available via rear panel header connector.
Power		
	Power input	24 V (+/− 2V) DC, 600 mA typical, 1000 mA max.
Case		
	Format and materials	1U 19” 250 mm deep rack mounting steel chassis with Al alloy front panel and polycarbonate decals. Fan−cooled.
	Protection rating	The case is designed to rating IP43 (protected against solid objects greater than 1mm in size, protected against spraying water).
	Weight	3.5 kg (7.7 lb)

	Dimensions	See figures.
Environment		
	Operating environment	10 to 35 C (15 to 25 C recommended), < 70% humidity, non−condensing, vibration < 0.1g all axes (1 to 100 Hz).
	Shipping and storage environment	−10 to 50 C, < 80% humidity, non−condensing, vibration < 1g all axes, 1 to 100 Hz.
Displays and Indicators		
	OLED display	Front panel 2x16 character blue OLED to report device status.
	Interlock state LEDs	Front panel LEDs. Each of the input and output relay or optocoupler states is shown by a dedicated LED. LED illuminated = state is good (allow beam). Selected room is shown by a dedicated LED.
	ICI status	Four rear panel LEDs showing ICI power, processor and communication status.
	Ethernet	Ethernet traffic indicator LEDs on RJ−45 connector.
Controls		
	Controls	None.

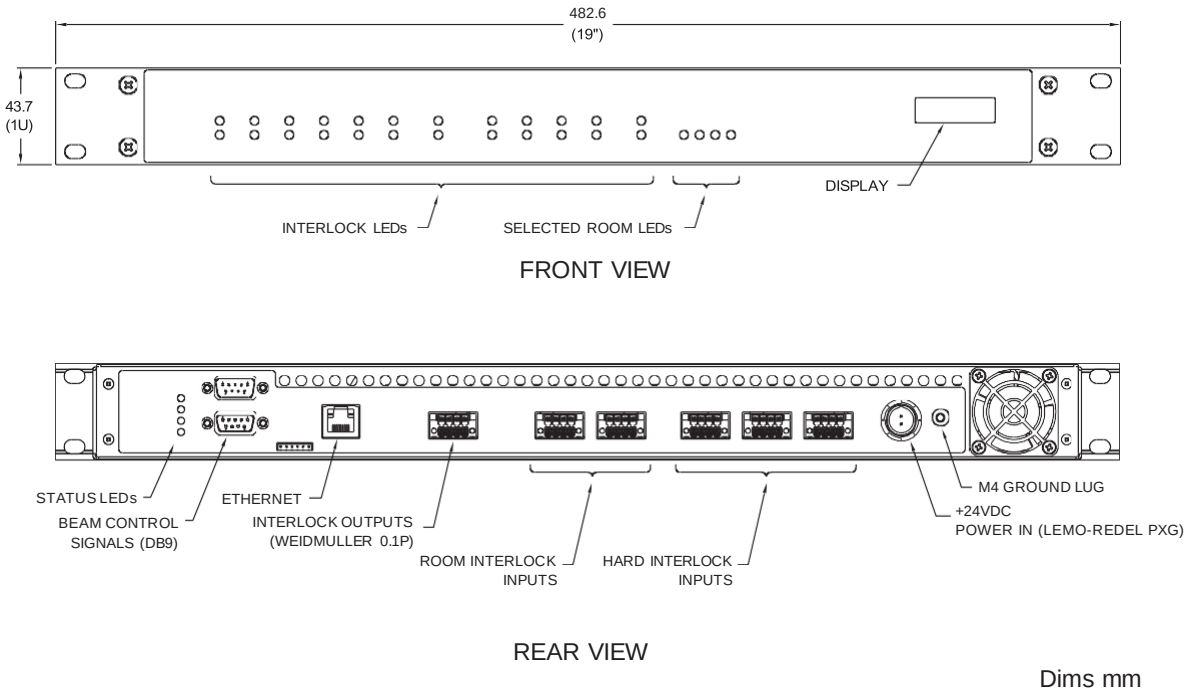


Figure 1 - ICI front and rear panels. Dimensions in mm.

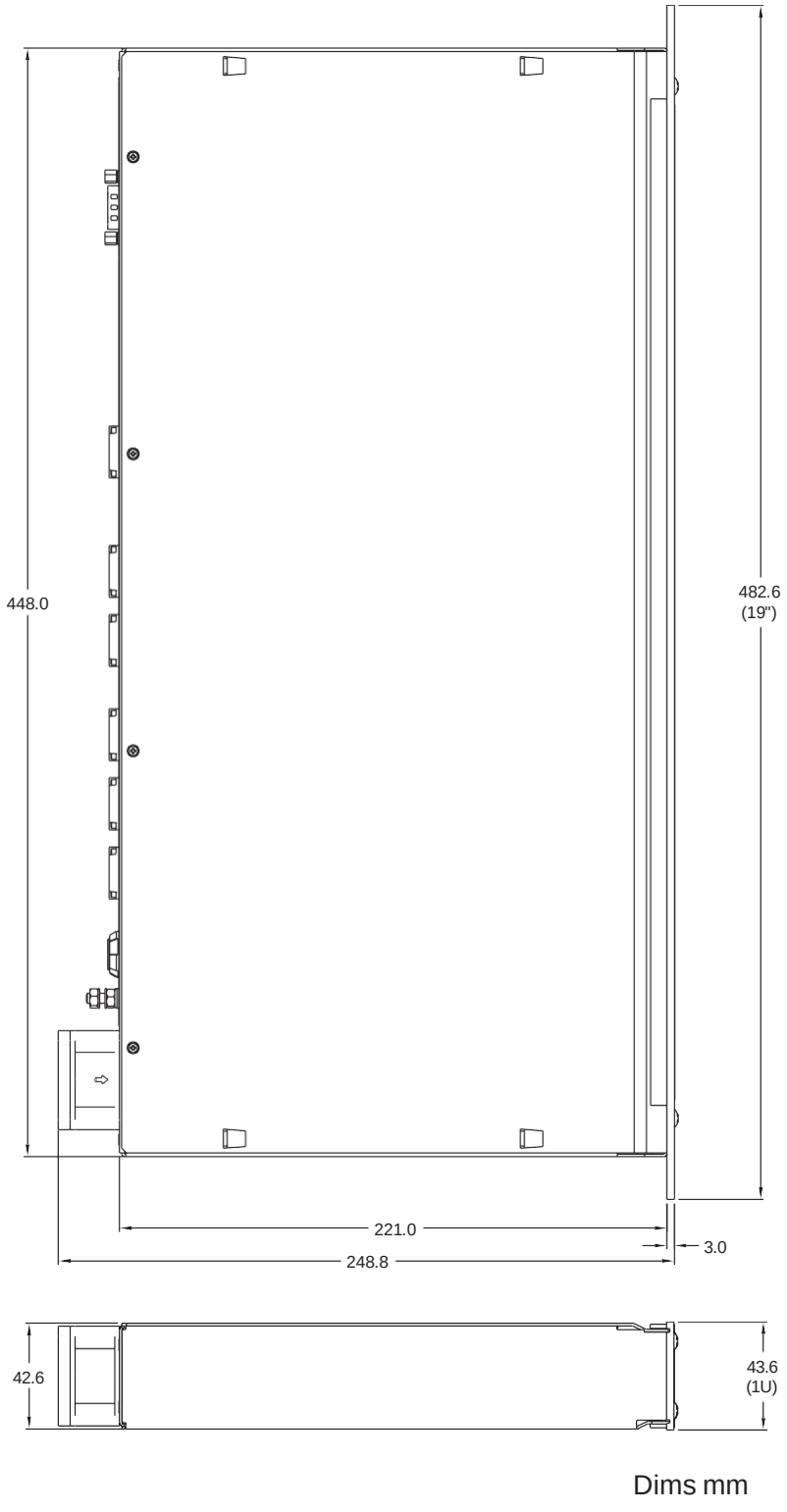


Figure 2 - ICI case plan and side views. Dimensions in mm.

9 Installation

9.1 Mounting

The ICI is intended for 19” rack mounting, but may be mounted in any orientation, or may be simply placed on a level surface. A fixed mounting to a secure frame is recommended in a permanent installation for best reliability, as this can be degraded by movement and vibration. In particular the level of vibration, movement and general disturbance in the vicinity of the ICI must not be such that it could compromise the rear panel connections.

The mounting position should allow sufficient access to connectors and cable bend radii. 60 mm minimum clearance is recommended at front and back of the device.

Best performance will be achieved if the ICI is in a temperature−controlled environment. No forced−air cooling is required in addition to the unit’s built−in fan, but free convection should be allowed around the back and sides of the case.

9.2 Grounding and Power Supply

A secure connection should be made using a ring lug, from the M4 ground lug to local chassis potential. This is the return path for any high voltage discharge passing via the ICI. +24 VDC power should be provided from a suitably−rated power supply with the following minimum performance:

Output voltage	+24 +/− 0.5 VDC
Output current	1000 mA minimum, 4200 mA maximum
Ripple and noise	< 1% pk−pk, 1 Hz to 1 MHz
Regulation	< +/− 5%

The ICI includes an internal automatically re−setting PTC fuse rated at 1.1 A that protects the internal circuitry. Additional 200 mA fuses limit the current that can flow via external connections. However, the external supply should in no circumstances be rated higher than 24 V at 5 A.

9.3 Interlock Input Connections

The ICI provides six hard interlock inputs grouped in pairs on three 8−pin Phoenix Combicon 3.5 mm 1787030 header connectors, four room (or soft) interlock inputs on two further 8−pin Phoenix connectors. The hard and room output interlock relay contacts are on the final 8−pin Phoenix connector. The connectors are polarized against incorrect orientation, but since they are all of the same type, the cables must be clearly identified.

A Phoenix 1790506 mating lock and release connector is supplied for customer use on each connector. The Phoenix 1790315 is an alternative mating connector using screw fastening. Individual wires should be multistrand insulated with overall cross section between 24 and 16

AWG. The larger wire gauges (22 to 16 AWG) are recommended for long cable runs. The wires should be bared at the end and clamped into the connector using the spring lock mechanism. Check that each wire is secure and making reliable electrical contact.

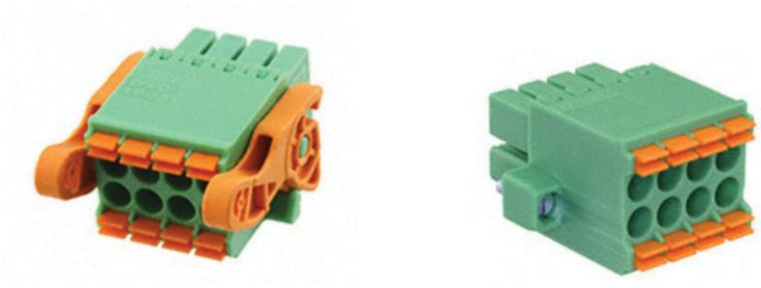


Figure 3 - Phoenix 1790506 and 1790315 mating connector types for ICI connections

Hard and room (soft) interlock inputs are intended for 24 VDC logic. A 200 mA fused 24 VDC outlet is included for each connection that can be used as the voltage source, as shown in the following figure.

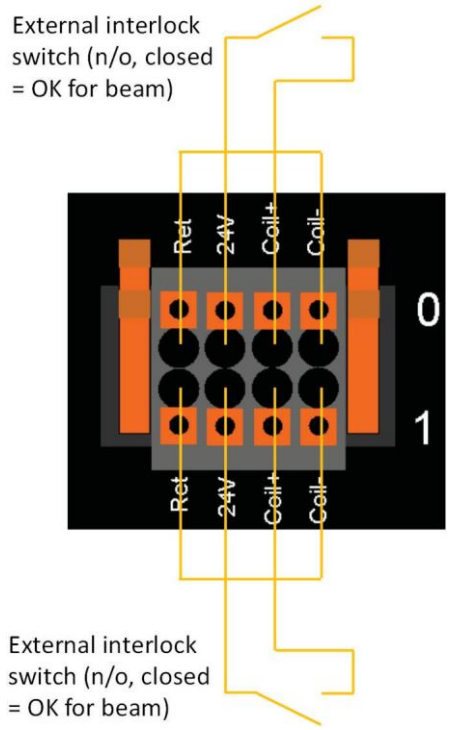


Figure 4 – Connecting to external interlock switches using ICI 24 V power

The hard interlock inputs connect to 24 VDC relay coils which must be energized to set the “OK for beam” state. The room (soft) interlock inputs connect to bipolar optocoupler diodes which can be connected as shown previously in figure 4. Alternatively, lower voltage logic such as 12

V or 5 V can be used for room (soft) interlock inputs, but in this case the voltage source must be external to the ICI.

Any unused hard interlock inputs must be shorted to allow the “OK for beam” state to be reached. Any unused room interlock inputs can be left unconnected provided that the missing room is never selected. It is therefore simpler if these are shorted also.

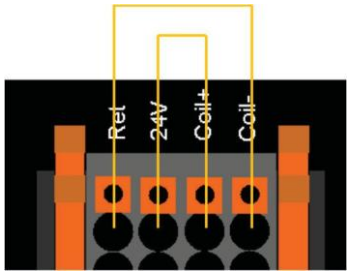


Figure 5 – Shorting plug configuration

9.4 Interlock Output Connections

Both hard and room relay inputs combine to form a single hard interlock output and a single room (soft) interlock output which appear as safety relay contact pairs. These should be connected to high−reliability fail−safe means of disabling the beam, preferably independent. Such beam disable means would generally be independent of the Beam Enable and Current Command signals that are used to control the beam for dose control.

The outputs may be used simply as contact closures which enable the external beam shutdown device to allow beam, or as 24 VDC logic signals which enable the external beam shutdown device to allow beam. Both options are illustrated in the following figure.

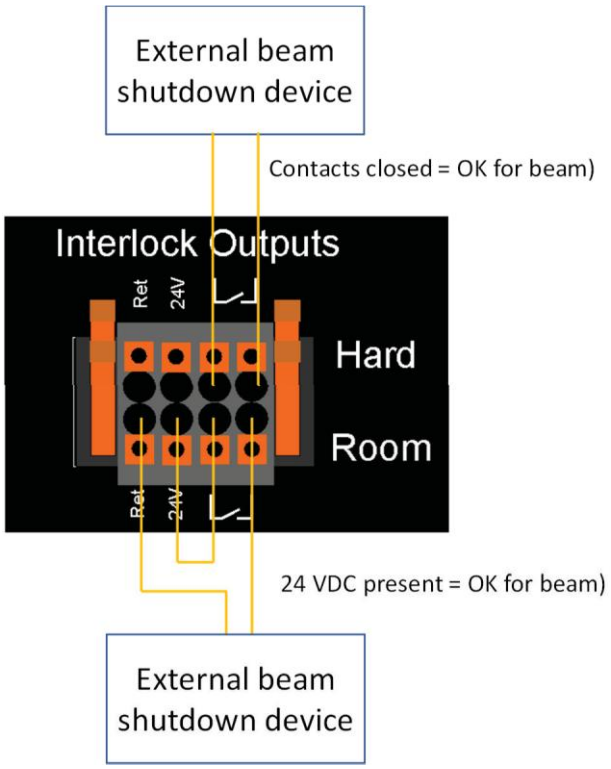


Figure 6 – Connection options for beam shutdown devices

9.5 Passthrough connections

When the ICI is used together with the Pyramid ACI there is a passthrough connection that carries Beam Enable and Current Command signals through the ICI where they can be interrupted. The selected room address is also communicated to the ICI on the same connector as a two bit digital pattern. Other lines allow the ACI or other receiving device to see the hard or soft interlock states and confirm that the connecting cables are in place.

If the ICI is used in isolation, then the room address bits must be provided to the ICI to ensure correct room (soft) interlock multiplexing behavior. The two through channels with fast relays in series can be used to switch any logic level or analog signals. Although this switching is not presented as a primary means of beam interlocking, it can be used to provide additional faster acting protection.

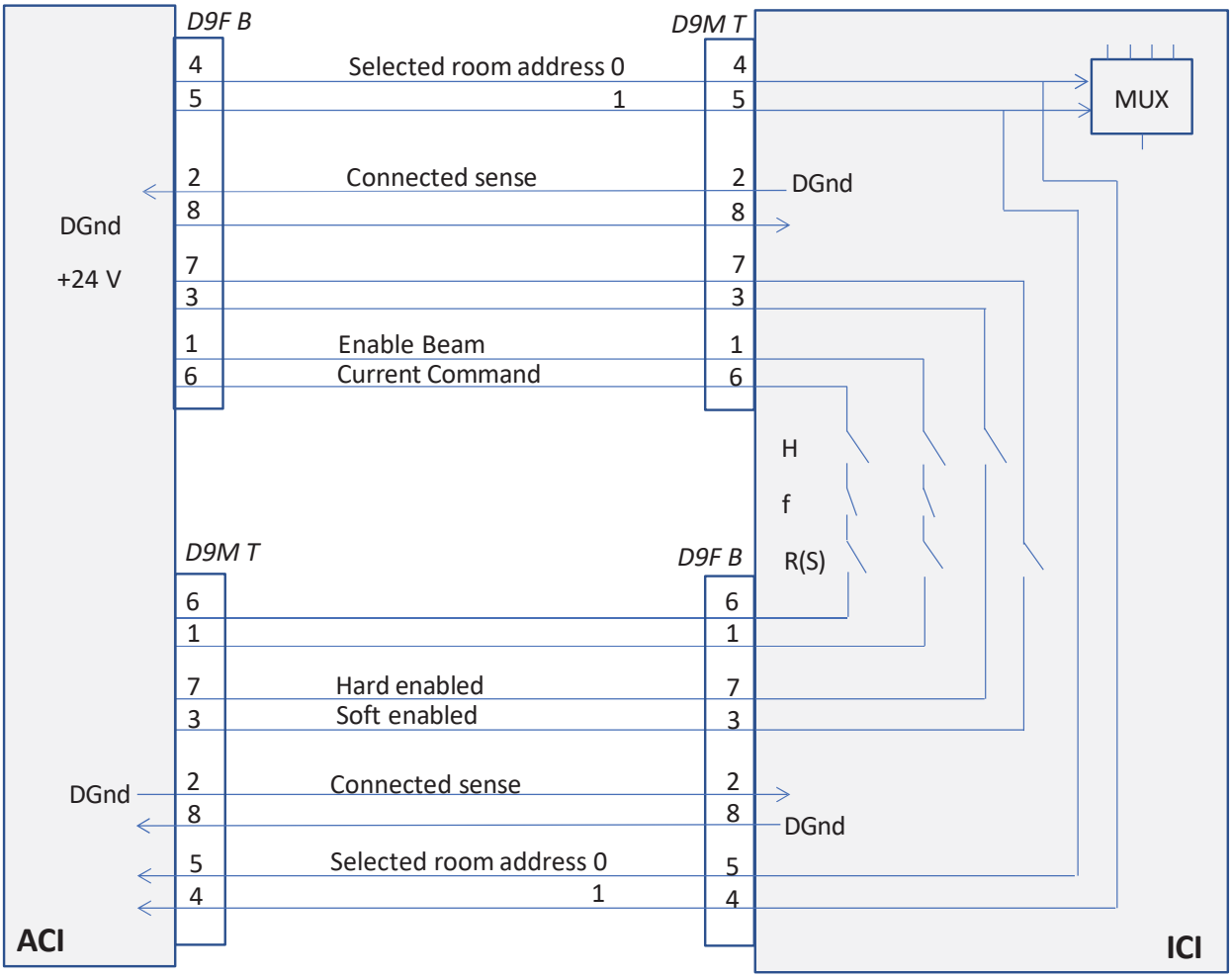


Figure 7 – Passthrough connections

9.6 Detailed connection example

A typical facility has multiple treatment rooms that must share a single accelerator. The figure below shows an example of a scheme using the ICI and ACI in a multiroom system.

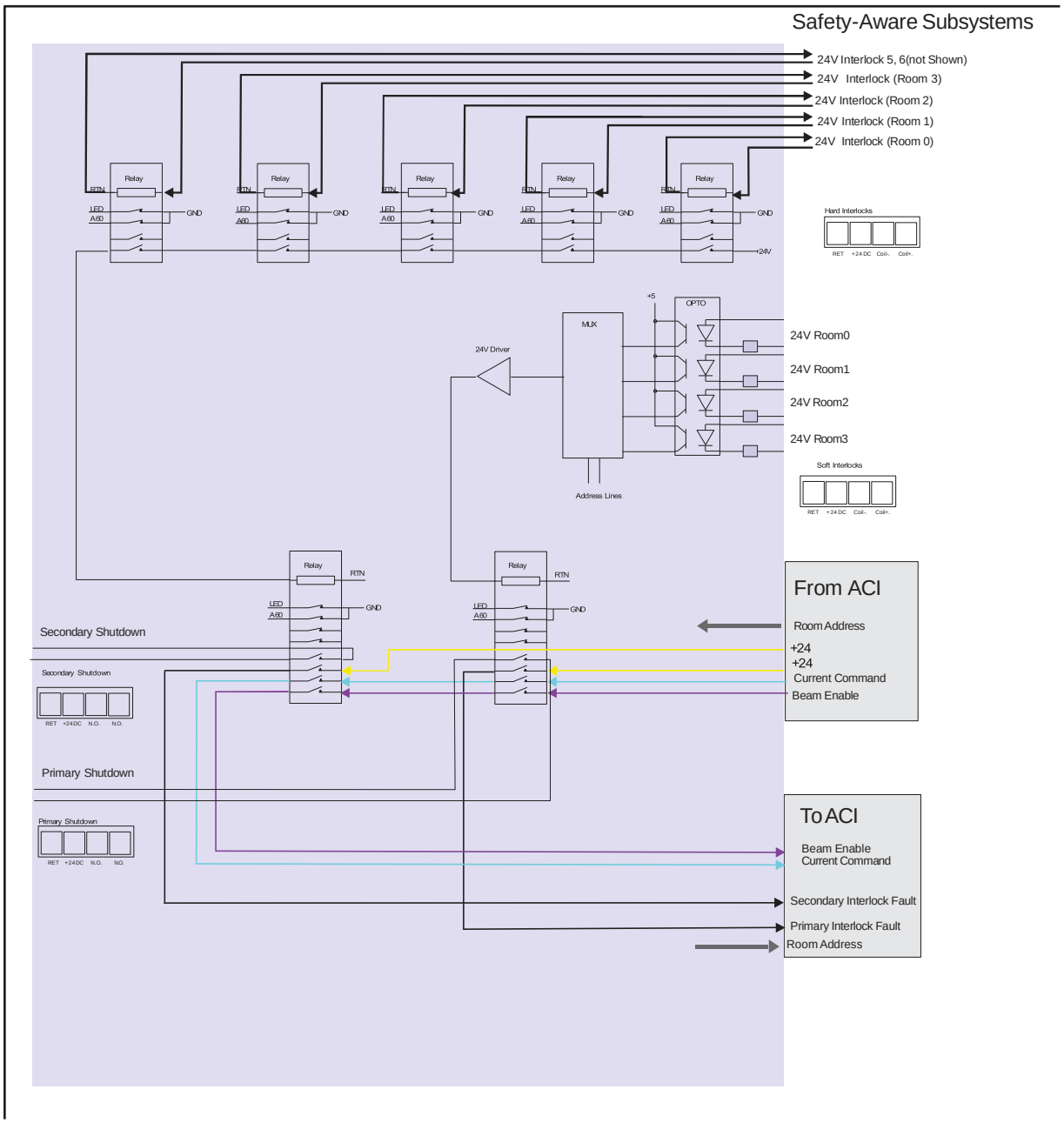


Figure 8 – ICI signal connections

The following connections are made to each subsystem in this example.

9.6.1 Power

Function	Signal type	ICI connection	Termination	Cable type	Target connection	Comments
ICI power	24 VDC	Input +24V – 700mA	Redel PAG.M0.2 or PFG.M0.2	PSU24–40–1R cable or CAB–LR–3–REDEL if using PD8	PSU24–40–1R	

9.6.2 Interlocks

Function	Signal type	ICI connection	Termination	Cable type	Target connection	Comments
Interlock outputs	24 VDC logic	Current Command, 0–20mA or 10V	Phoenix 8 pin	Twin core twisted pair insulated 16–24 AWG.	System components to shut off beam	
Room interlock inputs	24 VDC logic	I Monitor Input	Phoenix 8 pin	Twin core twisted pair insulated 16–24 AWG.	Pyramid scan/dose real time controllers, other room related inputs	Can optionally receive inputs from patient positioner, CM100, and other sources as needed.
Signal interlock outputs	Analog and digital TTL	Beam Control Signals – Signals Out	D9 male	9–pin ribbon cable	ACI or other suitable device	Terminate with loop back connector on inputs if interlocking not needed.
Signal interlock inputs	Analog and digital TTL	Beam Control Signals – Signals In	D9 female	9–pin ribbon cable	ACI or other suitable device	Terminate with loop back connector on outputs if interlocking not needed.

9.6.3 Communications

Function	Signal type	ICI connection	Termination	Cable type	Target connection	Comments
Ethernet interface	Ethernet 10/100/1000	Ethernet	RJ45 jack	CAT5	Treatment control system	1000kb recommended

9.7 Connection validation and security

CAUTION

Once all connections are made to the ICI they must be carefully checked by another qualified person for physical integrity, electrical integrity, and conformance to the system electrical drawings. The response of the ICI to all the connected inputs must be validated. Only then can the installation be cleared for beam interlocking.

Inspection of the connections should be performed during routine preventative maintenance inspections. Access to the connections should be restricted to trained personnel. If there is any suspicion that the connections have been altered or compromised, then the system must be taken off−line until it can be re−qualified.

The ICI is able to monitor its own internal relay states and report the results via Ethernet to a host computer. This feature should be used by host software to identify any deviation from expected behavior.

10 How the ICI Works - An Overview

The ICI provides a hardware logic circuit that allows multiple inputs to be combined to produce two independent control outputs intended to enable beam when all inputs are good. The summary logic is shown in the following figure, where the logic is for propagation of the good state. All hard interlock inputs must be good and the room (soft) interlock for the room selected by the address bits must be good to set the outputs to good.

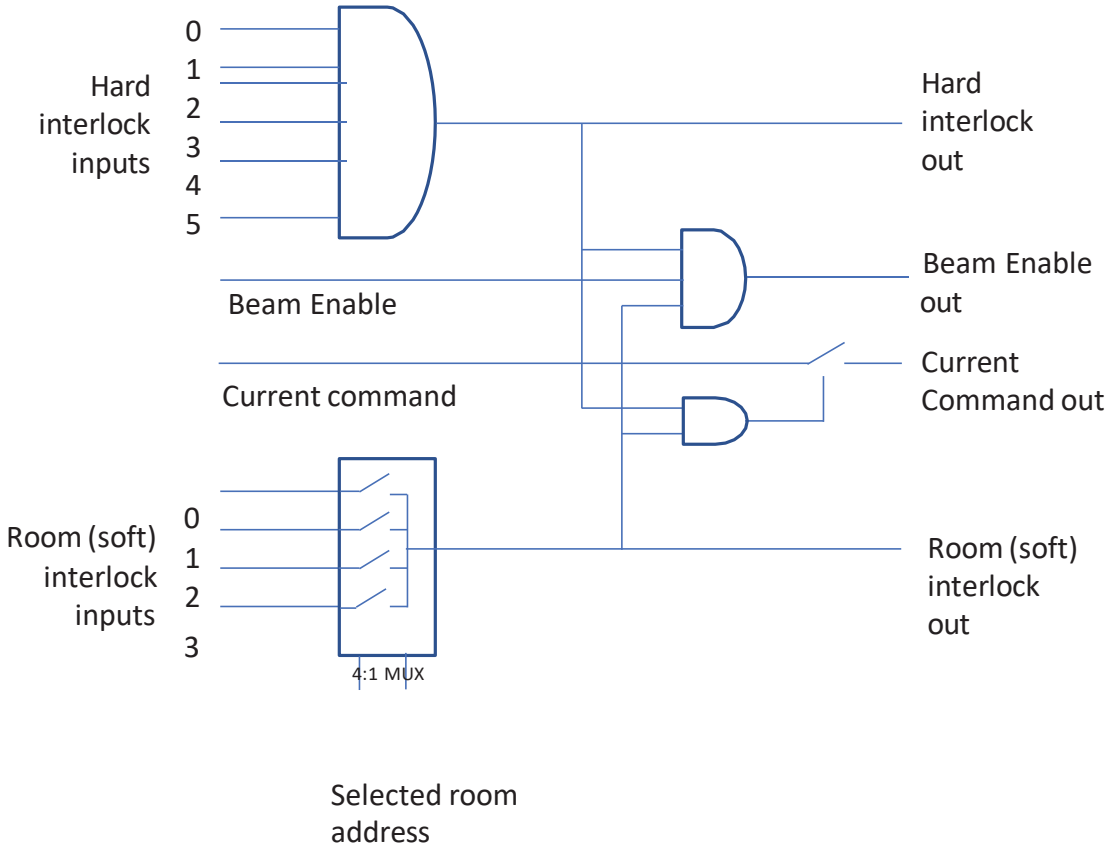


Figure 9 – ICI summary overall hardware logic

The implementation of the logic uses primarily safety−rated relays (IDEC RF1V−4A2B−D24). The room interlock chain also uses opto−couplers and CMOS muxes. The gating path for the Beam Enable and Current Command control signals also uses fast signal relays (Coto 2211−05−301) for faster response to an interlock than is available from safety−rated relays.

The following figure provides more details of the hardware logic.

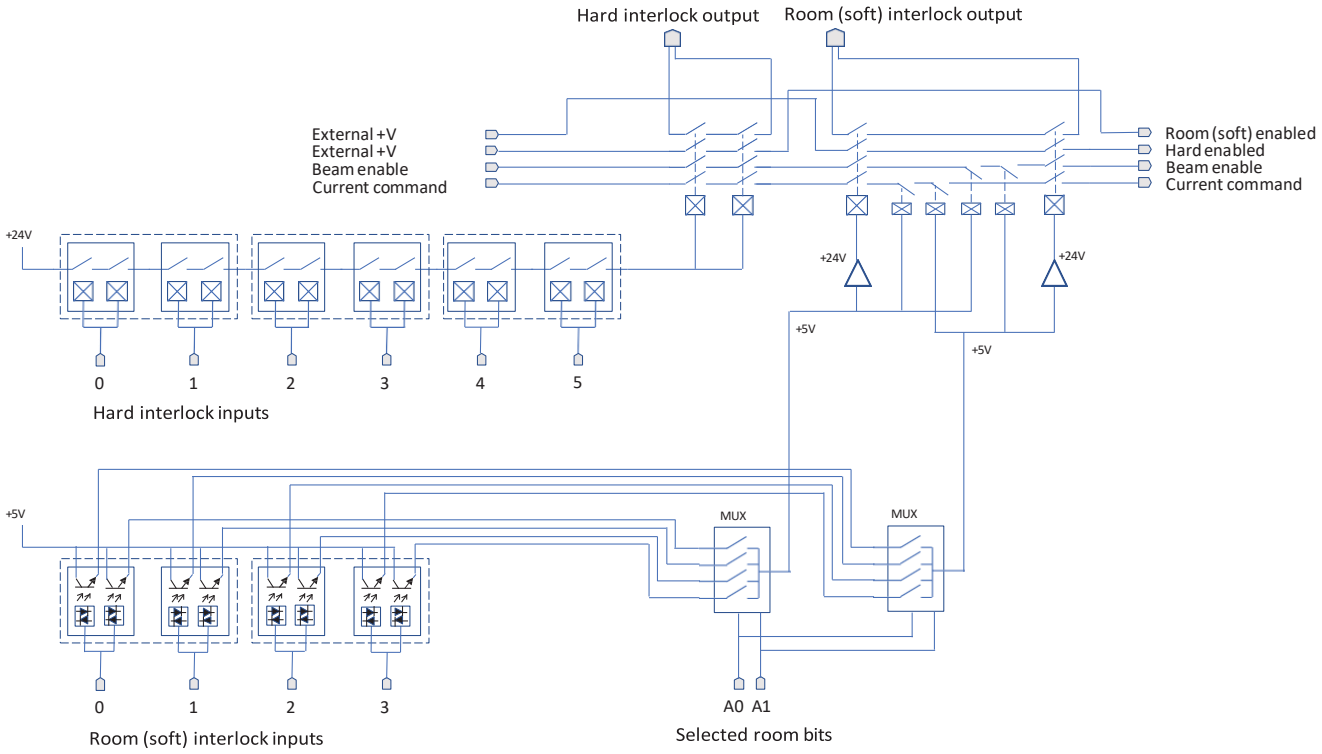


Figure 10 – ICI hardware component schematic

10.1 Hard Interlock Chain

The hard interlocks connect to the coils of a series chain of relays driven by the six inputs. All relays must be energized for the final “output” relay to be energized, creating the “Hard Interlock Status GOOD” state. Each hard interlock input drives a pair of safety relays for redundancy. Both must operate correctly to propagate the good state along the chain.

Other contacts on the relays are used to switch front panel LED indicators and monitor signals read by the ICI processor that check the relays are switching as expected.

The switched 24 V output from the relay chain is used to drive the coils of a series redundant safety relay pair that form the switched hard interlock output. All inputs must be good and all relays must function correctly before the output closes.

The typical use of the hard interlocks is hardware failures and failures that are not associated with any particular treatment room. It is also available as an escalation in the event of no response to the soft interlock.

10.2 Room (Soft) Interlock Chain

Each of the four room interlocks drive pairs of opto−couplers. One opto−coupler output from each input connects to a 4:1 MUX which only passes the good signal from the selected room as given by the two−bit address. The other opto−coupler output from each input connects to a parallel redundant 4:1 MUX. The net result is the creation of two soft interlock signals, both of which must be good to propagate the “Soft Interlock Status GOOD”.

The switched 5 V output from the MUXes is stepped to 24 V used to drive the coils of a series redundant safety relay pair that form the switched soft interlock output. All inputs must be good and all relays must function correctly before the output closes.

The typical use of the soft interlocks is irradiation map violations occurring during beam delivery in the active treatment room.

10.3 Control Signal Passthrough

Two incoming control signals, typically Beam Enable and Current Command are routed through contacts on the hard and soft relays. They also pass through series pairs of fast signal relays which are driven by the 5 V signals from the MUXes. This allows the dose delivery control signals to be inhibited in addition to the primary hard and room interlock responses.

Note that:

- The Beam Enable and Current Command signals are interrupted by either the soft or hard interlock condition.
- The Current Command is a current that is set to zero on fault
- The Beam Enable digital logic signal is pulled down to ground at the ACI. A similar arrangement should be made if the ACI is not being used with the ICI.
- The soft and hard fault states can be independently read back.

Two other passthrough signals are switched by the output relays, one by the hard relay pair, the other by the room (soft) relay pair. Where the ICI is used in combination with the ACI, these signals are used to communicate directly to the ACI the output interlock state by switching 24 V logic. The ACI reports both states to the host system, and also uses detection of a hard interlock to remove power from all beam stop outputs so that all connected beam stops will close.

11 User Interface

The ICI supports a web browser interface that allows a remote computer to monitor its state. This software system can only monitor and has no control function. All interlocking logic is done in hardware.

11.1 Home

This tab shows the ICI I/O in table format. All inputs are displayed by function and by room (if applicable). Redundant relay pairs are individually monitored.

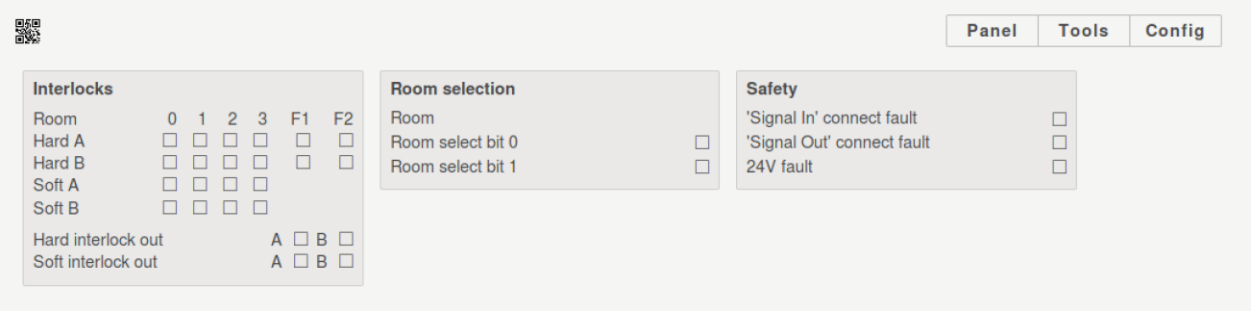


Figure 11 - ICI home screen

11.2 Tools

For factory use only.

11.3 Config

This tab allows basic configuration tasks to be performed.

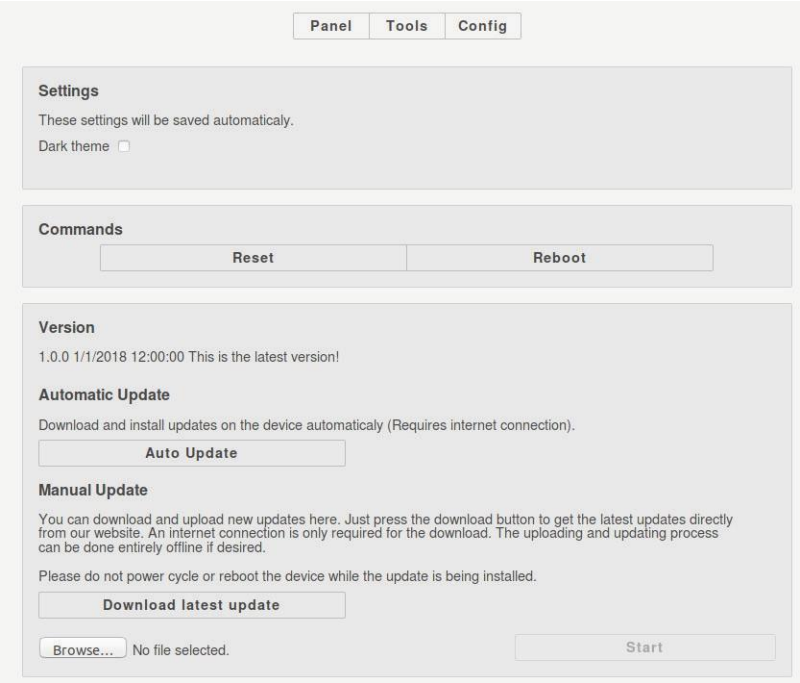


Figure 12 - User interface Config tab

11.3.1 Settings

Checking the “Dark Theme” button changes the background look of the displays. This parameter should be remembered by your browser.

11.3.2 Commands

Pressing the “Reset” button resets the BBB processor card. Pressing the “Reboot” button reboots the BBB.

11.3.3 Update Firmware

This feature allows the latest firmware to be updated to the ICI device. Select the file with the Browse button, then press Start. The computer must be attached to the internet for this to work as it updates directly from the www.ptcusa.com website.

12 Connectors and Indicators

12.1 Rear Panel

The ICI real panel is shown in the diagram below.

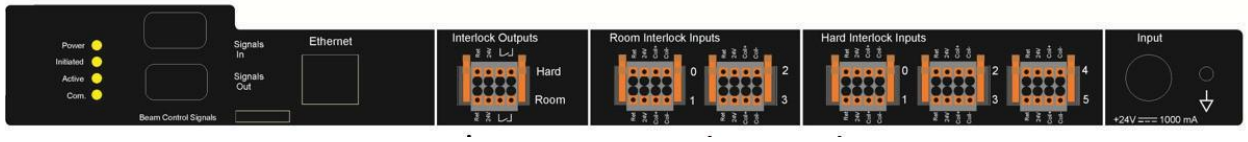


Figure 13 - ICI rear panel

The connectors and indicators are described from left to right.

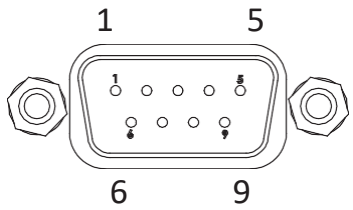
12.1.1 Indicators

The following indicators are on the rear panel.

Power	Indicates if the ICI is powered up.
Initiated	Indicates if the ICI has powered up successfully.
Active	Indicates if the ICI is active and behaving normally.
Com	Not used.

12.1.2 Passthrough signals In and Signals Out

D-Sub 9-pin male.

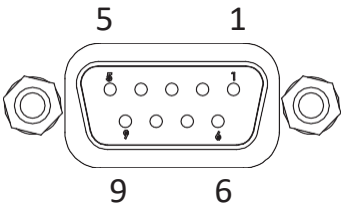


(External view on connector / solder side of mating plug)

1	Beam enable in	6	Current command in
2	Digital ground	7	Soft output relay contact in
3	Hard output relay contact in	8	Top connect sense
4	Room select bit 0	9	Digital ground
5	Room select bit 1		

12.1.3 Passthrough signals out

D−Sub 9 pin female.



(External view on connector / solder side of mating plug)

1	Gated beam enable	6	Gated current command
2	Digital ground	7	Hard output relay contact out
3	Soft output relay contact out	8	Digital ground
4	Room select bit 0	9	Digital ground
5	Room select bit 1		

12.1.4 Ethernet

RJ−45 jack. To mate with standard RJ−45 plug.

Auto MDIX facility − cable can be direct or crossover type.

12.1.5 Diagnostic serial port

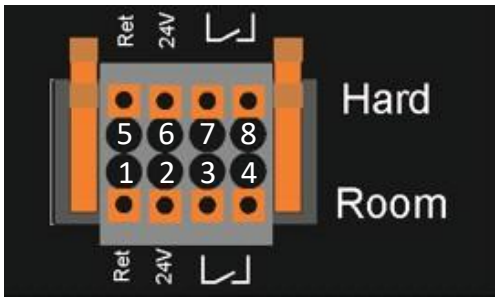
Six pin header serial connection to internal processor board. Mating connector TE Connectivity 926475−6.

1	DGnd	4	Rx
2	n/c	5	Tx
3	n/c	6	n/c

12.1.6 Interlock outputs

Phoenix 1787030 8 pin 3.5 mm header. The locking mating connector is Phoenix 1790506 or Phoenix 1790315.

Wires are inserted directly into the mating connector, 16−24 AWG, insulation stripped back 10 mm. Bootlace ferrules may be used for stranded wire.



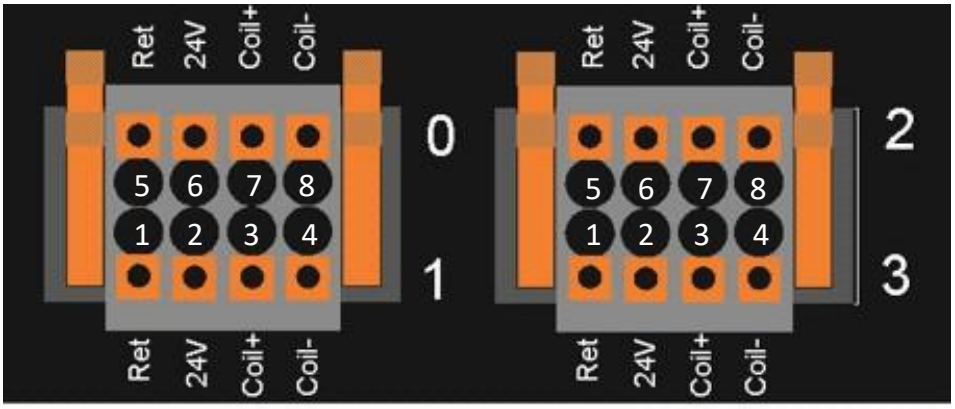
1	Room (soft) interlock 24V return	5	Hard interlock 24V return
2	Room (soft) interlock 24V	6	Hard interlock 24V
3	Room (soft) interlock contact com	7	Hard interlock relay contact n/o
4	Room (soft) interlock relay contact n/o	8	Hard interlock relay contact com

12.1.7 Room (soft) interlock inputs

Phoenix 1787030. The mating connector is Phoenix 1790506.

Wires are inserted directly into the mating connector, 16–24 AWG, insulation stripped back 10 mm. Bootlace ferrules may be used for stranded wire.

The inputs drive bidirectional opto–coupler photodiodes (not relay coils).



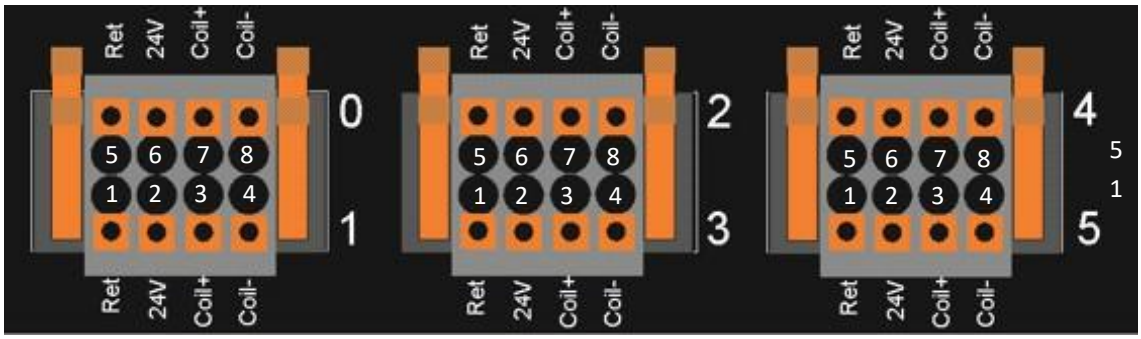
Left connector 0/1			
1	Room 1 (soft) interlock 24V return	5	Room 0 (soft) interlock 24V return
2	Room 1 (soft) interlock 24V	6	Room 0 (soft) interlock 24V
3	Room 1 (soft) interlock photodiode terminal 1	7	Room 0 (soft) interlock photodiode terminal 1
4	Room 1 (soft) interlock photodiode terminal 2	8	Room 0 (soft) interlock photodiode terminal 2
Right connector 2/3			
1	Room 3 (soft) interlock 24V return	5	Room 2 (soft) interlock 24V return
2	Room 3 (soft) interlock 24V	6	Room 2 (soft) interlock 24V
3	Room 3 (soft) interlock photodiode terminal 1	7	Room 2 (soft) interlock coil photodiode terminal 1
4	Room 3 (soft) interlock photodiode terminal 2	8	Room 2 (soft) interlock photodiode terminal 2

12.1.8 Hard interlock inputs

Phoenix 1787030. The mating connector is Phoenix 1790506.

Wires are inserted directly into the mating connector, 16−24 AWG, insulation stripped back to 10 mm. Bootlace ferrules may be used for stranded wire.

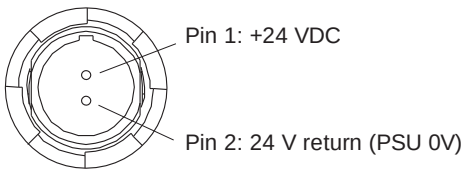
The inputs drive 24 VDC coils; polarity must be observed.



Left connector			
1	Room 1 (hard) interlock 24V return	5	Room 0 (soft) interlock 24V return
2	Room 1 (hard) interlock 24V	6	Room 0 (soft) interlock 24V
3	Room 1 (hard) interlock coil+	7	Room 0 (soft) interlock coil+
4	Room 1 (hard) interlock coil−	8	Room 0 (soft) interlock coil−
Middle connector			
1	Room 1 (soft) interlock 24V return	5	Room 0 (soft) interlock 24V return
2	Room 1 (soft) interlock 24V	6	Room 0 (soft) interlock 24V
3	Room 1 (soft) interlock coil+	7	Room 0 (soft) interlock coil+
4	Room 1 (soft) interlock coil−	8	Room 0 (soft) interlock coil−
Right connector			
1	Room 1 (soft) interlock 24V return	5	Room 0 (soft) interlock 24V return
2	Room 1 (soft) interlock 24V	6	Room 0 (soft) interlock 24V
3	Room 1 (soft) interlock coil+	7	Room 0 (soft) interlock coil+
4	Room 1 (soft) interlock coil−	8	Room 0 (soft) interlock coil−

12.1.9 24V Power

Two−pin Redel PXG.M0.2GG.NG female. To mate with Redel PAG.M0.2 type or PFG.M0.2 type free plugs. Suitably terminated 24 V power supplies and leads are available from Pyramid Technical Consultants, Inc.



12.1.10 Ground lug

M4 threaded stud. To mate with M4 ring lug.

12.2 Front Panel

The ICI front panel is shown in the diagram below.

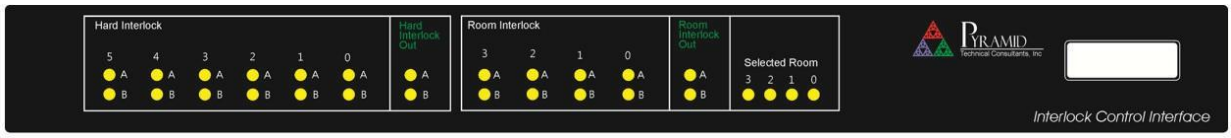


Figure 14 - ICI front panel

12.2.1 Indicators

The following LED indicators are on the front panel.

Hard interlock 0A–5A and 0B–5B	Interlock relay status for each of the two hard interlock relays for each of inputs 0 to 5.
Hard interlock out A and B	Hard interlock relay status for each of two relays that are in series on the output.
Room interlock	Interlock input status for each of the two room (soft) interlock optocoupler diodes for each of room 0–3.
Room interlock out A and B	Room (soft) interlock relay status for each of two relays that are in series on the output.
Selected room	Indicates which room is currently selected by the ACI and communicated to the ICI via the passthrough in connector.

12.2.2 Alphanumeric display

Blue OLED display, 2 lines x 16 characters.

13 Communications Interface

13.1 EPICS Process Variables

The ICI connects to the client via an Ethernet interface. The device acts as an EPICS server, and all information with client applications is exchanged using this protocol. For more information on EPICS please go to the EPICS website at http://www.aps.anl.gov/epics/index.php.

The PV names will start with the ICI unit's IP address so that they are unique. The following parameters are supported.

13.1.1 Network Configuration

The ICI uses EPICS communication over standard local area network hardware. Addressing is using the IP4 standard, and it supports static and dynamic (DHCP) address assignment. The device can be configured via the serial interface, or by your own host software using the appropriate procedure calls.

Most control and data acquisition systems are set up with fixed addresses assigned by the network administrator. It is also typical to isolate such networks from the internet to prevent unauthorized access, and to allow operation without firewalls which can disrupt communications.

In order for the host computer and the ICI to communicate, they must be within the same subnet. It is typical to limit a local network to 256 addresses by setting the IP4 subnet mask to 255.255.255.0. Then the ICI and the host must have the first three bytes of their addresses common and must differ in the last byte. For example, the host could be 192.168.100.11 and the I128 at 192.168.100.20. The last byte must also not conflict with any other devices on the same subnet. Addresses with last byte 0 and 255 are reserved for special functions in TCP/IP. See the section on "File Setups" for information on changing the IP address of the unit.

13.1.2 Process variables

The ICI supports a series of process variable (PVs) that can be used to exchange information with the ICI over the EPICS interface. Each process variable can be address by using the assigned PV name as needed. If more than one ICI is used on the system, then the PV name must be preceded by the ICI IP address and a colon in order to make the address unique.

For example, to address the hard interlock signal input from room 1, the PV name is /ici/ub1/3. If the IP address of the ICI is 192.168.100.20, then the proper full name of the PV would be

```
192.168.100.20:/ici/ub1/3
```

Below is a list of all PV names:

PV Name	Description	Readonly	Type
/ici/ub2/1	Goes high if the 'Signal In' top connector is not plugged in.	TRUE	bool
/ici/ub2/2	Goes high if the 'Signal Out' bottom connector is not plugged in.	TRUE	bool

/ici/ub2/3	Goes high if the 24V supplies drop below 18V. This would signify hardware failure.	TRUE	bool
/ici/ub3/5	Normally high. Outputs on the back. Goes low if any room hard interlocks go low.	TRUE	bool
/ici/ub3/6	Normally high. Outputs on the back. Goes low if any room hard interlocks go low.	TRUE	bool
/ici/room	The selected room. Only valid if the 'Signal In' and 'Signal Out' connectors are plugged in.	TRUE	int32
/ici/ub1/1	Normally high. Hard interlock signal from room 0.	TRUE	bool
/ici/ub1/2	Normally high. Hard interlock signal from room 0.	TRUE	bool
/ici/ub4/5	Normally high. Soft interlock signal from room 0.	TRUE	bool
/ici/ub4/6	Normally high. Soft interlock signal from room 0.	TRUE	bool
/ici/ub1/3	Normally high. Hard interlock signal from room 1.	TRUE	bool
/ici/ub1/4	Normally high. Hard interlock signal from room 1.	TRUE	bool
/ici/ub4/7	Normally high. Soft interlock signal from room 1.	TRUE	bool
/ici/ub4/8	Normally high. Soft interlock signal from room 1.	TRUE	bool
/ici/ub1/5	Normally high. Hard interlock signal from room 2.	TRUE	bool
/ici/ub1/6	Normally high. Hard interlock signal from room 2.	TRUE	bool
/ici/ub3/1	Normally high. Soft interlock signal from room 2.	TRUE	bool
/ici/ub3/2	Normally high. Soft interlock signal from room 2.	TRUE	bool
/ici/ub1/7	Normally high. Hard interlock signal from room 3.	TRUE	bool
/ici/ub1/8	Normally high. Hard interlock signal from room 3.	TRUE	bool
/ici/ub3/3	Normally high. Soft interlock signal from room 3.	TRUE	bool
/ici/ub3/4	Normally high. Soft interlock signal from room 3.	TRUE	bool
/ici/ub4/1	Normally high. Hard interlock signal from room F1.	TRUE	bool
/ici/ub4/2	Normally high. Hard interlock signal from room F1.	TRUE	bool
/ici/ub2/4	Normally high. Hard interlock signal from room F2.	TRUE	bool
/ici/ub2/5	Normally high. Hard interlock signal from room F2.	TRUE	bool
/ici/ub4/4	The 0th bit of the room selection signal.	TRUE	bool
/ici/ub4/3	The 1st bit of the room selection signal.	TRUE	bool
/ici/ub3/7	Normally high. Outputs on the back. Goes low if the selected room soft interlocks go low.	TRUE	bool
/ici/ub3/8	Normally high. Outputs on the back. Goes low if the selected room soft interlocks go low.	TRUE	bool

14 Fault Finding

Symptom	Possible Cause	Confirmation	Solution
Device will not boot or communicate as seen on the OLED display.	Damage to ICI.		Contact Pyramid Technical Consultants, Inc.
	Failed firmware update.		Contact Pyramid Technical Consultants, Inc.
	Network IP addresses between ICI and client not compatible.	Check network addresses and IP masks are compatible.	Change addresses or configuration as needed.
	Duplicate Ethernet address of ICI.	Check network addresses. Turn off ICI and ping address.	Change ICI address.
	More than one ICI on the network but not using IP address in EPICS PVs	EPICS client will receive error message on second instance.	Precede EPICS PV name with IP address and colon.
Output interlock does not close when expected	Input connector not present or not mated correctly.	Visual inspection.	Correct connections, cross–check and test operation.
	Input logic signal wrong polarity (hard interlock inputs).	Check signals and cabling.	Correct driving circuit as needed. Correct connections, cross–check and test operation.
	Passthrough connection missing or faulty	Visual inspection and electrical test of passthrough cables.	Correct connection or replace cables as necessary. Cross–check and test operation.

		Check cable integrity signals on ACI computer user interface.	
Output interlock does not open when expected.	Shorting connector has been put in an input that should connect to a real input.	Visual inspection	Correct connections, cross–check and test operation.
Room (soft) output interlock does not open when expected.	No room is selected.	Check front panel LEDs. Check status on ACI computer user interface.	Ensure a room is selected.
	Room address bits not reaching ICI.	Check cables. Check status on ACI computer user interface.	Correct connections, cross–check and test operation.

15 Maintenance

15.1 User Serviceable Parts

There are no user−serviceable parts inside the ICI.

15.2 Cooling Fan Maintenance

If there is buildup of dust in the filter, you should clear this by vacuum cleaning in situ, or by removing the filter element and cleaning it separately with an air jet. Note that detaching the filter element also detaches the fan from the case.

Figure 15 - Fan filter removal

If the fan fails, it is necessary to open remove the lid of the case to access the power connector. Due to risk of contamination or electrostatic discharge damage, we recommend that you consult Pyramid Technical Consultants, Inc. before attempting this.

To remove the lid of the case, remove four M2.5 cross−head screws from the rear top surface, and slide the cover backwards to disengage from the front panel.

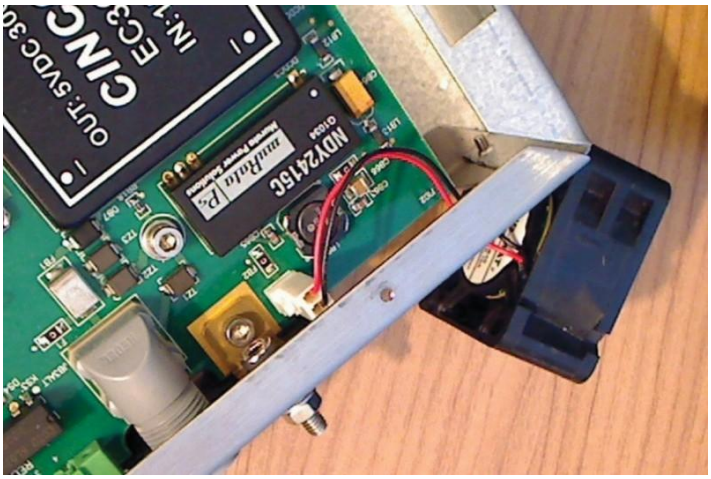


Figure 3 - Fan power connector (2 pin Molex)

The ICI is fitted with a 1.1 amp automatically resetting positive temperature coefficient (PTC) fuse in the 24 VDC input. No user intervention is required if the fuse operates due to overcurrent. The fuse will reset when the overcurrent condition ends.

16 Returns Procedure

Damaged or faulty units cannot be returned unless a Returns Material Authorization (RMA) number has been issued by Pyramid Technical Consultants, Inc. If you need to return a unit, contact Pyramid Technical Consultants at support@ptcusa.com, stating

- model
- serial number
- nature of fault

An RMA will be issued, including details of which service center to return the unit to.

17 Support

Manual and software driver updates are available for download from the Pyramid Technical Consultants website at **www.ptcusa.com**. A secondary site can be found at **www.ptceurope.com**. Technical support is available by email from support@ptcusa.com. Please provide the model number and serial number of your unit, plus relevant details of your application.

18 Disposal

We hope that the ICI gives you long and reliable service. The ICI is manufactured to be compliance with the European Union RoHS Directive 2002/95/EC, and as such should not present any health hazard. Nevertheless, when your ICI has reached the end of its working life, you must dispose of it in accordance with local regulations in force. If you are disposing of the product in the European Union, this includes compliance with the Waste Electrical and Electronic Equipment Directive (WEEE) 2002/96/EC. Please contact Pyramid Technical Consultants, Inc. for instructions when you wish to dispose of the device.

Revision History

The release date of a Pyramid Technical Consultants, Inc. user manual can be determined from the document file name, where it is encoded YYMMDD. For example, ICI_UM_180607 would be a ICI manual released on 7 June 2018.

Version	***Changes***
ICI_UM_180607	First general release.
ICI_UM_180622	Internal revisions made to align with datasheet.
ICI_UM_250722	Updated address and removed outdated references