Datasheet **ACI**

Accelerator Control Interface for Particle Therapy Systems

Features

- Interfaces to most particle therapy accelerator types
- Allows accelerator to connect to up to three treatment rooms plus “room 0”
- Suitable for “step and shoot” and continuous scanning beam delivery
- Communications to treatment room dose control systems via fiber optic channels
- Communication to dose control and room servers via Ethernet
- High level of electrical isolation on all signal and communication paths
- Options for current or voltage levels on analog signals
- Beam stop control and monitoring
- Beam control signals can be routed via an interlock unit to provide a fast beam off method
- Compatible with Pyramid ICI Interlock Control Interface
- Display showing key configuration and diagnostic information
- Web-browser interface for remote monitoring

Applications	• Connecting Pyramid treatment nozzle systems to beam production accelerator systems. • Generic particle therapy accelerator interfacing. • In combination with Pyramid ICI to provide a beam control and inter-locking system.

Connections to accelerator and beamline control	
Current Command out	Analog beam current command. Configurable as either 0 to +10 VDC or 0 to 20 mA current.
Enable Out	Digital fiber optic signal to turn beam on and off for dosimetry control. Note: an internal switch setting allows this signal to only pass to the fiber optic transmitter if the Beam Ready input is present. Note: the signal is routed via the Beam Control connectors. It can therefore be interrupted by an external device (Pyramid ICI or equivalent) as part of an interlock response.
Beam Ready input	Digital fiber optic signal indicating that accelerator system is ready to deliver beam. Note: an internal switch setting allows this signal to be used to gate the Enable Out signal.
Beam Enabled input	Digital fiber optic signal indicating that accelerator system is enabled to deliver beam (beam should be present).
Frequency In	Digital fiber optic signal with frequency representing the beam energy.
Reserved In	Digital fiber optic signal reserved for future use.
Monitor Input Q	Analog input 0 to +10 V indicating how much charge remains in a synchro-
Monitor Input I	Analog input 0 to +10 V indicating the signal from a measurement by the accelerator of its beam current level.
Room Select Set	Two bit digital control pattern to set active treatment room in ACI. Bidirectional opto-coupled inputs, 5 to 24 V into 10k series resistance. Note: an internal switch allows this selection to be made instead by an Ethernet message.
Room Select Readout	Two bit digital readout pattern (two relay isolated contact pairs) to allow a remote system to validate the ACI room selection.
Connections to treatment rooms	
Enable Room 0,1,2,3	Digital fiber optic inputs requesting beam from rooms 0,1,2,3. Only the input from a selected room is routed to the accelerator by the ACI.
Transmit / Receive Room 0,1,2,3	Digital fiber optic 10 Mb/s communication channel between M40 I/O devices in the ACI to loop controllers in each treatment room. Control signals to the ACI are: Beam current command and room beam stop in/out. Only the beam current command input from the selected room is routed to the accelerator by the ACI. Only the beam stop “open” command from the selected room 1,2 or 3 is routed to the appropriate beam stop connector by the ACI. The “open” command for room 0 is always routed through, irrespective of the room selection condition. Signals monitored by the ACI and sent via the communication channel are: Beam current readback, compliance voltage of the beam current command (fault detection), synchrotron charge remaining, beamOK state, room beam stop in/out states, room selected flag, hard and soft interlock flag, beam enabled flag, beam energy frequency value.

Connections to beam stops	
Beam Stop Control 0,1,2,3	Output switchable 24 VDC power to actuator solenoids 0,1,2,3. 24 VDC present should drive stop out of beam (fail safe arrangement). Outputs only enabled for a selected room and for room 0. Inputs for remote contact closures indicating beam stop fully in beam or fully out of beam.
Connections to interlock system	
Beam Control Out to Beam Control In	Signals available for routing via an external interlock device where they can be interrupted as required by an interlock condition: Beam enable command digital Current command analog The ACI delivers the room select bits to the external interlock device where they can be used to route room-centric (soft) interlock response. If no external interlock device is used, then the Out and In connectors should be linked instead by a 9-way pin to pin cable. The ACI detects if there is no connection between Out and In.
Connections to supervising computer	
Ethernet	10/100/1000 BaseT TCP/IP Ethernet connection allows control and monitoring of some digital states. Control: Room select bits 0,1 (alternative to Room Select connector input) Reserved fiber optic output. Monitor: Beam Ready Beam Enabled Beam Enable inputs from rooms 0,1,2,3 Room selected readback bits 0,1 Beam energy frequency Reserved fiber optic input The ACI supports a web browser interface that allows these signals to be controlled and monitored remotely.
Controls and switches	
Front panel	Four fiber optic communication loop address selection switches for embedded M40 devices handling rooms 0,1,2,3.
Internal	SW2 Beam Enable is or is not gated by Beam Ready (Beam OK) SW3 Room select command bits by Room Select connector or Ethernet SW7 Charge remaining readback 0-20 mA or 0-10 V SW8 Beam current readback 0-20 mA or 0-10 V

Connections to embedded M40 devices

Connections used

Four connections for rooms N = 0,1,2,3

Pin	*Type*	*Function in ACI*
1	Analog In 7	None - connected to DGnd
2	Analog In 5	Board installed sense
3	Analog In 3	Board installed sense
4	Analog In 4	Current Readback
12	Analog Out 7	None - not connected
13	Analog Out 5	None - not connected
14	Analog Out 3	None - not connected
15	Analog Out 1	Current Command for Room N
16	Analog In 8	None - connected to DGnd
17	Analog In 6	None - connected to DGnd
18	Analog In 4	Current compliance voltage (internal check)
19	Analog In 2	Charge remaining
20	Digital In 2	Beam ready (OK)
21	Digital In 4	Beam stop “in” sense room N
22	Digital In 6	Room N selected
23	Digital In 8	Hard interlock set (by external interlock device, ICI)
24	Digital Out 2	None - not connected
25	Digital Out 4	None - not connected
26	Digital Out 6	None - not connected
27	Analog Out 8	None - not connected
28	Analog Out 6	None - not connected
29	Analog Out 4	None - not connected
30	Analog Out 2	None - not connected
31	Shield	Chassis connection
32	PSGnd	Power supply ground for M40
33	+24 VDC	24 V power for M40 (200 mA fused in ACI)
34	Digital In 1	Beam Enabled
35	Digital In 3	Beam energy frequency
36	Digital In 5	Beam stop “out” sense room N
37	Digital In 7	Soft interlock set (by external interlock device, ICI)
38	Digital Out 1	Beam stop command room N (set to open beam stop)
39	Digital Out 3	None - not connected
40	Digital Out 5	None - not connected
41	Digital Out 7	None - not connected
42	Digital Out 8	None - not connected
44	+5 VDC Out	None - not connected

Other pins connect DGnd

Service diagnostics

Serial debug port	Six pin header serial connection to BBB card, rear panel. Mating connector TE Connectivity 926475-6

1	DGnd	4	RX
2	n/c	5	TX
3	n/c	6	n/c

USB	Internal USB port on BBB card or via serial-USB adaptor (DFR0065) on debug port.

Displays

Alphanumeric display	2 x 16 character blue OLED on front panel for device status reporting.
LEDs	Four sets of four green LEDs showing status of M40 embedded I/O devices. 1 Power on 2 Activity 3 Network 4 Device In normal operation 1 and 4 should be illuminated.
Power indicator	Illuminated Pyramid logo on front panel when +5 VDC internal voltage rail is present

Processors and OS

ACI BeagleBone Card	TI Sitara AM335x (ARM Cortex A8) 1 GHz with dual PRU, QNX OS. Performs POST tests of relay function, RAM and flash, memory, battery function, Ethernet connection. ACI is disabled if POST fails.
M40 devices	PIC 18LF8722, no OS.

Operation	

Power	
Input	24(+/- 2) VDC 1200 mA; fused 1100 mA nominal for main circuit and 200 mA for cooling fan with PTC fuses.
Output	Isolated +15 V and -15 V, 65 mA supplies available on rear panel connector for use with external isolation amplifiers as necessary.
Front panel connectors	Do not use. Embedded M40 devices are powered by internal connection.
Case	
Format	19” rackmount 1U by 250 mm deep with rear panel cooling fan. See figures for dimensions.
Materials	Steel chassis with Al alloy front panel, polycarbonate decals.
Protection rating	IP43 (protected against solid objects greater than 1mm in size, protected against spraying water)
Weight	3.5 kg (7.7 lb)
Environment	
Operating	10 to 35 C (15 to 25 C recommended), < 70% humidity, non-condensing, shock and short term vibration < 0.2g all axes (1 to 100 Hz). Recommended location is outside radiation area. May be located in a moderate radiation area together with similar electronics, clear of known or expected radiation hot spots. Monitor operation during commissioning and relocate if necessary.
Shipping and storage	-10 to 50 C, < 80% humidity, non-condensing, shock and short term vibration < 1g all axes, 1 to 100 Hz.

Connectors

Fiber optic digital logic inputs	Eight receivers, HFBR 2515 ST bayonet connector (dark gray), rear panel, for multimode HCS fiber, 640 nm visible light.
Fiber optic digital logic outputs	Two transmitters, HFBR 1515 ST bayonet connector (light gray), read panel, for multimode HCS fiber, 640 nm visible light.
Fiber optic communication channels	Four HFBR receiver/transmitter pairs, front panel, ST bayonet connectors for 10 Mb/s communications to Pyramid loop controllers. Multimode HCS fiber, 640 nm visible light.
Current Command	Two BNC connectors, rear panel, for 0-20 mA and 0-10 V outputs.

Beam control signals outgoing (bottom: to ICI)	DSub 9 pin female, rear panel

1	Beam enable out	6	Current command out
2	Connected sense	7	24 VDC fused
3	24 VDC fused	8	DGnd
4	Room select bit 0 out	9	DGnd
5	Room select bit 1 out		

Beam control signals incoming (top: from ICI)	DSub 9 pin male, rear panel

1	Beam enable return	6	Current command return
2	DGnd	7	Hard enabled
3	Soft enabled	8	n/c
4	Room select bit 0 return	9	DGnd
5	Room select bit 1 return		

Ethernet	RJ-45 jack, rear panel
Monitor Input Q	BNC, rear panel, 0-20 mA or 0-10 V (internal switch selection)
Monitor Input I	BNC, rear panel, 0-20 mA or 0-10 V (internal switch selection)
Room Select	Phoenix 1787030 locking 3.5 mm header 8 position, rear panel. Mating connector Phoenix 1790506 or Phoenix 1790315.

1	Room selected bit 0 comm	6	Room select bit 0 opto in
2	Room selected bit 0 n/o	7	Room select bit 0 opto in
3	Room selected bit 1 comm	8	Room select bit 1 opto in
4	Room selected bit 1 n/o	9	Room select bit 1 opto in

(Opto inputs are bidirectional)

Connectors (continued)

Beam Stop Control

Four DSub 9 pin male, rear panel for beam stops N = 0,1,2,3

1	Beamstop N switched 24 VDC	6	PSGnd (24 V ref)
2	Beam stop N in limit switch	7	PSGnd (24 V ref)
3	Beam stop N out limit switch	8	PSGnd (24 V ref)
4	n/c	9	n/c
5	n/c		

Remote limit switch should be n/o and close to connect relevant limit switch input to PSGnd to indicate limit is reached.

Iso Power

Lemo EPG.0B four pin connector, rear panel.

1	+15 VDC isolated	3	Isolated Gnd
2	-15 VDC isolated	4	Opto indication +5V present

When +5 VDC is available to the isolation power supply, pin 4 is connected to pin 3 via a transistor switch.

Power Input

Lemo Redel PXG.M0.2GG.NG. To suit mating connector PAG.M0.2GL type as fitted to Pyramid power supply PSU24-100M-1R.

1	+24 VDC in
2	24 V rtn

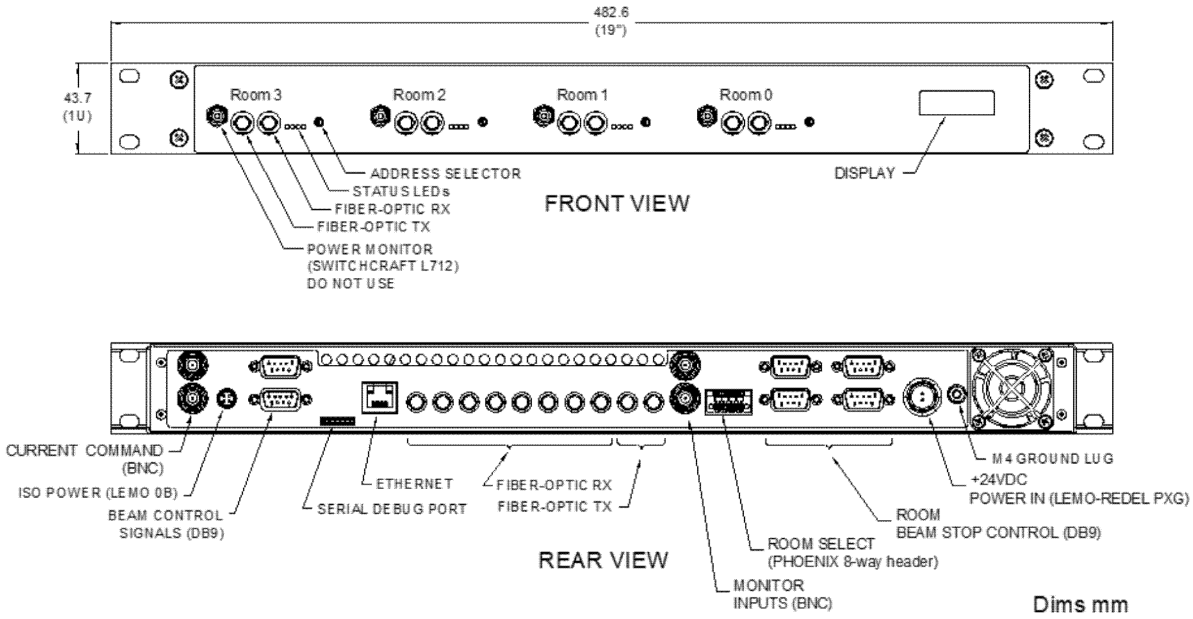
Ground lug

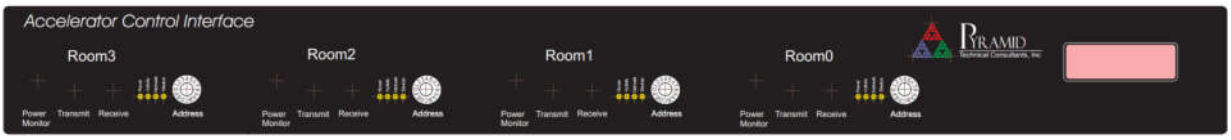
M4 threaded stud.

Datasheet

ACI

ACI front and rear panels

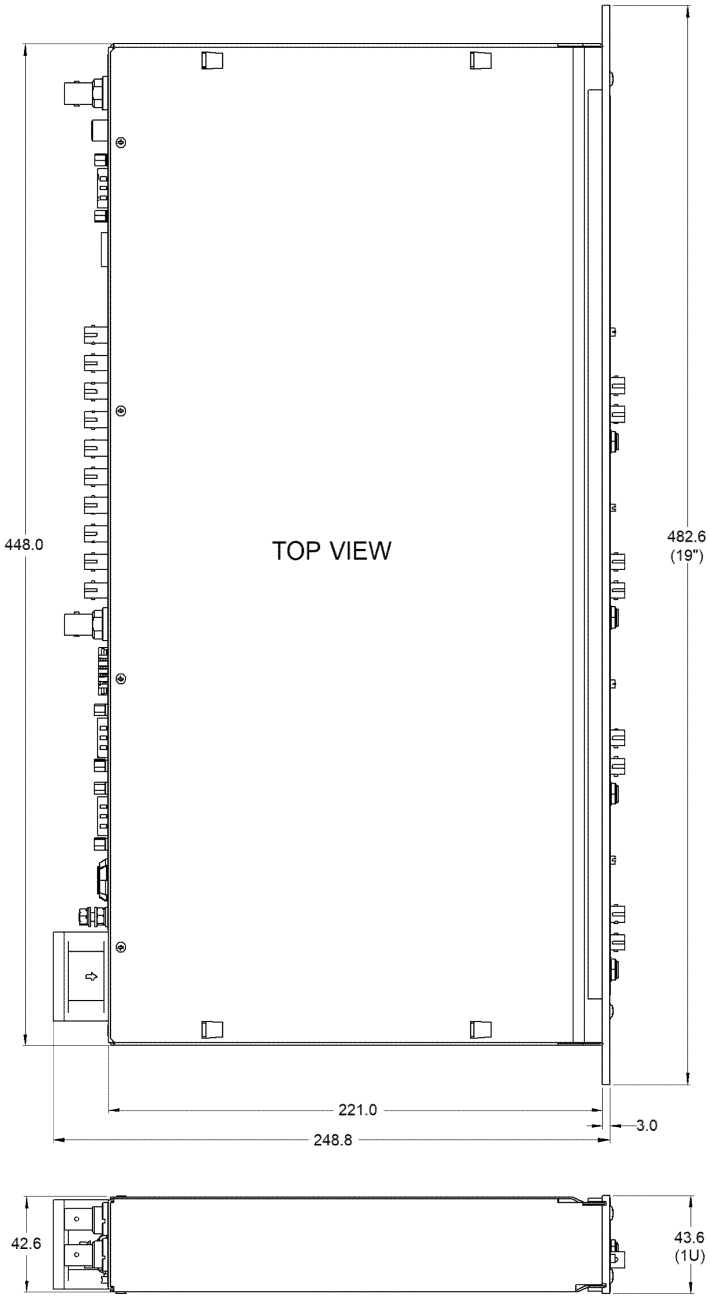




Ordering information

ACI-G	Accelerator Control Interface for particle therapy systems.
	Enquire about pre-configuration to suit a specific system.

ACI top and side view



Dims mm

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