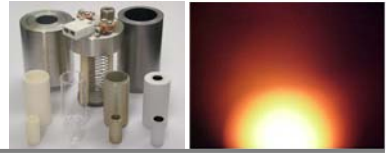


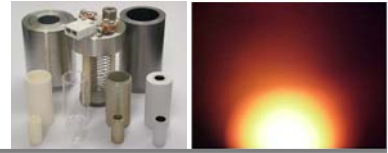
## Controller Automation





Controller Automation, Model II+





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## Automation with the RADAK II+ power controller

### *II+ I/O Points:*

#### Inputs

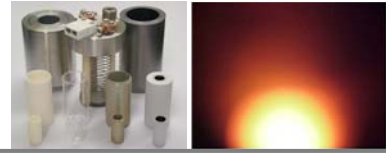
- 5 Programmable Digital inputs
- 2 Dedicated digital inputs (Channel select and External SCR control select)
- 1 SCR Control signal BNC
- 1 Channel select input
- 1 External SCR control select

#### Output Relays (2A, 264Vac max.)

- 1 Dedicated Alarm (SPDT)
- 2 Programmable (SPST)

#### RS232 serial communications

- 1 DB9 serial adapter



## Configurations:

### Digital Input

The digital inputs can be used to initiate various events in the temperature controller, such as starting and stopping programs, selecting a specific program to run, or selecting a different PID set to use.

Each of the five digital inputs may be configured to activate one of the following events:

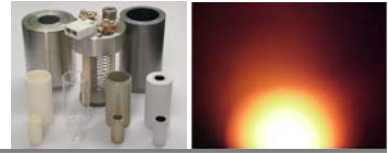
Manual mode select	Simulate pressing of the up button
Remote setpoint select	Simulate pressing of the down button
Setpoint 2 select	Simulate pressing of the cycle button
PID set 2 select	Simulate pressing of the page button
Integral hold	Skip to End of Current Segment, without changing the setpoint
One-shot self-tune enable	Program holdback enabled
Adaptive tune enable	Setpoint Rate Limit Enable
Acknowledge alarms	Program waits at the end of the current segment
Select Full access level	Program Run ( <i>closed</i> ) / Reset ( <i>open</i> )
Keylock	Program Reset ( <i>closed</i> ) / Run ( <i>open</i> )
Run program	Reset program
Hold program	Process Value Select: Closed = PV1 / Open = PV2
Run program ( <i>closed</i> ) / Hold ( <i>open</i> )	Advance to End of Segment and to target Setpoint
Standby - ALL control outputs turned OFF	

To use these capabilities, the temperature controller must be configured with the intended function of each input. Once configured, the digital inputs are activated by connecting their respective input lines to the digital I/O common lead.

### Relay Output

The relay outputs can be used to signal various events in the temperature controller, such as temperature alarms, program end, sensor break, load failure, or programmed event.

The RADAK II+ has one alarm relay and two programmable relays. Both the alarm relay and the programmable relays have the same functions, however, the alarm relay provides both a normally open (NO) and normally closed (NC) contact where the programmable relays have only one contact which can be configured as NO or NC.



Each of the three relays may be configured to signal *any combination* of the following events:

- |                                     |   |
|-------------------------------------|---|
| Alarm 1 active YES / no             | Programmer event output (1 to 8) active YES / no                |
| Alarm 2 active YES / no             | Load failure alarm YES / no                                     |
| Alarm 3 active YES / no             | Tuning in progress YES / no                                     |
| Alarm 4 active YES / no             | New Alarm has occurred YES / no                                 |
| Controller in manual mode YES / no  | End of setpoint rate limit, or end of program YES / no          |
| Sensor break YES / no               | Voltage output open circuit, or mA output open circuit YES / no |
| Process Value out of range YES / no |   |

To use these capabilities, the temperature controller must be configured with the intended function of each relay. Once configured, the relay will complete the circuit between the NO and common lead when any of the events it is assigned occurs.

### *RS232 serial communications*

All parameters that can be accessed through the operator interface may also be accessed via RS232 serial communications.

There are several methods available to perform the actual communications. Commands may be sent and received manually from any windows based terminal application. Communication can be performed through software written by the end user (see sample programs attached). Eurotherm iTools software provides an extensive suite of applications for communicating with and operating the 2404 controller, which is the heart of the RADAK II+.

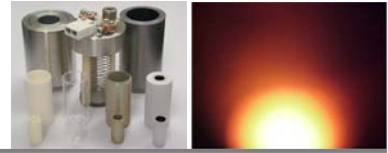
### *Example Control Schemes:*

#### *Goal*

Condition the source to 1400°C, deposit 200Å of material at 10Å/sec, ramp source back to ambient temperature.

#### *Equipment*

- A vacuum chamber equipped with a RADAK furnace
- Suitable source shutter
- Crystal deposition rate monitor
- Deposition controller with input and output capabilities
- RADAK II+ power controller.



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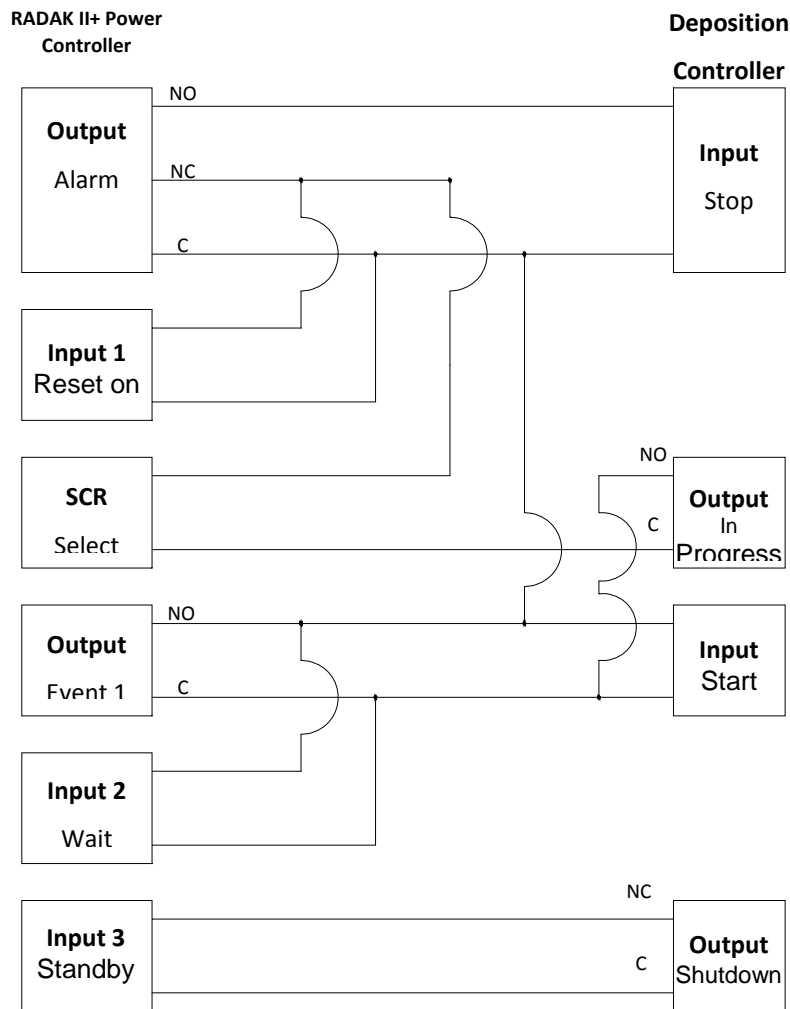
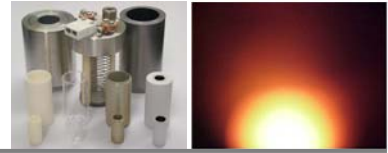
*Assumptions*

- All equipment is installed and operating properly.
- Both the RADAK II+ and the deposition controller have been calibrated and operating with appropriate PID's, tooling factors, etc.
- The crystal is positioned in the system such that deposition rate is monitored with the source shutter open or closed.
- The deposition controller is wired to control the source shutter
- The deposition controller is configured for shutter delay (controller establishes proper, stable rate prior to opening the shutter).

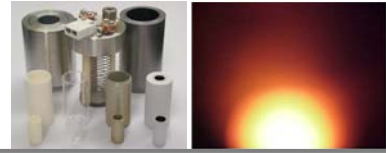
As mentioned above, each digital input and each relay output must be configured with an associated event(s). See the RADAK II+ power controller manual for a detailed description of the event assignment procedure.



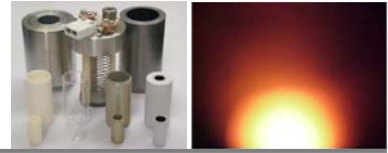
RADAK II+ Configuration	
Item	Description
Alarm 1 setpoint - 100°C	Indicates furnace hot. Prevent system vent with hot furnace
Alarm relay close on:	
Alarm 1 active	Furnace over temp or temp. unknown. Reset power controller, return furnace control to power controller, and signal deposition controller to stop.
Sensor break	
Programmable relay 1 close on:	
Event output 1	Triggered by power controller program, signals the deposition controller that the furnace is at deposition temperature, and enables external furnace control.
Digital input 1	
Reset Controller on Open	Resets power output to minimum and terminates program operation.
Digital input 2	
Wait on close	Tied to event output 1, causes program operation to hold while deposition controller runs the deposition.
Digital input 3	
Standby on close	Tied to deposition controller end of process, alarm, fault, etc. causes event output 1 to clear, transferring control of the furnace back to the power controller resuming program operation for source shutdown.





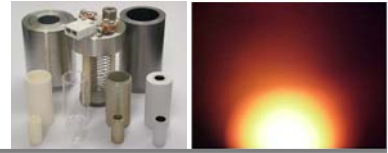
*Deposition sequence*

1. Operator initiates process by pressing the Run/Hold button on the power controller front panel
2. Power controller program segment one raises source temperature to 400°C over 20 minutes.
3. Power controller program segment two maintains the source at 400°C for 2 minutes to condition source.
4. Power controller program segment three dwells at 400°C and activates output event 1.
5. Output event 1 signals the deposition controller to start the deposition and places the power controller in a “wait” state holding the program in the segment three dwell.
6. The deposition controller enters its “in progress” state, closing the in progress output relay.
7. With the in progress relay (NO), output event 1 relay (NO), and alarm relay (NC) contacts closed, the SCR select relay is energized transferring furnace control to the deposition controller.
8. The deposition controller enters the “shutter delay” state, adjusting furnace power as required to stabilize rate at 10Å/sec.
9. The deposition controller enters the “deposit” state and opens the shutter, varying furnace power as necessary to maintain deposition rate at 10Å/sec
10. At 200Å, the deposition controller enters the “end of process” state, closes the source shutter and opens the normally closed shutdown relay.
11. With the shutdown relay’s (NC) contact open, the power controllers input 3 is activated causing a standby event.
12. The standby event clears all digital outputs (except alarms) on the power controller. Clearing the event 1 output de-energizes the SCR relay, transferring furnace control back to the power controller. Clearing the event 1 output also releases the controller from its “wait” state resuming program operation.



- 13. The power controller reduces the furnace temperature setpoint to 0 over 20 minutes.
- 14. Deposition is complete.

		Program	1	2	3						4				
RADAK Power Controller II+	Furnace Temperature	400° 25°C	[Temperature profile: ramps up from 25°C to 400°C in step 1, stays at 400°C through steps 2-12, then ramps down to 25°C in step 13]												
	Output Alarm	1 0	[Alarm signal: 0 throughout]												
	Output	1 0	[Output signal: 0 until step 2, then 1 until step 12, then 0]												
	Input 1	0 1	[Input 1 signal: 0 throughout]												
	Input 2	1 0	[Input 2 signal: 1 from step 2 to 12, 0 otherwise]												
	Input 3	0 1	[Input 3 signal: 0 until step 10, 1 from step 10 to 13]												
	Input	1 0	[Input signal: 1 from step 6 to 12, 0 otherwise]												
Deposition Controller	Input	1 0	[Input signal: 1 from step 4 to 12, 0 otherwise]												
	Input	1 0	[Input signal: 0 throughout]												
	Output	1 0	[Output signal: 0 until step 10, 1 from step 10 to 13]												
	Output		[Output signal: 1 from step 6 to 12, 0 otherwise]												
Sequence Step			1,2	3	4	5	6	7	8,9	10	11	12	13		



**Other automation options**

Use the II+ controllers' logic input as a vacuum interlock.

Logic A will be configured for standby (StbY). In standby mode, all controller outputs (power) are turned off, and the temperature setpoint display will alternate between the set temperature and StbY.

To configure the logic input, place the controller in configuration mode (see the explanation in the manual). Use the advance button to select the logic A menu (LA). Use the scroll button to advance to the function (Func) screen (Figure 2). Use the up/down buttons to select reset (rES). Use the advance button to return to the top menu and advance to the exit screen. Use the arrows to select yes then advance to reboot the controller.

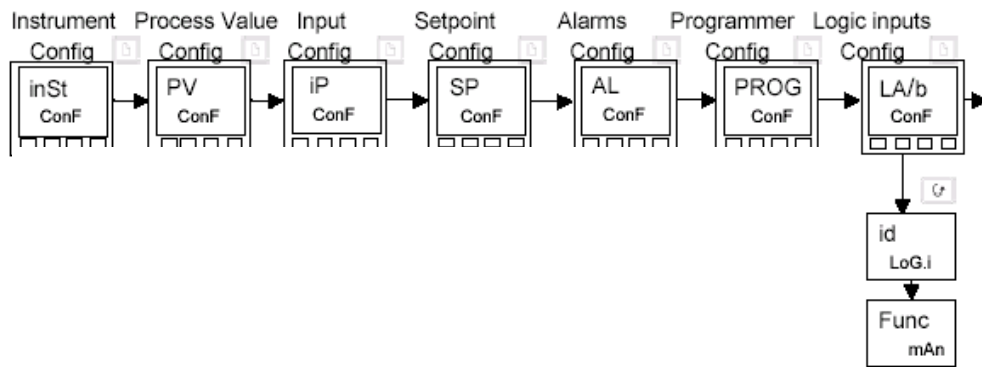
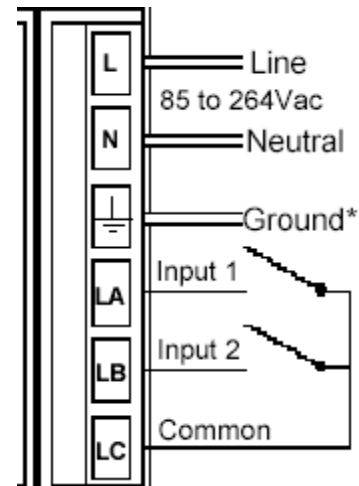
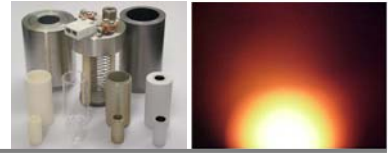


Figure 2 Menu structure to access the logic function in config mode.

Controller wiring. Logic A input 1 is accessed through I/O cable 4 wire 1 (red). Logic A common is on cable 4, wire 0 (black). Closing the circuit between these two wires will place the controller in standby mode holding program execution and turning all power output off. Program execution/power output will resume once the circuit is opened.





### **A few other thoughts:**

You may want to disable the manual feature. In this controller, manual means manually overriding the pid and setting the power output. Despite the warning in the instruction manual, we've had more than one customer place the unit in manual mode and, thinking they were setting temperature, get very frustrated that they could not raise the temperature setpoint above 100. Having inadvertently set the power output to 100%, the furnace temperature quickly rises above 1000°C. There is a decent section in the manual on disabling this feature.

Remote trim. As an alternative to driving the scr directly via the bnc connector on the rear panel, remote trim may be used. With remote trim, your external voltage signal is used to vary the controller temperature setpoint by a preset range. This allows the rate controller to produce an error signal but leaves actual temperature control to the controllers pid. The downside of this method is that you need to have a good idea of the range to be set for the trim. It takes a little experimenting to determine the proper range for the trim. If the range is something that will be changed often, it is possible to promote these setpoints to the operator screen so you don't have to go into configuration every time. If you're interested, contact us and we'll help you set it up.

Eurotherms auto-tune feature is a good starting point for calibration but can produce some prohibitively long time constants for operation at lower temperatures (100-300°C). Integral and derivative times in the hundreds of seconds may produce a smooth ramp rate but it's a long wait. The controller has a feature called gain scheduling which allows two pid's to be used depending on the temperature of the furnace. The controllers are shipped with gain scheduling enabled and set for 500°C.

If you don't already have iTools from Eurotherm, it can be quite useful  
<http://www.eurotherm3.com/itools/itdnlds.htm> .