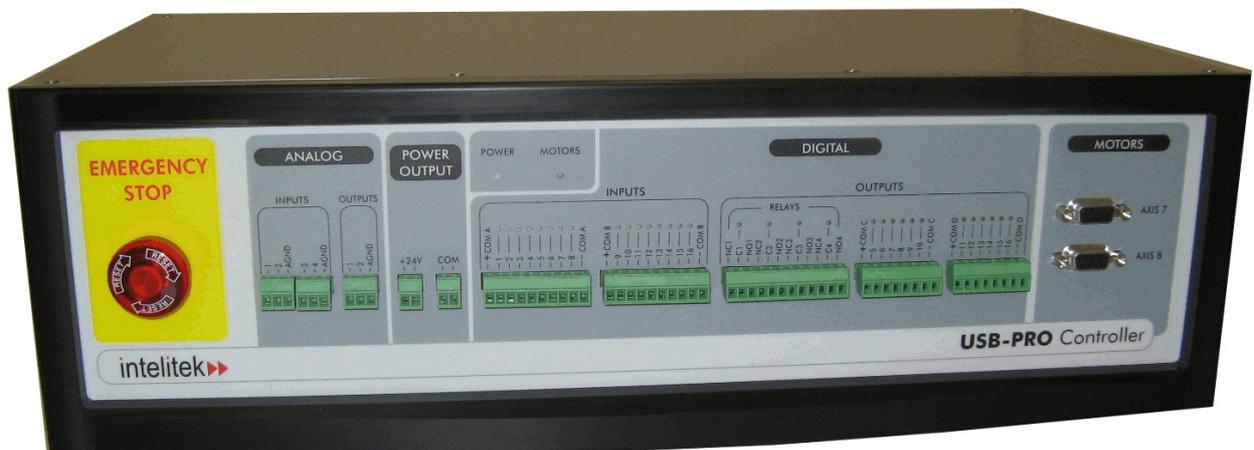


Controller USB-Pro



User Manual

Catalog #200029 Rev. B

intelitek ▶▶

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Warnings

1. Do not operate the **Controller USB-Pro** until you have studied this manual thoroughly.
2. Do not install or operate the **Controller USB-Pro** under any of the following conditions:
 - Where a safety ground connection does not exist.
 - Where the ambient temperature drops below 0°C or exceeds 45°C.
 - Where exposed to large amounts of dust, dirt, salt, iron powder, or similar substances.
 - Where subject to vibrations or shocks.
 - Where exposed to direct sunlight.
 - Where subject to chemical, oil or water splashes.
 - Where corrosive or flammable gas is present.
 - Where the power line contains voltage spikes, or near any equipment which generates large electrical noises.
3. Do not plug the Controller into the mains before confirming that the nominal voltage (as seen on the cover of the AC fuse drawer at the back of the Controller) is between 100-240VAC.
4. Do not connect voltage to an input port which exceeds 30VDC.
5. Never connect voltage from a power supply directly to any open collector outputs (5–16). The open collector outputs must always be connected to a load.
6. Never connect a load to any voltage exceeding 30VDC.
7. Do not exceed current limitations for open collector outputs: 200mA max
8. Never drive a current of more than 5A through the relay outputs.

Emergency Button

Pressing the Emergency button disconnects the power signals to the robot and Axes 7 and 8, and halts the Scorbase program. The EMERGENCY button lights up, and the digital and analog outputs freeze their status.

Safety

9. Turn off the Controller's POWER switch before you do any work within the operating range of a connected robot or automated device.
10. Turn off the Controller's POWER switch before you connect any inputs or outputs.
11. Turn off the Controller's POWER switch **and** disconnect the power cable from the AC power outlet before you remove the AC power fuse. The power supply unit contains dangerously high voltage; the power cable must be disconnected to remove possible shock hazard.
12. The power cable must have a ground connection. If your power outlet does not have a safety ground, connect an external grounding terminal.
- ⚠ *The Controller is designed to work with a safety ground connection. Failure to connect the power cable to a grounded outlet could result in electrical shock.*
13. It is strongly recommended that additional safety devices, such as mushroom emergency buttons and warning lights, be installed in your system.
14. To immediately abort all running programs and stop all moving axes, either press the Controller's red EMERGENCY button, the Teach Pendant's red EMERGENCY button, or the optional external EMERGENCY button if one is connected.
15. If the distance between the robot and the Controller is greater than 1.5m, ensure that an EMERGENCY button is easily accessible, either with an external EMERGENCY button, or from the Teach Pendant.
16. Make sure servo control is off and that the hardware is configured properly before you connect a peripheral(s).
17. Do not attempt to open the Controller's cover except to change I/O settings.
18. The Controller's humidity should not exceed 35%-65% in storage, or 35%-90% in operation.

Safety Instructions for Robots (Controller and Arms)

19. Define a safety area with at least one meter of free space all around the robot.
20. Make sure the robot base is properly and securely bolted in place.
21. Make sure the cable from the body to the base can move freely during all movements of the robot's base axis.
22. Make sure both the encoder cable and the robot power cable are properly connected to the Controller before it is turned on.
23. Make sure the robot arm has ample space in which to operate freely.
24. Make sure a guardrail or rope has been set up around the Scorbot ER 9Pro operating area to protect both the operator and bystanders.

25. Do not enter the robot's safety range or touch the robot when the system is in operation.
 26. Press the Controller's EMERGENCY button before you enter the robot's operating area.
 27. Turn off the Controller's POWER switch before you connect any inputs or outputs to the Controller.
- ☞ *To immediately abort all running programs and stop all axes of motion, do one of the following:*
- Press the red EMERGENCY button on the Controller.
 - Press the red EMERGENCY button on the Teach Pendant.
 - Press the external EMERGENCY button.

Table of Contents

Warnings.....	i
Emergency Button	i
Safety	iii
Safety Instructions for Robots (Controller and Arms)	iii
Table of Contents.....	v
1	1-1
General Information.....	1-1
Unpacking and Handling	1-1
Acceptance Inspection	1-1
Controller Specifications	1-3
2	2-1
Installation and Configuration	2-1
Installing a Remote Emergency Button (Optional)	2-2
Installation of Computer–Controller.....	2-2
Installing Peripheral Axes.....	2-3
Robot–Controller Installation	2-4
Scorbot-ER 14Pro.....	2-4
Scorbot-ER 9Pro.....	2-4
Peripheral Devices and Equipment.....	2-5
Teach Pendant.....	2-5
Install the Teach Pendant Mounting Fixture	2-5
Connect the Teach Pendant	2-5
Teach Pendant Not Connected.....	2-5
Inputs/Outputs.....	2-5
Peripherals	2-6
3	3-1
Controller Functions	3-1
Controller State Indicator (6).....	3-2
Motors State Indicator (7).....	3-2
Emergency Buttons.....	3-2
User Power Output	3-3
Digital Output Terminals	3-3
Digital Input Terminals.....	3-3
Digital Input and Output LEDs.....	3-3
Analog Output Terminals	3-3
Analog Input Terminals	3-3
4	4-1
Inputs/Outputs & User Power Supply.....	4-1
Optical Isolation.....	4-1
Sink/Source.....	4-1
Digital Inputs	4-2
Maintaining Electrical Isolation.....	4-3
Connecting the Inputs	4-3
Activating the Inputs.....	4-3
Digital Outputs.....	4-5
Maintaining Electrical Isolation	4-6
Activating Relay Outputs	4-6
Activating Open Collector Outputs	4-8
Analog Outputs.....	4-9

Analog Inputs.....	4-10
5	5-1
Controller Components.....	5-1
Main Board	5-2
LEDs Board	5-4
PSU	5-5
Maintenance.....	5-6
Inspection.....	5-6
Troubleshooting	5-7
Repair and Upgrade Procedures	5-10
Opening the Controller	5-10
Fuse Replacement	5-10
6	6-1
Theory of Control	6-1
Servo Control.....	6-1
Digital Control	6-2
Velocity Profiles	6-6
Path Control	6-6
The Control Parameters	6-7
Appendix A.....	1
Configuration Summary	1
Appendix B.....	1
Connector Pin Assignments.....	1
Appendix C.....	1
System Overview	1
Appendix D.....	1
Schematic Diagram.....	1

1

General Information

This chapter contains instructions for unpacking and inspecting the Controller USB-Pro. This chapter also includes the Controller's specifications.

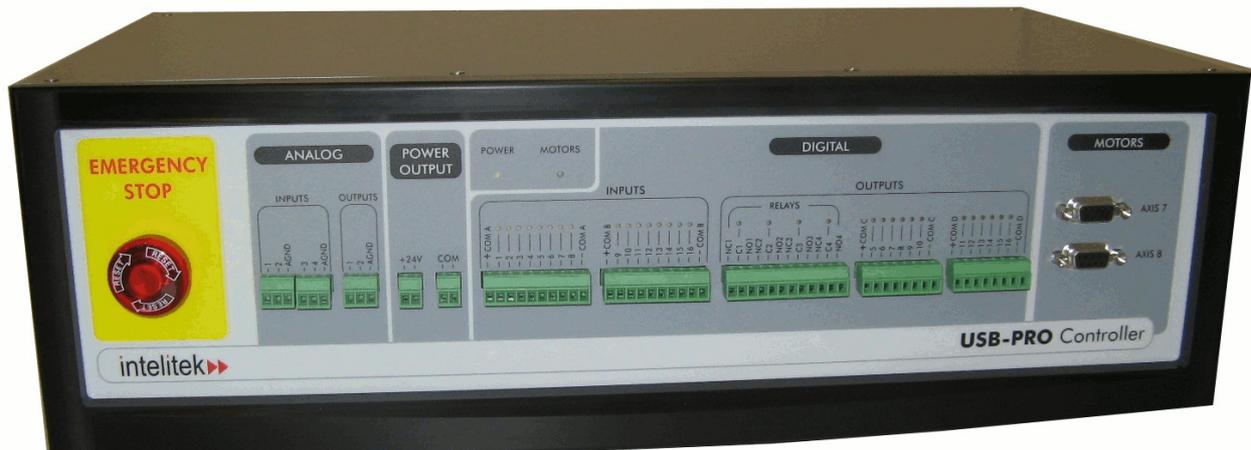


Figure 1-1: Controller USB-Pro

- ☞ Read this chapter and the Safety warnings at the beginning of the manual carefully before you unpack the Controller.

Unpacking and Handling

The Controller weighs 7.5 kg (approximately 16.5 lbs.). Do not grasp the Controller on either the front or back panel.

- ☞ Save the packing materials and shipping carton. You may need them later for shipment or for storage of the Controller.

Acceptance Inspection

After removing the Controller from the shipping carton, examine it for signs of shipping damage. If any damage is evident, do not install or operate the Controller. The following items are standard components in the **Controller USB-Pro** package. Make sure you have received all the items listed on the shipment's packing list. If anything is missing, contact your supplier.

Table 1: Standard Controller USB-Pro Package

Controller	AC Power Cable
Cables	USB Cable
2 Emergency By-Pass Plugs	Installed in the Controller (at Teach Pendant Connector and External Emergency Button Connector [(8) and (9) in Figure 2-1])
Documentation	Controller USB-Pro User Manual

Table 2: Optional Items

Item	Description	Catalog No.
Teach Pendant	Supplied with: Mounting fixture; <i>Teach Pendant User Manual.</i>	001709
I/O Interface Box	Used to connect I/O through the back panel.	034025
Rotary Table		001009
Linear Slide Base 1M		001016
Linear Slide Base 1.8M		001017
X/Y Positioning Table		001014
Linear Positioning Table		001013
Linear Conveyor		001010
Motor Kit		001234

Controller Specifications

The following table gives the specifications of the **Controller USB-Pro**.

Table 3: Controller USB-Pro Specifications

Item	Specification
Storage Temperature	-20°C-85°C (-4°F-185°F)
Ambient Operating Temperature	0°C-55°C (32°F-131°F)
Ambient Temperature for Long-term Reliability	45°C (113°F) max.
Storage Humidity	35%-65%
Operating Humidity	35%-90%
Vibration	0.5G (4.9m/s ²)
Condensation and Freezing	None
Type of control	Real-time; PID; PWM
Servo axis drivers	8 axes for robot and peripherals
Path control	Joint; Linear; Circular
Speed control	10 speed settings; Travel time definitions
Control parameters	160 parameters, many are user-accessible; Servo control; PID; speed; velocity profile; axis position error; gripper operation; impact; limit protection; homing; Cartesian calculations.
Power requirements	110-220 VAC ±10%, 50-60Hz, 1000 W
Internal power supplies	Servo: 48V Digital: 5V/12V/24V
MicroController	MicroController ARM7TDMI Processor: 32-bit RISC Architecture with 256 Kbytes of Internal High-speed Flash
Communication	USB type A cable connection to PC; Plug and play without rebooting; Integrated RS232 for Teach Pendant;
Inputs	16 digital inputs: 24V max., Sink/Source configurable; 4 analog inputs: input voltage 0-10V
Outputs	16 digital outputs: 24V max.; 4 relays; 12 open collector, sink/source configurable; 2 analog outputs: output voltage 0-10V
User power supply	12 VDC (1A) and 24 VDC (2A) terminals, for connection of remote switches, sensors, etc.
Programming	Scorbase for ER 9Pro/ER 14Pro software, with Multi tasking – Up to 100 concurrent programs; In-program parameter

	manipulation.; Built in Scripting; ON line Graph With PWM and position error; Robocell for ER 9Pro/ER 14Pro: 3D simulation software (optional); Teach Pendant for Controller USB and USB-Pro: (optional); Programming Interface
Position definition	XYZ coordinates; Joint coordinates (degrees); Encoder counts; Absolute and relative positions; In program position manipulation
LED indicators	Main power, power on, communicating with PC; Motor on; Digital Inputs / Digital Outputs; Emergency
Weight	7.5 kg (16.5 lb)
Dimensions	460x140x245 mm (18.1''x5.5''x9.6'')
Operating temperature	2° - 40°C (36° - 104°F)
Safety features	Certified for CE safety compliance; Emergency Button on Controller front panel/ Teach Pendant/remote; Input/Output short-circuit protection; Over-current protection; Communication error; impact; thermic overload

2

Installation and Configuration

The installation instructions in this chapter refer to Figure 2-1.

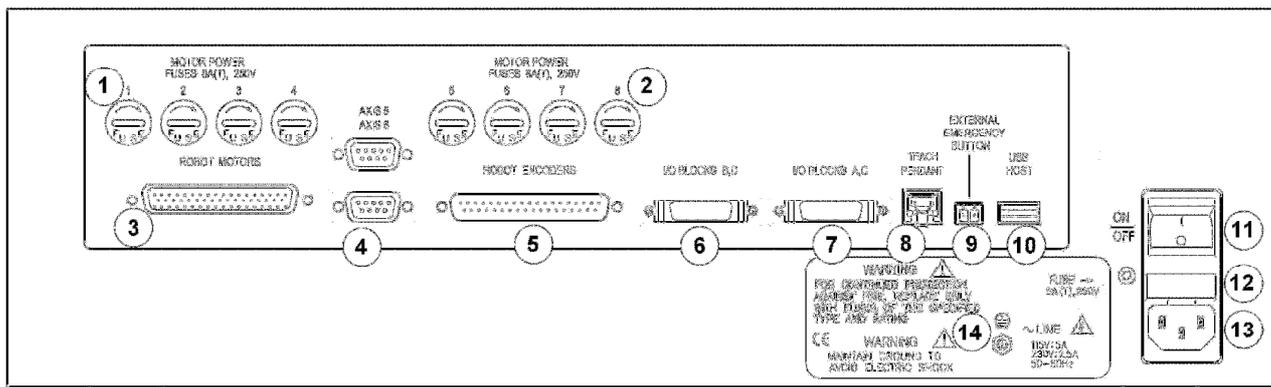


Figure 2-1: Controller USB PRO Back Panel

1	Motor Power Fuses Axes 1 to 4
2	Motor Power Fuses Axes 5 to 8
3	Robot Motors Power Connector
4	Auxiliary Axes 5 and 6 Connectors
5	Robot Encoders Connector
6	I/O Blocks B,D Connector
7	I/O Blocks A,C Connector
8	Teach Pendant Connector/ By-Pass Plug Connector
9	External Emergency Button Connector
10	USB Host Connector
11	Power ON/OFF Switch
12	Power Input Fuse
13	Power Line Socket
14	Safety Ground Terminal

Installing a Remote Emergency Button (Optional)

The External Emergency Button Connector at the back of Controller USB-Pro (9) allows you to add a remote button (such as a mushroom button) that will function exactly like the Controller's EMERGENCY stop button.

To connect a remote emergency button, do the following:

1. Make sure the EMERGENCY terminal contacts are normally closed (NC).
2. Remove the jumper wire that shorts the two terminals of the EMERGENCY terminal (9) on the back panel of Controller USB-Pro.
3. Connect the two wires from the remote Emergency Button terminals to the EMERGENCY terminal (9).

Installation of Computer–Controller

It is recommended that you connect and check the computer-Controller setup before installing the robot or any other hardware.

☞ *Install Scorbase before installing the Controller, for details, refer to Chapter 2: Starting Scorbase in the Scorbase for ER 9Pro/ER 14Pro User Manual.*

☞ *Do not cover or block the Controller on either side.*

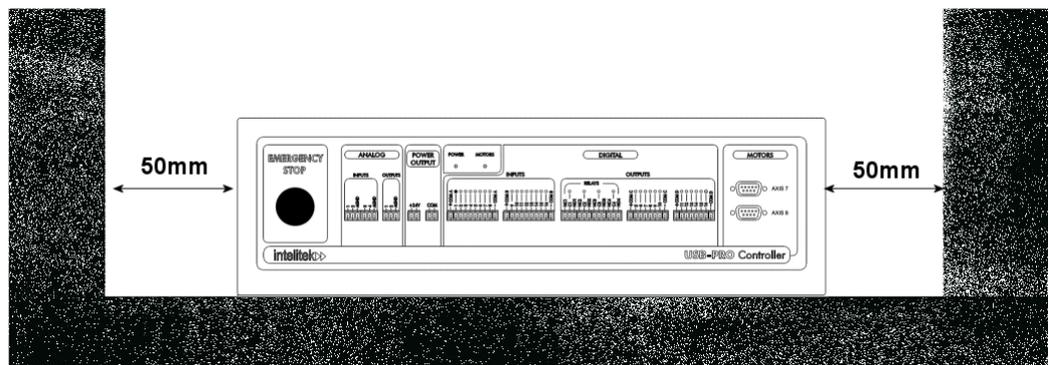


Figure 2-2: Distance Around the Controller

☞ *Ensure that the supplied voltage is suitable for the Controller's requirements. See specifications on the back panel of the Controller ((14) in Figure 2-1).*

1. Make sure the Controller power switch (11) is turned off.
2. Connect the AC power cable to the Controller (13) and to the AC power supply outlet.
3. Connect the USB cable to the USB Host Connector (10) on the Controller and to the USB Host Connector on the computer.
4. Connect the computer power cable to an AC power source.
5. If you will *not* be using a Teach Pendant, connect the Emergency By-Pass plug into the Teach Pendant port (8).

If you will be using a Teach Pendant, connect it at this time. Follow the instructions for installing the Teach Pendant later in this chapter.

It is recommended that you set the Teach Pendant Auto/Teach switch to AUTO before you power on the system.

Make sure the Controller's EMERGENCY button, and the external and TP EMERGENCY buttons are depressed.

6. You may now turn on the system.

Installing Peripheral Axes

The D9 connectors on the front panel of Controller USB-Pro, marked AXIS 7 and AXIS 8 (See Figure 3-1), are used for connecting optional SCORBOT motorized devices that can be controlled by Controller USB-Pro.

To connect peripheral axes, do the following:

1. Turn off Controller USB-Pro before you connect any devices.
2. Configure the peripheral axes using the Scorbse software. Refer to the Scorbse user manual.
3. Connect the peripheral device's cable with D-type connector to the D9 connector on the Controller.
4. Tighten the cable connector screws.

Robot–Controller Installation

After you have completed the computer/terminal setup and verified that the system is functioning, you may proceed with the robot installation.

Perform the robot hardware installation according to the procedure detailed in the chapter, “Installation” in your robot’s *User Manual*.

Special instructions for specific robots are given below:

Scorbot-ER 14Pro

When the Controller is configured for **Scorbot-ER 14Pro** operation, **axis 5** is reserved by default for an electrical gripper, although it can also be configured for another peripheral device. The remaining axes may be used for other peripherals (See the previous section: Installing Peripheral Axes).

To add a peripheral axis using the Hardware Setup dialog box which can be accessed by selecting **Options | Hardware Setup** from the Menu bar in Scorbace.

Scorbot-ER 9Pro

When the Controller is configured for **Scorbot-ER 9Pro** operation, **axis 6** is reserved by default for an electrical gripper, although it can also be configured for another peripheral device. The remaining axes may be used for other peripherals (See the previous section: Installing Peripheral Axes).

To add a peripheral axis using the Hardware Setup dialog box which can be accessed by selecting **Options | Hardware Setup** from the Menu bar in Scorbace.

Peripheral Devices and Equipment

☞ *The Controller must be turned off before you connect any devices.*

Teach Pendant

Install the Teach Pendant Mounting Fixture

This special fixture is required for reasons of safety. Install this fixture safely outside the working range of the robot and peripheral axes. The fixture has a magnetic strip which activates a magnetic switch on the Teach Pendant. When the Teach Pendant is mounted in this fixture, programs can be executed from the Teach Pendant; when the Teach Pendant is hand-held, program execution cannot be activated from the Teach Pendant. The fixture for mounting the Teach Pendant is supplied with a set of screws for mounting.

Connect the Teach Pendant

If you do not intend to connect the Teach Pendant, skip this section, and go to the following section, “Teach Pendant Not Connected”.

1. Remove the By-Pass Plug from (8) in Figure 2-1, and connect the Teach Pendant cable.
2. Connect the other side of the cable to the Teach Pendant.

Teach Pendant Not Connected

☞ *When the Controller USB-Pro Teach Pendant is not connected to the Controller, the Emergency By-Pass Plug must be connected instead.*

This plug prevents the Controller from activating EMERGENCY status when the Teach Pendant is absent.

Connect the by-pass plug to the Controller’s Teach Pendant Connector ((8) in Figure 2-1).

Inputs/Outputs

In addition to connecting I/Os through the terminals on the Controller front panel (Chapter 3), the I/O connectors ((6) and (7) in Figure 2-1) at the back of the Controller may be used to connect external I/O devices directly or by means of an I/O Interface Box.

Peripherals

The following peripheral devices can be installed to the Controller:

- Conveyor belt (gray), 24V
- Linear positioning table 0.3 m, 24V
- XY positioning table, 24V
- Rotary table (black), 24V
- Motor kit (127:1), 24 V
- Slidebase (USB), 1.0 m, 24V
- Slidebase (USB), 1.8 m, 24V

☞ *Do not connect any unsupported devices.*

To configure the attached devices select **Options | Hardware Setup** from the Menu bar in Scorbace.

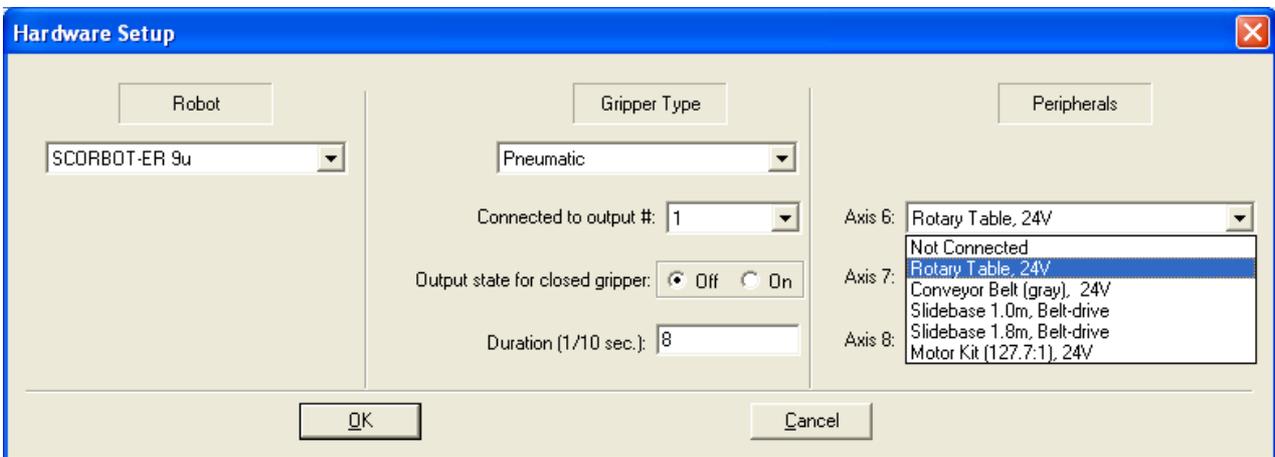


Figure 2-3: Hardware Setup Dialog Box

The Hardware Setup dialog box allows you to select the relevant peripherals which are attached to the available axes.

3

Controller Functions

The descriptions in this chapter refer to Figure 3-1.

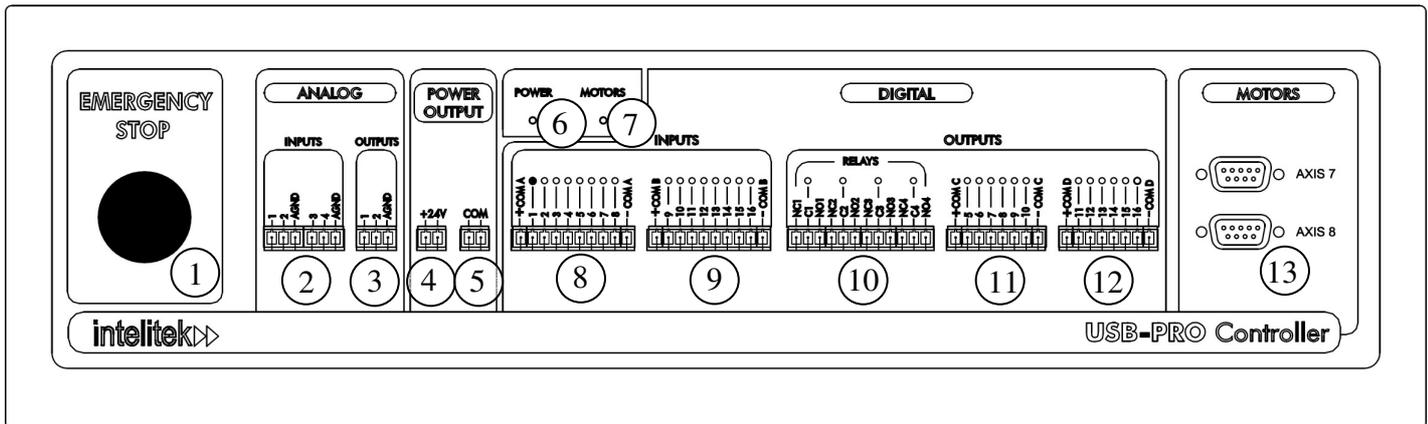


Figure 3-1: Controller USB-Pro Front Panel

1	Emergency button
2	Analog Inputs 1 to 4
3	Analog Outputs 1 and 2
4	+24V User Power Output
5	Common 24V User Power Output
6	Controller State Indicator
7	Motors State Indicator
8	Digital Inputs 1 to 8
9	Digital Inputs 9 to 16
10	Digital Outputs [relays] 1 to 4
11	Digital Outputs [Open Collector] 5 to 10
12	Digital Outputs [Open Collector] 11 to 16
13	Auxiliary axes 7 and 8 connectors

Controller State Indicator (6)

When software is activated in online mode, the Controller State Indicator changes color to indicate the following:

- **Green:** The Controller is turned on and is communicating with the PC (On-line mode).
- **Red:** The Controller is turned on but is currently **not** communicating with the PC. (Off-line mode/Simulation).
- **Red Flashing:** Interim state. The Controller has lost communication with the PC. The Controller will either regain Communication (the Controller State Indicator will turn to green), or will change to Off-Line state (the Controller State Indicator will turn to Red).

Motors State Indicator (7)

The green Motors State Indicator indicates whether or not power is being supplied to the motors. This LED lights after Scorbace is activated and the CON (control on) command is issued.

The Motors State Indicator switched off when any of the following occurs:

- COFF (control off) command is issued
- EMERGENCY button is pressed
- Controller USB-Pro detects a communication time-out
- Controller USB-Pro detects an over-current error
- Thermic overload occurs
- Impact occurs
- Scorbace closes.

Emergency Buttons

When any of the EMERGENCY buttons are pressed, the following occurs:

- Motor power is disconnected; all motor movement stops; the green Motors State Indicator switches off
- The COFF (control off) state is activated
- The red EMERGENCY button illuminates
- An emergency message appears on monitor
- All running programs are aborted
- The user power supply remains in normal operation
- HOME and CON cannot be activated
- The digital and analog outputs freeze their status

☞ *Pressing an Emergency button will not stop the operation of a remote output device. To stop the output device, use its own Emergency Stop button.*

To resume normal operation, do the following:

1. Release the EMERGENCY button by turning it clockwise, as indicated by the arrows on the button.

When the EMERGENCY button on the front panel is pulled out or a remote Emergency Button is released, the following occurs:

- The red EMERGENCY button light switches off.
 - A message appears on the Scorbase screen, prompting you to select CON (control on) to return to the Control On state. By selecting cancel the Controller will remain in Control Off state.
2. Activate CON. The green Motors State Indicator switches on.
 3. Reactivate user programs. (All positions, including Home, remain in memory.)

User Power Output

The User Power Supply allows external devices in the user's applications to receive power from the Controller.

- +24VDC 2A regulated floating power supply (4)
- Floating Common (5)

Devices can also be connected using an I/O Interface box connected to the Controller's back panel.

Digital Output Terminals

The 16 outputs allow the robotic system to transmit signals to external devices in the robot's environment. The Controller USB-Pro has two types of outputs: 4 relay outputs (10) and 12 open collector outputs ((11) and (12)).

Devices can also be connected using an I/O Interface box connected to the Controller's back panel.

Digital Input Terminals

The 16 inputs ((8) and (9)) allow the robotic system to receive signals from external devices in the robot's environment.

Devices can also be connected using an I/O Interface box connected to the Controller's back panel.

Digital Input and Output LEDs

16 green LEDs, corresponding to outputs 1–16, light up when the outputs are on.

16 orange LEDs, corresponding to inputs 1–16, light up when the inputs are on.

Devices can also be connected using an I/O Interface box connected to the Controller's back panel. Refer to Figure 5-2.

Analog Output Terminals

Analog outputs 1 and 2 (3) allow the control of devices that operate using an analog input voltage, such as an LED or a motor driver.

Analog Input Terminals

Analog Inputs 1-4 (2) allow Controller USB-Pro to receive data from analog sensors.

4

Inputs/Outputs & User Power Supply

☞ *Read this Chapter thoroughly before making any output, input or power supply hardware connections.*

Controller USB-Pro has 16 digital inputs and 16 digital outputs. The I/Os are accessible from either the terminals on the Controller's front panel or the ports on the Controller's back panel. Two user power supplies are also provided.

☞ *Avoid the risk of malfunctions and shorts:*

Make sure all wires are connected to either the front terminals or back ports. Make sure Controller outputs are not connected to each other.

Before describing the specific details of the Controller USB-Pro inputs and outputs, it is necessary to explain two important features of this Controller: optical isolation and sink/source modes.

Optical Isolation

Optical isolators are devices which were designed to solve the problem of interfacing electronic equipment in electrically noisy environments. If a non-isolated direct connection is used, noise entering through the terminals or ground and power lines can disrupt system operation, resulting in the generation of erroneous logic signals. In severely noisy environments, noise may even damage electronic circuitry.

When electrical isolation is maintained, system communication is not affected by common-mode noise.

The optical isolator uses visible or infra-red light to establish communication between local and remote equipment.

The isolator consists of a light emitter on one end and a light detector on the other.

When the light emitter side is off (dark), the detector is off. When the light emitter side turns on, the detector changes its state to on.

Sink/Source

The I/O terminals of the Controller USB-Pro can be configured to work in one of the two modes:

- Sink
- Source

In simple terms, an electrical source is comparable to a water faucet, while an electrical sink is comparable to the tub into which the water flows.

For proper I/O operation, a paired Source/Sink connection is required, as shown in the following tables:

Controller Input	External Device Output
Source	Sink
Sink	Source

Controller Output	External Device Input
Source	Sink
Sink	Source

To set the Source/Sink mode of an input, set the corresponding switch on the Controller's main board to either the Source or Sink position.

Figure 4-1 shows the default setup:

Inputs 1 to 16: Source

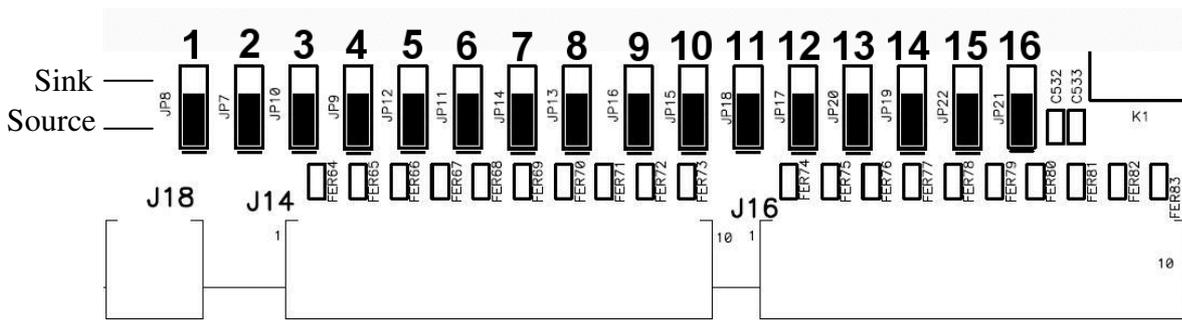


Figure 4-1: Input Switches Default Position (Source)

To set the Sink/Source mode of an output, set the corresponding switch on the Controller's main board to either the Sink or Source position.

Figure 4-2 shows the default setup:

Outputs 5 to 16: Sink

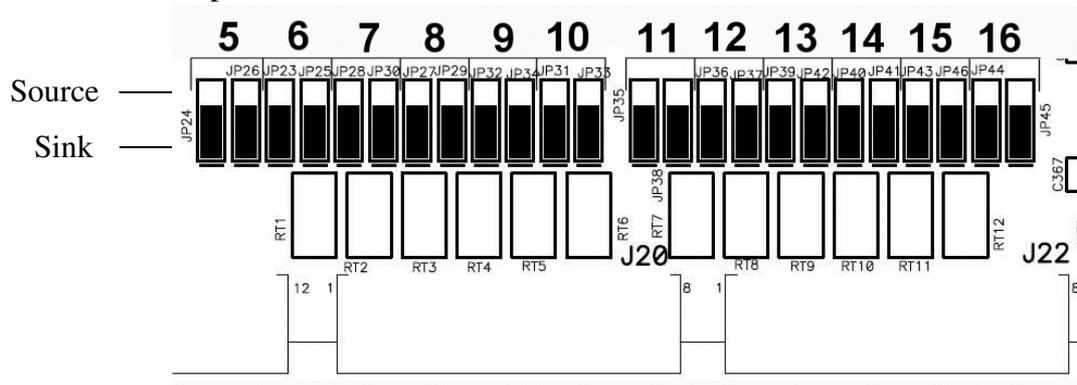


Figure 4-2: Output Switches Default Position (Sink)

Note: Output dipswitches are in pairs (5-16).

Digital Inputs

Controller USB-Pro has 16 inputs, which are divided into two optically isolated blocks (Blocks A and B), as shown in Figure 4-3. Each block is floating and can be referenced to a different external device or to the Controller's frame ground. In addition, any input can act as Source or as Sink.

The Controller input circuits use opto-isolators to ensure proper electrical isolation between the Controller and other electronic equipment in the system.

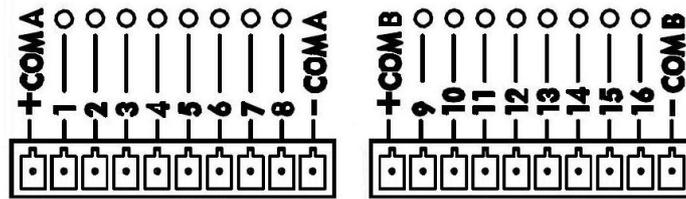


Figure 4-3: Input Terminals on Front Panel

Input terminals are connected to the light emitting side of the opto-couplers. The opto-coupler light detector side is connected to the internal circuits of the Controller, and is referenced to the Controller's common terminal.

Maintaining Electrical Isolation

To maintain the Controller's electrical isolation, do the following:

- Dedicate an isolated input block to one external device.
- Connect the COM- block to the external device's common terminal.
- Connect the COM+ block terminal to the external device's positive voltage terminal.

In this way the light emitter side of the opto-coupler is referenced to the external device's power and common terminal while the light detector is referenced to the Controller's power and common terminal—and electrical isolation is maintained.

Connecting the Inputs

Before connecting Controller inputs to external device outputs, be sure to check whether the external device output is a sink or a source type output.

Some manufacturers use the terms NPN and PNP.

- An NPN output is a sink-type output.
- A PNP output is a source-type output.

If the external device output is a sink (NPN) type, be sure to set the Controller's input switch to its Source position.

If the external device output is a source (PNP) type, be sure to set the Controller's input switch to its Sink position.

Activating the Inputs

The inputs are activated by external devices' outputs which are connected to corresponding inputs on the Controller.

Source (Default) Configuration:

External voltage of 0VDC will turn the input ON.

Sink Configuration:

External voltage of 12VDC to 24VDC will turn the input ON.

☞ *Do not connect a voltage to input ports which exceeds the voltage present on the COM+ terminal of the input block.*

Figure 4-4 - Figure 4-7 show diagrams of the input circuit in both Sink and Source modes for both external and internal power supply.

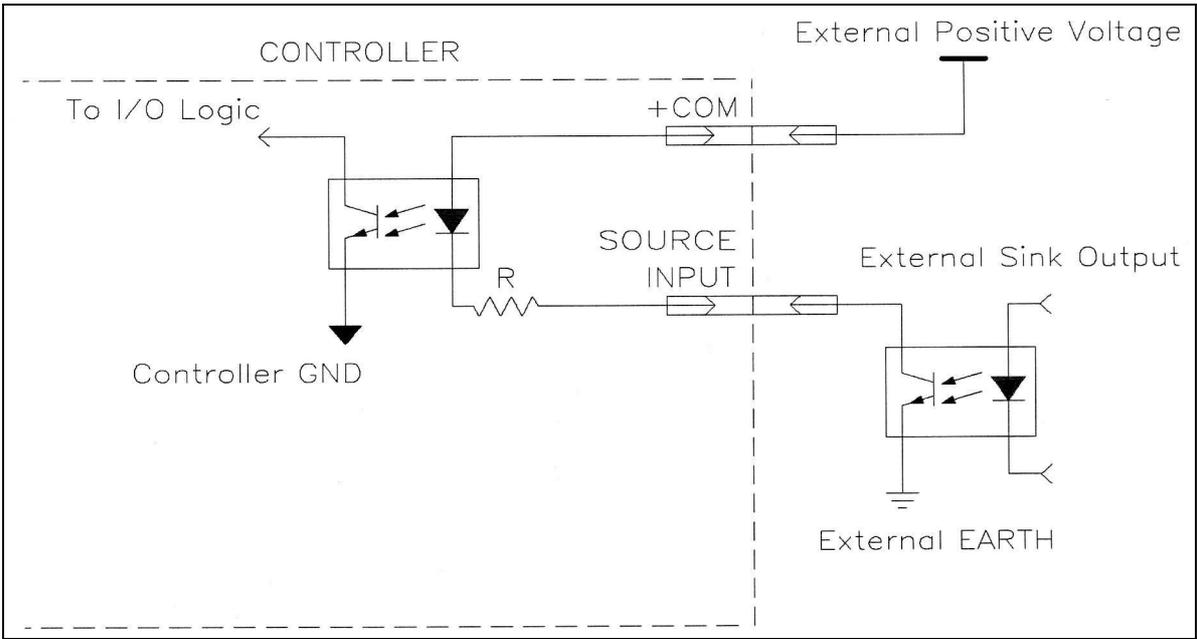


Figure 4-4: Input Circuit (Source) - External PSU

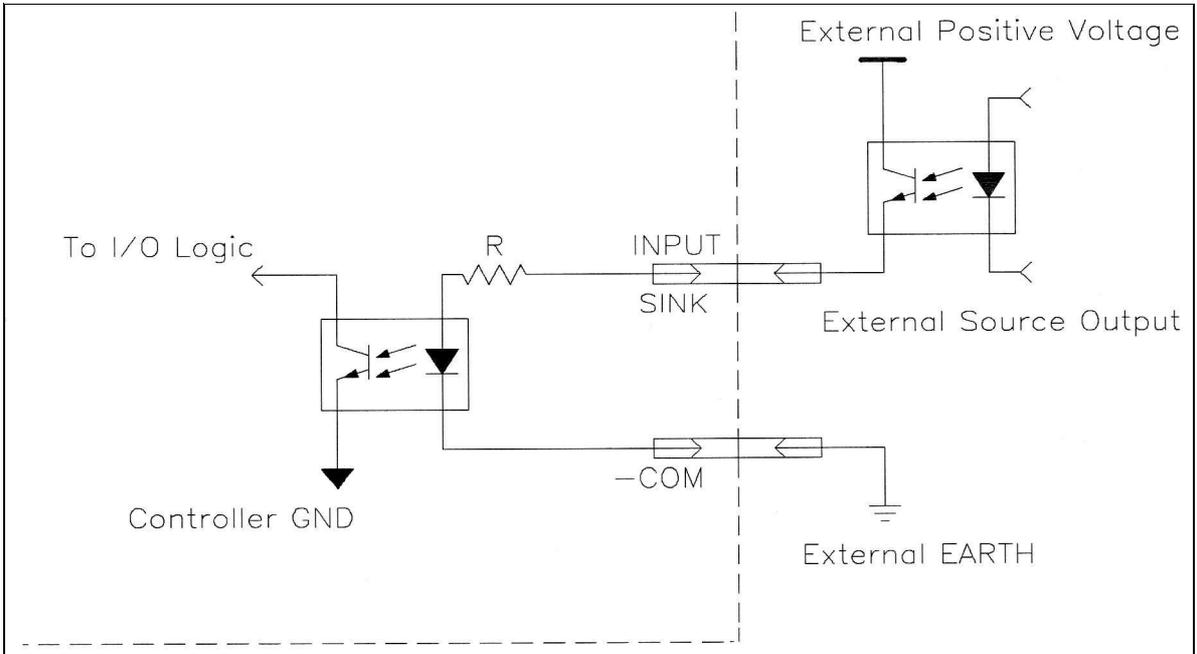


Figure 4-5: Input Circuit (Sink) - External PSU

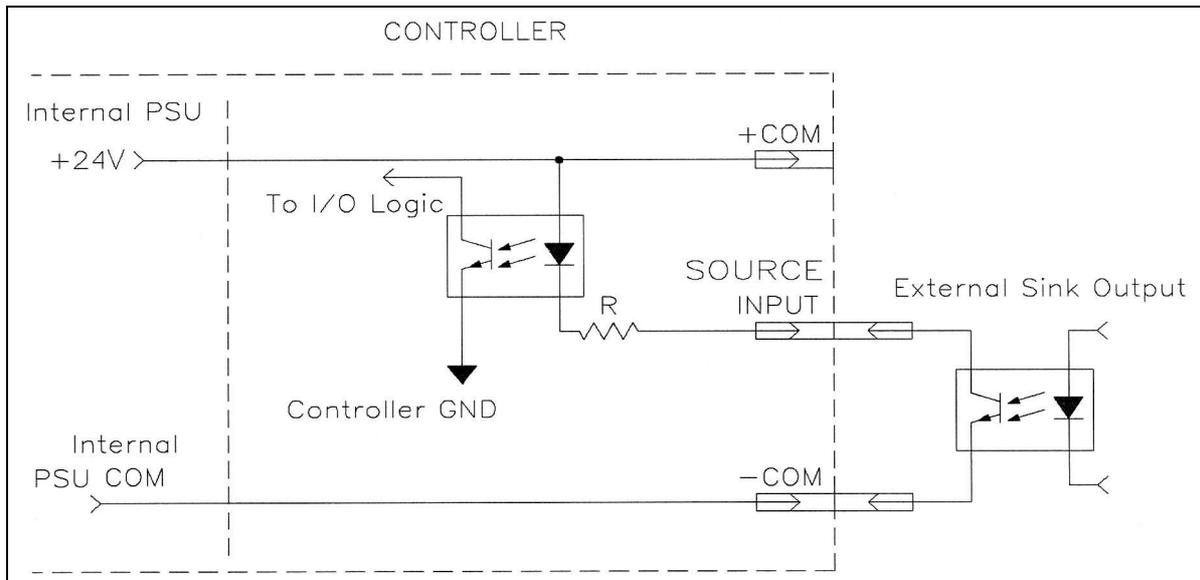


Figure 4-6: Input Circuit (Source) - Internal PSU

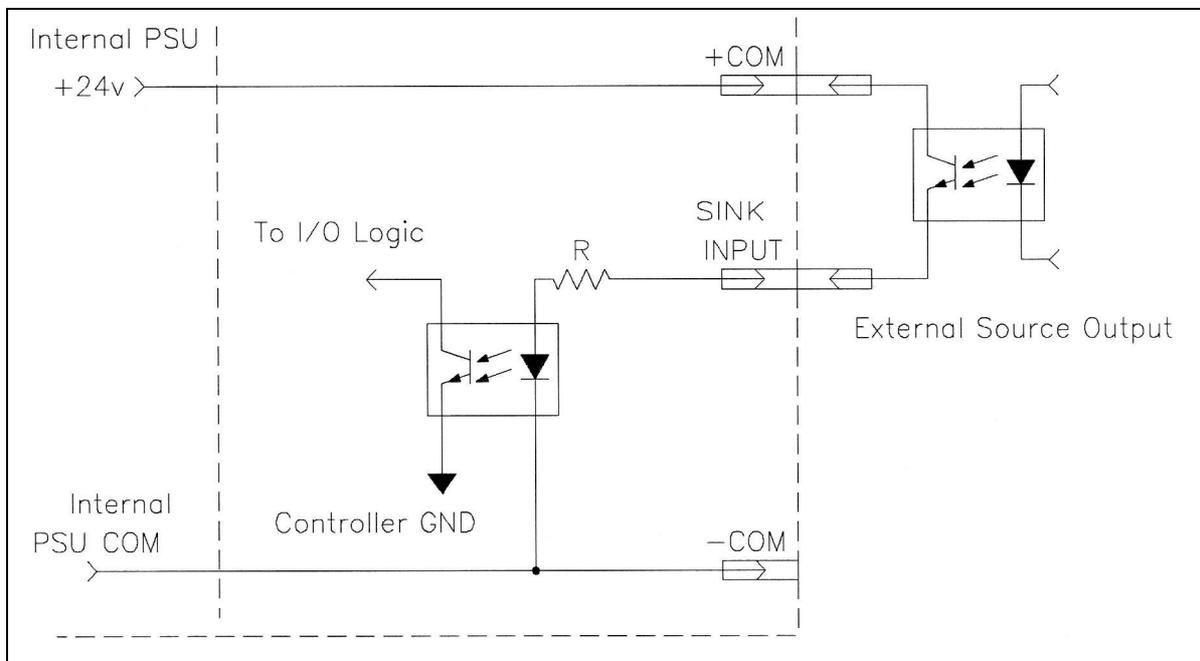


Figure 4-7: Input Circuit (Sink) - Internal PSU

Digital Outputs

Controller USB-Pro has 16 outputs. Four are relay outputs with both Normally Open and Normally Closed contacts, as shown in Figure 4-8. The other 12 outputs are open collector types, which are divided into two optically isolated blocks (Blocks C and D), as shown in Figure 4-9. Each block is electrically floating and can be referenced to a different external device. In addition, any open collector output can act as a source or as a sink.

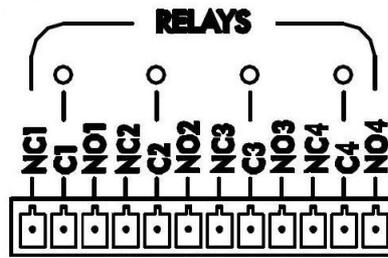


Figure 4-8: Relay Output Terminals on Front Panel

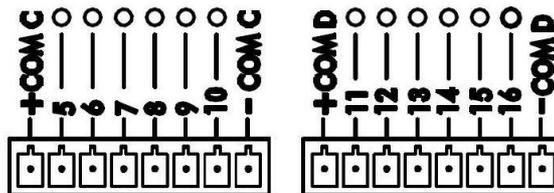


Figure 4-9: Open Collector Output Terminals

Open collector output terminals are connected to the light detector side of optocouplers and should be referenced to external device power and ground. The optocoupler light emitting side is connected to the internal circuits of the Controller, and referenced to Controller's power and ground.

Maintaining Electrical Isolation

To maintain electrical isolation between the Controller and an external device, do the following:

- Dedicate an isolated output block to one external device.
- Connect the COM- block terminal to the external device's common terminal.
- Connect the COM+ block terminal to the external device's positive voltage terminal.

Activating Relay Outputs

Outputs 1 to 4 include relays in their final stage. Each relay includes the three contact points:

- Common (C)
- Normally Closed (NC)
- Normally Open (NO).

Maximum current allowed: 5A

☞ *Never drive a current of more than 5A through the relay outputs.*

Figure 4-10 shows the ON and OFF states of the relay outputs.

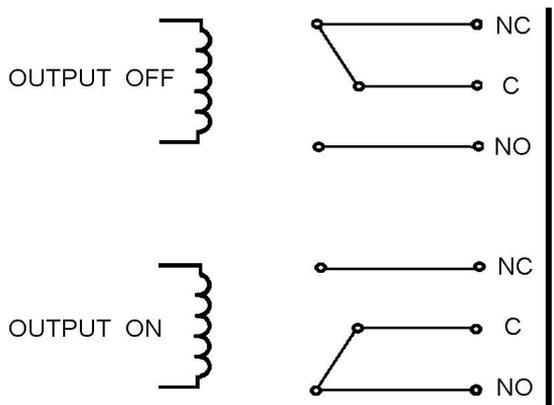


Figure 4-10: Relay Output States

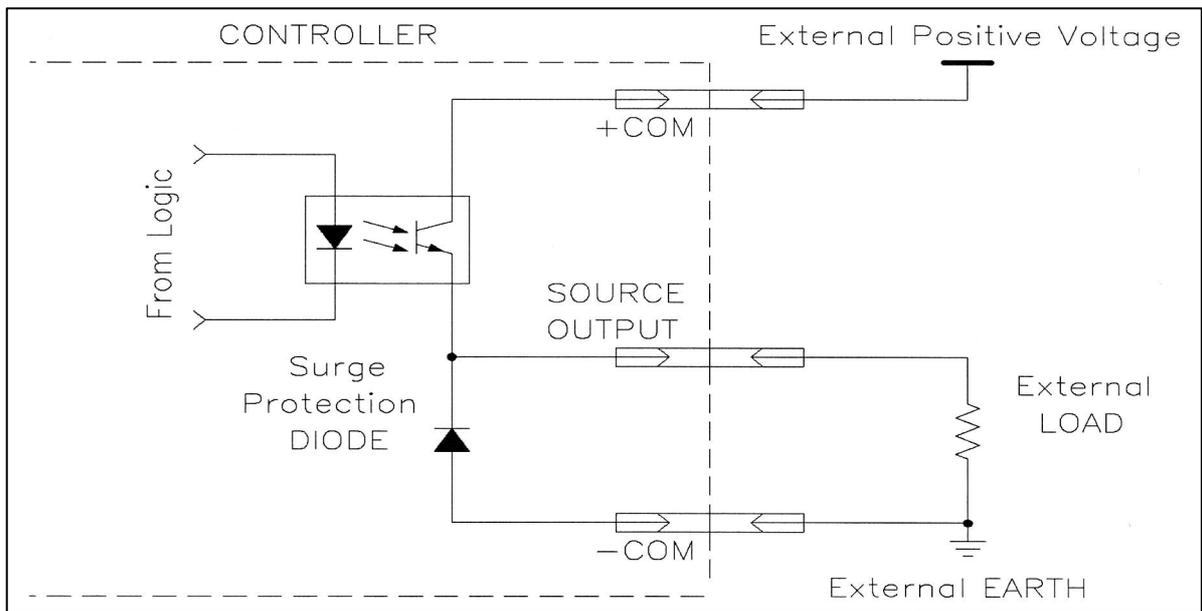


Figure 4-11: Output Circuit (Source) - External PSU

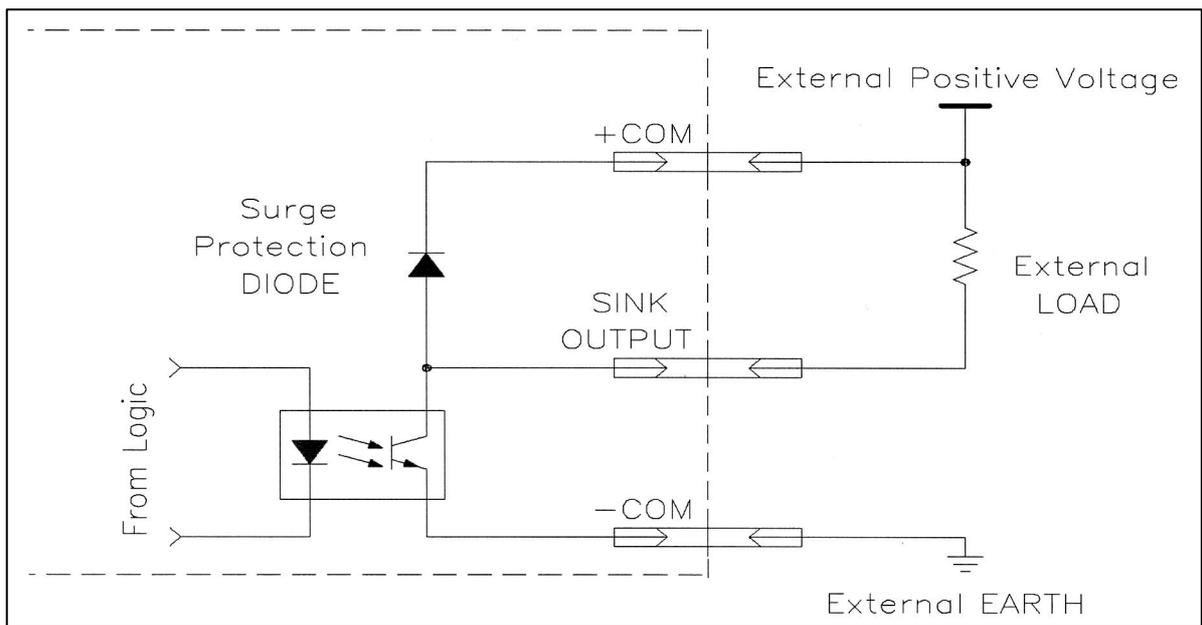


Figure 4-12: Output Circuit (Sink) - External PSU

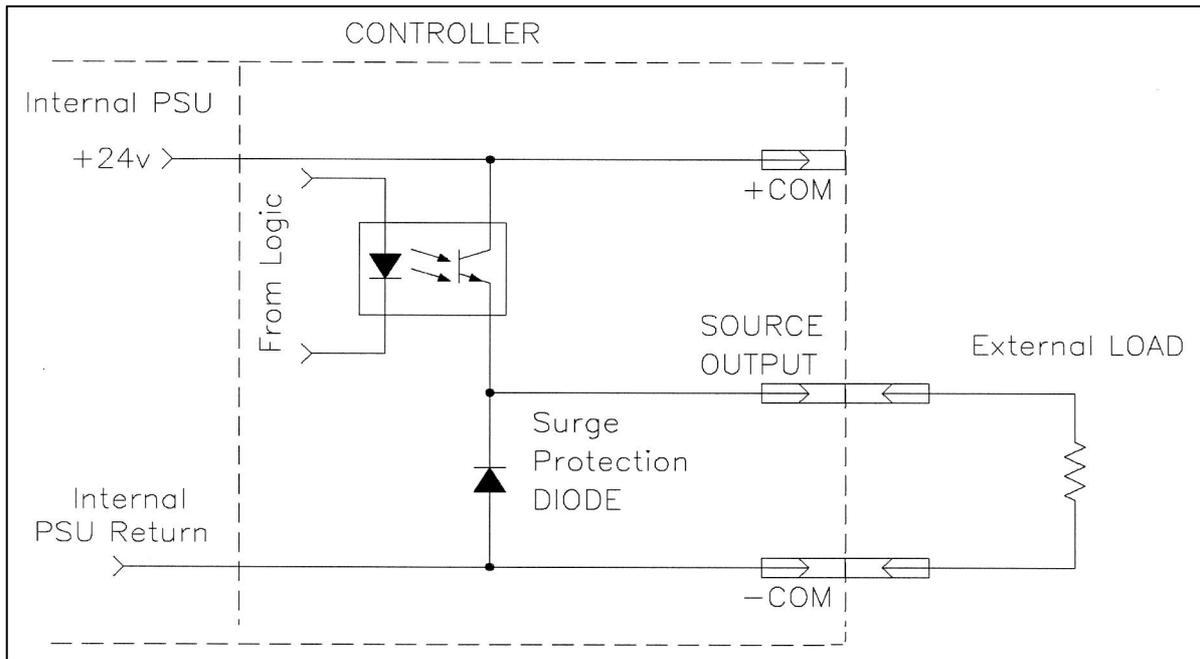


Figure 4-13: Output Circuit (Source) - Internal PSU

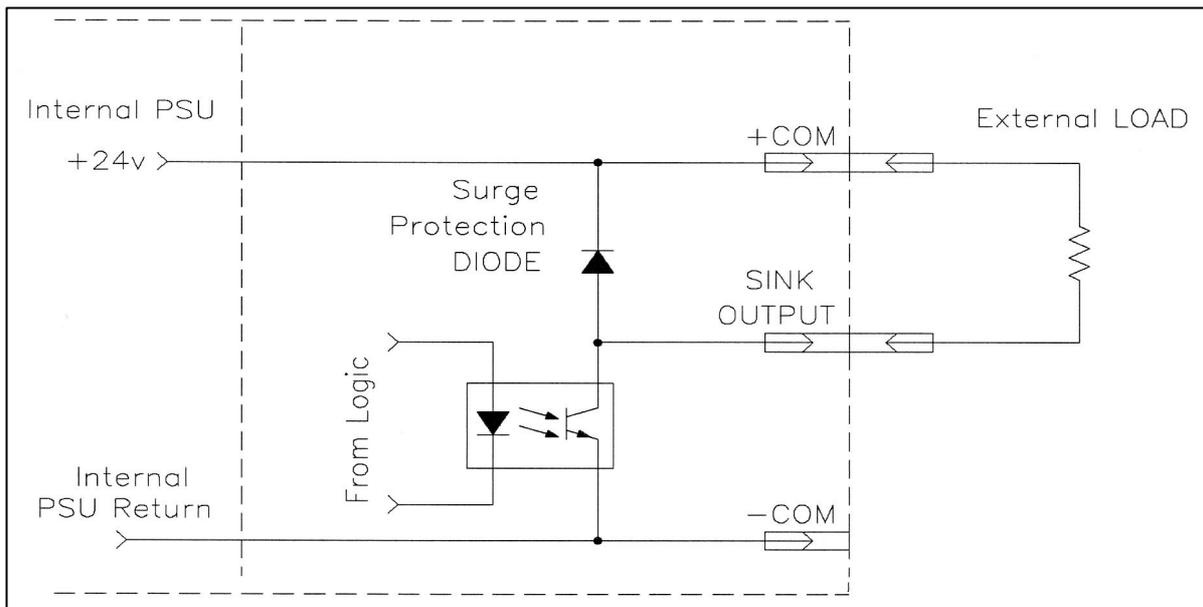


Figure 4-14: Output Circuit (Sink) - Internal PSU

Activating Open Collector Outputs

Before connecting Controller outputs to external device inputs, be sure to check whether the external device input is a sink or a source type input.

If the external device input is a sink type, be sure to set the Controller's output switch to its Source position.

If the external device input is a source type, be sure to set the Controller's output switch to its Sink position.

Outputs 5 to 16 include a transistor with an open collector in their final stage. These outputs must be connected to a load; never connect directly to power or ground. When using an inductive load, such as a solenoid or a relay, connect a reversed biased protection diode across the load. When connecting an open collector output to an input, you can connect directly. Figure 4-4 - Figure 4-7 show the proper I/O connections.

Maximum current allowed: 200mA

- ☞ *Never connect voltage from a power supply directly to any open collector outputs (outputs 5–16). The open collector outputs must always be connected to a load. Never connect a load to any voltage exceeding 30VDC.*

Figure 4-11 - Figure 4-14 show diagrams of the output circuit in both source and sink modes for both external and internal power supply.

Analog Outputs

Analog outputs 1 and 2 allow you to control devices that operate using an analog input voltage, such as an LED or a motor driver.

The analog outputs have an 8-bit resolution D/A converter (DAC) and an output voltage of 0–10V DC. The voltage is controlled via SCORBASE (output word 0–255 \Leftrightarrow 0–10 V).

The analog output current is limited to 20 mA. Use a hardware driver (booster) to energize a device requiring higher voltage or current.

Figure 4-15 shows the interconnection scheme for analog outputs. Figure 4-16 shows the actual analog outputs.

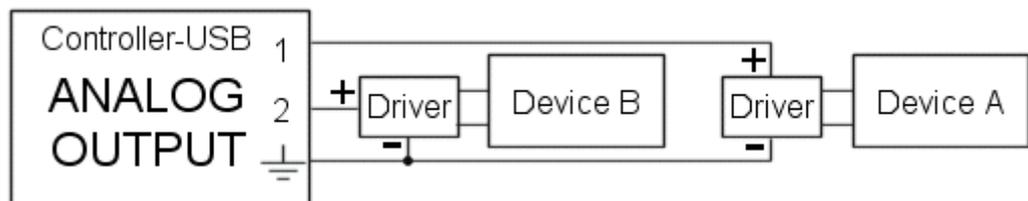


Figure 4-15: Interconnection Scheme: Analog Outputs

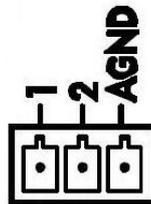


Figure 4-16: Analog Output

Analog Inputs

Analog Inputs 1-4 allow Controller USB-Pro receive data from analog sensors. DC voltage between 0 and 10 volts may be provided to the analog inputs. The analog inputs are read with an 8-bit resolution by SCORBASE software commands. Figure 4-17 shows the interconnection scheme for a passive sensor such as a thermistor or photoresistor.

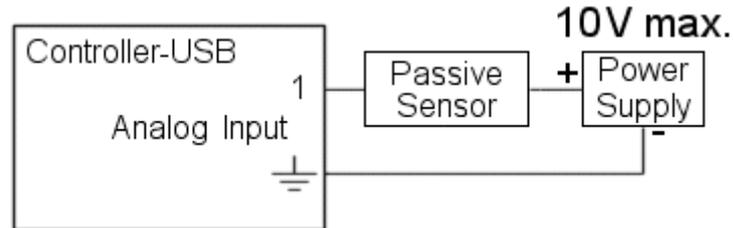


Figure 4-17: Interconnection Scheme: Passive Analog Input

Figure 4-18 shows the interconnection scheme for an electronic analog sensor. Note that the sensor input terminal is not shown, as each electronic sensor has its own design.

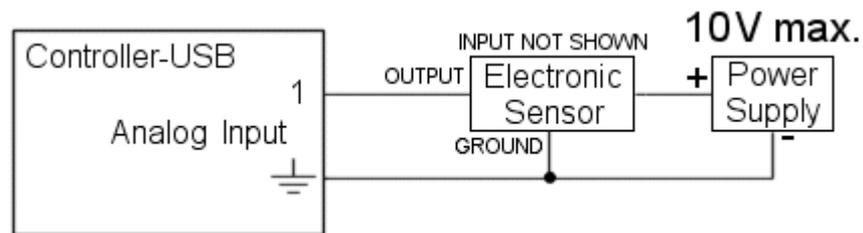


Figure 4-18: Interconnection Scheme: Electronic Analog Input

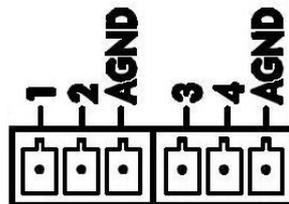


Figure 4-19: Analog Inputs

Notes:

- Before connecting any sensor to any input, make sure Controller USB-Pro is switched off.
- Do not connect voltage exceeding +10 VDC to the analog inputs. Note that this is significantly lower than the limit for digital inputs.
- **Connecting DC power with reversed polarity may damage the electronic circuits and components in Controller USB-Pro and external sensors. Do not connect AC power to any input on Controller USB-Pro.**
- The voltage from 0 to 10 VDC is interpreted as an 8-bit binary number between 0 and 255.
- **Be sure to observe the polarity, and be sure to protect against accidentally providing more than 10V to the analog sensor input.**

5

Controller Components

This chapter describes the main circuit boards in the Controller USB-Pro. The following sections and diagrams describe the most important components on each circuit board. It is recommended that you familiarize yourself with these components. Some of these items may require replacement. The number next to each description indicates the number identifying the item in the accompanying diagram. Jumper and switch configurations are detailed in Appendix A.

1	USB Host connector
2	External Emergency Button Switch connector
3	Teach Pendant connector
4	External I/O Box Blocks A,C connector
5	External I/O Box Blocks B,D connector
6	Robot Encoders Connector
7	Auxiliary Axes 5 and 6 connectors
8	Robot Motors Power Connector
9	Axes Fuses Connectors
10	U1 – MicroController by Atmel [CPU]
11	U84 – Complex Programmable Logic Device by Lattice [CPLD]
12	Digital Power Supply Area
13	Motors Power Elements Area
14	Analog Inputs Connectors
15	Analog Outputs Connector
16	24V User Power Outputs
17	Digital Inputs connectors
18	Output to LED board connector
19	Inputs Sink/Source Selector switches
20	Digital Outputs [Relays, Outputs 1 to 4] Connector
21	Outputs Source/Sink Selector switches
22	Digital Outputs [Open Collector, outputs 5 to 10] Connector
23	Digital Outputs [Open Collector, outputs 11 to 16] Connector
24	Auxiliary Axes 7 and 8 Connectors
25	Front Panel Emergency Button Connector
26	Power Input Connector

LEDs Board

1	Controller State Indicator (BICOLOR)
2	Motors State Indicator (GREEN)
3	Digital Inputs 1 to 8 Indicators (GREEN)
4	Digital Inputs 9 to 16 Indicators (ORANGE)
5	Relay Outputs 1 to 4 Indicators (GREEN)
6	Digital Outputs 5 to 10 Indicators (GREEN)
7	Digital Outputs 11 to 16 Indicators (GREEN)

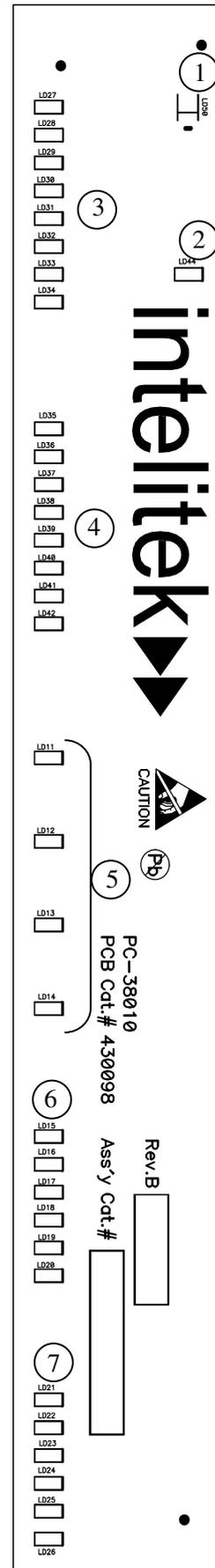


Figure 5-2: Indicators Board

PSU

The PSU is a high efficiency power supply.

Output Power	1000W
Output Voltage	48VDC
Output Current	21A max
Max input current	6A
Protected from	Overvoltage; overcurrent; overtemperature
Fans	2 internal fans operated with variable speed control
Size (W*H*D)	127x41x290mm
Safety standards	UL60950; EN60950



Figure 5-3: PSU

Maintenance

To ensure continued optimum performance of Controller USB-Pro, follow all safety guidelines and warnings and regularly perform the inspection procedure.

Inspection

Perform a routine inspection of your system at the start of every working session, in the following order:

1. Before you power on the system, check the following items:
 - The installation meets all safety standards.
 - The robot is properly secured to the work surface.
 - All cables are properly and securely connected.
Cable connector screws are fastened.
 - Replace any cables that show signs of abrasion or wear.
 - No output is connected directly to a power supply.
 - No people are within the robot's working area.
2. After you have switched on the PC and Controller USB-Pro, check the following items:
 - The bicolor power LED is red when the power is ON, and green when power is ON and the software is online.
 - Green Motors LED is on after Scorbases starts and Control On (CON) is selected.
 - No unusual noises are heard.
 - No unusual vibrations are observed in any of the robot axes.
 - There are no obstacles in the robot's working area.
3. Bring the robot to a position near home, and activate the homing procedure.
Check the following items:
 - Robot movement is normal.
 - No unusual noise is heard when robot joins move.
 - Robot reaches home position in all five axes, gripper and peripheral axes 7 and 8 (if connected), and Homing Complete message appears.

Troubleshooting

This section describes possible Controller problems and suggestions for correcting them. Complete instructions for removing and replacing Controller components are given in the section, “Upgrade and Repair Procedures,” later in this chapter. Refer also to your robot’s User Manual for additional troubleshooting instructions.

Whenever you encounter a malfunction, try to locate the source of the trouble by replacing the suspected faulty component – for example, the Controller, the robot arm, cables – with an identical component from a working system.

Do not open Controller USB-Pro (except to change jumper setting). There are no user-serviceable parts inside. Do not attempt internal repair procedures. Contact your agent or dealer.

The following guidelines outline common symptoms and possible remedy.

1. *Controller USB-Pro power does not turn on.*

The Controller State Indicator on Controller USB-Pro front panel does not light up.

☞ *Disconnect the Power supply.*

- Check the AC power fuse ((12) on Figure 2-1).
- Make sure the AC power matches Controller USB-Pro voltage requirements, as seen on the tag at the back of Controller USB-Pro.
- Verify that Controller USB-Pro power switch is on.
- Make sure AC power is being supplied to the power outlet.
- Make sure the power cable is connected to both the proper power source and Controller USB-Pro.

2. *No communication between Controller USB-Pro and computer.*

Controller State Indicator is red.

1. Make sure the connecting cable is properly connected to Controller USB-Pro and to the computer.
2. Select On-line mode.
3. Exit Scorbace, and restart the program. Activate On-line mode.
4. If the Controller State Indicator is still red, turn the Controller off. After a few seconds, turn the Controller back on and activate On-line mode.
5. If problem persists, replace USB cable.

3. *Controller USB-Pro is in CON state, but robot arm cannot be activated; or one axis fails to respond and an error message is displayed.*

- Refer to the System Messages section of the Scorbace for ER 9Pro/ER 14Pro User Manual.
- Verify that the green Motors LED is lit.
- Make sure an obstacle is not blocking the robot.
- Make sure none of the axes have reached their mechanical limit.
- Make sure the robot cable is properly connected to Controller USB-Pro.
- Disconnect the power cable from the mains, and check the specific fuses for each axis.

4. *The gripper does not respond to open or close commands, or responds incorrectly.*

Servo Gripper:

1. Ensure the gripper's cable is properly connected to the arm.
2. Check the correct gripper has been configured in the Hardware Setup in Scorbace. For details see the Hardware Setup section in the Scorbace for ER 9Pro/ER 14Pro User Manual.

Pneumatic Gripper:

1. Check all the cables are correctly and securely installed.
2. Check the air hoses are correctly and securely installed.
3. Check the air supply.
4. Check the correct gripper has been configured in the Hardware Setup in Scorbace. For details, refer to the Hardware Setup section in the Scorbace for ER 9Pro/ER 14Pro User Manual.

5. *Motor turns constantly in one direction, or responds incorrectly.*

- Make sure the robot cable is properly connected to Controller USB-Pro.
- Change the Controller to COFF state. Manually move each axis separately, whilst checking the encoder counts change in the Encoder Counts dialog bar. For details, refer to the Encoder Counts Dialog Bar section in the Scorbace for ER 9Pro/ER 14Pro User Manual.
- Check the configurations in the Hardware Setup in Scorbace. For details see the Hardware Setup section in the Scorbace for ER 9Pro/ER 14Pro User Manual.
- Turn Controller USB-Pro off. Then turn it on again and select on-line mode.
- If problem persists, contact your agent.

6. *Errors in the accuracy of the robot*

- Run the problematic program in Scorbase, and check whether the problem occurs again.
Check during the program that the Robot does not hit an object.
- A faulty encoder may cause position deviations in one or more of the axes during the running of a program.
- Home the Robot. Teach a new position for one axis in Scorbase. Mark down the position, move the robot and return to the marked position. Repeat this with each axis to check which is the problematic axis.

7. *Controller USB-Pro does not receive an input signal.*

- Check the input indicator is on.
- Check the input wires are correctly and securely installed.
- Check the switch settings (requires opening of the Controller's cover. See page 4-1 for details).

8. *Controller USB-Pro does not issue output signals.*

- Check the output indicator is on.
- Check the output wires are correctly and securely installed.
- Check the switch settings (requires opening of the Controller's cover. See page 4-2 for details).
- Check whether a load has been connected properly.

9. *No communication between the Controller and the Teach Pendant.*

- Make sure the Teach Pendant cable is properly connected to the Teach Pendant and the Controller.
- Do not attempt to open the Teach Pendant. There are no user-servicable parts inside.
- Turn off the Controller. Turn the Controller back on, and activate On-line state.

10. *I/O state indicator does not light up*

- In Scorbase, run a command using the I/O, to check whether the whole I/O is problematic or just the indicator.
- If only one I/O port is problematic, move the device to a different one, and change the program to match the port.

11. *EMERGENCY lamp remains lit even after the EMERGENCY button is released.*

- Check that all other EMERGENCY buttons are not pressed.
Otherwise check the bypass EMERGENCY plugs have been inserted in the Teach Pendant and external EMERGENCY connectors on the back panel

Repair and Upgrade Procedures

Opening the Controller

There are no user-serviceable parts inside. Do not attempt internal repair procedures. Contact your agent or dealer.

You may open Controller USB-Pro only when you need to change I/O switch settings:

1. Disconnect the power supply cable.
2. Release the screws holding the cover of the Controller USB-Pro.
3. Raise the cover gently.

Changing I/O Switch Settings

☞ *Refer to Figure 4-1, Figure 4-2 and Figure 5-1.*

1. Open the Controller, as instructed above.
2. Locate the switches (Inputs (19), Outputs (21) in Figure 5-1) on the Main Board.
3. Change the switch settings.

Fuse Replacement

☞ *Disconnect the power cable from the Controller before replacing a fuse.*

Power Input Fuse ((12) in Figure 2-1):

1. Use a small screwdriver to open the fuse drawer at the back panel of the Controller.
2. Replace the fuse with a suitable fuse.
3. Push the fuse drawer back to its normal position.

Motor Power Fuses ((1) and (2) in Figure 2-1):

1. Turn the Fuse cover to release it.
2. Remove the Fuse from the cover, and replace it with another suitable fuse.
3. Place the cover back in the Controller, and turn it to secure it.

6

Theory of Control

The function of the Controller is to instruct the movements of the robot arm or other devices in the robotic system, to monitor these movements, and to make adjustments automatically in order to correct any errors.

Servo Control

Open Loop Control

In open-loop (non-servo) control, the system does not check whether the actual output (position or velocity) equals the desired output.

In open-loop control systems the Controller output signal (U_r) is determined only by the input signal (r). If the system response is incorrectly predicted, or if the output signal is affected by other factors, deviations from the desired state will occur. Since no feedback exists, the system is unable to correct output errors.

In open loop robotic control, power is applied to the motors according to a predefined program. The path and speed cannot be precisely predicted, since they are determined by the torque and load on the motors, and other environmental factors.

Closed-Loop Control

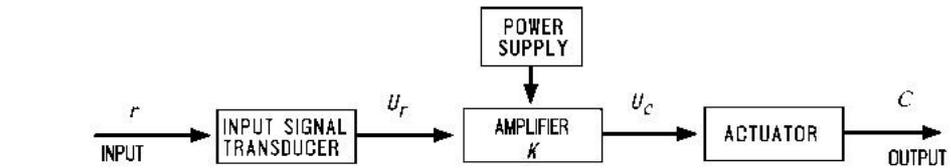
In closed-loop control, the control system measures the output signal (C), compares it with the input (desired) signal (r), and corrects any errors.

Figure 6-1 compares schematic diagrams of open-loop and closed-loop control systems.

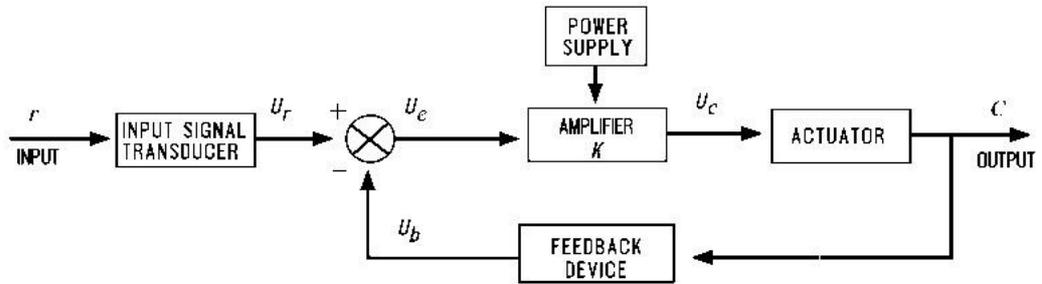
In servo control systems, a feedback device, commonly an optical encoder, measures the output (C) (the amount, speed and direction of motor rotation), converts it to an output signal (U_b), and transmits it to the comparator.

A comparator (\otimes) connects the input and feedback signals, produces an error signal equal to the algebraic difference of its two input signals. The comparator output—the error signal—is denoted here as U_e .

The error signal is the most important value in the closed-loop system. The system aims to reduce U_e to the smallest possible value. When $U_e = 0$, the output signal (the actual state) is equal to the input signal (the desired state).



A - OPEN-LOOP CONTROL



B - CLOSED-LOOP CONTROL

Figure 6-1: Open-Loop and Closed-Loop Control

Digital Control

Unlike analog control systems, in which all signals within the Controller are continuous analog signals, digital control systems are those in which some of the signals within the Controller are discrete digital signals, due to the presence of microprocessors.

In digital control systems, the Controller must be capable of converting between analog and digital signals. For the microprocessor to read an analog signal, the signal must first pass through an Analog to Digital Converter. The ADC samples—that is, reads—the signal at periodic intervals and stores the value for the processor to read. For the microprocessor to transmit an analog signal, it must send the discrete values of the signal to a Digital to Analog Converter. The DAC holds the output continuously until given a new value.

Controllers use microprocessors to calculate the state (position, velocity, etc.) error (e) for each motor and the control signal (U_c) which is sent to the motors to correct the error. The control signal is converted to an analog signal by a DAC and then amplified before driving the motor.

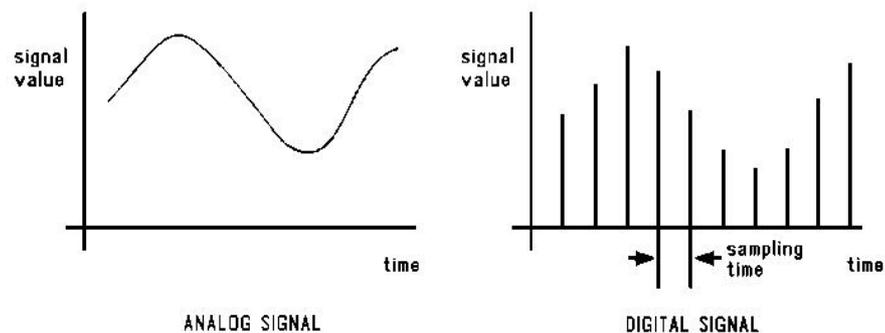


Figure 6-2: Analog and Digital Signals

The feedback device measures the actual state and produces an analog signal. The feedback signal is converted by a ADC so that the processor can read it to compute e .

A digital control system can be programmed to compute any number of control equations. The processor's control program is a continuous loop whose basic steps are as follows:

1. Read desired state from memory.
2. Read actual state from feedback device.
3. Calculate the state error (e).
4. Calculate control signal from control equation.
5. Go back to step 1.

The main difference between digital and analog Controllers is the time delay caused by the processor's computations. This time delay is, in effect, the sampling time of the DAC and of the output control signal it produces. If the processor can complete a loop within a few milliseconds, the sampling time will be rapid, and the digital Controller will produce an output similar to the equivalent analog Controller.

On the other hand, if the processor is slow to make the computations, the Controller will be unaware of fast changes in the feedback signal and the control signal will be based on "old" measurements. The greater the delay, the more the response will oscillate, eventually becoming unstable.

Transient and Steady State Responses

When the desired input signal (r) changes suddenly, the system will react in two phases, as shown in Figure 6-3. The initial reaction to a change in the input signal is called the transient response. The second part of the reaction is known as the steady state response. Once the input signal (r) has remained constant for some time, and the error between the input and output signals has stabilized, the system is said to be in steady state. The transition from transient to steady state is not a cleanly defined break.

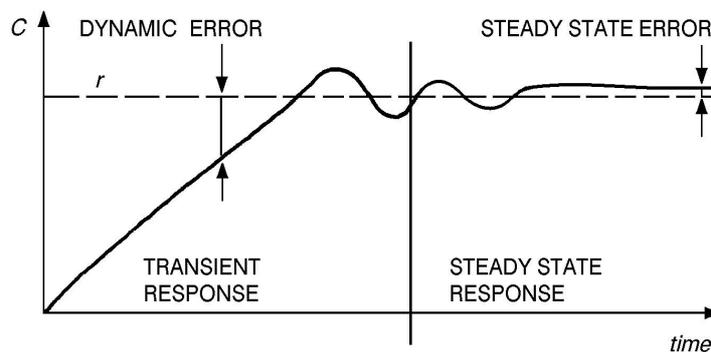


Figure 6-3: Transient and Steady States

This constant error, known as the steady state error, should be reduced as much as possible by the control system.

Increasing the amplitude of the Controller output signal (that is, increasing the Controller gain) can reduce the steady state error and enable a more rapid approach to the steady state value. The greater the Controller gain, the faster the system reacts.

However, excessive gain may lead to a phenomenon called overshoot—a rise in the controlled value to a point above the desired value, followed by a drop below the desired value, repeated several times before stabilization. This, in effect, causes the actual value to oscillate around the desired value. Further increase of the Controller gain may lead to instability of the entire system—that is, uncontrollable oscillation. A control system is damped when it reaches steady state without overshoot. A critically damped response is the fastest approach to steady state without overshooting; an overdamped response is a slow approach to steady state. Figure 6-4 shows different transient responses.

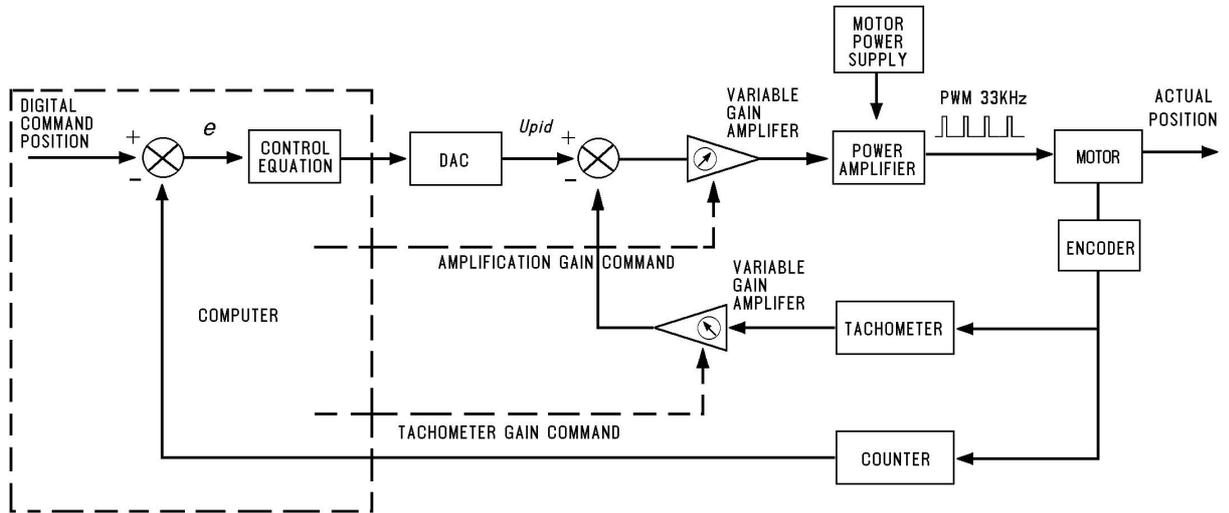


Figure 6-4: Transient State Responses

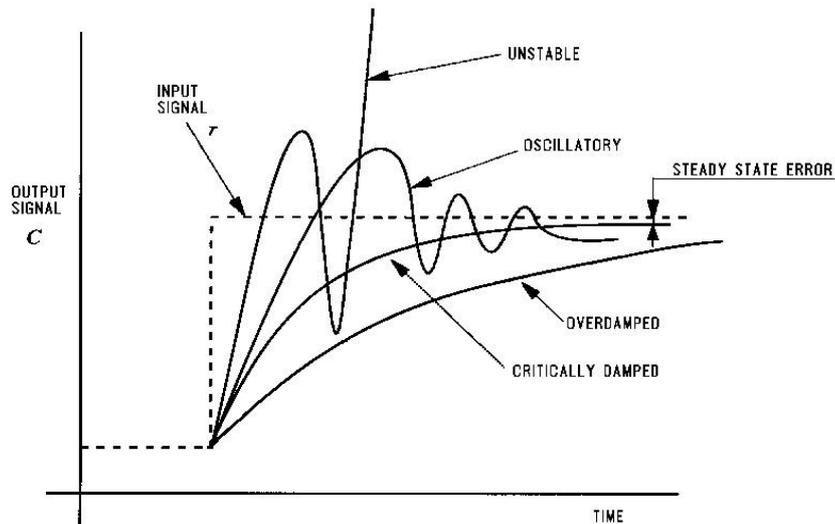


Figure 6-5: Controller USB-Pro Control Loop

Controller Control Process

An example of the basic steps of a Controller control loop are described below. Refer to Figure 6-5. The entire control cycle takes about 10ms.

1. The processor calculates the command position and speed once per cycle. It outputs a digital value to the DAC unit.
2. The DAC unit output is compared to the tachometer output and the difference is amplified to give a PWM output to the motor.
3. The power amplifier drives the motor by switching a voltage to it, in a duty cycle proportional to the output of the gain amplifier. The motor cannot react to this high frequency of switching and is therefore affected by only the average value of the voltage.

This method of controlling the time during which current flows through the motor, rather than controlling the value of the current, is known as PWM (Pulse Width Modulation) control. Refer to Figure 6-6.

4. As the motor rotates, the encoder attached to it produces a number of pulses proportional to the amount of rotation.

Once per cycle the processor reads the encoder pulse count and calculates the motor's position and speed (rate of encoder counts). The processor then compares the actual (output) position and speed values with the desired (input) ones, determines the error values and takes the necessary action to cancel them.

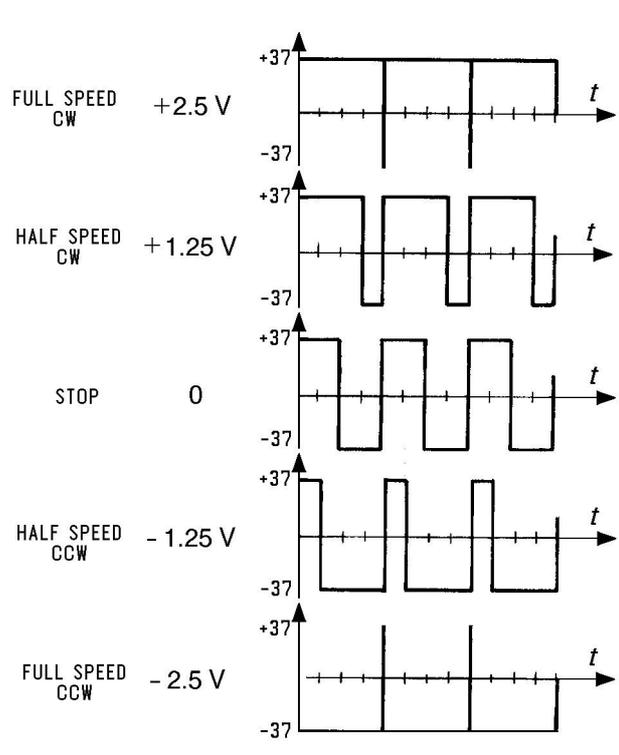


Figure 6-6: Controller Control Signals

Velocity Profiles

The following descriptions of velocity profiles are illustrated in Figure 6-7.

Paraboloid

The paraboloid profile causes the motors to accelerate slowly until maximum speed is reached, then decelerate at the same rate.

Sinusoid

The sinusoid profile causes the motors to accelerate and decelerate quickly at the start and end of movement, with a constant speed along the path.

Trapezoid

The trapezoid profile causes the motors to accelerate quickly until maximum speed is reached, then decelerate at the same rate.

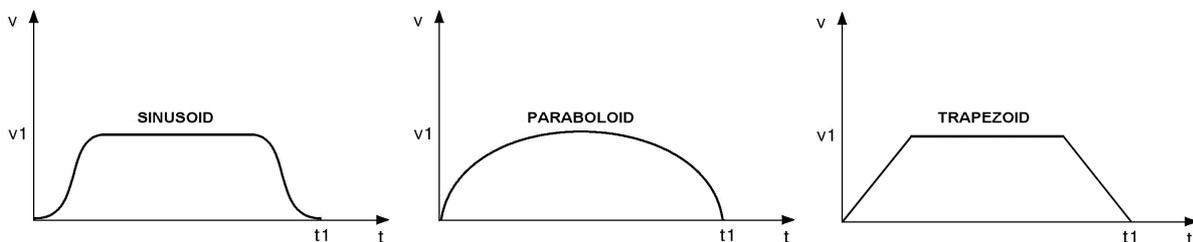


Figure 6-7: Velocity Profiles

Path Control

It is desirable that the path and speed of a robot between taught points be predictable. Ideally, the path between consecutive points is traversed at a constant velocity with defined acceleration and deceleration segments.

Along the path, motion of all joints should be proportional, so that all the joints start and finish moving at the same time. The method of coordinating the movement of the joints so that all joints reach the desired location simultaneously is termed joint interpolation.

Point-to-Point Control

Point-to-point control (PTP) involves the positioning of the robot's end effector at given points, without defining the exact path of the end effector between any two points.

Point-to-point control is suitable for applications which require an exact and static position of the end effector at the points where operations will be performed.

In principle, point-to-point control can be used to guide the robot through a large array of positions, thus resulting in a complex path. In order to obtain such a path, points must be defined and recorded in a very close sequence. The number of positions will be limited, however, by the capacity of the control system to maintain positions in memory.

Continuous Path Control

Continuous path control (CP) involves the movement of the end effector between two points along a path defined by a mathematical formula. This method of control is suitable for applications in which the end effector executes operations along a precise trajectory.

During program execution, the control system calculates and plans the path, and instructs the robot motors to move accordingly.

When continuous path control is required, the processor divides the path into short segments, and interpolates the motion of the joints as frequently as possible. Three type of CP control are possible.

- **Joint Control:** Each axis moves according to the trajectory profile. The gripper path is not defined; only the start and end points are defined. All axes start and stop movement at same time.
- **Linear Path Control:** The axes are coordinated in order to move the TCP (tool center point; tip of the gripper) in a straight line according to the trajectory profile.
- **Circular Path Control:** The axes are coordinated in order to move the TCP along a circular path according to the trajectory profile.

The Control Parameters

In the robotic system, as is common in closed-loop systems, the controlled value (C) is measured by an optical encoder. The encoder signals serve as feedback to the Controller, enabling it to correct any deviations from the desired value.

Since control systems cannot react immediately to the input signal, there will always be a lag between the generation of an error signal and the actual correction of the controlled value.

The PID (proportional, integral, differential) control parameters allow the Controller to adapt to various conditions of operation, such as overcoming nonlinear functions in the system.

Proportional Control

The proportional parameter is the gain of the control system. Its value determines the reaction amplitude to position errors.

When a position error exists (that is, the actual motor position is off by a certain amount of encoder counts), the processor multiplies the error by the proportional parameter and adds the product to the DAC value, thereby reducing the error.

The proportional parameter is the parameter in the PID control system which acts most quickly in reducing the position error, especially during motion. It is also the first parameter to respond to position errors when the robot has stopped at a target position.

The greater the proportional parameter, the faster the system responds and reduces the error. But, using too great a value for the proportional parameter will cause the axis to oscillate.

The main disadvantage of proportional control is that it cannot completely cancel the error, because once it has reduced the error it cannot generate enough power to overcome friction in the system and propel the axis to its target position.

Even in steady state, under load, the controlled value (output signal) will always be different from the desired value (input signal). The steady state error can be reduced by increasing the gain, but this will increase the oscillation and reduce stability.

Differential Control

In differential control, the Controller output (C) is a function of the rate at which the error (Ue) changes. The faster the rate of change of the error, the greater the Controller output (C). In other words, the Controller is sensitive to the slope of the error signal.

The differential parameter is responsible for reducing the speed error. The control system calculates the actual speed once per cycle and compares it to the desired value. While the robot is accelerating (during the first part of path) the differential acts as a driving factor.

While the robot is decelerating (during the second, and last, part of path), the differential acts as a braking factor. A good differential setting will result in a clean and smooth motion along the entire path. Lack of the differential will cause overshoot at the end of path. High differential values will cause small vibrations along the path.

In this control method, the Controller predicts the value of the error in accordance with the error signal slope, and causes the correction to take place in advance.

However, if the error is constant and unchanging, differential control will not be able to reduce the error to zero.

Integral Control

In integral control, all the state errors which have been recorded each cycle are totalled and their sum is multiplied by the integral parameter value.

In integral control, the Controller output (C) reduces the error signal (Ue) to zero at a rate proportional to the size and duration of the error. In other words, the greater the error, the greater the Controller output; and, the longer the duration of the error, the greater the Controller output.

The main advantage of integral control is that the steady state error is always reduced to zero since its value increases each cycle, thus strengthening the control system's ability to react and reduce the error. However, using too great a value for the integral parameter may cause overshoots, while too small a value may prevent the cancellation of a steady state error.

Unlike the proportional parameter, the integral parameter takes effect more slowly and is less noticeable during motion. However, when the axis comes to a complete stop and the proportional parameter can no longer reduce the steady state error, the integral parameter takes over and can cancel the error completely

Proportional–Integral–Differential Control

The PID control method enables optimal exploitation of all three types of control—proportion, integral and differential. In this manner, it creates an output response which follows the input signal closely, without gaps or lags, in both slow and rapid processes, including those in which the load is in a constant state of change. In summary, the PID control parameters serve the following functions:

- Proportional Parameter: Enables fast and powerful reactions of the arm to movement commands. Responsible for the repeatability of the motion.
- Integral Parameter: Assists the proportional parameter in eliminating steady state errors.
- Differential Parameter: Provides the required damping.

Appendix A

Configuration Summary

Table 4: JUMPERS

Board	Jumper	Connection	Description
Main Board	J4	OPEN*	Do not change these settings.
	JP4	OPEN*	
	JP5	OPEN*	
	JP47	OPEN*	
	JP48	CLOSED*	

* Default factory setting.

Table 5: SWITCHES

Board	Switch	Setting	Description	
Main Board	JP24 JP26	SINK*/SOURCE	Output 5	
	JP23 JP25	SINK*/SOURCE	Output 6	
	JP28 JP30	SINK*/SOURCE	Output 7	
	JP27 JP29	SINK*/SOURCE	Output 8	
	JP32 JP34	SINK*/SOURCE	Output 9	
	JP31 JP33	SINK*/SOURCE	Output 10	
	JP35 JP38	SINK*/SOURCE	Output 11	
	JP36 JP37	SINK*/SOURCE	Output 12	
	JP39 JP42	SINK*/SOURCE	Output 13	
	JP40 JP41	SINK*/SOURCE	Output 14	
	JP43 JP46	SINK*/SOURCE	Output 15	
	JP44 JP45	SINK*/SOURCE	Output 16	
		JP8	SOURCE*/SINK	Input 1
		JP7	SOURCE*/SINK	Input 2
		JP10	SOURCE*/SINK	Input 3
		JP9	SOURCE*/SINK	Input 4
		JP12	SOURCE*/SINK	Input 5
		JP11	SOURCE*/SINK	Input 6
		JP14	SOURCE*/SINK	Input 7
		JP13	SOURCE*/SINK	Input 8
		JP16	SOURCE*/SINK	Input 9
		JP15	SOURCE*/SINK	Input 10
		JP18	SOURCE*/SINK	Input 11
		JP17	SOURCE*/SINK	Input 12
		JP20	SOURCE*/SINK	Input 13
		JP19	SOURCE*/SINK	Input 14
		JP22	SOURCE*/SINK	Input 15
		JP21	SOURCE*/SINK	Input 16

* Default factory setting.

Appendix B

Connector Pin Assignments

Table 6: Pinout of I/O Blocks A, C, and B, D Connectors

Pin No.	Signal Name	Pin No.	Signal Name
1	Not Connected	1	Not Connected
2	Not Connected	2	Not Connected
3	+12V User PSU	3	+12V User PSU
4	+12V User PSU	4	+12V User PSU
5	+24V User PSU	5	+24V User PSU
6	+24V User PSU	6	+24V User PSU
7	PSU Common	7	PSU Common
8	+ COM Block C	8	+ COM Block D
9	Output 5	9	Output 11
10	Output 6	10	Output 12
11	Output 7	11	Output 13
12	Output 8	12	Output 14
13	Output 9	13	Output 15
14	Output 10	14	Output 16
15	- COM Block C	15	- COM Block D
16	PSU Common	16	PSU Common
17	+ COM Block A	17	+ COM Block B
18	Input 1	18	Input 9
19	Input 2	19	Input 10
20	Input 3	20	Input 11
21	Input 4	21	Input 12
22	Input 5	22	Input 13
23	Input 6	23	Input 14
24	Input 7	24	Input 15
25	Input 8	25	Input 16
26	- COM Block A	26	- COM Block B
27	PSU Common	27	PSU Common
28	Output 1 NC	28	Output 3 NC
29	Output 1 COM	29	Output 3 COM
30	Output 1 NO	30	Output 3 NO
31	Output 2 NC	31	Output 4 NC
32	Output 2 COM	32	Output 4 COM
33	Output 2 NO	33	Output 4 NO
34	PSU Common	34	PSU Common
35	Not Connected	35	Not Connected
36	Not Connected	36	Not Connected

Table 7: Robot Encoders Connector 37 Pin

Pin No.	Signal
1	+5V
2	+5V
3	GND
4	GND
29	GND
30	GND
37	ENABLE
AXIS 0	
8	COMEN0
5	CHA0
6	CHB0
7	CHC0
31	MSWITCH
AXIS 1	
12	COMEN1
9	CHA1
10	CHB1
11	CHC1
32	MSWITCH
AXIS 2	
16	COMEN2
13	CHA2
14	CHB2
15	CHC2
33	MSWITCH
AXIS 3	
20	COMEN3
17	CHA3
18	CHB3
19	CHC3
34	MSWITCH
AXIS 4	
24	COMEN4
21	CHA4
22	CHB4
23	CHC4
35	MSWITCH
AXIS 5	
28	COMEN5
25	CHA5
26	CHB5
27	CHC5
36	MSWITCH

Table 8: Robot Motors Power Connector 50 Pin.

Pin No.	Signal name
1,2	Motor1_CW
19,20	Motor1_CCW
36,37	Motor2_CW
5,6	Motor2_CCW
23,24	Motor3_CW
40,41	Motor3_CCW
9,10	Motor4_CW
27,28	Motor4_CCW
44,45	Motor5_CW
13,14	Motor5_CCW
31,32	Motor6_CW
48,49	Motor6_CCW
17	GND
50	+24V

Table 9: Auxiliary Motors Connector D9 (Motors 7,8, and 5, 6 on Back Panel).

Pin No.	Signal name
1	Motor CW
2	+5V_Motors
3	Pull-up Resistor
4	Home Switch
5	GND Motors
6	Encoder B Pulse
7	Encoder C Pulse
8	Encoder A Pulse
9	Motor CCW

Table 10: USB Interface Connector

Pin No.	Signal name
1	USB Power (+5V)
2	USB_DN
3	USB_DP
4	GND

Appendix C

System Overview

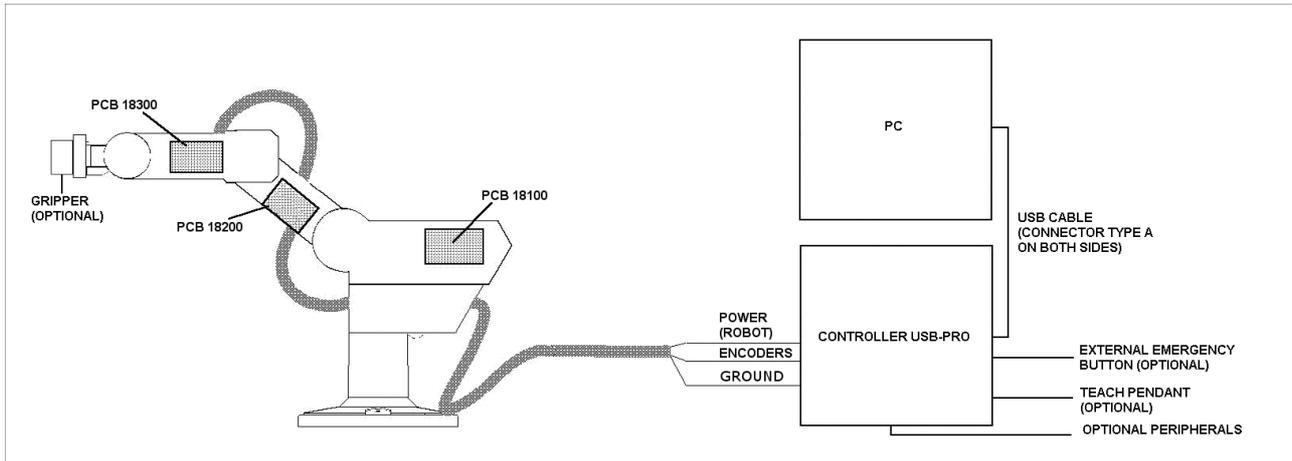


Figure 6-8: System Overview

Figure 6-8 depicts the system overview. The Computer is an integral part of the System. **The Controller will not work if it is not attached to a computer running Scorbace.**

Appendix D

Schematic Diagram

