SkillsUSA
2011 Contest Projects

Robotics and Automation Technology

Click the “Print this Section” button above to automatically print the specifications for this contest. Make sure your printer is turned on before pressing the button.

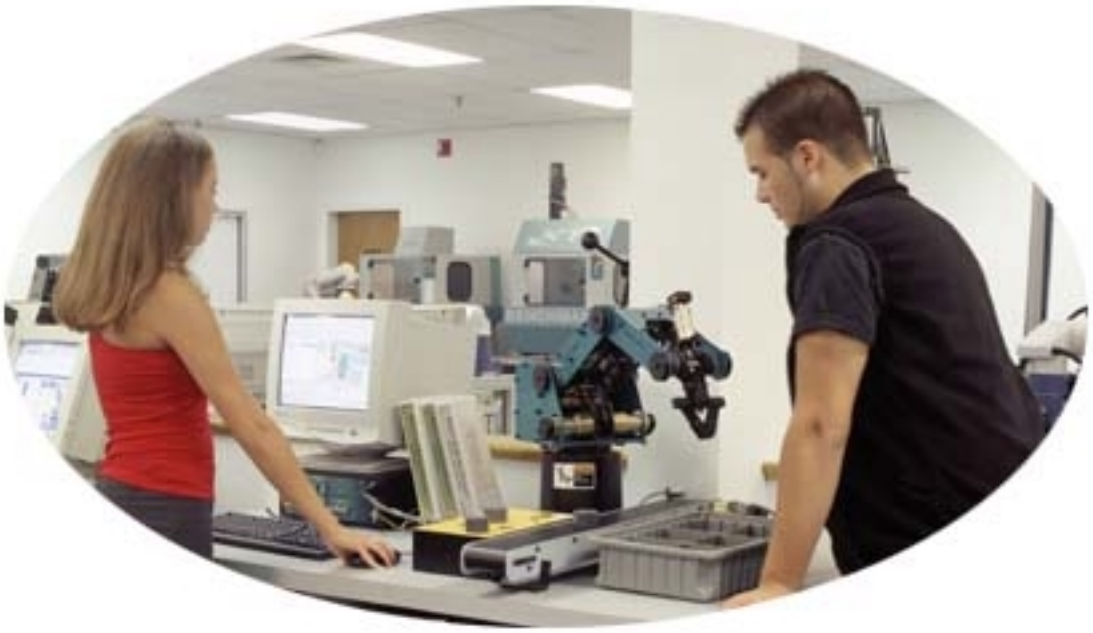
Er-4u Software Er-4u User Manual Scorebase Manual Robocell Manual Sample Contest 2011 Itinerary	**2011 Robotics and Automation Technology**  Robotics and Automation Technology Challenges two-person teams to demonstrate operation of an intelitek ER-4U, 5-axis servo-robot along with a set of sensors and motorized devices to resolve a simulated production process problem. They demonstrate and set-up a robotic workcell from a word problem task. Contestants are required to create a flow chart and sequence of operation. Teams are judged on efficiency, speed and teamwork.

2011 Robotics & Automation Itinerary

6/21/11	Tuesday	8:30 am	Lobby 1500, Conference Center
			(All Contestants and Instructors are required to attend with computers and tooling)
		9:00 am - 9:30 am	Orientation (All Contestants and Instructors)
		9:30 am - 12:30 pm	Group B Practice and warm-up
		12:00 pm - 1:30 pm	Lunch in 2502 A&B, Conference Center (Group A)
		12:30 pm - 1:30 pm	Lunch in 2502 A&B, Conference Center (Group B)
		1:30 pm - 4:30 pm	Group A Practice and warm-up
6/22/11	Wednesday	8:00 am	Group A Meet at Bartle Hall, Conference Center (enter New Ballroom Plaza entrance)
		8:30 am - 12:00 pm	Contest
		12:00 pm - 12:30 pm	Lunch
		12:30 pm – 5:00 pm	Contest cont'd.
6/23/11	Thursday	8:00 am	Group B Meet at Bartle Hall, Conference Center (enter New Ballroom Plaza entrance)
		8:30 am - 12:00 pm	Contest
		12:00 pm - 12:30 pm	Lunch
		12:30 pm – 5:00 pm	Contest cont'd.
6/24/11	Friday	11:00 am – 1:00 pm	Robotics Debriefing, Room 1501A, Bartle Hall
			(All Contestants and Instructors are required to attend)

SAMPLE SKILLS USA CHAMPIONSHIP

ROBOTICS AND AUTOMATION TECHNOLOGY COMPETITION



intelitek

Contents

Introduction

This document describes the Skills USA Championship - Robotics and Automation Technology Competition and includes all the paperwork for that competition. This document may be used as a blueprint for state, regional, or local competition. If you wish help in developing a competition for your state of refine an existing one, please contact Juan Ruiz at intelitek, 1-800-22-12763, ext. 117, for additional information.

Acknowledgments

The success of this competition will be the motivation of the contestants and their instructors, the determined efforts of the National and State Technical Committees, and the generosity of the companies donating equipment and material.

The following are contributors to the Skills USA Championships, Robotics and Automation Technology competition:

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Robotics and Automation Technology Competition

OVERVIEW:

Robotics and Automation encompass a large field of manufacturing technologies. The integration of these processes is making the United States competitive in today's world market. It is essential that the labor force be on the leading edge of current and emerging technologies to maintain industry leadership in these manufacturing processes. With today's complex manufacturing problems, no individual can be an expert in all areas, so it is imperative for manufacturers to mold the necessary skills into a team using their combined resources to resolve problems. Workers in the field of Robotics and Automation have found the team approach to be successful, as it is our hope to emulate industry whenever possible. Therefore, we will use the Team approach in this competition. We suggest a two-person team comprised of a specialist from the following fields: Robot Programmer and Electro-mechanical Integration specialist.

Installing a new, up-to-date system, in a prompt manner is highly beneficial to remain competitive in the industrial market. The ability to change an existing system to a more efficient operation saves time in bringing a new product to market and reduces production time, thus lowering job costs.

Statement of the Problem

Robotics and Automation Inc. has just hired you. You have been teamed up with another new hire and assigned to a project, which involves designing a new production line. Engineering has provided you with a description of the required process and a list of equipment and material available for use in the system you are to design and implement. This task has also been assigned to other newly hired people who are paired into teams. As you may surmise, doing an outstanding job on this assignment could establish your future with Robotics and Automation Inc. Your assigned team number will be your team name.

Quality and production cost is essential in remaining competitive in the manufacturing industry. Therefore, you can be certain that, completeness of your project, elapsed time for you to come on line, cycle time, insight into good implementation techniques, will all be considered in your job performance and evaluation.

Directions

Your assignment is to:

Implementation

Using the description of the process and the provided equipment and material you are to layout your production system and develop a robot program to fulfill the requirement of the task. Complete documentation of the project is required. Documentation is to include: a sketch of the layout and equipment placement, a flow chart of the program, a copy of the robot program, Input and Output assignments, terminal strip assignments and block diagram.

Line updating

Requirements of the project have changed. You are required to update your program and layout to meet the new requirements. Documentation for the updated system must reflect the changes. Cycle time has become an issue, and must be brought to a minimum. Maximum use of programming commands will also be evaluated.

Guidelines

The project manager has provided the base outline of the materials within this document to begin your planning implementation. Your success on this project is based upon the following criteria:

1. Providing complete documentation of the project.
    a. Sketch of layout
    b. Flow chart
    c. Robot program
    d. Input and output assignment
    e. Terminal strip assignment
    f. Wiring block diagram
2. Using the proper technology for the preparation of the documentation
3. Packaging the documentation in an orderly and professional manner
4. Effective use of teamwork in managing the project
5. Safety in the manufacturing process
6. Efficient use of time, material and resources

Team Guidelines

1. Your team is organized for primary responsibilities and duties.
2. There will be a team leader identified to interact with judges.
3. Your breaks are based upon team decisions with the exception of the mandatory lunch break.
4. Breaks are to be taken within assigned individual work areas other than group breaks.
5. Team members must notify a Technical Committee member or a judge before taking a bathroom break. Only one member of a team is permitted to leave at a time and must be accompanied by member of the Courtesy Corp.
6. In case of a software or hardware problem:
7. The team leader will communicate any problem(s) to a judge so that the running time clock may be stopped for that team. In the case of a stopped time clock, all work will stop for the entire team until the problem(s) is resolved.
8. SCORBASEpro for SCORBOT ER 4pc has been provided to you and should be loaded on the provided computer.
9. You must save your final programs to a 3.5" disk, which will be provided. This disk is a part of your project documentation.
10. No more than 8 hours will be allowed to complete the contest. Stopped clock as referenced in item 6 above will be considered.

Official Competition

This is an official Skills USA Championships sanctioned competition. This competition is unique in that it is team oriented linking two technologies and it is extremely hardware and software intensive.

Purpose

To evaluate each school's preparation of students for employment in the emerging arena of robotics and automation and the team approach to the problem-solving work environment and to recognize outstanding performance in the use of new work styles and technology by students and schools.

Sample - **Clothing Requirements** - Refer to current VICA General Regulations.

White work pants (#240), white work shirt (#230), leather shoes (Leather or canvas athletic shoes are not acceptable), and safety glasses with side shields or goggles in designated areas. Prescription glasses can be used only if equipped with side shields. If not, they must be covered with goggles. Refer to VICA General Regulations.

Eligibility

Open to active VICA members enrolled in programs with robotics and Electro-mechanical, automated manufacturing as the occupational objective.

Scope of Contest

Teams of two will demonstrate their ability to perform, exhibit, and compile skills and knowledge necessary from the following list of competencies determined by the Robotics and Automation Technology Skills USA Technical Committee Members.

The team will be provided with a written description of the task requirement and a list of the available equipment and material. The team will develop a system layout and robot program then demonstrate their product. Upon completion of this task they will be provided a requirement to refine their system design and again demonstrate it's functionality.

A. **Perform analysis of task**

1. Evaluate written task
2. Evaluate provided equipment and material
3. Evaluate system revision

B. **Design, Sketch and Plan**

1. Determine sequence of operation
2. Select equipment and material to meet functional need
3. Create Flow Chart
4. Create layout
5. Create Input and Output Assignment
6. Create Terminal Strip Assignment
7. Create Wiring Block Diagram
8. Process system revision

C. **Implement Design**

1. Develop robot program
2. Install equipment
3. Integrate equipment with system controller
4. Modify system to meet revision requirements

D. **System Performance**

1. Perform functional test for total system operation
2. Present system for evaluation
3. Perform functional test to meet revision requirements
4. Present revised system for evaluation

Group Organization and Goals

This is a group competition and all members may interact at will. It is our hope that the competition will run much like industry.

The robot programmer will program the robot and peripheral equipment.

The Electro-mechanical integrator will install the peripheral equipment and integrate it into the system

It is expected that when a team member has spare time they will help the other team member.

It is our hope that one person will not dominate a team. We do not want one person doing all the work while the other team member just assists. Each team member must take an active role in this competition. We have taken this course to promote creativity in organization of production responsibility.

All members are responsible for double-checking each other's work and quality control.

General Information

1. This competition will be accomplished using intelitek's ER 4pc robot, linear slide base, conveyor, and teach pendent.
2. Other equipment and material is from local supply sources.
3. Each team will provide one computer.
4. Teams will consist of two members.

Goals

1. To have every team complete the contest.
2. To have each member demonstrate reading and writing skills.
3. To have each team member use their critical thinking and problem solving abilities.
4. To have each team member illustrate responsibility, teamwork, and self-management skills.

Notebooks

Each team will be issued a notebook and information packet. This will be a three-ring binder that will allow the team to complete the documentation of their assigned task.

Required Materials

The team will require the following equipment and material to complete the competition. The Technical Committee provides most of the required equipment and materials, but the team must also bring certain items.

Robotics and Automation Technical Committee Provides:

Computer	Printer
SCORBOT ER-4pc robot	SCORBASEpro software and manuals
Teach Pendent	Linear Slide Base
Conveyor	Pneumatic parts feeder
Pneumatic press with position sensors	Proximity sensor
Photo sensor	Micro-switches
Template testing station	Template storage area
Templates with programming pins	Wax and Metal blocks
Task assignment	Notebooks
Blank Diskettes	Power strips
Extension cords	Mounting platforms

Teams Provide:

Wire cutters/diagonals 6”		Long nose/needle nose pliers 6”
Screwdrivers (3” to 6” blade length)		Wire Strippers
Common:	1/8”	Safety Glasses (2 pair)
	1/4”	Allen wrenches: 5mm, 3mm, and 7/64”
	3/8”	Multimeter with leads
Phillips:	# 0	Pencils (2) (sharpened)
	# 1	6” or 12” ruler
	# 2	

Hookup wire, 20 – 24 AWG, 4 color minimum, 150’ each color

Watch with second hand or digital counter or stop watch

Points will be deducted for items listed and not provided by the team. (2 points per item)

You will not be permitted to borrow from other contestants

Optional items:

Power screwdriver (w/cross point & common bits) to mount components to platform

Hammer small	Tape measure
Soldering iron (35 watt) with solder	Flow chart template
Electric drill 3/8” with bits	

Other tools will be available.

Do not use a tools box larger than absolutely necessary for your tools.

Suggested Division of duties

Task analysis	Both team members
System layout	Both team members
Robot program	Robot programmer
Equipment placement	Electro-mechanical integration tech
Electrical integration	Electro-mechanical integration tech
System layout sketch	Electro-mechanical integration tech
Program flow chart	Robot programmer
Hard copy of program	Robot programmer
Notebook	Both team members

Safety

The safety aspects are judged in this contest because in the real industrial environment safety is an economic business factor. The welfare of employees is in the best interest of any employer and employee to maintain the effectiveness and competitiveness of the company. Also, the safer a company is in their working environment the more cost effective they become which enables the company to obtain better insurance. In addition, workman compensation fees are reduced if the accident history of a company is good.

If, during this contest, a team or team member violates a safety rule or operates their system in an unsafe condition, the following rule will be in effect.

1st Violation:

Team will be issued a written notice

2nd Violation

Team will have 50 points deducted

3rd Violation

Team will be disqualified

Some safety issues

1. Team members must keep their work area reasonably clean. Clean work places allow efficient and safe working conditions
2. Team members must keep other team members and teams aware of possible dangerous situations, such as: flying debris from wire cutting and stripping and/or noise
3. The Emergency Stop Switch must be depressed when working on an active system other than when an active system is required to accomplish a required part of the task, such as teaching the robot positions.
4. Team members must wear safety glasses when they are in proximity of an operational system or performing tasks that require safety glasses, such as cutting and stripping wire.
5. Overall safety is not limited to the above rules. Unsafe acts or practices will not be tolerated.

Proper safety practices are vital in all stages of this competition. Points will be deducted and/or contest

Robotics and Automation Technology Competition Briefing

1. Welcome to the Robotics and Automation Technology competition briefing. Tuesday you were given an opportunity to setup your system and test the equipment that you will use in this contest. All of your questions should have been answered during the practice session. If you have any further questions please ask them at the end of this briefing.
2. While in the contest work area, please observe all safety precautions, unsafe acts could disqualify you from participating in the contest.
3. If you have questions during the competition, contact a competition official. The official will evaluate your question and determine if it is a question that all teams should hear. If the official deems that all should hear, the response will be given for all to hear. If the answer is in the documentation provided, the question will not be answered. If it is obvious that you should know the answer to the question you are asking there will be no answer.
4. Restroom breaks, contact a contest official and you will be escorted to the restroom, only one person at a time.
5. Breaks, no official break will be given, other than a lunch break.
6. Lunch, box lunches will be served to you in the contest area. All teams will break for lunch at the same time.
7. Do not communicate with anyone other than your team member or a contest official. Communication with anyone other than the above mentioned, shall be grounds for disqualification from the contest.
8. Start the competition when told to do so, and stop when instructed.
9. You will be apprised of time remaining as the contest nears completion.
10. There will be a mandatory debriefing after the final contest is completed, you will be informed when and where, to attend.
11. Any questions?
12. Good luck!

Robotic and Automation Technology Competition Directions

Your team is to assess the following attached task, then determine the layout and positioning of the provided components and develop a robot-controlled program to achieve the desired results.

Task

The task is detailed on the last 2 pages of this section.

Information

The ER4pc robot has been mounted onto the Linear Slide Base in the center of the work platform. This provides a work envelope on either side of the slide base. The controller has been placed on the platform with the fuse block. The Emergency Stop switch is on the rear corner and the Teach Pendent is on the front corner of the platform opposite the controller. The remaining items are to be placed on the platform at your discretion. The choice is yours. Place them for the best implementation of your solution to the task.

Equipment/Material Supplied:

1. Computer
2. ER-4pc robot
3. Teach Pendent
4. Linear Slide Base
5. Conveyor with photo-sensor
6. Electro-Pneumatic Parts Feeder with part in stack sensor and part in place switch
7. Electro-Pneumatic Press with a position sensor
8. 24 Volt DC power supply, mounted with terminal strip and relay
9. Stack lights
10. Templates (2), programmable with pins
11. Template Testing Station
12. Storage area with 4 spaces
13. Sensor station with proximity switch and micro switch
14. Bad parts bin
15. Emergency stop switch

16. Blocks; 8, 2 nonmetallic and 2 metallic with holes and 2 nonmetallic and 2 metallic without holes (the hole is a round hole in the bottom of the block)
17. Template Staging Area overlays (2)
18. Terminal strips (2)
19. E-Stop switch
20. Power strip and extension cord
21. Task assignment
22. Notebook with formatted diskette
23. Mounting platform
24. Networked printer

Evaluation

After your team has made the workcell layouts, developed and tested the program, and are ready for evaluation, call a judge to perform the evaluation. For the judge to evaluate your process, your team will start the program from the beginning. You may be asked to repeat the process.

In the event your program does not meet the task requirements a 5% deduction will be assessed for each attempt.

Documentation

A system that no one other than you can use, troubleshoot or understand how it is designed to work is of little value. Therefore, it is necessary to fully document your system design.

The following items will be given maximum attention in evaluating your system:

1. Does the system function to achieve the assigned task?
2. Is the program remarked to make it easy to follow?
3. Does the system layout match the system layout sketch?
4. Does the flow chart match the hard copy of the program?

Required Documentation

1. Flow Chart of program
2. Sketch of system layout
3. Input and output assignment
4. Terminal strip assignment
5. Wiring block diagram
6. Program on 3.5" disk with Printout

Other Items for Evaluation

1. Were the templates accurately placed on the template overlays?
2. Was the system completed in a timely manner?
3. Is the program efficient?
4. Were safety rules adhered to?
5. Do the Stack Light display proper warnings?
6. Are sensors functional?
7. Neatness and housekeeping.

Initialization

Place the blocks in the parts feeder in a random order. The parts feeder only holds 7 parts. Use assortment of all available blocks. Place the blocks in the feeder with the holes down and the wax blocks with the washer toward the side of the feeder with the yellow 1 and sensor.

Manually configure templates with provided locator pins, 8 per template, to hold 2 blocks each. The pins must define the position for each block individually.

Place programmed templates on the top self of the storage area

Special criteria

Before any robot motion, safety warnings must be given. The Stack Lights will be used to give this warning. Illumination of the appropriate light at the proper time is essential. See Stack Light Uses, page Specs & Doc 1.

As events occur the Stack Lights must illuminate the proper color to depict the event. See list, page Specs & Doc 1 of Stack Light uses.

When parts without holes are gently placed in the bad parts bin this event must be signaled. See list, page Specs & Doc 1 of Stack Light uses.

Bad parts must be counted. The count of bad parts must be displayed with the Print To Log command.

SAMPLE **Task**

You are to develop a non-terminating looping robot controlled program that does the following basic robot motion tasks:

Task description

- Start
- Program checks that all devices are in start-up position.
- Test templates to determine if it is type 1 or type 2.
- Place template in the proper template staging area.
- Check if part is available in the parts feeder stack to be moved or processed.
- Get part from parts feeder and continue as long as parts are available.
- Check part present sensor if part is available for pick up.
- Move part to simulated machining area (pneumatic press).
- Release part.
- Program should actuate air cylinder, allowing the cylinder to fully extend in approximately 4 seconds. After the cylinder is fully extended the air pressure will start to build up on the input port side of the cylinder. Connected to this port is an adjustable pneumatic pressure switch. This switch must be set to trip at approximately 40 psi. When the switch trips, actuates, it must signal the controller that the process is completed and hold the cylinder in the down position for 4 seconds. Then allowing the cylinder to return to the start, retracted, position. The retract action must take approximately 4 seconds.
- Place processed part on end of conveyor opposite photo-sensor.
- Part must travel down conveyor until a sensor senses the part presence and then controller stops.
- Conveyor
- Remove part from conveyor using robot.
- Move part to Sensor test fixture (yellow box).
- Test part for presence of hole.
- If hole is not present it is a bad part, gently place in bad parts bin. Each time a Bad Part is encountered Print to Screen Log the number of bad parts.

- Next, check part to determine if metallic or non-metallic.
- If part is metallic, place on metallic place on template; (type 1 template, magnet on left).
- If part is non-metallic place part on non-metallic template; (type 2 template, magnet on right).
- Continue this looping process until all parts in parts feeder are used..
- After all parts are processed, return loaded templates to their storage area.
- Place type 1 template on the lower left and type 2 templates on the lower right shelf.
- Move robot to perch/home position, extend all axes vertically, signaling the end of a complete cycle.
- Next Print to Screen Log.
- When instructed; manually unload parts from templates, return templates to top shelf and wait for judge to reload parts feeder.

Note 1 You must use the teach pendant to teach, re-teach, jog, or make any other movement of the robot and/or peripheral device.

Note 2 There are other related tasks that are to be performed at various different locations, see documentation.

Note 3 The program shall run as long as there are parts available from the parts feeder, from 1 up to 7 parts.

Note 4 During evaluation phase the judge(s) will randomly load parts feeder.

SAMPLE - **Practice Session Briefing**

1. This is an official Skills USA Championship contest that was approved by National VICA in 1998.
2. While in the work area please observe all safety precautions. Unsafe acts may disqualify you from participating in the actual contest.
3. Today is a practice day for you and your teammate to familiarize your self with the supplied contest equipment. Set up your computer, controller, slide base, conveyor and robot by following the *Instructions for Robot Setup*
4. Note the setup of the workspace at this. When you finish today, leave it in the same condition.
5. You will be introduced to equipment that you will use in the actual contest. You will be given time and necessary help, if needed, to write programs that will test all of the components.
6. The equipment other than the robot, slide bases and teach pendant will not be secured to the platform during this practice session.
7. Practice hours are outlined on the provided agenda.

Instructions for Robot Setup

1. The Robot platforms have been positioned on a table in their desired location. The computer has been set up on the remaining area of the table with the tower on the floor.
2. The Robot, Slide Base, Teach Pendant Stack Light and E-stop switch are fastened to the platform. These are the only pieces of equipment that have a permanent home. The remaining equipment and material will be placed as you see fit to enhance your system setup.
3. The SCORBASEpro software is already loaded on the computer. User's manuals for SCORBASEpro, SCORBOT-ER4pc, Controller-PC and Teach Pendant are available
4. You have been furnished with instructions, data sheets and/or schematics of the supplied equipment. Use the provided literature to determine how to connect the devices correctly.
5. Turn your Computer and Controller OFF. Connect the following: Robot to Controller, Controller to Computer, Slide base to axis 7 on the Controller, and the Conveyor to axis 8 on the Controller.
6. Activate SCORBASEpro software as described in the SCORBASE User's Manual page 6.
7. Insure that SCORBASEpro for SCORBOT-ER 4pc screen is visible.

8. Attach the slide base and Conveyor to the system using the pull-down *Options\Setup\Peripherals* in the SCORBASEpro software. Click on *Options* pull-down. Click on *Setup.* Click on *Peripherals* Select *axis 7*. Select slide base 1 .0 m Belt-drive. Using the same procedure Attach the Conveyor to axis 8 Select Conveyor Belt (gray) 12v. See page 80 in the SCORBASE Users Manual.
9. Home the robot and slide base as described in the User's Manual page 12.
10. The setup is complete.

Setup and Practice

1. Do not proceed unless you have finished the Robot Setup.
2. You will be asked to write simple programs to test the Inputs as you connect equipment to the Inputs. Use the *SCORBASE for Windows* users manual. Have the sensed Input turn on an Output LED. If you need help ask a contest official.
3. Connect the switch on the Sensor Box to the Controller. Connect one wire to the ground terminal on the Input bus and the other wire to one of the Inputs. Actuating the switch should illuminate the LED associated with the Input to which you connected the wire. Write a program that causes an Output LED to illuminate when an Input is detected. Test this Input by actuating the switch. Test all Inputs and Outputs.
4. Connect the Proximity Sensor in the Sensor Box. Look at the Specifications and Documents section of notebook. Connect the signal lead to an Input and the power leads to the 24-volt power supply. Use a piece of plastic/wax to illuminate the LED. Did it illuminate? _____Try a piece of metal. How far from the sensor will the LED stay illuminated?____ Use a ruler to measure the distance.
5. Connect the Emergency Stop switch to the Controller. Use the SCORBOT ER 4pc Users Manual for additional information. Ask a contest Official if you need help. Test the Emergency Stop switch. Depressing the Emergency Stop switch should stop all movement of the Robot and Slide base and the light below the e-stop button on the controller should illuminate.
6. Practice moving the robot and slide base in both the Joint and XYZ modes. Use the mouse, keyboard and teach pendant.
7. Practice teaching the robot and slide base positions using all the available options as in #7 above.

8. Write short programs to verify the positions you have taught. Remember to **SAVE** your work.
9. Connect the Photo-sensor that is attached to the Conveyor. Look at the Specifications and Documents section of notebook. Adjust the sensitivity (if available) so a Block passing the sensor will cause it to activate. Determine where the PINK wire must be attached to obtain the desired results.
10. Write a short program to start and stop the conveyor using the signal from the Photo-sensor. Use both aluminum and wax blocks
11. All Outputs must be wired through the fuse block. The fuse block is already connected to the necessary out put terminals. DO NOT move any of connections or add any wires to these connections. The Common terminal of Outputs 1, 2, 3 & 4 are fused with 1.5 amp fuses. These are relay output and the NC and NO terminals do not require fusing. Outputs 5, 6, 7 & 8 are fused with 500 milliamp fuses. If a fuse blows contact a contest official for a replacement. During the contest you will be provided one extra of each of the fuses (1 – 1.5 amp and 1 – 500 milliamp). If you require additional fuses penalty points will be assessed.
12. Connect the pneumatic Parts Feeder, the solenoid to an Output and the Part present switch to an Input. Connect the Part in Stack sensor to 24 volts DC and Signal to the Signal Conditioner IN on the Sensor Box, connect the Signal Conditioner OUT to an Input. Test both solenoid, sensor and switch.
13. Write a short program to cause the Robot to pick up a part if present and open and close gripper if no part is present.
14. Stack Light; using the documentation determine how the Stack Light is to be wired. In most cases try to use the open collector outputs to control the Stack Lights.
15. Arbor press with position sensors, you will wire up pneumatic lines during contest and use cylinder position sensors
16. Storage pallet part type identification using magnets and test fixture, investigate how it works.
17. Before leaving, configure your workstation to the condition it was when you started.
18. Today is the day to ask questions. If in doubt ask.
19. The drawing of Flowcharts has not been addressed during this session however you will be expected to develop one during the contest.

IF IN DOUBT ASK!

20. Turn OFF your system.
21. If you participate in the contest on Thursday June 28th. Take all of your belongings with you. You may leave your tools in the designated area. You will not be permitted in the contest area Wednesday June 27th.
22. If you participate in the contest on Wednesday June 27th. Leave your tools at your workstation. Leave the workstation neat and orderly as it was when you arrived

Robotics and Automation Contest Scoring

SAMPLE

System Functions According to Task		Points	200		
Number of Attempts	1	Multiplier	1.0		
				TOTAL	200
System Operational Time		Place	1st	Points	20
Cycle Time		Place	1st	Points	20
Program Printout (final program)				Points	60
Template Position Score				Points	10
System Layout Score				Points	20
Flow Chart Score				Points	20
Input/Output Assignment				Points	16
Terminal Strip Assignment				Points	24
Block Diagram				Points	10
Neatness and Professionalism				Points	10
Tool Inventory				Points	20
				TOTAL	430
Safety Deduction					0
				GRAND TOTAL	430

SAMPLE

Robotics and Automation Contest Scoring

Team # _____ **Judge #** _____

Start Time _____ **Operational Time** _____

Cycle Time _____

Points

System Functions According to Task	Points _____		
Number of Attempts _____	Multiplier _____		
		TOTAL	_____
System Operational Time	Place _____	Points	_____
Cycle Time	Place _____	Points	_____
Program Printout (final program)		Points	_____
Template Position Score		Points	_____
System Layout Score		Points	_____
Flow Chart Score		Points	_____
Input/Output Assignment		Points	_____
Terminal Strip Assignment		Points	_____
Block Diagram		Points	_____
Neatness and Professionalism		Points	_____
Tool Inventory		Points	_____
		TOTAL	_____
Safety Deduction			0
		GRAND TOTAL	430

System Functionality Scoring

Team # _____ **Judge #** _____

- Award **10 points** for each of the questions if it can be answered YES.
- Award **0 points** for each of the questions if it can be answered NO.
- No partial credit.

23. Does the Green light come ON for 2 seconds when a good part is identified? Points _____
24. Is Red light ON when program running to indicate an unsafe condition? Points _____
25. Is the Yellow light ON when program not running? Points _____
26. Does the Robot present each Block to the Proximity Sensor? (if it is previously determined that the part is to be disposed of, it is not necessary to present it to the Proximity Sensor) Points _____
27. Does the Robot present each Block to the Hole Sensor? Points _____
28. Does the program select the proper blocks for disposal? Points _____
29. Does the program count bad parts with the print to log as parts are placed in the Bad Parts Bin? Points _____
30. Does the Blue light come ON when signaling a bad part? Points _____
31. Does the program put the metallic blocks on Template #1 and the nonmetallic blocks on Template #2? Points _____
32. Does the program stop when the parts feeder is out of parts? Points _____
33. Is the correct template selected? Points _____
34. Was the teach pendent used for manual movements of the robot? Points _____
35. Does the E-Stop function correctly? Points _____
36. Did team verify wiring? Points _____
37. Were no more than 2 extra fuses used? Points _____
38. Was pressure switch adjusted to trip at approximately 40 psi? Points _____
39. Did it take approximately 4 seconds for the cylinder to extend? Points _____
40. Did the cylinder hold in the down position for approximately 4 seconds? Points _____
41. Did it take approximately 4 seconds for the cylinder to retract? Points _____
42. Was print to log used at end of program? Points _____

TOTAL POINTS _____
(Possible points 200)

Robot Program Scoring

Team # _____ **Judge #** _____

1. A diskette with their program is required, otherwise there would not be a program to print out.
2. If the program performs the assigned task, the program must be OK. It must be evaluated for documentation and any redundant code.
3. Since each program is different, they cannot be evaluated identically.
4. Score the program documentation as follows:

   A. Is the program remarked sufficiently to understand the program flow?

   B. Deduct 6 points from the base score of 60 points for each instance that the program cannot be followed.

   C. Annotate the program with a red pencil for each occurrence.

0 errors	=	60 points
1 error	=	54 points
2 errors	=	48 points
3 errors	=	42 points
4 errors	=	36 points
5 errors	=	30 points
6 errors	=	24 points
7 errors	=	18 points
8 errors	=	12 points
9 errors	=	6 points
10 errors	=	0 points
10 + errors	=	0 points

TOTAL POINTS _____
(Possible points 60)

Template Positioning Scoring

Team # _____ **Judge #** _____

If part is centered on template and not touching the bold line award 10 points

If template touches the inside line award 8 points

If template touches the white area between the lines award 6 points

If template touches the outer line award 4 points

If template touches the white area outside the outer line award 0 points

Template #1 _____

Template #2 _____

Points _____ = _____
Divide by 2

TOTAL POINTS _____
(Maximum points 10)

System Layout Scoring

Team # _____ **Judge #** _____

Draw a sketch of the layout of your system. Use a straight edge. Be neat and legible.

Check the following items for accuracy. Are the items drawn on sketch as physically placed on system?

No partial points. Award either 2 points or 0 points.

1.	Parts Feeder	2 Points _____
2.	Sensor Box	2 Points _____
3.	Conveyor	2 Points _____
4.	Template #1	2 Points _____
5.	Template #2	2 Points _____
6.	Stack Light	2 Points _____
7.	Robot	2 Points _____
8.	Bad Parts Bin	2 Points _____
9.	Emergency Stop Switch	2 Points _____
10.	Was straight edge used for sketch?	2 Points _____

TOTAL POINTS _____
(Possible points 20)

Input and Output Assignment Scoring

Deduct 1 point for each item omitted or incorrectly listed.

If an item is not legible, deduct 1 point.

INPUTS

1. Parts present sensor, part _____
2. Part present switch, part feeder _____
3. Photo sensor, conveyor _____
4. Proximity sensor, box _____
5. Hole switch, box _____
6. Pressure switch, press _____
7. Cylinder up, press _____
8. Template ID switch _____

OUTPUTS

1. Part feeder solenoid _____
2. Cylinder UP _____
3. Cylinder Down _____
4. Red Light _____
5. Yellow Light _____
6. Green Light _____
7. Blue Light _____

TOTAL POINTS _____
(Possible points 16)

Terminal Strip Assignment Scoring

Deduct 1 point for each item omitted or incorrectly listed.
If an item is not legible deduct 1 point.

List Faults:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____
21. _____
22. _____
23. _____
24. _____

TOTAL POINTS _____
(Possible points 24)

Block Diagram Scoring

Does the block diagram accurately depict the system? If not, deduct 1 point for each fault.

List Faults:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

0 errors	=	10 points
1 error	=	9 points
2 errors	=	8 points
3 errors	=	7 points
4 errors	=	6 points
5 errors	=	5 points
6 errors	=	4 points
7 errors	=	3 points
8 errors	=	2 points
9 errors	=	1 points
10 errors	=	0 points

TOTAL POINTS _____
(Possible points 10)

System Operational Time

(Elapsed time for system to be fully operational)

Team # _____ **Judge #** _____

Start Time _____ **Operational Time** _____

Did this team have any official down time? Yes_____ No_____
If so, adjust operational time.

Attempts Multiplier

A team that has a successful run on the first attempt receives a multiplier of 1.0 (100%). Each additional attempt changes he multiplier by a factor of 0.05 (5%).

Number of attempts	1	multiplier	=	1.00
	2		=	0.95
	3		=	0.90
	4		=	0.85
	5		=	0.80

Deduct 0.05 from multiplier for each additional attempt

Multiplier _____

Cycle Time

(Time for system to run complete cycle)

Team # _____ **Judge #** _____

Stop time _____

Start time _____

Run time _____

Inventory of Required Material Team Provides:

Points will be deducted for items listed and not provided by the team. (1 point per item.)

Points may be deducted for tools brought that are not list. (1 point per item.)

Borrowing from other contestants is not permitted.

- Wire cutters/diagonals 3 to 6" _____
- Screwdrivers (3" to 6" blade length)
  - Common 1/8" _____
    - 1/4" _____
    - 3/8" _____
  - Phillips # 0 _____
    - # 1 _____
    - # 2 _____
- Long nose/needle nose pliers 3 to 6" _____
- Wire strippers _____
- Safety glasses (2 pair) _____
- Hookup wire, 20 – 24 AWG, 4 color minimum, 150' each color
  - 1st. color _____
  - 2nd.color _____
  - 3rd. color _____
  - 4th. Color _____
- Allen wrenches
  - 5mm _____
  - 3mm _____
  - 7/64" _____
- Multimeter with leads _____
- Pencils 2 (sharpened) _____
- 6" or 12" ruler _____
- Watch with second hand or digital counter or stop watch _____

TOTAL POINTS _____
(Possible points 20)

Neatness and Professionalism

Score each item YES or NO, 2.5 or 0 points

Over all wiring (neatness)

1. Were tie wraps used? _____
2. Were adhesive hold-downs used? _____

Housekeeping

1. Unused materials removed from Robot work area (tools, equipment, test devices, etc.) _____
2. Trash cleaned from work area? _____
   (wire, insulation, tie wraps, etc) _____

TOTAL POINTS _____
(Possible points 10)

Safety Violation Form

Team # _____ **Date** _____

Warning # _____ **Time** _____

Violation _____

TEAM REPRESENTATIVE _____
SIGNATURE

SAFETY REPRESENTATIVE _____
SIGNATURE

Stack Light Specifications

Stack the lights as follows:

RED	4	TOP
YELLOW	3	
GREEN	2	
BLUE	1	BOTTOM
BASE		

Refer to BULLETIN 855T located in back cover of notebook for:
- Module and Cap Mounting Procedures
- Electrical Connection

Stack Light Uses

RED	ON when the robot workspace is unsafe (see note). When the Robot program is running.
Yellow	ON when the Robot program is not running
Green	ON for 2 seconds when a "Good Part" is identified.
Blue	ON for 2 seconds when a "Bad Part" is identified.

Note: The RED light should be ON whenever the Robot or Slide Base can be moved. Such as when power for the motors is on. With the equipment available this cannot be achieved therefore, the above will have to suffice.

Power Supply (24 volt DC) with Relay and Terminal Strip

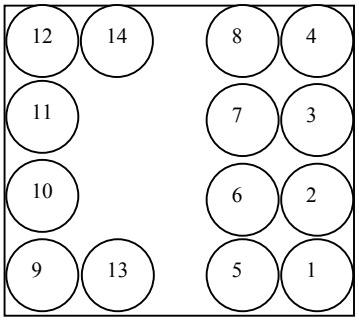
The 24V DC power Supply, Relay and Relay Base, and Terminal Strip are mounted on a base that may be attached to the platform. The Power Supply is pre-wired to the Terminal Strip.

Terminals 1 thru 6 are +24V DC

Terminals 7 thru 12 are –24V DC (ground).

The Relay has a 24V coil and 4 sets of relay contacts each with:

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



RELAY BASE

Section A	1. NO	5. NC	9. C
Section B	2. NO	6. NC	10. C
Section C	3. NO	7. NC	11. C
Section D	4. NO	8. NC	12. C
Coil	13. -24V DC (ground)		
	14. +24V DC		

Sensor Box

1. The Sensor Box contains an Inductive Proximity Sensor, a Micro-switch and a signal conditioner.
2. Terminal strip
   Proximity Sensor:
   1 +24 Volts DC
   2 0 Volts DC (ground)
   3 Signal. The signal goes LOW when the sensor is activated
   Micro-switch:
   4 Common
   5 NC
   6 NO
   Signal Conditioner
   7 Signal IN
   8 Signal OUT
3. If in doubt, ASK a contest official.

Photo-sensor (on conveyor)

The Photo-sensor:

Brown	+24 Volts DC
Blue	0 Volts DC (ground)
Black	Signal. The signal goes LOW when the sensor is activated
Pink	Pink to Brown – Light ON Pink to Blue – Light OFF

Sensitivity is adjustable on some models

Template Testing Station

The Template Testing Station has two Magnetic switches imbedded in the base. One switch is on the right and the other on the left. The switch locations correspond to the magnets attached to the lower side of the Templates. The magnets are behind the white stickers. The Template with the sticker on the left is a type 1 Template and the Template with the sticker on the right is a type 2 Template.

Three wires are connected to the switches, one wire is common (black) to both switches. The other two wires are connected (red to left and green to right) one to each switch. Closing a switch with a magnet provides continuity from the common wire to the wire that is attached to that switch.

Pneumatic Parts Feeder

The parts feeder is an assembled devise that consists of:

Adjustable regulator

Solenoid valve

2-way valves (2)

Valve with roller switch

Double acting cylinder

Double acting cylinder with flow control valves

Part-in-stack detection sensor

Micro-switch.

Theory of operation:

Air from the adjustable regulator via the solenoid is applied to the 2-way valve that is connected to the long cylinder, the valve with the roller switch and the solenoid valve. When 24 volts DC is applied to the solenoid valve, both 2-way valves are actuated causing both cylinders to extend. The flow control valve controls the rate of extension of the long cylinder. The removal of the 24-volt from the solenoid valve allows the long cylinder to retract. The flow control valve controls the rate of retraction. When the plunger on the long cylinder trips the roller switch, the short cylinder is allowed to retract. The part detection sensor senses if a part is present in the feeder stack. The signal provided is approximately 24V DC when the sensor is activated. The micro switch is for detecting if a part is present at that location.

Terminal strip

1.	Red	Normally Open	Micro Switch
2.	Black	Normally Closed	
3.	Green	Common	
4.	Not used		
5.	Not used		
6.	Black	Signal	Sensor (6, 7 & 9)
7.	Blue	Ground	
8.	Black	Ground	Solenoid (8 & 10)
9.	Brown	+24V DC	
10.	Red	+24V DC	

Fuse Block

1, 2, 11 & 12 Black & White, Spare

	Relay Output Common				Open Collector Output		
			Fuse size				Fuse size
3.	1	Brown	1.5 amp	7.	5	Green	500 milliamp
4.	2	Red	1.5 amp	8.	6	Blue	500 milliamp
5.	3	Orange	1.5 amp	9.	7	Violet	500 milliamp
6.	4	Yellow	1.5 amp	10.	8	Gray	500 milliamp

Pneumatic Press with Sensors

The press requires assembling of the pneumatics and consists of:

- Double acting cylinder
- 2-way solenoid valve
- Flow control valves (3)
- Tubing
- Fittings
- Pressure switch, adjustable
- Pressure gage

Theory of operation:

The part press receives its air supply from the system air supply. When 24 volts DC is applied to one of the solenoid valves the cylinder moves to an associated position (extended or retracted) When the 24 volts is removed from that solenoid valve and applied to the other solenoid the cylinder moves to the other position (extended or retracted). A sensor determines if the cylinder is retracted. The sensor is a magnetic switch that closes when an internal portion of the cylinder is in close proximity to the switch. The flow control valves control the rate of extension and/or retraction of the cylinder. A flow control valve determines the rate the pressure is available to the extension side of the cylinder. The adjustable pressure switch may be adjusted to actuate the contacts: common, normally closed, and normally closed at the desired pressure. The pressure gage facilitates determining the air pressure.

Terminal strip

1. Spare
2. Spare
3. Common } Pressure Switch
4. Normally Open
5. Normally Closed
6. White } UP Sensor
7. Black
8. White } Not Used
9. Black
10. To Output } Extend
11. + 24V DC } Solenoid
12. To Output } Retract

Acceptable Flow Chart Symbols

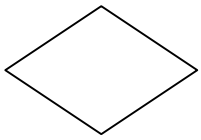
Quite often, when employed by a Company or a Corporation, anything that you produce belongs to them. The corporation owns the patents and copyrights. Therefore, complete documentation is quite essential. You may think that keeping the knowledge to yourself is job security but at some time in your career you could be the recipient of an undocumented system. In this situation you will want all the documentation you can find. Document your work completely.

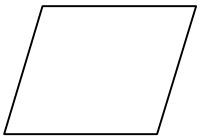
1. The Flow Chart symbols must be the symbols provided on the next page. Straight lines should be drawn with a straight edge. The program must start and stop with a Terminator symbol. Continuations without lines must use Connectors with identifying characters such as (A, b, 1 or 2 etc.). Use these symbols to develop your Flow Chart.
2. The symbols are representative of the required shapes. You may change the size to meet your needs.
3. Use a straight edge to draw the symbols.
4. Be neat. If the judges can't read them they can't score them. Points lost.
5. You Flow Chart and Robot Program must coincide. The Flow Chart/Robot Program scoring will be based on how well you designed your Flow Chart before you started developing your Robot Program.

Flow Chart Symbols

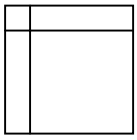

Process


Alternate Process

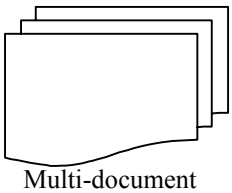

Decision


Data

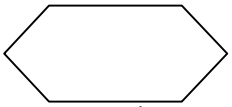

Predefined Process

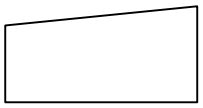

Internal Storage


Document

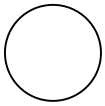

Multi-document

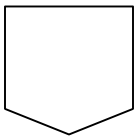

Terminator

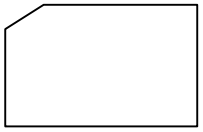

Preparation

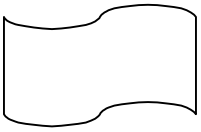

Manual Input

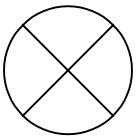

Manual Operation

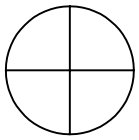

Connector

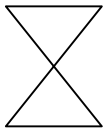

Off-page Connector

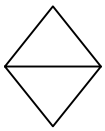

Card

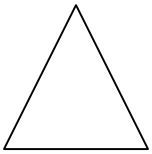

Punched Tape

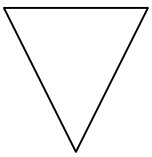

Summing Junction

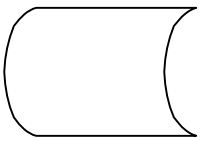

Or

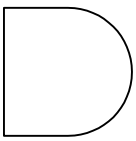

Collate

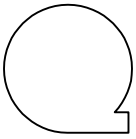

Sort

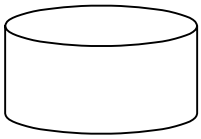

Extract

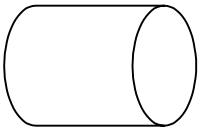

Merge


Stored Data


Delay


Sequential Access Storage


Magnetic Disk


Direct Access Storage


Display

Input and Output Assignment

INPUTS

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

OUTPUTS

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

Terminal Strip Assignment

TERMINAL

Connection to Controller		Connection to Devise
	1.	
	2.	
	3.	
	4.	
	5.	
	6.	
	7.	
	8.	
	9.	
	10.	
	11.	
	12.	
	13.	
	14.	
	15.	
	16	
	17.	
	18.	
	19.	
	20.	
	21.	
	22.	
	23.	
	24.	

Block Diagram

Draw a block diagram of your system. Use a straight edge. Be neat and legible.

Total Points _____

System Layout

Draw a sketch of the layout of your system. Use a straight edge. Be complete, neat and legible. Drawing does not need to be to scale.

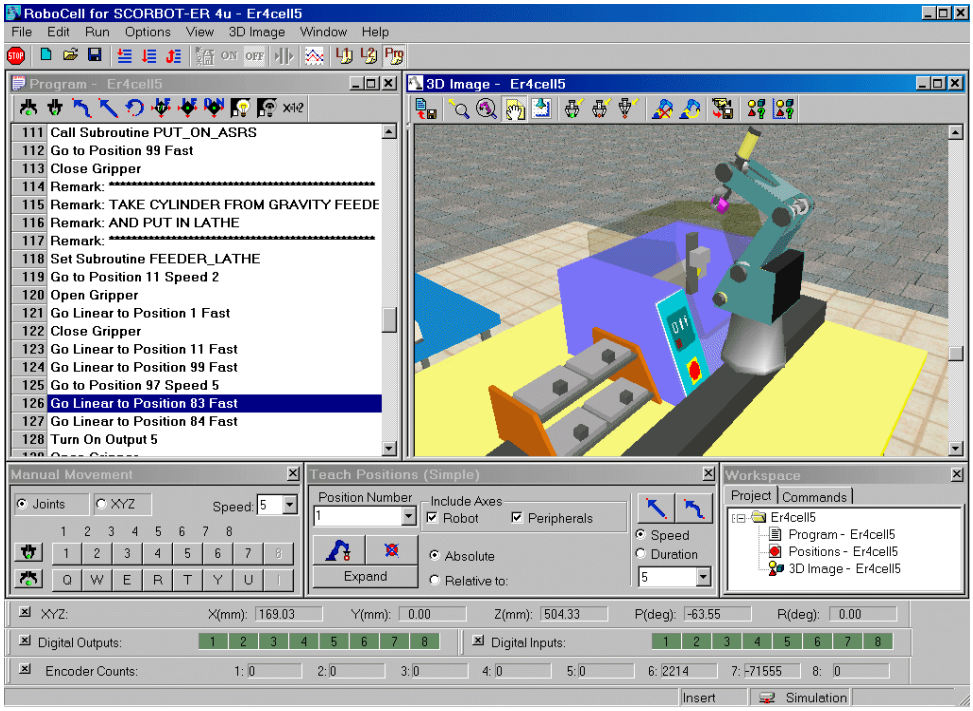
Total Points _____

RoboCell

Version 5.0.1. and higher

for

SCORBOT-ER4u
SCORBOT-ER2u



User Manual

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Table of Contents

1

Introducing RoboCell

RoboCell is a software package that integrates four components:

- SCORBASE, a full-featured robotics control software package, which provides a user-friendly tool for robot programming and operation.
- A Graphic Display module that provides 3D simulation of the robot and other devices in a virtual workcell.
- CellSetup, which allows a user to create a new virtual robotic workcell, or modify an existing workcell.
- 3D Simulation Software Demo to demonstrate RoboCell's capabilities.

This manual covers all features and operation of the Graphic Display and CellSetup modules. It provides support for all current versions of RoboCell.

SCORBASE menus and commands are described in the SCORBASE User Manual.

2

Starting RoboCell

System Requirements

For best performance, the following system is recommended:

- Computer: Minimum - Pentium III PC with 450 MHz processor, or higher, equipped with a CD drive.
- At least 128 MB of RAM.
- A hard drive with at least 60 MB of free disk space.
- Windows 98/2000.
- A Super VGA or better graphics display, minimum 256 colors.
- A mouse or other pointing device.
- USB port, if robot controller is connected.

Software Licensing

The RoboCell software is protected by a licensing agreement. Full details on Intelitek software licensing are provided in Chapter 10.

Installing the Software

The RoboCell software is supplied on a CD which also contains SCORBASE. Close any applications that are open before proceeding with the installation procedures. If you are about to reinstall the software, or install a newer version to an existing RoboCell directory, it is recommended that you back up any existing user-created files before you begin the installation. It is also recommended that you remove the previous RoboCell version for Windows installation using the software's Uninstall utility (see Uninstall later in this section).

To install RoboCell:

- Insert the CD into the CD-ROM drive to start the installation procedure.
- If the procedure does not start, either:
- From the Windows task bar, click Start | Run and type D:Setup (where D: is your CD drive),

  or

- Using Windows Explorer, explore the CD drive and click  Setup.
- Wait until the Installation window is displayed.

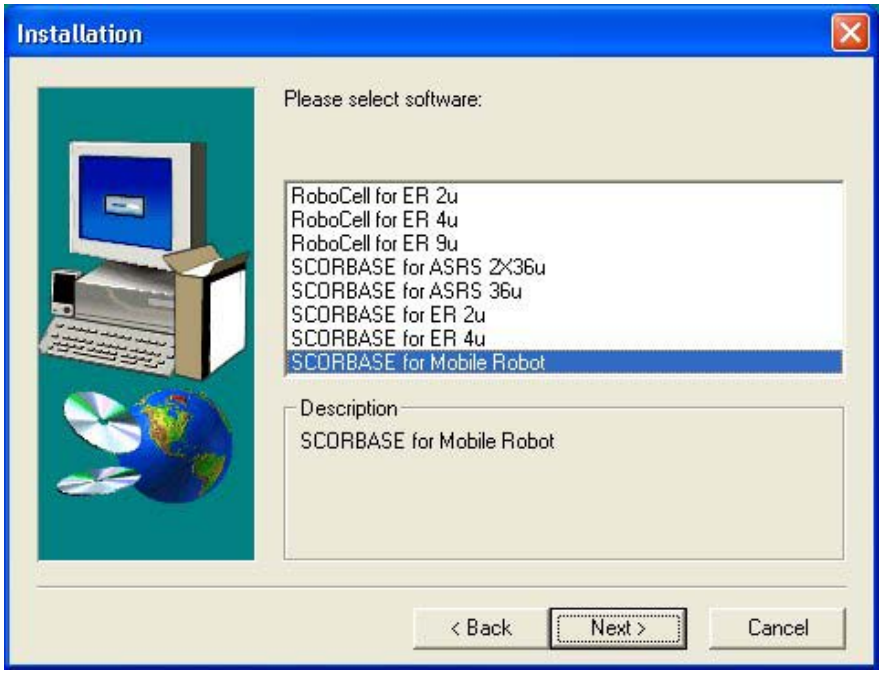


Figure 2-1: Installation Window

- Select RoboCell for ER 2u, RoboCell for ER 4u, SCORBASE for ER 2u or SCORBASE for ER 4u. The robot that you select becomes the default robot while you are working in RoboCell, although you can choose to open a new project and work with the other robot (see Opening CellSetup).
- Click Next to open the User Information window.

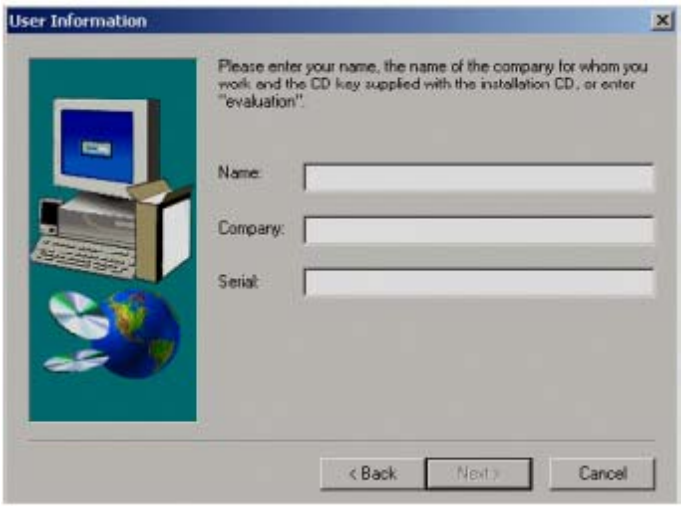


Figure 2-2: User Information Window

- Enter the User Name, Company, and the Serial number printed on the CD. The serial number is made up of 12 characters in the following format: XXXX-XXXX-XXXX. If you are using RoboCell for evaluation, type Evaluation in the Serial field.
- Click Next. The Intelitek Software License window is displayed.

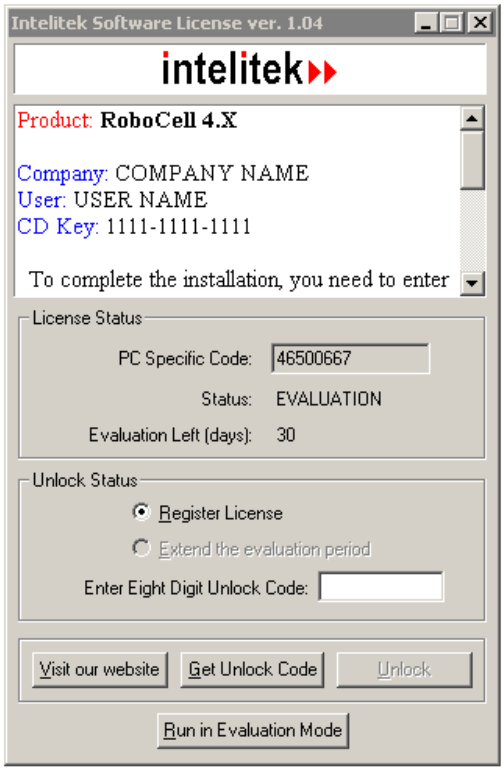


Figure 2-3: Intelitek Software License Window

See Chapter 10 for full details on Intelitek software licensing.

RoboCell Utilities

These utilities are available from the RoboCell group:

- CellSetup
- 3D Simulation Software Demos
- Uninstall

3D Simulation Software Demos

Demonstration files included with the software allow you to observe the capabilities of RoboCell. To run these demo files, do the following:

1. Activate the demos by selecting Start | Programs | RoboCell | 3DSimulation Software Demos. The default demo opens and starts automatically.
2. To view another demo file, select File | Open, or click on the Open icon.
3. Select the desired *.DMO file from those listed in the Open window. The program starts automatically.
4. To stop a demo, select File | Stop.
5. Use the Menu options or Toolbar icons to navigate in the virtual cell. See Chapter 4, CellSetup for full details.
6. To exit the Demos utility, select File | Exit.

Uninstall

To uninstall RoboCell, do the following:

1. From the RoboCell program group, select Uninstall.
2. Follow the instructions which appear on the screen.

Chapter 10, Intelitek Software Licensing, provides full details on the procedures for protecting your license, transfering the license from one PC to another, and returning the license to Intelitek for retrieval at a later stage.

Quitting the Software

To close RoboCell (or its components), do any of the following:

- From the Menu Bar, select File | Exit.
- Click the Close box in the SCORBASE Title Bar.
- Press [Alt]+F4.

3

Graphic Interface

The 3D image you see on your screen is the output of a virtual video camera fitted in the workcell. You can use the mouse to manipulate the image.

The Graphic Display and CellSetup in RoboCell have the same graphic interface.

Rotate

To rotate the scene (move the camera around the center of the image):

- Place the cursor anywhere in the graphic window and click the right mouse button. The cursor changes to a magnifying glass.
- Keep the right mouse button depressed and drag to the right to rotate the scene counterclockwise.
- Similarly, keep the right mouse button depressed and drag to the left to rotate the scene clockwise.

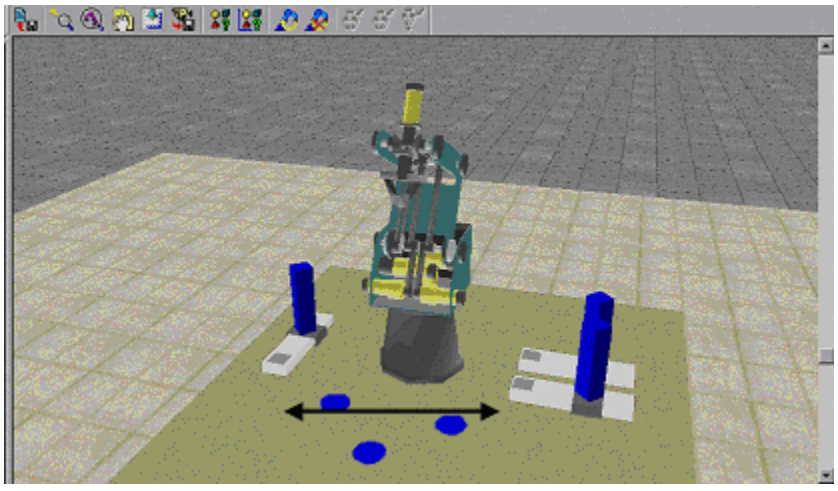


Figure 3-1: Rotating the Scene

The image rotates around its center point. To change the center point, use the Redirect Camera tool (see View Menu on page 17).

Zoom

To zoom in or out:

- Place the cursor anywhere in the graphic window and click the right mouse button. The cursor changes to a magnifying glass.
- Drag up to zoom in.
- Drag down to zoom out.

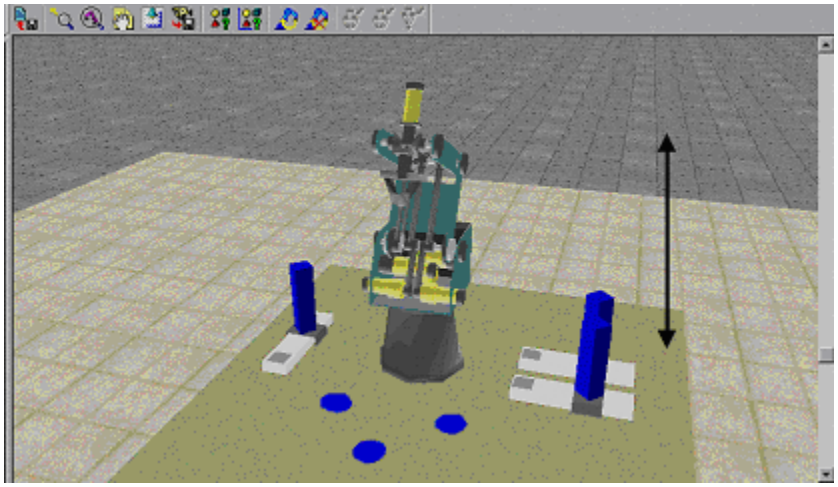


Figure 3-2: Zooming with Camera

The image zooms in and out while its center point remains fixed. To change the center point, use the Redirect Camera tool (see View Menu on page 17).

Angle

To change the angle of the overhead scene (to move the camera up or down), place the cursor on the vertical scroll bar and drag it up or down.

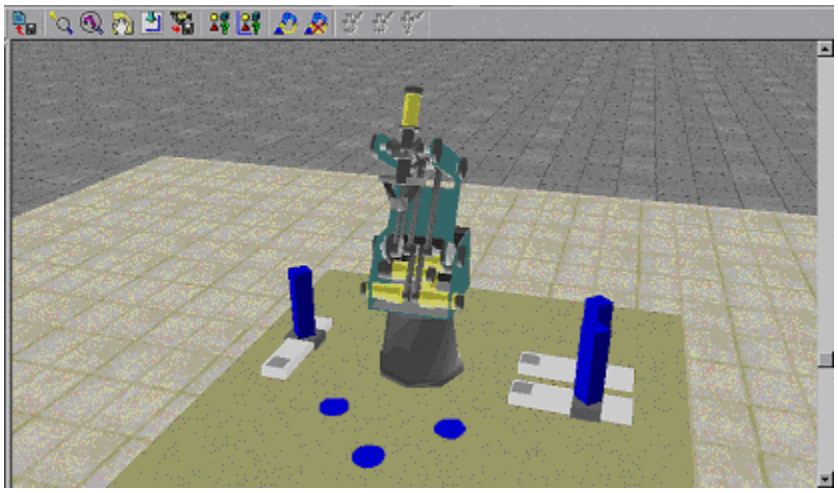


Figure 3-3: Changing Camera Angle

The camera moves up or down while the center point of the image remains fixed. To change the center point, use the Redirect Camera tool (see View Menu on page 17).

Brightness

To change cell illumination (bright or dark), click the right mouse button and drag in any direction, while holding down [Ctrl]. The cursor changes to a light bulb.

4

CellSetup

CellSetup allows you to create a new virtual workcell, or modify an existing one. A workcell created using CellSetup can be theoretical or a replica of actual robotic installations.

After creating a workcell, you can open it in RoboCell, where you can define positions, write programs and run them. If a controller and a robot are connected to your computer, you can switch RoboCell to On-Line, and run the virtual robot in the virtual cell, together with the real robot in the real cell.

Opening CellSetup

To open CellSetup:

- Select Start | Programs | RoboCell | CellSetup. After initialization, the following screen appears:

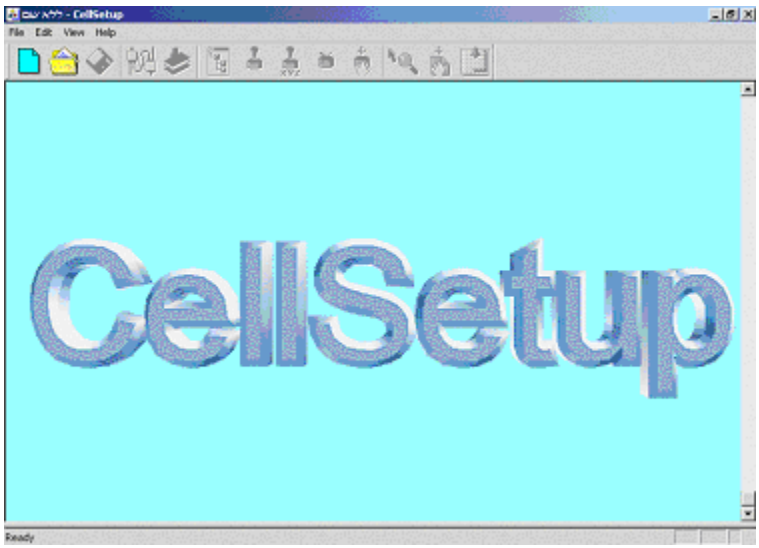
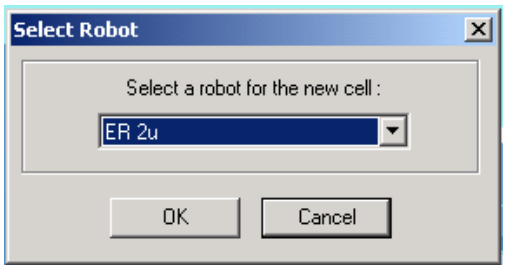


Figure 4-1: CellSetup Opening Screen

- Select File | New to create a new workcell. At this stage you can choose to work with either the default robot that you selected during installation or another robot.



- If you want to open an existing workcell, select File | Open from the Opening Screen. For further details, see File Menu below.
- If you are working in RoboCell and you want to modify the current workcell you are using, select File | Edit 3D Model. CellSetup opens with your current workcell. At this point, you cannot open another cell, therefore the New and Open options are not available. When you exit CellSetup after having completed your modifications, you will return to RoboCell where the newly edited cell will be displayed. For further information, see Chapter 5, Working in RoboCell.

CellSetup Window

Figure 4-2 shows an existing workcell in the CellSetup window. The window comprises:

- A Menu Bar containing all command menus and options.
- A Toolbar containing icons for the most commonly used options.
- Working area containing the workcell objects.
- A Status Bar displaying RoboCell status messages.

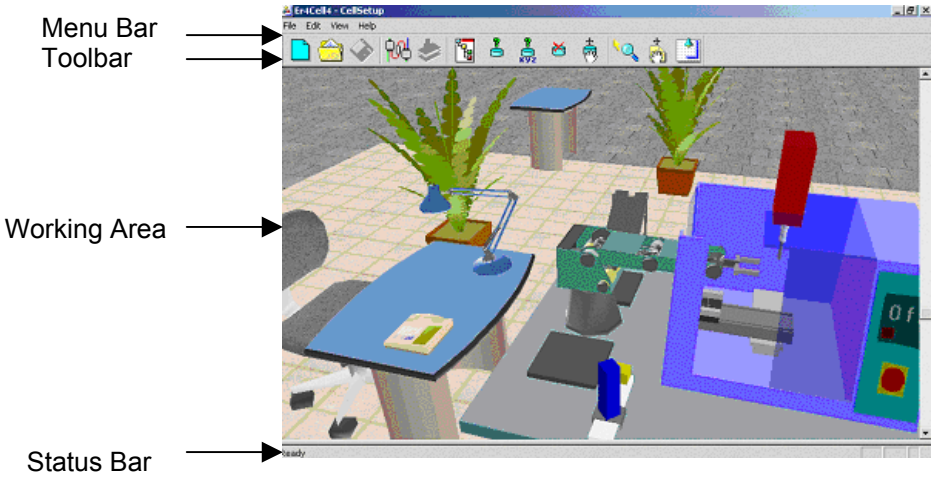
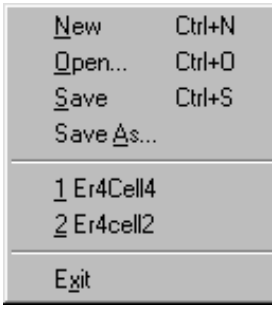


Figure 4-2: CellSetup Window

File Menu



Cell data is stored in a *.3DC file. The File menu contains the usual Windows functions that allow you to load and save 3DC files, and to exit the software.

In addition, you can open the most-recently opened workcell files from this menu.

***Note**: Only one workcell file can be opened at a time.*

New	After you select the robot that you want to work with (either ER 4u or ER 2u), opens a new, untitled, CellSetup file, and opens the New Object menu. This icon and menu option are available only if CellSetup is opened from the Programs menu.

Open	The Open dialog box appears. You can open an existing CellSetup file (e.g., robo1.3DC). The cell defined in the file is displayed and the New Objects menu opens. This icon and menu option are available only if CellSetup is opened from the Programs menu.

Save	Saves the current placement of all objects in the cell to a CellSetup file. Default file extension is 3DC.
Save As…	Saves the currently active CellSetup file under a new file name. ***Note**: Peripheral axes are redefined (through the robot's properties menu) in the new file created by the Save As operation.*
Print 3D Image	Prints the currently displayed 3D image.
Print Preview 3D Image	Opens a dialog window that shows how the printed cell will appear on paper.
Exit	Closes CellSetup.

Edit Menu

The Edit menu contains functions that allow you to add new objects, delete and relocate objects and drag them (change their position in the cell). Through this menu you can also set the floor size and cell textures.

New Object

Opens/closes the New Object menu. From this menu you can select objects to add to the cell. For detailed information, see New Objects Menu.

Delete Object

Activates the delete mode in order to delete an object from the cell.

Using the cursor, point and click on the object you want to delete. Click Yes to confirm the deletion. If you click No, the delete mode remains in effect, allowing you to select and delete another object.

Press [Esc] to cancel the delete mode.

Drag Object

Activates the drag mode in order to relocate an object in the cell.

Using the cursor, point and click on the object you want to relocate and drag it to its new position. The drag mode remains in effect until you select another option or press [Esc].

Floor Size

Opens the Set Floor Size dialog box where you can set the X and Y dimensions of the cell. Click OK to confirm the new size or Cancel to close the dialog box.

Set Texture

Opens a sub-menu listing cell textures: floor, land and background. Select the desired .bmp file for the specified texture.

View Menu

The View menu enables control of the position and name labels, and the virtual camera position. Through this menu you can toggle the display of the Toolbar and Status Bar.

Controller Setup

The robot controller has eight digital input and eight digital output connections. Certain objects that are placed in the cell have a predefined number of input and/or output positions at which they can be connected to the controller. For further information, see the section describing each specific object in New Objects Menu below.

In addition, peripheral devices can be connected to axes 7 and 8 of the controller (see Robot Configuration and

Peripheral Axes below).

Through the Controller Setup dialog box (see Figure 4-3) you can view the defined objects and modify their input, output and axes connections under the appropriate tab.

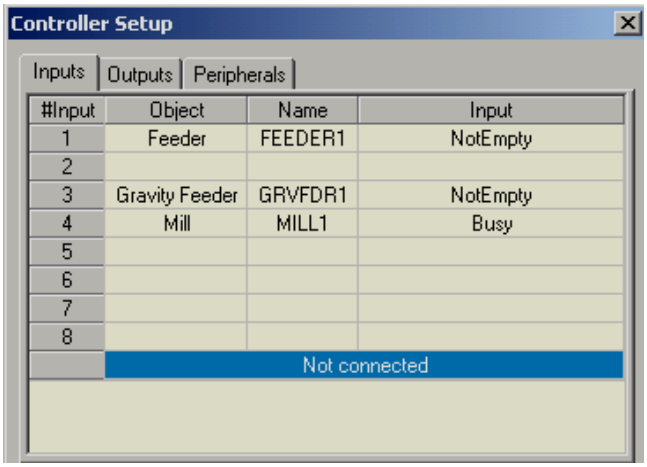


Figure 4-3: Controller Setup

Devices that have not yet been connected are listed under Not connected.

To connect a non-connected device, click on the device and drag it to a free input/output/axis. A plus (+) sign appears next to the cursor.

To modify an existing connection, drag the input/output/peripheral to a new setting. A swap sign appears next to the cursor. If you drag the device to a setting that already has a connected device, the new device replaces the previous device which is disconnected and relocated under Not connected.

To disconnect input/output/peripheral, drag the object to the Not connected list. A minus (-) sign appears next to the cursor.

Show Names

Shows/hides the Object Name labels (see Figure 4-4). When you select this option, a label on each object shows its name. Names are assigned by the software but can be renamed by the user in the object's properties menu.

This option cannot be selected together with Show Positions.

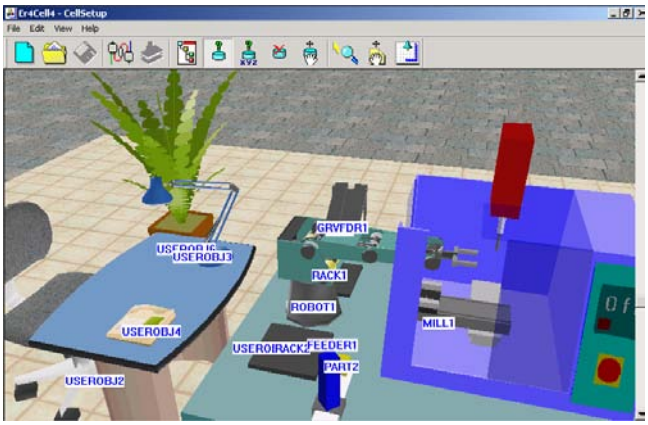


Figure 4-4: Show Object Names

Show Positions

Shows/hides the Object Position labels (see Figure 4-5). When you select this option, a label on each object shows its position. The coordinates that appear on the object's label indicate the object's position (X, Y coordinates) relative to the cell's point of origin.

This option cannot be selected together with Show Names.

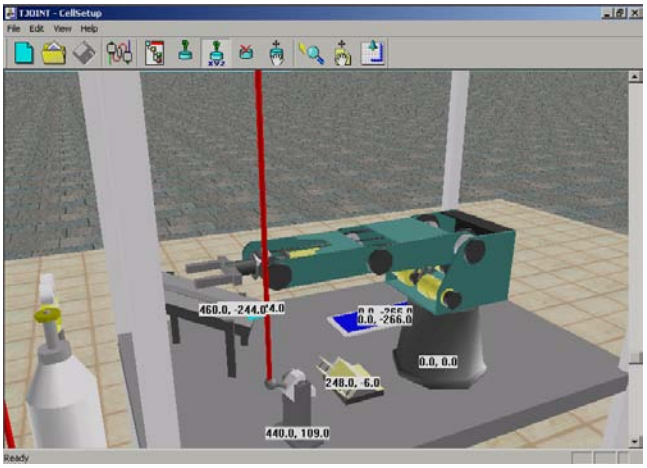


Figure 4-5: Show Object Positions

Redirect Camera

Allows you to select a different focal point in the graphic display of the cell.

To change the center point of the graphic display window, click on the icon or menu option. Use the cursor to point and click on any spot in the scene. This now becomes the new center point of the display. All zooming of the

view will focus on this point; all rotations will revolve around this point.

Press [Esc] to cancel the Redirect Camera mode.

Drag 3D Frame	Activates the drag mode in order to relocate the entire cell in a new position. Click anywhere in the image and drag the entire cell to a new position. The drag mode remains in effect until you select another option or press [Esc].

Camera Top	Resets camera position to display an overhead view of the cell. You can rotate or zoom in/out of this view. Use the vertical scroll bar to alter the angle of the view.
Scene Origin	Shows the origin of the cell at floor level (under the center of the robot's base) as a red cross marked with X and Y axes. The positions of all objects are defined as relative to this point of origin. When manipulating the graphic display, the cross may disappear momentarily. Rotating the view does not change the X and Y dimensions of the cell.
Toolbar	Shows/hides the Toolbar.
Status Bar	Shows/hides the Status bar.

Help Menu

RoboCell Help	Opens RoboCell on-line help.
About	Shows the RoboCell software version.
Registration	Opens the Software License Window for registration, and for transferring RoboCell license to another computer. (See Chapter 10 for further information.)

Objects

Object Placement

To place a new object in the cell, do the following:

1. Double click on the object's name in the New Objects menu.
2. Move the cursor into the graphic scene.
3. Point and click on the location where you want to place the object. You may need to wait a moment for it to appear; *do not double click.*

If you have trouble placing an object in the exact spot you want, zoom in and out, and adjust the view from top to bottom until you can more accurately place the object.

Most objects are placed in the cell automatically at table level. These objects will appear to float in space unless a table has also been placed in the cell.

The height of some objects (template, jig, cylinder and cube) is determined at the time they are placed in the cell.

If, for example, you click on the conveyor when placing a cube in the scene, the cube will be placed on the conveyor at the proper height.

It is recommended that a table be placed in the cell before any of these four objects is added to the cell. Otherwise, these objects may be set on the cell floor and are hidden when a table is added.

Once an object's height is set, it cannot be changed in CellSetup. For example, you cannot move the cube from the table onto the conveyor. Moving an object whose height has been set will cause it to float in space or penetrate another object. If the setup is saved with a floating object, the object will fall to the surface below it when the file is loaded in RoboCell.

To change an object's height in CellSetup, you must delete the object and create a new one.

To move an object, simply click on it and drag it to another position. Or use the object's properties menu to set precise position coordinates.

The robot cannot be dragged to another position. Its position can be changed only by means of its properties menu.

Object Configuration

Selecting some of the objects from the New Object list will open a configuration dialog box for defining the object's permanent attributes (such as size and color). Attributes must be set before an object can be placed in a cell.

An object's configuration cannot be changed once the object has been placed in the cell. You must delete the original object, and select and configure the object again from the New Object list.

Objects that have configuration options are described later in this section.

Object Properties Menu

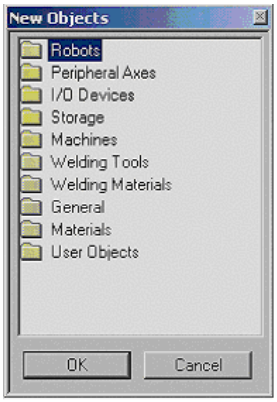
Double clicking on an object that has already been placed in the cell opens the Object Properties menu.

Object properties can be changed at any time during cell setup.

All Object Properties menus contain the object's name and the following options. Some objects have additional properties which are described in the individual sections.

Rename	Every object is automatically assigned a name and a number when it is placed in the cell. This name is displayed in the object's properties menu. The number indicates the order in which objects of the same type were added to the cell (e.g., FEEDER1, GFEEDER2). Clicking on Rename opens a dialog box that allows you to change the name of the object. The number can be changed or deleted.
Rotate	Objects can be rotated to any degree, in the minus (clockwise) or plus (counterclockwise) direction. Clicking on Rotate opens a dialog box that allows you to change the object's orientation. The degree of rotation is always defined relative to the object's default (predefined) orientation.
Position	The cell has a point of origin at table level defined by XY coordinates (0,0). All object positions are defined in XY coordinates relative to this point of origin. For most objects these XY coordinates indicate the center of the object's base. By default, the robot is placed in the cell with the center of its base (i.e., the robot's point of origin) at the cell's point of origin. Clicking on Set Position opens a dialog box that allows you to change an object's X and/or Y coordinates.
Show Text	Shows/hides the label for the selected object. This option can only be activated when View | Object Names or View | Object Positions is selected.

New Objects Menu



New objects are added to the cell using the New Objects menu. The objects are arranged in groups (robots, peripheral axes, etc.).

To add a new object to the cell, click on the desired object group (folder) and then select the specific object. The groups are detailed below.

Robots

The robot, which is automatically placed at the cell's point of origin, should be the first object you place in the cell.

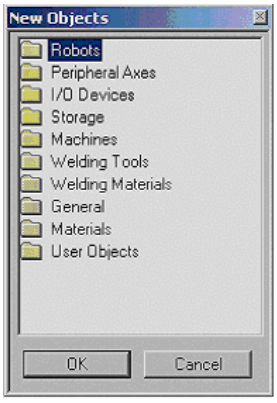
The robot cannot be dragged to a new location. Its position can be changed only by means of the robot's Properties menu (see Object Properties Menu).

Only one robot can be placed in the cell.

To add a robot to the cell:

- Click Robots. Select either ER 4u or ER 2u.

Robot Configuration



A dialog box titled ROBOT1 opens allowing you to define whether or not the robot is mounted on a linear slidebase (LSB), a peripheral device that enables linear movements of the robot unit.

By default, the robot has No Slidebase and when you confirm this option, the robot is immediately placed in the cell.

Alternatively, these slidebase options are available:

- Slidebase 1.0 m, belt drive
- Slidebase 1.8 m, belt drive

If you select a slidebase, the Robot Configuration dialog box looks like this:

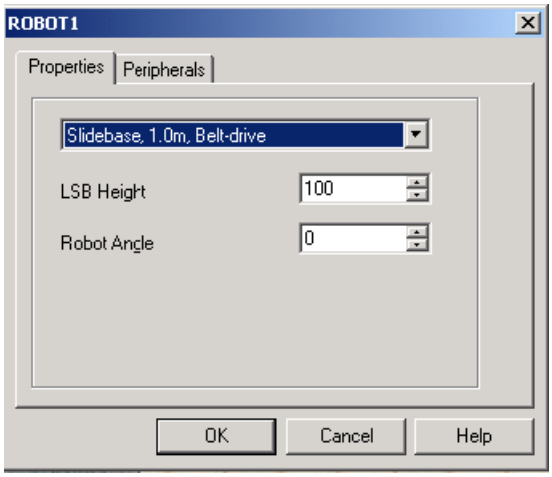


Figure 4-6: Robot Configuration

Properties tab:

LSB Height	By default, the LSB Height is 100 mm, which is the actual height of standard SCORBOT slidebases.
Robot Angle	By default, the robot is mounted perpendicular to the slidebase at 90º.

If you select a slidebase, the robot and the slidebase are treated as one object in the cell.

Peripherals tab:

To select a controller peripheral axis that controls the slidebase (and any other peripheral device that has already been defined), click on the Peripherals tab.

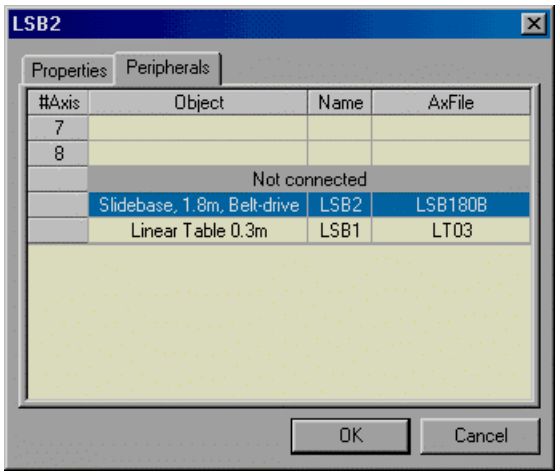


Figure 4-7: Axis Selection for Peripherals

Peripheral devices can be connected either to axis 7 or to axis 8. To connect a device listed under Not connected, click on it and drag it to one of the free controller axes. If you drag the device to an axis that already has a connected device, the new device replaces the previous device which is disconnected and relocated under Not connected.

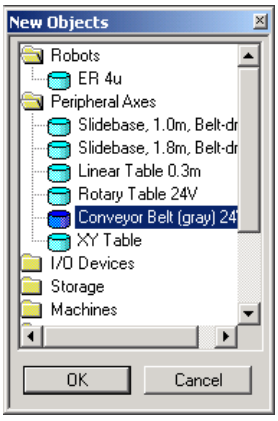
You can leave the slidebase not connected at this stage and connect it later using View | Controller Setup, or the Controller Setup icon.

Robot Properties

In addition to the standard object properties (see Object Properties Menu above), this option is listed as a Robot property:

Show Envelope	Displays the span of the robot's working range. This option facilitates the placing of objects within the reach of the robot.

Peripheral Axes



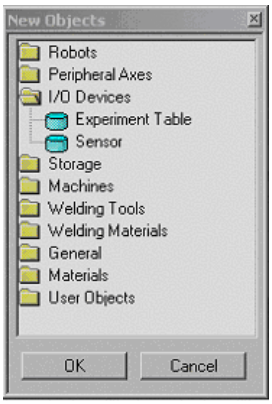
Peripheral devices include a motor with speed and position control. They are connected as axis 7 or axis 8 of the controller.

To place a peripheral device in the cell, click Peripheral Axes and select the required device.

If you select either of the slidebases or a linear table, you will be asked to define the LSB Height as described in Robot Configuration, Properties tab, above.

For all devices you have the opportunity of allocating the controller axis at this stage (see Robot Configuration, Peripherals tab, above).

I/O Devices



RoboCell I/O (input/output) devices can be connected to any free input/output terminal. The robot controller has eight digital input and eight digital output connections.

To place an I/O device in the cell, click the I/O Devices group and select the required device.

Experiment Table

An experiment table includes the following input and output devices:

- Four (4) touch sensors – (input device). Activated when there is a part on the switch, or something activates the switch.
- Lamp – (output device).
- Buzzer – (output device).

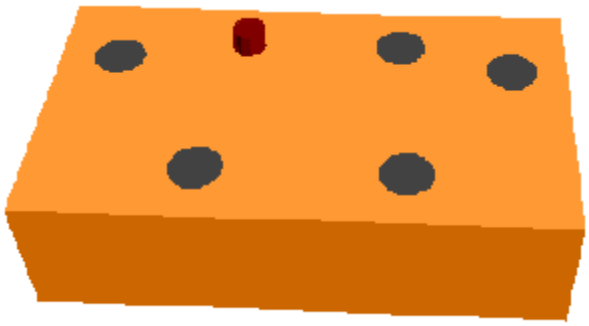


Figure 4-8: Input/Output Devices

When you select Experiment Table, this dialog box opens enabling you to define the input and output connections (see the Controller Setup option under View Menu):

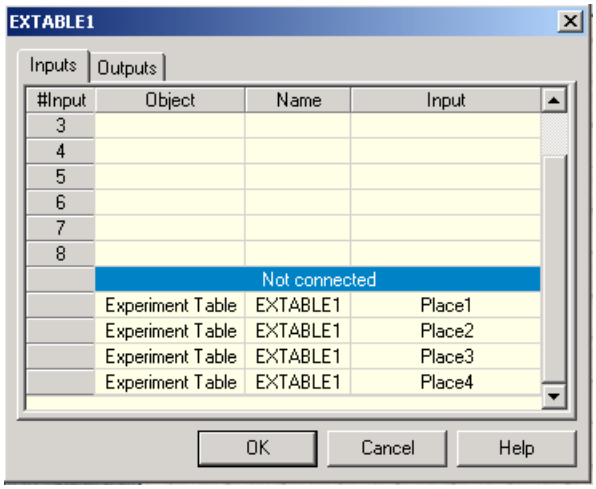


Figure 4-9: Experiment Table Input/Output Configuration

Although one of the experiment table inputs may be disabled if the input is later defined for another device, all other switches will remain connected to their defined inputs.

In RoboCell, a sound is emitted when the outputs that control the buzzer and lamp are turned on and off. The experiment table outputs use the Windows sounds associated with the following events:

- Buzzer On: - Exclamation
- Buzzer Off: - Critical Stop
- Lamp On: - Asterisk
- Lamp Off: - Information

In addition, the lamp in the Graphic Display turns bright red when its associated output is turned on.

Sensor

RoboCell includes digital sensors that can be configured to detect specific objects based on their color and/or material (metal, plastic, wood, etc.). The objects are listed in the Materials group and their properties are defined when they are placed in the cell (see User Parts and Objects).

When you select Sensor, this dialog box opens enabling you to define the color/material to which the sensor is sensitive, as well as the sensor's height.

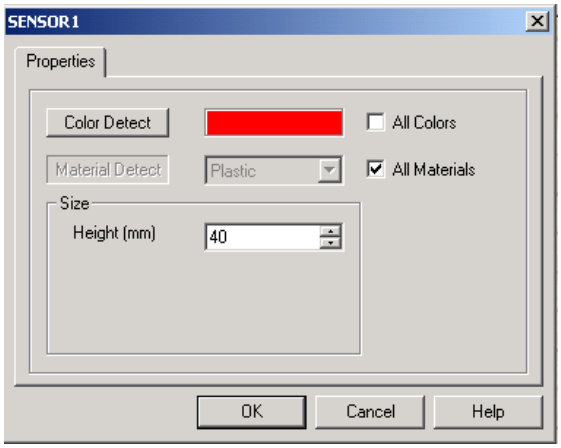


Figure 4-10: Sensor Configuration

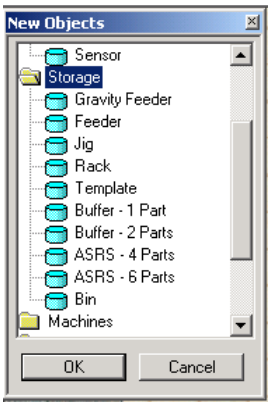
Color Detect

By default, the sensor is set to detect all colors. To set it to a specific color, uncheck All Colors. Click Color Detect to open a color palette from which you can select the required color.

If the sensor is configured to be sensitive to All Colors, the sensor in the cell is colored different shades of gray with its upper part in white. This distinguishes it from a sensor configured to be sensitive to gray, which is entirely gray.

Material Detect	By default, the sensor is set to detect all materials. To set it to a specific material, uncheck All Materials. Select a material (Metal, Glass, Plastics, or Wood) from the drop-down list.
Height (mm)	Defines the height (above table level) at which the sensor will be placed in the cell. The default height is 40 mm. If you increase the height, the stand on which the sensor is mounted will appear taller.

Storage



The storage devices in RoboCell enable you to store, place and retrieve objects listed in the Materials group.

Gravity Feeder

The Gravity Feeder is an inclined plane on which objects are placed, one above the other.

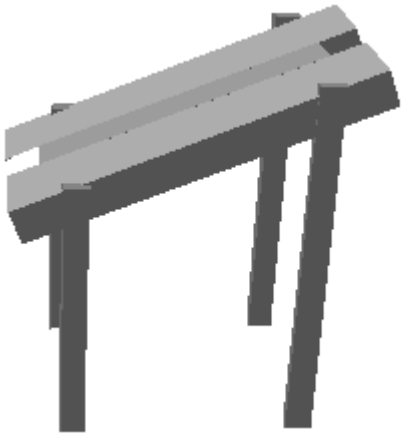


Figure 4-11: Gravity Feeder

Unlike most objects, the feeder's position is defined as the point at which the robot takes an object from the lower part of the feeder. All the remaining objects slide down the feeder to be taken in turn.

When placing objects on the gravity feeder, you must position them in the light gray section of the feeder's mouth
(as shown by the Cursor in Figure 4-11).

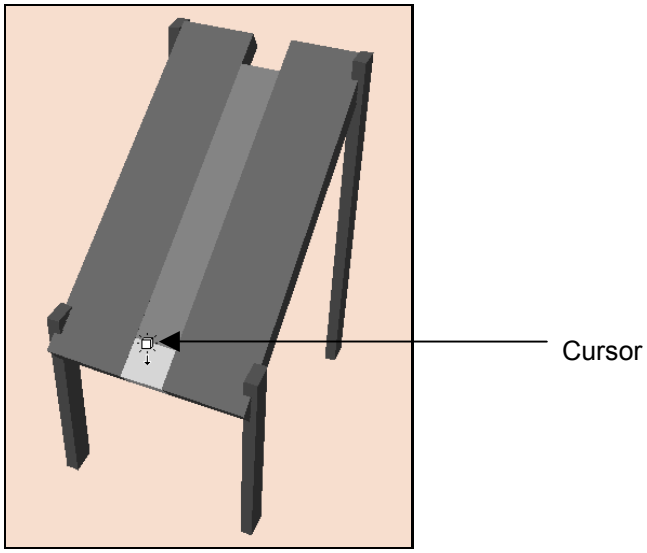


Figure 4-12: Placing Objects in Gravity Feeder

The feeder is fitted with a touch sensor (named NotEmpty) located at the lower part of the feeder. The sensor indicates when there are parts in the feeder, i.e., it is on when the feeder is not empty.

Feeder (Pneumatic Feeder)

The (pneumatic) feeder is constructed from a magazine of objects and a pneumatic cylinder fitted at the lower section.

The feeder is also fitted with a touch sensor that is pressed (the input is on) when there are parts in the feeder (NotEmpty sensor)

The pneumatic cylinder is controlled via a controller output. When the output is turned on, the piston extends, pushing out the next object.

The robot picks the objects from the feeder output tray, and the feeder position is defined as the point at which the robot takes an object from the feeder.

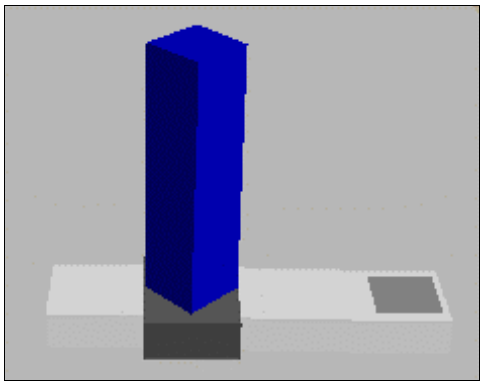


Figure 4-13: Robot Position for Picking Objects

Feeder Configuration

Configuration for the Gravity Feeder and the Pneumatic Feeder is described below. The differences between the two methods are indicated.

When you select a feeder, a configuration dialog box opens:

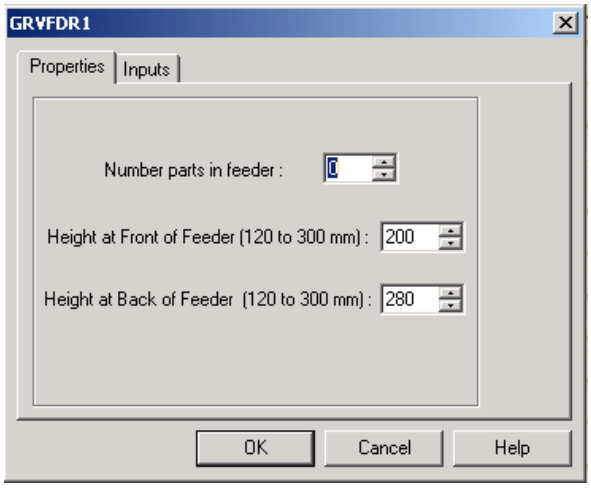


Figure 4-14: Gravity Feeder Configuration

Properties tab:

Number of Parts in Feeder	Defines the number of parts that are loaded in the feeder at the start of operation (when the cell is opened or reset). Only one material object (e.g., cylinder, cube) should be placed in a parts feeder. The software multiplies the object by the number of parts specified. Default: 0
Height at Front of Feeder (Gravity Feeder only)	Defines the height of the lower part of the feeder above the table level. Default: 200
Height at Back of Feeder (Gravity Feeder only)	Defines the height of the higher part of the feeder above the table level. Default: 280

Inputs tab:

To define the robot controller input to which the feeder's NotEmpty sensor is connected, click on the Inputs tab.

Outputs tab: (Pneumatic Feeder only)

To define the robot controller output to which the feeder is connected, click on the Outputs tab. A new part appears in the feeder when the output is turned on.

Feeder Properties

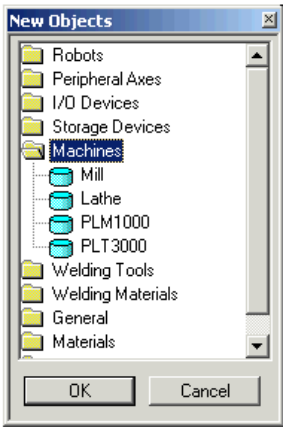
In addition to the standard object properties (see Object Properties Menu), this option is also listed in the Feeder Properties menu:

Capacity	Enables you to alter the number of parts loaded in the feeder after the feeder has been configured.

Jig, Rack, Template, Buffers, ASRS and Bin

No settings are required for these storage devices. Double click on the desired device and place them in the cell at the desired location.

Machines



The Machines group includes two Mills (**Mill**, **PLM1000**) and two Lathes (**Lathe**, **PLT3000**). A CNC controller controls these machines. The robot controller and the machine controller communicate through inputs and outputs. The machine output is the controller input, and vice versa.

All these machines are configured in the same way.

When you select any of these machines, a configuration dialog box opens:

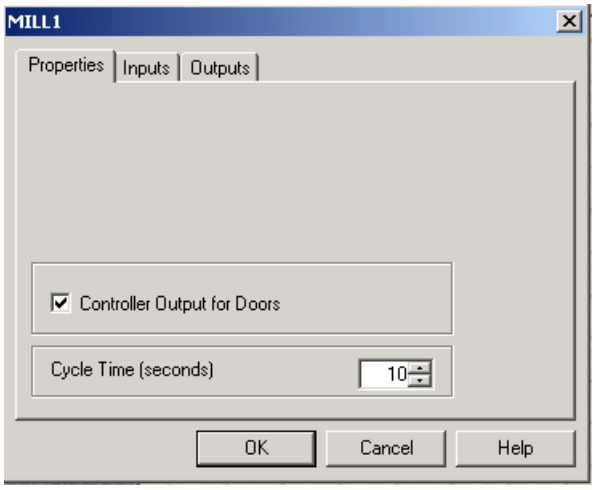


Figure 4-15: Machine Configuration

Properties tab:

Controller Output for Doors	Specifies whether or not the machine doors are controlled by the robot controller output. If the doors operate independently of the robot controller, they open and close at the beginning and end of the machine cycle.
Cycle time (seconds)	Sets the amount of time (in seconds) of the machine process. Default: 10.

Inputs tab:

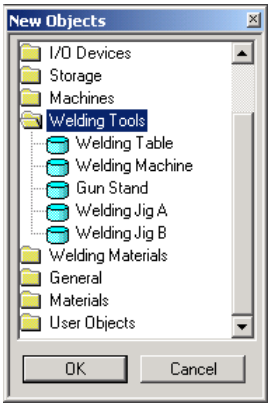
Controller input (machine output)	The machine informs the controller that a process is being carried out, i.e., when the input is on, the machine is busy.

Outputs tab:

Controller output (machine input)	Closes and opens the machine door. The machine cannot start if the door is open.
Controller output (machine input)	Closes and opens the machine chuck. The chuck holds the object during the process.
Controller output (machine input)	Sets the robot controller output to which the machine is connected. The machine cycle starts when the output is turned on.

To modify the configuration after the machine has been placed in the cell, double-click on the machine to open its Object Properties menu (see Object Properties Menu). Select Machine Setting to open the Configuration dialog box.

Welding Tools



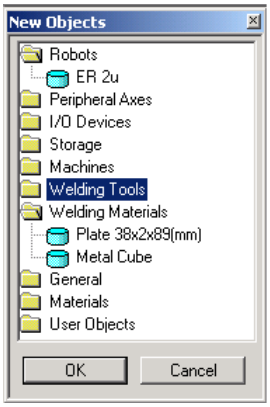
The Welding Tools group includes:

- Welding Table
- Welding Machine
- Gun Stand
- Welding Jig A
- Welding Jig B

Full details on use of the welding tools are provided in Chapter 7, Welding Features.

Welding Table	The welding table holds the welding object and it should be placed in the cell just before or after the robot (the first object) has been placed. Most welding objects are automatically placed at the correct default welding table height, even if they are not placed directly on the welding table.
Welding Machine	The welding machine supplies the electrical power required to weld the materials. It is connected to the welding gun by a cable. You cannot save a cell containing *only* a welding gun or *only* a welding machine. Neither or both must be present in order to save the cell.
Gun Stand	The gun stand holds the welding gun between welding sessions. The robot picks the gun from the stand before starting the weld, and returns it to the stand when the welding is finished.
Welding Jig A	Welding Jig A is a device used to securely hold two materials being welded together in a T-joint.
Welding Jig B	Welding Jig B can be used for various types of welds.

Welding Materials



The Welding Materials group includes the plate and the metal cube.

Usage of the welding materials is detailed in Chapter 7, Welding Features.

Plate 38 x 2 x 89

Plate refers to the welding metal plates which are used with Welding Jig A. When you select Plate, this dialog box opens:

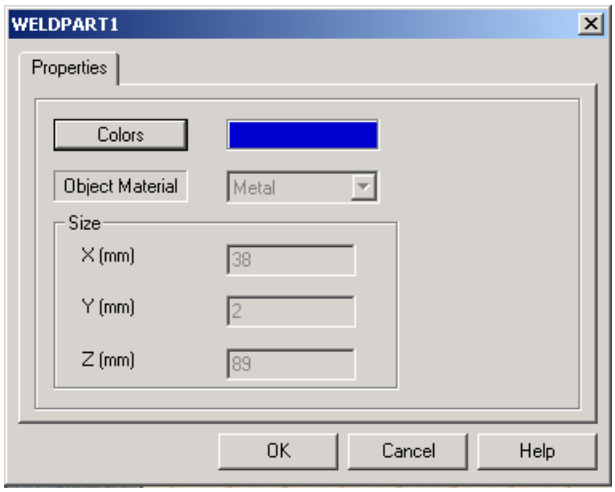


Figure 4-16: Welding Plate Configuration

Colors — You can define the color of the plate to which the sensor is sensitive. The default color is blue. To change the color, click Colors. This opens a color palette from which you can select the required color. Make sure the color you select is compatible with the sensor's detection definition.

Size — The default dimensions of the plates are 38 x 2 x 89 mm. These are for display purposes only and cannot be changed.

Metal Cube

When you select Metal Cube, this dialog box opens:

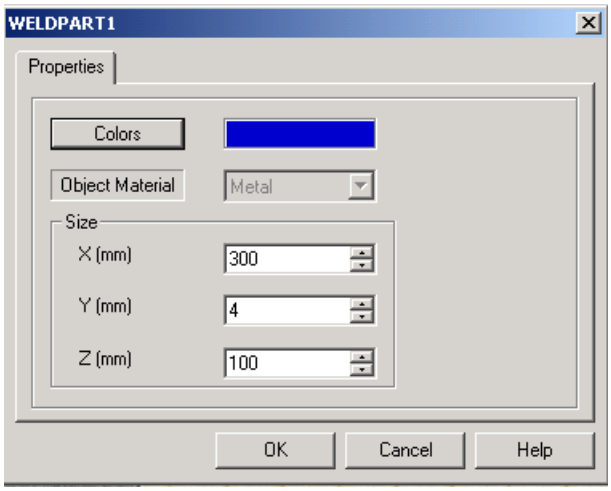
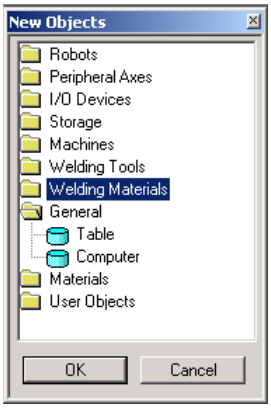


Figure 4-17: Metal Cube Configuration

Colors	Define the color of the cube in the same way as described for the Plate.
Size	The default dimensions of the cube are: 300 x 4 x 100 mm, which you can modify if desired.

General



The General group includes a table and a computer (which is for display purposes only).

Table

It is a good idea to place the table in the cell just before or after the robot has been placed. It is also recommended that you place one or more tables in the cell so that objects do not float in space or lie on the floor. Most objects will be displayed at the correct height, even if they are not sitting on tables.

When you select Table, this dialog box opens:

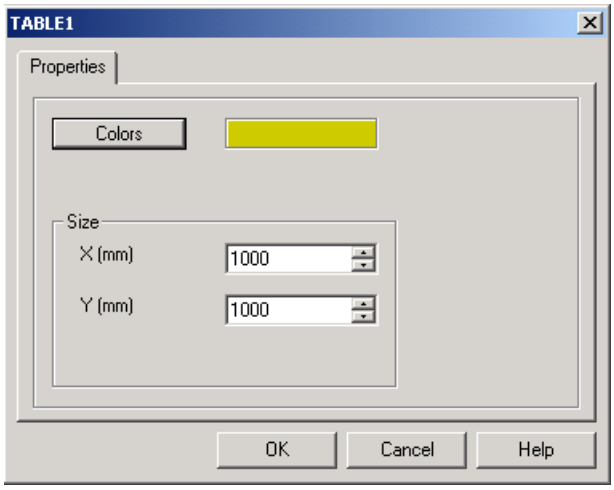


Figure 4-18: Table Configuration

Colors — To change the color, click Colors. This opens a color palette from which you can select the required color.

Size — Defines the width and length of the table. X and Y dimensions are always in accordance with the X and Y dimensions of the cell. (Use the View | Scene Origin option to display the X and Y dimensions of the cell.)

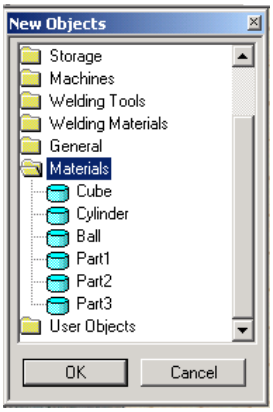
Table Properties

The Table Properties menu does not have a Rotate option (see Object Properties Menu). Instead it has a Resize option for scaling the table's dimensions.

Scale X; Scale Y — Enter a ratio value (e.g., 2 or 0.5) in the X and Y fields. Both fields must contain a value. If you want to change only one dimension, be sure to enter 1 in the other field (do not enter 0).

Resizing is progressive. The scale reverts to 1 each time the table is resized.

Materials



The Materials group includes objects that can be manipulated by the robot:

- Cube
- Cylinder
- Ball
- User defined parts (see User Parts and Objects below)

You can place as many objects as needed.

Cube/Cylinder/Ball

When you select Cube/Cylinder/Ball, the Object Configuration dialog box opens:

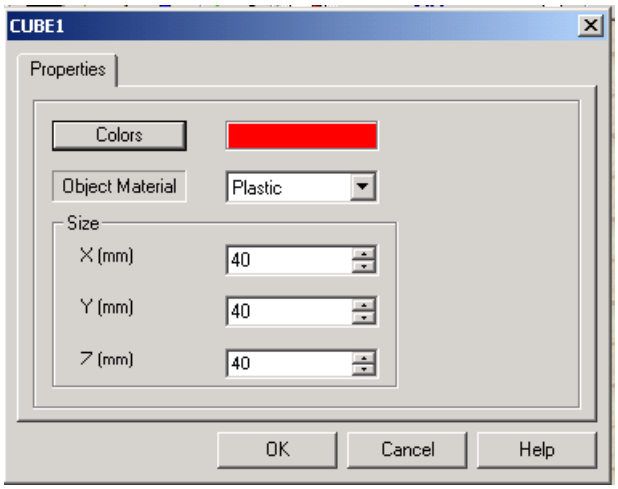


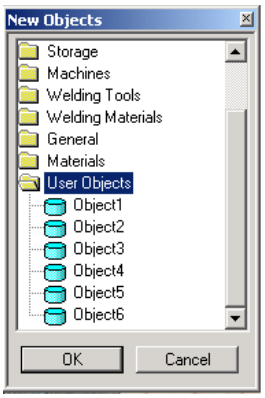
Figure 4-19: Cube Configuration

Colors — You can define the color of the plate to which the sensor is sensitive. The default color is red. To change the color, click Colors. This opens a color palette from which you can select the required color. Make sure the color you select is compatible with the sensor's detection definition.

Object Material — The cell sensor can differentiate between different materials. The default material is plastic. Other available materials are glass, metal and wood. When metal is selected, you can perform welding using the features described in *Chapter 7, Welding Features*.

Size (mm) Cube: X, Y, Z Cylinder: Diameter, Height Ball: Diameter	The default dimensions of the objects can be modified if desired.
Horizontal/Vertical (for Cylinder only)	Defines whether the cylinder is placed in a horizontal or vertical position. Cylinders that are placed in the lathe should be defined as horizontal.

User Parts and Objects



Parts

To insert a part or an object, select the desired part/object from the Materials/User Objects group.

Point and click on the location where you want to place the part/object. You may need to wait a moment for the cursor to appear. *Do not double click.*

Parts are basic shapes that can be used to simulate any type of material the user chooses. Simply click on Part 1, 2 or 3 to add a new part to the cell.

In RoboCell, parts are changed to show what they look like at the end of the mill or lathe machining process. You may design your own finished parts.

User parts are stored as files in RWX format. The robot and machines can manipulate these objects. User part files are saved as PART*_0.RWX (where * represents 1, 2, or 3), and finished parts are named PART*_1.RWX. The files are located in the SBWSIM*n* RESOURCE folder.

Objects

The objects included in the User Objects group are for illustration purposes only. User Object files are named USER*.RWX. The files are located in the SBWSIMn\RESOURCE folder.

Advanced users who know how to create 3D objects in RWX format can design and use such objects in the robotic cell. No more than three user-defined parts and eight user objects may be used at one time. For further directions on designing user parts/objects, see Designing User Parts and Objects below.

Designing User Parts and Objects

Modify an Existing User Part File

You may change the existing user part to create your own user part. To modify an existing user part, do the following:

1. Open the SBWSIMx folder.
2. Open the RESOURCE folder.
3. Using a text editor that saves files in plain ASCII format, such as Notepad or DOS Edit, open one of the existing user part files (PART1_0.RWX, PART2_0.RWX or PART3_0.RWX). The file looks like the following example:

```
ModelBegin
  TransformBegin
       Color 0.0 1.0 1.0
       Surface 0.4 0.3 0.2
       Opacity 1.000000
       LightSampling Facet
       GeometrySampling Solid
       TextureModes Lit
       Texture NULL
       ClumpBegin
        Translate 0.0 0.0251 0.0
              Tag 1
              Block 0.05 0.05 0.05
                   ClumpBegin
                   Tag 2001
                   Color 1 0 0
                   Opacity 1
                   Block 0.03 0.02 0.07
                   ClumpEnd
    TransformEnd
ModelEnd
```

4. Edit the file to create your own part.
5. Save the file. Since you can only have three user part files at a time, you must replace the original file. *Do not change the file name*.
6. To create your own finished part, edit the Part*_1 file.

   *If you do not want to create a finished part, delete the Part*_1 file.*

Create a New Part/Object File

If you can create your own user part and user object files, do the following:

1. Open a text editor that saves files in plain ASCII text, such as Notepad or DOS Edit.
2. Write the program to create your own part.
3. Save as file type .RWX. (You must name the file PART1_0.RWX, PART2_0.RWX, or PART3_0.RWX.)
4. To create a finished part, name the file PART*_1.RWX. There must also be a PART*_0.RWX file to go with it (i.e., in order for there to be a PART1_1 file there must be a PART1_0.RWX file).
5. Copy the files to the SBWSIM*n*\RESOURCE folder.

   Note: It is recommended that you do not discard the original files supplied with RoboCell. Save the original files under different file names.
6. To create a User Object, follow the above steps and name the file USER*.RWX. USER*.RWX files cannot be manipulated by the robot or machines. You must replace the original user object files.

Import a CAD File

You can create a 3D object in a CAD program, and import it to RoboCell. To import a CAD file do the following:

1. Create a file in any CAD program. Save as *.DXF or *.3DC.
2. Use the *DXFtoRWX***,** or *3DCto RWX* converter to convert the file to RWX format.
3. Name the files PART1_0.RWX, PART2_0.RWX, or Part3_0.RWX.
4. To create a finished part, name the file PART*_1.RWX. There must also be a PART*_0.RWX file to go with it (i.e., in order for there to be a PART1_1.RWX file there must be a PART1_0.RWX file).
5. Copy the file to the SBWSIM*n*\RESOURCE folder.

To import a *user object*, follow the above steps and name the file USER*.RWX.

For more information on RWX files, consult a manual on RWX programming.

5

Working in RoboCell

RoboCell integrates the SCORBASE robotic software with a graphic display module, which allows you to define (teach) robot positions and execute robot programs in a virtual robotic workcell.

RoboCell's user interface and menus are similar to those of SCORBASE. The main differences are detailed in this chapter. They include:

- The graphic module, which enables position definition and SCORBASE program execution in a virtual or real workcell.
- Additional options which facilitate the integration of SCORBASE in RoboCell appear in RoboCell menus.

All SCORBASE operations, menu items and programming language are described in the SCORBASE User Manual.

RoboCell Menus

When you open Robocell and select New Project, this window appears:

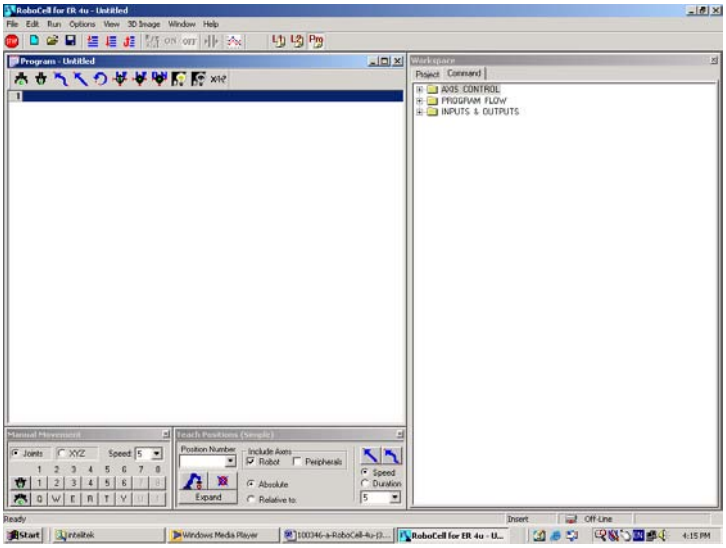
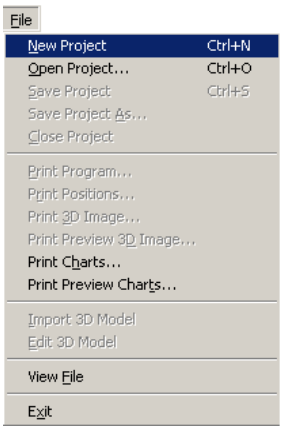


Figure 5-1: New Project Window

File Menu



The following options are available from the *File* menu:

New Project

Opens a new untitled project (see Figure 5-1).

The new untitled project does not include a robotic workcell (3D window).

To add a workcell, do one of the following:

- Select File | Import 3D model to open an existing workcell file.
- Select File | Edit 3D model to open CellSetup and create a new workcell.

Open Project

Opens the Load Project window which lists SCORBASE files (without a virtual cell), and RoboCell files (that include a virtual cell).

Save Project

Saves the project (program, positions and graphics).

Save Project as….

Saves the project (program, positions and graphics) under a different name.

Print Program

Prints the SCORBASE program.

Print Positions

Prints the positions defined by the user.

Print 3D image

Prints the graphic cell. The output is an image of the current cell.

Print Preview 3D Image

Opens a dialog window that shows how the printed cell will appear on paper.

Print Charts

Opens a dialog box to select the chart of a specific axis for display or printout. Only one axis can be selected at a time.

Print Preview Charts	Opens a window that displays the chart of the selected axis showing how it will appear on paper.
Import 3D Model	Opens the Import 3D Model window which lists graphic module files (*.3DC files). Select one of the files to open the graphic display module window. When you save the project, the current workcell is included as part of the project.
Edit 3D Model	Opens CellSetup. If the project already includes a workcell, CellSetup opens that workcell for editing. Otherwise, CellSetup opens with a new untitled empty cell.
View File	Opens the View File window which lists the following files: • Graphic module files (*.3DC) • SCORBASE programs (*.sbp) *(**Note:** It is possible to copy and paste an sbp file into your own project.)* • Position data (*.pnt) When you select a file, a window opens displaying that file.
Exit	Closes RoboCell.

Edit Menu

The Edit menu is identical to the SCORBASE menu, which is used to edit SCORBASE programs. See the SCORBASE User Manual (or Help file) for a description of this menu's options.

Run Menu

The Run menu is identical to the SCORBASE menu whose options allow you to run the SCORBASE programs and send the robot home.

If you select Options | Simulation, running a SCORBASE program will run the robot in the virtual cell.

If you select Options | On-Line (and a robot connected to the computer) the virtual and real robot will work together.

Options Menu

The Options menu is similar to the SCORBASE menu. The only difference is the Simulation option. When checked, the robot in the virtual cell will run according to the SCORBASE program instructions. See the SCORBASE User Manual (or Help file) for a description of this menu's options.

Note: Advanced Commands are detailed in the SCORBASE User Manual. The ViewFlex Commands are detailed in the ViewFlex User Manual.

View Menu

The View menu is identical to the SCORBASE menu whose options allow you to toggle the display of SCORBASE dialog bars and menus.

3D Image Menu

The options of this menu are described in Graphic Display Modulebelow.

Window Menu

The options of the Window menu offer screen settings that enable optimal usage of the screen while you are carrying out various operations such as defining positions, programming and running the SCORBASE programs.

Graphic Display Module

The graphic module file is an integral part of a RoboCell project. Opening or saving a project opens or saves the RoboCell program, robot positions and graphic module data as one entity.

You can open a new RoboCell project and then import a virtual cell from an existing project or a cell created using CellSetup (File | Import 3D Model).

Only one CellSetup file/window can be opened at a time.

When you open a project which already contains a workcell, the graphic display module window appears. The window is titled 3D image and the project name.

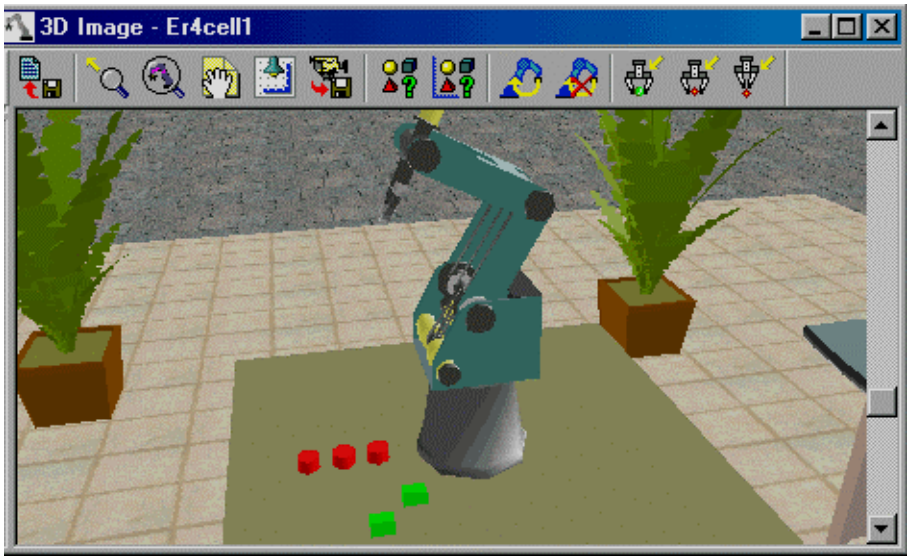


Figure 5-2: 3D Image Window

The 3D image portrays the robotic workcell and all its components. Using the graphic display tools described in Chapter 3, you can manipulate the image and view it from different angles by controlling the angle and position of the virtual "camera" that monitors the workcell. Other tools enable you to see other data related to the cell (such as object name, position or the number of part in a feeder).

3D Image Menu & Toolbar

All graphic display tools are accessible from the 3D Image Menu. Frequently used tools can also be accessed from the toolbar.

Reset 3D Model

Returns the workcell image to the initial setting and position (saved in CellSetup).

This tool is useful when you want to initialize the workcell before re-running a program.

Top View

Resets camera position to the top center point of the cell.

Drag Image

Activates the drag mode in order to drag the entire image to a new position.

Using the cursor, point and click anywhere on the image and drag it to its new position. The drag mode remains in effect until you select another option or press [Esc].

Camera Sub-options:

The 3D image window displays the output of a virtual camera that is fitted in the workcell. Manipulating the camera determines how the image is displayed in the window.

Redirect Camera

Selects the point that will always be in the center of the screen (while rotating, zooming and changing the camera's angle).

The Redirect Camera mode remains in effect until you select another option or press [Esc].

Follow me Camera

Enables you to follow the movement of any object (robot gripper, certain object, etc.) when the workcell is running.

To select the point, choose a point on a moving object (part of the robot or an object).

Press [Esc] to exit Redirect Camera.

Save Camera Position

Saves the current camera position. Only one camera position can be saved. Saving a new position overwrites the previously saved position.

Restore Camera Position

Restores the position recorded using Save Camera Position.

Labels Sub-options:

Object Names

Shows/hides Object Name labels.

Object Positions

Shows/hides Object Position labels.

The label displays the X and Y coordinates of the object position that is relative to the coordinates of the 3D model.

Object Positions in Robot Coordinates

Shows/hides Object Position Robot Coordinates.

The object position displayed is relative to the robot coordinates. The robot coordinates may be different from cell coordinates if:

- The robot was moved after initial setting (in CellSetup)
- The robot is equipped with LSB. When the robot moves, the position of objects relative to the robot changes.

	Number Parts in Feeder	Shows/hides a label that displays the number of remaining objects in a feeder.
	Send Robot Sub-options	Select Options | Simulation to enable the Send Robot options.
	Send Robot to Object	Sends the robot to the selected object. Make sure the gripper is open before sending the robot to the object. This option is useful for defining a robot pick position.
	Send Robot to Point	Sends the robot to the selected point. This option is useful for defining a robot place position.
	Send Robot to Above Point	Sends the robot to a point above the selected point on the table. Default: point 100 mm above the selected point.
	Options for Send Robot	Opens the Send Robot Options dialog box enabling you to define the vertical offset values and the gripper's orientation when Send Robot commands are executed.

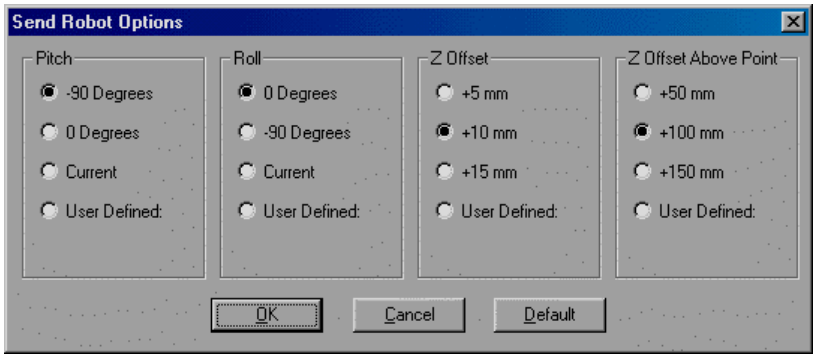


Figure 5-3: Send Robot Options

The settings remain in effect for all subsequent Send Robot commands. When the gun is selected, default gun settings are used automatically; user-defined settings are ignored.

By default, the robot moves to an object or point with the gripper perpendicular (-90) to the table and with no (0) rotation.

You may also use the SCORBASE Manual Movement dialog box (see Robot Manual Manipulation) to adjust the orientation (pitch and roll) of the gripper. You can then select the option Use Current to maintain the gripper's orientation during subsequent Send Robot commands.

The Z-offset value is used by the Send Robot to Object and Send Robot to Point commands. The Z-offset Above Point value is used by the Send Robot Above Point command.

Show Path	When selected, a line showing the gripper path is drawn on the screen as the robot moves. The distance between the points is proportional to the TCP speed.
Clear Path	Clears the robot path that was drawn using Show Path.
Show Origin	Shows the origin of the cell at floor level (under the center of the robot's base) as a red cross marked with X and Y axes. The positions of all objects are defined as relative to this point of origin. When manipulating the graphic display, the cross may disappear momentarily. This option is the same as Scene Origin described in Chapter 4, CellSetup.
Show Robot Work Envelope	Displays the span of the robot's working range allowing you to see whether objects are within the reach of the robot. This option is the same as the Show Envelope option of the Robot Properties.
Welding Settings	Opens the Welding Setting dialog box, which enables definition of the welding parameters (see Figure 7-7).

6

Cell Operation

Operating and programming the robot in RoboCell is similar to working with a hardware robot. Graphic display features and automatic operations, such as Cell Reset and Send Robot commands, enable quick and accurate programming.

Robot Manual Manipulation

The SCORBASE Manual Movement dialog box allows you to manipulate the robot and peripheral axes in the simulated cell in the same way that it provides control of an actual robotic system.

Figure 6-1: Manual Movement Dialog Box

Clicking with the mouse on the keys on the Manual Movement dialog box keys, or pressing keys on the keyboard, moves the virtual robot axes. Movement of an axis continues as long as the button or key is pressed, or until a software or hardware limit is reached.

Note: In ER2, axis 6 is disabled.

Use the Open Gripper and Close Gripper buttons to control the gripper.

Machine Operation

You can operate the Mill or Lathe directly from the Digital Output dialog box, or with program commands (see Program Execution). A program continues to run after the machine begins to operate.

Be sure to close the chuck on the Mill or Lathe before you open the Robot gripper to release it. A part placed in the Lathe will drop to the bottom unless the chuck is closed before opening the robot gripper.

A part placed in the Mill may fall once the Mill cycle begins, if the chuck is not closed before starting the cycle.

Mill and Lathe will work only if the door is closed.

Send Robot Commands

Send Robot commands can often be used instead of the SCORBASE Manual Movement dialog box. Commonly, however, you will use the Manual Movement dialog box to adjust the robot's position after using a Send Robot command.

When SCORBASE is operating online with an actual robotic cell, the Send Robot commands and options are disabled.

When using the Send Robot commands, be aware of certain characteristics of the following objects.

Feeders	Click on the part in the feeder (and not the feeder itself), to select it as the target position for the Send Robot to Object command. To easily pick up a part from the feeder, select a pitch of 0° and a roll of (-90°) in the Send Robot Options dialog box.
Lathe	Each of the four clamps in the chuck can be a target object. You cannot use the Send Robot to Object command to place an object in the lathe. Object must be placed in the chuck manually. Only cylinders can be placed in the chuck. Use the Manual Movement dialog box to position the cylinder exactly.
Mill	Click on the jig in the mill to select it as the target for the Send Robot to Point command. Use the grid on the jig to help place the object.

Table	Use the Send Robot to Point (not Send Robot to Object) command and select a specific target point on the table. The robot moves to that position with the offset defined in the Options for Send Robot dialog box.
Template	Although it is regarded as one object, the template is comprised of two objects, the tray and the handle, either of which can be a target object. The template has only one position, defined by the center of the tray. Use Z-offset 35 mm to send the robot to the template tray. Use Z-offset 0 mm (user-defined) to send the robot to the template handle.

Gripper

Grasping Objects

The robot gripper in RoboCell will grasp an object only as a result of Close Gripper commands.

When the gripper closes on an object, the object is pushed into the center of gripper.

In addition, cubes and horizontal cylinders are rotated into alignment with the gripper jaws, provided the rotation offset does not exceed 35º. When the offset is about 45º, the gripper simply grasps the object at its corners.

Since objects are rotated around their center, a long object that will be grasped far from its center must be aligned with the gripper as much as possible before the gripper is closed.

Releasing Objects

RoboCell operates in a gravitational field. Objects that are released from the gripper will fall to the first surface below them.

If more than half of an object's base rests on a surface, the object will remain on the surface. Otherwise it will fall onto the surface below.

Objects can be picked up and released at any rotation.

Impact Detection

RoboCell checks for the following impact conditions:

- The tip of the gripper hits an object or the robot itself.
- The edge of the gripper motor (mounted on top of the gripper) hits an object or the robot itself.
- An object held by the gripper hits another object or the robot.

RoboCell's impact error message is the same one sent by SCORBASE when an actual robot cannot reach a target position. Since there are no mechanical (motor) or electrical (encoder) failures in simulation, you can assume simply that the gripper or an object held by the gripper has collided with the robot or another object.

The Graphic Display status line indicates the object on which the impact has occurred.

In response to the impact error message, select OK to resume Control On. Then move the robot away from the impact condition. If a Send Robot command caused the impact, the robot will resume movement from the position that preceded the Send Robot command.

When SCORBASE is operating online with an actual robotic cell, SCORBASE controls impact detection and response, and Cell Simulation's impact detection function is disabled.

Defining Positions

RoboCell provides the methods described below for defining robot positions. A position is identified by its assigned number.

Recording Position #1

1. Use the SCORBASE Manual Movement dialog box to manipulate the virtual robot in the same manner in which you would manipulate an actual robot.
2. When the position is reached, type a number in the position number field in the Teach Position (Simple) dialog box.
3. Click Record.

If the position number has been used previously, the new position will overwrite the previous position data.

Recording Position #2

1. To send a robot to a required position, use the Send Robot to Object/Position/Above Position tools.
2. If needed, use the Manual Movement dialog box for fine-tuning.
3. When the position is reached, type a number in the position number field in the Teach Position (Simple) dialog box.
4. Click Record.

If the position number has been used previously, the new position will overwrite the previous position data.

Teaching Position

1. In the Graphic Display window, select View | Object Positions to see the X and Y coordinates of an object.
2. Zoom in on the object or point whose coordinates you want to record.
3. Click the Teach Position (Simple) Expanded button to open the Teach Position dialog box.

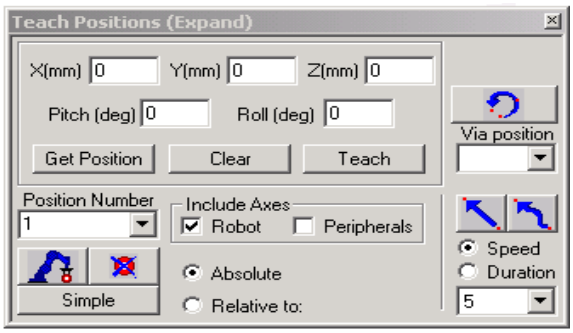


Figure 6-2: Teach Positions Dialog Box (Expanded)

4. Type the position coordinates in the X, Y, Z, P, and R fields.
5. Enter a number in the position number field.
6. Click Teach.

Note: If you click Record position, the current robot position is recorded (and not the position defined by the coordinates you entered in the X, Y, Z, P, and R fields).

If the position number has been used previously, the new position will overwrite the previous position data.

Fine-tuning a Position

To modify existing positions:

1. Click Teach Position (Simple) Expanded to open the Teach Position dialog box.
2. Select the position you want to modify in the Position Number field.
3. Click Get Position. The position data appears in the X, Y, Z, P, and R fields.
4. Modify the required coordinate.
5. Click Teach to overwrite the previous position.

Program Execution

Executing programs in RoboCell is the same as executing programs when using an actual robotic system.

Since different cell configurations can be loaded and changed in RoboCell, keep in mind that positions and programs are not loaded together with their workcell.

To use a workcell with its positions for a new project save the project with the workcell and positions under a different name, using the Save as option in the File menu.

Then delete the program and write a new one (the positions and the cell remain unchanged).

7

Welding Features

Introducing Welding Features

RoboCell welding features contain 3D-solid modeling robotic welding options for teaching modern techniques of arc welding.

The software features the following:

- Welding of multiple parts both online and in simulation.
- Accurate display and manipulation of welded parts both online and in simulation.
- Single-command character generator that calculates and teaches all positions required for producing any text string.
- Predefined welding cells and fully functional demonstration programs for simulated execution.

A typical welding cell is shown in Figure 7-1.

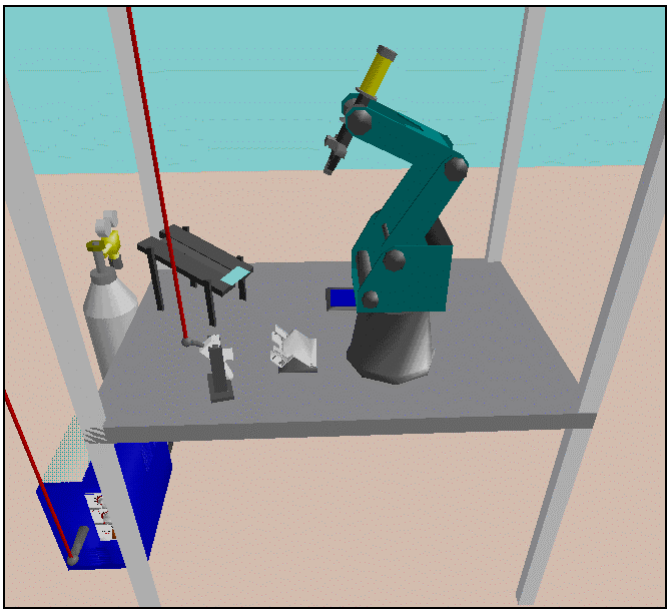


Figure 7-1: Welding Cell

Welding features enable several types of welding processes: T-joint welds, butt welds and the welding of letters and numerals.

- **T-joint weld:** A T-joint weld is shown in Figure 7-2.

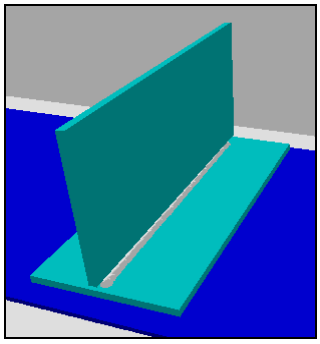


Figure 7-2: T-joint weld

- **Butt weld:** Weld in which the pieces are welded side-by-side.

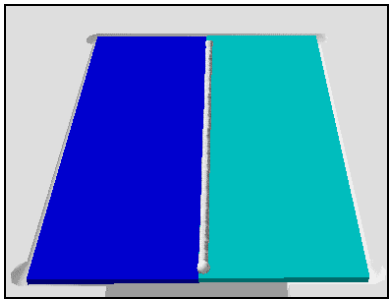


Figure 7-3: Butt Weld

- **Letters and numerals:** A gun is used to weld letters or numerals on a large metal plate placed on the butt jig.

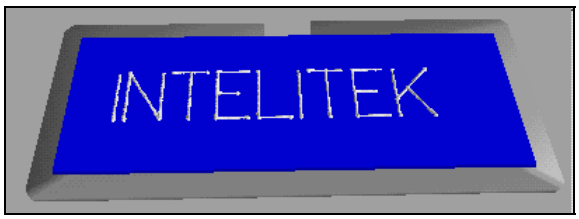


Figure 7-4: Letters and Numerals

The workcell allows fully automatic T-joint welding operations:

- retrieval of metal plates from gravity feeder
- loading of parts into T-joint jig
- retrieval of MIG gun
- arc welding
- returning of gun

- unloading of weld from jig for cooling.

Welding of a butt joint or of numerals/letters is performed similarly. However, for these processes, the metal sheets must be placed in the jig during the cell setup stage. The robot's work envelope does not allow it to place and remove parts from this jig.

CellSetup Welding Tools

The welding tools available in CellSetup are described below. (See also Chapter 4, CellSetup.)

Welding Tools

Welding Table Configuration

The welding table should be placed in the cell just before or after the robot (the first object) has been placed. Most welding objects are automatically placed at the correct default welding table height, even if they are not placed directly on the welding table.

The welding table configuration dialog box contains the following options:

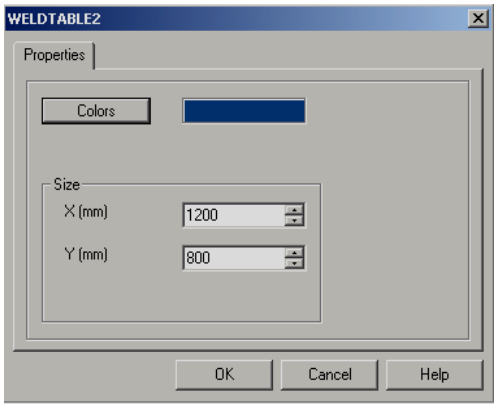


Figure 7-5: Welding Table Configuration

Colors

Opens the color pallet to define the color of the welding table. The booth poles will remain default gray.

To distinguish the table, use a color that is different from the colors used for the floor and background.

X (mm); Y (mm)

Defines the length and width of the table in millimeters. X and Y dimensions are always in accordance with the X and Y dimensions of the cell. (Use the Show Cell Origin option to display the X and Y origin of the cell.)

You can accept or change the default dimensions of 1200 x 800 mm, which represent the width of the welding booth's table supplied with the Automated Welding tekLINK.

Welding Machine Properties

The Welding machine supplies the electric energy required for the welding process to the welding gun. As such, you cannot save a cell containing *only* a welding gun or *only* a welding machine. Neither or both must be present in order to save the cell.

To open the welding machine properties window do one of the following:

- Select 3D Image | Welding Setting from the RoboCell main menu.
  Note: The Welding Setting option is only enabled if you have defined a welding machine and a welding gun in the cell.
- Double click on the welding machine image in the 3D window.

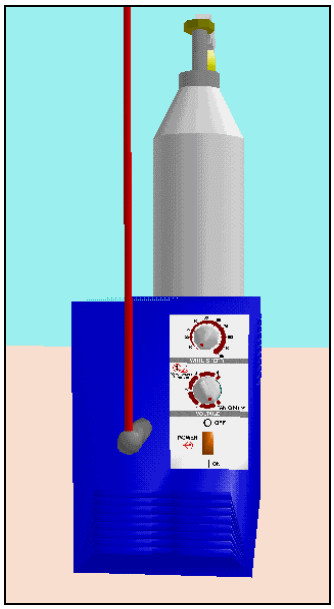


Figure 7-6: Welding Machine Image

The welding machine Properties menu contains the following additional option:

Welding Settings

Opens the Welding Settings dialog box (see Figure 7-7) which enables definition of the following weld parameters:

- Voltage Tap
- Wire Diameter
- Wire Speed
- Shielding Gas

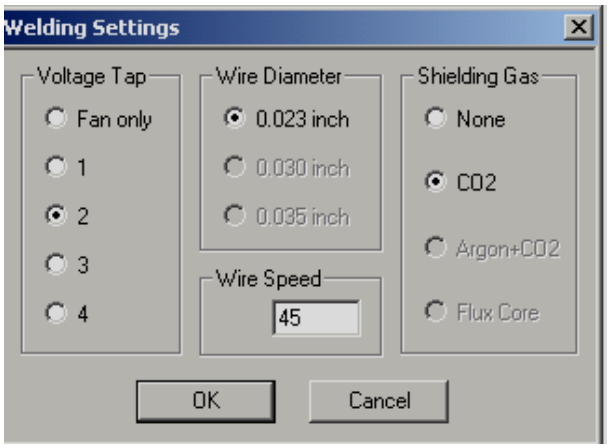


Figure 7-7: Welding Settings Dialog Box

Voltage Tap

Sets welding machine voltage output supplied to the welding gun, an important variable in determining the quality and appearance of a weld. The voltage tap value is a reference number (and 2 does not indicate a voltage value).

The voltage tap should be set according to several factors, such as robot speed, wire speed and metal thickness.

Wire Diameter

Sets diameter of the welding wire being fed to the MIG welding gun. Cannot be changed.

Default of wire diameter used in the AMT tekLINK is 0.023 inch.

Wire Speed	Sets speed at which the wire is fed to the MIG welding gun. Also known as feed rate.
Shielding Gas	Sets type of gas for shielding the weld from oxidation, which causes rust and poor joining of the welded pieces. The system only works with CO_2 gas.

The default parameters are set according to the Millermatic recommended settings *(*see Millermatic User's Manual).

Some parameters are interrelated. For example, changing the voltage tap causes the wire speed default to change automatically. Note that the wire speed can also be changed independently of the voltage tap.

Welding settings can also be changed by the user when working within the Graphic Display window. The settings will remain in effect for all subsequent simulated welds.

Note: *Changes in this dialog box do not affect the actual Millermatic welder settings.*

This dialog box can also be accessed by double-clicking on the welding machine knobs. Note that parameter changes are reflected in the knobs' positions.

Controller Output Number for Welding Machine	The welding machine operation is controlled using a controller output. After placing the welding machine (in CellSetup) you should assign a free controller output for controlling the welding machine.

Gun Stand

The gun stand does not require the user to define any additional configurations or properties. The user need only place it in an accessible position on the welding table. CellSetup draws the cable that connects the welding machine to the gun.

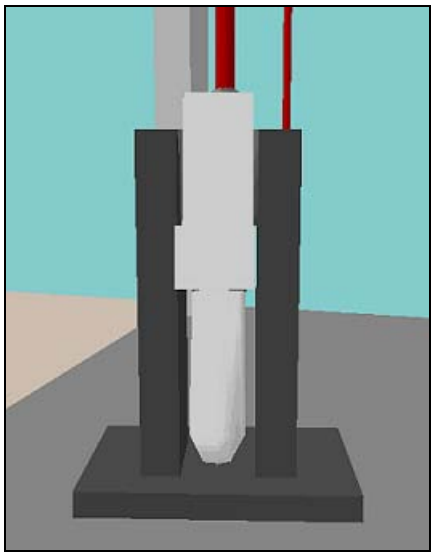


Figure 7-8: Gun Stand

You cannot save a cell containing *only* a welding gun or *only* a welder. Neither or both must be present in order to save the cell.

Welding Jig A (T-Joint)

Welding Jig A is a device used to securely hold two materials being welded together in a T-joint. This jig does not require the user to define any additional configurations or properties. The user need only place it in a position on the welding table in which the robot can access the jig from both ends to place and remove parts.

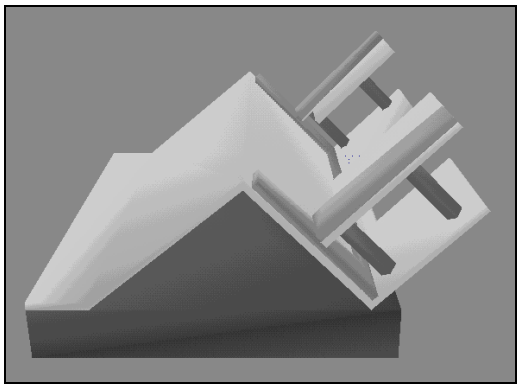


Figure 7-9: Welding Jig A

Welding Jig B

Welding Jig B can be used for various types of welds. The grooved area in the center of the jig can be used to securely hold two metal sheets side-by-side to create a butt weld. The jig can also be used to hold the larger nameplates used with the SCORBASE Write command. For more information, see the SCORBASE User Manual.

Welding Jig B does not require the user to define any additional configurations or properties. The user need only place it in an accessible position on the welding table.

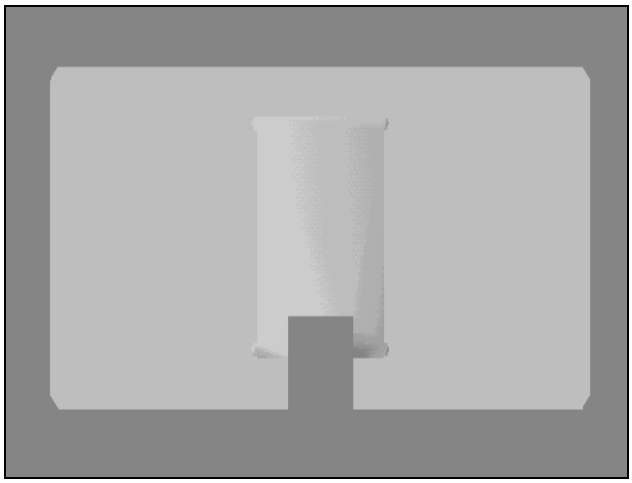


Figure 7-10: Welding Jig B

Welding Materials

Plate 38 x 2 x 89

Plate refers to the welding metal plates which are used with Welding Jig A. When you select Plate, this dialog box opens:

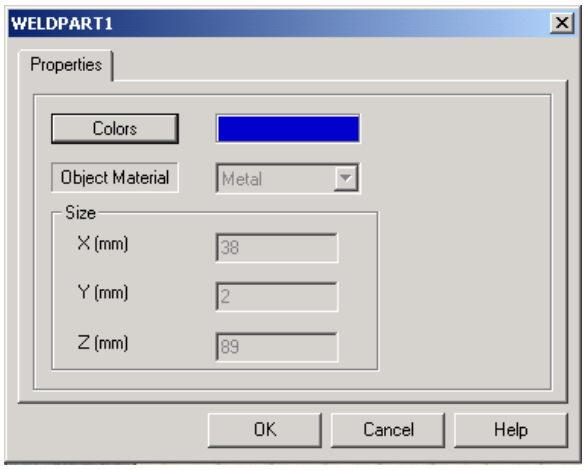


Figure 7-11: Welding Plate Configuration

Colors — You can define the color of the plate to which the sensor is sensitive. The default color is blue. To change the color, click Colors. This opens a color palette from which you can select the required color. Make sure the color you select is compatible with the sensor's detection definition.

Size — The default dimensions of the plates are 38 x 2 x 89 mm. These are for display purposes only and cannot be changed.

Metal Cube

When you select Metal Cube, this dialog box opens:

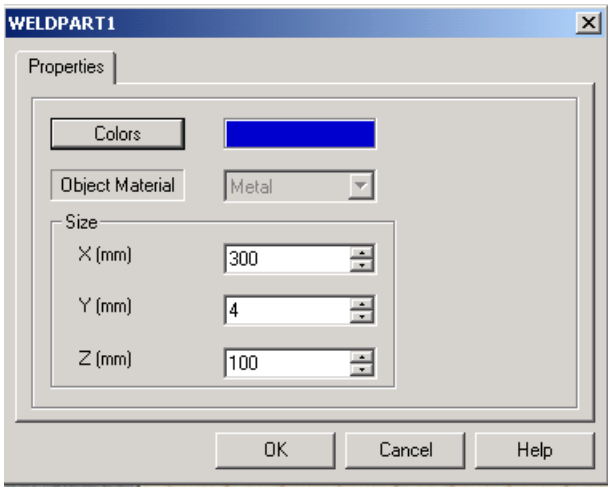


Figure 7-12: Metal Cube Configuration

Colors	Define the color of the cube in the same way as described for the Plate.
Size	The AMT tekLink uses parts whose dimensions are: 300 x 4 x 100 mm (default), which you can modify if desired. Any dimensions can be defined provided that the cubes are compatible with either welding Jig A or B.

Additional Welding Features

The RoboCell's Graphic Display includes the following features:

Advanced Send Robot Commands

Recording Positions for Welding Jig A

Welding features enable easier recording of positions for Welding Jig A. To record the position for placing a part in the left side of the jig, use the Send Robot to Object option and click anywhere on the protruding parts of the jig (indicated by the number "1" in Figure 7-13). RoboCell will automatically send you to the correct position for placing the part. Note that this position is also used for removing the welded part from the jig.

To place parts in the right side of the jig, click on any of the areas numbered "2" in Figure 7-13.

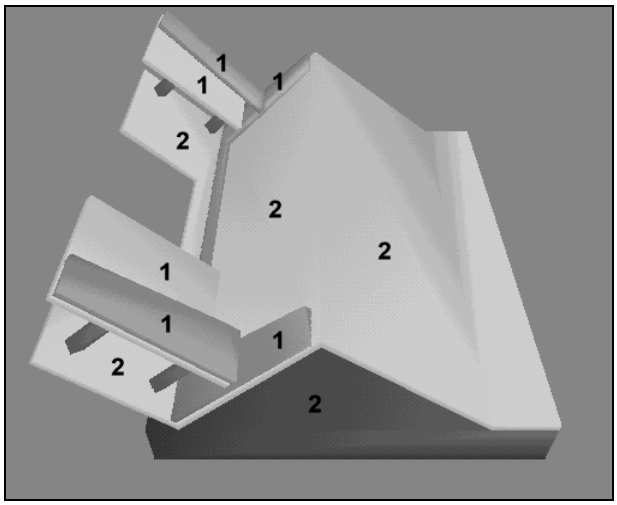


Figure 7-13: Recording Positions for Welding Jig

Recording Positions for Welding Gun

Welding features include a built-in feature to facilitate recording the pick position for the welding gun. To record the position for picking the gun, use the Send Robot to Object option and click on the gripper adapter handle on the gun. RoboCell will automatically send you to the correct position for properly picking the gun.

Welding Booth Doors

The welding booth doors can be viewed or removed by double-clicking anywhere on the booth.

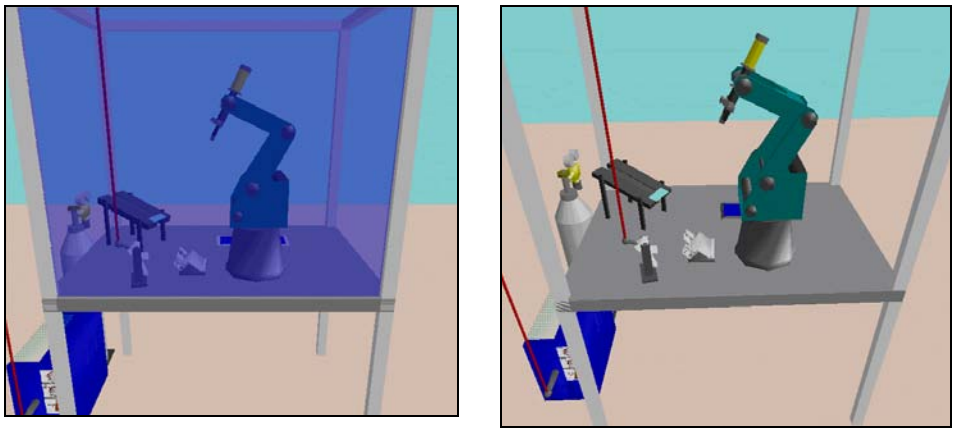


Figure 7-14: Welding Booth Doors Image

Welder

The welder has the following built-in features:

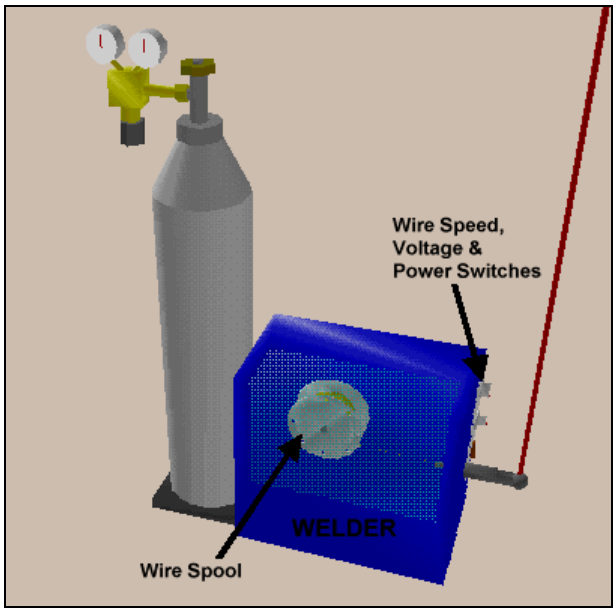


Figure 7-15: Built-in Welder Features

Wire Spool Motion	During the welding process, the wire spool turns just as it does in reality.
Wire Speed, Voltage and Power Switches	The knobs on the welder accurately reflect the welding settings defined via the *Welding Settings* dialog box. Double clicking on any knob opens the dialog box.

Welding Parameters

Successful automated welding is often not the result of reliable technology, but of proper planning. Therefore, it is extremely important to work only with the optimal parameter settings defined by the manufacturer. The following welding parameters can be modified:

Parameter	How to Change Parameter
Inert Gas Shield	From the Welding Settings dialog box, select either None or CO_2.
Voltage Tap	From the Welding Settings dialog box, select one of the reference numbers.

Parameter	How to Change Parameter
Wire Feed Rate	From the Welding Settings dialog box, select one of the reference numbers. Automatically changes when voltage tap is changed.
Rate of Travel	To define the rate of travel (the speed of the robot and the welding gun in the welding procedure), use the *Duration* setting in the *Go To position* dialog box. By changing the duration it takes to get from position A (weld start position) to B (weld end position), the robot's speed is changed – thus changing the speed at which it will weld.
Distance of Electrode from Materials to be Welded	When recording the start/finish welding positions, you define this distance by defining the positions' Z value. Welding only occurs when the electrode of the welding gun is located at a proper distance above "weldable" material. This feature was built-in to enable more accurate recording of the start welding position. Once the software recognizes that welding is "allowed", the gun emits wire that creates a seam between the two materials. Welding will not occur in the following situations: • The electrode of the welding gun is too close or too far from the material. • The welding gun is located above a material that the software recognizes as "non-weldable".
Angle of electrode	When recording the start/finish weld positions, you define this angle by defining the positions' pitch.

Welding Process

Welding Gun Operation

As welding occurs, sparks will fly from the welding gun, as shown in the figure below.

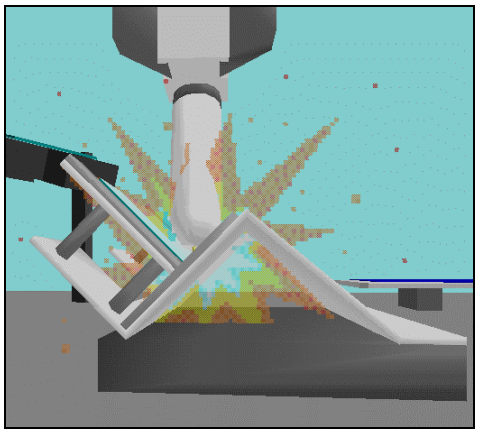


Figure 7-16: Sparks from Welding Operation

Weld Temperature

Changes in the temperature of the welding seam can also be seen by zooming in on it during and after the welding. Immediately after the welding, the seam is red and yellow – indicating that it is extremely hot. Slowly, it changes to a grayish color – indicating that it has cooled.

Welded Part

After the welding process is completed, RoboCell regards the two metal pieces as one.

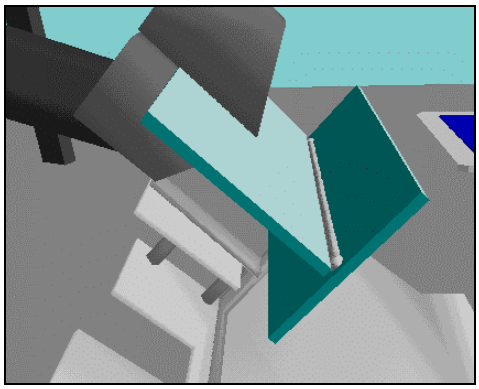


Figure 7-17: Completed T-joint Welding Process

Weld Analysis

RoboCell allows you to observe the quality of a weld at the end of the welding process. Depending on the welding settings used to create the weld, the appearances of welds may differ.

After welding two metals together, double-click on the seam to open the Weld Properties window.

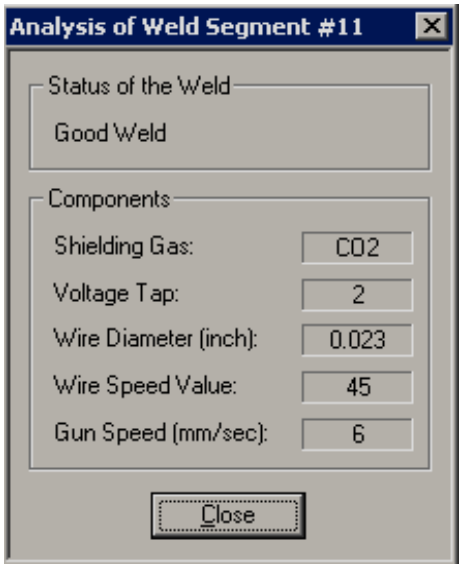


Figure 7-18: Weld Properties Window

The window displays the following information:

- Status of the weld (i.e., good, bad, etc.)
- Whether shielding gas was used or not.
- Selected voltage tap value.
- Wire diameter used.
- Wire speed reference value that was used.
- Speed of the welding gun.

8

Replicating Real and Simulated Cells

RoboCell's representation of robot and devices are based on actual dimensions and functions of SCORBOT equipment. Thus, programming performed in RoboCell can be used with an actual robotic installation.

From Simulation to Real

Using CellSetup and Cell Simulation, create a cell, record all positions to be used by the SCORBASE program, write the SCORBASE program and verify program execution.

Then, to construct an actual robotic installation that duplicates the simulated cell:

1. Using CellSetup as a guide, place all objects and devices in their approximate locations.
2. To print a 3D Image, select File | Print 3D Image.
3. If necessary, hide some labels and/or change the angle and zoom of the camera, and print several cell maps.
4. Consider your SCORBASE program and determine which of the recorded positions must be precise; for example, the point at which the robot takes an object from a feeder, or the point at which the robot places a part in a machine.
5. In SCORBASE On-Line mode, send the robot to these key positions. Adjust the location and orientation of the actual objects and devices (e.g., feeder, machine) according to the location of the gripper.

If you are unable to relocate the object or device, you can rerecord the position coordinates.

From Real to Simulation

To create a simulated cell based on an actual installation, you will need to know the exact location and orientation of every element in the cell.

If the cell layout is simple, this information can be obtained through a coordinate grid or a ruler. For a more complex cell layout, you will probably need a technical drawing (e.g., AutoCAD) which shows the center point and orientation of all objects.

All measurements should be made with both the robot and the cell at the same point of origin and with the same orientation.

9

Sample RoboCell Projects

Your RoboCell package contains a number of sample projects to help familiarize you with the capabilities of RoboCell. These are accessible by means of the File Open command. Press [ctrl]-O on your keyboard, select Open Project from the File menu, or click on the Open icon in the toolbar. You will be shown a listing of all the *.WS files in the following subdirectory:

C:\Program Files\Intelitek\RoboCell\Projects\ER4u

3D Project Descriptions

ER4Cell1

Builds two towers, one of cylinders and one of rectangular blocks. Demonstrates the use of numbered positions.

ER4Cell2

Builds two towers from parts supplied by parts feeders. Demonstrates the use of named variables for positions.

ER4Cell3

Part sorting. Demonstrates the control of inputs and outputs.

ER4Cell4

Order cylinders and process parts. Demonstrates complex PICK movements and program control using IF statements.

ER4Cell5

Lathe and mill tending. Demonstrates complex operation involving robotic arm mounted on slidebase, two parts feeders, a lathe, a mill and various input/output functions.

ER4Cell6

Similar to ER4Cell5, using the Intelitek ProLight lathe and mill. Demonstrates visual representations of the path taken by the TCP (Tool

Center Point).

Butt Joint

Picks up welding tool to weld two parts in a butt joint.

Excel_EX1

Demonstrates the use of VBScript to transfer values from SCORBASE into Excel spreadsheets.

Intelitek

Demonstrates use of the SCORBASE "Write" command.

MICROCIM

Simulation of an OpenCIM device driver interface.

New Project

Empty project.

Polygon

Demonstrates the use of VBScript to transfer values from user input to SCORBASE and make floating-point calculation available to SCORBASE.

Script Demo

Demonstrates the interaction between SCORBASE and VBScript.

Serial Port

Demonstrates using RoboCell to send text messages via serial communications port.

Tjoint

Demonstrates complex pick & place movements and control of welding tool.

10

Troubleshooting

Problem	Solution
Installation not successful.	Make sure all applications, including anti-virus monitors and network drivers, are closed. Then try installing the software again.
Program not responding correctly.	There may be a message box hidden behind the application window. Minimize the application windows to check for messages or prompts.
Robot cannot be dragged to another position.	By default, the robot is placed at the cell's point of origin to simplify the teaching of positions. The robot's position can be changed only by means of its Properties menu.
Screen layout is jumbled or crowded.	Use the SCORBASE View | Simulation & Teach or View | Simulation & Run to reset the screen layout. You can also use the SCORBASE Options | Load User Screen to reset a screen layout that you set and saved previously.
Peripheral axes do not move in RoboCell.	When SCORBASE is operating on-line, the peripheral settings defined in the CellSetup file are not loaded; the peripheral setup defined in SCORBASE is retained. Simulated peripheral axes that do not match the SCORBASE definitions will not respond to SCORBASE commands in the Graphic Display.

11

Intelitek Software Licensing

The software is protected by a licensing agreement. Once installed, you can use the fully operational software for a 30-day evaluation period. To continue using the software after this period, you need an **unlock code** from Intelitek.

To obtain an unlock code, you need to complete three steps:

1. Install the software from the CD.
2. Send the CD key and the PC-specific code to Intelitek.
3. Upon receipt of the unlock code, enter it in the Registration dialog box.

The sections below provide detailed instructions on how to use the software license.

- Register your software and receive a PC-specific unlock code for each license purchased.
- Protect your license.
- Transfer a license from one PC to another PC.
- Return a license to Intelitek, so you can retrieve it later.
- Frequently asked questions.

Register your software and receive a unlock code

- During the software installation, you will be prompted to enter the **CD key**. This number is found on the CD case. (Make sure to keep the CD key in a safe place.)
- The installation procedure generates a **PC-specific code**. This code is found in the Registration dialog box.
- To receive the **unlock code** for the software you installed, you must send Intelitek both the CD key and the PC-specific code. The Registration dialog box provides several methods for obtaining the unlock code.

- **Automatic from Intelitek website**
  - If Internet access is available on the PC, do the following:
    In the Registration dialog box, select Get Unlock Code and select From Intelitek.com. The software will automatically connect to Intelitek's website. The unlock code will automatically be installed on your PC and you will see a message that the software is now licensed.
  - If you have Internet access, but not on the same computer on which the software is installed, do the following:
    Using your Internet browser, go to:
    http://www.intelitek.com/support/software-licenses/index.html
    Enter your CD key and the PC-specific code as instructed.
    The unlock code will be displayed automatically.
    Enter the unlock code in the Registration dialog box and select Unlock.
- **Email** (uses Intelitek's software licensing service).
  In the Registration dialog box, select Get Unlock Code and select By Email.
  - If email is available on the PC, a new email message containing all required details will open. Fill in the requested user information (optional), and click Send. The licensing service will send back an unlock code.
    Enter the unlock code in the Registration dialog box and select Unlock.
  - If you have email service, but not on the same computer on which the software is installed, a Notepad window containing all required details will open. Fill in the requested user information (optional), and then transfer the text/file to your email program.

    Send to: info@intelitek.com
    Subject line: Intelitek Software License

    To ensure automatic processing, use this exact subject line and do not edit the automatically generated text in the message. You may add text and comments to the end of the message.

    Once you receive the unlock code, enter it in the Registration dialog box and select Unlock.
- **Fax or Phone**: If you do not have Internet or Email service, select Get Unlock Code and select By Fax or Phone. A Notepad window containing all required details will open. Fill in the requested user information (optional), and then print out the document. Contact your local dealer or Intelitek with the printed information.

Protect your license

Every unlock code is unique. It will become invalid (and cause the software to stop functioning) when you change a physical component in your PC (e.g., hard disk, network card, CPU), format your disk, or install a new operating system.

- If you want to upgrade your PC and keep your software operational, **you must first transfer the license (unlock code) to another PC.**
- Once you have upgraded your system, reinstall the software (if necessary) and transfer the license back.

If you do not have a PC available for the temporary transfer operation, **return the license to Intelitek.** You will be able to retrieve the license by following the standard procedure for obtaining the unlock code.

Transfer a license from one PC (source) to another PC (target)

- On the target PC install the software and get the PC-specific code from the Registration dialog box.
- On the source PC, open the Registration dialog box. Enter the PC-specific code of the target PC and Select Transfer. The software on the source PC will generate a new unlock code for the target PC and will remove the license from the source PC.
- On the target PC, enter the new unlock code in the Registration dialog box.

Return a license to Intelitek, so you can retrieve it later

Use this procedure when you need to remove a software license and do not have a target PC available.

- From the Registration dialog box, select Remove the License and click Remove. The software will generate a unique Remove code.
- Send the Remove code and your CD key to Intelitek using one of the methods described above (email, website, fax/phone). We will confirm the codes and update our licensing registration records.
- When you are ready to retrieve your license, install the software (if necessary) and follow the instructions for obtaining an unlock code.

FAQs – Frequently Asked Questions

What is a CD key?

This is the code on a label on the CD. It allows Intelitek to track software that has been purchased.

What do I do if I do not have a CD key?

When prompted to enter the CD key during the software installation, enter the word "evaluation". This will allow you to install the software for a trial period.

What is a PC-specific code?

This is a code generated by the software. It is unique for each PC and each installation of the software. This code allows Intelitek to generate the unlock code for the PC on which you installed the software. The PC-specific code is displayed in the Registration dialog box.

What is an unlock code?

This is a code that allows you to use the software after the evaluation period expires. You need to send your CD key and PC-specific code to Intelitek. We will reply with the unlock code for the software you purchased.

How do I install and register the software on more than one PC?

Repeat the procedure for obtaining an unlock code as many times as necessary.

Alternately, install the software on all PCs and make a note of the PC-specific code generated on each PC. You can then send us one email or fax listing all the PC-specific codes. You will receive unlock codes for each PC. (***Note:*** *this will be handled manually by our technical support and may take several days*).

Why should I give you my personal details when I request the unlock code?

This will allow us to keep you informed about products, upgrades and services available for your system and software. It will also allow us to help you in case of a lost license.

How can I recover the unlock code after a disk crash or other system failure?

Once you have restored and reactivated your PC, reinstall the software. If it resumes operation in Evaluation mode, follow the procedure for obtaining an unlock code. Include a comment explaining why you need a new unlock code. (***Note:*** *this will be handled manually by our technical support and may take several days*).

How can I extend the evaluation period?

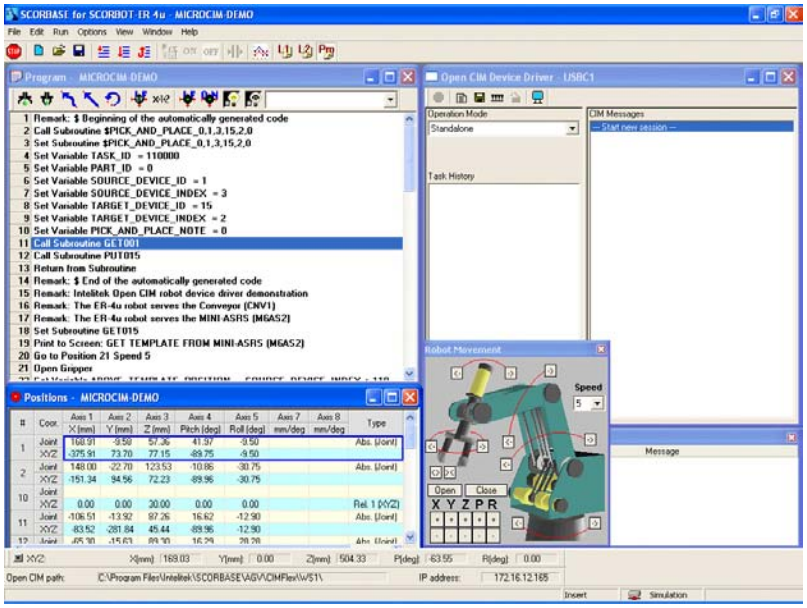
The 30-day evaluation period begins as soon as the software is installed. Reinstalling the software on the same PC will not renew the evaluation period.

Under certain circumstances we will extend your evaluation period. Use the Get unlock code option in the Registration dialog box to request a time extension. Be sure to send us your CD key, PC-specific code, and the reason for your request.

After approving your request we will send you an unlock code that will extend the evaluation period. When you receive the unlock code, do the following:

- Enter it in the Registration dialog box.
- Select the option to Extend the Evaluation Period.
- Select Unlock.

SCORBASE



Version 5.3 and higher

for
SCORBOT ER-4u
SCORBOT ER-2u
ER-400 AGV Mobile Robot

User Manual

Catalog #100342, Rev. G

February 2006

SCORBASE USER MANUAL

Catalog #100342, Rev. G

February 2006

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Table of Contents

1

Introducing SCORBASE

SCORBASE for SCORBOT ER-4u is a robotics control software package for robot programming and operation. SCORBASE for SCORBOT ER-4u provides numerous capabilities:

- Communication with the robot controller over USB channel.
- Control and real-time status display of five robot axes, gripper and two peripheral axes.
- Full support and real-time status display of eight digital inputs, eight digital outputs, four analog inputs, and two analog outputs.
- Position definition and display as well as manual robot movement in reference to Joint Coordinate System (encoder units).
- The Cartesian Coordinate System (X,Y,Z Pitch and Roll) is also used.
- Robot movement definition as Go to Position, Go Linear, or Go Circular, with ten active speed settings. (Availability depends on Experience Level setting.)
- Default setting of 1000 positions and 1000 active program lines.
- Interrupt programming for handling responses to changes in digital input status.
- Variable Programming, in three levels of complexity, to moderate the learning curve. This makes it possible for beginners to start at a lower level, and advance through the levels, as they become more skilled in robotics programming.
- Saving and loading projects.
- SCORBASE can be installed as part of RoboCell, an interactive graphic software package, which provides simulation of the robot and other devices in the workcell.

This manual describes all the features and operations for all Experience Levels of SCORBASE. When necessary, illustrations show the differences in the levels, and descriptions note the availability of options and commands.

2

Starting SCORBASE

The instructions in this chapter are for SCORBASE only.

If you intend to install SCORBASE as part of the RoboCell software package, follow the instructions in Chapter 2, Starting RoboCell, in the RoboCell User Manual.

System Requirements

SCORBASE for ER-4u computer requirements are:

- Pentium III with 450 MHz processor, or higher, equipped with CD drive.
- At least 128 MB of RAM.
- A hard drive with at least 60 MB of free disk space.
- Windows 98/2000/Me/XP.
- A Super VGA or better graphics display, minimum 256 colors.
- A Mouse or other pointing device.
- USB port.

Installing the Software

The SCORBASE software is supplied on a CD which also contains RoboCell. Close any open applications before proceeding with the installation procedures. If you are about to reinstall the software, or install a newer version to an existing SCORBASE directory, it is recommended that you back up any existing user-created files before you begin the installation. It is also recommended that you remove the previous SCORBASE version for Windows installation, using the software's Uninstall utility.

To install SCORBASE:

- Insert the CD into the CD-ROM drive to start the installation procedure.

- If the procedure does not start, either:
- From the Windows task bar, click Start | Run and type D:Setup (where D: is your CD drive), or
- Using Windows Explorer, explore the CD drive and click Setup.
- Wait until the Welcome window is displayed.

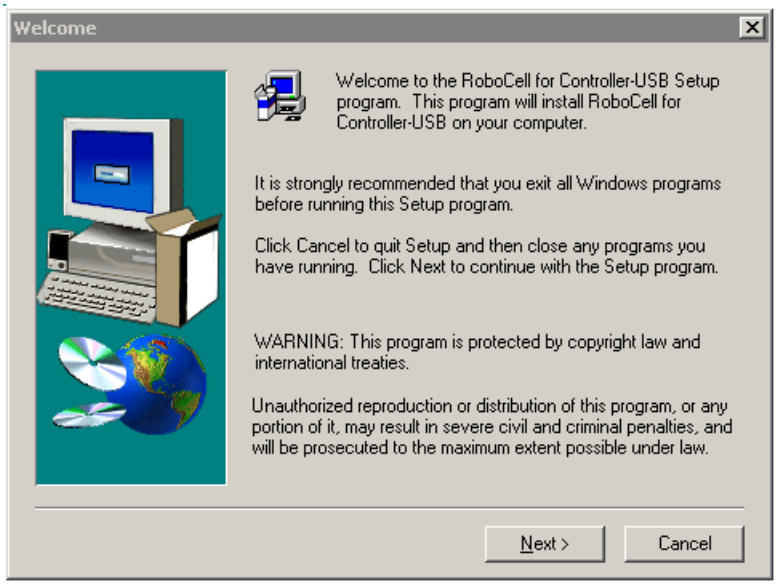


Figure 2-1: Welcome Window

- Click Next to open the Software Selection Window.

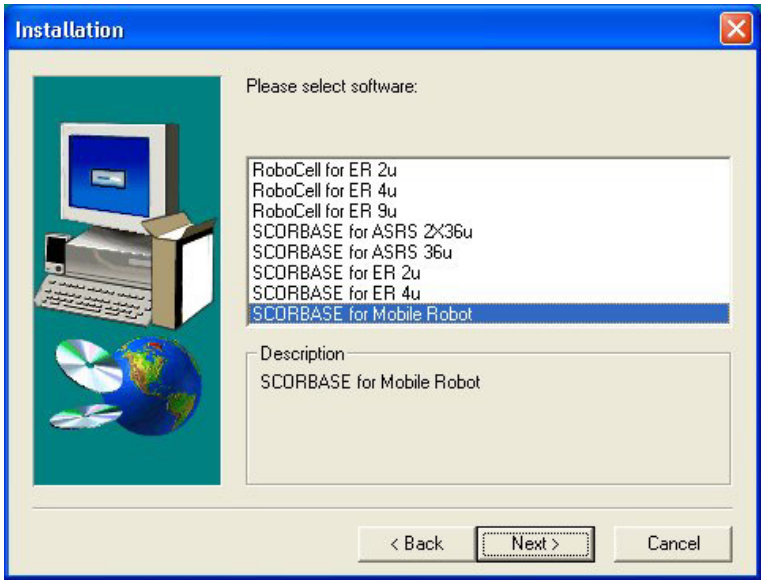


Figure 2-2: Software Selection Window

- Select RoboCell for ER 2u, RoboCell for ER-4u, SCORBASE for ER 2u or SCORBASE for ER-4u. The robot that you select becomes the default robot while you are working in SCORBASE, although you can choose to open a new project and work with a different robot. See the Hardware Setup option in the Options Menu.
- Click Next to open the License Agreement Window.

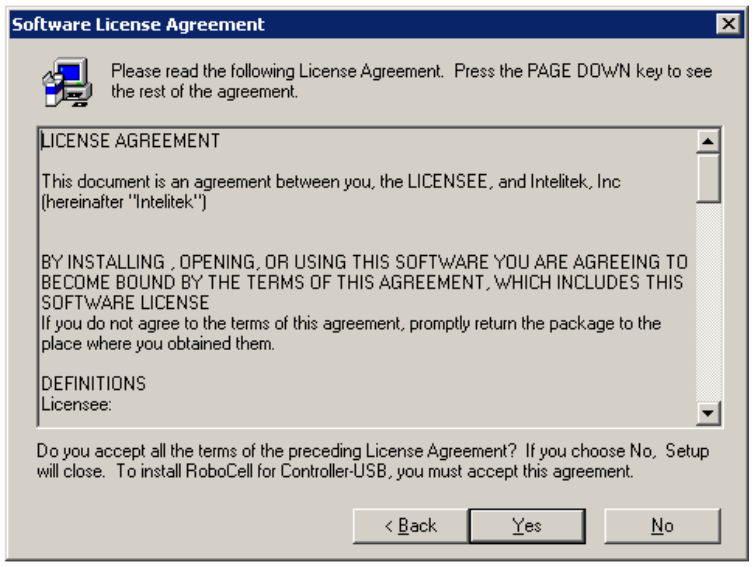


Figure 2-3: License Agreement Window

- Review the Intelitek software license agreement. You must accept the terms of this agreement in order to proceed with the installation. To accept, choose Yes. The Choose Destination window opens.

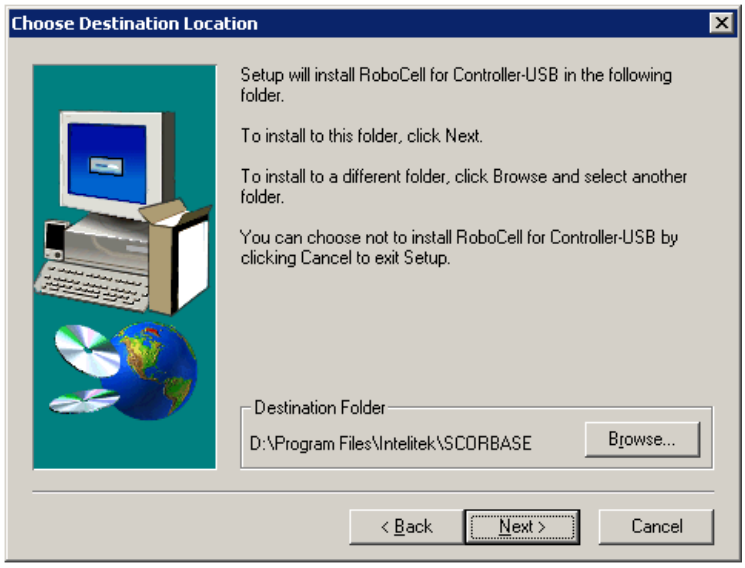


Figure 2-4: Choose Destination Window

- The default destination folder for the files is:
  \Program Files\Intelitek\SCORBASE
  Click Next to accept the default, or click Browse to select another folder and then click Next to open the Select Program Folder window.

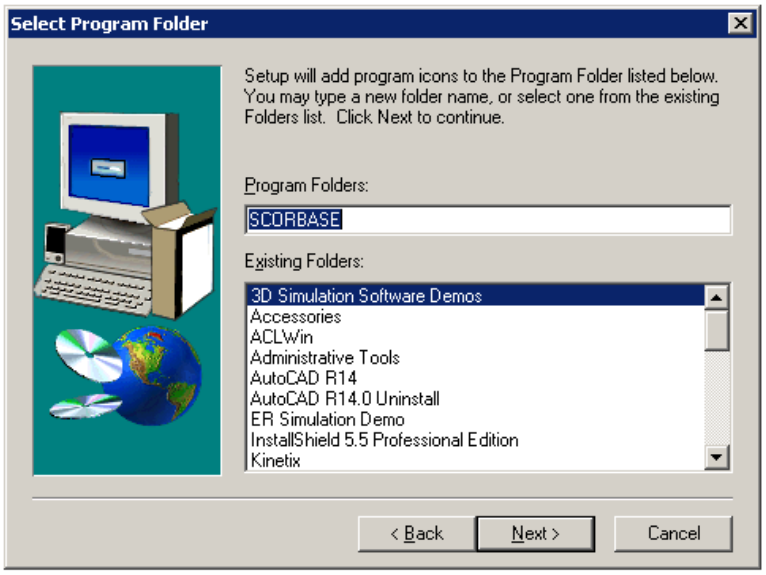


Figure 2-5: Select Program Folder Window

- In the Select Program Folder window you are requested to select the folder to which the program icons will be added.
- Click Next to complete the installation procedure.

Uninstalling the Software

To uninstall SCORBASE:

1. From the RoboCell program group, select Uninstall.
2. Follow the instructions which appear on the screen.

Starting SCORBASE

To start SCORBASE:

1. Make sure that all the components to be used are installed and connected according to the installation procedures detailed in the User Manuals supplied with the robot and controller.
2. Turn on the computer and the controller.
3. Select Start | Programs | SCORBASE for ER-4u.

4. Select the SCORBASE for ER-4u command. After initialization, the following screen appears:

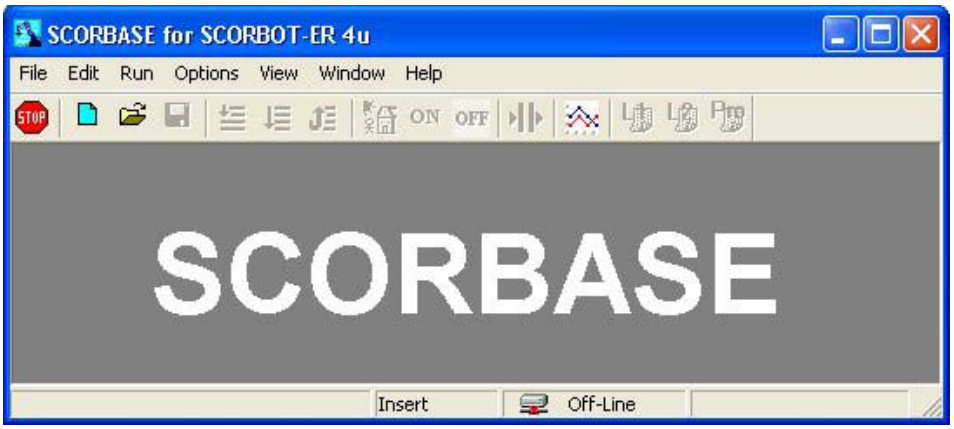


Figure 2-6: SCORBASE Opening Screen

If SCORBASE opens in Off-line mode or the controller is not detected, the program will load and operate in Off-line mode.

Only one instance of SCORBASE can be active at a time.

Quitting the Software

Stop the SCORBASE program (if running). If you have unsaved changes in the project, SCORBASE prompts you to save the changes before closing.

To close SCORBASE (or its components), do any of the following:

- From the Menu Bar, select File | Exit.

5. Click the Close box in the SCORBASE Title Bar.

- Press [Alt]+F4.

See page 9.

3

Menus Overview

The SCORBASE Window

Figure 3-1 shows the SCORBASE opening screen which comprises:

- A Title Bar containing the screen name and the usual Windows controls for sizing and closing the application screen.
- A Menu Bar containing all SCORBASE command menus and options.
- A Toolbar containing icons for the most commonly used options.
- A Status Bar displaying information regarding the SCORBASE software, modes of operation, current activity, etc. When you position the mouse over an icon, a description of the icon appears in the status bar.

Note: The System menu (displayed by right clicking the Title Bar) contains the **Always on Top** menu item, enabling you to display the application on top at all times.

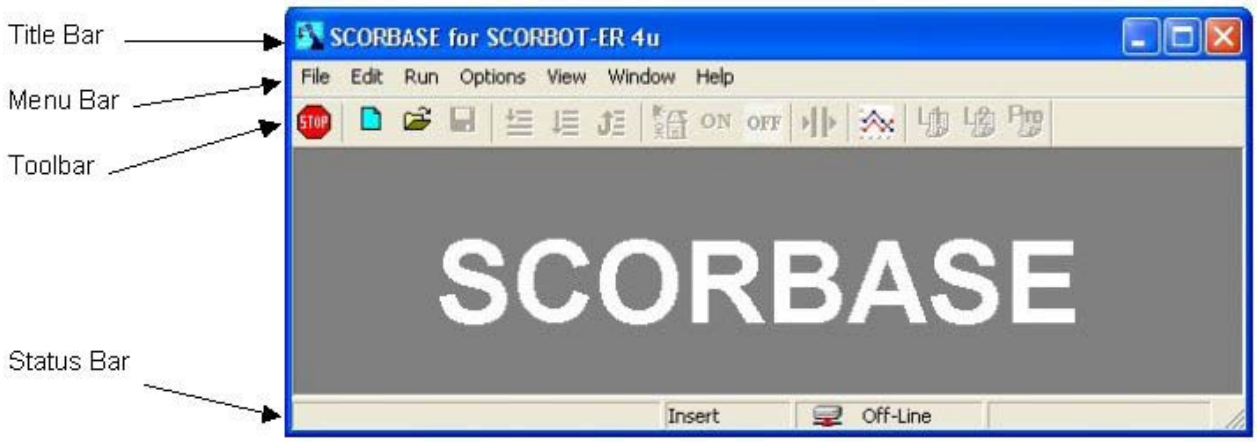


Figure 3-1: SCORBASE Window

File Menu

A SCORBASE project contains a program (SBP file), user-defined positions (PNT file), and a project data file (WS file). If RoboCell is also being used, the project includes the cell image (3DC file). Throughout this manual, the term "project" refers to the program positions (and image) files saved by the user as one entity.

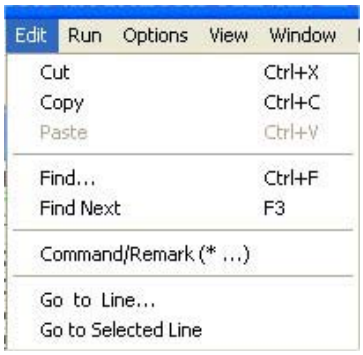
The File menu contains the usual Windows functions that allow you to open new or previously saved projects, save and close projects. You can print files containing robot programs and positions, and exit the software.

The File menu options are:

New Project (Ctrl+N)	Opens a new, untitled, project. See page 84.
Open Project (Ctrl+O)	Opens the Load Project window which lists SCORBASE files (without a virtual cell).
Save Project (Ctrl+S)	Saves the currently active project (program, positions and graphics).
Save Project As...	Saves the currently active project under a new project name.
Close Project	Closes the currently open project.
New Script	Opens Notepad.
Open Script	Opens File Selector box for opening an existing Visual Basic script file.

Print Program	Prints the program. (Program window must be active).
Print Positions	Prints the user-defined positions. (Positions Window must be active)
Print 3D Image	Reserved for RoboCell program option.
Print Preview 3D Image	Reserved for RoboCell program option.
Print Charts	Opens a dialog box to select the specific axis chart for display or printout. Only one axis can be selected at a time. See page 17.
Print Preview Charts	Displays the selected axis chart before printout.
Import 3D Model	Reserved for RoboCell program option.
Edit 3D Model	Reserved for RoboCell program option.
View File	Enables you to view a file from those listed: • Graphic module files (*.3DC) • SCORBASE programs (*.sbp) • Position data (*.pnt) When you select a file, a window opens displaying that file.
Exit	Closes SCORBASE. If changes to a program or position file have been made but not yet saved, a message appears giving you the opportunity to save the file before you exit SCORBASE.

Edit Menu



The Edit menu contains the usual Windows functions that allow you to edit program files.

Cut (Ctrl+X)	Deletes selected text or lines from the program lines, and places it on the Windows and SCORBASE clipboards. See page 41.
Copy (Ctrl+C)	Places a copy of selected text or lines from the program lines on the Windows and SCORBASE clipboards. See page 41.
Paste (Ctrl+V)	Inserts the contents of the SCORBASE clipboard into the program lines. See page 41.
Find (Ctrl+F)	Opens a dialog box that allows you to search for a particular text string, SCORBASE command, or command argument. See page 41.
Find Next	Repeats the last Find operation for the next occurrence. See page 41.
Command/Remark (*…) (Ctrl+R)	Inserts/deletes asterisk at beginning of a SCORBASE program command line. This action toggles the command line between a remark and an executable command. See page 41.
Go to Line	Opens a dialog box that displays the total number of lines in the program, and prompts you for a line number. The program editor jumps to the line you specify. See page 41.
Go to Selected Line	Display the line selected. Useful for long programs. See page 41.

Run Menu

The Run menu contains SCORBASE commands for homing the robot and peripheral axes (see Chapter 4, page 21), and executing programs.

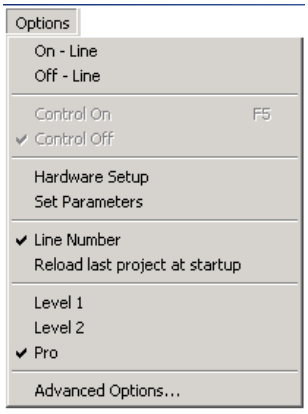
Note: If the software is operating Off-line, only the Run program options are available in this menu.

Search home - all axes	Homes both the robot and any configured peripheral axes. See page 22.
Search home – robot	Homes the robot. This command is available only if the system has been homed once, after opening SCORBASE. See page 23.
Search home – peripherals	Homes the peripheral. This command is available only if the system has been homed once, after opening SCORBASE. See page 23.
Go home – all axes	Sends the robot and peripherals to their home positions. See pages 22 and 23.
Go home - robot	Sends the robot to its home position. This command does not home the robot. See pages 22 and 23.
Go home – peripherals	Sends the peripherals to their home position. This command does not home the peripherals. See pages 22 and 23.
Run single line (F6)	Executes the selected (highlighted) program line. See page 78.
Run single cycle (F7)	Executes the program from the selected (highlighted) program line to the end of the program. 78.

	Run continuously (F8)	Executes the program from the selected (highlighted) program line. When the last program line is reached, the program starts again from the first line. See page 78.
	Stop (F9)	Immediately stops program execution and movement of all axes. See page 79.
	Pause (F10)	Stops program execution after the current line is executed. See page 79.

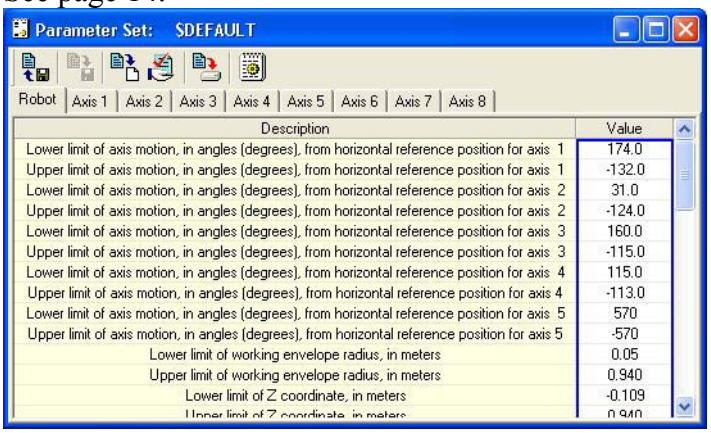
Note: Pause and Stop are software methods for halting program execution. In an actual emergency situation, you should use the EMERGENCY button on the controller or the ABORT key on the Teach Pendant.

Options Menu



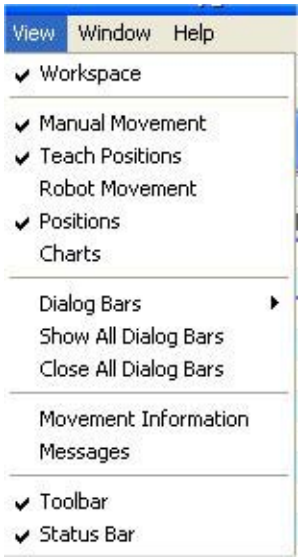
The Options menu allows you to define your preferences for operating the software.

On-Line	Establishes communication with the controller. See page 23.
Off-line	SCORBASE does not communicate with the controller, even though it may be connected. Off-line mode is useful for checking and debugging programs. See page 23.
 Control On *(F5)*	Enables servo control of the axes. See page 24.
 Control Off	Disables servo control of the axes. See page 24.
Hardware Setup	Opens the Hardware Setup dialog box where you can define the peripheral devices which are connected and operated by the controller as axes 7 and 8.

	Set Parameters	Opens the Parameter Set Window (see Figure 10-12 and Figure 10-13). You have to activate Advanced Commands before can you utilize Set Parameters. See page 14.  *Figure 3-2: Parameter Set Window* Parameters can be set for the robot and for each one of the eight axes. Select the appropriate tab and set the desired parameters.
	Line Number	Shows/hides program line numbers in the program window.
	Reload Last Project at Startup	When checked, opens the last project saved when SCORBASE is started.
	Level 1	Displays list of commands and options at introductory level. Commands related to Level 2 and Pro are disabled. See page 99.
	Level 2	Displays list of commands and options at advanced level. Commands related to Pro are disabled. See page 99.
	Pro	Displays list of all commands and options. See page 99.

Advanced Options	Opens a dialog box in which these options are available: • Advanced Commands (See page 41). • ViewFlex Commands (see the ViewFlex User Manual).  *Figure 3-3: Advanced Options Dialog Box* When one or both options are checked, the corresponding commands (Advanced Commands and Vision Commands) are listed under the Command tab of the Workspace Window.

View Menu



The options in the View menu allow you to show/hide SCORBASE dialog bars and windows.	
Workspace	Shows/hides the Workspace Window. Through this window, the user can access the project files and the SCORBASE commands tree. See page 41.
Manual Movement	Shows/hides the Manual Movement Dialog Box. This box enables manual control over the movements of the robot, the gripper and peripheral axes.

Teach Positions	Shows/hides the Teach Positions Dialog Box. This box enables recording, teaching and deleting positions. It also enables the user to send the robot and/or peripherals to a previously defined position. The functions available depend on the current Experience Level setting.
Robot Movements	Opens the Robot Movement Dialog Box. Pressing on a selected axis moves it in the selected direction.
Positions	The Positions Window displays the positions of the currently open project. The list is presented in tabular format.
Charts	Opens Charts.
Dialog Bars	Toggles the display of seven dialog bars that enable the following: • *Joints* – Displays the robot's joints angle (five joints). • *XYZ* - Displays the robot tool center point (TCP) position and orientation. The coordinate system origin is at the center of the robot base at table level. • *Digital outputs* - Displays the status of digital outputs 1-8 (dark green - off; light green - on). Click on an output to show/hide its status. • *Digital inputs* - Displays the status of digital inputs 1-8 (dark green - off; light green - on). In *Off-line* clicking on input toggles its status. • *Analog outputs* - Displays the value of analog output 1&2 (0-255)-(0-10 volt). • *Analog inputs* - Displays the value of analog input 1-4 (0-255). In *Off-line* you may set the analog input value. • *Encoders* – Displays the encoder counts of axes 1-8. (Encoders are zeroed after homing the system.) See pages 39 and 80.
Show All Dialog Bars	Displays all seven dialog bars.
Close All Dialog Bars	Closes all seven dialog bars

Movement Information	Displays the following data: • Position error of eight axes in encoder counts • Home switch status of all eight axes *PWM for one selected axis. The PWM (Pulse Width Modulation) is the controller output for the selected axis motor.*
Messages	*Opens the Messages Window.* The data displayed in the Messages window is printed using the PS (Print to Screen & Log) commanding SCORBASE.
Toolbar	Shows/hides the programming toolbar (default on).
Status Bar	Shows/hides the lower status bar (default on).

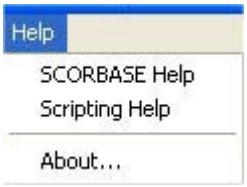
Window Menu

The Window menu enables you to select the desired window layout options.

Simulation & Teach	Sets the screen to display the RoboCell window and dialog bars required to define positions. This is disabled in SCORBASE.
Teach & Edit	Opens Program Window, Workspace Window, Manual Movement Window and Teach Position Window.
Run Screen	Displays the Program Window, together with its toolbar.
Project Screen	Displays the Program Window and Positions Window.
Open CIM Screen	Displays Program Window, Open CIM Device Driver Window, and CIM Messages Window.
User Screen	This allows the user to customize the screen layout according to personal preference.

Save User Screen	This saves the User Screen layout for later recall with the User Screen command.
[Project Name]	Displays the file name of the open project.

Help Menu



The Help menu options:	
SCORBASE Help (F1)	Opens SCORBASE on-line help.
Scripting Help	Opens help files for Visual Basic scripting.
About	Shows the SCORBASE software version.

Charts

SCORBASE charts can be configured to display the following data (Y-axis) vs. time (X-axis).

- Encoder counts (axis position), represent the actual axis position. The encoder counts are shown in a blue line.
- Position error is the difference between the required axis position and the actual axis position. The error is expressed in encoder counts and shown in a red line.
- The PWM value represents the controller output. The error and the axis control parameters determine the PWM value shown in a green line.

The data for each axis (1-8) is shown in a different chart. Sample charts for axes 1 and 2 are shown in Figure 3-4.

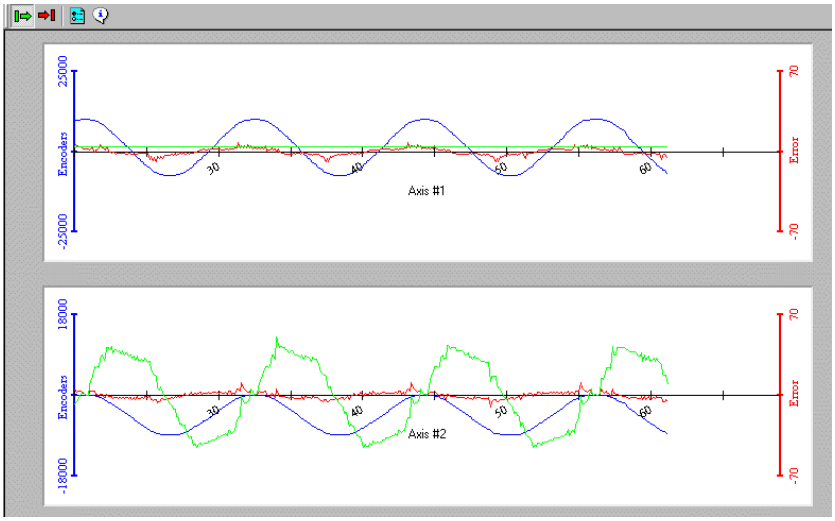


Figure 3-4: Chart for Two Axes

To open the Charts window, do one of the following:

- Click the Charts icon in the toolbar  .
- Select View | Charts.

The following options are available in the Charts window toolbar:

	Start chart	Starts drawing the chart.
	Stop chart	Stops drawing the chart.

Options	Opens the Chart Options dialog box where you can select the data to be displayed in the chart(s).

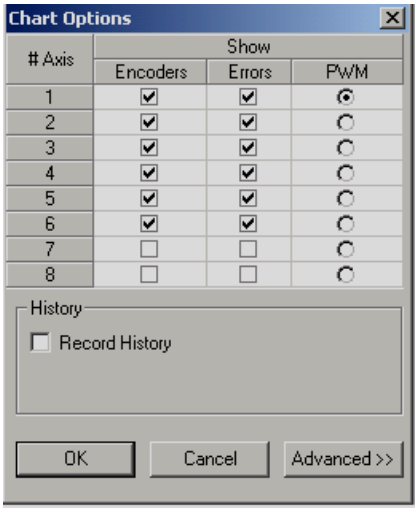


Figure 3-5: Chart Options Dialog Box

Click the data that you want displayed in the charts.

The example shown in Figure 3-5 results in the display of the Encoder, Error and PWM of axis 1, as well as the display of the Encoder and Error for axes 2 through 6. Since each axis is shown in a different chart, six charts will be displayed.

Any chart can be saved to a history (*.his) file. To do so:

- Check the Record History box.
- Click the Browse button (which becomes available) to open the window.
- Select the folder and enter the name of the file to be saved.

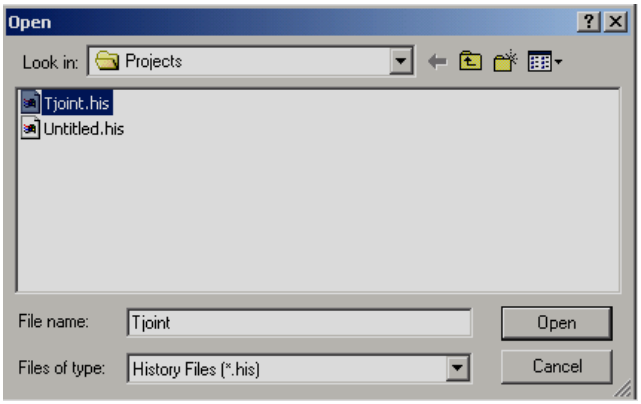
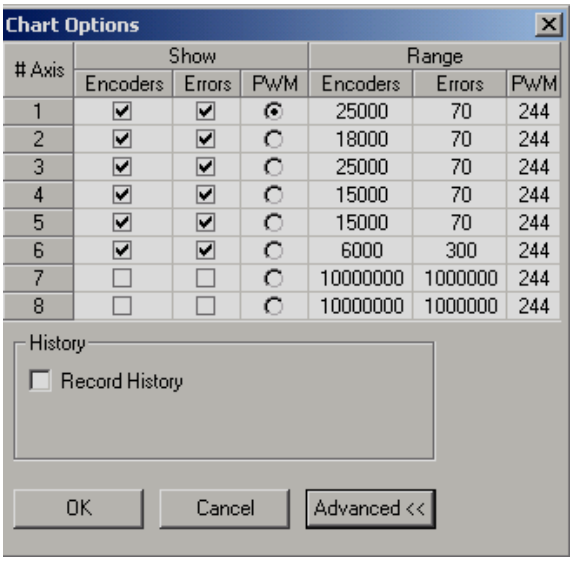
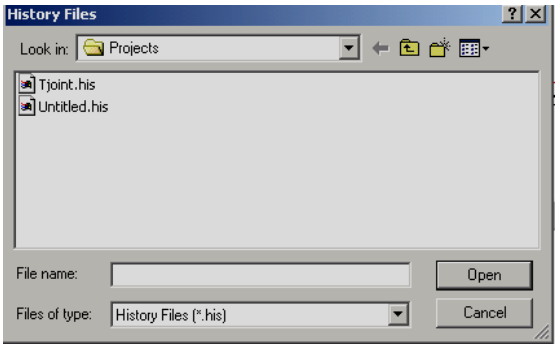


Figure 3-6: Open Project Dialog Box

		To set the resolution of the chart for the Encoder, Errors and PWM: • Click the Advanced button in the Chart Options dialog box. The Range column opens.  *Figure 3-7: Chart Options Dialog Box*
	History	Opens the History Files Window. Select the desired history (*.his) file from the list or browse to locate it.  *Figure 3-8: History Files Window* ***Note**: To open a history file you must first stop drawing the chart.*
	Legend	Displays the colors used in the charts for Encoder, Error and PWM. *Encoders* – Blue *Error* – Red *PWM* – Green

4

Homing and Control

General

The robot and peripheral axes location is monitored and controlled using encoders. To initialize the encoders and to obtain repeatable performance the axes must first reach a predefined position known as *hard home*. All recorded positions and movements refer to the hard home position. The homing procedure finds the hard home for the selected axes.

SCORBASE offers two commands relating to the home position.

- Search Home is the procedure for homing. During Search Home, each axis is homed separately. The controller activates the currently homed motor axis, until its micro-switch is pressed. Then the controller initializes the axis encoder counter and turns to home the next axis. After all configured axes are homed, the homing procedure ends.
- Go Home sends the selected axes to a position where the encoders' value is zero. *Note: This command does not home the axes.*

The two commands are available in three levels:

- Search / Go home all (applies for all active axes)
- Search / Go home robot (applies for the robot)
- Search / Go home peripherals (applies for axes 7 & 8).

Homing

Search Home All Axes

To start the homing procedure, do one of the following:

- Select Run | Search home - all axes.
- Click the Search Home  icon.

A window opens displaying the number of the axis currently being homed. Each time an axis is successfully homed, a checkmark appears next to the axis number. After the five axes and the gripper have been homed, a checkmark appears next to Robot.

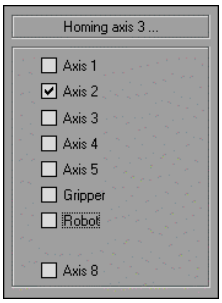


Figure 4-1: Homing Status Window

To abort homing while the procedure is still in progress, do one of the following:

- Press [F9] (Stop command)
- Press the red EMERGENCY button on the controller.
- Press the EMERGENCY key on the Teach Pendant.

If the homing procedure fails, a message appears.

The Search Home - All Axes command executes the robot's homing procedure as well as that of any peripheral devices that have been configured in the Options | Peripherals Setup menu. The command is available only when SCORBASE is On-line for the first time.

If the system has already been homed and you change SCORBASE to Off-line mode, there is no need to home the system again when you return to On-line mode.

When SCORBASE is in Off-Line Mode, or when RoboCell is installed, the homing procedure is not required, although it can be executed. The homing procedure initializes Joint and XYZ values according to a software definition.

All encoders are set to 0, while the robot Cartesian coordinates are set according to a software model.

Search Home - Robot

This command runs the homing procedure for the robot. Homing of the peripherals is enabled only after the system has been homed once.

Search Home - Peripherals

This command runs the homing procedure for the configured peripherals. Homing of the robot is enabled only after the system has been homed once.

Go Home Command

Go Home All Axes – Robot – Peripherals

After the axes have been homed, select Run | Go Home - All Axes to send the axes back to their home position at any time. This command sends the robot and peripherals to a position where the axes encoders value equals zero. The Go Home command does not run the homing procedure.

Selecting the Go Home - Robot or Go Home - Peripherals command sends the selected axis to its home position.

On-Line Mode / Off-Line Mode

SCORBASE can run either in On-line or in Off-line mode. In On-line mode, SCORBASE communicates with the controller over the USB channel. If the Control On state is selected, SCORBASE controls the robot, peripherals and I/O device. In Off-line mode, SCORBASE can be used only in the Control Off state (useful for programming and debugging). The active mode is displayed in the status bar.

To change to On-line, select Options | On-line.

To change to Off-line, select Options | Off-line.

If SCORBASE is opened in On-line, or On-line is selected from the Options menu, this message appears as SCORBASE searches for the controller:

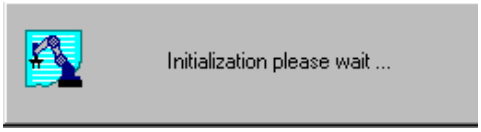


Figure 4-2: Controller Search Status Window

If the controller is detected, On-line mode is activated.

If the controller is not detected, Off-line remains the active mode.

Control On / Control Off – CON/COFF

The Control On state enables servo control of the axes. This state is available only in On-line mode. In the Control Off state, axis movement commands cannot be executed. The Control state (On or Off) is displayed in the lower right corner of the status bar.

To enable control of the axes, do one of the following:

- Select Options | Control On.
- Click the Control On icon. 

- Press the F5 key.

To disable control, do one of the following:

- Select Options | Control Off
- Click the Control Off icon. 

If you have disabled control and SCORBASE opens in On-line mode, or On-line mode is selected after detection of the controller, this prompt appears:

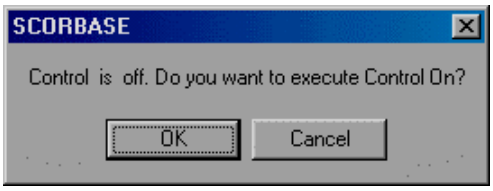


Figure 4-3: Control On Confirmation Dialog Box

Press OK to enable control or press Cancel to remain in the Control Off state.

The controller automatically disables control if an impact condition, trajectory error or thermic overload error occurs during execution of a movement command. If you attempt to move the axes when control is disabled, this error message appears:

Figure 4-4: Axis Move Error

When SCORBASE is in Off-line mode, the Control On/Off state cannot be altered.

5

Position Definition

Every SCORBASE project includes a set of pre-defined positions and a program that sends the robot from one position to the other. Prior to running a program all the positions used in that program should be defined. SCORBASE offers various tools to define and store positions that will be used in the programs.

The following SCORBASE tools are used in the position definition process.

- Manual Movement Dialog Box
- Teach Positions Dialog Box
- Robot Movement Dialog Box
- Position Data Dialog Bars
- Positions Window

To activate the dialog boxes which are most useful for position definition, select Window | Teach & Edit.

Any of the following four methods can be used for position definition:

No.	Method	Level
1	Absolute position Joint coordinates	1, 2, Pro
2	Relative position Joint coordinates	2, Pro
3	Absolute position Cartesian coordinates	2, Pro
4	Relative position Cartesian coordinates	2, Pro

Note: Peripheral position definition can only be performed in the Pro level.

Joint and Cartesian Coordinate Systems

Defining a position in SCORBASE can be done by using either the Joint or Cartesian coordinate systems. In both systems, a robot position is defined using five parameters derived from the data supplied by the five axes encoders. An encoder is an angular movement sensor attached to the axes motor.

A Peripheral position is always defined using one variable that stores the sensor output (encoder value) of that position.

Joint Coordinate System

A robot position in Joint coordinates is defined by five angle values, representing each angle of the joints. The joint names are Base, Shoulder, Elbow, Pitch, and Roll.

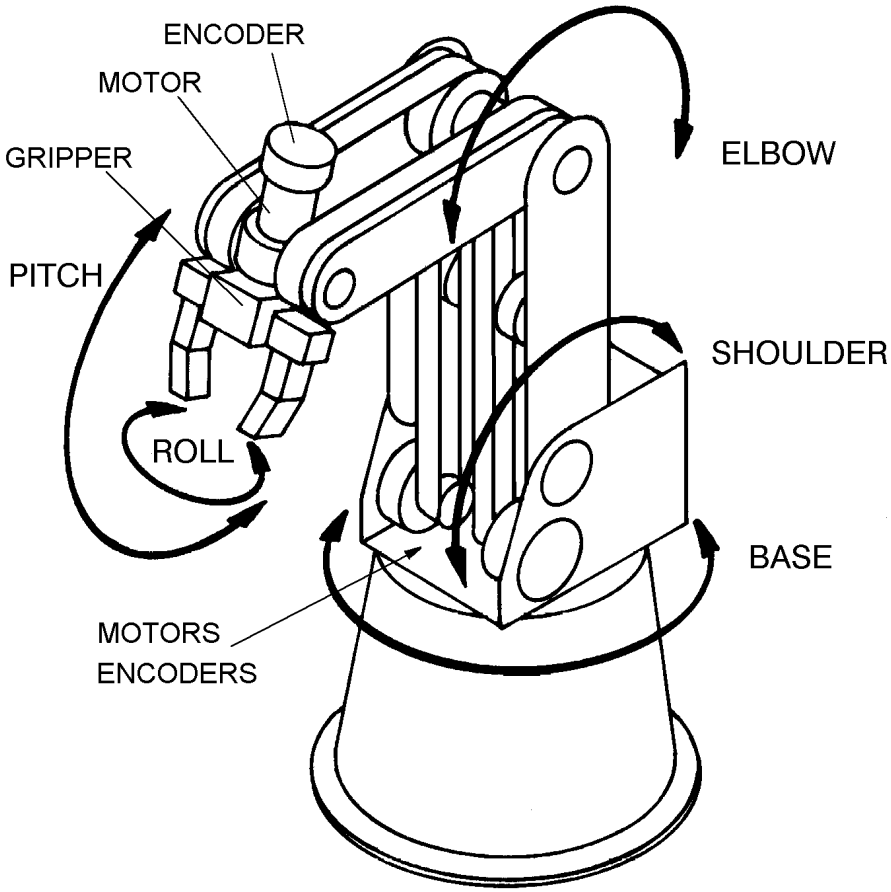


Figure 5-1: Robot Joints

For example, after homing, the robot position in Joints coordinates is:

Axis #1 - Base = (0°)

Axis #2 - Shoulder = (–120°)

Axis #3 - Elbow = (~95°)

Axis #4 - Pitch = (~88°)

Axis #5 - Roll = (0°)

Cartesian Coordinate System (XYZ)

A robot position in Cartesian (or XYZ) coordinates is defined by these parameters.

- The distance of the robot's Tool Center Point (TCP) from the point of origin (the center bottom of the robot base), along the three axes that describe three-dimensional space (X,Y,Z).
- The Pitch (P) and Roll (R) angles of the gripper, specified in angular units.

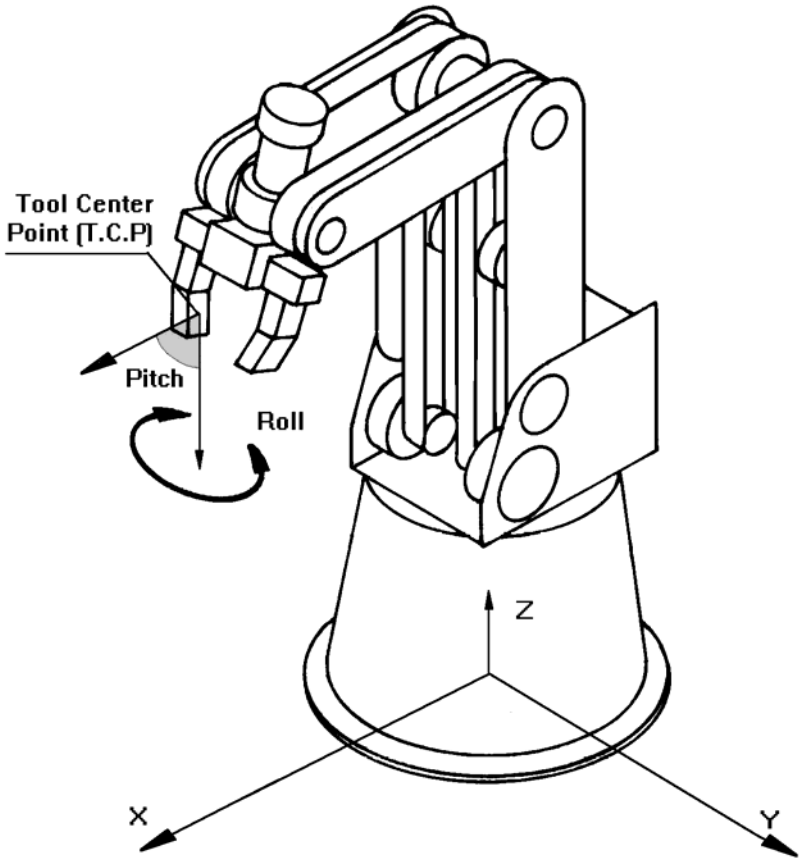


Figure 5-2: Tool Center Point in Cartesian (XYZ) Coordinates

For example, after homing, the robot position in Cartesian coordinates is defined as:

X = (~169) [mm]

Y = (0) [mm]

Z = (~503) [mm]

Pitch = (~-63°)

Roll = (0°)

A position recorded in one coordinate system can be converted by SCORBASE to another coordinate system.

Absolute and Relative Positions

SCORBASE offers two methods of defining a robot or peripheral position: Absolute and Relative. The two methods are applicable in Cartesian and in Joint coordinates.

An *absolute* position is defined using all five robot position parameters. If the Joint coordinate system is used, the robot position is defined using the Base, Shoulder, Elbow, Pitch, and Roll angles. In the XYZ coordinate system, a position is defined using the X, Y, Z values in millimeters, and the Pitch and Roll angles in degrees. An absolute position is usually a fixed position in world space.

A *relative* position is a position whose coordinates are defined as an offset from a *reference position* coordinates. If the coordinates of the reference position change, the relative position moves along with it, maintaining the same offset. A relative position can be defined in either Cartesian or Joint coordinate values.

A position can also be defined as *relative to current*. In this case, the relative position is calculated as an offset from the coordinates of the current robot position.

Record and Teach

Although the terms *teach* and *record* are often used interchangeably, SCORBASE makes the following distinction:

Record position: defines a robot position in a Joint coordinates system.

Teach position: defines a robot position in a Cartesian coordinates system.

Manual Movement Dialog Box

Recording a robot position (in Joint coordinates) is done by manipulating the robot to the required position and then recording it. The Manual Movement dialog box allows direct control and manipulation of the robot and peripheral axes.

The Manual Movement dialog box is automatically opened when a project is opened, or when the Window | Teach & Edit display setting is selected.

To open the Manual Movement dialog box when there is no open project, select View | Manual Movement.

Figure 5-3: Manual Movement Dialog Box (Joints)

Note: Axis 6 is not applicable for SCORBOT ER-2u. Axes 7 and 8 are only applicable when defined using the Options | Hardware Setup dialog box.

The following chart explains how clicking the buttons in the Manual Movement dialog box (or pressing the corresponding keys on the keyboard) controls the robot and peripheral movements.

Joints — When Joints is selected, clicking the buttons (or pressing the corresponding keys on the keyboard) moves one robot axis at a time, as described below:

Keys	Joint Motion
1 / Q	Rotates the BASE right and left.
2 / W	Moves the SHOULDER up and down.
3 / E	Moves the ELBOW up and down.
4 / R	Moves the wrist (PITCH) up and down.
5 / T	Rotates the wrist (ROLL) right and left.
6 / Y	Opens and closes gripper via servo control.
7 / U	Moves peripheral axis #7 (if connected).
8 / I	Moves peripheral axis #8 (if connected).

Figure 5-4: Manual Movement Dialog Box (XYZ)

XYZ

When XYZ is selected, clicking the buttons (or pressing the corresponding keys on the keyboard) moves the TCP, as described below.

Movements in XYZ mode are sometimes a combination of simultaneous movements of a few axes.

Keys	XYZ Motion
1 / Q	TCP moves along X-axis (back and forth).
2 / W	TCP moves along Y-axis (right and left).
3 / E	TCP moves along Z-axis (up and down).
4 / R	Axes move in order to change the gripper's pitch angle; the TCP position does not change.
5 / T	The gripper rolls; the TCP position does not change.

Open Gripper	Completely opens the gripper.

Close Gripper	Completely closes the gripper.

The robot can be manipulated from the Manual Movement dialog box before it has been homed in Joint mode only. In fact, it is often necessary to bring the robot into a more suitable position before initiating the homing routine. However, an axis limit error message may appear during manipulation of a robot that has not been homed.

Movement of an axis continues as long as the button or key is pressed, or until a software or hardware limit is reached.

Robot Movement Dialog Box

The Robot Movement dialog box enables control over the robot in XYZ and Joint modes.

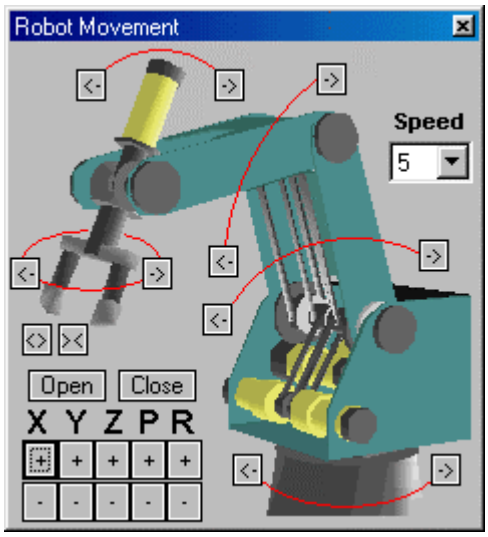


Figure 5-5: Robot Movement Dialog Box

Clicking on an axis image or the XYZPR buttons moves the robot as described above at Manual Movement Dialog Box.

To open the Robot Movement dialog box, select View | Robot Movement.

Teach Positions Dialog Box

The Simple/Expanded Teach Positions dialog box enables the following:

- Teaching positions (in Cartesian coordinates).
- Recording positions (in Joint coordinates).
- Sending the axes to the recorded positions (when program is not running).
- Go to Position
- Go Linear
- Go Circular

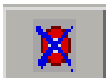
To display the description of the function of each icon in the Teach Position dialog box, simply place the mouse on the desired icon without clicking a mouse button.

The user can define 1,000 positions. A higher computer (CPU and memory) can hold more positions.

Simple (Level 1)

Figure 5-6: Teach Positions Dialog Box (Simple), Level 1

The Teach Positions (Simple) dialog box offers the following options:

Position Number		1, 2 & Pro	A numerical name for position.
	Record	1, 2 & Pro	Records the current robot position (in joint coordinates) to the position displayed in the position number field.
	Delete	1, 2 & Pro	Deletes from memory the position in the position number field.
	Go to Position	1, 2 & Pro	Executes the Go to Position command, which sends the robot's TCP (Tool Center Point) from its current position to the selected position.
Speed		1, 2 & Pro	Selects the speed for all movement commands. 10 fastest, 1 slowest, 5 default.

Simple (Advanced Level)

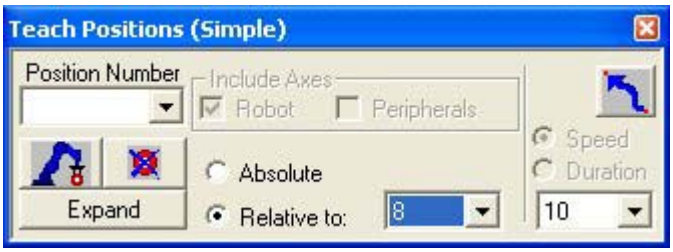


Figure 5-7: Teach Positions Dialog Box (Simple) for the Level 2 (Advanced) user.

At the Advanced level, the Teach Positions dialog box offers all the commands available at Level 1, and also all of the following:

Expand	2 & Pro	Opens the Teach Positions (Expanded/Simple) dialog box.

Absolute / Relative to	2 & Pro	Defines positions either as absolute or relative to another position. When Relative to is selected, a Relative to field appears. Select either an existing position or Current. A position that is Relative to Current means that the reference position is the robot position at the time it is sent to that position. Relative to is only available to Level 2 and Pro.

Expand (Advanced and Pro Levels)

Click Expand to open the Teach Positions (Expanded) dialog box:

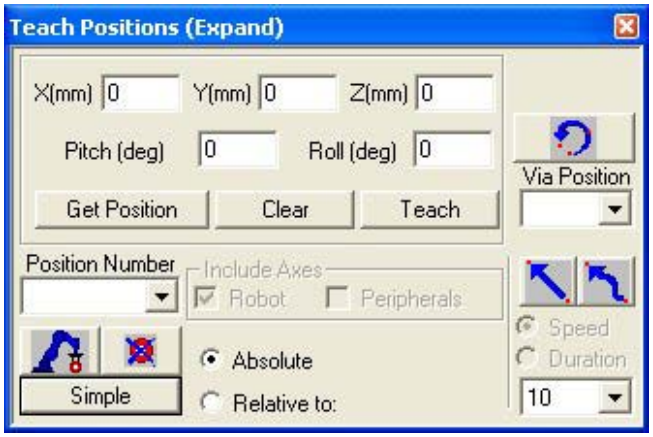


Figure 5-8: Teach Positions (Expand) Dialog Box for Level 2 (Advanced) user

X(mm), Y(mm) Z(mm), Pitch(deg), Roll(deg)	Fields for displaying or changing the Cartesian coordinates of the selected position. See page 27.
Get Position	Displays the Cartesian coordinates of the selected position. See page 27.
Clear	Clears all position coordinate fields. The position data does not change.
Teach	Teaches position using the Cartesian Coordinate System.
 Go Circular	Executes the Go Circular to Position command. This command sends the robot in a circular path to the target position (in the position number field), via the position specified in the Via position field. The circular motion applies only to the robot.

Via position	Selects the intermediate position through which the Go Circular movement passes.
Go Linear to Position	Executes the Go Linear to Position command. Sends the axes in a straight line to the selected position.
Simple	Toggles to the Teach Position (Simple) dialog box.

Simple (Pro Level)

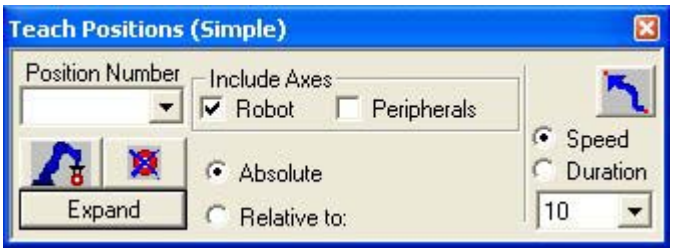


Figure 5-9: Teach Positions (Simple) Dialog Box (Pro Level)

At the Pro level, the Simple Teach Positions dialog box offers the following additional commands:

Include Axes	Pro	Instructs the controller to define coordinates for axes for Robot, Peripheral or both. A peripheral position can be recorded only in the Pro level.
Duration	Pro	Defines the time it takes to complete a movement command. The time is defined in tenths of a second. For further information, See page 47.

These commands remain available when the Teach Positions dialog box is expanded.

Recording Positions (Joint Coordinates)

Record Absolute Position (Levels 1, 2 & Pro)

To record an absolute position:

1. Use either the Manual Movement dialog box or the Robot Movement dialog box to move the robot to the position you want to record.
2. Click on the Teach Position dialog box.
3. Type a position number in the Position Number field, or select an existing position number if you want to modify (overwrite) a previously defined position.
4. Select Absolute.
5. Select Include Axes (Robot or Peripherals):
   a. Robot: to record a position for the robot axes.
   b. Peripherals: to record a position for the peripheral axes (Pro level only).
   c. The user can select both.
6. To record the current position, click the Record Position icon.

Record Relative Position (Pro Level)

To record a relative position:

1. Make sure you have first defined a reference position.
2. Move the robot to the position whose coordinates you want to record as relative to another position.
3. In the Position Number field in the Teach Positions (Simple) dialog box, enter a new position number.
4. Select Relative to, and enter a number (or select Current) for the reference position in the Relative to field.
5. Click Record. You have now recorded a relative position.

A position that is Relative to Current means the specified offset will be computed from the location at which the robot is positioned at the time it is sent to the relative position. If the reference position changes, the relative position also moves.

Teaching Positions (XYZ Coordinates)

In order to teach a position in XYZ coordinates, click Expand. See page 27.

Teach Absolute XYZ Position (Levels 2 & Pro)

To teach an absolute XYZ position

1. Click Expand.
2. Enter XYZ, Pitch and Roll values.
3. Click Teach.

To use existing position coordinates to define a new position (or modify that position's coordinates), do the following:

1. In the Position Number field in the Teach Positions dialog box, select an absolute position number.
2. Click Get Position. The XYZPR values of the position now appear in the XYZ, Pitch and Roll fields. ***Note:*** *If the position is relative, only the offset values will be displayed*.
3. In the Position Number field, enter a different number (or leave the position number if you want to modify that position).
4. To record a position for the robot axes, click Robot.
   To record a position for the peripheral axes, click Peripherals.
   To record positions for both, click Robot and Peripherals.
5. In one or more of the coordinate fields, enter a new value (in millimeters or degrees).
6. Click Teach.

Warning: If you click Record, the current TCP coordinates will be written to the selected position.

Teach Relative XYZ Position (Levels 2 & Pro)

To record a relative XYZ position:

Make sure you have first recorded the reference position.

1. In the Position Number field, in the Teach Positions dialog box, enter the new position number.
2. Select Relative to, and enter the number of the reference position in the Relative to field. All XYZ coordinate fields are blank or show 0.
3. In one or more of the coordinate fields, enter a new value (in millimeters or degrees).
4. Click Teach.

A position that is relative to current means the specified offset will be computed from wherever the robot is located at the time it is sent to the relative position.

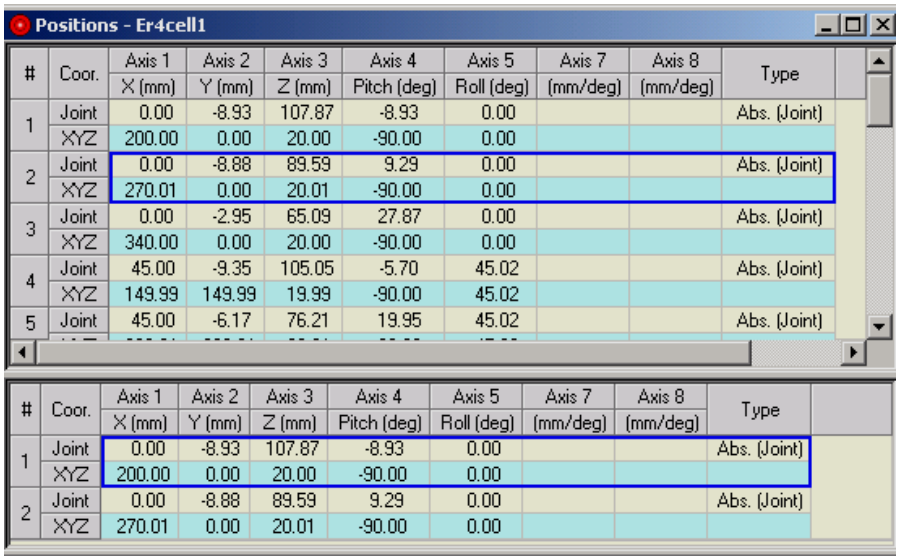
If the reference position changes, the relative position moves accordingly.

Positions Window

Positions

The Positions window displays a list of the positions of the currently open project. The list is presented in tabular format. As default, the table presents position information in both the Joint Coordinate System and the Cartesian Coordinate System.

When fully open, the window is divided horizontally into two panels. By dragging the bottom edge of the window, you can reveal the bottom panel. The top panel displays all positions in the project (Position Inventory Panel). The bottom panel (Watch Panel) displays the positions which have been selected for watching.



#	Coor.	Axis 1 X (mm)	Axis 2 Y (mm)	Axis 3 Z (mm)	Axis 4 Pitch (deg)	Axis 5 Roll (deg)	Axis 7 (mm/deg)	Axis 8 (mm/deg)	Type
1	Joint	0.00	-8.93	107.87	-8.93	0.00			Abs. (Joint)
	XYZ	200.00	0.00	20.00	-90.00	0.00			
2	Joint	0.00	-8.88	89.59	9.29	0.00			Abs. (Joint)
	XYZ	270.01	0.00	20.01	-90.00	0.00			
3	Joint	0.00	-2.95	65.09	27.87	0.00			Abs. (Joint)
	XYZ	340.00	0.00	20.00	-90.00	0.00			
4	Joint	45.00	-9.35	105.05	-5.70	45.02			Abs. (Joint)
	XYZ	149.99	149.99	19.99	-90.00	45.02			
5	Joint	45.00	-6.17	76.21	19.95	45.02			Abs. (Joint)

#	Coor.	Axis 1 X (mm)	Axis 2 Y (mm)	Axis 3 Z (mm)	Axis 4 Pitch (deg)	Axis 5 Roll (deg)	Axis 7 (mm/deg)	Axis 8 (mm/deg)	Type
1	Joint	0.00	-8.93	107.87	-8.93	0.00			Abs. (Joint)
	XYZ	200.00	0.00	20.00	-90.00	0.00			
2	Joint	0.00	-8.88	89.59	9.29	0.00			Abs. (Joint)
	XYZ	270.01	0.00	20.01	-90.00	0.00			

Figure 5-10: Positions Window, fully opened to display both the Position Inventory Panel and the Watch Panel.

Each row in the top portion of the table represents a single position. To manipulate the list:

- Select a position (row).
- Right-click to display the popup window.

Position Popup Window

Position No.	Displays the number of the position.
Delete	Deletes the selected position.
Delete All	Deletes all listed positions from the Position Inventory Panel and the SCORBASE memory.
Add Watch	Copies the position data to the watch list, visible in the Watch Panel.
Show Joint	Shows only Joint values of **all** positions. See page 26.
Show XYZ	Shows only the XYZPR of **all** positions. See page 27.
Show Both	Shows both Joint and XYZPR values of **all** positions.

Note: The peripheral positions are always displayed using encoder counts.

Watch Popup Window

Position No.	Displays the number of the position.
Remove	Removes the selected position from the watch list, but does not affect its presence in the overall list.
Remove All	Removes all listed positions from the watch list, but does not affect their presence in the overall list.
Show Joint	Shows only Joint values of **all** positions. This can be set to a value different from the Position Inventory Panel. See page 26.
Show XYZ	Shows only the XYZPR of **all** positions. This can be set to a value different from the Position Inventory Panel. See page 27.
Show Both	Shows both Joint and XYZPR values of **all** positions.

Position Data Dialog Bars

SCORBASE offers three dialog bars that display all axes, encoder counts and the robot position in reference to both the Cartesian Coordinate System (XYZ) and the Joint Coordinate System. All dialog bars are accessible at all levels via the View menu. They may also be opened or closed using the View | Show All Dialog Bars or View | Close All Dialog Bars commands.

Encoder Counts Dialog Bar

The Encoder Counts dialog bar displays the current values of the encoders for each of the eight axes.

Figure 5-11: Encoder Counts Dialog Bar

To display the Encoder Counts dialog bar, select View | Dialog Bar | Encoders.

The encoder values change whenever the axes are moved.

These values are set to 0 (or close to zero) after the Search Home All Axes command is executed.

XYZ Dialog Bar

The XYZ dialog bar displays the current Cartesian Coordinate System (XYZ PR) values of the TCP.

Figure 5-12: XYZ Dialog Bar

To display the XYZ dialog bar, select View | Dialog Bar | XYZ.

The values shown in the above example are the Joint values after the Search Home command is executed.

Joints Dialog Bar

The Joints dialog bar displays the angles between the two links of the joint, in degrees.

Figure 5-13: Joints Dialog Bar

To display the Dialog bar, select View | Dialog Bar | Joints.

The values shown in the above example are the XYZ values after the Search Home command is executed.

Using a Teach Pendant with SCORBASE

The Teach Pendant is a hand-held terminal that gives the operator direct control of the robot and peripheral axes. In addition to controlling movement of the axes, the Teach Pendant may be used for recording positions, sending the axes to recorded positions, and other functions.

To control the axes from the Teach Pendant, SCORBASE must be operating in the On-line mode, and the Teach/Manual switch on the Teach Pendant must be switched to Teach. This disables control of the axes from SCORBASE dialog boxes.

All Teach Pendant operations are reflected in the SCORBASE dialog boxes. For example, positions recorded by the Teach Pendant will appear in the Position Number list in the Teach Positions dialog box; and encoder and XYZ values will change in the Encoder Counts and XYZ dialog boxes.

The Teach Pendant operation is described fully in the Teach Pendant for Controller User Manual.

6

Program Editing

A SCORBASE program is a set of instructions written by the user to control the robot, peripheral equipment and to communicate with external I/O devices. This chapter explains how to create and edit a SCORBASE program.

The following tools are used for program editing:

- Program commands editor.
- Command tree that lists all SCORBASE commands.

Opening and Closing a Program

Every SCORBASE program is part of a SCORBASE project. A project also includes the user-defined positions, project data and, if RoboCell is installed, a virtual cell (3dc file). Only one project can be opened at a time.

To open a saved program, open the project containing the desired program by doing one of the following:

- Select File | Open Project…
- Click on the Open an Existing Project icon. 
- Press Ctrl + O.

In all cases, the *Load Project* window will open, prompting you to select the project that contains the program you want to edit.

The program is displayed in the Program Window.

To create a new project, do one of the following:

- Select File | New Project…
- Click on the Create a new project icon. 
- Press Ctrl + N.

By default, the new project is opened with the Teach & Edit layout. This layout displays four windows:

- Program Window that holds the SCORBASE program.
- Manual Movement Dialog Box.
- Teach Positions Dialog Box.
- Workspace Window that shows:
- Project data, i.e., positions, user program and graphical display (if installed).
- SCORBASE Command Tree.

The Program Window contains the text of the SCORBASE program currently loaded. Its title bar displays the name of the project. Also shown by default is the programming toolbar. The toolbar contains a drop-down list of all subroutines available, for quick navigation.

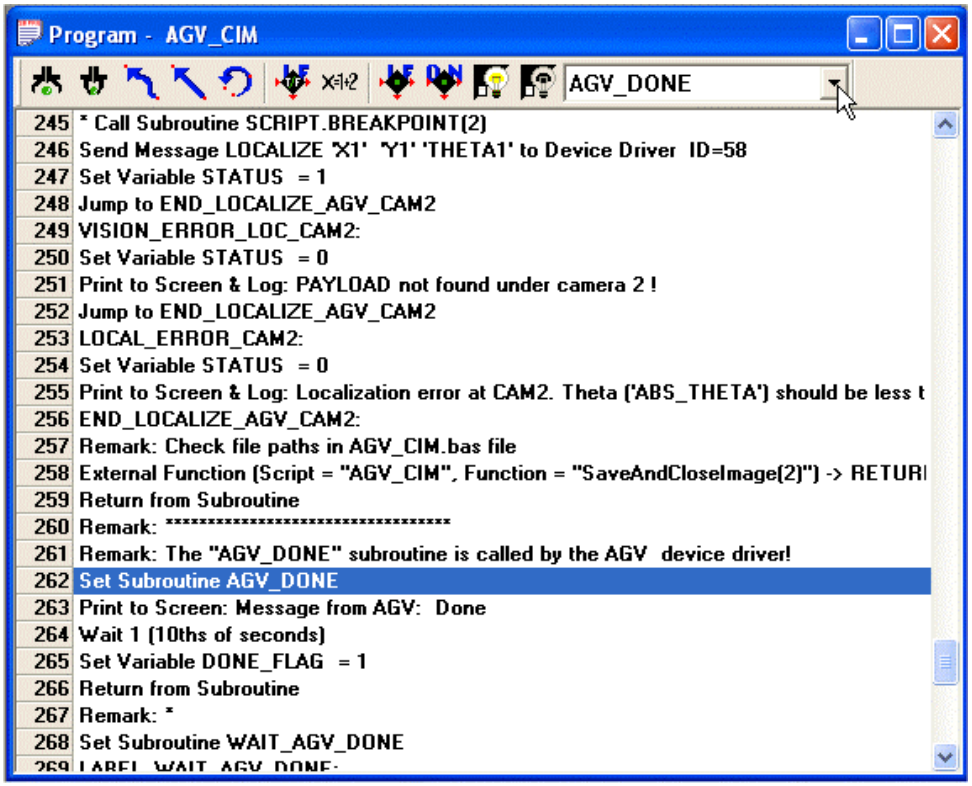


Figure 6-1: Program Window

The Workspace Window contains two tabs to switch between the project files and the commands currently available.

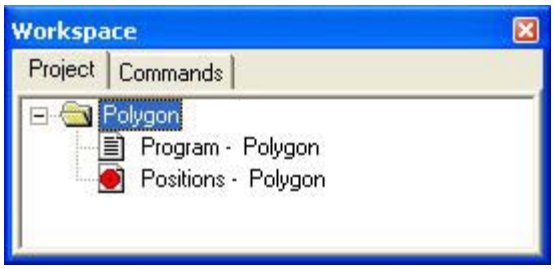


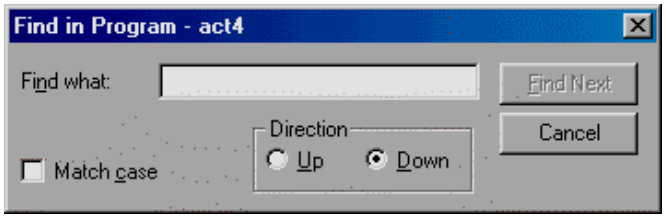
Figure 6-2: Workspace Window – Project Tab

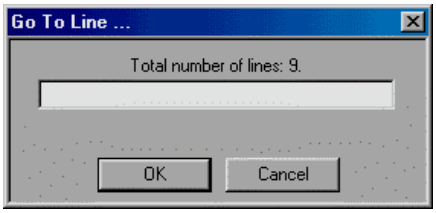
The Commands tab displays the Command Tree, which in turn displays all of the commands available for the currently set Experience Level.

Program Editing Tools

SCORBASE is a text-based programming language in which every command is a single text line. SCORBASE programs are edited by means of the usual Windows text editing options, which can be accessed:

- Via the Edit menu
- By pressing the designated keys
- By right-clicking the mouse in the Program Window to open a pop-up menu.

Cut - Ctrl+X	Deletes selected text or lines from the program, and places it on the Windows and SCORBASE clipboards.
Copy - Ctrl+C	Places a copy of selected text or lines from the program on the Windows and SCORBASE clipboard.
Paste - Ctrl+V	Inserts the contents of the SCORBASE clipboard into the program.
Find - Ctrl+F	Opens a dialog box that allows you to search for any string, such as a command or text.  *Figure 6-3: Find Dialog Box*

Find Next - (F3)	Repeats the last Find operation for the next occurrence. (Accessible also from the Find dialog window).
Command/ Remark (*…)	Inserts/deletes asterisk at beginning of a command line. SCORBASE ignores command lines that start with an asterisk. This feature is useful for debugging.
Go to Line	Opens a dialog box that displays the total number of lines in the program and prompts you for a line number. Type in the number. The program editor will jump to the line you specify.  *Figure 6-4: Go To Line Dialog Box*
Go to Selected Line	Automatically scrolls the Program Window to display the line which you have selected. This is useful for long programs when you have selected a particular line and then scrolled away from it. In very short programs which fit within a single window, this function has no visible effect.

In addition, use the keyboard for the following functions:

[Ins]	Toggles between Insert Mode and Overwrite Mode. The currently active mode is shown in the Status bar at the very bottom of the SCORBASE window. In Insert Mode, a new command is inserted into the program above the line currently marked by the cursor.
[Del]	Deletes the line or lines currently marked by the cursor.
[Ctrl+Home]	Brings the cursor to the first line of the program.
[Ctrl+End]	Brings the cursor to the last line of the program.
[PgUp]	Displays the previous page of program lines.
[PgDn]	Displays the next page of program lines.

Adding and Editing Commands

SCORBASE commands are organized in a Command Tree, which is displayed in the Workspace Window. SCORBASE only displays the commands which are available in the currently set Experience Level.

- At the Introductory level (Level 1), only basic commands appear in the Command Tree.
- At the Advanced level (Level 2), the number of commands is increased.
- At the Professional level (Pro Level), all commands are accessible.

To see the Command Tree, click the Command tab in the Workspace Window.

SCORBASE commands are grouped into these categories:

- Axis & Control
- Program Flow
- Inputs & Outputs
- Advanced - By default, this category is hidden. Select Options | Advanced Options | Advanced Commands to display these commands.
- Vision - By default, this category is hidden. Select Options | Advanced Options | ViewFlex Commands to display these commands.

Clicking on a category opens/closes the list of commands.

To add commands to a program, do one of the following:

- Double-click on the desired command in the Command Tree.
- Type the two letters written next to the command.
- Click on the command icons in the Program Window (applicable only for selected commands).

If you are working in Insert Mode, the new command line is added above the currently selected (highlighted) line. If you are working in Overwrite Mode, the new command replaces the selected line. Toggle between the two modes using the [Ins] key. Many commands open dialog boxes for completing the command line parameters.

To change a command parameter, click on the command to re-open the command dialog box. Change the required parameter, and click OK to close the dialog box. ***Note:*** *For safety reasons, certain parameters are not accessible by the user, i.e., they appear grayed, and can be changed only by Intelitek support personnel.*

To delete, cut, copy and paste a line, use the usual Windows tools.

Axis Control Commands

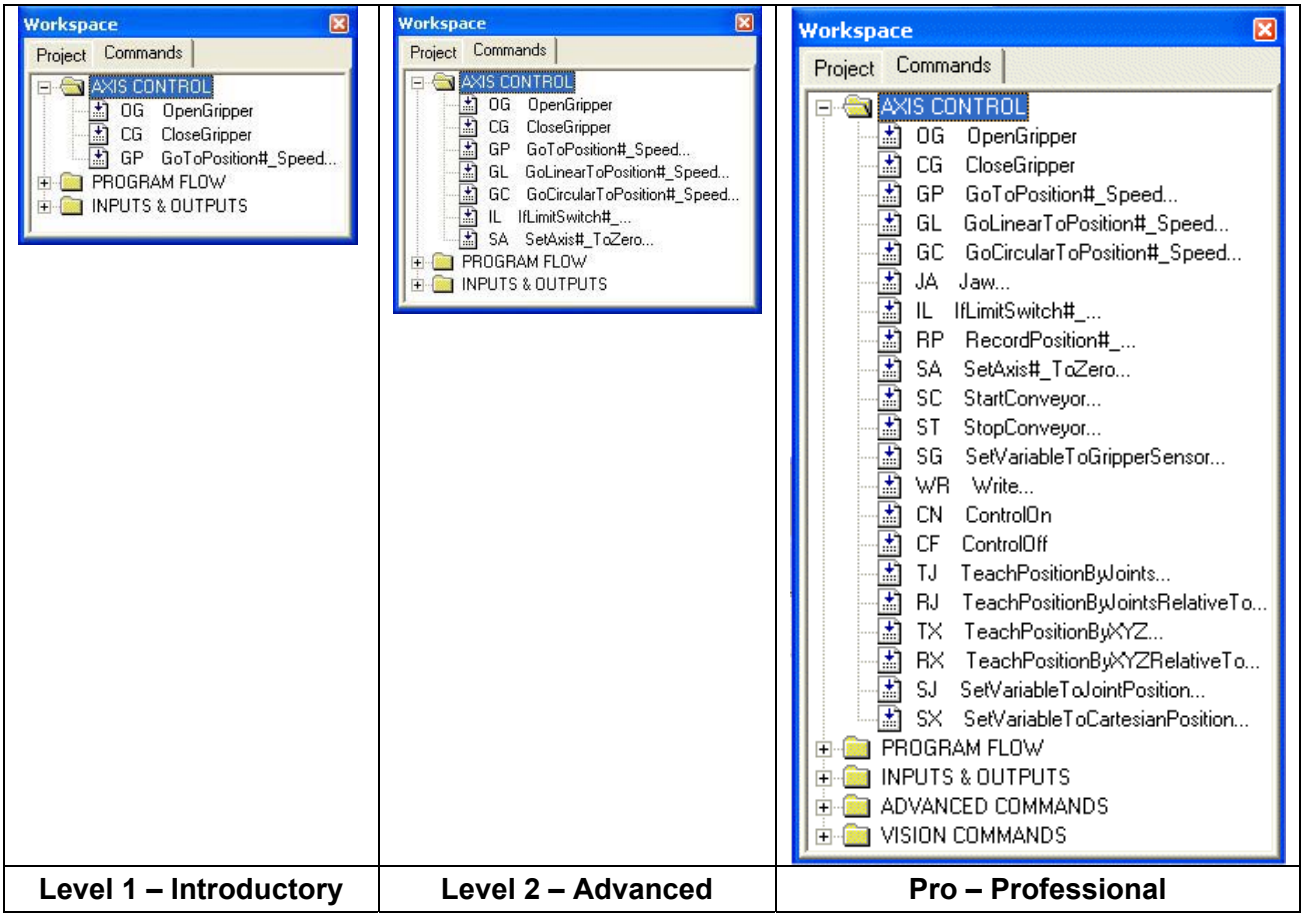


Figure 6-5: Command Tree - Axis Control

Icon	Command	Levels	Description
	OG Open Gripper	1,2,Pro	Fully opens the gripper.
	CG Close Gripper	1,2,Pro	Fully closes the gripper (on itself, or on a grasped object).

GP Go to Position	1,2,Pro	Opens the Go to Position Dialog Box. The Go to Position command sends the robot to a recorded position, in the shortest time, using Point to Point (P to P) control. In Point to Point control, all axes move independently and there is no control over the TCP trajectory.  *Figure 6-6: Go To Position Dialog Box*

Movement Control	
Target Position	The destination of the movement. Enter a number or a variable in this field.
Speed/Duration	
Fast	Executes the movement at the fastest speed possible.
Speed	Executes the movement at a slower speed. Enter a number from 1 through 9, or a variable, in the Speed field. Default: 5 (average speed).
Duration	Executes the movement in a specific amount of time. Enter the time in tenths of a second, or a variable. Available only in Pro Level.
Via Position	The position via which the destination of the movement is reached. Enter a number or a variable in this field.

GL Go Linear to Position #_Speed ...	2,Pro	Sends the robot's TCP (tool center point) from its current position to the target position, along a linear path (straight line). The linear motion applies only to the robot axes.

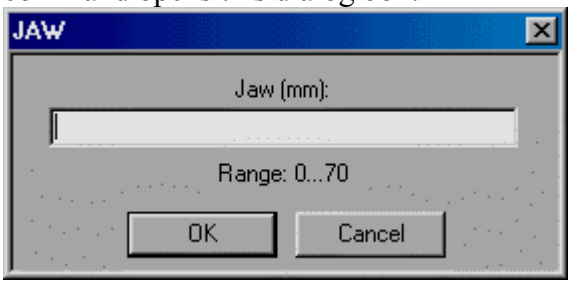
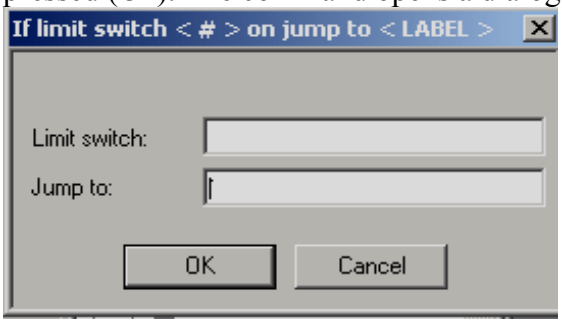
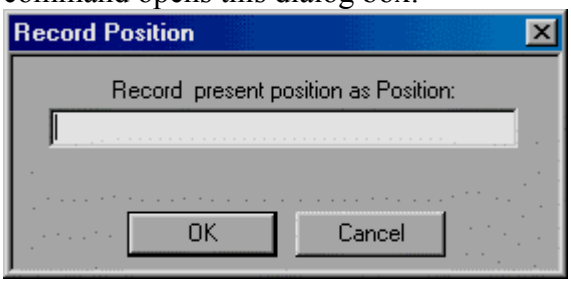
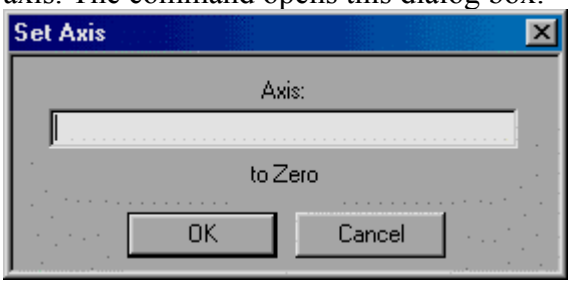
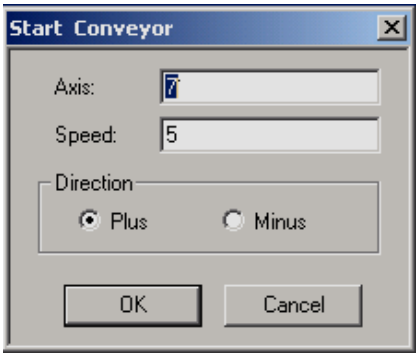
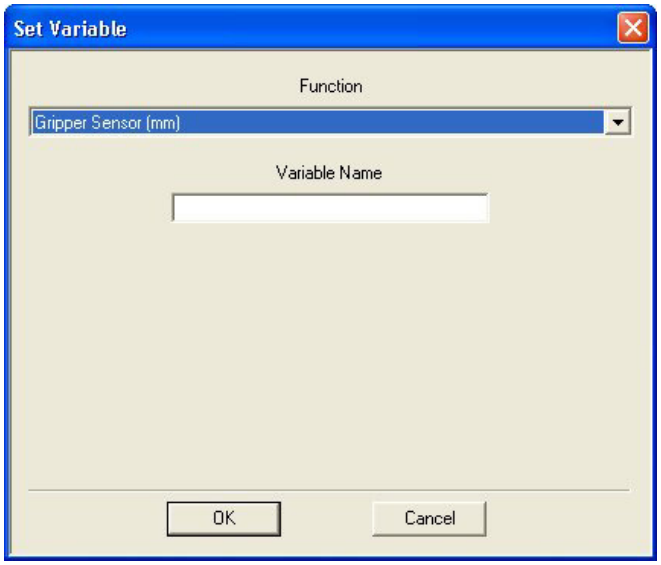
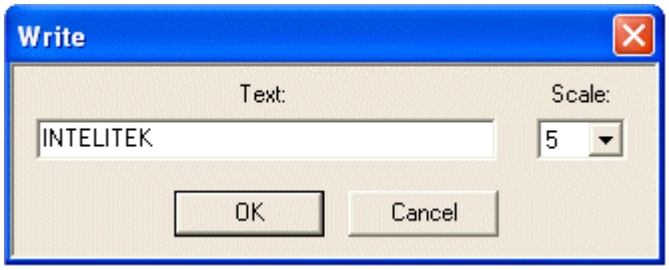
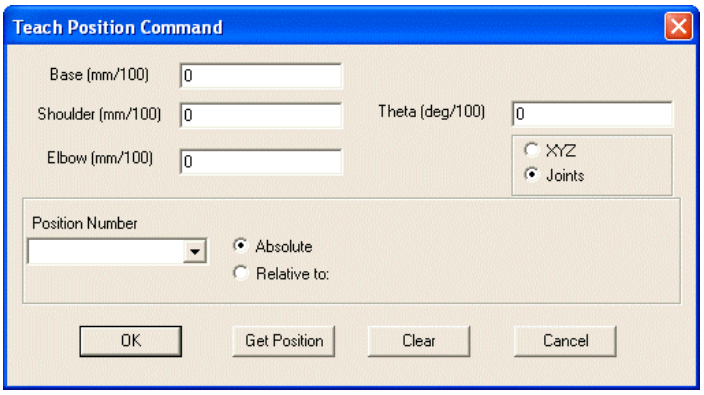
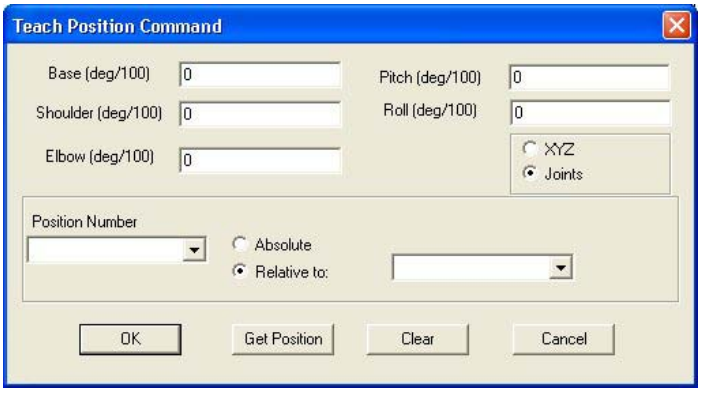
<table>
<tr><td rowspan="2">GC Go Circular to Position #_ Speed...</td><td>2,Pro</td><td colspan="2">Sends the robot's TCP in a circular path to the target position, via the position specified in the Via Position field. The circular motion applies only to the robot.
Note: The Circular command follows the circle defined by the three positions (current TCP position, target position, and the intermediate position specified in the Via position field).</td></tr>
<tr><td colspan="2"></td><td>Via Position</td><td>The position via which the destination of the movement is reached. Enter a number or a variable in this field.</td></tr>
<tr><td>JA Jaw</td><td>2,Pro</td><td colspan="2">Moves the gripper's jaw to the specified span. The command opens this dialog box:
 

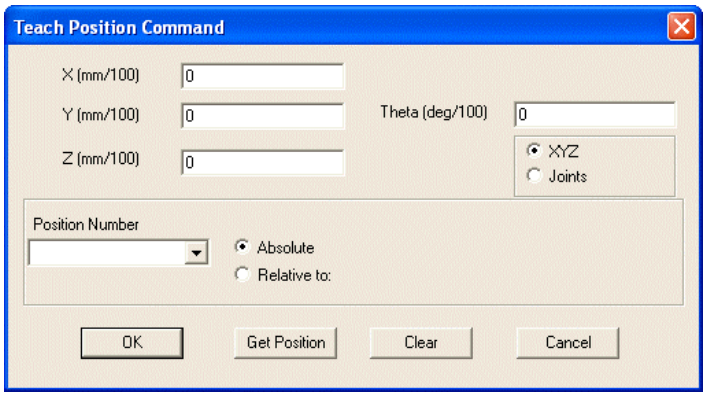
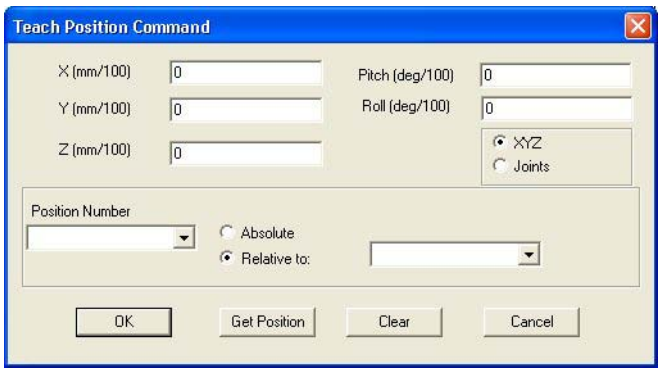
Figure 6-7: Jaw Dialog Box
Enter a number or a variable in the Jaw field.
Note: Accuracy cannot be guaranteed if the width is less than 5 mm or greater than 65 mm.
Jaw activates Servo Control for the gripper motor, whereas Open Gripper and Close Gripper commands do not use the gripper axis Servo Control.
Unless you need the Jaw command for a specific application, the Open Gripper and Close Gripper commands are recommended.
Note: This command is not available for SCORBOT ER-2u.</td></tr>
</table>

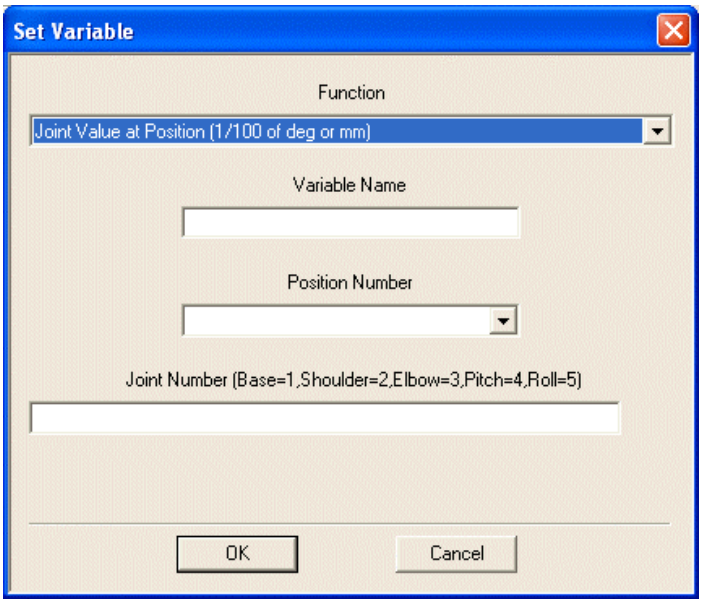
IL If Limit Switch < # > on jump to <Label>	2,Pro	The IL is a conditional jump command. It causes program execution to jump to the line that contains the specified Label, if the selected axis micro switch is pressed (On). The command opens a dialog box.  *Figure 6-8: If Dialog Box* Enter the Axis number or a variable in the Limit Switch field. Enter the name of a Label in the Jump to field.
RP Record Position #_	Pro	When the Record Position command is executed (during program execution), the controller records the current position data to the specified position. The command opens this dialog box:  *Figure 6-9: Record Position Dialog Box* Enter a position number or a variable in the Record Present Position as Position field. The Record Position command is useful when a position (and all relative positions that refer to that position) must be relocated, during program execution. This command updates the position data.

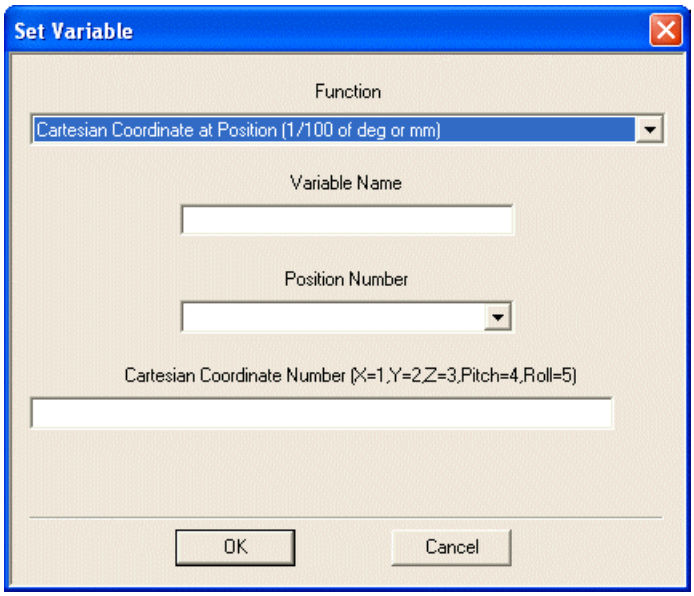
SA Set Axis #_ ... (to Zero)	2,Pro	Initializes (sets to 0) the encoder count of the selected axis. The command opens this dialog box:  *Figure 6-10: Set Axis Dialog Box* Enter a number or a variable in the Axis field.
SC Start Conveyor	Pro	Starts the conveyor, as a speed-controlled conveyor. Movement of the conveyor will continue until a Stop Conveyor (ST) command is encountered. The command opens this dialog box:  *Figure 6-11: Start Conveyor Dialog Box* • Enter the Axis number in the Axis field • Enter a number or a variable in the Speed field. • Select a movement direction (Plus or Minus). **Note:** When operating a speed controlled conveyor by means of the Start/Stop Conveyor commands, do not record positions, and/or use the Set Axis (to Zero) command for the conveyor, in the same program.
ST Stop Conveyor	Pro	Stops the continuous motion of a conveyor that was initiated by a Start Conveyor (SC) command.

SG Set Variable to Gripper Sensor	Pro	Assigns the value of the gripper opening (in mm) to a variable. This command is useful when there is a need to measure the object in the gripper, or to check the gripper status (open, closed or gripping an object).  *Figure 6-12: Set Variable (Gripper Sensor) Dialog Box* In the Name field, enter the name of the variable. For more information on variables, see page 75. ***Note:*** *This command is not available for SCORBOT ER-2u.*
WR Write		Commands the gripper to convert the letters specified into lettering on the workpiece. The size is controlled by the Scale setting (1-10).  *Figure 6-13: Write Dialog Box*
CN ControlOn		Enables axis control by the controller. See page 24.
CF ControlOff		Disables axis control by the controller. See page 24.

TJ Teach Position By Joints	Pro	Teaches the position as defined by the absolute positions of the joints.  *Figure 6-14: Teach Position (Absolute Joints) Dialog Box* Enter a new unique number in the Position Number box. Enter the values for Base, Shoulder, Elbow, Pitch and Roll in 1/100ths of a degree.
	Pro	Get Position — Copies the values of the robot's current position into the appropriate boxes.
	Pro	Clear — Clears the values from all the boxes.
RJ Teach Position By Joints Relative to Position	Pro	Teaches the position as defined by the positions of the joints relative to another defined position.  *Figure 6-15: Teach Position (Relative Joints) Dialog Box* Enter a new unique number in the Position Number box. Enter the values for Base, Shoulder, Elbow, Pitch and Roll in 1/100ths of a degree, and choose which point this new one is to be calculated from.

TX Teach Position by XYZ	Pro	Teaches the position as defined by the absolute Cartesian coordinate of the TCP (Tool Center Point).  *Figure 6-16: Teach Position (Absolute XYZ) Dialog Box* Enter a new unique number in the Position Number box. Enter the values for X, Y and Z in 1/100 mm, and Pitch and Roll in 1/100ths of a degree.
RX Teach Position by XYZ Relative to Position	Pro	Teaches the position as defined by the Cartesian coordinate of the TCP (Tool Center Point) relative to another defined position.  *Figure 6-17: Teach Position (Relative XYZ) Dialog Box* Enter a new unique number in the Position Number box. Enter the values for X, Y and Z in 1/100 mm, and Pitch and Roll in 1/100ths of a degree.

SJ Set Variable to Joint Position		Allows you to set a variable to the value of a specified joint at a specified position number.  *Figure 6-18: Set Variable to Joint Position Dialog Box* Enter the name of the variable in the Variable Name field and select the position number from the Position Number drop-down list. Enter an integer between 1 and 5 for the Joint number, as follows: Base 1 Shoulder 2 Elbow 3 Pitch 4 Roll 5 You may also insert a variable which contains one of these values.

SX Set Variable to Cartesian Position		Allows you to set a variable to the value of a specified Cartesian coordinate at a specified position number.  *Figure 6-19: Set Variable to CartesianPosition (Relative XYZ) Dialog Box* Enter the name of the variable in the Variable Name field and select the position number from the Position Number drop-down list. Enter an integer between 1 and 5 for the Cartesian coordinate number, as follows: X 1 Y 2 Z 3 Pitch 4 Roll 5 You may also insert a variable which contains one of these values.

Program Flow Commands

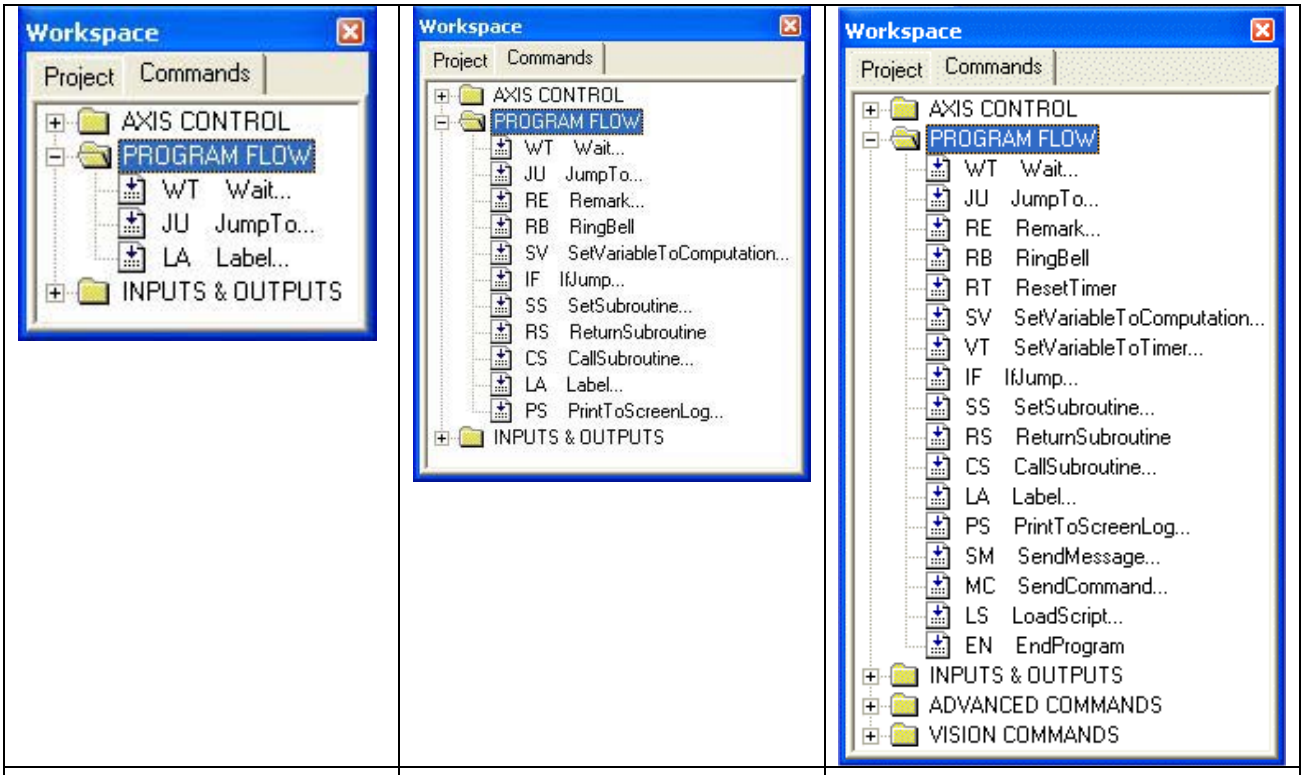
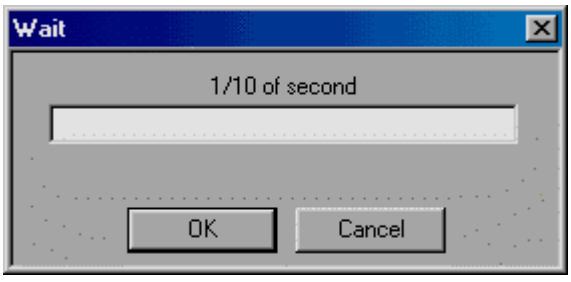
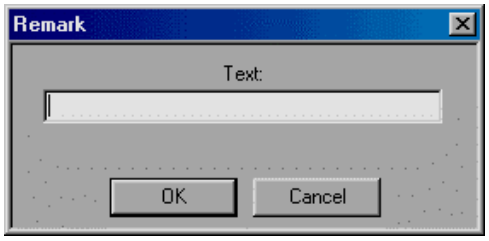


Figure 6-20: Command Tree - Program Flow branch

Icon	Command	Levels	Description
	WT Wait (10ths of second)	1,2,Pro	Halts program execution for a time specified in tenths of a second. The command opens this dialog box:  *Figure 6-21: Wait Dialog Box* Enter a number or a variable in the 1/10 of second field.

JU Jump to	1,2,Pro	This unconditional jump command causes the program pointer to jump to the line that contains the specified Label. The command opens this dialog box:  *Figure 6-22: Jump To Dialog Box* Enter the Label name in the Jump to field. (Be sure to include a line with this Label in your program.) When the Jump command is used, Jump is checked in the dialog box. You can modify the Jump command to an IF jump command (conditional jumping) only in Levels 2 and Pro.
RE Remark	2,Pro	Allows insertion of a comment line for explanation and documentation into the program. The command opens this dialog box:  *Figure 6-23: Remark Dialog Box* Enter up to 47 characters of text, including spaces.
RB Ring Bell	2,Pro	When executed, this command produces a beep, using the computer's internal loudspeaker.
RT Reset Timer	Pro	SCORBASE uses a timer that measures time in units of tenths of a second. The timer starts operating when SCORBASE is opened. The Reset Timer command resets the value of the SCORBASE timer to 0. To use the timer, the timer value must be assigned to a variable, using the Set Variable command. (See page 58 for more details).

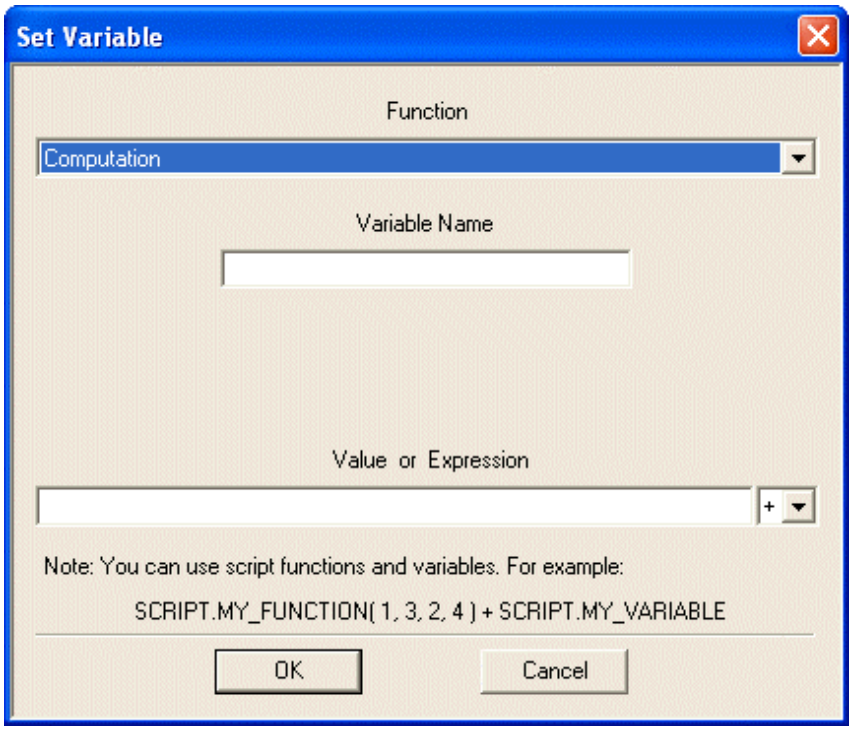
	SV Set Variable to Computation	1,2,Pro	Allows you to assign a value, or an expression (result of a specific computation), to a variable. The command opens the Set Variable dialog box (Computation is selected by default).  *Figure 6-24: Set Variable (Default) Dialog Box* In level 2, the Set Variable value can only be a result of computation. In the Pro level, variable values can be derived from other sources. For further information, see pages 51, 54, 55, 60, and 72.	
			Variable Name	Enter the name of the variable. The first character must be a letter.
			Value or Expression	Enter a value or a formula. To set the variable to a fixed value, enter a number (in the range of +/-1000000). To set the variable to the result of a computation, enter a string that consists of two arguments and an operator. An argument can be either an integer or a variable (e.g., fun*2). Click on the arrow to see a list of operators, or use the following list:

Figure 6-25: Operators Drop-Down List, Set Variable Dialog Box

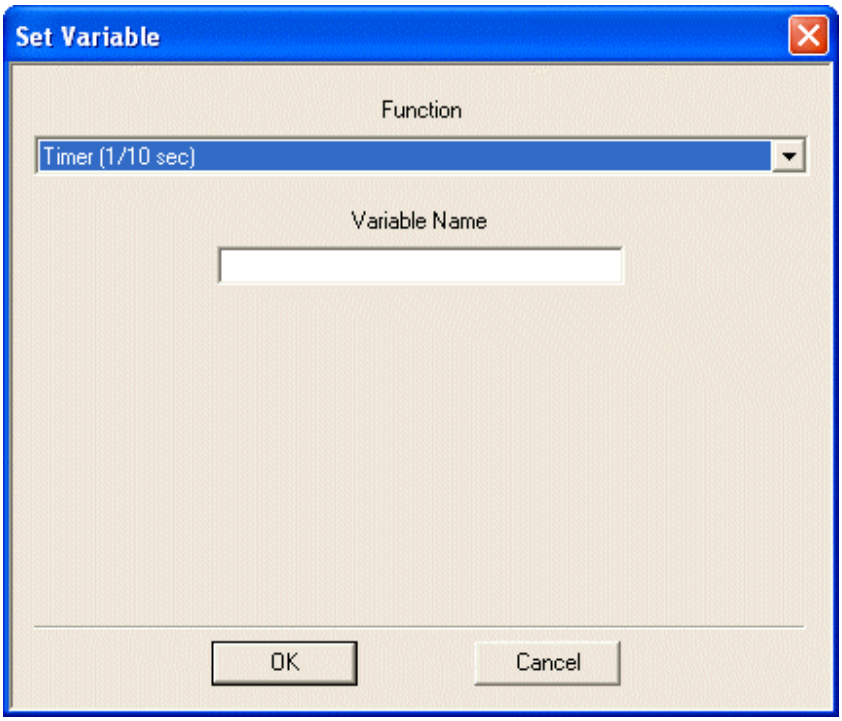
Arithmetic Operators	
+ * - / \	Addition Multiplication Subtraction Division Floating Point Division
Algebraic Operators	
^	Power (raises the first argument to the power of the second argument).
MOD	Modulus (returns the remainder of the first argument divided by the second).
Logical (Boolean) Operators	
NOT	Not
AND	And
OR	Or
XOR	Exclusive or
EQV	Equivalent (Null or Boolean values only)
IMP	Implication (Null or Boolean values only)

The result of a logical operation is 1 (True), or 0 (False). Any operand with a non-zero value is considered true, while a zero value is considered false.

A value assigned using the SV command can be used for conditional jumping using the IF <Condition> Jump command. Actions can then be generated according to the variable value. The following example jumps the program cursor to a label if more than three seconds elapse after timer reset:

```
Reset Timer
…
Set Variable TIME to timer
IF TIME > 30 jump to PICKUP
```

For more information on variables, See page 75.

VT Set Variable to Timer	Pro	Allows you to assign the current value of SCORBASE timer to a variable. The SCORBASE timer starts operating when SCORBASE is opened.  *Figure 6-26: Set Variable Dialog Box (Timer)* To initialize the SCORBASE timer in a program, use the Reset Timer (RT) command.

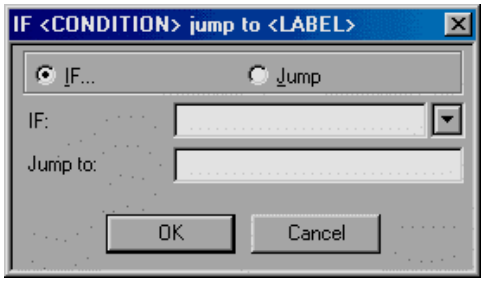
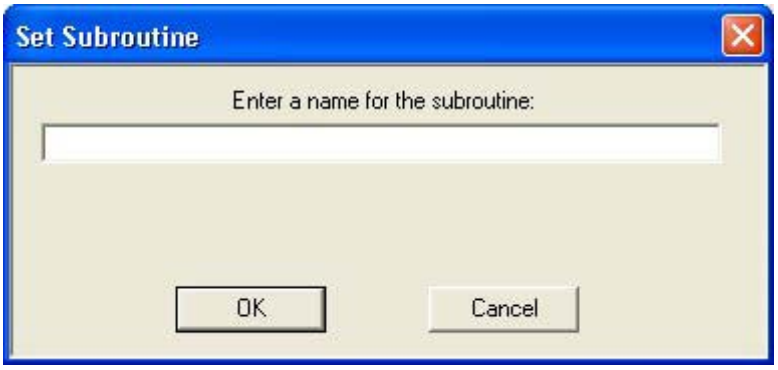
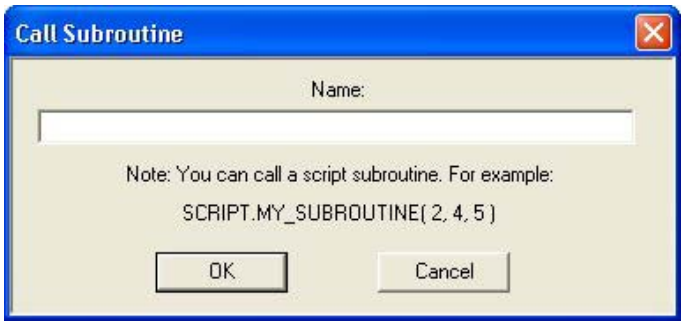
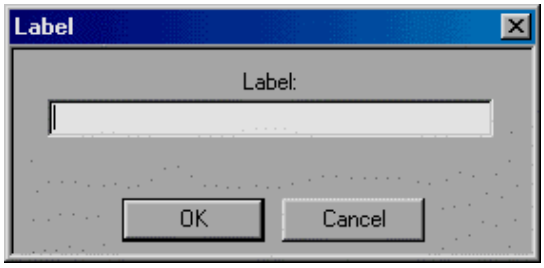
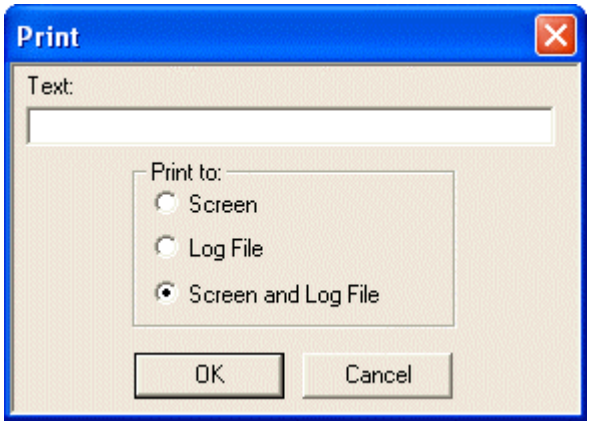
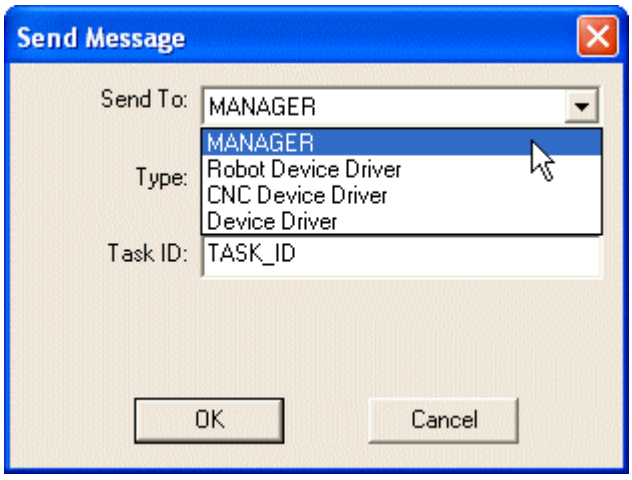
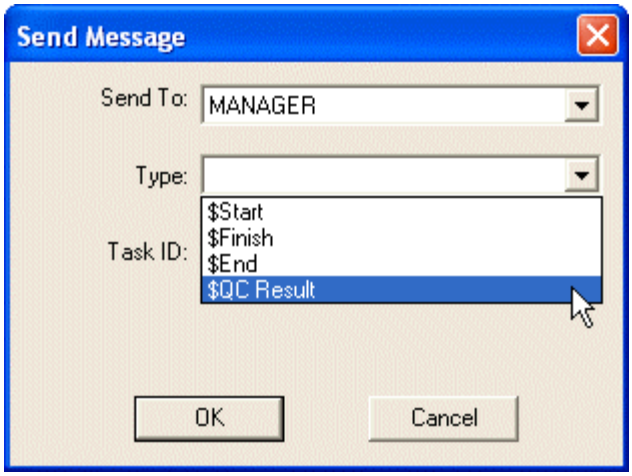
<table>
<tr><td>  </td><td>IF If Jump to</td><td>2,Pro</td><td>A conditional branch command, which is used to determine the program flow in relation to the value of the variables. The command opens this dialog box:
 

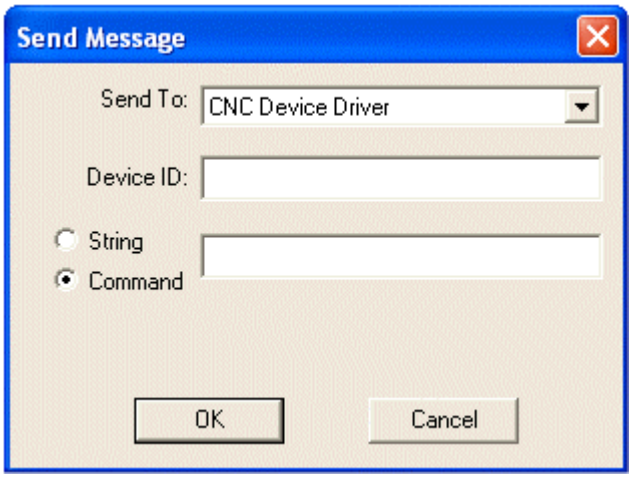
Figure 6-27: If/Jump Dialog Box
If the condition in the IF field is true, program execution jumps to the line specified by the label in the Jump to field.
If the condition in the IF field is false, program execution skips to the following line.</td></tr>
<tr><td></td><td></td><td></td><td><table>
<tr><td>IF</td><td>Enter the condition. The condition includes a variable name, a comparison operator and another variable name, or a number.</td></tr>
<tr><td>Jump to</td><td>Enter the name of a Label. (Be sure to include a line with this Label in your program.)</td></tr>
</table></td></tr>
<tr><td></td><td></td><td></td><td>Example:
<pre>If COUNTER > 0 jump to START_LOOP
Go to Position 1 speed 5
…
START_LOOP:
Go to Position 2 speed 5</pre>If the value of Counter is greater than zero, the robot will go to Position #1.
If the value of Counter is equal to or less than zero, the robot will go to Position #2.
Use two equal signs (= =) for equal operators. For example:
<pre>If COUNTER == 0 jump to END</pre>The IF jump command can be converted to an unconditional jump command by selecting Jump (instead of If).</td></tr>
</table>

SS Set Subroutine	2,Pro	Creates a subroutine. You can program up to 64 subroutines in one program. The command opens this dialog box:  *Figure 6-28: Set Subroutine Dialog Box* In the Name field, enter a name or number for the subroutine. ***Note:*** *Create subroutines only at the end of the main program. Every subroutine must end with a* Return from Subroutine *command.*
RS Return from Subroutine	2,Pro	Marks the end of a subroutine. At run time, this command terminates the execution of the subroutine, and the program resumes execution at the line that follows the Call Subroutine command. ***Note:*** *Every subroutine must end with a* Return from Subroutine *command.*

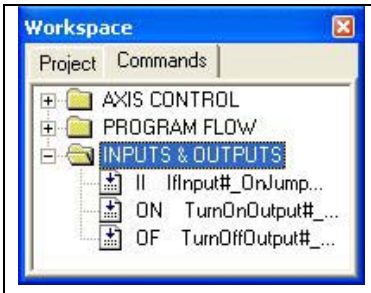
CS Call Subroutine	2,Pro	Activates the specified subroutine. The command opens this dialog box:  *Figure 6-29: Call Subroutine Dialog Box* In the Name field, enter the name of the subroutine. ***Notes:*** *Use the* Call Subroutine *command either from the main program or from another subroutine command.* *You can call the same subroutine repeatedly in the same program.* *You can call a subroutine from a Visual Basic script that is loaded. Append the prefix* **SCRIPT**. *to the beginning of the Visual Basic subroutine name. If more than one VB script is loaded, it is the responsibility of the programmer to ensure that there is no conflict of names.* *After the subroutine is executed, the program resumes execution from the line that follows the* Call Subroutine *command.*
LA Label	1,2,Pro	Marks a line in the program that is referenced by a Jump command. The command opens this dialog box:  *Figure 6-30: Label Dialog Box* In the Label field, enter a name. Do not include blank spaces – use an underscore. Do not use the same label name more than once.

PS Print to Screen & Log	2,Pro	Instructs SCORBASE to print data containing strings, messages and variable values to a log file, or to the message window, or to both. The command opens this dialog box:  *Figure 6-31: Print Dialog Box* Enter text and spaces of up to 47 characters. To print a value of a variable, place the variable name in single quote marks. For example: VARX='X' will print as VARX=50 (when the value of X is 50). Click the desired print destination.

SM Send Message	Pro	Sends a message to MANAGER, Robot Device Driver, CNC Device Driver, or Device Driver.  *Figure 6-32: Send Message (Device) Dialog Box* For a message to the MANAGER, select the type of message from the list of available types. Type a Task ID, and select a message from the drop-down menu. Consult the Open CIM user manual for more details.  *Figure 6-33: Send Message (Manager) Dialog Box* For other device drivers, type the ID of the Device you wish to receive the message, and enter the string to be sent.

MC Send Command	Pro	Sends a command to the CNC Device Driver. This is the same dialog box as the SM command, except that the default device is the CNC Device Driver, and the default message is a command, rather than a string.  *Figure 6-34: Send Command (CNC Device) Dialog Box* Enter the device ID and the command in the boxes.
LS Load Script	Pro	Loads a Visual Basic script by means of the following dialog box:  *Figure 6-35: Load Script Code Box* The script must be located in the same subdirectory as the SCORBASE project file. You must be sure that the LS command is actually executed before you attempt to call any of the affected subroutines or variables. You may load more than one script into a single SCORBASE project. However, it is the programmer's responsibility to ensure that there are no name conflicts.
EN End Program	Pro	This command simply enters the command End on the selected line of the program. It signifies the end of the program. It may be used in more than one subroutine, such as subroutines which respond to various error conditions.

Input/Output Commands



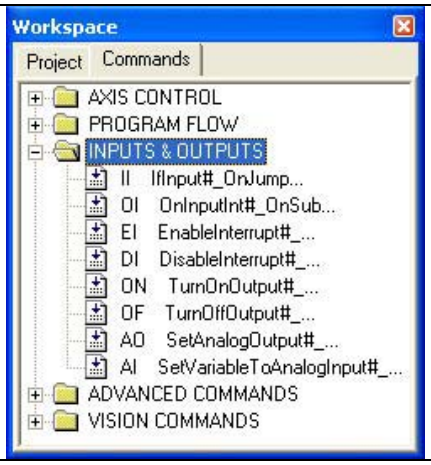


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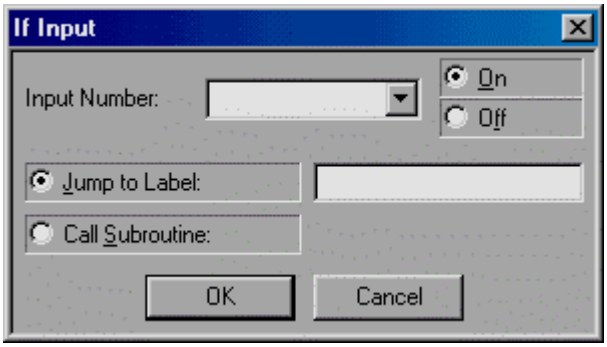
Figure 6-36: Command Tree - Inputs & Outputs Branch

II If Input # On/Off Jump	1,2,Pro	Causes the program to jump to a label or call a subroutine, if the state of the tested digital input matches the status specified (On or Off). The command opens this dialog box:  *Figure 6-37: If Input Dialog Box* In the Input Number field, enter the number of digital input (1-8), or a variable. Select either On or Off for the state of the input. Select either Jump or Call Subroutine; then complete the active field. In the Jump to Label field, enter the name of a Label. In the Call Subroutine field, enter the name of a subroutine, or a variable.

OI On Input Interrupt # On/Off	Pro	Sets the condition for an input interrupt service. The service (Call Subroutine or Run Subroutine) will be performed whenever the condition (input status) is satisfied, regardless of the current program pointer position. The command opens this dialog box:  *Figure 6-38: On Input Interrupt Dialog Box*

Input Number	Enter the number of a digital input, a variable or the word ANY. Use of the word ANY causes any input (1-8) to evoke the interrupt state.
On/Off	Select the state of the input.
Call Subroutine	Enter the name of a subroutine that will be executed in case of interrupt. Execution of the main program is suspended until completion of the subroutine.
Run Subroutine	Enter the name of a subroutine that will be executed in case of interrupt. Execution of the main program continues, and the subroutine is spawned as a concurrent process.

An interrupt command causes the program to halt the command it is currently executing (which can also be a movement or a delay), and to immediately execute the command specified for this interrupt. If the specified command is a Call Subroutine, the program will resume from the point where it was suspended, as soon as the subroutine completes its execution. If the specified command is a Run Subroutine, the main program resumes immediately after the concurrent process is started.

An interrupt command can be disabled and enabled by means of the EI (Enable Interrupt) and DI (Disable Interrupt) commands described below.

Example:

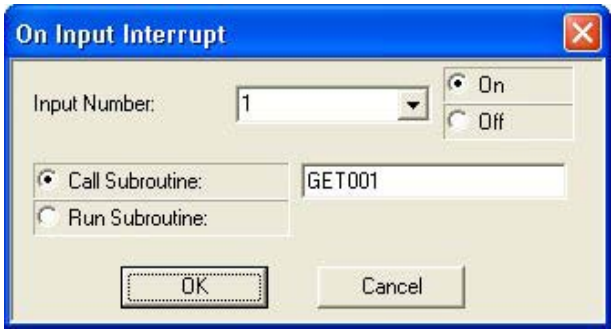


Figure 6-39: On Input Interrupt (Call) Dialog Box

This inserts the following line of code:

```
On Input Interrupt 1 On Call Subroutine GET001
```

When Input 1 is turned on, the program immediately calls subroutine **GET001**. If any axes are moving when the interrupt occurs, they will immediately stop. When the subroutine is completed (Return from Subroutine command is reached), the axes will reassume the position and status that were interrupted, and the program will continue from that point.

DI Disable Interrupt #	Pro	Causes the specified input interrupt to become inactive. When an interrupt is inactive, it is disregarded until the EI (Enable Interrupt) command reactivates it. The command opens this dialog box:

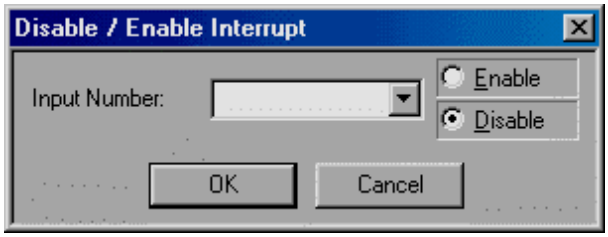
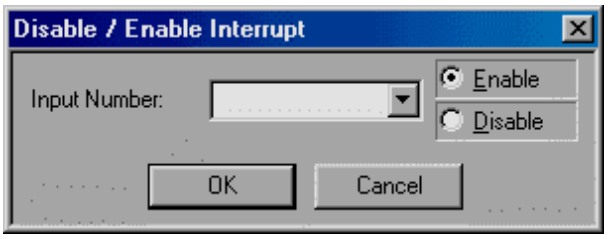
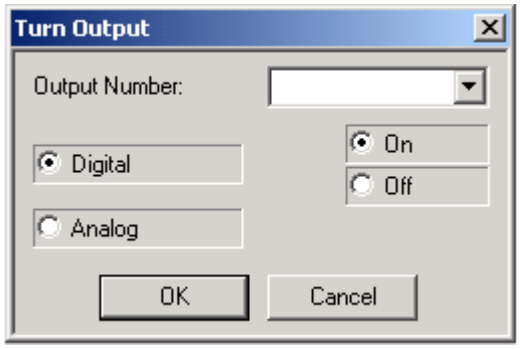


Figure 6-40: Disable Interrupt Dialog Box

Input Number	Enter an input number, a variable, or the word ALL.
Enable/Disable	Select Enable in order to modify the command.

EI Enable Interrupt #	Pro	Causes the specified input interrupt to become active. The command opens this dialog box:  *Figure 6-41: Enable Interrupt Dialog Box* When an interrupt is active, it is waiting for an interrupt status (defined using the OI [On Interrupt] command described above).	
		Input Number	Enter an input number, a variable, or the word ALL.
		Enable/Disable	Select Disable in order to modify the command.
ON Turn On Output #	1,2,Pro	Sets the state of the specified digital output On. The command opens this dialog box:  *Figure 6-42: Turn On Output Dialog Box*	
		Output Number	Select a number or type a variable name.
		The default settings of Digital and On can be changed.	

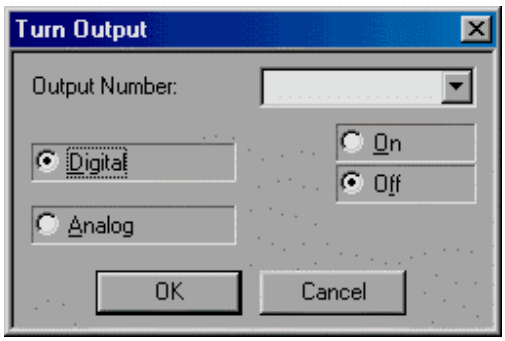
<table>
<tr><td>  </td><td>OF Turn Off Output #</td><td>1,2,Pro</td><td colspan="2">Sets the state of the specified digital output Off. The command opens this dialog box:
 

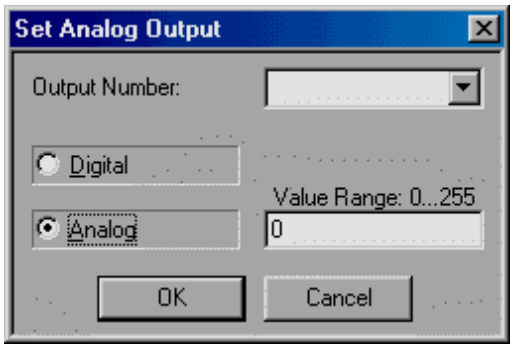
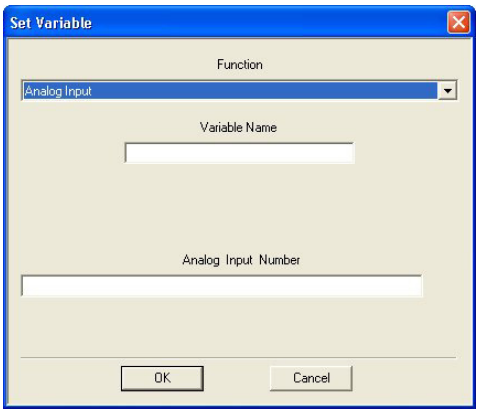
Figure 6-43: Turn Off Output Dialog Box</td></tr>
<tr><td colspan="3"></td><td>Output Number</td><td>Select a number or type a variable name.</td></tr>
<tr><td colspan="3"></td><td colspan="2">The default settings of Digital and Off can be changed.</td></tr>
<tr><td></td><td>AO Set Analog Output #</td><td>Pro</td><td colspan="2">Sets the state of the specified analog output. The command opens this dialog box:
 

Figure 6-44: Set Analog Output Dialog Box</td></tr>
<tr><td colspan="3"></td><td>Output Number</td><td>Enter a number (1 or 2), or a variable.</td></tr>
<tr><td colspan="3"></td><td>Value Range</td><td>Enter a number between 0 and 255 which corresponds to the output voltage. The range of the output voltage is 0-10 Volts.</td></tr>
<tr><td colspan="3"></td><td colspan="2">The Analog default setting can be changed.</td></tr>
</table>

AI Set Variable to Analog Input #	Pro	Sets the value of the specified analog input to a variable. The command opens this dialog box:  *Figure 6-45: Set Variable (Analog) Dialog Box*

Variable Name	Enter the name of the variable. The first character of the name must be a letter.
Analog Input Number	Enter an input number (1-4) or a variable, where the variable value is an integer in the range of 0-255 corresponding to a controller input voltage of 0-10 volts.
See also the description of the Set Variable commands in the preceding sections of this chapter.	

Advanced Commands

Advanced Commands are displayed in the Command Tree when you select Options | Advanced Options | Advanced Commands.

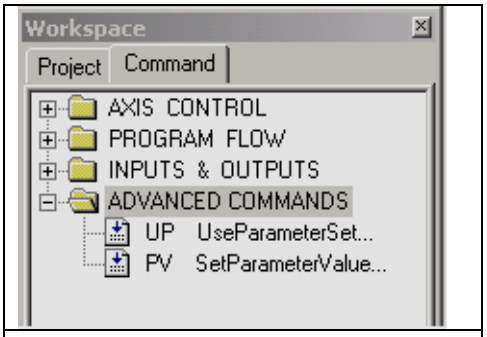


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Figure 6-46: Command Tree - Advanced Commands

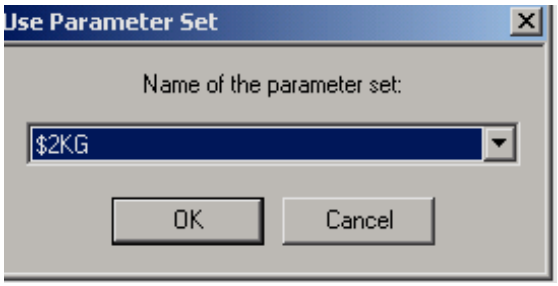
<table>
<tr><td>UP Use Parameter Set</td><td>Pro</td><td>Specifies the Parameter Set to be used. The command opens this dialog box:
 

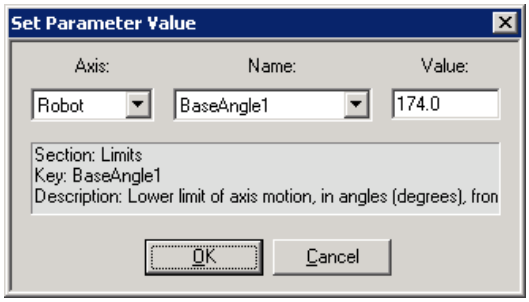
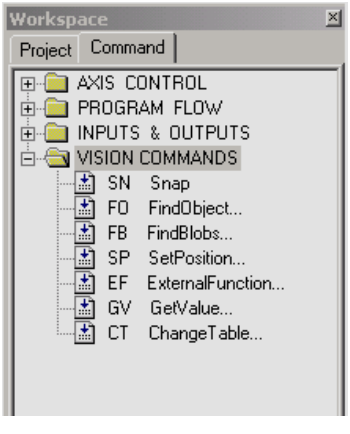
Figure 6-47: Use Parameter Set Dialog Box
Open the drop-down list to select the desired Parameter Set and click OK.
See page 96 for further information.</td></tr>
<tr><td>PV Set Parameter Value</td><td>Pro</td><td>Sets the value for a selected device parameter by name. The command opens this dialog box:
 

Figure 6-48: Set Parameter Value Dialog Box
<table>
<tr><td>Axis</td><td>Open the drop-down list to select the axis for which you need to change the parameter.</td></tr>
<tr><td>Name</td><td>Open the drop-down list to select the parameter whose value needs to be changed.</td></tr>
<tr><td>Value</td><td>Enter the new value.</td></tr>
<tr><td colspan="2">The details of the selected parameter are automatically displayed.</td></tr>
</table></td></tr>
</table>

Vision Commands

Vision Commands are displayed in the Command Tree when you select Options | Advanced Options | ViewFlex Commands. See the ViewFlex User Manual for full details.



Pro – Professional

Figure 6-49: Command Tree - Vision Commands

7

Variable Programming

The SCORBASE language allows variable programming. Variables allow you to write commands that change as the state of the robot or its environment changes during program execution. Therefore they are useful for creating loops and subroutines in robot programs.

To use a variable, it must first be defined using the Set Variable to Computation command. See pages 41 and 58.

Variable names can be up to 22 characters long. It is recommended, however, that you use meaningful names that are as short as possible. The first character of the name must be alphabetic.

SCORBASE has full access to variables in Visual Basic scripts that are loaded in memory. The variable name must begin with **SCRIPT.**, for example: **SCRIPT.A**. Values can be transferred both to and from variables in external Visual Basic scripts.

In most editing commands, a variable can be specified instead of a numeric value.

A variable cannot be used to specify a Label or a Subroutine.

If, at run time, the program encounters a variable whose value is not defined or is out of range, an error message is displayed.

Figure 7-1: Undefined Variable Error Message

Using a Variable Instead of a Numeric Value

Example #1

```
Set Variable station1=5
```

```
Set Variable lamp=1
Go to Position station1 fast
Turn on output lamp
```

In this example, one of the robot stations named "*station1*" is recorded as position #5 and a lamp is connected to output #1. When the program initiates, the value (5) is assigned to the variable named *station1* and the value (1) is assigned to the variable *lamp*. The following program lines send the robot to position "*station1*" and turn on a "*lamp*". Using a meaningful name for the variable makes the programming, debugging and maintenance easier.

Example #2

```
Set variable pos = 0
Start:
Set variable pos = pos +1
Go to position pos fast
Wait 50 (10ths of seconds)
If pos < 5 jump to start
```

In this example, the robot moves to Positions #1, #2, #3, #4 and #5. At each position, the robot waits 50 seconds. After waiting at position #5, the program terminates.

Example #3

```
Start:
Set variable tested = 0
Loop:
Set variable tested = tested +1
If input tested off call sub off
If input tested on call sub on
If tested < 8 jump to loop
Jump to start

Set Subroutine off
Turn off output tested
Return from subroutine.

Set Subroutine on
Turn on output tested
Return from subroutine
```

In this example, the program sequentially scans digital inputs 1 through 8 in an endless loop.

If the tested input is *On,* the program turns **on** the corresponding output.

If the tested input is *Off,* the program turns the corresponding output **off**.

Monitoring Variable Value

To monitor a variable value, SCORBASE offers the following tools:

1. When SCORBASE is running and a Set Variable command is executed, the current value of the variable is displayed in the status line at the bottom of the screen.
2. When the program is *not* running, click on the Set Variable command in which the value is assigned to the variable, and then execute this line using the Run Single Line command. The variable value is displayed in the status line at the bottom of the screen.
3. The Print to Screen & Log (PS) command can also be used to print the actual value of a variable, by placing the variable name within single quote marks in the text to be printed.

Example:

```
Set Variable z = 5
Set Variable x = 9
Set Variable y = x - z
Print to screen z='z' x='x' y='y'
```

When the program is running, the following messages appear in the status bar:

1. When the first line is executed, the message is z=5
2. When the second line is executed, the message is x=9
3. When the third line is executed, the message is y=4
4. When the fourth line is executed, this window opens:

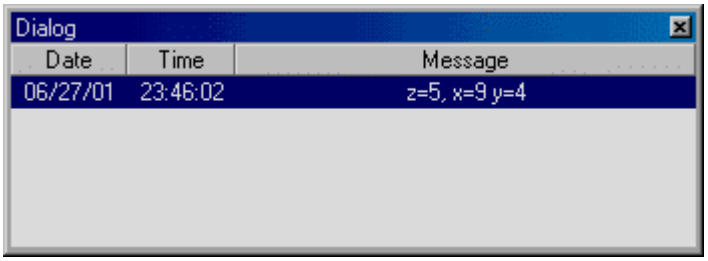


Figure 7-2: Variable Status Dialog Window

8

Program Execution

The Program Window and the dialog bars described in this chapter are used for activating and monitoring program execution.

Select Window | Run Screen to display only the Program window, which shows the section of the program currently executed.

- Status Bar - indicates the currently executed line or current value of a variable.
- Inputs and Outputs Dialog Bars - show the Analog Input, Analog Output, Digital Input, Digital Output values. To activate the dialog bars that are most useful for program execution, select View | Dialog Bars and then the desired dialog bar from the pop-up menu.
- Log file - records data during program execution.

Running a Program

SCORBASE offers three modes of running a program. To select the running mode do one of the following:

- Click the appropriate Run icon in the toolbar.
- Select one of the Run options in the Run Menu.
- Press the function key.

 Single line (F6)	Runs the currently selected (highlighted) line.
 Single cycle (F7)	Runs the program from the currently selected (highlighted) line. Running stops after the last line is executed.
 Continuous (F8)	Runs the program from the currently selected (highlighted) line. After the last line is executed, program execution continues from the first line.

The *[Run]* key on the Teach pendant *cannot be used* to start execution of SCORBASE programs.

Note: Always restart execution of a program from the first line after you have changed program data (e.g., recorded new coordinates for a position, edited a program line, etc.).

Halting Program Execution

Stop and Pause are the two methods of halting program execution from SCORBASE.

To stop or pause programs from SCORBASE do one of the following:

- Click the appropriate icon in the toolbar.
- Select Run | Stop, or Run | Pause.
- Press F9 / F10 - Make sure the SCORBASE application is the currently active window before you press F9 (STOP) or F10 (PAUSE).
- To STOP the program you can also press the red EMERGENCY button on the controller or press the ABORT key on the Teach Pendant (if installed).

Stop (F9)	Program execution is stopped **immediately**. Use this command only in emergencies. If the workstation is connected only to a stationary robot such as an ER-4u, the STOP command is sent directly to the device. However, other devices such as the ER-400 AGV Mobile Robot require the user to define a subroutine with the name ON_STOP. When the STOP button or F9 is pushed, the ON_STOP subroutine is called. The subroutine might contain a line such as **Turn Off Output 1**. Here is an example for use with the ER-400 AGV Mobile Robot:  *Figure 8-1: Program Window – ON_STOP subroutine.*
Pause (F10)	Stops program execution only after the current command has been executed. Thus, axes may continue moving (to complete their motion) after the Pause command is issued.

Inputs and Outputs Dialog Bars

Digital Inputs & Outputs Dialog Bars

The Digital Inputs & Outputs dialog bars show the status of the controller digital inputs and outputs. The display is available in all modes of operation.

Figure 8-2: Digital Input Dialog Bar

Figure 8-3: Digital Output Dialog Bar

In both dialog bars, when the I/O status is *Off* (false), the matching I/O number is dark green. When the I/O status is *On* (true), the matching I/O number is light green

If control is On, the sixteen Output / Input LEDs on the front panel reflect the I/O status.

If control is On, clicking on an output number in the Digital Output dialog bar toggles the status of the controller's digital outputs.

In *Off-line* the Digital Output dialog bar can also be used to simulate the status of controller's digital inputs. This option is useful for checking the If Input#_onJump command.

In On-line mode, to test the program response for the If Input#_onJump command, short the designated input terminal to the digital input ground.

Analog Inputs & Outputs Dialog Bars

SCORBASE can monitor and control four (4) analog inputs and two (2) analog outputs. The Analog Inputs & Outputs dialog bars show the values of the controller Analog Inputs and Outputs. These dialog bars may also be opened or closed using the View | Show All Dialog Bars or View | Close All Dialog Bars commands.

Figure 8-4: Analog Input Dialog Bar

Figure 8-5: Analog Output Dialog Bar

The Analog Inputs and Output resolution is 8-bit. The Analog Input / Output range is from 0 (minimum) to 255 (maximum).

Output values can only be manipulated when SCORBASE is operating On-line. To change the value of an Analog Output, do one of the following:

- Click Output (the color turn from light yellow to white), and type a number.
- Use the AO (Set Analog Output #) command, and run this line.

When the controller receives an Analog Input signal from an external device, the value (0-255) of the signal is reflected in the Input Value field.

SCORBASE Log File

The SCORBASE log file records the messages printed using the PS (Print to Screen Log) command. To print to a message to the log file, click either Log File or Screen and Log File.

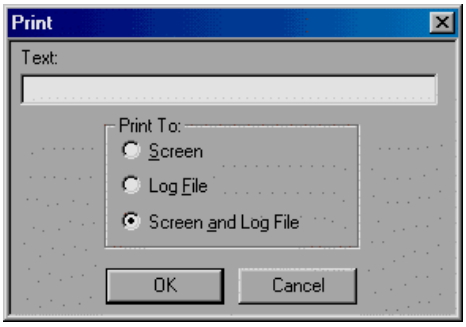


Figure 8-6: Print To Screen Command

The Log file is initialized (cleared) each time SCORBASE is loaded.

To see the file content, open the file SCBS.LOG using a text editor (such as WordPad). The file is located in the SCORBASE subdirectory named BIN.

SCORBASE generates a backup file each time the program is closed.

9

Project Files Management

A SCORBASE project includes the following files:

- SCORBASE program (file extension *.SBP)
- Recorded Position files (file extension *.PNT)
- Project data (file extension *.WS)
- Graphic image (if RoboCell is installed – file extension *.3DC).

All commands (except for Open) relate only to the SBP, PNT and WS files.

Opening or saving a project from the File menu opens or saves all project files (three or four files).

As default, all files are located in the Projects directory (folder) in the ER 2U or ER-4U directory (depending on which robot is being used for the project).

Project Management

SCORBASE project files are managed by means of the usual Windows file tools, which can be accessed by icons or via the File menu.

 New (Ctrl+N)	Opens a new, untitled, project named *Untitled*. All project-related files are created.
 Open (Ctrl+O)	Opens a Load Project File dialog box for opening a previously saved project. All project-related files are opened. Only one project may be open at a time.

Save (Ctrl+S)	Saves the currently active project. If the project has not previously been saved (i.e., is untitled), a dialog box for specifying the project name opens. All project-related files are saved, including Program, Positions and Graphics.
Save As...	Opens the Save Project dialog box for saving the currently active project under a new name. All project-related files are saved under that new name. As default, all projects are saved in a Projects folder.
Close Project	Closes the currently open project.
New Script	Opens Notepad. The user can then begin to write a new Visual Basic script file.
Open Script	Opens File Selector box for opening an existing Visual Basic script file.
Print Program	Prints the program. The Program window must be active to select this option
Print Positions	Prints the position table. The Position window must be open and active to select this option. You can open the Position window by selecting View | Positions.
Print 3D image	Prints the 3D image (if RoboCell program is installed).
Print Preview 3D Image	Opens a dialog window that shows how the printed cell will appear on paper.
Print Charts	Opens a dialog box to select the specific axis chart for display or printout. Only one axis can be selected at a time.
Print Preview Charts	Opens a screen, which displays the selected axis chart before printout showing how the printed cell will appear on paper.
Import 3D Model	Opens the Import 3D Image dialog window showing the graphic module files (*.3DC files).

Edit 3D Model	Opens the Graphic Module in CellSetup.
View File	Opens the *View File* window to display the program or position of any selected project.
Exit	Quits SCORBASE. If changes to a program or position file have been made, but not yet saved, a warning message will be displayed.

10

System Configuration

SCORBASE offers the following options for system configuration:

- Window Layout options.
- Experience level.
- Hardware setup.

Window Layout Options

Window Menu

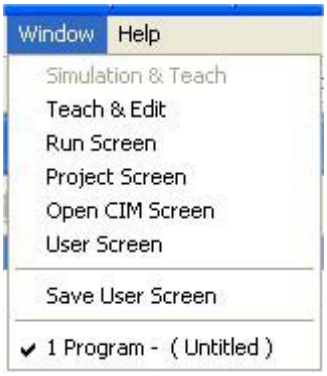


Figure 10-1: Window Menu

The display options enable optimal usage of the screen area. SCORBASE offers five basic display options and a wide range of dialog bars and windows through which the user can see and change system data.

Simulation & Teach

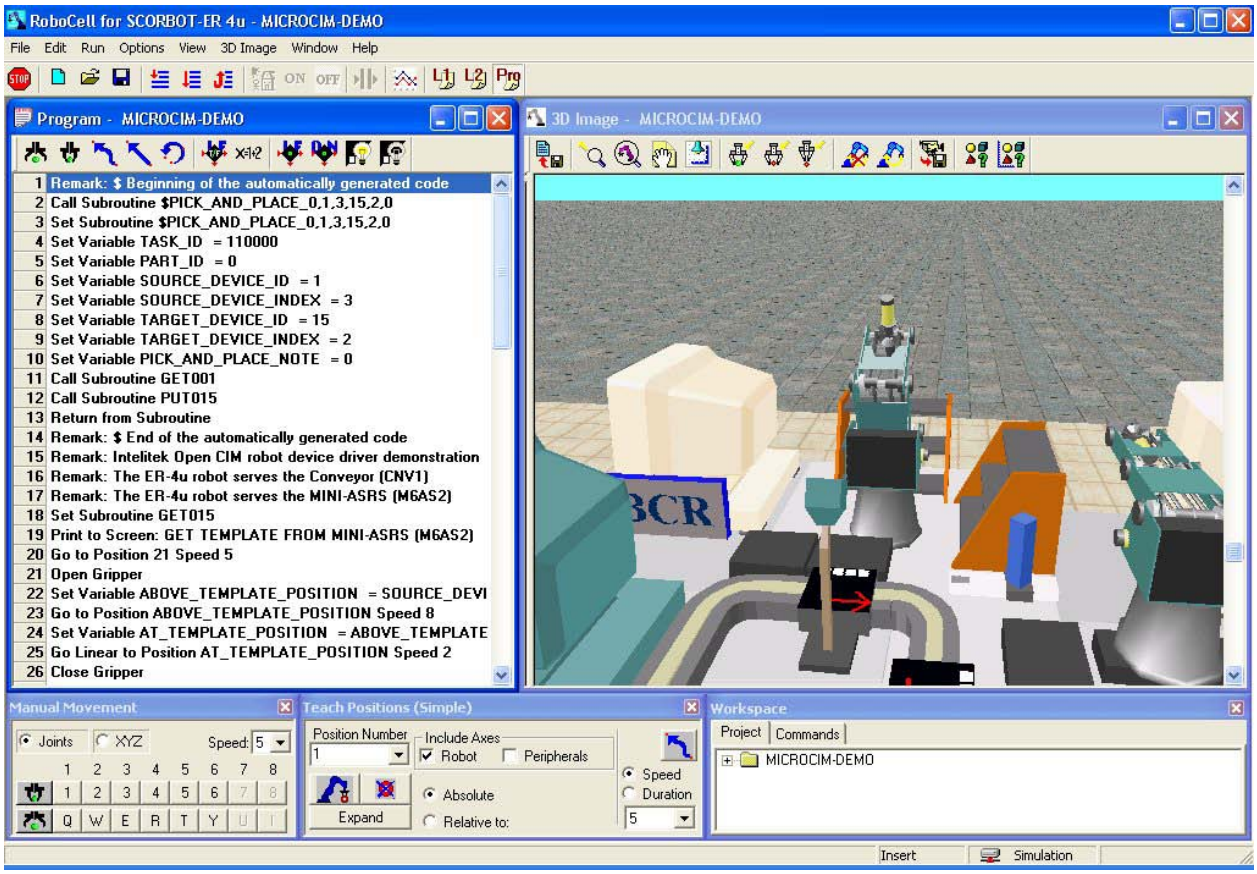


Figure 10-2: Simulation and Teach Screen

Available only if RoboCell is installed. This layout option displays the following windows:

- Program Window that holds the SCORBASE program.
- 3D Image
- Manual Movement Dialog Box
- Teach Positions Dialog Box
- Workspace Window that shows:
- Project tab
- Commands tab

For further information, see the RoboCell User Manual.

Teach & Edit

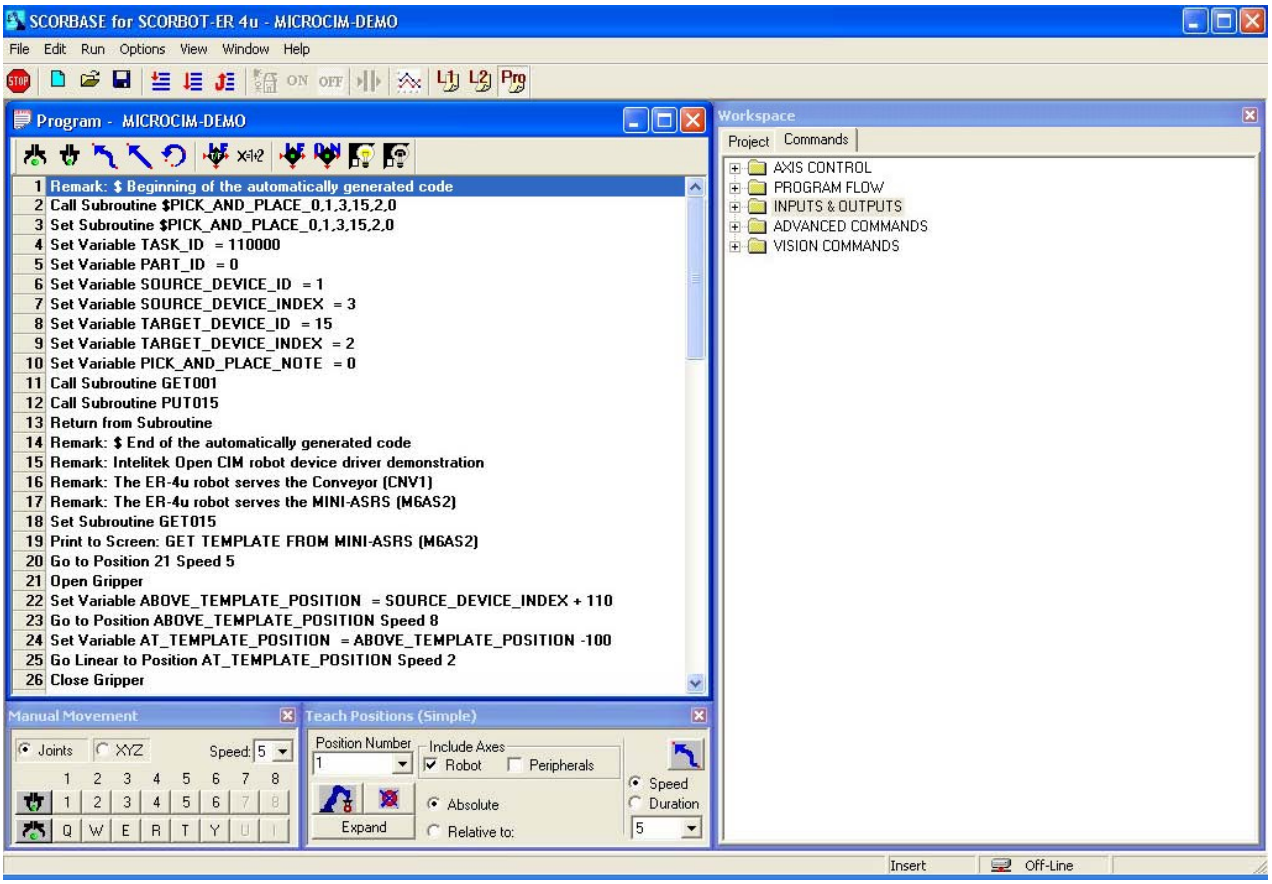


Figure 10-3: Teach & Edit Screen

When a SCORBASE project is opened, the screen is set for the Teach & Edit display mode by default. In this mode, these windows and dialog boxes are displayed:

- Program Window that holds the SCORBASE program.
- Manual Movement Dialog Box
- Teach Positions Dialog Box
- Workspace Window that shows:
- Project tab
- Commands tab

To open the Teach & Edit layout, select Window | Teach & Edit.

Run Screen

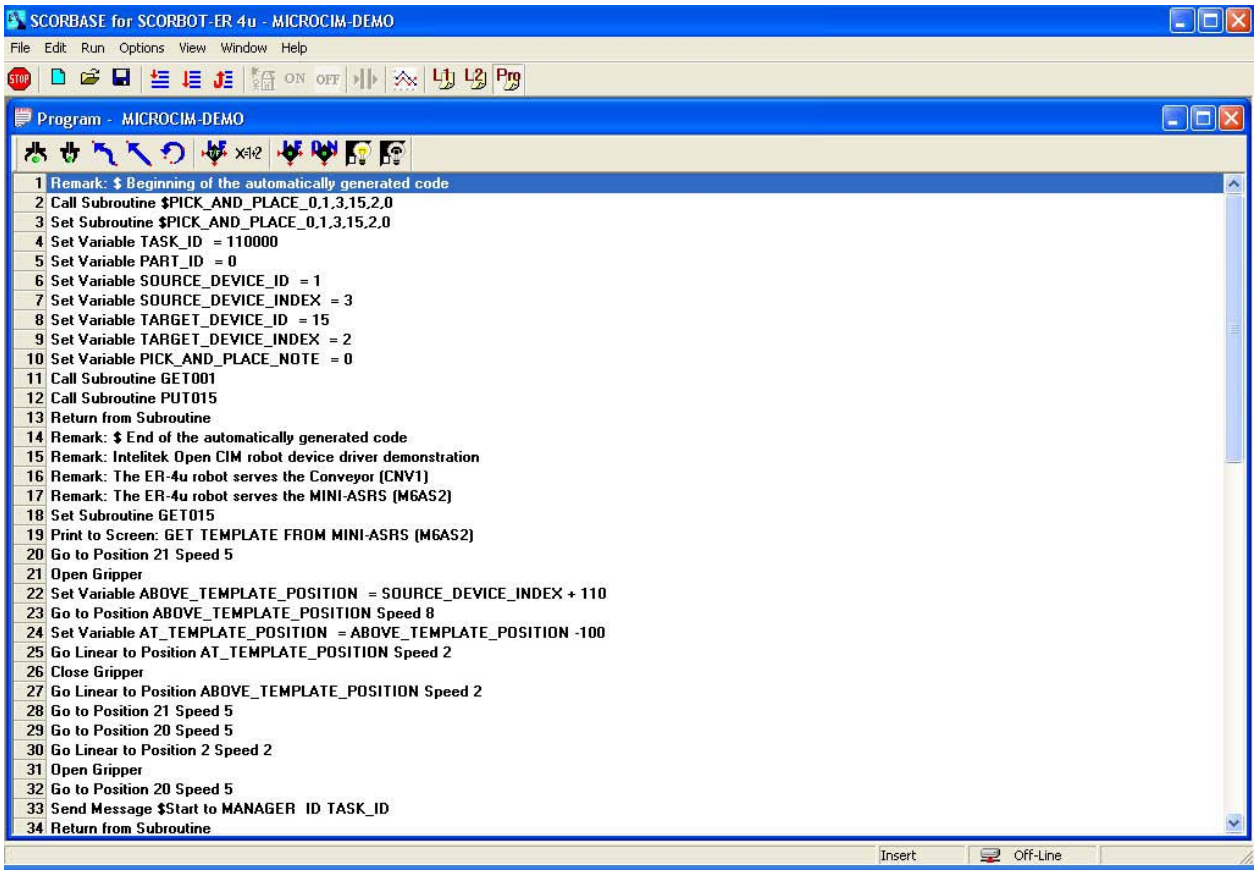


Figure 10-4: Run Screen

The Run Screen display option opens only the Program Window. When the program is running, the currently executed line is highlighted and information on the currently executed command is displayed in the status bar.

To open the Run Screen layout, select Window | Run Screen.

Project Screen

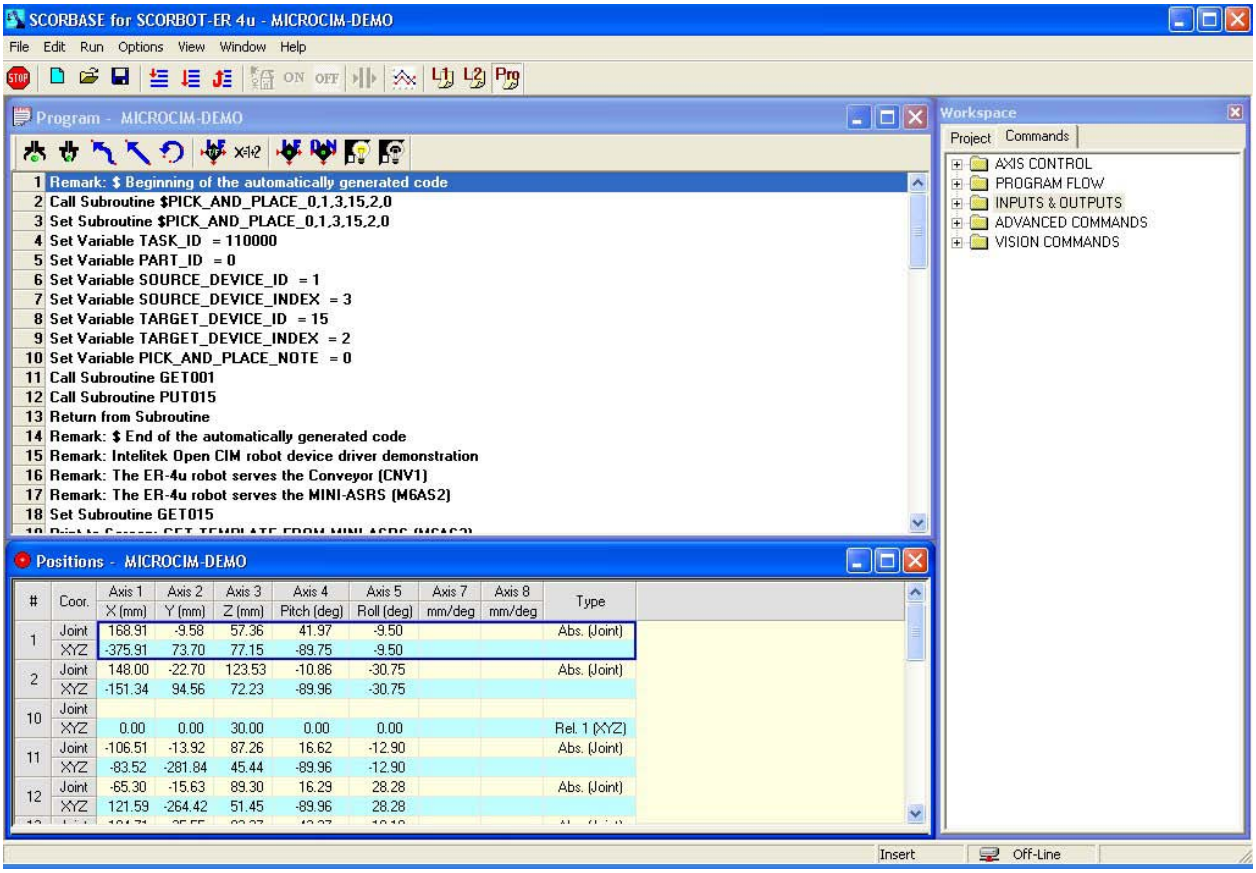


Figure 10-5: Project Screen

The Project Screen option displays the following:

- Program Window that holds the SCORBASE program.
- Workspace Window that shows:
- Project tab
- Commands tab
- Positions Window

When the program is running, the currently executed line is highlighted, and information on the currently executed command is displayed in the status bar.

To open the Project Screen layout, select Window | Project Screen.

Open CIM Screen

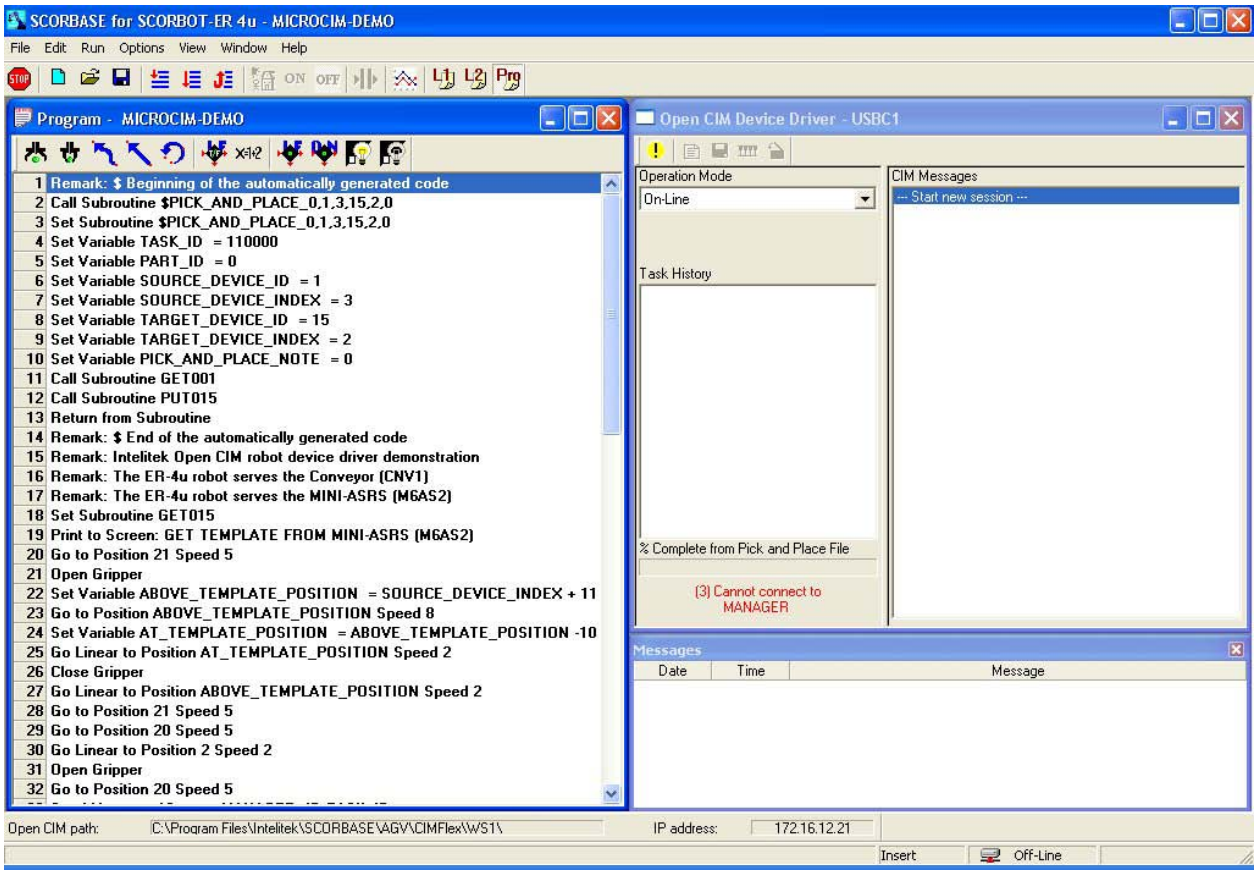
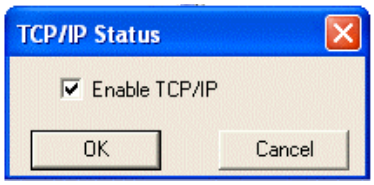


Figure 10-6: Open CIM Screen

The Open CIM Screen option displays the following:

- Program Window that holds the SCORBASE program.
- Open CIM Device Driver Window, which provides:
- Toolbar, with button for Manual Stop 
- Operation Mode selector
  - Online
  - Simulation
  - Standalone. When this option is selected, you may press the  icon on the toolbar to open the TCP/IP dialog box for establishing communications with other Open CIM applications.



- Task History panel
- Percentage Complete from Pick & Place File
- CIM Messages panel
- Messages Window

To use the Open CIM Screen layout, select Window | Open CIM Screen.

User Screen; Save User Screen

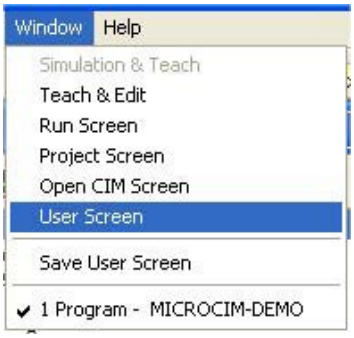


Figure 10-7: Window Menu – Select User Screen

By default, the User Screen displays the same windows as the Teach & Edit Screen. However, the user can customize the layout of the windows to the needs of the project. This is useful when you have specified one or more dialog bars under the View menu. See page 100.

To save the layout for future use, select Window | Save User Screen.

Whenever you desire to use that layout again, select Window | User Screen.

Other Options

Options Menu

Hardware Setup

SCORBASE allows you to define the devices that are connected and operated by the controller as Axes 7 and 8. The following peripherals can be connected to the USB Controller:

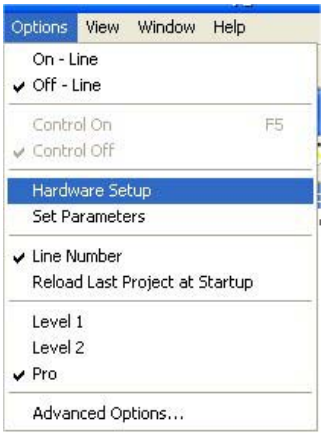


Figure 10-8: Options Menu – Hardware Setup

Catalog number	Description
1009	Rotary Table, 24V
1010	Conveyor Belt (gray), 24V
1020	1.0m Linear Slidebase, belt-drive, 24V
1021	1.8m Linear Slidebase, belt-drive, 24V
1013	Linear Table 0.3m, 24V
1014	XY-Table, 24V
1234	Motor Kit 24V

Note: The following peripherals are not supported:

- 1.0m Linear Slidebase, belt-drive, 24V Catalog #1018
- 1.8m Linear Slidebase, belt-drive, 24V Catalog #1019

Contact your local distributor for further information.

Do not change the hardware setup unless you are authorized to do so. To define the devices, select Options | Hardware Setup. The Hardware Setup dialog box opens. Click on the arrow to open the list of available devices, and then click on the desired device.

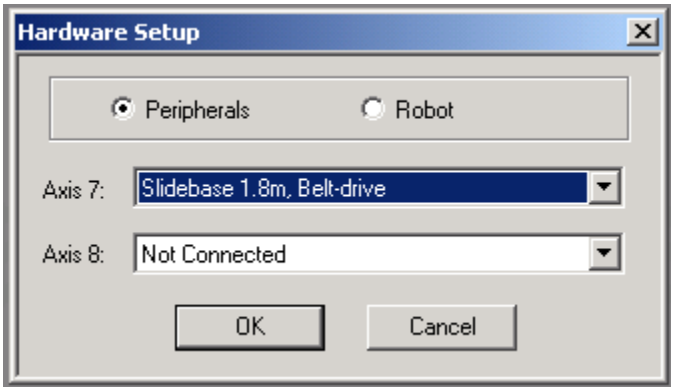


Figure 10-9: Hardware Setup Dialog Box (Initial)

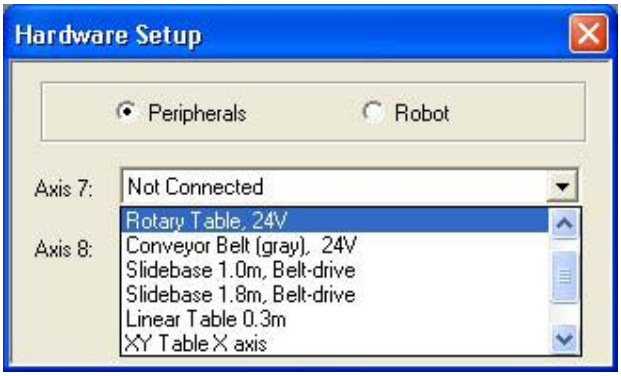


Figure 10-10: Hardware Setup Peripherals Dialog Box showing default settings

The Hardware Setup option also enables you to work with a different robot from the one you selected during installation. See page 2. To do so, click the Robot radio button.

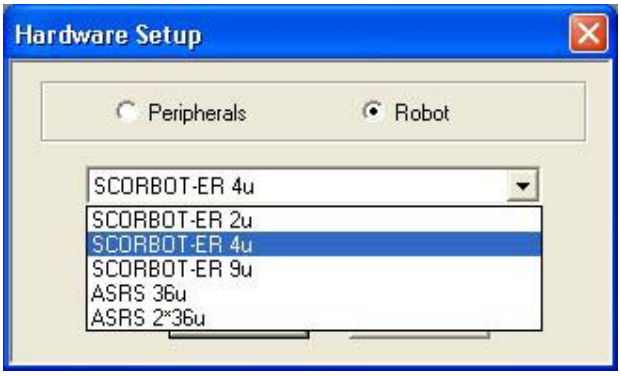
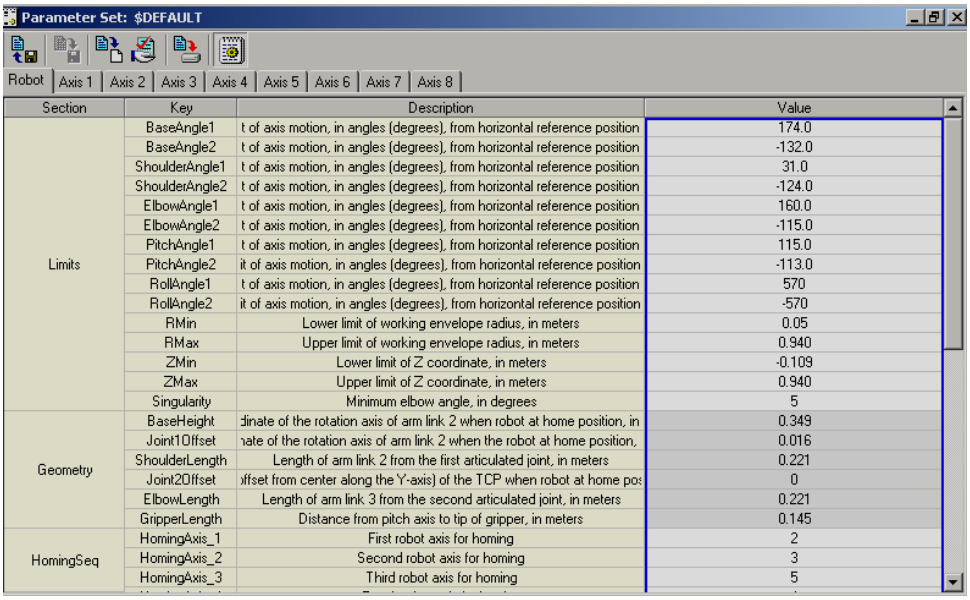


Figure 10-11: Hardware Setup Robot Dialog Box.

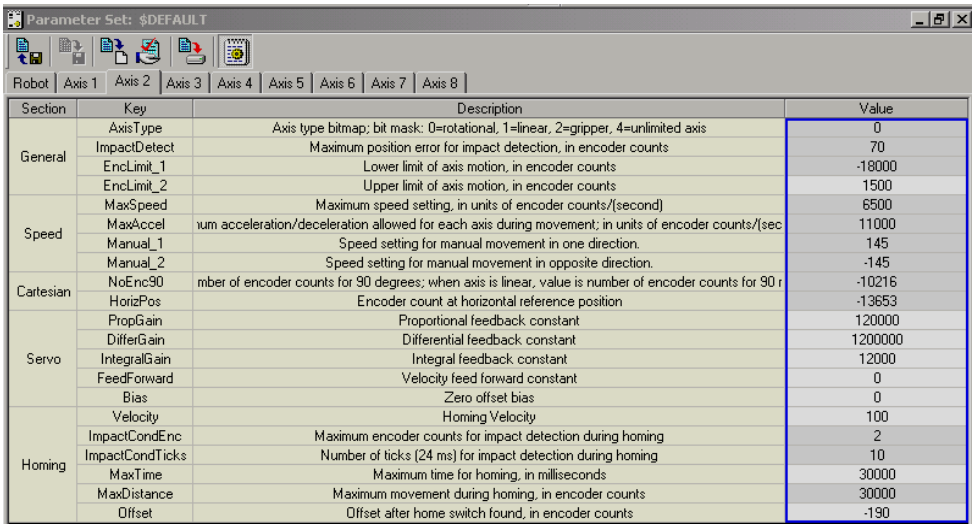
Select the desired robot and click OK.

Parameter Set Window



Section	Key	Description	Value
Limits	BaseAngle1	t of axis motion, in angles (degrees), from horizontal reference position	174.0
	BaseAngle2	t of axis motion, in angles (degrees), from horizontal reference position	-132.0
	ShoulderAngle1	t of axis motion, in angles (degrees), from horizontal reference position	31.0
	ShoulderAngle2	t of axis motion, in angles (degrees), from horizontal reference position	-124.0
	ElbowAngle1	t of axis motion, in angles (degrees), from horizontal reference position	160.0
	ElbowAngle2	t of axis motion, in angles (degrees), from horizontal reference position	-115.0
	PitchAngle1	t of axis motion, in angles (degrees), from horizontal reference position	115.0
	PitchAngle2	it of axis motion, in angles (degrees), from horizontal reference position	-113.0
	RollAngle1	t of axis motion, in angles (degrees), from horizontal reference position	570
	RollAngle2	it of axis motion, in angles (degrees), from horizontal reference position	-570
	RMin	Lower limit of working envelope radius, in meters	0.05
	RMax	Upper limit of working envelope radius, in meters	0.940
	ZMin	Lower limit of Z coordinate, in meters	-0.109
	ZMax	Upper limit of Z coordinate, in meters	0.940
	Singularity	Minimum elbow angle, in degrees	5
Geometry	BaseHeight	dinate of the rotation axis of arm link 2 when robot at home position, in	0.349
	Joint1Offset	nate of the rotation axis of arm link 2 when the robot at home position,	0.016
	ShoulderLength	Length of arm link 2 from the first articulated joint, in meters	0.221
	Joint2Offset	ffset from center along the Y-axis) of the TCP when robot at home pos	0
	ElbowLength	Length of arm link 3 from the second articulated joint, in meters	0.221
	GripperLength	Distance from pitch axis to tip of gripper, in meters	0.145
HomingSeq	HomingAxis_1	First robot axis for homing	2
	HomingAxis_2	Second robot axis for homing	3
	HomingAxis_3	Third robot axis for homing	5

Figure 10-12: Parameter Set Window - for Robot



Section	Key	Description	Value
General	AxisType	Axis type bitmap; bit mask: 0=rotational, 1=linear, 2=gripper, 4=unlimited axis	0
	ImpactDetect	Maximum position error for impact detection, in encoder counts	70
	EncLimit_1	Lower limit of axis motion, in encoder counts	-18000
	EncLimit_2	Upper limit of axis motion, in encoder counts	1500
Speed	MaxSpeed	Maximum speed setting, in units of encoder counts/(second)	6500
	MaxAccel	um acceleration/deceleration allowed for each axis during movement; in units of encoder counts/(sec	11000
	Manual_1	Speed setting for manual movement in one direction.	145
	Manual_2	Speed setting for manual movement in opposite direction.	-145
Cartesian	NoEnc90	mber of encoder counts for 90 degrees; when axis is linear, value is number of encoder counts for 90 r	-10216
	HorizPos	Encoder count at horizontal reference position	-13653
Servo	PropGain	Proportional feedback constant	120000
	DifferGain	Differential feedback constant	1200000
	IntegralGain	Integral feedback constant	12000
	FeedForward	Velocity feed forward constant	0
	Bias	Zero offset bias	0
Homing	Velocity	Homing Velocity	100
	ImpactCondEnc	Maximum encoder counts for impact detection during homing	2
	ImpactCondTicks	Number of ticks (24 ms) for impact detection during homing	10
	MaxTime	Maximum time for homing, in milliseconds	30000
	MaxDistance	Maximum movement during homing, in encoder counts	30000
	Offset	Offset after home switch found, in encoder counts	-190

Figure 10-13: Parameter Set Window - for Axes

SCORBASE contains the following parameter sets:

Parameter Set	Description
$2KG	Moves objects that weigh about 2 kg.
$3KG	Moves objects that weigh about 3 kg.
$Current	Current parameter set loaded to the controller.
$Default	Default set when parameters are optimized.
Maxspeed	Activates the robot at maximum speed.

To modify any of the parameters of the above vendor-supplied sets you must save the set under a different name. Click the Save As icon to open the dialog box. Enter the name of the new Parameter Set and click OK to save it.

Figure 10-14: Parameter Set Window toolbar

Use the Parameter Set Window toolbar to select one of the following options:

 Open	Displays the Open Parameter Set window. Select the desired Parameter Set from the list.
 Save	Saves the Parameter Set after changes have been effected. A Parameter Set marked with the $ symbol cannot be changed and saved. The set must first be saved under a new name using the Save As icon.
 Save As	Opens the Save Parameters Set As dialog box. Enter the name of the new Parameter Set and click OK to save it.
 Default	Displays the $Default Parameter Set.
 Apply	Loads the selected Parameter Set to the controller.
 View	Opens the selected Parameter Set Window, which lists all the parameter keys, with description and value, included in the Parameter Set. The keys are listed by sections. See page 96.

Line Number

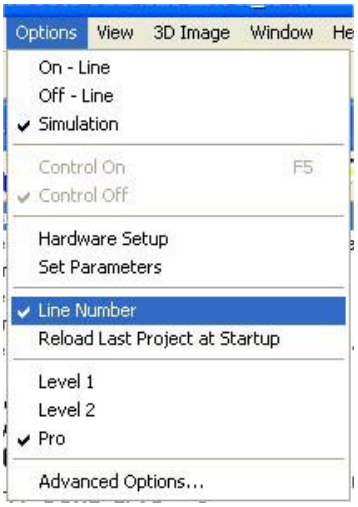


Figure 10-15: Options Menu – Line Number Selection

By default, SCORBASE displays program line numbers in the Program Window. If you wish to hide them, uncheck the toggle under Options | Line Number.

Reload Last Project at Startup

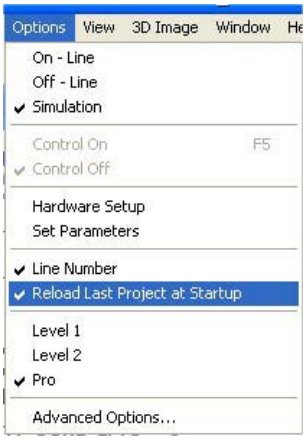


Figure 10-16: Options Menu – Reload Last Project Selection

When SCORBASE is initiated, the program can be set up to automatically open the last project. To toggle this option, select or deselect Options | Reload Last Project at Startup. A checkmark appearing next to this option indicates that the option is on.

Experience Level

SCORBASE offers three experience levels:

- Introductory (Level 1)
- Advanced (Level 2)
- Professional (Pro Level)

A higher level offers more commands and tools. Levels can be selected from the Tool bar or from the Options menu.

	Level 1	Displays list of commands and options at introductory level. Commands related to Level 2 and Pro are disabled.
	Level 2	Displays list of commands and options at advanced level. Commands related to Pro are disabled.
	Pro	Displays list of all commands and options.

Display of the Advanced Commands and the Vision Commands is activated by selecting Options | Advanced Options.

View Menu

The following display options are available from the View menu:

Movement information	Displays the following: • Position error for all eight axes • Home switch status (for all eight axes). The number 1 indicates the switch is on (pressed) while 0 indicates the switch is off (released). • Selected axis (1 – 8) PWM value. The PWM value indicates the power sent to the axis motor.  *Figure 10-17: Movement Information Dialog Box*

Messages	Displays the content of the PS (Print To Screen) commands.  *Figure 10-18: Messages Window*

These two commands produce a window which overlaps the existing windows. The user should readjust the positions and sizes of these windows according to personal preference.

Dialog Bar Display Options

All Dialog bars are accessible from the View menu. Select View | Dialog Bars.

Joints	Shows angle of the robot joints. See page 39.
XYZ	Shows position coordinates of the TCP. See page 39.
Digital output	Shows digital output status and enables toggling an output status. See page 80.
Digital input	Shows the digital input status. Enables toggling an input status in Off-line mode, for program debugging. See page 80.
Analog output	Displays the value (0-255) of Analog output 1 and 2. These values can also be modified through this dialog bar. See page 82.
Analog input	Displays the value (0-255) of Analog inputs 1-4. Enables setting a value for an input in Off-line mode, for program debugging. See page 82.
Encoders	Shows the values of the eight encoders. See page 39.

Each of these options adds a dialog bar to the bottom of the screen, overlapping whatever windows are displayed. The user can retile the screen by reselecting the desired Window Layout Options from the Window menu.

Appendix A

Command Line Options

The following table describes the command line options that enable the integration of user applications with SCORBASE.

Before operating SCORBASE with these command line options, follow and obey all warnings and cautions provided in the user application manuals to prevent, for example, hazards from moving parts.

The SCORBASE command line format that is required when using the options described in the table is provided, as follows:

SCORBASE.EXE [Optional INI File] [Optional Switches]

Option	Description
/O	Loads SCORBASE in online mode. For example, **SCORBASE.EXE SCBS.INI /O**
/S	Loads SCORBASE in simulation mode. For example, **SCORBASE.EXE SCBS.INI /S**
/H	Performs auto homing from online mode. For example, **SCORBASE.EXE SCBS.INI /H**
/L	Loads a specific workspace in simulation mode. For example, **SCORBASE.EXE SCBS.INI /L="C:\PROGRAMES\INTELITEK\ ROBOCELL\PROJECTS\ER4u\Er4Cell1.WS**"
/R	Loads a specific workspace and runs SCORBASE. For example, **SCORBASE.EXE SCBS.INI /R="C:\PROGRAM FILES\INTELITEK\ROBOCELL\ PROJECTS\ER4u\Er4Cell1.WS**"
/I	Open CIM Robot Device Driver configuration file. For example: **SCORBASE.EXE /I=USBVD1.INI**
/N	Open CIM Robot Device Driver number.
/T	Displays the SCORBASE application on top of the desktop at all times.

/U	Prevents the SCORBASE application from staying on top of the desktop. This command can be activated only when SCORBASE is open.
/M	Minimizes the SCORBASE application. This command can be activated only when SCORBASE is open.
/E	Restores the SCORBASE application. This command can be activated only when SCORBASE is open.
/C	Closes the SCORBASE application. This command can be activated only when SCORBASE is open.
/CIMDD_ONLINE	Open CIM-SCORBASE device driver mode: Online
/CIMDD_SIMUL_AUTO	Open CIM-SCORBASE device driver mode: Simulation
/CIMDD_STANDALONE_ONLY	Open CIM-SCORBASE device driver mode: Standalone

Examples of SCORBASE command line procedures are provided, as follows:

Loading a workspace in simulation mode:

- At the prompt, type the following:
  SCORBASE.EXE /S /L=”C:\PROGRAM FILES\INTELITEK\ ROBOCELL\PROJECTS\ER9u\Act3.WS”. The workspace will be loaded in simulation mode.

Loading the software in online mode and homing the robot:

- At the prompt, type the following:
  SCORBASE.EXE /O /H /R=”C:\PROGRAM FILES\INTELITEK\ROBOCELL\PROJECTS\ER4u\Er4Cell1.WS”. The workspace will be loaded in online mode and the robot will be homed.

SCORBOT-ER 4u

User Manual

Catalog #100343 Rev.B

intelitek

(September 2001)

Catalog #100343 Rev.B

Read this manual thoroughly before attempting to install or operate the equipment.
If you have any problems during installation or operation, call your agent for assistance.

website: www.intelitek.com

email: info@intelitek.com

Table of Contents

CHAPTER 1

General Information

This chapter contains instructions for unpacking and handling the **SCORBOT-ER 4u** robot.

About SCORBOT-ER 4u

The **SCORBOT-ER 4u** was designed and developed to emulate an industrial robot. The open structure of the robot arm allows students to observe and learn about its internal mechanisms.

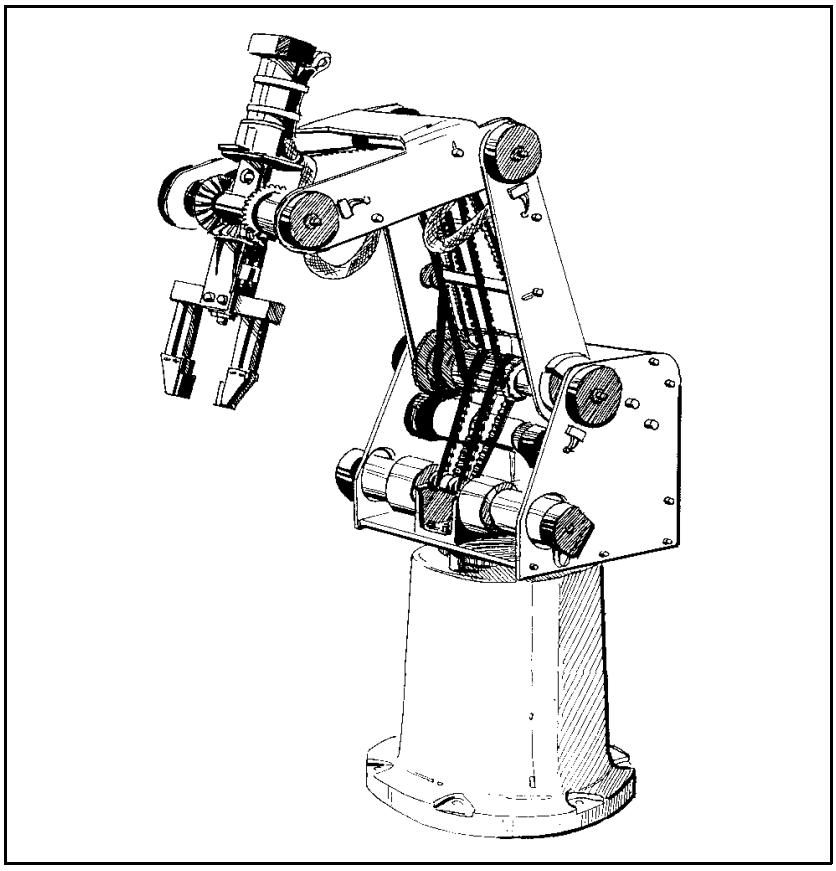


Figure 1: SCORBOT-ER 4u Robot Arm

Acceptance Inspection

The robot arm and its controller are packed in two separate cartons. *Save the original packing materials and shipping carton*. You may need them later for shipment or storage.

After removing the robot arm from its shipping cartons, examine it for signs of shipping damage. If any damage is evident, do not install or operate the system. Notify your freight carrier and begin appropriate claims procedures.

The standard **SCORBOT-ER 4u** package includes the following items:

- **SCORBOT-ER 4u** Robot arm
- Power cable 100/110/220VAC
- 3 bolts for mounting robot; set of hex wrenches
- ***SCORBOT-ER 4u*** *User Manual*

Refer to the *Controller-USB User Manual* for information about the control unit's standard and optional components.

Make sure you have received all the items listed on the shipment's packing list. If anything is missing, contact your supplier.

Repacking for Shipment

Be sure all parts are back in place before packing the robot.

☞ *The robot should be repacked in its original packaging for transport.*

If the original carton is not available, wrap the robot in plastic or heavy paper. Put the wrapped robot in a strong cardboard box at least 15 cm (about 6 inches) longer in all three dimensions than the robot. Fill the box equally around the robot with resilient packing material (shredded paper, bubble pack, expanded foam chunks).

Seal the carton with sealing or strapping tape. Do not use cellophane or masking tape.

Handling Instructions

Lift and carry the robot arm only by grasping the body or the base.
See Figure 2.

Do not lift and/or carry the robot arm by its gripper, upper arm or forearm.

Do not touch the microswitches, cams or encoders.

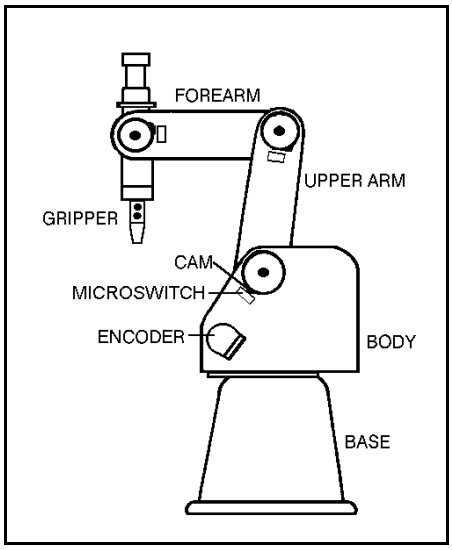


Figure 2: Robot Arm Parts

CHAPTER 2

Specifications

This chapter includes the specifications the **SCORBOT-ER 4u** robot arm and descriptions of its components.

SCORBOT-ER 4u Specifications	
Mechanical Structure	Vertical articulated
Number of Axes	5 axes plus servo gripper
Axis Movement Axis 1: Base rotation Axis 2: Shoulder rotation Axis 3: Elbow rotation Axis 4: Wrist pitch Axis 5: Wrist roll	 310° +130° / –35° ±130° ±130° Unlimited (mechanically); ±570° (electrically)
Maximum Operating Radius	610 mm (24.4")
End Effector	DC servo gripper, with optical encoder, parallel finger motion; Measurement of object's size by means of gripper sensor and software.
Maximum Gripper Opening	75 mm (3") without rubber pads 65 mm (2.6") with rubber pads
Homing	Fixed position on each axis, found by means of microswitches
Feedback	Optical encoder on each axis
Actuators	12 VDC servo motors
Motor Capacity (axes 1–6)	15 oz. in Peak Torque (stall) 70 W Power for Peak Torque
Gear Ratios	Motors 1, 2, 3: 127.1:1 Motors 4, 5: 65.5:1 Motor 6 (gripper) 19.5:1
Transmission	Gears, timing belts, lead screw
Maximum Payload	1 kg (2.2 lb), including gripper
Position Repeatability	±0.18 mm (0.007") at TCP (tip of gripper)
Weight	10.8 kg (23.8 lb)
Maximum Path Velocity	600 mm/sec (23.6"/sec)
Ambient Operating Temperature	2°–40°C (36°–104°F)

Structure

The **SCORBOT-ER 4u** is a vertical articulated robot, with five revolute joints. With gripper attached, the robot has six degrees of freedom. This design permits the end effector to be positioned and oriented arbitrarily within a large work space.

Figures 3 and 4 identify the joints and links of the mechanical arm.

The movements of the joints are described in the following table:

Axis No.	Joint Name	Motion	Motor No.
1	Base	Rotates the body.	1
2	Shoulder	Raises and lowers the upper arm.	2
3	Elbow	Raises and lowers the forearm.	3
4	Wrist Pitch	Raises and lowers the end effector (gripper).	4+5
5	Wrist Roll	Rotates the end effector (gripper).	4+5

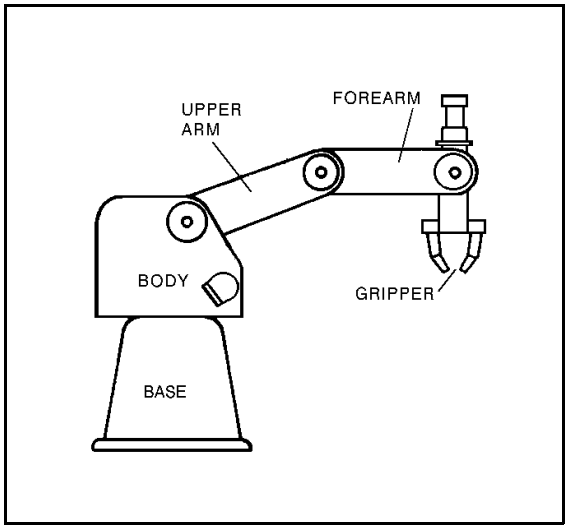


Figure 2-3: Robot Arm Links

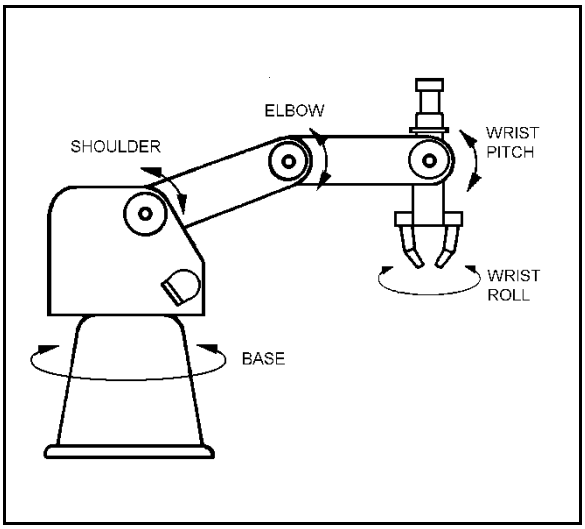


Figure 2-4: Robot Arm Joints

Work Envelope

The length of the links and the degree of rotation of the joints determine the robot's work envelope. Figures 5 and 6 show the dimensions and reach of the **SCORBOT-ER 4u**.

The base of the robot is normally fixed to a stationary work surface. It may, however, be attached to a slidebase, resulting in an extended working range.

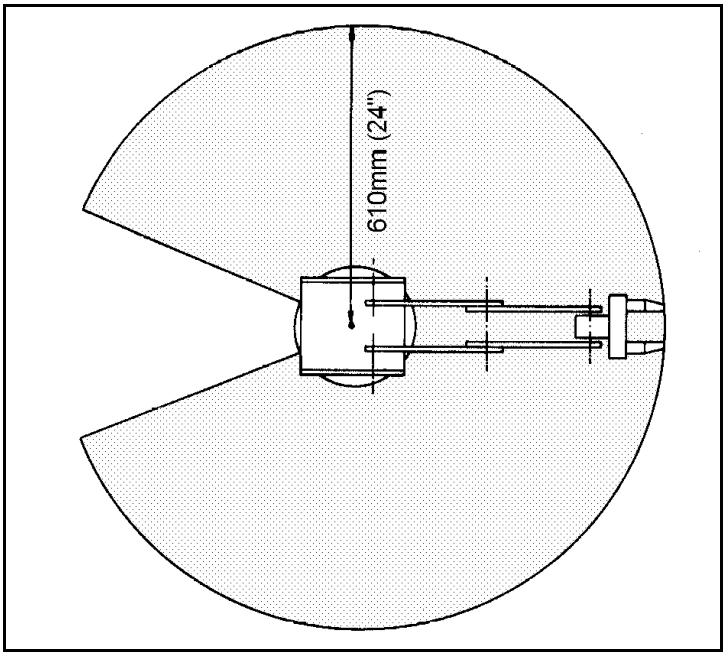


Figure 5: Operating Range (Top View)

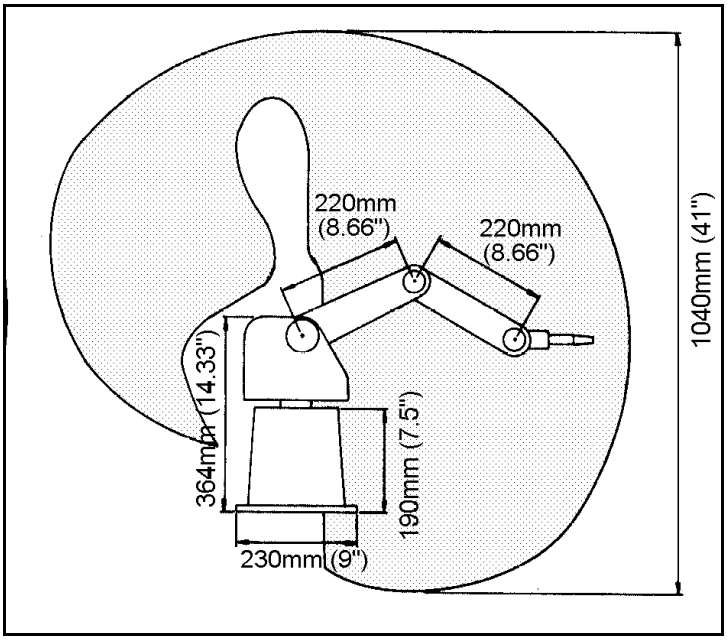


Figure 6: Operating Range (Side View)

Motors

The robot's five axes and gripper are operated by DC servo motors. The direction of motor revolution is determined by the polarity of the operating voltage: positive DC voltage turns the motor in one direction, while negative DC voltage turns it in the opposite direction.

Each motor is fitted with an encoder for closed-loop control.

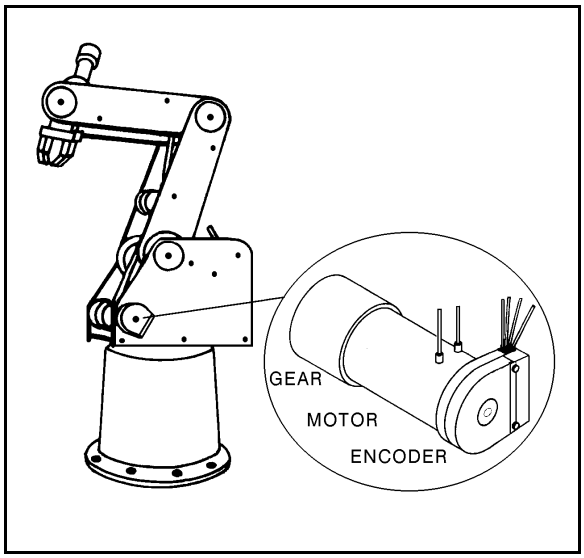


Figure 8: Motor

Encoders

The location and movement of each axis is measured by an electro-optical encoder attached to the shaft of the motor which drives the axis.

When the robot axis moves, the encoder generates a series of alternating high and low electrical signals. The number of signals is proportional to the amount of axis motion. The sequence of the signals indicates the direction of movement.

The controller reads these signals and determines the extent and direction of axis movement.

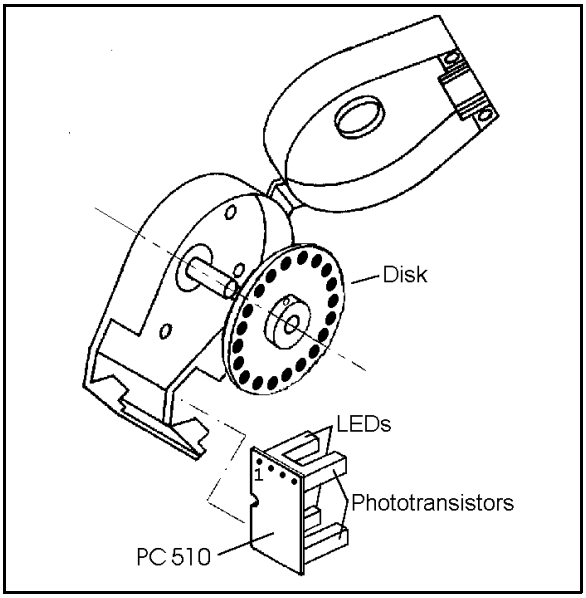


Figure 7: Encoder

Microswitches

The **SCORBOT-ER 4u** has five microswitches— one on each axis—which serve to identify the robot's home position.

During the homing procedure, the robot joints are moved one at a time. Each axis is moved until the its home switch is activated. The axis is then moved slightly until the the switch shuts off—at that point the joint is at home.

When all joints are at home, the robot is at home. This is the point of reference for robot operation. Whenever the system is turned on, the robot should be sent to this position, by means of a software homing routine.

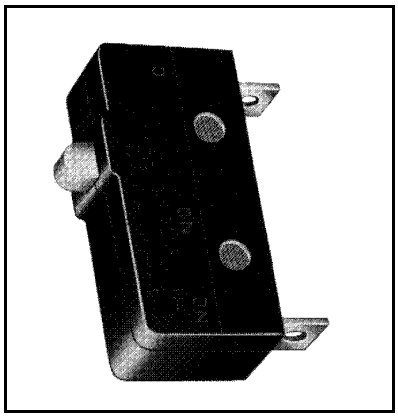


Figure 9: Microswitch

Transmissions

Several kinds of transmissions are used to move the links of the robot arm.

- Spur gears move the base and shoulder axes.
- Pulleys and timing belts move the elbow axis.
- Pulleys and timing belts, and a bevel gear differential unit at the end of the arm move the wrist pitch and roll axes.
- A lead screw transmission opens and closes the gripper.

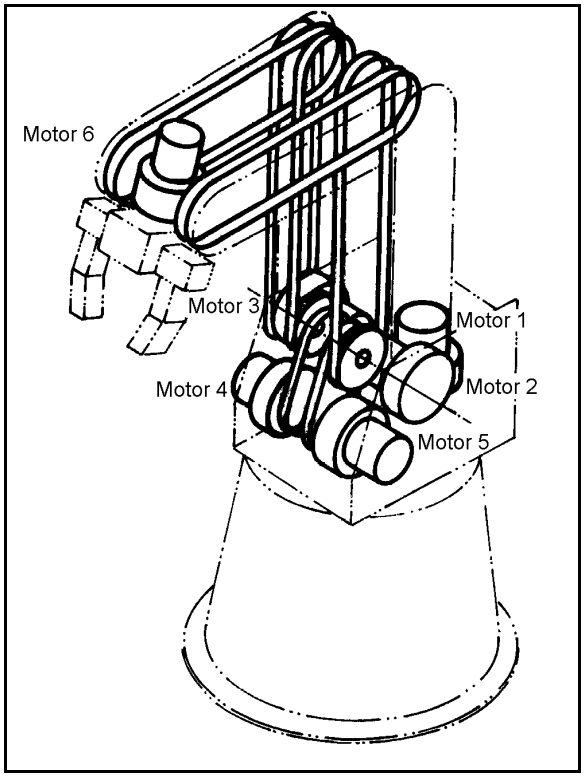


Figure 10: Transmissions

Gripper

The **SCORBOT-ER 4u** has a servo jaw gripper fitted with rubber pads. These pads can be removed to allow the attachment of other end effector devices, such as suction pads.

Three bevel gears form a differential gear train which moves the wrist joint. When motors 4 and 5 are driven in opposite directions, the wrist pitch moves up and down. When motors 4 and 5 are driven in the same direction, the wrist rolls clockwise and counterclockwise. A leadscrew coupled directly to motor 6 causes the gripper to open and close.

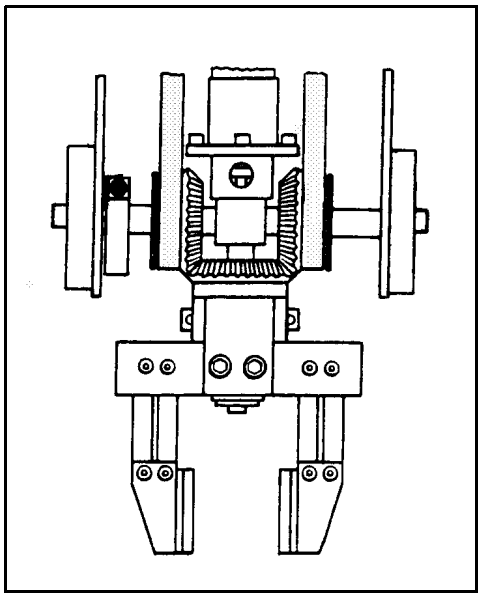


Figure 11: Gripper

CHAPTER 3

Safety

This chapter contains important safety guidelines and warnings.

☞ *Read this chapter carefully before you attempt to install or use the robot system.*

Precautions

This manual provides complete details for proper installation and operation of the **SCORBOT-ER 4u**. Do not install or operate the robot until you have thoroughly studied this *User's Manual*. Be sure you heed the safety guidelines for both the robot and the controller.

1. Make sure the robot base is properly and securely bolted in place.
2. Make sure the robot arm has ample space in which to operate freely.
3. Make sure a guardrail, rope or safety screen has been set up around the **SCORBOT-ER 4u** operating area to protect both the operator and bystanders.
4. Do not enter the robot's safety range or touch the robot when the system is in operation. Before approaching the robot, make sure the motor switch on the controller front panel has been shut off.
5. Make sure loose hair and clothing is tied back when you work with the robot.

☞ *To immediately abort all running programs and stop all axes of motion, press the EMERGENCY STOP button on either the teach pendant or the controller.*

Warnings

- Do not install or operate the **SCORBOT-ER 4u** under any of the following conditions:
  - Where the ambient temperature or humidity drops below or exceeds the specified limits.
  - 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.
- Do not overload the robot arm. The combined weight of the workload and gripper may not exceed 1kg (2.2 lb). It is recommended that the workload be grasped at its center of gravity.
- Do not use physical force to move or stop any part of the robot arm.
- Do not drive the robot arm into any object or physical obstacle.
- Do not leave a loaded arm extended for more than a few minutes.
- Do not leave any of the axes under mechanical strain for any length of time. Especially, do not leave the gripper grasping an object indefinitely.
- Since the **SCORBOT-ER 4u** motors are rated 12VDC nominal, while the controller motor drivers supply 24VDC, do not drive axes continuously in one direction at maximum speeds.

CHAPTER 4

Installation

Before installing the **SCORBOT-ER 4u**, be sure you have read and understood the safety instructions and warnings detailed in Chapter 1.

Be sure you have ample space to set up the robotic system, as shown in Figure 12.

1. Set up the **SCORBOT-ER 4u** on a sturdy surface with a minimum 700mm of free space all around the robot.

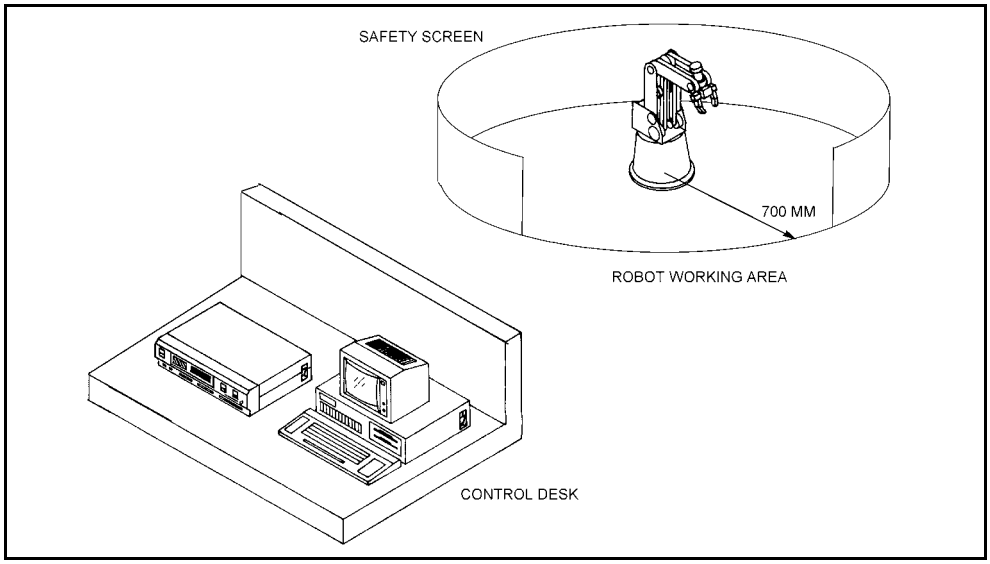


Figure 12: SCORBOT-ER 4u Installation

2. Fasten the base of the robot arm to the work surface with at least 3 bolts 120° apart, as shown in Figure 13.

   Robot Base ∅ 240 mm (9.49")
   Pitch Circle ∅ 207 mm (8.15")
   Hole (6 off) ∅ 8.5 mm (0.33")

   Make sure the robot is securely bolted in place. Otherwise the robot could become unbalanced and topple over while in motion.

3. Set up a guardrail, rope or safety screen around the robot's operating area to protect both the operator and bystanders.

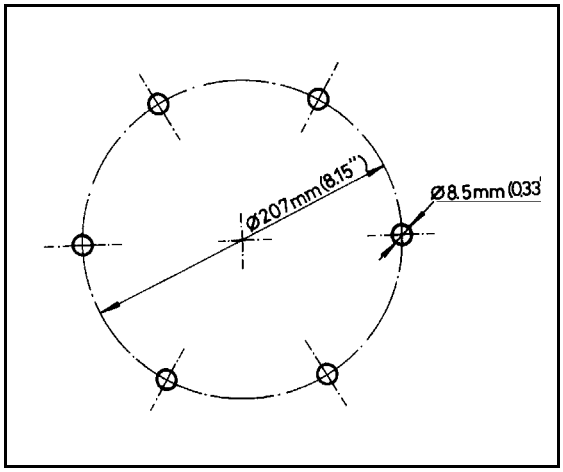


Figure 13: Robot Base Plate Layout

4. Place the controller and computer on a sturdy surface at a safe distance from the robot—well outside the robot's safety range.
5. Connect the robot cable (D50 connector) to the controller.
6. Make sure all other connections have been made in accordance with the instructions in the *Controller-USB User Manual*.
7. Turn on the computer and the controller.

CHAPTER 5

Operating Methods

The **SCORBOT-ER 4u** can be programmed and operated by means of **SCORBASE** software and by a teach pendant. Software and teach pendant operation is described fully in the other manuals supplied with the system.

SCORBASE Software

SCORBASE is a Windows-based robotic control software package which has been designed for use with the **SCORBOT-ER 4u.** Its menu-driven structure and off-line capabilities facilitate robotic programming and operation.

SCORBASE communicates with the robot controller by means of an USB channel.

SCORBASE can be operated in three levels. **SCORBASE** Level 1 and Level 2 are recommended for those who wish to learn robotic programming from the most basic stages. Level Pro contains programming commands and options for advanced users.

SCORBASE is described fully in the ***SCORBASE User Manual.***

Teach Pendant

The teach pendant is an optional device.

The teach pendant is a hand-held terminal which is used for controlling the robot and peripheral equipment connected to the same robot controller. The teach pendant is most practical for moving the axes, recording positions, and sending the axes to recorded positions. Other functions can also be executed from the teach pendant.

The teach pendant's user manual fully describes the various elements and functions of the teach pendant.

CHAPTER 6

Maintenance

Maintenance

The maintenance and inspection procedures detailed below will ensure continued optimum performance of the **SCORBOT-ER 4u** system.

Daily Operation

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 bolted to the work surface.
   - All cables are properly and securely connected.
     Cable connector screws are fastened.
   - No output is connected directly to a power supply.
   - No people are within the robot's working range.
2. After you have switched on the PC and the controller, check the following items:
   - The power and motor LEDs on the controller light up.
   - 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 range.
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 arm moves.
   - Robot reaches home position in every axis.

Periodic Inspection

The following inspections should be performed regularly:

1. Visually check leads, cables and rubber components. Replace any cables which show signs of abrasion or wear.
2. Check all bolts and screws in the robot arm using a wrench and screwdriver. Retighten as needed.
3. Check all the tension of robot arm belts. When you press on a belt, the slack should be no greater than 2mm (0.08"). Refer to Figure 14.

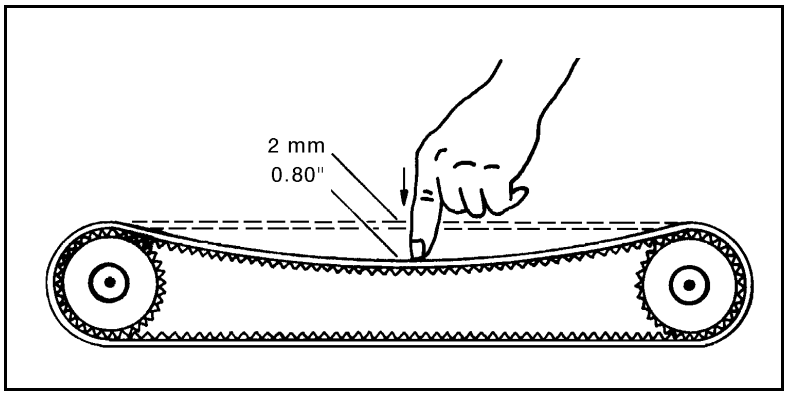


Figure 14: Belt Tension

Qualified Technician Only: Tighten the belts only if you are absolutely certain they are slipping or retarding the motors. For complete information, refer to the section, "Adjustments and Repairs," later in this chapter.

4. **Qualified Technician Only:** Check for excessive backlash in the base axis. For complete information, refer to the section, "Adjustments and Repairs," later in this chapter.

Troubleshooting

☞ *The procedures in the section are intended only for technicians who have received proper training and certification from the manufacturer.*

Do not attempt to perform procedures for which you are not qualified.

Whenever you encounter a malfunction, try to pinpoint its source by exchanging the suspected faulty component—for example, servo control card, controller, robot arm, PC, cables—with an identical component from a working system.

Do not open the controller. There are no user-serviceable parts inside. Do not attempt repairs for which you are not qualified. Contact your agent or an authorized technician for repairs.

The following chart provides guidelines for identifying and rectifying problems which you may encounter. Refer also to the ***Controller-USB*** *User Manual* for additional troubleshooting instructions and information.

---

1. *Controller functioning, but the robot cannot be activated.*
   - Make sure an obstacle is not blocking the robot.
   - Make sure none of the axes has reached its mechanical limits.
   - Make sure the controller's green MOTORS LED is lit.
   - Make sure the controller is in the Control Off state. Then activate the Control On state from the PC or TP.
   - Make sure the robot cable is properly connected to the controller.

---

2. *Robot does not find Home position in one or all of the axes.*
   - Make sure the homing command was properly issued.
   - Make sure the robot cable is properly connected to the controller.
   - Make sure system homing parameters are properly set.
     Make sure system homing parameters have not been erased.
   - Check the home microswitches, as follows:

     From the View menu, select Movement Information.

     While moving the robot manually, observe the status of the home microswitches in the Movement Information dialog box.
   - **Qualified Technician Only:**
     - If the above procedures show an error, check the microswitch itself. Use a small screwdriver to press down on the microswitch. You should hear it click and see it pop back up. If this does not happen, the microswitch should be fixed or replaced.
     - If the microswitch has clicked, depress it again and, with an ohmmeter, check whether the microswitch shorts its two poles.

- If there is a short, depress the switch again and check the wires between the microswitch and D50 connector.
- If there is a short, depress the switch and check the two microswitch pins in the D50 connector. (Refer to Chapter 8 for wiring and pin information).

---

3. *One axis turns constantly in one direction.*
   - Press and release the controller Emergency button to reset the controller. Then give the command to home the robot.

---

4. *One of the axes or gripper does not respond, or does not function properly.*
   - Make sure you have performed all steps in Item 1 and Item 2.
   - Turn the controller off, then on again.
   - Check the **encoder**. To display encoder readings, select **View|Encoders**.

     Enter the command Control Off (to disable servo control) and then *physically* move the axis in question in both directions. The encoder reading should rise for rotation in one direction and fall for rotation in the opposite direction.

     If the encoder readings do not change, the problem is caused by a faulty encoder, a break in the encoder wiring, or a faulty connection on a PCB within the robot.

5. *Errors in the accuracy of the robot. Controller does not read the encoder, or fails to show changes in encoder readings.*

   Qualified Technician Only:

   - Using an oscilloscope, check the signals (P_0 and P_1) received from the encoder's two phototransistors. Figure 15 shows the wave diagrams which emanate from the two channels of the encoder (P_0 and P_1) with respect to the time axis. The top two signals should be clean square waves:

     V_L (low) value should be 0.4V or less.
     V_H (high) value should exceed 4 V.

     In addition, check the third wave, which shows the sum of the two waves. The diagram reflects a time shift of a quarter cycle between the two waves.

     If the waves are distorted with an incorrect shift between them, the encoder is faulty and should be adjusted or replaced.

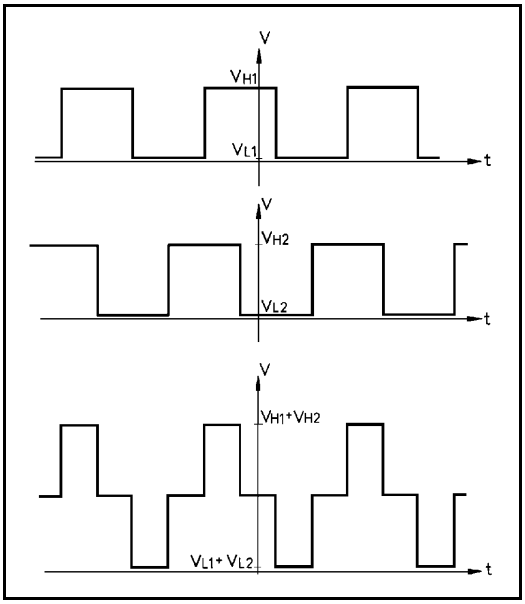


Figure 15: Encoder Signals

6. *Errors in the repeatability of the robot.*

   Qualified Technician Only:

   - Try to identify the faulty axis. If many or all axes are faulty, look for an electrical noise source in your environment.
   - Check the encoder. Follow the procedures in Item 3 and Item 4.
   - If no problem found by means of Items 8 and 9, do the following:

     Bring the robot to a starting position. Using a pencil, draw a fine, continuous line on the robot which crosses from one link to the adjacent link at the joint in question.

     Select **View|Encoders** to display the encoder readings.

     Enter the command Control Off (to disable servo control).

     Physically move the axis to another position. Then return to the starting position marked by the line you drew. Check the encoder reading for the axis again. It should be within several counts of the first reading. Repeat this step a number of times. If the error in the encoder reading accumulates, the encoder needs to be replaced.
   - Check the transmission for loose points or damage. Check for continuity of movement in all the relevant transmission components (gears and belts moving together with the drive shaft of the motor).

7. *Gripper opens and closes too freely; weak gripping force; or the gripper motor rotates endlessly.*

   Qualified Technician Only:

   - The Oldham coupling in the gripper assembly is loose. Follow the instructions in the section, "Adjustments and Repairs," later in this chapter.
   - Alternately, the gripper gear is broken, and must be replaced.

8. *Too much freedom (backlash) in the base axis.*

   Qualified Technician Only:

   - Refer to the section, "Adjustments and Repairs," later in this chapter.

9. *Unusual noise.*

   Qualified Technician Only:

   - Loose screws.
   - Poor lubrication.
   - Worn motor brushes.
   - Worn timing belt.

Adjustments and Repairs

☞ **These procedures are to be performed only by a qualified technician who has received proper training and certification from the manufacturer.**

Adjusting the Timing Belts

Qualified Technician Only

When you check the tension of robot arm belts, as indicated in Figure 8-1 at the beginning of this chapter, the slack should be no greater than 2mm (0.08"). Tighten the belts only if you are absolutely certain they are slipping or retarding the motors.

- Figure 16 shows how to tighten the belts in the forearm which move the wrist axes (pitch and roll). Loosen the two screws (1) which hold the tension shaft. Press down on the shaft and retighten the screws.
- Figure 17 shows how to tighten the belts in the upper arm which move the wrist axes (2), and the belt which moves the elbow axis (3).
- Figure 18 shows how to tighten the two belts in the robot base which move the wrist axes. First, loosen the screw (5), and then loosen either one or both screws (4). Then, to tighten the belts, simultaneously pull the appropriate motor and retighten screw(s) (4). Finally, retighten screw 5.

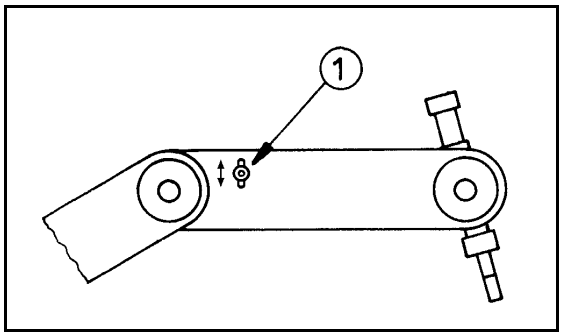


Figure 16: Tightening Belts in Forearm

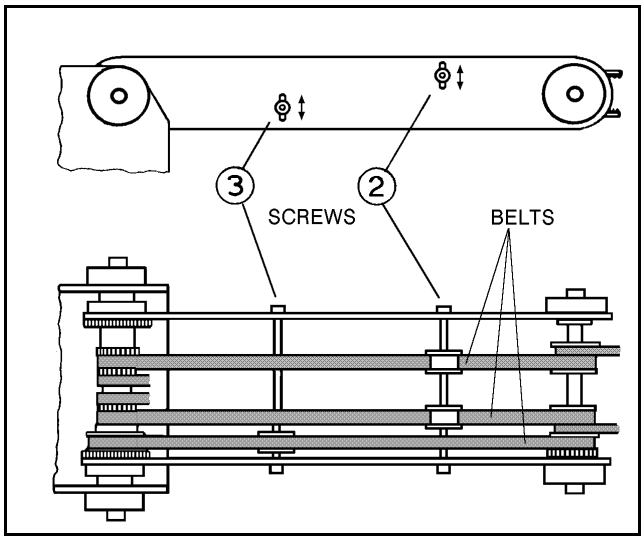


Figure 17: Tightening Belts in Upper Arm

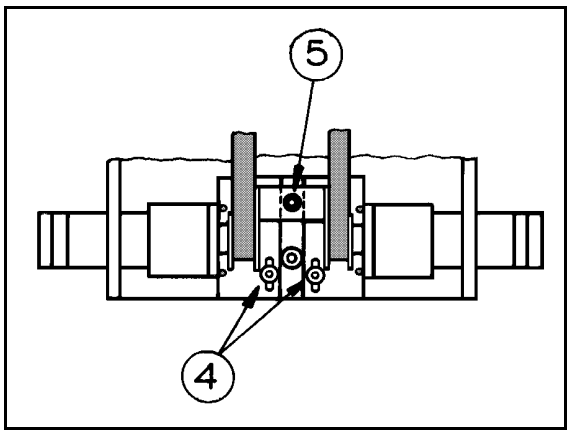


Figure 18: Tightening Belts in Robot Base

Adjusting Base Anti-Backlash

Qualified Technician Only

Refer to the exploded views of the robot in Figures 22 and 23.

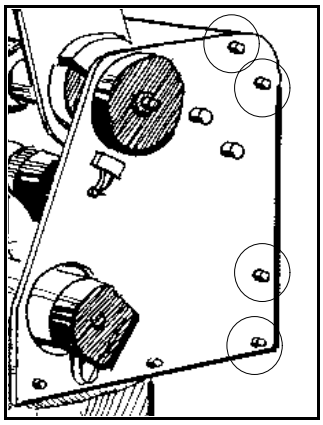


Figure 19: Shoulder Cover Screws

1. Refer to Figure 19. Remove the shoulder cover:
   - Remove the top three screws on each side of the shoulder cover.
   - Loosen (or remove) the bottom screw on each side.
2. Refer to Figure 23. Remove the base lock nut (S286).
3. Refer to Figure 22.
   - Remove the two socket head cap screws (S19), and detach the base motor from the base plate (12).
   - Check the set screw (S151) that holds the spur gear (S25) to the base motor gear (S309). If it is loose, tighten it.
   - Reattach the base motor to the base plate.
4. Refer to Figure 22. The anti-backlash unit has four gears. Two gears (22 and 27) are on top of one other with a spring (23) fitted in between. Stretch the anti-backlash spring in the base transmission:
   - Make sure the robot is bolted in place.
   - Remove the outermost gear (20). The gear (22) is now free. Note the small unused hole on the base plate near the gears (22 and 27). It will enable you to lock the gear (22) in the next step.
   - To prevent the gear (22) from moving during the following steps, lock the gear by inserting a short pin through this hole and into a groove in this gear. Make sure the pin does not touch the gear (27) and that the gear (27) is free to rotate.
   - Mark the two teeth which are directly above one another on the gears (22 and 27), one on the upper gear and one on the lower gear.
   - Manually turn the robot counterclockwise a distance of six teeth between the marked teeth. The spring should now be correctly stretched.
   - Return the gear (20) to its position and fasten the screw.
   - Remove the locking pin.
5. Replace the base lock nut (S286).
6. Replace the shoulder cover.

Tightening the Oldham Coupling in Gripper

Qualified Technician Only

Refer to the exploded view of the gripper assembly in Figure 20.

Gripper Disassembly

1. Remove the gripper motor (S312) from the plate (112) by unscrewing the three bolts (2 bolts S12 and one bolt S14). The Oldham coupling (S313) has three parts—two metal parts fitted with bolts and an intermediate plastic part. When you remove the motor, one metal piece of the coupling stays attached to the shaft. The second metal piece of the coupling stays attached to the lead screw (94). The plastic piece remains attached to either one of the two metal pieces.
2. Remove the lead screw (94) from within the shaft (105) by turning it counterclockwise.
3. Fasten both metal pieces to their respective shafts by firmly tightening the Allen screws (one piece to the motor output shaft; the other to the lead screw.)
   Note: When tightening the coupling piece to the motor output shaft, make sure the coupling is 1.5mm to 2mm away from the plate (112).

Gripper Reassembly

1. Make sure the coupling's plastic piece is attached to the metal piece attached to the lead screw (94). Keep the gripper fingers closed. Screw the lead screw (94) with the coupling piece attached, clockwise into the shaft (105), as tightly as possible. Now release the gripper fingers.
2. Refit the motor by aligning the coupling fitted to the motor output shaft together with the plastic coupling piece attached to the metal piece attached to the lead screw (94).
3. When all the coupling sections are aligned and attached, turn the motor body until the holes in the plate (112) align with those in the gear motor support (91). Reinsert and tighten the three bolts which you removed at the beginning of the procedure.

CHAPTER 7

Parts Lists

This chapter contains isometric drawings of the robot arm.

Note that the **SCORBOT-ER 4u** robot arm has several enhanced features which do not appear in these drawings. They are:

- Improved encoders on all motors provide greater accuracy. The encoder disk has 20 slots; the encoder housing and circuitry have also been upgraded.
- Motor supports (items 34 and 35) for the shoulder and elbow axes have been improved; their dimensions have changed, and counter bearings have been added, to increase strength and stability.
- Plates have been added to the robot arm frame, across the forearm and upper arm, and around the shoulder, to increase strength and stability.

Dwg #	Cat #	Description
1	113012	Bearing housing cover (plastic)
2	111401	Main shaft base
S 2	306003	Socket head cap screw #4-40 X 1/4
S 3	306004	Socket head cap screw #4-40 X 3/8
4	113004	Base plate
5	113001	Base
S 6	306201	Socket head cap screw #6-32 X 1/4
S 8	306002	Socket head cap screw #2-56 x 3/8
11	111906	Spur gear (120 teeth)
S 11	306204	Socket head cap screw #8-32 x 1/4
12	112103	Bottom Plate - shoulder
S 12	301205	Socket head cap screw #8-32 x 3/8
S 13	306206	Socket head cap screw #8-32 x 1/2
S 14	306207	Socket head cap screw #8-32 x 5/8
15	112401	Support base - motors 4+5
16	112403	Support clamp - motors 4+5
17	110205	Right side plate - shoulder
18	110210	Left side plate - shoulder
S 18	306401	Socket head cap screw #10-32 x 3/8
S 19	306402	Socket head cap screw #10-32 x 1/2
20	111901	Anti-backlash spur gear (transfer)
S 20	306404	Socket head cap screw #10-32 x 3/4
S 21	306405	Socket head cap screw #10-32 x 7/8
22	111902	Anti-backlash spur gear (upper)
S 22	306407	Socket head cap screw #10-32 x 1/4
23	113501	Anti-backlash spring
S 23	306403	Socket head cap screw #10-32 x 5/8
24	107003	Washer
S 24	306408	Socket head cap screw #10-32 x $1^1/2$
S 25	321001	Ball bearing (motor 1 gear)
S 26	306602	Socket head cap screw #1/4-20 x 1
27	111903	Anti-backlash spur gear (base)
S 27	306602	Socket head cap screw #1/4-20 x 5/8
28	111907	Spur gear (base motor)
S 31	306414	Socket head cap screw #10-32 x 3/4 x 1/4 shoulder
32	319404	Spur gear (motors 2+3)
34	112412	Motor support (motor 2)
35	112412	Motor support (motor 3)
37	112402	Motor support (motors 4+5)
38	319406	Timing belt pulley (motors 4+5)
40		Rear cross bar [*not used in ER 4u*]
46	111402	Main shoulder shaft
47	111909	Timing belt pulley
48	111911	Timing belt pulley

Dwg #	Cat #	Description
49	111905	Spur gear (72 teeth)
52	111405	First tension shaft
53	113013	Tension wheel
55	111406	Second tension shaft
56	113014	Tension pulley
57	112406	Clamp – lower arm – left side plate
58	110215	Upper arm – right side plate
60	111904	spur gear (right – 72 teeth)
61	110220	Upper arm – left side plate
63	112407	Clamp – lower arm – left side plate
64	111403	Middle shaft
67	107001	Aluminum spacer
70	111910	Timing belt pulley
S 70	306007	Flat head socket screw #4-40 x 1/4
72	111407	Third tension shaft
74	111404	Gripper axis
76	112439	Stopper (motors 4+5)
77	110705	Base plate limit switch
S 81	306201	Flat head socket screw #8-32 x 3/8
82	113008	Timing belt pulley + miter gear
S 82	306211	Flat head socket screw #8-32 x 1/2
84	110228	Forearm left side plate
86	111912	Timing belt pulley
87	112114	Flange
S 87	306410	Flat head socket screw #10-32 x 1/2
88	110223	Forearm – right side plate
91	112408	Gripper gear motor support
S 91	306412	Flat head socket screw #10-32 x 1/4
94	113801	Lead screw
96	112117	Gripper bridge
97	112118	Gripper finger (inner)
98	112119	Gripper finger (outer)
99	112120	Gripper finger (short)
100	112113	Gripper clamp
101	110703	Mounting plate – gripper
102	113201	Rubber pad – gripper
103	111409	Pivot pin
105	111408	Main shaft – gripper
107	113802	Lead nut – gripper
108	112115	Bearing housing
109	112116	Bearing housing cover
112	110229	Gripper motor base plate
113		Spring [*not used in ER 4u*]
S 115	45008	Encoder circuitry (20 slots)

Dwg #	Cat #	Description
116	113009	Miter gear (bottom)
S 116	45008	Encoder circuitry (20 slots)
127	107009	Spacer washer (for base bearing)
S 139	306008	Socket head set screw #4-40 x 1/8
S 145	306213	Socket head set screw #8-32 x 3/16
S 151	306413	Socket head set screw #10-32 x 3/16
S 153	306214	Socket head set screw #8-32 x 1/4 (without head)
S 187	302002	Socket binding head screw M2 x 10 (limit switch)
S 188	302001	Slotted binding head screw M2 x 8 (limit switch)
S 189	302006	Slotted binding head screw M2x20 (encoder housing)
S 206	313001	Washer (for screw #4-40)
S 207	107012	Washer (black); internal; for plastic cover ∅ 12.5 x ∅ 5.5 x 0.6
S 208	313004	Washer for screw #10-32
S 209	313005	Washer for screw ∅1/4
S 212	314508	Washer lock; black; external ∅ 5
S 215	314002	Spring washer (for screw #4-40)
S 216	314003	Spring washer (for screw #6-32)
S 217	314004	Spring washer (for screw #8-32)
S 218	314005	Spring washer (for screw #10-32)
S 219	314006	Spring washer (for screw ∅ 1/4)
S 225	314503	Lock washer M2
S 227	313003	Washer (for screw #8-32)
S 232	107008	Teflon washer ∅ 1/4" x ∅ 3/8" x 0.6mm
S 233	107007	Teflon washer ∅ 1/4" x ∅ 1/2" x 0.6mm
S 234	113016	Nylon washer ∅ 11 x [a] 4 [not used in ER 4u]
S 240	310001	Hexagonal nut M2
S 253	316006	E-Ring ∅ 1/8 DIN 6799
S 254	316003	Retaining ring ∅ 10 DIN 471
S 255	316004	Retaining ring ∅ 12 DIN 471
S 257	316302	Retaining ring ∅ 25 DIN 471
S 260	320005	Ball bearing ∅ 8 x ∅ 22 x 7
S 261	320004	Ball bearing ∅ 10 x ∅ 19 x 5
S 262	320006	Ball bearing ∅ 10 x ∅ 26 x 8
S 263	320203	Ball bearing ∅ 25 x ∅ 47 x 8
S 268	320701	Needle bearing ∅ 12 x ∅ 16 x 10
S 269	320702	Needle bearing ∅ 12 x ∅ 19 x 16
S 270	320704	Needle bearing ∅ 15 x ∅ 21 x 12
S 270	320705	Bushing for #320704
S 275	320501	Thrust bearing ∅ 10 x ∅ 24 x 2
S 276	320502	Thrust washer ∅ 10 x ∅ 24 x 1
S 277	320503	Thrust washer ∅ 10 x ∅ 24 x 2.5
S 278	320504	Thrust bearing ∅ 12 x ∅ 26 x 2
S 279	320505	Thrust washer ∅ 12 x ∅ 26 x 1
S 283	314501	Lock washer

Dwg #	Cat #	Description
S 285	310401	Lock nut – gripper
S 286	310402	Lock nut – base KM 5
S 288	100706	Washer ∅ 10.5 x ∅ 20 x 0.5
S 289	100705	Washer ∅ 12.5 x ∅ 22 x 0.5
S 293	319201	Timing belt
S 294	319202	Timing belt
S 295	319203	Timing belt
S 300	315202	Flange – timing belt pulley
S 301	315201	Flange – timing belt pulley
S 308	317501	Pivot pin ∅ 1/8" x 3/8"
S 309	430901	Motor Gear - base; 127.7:1
S 310	430901	Motor Gear - shoulder/elbow; 127.7:1
S 311	430902	Motor Gear - pitch/wrist 65.5:1
S 312	430903	Motor Gear - gripper
S 313	319001	Coupling
S 315	410802	Limit switch
S 316	310802	Nut for harness
S 317	300006	Harness clamp
S 318	113006	Rubber plug (base)
S 319	300007	Harness clamp
S 320	314007	Conical washer
S 322	113203	Rubber grommet
S 324	113202	O-ring (rubber)
S 325	113204	Rubber stopper
S 350	317801	Roll pin ∅ 1/8 x 1 1/4
S 351	317502	Ball bearing ∅ - 3.5 mm
414	105003	Encoder disk (20 slots) - gripper
427	113005	Encoder housing (plastic)
429	105003	Encoder disk (20 slots)

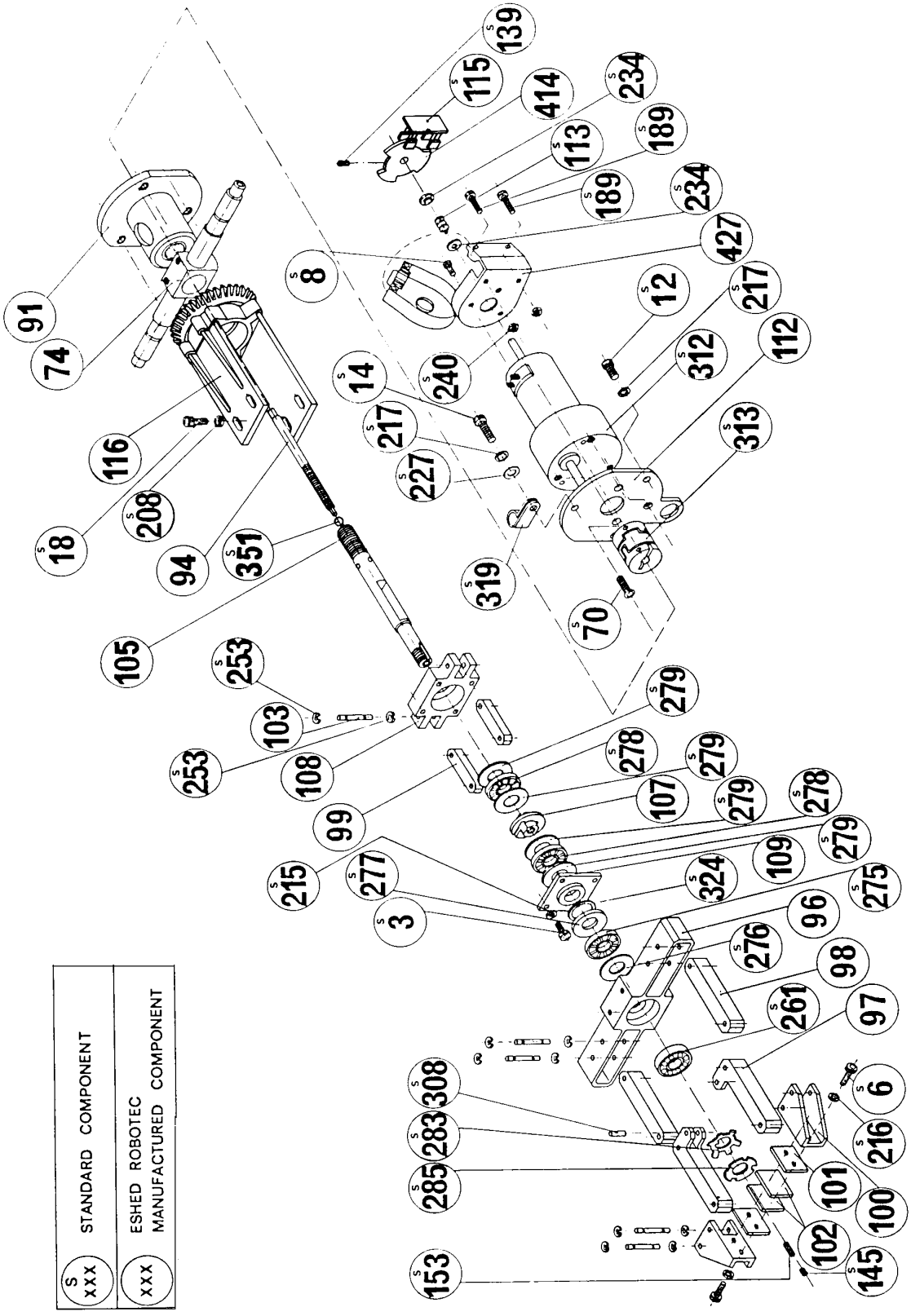


Figure 20: Gripper Assembly

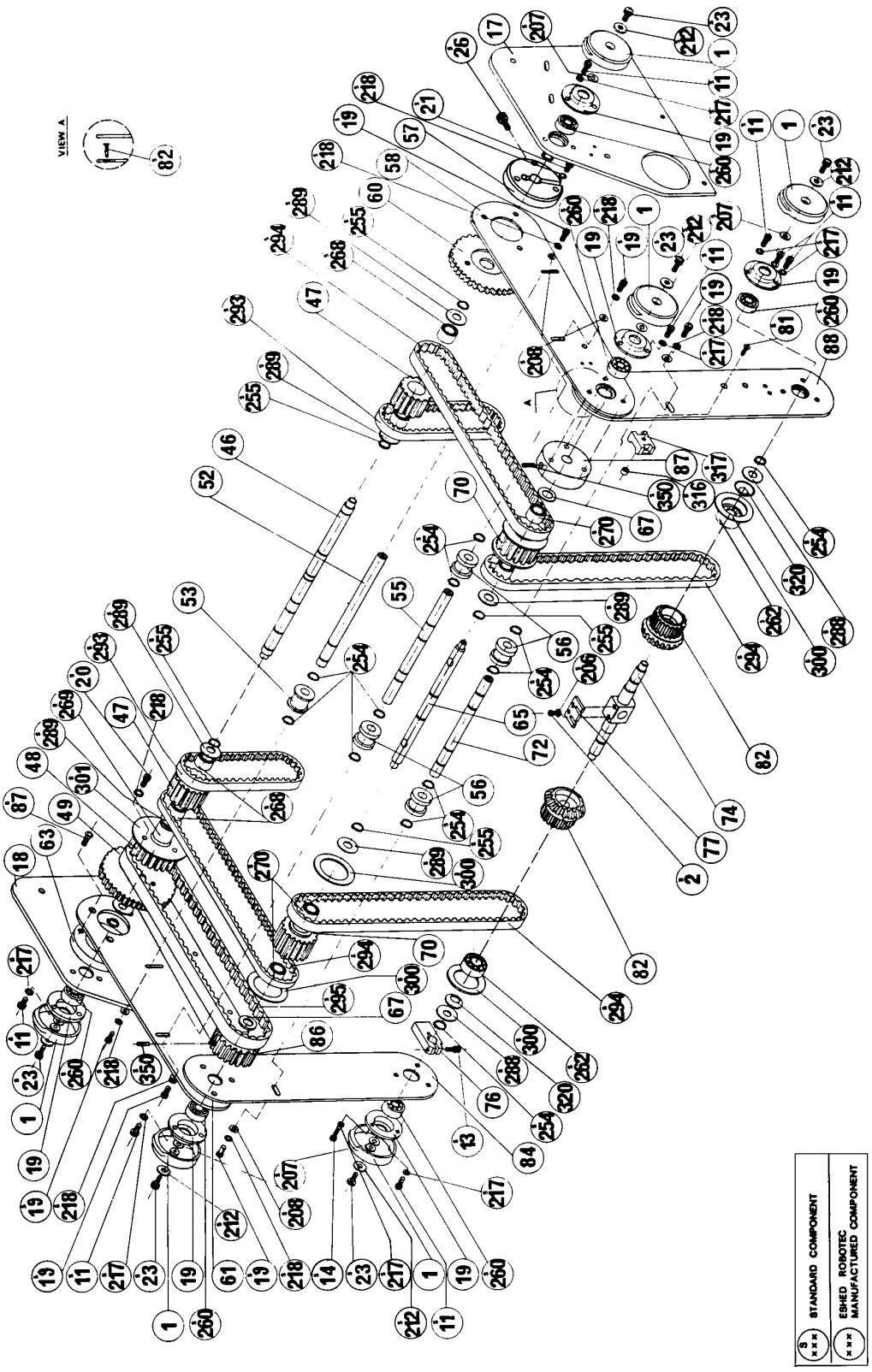


Figure 21: Robot Arm Assembly

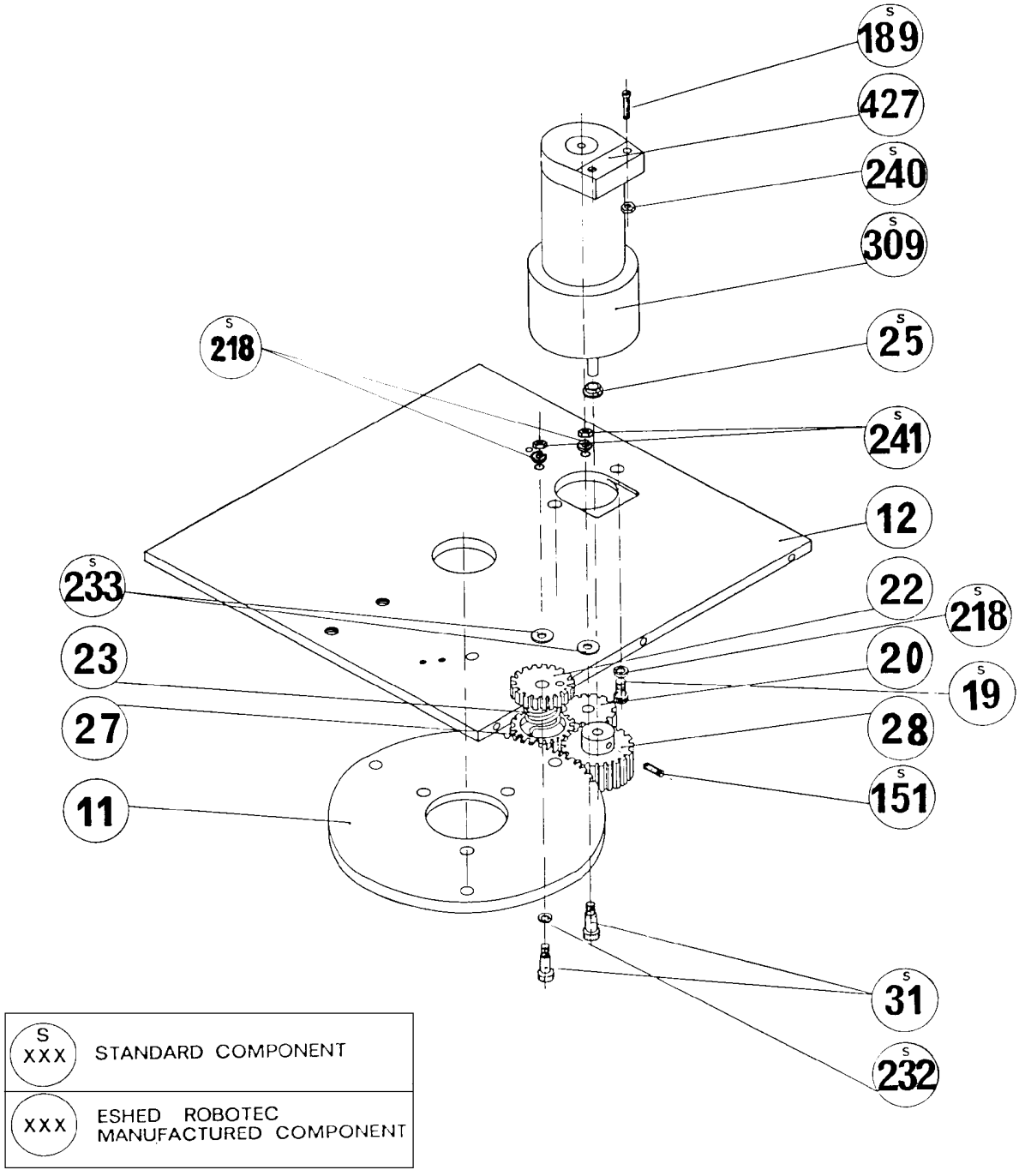


Figure 22: Anti-Backlash Assembly

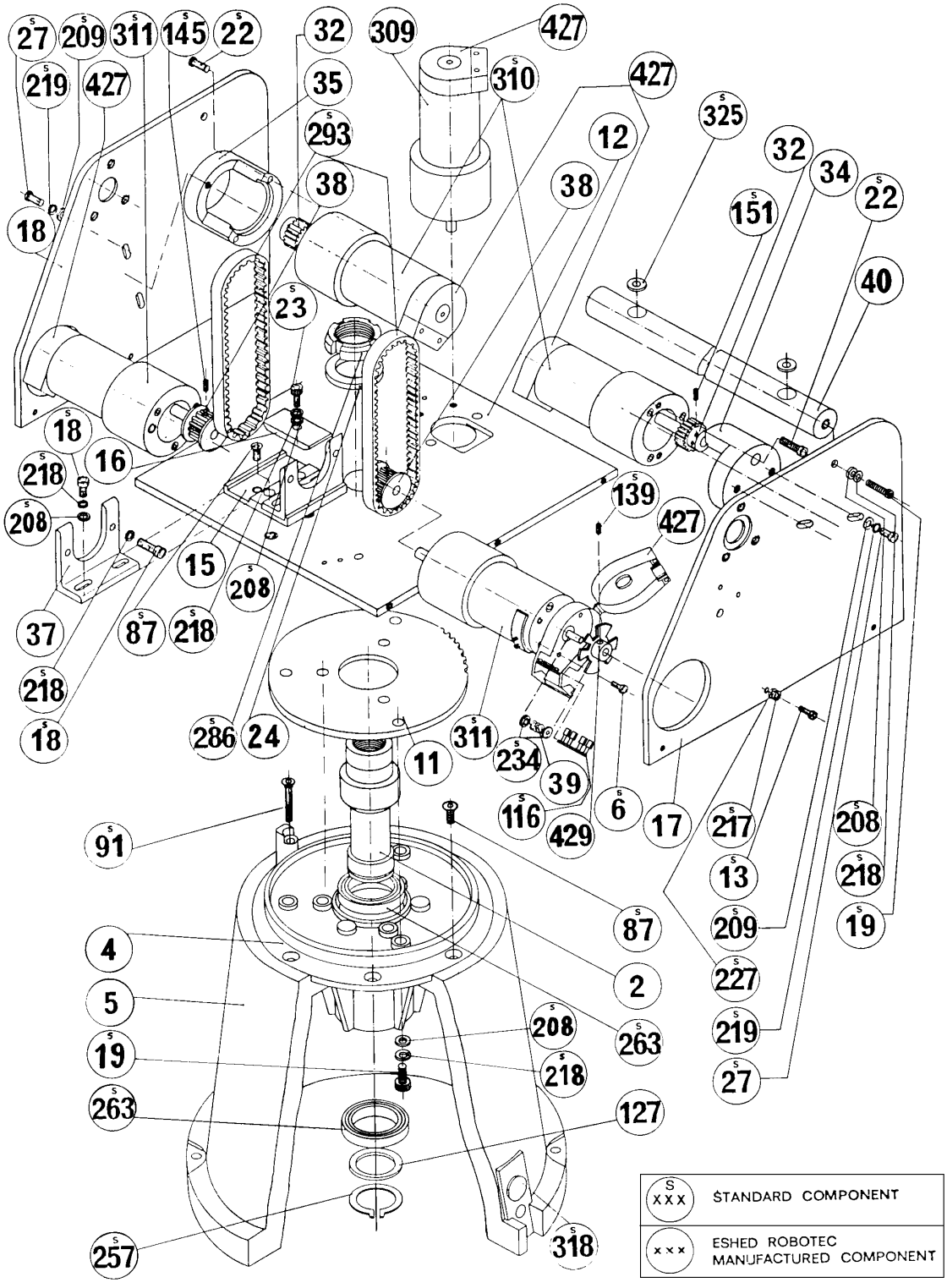


Figure 23: Base and Motors Assembly

CHAPTER 8

Wiring

Robot Wiring

The robot is connected to the controller by means of a cable which runs from the robot base to the D50 connector marked ROBOT on the rear panel of the controller.

The leads from the five motors on the robot body and their encoders are connected directly to the D50 connector on the robot cable. The leads from the gripper motor and the microswitches on the arm reach the D50 connector via a square 12-pin Molex connector in the base of the robot; these leads are particularly flexible and resistant to breakage, even after extensive movement of the robot arm.

The following table details the wiring for the various electrical components in the **SCORBOT-ER 4u** robot.

(* indicates two wires on same pin.)

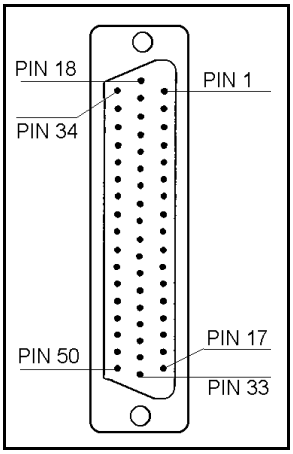


Figure 24:
Robot D50 Connector

SCORBOT-ER 4u Wiring								
	Robot Arm Signal				Lead to Molex 12-pin Connector		Lead to D50 Connector	
Axis	Motor	Encoder	Pad #	Microsw.	Color	Pin#	Color	Pin #
1	+						white	50
	–						gray/green	17
2	+						white	49
	–						white/green	16
3	+						white	48
	–						orange/brown	15
4	+						white	47
	–						orange/green	14
5	+						white	46
	–						orange/gray	13
Gripper	+				gray	8	white	45
	–				yellow	7	orange/blue	12

SCORBOT-ER 4u Wiring								
	Robot Arm Signal				Lead to Molex 12-pin Connector		Lead to D50 Connector	
Axis	Motor	Encoder	Pad #	Microsw.	Color	Pin#	Color	Pin #
1		GND	1				white	33*
		P_1	4				white/gray	5
		V_{LED}	2				yellow	11
		P_0	3				brown	2
2		GND	1				white	32*
		P_1	4				white/orange	21
		V_{LED}	2				yellow	27
		P_0	3				gray	1
3		GND	1				white	31*
		P_1	4				brown/blue	4
		V_{LED}	2				yellow	10
		P_0	3				green	36
4		GND	1				white	30*
		P_1	4				green/brown	20
		V_{LED}	2				yellow	26
		P_0	3				orange	35
5		GND	1				white	29*
		P_1	4				green/blue	3
		V_{LED}	2				yellow	9
		P_0	3				blue	18
Gripper		GND	1		black	12	white	28*
		P_1	3		green	11	gray/blue	19
		V_{LED}	2		yellow	10	white	25
		P_0	4		brown	9	white/blue	34
1				GND			white	33*
				MS			brown	23
2				GND			white	32*
				MS			gray	7
3				GND	white	1	white	31*
				MS	white	2	orange	24
4				GND	blue	3	white	30*
				MS	blue	4	green	8
5				GND	orange	5	white	29*
				MS	orange	6	blue	6
Gripper				*no connection*			white	28*
							brown/gray	22

Single Axis Wiring

In addition to the robot's six motors, the controller can control two additional motors (axes 7 and 8) which operate peripheral devices. These additional motors are connected to the controller by means of D9 connector ports on the front of the controller.

The following table details the wiring for a motor, encoder, and (optional) microswitch when connected to the controller. Refer to Figures 25 and 26.

Function	Encoder (PC510) Pad #	D9 Connector Pin #
Motor Power (+)		1
Motor Power (–)		9
Encoder Phototransistor (P_0)	3	8
Encoder Phototransistor (P_1)	4	6
Encoder LED voltage (V_{LED})	2	3
Encoder Ground (GND)	1	5 + Shield
Microswitch Signal (MS) *		4
Microswitch (GND) *		5

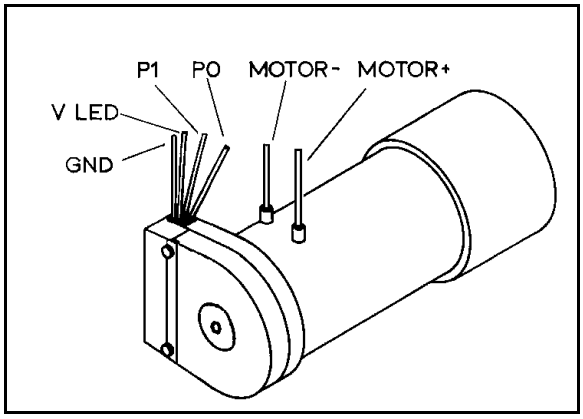


Figure 25: Motor Wiring

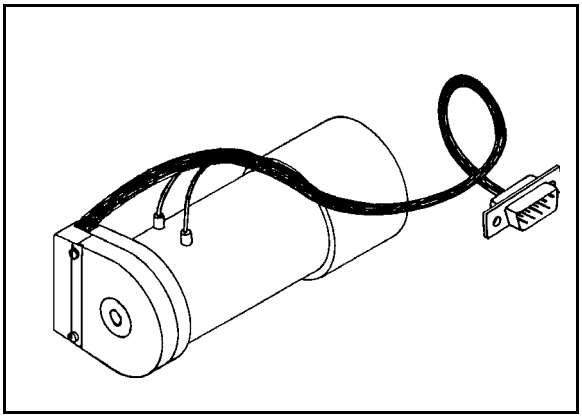


Figure 26: Motor with D9 Connector