TECAN

# Operator's Manual

# RSP 9000 Series

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# 1 - GETTING STARTED

## 1.0 ABOUT THIS REFERENCE

### Introduction

This technical reference is designed to describe the installation, operation and maintenance of the RSP 9000. In this reference, the assumption is made that the reader is technically proficient in electrical, mechanical, and software engineering. All of the necessary drawings and specifications are included to facilitate the integration of the RSP 9000 into your project.

All questions about the RSP 9000, available options, and this reference should be directed to Tecan Systems Customer support representative.

### 1.1 Warnings, Cautions, and Notes

There are three informational notices used in this reference. These notices are designed to highlight important information or to warn the user of a potentially dangerous situation. The following notices will have the same level of importance throughout this reference.

**WARNING** **Indicates a possibility of severe personal injury, loss of life, or equipment damage if instructions are not followed.**

**CAUTION** **Indicates a possibility of equipment damage if instructions are not followed.**

**NOTE** **Gives helpful information about the RSP 9000.**

### 1.2 Abbreviation, Symbols, and Measurements

Both the SI (System International), and English Standard abbreviations/measurements are used. However, the “English Standard” measurements have been converted from SI. A complete listing of Abbreviations and symbols can be found in Appendix A, “Symbols and Abbreviations.”

### 1.3 Related References

All of the following documents, are related to the RSP 9000 and may help in integrating the RSP 9000 into your instrumentation:

- *TECAN MODULO-1 Stepper Motor Controller/Driver Manual*
- *TECAN RSP 5000 Series Software Manual*
- *CAVRO Robotic User Interface (RUI) Software Manual*

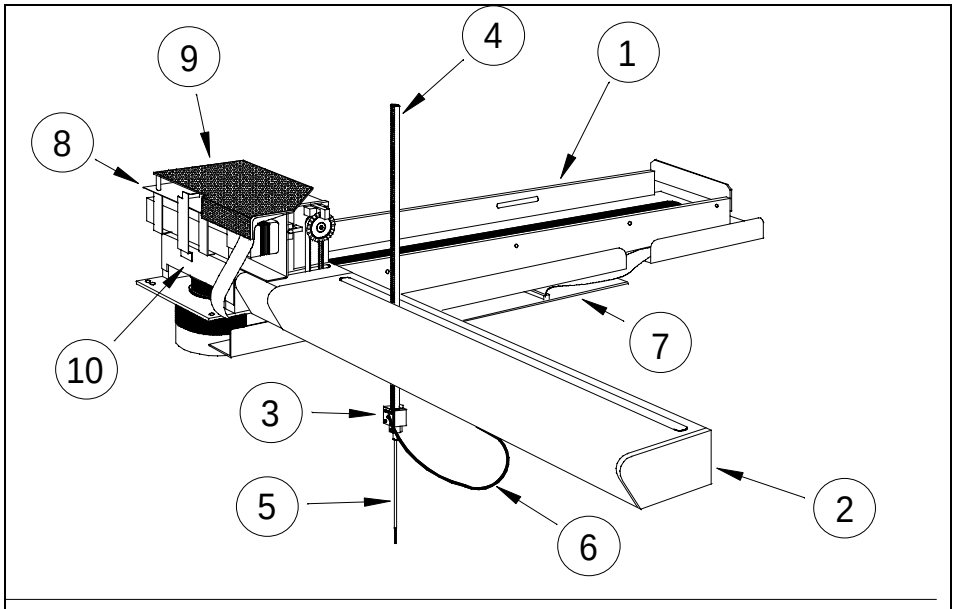
Contact your customer support representative for a listing of current and future options.

## 2.0 GENERAL INFORMATION

### 2.1 RSP (Robotic Sample Processor)

The RSP 9000 is a robotic module that allows the system integrator to build a complete sample handling system with minimal effort. This instrument has modular electronics and a sophisticated command set which when combined with diluters, valves, stirrers and various other options, can perform virtually any sample handling operation. The electronics on the RSP 9000 coordinates the communication between the robotic and other smart device through a single RS-232 cable.

Complete instrument specifications can be found in Appendix B, “Instrument Specifications”. The major components of the RSP 9000 are shown in Figure 1-1.




1. X-frame
2. Arm
3. Insulation Block
4. Z-rack
5. Sampling Tip
6. Coax Cable
7. CCU-9000
8. ADRI-9 Board
9. ADRI-9 Board Cover
10. X-slide

**Figure 1-1 RSP 9000 Components**

### 2.2 Communications

The RSP 9000 requires an external host (PC, MAC, etc.) to function. The external device communicates through an RS-232 interface with CCU. The CCU handles all communication within the RSP including additional diluters, valves, etc. The format of the communication between the PC and the RSP are ASCII commands that are packaged in a TECAN Protocol. (See Chapter 3, “Communications”).

Tecan Systems offers two software programs for the external host (PC) to facilitate the integration of the RSP module and options. The Cavro RUI Software is a menu driven program for simple applications. Tecan Systems also offers a Turbo-Pascal program called Integrator for more complicated applications.

## 3.0 PRINCIPLES OF OPERATION

### 3.1 Overview

The RSP 9000 is a robotic module which has three functional axes X;Y;Z. Each axes has its own intelligent control and stepper motor. The RSP 9000 is designed to move it sampling tip(s) to specified

locations, detect liquid, and control other optional micro-processor-driven smart devices. The RSP 9000 Series hardware is based on a modular design concept in which the major functions are performed by different components of the instrument. The main components of the RSP 9000 are:

- Central Control Unit (CCU-9000)
- Arm (ADRI-9) Board
- X/Y/Z Movement Mechanism
- Initialization Devices
- Variable Sensitivity Liquid Detector (ALIDUM)
- Optical Step Loss Detectors

### 3.2 Central Control Unit (CCU)

The CCU-9000 receives commands through an RS-232C connector from the external computer. After evaluating the command, the CCU-9000 returns an acceptance or rejection message to the external computer. The CCU-9000 then forwards the approved command to the proper device and sends a “completion” message to the external computer once the device finishes its task. The CCU-9000 waits for a final “received” message from the external computer. See Figure 1-2. Communication between the external computer and CCU-9000 is full duplex. This allows both systems to transmit simultaneously to each other. The CCU also contains the drive electronics for the X-axes motor(s) and connectors for communicating with devices such as pumps, valves, etc.

| | | |
|---|---|---|
| | Command Message | |
| (Step 1) External Computer | ----------> | CCU 9000 |
| | Acknowledgment | |
| (Step 2) External Computer | <---------- | CCU 9000 |
| | Command Executed | |
| (Step 3) External Computer | <---------- | CCU 9000 |
| | Acknowledgment | |
| (Step 4) External Computer | ----------> | CCU 9000 |

**Figure 1-2 Flow of Communication (Handshake)**

### 3.3 ARM (ADRI-9) Board

The ADRI-9 Board is located on the back of each arm. This board contains the drive electronics for the motors for the Y and Z axes. The motor drivers are contained in the Modulo-1 modules which have a proprietary masked microprocessor. The Modulo-1 interfaces with the step loss detectors and the ALIDUM variable sensitivity level detector.

## 3.4 X/Y/Z Movement Mechanism

The RSP 9000 movement mechanism is supported by a machined aluminum extrusion called the X-frame. Mounted on the X-frame are the X-axis guide rails and X-stepper motor for each arm. The X-Slide is attached to the X-axis guide rails by three rollers and belt driven with the X-stepper motor. Together, these parts guide the right and left movement of the arm. The X motor is controlled by the CCU-9000.

The following items are mounted on the arms:

- ADRI-9 electronics board
- Liquid Level Sensor Module (ALIDUM)
- Y-direction stepper motor
- Z-direction stepper motor
- Square shaft pinion
- Y-axis guide rails
- Z-bearing
- Z-Rack
- Insulation Block and probe

The Y-block is attached to the Y-axis guide rails with three rollers and is belt-driven by the Y-stepper motor that guides the front to rear movement of the Y-axis.

The Z-rack is placed through the Y-block and is driven by a square shaft attached to the Z-stepper motor. Attached to the Z-rack is the insulation block and the sampling tip.

The square shaft pinion, Z-bearing, and Z-motor control up and down movement of the Z-rack. The Y/Z-motors are powered and controlled by electronics located on the ADRI-9 board. Each motor has its own microprocessor control that allows the drives to rum simultaneously.

Depending on the RSP 9000 configuration, two such X/Y/Z movement mechanisms may be present; one for each arm. Because two arms share the same X-slide, special safe guards have been built into the firmware to prevent collisions.

## 3.5 Initialization Devices

The RSP 9000 uses two methods to initialize each robotic arm. The X movement mechanisms are initialized by slotted optical switches located on the ADRI-9 board. Metal flags are mounted to the X-frame and Y-block. When the flags are detected by the slotted optical switches, the movement mechanism are initialized.

The Z-movement mechanism is initialized by using the ALIDUM liquid Level sensing module. When the metal flag on the top of the insulation block contacts the initialization ring, the Z-axis is initialized.

## 3.6 Variable Sensitivity Liquid Detector (ALIDUM)

Each sampling tip on the RSP 9000 is connected to a variable sensitivity liquid detector (ALIDUM) module which is mounted on the ADRI-9 board. The liquid detector enables the sampling tip to detect ionic solutions upon contact. (See Chapter 2, Section 7, for instructions for setting the sensitivity of the ALIDUM).

The detectors operate by monitoring capacitance between the sampling tip and the instrument work surface which is grounded to the RSP. When the sampling tip touches a liquid surface there is a change in capacitance, which generates a detection signal in the ALIDUM. The liquid detection systems generates a signal when entering and leaving the liquid. The following modules make up the liquid:

- ALIDUM Module
- Sampling Tip
- Insulation Block

## 3.7 Step Loss Detection (SLD)

The SLD system utilizes slotted optical switches to monitor all of the stepper motors. An encoder wheel is mounted to the shaft of each stepper motor. The encoder wheels move between the slotted optical switches, which allows the Modulo-1 to monitor the number of steps each motor has turned. This system ensures “positive tracking” of the sampling tip’s location and the detection of lost steps in the X/Y/Z-directions during operation (See Figure 1-3). Should loss step be detected, an error message is sent to the computer. The Cavro software programs have several options to recover from a step loss error.

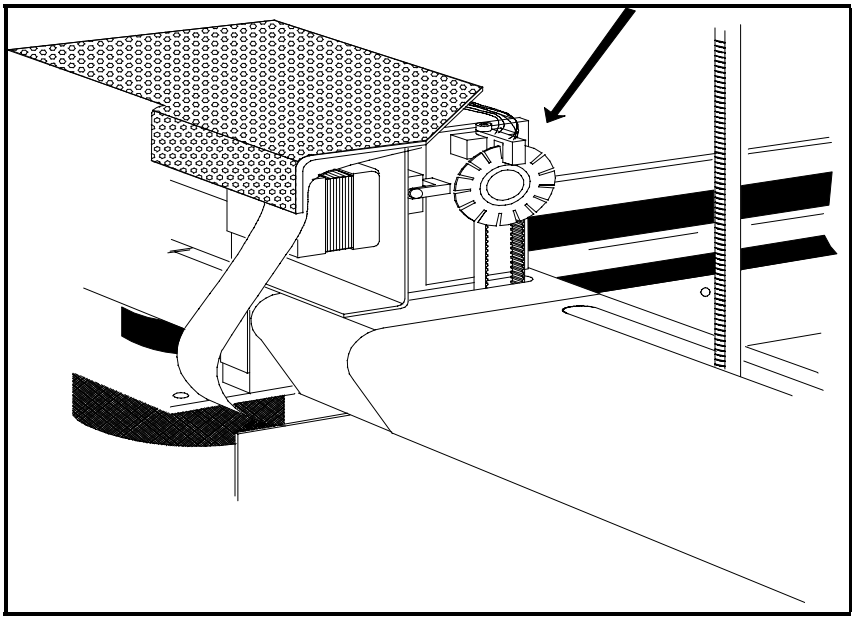


**Figure 1-3 Step Loss Detector on Z-Axis Motor**

# 2 - HARDWARE INSTALLATION

## 1.0 MOUNTING CONSIDERATIONS

The RSP 9000 should be mounted on a rigid frame. It is recommended that a cross brace be installed on the frame for a two arm system to reduce any swaying which can cause loss of steps.

The RSP's liquid detection system requires that the work surface and X-frame be connected to the same electrical ground. This can be accomplished by mounting the RSP 9000 to metal supports, which in turn are mounted to a metal work surface. However, the supports for the RSP 9000 can be made of nonconductive material, but an electrical connection from the X-frame must be made to the metal work surface.

**NOTE: When using the ALIDUM variable sensitivity level sensor, the work surface should be a metal plate that is grounded to the frame of the RSP9000. This plate can be covered with virtually any coating, providing that the coating does not greatly reduce capacitance between the work surface and the samples.**

**NOTE: Complete mounting specifications can be found in Appendix C, Additional Figures".**

## 2.0 UNPACKING THE INSTRUMENT

### 2.1 Visual Inspection

Look at the exterior of the box and check the following:

- Water damage or discoloring
- Cuts or gashes
- Collapsed corners
- Crushed top or sides
- Missing shipping straps

**NOTE: If any of the above items are found, contact a customer support representative immediately.**

## 2.2 Removing the Instrument from the Box

**CAUTION: Before removing the RSP 9000 from the box, prepare the mounts according to Figure C.2, Mounting Measurements (Appendix C, "Additional Figures"). Setting the Instrument down incorrectly can cause damage.**

Before unpacking the RSP 9000, make sure there is sufficient space to lay out the instrument and accessories. This makes checking the contents of the box against the packing list easier. Follow the steps below to prevent damage to the instrument.

1. Remove shrink wrap from outside of shipper.
2. Cut the straps on the top of the shipping box.
3. Remove upper portion of shipping box.
4. Remove the inner container.
5. Cut the tape along the top of the inner container, making sure that the cutting device does not touch the RSP 9000.
6. Unfold the inner container until all four sides are flush with the floor.
7. Remove the small accessory box from packaging.

**CAUTION: Do not lift the RSP 9000 by the arm(s). Damage to the X/Y/Z movement mechanism may occur.**

8. Grip the instrument by the X-frame, just below the arms and gently lift the RSP 9000 out of the packing.
9. Secure the RSP 9000 to its prepared mounts.

**CAUTION: Do not place the RSP 9000 down on the CCU-9000 board. Damage to the electronics may occur.**

10. Open the small accessory box and place the contents on an open surface.
11. Check to make sure that all parts on the packing list have been received.

**NOTE: If any parts missing from the packing list, call a customer support representative immediately.**

## 3.0 SETTING UP THE INSTRUMENT

Mount the RSP 9000 utilizing all six mounting holes: four bolt holes, and two indexing pin holes. (See Appendix C, Figure C.2 Mounting Measurements.) The following tools are required to install the RSP 9000:

- Allen wrenches (2, 2.5,3, and 5 mm)
- Screw Driver (flat 2mm)

The following assembly instructions should be followed to prevent damage to the instrument.

1. Remove the “red” transport screw(s), located at the end(s) of the X-frame. (See Figure 2-1 Removing the Transport Screws.)

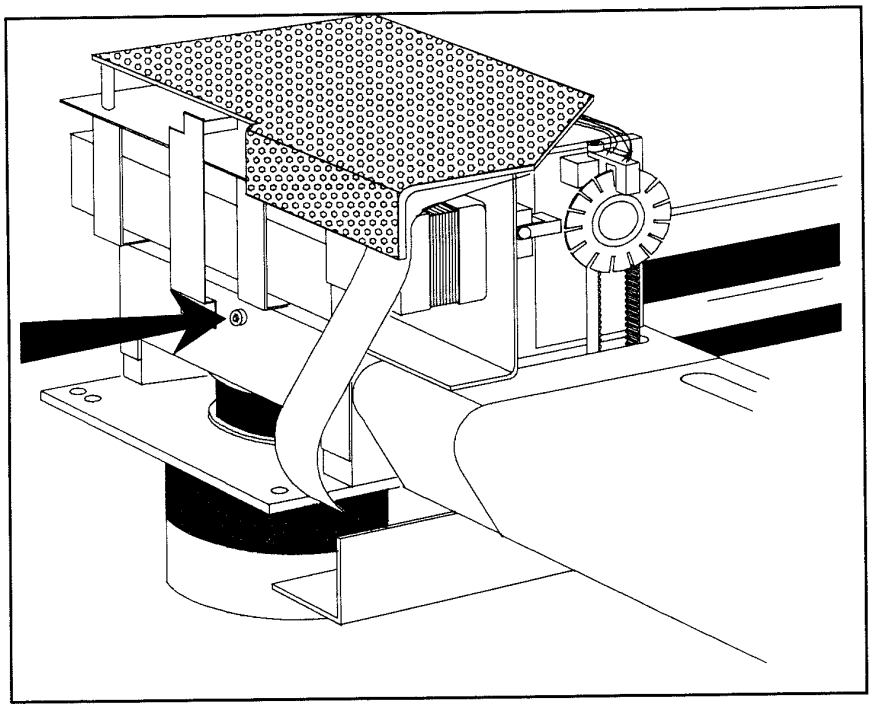


**Figure 2-1 Removing the Transport Screws**

2. Move arm(s) toward center of X-axis. Remove transport bracket(s). See Figure 2-2 Removing the Transport Brackets.)

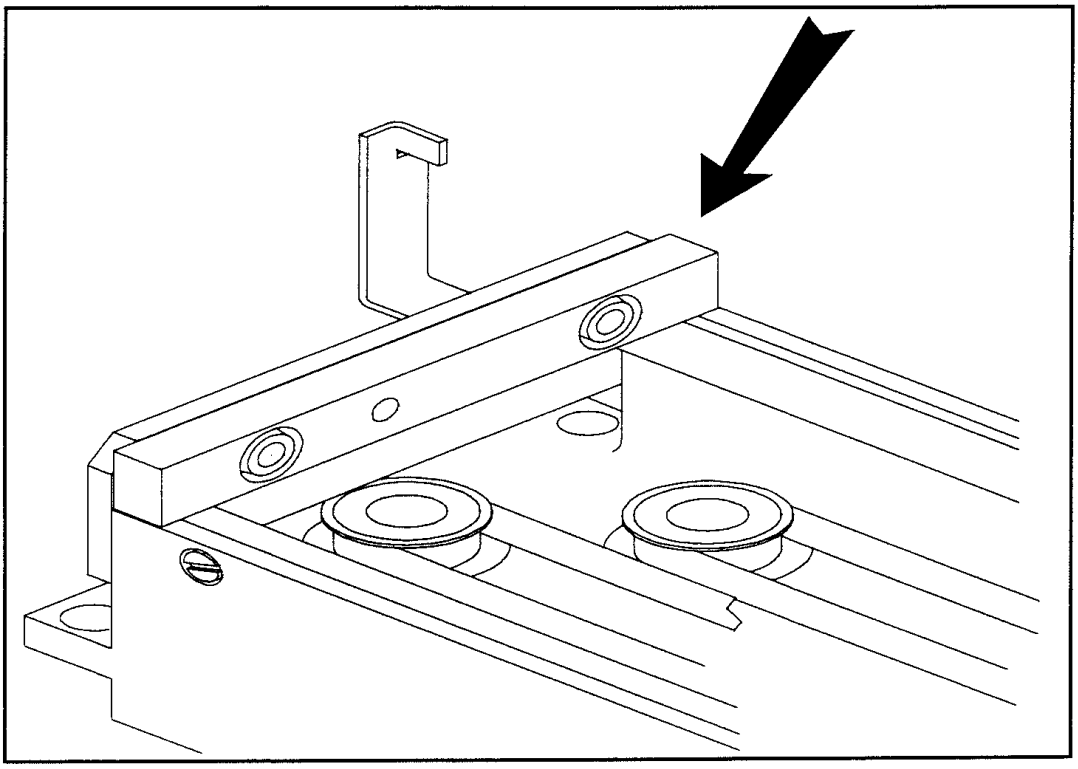


**Figure 2-2 Removing the Transport Brackets**

3. Insert the Z-Rack into the bottom of the Z-bearing with the set screw cavity at the bottom. The teeth should be oriented away from the flat side of the arm. (See Figure 2-3 Inserting the Z-Rack into the Z-bearing.)

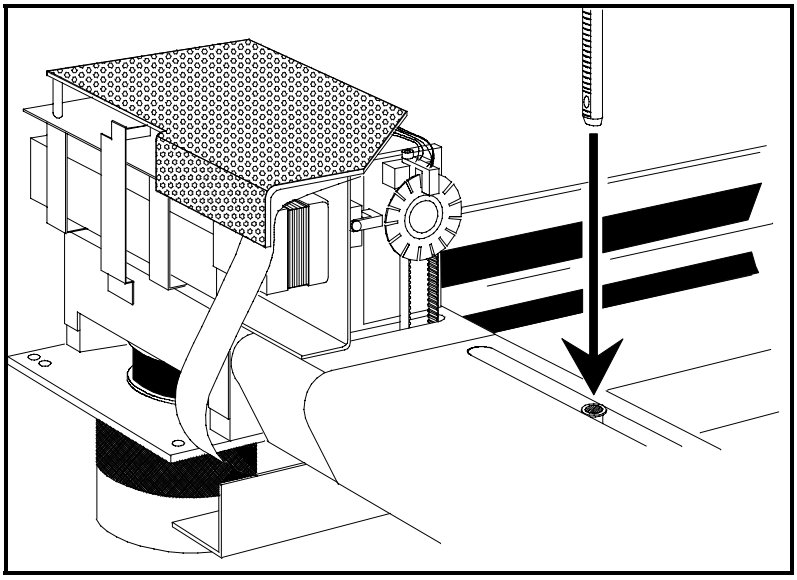


**Figure 2-3 Inserting the Z-Rack into Z-bearing**

**NOTE** **The teeth of the left arm Z-rack must face to the left and the teeth of the right arm Z-rack must face to the right when inserting them to the Z-bearings.**

**CAUTION: Do not force the Z-rack into the Z-bearing. The Z-bearing may be damaged if excessive force is used while inserting the Z-Rack. Turn the square shaft pinion (On the underside of the arm) if the Z-rack does not slide easily into Z-bearing.**

4. Position the Z-rack so equal amounts are visible above and below the arm.

5. Remove a sampling tip and the sampling tip set screw from the accessory bag.

6. Insert the system tubing through the top of the Z-Rack until it extends 3 cm (1.2 in) from the bottom.

**NOTE: The system tubing is not supplied with the RSP 9000 and is only needed for liquid handling applications.**

**CAUTION: Electrostatic discharge to the sampling tip may damage the ALIDUM.**

7. Insert the non-Teflon coated end of the sampling tip through the sleeve of the insulation block until approx. 1cm (0.4 in) is visible through the top. (See Figure 2-4. Connecting the System Tubing.)

8. Attach the system tubing to the non-teflon coated end of the sampling tip.

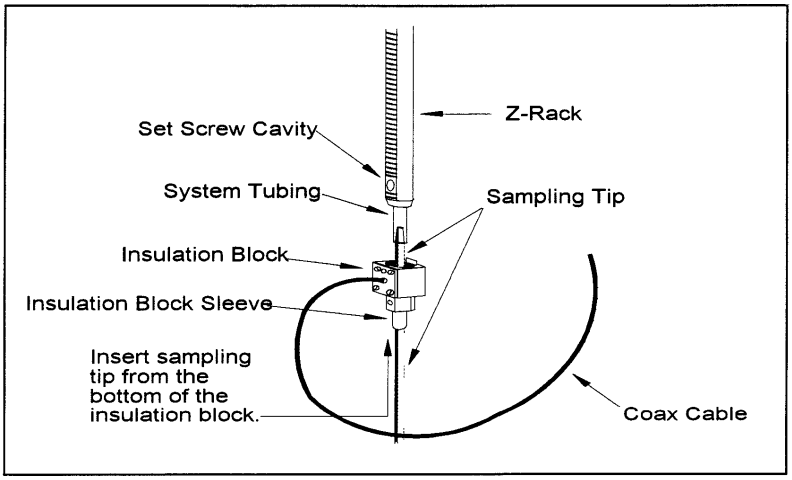



**Figure 2-4 Connecting the System Tubing**

9. Install the insulation block on the Z-rack so that the insulation block sleeve is facing down and the coax cable is to the left for the left arm and to the right for the right arm. Ensure that the coax cable is not twisted when it is attached to the Z-rack.

10. Maintaining the insulation block position in step 9, push the insulation block onto Z-rack until firmly seated.

11. With an allen wrench, tighten the insulation block set screw (clockwise) until it makes contact with the Z-rack. (See Figure 2-5 Securing the Sampling Tip.)

12. Install the sampling tip set screw and turn it clockwise into the threaded hole in the insulation block sleeve.

13. Gently adjust the sampling tip with the attached tubing through the insulation block until alignment groove on the sampling tip is aligned with the bottom of the insulation block sleeve.

14. While holding the sampling tip in position (step 13), tighten the sampling tip set screw.

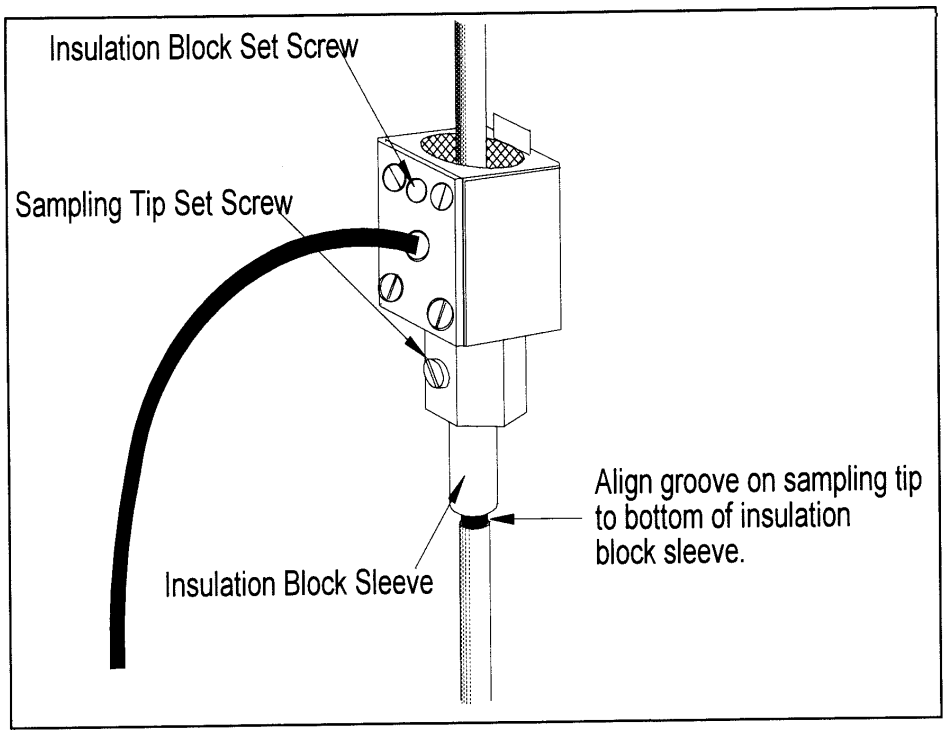



**Figure 2-5 Securing the Sampling Tip**

## 4.0 POWER SUPPLY REQUIREMENTS

**NOTE: Recommended power supplies are listed in Appendix E.**

**NOTE: Customers are responsible to provide power supplies that comply to local and application-specific safety requirements.**

The power supply specifications below apply to all current models of the RSP 9000. Please note the difference in amperage between the one and two arm instruments. These specifications are for the RSP 9000 with **no options connected.**

| Instrument | Voltage | Ripple Voltage | Current |
|---|---|---|---|
| One Arm | 24 VDC (+10/-10%) | ≤ 5 V peak to peak @ 100 Hz typical | 2.5 A @ 24 VDC |
| Two Arm | | | 4 A @24 VDC |

These specifications were tested using the following speeds:

| Item | X-axis | Y-axis | Z-axis |
|---|---|---|---|
| Start Speed | 50 steps/s | 200 steps/s | 400 steps/s |
| End Speed | 4000 steps/s | 4000 steps/s | 4000 steps/s |
| Acceleration | 10000 steps/s$^2$ | 20000 steps/s$^2$ | 30000 steps/s$^2$ |

## 5.0 CONNECTING THE POWER

1. Locate the “J2” connector on the CCU-9000 board for 24 VDC power input. (See Appendix C, “Additional Figures” Figure C7, CCU-9000 Board Layout.)

2. Insert the 2-pin power plug on the power cable into the “J2” connector on the CCU-9000, making sure the pins are properly aligned.

3. Check to make sure that the plug is fully seated in its connector on the CCU-9000 board.

4. Attach the other end of the power cable to an appropriate 24 VDC power supply, making sure that the red wire is connected to the positive terminal.

# 6.0 RUNNING SELF TEST

**WARNING: Ensure that all objects are removed from the work surface. Keep all body parts out of the operating range of the arm(s) when the RSP 9000 is in operation.**

## 6.1 Overview

The self test of the RSP 9000 is designed to check the X/Y/Z-movement mechanism. Once activated, the self test will perform 27 moves to random position for each arm. After finishing these moves the RSP 9000 will initialize and report (through the use of LEDs) any detection of lost steps. The self test will also report any collisions. The self test will repeat this cycle (reporting any errors found) until the power is turned off.

## 6.2 Starting the Self Test

1. Turn off the power to the RSP 9000

2. Turn the address switch on the CCU-9000 board to position “F”. (See switch SW1 on the Figure C.7, CCU-9000 Board Layout, Appendix C, “Additional Figures”)

3. Ensure that all items are removed from the work surface and that all axes can move through their full mechanical ranges.

**CAUTION: The maximum machine range is used in the self test. If the RSP 9000 is not mounted properly, the probe will crash into the work surface. Make sure the machine range in the instrument setup is adjusted to the Z height of the instrument or damage may occur. (See Appendix B for default machine ranges for each RSP 9000 model.)**

4. Turn off the power to the RSP 9000. The self test will run until the power is turned off.

**NOTE: There will be approx. a three second delay before the self test starts.**

## 6.3 Reading the Light Emitting Diodes (LEDs)

The LEDs on the CCU-9000 board are used to display the normal Operation Signal, Self Test Signal, Lost Steps Detected Signal, and Hardware Error Signal. There are two sets of LEDs on the

instrument: LED 1 for the left arm, and LED 2 for the right arm. (See Figure 2-6, “Left and Right LEDs.)

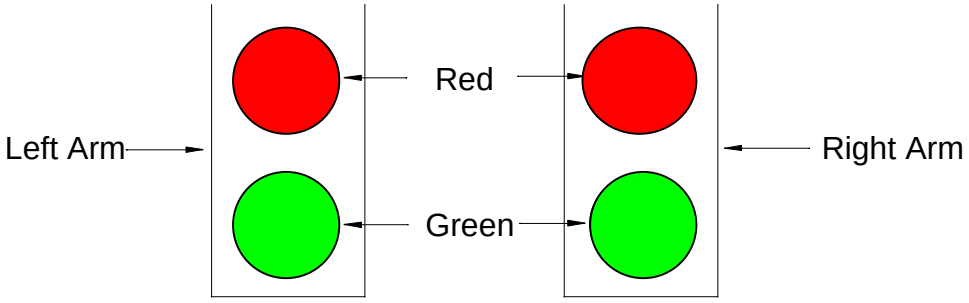



**Figure 2-6 Left and Right LEDs**

**Table 2-1 LED Functional Description**

| LED 1/LED2 | MODE OF OPERATION Blinking (on once per sec) | DETECTION OF LOST STEPS Rapid Blinking (on twice per sec) | DETECTION OF HARDWARE PROBLEMS (remains lit) |
|---|---|---|---|
| Red | Self Test OK | Detected X-axis | Problem on X-axis |
| Green | Normal mode OK | Detected Y-axis | Problem on Y-axis |
| Red & Green | Firmware download | Detected Z-axis | Problem on Z-axis |

**NOTE: The LEDs will signal the first error detected until the instruments is turned off.**

**NOTE: LED1 and LED2 are separate indicators for the left and right arms. If lost steps are detected on one arm, only that arm LED will signal lost steps (See Figure 2-6 Left and Right LEDs.)**

## 7.0 CONNECTING THE EXTERNAL COMPUTER

1. Locate the J15 connector on the CCU-9000 board for the RS-232 C serial interface cable (See Appendix C, Figure C-7 CCU-9000 Board Layouts.)

2. Take the 10-pin plug on the external computer to CCU-9000 cable and insert it into the JP15 connector on the CCU-9000 board. Connect the other end of the cable to the proper com port on the external computer.

## 8.0 SETTING THE SENSITIVITY OF THE LIQUID LEVEL SENSOR

The RSP 9000 has a variable sensitivity liquid level sensor (ALIDUM) that can be set at different levels. The level sensor is set at the “standard” setting at the factory. If additional sensitivity is needed, the sensitivity of the liquid level sensor can be selected by a combination of hardware and software settings. The following is the procedure for setting the hardware switches:

1. Remove the top cover of the RSP 9000.

2. Remove the perforated cover on top of the ADRI-9 board located at the back of the arm by removing the four (4) socket head screws.

3. Set the switches to the desired sensitivity using the chart below.

**Table 2-2 ALIDUM Sensitivity Settings**

| ALIDUM Sensitivity | Sensitivity Factor | SW3 Setting* | SW4 Setting* | Software Setting |
|---|---|---|---|---|
| Standard | 1 | Disable | N/A | N/A |
| | 1 | Enable | High | SS0 |
| High | 3 | Enable | High | SS1 |
| | 1 | Enable | Very High | SS0 |
| Very High | 5 | Enable | Very High | SS1 |

* See switch settings on ALID-9 board.

+ See software sensitivity command SS.

# 3 - COMMUNICATIONS

## 1.0 COMMUNICATION PROTOCOL

### 1.1 Protocol Definition

All communication with the RSP 9000 is initiated by an external computer sending a command message to the CCU-9000.

If the command message is received correctly by the CCU-9000, an acknowledgment message is returned to the external computer and the command is executed. Upon completion of the command, the CCU-9000 sends an answer message to the external computer. If the answer message is received correctly by the external computer, an acknowledgment message is sent to the CCU-9000.

If either the external computer or CCU-9000 does not receive or understand a transmitted message, no acknowledgment is returned. The sender, not receiving an acknowledgment, will retransmit the message after a 900-millisecond delay. If a command message is understood by the CCU-9000, but the acknowledgment is not understood by the external computer, the external computer will retransmit the command message up to four times. The CCU-9000 receiving the repeated command message, checks the sequence number and discards the repeated command. However, it will send another acknowledgment message to the external computer. This system ensures that repeated command messages will only be executed once.

The transmission system used for the CCU-9000 is full duplex. The external computer can send messages to different devices without receiving acknowledgment for the previously sent message.

***Note:*** **The external computer can only send one command message per device until it receives an acknowledgment message from that specific device. The CCU-9000 can send an acknowledgment of a previously addressed device while receiving a command from another device.**

In the case of multiple block retransmissions, there may be time synchronization errors in the robotic functions; however, the probability of such an occurrence is minimal. (See Appendix H “Summary of ASCII Characters.”)

## 1.2 Communications Setup

| | |
|---|---|
| Serial communications link: | RS-232-C |
| CCU-9000 connector: | Fujitsu 10-pin crimp |
| Data transmission rate: | 9600 baud (bps) |
| Data Format: | 8 bits<br>1 stop bit<br>no parity |

***Note:*** **The communications cable supplied with the RSP 9000 is wired for use with the Cavro software programs that have their own com port drivers. When using other programs with DOS com port drivers, the com port cable must be modified by soldering a jumper wire between pin #6 and pin #20. (See Figure 3 below.) This modification routes the signal to the proper pins so that the DOS program will recognize that the RSP 9000 is connected.**

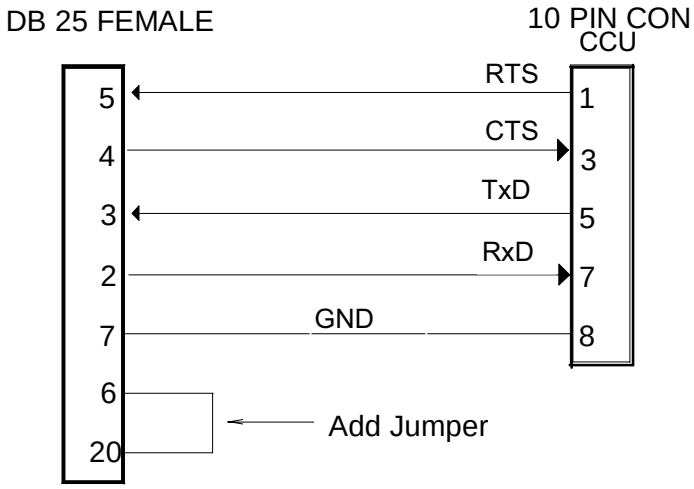



**Figure 3-1 - Modifications to Communications Cable**

## 1.3 Vertical Redundancy Checksum

For each data message that is transferred, a vertical redundancy checksum (VRC) is generated and transmitted at the end of the message.

All data bytes in a message block are “XORed” to form an 8-bit checksum, which is sent as the last character of a message block. The receiving processor compares the transmitted value to a computed value. If the computed and transmitted value match, an error-free transmission is assumed by the processor.

## 2.0 COMMAND MESSAGE BLOCK FORMAT

| Command Message Block Fields | Description of Block Fields in Command Message | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **STX** | Start of text character: ASCII hexadecimal [02] (Typed: CTRL-B) | | | | | | | | |
| **Control** | Control byte (see Table 1) | | | | | | | | |
| | Bit No.: | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| | Data: | 0 | 1 | 0 | 0 | Rep | Seq#2 | Seq#1 | Seq#0 |
| **Arm Address** | ARM: ASCII typed [1..2] (Left arm = 1; Right arm = 2) | | | | | | | | |
| **Device Address** | DEVICE: ASCII typed [1..9] (Example: arm = 8; diluters = [1..4]) | | | | | | | | |
| **Message Block** | Command Message: variable length (ASCII/typed) | | | | | | | | |
| **ETX** | End of Text Character: ASCII Hexadecimal [03] (typed: CTRL-C) | | | | | | | | |
| **VRC** | Vertical Redundancy checksum<br>(XOR of all characters, including STX and ETX) (Binary) | | | | | | | | |

| Bit | Mnemonic | State | Definition |
|---|---|---|---|
| 7 | --- | 0 | Always = 0 |
| 6 | --- | 1 | Always = 1 |
| 5 | --- | 0 | Always = 0 |
| 4 | --- | 0 | Always = 0 |
| 3 | Rep | 0<br>1 | Command message sent on the first attempt<br>Command repeated |
| 2 | Seq#2 | 0 = off<br>1 = on | Message sequence number to device [1..7]<br>On for message 4, 5, 6, and 7 |
| 1 | Seq#1 | 0 = off<br>1 = on | Message sequence number to device [1..7]<br>On for message 2, 3, 6, and 7 |
| 0 | Seq#0 | 0 = off<br>1 = on | Message sequence number to device [1..7]<br>On for message 1, 3, 5, and 7 |

**Table 3-1 - Control Byte of the Command Message**

***Note:*** **If the control byte is hexadecimal [40], the message is an acknowledgment (ACK). An ACK message does not contain an error code or answer message. If bit-3 is equal to "1", then the sequence is repeated.**

## 3.0 ACKNOWLEDGMENT MESSAGE FORMAT

| Acknowledgment Message Block Fields | Description of Block Fields in Acknowledgment Message |
|---|---|
| **STX** | Start of text character: ASCII hexadecimal [02] (Typed: CTRL-B) |
| **Control** | Control Character (always hexadecimal 40) |
| **Arm Address** | ARM: ASCII typed [1..2] (Left arm = 1; Right arm = 2) |
| **Device Address** | DEVICE: ASCII typed [1..9] (Example: arm = 8; diluters = [1..4]) |
| **ETX** | End of Text Character: ASCII Hexadecimal [03] (typed: CTRL-C) |
| **VRC** | Vertical Redundancy Checksum<br>(XOR of all characters, including STX and ETX) (Binary) |

## 4.0 ANSWER MESSAGE FORMAT

| Answer Message Block Fields | Description of Block Fields in Command Message | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **STX** | Start of text character: ASCII hexadecimal [02] (Typed: CTRL-B) | | | | | | | | |
| **Control** | Control byte (see Table 3-1) | | | | | | | | |
| | Bit No.: | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| | Data: | 0 | 1 | IVA | Done | Rep | Seq#2 | Seq#1 | Seq#0 |
| **Arm Address** | ARM: ASCII typed [1..2] (Left arm = 1; Right arm = 2) | | | | | | | | |
| **Device Address** | DEVICE: ASCII typed [1..9] (Example: arm = 8; diluters = [1..4]) | | | | | | | | |
| **Error Code** | Only sent if bit-4 of Control Byte (Done) is on set | | | | | | | | |
| **Answer Block** | Answer Message: variable length (ASCII/typed) | | | | | | | | |
| **ETX** | End of Text Character: ASCII Hexadecimal [03] (typed: CTRL-C) | | | | | | | | |
| **VRC** | Vertical Redundancy Checksum<br>(XOR of all characters, including STX and ETX) (Binary) | | | | | | | | |

| Bit | Mnemonic | State | Definition |
|---|---|---|---|
| 7 | --- | 0 | Always = 0 |
| 6 | --- | 1 | Always = 1 |
| 5 | IVA | 0<br>1 | Address OK<br>Invalid arm or device address |
| 4 | Done | 0<br>1 | Device Error: Error code to follow<br>Answer completed without error |
| 3 | Rep | 0<br>1 | Command message sent on the first attempt<br>Command repeated |
| 2 | Seq#2 | 0 = off<br>1 = on | Message sequence number to device [1..7]<br>On for message 4, 5, 6, and 7 |
| 1 | Seq#1 | 0 = off<br>1 = on | Message sequence number to device [1..7]<br>On for message 2, 3, 6, and 7 |
| 0 | Seq#0 | 0 = off<br>1 = on | Message sequence number to device [1..7]<br>On for message 1, 3, 5, and 7 |

**Table 3-2 Control Byte of the Answer Message**

***Note:*** **If the control byte is hexadecimal [40], the message is an acknowledgment (ACK). An ACK message does not contain an error code or answer message. If bit 3 is equal to "1", then the sequence is repeated**.

## 5.0 COMMUNICATION SEQUENCE EXAMPLE

The sequence illustrated below shows the typical transfer of data between the external computer and the CCU-9000. This example also shows how two commands can be sent and processed individually by the CCU-9000.

1. External Computer to CCU-9000

   Initialize the left arm.

| STX | Control | Arm # | Device # | Message | ETX | VRC |
|---|---|---|---|---|---|---|
| <Ctrl-B> | 01000001 | 1 | 8 | PI | <Ctrl-C> | P |
| 02h | 41h | 31h | 38h | 50h 49h | 03h | 50h |

2. External Computer to CCU-9000

Initialize the right arm.

| STX | Control | Arm # | Device # | Message | ETX | VRC |
|---|---|---|---|---|---|---|
| <Ctrl-B> | 01000010 | 2 | 8 | PI | <Ctrl-C> | P |
| 02h | 42h | 32h | 38h | 50h 49h | 03h | 50h |

3. CCU-9000 to External Computer

Acknowledgment message for left arm initialization.

| STX | Control | Arm # | Device # | ETX | VRC |
|---|---|---|---|---|---|
| <Ctrl-B> | 01000000 | 1 | 8 | <Ctrl-C> | H |
| 02h | 40h | 31h | 38h | 03h | 48h |

***Note:*** **This acknowledgment might be sent to the external computer at the same time the initialization command for the second arm is received from the computer.**

4. CCU-9000 to External Computer

Acknowledgment message for right arm initialization.

| STX | Control | Arm # | Device # | ETX | VRC |
|---|---|---|---|---|---|
| <CtrlB> | 01000000 | 2 | 8 | <Ctrl-C> | K |
| 02h | 40h | 32h | 38h | 03h | 48h |

5. CCU-9000 to External Computer

Left arm has completed initialization.

| STX | Control | Arm # | Device # | ETX | VRC |
|---|---|---|---|---|---|
| <CtrlB> | 01010001 | 1 | 8 | <CtrlC> | Y |
| 02h | 51h | 31h | 38h | 03h | 59h |

6. External Computer to CCU-9000

Acknowledgment for answer to left arm initialization complete.

| STX | Control | Arm # | Device # | ETX | VRC |
|---|---|---|---|---|---|
| <CtrlB> | 01000000 | 1 | 8 | <CtrlC> | H |
| 02h | 40h | 31h | 38h | 03h | 48h |

7. CCU-9000 to External Computer

Right arm has completed initialization.

| STX | Control | Arm # | Device # | ETX | VRC |
|---|---|---|---|---|---|
| <CtrlB> | 01010010 | 2 | 8 | <CtrlC> | Y |
| 02h | 52h | 32h | 38h | 03h | 59h |

8. External Computer to CCU-9000

Acknowledgment for answer to right arm initialization complete.

| STX | Control | Arm # | Device # | ETX | VRC |
|---|---|---|---|---|---|
| <CtrlB> | 01000000 | 2 | 8 | <CtrlC> | K |
| 02h | 40h | 32h | 38h | 03h | 48h |

***Note:*** **The CCU-9000 does not chain commands to the same device. Therefore, the external computer must receive a "completion of command message" before another command is sent to the same device or a command overflow error will occur.**

## 6.0 COMMUNICATION ERROR SEQUENCE

The sequence illustrated below shows one of the error codes that can be sent by the RSP 9000. This is a random example of what could happen in the communications between the external computer and the RSP 9000.

1. External Computer to CCU-9000

   Initialize the left arm.

| STX | Control | Arm # | Device # | Message | ETX | VRC |
|---|---|---|---|---|---|---|
| <CtrlB> | 01000001 | 1 | 8 | PI | <CtrlC> | P |
| 02h | 41h | 31h | 38h | 50h 49h | 03h | 50h |

   ***Note:*** No acknowledgment was received from the CCU-9000 after 900 ms.

2. External Computer to CCU-9000

   Initialization command resent for left arm.

| STX | Control | Arm # | Device # | Message | ETX | VRC |
|---|---|---|---|---|---|---|
| <CtrlB> | 01001001 | 1 | 8 | PI | <CtrlC> | X |
| 02h | 49h | 31h | 38h | 50h 49h | 03h | 58h |

3. CCU-9000 to External Computer

   Acknowledgment message for left arm initialization.

| STX | Control | Arm # | Device # | ETX | VRC |
|---|---|---|---|---|---|
| <CtrlB> | 01000000 | 1 | 8 | <CtrlC> | H |
| 02h | 40h | 31h | 38h | 03h | 48h |

4. CCU-9000 to External Computer

   Left arm has completed initialization.

| STX | Control | Arm # | Device # | ETX | VRC |
|---|---|---|---|---|---|
| <CtrlB> | 01010001 | 1 | 8 | <CtrlC> | Y |
| 02h | 51h | 31h | 38h | 03h | 59h |

5. External Computer to CCU-9000

Acknowledgment for answer to left arm initialization complete.

| STX | Control | Arm # | Device # | ETX | VRC |
|---|---|---|---|---|---|
| <CtrlB> | 01000000 | 1 | 8 | <CtrlC> | H |
| 02h | 40h | 31h | 38h | 03h | 48h |

## 7.0 DEVICE ERROR CODES

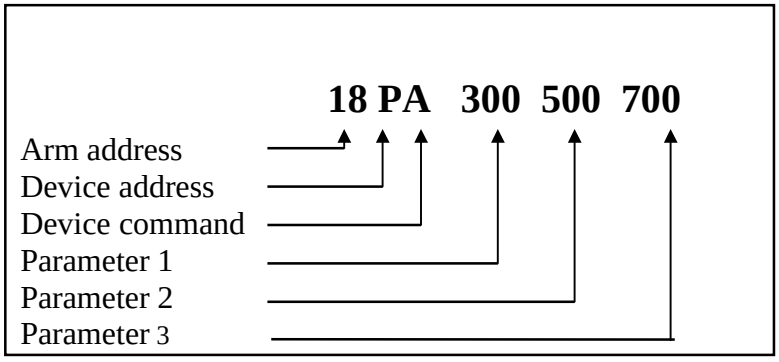
| Error Code | Device No. 8 | All Other Devices |
|---|---|---|
| 1 | Initialization error | Initialization error |
| 2 | Invalid command | Invalid command |
| 3 | Invalid operand | Invalid operand |
| 4 | Invalid command sequence | Invalid command sequence |
| 5 | Device not implemented | Device not implemented |
| 6 | Time out error | Time out error |
| 7 | Device not initialized | Device not initialized |
| 8 | Command overflow | Command overflow |
| 9 | No liquid detected with ZX-command | Reserved |
| 10 | Entered move for Z-axis out of range | Reserved |
| 11 | Not enough liquid detected with ZX-command | Reserved |
| 12 | No liquid detected with ZZ-command | Reserved |
| 13 | Not enough liquid detected with ZZ-command | Reserved |
| 14 | Reserved | Reserved |
| 15 | Reserved | Reserved |
| 16 | Reserved | Reserved |
| 17 | Arm collision avoided | Reserved |
| 18 | Reserved | Reserved |
| 19 | Reserved | Reserved |
| 20 | Step loss detected on X-axis | Reserved |
| 21 | Step loss detected on Y-axis | Reserved |
| 22 | Step loss detected on Z-axis | Reserved |
| 23 | Step loss detected on X-axis of opposing arm | Reserved |
| 24 | ALIDUM pulse time out | Reserved |
| 25 | Tip not fetched (used with DiTi A/C option) | Reserved |
| 26 | Tip crash (used with DiTi A/C option) | Reserved |
| 27 | Tip not clean (used with DiTi A/C option) | Reserved |

***Note:*** **Error codes [1..8] are common errors for all devices. Error codes [9..63] are device specific.**

# 1.0 COMMAND SET STRING STRUCTURE

Each command the RSP 9000 sends or receives contains information that allows transparent or processed communication to occur between devices. There are five parts to each system command:

- Arm address (1 or 2)
- Device address (device to be controlled)
- Device command (action to be performed)
- Required or optional parameters




***Note:*** **When using Tecan Integrator or RUI Software, there must be a "#" at the beginning of each command.**

## 1.1 Arm Address

The arm address is a logical indicator for devices. The number "1" tells the RSP 9000 that the device being called upon is logically connected to the left arm address (single arm for one arm instruments). The number "2" tells the RSP 9000 that the device being called upon is logically connected to the right arm address. The left arm, being a physical device, is assigned to arm address 1 and the right arm is assigned to arm address 2.

## 1.2 Device Address

The device address tells the RSP which "device" is receiving the following command/parameter(s) and allows the CCU-9000 to control transparent and controlled communications. Below is a listing of device addresses and their meanings.

| Device Address | Device |
|---|---|
| Device 9: | Interactive motor drive control (Modulo-1) |
| Device 8: | X, Y, and Z arm commands |
| Device 7: | Valve, stirrer, and auxiliary device |
| Device 5: | Linear rack drive |
| Device 4: | Diluter |
| Device 3: | Diluter |
| Device 2: | Diluter |
| Device 1: | Diluter |

***Note:*** **There are four different device numbers for diluters so they can operate independently from one another.**

## 1.3 Device Command

The device command is a single or dual letter command that is sent to a specific device for execution. Some device commands have no variables; however, other device commands have several. A complete listing of the RSP 9000 device commands can be found later in this chapter. Descriptions of the device commands indicate what parameters are required or optional give examples of proper usage. All device commands for RSP 9000 supported options can be found in their respective manuals.

## 1.4 Parameters

Parameters are specific to each command. Parameters are explained in the command summary for each individual command, including ranges and whether the parameter is required or optimal.

### 1.5 Words to Know before Continuing

Refer to the following terms in the Glossary before continuing, they will aid in your understanding of the commands and how they are used:

| | | |
|---|---|---|
| ***Absolute field*** | ***Defined field*** | ***Coordinate*** |
| ***Fixed position*** | ***Position*** | ***Rack*** |
| ***Tray*** | ***Tracking speed*** | ***Offset*** |
| ***Position counter*** | ***RAM*** | ***Mnemonic*** |
| ***SLD*** | ***Volatile memory*** | ***Nonvolatile memory*** |
| ***ALIDUM*** | ***Sensitivity*** | ***DITI*** |

## 2.0 COMMAND SYNTAX RULES

- Never insert spaces between the “number sign,” “arm address”, “device address,” and “device command”.
- There must always be one or more spaces between parameters.
- All parameters are shown enclosed by square brackets “[]”, but are only used for visual effect. Do not place them in command lines.
- All parameters which can be omitted must be replaced with a comma (placeholder).
- The “*” symbol indicates parameters which will retain their old values when omitted. Example: 18PF [FixPosNo] [X*] [Y*] [Z*]
- The “°” symbol indicates parameters which will have their value set to “0” when omitted. Example: 18PA [X°] [Y°] [Z°]
- Parameters without the “*” or “°” symbol cannot be omitted.
- When using Integrator or RUI Software Packages, a number sign (#) must be placed at the beginning of each command string.

## 3.0 DEVICE COMMANDS

Use the following list to locate individual commands:

## 3.1 Set Commands (Device #8)

### *OM [X*] [Y*] [Z*]*

*Set Overall Machine Limitation*

This command sets the physical limitation range (in volatile RAM) of the RSP 9000. It is used as a safety for the SM/SA-commands to ensure that the X/Y/Z-axes ranges cannot be set to invalid machine positions. After firmware is downloaded, the OM-command range is set to 1000, 1000, 1000. After definition, maximal range can be stored in non-volatile memory with the OW-command.

[X*] [Y*] [Z*] = X / Y / Z coordinates in steps [0..8000]
(Preset on delivery)
**Generated Errors:** (3) Invalid operand

### *OX / OY / OZ [InitOffset*]*

*Set Initialization Offset for X / Y / Z*

This command sets the initialization offset to the entered parameter [InitOffset] for the given axis. The offset parameter entered is implemented only after an initialization command is given.

[InitOffset*] = Steps to be offset. [5 ≤ parameter ≤ 100]
Default: (X / Y-axis = 5) (Z-axis = 20)
**Example:** #18OX50
Sets the initialization offset for the X-axis to 50 steps. However, there is no physical movement of the arm. The new offset entered will take effect at the next X-axis initialization. Effective range of each axis is the overall machine range (OM) minus the offset for that axis.
**Generated Errors:** (3) Invalid operand

### *XO / YO / ZO [±InitOffsetRel*]*

*Adjust Initialization Offset for X / Y / Z*

This command offsets the X/ Y/ Z-axis plus or minus the entered number of steps [±InitOffsetRel]. The entered parameter [InitOffsetRel] is added to the current offset. This command affects the OX /OY/ OZ setting. The relative movement cannot exceed the range for the OX /OY/ OZ-commands.

[±InitOffsetRel] = Plus or minus number of steps X /Y /Z-axis
**Example:** #18XO 50
If InitOffset is currently at 5 for the X-axis and then 18XO 50 is given, the X-axis moves +50 steps to an offset coordinate of 55. The next initialization will offset to this location. **Generated Errors:** (3) Invalid operand

## *OW*

*Write Parameters to EEPROM*

This command writes all parameters set by the following commands to the EEPROM (nonvolatile memory).

- OM-command
- OT-command
- OX /OY /OZ-commands
- XO/ YO /ZO-commands
- OL-command

**Generated Errors:** None

## *SM [X*] [Y*] [Z*]*

*Set Range for Absolute Field*

The SM-command sets the absolute field range (in volatile RAM) for all axes of the instrument. If the system has two arms, the range of [X*] determines the minimal distance between the arms (the higher [X*] the smaller the minimal distance.) The machine range cannot exceed the maximal values defined by the OM-command. After the system starts, the SM-command values are the same as the OM-command values.

[X*] [Y*] [Z*] = Set maximum X/ Y/ Z-axis coordinates for absolute field range.

**Example:** #18SM 2500, 1500, 1000

Sets the absolute field range (in steps) for the left arm to 2500/1500/1000 (X/Y/Z).

**Generated Errors:** (3) Invalid operand

## *SA [Z-Max*] [Z-start*] [Z-dispense*] [Z-travel*]*

*Set Z-Parameters for Absolute Field*

The SA-command sets (in volatile RAM) four X-axis heights for the absolute field. The SA-values are valid until the SA-command is either re-entered or until the RSP 9000 is turned off. The only time these values are in effect is when the machine is traveling in the absolute field.

[Z-Max*] = Maximum Z-axis height to search for liquid. (This should be the lowest working position in the absolute field.)

[Z-start*] = Start height for the Z-axis to turn on liquid detection.

[Z-dispense*] = Dispense height for the Z-axis.

[Z-travel*] = Z-axis travel height (valid for fixed positions).

**Example:** #18SA 500 400 380 200
Left arm Z-axis positions for the absolute field set to 500 steps for maximum Z-position to search for liquid, 400 steps for start position for the Z-axis to turn on liquid detection, 380 steps for dispense height for Z-axis, and 200 steps for Z-axis travelheight.
**Generated Errors:** (3) Invalid operand

## *SW [WasteNo] [X*] [Y*] [Z*]*

*Set Coordinates for Waste Stations*

The SW-command sets fixed positions (in volatile RAM) for the waste stations in the absolute field.

[WasteNo] = Waste station number [1..3]
(Stored as fixed position number [54..56].)
[X*] [Y*] [Z*] = X /Y Z-coordinates (in steps).
**Example:** #18SW 1 1100 200 600
Sets waste station #1 (fixed position #54) for the left arm to 1100/200/600
**Generated Errors:** (3) Invalid operand

## *SC [CleanerNo] [X*] [Y*] [Z*]*

*Set Coordinates for Cleaner Stations*

The SC-command sets fixed positions (in volatile RAM) for the cleaner stations in the absolute field.

[CleanerNo] = Cleaner station number [1..3]
(Stored as fixed position number [51..53].)
[X*] [Y*] [Z*] = X /Y Z-coordinates (in steps).
**Example:** #18SC 2 1100 225 600
Sets cleaner station #2 (fixed position #52) for the left arm to 1100/225/600(X/Y/Z).
**Generated Errors:** (3) Invalid operand

## *SL [Speed*]*

*Set Search Speed for Liquid Search Commands*

The SL-command sets the search speed (in volatile RAM) the Z-axis will use while moving from Z-start to Z-Max.

[FastSpeed*] = The search speed from Z-start to Z-Max. [5..1500]
(Default = 800)
**Generated Errors:** (3) Invalid operand

## *SP [ON/OFF]*

*Set Position Recovery*

If SP is set to on, the RSP 9000 tries to reposition the arm when step loss is detected to the position from the last command executed. If the RSP 9000 loses steps while trying to recover from the first lost steps, the arm will stop. If SP is set to off, the RSP stops immediately upon the detection of lost steps and does not attempt position recovery. (An error message will be generated.) SP-command parameters are stored in volatile RAM.

[ON/OFF*] = ON : 1, OFF : 0 (Default at start-up "0")
(If omitted, the value of [ON/OFF] is toggled.)
**Generated Errors:** (3) Invalid operand

## *SS [Sensitivity]*

*Set Liquid Detection Sensitivity*

Sets the ALIDUM sensitivity (in volatile RAM) for the ZX / ZZ-commands. The SS-command remains valid until the SS-command is re-entered or until the power is turned off.

[Sensitivity] = 0 = low sensitivity (default)
1 = high or very high sensitivity selected by SW4 or ADRI-9 board (only available if SW3 on ADRI-9 board is set to "enable.") See Appendix C, Figure C.9, ADRI-9 Board Layout.
**Generated Errors:** (3) Invalid operand

## *FX [StartSp*] [EndSp*] [Accel*]*

*Set X-Ramp Parameters*

This command sets the X-axis stepper motor ramp settings (in volatile RAM).
[StartSp*] = Start speed in steps/s [50..200] (Default : 50)
[EndSp*] = End speed in steps/s [50..4400] (Default : 4000)
[Accel*] = Acceleration in steps/$s^2$ / 1000 [3..40] (Default : 10)
**Generated Errors:** (3) Invalid operand

## *FY [StartSp*] [EndSp*] [Accel*]*

*Set Y-Ramp Parameters*

This command sets the Y-axis stepper motor ramp settings (in volatile RAM).

[StartSp*] = Start speed in steps/s [50..800] (Default : 200)
[EndSp*] = End speed in steps/s [50..4400] (Default : 4000)
[Accel*] = Acceleration in steps/s$^2$ / 1000 [3..80] (Default : 20)
**Generated Errors:** (3) Invalid operand

## *FZ [StartSp*] [EndSp*] [Accel*]*

*Set Z-Ramp Parameters*

This command sets the Z-axis stepper motor ramp settings (in volatile RAM).

[StartSp*] = Start speed in steps/s [50..800] (Default : 4000)
[EndSp*] = End speed in steps/s [50..4400] (Default : 4000)
[Accel*] = Acceleration in steps/s$^2$ / 1000 [3..80] (Default : 30)
**Generated Errors:** (3) Invalid operand

## *SD [Mode 2], [Mode 1]*

*Set Detection Mode*

This enables or disables the DiTi -A/C option. It also sets the sensitivity setting for the ALIDUM.

[Mode 2] = 0 or 1
0 = The airflow monitoring (DiTi option) is disabled. I/O 2 is free programmable (See #19 SL and SD commands). Switch SW2 on ADRI-9 board must be set to “enable.”
1 = The airflow monitoring (DiTi option) is enabled. Switch SW2 on ADRI-9 board must be set to “enable.” I/O 2 is not programmable with the #19 SL or SD commands.
[Mode 1] = 0 or 1
0 = The sensitivity switching on the ALIDUM is “enabled.” Switch SW3 on ADRI-9 board must be set to “enable.” I/O 1 is not programmable with the #9 SL or SD commands.
1 = The sensitivity switching on the ALIDUM is “disabled.” I/O 1 is free programmable with the #9 SL or SD commands. Switch SW3 on ADRI-9 board must be set to “disable.” (See Appendix C, Figure 9, ADRI-9 Board Layout.)
These settings can be stored in the EEPROM with the OW command.
**Generated Errors** (3) Invalid operand

## *ST [X]*

*Set Tip Option*

Switches between normal tip and use of the DiTi option. (See DiTi Manual.)

[X] = 0 or 1
0 = Normal tip (default at start up)
1 = DiTi implemented
**Example:** #18ST1
Sets detection mode to DiTi option.

### 3.2 Arm Positioning Commands (Device #8)

Device #8 commands are used to control the arm(s) of the RSP 9000. These commands are used with command arm / device #18 and #28.

## *PI*

*Position Initialization X-/Y-/Z-axes*

This is the command which must be sent to initialize the right and left arms; X/Y/Z-axes. No X/Y/Z-movement commands for device #8 are accepted before the PI command is executed. When the PI command is entered, the X/Y/Z-axes move to their initialization positions. When the initialization flag of each axis has been detected, they move to an initial offset position. This position is assigned coordinate value of “0”. Each individual axis may be initialized and moved separately (see XI/YI/ZI-commands).
**Example:** #18PI
Initialization of the left arm X/Y/Z-axes.
**Generated Errors:** (3) Invalid operand

## *FI*

*Fake Initialization X-/Y-/Z-axes*

***Caution:*** **This command performs no physical initialization of the instrument. It is intended for software test purposes only. Incorrect usage may damage the instrument.**

***Caution:*** **To avoid crashing, always retract the Z-axis before initiating any other movement commands.**

***Note:*** **On a two-arm instrument an arm can only be moved in the X-direction after the other arm has been initialized; otherwise, error 17 (arm collision avoided) occurs.**

The FI-command tells the firmware (sets flag) that the X/Y/Z-axes have been initialized; however, no mechanical initialization is executed. The current position coordinates of each axis are still valid. If power is disconnected and turned on, using the FI-command will give all axes positions the position value of “0”.
**Example:** #18FI
Fake initialization of the left arm.
**Generated Errors:** none

## *XI/YI/ZI [Speed*]*

*Position Initialization for X-/Y-/Z-Axes*

This function may be necessary after an arm collision or if the accuracy is bad due to lost steps. For example, the XI-command initializes the X-axis of the defined arm. An override motor speed (not stored in memory) for axis initialization may be placed at the end of the command, but to achieve the proper initialization position of any axis, the XI / YI / ZI-command must be given without the [speed*} parameter.

[Speed*] = Speed in steps/s X-axis: [5..400] (Default : 150)
Y-axis: [5..800] (Default : 400)
Z-axis: [5..800] (Default : 650)

**Example:** #18XI
X-axis initialization of the left arm (default speed).
**Example:** 18YI 600; #18YI
Y-axis initialization of the left arm (speed 600 step/s), then reinitialization with the default speed to ensure proper initialization position.
**Generated Errors:** (1) Initialization Error. Initialization was not successful.

## *PA [X°] [Y°] [Z°]*

*Position Absolute for All Axes*

The PA command moves the X/Y/Z-axes to the entered coordinates (in steps) in the absolute field. After using this command, all Z-positions set with the SA command are in effect.

[X°] [Y°] [Z°] = Coordinates in the absolute field.

***Note:*** **See Appendix B, "Specifications" for the maximum range (in steps) of each axis.**

**Example:** #28PA 300 300 300
Moves the right arm (in steps) to position 300/300/300 (X/Y/Z).
**Example:** #28PA 200 500
Moves the right arm (in steps) to position 200/500/0 (X/Y/Z).
**Example:** #28PA , , 400
Moves the right arm (in steps) to position 0/0/400 (X/Y/Z).
**Generated Errors:** (3) Invalid operand--out of range (machine setup)
(17) Arm collision avoided -- X-axis only

## *XA/YA/ZA [Coord°]*

*Position Absolute for Single Axis*

These commands move any one of the three axes individually to an absolute position (in steps) leaving the other two axes unchanged.

**Caution*:* The XA/YA/ZA-commands use absolute field parameters. They DO NOT use X/Y/Z ranges specified for defined fields or fixed positions. The movement of any axis is direct and may cause the Z-axis to crash with work surface components if used improperly.**

[Coord°] = A coordinate in the specified axis range.
(Range is defined by SM-command settings.)

***Note:*** **See Appendix B, "Specifications" to find the individual axis ranges in steps.**

**Example:** #18YA 500
Moves the left arm's Y-axis to coordinate 500 leaving the X/Z-axes in the same position prior to the command being executed.
**Generated Errors:** (3) Invalid operand--out of range (machine setup)
(17) Arm collision avoided -- X-axis only

## *XR/YR/ZR [± Steps°]*

*Position Relative for Single Axis*

Moves a single axis relative to its actual position [±Steps]. All other axes remain unchanged.

***Caution:*** **The XR/YR/ZR-commands use absolute field parameters. They DO NOT use Max-range parameters specified for defined fields or fixed positions. The movement of any axis is direct and may cause the Z-axis to crash with work surface components if used improperly.**

[± Steps°] = The number of steps to position axis from current location.
**Example:** (After #18PI) #18ZR20
Moves the left arm's Z-axis 20 steps from the initialization position of 18PI.
**Example:** (After 18ZR 20) 18ZR50
Moves the left arm's Z-axis downward 50 steps to position 70.
**Generated Errors:** (3) Invalid operand--out of range (machine setup)
(17) Arm collision avoided -- X-axis only

## *XS/YS/ZS [± Steps°] [Speed*]*

*Position Relative, Slow Speed*

These commands move the X/Y/Z-axis relative to its actual position ±steps. All other axes remain unchanged. Same as XR/YR/ZR-commands, but a tracking speed may be entered.

[± Steps°] = Number of relative steps.
[Speed*] = Speed in steps/s X-axis: [5..400] (Default : 150)
Y-axis: [5..800] (Default : 400)
Z-axis: [5..800] (Default : 400)

***Note:*** **Check Appendix B to find the individual axis ranges in steps.**

***Caution:*** **The XS/YS/ZS-commands use absolute field parameters. They DO NOT use X/Y/Z ranges specified for defined fields or fixed positions. The movement of any axis is direct and may cause the Z-axis to crash with work surface components if used improperly.**

**Example:** (After #18PI) #18ZS 100 100
Moves the left arm's Z-axis downward 100 steps with a speed of 100 steps/s. The X/Y-axes will not move.
**Generated Errors:** (3) Invalid operand--out of range (machine setup)
(17) Arm collision avoided -- X-axis only

### *PW [WasteNo]*

*Move to Waste Position Location*

The PW-command moves the Z-rack to one of three predefined waste positions [WasteNo] defined with the SW-command.

***Note:*** **This command will only work if the waste positions being called upon have been predefined. If they are not defined, the arm will move to coordinates 0/0/0 (X/Y/Z).**

[WasteNo] = Waste position [1..3]
Waste position [1..3] corresponds to PF [54..56]
**Example:** #18PW 1
Moves the left arm to the predefined waste position #1.
**Generated Errors:** (3) Invalid operand--Invalid [ReagNo]
(17) Arm collision avoided -- X-axis only

### *PC [CleanerNo]*

*Move to Cleaner Position*

The PC-command moves to one of three predefined cleaner positions defined with the SC command.

[CleanerNo] = Cleaner position [1..3]
Cleaner position [1..3] corresponds to PF [51..53]

***Note:*** **This command will only work if the cleaner positions have been predefined using the SC-command. If they are not defined, the arm will move to coordinates 0/0/0 (X/Y/Z).**
**Example**: #18PC 1
Moves the left arm's three axes to cleaner position #1.
**Generated Errors:** (3) Invalid operand--Invalid [CleanerNo]
(17) Arm collision avoided -- X-axis only

## 3.3 Rack Definition Commands

### *SF [FixPosNo] [X*] [Y*] [Z*]*

*Set Coordinates for a Fixed Position*

The SF-command is used to set up to 50 fixed positions within the absolute field.
[FixedPosNo] = Fixed position number [1..50]
[X*] [Y*] [Z*] Coordinates in steps
**Example:** #18SF1 1000 500 500
Sets fixed position #1 (reagent1) in steps to 1000/500/500 (X/Y/Z).
**Generated Errors:** (3) Invalid operand.

## *SR [FixPosNo] [Z-Max*] [Z-start*] [Z-dispense*]*

*Set Z-Parameters for a Fixed Position*

This command sets the Z-parameters for fixed position [FixedPosNo]. Z-travel height parameter is used from the SA-command setting.

| | |
|---|---|
| [FixPosNo] = | Fixed position number [1..50] |
| [Z-Max*] | Maximum height for liquid detection (SM-range) |
| [Z-start*] | Start height for liquid detection (SM-range) |
| [Z-dispense*] | Dispense height for Z-axis (SM-range) |
| **Example:** | #18SR 4 1500 150 600 |

For fixed position number 4, sets maximum Z-position for liquid detection to 1500, the start position for liquid detection to 150 and the dispense height for the Z-axis to 600.
**Generated Errors:** (3) Invalid operand.

## *D% [RackType*] [#ofColumns*] [#ofRows*] [X-Pos0*] [Y-Pos0*] [X-Pos1*] [Y-Pos1*] [± DispOfRowX*] [DispOfColY*]*

*Set Parameters for a Defined Field (Rectangular)*

This command defines a defined field in the form of a matrix. When stepping through such a rack, start at the first position and scan the rows column by column (or the columns row by row) and wrap around to the first position. If an offset is defined, every second row (X offset) or column (Y offset) is shifted relative.

| | |
|---|---|
| % = | [A..Z] (Placeholder for tray identifier.) |
| [RackType*] = | Position sequence (0 = left/right; 1 = front/rear) |
| [#ofColumns*] = | Number of columns in defined field. |
| [#of Rows*] = | Number of rows in defined field |
| [X-Pos0*] [Y-Pos0*] = | First corner position |
| [X-Pos1*] [Y-Pos1*] = | Second corner position |
| [±DispOfRowX*] = | X-offset of row displacement |
| [±DispOfColY*] = | Y-offset of column displacement |
| **Generated Errors:** | (3) Invalid operand. |

## *D% [PosSeq*] [TotNumPos*] [NumConCircles*] [CenterX-Pos*] [CenterY-Pos*] [CirRadius1*] [Angle1*] [CirRadius2*] [Angle2*]*

*Set Parameters for a Defined Field (Circular)*

This command defines a “Defined Field” in the form of concentric circles. When stepping through a circular “Defined Field,” start in the first position (Xcenter + Radius1/Ycenter by Angle 0) of the first circle. After reaching the last position of the first circle, this function jumps to the first position of the second circle. After the last position of the second circle it wraps around to the first position of the circle.

| | |
|---|---|
| % = | [A..Z] (Placeholder for tray identifier.) |
| [PosSeq*] = | Position sequence: (2 = clockwise; 3 = counterclockwise) |
| [TotNumPos*] = | Total number of positions per circle [1..1000]<br>If 2 circles, total number of positions = TotNum Posx2! |
| [NumConCircles*] = | Number of concentric circles [1..2] |
| [CenterX-Pos*] = | Center X-position for all circles |
| [CenterY-Pos*] = | Center Y-position for all circles |
| [CirRadius1*] = | Radius of 1st circle in 0.1 mm (0.0039 in.) |
| [Angle1*] = | Angle of 1st position in 0.001 Radians |
| [CirRadius2*] = | Radius of 2nd circle in 0.1 mm (0.0039 in.) |
| [Angle2*] = | Angle of 2nd position in 0.001 Radians |
| **Generated Errors:** | (3) Invalid operand. |

## *D% [RackType*] [LiRaNo*] [X-Pos*] [Y-posFirst*] [y-PosLast*]*

*Set Parameters for a Defined Field (Linear Rack)*

The D%-command for the Linear Rack Drive defines the position and type of rack and assigns it to a LiRa. There are three types of racks available. All of these racks can be assigned a Defined Field, but only one at a time (with one D%-command). At least one rack must be assigned for every mounted LiRa. All of the racks used must have their Z-positions defined separately (E%-command).

| | |
|---|---|
| % = | [A..Z] (Placeholder for tray identifier.) |
| [RackType*] = | 17 : Type 1 (8-position)<br>18 : Type 2 (4-position) (for future 4-position rack)<br>19 : Type 3 (4-position) (for available 4-position rack) |
| [LiRaNo*] = | Linear Rack Number [1..2] |
| [X-Pos*] = | X-coordinate for all rack locations |
| [Y-PosFirst*] = | Y-coordinate for the first tube in rack |
| [Y-PosLast*] = | Y-coordinate for the last tube in rack |
| **Generated Errors:** | (3) Invalid operand. |

## *E% [Z-max*] [Z-start*] [Z-dispense*] [Z-travel*] [RackType*]*

*Set Z-Parameters for a Defined Field*

This command sets the Z-position for trays to the entered parameters. This command may not be used until the tray is defined by the D%-command.

| | |
|---|---|
| % = | [A..Z] (Placeholder for tray identifier.) |
| [Z-Max*] = | Lowest position for liquid (lowest position in field) |
| [Z-start*] = | Z-axis coordinate for activating liquid detection (ALIDUM) |
| [Z-dispense*] = | Dispense height for Z-axis |
| [Z-travel*] = | Axis travel height |
| [RackType*] = | Only used for LiRa. Describes rack type [17..19].<br>17 : Type 1(8-position)<br>18 : Type 2 (4-position) (for future 4-position rack)<br>19 : Type 3 (4-position) (for available 4-position rack) |
| **Generated Errors:** | (3) Invalid operand. |

### 3.4 Rack Positioning Commands

## *PF [FixNo]*

*Move to Fixed Position*

This command moves the Z-rack to a predefined fixed position implemented with the SF or SR-commands.

[FixNo] = A fixed position number between [1..50]

***Note:*** **If the [FixNo] is between 1 and 50, it can also be used as a reagent number.**

**Example:** #18PF 1
Left arm is moved to the fixed position #1.
**Generated Errors:** (3) Invalid operand--Invalid [FixNo]
(17) Arm collision avoided -- X-axis only.

## *BF [pos] [win]*

*Discard Tip*

Discards a disposable tip at position [pos] in waste bag that is defined as a reagent rack.

[pos] = Position in the reagent rack defined as waste bag position.
[win] = Number of steps over the specified position to discard the tip (1-60).
**Example:** #18BF7,60
Discards tip at position 7 with 60 retract steps.

## *PR [ReagNo]*

*Move to Reagent Position*

This command moves to a reagent position. It performs the same function as the PF-command since reagent and fixed positions are the same.

[ReagNo] = Reagent number relates to fixed position [1..50]
**Example:** #18PR 1
The left arm is moved to the reagent position defined as Number 1.
**Generated Errors:** (3) Invalid operand--Invalid [ReagNo]
(17) Arm collision avoided -- X-axis only.

## *ZD [± Steps°]*

*Move to Z-Dispense Height*

Moves the Z-rack to the dispense height defined for the position. If the current location of the Z-rack is not in a defined field, it moves to the dispense height defined by the SA-command setting plus or minus the number of steps indicated by [+Steps°].

[+Steps°] = Offset to the defined dispense height.
**Example:** #18ZD +50
Moves the left arm's Z-rack 50 steps lower than the predefined Z-dispense height.
**Generated Errors:** (3) Invalid operand -- Entered absolute Z-parameter is out of range.

## *ZM [± Steps°]*

*Move to Z-Max Height*

This command moves the Z-rack to the Z-max height, defined for the current position. If the current location of the Z-rack is not in a defined field, it moves to the Z-max defined by the SA-command setting, plus or minus the number of steps indicated by [±Steps°].

[±Steps°] = Offset to the defined maximal Z-position.
**Example**: #28ZM -20
Moves the right arm's Z-rack 20 steps higher than the predefined Z-maximum height.
**Generated Errors:** (3) Invalid operand --Entered absolute Z is out of range.

## *ZT [± Steps°]*

*Move to Z-Travel Height*

The ZT-command moves the Z-rack to the travel height defined for the current position (plus or minus entered number of steps). If the current location of the Z-rack is not in a defined field, it moves to the dispense height defined by the SA-command setting (plus or minus the number of steps indicated by [±Steps°].

[±Steps°] = Offset to the defined Z-travel height.
**Example:** #18ZT
Moves the left arm's Z-rack to the defined Z-travel height.
**Generated Errors:** (3) Invalid operand --Entered absolute Z out of range.

## *ZX [Subm°] [Add°] [Z-max*] [Sensitivity]*

*Move Z-Rack, Detect Liquid, Submerge*

The ZX-command moves the Z-rack to Z-start and then searches downward until it detects liquid or reaches Z-Max. If no liquid is detected, the Z-rack will move back up to position "0" and generate error code 9 (no liquid detected). If liquid is detected, the Z-rack will be lowered to the specified [Subm°) steps and verify that the [Add°] steps can be lowered before reaching Z-max. If this is not possible, error code 11 (not enough liquid) is generated.

| | |
|---|---|
| [Subm°] = | Submerge distance (in steps). |
| [Add°] = | Required distance to maximum Z-coordinate for liquid detection (in steps). |
| [Z-Max*] = | Override Z-max height (in steps) |
| [Sensitivity] = | 0 or 1. (Same function as the SS command.) This parameter overrides the setting of the SS command until the liquid search is finished. |
| **Generated Errors:** | (3) Invalid operand.<br>(9) No liquid detected.<br>(11) Not enough liquid detected<br>(27) Tip not clean (Diti AC only) |

## *ZZ [Subm°] [Add°] [Z-Max*] [Sensitivity]*

*Move Z-Rack, Detect Liquid, Submerge*

Same as the ZX-command, but the Z-rack will remain at Z-max upon error. The reported error codes are different.

| | |
|---|---|
| [Subm°] = | Submerge distance (in steps). |
| [Add°] = | Required distance to maximum Z-coordinate for liquid detection (in steps). |
| [Z-Max*] = | Override Z-max height (in steps) |
| [Sensitivity] = | 0 or 1. (Same function as the SS command.) This parameter overrides the setting of the SS command until the liquid search is finished. |
| **Generated Errors:** | (3) Invalid operand.<br>(12) No liquid detected.<br>(13) Not enough liquid detected<br>(27) Tip not clean (Diti AC only) |

## *U% [xPos°] [yPos°] [zPos°]*

*Position Absolute for All Axes*

The U%-command performs the same function as the PA-command but the Z-height of the specified defined field is used instead of the SA-command settings.

[xPos°] [yPos°] [zPos°] = Coordinates in the absolute field.
**Generated Errors:** (3) Invalid operand.
(17) Arm collision avoided.

### *G% [pos],[rt],[win1],[win2]*

*Get a Tip*

Picks up a tip from a defined tray [tray], at position [pos].

| | |
|---|---|
| % = | Tray number as implemented (a...z). |
| [pos] = | Position in tray (1...max. position as defined). |
| [rt] = | Rack type (0 = normal rack). |
| [win1] = | Number of steps gained with tip pick up (1-20), e.g. 10. |
| [win2] = | Number of steps gained until crash alarm (40-60), e.g. 60. |
| **Example:** | #18GA1,,15,40 |
| **Generated Errors:** | (25) Tip not fetched |
| | (26) Tip Crash |

### *T% [RackPos] [RackType*]*

*Move to Defined Field Position*

The T%-command moves the arm's axes to a defined field. If the last move was already in the same defined field, the travel height of the defined field is used; otherwise the travel height of the absolute field is used.

| | |
|---|---|
| % = | [A..Z] (Placeholder for defined field identifier). |
| [RackPos] = | Rack position, if 0 or omitted, increment to next position. The position counter is set to the value of the last position accessed. |
| [RackType*] = | 0 = Normal rack, not linear rack |
| | 16 = move near linear rack (type yet unknown) |
| | 17 = rack type 1 (8-pos) |
| | 18 = rack type 2 (4-pos) (for future 4-pos rack) |
| | 19 = rack type 3 (4-pos) (for current 4-pos rack) |

**Example:** #18TA1
Move the Z-rack of the left arm to defined field TA, position "1"
**Generated Errors:** (3) Invalid operand.
(17) Arm collision avoided.

## 3.5 Report Commands

### *RV [Firmware°]*

*Report Firmware Version*

RV0 = Reports firmware version and date in this format: “RSP9000-Vn.nn-MM/YY”

RVI = Reports boot EPROM version and date in this format: “RSP9000-BOOT-Vn.nn-MM/ YY”

**Generated Errors:** (3) Invalid operand.

## *RX/RY/RZ 0* [Sel°]*

*Report Current Parameters for All Axes*

This command reports the current parameters of the X/Y/Z-axis. Only one axis parameter can be reported at a time.

0* = A zero must be entered after the command and before the [Sel].

A value selector [Sel°] is needed:

| | | |
|---|---|---|
| 0 | - | Report current position |
| 1 | - | Report error steps upon last initialization |
| 2 | - | Acceleration [steps/ramp] |
| 3 | - | Report start speed [steps/s] |
| 4 | - | Report end speed [steps/s] |
| 5 | - | Report initialization speed [steps/s] |
| 8 | - | Report initialization offset |
| 9 | - | Report actual machine range (set by SM-command) |
| 10 | - | Report maximum machine range (set by OM-command) |
| 11 | - | Report test range (set by OT-command) |

**Generated Errors:** (3) Invalid operand.

## *RM*

*Report Z -Max to Current X/Y-Position*

If the X/Y-position is in a defined field, the value is given from the Z-position defined for the specific rack. Otherwise, it is taken from the SA-command setting.

**Generated Errors:** (None)

## *RS*

*Report Z-Start Assigned to Current X/Y-Position*

If the X/Y-position is a defined field, the value is given from the Z-position defined for the specific rack. Otherwise, it is taken from the SA-command setting.

**Generated Errors:** (None)

## *RD*

*Report Z-Dispense Assigned to Current X/Y-Position*

If the X/Y-position is a defined field, the value is given from the Z-position defined for the specific field. Otherwise, it is taken from the SA-command setting.
**Generated Errors:** (None)

## *RT*

*Report Z-Travel Assigned to Current X/Y-Position*

If the X/Y-position is in a defined field, the value is given from the Z-position defined for the specific field. Otherwise, it is taken from the SA-command setting.
**Generated Errors:** (None)

## *RC*

*Report Capture Position*

The capture position is the Z-position where liquid detection system detects a change in the capacitance for the first time using the ZS-command.
**Generated Errors:** (None)

## *RE*

*Report Capture Events*

This command reports the number of times the ALIDUM detects a change in capacitance, for example during a ZS-command.
**Generated Errors:** (None)

## *RF [FixNo]*

*Report X-Coordinate of a Fixed Position*

This command reports X-axis position of the Fixed Position [FixNo].

[FixNo] = Fixed position number.
**Generated Errors**: (3) Invalid operand

### *RL [Sel°]*

*Report Z-Axis Values and Parameters*

This command reports the values of the Z-axis using the following [Sel°] numbers.

| | | |
|---|---|---|
| 0 | - | Report Z-max of current X/Y-position (See RM-command.) |
| 1 | - | Report Z-start of current X/Y-position (See RS-command.) |
| 2 | - | Report Z-dispense of current X/Y-position (See RD-command.) |
| 3 | - | Report Z-travel of current X/Y-position (See RT-command.) |
| 4 | - | Report capture position (See RC-command.) |
| 5 | - | Report capture events (See RE-command.) |
| 6 | - | Report current setting for liquid detection sensitivity. |
| 7 | - | Report liquid detection fast speed. |
| 8 | - | Report liquid detection slow speed. |

**Generated Errors**: (3) Invalid operand.

### *Q% [RackPos]*

*Report X-Coordinate of Position in a Defined Field*

% = Placeholder for defined field identifier [A..Z]
[RackPos] = Position number.
**Generated Errors:** (None)

## 3.6 Device #6 Smart Wash Commands

### *SW [Time°]*

*Start Smart Wash Pump*

[TIME] = Time in 0.1 seconds. If no time is specified, the pump will stay on indefinitely.

Example: 1GSW10
**Generated Errors:** (3) Invalid Operand.

### *SC Stop Smart Wash*

## 3.7 Device #9 Interactive Motor Drive Control Commands

The device #9 commands allow the user to have absolute control of the arm(s) while device #8 is busy. It also gives the user direct control over the Modulo-1 by ignoring all safety features of the CCU, e.g., arm collision control. The third function of the device #9 allows digital input/output line control.

## *SX/SY/SZ*

*Stop X/Y/Z-Drive Movement Immediately*

This function is recommended only to stop the movement of the XS/YS/ZS-commands. If other movements are stopped with these commands, the axis must be reinitialized. If position recovery is set to on, the arm will try to reposition after stopping.
**Generated Errors:** (23) Step loss detected on opposite arm (device #8).

## *RX/RY/RZ ,* [Sel°]*

*Report Current X-/Y-/Z-Position and Parameters*

This command reports the current position of the X/Y/Z-axis. It performs the same functions as the RX/RY/RZ-commands for device #8 except that it can retrieve the data if device #8 is busy. Only one axis position can be reported at a time. A value selector [Sel°] is needed.

* = A comma must be entered after the command and before the [Sel].

| | | |
|---|---|---|
| 0 | - | Report current position |
| 1 | - | Report error steps upon last initialization |
| 2 | - | Report steps/ramp |
| 3 | - | Report start speed [steps/s] |
| 4 | - | Report end speed [steps/s] |
| 5 | - | Report initialization speed [steps/s] |
| 6 | - | Report machine type |
| 7 | - | Report machine type |
| 8 | - | Report initialization offset |
| 9 | - | Report actual machine range (set by SM-command) |
| 10 | - | Report maximum machine range (set by OM-command) |
| 11 | - | Report test range (set by OT-command) |

**Generated Errors:** (3) Invalid operand.

## *SD [InOutNo] [Direct°]*

*Set Signal Direction of Digital I/O-Pins on ADRI-9 Board Connector*

I/O 1 is used for liquid detection sensitivity selection if switch SW3 on the ADRI-9 board is set to “enable. I/O 2 is used for DiTi options if switch SW2 on the ADRI-9 board is set to “enable.” I/O 3 is not used.

[InOutNo] = [1..3] (1 = pin-1), (2 = pin-3), (3 = pin-7)
[Direct°] = Direction of entered pin [0 = input, 1 = output]

**Note: See Appendix C, ADRI-9 Board Connectors (J8, SW2, SW3)**

**Example:** #19SD1,1
Sets the I/O line 1 to an output.
**Generated Errors:** (3) Invalid operand

## *SL [InOutNo] [Value°]*

*Set Output Value for I/O-Pins on ADRI-9 Connector*

The I/O pin that needs to be set high or low, first has to be defined as a output with the SD command.

[InOutNo] = [1..3] (1 = pin-1), (2 = pin-3), (3 = pin-7)
[Value°] = [1 or 0]

**Note: See Appendix C, ADRI-9 Board Connectors (J8, SW2, SW3)**

**Example:** #19SL2,1
Sets the I/O pin number 2 to 1 (high).
**Generated Errors:** (3) Invalid operand

## *RL [InOutNo]*

*Read Input From I/O-Pins on ADRI-9 Board Connector*

[InOutNo] = [1..4] (1 = pin-1), (2 = pin-3), (3 = pin-7), (4 = pin-8)
Answer Command = [1 = On, 0 = Off]

**Note: See Appendix C, ADRI-9 Board Connectors (J8, SW2, SW3)**

**Example:** #19RL3
Reads input from I/O line 3.
**Generated Errors:** (3) Invalid operand

## *RD [InOutNo]*

*Read Signal Direction of Digital I/O-Pin on ADRI-9 Board Connector*

[InOutNo] = [1..3] (1 = pin-1), (2 = pin-3), (3 = pin-7)
Answer = [1 or 0] [1 = input, 0= output]

**Note: See Appendix C, ADRI-9 Board Connectors (J8, SW2, SW3)**

**Example:** #19RD1
Indicates whether I/O 1 is set as an input or output.
**Generated Errors:** (3) Invalid operand

***Caution:*** **The following commands ignore the arm movement safety features of the CCU and should only be used after contacting Tecan Systems. An additional manual is needed to use these commands (Modulo-1 Stepper Motor Controller/Driver Manual).**

## *X%/Y%/Z% [p1, p2, p3]*

*Direct Control of Modulo-1*

These commands allow the user to communicate directly to the Modulo-1 for the X/Y/Z-axes and disregard all arm control safety features.

% = Is a placeholder for Modulo-1 command mnemonics.
[p1..p3] = The command parameters for Modulo-1 as described in Tecan's Modulo-1 Stepper Motor Controller/Driver Manual.
**Generated Errors:** (Modulo-1 errors)

## *T% [Adr] [p1] [p2] [p3]*

*Direct Control of Modulo-1 at Address*

This command is used to communicate with any device on the Modulo-1 chain. It can be used with either device number "19" or "29" to communicate with any Modulo-1.

% = Placeholder for Modulo-1 command mnemonics.
[Adr] = The RS-485 chain address of the Modulo-1.
[p1..p3] = The command parameters for Modulo-1 as described in Tecan's Modulo-1 Stepper Motor Controller/Driver Manual.

## 3.8 Alternate Diluter Commands For Use With Integrator

**Note: Tecan Integrator Software programs do not accept the following Cavro diluter report commands. Therefore the listed commands for Integrator must be used.**

| Integrator Commands | Cavro Diluter Commands | Description |
|---|---|---|
| RZ | ? | Report absolute plunger position |
| RS | F | Report buffer status |
| RD1 | % | Report number of valve movements |
| RD2 | $ | Report lost valve steps |
| RD3 | * | Report voltage |
| RZ1 | ?1 | Report start speed |
| RZ2 | ?2 | Report top speed |
| RZ3 | ?3 | Report cutoff speed |
| RQ | Q | Report operational status |

## Cavro *EXPRESS*™

**Robotic Software Development Kit (SDK)**
**Robotic Applications Development Kit (RAD) with VBA**

## Cavro *EXPRESS* – *Develop robotic applications faster and easier*

Cavro's ***EXPRESS*** software provides cutting edge software tools with virtually unlimited pipetting functions, not only for your requirements today but also looking forward to future. Professional programmers and application developers utilizing Cavro's MSP/RSP robotic hardware will be well prepared to take on most clinical and life sciences applications.

## ROBOTIC SOFTWARE DEVELOPMENT KIT (SDK)

### *Communication and Hardware Support COM Objects*

A library of Common Object Modules (COM) which are usable with any 32-bit Windows development system. The SDK will provide programming tools for Cavro MSP/RSP robotic hardware, with support for all standard Cavro liquid handling modules (syringe pumps etc.). All system parameters are maintained in an ADO /Active-X-Data Objects) compliant database for easy COM integration.

### EXPRESS Software Package

**SDK** – Programmers kit.

**RAD** – Full version including Microsoft VBA.

Kit consists of COM objects like; Communication DLL, Worktable.ocx, Hardware.ocx, Liquid handling.DLL, Liquid class.ocx, Script engine.ocx, Random test.ocx

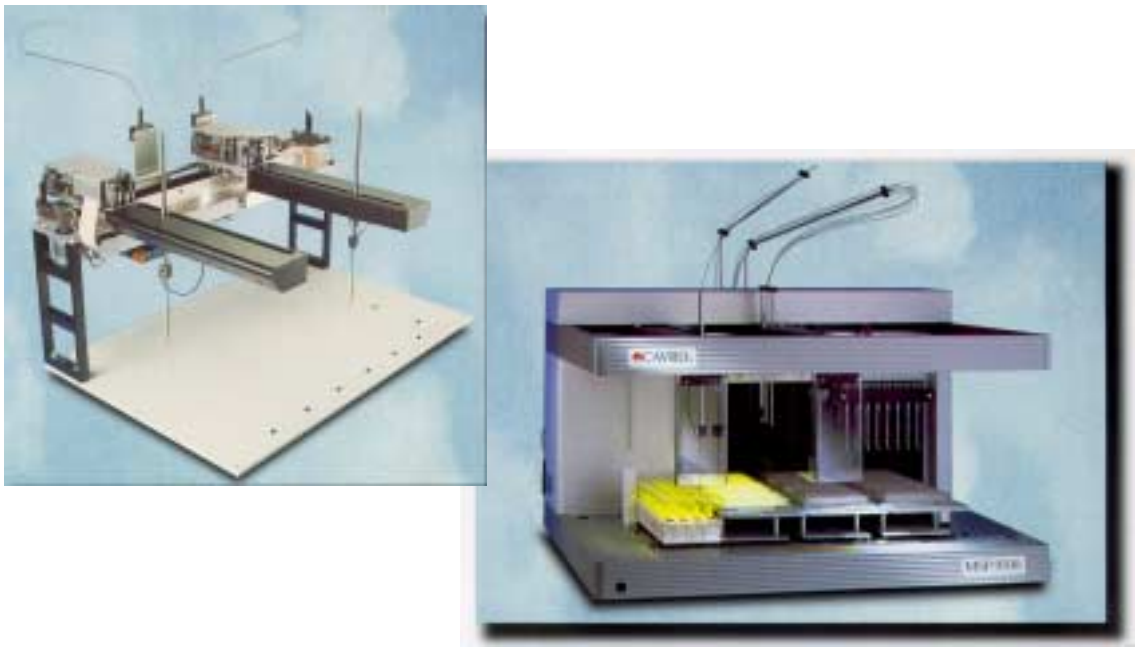
**Object Library Includes:**

- Worktable/Object Editor
- Hardware Definition Module
- Liquid Handling Library
- (RSP) Communication Server
- Liquid Class Editor

**Database Include**

- Liquid Classes
- Worktable/Hardware Devices

Cavro ***EXPRESS*** ***software is compatible with both Cavro MSP and RSP robot families.***

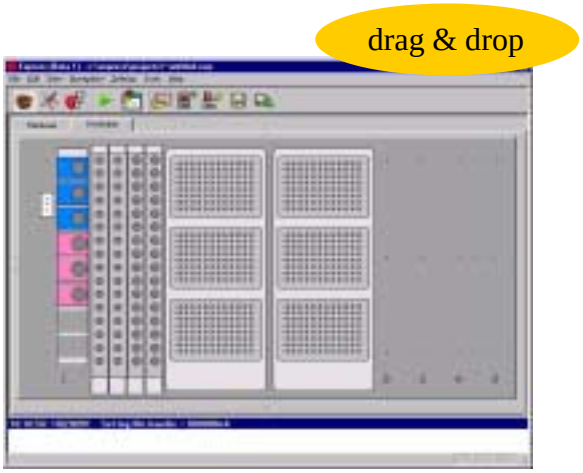


# ROBOTIC APPLICATIONS DEVELOPMENT (RAD) KIT WITH VBA

*VBA Program Development Environment (Open Architecture)*

The Robotic Applications Development Kit provides a sophisticated development language (Microsoft VBA) with all the components of the Robotic Software Development Kit (SDK) above. This provides laboratory application developers a rapid methods development environment utilizing current programming standards with a graphical user interface and a convenient means of setting up all elements of the system as well as selecting and running predefined applications. (Demonstration applications are provided and contract programming of your application is available from Tecan Systems.)


Define your instrument hardware (probes and device modules)

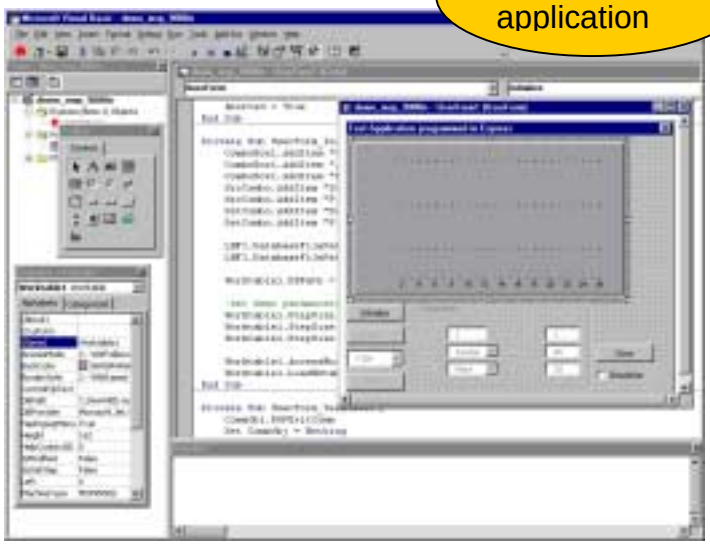



Setup your instrument worktable (carriers/racks)

intelligent liquid handling

Program your pipetting functions (handy visual interface)

Write your application



Write your application in the familiar VBA environment.

## CAVRO EXPRESS SPECIFICATIONS

***Robotic Software Development Kit (SDK)***

CD ROM (with installation program, COM Library and help file) Technical Reference Manual

BASIC FUNCTIONS:

- Object libraries include worktable/object editor (graphical), hardware definition module (graphical), liquid handling library (graphical) and communications server.
- Drag and drop placement of worktable objects onto worktable.
- Databases include liquid class data, worktable/hardware devices.
- Error trapping with programmer control of error recovery.
- Keyboard Operation and Random Move (XYZ motion test) diagnostics.
- Independent, simultaneous movement of arms.
- Choice of 1 to 8 tip liquid handling when operating an eight-channel multi-channel probe.
- Support for hardware-based liquid level sensing with error trapping and recovery options.
- Disposable tip probe support that includes 10, 200 and 1000 uL tips, custom-defined tips and both conductive (liquid level sensing) and non-conductive tips.
- Simulation mode (check for invalid positions, fatal errors and other technical problems. Verifies that commands are valid and provides minimal logic check and display check – assumes all hardware commands are successfully completed.)
- Reference point check (moves probe to reference point for visual validation.)
- Maintenance mode provides maintenance schedule and service interval information for standard Cavro devices.

### *Robotic Applications Development Kit (RAD) with Microsoft VBA*

CD ROM (with installation program, COM library, VBA, application development "shell", applications examples and help file). QuickStart Manual, Technical References Manual, Microsoft VBA Documentation.

BASIC FUNCTIONS:

All the components of the Robotics Software Development Kit (SDK) and:

- ♦ Microsoft VBA with programming tools for Windows applications.
- ♦ Rapid development environment with graphical user interface.
- ♦ High level commands include: System Prime, Probe Cleaning, Aspirate, Dispense, Multi Dispense.
- ♦ Low level command terminal.
- ♦ Comprehensive help.

### *Common to Both of the Above Software Packages*

INTERFACES TO OTHER SYSTEMS:

External compatible with a wide range of active-X controls (which might include other devices such as bar code readers.)

MODULAR DEVICE SUPPORT:

Your robotic hardware may or may not be compatible with these devices – contact factory for further information.

- MiniWash, XL 3000 Syringe Pump (standard and high resolution), XL 300X Multi-Channel Syringe Pump, SV-X Multi-Port Valve, Peristaltic Pump, I/O Board, LO Board, XE 1000 Syringe Pump, Injection Module for Liquid Chromatography.

DEVICE SUPPORT:

- Control of up to 4 "Smart" devices and up to 2 I/O ports per robot arm.
- Backwards-compatibility with all Cavro MSP's and RSP's shipped with firmware version 4.20, 7/96. (Note MSP 9000's shipped prior to EXPRESS Robotic Software release with require a reference point upgrade).

RACK SUPPORT:

- Compatible with most Cavro standard MSP/RSP carriers/racks. Custom carriers/racks may be implemented in the software.

ROBOTIC HARDWARE SUPPORT:

- Compatible with all three arms types (Standard, Compliant. Power) and in any combination. One Arm or 2.

PROBE SUPPORT:

- Standard tip, Cap Piercing Probe, DiTi-C Disposable Tip, 8-Channel Probe, Dual Lumen Tip

WASH STATION SUPPORT:

- 3-position or 8-position

For more information please ask for the Express Manual or DEMO CD Disk.

# 1.0 MAINTENANCE

Maintenance must be performed on a regular basis in order to maintain the RSP's 9000 accuracy and precision. Table 6-1 Maintenance Schedule, outlines the proper intervals to check or replace components of the instrument.

**NOTE: Maintenance routines can be found in Section 2, Routines**

The following definitions are used within the maintenance schedule.

C = Clean this item.

X = Perform Service.

R = Replace component

S = Special case

– = No action necessary

**Table 6-1 Maintenance Schedule**

| Items | Daily | Weekly | 6 Months |
|---|---|---|---|
| Insulation block cable | – | X | R |
| Sampling Tip | C/X | C/X | R |
| Z-Rack | – | C | C |
| Overall System | – | – | C |
| Lubrication | – | – | S |

# 2.0 ROUTINES

## 2.1 Sampling Tip

The sampling tip must be cleaned daily/weekly and replaced when bent or when the Teflon coating is damaged.

**CAUTION: Electrostatic discharge to the sampling tip may damage the ALIDUM.**

1. Turn off power to the RSP 9000

2. Examine the Teflon coating on the sampling tip to ensure that it is not cracked or chipped. If the Teflon coating is damaged, replace the sampling tip. (See “Replacing the Sampling Tip”.)

3. Clean the sampling tip by wiping gently with a lint-free cloth dampened with isopropyl alcohol.

## 2.2 Z-rack

The Z-rack must be cleaned weekly.

**NOTE: Do <u>not</u> use alcohol or solvents when cleaning the Z-rack.**

1. Turn off the power to the RSP 9000.

2. With a lint-free cloth, wipe the Z-rack thoroughly. If necessary, use a toothbrush to remove dust or dirt from the teeth of the Z-rack.

## 2.3 Insulation Block/Cable Assembly

The insulation block/cable assembly must be inspected weekly and replaced every six month. Examine the coax cable where it connects to the insulation block. If there is any residue, liquid, or if the cable is cracked at this connection, replace the insulation block/cable assembly.

**NOTE: Instructions on how to replace the insulation block/cable assembly can be found under “Replacing the Insulation Block/Cable Assembly.”)**

## 2.4 Cleaning

The RSP 9000 must be cleaned every six months. However, if the instrument is operated in a dusty or humid environment, it must be cleaned more often follow the instructions to prevent damage to the instrument.

**CAUTION: Use only isopropyl alcohol and a lint-free cloth to clean the RSP 9000. Other cleaning agents may affect the performance of the instrument. Never clean the X/Y-axis guide rails or Z-rack with alcohol or solvents. Serious damage to the instrument may occur.**

1. Turn off the power of the RSP 9000.

2. Clean the Z-rack.

3. Clean the sampling tip.

4. Wipe the arm(s) using a lint-free cloth dampened with isopropyl alcohol to remove any residual dust.

5. Wipe the inside of the flex cable channel using a lint-free cloth dampened with isopropyl alcohol.

**CAUTION: Do not wipe the X/Y-axis guide rails. The guide rails are lubricated with a grease which does not require removal unless found to be "extremely" dirty.**

6. Wipe the inside of the X-frame with a lint-free cloth dampened with isopropyl alcohol, ensuring that the lubricant on the X-axis guide rails is not removed.

7. Wipe the square shaft pinion located underneath the arm(s) using a lint-free cloth dampened with isopropyl alcohol.

**CAUTION: When cleaning the square shaft pinion, ensure no alcohol enters the Z-bearing or is wiped on the Y-axis guide rails.**

## 2.5 Lubrication

The RSP 9000 does not require lubrication under normal operating conditions. If the lubricant applied at the factory should be wiped away or if the X/Y-axis guide rails become dirty, cleaning and lubrication is necessary. Follow the instruction below when applying lubricants.

1. Turn off the power of the RSP 9000.

2. Move the arm(s) to the far right side of the X-frame.

3. Clean the X-axis guide rails using a lint-free cloth and isopropyl alcohol.

4. While moving the arm(s) to the left side of the X-frame, clean the three roller bearings mounted to the base of the X-slide.

5. Wipe the section of the X-axis guide rail that was covered by the arm(s).

**NOTE: A list of recommended lubricants can be found in Appendix B.**

6. Using a finger tip, apply a thin film of lubricant to both X-axis guide rails.

7. If the Y-axis guide rails are dirty, perform steps 2 through 6 for the X-axis components.

# 3.0 PART REPLACEMENT

## 3.1 Replacing the Sampling Tip

1. Turn off the power of the RSP 9000.

2. Loosen the sampling tip set screw using a screw driver. (See Figure 6-1.)

3. Loosen the insulation block set screw using an allen wrench.

4. Gently pull downward on the insulation block until the system tubing is approx. 2 cm below the Z-rack.

**CAUTION: Electrostatic discharge to the sampling tip may damage the ALIDUM.**

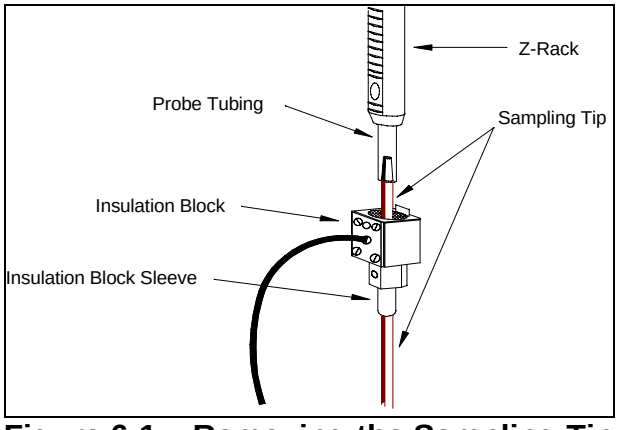



**Figure 6-1 Removing the Sampling Tip**

5. While holding the sampling tip, remove the system tubing.

6. Remove the sample tip from the insulation block.

**CAUTION: Do not slide the Teflon coated end of the sampling tip through the insulation block. The teflon coating may be damaged.**

7. To reinstall the sampling tip, refer to “Setting Up the Instrument,” step 6 through 14.

### 3.2 Replacing the Insulation Block/Cable Assembly

1. Turn off the power to the RSP 9000.

2. Remove the sampling Tip. Refer to “Replacing the Sampling Tip.

3. Remove the plastic cable binder underneath the arm(s) holding the coax cable.

**NOTE: Use a small wire cutter to remove the plastic cable binder. A new cable binder is included with each replacement insulation block assembly.**

4. Push the coax cable through the back end of the arm(s) until the gold connector is visible. See Figure 6-2 to locate the coax cable connector.

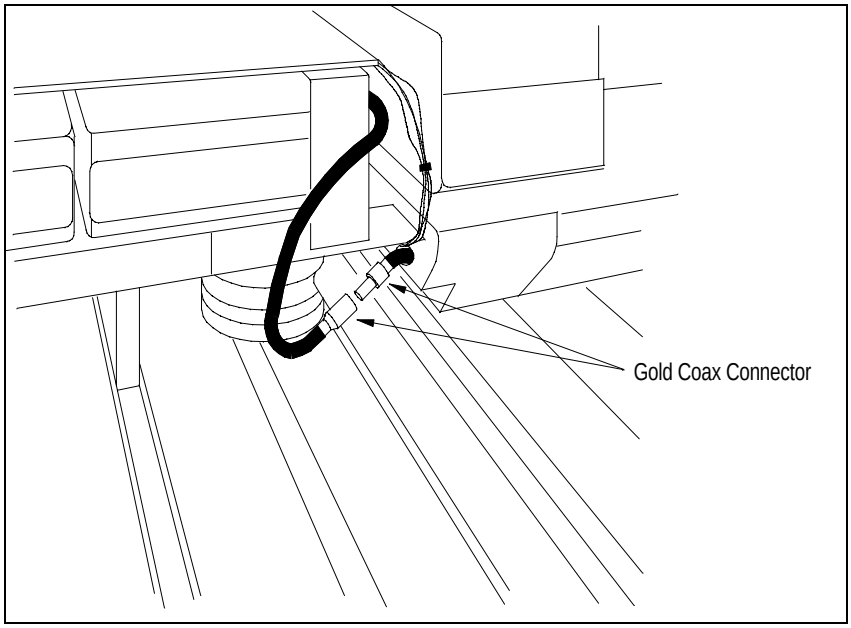



**Figure 6-2 Disconnecting the ALIDUM Coax Cable**

5. Disconnect the coax cable by gently sliding back the releasing cover on the insulation block side of the gold connector. This will release the cable from the ALIDUM cable.

6. To remove the insulation block assembly, carefully pull the coax cable forward through the arm.

7. Install the new insulation block and feed the cable from the front through the hole in the arm mounting back.

8. Attach the gold connector to the matching connector on the coax cable. Be sure that the connector is firmly seated.

9. Reinstall the sampling tip. (Refer to “Replacing the Sampling Tip).

10. Adjust the ALIDUM coax cable until all of the slack is removed from behind the arm(s).

**CAUTION: Ensure the ALIDUM coax cable is not twisted or kinked.**

11. Fasten the coax cable to the arm using the new plastic cable binder provided.

### 3.3 Replacing the Flex Cable

1. Turn off the power to the RSP 9000.

2. Remove the ADRI-9 board cover.

3. Disconnect the flex cable from the ADRI-9 board by holding the connector at its ends and gently pull straight upward.

4. Open the flex cable clamp located underneath the flex cable guide (located just right of the CCU-9000)

5. Remove the four screws which hold the CCU-9000 board in place.

6. Lower the CCU-9000 board approx. 2 cm.

7. Disconnect the flex cable from the CCU-9000 board.

8. Remove old cable noting how it is routed over and under the flex cable supports.

9. Inspect the new flex cable ensuring that the foam protective strip is attached to the ADRI-9 end of the cable (see Figure 6-3).

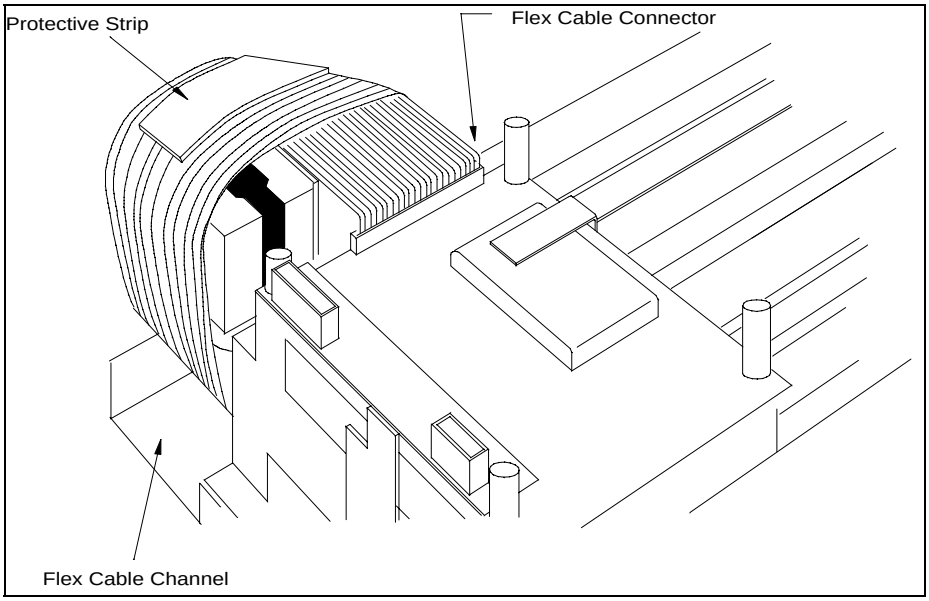



**Figure 6-3. Installing the Flex Cable**

10. Connect the end of the flex cable with the foam protective strip to the ADRI-9 board. (See Figure 6-3.)

11. Run the flex cable through the flex cable channel and flex cable clamp.

12. Carefully push the connector of the flex cable onto its appropriate base on the CCU-9000 board.

13. Reattach the CCU 9000 board to the X-frame using all four allen screws.

14. Close the flex cable clamp.

**CAUTION: Make sure the flex cable is not twisted or kinked and is lying flat in the flex cable channel.**

15. Reattach the ADRI-9 board cover.

### 3.4 Replacing the Y- and Z-axis Optical SLD Sensors

1. Turn off the power to the RSP 9000.

2. Remove the ADRI-9 board cover.

3. Remove the screw holding the Y-/Z-axis slotted optical sensor in place.(See Figure 6-4.)

4. Using wire cutters, cut the plastic cable binders holding the optical sensor wire in place.

5. Loosen the ALIDUM bracket.

6. Disconnect the slotted optical sensor connector from its base on the ADRI-9 board.

7. Run the wires of the new slotted optical sensor under the ALIDUM bracket.

8. Attach the connector of the slotted optical sensor to its base on the ADRI-9 board.

9. Tighten the ALIDUM bracket.

10. Attach the new slotted optical sensor.

11. Replace all three cable ensuring all the cables are bound together. Space the cable binders approximately 1 inch apart.

12. Reattach the ADRI-9 board cover.

**CAUTION: Make sure the screws for the ADRI-9 board cover do not sever the slotted optical sensor cables.**

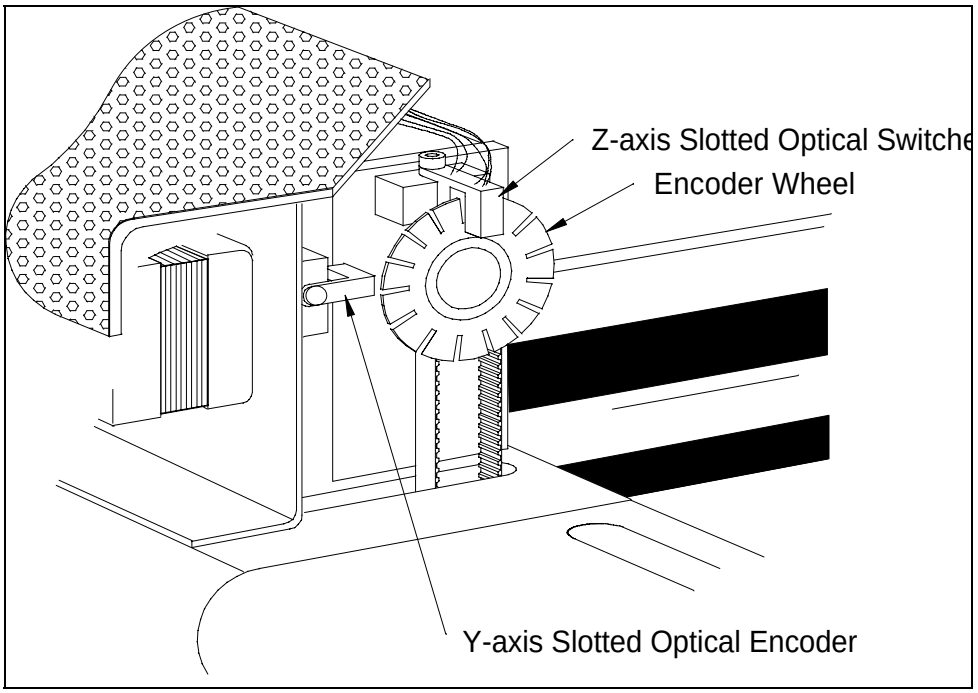



**Figure 6-4. Y-axis and Z-axis Slotted Optical Sensor**

## 3.5 Replacing the X-Axis Optical SLD Sensor

1. Turn off the power to the RSP 9000.

2. Move the arm to the center of the RSP 9000.

3. Remove the allen screw from the optical sensor block. (See Figure 6-5.)

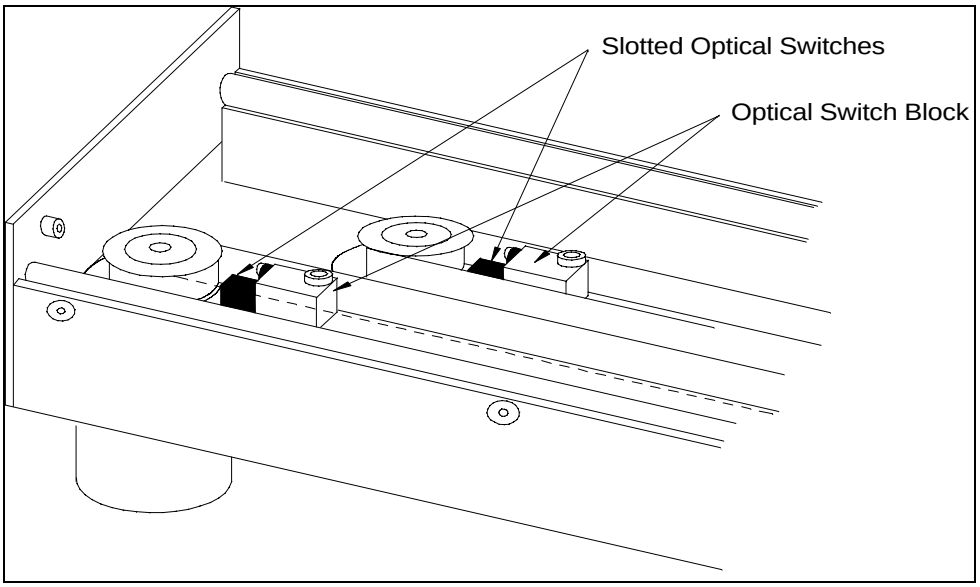



**Figure 6-5 Optical Switch Board**

4. Remove the four screws that hold the CCU-9000 board in place.

5. Cut the plastic cable binders (using small wire cutters) that hold the slotted optical sensor wires in place.

6. Unplug the slotted optical sensor connector from its base on the CCU-9000 board.

7. Pull the optical sensor block and the slotted optical sensor away from the X-frame.

8. Remove the allen screw holding the slotted optical sensor to the optical sensor block.

9. Attach the new slotted optical sensor to the optical sensor block.

10. Feed the wires of the slotted optical sensor through the hole in the top of the X-frame (Located by the X-axis motor).

11. Guide the optical sensor block back into its original position.

12. Attach the optical sensor connector into its appropriate base on the CCU-9000 board.

13. Secure the loose wires of the optical sensor (using the plastic wire binders included) to the other wires underneath the X-frame.

14. Reattach the flex cable to the CCU-9000 board.

**CAUTION: Ensure no wires or cables leading to the CCU-9000 are creased or twisted.**

**CAUTION: Ensure the slotted optical sensor is not touching the encoder wheel.**

15. Attach the CCU-9000 board to the X-frame.

### 3.6. Replacing the ALIDUM

1. Turn off the power to the RSP 9000.

2. Remove the ADRI-9 Board cover.

3. Remove the ALIDUM bracket.

**NOTE: Notice how the optical sensor wires run underneath the ALIDUM bracket.**

4. Carefully unseat the ALIDUM from the ADRI-9 board.

**NOTE: Only lift up on the ALIDUM until the pins are free from the ADRI-9 board.**

5. Follow the coax wire out of the ALIDUM to the gold connector.

6. Disconnect the ALIDUM from the insulation block cable by separating the gold connectors (see Figure 6-2).

7. Discard the old ALIDUM.

8. Install the new ALIDUM by following these directions in reverse order (Steps 6 - 1).

### 3.7 Replacing the ADRI-9 Board

1. Turn off the power to the RSP 9000.

2. Remove the ADRI-9 board cover.

3. Disconnect all cables from the ADRI-9 board.

**NOTE: Document where the cables connect to the ADRI-9 board. A diagram of the ADRI-9 board can be found in Appendix C. Remember to disconnect the ALIDUM cable.**

4. Remove the four hexagon spacers from the ADRI-9 board.

5. Remove the ADRI-9 board.

**NOTE: Do not try to lift the ADRI-9 board straight up. Turn the board a little to the left or right and then lift.**

6. Install the new ADRI-9 board by following these steps in reverse (Steps 6 - 4).

**CAUTION: Ensure the SW1-4 switches on the new ADRI-9 board are set in the same positions as the ADRI-9 board that was removed. The RSP 9000 will not function if these switches are set in the wrong positions.**

### 3.8 Replacing the Arm

1. Turn the power off.

2. Remove the Z-rack, insulation block and sampling tip. (See “Replacing the Sampling Tip”.

3. Remove the ADRI-9 board. (See Replacing the ADRI-9 Board”)

4. Remove the front ADRI-9 bracket by removing the two 2.5 mm screws. (See Figure 6-6 Removing the Arm.)

5. Remove the three screws holding the arm on the X-slide.

6. Install the new arm by following these directions in reverse order steps 5-1.

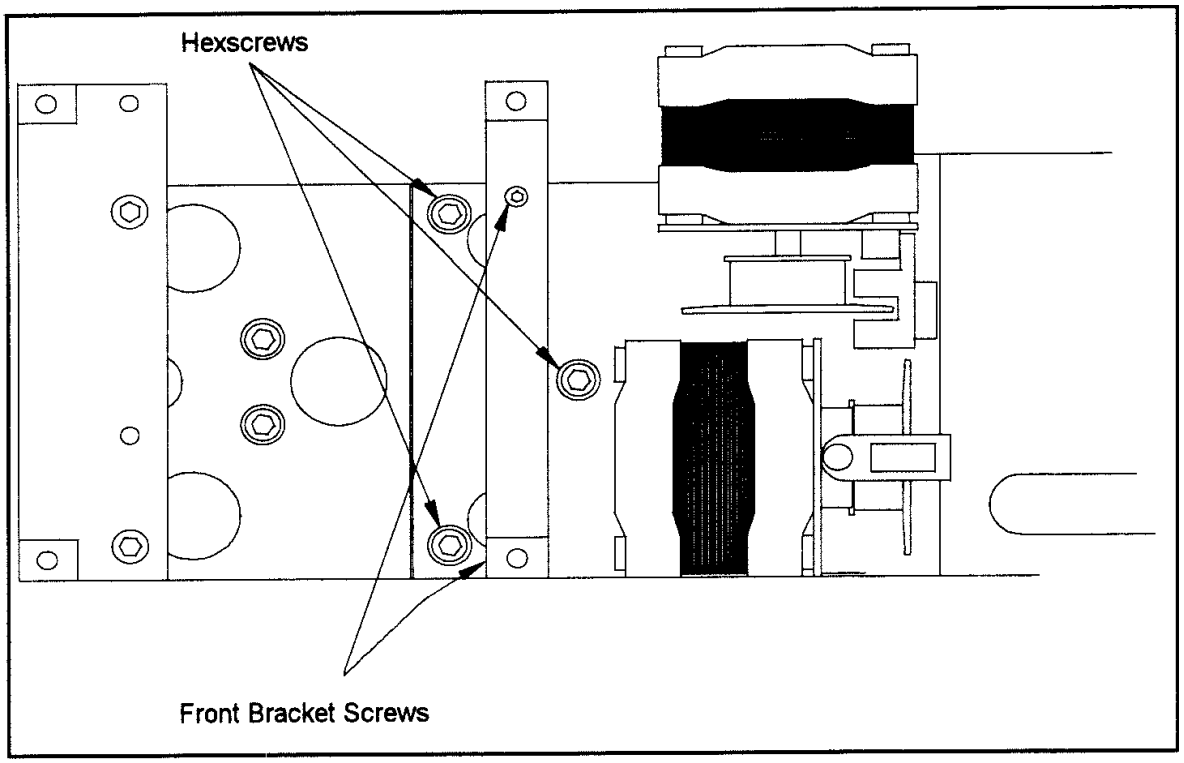



**Figure 6-6. Removing the Arm [top view]**

### 3.9 Replacing the CCU-9000 Board

1. Turn off the power to the RSP 9000.

2. Remove the four screws holding the CCU-9000 board to the X-frame.

3. Unplug all the wires connecting to the CCU-9000 board.

**NOTE: Document where the connectors plug into the CCU-9000 board. (See Appendix C.)**

4. Remove the old CCU-9000 board.

5. Follow these steps in reverse order to install the new CCU-9000 board.

# 4.0 TROUBLESHOOTING

## 4.1 Error #1: Initialization Error

| Possible Cause | Corrective Action |
|---|---|
| **General** | |
| Flex cable defective | Replace flex cable |
| Fuse FU1 or FU2 on CCU-9000 defective | Replace fuses /call customer support |
| Mechanical movement blocked | Check movement mechanism for obstructions |
| CCU-9000 defective | Replace CCU-9000 |
| **X-axis** | |
| Fuse FU3 or FU4 defective on CCU-9000 | Replace fuses /call customer support |
| X-motor defective | Replace X-motor |
| X-motor to CCU-9000 cable lose | Check cable connections |
| X-initialization flag bent | Adjust flag into slotted optical sensor |
| Slotted optical sensor defective on ADRI-9 | Replace ADRI-9 board |
| Selector switch SW-1 on ADRI-9 set wrong | Select right or left arm switch setting |
| Arm locked in place | Remove shipping block and screw |
| **Y-axis** | |
| Y-motor defective | Replace Y-motor |
| Y-initialization flag bent | Adjust flag into slotted optical sensor |
| Slotted optical sensor defective | Replace slotted optical sensor on Y-motor |
| Connection from optical sensor to ADRI-9 | Check cable connection |
| ADRI-9 board defective | Replace ADRI-9 board |
| Y-belt defective | Replace or adjust belt |
| **Z-axis** | |
| Cable connection from ADRI-9 to Z-motor | Check cable connection |
| ALIDUM defective | Replace ALIDUM |
| Initialization flag bent | Replace insulation block/cable assembly |
| ADRI-9 board defective | Replace ADRI-9 board |
| Z-motor defective | Replace Z-motor |
| **Final test procedure:** | Self test, P1, X1, Y1, Z1 commands |

## 4.2 Error #2: Invalid Command

| Possible Cause | Corrective Action |
|---|---|
| Program failure | Refer to software manual |
| Entered unknown command | Refer to command set |
| **Final test procedure:** | None |

## 4.3 Error #3: Invalid Operand

| Possible Cause | Corrective Action |
|---|---|
| Program failure | Refer to software manual |
| Command parameters out of valid range | Refer to command set |
| Wrong setup ranges | Check instrument setup ranges |
| **Final test procedure:** | None |

## 4.4 Error #4: Invalid Command Sequence

| Possible Cause | Corrective Action |
|---|---|
| Program failure | Refer to software manual |
| **Final test procedure:** | None |

## 4.5 Error #5: Device Not Implemented

| Possible Cause | Corrective Action |
|---|---|
| Device not receiving power | Check power supply and cables |
| No communication to device | Check communication |
| Cable broken or plug unseated | Check all cables and connections |
| Electronics board broken | Replace electronics board |
| Address switch not properly set | Set device with correct address |
| Communications protocols do not match | Refer to technical manuals |
| **Final test procedure:** | None |

## 4.6 Error #6: Time-out Error

| Possible Cause | Corrective Action |
|---|---|
| Device not responding | Check communications |
| Time limit exceeded | Check device |
| **Final test procedure:** | None |

## 4.7 Error #7: Device Not Initialized

| Possible Cause | Corrective Action |
|---|---|
| Program failure | Refer to software manual |
| Initialization command not sent before using other devices | Initialize device |
| **Final test procedure:** | None |

## 4.8 Error #8: Command Overflow

| Possible Cause | Corrective Action |
|---|---|
| Program failure | Refer to software manual |
| Command line too long | Refer to command set |
| Too many commands on one line | Refer to command set |
| **Final test procedure:** | None |

## 4.9 Error #9 and #12: No Liquid Detected

| Possible Cause | Corrective Action |
|---|---|
| Liquid volume too small | Increase liquid volume |
| Deionized liquid is used | Test to ensure ionic liquid is being used |
| Liquid is not in close proximity to electrical ground plane of instrument | Decrease gap between liquid and electrical ground plane of instrument |
| Poor cable connections | Check ALIDUM cable connection |
| ALIDUM cable defective | Replace insulation block/cable |
| ALIDUM defective | Replace ALIDUM |
| ALIDUM sensitivity set too low | Adjust ALIDUM sensitivity |
| Flex cable defective | Replace flex cable |
| **Final test procedure:** | None |

## 4.10 Error #10: Entered Move for Z-axis Out of Range

| Possible Cause | Corrective Action |
|---|---|
| Tried to move lower than Z-max | Enter Z-parameter less than Z-max |
| Program failure | Refer to software manual |
| Final test procedure | None |

## 4.11 Error #11 and # 13: Not Enough Liquid Detected

| Possible Cause | Corrective Action |
|---|---|
| Not enough liquid to aspirate | Add liquid |
| Wrong Z-max defined | Adjust Z-parameters in setup firmware |
| Tube diameter incorrectly defined | Define in rack definition |
| **Final test procedure:** | None |

## 4.12 Error #17: Arm Collision Avoided (two arm instrument)

| Possible Cause | Corrective Action |
|---|---|
| Second arm not initialized before moving first arm | Initialize second arm |
| Tried to move X-slide to a position where it would hit the other X-slide | Position X-slide out of the way. |
| **Final test procedure:** | None |

## 4.13 Error #20, #21, #22, and #23: Step Loss Detected

| Possible Cause | Corrective Action |
|---|---|
| Acceleration rate too high | Reset acceleration rate with FX/FY/FZ- commands |
| Mechanical movement blocked | Check for blocked movement mechanism |
| Slotted optical sensor for SLD is defective | Replace slotted optical sensor |
| Encoder wheel for slotted optical sensor loose or defective | Replace or tighten slotted encoder wheel |
| Stepper motor defective | Replace stepper motor |
| **Final test procedure:** | Self test |

### 4.14 Error #24: ALIDUM Pulse Time-out

| Possible Cause | Corrective Action |
|---|---|
| ALIDUM sensitivity too high or low | Adjust ALIDUM sensitivity |
| ALIDUM defective | Replace ALIDUM |
| ALIDUM cable defective | Replace insulation block/cable |
| **Final test procedure:** | Check with ZX/ZZ-command |

### 4.15 Error #25: Tip not Fetched (Used with Diti A or C Options)

| Possible Cause | Corrective Action |
|---|---|
| No tips present | Replace or refill the tip rack |
| Probe not aligned with tips | Check tip positioning in the tip rack |

### 4.16 Error #26: Tip Crash (Used with Diti A or C Options)

| Possible Cause | Corrective Action |
|---|---|
| Probe not aligned with tips | Check positioning in the tip rack |
| Tip rack or support rack not installed properly | Check positioning of the tip rack and tip support rack |
| Incompatible brand of tip used | Check if correct brand of tip is used |

### 4.17 Error #27: Tip not Clean (Used with Diti A or C Options)

| Possible Cause | Corrective Action |
|---|---|
| Used or clogged tip | Remove tip, abort and restart program |
| Diti air detection channel blocked with fluid | Dry air channel with absorbent paper points |

# 5.0 DIAGNOSTIC ROUTINES

## 5.1 Introduction

The diagnostic routines are used to verify proper operation of the instrument after maintenance and service procedures and to investigate suspected malfunction of the RSP 9000. The following four commands are found under the command “Diagnose” in the RSP 9000 main menu.

1. Keyboard Operation – Enables the operator to direct the function of a single RSP 9000 component from the keyboard by the entry of “string commands”. This feature is useful in isolating a component for observation and/or evaluating or in recovering from sampling accidents (“crash”). In the event of a sampling accident, use the <F10> key to access keyboard operations.

2. Random X/Y/Z Test – Checks the operation of the arms in left/right, front/back, and up/down positions.

3. Liquid Detection Checkout – Test the liquid detector for each RSP 9000 arm.

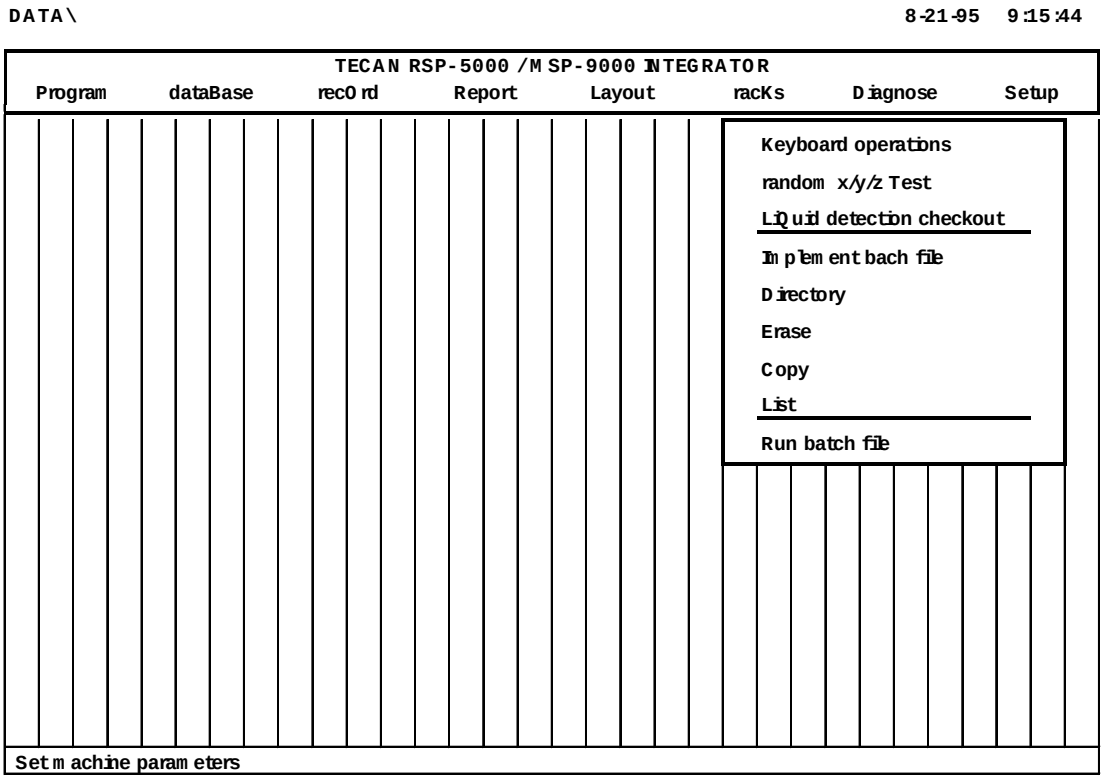
4. Batch Files – Permits the user to group together into a file a sequence of frequently used string commands. The file may then be run any time the operator wants to repeat the same sequence of commands without entering the commands via the keyboard. This feature also permits the operator to test more than one component or component function without having to enter separate command strings.

## 5.2 Keyboard Operation

This command is used to direct the operation of a single RSP 9000 component by entering command strings from the computer keyboard. To run this diagnostics routine, choose “Diagnose” from the main program menu and then select “Keyboard Operation”. A special window will then appear on the screen allowing the entry of string commands from the keyboard. Each string command consists of an arm number (preceded by # character), device number, command, and additional command parameters where required.

| Example: | #1 | 8 | ZX | 10,5,1000 |
|---|---|---|---|---|
| | Arm number | Device number | Command | Parameters |

**Figure 6-7 RSP 5000/ MSP 9000 Integrator Screen Display**



String commands can be sent to six different devices for each arm.

| Device # | Device Description |
|---|---|
| 1 | Syringe #1 (address 0) |
| 2 | Syringe #2 (address 1) |
| 3 | Syringe #3 (address 2) |
| 4 | Syringe #4 (address 3) |
| 6 | Fast wash option |
| 8 | X/Y/Z arm commands |
| 9 | Modulo-1 commands |

A summary that lists all of the available string commands and the syntax rules for command string structure given in Appendix F. Refer to this Chapter for further details concerning command strings.

## 5.3 Random X/Y/Z Test

The Random X/Y/Z Test automatically drives each RSP 9000 arm to random locations on the instrument work table simultaneously recording information about the errors, skipped steps, and the parameters of the current test cycle. To perform the random X/Y/Z test:

1. Check the RSP 9000 setup to verify that the Z-max value will not result in the probe crashing into the work table.

2. Fill the system with liquid so that the probe contains liquid.

3. Select “Diagnose” from the main menu and then select “Random X/Y/Z Test”. The operator will then be prompted to remove everything from the RSP 9000 work table and ask for a “yes” or “no” entry (Y or N) when the operator is ready to begin.

**CAUTION: To prevent collisions remove everything from the work surface before starting the X/Y/Z Test.**

4. After clearing the work surface, enter “Y” to begin the test. The following information will appear on the screen.

   # of Init Errors: The number of errors occurring during the initialization cycle. This number must be zero (0).

   Steps Lost After Last Init: The number of steps lost between two initializations. This number must not exceed three (3).

   Max, Error Steps: The maximum number of steps lost during the entire test. This number must not exceed three (3).

Programmed Ramp, Start and End Frequencies: Factory set values.

# Moves Done: Shows the total number of moves completed by the arm. At least 1,350 moves should be completed in a random test.

# Inits Done: The total number of initializations the arm has performed. A minimum of fifty (50) initializations are recommended for meaningful run.

Once begun, the test continues either the F10 function key is pressed to temporarily interrupt the test or the ESC key is pressed to end the test. The test results may be printed out by responding to the screen prompt.

5. After running the random test, check for the formation of liquid at the probe tip and on the work surface. The presence of drops may indicate a loose connection or air leakage somewhere in the liquid system. Manually tighten all liquid system connections if necessary.

## 5.4 Liquid Detector Checkout

The Liquid Detector Checkout is used to test the function of the liquid detector by repetitive measurements of known quantities of liquid contained in several sample tubes.

1. To begin the Liquid Detector Checkout, select “Diagnose” from the main menu and then select “Liquid Detector Checkout”. The following test parameters can then be selected by the user by referring to prompts on the screen.

Layout: Select from the current Layout Directory (it may be desirable to have a special Layout just for the Liquid Detector Checkout.)

Speed: Tip speed (steps/sec) in the Z-direction while searching to detect the liquid.

Arm: Select arm (1 or 2) to be used for each test position.

Tray: Select tray from current Tray Directory.

Pos: The position of the sample tube(s) within a specified tray.

Liquid: Answer /yes/no) whether there is liquid in the container at the designated tube position. At least 300 uL of ionic fluid is needed in each tube where liquid is going to be detected. At least one tube with no liquid should be run to test for false positives.

ToDo: How many times to repeat liquid detection checks at a specific tube position. A total of at least twenty-five (25) is recommended in each position.

Uncert: The statistical uncertainty (%) associated with the number of repetitive trials entered in the “ToDo” column (automatically calculated). The operator can alternatively enter from the keyboard the acceptable uncertainty level and the required “ToDo” figure will be calculated.

The parameters above can be saved and used again later.

2. After completing a test layout, install the selected trays in the correct positions on the worktable. Fill tubes with known quantities of liquid. (300 uL of 0.05 M Sodium chloride is recommended to test the minimum limit of the liquid detector.) Tap water may also work depending upon its mineral content. Tube volumes may vary. Some tubes be empty to test if the detector is too sensitive. Use round bottom tubes with 12 mm or 13 mm diameters.

3. Place each tube into its designated position in the layout. To begin the test run, press the <HOME>key. During execution of the liquid detector checkout, the following information is displayed on the screen for each position sampled.

StepsDone: How many detections have been completed.

Error: How many detection errors occurred (how many times liquid was not detected in tubes containing at least 300 uL liquid and how many times liquid was detected in tubes containing no liquid.) This is set by entering YES or NO in step 1 above.

**NOTE: For a successful completion of the test, this number must be zero (0).**

Min. The minimum height in steps of the detected liquid level.

Max. The maximum height in steps of the detected liquid level.

**NOTE: The difference between the min. and max. values must not be more than ten (10) steps.**

Dev. The standard deviation (SD) for the variations in the height of the liquid level detected.

Uncert: The statistical uncertainty (%) of the values obtained from the multiple tests at each position. this value may be ignored unless other values are out of range.

4. Press the ESC key to discontinue a test in progress and the END key to leave the Liquid Detector Checkout. Enter <F4> to print the results of the test.

   The Liquid Detector Checkout is successfully completed only if there were no detections errors, the difference between the minimum and maximum values of the detected liquid level for each tube is less than ten (10) steps, and the standard deviation is less than 2.0%.

## 5.5. Batch Files

Batch files are used to send standard sequences of frequently used command strings to the RSP 9000. (For information on command strings, refer to Appendix B of this manual.)

There are five batch file commands under the “Diagnose” command in the main menu.

Run Batch File: Selects and runs an existing batch file.

Implement Batch File: Creates a new or changes an existing batch file. There are subcommands that permit the creation of Do loops and options for suspension of programs to allow user interaction.

Directory: Displays a directory of available batch files.

Erase: Deletes a batch file from memory.

Copy: Copies a batch file to another disk or another subdirectory on the same disk.

# A - Symbols and Abbreviations

| Symbol | Meaning |
|---|---|
| + | Plus or positive |
| - | Minus or negative |
| ° | Degree(s) |
| Ω | Ohm(s) |
| X | Multiply by |
| ÷ | Divide by |
| = | Equal to |
| ± | Plus or minus |
| ≠ | Not equal to |
| ≈ | Approximately equal to |
| < | Less than |
| > | Greater than |
| ∅ | Diameter |
| : | Ratio |
| Ctrl | Control key on keyboard |
| √ | Square root |
| ∑ | Summation of |
| Π | Pi (3.14159) |
| Δ | Delta |
| ∞ | Infinity |
| ( ) | Parenthese (highlighted text) |
| [ ] | Brackets (enclose parameters) |
| ⏚ | Earth Ground |
| { } | Braces (enclose commands) |
| # | Number symbol |

| Symbol | Meaning |
|---|---|
| A | Ampere (Amp) |
| AC | Alternating Current |
| Hz | Hertz |
| cm | Centimeter |
| DC | Direct Current |
| kg | Kilogram |
| m | Meter |
| mm | Millimeter |
| N | Newton |
| V | Volt |
| W | Watt |
| ft | Foot |
| in | Inch |
| lbs | Pounds |
| s | Second |
| °C | Degrees Celsius |
| °F | Degrees Fahrenheit |
| min. | Minimum |
| max. | Maximum |
| sf | Start frequency |
| ef | End frequency |
| acc. | Acceleration |
| 0<br>1 | Power Off<br>Power On |
| step | The smallest addressable increment for X/Y/Z movement (a half step for motors) |
| @ | At |

# B - Instrument Specifications

## 1.0 DIMENSIONS

| Item | RSP 9321 | RSP9621 | RSP 9351 | RSP9352 | RSP 9651 | RSP 9652 |
|---|---|---|---|---|---|---|
| No. of arms | 1 | 1 | 1 | 2 | 1 | 2 |
| Overall length | 520 mm (20.47 in) | | 780 mm (30.70 in) | | | |
| Overall depth | 407 mm (16.02 in) | 557 mm (21.92 in | 407 mm (16.02 in) | | 557 mm (21.92 in) | |
| Overall height (excl. Z-Rack) | 183 mm (7.20 in) | | | | | |
| Instrument weight | 8.5 kg (18.7 lbs) | 9.0 kg (21.0 lbs) | 10.5 kg (23.1 lbs) | 13.0 kg (28.6 lbs) | 11.0 kg (24.3 lbs) | 14.0 kg (30.0 lbs) |

**NOTE: Instrument weights may vary due to the installation of different options**

## 2.0 X-AXIS DATA

| Item | RSP 9321 | RSP9621 | RSP 9351 | RSP9352 | RSP 9651 | RSP 9652 |
|---|---|---|---|---|---|---|
| X-travel range | 383 mm (15.07 in) | | 643 mm (25.31 in) | 566 mm (22.28 in) | 643 mm (25.31 in) | 566 mm (22.28 in) |
| X-travel range in steps* | 1714 steps | | 2877 steps | 2533 steps | 2877 steps | 2533 steps |
| Initialization Offset | 5-1000 steps Adjusted for absolute position | | | | | |
| Tip to Tip minimum | N/A | N/A | N/A | 30 mm (1.18 in) | N/A | N/A |
| Resolution per half step | 0.2234 mm (0.008 in) | | | | | |
| Accuracy over travel | ± 0.20 mm (± 0.007 in) | | | | | |
| Reproducibility | ± 0.05 mm (± 0.019) | | | | | |
| Start Speed | 50 steps /s = 11 mm/s (0.43 in/s) | | | | | |
| End Speed | 4000 steps/s = 894 mm/s (35.196 in/s) | | | | | |
| Acceleration | 10000 steps/s² = 2235 mm/s² (87.9 in/s²) | | | | | |

* If initialization offset values are as shown. The travel range in each axis will change depending upon the initialization offset values. If the initialization offset is increased, the travel range will be reduced.

## 3.0 Y-AXIS DATA

| Item | RSP 9321 | RSP9621 | RSP 9351 | RSP9352 | RSP 9651 | RSP 9652 |
|---|---|---|---|---|---|---|
| Y-travel range | 150 mm (5.90 in) | 300 mm (11.81 in) | 150 mm (5.90 in) | | 300 mm (11.81 in) | |
| Y-travel range in steps* | 1054 steps | 2109 steps | 1054 steps | | 2109 steps | |
| Initialization Offset | 5-1000 steps Adjusted for absolute position | | | | | |
| Resolution per half step | 0.1422 mm (0.005 in) | | | | | |
| Accuracy over travel | ± 0.15 mm (± 0.006 in) | | | | | |
| Reproducibility | ± 0.05 mm (± 0.019) | | | | | |
| Start Speed | 200 steps /s = 28 mm/s (1.1 in/s) | | | | | |
| End Speed | 4000 steps/s = 569 mm/s (22.4 in/s) | | | | | |
| Acceleration | 20000 steps/s² = 2845 mm/s² (112 in/s²) | | | | | |

* If initialization offset values are as shown. The travel range in each axis will change depending upon the initialization offset values. If the initialization offset is increased, the travel range will be reduced.

## 4.0 Z-AXIS DATA

| Item | RSP 9321 | RSP9621 | RSP 9351 | RSP9352 | RSP 9651 | RSP 9652 |
|---|---|---|---|---|---|---|
| Y-travel range | 167 mm (6.8 in) | | | | | |
| Y-travel range in steps* | 1700 steps standard<br>3400 steps with 2:1 gear option | | | | | |
| Initialization Offset | 20 steps standard<br>40 steps with 2:1 gear option<br>60 steps for DITI option | | | | | |
| Resolution per half step | 0.0982 mm (0.004 in) | | | | | |
| Accuracy over travel | ± 0.15 mm (± 0.006 in) | | | | | |
| Reproducibility | ± 0.05 mm (± 0.019) | | | | | |
| Start Speed | 400 steps /s = 39 mm/s (1.54 in/s) | | | | | |
| End Speed | 4000 steps/s = 393 mm/s (15.5 in/s) | | | | | |
| Acceleration | 30000 steps/s² = 2945 mm/s² (115.9 in/s²) | | | | | |

* If initialization offset values are as shown. The travel range in each axis will change depending upon the initialization offset values. If the initialization offset is increased, the travel range will be reduced.

## 5.0 CCU-9000 BOARD MATING CONNECTORS

| Connectors | Quantity | Type | Manufacturer (partnumber) |
|---|---|---|---|
| Power Supply | 2 | 2-pin | Weidmueller /128176 |
| RS-232 to host | 1 | 10-pin crimp | Fujitsu/FCN 723B 01012 |
| RS-485 to diluter | 2 | Dubox 1 x 4 | Du Pont/65240-004 |
| RS-485 to Modulo-1 | 2 | Dubox 1 x 4 | Du Pont/65240-004 |
| RS-232 to external device | 1 | 10-pin crimp | Fujitsu/FCN 723B 01012 |

**NOTE: US distributor for Weidmueller : Weidmueller Terminations INC., 821 Southlake Boulevard, Richmond, VA 23236, Phone (804) 794-2877**

## 6.0 FUSES

**WARNING: For continued protection against risk of fire, only replace fuses which meet the following specified types and current ratings.**

The following fuses must be used to assure safe operation of the RSP 9000.

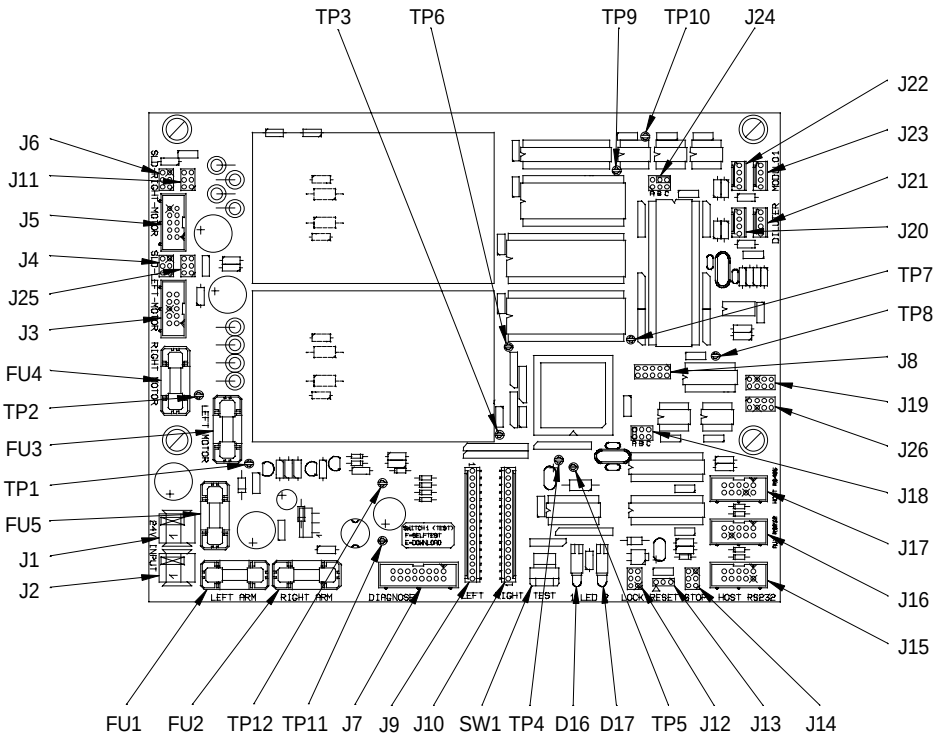
| Name | Location | Type |
|---|---|---|
| Left Arm Fuse | CCU-9000 (FU1) | F 2.0A/250 V |
| Right Arm Fuse | CCU-9000 (FU2) | F 2.0A/250 V |
| Left Motor Fuse | CCU-9000 (FU3) | F 1.6A/250 V |
| Right Motor Fuse | CCU-9000 (FU4) | F 1.6A/250 V |
| Line Signal Fuse | CCU-9000 (FU5) | T 3.15A/250 V |

## 7.0 OTHER

The following general specifications apply to all RSP 9000 models.

| Item | Specification |
|---|---|
| Storage Temperature Range | 0-50°C (32-122°F) |
| Operating Temperature Range | 15-40°C (59-104°F)<br>Humidity 30 to 85% relative non condensing |
| Life Expectancy | X-axis > 5 million moves<br>Y-axis > 5 million moves<br>Z-axis > 10 million moves |
| Recommend Power Supplies | KEPCO RAX, DELTA POWER SOURCE<br>See Appendix E for Models and Dealers |
| Lubrication | DIN 51825 KP2K<br>Kluber: Paraliq GA351<br>Shell: Retinax A<br>Mobil: Savavex Grease L2 |
| Safety | The RSP 9000 series instruments are designed to meet the safety requirements according to:<br>IEC 601-1 Class III equipment (SEL V)<br>IEC 1010-1 Class III equipment (SELV)<br>UL 1262, Limited Circuit, Type I |
| Packaging | Stacked: five units max.<br>Box can withstand falls from 0.6 m (1.9 ft) |

# C - Additional Figures

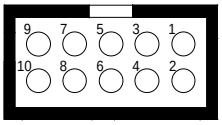



J1: 24 VDC Input (parallel to J2)
J2: 24 VDC Output (parallel to J1)
J3: Left X-motor Connector
J4: Left X-motor Step Loss Detection Connector
J5: Right X-motor Connector
J6: Right X-motor Step Loss Detection Connector
J7: Diagnostic Device Connector
J8: Emulator Connector
J9: Left Flex Cable Connector
J10: Right Flex Cable Connector
J11: X Initialization Sensor Connector Right
J12: Cover Lock Connector (not implemented)
J13: Reset Switch Connector (not implemented)
J14: Stop Switch Connector (not implemented)
J15: RS 232 C External Computer Connector
J16: RS 232 C Auxilary Device Connector
J17: RS 485 / 422 External Computer Connector
J18: Selector Jumper for RS 232 C or RS 485 / RS 422 to host
J19: I/O Connector Left Arm
J20: RS 485 Diluter Bus (terminator)
J21: RS 485 Diluter Bus Connector
J22: RS 485 Modulo-1 Bus (terminator)
J23: RS 485 Modulo-1 Bus Connector
J24: Configuration Selector (not implemented)
J25: X Initialization Sensor Connector Left
J26: I/O Connector Right Arm
FU1: Left Arm Fuse
FU2: Right Arm Fuse
FU3: Left X-motor Fuse
FU4: Right X-motor Fuse
FU5: 5 VDC Fuse
D16: LED - 1
D17: LED - 2
SW1: Address Switch (16 position)

TP1: Test Point (VPP 24VDC)
TP2: Test Point (Power GND)
TP3: Test Point (VCC 5VDC)
TP4: Test Point (GND)
TP5: Test Point (CCU Reset)
TP6: Test Point (VPG 1.5 VDC nominal, 12.5 VDC for firmware download)
TP7: Test Point (GND)
TP8: Test Point (VCC 5VDC)
TP9: Test Point (GND)
TP10: Test Point (VCC 5VDC)
TP11: Test Point (VCC 5VDC)
TP12: Test Point (GND)

| BY | DATE | CAVRO |
|---|---|---|
| DR C. Bui | | |
| CK | | TITLE Figure D.1 CCU Board Layout |
| ENG | | |
| APPD | | SIZE / CODE / DWG NO / REV |
| | | SHEET 1 OF 1 |

J15 / J16 / J17




J15
RS 232 C to Host

1: RTS
2: Indexing Key
3: CTS
4: GND
5: TxD
6: GND
7: RxD
8: GND
9: Not Connected
10: GND

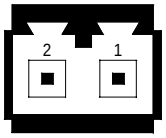
J16
Auxillary RS 232 C*

1: RTS
2: +5VDC
3: CTS
4: +5VDC
5: TxD
6: Not Connected
7: RxD
8: Indexing Key
9: Not Connected
10: GND

J17
RS 485 / 422 to Host

1: B1 Sender
2: GND
3: B2 Receiver
4: Indexing Key
5: A1 Sender
6: GND
7: A2 Receiver
8: Not Connected
9: Not Connected
10: Not Connected

J1 / J2




J1
1. +24 VDC Output
2. GND

J2
1. +24 VDC Input
2. GND

J20 / J21 / J22 / J23

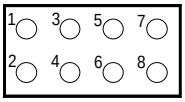

J20 / J21
Diluter / Option Bus

1. Bus Terminator
2. RS 485 A Line
3. RS 485 B Line
4. Bus Terminator

J22 / J23
Modulo-1 Bus

1. Bus Terminator
2. RS 485 A Line
3. RS 485 B Line
4. Bus Terminator

J19 / J26




J19 I/O Lines Left

1. + 24 VDC
2. + 24 VDC
3. Indexing Key
4. + 5 VDC
5. Input Line 4
6. Input/Output Line 3
7. GND
8. GND

J26 I/O Lines Right

1. + 24 VDC
2. + 24 VDC
3. + 5 VDC
4. Indexing Key
5. Input Line 4
6. Input/Output Line 3
7. GND
8. GND

* = To be implemented (intended for Bar Code Reader)

All views are shown looking into the connectors.

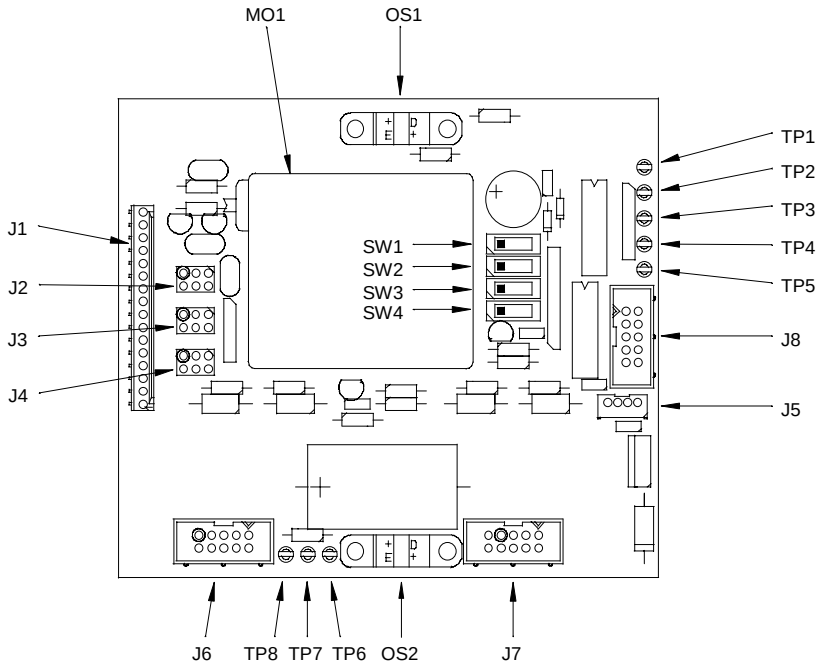
| BY | DATE |
|---|---|
| DR C. Bui | 11/95 |
| CK | |
| ENG | |
| APPD | |

CAVRO

TITLE
Figure D.2
Connector Pinouts

| SIZE | CODE | DWG NO | REV |
|---|---|---|---|
| | | | |

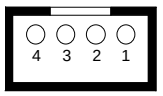
SHEET 1 OF 1




## CodeDescriptio

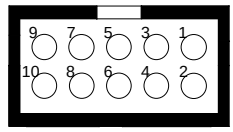
J1: Flex Cable
J2: Optical Switch Connector (Y-
J3: Optical Switch Connector (Step Loss
J4: Optical Switch Connector (Step Loss
J5: DITI Connector (Power /
J6: Y-axis Motor
J7: Z-axis Motor
J8: Switchable Input / Output
MO1 ALIDUM (Adaptive Liquid Level
OS1 Optical Switch X-axis (Left Arm X-axis
OS2 Optical Switch X-axis (Right Arm X-axis
SW1- Selector Switches (see
TP1 Test Point
TP2 Test Point (VCC
TP3 Test Point (X-axis Initialization
TP4 Test Point (Y-axis Initialization
TP5 Test Point (Liquid Detection
TP6 Test Point (Power
TP7 Test Point (VPP
TP8 Test Point

## J5




1: +12VD
2: Liquid Detection Signal (Air
3: Air Detect
4: Power

## J8




1: Input / Output
2: SLD Z-
3: Input / Output
4: VCC
5: GN
6: Liquid
7: Input / Output
8: Input
9: Power
10: VPP

## Selector

| | |
|---|---|
| SW1 | Arm<br>Left  Right |
| SW2 | DITI<br>Enabl  Disabl |
| SW3 | ALIDUM<br>Switching by<br>Enabl  Disabl |
| SW4 | Value for<br>Sensitivi<br>High  Very |

Standard settings for a left arm

| BY | DAT |
|---|---|
| D<br>C. | 7 - 18 - |
| CK | |
| EN | |
| APP | |

CAVRO

TITL
Figure
ADRI-9 Board

| SIZ | COD | DWG | RE |
|---|---|---|---|
| A | | | A |

SHEE 1 OF 1

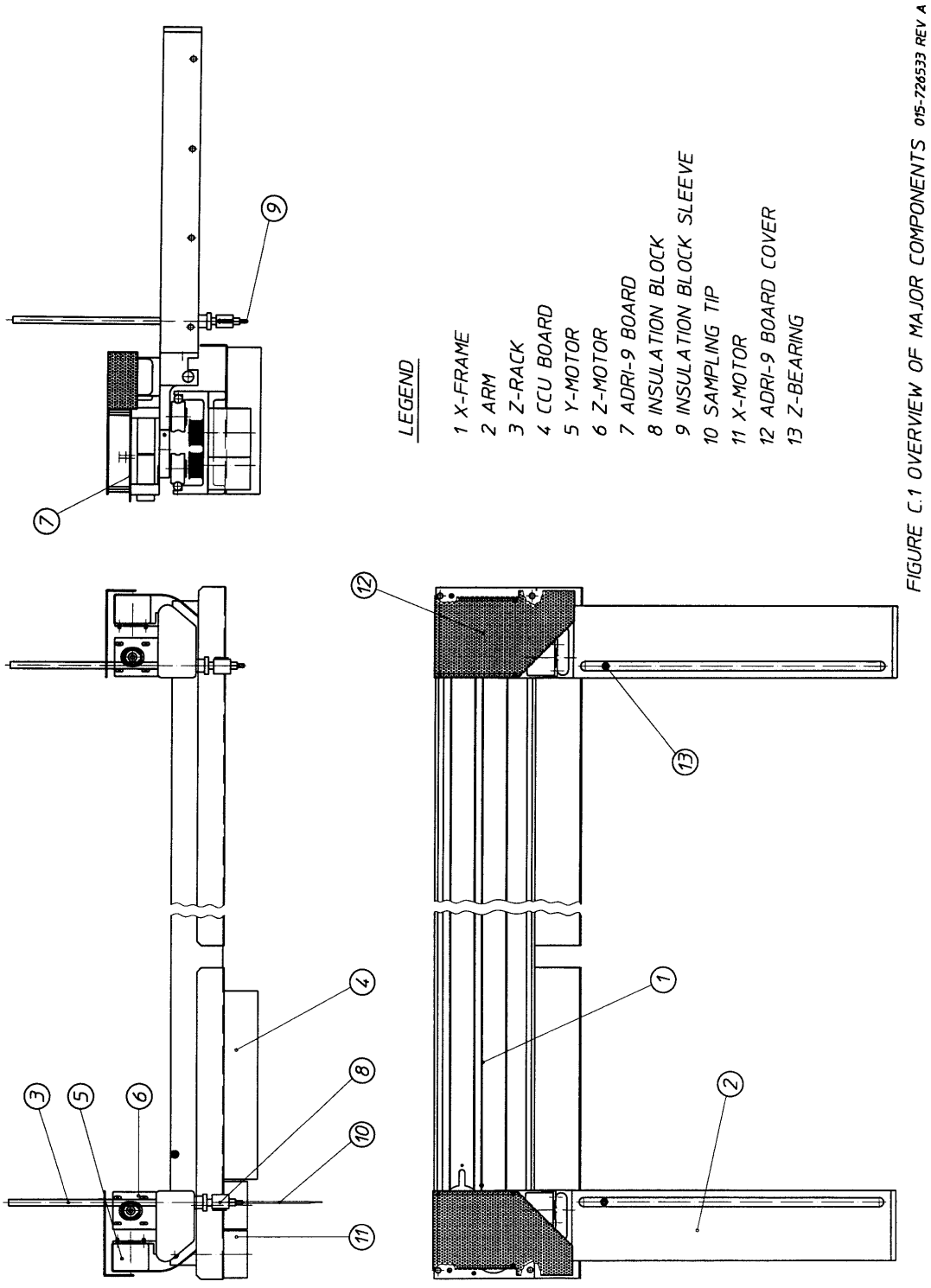
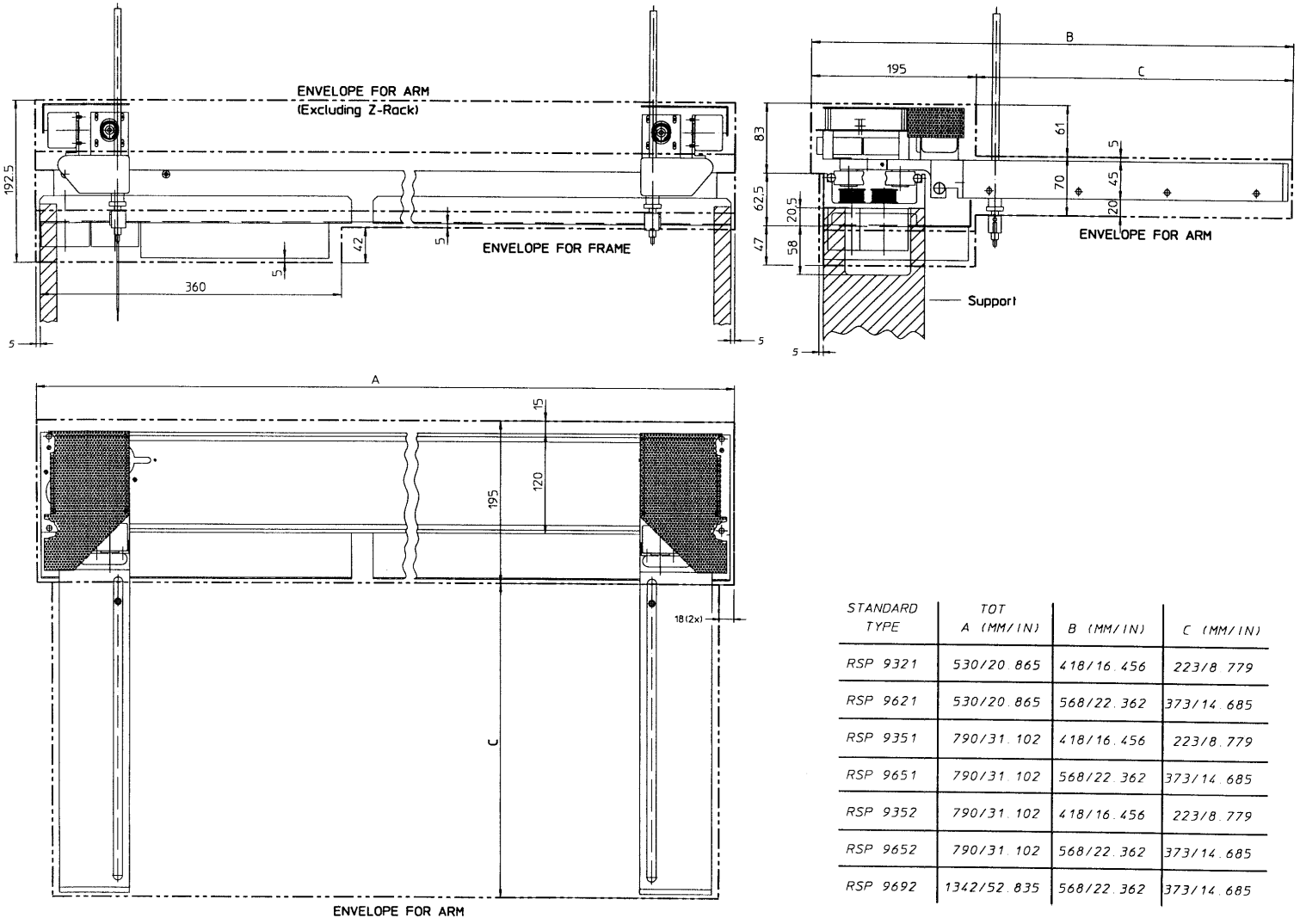
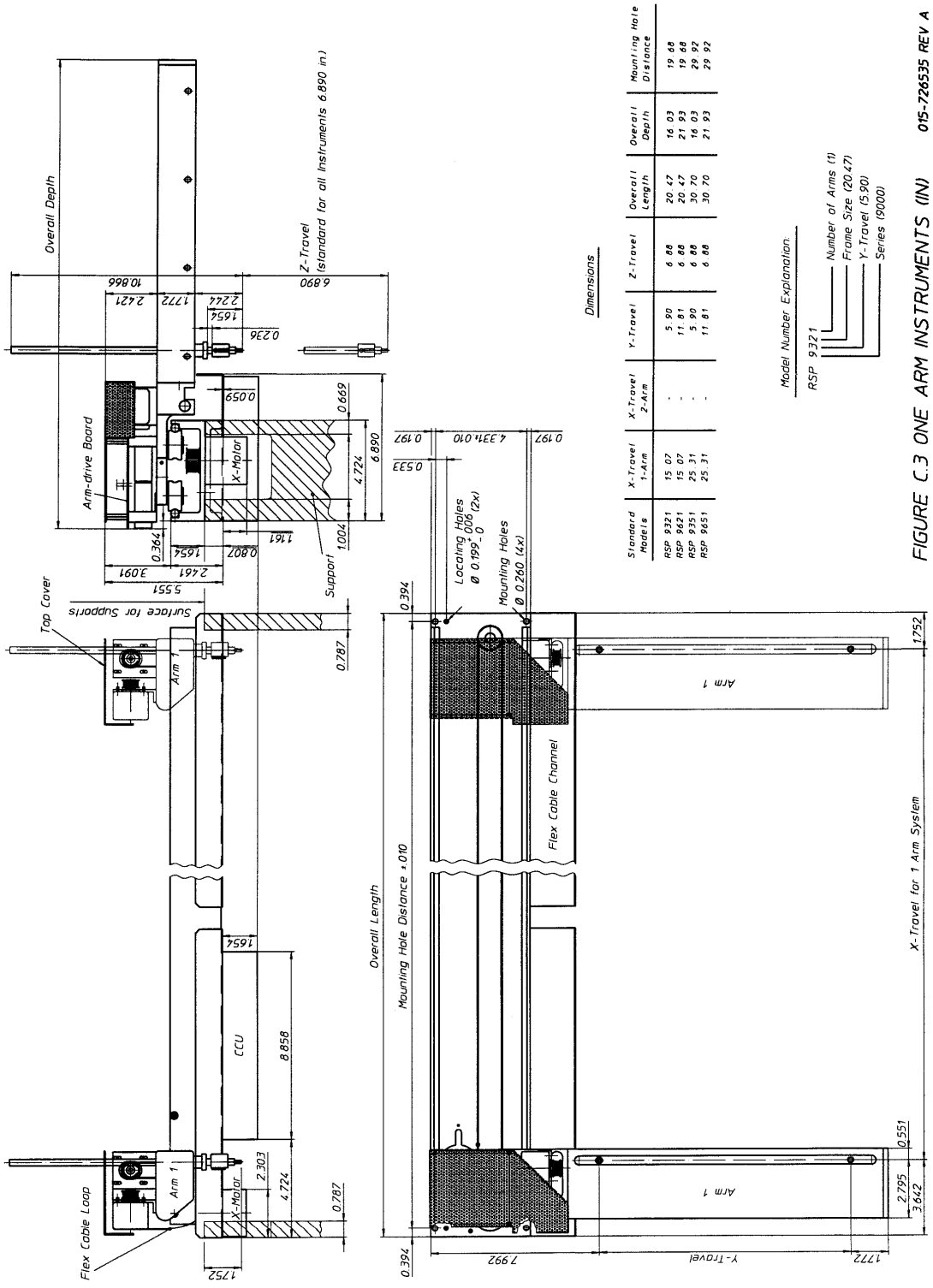



FIGURE C.1 OVERVIEW OF MAJOR COMPONENTS 015-726533 REV A



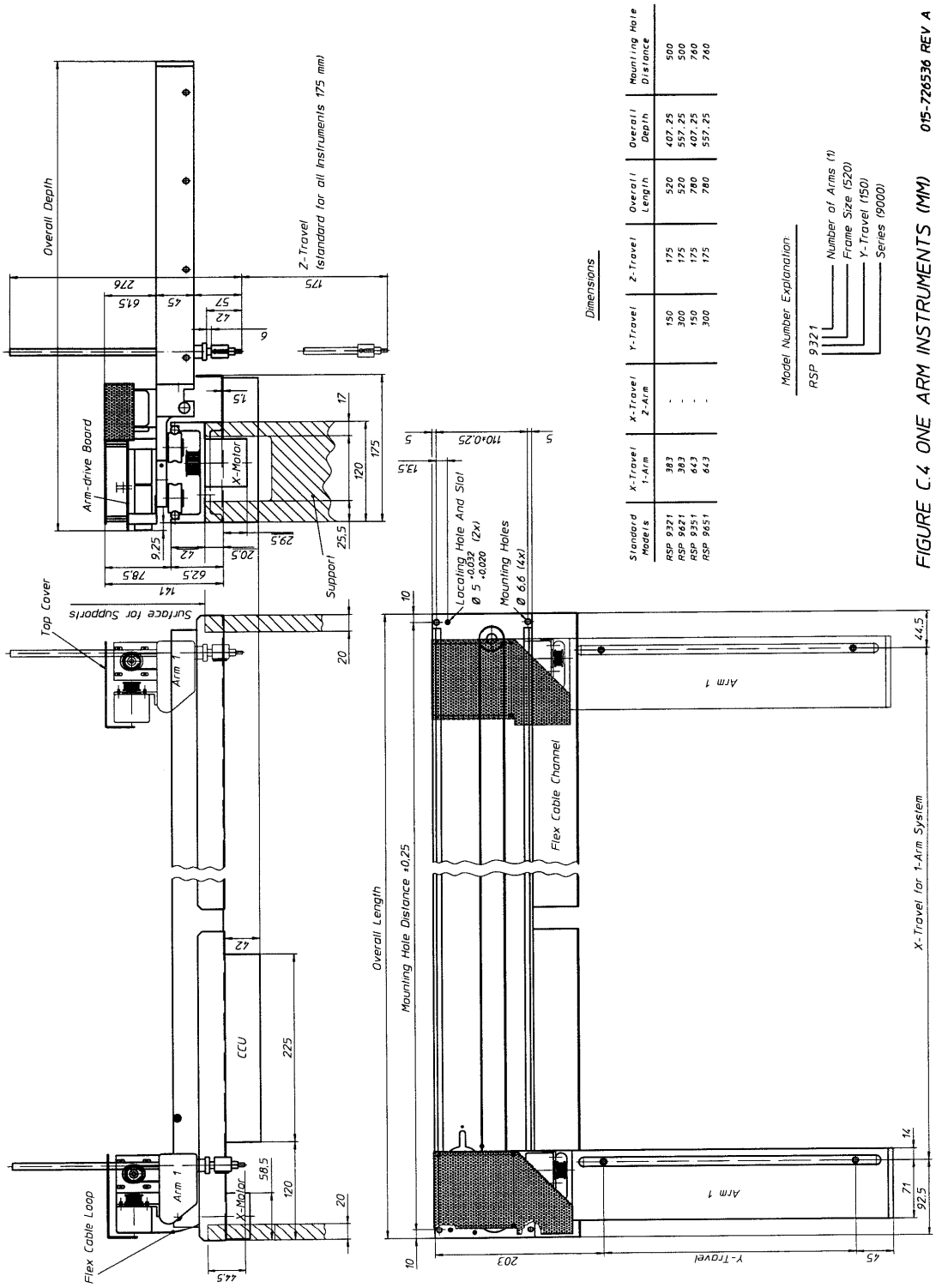

| STANDARD TYPE | TOT A (MM/IN) | B (MM/IN) | C (MM/IN) |
|---|---|---|---|
| RSP 9321 | 530/20.865 | 418/16.456 | 223/8.779 |
| RSP 9621 | 530/20.865 | 568/22.362 | 373/14.685 |
| RSP 9351 | 790/31.102 | 418/16.456 | 223/8.779 |
| RSP 9651 | 790/31.102 | 568/22.362 | 373/14.685 |
| RSP 9352 | 790/31.102 | 418/16.456 | 223/8.779 |
| RSP 9652 | 790/31.102 | 568/22.362 | 373/14.685 |
| RSP 9692 | 1342/52.835 | 568/22.362 | 373/14.685 |

FIG. C.2 ENVELOPE CLEARANCE 015-726534 REV A



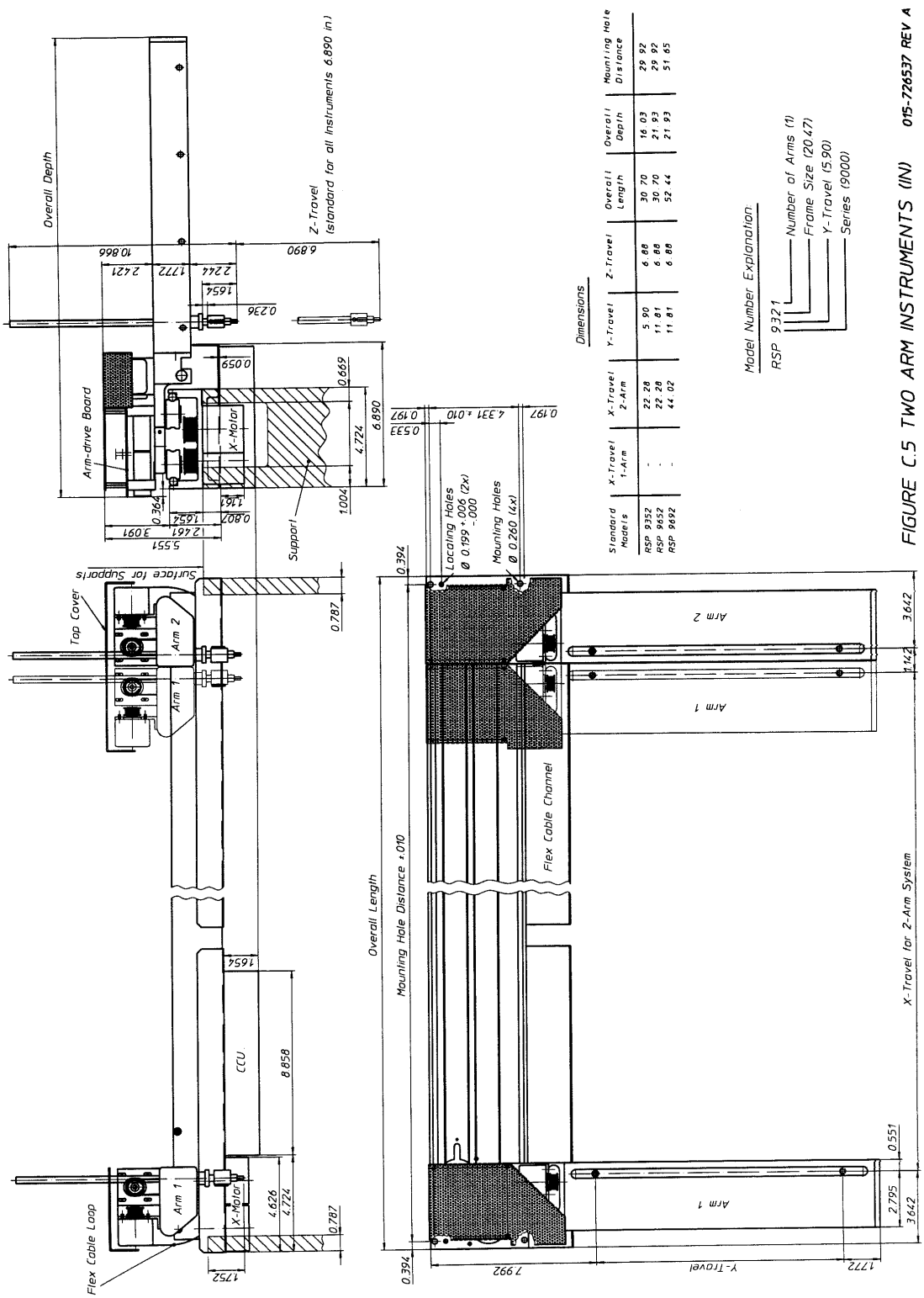

| Standard Models | X-Travel 1-Arm | X-Travel 2-Arm | Y-Travel | Z-Travel | Overall Length | Overall Depth | Mounting Hole Distance |
|---|---|---|---|---|---|---|---|
| RSP 9321 | 15.07 | - | 5.90 | 6.88 | 20.47 | 16.03 | 19.68 |
| RSP 9621 | 15.07 | - | 11.81 | 6.88 | 20.47 | 21.93 | 19.68 |
| RSP 9351 | 25.31 | - | 5.90 | 6.88 | 30.70 | 16.03 | 29.92 |
| RSP 9651 | 25.31 | - | 11.81 | 6.88 | 30.70 | 21.93 | 29.92 |

FIGURE C.3 ONE ARM INSTRUMENTS (IN) 015-726535 REV A




| Standard Models | X-Travel 1-Arm | X-Travel 2-Arm | Y-Travel | Z-Travel | Overall Length | Overall Depth | Mounting Hole Distance |
|---|---|---|---|---|---|---|---|
| RSP 9321 | 303 | - | 150 | 175 | 520 | 407.25 | 500 |
| RSP 9621 | 303 | - | 300 | 175 | 520 | 557.25 | 500 |
| RSP 9351 | 643 | - | 150 | 175 | 780 | 407.25 | 760 |
| RSP 9651 | 643 | - | 300 | 175 | 780 | 557.25 | 760 |

FIGURE C.4 ONE ARM INSTRUMENTS (MM) 015-726536 REV A




| Standard Models | X-Travel 1-Arm | X-Travel 2-Arm | Y-Travel | Z-Travel | Overall Length | Overall Depth | Mounting Hole Distance |
|---|---|---|---|---|---|---|---|
| RSP 9352 | - | 22.20 | 5.90 | 6.88 | 30.70 | 16.03 | 29.92 |
| RSP 9452 | - | 22.20 | 11.81 | 6.88 | 30.70 | 21.93 | 29.92 |
| RSP 9692 | - | 44.02 | 11.81 | 6.88 | 52.44 | 21.93 | 51.65 |

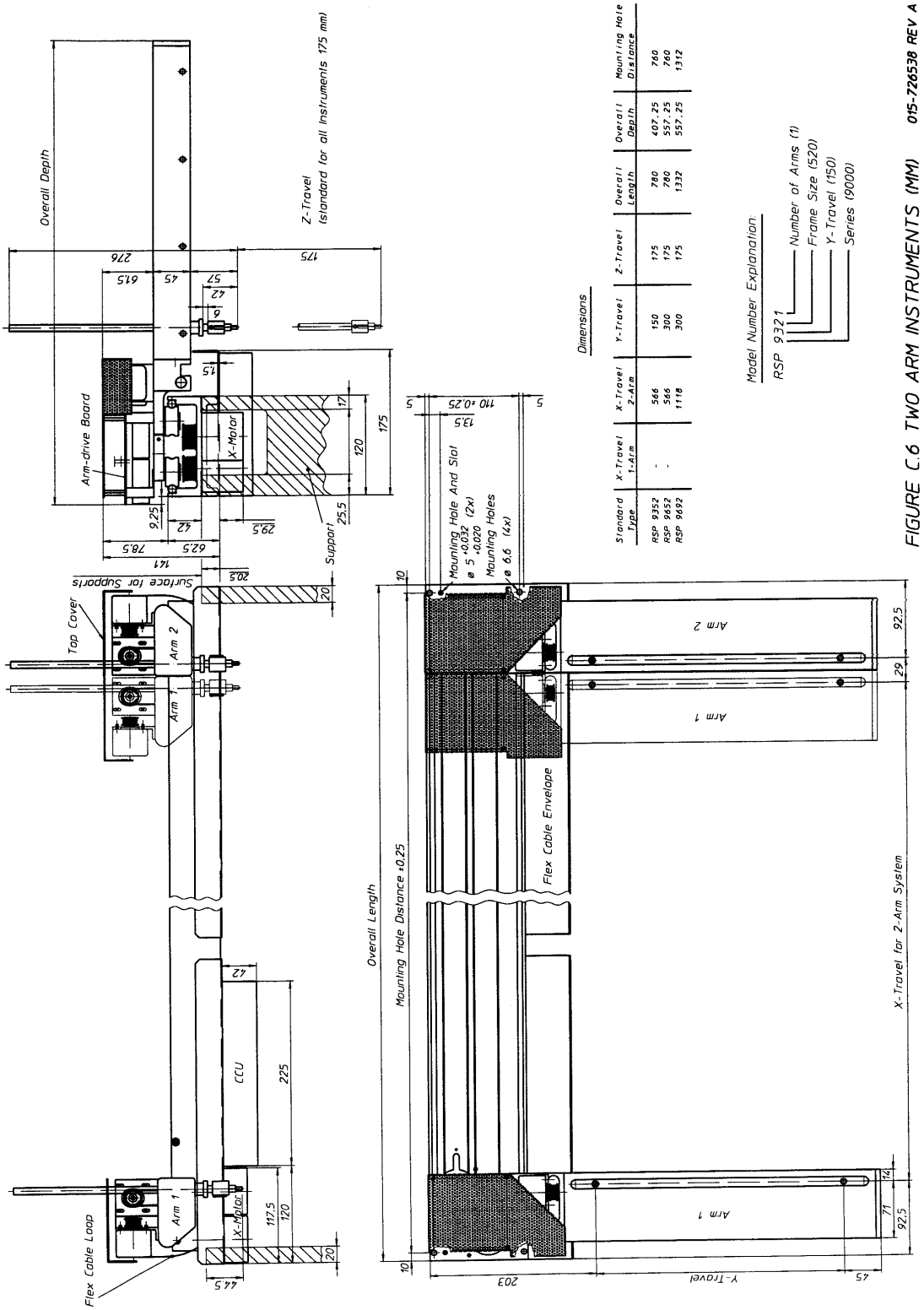



FIGURE C.6 TWO ARM INSTRUMENTS (MM) 015-726538 REV A

# D - Recommended Power Supplies

**KEPCO, Inc.**

| | | |
|---|---|---|
| RSP 9000 Only | Model RAX 24-4.2K | (24VDC/4.2A) |
| RSP 9000 with Options | Model RAX 24-7.2K | (24VDC/7.2A) |

| | |
|---|---|
| **Headquarters**<br>131-38 Sanford Avenue<br>Flushing NY, 11358<br>USA<br>Phone: 718-767-102 | **Eastern Region USA**<br>5 Kane Industrial Drive<br>Hudson, MA 01749<br>USA<br>Phone: 508-562-6515, Fax: 508-562-6548 |
| **Western Region USA**<br>4713 First Street, Suite 295<br>Pleasanton, CA 94566<br>USA<br>Phone: 415-484-2922, Fax: 415-484-3723 | **Europe**<br>Zone N, Salamander Quay West<br>Park Lane, Harefield<br>Middlesex UB9 6NZ England<br>Phone National: 0895-825-046<br>Phone International: +44 895-825-046 |

**Delta Power Source**

| | | |
|---|---|---|
| RSP 9000 Only | Model WRD 24SX | (24VDC/4.5A) |
| RSP 9000 with Options | Model WRE 24SX | (24VDC/7A) |

| | |
|---|---|
| France<br>AK Electronique<br>54, AV Emile Zola<br>F-75015 Paris<br>Phone: 1-4575-53-53, Fax: 1-4577-99-98 | Germany<br>Electrosil GmbH<br>Warnstedstrasse 59<br>2000 Hamburg 54<br>Phone: +49 40-54-45-46, Fax: 40-54-43-65 |
| Italy<br>Cosmos Electronic IT.SRL<br>Via Max Sparer 5<br>39507 Appiano-Bolzano<br>Phone: 0471-51-645, Fax: 0471-51-216 | Switzerland<br>Alcatrac AG<br>Muhlenhaldenstrasse 6<br>CH-8953 Dietikon<br>Phone: 01/741 46 44, Fax: 01/741 19 60 |

**NOTE: Tecan Systems assumes no responsibility for recommended power supplies meeting local or application specific safety requirements.**

# E - RSP 9000 Series Spare Parts List

**Table E-1.**

| Part Number | Description |
|---|---|
| 726382 | Arm Left Complete Yt = 150 mm |
| 726381 | Arm Right Complete Yt = 150 mm |
| 726380 | Arm Left Complete Yt = 300 mm |
| 726379 | Arm Right Complete Yt = 300 mm |
| 722422 | Z-Rack, Z-Travel = 175 mm |
| 726309 | Insulation Block with Cable L = 380 mm |
| 727027 | Probe Single Tip, Teflon coated |
| 725877 | Probe, Cap Piercing Probe |
| 725742 | Central Control Unit (CCU), 2 arm |
| 725743 | Arm Board without ALIDUM Module |
| 725741 | ALIDUM (spare) |
| 726095 | Opto Sensor Assembly |
| 723638 | Plug Terminal Resistor, RS-485 |
| 723486 | Power Supply |
| 723489 | Cable, Interface, PC (25-pin) to CCU (2M) |
| 724126 | Cable Power Supply to CCU |
| 724127 | Cable Flexible Arm (Left) |
| 724128 | Cable Flexible Arm (Right) |
| 724102 | Cable, XL 3000 Diluter |
| 725999 | Fuse Kit (1x 1.6A, 1x 2.0A, 3x 3.15A) |
| 726299 | X Motor, Left |
| 726392 | X Motor Right |
| 726200 | Y Motor |
| 726201 | Z Motor (STD) |
| 726114 | Z Motor Cap Piercing |
| 726672 | Spares Screw Kit (2 Probe screws and 4 Insulation Block Screws) |
| 723487 | Integrator Software (including Manual) |
| 726507 | RSP 9000 Series Operator’s Manual |
| 722438 | Wash Station |
| 724275 | Tubing, Interconnect |
| 722540 | Tubing, Probe |
| 721370 | Tubing, Reagent |
| 722546 | Tubing, Support |
| 722547 | Tubing, Waste |
| 722200 | Connector, I-Block |
| 722543 | Black Tubing Guide |
| 722544 | Metal Tubing Support |

# F - Command Summary

## 1.0 SET COMMANDS

**Table F-1.**

| COMMAND | DEFINITION |
|---|---|
| OM [X*] [Y*] [Z*] | Set Overall Machine Limitation |
| OT [X*] [Y*] [Z*] | Set Self Test Range |
| OX/OY/OZ [InitOffset*] | Set Initialization Offset of X/Y/Z |
| XO/YO/ZO [±InitOffsetRel] | Adjust Initialization Offset for X/Y/Z |
| OW | Write Parameters to EEPROM |
| SM [X*] [Y*] [Z*] | Set Range for Absolute Field |
| SA [Z-Max*] [Z-start*] [Z-dispense] [Z-travel*] | Set Z-Parameters for Absolute Field |
| SW [WasteNo] [X*] [Y*] [Z*] | Set Coordinates for Waste Stations |
| SC [CleanerNo] [X*] [Y*] [Z*] | Set Coordinates for Cleaner Stations |
| SD [Mode 2] [Mode 1] | Set Detection Mode (DiTi Option) |
| SL [Speed*] | Set Search Speed for Liquid Search |
| SP [ON/OFF] | Set Position Recovery |
| SS [Sensitivity] | Set Liquid Detection Sensitivity |
| ST [x] | Set Tip Option (DiTi Option) |
| FX [StartSp*] [EndSp*] [Accel*] | Set X-ramp Parameters |
| FY [StartSp*] [EndSp*] [Accel*] | Set Y-ramp Parameters |
| FZ [StartSp*] [EndSp*] [Accel*] | Set Z-ramp Parameters |

## 2.0 ARM POSITIONING COMMANDS

**Table F-2**

| COMMAND | DEFINITION |
|---|---|
| PI | Position Initialization for X/Y/Z-axes |
| FI | Fake Initialization X/Y/Z-axes |
| XI/YI/ZI [Speed*] | Position Initialization for X/Y/Z-axes |
| PA [X°] [Y°] [Z°] | Position Absolute for all Axes |
| XA/YA/ZA [Coord°] | Position Absolute for Single Axis |
| XR/YR/ZR [±Steps°] | Position Relative for Single Axis |
| XS/YS/ZS [±Steps °] [Speed°] | Position Relative, Slow Speed |
| PW [WasteNo] | Move to Waste Position |
| PC [CleanerNo] | Move to Cleaner Position |

## 3.0 RACK DEFINITION COMMANDS

**Table F-3**

| COMMAND | DEFINITION |
|---|---|
| SF [FixPosNo] [X*] [Y*] [Z*] | Set Coordinates for Fixed Position |
| SR [FixPosNo] [Z-max*] [Z-start*] [Z-dispense*] | Set Z-parameters for Fixed Positions |
| D% [RackType*] [#of Rows] [X-Pos0*] [Y-Pos0*] [X-Pos1*] [Y-Pos1*] [±DispOfRowX*] [±DispOfColY*] | Set Parameters for Defined Field (Rectangular) |
| D% [PosSeq*] [TotNumPos*] [NumConCircles*] [CenterX-pos*] [CirRadius1*] [Angle1*] [CirRadius2*] [Angle2*] | Set Parameters for Defined Field (Circular) |
| D% [RackType] [LiRaNo*] [X-Pos*] [Y-PosFirst*] [Y-PosLast*] | Set Parameters for Defined Field (Linear Rack) |
| E% [Z-Max*] [Z-start*] [Z-dispense*] [Z-travel*] [RackType*] | Set Z-parameters for Defined Field |

## 4.0 RACK POSITIONING COMMANDS

**Table F-4**

| COMMAND | DEFINITION |
|---|---|
| PF [FixNo] | Move to a Fixed Position |
| PR [ReagNo] | Move to a Reagent Position |
| ZD [[±Steps°] | Move to Z-dispense Height |
| ZM [±Steps°] | Move to Z-Max Height |
| ZT [±Steps°] | Move to Z-Travel Height |
| ZX [Subm°] [Add°] [Z-Max°] [Sensitivity] | Move Z-rack, Detect Liquid, Submerge |
| ZZ [Subm°] [Add°] [Z-Max°] [Sensitivity] | See ZX command |
| G% | Get a Tip (DiTi Option) |
| BF [No] [Win] | Discard Tip (DiTi Option) |
| U% [xPos*] [yPos*] [zPos*] | Position Absolute for all Axes |
| T% [RackPos] [RackType*] | Move to a defined Field Position |

## 5.0 REPORT COMMANDS

**Table F-5**

| COMMAND | DEFINITION |
|---|---|
| RV | Report Firmware Version |
| RX/RY/RZ 0* [Sel°] | Report Current Position and Parameters |
| RM | Report Z-Max Assigned to Current Y/Z Position |
| RS | Report Z-start Assigned to Current Position |
| RD | Report Z-dispense to Current Position |
| RT | Report Z-travel Assigned to Current Position |
| RC | Report Capture Position |
| RE | Report Capture Events |
| RF [FixNo] | Report X-Coordinate of Fixed Position |
| RL [Sel°] | Report z-axis Values and Parameters |
| Q % [RackPos] | Report X-coordinate Position in Defined Field |

## 6.0 INTERACTIVE MOTOR DRIVE CONTROL COMMANDS (DEVICE 9)

**Table F-6**

| COMMAND | DEFINITION |
|---|---|
| SX/SY/SZ | Stop X/Y/Z-drive Movement Immediately |
| RX/RY/RZ [Sel°] | Report Current X/Y/Z-position and Parameters |
| SL [InOutNo] [Value] | Set Output Value for I/O-pins on ADRI-9 Board Connector |
| RL [InOutNo] | Read Input Value for I/O-pins on ADRI-9 Board Connector |
| SD [InOutNo] [Direct°] | Set Signal of Digital I/O-pins on ADRI-9 Board Connector |
| RD [InOutNo] | Read Digital I/O-pins on ADRI Board Connector |
| RG | |

# G - Implementing Pumps and Accessories

## 1.0 INTRODUCTION

The RSP 9000 can be run with a variety of Cavro pumps and “smart” devices. The following is a list of Cavro pumps that can currently be controlled by the RSP 9000 using the Integrator software program.

- XL 3000 Modular Digital Pumps
- XL 3000 Multi-Channel Pump Modules (2-8 Channels)
- XP 3000 Modular Digital Pumps
- Smart Peristaltic (SP) Pump Modules (1-4 Channels)
- Smart Valve (SV) Modules (3,4 and 6 Way)

## 2.0 INSTALLATION AND SETUP OF XL DEVICES

1. Set SW2 dip switch on the XL device to the following positions: SW2-1 Down; SW2-2 Up; SW2-3 Down; SW2-4 Down.

2. Set SW1 device address switch (rotary) to position 0..7. Each device must have a separate address. Usually, First Pump = 0, second pump = 1, etc.

3. Connect XL Device to RSP 9000 using CCU/XL 3000 cable. The cable can be made (see Figure G-1) or purchased from Tecan Systems (P/N 724102). When using XP 3000 Pumps, used DB15/edge connector adapter (P/N 725744).

4. Connect the edge connector to the back of the XL device. Connect the orange power plug to J2 connector on the CCU board. Connect blue communications plug to J21 connector on the CCU board.

**WARNING: All connectors are keyed. Check orientation of plugs before inserting into the connectors on the CCU board. DO NOT force plugs into connectors.**

5. Turn on the computer and RSP 9000 power supply. You should immediately hear the valve(s) initialize on the XL 3000 pump(s).

## 3.0 PROGRAMMING PUMPS AND OTHER SMART DEVICES USING INTEGRATOR SOFTWARE

Since the XL 3000 pumps and other smart devices are controlled through the RSP 9000 software, they must follow the RSP 9000 nomenclature. All pump commands are proceeded by an arm and device number. All pump commands with the exception of report commands are terminated with an “R”.

*Example: The command to initialize pump 1 (with address switch = 0) is #11ZR*

See the device Operator’s Manual for complete list of commands. When operating the pumps with the RSP 9000, all commands are the same as written in the pump manuals with the exception of report commands. The changes for these commands are found in Chapter 3, Section 3.7.

## 4.0 DEVICE ADDRESS NUMBER

When using an RSP 9000 with 2 arms, up to eight pumps or smart devices can be controlled by commands located in either left and/or right portions of the Integrator Software.

When using a single arm RSP 9000, up to four pumps or smart devices can be operating using standard commands in the left Integrator program. An additional four devices can be controlled by setting up a right Integrator program or by using the special Integrator command “RESULT:=COMMAND (‘...’) in the left program. For example to initialize a fifth XL 3000 pump with a one arm RSP 9000, the command would be.

Result :=Command (‘#21ZR’)

The following are the device numbers and address switch designations (SW2) for devices assigned to the left and right arms

**Table G-1**

| Arm | Device Number | Address Number |
|---|---|---|
| Left Arm – Pump 1 | #11 | 0 |
| Left Arm – Pump 2 | #12 | 1 |
| Left Arm – Pump 3 | #13 | 2 |
| Left Arm – Pump 4 | #14 | 3 |
| Right Arm – Pump 5 | #21 | 4 |
| Right Arm – Pump 6 | #22 | 5 |
| Right Arm – Pump 7 | #23 | 6 |
| Right Arm – Pump 8 | #24 | 7 |

# H - ASCII Chart—Codes for U. S. Characters

| Dec | Hex | Character or Function | Dec | Hex | Character or Function |
|---|---|---|---|---|---|
| 0 | 00 | none | 41 | 29 | ) |
| 1 | 01 | Control A | 42 | 2A | * |
| 2 | 02 | Control B | 43 | 2B | + |
| 3 | 03 | Control C | 44 | 2C | , (comma |
| 4 | 04 | Control D | 45 | 2D | - (en dash) |
| 5 | 05 | Control E | 46 | 2E | . (period) |
| 6 | 06 | Control F | 47 | 2F | / |
| 7 | 07 | Control G | 48 | 30 | 0 |
| 8 | 08 | Control H | 49 | 31 | 1 |
| 9 | 09 | HT | 50 | 32 | 2 |
| 10 | 0A | LF | 51 | 33 | 3 |
| 11 | 0B | VT | 52 | 34 | 4 |
| 12 | 0C | FF | 53 | 35 | 5 |
| 13 | 0D | Carriage Return | 54 | 36 | 6 |
| 14 | 0E | SO | 55 | 37 | 7 |
| 15 | 0F | S1 | 56 | 38 | 8 |
| 16 | 10 | none | 57 | 39 | 9 |
| 17 | 11 | DC1 | 58 | 3A | : |
| 18 | 12 | DC2 | 59 | 3B | ; |
| 19 | 13 | DC3 | 60 | 3C | < |
| 20 | 14 | DC4 | 61 | 3D | = |
| 21 | 15 | none | 62 | 3E | > |
| 22 | 16 | none | 63 | 3F | ? |
| 23 | 17 | none | 64 | 40 | @ |
| 24 | 18 | CAN | 65 | 41 | A |
| 25 | 19 | none | 66 | 42 | B |
| 26 | 1A | none | 67 | 43 | C |
| 27 | 1B | ESC | 68 | 44 | D |
| 28 | 1C | none | 69 | 45 | E |
| 29 | 1D | none | 70 | 46 | F |
| 30 | 1E | none | 71 | 47 | G |
| 31 | 1F | none | 72 | 48 | H |
| 32 | 20 | b/ (space) | 73 | 49 | I |
| 33 | 21 | ! (Roman) | 74 | 4A | J |
| 34 | 22 | “ | 75 | 4B | K |
| 35 | 23 | # | 76 | 4C | L |
| 36 | 24 | $ | 77 | 4D | M |
| 37 | 25 | % | 78 | 4E | N |
| 38 | 26 | & | 79 | 4F | O |
| 39 | 27 | ‘ (apostrophe) | 80 | 50 | P |
| 40 | 28 | ( | 81 | 51 | Q |

| Dec | Hex | Character or Function |
|---|---|---|
| 82 | 52 | R |
| 83 | 53 | S |
| 84 | 54 | T |
| 85 | 55 | U |
| 86 | 56 | V |
| 87 | 57 | W |
| 88 | 58 | X |
| 89 | 59 | Y |
| 90 | 5A | Z |
| 91 | 5B | [ |
| 92 | 5C | \ (backlash) |
| 93 | 5D | ] |
| 94 | 5E | ^ (control) |
| 95 | 5F | - (em dash) |
| 96 | 60 | ` (tick) |
| 97 | 61 | a |
| 98 | 62 | b |
| 99 | 63 | c |
| 100 | 64 | d |
| 101 | 65 | e |
| 102 | 66 | f |
| 103 | 67 | g |
| 104 | 68 | h |
| 105 | 69 | i |
| 106 | 6A | j |
| 107 | 6B | k |
| 108 | 6C | l |
| 109 | 6D | m |
| 110 | 6E | n |
| 111 | 6F | o |
| 112 | 70 | p |
| 113 | 71 | q |
| 114 | 72 | r |
| 115 | 73 | s |
| 116 | 74 | t |
| 117 | 75 | u |
| 118 | 76 | v |
| 119 | 77 | w |
| 120 | 78 | x |
| 121 | 79 | y |
| 122 | 7A | z |
| 123 | 7B | { (left brace) |
| 124 | 7C | \| (vertical bar) |
| 125 | 7D | } (right brace) |
| 126 | 7E | ~ (tilde) |
| 127 | 7F | DEL |

# I - Glossary

***Absolute Field:***

The instrument can move to any coordinate within the ranges specified by the SM Command. The ranges define the absolute field. The SA-command sets the four Z-heights for the absolute field.

***Accuracy:***

The degree of conformity of a measure to a standard or true value.

***ADRI-9 Board:***

The electronics board that is mounted to the arm(s) of the RSP 9000 series instruments. The ALIDUM and Modulo-1 components can be found on the ADRI-9 board.

***ALIDUM:***

The ALIDUM monitors the capacitance between the sampling tip and the electrical ground (X-frame). The ALIDUM generates a signal to the CCU-9000 board when there is a sudden change in capacitance. This change can be caused by the sampling tip coming in and out of contact with an ionic solution or by the flag on the insulation block touching the initialization ring. This change in capacitance is used to detect liquids and to initialize the Z-rack.

***Application:***

A specific job being executed on the RSP 9000 e.g. RIA, EIA, etc.

***Application Package:***

A software package that allows easy implementation of applications through a series of menus on a video display terminal.

***Arm:***

The RSP 9000 component that is mounted to the X-Slide and contains the Y and Z-axis control mechanism.

***CCU-9000 Board:***

The central electronics board for the RSP 9000 Series instrumentation. The main microprocessor and flash EPROM are located on this board. The CCU-9000 board is in the control center for the RSP 9000 and all of its optional devices.

***Cleaner Position:***

A position on the work surface that is used to clean the sampling tip(s).

***Command:***

A combination of user entered parameters that instruct the RSP 9000 to perform different actions. Example: #18PI. This instructs the RSP 9000 to initialize the left arm (all three axes). Commands can also be used to control optional devices.

***Coordinate:***

Any number or set of numbers used to specify a point on one or more axes in steps.

***Defined Field:***

A defined field is the physical description of an array of positions within the absolute field. It is defined by the X and Y coordinates of certain elements, the four different Z-heights and other parameters. A typical example of a defined field is a rectangular rack.

***Device:***

An addressable component of the RSP 9000 or additional option that can communicate with the CCU-9000, e.g., arm, diluter, valve, stirrer etc.

***EEPROM:***

Electrically erasable, programmable, read-only memory that contains firmware programs.

***External Computer:***

Any microprocessor that can communicate with the RSP 9000 according to the communications protocol found in Chapter 3.

***Firmware*:**

The term used to describe the software that is stored in a fixed form on the RSP 9000's flash EPROM and EEPROM.

***Fixed Position:***

A position described by X/Y/Z- coordinates within the absolute field. Every fixed position can have a Z-start, Z-dispense and Z-max heights assigned to it. The Z-travel height is taken from the absolute field.

***Flex Cable:***

A thin 16-wire cable that is used as the medium for power/data transmission from the CCU-9000 to the ADRI-9 board.

***Initialization:***

A term used to describe the calibration of one or more axes of the RSP 9000. The axes are offset to a predefined position. When the RSP 9000 is fully initialized, the X/Y/Z- coordinates are 0,0,0. The RSP 9000 operates using an absolute coordinate system that requires an X/Y/Z-calibration.

***Insulation Block:***

Insulates the sampling tip from the Z-Rack and connects the sampling tip to the ALIDUM to provide a controlled electrical flow for measuring capacitance. The insulation block also holds the metal flag that is used for initializing the Z-axis.

***Intelligence Device:***

A microprocessor driven device that has the ability to understand and reply to commands from another microprocessor. These devices also return self generated error messages.

***LED:***

The acronym LED stands for Light Emitting Diode. The LEDs used in the RSP 9000 are used for indicating lost steps on an axis or hardware problem. The green LEDs should flash on and off if the RSP 9000 is functioning properly.

***LiRa:***

An acronym that stands for linear rack drive.

***Master/Slave:***

These terms reflect the relationship between two devices of different RSP 9000 components. (It can also refer to the relationship of the external computer and the RSP.) The master controls the actions of the slaves. Hence, the failure of the master effects all of the slaves. The failure of a slave does not effect any of the other slaves or the master device. The slave does not transmit a message unless requested to by the master.

***Message:***

A computer block of data that is transmitted or received by the external computer, CCU-9000 or device.

***Mnemonic:***

An abbreviation used to help programmers remember a variable name and what the variable means.

***Modulo-1:***

An intelligent electronic component that controls the operation of the stepper motors.

***Nonvolatile Memory:***

Nonvolatile memory will retain all entered data until erased. Power interruptions will not erase the contents of this storage media. (An EEPROM is used on the CCU-9000 board.)

***Offset:***

After the RSP 9000 detects the initialization signal in one of the three axes (metal flag in Z-axis, slotted optical switch in X/Y-axes) during initialization cycle, it moves back a certain distance. This distance is the offset.

***Position:***

A location on the work surface specified by an X/Y/Z-coordinate.

***Precision:***

The degree of refinement with which an operation is performed.

***Program:***

A set of instructions for a computer to execute.

***Rack:***

The physical arrangement of tubes or containers in a holding device that can be defined on the work surface. (See “Defined Field”)

***RAM:***

An acronym for random access memory, a memory device whereby any location in memory can be found, on average, as quickly as any other location.

***Ramping:***

The acceleration and deceleration of stepper motors to achieve smooth movement in the X/Y/Z-axes.

***RS-232 C:***

Electronic Industries Association (EIA) Recommended Standard 232 C defines a standard way of transmitting serial data by wire. The connection line includes lines for sending and receiving data, ground connections and usually one or more control lines. The signal voltages are 5 to 15 volts (binary 0 on the data lines, “high” or “true” on the control lines) and –5 to –15 volts (binary 1 on the data lines, “low” or “False” on the control lines.) Mode of Operation: Single ended.

***RS-485:***

The 4-wire RS-485 is the same as RS-3\232 C format; however, it allows for several drivers and receivers over a wider voltage range.

***Sampling Tip:***

A hollow stainless steel tube that has a Teflon coated end for aspirating, dispensing and detecting liquids on the RSP 9000 Series instruments.

***SLD:***

An acronym for step loss detector (detection).

***Step:***

A step is the smallest addressable increment of movement on the X/Y/Z-axes. (See Appendix B for specifications for individual axis step distances.)

***Tray:***

See “Rack” and “Defined Field”.

***Valve:***

A device by which the flow of liquid or gas may be regulated or directed by a moving part.

***Volatile Memory:***

A type of data storage media that will be erased if the power supply is interrupted.

***Waste Position:***

A position on the work surface used to dispense waste from the sampling tip and system tubing.

***X/Y/Z-movement:***

The left-right (X), front-back (Y), and up-down (Z) motion in the three axes (X/Y/Z).

***XOR:***

A mathematical function written in the software to produce an eight-bit checksum used in verifying if a message has been received correctly by a microprocessor.

***Z-dispense:***

The height of the Z-Rack at which the liquid is dispensed during liquid handling operations.

***Z-max:***

The lowest position of the Z-rack in the absolute field or in a defined field. During a “search liquid command” the instrument will search for liquid from Z-start down to Z-max. If the Z-rack reaches Z-max without finding liquid, it stops (ZZ-command) or moves back to Z-coordinate 0 (ZX-command) and generates an error message. Certain commands can override the Z-max value.

***Z-rack (toothed):***

The vertical bar on the RSP 9000 that carries the insulation block and sampling tip. The Z-rack moves in the Z-direction (up and down.)

***Z-start:***

The height of the Z-rack at which the ALIDUM is switched on during a “search liquid command” (ZX,ZZ). It is usually at the rim of the liquid container.