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Title: ARIES NDA ROBOT OPERATORS' MANUAL

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CHAPTER 2 SYSTEM STARTUP

2.1 Cable Connections

The cable connectors for the motors, amplifiers, force sensor, etc. are described in the Adept MV Controller User's Guide. Figure 2 is a picture of the Adept chassis, in the back of Rack #1.

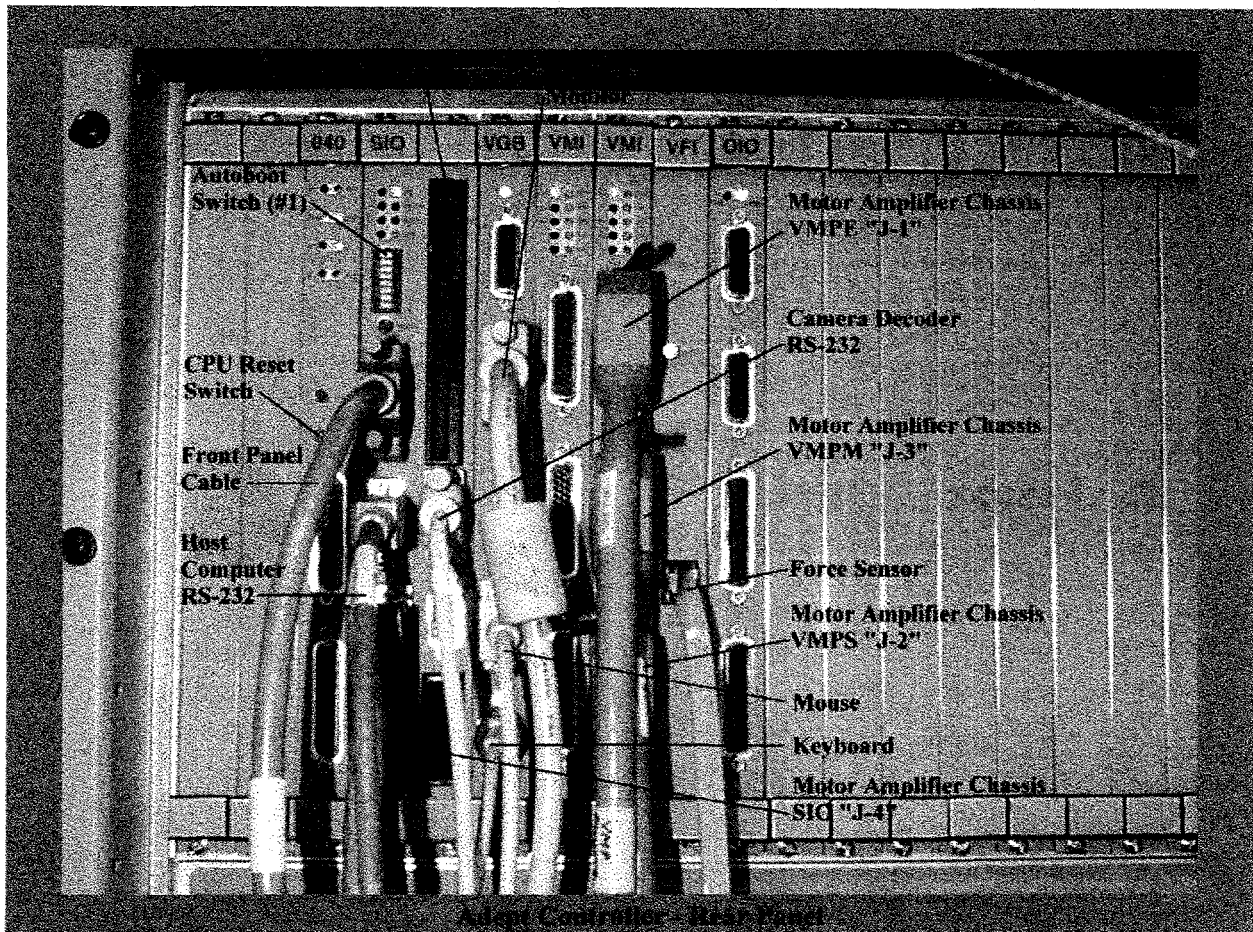


Figure 2, Rear Panel

There must be an RS-232 cable connecting serial port #1 on the SIO card and the SUN Workstation Host computer. There must be another RS-232 cable connecting serial port #2, located just below the floppy disk drive, and the input/output port on the camera control module.

2.2 Front Panel Switches and Settings

The red power switch at the top of the robotic electronics rack must be set to the "on" position. When it is in the "on" position, it will be lighted. The power switch in the amplifier chassis in the bottom of the electronics rack must be pushed in. There will be a small amber light in the center of the switch, when the power is on. The camera power switch in the yellow module in the electronics rack must be pushed in. It also will have a small amber light in the center, when the power is on. It is useful to have the Panasonic Video Monitor turned on, but it is not necessary for system operation. There will be a small red light at the bottom of the monitor, when the power is on. This display will show the output from the camera, which is mounted on the Z-axis of the robot.

Figure 3 is a diagram of the Adept Front Panel. The red circle on the right-hand side is an E-Stop button. It must be pulled out for the system to operate. The circle with the wide stripe in it represents the System Power switch. It must be in the "on" position (turned to the right) for the computer system to operate (on is labeled with a "1" and off is labeled with a "0"). After the power has been turned on, the switch will be lighted and will be green in color.

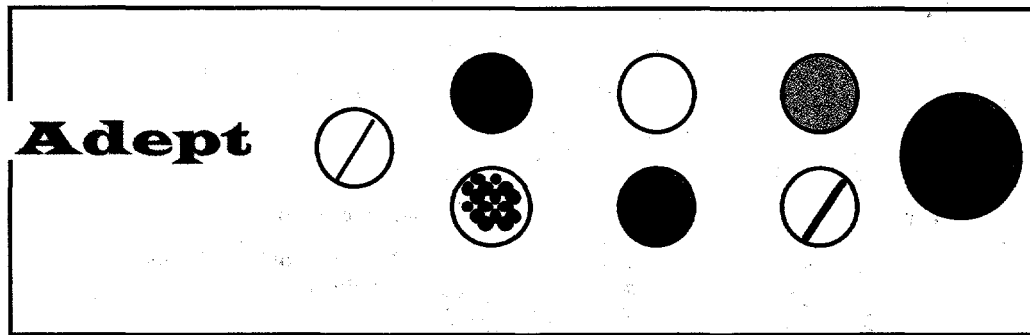


Figure 3, Front Panel

The yellow-orange circle represents the High Power indicator. It will be lighted when power to the robotic arm has been enabled. The white circle represents the program running indicator. It will be lighted when the robot is under program control.

The circle with the stripe, on the left-hand side of the diagram represents the key lock. The lock had three positions; Pendant, Terminal, and Network. The key must be turned to the "Terminal" position. The circle containing the black dots represents the manual control pendant connector. Either the pendant or the by-pass plug must be inserted into this connector, for the robot to function.

The green circle represents the program start switch/indicator. It is used only when a program is started from the manual control pendant. It will not be used with the Aries system.

The black circle represents the Lamp Test button. To test all the lights on the panel, push the Lamp Test button. Lamps that are working will be lighted.

2.3 Pole Lights

There are pole lights mounted on the east and west ends of the robotic structure. Each contains two lights, one red and one amber. The amber lamps will be lighted when there is power to the amp chassis, in the lower part of the electronics rack. The red lamps will be lighted when high power has been enabled, meaning the robot can move at any time.

2.4 Air Pressure

If there is insufficient compressed air, the gripper on the robotic arm will not function. The gripper needs 60 psi and there is a sensor to check this pressure. When there is insufficient air pressure, the "Air Pressure" item in the main window of the User Interface will say "OFF" and the program will not allow the robot to pick up or set down an item. There is a pressure regulator on the wall behind the electronics racks, behind the main ARIES control rack. The air pressure sense switch is set for 50 psi.

2.5 Light Curtain

The light curtain will be turned on automatically when the main program is started. This curtain functions as an E-Stop if an object interrupts the light beam. During operation, no object should break the light curtain path. If a break does occur, red LED(s) will illuminate on the transmitter/receiver assembly, showing the height of the beams that are interrupted. The range of the curtain is from just below the platform table-top to the top of the platform structure.

There is a light curtain control box mounted just below the table-top, on the front side of the platform. There is a key switch in the box; it must be set on the option "CS OPERATE". There is also a toggle switch in the box, labeled "Light Curtain Bypass". The switch must be in the DOWN position for the light curtain to operate as part of the safety system. The light curtain is bypassed when the switch is in the UP position; it may be turned on but it will not operate as an E-Stop.

2.6 Computer Startup

When the power switch at the top of the robotic electronics rack is set to the "on" position, the computer will automatically boot and load the operating system (V+). If operations are fully automated, the ARIES NDA program will also be loaded and run automatically. The computer may also be booted by pushing the reset switch on the card labeled "040", in the back of the

electronics rack (see Figure 2). The power switch at the top of the rack, on the front, must be in the "on" position for the reset switch on the system board to work.

2.7 Calibration

The robot must be "calibrated" before it will operate. When operations are fully automated, calibration will take place when the system is powered on. If the calibration process has not be automated, the operator must type the commands "en po" and then "cal" at the system prompt. The calibration routine will ask the user if he/she really wants to do a calibration. The answer is "y". The calibration procedure utilizes the Z, Y, and X axes in sequence to establish the home positions. Each axis will stop at its "home" position. An error may occur during the calibration process, so it may be necessary to issue the calibration commands more than once.

2.8 Program Startup

When operations are fully automated, the main program (NDAGUI) will be loaded and run automatically. If this process has not be automated, the operator must type the following commands:

```
cd nda
load ndagui
ex 6 a.startup
```

The startup program will execute the "robotd", which is a program to process requests from the Host and send commands to the robot. It will also open the connection to the Host computer and start the user interface. A number of initialization and reset operations will take place. When these operations have been completed, the Main Window will be displayed.

2.9 Establish Communications with Host Computer

The software module which communicates with the Host will be started automatically. The Main Status Window will show whether the connection is on or off. If the serial connection is off, the user may establish the Host connection by selecting the "Connect/Disconnect NDA host" from the main menu in the Status Window.

2.10 Force Sensor Settings

The force sensor has two operating modes: protect mode and guarded mode. Protect mode turns off high power to the robot and applies the robot's brakes when a user-specified force or moment level is exceeded. Protect mode is enabled when the robot program is started. It is used for crash

detection and is set for a maximum force of 50 pounds or moment of 50 inch-pounds.

Guarded mode stops the robot at its current position when one of up to two user-configurable force trip conditions is exceeded. It is enabled when items are being picked up or set down. The software adjusts the configuration for this mode, based on the upcoming motion. The robot uses guarded mode moves to find the knob of a plug or container, to find the top of the item after finding the knob, and to determine when an item has reached the table-top or well bottom. It is also used to check for an item which might be stuck in a well or set-down location, to determine when an item has been dropped, and to check for an item caught on the knob after it should have been released.

The guarded mode, Z-axis downward moves consist of two separate steps. First the gripper moves from the ceiling height until it is within approximately 25 millimeters of its destination. If force sensor data indicates contact with an item during this move, an error will occur. The arm is stopped and then started on a 50 millimeter move where it looks for force sensor data indicating contact with the knob (on a pick up) or item contact with the set down location. An error will result if the knob or set down location is not contacted within the given distance.

Before the gripper moves down to pick up an item, a force sensor guarded mode trip condition of one pound is set for the Z-axis. After finding the knob, the arm will retract 2 mm and the gripper will open. The trip condition of one pound is re-enabled and the arm moves down again. The trip condition will be met when the gripper touches the item top. The arm will retract 0.75 mm, the gripper will close, and the arm will retract another 2 mm. The force sensor is then set for a trip condition of a negative forty pounds by the Z-axis. The arm will retract 5 mm; the trip condition will not be met unless the item is stuck in its location. Next the force sensor is configured for two trip conditions, a negative fifty pound force by the Z-axis and a seventy-five inch-pound moment about the X- or Y-axis. These conditions will check for a dropped item and for an out-of-alignment situation in a well.

When an item is to be set down, the force sensor is configured for two guarded mode trip conditions. The first is a one pound force by the Z-axis and the other is a seventy-five inch-pound moment about the X- or Y-axis. The first condition will be met when the item touches its set-down location; the second will be met only if the item is not aligned properly with a well. After the one-pound trip, the gripper is opened and the trip condition is reset for a negative five pound force by the Z-axis. The arm then retracts 5 mm. The trip condition will not be met unless the item is caught on the gripper. The arm continues to retract until it reaches the "taught point" above the item.

CHAPTER 3

USING THE MAIN MENU

After the program has been started, the Main Status Window and the Message Window will be displayed on the screen. These windows will overlay the usual Adept monitor screen (the blue screen in the background of Figure 4). Other windows may be opened or closed, depending upon which items of operation are of current interest. Figure 4 shows the Main Status Window in the upper left. The message window is not shown in that figure. The other two windows shown are the Force Sensor Window and the Operations Window.

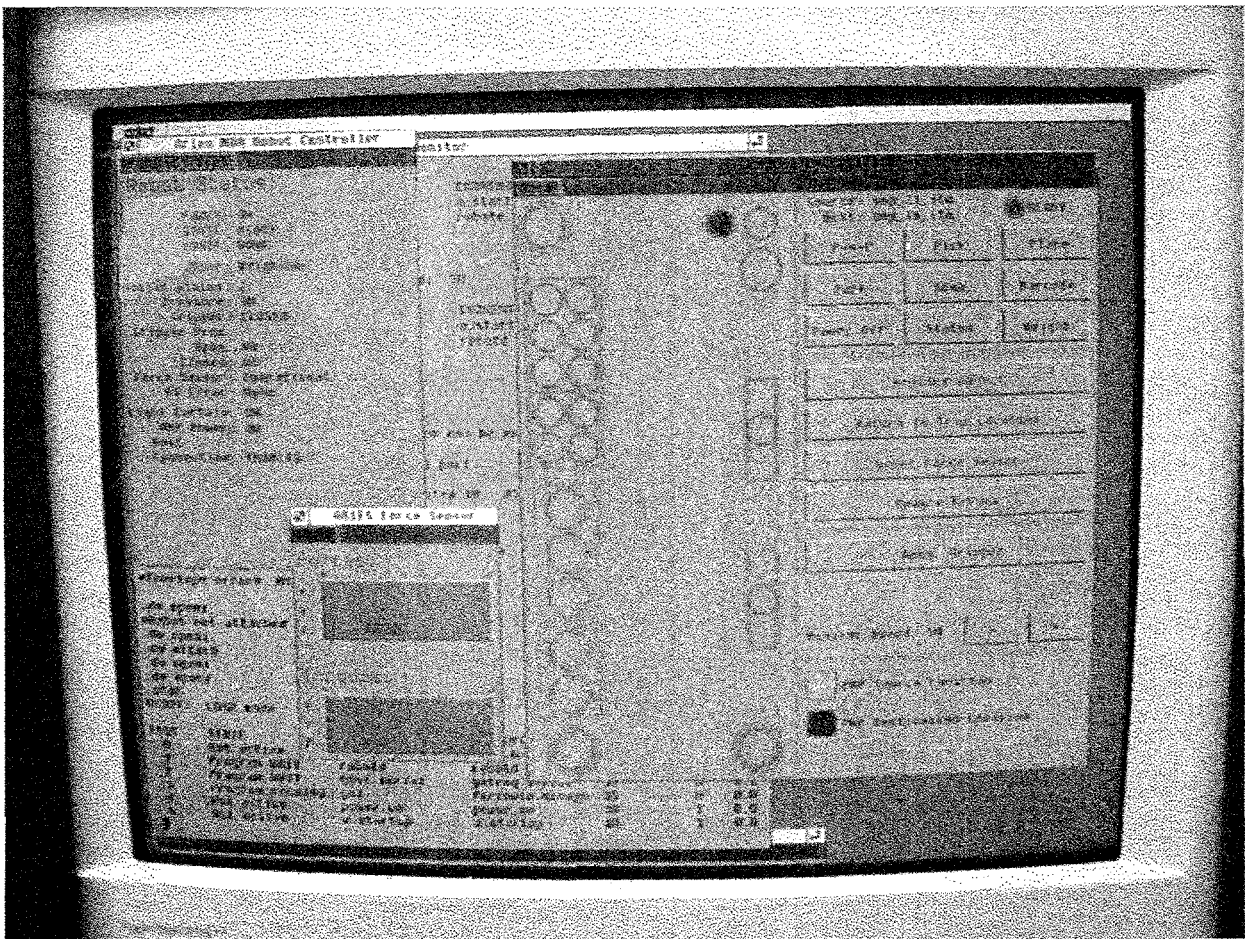


Figure 4, Monitor Screen Windows Display

3.1 Main Status Window

The Status Window is a display of various states important to the operation of the system. The items displayed in the window and sample values for the states are shown in Figure 5.

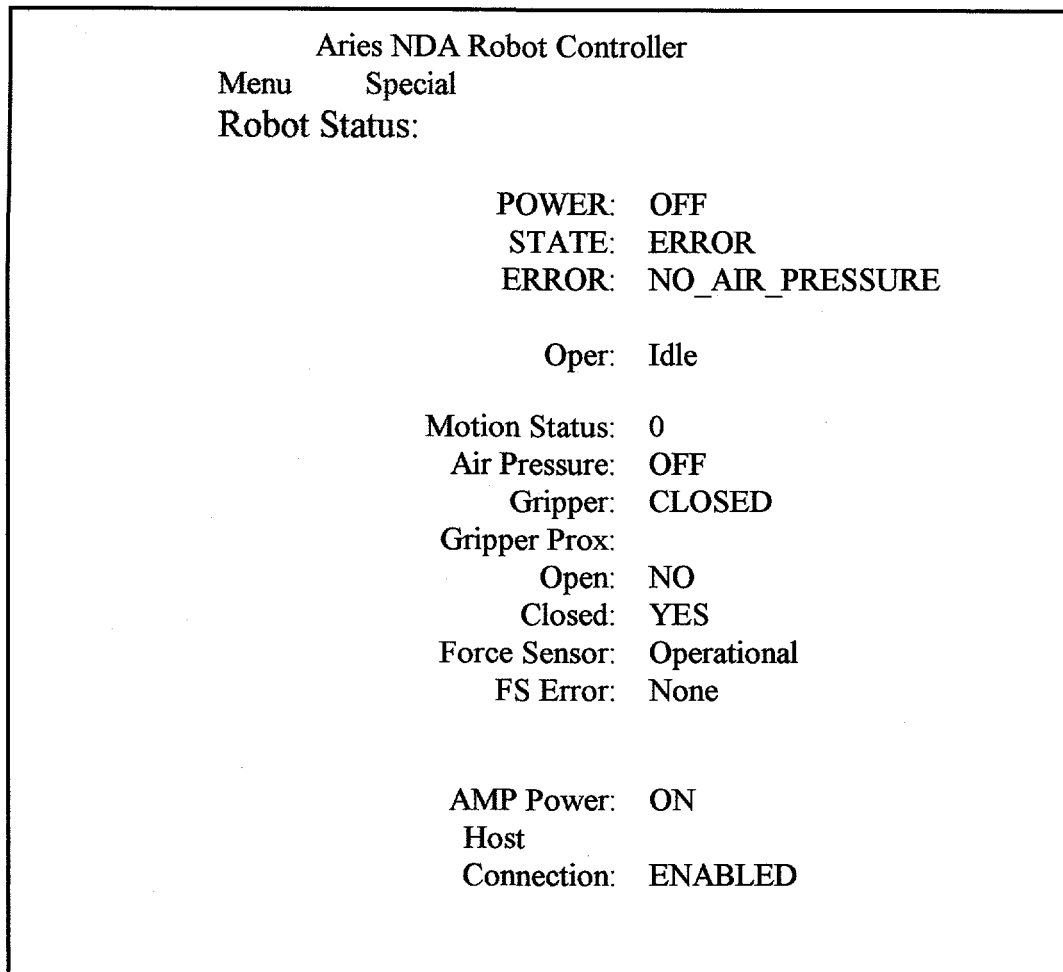


Figure 5, Status Window

The operator cannot change any of these status values from the Main Window, it is only a display. The values are updated by the software when there are changes in the system. This window also gives the user access to the Main Menu and to the Special Menu.

3.1.1 Main Menu Options

The Main Menu may be displayed by moving the mouse cursor to the word "Menu" at the upper left of the Status Window and then pushing the left mouse button. Continue to hold the mouse button down to see the menu. To make a selection from the menu, continue holding the mouse button down while moving the cursor to the desired option. The selection has actually been made when the mouse button is released. The menu contains the following options:

- Message Window Off
- Force Window On
- Operations Window On
- Disconnect NDA host
- Stop Robotd
- Stop GUI
- End

The first item in the menu will say "Message Window Off" when the menu is first displayed. This phrase does not mean the window is "off" but that the menu option may be used to turn the window off (no longer display the window). Move the mouse cursor to this option to close the Message Window. When the menu is again displayed, the option will say "Message Window On". The window may be turned "on" (displayed) by moving the mouse cursor to that menu option.

The Operations Window (shown on the right in Figure 4) displays a diagram of the robotic work space, as well as buttons for performing tasks; turning the power on, reporting the weight of an item, picking up an item, etc. This window may be turned off or on (displayed or not displayed), as described for the Message Window in the previous paragraph. The Force Sensor Window may also be turned off or on in the same way. The Force Window is a real-time display of forces and moments reported from the force sensor on the robotic arm. The window is shown in the lower left area of Figure 4.

The Robotd and GUI items on the menu are used to start or stop those sections of the computer program. To change the state of either the robotd or the gui, click the left mouse button on the appropriate menu option. The robotd routine is a background process which handles requests for robot information and actions. It uses a queuing system, with flags, to process requests from either the host computer or from the Operations Window. The gui routine opens the graphical user interface to the NDA system. It consists of the Main Window, the Message Window, the Force Sensor Window, and the log file viewing window.

To stop execution of the ARIES robot program, click on the "End" option on the Main Menu. It is not necessary to stop the robotd and gui routines separately. The "End" option will close all of the windows and stop execution of all routines.

3.1.2 Special Menu Options

The Special Menu may be displayed by moving the mouse cursor to the word "SPECIAL" at the upper left of the Status Window and then pushing the left mouse button. Continue to hold the mouse button down, to see the menu. To make a selection from the menu, continue holding the mouse button down while moving the cursor to the desired option. The selection has actually been made when the mouse button is released. None of the menu options will be used during normal operations. The menu contains the following options:

- Turn on dummy run
- Reset gstatus
- re-init location table

These options may be used during manual error recovery, testing, or debugging the program. A "dummy run" allows the program to run without actually using the robot. The "gstatus" variable keeps track of the main system status; whether there has been an error or whether the robot is busy, ready, or inactive.

3.2 Operations Window

The heading "Manual Operations" is printed at the top of the Operations Window and the word "Menu" appears in the upper left corner of the window. This menu may be displayed by moving the mouse cursor to the word "Menu" and then pushing the left mouse button. Continue to hold the mouse button down, to see the menu. To make a selection from the menu, continue holding the mouse button down while moving the cursor to the desired option. The selection is actually made when the mouse button is released. The menu contains the following options:

- Shutdown robotd
- Close Window

This window may be closed by using the close option on this menu, or by using the "Operations Window Off" option, from the main menu (section 3.1.1). The robotd program may be stopped by using the option from this menu, or by using the "Stop Robotd" option from the main menu.

3.2.1 Table Top Diagram

The table diagram on the left side of the Operations Window shows all of the places for NDA instruments, for container storage, and for plug storage. These locations may be used to indicate source and destination for robot moves. A source location is selected by moving the mouse cursor to a circle on the diagram and clicking the left mouse button; the