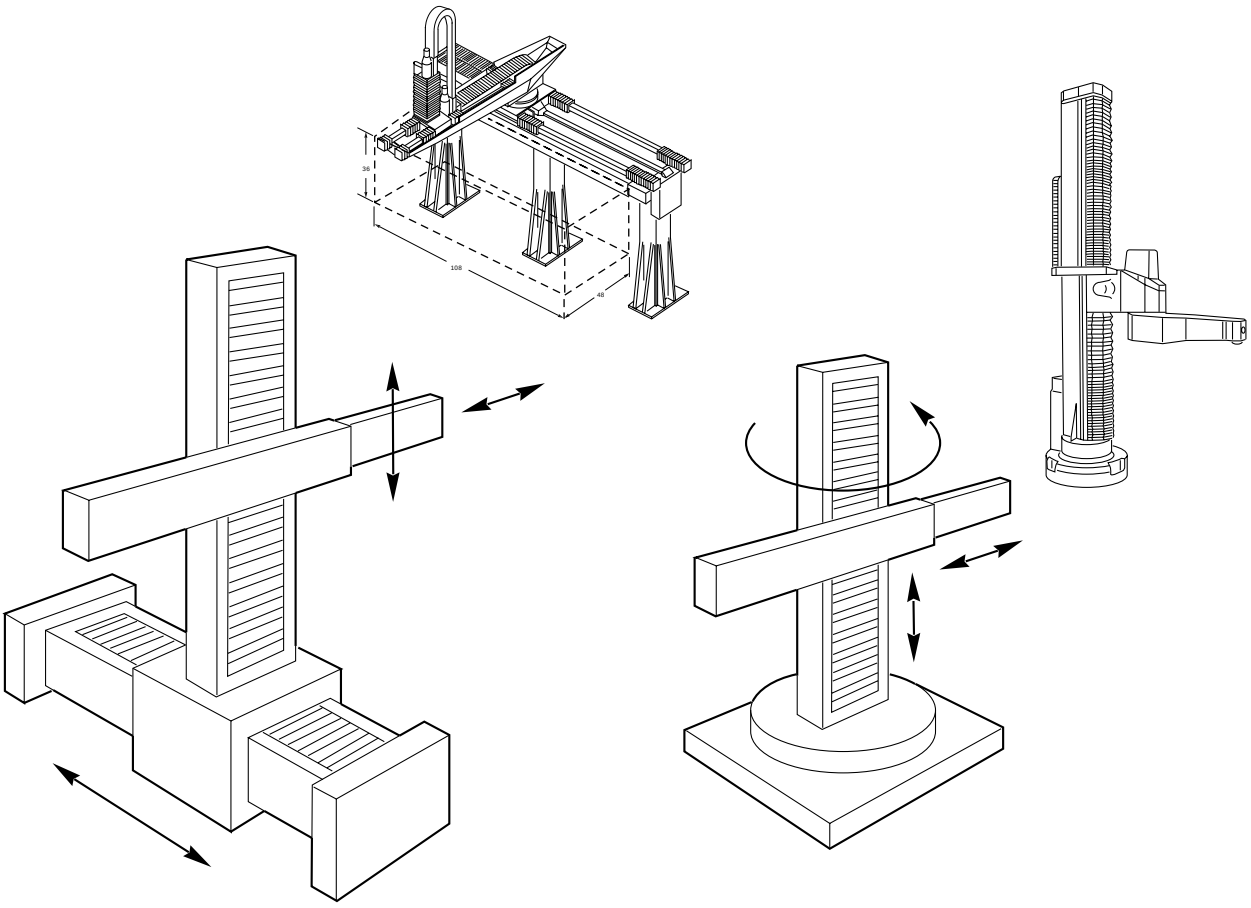
"RX" and "RX changed to RXB" family
CS7B - CS7 MB

OPERATOR MANUAL

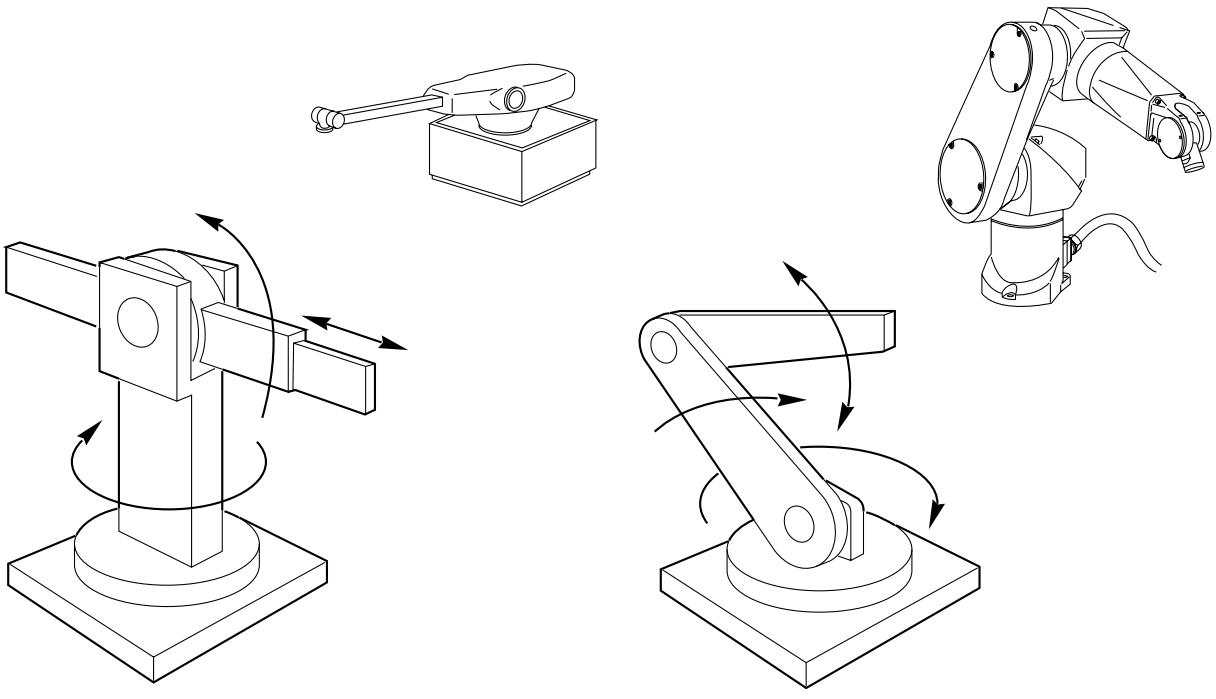
D.280.096.04.B - 06/00

1st edition 99.07

DIFFERENT CATEGORIES OF ROBOTS
GEOMETRICAL CONFIGURATIONS

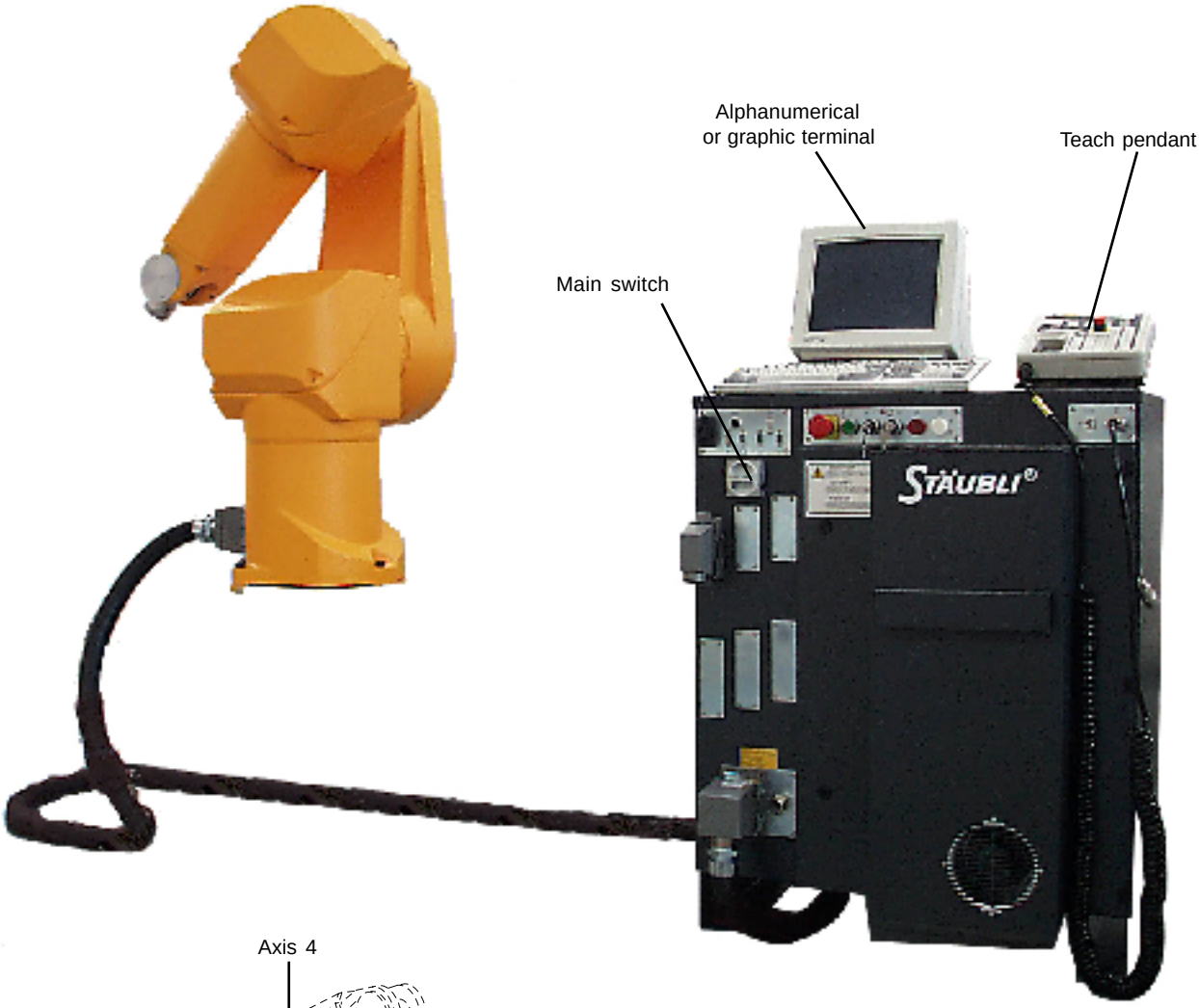


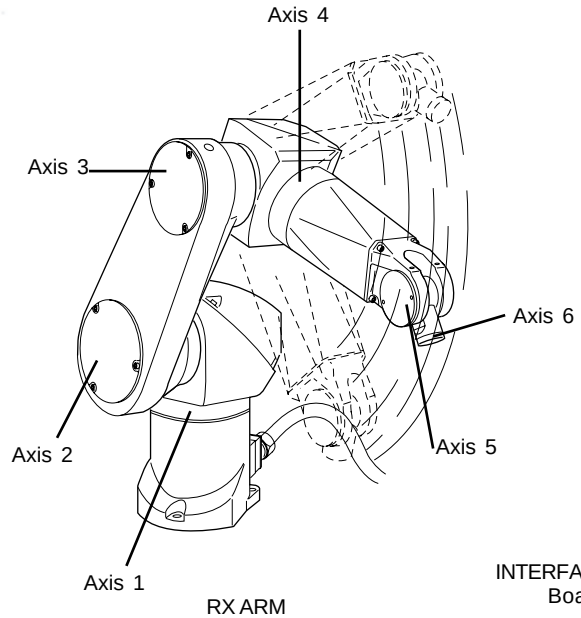
CARTESIAN COORDINATES



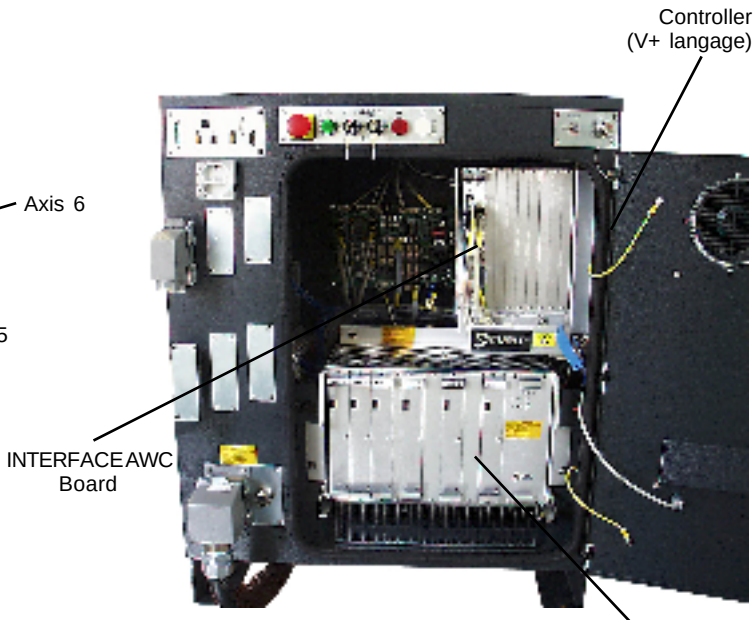
POLAR COORDINATES

PRESENTATION and FUNCTIONALITIES OF THE STAUBLI ROBOT SYSTEM





RX ARM



V+ LANGUAGE

The V+ language is adapted to the robotics and allows the **robot arm** or **outputs** to execute specific tasks.

The V+ language has its owner syntaxis which commands its structure.

Some definitions :

A PROGRAM is a sequence of instructions which will be executed the ones after the others.

The VARIABLES are the datas on which these instructions work; there ara 3 types:

- the LOCATIONS positions stored in arm work envelope used to define the motion of the arm;
- the REALS digital values used for calculations;
- the STRINGS OF CHARACTERS messages in text form which are displayed on terminal screen.

CONTENTS

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CHAPTER 1

SAFETY

CHAPTER 1 - SAFETY

RULE No. 1

Check that no-one is within the robot work envelope when switching arm power on. Always take tool offset into account.

the cell must be closed.

RULE No. 2

During resumption of cycle or after an operation in cell, always start up the robot at slow speed. After complete execution of a cycle, you can always increase the speed gradually until final required value is reached.

RULE No. 3

Each time that the robot is moved using the teach pendant, select a low speed (speed potentiometer, SLOW key).

RULE No. 4

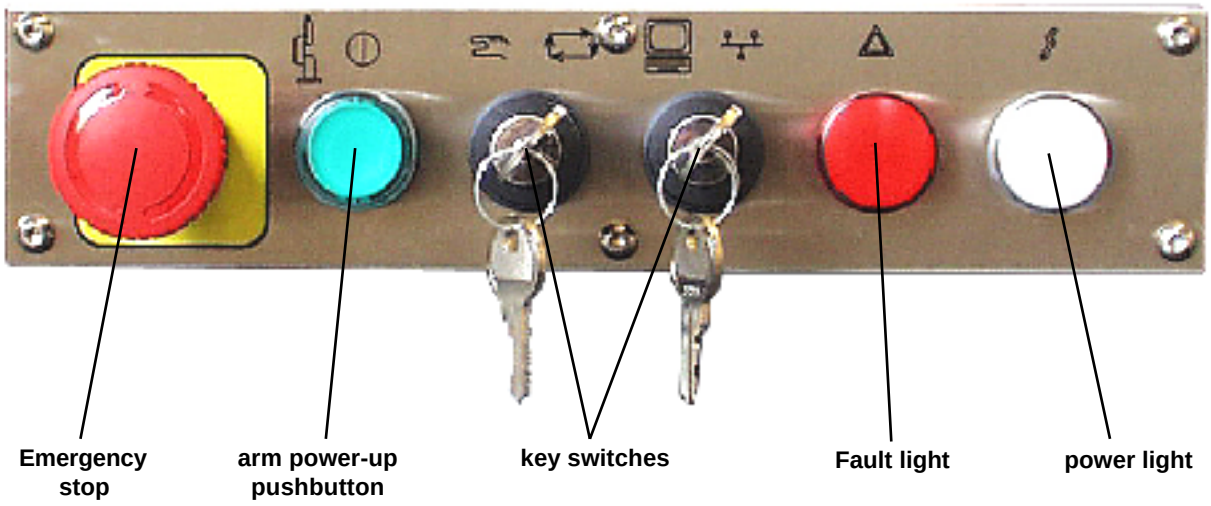
Before any maintenance on the arm or in the controller, switch off the power to the arm then to the controller.

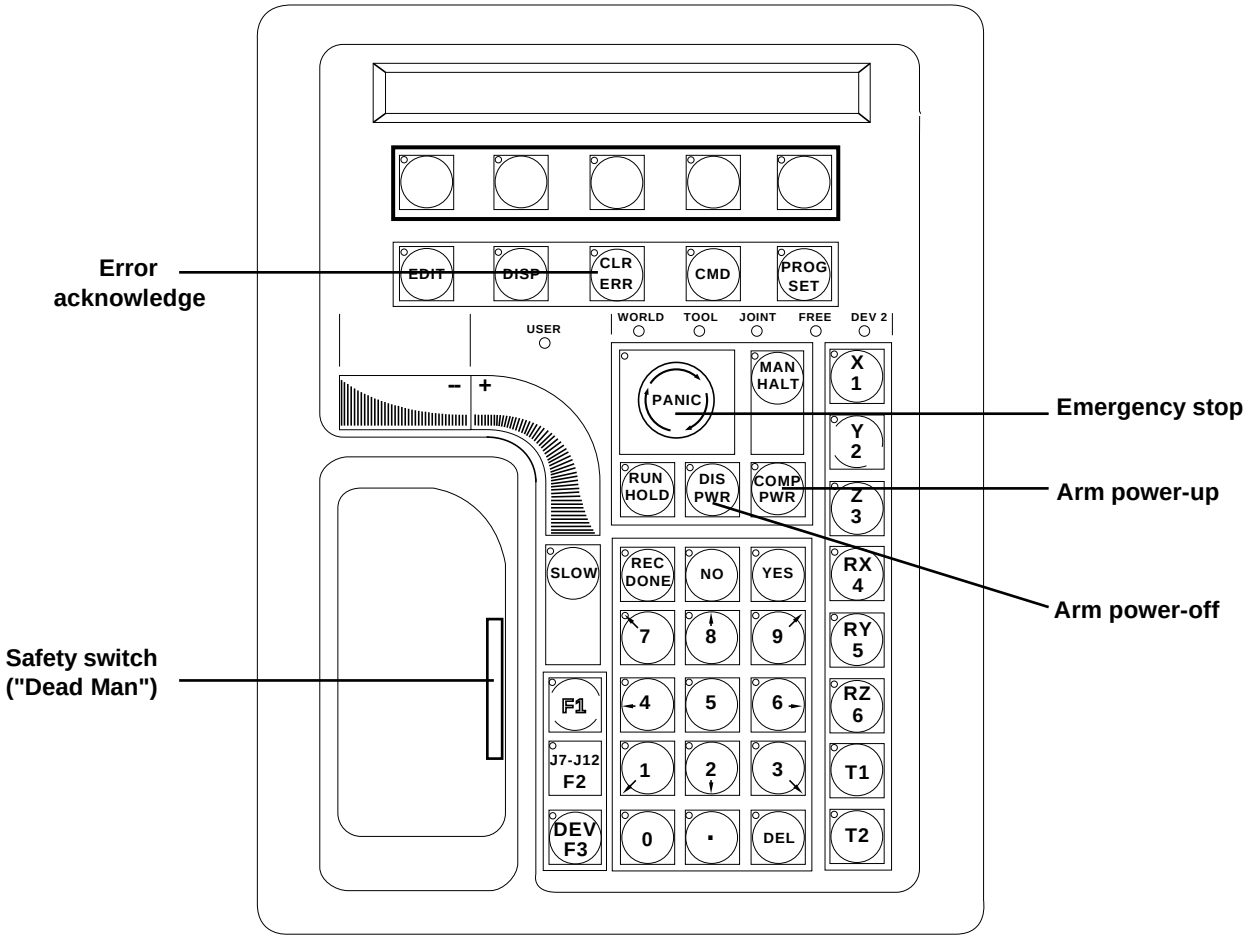
RULE No. 5

Controller door must be kept closed.

CHAPTER 2

ROBOT START-UP





Auto mode is requested to execute the auto calibration at the startup.
In the case of startup with the switch on MANU position, it creates a V+ error *robot interlocked* and the arm is not calibrated.

CHAPITRE 2 - ROBOT START-UP

2.1. INTRODUCTION

The robot can operate in two modes:

- **Automatic mode:**
  used to execute the production cycle, cell closed, nobody inside; arm movements are controlled by a program.
- **Manual mode:**
  used to move the arm with the manual control pendant (slow speed); the operator can enter the cell holding the manual control pendant.

2.2. CONTROL POWER-UP

- Check that the two key switches are set to (automatic mode) and (local mode).
- Set to 1 (ON) the general circuit breaker.
- Set to 1 (ON) display console (or start up PC for AdeptWindows PC interface).

Various messages will be displayed on the screen:

- *Loading…* which indicates that the system is loading its memory.
- The system version numbers.
- *Auto calibration…* which performs absolute calibration of the arm.

Throughout startup, the FAULT light is on.

Wait until "." is displayed on the left of the screen indicating that controller startup is completed.

Automatic startup procedure:

In most cases, the application program is triggered automatically by an automatic startup procedure.

This procedure depends on the configuration of the cell (operator terminal or interface on PC).

2.3. ARM POWER-UP

2.3.1. AUTOMATIC MODE ( )

- On the controller, set key switch to .
- On keyboard, type ENABLE POWER (or EN PO) or press the COMP/PWR key on the manual control pendant.

  The *"Press HIGH POWER button to enable power"* message is displayed on the screen.
- On the controller, press the green ⏻ button (flashing) within 15 seconds. The green button stays on.

If you have not pressed ⏻ within 15 seconds, the pushbutton stops flashing and procedure must be repeated.

2.3.2. MANUAL MODE ( )

- On the controller, set key switch to .
- Take hold of the manual control pendant, press and hold the safety switch ("Dead man").
- Press the COMP/PWR key on the manual control.

  The *"Push, release, hold MCP enable switch"* message is displayed on the screen.
- Within 10 seconds, release then repress and hold the safety switch.

  The *"Press HIGH POWER button to enable power"* message is displayed on the screen.
- On the controller, press the green ⏻ button (flashing) within 15 seconds. The green button stays on.

If you have not pressed ⏻ within 15 seconds, the pushbutton stops flashing and procedure must be repeated.

> ⚠ **USE IN MANUAL MODE**
>
> **When the safety switch ("Dead man") is released, power to the arm is automatically cut off.**
>
> **To reactivate it, press and hold the safety switch, then press the COMP/PWR button on the manual control pendant.**

Exceeding the assigned power-up times may trigger an aural signal and an error message may flash on the manual control pendant.

Before restarting the procedure, press the CLR ERR button. If required, do this several times until the light on the key goes off.

2.4. CUTTING OFF POWER ON ARM

> ⚠ **ROBOT's arm must be static and no robot programs must be in progress.**

There are 5 possibilities:

1. switching on DIS PWR button of the teach pendant.
2. typing DISABLE POWER (DIS PO) on keyboard.
3. switching on the "ermergency stop" push button of the controller or of the teach pendant.
4. switching again on ⏻ button when the ARM POWER indicator light is on.
5. modifying the switch position.

Cutting off power on arm in manual mode triggers an error on the manual control pendant that must be acknowledged (by pressing the CLR ERR key).

CHAPTER 3

TEACH PENDANT USE

CHAPTER 3 - TEACH PENDANT USE

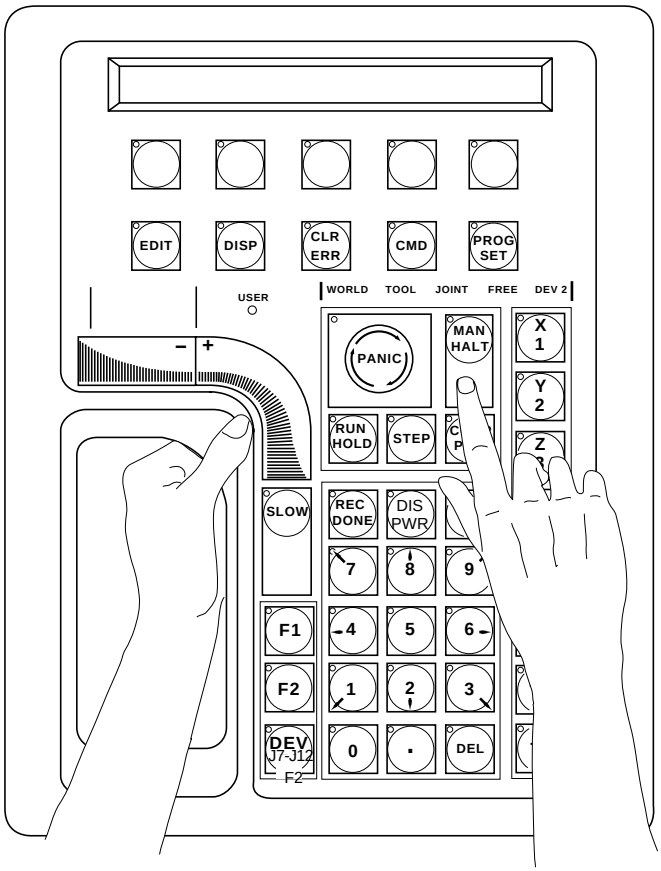
Once the controller has been switched on, there are two ways to move the arm :

- via the teach pendant
- by running a program.

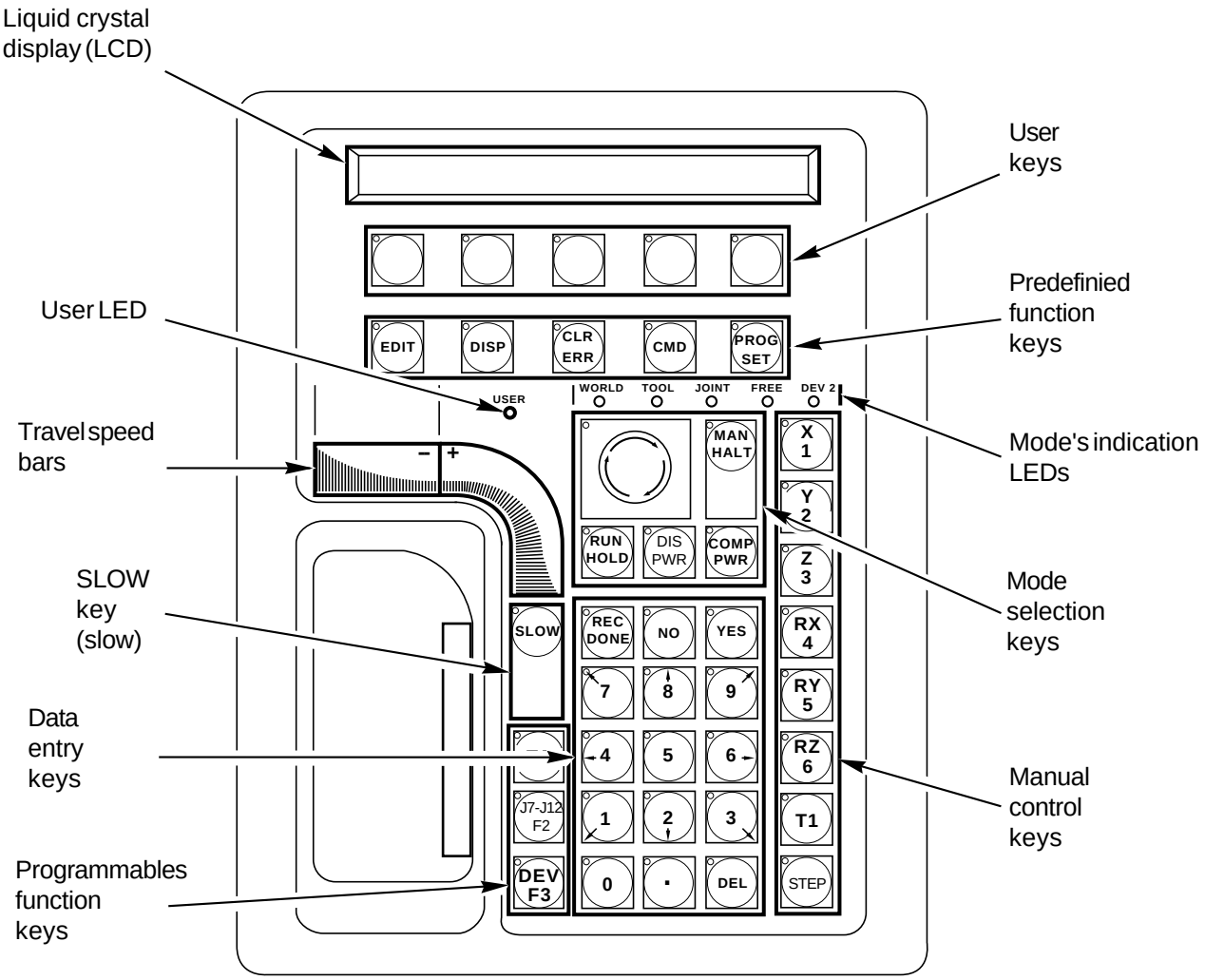
3.1. GENERAL

The controller allows the robot to be controlled from the optional teach pendant (also called manual control pendant).

To use the pendant, place your left hand in the LH opening of the pendant by keeping the safety switch ("Dead man") pressed, and, using your left thumb, press the manual travel speed bars. Use your right hand for all the other functions. The various groups of keys will be explained in this section.

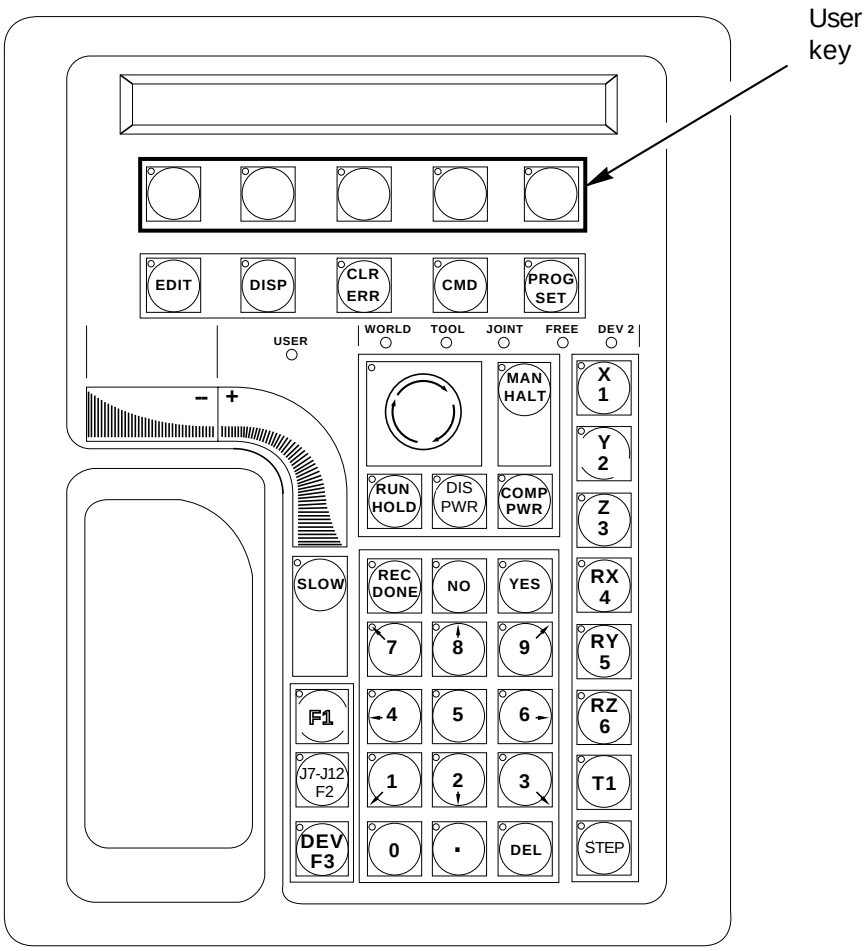


3.2. PRESENTATION OF TEACH PENDANT KEYS



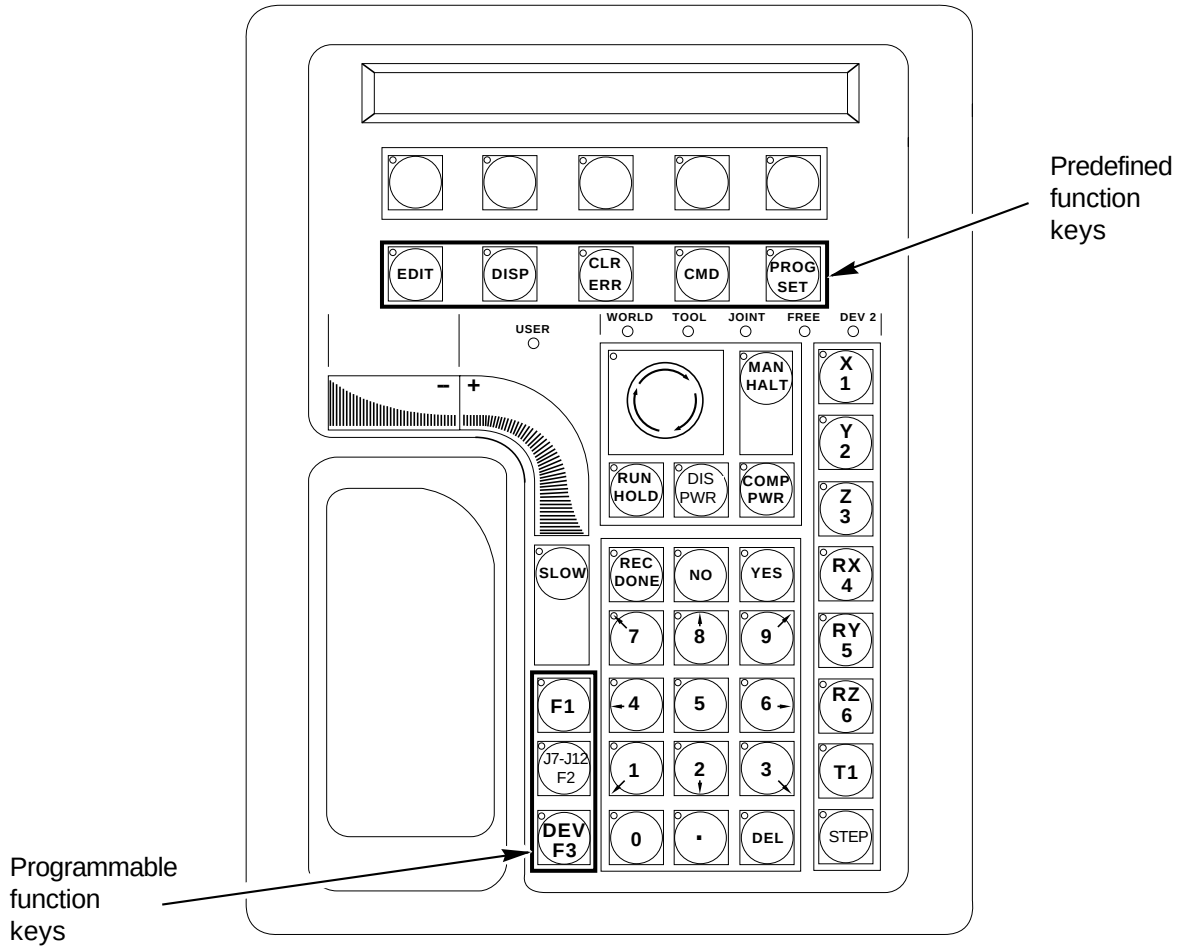
3.2.1. USER KEYS

The user keys without set names under the LCD allow you to make the choices offered by the predefined function keys below or to choose an option in the menu displayed on the LCD by pressing the corresponding key during the execution of the application program.

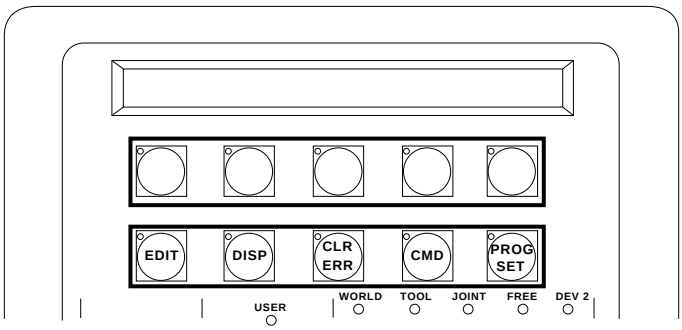


3.2.2. FUNCTION KEYS

The function keys allow you to start specific operations.
There are two types: predefined and programmable.

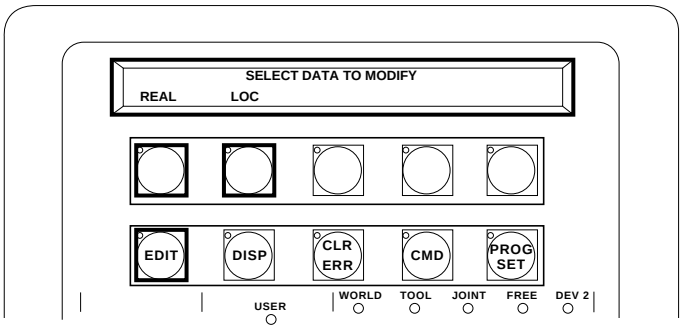


The pendant has five predefined function keys used in conjunction with the operating system. These keys are described below.



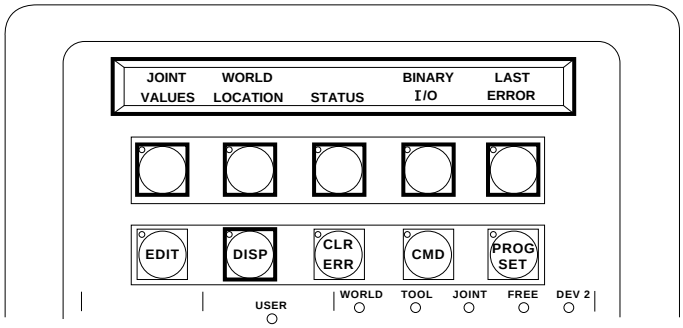
EDIT function

The EDIT function key allows the location and real variables to be edited so that they can be modified, if applicable, by using the numerical teach pendant keys.



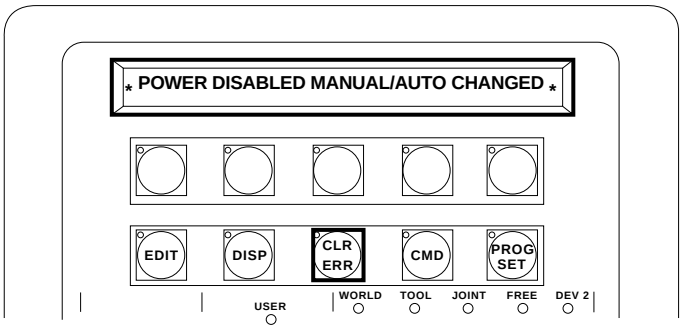
DISP function

The DISP function key is used to display on the teach pendant (from right to left in the figure below), the joint values, the values according to the WORLD location, the status of the system, the binary I/O status or the last error message.



CLR ERR function

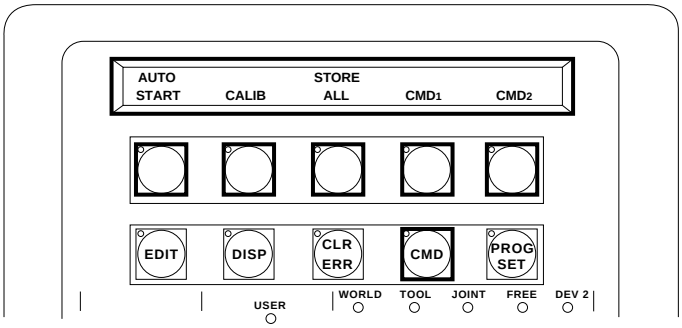
Each time an error occurs, the pendant generates an audible warning, displays a flashing error message and switches on the CLR ERR button LED. In manual mode, no other actions will be accessible while CLR ERR button LED is on.



Press the CLR ERR button to continue execution. The error message is deleted and the teach pendant returns to the state it was in prior to the error.

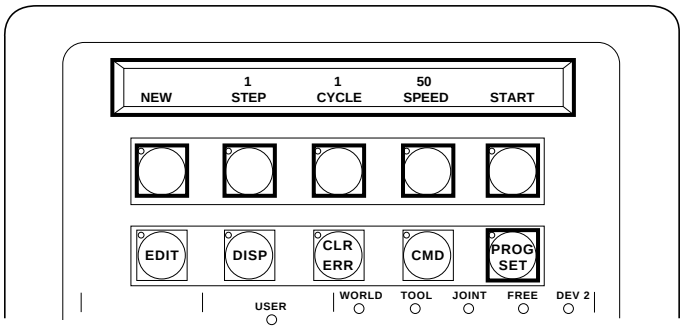
CMD function

The CMD function key is used (from left to right in figure below) for automatic start, storing of complete memory on disk (STORE ALL), or to activate the command programs CMD1 or CMD2) (loading, execution, saving).



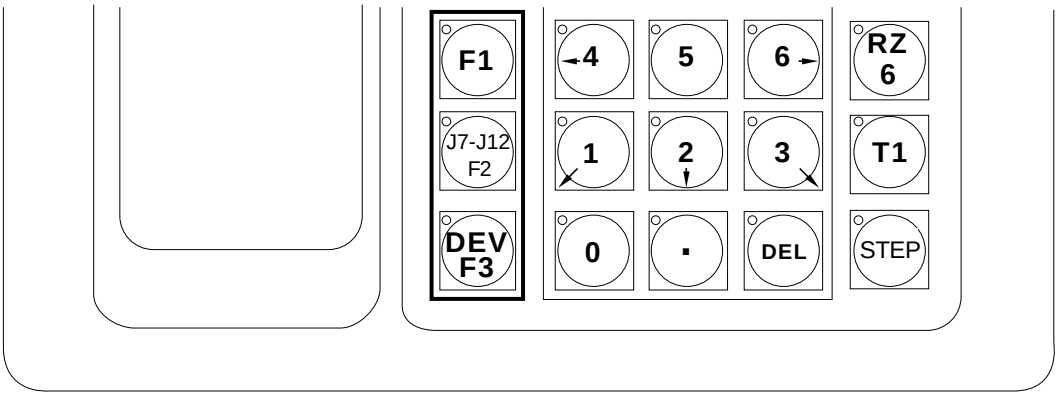
PROG SET function

The PROG SET function key allows you to select a new program to be executed, set the number of start-up steps, set the number of program cycles to be executed, adjust the monitor speed and (or) initialize/start the application program resident in memory.



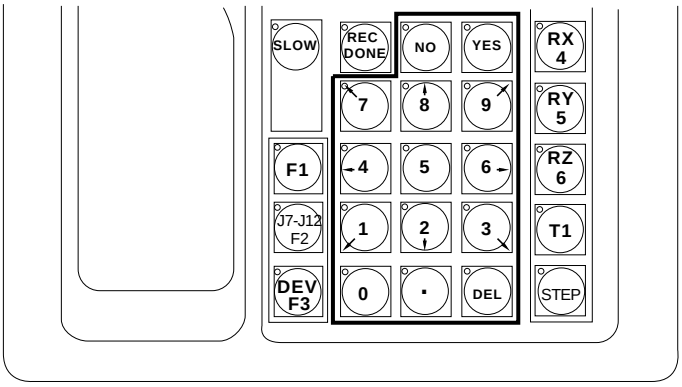
F1, J7-J12/F2, DEV/F3 keys

The three free programmable function keys (F1, F2 and DEV/F3) can be used by any application program for specific needs (these keys are also used to control the external joints).



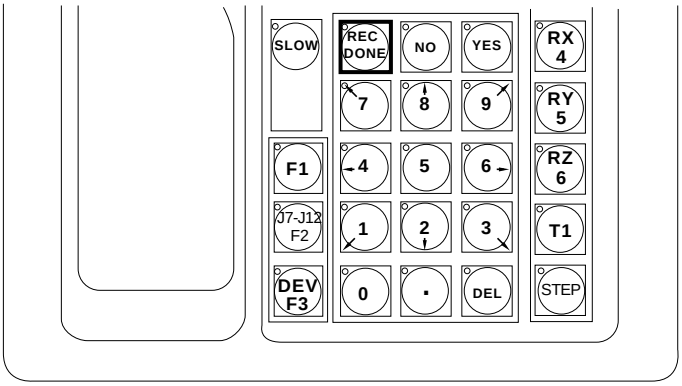
3.2.3. DATA ENTRY KEYS

The data entry keys allow you to reply to messages displayed on the pendant LCD. These keys are: +/Yes, -/No, Del (delete), the numerical keys 0 to 9 and a decimal point.



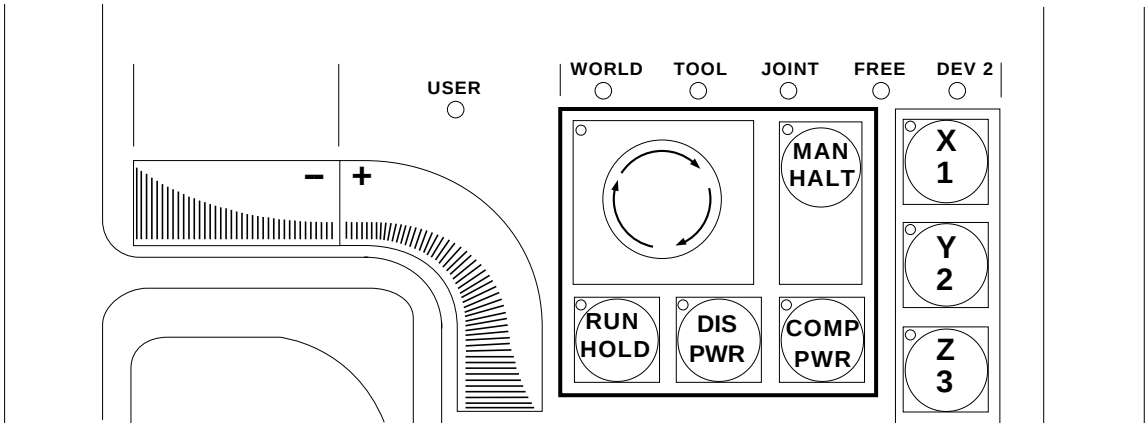
REC/DONE key

The REC/DONE key behaves in the same way as the terminal keyboard -ENTER- key.
When the LED of this key flashes and the data to be entered are keyed in, press the REC/DONE key to complete data entry. This key is also used to teach locations.



3.2.4. MODE SELECTION KEYS

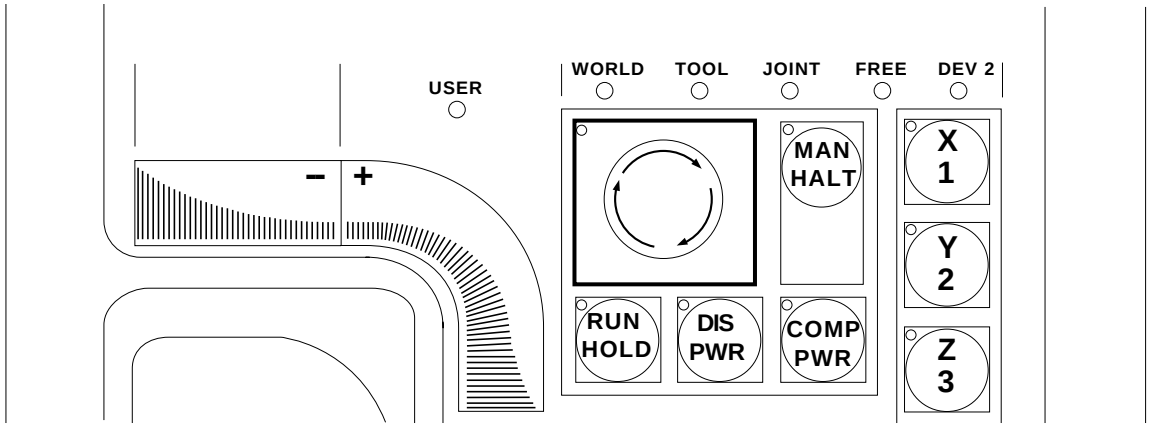
The mode selection keys are the only pendant keys allowing you to change the robot arm movement mode.



EMERGENCY STOP button

The EMERGENCY STOP button stops the robot by deactivating the arm power supply (which activates the brakes) and stops the program by creating a system error. This key must be used in case of emergency only. For easy identification, they are coloured red and yellow.

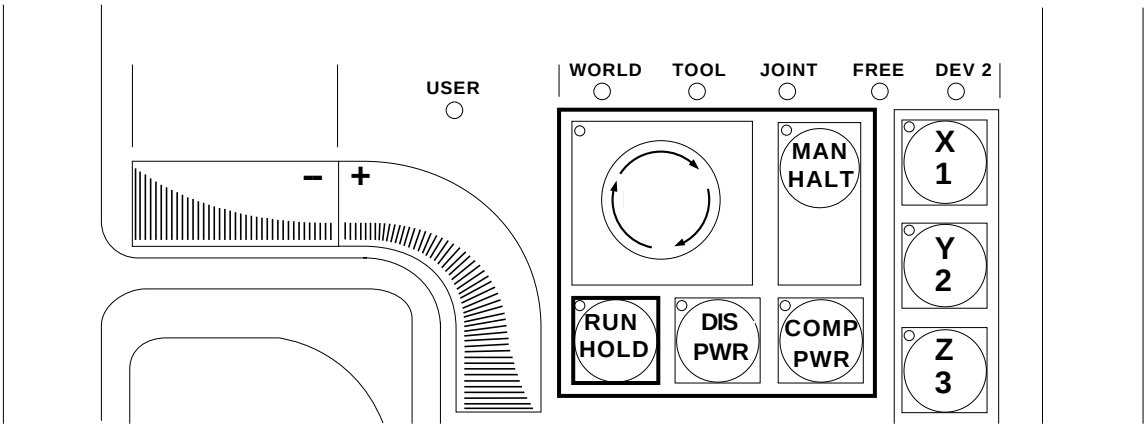
Regular use of this button (like all system emergency stops) will reduce the life of the motors.



RUN/HOLD key

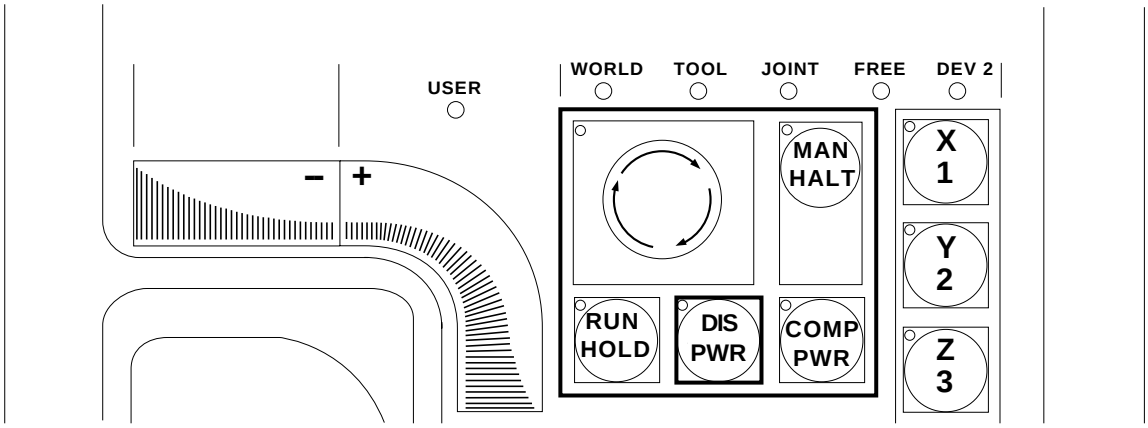
The HOLD function of this key causes the immediate stop of the robot arm. The program sequence is interrupted and the message "HOLD" is displayed on the visual display unit.

Then if RUN/HOLD is pressed again, the cycle will continue while the key is pressed (AUTO mode on control panel).



DIS PWR key

Create a Disable Power as the monitor command.



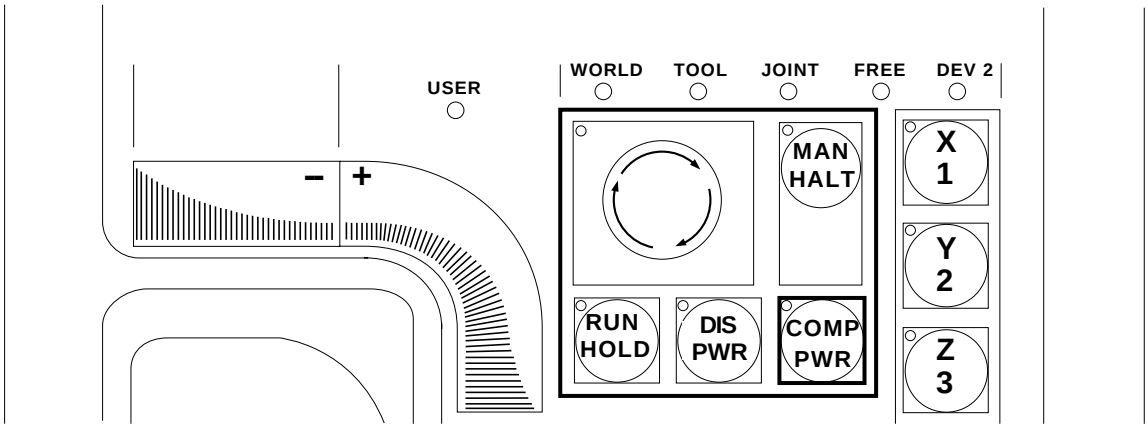
COMP/PWR key

The PWR (POWER) function of this key is to authorize arm power-up (equivalent to ENABLE POWER).

The COMP (COMPUTER) function of this key is to authorize execution of programs.

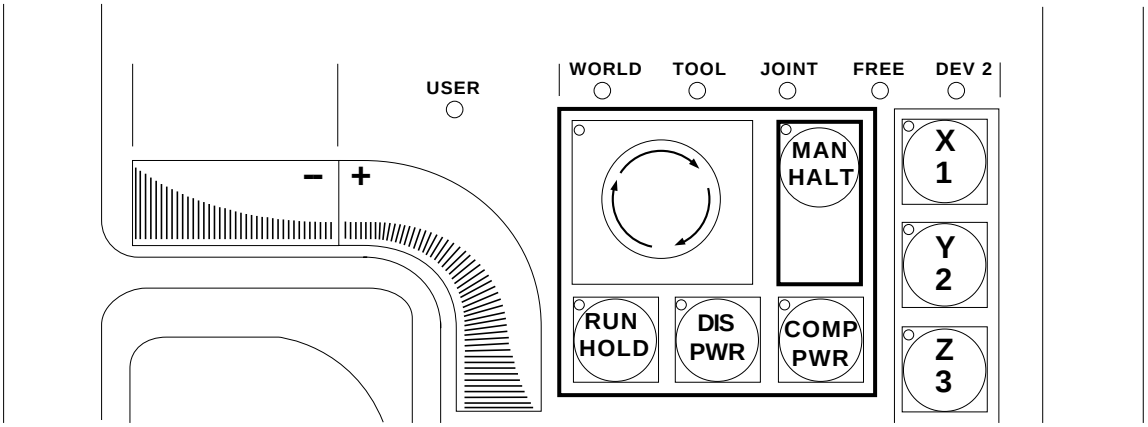
When this button is pressed, the ⏻ press button blinks and the system is waiting for an action on it (after 15 seconds the system is desactived).

If the execution of a program is requested and the COMP/PWR key is inactive (MAN/HALT key activated), the **COMP MODE DISABLED** message is displayed on the terminal screen and the program is stopped.



MAN/HALT key

The MAN/HALT function of this key causes the immediate stop of the robot arm. The execution of the program is interrupted and the **COMP MODE DISABLED** message is displayed on the visual display unit.



The MAN function of this key is to enable selection of manual motion mode. In manual mode, all motion instructions given via the system terminal keyboard have no effect on the robot arm (**COMP MODE DISABLED** message).

The manual mode is accessible only from the computer mode (COMP) and when the arm is powered. The system remains in manual mode until ARM POWER is deactivated or the COMP/PWR key pressed.

The system is in WORLD mode when manual mode is pressed for the first time after switching on the system. Once in manual mode, press the MAN/HALT key successively to select required mode (WORLD —> TOOL —> JOINT —> FREE and return to WORLD). If you quit then return to manual mode (without switching off the controller), last activated status is automatically chosen.

NOTE : To comply with safety standards, the FREE MODE is no longer operative.

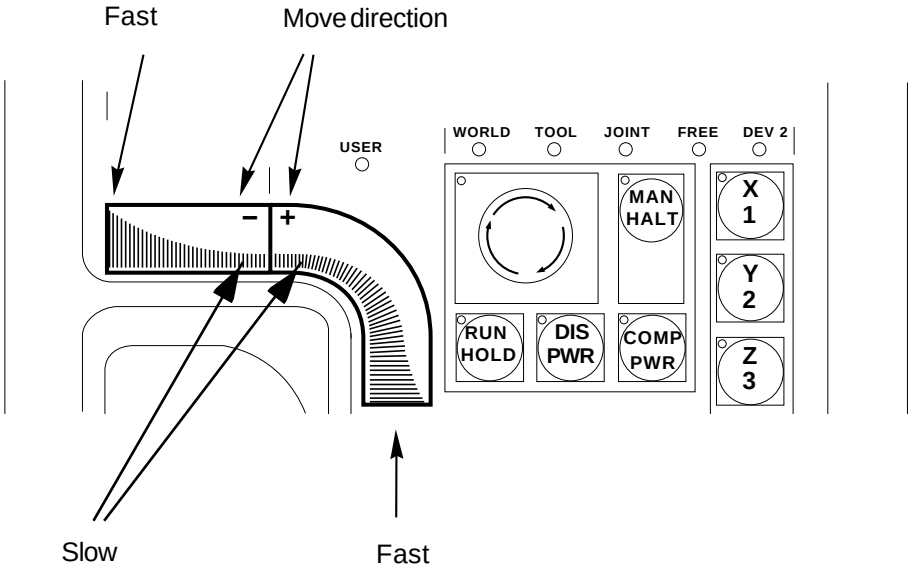
Use of all thes motion modes is described in paragraph 3.3

3.2.5. MANUAL CONTROL KEYS

The keys on the RH side are the manual control keys. Once in manual mode, these keys allow you to select the direction of each joint for manual motion: X/1, Y/2, Z/3, RX/4, RY/5, RZ/6. These keys are described later in the robot motion modes.

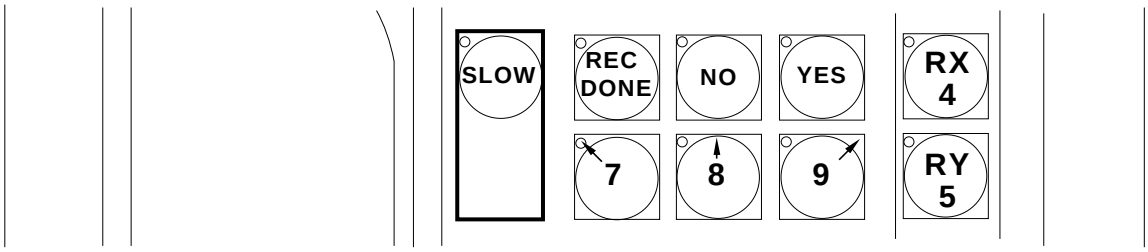
Speed bars

The speed bars allow you to select the speed and manual motion direction. Robot motion is started by pressing the speed bars with your left thumb. You can select a fast or slow speed in the two motion directions (+/-).



SLOW key

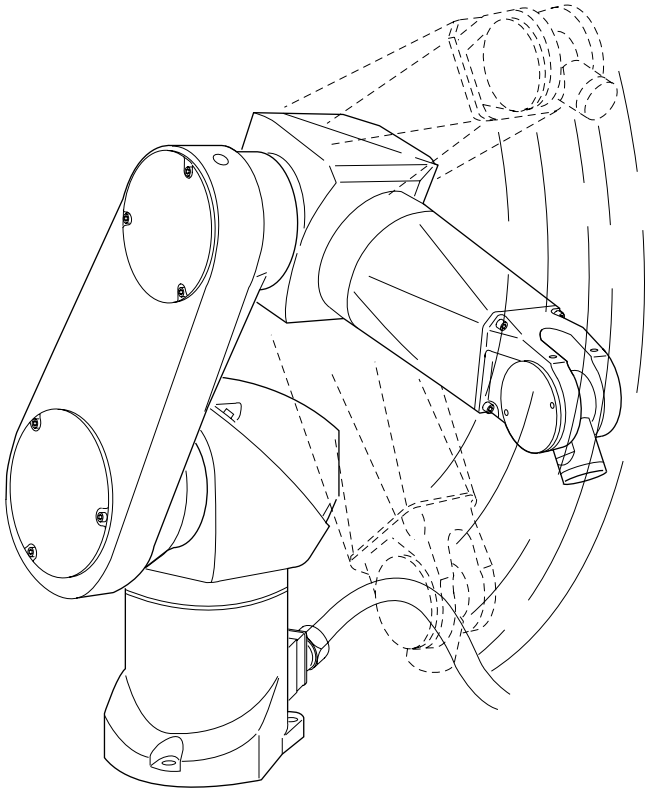
The SLOW key allows you to select between two different speed bar ranges. You can select a normal or very slow travel speed.



3.3. ROBOT MANUAL MOTION MODES

3.3.1. JOINT MODE

Joint motion is made around the axes of the various joints 1, 2, 3, etc. Rotational direction is given by the + or - speed bar keys.



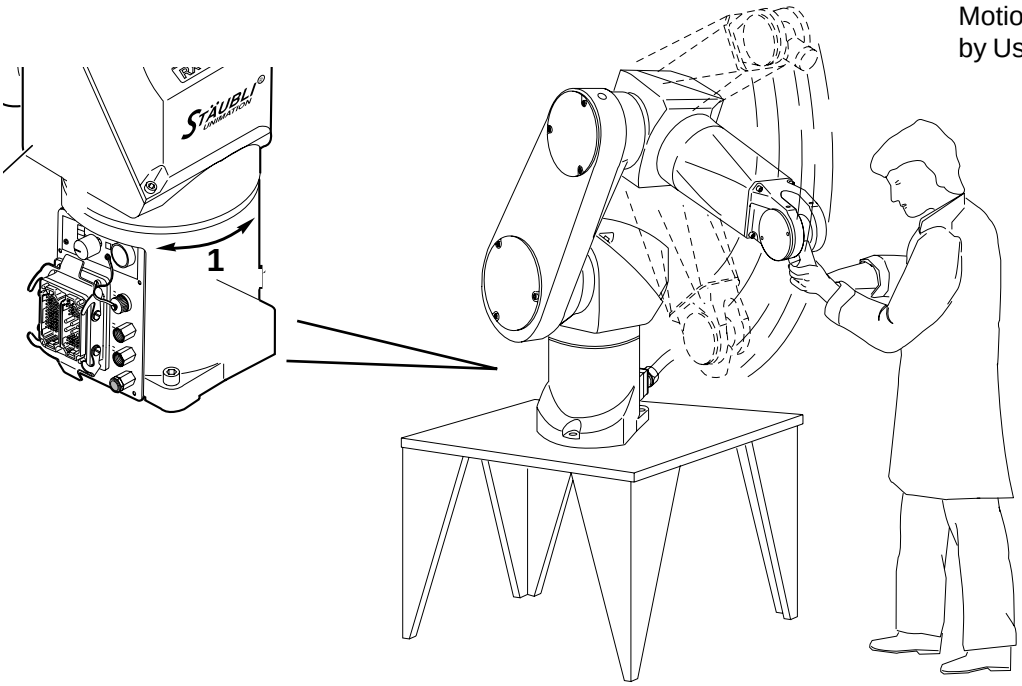
3.3.2. FREE MODE

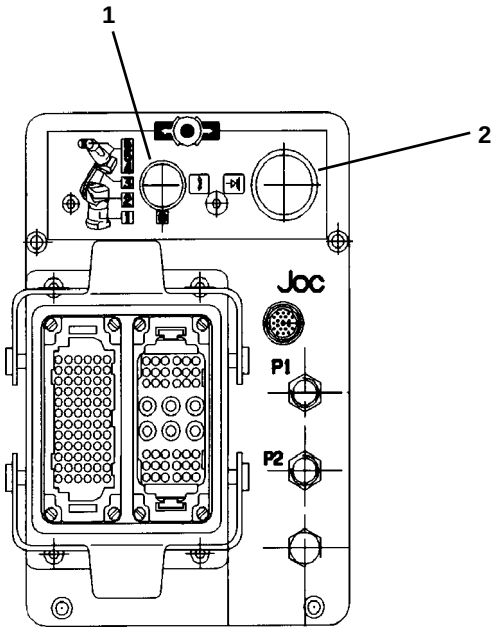
For safety reasons, the FREE key is no longer operational. To free the joints, use the brake release selector located on the rear of the robot arm.

3.3.3. BRAKE RELEASE SYSTEM

The controller is power on. Put the button of joints selection (1) on the joint concerned. Make sure that the arm and the load are well fixed in relation with this joint. Pressing the brake release push button (2), the selected joint is totally free. Take care to the fall of some axes under the gravity action. As soon as the button is released, the motor is braked again and the joint blocked.

> ⚠ **The arm must then be supported manually.**





Note: • Take care of joint 4 and 6 over rotation
• Joint 5 is not reversible

3.3.4. COORDINATES SYSTEMS

3.3.4.1 PRELIMINARY

- To locate a point in space (3D), we use a coordinate system.

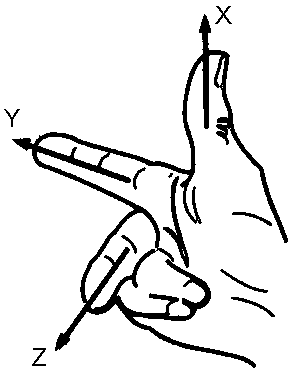
- The coordinate system is represented by origin and 3 axis called X Y Z all perpendicular "in between".

- The orientation of these 3 axis follows the "rule of the 3 fingers" of the RIGHT HAND.

Where X: Thumb

Y: Index finger

Z: Middle finger



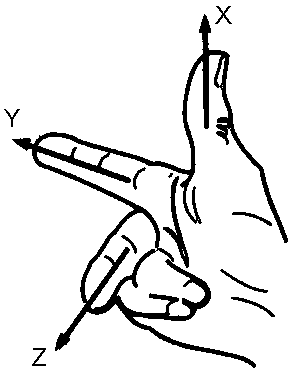
!!! Right hand !!!

OR

X: Index finger

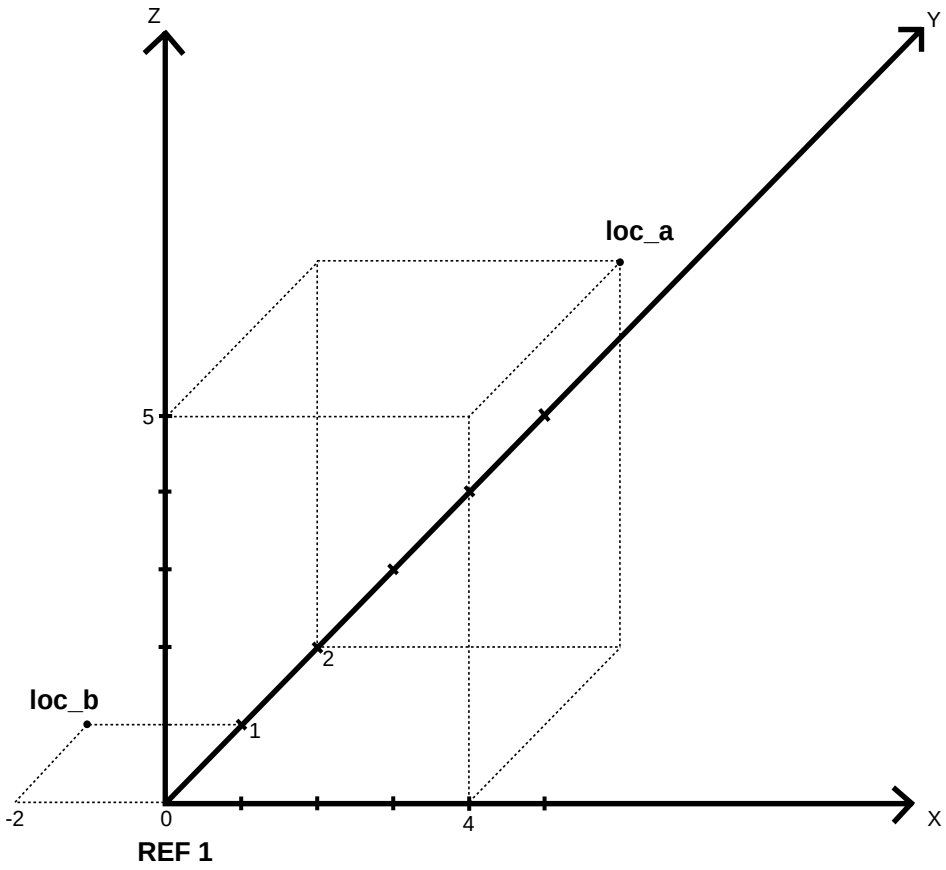
Y: Middle finger

Z: Thumb



!!! Right hand !!!

Example :



In the coordinate system REF 1:

- Location **loc_a** has for coordinates (4, 2, 5)

- Location **loc_b** has for coordinates (-2, 1, 0)

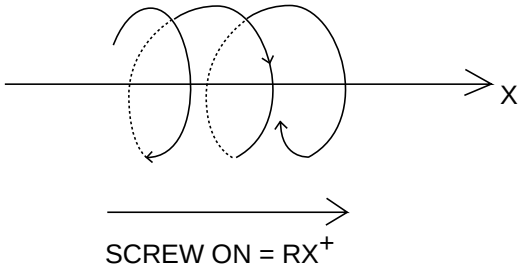
Translation

A move in the direction of axis X will be called X^+ and in the opposite direction of axis will be called X^-. Same for Y (Y^+, Y^-) and Z (Z^+, Z^-).

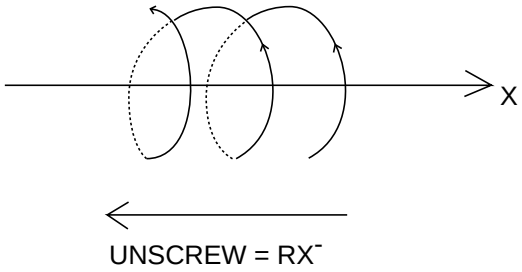
Rotation

RX represents a rotation around axis X.

To determine the sign of the rotation, when you do the move of rotation, if you screw on in the direction of the axis X, you are doing RX^+, else RX^- (rule of the SCREW or CORK-SCREW). Same for Y (Y^+, Y^-) and Z (Z^+, Z^-).



SCREW ON = RX^+



UNSCREW = RX^-

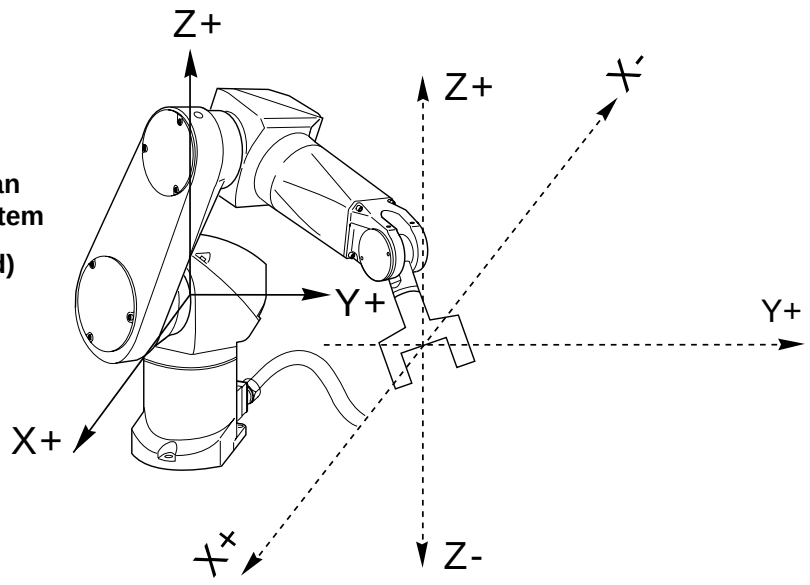
3.3.4.2. COORDINATE SYSTEM IN RX ROBOTS

WORLD Coordinate system (WORLD mode on the teach Pendant)

All translation motions are parallel to the WORLD coordinates. The RX, RY and RZ rotations are made with respect to the WORLD coordinates. The motions are made by pressing the + or - speed bar keys.

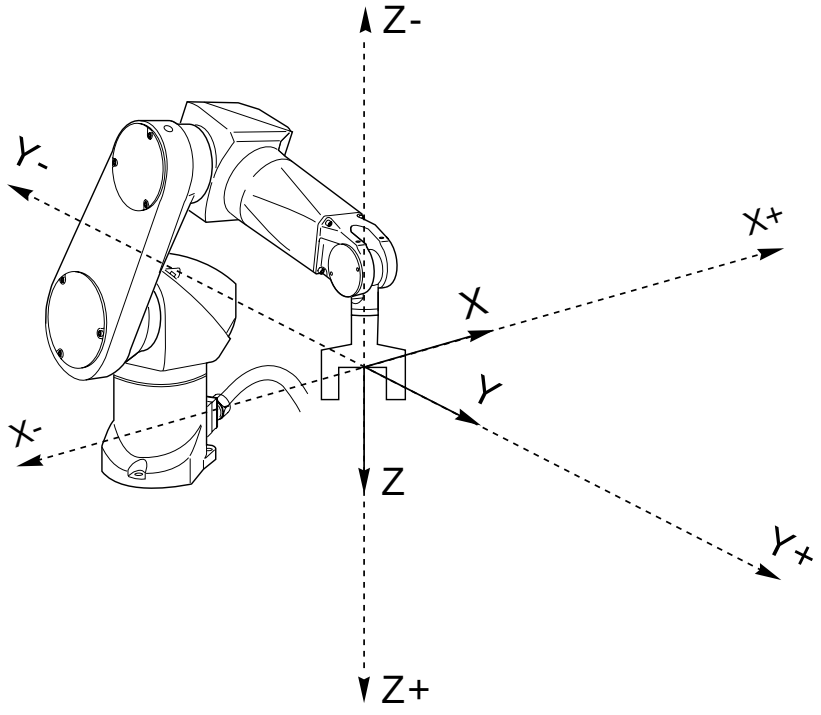
BASE Cartesian Coordinate System

(WORLD fixed)

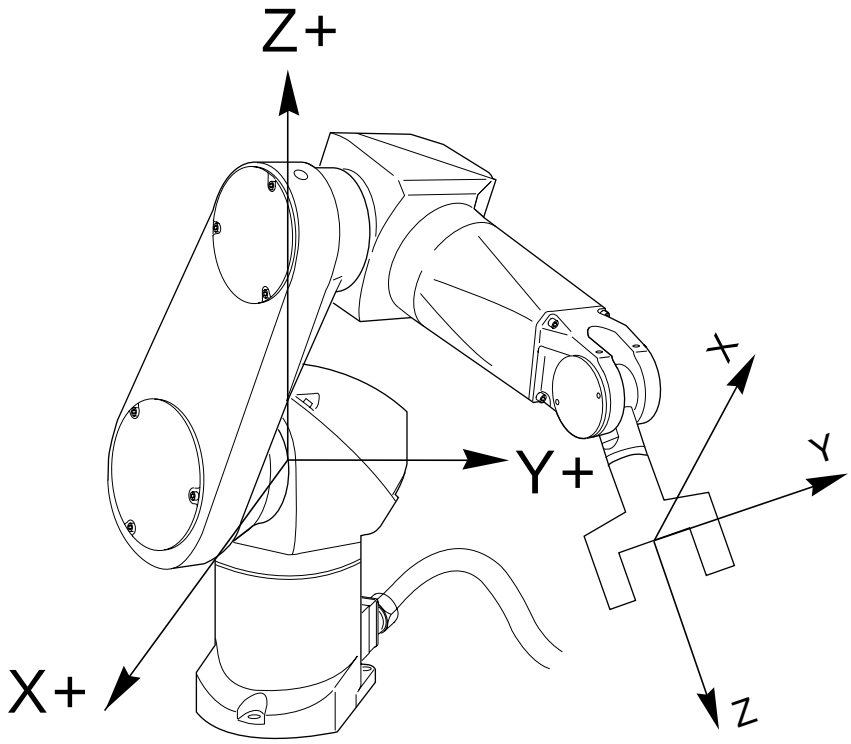


TOOL Coordinate System (TOOL MODE on the teach Pendant)

All motions are parallel to the TOOL coordinates. Joint X is attached by the groove in tool attachment clamp. The RX, RY and RZ rotations are also made with respect to the TOOL coordinates. The motions are made by the + or - speed bar keys.



3.3.5. HOW TO VISUALIZE THE CURRENT POSITION OF THE ARM



A point located in space will always be represented by 6 parameters, X, Y, Z, y, p, r.

- Value of X, Y, Z will be expressed in mm and represents the distance between the tool flange center and the origin of the base Cartesian coordinates. These values represent the robot position.

- Value y, p, r will be expressed in degrees and represents the orientation of the local tool coordinates.

See definitions in Appendix (A2).

WHERE

EFFECT Gives robot position and status of the hand at time when this command is declared.

SYNTAX **WHERE** value

If "value" given is none zero, the values are permanently displayed.
Press **^C** (**Ctrl C**) to stop it.

NOTE Points are displayed in Cartesian and revolute values.

EXAMPLE WHERE

Position %	X	Y	Z	y	p	r	
base ref. in mm	45.53	35.28	-28.42	90	-85.32	17.427	
Angular position	Jt1	Jt2	Jt3	Jt4	Jt5	Jt6	Hand
in degrees	-3.47	-85.983	84.728	-69.46	6.438	5.87	1.000

CHAPTER 4

EXECUTION AND CONTROL OF A PROGRAM

CHAPTER 4 - EXECUTION AND CONTROL OF A PROGRAM

4.1. HOW TO TRIGGER EXECUTION OF A PROGRAM

We will consider that the program was produced by an **integrator** or **an in-house programmer**, but, prior to this, we will give the writing conventions that we will use throughout this document.

For reasons of simplicity, we will use **BOLD UPPER CASE** characters to describe the commands or instructions. Mandatory parameters will be given in **bold lower-case** characters.

Optional parameters will be given in ordinary lower case characters.

Example: **EXECUTE prog name**, number of loops, step **EXECUTE PROG**, 3, 2
means that program name PROG is mandatory, but 3 and 2 are optional.

> **NOTE**
>
> Certain instructions may be entered with a minimum syntax.
>
> For example, EXECUTE --> EX, EDIT --> ED
>
> However, we request that this is only used after a certain amount of experience has been gained in programming to avoid all ambiguities and interpretation errors.

To start a program, the following command is used:

EXECUTE prog name, number of loops, 1st loop step

Example: EX TOTO, 3, 4

We wish to execute the program TOTO, 3 times successively, (a negative number would lead to the execution of an unlimited number of loops) from program step No. 4, for execution of 1st loop only.

Example : EX TOTO, 1, 2

We require execution of TOTO program once only from step No. 2 (for first loop).

Example : EX TOTO, 1 or EX TOTO

Execution of program TOTO once only from step No. 1.

> **REMARK**
>
> If execution has **already been performed** once and you wish to execute the same program, simply enter EX.

The name of a program must always:

Start by a letter and never a number.
Include a maximum number of 15 characters, alphabetical (a - z), digits (0 - 9), underlined characters (-), and possibly points (.), and be entered as upper case or lower case characters. V+ language always displays program names in lower case letters.

No other characters or spaces are permitted.

Example : Correct program name:
TOTO.PROG
TOTO.12
TOTO_Num1
However, 1TOTO or TOTO+ is incorrect
PI is incorrect (it is a key word).

The rules above are also valid for the names of the locations and real variables etc.

Also, there is a risk that certain names may be confused with certain reserved words which are given in the list that you can consult at the end of this manual.

Before triggering a program for the first time, comply with the following conditions :

- Prohibit all access to the area where the robot is working.

- Always do a no-load simulation standing by to intervene on the emergency stop pushbutton.

- Perform the first cycles at slow speed (SP 2 to SP 15 depending on application). You will always have the time to increase speed gradually.

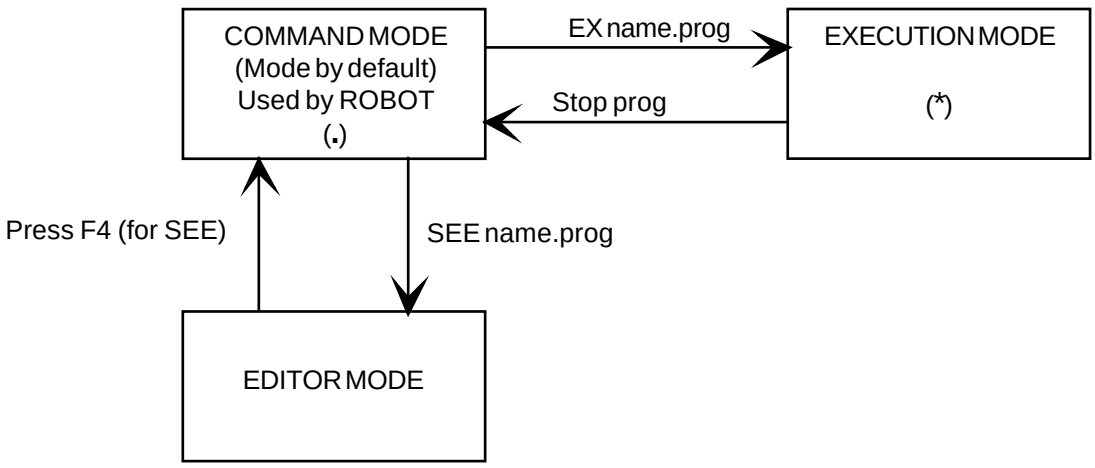
- Save your application program on disk or floppy.

We can mention here that there are two other system prompts; these are [*] and [?].
The table below summarizes the three base indications.

Indication given by robot	Mode	Action
.	Command	Only commands of DIR, FDIR, FORMAT type etc. can be given to the robot.
*	Execution	Commands of AB, PANIC type etc. can be given.
?	Edit	Only editor instructions or commands can be given (editor EDIT).

Remark: Command mode includes a buffer of 15 commands which can be selected using the and keys on the keyboard.

It is possible to move from one MODE to another as follows :



4.2. HOW TO ADJUST ROBOT SPEED

To specify on arm motion speed, you must use the SPEED command.

SYNTAX **.SPEED** value

"value" represents the robot maximum speed percentage
(value must be between 1 and 100)

This speed adjustment is called “monitor speed”

EXAMPLE **.SPEED 50** or **SP 50**
.EXECUTE TOTO

Starts the TOTO program with arm motions limited to 50% of maximum speed.

NOTE

There is no need to stop execution of program in progress to modify arm motion speed.

Example
.SPEED 10
.EXECUTE TOTO] command mode
SPEED 50 execution mode

Never specify a speed greater than the one recommended by the application.

NOTE

For certain applications (insertion, assembly, etc.), motions can be made at low speed in spite of a high monitor speed setting. Indeed, by program, a lower speed can be specified.

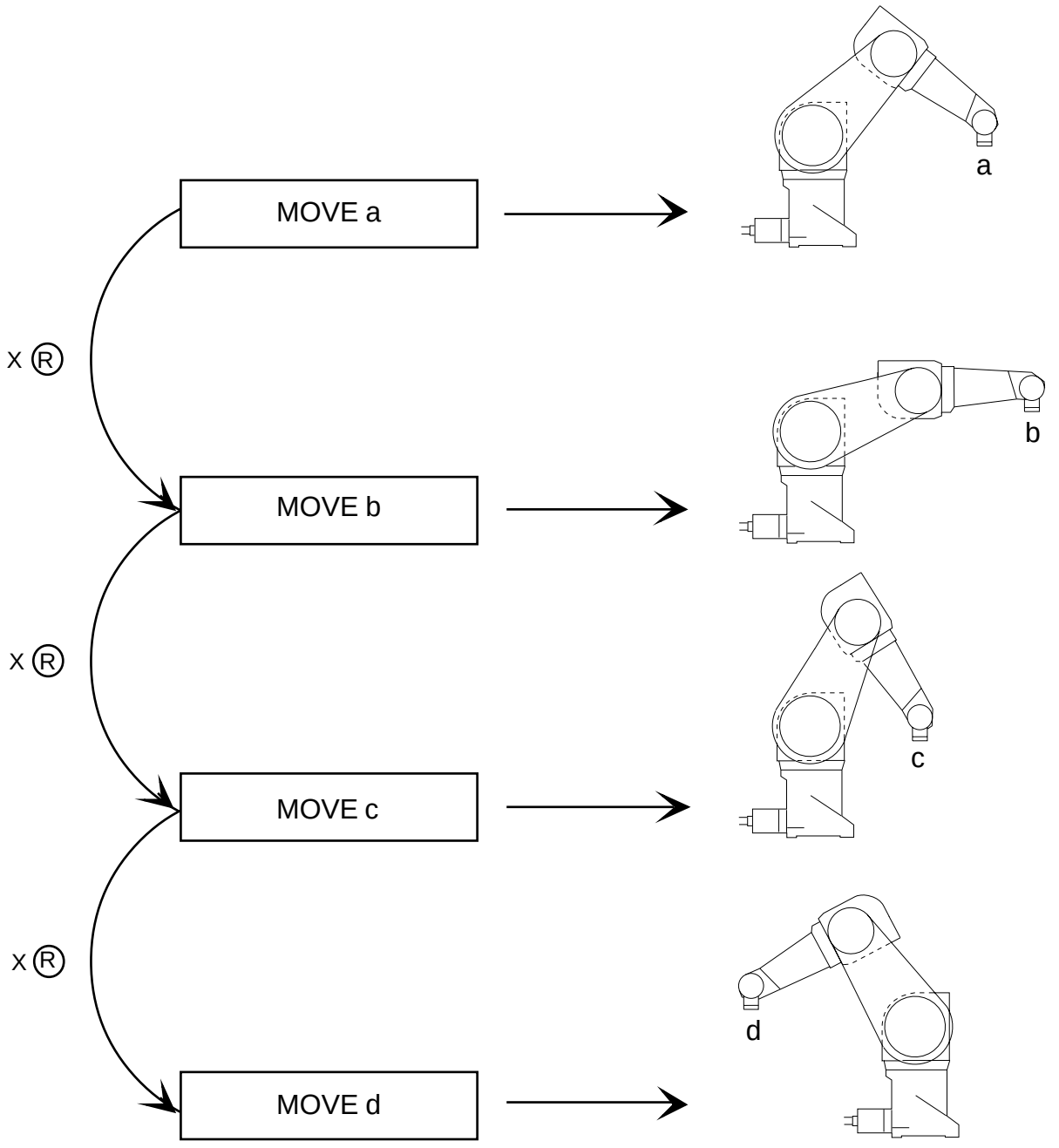
4.3. HOW TO EXECUTE A PROGRAM STEP BY STEP

By the following command:

XSTEP prog name, number of loops, Step

The description of the parameters and the action of this command are the same as the EXECUTE command that we discussed previously except that only one instruction is executed at the time.

To execute the next step, simply type **X** then hit the RETURN key.



PS : ® corresponds to hitting the - RETURN - key on the programming keyboard (or - ENTER - depending on type of keyboard).

4.4. HOW TO FOLLOW THE EXECUTION OF A PROGRAM

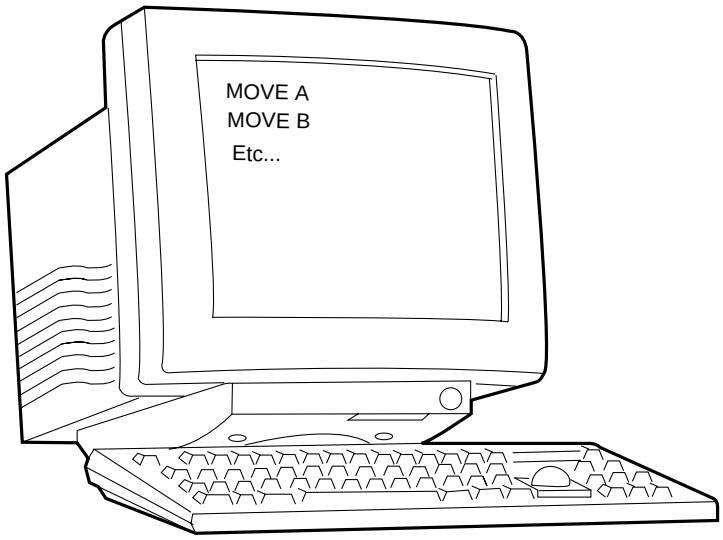
In command mode (.), type the following command:

ENABLE TRACE (EN TRACE)

The various instructions will be displayed and scrolled on the screen as execution progresses. This allows the running of the program to be followed.

To return to normal mode, use the following command:

DISABLE TRACE(DIS TRACE)



4.5 HOW TO EXECUTE A SINGLE INSTRUCTION

EFFECT All the **program instructions** that we will examine can be executed in command mode if prefix "**DO**" is added.

SYNTAX **DO instruction**

NOTE If a DO instruction is given alone when a DO instruction has already been executed, the new DO will be equivalent to the previous DO.

EXAMPLE MOVE a can be executed in command mode, if you write:

DO MOVE a

Otherwise "illegal monitor command" will be displayed.

EXAMPLE DO b = (a * 4) / 7 + 4 - 2 ((3 + 8 - 2) / 4) - 3 (Return)

The result calculated immediately when - Return - key is pressed will be assigned to variable b.

If DO (Return) is typed now, the machine will repeat all the calculations and assign them to b thus avoiding retyping of the complete formula.

4.6. HOW TO STOP A PROGRAM DURING EXECUTION

- Press the **RUN/HOLD** pushbutton on the teach pendant if you wish to immediatly stop the arm and the program,

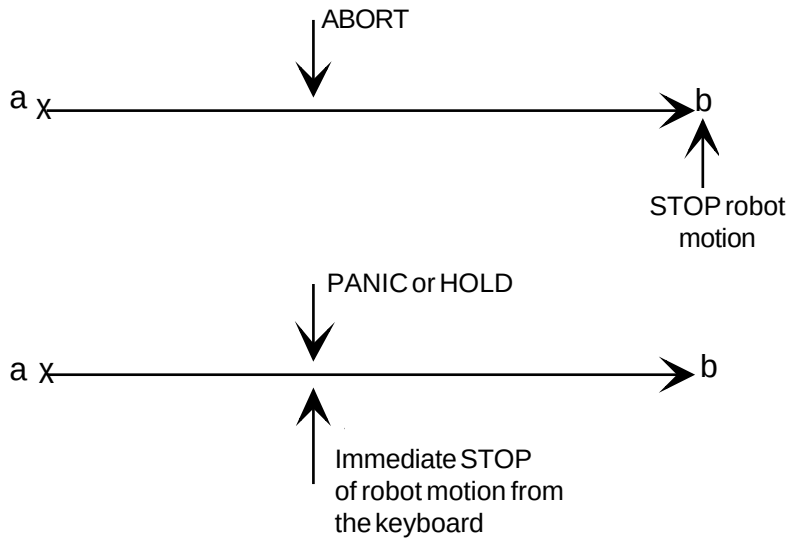
or

- Enter **ABORT** via keyboard if stop is to be made at end of execution of instruction in progress,

or

- By typing **PANIC** via keyboard if immediate stop is required.

This command has the same function as pressing the MAN/HALT pushbutton.
Under internal software control, it causes immediate stop in the robot motion and stops the execution program from the screen/keyboard.

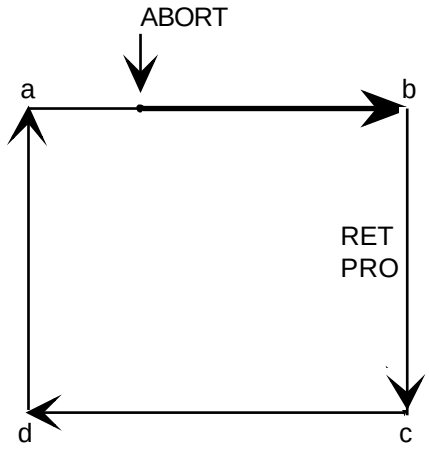


4.7. HOW TO RESTART A PROGRAM

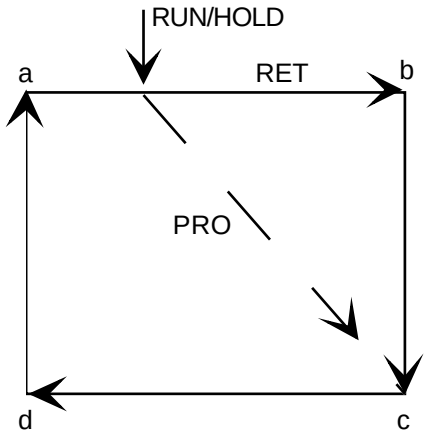
Two cases can occur.

4.7.1. STOP BY ABORT

Either RETRY or PROCEED can be used.



4.7.2. STOP BY RUN/HOLD OR MAN/HALT ON TEACH PENDANT



4.8. MULTITASKS PROGRAMS

The V+ system is able to execute several tasks at the same time.
7 tasks (0 to 6) are available in the standard version and 28 tasks (0 to 27) in the V+ extension version.
The syntax of the declaration in multitasks functionning is the following:

By default num_task=0

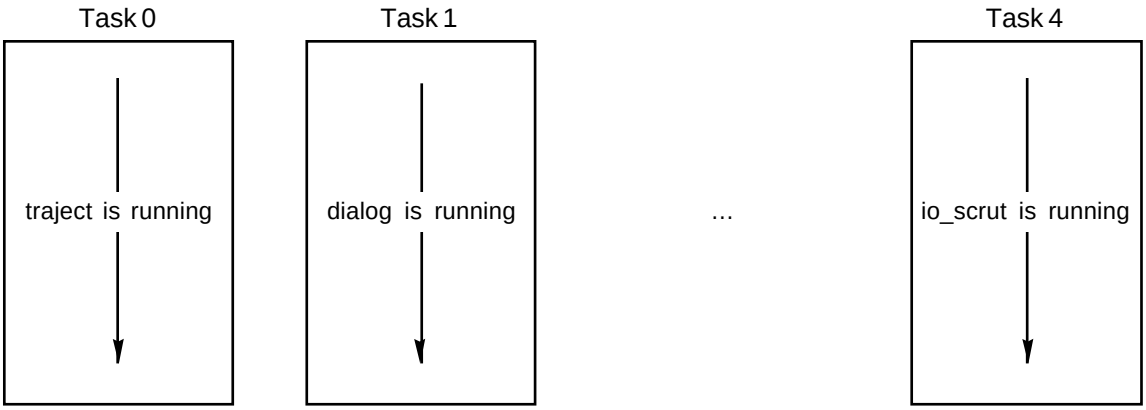
EXECUTE num_task Program name, cycles, step

ABORT num_task

PROCEED num_task

RETRY num_task

Example :
- EXECUTE traject
- EXECUTE 1 dialog
- EXECUTE 4 io_scrut



STATUS

EFFECT Gives the internal status of the robot, that is:
- The program being executed,
- Program step,
- Number of cycles performed, task status, etc...

SYNTAX **STATUS** value

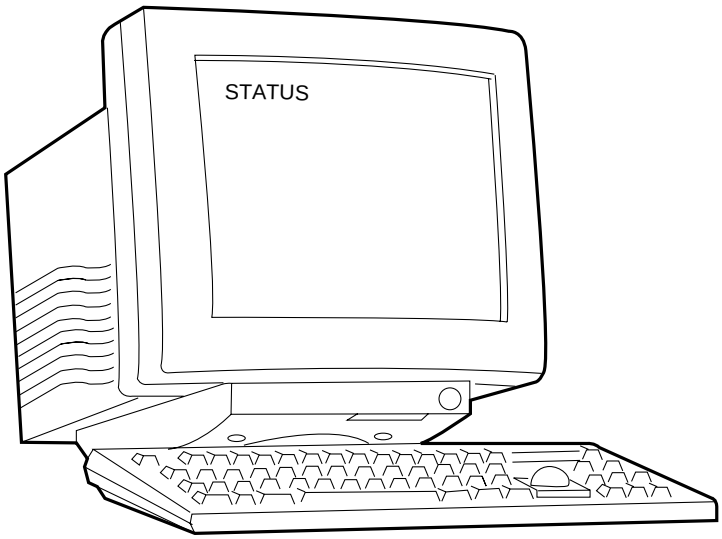
Where value can take value -1, 0 (or positive number)

Value at -1 :
Status of all active tasks are displayed continually until CTRL+C is pressed.

Value at 0 (or positive) :
Indications are shown once only.

NOTE If value is omitted, indications are shown once only.

EXAMPLE STATUS



KILL

TYPE Instruction or monitor command

EFFECT Clears the program execution stack and detaches any I/O devices that are attached.

SYNTAX KILL task.num

PARAMETER

task.num Integer specifying system task (0, 1, 2, etc.) to be activated. Default value: 0.

REMARK The KILL command is only valid when the specified program is not being executed (program terminated or aborted by ABORT task.num).

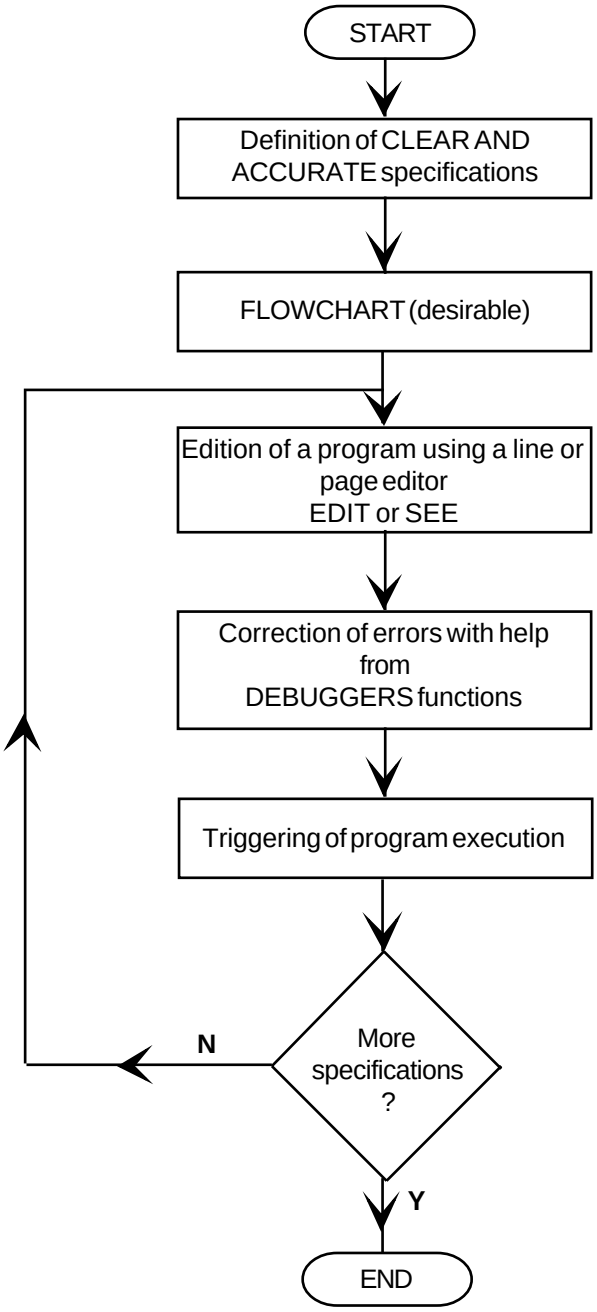
CHAPTER 5

EDITOR

CHAPTER 5 - EDITOR

5.1. PRELIMINARY

Before the editor of a program, a great time in developpement of an application is dedicated to the **analysis** of it.



The analysis will permit to write a well structured program, easier to read and understand and easier to maintain.

5.2. HOW TO EDIT A PROGRAM

An editor allows you to :
- Modify a program.
- Insert new instructions.
- Delete instructions.
- Search for certain instructions, etc..

There are 2 editors :
- A line editor: **EDIT**
- A full-page editor: **SEE**

5.2.1. LINE EDITOR: **EDIT**

This editor is dealt with in the appendix for persons well acquainted with VAL language.

The LINE editor (EDIT prog.name) is less powerful than the PAGE editor (SEE prog.name), but it is the only editor which allows the robot to be placed in TEACH MODE.

The teach mode allows you to easily teach the robot a trajectory to be followed in its work envelope. To change to teach mode, proceed as follows:

Enter **EDIT prog.name**

When in EDITOR MODE (?) type T name.location ®
(or TS name.location ® to obtain the segments of the straight lines).

Record the instructions and the associated positions which make up the trajectory that the robot must reproduce by pressing the RECORD pushbutton on the teach pendant (REC/DONE).

To quit the teach mode, press - RETURN - and quit line editor by typing E ®

5.2.2. FULL-PAGE EDITOR: **SEE**

This editor has higher performances.

We shall now look at the main PAGE editor commands.

If you are in command mode (.), go to editing mode by entering:

SEE prog.name

If prog.name is not resident in system memory, you are asked to create it on the bottom of the screen.

«Prog.name» doesn't exist. Create it ? Y/N

If you reply «Y», the program will be created and the SEE editor cursor will move towards the top of the editing window automatically entering the line specifying the program name.

. PROGRAM Prog.name ( )

and program creation can start.

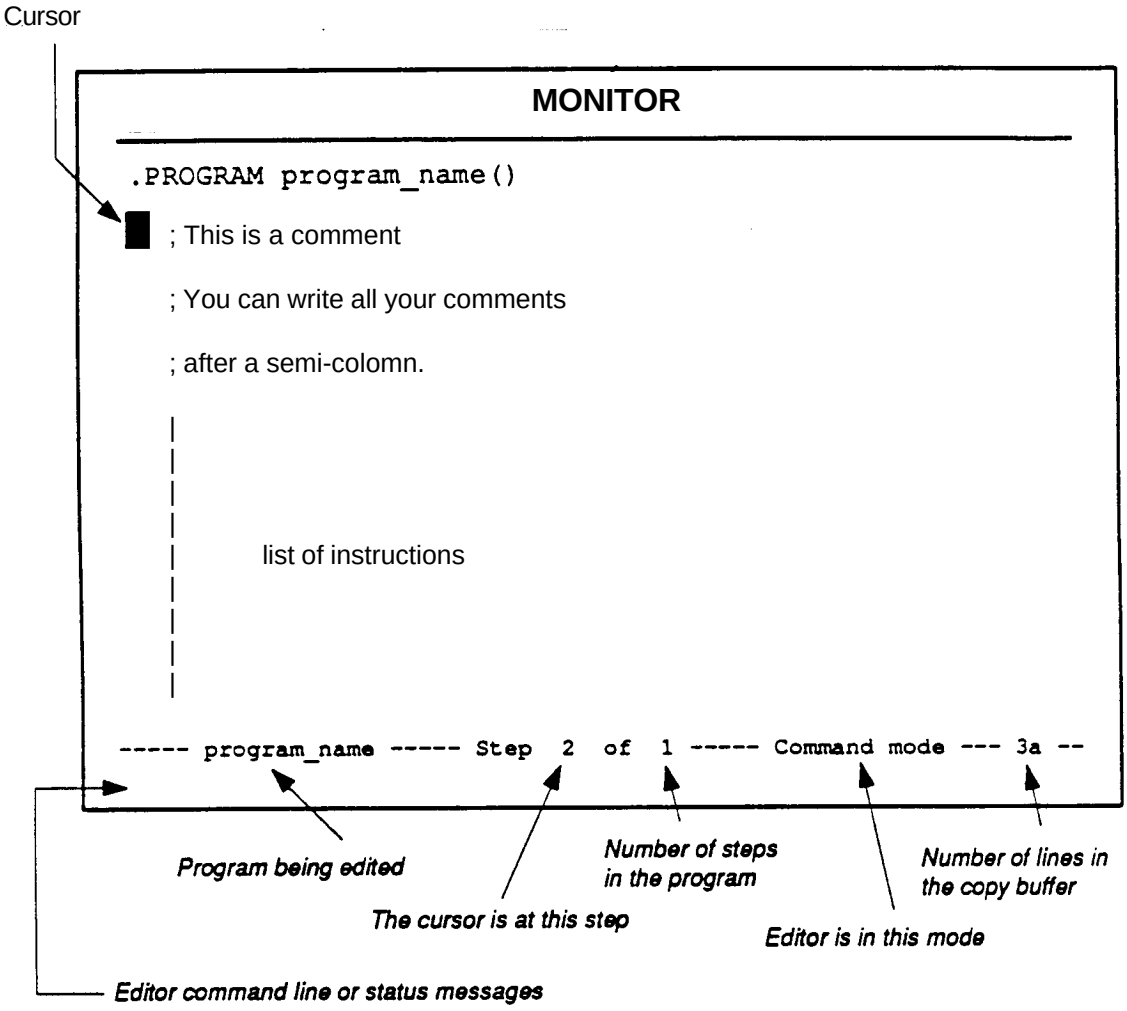
If you reply «N» or press the - RETURN - key, you will return to the system and the named program will not be created.

If «prog.name» is omitted, last edited or executed program is recalled.

ADVICE:

Try to avoid lines exceeding the editing window's width (80 columns), since the whole line will not be visible, and program flow and readability may be difficult to track.

The following page editing window will be displayed:



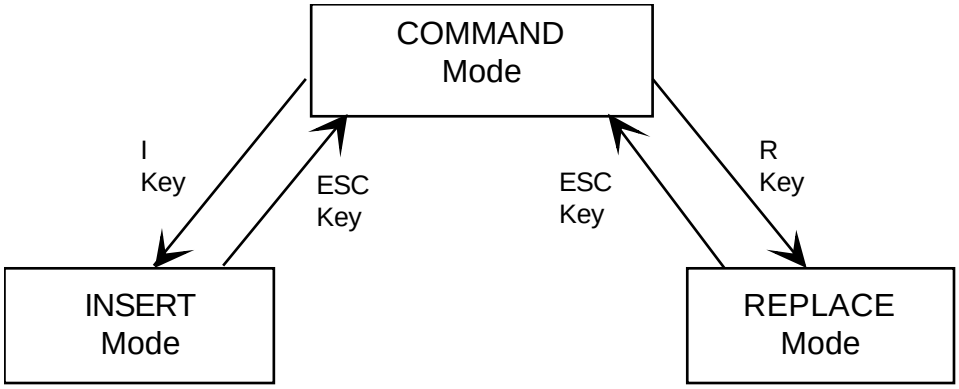
The SEE editor has three main editing modes : COMMAND, INSERT and REPLACE.

The COMMAND mode is the mode initially taken by the editor. In this mode, new program code is not entered, only special editor commands are active.

The INSERT mode allows **new characters to be inserted** into the program at the position where cursor is placed. The cursor and existing codes move to the right of the screen.

The REPLACE **mode allows existing text** to be replaced by new text. The character entered replaces the one located above the cursor, the cursor moves to the right of the screen.

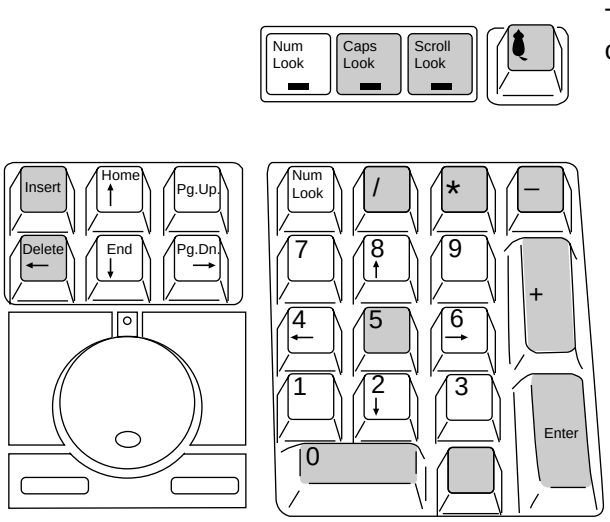
CHANGE OF MODE

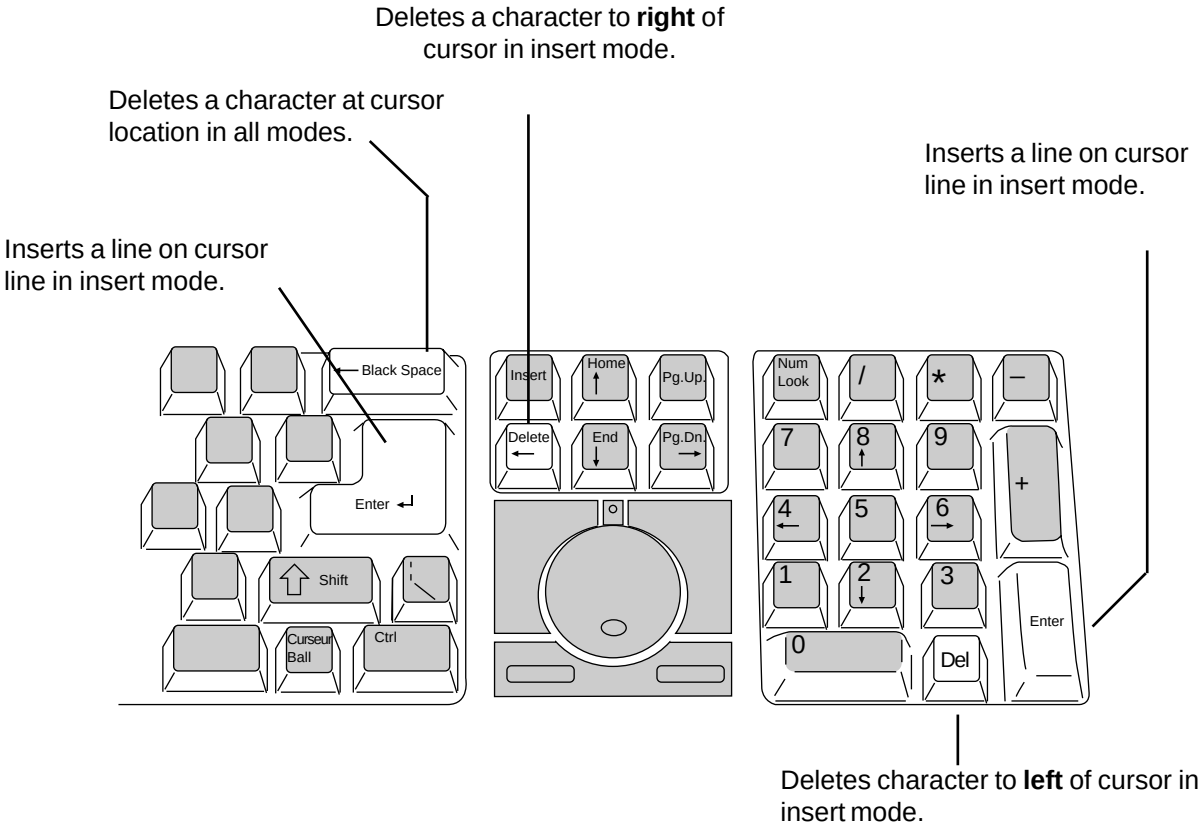


Note Other LINE EDITOR commands exist, they are given at the end of this manual (appendix).

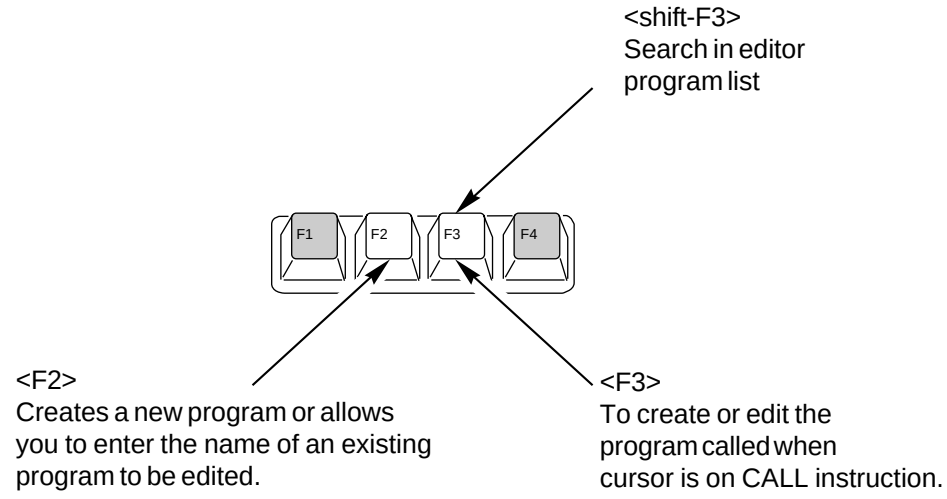
5.3. EDITING FUNCTION KEYS OF THE SEE EDITOR

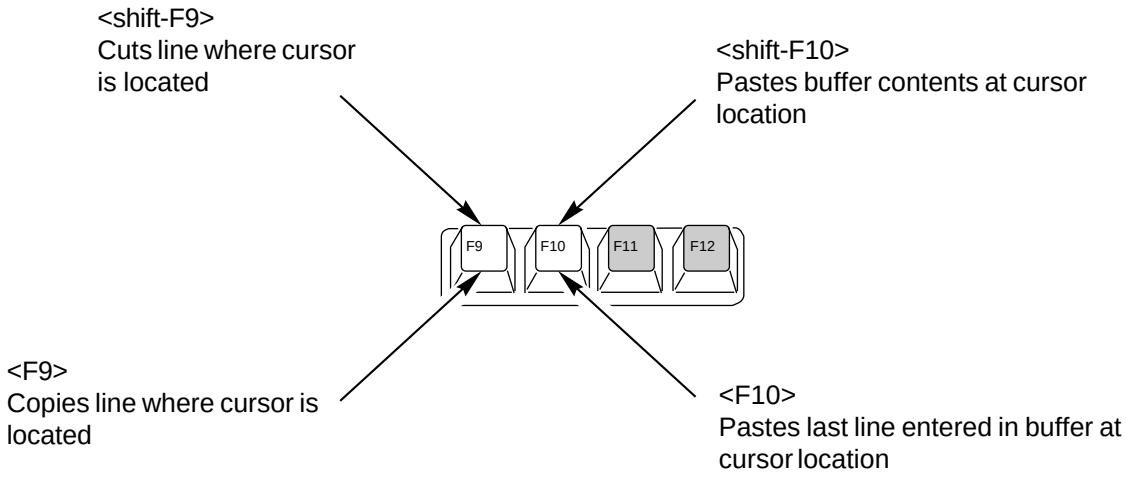
5.3.1. CURSOR CONTROL



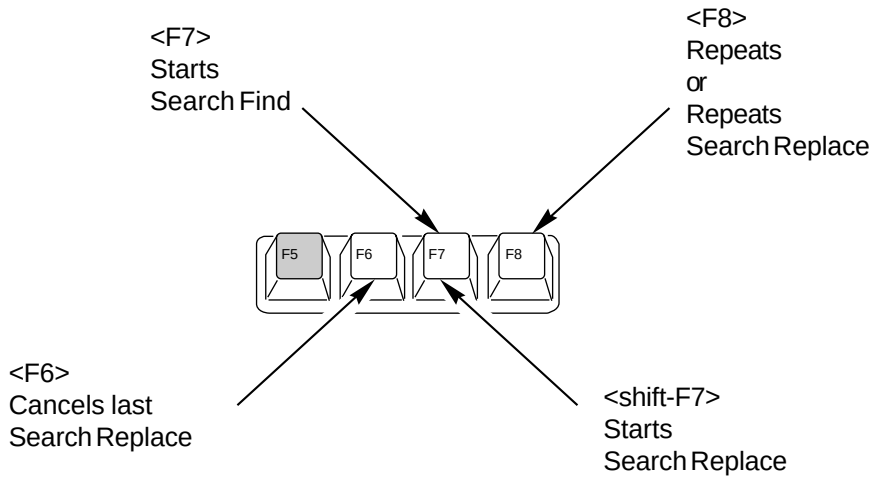


5.3.2. EDIT MULTIPLE PROGRAMS





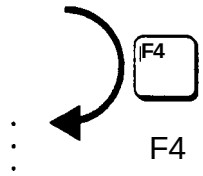
5.3.3. SEARCH, FIND AND REPLACE



5.3.4. TO QUIT EDITOR

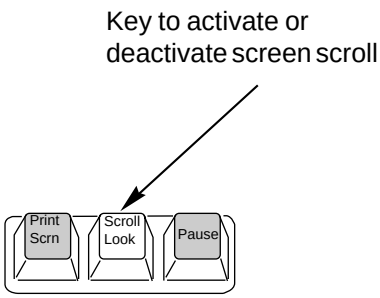
Simply press key F4.

Caution: Make sure that buffer (copy, cut, paste) is empty.



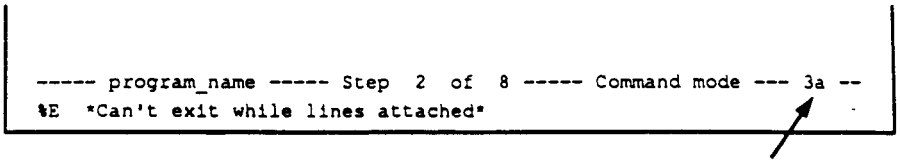
For the robots equiped by a WYSE terminal, press <CTRL-E>, it means press simultaneously "CTRL" and on key E.

5.3.5. EDITOR ENVIRONMENT PROBLEMS



If this task has already been used, then display is locked and a red band is displayed on top of the screen.

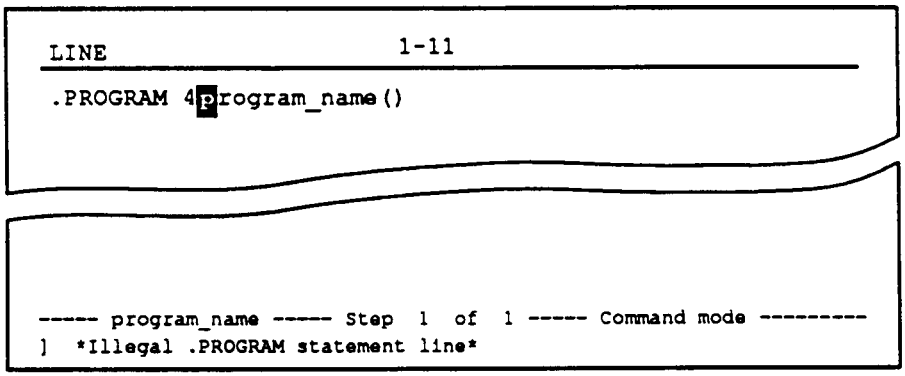
Attempt to exit editor when buffer is not empty.
When you have pressed function key F4, the following will be displayed :



To solve the problem, proceed as follows:

1. Enter number of attached lines
2. Press Ctrl + K

Attempt to change program_name with editor



Function key to solve problem

CHAPTER 6

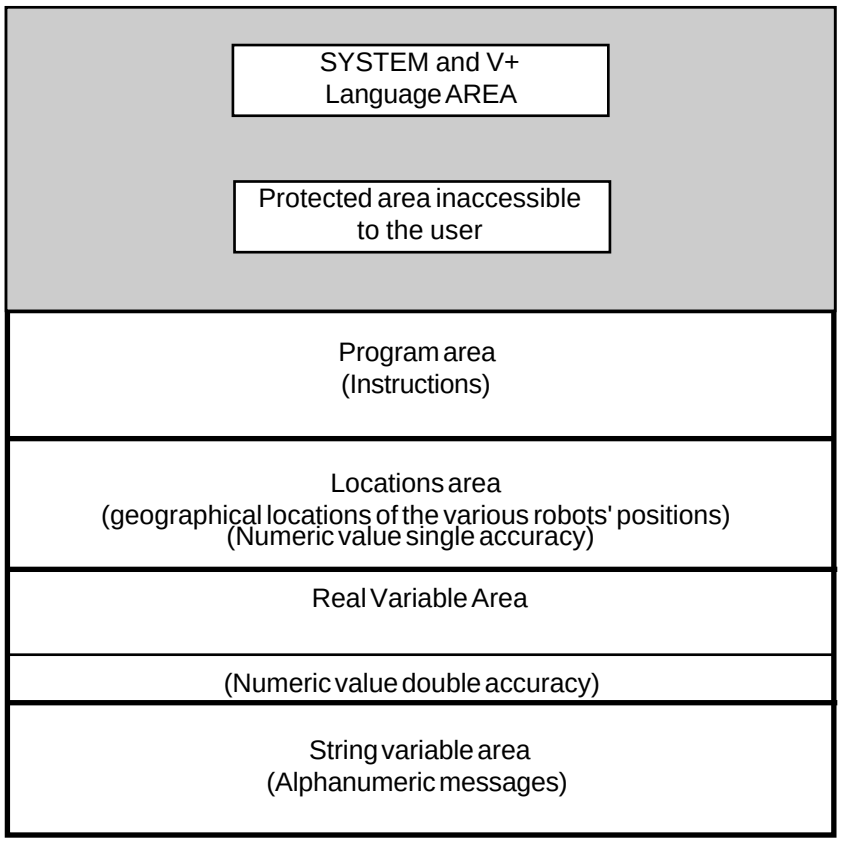
DECLARATION OF VARIABLES AND OPERATIONS ON MEMORY

CHAPTER 6 - DECLARATION OF VARIABLES AND MEMORY OPERATIONS

All programs loaded using the editor are stored by the robot controller in the RAM-CMOS memory.

The same applies to the real variables, locations and string variables associated with the user programs (still called application programs).

Before triggering the program, you must define the various location variables which make up the program and initialize the real, string variables, etc. that you will use.



Caution: names of LOCATION variables must be different from names of real variables.

Example: MOVE a

~~a = 3.14~~ use variable b = 3.14

6.1 REAL VARIABLES

This consists of assigning an integer (eg: 123) or a real value (eg: 1.238) to a name.
V+ considers that integrals are specific real value cases. **INTEGERS** must be between -16 777 216 and 16 777 215.

Example : DO a = 12 (Monitor command)
a = 12 means that 12 has been assigned to variable named a (Program instructions).

It also means that 12 is the content of variable a.

In the V+ case, the value must mandatorily be between:
+/-3.4 * 10^{38} or under the "scientific notation" +/-3.4E + 38

The real values are stored with an accuracy of around 7 digits after the decimal point, however, rounding off generated by the computer must be taken into account.

Remember that, for example, 2.1 * 10^{6} corresponds to the number 2 100 000 and 2.1 * 10^{-6} is equal to 0.0000021.

This type of notation is called the scientific notation.

What mathematical operations can be performed on real variables?

OPERATORS	SYMBOLS	EXAMPLES
Addition	+	x = 3 + 2
Subtraction	-	x = (3 + 2) - 1
Multiplication	*	x =((3 + 2) - 1) * 4
Division	/	x = ((3 + 2) - 1) / 5
Modulus	MOD	x = 39.3 MOD 7.4 -> x = 2.3

Other operators and functions are available but do not fall within the scope of this course and will be examined in the level 2 V+ course.

A numerical expression consists of numerical functions, constants and variables.

EG: x = ((3 + 2) - j) * 3.14

When forming numerical expressions you must bear in mind that certain operations are performed before others and especially that expressions between the most nested parentheses are always performed first.

EG: a = a + 1 is possible in computer language. It takes the value in memory, perform the calculation and store the result at the same place. The previous value is lost !

6.2 STRING VARIABLES

A string of alphanumerical characters is assigned to a variable preceded by a $ (dollar).

SYNTAX $name = "alphanumerical characters"

EXAMPLE $reply = "reply by Yes or No"

NOTE The name of the variable following the "$" must not have more than 15 characters (other characters will be truncated without warning).
Each variable name must start by a letter and can contain only letters, numbers, points and underlined characters.
Characters can be entered in upper case and/or lower case, the system will display and consider them as lower case characters.
Avoid using names belonging to the list of keywords as variable names (see appendix at the end of the document).
The content of a character string must not exceed 126 characters and must not contain « characters (quotes to avoid confusion with delimiters).

WHAT OPERATIONS CAN BE PERFORMED ON STRING VARIABLES ?

Strings can be concatenated.

EXAMPLE $Total.1_compt = "All" + "Is" + "Well"...» will be equivalent to:
$Total.1_compt = "All is well..."

6.3. LOCATION VARIABLES

6.3.1. CARTESIAN LOCATIONS / PRECISIONS LOCATIONS

A precision point is a location whose coordinates are not expressed in Cartesian coordinates (in mm with respect to the X, Y, Z axes, etc.) but in degrees with respect to an absolute position specific to each joint.

It is recognized or declared as a precision point when # is added in front of the location name.

Example : #a and a are two separate locations.

One is defined in angular coordinates (#a).

The other is defined in Cartesian transform coordinates (a).

	JT1	18°		X	120 mm
	JT2	-123°		Y	12 mm
#a	JT3	+14°	a	Z	5 mm
	JT4	90°		y	90°
	JT5	-90°		p	-90°
	JT6	0°		r	0°

The advantages of precision points are :

Precision points describes the configuration of the arm.
Precision points prevent axis alignment problems on 6-axis robots (singularity).

The disadvantages of precision points are:

No correlation with the metric system as dimensions are not expressed in mm.

6.3.2. DEFINE A LOCATION IN MONITOR COMMAND MODE

For this, use the **POINT variable.name** command

Example: **POINT a** (Return)

X/JT1	Y/JT2	Z/JT3	y/JT4	p/JT5	r/JT6
0	0	0	0	0	0

CHANGE ? 10,30, - 15,18 (Return)

X/JT1	Y/JT2	Z/JT3	y/JT4	p/JT5	r/JT6
10	30	-15	18	0	0

CHANGE ?(Return)

You have assigned dimensions X, Y, Z, etc. to a location named a.

This instruction is only active in command mode.

This instruction is also available for precision locations.

Example: Definition of the TOOL transformation.

6.3.3. HOW TO MOVE THE TOOL REFERENCE SYSTEM

Why move the tool frame to the tool extremity ?

It is always good practice, during an industrial application, to position the tool coordinates not at the centre of the tool flange (default setting), but to the end of the tooling:

- It makes the teaching of locations easier: minimize the manual motion operations;
- It allows to control the position and the speed of trajectory at the tool extremity;
- When using a cutting tool, it's easier to correct its geometrical characteristics than to teach again all locations of the application.

If the geometrical and dimensional characteristics of the tool to be fitted to the end of the wrist are known, it will be easy to move the tool coordinates with the following instruction...

TOOL

EFFECT Moves the **tool coordinates** from the tool flange center to the end of the tooling.

SYNTAX **TOOL** offset

TOOL is one of the rare instructions which can be used in program mode and command mode.

This instruction is essential to control the actual extemity of the effector.

NOTE To verify the accuracy of your tool transformation, use manually the Rotations RX, RY, RZ in tool mode of the teach Pendant.

CAUTION **TOOL NULL cancels previously defined transformation, a NULL transformation displays the following values**

X	**Y**	**Z**	**y**	**p**	**r**
0	**0**	**0**	**0**	**0**	**0**

EXAMPLE **.POINT offset**

(Introduce the transformation values)

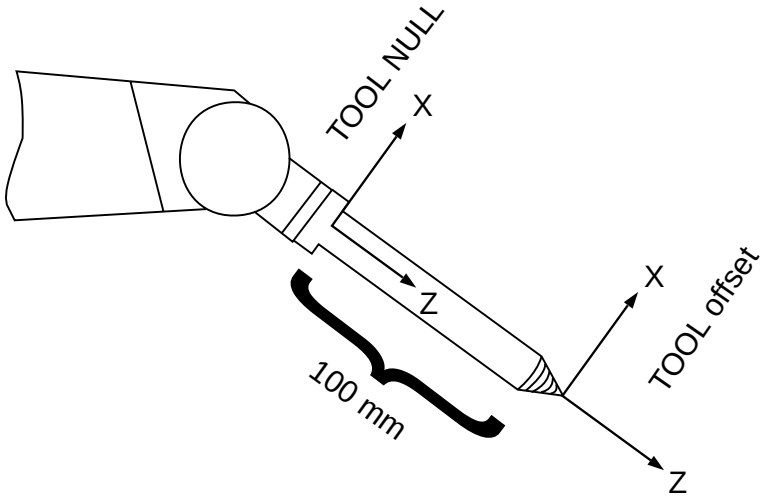
	X	Y	Z	y	p	r
offset	0	0	0	0	0	0

CHANGE ? 0, 0, 100

X	Y	Z	y	p	r
0	0	100	0	0	0

.TOOL offset

These 2 commands the tool coordinate system will place at 100 mm from the robot flange. LISTL TOOL gives the displacement values of the current TOOL transformation.



6.3.4. HOW TO DEFINE A LOCATION BY TEACHING

Move the robot to the required position and enter via keyboard :

HERE a (Return)

X/JT1	Y/JT2	Z/JT3	y/JT4	p/JT5	r/JT6
120	12	-80	85	-40	0

CHANGE ? (Return)

When the RETURN key is pressed, the current robot arm position coordinates are assigned to location a.

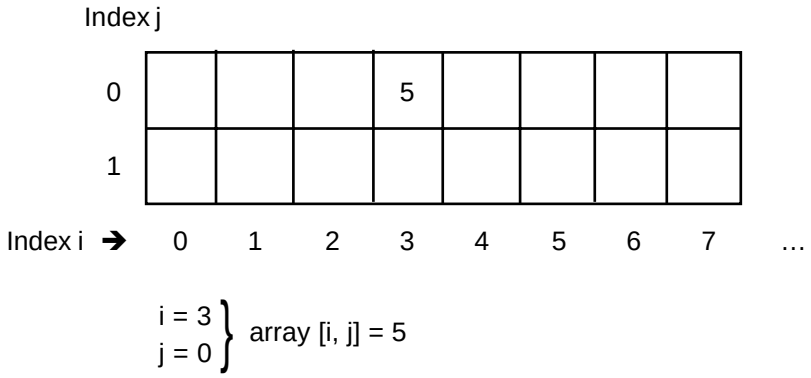
This command is also available for precision locations: HERE #start

Unlike POINT, the HERE instruction is active both in command and program modes.

6.4. INDEXED VARIABLES:ARRAYS

Names of real variables or locations or strings can accept square brackets to indicate that they are dimensioned variables (still called indexed variables). Dimensioned variables can be of orderes 1, 2 or 3.

Example of 2 dimensions array:



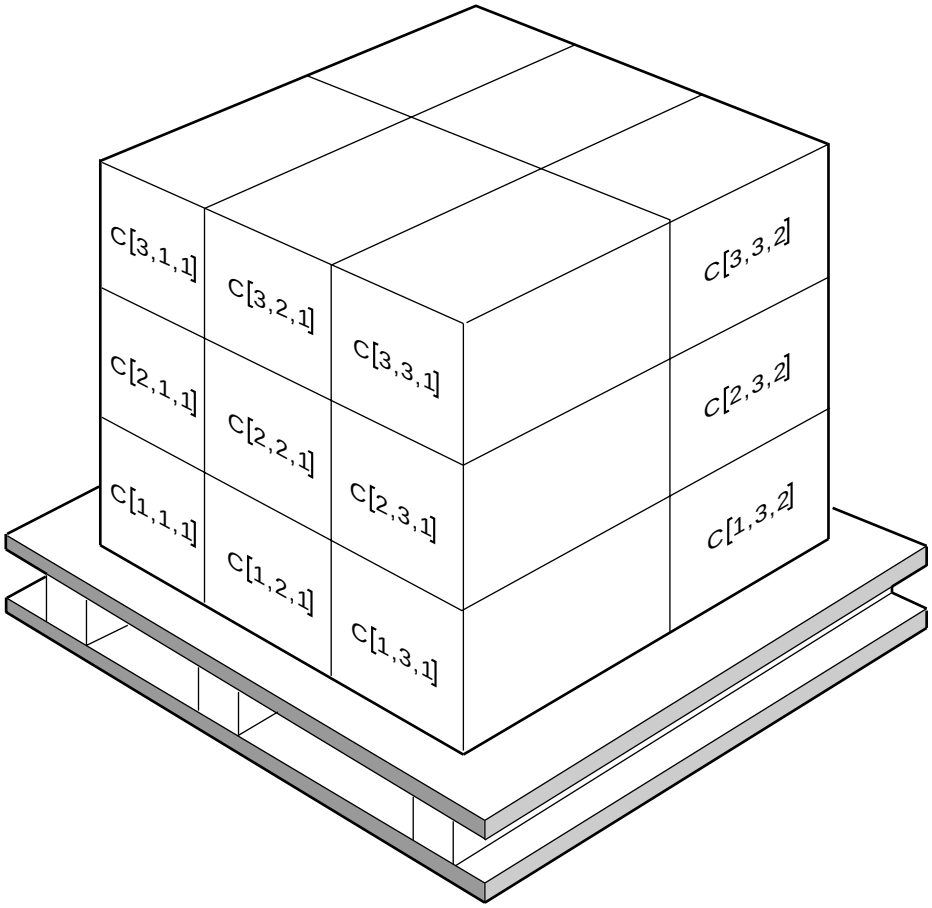
EXAMPLE b [1]=56.89

EXAMPLE HERE c [1,4,7]

EXAMPLE $a [1,6]="I've understood..."

NOTE Location, real and especially string indexed variables take up a lot of memory space. They must only be used when necessary.

These variables are very useful for defining tables of numbers or positions.



We can see that :

The first index between square brackets represents position in height.
The second index represents the width.
The third index represents the depth.

This makes it very easy to locate a packet on a pallet.

Also, a variable or a mathematical expression can be used for the index instead of a numerical value which can sometimes make the program easier to write.

TEACH

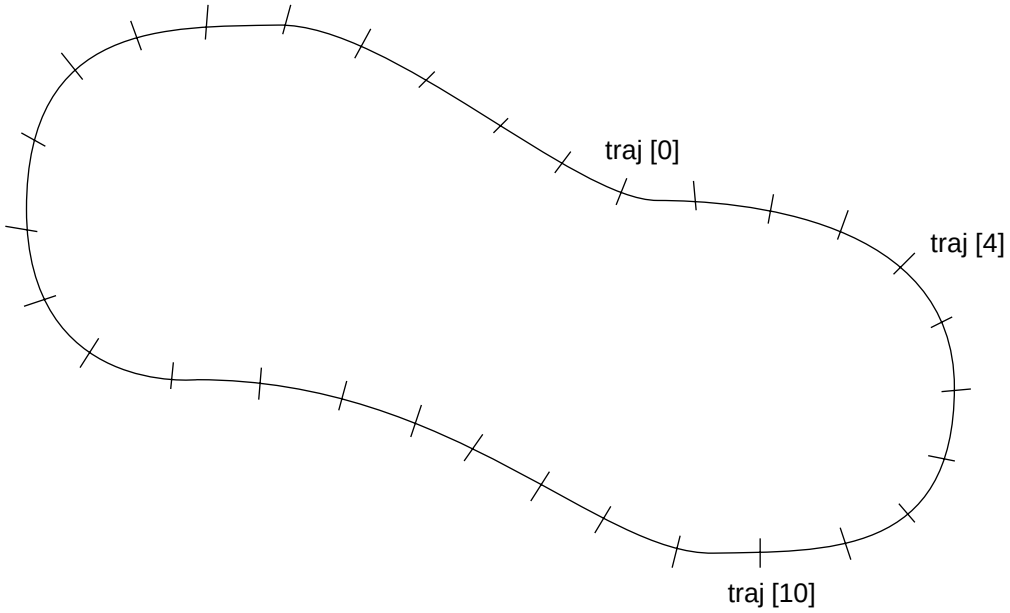
TYPE Monitor Command

EFFECT Very useful and fast for teaching a lot of locations along a trajectory

SYNTAX **TEACH loc.name[**index**]**

NOTE index can take any positive integer value

EXAMPLE **TEACH traj[ ] (RETURN)**



The REC/DONE key is blinking on the teach Pendant :

Each time you press the REC/DONE key, the system memorises the location. The index is automatically increased at each memorization.

	X/J1	Y/J2	Z/J3	y/J4	p/J5	r/J6
traj[0]	_	_	_	_	_	_
traj[1]	_	_	_	_	_	_
traj[2]	_	_	_	_	_	_

To exit from teaching, just press ENTER key on the keyboard.

6.5. MEMORY OPERATIONS

The following monitor commands will be very useful to manage the system and debug programs.

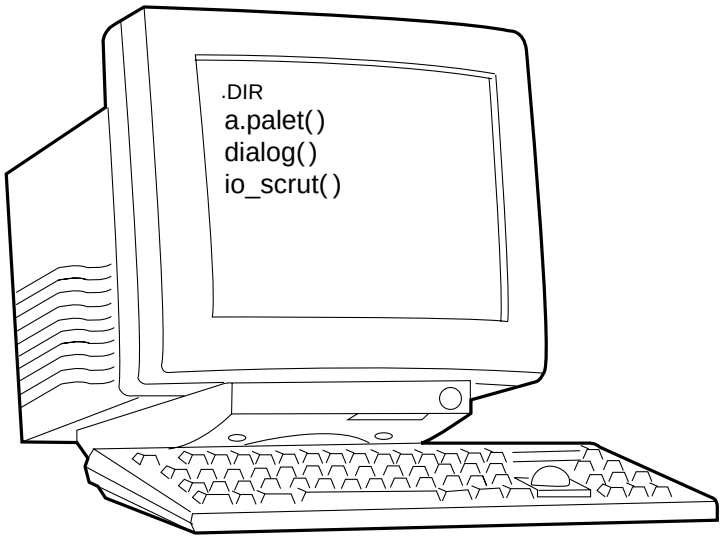
DIR

TYPE Monitor Command

EFFECT Display program titles

SYNTAX **DIR**

EXAMPLE DIR
The following will be displayed on the screen:
.PROGRAM a.palet( )
.PROGRAM dialog( )
.PROGRAM io_scrut( )
These are the titles of the various programs and not the contents.



LIST

TYPE Monitor Command

EFFECT Display memory contents
This can only be done in command mode (.)

SYNTAX **LISTP** to display program contents.

EXAMPLE LISTP prog3, paint
will display on screen:

```
.PROGRAM prog3()
1       MOVE a
2       MOVE b
.END

.PROGRAM painting()
1       MOVE k
2       MOVE g
.END
```

SYNTAX **LISTL** to obtain a display of various location coordinates.

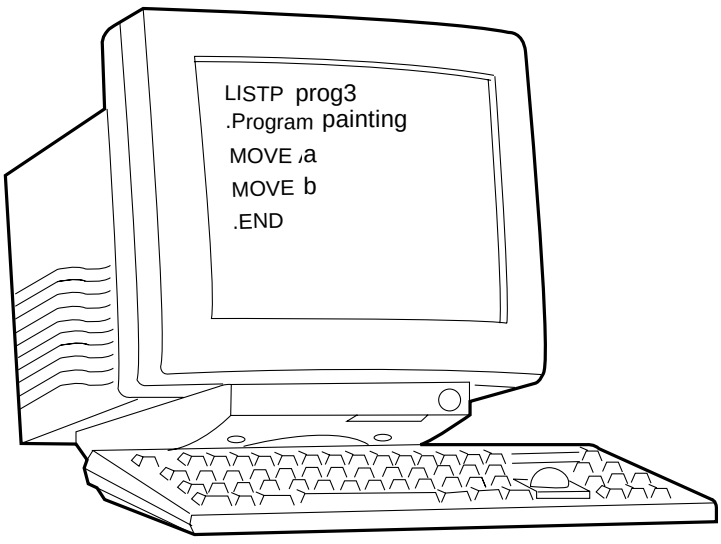
EXAMPLE LISTL #a,b,c, etc..

SYNTAX **LISTR** to obtain content of real variables.

EXAMPLE LISTR x,y,z, etc..

SYNTAX **LISTS** to display string variables.

EXAMPLE **LISTS** $name, $toto



NOTE: TERMINAL CONTROL CHARACTERS

(Screen-Keyboard)

These control characters are operative when the CONTROL key and the corresponding alphanumeric key are pressed. They facilitate reading of programs on screen.

EXAMPLE For ^C, simply press the "CTRL" key and the C key.

- ^C Stops execution of DIRECTORY, LISTP, STORE instructions, etc., but not the execution of the program in progress.

- ^S Stops scrolling of a program on display.

- ^Q Restarts scrolling interrupted by ^S.

} or SCROLL lock key

- ^W Slows down scrolling to make contents easier to read.
A second ^W will return you to previous state.

NOTE The codes above are not active on all terminals.

COPY

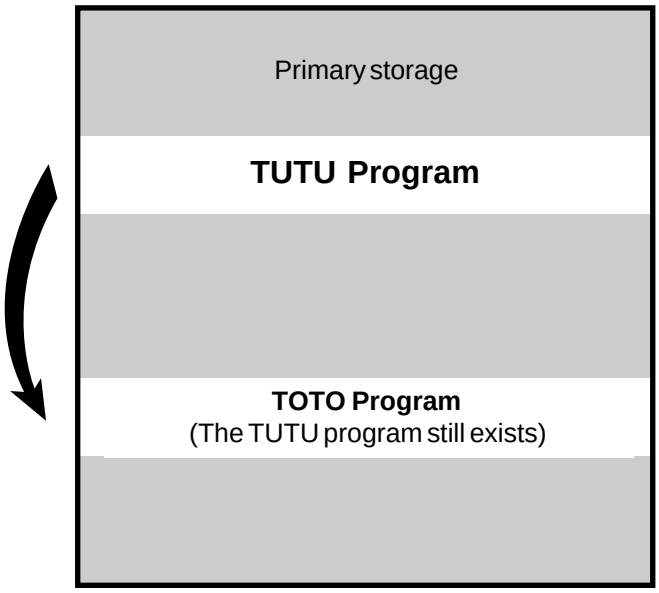
TYPE Monitor Command

EFFECT Copy programs

SYNTAX **COPY new prog name = old prog name**

EXAMPLE COPY TOTO = TUTU

You will obtain a copy of the TUTU program called TOTO.



RENAME

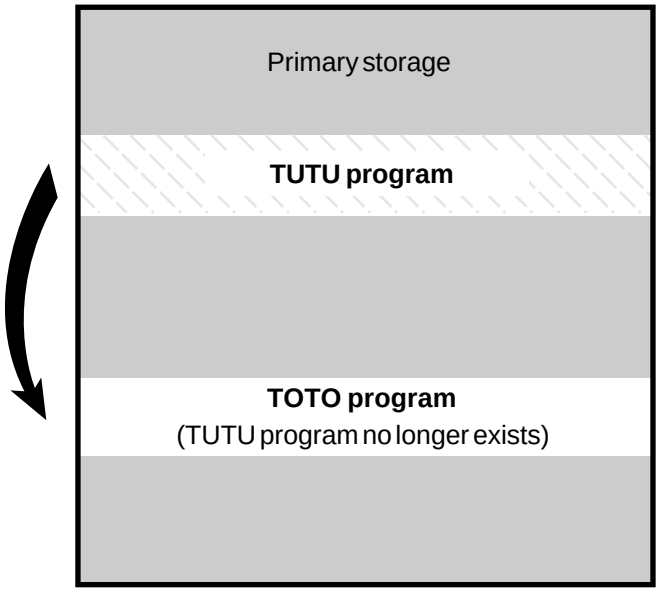
TYPE Monitor Command

EFFECT Rename programs, locations, real variables, etc

SYNTAX **RENAME new prog name = old prog name**

EXAMPLE RENAME TOTO = TUTU

After this instruction has been executed, TUTU PROG is called TOTO.



DELETE

TYPE Monitor Command

EFFECT Delete programs, locations, real, variables, etc

SYNTAX **DELETE prog 1 [,..., prog n] for programs, locations, associated variables.**

EXAMPLE DELETE prog1,TITI, etc.

SYNTAX **DELETEP prog 1 [,..., prog n] for programs,**

EXAMPLE DELETEP TOTO will delete TOTO.PG

SYNTAX **DELETEL locations [,...locations] for locations.**

EXAMPLE DELETEL A,#P1, B6

Deletes location A, #P1 and B6.

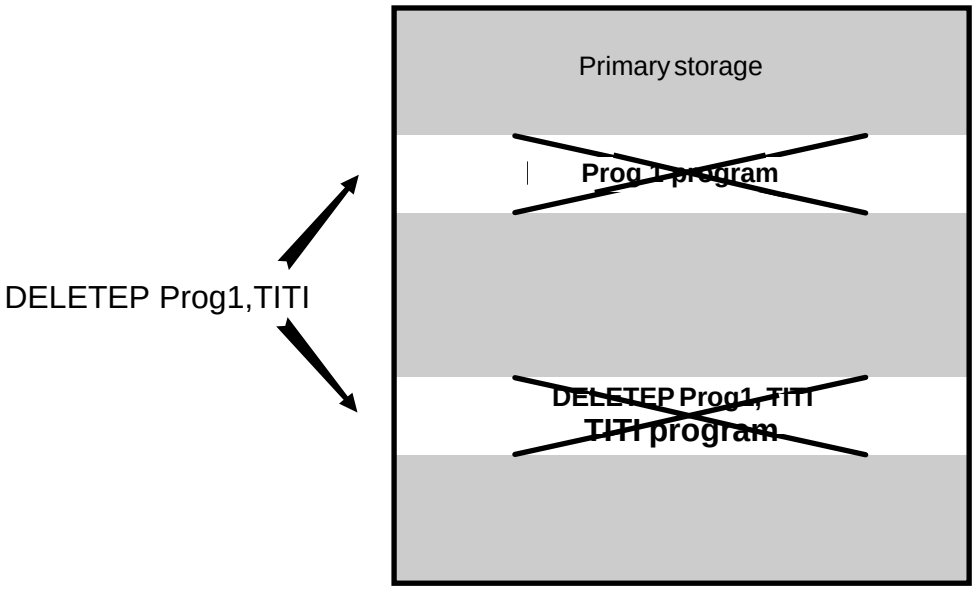
SYNTAX **DELETER real variable [,..., real variable] for real variables.**

EXAMPLE DELETER C,D,A[1].

If we had simply written A [ ], all A[1], A[2],..., A[n] dimensioned variables would have been deleted.

SYNTAX **DELETES string 1,[,...,] for strings.**

EXAMPLE DELETE $A,$YU



ZERO

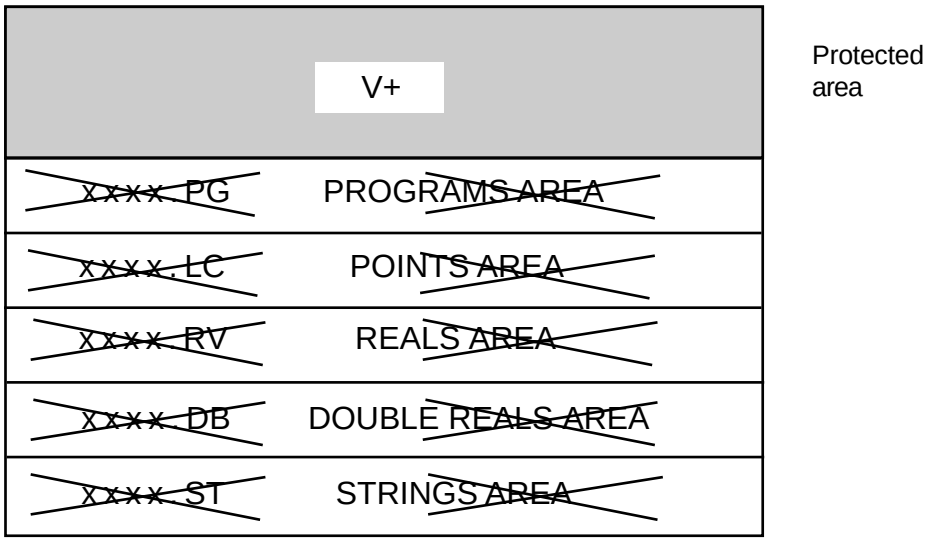
TYPE Monitor Command

EFFECT Dumps total memory contents and external inputs/outputs.

SYNTAX **ZERO**

The machine will reply : ARE YOU SURE (Y,N) ?

NOTE ZERO obviously cannot be incorporated into an Autostart program.



CHAPTER 7

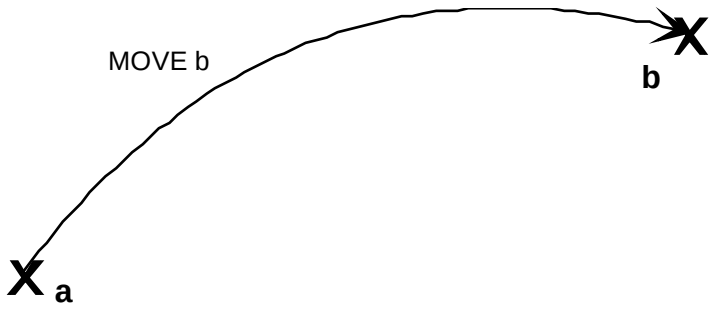
SOME MOTION PROGRAM INSTRUCTIONS

MOVE

EFFECT This instruction commands the robot to move to an indicated location along a trajectory not imposed by the user.

SYNTAX **MOVE location.name**

EXAMPLE



NOTE **The V+ software is based on a multitasking structure.**

The software executes, in parallel, an application program including robot arm motions and an input/output management calculation program.

Also, during execution of the various motion instructions, the robot will not wait for the end of the motion in progress to analyze and execute mathematical operations, input/output operations, etc. This may lead, if care is not taken, to the execution of unexpected motion instructions.

Hence, caution :

In the V+ software, remember that if instructions which do not make reference to motions are inserted between motion instructions, these will be executed in parallel with the motion.

EXAMPLE

```
MOVE a1
MOVE a2
x = h + 34.56      ;Calculation instruction
SIG 1              ;Instruction setting output No. 1 to logic 1
t = x + 56         ;Calculation instruction
MOVE b
...
```

We can see that instructions x, SIG 1, t will be executed **during motion to point a2**.

If simultaneous operation is not required, insert a BREAK instruction (see trajectory control chapter).

Hence :

```
MOVE a1
MOVE a2    ;Motion instruction
BREAK
x = 34.56  ;Calculation instruction
SIG 1      ;Instruction setting output No. 1 to logic 1
t = x + 56 ;Calculation instruction
MOVE b
```

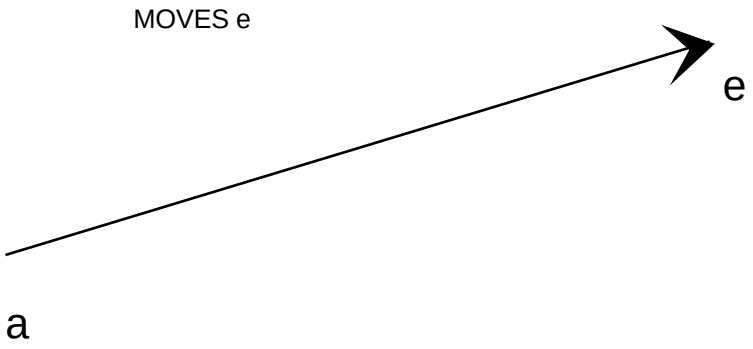
MOVES

EFFECT This instruction commands the robot to move to location along a straight line trajectory.

SYNTAX **MOVES location.name**

NOTE A straight line movement is not the fastest motion despite the fact that the path is the shortest.

EXAMPLE



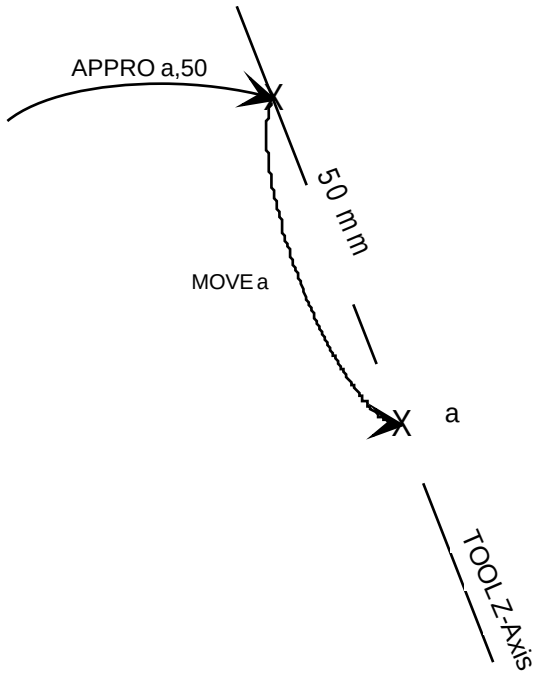
APPRO

EFFECT This instruction, generally followed by MOVE, allows the robot to approach location by a value in mm along tool Z-axis.

SYNTAX **APPRO location.name, distance**

NOTE The axis assigned to the distance will always be the tool Z-axis

EXAMPLE APPRO a,50



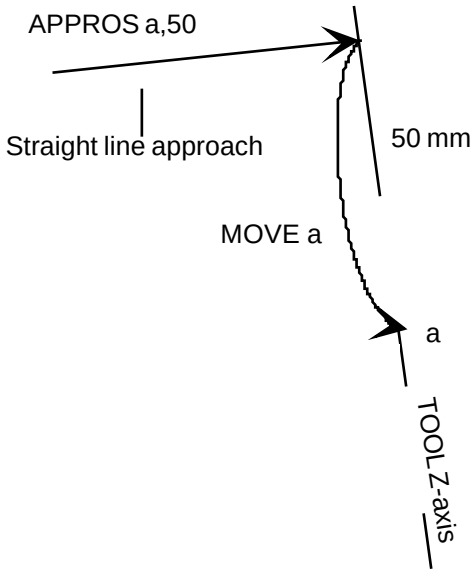
APPROS

EFFECT Same as previous instruction but location A approach is made along a straight line.

SYNTAX **APPROS location.name, distance**

NOTE The axis assigned to the distance will always be the tool Z-axis

EXAMPLE APPROS a,50



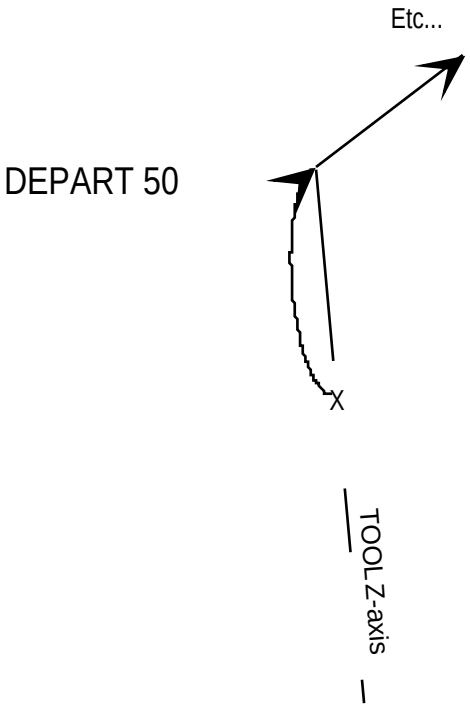
DEPART

EFFECT This instruction performs the opposite function to the APPRO instruction. It allows the robot to move from the point where it was located during the execution of the DEPART instruction, moving along the tool Z-axis by a value given in mm.

SYNTAX **DEPART distance**

NOTE The axis assigned to the distance will always be the tool Z-axis and movement will be made in relation to the position that the robot occupies at time when this instruction is executed.

EXAMPLE DEPART 50



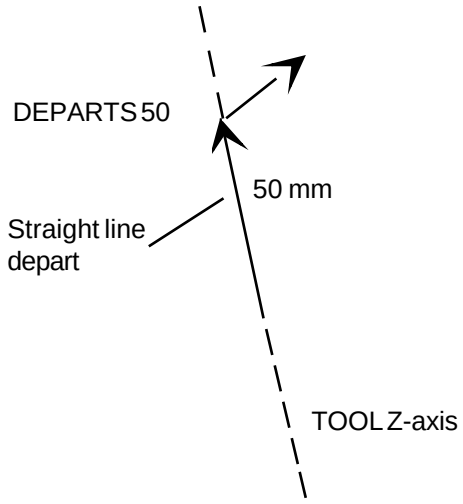
DEPARTS

EFFECT Same as previous instruction, but movement will be made along a straight line.

SYNTAX **DEPARTS distance**

NOTE The axis assigned to the distance will always be the tool Z-axis

EXAMPLE DEPARTS 50



OPENI, CLOSEI

EFFECT Robot solenoïd instructions.

SYNTAX

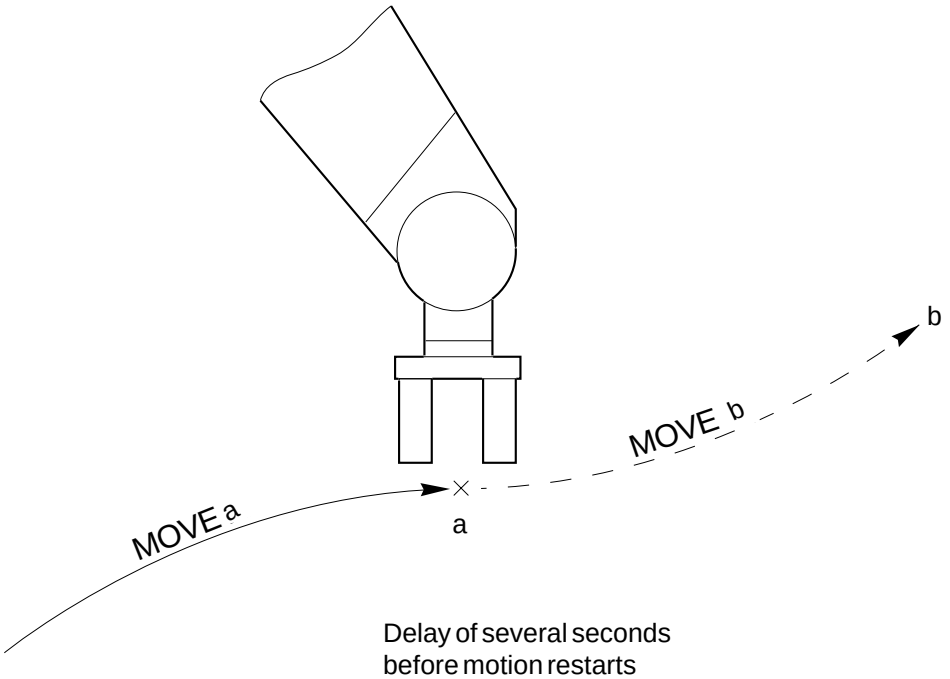
OPENI Immediate opening of pneumatic jaws.

CLOSEI Immediate closing of pneumatic jaws.

NOTE 50 ms delay by default.

EXAMPLE

```
MOVE a
OPENI     ;Immediate opening with breakpoint.
MOVE b
CLOSEI    ;Immediate closing with breakpoint.
...
```



OPEN, CLOSE

EFFECT Gripper motions instruction jaws.

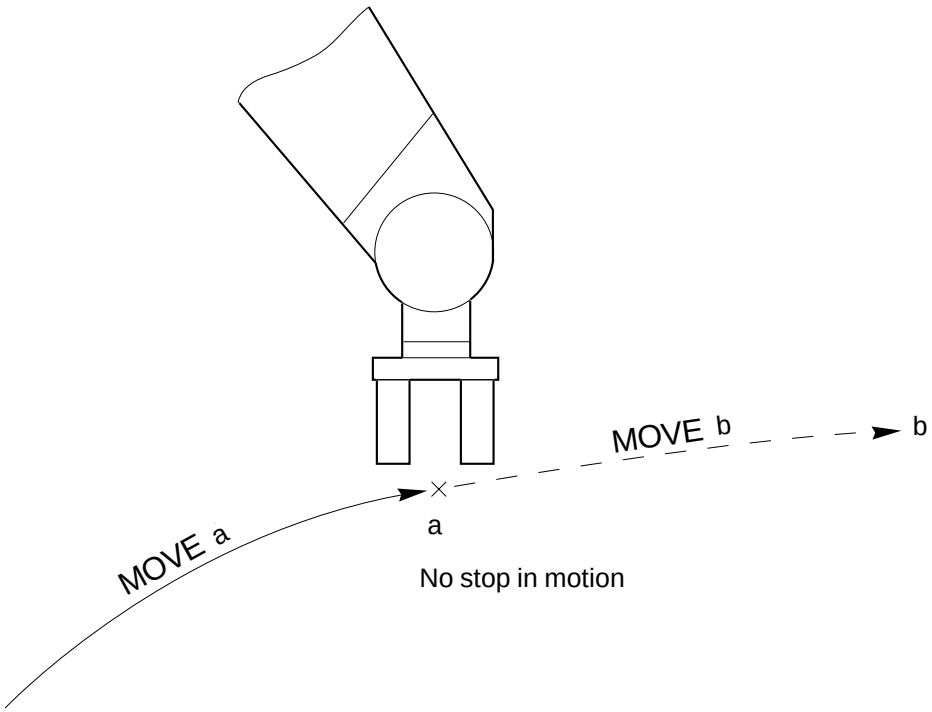
SYNTAX

OPEN	Opening of pneumatic jaws
CLOSE	Closing of pneumatic jaws.

NOTE It is often preferable to use OPENI, CLOSEI to be sure that there is a breakpoint ensuring a certain stability in the grip.

EXAMPLE

```
MOVE a
OPEN      ;Opening during motion to point B without breakpoint
MOVE b
CLOSE     ;Closing of jaws
…
```



DELAY

EFFECT Stops the robot for the time stipulated in the instruction. This time must be given in seconds and cannot be less than 16 ms.

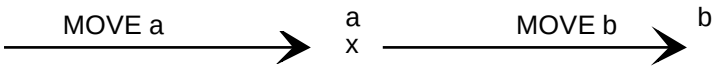
SYNTAX **DELAY time**

NOTE The delay is generated in software form.

CAUTION The DELAY instruction must be considered as a motion instruction to go nowhere.

EXAMPLE

```
MOVE a
BREAK
DELAY 180
BREAK
MOVE b
...
```



Wait 180 seconds

EXAMPLE

```
c = 2
MOVE a
BREAK
DELAY 30
BREAK          ;for b=3+c to be executed at the end of temporization
b=3+c
MOVE f
```

BREAK

EFFECT Switches to DISABLE CP mode only for the next motion instruction. It suspends execution of the program until the motion has reached its destination.

SYNTAX **BREAK**

NOTE BREAK is prefered to avoid execution of calculation and input/output management instructions, etc. (other than motion instructions) located between two locations.

EXAMPLE

```
MOVE a
MOVE b    ;Breakpoint on b
BREAK     ;as breakpoint recognized during motion to b
MOVE c
MOVE d
```

NOTE Use of this instruction is mandatory to observe the wait time with the DELAY instruction.

TYPE

EFFECT This instruction is used to display a message on the screen during the execution of a program and/or display the content of one or more declared variables.

SYNTAX **TYPE** control character, "message","variable",{etc.}

EXAMPLE TYPE /B, "VALUE OF x =",x

will display value of x = 3 if content of variable x is equal to 3 and terminal bell will sound.

Some of the most useful control characters are listed below:

/B Rings terminal bell;

/Cn Causes n line skips (n times CR and n times LF);

/S No line skips (no CR's or LF's);

/Un Moves cursor up n lines.

/Xn Moves cursor n spaces to the right.

CAUTION Control characters do not operate on all terminals.

EXAMPLES TYPE /C3, /B, "Hello"

TYPE /X30, "Hello"
<— 30 spaces —> Hello…

NOTE If TYPE includes no parameters, a blank line is generated.

PROMPT

EFFECT This instruction is used to enter values assigned to variables via the keyboard.

SYNTAX **PROMPT** "MESSAGE", **VARIABLE**

The program will be suspended until the operator replies.

The reply can be a real variable or variables and/or a string of characters.

If the user replies to several parameters, these must be separated by a comma.

NOTE Avoid requesting several values. It is preferable to request different values one after the other.

EXAMPLE 1 PROMPT "Give me the length of part", length.

EXAMPLE 2 PROMPT "Give me the programmer's name",$name

EXAMPLE 3 PROMPT "Enter + to increase or - to dicrease:", $ans

```
IF ($ans == "+") THEN
        distance = distance + 1
END

IF ($ans == "-") THEN
        distance = distance - 1
END
```

CHAPTER 8

DIGITAL INPUTS AND OUTPUTS

CHAPTER 8 - DIGITAL INPUTS AND OUTPUTS

8.1 EXTERNAL OUTPUTS (on/off)

These outputs are still called DIGITAL outputs.

Number depends on options selected when purchasing robot (256 max.).

Their addresses are as follows:

1—> output No. 1

2—> output No. 2

3—> output No. 3

4—> output No. 4

etc... until 8 in standard version.
The 7 and 8 outputs are used by default by the solenoid valves of the ROBOT arm.

Programming of outputs :

SIG 1, -2,...,8

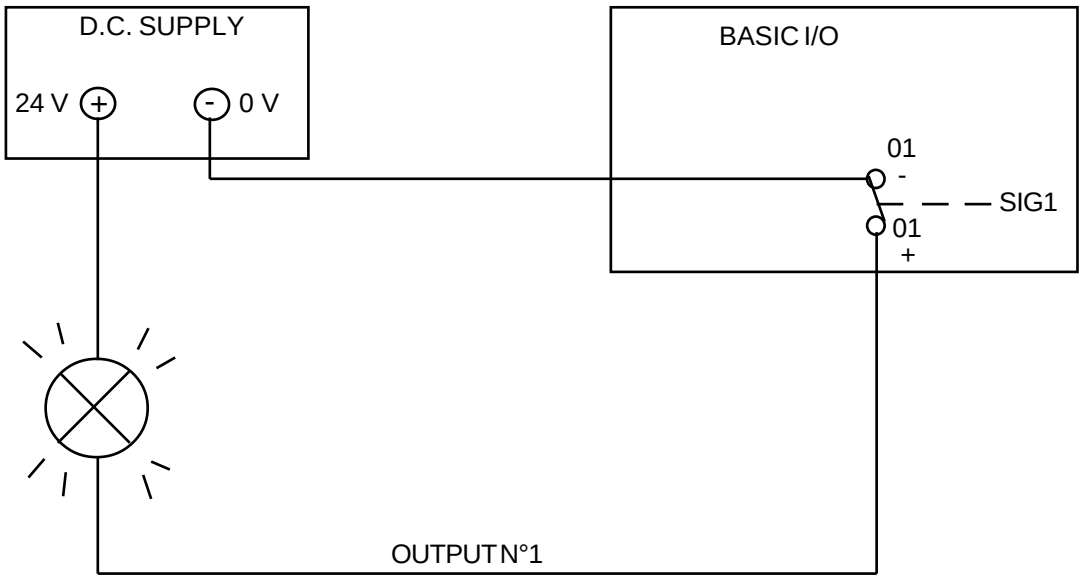
RESET

RUNSIG

SIGNAL val1, val2, val3, ...

With different values which can be constants, variables or mathematical expressions.

We shall now look at each of these instructions.



WIRING DIAGRAM

SIGNAL

EFFECT Activates the contact of an external digital output.

SYNTAX **SIG output1**, output2,...

NOTE The outputs remain as such until a new SIG instruction cancels the corresponding output.

This instruction operates in command mode and program mode.

EXAMPLE SIG 2, -1, 4

Outputs No. 2 and No. 4 will change to logic 1 and output No. 1 will change to logic 0.

EXAMPLE

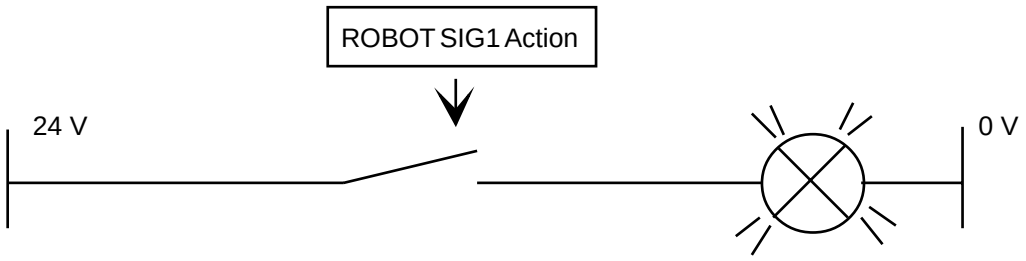
```
Sucker = 2
Grip1 = 1
Grip2 = 4
SIG Sucker,-(Grip1),Grip2
```

This example sets up same condition as previous example.

EXAMPLE

```
FOR OUTPUT = 1 TO 8
        SIG OUTPUT
        DELAY 1
        BREAK
END
...
```

In this case, outputs between 1 and 8 will pass to logic 1 in a sequence delayed by a one second interval.



RESET

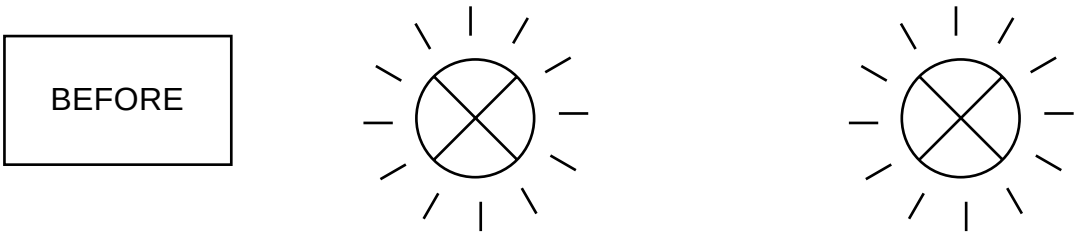
EFFECT Resets all outputs.

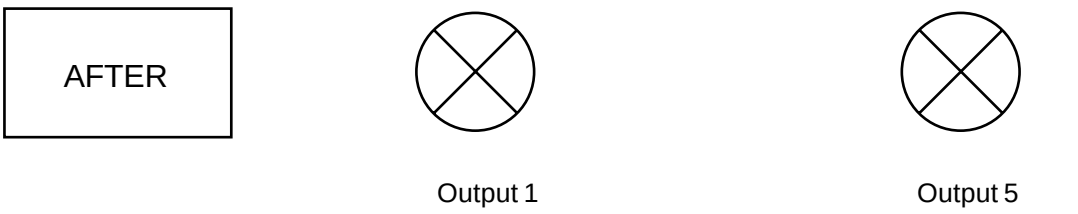
SYNTAX **RESET**

NOTE Switching off the controller also resets all outputs.

This instruction operates in command mode and program mode.

EXAMPLE
SIG 1,5
RESET Outputs 1 to 5 (and the other outputs at 1) will be reset





8.2. EXTERNAL INPUTS

Number depends on robot configuration when purchased (possible extension).

Their addresses are as follows :

1001 input No. 1
1002 input No. 2
1003 input No. 3
1004 input No. 4
1005 input No. 5
1006 input No. 6
...
1012 input No. 12
etc...

In STANDARD version, 12 inputs are available.

IO

TYPE Monitor command

EFFECT Displays the current states of the external binary input/output signals and/or the internal software signals.

SYNTAX IO sig_group

PARAMETERS

sig_group	Integer which, if specified, selects the binary signals to be displayed.
0	Display of binary output signals.
1	Display of binary input signals.
2	Display of system software signals.

EXAMPLES

Dashes	Signal not configured.
0	Low signal
1	High signal

WAIT...

EFFECT This instruction will interrupt the program until corresponding expression is valid.

SYNTAX **WAIT** <condition>

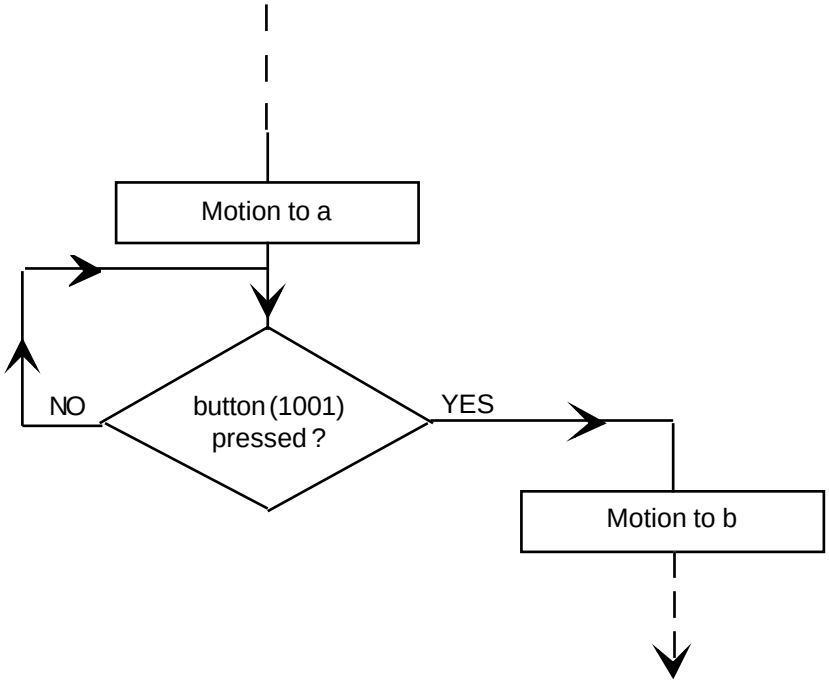
If the result of the operation is «0», the machine considers that the result is false.
For all other values, the result will be considered as true.

NOTE Inputs, outputs, variables, etc. can be tested.

EXAMPLE
```
WAIT SIG(1001,-1003,1002)
```

EXAMPLE
```
WAIT (SIG(1001,-2) OR SIG(1008))
```

EXAMPLE
```
MOVE a
WAIT SIG(1001)
MOVE b
...
```



CHAPTER 9

DISKETTE OR DISK SAVING OPERATIONS

CHAPTER 9 - DISKETTE OR DISK SAVE OPERATION

9.1 WHY YOU SHOULD USE A DIRECTORY

On account of their high capacities, diskettes or hard disks can contain a high number of files.

If all file names are conserved in a single list, searching for a file may take a long time.

By grouping files of the same type or those relevant to a given theme into subdirectories, you can reduce the time required to locate a given file. Also, deletion of a "PART1.V2" file in a given directory will not delete the same "PART1.V2" file located in another directory.

RECOMMENDATIONS

Always try to place files of a given application in the same directory.
Various commands will allow you to create, delete and select directories. We will look at these later.

9.2 WHY YOU SHOULD SAVE PROGRAMS

Although the memory is saved, when a program has been written, it should always be saved to avoid having to reconstruct it again at a later stage.

Saving is made under a file name defined by the user.

The meanings of the suffixes displayed after the file names are as follows:

PRO_NAME.XXX where XXX —> suffix

EXAMPLE TOTO.PG for application files
TOTO.LC for location files
TOTO.RV for real variable files
TOTO.DB for long real variable files
TOTO.ST for string files
TOTO.V2 for all of the above files.

ASSIGNMENT of a PHYSICAL unit.

The standard version includes a Compact Flash. However, optionally, a second "3-1/2" drive can be added.

The V+ language operating system uses designations "A:", "B:", "C:", "D:"

The standard 3-1/2" disk drive is called "B:".

The standard hard disk is called "D:".

When the controller is switched on, the system goes to "D:" by default.

However, the DEFAULT DISK command can be used to temporarily assign required unit or path.

EXAMPLE
```
DEF D = B:
DEF D = D:\program\toto\
```

9.3 COMMANDS ASSOCIATED WITH COMPACT FLASH OR FLOPPY DISK DRIVE

1. FDIRECTORY

2. DEF D =… OR CD

3. STORE, STOREP, STOREL, STORER, STORES…

4. LOAD

5. FDIRECTORY/C

6. FDIRECTORY/D

7. FLIST

8. FCOPY

9. FDELETE

10. FRENAME

FDIRECTORY

TYPE Monitor command

EFFECT Displays the files contained on the disk and the available storage space.

SYNTAX **FDIRECTORY**

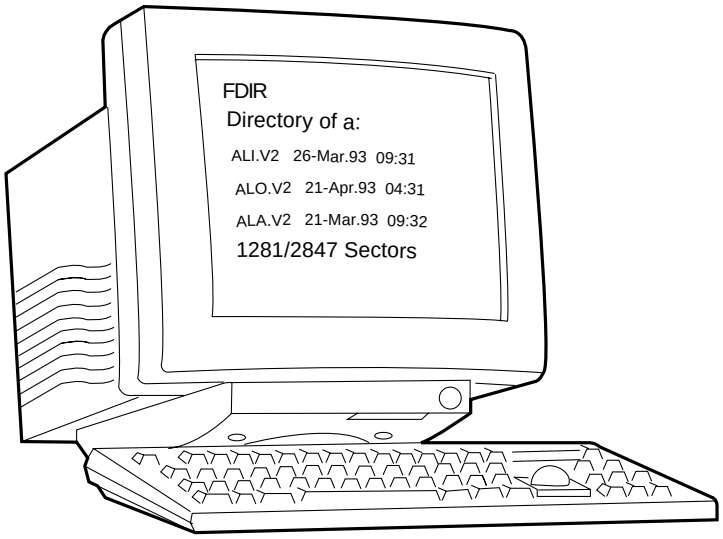
The system gives the following:
- Name
- Suffix
- Number of sectors that the file takes up.
- Codes of special attributes.
- Date and time when file was recorded.

NOTE **Attribute «P»** indicates that the file can be executed, but not edited, displayed or traced during execution, also, the programs cannot be transferred to disk.
Attribute «R» indicates that the file can be loaded into the memory and that program contents can be executed and displayed. The programs cannot however be edited or saved on disk.
Attribute «D» indicates a directory.

EXAMPLE FDIRECTORY TOTO.*

Displays the information of all TOTO files (TOTO.PG, TOTO.LC, etc.) on the disk taken by default and the current directory.

Generic characters can be used, for example, if FDIRECTORY f* is written, all files starting by f will be displayed.



DEF D =... or CD

TYPE Monitor command

EFFECT **Changes** the directory, or disk unit and/or diskette.

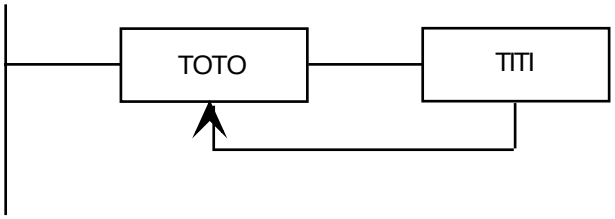
SYNTAX **DEF D=D:\Directory1\Directory2\etc...**
or **CD Directory 1**

EXAMPLE DEF D=D:\toto\titi\

NOTE **DEF D=.. moves you back one directory path (adjacent directory).**

EXAMPLE You are in directory D:\TOTO\TITI\
DEF D=.. will transfer you to directory D:\TOTO\

D : \



REMARK From the recent V+ language versions, the command cd.. is accepted to ensure compatibility with DOS.

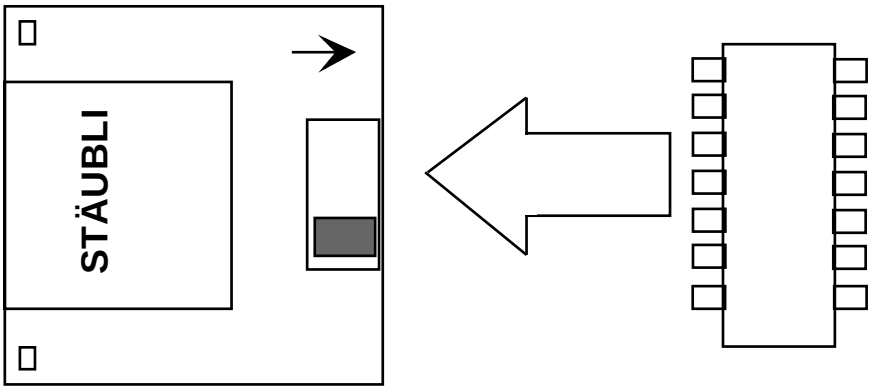
Also: cd D:\TOTO\TITI

cd (or def) also enable to visualize the default directory.

STORE, STOREP, STOREL, STORER, STORES...

TYPE Monitor command

EFFECT Stores the programs in the robot's RAM memory and the associated variables onto disk file.



SYNTAX **STORE File=Prog1,prog2,...,Prog n**

If no program is specified, all programs, variables and associated subprograms are loaded onto disk file.

Use STOREL to save locations only
STOREP for programs
STORER for real variables
STORES for strings

NOTE You should not create files with the ".BN*" extension.

STORER generates an xxx.RV and/or xxx.DB file following type of real variables encountered in the various programs.

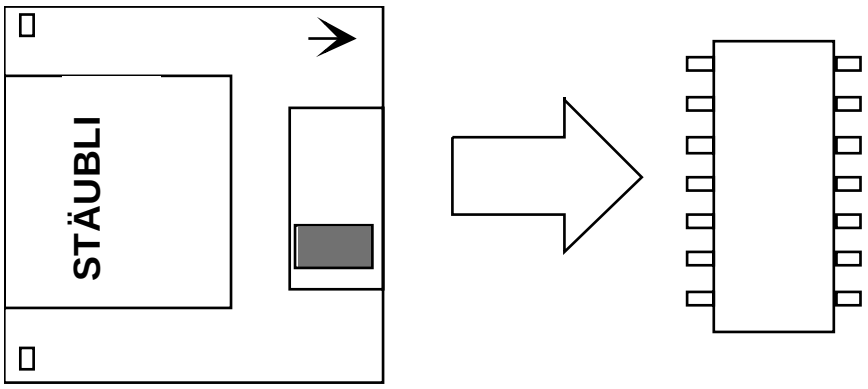
EXAMPLE STORE FICHE=PROG1,...,PRG6

NOTE The system saves the subprograms associated with the calling programs, it saves all that is required to run the application...

LOAD

TYPE Monitor command

EFFECT Loads the specified disk file into the robot's RAM memory.



SYNTAX **LOAD** File name.suf

LOAD D:pallet loads the "Pallet.V2" file located on the hard disk c: of the system.

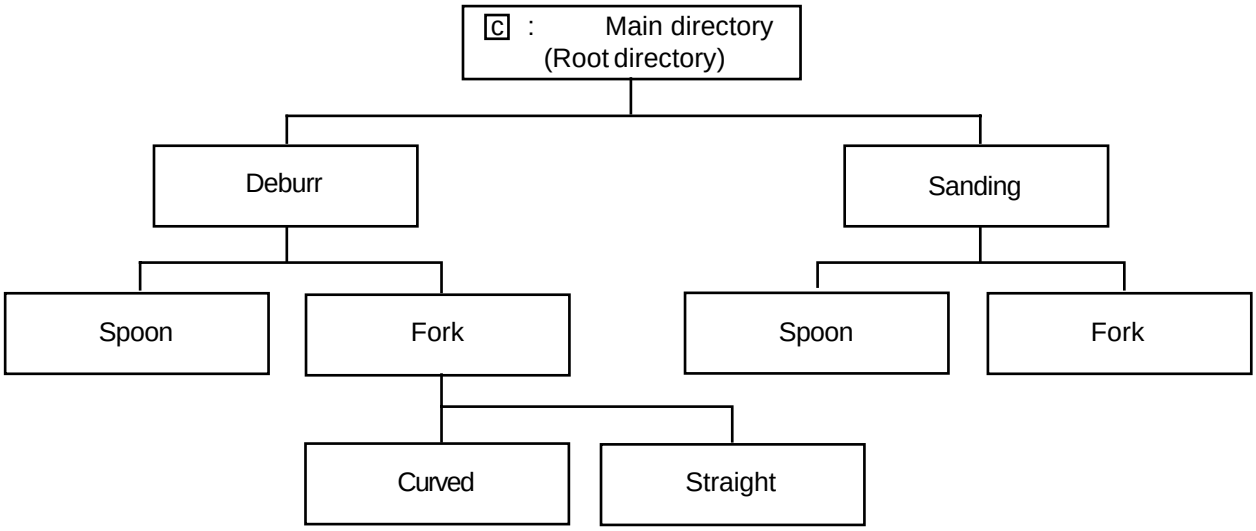
NOTE The system analyzes the syntax of the programs transmitted during transfer to disk.

EXAMPLE LOAD pallet.PG

FDIRECTORY/C

TYPE Monitor command

EFFECT **Creates** a directory from the current directory.



SYNTAX **FDIR/C**

EXAMPLE To define "Spoon" directory in "Deburr" branch

FDIR/C D:\DEBURR\ (if «Deburr» directory does not exist)

and then:
FDIR/C D:\DEBURR\SPOON\

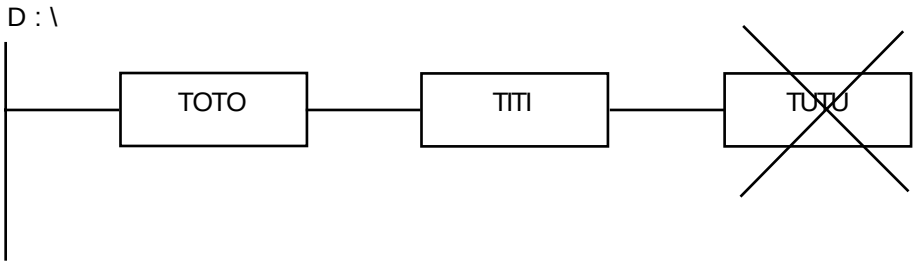
FDIRECTORY/D

TYPE Monitor command

EFFECT **Deletes** a directory from current directory.

SYNTAX **FDIR/D**

EXAMPLE FDIR/D D:\TOTO\TITI\TUTU\
Directory TUTU will be deleted.



FLIST

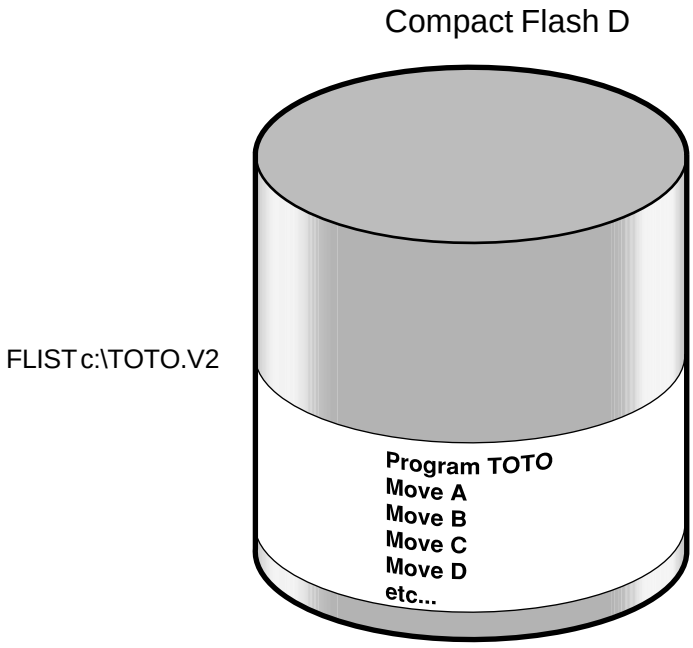
TYPE Monitor command

EFFECT Displays the content of the file on the disk(s) or in floppy disk drive.

SYNTAX **FLIST D:\file.V2**

NOTE If the file stipulated does not exist, an error will be indicated.

EXAMPLE FLIST D:TOTO.V2



FCOPY

TYPE Monitor command

EFFECT Copies an existing file onto a new file.

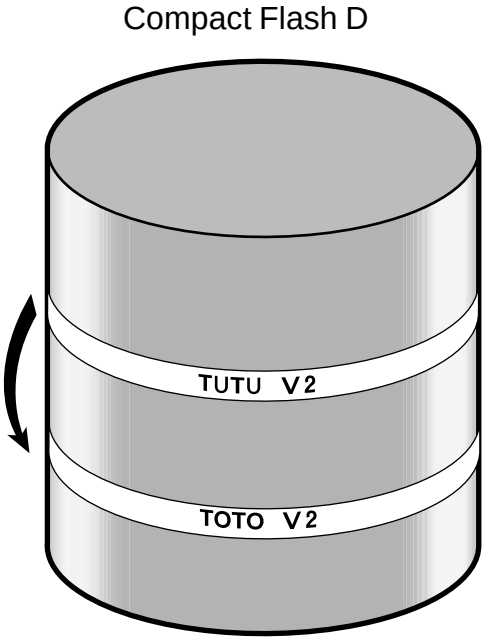
SYNTAX **FCOPY file Target=Source file**

EXAMPLE FCOPY D:NEWTOTO.V2=B:OLDTOTO.V2

NOTE Protected files cannot be copied.
If the source file has a read only attribute, the target file will also have this attribute.

REMARK FCOPY does not accept the symbol *.V2 for example.

FCOPY D: TOTO.V2 = D: TUTU.V2



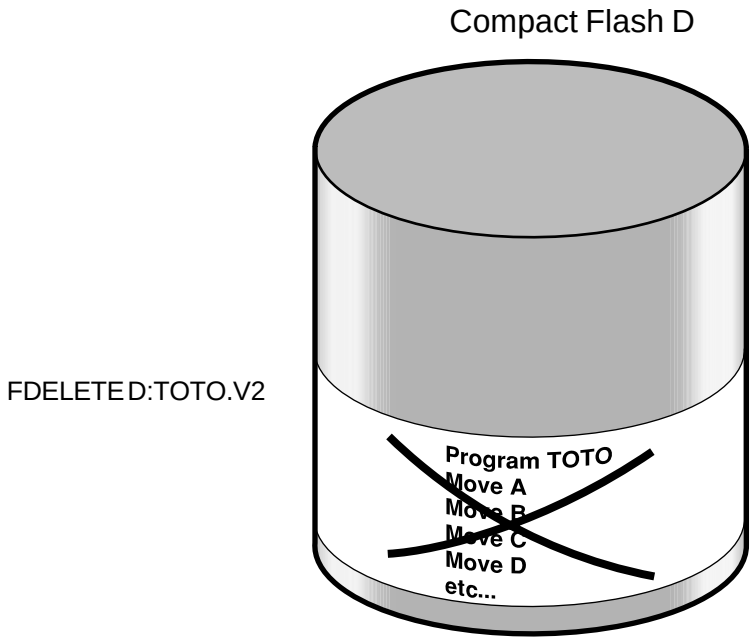
FDELETE

TYPE Monitor command

EFFECT Deletes specified file.

SYNTAX **FDELETE File.name**

EXAMPLE FDELETE *.V2 will delete all files ending with the V2 extension.



FRENAME

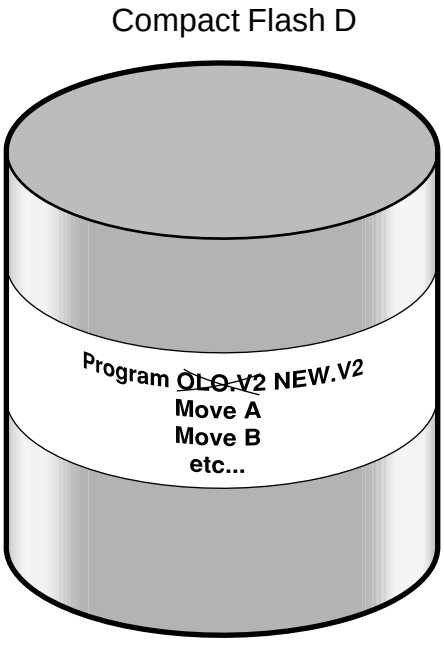
TYPE Monitor command

EFFECT Changes disk file name.

SYNTAX **FRENAME** D:New file name=Old file name

NOTE The system changes only the file name, the contents are not affected.

EXAMPLE FRENAME D:NEW.V2=OLD.V2



CHAPTER 10

CONTROL OF ROBOT CONFIGURATION

READY

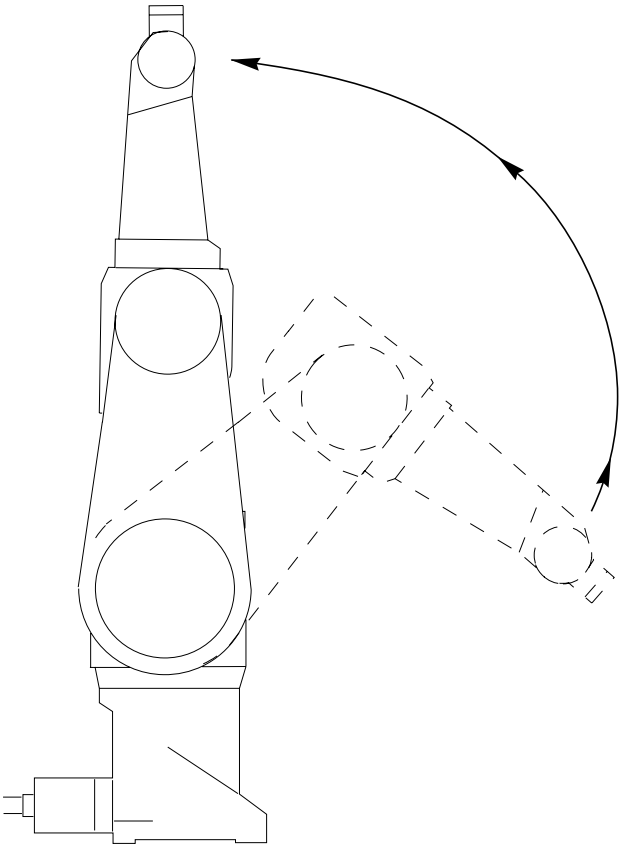
EFFECT Places robot arm in a specific reference position.

SYNTAX **READY**

NOTE Generally this specific position corresponds to the centre of all the axes.
This position may be slightly misaligned to each axis.

EXAMPLE .DO READY

READY



In order to check the alignment of the marks on each axis, do READY with an RX_B (coordinates adjusted in factory after V_REGAUTO.

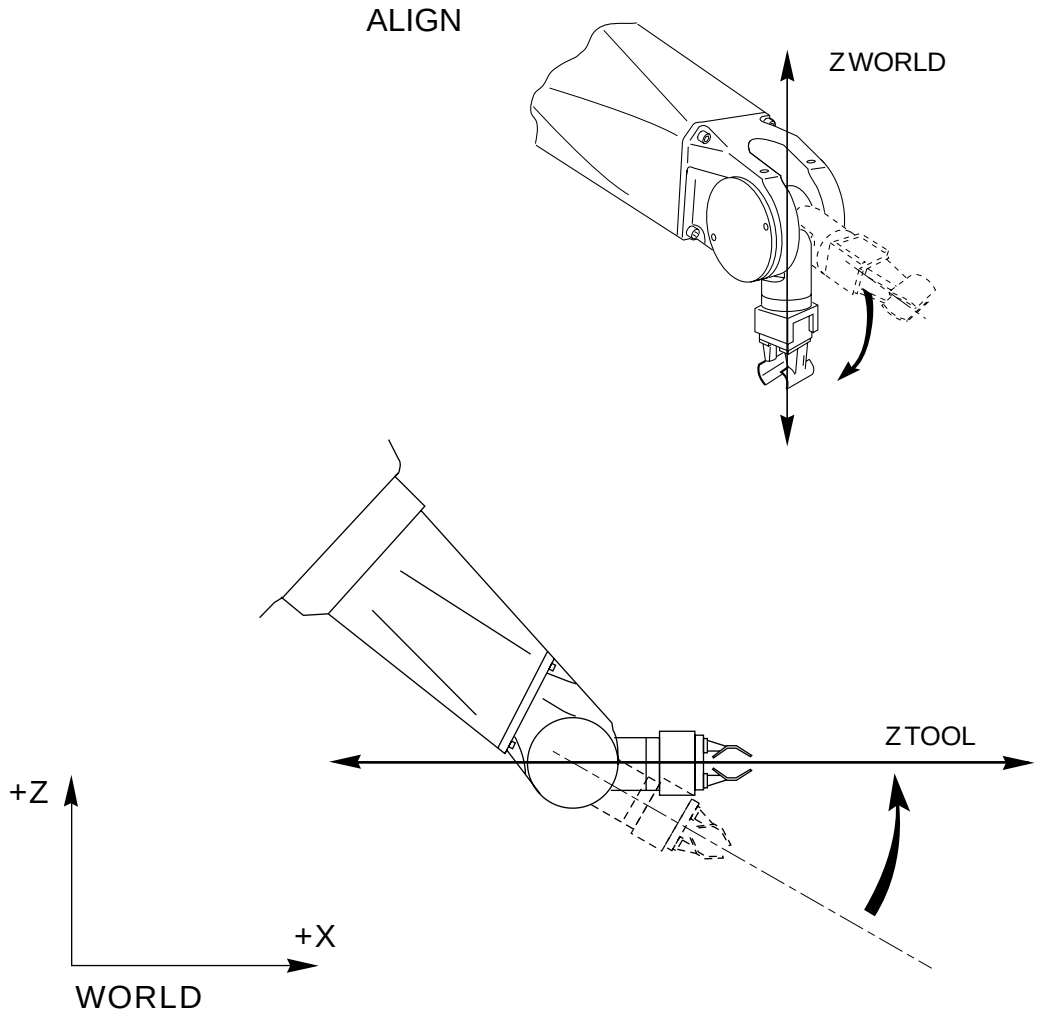
ALIGN

EFFECT Places the tool Z-axis parallel to the nearest axis of the world reference system (X or Y or Z).

SYNTAX **ALIGN**

NOTE This instruction avoids having to perform many handling operations using the teach pendant to set tool axes parallel with the Z-axis of the WORLD coordinates.

EXAMPLE . DO ALIGN



ABOVE - BELOW

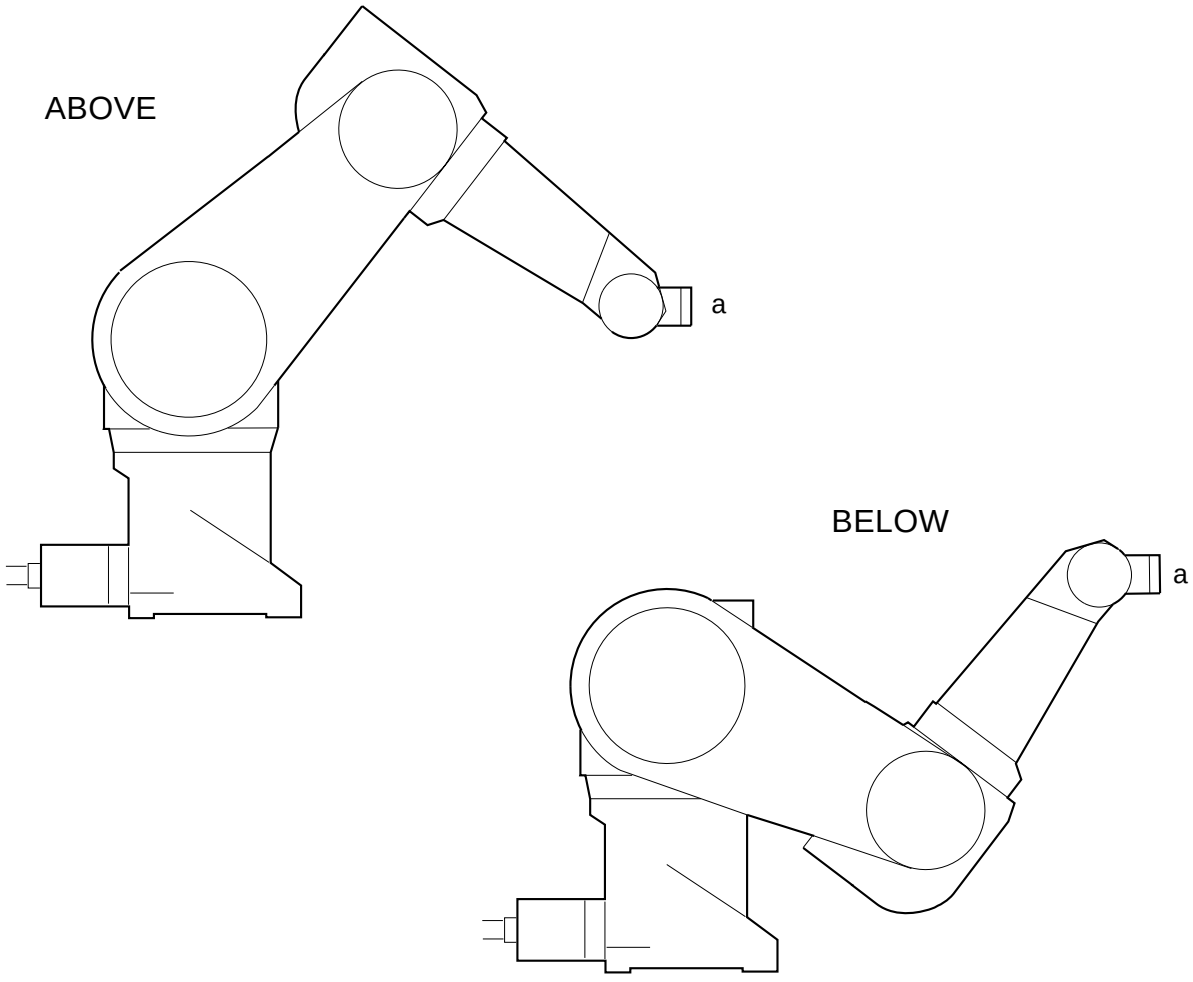
EFFECT This instruction allows the elbow to be placed in ABOVE or BELOW position whilst conserving same orientation and same position in space.

SYNTAX **ABOVE and BELOW**

NOTE This instruction is useful for avoiding certain collisions with workcell equipment. Only effective when moving to transformation locations.

EXAMPLE

```
.TEST Prog
  BELOW
  MOVE a
  ABOVE
  MOVE a
  ...
```



RIGHTY - LEFTY

EFFECT Allows RIGHTY of LEFTY configuration to be set up while conserving same orientation and position in space.

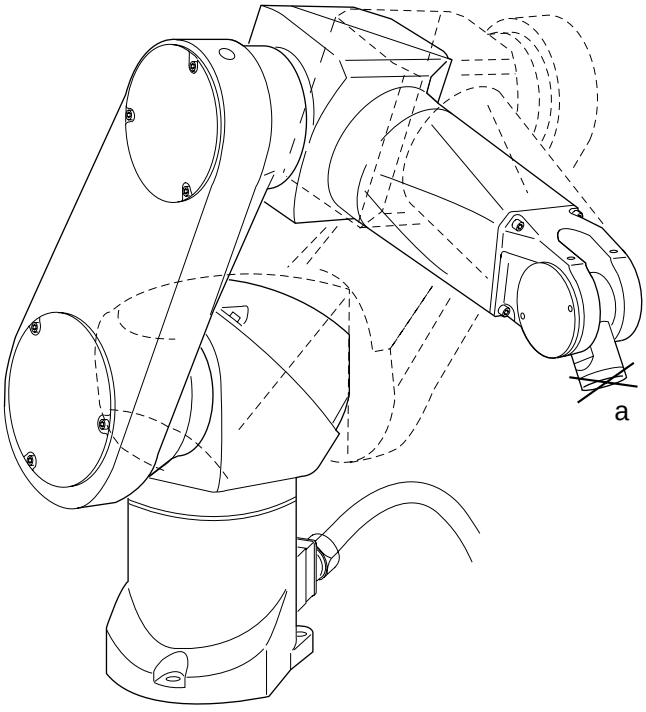
SYNTAX **RIGHTY and LEFTY**

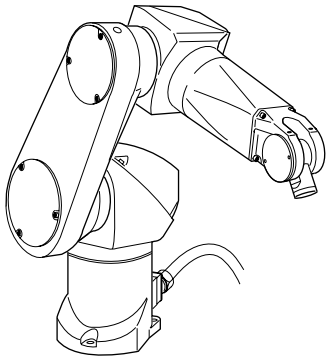
NOTE This instruction is useful for avoiding certain collisions with workcell equipment. Only effective when moving to transformation locations.

EXAMPLE

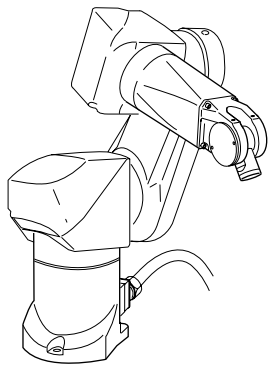
```
LEFTY
MOVE a
RIGHTY
MOVE a
...
```

RIGHTY - LEFTY





RIGHTY



LEFTY

FLIP - NOFLIP

EFFECT Sets joint 5 configuration whilst conserving same y, p, r angles in WORLD reference system and same X, Y, Z position.

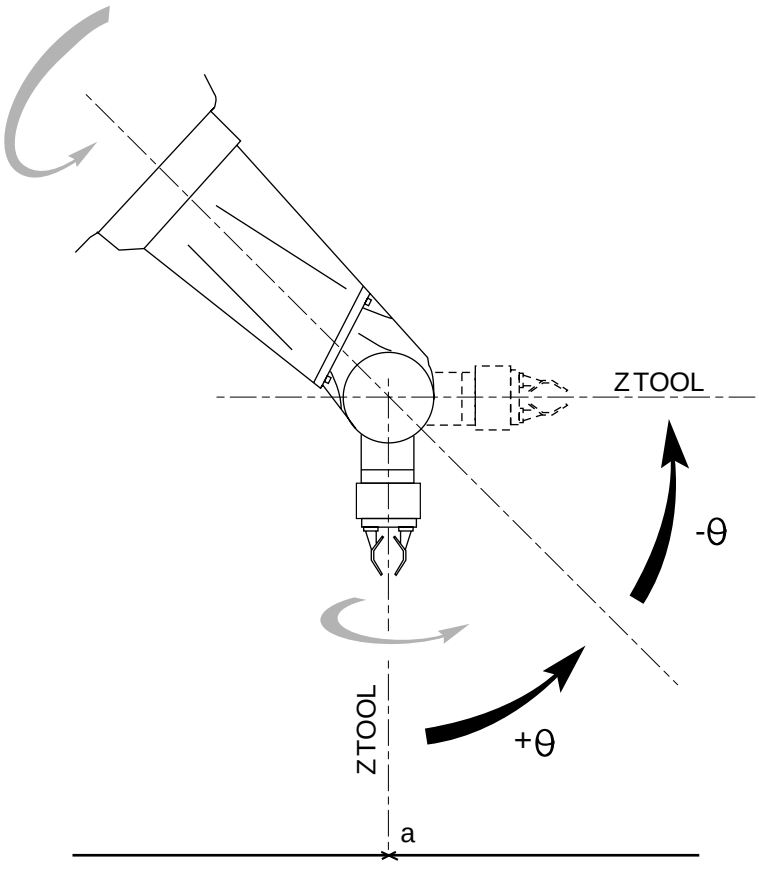
SYNTAX **FLIP and NOFLIP**

FLIP will give negative angle values at JT5
NOFLIP will give positive angle values at JT5.

NOTE This instruction is useful for avoiding certain collisions with workcell equipment.

EXAMPLE

```
FLIP
MOVE a
NOFLIP
MOVE a
```



APPENDIX

A.1. SAFETY NOTICE

The following notice is mandatory reading for all personnel involved with the operation, programming, maintenance or installation of the robot.

A robot, due to it's flexible, reprogrammable nature, represents a potential danger to personnel. It may not be possible to predict with any accuracy it's motion at any point in time.

The duty falls therefore upon the personnel involved to ensure the following:

- The area of operation of the robot is safeguarded by suitable physical barriers;
- No personnel can approach the robot whilst it is under program control;
- Reduced speed operations selected prior to personnel being in proximity with the robot arm;
- Adequate training is given to personnel involved in any of the above activities;
- Safe working practises are employed in all dealings with the robot;
- Personnel involved with the robot are aware of guidelines which are provided and details of any local safe working practises.

The following warnings should be complied with all dealings with the robot system.

DO NOT's:

- DO NOT replace any components or make any adjustments to the equipment with any electrical or pneumatic supply connected;
- DO NOT attempt to move the robot arm until it has been securely mounted;
- DO NOT block cooling fans when positioning the controller. Ensure that an unobstructed air flow is available;
- DO NOT stop arm motion by using the emergency stop button except under emergency conditions;
- DO NOT stop arm motion by using EMERGENCY STOP control except under exceptional circumstances. Arm motion should be stopped by aborting program or selecting hold mode;
- DO NOT stop arm motion by turning off cabinet mains control or isolator except under exceptional circumstances. Arm motion should be stopped by aborting program or selecting hold mode;
- DO NOT connect or disconnect any cables or pneumatic hoses unless all power has been removed from the system;
- DO NOT operate any equipment with the covers removed or doors open;
- DO NOT approach the arm when it is operating under program controlled conditions;
- DO NOT approach the arm when it is operating under teach conditions unless you personally have control of the arm via the teach pendant.

DO's:

- DO ensure that operating and maintenance personnel observe all safety precautions;
- DO ensure that the robot working area is enclosed by a suitable physical barrier, which is suitably interlocked with the robot control system such that entry forces an E-stop on the robot controller;
- DO realise that when establishing the barrier position, consideration should be given to the working envelope of the robot arm, including all payloads it may carry;
- DO attempt to physically limit the working envelope of the robot arm to the minimum necessary to carry out it's tasks;
- DO ensure that all possible obstructions are removed from the robot's working area;
- DO ensure that all personnel and obstructions are clear of the arm before applying ARM POWER;
- DO ensure that whenever applying emergency stop a hand is kept near "Emergency stop" or DIS PWR buttons, such that they can be easily operated should the need arise;
- DO ensure that power is removed before connecting or disconnecting any electrical equipment;
- DO ensure that the power is removed before opening any covers or attempting any mechanical or electrical maintenance;

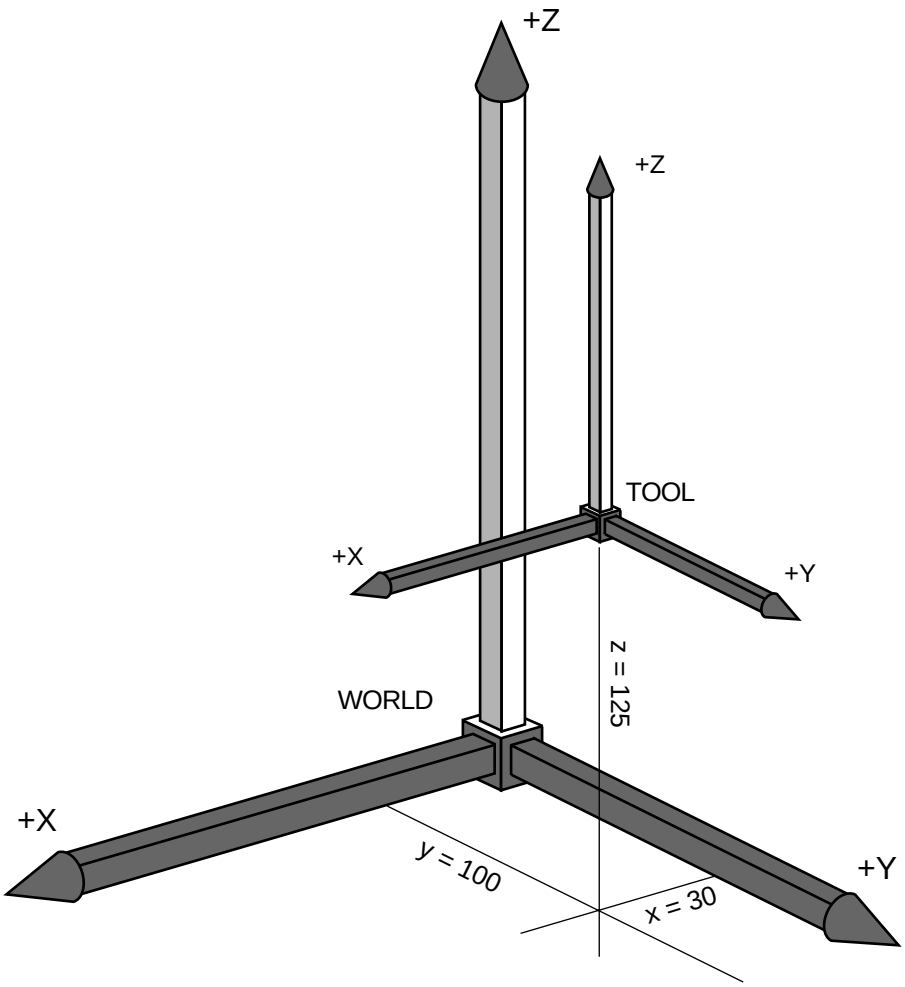
- Do follow the proper power up sequence when connecting components to line power;- DO start motions at low speed and only increase speed when paths are fully defined;
- DO realise that the automatic startup program will lead to the execution of a program and possible robot arm motion;
- DO ensure that any tools and loads fitted to the robot meet the payload and inertial requirements of the arm;
- DO realise that operations in excess of V+ speed 100 could cause over load of the motors and drive components in the robot.

The manualsinvolved in any of the above activities; provided by Stäubli, both for the robot system and the V+ programming language, are not intended as self-teaching guides. Personnel using them are expected to have undertaken a period of training such as that proposed by Stäubli.

Failure to comply with these and over warnings may rsult in serious injury to personnel and/or damage to the robot system.

A.2. TRANSFORMATION ELEMENTS

A.2.1. X, Y, Z, VALUES



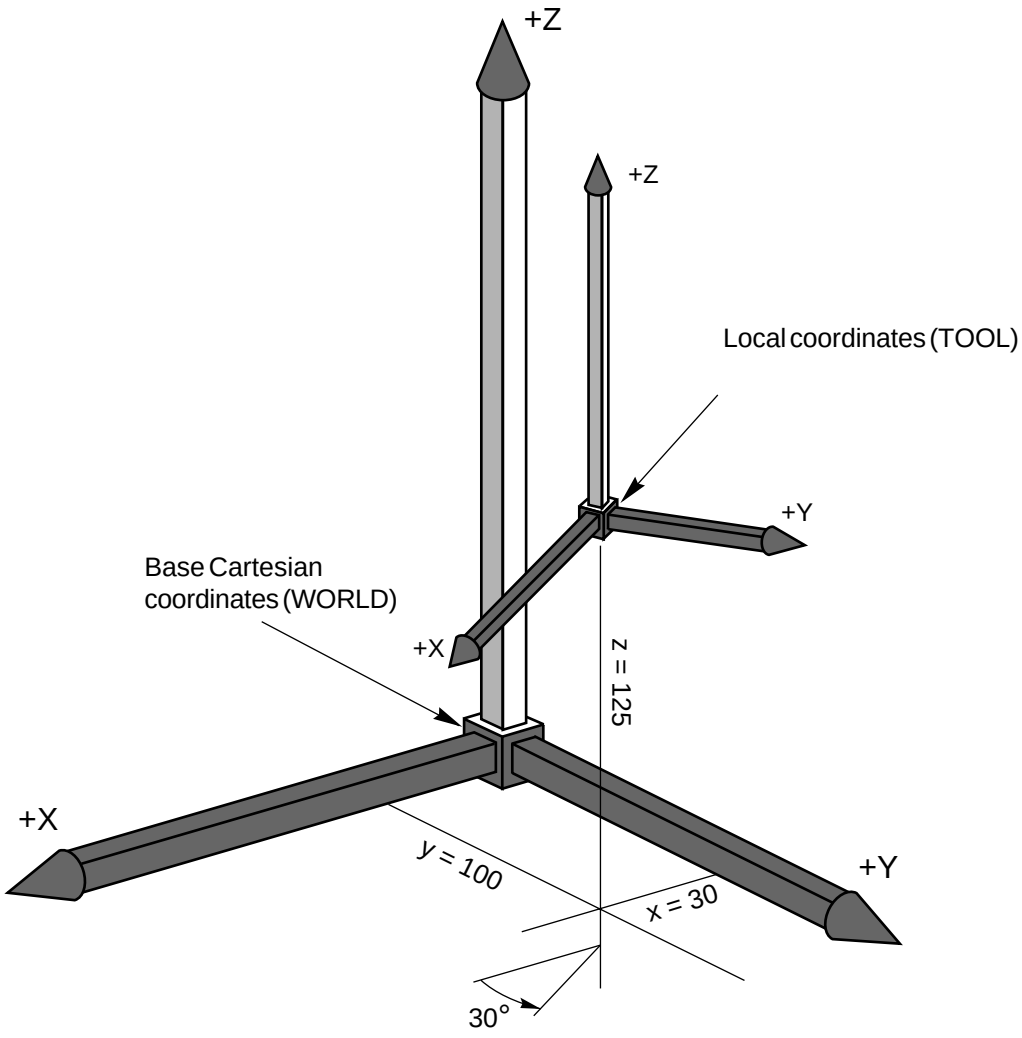
In this example, X = 30, Y = 100, Z = 125, yaw = 0, pitch = 0 and roll = 0.

There is no orientation of the local (TOOL) coordinates with respect to the base (WORLD) Cartesian coordinates.

A.2.2. YAW (y)

Yaw is the rotation around the Z-axis of the local coordinates (TOOL coordinates).

The figure below shows yaw rotation through 30°. Note that this is parallel to the base reference system but centred on any point in space.

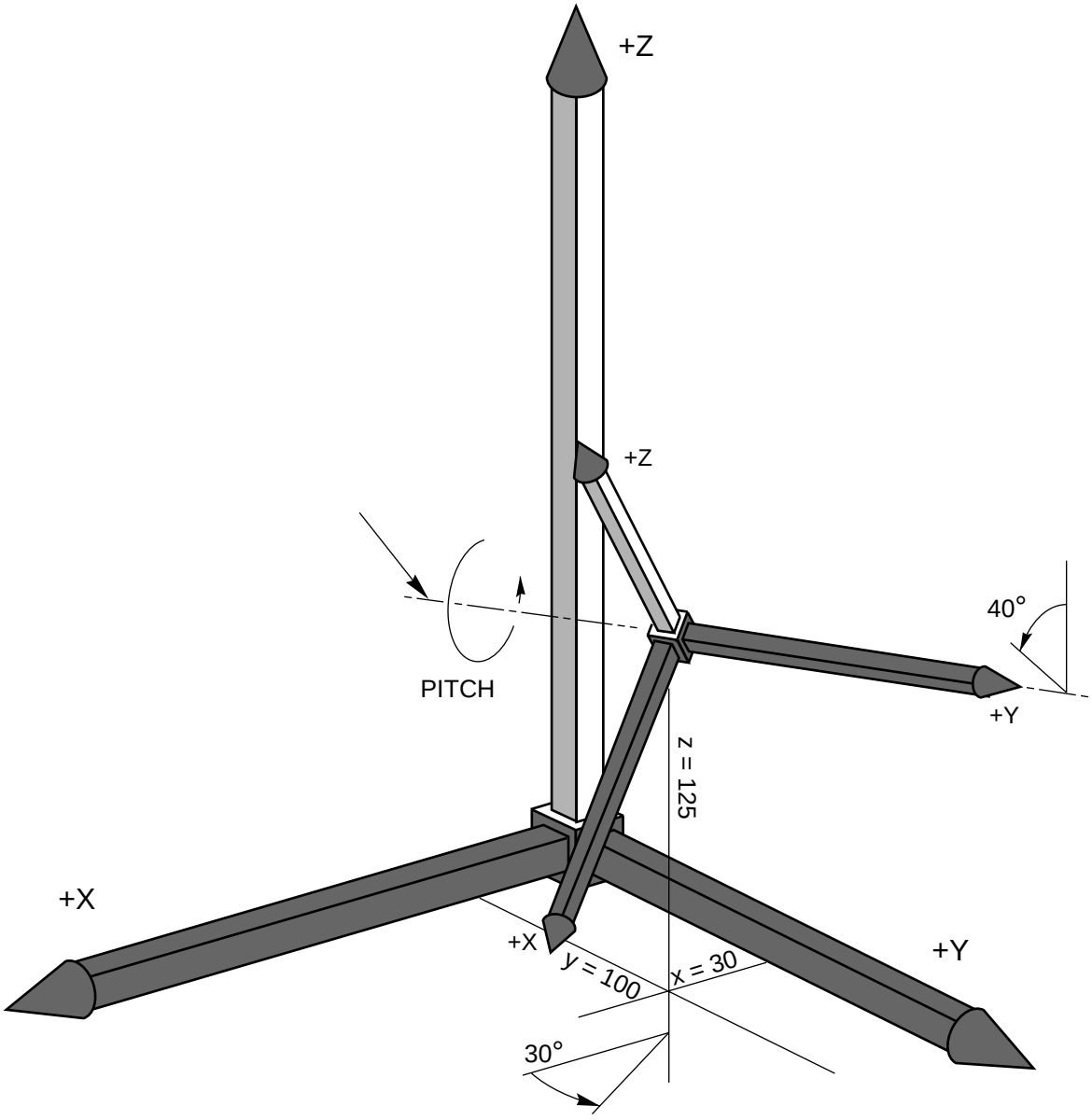


In this example, X = 30, Y = 100, Z = 125, yaw = 30, pitch = 0 and roll = 0.

A.2.3. PITCH (p)

Pitch is defined as the rotation around the Y-axis of the local coordinates **after** yaw rotation has been applied.

The figure below shows pitch rotation of 40°around the Y-axis of the local coordinates.

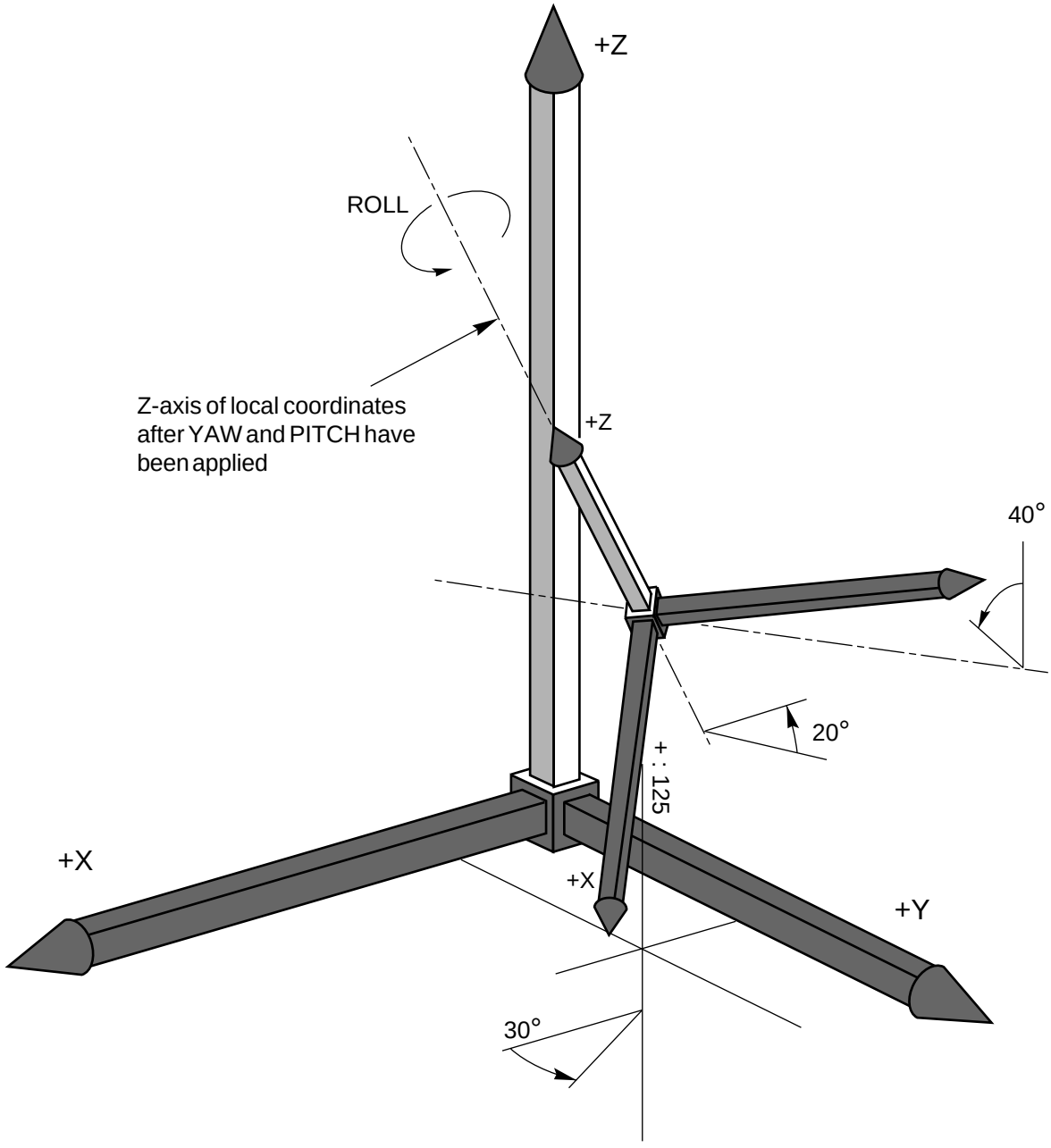


In this example, X = 30, Y = 100, Z = 125, yaw = 30, pitch = 40 and roll = 0.

A.2.4. ROLL (r)

Roll is defined as the rotation around the Z-axis of the local coordinates **after** YAW and PITCH rotations have been applied.

The figure below shows Roll rotation of 20° around the Z-axis of the local coordinates.



In this example, X = 30, Y = 100, Z = 125, yaw = 30, pitch = 40 and roll = 20.

A.3. LINE EDITOR

The advantage of this editor is that it is simple and compatible with the VAL 2 language editor.

This editor includes a certain number of commands.

NOTE These commands can be used only in editing mode («?» on LH side) to enter V^+ instructions into the robot.

These commands can be used to :
- Modify a program.
- Insert new instructions.
- Delete instructions.
- Search for certain instructions.
- etc...

We shall now look at these editor instructions.

If you are in execution mode (*) or in command mode (.), go to editing mode by typing : EDIT

(.) EDIT

EFFECT Places the robot in editor mode at specified line number.

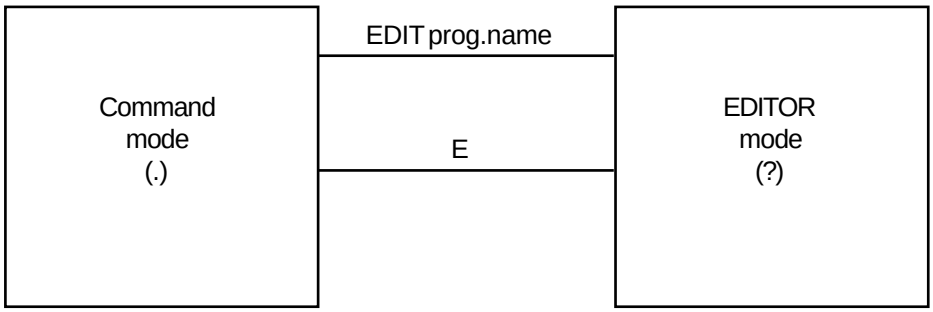
SYNTAX **EDIT** prog.name, n

n: No. of line on which you wish to be positioned in a previously edited program.

EXAMPLE EDIT TOTO,7

NOTE Avoid EDITING a running program as serious incidents may occur.

REMARKS As this command is frequently used, it is preferable to use ED instead of EDIT.



(?) E (EXIT)

EFFECT Quits editing mode and returns you to robot command mode, that is from (?) to (.).

SYNTAX **E**

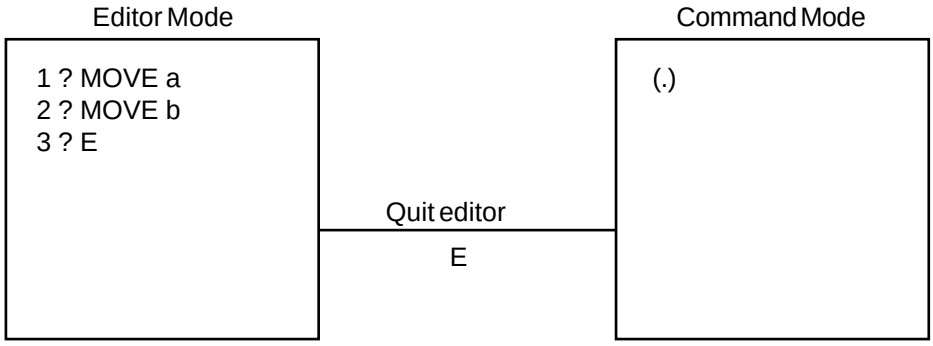
NOTE This command is only active when robot is in editor mode.

EXAMPLE

```
1 ? MOVE a
2 ? MOVE b
3 ? E
```

Return to command mode...
This command is used when you have finished writing or modifying a program.

REMARK You can exit from any program line.



(?) C (CHANGE)

EFFECT Changes from one program to another without leaving editor mode.

SYNTAX **C NAME**, n

n: Line No. to which you wish to go within declared PROG NAME.

If n is not specified, value by default is 1.

EXAMPLE

```
ED
PROG PROG1
1 ? MOVE a
2 ? MOVE b
3 ? MOVE c
4 ? C PROG2, 7    —>   PROG PROG2
                       7 ? MOVE b4
```

You will go to line 7 of PROG PROG2 (if PROG 2 already exists).

REMARK Same operation can be obtained by quitting editor mode with E and entering the other program with EDIT PROG2, 7

but this method is longer...

(?) D (DELETE)

EFFECT Deletes the specified number of lines.

SYNTAX **D** n
n : number of lines.

NOTE **If no value is specified for n, value by default is 1.**

EXAMPLE
ED TITI
1 ? MOVE a
2 ? MOVE b
3 ? MOVE c
4 ? MOVE d
5 ? MOVE f
6 ? MOVE g

If on line 2 ? MOVE b
you type: 2 ? **D** 3
you will delete line 2 and the 2 following lines.

Hence :
1 ? MOVE a
2 ? MOVE f
3 ? MOVE g

REMARK If you are 2 lines before the end of the program and you type D 21, deletion will not go back to start of program, it always stops at the end of the program.

(?) I (INSERT)

EFFECT Inserts one or more lines in a program.

SYNTAX **I**

NOTE To exit insertion mode, simply hit the -Return- key on a blank line.

EXAMPLE

```
ED TOTO
1 ? MOVE a        To insert MOVE c1 and MOVE c2 between lines 3 and 4
2 ? MOVE b
3 ? MOVE c
4 ? MOVE d
5 ? MOVE e

Therefore         4 ? MOVE d
                  4 ? I
                  4 ? MOVE c1
                  5 ? MOVE c2
                  5 ? (press -Return-)

Result            ED TOTO
                  1 ? MOVE a
                  2 ? MOVE b
                  3 ? MOVE c
                  4 ? MOVE c1
                  5 ? MOVE c2
                  6 ? MOVE d
                  7 ? MOVE e
```

Line numbers are automatically reassigned.

(?) L (LAST)

EFFECT Returns you to previous line.

SYNTAX **L**

NOTE To skip back several instructions, it is preferable to use the editor command S.

EXAMPLE

```
ED TOTO
1 ? MOVE a
2 ? MOVE b
3 ? MOVE c
4 ? MOVE d
4 ? L
3 ? MOVE c
```

You can only move back one step at the time.

REMARK If you enter L when on program line No. 1, you will remain on line No. 1, but this is nonsensical.

(?) S (SEARCH)

EFFECT Searches for required line number.

SYNTAX **S** n where n: line No.

EXAMPLE 1

```
ED TOTO
1 ? MOVE a
2 ? MOVE b
3 ? MOVE c
4 ? MOVE d
5 ? S 2
2 ? MOVE b
```

Search backwards

or

EXAMPLE 2

```
ED TOTO
1 ? MOVE a
2 ? MOVE b
3 ? MOVE c
4 ? MOVE d
5 ? MOVE e
6 ? S 20
20 ? MOVE k
```

Search forwards

REMARK If you specify a number which exceeds program line number, you will simply go to the end of the program.

(?) P (PRINT)

EFFECT Displays a certain number of lines on the screen.

SYNTAX **P** n where n: number of lines.

REMARK If P is given alone, only content of line where P command is located will be displayed.

NOTE Useful for displaying only a limited number of lines on screen.

EXAMPLE

```
ED TOTO
1 ? MOVE a
1 ? P 3
1 ? MOVE a
2 ? MOVE b
3 ? MOVE c
```

REMARK If you are 2 lines off the end of the program and you enter P21, display will always stop at end of program.

(?) R (REPLACE)

EFFECT Replaces characters in an instruction.

SYNTAX **R characters**

REMARK Blank characters must be considered as ordinary characters.

NOTE This concerns replacement and not insertion of characters.
Place the R just above the first character to be replaced.

EXAMPLE
ED TOTO
2 ? MOVE a
2 ? **R** S a ®
2 ? MOVES a

EXAMPLE
ED TOTO
2 ? MOVE a if you want to obtain:
2 ? 30 MOVE a

Do 2 ? MOVE a
2 ? **R** 30 will give the required result:
2 ? 30 MOVE a

(?) T (TEACH)

EFFECT Records the coordinates of a set of locations and automatically writes motion order associated with these locations (each time REC/DONE pushbutton located on teach pendant is pressed).
Allows robot to be set to teach mode.

SYNTAX **T** point.name

NOTE This mode is useful when a succession of locations is to be recorded.

EXAMPLE
ED TOTO
1 Program TOTO ( )
2 ? T d1
When REC/DONE pushbutton is pressed, the following will be displayed:

2 MOVET d1,0 if grip closed
or
MOVET d1,1 if grip open.

If Record is pressed again, the following will be obtained :
3 MOVET d2,0
etc...

Each time REC/DONE is pressed, location index is automatically incremented.

REMARK A location recorded in TEACH mode can be modified later.

(?) TS (TEACH STRAIGHT)

EFFECT This command is same as T, except that motions will be straight line motions between recorded locations.

SYNTAX TS variable name

NOTE This mode is useful when a succession of straight line locations is to be recorded.

EXAMPLE ED TOTO

1 Program TOTO ( )
2 ? TS d1

when REC/DONE pushbutton is pressed, the following will be displayed:

2 MOVEST d1, 0 if grip is closed or MOVEST d1, 1 if grip is open.

If REC/DONE is pressed again, the following will be obtained:

3 MOVEST d2,0

etc.

Each time REC/DONE is pressed, location index is automatically incremented.

REMARK T and TS can be mixed within a program, but this is tedious.