Introduction to Industrial Robot Programming

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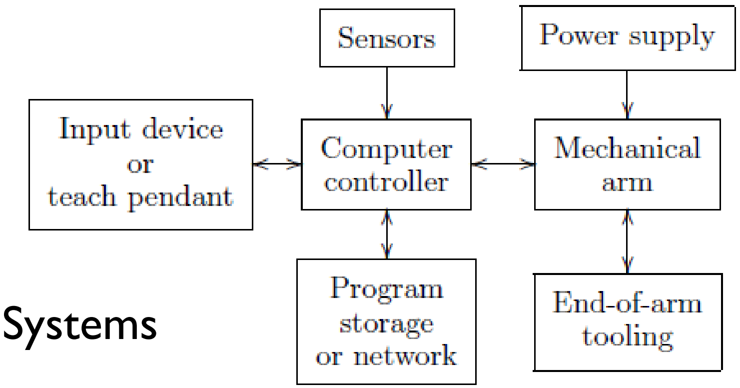
What is an industrial robot?

- An industrial robot is a robot system used for manufacturing.
- They can be programmed to perform dangerous, dirty and/or repetitive tasks with high
  - speed,
  - precision,
  - accuracy and.
  - endurance,
- Typical applications of robots include
  - welding,
  - painting,
  - assembly,
  - pick and place for printed circuit boards,
  - packaging and labeling,
  - palletizing,
  - product inspection,
  - and testing

Our robot: Stäubli TX90XL

- 6 axis articulated robot arm
- High-speed, high-resolution servo motors with absolute position sensors at each axis
- Nominal payload: $5\ kg$
- Repeatability: $\mp 0.04\ mm$
- Weight: $116\ kg$
- Arm reach: $1.5\ m$

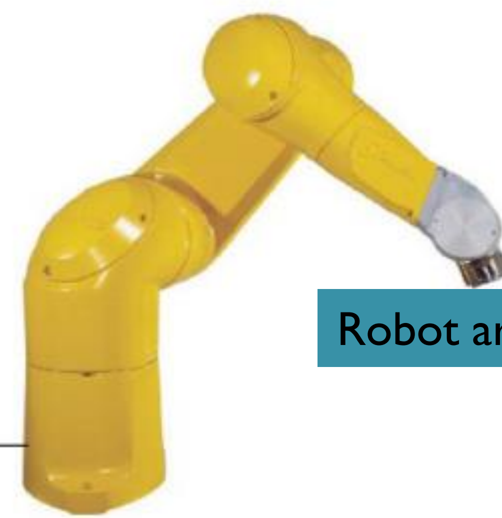
Our robot: Stäubli TX90XL



Robotic Systems

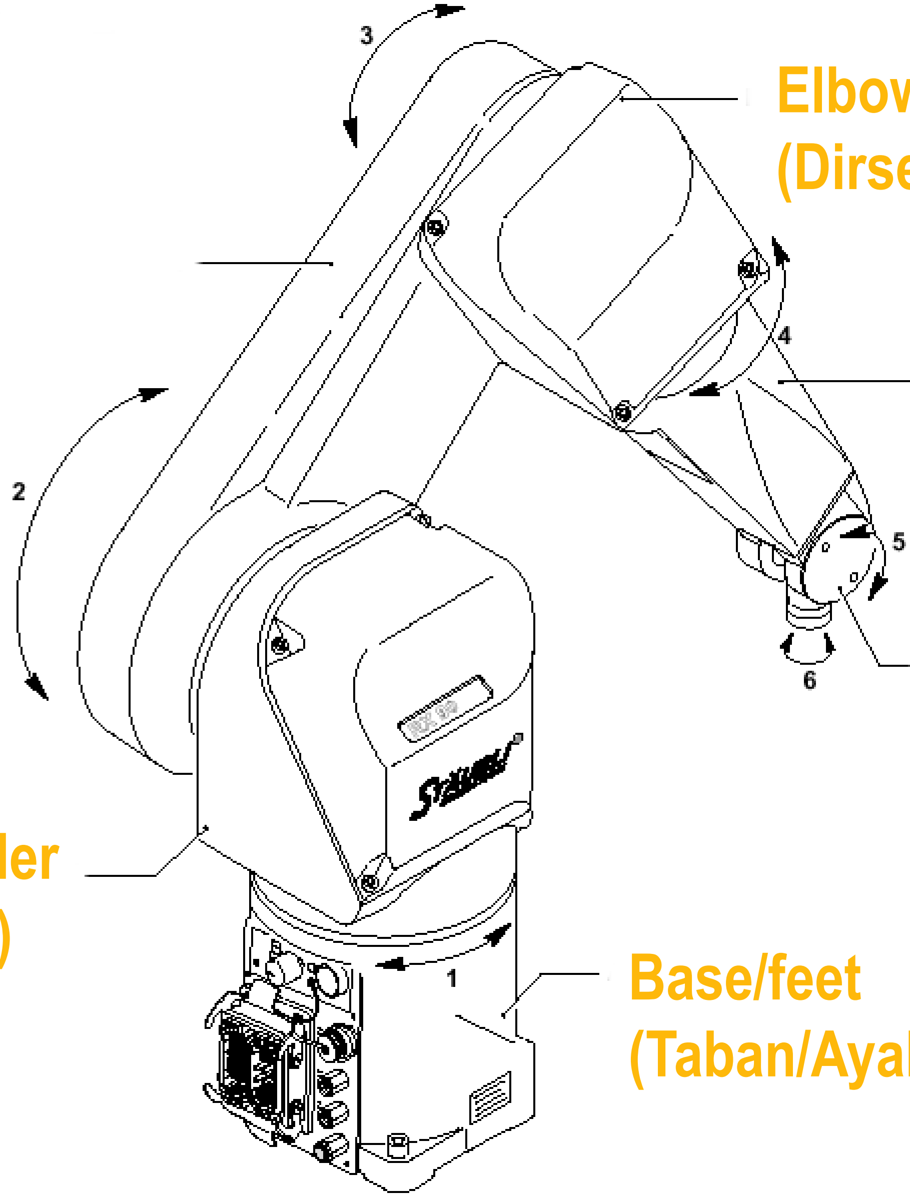
Manual control:
Pendant

Cabinet



Robot arm

KOL


Elbow
(Dirsek)
Wrist
(Bilek)
Shoulder
(Omuz)
Base/feet
(Taban/Ayak)
1
2
3
4
5
6

Cabinet : The Controller

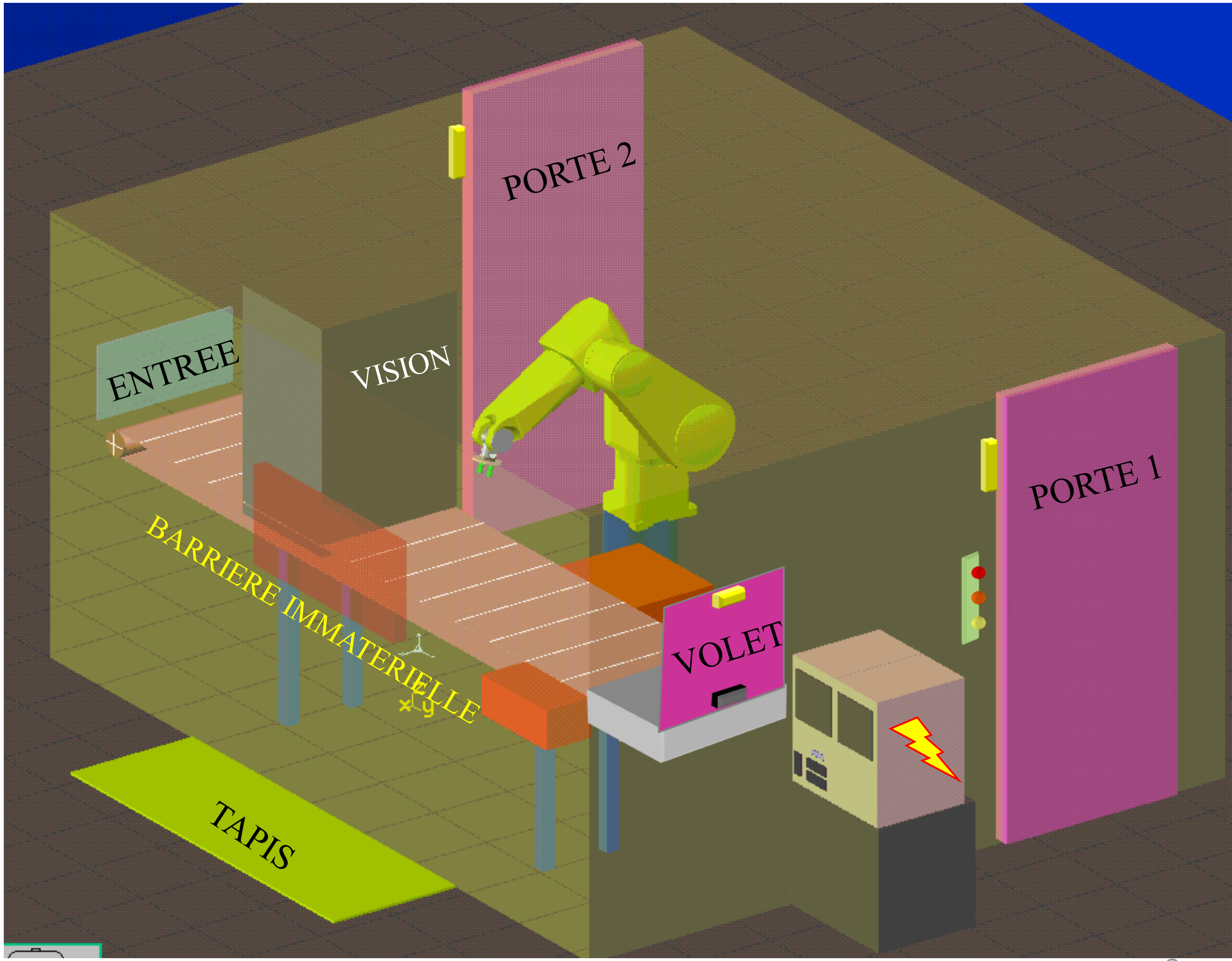
- The CS8C controller is made up of a processor (5), the intelligent part of the installation.
- The processor controls the robot via digital power amplifiers (1) dedicated to each axis of the arm.
- The electrical power is converted by the PSM (7) power section, the RPS (2) power supply, and the ARPS (3).
- To disconnect the system from the power supply, set the master switch (6), located on the front panel of the controller, to 0. Before doing so, you must stop the arm operations and switch off arm power supply.

Pendant

- The MCP (Manual Control Pendant) can be used to enable arm power supply and control its movements.

ROBOT CELL

- **Robot system is always installed in a security cell**

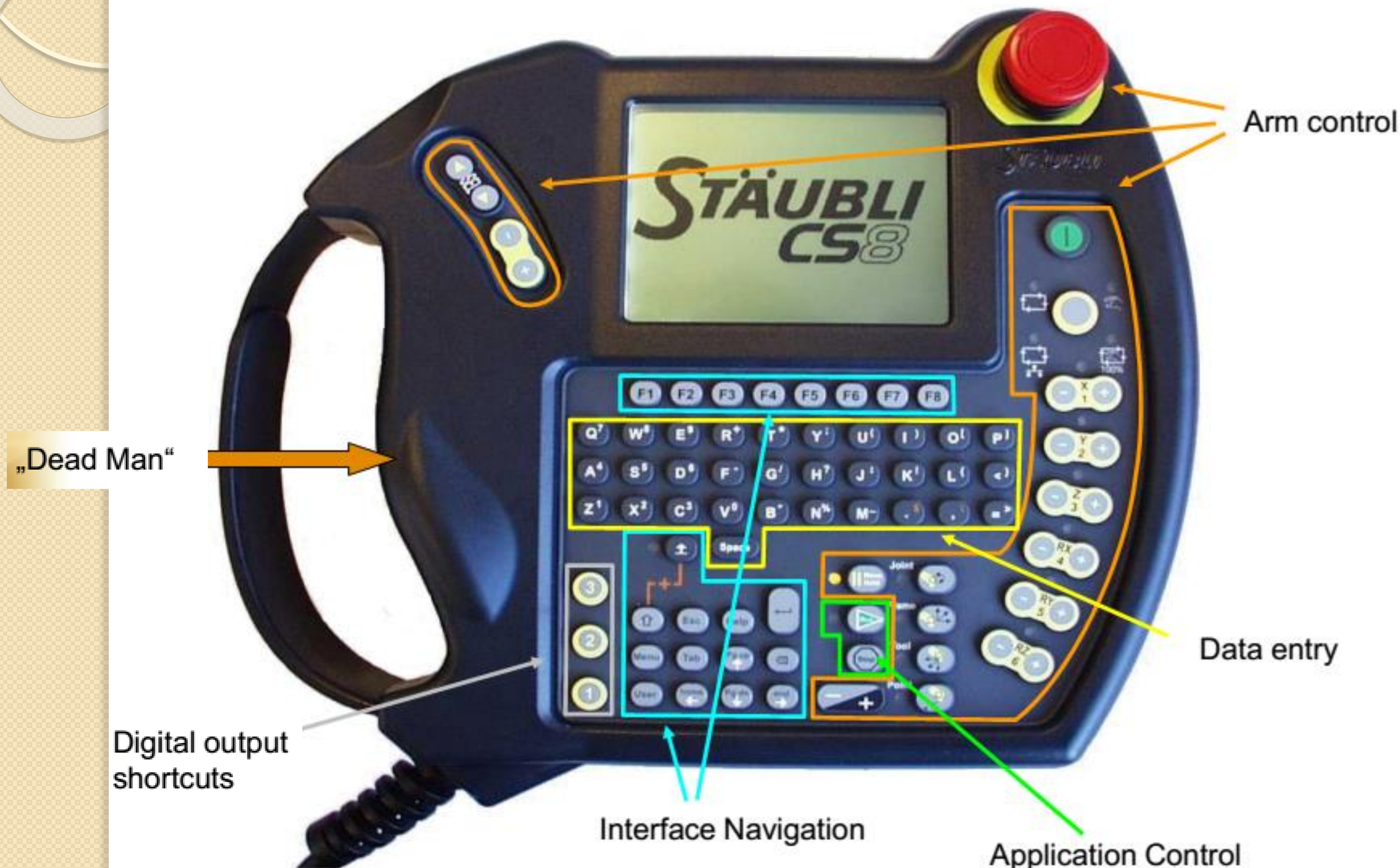


OPERATORS SECURITY

- Do not enter in the cell if the arm power is on
- Robot might move very fast
- Robot may make unpredictable move depending on the program
- Robot may damage itself and its surronding.
- Robot may cause serious engineering.

Do not work in the cabinet if the power is on.

Pendant


Arm control
„Dead Man“
STÄUBLI
CS8
Data entry
Digital output
shortcuts
Interface Navigation
Application Control

Safety

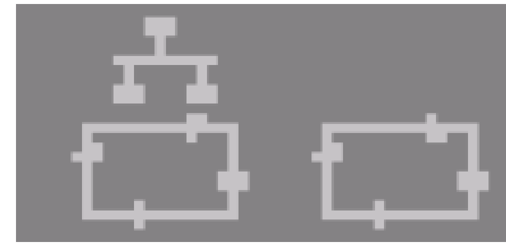
- Always operate the robot arm at low speed (%10 speed) at first
- Be ready to stop arm motion:
  - Emergency stop (the big red button),
  - Arm power off,
  - Move/hold key,
  - Dead man's switch.

Safety

- Do not use the robot pendant without supervision.
- Do not run your program without supervision.

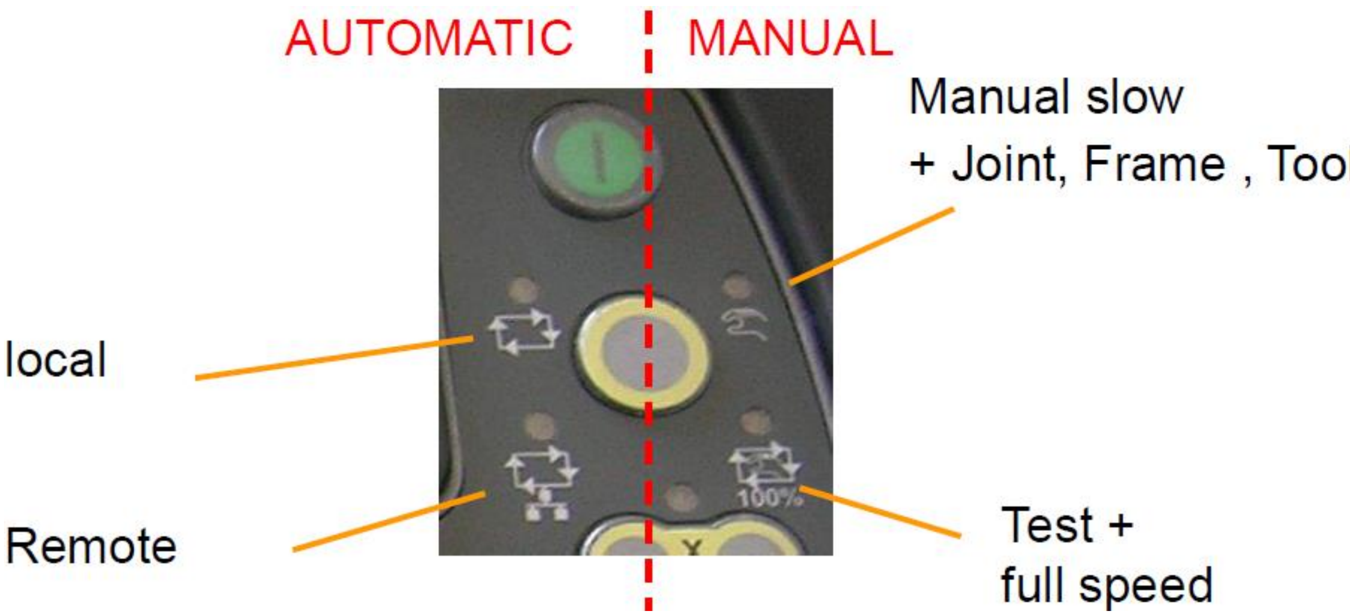
WORKING MODES INTRODUCTION

- AUTOMATIC (production mode)
  - The Robot cell is closed, nobody inside. The robot is under program control. Motions can be done at very high speed.



- MANUAL (Trajectory teaching, Manual motion to the start position)
  - This robot is controlled by the operator with teach Pendant in hands
  - The speed is limited to 250 mm/s maximum
  - The operator can be close to the robot

WORKING MODES

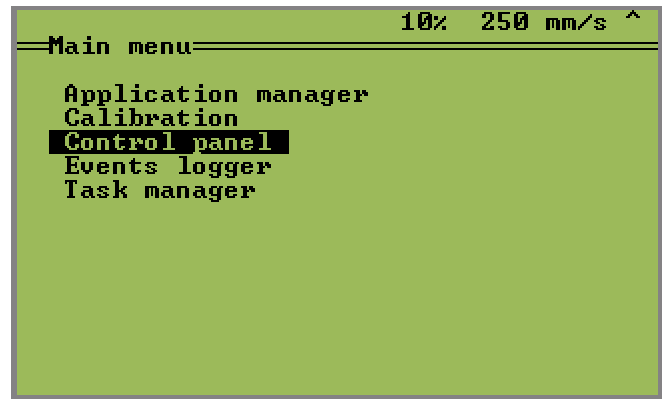


- No working mode selection from MCP
- Command by a key outside the robot cell

ROBOT STARTUP

1

2 Wait for main menu



3 An application can be automatically loaded and/or manually executed.

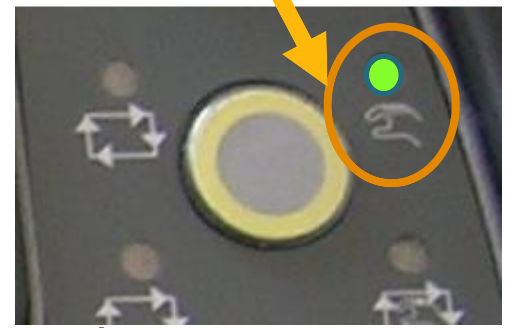
SYSTEM STOP

1 Arm power off

2 Main switch OFF

ARM POWER ON (MANU)

Manual Mode is selected.



1. MCP on park | MCP on hands

Cell opened

2. Remove and place it on
if > 15 seconds
| Release and maintain Dead Man
if > 15 seconds

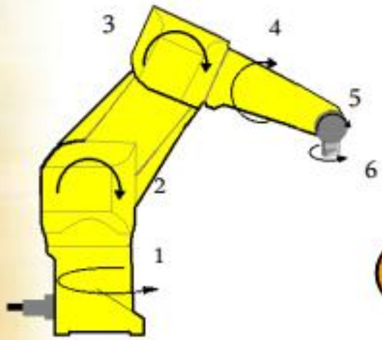
3. Arm power ON butonu

After pressing power button if the enable button (deadman) has been put into its middle position in the last 15 seconds or if the MCP has been placed on its holder in the last 15 seconds.

Manual movement

- Joint move: Moves the robot by rotating the individual joints
  - Cannot do linear movement
  - Is not subject to singularity
- Frame move: Moves the robot in a specified coordinate frame
  - Can do linear movement
  - Subject to singularity
- Tool move: Moves the robot with respect to the tool coordinate frame
  - Can do linear movement
  - Subject to singularity

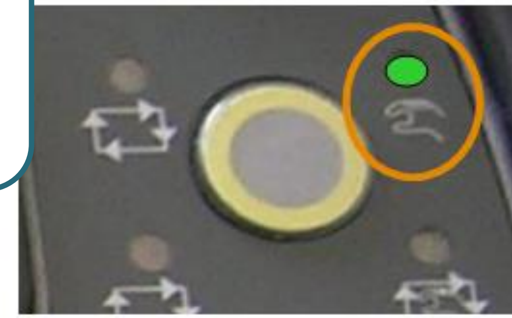
Manual movement with the joint move



1 Joint

2 Speed

- +

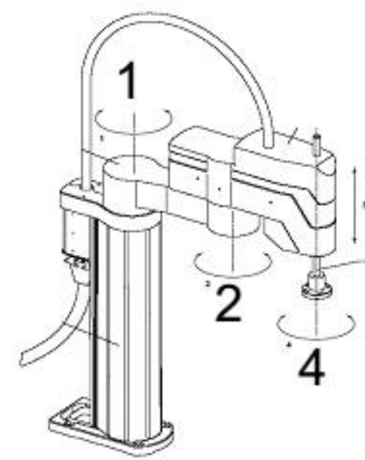


! Requested !

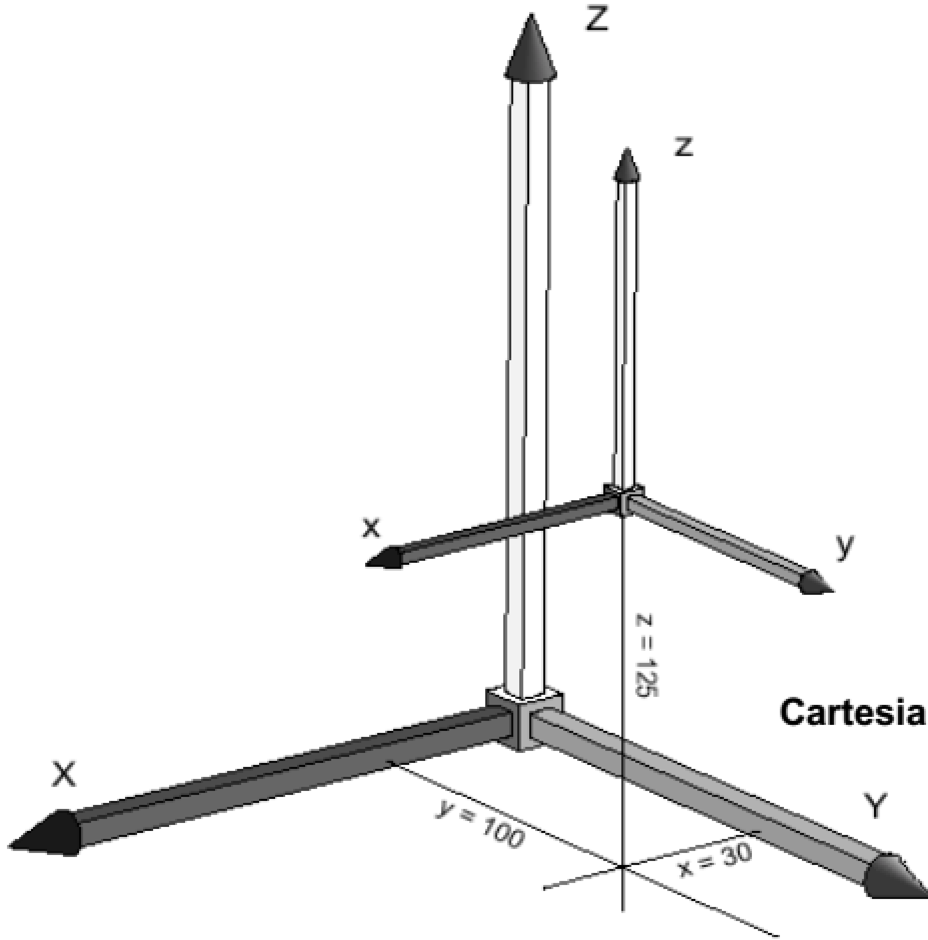
-JT1
-JT2
-JT3
-JT4
-JT5
-JT6

- +

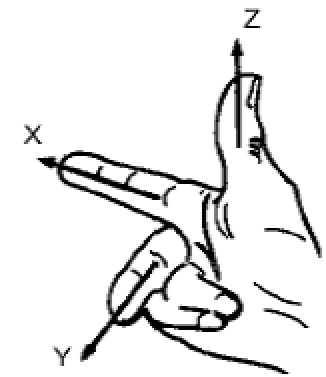
3



Manual movement with the frame move: Coordinate system



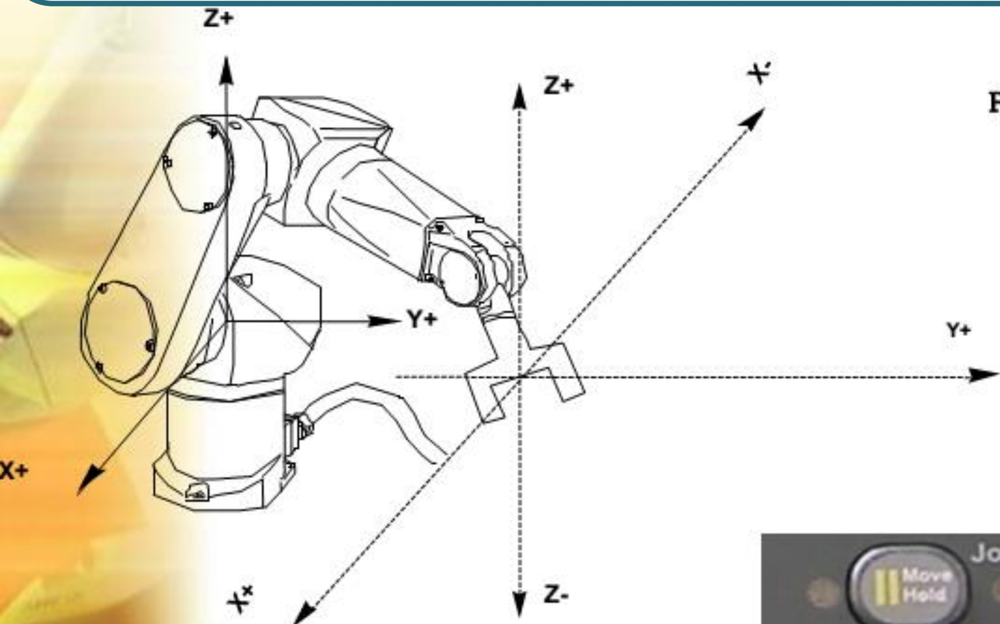
Cartesian Coordinate



!! Right Hand !!

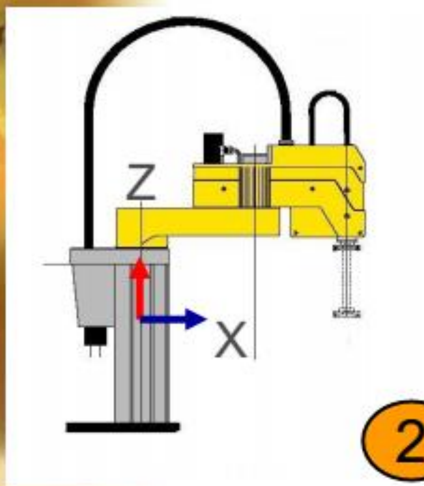
3 axis perpendicular each other

Manual movement with the frame move: Translation



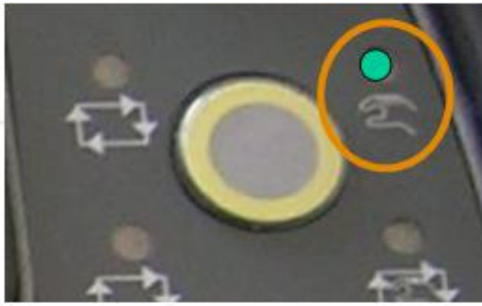
FIXED FRAME

« WORLD »



1 Frame

2 Speed



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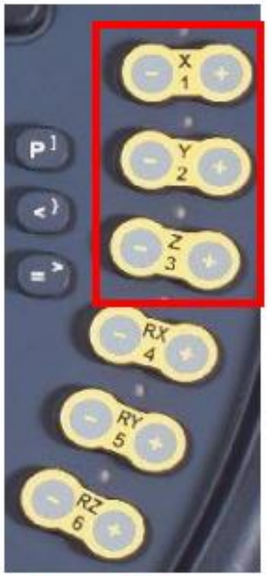
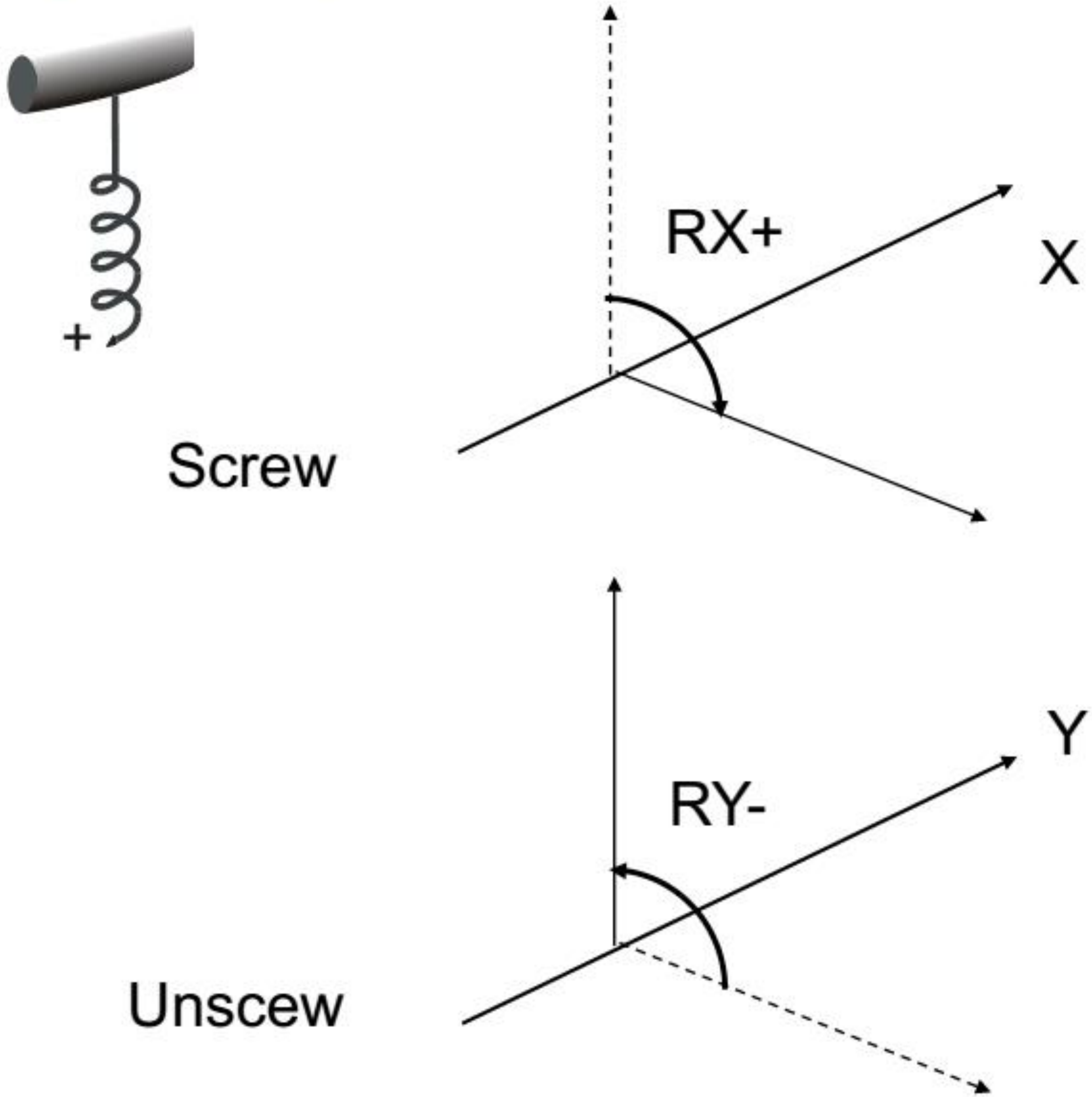


Translation

\- +

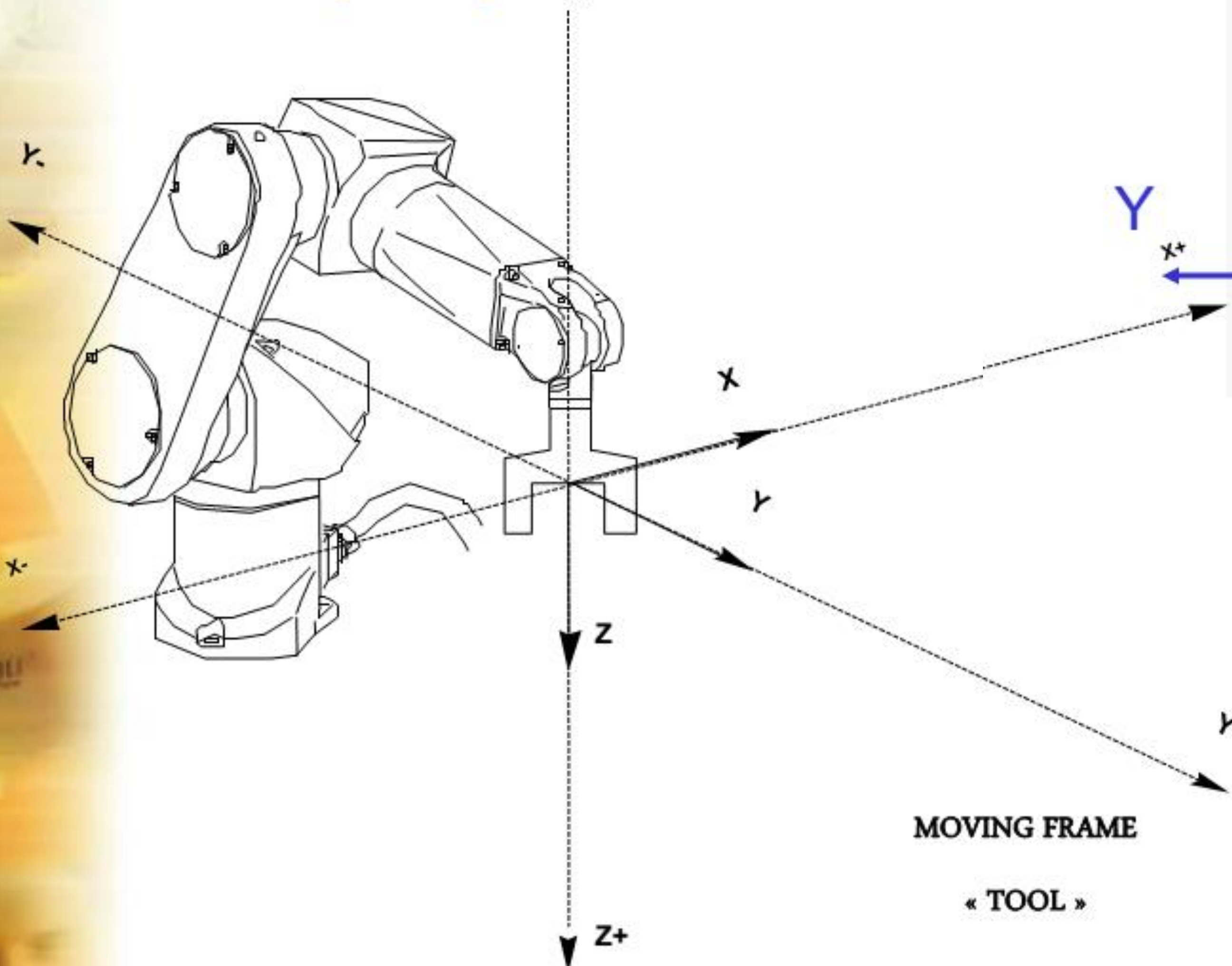
3

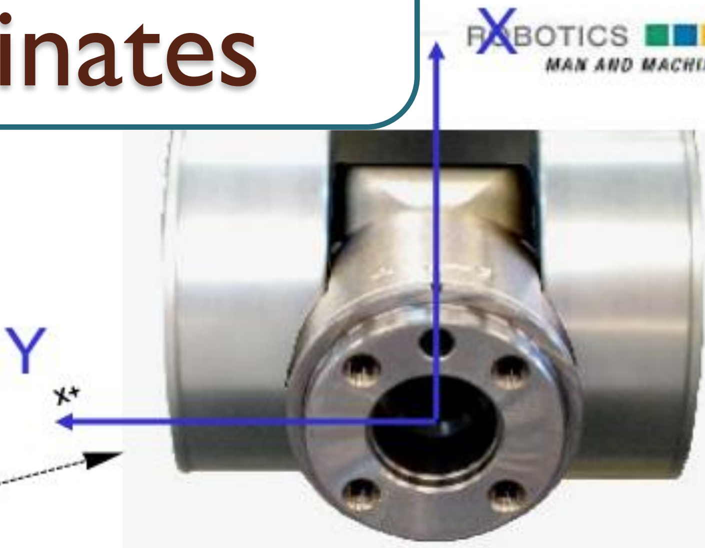
Manual movement with the frame move: Rotation

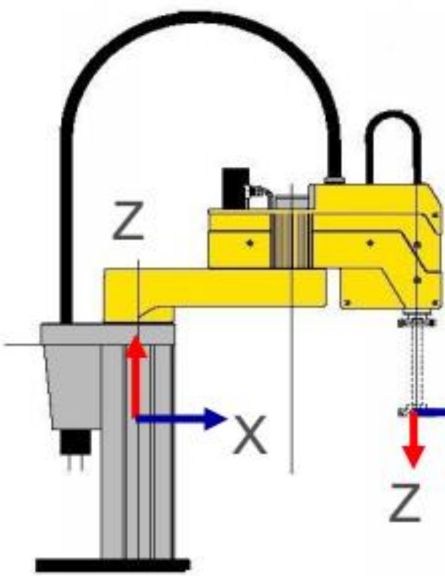


Rotation

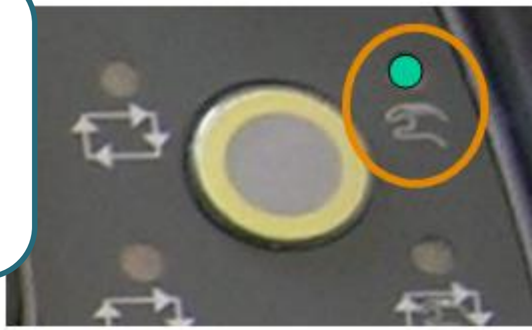
Manual movement with the tool frame: Coordinates



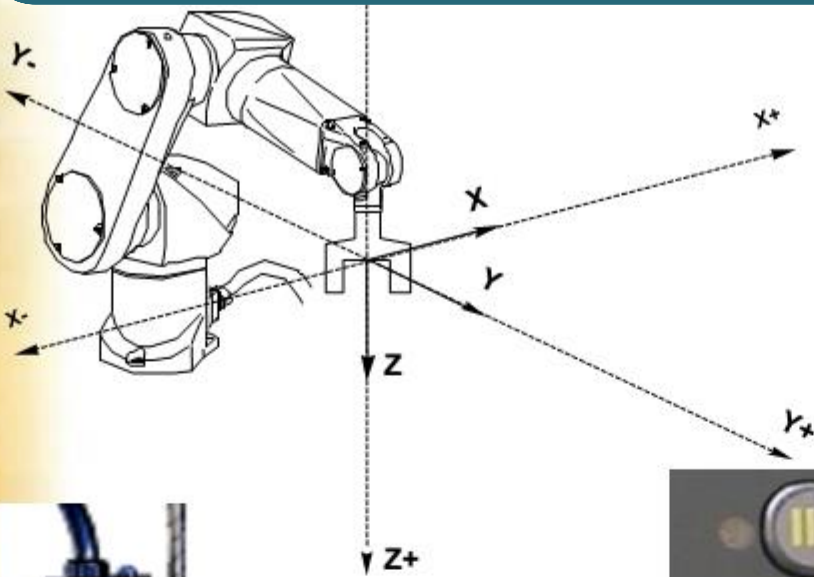




Manual movement with the tool frame:

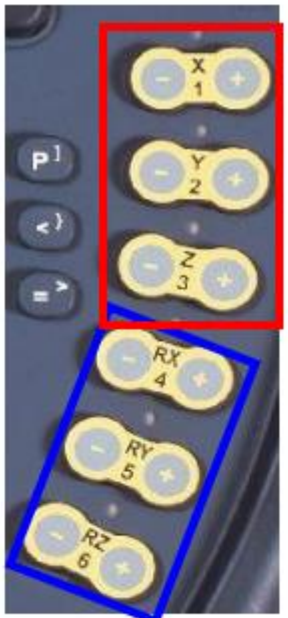


! Requested !



1

Tool



Translation

- +

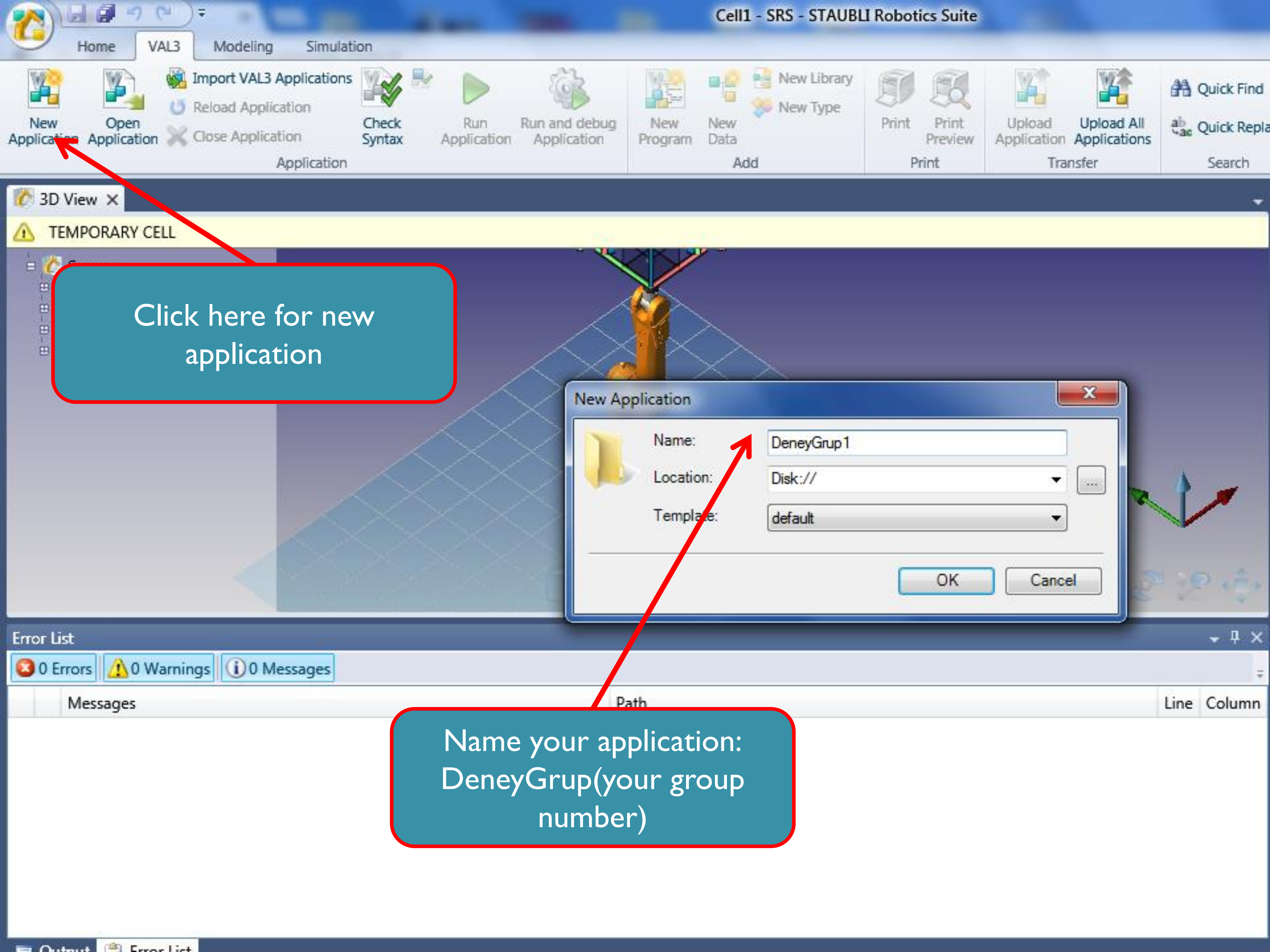
Rotation

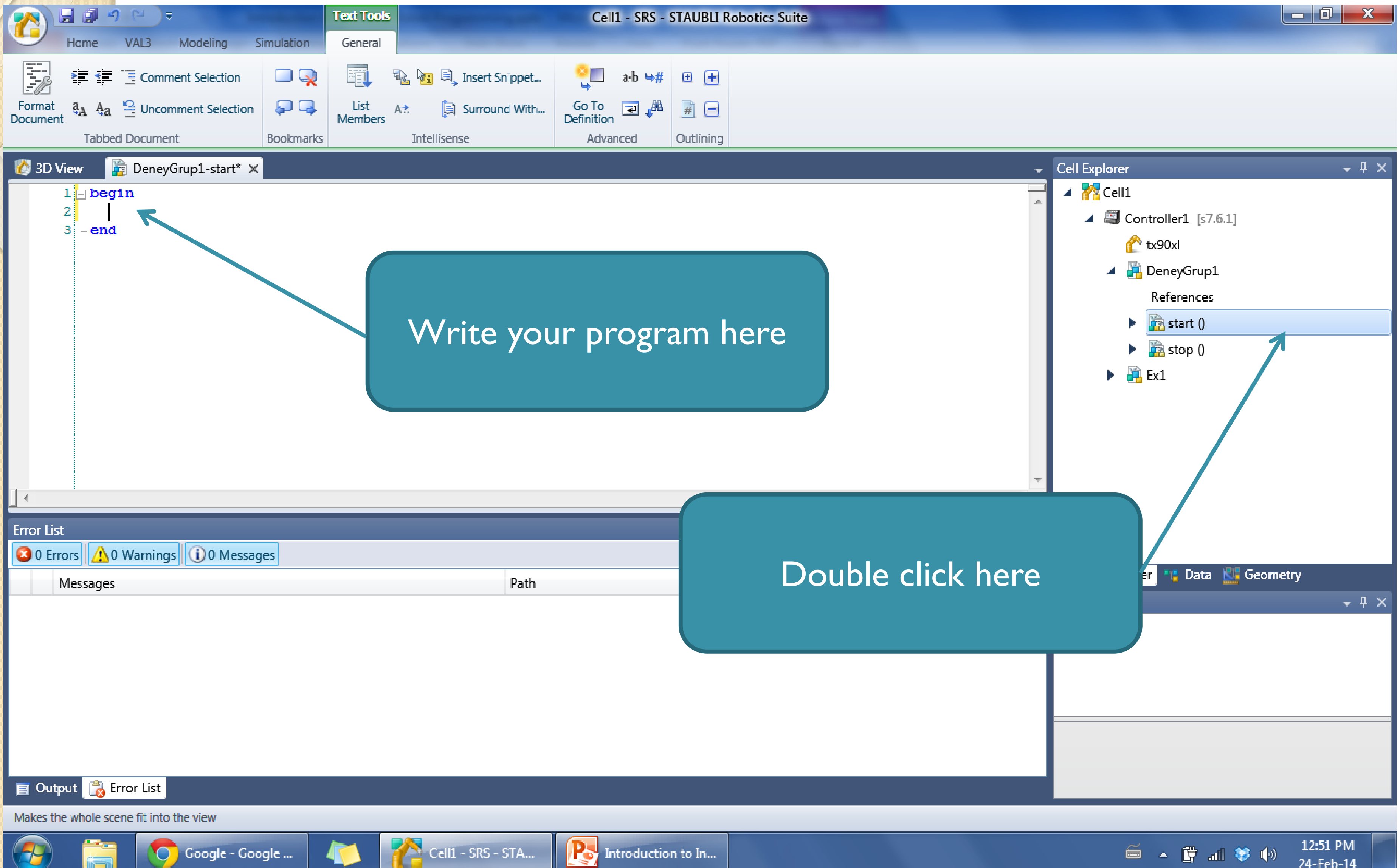
2 Speed

3

Creating applications with VAL3:

- Need:
  - VAL3 installed
  - A ‘cell’ defined (controller, robot, tool)
  - Licence (licence flash-disk attached to the computer)


Cell1 - SRS - STAUBLI Robotics Suite
Home
VAL3
Modeling
Simulation
New Application
Open Application
Import VAL3 Applications
Reload Application
Close Application
Check Syntax
Run Application
Run and debug Application
Application
New Program
New Data
New Library
New Type
Add
Print
Print Preview
Print
Upload Application
Upload All Applications
Transfer
Quick Find
Quick Repla
Search
3D View
TEMPORARY CELL
Click here for new application
New Application
Name:
DeneyGrup1
Location:
Disk://
Template:
default
OK
Cancel
Error List
0 Errors
0 Warnings
0 Messages
Messages
Path
Line
Column
Name your application: DeneyGrup(your group number)
Error List


Cell1 - SRS - STAUBLI Robotics Suite
Text Tools
Home
VAL3
Modeling
Simulation
General
Format Document
Comment Selection
Uncomment Selection
Tabbed Document
Bookmarks
List Members
Insert Snippet...
Surround With...
Intellisense
Go To Definition
Advanced
Outlining
3D View
DeneyGrup1-start*
begin
end
Write your program here
Cell Explorer
Cell1
Controller1 [s7.6.1]
tx90xl
DeneyGrup1
References
start ()
stop ()
Ex1
Error List
0 Errors
0 Warnings
0 Messages
Messages
Path
Double click here
Data
Geometry
Output
Error List
Makes the whole scene fit into the view
Google - Google ...
Cell1 - SRS - STA...
Introduction to In...
12:51 PM
24-Feb-14

View | DeneyGrup1-start* | Ex1-start

```
begin
    movej(jStart,tTool,mNomSpeed)
    movej(appro(p1,trAAppl),tTool,mNomSpeed)
    movel(p1,tTool,mNomSpeed)
    movel(p2,tTool,mNomSpeed)
    movel(p3,tTool,mNomSpeed)
    movel(p4,tTool,mNomSpeed)
    movel(p5,tTool,mNomSpeed)
    movel(p6,tTool,mNomSpeed)
    movel(p7,tTool,mNomSpeed)
    movel(p8,tTool,mNomSpeed)
    movel(p9,tTool,mNomSpeed)
    movel(p10,tTool,mNomSpeed)
    movel(p1,tTool,mNomSpeed)
    movej(appro(p1,trAAppl),tTool,mNomSpeed)
    movej(jStart,tTool,mNomSpeed)
    waitEndMove()
end
```

FUNCTIONS

VARIABLES

Applications: Structure

- Variable types:
  - pointRx: a point location in cartesian coordinates (p1, p2, p3, ...)
  - jointRx: a joint location in joint coordinates (jStart)
  - tool: a tool defined by the user (tTool)
  - trsf: a transformation (trAApl)
  - mdesc: motion descriptor (mNomSpeed)

Applications: Structure

- Functions:
  - movej(joint, tool, mdesc): move to a (point or joint) coordinate with specified tool and motion descriptor
  - movel(point, tool, mdesc): move linearly a point coordinate with specified tool and motion descriptor
  - appro(point, trsf): calculate a transformed point by using a point and a transformation
  - waitEndMove: wait for the current movement to end.

Movement with movej

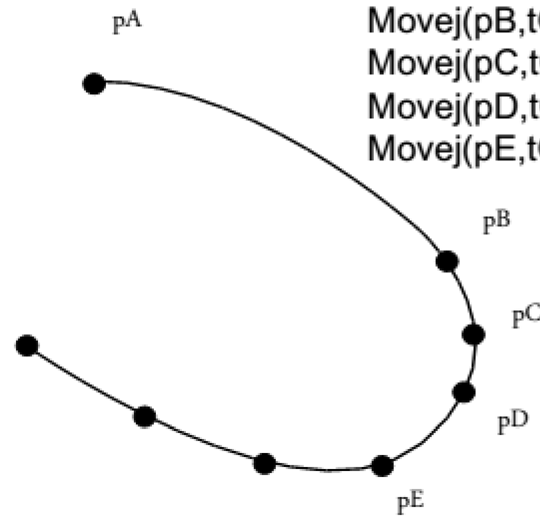
MOVEMENT : MOVEJ

Movej(pA,tGrip,mFast)
Movej(pB,tGrip,mFast)
Movej(pC,tGrip,mFast)
Movej(pD,tGrip,mFast)
Movej(pE,tGrip,mFast)

Movej(point,tool,mdesc)

or

Movej(joint,tool,mdesc)



Joint Interpolation : curved movement

Speed and acceleration described by motion descriptor

No problem of singularity crossing

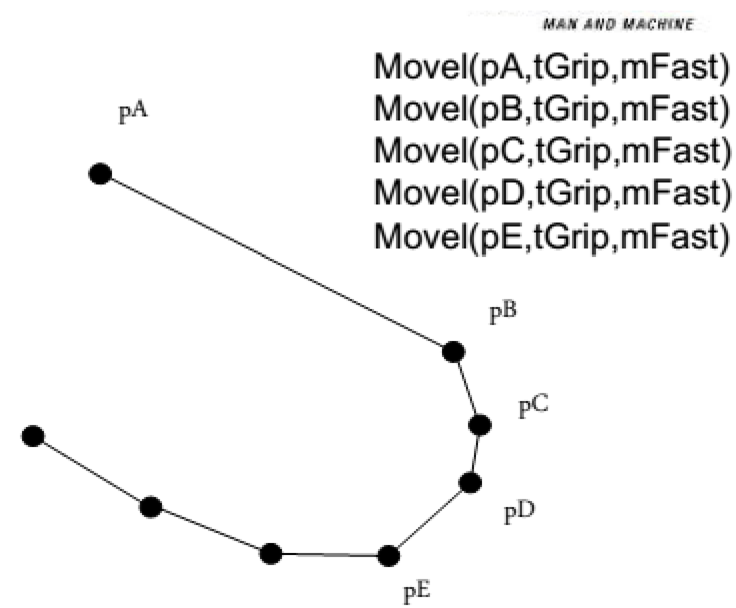
Motion to use if no constraint : Obstacle, insertion, . . .

Movement with movel

MOVEMENT : MOVEL

Movel(point,tool,mdesc)

Not available on JOINT



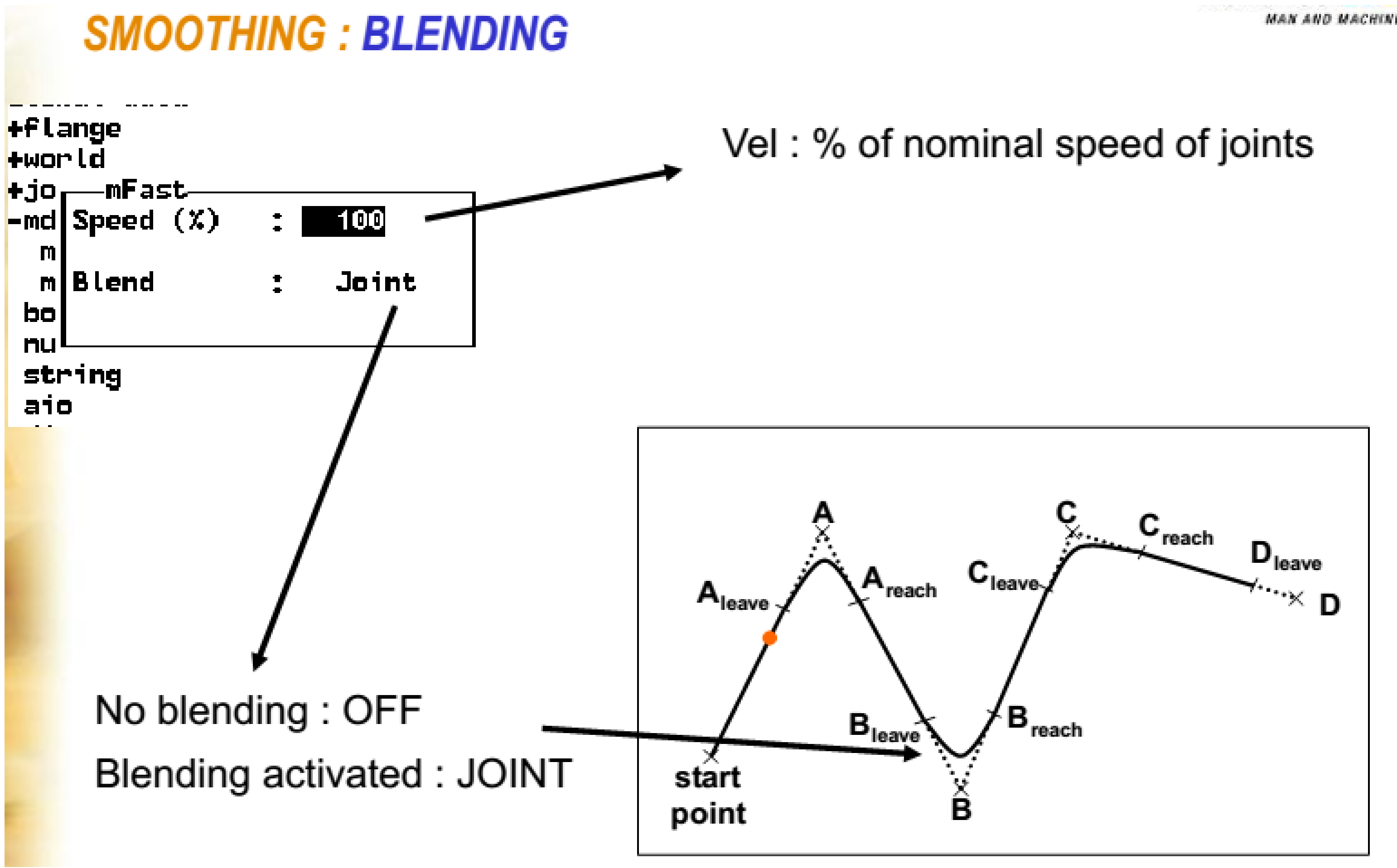
Cartesian Interpolation : straight line movement

Speed and acceleration described by motion descriptor

Problem of singularity crossing => slow down

Motion to use in case of constraint : obstacle, insertion, process, . . .

Motion descriptor parameters: blend



Example program:

View

```
begin
    movej(jStart,tTool,mNomSpeed)
    movej(appro(p1,trAAppl),tTool,mNomSpeed)
    movel(p1,tTool,mNomSpeed)
    movel(p2,tTool,mNomSpeed)
    movel(p3,tTool,mNomSpeed)
    movel(p4,tTool,mNomSpeed)
    movel(p5,tTool,mNomSpeed)
    movel(p6,tTool,mNomSpeed)
    movel(p7,tTool,mNomSpeed)
    movel(p8,tTool,mNomSpeed)
    movel(p9,tTool,mNomSpeed)
    movel(p10,tTool,mNomSpeed)
    movel(p1,tTool,mNomSpeed)
    movej(appro(p1,trAAppl),tTool,mNomSpeed)
    movej(jStart,tTool,mNomSpeed)
    waitEndMove()
end
```

Move to the starting location

Approach to point1

Move to point 1

Move to point 2

- Use as many points
- as necessary
-

Move to point 10

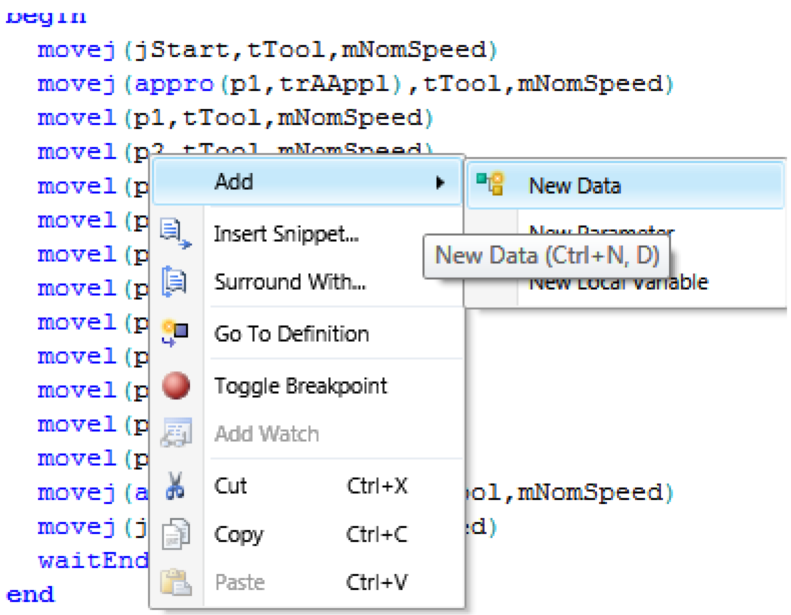
Move to point 1

Approach to point1

Move to the starting location

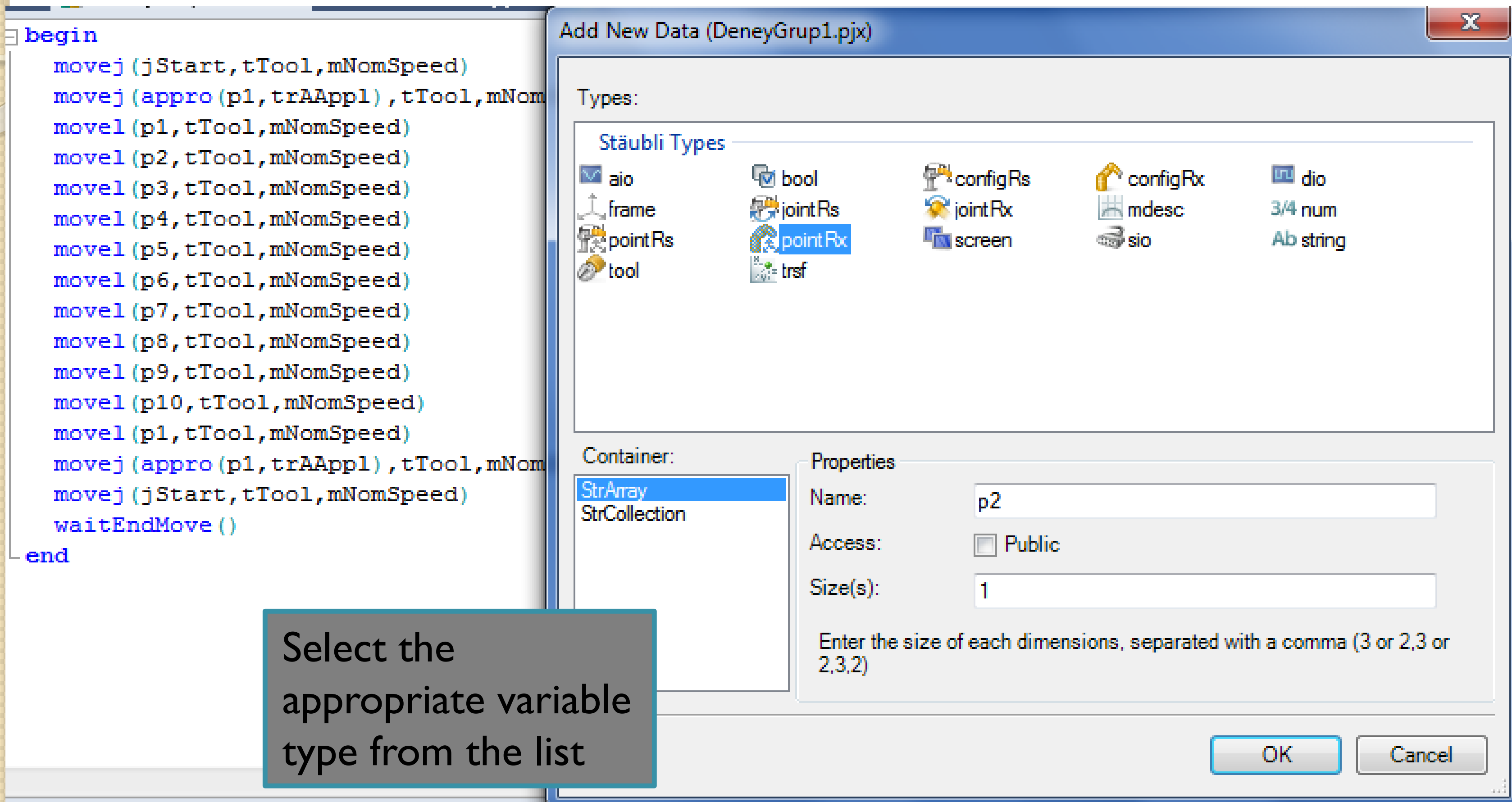
Wait for the movement to end

Adding variable definitions:



Right click on the variable to add (p2), select add, new data

Adding variable definitions:



Select the appropriate variable type from the list

Editing mdesc and trsf

Right click on a variable and select 'Go to definition' to edit the variable. Edit only mdesc and trsf this way.

- mdesc: mNomSpeed

3D View | DeneyGrup1-start* | Ex1 Data-mNomSpeed ×

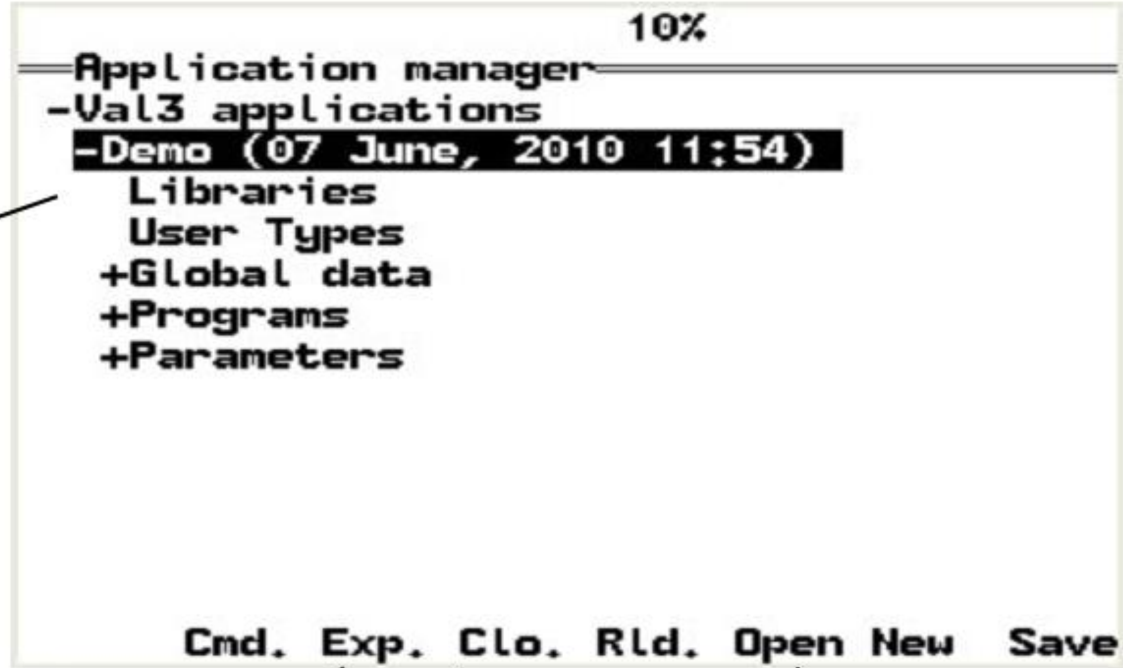
Index	accel	vel	decel	tvel	rvel	blend	leave	reach
0	100	100	100	99999	99999	joint	10	10

- trsf: trAApl

3D View | DeneyGrup1-start* | Ex1 Data-trAAppl × | Ex1-start

Index	x	y	z	rx	ry	rz
0	0	0	-100	0	0	0

Applications: using pendant



Application name
(save date)

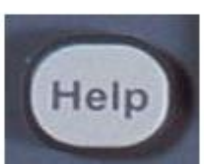
Contextual Menu

Export :
Copy

Close

Reload
(after SRS transfer)

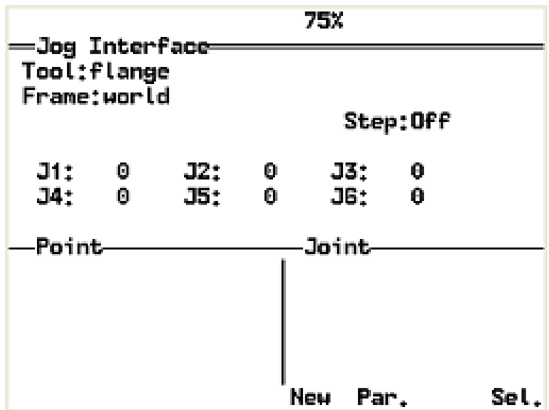
Open another application

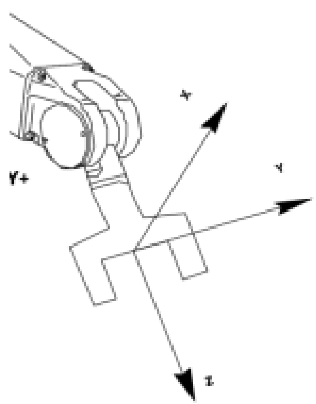


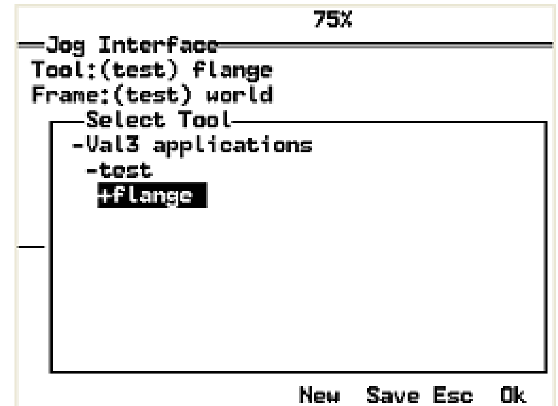
Help on menus

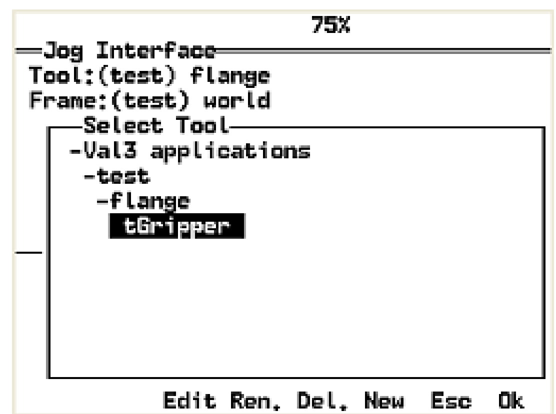
Applications: Teaching with pendant

TOOL SELECTION



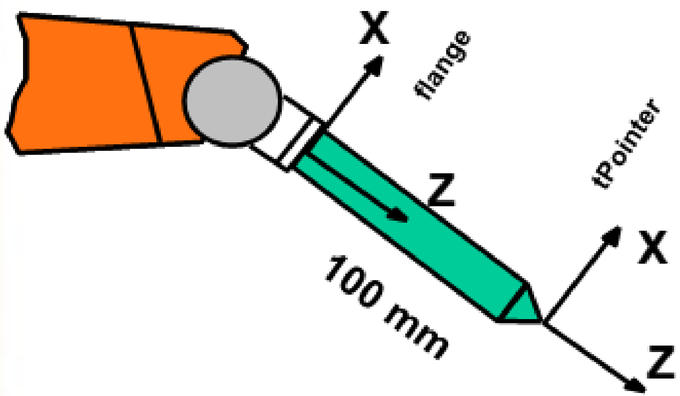






Applications: Teaching with pendant

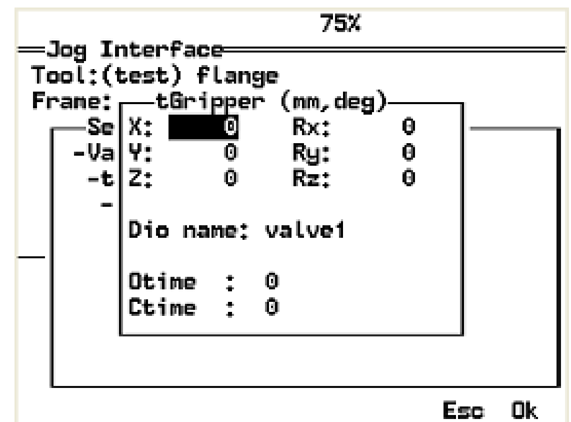
TOOL EDITION



Teach locations

Position and speed control

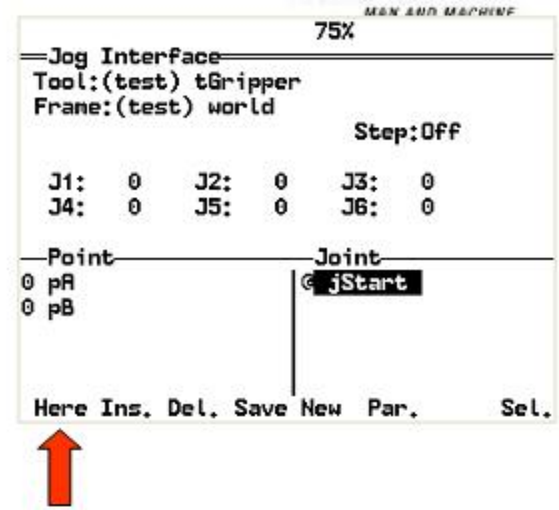
Geometrical adjustments

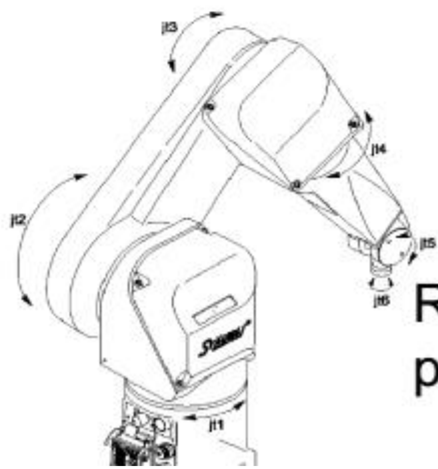


- Geometrical Definition
- Associated digital output
- Delay to open / close in secs.

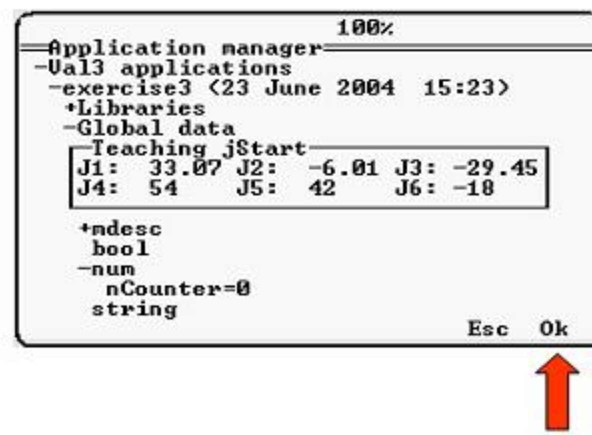
Applications: Teaching with pendant

Move to the desired position
by using the manual control



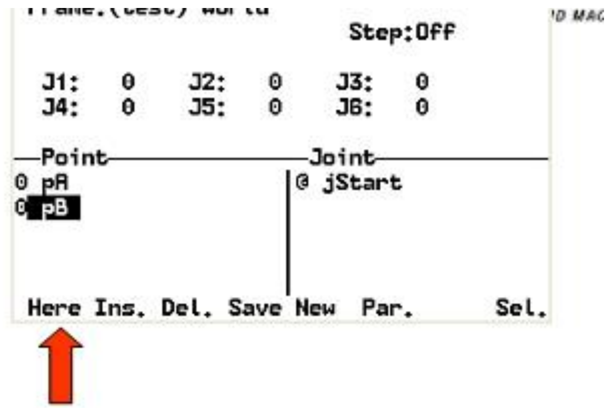


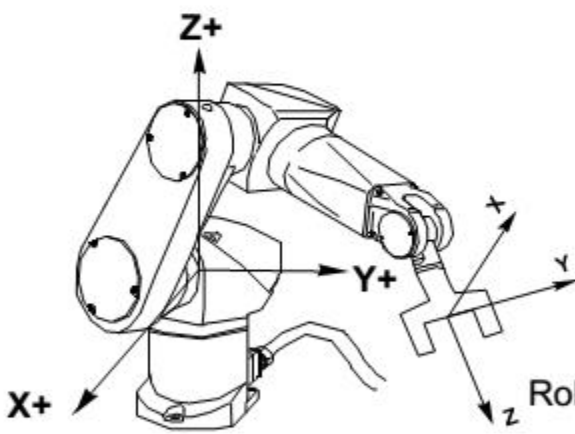
Robot at position



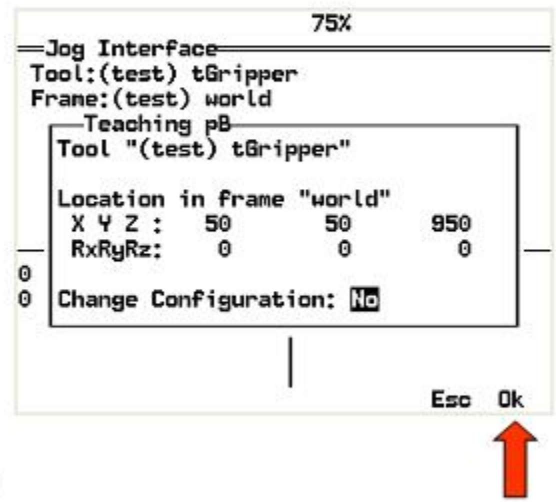
Applications: Teaching with pendant

Move to the desired position
by using the manual control





Robot at position



Elements of the jog interface

JOG INTERFACE

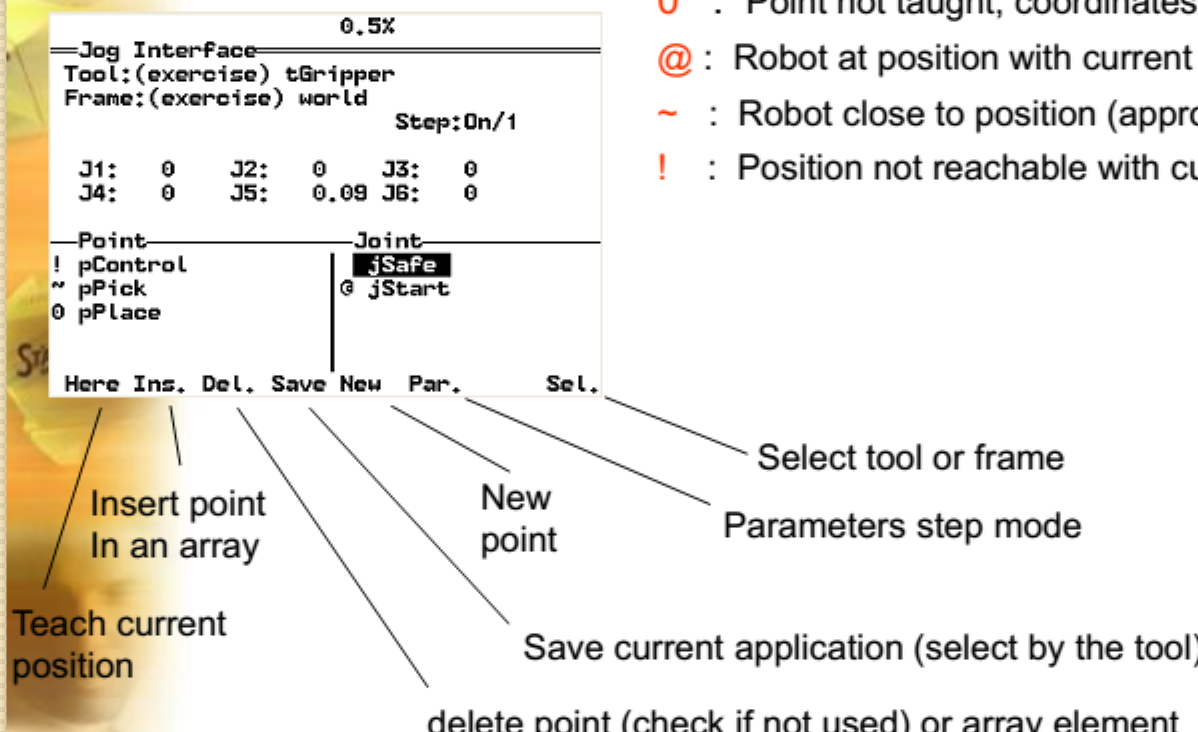
MAN AND MACHI

Points of an application

Symbols in front of points name :

VAL3 6.5+

- 0 : Point not taught, coordinates = 0
- @ : Robot at position with current tool (approx 0.01 mm)
- ~ : Robot close to position (approx. 1 mm)
- ! : Position not reachable with current tool

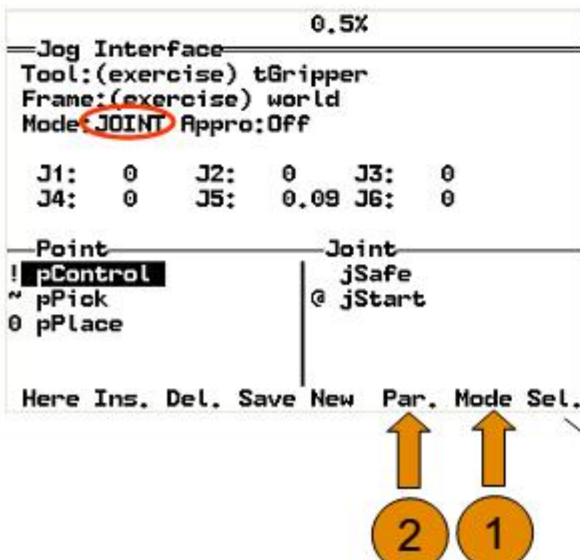


Re-teaching an existing point:

POINTS RE-TEACHING

- Possible to verify / re-teach points : POINT mode

1. movement type = Mode : JOINT
2. with/without APPRO : direction selection + distance



tool select

motion Control

JOINT→LINE→ALIGN

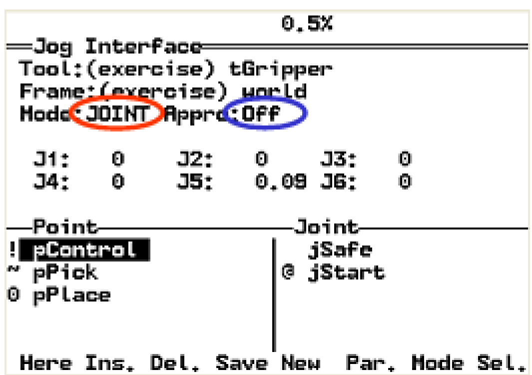
Re-teaching an existing point:

POINTS RE-TEACHING

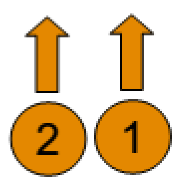
- Possible to verify / re-teach points : POINT mode

1 movement type = Mode : LINE

2 with/without APPRO : direction selection + distance



motion Control

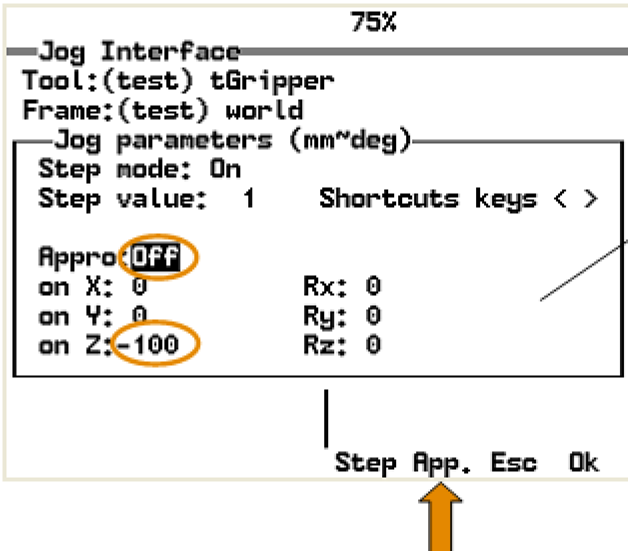


tool select

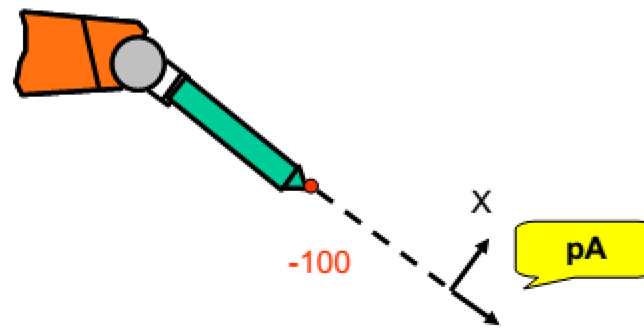
Re-teaching an existing point:

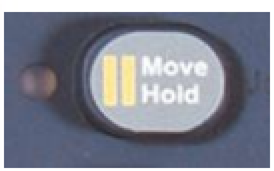
POINTS RE-TEACHING

Verify / re-teach points : APPRO mode



Editable values





motion Control

- Shortcuts : APPRO ON/OFF = F6 + F6

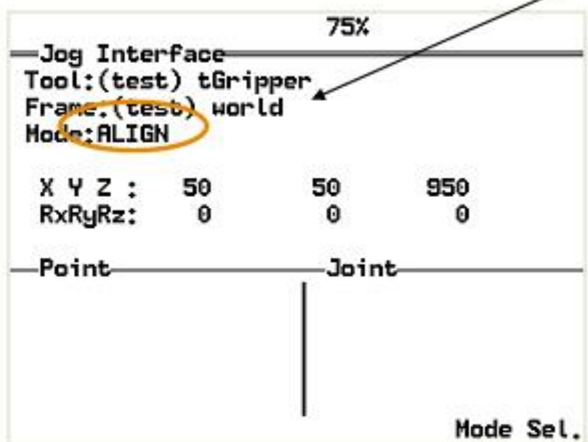
Re-teaching an existing point:

RE TEACHING : ALIGN

Possible to verify / re-teach points : POINT mode

3 move Type = Mode : ALIGN (related to current frame)

Align Z of the TOOL Z on the closest axis of current frame.

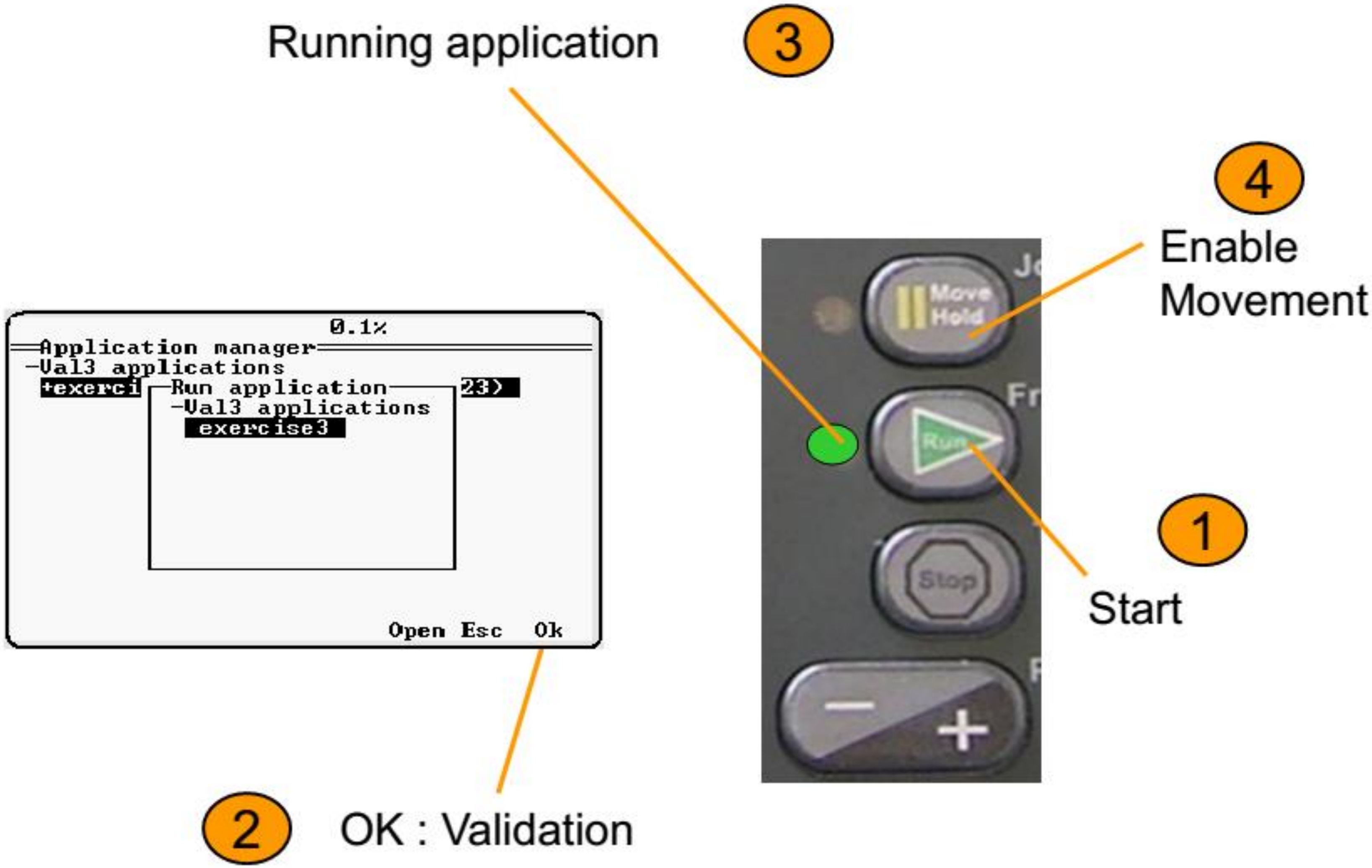


3

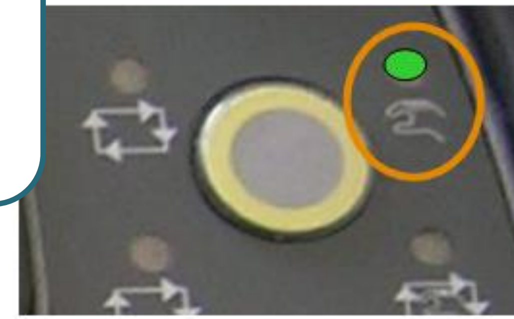
JOINT→LINE→ALIGN

motion Control

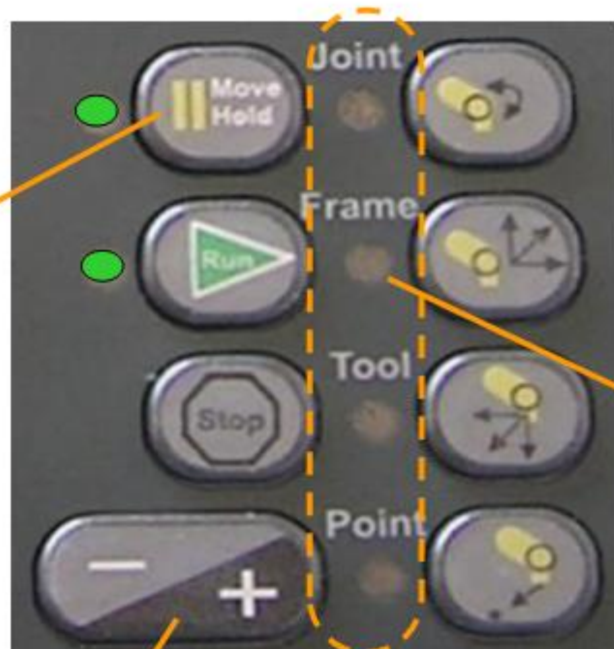
Running applications:



Running applications: Slow running



Cell opened



2

Motion when keep pressed

1

Remove current selected mode = press button

Speed adj.