

Initial setup procedure

1. Setting encoder offsets

Adopting principal of Encoder offset

Compensated encoder value

$$\begin{aligned} &= \text{Current actual encoder value} - \text{Encoder offset} \\ &= (\text{Current actual encoder value} - \text{actual encoder value at the time of encoder offset setting}) \\ &\quad + 400000h \end{aligned}$$

In case, where encoder offset setting is carried out at the identical position in each axes of robot, Compensated encoder value is always the same at the same pose of robot even though actual encoder value is changed due to replacement of motor.

Step position data in program is recorded in compensated encoder value, not in actual encoder value

In order to set encoder offset, hole or scale mark for reference position exists on the link of manipulator.

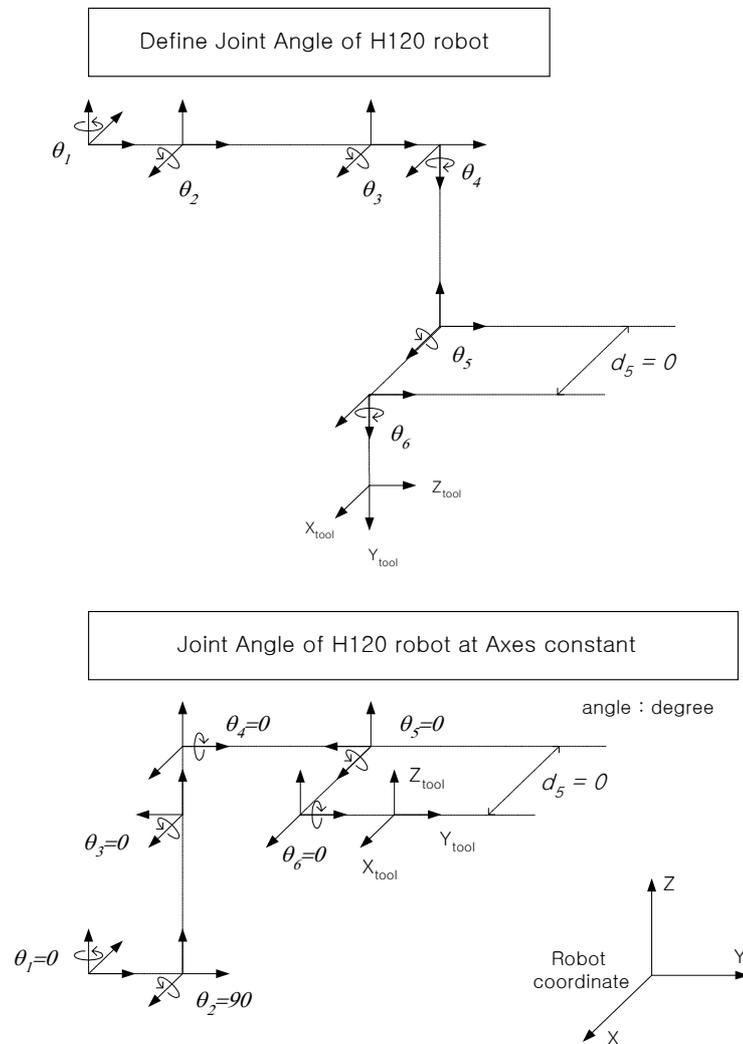
After replacement of motor, the program used in the previous without any changes as encoder offset is reset at reference position(Hole or scale mark),

Practically, encoder offset setting is not related the reference position of robot.

2. Axis constant ?

Angle, caused as link axis is rotated, between neighbor links is called Joint Angle or Link angle

When Joint Angle θ_1 , θ_2 , θ_3 , θ_4 , θ_5 , θ_6 created on link is respectively 0° , 90° , 0° , 0° , 0° , 0° , encoder value is setup.



Axis constant is essential data to acquire Joint Angle from (compensated) encoder value.

► Procedure that controller calculate position and pose of TCP (Tool Center Point).

Actual encoder value → Compensated encoder value → Axis Angle (Each axis) → Joint Angle (Link angle) → Position of TCP.

Axis constant as to S, H, V axis defines direction of linear coordinate system

Determines accuracy of linear interpolation trajectory and various shift movement

Position to set up Encoder offset is reference value however few accuracy error is existed.

Upon installation circumstance of robot and peripheral jig in actual line, S axis constant data is modified or upon the direction of tool attachment, R1 axis constant is modified for use.

3. Optimizing axis constant & tool length

1) Outline

Positions of robot and trajectory accuracy in space depend on the accuracy of mathematical modeling of robot mechanism being used planning path.

In general, accuracy error exists between modeling data and actual robot. These errors are the causes in reducing position accuracy and trajectory accuracy

Modeling accuracy error is divided into accuracy error in geometrical parameter and in non-geometrical parameter

Geometrical parameter includes link length of robot, tool offset length, and encoder data with respect to robot reference position. Non-geometrical parameter includes reduction gear ratio, backlash of gear, compliance, resolution of encoder, agitation of link caused by loosen bearing, cross coupling between links in respecting to mechanical structure of robot

Most industrial robot in default has error on said parameter but the error itself is ignorable in actual application of industrial site.

On the other hand, the error would be much bigger than error caused by other parameters because tool offset length and encoder data respecting to the reference position are set by human being.

Moreover, in case of tool offset length, it would be very difficult to have an accuracy data in 3 dimensional space under the situation where there is no exact tool data or change tool mounting caused by collision.

“Optimizing axis constant & tool length” function is to help users to improve accuracy in robot position and in trajectory by compensating tool offset length and error of encoder data to robot reference pose.

※ In order to use coordinate input method in Hi4 controller, robot parameter must be as accurate as possible to have the accurate pose data

2) Function in use

This must be implemented at setting robot system for the first time

▷ Function in execution

① In one point, more than 4 different poses have to be recorded with movement of 3 wrist axis in robot program. 6 steps are recommended

– Normally recorded in encoder data after auto conversion of encoder value, the function can be implemented as function is executed even though recorded as pose data

Note) In case of step recorded as pose type, if tool data is changed before execution of the function, the previous recorded value is meaningless.

- ② When high accuracy is required, it is recommended that the maximum step position error in X,Y,Z direction is within 1mm.
- ③ For heavy tool, the following two procedures are needed for implementation
 - Due to bending of tool or robot arm as to the result of heavy weight of tool, function for axis constant and tool length can not produce good results in accuracy.
 - ▷ Remove heavy tool and attach sharp pin for example needle on R1 frame, and carry out program and execute tool constant and tool length.
 - ▷ After implementing the above procedure, attaché the actual tool and execute optimize “Tool length”.

```

10:01:50** Axis/Tool optimize **A:0 S:L2
Setting = < Constant & Tool, Tool >
Program No.           = [  0 ]
Tool No.              = [  0 ]
permissible position error = [ 0.1]mm

Max step position error(X) =
                        (Y) =
                        (Z) =

Press [SHIFT]+[<-][>-] key.
>_
Execute
    
```

- ④ After optimization function, acquire accurate tool constant and tool data and record a point as pose record type to Base coordinate system.
 - This program is used to do auto calibration at the time of deformation or replacement of tool for the future.

4. Tool angle setting

Tool angle setting and calibration

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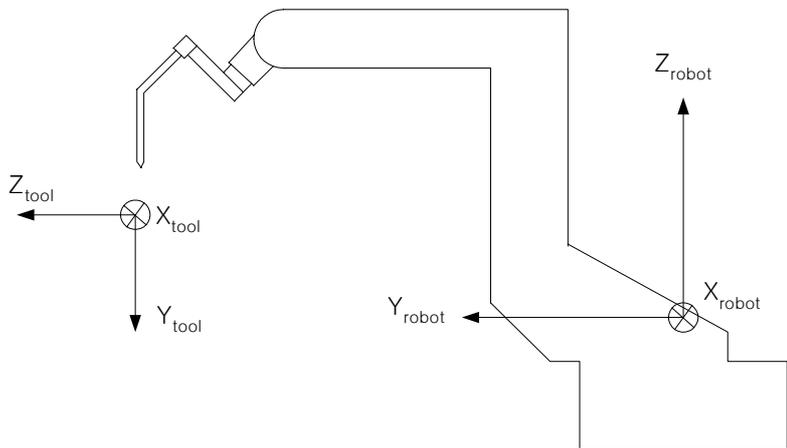
09:39:26 *** Tool data *** A:0 S:L2
Tool 0 : .....
Weight [ 6.0] Kg
Component: X      Y      Z
Angle [ 0.0] [ 0.0] [ 0.0] deg
Length [ 0.0] [ 0.0] [ 0.0] mm
Inertia [ 0.000] [ 0.000] [ 0.000] Kgm2
Center [ 0.0] [ 0.0] [ 0.0] mm
Select and Enter number. Press [SET].
>[0 - 1000.0]_
AutoSETg Ang.SETg Previous Next Complete
    
```

```

09:53:43 ***TOOL ANGLE SETg*** A:0 S:L2
By hogging, let the tool be parallel to
z-axis at any point directing downward.
Then, press PF5[Execute].
      /
     //  --HH|
    | //   HH|
    | //   HH| Body
Torch HH-   HH  -->Body
      H==H_
Side  H  H   Front H  H
-view ----- -view -----
Adjust angle by jogging, then push PF5.
>_
Execute
    
```

- ① Execute the function after X,Y,X direction in tool coordinate which is to be defined are respectively matched to the X, -Z, Y direction of robot coordinate system
- ② At this time forward direction of TCP is set as Y direction.

Tool pose for the tool angle setting



- ③ The above angle setting is that direction in jog movement is decided in the case of coordinate system setup as tool.
- FWD(Forward)/BWD(Backware) : Tool coordinate Y_{tool} in +/- linear movement
 - UP(Up)/DWN(Down) : Tool coordinate Z_{tool} in +/- linear direction
 - LFT(Left)/RHT(Right) : Tool coordinate X_{tool} in +/- linear direction
 - Rx+/- : Tool coordinate X_{tool} in +/- rotation direction (Tool TCP fixed motion)
 - Ry+/- : Tool coordinate Y_{tool} 의 +/- rotation direction (Tool TCP fixed motion)
 - Rz+/- : Tool coordinate Z_{tool} 의 +/- rotation direction (Tool TCP fixed motion)
- ④ Decide direction in executing shift function in tool coordinate

5. Automatic tool setting

Tool length and tool angle calibration

```

09:21:47 ***AUTO TOOL SETg*** A:0 S:L2
*) By jogging, place the tool-tip at
the point of reference step, with the
same pose just as it was positioned.
If the pose is not certain, execute
'Angle Setting' after this function.

Program No. = [ 0 ]
Step No.    = [ 0 ]
Tool No.    = [ 0 ]

Select and Enter number. Press [SET].
>[1 - 999]_
Execute

```

Place tool to the step position which is previously taught and execute function to have new tool length and angle. In this case, taught step position data must be accurately recorded as pose data. In other words, Step is recorded after “Optimizing axis constant & tool length” in implemented.