Robotika

Příklad: Přiřazení souřadnicových systémů dle DH-notace

Vladimír Smutný

Centrum strojového vnímání

Český institut informatiky, robotiky a kybernetiky (CIIRC)

České vysoké učení technické v Praze

Staubli Robot Paint TX250

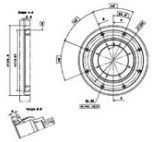
TXPaint250 painting robot

RS	TX	TX	TX
Scara / 4 axis	low payload/ 6 axis	medium payload/ 6 axis	heavy payload/ 6 axis

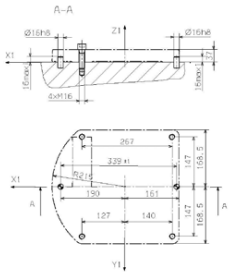
Staubli Robot Paint TX250

Motion range	Axis 2	± 137,5°
	Axis 3	± 155°
	Axis 4	± 540°
	Axis 5	± 540°
	Axis 6	± 540°
Work envelope	Maximum horizontal amplitude	2042,20 mm
	Maximum vertical amplitude	4168,60 mm
	Minimum reach between axis 2 and S point	508 mm
Maximum speed	Axis 1	120°/s
	Axis 2	110°/s
	Axis 3	160°/s
	Axis 4	360°/s
	Axis 5	360°/s
	Axis 6	385°/s
Maximum painting speed		1,5 m/s
Weight		250 kg
Brakes		All axis
Pneumatic painting pre-equipment located in elbow foundery	Version A	2 solenoid valves + 3 proportional valves
	Version B	1 pump motor + 2 proportional valves + 2 solenoid valves
Stäubli CS8 series controller		CS8C
Installation environment		
Working temperature according to standard directive NF EN 60 204-1		+5°C to 40°C
Humidity according to standard directive NF EN 60 204-1		30% to 95% max. non-condensing
Attachment methods		Floor/Ceiling
Certification (pending)		CSA-FM (USA)/CE (Europe) /TIIS (Japan)

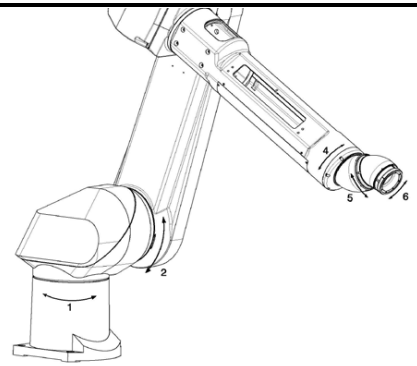
(1) Under special conditions, consult us.

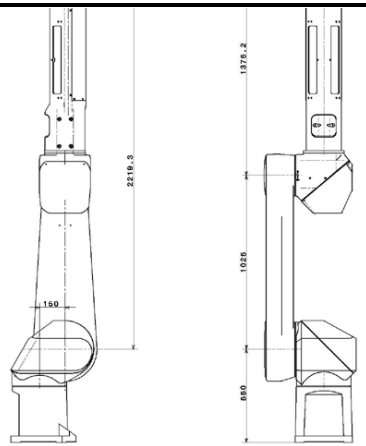


Mounting (not for vertical cable outlet option)

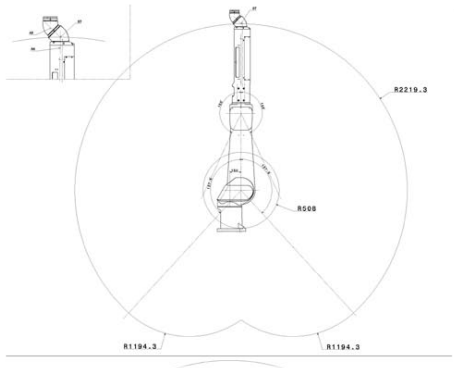


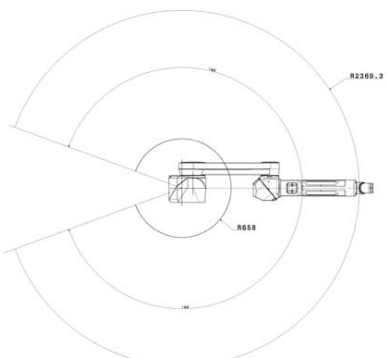
Staubli Robot Paint TX250





Work envelope





Staubli Robot Paint TX250

HOLLOW WRIST
All painting equipments fit inside the arm.
Reduced contamination risks.

STÄUBLI PATENTED REDUCTION GEAR SYSTEMS
Unmatched precision, flexibility and speed, high rigidity, reduced maintenance.

MULTIPLE APPLICATIONS
For plastics, wooden or metallic parts.
Application of primers, undercoats or varnishes.
Adapted to solvants, water or powder paints.

FM APPROVED

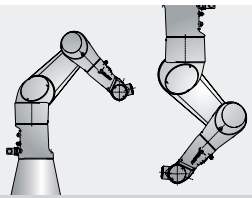
CE

CERTIFICATIONS
Pending for: USA (FM-CSA), Europe (CE) and Japan (TIIS)

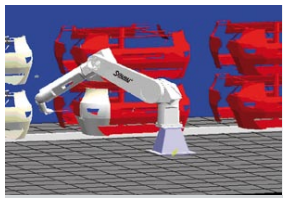
PaintiXen

PAINTIXEN PAINTING SOFTWARE
This software provides simplified robot use and programming of conventional water-based and powder painting applications or electrostatic applications.

ARM FINISH
Resistant to solvants, easy to clean.



MULTIPLE ATTACHMENT METHODS
Adaptability and flexibility (floor, ceiling).



SIMULATION
Simulation enables to define robot model, its position, cycle time and possible collisions.

COVER PROTECTION
A cover can be installed on the robot forearm for additional protection.

D181.574.04

Staubli is a trademark of Stäubli International AG, registered in Switzerland and other countries - June 2008 - 1 GB
Photos : Semaphore / P. Duvillard - © kalistene conseil 04 56 69 01 97

www.staubli.com/robotics

Stäubli Faverges SCA Headquarters
FR-74210 FAVERGES (Annecy)
Tel.: +33 4 50 65 62 87
Fax: +33 4 50 65 61 30
robot.sales@staubli.com

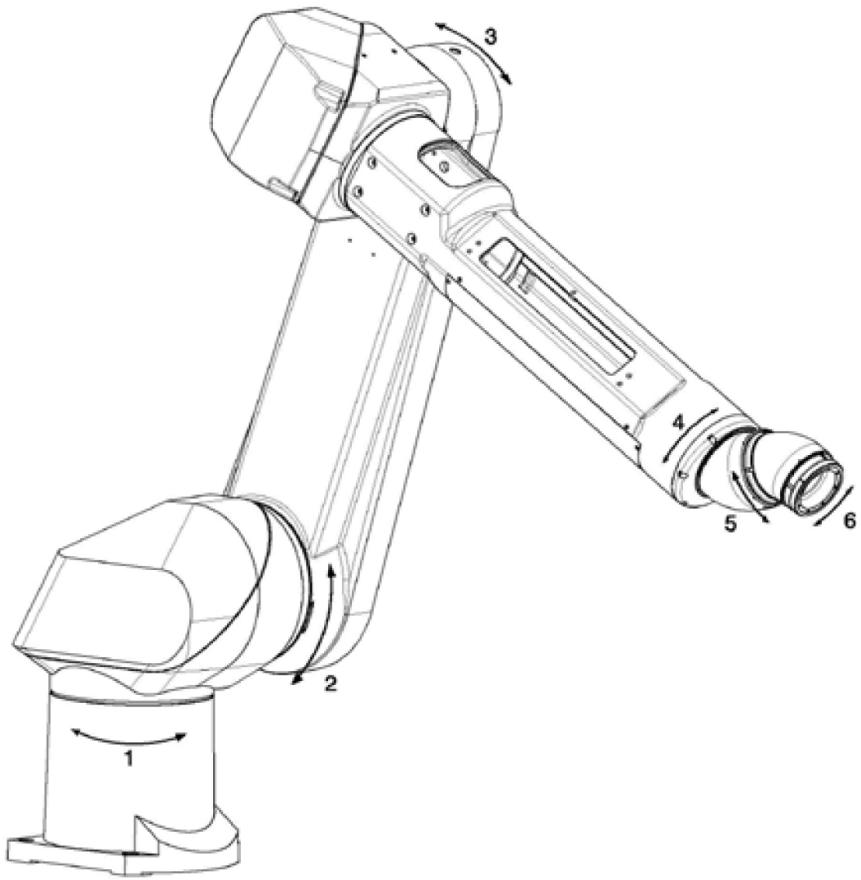
Stäubli Tec-Systems GmbH
DE-95448 BAYREUTH
Tel.: +49 921 883 0
Fax: +49 921 883 244
robot.de@staubli.com

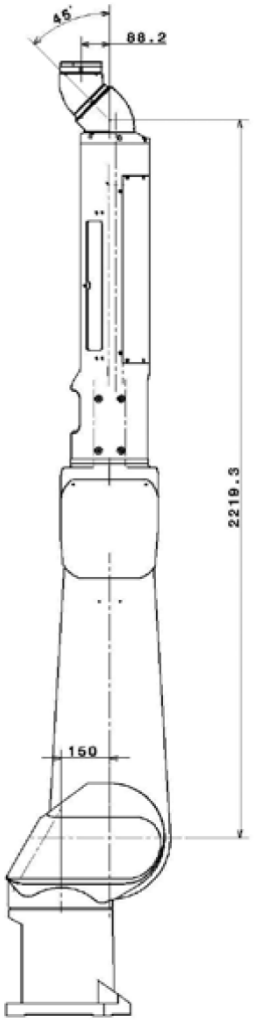
STÄUBLI

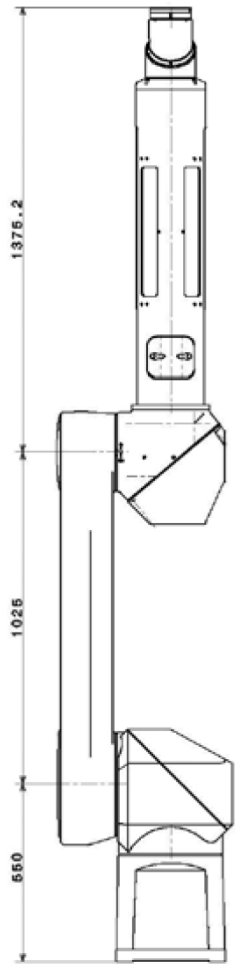
m p

1 2
3 4
5 6
7 8
9 10
11 12
13 14
15 16
17 18
19 20
21 22
23 24
25 26
27 28
29 30
31 32
33 34
35 36
37 38
39 40
41 42
43 44
45 46

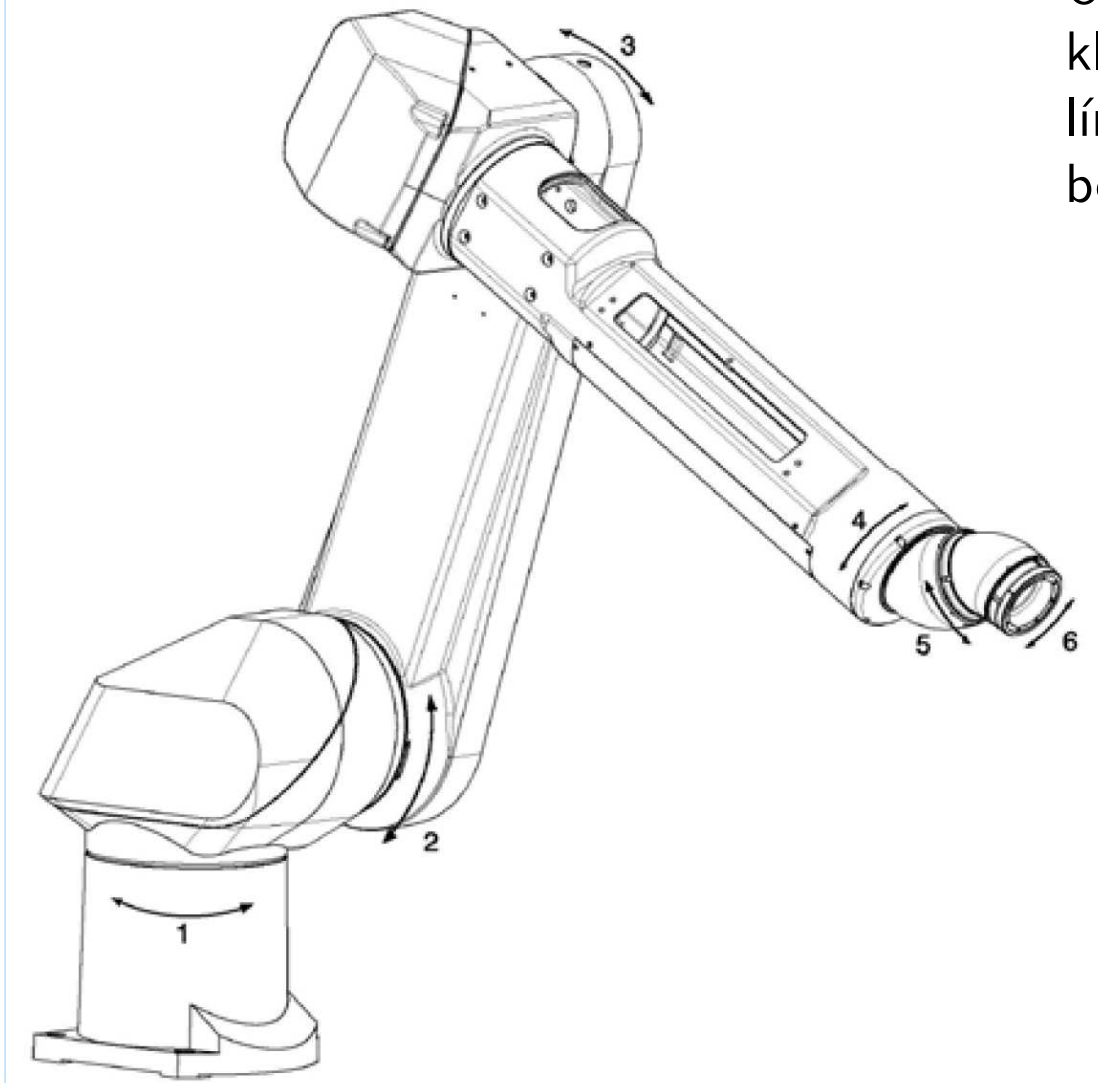
Staubli Robot Paint TX250





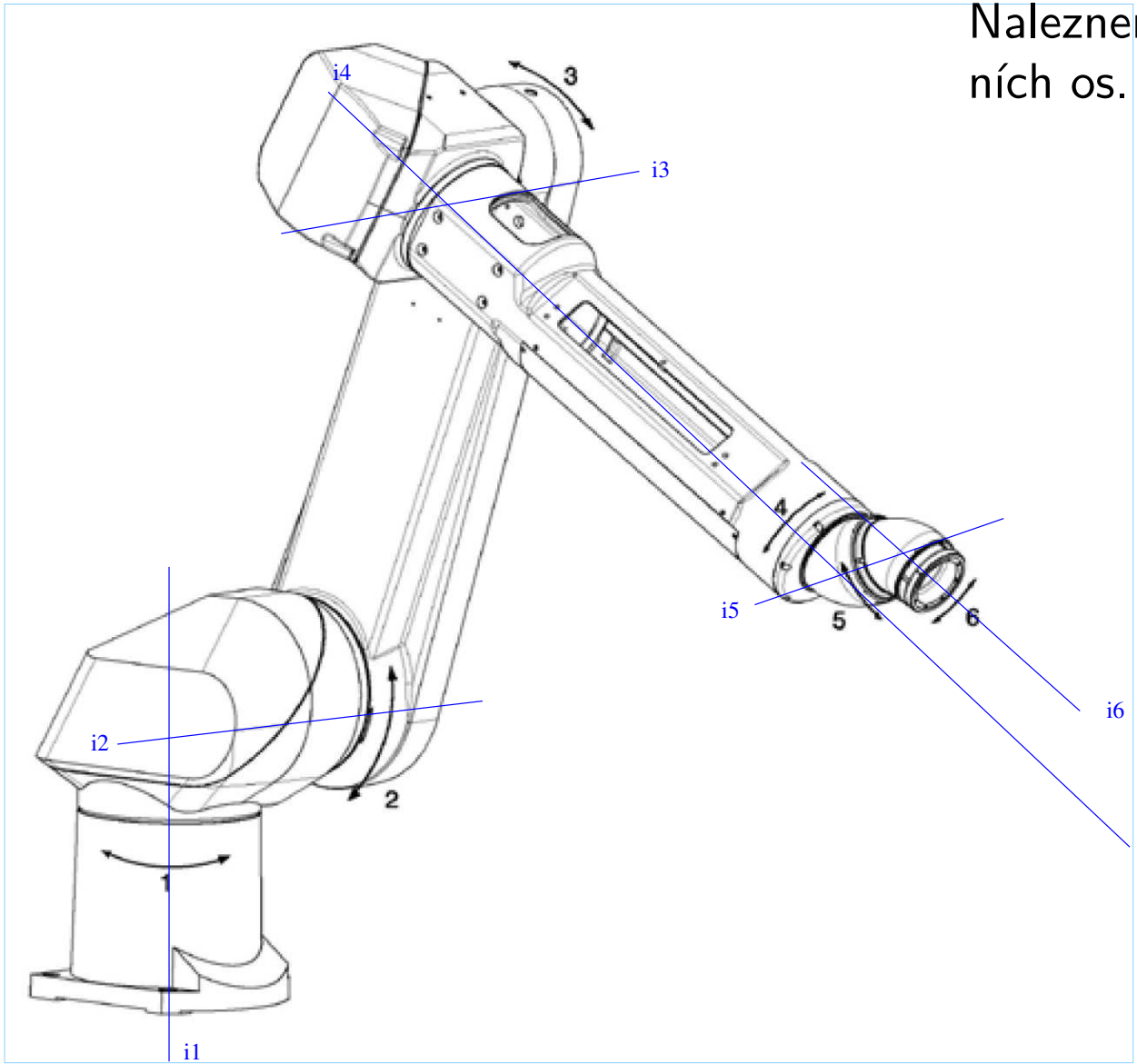


Staubli Robot Paint TX250 D-H notation



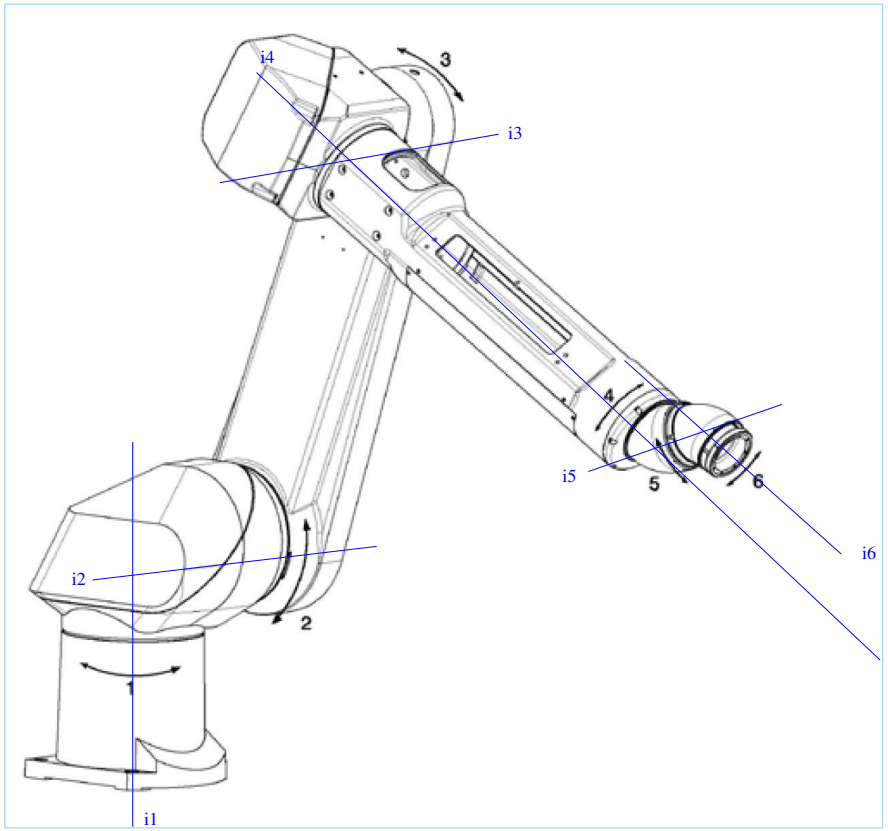
Určíme osy jednotlivých kloubů, pro posuvné zvolíme jednu z přímek rovnoběžných s osou pohybu.

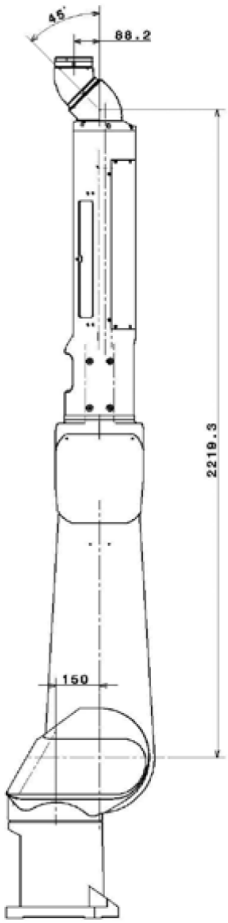
Staubli Robot Paint TX250 D-H notation

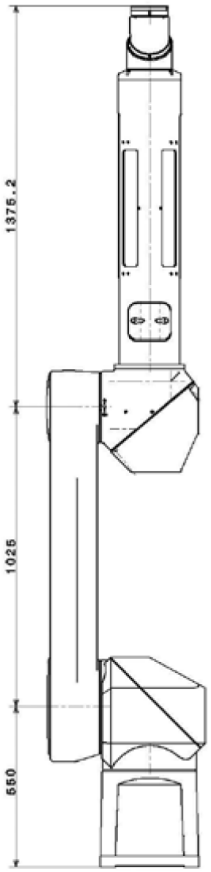


Nalezneme příčky sousedních os.

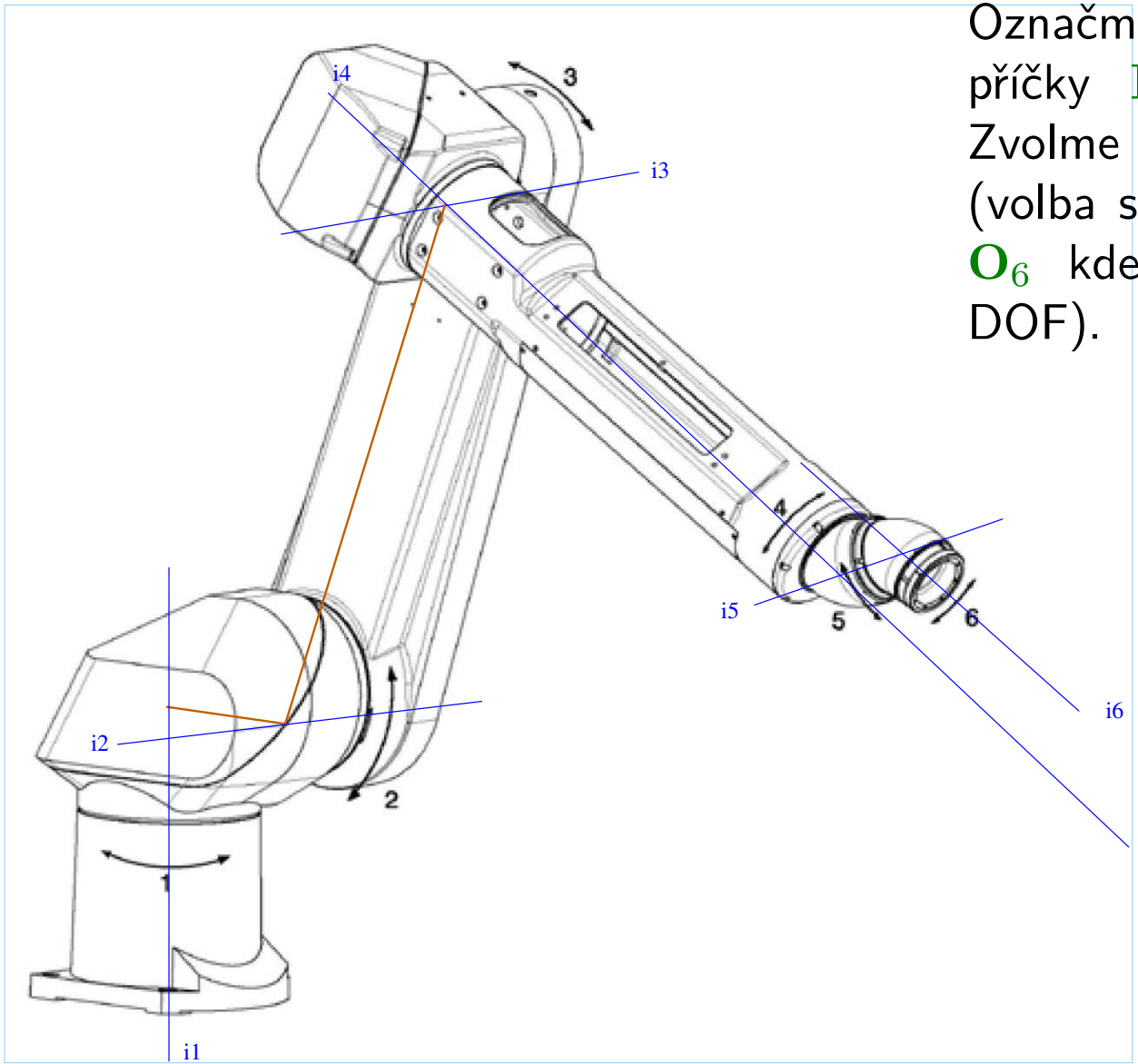
Staubli Robot Paint TX250 D-H notation





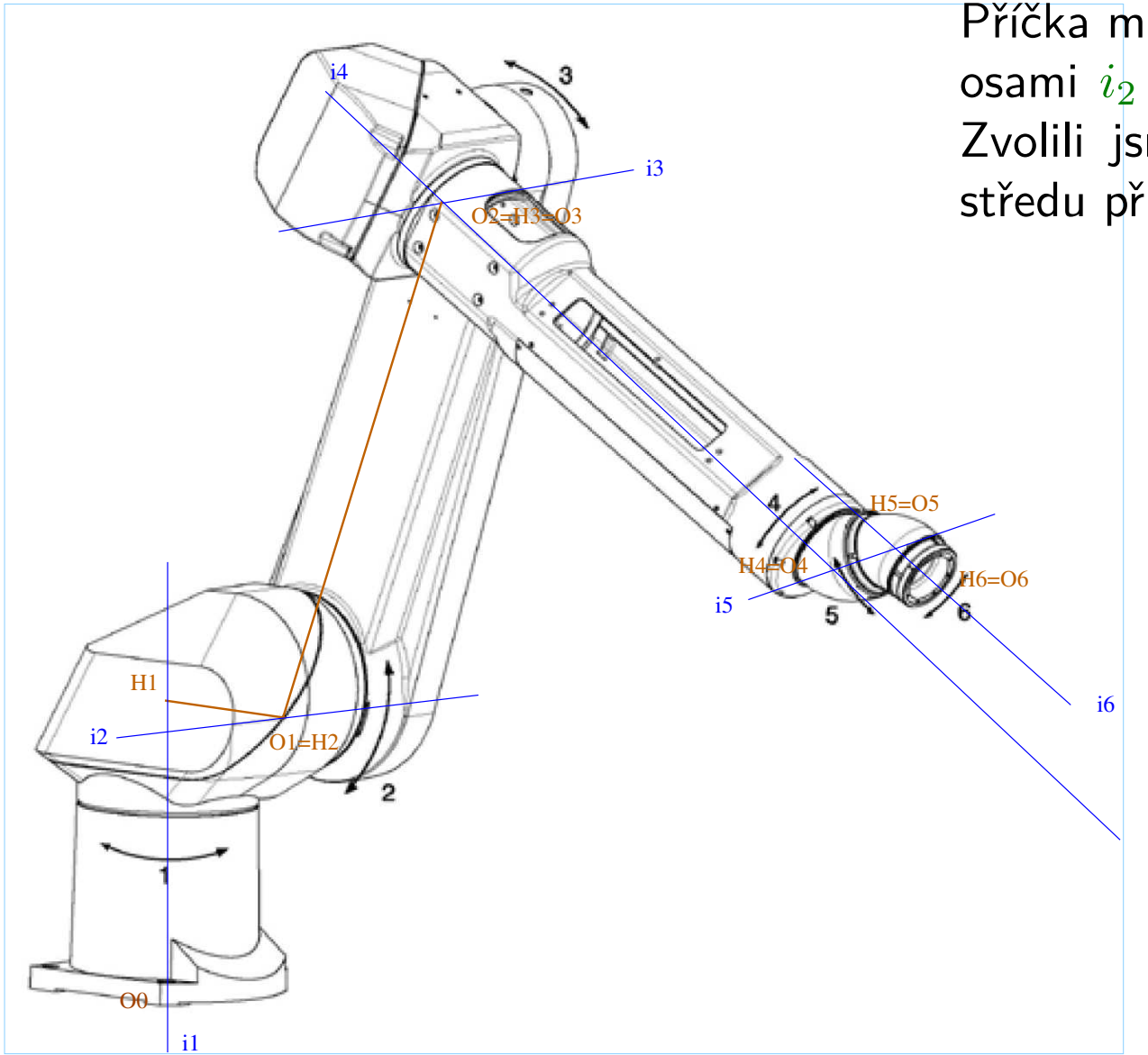


Staubli Robot Paint TX250 D-H notation



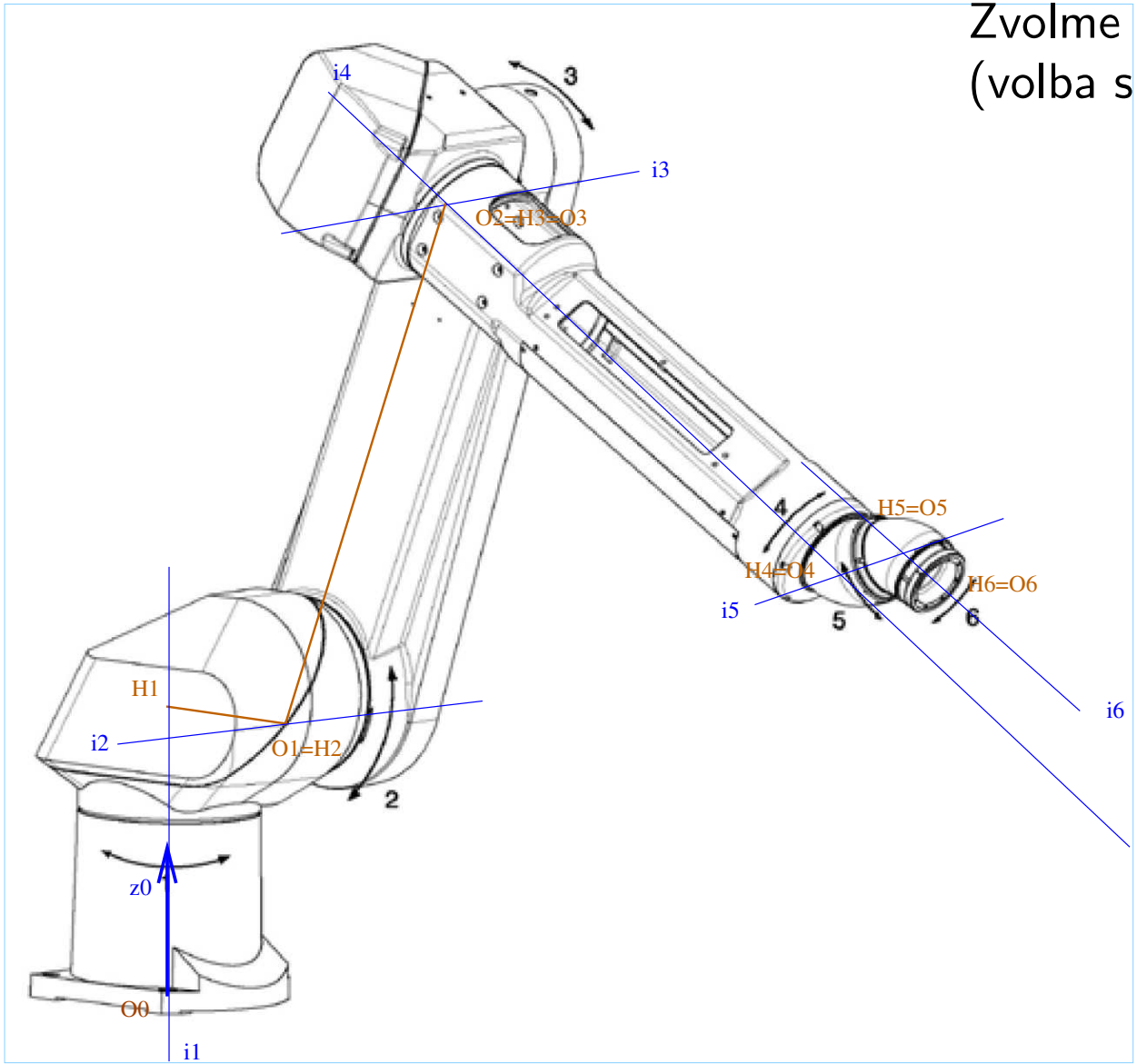
Označme začátek i-té příčky $\mathbf{H_i}$ a konec $\mathbf{O_i}$. Zvolme $\mathbf{O}_0$ kdekoliv na z_1 (volba s 1 DOF). Zvolme $\mathbf{O}_6$ kdekoliv (volba s 3 DOF).

Staubli Robot Paint TX250 D-H notation



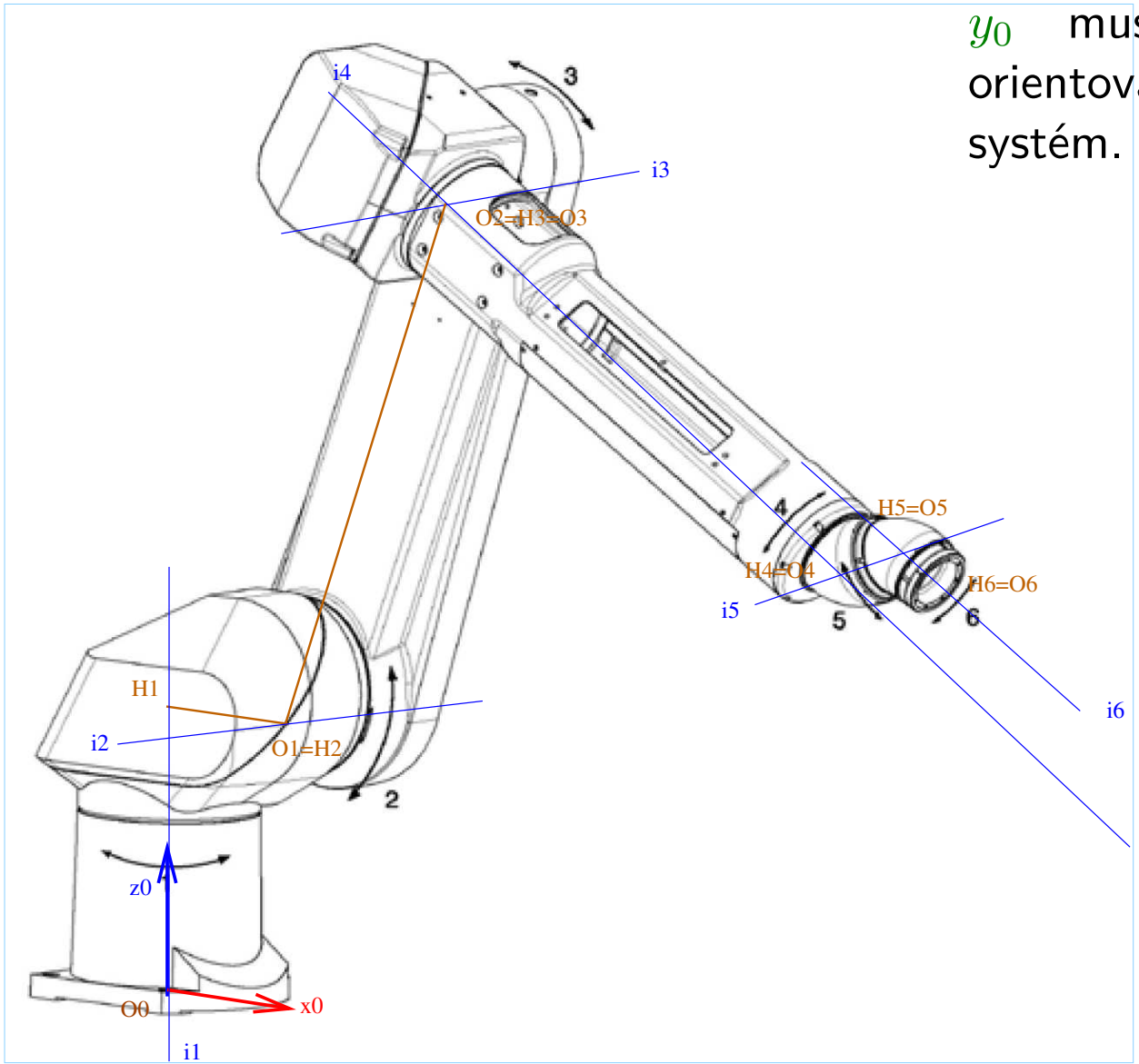
Příčka mezi rovnoběžnými osami i_2 a i_3 má 1 DOF. Zvolili jsme $\mathbf{O}_6$ na i_6 ve středu příruby.

Staubli Robot Paint TX250 D-H notation



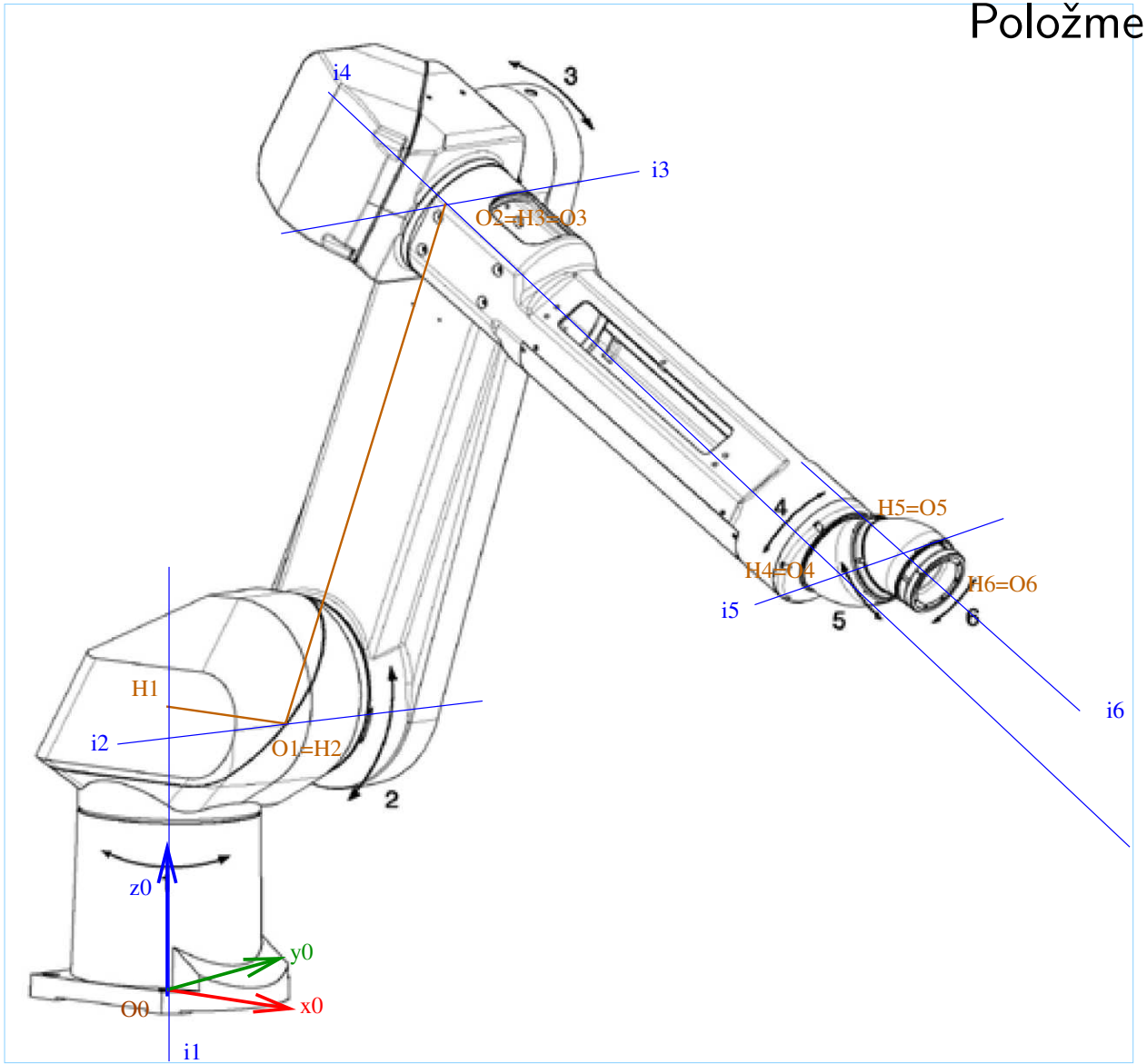
Zvolme x_0 kolmo k z_0 (volba s 1 DOF).

Staubli Robot Paint TX250 D-H notation



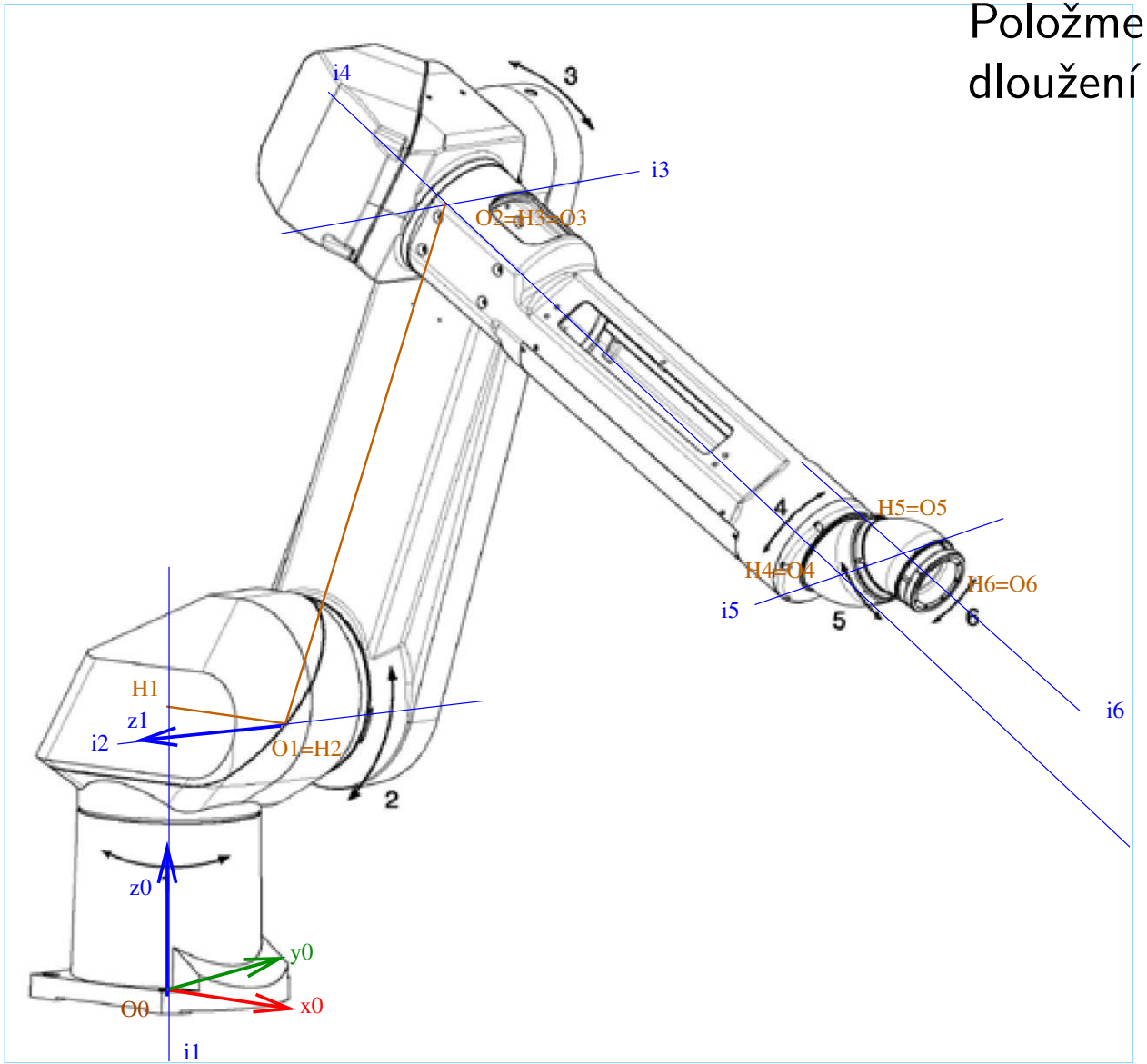
y_0 musí tvořit kladně orientovaný souřadnicový systém.

Staubli Robot Paint TX250 D-H notation



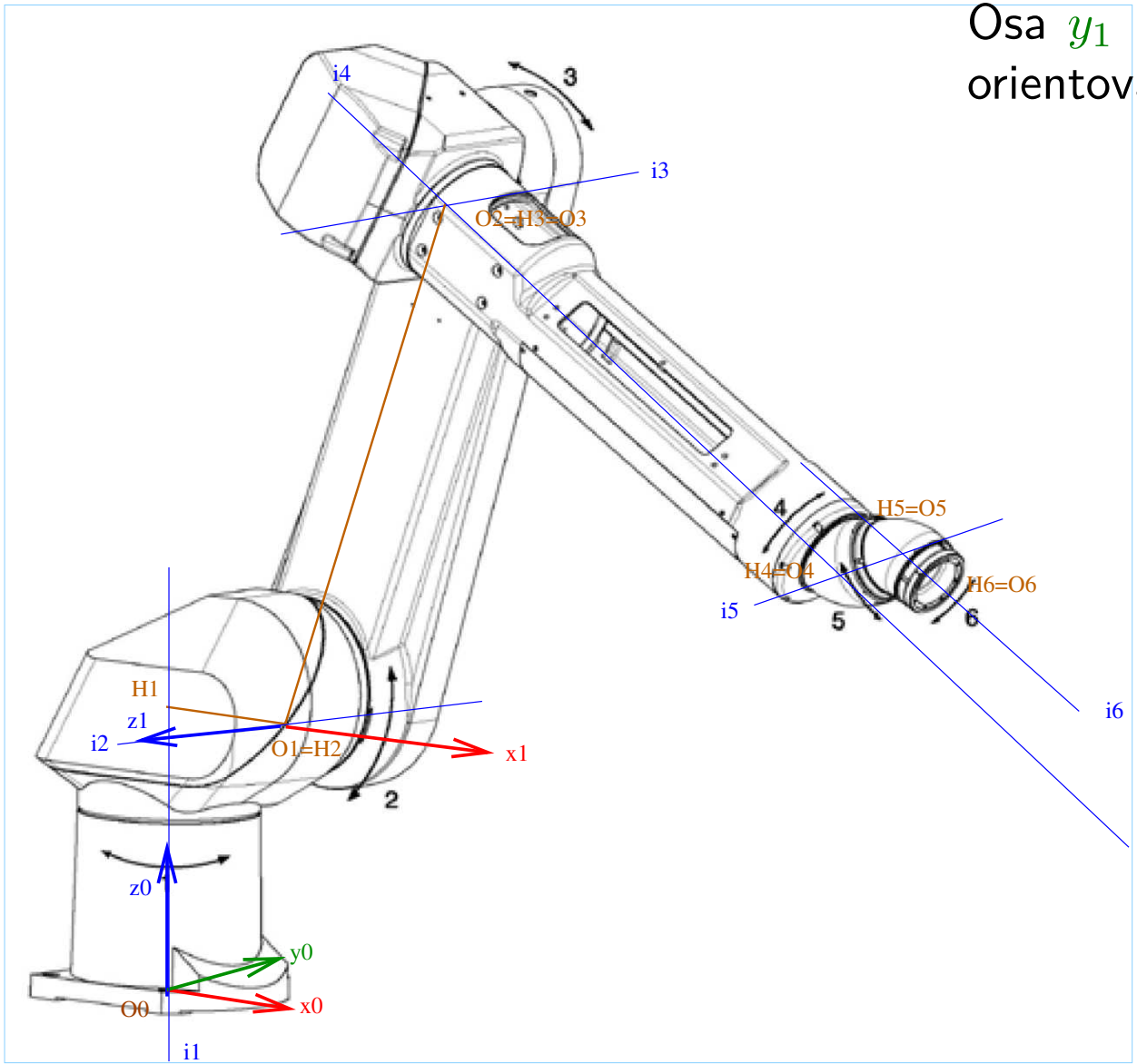
Položme osu z_1 do osy i_2.

Staubli Robot Paint TX250 D-H notation



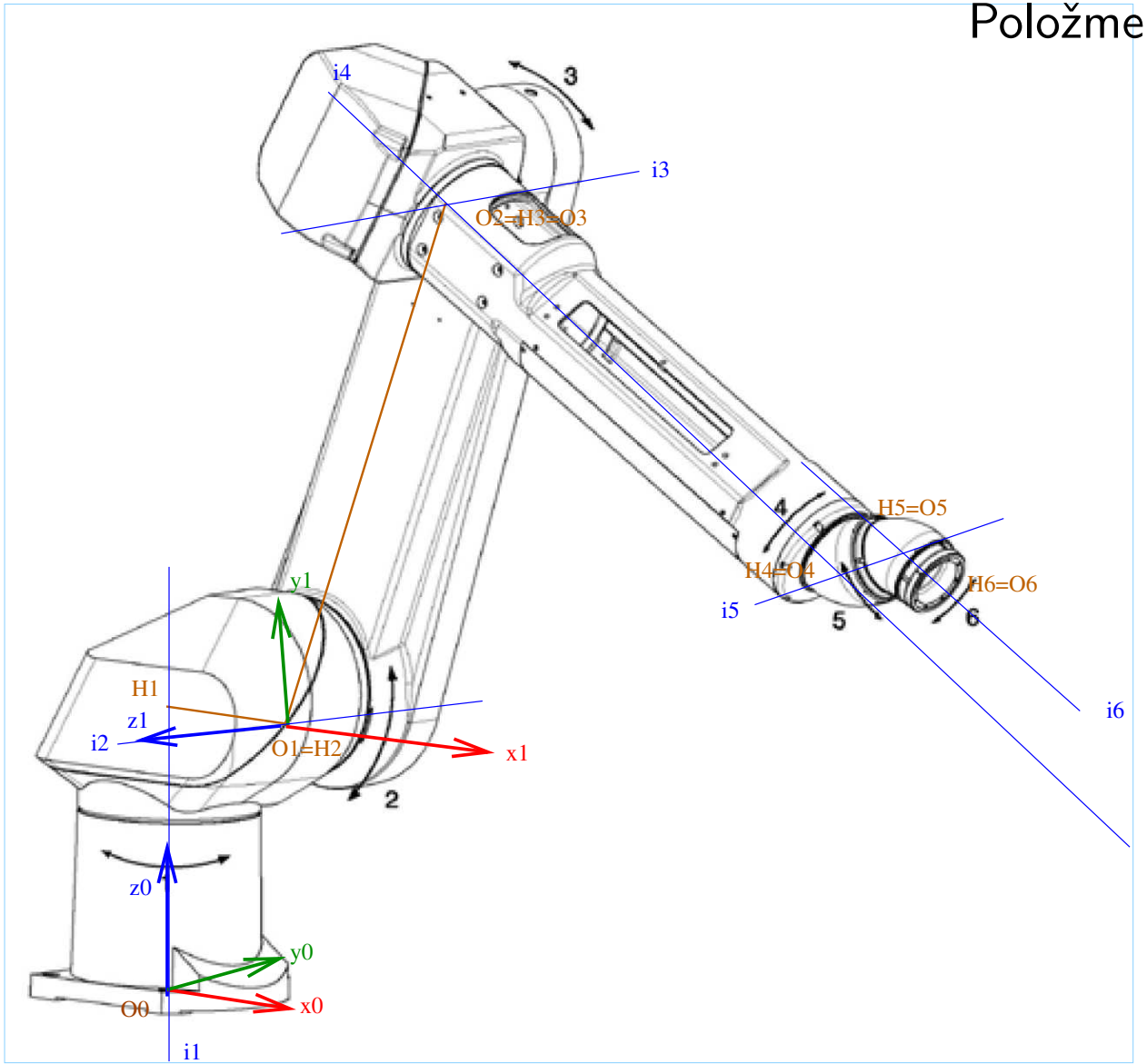
Položme osu x_1 do prodloužení příčky $\mathbf{H_1O_1}$.

Staubli Robot Paint TX250 D-H notation



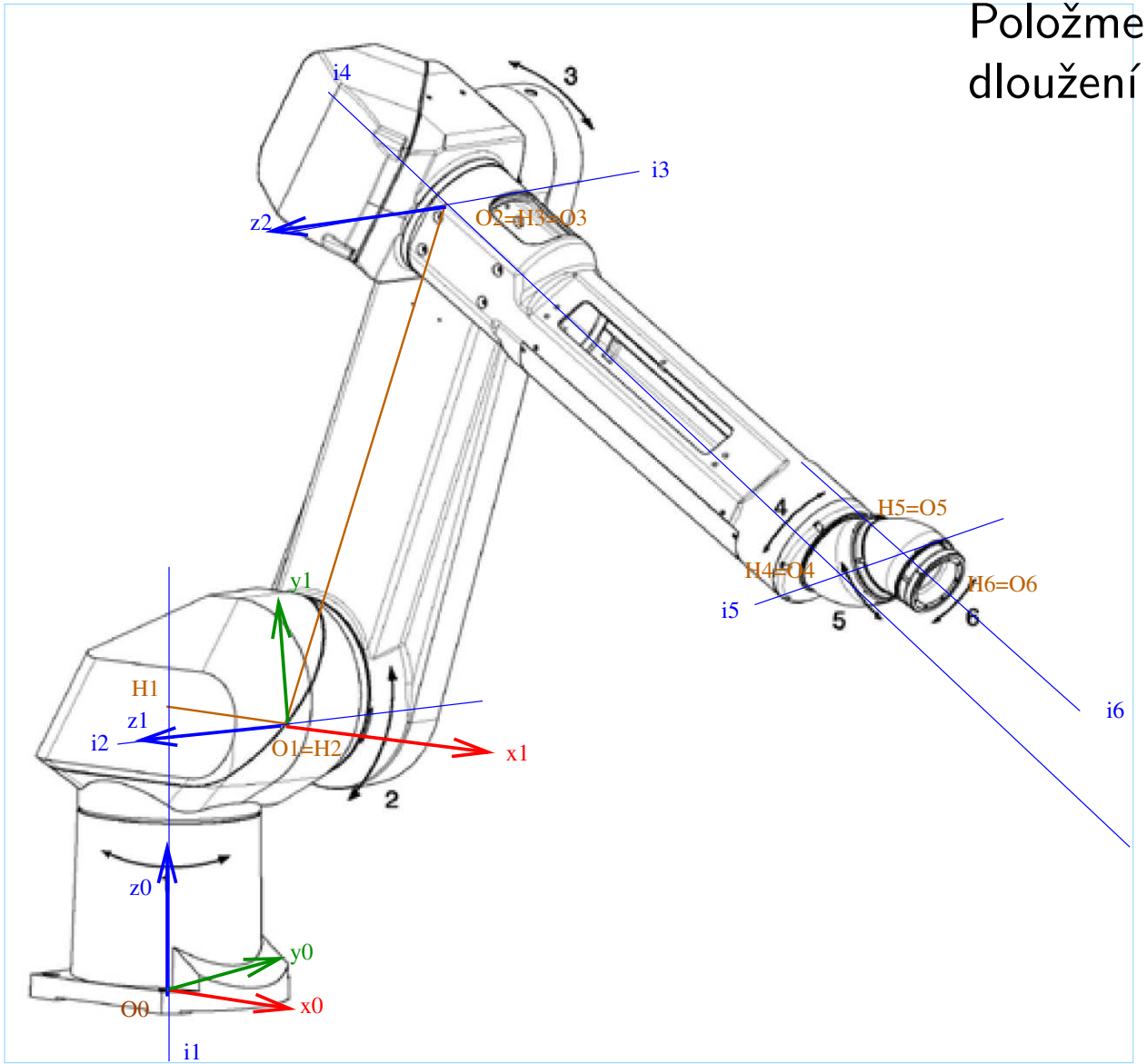
Osa y_1 musí tvořit kladně orientovaný systém.

Staubli Robot Paint TX250 D-H notation



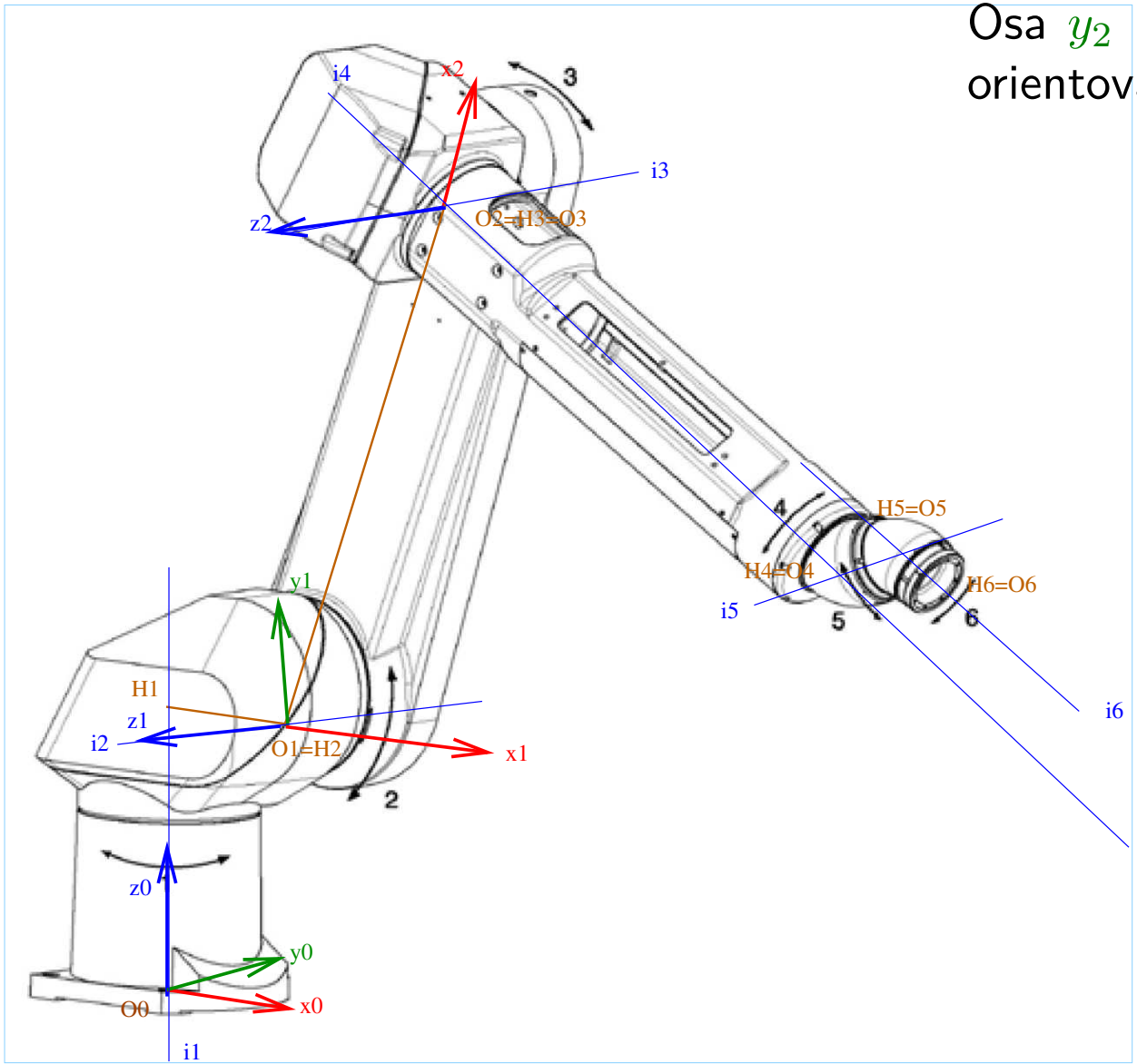
Položme osu z_2 do osy i_3.

Staubli Robot Paint TX250 D-H notation



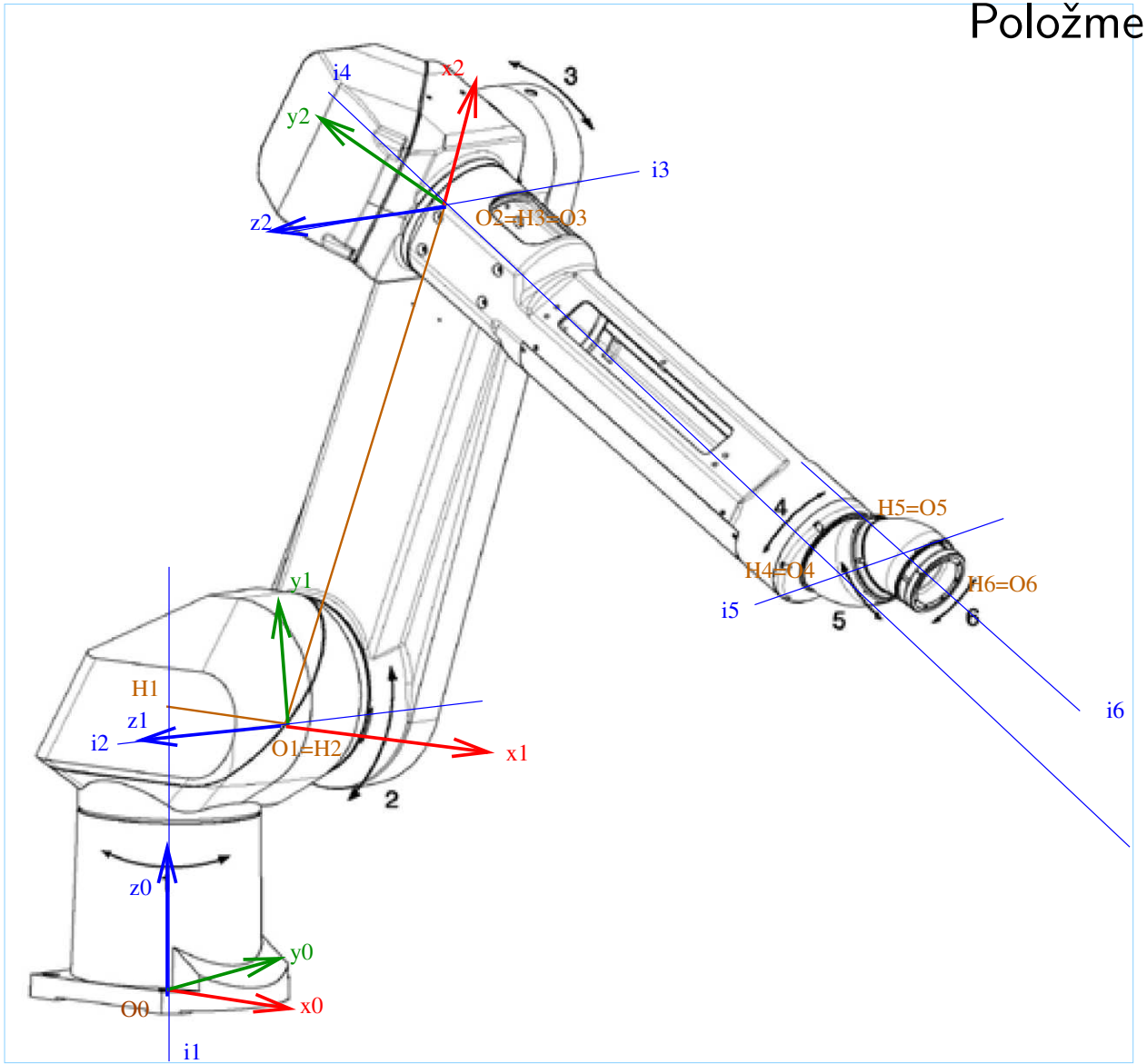
Položme osu x_2 do prodloužení příčky $\mathbf{H_2O_2}$.

Staubli Robot Paint TX250 D-H notation



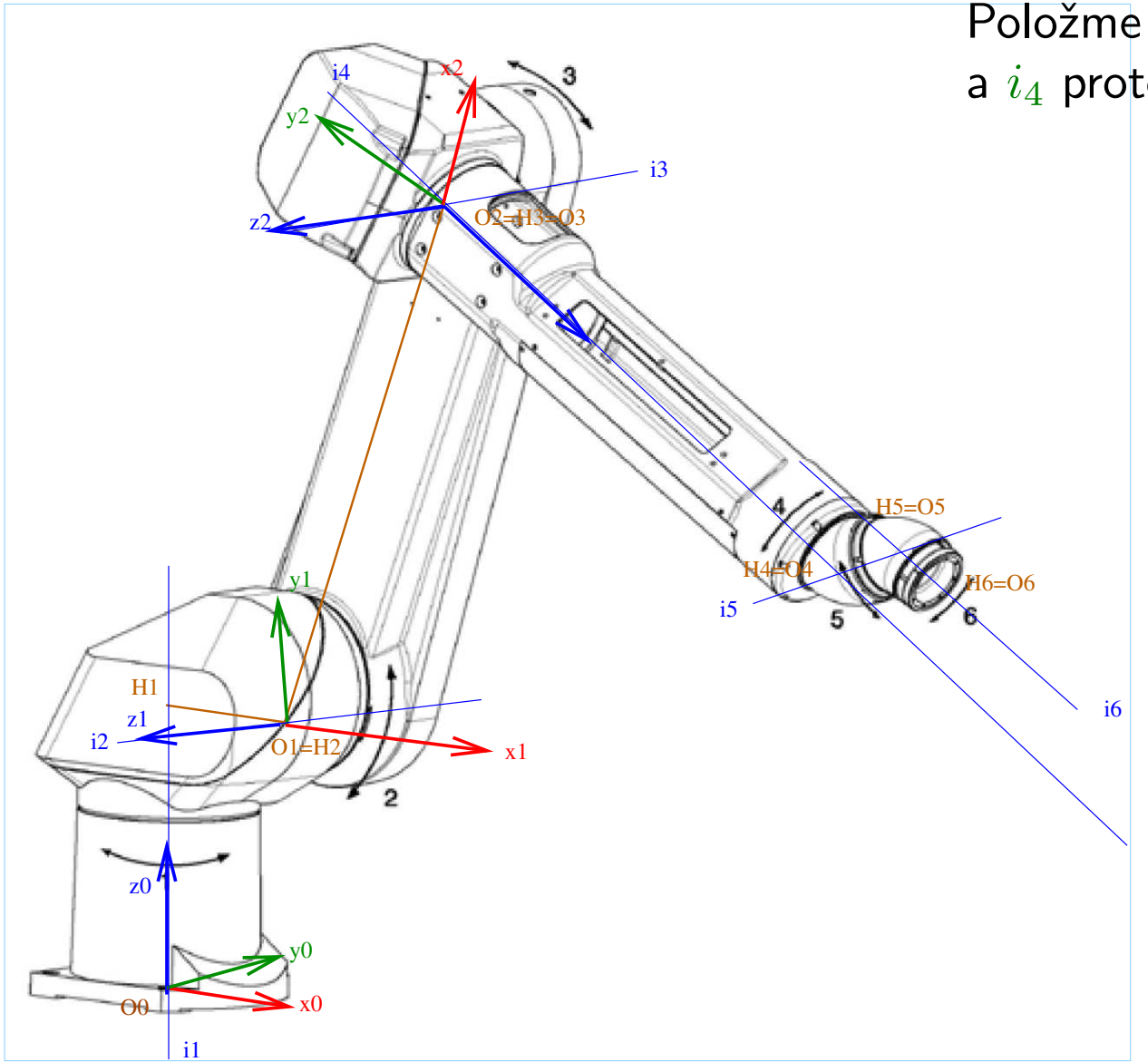
Osa y_2 musí tvořit kladně orientovaný systém.

Staubli Robot Paint TX250 D-H notation



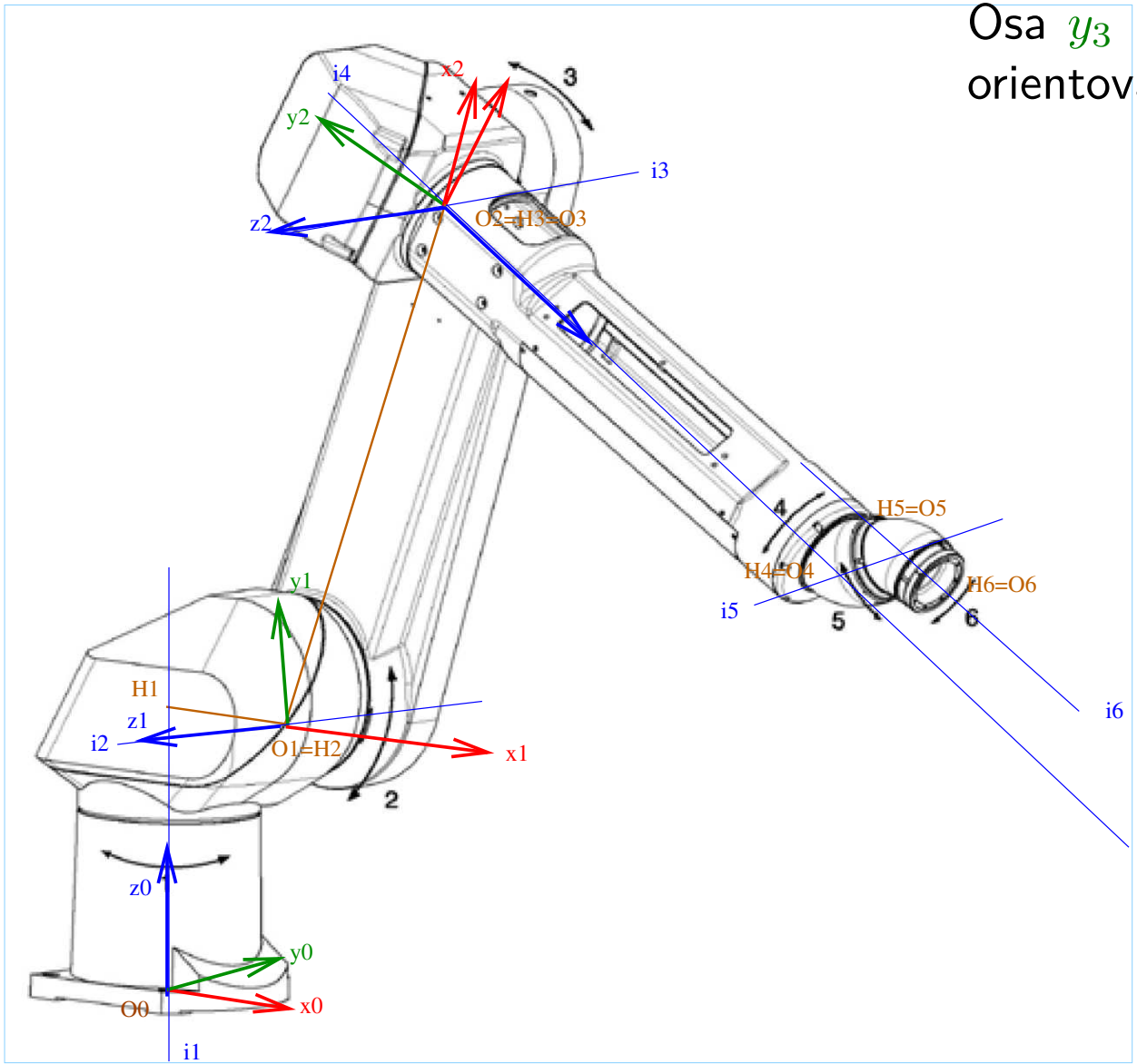
Položme osu z_3 do osy i_4.

Staubli Robot Paint TX250 D-H notation



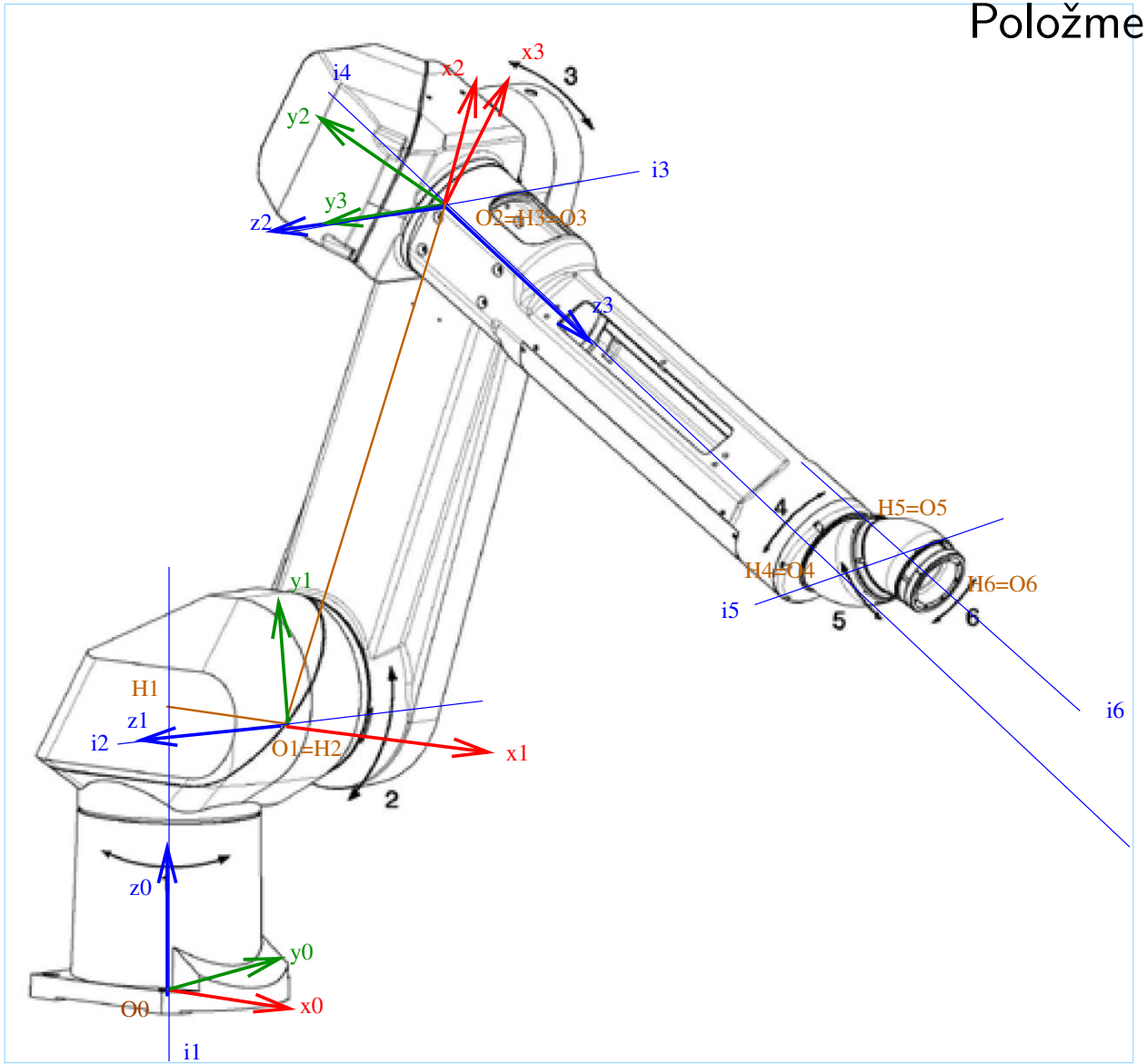
Položme osu x_3 kolmo k i_3 a i_4 protože $\mathbf{H_3 = O_3}$.

Staubli Robot Paint TX250 D-H notation



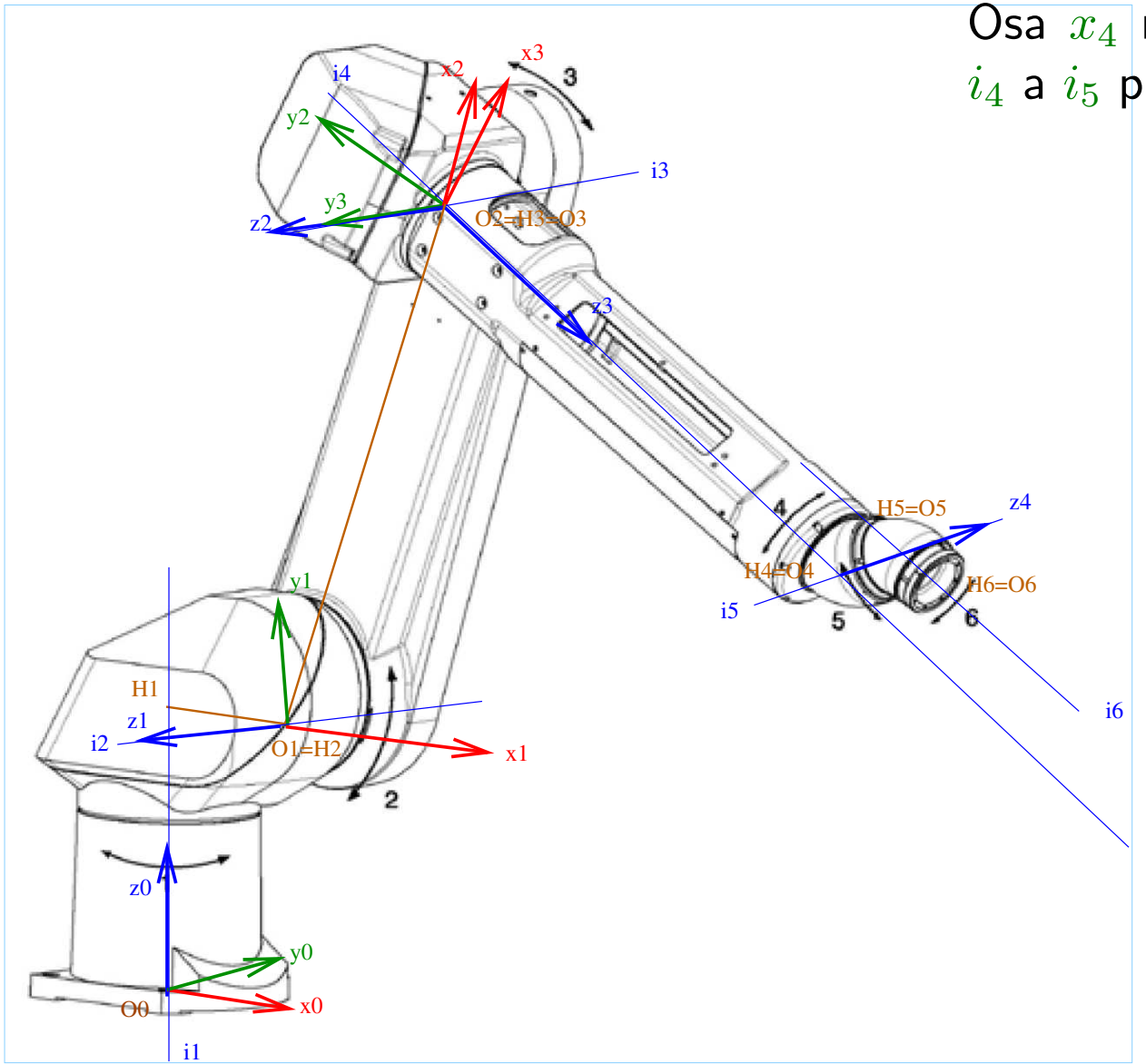
Osa y_3 musí tvořit kladně orientovaný systém.

Staubli Robot Paint TX250 D-H notation



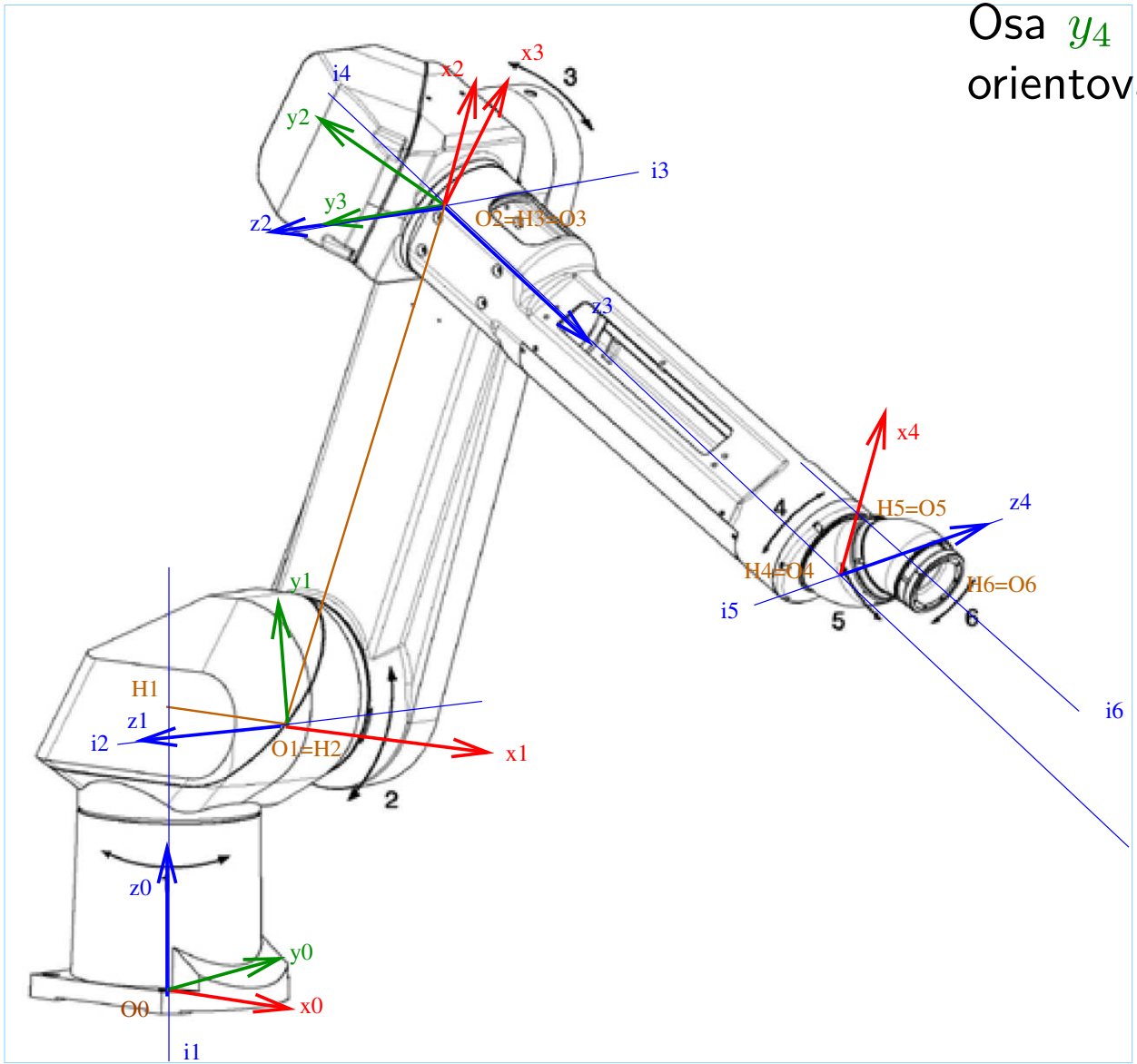
Položme osu z_4 do osy i_5.

Staubli Robot Paint TX250 D-H notation



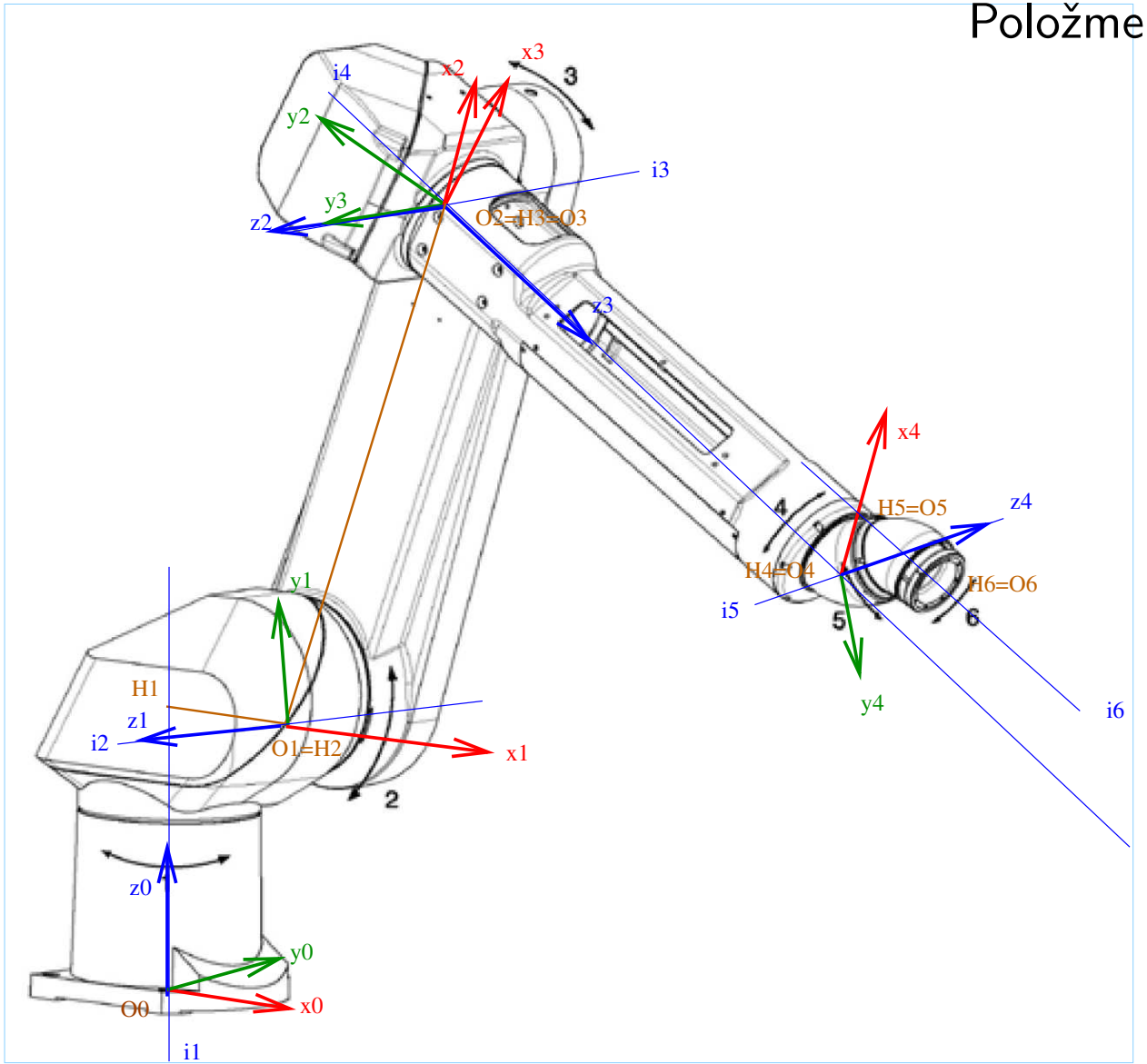
Osa x_4 musí být kolmá k i_4 a i_5 protože $\mathbf{H}_4 = \mathbf{O}_4$.

Staubli Robot Paint TX250 D-H notation



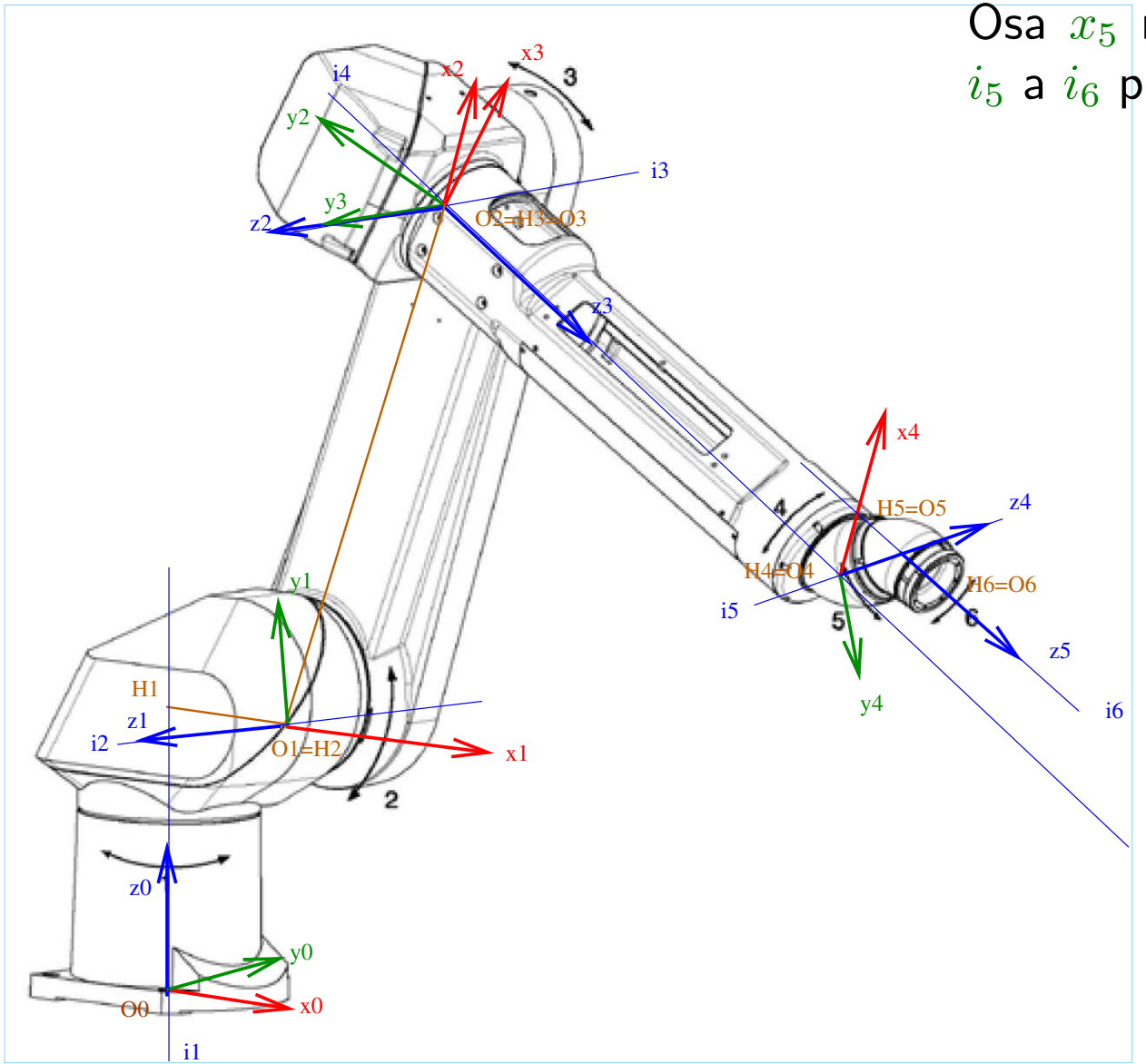
Osa y_4 musí tvořit kladně orientovaný systém.

Staubli Robot Paint TX250 D-H notation



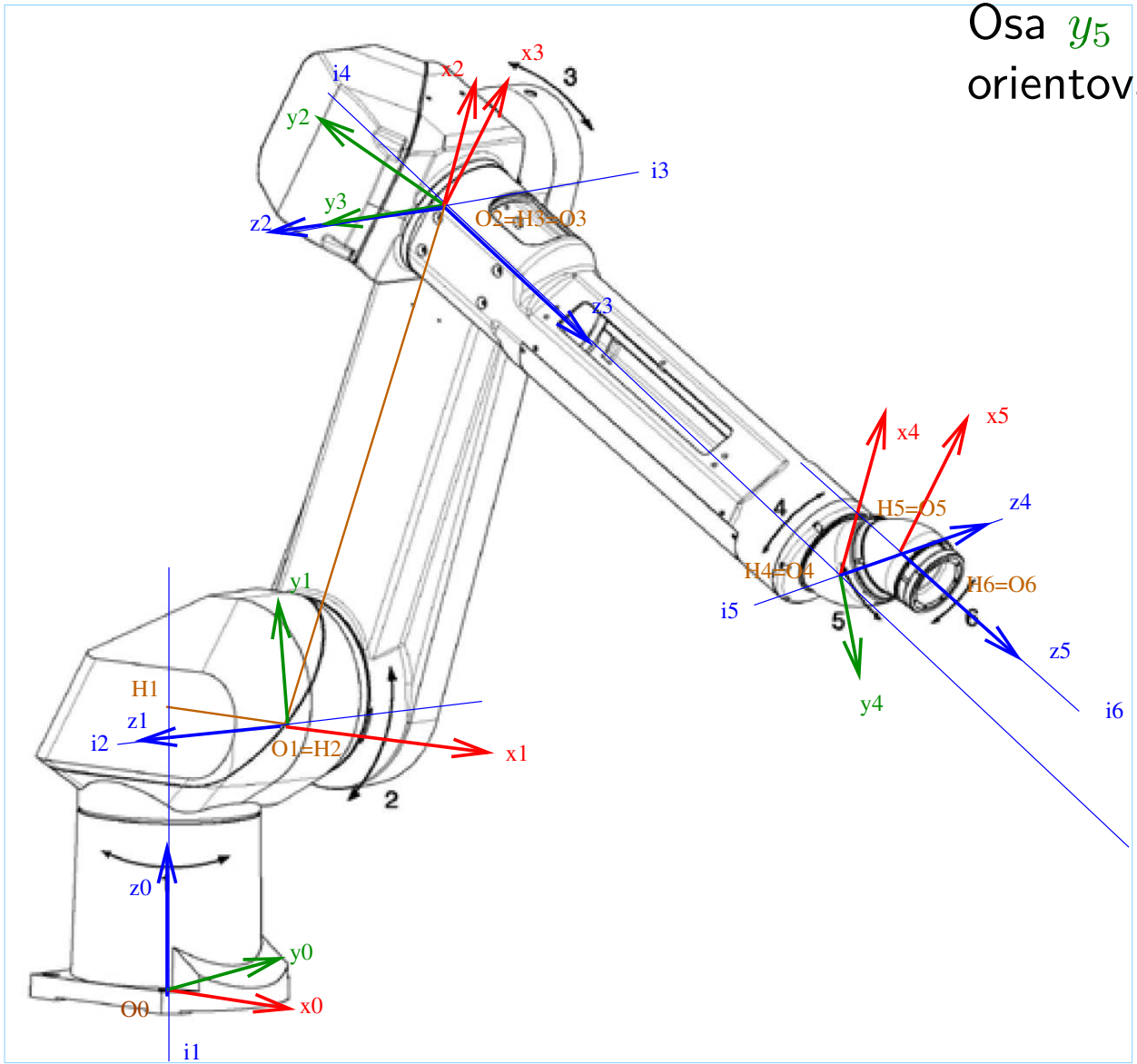
Položme osu z_5 do osy i_6.

Staubli Robot Paint TX250 D-H notation



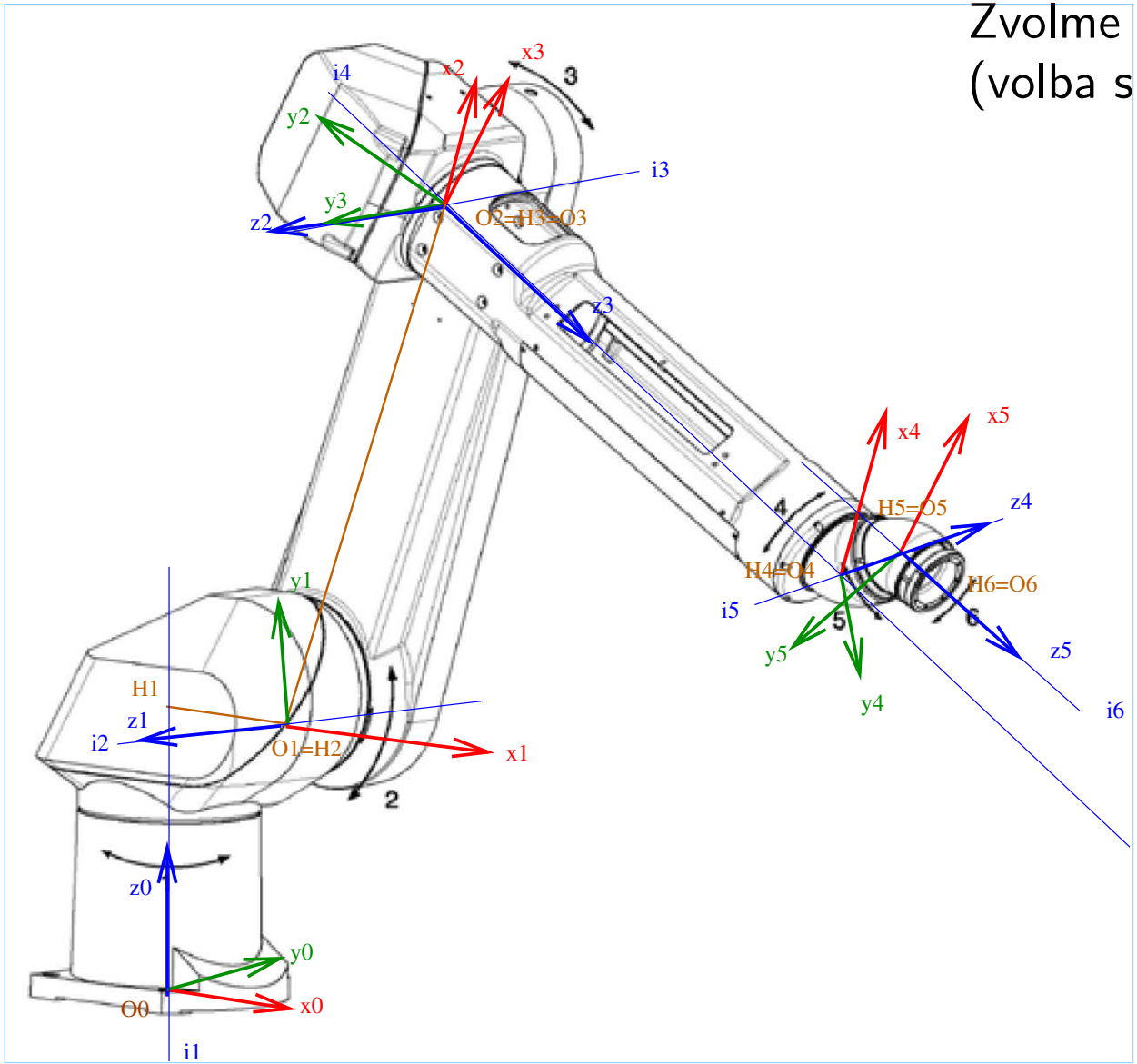
Osa x_5 musí být kolmá k i_5 a i_6 protože $\mathbf{H}_5 = \mathbf{O}_5$.

Staubli Robot Paint TX250 D-H notation



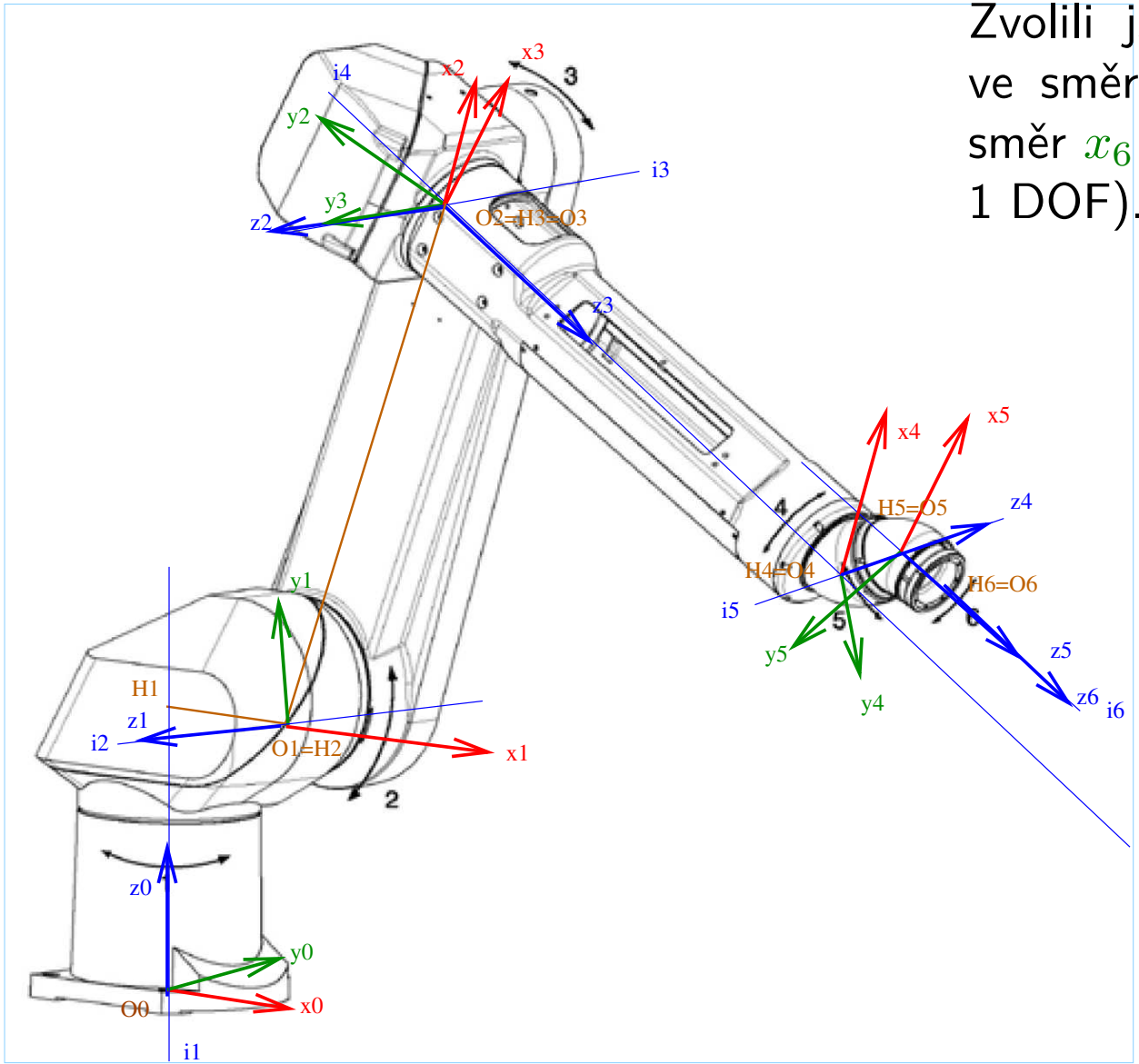
Osa y_5 musí tvořit kladně orientovaný systém.

Staubli Robot Paint TX250 D-H notation



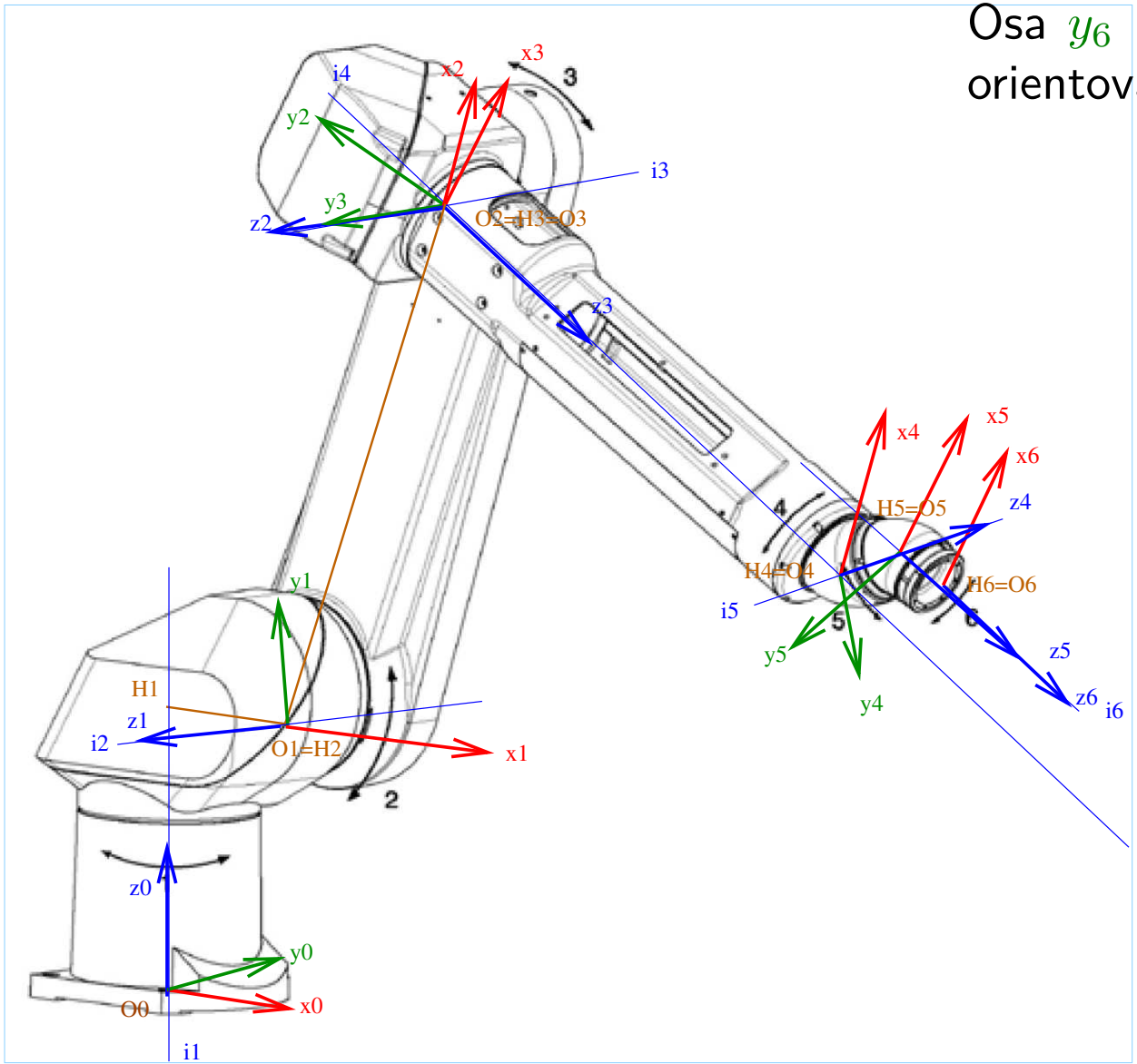
Zvolme osu z_6 libovolně (volba s 2 DOF).

Staubli Robot Paint TX250 D-H notation



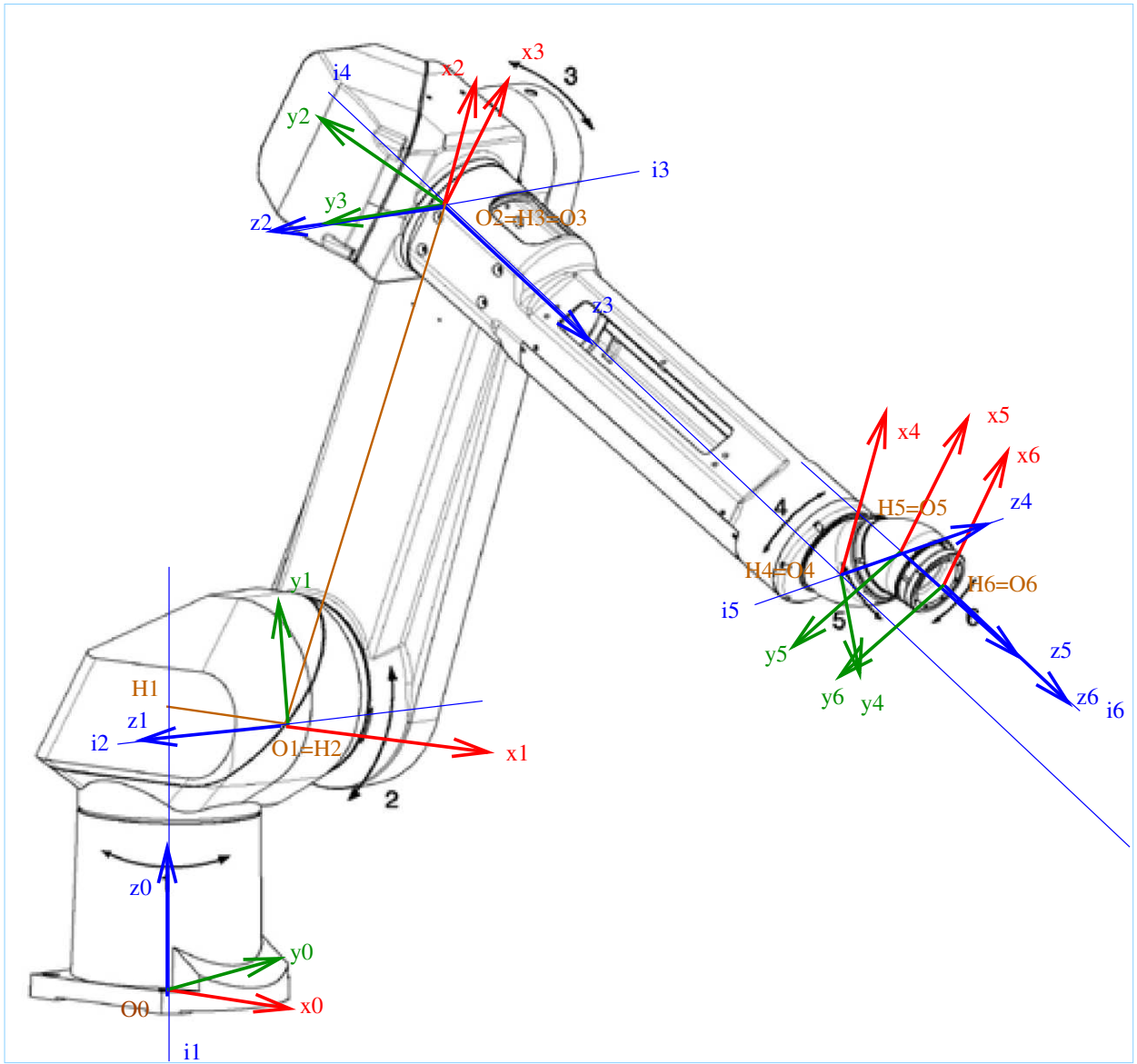
Zvolili jsme směr osy z_6 ve směru osy i_6. Zvolme směr x_6 libovolně (volba s 1 DOF).

Staubli Robot Paint TX250 D-H notation

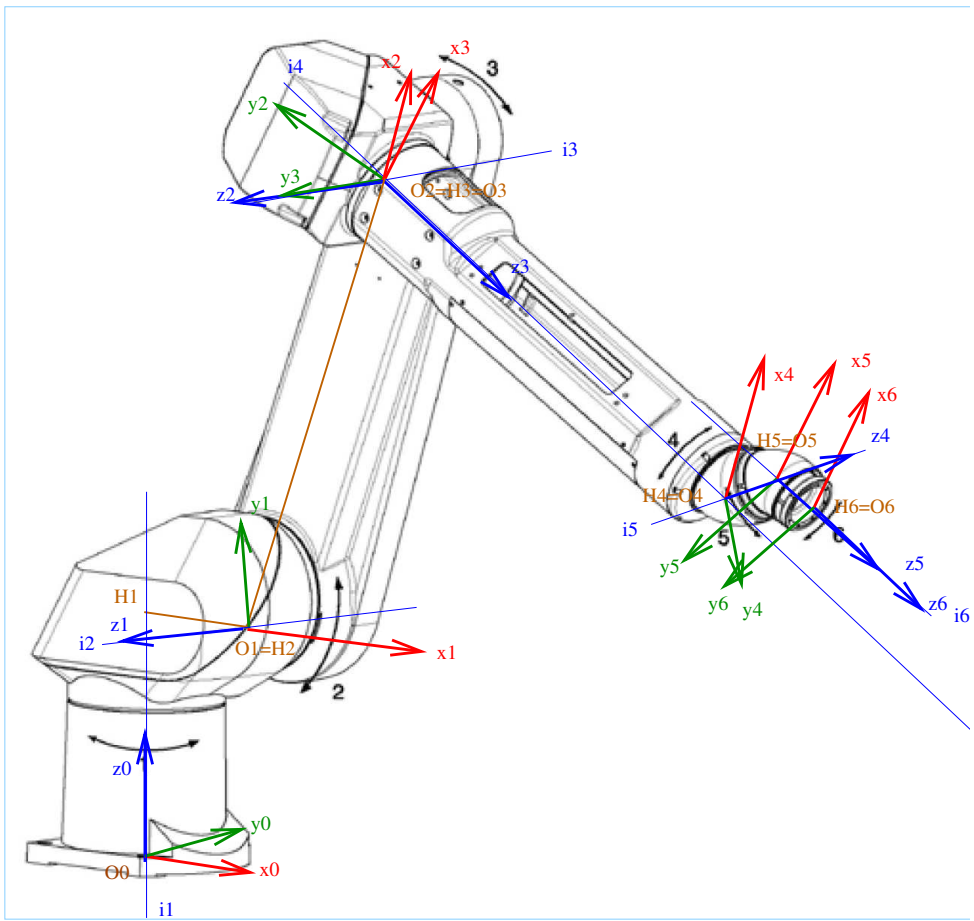


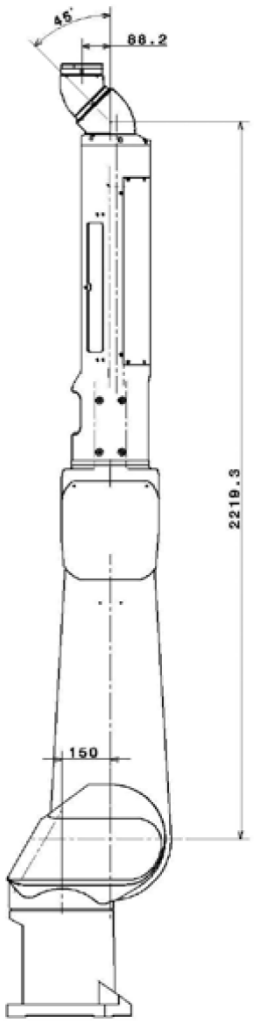
Osa y_6 musí tvořit kladně orientovaný systém.

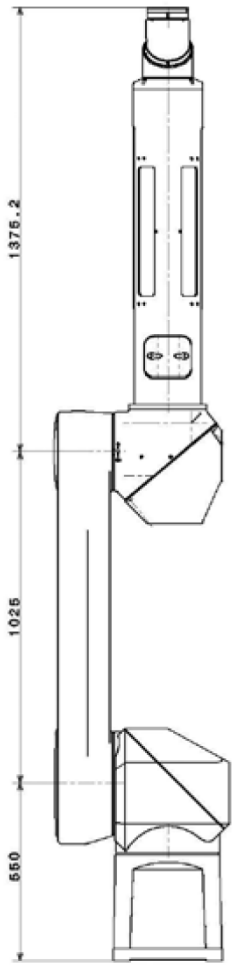
Staubli Robot Paint TX250 D-H notation



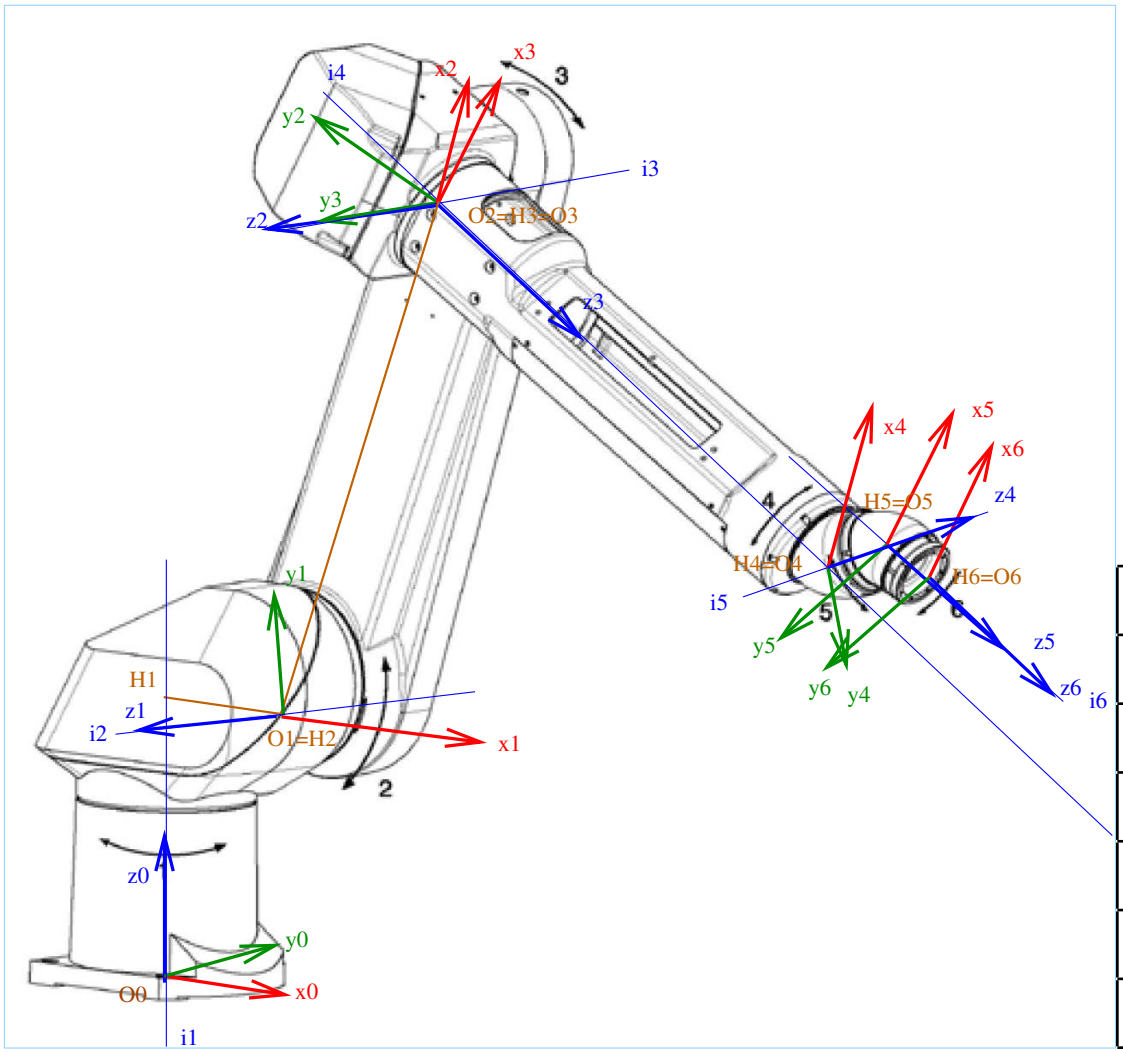
Staubli Robot Paint TX250 D-H notation





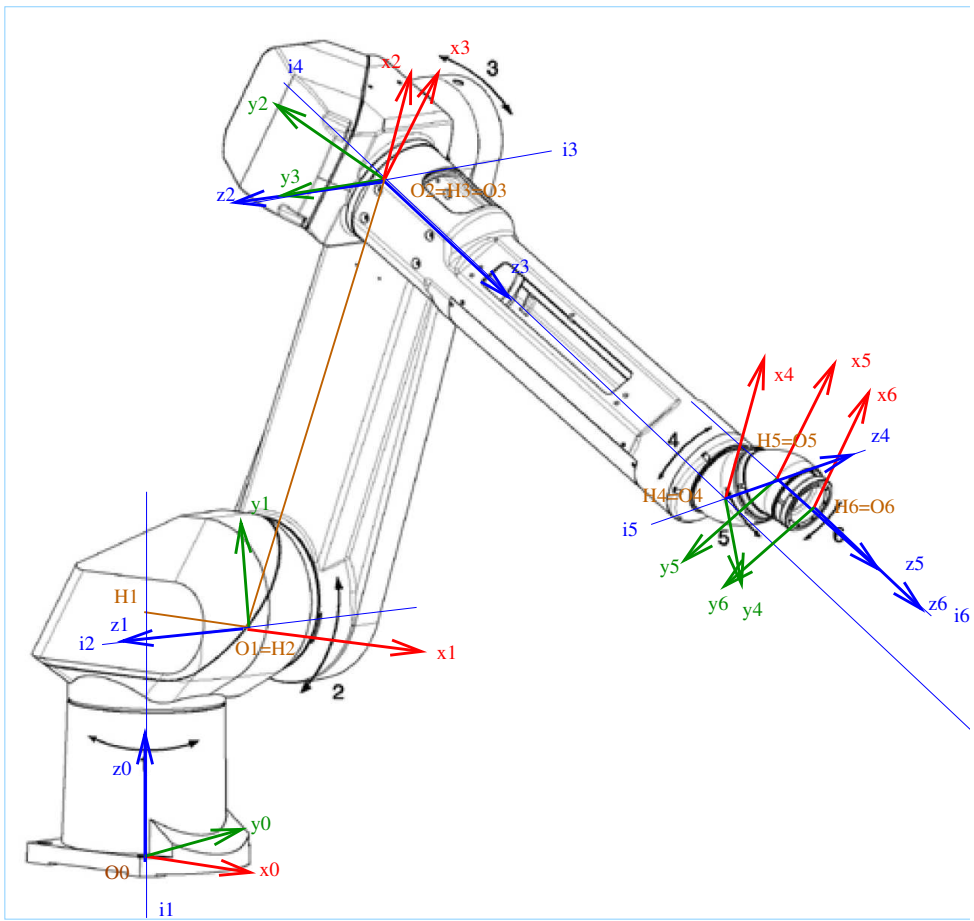


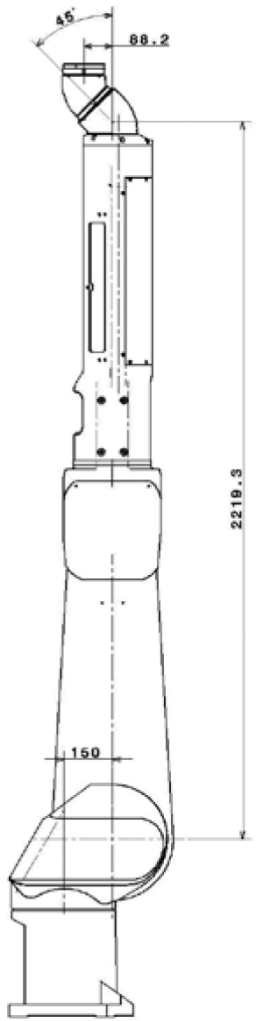
Staubli Robot Paint TX250 D-H notation

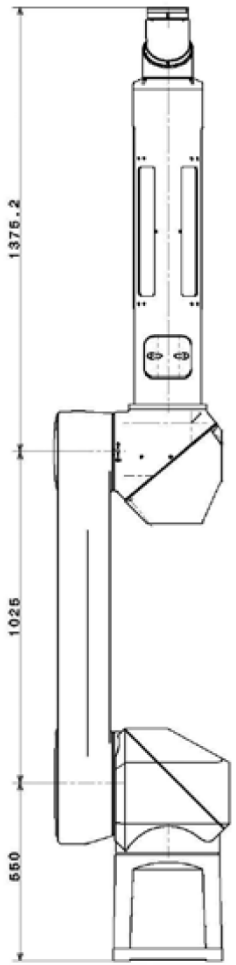


i	θ_i	d_i	a_i	α_i
1				
2				
3				
4				
5				
6				

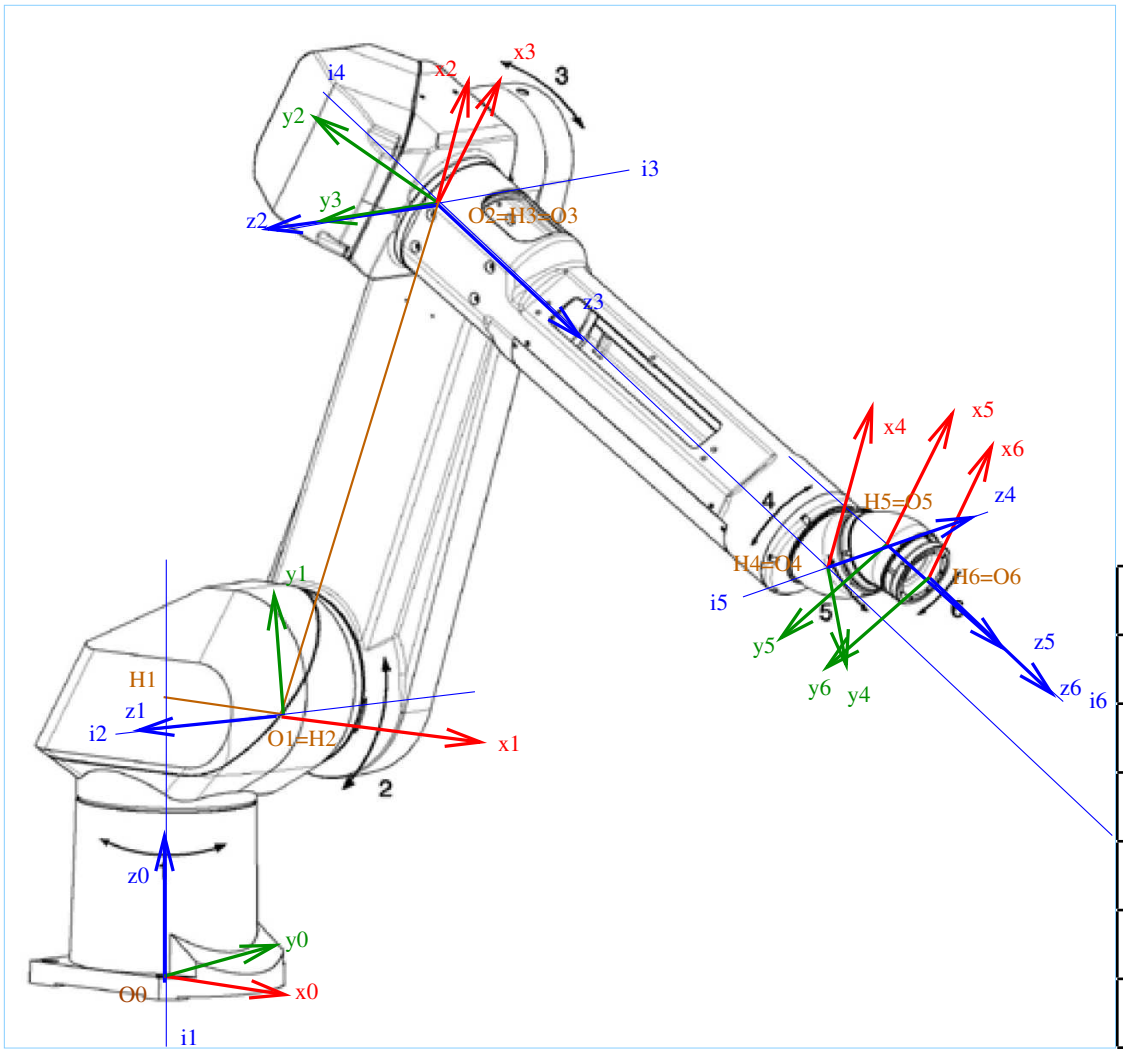
Staubli Robot Paint TX250 D-H notation





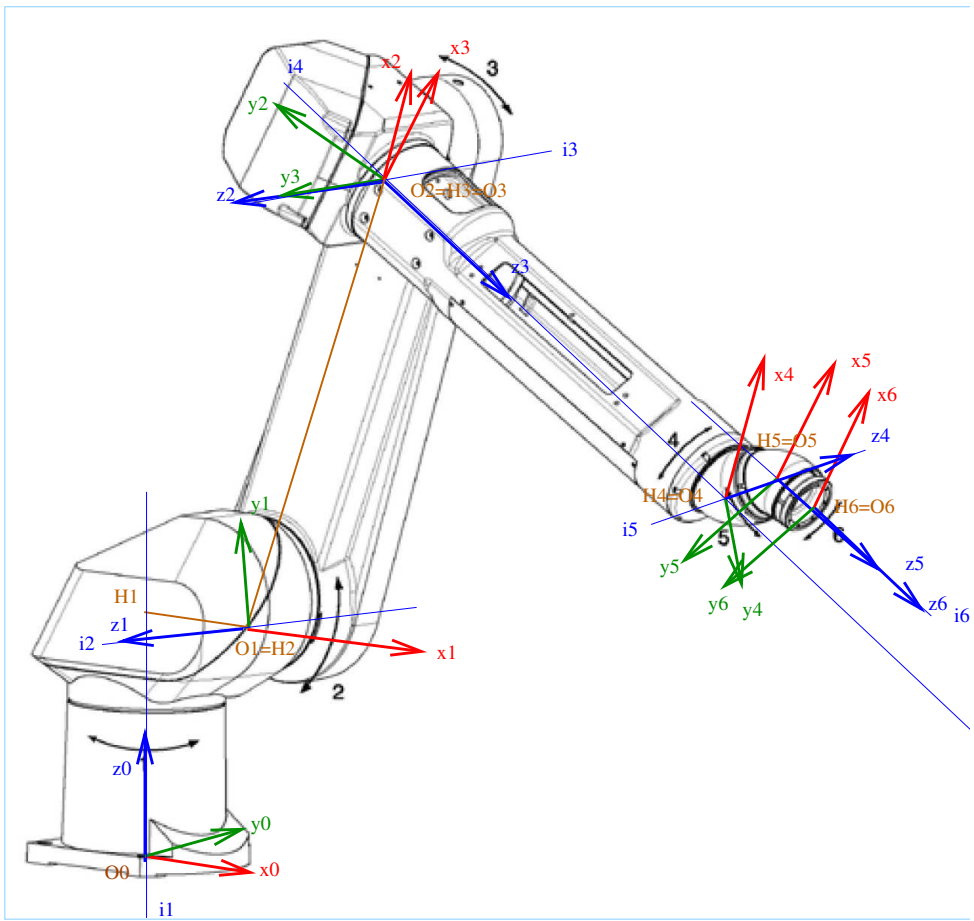


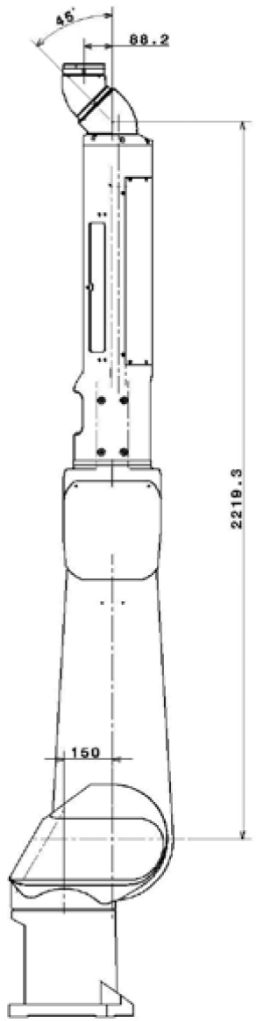
Staubli Robot Paint TX250 D-H notation

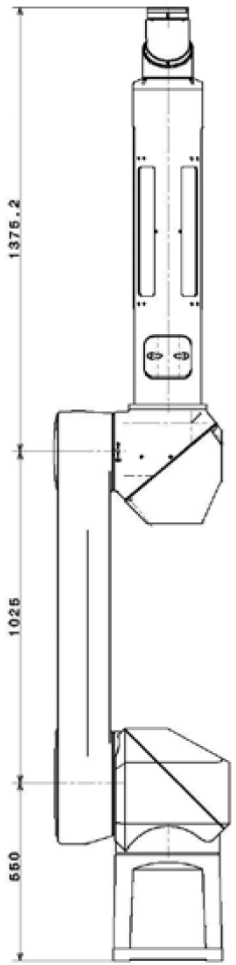


i	θ_i	d_i	a_i	α_i
1	θ_1	550	150	$\frac{\pi}{2}$
2				
3				
4				
5				
6				

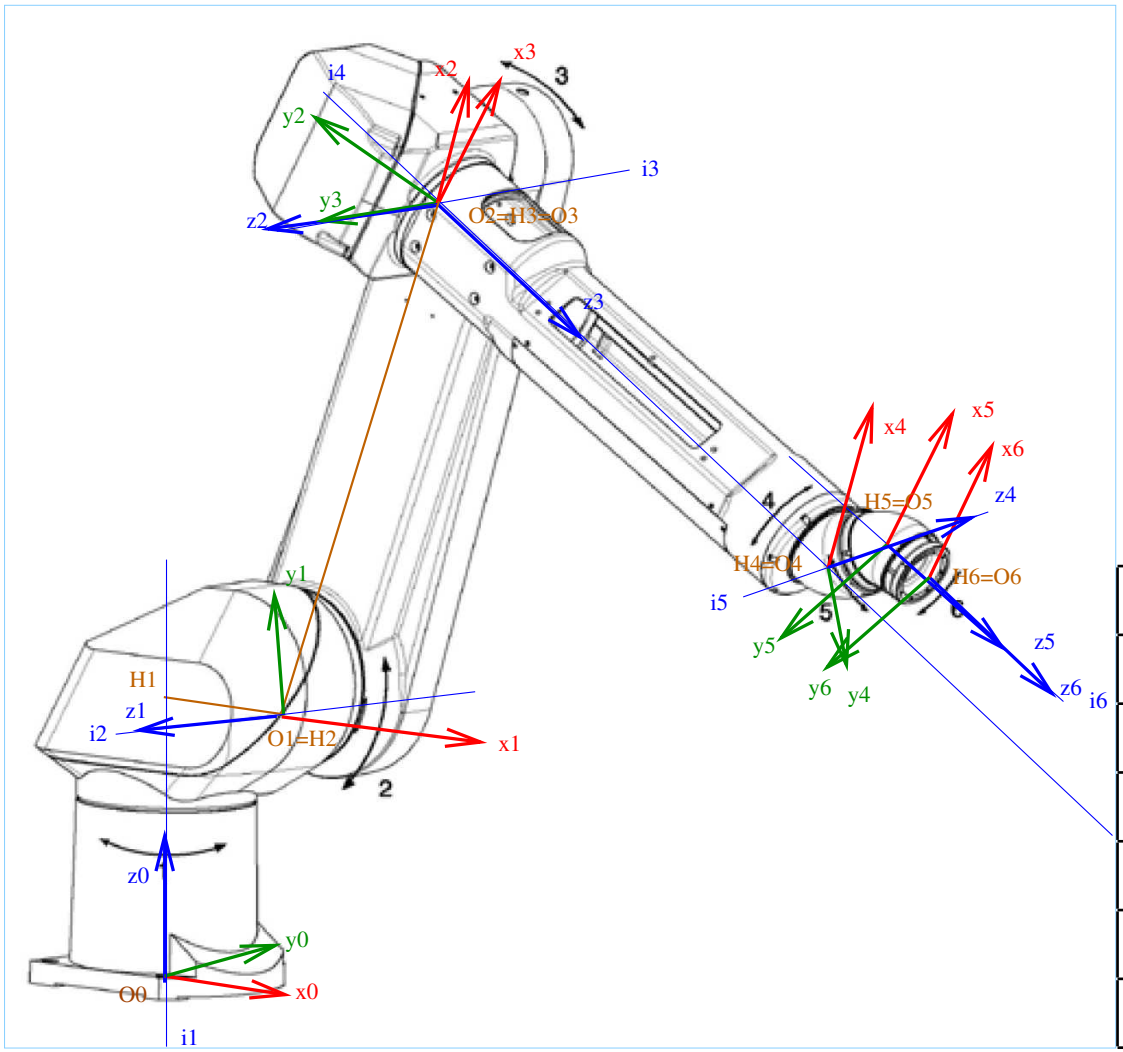
Staubli Robot Paint TX250 D-H notation





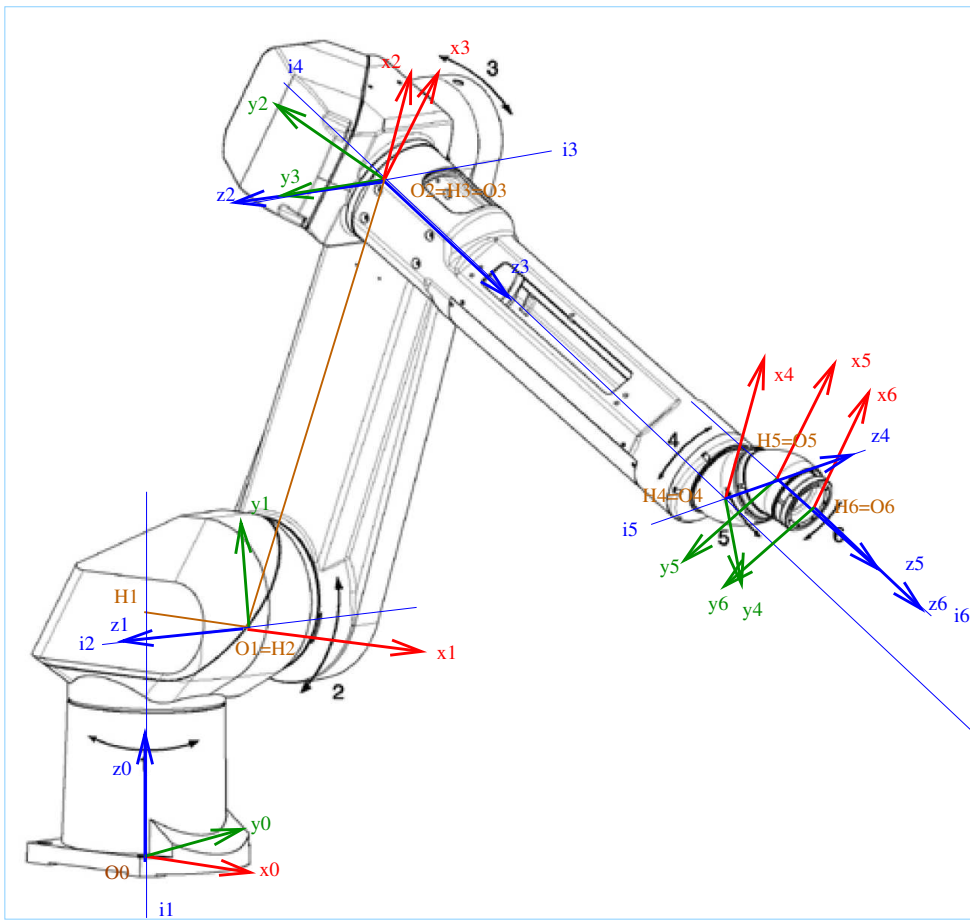


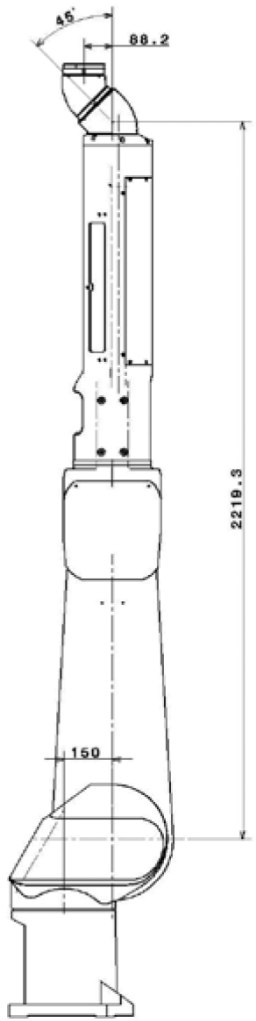
Staubli Robot Paint TX250 D-H notation

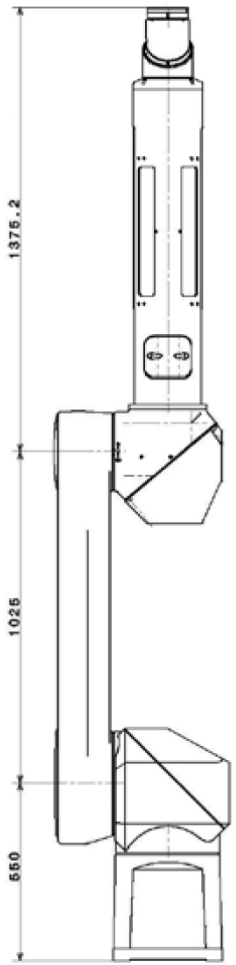


i	θ_i	d_i	a_i	α_i
1	θ_1	550	150	$\frac{\pi}{2}$
2	θ_2	0	1025	0
3				
4				
5				
6				

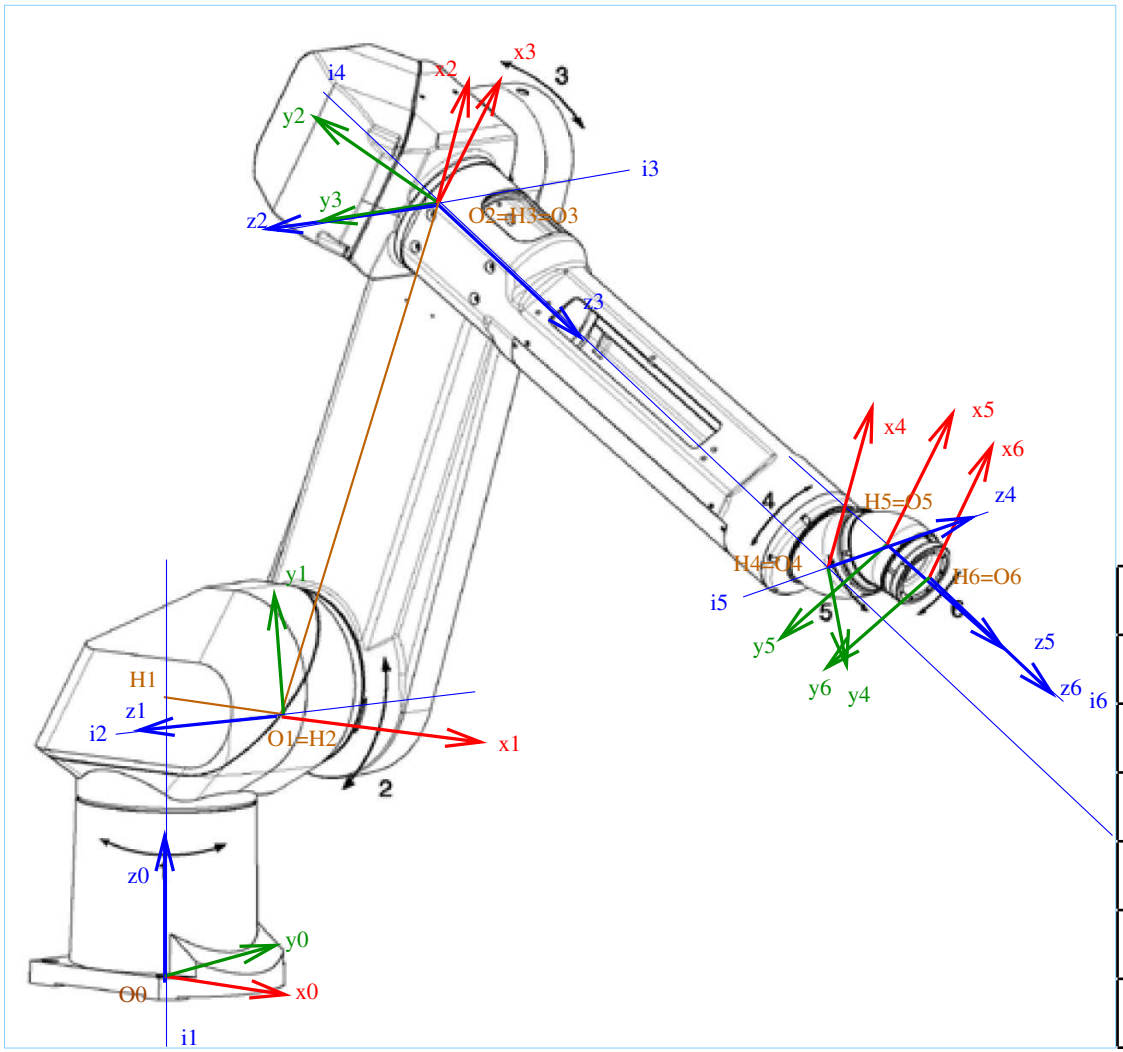
Staubli Robot Paint TX250 D-H notation





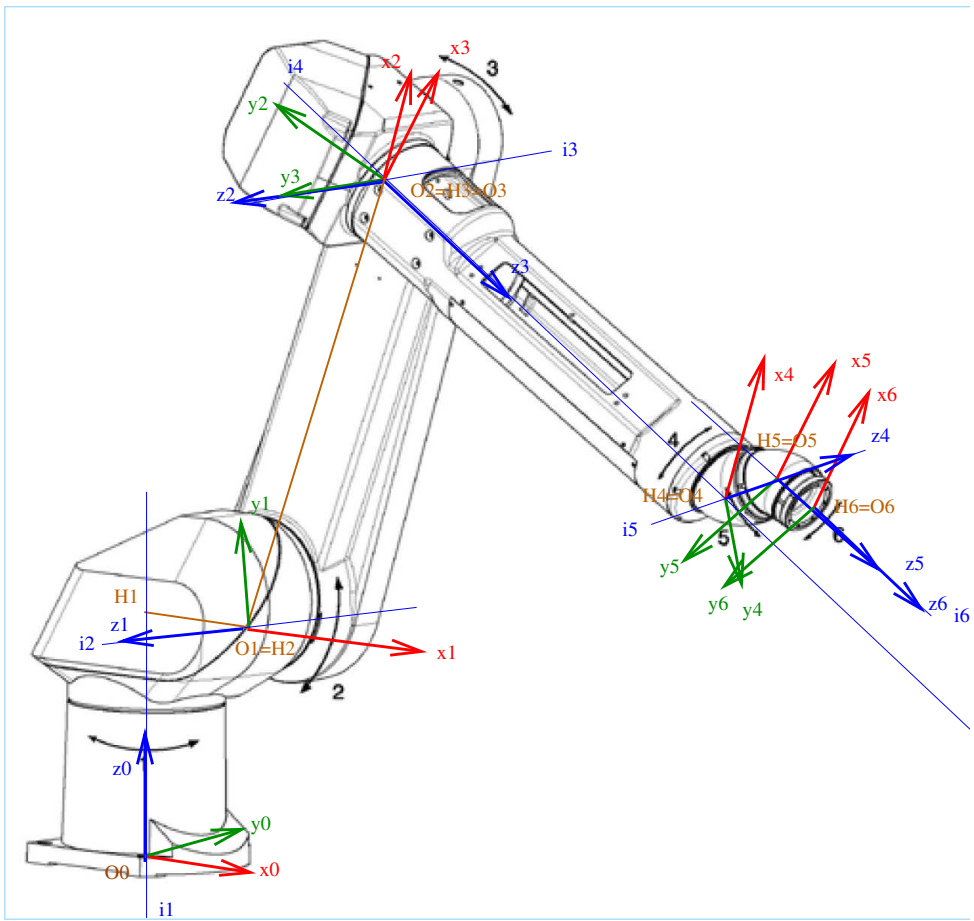


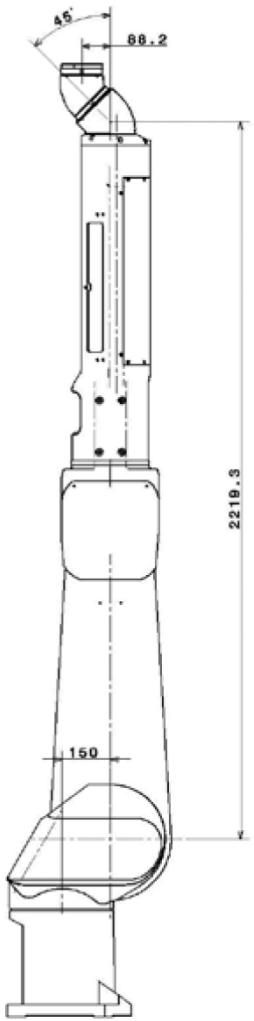
Staubli Robot Paint TX250 D-H notation

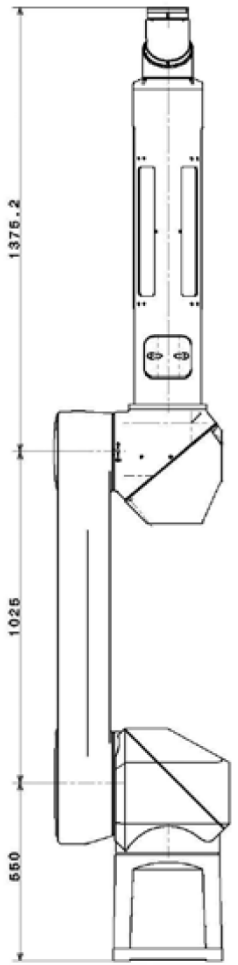


i	θ_i	d_i	a_i	α_i
1	θ_1	550	150	$\frac{\pi}{2}$
2	θ_2	0	1025	0
3	θ_3	0	0	$\frac{\pi}{2}$
4				
5				
6				

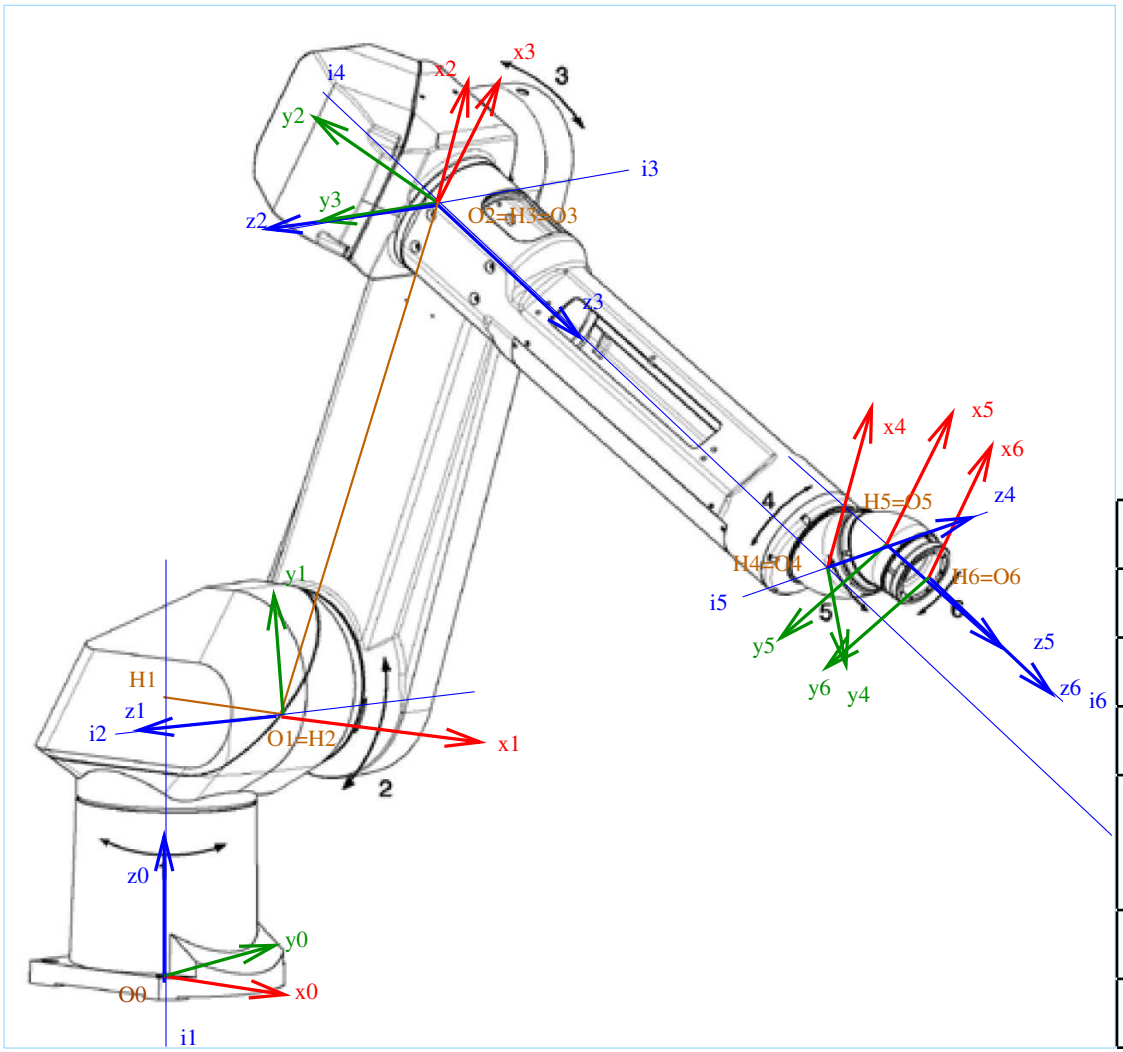
Staubli Robot Paint TX250 D-H notation





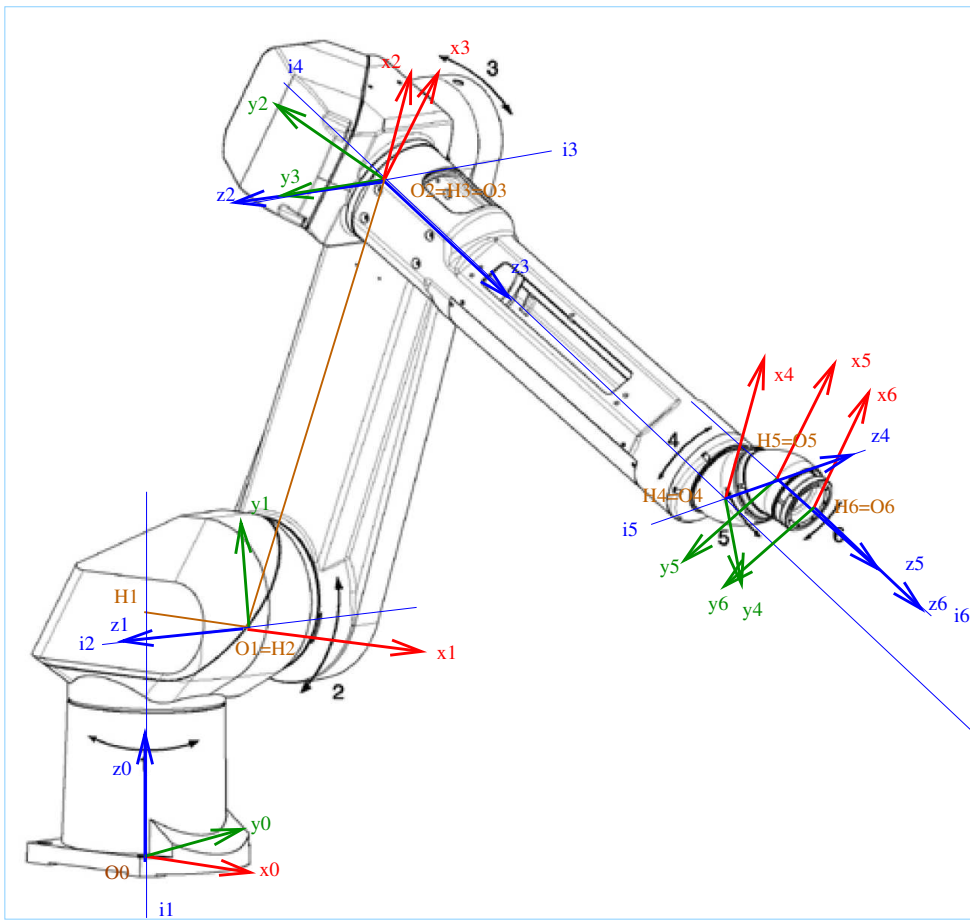


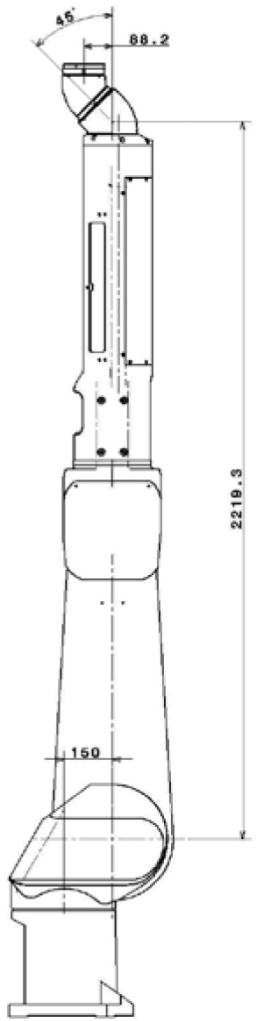
Staubli Robot Paint TX250 D-H notation

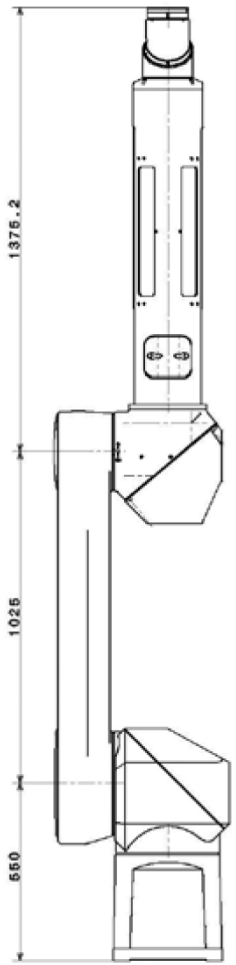


i	θ_i	d_i	a_i	α_i
1	θ_1	550	150	$\frac{\pi}{2}$
2	θ_2	0	1025	0
3	θ_3	0	0	$\frac{\pi}{2}$
4	θ_4	2219 -1025	0	$-\frac{\pi}{4}$
5				
6				

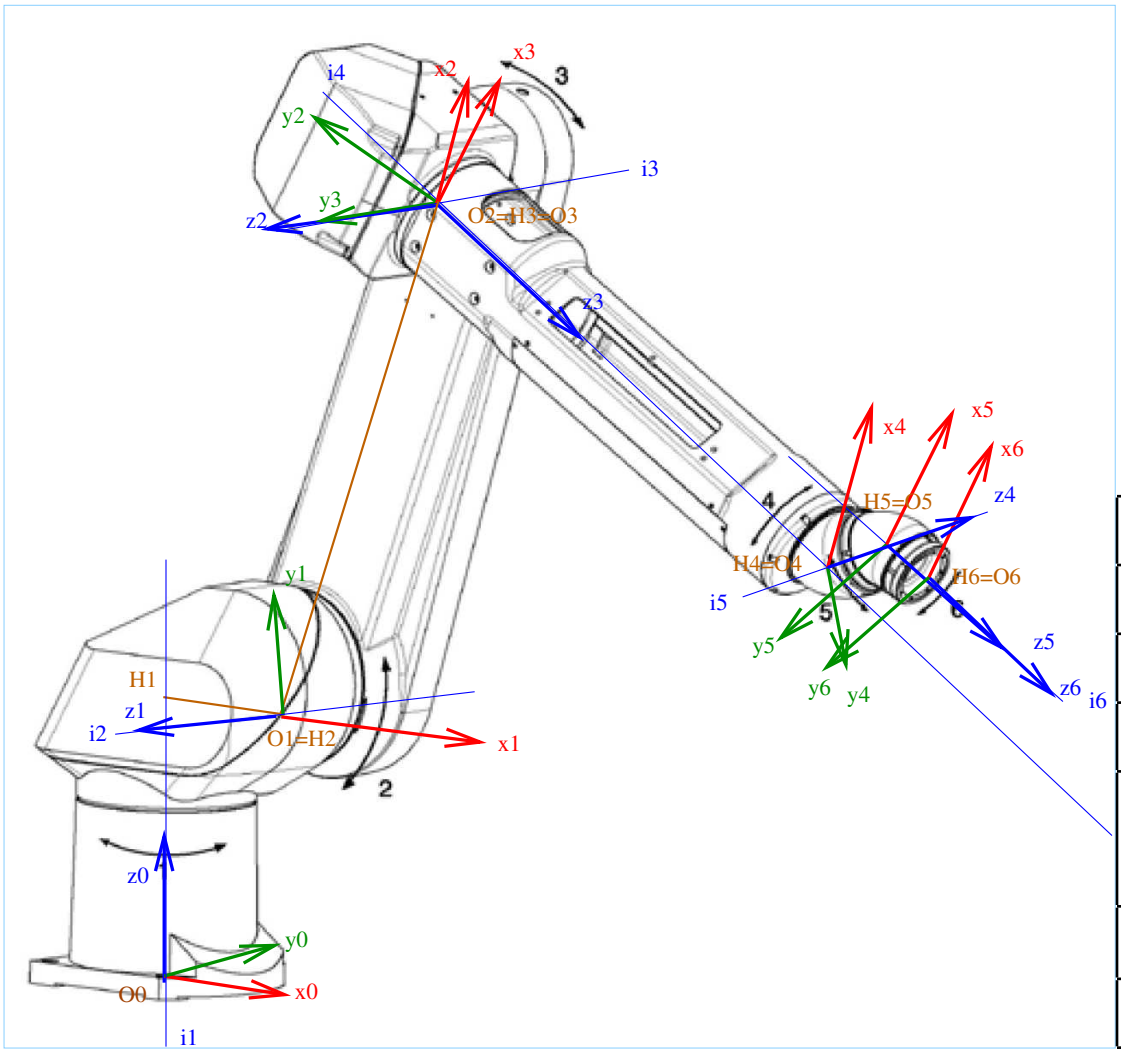
Staubli Robot Paint TX250 D-H notation





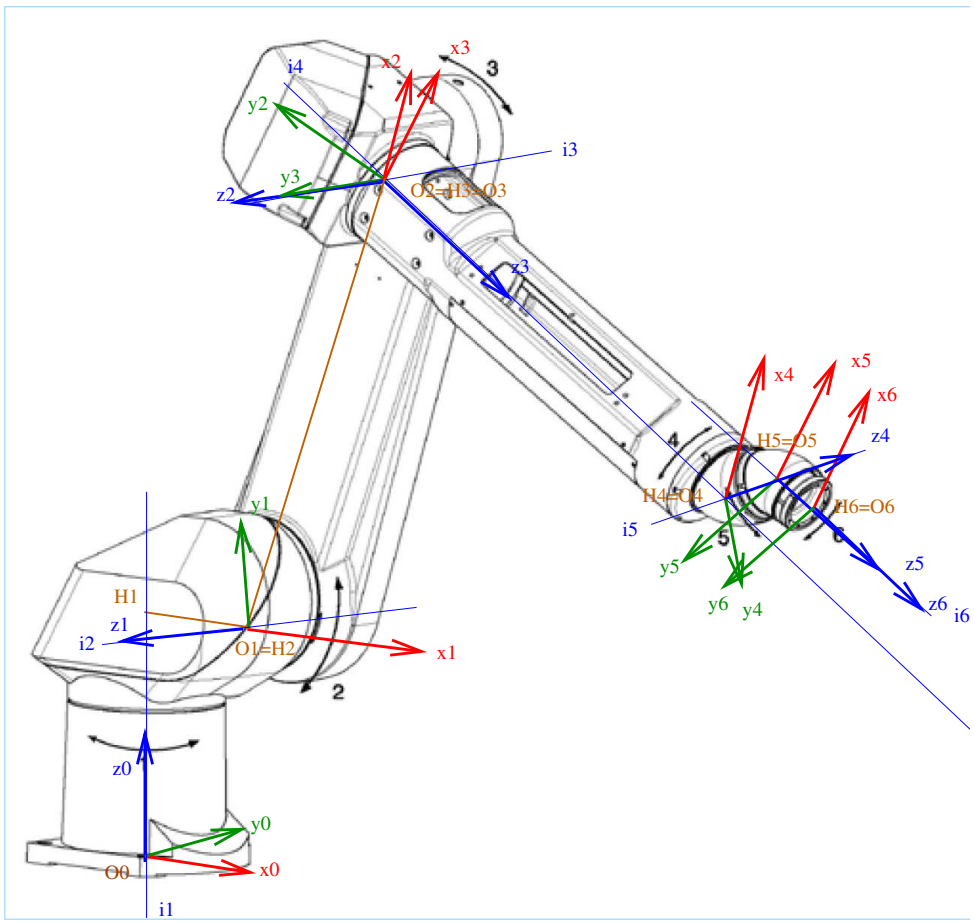


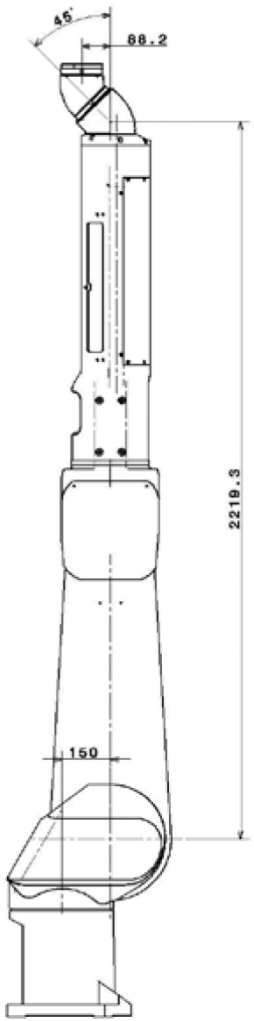
Staubli Robot Paint TX250 D-H notation

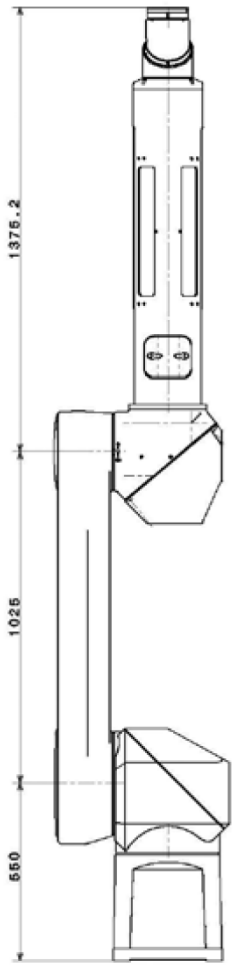


i	θ_i	d_i	a_i	α_i
1	θ_1	550	150	$\frac{\pi}{2}$
2	θ_2	0	1025	0
3	θ_3	0	0	$\frac{\pi}{2}$
4	θ_4	2219 -1025	0	$-\frac{\pi}{4}$
5	θ_5	$88\sqrt{2}$	0	$\frac{\pi}{4}$
6				

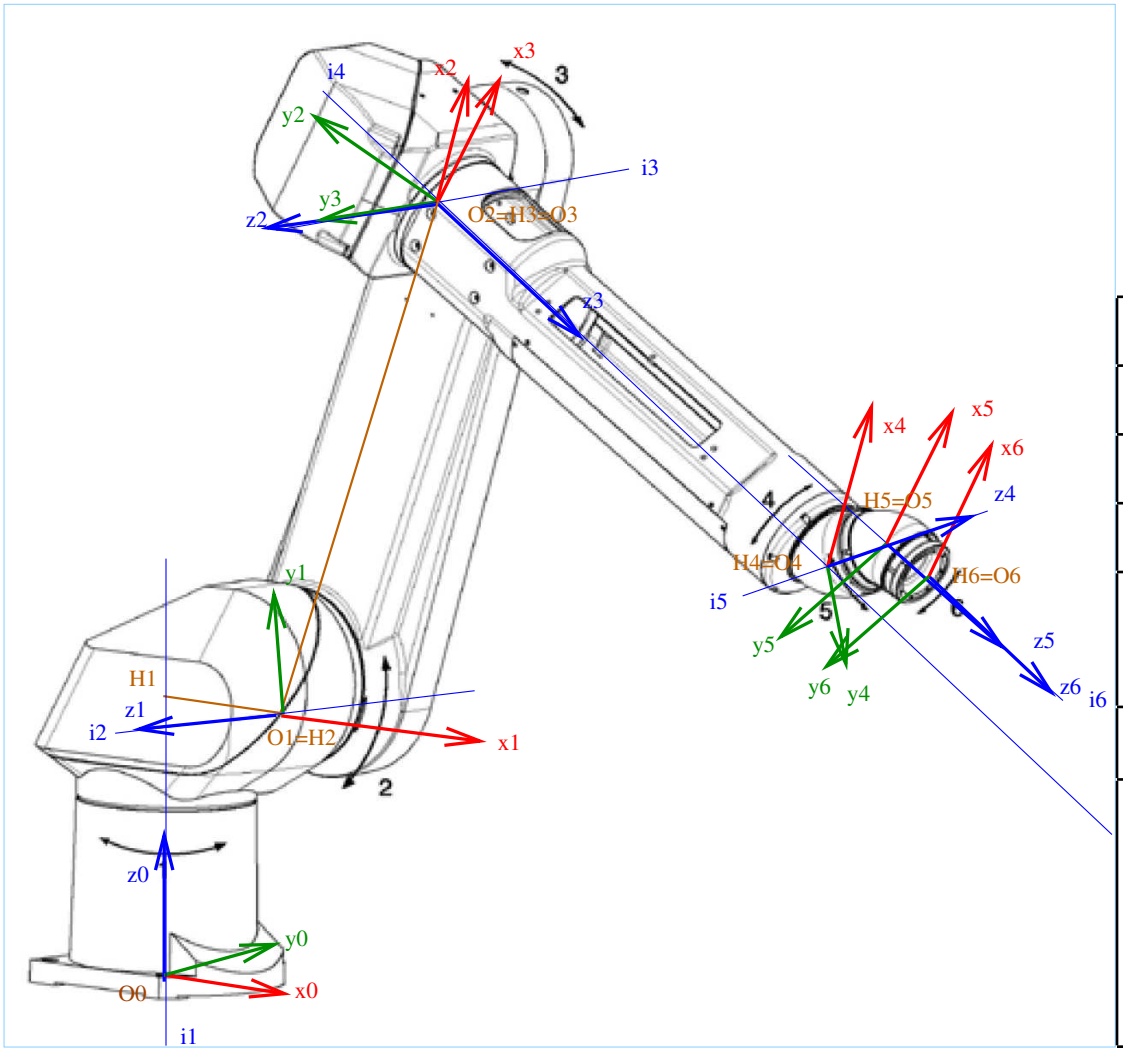
Staubli Robot Paint TX250 D-H notation







Staubli Robot Paint TX250 D-H notation



i	θ_i	d_i	a_i	α_i
1	θ_1	550	150	$\frac{\pi}{2}$
2	θ_2	0	1025	0
3	θ_3	0	0	$\frac{\pi}{2}$
4	θ_4	2219 -1025	0	$-\frac{\pi}{4}$
5	θ_5	$88\sqrt{2}$	0	$\frac{\pi}{4}$
6	θ_6	1375 $+1025$ -2219 -88	0	0

ROBOTICS

STÄUBLI

TXPaint250 painting robot

RS	TX	TX	TX
Scara / 4 axis	low payload/ 6 axis	medium payload/ 6 axis	heavy payload/ 6 axis

ROBOTICS

STÄUBLI

TXPaint250 painting robot

RS	TX	TX	TX
Scara / 4 axis	low payload/ 6 axis	medium payload/ 6 axis	heavy payload/ 6 axis

ROBOTICS

STÄUBLI

TXPaint250 painting robot

RS	TX	TX	TX
Scara / 4 axis	low payload/ 6 axis	medium payload/ 6 axis	heavy payload/ 6 axis

ROBOTICS

STÄUBLI

TXPaint250 painting robot

RS	TX	TX	TX
Scara / 4 axis	low payload/ 6 axis	medium payload/ 6 axis	heavy payload/ 6 axis

ROBOTICS

STÄUBLI

TXPaint250 painting robot

RS	TX	TX	TX
Scara / 4 axis	low payload/ 6 axis	medium payload/ 6 axis	heavy payload/ 6 axis

ROBOTICS

STÄUBLI

TXPaint250 painting robot

RS	TX	TX	TX
Scara / 4 axis	low payload/ 6 axis	medium payload/ 6 axis	heavy payload/ 6 axis

ROBOTICS

STÄUBLI

TXPaint250 painting robot

RS	TX	TX	TX
Scara / 4 axis	low payload/ 6 axis	medium payload/ 6 axis	heavy payload/ 6 axis

ROBOTICS

STÄUBLI

TXPaint250 painting robot

RS	TX	TX	TX
Scara / 4 axis	low payload/ 6 axis	medium payload/ 6 axis	heavy payload/ 6 axis

ROBOTICS

STÄUBLI

TXPaint250 painting robot

RS	TX	TX	TX
Scara / 4 axis	low payload/ 6 axis	medium payload/ 6 axis	heavy payload/ 6 axis

ROBOTICS

STÄUBLI

TXPaint250 painting robot

RS	TX	TX	TX
Scara / 4 axis	low payload/ 6 axis	medium payload/ 6 axis	heavy payload/ 6 axis

ROBOTICS

STÄUBLI

TXPaint250 painting robot

RS	TX	TX	TX
Scara / 4 axis	low payload/ 6 axis	medium payload/ 6 axis	heavy payload/ 6 axis

ROBOTICS

STÄUBLI

TXPaint250 painting robot

RS	TX	TX	TX
Scara / 4 axis	low payload/ 6 axis	medium payload/ 6 axis	heavy payload/ 6 axis

ROBOTICS

STÄUBLI

TXPaint250 painting robot

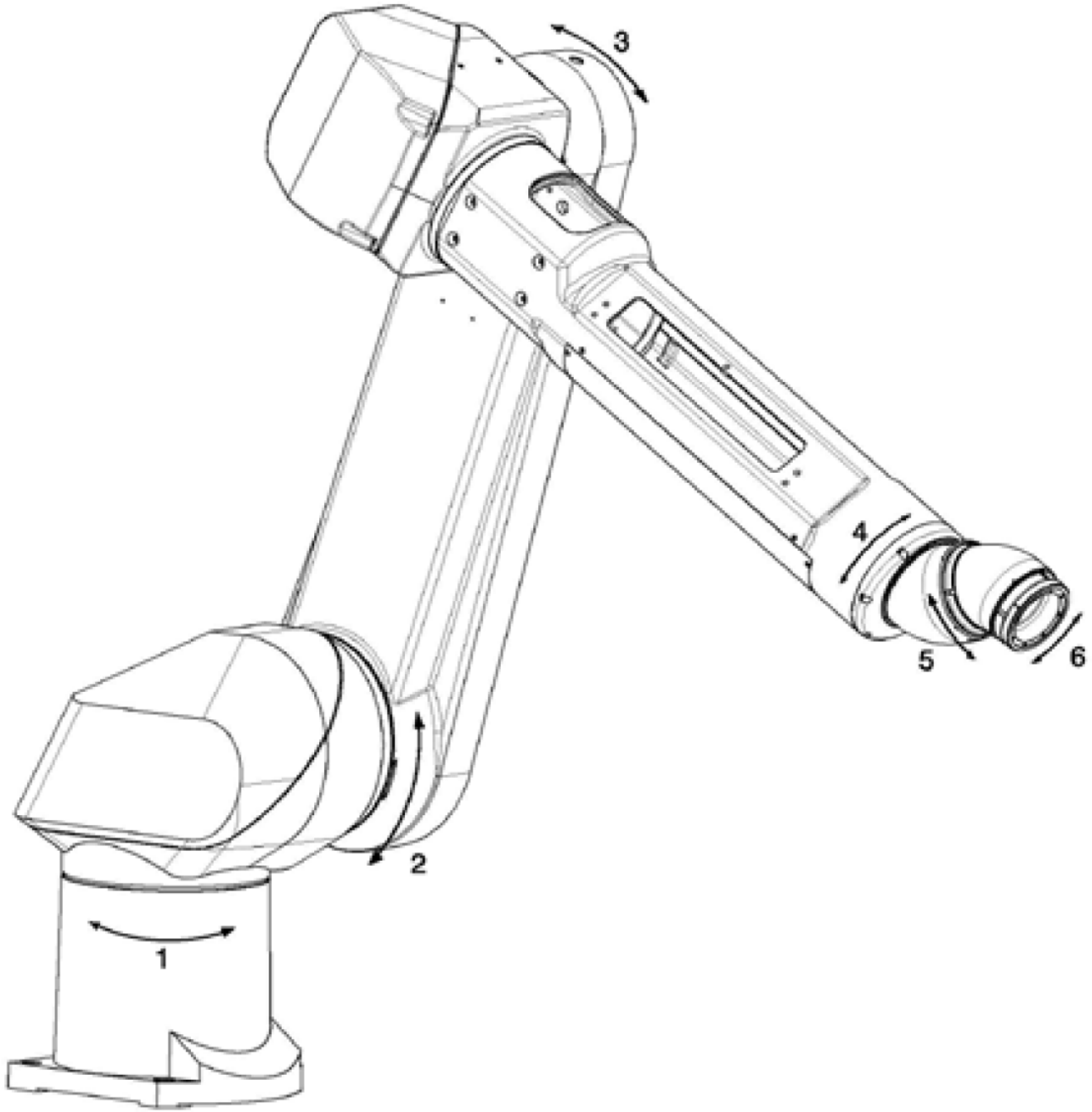
RS	TX	TX	TX
Scara / 4 axis	low payload/ 6 axis	medium payload/ 6 axis	heavy payload/ 6 axis

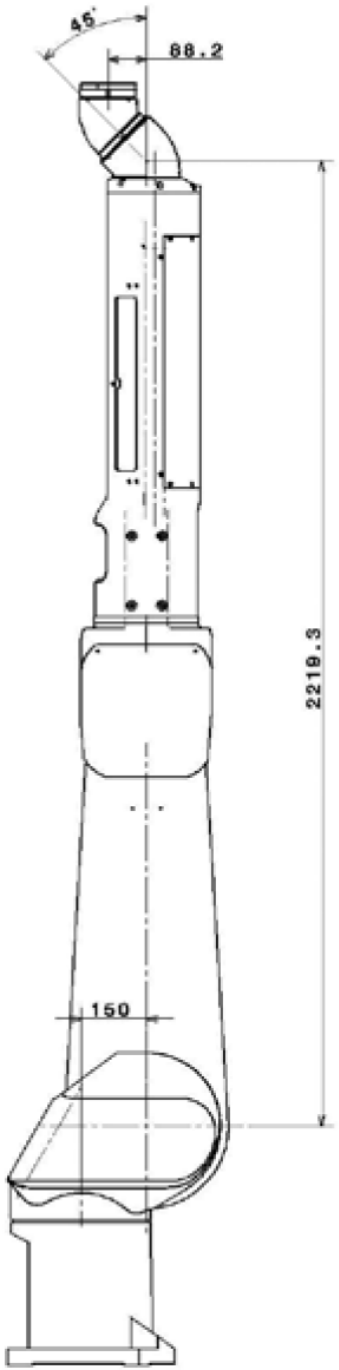
ROBOTICS

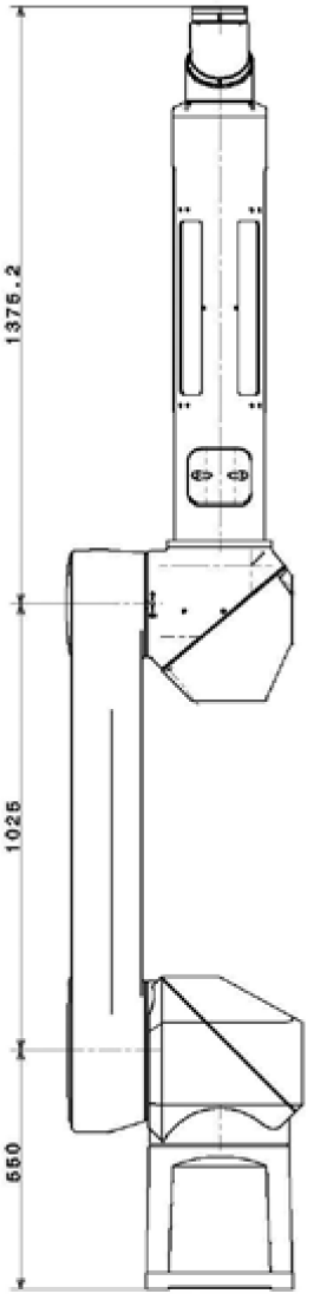
STÄUBLI

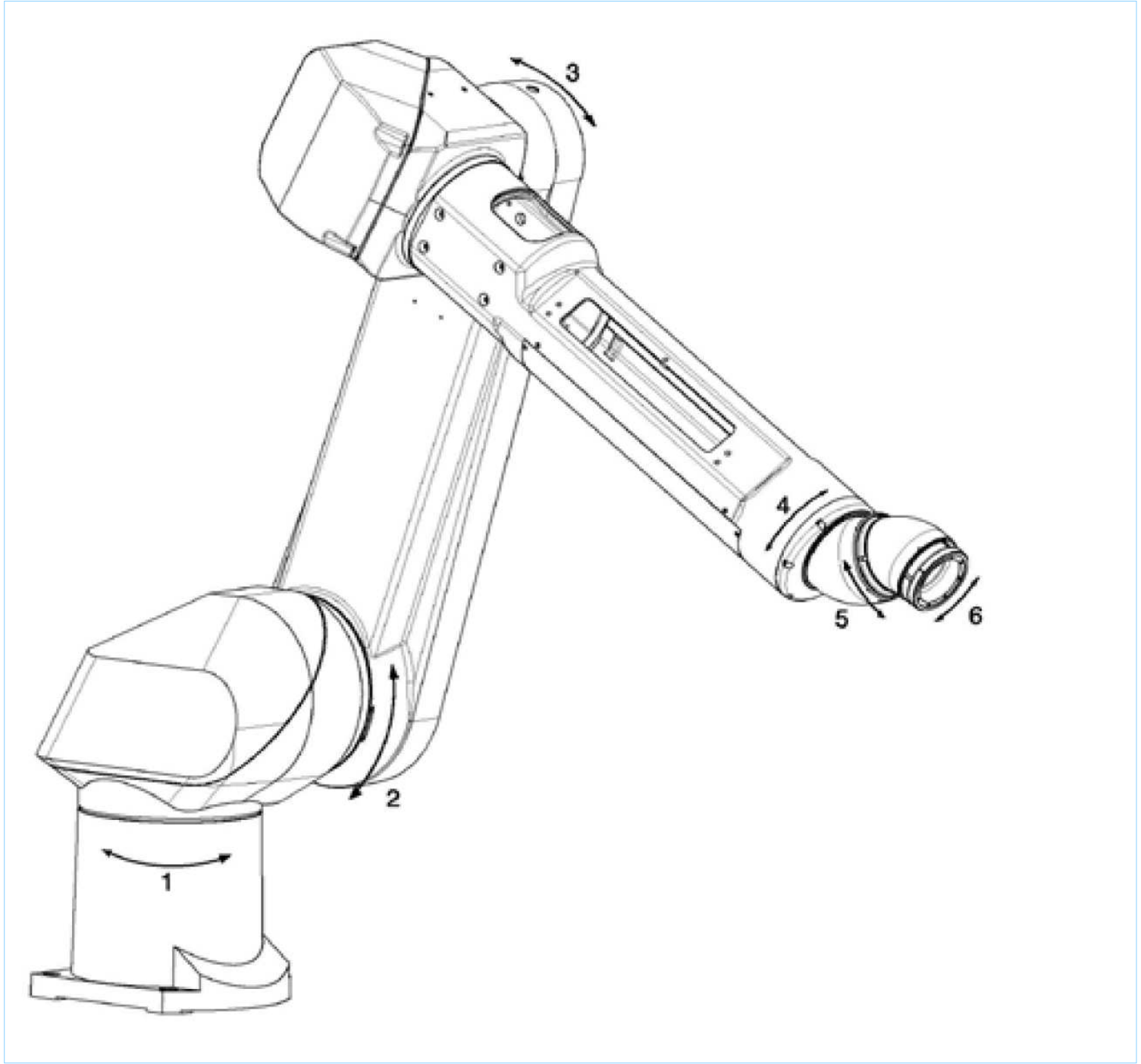
TXPaint250 painting robot

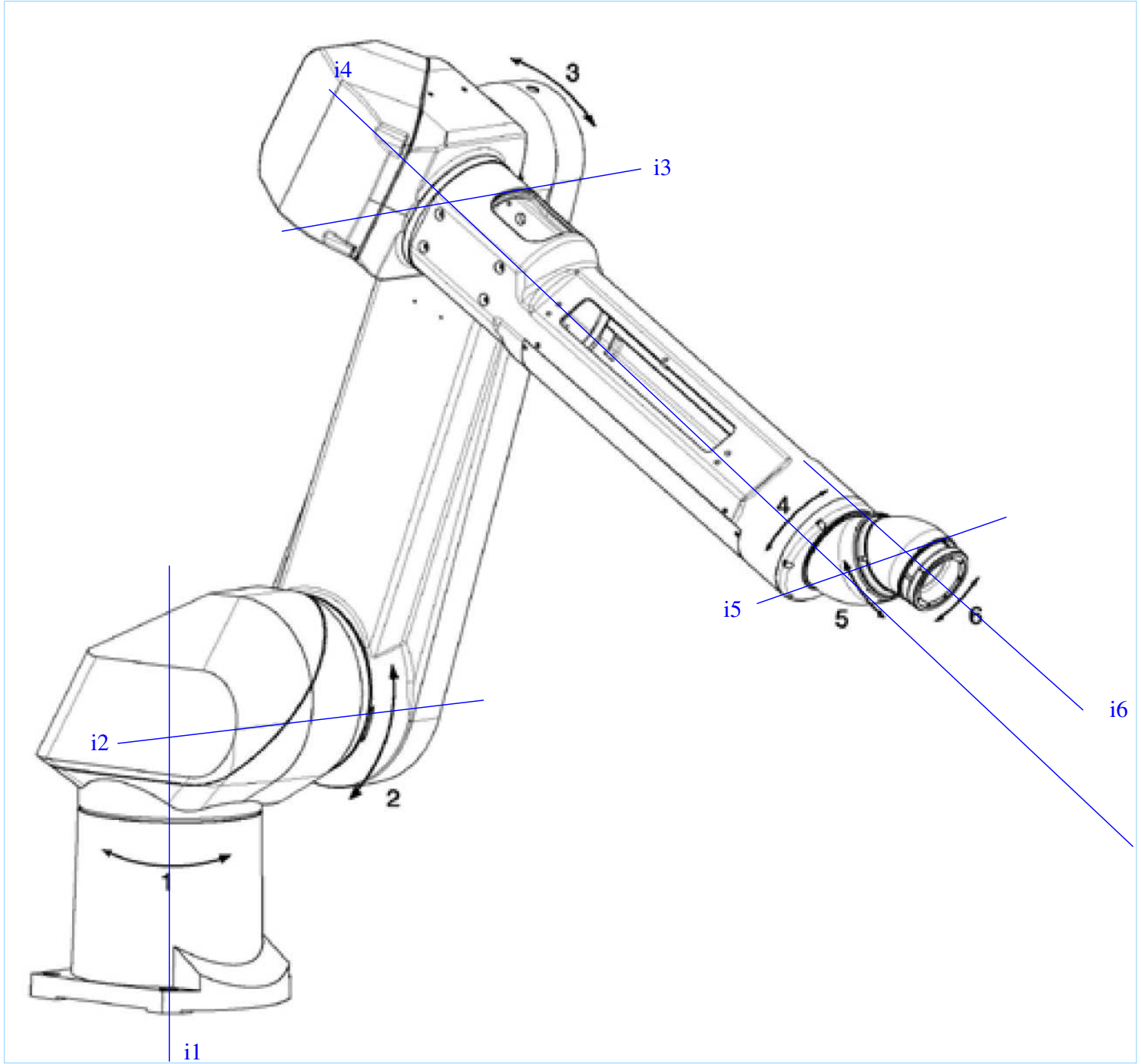
RS	TX	TX	TX
Scara / 4 axis	low payload/ 6 axis	medium payload/ 6 axis	heavy payload/ 6 axis

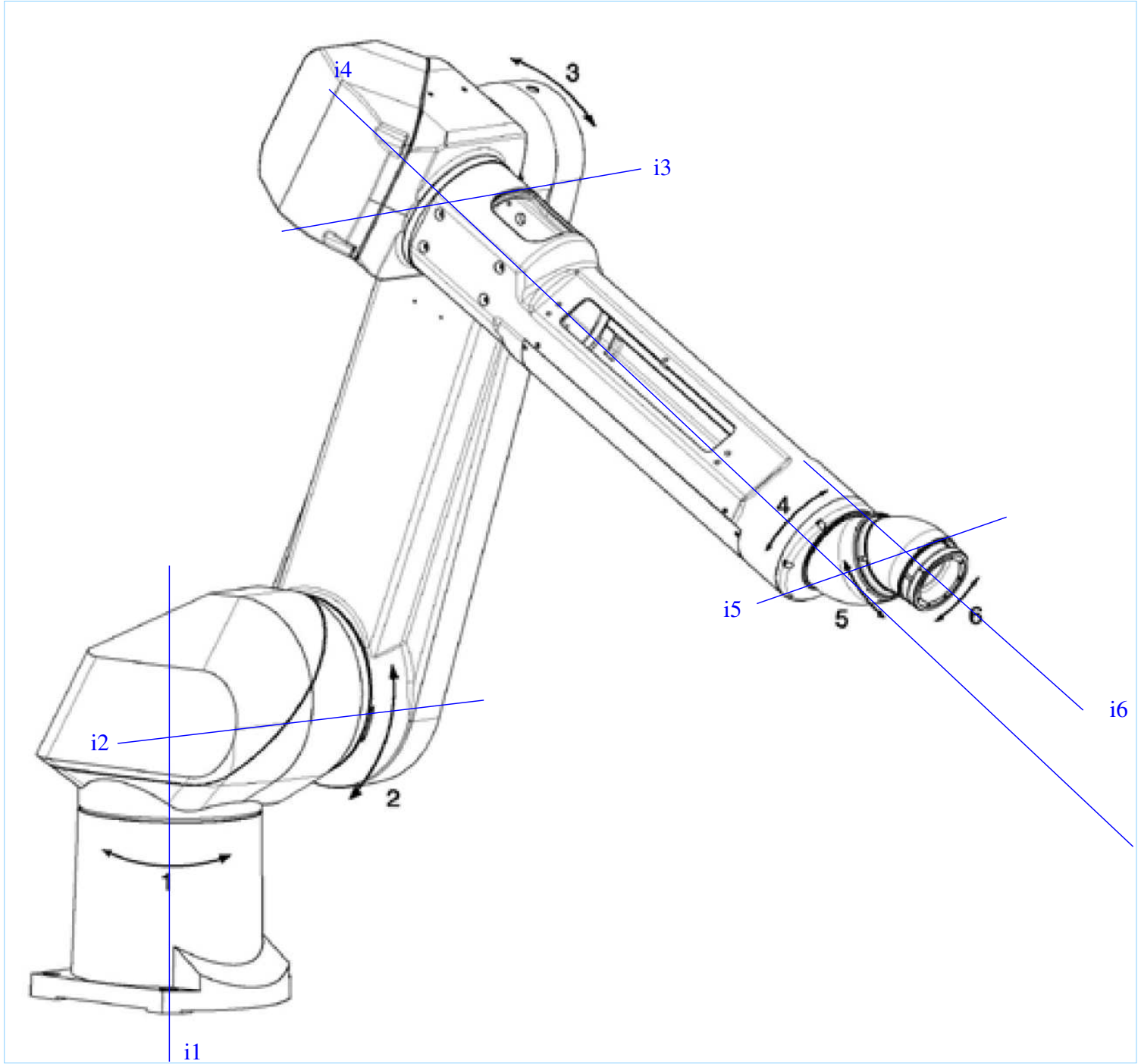

3
4
5
6
2
1

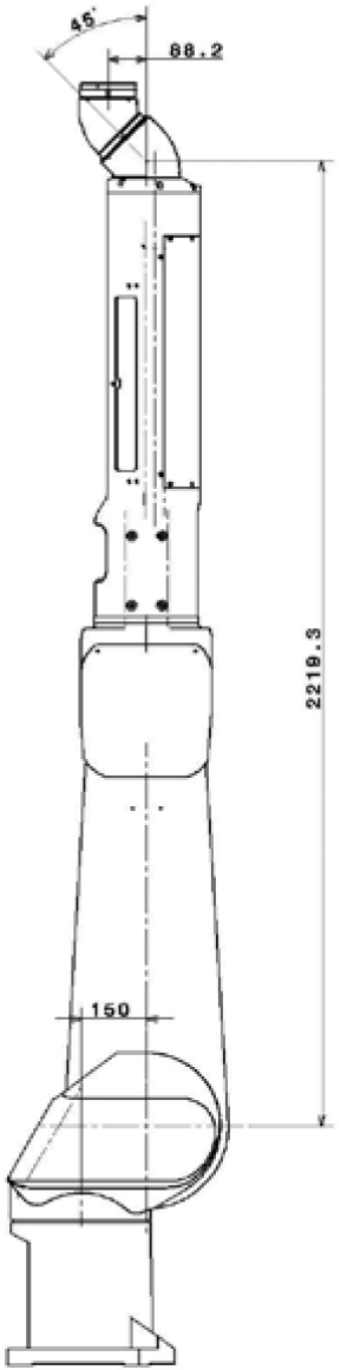

45°
68.2
2219.3
150

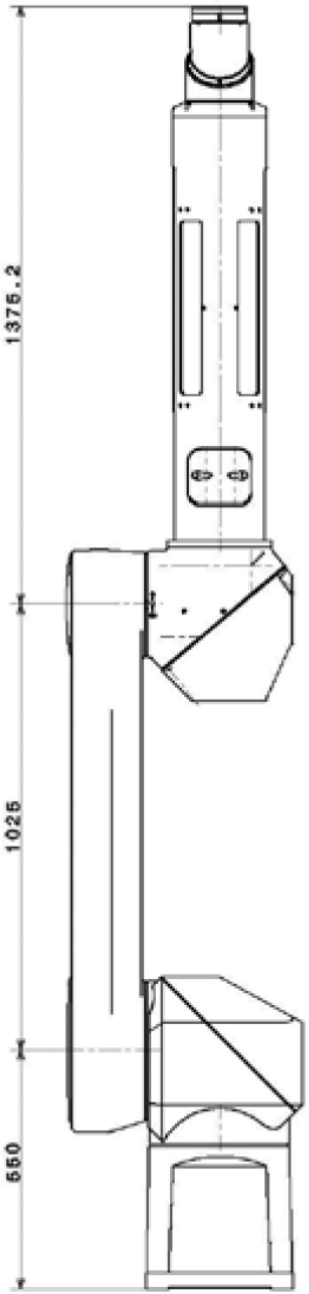

1375.2
1025
550

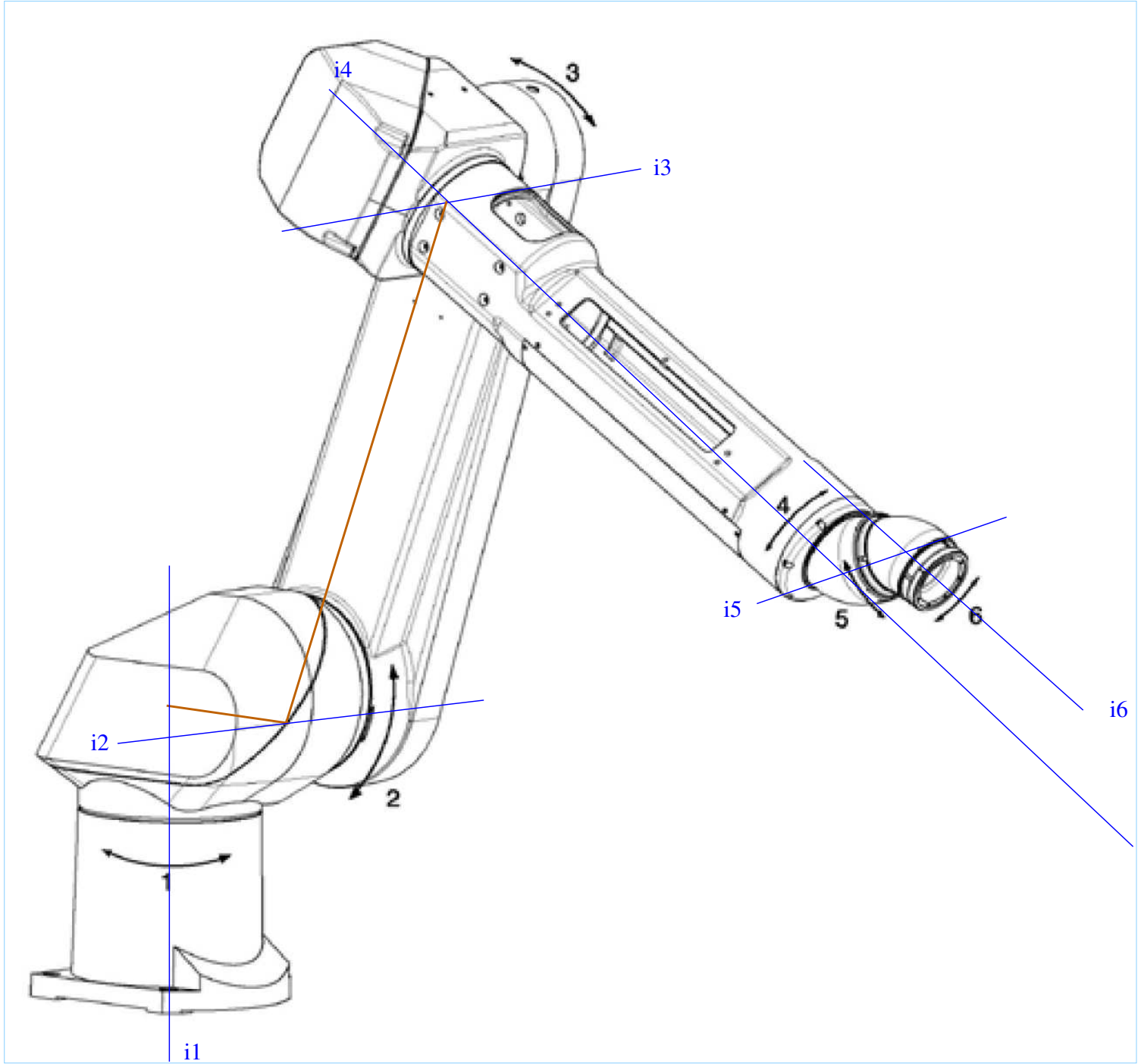

3
4
5
6
2
1

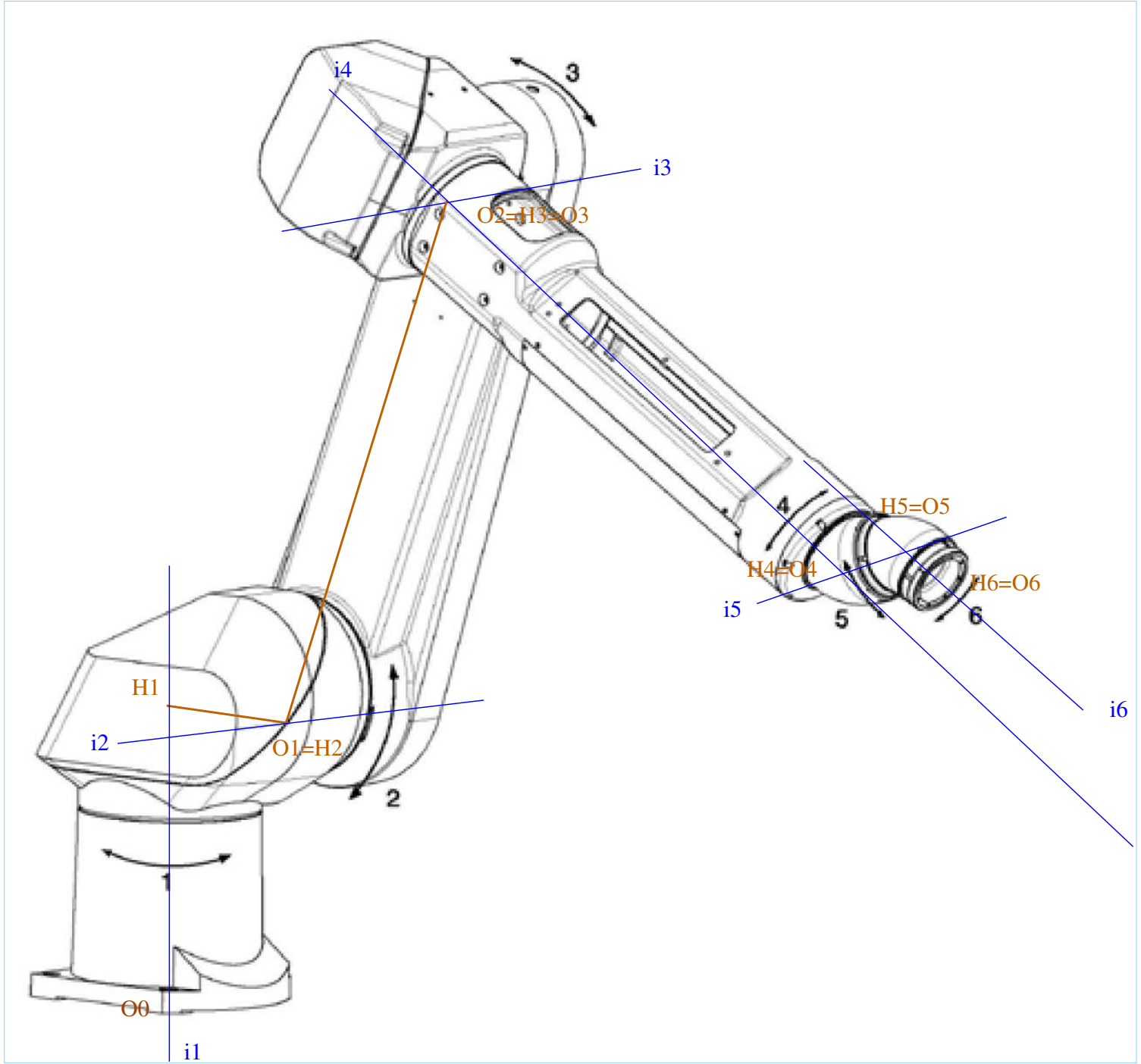

i4
3
i3
4
i5
5
6
i6
i2
2
1
i1

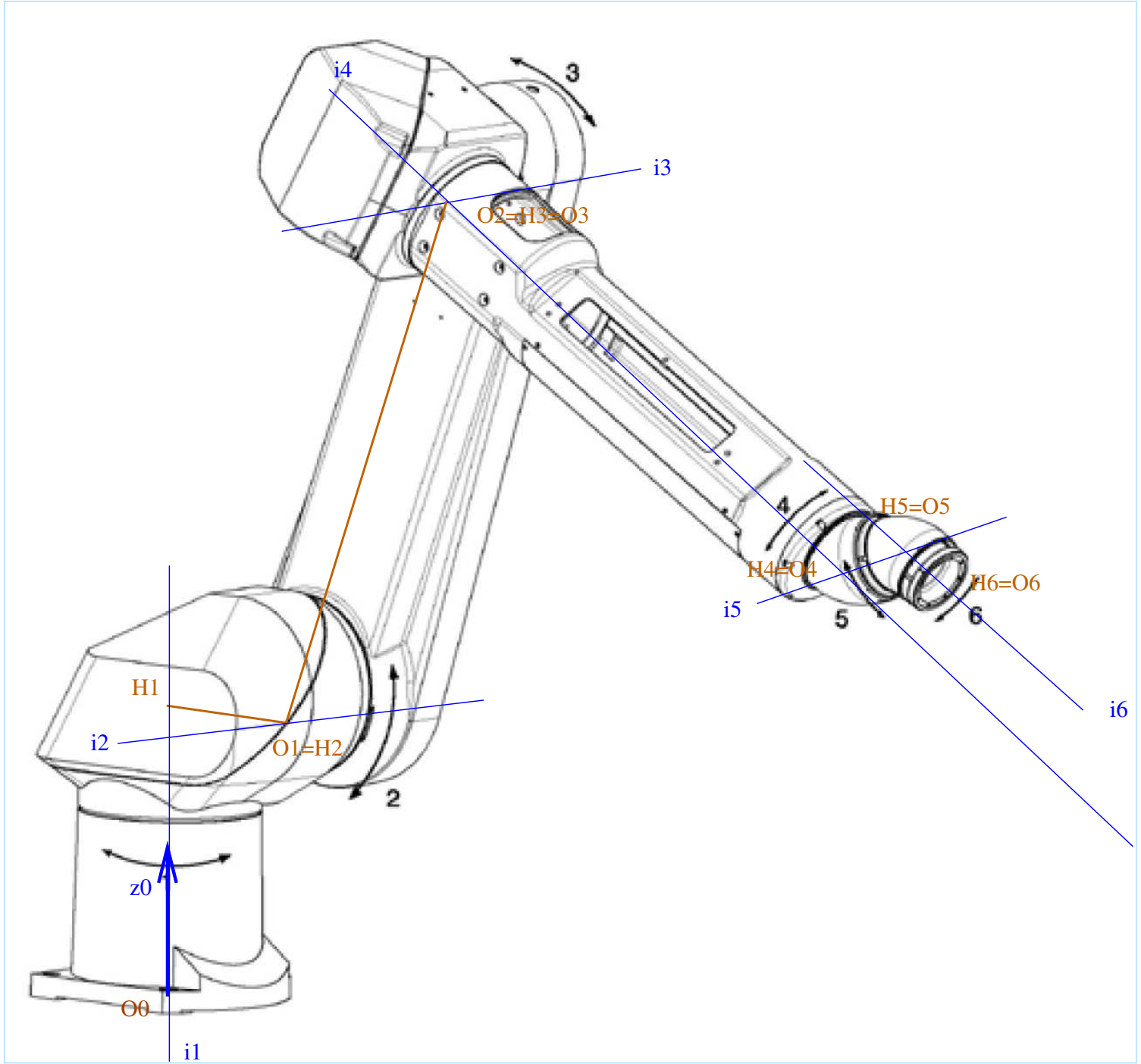

i4
3
i3
4
i5
5
6
i6
i2
2
1
i1

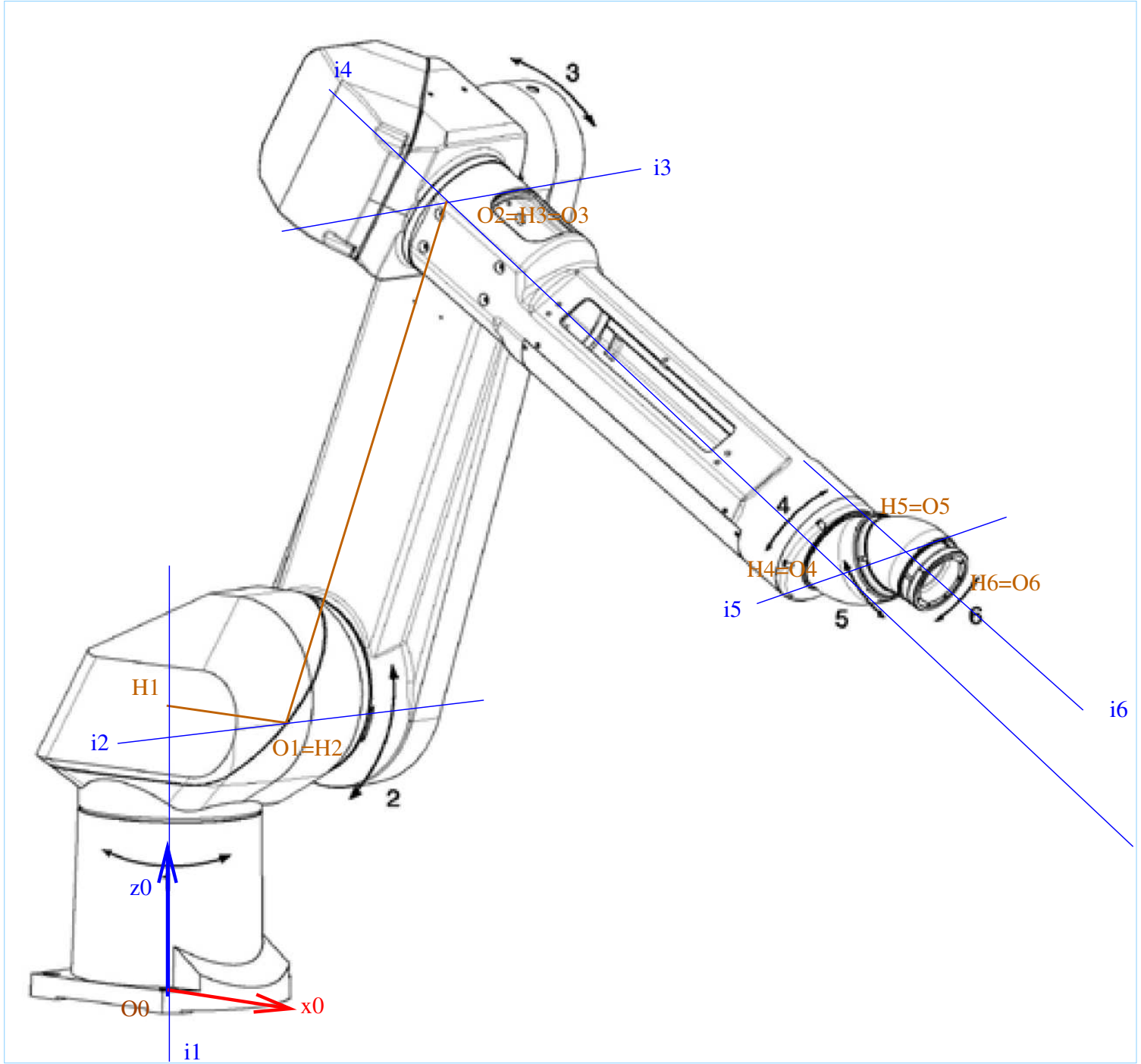

45°
68.2
2219.3
150

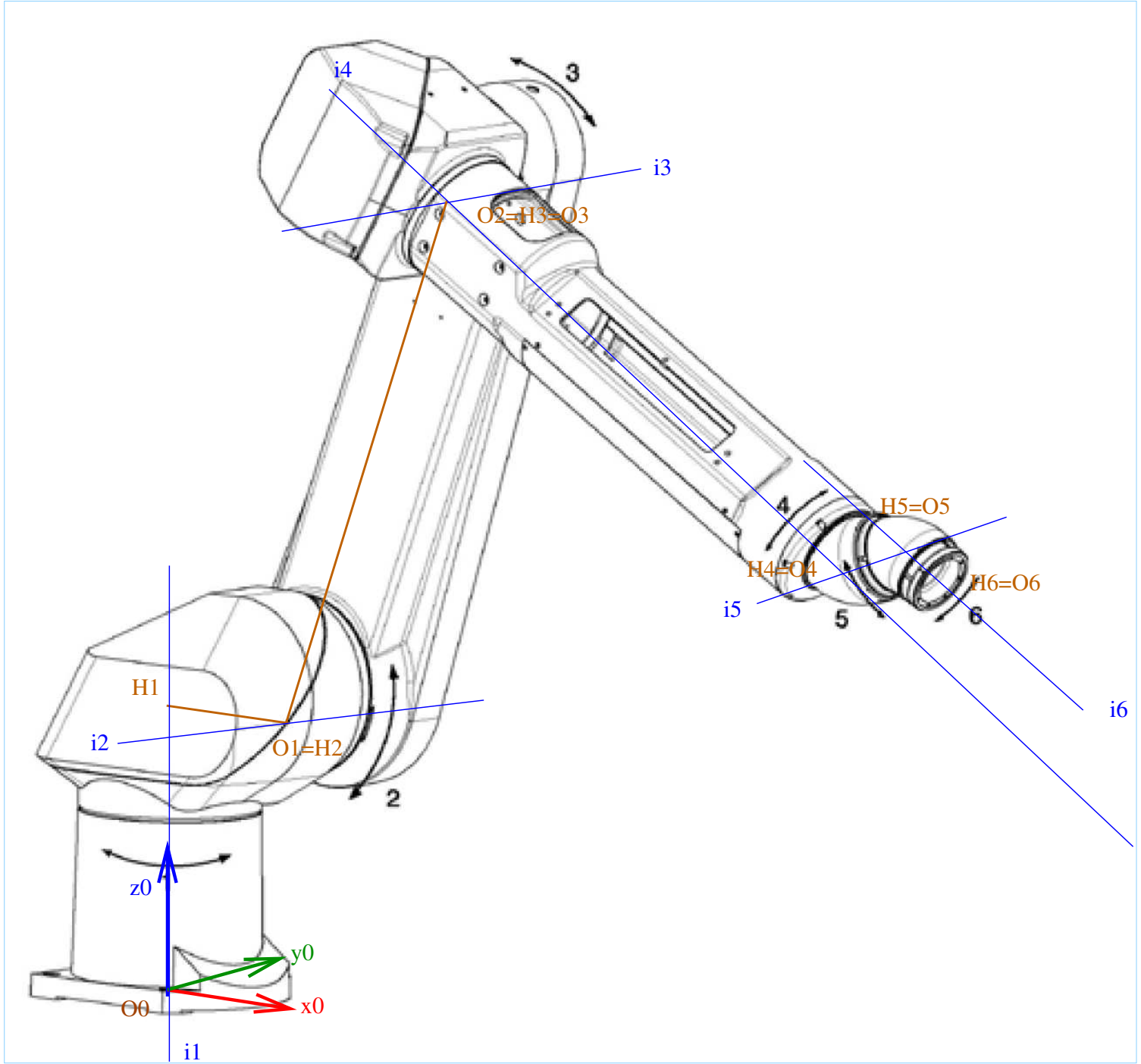

1375.2
1025
550

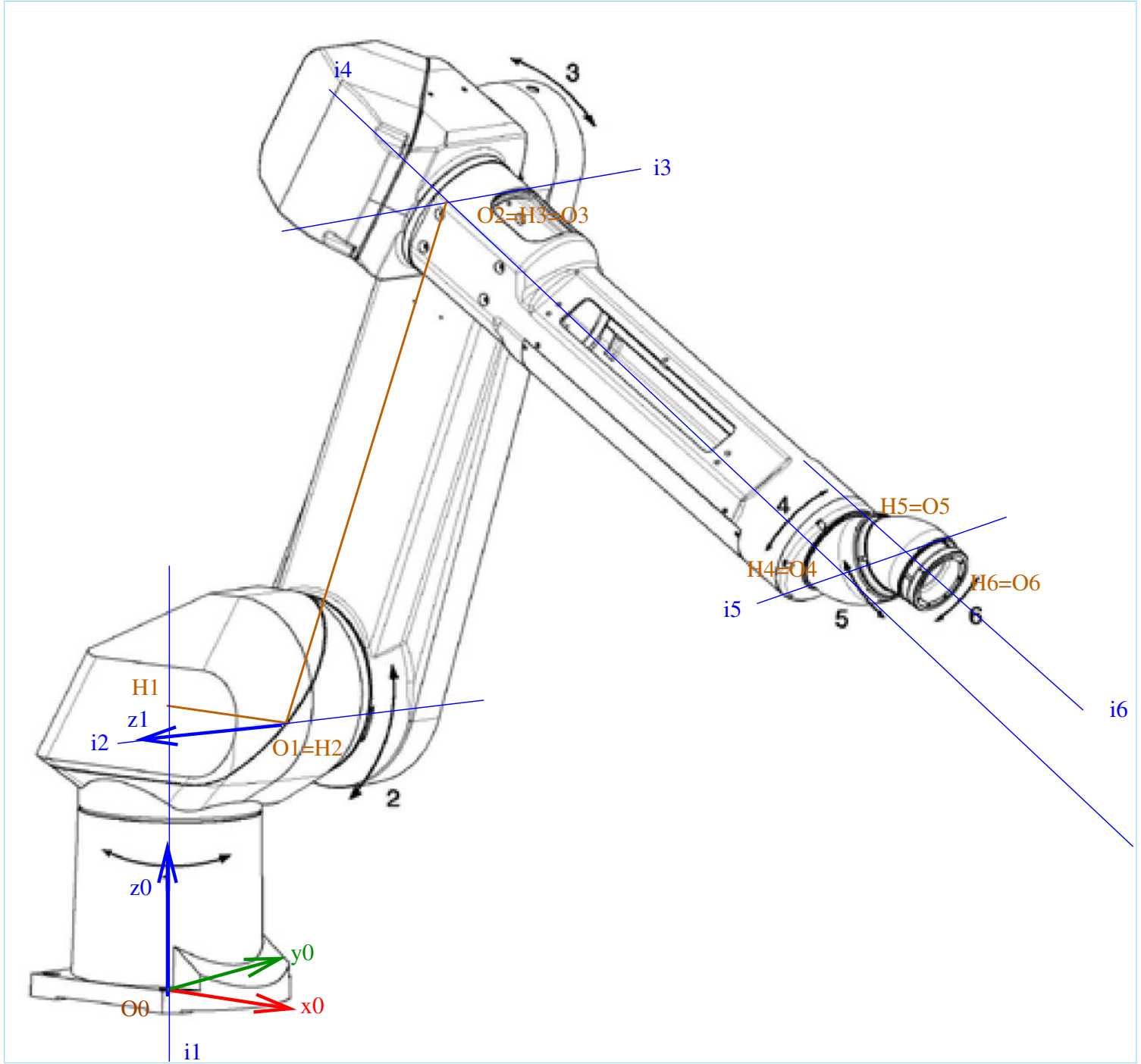

i4
3
i3
4
i5
5
6
i6
i2
2
1
i1

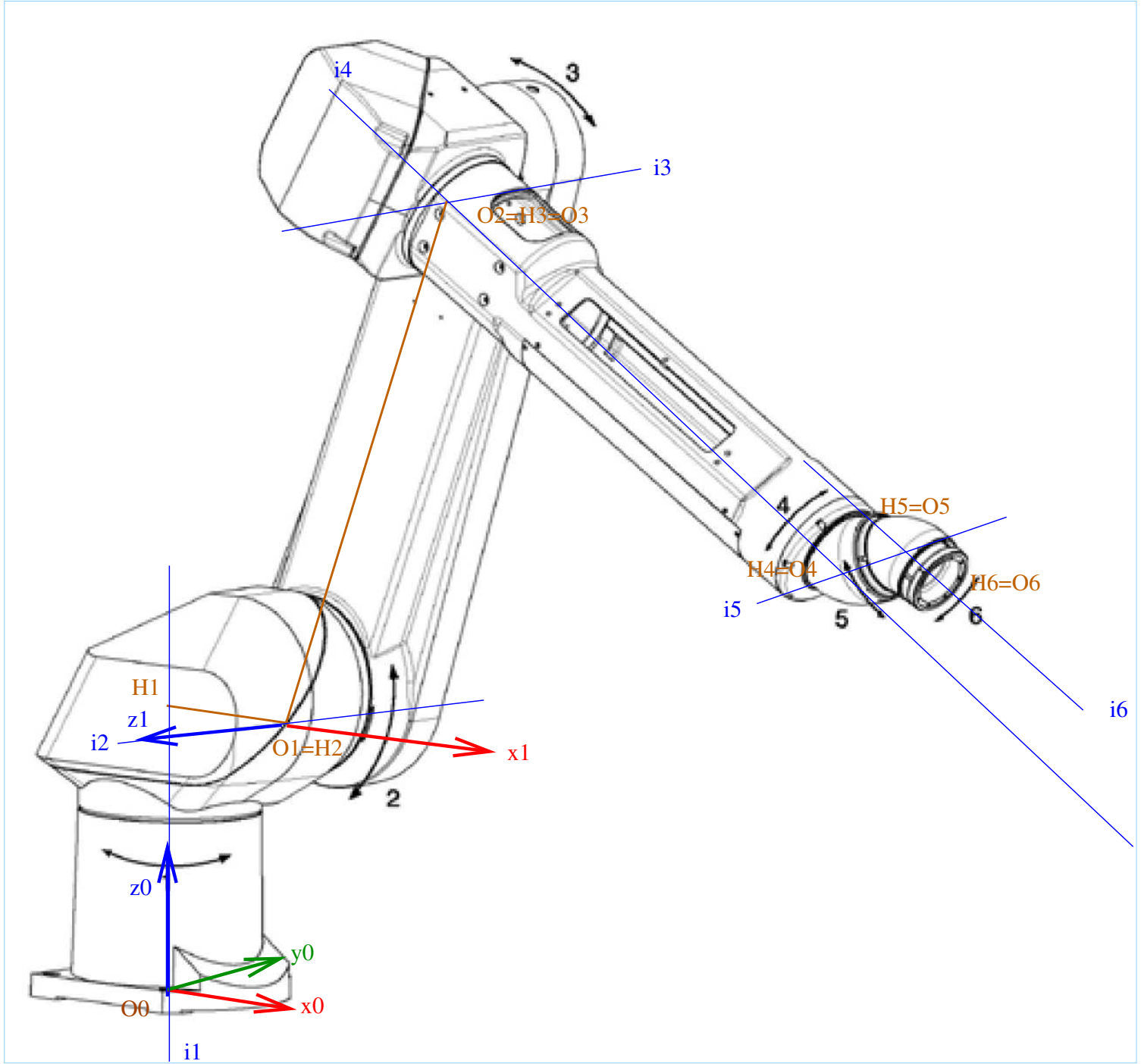

i4
3
i3
O2=H3=O3
H5=O5
4
H4=O4
H6=O6
i5
5
6
i6
H1
i2
O1=H2
2
1
O0
i1

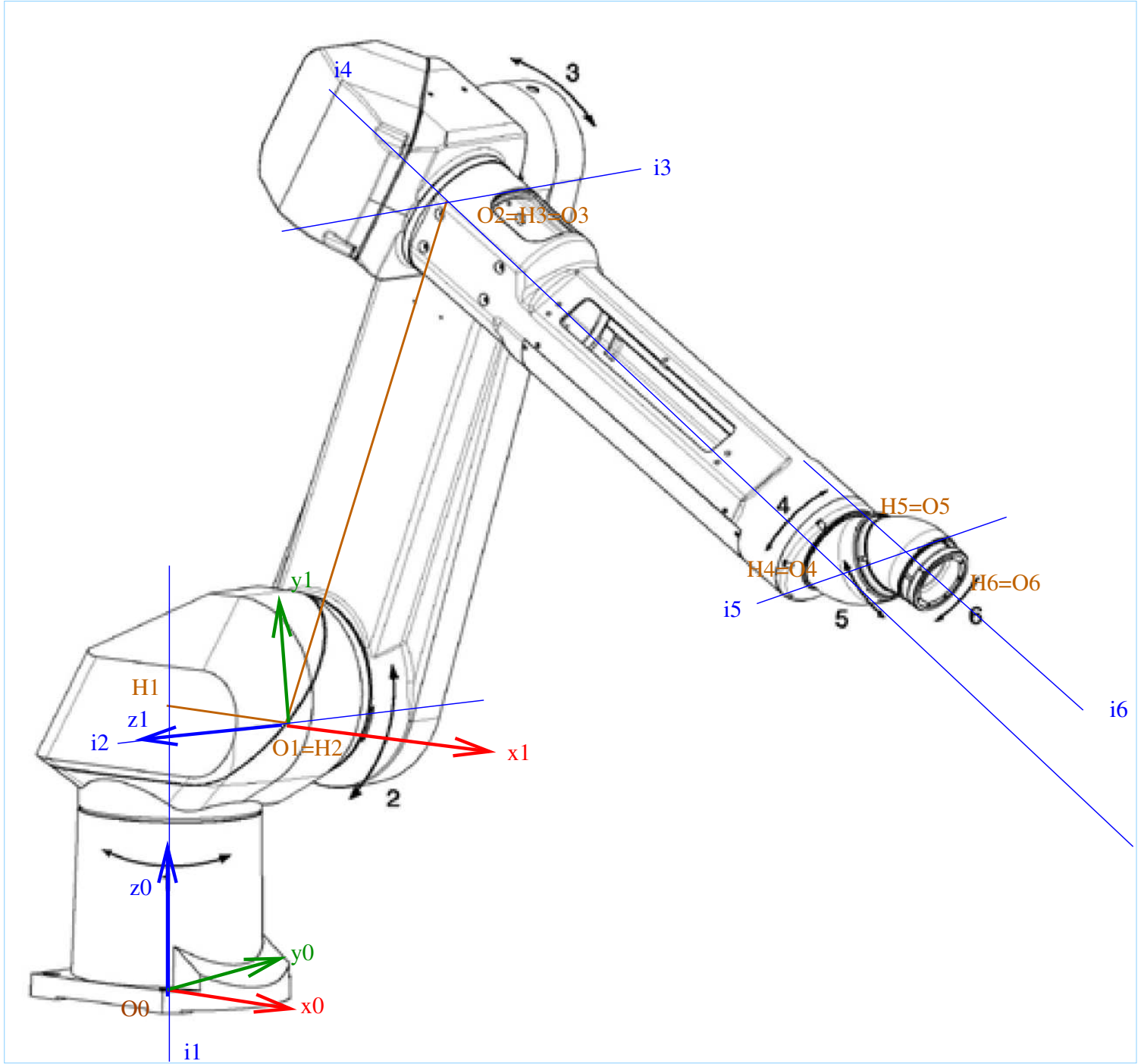

i4
3
i3
O2=H3=O3
H5=O5
4
H4=O4
H6=O6
i5
5
6
i6
H1
i2
O1=H2
2
z0
O0
i1

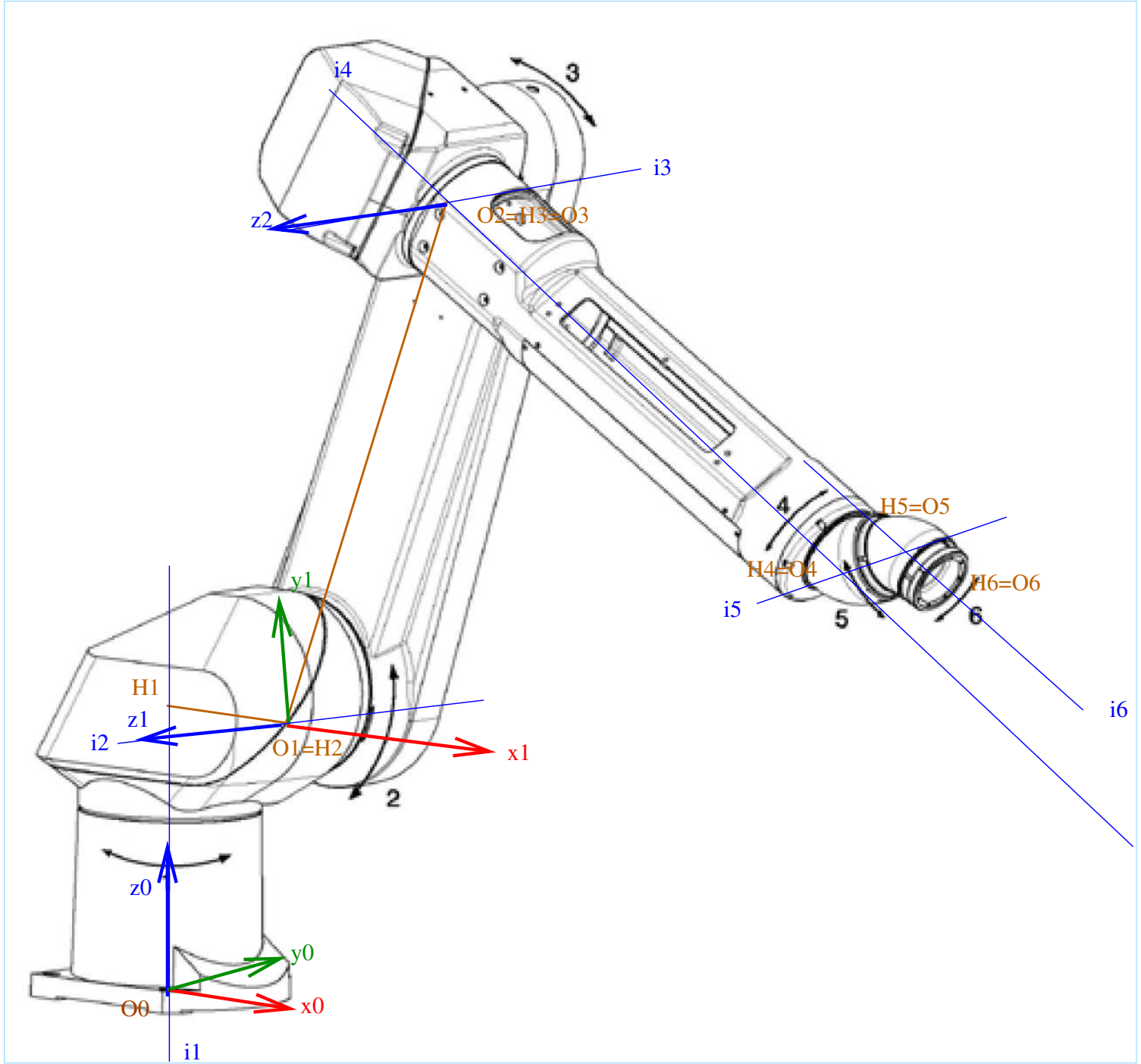

i4
3
i3
O2=H3=O3
H5=O5
4
H4=O4
H6=O6
i5
5
6
i6
H1
i2
O1=H2
2
z0
O0
x0
i1

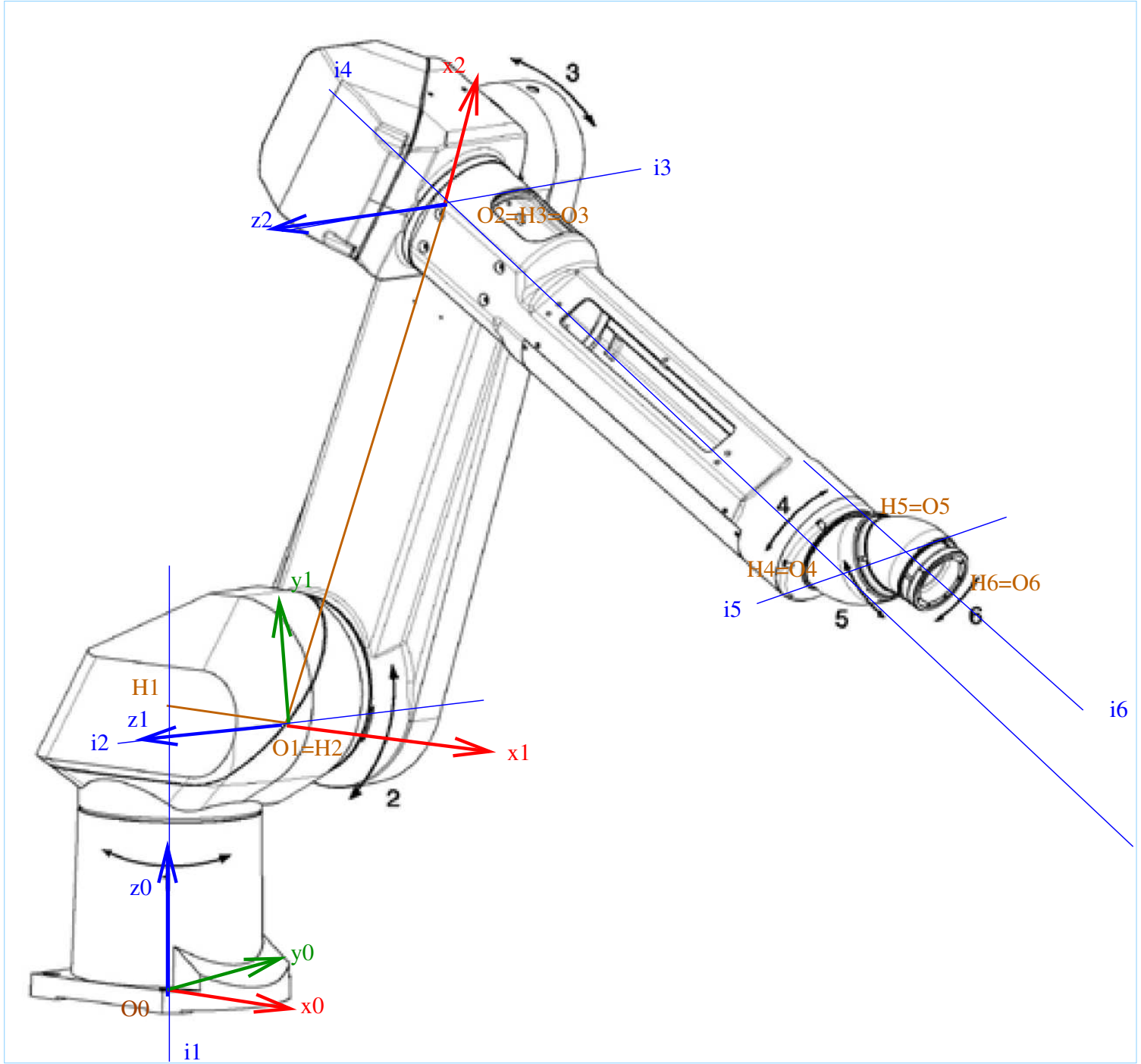

i4
3
i3
O2=H3=O3
H5=O5
4
H4=O4
H6=O6
i5
5
6
i6
H1
i2
O1=H2
2
z0
y0
O0
x0
i1

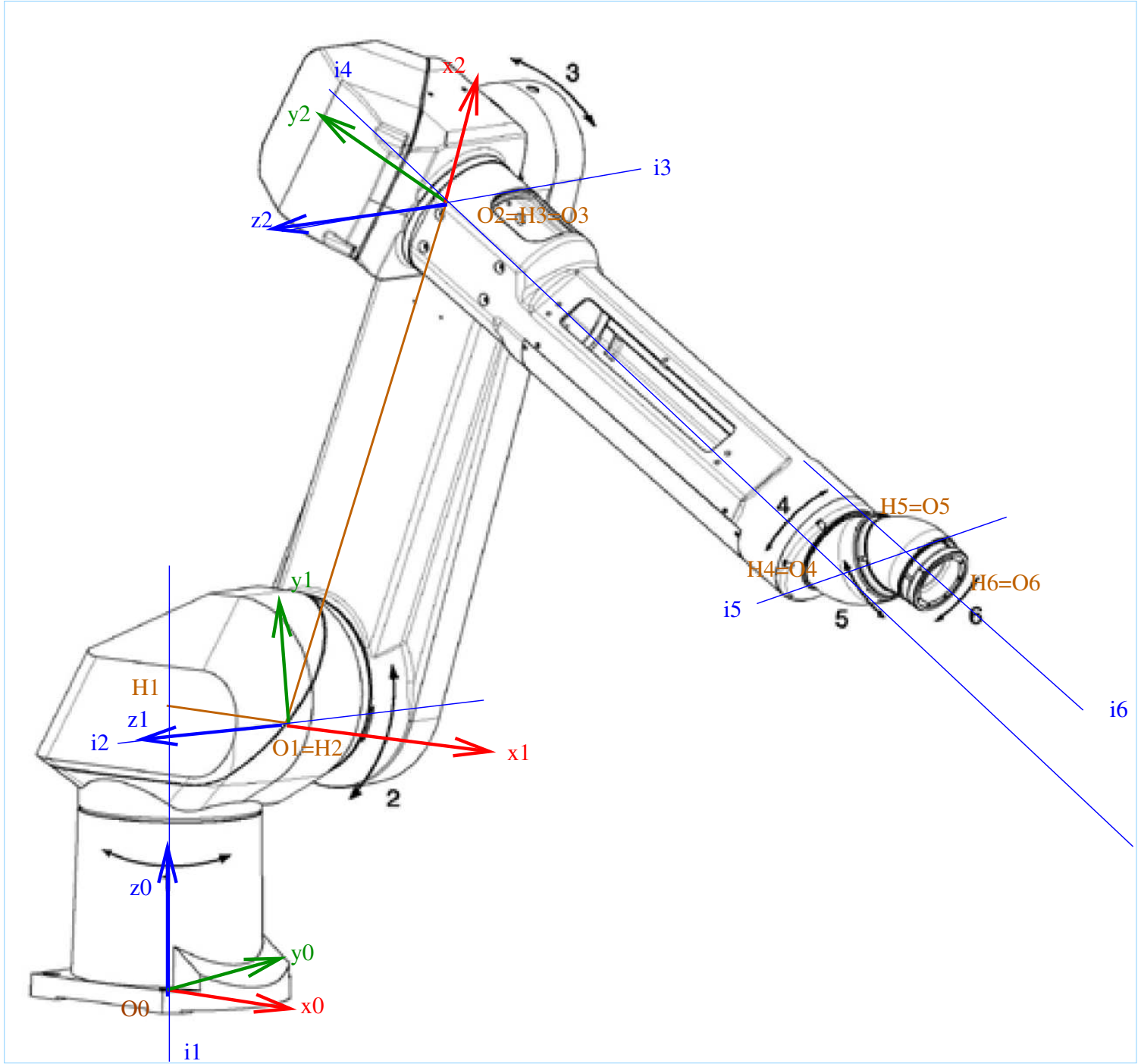

i4
3
i3
O2=H3=O3
H5=O5
4
H4=O4
H6=O6
i5
5
6
i6
H1
z1
i2
O1=H2
2
z0
y0
O0
x0
i1

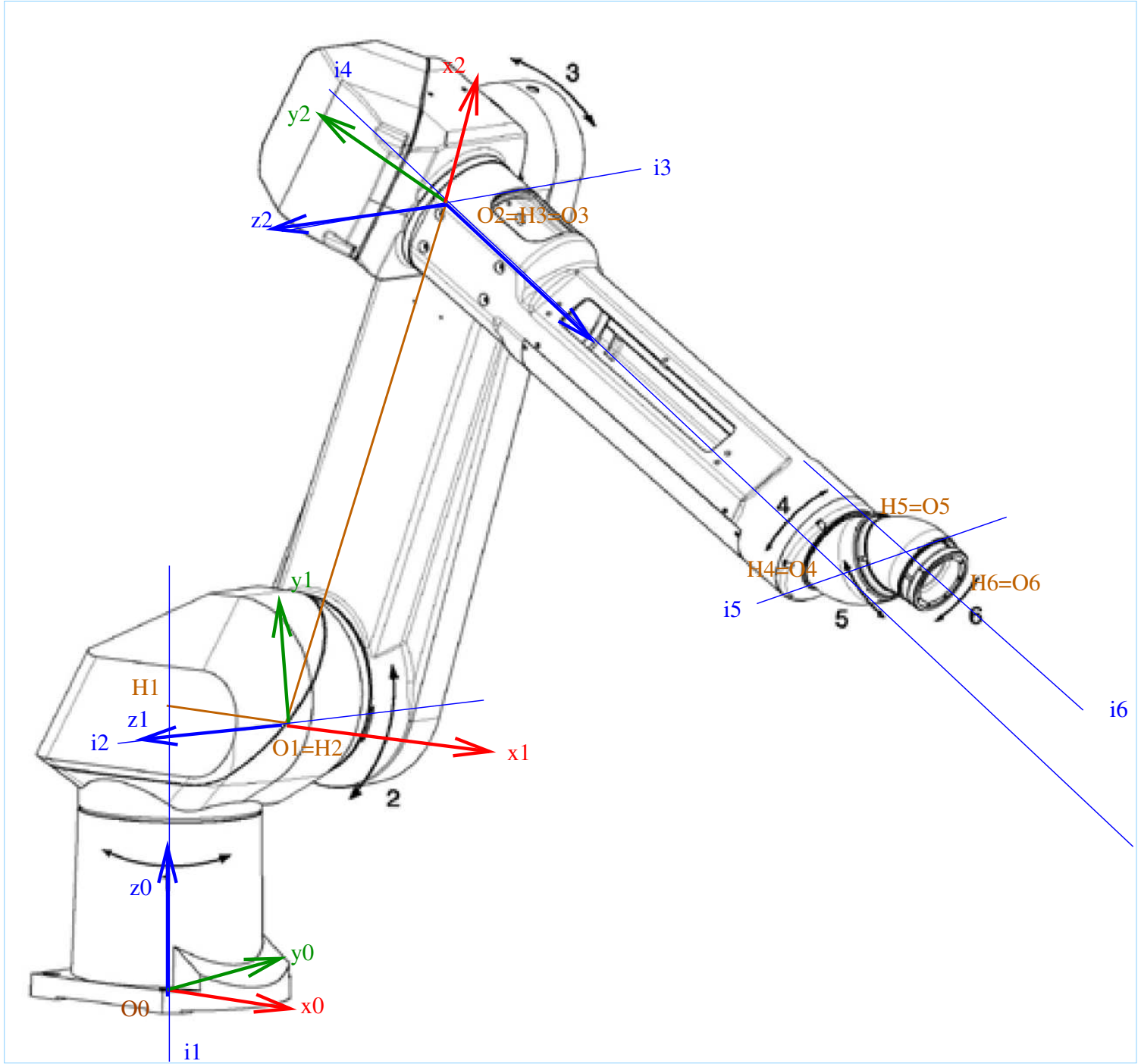

i4
3
i3
O2=H3=O3
H5=O5
4
H4=O4
H6=O6
i5
5
6
i6
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

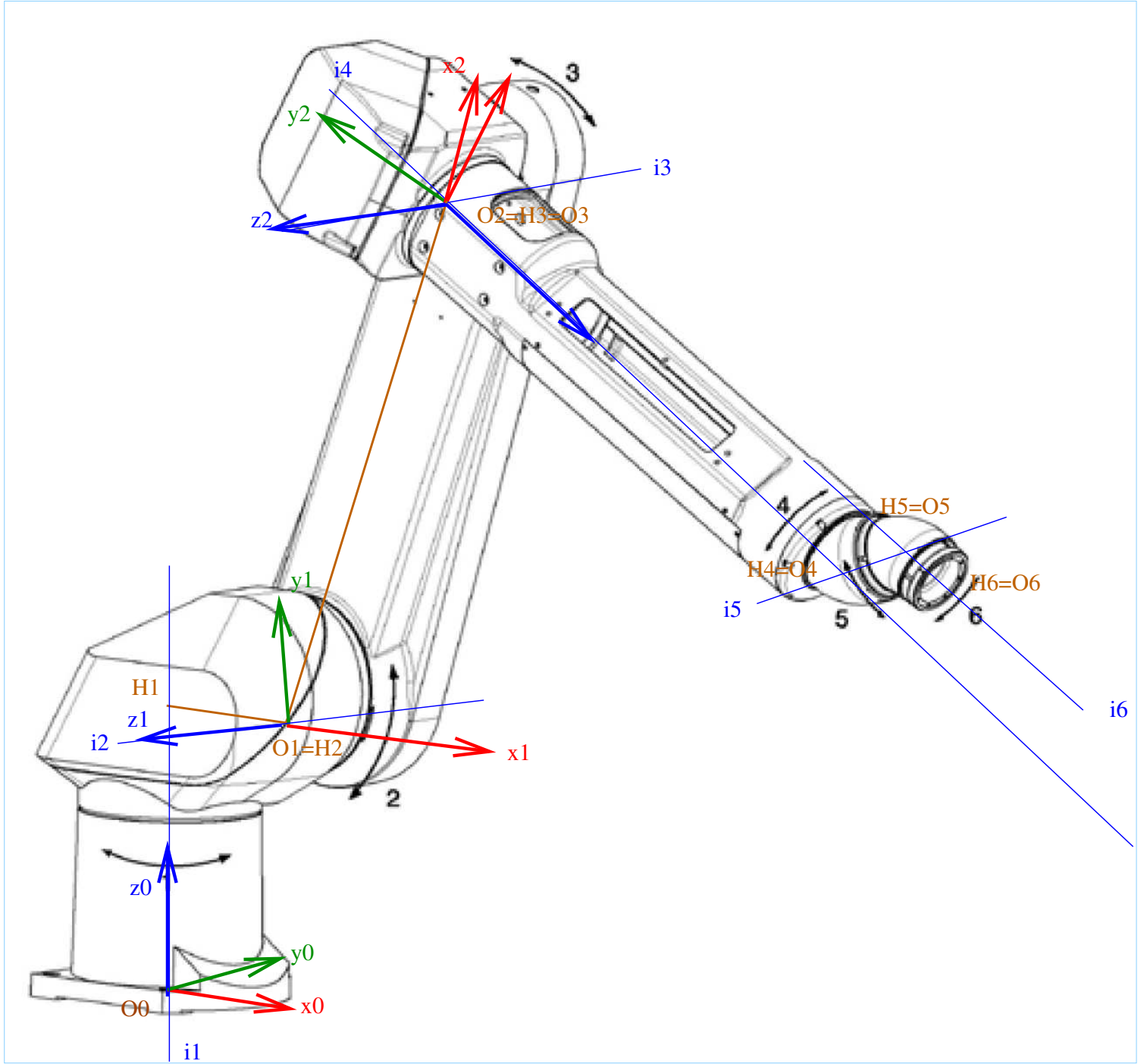

i4
3
i3
O2=H3=O3
H5=O5
4
H4=O4
H6=O6
i5
5
6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

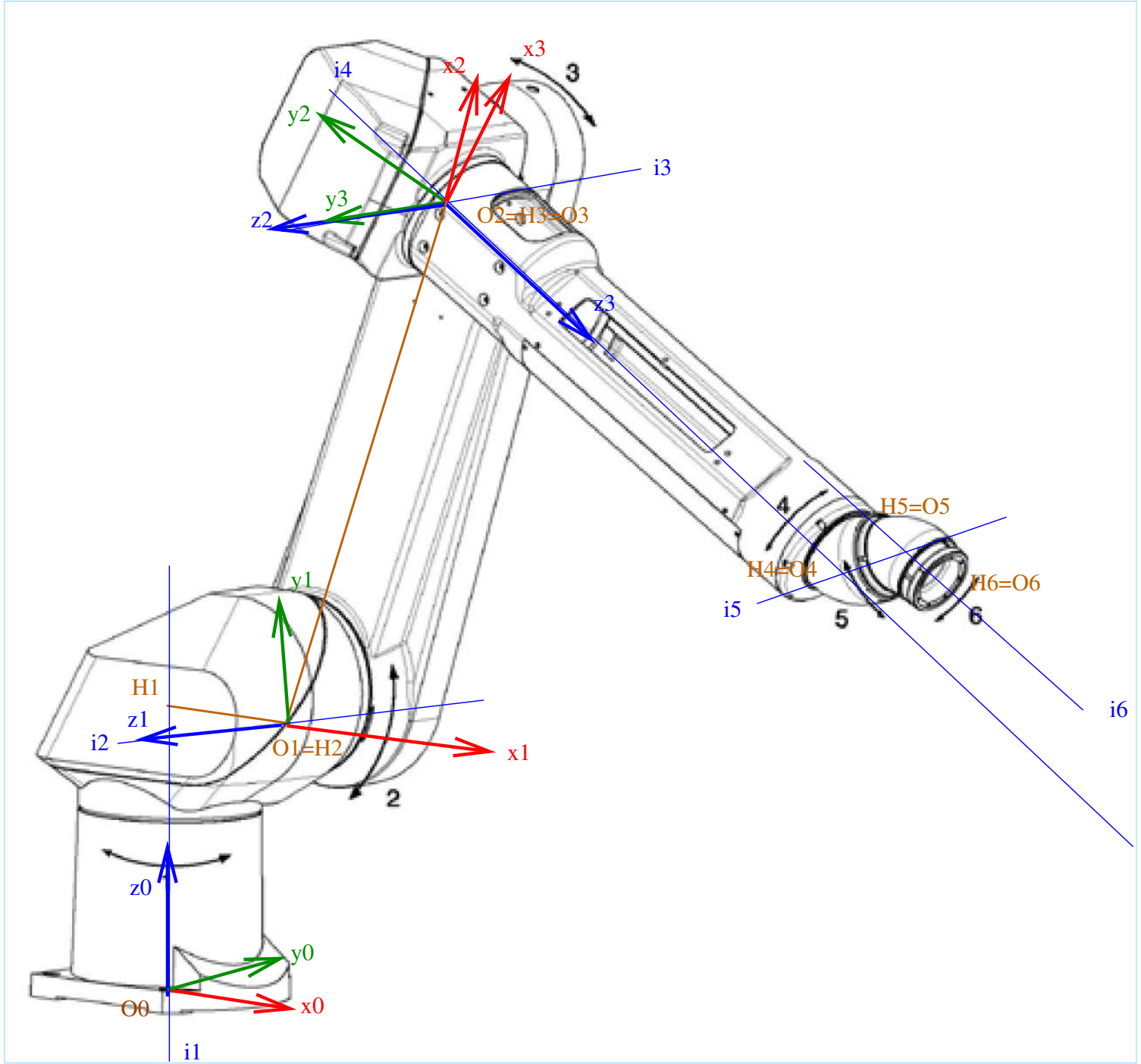

i4
3
i3
z2
O2=H3=O3
H5=O5
4
H4=O4
H6=O6
i5
5
6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

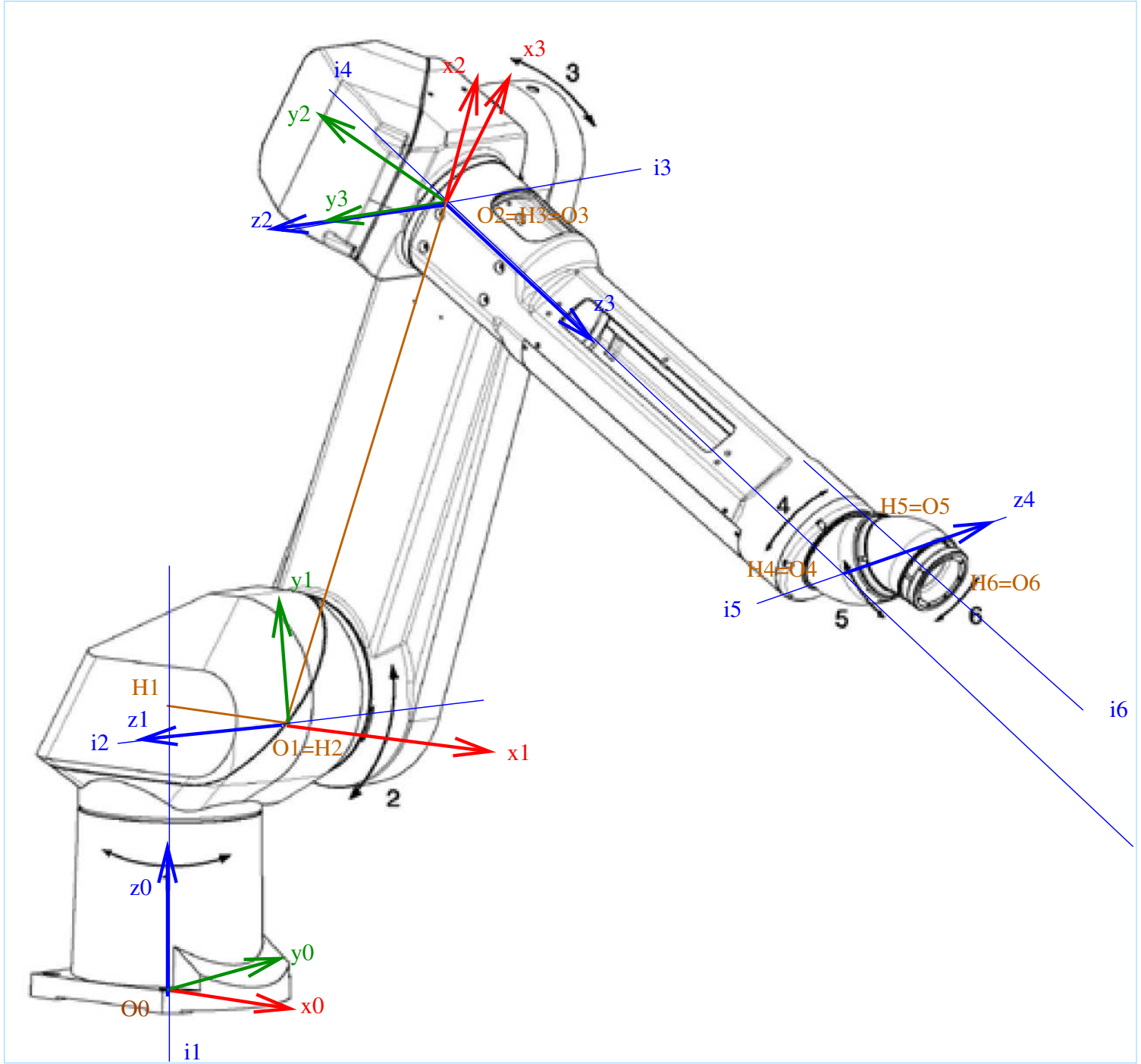

i4
x2
3
i3
z2
O2=H3=O3
H5=O5
4
H4=O4
H6=O6
i5
5
6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

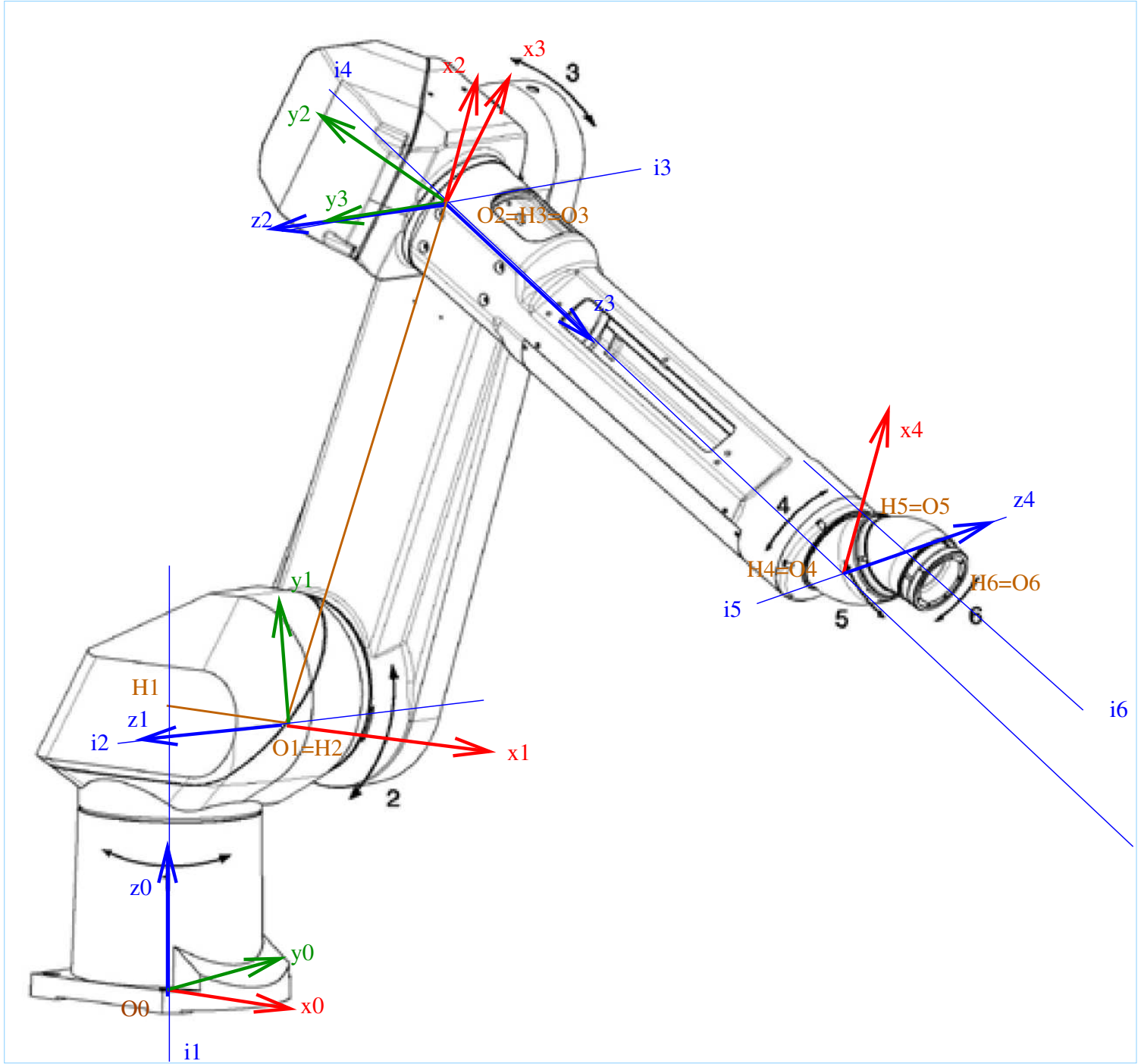

i4
x2
3
y2
i3
z2
O2=H3=O3
H5=O5
4
H4=O4
H6=O6
i5
5
6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

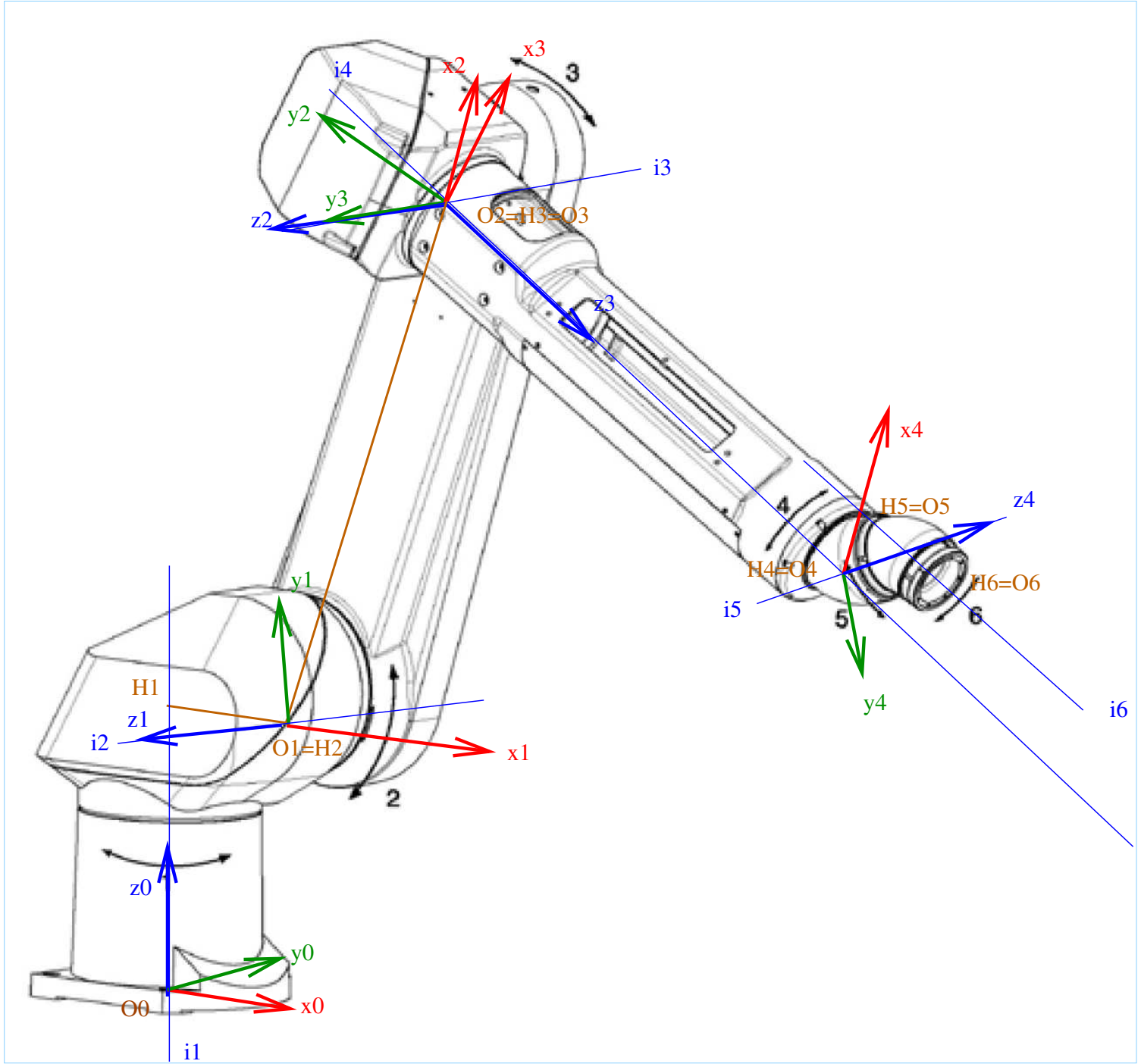

i4
x2
3
y2
i3
z2
O2=H3=O3
H5=O5
4
H4=O4
H6=O6
i5
5
6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

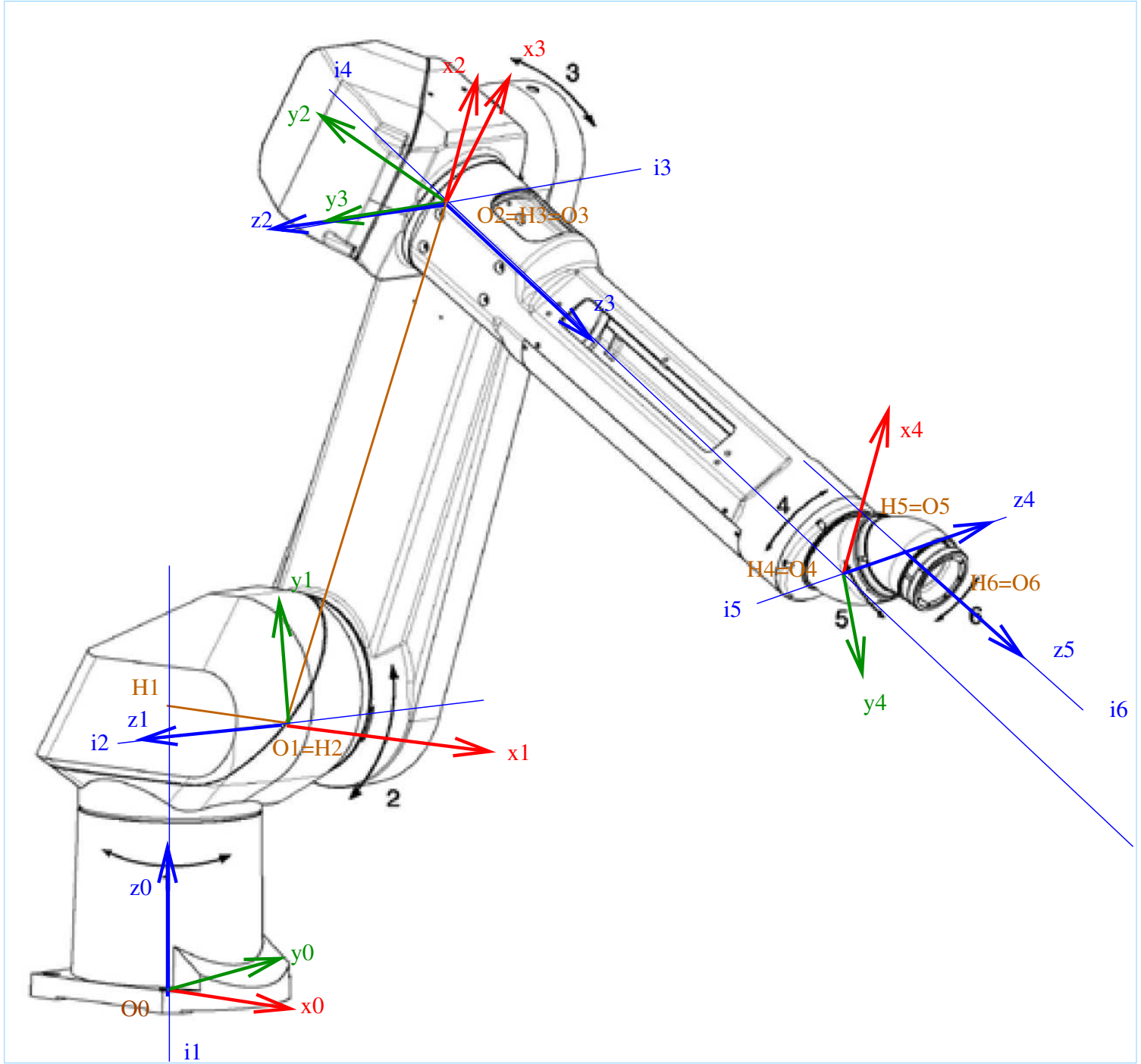

i4
x2
3
y2
i3
z2
O2=H3=O3
H5=O5
4
H4=O4
H6=O6
i5
5
6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

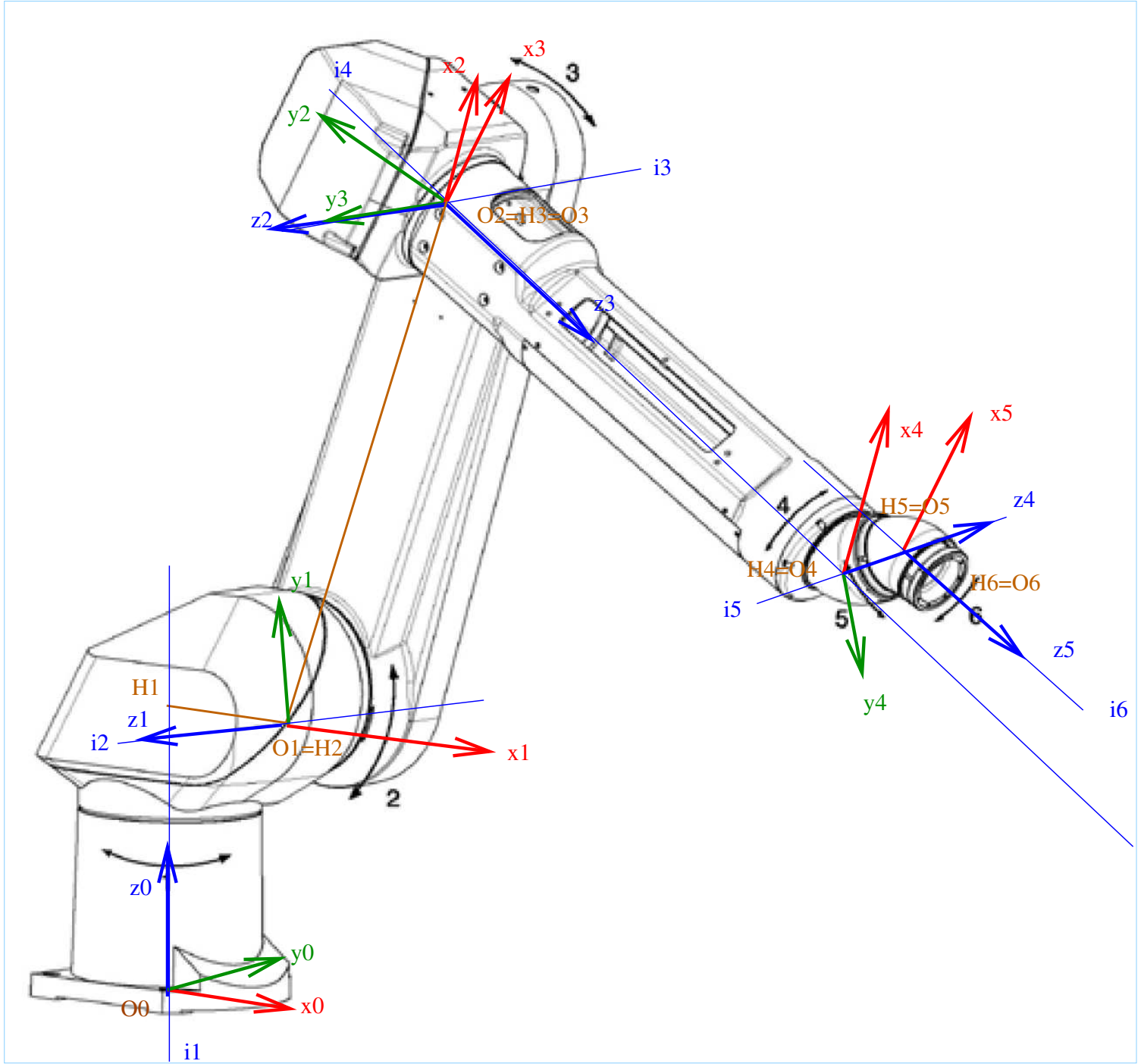

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
4
H5=O5
H4=O4
H6=O6
i5
5
6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

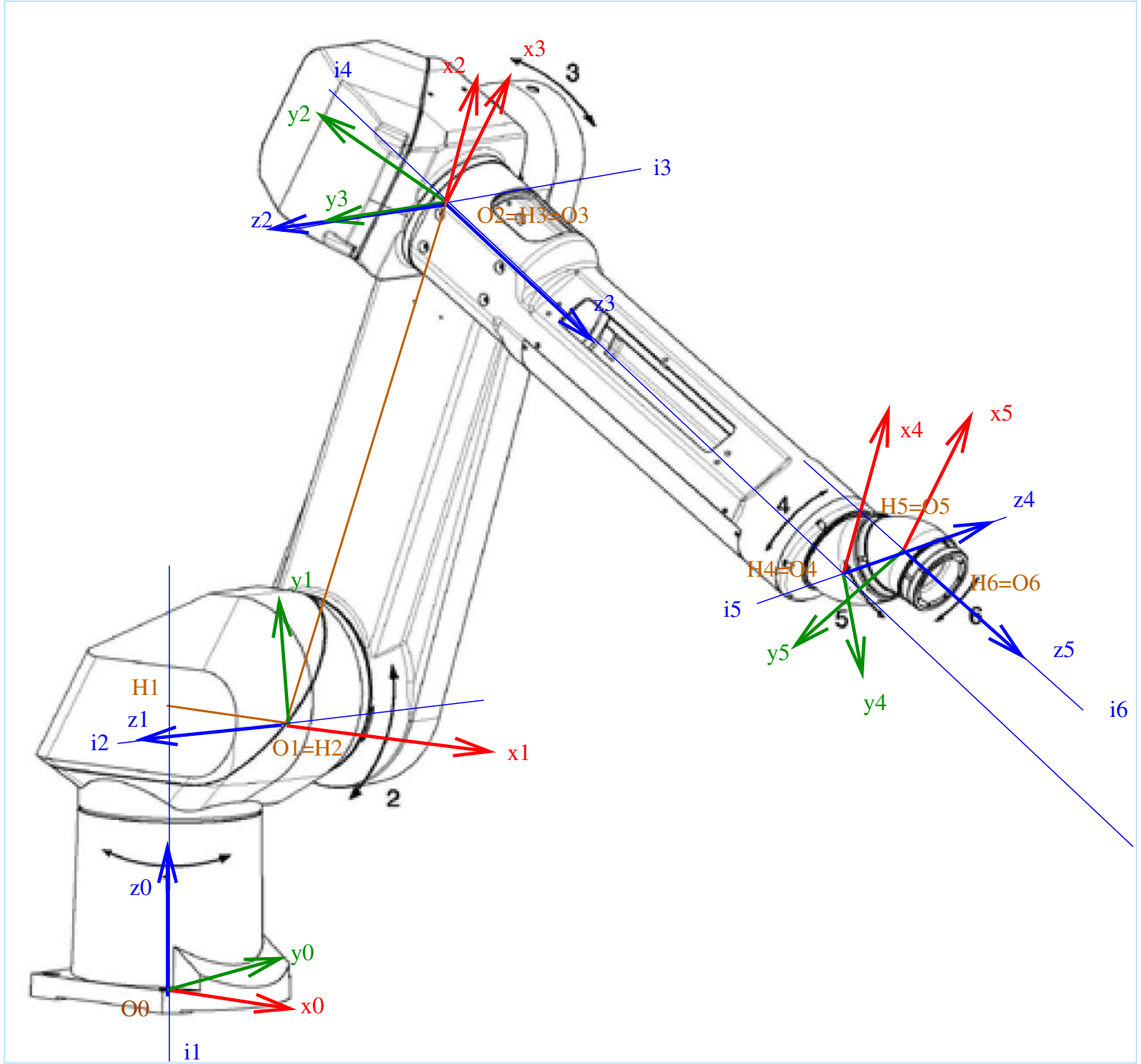

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
4
H5=O5
z4
H4=O4
H6=O6
i5
5
6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

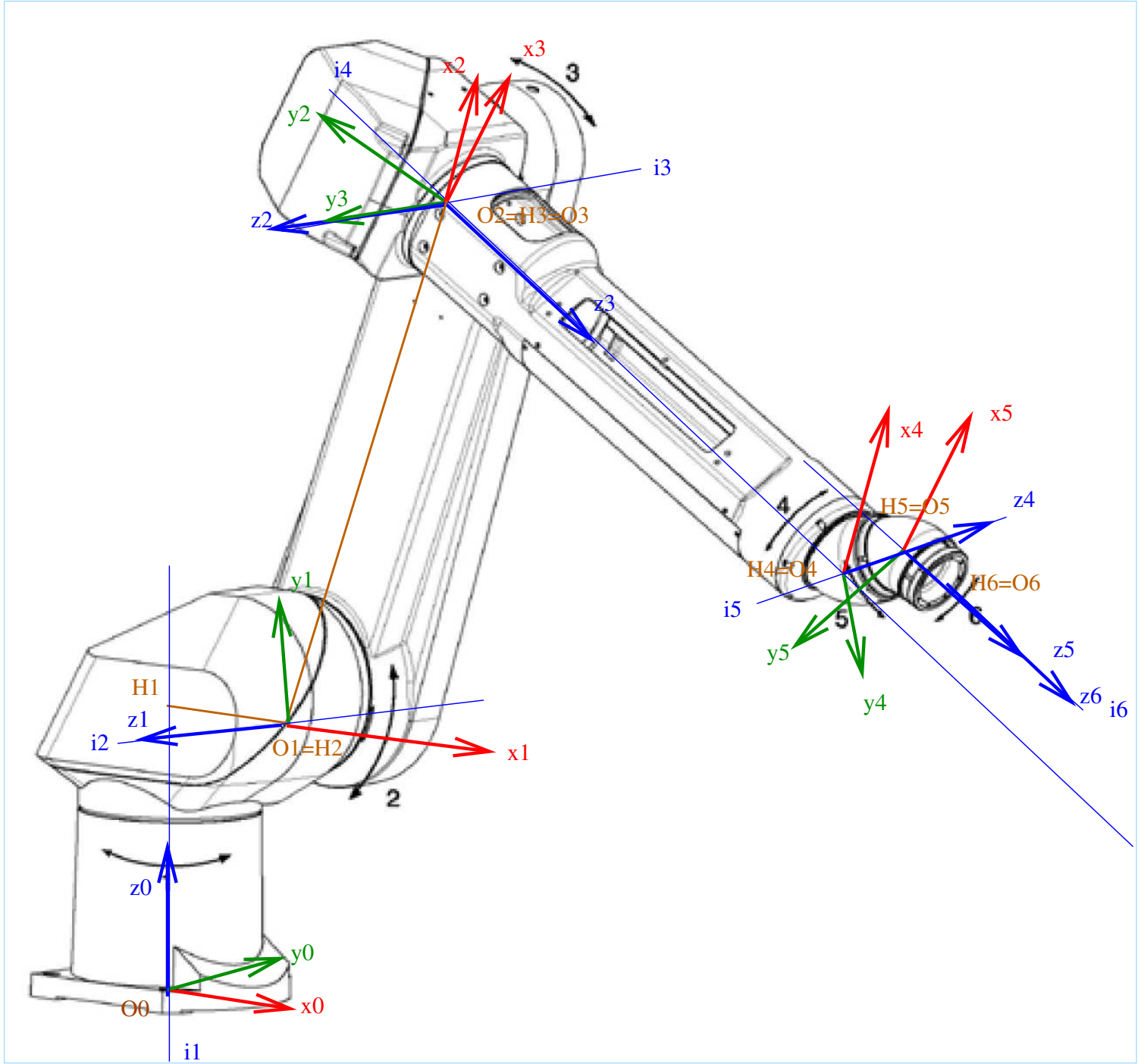

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
H5=O5
z4
4
H4=O4
H6=O6
i5
5
6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

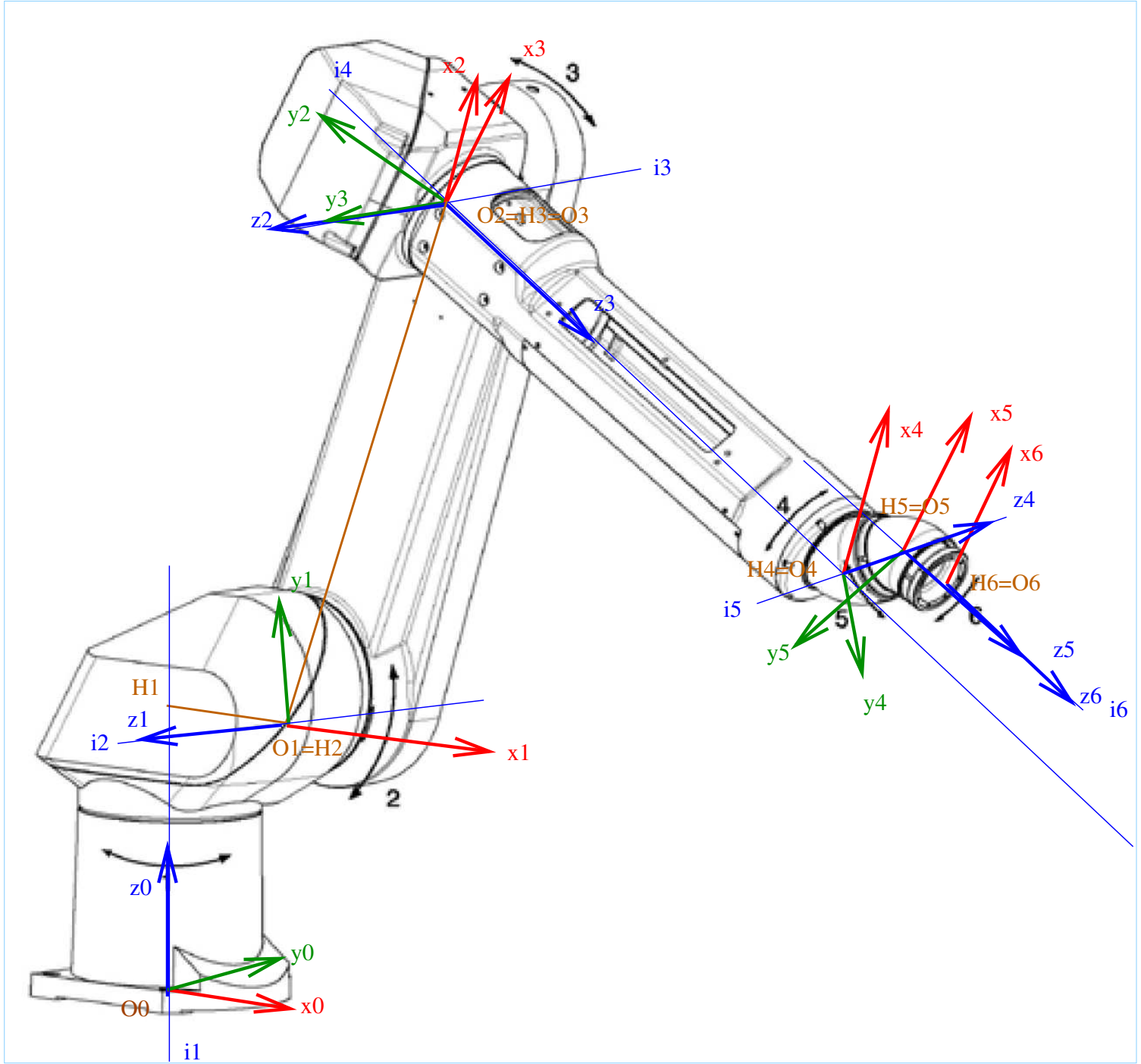

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
H5=O5
z4
4
H4=O4
H6=O6
i5
5
6
y4
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

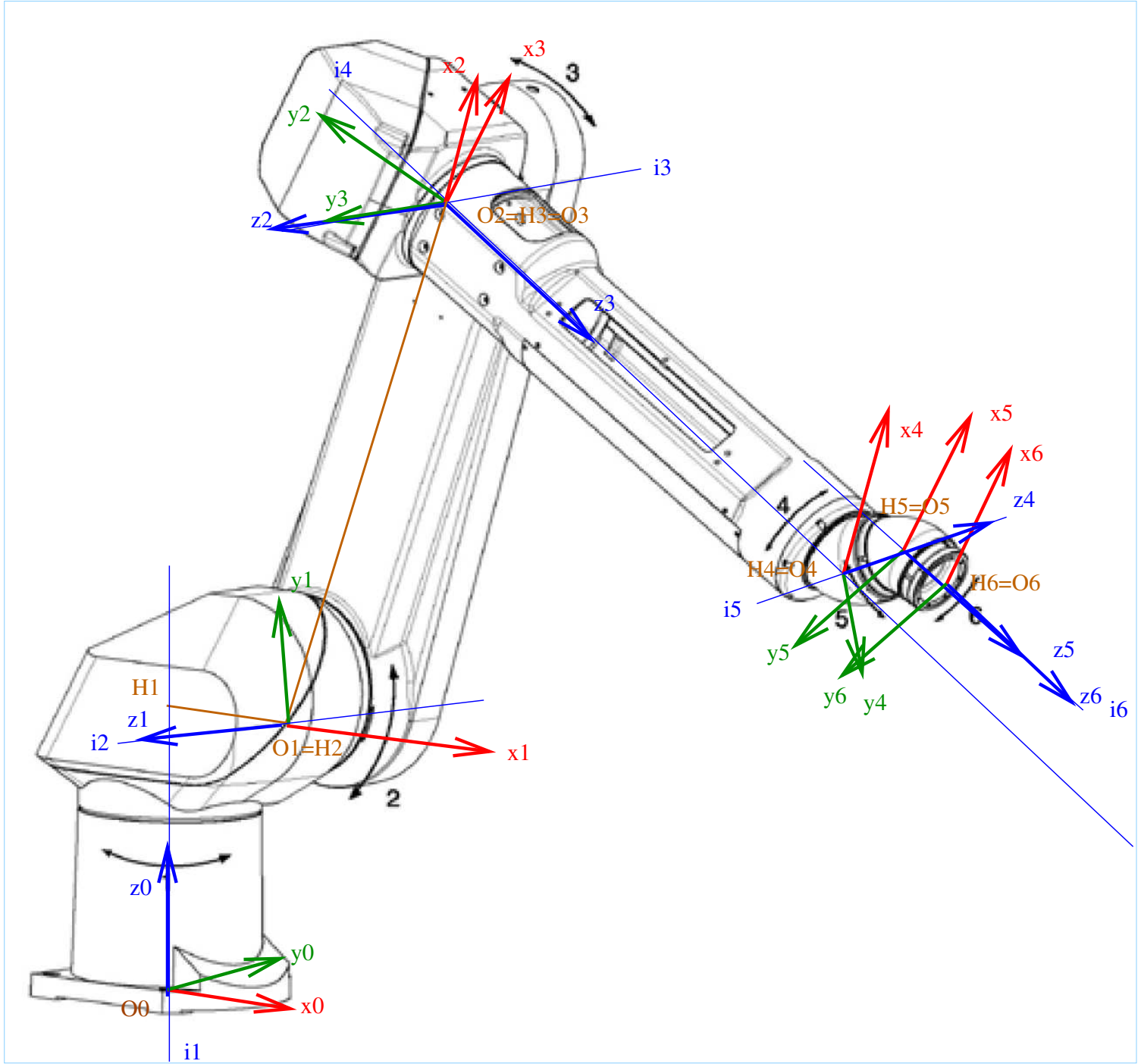

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
H5=O5
z4
4
H4=O4
H6=O6
i5
5
6
z5
y4
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

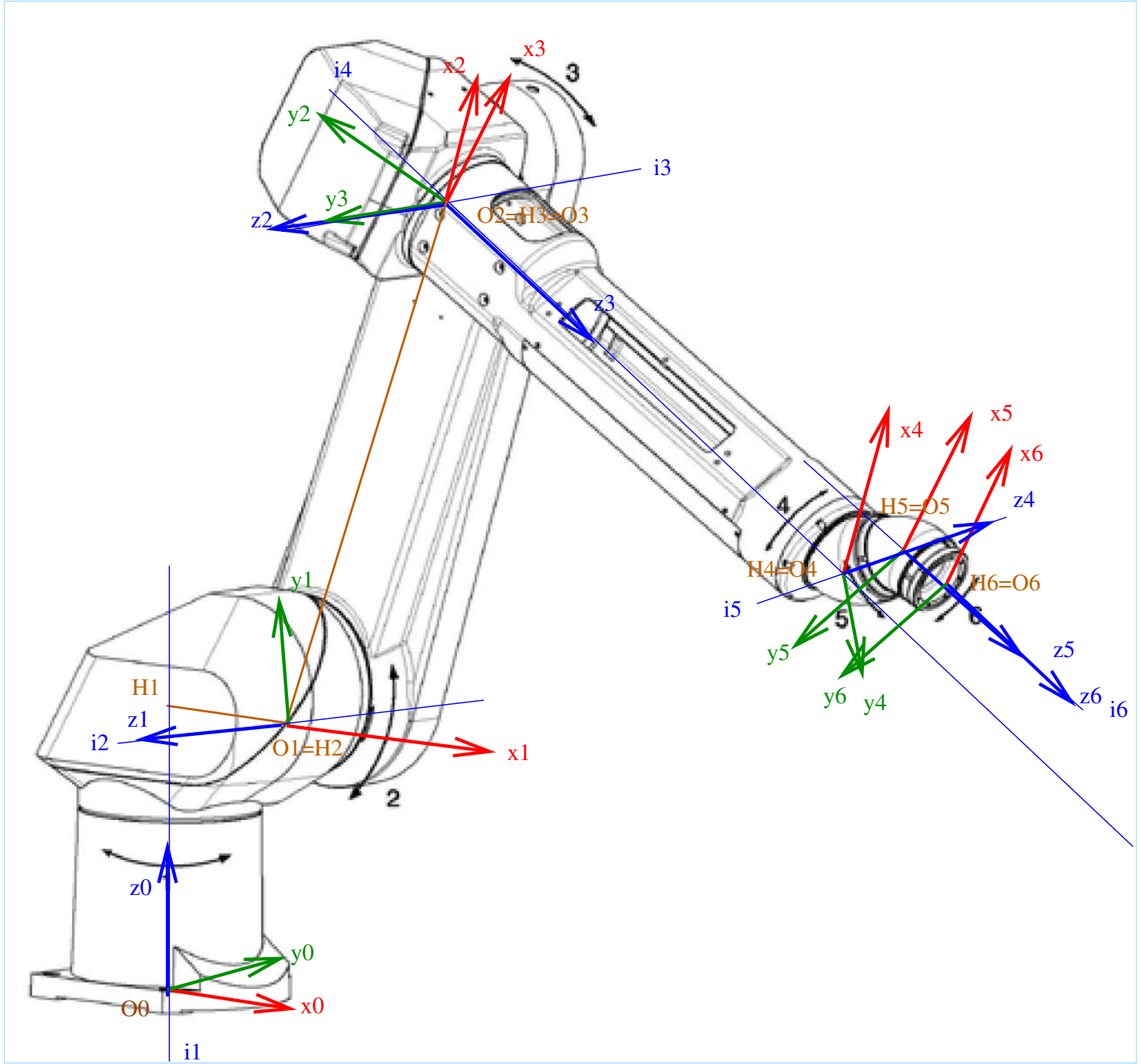

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
4
H5=O5
z4
H4=O4
H6=O6
i5
5
6
z5
y4
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

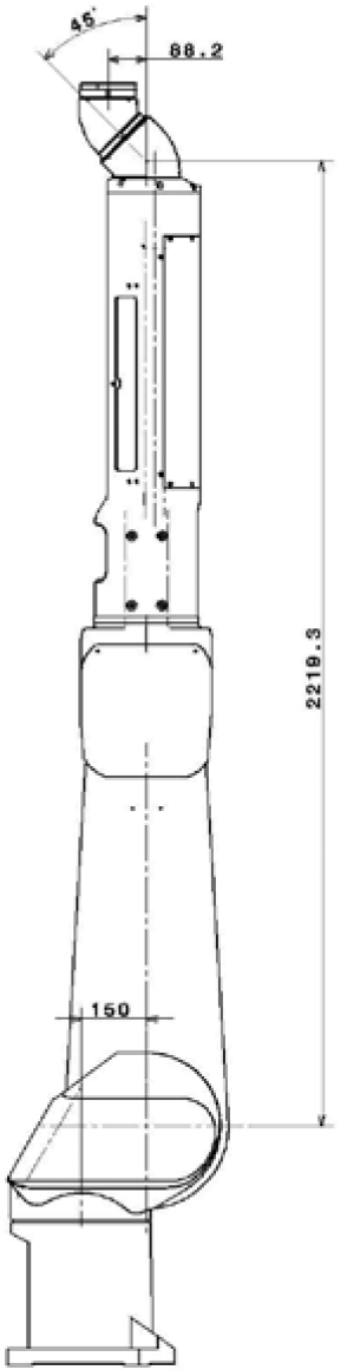

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
H5=O5
z4
4
H4=O4
H6=O6
i5
5
6
y5
z5
y4
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

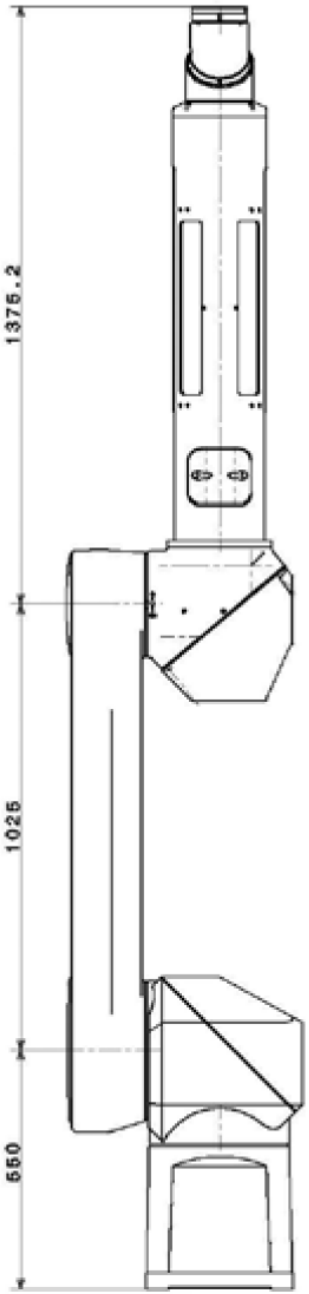

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
4
H5=O5
z4
H4=O4
H6=O6
i5
5
6
y5
z5
z6
i6
y4
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

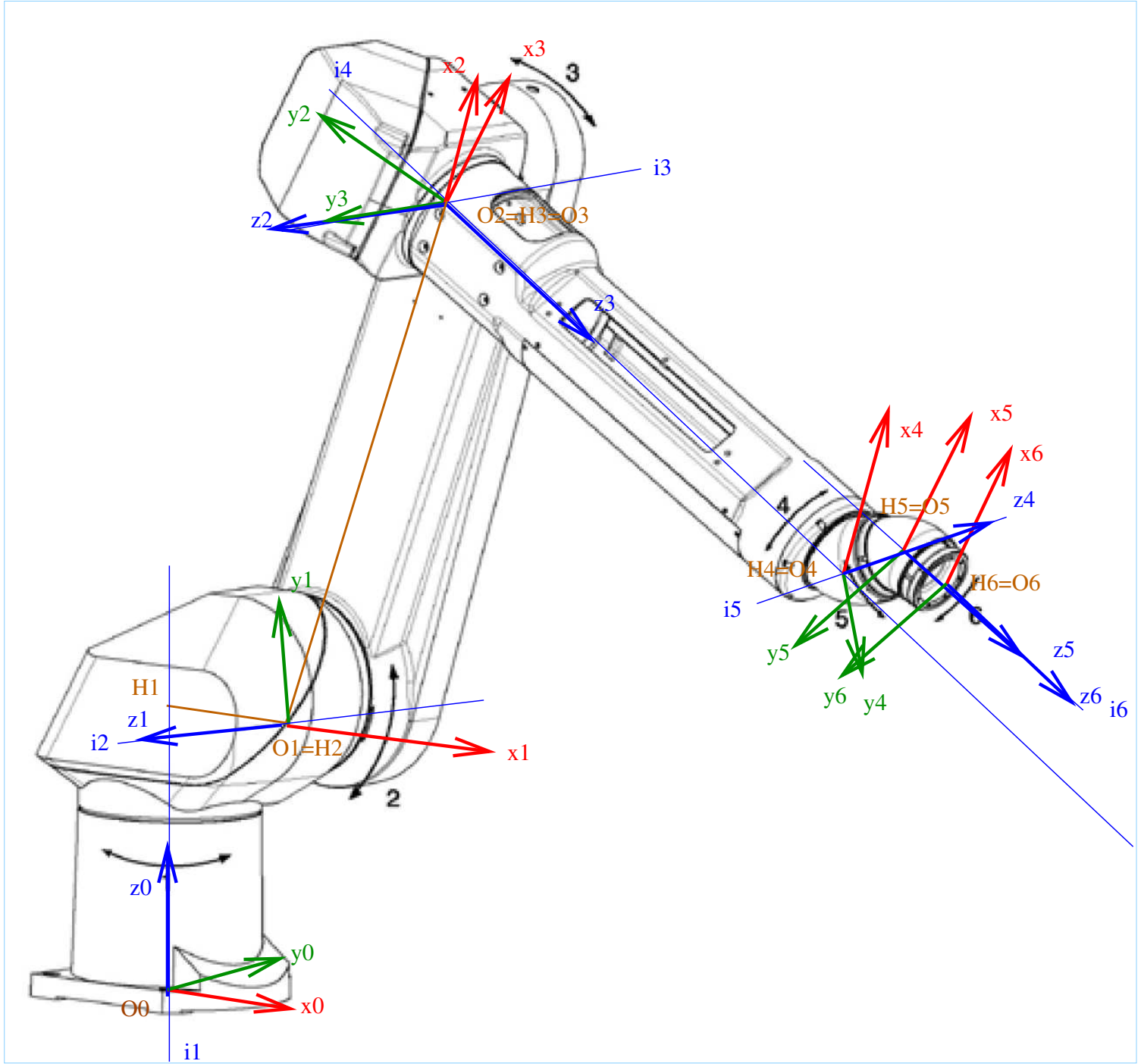

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
x6
z4
H5=O5
4
H4=O4
H6=O6
i5
5
6
y5
z5
z6
i6
y4
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

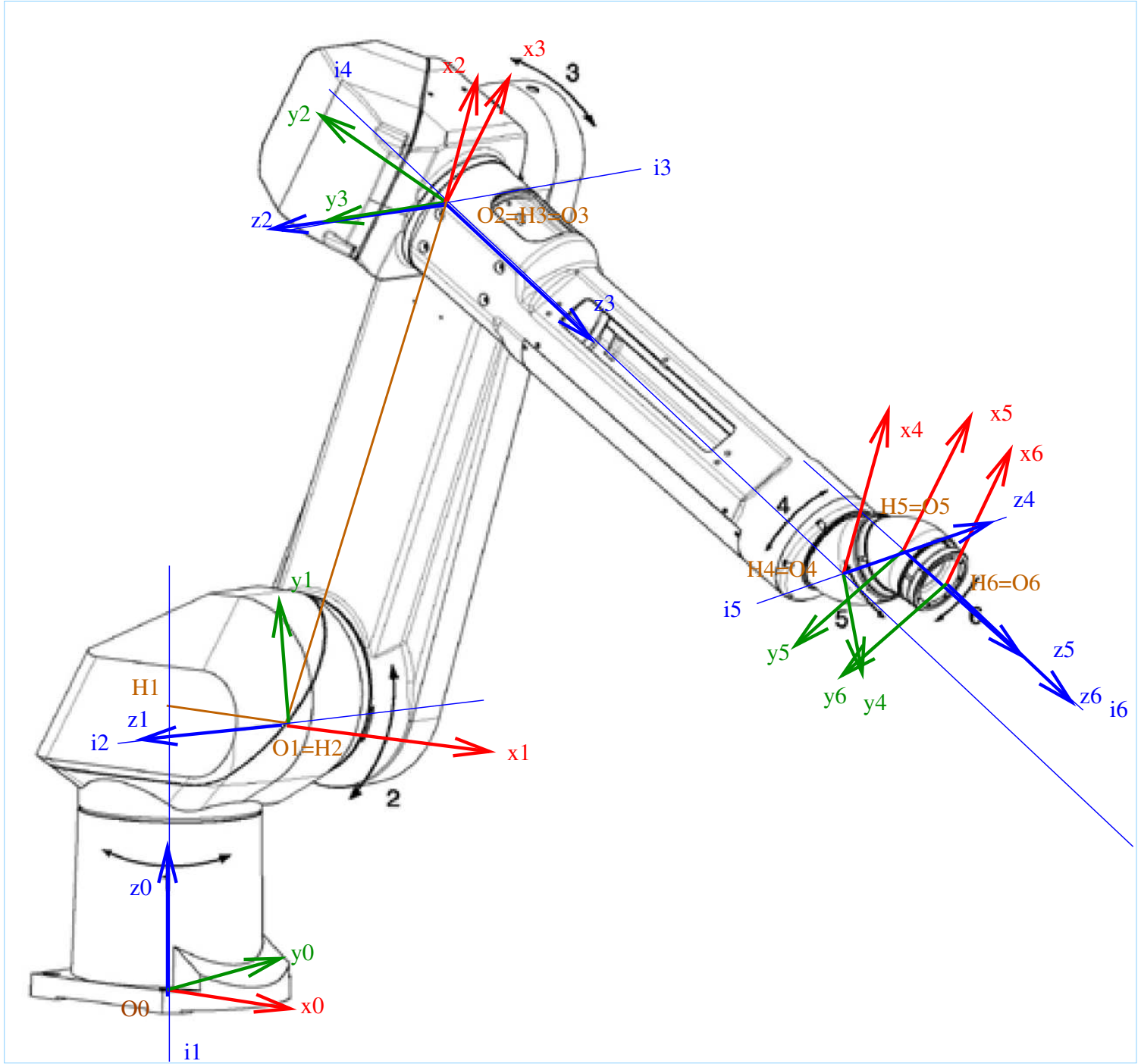

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
x6
z4
H5=O5
4
H4=O4
H6=O6
i5
5
6
y5
z5
y6
y4
z6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

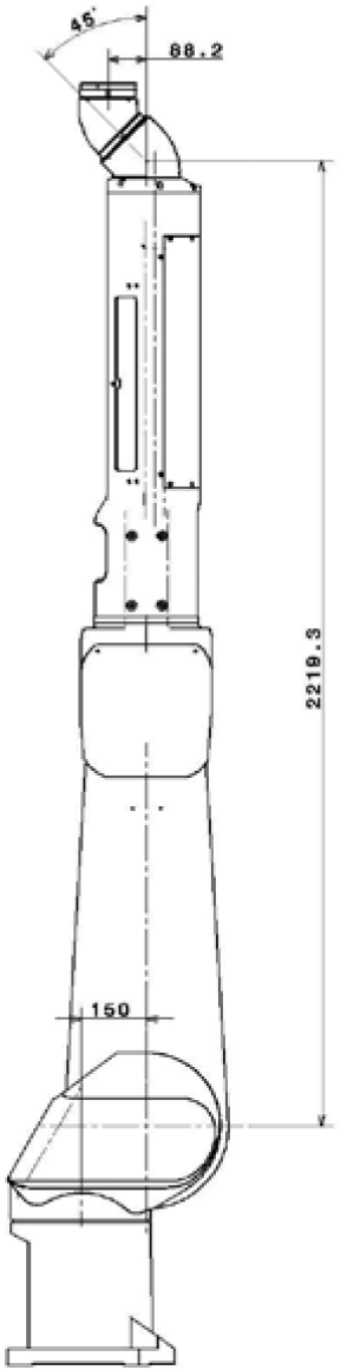

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
x6
z4
H5=O5
4
H4=O4
H6=O6
i5
5
6
y5
z5
y6
y4
z6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

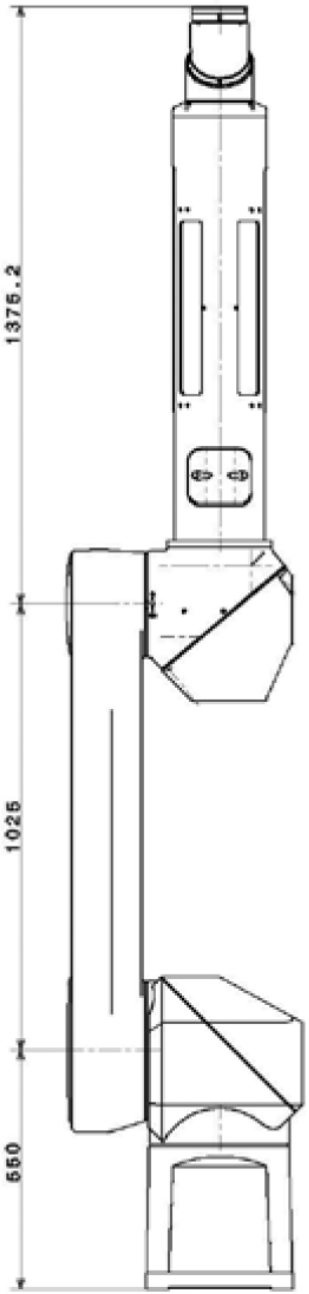

45°
68.2
2219.3
150

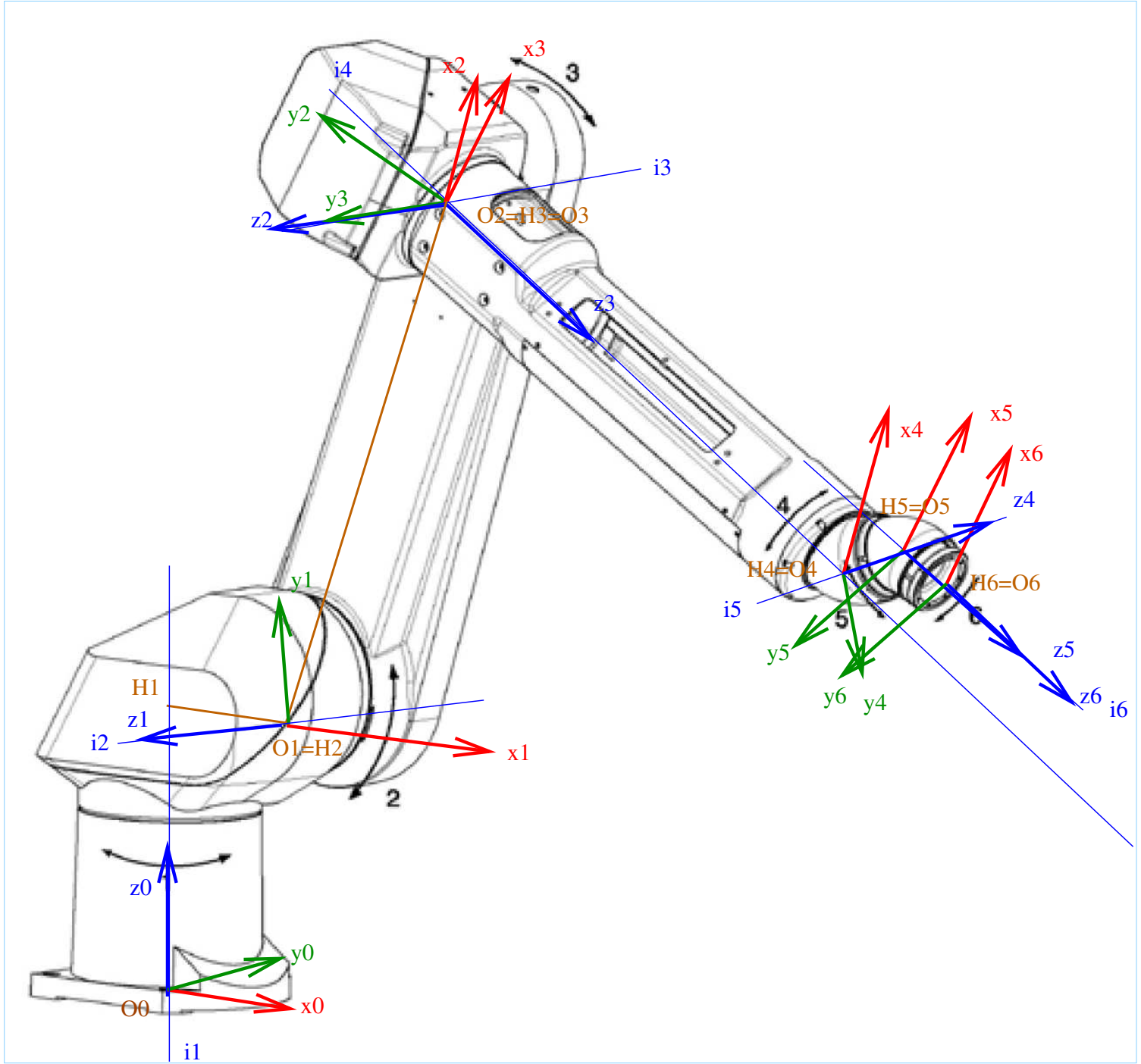

1375.2
1025
550

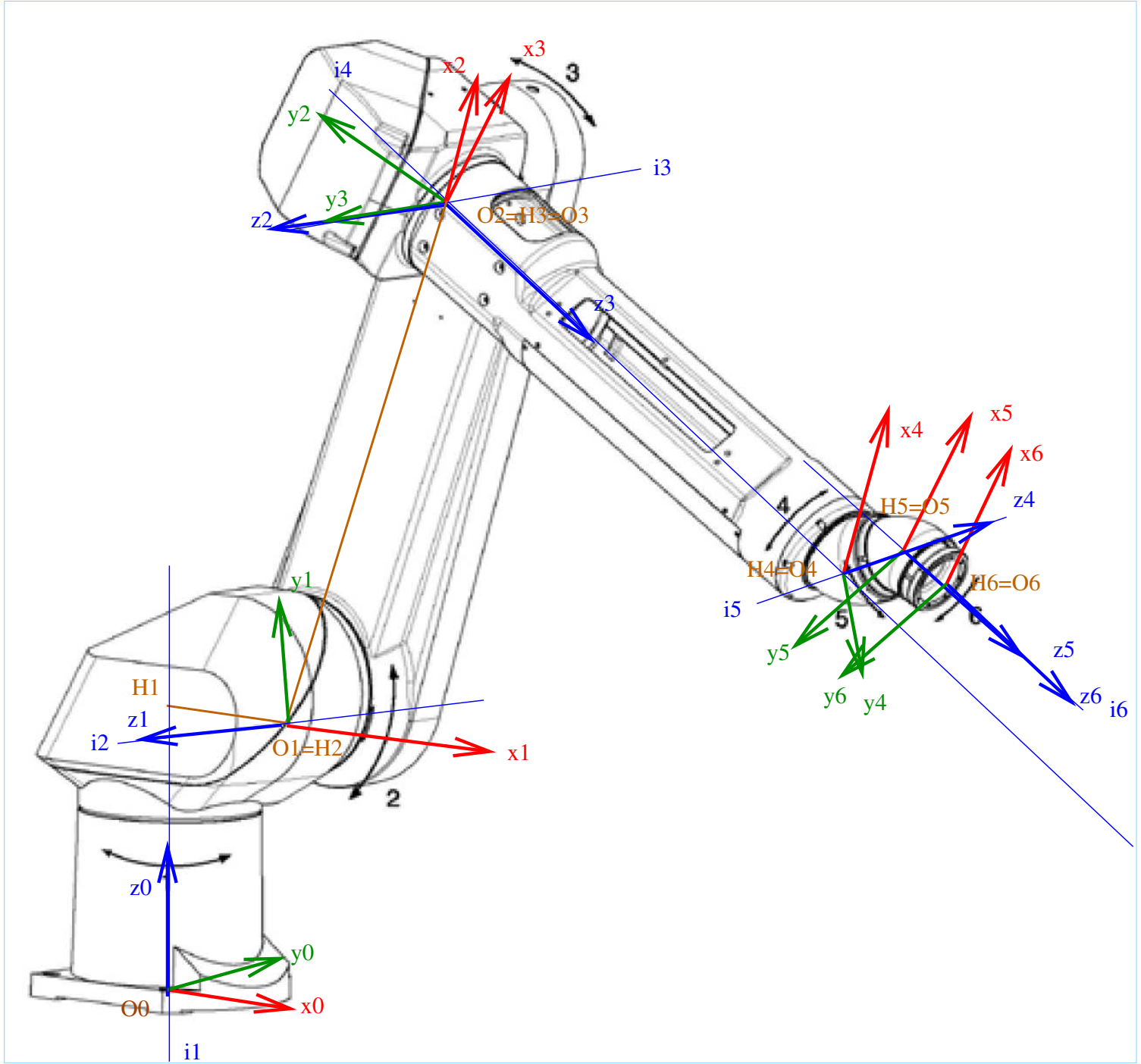

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
x6
z4
H5=O5
4
H4=O4
H6=O6
i5
5
6
y5
z5
y6
y4
z6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

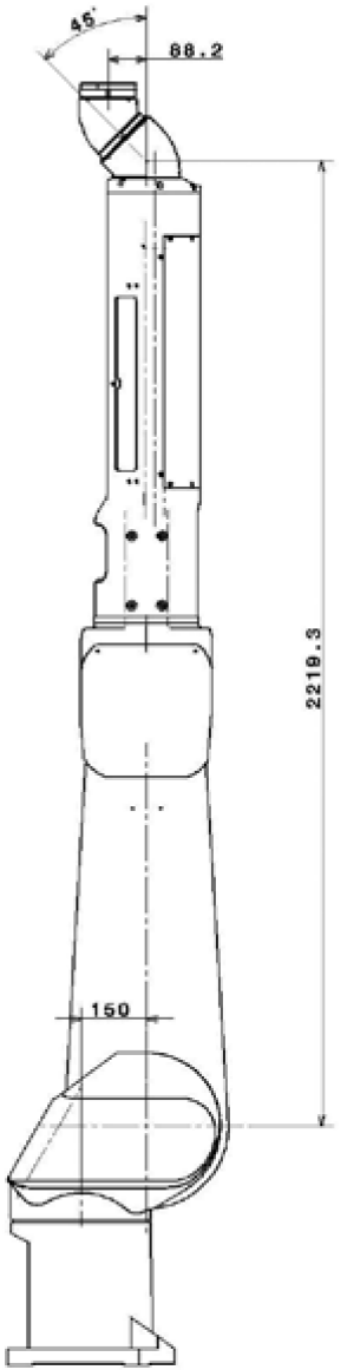

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
x6
z4
H5=O5
4
H4=O4
H6=O6
i5
5
6
y5
z5
y6
y4
z6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

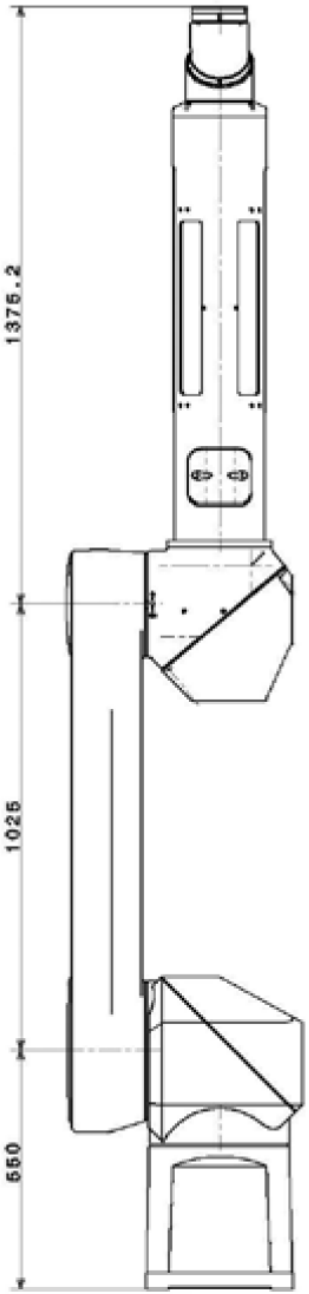

45°
68.2
2219.3
150

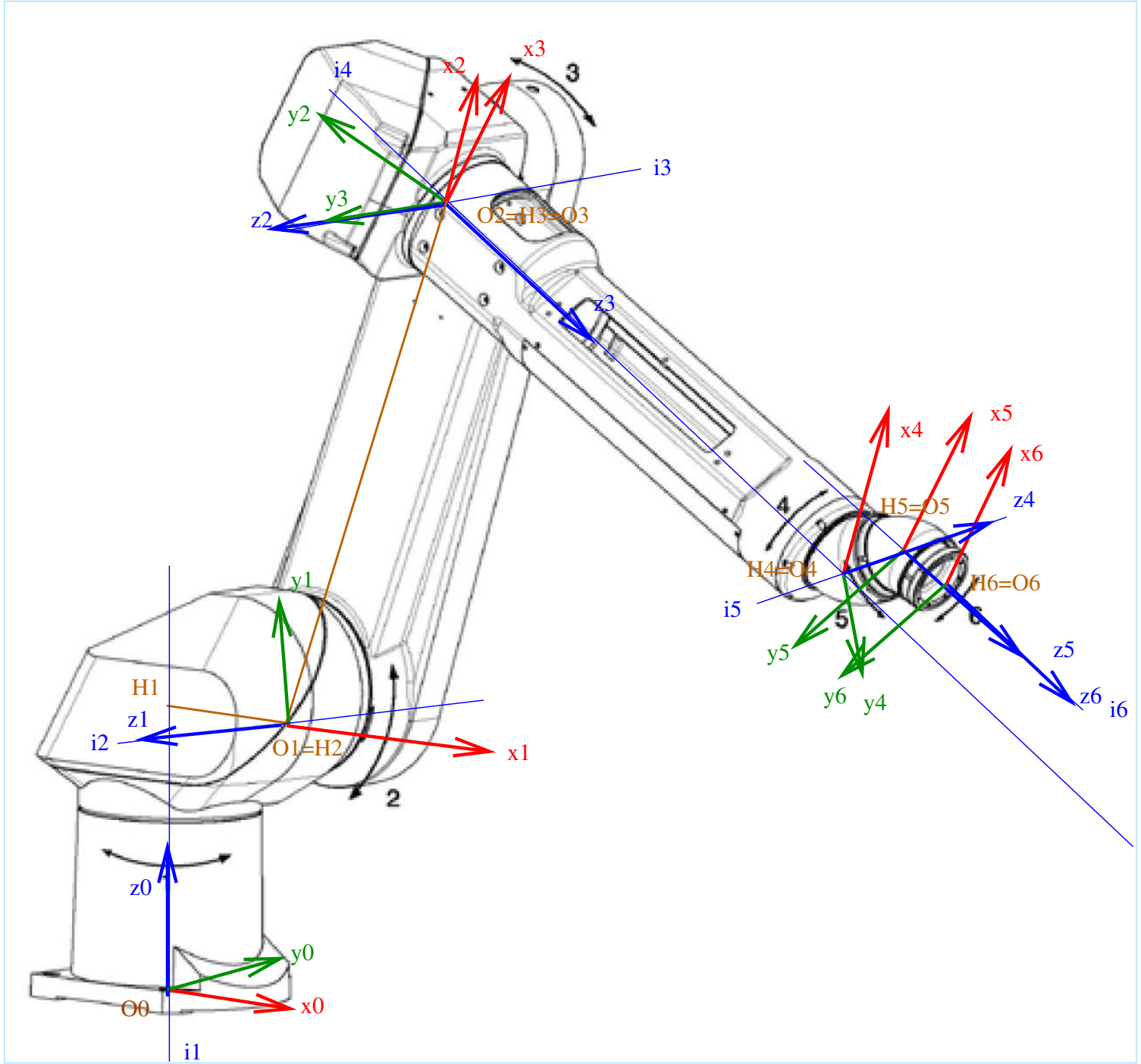

1375.2
1025
550

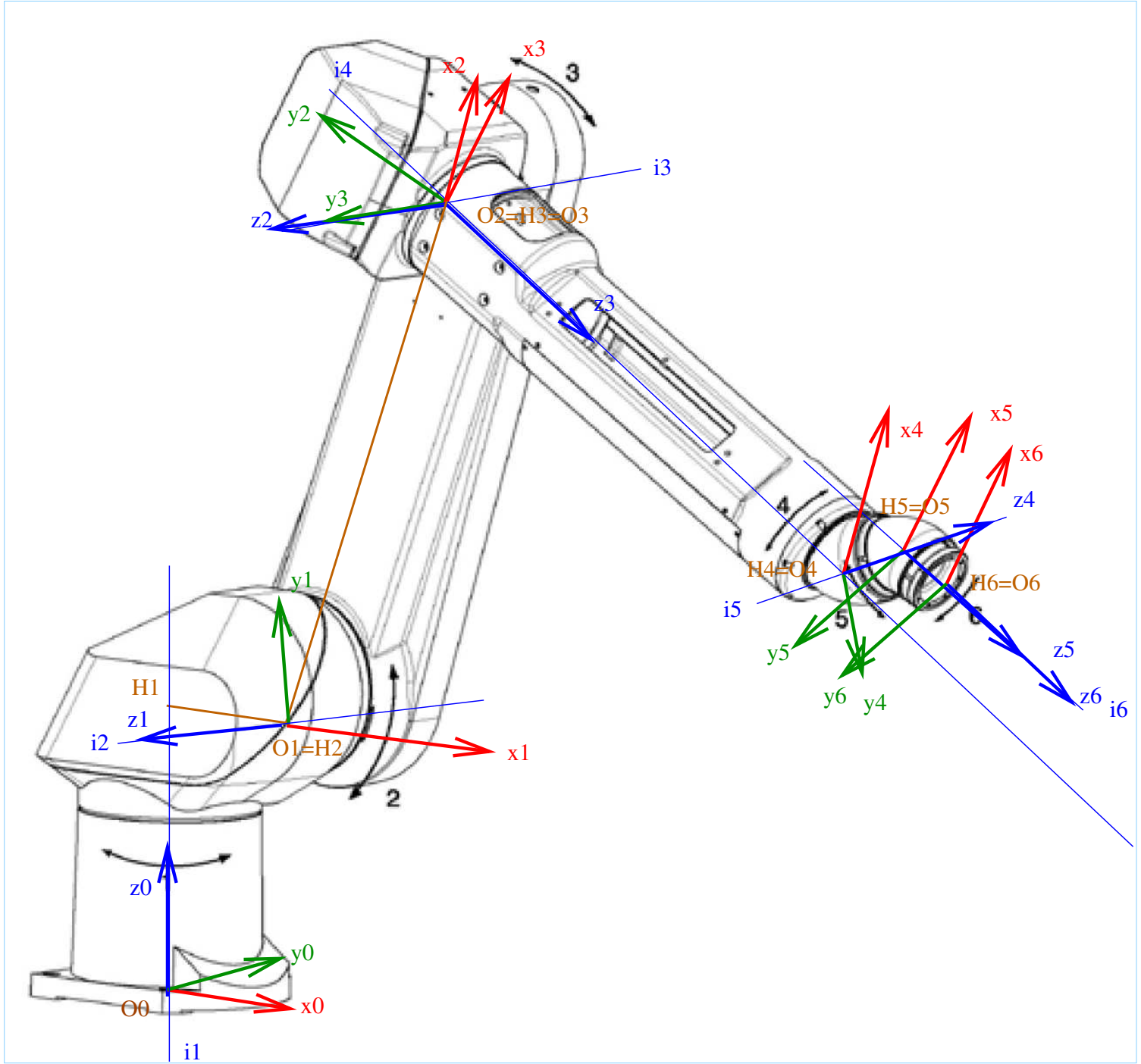

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
x6
z4
H5=O5
4
H4=O4
H6=O6
i5
5
6
y5
z5
y6
y4
z6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

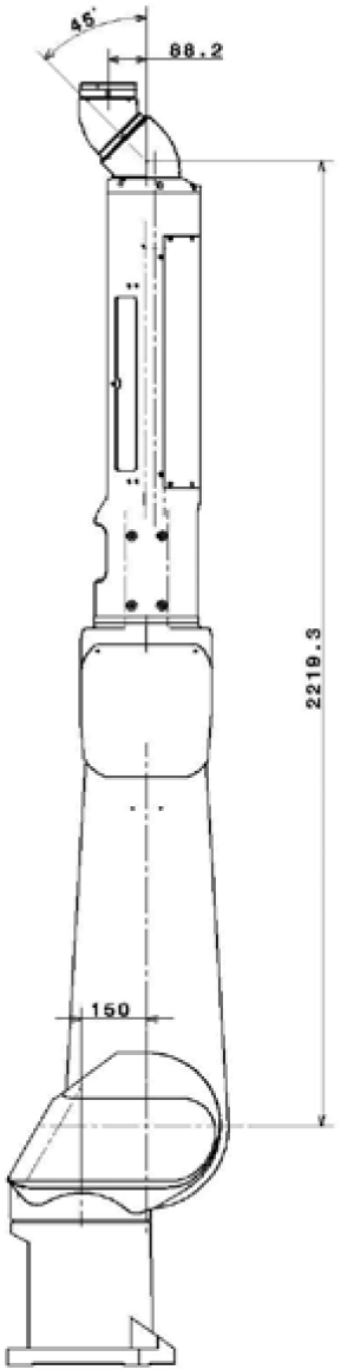

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
x6
z4
H5=O5
4
H4=O4
H6=O6
i5
5
6
y5
z5
y6
y4
z6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

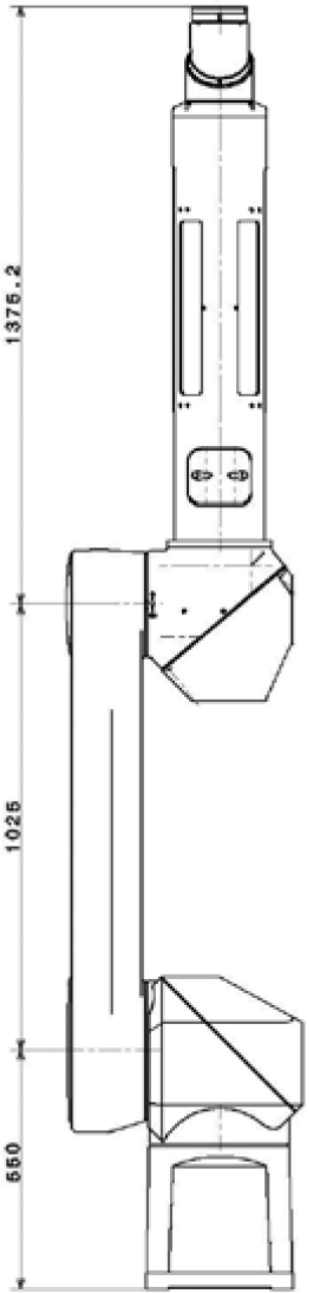

45°
68.2
2219.3
150

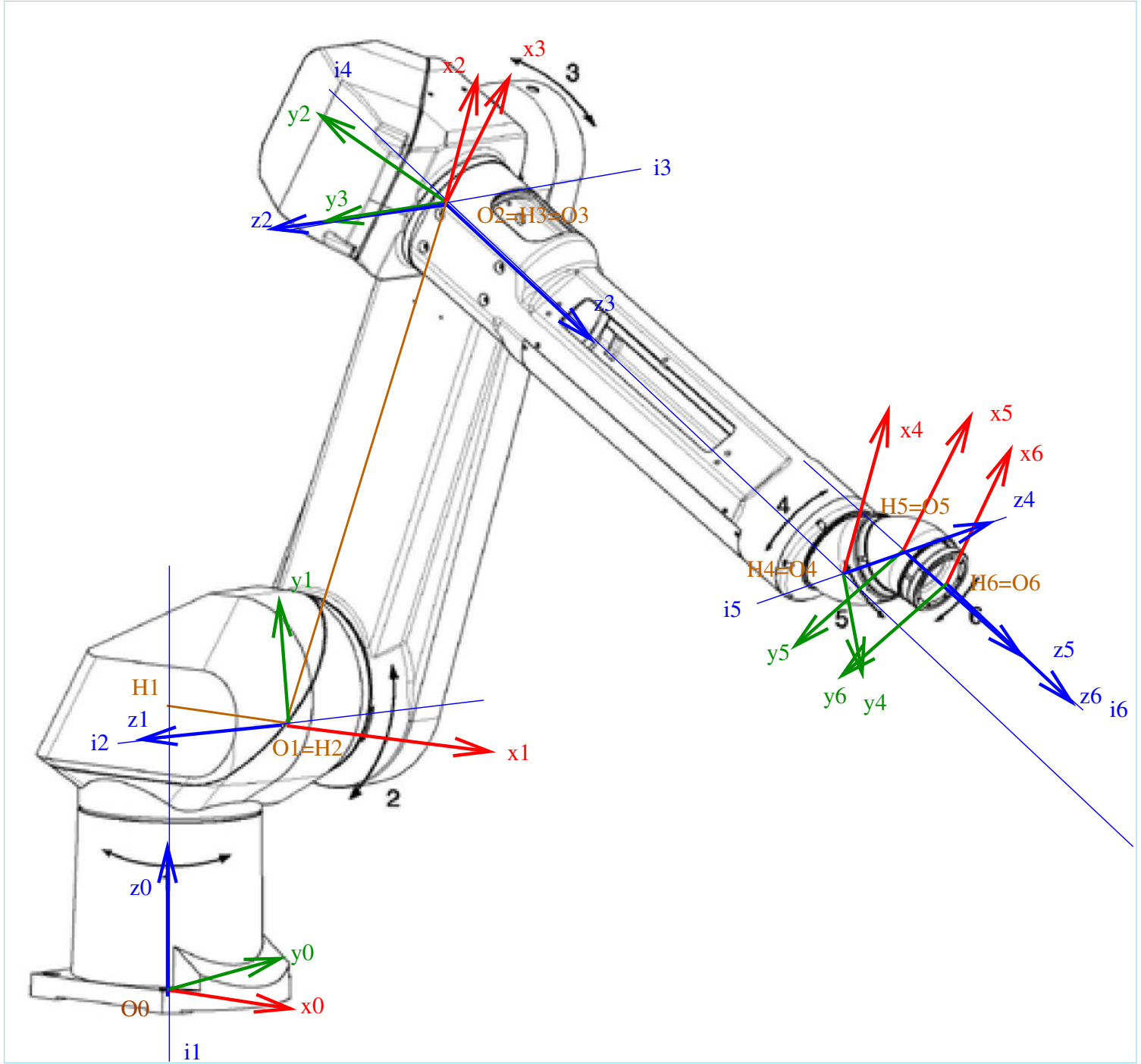

1375.2
1025
550

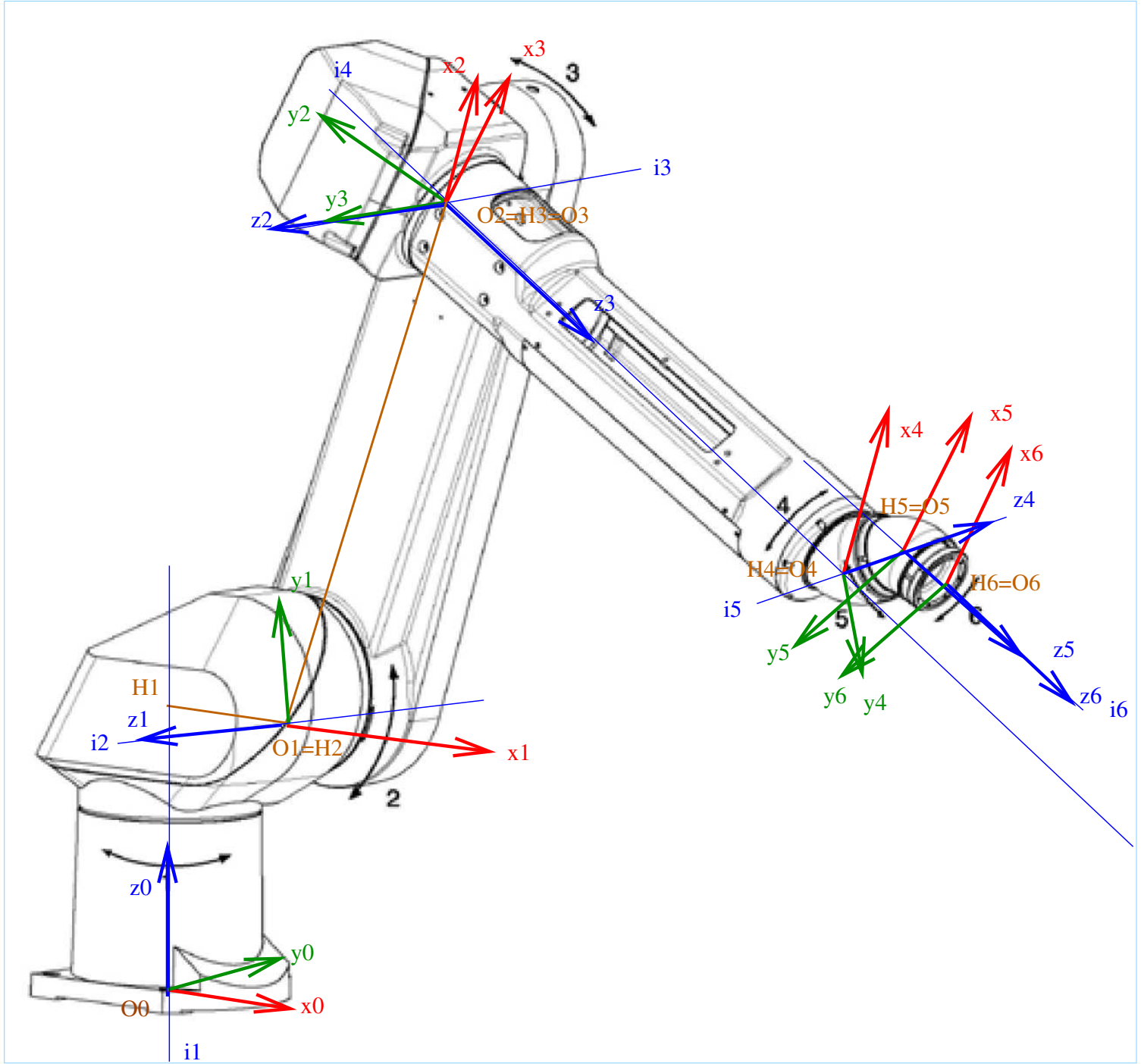

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
x6
z4
H5=O5
4
H4=O4
H6=O6
i5
5
6
y5
z5
y6
y4
z6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

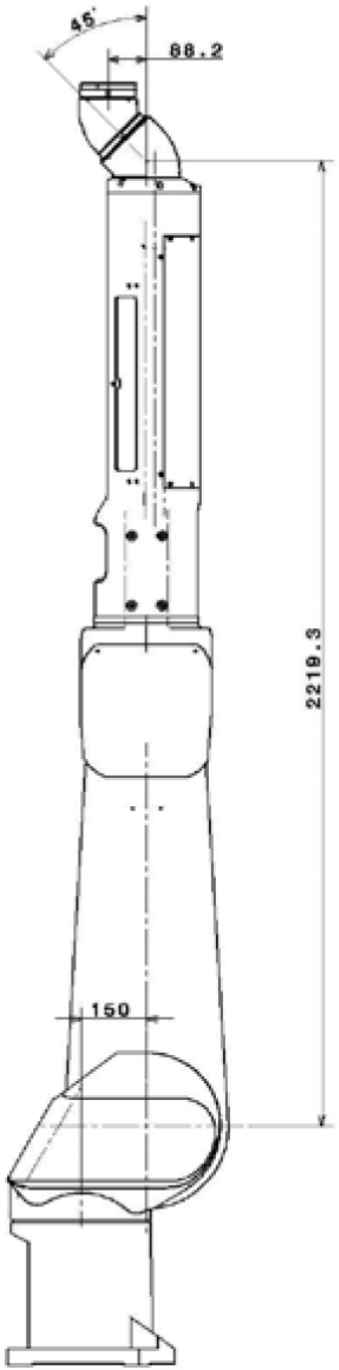

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
x6
z4
H5=O5
4
H4=O4
H6=O6
i5
5
6
y5
z5
y6
y4
z6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

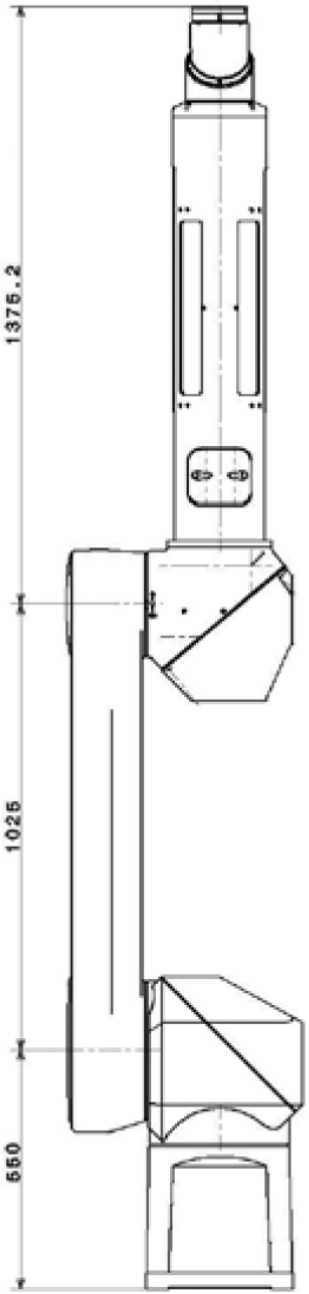

45°
68.2
2219.3
150

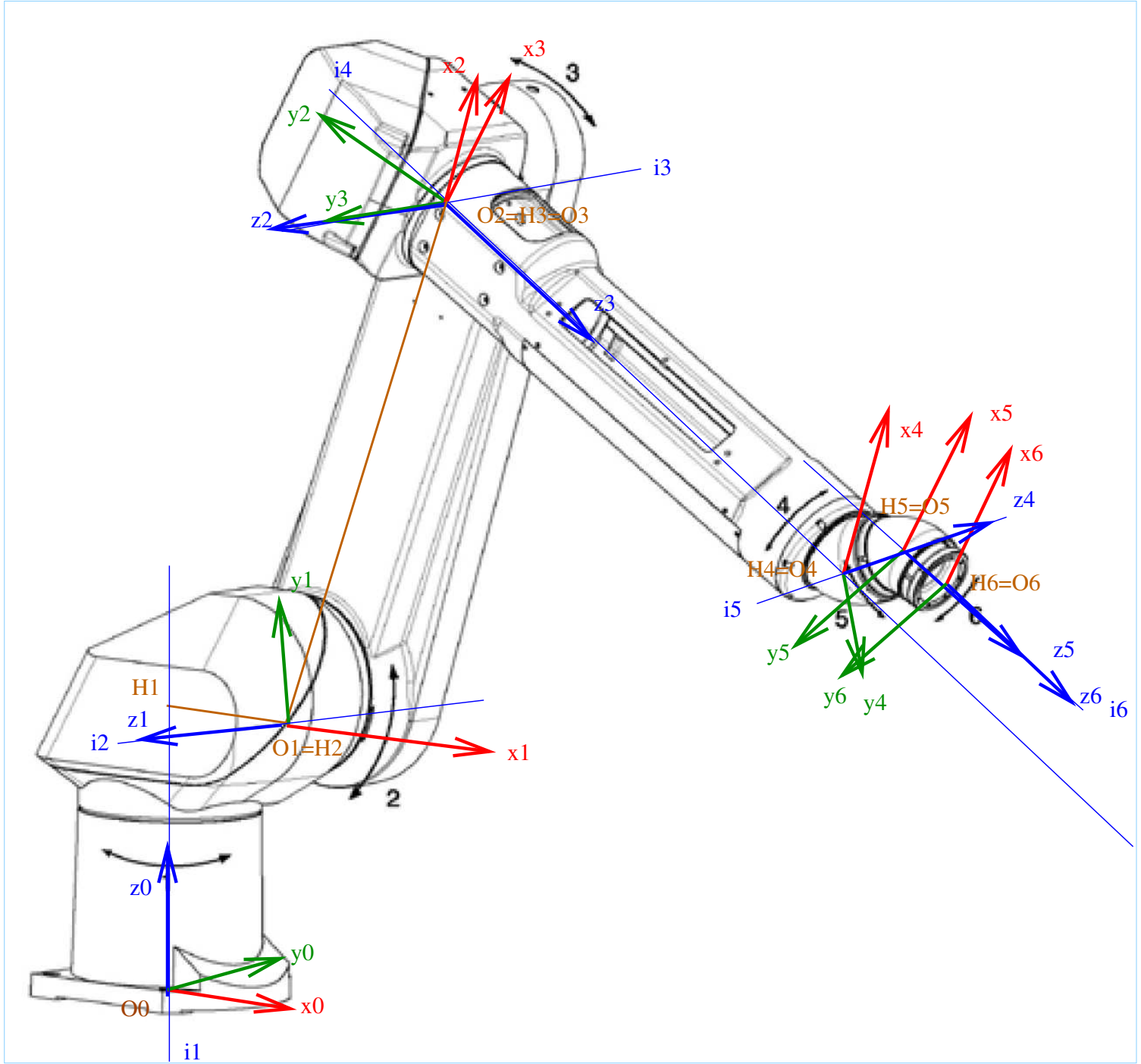

1375.2
1025
550

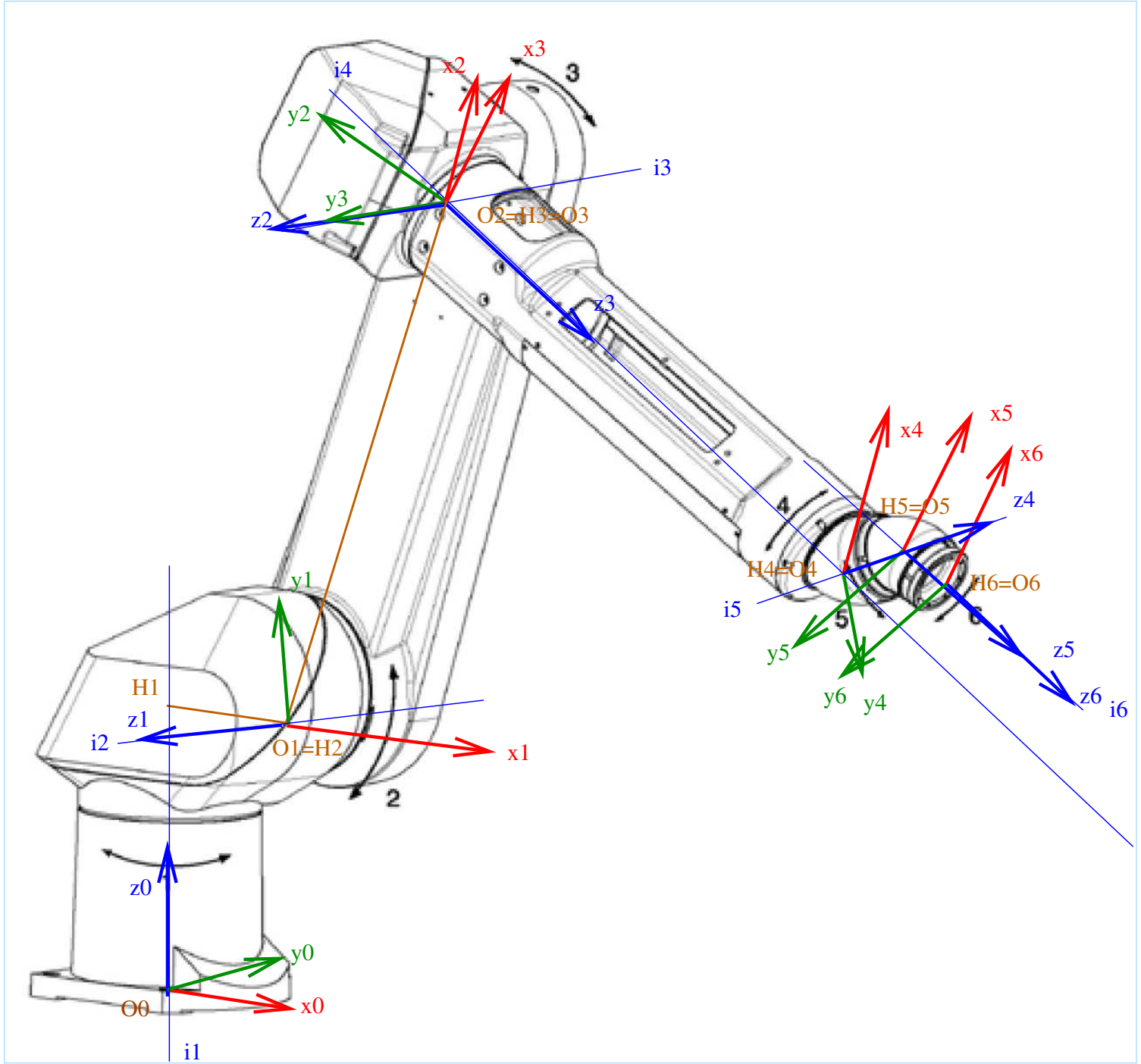

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
x6
z4
H5=O5
4
H4=O4
H6=O6
i5
5
6
y5
z5
y6
y4
z6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

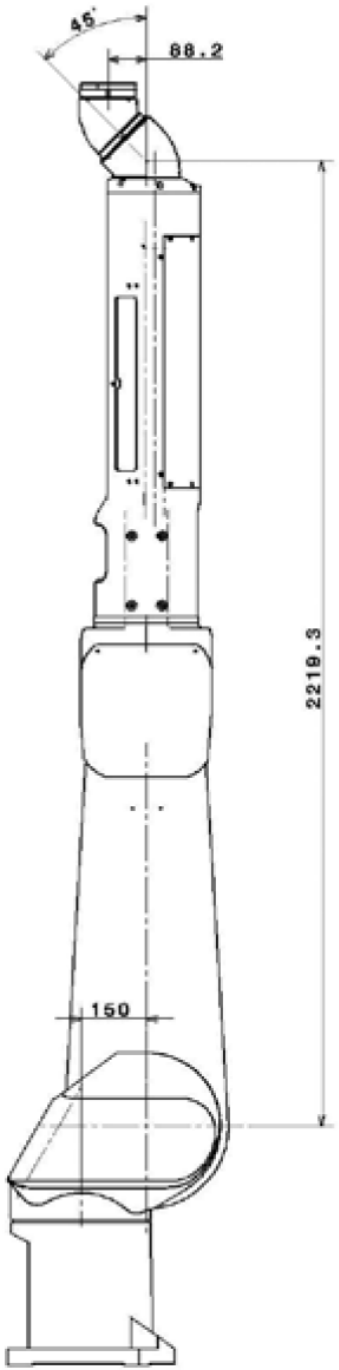

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
x6
z4
H5=O5
4
H4=O4
H6=O6
i5
5
6
y5
z5
y6
y4
z6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

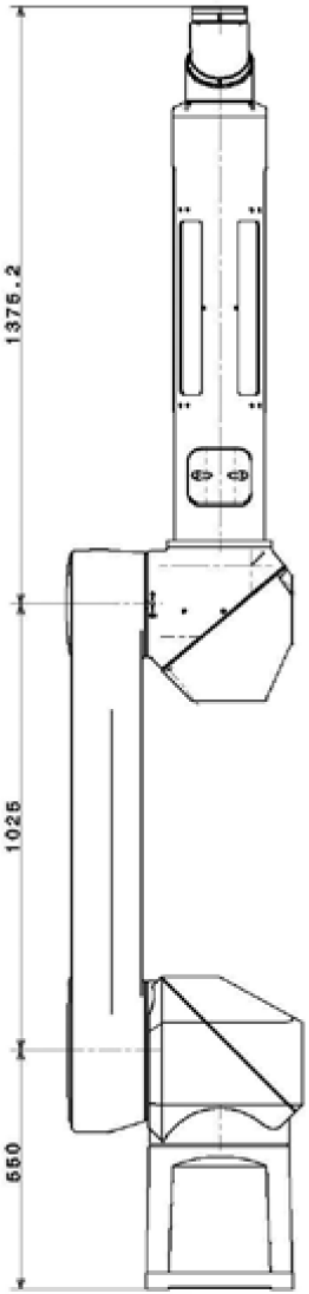

45°
68.2
2219.3
150

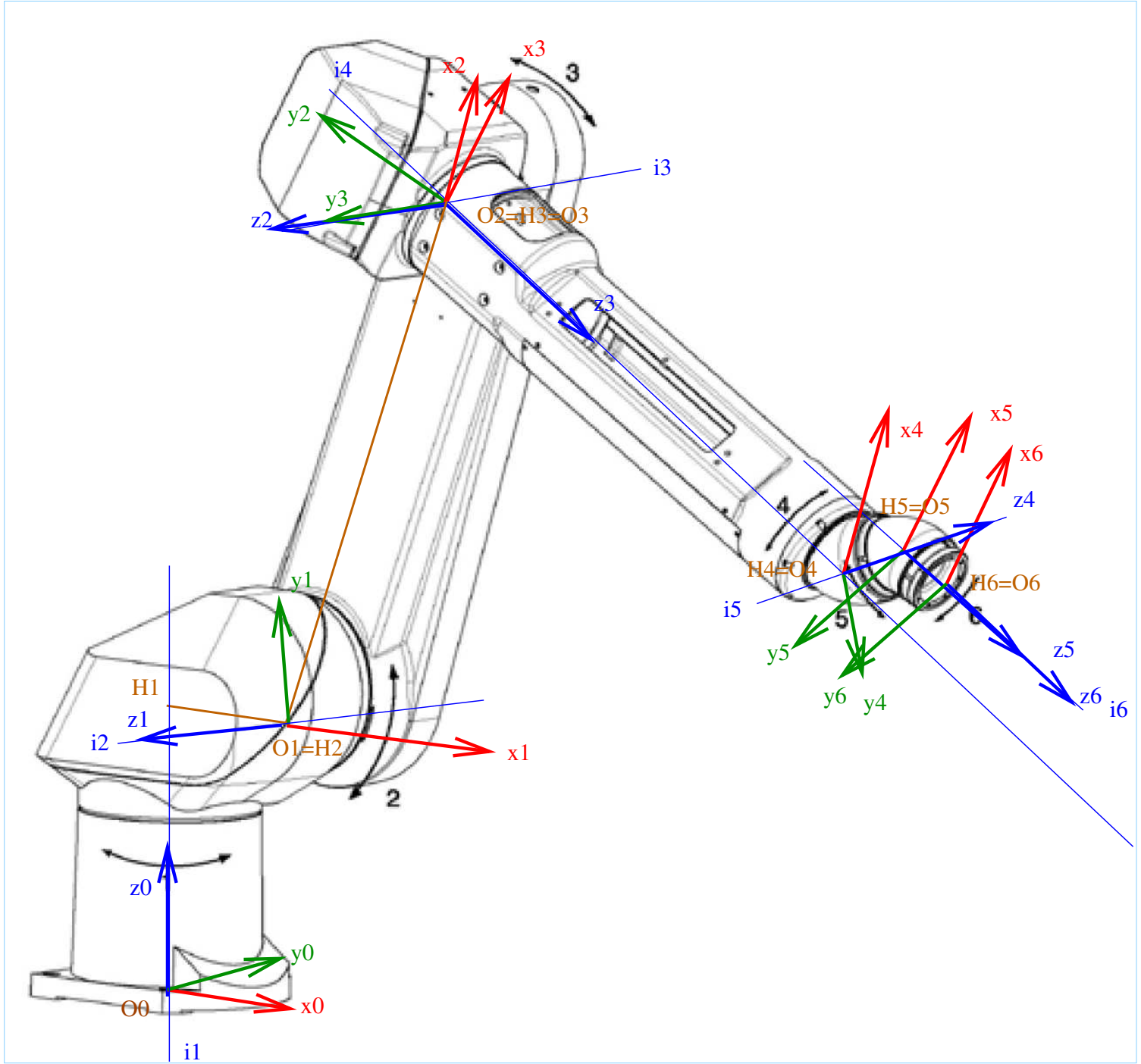

1375.2
1025
550

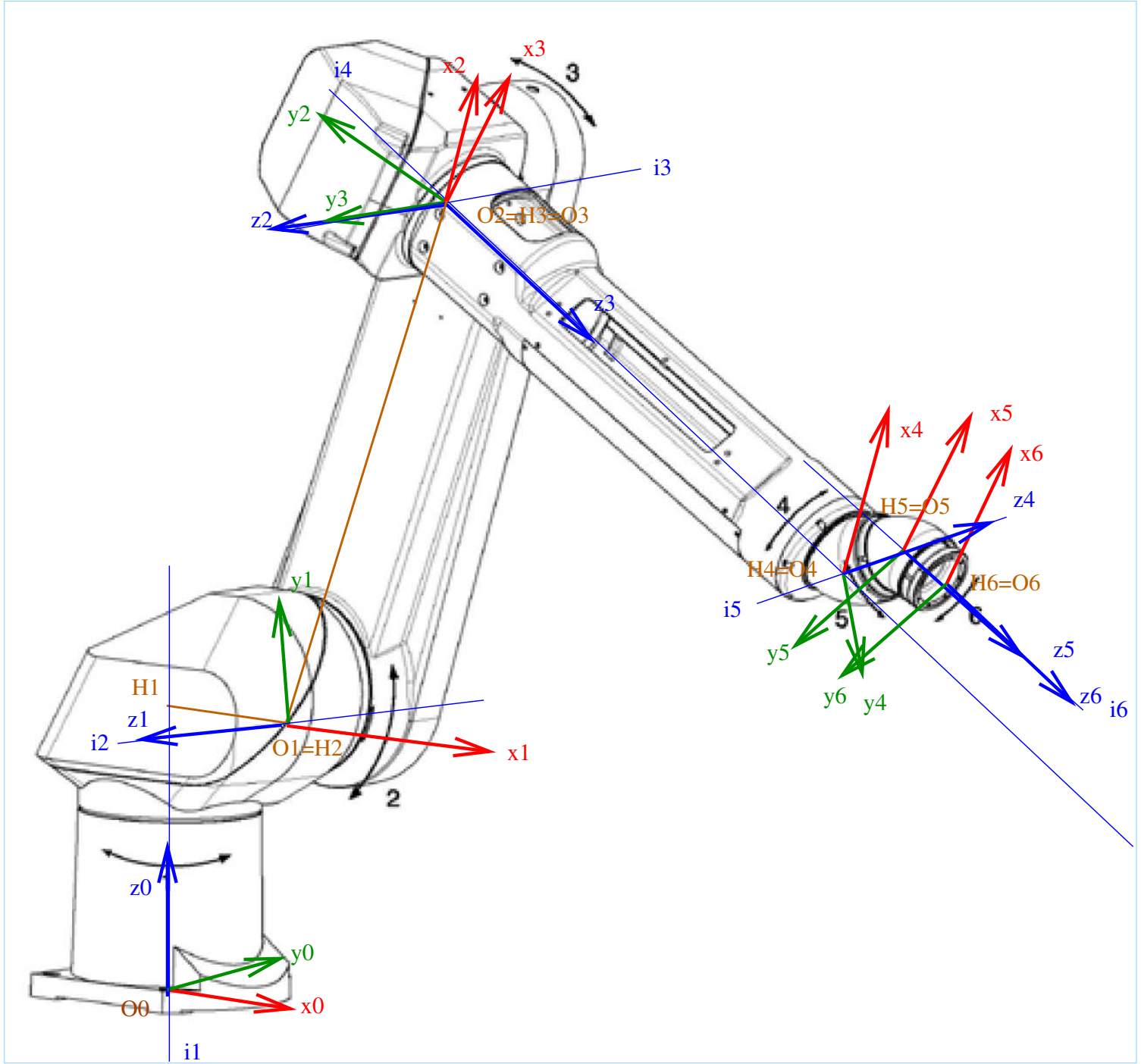

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
x6
z4
H5=O5
4
H4=O4
H6=O6
i5
5
6
y5
z5
y6
y4
z6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

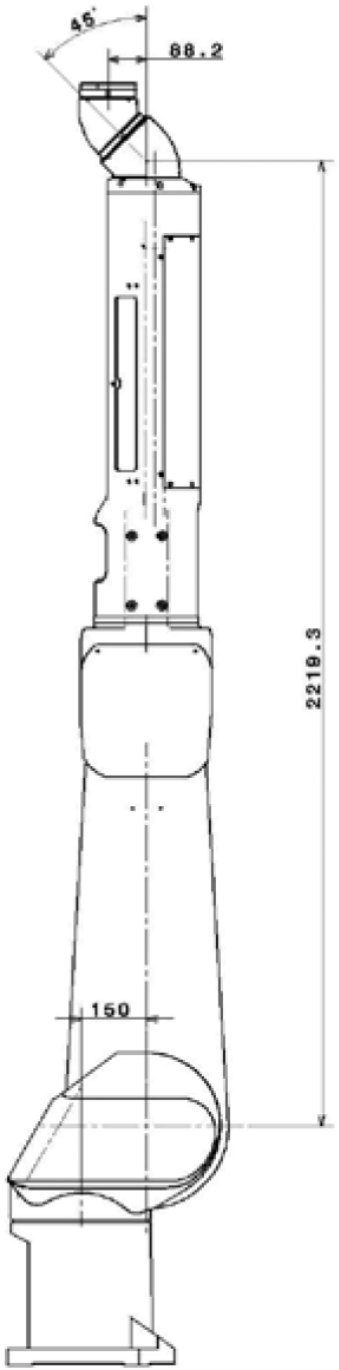

i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
x6
z4
H5=O5
4
H4=O4
H6=O6
i5
5
6
y5
z5
y6
y4
z6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1

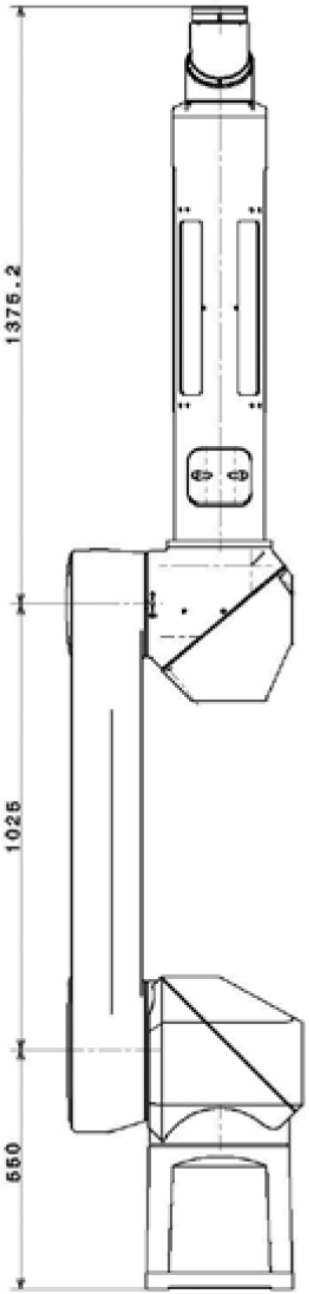

45°
68.2
2219.3
150

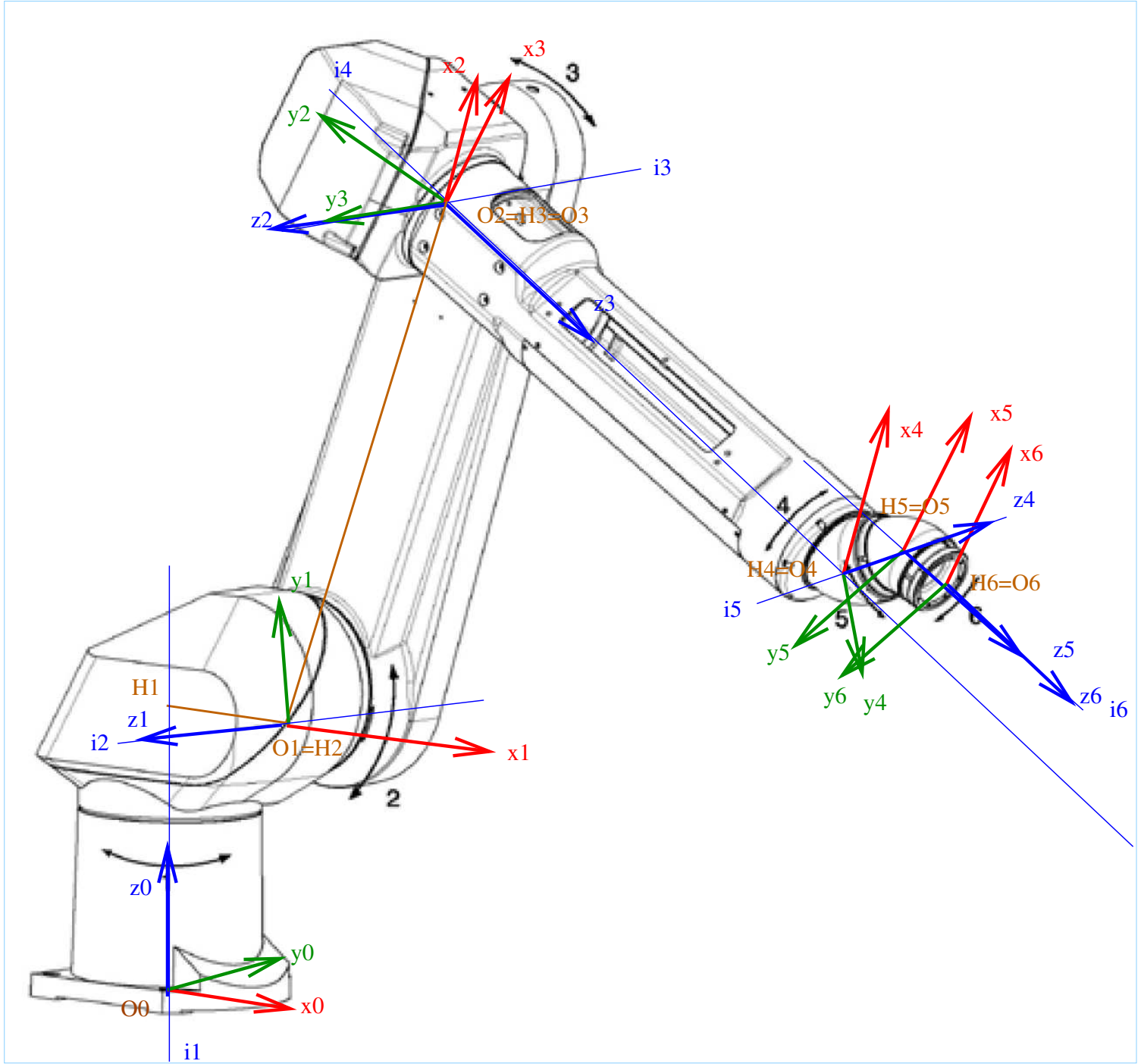

1375.2
1025
550


i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
x6
z4
H5=O5
4
H4=O4
H6=O6
i5
5
6
y5
z5
y6
y4
z6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1


i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
x6
z4
H5=O5
4
H4=O4
H6=O6
i5
5
6
y5
z5
y6
y4
z6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1


45°
68.2
2219.3
150


1375.2
1025
550


i4
x2
x3
3
y2
i3
y3
z2
O2=H3=O3
z3
x4
x5
x6
z4
H5=O5
4
H4=O4
H6=O6
i5
5
6
y5
z5
y6
y4
z6
i6
y1
H1
z1
i2
O1=H2
x1
2
z0
y0
O0
x0
i1