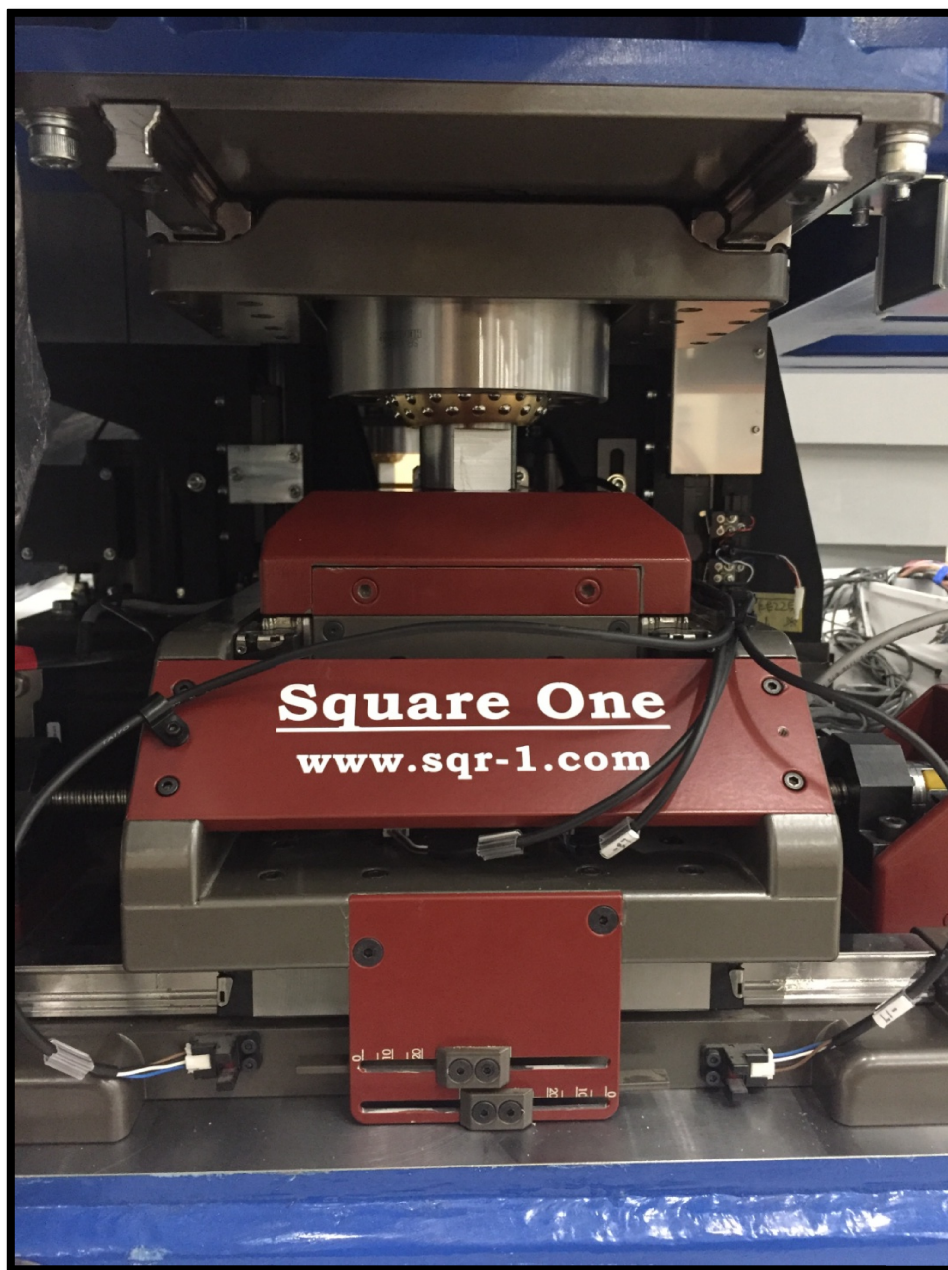


Mark IV Tri-Sphere Maintenance Manual

– FFT Beam Line, XFEL –



GENERAL ADVISEMENT SUMMARY:

Before use, it is advised to wipe down the system to remove any incidental particulate accumulation. This is particularly important to the exposed horizontal rails. Every month, it is recommended to run the system through its full range of travel to cycle grease through the moving parts (i.e.: jacks, ball screw nuts, all linear bushings). A visual inspection of the system is also recommended to look for any signs of damage, pinched or entangled wires or physical interferences.

Linear Rails:

Wipe the rails with a clean, low-lint rag before system use to remove any debris and dust. Re-lubrication is to be preformed every two years with *Dynalub 510*.

Ball Screw:

Wipe down the screw with a clean, low-lint rag before system use to remove any debris and dust. No re-lubrication is necessary.

Jack:

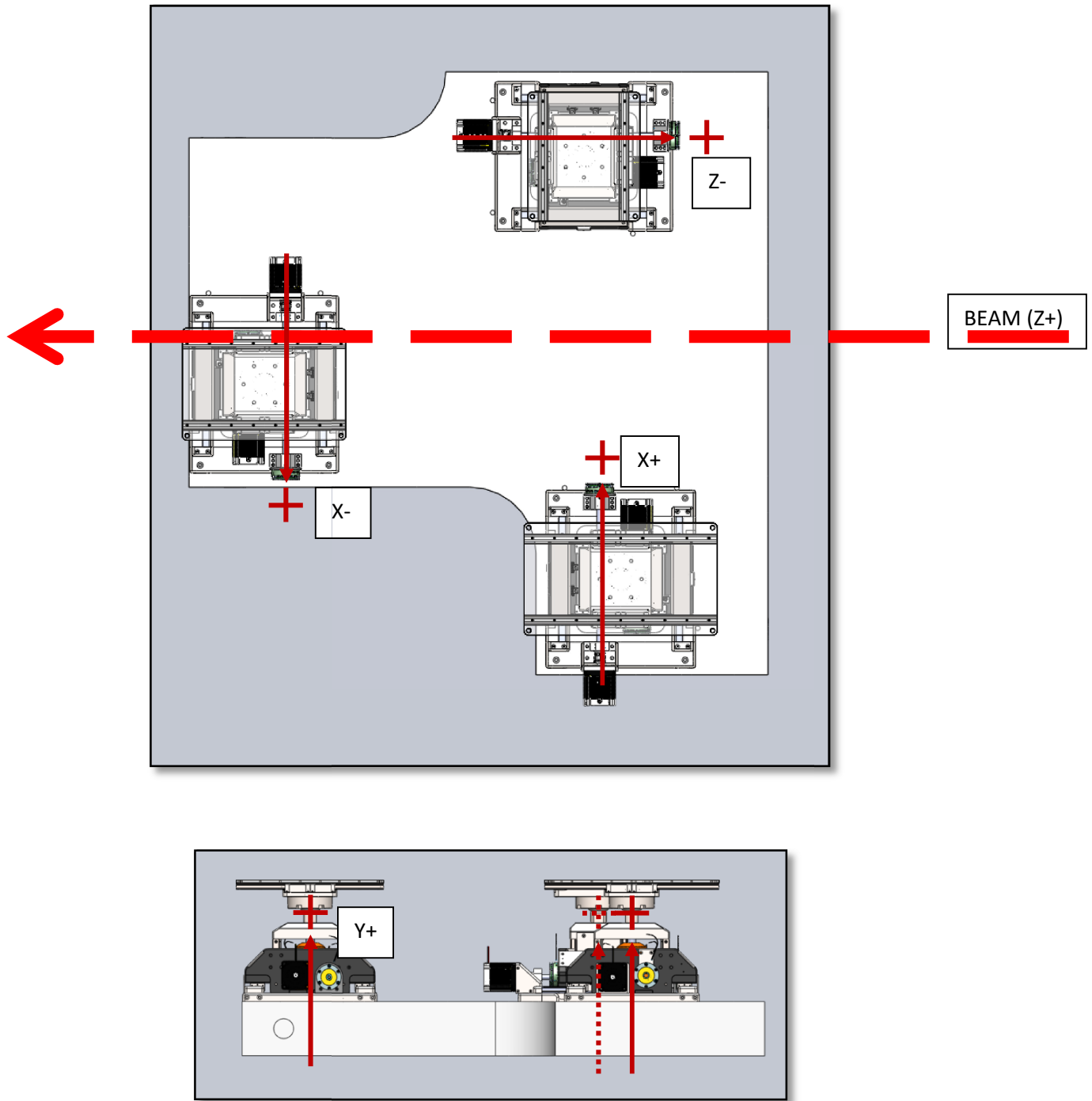
Lubrication should be preformed every two years using a non-oxidizing, non-channeling lubricant.

Replacement Parts

<i>Manufacturer</i>	<i>Description</i>	<i>Part Number</i>
Carlyle Johnson	8mm Bore Brakes	FEB030099SM8024
	1/2in Bore Brakes	FEB030099S05024
Panasonic	Flat Thru-Beam Sensor	PM-K65
	Right angle Thru-Beam Sensor	PM-Y65
	Cable	CN-14A-C3
McMaster-Carr	Coupler	2401K15
	Urethane Spider	2401K87
Sure Step	Motor	STP-MTRH-34097
Renishaw	Encoder Read Heads	RL32BAT050B30F
	Encoder Tape	A-9764-0015
	Encoder Fasttrack	A-9704-0015
Bosch-Rexroth	Pillow Blocks	R159161020
	Thrust Blocks	R159111020
	Rail (various sizes)	R1605 802 31
	Runner Blocks	R1622 814 20
	Ball Screw	FEM-E-C 16x5Rx3-4 1 3 T7 R 82Kxxx 72Kxxx 466.2mm 0 1
Nook	2 ton Jack	27414-03-0
Hephiast	Spherical Ball Joint	SRJ-048C-P

FFT - Mark IV Tri-Sphere BOM				Square One Systems Design	
Item Number	Part Number	Description	Manufacturer	Vendor	Quantity
1	FEB030099SM8024	8mm bore brakes	Carlyle Johnson	Carlyle Johnson	3
2	FEB030099S05024	1/2 in bore brakes	Carlyle Johnson	Carlyle Johnson	3
3	1110-3928-ND	Flat Thru Beam sensor	Panasonic	Digi-Key	7
4	1110-2084-ND	Connector cable	Panasonic	Digi-Key	14
5	1110-3931-ND	90° Thru Beam sensor	Panasonic	Digi-Key	7
6	2401K15	Coupler	McMaster	McMaster	12
7	2401K87	Urethane Spider	McMaster	McMaster	6
8	SRJ-048C-P	Spherical Ball Joints	Hephiast	Hephiast	3
9	RL32BAT050B30F	Encoder Read Heads	Renishaw	Renishaw	6
10	A-9764-0015	Encoder Tape 150mm	Renishaw	Renishaw	6
11	A-9704-0015	Encoder Fasttrack	Renishaw	Renishaw	6
12	P-AD03-0015	Adhesive Loctite 435	Renishaw	Renishaw	1
13	A-9589-0066	Encoder Fasttrack separator	Renishaw	Renishaw	1
14	R159161020	Pillow Blocks	Bosch-Rexroth	NWM	3
15	R159111020	Thrust Blocks	Bosch-Rexroth	NWM	3
16	R1605 802 31, 340mm 50 / 4*60 / 50mm	Horizontal Rail	Bosch-Rexroth	NWM	6
17	R1605 802 31, 196mm 8 / 3*60 / 8mm	Vertical Rail	Bosch-Rexroth	NWM	12
18	R1605 802 31, 350mm 25 / 5*60 / 25mm	Passive Rail 1	Bosch-Rexroth	NWM	2
19	R1605 802 31, 446mm 13 / 7*60 / 13mm	Passive Rail 2	Bosch-Rexroth	NWM	2
20	R1605 802 31, 524mm 22 / 8*60 / 22mm	Passive Rail 3	Bosch-Rexroth	NWM	2
21	R1622 814 20	Runner Blocks	Bosch-Rexroth	NWM	36
22	FEM-E-C 16x5Rx3-4 1 3 T7 R 82Kxxx 72Kxxx 466.2mm 0 1	Ball-Screw System	Bosch-Rexroth	NWM	3
23	VB-2000CPM	Kinematic Mounts	Bal-Tec	Bal-Tec	3
24	2000-CS	Kinematic Mounts	Bal-Tec	Bal-Tec	6
25	27414-03-0	Jack	Nook	Nook	3
26	STP-MTRH-34097	Motors	SureStep	Automation Direct	6
27	HW-201610CHSC	Control Enclosure	Automation Direct	Automation Direct	1
28	HW-MP2016FG	Control Enclosure Board	Automation Direct	Automation Direct	1
29	STP-EXTH-020	Motor Cable	Automation Direct	Automation Direct	6
30	Various	Panel Hardware	Various	Various	1
31	Various	Wire	Various	Various	1
32	Various	Connectors, Pins	Various	Various	1

FFT Mark IV Tri-Sphere Physical Layout and Specifications



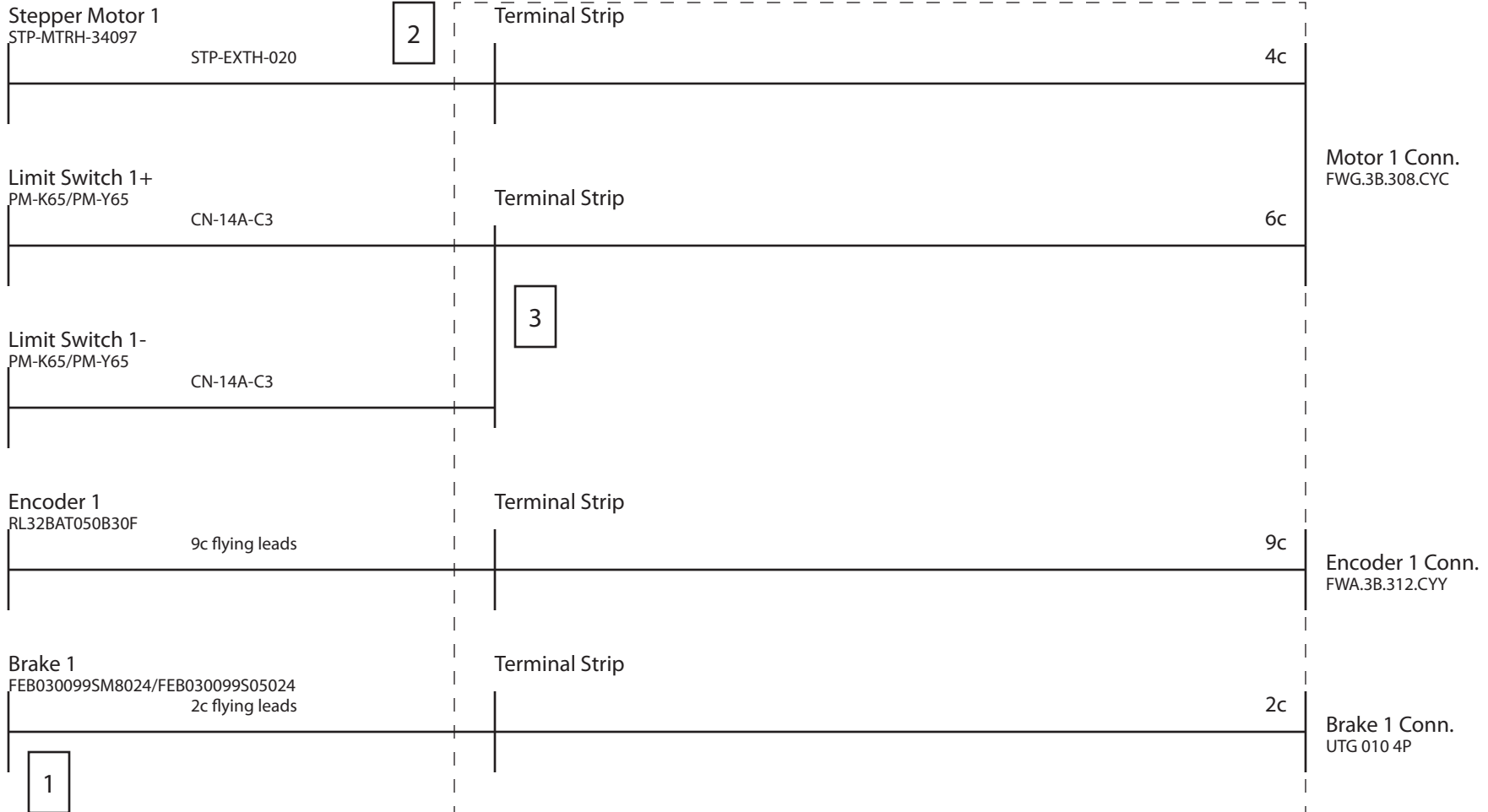
Gearing in Horizontal (Z, X):

- 1 revolution of the horizontal motor results in **5 mm** of horizontal travel.
 - Screw Pitch is **5 mm**.

Gearing in the Vertical (Y):

- 1 revolution of a vertical motor results in **0.265 mm** of vertical travel.
 - Gear ratio is **3.78 revs/1 mm** (96 rev/1 in).

Control Enclosure
HW-201610CHSC



NOTES

1. Diagram is for equipment set 1, sets 2-6 are identical
2. All equipment cables enter enclosure through strain relief
3. Limit switches share power and use the light on switch leg

FFT Delta Tau Wire List

Square One System Design

Cable #	Terminal #	Jack Color	Device	Description	Wire Color (bottom)	Delta Tau connector, pin #	Wire Color (top)	Internal Connection
1	1	Red	Motor 1	A	red	Amp 1, p1	red	
	2	Red	Motor 1	A'	white	Amp 1, p3	white	
	3	Red	Motor 1	B	green	Amp 1, p2	green	
	4	Red	Motor 1	B'	black	Amp 1, p4	black	
2	5	Red	(+) Limit 1	24 Vdc	brown		white	24 Vdc
	6	Red	(+) Limit 1	Com	blue		black	Com
	7	Red	(+) Limit 1	Dark On	white	Not Used		
	8	Red	(+) Limit 1	Light On	black	J4, p14	brown/white	
3	9	Red	(-) Limit 1	24 Vdc	brown		white	24 Vdc
	10	Red	(-) Limit 1	Com	blue		black	Com
	11	Red	(-) Limit 1	Dark On	white	Not Used		
	12	Red	(-) Limit 1	Light On	black	J4, p2	brown	
4	13	Red	Brake 1	24 Vdc	white		red	R1
	14	Red	Brake 1	Com	black		black	Com
5	15	Red	Encoder 1	5 Vdc	brown	X1, p4	orange	
	16	Red	Encoder 1	Com	white, green	X1, p12	lt. green	
	17	Red	Encoder 1	Clock +, MO +	purple	X1, p13	black/white	
	18	Red	Encoder 1	Clock -, MO -	yellow	X1, p6	green	
	19	Red	Encoder 1	Data +, SLO +	gray	X1, p14	brown/white	
	20	Red	Encoder 1	Data -, SLO -	pink	X1, p5	yellow	
	21	Red	Encoder 1	Shield	bare	X1, shell	bare	
6	22	Yellow	Motor 3	A	red	Amp 3, p1	red	
	23	Yellow	Motor 3	A'	white	Amp 3, p3	white	
	24	Yellow	Motor 3	B	green	Amp 3, p2	green	
	25	Yellow	Motor 3	B'	black	Amp 3, p4	black	
7	26	Yellow	(+) Limit 3	24 Vdc	brown		white	24 Vdc
	27	Yellow	(+) Limit 3	Com	blue		black	Com
	28	Yellow	(+) Limit 3	Dark On	white	Not Used		
	29	Yellow	(+) Limit 3	Light On	black	J4, p20	red/black	
8	30	Yellow	(-) Limit 3	24 Vdc	brown		white	24 Vdc
	31	Yellow	(-) Limit 3	Com	blue		black	Com
	32	Yellow	(-) Limit 3	Dark On	white	Not Used		
	33	Yellow	(-) Limit 3	Light On	black	J4, p8	purple	
9	34	Yellow	Brake 3	24 Vdc	white		gray	R3
	35	Yellow	Brake 3	Com	black		black	Com
10	36	Yellow	Encoder 3	5 Vdc	brown	X3, p4	orange	
	37	Yellow	Encoder 3	Com	white, green	X3, p12	lt. green	
	38	Yellow	Encoder 3	Clock +, MO +	purple	X3, p13	black/white	
	39	Yellow	Encoder 3	Clock -, MO -	yellow	X3, p6	green	
	40	Yellow	Encoder 3	Data +, SLO +	gray	X3, p14	brown/white	
	41	Yellow	Encoder 3	Data -, SLO -	pink	X3, p5	yellow	
	42	Yellow	Encoder 3	Shield	bare	X3, shell	bare	
11	43	Blue	Motor 5	A	red	Amp 5, p1	red	
	44	Blue	Motor 5	A'	white	Amp 5, p3	white	
	45	Blue	Motor 5	B	green	Amp 5, p2	green	
	46	Blue	Motor 5	B'	black	Amp 5, p4	black	
12	47	Blue	(+) Limit 5	24 Vdc	brown		white	24 Vdc
	48	Blue	(+) Limit 5	Com	blue		black	Com
	49	Blue	(+) Limit 5	Dark On	white	Not Used		
	50	Blue	(+) Limit 5	Light On	black	J5, p14	brown/white	
13	51	Blue	(-) Limit 5	24 Vdc	brown		white	24 Vdc
	52	Blue	(-) Limit 5	Com	blue		black	Com
	53	Blue	(-) Limit 5	Dark On	white	Not Used		
	54	Blue	(-) Limit 5	Light On	black	J5, p2	brown	
14	55	Blue	Brake 5	24 Vdc	white		blue	R5
	56	Blue	Brake 5	Com	black		black	Com
15	57	Blue	Encoder 5	5 Vdc	brown	X5, p4	orange	
	58	Blue	Encoder 5	Com	white, green	X5, p12	lt. green	
	59	Blue	Encoder 5	Clock +, MO +	purple	X5, p13	black/white	
	60	Blue	Encoder 5	Clock -, MO -	yellow	X5, p6	green	
	61	Blue	Encoder 5	Data +, SLO +	gray	X5, p14	brown/white	
	62	Blue	Encoder 5	Data -, SLO -	pink	X5, p5	yellow	
	63	Blue	Encoder 5	Shield	bare	X5, shell	bare	
				1				

16	64	Red	Motor 2	A	red	Amp 2, p1	red
	65	Red	Motor 2	A'	white	Amp 2, p3	white
	66	Red	Motor 2	B	green	Amp 2, p2	green
	67	Red	Motor 2	B'	black	Amp 2, p4	black
17	68	Red	(+) Limit 2	24 Vdc	brown	white	24 Vdc
	69	Red	(+) Limit 2	Com	blue	black	Com
	70	Red	(+) Limit 2	Dark On	white	Not Used	
	71	Red	(+) Limit 2	Light On	black	J4, p17	green/white
18	72	Red	(-) Limit 2	24 Vdc	brown	white	24 Vdc
	73	Red	(-) Limit 2	Com	blue	black	Com
	74	Red	(-) Limit 2	Dark On	white	Not Used	
	75	Red	(-) Limit 2	Light On	black	J4, p5	yellow
19	76	Red	Brake 2	24 Vdc	white	gray	R2
	77	Red	Brake 2	Com	black	black	Com
20	78	Red	Encoder 2	5 Vdc	brown	X2, p4	orange
	79	Red	Encoder 2	Com	white, green	X2, p12	lt. green
	80	Red	Encoder 2	Clock +, MO +	purple	X2, p13	black/white
	81	Red	Encoder 2	Clock -, MO -	yellow	X2, p6	green
	82	Red	Encoder 2	Data +, SLO +	gray	X2, p14	brown/white
	83	Red	Encoder 2	Data -, SLO -	pink	X2, p5	yellow
	84	Red	Encoder 2	Shield	bare	X2, shell	bare
21	85	Yellow	Motor 4	A	red	Amp 4, p1	red
	86	Yellow	Motor 4	A'	white	Amp 4, p3	white
	87	Yellow	Motor 4	B	green	Amp 4, p2	green
	88	Yellow	Motor 4	B'	black	Amp 4, p4	black
22	89	Yellow	(+) Limit 4	24 Vdc	brown	white	24 Vdc
	90	Yellow	(+) Limit 4	Com	blue	black	Com
	91	Yellow	(+) Limit 4	Dark On	white	Not Used	
	92	Yellow	(+) Limit 4	Light On	black	J4, p23	green/black
23	93	Yellow	(-) Limit 4	24 Vdc	brown	white	24 Vdc
	94	Yellow	(-) Limit 4	Com	blue	black	Com
	95	Yellow	(-) Limit 4	Dark On	white	Not Used	
	96	Yellow	(-) Limit 4	Light On	black	J4, p11	pink
24	97	Yellow	Brake 4	24 Vdc	white	blue	R4
	98	Yellow	Brake 4	Com	black	black	Com
25	99	Yellow	Encoder 4	5 Vdc	brown	X4, p4	orange
	100	Yellow	Encoder 4	Com	white, green	X4, p12	lt. green
	101	Yellow	Encoder 4	Clock +, MO +	purple	X4, p13	black/white
	102	Yellow	Encoder 4	Clock -, MO -	yellow	X4, p6	green
	103	Yellow	Encoder 4	Data +, SLO +	gray	X4, p14	brown/white
	104	Yellow	Encoder 4	Data -, SLO -	pink	X4, p5	yellow
	105	Yellow	Encoder 4	Shield	bare	X4, shell	bare
26	106	Blue	Motor 6	A	red	Amp 6, p1	red
	107	Blue	Motor 6	A'	white	Amp 6, p3	white
	108	Blue	Motor 6	B	green	Amp 6, p2	green
	109	Blue	Motor 6	B'	black	Amp 6, p4	black
27	110	Blue	(+) Limit 6	24 Vdc	brown	white	24 Vdc
	111	Blue	(+) Limit 6	Com	blue	black	Com
	112	Blue	(+) Limit 6	Dark On	white	Not Used	
	113	Blue	(+) Limit 6	Light On	black	J5, p17	green/white
28	114	Blue	(-) Limit 6	24 Vdc	brown	white	24 Vdc
	115	Blue	(-) Limit 6	Com	blue	black	Com
	116	Blue	(-) Limit 6	Dark On	white	Not Used	
	117	Blue	(-) Limit 6	Light On	black	J5, p5	yellow
29	118	Blue	Brake 6	24 Vdc	white	blue	R6
	119	Blue	Brake 6	Com	black	black	Com
30	120	Blue	Encoder 6	5 Vdc	brown	X6, p4	orange
	121	Blue	Encoder 6	Com	white, green	X6, p12	lt. green
	122	Blue	Encoder 6	Clock +, MO +	purple	X6, p13	black/white
	123	Blue	Encoder 6	Clock -, MO -	yellow	X6, p6	green
	124	Blue	Encoder 6	Data +, SLO +	gray	X6, p14	brown/white
	125	Blue	Encoder 6	Data -, SLO -	pink	X6, p5	yellow
	126	Blue	Encoder 6	Shield	bare	X6, shell	bare

Electical Junction Box - Terminal Block Wiring List

DESY-FFT Tri-Sphere

Terminal #	Jack Color	Device	Description	Wire Color (bottom)	FFT connector, pin #	Wire Color (top)	Internal Connection
1	Red	Motor 1	A	red	Motor 1, p1	red	
2	Red	Motor 1	A'	white	Motor 1, p2	white	
3	Red	Motor 1	B	green	Motor 1, p5	green	
4	Red	Motor 1	B'	black	Motor 1, p6	black	
5	Red	(+) Limit 1	24 Vdc	brown	Motor 1, p4	white	jumper
6	Red	(-) Limit 1	24 Vdc	brown			jumper
7	Red	(+) Limit 1	Com	blue	Motor 1, p3	black	jumper
8	Red	(-) Limit 1	Com	blue			jumper
9	Red	(+) Limit 1	Dark On	white	Not Used		
10	Red	(+) Limit 1	Light On	black	Motor 1, p7	red	
11	Red	(-) Limit 1	Dark On	white	Not Used		
12	Red	(-) Limit 1	Light On	black	Motor 1, p8	green	
13	Red	Brake 1	24 Vdc	white	Brake 1 p1	white	
14	Red	Brake 1	Com	black	Brake 1 p2	black	
15	Red	Encoder 1	5 Vdc	brown	Encoder 1, p7	white	
16	Red	Encoder 1	Com	white, green	Encoder 1, p8	black	
17	Red	Encoder 1	Clock +, MO +	purple	Encoder 1, p1	red	
18	Red	Encoder 1	Clock -, MO -	yellow	Encoder 1, p2	blue	
19	Red	Encoder 1	Data +, SLO +	gray	Encoder 1, p3	green	
20	Red	Encoder 1	Data -, SLO -	pink	Encoder 1, p4	brown	
21	Red	Encoder 1	Shield	bare	Encoder 1, p12	bare	
22	Yellow	Motor 3	A	red	Motor 3, p1	red	
23	Yellow	Motor 3	A'	white	Motor 3, p2	white	
24	Yellow	Motor 3	B	green	Motor 3, p5	green	
25	Yellow	Motor 3	B'	black	Motor 3, p6	black	
26	Yellow	(+) Limit 3	24 Vdc	brown	Motor 3, p4	white	jumper
27	Yellow	(-) Limit 3	24 Vdc	brown			jumper
28	Yellow	(+) Limit 3	Com	blue	Motor 3, p3	black	jumper
29	Yellow	(-) Limit 3	Com	blue			jumper
30	Yellow	(+) Limit 3	Dark On	white	Not Used		
31	Yellow	(+) Limit 3	Light On	black	Motor 3, p7	red	
32	Yellow	(-) Limit 3	Dark On	white	Not Used		
33	Yellow	(-) Limit 3	Light On	black	Motor 3, p8	green	
34	Yellow	Brake 3	24 Vdc	white	Brake 3 p1	white	
35	Yellow	Brake 3	Com	black	Brake 3 p2	black	
36	Yellow	Encoder 3	5 Vdc	brown	Encoder 3, p7	white	
37	Yellow	Encoder 3	Com	white, green	Encoder 3, p8	black	
38	Yellow	Encoder 3	Clock +, MO +	purple	Encoder 3, p1	red	
39	Yellow	Encoder 3	Clock -, MO -	yellow	Encoder 3, p2	blue	
40	Yellow	Encoder 3	Data +, SLO +	gray	Encoder 3, p3	green	
41	Yellow	Encoder 3	Data -, SLO -	pink	Encoder 3, p4	brown	
42	Yellow	Encoder 3	Shield	bare	Encoder 3, p12	bare	
43	Blue	Motor 5	A	red	Motor 5, p1	red	
44	Blue	Motor 5	A'	white	Motor 5, p2	white	
45	Blue	Motor 5	B	green	Motor 5, p5	green	
46	Blue	Motor 5	B'	black	Motor 5, p6	black	
47	Blue	(+) Limit 5	24 Vdc	brown	Motor 5, p4	white	jumper
48	Blue	(-) Limit 5	24 Vdc	brown			jumper
49	Blue	(+) Limit 5	Com	blue	Motor 5, p3	black	jumper
50	Blue	(-) Limit 5	Com	blue			jumper
51	Blue	(+) Limit 5	Dark On	white	Not Used		
52	Blue	(+) Limit 5	Light On	black	Motor 5, p7	red	
53	Blue	(-) Limit 5	Dark On	white	Not Used		
54	Blue	(-) Limit 5	Light On	black	Motor 5, p8	green	
55	Blue	Brake 5	24 Vdc	white	Brake 5 p1	white	
56	Blue	Brake 5	Com	black	Brake 5 p2	black	
57	Blue	Encoder 5	5 Vdc	brown	Encoder 5, p7	white	
58	Blue	Encoder 5	Com	white, green	Encoder 5, p8	black	

59	Blue	Encoder 5	Clock +, MO +	purple	Encoder 5, p1	red	
60	Blue	Encoder 5	Clock -, MO -	yellow	Encoder 5, p2	blue	
61	Blue	Encoder 5	Data +, SLO +	gray	Encoder 5, p3	green	
62	Blue	Encoder 5	Data -, SLO -	pink	Encoder 5, p4	brown	
63	Blue	Encoder 5	Shield	bare	Encoder 5, p12	bare	
64	Red	Motor 2	A	red	Motor 2, p1	red	
65	Red	Motor 2	A'	white	Motor 2, p2	white	
66	Red	Motor 2	B	green	Motor 2, p5	green	
67	Red	Motor 2	B'	black	Motor 2, p6	black	
68	Red	(+) Limit 2	24 Vdc	brown	Motor 2, p4	white	jumper
69	Red	(-) Limit 2	24 Vdc	brown			jumper
70	Red	(+) Limit 2	Com	blue	Motor 2, p3	black	jumper
71	Red	(-) Limit 2	Com	blue			jumper
72	Red	(+) Limit 2	Dark On	white	Not Used		
73	Red	(+) Limit 2	Light On	black	Motor 2, p7	red	
74	Red	(-) Limit 2	Dark On	white	Not Used		
75	Red	(-) Limit 2	Light On	black	Motor 2, p8	green	
76	Red	Brake 2	24 Vdc	white	Brake 2 p1	white	
77	Red	Brake 2	Com	black	Brake 2 p2	black	
78	Red	Encoder 2	5 Vdc	brown	Encoder 2, p7	white	
79	Red	Encoder 2	Com	white, green	Encoder 2, p8	black	
80	Red	Encoder 2	Clock +, MO +	purple	Encoder 2, p1	red	
81	Red	Encoder 2	Clock -, MO -	yellow	Encoder 2, p2	blue	
82	Red	Encoder 2	Data +, SLO +	gray	Encoder 2, p3	green	
83	Red	Encoder 2	Data -, SLO -	pink	Encoder 2, p4	brown	
84	Red	Encoder 2	Shield	bare	Encoder 2, p12	bare	
85	Yellow	Motor 4	A	red	Motor 4, p1	red	
86	Yellow	Motor 4	A'	white	Motor 4, p2	white	
87	Yellow	Motor 4	B	green	Motor 4, p5	green	
88	Yellow	Motor 4	B'	black	Motor 4, p6	black	
89	Yellow	(+) Limit 4	24 Vdc	brown	Motor 4, p4	white	jumper
90	Yellow	(-) Limit 4	24 Vdc	brown			jumper
91	Yellow	(+) Limit 4	Com	blue	Motor 4, p3	black	jumper
92	Yellow	(-) Limit 4	Com	blue			jumper
93	Yellow	(+) Limit 4	Dark On	white	Not Used		
94	Yellow	(+) Limit 4	Light On	black	Motor 4, p7	red	
95	Yellow	(-) Limit 4	Dark On	white	Not Used		
96	Yellow	(-) Limit 4	Light On	black	Motor 4, p8	green	
97	Yellow	Brake 4	24 Vdc	white	Brake 4 p1	white	
98	Yellow	Brake 4	Com	black	Brake 4 p2	black	
99	Yellow	Encoder 4	5 Vdc	brown	Encoder 4, p7	white	
100	Yellow	Encoder 4	Com	white, green	Encoder 4, p8	black	
101	Yellow	Encoder 4	Clock +, MO +	purple	Encoder 4, p1	red	
102	Yellow	Encoder 4	Clock -, MO -	yellow	Encoder 4, p2	blue	
103	Yellow	Encoder 4	Data +, SLO +	gray	Encoder 4, p3	green	
104	Yellow	Encoder 4	Data -, SLO -	pink	Encoder 4, p4	brown	
105	Yellow	Encoder 4	Shield	bare	Encoder 4, p12	bare	
106	Blue	Motor 6	A	red	Motor 6, p1	red	
107	Blue	Motor 6	A'	white	Motor 6, p2	white	
108	Blue	Motor 6	B	green	Motor 6, p5	green	
109	Blue	Motor 6	B'	black	Motor 6, p6	black	
110	Blue	(+) Limit 6	24 Vdc	brown	Motor 6, p4	white	jumper
111	Blue	(-) Limit 6	24 Vdc	brown			jumper
112	Blue	(+) Limit 6	Com	blue	Motor 6, p3	black	jumper
113	Blue	(-) Limit 6	Com	blue			jumper
114	Blue	(+) Limit 6	Dark On	white	Not Used		
115	Blue	(+) Limit 6	Light On	black	Motor 6, p7	red	
116	Blue	(-) Limit 6	Dark On	white	Not Used		
117	Blue	(-) Limit 6	Light On	black	Motor 6, p8	green	
118	Blue	Brake 6	24 Vdc	white	Brake 6 p1	white	
119	Blue	Brake 6	Com	black	Brake 6 p2	black	
120	Blue	Encoder 6	5 Vdc	brown	Encoder 6, p7	white	
121	Blue	Encoder 6	Com	white, green	Encoder 6, p8	black	
122	Blue	Encoder 6	Clock +, MO +	purple	Encoder 6, p1	red	
123	Blue	Encoder 6	Clock -, MO -	yellow	Encoder 6, p2	blue	

124	Blue	Encoder 6	Data +, SLO +	gray	Encoder 6, p3	green
125	Blue	Encoder 6	Data -, SLO -	pink	Encoder 6, p4	brown
126	Blue	Encoder 6	Shield	bare	Encoder 6, p12	bare

Termination Box Transfer Procedure

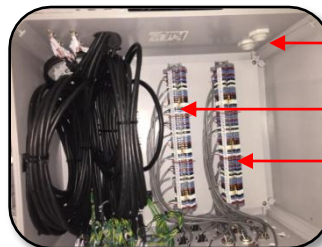
– Delta Tau Termination Box to FFT Termination Box) –

1. Remove all Tri-Sphere side (motors, encoders, brakes, limit switches) wires from the Delta Tau Termination Box's double stacked terminal blocks.
2. Insert all wires through FFT Termination Box (shared with Toyama) cable glands. These glands are located nearest the Yellow Actuator pair, on the bottom of the Termination Box. Pass the motor and brakes cables through one gland, and the encoders and limit switches through the other (see "*FFT-Tri_Sphere TB Wire List*").



Cable Glands

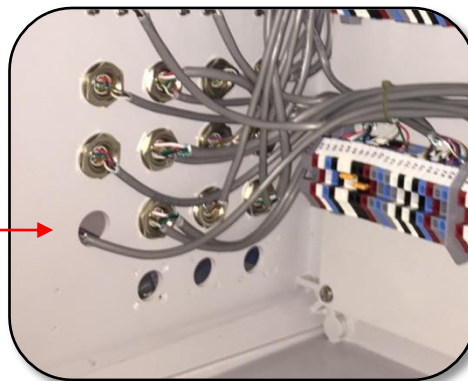
3. Using the "*FFT-Tri_Sphere TB Wire List*", land the wires in the corresponding numbered terminal block. The maximum tightening torque for these terminals is 0.5 N-m



Cable Glands

Numbered
terminal blocks

Note: There is a cable inside the FFT Termination Box that has been terminated with LEMO pins, but is not inserted into an accompanying connector. Once this missing connector has been installed, insert the pinned wires according to the adjacent connector.



Missing LEMO
connector

Memo

To: Tri-Sphere Users
CC:
Date: July 17, 2009
Re: Tri-Sphere Inverse Kinematics

This document describes the Inverse Kinematics for Square One's Tri-Sphere 6 degree of freedom positioning stage. These equations can be calculated to work with different coordinate systems and different rotational orders of operation. The equations given below are in Square One's default Tri-Sphere coordinate system.

FFT Tri - Sphere Configuration

Jack 1 Red

Null Position = [1150,100,0]

Travel Y (active 1) = ± 45

Travel Z (active 2) = ± 25

Jack 2 Yellow

Null Position = [0,0,0]

Travel X (active 3) = ± 45

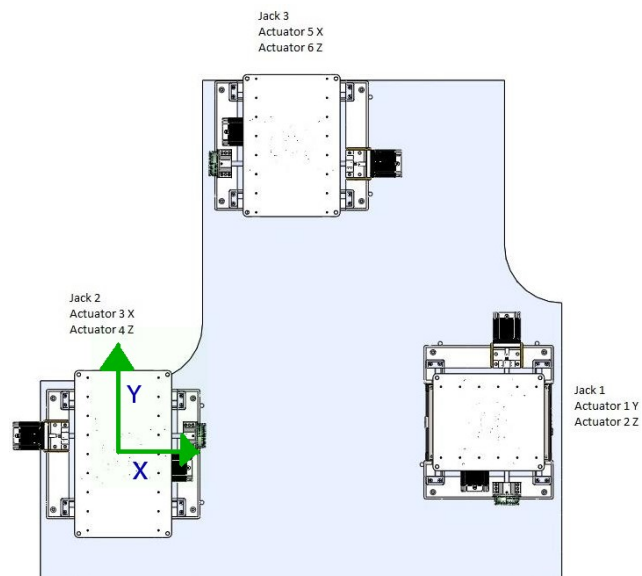
Travel Z (active 4) = ± 25

Jack 3 Blue

Null Position = [530,970,0]

Travel X (active 5) = ± 45

Travel Z (active 6) = ± 25



Transformation Matrix from Roll, Pitch, Yaw, Control Point and Target

$[TM]$ = transformation matrix

$[RM]$ = rotation matrix

$[Target]$ = target position of control point relative to origin of system

$[CP]$ = control point relative to origin of Tri – Sphere

$[angles]$ = $[roll, pitch, yaw]$

$$[roll] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(roll) & -\sin(roll) \\ 0 & \sin(roll) & \cos(roll) \end{bmatrix} = \text{about } y \text{ axis (parallel to active motion of red)}$$

$$[pitch] = \begin{bmatrix} \cos(pitch) & 0 & \sin(pitch) \\ 0 & 1 & 0 \\ -\sin(pitch) & 0 & \cos(pitch) \end{bmatrix} = \text{about } x \text{ axis (parallel to active motion of yellow and blue)}$$

$$[yaw] = \begin{bmatrix} \cos(yaw) & -\sin(yaw) & 0 \\ \sin(yaw) & \cos(yaw) & 0 \\ 0 & 0 & 1 \end{bmatrix} = \text{about } z \text{ axis (parallel vertical actuators)}$$

$$[RM] = [roll] * [pitch] * [yaw]$$

$$[CP_{rotated}] = [RM] * [CP]$$

$$[TM] = [RM] * ([Target] - [CP_{rotated}])$$

Jack 1 Actuator Inverse Kinematics from Transformation Matrix and Null Position

$$[X_{TNP}, Y_{TNP}, Z_{TNP}, 1] = [TNP] = \text{Transformed Null Position}$$

$$[X_{TPP}, Y_{TPP}, Z_{TPP}, 1] = [TTP] = \text{Transformed Passive Position}$$

$$[X_{NP}, Y_{NP}, Z_{NP}, 1] = [NP] = \text{Null Position}$$

$$[l, m, n, 0] = [SV] = \text{Slope Vector}$$

$$[TTP] = [TNP] + [1, 0, 0, 0]$$

$$[SV] = [TNP] - [TPP]$$

$$((X_{NP} - X_{TNP}) / l * m) = \Delta y$$

$$((X_{NP} - X_{TNP}) / l * n) = \Delta z$$

Jacks 2 and 3 Actuator Inverse Kinematics from Transformation Matrix and Null Position

$$[X_{TNP}, Y_{TNP}, Z_{TNP}, 1] = [TNP] = \text{Transformed Null Position}$$

$$[X_{TPP}, Y_{TPP}, Z_{TPP}, 1] = [TTP] = \text{Transformed Passive Position}$$

$$[X_{NP}, Y_{NP}, Z_{NP}, 1] = [NP] = \text{Null Position}$$

$$[l, m, n, 0] = [SV] = \text{Slope Vector}$$

$$[TTP] = [TNP] + [0, 1, 0, 0]$$

$$[SV] = [TNP] - [TPP]$$

$$((Y_{NP} - Y_{TNP}) / m * l) = \Delta y$$

$$((Y_{NP} - Y_{TNP}) / m * n) = \Delta z$$

Encoder and Limit values as installed at Desy FFT 6-23-2017

Square **One** Systems Design

	mm	counts		mm	counts
Vert Travel Soft		25 500000	Switch Travel		1 20000
Horz Travel Soft		45 900000			

			Hard stop +	Hard Stop -	Hard Travel	Center		Switch Location Calc+	Switch Location Calc -
Actuator 1	Red	Horz	Not Measured	Not Measured	1982738	1515490		2435490	595490
Actuator 2	Red	Vert	1856469	682630	1173839	1269550		1789550	749550
Actuator 3	Yellow	Horz	Not Measured	Not Measured	1975855	1517713		2437713	597713
Actuator 4	Yellow	Vert	1876964	715591	1161373	1296278		1816278	776278
Actuator 5	Blue	Horz	Not Measured	Not Measured	1983030	1496586		2416586	576586
Actuator 6	Blue	Vert	1868866	715982	1152884	1292424		1812424	772424
			Counts	Counts	Counts	Counts		Counts	Counts

			Switch Trigger +	Switch Trigger -	Encoder Limit +	Encoder Limit -		Travel Hard mm	Travel Encoder
Actuator 1	Red	Horz	Not Measured	Not Measured	2415490	615490		99.1369	90
Actuator 2	Red	Vert	1794355	737075	1769550	769550		58.69195	50
Actuator 3	Yellow	Horz	Not Measured	Not Measured	2417713	617713		98.79275	90
Actuator 4	Yellow	Vert	1863733	771655	1796278	796278		58.06865	50
Actuator 5	Blue	Horz	Not Measured	Not Measured	2396586	596586		99.1515	90
Actuator 6	Blue	Vert	1813422	760704	1792424	792424		57.6442	50
			Counts	Counts	Counts	Counts		mm	mm

Encoder Limits set in Motion Controller

Note: Hard Travel for each actuator measured prior to shipment from SQR-1