

Mobile Remote Robot Arm

2024.09.03

Lee Jae Pyeong

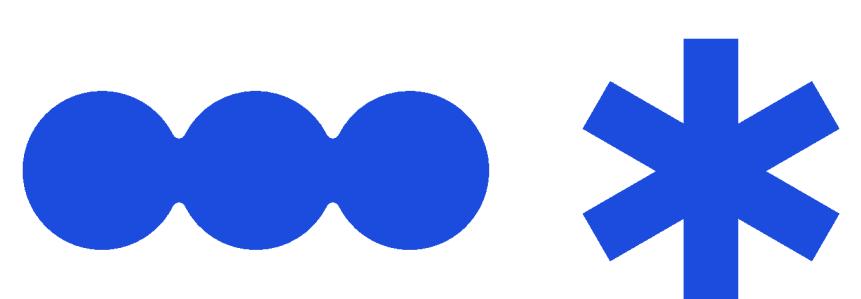
Lee Sang Won

Lee Jun Hee

HARMAN
ACADEMY 4TH



33248



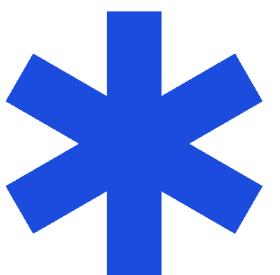
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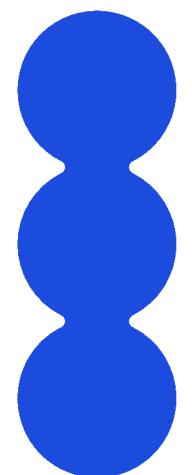
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LEE SANGWON

MECHANICAL DESIGN

&

MRRA_RX



LEE JAEPYEONG

PROJECT MANAGING

&

MRRA_BODY

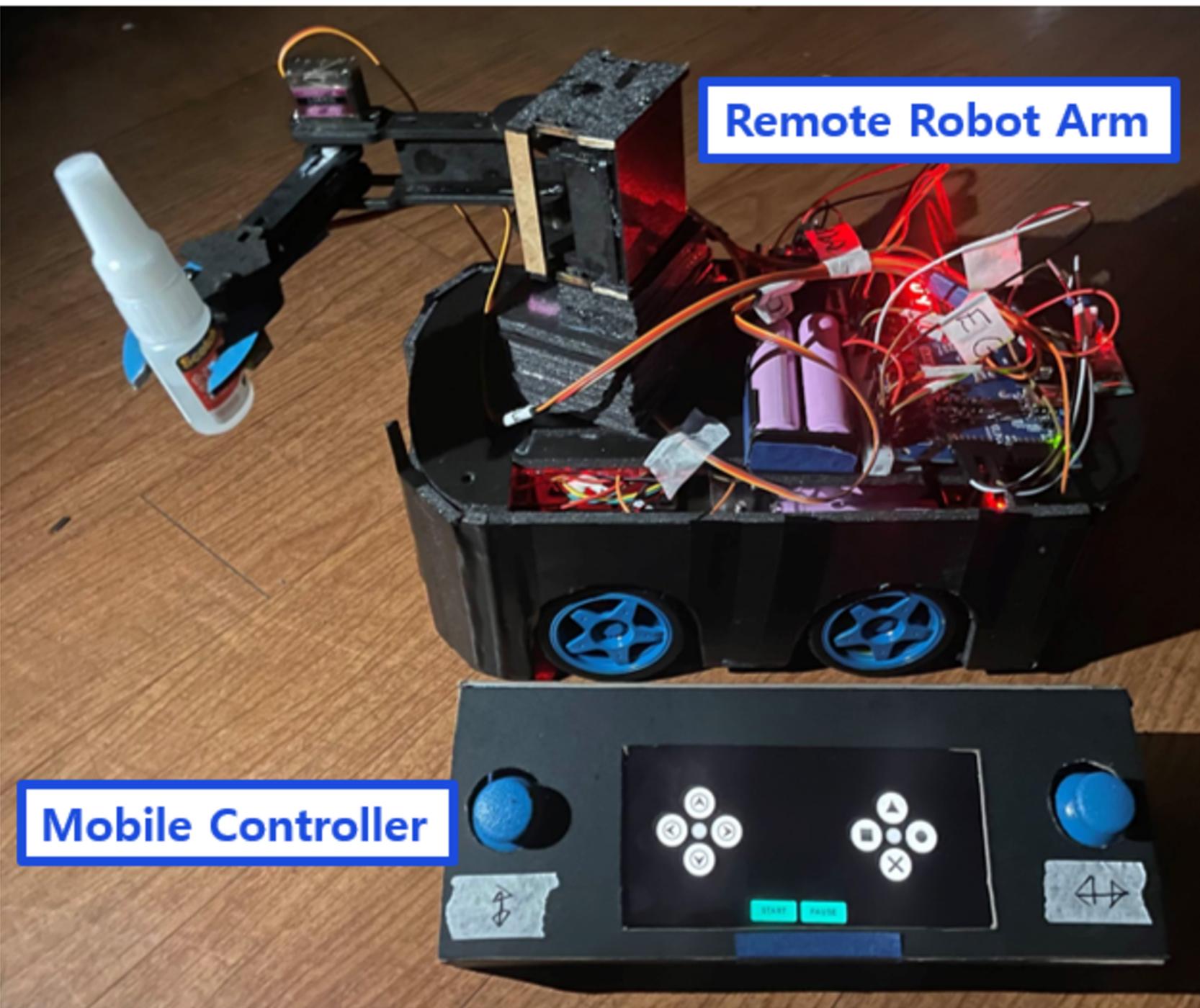


LEE JUNHEE

MECHANICAL DESIGN

&

MRRA_BASE



Inverse Kinematics (2DOF Manipulator)

$$\cos(\theta_2) = \frac{x^2 + y^2 - L_1^2 - L_2^2}{2L_1L_2}$$

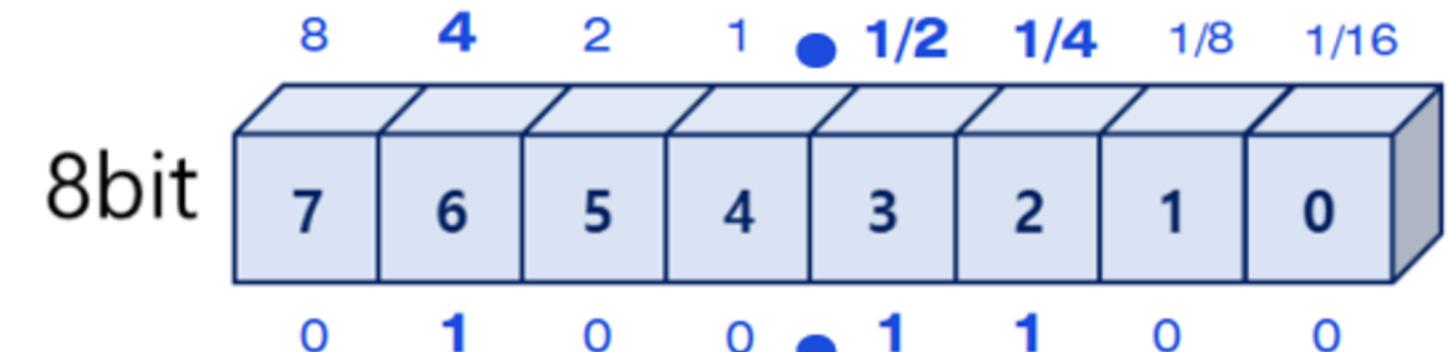
$$T_2 = \frac{L_2 \sin \theta_2}{L_1 + L_2 \cos \theta_2}$$

$$\theta_2 = \cos^{-1} \left(\frac{x^2 + y^2 - L_1^2 - L_2^2}{2L_1L_2} \right)$$

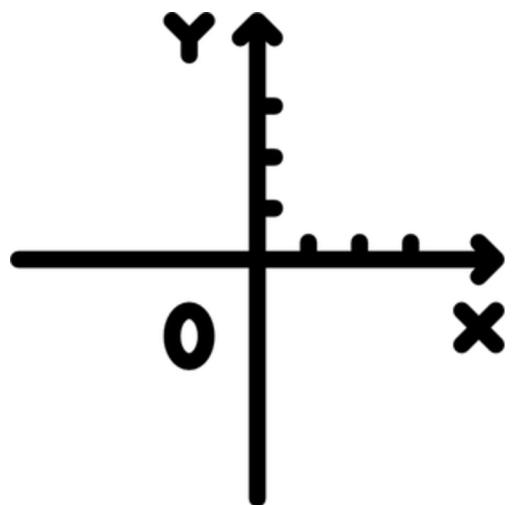
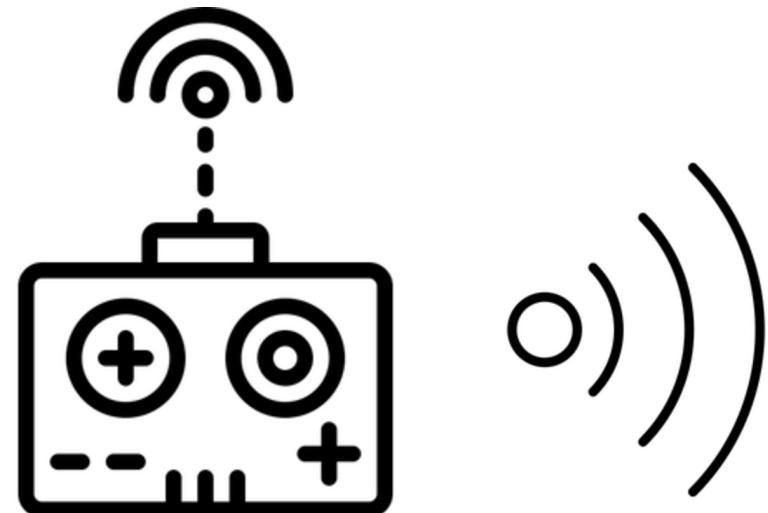
$$\theta_1 = \tan^{-1} \left(\frac{y}{x} \right) - \tan^{-1} (T_2)$$

Q Format (Fixed Point)

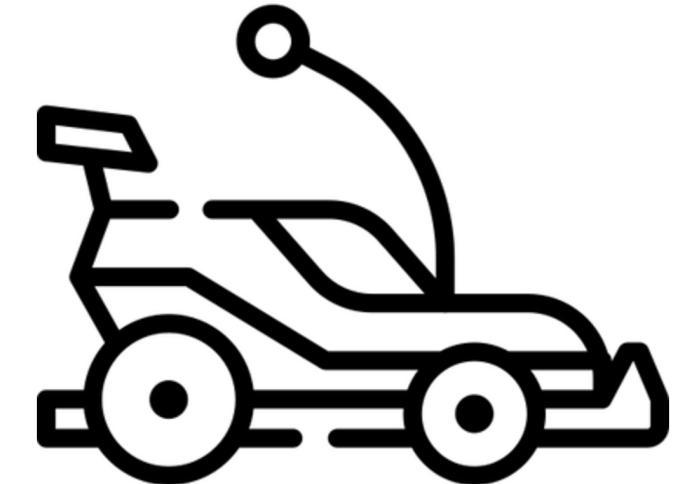
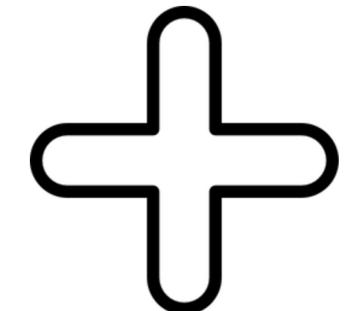
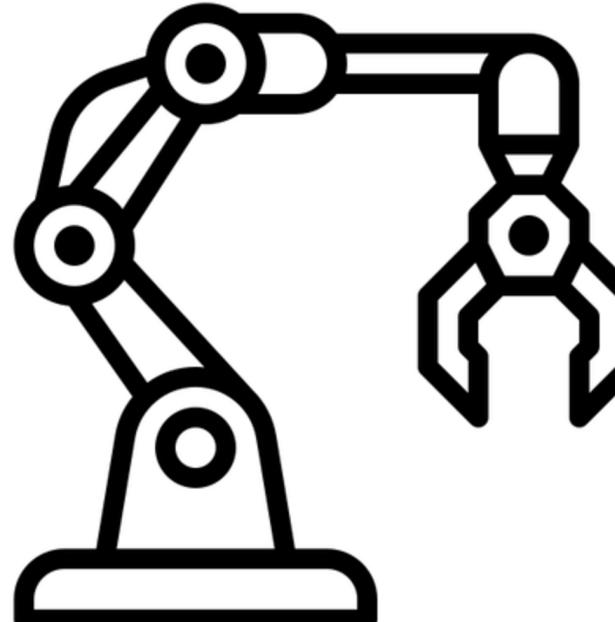
EX) $4.75 = 4 + 1/2 + 1/4$

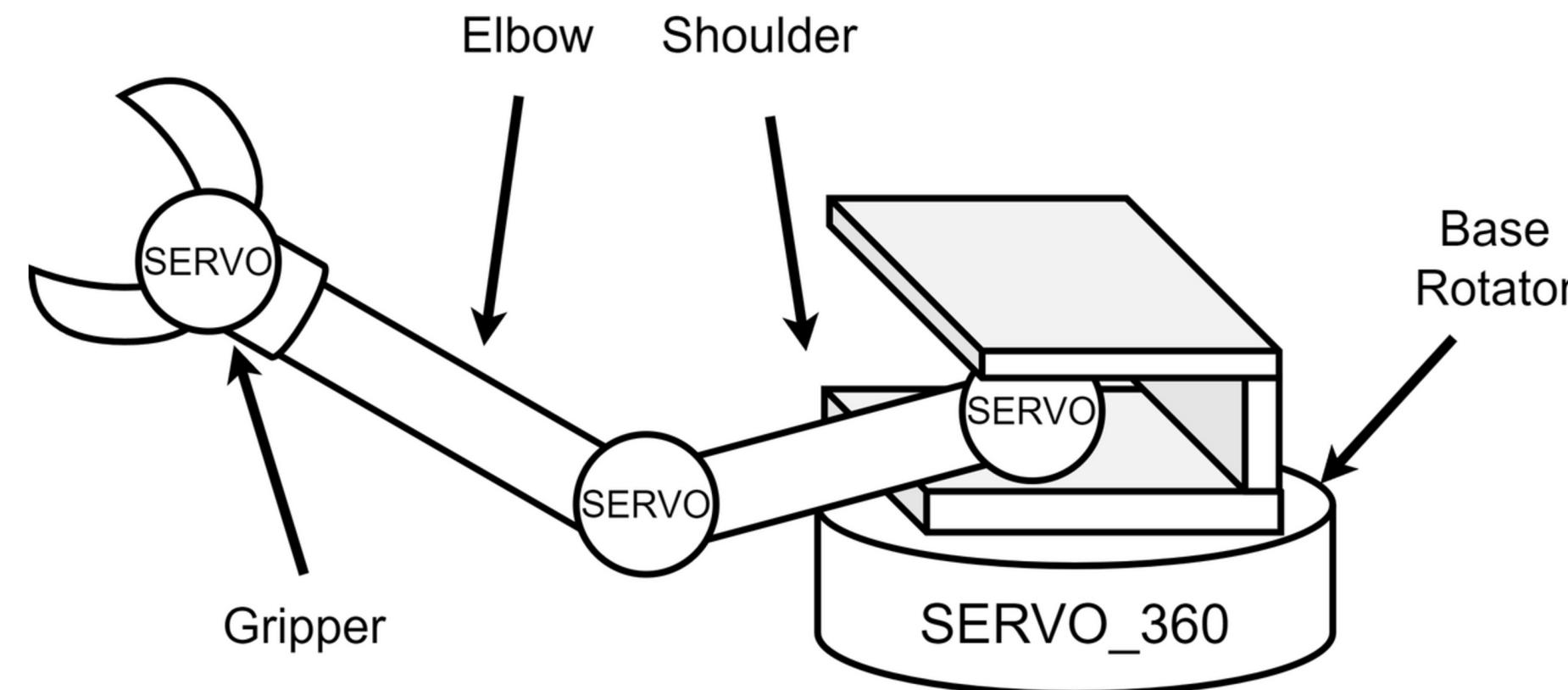


WIRELESS

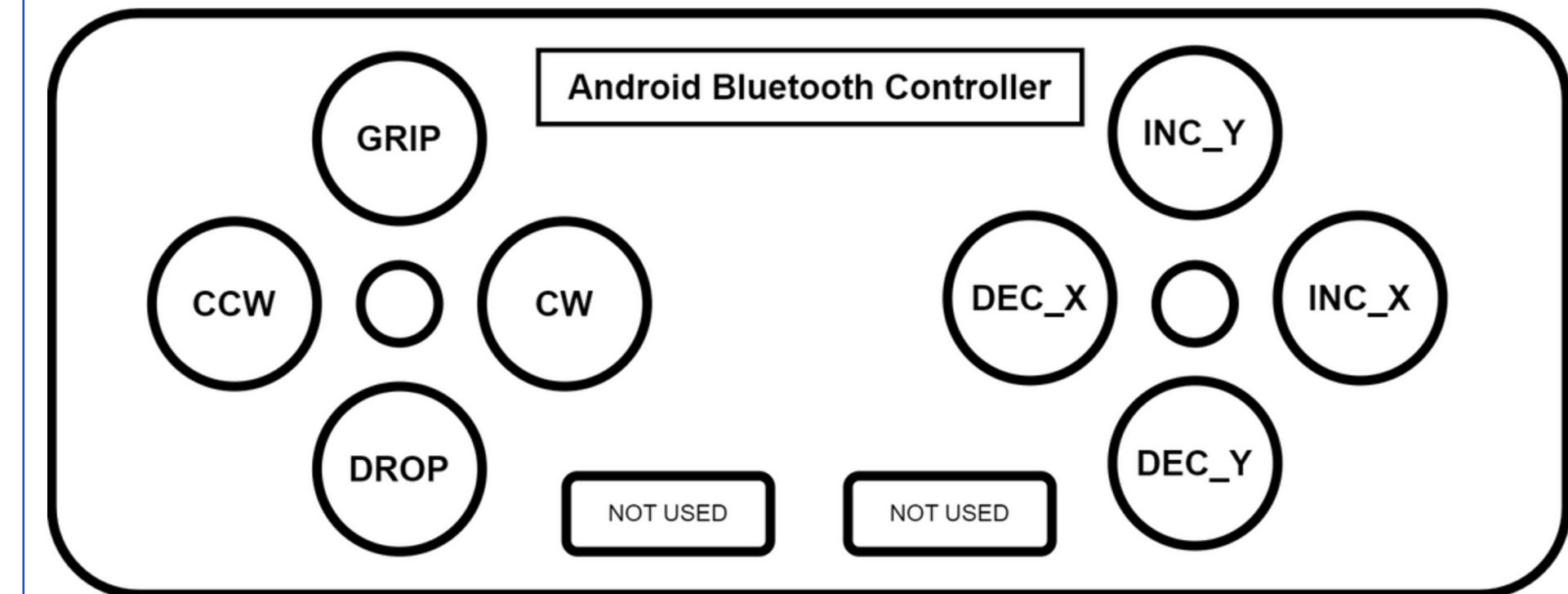


UTILITY



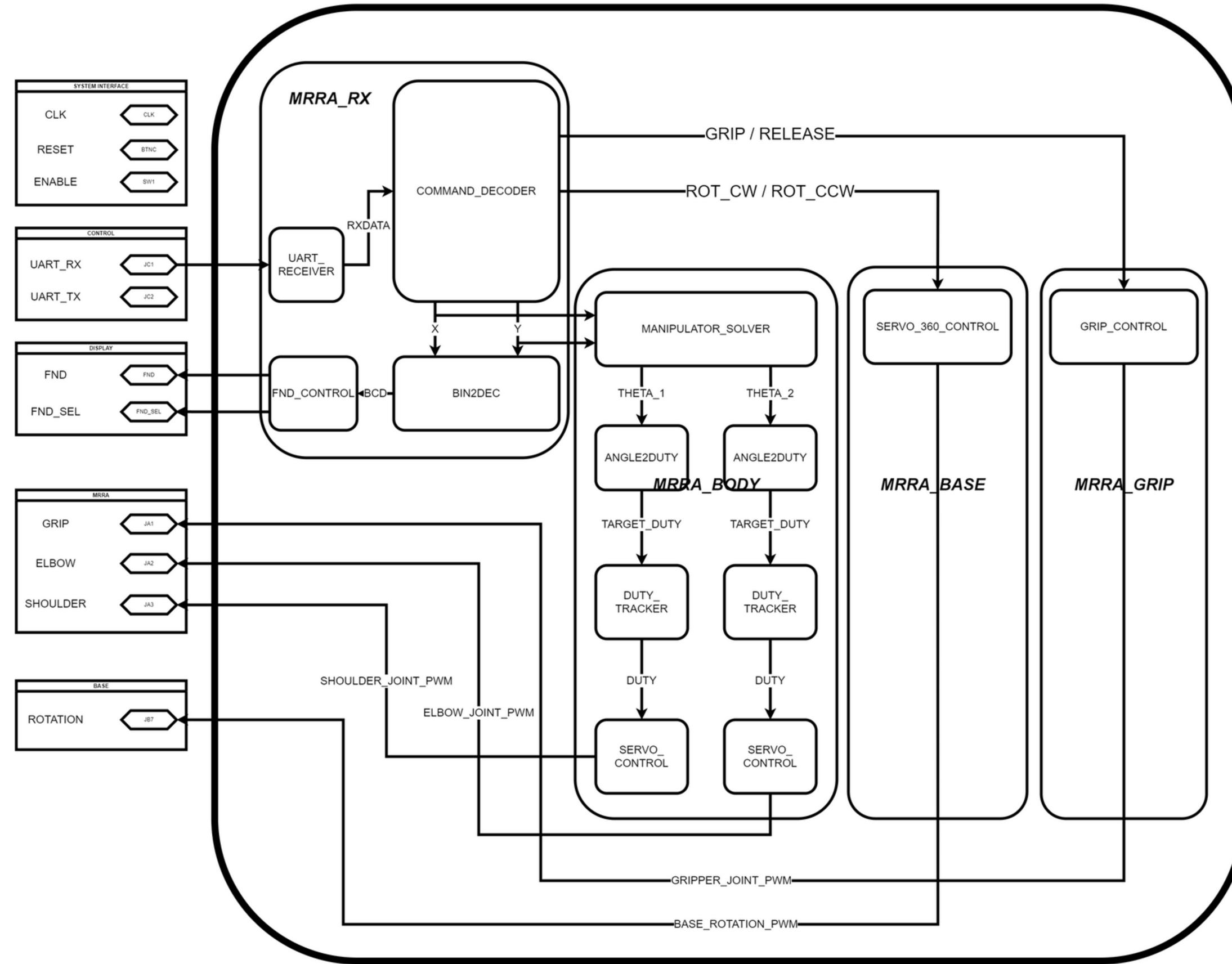


Mobile Remote Robot Arm

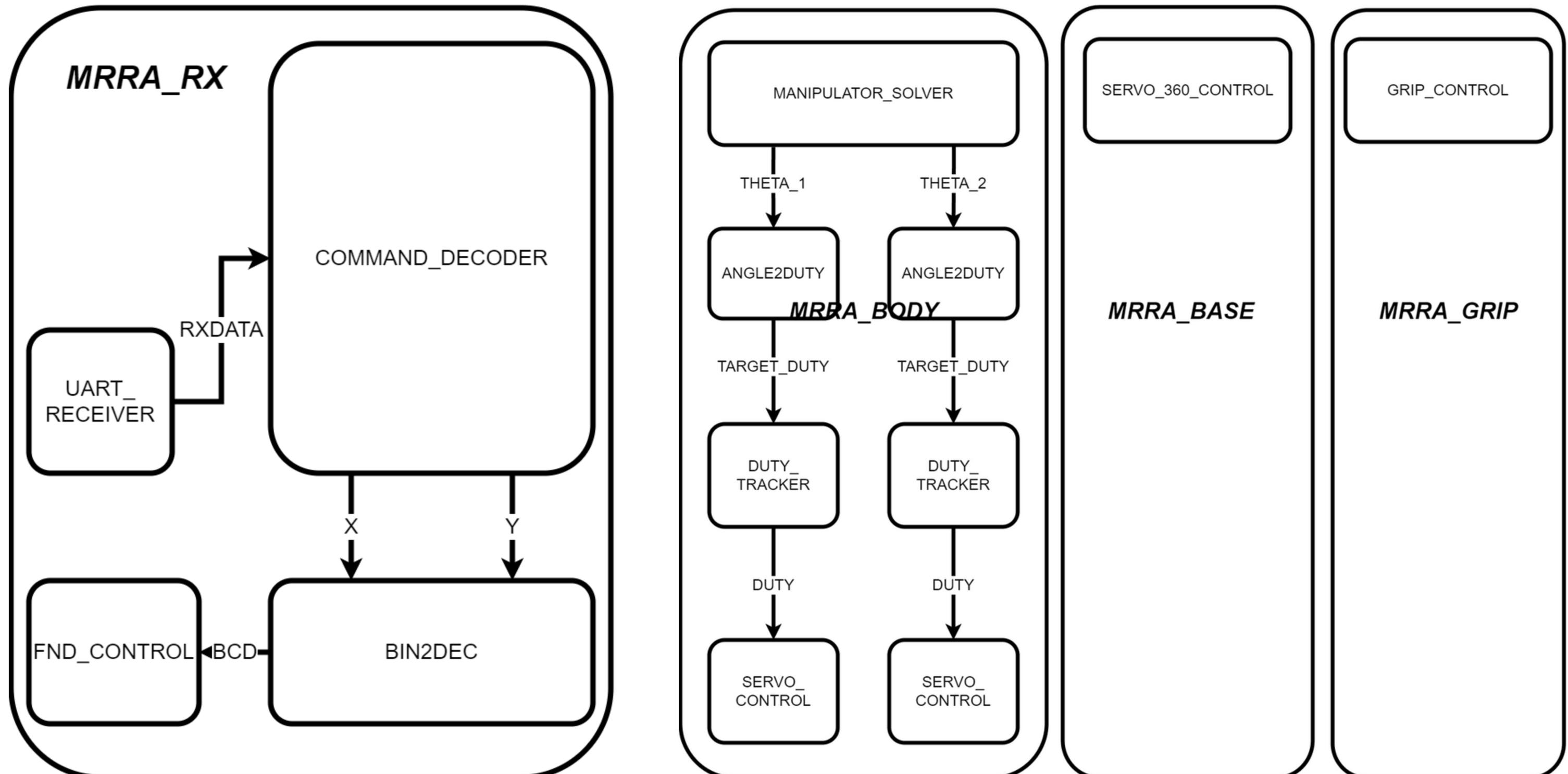


Mobile Remote Robot Arm Controller

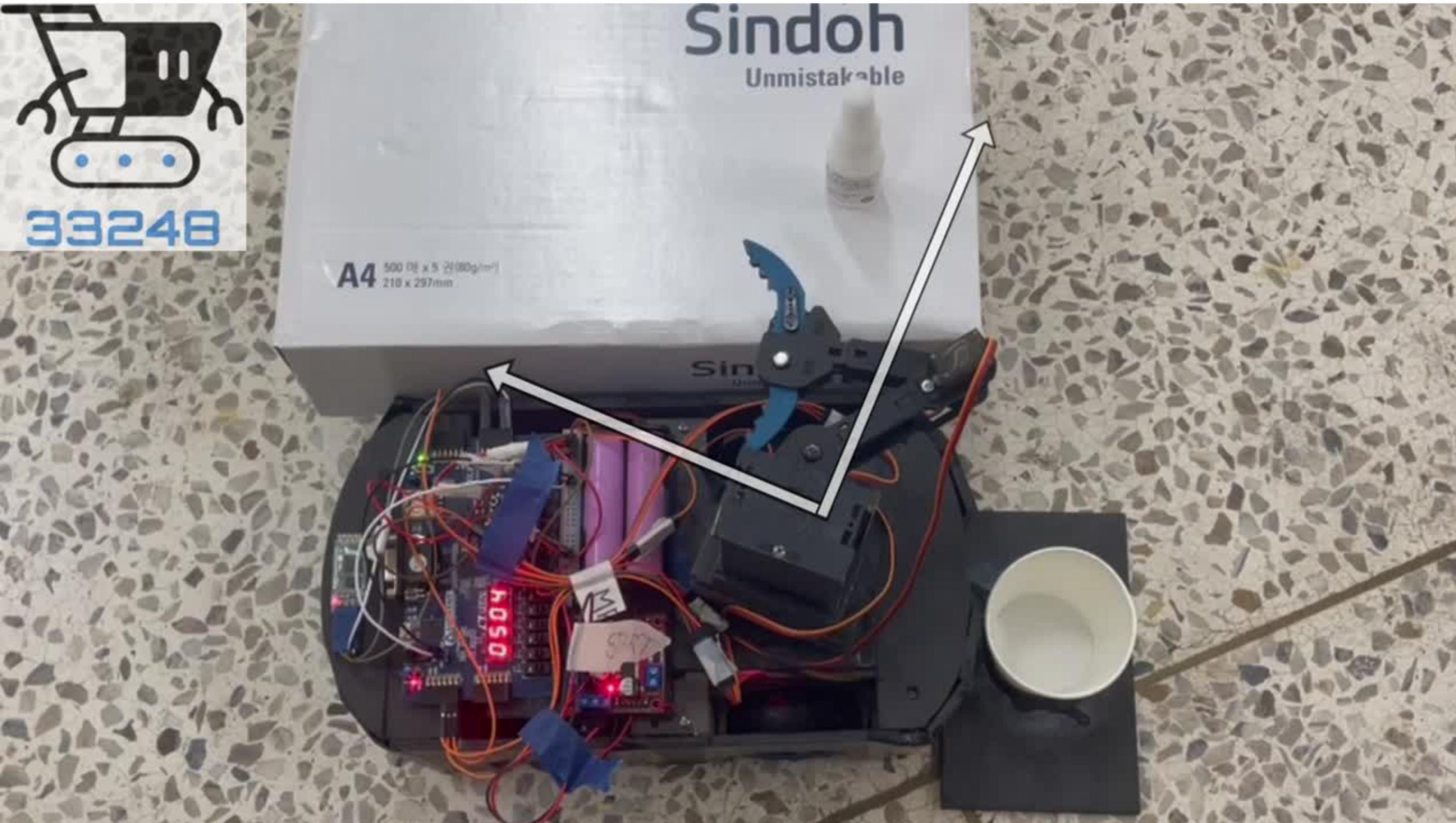
MobileRemoteRobotArm (MRRA)

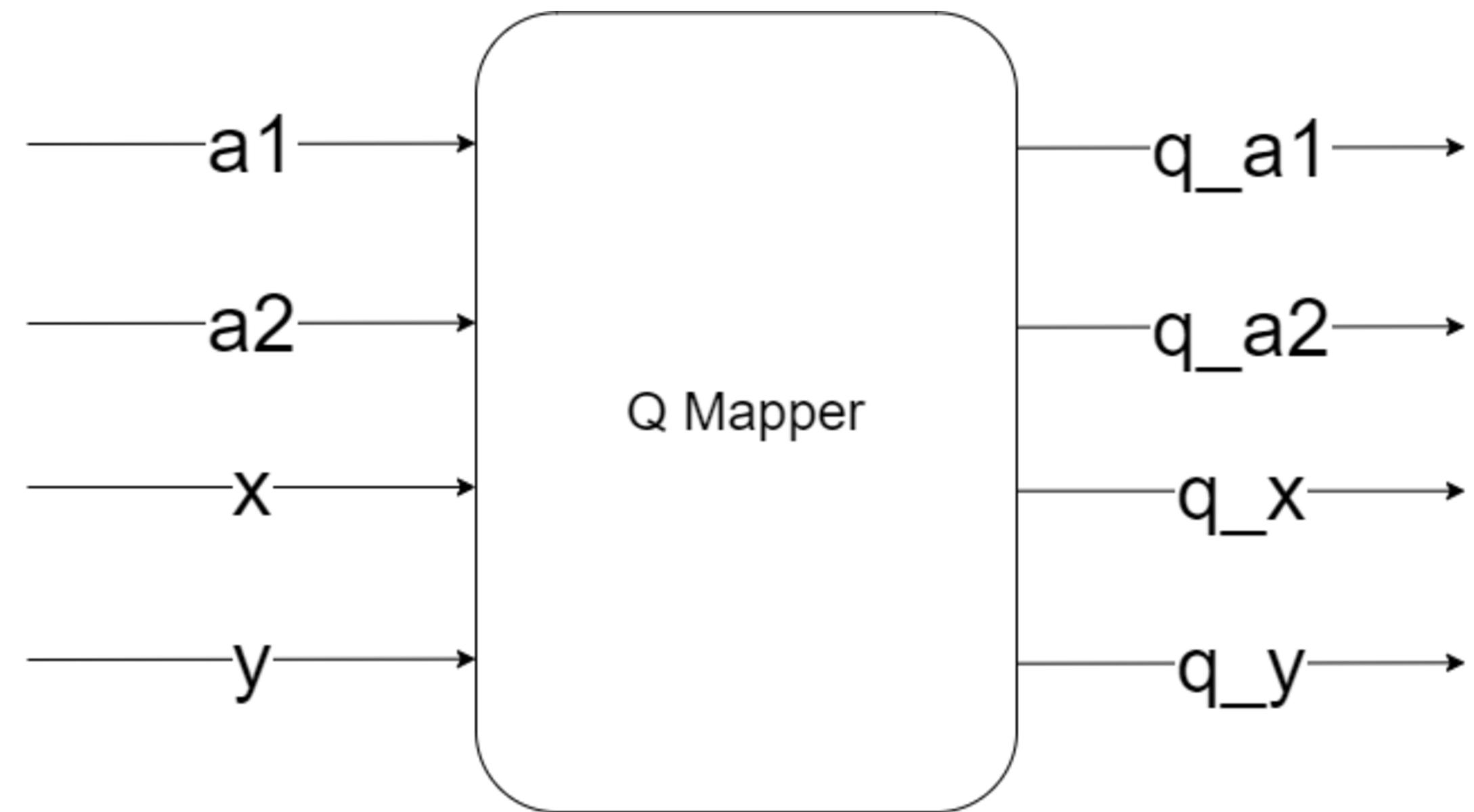
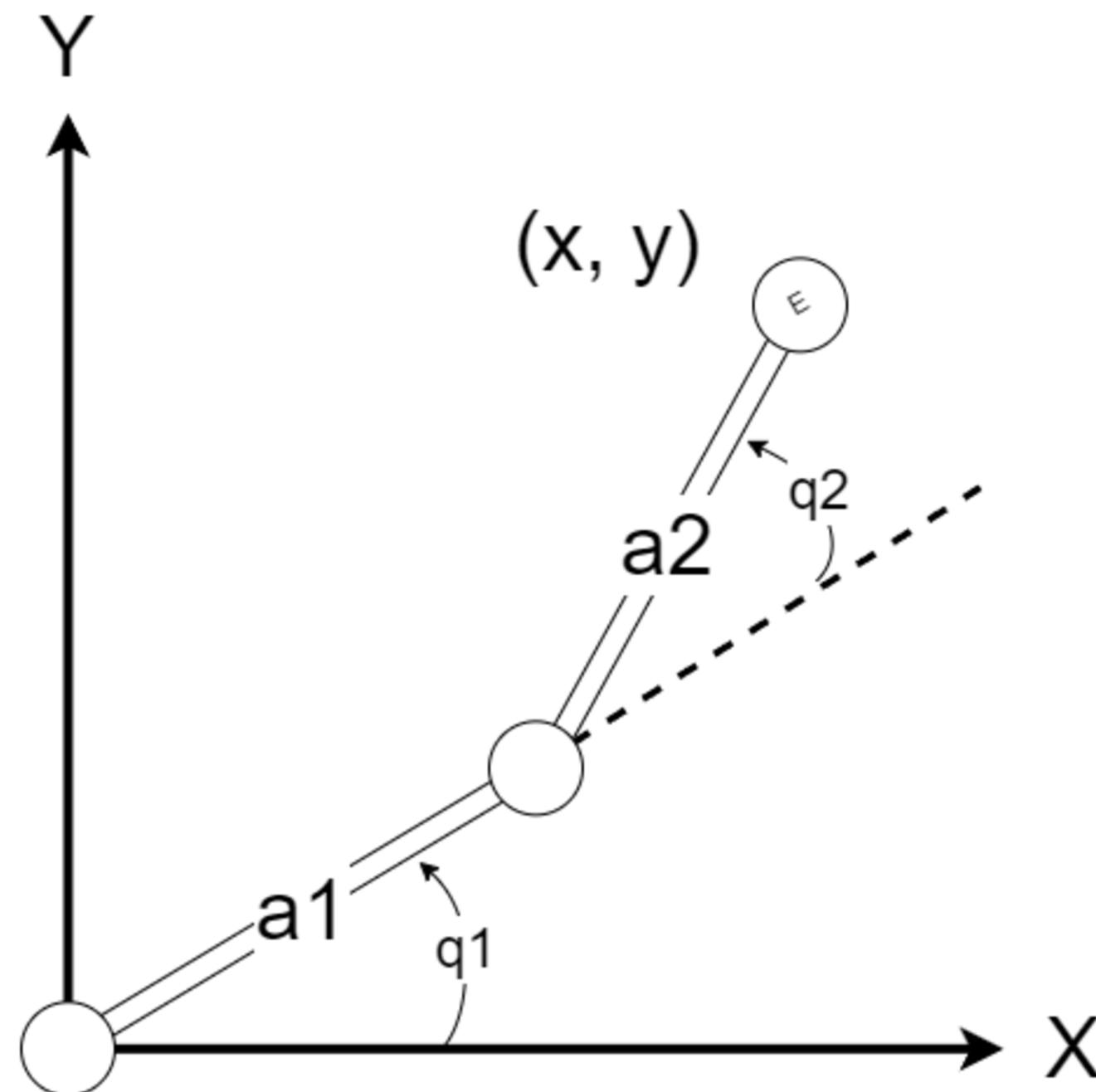


Block Diagram



Functional Demo (26s)

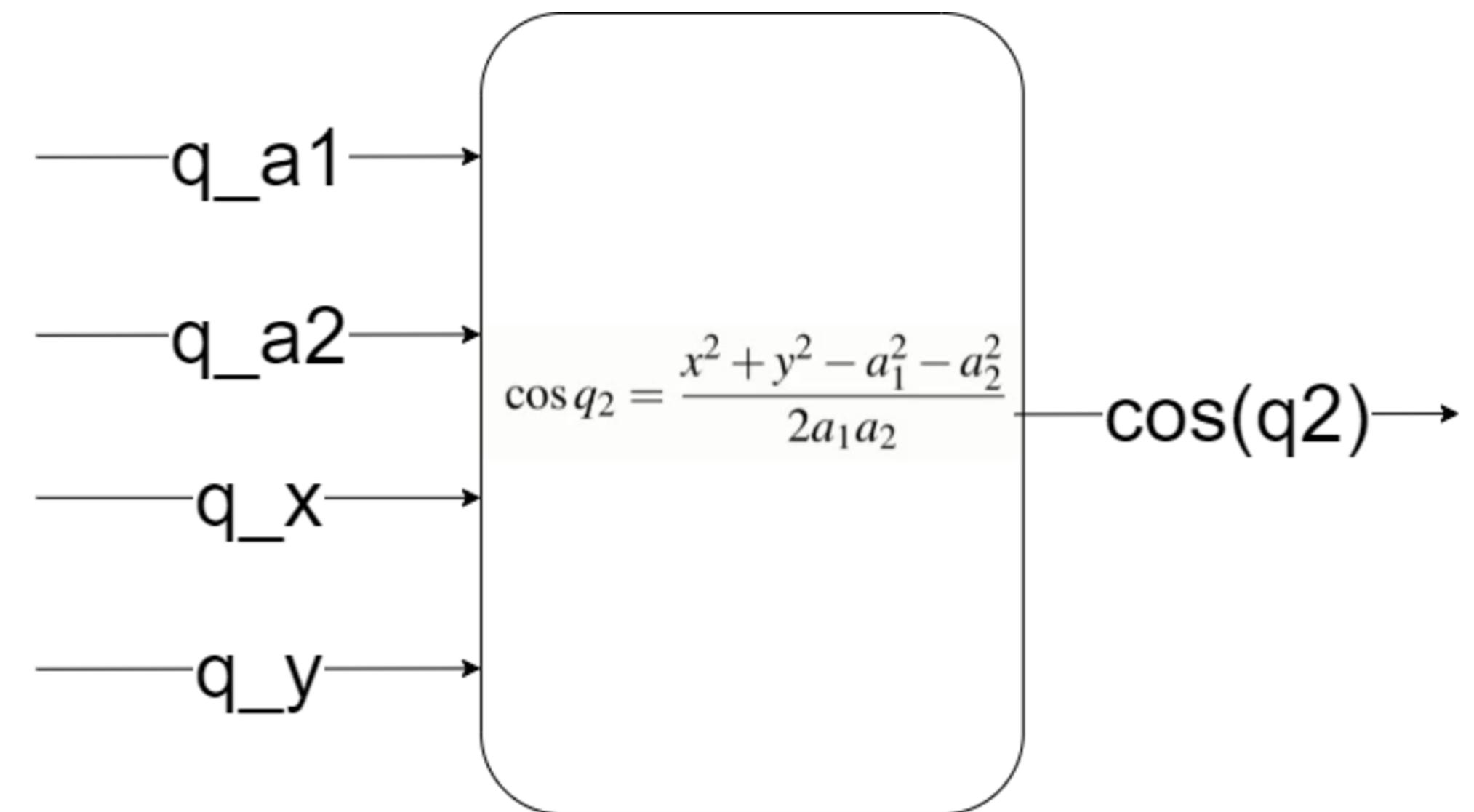
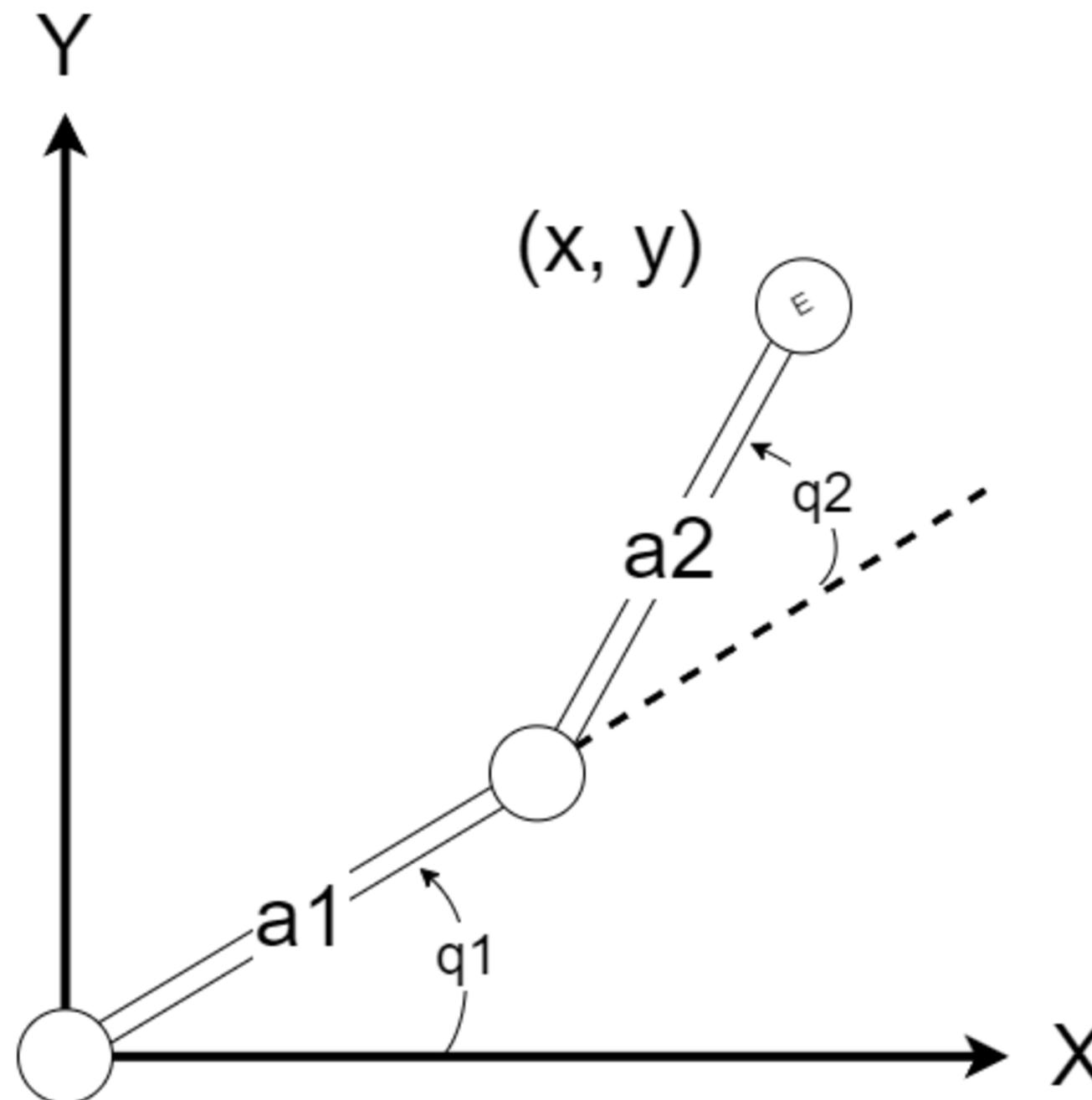




$$\cos(\theta_2) = \frac{x^2 + y^2 - L_1^2 - L_2^2}{2L_1L_2}$$

$$\theta_2 = \cos^{-1}\left(\frac{x^2 + y^2 - L_1^2 - L_2^2}{2L_1L_2}\right)$$

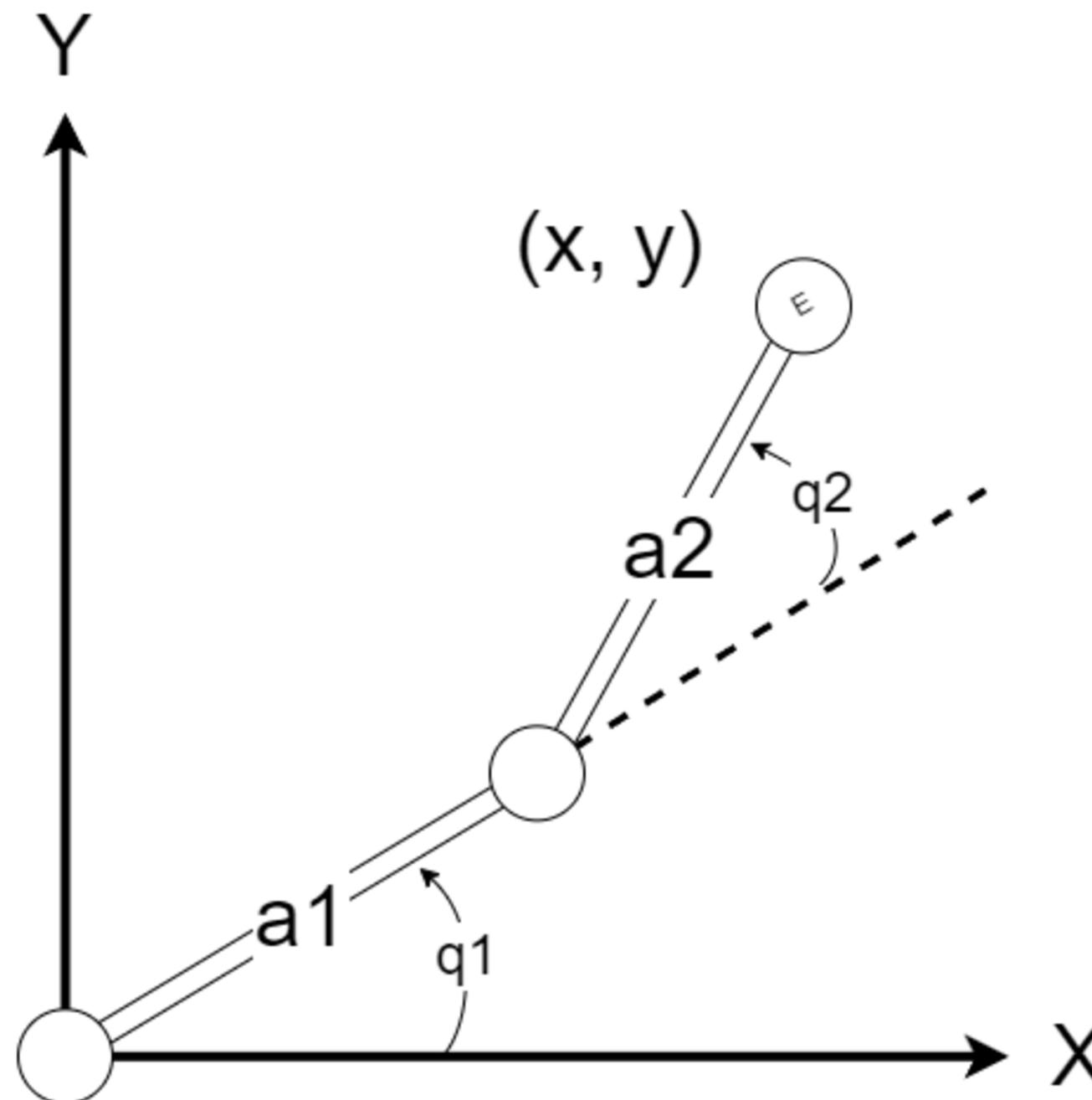
$$T_2 = \frac{L_2 \sin \theta_2}{L_1 + L_2 \cos \theta_2}$$



$$\cos(\theta_2) = \frac{x^2 + y^2 - L_1^2 - L_2^2}{2L_1L_2}$$

$$\theta_2 = \cos^{-1} \left(\frac{x^2 + y^2 - L_1^2 - L_2^2}{2L_1L_2} \right)$$

$$T_2 = \frac{L_2 \sin \theta_2}{L_1 + L_2 \cos \theta_2}$$



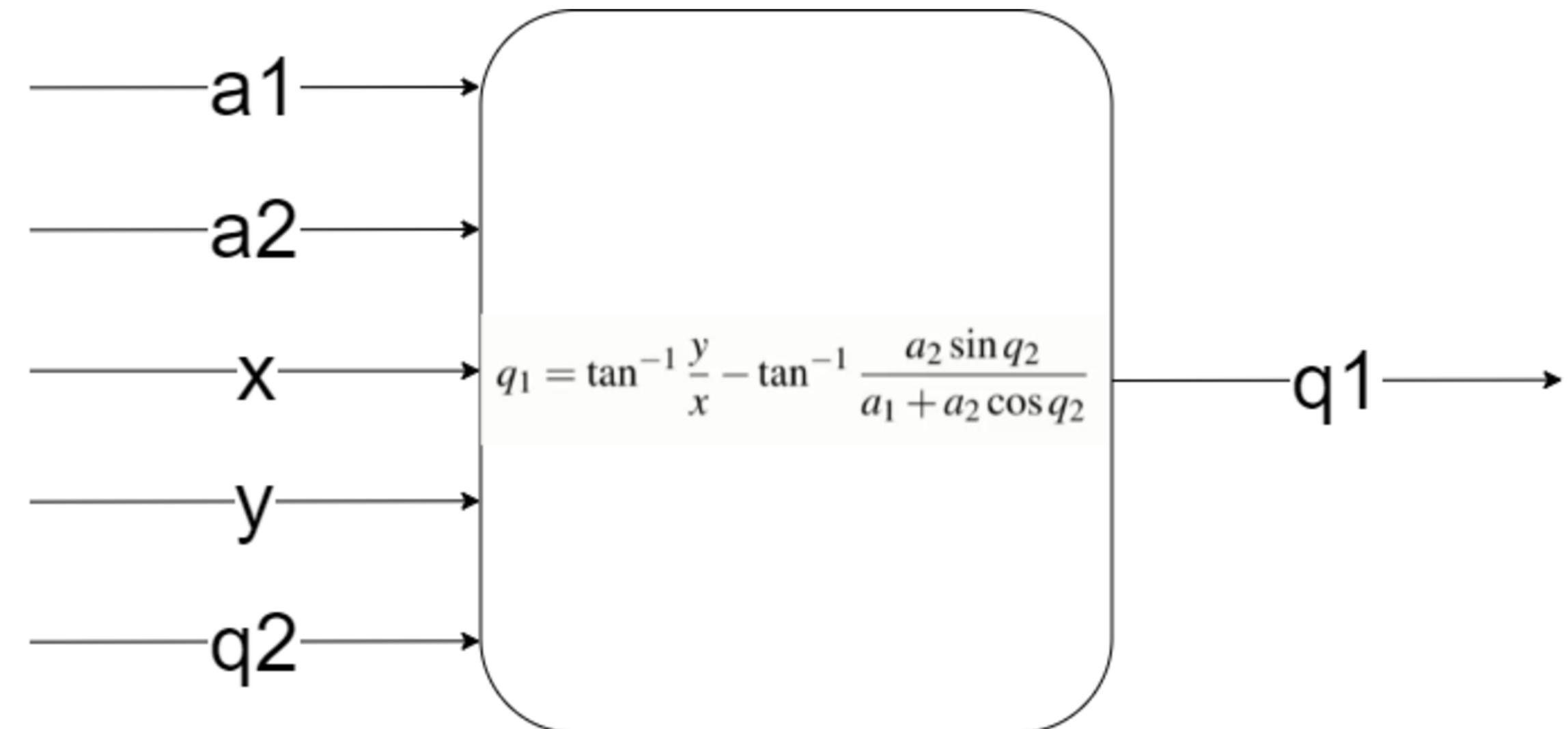
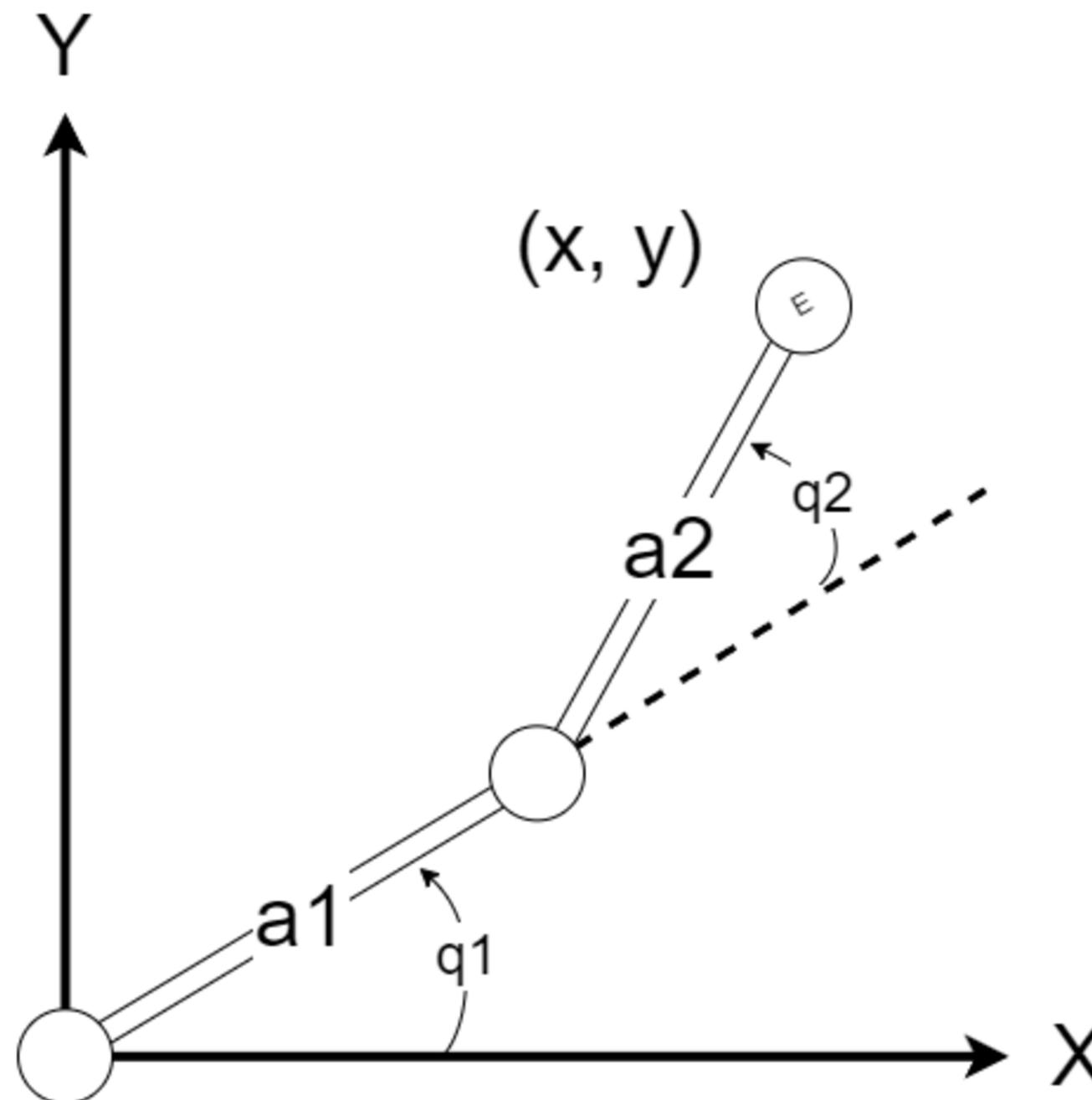
—cos(q2) →
$$q_2 = \cos^{-1} \frac{x^2 + y^2 - a_1^2 - a_2^2}{2a_1a_2}$$

q2 →

$$\cos(\theta_2) = \frac{x^2 + y^2 - L_1^2 - L_2^2}{2L_1L_2}$$

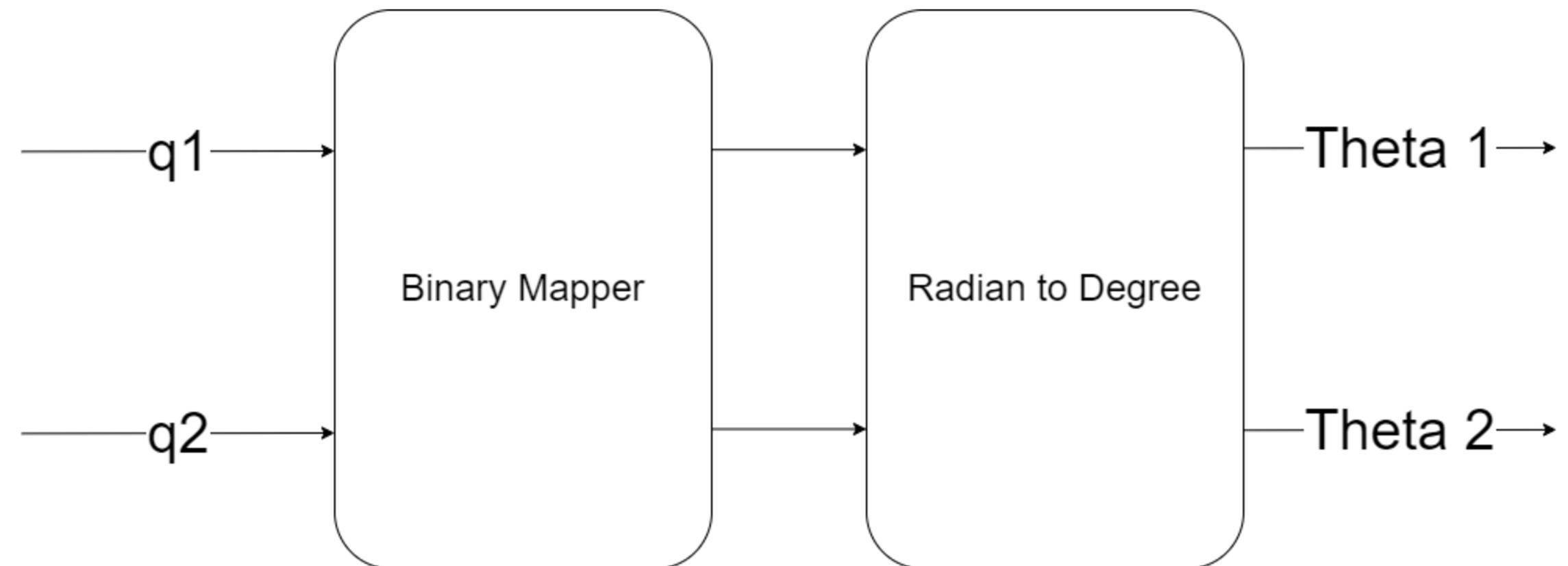
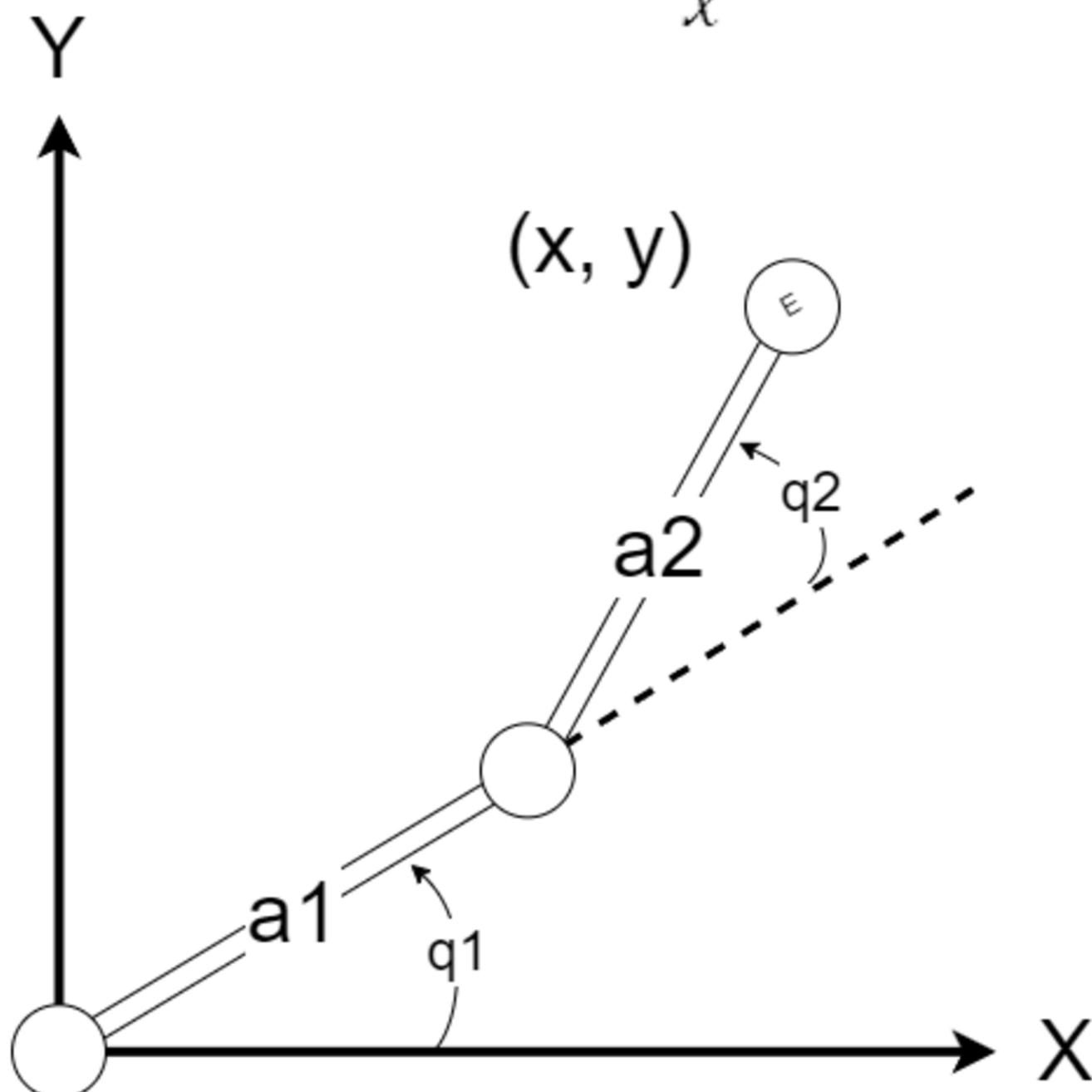
$$\theta_2 = \cos^{-1}\left(\frac{x^2 + y^2 - L_1^2 - L_2^2}{2L_1L_2}\right)$$

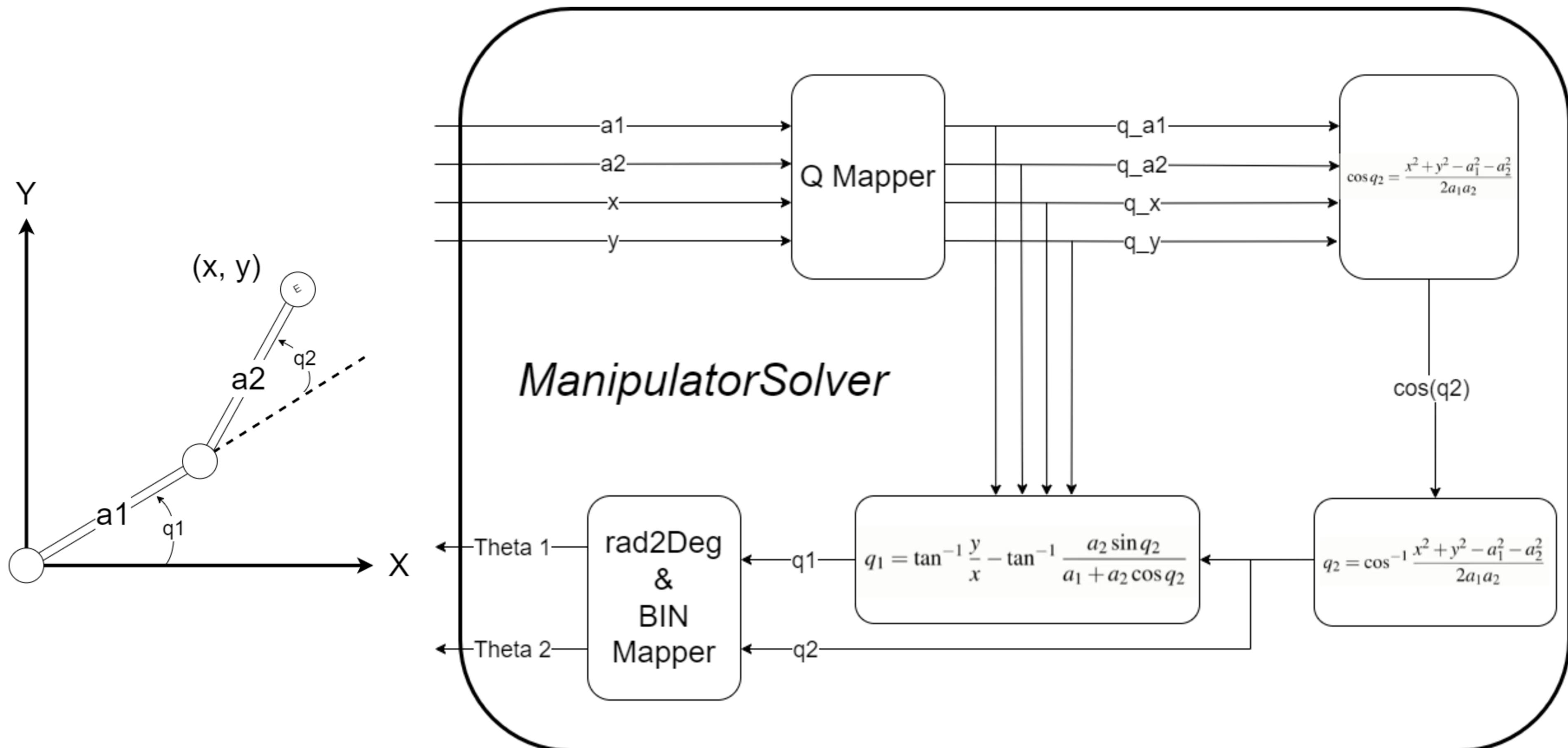
$$T_2 = \frac{L_2 \sin \theta_2}{L_1 + L_2 \cos \theta_2}$$

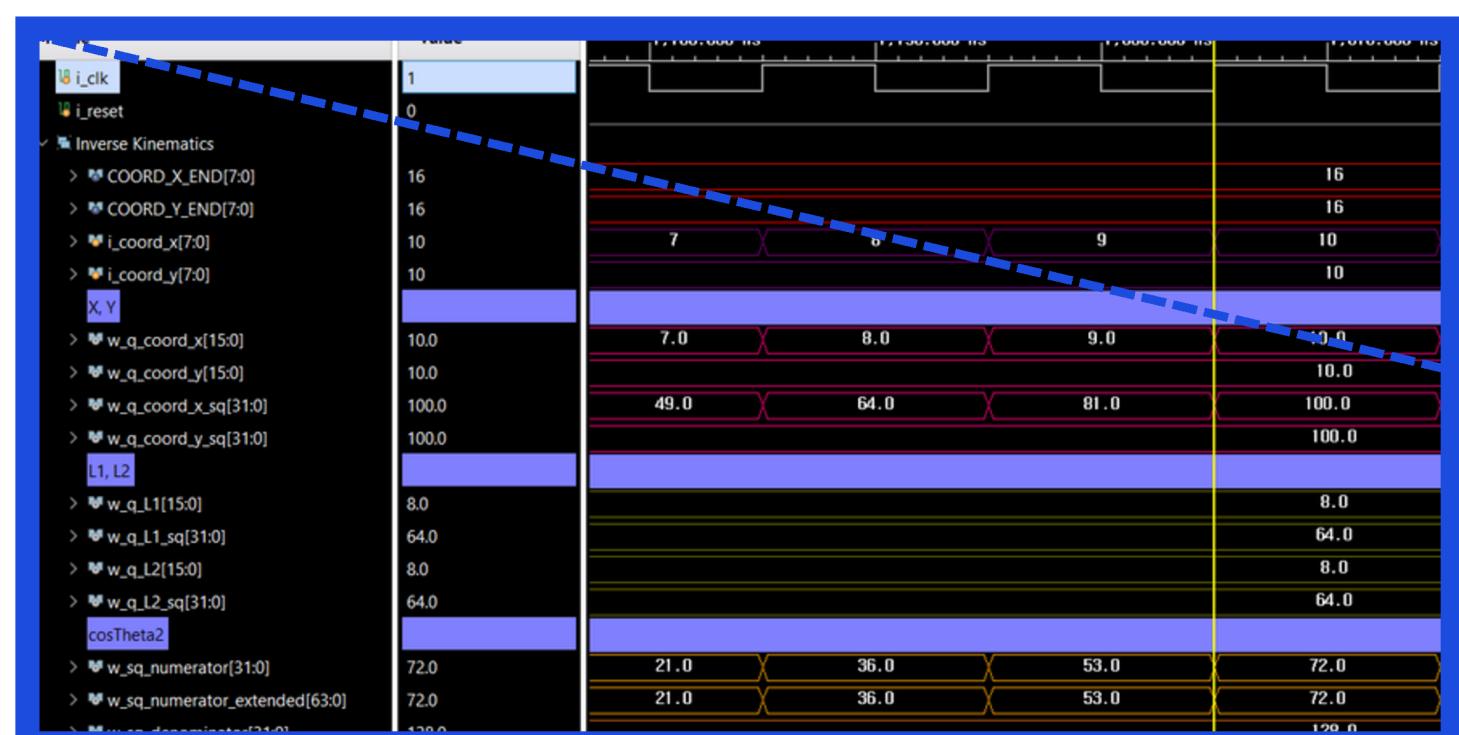


$$\theta_1 = \tan^{-1}\left(\frac{y}{x}\right) - \tan^{-1}(T_2)$$

$$\theta_2 = \cos^{-1}\left(\frac{x^2 + y^2 - L_1^2 - L_2^2}{2L_1L_2}\right)$$







COORD X	10.0
COORD Y	10.0
COORD X^2	100.0
COORD Y^2	100.0
L1^2	64.0
L2^2	64.0
NUMERATOR	72.0
DENOMINATOR	72.0

> w_cos_theta_2.temp[63:0]	0.5625
> w_cos_theta_2[15:0]	0.5625
> w_cos_theta_2[15:0]	144
Theta2	
> w_q_theta_2_rad[15:0]	0.97265625
> w_q_theta_2_rad[15:0]	249
sinTheta2	
> w_q_sin_theta_2[15:0]	0.828125
> w_q_sin_theta_2[15:0]	212
T2	
> w_sin_theta_2_numerator[31:0]	6.625
> w_sin_theta_2_numerator_extended[63]	6.625
> w_cos_theta_2_denominator[31:0]	12.5
> w_T2_temp[31:0]	0.529998779296875
> w_T2[15:0]	0.52734375
> w_T2[15:0]	135
Y/X	
> w_q_coord_y[15:0]	10.0
> w_q_coord_x[15:0]	10.0

COS(THETA2) 0.5625
THETA2_RAD 0.9726
NUMERATOR 6.625
DENOMINATOR 12.5
T2 0.5273

$$\theta_2 = \cos^{-1} \left(\frac{x^2 + y^2 - L_1^2 - L_2^2}{2L_1L_2} \right)$$

$$T_2 = \frac{L_2 \sin \theta_2}{L_1 + L_2 \cos \theta_2}$$

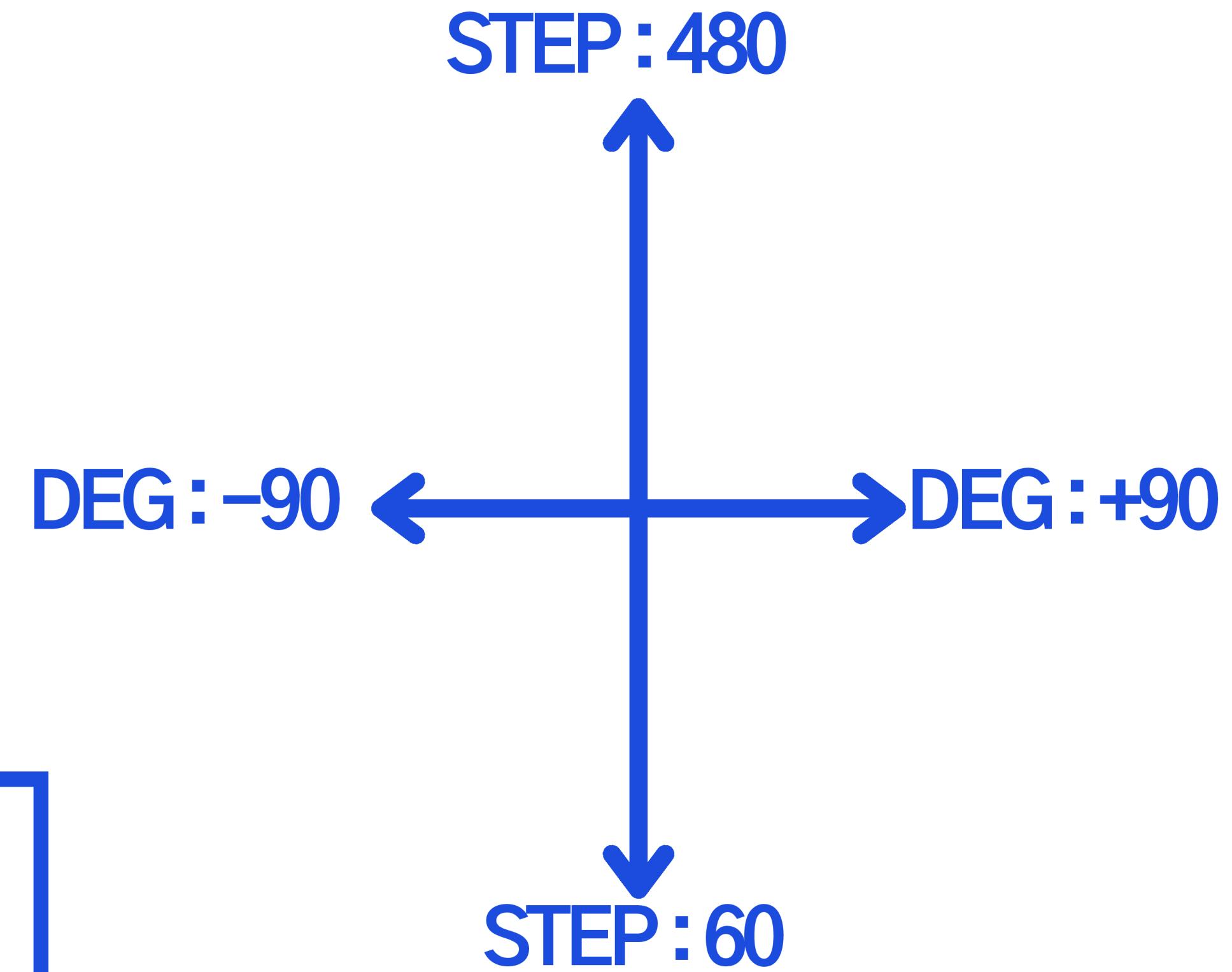
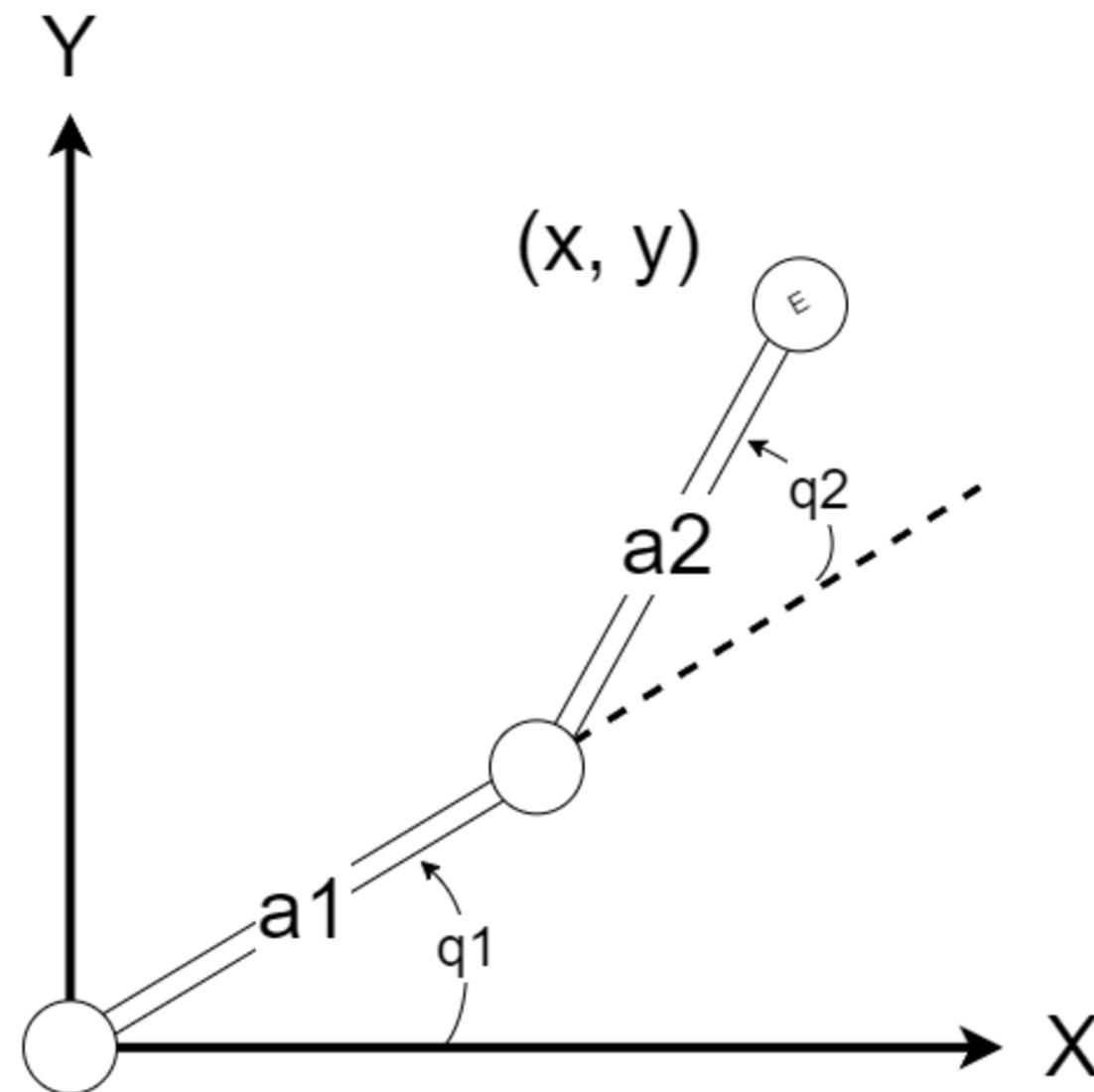
> w_q_x_over_x[15:0]	1.0	1.42578125	1.25	1.109375	1.0
> w_q_y_over_x[15:0]	256	365	320	284	256
Theta1					
> w_arctan_y_over_x[15:0]	0.78515625	0.9609375	0.99453125	0.83984375	0.78515625
> w_arctan_T2[15:0]	0.484375	0.703125	0.64453125	0.5793125	0.484375
> w_q_theta_1_rad[15:0]	0.30078125	0.2578125	0.25	0.26953125	0.30078125
Solution					
X,Y					
> w_q_coord_x[15:0]	10.0	7.0	8.0	9.0	10.0
> w_q_coord_y[15:0]	10.0				10.0
RAD					
Theta1_rad & Theta2_rad					
> w_q_theta_1_rad[15:0]	0.30078125	0.2578125	0.25	0.26953125	0.30078125
> w_q_theta_2_rad[15:0]	0.97265625	1.41015625	1.28515625	1.14453125	0.97265625
qTheta1_deg & qTheta2_deg					
> w_q_theta_1_deg[31:0]	17.2326507568359	14.7708435058594	14.3232421875	15.4422454833984	17.2326507568359
> w_q_theta_2_deg[31:0]	55.7263641357422	80.7920379638672	73.6304168701172	65.5735931396484	55.7263641357422

Y/X
ARCTAN(Y/X)
ARCTAN(T2)
THETA1_RAD
THETA2_RAD
THETA1_DEG
THETA2_DEG

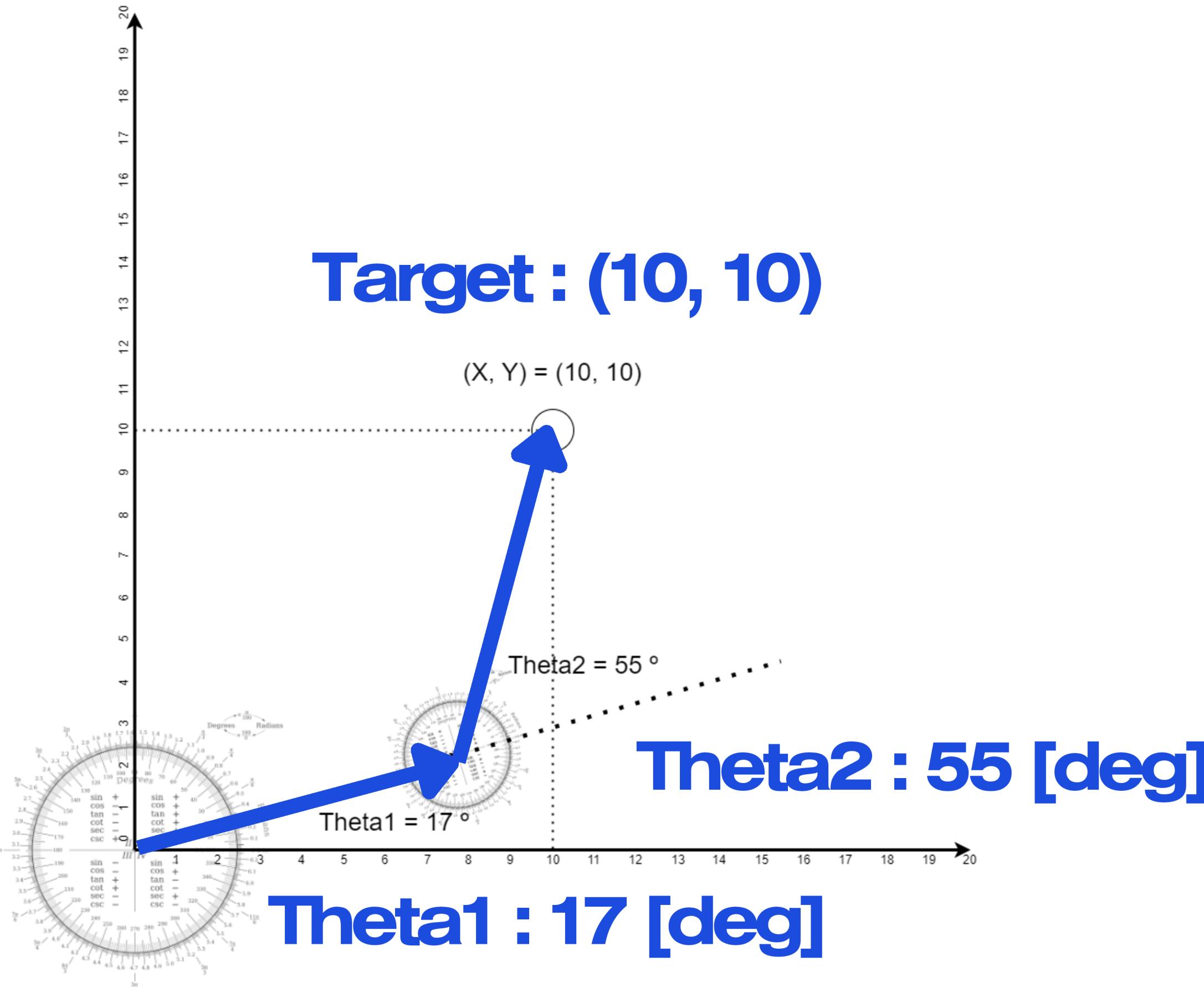
1.0
0.7851
0.4843
0.3008
0.9727
17.23
55.76

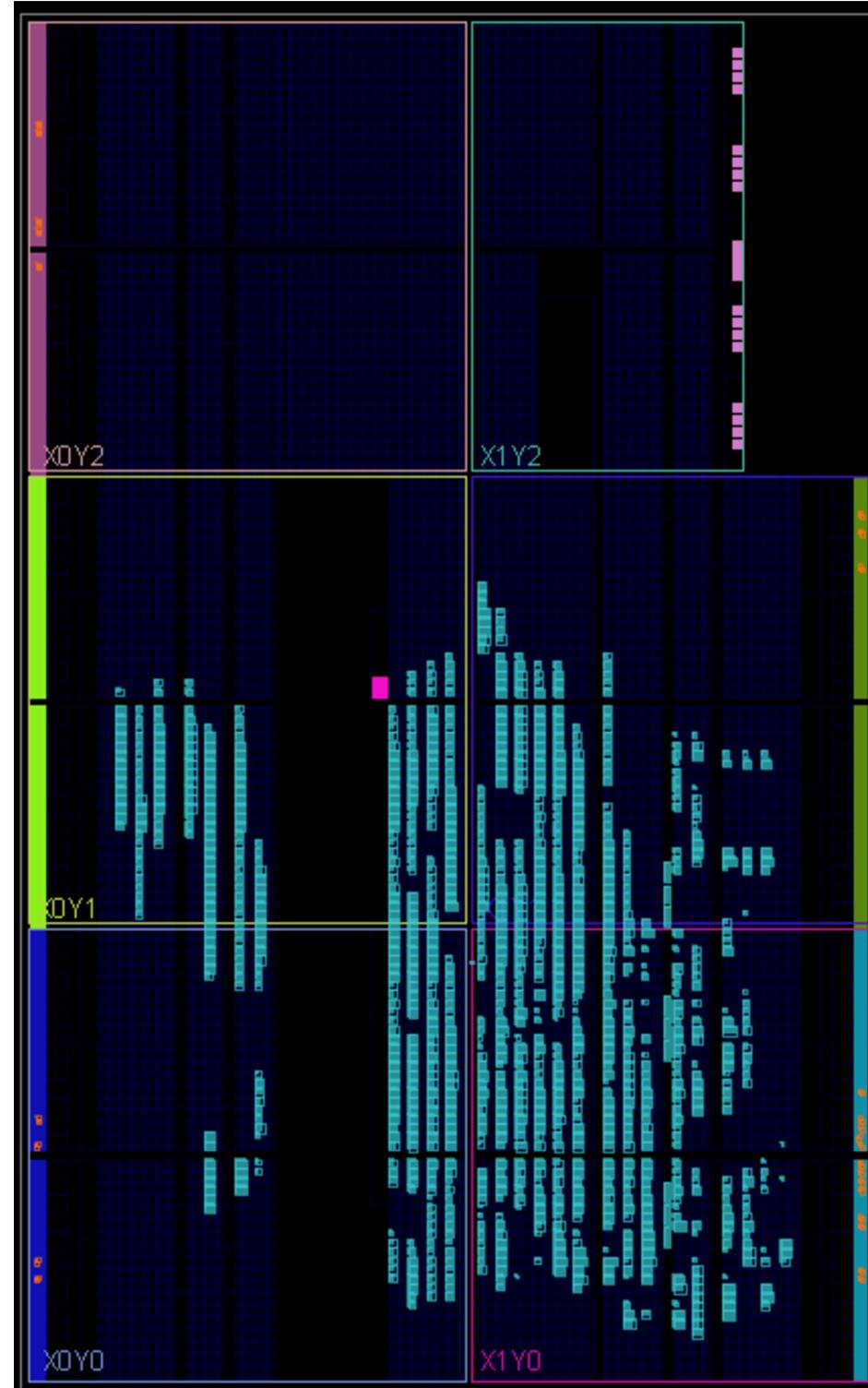
$$T_2 = \frac{L_2 \sin \theta_2}{L_1 + L_2 \cos \theta_2}$$

$$\theta_1 = \tan^{-1} \left(\frac{y}{x} \right) - \tan^{-1} (T_2)$$



THETA1_DEG	17
THETA2_DEG	55





Name	Slice LUTs (20800)	Slice Registers (41600)	7 Muxes (16300)	F8 Muxes (8150)	Slice (8150)	LUT as Logic (20800)	DSPs (90)	Bonded IOB (106)	BUFGCTRL (32)
top_mobileRemoteRobotArm	6211	474	86	5	1753	6211	9	25	1
MRRA_BASE (top_MRRA_base)	97	78	0	0	36	97	0	0	0
MRRA_BODY (top_MRRA_body)	5625	179	73	5	1556	5625	9	0	0
MRRA_END_EFFECTOR (top_MRRA_grip)	91	86	0	0	37	91	0	0	0
MRRA_RX (top_MRRA_rx)	398	131	13	0	156	398	0	0	0

HARDWARE RESOURCE

**LUT : 6,211
FF : 474**

Design Timing Summary

Setup	Hold	Pulse Width
Worst Negative Slack (WNS): 1.343 ns	Worst Hold Slack (WHS): 0.131 ns	Worst Pulse Width Slack (WPWS): 4.500 ns
Total Negative Slack (TNS): 0.000 ns	Total Hold Slack (THS): 0.000 ns	Total Pulse Width Negative Slack (TPWS): 0.000 ns
Number of Failing Endpoints: 0	Number of Failing Endpoints: 0	Number of Failing Endpoints: 0
Total Number of Endpoints: 593	Total Number of Endpoints: 593	Total Number of Endpoints: 438

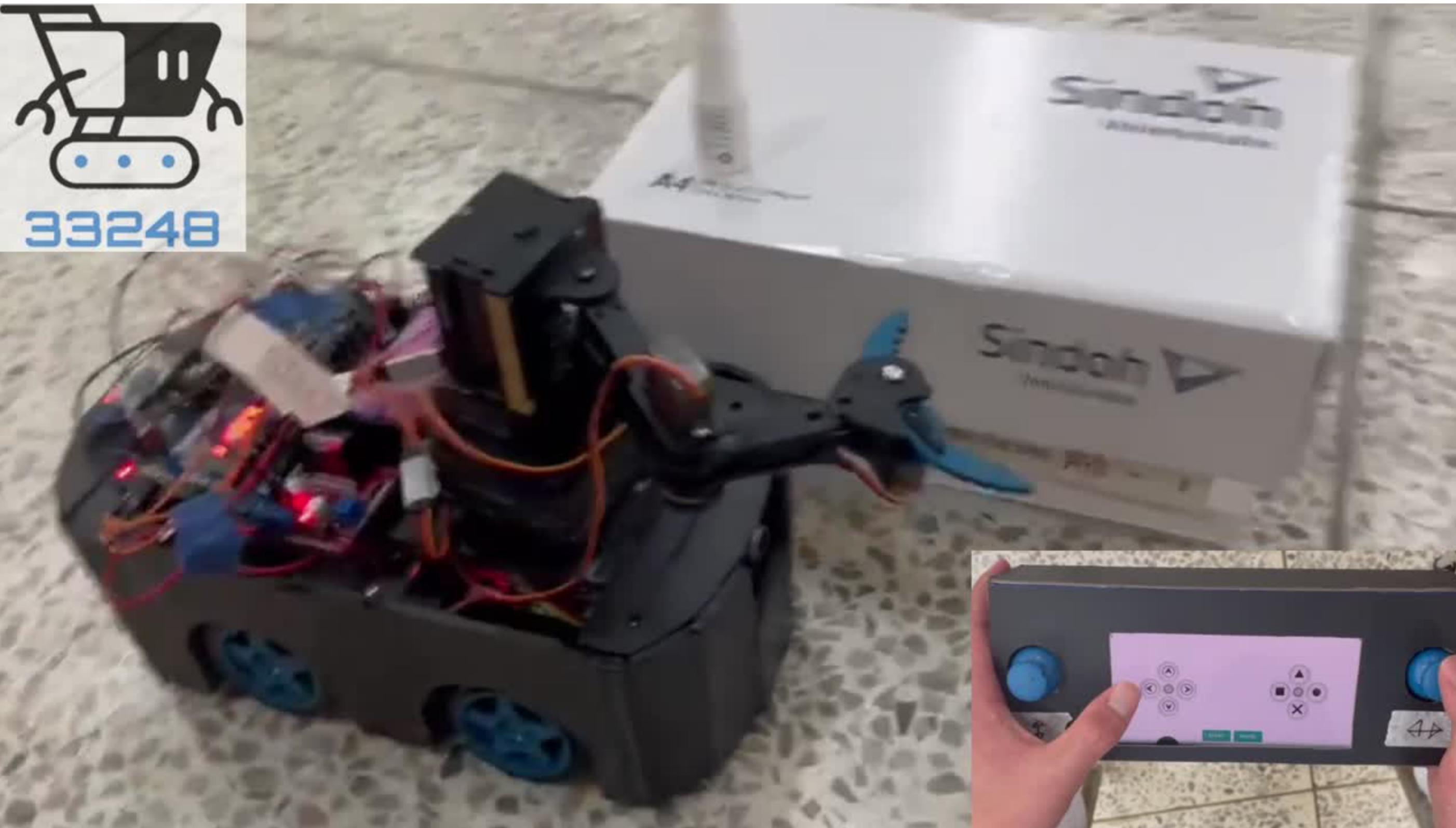
All user specified timing constraints are met.

WNS : ~1.3 ns WHS : ~0.1 ns

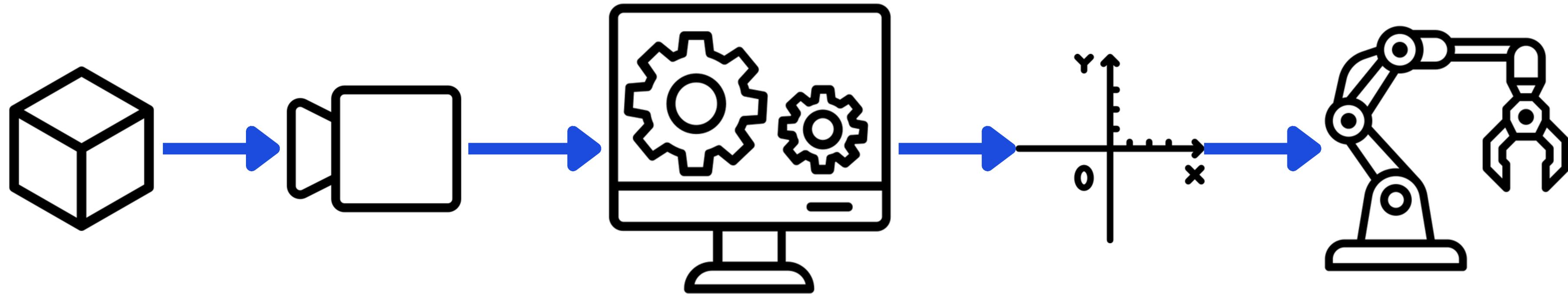
IMPLEMENTED DESIGN

TIMING SUMMARY REPORT

Demonstration Video (1m 24s)



Future Goal : Image2Coord



Get Image Data
From Target

Preprocessing

Coordinates of
Target

MRRA
Working

Q & A

Mobile Remote Robot Arm

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Lee JaePyeong

Research & Develop Dept.



Software Design

Lee SangWon

Research & Develop Dept.



Mechanical Design
Communication Design

Lee JunHee

Research & Develop Dept.



Mechanical Design
Public Relations