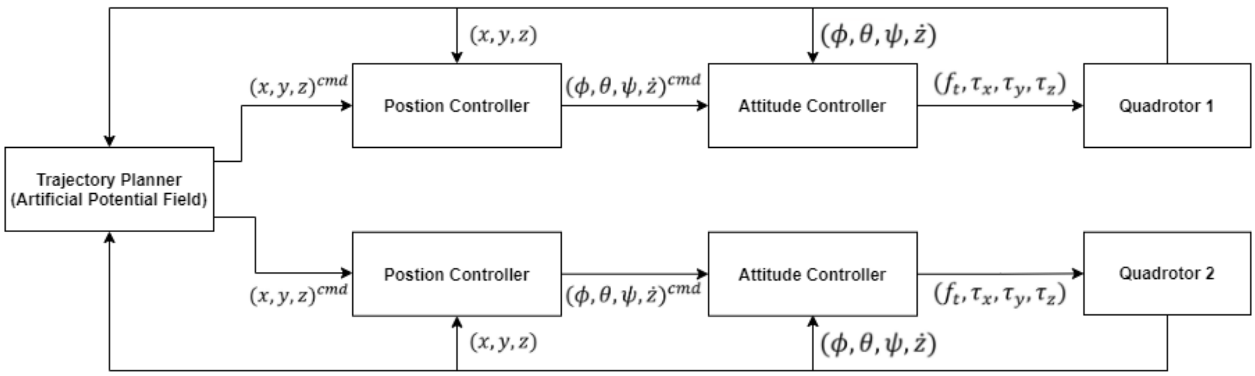
Bab 2

Pengontrol PID



Ref : [1]

Attitude Controller

$$\boldsymbol{f_t = mg - \left[K_{p,\dot{z}}\left(\dot{z}^{cmd} - \dot{z}\right) + K_{i,\dot{z}}\int\left(\dot{z}^{cmd} - \dot{z}\right) + K_{d,\dot{z}}\left(\ddot{z}^{cmd} - \ddot{z}\right)\right]}$$

$$\boldsymbol{\tau_x = K_{p,\phi}\left(\phi^{cmd} - \phi\right) + K_{i,\phi}\int\left(\phi^{cmd} - \phi\right) + K_{d,\phi}\left(\dot{\phi}^{cmd} - \dot{\phi}\right)}$$

$$\boldsymbol{\tau_y = K_{p,\theta}\left(\theta^{cmd} - \theta\right) + K_{i,\theta}\int\left(\theta^{cmd} - \theta\right) + K_{d,\theta}\left(\dot{\theta}^{cmd} - \dot{\theta}\right)}$$

$$\boldsymbol{\tau_z = K_{p,\psi}\left(\psi^{cmd} - \psi\right) + K_{i,\psi}\int\left(\psi^{cmd} - \psi\right) + K_{d,\psi}\left(\dot{\psi}^{cmd} - \dot{\psi}\right)}$$

Resource : [2]

Position Controller

$$\boldsymbol{\phi^{cmd}} =$$

$$\boldsymbol{\theta^{cmd}} =$$

$$\boldsymbol{\psi^{cmd}} =$$

$$\boldsymbol{\dot{z}^{cmd}} =$$

Trajectory Planner – Artificial Potential Field (APF)

$$\boldsymbol{m_i\dot{v}_i = u_i\,, i = 1, \dots, N}$$

$$\boldsymbol{u_i = f_{i,o}^{ob} + f_{i,j}^{s} + f_i^{t}}$$

Obstacle Potential Field $f_{i,o}^{ob}$

$$f_{i,o}^{ob} = \sum_{j \in N_i^{ob}} \left(F_{i,o}^{ob}\right)$$

$$N_i^{ob} = \left\{o, d_{i,o}^{ob} \le r^{ob}, o = 1, \dots, M\right\}$$

$$F_{i,o}^{ob} = \left(\left(\frac{1}{d_{i,o}^{ob}} - \frac{1}{r^{ob}}\right)\frac{k_{p1}^{ob}}{\left(d_{i,o}^{ob}\right)^2} - k_{p2}^{ob}\left(d_{i,o}^{ob} - r^{ob}\right)\right) n_{i,o}^{ob}$$

Swarm Potential Field $f_{i,j}^{s}$

$$f_{i,j}^{s} = \sum_{j \in N_i^s}\left(F_{i,j}^{s} - k_{vi}^{s}\left(v_i - v_j\right)\right)$$

$$N_i^{s} = \left\{j, d_{i,j}^{s} \le r^{s}, j = 1, \dots, N, j \ne i\right\}$$

$$F_{i,j}^{s} = \left(\left(\frac{1}{d_{i,j}^{s}} - \frac{1}{r_0^{s}}\right)\frac{k_{p1}^{s}}{\left(d_{i,j}^{s}\right)^2} - k_{p2}^{s}\left(d_{i,j}^{s} - r_0^{s}\right)\right) n_{i,j}^{s}$$

$$F_{i,j}^{s} = \left(-k_{p3}^{s}\left(d_{i,j}^{s} - r_0^{s}\right)\right) n_{i,j}^{s}$$

Target Potential Field f_i^t

$$f_i^t = F_i^t - k_{vi}^t\left(v_i - v_t\right)$$

$$F_i^t = \begin{cases} -\dfrac{k_p^t}{r^t}\left(p_i - p_t\right), & d_i^t < r^t \\ -k_p^t\left(\dfrac{p_i - p_t}{||p_i - p_t||}\right), & lainnya \end{cases}$$

[3]

Kriteria Performasi Pengontrol

1. **Mean Absolute Error**
2. **Integral Absolute Error**

Particle Swarm Optimization (PSO)

$$\boldsymbol{V_{pd}^{t+1} = wV_{pd}^{t} + c_1 r_1\left(pbest - X_{pd}^{t}\right) + c_2 r_2 (gbest^{t} - X_{id}^{t})}$$

$$\boldsymbol{X_{pd}^{t+1} = X_{pd}^{t} + V_{pd}^{t+1}}$$

[4]

Algoritma

Tabel Model Simulasi

Posisi Awal Quadrotor (x,y,z)	(0,0,0)
Thrust dan moment	0
dt	0.01
Durasi respon	5

Tabel Parameter PSO

Kriteria Performasi Pengontrol	Integral Absolute Error
partikel	100
w	0.5
C1	0.3
c2	0.4
iterasi	25
Jumlah parameter	3 (PID)
Range parameter	0-100

Parameter Pengontrol PID (Kp, Ki, Kd) attitude lain = (0,0,0)

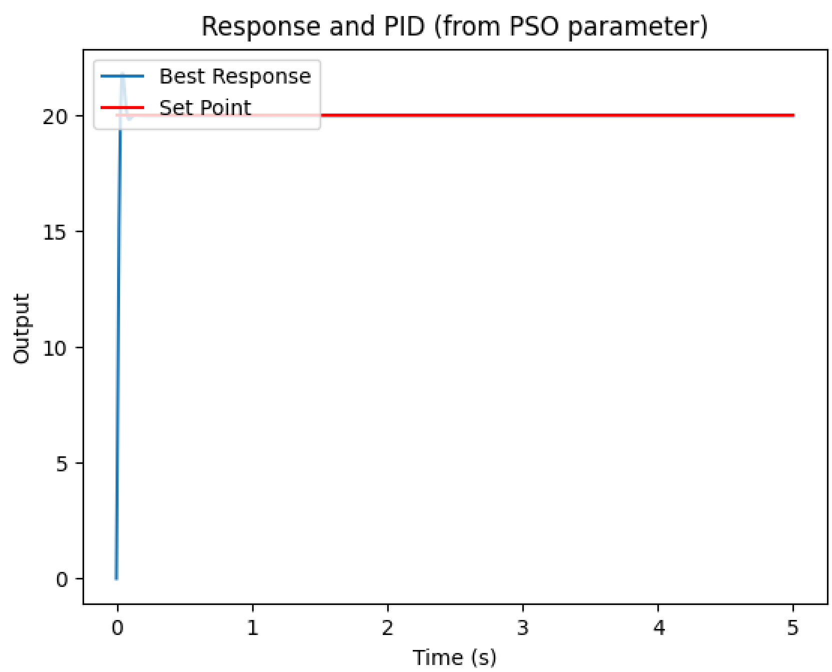
Percobaan

Attitude Controller

1. **Attitude yang dioptimasi : phi**

Setpoint = 20 derajat

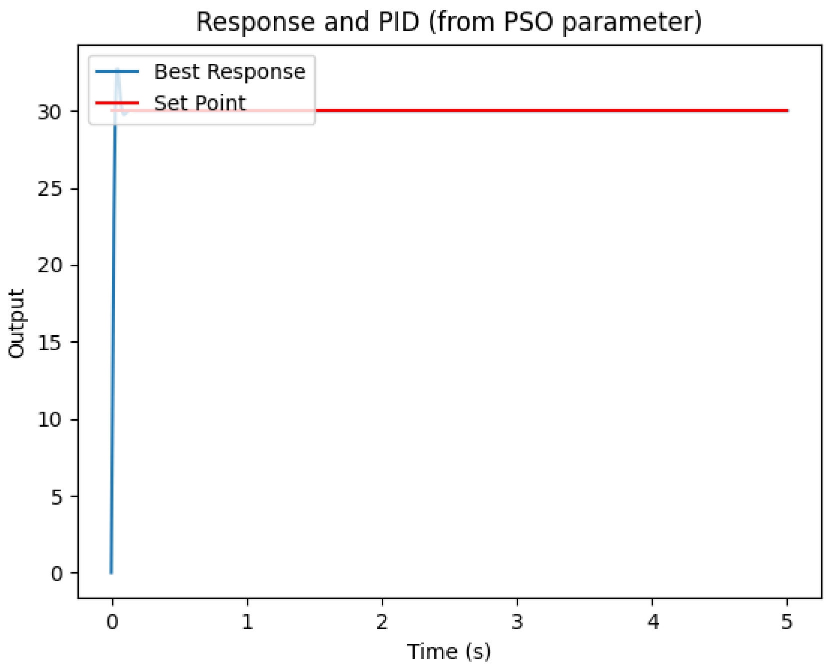
Hasil



Best fitness -> 42.749358873151905

Best parameter -> [0.   0.   0.88661492]

Setpoint = 30 derajat



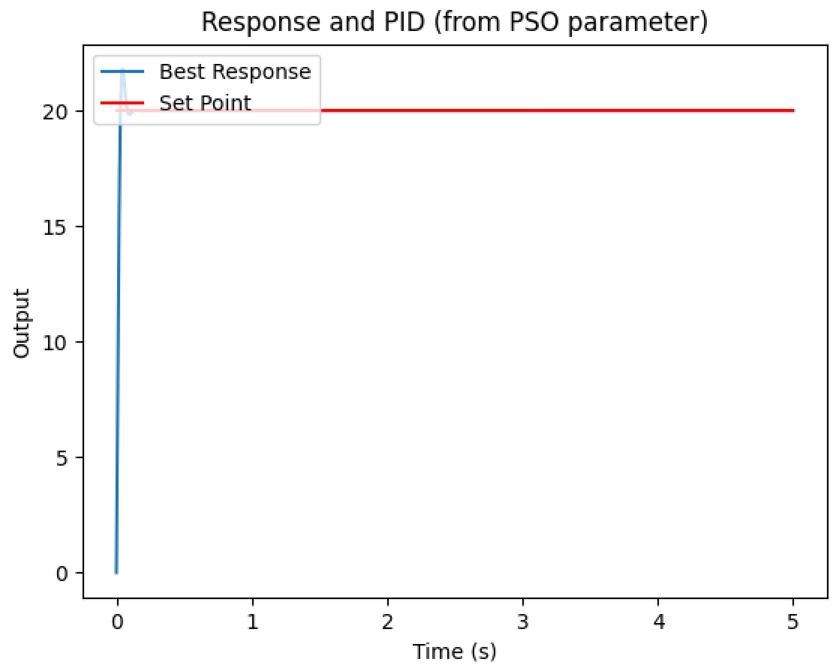
Best fitness -> 64.10906872784162

Best parameter -> [0. 0. 0.88616771]

2. Attitude yang dioptimasi : theta

Setpoint = 20 derajat

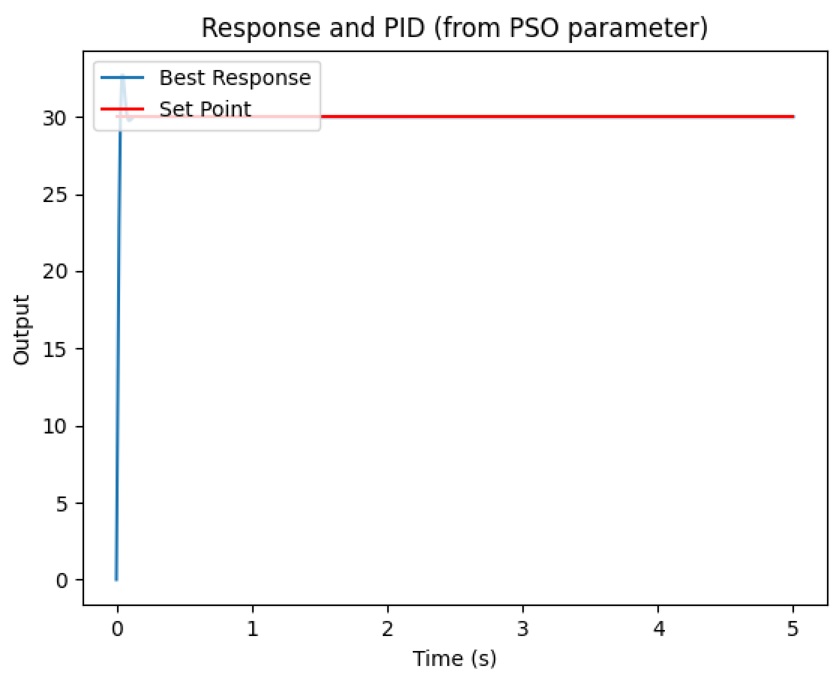
Hasil



Best fitness -> 42.739282592936405

Best parameter -> [0. 0. 0.88616339]

Setpoint = 30 derajat



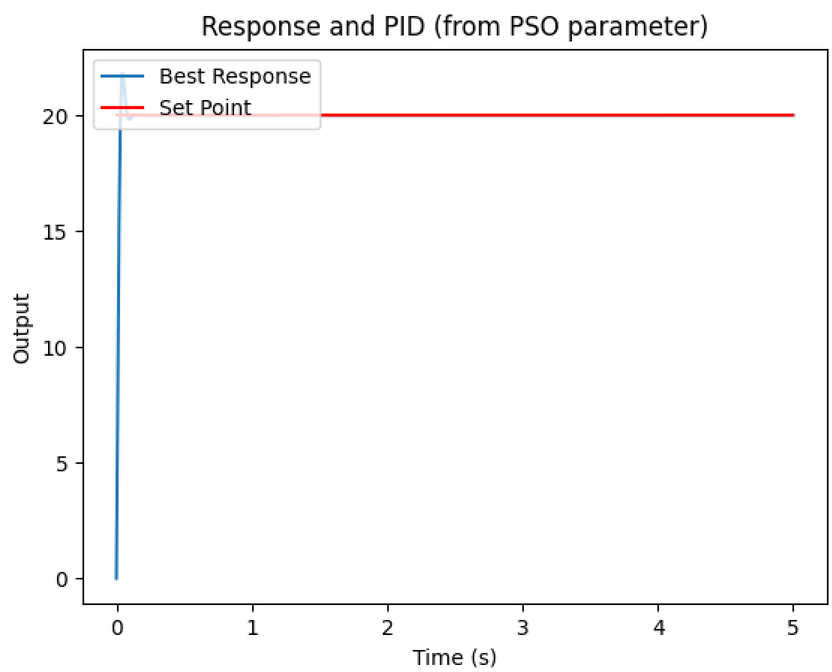
Best fitness -> 64.10980225307378

Best parameter -> [0. 0. 0.8861349]

3. Attitude yang dioptimasi : psi

Setpoint = 20 derajat

Hasil



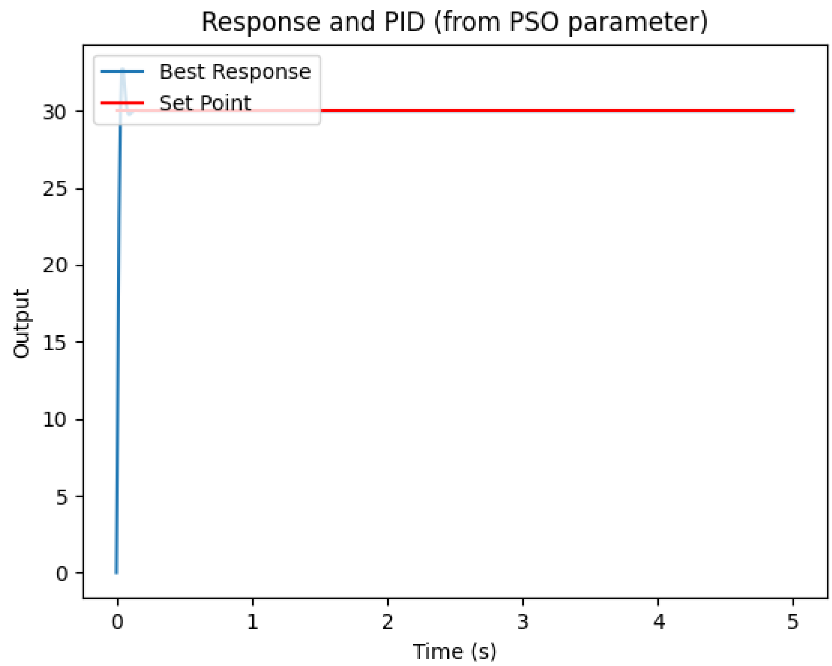
Total iteration -> 25

Best fitness -> 42.7392362967512

Best parameter -> [0. 0. 0.88616098]

Setpoint = 30 derajat

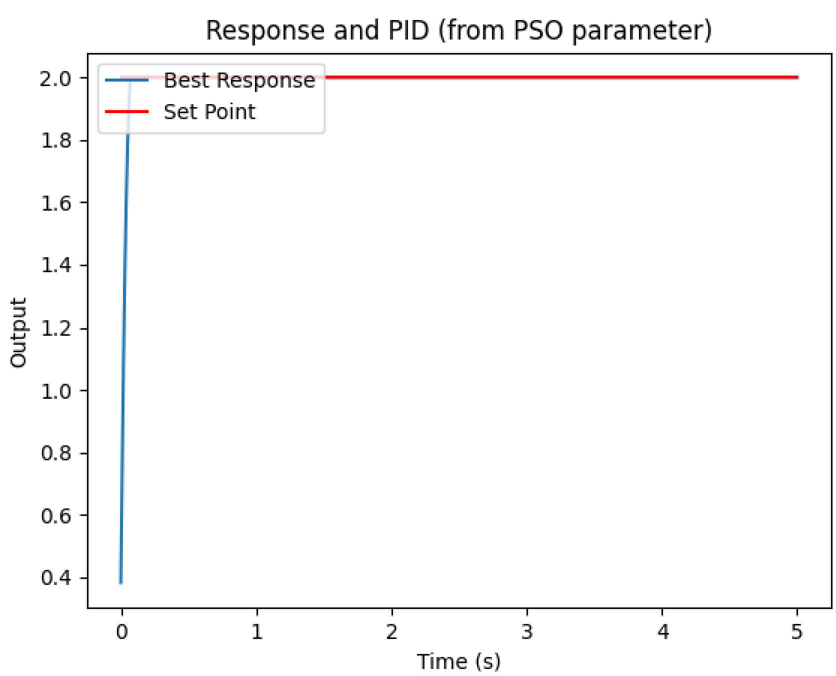
Hasil



4. Attitude yang dioptimasi : z dot

Setpoint = 2

Hasil



Best fitness -> 5.103908948419274

Best parameter -> [96.17007323 7.35729734 0.]

Position Controller

Parameter Pengontrol PID (Kp, Ki, Kd) position lain = (0,0,0)

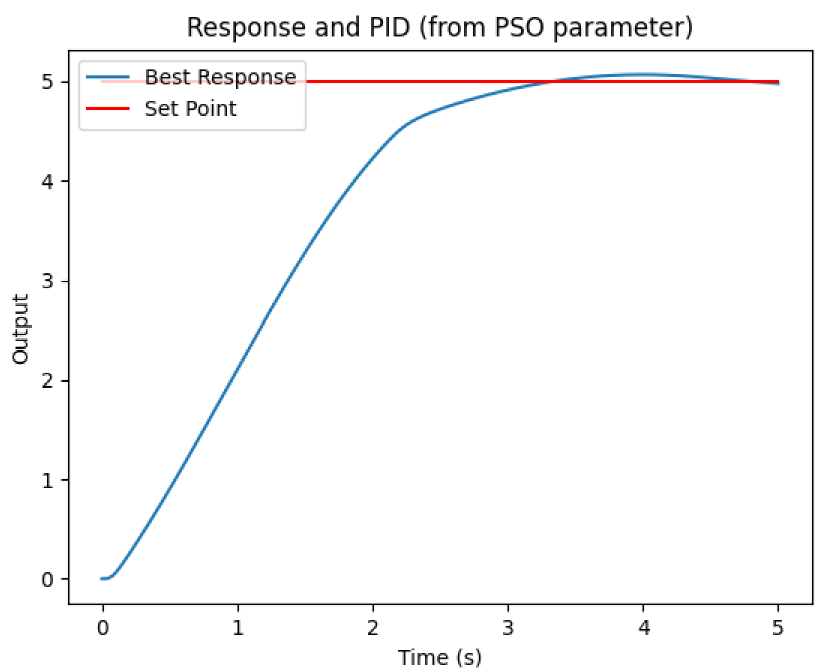
Parameter Pengontrol PID (Kp, Ki, Kd) attitude menggunakan hasil PSO setPoint 20 pada percobaan sebelumnya dan setPoint zdot 2

5. **Position yang dioptimasi : x**

State = (posisi x, y, z, kecepatan x, y, z, sudut phi, theta, psi, sudit dot phi, theta, psi)

State awal = (0,0,5,0,0,0,0,0,0,0,0,0)

Posisi awal = (0,0,5) ke (5,0,5)



Best fitness -> 626.2935904424725

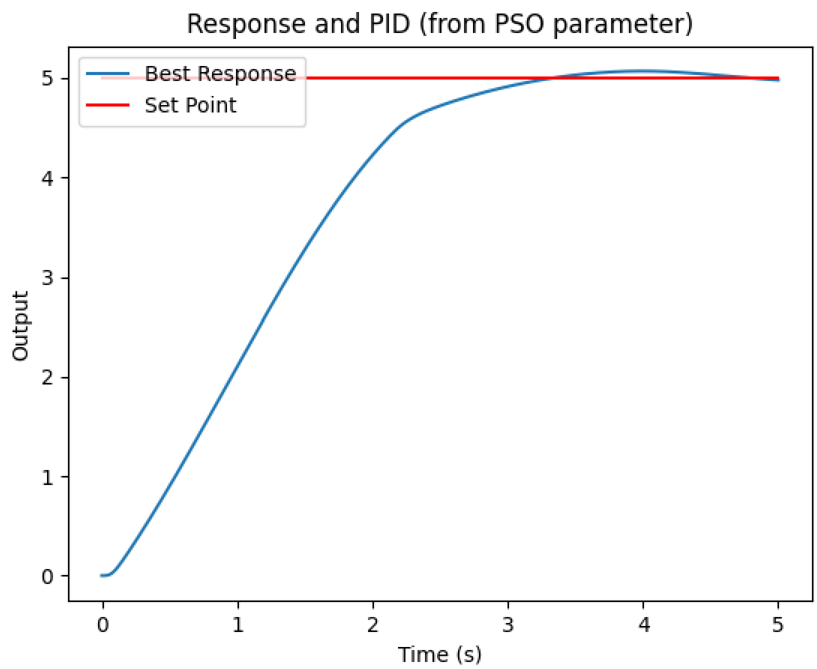
Best parameter -> [27.83997997 70.32934802 4.70222228]

6. **Position yang dioptimasi : y**

State awal = (0,0,5,0,0,0,0,0,0,0,0,0)

Posisi awal = (0,0,5) ke (0,5,5)

Hasil



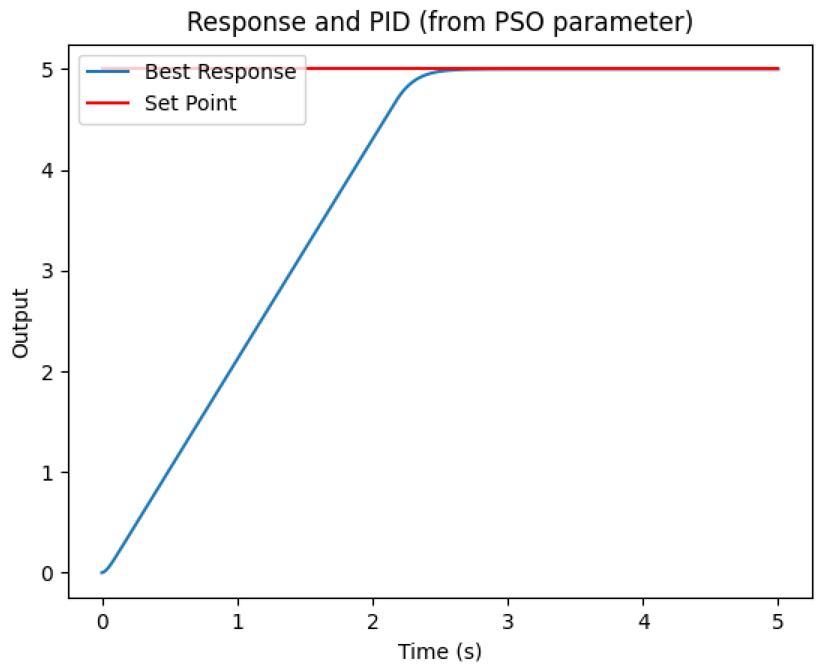
Best fitness -> 626.293636693713

Best parameter -> [27.83997036 68.08563516 47.6545511]

7. **Position yang dioptimasi : z**

State awal = (0,0,0,0,0,0,0,0,0,0,0,0)

Posisi awal = (0,0,0) ke (0,0,5)



Best fitness -> 592.2120136718738

Best parameter -> [0.84007563 88.32316777 68.43428605]

Kalman Filter

Implementasi

Referensi

[1] Y. Chen, G. Luo, Y. Mei, J. Yu, and X. Su, “UAV path planning using artificial potential field method updated by optimal control theory,” *Int. J. Syst. Sci.*, vol. 47, no. 6, pp. 1407–1420, Apr. 2016, doi: 10.1080/00207721.2014.929191.

[2] “SKYnSPACE/AE450,” *GitHub*. https://github.com/SKYnSPACE/AE450 (accessed Feb. 12, 2021).

[3] Y. Y. Nazaruddin, A. D. Andrini, and B. Anditio, “PSO Based PID Controller for Quadrotor with Virtual Sensor,” *IFAC-Pap.*, vol. 51, no. 4, pp. 358–363, Jan. 2018, doi: 10.1016/j.ifacol.2018.06.091.

[4] A. Taeib, A. Ltaeif, and A. Chaari, “A PSO Approach for Optimum Design of Multivariable PID Controller for nonlinear systems,” *ArXiv13066194 Cs*, Jun. 2013, Accessed: Feb. 09, 2021. [Online]. Available: http://arxiv.org/abs/1306.6194.