Attitude Control optimization of a Virtual Telescope for X-ray observations

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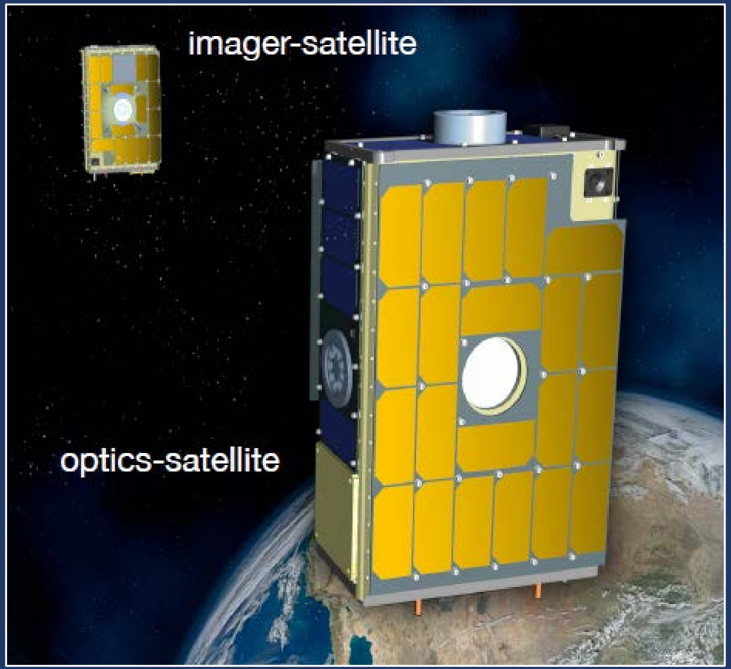
Outline

- Mission
- Orbit design
- Satellites’ dynamics
- Designing Guidance, Navigation and Control (GNC)
- Mission’s phases design
- Optimization phase
- Conclusion

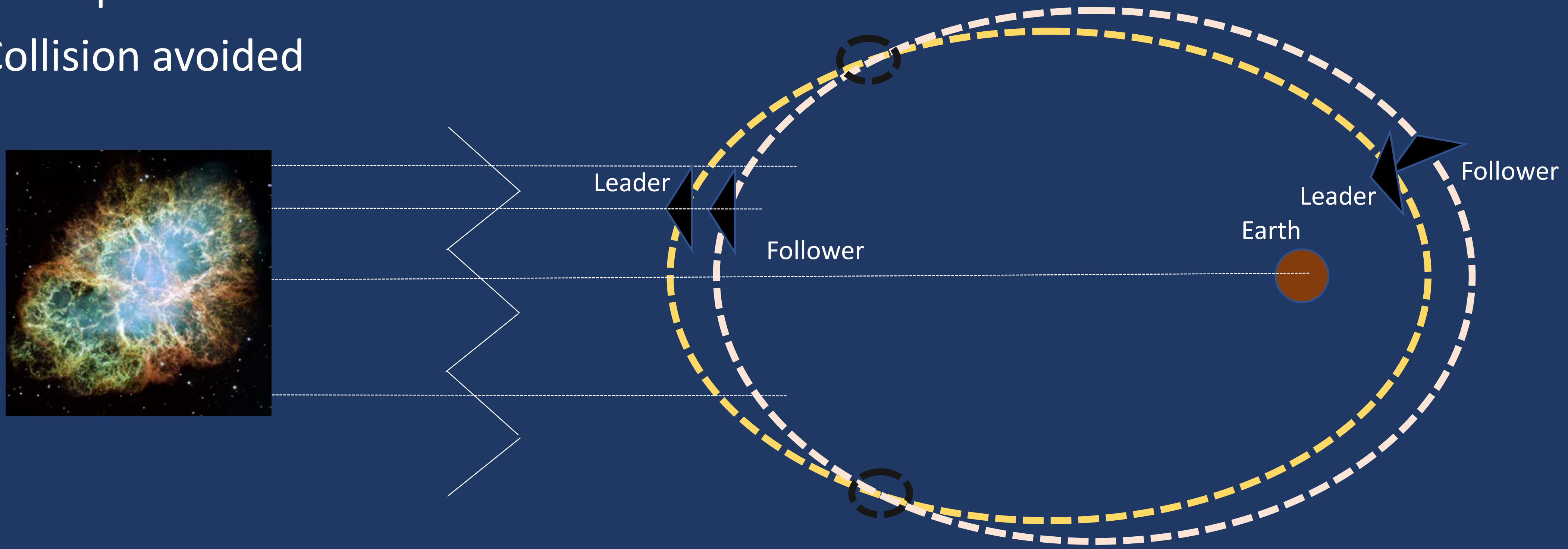
Mission

- Virtual Telescope for X-ray Observations
- Attitude formation control with sub-arcsecond accuracy
- Highly eccentric geostationary orbit
- Approximately 1 hour observing the Crab Nebula



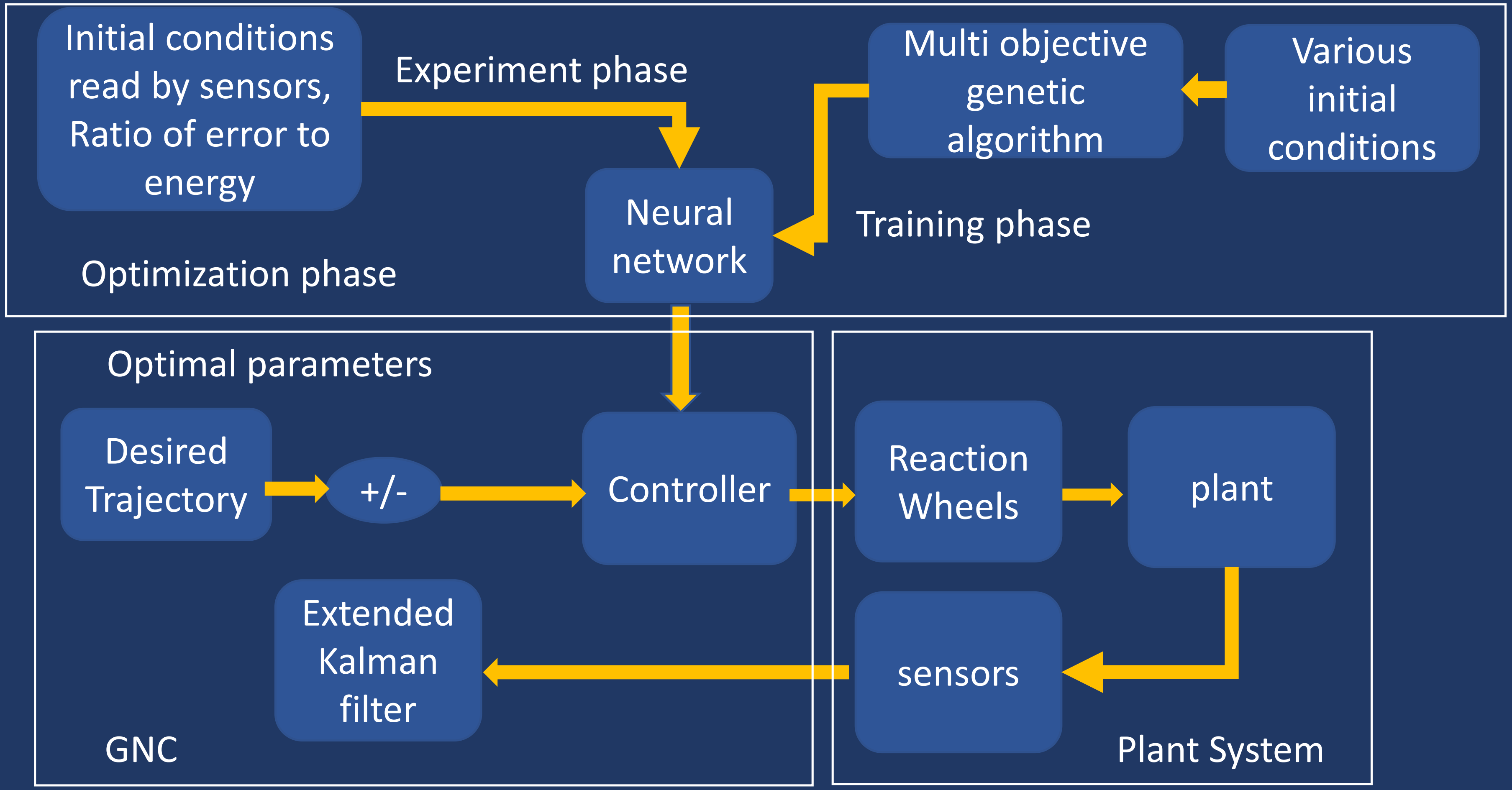
Orbit Design

- The orbits have the same parameters except the eccentricity
- Same period
- Collision avoided



GNC and Optimization

Objective function= Energy consumption and Error



Mission's phases Design

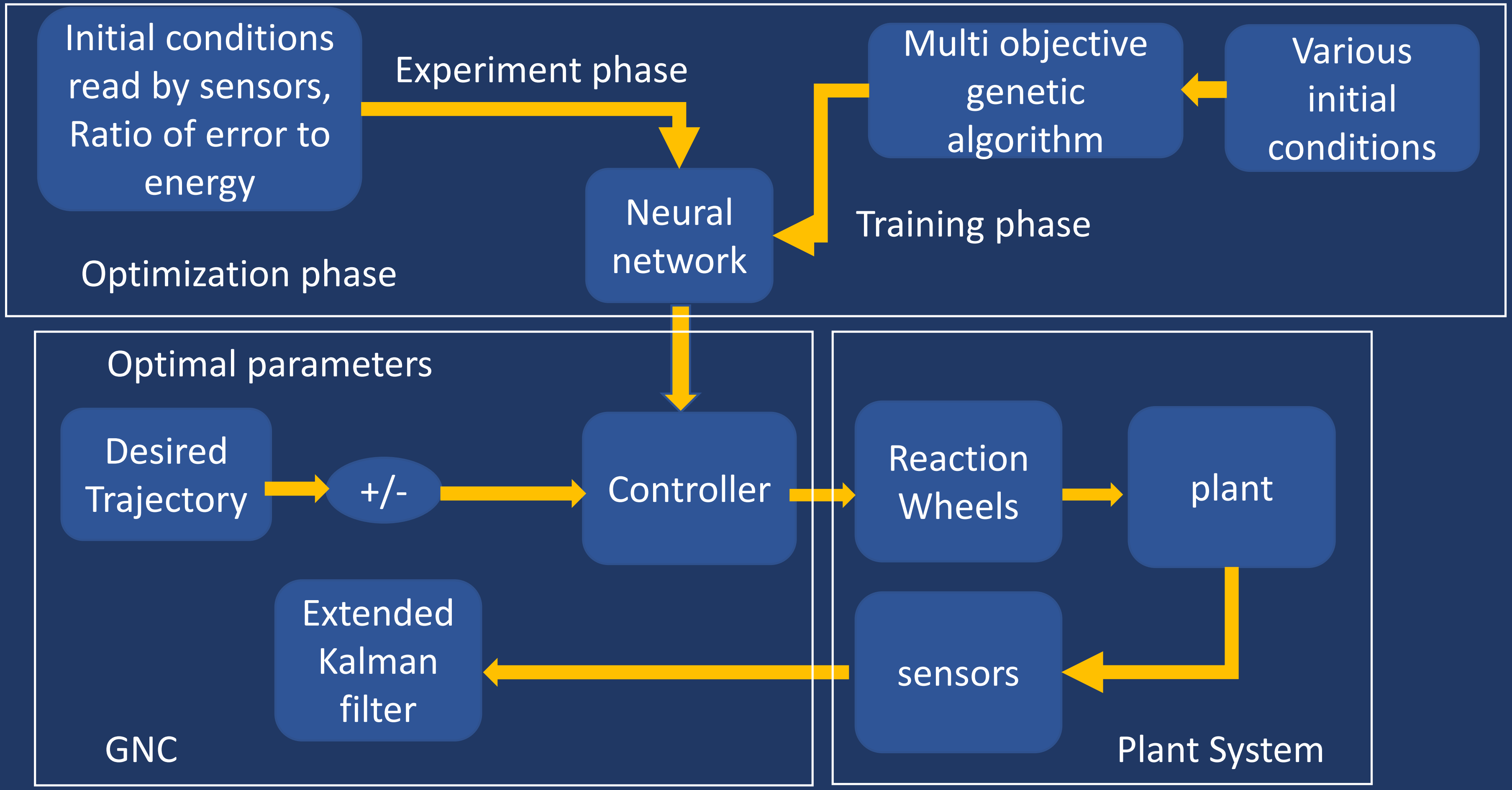
- Phase 1:
- The development phase
- Phase 2:
- Scientific phase
- Phase 3:
- Semi-open-loop formation phase

mission phases specifications

	controller	Sensors and filter	Camera
Phase 1	Sliding mode/PD	On	Off
Phase 2	Sliding mode/PD	On	On
Phase 3	Anti gravity gradient	Off	off

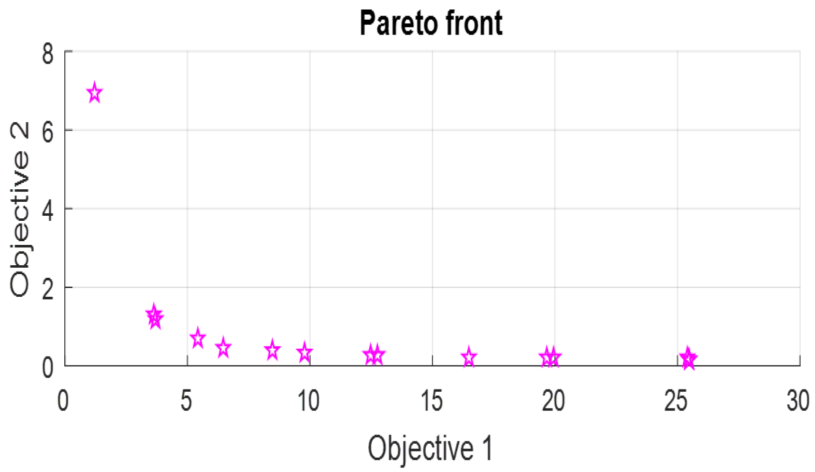
Phase 1:Development phase

Objective function= Energy consumption and Error in the last 30 seconds

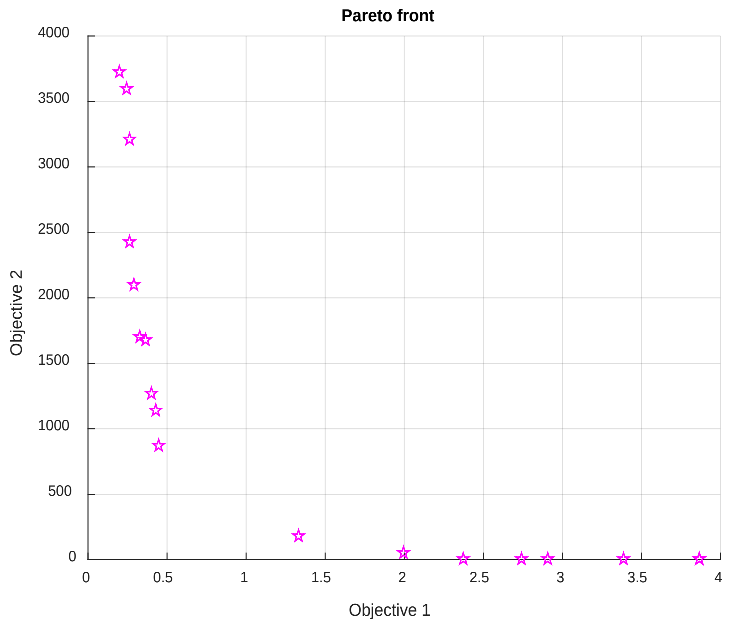


Pareto front

PD Controller

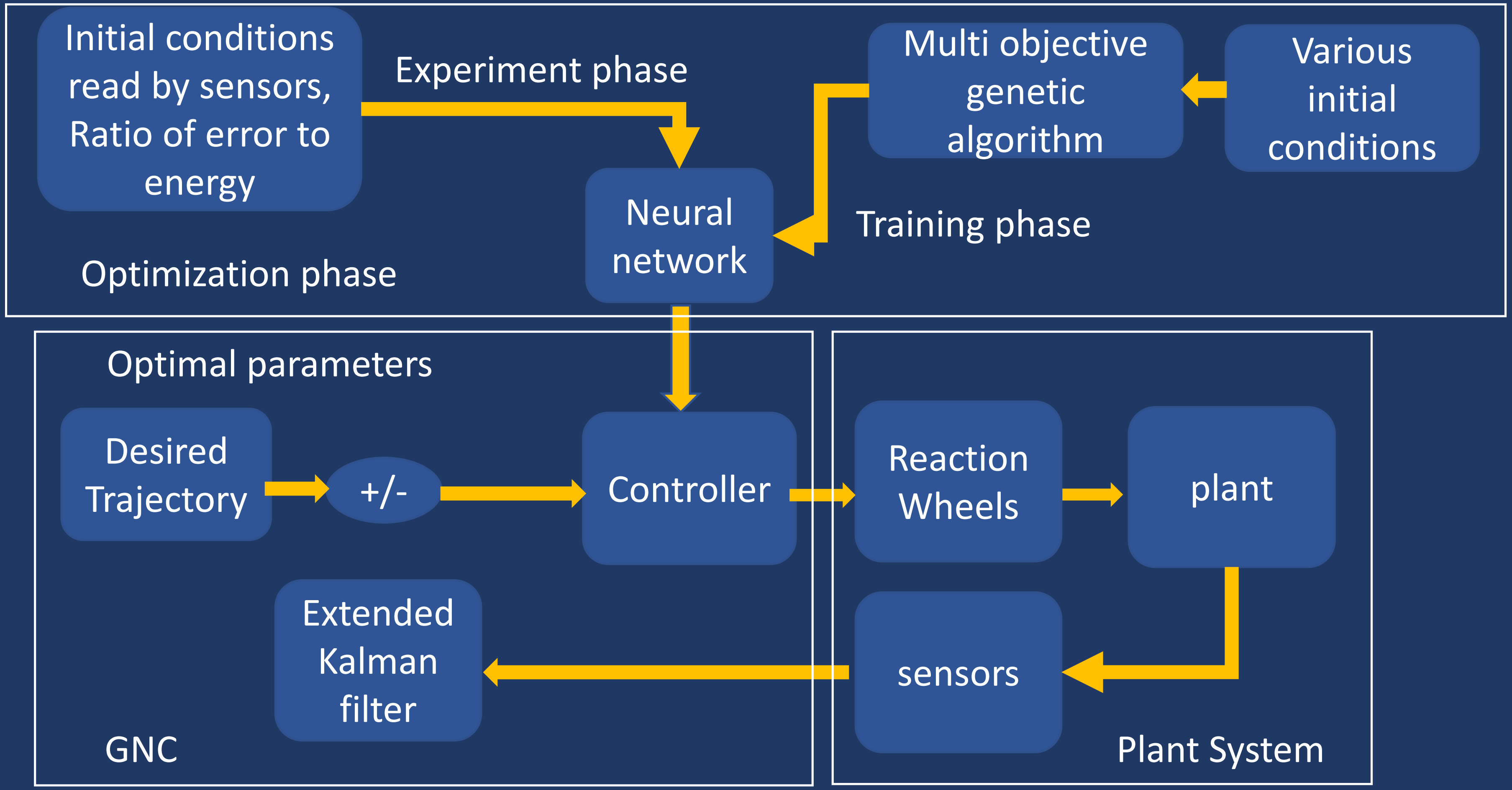


SMC



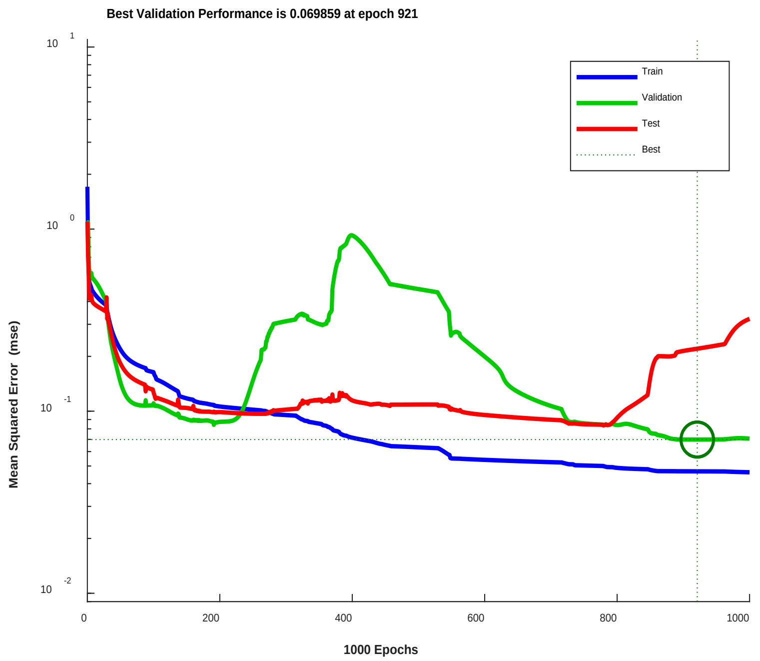
Phase 1:Development phase

Objective function= Energy consumption and Error in the last 30 seconds

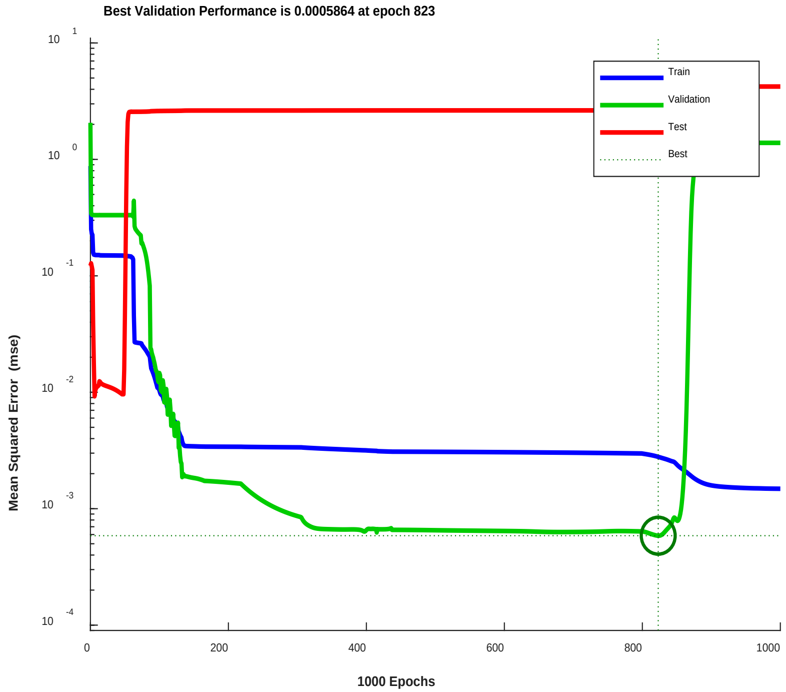


Neural network performance

PD Controller

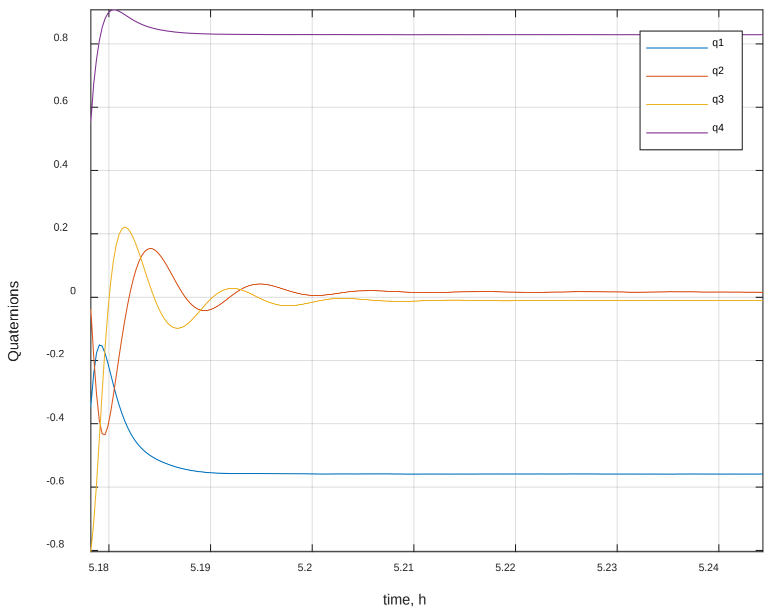


SMC

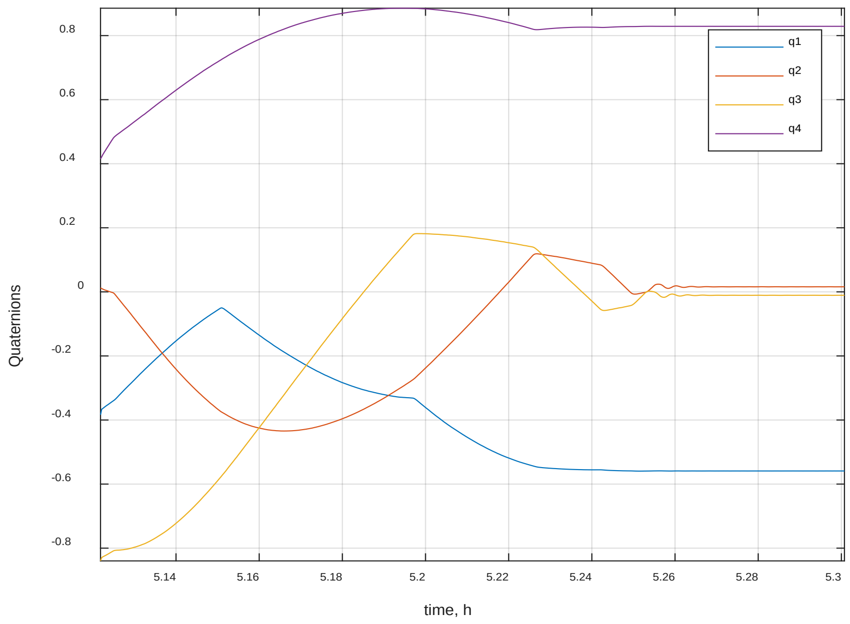


Results- Development phase

PD Controller

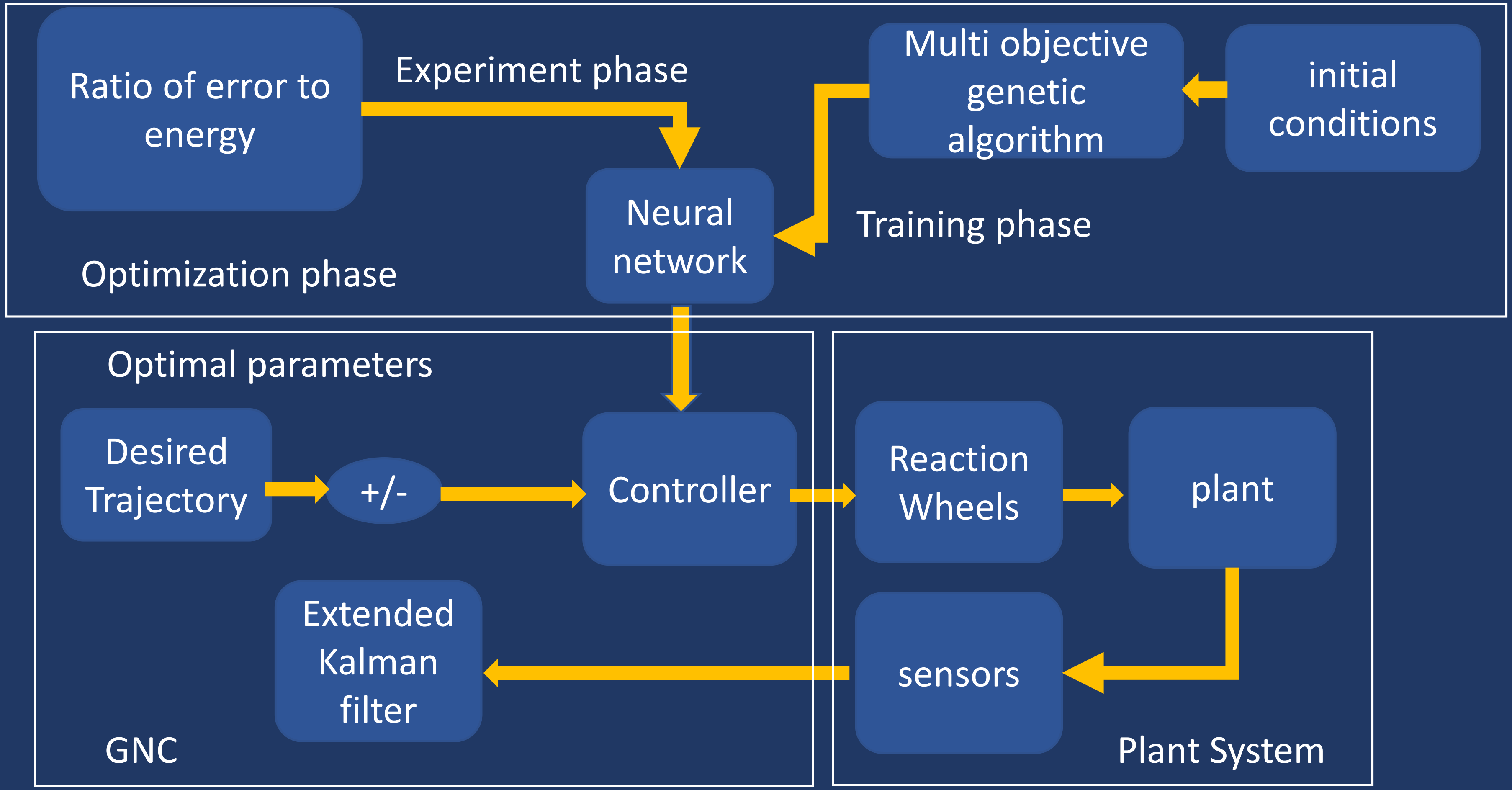


SMC



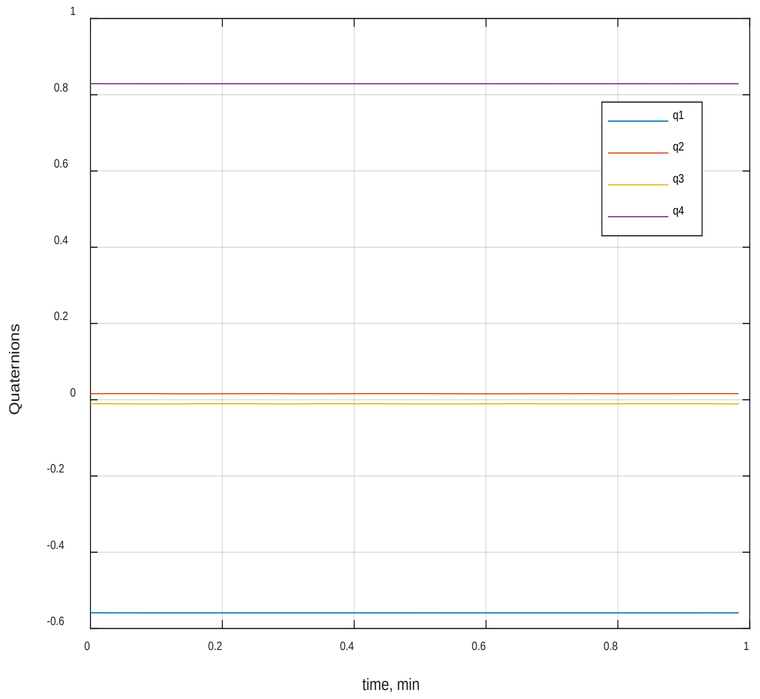
Phase 2: Scientific phase

Objective function= Energy consumption and Error

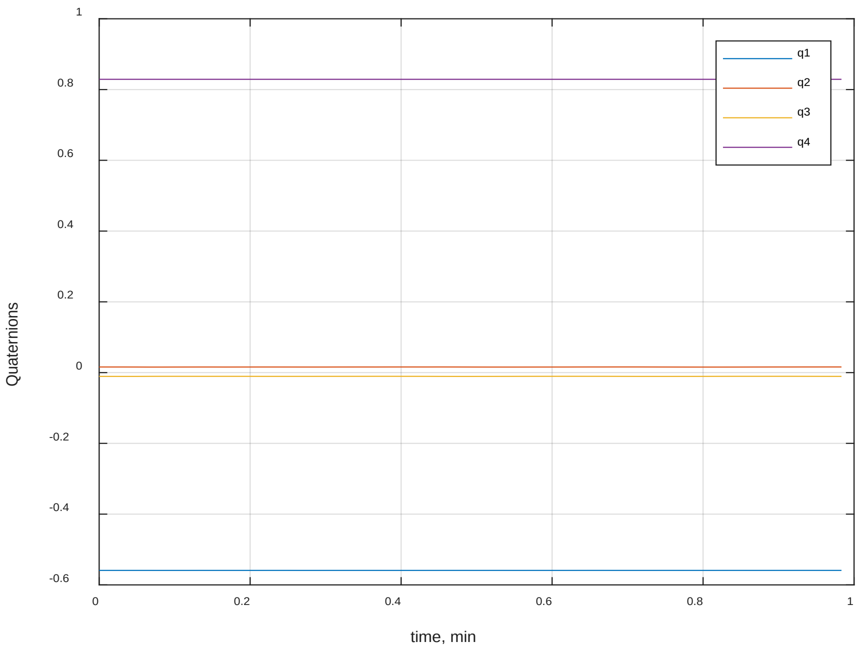


Results- Scientific phase

PD Controller

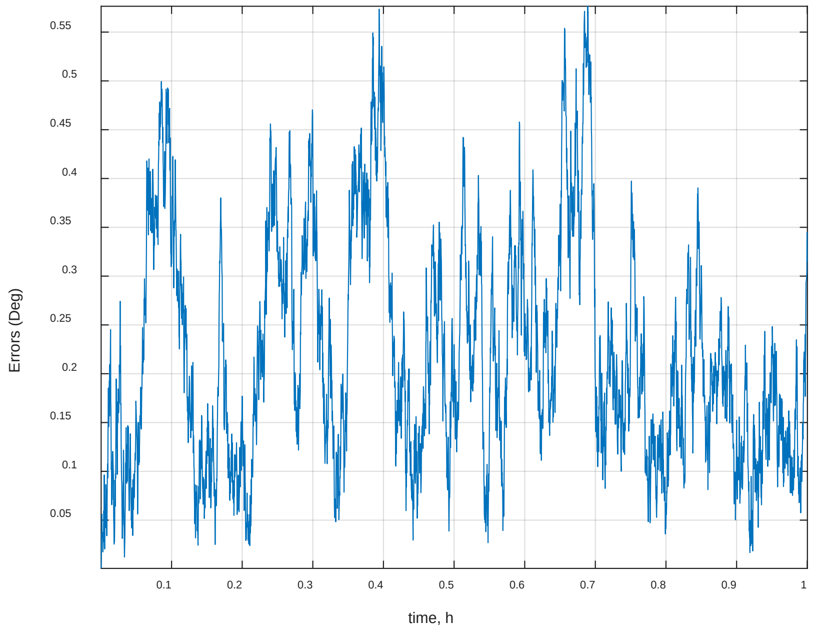


SMC



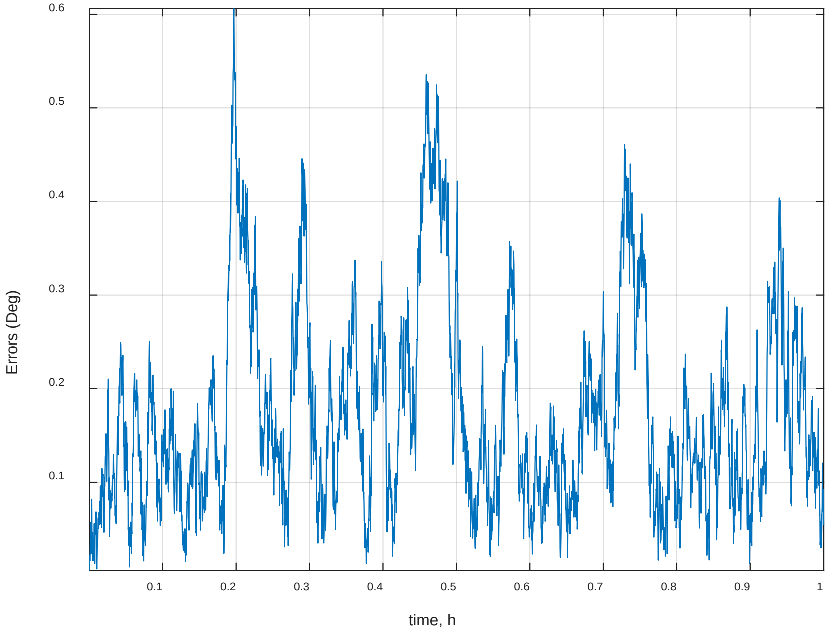
Error

Error (PD)



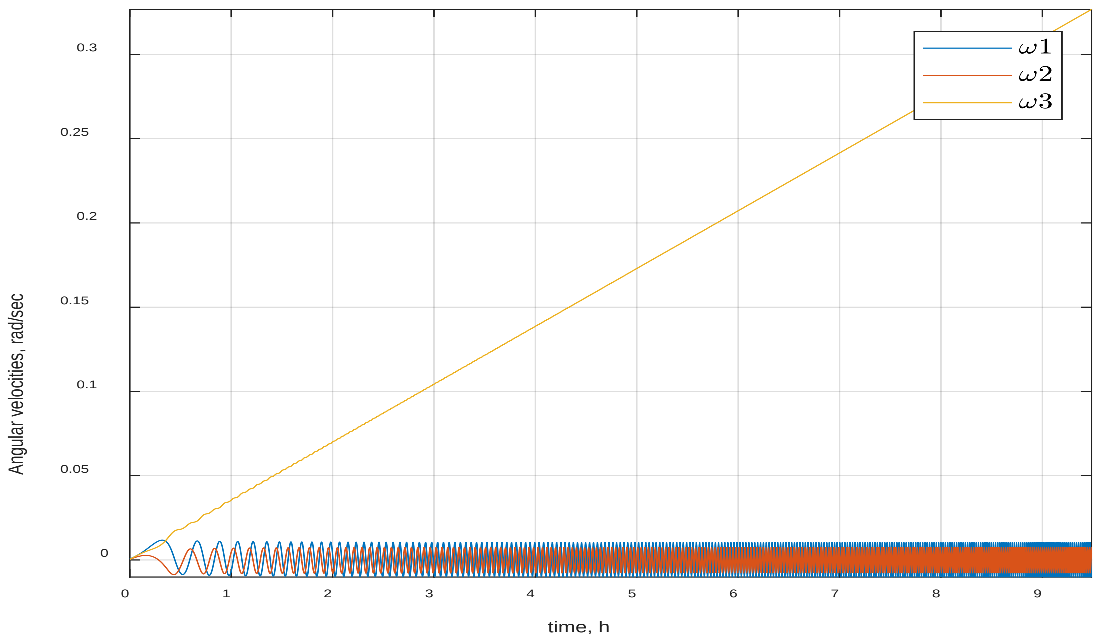
average accumulated error (PD)=0.2219 deg

Error (SMC)



average accumulated error (SMC)=0.1738 deg

Results- Semi open loop formation



Conclusion - Future Work

- The controllers are robust against system uncertainty.
- To reach the desired sub-arcsecond accuracy, we need to introduce additional constraints and techniques, such as relative position, more sensors, image processing techniques, filtering techniques, and machine learning techniques.
- In the future work, the third angular velocity, which is the axis pointing at the Crab Nebula, will be set for better accuracy, and the energy consumption will be optimized for the whole system.
- In the current research, the PD controller and sliding mode controller give similar results. In the future, the nonlinearity of the system will increase by the relative position control coupled with the system and these controllers response will be examined.
- In the future work, reinforcement learning algorithms as controlling techniques will be implemented on the system, and the accuracy will be compared to the current controllers.

Questions/Comments?

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