The Stability of the Fixed Wings Unmanned Aircraft Using the PID Method at KRTI 2019

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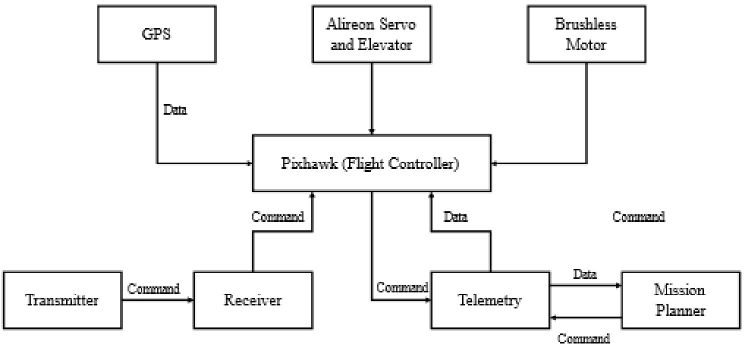
ABSTRACT



This study designed a UAV with an unmanned aircraft type with a Fixed Wings model that can perform the PID tunning process manually using the FBWA flight mode. An unmanned aircraft with the Fixed Wings type is designed to perform PID Roll tuning based on altitude and flight speed using the trial and error method increases the Proll value of 0.06 x 2 until the oscillation disappears and the final value of Proll is reduced by 50%. For the Iroll value, the increase in the value made is 0.1 x 2, increase it until it is sufficient and the final value of Iroll is reduced by 50%. For the Droll value, increase the value of 0.004 x 2 until the oscillation disappears and the final value of the Droll is reduced by 50%.

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1. INTRODUCTION

Unmanned Aerial Vehicle (UAV) Unmanned Aerial Vehicle (UAV) is an unmanned flying vehicle that is developing in the realm of defense or research agencies, the many benefits of this Unmanned System technology in supporting development activities in higher education [1]-[3], in the Indonesian flying robot contest (KRTI) held by the Directorate General of Higher Education (DIKTI) has several divisions, one of which is Racing Plane (RP) with the theme "Fast And on Track". long distance and the second variation flies manually based on parameters that have been determined before flying [4].

The vehicle can fly according to the flight plan using an autopilot system that functions by following the coordinates of the Global Positioning System (GPS) equipment that has been sent to the microprocessor [5]. Determination of signals and points on the route to be headed in that direction needs to be marked, which are also called waypoints. A waypoint is a point found on a GPS that has been marked in the form of a location point based on the coordinates of the latitude (Y) and longitude (X) axes. Determination of this waypoint really works on the GCS (Ground System Control) for the controller on the autopilot system on the plane [6], [7].

The PID controller (Proportional, Integral, Derivative) is a controller for determining the balance of an instrumentation system with the characteristics of feedback on the system to determine the P, I, and D values to be applied to the trial and error method system used in this study [9]. This PID controller is used by the aircraft to maintain the position of the aircraft while flying following a pre-planned trajectory, the aircraft is required to fly autonomously, maintain its balance when entering a transition mode where there is a change in servo movement which can change the orientation angle away from its setpoint [8], [9]. Control of Fixed Wings with PID control along with setting the parameters correctly will have an impact on Fixed Wings' flight stability and can maintain stability in various conditions. The solution to getting the PID parameter values correctly is to do PID tuning or tuning [10], [11].

This research was carried out by carrying out the PID tuning process with results related to a certain altitude as a reference for carrying out the tuning process and also related to flight speed which will also be the reference value used to carry out the tuning process [12], [13]. The PID tuning method is carried out using the Tial and Error method to obtain tuning data which will later become the updated PID values that will be used by Fixed Wings at each predetermined altitude and speed, the data retrieval process is carried out 3 times, each trial has a height and different speeds [14], [15].

2. METHOD

In this study, flying robots of the Fixed Wings type were used with 1 flight propulsion motor at the rear of the aircraft, Roll and Pitch propulsion using Alireon servo motors and elevators [16]. The tuning process that is carried out is only intended for Roll movements where Roll is driven using the Alireon servo. The tuning process that is carried out is also based on the height and speed of the Fixed Wings when flying.

2.1. System Design

The system block diagram is the system that will be run by the vehicle, using 2 block diagrams that work to show the work system of the Alireon Electrical servo and the GCS (Ground Control System) work system can be seen in Figure 1 and Figure 2.

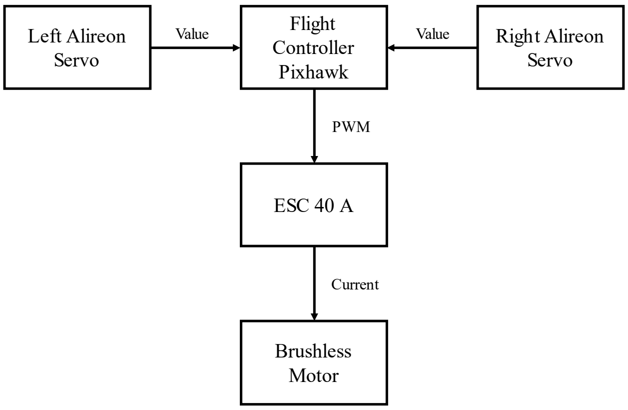

Figure 1. Block diagram of the Alireon servo electrical system

The control system in research carried out by flying robots by entering the results of PID tuning according to the required needs, then sending it to the flight controller via MAVlink (Micro Air Vehicle Link) via

Telemetry connected to the server computer can see changes in the PID value on Fixed Wings, The PID entered is the result of the tuning process carried out on the Fixed Wings, the altitude and speed sensors serve as altitude and speed reference values used on the Fixed Wings in flight so that they can determine the altitude and speed positions on the Fixed Wings which affect the tuning process. ongoing [17]. To find out the GCS work system on flights carried out can be seen in the following block diagram.

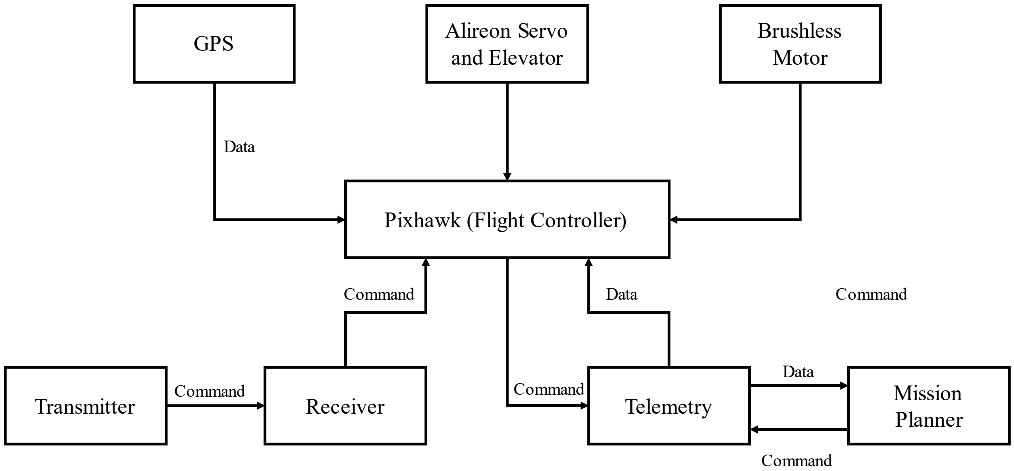

Figure 2. GCS work system block diagram

Ground Control Station work system, GCS can receive and send data. GCS can give flight commands and can also display information obtained from the vehicle while flying. The commands sent are flight parameters, flight mode and flight path. While the information displayed is in the form of speed, altitude, position, and the strength of the communication signal.

2.2. Algorithm

This system flow diagram shows the process of PID tuning by carrying out the prefix initialization of the connected Quadcopter via telemetry which is connected using MAVlink to the flight controller, then accessing data on the Quadcopter, reading the altitude and speed sensor values, after that carrying out the command process to run the program to PID tuning, then the flight controller will send the results of the PID tuning process which will be displayed on the GCS (Ground Control System) computer. The system flow chart is shown in Figure 3.

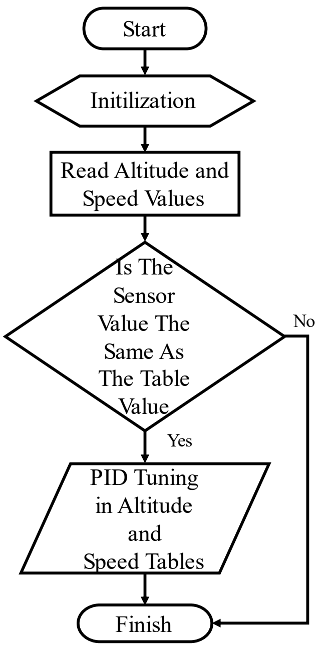

Figure 3. System flow chart

2.3. PID

Proportional integral derivative (PID) control is a feedback loop control mechanism that is widely used in control systems. The PID controller calculates the error as the difference between the measured process variable and the desired set point. The controller tries to minimize errors by adjusting the process control input [18]. The PID block diagram is shown in Figure 4.

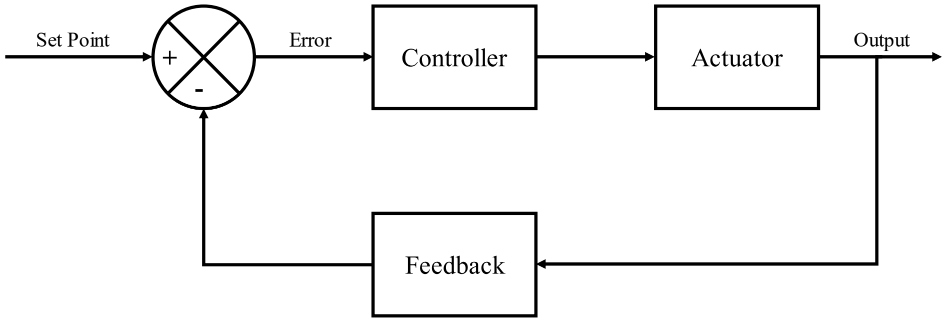

Figure 4. PID block diagram

After carrying out the PID tuning process, the P value was obtained from 10 trials, the next process is to determine the P value with equation (1).

$$P = Final\ tuning\ result\ -\ 50\% \tag{1}$$

Equation (1) is the equation used to determine the result value of the tuning process for the Proportional (P) parameter which is done manually based on each height and speed that is done. the next process is to determine the value of I with equation (2).

$$I = Final\ tuning\ result\ -\ 50\% \tag{2}$$

Equation (2) is the equation used to determine the result value of the tuning process for the Integral parameter (I) which is done manually based on each height and speed that is done. the next process is to determine the value of D with equation (3).

$$D = \ Final\ tuning\ result\ -\ 50\% \tag{3}$$

Equation (3) is the equation used to determine the result value of the tuning process for the Derivative parameter (D) which is done manually based on each height and speed that is done. The next process is the process by averaging the PID values with equation (4).

$$Average = \frac{Amount\ of\ data}{Lots\ of\ experimental\ data} \tag{4}$$

The equation that will be used to determine the average value of the PID tuning results in each data collection experiment with the average formula is the amount of data used divided by the amount of experimental data, so the results of the PID average are obtained, with the amount of data being the PID tuning value and the number of data is the number of experiments performed [19], [20].

3. RESULTS AND DISCUSSION

The prefix process carried out in this research is to test the flight speed data value retrieval which is divided into 3 parts, namely for flight speed 60 m/s, flight speed 70 m/s, flight speed 80 m/s, then continue to test altitude measurements Fixed Wings flying to the ground surface which occurs into 3 parts, namely for flights with a height of 70m, flights with a height of 80m, flights with a height of 90m, then proceed with carrying out the PID Tunning process at a speed of 60 m/s and a height of 70m, Tunning PID at a speed of 70 m/s and a height of 80m, Tunning PID at a speed of 80 m/s and a height of 90, after the data collection is carried out the next process is the process of determining the PID value to be tested, after testing the PID value the next is the process of determining the average PID that will be tested. used [21], [22].

3.1. Altitude and Flight Speed Testing

The altitude and flight speed testing phase carried out aims to determine the attitude caused by the vehicle in carrying out the process of tuning the PID value carried out, in this testing experiment it was divided into 3 types of experiments, namely testing an altitude of 70 meters and a speed of 60 m/s, the second test is testing for a height of 80 meters and a speed of 70 m/s [23], the last one is testing for a height of 90 meters and a speed of 80 m/s which can be seen in the Table 1, Table 2 and Table 3.

Table 1. Test results for altitude 70m and speed 60 m/s

No	Height 70 (M)	Speed 60 (M/S)
1	70.90	60.01
2	73.03	59.00
3	77.67	60.12
4	70.21	60.21
5	70.78	60.86
6	71.66	60.00
7	70.07	61.45
8	70.81	60.38
9	70.69	62.01
10	72.03	60.10
Average	**71.78**	**60.41**

Table 2. Test results for altitude 80 m and speed 70 m/s

No	Height 70 (M)	Speed 60 (M/S)
1	80.21	71.20
2	85.29	70.17
3	80.98	69.96
4	80.61	70.66
5	80.16	70.20
6	81.82	70.01
7	83.76	70.16
8	80.81	73.22
9	86.49	70.00
10	82.07	70.19
Average	**82.22**	**70.57**

Table 3. Test results for altitude 90 m and speed 80 m/s

No	Height 70 (M)	Speed 60 (M/S)
1	92.60	80.00
2	91.01	81.45
3	94.19	80.04
4	90.21	80.00
5	90.78	79.87
6	91.08	83.00
7	90.07	81.85
8	90.00	80.19
9	90.01	79.01
10	91.11	80.50
Average	**91.10**	**80.59**

Can be seen in the table the results of testing the altitude and flight speed of the vehicle with altitude testing of 70, 80, 90 meters carried out with 10 tests and flight speeds of 60 m/s, 70 m/s, 80 m/s with 10 tests, after carrying out the altitude and speed tests, the results obtained from the 1st test average for the 71.78 meter average height test and 60.41 m/s average speed test, while the 2nd test obtained of 82.22 meters and an average speed test of 70.57 m/s, and the 3rd test obtained was 91.10 meters and an average speed test of 80.59 m/s.

3.2. PID Tuning at an Altitude of 70 m and a Speed of 60m/s

The PID tuning process for a height of 70 meters and a flight speed of 60 m/s is carried out 10 times in flight testing and then looks for the average value of the results of the PID tuning which will later be used on fixed wings, then the PID tuning process will be carried out by using the trial and error method with a predetermined height and speed so that you will see the oscillations that arise from the addition of the PID Roll value for the addition of the Proll value of 0.06 x 2 at each increase from the prefix value or default pixhawk, increase until the oscillation disappears and the final value of Proll is reduced by 50% as shown in equation (1). For the Iroll value, the increase in value is carried out by 0.1 x 2 for each increase from the initial or default value of the parties, increase until it is deemed sufficient and the final value of Iroll is reduced by 50% as shown in equation (2). For the Droll value, the increase in value is 0.004 x 2 for each increase from the initial value or default pixhawk, increase until the oscillations disappear and the final value of Droll is reduced by 50% as shown in equation (3) where the results can be seen in the Table 4 [24], [25].

Table 4. PID tuning results for a height of 70m and a speed of 60 m/s

Proll	Iroll	Droll
1.07	0.24	0.120
1.07	0.24	0.120
1.07	0.24	0.120
1.07	0.24	0.120
1.07	0.24	0.120
1.07	0.24	0.120
1.07	0.24	0.120
1.07	0.24	0.120
1.07	0.24	0.120
1.07	0.24	0.120
1.07	0.24	0.120

The equation used to find the average PID is equation (4), the equation used to find the average is by the amount of data used divided by the amount of experimental data, the results of the average PID are obtained, with the amount of data being the tuning value PID and lots of data is the number of trials performed shown in Table 5.

Table 5. Average PID Results

	Proll	Iroll	Droll
Average	1.07	0.25	0.120

From the results of testing the PID average value used for a height of 70 meters and a speed of 60 m/s which will later be used to make flights, so that later it can be concluded that the PID for a height of 70 meters and a speed of 60 m/s used provides a more stable effect that where this can be seen from the roll angle which does not exceed ± 90°, which if the plane rolls more than 90° can cause Over Roll which can cause an accident during flight causing the vehicle to fall from a height. From the flight process carried out, we get a graph of the roll for the red color which is the degree to roll while the blue one is the target roll which can be seen in the Figure 5.

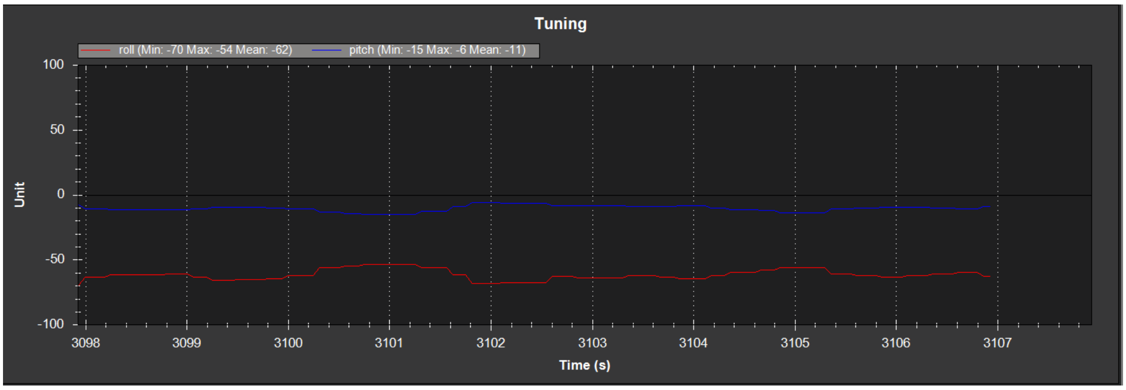

Figure 5. PID roll graph with a height of 70 and a speed of 60 m/s

3.3. PID Tuning at an Altitude of 80 m and a Speed of 70 m/s

The PID tuning process for a height of 80 meters and a flight speed of 70 m/s is carried out 10 times in flight testing and then looks for the average value of the PID tuning results which will later be used on fixed wings, then the PID tuning process will be carried out by using the trial and error method with a predetermined height and speed so that you will see the oscillations caused by the addition of the PID Roll value for the addition of the Proll value of 0.06 x 2 at each increase, increase until the oscillations disappear and the final value of the Proll is reduced by 50% as which can be seen in equation (1). For the value of Iroll, the increase in value is carried out by 0.1 x 2 for each increase, increase until it is sufficient and the final value of Iroll is reduced by 50% as shown in equation (2). For the Droll value, the increase in value is 0.004 x 2 for each increase, increase until the oscillations disappear and the final value of Droll is reduced by 50% as shown in equation (3) where the results can be seen in the Table 6 [24], [25].

The equation used to find the average PID is equation (4), the equation used to find the average is by the amount of data used divided by the amount of experimental data, the results of the average PID are obtained, with the amount of data being the tuning value PID and lots of data is the number of trials performed shown in Table 7.

Table 6. PID tuning results for a height of 80 m and a speed of 70 m/s

Proll	Iroll	Droll
1.67	0.34	0.184
1.67	0.34	0.184
1.67	0.34	0.184
1.67	0.34	0.184
1.67	0.34	0.184
1.67	0.34	0.184
1.67	0.34	0.184
1.67	0.34	0.184
1.67	0.34	0.184
1.67	0.34	0.184
1.67	0.34	0.184

Table 7. Average PID Results

	Proll	Iroll	Droll
Average	1.67	0.34	0.184

From the results of testing the PID average value used for a height of 80 meters and a speed of 70 m/s which will later be used to make flights, so that later it can be concluded that the PID for a height of 80 meters and a speed of 70 m/s used provides a more stable effect that where this can be seen from the roll angle which does not exceed ± 90°, which if the plane rolls more than 90° can cause Over Roll which can cause an accident during flight causing the vehicle to fall from a height. From the flight process carried out, we get a graph of the roll for the red color which is the degree to roll while the blue one is the target roll which can be seen in the Figure 6.

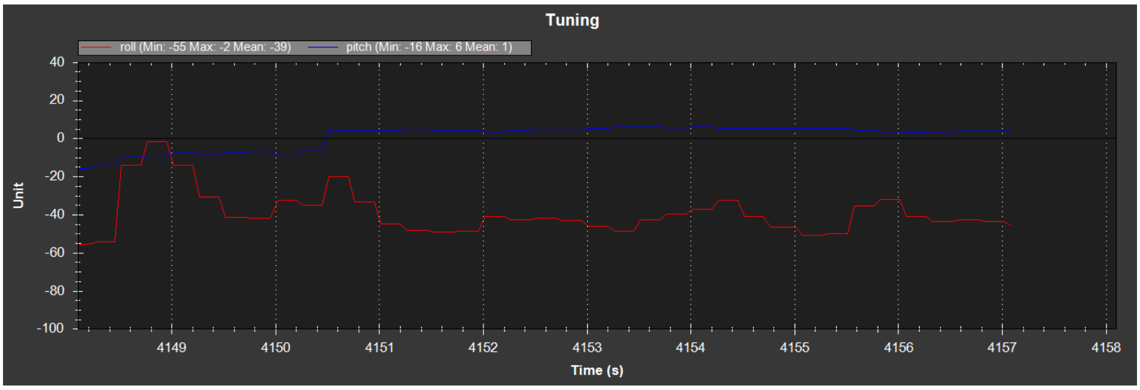

Figure 6. Graph of PID Roll with a height of 80 and a speed of 70 m/s

3.4. PID Tuning at an Altitude of 90 m and a Speed of 80 m/s

The PID tuning process for a height of 90 meters and a flight speed of 80 m/s is carried out 10 times in flight testing and then looks for the average value of the results of the PID tuning which will later be used on fixed wings, then the PID tuning process will be carried out by using the trial and error method with a predetermined height and speed so that you will see the oscillations caused by the addition of the PID Roll value for the addition of the Proll value of 0.06 x 2 at each increase, increase until the oscillations disappear and the final value of the Proll is reduced by 50% as which can be seen in equation (1).

For the value of Iroll, the increase in value is carried out by 0.1 x 2 for each increase, increase until it is sufficient and the final value of Iroll is reduced by 50% as shown in equation (2). For the Droll value, the increase in value is 0.004 x 2 for each increase, increase until the oscillations disappear and the final value of Droll is reduced by 50% as shown in equation (3) where the results can be seen in the Table 8 [24], [25].

The equation used to find the average PID is equation (4), the equation used to find the average is by the amount of data used divided by the amount of experimental data, the results of the average PID are obtained, with the amount of data being the tuning value PID and lots of data is the number of trials performed shown in Table 9. From the results of testing the PID average value used for a height of 80 meters and a speed of 70 m/s which will later be used to make flights, so that later it can be concluded that the PID for a height of 80 meters and a speed of 70 m/s used provides a more stable effect that where this can be seen from the roll angle which does not exceed ±90°, which if the plane rolls more than 90° can cause Over Roll which can cause an accident during flight causing the vehicle to fall from a height. From the flight process carried out, we get a graph of the roll for the red color which is the degree to roll while the blue one is the target roll which is shown in the Figure 7.

Table 8. PID tuning results for a height of 90 m and a speed of 80 m/s

Proll	Iroll	Droll
2.27	0.44	0.248
2.27	0.44	0.248
2.27	0.44	0.248
2.27	0.44	0.248
2.27	0.44	0.248
2.27	0.44	0.248
2.27	0.44	0.248
2.27	0.44	0.248
2.27	0.44	0.248
2.27	0.44	0.248
2.27	0.44	0.248

Table 9. PID average results

	Proll	Iroll	Droll
Average	2.27	0.44	0.248

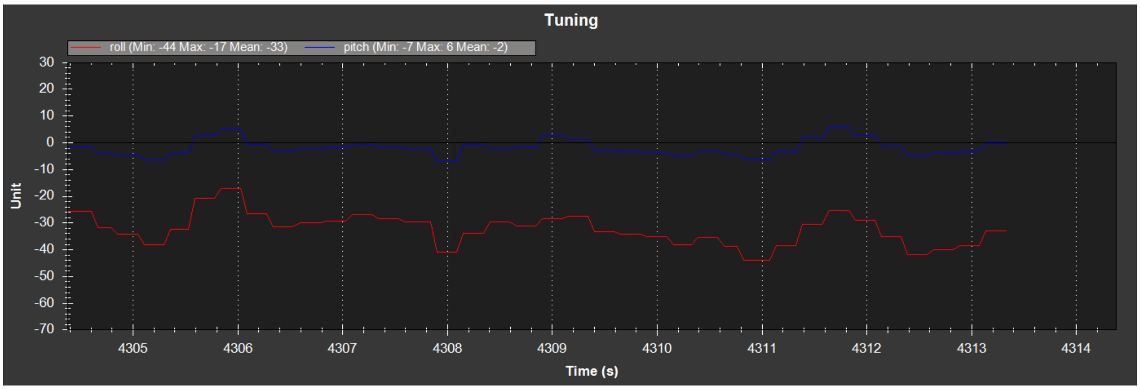

Figure 7. PID roll graph with a height of 80 and a speed of 70 m/s

4. CONCLUSION

After designing and building the system, then testing and analyzing it, conclusions can be drawn about the work system stability of the fixed-wing unmanned aircraft using the PID method at KRTI 2019 using the trial and error method. In the experiments carried out by testing the PID tuning at altitude and flight speed, the PID value was obtained which would later be used as the PID value in the flight based on the conditions for a height of 70m and a speed of 60m/s, the average PID Roll value was obtained with a Proll value = 1.07, Iroll = 0.25, and Droll = 0.120, while for the PID Roll average value for a height of 80m and a speed of 70 m/s with a Proll value = 1.67, Iroll = 0.34 and Droll = 0.184, and for the PID Roll average value for a height of 90m and a speed of 80 m/s the value of Proll = 2.27, Iroll = 0.44, and Droll = 0.248. From the information in the tables and graphs a comparison between the input PID from Pixhawk and the results of the updated PID tuning, the value is obtained by tuning the PID using the trial and error method which is based on the Altitude and Flight Speed values with the PID values which are divided into 3 according to flight speed and altitude are measured and it can be concluded from the results of this study the results of a comparison between the input PID values from pixhawk and the updated PID, the values generated by the updated PID produce slopes and better graphics than the input PID from pixhawk tested on each the altitude level compared to each updated PID value which is also tested at each flight speed which has a different value at each tested speed and the movement of the Fixed Wings is more stable.

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