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QUADCOPTER PROTOTYPE STABILITY ANALYSIS USING MATLAB SIMSCAPE LIBRARY

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Abstract. ***Nowadays, the use of quadcopters in daily life has become important due to its capabilities and ability to carry out many tasks in many fields like civil, military, industrial, and agricultural fields. The modelling of the quadcopter and deeply understanding its movements is very important to ensure that the simulations of its behaviour are as close as possible to reality and also helps us to design a flight controller. In this work, we used a modern technique on MATLAB (Simscape) to simulate a quadcopter in real-time. At first, we build a quadcopter using Simscape multibody then we simulated the PID regulator, the command algorithms, and the motor model with the applied forces on the body to achieve the global model that we can use to study the movement of the quadcopter on the three-axis which ensure a stable functioning. The results obtained show the stability of the four movements of the quadcopter (roll, pitch, yaw, and altitude).***

Keywords: Quadcopter, Electrical model, PID regulator, Simscape, Stability.

1. INTRODUCTION

Nowadays, with the incredible development of technology, especially electronics and computer science, which led to appear powerful microcontrollers and powerful software, this is what helped people to increase the performance of drones from both sides: software, and hardware. Some important applications of this aircraft are that it can be used in the army, entertainment, surveillance, aerial photography, agriculture, and transportation, where individual goods can be transported too anywhere. The irrigation has become more efficient when using drones to be watering, monitoring fields and detects water pooling or leaks using thermal cameras.

Quadcopters have a different behaviour from other planes, as they have four movements resulting from the rotation of four engines in diverse ways. To obtain a vertical movement, all the engines must rotate at the same speed. As for the other movements there are two types of quadcopters (+ and x), and each type has its own way of controlling [1].

The control of the quadcopter depends mainly on its stability [2-3]. Where a special control unit is designed based on the basic movements made by the aircraft during flight. These movements are controlled by special propellers that produce forces and this shows that the aerodynamic properties of the aircraft are very important as many researchers have studied these properties in depth [4]. In addition to the mechanical vibration characteristics of the propellers which help the quadcopter to fly safely in optimal conditions [5].

Ensuring drone stability is an important task for ensure a safety flying. So, to stabilize a quadcopter there are many different regulators used. The most important and widely used regulators in the field of drones are: PID and LQR [6-7]. In addition, other different hybrid regulators can be used (P-LQR, PD-LQR and PD2-LQR) [8]. However, the PID has the ability to correct the error and apply accurate and optimal control using three control terms: proportional, integral and derivative. As for the LQR is a method that used to find the optimal control action that ensure a high stability and performance to the system by reducing the cost J value using two matrices Q and R, where Q is a square matrix with rows equal the number of states, and R is square matrix with rows equal to the number of inputs. Also, many artificial intelligent techniques based on Artificial Neural Networks (ANN) are used for improving the response of the PID regulator and make the system more reliable [9-10].

To develop a quadcopter model under MATLAB (Simulink), it is important to understand the quadcopter behaviour and its movements (Altitude, Roll, Pitch, and Yaw). In addition to understand the relation between the different equations, there are different ways to simulate a quadcopter model on MATLAB. The different mathematical equations of a quadcopter can be used to create a Simulink model in several ways [11-12]. A mechanical model can be developed based on Simscape Multibody library with the help of an electric library to simulate the motors [13].

In this work, we studied the x-type, where in this type we can control the three movements (roll, pitch, yaw) through pairs of motors. Firstly, to achieve a roll movement, the speed of the two motors on the left must be increased, and the speed of the two motors on the right must be decreased. This applies torque around the x-axis to obtain a rotational