FLYING ROBOT

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Abstract. The Flying Robot described in this paper is an indigenously developed quadcopter controlled by a ATMEL microcontroller. The device consists of Arduino Mega as the core component and attached to it are two motor drivers L298N to power four DC motors. The Arduino is programmed to control the quadcopter movements such as Ascent, Descent, Forward, Backward, Right and Left. The wireless control capability of the quadcopter is achieved using RF Transmitter and RF Receiver pairs.

Keyword. UAV, UVS, Quadcopter, Robot, Arduino, Motor Driver, DC Motors.

INTRODUCTION

A quadcopter, also called a quadrotor helicopter or quadrotor [1] is a multirotor helicopter that is lifted and propelled by four rotors. Quadcopters are classified as rotorcraft, as opposed to fixed-wing aircraft, because their lift is generated by a set of rotors (vertically oriented propellers) [2]. Hence Quadcopter is an Unmanned Aerial Vehicle (UAV) which can be used for many applications such as reconnaissance, aerial survey of disaster areas, remote sensing, deforestation, logistic industries, etc.

One of the main advantages of quadcopter is that it can perform a vertical take-off and landing with very minimal space required. Hence it differs a lot from a conventional aircraft while maintaining the same amount of stability.

FLIGHT DYNAMICS

To maintain stability of any aircraft, three parameters governing the aircraft principal axes are: Yaw, Pitch and Roll (figure 1). The axes are alternatively designated as vertical, transverse, and longitudinal respectively.

Yaw – nose left or right about an axis running up and down
Pitch - nose up or down about an axis running from wing to wing
Roll - rotation about an axis running from nose to tail

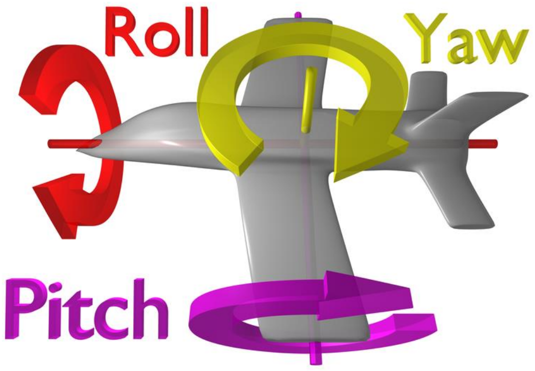


Figure 1. Three Principal Axes of an aircraft [4]

METHODOLOGY

Quadcopter uses 2 sets of identical fixed pitched propellers; 2 clockwise (CW) and 2 counter-clockwise (CCW) [1]. These use variation of RPM to control lift and torque. Control of vehicle motion is obtained by altering the rate of rotation of one or more motors, thereby changing its torque load and thrust/lift characteristics. The front and the rear propellers rotate counter-clockwise, while the left and the right ones turn clockwise. By changing the speed of each rotor it is possible to specifically generate a desired total thrust; to locate for the centre of thrust both laterally and longitudinally; and to create a desired total torque, or turning force [3].

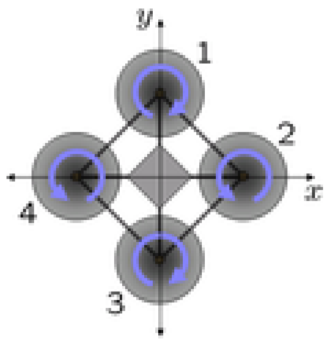
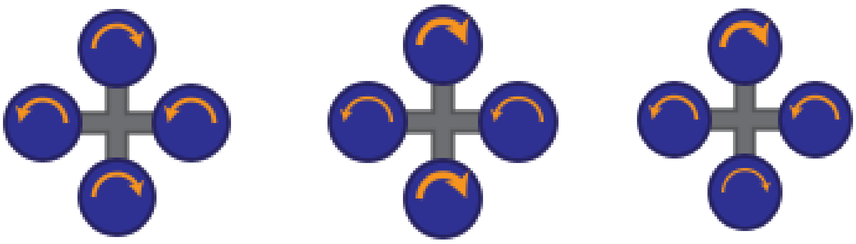


Figure 2. Quadcopter Rotor arrangement [2]

A quadcopter uses four identical DC motors (rotors) as mentioned in figure 2. Each rotor produces both a thrust and torque about its center of rotation, as well as a drag force opposite to the vehicle's direction of flight. If all rotors are spinning at the same angular velocity, with rotors one and three rotating clockwise and rotors two and four counterclockwise, the net aerodynamic torque, and hence the angular acceleration about the yaw axis, is exactly zero, which means there is no need for a tail rotor as on conventional helicopters. Yaw is induced by mismatching the balance in aerodynamic torques (i.e., by offsetting the cumulative thrust commands between the counter-rotating blade pairs).



a b c

Figure 3. Altitude adjustment or hovering (a), Yaw adjustment (b) and Pitch or Roll adjustment (c) of Quadcopter

Adjustment of Altitude or Hovering capability of Quadcopter

Quadcopter is capable of adjusting its altitude by applying equal amount of thrust to all its four rotors. This is achieved by maintaining same angular velocity (rpm) to all of its rotors as shown in figure 3(a).

Adjustment of Yaw

A quadrotor adjusts its yaw by applying more thrust to rotors rotating in one direction as shown in figure 3(b).

Adjustment of Pitch or Roll

A quadrotor adjusts its pitch or roll by applying more thrust to one rotor and less thrust to its diametrically opposite rotor as shown in figure 3(c).

BLOCK DIAGRAM

Figure 4 shows the block diagram of a flying robot. The main goal of the paper remains in designing a simple quadcopter capable of performing the six distinctive movements of an aircraft - Ascent, Descent, Forward, Backward, Right and Left. The Arduino Mega is programmed to propel the quadcopter for the above mentioned movements.

The core component of the project is an Arduino Mega which is programmed to control the above mentioned six distinctive movements of the four propeller motors of the quadcopter. The four dc motors (M_A, M_B, M_C, M_D) are powered by two motor drivers L298N. The commands from the Arduino are wirelessly transmitted using RF Tx module to RF Rx module.

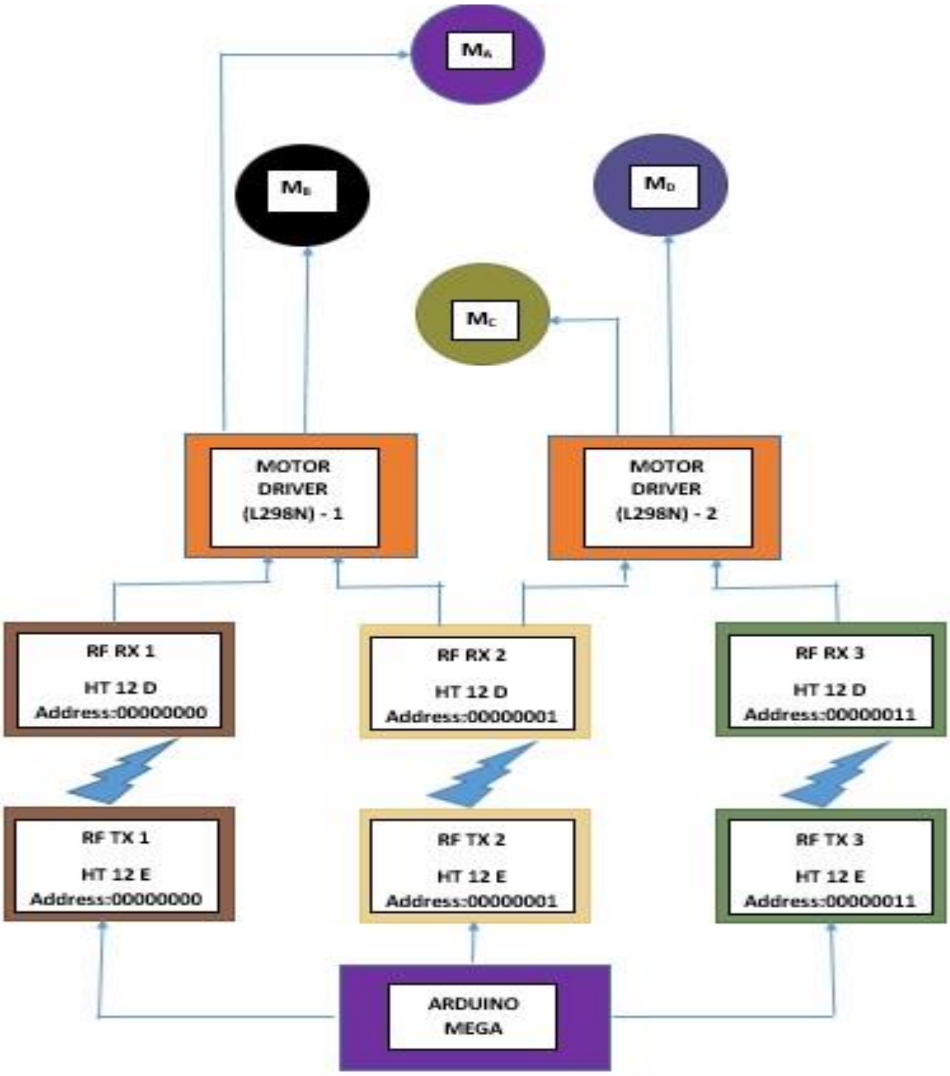
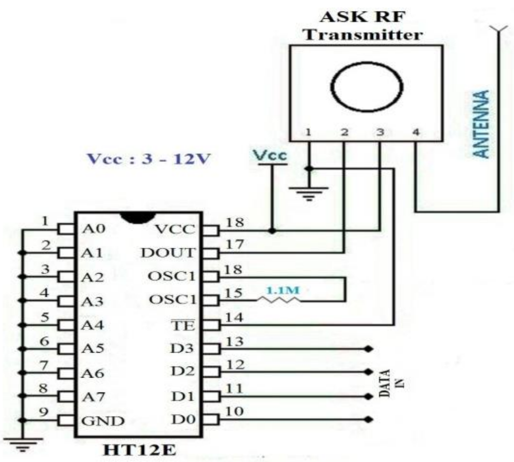


Figure 4. Flying Robot

RF Transmitter and RF Receiver circuitry



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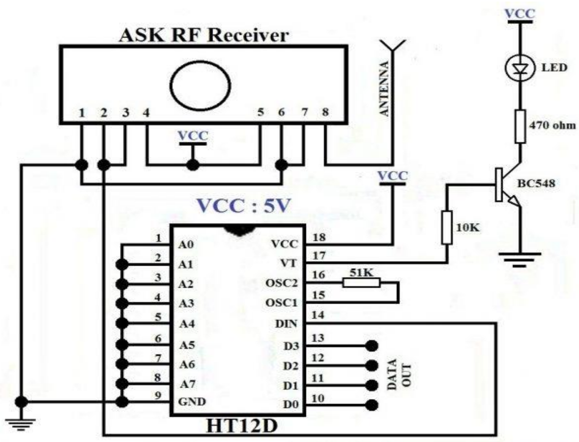

b

Figure 5. RF Transmitter (a) and RF Receiver (b) [5]

Figure 5 shows the circuit diagram of RF Transmitter and RF Receiver. Each RF Tx module consists of HT 12E encoder to convert the parallel data to serial data. Similarly, each RF Rx consists of HT 12D decoder to convert the serial data to parallel data. Three RF Tx and Rx pairs of different frequencies are employed to transmit three control signals (two for motor direction control and one for speed control of each dc motor). The Encoders and Decoders present in RF Tx and Rx pairs are assigned unique address to maintain synchronization between the respective pairs (figure 4).

OPERATIONAL FLOW CHART OF ARDUINO PROGRAM

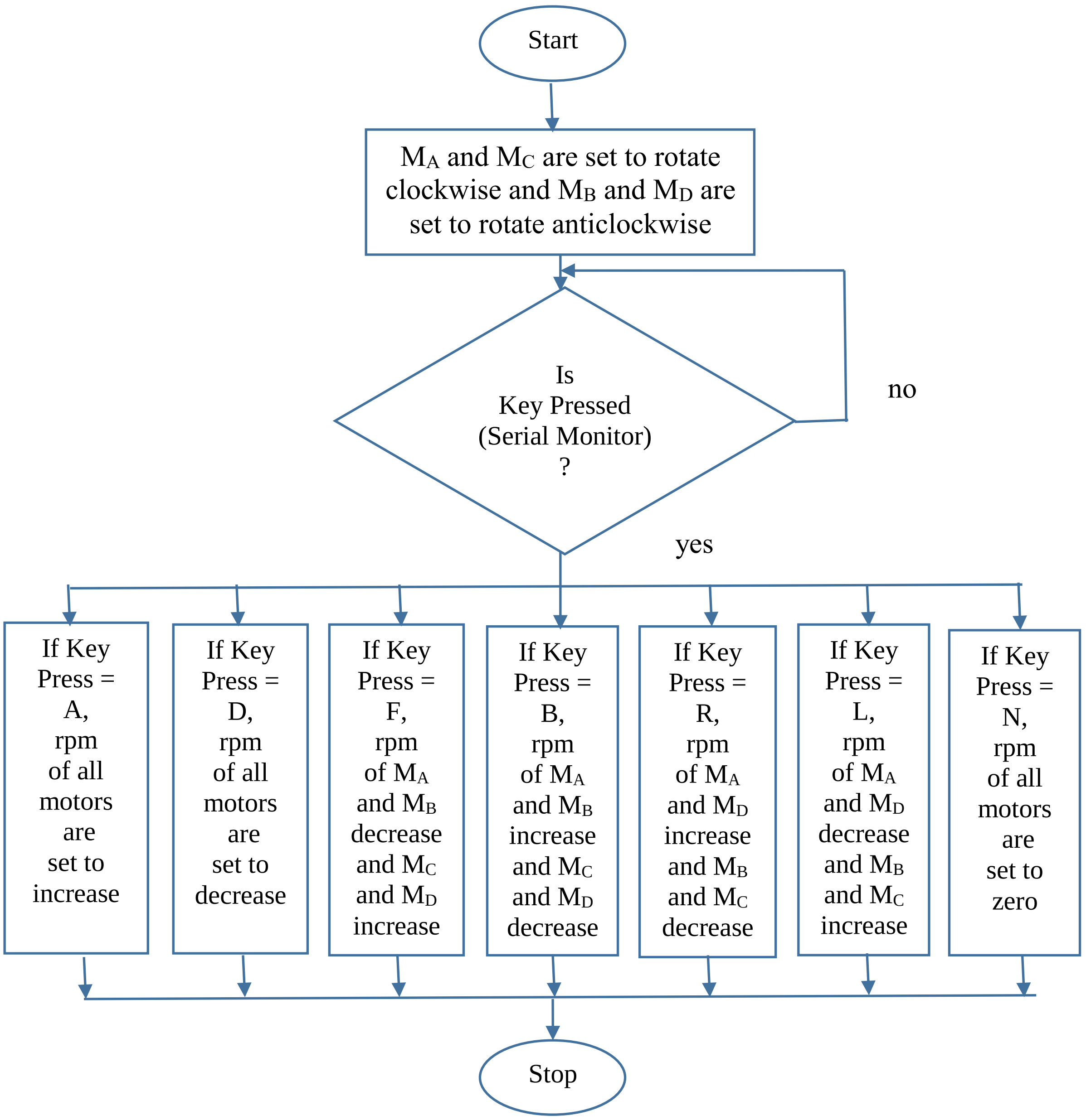

Figure 6. Operational Flow diagram of Arduino Program

The operational flow diagram of the Arduino program which drives the four motors M_A, M_B, M_C and M_D of the quadcopter according to the user pressed key in serial monitor of Arduino software is illustrated in figure 6.

RESULTS AND DISCUSSION

The quadcopter was programmed by Arduino for the six distinctive movements and the findings are tabulated (table 1) below:

Motor A – is programmed to Rotate Clockwise
Motor B – is programmed to Rotate Anticlockwise
Motor C – is programmed to Rotate Clockwise
Motor D – is programmed to Rotate Anticlockwise

Figure 7 shows the prototype of the "Flying Robot" which was designed and tested.

Figure 7. Flying Robot

Table 1. Quadcopter Movements

Quadcopter Movements	**Motor A**	**Motor B**	**Motor C**	**Motor D**
Ascent (A)	Increase Speed	Increase Speed	Increase Speed	Increase Speed
Descent (B)	Decrease Speed	Decrease Speed	Decrease Speed	Decrease Speed
Forward (F)	Decrease Speed	Decrease Speed	Increase Speed	Increase Speed
Backward (B)	Increase Speed	Increase Speed	Decrease Speed	Decrease Speed
Right (R)	Increase Speed	Decrease Speed	Decrease Speed	Increase Speed
Left (L)	Decrease Speed	Increase Speed	Increase Speed	Decrease Speed
No Rotation (N)	No Speed	No Speed	No Speed	No Speed

CONCLUSION

It is observed that the diagonal motors M_A and M_C rotate clockwise and M_B and M_D rotate anti-clockwise for all the six distinctive movements of the quadcopter. By adjusting the speed of rotation (rpm) of the four motors accordingly, the six distinctive movements of the quadcopter are achieved. The stability of the quadcopter will be established in the future design.

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