Quadcopter with Advanced Monitoring

by

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A comprehensive project report has been submitted in partial fulfillment of the requirements for the degree of

Bachelor of Technology

in

ELECTRONICS & COMMUNICATION ENGINEERING

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May, 2018

CERTIFICATE OF APPROVAL

This is to certify that the project titled "**Quadcopter with Advanced Monitoring**" carried out by

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for the partial fulfillment of the requirements for B.Tech degree in **Electronics and Communication Engineering** from **Maulana Abul Kalam Azad University of Technology, West Bengal**is absolutely based on his own work under the supervision of Mrs**. Tiya Dey Malakar**. The contents of this thesis, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma.

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DECLARATION

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ABSTRACT

A quadcopter or drone can be useful for certain scenarios such as search and rescue operations in remote areas, monitoring areas and boundaries, aerial photography. We can easily monitor one area by sitting at another place. This could be helpful in deploying preventive measures in case of trespassing by an uncouth entity. The simple advantage of drone photography is that you are able to get your camera higher in the sky for better perspectives. So many times, photographers wish, if there was a way to get a higher perspective to shoot a landscape. Higher perspectives make landscapes look longer and larger than they actually are. It's a great way to create better looking landscape photographs.

CONTENTS

LIST OF ABBREVIATIONS

UAV	Unmanned Aerial Vehicle
LiPo	Lithium Polymer
Tx	Transmitter
Rx	Receiver
CG	Centre of Gravity
ESC	Electronic Speed Control
RC	Remote Controlled
CW	Clockwise
CCW	Counter Clockwise
PI	Proportional Integral

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Chapter 1

Introduction

An Unmanned Aired Vehicle(UAV) / Drone is being made using flight controller “KK2.1.5” , 4 Electronic speed control units (ESC) of 30A, 4 x 3 phase brushless motors (1000KV) capable of capturing and delivering images during flight.

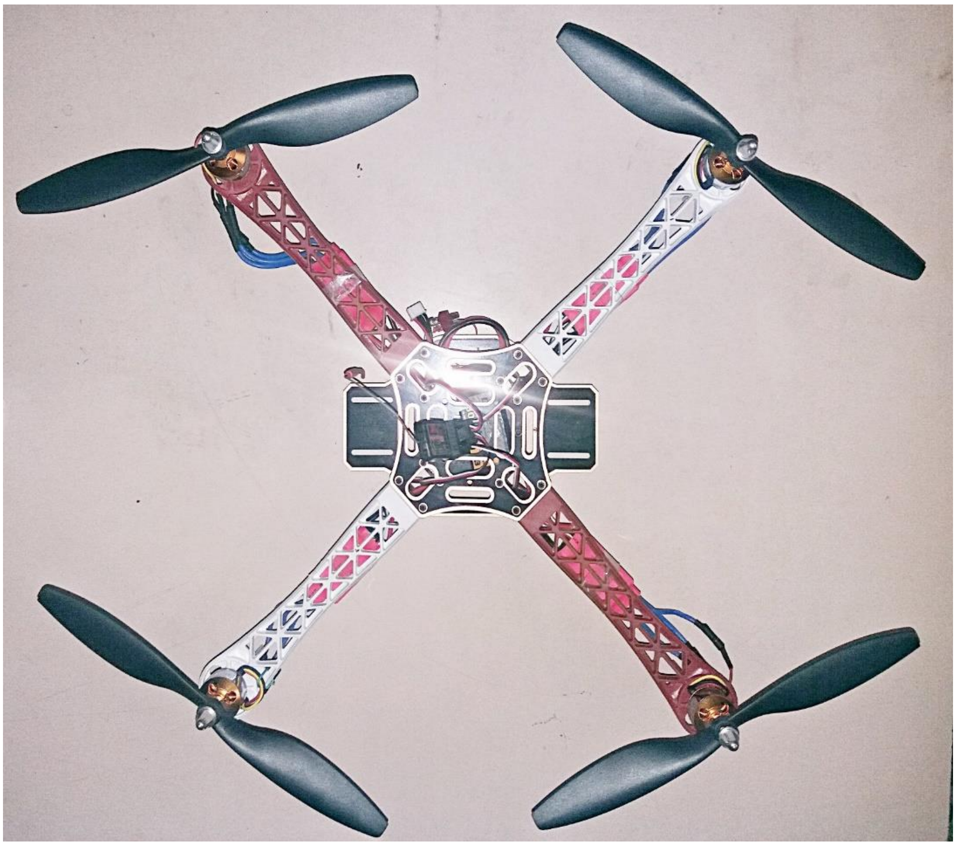

Fig. 1.1 Quadcopter Top View

1.1 Problem Statement

A quadcopter or drone can be useful for certain scenarios such as search and rescue operations in remote areas, monitoring areas and boundaries, aerial photography. In certain remote areas, in case of an emergency, there is often a limitation of human reach, in that case an unmanned aired vehicle (U.A.V.) can be sent to such areas for appropriate help. These U.A.V.s could capture the images, deliver medical care and can even bring food.

Quadcopters or drones can be used for surveillance of certain areas and boundaries for security purposes. We can easily monitor one area by sitting at another place. This could be helpful in deploying preventive measures in case of trespassing by an uncouth entity.

In aerial photography, we have certain applications such as shooting of a movies, sports, nature and wildlife and events.

1.2 List of Components

Components	Configuration
Flight Control Unit (FCU)	KK 2.1.5
Motors	BLDC 1000KV
Battery	LiPo 2200mAh 11.1V 25C
ESC	30A
Frame	Quad Arm
Transmitter & Receiver	FS-CT6B 2.4 GHz, 6 Channel
Balanced Charger	3-Cell Charging
Propeller	Twin Blade
Camera	Phone Holder

Table 1.1

1.3 Circuit Diagram

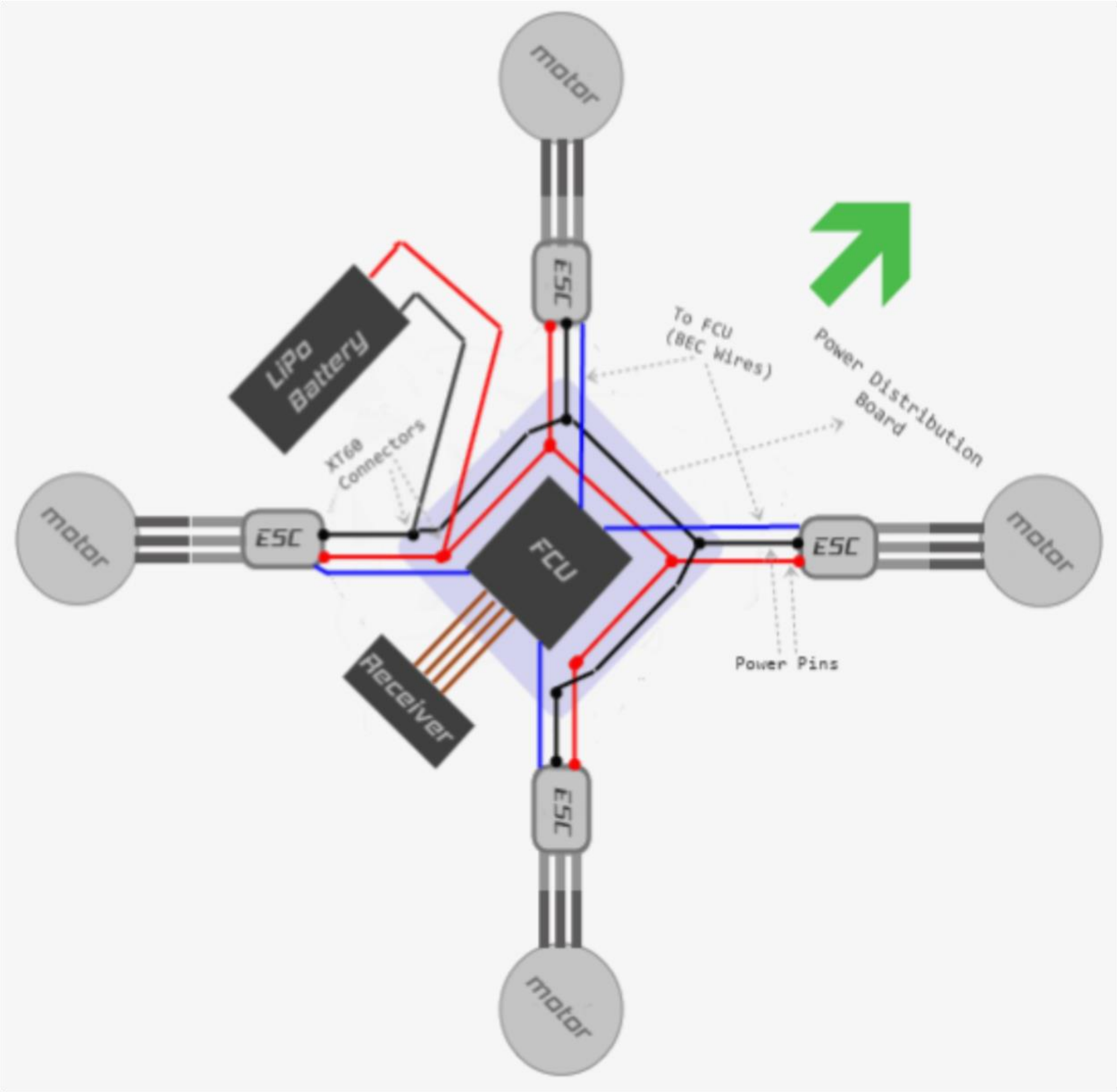

Fig. 1.2 Basic Wire Diagram of the Quadcopter

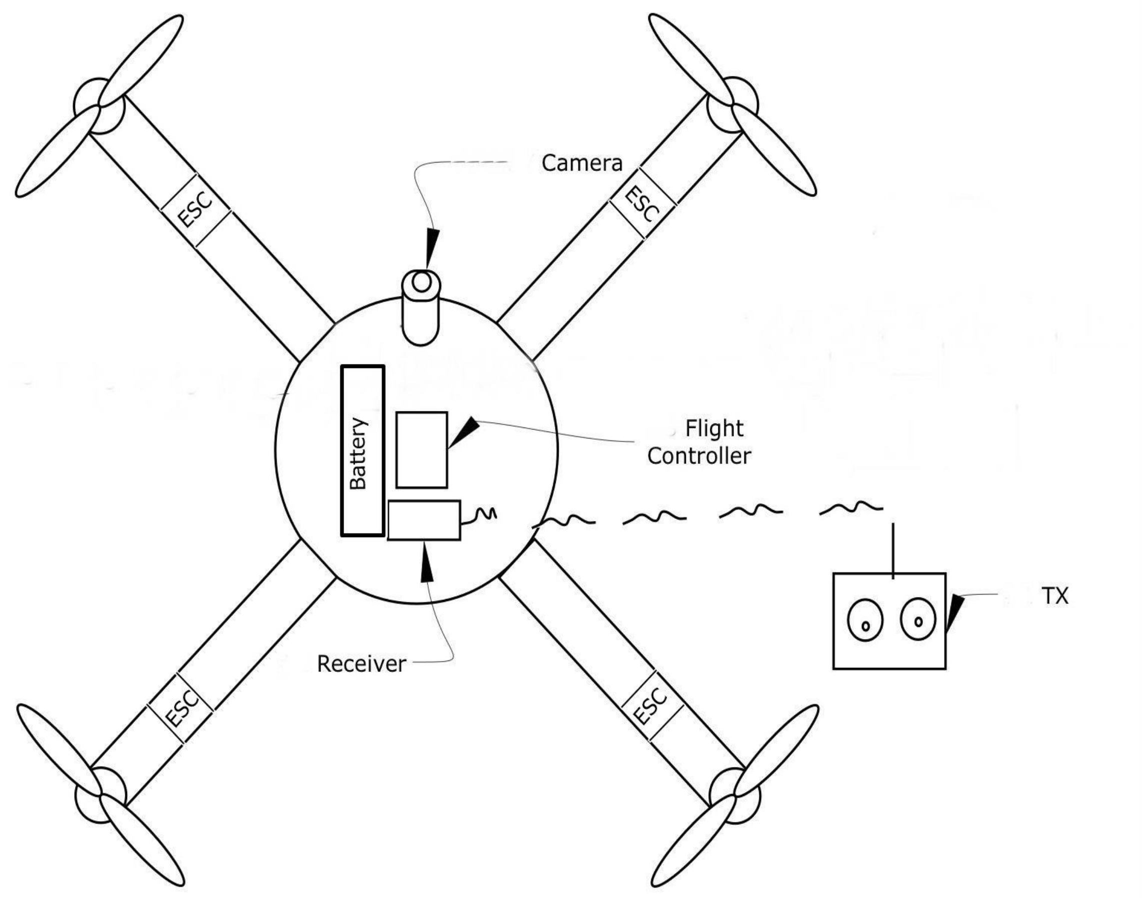

Fig 1.3 Component Placement

1.4 Working Principle

The Quadcopter or 4 Armed Drone works on the same principle of Aviation as a Helicopter does. It has 4 equally spaced motors arranged and placed at four corners of the structure forming a (X) like shape. Multirotor like Quadcopters are unstable without Electronic Assistance. Therefore to Balance it in the midair, a Microcontroller board or a Flight Control Unit (FCU) is required. It Takes the inputs from the Receiver Elevator, Rudder, Aileron and Throttle and Instructs the Electronic Speed Control Units to drive the motors accordingly.

In this case we are using a Flight Control Unit called KK 2.1.5. This Flight Control Unit is powered by the Atmega 644PA 8-bit AVR RISC-based microcontroller with 64k of memory. The Flight Controller have Gyroscope and Accelerometer to compute the details at very high speed and perform with ease.

The ESCs have 3 output pins which connects the Brushless Motors. The Reversal of these pins are responsible for the Direction or change of direction of the motor's rotation.

The Battery Eliminator Circuit (BEC) is present inside the ESC and it is used to power other electronics present on board, such as The Flight Control Unit, receiver, camera etc.

The 5V output returning from BEC is fed to the FCU along the Signal Pins, for each motors and ESCs. This Powers the FCU and connects the signal pins on board.

The motors are out runner Brushless DC motors with 3 phase configuration which is rated 1000KVA. The motors are connected to their individual ESCs respectively.

Quadcopters can be programmed and controlled in totally different ways. However the most common ones are in either rate (acrobatic) or stable mode. In rate mode, only the gyroscope is used to control the quadcopter balanced, it does not self-level.

If switched to stable mode, the accelerometer gets activated, helping to stabilize the quadcopter. The speed of the 4 motors can be adjusted automatically and perpetually to keep the quadcopter balanced.

The radio Transmitter and Receiver is used to control the quadcopter. In order for a quadcopter to work, four channels (throttle, elevator, aileron rudder) are required. Getting a transmitter with 6 or 8 channels is recommended for additional functionalities.

The Remote Control of transmitter has the Controls for Elevator / Rudder on the Left Side and Aileron / Throttle on the Right Side.

Lithium Polymer (LiPo) batteries are the most famous power source for controlling quadcopters.

LiPo batteries can have discharge rates sufficiently expansive to control even probably the most taxing multirotor. This settles on them the favored decision over different choices, for example, the Nickel Cadmium (NiCd) battery. This is likewise the essential reason they can be a genuine fuel source for multirotor.

To make anything fly, we have to balance its weight by generating an equivalent force (Lift) and balance moments about its Centre of Gravity (CG) by generating opposite moments.

A quad-copter generates these required moments and lift force using its four rotors. To fly stable in a particular orientation, net moment about the cg should always be zero or resultant of all the forces acting on the system should pass through its CG.

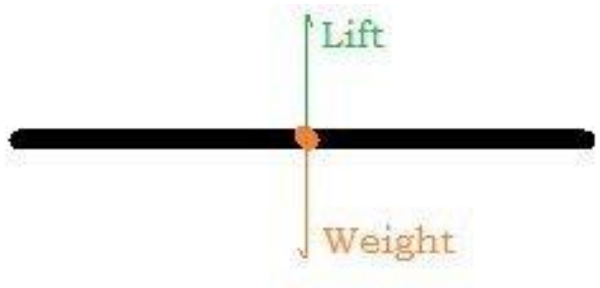

Fig. 1.4 Lift & Weight

If the resultant of the lift generated by all the rotors doesn't pass through CG, it creates a moment about the cg and tend to tilt the quad-copter until lift again passes through the CG.

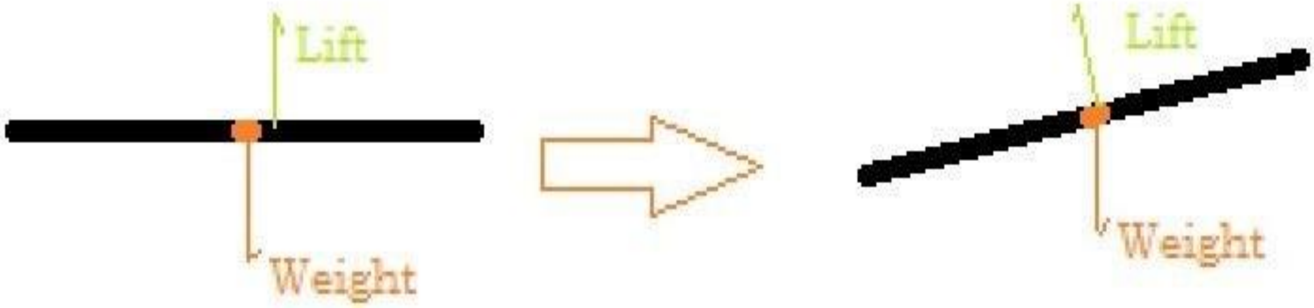

Fig. 1.5 Lift & Weight

Also to balance the angular momentum about the CG, two rotors are made to rotate clockwise and other two anti-clockwise.

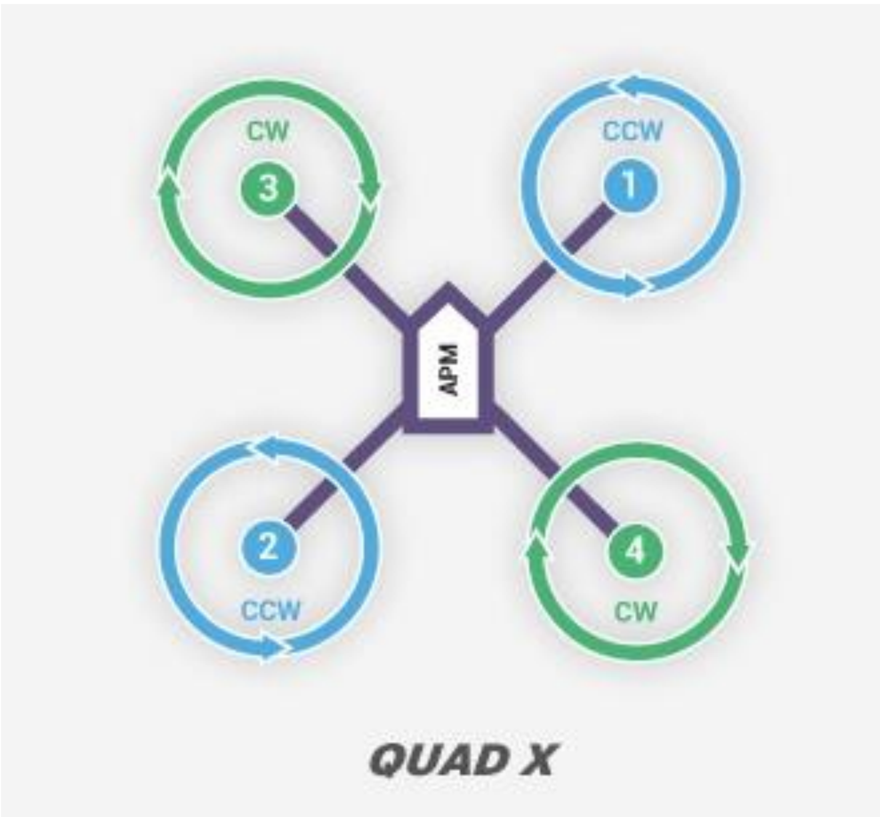

Fig. 1.6 Rotating Directions of the Propellers

In order for the quadcopter to hover in place, all the motors rotate at the same speed (or RPM). The rotation speed must be sufficient enough for the quadcopter to generate a 'lift', counteracting its own weight, but not so much that the quadcopter keeps climbing in altitude.

The torque effect acting on the body of the quadcopter by each of the motors should be cancelled out. Otherwise, expect the quadcopter to tend to want to yaw in a certain direction.

In order for the quadcopter to gain altitude, all four of the motors must increase the speed of rotation simultaneously. Conversely, to descend down, all four of the motors must decrease speed of its rotation simultaneously.

The ‘pitch’ control tells the quadcopter whether to fly forward or backward. In order to pitch forward for example, the speed of the motors at the rear of the quadcopter must increase, relative to the speed of the motors on the front. This ‘pitches’ the nose (front) of the quadcopter down, resulting in the forward movement. This is achieved by either increasing the speed of the rear motors or decreasing the speed of the front motors. Conversely, in order to ‘pitch’ backwards, the speed of the motors at the front of the quadcopter must increase relative to the speed of the motors at the back.

The ‘roll’ control tells the quadcopter to move side to side. In order to ‘roll’ to the right for example, the speed of the motor at the left of the quadcopters must increase, relative to the speed of the motors on the right. This ‘rolls down’ the right side of the quadcopter, resulting in a side-ways swaying movement.

This is achieved by either increasing the speed of the left motors or decreasing the speed of the right motors. Conversely, in order to ‘roll’ left, the speed of the motors of the right of the quadcopter should increase relative to the speed of the motors at the left.

The ‘yaw’ or ‘rudder’ is a rotation movement of the quadcopter. In this case, the rotation speed of diametrically opposing pairs of motors are increased or decreased, varying the torque in the direction of rotation of that pair causing the quadcopter to rotate in the direction of the increased torque.

All these factors are together responsible for the flight of the Quadcopter.

Configuration

2.1 KK 2.1.5

The KK 2.1.5 is packing new found power with updated sensors, memory and header pins. Designed exclusively for Hobby King by the grandfather of the KK revolution, Rolf R Bakke, the KK2.1 is the next evolution of the first generation KK flight control boards and has been engineered from the ground-up to bring multi-rotor flight to everyone, not just the experts. The LCD screen and built-in software makes installation and set-up easier than ever.

The original KK gyro system has been updated to the incredibly sensitive 6050 MPU system making this the most stable KK board ever and adds the addition of an auto-level function. At the heart of the KK2.1 is the ATMEL Mega 644PA 8-bit AVR RISC-based microcontroller with 64k of memory.

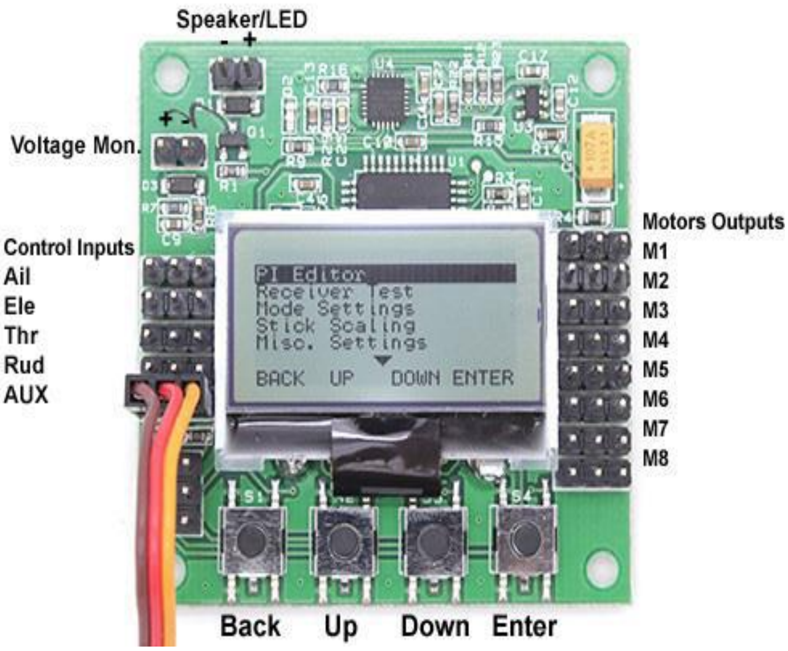

Fig.2.1 KK 2.1.5 FCU

An additional header has been added for voltage detection, so now there is no need for on-board soldering. A handy piezo buzzer is also included with the board for audio warning when activating and deactivating the board, which can be supplemented with an LED for visual signaling.

The KK2.1.5 has two 5V power busses. The first 5V bus is common across the receiver inputs, output 1 (M1) and the programmer port. This bus powers the KK2.1.X processor and needs to be as clean as possible (i.e. no noise from servos). The second 5V bus is common for outputs 2 to 8 (M2 to M8) only.

2.2 Electronic Speed Control Unit

Electronic Speed Controllers (ESC) are an essential component of modern quadcopters (and all multi rotors) that offer high power, high frequency, high resolution 3-phase AC power to the motors in an extremely compact miniature package. These craft depend entirely on the variable speed of the motors driving the propellers. This wide variation and fine RPM control in motor/prop speed gives all of the control necessary for a quadcopter to fly.

Quadcopter ESCs usually can use a faster update rate compared to the standard 50 Hz signal used in most other RC applications. PWM signals up to 400 Hz can be used in some cases, and other control options can increase this rate even higher. Also some software delays, such as low-pass filters, are removed in order to improve control latency.

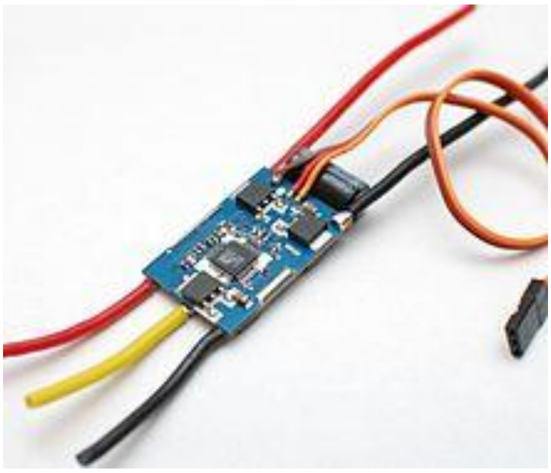

Fig. 2.2 ESC

Low-voltage cut-off (input voltage checking) and temperature limiting are not enabled, as reacting to such conditions on a multi-rotor will likely be worse than ignoring them. Make sure you use a Li-Po battery measurement system to avoid over-discharging LiPo batteries.

Once an input signal is received that is low enough to reach the "neutral" or "power-off" area, the ESC will arm (long beep), and the green LED will light. As the signal enters the motor start range, the ESC will attempt to start or run the motor, and continue to do so as long as input signal is above the neutral position. The amount of power used for starting is not fixed, just based on the power requested, limited and ramped at first to increase the chances of a successful start.

If a commutation time-out or long demagnetization period is detected, the red LED will light up. This should not occur in normal operation. Very brief flashes during rapid acceleration indicate that the demagnetization period exceeded the expected zero-crossing point and that countermeasures have been taken to avoid loss of synchronization. The green LED will remain off until the power is turned off and the motor stops.

2.3 Brushless Motor

Brushless DC motors use electric switches to realize current commutation, and thus continuously rotate the motor. These electric switches are usually connected in an H-bridge structure for a single-phase BLDC motor, and a three-phase bridge structure for a three-phase BLDC motor shown in Figure. Usually the high-side switches are controlled using pulse-width modulation (PWM), which converts a DC voltage into a modulated voltage, which easily and efficiently limits the startup current, control speed and torque. Generally, raising the switching frequency increases PWM losses, though lowering the switching frequency limits the system's bandwidth and can raise the ripple current pulses to the points where they become destructive or shut down the BLDC motor driver. 3-phase motors are the most popular and widely used.

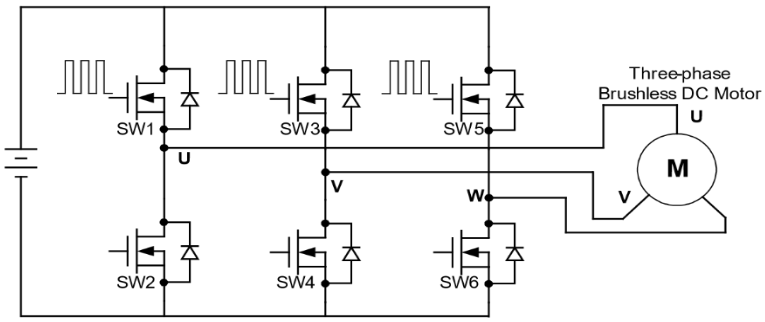

Fig.2.3 3 phase Brushless DC Motor

A three-phase BLDC motor requires three Hall sensors to detect the rotor's position. Based on the physical position of the Hall sensors, there are two types of output: a 60° phase shift and a 120° phase shift. Combining these three Hall sensor signals can determine the exact communication sequence.

BLDC motors have many advantages over brushed DC motors and induction motors. A few of these are:

- Better speed versus torque characteristics
- Faster dynamic response
- High efficiency
- Long operating life
- Noiseless operation
- Higher speed ranges

Fig. 2.4 BLDC Motor exterior

2.4 Twin Blade Propeller

A propeller is a type of fan that transmits power by converting rotational motion into thrust. A pressure difference is produced between the forward and rear surfaces of the airfoil-shaped blade, and a fluid (such as air or water) is accelerated behind the blade. Propeller dynamics, like those of aircraft wings, can be modelled by either or both Bernoulli's principle and Newton's third law. A marine propeller of this type is sometimes colloquially known as a *screw propeller* or *screw*, however there is a different class of propellers known as cycloidal propellers – they are characterized by the higher propulsive efficiency averaging 0.72 compared to the screw propeller's average of 0.6 and the ability to throw thrust in any direction at any time. Their disadvantages are higher mechanical complexity and higher cost.

On every quadcopter, there are two motors spin **CW** (clockwise) and two **CCW** (counter-clockwise). Therefore matching CCW and CW propellers are required to generate thrust, as well as having opposing yaw motion that cancel each other out in flight.

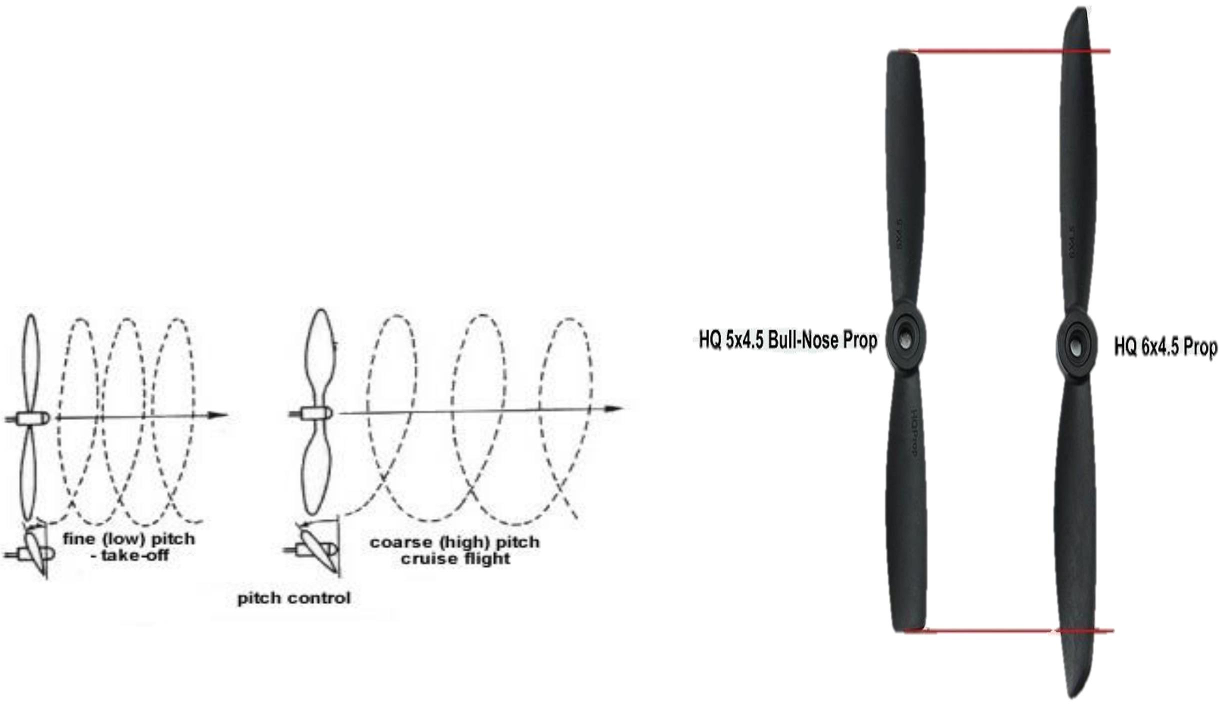

Fig. 2.5 Twin Blade Propellers

2.5 LiPo Cell

Lithium Polymer batteries (henceforth referred to as “LiPo” batteries), are a newer type of batteries used nowadays in many consumer electronic devices. They have been gaining in popularity in the radio control industry over the last few years, and are now the most popular choice for anyone looking for long run times and high power.

Just as with other lithium-ion cells, LiPo work on the principle of intercalation and de-intercalation of lithium ions from a positive electrode material and a negative electrode material, with the liquid electrolyte providing a conductive medium. To prevent the electrodes from touching each other directly, a microporous separator is in between which allows only the ions and not the electrode particles to migrate from one side to the other.

Li Po batteries offer three main advantages over the common Nickel-Metal Hydride (NiMH) or Nickel Cadmium (NiCd) batteries:

1. LiPo batteries are much lighter weight, and can be made in almost any size or shape.

2. LiPo batteries offer much higher capacities, allowing them to hold much more power.

3. LiPo batteries offer much higher discharge rates, meaning they pack more punch.

Fig.2.6 A LiPo Battery

There are some drawbacks of LiPo batteries:

1. Lipo batteries have a shorter life span than NiMh/NiCd batteries. They average only 300 – 400 cycles if treated properly.

2. The sensitive nature and chemistry of the batteries can lead to fire should the battery get punctured and vent into the air.

3. LiPos need specialized care in the way they are charged, discharged, and stored. The equipment can be price-prohibitive.

2.6 Balanced Charger

In a multiple-celled battery pack, it is possible for the individual cells to develop differences in their charge levels. Since Lithium Polymer (LiPo) batteries are very sensitive to overcharging, it's important that their cells be kept at or very near equal levels when charging. A balanced charger (or balancer) does this by monitoring the individual cell voltages in a pack through a connector on the pack (called a balance connector) and adjusting their rate of charge accordingly. When such a balancer is built into a charger, the charger is known as a Balance Charger.

Fig. 2.7 Balanced Charger

2.7 Transmitter and Receiver

The transmitter enables the user to control the aircraft from a distance, using 2.4 gigahertz spread spectrum radio signals.

Receivers are electric devices with built in antennas that intercept the radio signals from the transmitters, and convert them into alternating current pulses. The receiver then produces information and sends it to the Flight Control Board.

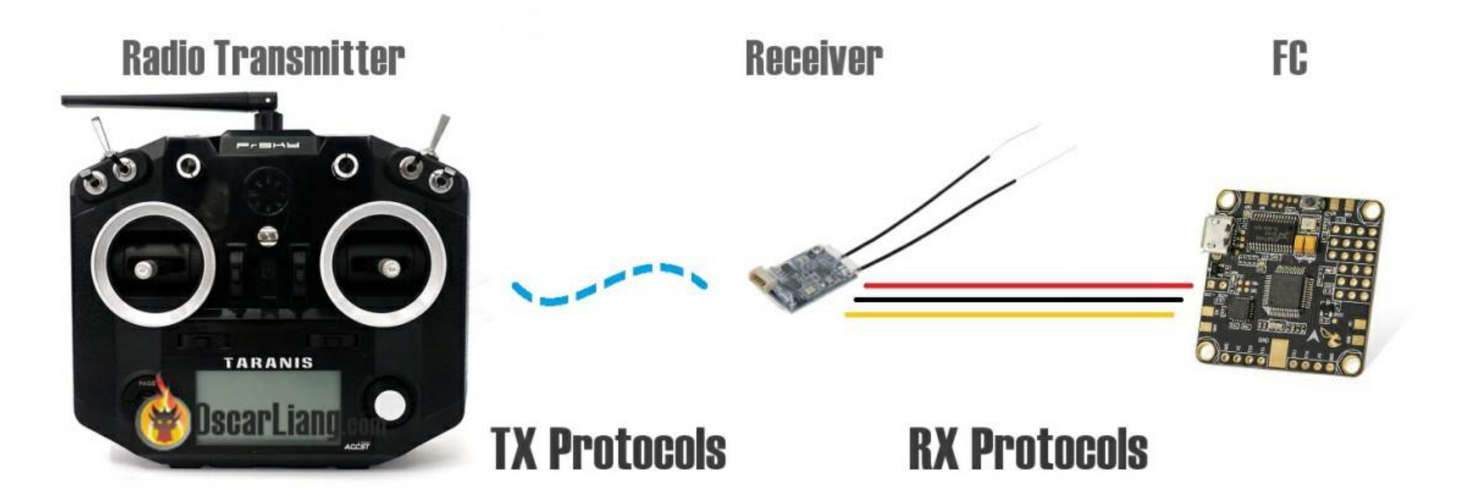

Fig. 2.8 A Tx & Rx Module

2.8 Phone Holder

The mobile phone holder is a unit that attaches phone to the quadcopter or drone for aerial photography and other camera features. It makes the phone detachable and supports most mobile phones. It can rotate up to 270^{o} (manual) allowing it to capture in a wide range of direction.

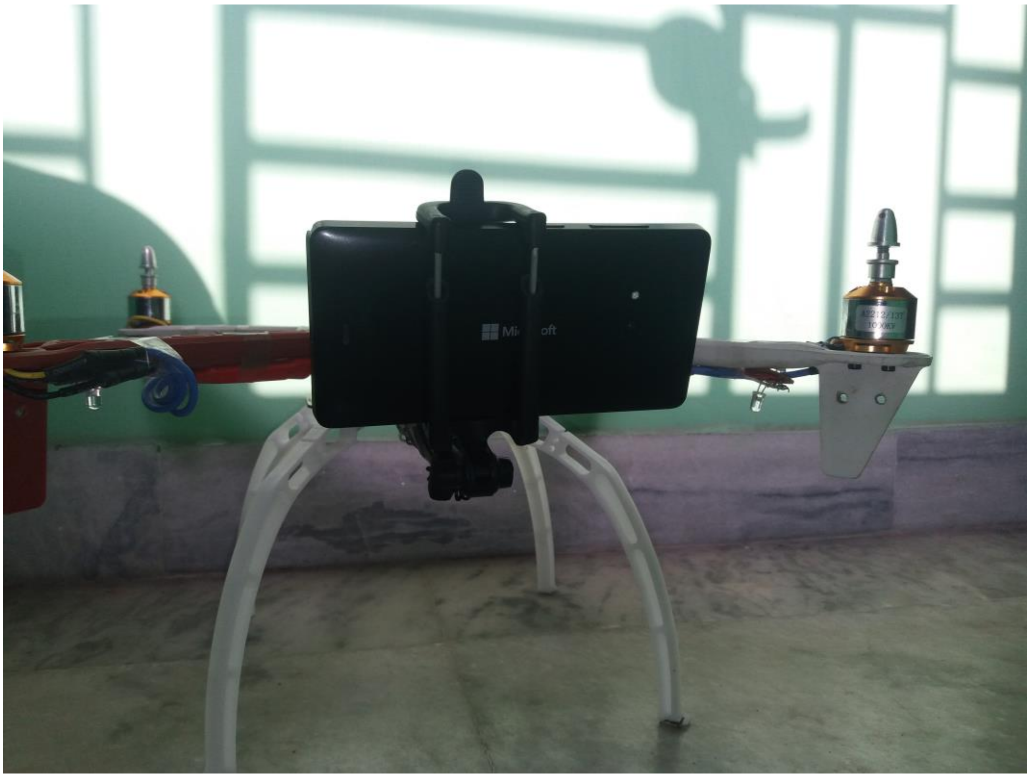

Fig. 2.9 Phone Holder attached to the Quadcopter

Chapter 3

Transmitter Tuning

3.1 T6 Configuration

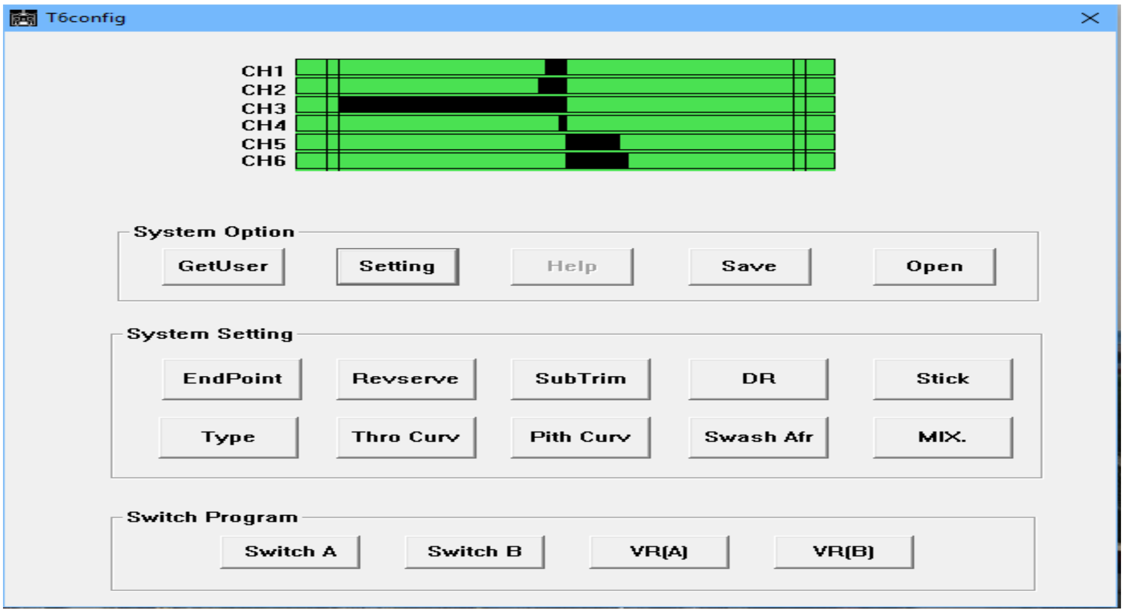

Fig. 3.1 T6Config Lowest Throttle, Channel 3 is throttle here

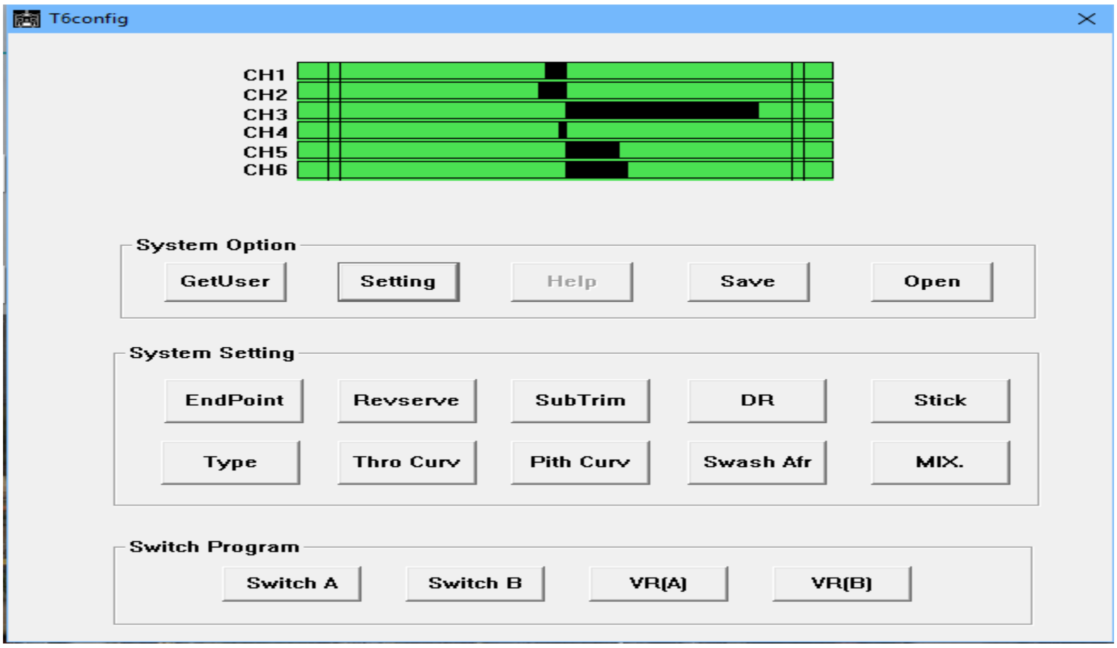

Fig. 3.2 T6Config. Highest Throttle, at Channel 3

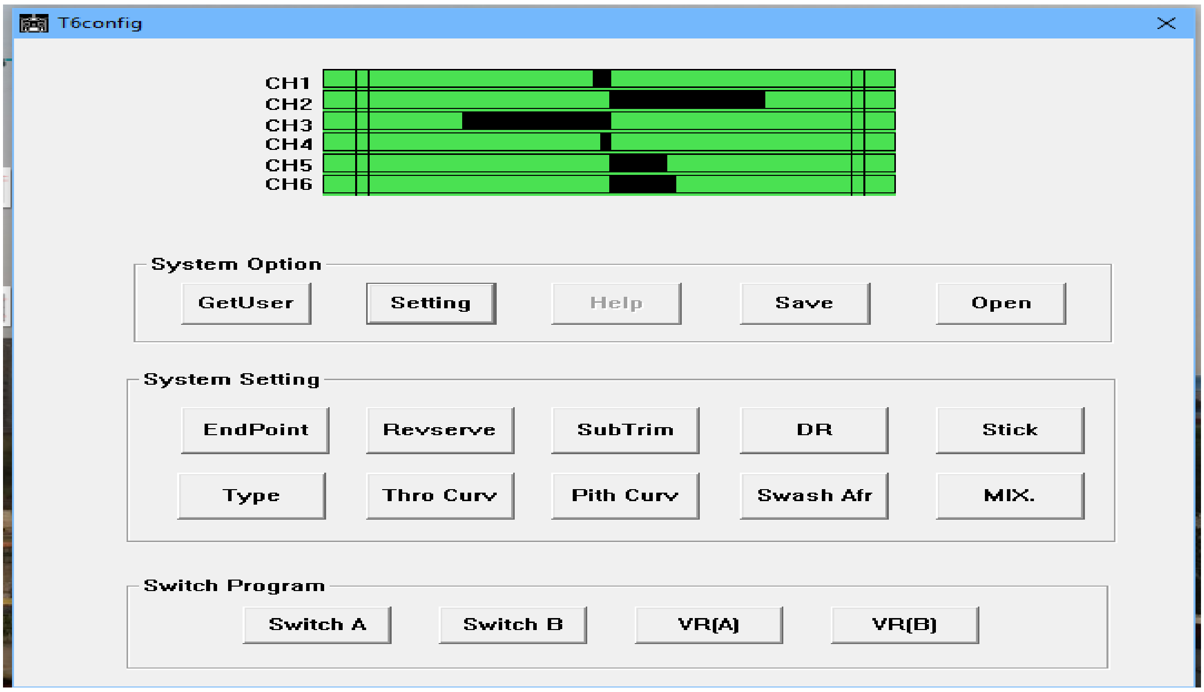

Fig. 3.3 Medium Throttle and Medium Elevator Settings

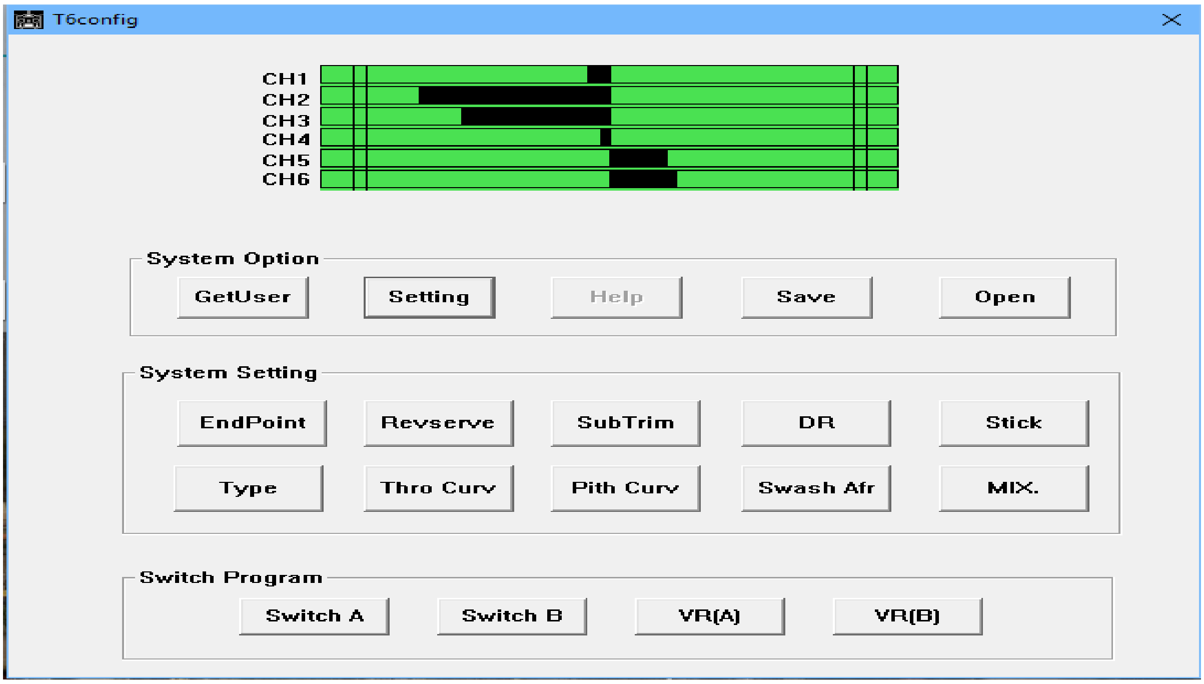

Fig. 3.4 Elevator Backward With Medium Throttle

3.2 Aircraft Type window

We select a model type and click “Type”. In the type window there are three choices:

1. ACRO
2. HELI-120
3. HELI-90

Only ACRO will be used. We select “ACRO” to begin programming our model.

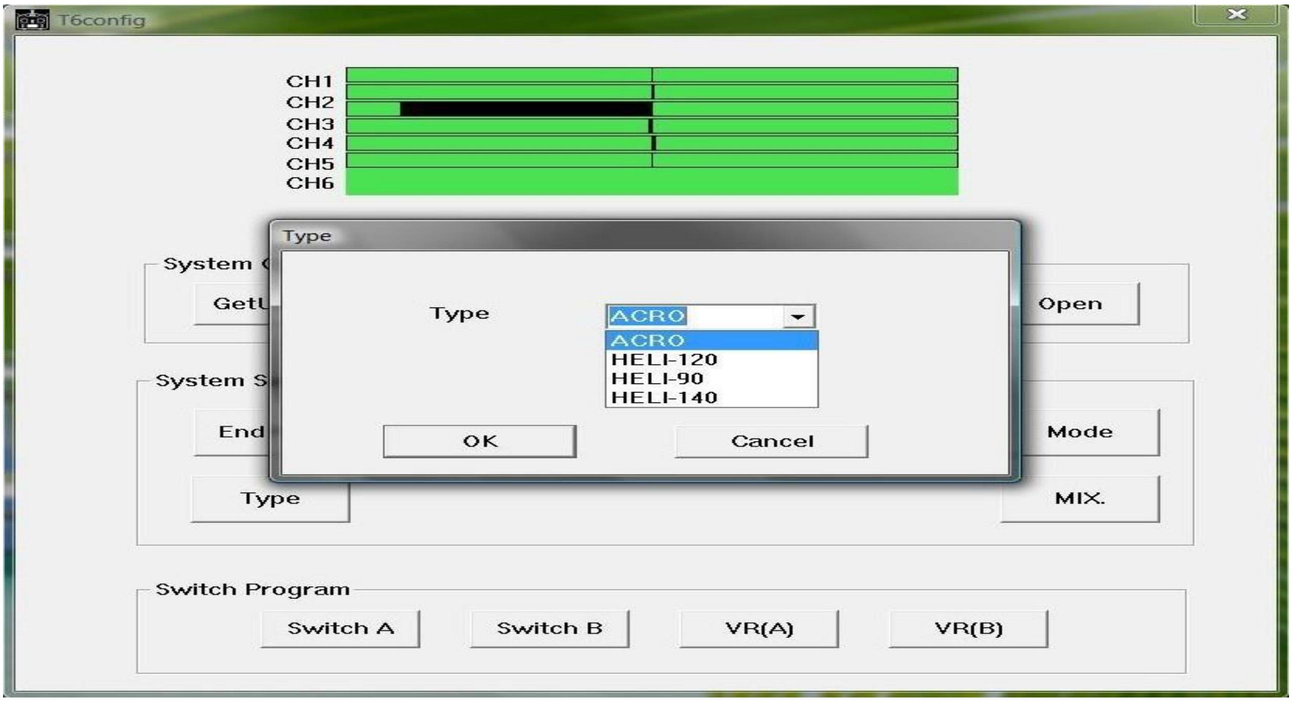

Fig. 3.5 Aircraft Type Selection for the Transmitter

3.3 Controls

The T6 channel arrangement is:

CH 1 Aileron

CH 2 Elevator

CH 3 Throttle

CH 4 Rudder

CH 5 Aux

CH 6 Aux

The T6 has 2 switches on either side of the carry handle. They are designated SW. A and SW. B. They can be assigned to different functions. These functions are:

NULL:	Deactivated
DR:	Dual Rates
ThroCut:	Throttle Cut

They can also be assigned to any of the three mixes. The switches can also be used to switch a mix on or, off. If we are using the T6 on an electric powered model, we would assign one of the switches as “Throttle Cut” for our safety.

The T6 has 2 variable knobs on the left and right sides of the face of the Tx. These are designated VR (A), and VR (B). They can be assigned to CH 5, or CH 6 through any of the three mixes.

The Tx has 2 gimbals with trim tabs for fine tuning the model in flight. There is a “Bind/Range Test” button in the lower left corner. This is used to bind the receiver (Rx) to the

Tx. To perform a range test we turn on the Tx and then power on the model. We will step away from the model approximately 30 yds.

Other than the “On/Off” switch the Tx has a tricolor LED. The LED shows green for fully charged batteries, yellow for slightly discharged batteries, and red for discharged batteries.

Chapter 4

K.K 2.1.5 Configuration

For better stability of the quadcopter we put certain values to the settings menu.

Fig. 4.1 Main Screen of the FCU KK 2.1.5

4.1 PI Editor

It enables us to adjust the control loop feedback parameters for Roll, Pitch and Yaw.

The proportional term (P) produces an output value that is proportional to the current error value. A high proportional gain results in a large change in the output for a given change in the error. If the proportional gain is too high, the quadcopter will overshoot and start to oscillate. Since the control loop compensates for errors 400 times a second too high a P gain will result in a high frequency oscillation. If the proportional gain is too low, the control action will be too slow to react on the quadcopter and it will be difficult to control.

The contribution from the integral term (I) is proportional to both the magnitude of the error and the duration of the error. The integral in a PI controller is the sum of the instantaneous error over time and gives the accumulated offset that should have been corrected previously. If the integral term is too high, the quadcopter will start to oscillate. Since the 'I' term is related to the duration of the error over time, too high as I gain will result in a low frequency oscillation. Too low as I gain will result in a less "locked in" feeling.

Fig. 4.2 Inside the PI Editor Menu and adjusting the ***Aileron Axis*** PI values for Stable Flight

Channel : 1

P gain: 50 **P limit: 100**

I gain: 25 **I limit: 20**

Fig. 4.3 Inside the PI Editor Menu and adjusting the ***Pitch Axis*** PI values for Stable Flight

Channel : 2

P gain: 50 **P limit: 100**

I gain: 25 **I limit: 20**

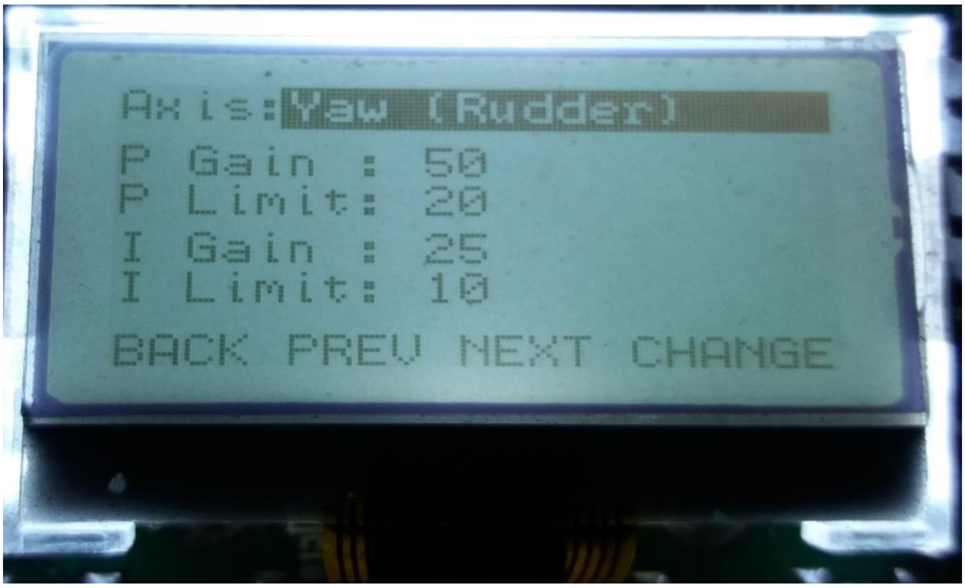

Fig. 4.4 Inside the PI Editor Menu and adjusting the ***Yaw Axis*** PI values for Stable Flight

Channel : 4

P gain: 50 **P limit: 20**

I gain: 25 **I limit: 10**

4.2 Mode Settings

4.2.1 Self-Level

- **Aux –** AUX channel controls the self-levelling function**.**
- **Stick –** Turn on Self-levelling by holding the aileron to the right when arming or disarming. Turn it off with left aileron. Note, if you only connect a 4 channel receiver to the KK2.1.X with Roll, Pitch, Throttle and Yaw then set Self-Level to Stick.
- **Always –** Self level is always on.
- **None –** Ignores the Accelerometers. Use if your Accelerometer is faulty and won't calibrate. Note, you will NOT be able to use self-level.

4.2.2 Link Roll Pitch

- **Yes** – Changes to the PI Settings for both Roll and Pitch when you make changes**.**
- **No –** You need to update the Roll and Pitch PI Settings separately.

4.2.3 Auto Disarm

- **Yes –** will automatically disarm after 20 seconds when armed and throttle is set to zero. (If Lost Model Alarm is set to "Yes" then you can't switch Auto Disarm Off).
- **No –** No Auto Disarm and no Lost Model Alarm.

4.2.4 Receiver *(if we change the receiver, we need to power cycle the KK2.1.5)*

- **Std –** Standard PPM receiver with 4 or 5 (inc Aux) connections to the KK2.1.X inputs.
- **CPPM –** Combined PPM receiver connection. This is all receiver channels combined/multiplexed onto one cable that should be connected to input 1 (top input).
- **DSM2 –** A DSM2 satellite receiver (not a main DSM2 receiver) connected to input 3 (middle input) via a level changing cable. Note that the receiver needs to be bound to the KK2.1.X, not a normal receiver. To bind the DSM2 satellite, we hold buttons 2&3 down on power up. The satellite will flash rapidly and you should follow your transmitter/receiver binding process. Some receivers bind and set the channels to a failsafe position. We may need to rebind after we set the correct directions using the Receiver Test menu.

- **DSMX** – A DSMX satellite receiver (not a main DSMX receiver) connected to input 3 (middle input) via a level changing cable. Note that the receiver needs to be bound to the KK2.1.X, not a normal receiver. To bind the DSMX satellite, we hold button 3 down on power up. The satellite will flash rapidly and we should follow our transmitter/receiver binding process. Some receivers bind and set the channels to a failsafe position. We should rebind after configuring your transmitter**.**
- **SBus –** A SBus receiver connected to input 3 (middle input) via an inverter cable.

4.2.5 Channel Map

- **No –** With a standard receiver, it is assumed that you will not map any channels.
- **Yes –** Swap channel order using Receiver Channel Map.

4.2.6 Lost Model Alarm

- **Yes –** When the KK2.1.X Auto Disarms, it will sound the buzzer. Note that Auto Disarm is forced on when "Yes" is selected.
- **No –** Lost Model Alarm disabled. Set to "No" to allow you to set Auto Disarm to "No".

Fig. 4.5 Mode Settings

4.3 Stick Scaling

These settings enables us to adjust the sensitivity of the transmitter stick. A higher number gives a more sensitive response. It is used in preference to increasing the rates in our transmitter. The default values are low for beginners that may not appreciate how sensitive the transmitter sticks can be in controlling a quadcopter.

- If we want to flip and roll, we need to increase the Roll and Pitch values.
- Increase the Yaw value to yaw to our liking.
- Throttle should be at 90. If we increase it too much, full throttle on the transmitter will run the motors at maximum and leave no headroom for the PI control loop to adjust the motors to keep it steady.

If we set the value to a negative value, it will reverse the transmitter channel. This is to enable the use of transmitters that don't allow us to change the direction for a channel. It only works for roll, pitch and yaw.

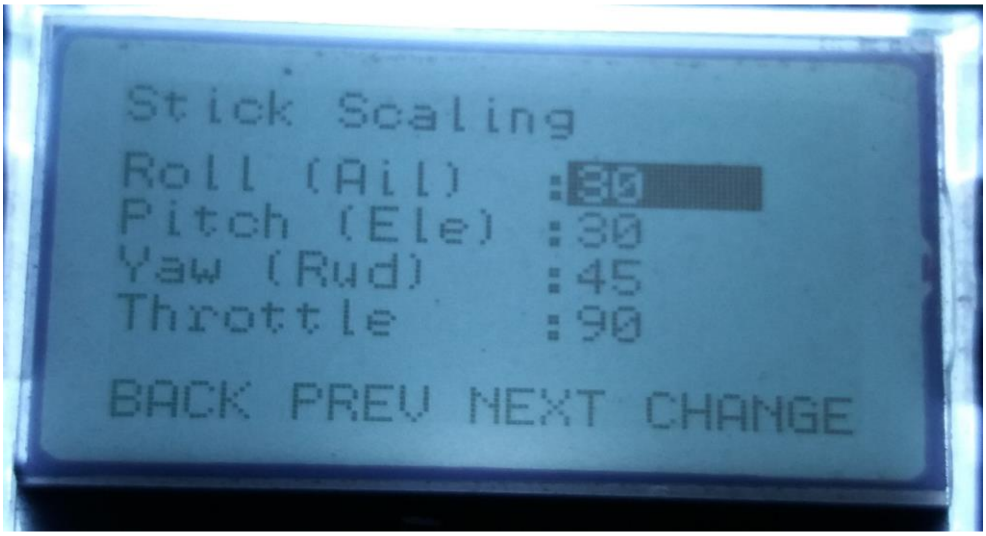

Fig. 4.6 Stick Scaling Menu

Stick Scaling

Roll: 30 **Pitch: 30**

Yaw: 45 **Throttle: 90**

4.4 Misc. Settings 1

Various settings

- **Minimum throttle –** ensures all motors start at the same rate. If some motors do not start when armed, we increase this value. This value also allows us to change the motor speed if we have Spin on Arm enabled. We set it at 10.
- **Height Dampening –** Compensates for the drop in height when the quadcopter is banked in a turn. Normally, the pilot will compensate for this dropping effect by increasing the throttle slightly. The default is 0 (disabled). We set it at 10.
- **Height D. Limit –** The percentage of motor power that can be used to apply the correction.
- **Alarm 1/10 volts –** When the flight battery +ve terminal is connected to the KK2.1.5 battery monitor pin, this sets the voltage alarm threshold when the buzzer sounds. If we want the buzzer to sound at 11.0 volts or less, set this value to 110. The default is 0 (disabled).
- **Servo Filter –** Software filter that smooths out the control signal to servos. Set this value at 50
- **Acc. SW filter –** Software filter in the KK2.1.5 code that smooths out the accelerometer reading. This value can be increased to mask vibrations. The default is 8 which results in a low pass filter coefficient of 0.03 (8/256).

Fig 4.7 Misc. Settings 1

Minimum Throttle: 10 **Height Dampening: 10** **Height D. limit: 30**

Alarm 1/10 volts: 110 **Servo filter: 50** **Acc SW filter: 8**

4.5 Misc. Settings 2

- **Board Offset**
  - 0 – Zero degrees offset. KK2.1.5 board faces forward.
  - +45 or -45 – KK2.1.5 board is mounted at 45 degrees.
  - +90 or -90 – KK2.1.5 board is mounted at 90 degrees.
  - 180 – 180 degrees offset. KK2.1.5 board faces backwards.

- **Spin on Arm**
  - **No –** When armed, with throttle at zero, motors are stopped.
  - **Yes –** When armed and throttle is at zero, motors run at the speed set by Minimum Throttle. This is useful if you want to fly and never want your motors to stop in flips and rolls for example.

- **SS Gimbal**
  - **No –** A normal camera gimbal is being used with one servo for Pitch and one for Roll.
  - **Yes –** Super Simple Gimbal is used where both servos work together to move Pitch and Roll in a differential configuration.

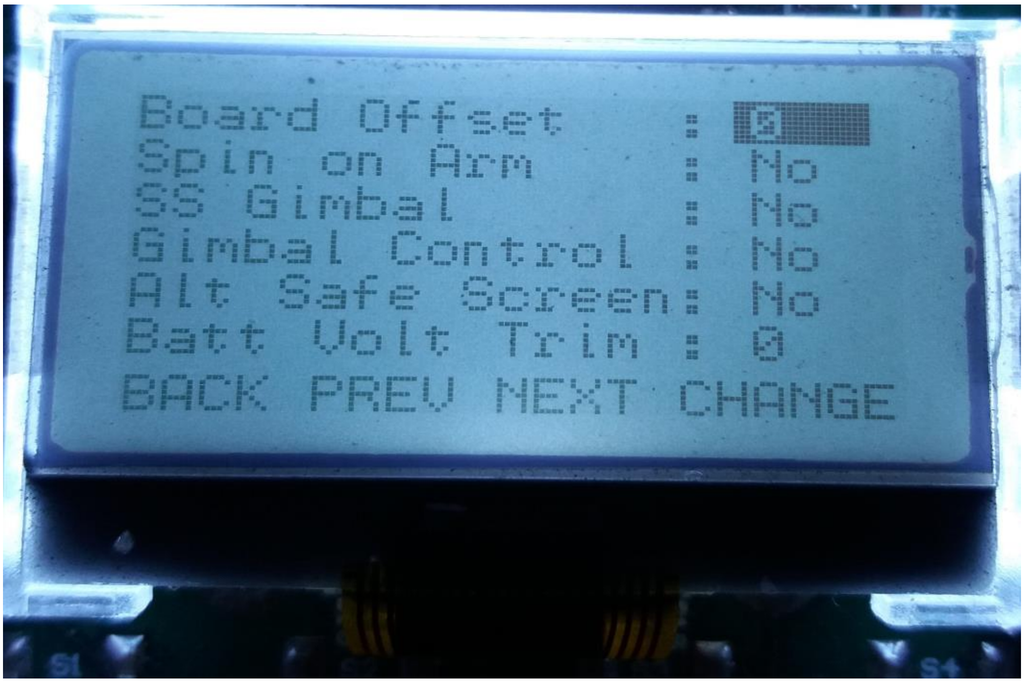

Fig. 4.8 Misc. Settings 2 Menu

- **Gimbal Control**
  - **No** – Gimbal offset is fixed as set in Camera Stab Settings.
  - **Aux** – Gimbal Pitch offset can be changed using the Aux channel. This enables you to change the Pitch offset with a Standard PPM receiver.
  - **6&7 –** Gimbal Pitch and Roll offset can be changed using the receiver Channel 6 and 7 outputs. Note that you will need to use this feature with a CPPM receiver, satellite receiver or SBus receiver.

- **Alt Safe Screen**
  - **No –** Standard SAFE screen layout
  - **Yes –** Alternative SAFE screen layout which displays the last Motor Layout selected

- **Batt Volt Trim**
  - Enables us to adjust the battery voltage reading by 0.1 volt increments if we are not satisfied with the value shown with the default trim value of 0. The range is +/0.6 volts. The value shown is 1/10th of a volt so a value of 6 is 0.6V.

4.6 Self-level Settings

Self-Level Settings are independent from normal PI settings.

- **P Gain –** The power of the self-levelling. Higher number is stronger. Too high will cause oscillations. To low and it's slow to self-level. Higher number gives the operator more stick control. Lower number reduces the operator stick control.
- **P limit –** Limits the max power of self levelling. Higher number is higher limit.
- **ACC Trim Roll** – compensates for self-level drift when the KK2.1.5 had the ACC calibrated when it wasn't exactly level.
- **ACC Trim Pitch** – compensates for self-level drift when the KK2.1.5 had the ACC calibrated when it wasn't exactly level.

It's better to calibrate the ACC with the KK2.1.5 level rather than use the trims. Make sure the KK2.1.5 is mounted level in the quadcopter.

Fig. 4.9 Self Level Settings

P Gain: 75 **P Limit: 20**

Acc Trim Roll: 0 **Acc Trim Pitch: 0**

4.7 Sensor Test

Displays the raw gyroscope and accelerometer sensor values.

- Must show "OK" when stationary.
- If it says “Not OK” when stationary, the sensor chip is faulty.
- Move the KK2.1.5 around to see that the numbers change. In this case, it is fine if the **sensors start reading “Not OK”.**

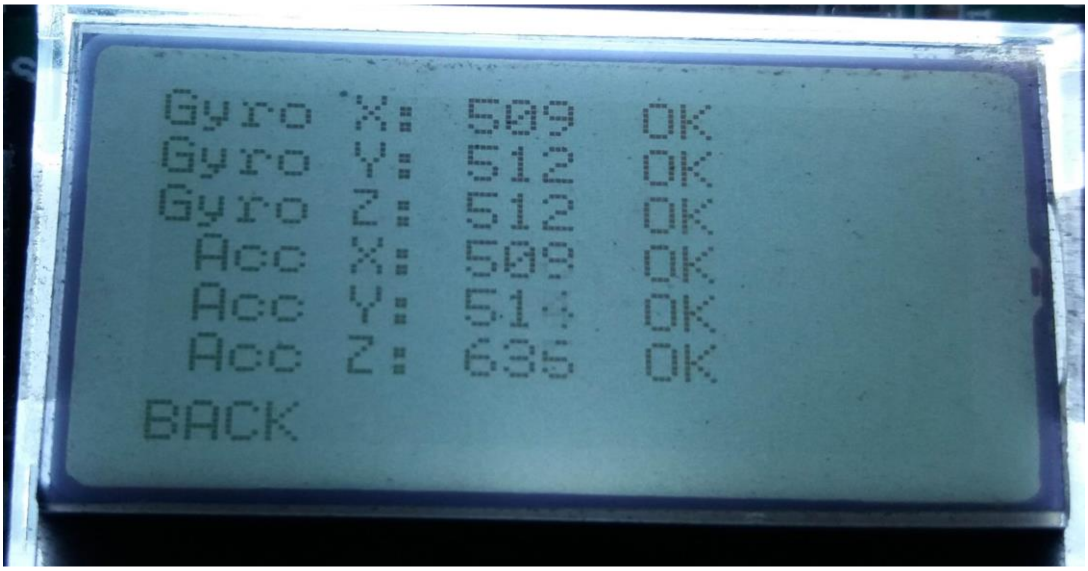

Fig. 4.10 Sensor Test for Gyroscope and Accelerometer

4.8 Show Motor Layout

Displays a graphical representation of the motors and servos

- Can be used to check the Motor direction and which outputs to connect the ESCs and Servos to. Note that this does not set the motor direction. That is set by the wires connected between your motor and ESC. If needed to reverse the motor, reverse two of the three motor wires.
- Enables us to see which Motor Layout we have selected and any changes we make in the Mixer Editor.

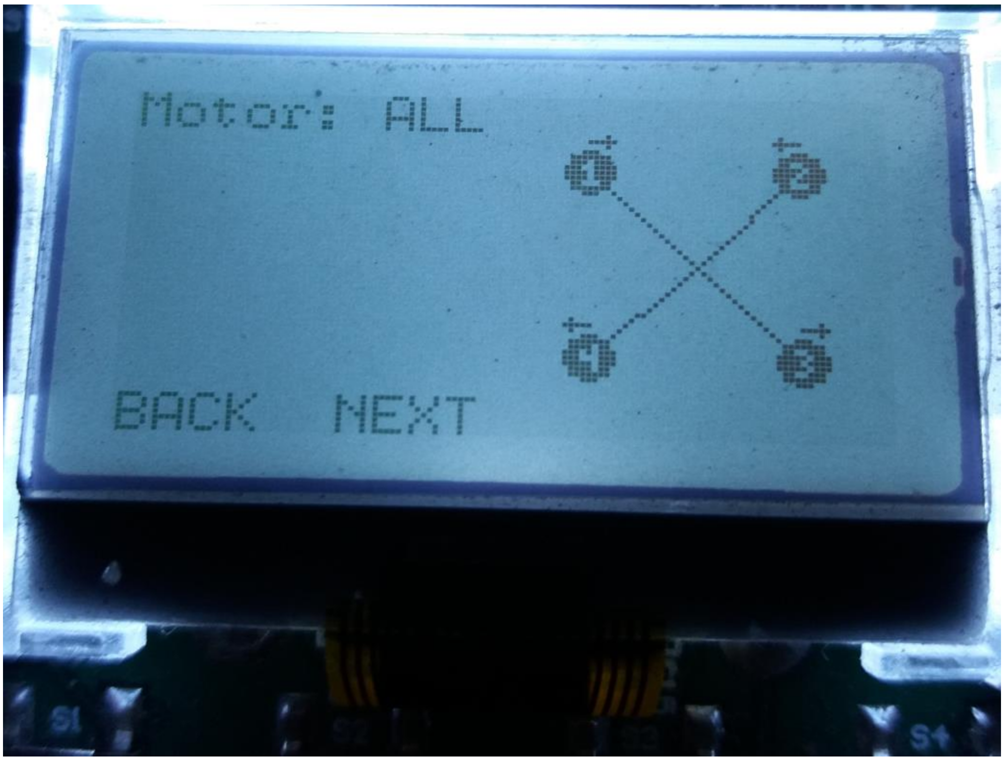

Fig. 4.11 Motor Layout

Chapter 5

Outcome

We have built the Quadcopter and Camera Phone has been attached to the Phone Holder.

As the Stability has been tested and calibrated, the Quadcopter successfully took off.

Fig. 5.1 The Quadcopter Flies in the sky

The Quadcopter can fly in the sky up to a permissible height. It can be used for Remote Reaching, Aerial Photography, Security ,etc.

The ability to shoot higher perspectives with drones is also a great way to shoot landscapes that don’t have foreground elements.

Safety measures have been taken while flying this drone, and maximum stability is aimed for the same.

Fig.5.2 Few Captures from and of the Drone at Evening

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3. https://www.dronetrest.com/t/kk2-1-flight-controller-guide/379