Dragon Bee

Nishit Dave, Ayoub Soud, Younes Enouiti and Akash Patel

Dept. of Electrical Engineering and Computer Science, University of Central Florida, Orlando, Florida, 32816-2450

***Abstract* — Dragon Bee is a project aimed to use MSP430 to control a drone by simulating the same signals used by radio frequency. Then, an android app will be used to communicate to the MSP430 through a Wi-Fi module. A camera will be then mounted on the bottom of the drone to let the user enjoy the fascinating snaps of pictures and videos. Multiple modes will be available at the user's smart phone with easy-to-navigate menu. This project differs from others because it uses Wi-Fi to control the drone instead of radio frequency control.**

***Index Terms* — APM 2.8, CC3100Module, Dragon Bee, MSP430F5529, PCB Design, Quad Copter, Wi-Fi Drone.**

I. INTRODUCTION

After the idea of unmanned aerial vehicle (UAV) have emerged early 1900's for military use, and the next big jump in transistor evolution came with the MOSFETs in 1960s, UAVs have invaded the commercial use. As public became interested in UAVs, the growth of UAV's has been dramatically increasing last decade. UAVs have become known as drones which it comes in variety of shapes such as Quadcopter, Tricopter … etc. The ability of flying, drones been used in multiple applications that require height. One of the very many areas in which aerial platforms from drones can be deployed is aerial photography.

The idea of choosing a Quad Copter project over couple other project ideas came after the team members suggested to go for something challenging, fun and resourceful. The main objective of this project is to build a Quad Copter using Wi-Fi control with aerial photography ability. Dragon Bee will put microcontroller in use and provide users the opportunity to send command from their smart phone. The implementation of multiple technologies like compass, gyros, barometer, and accelerometer will be implemented for its advance use. Without a camera pole and hands free, the user will be able to give Dragon Bee orders at first and enjoy an interactive stream of pictures and videos. 360fly camera gives the power to capture and save fully immersive, interactive 360° photos and videos. An easy and friendly user interface will be available to install on in any Android device. Including variety of options, Dragon Bee will provide multiple functions to achieve the goal Photographs for all.

II. SYSTEM COMPONENT

As it was explained previously, this project will be executed by bringing several components together and allowing them to communicate with each other in order to accomplish the task described in the introduction. The separate parts that will play their specific roles in the Dragon Bee will be described in this section; firstly as the individual hardware pieces, followed by the different modules, and ultimately by the method of communication that will allow them to interface with each other.

This project has five main components: Quadcopter, ArduPilot, Wi-Fi enabled MCU, mobile platform, and Wi-Fi 360 degree camera.

A. Quadcopter's Hardware

For the purpose of this project, choosing a Quadcopter's frame that would meet our needs was primordial. Though through research, we were able to determine that we need a frame that can hold all the necessary components to make the flight more stable and enjoyable.

1. Frame

The DJI F450 frame was the best fit for our needs. Its arms are merged with carbon fiber rods to make them durable. The frame is very light weight and has flexible mounting options. Replacement parts for the frame are easy to get.

Fig.1. DJI F450 Frame

2. Flight System

After the selection of the frame, the next component that follows would be the motor. The two common types of motors used in Quadcopters are brushed and brushless. The team chose the RHD 2212/920kV brushless motor simply because of its power-to-weight ratio. Next, propellers are required in the design and must generate enough thrust to fly the Quadcopter. Propellers are classified by a length and a pitch. To make sure we have the required thrust to lift the drone, we decided to go with 9.4" x 5.0" propellers. In order to maneuver the Quadcopter, the DC brushless motors need to be simultaneously controlled. The motors are multi-phased, so DC power won't work for the motors. There comes the need of electronic speed controllers or ECS's (one for each motor). Each ESC is controlled by a pulse-with-modulation (PWM) that can vary in frequency range. The best ESC fit for the motors on hand is the Simonk 30Amp Firmware Brushless.

Fig.2. RHD Motors, SimonK ESC's and Propellers

3. Power System

To ensure a good stable long flight of the quadcopter, the team chose the ZIPPY Flightmax 5800mAh 11.1v 3S LiPo battery. The max current of the battery chosen is high and will meet all the requirements (maxCurrent = capacity * C-rating). This will allow a minimum of 15 minutes flight while the quadcopter is hovering in the air.

Fig.3. Zippy Flightmax 5800 mAh Battery

To power the APM, motors and ESC's the team chose a Power Module (PM) that is used between battery and the flight controller APM, which works as a voltage regulator. The PM is a simple way of providing the flight controller with clean power from a Li-Po battery as well as current consumption and battery voltage measurements. Basic purpose of using the power module is to receive the high power voltages and drop down voltages but to provide a needed current. It is very essential to use power module for such reasons but which power module to use?
For flight controller APM 2.8, it is better to use 3DR Power Module. The main reason for it is because it's compatible with APM 2.8. It has 6-pos connector provides around +5.3 V power supply to APM board. APM 2.8 board has 6 pin PM port which can be connected directly from the 3DR power module 6-pin connector. PM can provide power to the APM 2.8 as well as current consumption and battery voltage measurements, all through a 6-pos cable. The on-board switching regulator outputs 5.3V and a maximum of 2.25A from up to a 3S Li-Po battery. The Power Module comes completely assembled with XT60 connectors, and wrapped in shrink tubing for protection.

PM is connected to ESCs and PDB (Power Distribution Board). It also has power output port to supply power to the motors. However, power module doesn't have sufficient power for servos or high current devices such as FPV transmitters. Servos must be power by separate ESC. Therefore, since using PDB is better option for power distribution to ESCs, power module's output port will be connected to the Input of PDB.

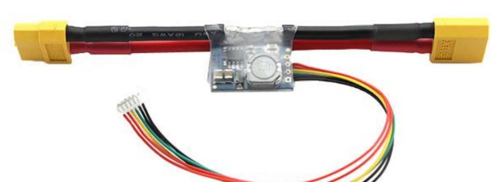


Fig.4. Power Module for APM 2.8

B. ArduPilot Module (APM)

The flight controller is the nerve center of a drone. There are so many Drone flight controllers on the market. Current flight control systems have many sensors available such as gyros, accelerometer, GPS, barometric pressure sensors, and list goes on. The main reason for choosing APM 2.8 is because of its open source firmware and its programming functionalities. APM has an on hand easy tuning for the Drone to have a stable flight. It is the best flight controller for "cinema flying" and "autonomous flying”. Learning the programming of the APM is a must for the project on hand to make sure everything works as it should be. The other benefits of the APM is the low power consumption, around 5V with 200mA draw, and low cost, $40 which is cheapest of all other flight controllers.

APM 2.8 features ATmega2560 main processor, 8bit atmel processor with 16 MHZ RAM. It also has ATmega32u4 MCU which handles USB functionality and ATmega32u4 which handles gyro and accelerometer duties. The APM 2.8 has plenty of interfaces for peripheral. This is extremely helpful for us since we will need UART telemetry port for APM and MSP430 communication.

Fig.4. ArduPilot Module (APM) 2.8

C. Wi-Fi enabled MCU

The microcontroller that will be implemented in the project on hand will be the MSP430F5529. The package used will be 80 pins. First, the Launchpad was used for programming and prototyping. Then a schematic was created for only the necessary components used. A PCB was created containing the MCU, the eZ-FET lite emulator, and all the necessary components for programming and debugging. The following two figures show the schematic created for the final PCB design.

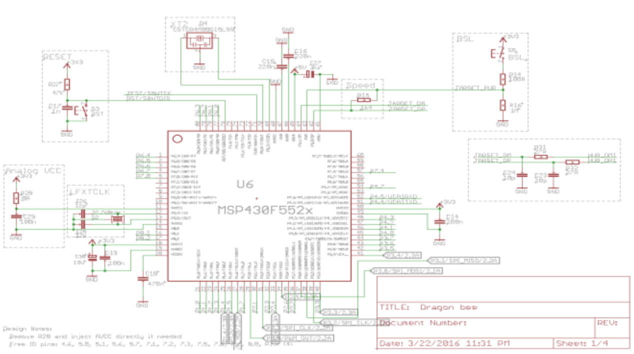


Fig.5. MSP430F5529 Eagle CAD Schematic

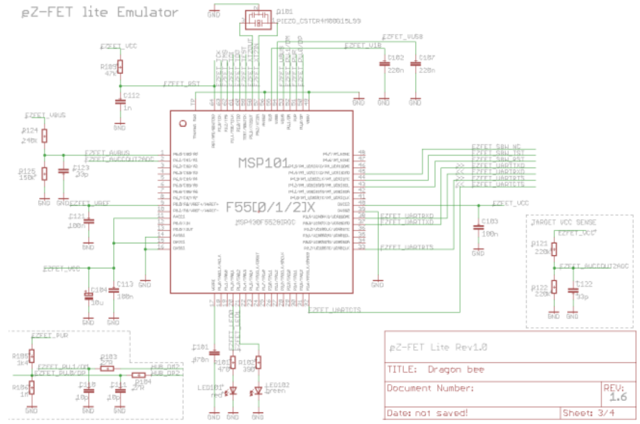


Fig.6. eZ-FET Eagle CAD Schematic

To make the MSP430F5529 Wi-Fi capable, the CC3100 Wi-Fi module was necessary. The CC3100 is a device that makes Wi-Fi connectivity possible by integrating all protocols for Wi-Fi and internet. This minimizes host MCU software requirements. The CC3100 provides a built in security protocols that are robust and easy to implement. The Wi-Fi network processor subsystem features a Wi-Fi Internet-on-a-Chip and contains an additional dedicated ARM MCU that completely offloads the host MCU. The CC3100 device has the ability to connect to either 8, 16, or 32-bit MCU over the SPI or UART Interface. The host MCU in the case of the project on hand is the MSP430F5529.
Both MSP430 and CC3100 were going to be implemented on one PCB. Due to the lack of foot prints for the CC3100 module, the team was forced to use the booster pack from Texas Instrument after getting approval.

D. Mobile Platform

Dragon Bee will be operated through an android app. The app is designed in the Android Studio using JAVA programing language. The app can be installed in any android device. The app screen is divided into two separate sections. One will be for live video streaming, and the other half will have the controlling buttons. The initial idea was to develop two modes. One of the modes is for manual operation and the second for “Follow Me” mode. Manual mode will give user the ability to fly the drone using manual parameters. User will select the Throttle, Yaw, Roll and Pitch values on the phone in the manual mode. Second mode is perhaps the best and eye catching mode of this project. In this mode, user have the complete freedom to fly the copter using the GPS coordinates from their smartphones.

The DragonBee Follow-Me Mode screen enters into a mode of operation where the drone is commanded to follow the location of the device running this application. In this mode of operation, the application acquires GPS location latitude and longitude coordinates from the onboard GPS device on a 2 second interval. These coordinates are sent to the drone using the “Follow Me” command also on 2 second intervals. They are also displayed on the Follow-Me activity screen. The Follow-Me activity uses the power manager service to acquire a wake lock to prevent the device from going to sleep fully. This enables the app to continue to acquire GPS coordinates and communicate them to the drone. This is a hands free mode. As of now, we have only been able to implement the manual mode.

The app will communicate using the UDP packet by opening a port in CC3100 module using Wi-Fi. It will use the IP address of the Wi-Fi module and port number to send the packet. Once phone is connected to DragonBee Wi-Fi, it will start to listen for the hearth beat of the flight controller. After that, it will wait for the user to Engage. More than one person can connect to Dragon Bee but only the user that presses the “Engage” button first will be allowed to send command to copter. The Figure 7 below explains the communication of the app to MSP430. The Figure 8 shows the android app prototype.

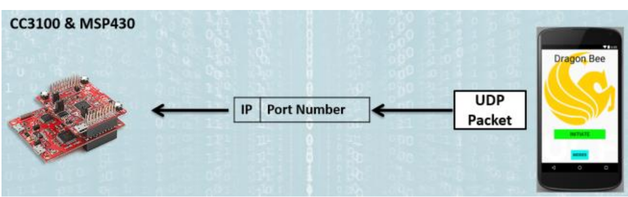


Fig.7. Communication of Android app and MSP430

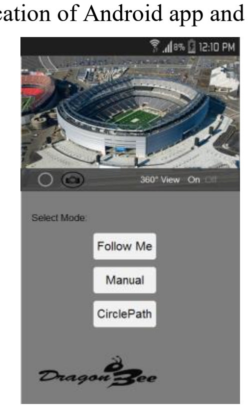


Fig.8. Prototype of the Dragon Bee Android App

E. Wi-Fi 360 degree camera.

There were few options to go with when we wanted video streaming and pictures taking. Go-pro was one of the primary options; however, it can’t be used for live video streaming. Therefore, the Wi-Fi camera that is going to be used for this project is the Fly360. This camera is well equipped with lots of features that makes the design of the whole project unique. One the features of the Fly360 is its own rechargeable 1600mah built in Li-Po battery which is good for up to 2-hours. This is perfect for the design on hand, because powering the camera will not be an issue to face. In other words, the camera will save the team some power that could be used to make the quadcopter fly for more time. Moreover, this camera will hold the charge for at least an hour after it is fully charged. The Fly360 is also Wi-Fi capable. This capability will be used to live stream videos and pictures to the same application that is controlling the drone.

The Fly360 camera is equipped with a 32 GB internal memory which will be used to save all the streamed data. This storage will allow us to capture good quality pictures and videos and therefore allow editing. The accelerometer sensor inside determines the camera orientation. This camera can record in both upside down and right side up. It supports both mobile OS IOS8+ and Android 4.3+, and has its app called 360Fly for live video streaming. However, we will sync it to our user app finding API using Android Studio.

Fig.9. Fly360 Wi-Fi Camera

III. System Concept

In order to complete this project, we deemed necessary to plan out a concept on how our system would operate ad how each one of the components would communicate with each other. The following diagram (Figure 10) represents our system design and how we envisioned our components communicating with each other:

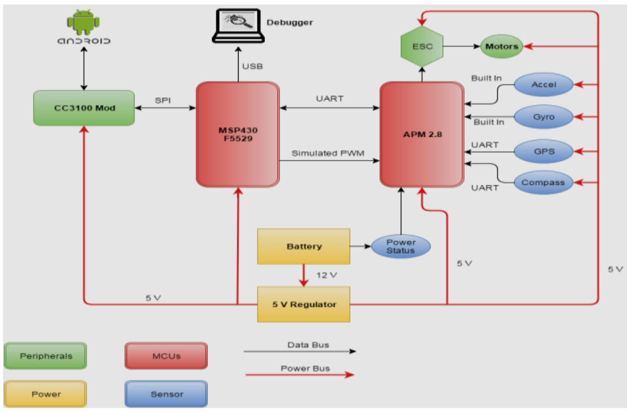


Fig.10. Overall Block Diagram

Two main parts of Dragon Bee drone design includes Hardware design and Software design. Hardware design includes the design part of a drone structure and connections, and the Software part of design includes mostly Android app designing.

A. Dragon Bee Assembly

Assembling the quadcopter is the most important step in making the project come to life. The DJI F450 frame will be assembled based on the manual provided with the kit. Then each one of the four motors will be placed at each corner of the frame. Furthermore, the propellers will be installed on each one of the motor. The middle of the frame will be used to attach the battery with a strap. The need of a strap is necessary for the battery, because this last will be taken out few times to get charged. ESC's are connected to the motors and strapped to the arms of the quadcopter's frame. The PCB, the CC3100 module, and the APM are all attached to the top of the drone and all the necessary connections will be made. The DJI F450 frame comes with a built in power distribution board, which will be used to power the ESC's through the Power Module. The Power Module is then connected to the battery.

B. ArduPilot/MSP430 Communication

The MSP430 will be communicating to the APM 2.8 via UART. In this type of communication, there will be connection that works between the APM 2.8 and the MSP430 and have a support for hardware flow control. The UART interface has no master/slave relationship which will assure data exchange between the MSP430 and the APM 2.8. This data exchange will be transferred independently from side to side in full duplex mode. The block circuitry for UART is the peace responsible for implementing serial communication. The UART acts as an intermediary between parallel and serial interfaces. On one end of the UART there is a bus of eight-or-so data lines and also some pins. On the other end there is the two serial wires called RX and TX. Figure 11 shows a simplified UART interface that most of microcontrollers have.

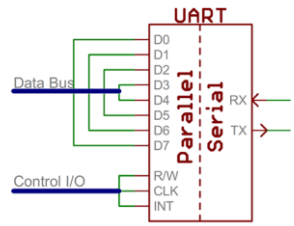


Fig.11. Simplified UART interface.

Both the MSP430 and the APM 2.8 used in the project are equipped with a UART interfaces. The hardware flow control makes use of two hardware lines, RTS (Request to Send) and CTS (Clear to Send) to allow each side indicate to the other side if is ready to handle data. TX (pin number 40) and RX (pin number 41) of the MSP430F5529 will be connected respectively to RX (pin number 45) and TX (pin number 46) on the APM 2.8. Figure 36 is a schematic that shows how to interface between the MSP430 and APM 2.8 utilizing UART.

We are using APM 2.8 auto pilot in this project. However, but the custom firmware is built by our team members to finish this project. The original firmware of the APM is designed to send and receive only radio frequency command. Since this project is purely based on Wi-Fi, the rewriting the firmware was must. In this new firmware, the Wi-Fi control was implemented very professionally and was tested successfully.

C. PCB

Printed circuit boards (PCBs) are the backbone of every electronic device out there. These boards are essential to making all components in a circuit connect together just right. With PCB's, it is possible to get rid of all the wires and bulky look of a certain electric design. This type of boards must have, interconnection with other circuits, placement, and the approximate final dimensions. The circuit schematic is drawn based on the concept of the project. In the case of the project on hand, the concept will be to short size all the components used. The electrical implementation of each function of the PCB will be taken into consideration.

The main PCB for our project houses the main microcontroller and it has the required ports to connect to the APM as well as the CC3100 module. The creation of the main microcontroller board proved to be a part of high complexity as the components required to power the microcontroller and the overall schematic involved many components to achieve basic functionality. Fully explaining the functionality of the main PCB would go out of the scope of this document. The following Figure shows the overall PCB that the team came up with.

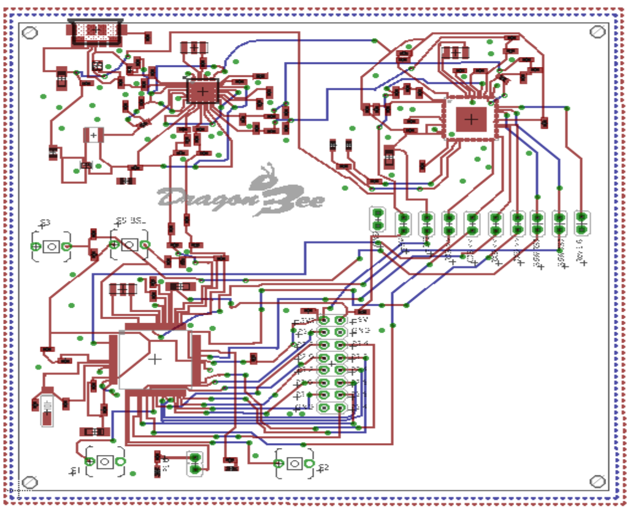


Fig.12. Dragon Bee PCB Layout

After completion of the schematic and the PCB layout, the Gerber files were sent to OSH Park PCB manufacturing and three boards were printed for the price of one. The Figure below shows the final PCB made.

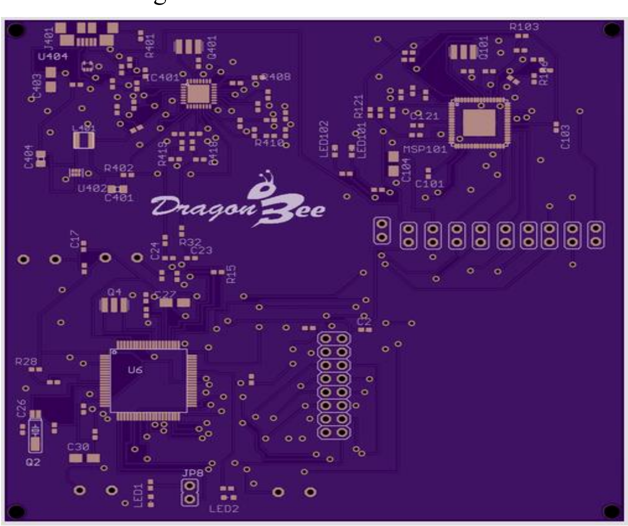


Fig.13. Dragon Bee PCB

The necessary parts needed for the PCB were all ordered from Digikey. Due to the small size of some components on the PCB, QMS Company was used to solder some of the parts.

IV. TESTING

Testing the project was extremely important as there are multiple subsystems that needed to be integrated to create the final product. Initially testing was done on each subsystem individually. Then all the systems were integrated and a final testing was done to verify the stability of the copter. The testing took place at Lake Clair at UCF. Before the final product, the drone was severely damaged in the testing few times. This was crucial for our project as it takes time to buy the damaged equipment and redo the testing.

A. Dragon Bee Testing

One of the main modes that would be implemented when testing Dragon is manual mode. Testing environment should be a wide open outdoor without trees or people around for safety purpose. One of the easiest ways is to attach Dragon Bee to a long enough fishing line with at least. Manual mode simply will be tested by pressing buttons located in the bottom of the screen with one button at a time. And each button will be pressed long enough to test if Dragon Bee will not exceed the limit range. If Dragon Bee reacts to each button accordingly, then Manual Mode is fully functional.

B. Wi-Fi Testing

The Wi-Fi testing was very important as it is the main objective of this project. Wi-Fi was tested using the UDP receiver app in the Windows PC many times while developing this app. The final Wi-Fi testing was done using manual mode. First step was to send the manual throttle to the copter over the Wi-Fi. Before we do that, the propellers were to be taken off to safety purpose. The throttle amount of 1200 was sent to the MSP430 and then it was forwarded to the APM. The motors started running and it completed our Wi-Fi testing. Different values were tested multiple times to verify its connectivity. The response time was very low so it was definitely in favor of this project.

C. Final Testing

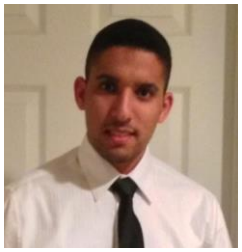
The final testing involves integrating all of the subsystems into the final product. This test verifies that all of the systems are working correctly together. This test involves the normal operating conditions that the Dragon Bee will be subjected to. Battery testing is crucial in this test because of the goal to verify that Dragon Bee can run for at least 15 minutes. This test will also involve the charging length to fully charge the battery to its maximum value and verify the functionality of all components.

V. Conclusion

The main goals of this project is to build a Quad Copter using Wi-Fi control with aerial photography ability. By doing extensive research and dedication, the group was able to achieve these goals by creating a unique Dragon Bee quadcopter that serves the needed purpose. Breaking this project into multiple subsystems allowed the design and testing to be done in efficient manner. From choosing the frame that holds all the parts to a microcontroller that was capable of integrating these subsystems was key to the success of the project. Dragon Bee will allow users to have control over quadcopter though Wi-Fi simulated phone and let users to enjoy an interactive 360° stream of videos and pictures hands free at the same time. An easy and friendly interface will be available to install in any android device.

This project shows the group's design capabilities utilizing the tools taught through UCF's engineering program. This project expanded the group's engineering toolbox by forcing the group to learn new real world applications. Learning Eagle CAD software, behavior of PWM, Java coding, and app designing are some of the skills that will be an added benefit in future careers of each team members. Testing and troubleshooting real world design issues as a group also creates another invaluable skill set that can be used throughout the group's future career. Lastly meetings, reports, meeting, deadlines, and the need to achieve success in the prototyping of the project has given this group a small taste of what's ahead in the career that we have chosen.

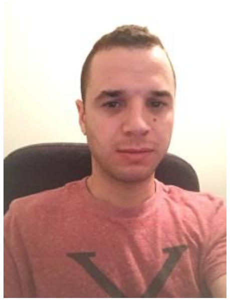
VI. Biographies



Younes Enouiti is a 29 year old Electrical Engineering student with a Minor in Mathematics. Prior to going for this degree, Younes has always showed interest in electronics coding, repairing computers and fixing other various electrical devices in his free time. Younes hopes the knowledge he gained at the University of Central Florida will be put to use in Power Engineering. Younes has interest in Mathematics as well and showed interest in staying at University of Central Florida and obtaining another degree in Applied Mathematics.

Akash Patel is a 24 years old senior at the University of Central Florida. Akash will be obtaining his Bachelors of Science in Computer Engineering in May of 2016. He will be the first graduate in his family. After the graduation, he will be pursuing a career in the Android App Development Companies. Akash hops to be expert in Java Programming and get a decent job in Atlanta as he is from Georgia.

Nishit Dave is a 24 year old Electrical Engineering student at the University of Central Florida. Dave will be obtaining his Bachelor's Degree in Electrical Engineering in May 2016. Dave is looking to work for Power Generating and Distribution Company.



Ayoub Soud is a 29 year old Computer Engineering student. He is interested to work in the Embedded Systems Area, specializing in Firmware Development. He has also showed interest in pursuing a Master's Degree in Digital Forensic.

References

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[2] CC3100 Wi-Fi Module: http://www.ti.com/product/CC3100/datasheet

[3] ArduPilot 2.8: http://copter.ardupilot.com/wiki/common-apm25-and-26-overview/