

Design of Test Rig for Fuel Probes Pre-Installation Check in a Non-Linear Tank for Helicopter Using Embedded Systems

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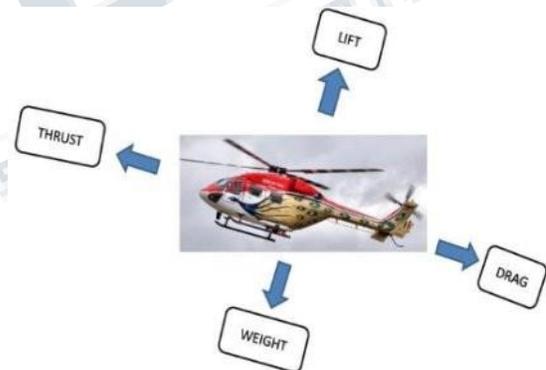
Abstract: During the manufacture of helicopter and its subsequent assembly stage, it is required to test every component that goes into helicopter. The fuel probe is one among them. Large amount of fuel is required in order to travel more distance. For this purpose the amount of fuel in a tank is to be measured frequently and this task is performed by fuel probes. The normal operation of fuel probes need to be tested before it can be installed in helicopter. But the existing method is laborious and time consuming. Our project aims at reducing the time and effort required to test the probe and to display the quantity of fuel in the helicopter tanks. Helicopter fuel system consists of five fuel tanks. Each tank has fuel probes for measuring the quantity of fuel which will be displayed in cockpit. To check for proper working condition of fuel probes, the probes are tested in a common tank. The testing is done with the help of suitable microcontroller kit. The altitude of fuel indicates the different frequency levels with respect to fuel probes. The software part of project involves the coding of microcontroller. The calculations such as quantity of fuel in kgs and liters are done using the appropriate interpolation formula and display the calculated value on suitable LCD display.

I. INTRODUCTION

The fuel sensor probes are light-weight durable and cost effective. They have been developed to withstand any flight conditions with outstanding reliability. Probes are provided with the weak or fragile section so that during crash the probes will break and the broken piece will remain inside the tank without piercing the tank. Fuel probes are sensors that generate particular frequencies corresponding to the fuel level in the tanks. This will be reported to the cockpit regularly. So that the person in the cockpit can know about the fuel quantity.

Working principle of Helicopter

This principle states that, "As the air velocity increases, the pressure decreases and as the velocity decreases, the pressure increases".



Figure(1): Forces acting on the Helicopter

The wings of the airplane create a lift force when they move through the air. During flight, there are four forces acting on the helicopter or airplane and those are LIFT, DRAG, THRUST, and WEIGHT. In order to make the wings to move through the air, the plane itself has to move. A helicopter works by having its wings move through the air while the body stays still. The helicopter's wings are called Main Rotor Blades. The shape and the angle of the blades move through the air will determine how much Lift force is created. After the helicopter lifted off the ground,

the pilot can tilt the blades, causing the helicopter to tip forward or backward or sideward.

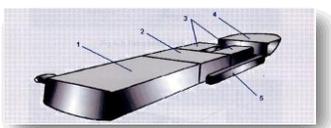
In Helicopter Lift is obtained by means of one or more power driven horizontal propellers which called Main Rotor. When the main rotor of helicopter turns it produces lift and reaction torque. Reaction torque tends to make helicopter spin. On most helicopters, a small rotor near the tail which called tail rotor compensates for this torque. On twin rotor helicopter the rotors rotate in opposite directions, their reactions cancel each other.

II. HELICOPTER FUEL SYSTEM

The purpose of helicopter fuel system is to ensure continuous supply of fuel to both engines under all operating conditions. The fuel is contained in five flexible fuel cells/tanks which are located under cabin floor boards. There are five fuel tanks and two expansion space cells. An additional fuel tank of 250ltr capacity can be mounted in the cabin when required. The fuel cells are constructed to fit into the fuel bay compartments in the fuselage structure. Each cell is close fit in the structure and is held in place by molded bolt ring and by lengths of Velcro tape. Fuel tanks are made of flexible light weight hycalite welding. One gravity refueling point and one pressure refueling point are provided in under carriage version and only one gravity refueling point is provided in skid or wheel version. These points are provided in front main tank on starboard side of fuselage. Various types of hycalites are used to manufacture fuel tanks in helicopter.

There are three main tanks and two supply tanks. Each tank has a fuel pump, fuel gauze and a drain valve, an additional pump is provided in the front main tank. Front main tank and middle main tank are interconnected at top and bottom. Middle main tank and supply tanks are interconnected at the top. Electrically operated fuel cock is provided in each fuel feed line to the engine to shut off fuel supply during emergency.

The location of fuel tanks is as shown in figure 2:

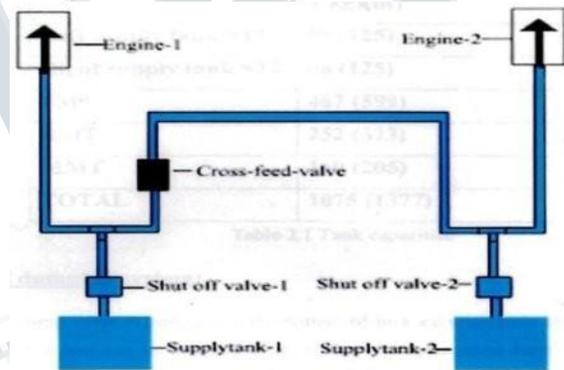


Figure(2): Fuel tanks of the ALH

The fuel tanks are identified by following abbreviations:

1. FMT : Front Main Tank
2. MMT : Middle Main Tank
3. ST1 : Supply Tank 1ST2 : supply Tank 2
4. RMT : Rare Main Tank
5. ET : Expansion Tank

Front and middle tanks get filled up simultaneously. Supply tanks and rare main tank are filled by transfer pumps from front and middle tanks. During operation, after approximately 160kg of fuel has been consumed from FMT and MMT combined, fuel from RMT needs to be transferred to FMT by operation of RMT, a transfer pump by the pilot.

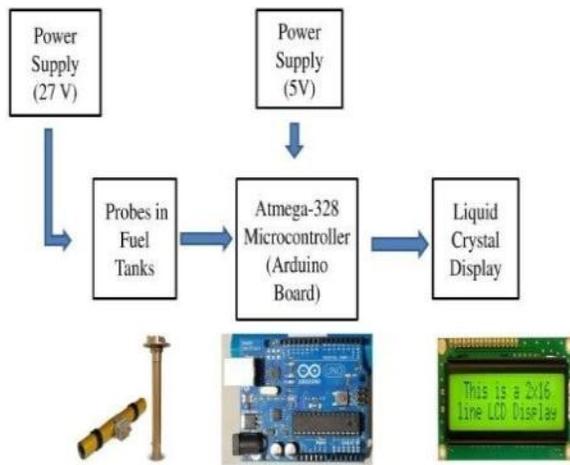


Figure(3): Cross Feed System

Fuel is piped through fuel lines to a fuel control valve (usually known as the fuel selector). This valve serves several functions. The function is to act as a fuel shut off valve. This is required to provide the crew with a means to prevent fuel reaching the engine in case of an engine fire. The second function is to allow the pilot to choose which tank feeds the engine. Many aircraft have the left tank and right tank selections available to the pilot. Cross feed valve is provided to supply fuel for both engines from single supply tank in case of failure of one of the prime pump. The cross feed is also operated during OEI landing to consume fuel from both the supply tanks and thereby reducing the weight of the helicopter.

Figure(5): Arduino Uno Board

III. BLOCK DIAGRAM



Figure(4): Block diagram of working module

Helicopter fuel system consists of fuel tanks. It has fuel probes for measuring the quantity of fuel, which will be displayed in cockpit. To check for proper working condition of fuel probes, the probes are tested in order to excite these fuel probes 27V supply will be given. The testing is done with the help of suitable microcontroller kit. The altitude of fuel indicates the different frequency levels with respect to fuel probes. The software part of project involves the coding of microcontroller. The quantity of fuel in kgs is calculated and its value is displayed on suitable LCD display. And the required connections are as shown in the above figure.

IV. HARDWARE IMPLEMENTATION



In its simplest form, an Arduino is a tiny computer that you can program to process inputs and outputs going to and from the chip. The Arduino is what is known as a physical or embedded computing platform, which means that it is an interactive system that through the use of hardware and software can interact with its environment.

The Arduino can be used to develop standalone interactive object or it can be connected to a computer to retrieve or send data to the Arduino and then act on that data (E.g.: send sensor data out to the internet). The Arduino can be connected to LEDs, dot matrix display, LED display, buttons, switches, motors, temperature sensors, pressure sensors, distance sensors, web cams, printers, GPS receivers and Ethernet modules. The Arduino board is made of an Atmel AVR microprocessor, a crystal or oscillator (basically a crude clock that send time pulses to the microcontroller to enable it to operate at the correct speed) and a 5V linear regulator. Arduino may also have a USB connector to enable it to be a PC or MAC to upload or retrieve data. The word exposes the microcontrollers' I/O (Input/Output) pins to enable you to connect those pins to other circuits or to sensors, etc.

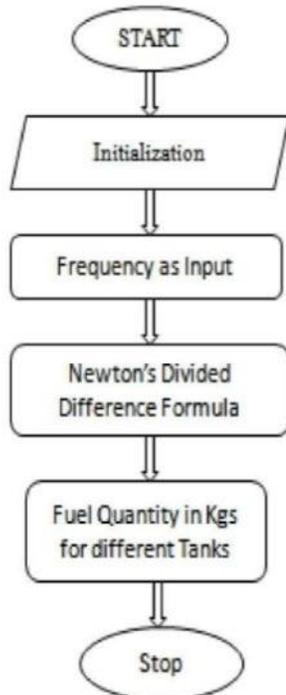
To program the Arduino you also use the Arduino IDE (Integrated Development Environment) which is a piece of free software that enables you to program in the language that the Arduino understands. In the case of Arduino the language is C. The IDE enables you to write a computer program, which is a set of step by step instructions and then upload to the arduino. Then the Arduino will carry out those instructions and interact with the world outside

The Arduino Uno is a microcontroller board based on the atmega-328 (data sheet).It has 14 digital-input/output pins(of which 6 can be used as PWM output), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power check, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an ac to dc adapter or battery to get started. The Arduino Uno board is as shown in fig.

The Uno differs from all preceding boards in that it does not use the FTDI USB to serial driver chip. Instead it features the Atmega 16 U2 (Atmega 8U2 up to version R2) programmed as a USB to serial convertor.

The Atmega48PA/168PA/328P AVR is supported with a full suite of program and system development tools including: C compilers, Macro assemblers, program debugger/simulators, in circuit emulators and evaluation kits.

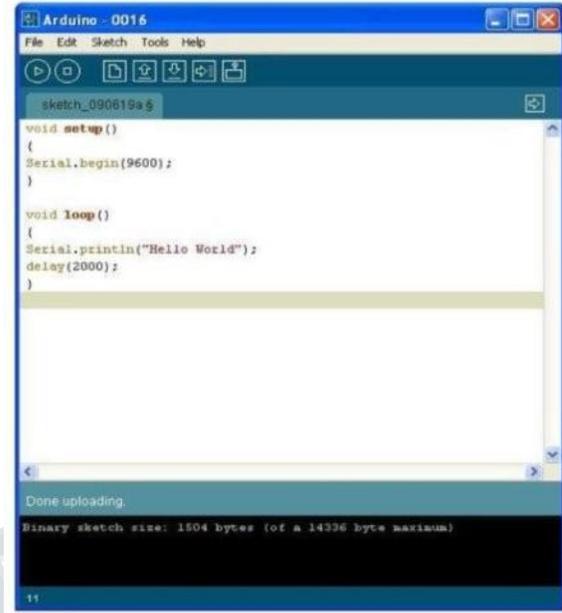
V. SOFTWARE IMPLEMENTATION



Figure(6): Flow of Project

The software part of the project involves in coding of the Microprocessor to perform calculations according to the interpolation formula (in this case, the interpolation method used is the Newton's divided difference method) and to display the calculated value on the LCD display unit as desired.

The code is written in c and then slight changes are performed on it to make it compatible with the Arduino Uno board.



Figure(7): Sample Arduino Editor Window

VI. ADVANTAGES

- v This project can be used to test the fuel probes without being installed on helicopter.
- v Time required to test fuel probe is very less.
- v The quantity of fuel can be digitally displayed which was not implemented on ground.

VII. APPLICATIONS

This concept can be used to check aircraft fuel system in the helicopters which are used for the civil and military purposes.

VIII. RESULTS

Figure(8): Results to be Display

The display shows the practical output. When the probe from the particular tank is selected from the switching circuit, then the microcontroller calibrated the quantity of fuel in that tank and displays it on the display interface as shown in figure. The left hand side on the is the value of frequency generated by the probe, the center part indicates the fuel tank selected, and the right hand side of LCD displays thee fuel quantity in kgs

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