Project report on

“FLY BY WIRE”

Submitted in partial fulfillment of the award of the

BACHELOR OF SCIENCE
IN
AERONAUTICS
(MECHANICAL)

By

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BONAFIDE CERTIFICATE

This is to certify that project report titled " **FLY BY WIRE"** , is a bonafide record of work carried out by **Mr. ANIKET PRAKASH PATIL** during the final semester from **February 2021** to **May 2021** under my guidance, in partial fulfillment of the requirements for the award of **Bachelor of Science** in **Aeronautics** (**Mechanical).**

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Ms.Roma Goregaonkar
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DECLARATION

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Place:

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ACKNOWLEDGEMENT

It is my pleasure to be indebted to various people, who directly or Indirectly contributed in the development of this work and who influenced my thinking, behavior, and acts during the course of study. I express my sincere gratitude to my Project Guide ***Dr.M Suresh Kumar*** for providing me an opportunity to work under him. I am thankful to him for his support, cooperation and motivation provided to me during the project for constant inspiration, presence and blessings.

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ABSTRACT

Fly-by-wire (**FBW**) is a system that replaces the conventional manual flight controls of an aircraft with an electronic interface. The movements of flight controls are converted to electronic signals transmitted by wires, and flight control computers determine how to move the actuators at each control surface to provide the ordered response. It can use mechanical flight control backup systems (like the Boeing 777) or use fully fly-by-wire controls.

Fly-by-wire control systems (FBWCS) introduce particular correlations between the aircraft inputs (deflection angles) and outputs which lead to biased parameter estimates in the absence of de-correlating actions such as extra-signals. This problem has been investigated with the aim of finding quickly non biased parameter values from flight data on aircraft inputs, outputs and pilot inputs, in order to provide an iterative optimization scheme with good initial values. A methodology including input design, instrumental variable estimation and automatic estimation strategy, was developed, analyzed on simulated cases and tested with real flight data.

PROJECT RECORD BOOK

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CHAPTER 1: INTRODUCTION

The potential benefits of fly-by-wire (FBW) control of civil transport aircraft have long been recognised, and some of the first aircraft to which the technique was applied were the Concorde (elevon control) and the Boeing 767 for the control of its wing spoiler system. It was only with the design and development of the Airbus A320, however, that benefits have been fully exploited whereby FBW /digital computer systems have complete control over all flight control surfaces. Another significant feature of this aircraft is that each pilot has a side-stick type of controller in place of the more conventional control column. An FBW system has a number of advantages, the most notable of which may be highlighted as follows:

• **Weight saving**. The elimination of the conventional connecting rods, cables and pulleys, together with the mechanical adjustment, feel and interconnection units, saves considerable weight even after allowing for the weight of the computers and cable systems which are introduced as replacements.

• **Reduced maintenance times**. Conventional control systems can be very manpower consuming where· maintenance is concerned because of the need to make many adjustments to the mechanical control runs in situ. Moreover, it can take numerous flight tests to correct some conventional control system adjustment problems. Maintenance down-times can be reduced signific:antly through the greater use of line replace~ble units which is possible in FBW control systems and digital flight control systems, once developed fully, should need little or no physical maintenance action.

• **Gust load alleviation**. Another advantage of the use of FBW, which has been utilised for some years, is that it may be used to control the ailerons in a manner which will alleviate the effects of wind gusts. Normally, when an 1 aircraft encounters an up-gust of wind the immediate effect is 292 Fly-by-wire (FBW) Control Systems for the lift generated by the wing to increase, causing the aircraft to climb, often quite violently. This has the effect not only of causing discomfort to the passengers but also of putting considerable stress on the aircraft structure.

• **Automatic manoeuvre envelope protection**. In most commercial types of aircraft, the control systems are such that manoeuvres can be initiated which would be beyond the flight manoevuvre

limits these aircraft require in the normal course of their operation. With FBW controlled-aircraft, however, the pilot demands requisite control surface deflections from computers that are programmed such that the command signals generated and distributed, are tailored to match the flight criteria established for the particular type of aircraft. In other words, the computers limit the response of the controls and thereby ensure that flight manoeuvre envelope limits of bank, pitch, yaw, speed, angle of attack and 'g' forces are not .exceeded.

• **Improved handling**. From the pilot's viewpoint perhaps the most obvious feature of FBW systems is the improvement in handling characteristics which they can bring. The many small deficiencies in handling of even modern airliners can be eliminated through the efficient use of computers which can make the aircraft responses to control inputs match exactly what the pilot would want them to be.

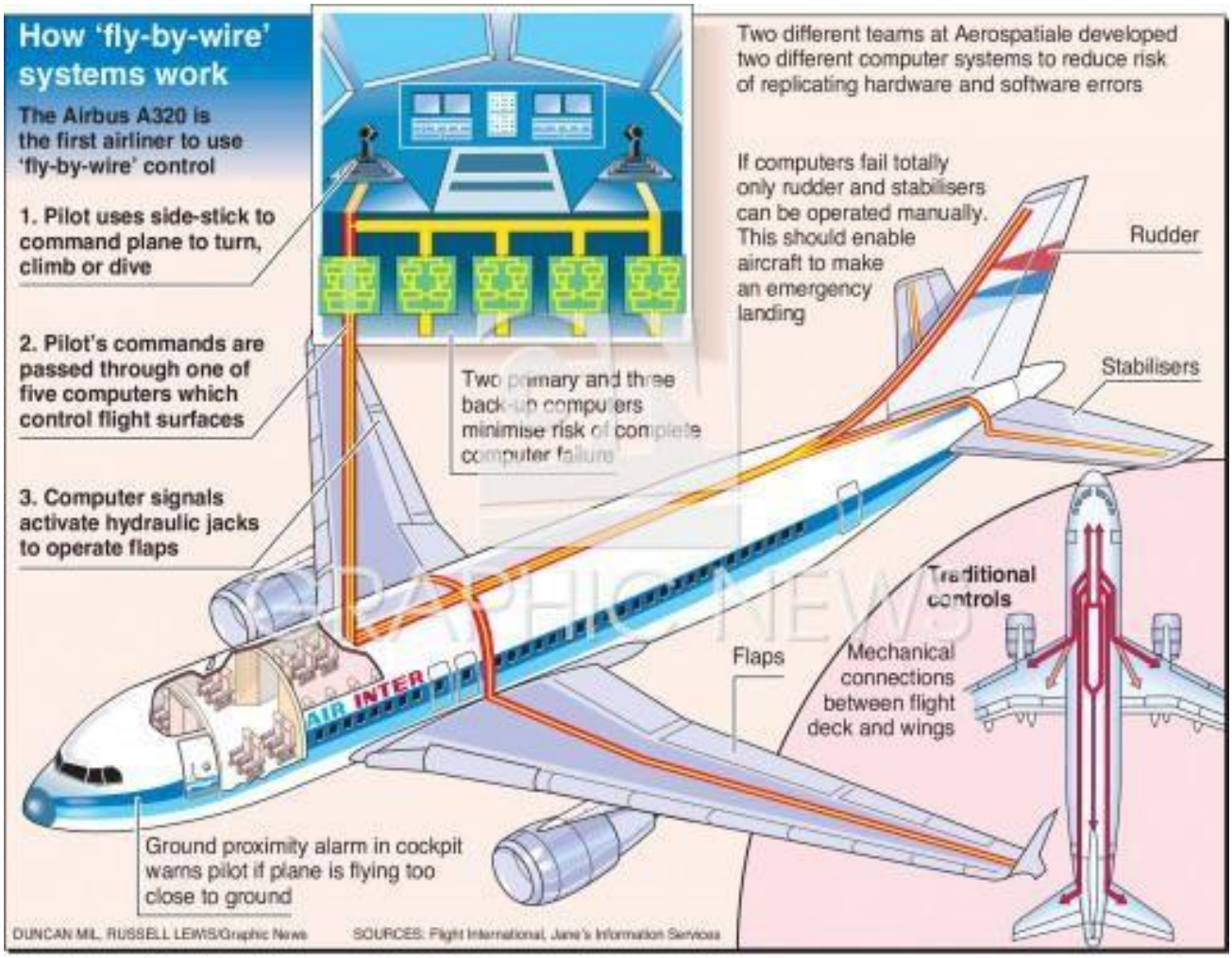


Fig1.1- A320 Fly By Wire Working Sysmatic

CHAPTER 2: NEED FOR FLY BY WIRE

i. Traditional mechanical and hydro-mechanical flight control systems use a series of levers, rods, cables, pulleys, and more which pilots move to adjust control surfaces to aerodynamic conditions.

ii. Their hands on design give pilots a direct, tactile feel for how the aircraft is handling aerodynamic forces as they fly.

iii. On the other hand, mechanical systems are also complicated to operate, need constant monitoring,

iv. Are heavy and bulky, and require frequent maintenance.

v. Because fly-by-wire is electronic, it is much lighter and less bulky than mechanical controls, allowing increases in fuel efficiency and aircraft design flexibility, even in legacy aircraft.

vi. And to prevent flight critical failure, most fly-by-wire systems also have triple or quadruple redundancy back-ups built into them.

vii. Further innovations to the system are also in development, including fly-by-wireless, fly-by-optics, power-by-wire, and more.

CHAPTER 3: HISTORY OF FLY BY WIRE

- "Fly-by-wire" technology translates the pilot's actions into electronic signals, which computers use to manipulate flight controls
- . The computers constantly monitor pilot input and prevent the aircraft from exceeding its flight envelope, thereby increasing safety.
- And because fly-by-wire replaces heavy, complex mechanical linkages with lighter electrical wires, it is more efficient.

- Invented by NASA in the 1970s and first used in fighter aircraft, this technology was a direct spin-off from the space program, which used fly-by-wire systems to maneuver the Apollo lunar module.
- In 1972, NASA research pilot Gary Krier became the first to fly a digital fly-by-wire aircraft when he piloted NASA's highly modified F-8C Crusader jet fighter.
- The Airbus A320 revolutionized commercial aviation by introducing digital fly-by-wire technology in civil airliners
- . Featuring a glass cockpit with a unique side-stick controller to fly the aircraft, the A320 set a new standard for safety and efficiency.
- Every new airliner designed since it entered service in 1988 has incorporated glass cockpit and fly-by-wire technology.

Fig 3.1 – Digital FBW System

CHAPTER 4: FLOWCHART OF TYPICAL FBW SYSTEM

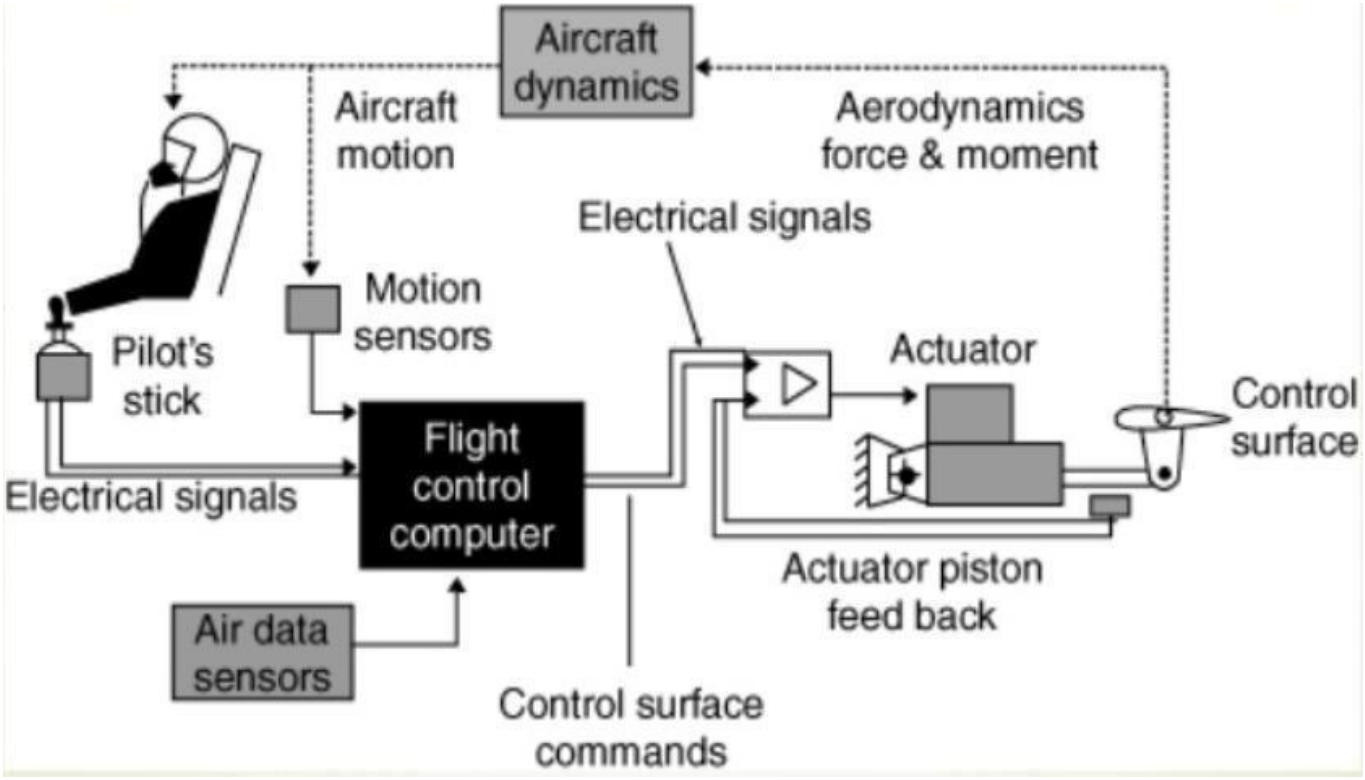


Fig 4.1-Flow Chart Of FBW System

CHAPTER 5: ELECTRONICS IN FLY BY WIRE SYSTEM

In "FBW" aircraft, the control inputs are instead sent to calculators which deliver actual orders to actuators. Each FWB system, in addition to introducing calculators into the pilot-control surface chains, also gets information from sensors to measure the aircraft response to orders (feedback).

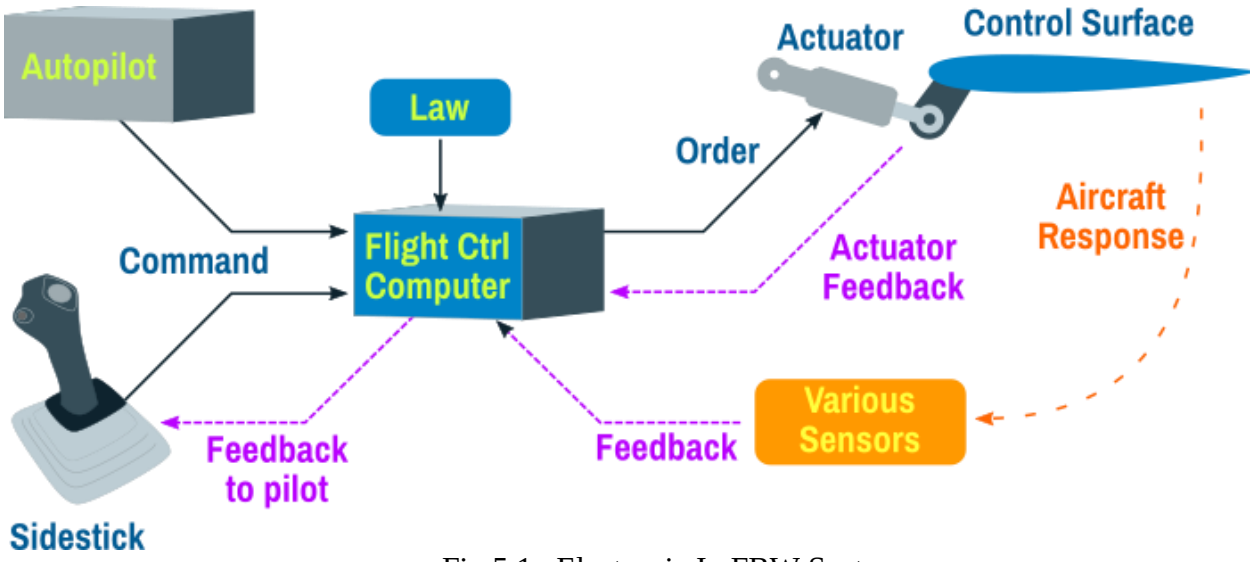


Fig 5.1 –Electronic In FBW System

This design has two advantages:

There is an actuator (e.g. an hydraulic jack), so the pilot (or the autopilot) has to exert on the control inputs only a fraction of the actual force that needs to be exerted by the actuators on the control surfaces.

More important for the concept, the calculator can supervise the pilot commands, so that the aircraft is never put in unwanted or dangerous configuration, e.g. stalled.

This system is similar to the full authority digital engine control (FADEC) used for the engines.

The main calculators for Airbus A320 family are:

- ELAC: elevator and aileron computer
- SEC: spoiler and elevator computer
- FAC: flight augmentation computer
- SFCC: secondary flight control computer

They are redundant and some functions dedicated to one computer can also be executed on other computers.

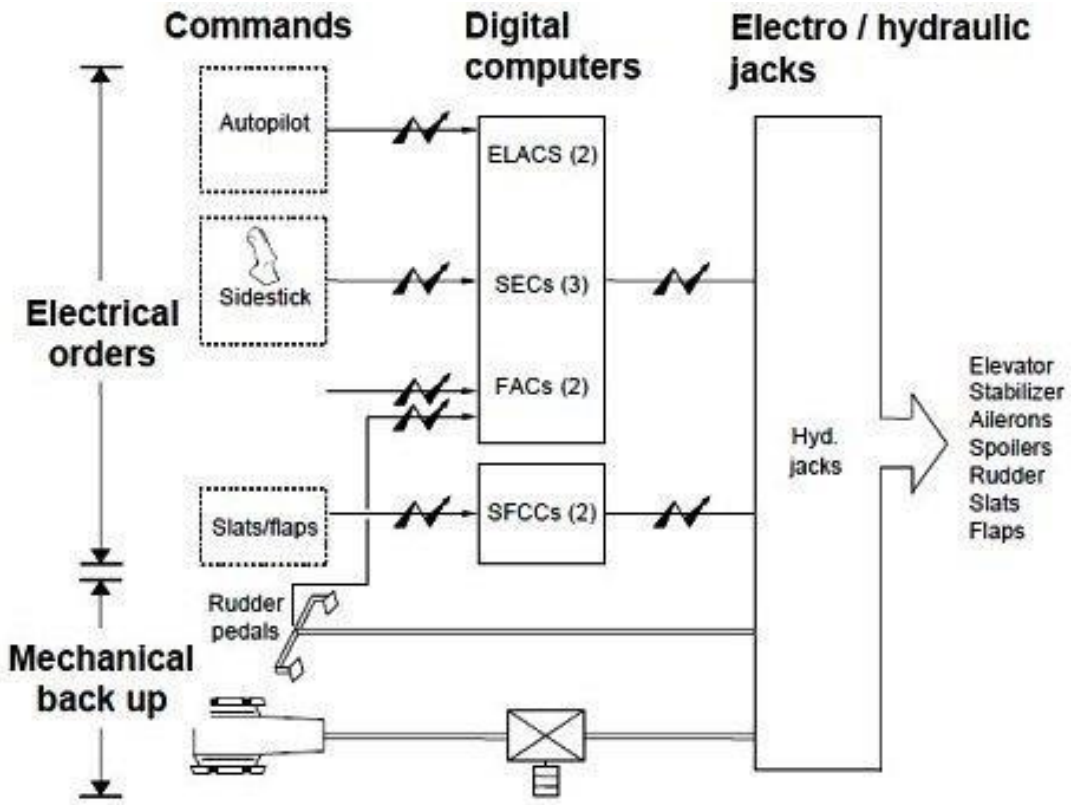


fig 5.2-Chart Of System Working

CHAPTER 6: CONTROL OF AIRCRAFT

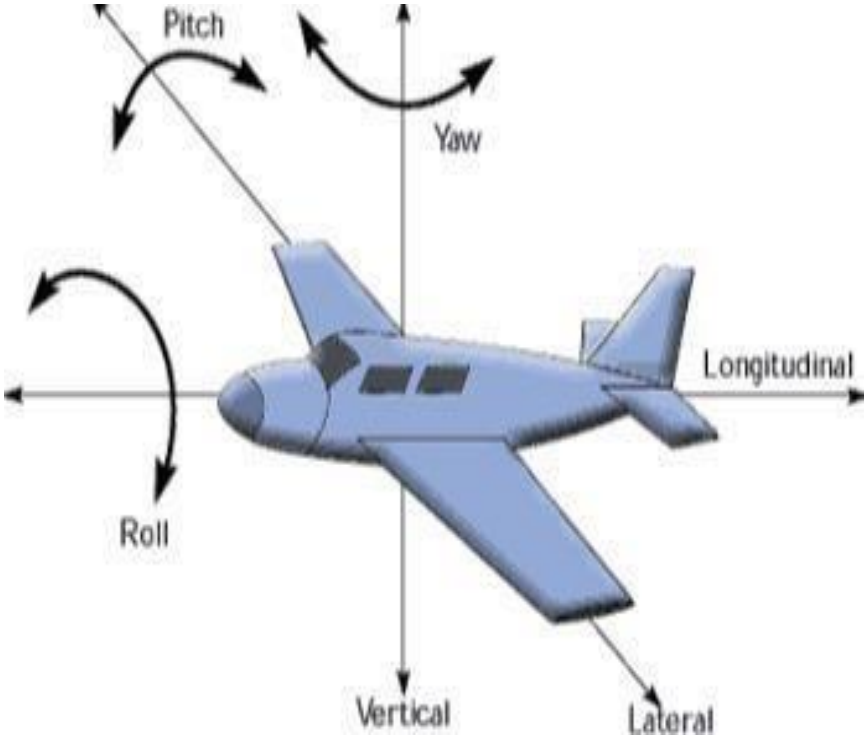


Fig 6.1-Aircraft Principal Axis

- ✓ Fly-by-wire control systems allow aircraft computers to perform tasks without pilot input.
- ✓ Automatic stability systems operate in this way.
- ✓ Gyroscopes fitted with sensors are mounted in an aircraft to sense rotation on the pitch, roll and yaw axes.
- ✓ Any movement (from straight and level flight for example) results in signals to the computer, which can automatically move control actuators to stabilize the aircraft.

CHAPTER 7: BASIC CONTROL LOOP

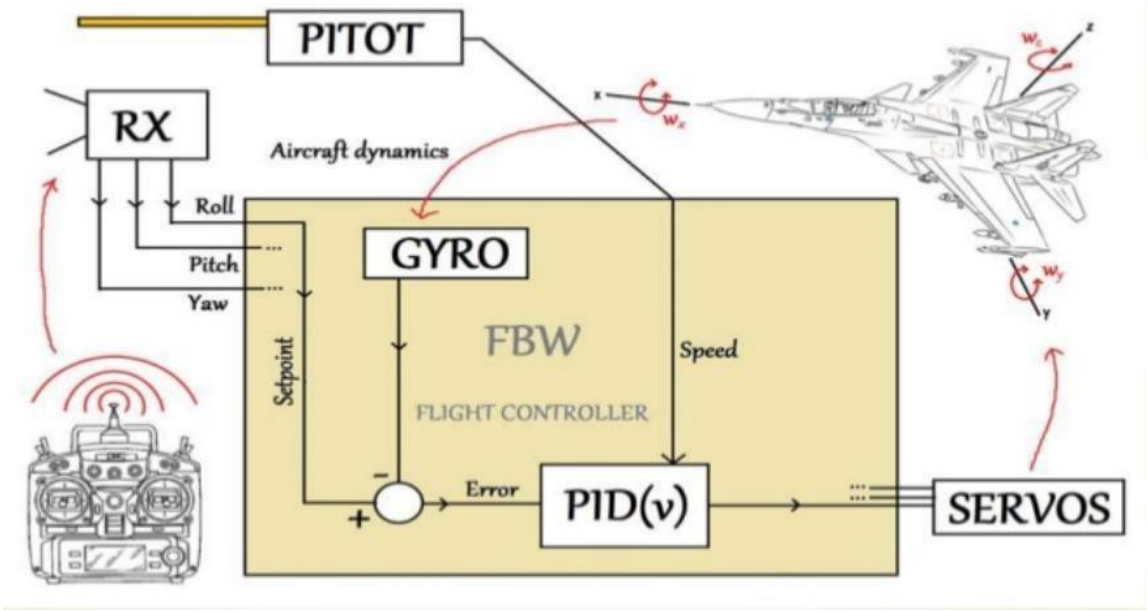
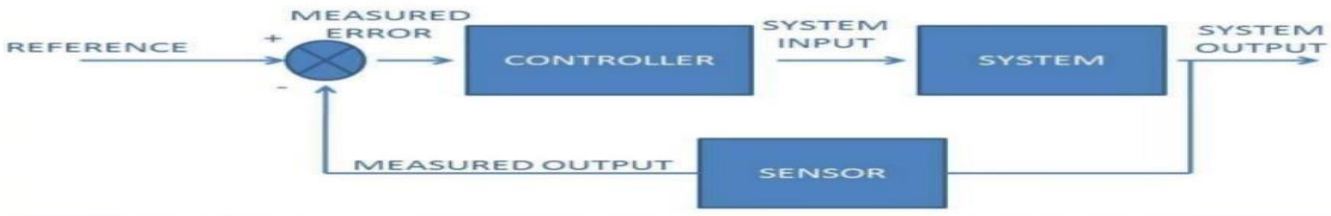


Fig7.1 Aircraft Dynamics

A pilot commands the flight control computer to make the aircraft perform a certain action, such as pitch the aircraft up, or roll to one side, by moving the control column or sidestick. The flight control computer then calculates what control surface movements will cause the plane to perform that action and issues those commands to the electronic controllers for each surface. The controllers at each surface receive these commands and then move actuators attached to the control surface until it has moved to where the flight control computer commanded it to. The controllers measure the position of the flight control surface with sensors such as LVDTs.

Fig7.2



CHAPTER 8: TYPES OF FLIGHT CONTROLS

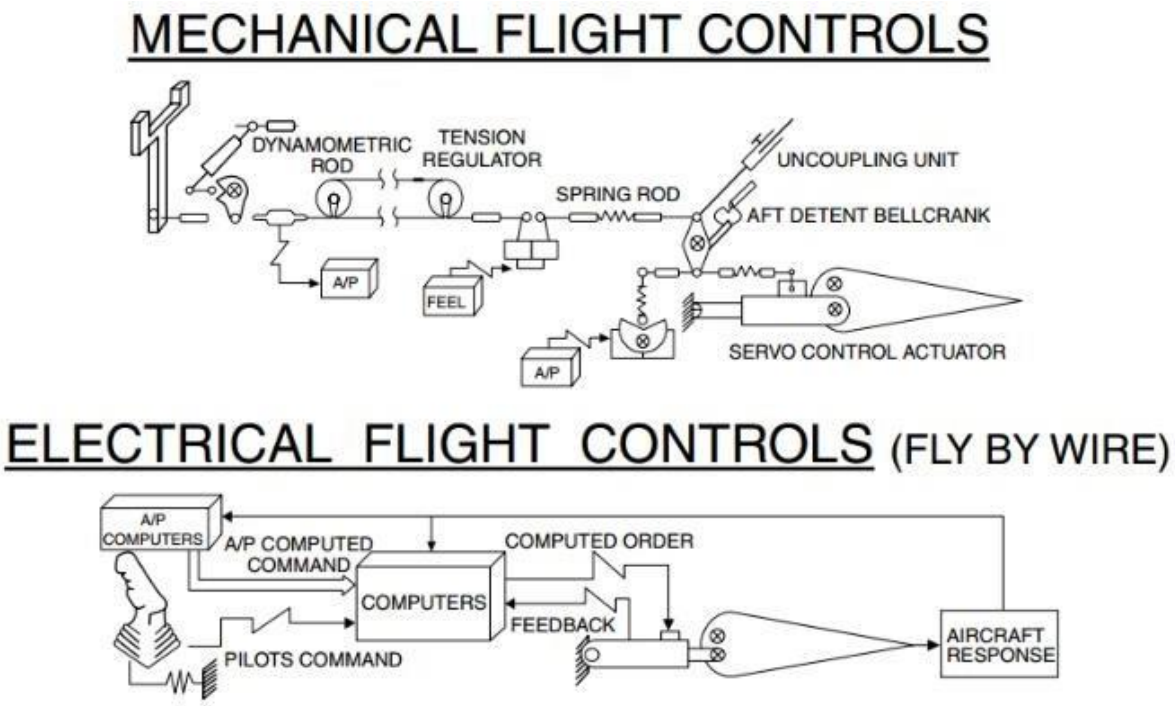


Fig 8.1-Types Of Flight Control

CHAPTER 9 : TYPES OF FLY BY WIRE SYSTEM

ANALOG SYSTEM

 Replace the hydro mechanical or electro mechanical control systems with electronic circuits.

 Control systems in the cockpit operate signal transducers, to generate the appropriate electronic commands.

- Signals are then processed by an electronic controller with an analog signal.

DIGITAL SYSTEM

 Pilot can literally “Fly-via-computer"

 Increase electronic stability, as system is less dependent on the values.

- Increases the flexibility of flight control system
- Multiple redundancy techniques
- Increase electronic stability, as system is less dependent on the values

CHAPTER 10: COMPARISON & APPLICATION

1. COMPARISON

ANALOG SYSTEM	*DIGITAL SYSTEM*
ACCURACY LOW	ACCURACY HIGH
CIRCUIT IS COMPLICATED	CIRCUIT IS SIMPLIFIED
CALIBRATION IS TOUGH	CALIBRATION IS EASY

2. APPLICATION

- Technology used in both military & civilian aircrafts.
- Satellite manufacturers use this technology in their vehicles and
- Space shuttle
- Several unmanned aerial vehicles (UAV), IAI Heron, etc.
- Airbus A320, Boeing 777, Dassault Raffael, Stealth bomber: F-117, Mikoyan Mig 29K, etc

CHAPTER 11: ADVANTAGES & DISADVANTAGES

ADVANTAGES

- Reduced wear and tear due to less mechanical contacts
- Intelligent control system.
- Higher accuracy and maneuverability
- Increased safety and reliability
- Improved survivability and mission performance
- Ease of assembly and maintenance

DISADVANTAGES

- Sometimes software failures due to hacking.
- Technical issues.
- electromagnetic interference such as lightning strikes could be a problem

CHAPTER 12: PROJECT RELATED COMPONENTS

1. Arduino
2. Servo motor
3. Joystick module
4. Jumper wire
5. Bread board
6. Battery
7. Cardboard
8. Wood
9. Pulley
10. Electrical wires

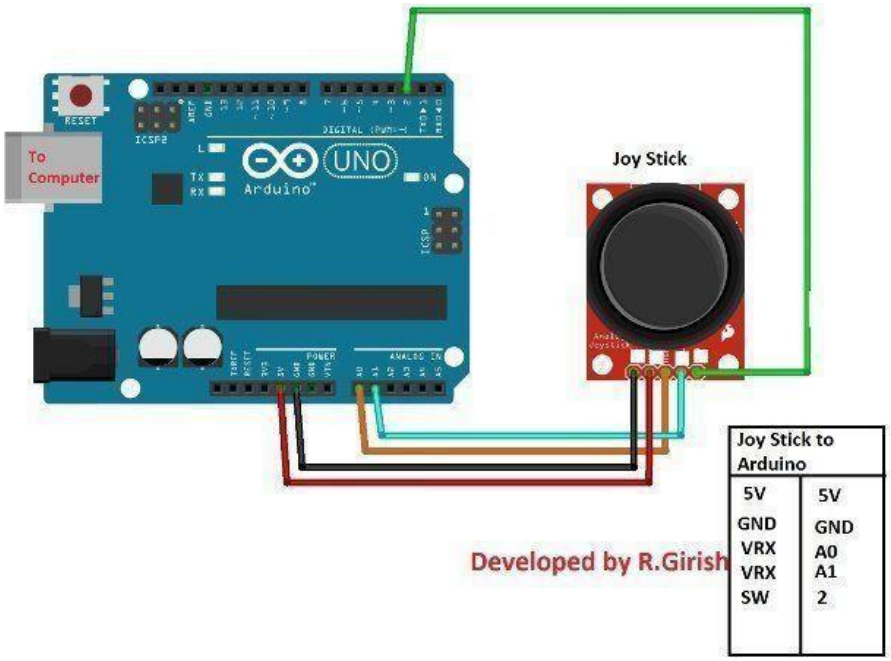


Fig12.1 Circuit Diagram (a)

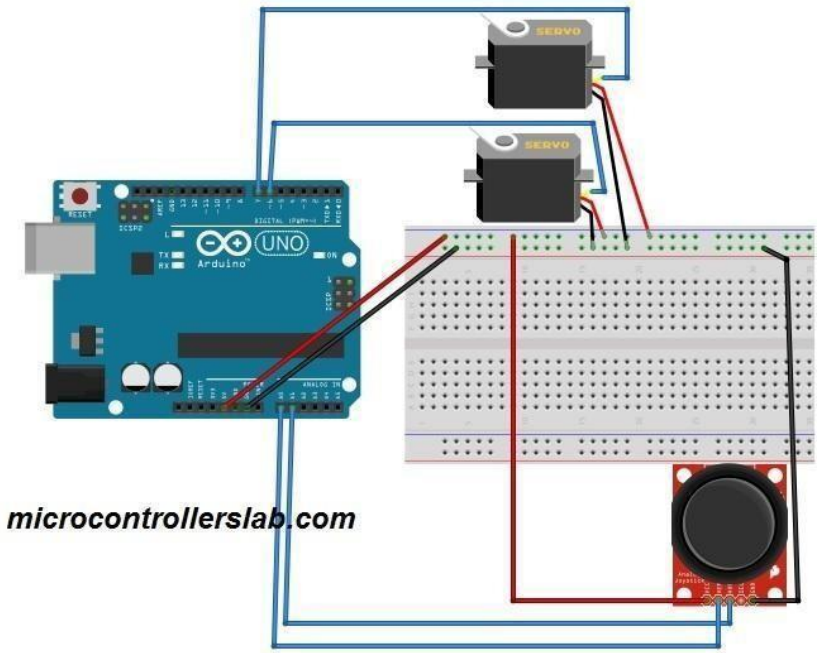


Fig 12.2-Circuit Daigram (b)

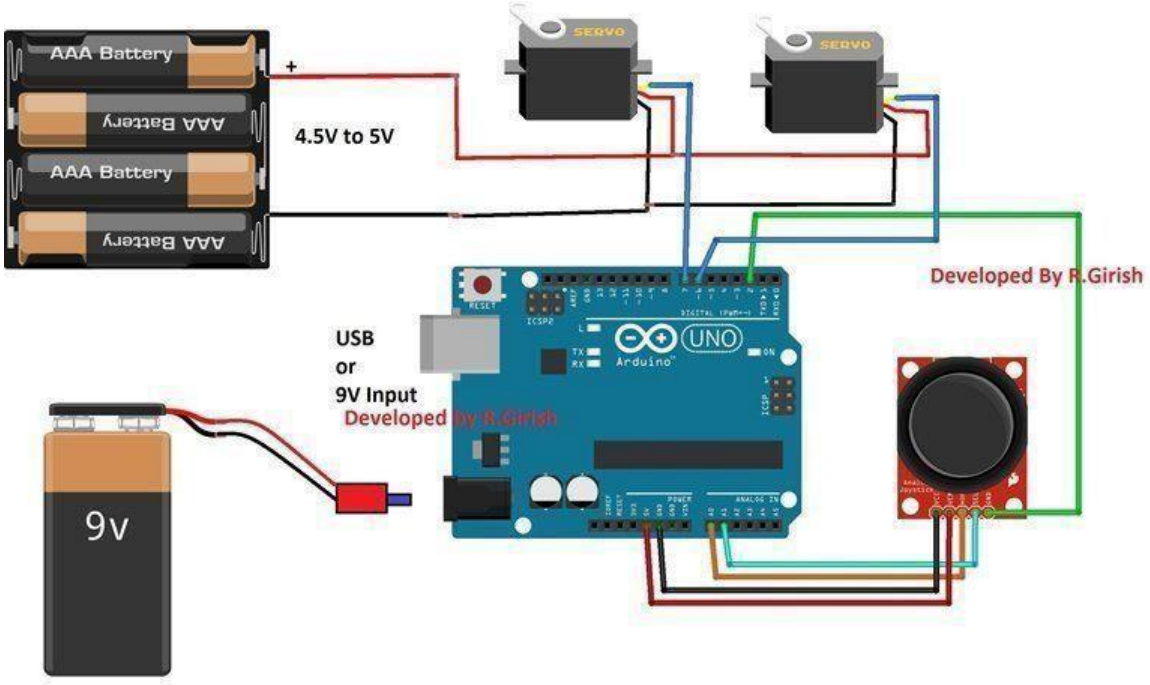


Fig12.3 – Circuit Diagram (c)

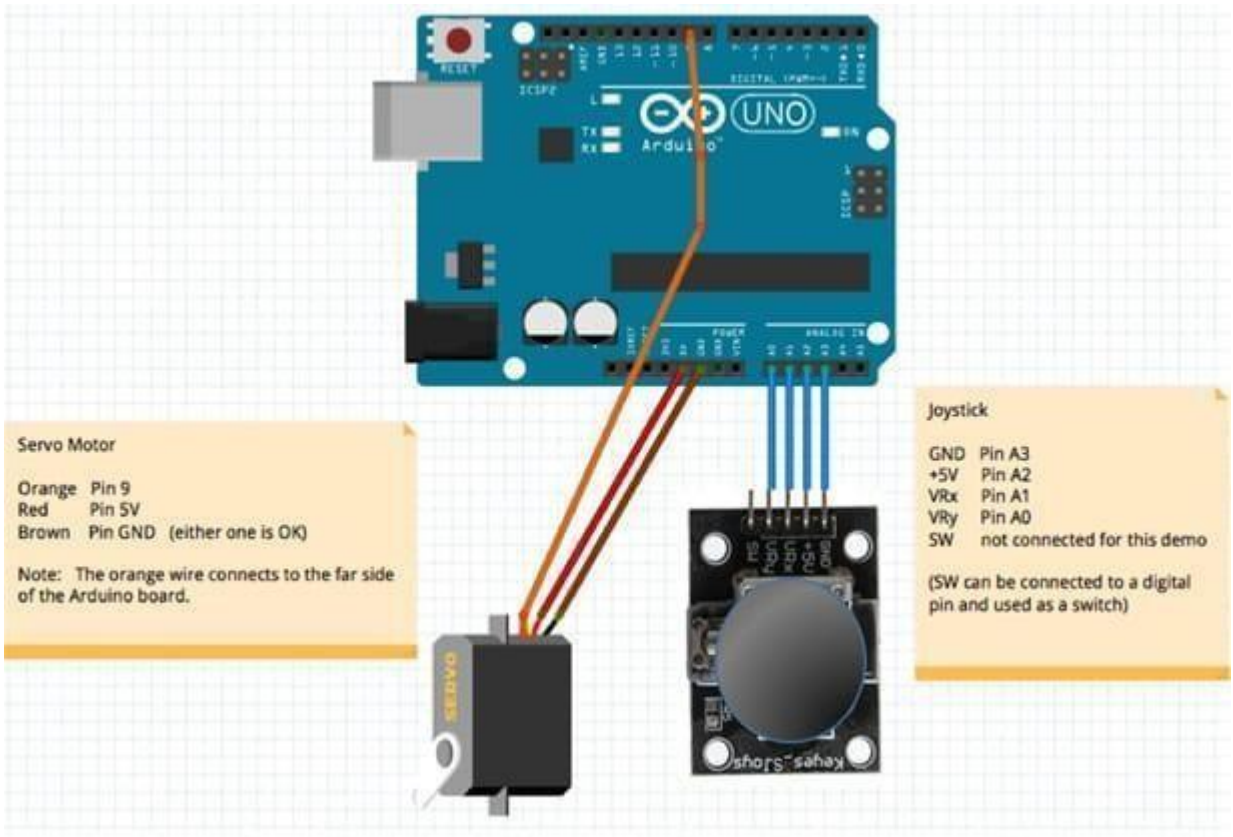


fig 12.4-circuit diagram (d)

CHAPTER 13: CONCLUSION

Fly by wire is an extremely safe and reliable technology which can be embraced. It is one of the greatest back through in aviation history. It has good scope of improvement over the coming years and is definitely worth investing. Fly-By-wire is a technological advancement in aviation that simply has no cons, makes the aircraft fly smoother and incorporates a higher level of safety.

Fly-by-wire provides more delicate and user-friendly facilities in flight control. Provide more security for which every human being is concerned. Controlling an aircraft becomes easier with the help of Fly-by-wire system. Gap between the flight controls and pilot is reduced.

Using of fly-by-wire flight control systems has created huge benefits for the aerospace industry, reducing the weight of the flight control system, creating multi redundant flight control systems which ultimately increases the flight safety for all airplane equipped with fly-by-wire systems.

CHAPTER 14: REFERENCE

- ✓ *https://aviation.stackexchange.com/questions/47711/what-are-the-main-components-of-the-airbus-fly-by-wire-system-is-ecam-related-t*
- ✓ *https://www.baesystems.com/en-us/definition/what-are-fly-by-wire-systems*
- ✓ *AUTOMATIC FLIGHT CONTROL BY PALLET BOOK*
- ✓ *https://en.wikipedia.org/wiki/Fly-by-wire*