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PRIMARY FLIGHT CONTROL OF BOEING-777

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Abstract

The control surfaces are very basic components to fly the aircraft. This paper focuses on Fundamental concept of Fly-by-wire system, Fundamental concept of ARINC-629, Implementation of ARINC-629 in Boeing-777, Avionics interfaces of primary flight control surfaces viz. Aileron, Flaperon, Rudder, Elevator as part of Fly-by-wire system.

Keywords*- Fly-by-wire, Arinc (Aeronautical Radio Incorporated) -629, Aileron, Flaperon, Rudder, Elevator.*

I. INTRODUCTION

A FBW system actually replaces manual control of the aircraft with an electronic interfaces. The movement of flight controls are converted to electronic signals and flight control computer determine how to move the actuators at each control surface to provide the expected response.

1.1. Fundamental Concept Of Fly–By-Wire

Component of FBW system

1. Actuator (Power control unit)
2. Power circuit (Actuator control electronics)
3. Computer (PFC)

There are two types of Fly-by-wire system

1) Analog system
It uses circuit to implements control laws specific to each aircraft.

2) Digital system
It uses software to implements control laws specific to each aircraft.

1.2. Benefits of Fly-By-Wire system

1. A more efficient structure design
2. Increase fuel economy
3. Decrease weight
4. Better control & protection
5. Improve reliability

1.3. Limitation of Fly-By-Wire system

Traditional mechanical or hydraulic control system usually fail gradually, While in FBW the loss of all flight control computers could immediately make the aircraft uncontrollable

II. Fundamental Concept of ARINC-629

- ARINC is an acronym for Aeronautical Radio Incorporated.
- There are two functions of ARINC

(1) It provides services to airlines, mainly operation of a private air-ground communications system called the Aeronautical Telecommunication Network (ATN).
(2) It generating avionics standards and research.

IN BOEING-777
ARINC-629 is used which is a twisted Pair of wires with termination resistor at each end.

Components of Data bus ARINC-629 System

(1)Data Bus Cable
(2)Current Mode Couplers
(3)Stub Cables
(4)Serial Interface Modules
(5)Terminal Controllers

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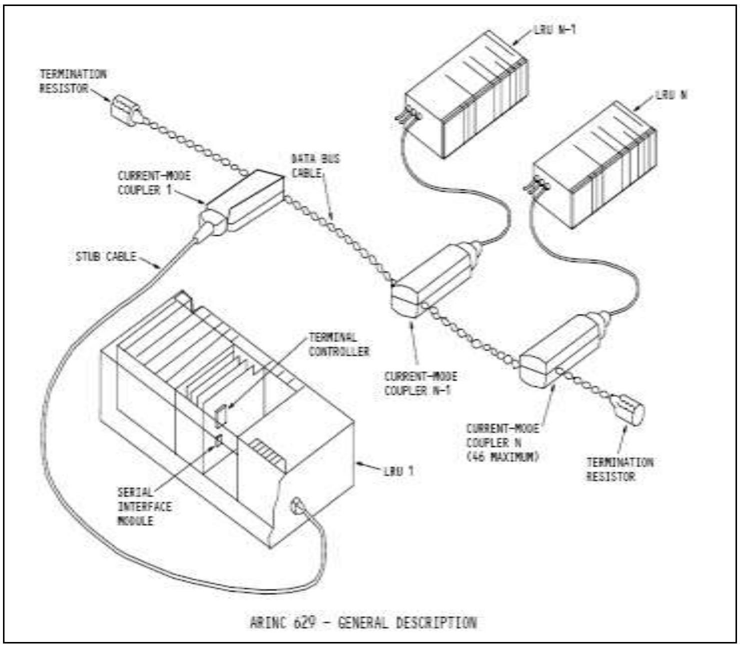

Figure 1- ARNC 629- General Discription

2.1. Characteristics

1. LRUs send data one at a time in sequence.
2. The LRUs receive data at the same time.
3. Communication on ARINC-629 is bi-directional, LRUs can transmit and receive data on the same bus.

4. One LRU can connect to more than one data bus through separate couplers on each bus
5. All data on the bus is available to all the LRUs on that bus.

2.2. Configuration

These are the 11 ARINC-629 data buses

1. 4-System buses
2. 4-AIMS inter cabinet buses
3. 3-Flight Control Buses

2.3. Functional Description

1. Each LRU uses one or more CMC to connect to data buses.
2. A CMC and it's terminal move data to and from the bus.
3. Only one terminal on a bus transmits at a time.
4. Each terminal monitors the bus and does not transmit until there is a in data movement on the bus from other LRUs.

2.3.1. Current Mode Coupler

Purpose:- The current mode coupler connects the bus cable to the stub cable.

2.3.2 Bus Cable & Bus Panel

Purpose:- The bus cable moves data between LRUs

2.3.3. Stub Cable

Purpose:- The stub cables are for bi-directional data moment between the LRU and the current-mode-coupler. The stub cables also supply power from the LRUs to the CMCs.

III. Flight Controls of Boeing-777

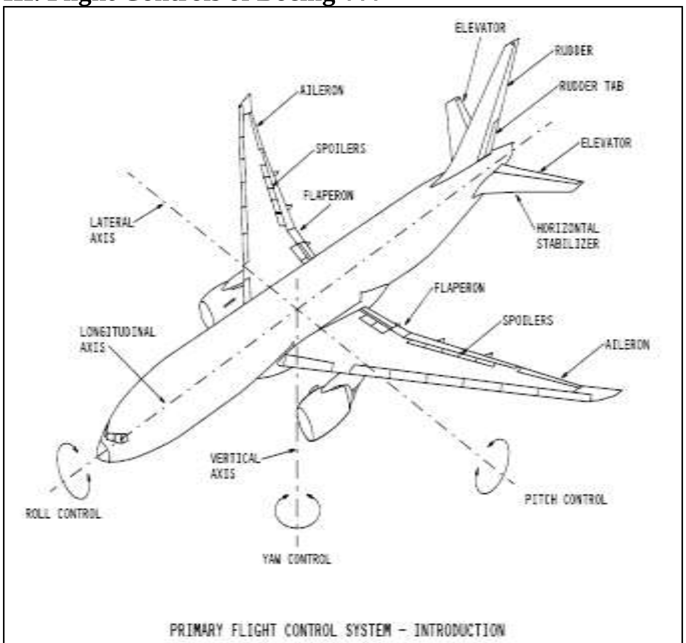

Figure-2 Flight Control System of Boeing-777

3.1. Primary control surfaces operated by the PFCs are

1. One aileron on each wing
2. Seven spoiler on each wing
3. One horizontal stabilizer
4. One elevator on each side of the horizontal stabilizer
5. One rudder tab.

3.2 Secondary control surfaces

1. Seven L.E slats on each wing
2. One Kruger flap on each wing
3. One single slotted outboard flap on each wing
4. One double slotted inboard flap on each wing

3.3. Implementation of FBW concept & ARINC-629 in PFC B-777

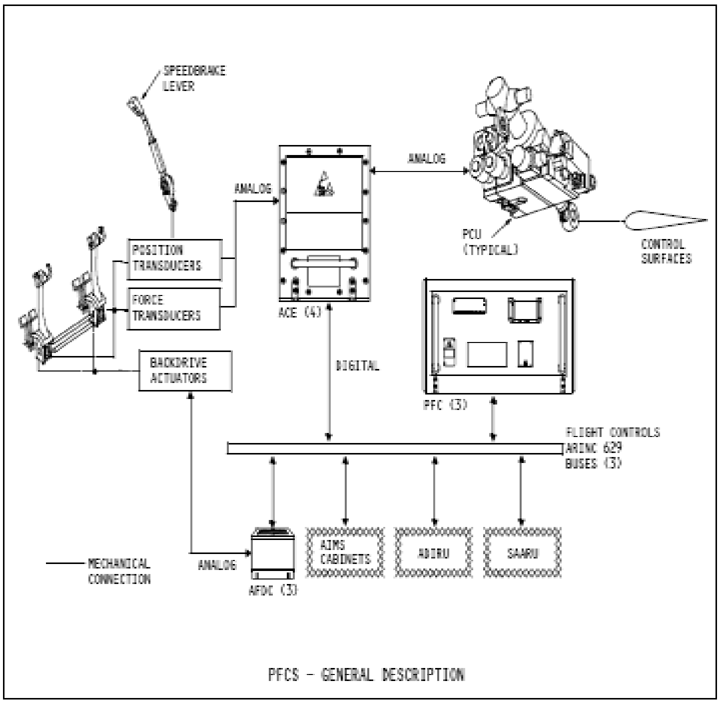

Figure-3 FBW and ARINC-629 in PFC B-777

3.3.1. Component used

Position transducers	ACE(4)
Force transducer	PFC(3)
Flight control bus(3)	AIMS
SAARU	PCU

Position and force transducer change the pilot's manual command of the control wheel, the control columns, the rudder pedals and the speed brake lever to analog electrical signals.

These signals go to the four actuator control electronics (ACEs). It changes the signal to digital format and send them to the three primary flight computer (PFCs).

PFCs receive data from following by three flight controls ARINC-629 buses

(1) The airplane information management system (AIMS)

(2) The airdata inertial reference unit (ADIRU)
(3) The secondary attitude air data reference unit (SAARU)

- In this all information are in digital format
- By using these information PFCs sends command signal to ACEs based on control laws and flight envelope protection functions.
- The control laws supply stability augmentation in the pitch and yaw axes.
- The flight envelope protection in all three axes
- By receiving these digital signal from PFCs, ACEs converted them into analog format and send to PCUs
- PCUs moves control surfaces by using these signal

1 PCUs controls each spoiler
2 PCUs controls each aileron, flaperon, & elevator
3 PCUs control the rudder.

AIMS gives information about Outside Air Temperature (OAT) and Angle Of Attack (A.O.A)

- ADIRU=ADC+IRU

Where,

ADIRU = Air data inertial reference unit
ADC = Air data computer
IRU = Inertial reference unit

- ADC gives information about Airspeed and Altitude.
- IRU gives information about Attitude of the Airplane on three axes & Heading of the Airplane
- Secondary Attitude Airdata Reference Unit (SAARU) has fiber optics gyro this provides Airspeed, Altitude, Attitude, Heading.
- SAARU is stand by unit for ADIRU.

IV. Aileron & Flaperon Control

Aileron & Flaperon are controlled by Control Wheel.

4.1 Wheel position Transducer

There are six transducer, Three for each Control Wheel, these transducers send analog signal to the ACEs.
These Analog signal have a relation to the Control Wheel position and it's movement.

4.2Wheel force transducer

There are two transducer, one for each Control Wheel, these transducers send analog signal to the ACEs.
These Analog signal shows the quantity of force which pilots apply to the Control Wheel.

Figure-4 Aileron and Flaperon of Boeing-777

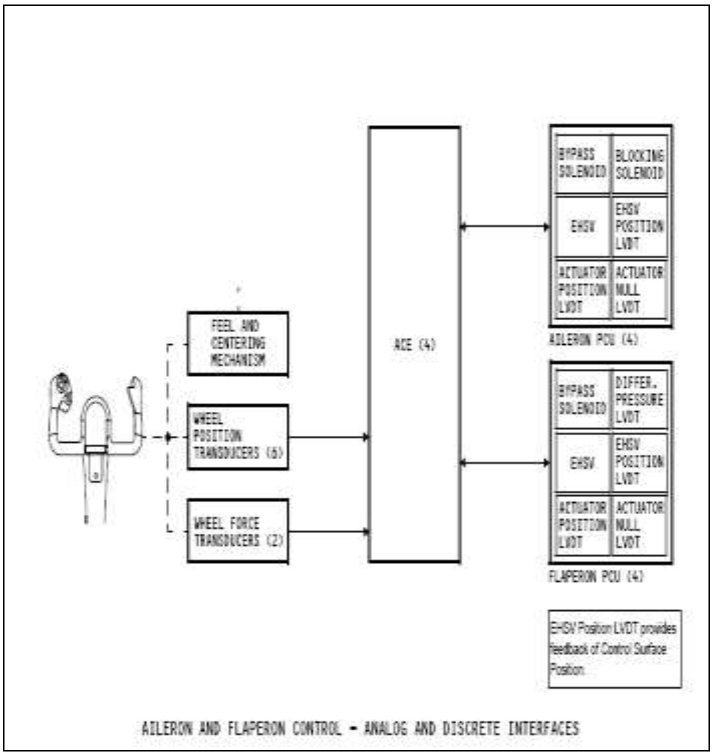

Figure-5 Aileron and Flaperon Control

4.3. Aileron PCU Function

It operates in three different Modes
(1) Normal Mode
(2) Bypass Mode
(3) Blocking / Damped Mode

4.3.1. PCU Operational Matrix:-

SOLENOID CONDITIONS	PCU MODES OF OPERATION		
	NORMAL	BYPASS	BLOCKING/ DAMPED
BYPASS SOLENOID	E	D	D
BLOCKING SOLENOID	E/D	E	D
LEGEND: E = ENERGIZED D = DE-ENERGIZED			

Table-1 PCU Operational Matrix (Aileron)

4.4.1. PCU Operational Matrix

VALVE CONDITIONS	PCU MODES OF OPERATION	
	NORMAL	BYPASS
BYPASS SOLENOID	E	D
LEGEND: E = ENERGIZED D = DE-ENERGIZED		

Table-2 PCU Operational Matrix (Flaperon)

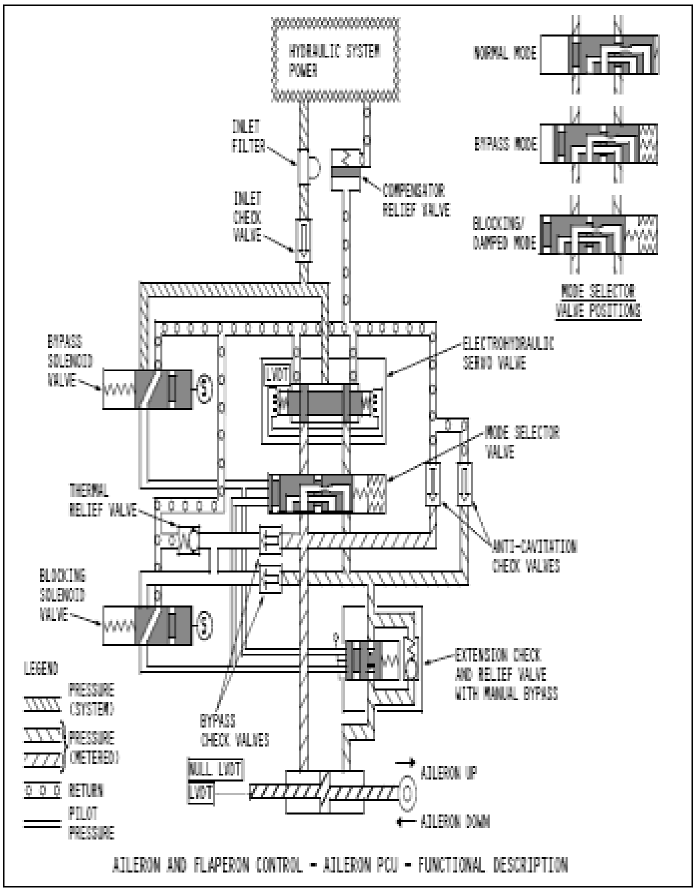

Figure-6 Aileron PCU Functional Description

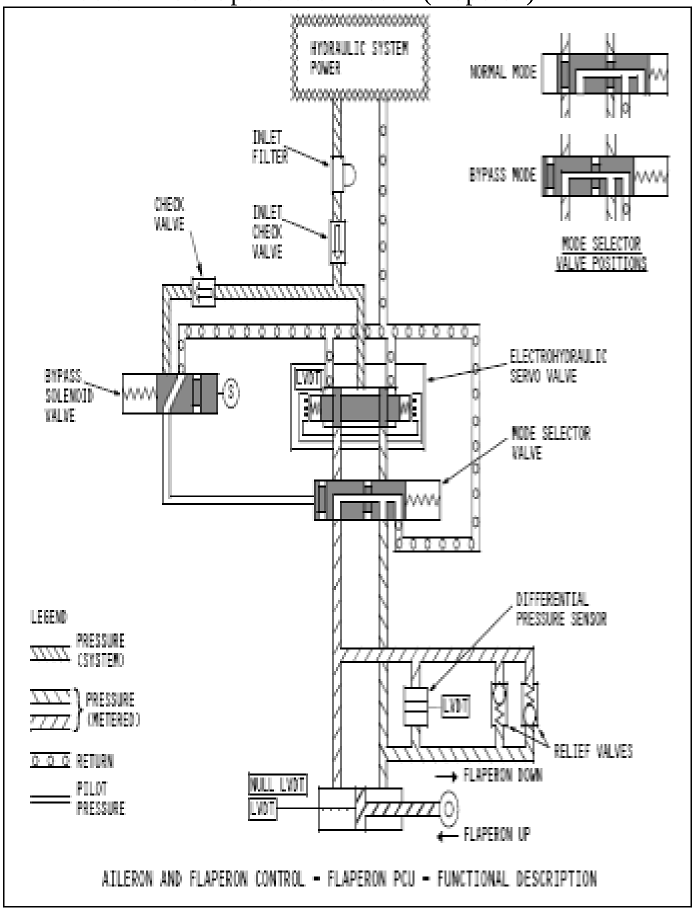

Figure-7 Flaperon PCU Functional Description

4.4. Flaperon PCU Function

It operates in two different modes:

(1) Normal Mode
(2) Bypass Mode

V. Rudder Control

Rudder is controlled by Rudder Paddle

Figure-8 Rudder of Boeing-777

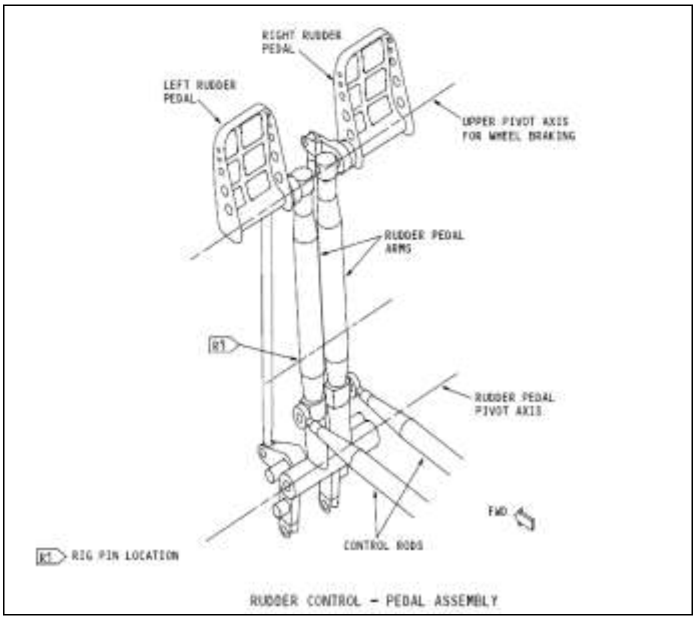

Figure-9 Rudder Control By Pedal Assembly

5.1. Rudder Pedal position Transducer

There are four transducer, Two for each Rudder Pedal Set, these transducers send analog signal to the ACEs.
These Analog signals are in proportion to the rudder pedal position and their movement.

5.2 Rudder Pedal force transducer

There are two transducer, one for each Rudder Pedal Set, these transducers send analog signal to the ACEs.
These Analog signal shows the quantity of force which pilots apply to the Rudder Pedals.

5.3 Rudder PCU Function

SOLENOID CONDITIONS	PCU MODES OF OPERATION		
	NORMAL	BYPASS	DAMPED
PRESSURE REDUCER SOLENOID	E/D	E/D	D
BYPASS SOLENOID	E	D	D
DAMPED SOLENOID	E/D	E	D
LEGEND: E = ENERGIZED D = DE-ENERGIZED			

Table-3 PCU Operational Matrix (Rudder)

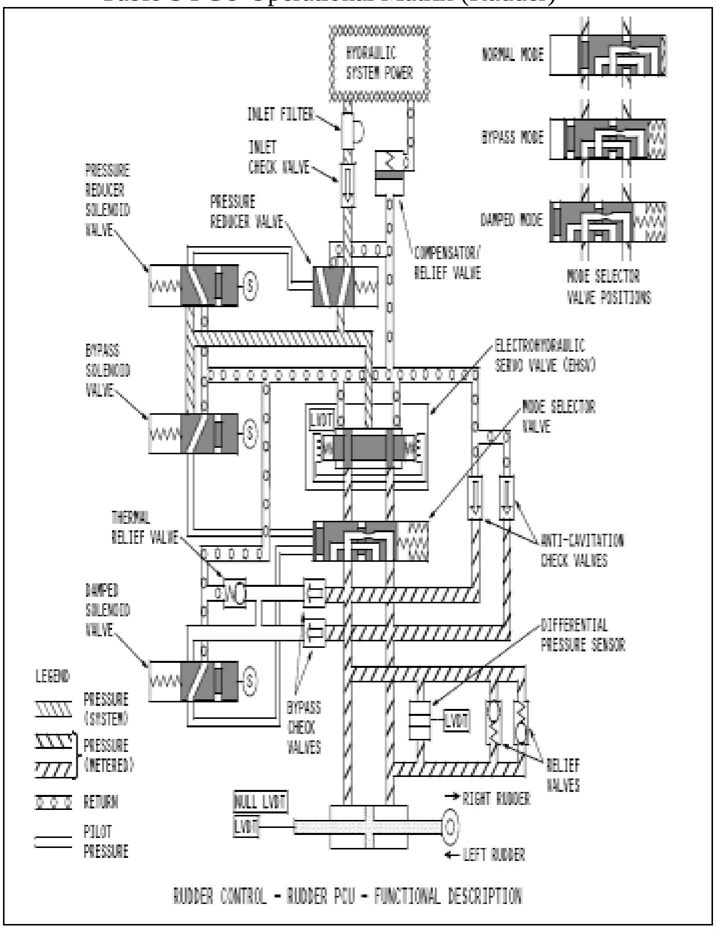

Figure-10 Rudder PCU Functional Description

VI. Elevator Control

Elevator is controlled by Control column.

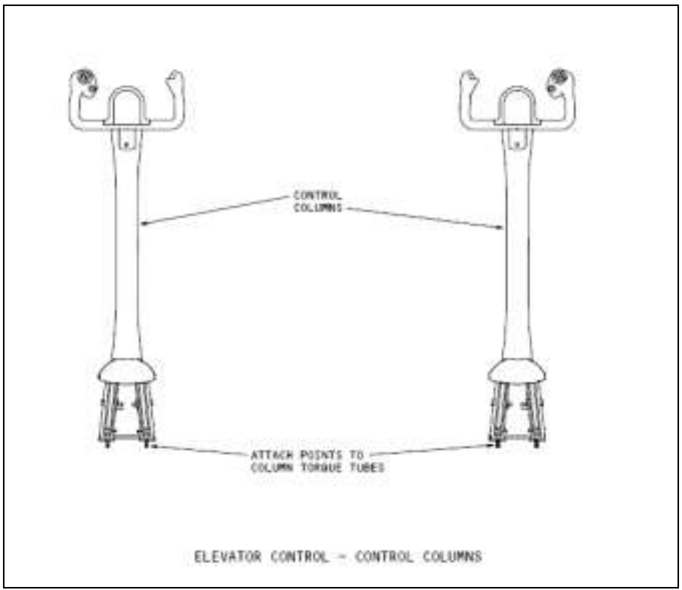

Figure-11 Elevator Control By Control Column

Figure- 12 Elevator of Boeing-777

6.1. Column position Transducer

There are six transducer, Three for each Control Column, these transducers send analog signal to the ACEs.
These Analog signals are in proportion to the Control Column position and their movement.

6.2. Column force transducer

There are four transducer, two for each Control Column, these transducers send analog signal to the ACEs.
These Analog signal shows the quantity of force which pilots apply to the Rudder Pedals.

4.3. Elevator PCU Function

The elevator PCU operates in three different Modes

(1) Normal Mode
(2) Bypass Mode
(3) Blocking Mode

4.4. PCU Operational Matrix:-

SOLENOID CONDITIONS	PCU MODES OF OPERATION		
	NORMAL	BYPASS	BLOCKING
BYPASS SOLENOID	E	D	D
BLOCKING SOLENOID COIL 1	E	E/D	D
BLOCKING SOLENOID COIL 2	E/D	E	D
PRESSURE REDUCER SOLENOID	E/D	E	D
LEGEND:	E = ENERGIZED	D = DE-ENERGIZED	

Table-4 PCU Operational Matrix (Elevator)

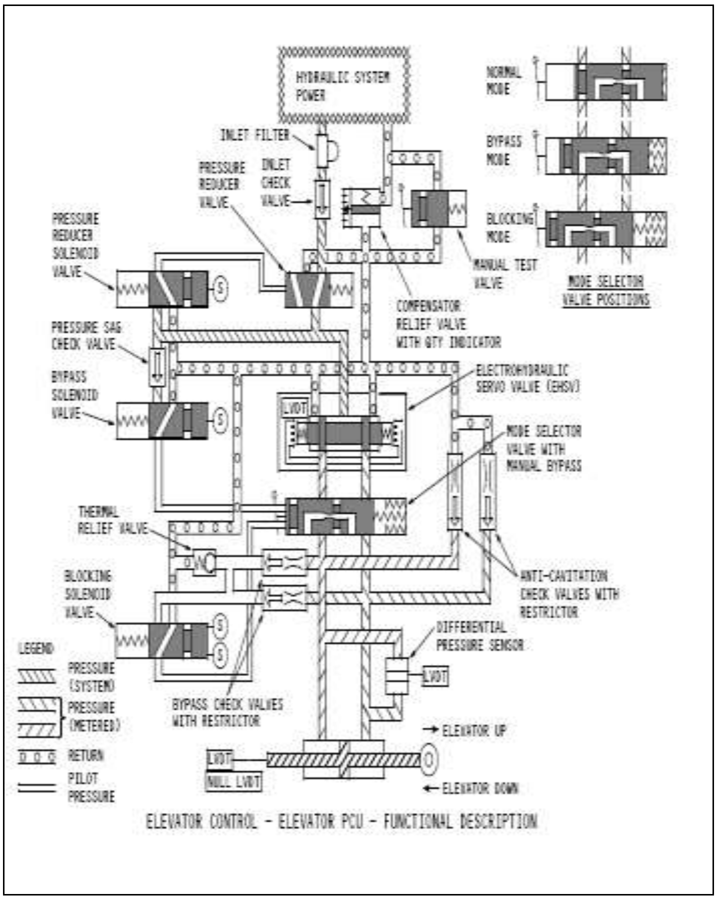

Figure-13 Elevator PCU Functional Description.

VII. Conclusion

A FBW system actually replaces manual control of an aircraft with electronic interfaces. The movement of flight controls are converted to electronic signals and flight control computer determine how to move the actuators at each control surface to provide the expected response.

ARINC-629 provides services to airlines, mainly operation of a private air-ground communications system called the Aeronautical Telecommunication Network (ATN).
and It generating avionics standards and research.

So By implementation of Fly-By-Wire System and ARINC-629 in Boeing-777, we can easily control the primary control surfaces like Aileron and Flaperon, Rudder and Elevator respectively by Control Wheel, rudder pedal and control column.

VIII. References

[1] Air India Taining Manual E-200.
[2] www.airindia.in
[3] www.boeing.com
[4] Tischler Mark B., (1996) Advances in Aircraft Flight Control, Taylor & Franc.
[5] Y.C. (Bob) Yeh, "Triple-Triple Redundant 777 Primary Flight Computer", Boeing Commercial Airplane Group, 1996 IEE.
[6] Raymond E.T.,(1993) Aircraft Flight Control Actuation System Design, Society Automotive Engineer.
[7] Ronald R.Hornish, "777 Autopilot Flight Director System", Collins Air Transport Division, 1994 IEE.
[8] Michael J.Gries, "System Engineering for the 777 Autopilot System", 14th Digital Avionics System Conference, September 1995
[9] Engin Uzuncaova, Miguel A. Ayal, "Boeing 777 Flight *Control System", CiteSeer*.