AIR DATA SYSTEM

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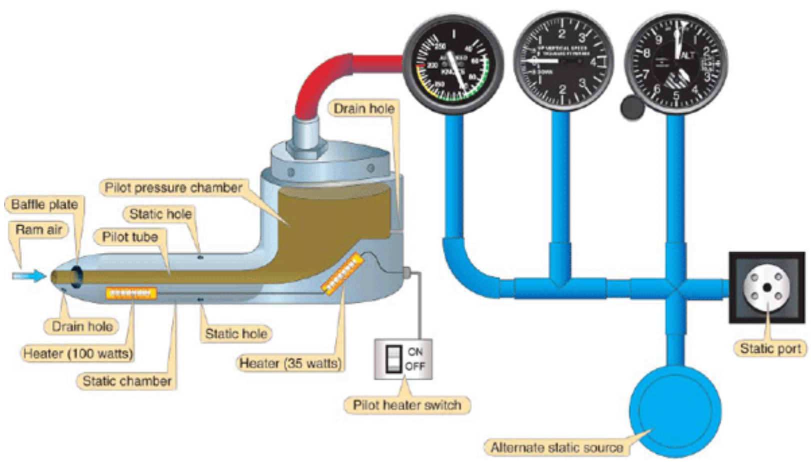
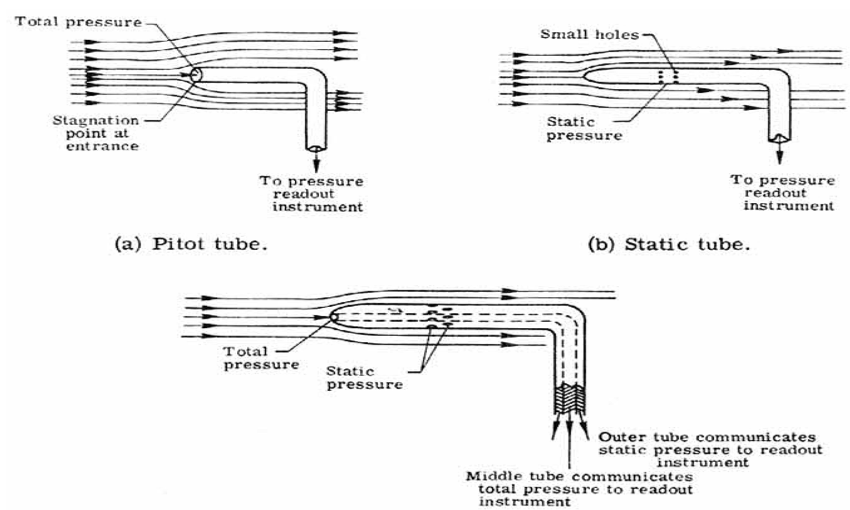
Our Adventure today

- Traditional Pitot tube
- Introduction to the Integrated Electronic Standby Instrument(IESI) and Air Data System(ADS)
- Architecture of ADS
- Modeling and Calculation of parameters
- Design of Air Data System

The Ancestor(Pitot tube)

- The Pitot tube compares the pressure outside an aircraft to the pressure inside it(static).
- Used to be a complete analog system.
- Modern aircrafts still use it with help of pressure transducer.





(a) Pitot tube. (b) Static tube. (c) Pitot-static tube.

The Physicist…

- Point I :Pressure =Ps(static), v1= random
- Point II :Pressure = Pt(total), v2= 0
- Point III :Pressure = Ps(static), v3=v1
- Dynamic pressure q=Pt-Ps

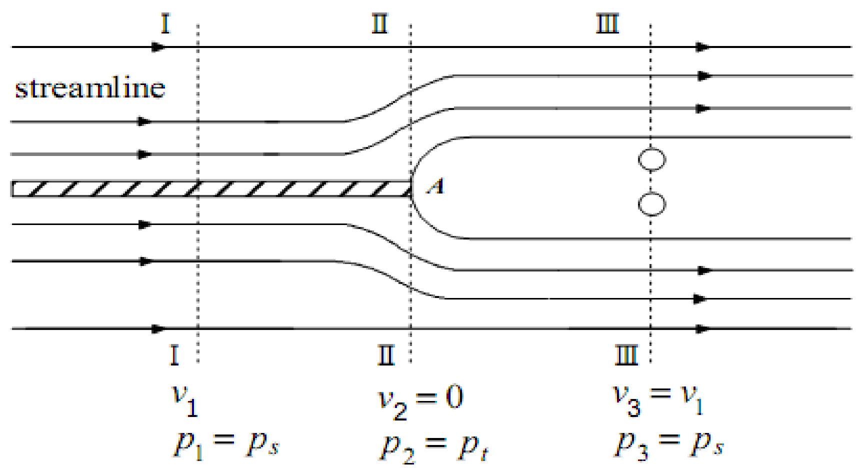


Figure 2. Cross-section of a Typical Pitot Static Tube

The digital trend…

- The ADS is currently used as a standby system.
- Measure Outside pressure and temperature and calculates Altitude, Airspeed and Mach number.
- Components:
  - Embedded Computer(686CORE)
  - Inertial Measurement Unit(IMU)
  - Two Pressure Sensors/Transducers
  - Temperature sensor
  - Digital Compass
  - Algorithms like Strapdown

  Inertial Navigation System(SINS)

Lets be an System Architect

- Has two precision pressure transducers(PPT), forming a Pressure Measurement Unit(PMU).
- A temperature module(Ti Module).
- Core Microprocessor(686CORE).
- An LCD display(AMLCD).
- Control Panel.

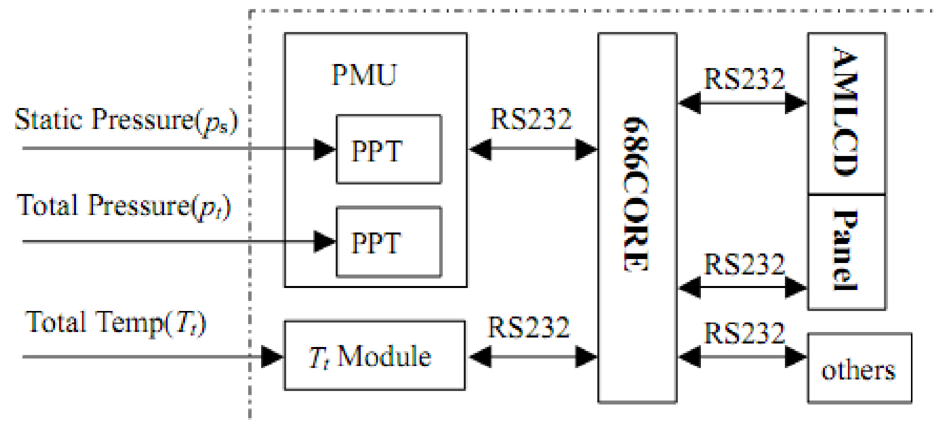
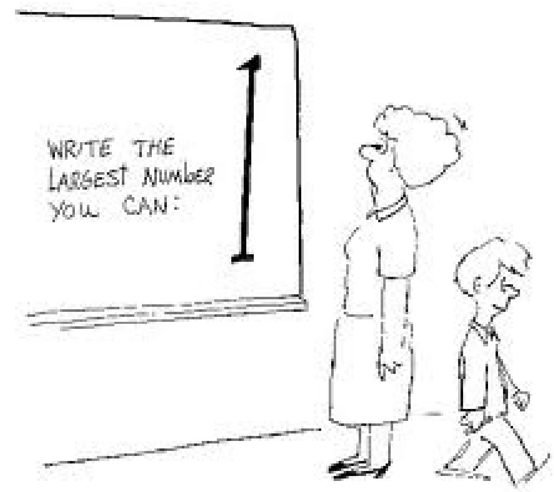


Figure 1. Architecture of the ADS

The Mathematician

- International Standard for Atmosphere(ISA) given by International Civil Aviation Organization(ICAO).
  - *Altitude Equation*
    - *Atmospheric pressure reduces with Altitude.*

$$\frac{dp}{p} = -\frac{g}{RT}dh \qquad (1)$$



Where,

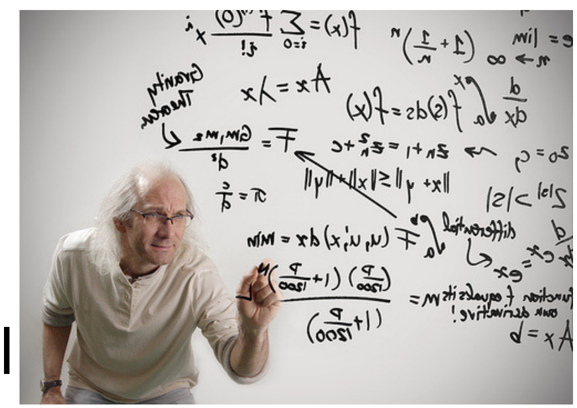
- P = Pressure at altitude h.
- g = Gravitational Constant(9.8 m/s^2).
- R = Universal gas Constant(287.3 J/kg).
- T = Air Temperature at Altitude h.

Still a Mathematician…

- ISA has several altitude regions in which air temperature is defined.
- Sea-level temperature 288.15K or 15 degree Celsius
- Varies linearly till 11km from sea level to 216.65K
- From 11km to 20km constant temperature of 216.65K

$$T_h = \begin{cases} T_0 - \beta_0 \bullet h & -2000m \le h \le 11000\ m \\ T_{11} & 11000\ m < h \le 20000\ m \end{cases} \qquad (2)$$

Where,
T_h= Temperature at altitude h.
T_0= Temperature at sea-level.
B_0=Temperature gradient = 0.0065
T_{11}=Temperature at 11km from sea-level



Some Fluid Mechanics?

Types of fluid flows

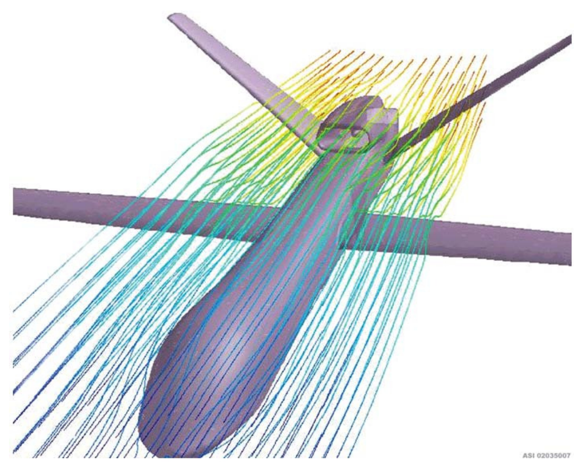
- Incompressible(v< 30% of sonic velocity)
- Subsonic Compressible(30% sonic velocity>v<sonic velocity)
- Supersonic(v>Sonic velocity)
- Fluid speed given as Mach numbers

$$M = \frac{v}{c}$$

Where,

- M= Mach number
- v= Velocity of the fluid
- c = Velocity of sound

(4)

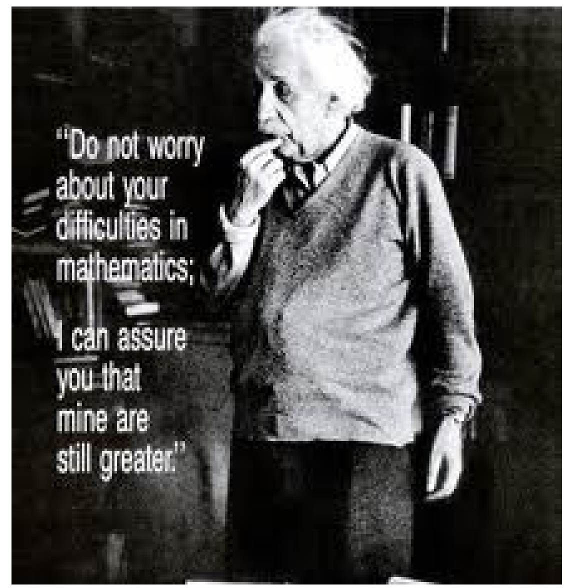


Being a Mathematician is not easy..

- Perfect Gas Equation
  - Relates pressure, temperature and Density of Fluid

$$\rho = \frac{p}{RT} \qquad (5)$$

Where,
ρ = Density of fluid
P = Pressure given by fluid
T =Temperature of fluid
R = Universal Gas Constant

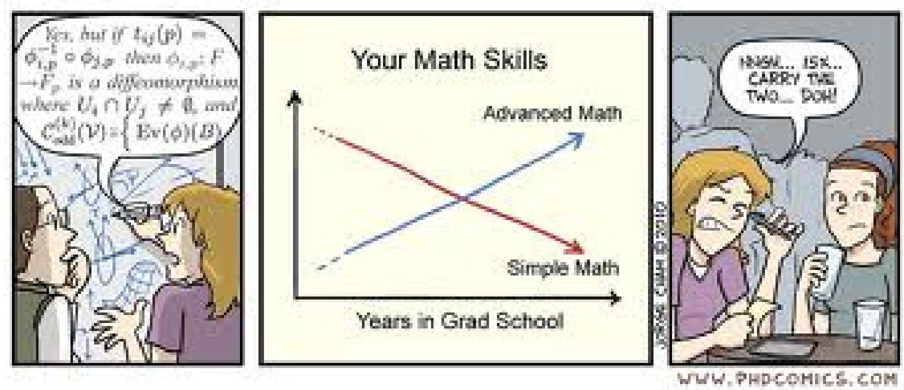


Maths! Maths! Maths!

- The speed of sound varies with altitude

$$c = \sqrt{k \frac{p_s}{\rho_s}} = \sqrt{kRT_s} \qquad (6)$$

$$v = M \cdot c = M \cdot \sqrt{kRT_s} \qquad (7)$$



Design time…

- Ring Network protocol used.
- RS-232 used for communication
- Master-Slave relation between CORE and PPT.
- Each module has its own ID.

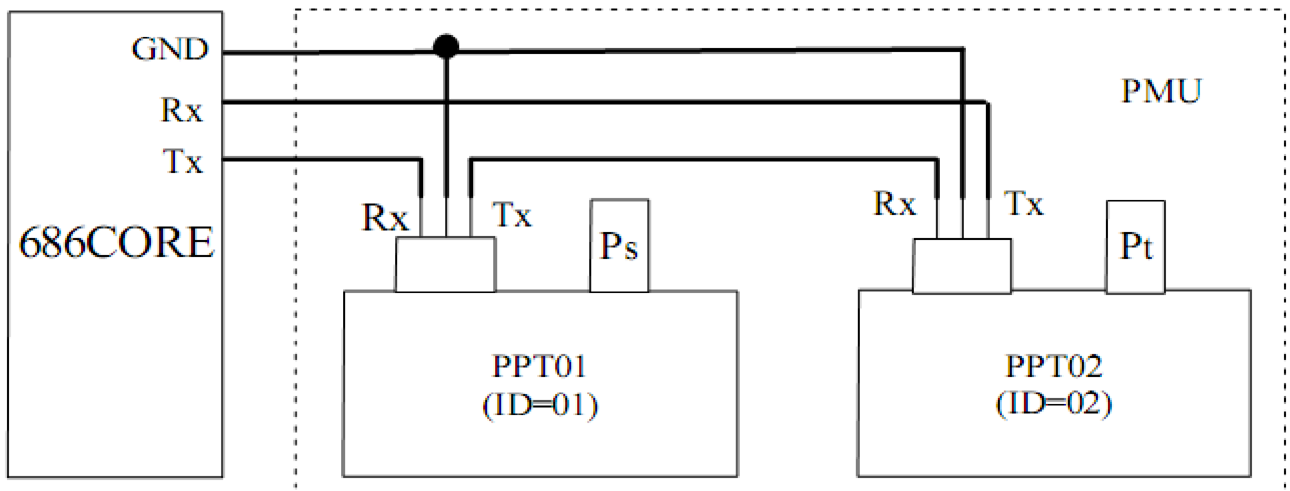


Figure 3. RS-232 PPT Ring Network

Algorithm

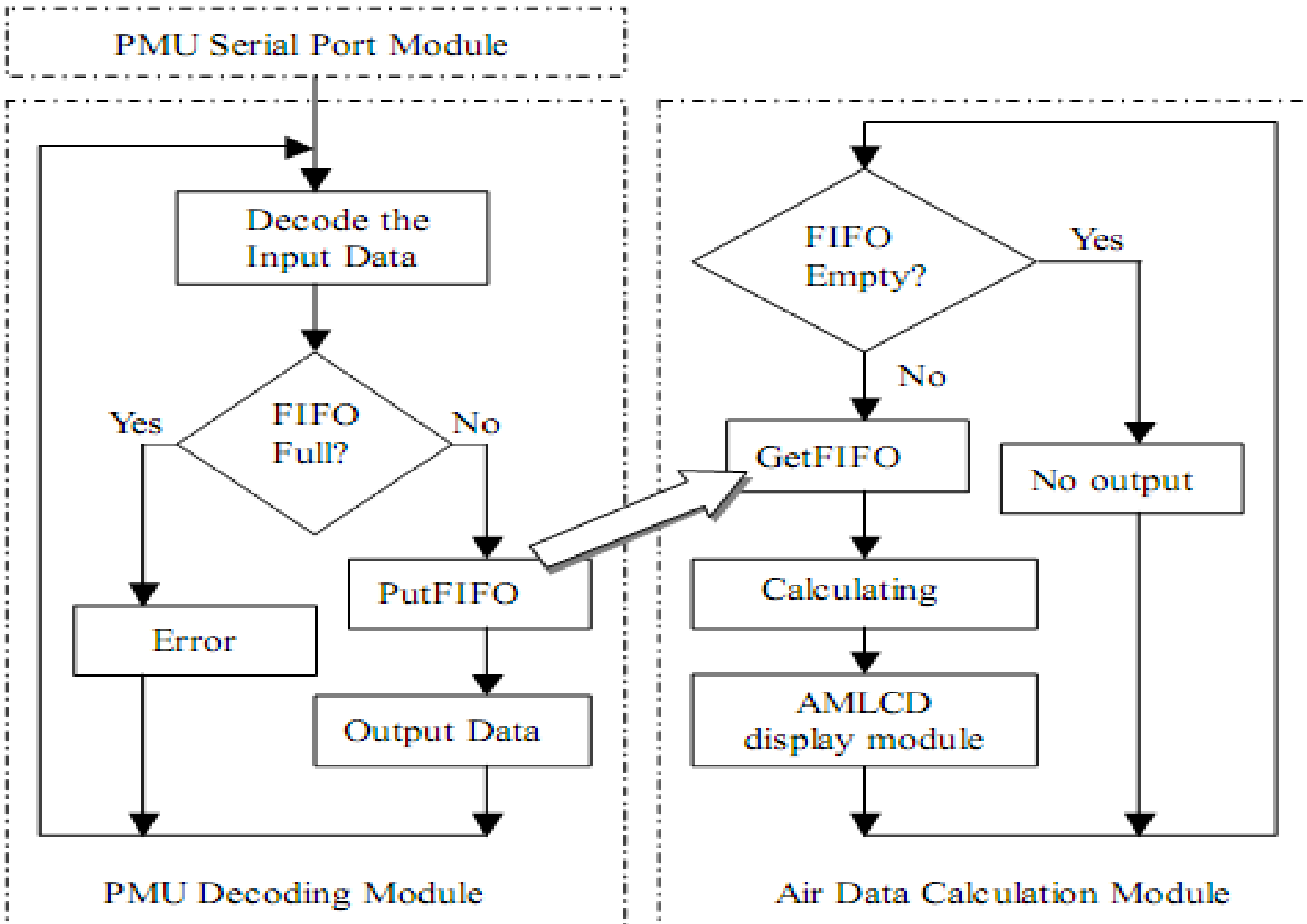


Figure 4. Application Software Modules of the ADS

Conclusion

- ADS makes flying more safer.
- It is reliable even to be made a primary system for Air Data Collection.
- The ADS includes Altimeter, Airspeed, Mach number and Temperature sensor all in one system.
- Avoid:

Q & A?