Thank You

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ACCELERATED THERMAL AGING

- This Simulates deterioration due to temperature exposure
- Instrument is kept at elevated temperature in a thermal chamber for time as decided by Arrrhenius equation
  - ✓ Ambient temperature is 45^0 C
  - ✓ Instrument Life is 10 years
  - ✓ Thermal Chamber Temperature kept at 85^0 C
  - ✓ Duration of Testing will be152 days

THERMAL CHAMBER

LOCA TEST CHAMBER

SEISMIC SHAKE TABLE

TEST FACILITIES AVAILABLE IN INDIA

- **RSD BARC**
  - ✓ Radiation Ageing, Thermal Ageing, LOCA test
- **R&D Centre, TAPS 3&4**
  - ✓ Radiation Aging, Thermal Ageing, LOCA test
- **ERDA Vadodara**
  - ✓ Thermal Ageing and LOCA test
- Test facility for LOCA and MSLB is being setup at IIT, Mumbai

Shake Table test facilities in India

- **ERDA, Baroda** : 150 Kg Uniaxial shaketable (0.6m x 0.6m)
- **ECIL, Hyderabad** : 100 Kg Uniaxial shaketable
  - ✓ (0.7m x 0.7m), 35 cm stroke length
- **SERC, Chennai** : 30 T Triaxial shaketable
  - ✓ (4m x 4m), 4 vertical & 4 hori. Actuators
- **CPRI, Bangalore** : 10 T Triaxial table
  - ✓ (3m x 3m), 4 ver & 4 hor actuators
- **IGCAR,** : 10 T Triaxial table
- **Kalpakkam** : (4m x 4m), 4 ver & 4 hor actuators
- **IIT Roorkee** : 20 T Biaxial shaketable
  - ✓ (3.5m x 3.5m), 2 ver & 1 hor actuator

OPERATING EXPERIENCES WITH PROGRAMMABLE LOGIC CONTROLLER (PLC) SYSTEM IN INDIAN NUCLEAR POWER PLANTS.

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OVERVIEW

- **INTRODUCTION**
- **PLC ARCHITECTURE**
- **CHALLENGES ASSOCIATED WITH PLCs**
  - ✓ **Performance**
  - ✓ **Obsolescence**
- **CONCLUSION**

INTRODUCTION

Systems in Indian NPPs are categorized based on their significance to nuclear safety.

- Safety Critical (Class IA)
- Safety Related(Class IB and IC)
- Not Important to Nuclear Safety (Class NINS)

PLCs are used in IB and NINS applications.

Usage of PLCs in NPPs

- Control of various process interlocks and control functions (Station-PLC)
- Control of Main and Emergency airlocks (Airlock PLC)
- Dryer control (Dryer PLC)
- Emergency transfer of load (EMTR PLC).

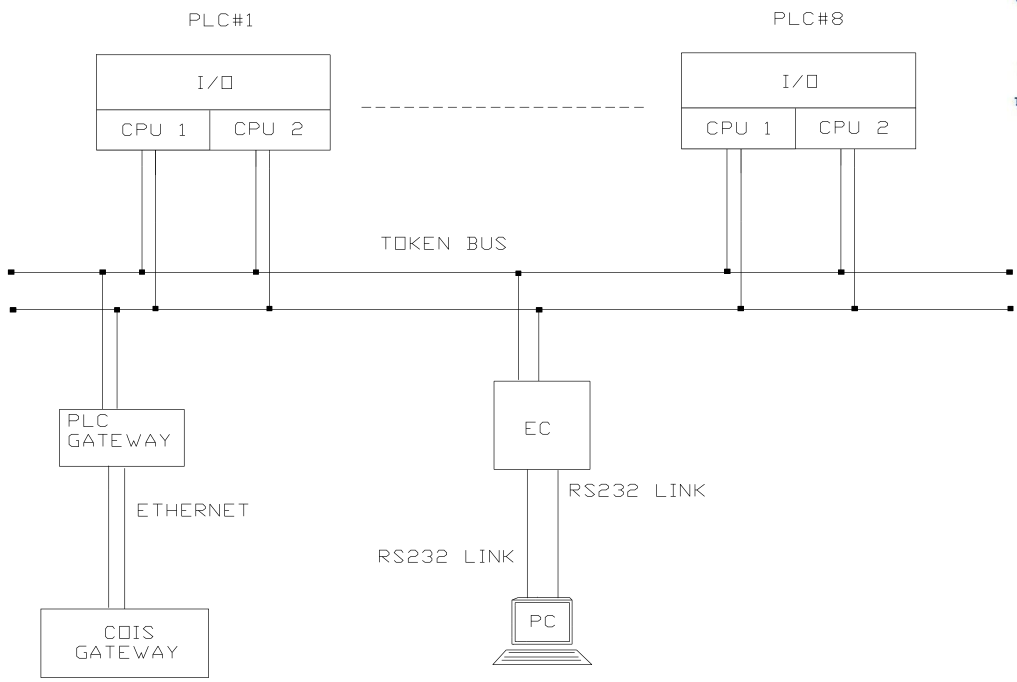
PLC ARCHITECTURE

Two kinds of architecture are employed in PLC implementation:-

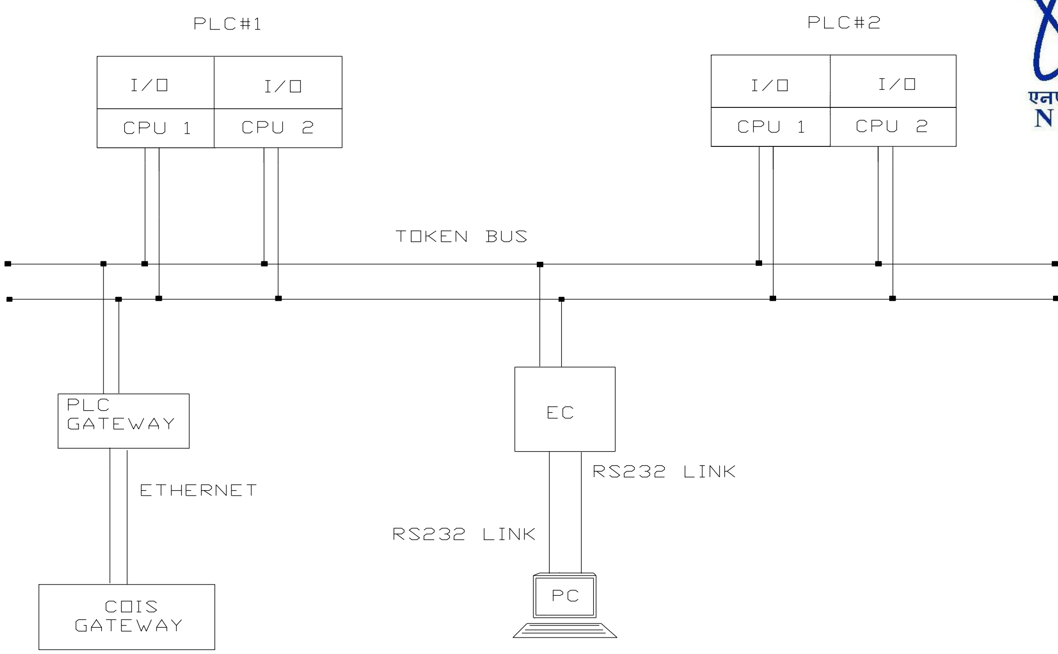
- Dual processor hot standby where each PLC has two redundant processors with common I/Os

- Dual computer hot standby where each PLC has single processor but one PLC is standby to other

A number of such PLCs are connected through dual redundant token bus networks, and exchange data and information necessary for generation of outputs. In each network an engineering work station serves as an operator interface.



PLC ARCHITECTURE WITH COMMON I/O AND REDUNDANT PROCESSORS



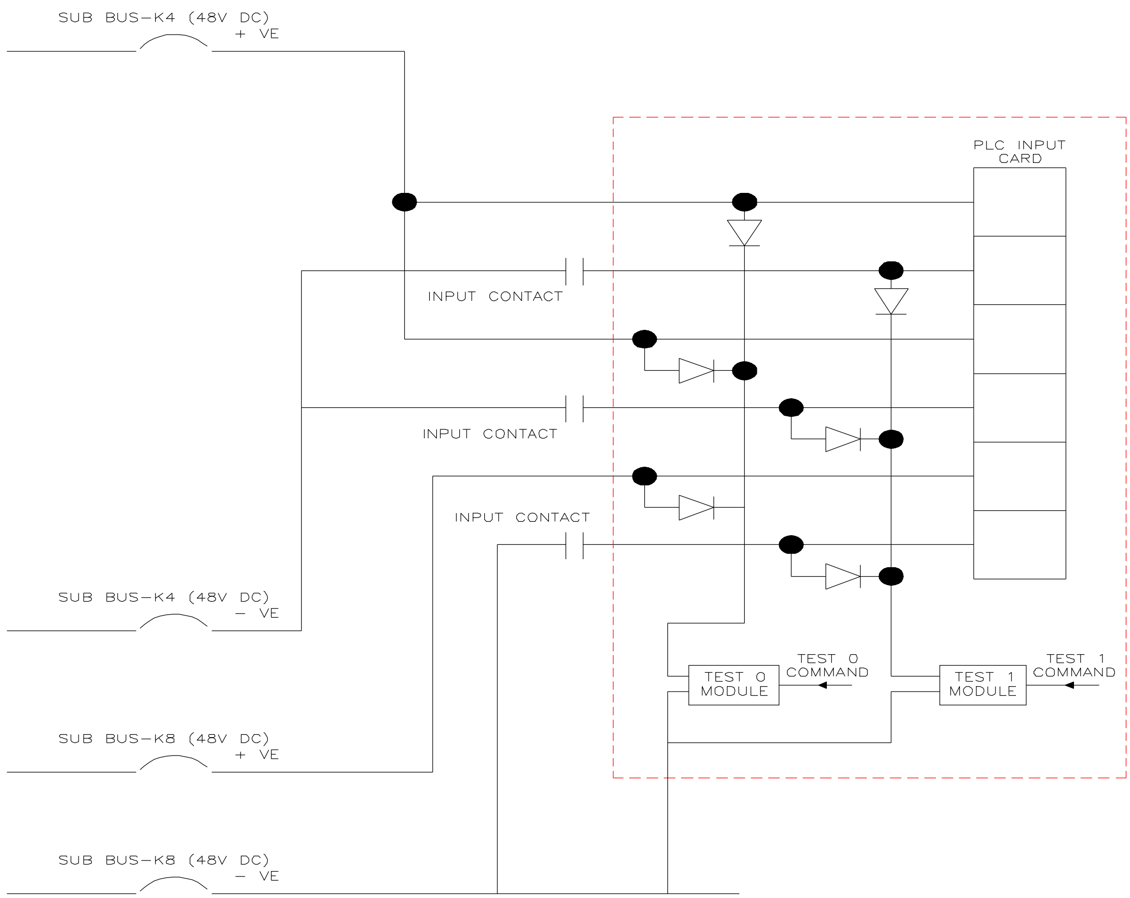
PLC ARCHITECTURE WITH REDUNDANT I/O AND REDUNDANT PLCs

CHALLENGES ASSOCIATED WITH PLCs:

I) PERFORMANCE

a) **Spurious ground fault indication in 48 V DC control power supply**

This was attributed to high off-state current of FIT (Finite Impulse Test) modules. It has been addressed by using low off state current FIT modules having low leakage current, by reducing FIT frequency and by providing dedicated built-in field input interrogation power supply.



SIMPLIFIED ARRANGEMENT IN FIELD INPUT CARD

(b) **PLCs going Out of network**

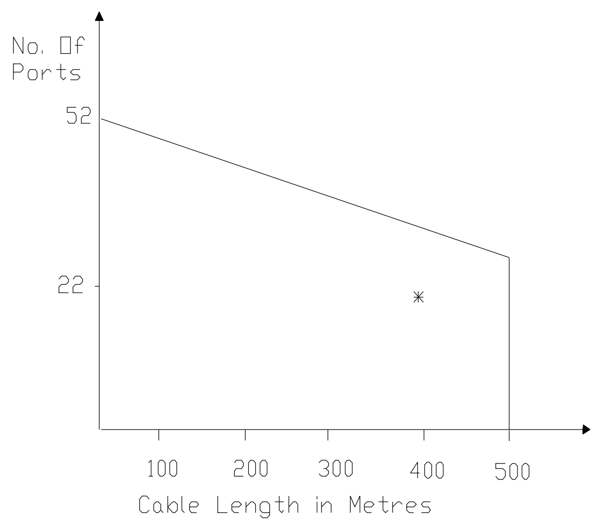
- observed in all the plants
- impact was significant in NPPs where LAN was also used for sharing control signals among the PLC nodes (i.e. information required for generating outputs used in controlling various equipments)
- resulting into process disturbances.

The problem was attributed to:

- Longer length of LAN cable
- Weak signal strength
- Improper Grounding of LAN cable shields

In initial NPPs

- No. of nodes on LAN is 22 and the length of LAN cable was around 400 meters.
- Stretching and bending of cable in cable trays and improper grounding of the cable shield,
- The minimum signal strength (10dBmV min.) at the receiving node was not available.



RELATION BETWEEN ON OF NODES AND CABLE LENGTH

Modifications:

- LAN network is split into number of smaller networks.
- Maintaining the bending radius of trunk cable > 7 inches
- Laying of LAN cable in metallic conduit
- Multipoint grounding of LAN cable as per IEEE-1050.
- Validation of LAN

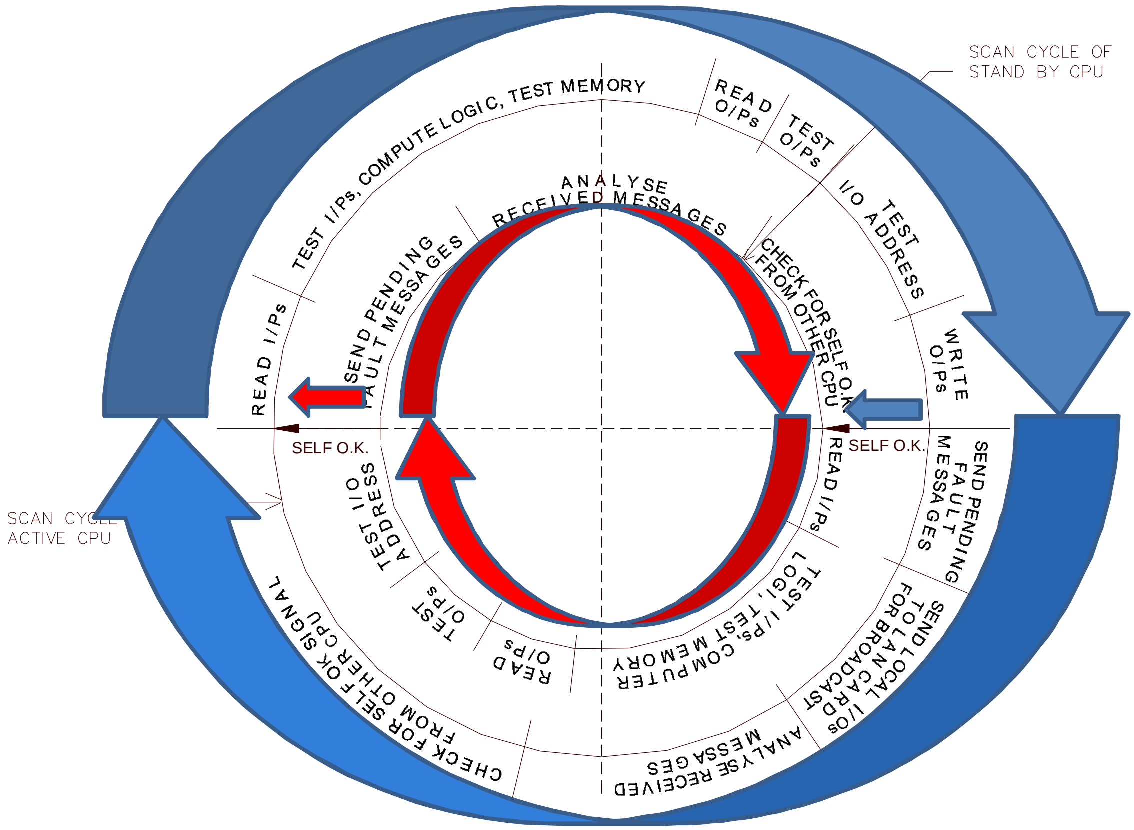
To avoid the disturbance on loads due to communication failure, the use of LAN is restricted to information function only.

After carrying out the above modifications, the LAN parameters were measured and results are summarized.

LAN Parameters		Before modification	After modification & with multipoint grounding
Signal attenuation		36.13 dB	4.98 dB
Noise	Peak	+4 dBmV	-10 dBmV
	Average	-19 dBmV	-20 dBmV
Return Loss		-30.01 dB	-31.82 dB

(c) **Halting of CPU**

- One CPU halting in dual processor hot standby PLC configuration.
- The problem attributed to loss of synchronization between two running CPUs.
- Loss of synchronization between the running CPUs occurred due to elongation of cycle time of PLC. Because of this, each CPU considered other CPU faulty and tried to acquire the bus leading to bus contention and subsequent halting of one CPU.



SCAN CYCLE OF A CPU

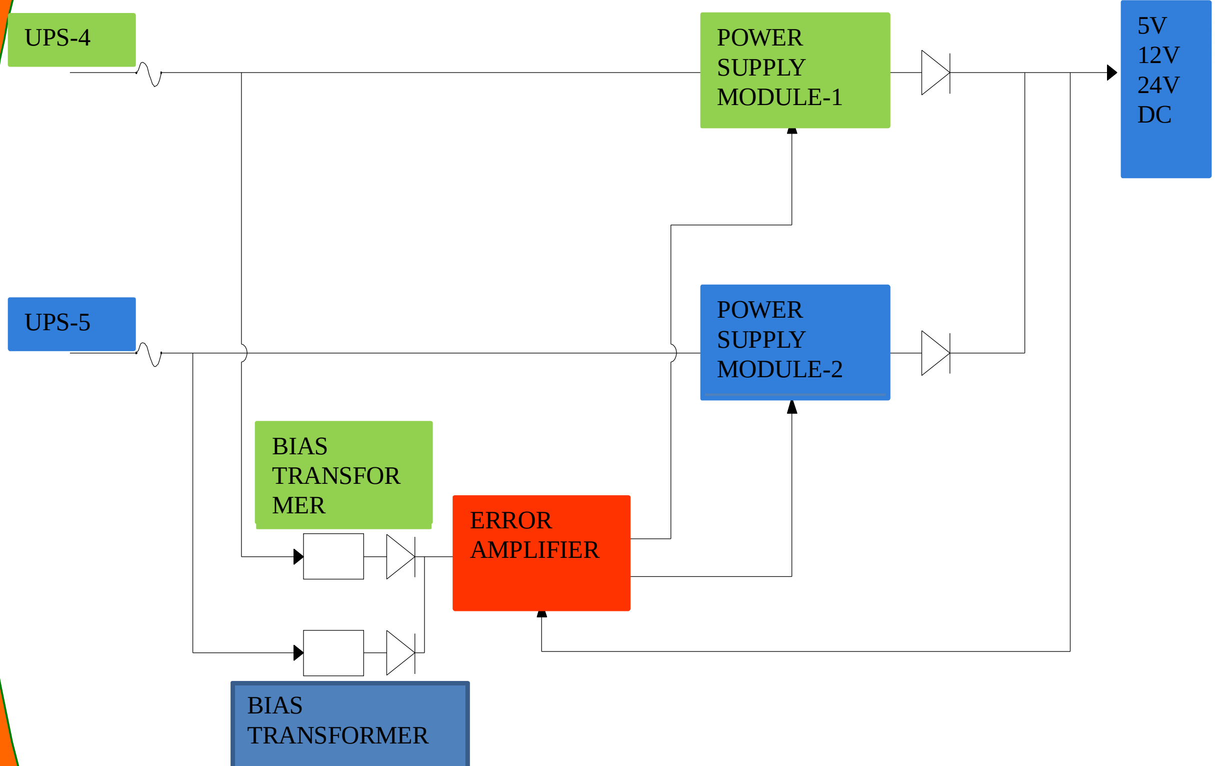
Modification:

To address the CPU halting problem, PLC software is modified to implement the fixed period of execution for the scan task so that the communication task can be kept at lower priority.

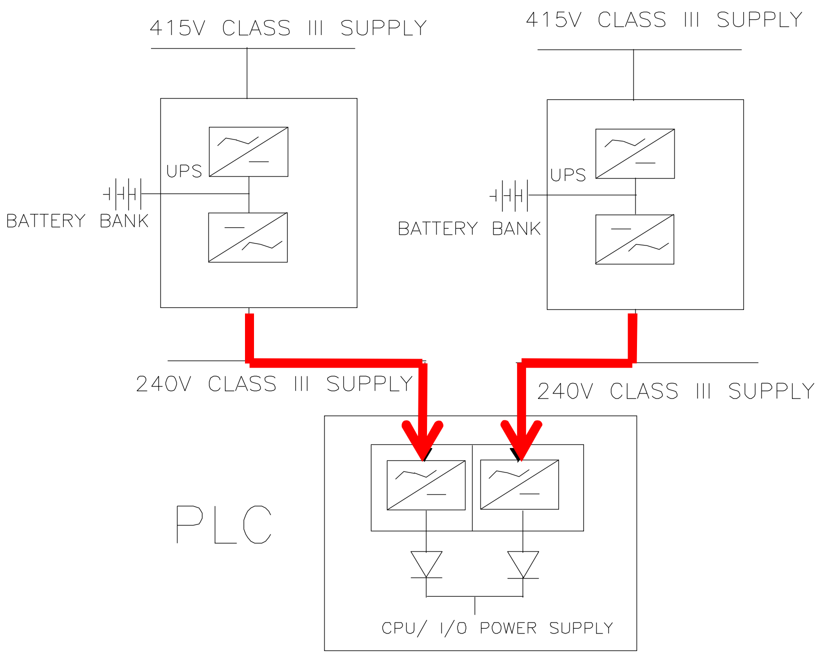
d) Power Supplies of PLC

In the previous design of power supply, common circuit was present for paralleled power supply modules & there was failure in the common circuit.

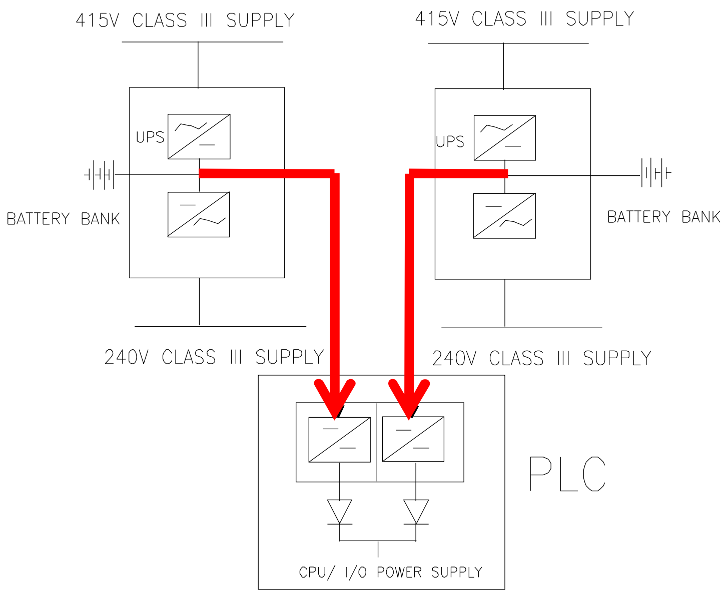
In the new design power supplies are made fully independent without any common circuit.



POWER SUPPLY SCHEME EMPLOYED IN PLC SYSTEM



PLC POWER SUPPLY SCHEME (OLD)



MODIFIED PLC POWER SUPPLY SCHEME

Modifications:

•DC to DC SMPS is used in place of AC to DC SMPS

•

•Independent error amplifier is used to ensure current sharing.

•Source power supply to DC to DC SMPS is taken from intermediate DC bus of UPS which has a battery back-up.

Failure of any UPS will not lead to unavailability source power supply to DC to DC SMPS.

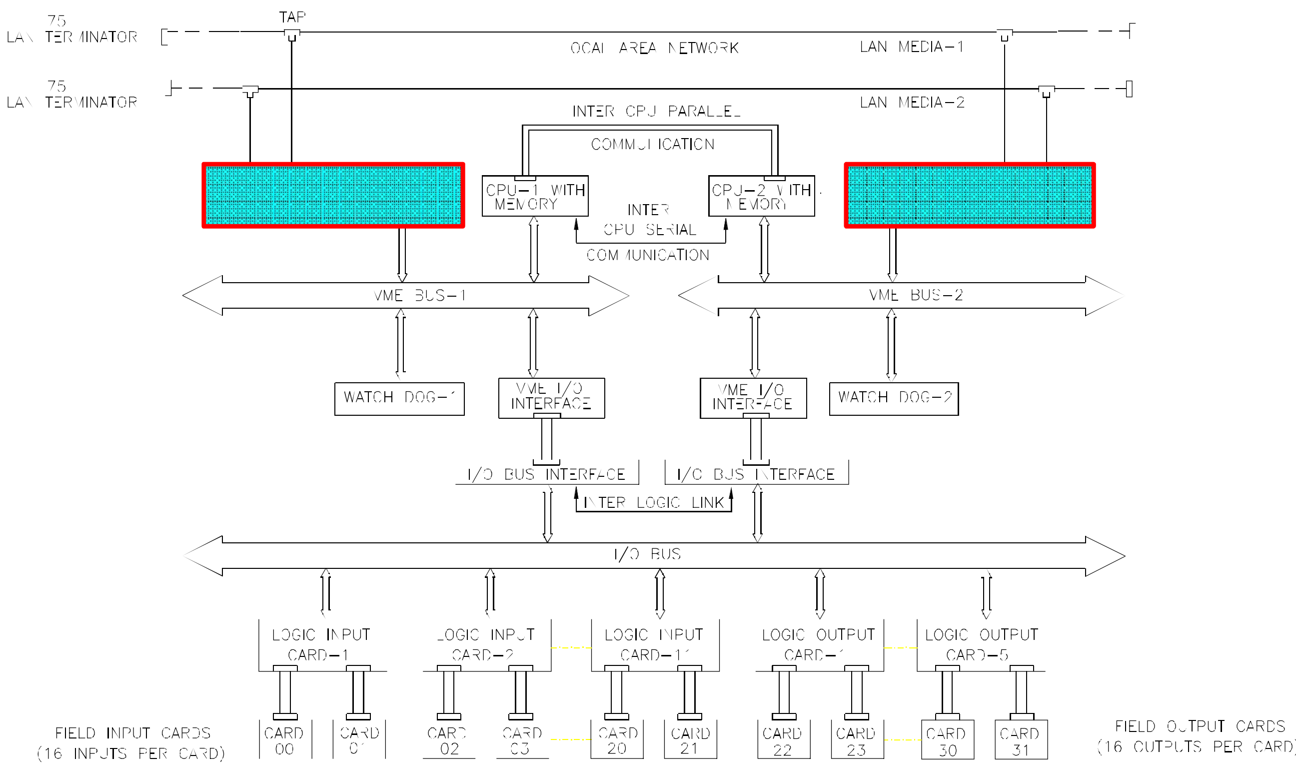
II) OBSOLESCENCE

Hardware for following boards not available.

- TBC VME
- TBC MODEM

} Used in Token Bus

To overcome obsolescence design modification is carried out to replace token bus with dual Ethernet LAN. This Ethernet LAN is retrofitted in EMTR PLC and Airlock PLCs. Based on this performance, the implementation of Ethernet network is being considered for other PLCs also.



A TYPICAL PLC IN NPPs

CONCLUSION

- PLC system is running satisfactorily after carrying out all the above modifications in the existing operating NPPs.

- Up-gradation of Token Bus with Ethernet is taken up to address obsolescence.

Thank You

System Reliability and Updation

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Presented by: Lalit Kumar Singh

Abstract

- Reliability Modeling of system based on Bayesian Network
- Limitations of traditional reliability analysis
- Fault Tree Diagram -> Bayesian network
- Advantages
- Impact of change of subsystem reliability change on other subsystems/system
- Emergency Core Cooling System

Introduction

- Traditional techniques assumption:

-all the failures are independent and the rate of failure is constant (using BN it is possible to include local independencies into the model, by directly specifying the causes that influences a given effect)

-due to the approximations in the computational model and the limited statistical data on the input variables, there may be uncertainty in this computation

Introduction contd…

- -BN has power of predictive (fwd) and diagnostic (bwd)analysis; fwd: P(occ. of any node is cal on basis of prior P of root nodes) & conditional dependence on each node. Bwd: concerns the comp. Of posterier P of any given set of variables given some observtn

- Work on system safety and Bayesian Networks were developed by Kang & Venkatesk [1]

- In the paper [3] the authors describe the stochastic modelling techniques such as Fault Trees and Petri Net

Introduction contd…

- Bayesian networks have been applied mostly in the field of Artificial intelligence and now have gain popularity in the field of engineering decision strategy [8]

- It has not been used in the reliability analysis of Nuclear Power Plant structures

Bayesian networks

- acyclic graph that represents a joint probability distribution over a set of random variables V
- The network is defined by a pair $B = (G, \theta)$

-G is the DAG whose nodes $X_1, X_2, \ldots, X_n$ represents random variables; edges represent direct dependencies between these variables.

- θ : set of parameters of the network. Set contains parameter $\theta_{x_i|\pi_i} = P_B(x_i|\pi_i)$ for each x_i of X_i conditioned on π_i , the set of parents of X_i in G.
- B defines unique joint probability distribution over V

$$P_B(X) = P_B(X_1, X_2, \ldots, X_n) = \prod_{i=1}^{n} P_B(X_i|\pi_i)$$

$$= \prod_{i=1}^{n} \theta_{x_i|\pi_i} \ldots\ldots\ldots\ldots\ldots (1)$$

Bayesian networks contd…

- The marginal probability of X_i is:

$$P(X_i) = \sum_{X \in X_i} P(X) \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

- Assuming an event E has occurred, we have:

$$P(X|E) = \frac{P(X,E)}{P(E)} = \frac{P(X,E)}{\sum_X P(X,E)} \ldots\ldots\ldots\ldots\ldots (3)$$

Bayesian networks contd…

- So, the joint probability of the Bayesian network, given in Figure2 is:

$$P(X) = P(H)P(I)P(F)P(E|H,I,F)P(D)P(B|D,E) \times P(G)P(C|F,G)P(A|B,C) \quad (4)$$

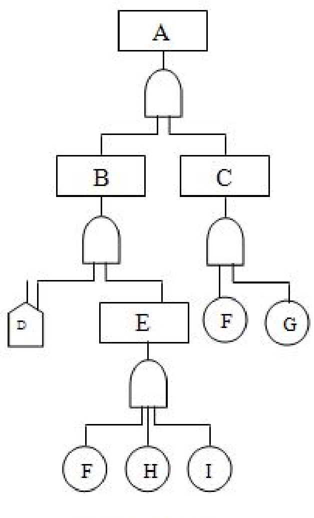

Figure1. Fault Tree

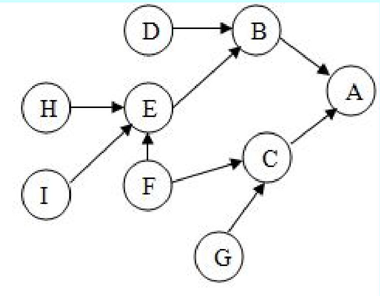

Figure2. Bayesian Network of Figure1

Bayesian networks contd…

- The subsystem failure probability is:

$$P(A=1) = \sum_{A=0}^{1}\sum_{B=0}^{1}\cdots\sum_{I=0}^{1} \begin{array}{l} P(H)P(I)P(F)P(E|H,I,F)P(D)P(B|D,E) \\ \times P(G)P(C|F,G)P(A=1|B,C) \end{array} \ldots\ldots\ldots\ldots\ldots(5)$$

- Hence in case of subsystem failure , marginal probability of all the nodes in the network can be updated as:

$$P(X|A=1) = \frac{P(X, A=1)}{P(A=1)} \ldots\ldots\ldots\ldots..(6)$$

Emergency Core Cooling System

Series system

- A & B : 2 basic events

A	B
Pump1	Pump2

Table1. Basic events for ECCS status

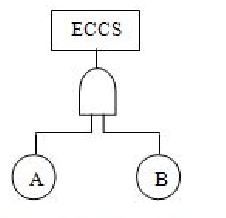

Figure3. Fault Tree of ECCS

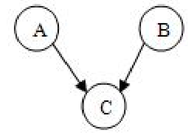

Figure4. BN of figure3

- Here C is ECCS. Fig4 infers that A & B are independent

A	B	P(C=1| A, B)
0	0	0
0	1	1
1	0	1
1	1	1

Table1. Probability of C failure given A & B in case of series system

- The dependence could be the statistical correlation between the states of A and B due to the common random variables in their limit states.

Emergency Core Cooling System

- Hence $P(AB) \neq P(A)P(B) \ldots\ldots\ldots\ldots\ldots\ldots..(7)$
- Let $P(X=1) = P(X)$
  $P(X=0) = P(\bar{X})$.

$$P(C) = 1 \times P(A)P(B) + 1 \times P(A)P(\bar{B}) + 1 \times P(\bar{A})P(B) + 0 \times P(\bar{A})P(\bar{B})$$

$$= P(A) + P(B)[1 - P(A)]$$

$$= P(A) + P(B) - P(A)P(B) \ldots\ldots\ldots\ldots\ldots\ldots(8)$$

- We make 2 modifications:

i. consider all the input random variables as root nodes. Eg. S_i - strength of node i; ω - applied load

- failure probability $P(i) = f(S_i, \omega) \ldots\ldots\ldots\ldots\ldots\ldots\ldots..(9)$

Emergency Core Cooling System

- Then we construct BN in case of correlated and uncorrelated variables as:

Then we construct BN in case of correlated and uncorrelated variables as shown in Figure5(a) and 5(b) respectively.

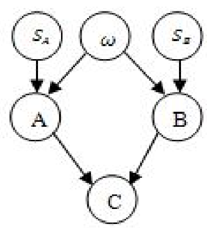

Figure5a.Modified BN (not correlated variables)

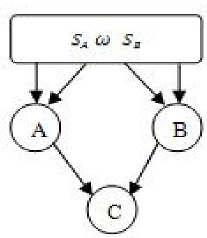

Figure5b. Modified BN (correlated variables)

Emergency Core Cooling System

- BN does not allow cycles but still can be created like figure5, by incorporating additional information on sequential failure probabilities as shown in Table2.

- Parallel Systems

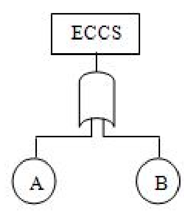

Figure6. Fault Tree of ECCS

A	B	P(C=1| A, B)
0	0	0
0	1	P(A_B = 1|B=1, A=0)
1	0	P(B_A = 1|A=1, B=0)
1	1	1

Table2. Probability of C failure given A & B in case of parallel system

A_B : updated state of A after B fails

B_A : updated state of B after A fails

Emergency Core Cooling System

- Example $P(C=1|A=1, B=0) = P(B_A = 1|A=1, B=0)$ means that the probability that C=1 will occur given A fails "first" is equal to B's failure probability given A fails "first", since C=1 is defined when both A & B fail.
- Through this construction of the conditional probability table for P(C=1|A,B), the problem of multiple failure sequences and the effect of failure of 1 pump on another can be solved in BN
- Hence, this approach allows modeling both types of dependence: statistical and sequential

Emergency Core Cooling System

- So, the probability of ECCS function failure for series system (Fig3), using eq (1) & (2) is given as:

$$P(C=1) = \sum_{A=0}^{1}\sum_{B=0}^{1}\int_{s_A}^{\square}\int_{s_B}^{\square}\int_{\omega}^{\square} P(C=1|A,B)P(A|s_A,\omega)\ P(B|s_B,\omega)\,f(s_A)f(s_B)f(\omega)\,ds_A ds_B d\omega \ldots\ldots\ldots(10)$$

- If these random variables are correlated, $f(s_A)f(s_B)f(\omega)$ needs to be replaced by their joint pdf.
- For clarification if suppose in case of series system, each node A and B takes half load, then following conditional probabilities can be used in equation:

$$P\left(A=1\middle|s_A\le\frac{\omega}{2}\right)=1,$$
$$P\left(A=0\middle|s_A\ge\frac{\omega}{2}\right)=1$$

And

$$P\left(B=1\middle|s_B\le\frac{\omega}{2}\right)=1,$$
$$P\left(B=0\middle|s_B\ge\frac{\omega}{2}\right)=1$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(11)$$

Emergency Core Cooling System

- The equation 10 can be solved using multi-normal integration or Monte Carlo simulation without complete numerical integration
- Similarly in case of parallel system when one Pump A fails, other pump B can take the full load. We need to consider A_B and B_A

$$A_B = 1 \Rightarrow s_A \leq \omega$$

$$B_A = 1 \Rightarrow s_B \leq \omega \quad \ldots\ldots\ldots\ldots\ldots\ldots (12)$$

Emergency Core Cooling System

- So

$$P(C=1) = P(C=1|A=1,B=1)P(A=1,B=1) + P(C=1|A=0,B=1)P(A=0,B=1) + P(C=1|A=1,B=0) \times P(A=1,B=0) + P(C=1|A=0,B=0)P(A=0,B=0)$$

$$= P\left(s_A \le \frac{\omega}{2} \cap s_B \le \frac{\omega}{2}\right) + P\left(s_A \le \omega \middle| s_A \ge \frac{\omega}{2} \cap s_B \le \frac{\omega}{2}\right) \times P\left(s_A \ge \frac{\omega}{2} \cap s_B \le \frac{\omega}{2}\right) + P\left(s_B \le \omega \middle| s_A \le \frac{\omega}{2} \cap s_B \ge \frac{\omega}{2}\right) \times P\left(s_A \le \frac{\omega}{2} \cap s_B \ge \frac{\omega}{2}\right)$$

$$= P\left(s_A \le \frac{\omega}{2} \cap s_B \le \frac{\omega}{2}\right) + P\left(s_A \le \omega \cap s_A \ge \frac{\omega}{2} \cap s_B \le \frac{\omega}{2}\right) + P\left(s_B \le \omega \cap s_A \le \frac{\omega}{2} \cap s_B \ge \frac{\omega}{2}\right) \quad \text{......(13)}$$

- Failure probability using Fault Tree approach is given by considering the same failure sequence:

$$A \to B \equiv s_A \le \frac{\omega}{2} \cap s_B \le \omega$$

$$B \to A \equiv s_B \le \frac{\omega}{2} \cap s_A \le \omega$$

- Hence

$$P(C=1) = P(A \to B) \cup P(B \to A)$$

$$= P\left[\left(s_A \le \frac{\omega}{2} \cap s_B \le \omega\right) \cup \left(s_B \le \frac{\omega}{2} \cap s_A \le \omega\right)\right]$$

$$= P\left[\left(s_A \le \frac{\omega}{2} \cap \left(s_B \le \frac{\omega}{2} \cup \left(\frac{\omega}{2} \le s_B \cap s_B \le \omega\right)\right)\right) \cup \left(s_B \le \frac{\omega}{2} \cap \left(s_A \le \frac{\omega}{2} \cup \left(\frac{\omega}{2} \le s_A \cap s_A \le \omega\right)\right)\right)\right]$$

Emergency Core Cooling System

$$= P\left[\left(s_A \le \frac{\omega}{2} \cap s_B \le \frac{\omega}{2}\right) \cup \left(s_A \le \frac{\omega}{2} \cap \frac{\omega}{2} \le s_B \cap s_B \le \omega\right) \cup \left(s_B \le \frac{\omega}{2} \cap \frac{\omega}{2} \le s_A \cap s_A \le \omega\right)\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots (14)$$

- These 3 events are mutually exclusive, so

$$P(C = 1) = P\left(s_A \le \frac{\omega}{2} \cap s_B \le \frac{\omega}{2}\right) + P\left(s_A \le \frac{\omega}{2} \cap \frac{\omega}{2} \le s_B \cap s_B \le \omega\right) + P\left(s_B \le \frac{\omega}{2} \cap \frac{\omega}{2} \le s_A \cap s_A \le \omega\right) \ldots\ldots\ldots\ldots\ldots (15)$$

- Equation 13(BN) and 15(traditional) are identical

Reliability updation

- If ECCS failure is observed, in case of series system; failure probability of A & B and probability distribution of random variable can be updated as:

$$P(A=1|C=1)=\frac{P(A=1,C=1)}{P(C=1)}=\frac{P(A=1}{P(C=1}=\frac{P(s_A\le\frac{\omega}{2})}{P(C=1)}$$

$$P(B=1|C=1)=\frac{P(B=1,C=1)}{P(C=1)}=\frac{P(B=1)}{P(C=1)}=\frac{P(s_A\le\frac{\omega}{2})}{P(C=1)}$$

$$f(s_A|C=1)=\frac{dF(s_A|C=1)}{ds_A}=\frac{d}{ds_A}(\frac{P(S_A\le s_A,C=1}{P(C=1)})$$

- P(C=1) can be calculated from equation 10. Similarly distribution of other variables can be found out. If B failure is observed, other nodes can be updated as:

$$P(A=1,B=1)=\frac{P(A=1,B=1)}{P(B=1)}$$

$$f(s_B|B=1)=\frac{dF(s_B|C=1)}{ds_B}=\frac{d}{ds_B}(\frac{P(S_B\le s_B,B=1}{P(B=1)})$$

$$P(C=1,B=1)=\frac{P(C=1,B=1)}{P(B=1)}=\frac{P(B=1)}{P(B=1)}=1$$

Reliability updation

- Similarly for parallel system

$$P(C=1,B=1)=\frac{P(C=1,B=1)}{P(B=1)}=$$
$$\frac{P(C=1|A=0,B=1)\times P(A=0,B=1)}{P(B=1)}$$
$$+\frac{P(C=1|A=1,B=1)\times P(A=1,B=1)}{P(B=1)}$$
$$=\frac{P\left(s_A\le\omega\cap s_A\ge\frac{\omega}{2}\cap s_B\le\frac{\omega}{2}\right)+P(s_A\le\frac{\omega}{2}\cap s_B\le\frac{\omega}{2})}{P(s_B\le\frac{\omega}{2})}$$

- All the joint probabilities, mentioned in the above equations may be obtained by Monte Carlo simulation.

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[11] S. U. Chang, C. R. Lin, and C. T. Chang, " A Fuzzy Diagnosis Approach using Dynamic Fault Trees," Chemical Engineering Science, Vol. 57, pp. 2971-2985, 2002

Integrated communication – present and future possibilities

Unifying security and safety communication over IP infrastructure

Background - Past

- Analogue/digital solutions
- Proprietary solutions offered limited integration
- Cabling tailored to use

Background - Present

- Networked solutions becoming available on most platforms
- Integrated solutions desired/required
- Ethernet/structured cabling more widespread

Industrial buses on Ethernet

SCADA

Structured cabling

- Common cabling scheme
- Cat. 5 (or better) cabling
- Power distribution (PoE or PoE+)

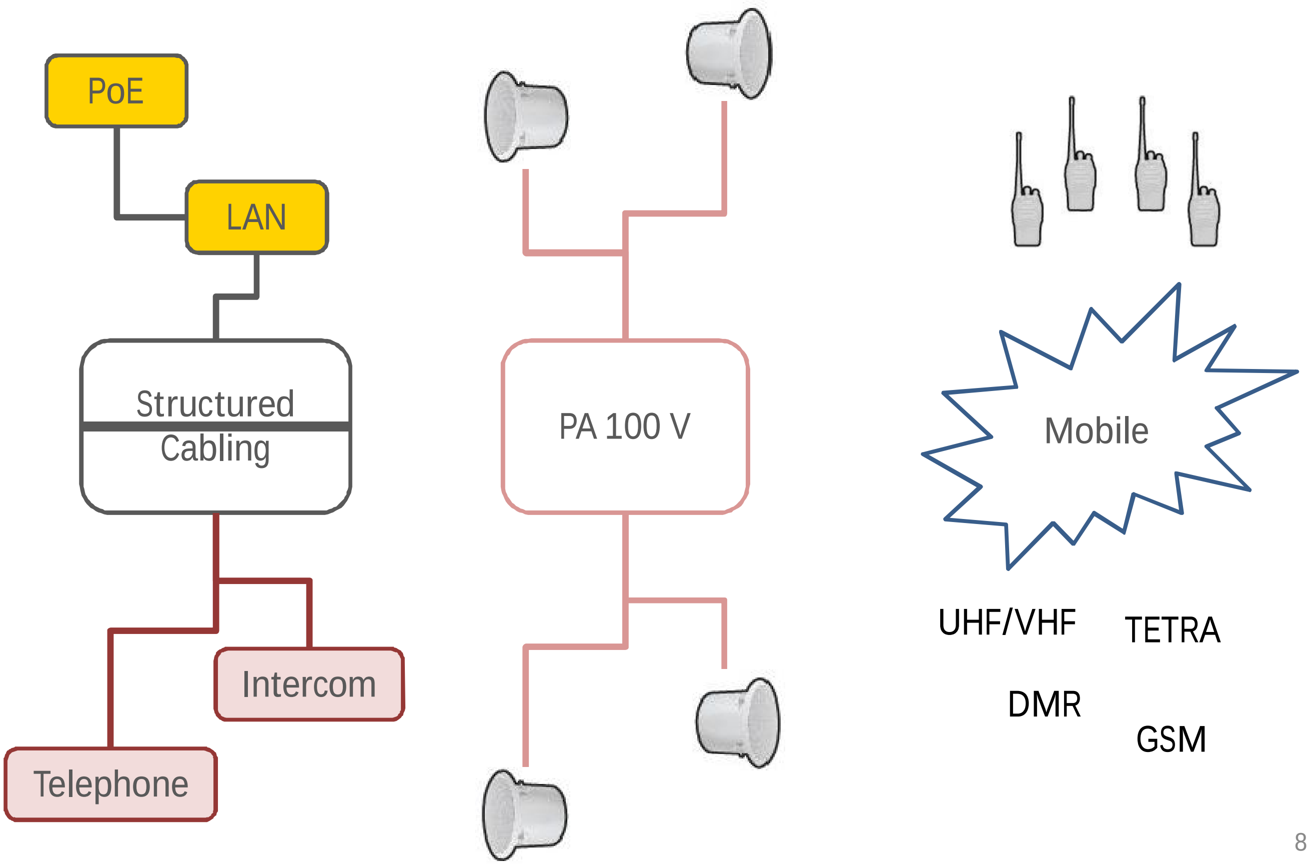
Structured cabling

- Flexible and unified infrastructure
- Future-proof
- Compatible with analogue and IP systems

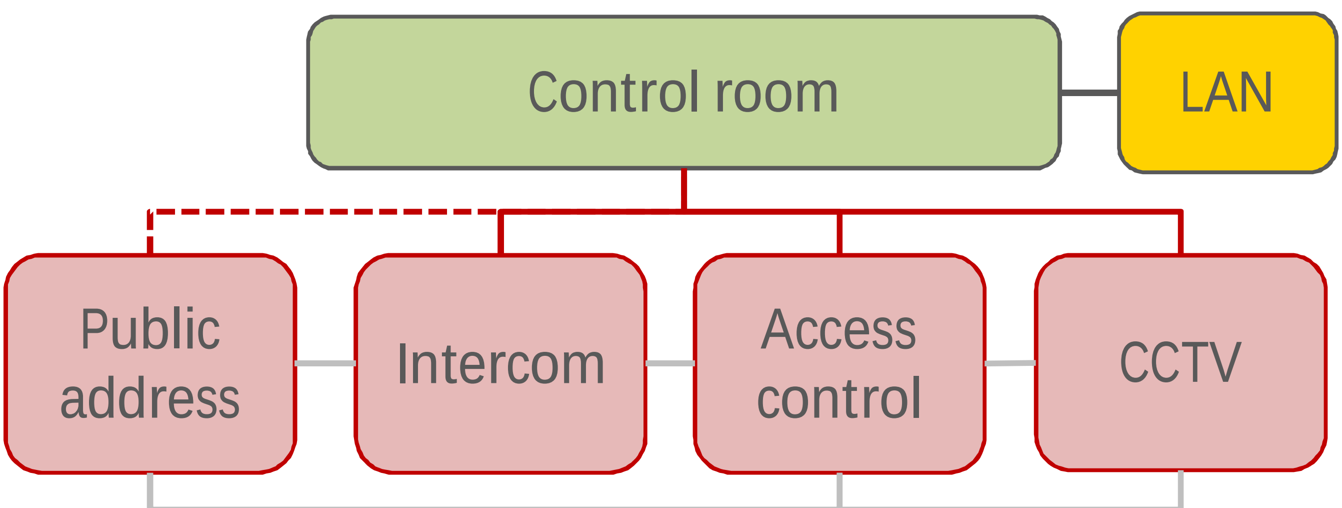
Where are we today?

- A lot of systems share common distribution infrastructure (structured cabling)
- Still individual and proprietary platforms
- Standardization is increasing

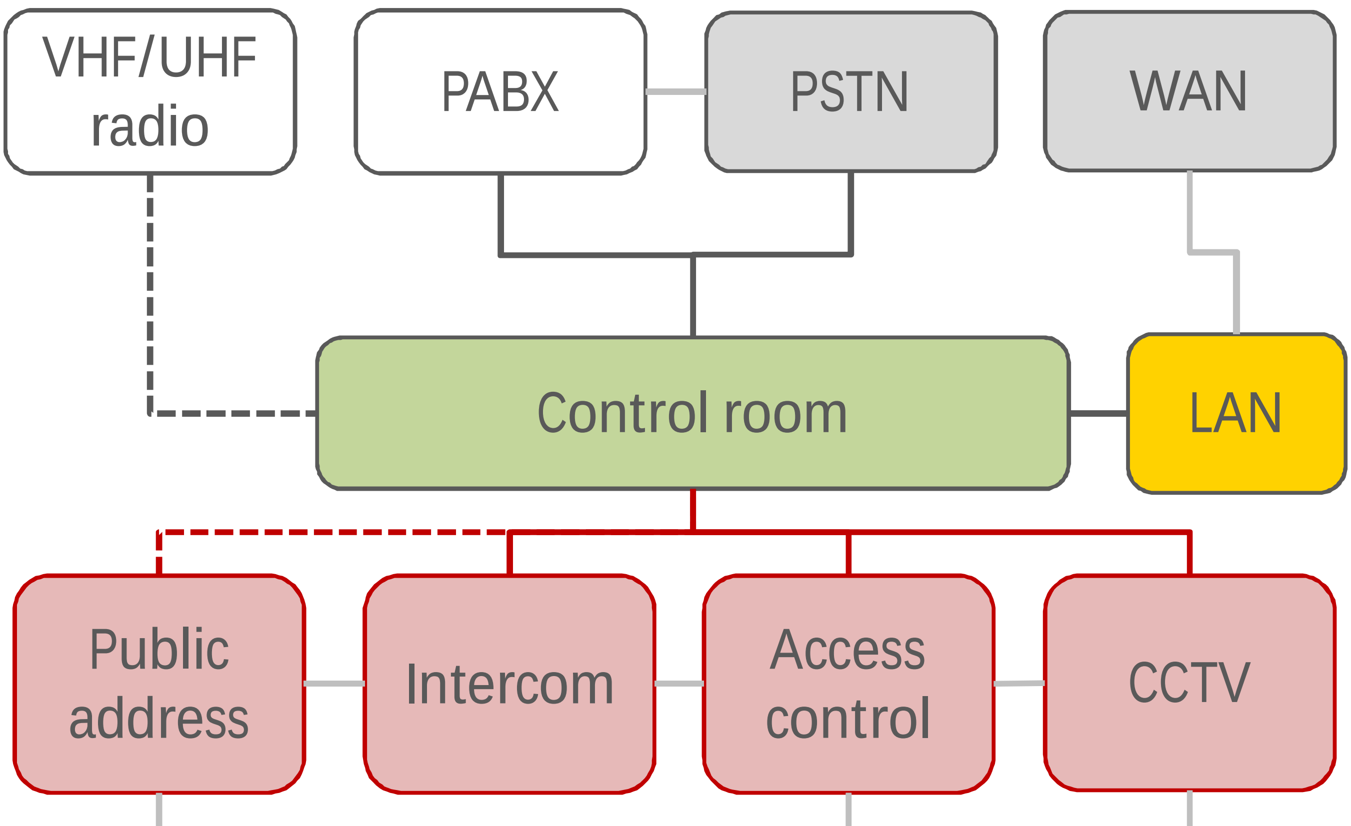
Modern infrastructure



Traditional Com/Sec system



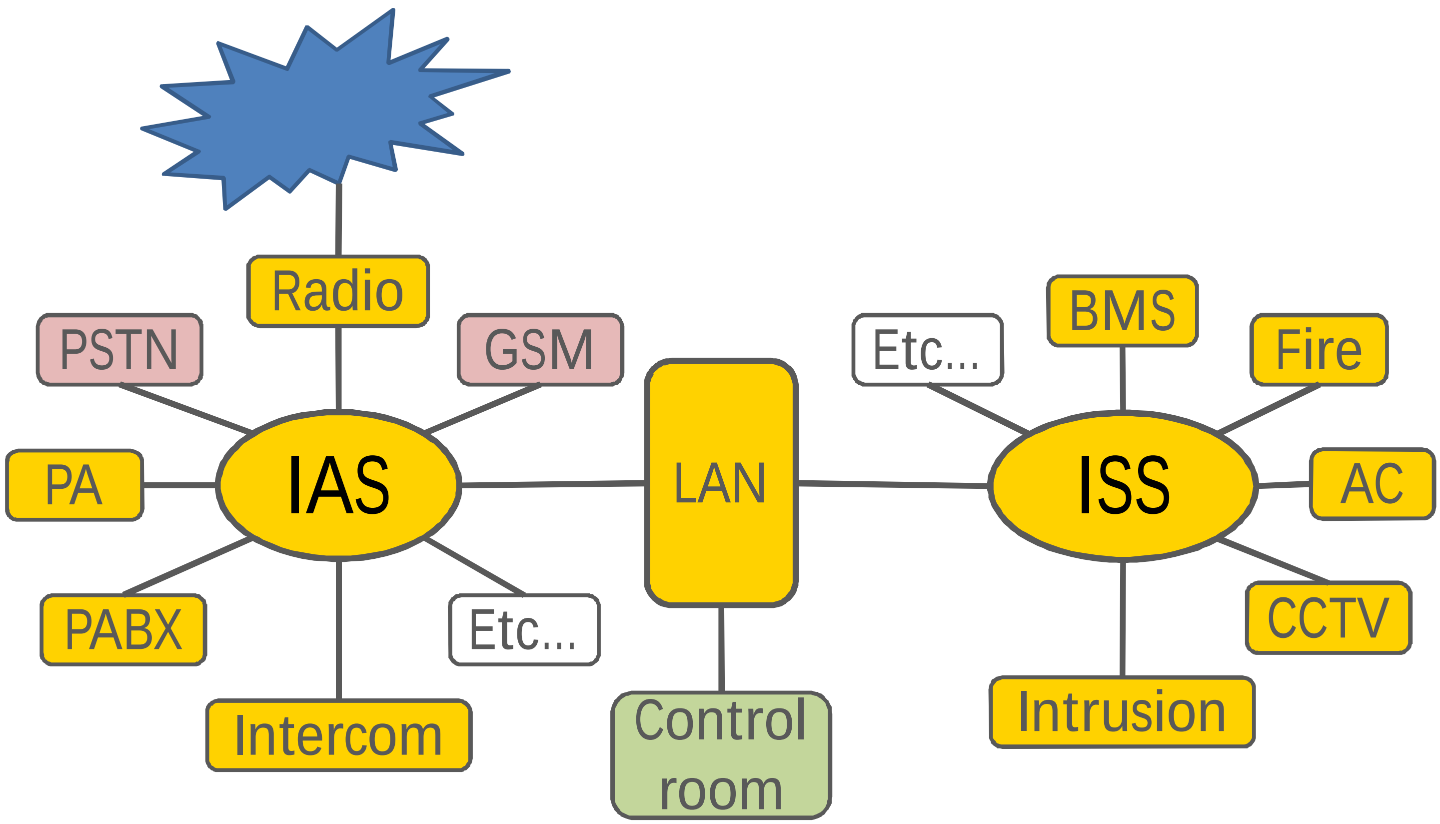
Traditional Com/Sec system



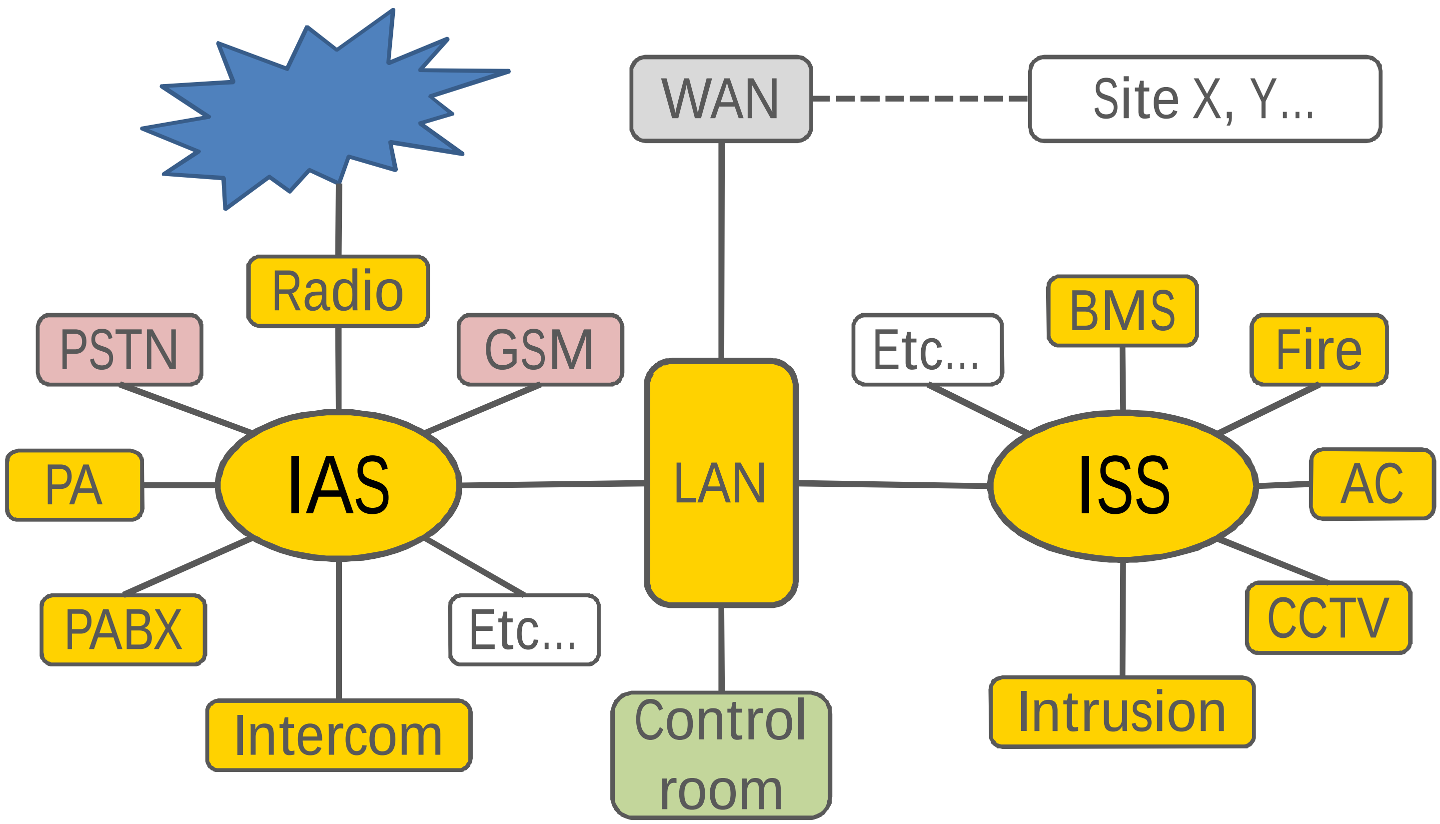
Traditional Com/Sec systems

- Dispatch/Control-room acts as hub
- Low level of integration
- Analouge communication dominates

Integrated Com/Sec system



Integrated Com/Sec system



Benefits - Financial

- Reusing existing infrastructure
- Increased utilization of human resources
- Distributed systems + Unified cabling = less investment and maintenance cost

Benefits - Operational

- Automation = Reduced response time in case of an undesired event
- Automation = Reduced risk of human error
- Integration = increased capability of exisitng systems

Benefits - Maintenance

- Redundancy = reduced down-time = less maintenance
- No custom-made or obsolete physical interfaces
- Networked solutions permits remote configuration, diagnostics and SW maintenance

Benefits - Flexibility

- Common protocols = Less chance of tie-in to a single provider
- Infrastructure may be repurposed should needs change
- Ethernet = Scalability and modularity

Future

- More integration / virtualisation
- User experience / user friendliness
- Virtual interfaces / Touch-screen

Thank you

Background - Platforms

SCADA (LAN)

Application platform (LAN)
PCs | Peripherals | Data Storage | App Servers

Security platform
CCTV | BMS | Access | Fire

Communications platform
Telephony | Mobile | Intercom | Public Address

Background - Platforms

SCADA LAN

Application LAN

PCs Peripherals Data Storage App Servers

Communication, Safety and Security LAN

CCTV BMS Access Fire

Telephony Mobile Intercom Public Address

ISA Delhi Section

NEW High Sensitivity Single Beam Infrared Gas Analyzers

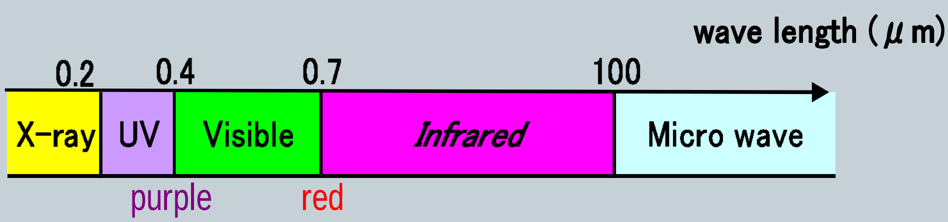
Agenda

- Introduction – Basics of NDIR Principle
- Analyser Types Dual beam vs. Single Beam
- New Series of High Sensitivity Single Beam Analyser
- Basic Configuration
- Technical advantages
  - Enhanced Sensitivity
  - Ease of Use
  - Cancellation of Zero Point Drift
  - Small Size
  - Compact Internals
  - Abundant Features
- Technical Specifications Comparison
- Conclusion

Non Dispersive Infrared Principle

①What is Infrared ray ?

Part of electro magnetic wave
of which wave length is longer than visible ″red ″.

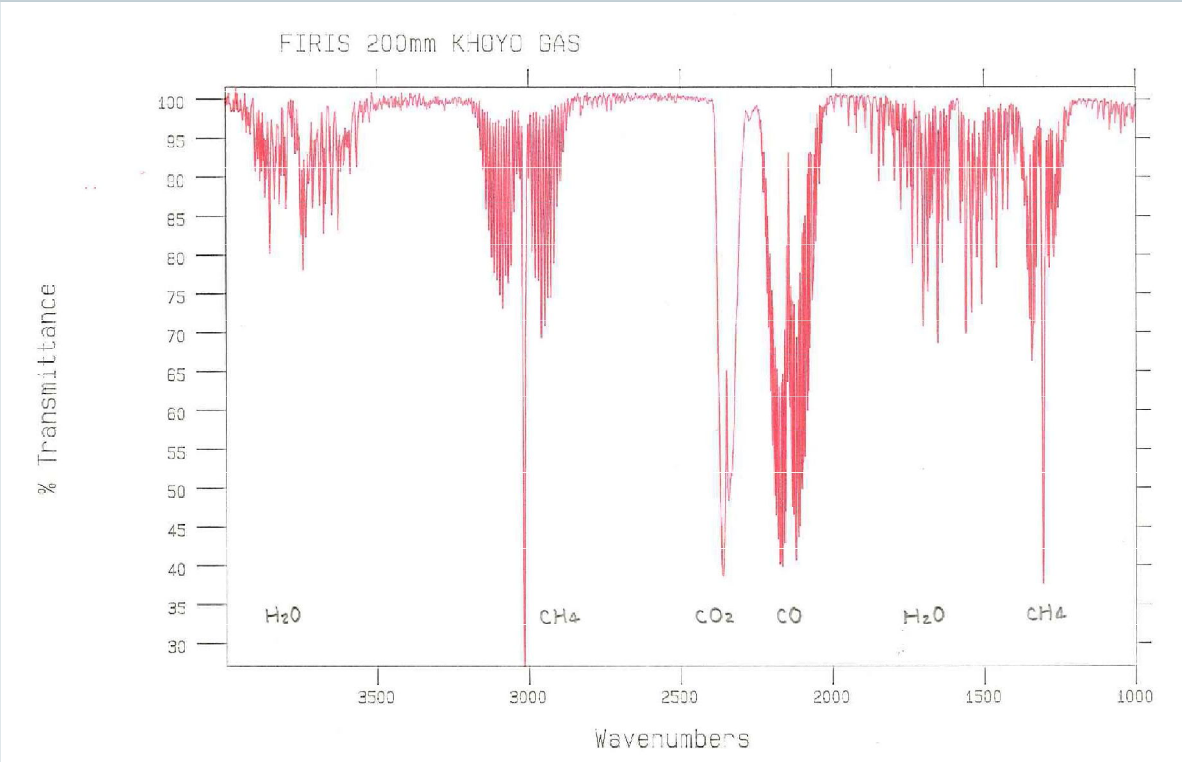


②Molecules absorb Infrared energy at it's own wave length.

Magnitude of absorption is proportional to the product of gas concentration and path length = *Lambert – Beer's Low*

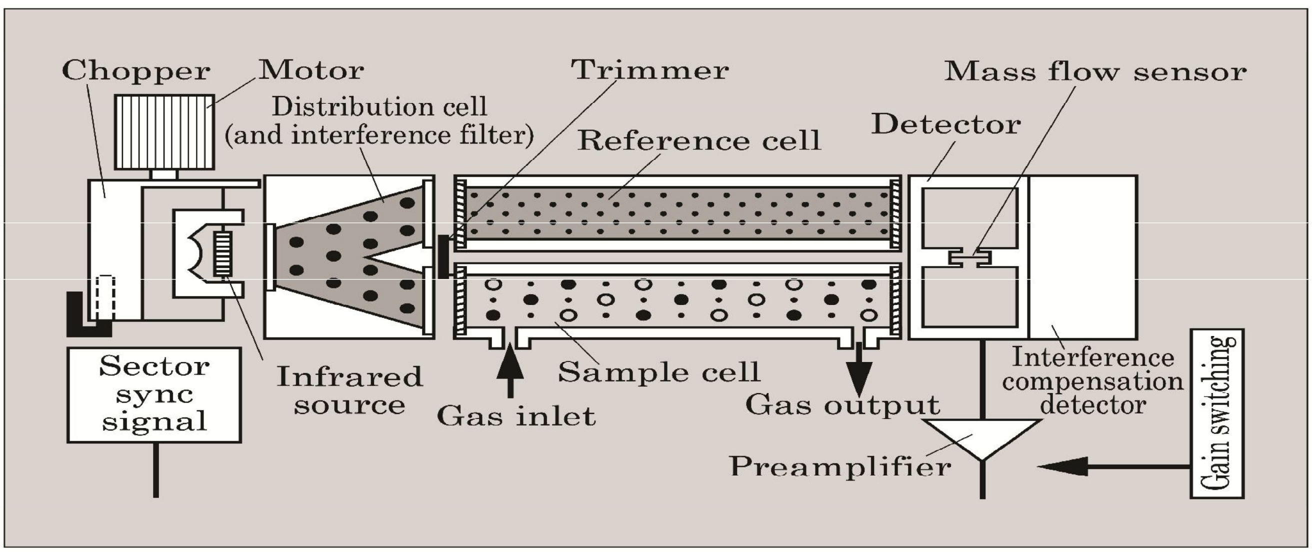
We can determine the gas concentration by measuring intensity of Infrared energy

Infrared Absorbance spectra



Dual Beam NDIR Type

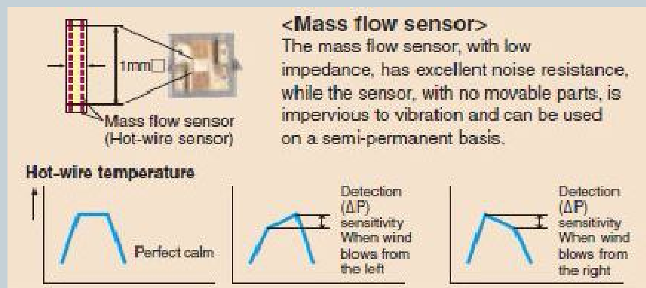
- ☆ High accuracy measurement in low concentration
- ☆ Measurement with high sensitivity Mass flow sensor
- ☆ Minimum cross sensitivity with Dual detector system
- ☆ Flexibility for measuring components

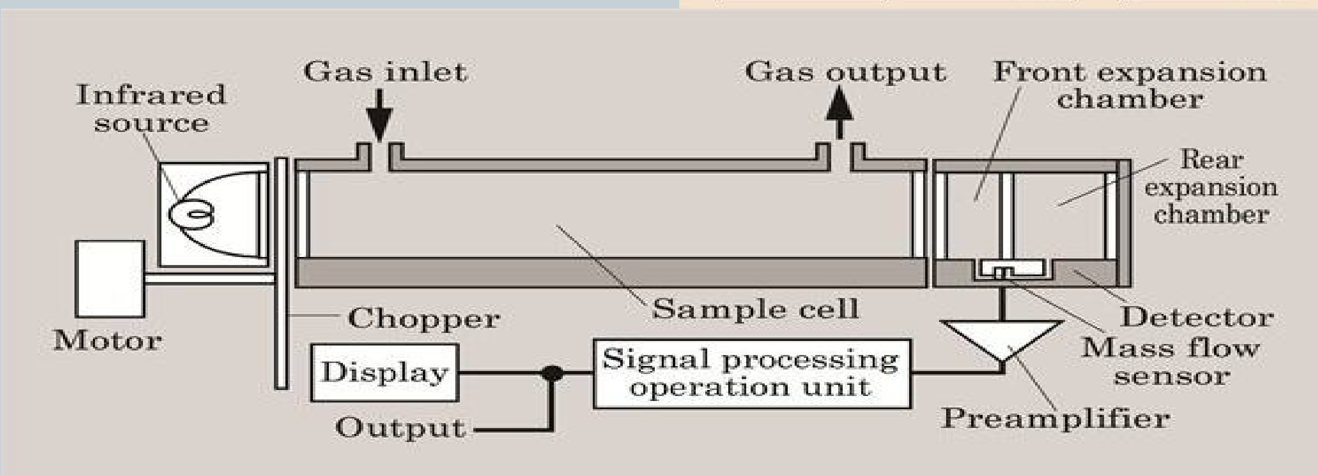


Single Beam NDIR Type

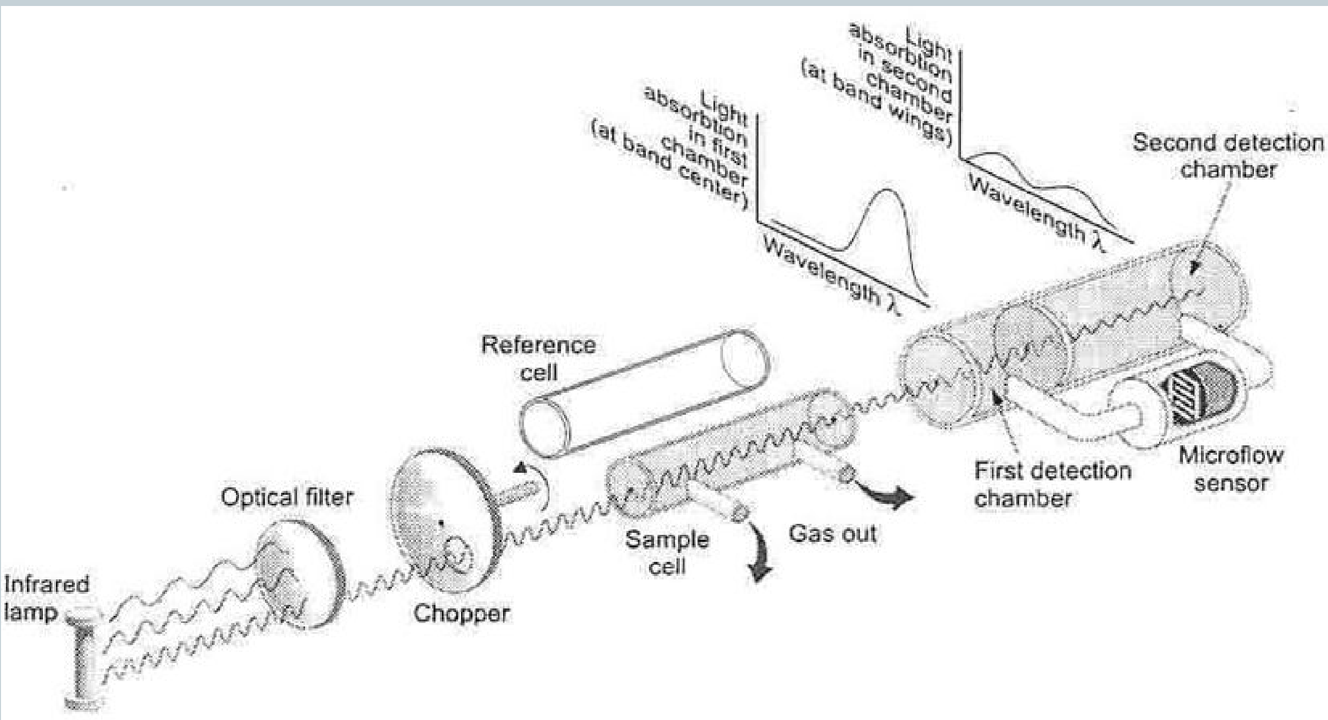
☆ **Simple structure , Easy to use and Easy maintenance**

☆ **Excellent stability and High-accuracy measurement with Mass flow sensor**





Single Beam NDIR Principle



New Series Analysers

- **General use model**

  Min. measuring range : 0 to 200ppm NO/SO2/CO

  0 to 100ppm CO2

  Applications: Incinerator Combustion Control, Hot Oven , Boiler Combustion Control, Cement Plant Process Monitoring, Emission Monitoring, Furnace Monitoring

- **High performance model with Sample Switching**

  Min. measuring range : 0 to 50ppm NO/SO2/CO/CO2

  Applications: Waste Incineration Emission Monitoring, Gas Fired Power Plants Emission Monitoring, Steel Plant Exhaust Gas Monitoring

- **Ultra low concentration with Sample Switching**

  Min. measuring range : 0 to 5 ppm CO/ CO2
  0 to 10 ppm NO/SO2

  Applications: Gas Supply Product Monitoring, Impurity Monitoring, Air Quality Measurement, Green house Gas Global Warming monitoring

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ZP Series Single Beam Type

Fuji Electric

Enhanced sensitivity of Mass Flow Sensor

- State of the art design & manufacturing process realized 2 times higher S/N than current sensor
- Durable construction with moving parts enables resistance to vibration
- Low impedance enables high S/N and resistant to noise

Multi layer detectors assures

- Minimum cross-sensitivity to coexistence gases
- Measurement with High stability

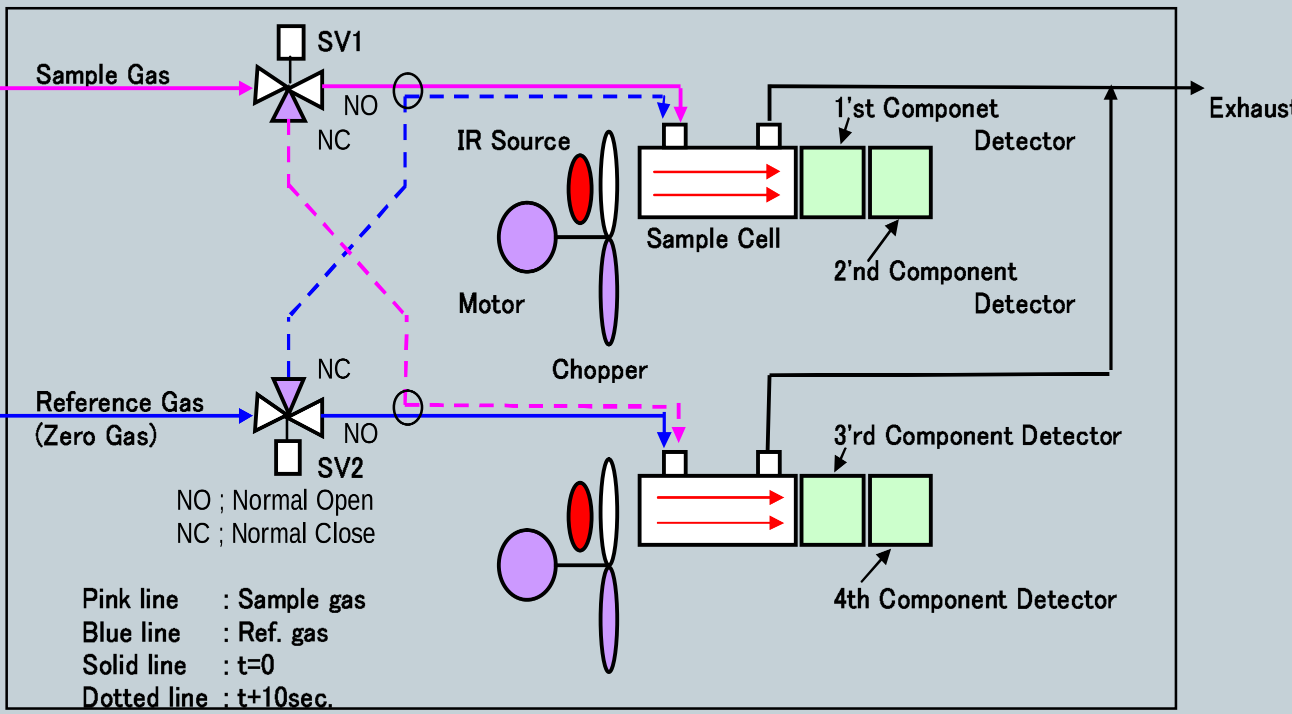
Easy to maintain & Easy to use menu driven with large LCD

- Robust single beam system requires no optical adjustment

Barometric pressure compensation available

- Supports correction for transient weather disturbances

Sample Switching Technique



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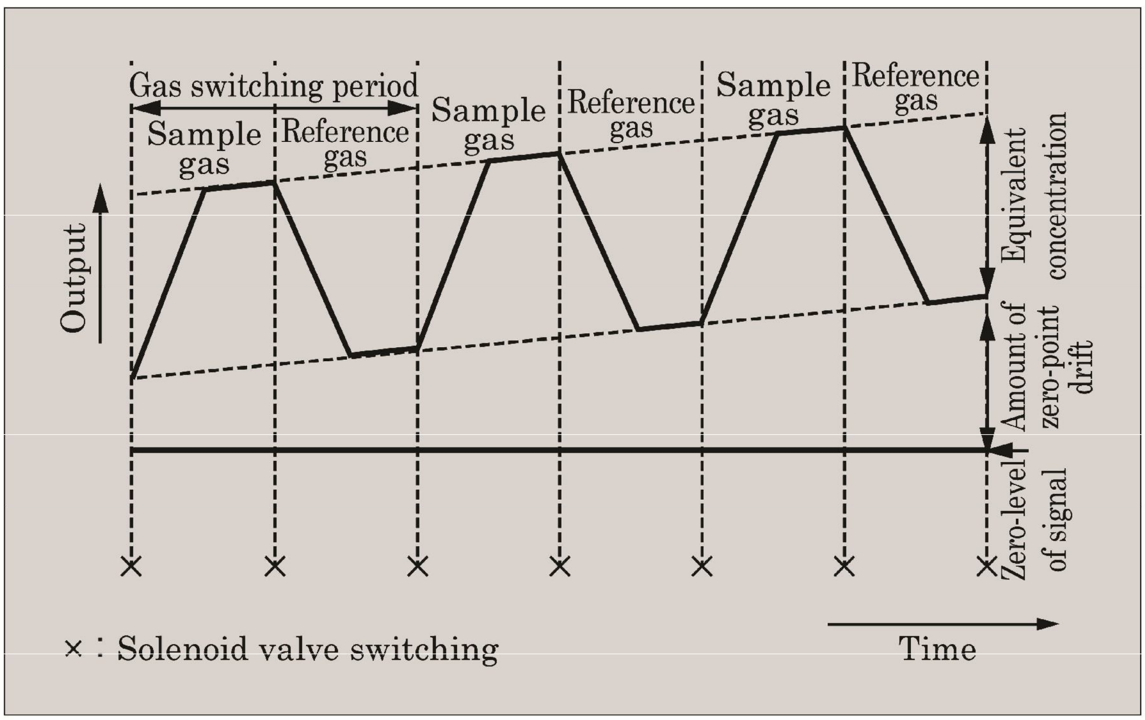
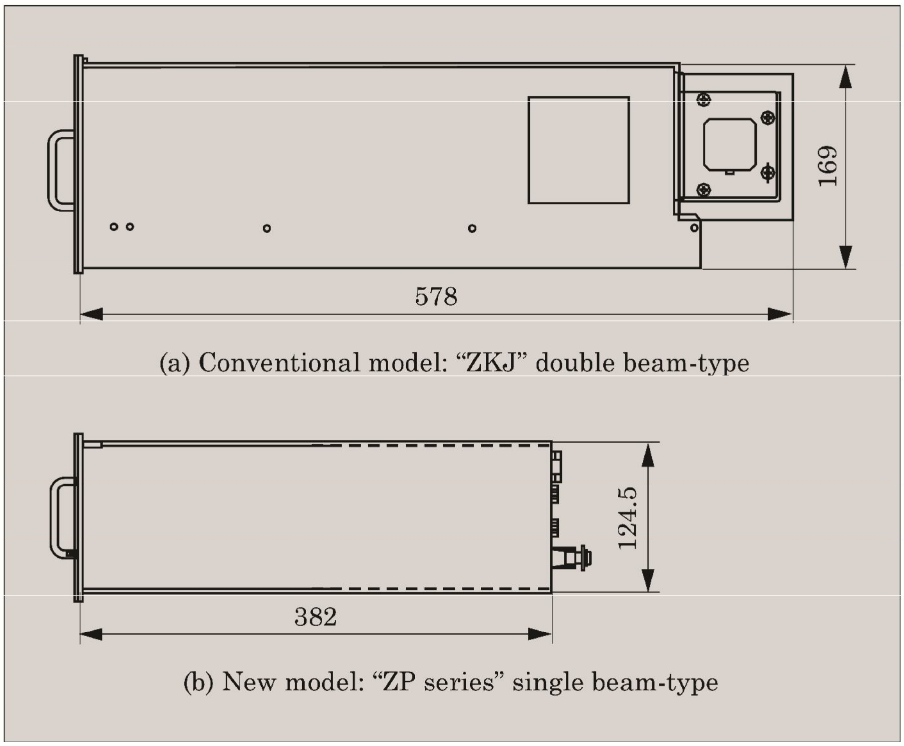
Cancellation of Zero point Drift

Fuji Electric



Small Size Easy to Handle



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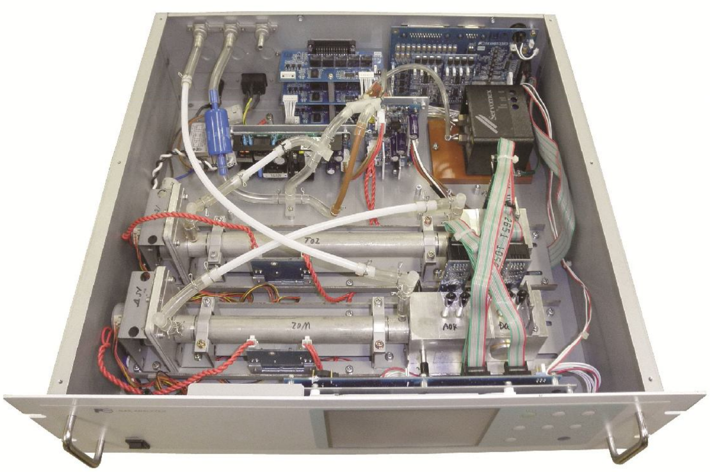
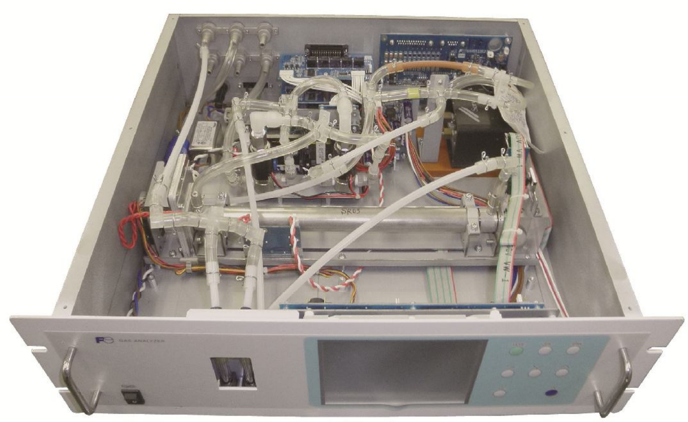
Compact Internals

Fuji Electric

General Use Model
Compact & Ease of Use



High Performance Model
With Sample Switching



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Abundant Features

Fuji Electric

- Output Range Hold
- Range Switching (Automatic/ Manual)
- Range Identification Contact Output
- RS-485 Communication and Analog and Digital Outputs
- Auto Calibration (+Remote Start) with Calibration Status Contact
- O2 Correction output
- Upper / Lower Limit Alarm Contact Output
- Instrument failure Contact Output
- Calibration Error Contact Output
- CO Peak Alarm Output
- Atmospheric Pressure Correction
- Average Value Reset Contact Input

Technical Specifications Comparison

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Model		ZPA	ZPB	ZPG
Measuring Principle		Non-Dispersive Infrared absorption		
Measuring Method		Single Beam	Single Beam Sample Swiching	
Measurable Components		NO, SO_2, CO, CO_2, CH_4	NO, SO_2, CO, CO_2	
Minimun Measuring Range	NO	0 to 200 ppm	0 to 50 ppm	0 to 10 ppm
	SO_2	0 to 200 ppm	0 to 50 ppm	0 to 10 ppm
	CO	0 to 200 ppm	0 to 50 ppm	0 to 5 ppm
	CO_2	0 to 100 ppm	0 to 20 ppm	0 to 5 ppm
	CH_4	0 to 500 ppm	-	-
Range Ratio		Up to 1 : 10		
Repeatability		Better than ±0.5% of Full Scale (*Note1)		
Linearity		Better than ±1% of Full Scale		
Zero Drift		Less than ±2% FS /week (*Note2)	Less than repeatability	
Span Drift		Less than ±2% FS /week		
Response time		Less than 10 sec.	Less than 30 sec.	
Dimensions		133H x 483W x 448D mm		
Measuring Range Compatible Current Model		ZRE (Single Beam) 	ZKJ (Double Beam) 	None

(*Note 1) For measuring range < 200ppm, Better than ±1%FS

(*Note 2) Using auto zero calibration for measuring range < 500ppm

Conclusion

- Small Size High Sensitivity measurement

- Simple Maintenance due to Single Beam Design

- No zero drift
  Sample gas and zero gas are switched per 10 seconds to compensate zero point

- S/N ratio is improved more than 4 times than standard single beam with state of the art signal processing technique

- Using Sample Switching method and State of the Art Signal Processing allows for stable low- concentration measurement just like in Traditional Dual Beam Analyzers

- Supports a Wide Range of Measurements for different applications

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Thank You

Fuji Electric

aic

Sanjeev Kumar Gupta
Director & CEO
Analyser Instrument Co. Pvt. Ltd.
www.aicplindia.com

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Real Time Measurement of Carbon in fly ash -----ISA POWAT13

13th April 2013 Delhi

By: Anup Shukla ABB Limited

ISA Delhi Section

Advanced microwave technology to measure unburned carbon in ash

- Non-extractive monitoring measures carbon across the width of the back-pass.
- Real-time monitoring provides data that enables easy integration into Combustion Optimization systems.
- A simple design, with minimal moving parts, provides fast installation and less maintenance.

Carbon In Ash Measurement –Advantages

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Increased !!!

- Increased combustion efficiency
- Increased quality of Fly Ash resulting in better sale price!
- Improved Mercury capture
- Loss of Ignition availability
- Balanced plant efficiency

- Reduced operating cost
- Reduced amount of Fly Ash & reduced Land Filling
- Reduced manual LOI procedure

Reduced !!!

Carbon In Ash Measurement
LOI – Excellent Measure of Efficiency

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- LOI is a measure of Carbon in Fly Ash
- CIA helps in optimizing boiler efficiency through real time measure of Carbon in Ash (LOI)
- LOI responds to efficiency loss much sooner than CO

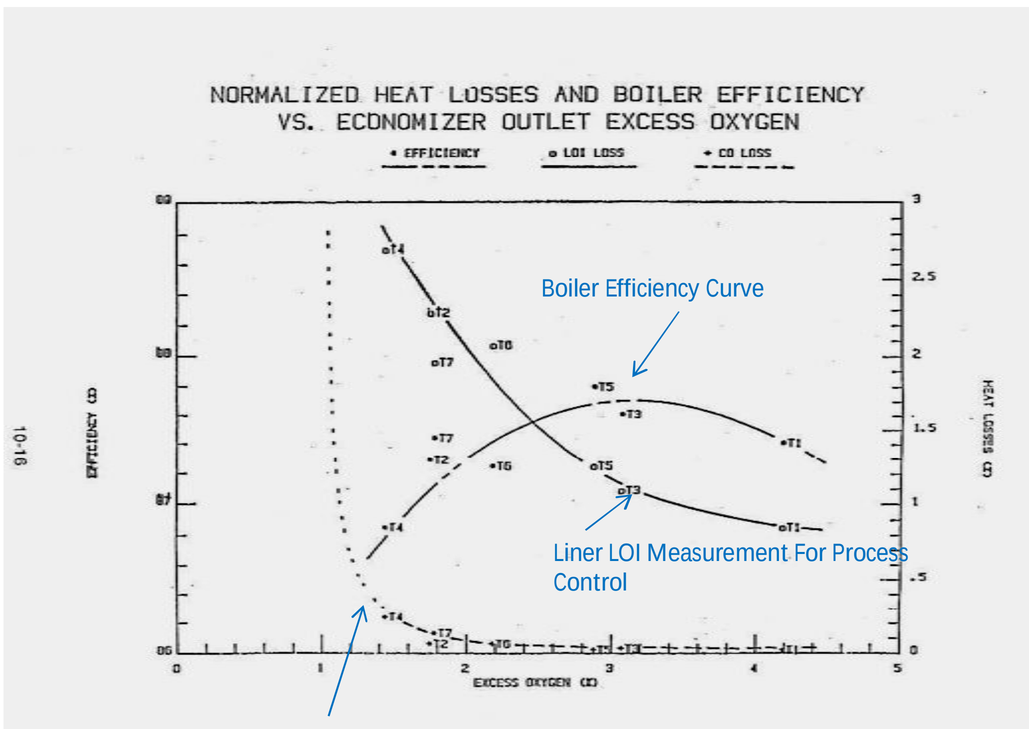

FIGURE 6: CO vs LOI

Non-linear & low sensitivity CO measurement, unsuitable for process control

Source Land Combustion, Ken Greaves

Carbon In Ash Measurement
LOI – Excellent Measure of Efficiency

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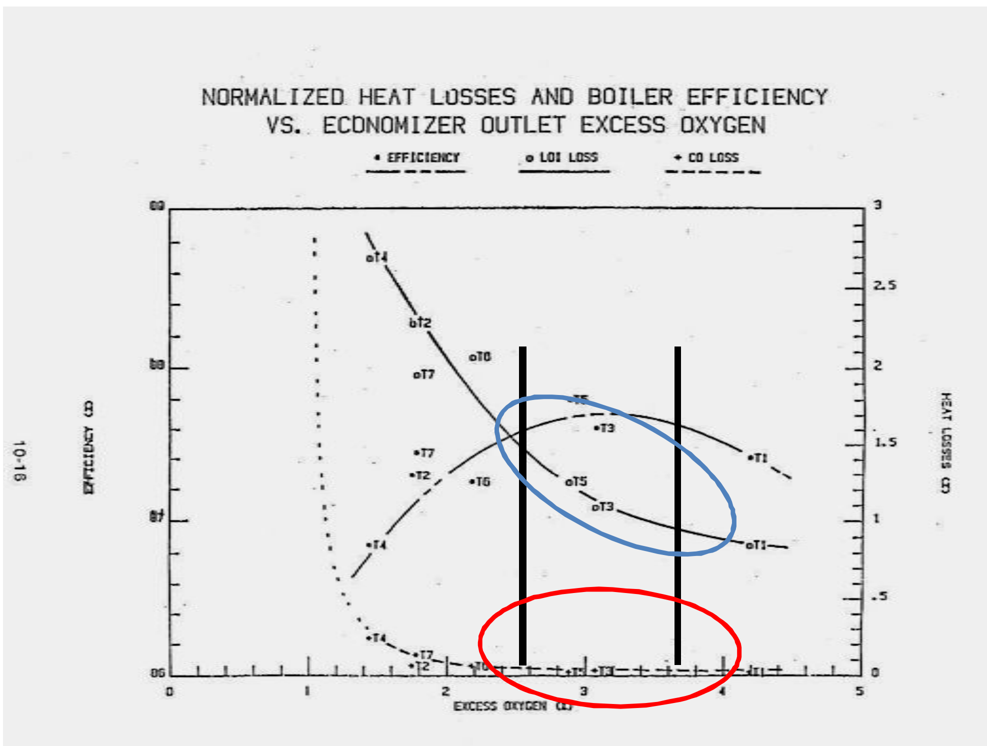

FIGURE 6: CO vs LOI

Source Land Combustion, Ken Greaves

- LOI is much more linear than CO, so you can control the process from this signal
- LOI responds to efficiency loss much sooner than CO.

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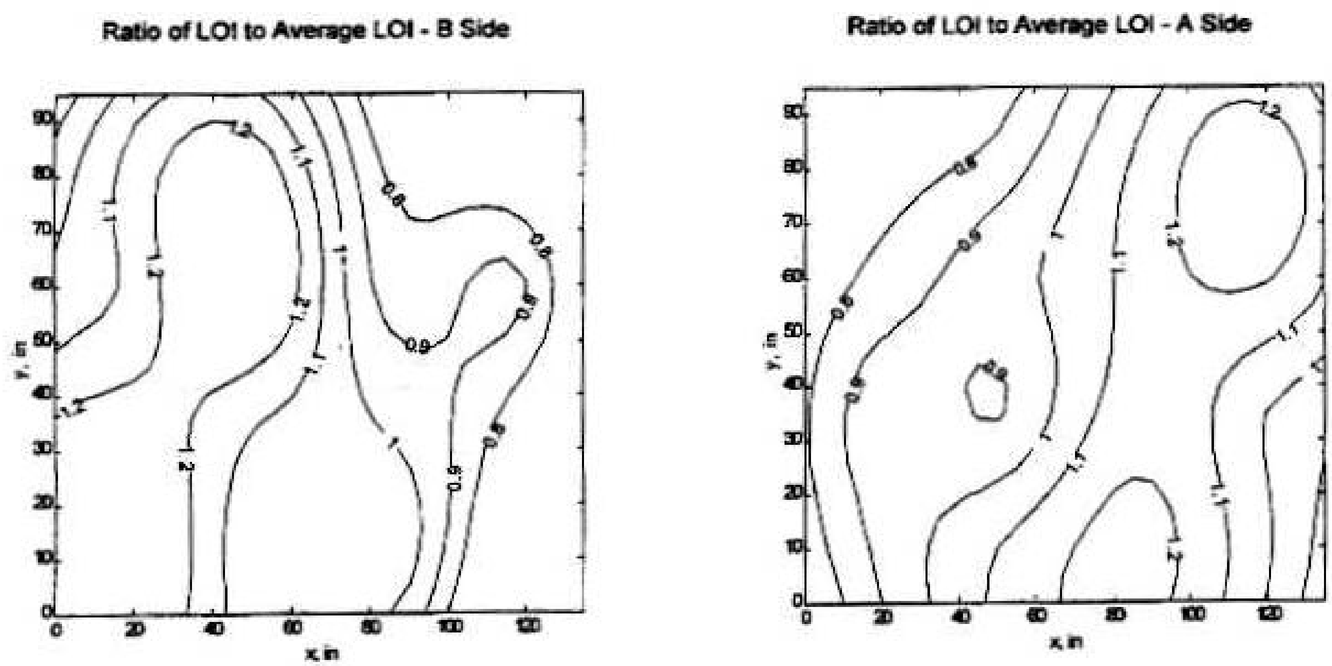
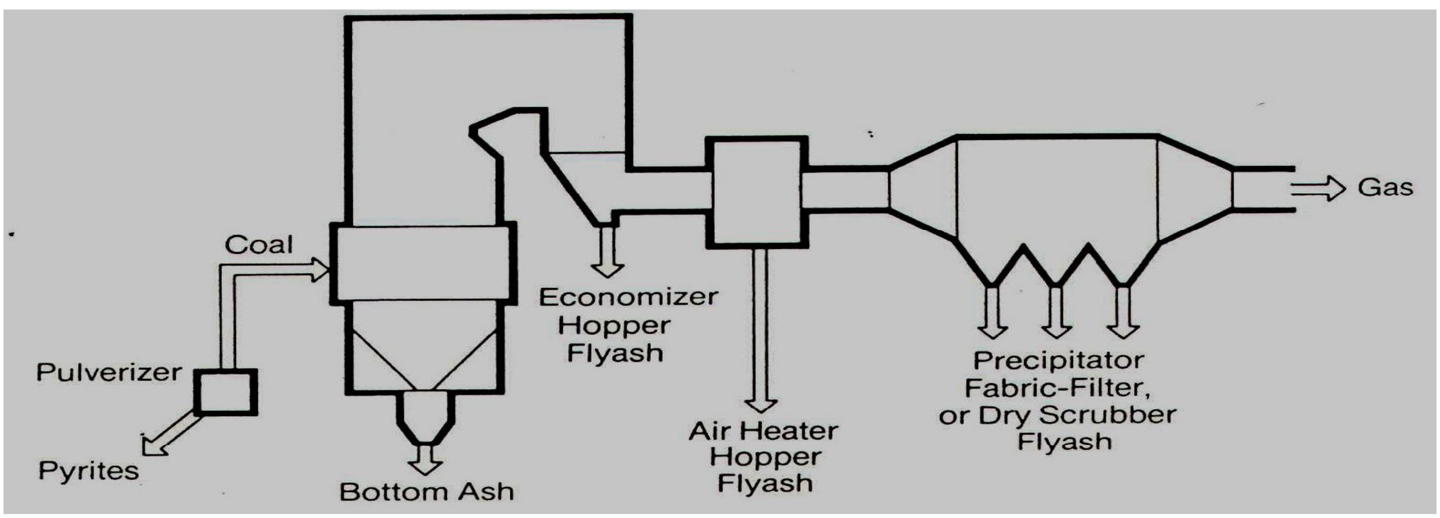
Accuracy problems with duct sampling



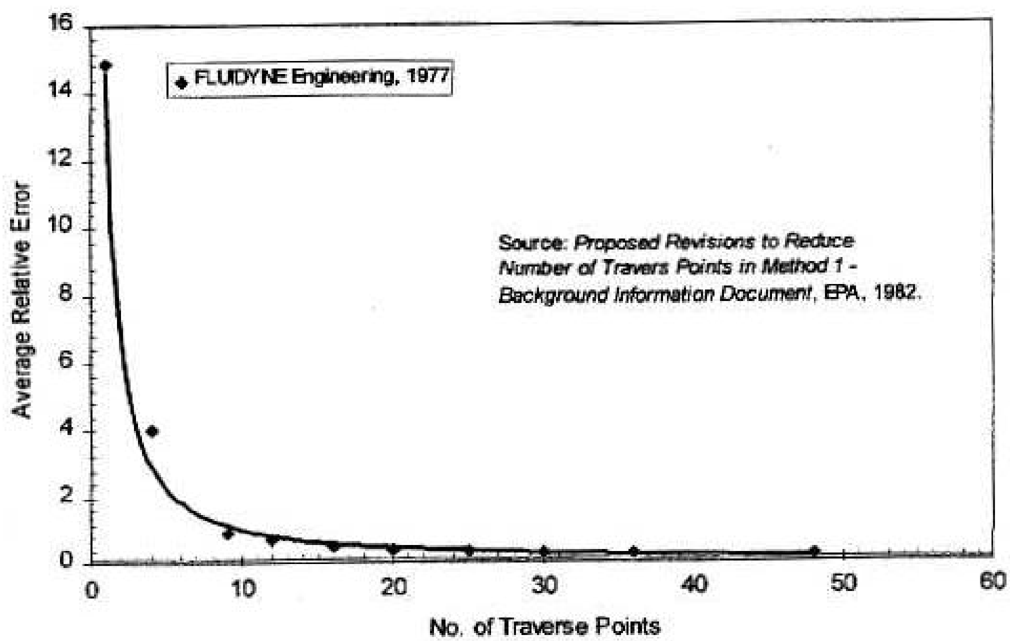
Typical Gas Distribution In Exit Gas Outlet Duct : 40% Variation Across Width of Unit

Accuracy Problems With Hopper Sampling

- Ash Hopper Deposits Vary As A Function Of:
  - Unit Load
  - Carbon Content in Ash
    - Ash w/ Carbon ~ 35 - 65 # / ft^3
    - Ash w/o Carbon ~ 90 - 180 # / ft^3



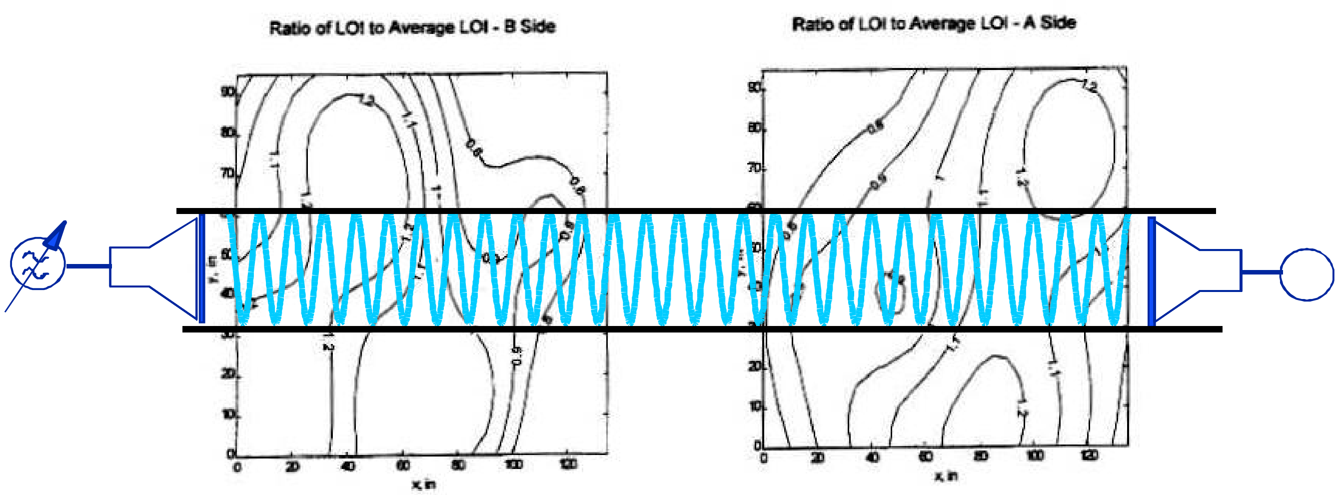
Accuracy problem with duct sampling



Due to Gas Distribution Within The Duct,

Upwards Of 20 Extractive Taps May Be Required

Accuracy Problems With Duct Sampling



Duct Gas / LOI Stratification Is Not a Problem When Instrument Is Not Dependent On Point Sampling