Distributed Plant Automation System

PROJECT REPORT

P-280

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1996 - 97

IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF
BACHELOR OF ENGINEERING IN
ELECTRICAL AND ELECTRONICS ENGINEERING
OF THE BHARATHIAR UNIVERSITY, COIMBATORE

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

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Certificate

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DISTRIBUTED PLANT AUTOMATION SYSTEM

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in partial fulfilment for the award of the degree of

Bachelor of Engineering in

Electrical and Electronics Engineering Branch

of the Bharathiyar University, Coimbatore during

the academic year 1996-1997

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DT.: 29.03.97

CERTIFICATE

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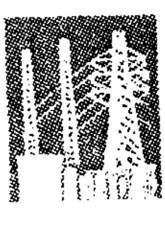

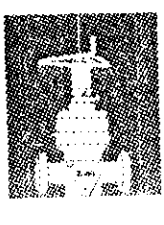

(A Government of India Undertaking)
Regd. Office : BHEL House, Siri Fort, New Delhi - 110 049.

ACKNOWLEDGEMENT

We are extremely grateful to our guide Dr. K.A. PALANISWAMY M.Sc. (Engg.) Ph.D. M.I.S.T.E, C. Engg.(I), F.I.E., Professor & Head, Department of Electrical and Electronics Engineering , for his excellent guidance, constructive criticisms and help in completion of this project.

We are highly indebted to our Principal Dr. S. SUBRAMANIAN B.E. M.Sc. (Engg.) Ph.D. SMIEEE for the facilities provided to accomplish this project.

We are extremely grateful and indebted to Mr. K. SHANMUGAM DGM/C&I for allowing us to do this project work in Engineer Controls and Instrumentation Department at BHEL, Trichy.

We feel elated in manifesting our sense of gratitude to our industrial guide Mr. S. DAKSHINA MOORTHY product Engineer, Controls and Instrumentation department for his valuable help.

We also like to convey our sincere thanks to the following members at BHEL, Trichy for their excellent advice and help.

1. Mr. G. MATHIYALAGAN, DGM (C&I DEPT.)
2. Mr. P.V. RAMAN, Sr. Manager (C&I DEPT.)
3. Mr. R. ANBARASU, DEPUTY MANAGER (C&I DEPT.)

4. Mr. SUBRAMANIAN, PRODUCT ENGINEER (C&I DEPT.)
5. Mr. VAIRAVAN, DESIGN ASSISTANT (C&I DEPT.)
6. MR. VISHWANATHAN, (C&I DEPT.)

We wish to thank the other staff members of the Electrical & Electronics Department for their encouragement during the execution of this project.

Finally we express our heartful thanks to all our friends who have directly or indirectly helped us in successful completion of this project.

SYNOPSIS

This project deals about the distributed digital control concepts and about the, decentralised concept that is being implemented in the modern control system. It also gives idea about how different process units in a process plant are linked and how the different parameters are being timely controlled and monitored efficiently. The PROCONTROL SYSTEM implemented in BHEL gives the main features and various strategies to perform all tasks required for process control. The project includes a software which has been developed for tripping up of a boiler during the occurrence of any fault condition, in which the control process come under distributed digital control concept.

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CHAPTER - I

INTRODUCTION

The industrial revolution came into existence and products began to be manufactured by machines which called for control systems. The control system is that means by which any quantity of interest in a machine, mechanism or other equipment is maintained or altered in accordance with a desired manner.

To meet the needs of the industrial revolution indicating instruments were invented. They are used to tell an operator that his process is running as it should. Self regulating control devices also began to be used. Measurement and control was local, located right at the point of measurement.

It soon became obvious that there were advantages in having a number of indications in one place and transmitters were developed, to sense process parameters from remote places. The complexity of many parameter maintenance of system at the desired value, operators intelligence and interruption at emergency conditions called for control systems having more features.

Importance of automatic control against manual control.

Automatic control has played a vital role in the advance of Engineering and Science. In addition to its extreme importance in space vehicle systems, missile guidance system, robotics system etc., automatic control has become an important and integral part of modern manufacturing and industrial process. For example Auto control is essential in such industrial operations such as controlling pressure, temperature, humidity, viscosity and flow in process industries .

Since advance in the theory and the practice of automatic control provides the means for attaining optional performance of dynamic systems, improving productivity, relieving the drudgery of many routine repetitive manual operations and more, most Engineers and Scientists must now have a good understanding of this field.

An application of **DISTRIBUTED DIGITAL CONTOL SYSTEMS** in power plants is studied and presented in this report.

CHAPTER 2

MODERN CONTROL SYSTEMS AND DEVELOPMENT

2.1 Digital Control Systems :

Digital Control Systems are usually configured with microprocessors operating at high frequencies are used in complex systems working with more inputs and higher order non linearity's like Boiler Plants, Rocket launching control etc.,

However, the advantages of Digital Controls Systems for this complex situation experiments helped the field of engineering to extend the same for even less complicated systems. At present all the controls in the power station are being controlled with the help of digital control systems, as it helps for configuring many more control systems or with marginal additions of hardware. The same practice exists in Steel, Fertiliser , Paper mills, Refinery plants, Boiler plants, Chemical plants etc.,

2.2 Advantage of digital controller systems

Digital control systems are increasingly popular in many applications.

The following reasons favour digital systems .

- Digital systems inherently have very high immunity which leads to higher reliability.
- Analog systems suffer from drift of the operating and tuning parameters with passage of time. In a digital system parameter once set remains stable.
- Digital systems have high sensitivity and desired accuracy can be built into the design.

- Since the control algorithms are implemented in software, the system is highly flexible and different configurations and designs changes can be implemented without changing any hardware.
- Digital Systems are more compact and light weight.
- Usually Digital Systems costs less than their analog counterparts.
- Considering the supporting components the digital like encoders are usually more analog equivalents.
- Setting of loop parameters is easy, software control can be done from remote systems.
- Improved diagnostics is possible.
- Digital Systems provides superior interfacing to other control system components.

Presently dedicated electronic modules are available which can support the function usually encountered in a position control application. These systems are able to provide a closed loop update time of less than 1milli second. They can even include facilities for stored program for executing complex positioning commands in sequence.

To improve systems further dedicated motion control chips have appeared which pack most of the functions into single integrated circuit. So the application of the Digital Control Systems is void and vast in a techno economical advantage.

There systems antidated the development of electronic. For the reasons, of cheapness and safety, Pneumatic equipment took and maintained an early lead in the industry.

2.3.2 <u>Hydraulic Systems :</u>

The Hydraulic controls have been most commonly used for heavy duty service in Steel mills, Coke furnace etc.,, characterised by extremely durable constructions. Typical applications are Turbine, Engine control flow and Pressure Control, Gas holder level control and Gas mixing control. These are located in the field rather than in a central control, room.

Soon significant changes took place in instrumentation and control room design as result of changes in technology and a better understanding of industrial processes.

Then the electronic & electric controllers were developed. First the vacuum-tube version with advent of transistors, op-amps and PCB's. The circuits became Dc powered, the instruments became smaller and distances for transmission increased. The control instrument image is distorted almost beyond recognition in the electronic control systems of today.

2.4 Control using Computers :

Control using computers has seen over 25 years of practice. The first digital computers control system was a supervisory control system that is , the computer changed the set point on the plant's regular analog controllers to achieve its control action. It did not actually move any valves itself. This type of control was to come later and is of second form.

The third form of use of digital computers for control was **Direct Digital Control,** more commonly referred to as DDC. In this form, computers generated signals went directly to the final control device, the controllers function was supplied as part of the computer programming. Figure 2.1. shows the scheme for Direct Digital Control Systems.

The concept here is to rely on a single high -speed special purpose digital computers that is time-shared among a numbers of control loops. The computers replaces the numerous conventional controllers of the individual loop.

The computer calculates the desired values of input variables and these calculated values are applied directly to the process. It not only increased efficiency of the job but also opened up increased flexibility in the type of control action as well as option to reprogram the control action should than become desirable.

Most of the computers control systems implemented during the 70's were centralised where by a single large process computers was used to acquire data form one or a number of processes and control large number of process loops.

2.5 Demerits of Centralised Control System :

In the case of direct digital control, the computers executed the control function, time sharing the processor among many control loops simply because the high cost of the computer had to be spread over the entire control project to justify its economic viability over conventional controllers. Thus demanded high reliability, often requiring a second computer- idling on unessential tasks for back or alternatively a complete analog control system for back up.

Failure of this computer, for whatever reasons, the entire plant area that it serviced had to be shut down. Here the controlling is done in a sequential manner, if suppose we have to control at random any one of the controls it is not possible. And also that for this centralised system the cables have to run from the control room to the field for every parameter and hence, the cost of the cable is high.

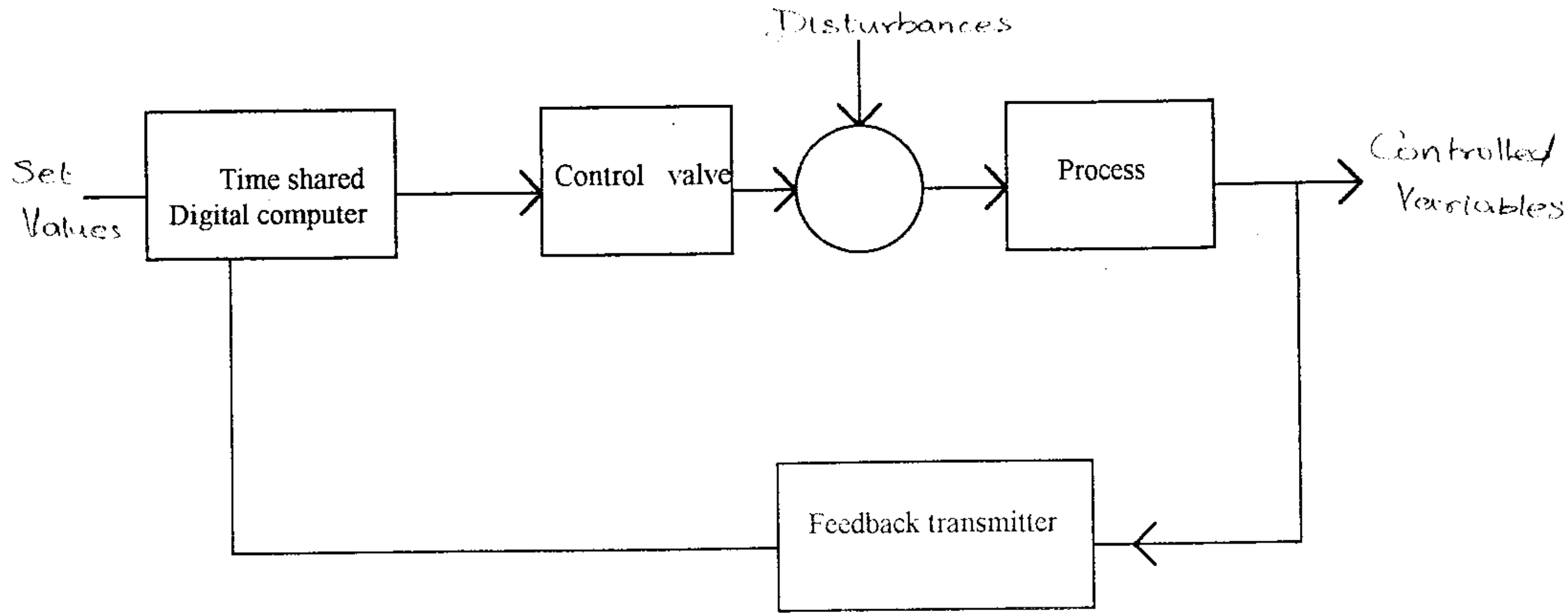


Fig (2-1) SCHEME FOR DIRECT DIGITAL CONTROL SYSTEM

CHAPTER 3.0

DISTRIBUTED DIGITAL CONTROL SYSTEMS

3.1: DISTRIBUTED CONTROL CONCEPT.

The problems based in the use of centralised computer for control brought forth the concept of de-centralisation of digital control equipment with a Control system implemented as a number of self contained units, it is possible to add more processing power (or) increase back up for a particular unit simply by adding more processing units to the system. A communication medium provides the necessary path for the interchange of information between the processing units. Towards the end of the seventies, this concept of distributed control became reality and owes its existence to the inexpensive availability of microprocessors M.P.

Distributed control implies that the actual control and management functions are infact, distributed throughout the entire plant in several processing units. The control system is now composed of many microprocessors which are linked together to form a distributed control systems.

The task of measurement, DDC, Operation, communications, segmented control, etc.,., are distributed among a Number of separate processing units each of which will incorporate a micro computer are linked via common serial communication high way and are configured in a hierarchial structure.

3.2 DDC OVERVIEW

Distributed control thus represents the physical distribution of digital controllers among plant processes and functional distribution of risk associated with component failure. Physical and functional distribution have two major advantages over Central computer concept, reliability and speed. Provides the capability for implementing high level automation. True distributed control, the controller to the process, allowing the controller via communication network, to update the operator, in the control room, on what is happening at the process units and allowing the operator to take actions like change of set point or manual control. The controller can thus be housed away from the lowest in the plan-wide chain of the system and are used primarily to control and monitor. At the intermediate level data are verified validated. Finally at the highest level, long term functions are implemented, such as optimization, energy management and the integration of local functions.

3.3 PROCESS CONTROL AND PROCESS MANAGEMENT

When a process is automated, the first general efforts are due towards the measurement of process variables and simple techniques to establish basic control over the operation of the plant. As process control functions become more elaborate and higher levels of plant automation are under taken there is a need to automise more of the management of the plant. The mayor initial thrust of automation are towards plant control but as automation increases the focus shifts to more and more automation of the management function.

3.4 OVERALL CONTROL CONFIGURATION

The analysis presented above reveals that process automation involves large number of individual control and management functions. It must be realised that any process is actually a collection of individual sub-process. It is thus evident that the functions enumerated earlier would be required for the automation of each subprocess. The problem of an over all control configuration is thus executing the individual functions for each of the sub-process and integrating these individual pieces of automation into a functional and viable system.

Process automation system for several years had a very simple monolithic from or configuration. Analog signals from individual measurement sensors were transmitted to a central control room and control signals to the actuators were returned in analog form. The concept of the Central control room is necessary for effective plant management technology limitations, till recently necessitated the housing of the complete automation hardware in the control room, resulting in enormous amounts of cable links to and from the field equipment. It thus becomes clear that proper plant management requires plant management functions to be performed from a Central locations and economical considerations would require the process control functions to be located near the process. We thus have geographical distribution of the control hardware having defined geographical distribution it becomes clear that the individual functions for each of the sub-process will now be distributed is these geographically distributed units. We thus have a geographical distribution of process control units and functional distribution of task both at the process and management levels.

The process control units directly interface to the plant and is the centre for the execution of the process control functions. The structure of the process control units itself can vary; but what is most important here is to understand. That each process control unit is associated with a group of tasks within the overall control scheme of the plant, the process unit itself maybe comprised of smaller units. The management units enable the overall supervision and operation of the plant. These units provide the display and data retrieval facilities for the operator, supervisor and engineers as well as the computational capabilities for the overall profitable management of the plant. The management units are housed in the Central control room and provides the operator with access to all controller data such as set points, process variable measurement controller output levels etc., Sophisticated displays are also available and the supervisory or management functions are easily implemented within the control room itself. The communications link provides the path for the transfer of data among all units of the system and is a vital feature for a successful distributed control system implementation.

3.5 HARDWARE OF DISTRIBUTED CONTROL SYSTEM

It has been earlier defined that a control system comprises two basic functions namely, process functions and management functions. A suitable collections at these functions in well - defined hardware units are distributed to achieve the overall plants management and control strategy. Thus, distributed control hardware comprises process control units and management units.

3.5.1 PROCESS UNIT

The basic functions of the process units are to interface with plant equipment and maintain the assigned plant equipment at a desired operating condition, provide the necessary sequencing of the equipment for start - up and shutup operations and also protect equipment. In other words process words are required to function as closed loop controllers, open-loop controllers, batch controllers or as simple monitory equipment. All of the above functions would be performed within one process unit itself. when a process unit is used to perform closed - loop control of more that one loop, it is called a multi-loop controller. when within a process unit a single microprocessor is dedicated to a single control loop, the same is known as a single loop controllers.

The various units of the distributed control system are linked through a data highway. Thus, every process unit has to be provided with data highway interface through a data highway. Thus, every process unit has to be provided with data highway interface through which it is able to task to other process and management units. Thus a process unit will comprise plant input /output equipment, microprocessor to perform multiloop, single loop and other control functions described earlier and data highway interface.

3.5.2 MANAGEMENT UNITS

The management units provides the distributed controller system with the full range (or) operator, engineer, supervisor and managerial requirements. The key element of the management unit is the operator interface generally comprises micro computer and its associated software along with hardware units for controlling the CRT's printers and mass storage devices.

Report generations and data achieving are important management functions, while certain systems provides this as a part of the operator station. Other systems include this as a separate package unit (or) part of a management computer. The process computer or supervisory computer or management computer as it is some times called, is the third management unit. It is important to note that the need for this unit depends on the applications as well as the capabilities of the distributed control system. It requires a computer for even such functions as report generations and data achieving, while others can do without a computer even for advanced calculation and limited optimization routines. In late case, these functions are distributed in the operator station or logger units.

3.5.3 DATA COMMUNICATIONS

The performance of a distributed process control system is to a large extent determined by the architectural and functional specifications of its communications system. Recall that all components of a distributed control system are linked together by a data communication network. Information in the system must be updated at an acceptable rate and must be instantly available for use by operators in monitoring plant status, chancing parameters and performing manual control. The performance criteria for an acceptable data - communications network include the following.

- Any station should be able to communicate with any other station on a one to one basis at any time.
- Operation should be able to directly manipulate output modules if local controller fails.

- Availability should be higher and response time should be equal to conventional control system so that functions such as alarm monitoring and over ride control are carried out by a data network rather than by hard wired links.
- The network should also carry electrical system signals, used for logic control equipments and protection.

The performance of the transmission system to meet the above functional requirement is gain limited by the autonomy potential of the control system components. If the autonomy potential is low, the demand on availability for data transmission on the central monitoring and operating system rises drastically.

The date rate of transmission is also affected by this. If the sub-system has only limited functional capabilities, it needs to transmit and receive more information, which seriously loads the data bus.

3.6 PROCESS STRUCTURE

Analysis of processor in Industry advocates the advisability of dividing the complex overall process into individual sub-processor having distinctly defined function. This decisions at the process is clearly defined groups termed as functional group results in hierarchial process structure. The hierarchial structure is governed in the horizontal direction by the number of drivers which is the size of the process. In the vertical direction, there is a distinction made between three fundamental levels, these being the

- Drive level
- Functional Group Level
- Unit level

Fig. 3.1 shows the various levels of process structure

The drive level is the lowest level and to which belongs the individual process equipments and associated electric drives. The function group is that part of the process which fulfills a particular defined task. For example Induced draft control, Feed water control, Blooming mill control etc., Thus at the time of planning it is necessary to identify each function group in a clear manner by assigning it to a particular process activity. Each function group contains a combination of its associated individual equipment drives. The drive levels are subordinate to this level. The function groups are combined to obtain_the overall process control function at the unit level.

3.7 GENERAL SYSTEM REQUIREMENTS

The following are the system requirement for distributed control of a large plant complex.

- Complete operator control for a plant unit uninterrupted even when system communication breakdown occurs.
- Engineer / Operators access for plant information data as well as control of multiple units from a single supervisory control room.
- Sensor input/output connections to local measurements or remote attachment to Microprocessors controllers. Unified software scheme for available definition irrespective of hardware connection.

- DDC and supervisory control at plant unit level with communications for supervisory and optimum set point calculation from a higher level system.
- For discrete batch processes in a unit access to a prepared data bus to activate for e.g., a new batch or test. Provide the same as data base for transfer of discrete data logs.
- Access to a large data bus for each of the desired variables in the plant unit, for historic, Trod and logging purpose.
- Mechanisms for retrieving the transferred date for plots, as well as calculations such as regression analysis, modelling , optimisation of production purpose.
- Ability to modify operational data base at the plant unit level with integrity checking for operator / Engineer entries as well as ability to occasionally add and activate new variables without distributing the rest of the plant unit control system. Ability to add new unit control system continuous or discrete without affecting other units.
- Separable Engineer / Operator interface for accessing and rectifying different parts of the control characteristics for each variable. For e.g., only an Engineer with proper password authorisation may modify tuning constants, where as an operator may set points, limits roll over to manual control etc.,
- Tracking of all operator / Engineer actions by logging them on a large data base.
- Provide all levels of control from the basic monitoring of variables to sophisticated interactive control such as cascade, feed forward and multi variable control.

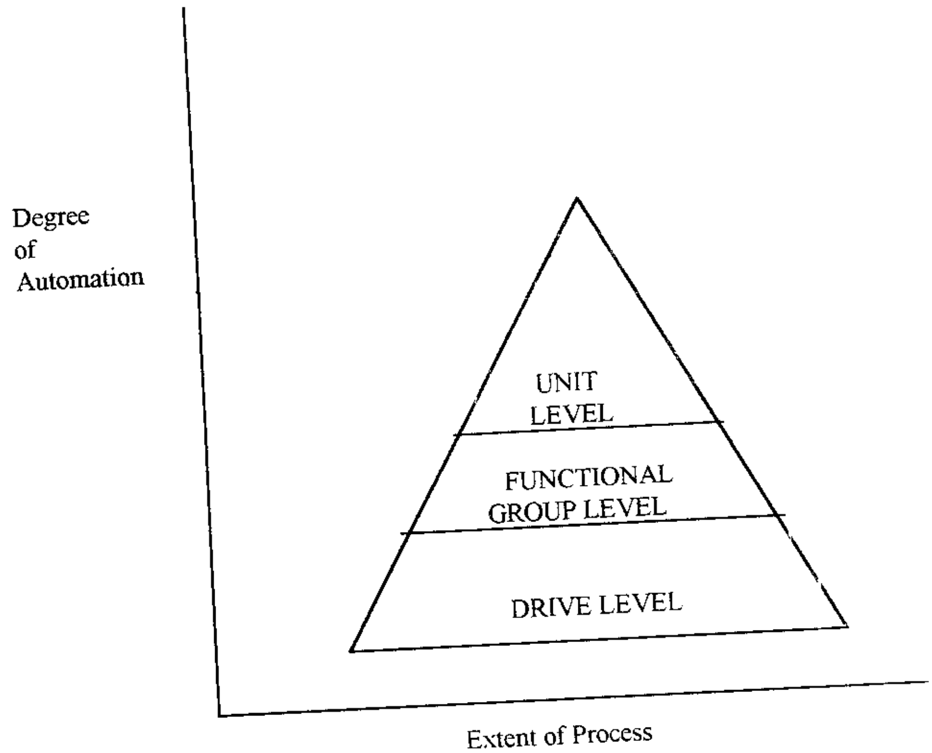


Fig (3.1) **PROCESS STRUCTURE**

CHAPTER 4

PROCONTROL SYSTEMS

4.1 Introduction :

Procontrol P System comprises equipment for controlling monitoring process. It performs all tasks required for process control. Signal Conversion, Transmission, monitoring Binary Control, Analog Control, Protection, and Communication.

Procontrol P has a decentralised hierarchical structure and is based on a digital, programmable control system. A bus oriented data transmission and distribution system, consisting of a local bus and an infra-plant bus. transmits the information between the components of the control and monitoring system. All signals - measured values and commands are checked cyclically and transmitted successively via the bus system.

The point of origin of each signal is connected via short line to the next station where the signal is converted to a digital signal and transmitted to the local bus. The local bus interconnects all modules belonging to a stations.

The station contain Input, output and processing modules. An intra plant bus connects all stations. This bus transmits the signals to all stations from where they are retransmitted to locations where they are required for processing, command output signalling etc., The bus access coupler of the intra plant bus ensures that coupling to the stations is free of feed back. Each intra plant bus line can be in two-channel arrangement should one bus line fail, the signal receiver automatically changes over to the back up bus line. The main concepts of Procontrol P are summarised as follows

- Modular Hardware & software, extended partitioning simple system configuration and programming .
- Extended monitoring functions, hot repair capability

4.2 Structure of Power Plant Process

Analysis of power plant process indicates the advisability of dividing. The complex overall process into individual sub process having clearly defined process functions.

The division of the process into clearly defined group in a horizontally and vertically organised hierarchical process structure as shown in fig 4.1.

The hierarchical structure in the horizontal direction is determined by the number of drives (e.g. Pumps, blower, valves) i.e. the size of the process, in the vertical direction there are basically there hierarchical levels there being the

- Individual Control Level
- Group Control Level
- Process Control Level

At the Individual control level i.e. the bottom level are the equipment drives. The individual group control systems are located at the intermediate level, the group control level, and comprise the individual process unit and their drives. The group control is always at a higher level than the individual control level.

A group is that part of a process that fulfils a particular, clearly defined autonomous task e.g. the supply of feed water. For this reason it is necessary, to choose a designation which defines a particular process task, when identifying a group, example Feed water supply.

At the top level the process control level all control groups interact for the purpose of controlling the overall process.

Individual control, group control and process control levels are process- related terms. They are defined according to the technical process and not from the control engineering aspect.

4.3 Main Design Concepts :

The Procontrol P system has been developed for full utilisation of the serial data bus technique. The main characteristics of this technique are

1. Very high data transmission for real time control.
2. Purely cyclic mode of operation.
3. Redundant, fault tolerant, multi-channel structure.

Due to these characteristics it has become possible to extend the bus technique into the process area (Boiler, etc.) and to obtain a truly distributed control system configuration having.

- Functional distribution of control functions
- Geographical distribution of control hardware.

4.4 Module Overview :

To perform the tasks assigned to it, the Procontrol P system is equipped with modules for the following functions.

- Measured value processing, binary and analog control.
- Data transmission
- Communication between man and the control and monitoring system.

The processing modules are equipped with microprocessors. Any one of the above mentioned functions can be performed by plugging the corresponding module into the stations. Moreover each station is equipped with basic modules for executing data traffic, for fault diagnosis and for power supply.

Fig (4.2) shows the configuration of a station and the different types of module.

All modules contain function - supervision facilities. Disturbance annunciation are retransmitted cyclically to the intra plant bus system.

Further more, the microprocessors of all modules connected to the local bus are capable of self diagnosis the result of which is transmitted as a diagnosis annunciation

4.5 Basic modules :

For the power supply of the station there is a choice between 24-240 V.d.c and 110-220 V.a.c. The stations are connected to the intra - plant bus line via bus access couplers. In the station data is exchanged with the intra - plant bus line via local bus/ intra-plant bus line couplers. As shown in fig (4.3) with this method it is possible to maintain the redundant structure of the data transmission equipment. The data traffic within the station is controlled by the bus traffic director.

The traffic director is self sufficient and independent of the intra-plant bus system. The service case can be connected to the bus via sockets on front of the modules. With this case it is possible, for instance, to charge parameters and to follow or simulate signals.

4.5.1 Input - Modules.

Binary and Analog input modules are available for the input of signals to the Procontrol P system. With these modules it is possible to connect binary transmitters, transducers (0/4 - 20m.A), resistance temperature detectors and throw couples, and can handle any type signal such as single, double throw contact, RTD's, milli amp. There modules have an extended and integrated monitoring capability to detect disturbances which may occur at the module, transmitter level or in the field cabling.

4.5.2 Output Modules :

For the output of signals, both binary and analog output modules are available. These supply output signals are in the form 0/24 V and 0/4-20m.A. In case of disturbance in a measurement loop, the corresponding output module can retain the output status as it was prior to the disturbance or change its status according to a pre-determined position.

4.5.3 Processing Modules :

Procontrol P has two basic types of processing modules.

- Individual control module
- universal processing module

These modules are connected to the local bus, where by one or several of them can be connected to the same bus or to various ones.

*** Individual control module.**

The individual control module is implemented to control, supervise, monitor and protect - one individual final control element of any type (on/off or modulating) such as valves, pumps and fans etc.

This module is equipped with a microprocessor and forms with its built-in input / output a compact and dedicated control entity to control each final control element.

A serial input/output interface to the local bus is available .This link is mainly used to receive process signals required for inter lock and permissive logic, individually programmed within the individual control module. It is also used to interface with the control room operator station and with higher levels of automation units.

Additional and optional input / output capability is provided to interface the individual control module with the control room via hardwired signal cables. The fig(4.4) shows the typical individual control module.

The programmable processor allows to build control, permissive and protection functions which are dedicated to the operating conditions of the final control element. Further more, this processor allows to build extensive monitoring and signalling programs to provide the operating and maintenance staff with relevant data in relation to the status of each single item in the control loop.

The application of individual control modules applies when process availability is of prime importance. Redundant process control elements can be controlled each with a dedicated individual control module. This partitioning capability combined with the capability to allocate each individual control module to any local bus within the plant control system provide a fault tolerate concept and a clear system transparency.

*** Universal processing module**

The universal processing module is implemented for two different type of application, as :

- Automation unit, functionally superimposed on the individual control module.
- Processing unit, performing combined individual control and automation functions.

The universal processing module has a large and fast programming capability. This module can perform all kinds of control algorithms either binary or analog control functions or any macro-functions which is a combination of various basic function.

<u>Implementation of the universal processing module for automation :</u>

The universal module is used for automation, only when drive control modules are used for controlling each individual final control element. In this control concept, the automation is super imposed on the individual control modules and only performs automation functions.

<u>Implementation of the universal processing module for industrial type of control</u>

In many control application, the control strategy does not require an extensive partitioning. In this case, universal processing modules can be implemented to simultaneously perform individual control functions, as well as automation functions. Interface with the process can be done with conventional input/output modules.

4.6 Data Transmission

An importance component of the Procontrol P system is the digital two level serial data transmission system is the digital two -level data transmission system. the so-called

- Intra - plant bus
- Local bus.

Instead of transmitting each measured value and each command via its own cable or cable wire, the signals are transmitted together via a small number of special cable using the multiplex method.

Feature of the bus Systems :

Name	Information bit rate (M Band)	Max. Length (mts)	Application Zone
Intra-Plant bus	0.27	2000	Complete Plant
Local Bus	0.2	30	within the stations

4.6.1 Intra - Plant Bus

This bus system consists of the address transmitter and the coaxial cable. The address transmitter controls the signals transmission sequence, while transmission takes place via the cable.

Input and output of data on the intra plant bus takes place in the stations.

A Bus access coupler links each station to the bus. By segregating the potentials in the Bus access coupler, a disturbance in one station will have no effect on the other stations.

4.6.2 Local Bus

The chief components of the local bus are the Bus traffic director type 70 BV01 and the bus circuit board 70 BL 01. The bus traffic director controls the signal transmission sequence with the circuit board representing the means vice which transmission takes place.

The bus circuit board is a P.C.B. , mounted on the rear of the sub-rack. The Input , output processing modular are connected to the local bus by plugging them into the sub-rack. The local is connected tot he intra plant bus by means of the coupler 70 BIC 02 and the Bus access coupler for the intra plant bus. In this way not only are couplings to redundant intra way not only couplings to redundant intra plant bus lines are possible, but also the coupling of 2 local buses the a BAC, as well an all combinations there of.

4.7 Man - Process Inter face

Procontrol P overall Man - process interface is the actual interface between the plant management operating / maintenance personnel and the process as well as the control system.

The functions of this interface includes

- Operator stations
- Plant monitoring stations
- Engineering station

The function of the man-process interface does not include any control algorithms of the process since there functions are parts of the control and automation package.

The man-process interface works totally independent from the control and automation function to keep a clear overall control system partitioning . The data exchange between this interface and rest of the control and automation system is executed over the intra-pant buses.

The modular concept of the man machine interface offers system flexibility is regard to dedicated conceptual partitioning as shown in fig. (4.5)

4.7.1 Operator station

The operator station consist of two different techniques - Conventional stations with push-buttons, lamps and indicators or CRT - based stations . Both these techniques can be implemented separately where by redundant CRT stations can be implemented or both together.

The conventional station as well as CRT based stations provide the possibility to tune individual control loop as well as automation loops and to perform interface monitoring functions. Such simple indication functions, as tabulations, bar charts, trends ,mimic displays.

4.7.2 Plant monitoring systems :

The plant monitoring system informs the plant personnel of overall plant behaviour and historical data. This data allows the plants management, operator and maintenance personnel to take decision in regard to.

- Scheduling of further plant output
- Operation of the plant
- Recording of plant operational data
- Scheduling of plant maintenance output

The plant monitoring systems provides via CRT, Printer, Hard Copy. Unit or Plotter, Plant Real or Non-real time data or calculated data such as

- Plant efficiency
- Life time calculation and monitoring
- Early detection of beginning deterioration of process components.

These data are indicated either in a tabulation, bar chart, curve or mimic display form.

4.7. 3 Engineering station

The engineering station allows to dialogue and record control system internal disturbances. This station also allows to develop programs, control schemes directly via CRT/Key board.

4.8 System Programming and Configuration

The programming technique is based on oriented language using either standard control symbols or filling the blank technique. This technique combined with the Procontrol P hot repair capability and modular concept allows the power plant personnel, having no background in microprocessor or computer language to maintenance the control system on a 24 hour basis.

Only complex calculation functions e.g. efficiency calculations, require computer language know -how. There calculator are part of the plant monitoring system which has no process /plant control or protection functions. Possible program failure would not have an impact on the plant or control availability.

4.8.1 Programming of Procontrol P Control and Automation System

The control and automation part of Procontrol P offers two basic ways to write programs :

- On a listing basis
- On a functional diagram basis

There programs can be written on a CRT /Key board station e.g. The engineering station

Program listing :

Program listing consists of addressing control functions to the related input /output. This addressing is very simple and since using Alphanumeric codes, easily understandable by anyone. The basic functions used correspond to the control functions AND, OR, ADD etc.

Functional Diagrams :

The programming via functional diagrams consists of developing control schemes which are simultaneously displayed on CRT, the way the plant personnel is used reading them on hard copy.

4.8.2 Program Language.

The actual programs for the control functions (AND, OR, PID etc.) or subprograms for the macro -functions (complex algorithms) are resident in a memory of each individual processing module.

The creation of control schemes consists of addressing there functions and their related input/output with this technique, control schemes only have to be checked in regard to the association of the control functions and not the correct execution of each functional program. This technique presents a great time saving during the reconfiguration of control schemes.

4.9 System Internal Monitoring and Diagnostic Capability, Alarming :

Procontrol P has an extensive monitoring and diagnostic capability, covering control internal and system peripheral equipment. This capability, has been distributed at the electronic module level. The combination of this Capability with other system techniques, such as

- Modular hardware, Software structure
- Clear Segregation between data processing and transmissions functions.

Confines system disturbances at the electronic board level, presenting disturbance propagation within the control system. Consequently each PROCONTROL P electronic module is an operating entity.

Since they are the prime elements in plant control and protection special attention has been paid to :

- Input/Output modules
- Individuals control & universal processing modules
- Data transmission network

The selection of fast cycle mode of operation for all these individual elements has been dictated by the need for a deterministic type of operations.

This deterministic type of operations offers an optimal way to monitor running functions and systems elements. The combination of the cycle mode of operation and built in monitoring functions at the board level leads .

- To detect and annunciate disturbances at the time they occur and not at the time the control function is needed by the process.
- To remove possible erroneous transmission of the transmission path.

The fast cycle mode of operation provides a fast failure recovery feature without inhibiting or delaying other transmissions.

4.9.1 Trouble Shooting :

Procontrol P basic trouble shooting procedures consist of replacing distributed modules or programs with corresponding new ones. It can be executed on 24 hrs basis without the need to switch off the process/plant . It guarantees

- Active control, protection of functions / loops to remain operational during the entire trouble-shooting procedure.

4.10 System Data :

1. Configuration

Intra plant bus

Arrangement of intra plant bus lines	Independent, line arrangement	
No. of intra plant bus lines	Maximum	16
Length of an Intra Plant Bus line measured from the address transmitter	Maximum	±1000m
No. Of station per Intra Plant Bus line	Maximum	64
No. of stations per entire control and monitoring system	Maximum	1024

Local Bus

Length of a local bus line	Maximum	3m
With additional modules	Maximum	30m
No. of modules per local bus	Maximum	64
Distance between intra-plant bus access coupler & local bus / intra plant bus coupler	Maximum	3m

2. Data Transmission :

Intra - Plant bus

No. of address for a maximum of 64 stations	256 x no. of stations 16384 address
Time required to transmit 1 telegram	60 Ms typical
Information bit rate	266.7 K Baud typical
Signal Code	DPDM
Amplitude	+ 15v
Data Security via	Parity bit, counting of binary characteristics monitoring of time and amplitude per bit
Transmission means	
- Co-axial cable type	RG 213U
- Characteristic Impedance	50 ohms

Local bus

Service address	2 every 10 ms
useful address per cycle for a cycle time of 5 ms	64
useful address per cycle for a cycle time of 10 ms	128
Information bit rate	204.8 B K Baud
Type of modulation	Pulse modulation
Amplitude	-10V low active
Data security via	Parity bit, clock monitoring, data valency on local bus, address cycle, watch dog timer,
Transmission means :	
- Within a sub-rack	Prefabricated P.C.B., type, 70 BL O1
- Between 2 sub-rack	Prefabricated round cable, type 70 BL 02
- Between 2 cubic	Prefabricated round cables type 70 BL O3

3. Input and output

Analog signals

Module signals	0/4 to 20 mA 100 ohms input resistance - 10 to +10 V, 100 K ohms input resistance
Module output	0/4 to 20 mA 500 ohms maximum Permissible load -10 to +10v 4 mA load capacity

Binary Signals

Module inputs

Permissible voltage for "0" signal	-30 to +3v
permissible voltage for "1" signal	11.2 to 30 v
Standard Input resistance	15 K ohm (appro.) 1 standard
Delay	Typical value 6 milli seconds

Contact inputs

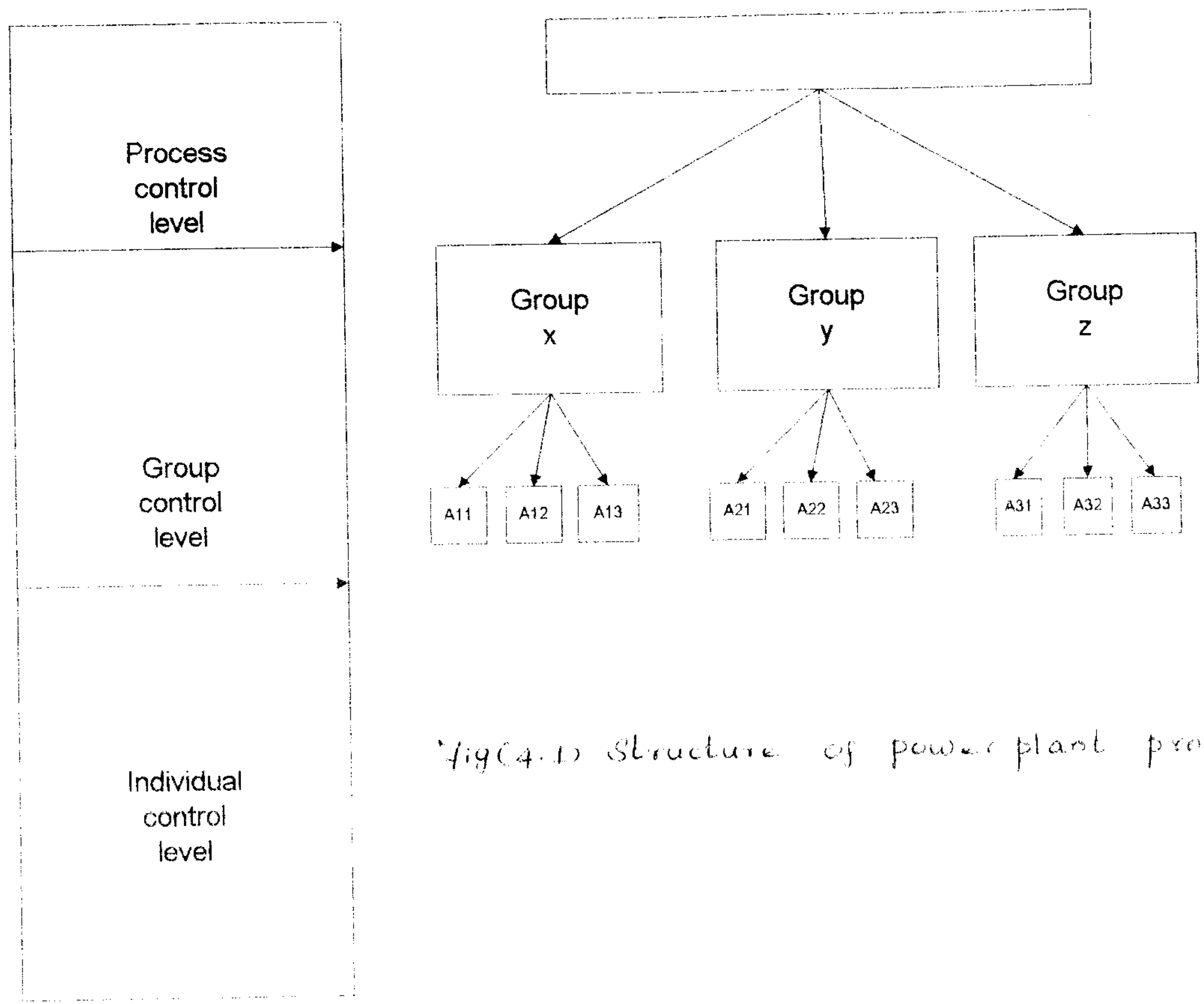
Voltage between the module terminals with open contact	48 vdc
Contact current for closed contact	5 mA
Permissible link resistance (outgoing and incoming leads)	<= 90 ohms

Modules Outputs

"0" signals	0 to + 1V
"1" signals	11.7 to 30 v fo5 +1NL output 13.7 to 30v for outputs >= 3 NL

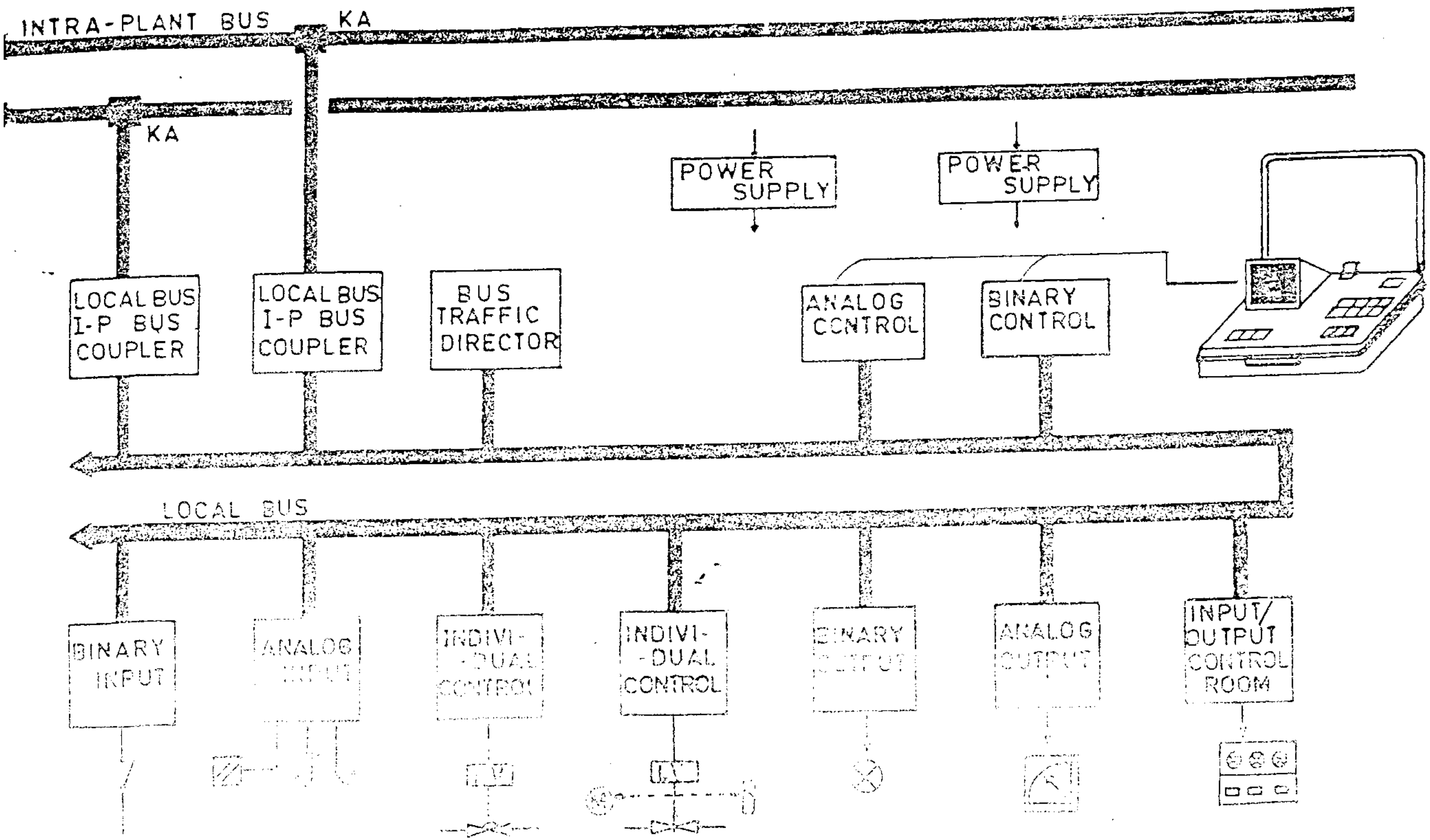
4. Power supply :

operating voltage static	19.5 to 30 Vdc (operating limit)



Fig(4.1) Structure of power plant process

Fig(4.2) CONFIGURATION OF A STATION



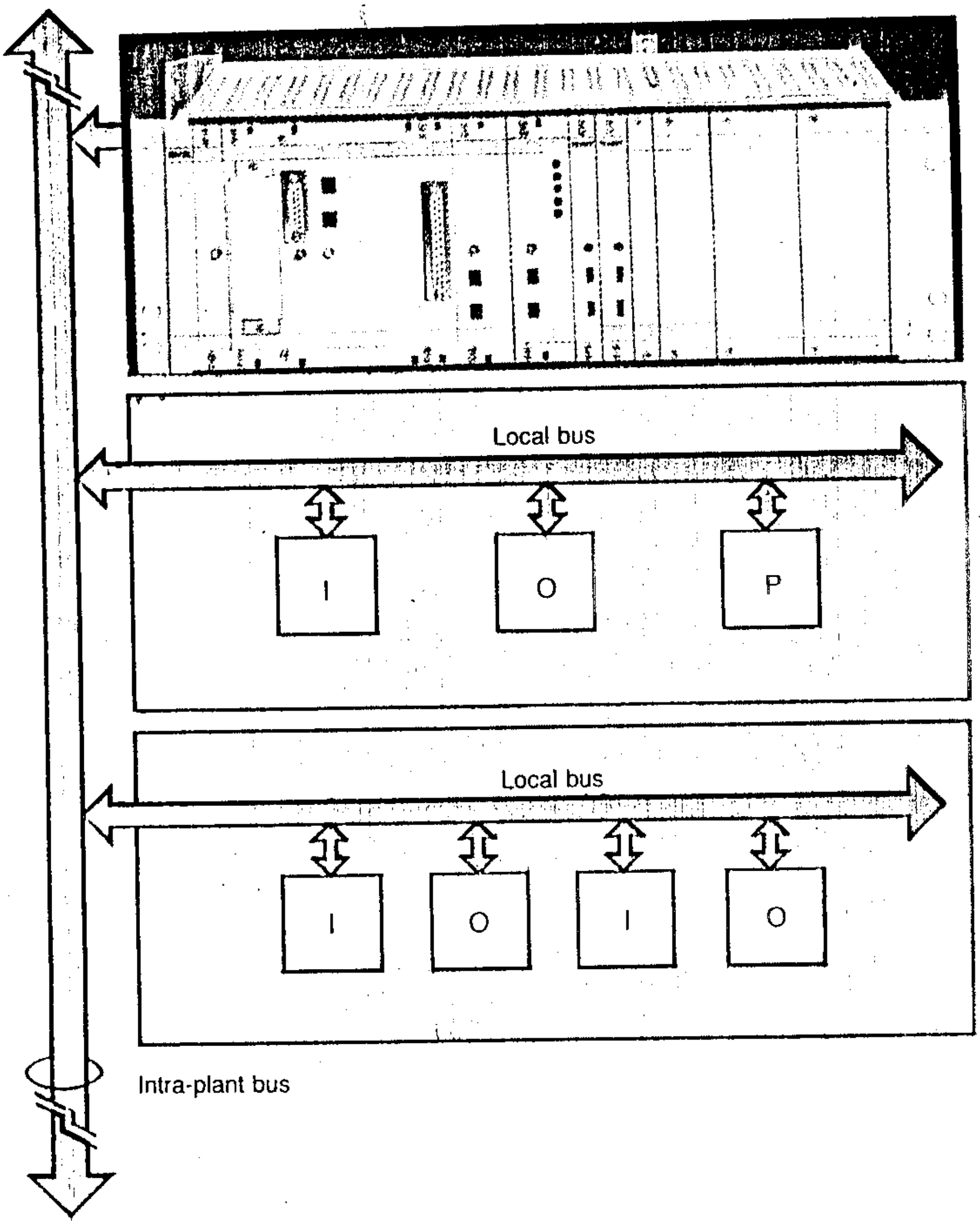


Fig (4.8) PROCONTROL P. BUSES

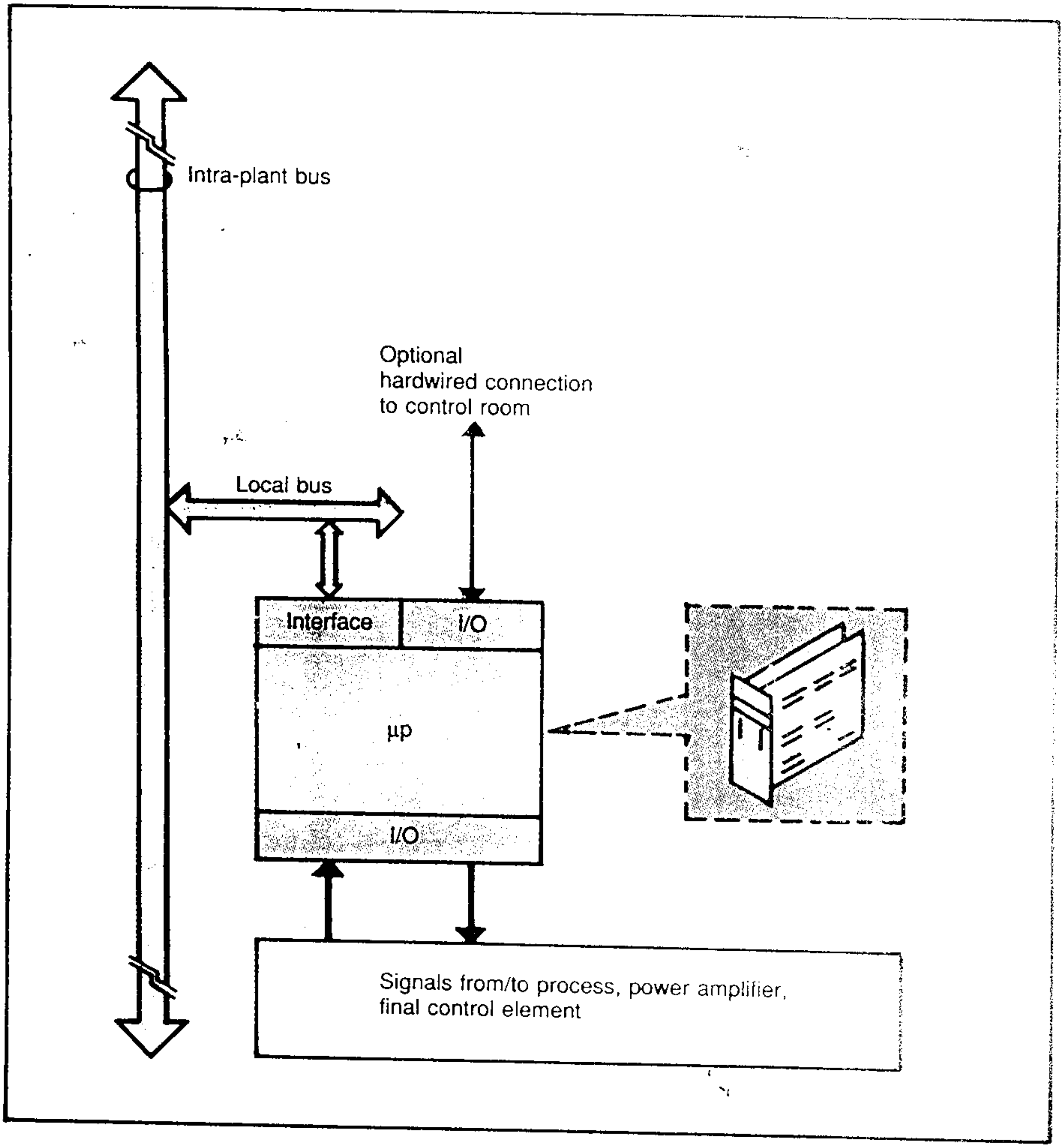


Fig (4.4) INDIVIDUAL CONTROL MODULE

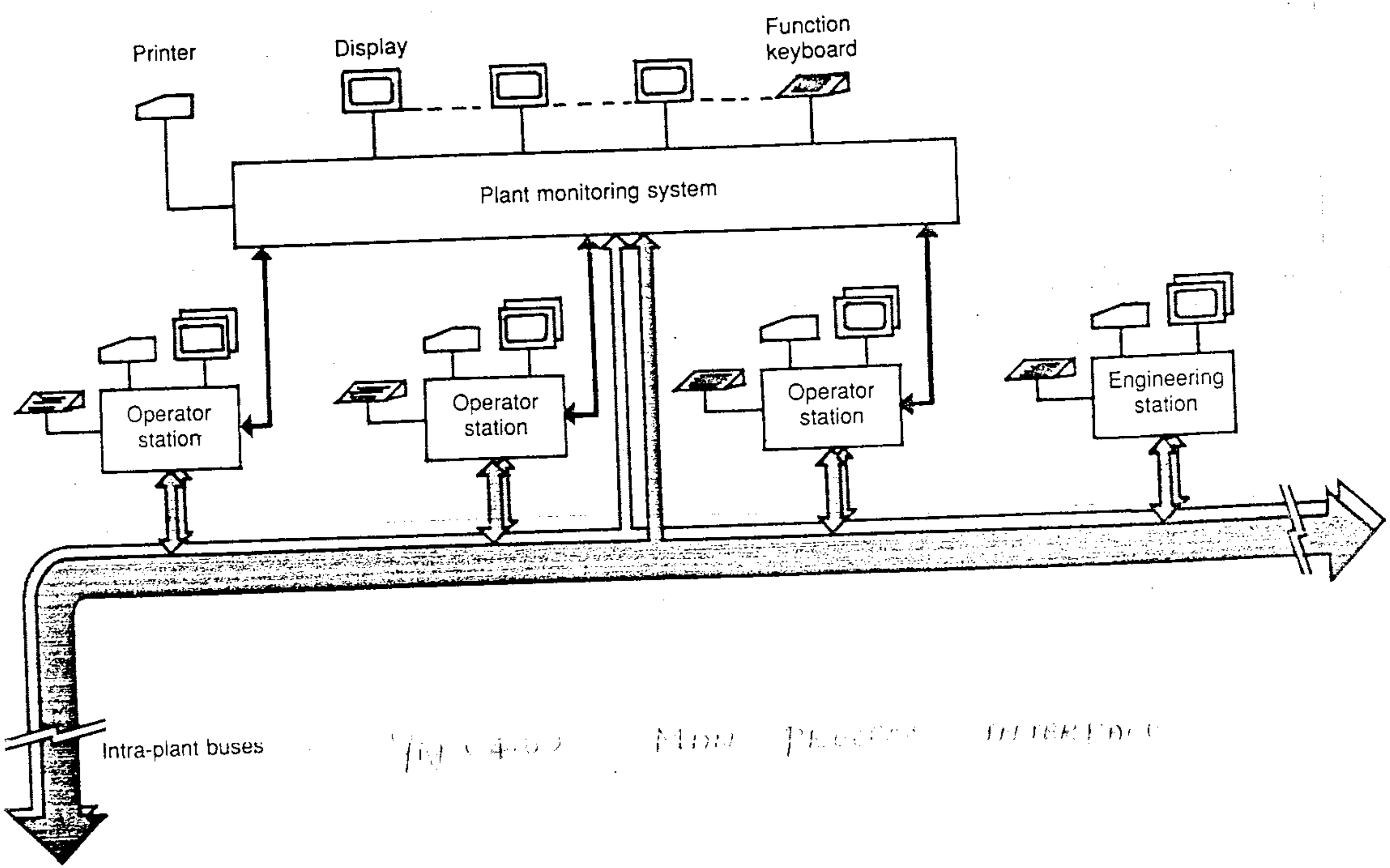


Fig [illegible] Man Process Interface

CHAPTER - 5

BOILER AUTOMATIC CONTROLS

5.1 INTRODUCTION

The Boiler is one of the most essential element in Thermal power station. The Boiler has following primary requirements like

- The Boiler must be capable of producing and maintaining the desired steam pressure safely.
- The boiler should be capable of delivering safely the steam at the desired rate, pressure, temperature and quality.
- The Boiler must be capable of quick starting and loading.
- The Boiler must be capable of burning high ash content coal efficiently.

Hence for this purpose it should have some control system available to work efficiently. There are many automatic control loops for the proper functioning of the Boiler. Some of the control loops are given below in brief :

1. Feed water control 2. P.A. Header Pressure Control 3. Mill outlet temperature and Airflow control 4. Combustion control 5. Fuel flow control 6. Air flow control 7. SCAPH steam flow control 8. SH steam temperature control 9. RH steam temperature control.

FEED WATER CONTROL

The objective of this control system is to maintain the Drum level to the normal water level at all loads. At lower loads [less than 30% MCR] start up feed control valve is used and at higher loads full load feed control valve is used as final control element. If the full load feed control valve is taken for maintenance, standby feed control valve will be used.

Drum level is measured at left and right side of the drum with level transmitters through temperature compensated constant head unit. The pressure compensated drum level signal may be averaged or anyone may be selected for control. Excessive deviation between left and right side is alarmed and the control shall be tripped to manual.

P.A. HEADER PRESSURE CONTROL

Main objective of this control is to adjust the PA header pressure. According to the feeder speed . That is out of all the feeders, the feeder speed which is higher than that of others is considered as set valve for this control.

MILL OUTLET TEMPERATURE AND AIR FLOW CONTROL

Objective of this control system is to adjust the mill air flow according to the feeder speed and to maintain the mill outlet temperature at the constant set valve. Mill air flow is maintained by adjusting the hot air regulating damper while the mill outlet temperature is maintained constant by adjusting the cold air regulating damper.

COMBUSTION CONTROL

Objective of this control is maintain the turbine throttle pressure constant at the desired Valve by adjusting the firing rate [Both fuel flow and air flow].

AIR FLOW CONTROL

The secondary air flow is measured at left and right side of the ducts of wind box by means of Aero-foils. Each flow will have pressure and temperature compensation . The flow is linearised by means of square root extractors. The total PA flow , obtained by summing the air flow through each will in service is added to obtain total air flow to the Boiler. This signal is compared with the developed set point.

FUEL FLOW CONTROL

Fuel flow demand from combustion control and air flow signal, air flow control connected for fuel air ratio are compared and the lower is selected for the set point of the fuel flow controller (lead - lag system). This is to ensure that under any circumstance the fuel flow should be lesser than the air flow.

SCAPH - STEAM FLOW CONTROL

This control system is applicable if the SCAPH steam flow is provided with flow control value if a manual regulating value is provided, this control system is not applicable.

SH/RH - STEAM TEMPERATURE CONTROL

Steam temperature control is provided by a combination of burner nozzle. Title positioning and SH, RH De-Super heating spray. Steam temperature is maintained by allowing nozzle tilt to respond to the lower of either SH or RH outlet temperature, with spray responding to the higher.

5.2 FURNACE DRAFT CONTROL

The main objective of the control is to maintain the furnace pressure constant at the desired set value at all loads. This is achieved by changing the flow of flue gas by changing the flow speed through VFD. Furnace pressure is measured by the transmitter and medium value auto selector is used to select the mid value. Recommended control range for the pressure transmitter is -50 mm w.c. to +50mm w.c. Excessive deviation, between the mid valve selector and individual transmitter output is alarmed. Excessive furnace pressure is monitored for directional block on Induced Draft Fans (ID) and Forced Draft fans (FD). Furnace pressure is compared with set point and error will have proportional and integral action. FD fan demand signal is added as a feed forward feature. MFT feed forward feature is provided to minimise negative furnace pressure excursion. Separate auto/manual station and speed indicator for each ID fan regulating device is provided.

To have equal loading of the ID fans, each ID fan motor current is measured, averaged and compared. The difference is used for taking corrective action. The connected signal is used to position the ID fan regulating units. Fig 5.1 shows the schematic diagram of Furnace Draft Control.

Following improvements may made for the effective Furnace Draft Control :

- A low pass filter, after the pressure transmitter to avoid transmit surges for stable control, shall be included.
- In order to assure instantaneous response of the furnace draft control system to the negative furnace pressure excursion which accompanies a Master Fuel Trip (MFT) the use of feed forward feature is recommended, when ever MFT occurs. This feed forward feature instantaneously biasis the demand signal to the VFD control of fan motors towards min speed by an adjustable amount. This bias is gradually removed over an adjustable time period, thus allowing the normal draft control to take over completely.
- It is recommended to provide directional blocks on both ID & FD fan controls. Excessively low furnace pressure, blocks further increasing of ID fan speed and further closing of FD fan control device. Conversely excessively high furnace pressure, blocks further decreasing of ID fan speed

and further opening of FD control devices. High/ Low alarm direct pressure switches and transmitter switches must agree for directional blocks. Directional blocks are to be included after manual auto stations.

- Furnace pressure transmitter range for control shall be - 50 mm to + 50 mm w.c.
- ID fan control devices may be selected for release to auto to operate with boiler interlock signal.

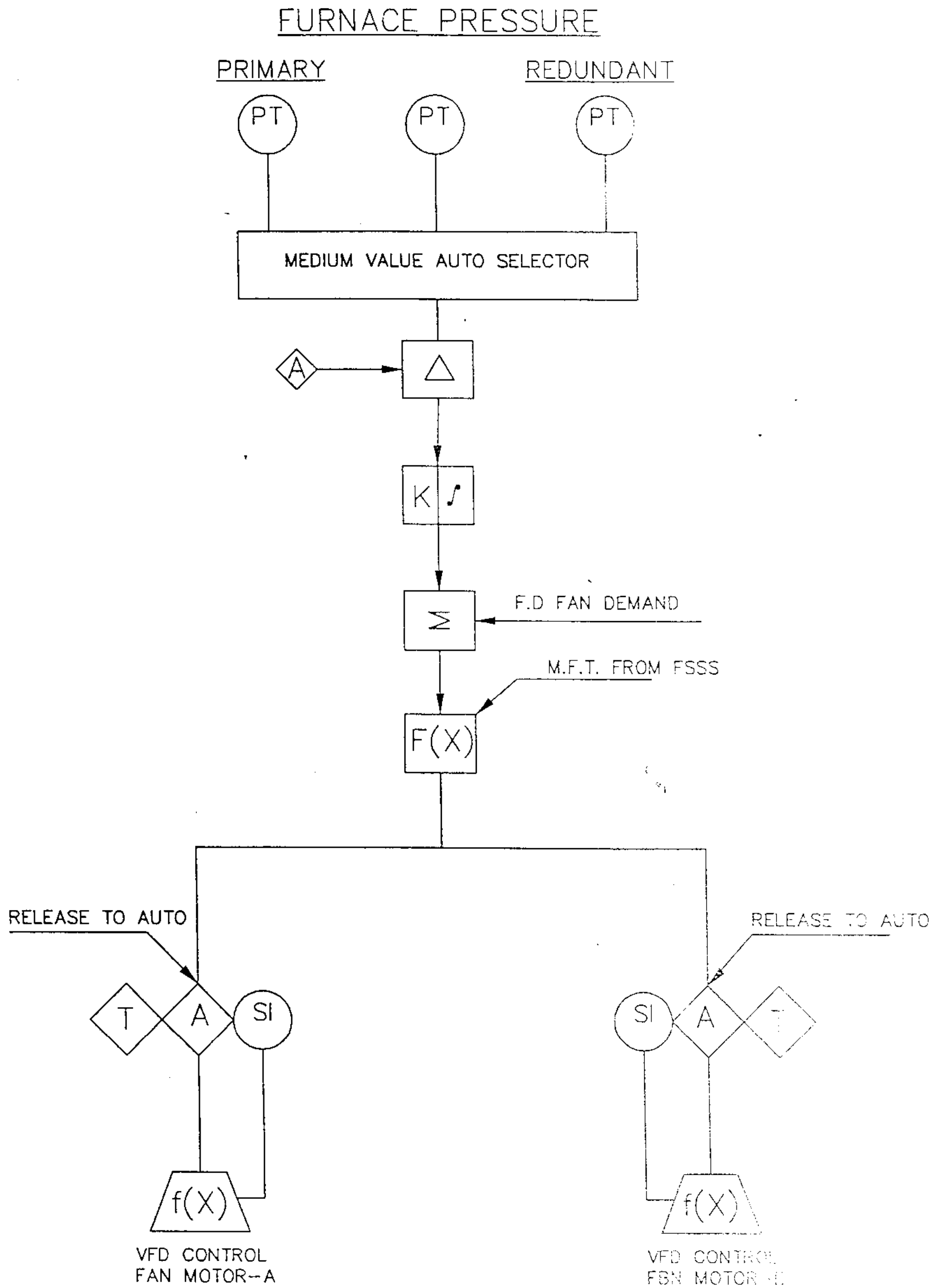


Fig 5.1 FURNACE DRAFT CONTROL

CHAPTER - 6

SOFTWARE

All the features of microprocessor based control system are implemented using personal computers. Computers have their own advantages as they possess high speed and occupy less space with very large memory capacity. Use of computers in a control room greatly reduces the manual labours together with the fast detection of faults.

The software has been developed in "C" language for the tripping up of a boiler, while it is running. The conditions which could cause the tripping of the boiler is as follows :

1. Forced drive fan's off
2. Induced Draft fan's off
3. Emergency trip
4. Furnace pressure high
5. Furnace pressure low
6. Turbine Tripped
7. Drum Level High
8. Drum Level Low
9. Air Flow < 30%
10. Flame Failure

If any of the conditions fails, the Boiler will trip. After the boiler trips it has to be restarted. The system will wait till the conditions required to start the boilers are ready and it indicates the readiness of the boilers for starting,

Now with purge command start, Boiler will be started. If there is a trip, then it is indicated in the PC monitor.

The results got from the software for the conditions specified are shown in the fig 6.1 and 6.2

```
/*                    "PROGRAM TO CONTROL BOILER "                    */
#include <graphics.h>
#include <conio.h>
#include <stdio.h>
main()
{
int gm, gd=DETECT;
int a1,a2,b1,b2,b3,b4,b5,b6,b7,b8,b9,b10,op;
printf ("\n      GIVE THE INPUT FOR EVALUATION:- \N");
printf ("\n F.D Fans Off:");
scanf ("%d",&b1);
printf ("\n I.D Fans Off:");
scanf ("%d",&b2);
printf ("\n Emergency Trip :");
scanf ("%d",&b3);
printf ("\n Furnace Pressure :");
scanf ("%d",&b4);
printf ("\n Furnace Pressure low :");
scanf ("%d",&b5);
printf ("\n Turbine Tripped :");
scanf ("%d",&b6);
printf ("\n Drum Level High :");
scanf ("%d",&b7);
printf ("\n Drum Level Low :");
scanf ("%d",&b8);
printf ("\n Air Flow < 30% :");
scanf ("%d",&b9);
printf ("\n Flame Failure Trip :");
scanf ("%d",&b10);
printf ("\n Input 1 :");
scanf ("%d",&a1);
printf ("\n Input 2 :");
scanf ("%d",&a2);
b2=a1&&a2;
```

```
op=b1¦¦b2¦¦b3¦¦b4¦¦b5¦¦b6¦¦b7¦¦b8¦¦b9¦¦b10;
clrscr();
initgraph(&gd,&gm,"c:\tc\bgi");
setcolor (WHITE);
line(10,30, 50,30);
line(50,30, 50,50);
line(10,50, 50,50);
line(10,30, 10,50);
line(15,38, 45,38);
line(30,34, 30,38);
circle(20,42,0.3);
circle(40,42,0.3);
line(50,40, 80,40);
line(80,38, 80,72);
line(80,45, 100,45);
line(100,45, 100,55);
line(100,55, 80,55);
line(80,70, 50,70);
line(50,60, 50,80);
line(10,60, 10,80);
line(10,80, 50,80);
line(10,60, 50,60);
line(15,68, 45,68);
line(30,64, 30,68);
outtextxy(110,2,"BOILER TRIP PROTECTION");
outtextxy(100,11,"F.D FANS OFF");
outtextxy(100,31,"I.D FANS OFF");
outtextxy(100,51,"EMERGENCY TRIP");
outtextxy(100,71,"FURNACE PRESSURE 'HIGH'");
outtextxy(100,91,"FURNACE PRESSURE 'LOW'");
outtextxy(100,111,"TURBINE TRIPPED");
outtextxy(100,131,"DRUM LEVEL 'HIGH'");
outtextxy(100,151,"DRUM LEVEL 'LOW'");
outtextxy(100,171,"AIR FLOW < 30%");
outtextxy(100,191,"FLAME FAILURE TRIP");
outtextxy(360,55,"RESET MFR TO");
outtextxy(360,145,"BOILER TRIP");
```

```
outtextxy(424,90,"MFR");
outtextxy(580,55,"BOILER");
outtextxy(580,62,"TRIP");
outtextxy(10,22,"I/P.1");
outtextxy(10,88,"I/P.2");
circle(20,72,0.3);
circle(40,72,0.3);
line(100,10, 320,10);
line(100,30, 320,30);
line(100,50, 320,50);
line(100,70, 320,70);
line(100,90, 320,90);
line(100,110, 320,110);
line(100,130, 320,130);
line(100,150, 320,150);
line(100,170, 320,170);
line(100,190, 320,190);
line(320,5, 320,195);
circle(360,100,40);
line(400,100, 560,100);
line(420,80, 460,120);
line(460,80, 460,120);
line(420,120, 460,120);
line(420,80, 420,120);
circle(600,100,40);
if (op==1) floodfill(600,100,WHITE);
else floodfill (600,100 BLACK);
getch();
closegraph();
}
```

GIVE THE INPUT FOR EVALUATION :-

F.D Fans Off :0

I.D Fans Off :0

Emergency Trip :0

Furnace Pressure :0

Furnace Pressure Low :0

Turbine Tripped :0

Drum Level High :0

Drum Level Low :0

Air Flow < 30% :0

Flame Failure Trip :0

INPUT 1 :0

INPUT 2 :0

For the above inputs the boiler is not tripped and the corresponding output is shown in fig. 6.1.

GIVE THE INPUT FOR EVALUATION :-

F.D Fans Off :1

I.D Fans Off :1

Emergency Trip :1

Furnace Pressure :1

Furnace Pressure Low :1

Turbine Tripped :1

Drum Level High :1

Drum Level Low :1

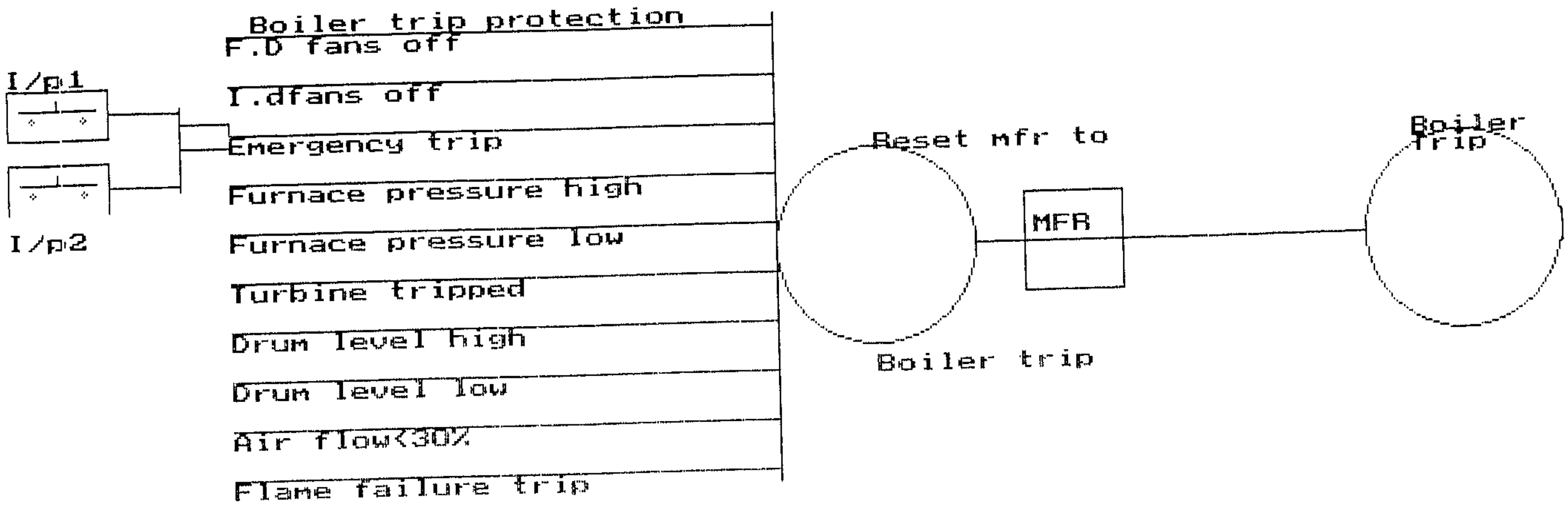
Air Flow < 30% :1

Flame Failure Trip :1

INPUT 1 :1

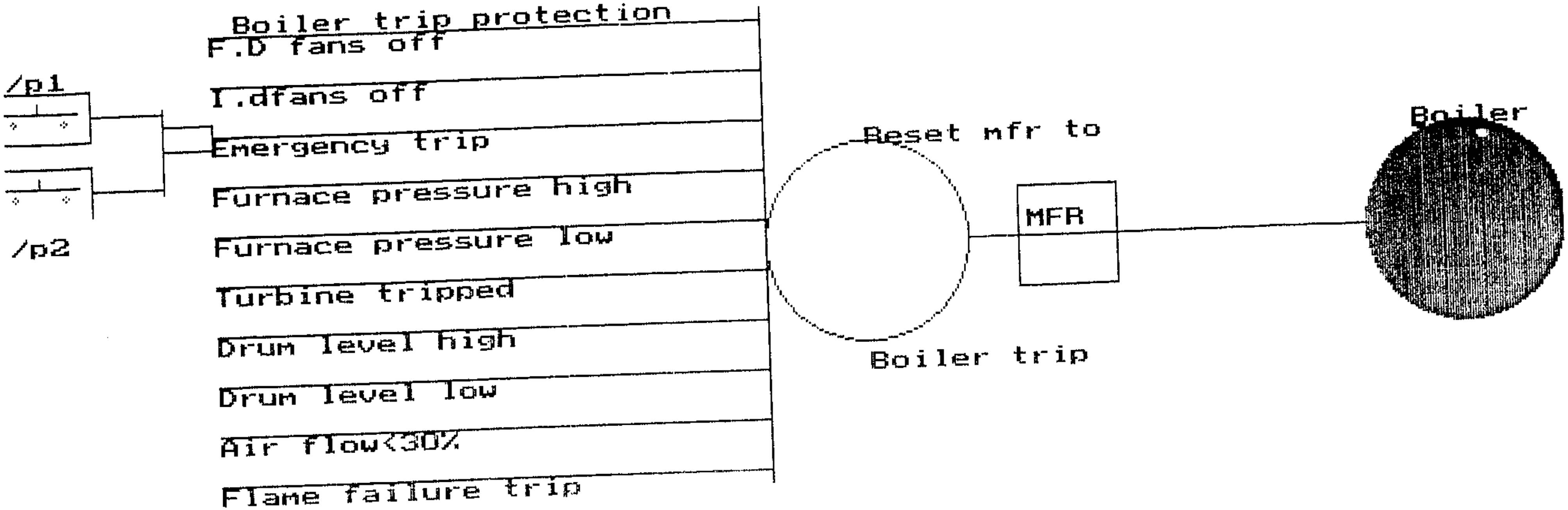
INPUT 2 :1

For the above inputs the boiler is tripped and the corresponding output is shown in fig. 6.2.



Boiler trip protection
F.D fans off
I.dfans off
Emergency trip
Furnace pressure high
Furnace pressure low
Turbine tripped
Drum level high
Drum level low
Air flow<30%
Flame failure trip
I/p1
I/p2
Reset mfr to
Boiler trip
MFR
Boiler trip

Fig (6.1)



Boiler trip protection
F.D fans off
I.dfans off
Emergency trip
Furnace pressure high
Furnace pressure low
Turbine tripped
Drum level high
Drum level low
Air flow<30%
Flame failure trip
/p1
/p2
Reset mfr to
Boiler trip
MFR
Boiler

Fig (6.[illegible])

CHAPTER 7

CONCLUSION

Distributed Automation in the process industries improves the functioning of the system. The increased Data acquisition, wide control flexibility, faster control, feed forward control extra are in-built, in the system. In the distributed system geographical distributed or functionally distributed systems are envisaged.

The Automation by Distributed Digital Control reduces the operating error and the defined parameters are very few. This enhances the operators dependability and there by increases the reliability .

The distributed digital control has got comparable advantages features over the ordinary centralised control systems and we could gain good knowledge of the above from this project. The software developed in "C" language for monitoring the operation of the Boiler for different input conditions is found useful.

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