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MICROPROCESSORS IN PROCESS CONTROL

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INTRODUCTION

The development — the microprocessor, or so called "computer-on-a-chip" — ushered in a new era in electronics. It has revitalized the mature industries and is playing an increasingly prominent role in our daily lives.

The microprocessor and other semiconductor products are helping to reverse a trend of declining productivity that has plagued the world's industrialised nations. The microprocessor is resulting in products that are smaller, more reliable, use less energy and are less costly than their predecessors.

The instrumentation and control industry is currently witnessing a switch from conventional analog controls to newer technologies such as digital, microprocessor — based and distributed systems. This shift in emphasis is proceeding much faster than any previous shift in process control technology. For example, the shift from local control to central control and from pneumatic to electronic technologies took place over extended periods of time, both lasting nearly a decade. Currently, the acceptance of microprocessor — based technology is rapidly replacing conventional centralized analogs (electronic and pneumatic) with distributed digital control systems.

The speed at which distributed control is gaining acceptance can be attributed to several factor :—

i) the need for more sophistication and precision in control systems to get maximum yield from a process;

ii) the pressing need for clearer, simpler aids for operator;

iii) the need to control the rapidly escalating costs, particularly those associated with the physical installation of control systems, such as cabling and control room; and

iv) the clear acceptance of microprocessor technology by broad segments of industry and by the instruments and control engineers in particular.

DEFINITIONS :

Distributed control system :- The most obvious form of distributed control is the system in which each loop controller is physically located on the process close to the control actuator and measurement senser for that loop.

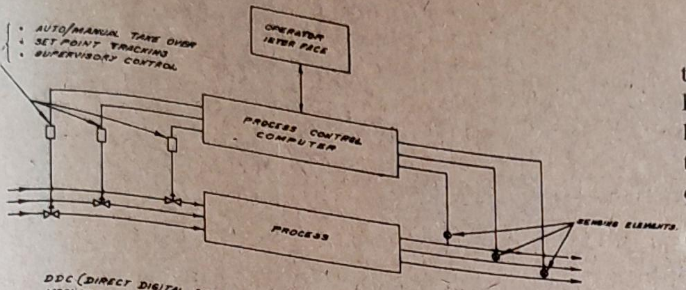
Centralized control system :— When all the loop controllers have been brought together in central control room in order to centralize the loop display instruments integral to the controllers.

Centralized computer control :— A single central computer is used to control all the loops while the loops simulated one at a time in sequence and the calculated control output held until the next time the same loop was scanned for control. Computers were so unreliable that two or some times three computers were seen in parallel so that in case one fails the other should take care of the control.

Three decades of process control History :

(a) Pneumatic Controllers — Before 1950 most automatic control in the continuous process were truly distributed. The difference was that they were not integrated systems, but rather a too-far-flung and disorganised set of independent control loops. Thus, a flow controller could be mounted on the process unit it controlled. Perhaps on the very same pipe in which it controlled the flow rate and very near the differential pressure taps sensing the flow rate and the valve being adjusted by the controller. Along with the controller recorder was also mounted to see that the process and controller were alright when the operator was attending some other part of the process, also in addition it provided a record of an overall performance of the process and comparision with other parameters. So what an early process control needed most was a way for the plant operator to see his all real time indicators at-once.

All the early control loops were mechanical in nature, sensing the physical motion of a diaphragm or bourdon tube or a diaphragm or piston actuated valve stem. The development of pneumatic amplifiers which operated at low pressures, and standardization of input pressure range 3-15 psi accepted indicators, controllers and recorders led to a wide spread use of pneumatic signal transmission used by industrial process controls. This pneumatic signal trans-



DDC (DIRECT DIGITAL CONTROL) WITH HARDWARE BACK-UP. THREE TYPES OF BACK-UP MECHANISMS PROTECT AGAINST COMPUTER FAILURE: AUTO/MANUAL TAKEOVER, SET-POINT TRACKING, AND SUPERVISORY CONTROL

Fig. 2

With setpoint tracking devices, the set point tracked the process measurement when the computer was running. In the event of a computer failure, the backup device would take control at the last setpoint and measurement values. An auto/manual function was also available, thereby allowing three levels of process control — direct digital control, local control and manual intervention. With supervisory control in contrast, the computer provided a set point only to the hardware controller, which was responsible for all control functions.

Regardless of the backup mode, new problems arose. Backup reduced the advantage of direct digital control over conventional hardware. Cabling was also a difficulty. For each computer and backup device to have all the information required a substantial amount of hardwiring was needed between devices. Furthermore, when the operator had two different interfaces and one of these might not be used for months of a time, ease and effectiveness of operator control were bound to suffer.

The centrally located process computer in DDC made the sophistically integrated control availabe, its complex software structures required extremely time consuming efforts at all the design, programming, commissioning, maintenance and extension stages.

(c) **Distributed control :—** The beginning of the trend of distributed control came from the desire to reduce the number of wires connecting all the sensors and actuators, in an individual plant leading to central control room.

The most obvious form of the distributed control is the system in which each loop controller is physically located on the process close to the control actuator and measurement sensor for that loop. It is just opposite to the earlier control systems where loop controllers were brought to the control room in order to centralize the loop display instruments integral to the controllers. Since each loop controller is handling individual loop only, the loss of that controller hardware or software will not cause dangerous operational conditions on other controllers or plant shutdown.

Putting the controller near the process has one major benefit of reduction in cabling cost. In addition, the progress loop itself is physically shortened. This reduces the possibility of physical damage due to unforseen accident (the long cables some times get deteriorated because of the environment through which they are passing, for example, many times the long cables get damaged because of oil socking, due to chemicals etc.). Also the shorter cable length makes the signal less susceptible to electrical noise.

The central control room houses the central operators stations, which is merely supervisory, but from which all the loop variables can be viewed and all loop controller tuning constants can be changed or set. Each control loop operates independent of any information from the control room.

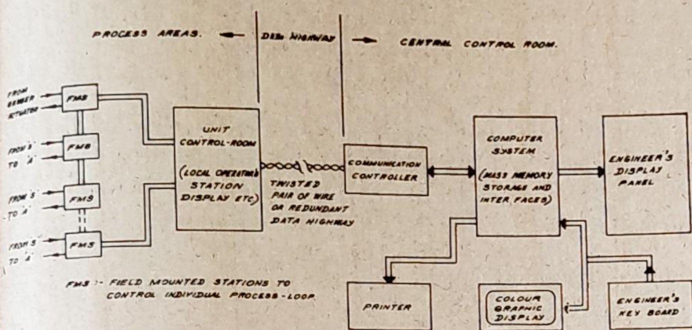
All field mounted loop controllers or out stations are connected to the unit control room with the help of data-highway which consequently leads to the control room. Loss of long, usually redundant, digital databus or highway means loss of only the operator intelligent, but the controllers continue to operate locally.

A hypothetical model of Distributed control :—

Each controller in itself is a small computer on a chip, called microprocessor, controlling a single process or control loop. The controller is sealed in an environmental sealing to protect it from any kind of damage and is made capable for operating in industrial temperature range.

The advent of microprocessor, plus the development of standardized communication techniques for connecting the various parts of a systems, have now made it possible to design cheaper distributed system of this type using remote microprocessor based outstations. For example, the control-room may consist of a central minicomputer (i.e. like PDP-11) which is supervisory in nature and the different out stations may be 8085 based cards designed to withstand industrial environments. The out-stations can be situated at any distance from the central computer and communication can be via normal two twisted wire link or optical fibre. The later giving a very good noise free link.

The overall system is designed to monitor plant parameters, including analog values (temperature, pressure, flow etc.) and digital states (on|off, running etc.) and to initiate control outputs alarm sequences and information recording or display in a variety of formats. The central computer can be linked with a range of peripherals (Fig-3), which in a typical system would include one or two printers, one or two alphanumeric display panels, an operators control panels, a seperate engineers keyboard for set point adjustments etc. and a colour graphic display.



A HYPOTHETICAL MODEL OF DISTRIBUTED CONTROL SYSTEM

FIG.-3

Day to day running of the system is normally performed by an operator from the operator control panel. This panel would typically be designed to fit in with the existing control room layout and ergonomics, and would contain keys and indicators labelled with their functions, so that existing operators can understand it without specialized training. This means that operation is simple, convenient and fast — an important consideration in alarm or emergency conditions.

The engineers keyboard is for modifications to be carried-out for adjustment of setpoint, alarm limits, display conditions when the system is on-line. Bubble memories can be used in the central computer for fast response and large amount of data storage. It can then be printed or displayed on colour graphics.

Remote intelligent out-stations can be located at different points around the plant and each can moniter and control a different number of parameters. However, they are all identical in mechanical format, consisting of a series of micro processor cards linked by a standard bus. All decoding, addressing, bus input|output electronics and control output cards are common to each out-station, and signal conditioning cards can be selected and plugged into allocated slots within each unit to handle the appropriate monitoring functions. A programmable Read only Memory (ROM) in each unit provides the addressing for each application. Communication between the central computer and the remote outstations is handled serially using a RS-232C link or 20 mA current loop. The characteristics and protocol format of the bus are standardized to follow ASCIIP code.

The centralized control system concept bring all loop indicators into the control-room for integrated plant operations. The problem is that controllers are in control-room, so loops are long and vulnerable to noise and damage. Total wiring or tubing is excessive and costly. The fully distributed system mounts each loop controller in the field and reduces plant control wiring to an absolute minimum, while still maintaining full plant information and supervising control in the central control room. In short :—

1) the autonomy of the local controllers allow the reliability and simplicity of structure of generation-1 schemes to be attained without special provision being made.
2) Inter communication to local controllers from control room via data high-way allows integrated control of the process as in generation-2 systems, and
3) the complete system can be configured, commissioned and operated without the need for extensive software efforts. The system can be readily expanded and modified.

There are many varieties of microprocessor based single loop controllers available from different suppliers, among them few are listed below :

1. Single loop controller from Bailey Controls Co.
2. Series 8800 by Esterline Angus.
3. Provox single loop controllers by Fisher Controls Co.
4. 270D series from Foxboro Co.
5. Homae 300 series by Hokushin Electric Works Ltd.
6. Model 2300A by Iveron Pacific Corpn.
7. The H-Bc by Kent Process Control Ltd.
8. Model MSI-140 by Microcomputer System Inc.
9. The 5620R by Taylor Instruments Co.
10. TDC — 2000 from Honeywell.

References :—

1. 'DDC experience in a chemical process', by J.W. Bernard and Wujkowsky, 20th Annual ISA conference proceedings — 30.1.3.65 vol. 20 1965.
2. R.D. Garten "Microprocessor based Instrumentation from the operations point of view", AKHE meeting, Houston, Texas 198.
3. S. Chandra "Communication network for distributed data acquisition and control in industrial plants", IEEE trans. Ind. Elect. cont. Inst., August 1978.