

Control Configuration System as a Key Element in Distributed Control System

Goodarz Sabetian, Sajjad Moshfe

Abstract—Control system for hi-tech industries could be realized generally and deeply by a special document. Vast heavy industries such as power plants with a large number of I/O signals are controlled by a distributed control system (DCS). This system comprises of so many parts from field level to high control level, and junior instrument engineers may be confused by this enormous information. The key document which can solve this problem is “control configuration system diagram” for each type of DCS. This is a road map that covers all of activities respect to control system in each industrial plant and inevitable to be studied by whom corresponded. It plays an important role from designing control system start point until the end; deliver the system to operate. This should be inserted in bid documents, contracts, purchasing specification and used in different periods of project EPC (engineering, procurement, and construction). Separate parts of DCS are categorized here in order of importance and a brief description and some practical plan is offered. This article could be useful for all instrument and control engineers who worked is EPC projects.

Keywords—Control, configuration, DCS, power plant, bus.

I. INTRODUCTION

DCS (Distributed Control System) or PLC (Programmable Logic Controller) could be selected as a brain in automation. There is a tradeoff between the number of I/O and speed that we expect from the control system. In a sizeable number of I/O which the response time is about 1msec, DCS is preferred. For very fast systems (response time less than 1msec) with fewer number of I/O, PLC is chosen. The protection system and ESD (Emergency Shutdown Devices) uses the latter one. We will see that DCS can be composed of some PLC. Furthermore, it depends on our requirements, cost, and expectation of the automation system. These systems could be merged in some configurations. The question has been answered in an article “DCS or PLC? Seven questions to help you select the best solution” made by Siemens [1]. Two practical systems of two famous brands (Siemens and Hitachi) are studied here with a brief description and abbreviation mentioning that helps the readers to realize these systems more easily.

II. CONTROL SYSTEM HIERARCHY

Before we start to study the control system in more detail, it

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is better to have a look at the control system hierarchy (Fig. 1). It's like a pyramid. Enterprise management level who is the most priority to command the system, is on top of it. Gradually comes down and decrease the priority in different layers and at last to field equipment. Commands comes down and feedbacks vice versa.

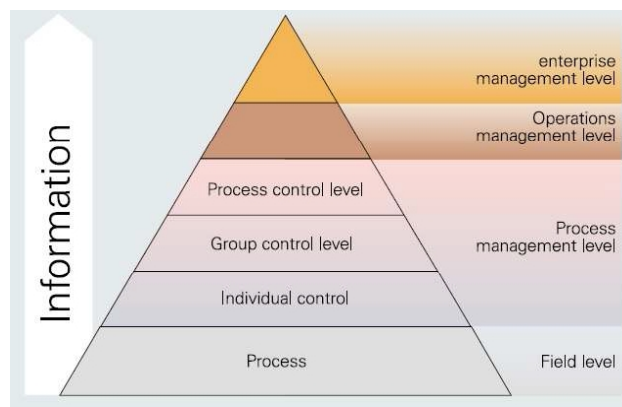


Fig. 1 Automation hierarchy, [2]

III. CONTROL CONFIGURATION SYSTEM

A typical design (Siemens made) is shown as follows (Fig. 2): Let us have an imaginary journey in this automated system. Field level: Start from field devices ascending gradually. Here we have the information sources (input signals to DCS) about the process such as temperature, pressure, flow, position and so on. These physical behaviors of process, convert to input electrical signals (examples: analogue: 4_20 MA or digital: 0_24 VDC) via transmitters, switches and other detectors. Individual control level: Signals from field level comes here directly or path through via a Profibus (in field bus configuration). FUM (function unit module) collect normally similar signals and give them to AP (automation processor). There is some initial processing on them. They receive the signals from site in connection pin out and backplane (wrapping method in previous and backplane bus in recent design). The signals are transmitted to the AP by the aid of modules named IM (Interface module). Group control level: The main process activity done in APs. All the logic load on them and they decided automatically which command should be issued. They connect to the upper part by modules named CP (communication processor). This connection will be done by FO (fiber optic) or network cables via OSM (optical switch module) or Bridge (will be discussed later). Process control level: There are two basic buses (loop) that made by LAN

(local area network) FO cables. Lower: Field bus, and upper: Terminal bus. ES (engineering station) where logic could be loaded and modified, OM (operation monitoring) where the operational pages configured, DS (diagnostic system) that

identifies the problems in the system, connect these two buses together. Operators can control and monitor the whole process by means of OT (operational terminal).

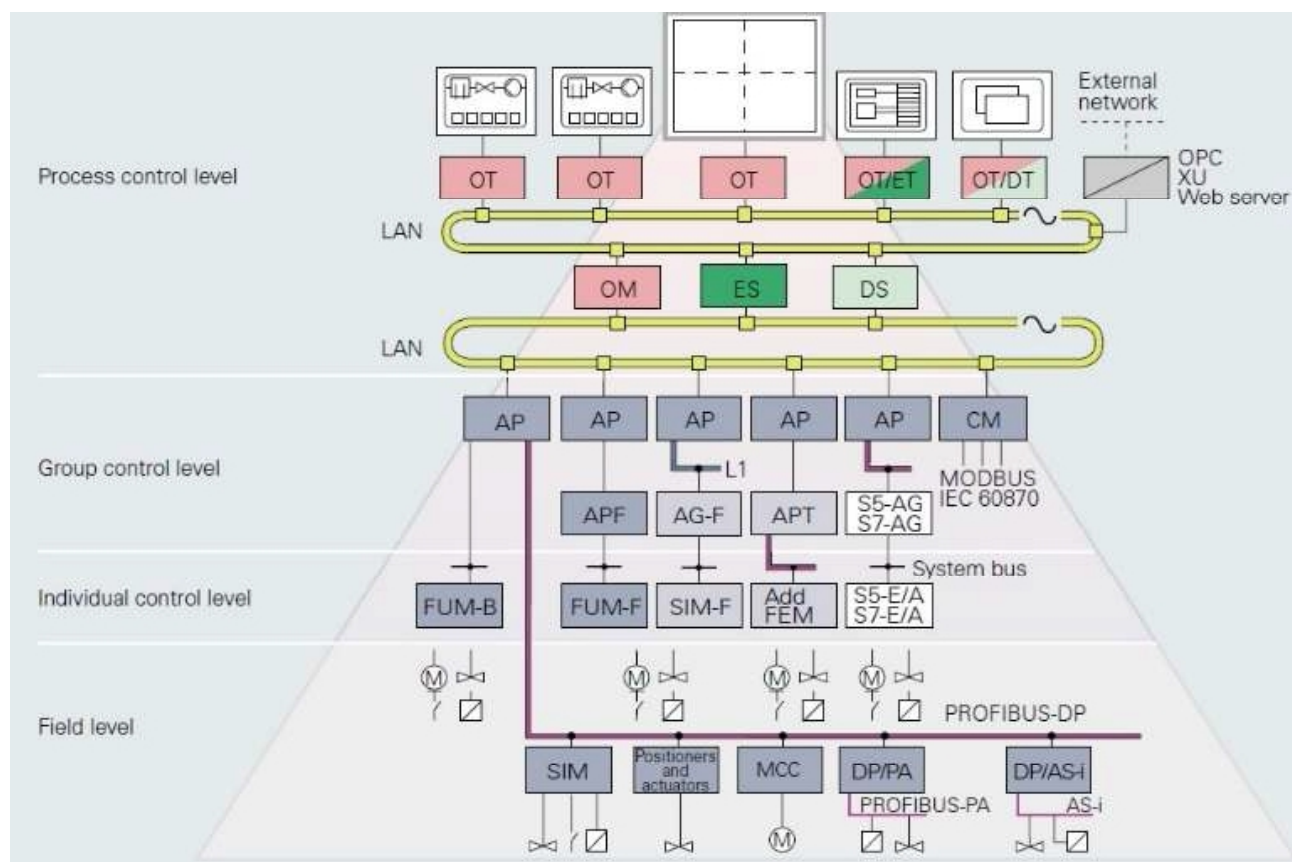


Fig. 2 Equipment Priority [2]

IV. SIEMENS CONTROL CONFIGURATION SYSTEM

We begin our technical approach with a practical example (Fig. 3 (a)) of TXP (Teleperm XP) version of Siemens DCS in X Gas turbine power plant (4 X 159 MW Ansaldo V94.2 gas turbines):

From top descending down: there are 6 OT; 1 OT for each GT (gas turbine), 1 for shift leader and another one for E/M BOP (electrical and mechanical balance of plant systems, such as fuel oil forwarding and unloading systems and others that are common in 4 units). OT (HMI human interface) consists of monitor, keyboard, and mouse as shown in the picture. B/W (black and white) printer considered for some of them. One color printer allocates totally. SU (server unit) do the archives and store log and events in its' hard or MOD (magnetic optical disk), 2 of them are in redundant arrangement. Administrators can run and modify the network programs by KVM switch. All of the devices mentioned in this paragraph are merely connected to Terminal Bus. There are some others that connect two buses together: ES/DS (engineer / diagnostic station) is a combined terminal, process logic can be loaded and modified here, it has the most use in commissioning

period, simulation, I/O check, logic check, loops check, tuning, parameter modification are its' duties. DAT (data access tape) is a magnetic tape that contains the OS (operating system) software for ES, PU, and OTs and could be down/up loaded through commissioning as back up. PU (processor unit); each pair of GT units has two of them redundantly. Inputs from site are processed logically, and outputs from DCS transmit to field through these processor units. These devices work with terminal and plant bus simultaneously.

Time reference for the system which is called "master clock" is provided from two sources: a) external: GPS (global position system), antenna and clock master module, and b) One of AP could be selected for clock provider. If each of them fails, the other does the job. This time is a reference for all LOG, Trend, Event and Cycle in DCS.

The buses are loop type, in other word they are "virtual access ring," and this arrangement lets the information transmit in the opposite direction, if anywhere the bus, disconnect. The system can continue its' job in the worst case. Redundant ring concept increases the reliability of the system.

Plant buses are designed redundantly for each pair of GT

(double FO ring). GT pair buses are connected together by Bridge (recently OSM: optical switch module). AC and DC power supply cabinet provide the required energy for the devices. LAN cabinets cover all of network bus connections. Automation E/M BOP receives and transmits signals from/to common systems. SCADA (supervisory control and data acquisition) gathers the information for dispatching area and national centers (AOC and SCC) [4].

Now, we are yet in CCB. On our path to the field, we must go to the LCR (local control room) it is known as Messa in Ansaldo design. The relevant part of the control configuration

diagram is shown in Fig. 3(b), because of similarity, units 1 and 2 have been omitted.

There is an OT with its' accessories for the operation (Fig. 3 (b)). The automation cabinets are boundary limit between instruments, devices in site, and control system (if the junction boxes ignored). All information input signals from the site and all command output from DCS are transmitted through these. Vibration, flame detection, protection and GT control, panels, systems are arranged in this room. They can be programmed and test by PG (a laptop contains related software that used in commissioning period).

X Central Control Room

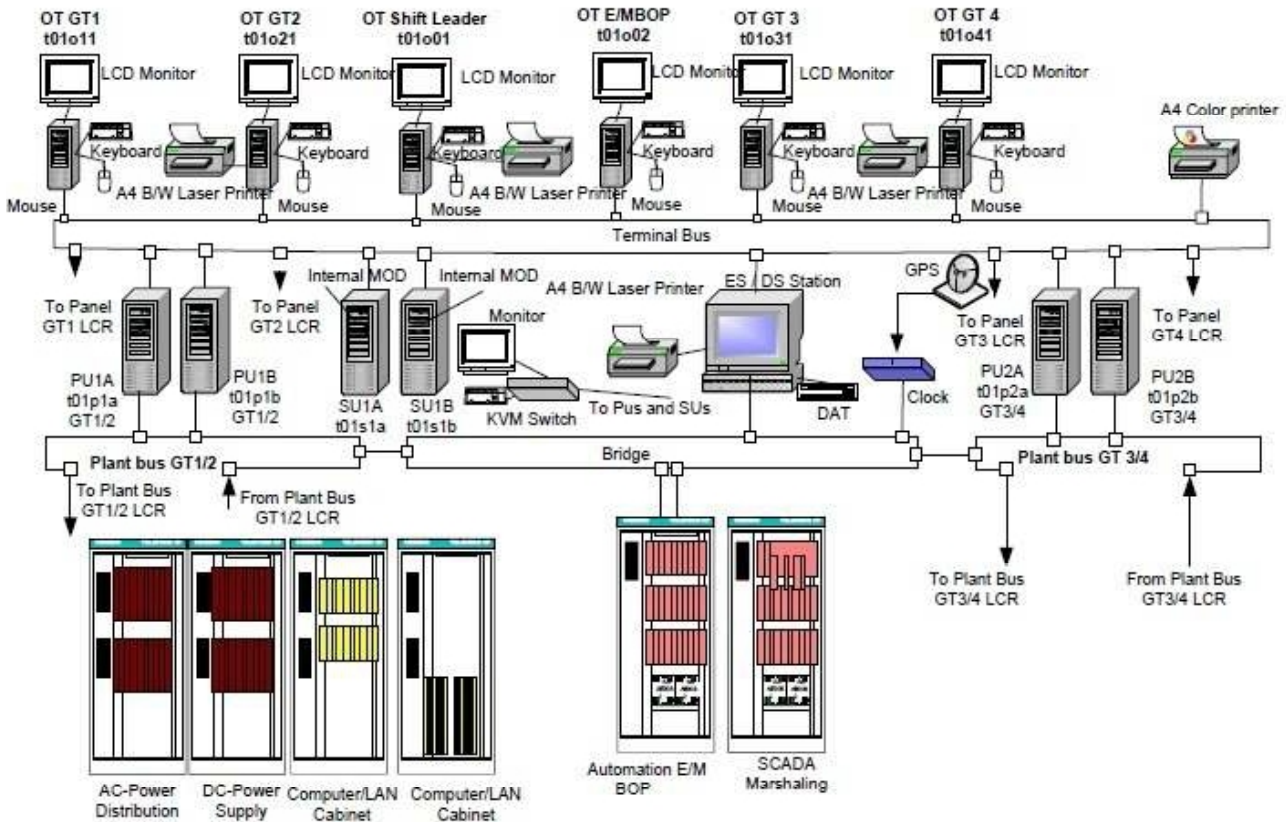


Fig. 3 (a) X Control Configuration Diagram, PART I, [3]

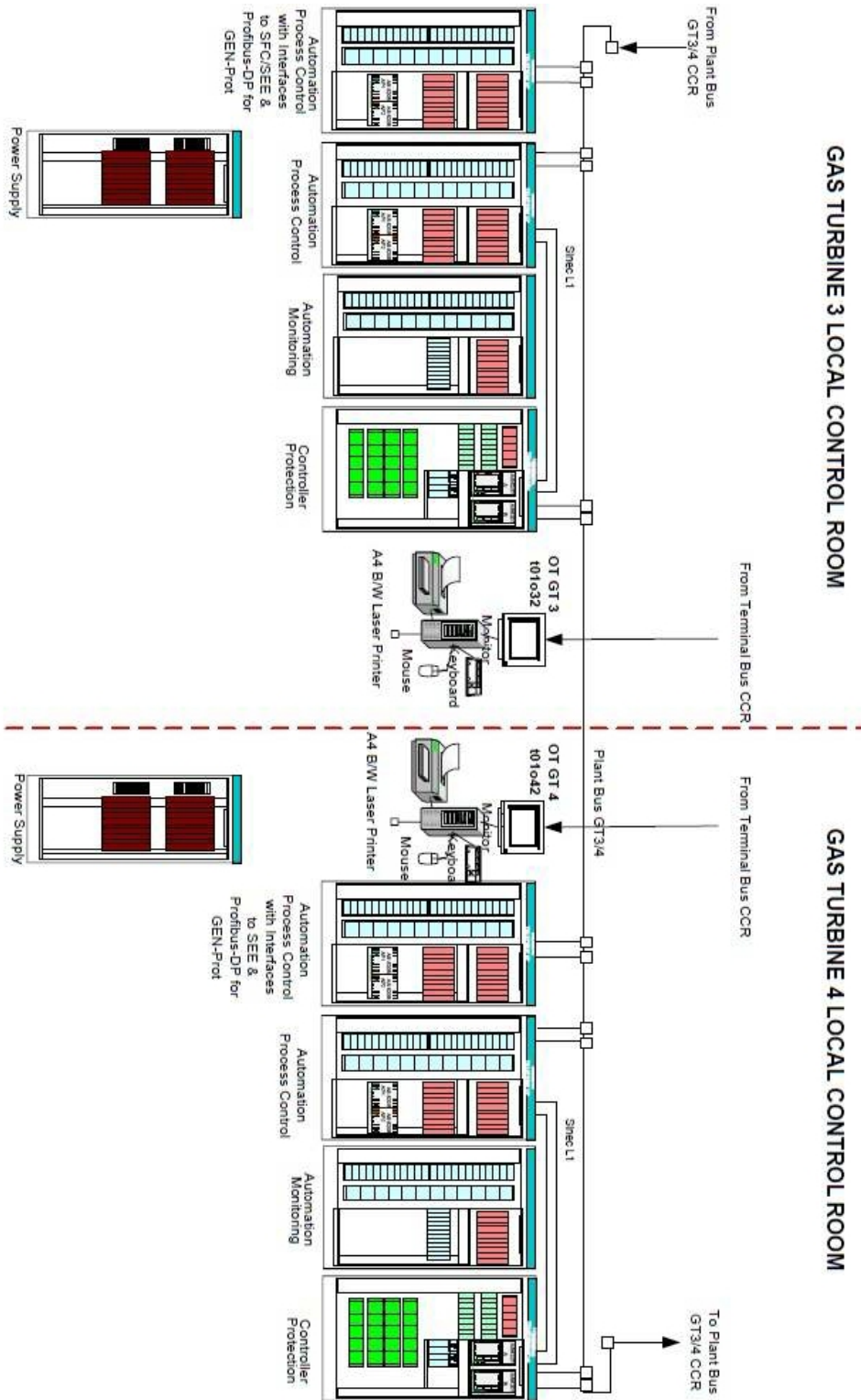


Fig. 3 (b) X Control Configuration diagram, part 2, [3]

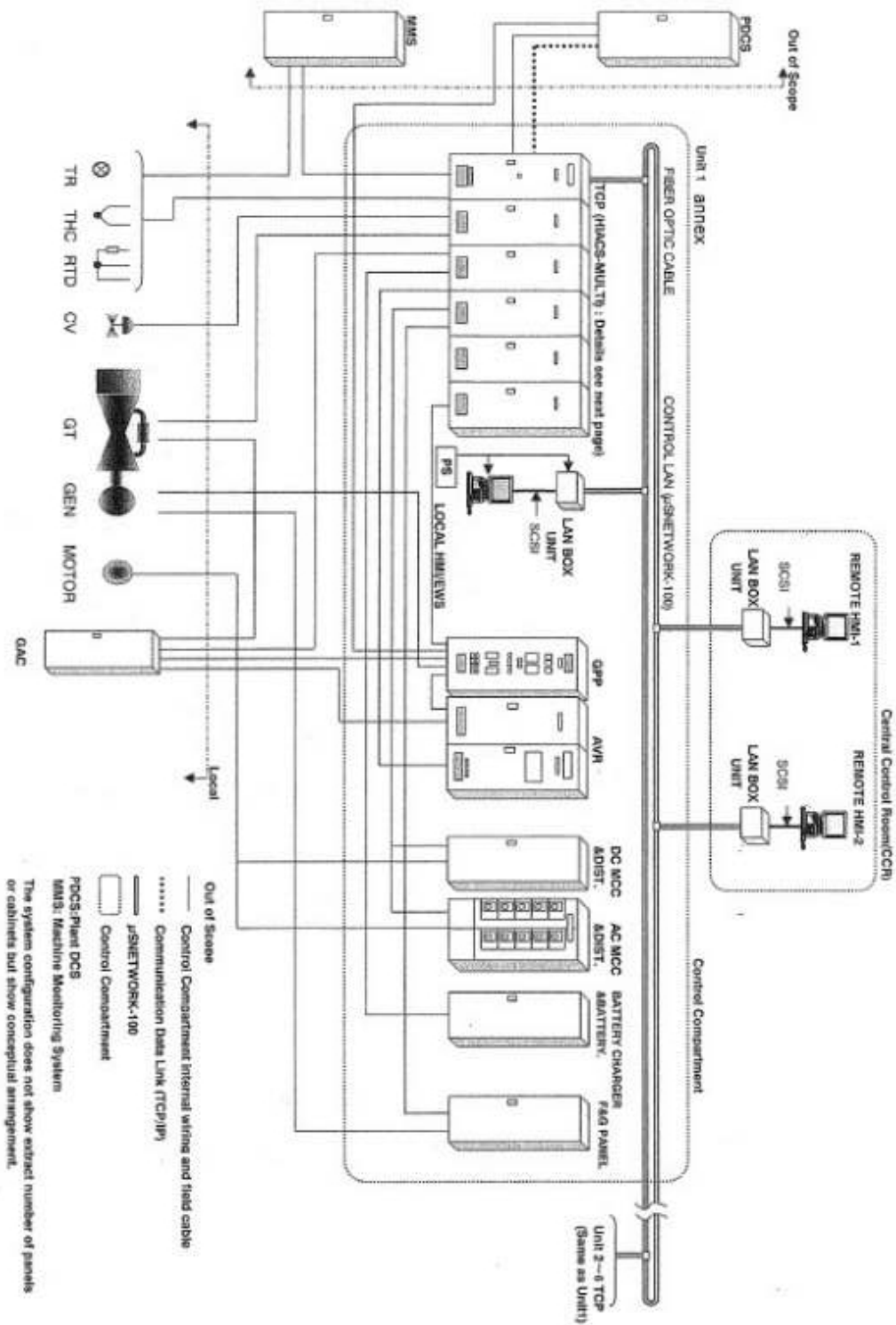


Fig. 4 (a) Y Configuration, part 1, [5]

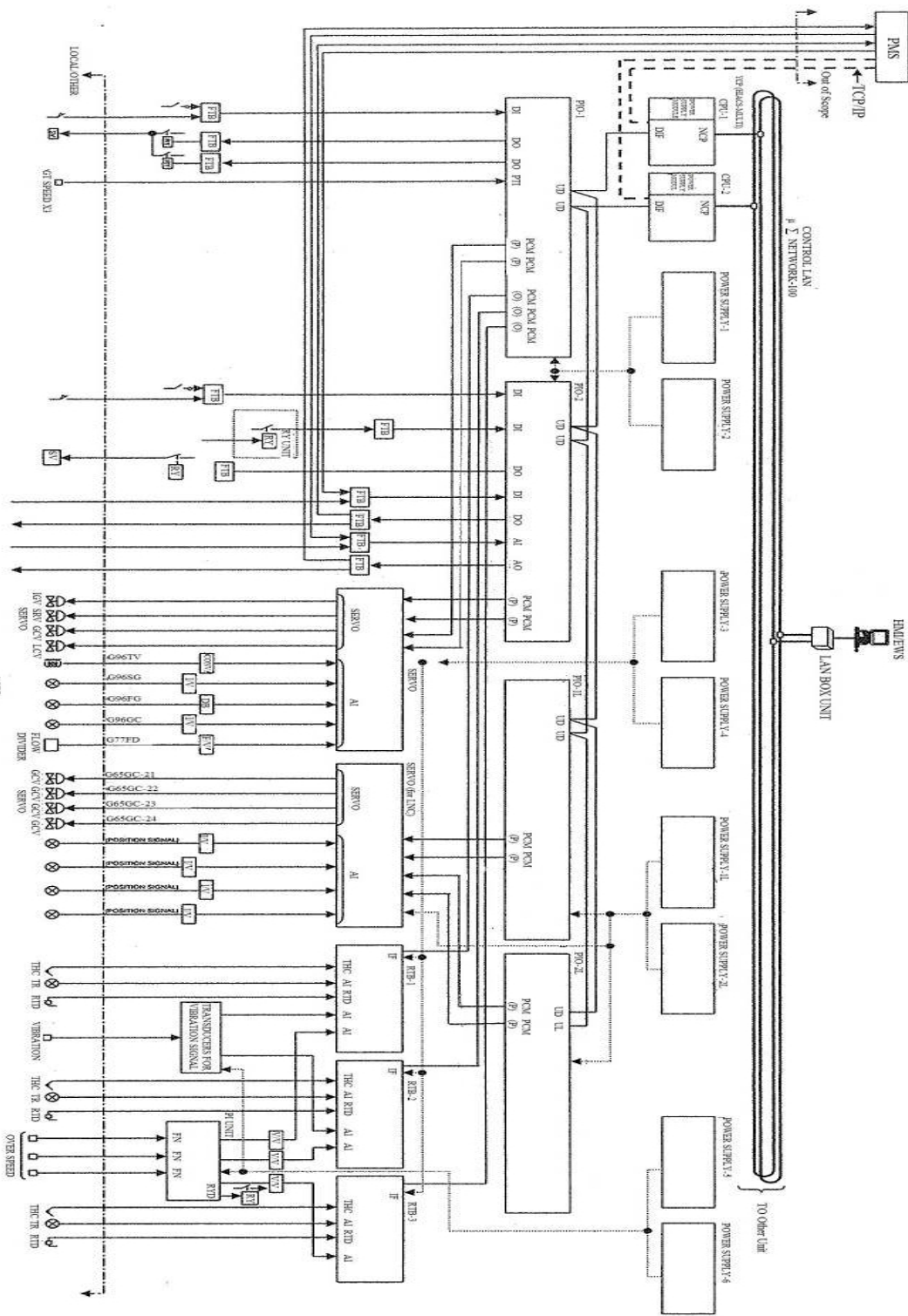


Fig. 4 (b) Y Configuration, part 2, [5]

V.HITACHI CONTROL CONFIGURATION SYSTEM

Our next step is to study a DCS system designed by Hitachi, another famous brand that used in petrochemical industry “Y

Olefin Complex” as shown in Figs. 4 (a), (b).

There are 1 CCB and 6 LCR (as annex). Signals are transmitted to/from GT and DCS via TCP (turbine control

panel). There is not a separate location for the instrument, electric systems because the plant is too small. These systems and MCC (motorized control system for GT) are allocated in LCR. 2 OT is designed for CCB and 1 for each LCR. Main processors are in TCP panels. GPP (generator protection panel) and AVR (automatic voltage regulator) control generator. F&G (fuel and gas) panel monitor the gas leakage in the plant and alarm if the gas concentration more than specified LEL (lower explosive limit) in specific areas. Battery and battery charger are also seen in LCR cause of the small size of the plant. GAC (generator auxiliary cabinet) is located on the site and contains main breaker, earth switch and auxiliary breakers between generator and grid. More detail of the signal transition method could be seen in the following picture (Fig. 4 (b)): RTD (resistance temperature differential) and TC (thermocouple) are examples of inputs to DCS, Servo (such as IGV: inlet guide vane actuator) commands are examples of output from DCS to site as indicated.

Legend for two last figures are as follows:

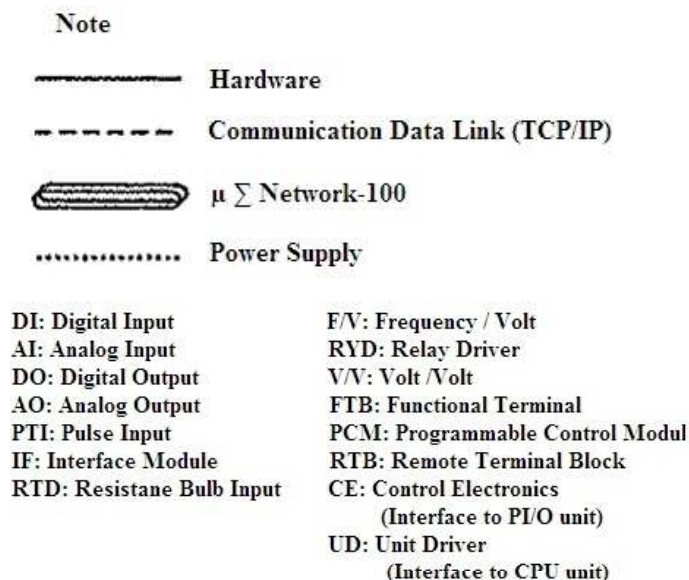


Fig. 5 Legend for Hitachi DCS [5]

VI. CONCLUSION

As shown in the above mentioned projects, the control configuration diagram is one of the most important document that should be designed in the starting level of the project. It is an ICW (input for civil work) drawing that specifies the equipment arrangement in CCR, LCR and finally the civil design for these rooms. Contracts, bids, purchase specifications, overall and detail design for every huge industrial project automation should contain this drawing.

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