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Development Of EMCS In Power Plants

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***Abstract*— Recently improvement of automation systems for power plants became essential for increasing the power plant realiability with preserving the cost value used for built these automation systems. In Abu-Qir thermal power plant unit 6&7, existing Electrical Monitoring and Control System (EMCS) contains some imperfections, this control system responsible for control on Power Plant Electrical Distribution System (PPEDS) which feeding the electrical power to all power plant equipment so it represents backbone of power plant . A proposes automation system model is viewed to mitigate defects in existing EMCS to obtain a reliable performance of power plants. Further, this development could be applied for any industrial process have same system architecture.**

Keywords*— *SCADA system; industrial automation; thermal power plants.

I. Introduction

(PPEDS) is portion of the power delivery that takes the electricity from high-voltage transmission circuits and delivers it to service equipments through A power distribution network which include HV/MV power transformer(s), MV substation and switchgear, MV/LV power transformer(s), The distribution voltage is then transformed to low voltage panels as a Load Centre (LC), either for lighting and small power applications, or for electrical motors, which is usually fed from a dedicated motor control center (MCC) figure (1), shown the PPEDS [1, 2].

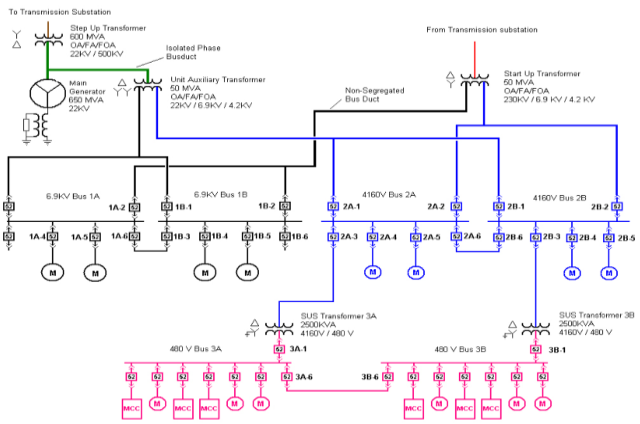

Fig. 1. Representation of PPEDS.

Existing PPEDS divided to five zones as shown in figure (2), 1, 2 have MV switch gear, LC, MCC panels, zone 3, 5 contains a LC, MCC panels, zone 4 contains LC control panel all these panels responsable to fed reliable power for these service equipments [3].

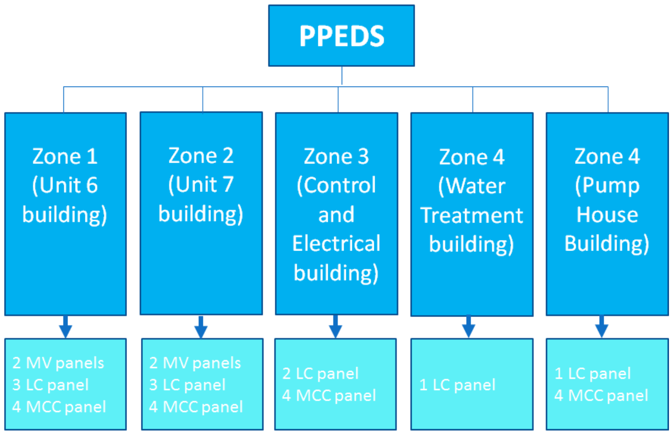

Fig. 2. Existing PPEDS.

EMCS is a supervisory control and data acquisition system (SCADA) refers to the combination of telemetry and data acquisition then send commands to the controlled process which is PPEDS in this case. A SCADA system consists of a number of programmable logic controller [PLC] or remote terminal unit (RTUs) collecting field data and sending that data back to a master station via a communications system. The master station displays the acquired data and also allows the operator to perform remote control tasks [4, 5].

SCADA system components review can be shown figure (3), and it is summarized as a follows to doing control and monitoring functions:

1. Field devices: are represented in control system as digital I/Os or analog I/Os signals or communication data.
2. Controller: is represented in system architecture as a PLC which works with many auxiliary components such as digital input/ or output modules, analog signal modules, communication modules…etc.
3. Human Machine interface (HMI): Which is used for graphical interface and data acquisition at field zone.
4. Network and its devices: used to connect between control devices have a communication protocols. Network devices used in case of connecting between differ communication protocols, devices such as repeaters, Ethernet switches…etc.
5. SCADA Server: to display real-time data received from the IEDs, PLCs connected in the

PPEDS, keep historical records of data received and retrieve these records when required, activate alarms when necessary, also can be used for diagnosing of system faults

6. SCADA operator work station: used for display real-time data which are taken from SCADA server, also display alarms and events [5].
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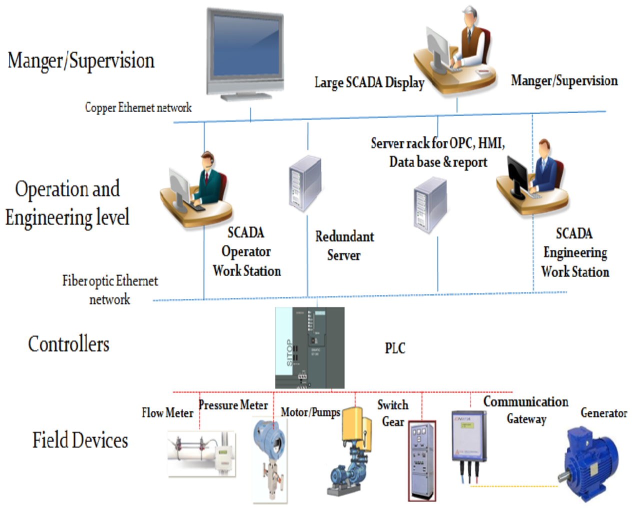

Fig. 3. SCADA system architecture.

Digital technology adds a several advances which improve the performance, efficiency, reliability, and security of SCADA systems [6], over all for any automation system many configurations can be built for the same automation process, but between these configurations one is a most compatible, reliable, and highly performance system, through this search existing EMCS system is shown with viewing that its imperfections, and how to improve it through the proposed system, cost and reliability have been considered as key factors for designing proposed EMCS of power plant.

II. Existing EMCS Review

The configuration of control system depend on process architecture, so as PPEDS is divided to five zones also EMCS divided to five zones, each of these zones have a control system "PLC completed with interface and communication modules, industrial Ethernet switch, HMIs, communication system", zones control systems connected with each other through optical fiber communication loop, figure (4) shows practical EMCS of AQTPP

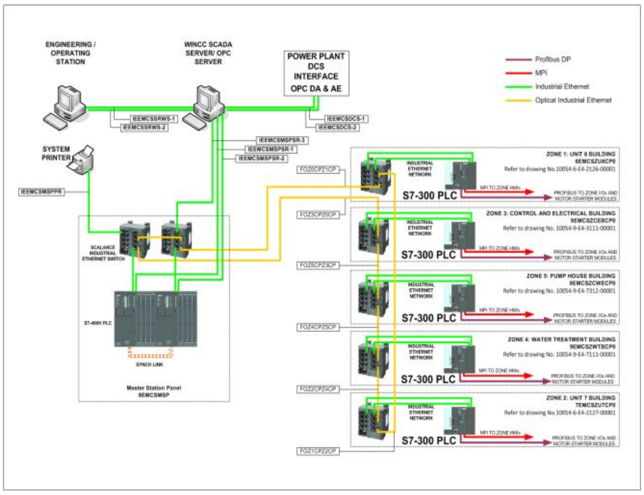

Fig. 4. Existing EMCS architecture.

A main redundant PLCs collect data from zones control units through the optical fiber communication loop, and connected to SCADA system server which works as data archiving, as a OPC server for share its data with DCS "OPC means Open Platform Communications which is a popular standards-based data-connectivity method used for communicate between controllers, and/or applications without getting caught up in the usual custom driver-based connectivity problems" this technique used since EMCS and DCS supplied with different manufacturer controller", also SCADA server is used as engineering station for diagnosing system faults and download programs to PLC . Operator Work Station is used for viewing real time data to follow up the PPEDS. Communication protocols used are Profibus, MPI and Ethernet TCP/IP. The monitoring and control data from PPEDS could be detailed as follows:

- MV panels: fully control and monitor for incoming and LC outgoing circuit breakers, and monitor status of medium voltage motors.
- LC panels: fully control and monitor for incoming and outgoing circuit breakers.
- MCC panels: just monitoring current and voltage of motors breakers with staring device' SIMCODE existing motor start device under manufacturer of SIMENS'

III. EMCS Assessment And Enhancement

A specific strategy of improving existing EMCS system to make it most economical, higher performance, more reliable as much as possible to get on the proposed system. Displaying that through the following items:

A. *Field control components and network topology design*

The control component used can be specified for each PPEDS zone as:

1. Zone main control panel: which contains a main PLC as main brain of each zone which doing all control features. Since each MV& LC panels contains interface module (IM) connected with PLC through Profibus network to transfer data of each panel to PLC, also each panel have HMI for field visualization and control connected with PLC through MPI network as shown in figure (5). Zone main PLC configured with communication module to connect with zone Ethernet switch for sending the data to master PLC through optical fiber network.
2. Medium voltage & Load center panels: each contains a status and control signals are connected to digital inputs and outputs modules in a control panel, these modules configured with interface module which is sent the data to zone PLC.
3. PLC read data from MCC SIMOCODE breakers directly through Profibus network, also each MCC panel contain HMI for just view readable data.

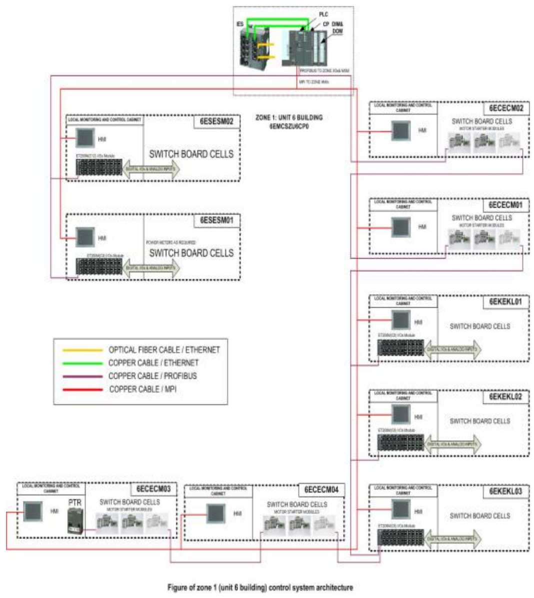

Fig. 5. Zone 1existing system architecture.

The system evaluation could be itemized as following

❖ PLC of zone 1: is a lack in working memory space (WMS) since it have a 15% WMS as shown in figure (6)

➢ Thus adding or change the existing control program to larger program to correct some defection through long term of process operation, largest blocks for any reason make PLC unfit to operation, plus increasing the program scan cycle time which lead to slow execute control commands.

✓ To avoid this demerits, a PLC with large working memory should be used, by changing existing PLC model with other have as minimum 25% WMS, since PLC work memory non expandable.

Other zones PLCs achieve acceptable WMS and are work efficiently for handling the data between field devices and master redundant PLC. Communication Processor (CP) used in zone control panel works properly. Industrial Ethernet switch used working efficiently for handling data between zone PLC and master PLC through optical fiber network

❖ Interface modules (IM) used in MV& LC panels: in EMCS 14 interface modules used have a connectivity with 8 or 12 signal module, among them only one in unit6 MV having connectivity with 12 signal module.

➢ Using of different IM types increase system spare part components

✓ So, IM have a connectivity with 12(IM-12) signal module should be replaced with two IM have a connectivity with 8 signal module, or replace of IMs in MV panels with IM-12 for future extension.

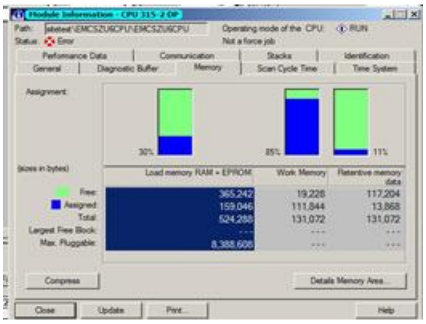

Fig. 6. Zone 1 PLC memory usage.

❖ In MV& LC panels Digital Input Modules (DIM): types used are 16, 32 and 64 signal, characterized by optically isolation, but

➢ Using of DIM with 64 cause a risk since one DIM from this type can be connected with all digital signal of panel, when it fail couldn't read any data form the panel. Also all DIM for MV panels specified without time stamp which make diagnosing faults impossible. So

✓ DIM-64S should be replaced with two DIM-32 signal type, and all DIM in MV panels should be specified with time stamp.

❖ Digital output Modules (DOM): used in panels from types 16, 32 optically isolated digital output signals

✓ Optocoupler features with higher speed switching and longer lifetime than relay output type, so better DOM are installed in existing EMCS.

❖ Analog input Modules (AIM) used in panels from types AI 2 channel resolution 14 bit or 8 channel with resolution 13 bit, which given that maximum error 0.05% from measured value, which is very well.

❖ In MCC panels control: Profibus communication network are applied for collecting data from MCC breakers, Profibus protocol is Fastest Fieldbus, but

➢ Common problem is losing the communication with SIMCODE, which disable communication with all devices after this losing point since termination for movable parts in network is weak, figure (7) show Profibus termination connector.

✓ a separate segment bus for MCC panels should be installed to avoid losing the communication with fully controlled devices such as LC or MV which is higher priority than MCC panels

Fig. 7. SIMCODE termination connector.

❖ HMI at field level a proper HMIs are installed since is specified with 10.4" TFT display, 6 MB usable memory for user data, having RS485 and Ethernet interface ports.

➢ Existing system configure a HMI for each MV, LC, MCC panel. However HMI of MCC is used for visualize a little data, so

✓ Using of main single HMI for readable data of zone MCC panels, more proper and less expensive.

❖ Profibus network which installed between zone PLC and IMs, SIMOCODE in same zone, which is proper protocol since is fastest fieldbus transmission rate up to 12MB, Plug & play operation Up to 126 stations may connect to the bus, Up to 32 stations per bus segment, but

➢ Using of Profibus repeater after 9 communication point unacceptable, since it should be installed in case of Lange distance (>100 m) between PLC slave equipment ' SIMCODE or IM in existing system ' or If network contains more than 32 station.

✓ So, Profibus repeaters installed should be eliminated, and using of one repeater for each two MCC panels to a void long distances and another one for dividing Profibus network to separate segments to avoid MCC problem mentioned above.

By applying above proposed solutions for each zone to make system more reliable and most economical can obtain that the system architectures for all zones as follows:
For zone 1: figure (8) shows that proposed system architecture, with compared between figure (5) and figure (8)

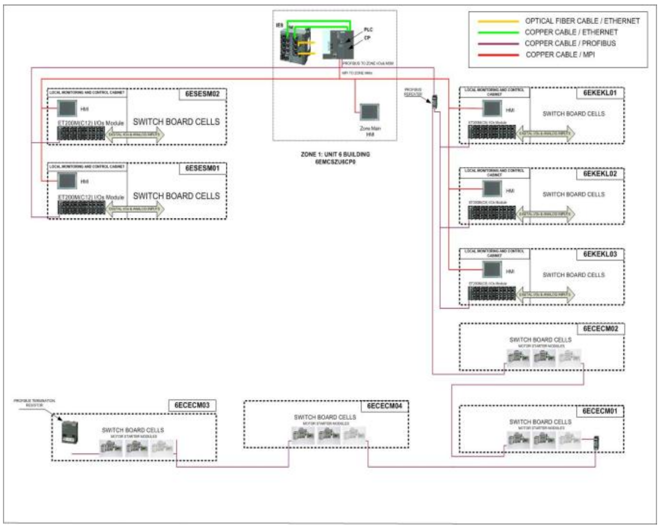

Fig. 8. Zone 1proposed system architecture.

it is cleared that proposed solutions are applied such as:

- divide Profibus network to three segments one for 2 MV panels on the left side of PLC, and two segments through Profibus repeater one for 3 LC panels, and other for 4 MCC panels.
- Eliminate of HMI of MCCs with one HMI.
- Adding one repeater for latest MCC panels in network.

For zone 2: figure (9) view the existing system architecture of zone 2 which are considered typically with zone 1, so same criteria used to improve the EMCS performance, figure (10) shows that the proposed control system for zone 2.

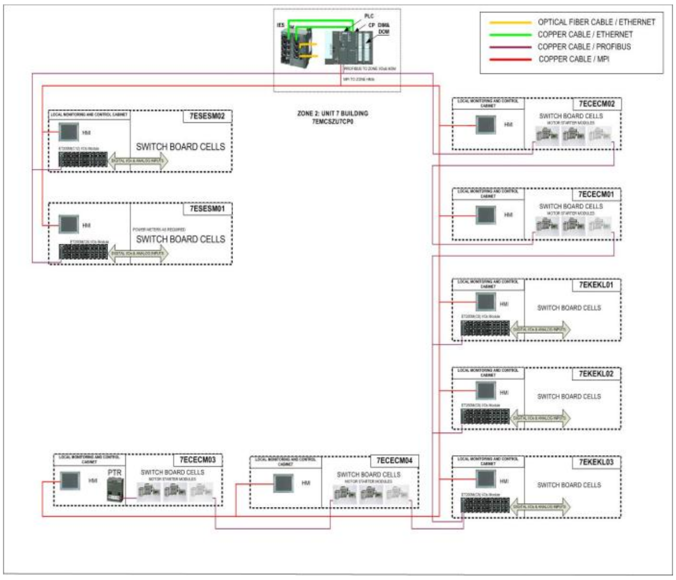

Fig. 9. Zone 2 existing system architecture.

For zone 3: figure (11) view the existing system architecture of zone 3 with applying same criteria in above zones, figure (12) showing the proposed system architecture of zone 3 with considering that dividing of Profibus network for two segments one for 2 LC on the left side of PLC and the second segment for 4 MCC panels without needing Profibus repeater.

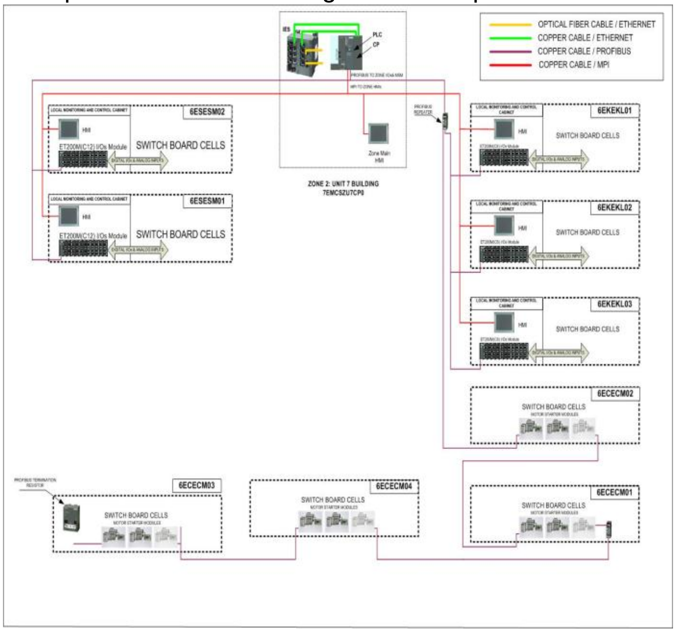

Fig. 10. Zone 2 proposed system architecture.

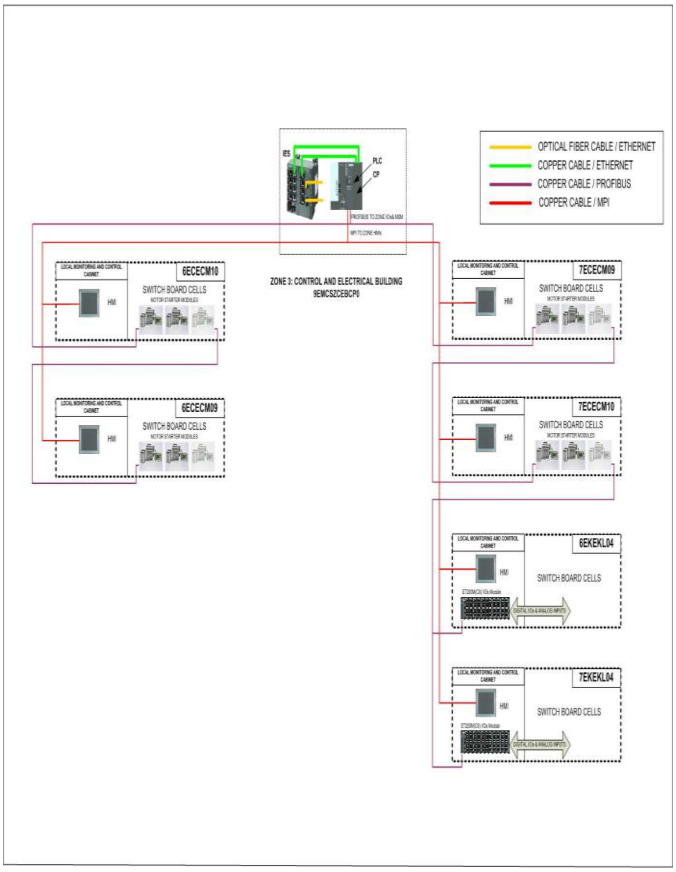

Fig. 11. Zone 3 existing system architecture.

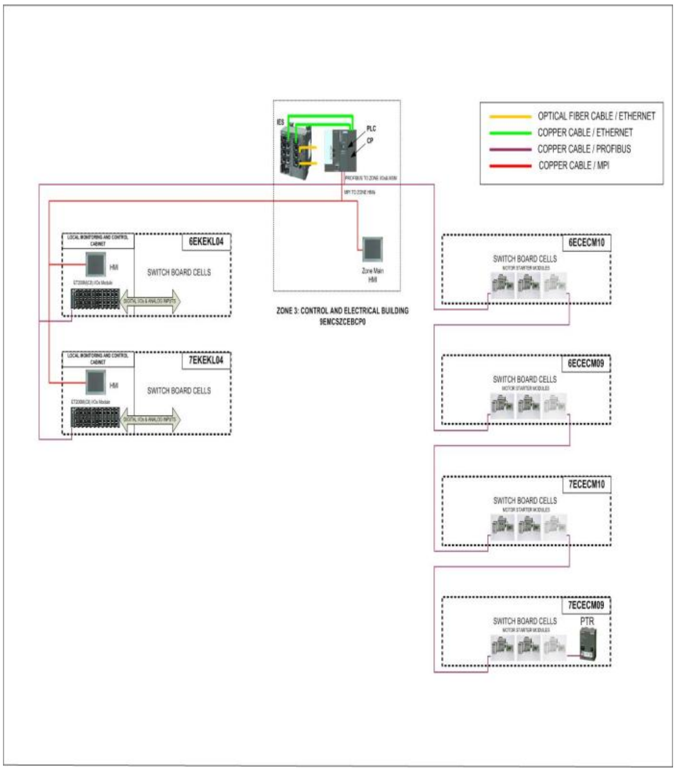

Fig. 12. Zone 3 proposed system architecture.

For zone 4: This zone have only one LC panel, existing and proposed system architecture is identical and it is shown in figure (13)

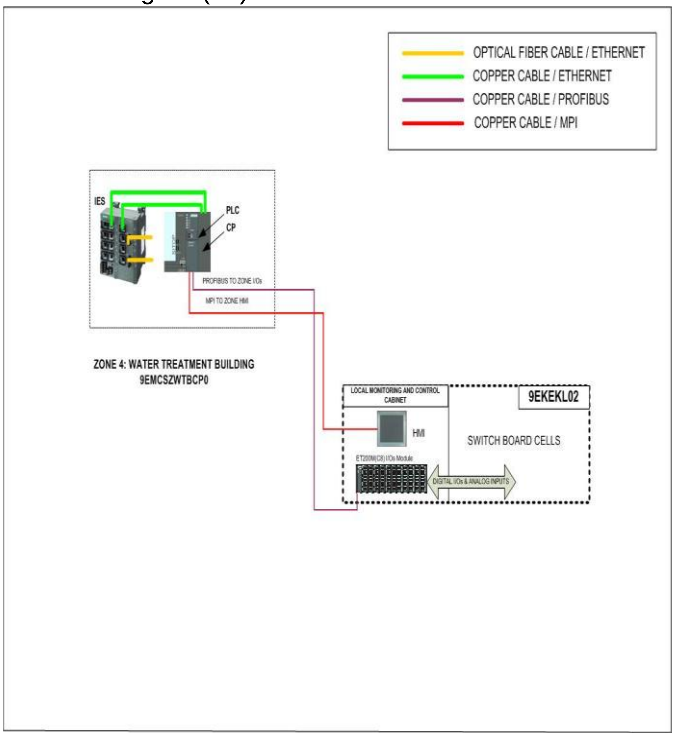

Fig. 13. Zone 4 existing/proposed system architecture

Finally zone 5: figure (14) view the existing system architecture of zone 5 with applying same criteria used in zone 3 get on the figure (15) which showing the proposed system architecture of zone 5 with adding a feature of make HMI of LC works more sufficient since

HMI of LC is connected directly with PLC not through HMIs of MCC panels and finally to HMI of LC as means the cable length is shorten with good performance.

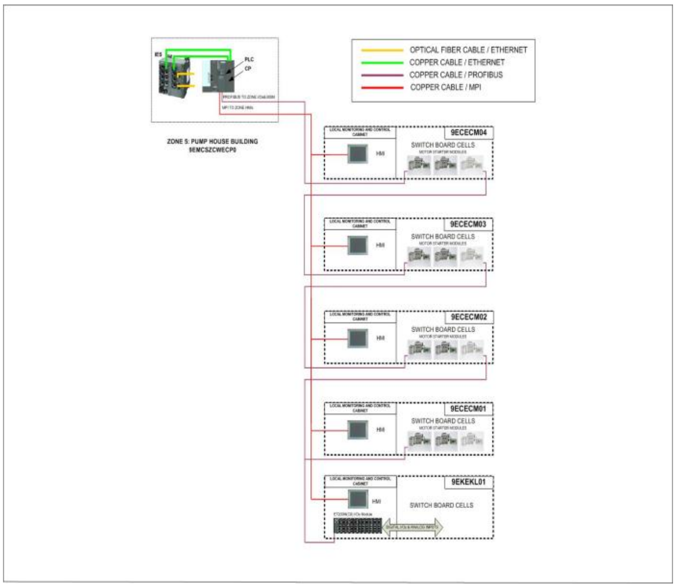

Fig. 14. Zone 5 existing system architecture.

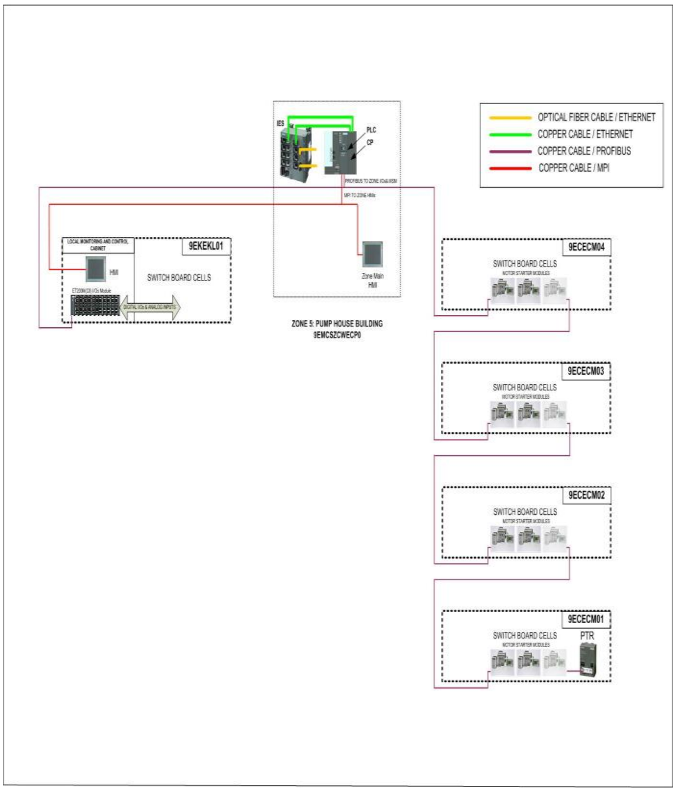

Fig. 15. Zone 5 proposed system architecture.

B. Master control panel design

The control components used are

1. Redundant PLC unit: just responsible for handling the data between five zone and SCADA server, two CPUs are synchronized and hot redundant which means that one is main and the other is hot standby, each of used have two communication port MPI& Profibus for programming only.
2. communication processor: for connecting each master PLC to industrial Ethernet switch in master panel "to read/ write data from/to zones PLCs" through communication network, and connecting each master PLC to SCADA server at main control room, these communication networks are separate from each other. As shown in figure (16)
3. Two industrial Ethernet switch: same specification of industrial switch in item F, using of two switches to make a redundant Ethernet network between SCADA server

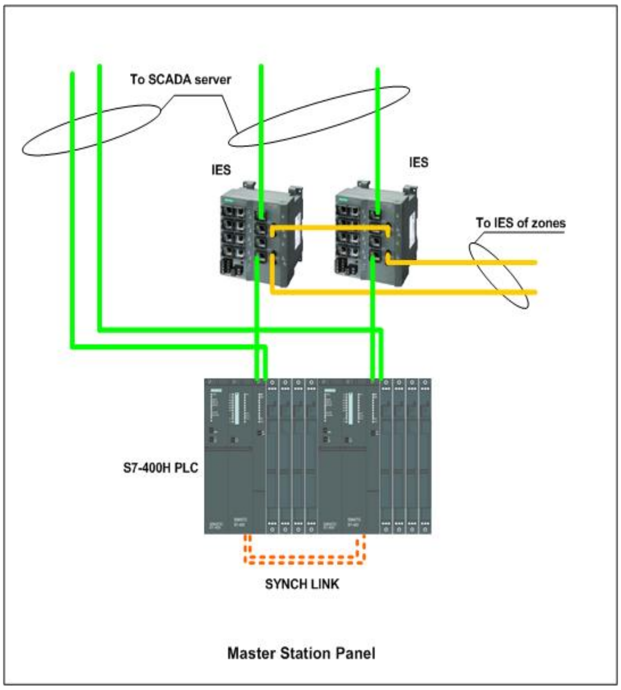

Fig. 16. Master panel configuration.

❖ Master redundant PLC (MRPLC) used in existing system slow down system performance, as the time consumption of data exchanging between SCADA server and zones PLC through MRPLC is longer than that is consumed in case of eliminating the MRPLC in the proposed system. Rather than decreasing the time response of the system, it becomes more reliable and the system cost decreased, also no major benefit for using MRPLC in system without installing redundant PLC at zone. Elimination of MRPLC is shown in proposed system architecture in Figure (18) as comparison with figure (4) of existing system architecture.

C. Operation and management level design

The control equipment used are:

1. SCADA server: SCADA PC specified with high configuration so as to doing many tasks, between

this specification Hot swap HDD, hot swap redundant power supplies, hot swap redundant fans, high speed processor, large capacity RAMs and PC communication processors (CP) each have 2 redundant Industrial Ethernet ports to connect with redundant PLC master station, another CP for connection with EMCS operator station, one for connection with EMCS fiber optic Ethernet network and one for sending data under OPC technology to DCS as shown in figure (17).

2. SCADA Operator work station have a specs less than SCADA serve and it works efficient.

3. Laser color printer for printing of events and alarm of system.

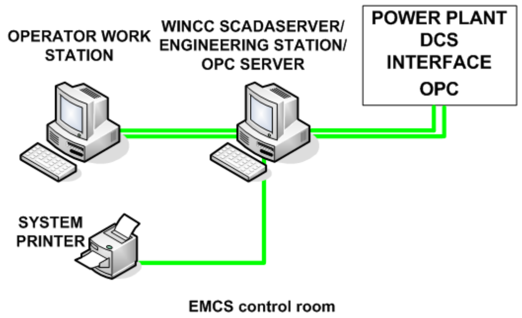

Fig. 17. EMCS operation and management level architecture

- Proposed system configuration replaces the SCADA server and OWS in existing system with two hot redundant SCADA servers, which make system more reliable. Figure (18) shows the proposed EMCS architecture. This modification dose not increasing the cost with great rate, since
- Existing system operator work station (OWS) is used as server with adding accessories such as communication interfaces to communicate with fiber optic network, adding HDD capacity, RAM. Some of these accessories can be taken from existing server such as communication interface of existing with OWS. Also in proposed system configuration need to add accounts of persons such as operator engineers, maintenance engineers ….etc. for define tasks required for each person as safety of operation.
- No changes are done on optical fiber communication network, since it represents a perfect interface with zones PLC in terms of saving a communication with all PLC in case of damage of any cable segment.

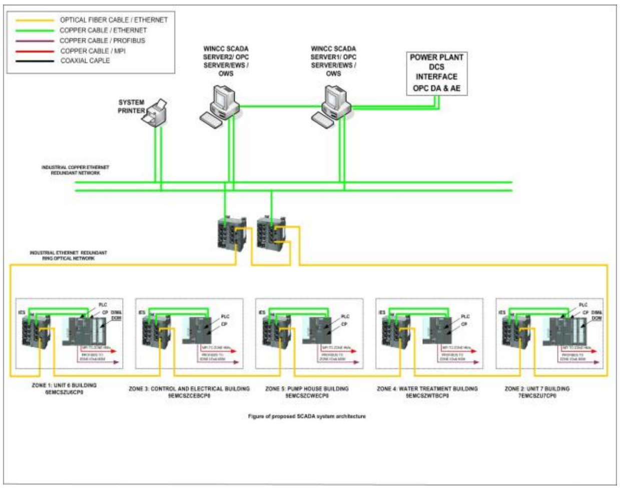

Fig. 18. EMCS proposed system architecture

IV. CONCLUSION

There are main features are obtained from proposed system can be summarized as follows:

- Reliability: aim from proposed system is increasing the existing system reliability. Through modifying of system networks as shown above in proposed architectures and duplicate the EMCS server.
- Time response: proposed SCADA system eliminate MRPLC to reduce consumption time for exchange the data between zone PLC and SCADA server.
- Cost down by nearly 25% from system total cost: since some control devices are eliminated such as MRPLC, Profibus repeaters and many HMIs, also reduce communication cables installed. The components are modified such as IM of MV panels, OWS don't increase cost comparing with cost down due to eliminated components.
- Engineering work: proposed system configuration reduce the time required for finishing engineering work such as such as programming of MRPLC.
- Troubleshooting: since proposed system contain components less than that used in existing system, so proposed system decreases of the troubleshooting time and it provides effort required for solving problems.

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