ACHIEVING UNIFIED HMI THROUGH DCS INTEROPERABILITY

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ABSTRACT

Packaging concept in a coal fired power plant has many advantages; the first & foremost being that of cost. But needless to say, one of the de-merits is the plethora of control system (DCS & PLC) & consequently the variety in HMI. Uniformity of the front end to the process being controlled has always been the wish list of the end user i.e. the operator, being oblivious to the underlying dynamics of the control platform. One of the traditional & very obvious approach of achieving this is to go for a total turnkey package, with a single DCS for the main plant.

This paper presents the concept of Unified HMI through DCS inter-operability, a technology alternative to achieving the same through total turnkey packaging. In this concept, the drives of one DCS is operated by the HMI of another DCS, leading to a single unified HMI for the control room. The design considerations in evolving this concept has been described along with details of implementation in intra package and inter package scenarios.

KEYWORDS

Unified HMI, Distributed Control system (DCS), OPC, Modbus, Response time, Inter- operability

1.0. INTRODUCTION:

Ever since the introduction of Distributed Control Systems (DCS), the operator interface to the process had undergone a sea change; from push button stations to CRT to latest state of the art workstations & large video screens (LVS). Today, fast navigation, trends, LVS based annunciation provide the operator all tools for effective operation.

The DCS/PLC based systems of early 90's eras were based on proprietary Operating systems, both for the control system as well as for Human Machine Interface (HMI) .The communication network between the control system and HMI was also proprietary, requiring system specific interfacing hardware and software. Now with systems based on open architecture & commercial off the shelf (COTS) hardware, the capabilities of the HMI have increased many fold; so are the demands from these systems. Availability of process data from open architecture systems & the portability of the same to third party software through communication interfaces has become very common & the slogan "Field to Boardroom" has become the buzzword today. Can the advancements lead to a situation of true inter-operability in DCS? Let us examine in detail.

2.0. A TYPICAL DCS/PLC NETWORK IN A POWER PLANT

A typical DCS consists of Control system in which the interlock, protections & sequences (OLCS) & modulating controls (CLCS) are implemented and the HMI (Human Machine Interface) through which drive/sequence operations, plant monitoring, historical event & trend analysis etc. is carried out. An overview of the same is given in Figure 1.

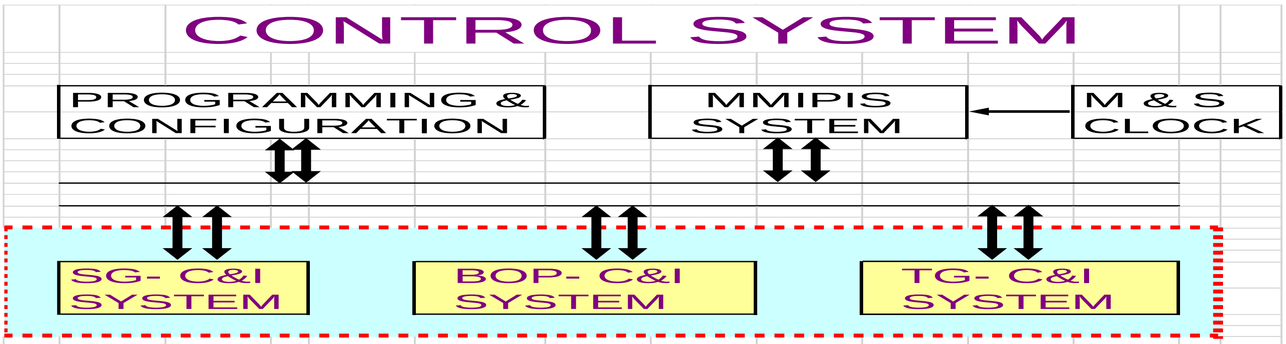


Figure - 1 Typical DCS

In present day scenario, in a DCS, the HMI & the control system are tightly coupled with proprietary interfaces, with the result that HMI of one DCS cannot usually work with the control system of another DCS, unless special interfaces are developed by both the DCS suppliers.

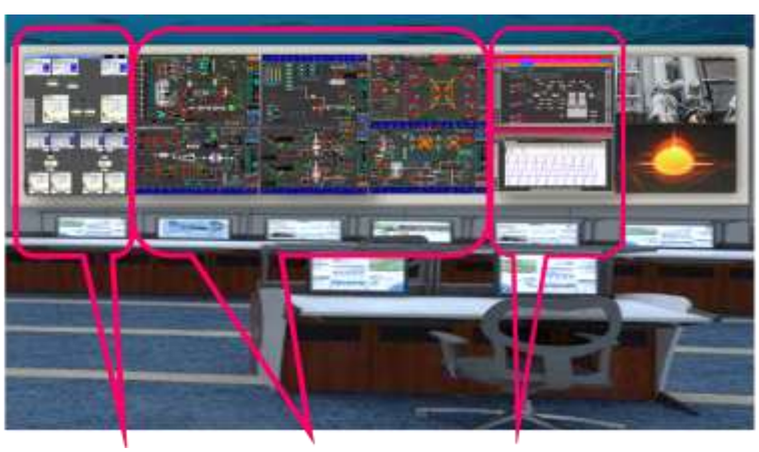
3.0. PACKAGING CONCEPT IN POWER PLANT:

The number of contracting packages for a power plant depends on various considerations; some of these being Cost, Engineering (which includes interfacing requirements), and Vendor base.

The control system (DCS or PLC) for the equipment being supplied under a package is either a part of the package or procured separately, either in part or whole. This has led to various packaging philosophies, for main plant as detailed below:

a) Main plant turnkey where the entire main plant equipment (SG, TG and main plant auxiliaries) is procured under a single package
b) SG-TG: where SG equipment is procured under SG package and TG equipment under TG package. In this case, one DCS is there for integral controls of SG equipment in SG package, another DCS for the integral controls of TG equipment in TG package. For the balance of plant controls of main plant, a separate Station C&I package is provided.

At present we will confine the treatment to SG-TG at b) where three different DCS are provided for main plant controls, each with its own HMI. As a result, the operator in the main plant control room has to operate the plant from three different HMIs. A typical arrangement of screens in such an arrangement is depicted in Figure 2.



SG DCS HMI BOP DCS HMI TG DCS HMI

Figure 2 - Operating screens in a SG TG packaging concept in a power plant

Another variant of b) is that within a package itself, there are two control systems, Eg. TG package where TG integral controls are implemented in the DCS of the TG OEM & balance of plants controls of TG package in another DCS. This aggravates the situation leading to as many as four different HMIs in the unit control room.

4.0. NEED FOR UNIFIED HMI:

Different HMIs in the unit control room means different set of faceplates, different look of graphics, different tools & GUI for HMI functions like trend, logs, trip analysis etc., and different views of alarms/events.

This also leads to a situation where operation of any area of the main plant cannot be done from any workstation or LVS. It has to be done from the workstation/LVS earmarked for a particular area. This eventually leads to increase in number of screens & also to a certain extent, increase in number of operators.

This is tantamount to something pointed out by an Operations personnel in some meet - "A Car with multiple steering".

Having a single HMI increases ease of operation especially during plant disturbances, thereby providing intangible benefits.

5.0. STRATEGIES FOR HMI UNIFICATION:

A) Single DCS for the main plant:

A single DCS for the entire main plant automatically ensures that the HMI also is single. This can be achieved either through a single main plant EPC package with a single DCS for entire package, or separating out the controls of the main equipment in a separate package. The latter is not generally achieved especially in case of turbine integral controls.

B) **DCS Inter-Operability:**

The strategy here is to overcome the constraints of packaging philosophy by having a single HMI in multiple DCS situations through DCS inter-operability i.e. to have communication links between the two DCS through which the drives of one DCS is operated from the HMI of another DCS.

6.0. DCS INTER-OPERABILITY SCENARIOS:

Considering that one DCS (Master DCS) has to operate another DCS (Slave DCS), some scenarios are described below, & depicted pictorially in Figure-3A-3D.

Scenario A: The control system of Slave DCS is interfaced with the HMI of Master DCS, through a gateway interface, specifically developed for the purpose. Obviously, this solution is not standard, and needs to be developed for every combination of Master & Slave. Above all, it involves a great deal of effort on the part of developers of both the DCS.

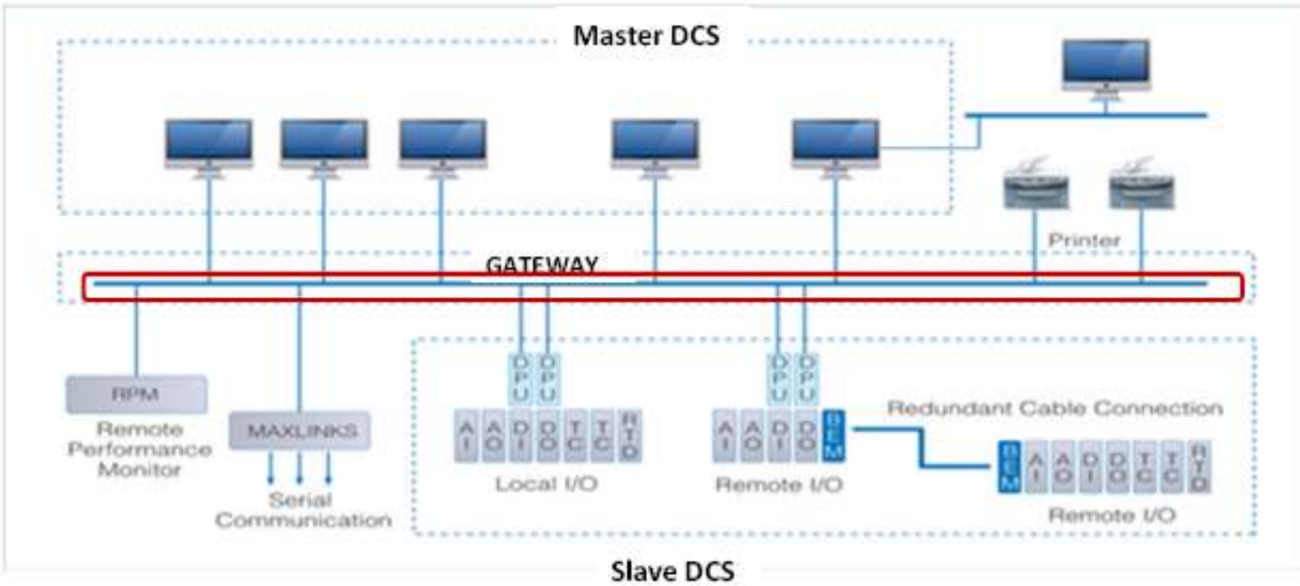


Figure 3A - Scenario A

Scenario B: The HMI of Slave DCS is interfaced with the HMI of Master DCS, typically through OPC, for transfer of signals including operation command & feedbacks. The HMI of Master DCS apart from having the database of drives of Master DCS, has also the database of drives of Slave DCS.

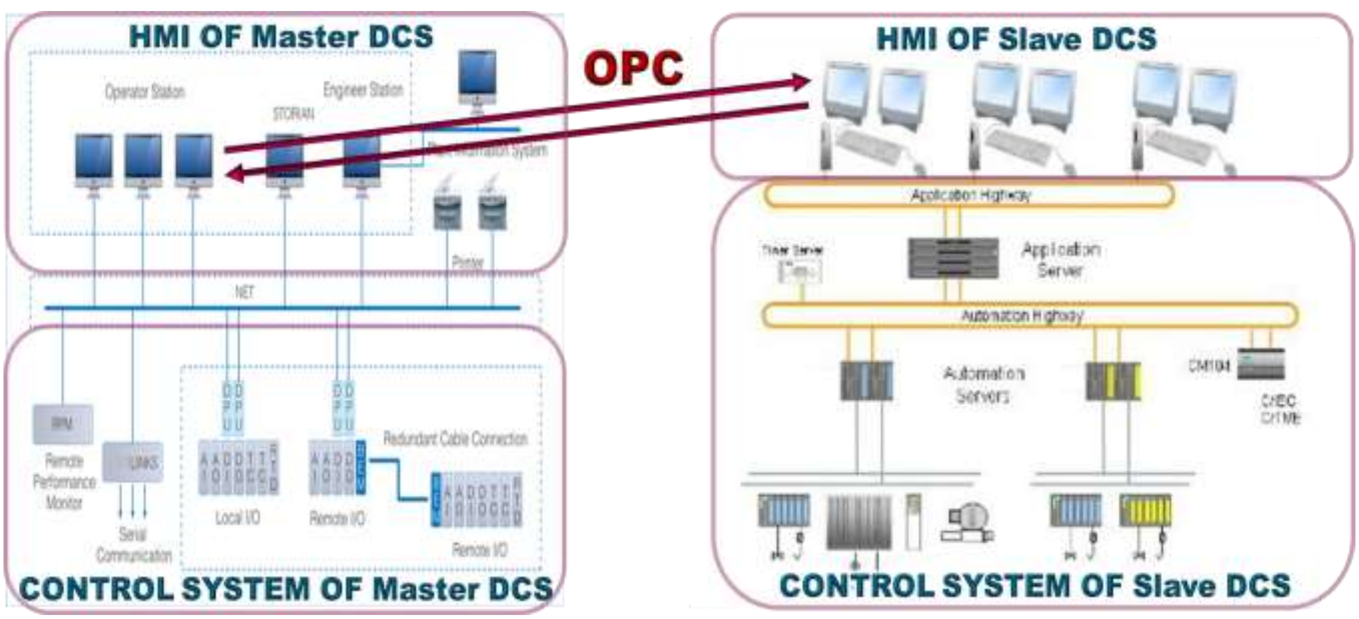


Figure 3B - Scenario B

Scenario C: The control system of Slave DCS is interfaced with the control system of Master DCS for transfer of signals including operation command & feedbacks through typically MODBUS TCP/IP protocol.

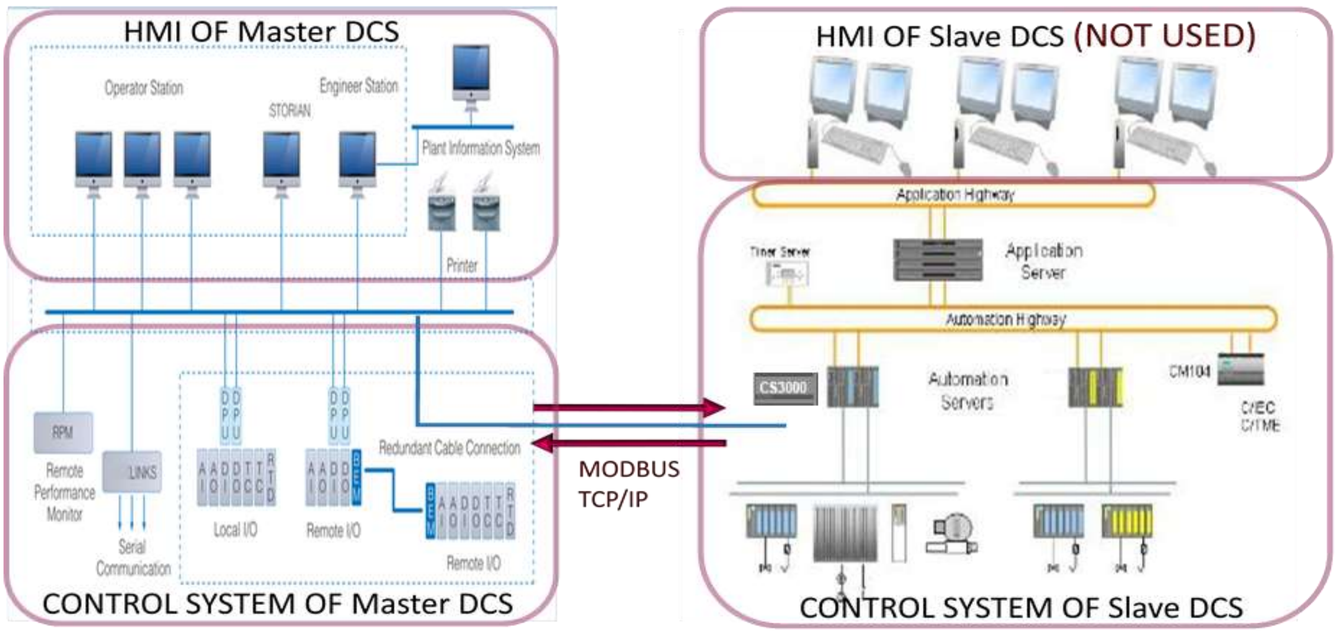


Figure 3C - Scenario C

Scenario A is always very specific for the combination of Master & Slave DCS & also involves huge efforts for development of a proprietary interface between the DCS. Hence, this option was not further explored.

Scenario B can be used if the OPC implementation can guarantee a deterministic response time or the timings are not very demanding eg. for supervisory commands, say initiation of drive command sequences. For direct drive operation, especially for critical drives, where latency cannot be tolerated, this will not be a right solution.

Scenario C uses typically MODBUS TCP/IP protocol to transfer signals between Master DCS & Slave DCS. The entire signals (analog & binary) & the drive signals of Slave DCS are mapped in the Master DCS. The sizing of database of Master DCS takes into account this aspect. Due to its deterministic timings, real time command response times can be achieved in this scenario & hence quite suited for the power plant controls. Another advantage with this scenario is for extremely critical controls like Turbine Governing, the signal exchange for command & feedback between Master DCS & Slave DCS can be implemented using hardwiring; the 'Good Old' 4-20 mA signals used typically for sending commands from Feed water controls to TDBFP speed controls or from Combustion controls to Feeder controls.

All the above merits with Scenario C makes the realization of Unified HMI pragmatic and do-able. The implementation in intra package and inter package scenarios also use this scheme.

Another variant is the case of Scenario D where both Master & Slave DCS are operated from a separate independent HMI under a HMI package. In this case, all the drives of both DCS have to be operated from a HMI different from its native HMI. In Scenario C, at least the drives of Master DCS, the operation is from its native HMI, which is the preferred scenario. Due to this, scenario D is not further explored.

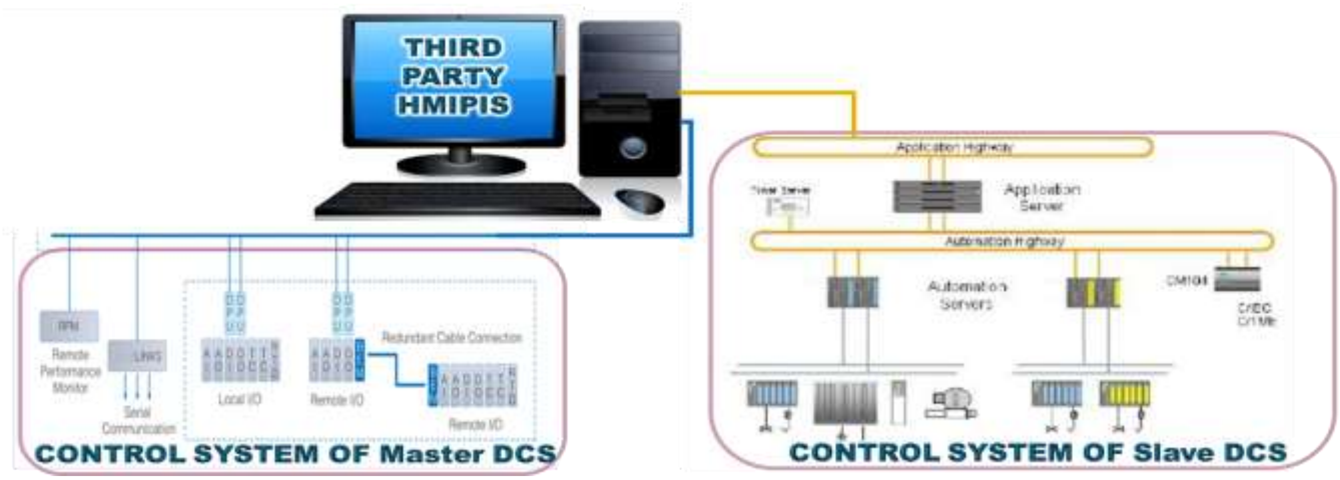


Figure 3D - Scenario D

7.0. INTRA PACKAGE UNIFIED HMI:

As pointed out at 3.0 above, sometimes, TG package within itself has two DCS, one for TG integral controls & other for balance controls, leading to a situation of two different HMI for operating the drives of TG package in the control room. While a single DCS could not be specified, requirement of a single unified HMI was specified in such situations in the tender specifications from Mauda-II TG package onwards, i.e. if two DCS are supplied by the TG package vendor, HMI shall be a single unified system. This was a triggering point for the implementation of Unified HMI in Intra Package scenario.

8.0. INTER PACKAGE UNIFIED HMI:

Having the scheme of Unified HMI within package (Intra package) leaves most of the design aspects to the package vendor, i.e. a single vendor and are finalized during the detailed engineering stage. This provides a lot of flexibility to the vendor in these aspects.

However, specifying such a concept for Inter package is quite challenging as many of the design aspects has to be specified outright in the tender stage and the coordination between the different package vendors is to be carried out by NTPC. The first & foremost criteria is who will become the Master DCS. In the packaging system as prevalent today in NTPC, there are three packages, SG EPC, TG EPC & BOP EPC (for off sites). Hence, the choice of master for main plant HMI has to be between DCS of SG EPC & TG EPC. The controls being envisaged in these packages are indicated in the following table.

Sl. No.	SG EPC Controls	TG EPC Controls
1.	SG Integral	TG Integral
2.	SG BOP	TG BOP
2.	SG Standalone (Compressor, CW/CT, ESP AC)	TG Standalone (CPU Regeneration, CPU Vessel, Main Plant AC)
3.	AHP	
4.	FOPH	
5.	AUX BOILER	

The considerations which typically go into the selection of the master DCS are:

a) Coverage of drives: One criteria can be that maximum drives in the main plant should be operated from its native HMI, in which case, the DCS which has substantially more drives becomes the master.

b) Coverage of controls: Another criteria for the selection of master is the DCS where most of the important control loops of the generating unit (such as Combustion controls, steam temperature controls, feed water controls) are implemented.

Applying the above considerations to the main plant of a coal fired thermal power plant makes SG DCS as an obvious choice for the Master. Although it is a very tough job of implementing Unified HMI in Inter Package scenario, however with the technical knowhow and experience of Mouda St II TG Package, this philosophy has been specified in EPC projects starting from Telengana onwards. This was possible only because of support from NTPC management.

9.0. SOME DESIGN ASPECTS OF THE TELANGANA IMPLEMENTATION:

In Telangana, BHEL is the SG package vendor and ABFPPL/ GE A&C is the STG package vendor. Here, there are two DCS, maxDNA of BHEL and ALSPA of ABFPPL. Due to the specification requirement of Unified HMI, a scheme for operation of ALSPA drives from the HMI of maxDNA was conceptualized & finalized with NTPC after several rounds of discussions and rigorous testing. An overview sketch of the same is given below in Figure 4.

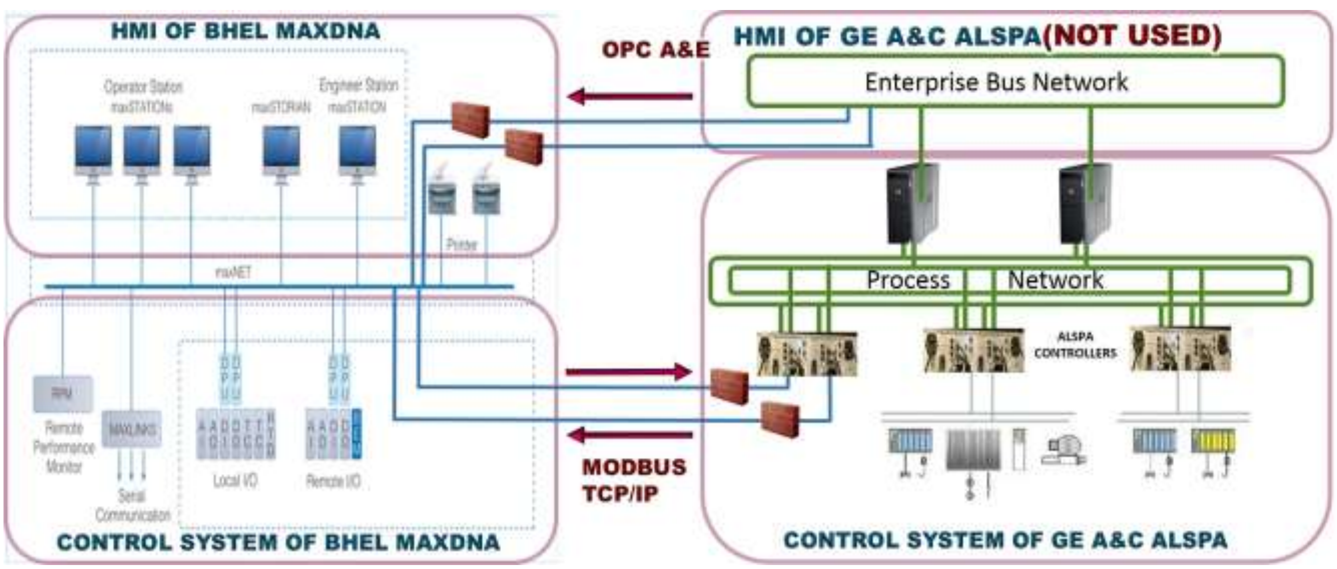


Figure 4 - Telangana implementation

The salient features of this scheme are detailed below:

a) Alspa controller pairs dedicated to individual FGs have Modbus interface. The controllers are configured as Modbus slave. Redundant Modbus slaves have one to one connectivity with redundant maxDNA Modbus masters through redundant firewalls configured in HA mode. All drive level, SGC, SLC and process signals of Alspa system dedicated to a certain FG are transferred to maxDNA using these links.
b) Thus all FG pairs are having these redundant Modbus links for transfer of these signals.
c) With the OLCS and CLCS timings fixed at Alspa end, the cycle time is set at 20 msec, 60 msec & 400 msec for time class critical, high & normal respectively for different type of signals.
d) Bump less switchover between the redundant MODBUS links is ensured.

e) All Drive macros of Alspa system are mapped to the maxDNA system maintaining the homogeneity of look and feel of the Unified HMI.

f) Due to the requirement of time stamping, alarms are transferred over OPC A&E from Alspa HMI to maxDNA HMI. i.e. an additional redundant HMI OPC link is provided for alarms and events.

g) The native HMIs are planned to be kept in Programmer room and Unified HMI in CCR.

The scheme is tested extensively at the works of GE A&C, where a prototype of maxDNA system with the required interfaces, operator stations, historians is arranged by BHEL, EDN Bangalore. The critical part of the testing are the achieved command response times, which are very close to the times achieved with the native HMI. Another critical area is the changeover between the MODBUS links, since the resiliency as provided in the native HMI has to be maintained in the Unified HMI.

Last but not the least, it is being ensured right from the very beginning that commissioning of the TG controls takes place from the Unified HMI right from the initial commissioning stage. The habits formed during the initial commissioning remain throughout the plant cycle & hence this aspect is critical to success of the scheme. It may not be out of place to mention here that in one of the power plants, unified HMI was conceived & implemented, but both the HMIs were placed on the Unit Control desk, & due to this, operators were using only the native HMI, defeating the purpose of the Unified HMI concept.

10.0. CONCLUSION:

Technology has to be harnessed to overcome the barriers of packaging system and to create a seamless operator interface in the control room, with the underlying dynamics & jugglery being oblivious to the operation personnel. The importance of prudent & pragmatic engineering in the finalization of the Unified HMI scheme for any DCS combination cannot be undermined. The cycle times of the MODBUS links, the quantity of MODBUS links & signal distribution among these links, the redundancy & the resiliency of the MODBUS links, mapping of the signals & the mimic engineering has to be done meticulously. This leads to huge efforts on the part of the DCS vendors as well as the customer’s engineers, but the efforts are worth the result.

Depending upon the feedback of implementation, this scheme is likely to undergo improvements & eventually, the day will not be far when the entire controls of the TG package will be executed in SG package, barring the core controls of TG, namely turbine governing, turbine protection and turbine stress control.

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