GE Oil & Gas

Using Mark* VIe as an AGC Supervisory Controller

Formosa Plastics Corporation USA, Point Comfort, Texas

1 The Partners

The Point Comfort Plant, 120 miles southwest of Houston, is a 1,600 acre petrochemical complex that went on line in 1983 and has had two major expansions in 1994 and 1998. Today they operate production units for vinyl chloride monomer, PVC, ethylene dichloride, olefins, polyethylene, polypropylene, chlor-alkali, ethylene glycol, and cogenerated electricity. The plant has 1,800 employees and contractors.

Formosa Plastics first installed a GE MS6001B gas turbine with Mark IV controls and HRSG to match the scale of their initial VCM/PVC manufacturing plant in 1987. Since then, as chemical manufacturing expanded, so did the demand for cogenerated power. Figure 1 shows the cogeneration units running today at Point Comfort.

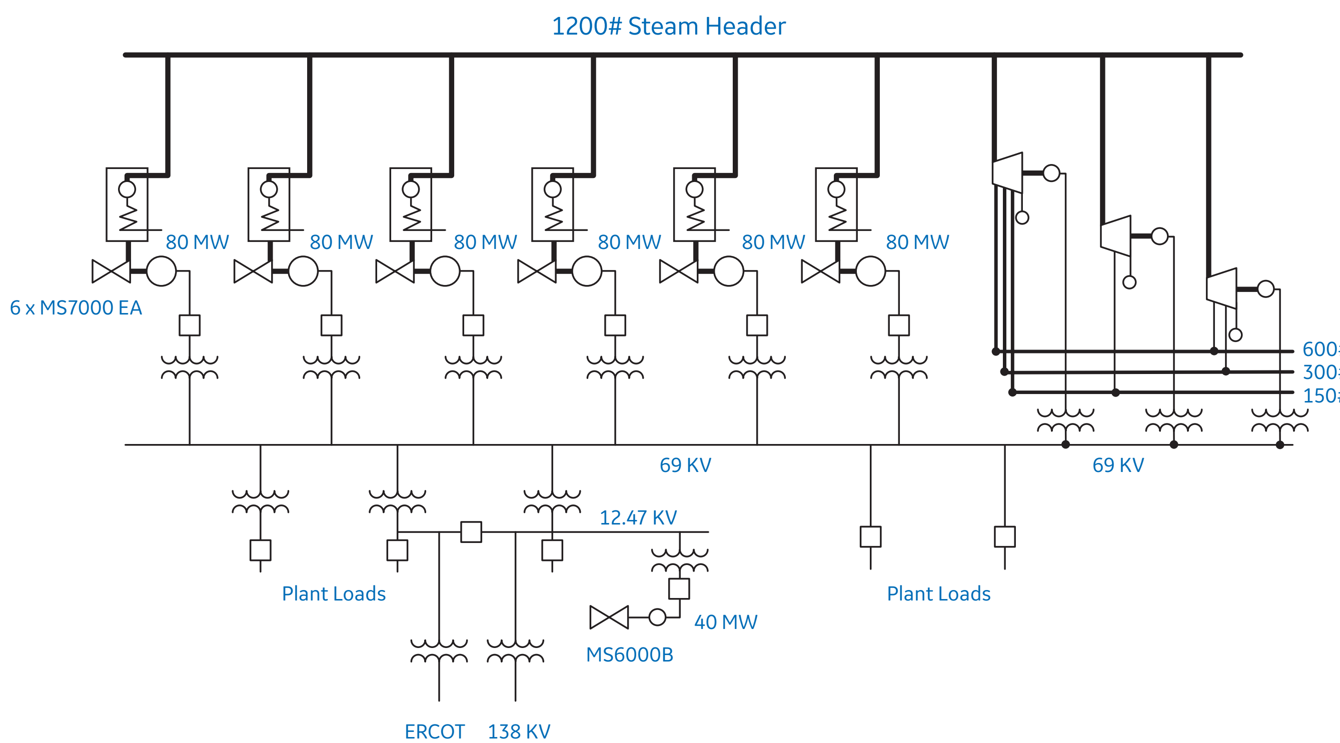


Figure 1

The Electric Reliability Council of Texas (ERCOT) is the independent system operator (ISO) for 85% of Texas's electric load. They manage the dispatch of power and the financial settlements for the competitive wholesale power market in its territory. Formosa Plastics is connected to the ERCOT grid, and has elected to sell surplus power into the ERCOT power market. Formosa Plastics receives an electronic signal designating the net power output to the grid from the aggregate of all the turbine generators online. The automatic generator control (AGC) receives the ERCOT demand signal, senses which of its connected turbines are on line, and calculates how to increase or decrease output on each turbine to match the ERCOT net output demand. At the same time, varying steam and electrical demands from process plant operations affect the gas and steam turbine outputs, HRSG steam makes, and extraction flows, all of which can alter the net electrical power export to the grid. The AGC senses the error from the net power set point ERCOT provides, and adjusts individual turbine set points accordingly to eliminate the error.

Formosa also sells ancillary services to help support ERCOT's load balancing to accurately maintain system frequency. When in this mode of operation, the plant operator is able to select which gas turbines will be available to participate in ERCOT's load balancing. The outputs of those turbines are then adjusted by the AGC to help balance the grid demands and control system frequency. AGC enables the continuous control by ERCOT of Formosa Plastics generation assets while protecting chemical plant operations from power and steam production levels deviating outside the bounds set by the operators.

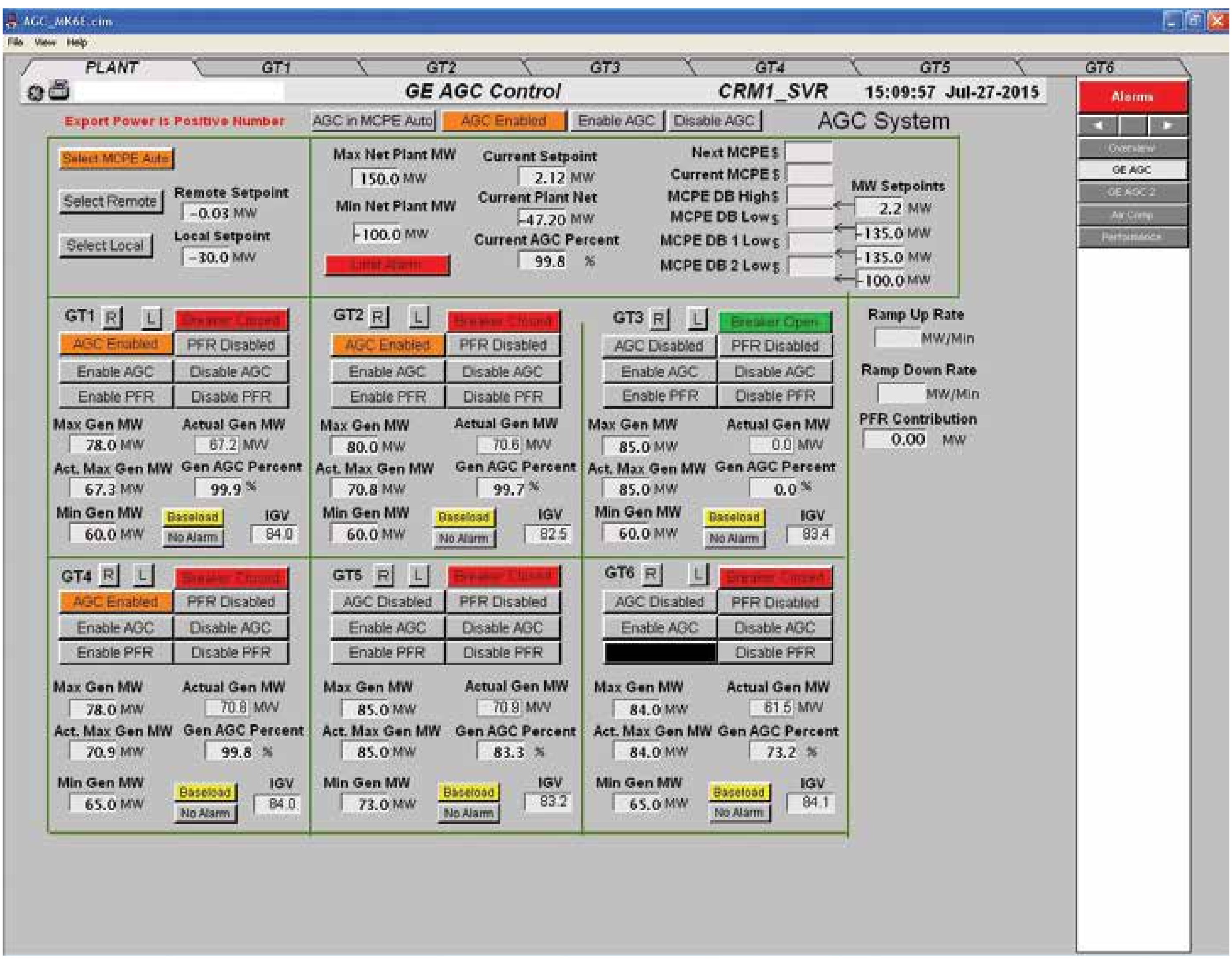


Figure 2

2 The Technology

Automatic Generator Control (AGC) is a supervisory control for turbine controllers that accepts loading requests from the ISO and relays load commands to individual turbines. The AGC supervisory control feeds back information about the status of generation assets and plant electricity production to the ISO. Formosa Plastics installed an Allen Bradley PLC to handle the AGC functions, and to interface to GE turbine controls and ERCOT dispatchers. The AGC hardware and software was provided by a third party. As more turbines were added, and whenever certain ERCOT regulations changed, AGC software modifications were required. The third party provider was able to provide the needed AGC software maintenance services for a time, but after several years, personnel changes diminished their ability to support Formosa Plastics with AGC maintenance and modifications.

Mark VIe migrations were performed for GT 1 through GT 5 in 2011 and 2012 to upgrade existing Mark IV controls which were first introduced to the industry in 1982. New Ethernet networks were constructed to support gas turbine operations from a central control room. The plant adopted the topology outlined in Figure 3.

These migrations required some modification to the existing AGC controller. This need, and the absence of support for their existing AGC, occasioned the design of a new AGC controller applying the same Mark VIe platform.

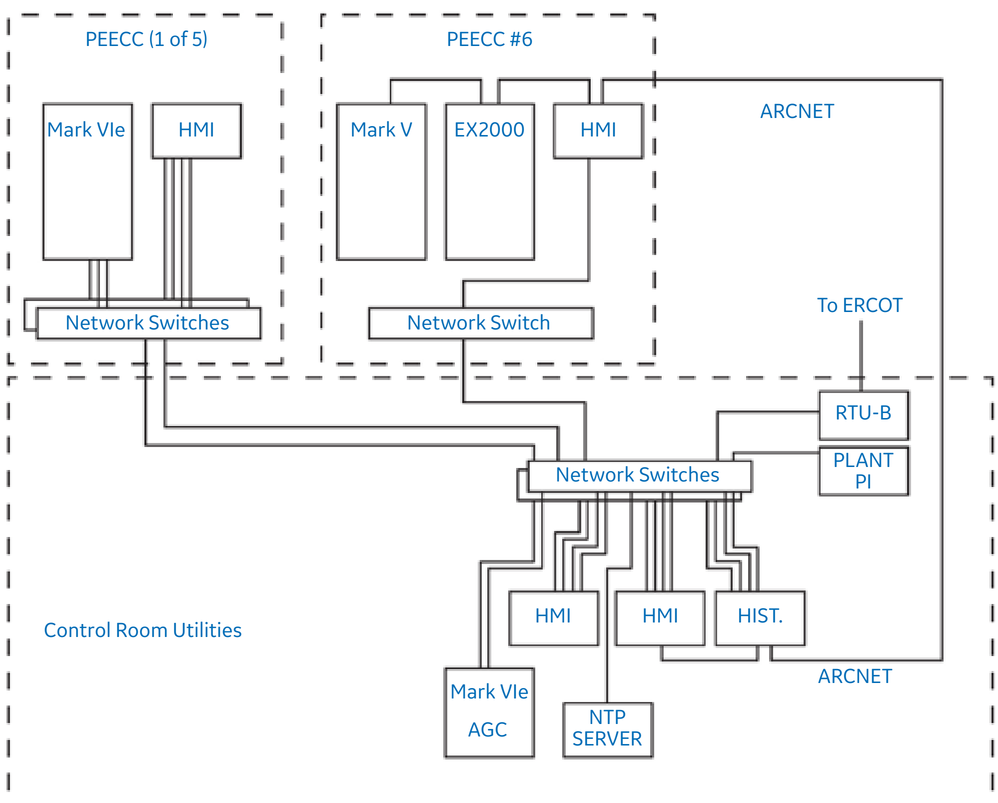
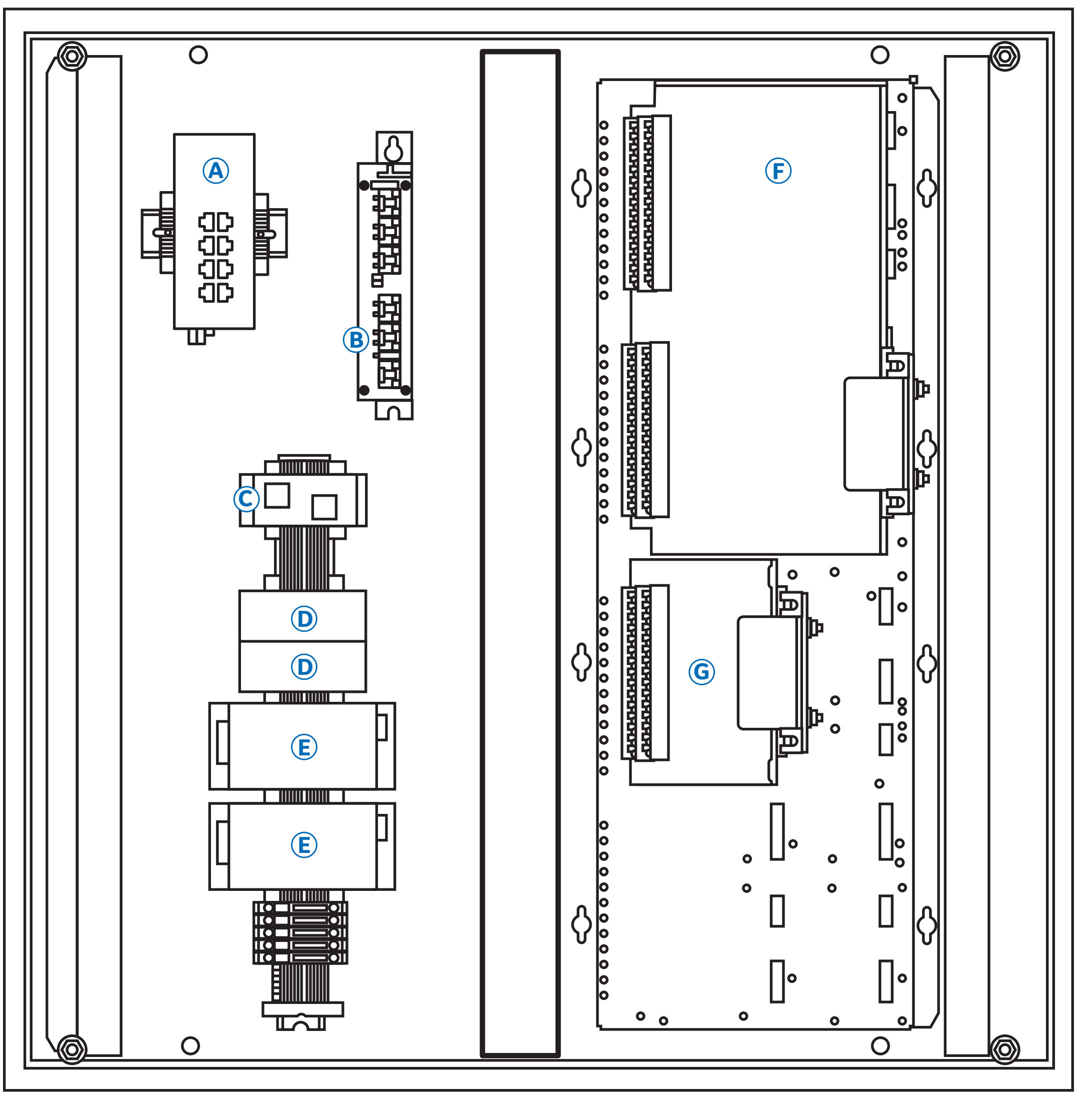


Figure 3

3 The Solution

The application of an AGC controller must be customized to suit specific plant assets and strategies that support obligations to the ISO. The commands from ERCOT are direct and simple and are delivered via Modbus between a GE Harris remote terminal unit (RTU) at site and the AGC controller. With the GE data highway infrastructure already in service for the migrations to Mark VIe, the interface from AGC to the individual Mark VIe turbine controls was greatly simplified. A simplex Mark VIe UCSA processor was selected to support the less than critical nature of the application. UCSA has RJ45 ports to connect to the plant data highway (PDH) to communicate to the Mark VIe turbine controls of gas turbine Units 1 through 5, and to support Modbus communication to Formosa Plastics' RTU-B that in turn communicates with ERCOT dispatchers.

Gas turbine unit 6 is connected differently. Its Mark V control communicates using the Arcnet protocol and does not have a direct connection to our PDH to communicate with AGC. Instead, a Mark VIe PDIO discrete I/O pack, terminal board and IONet switch were added to the AGC Mark VIe scope to accommodate hardwiring to Mark V, enabling raise and lower signals from AGC to command the needed load changes.



A I/O net switch
B UCSA controller
C Lantronix serial comm
D Breakers
E Power Supply
F PDIO/TBDS for discrete IO
G PSCA/SSCA (not used)

Source: 242D7586 5H4

Figure 4

Additional supervisory functions are practical to add to the AGC controller. Although the steam turbines have non-GE controls, an AGC algorithm aids the operators by automatically shifting extraction steam loading to and from Steam Turbine Unit 3 as chemical plant energy demands draw Units 1 and 2 from advantageous operating points. Simplified logic in the AGC controller drives raise or lower digital governor inputs to rebalance steam loads among the units.

New ERCOT regulations for Primary Frequency Response (PFR) have triggered another functional addition to the AGC controller. As the supplier of the turbines, the turbine controls, and AGC, GE was well positioned to help Formosa Plastics comply with the PFR regulations. PFR has the objective for the ISO of having all connected turbines to pick up or drop load to resist grid frequency excursions in the manner of a droop governor. While the turbines at Formosa Plastics all operate with droop governors, most also run to a load set point provided by AGC. In this case, a grid frequency excursion would be answered with a helpful droop response from each governor, but, the droop responses would be negated by an AGC reaction to restore outputs to their load set points, defeating the droop responses that would have been helpful to counteract the frequency excursion. The solution was to apply a PFR droop bias, active only during a grid frequency excursion, on top of the AGC load set points, giving ERCOT its desired frequency support. Because the AGC uses Mark VIe, GE was able to add the PFR droop bias into the AGC logic and ensured evaluation of certain details of the ERCOT PFR regulations, which specify a minimum level of performance for frequency support. Consideration was given to actuator wear resulting from the tight deadband specified by ERCOT, and to the speed of PFR response required by ERCOT. These concerns were addressed by collaboration among Greenville gas turbine controls engineering, Schenectady Power Systems Engineering Consulting, and Longmont AGC software designers to assure successful implementation.

4 Future Implications

Additional utilities projects are being considered to take advantage of the Mark VIe platform and the control networks already in place at the Point Comfort site. The existing steam turbine controls are being considered for Mark VIe retrofits, as is the MS6001B. Existing analog exciters on the gas turbines could be fitted with EX2100e digital front ends. In the future, the Mark V and EX2000 for GT 6 could be migrated to Mark VIe and EX2100e to eliminate the Arcnet network. Additional turbine are being considered for a new utilities area to support a proposed, large chemical process plant expansion, and if GE turbines with Mark VIe controls are selected, Formosa Plastics could extend the GE networks and control platforms to those new turbine generators. Such an architecture enables the use of common HMIs, an existing Historian, an existing time server for time synchronization of all controllers on the network, AGC to expand participation in ERCOT power markets, and coordinated strategies for PFR and for isochronous load sharing. In a more distant future, the Mark VIe control platform can be extended to the HRSGs and balance of plant. Should future regulations require cyber security implementation, GE SecurityST* will be able to provide those safeguards.

Four takeaways on success are:

- Ability to apply the versatile Mark VIe platform in a unique way that integrates with other Mark VIes in the plant
- Core OEM knowledge of turbines and controls leads to ability to support unique and specific customer needs
- A commitment to help you manage the life of your Mark VIe control system through lifecycle management programs, including comprehensive parts support and technology upgrades to extend the life of your system
- Working together as one GE to provide an overall solution to customer means we have organizational depth to understand new PFR regulations, a vast network of resources

References

242D7586 Layout

242D7587 Wiring Diagram

231D8549 Network Topology

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