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# CHALLENGES IN REALIZING INSTRUMENTATION AND REMOTE CONTROL SYSTEMS FOR TESTING CRYOGENIC ENGINE AND STAGE

**Abstract**

For the development of upper stage cryogenic engine and stages, grounds tests are necessary. In order to have successful ground hot tests, realizing Instrumentation and Remote Control systems are challenging one because it needs: (1) High Accuracy Measurements in low temperature conditions to the LH2 level (up to 16K). (2) Proper design and execution of canalization lines to pressure measurements. (3) Cryogenic propellants being hazarders, requirements of remote operations exist. It is very challenging to execute huge numbers commands for EP/Control valves in remote mode. (4) Remote Servicing of LOX/LH2 is advocated with stringent accuracy for liquid level. (4) Dedicated safety instrumentation With these points in mind, commissioning and realizing of Instrumentation and Control system for testing cryogenic upper stage with new state-of-the-art technology has been achieved. Following are some of the technologies developed as a part of realization: (1) Realized control system to command more than 1000 numbers for EP/Control valves without any ambiguity in redundant configuration and well designed digital and analog modules. (2) Conceived proper PLC based control system with large number of input/output remote modules and with reliable i/o network configuration to meet the cycle time of control in 10 msec. (3) Dedicated Software modules for the automation of process like medium substitution of LOX/LH2 lines, chilling of propellant feed lines and Hot test, Shut down, Abort sequence, Safety interlock modules are developed. (4) Special Signal conditioners for measuring LH2 temperature with pulsed DC excitation technique is conceived. (5) SMART transmitters based measurements were realized. (6) Realized Period mode signal conditioners for the speed/flow measurements. (7) LH2 booster pumps are mounted inside the LH2 tank. Therefore, to measure the pump vibration which is low temperature conditions, special techniques are adapted. (8) Designed and realized dynamic chamber pressure measurements for engine combustion instability analysis. (9) Developed special safety sensors for detecting the leaks of LOX/LH2 in the process pipe lines and engine, stage systems. (10) Realized Capacitance type liquid level, depletion sensors with dedicated level sensor algorithms to fill the LOX/LH2 with high accuracy. (11) High speed Data Acquisition System to provide 1ms data for the performance analysis. With the implementation, testing of upper stage cryogenic engine and stage have been tested successfully.