

## A.6: Measures for reliability enhancement of machine interlock system for Indus-2

The machine interlock system in Indus-2 is a computer based interlock system. For most of the machine parameters, it handles secondary interlocks as additional safety mechanism, where the primary interlocks are implemented within the systems. Several important enhancements were recently completed with the aim to reduce the spurious trips, capture transient events, and increase the reliability through incorporating measures of self-diagnostics and redundancy. Work has been carried out to develop different types of hardware boards and modules, modified data acquisition scheme to improve process response time and changes in application firmware of Real Time Operating System (RTOS) OS9, SCADA GUIs and database. Following enhancements were done at the system hardware level:

*1. New 32-channel isolated Digital Input (DI) board with self-diagnostics feature:* The 32-channel isolated digital input boards are replaced with new version which now include self-diagnostic feature (Figure A.6.1). All input channels are individually tested at programmed interval. The test data is recorded into the local memory and updated after every test. The actual status of each input channel before the test is kept in different memory location to preserve actual input status. The test results are updated to central database and alarms generated whenever any channel fails.

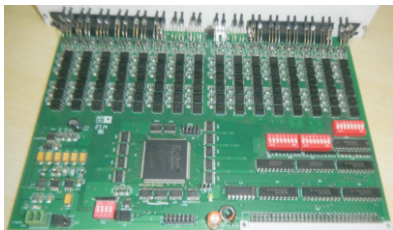


Fig. A.6.1: 32-channel optically isolated DI board with self-diagnostics.

*2. New 32-channel isolated Digital Output (DO) board with self-diagnostics feature:* The 32-channel isolated digital output boards are replaced with new version which has self-diagnostic feature (Figure A.6.2). All channels of this board are repeatedly tested with the help of auxiliary relays at programmed intervals. At the start of the diagnostic test, first the actual output conditions are read and accordingly the test is performed. The output contacts do not change state or chatter during the test. The test results are updated into central database and accordingly alarms are generated in case of abnormality.

*3. Hot swappable redundant VME bus power supplies:* To enhance reliability and availability of the system for 24x7 mode operation, the VME power supply is used in redundant mode.

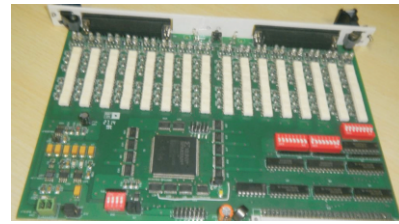


Fig. A.6.2: 32-channel DO board with self-diagnostics.

Current sharing module is developed (Figure A.6.3) for VME power supply. It connects with two VME power supplies of same type and lets them work in current sharing mode. Now the faulty VME power supply can be hot swapped. Redundant VME power supplies have been implemented using such current sharing modules in five VME crates for the machine interlock system of Indus-2.

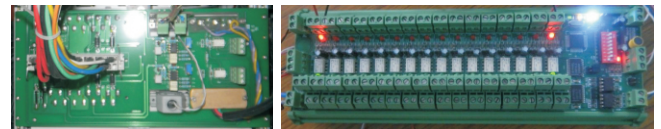


Fig. A.6.3: Current sharing (left) and latching modules (right).

*4. New 16-channel input signal filtering and latching module:* Filtering and latching of all field signal inputs have been incorporated. This helps to filter out the spurious signals of transient nature and latch and log the inputs which then trigger the trip event. This reduces the spurious trips and helps latch and isolate the actual trip events. Presently, thirty-eight 16-channel filtering, latching and monitoring modules are installed. The modules can be remotely reset to de-latch the inputs when due observations have been made after the trip.

Extensive efforts were required at different layers of control system to match the above hardware changes and additions in software. The work involved development of software in SCADA, OS-9, drivers for new boards communication and error handling etc. The software now facilitates various diagnostic test and error data handling. Database server and webpages were also modified for adding these new features. Status and alarms are incorporated for card failure, power supply failure and communication failure. Communication speed and system update rate have been improved.

Measures for reliability enhancement of machine interlock system for Indus-2 were implemented in phased manner. All said modifications and changes were completed and deployed in the system in the long shutdown of December 2019. The system runs satisfactorily in round-the-clock mode operation. After commissioning of the enhanced system, some trip events occurred, which were captured and handled as desired without any spurious event.

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