A SAFETY SYSTEM FOR EXPERIMENTAL MAGNETS BASED ON COMPACTRIO
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Introduction

The design of the custom Magnet Safety System (MSS) for the large LHC experimental magnets began in 1998 and it was first installed and commissioned in 2002. Some of its components like the isolation amplifier or ALTERA Reconfigurable Field-Programmable Gate Array (FPGA) are not available on the market any longer.

A review of the system shows that it can be modernized and simplified by replacing the Hard-wired Logic Module (HLM) by a CompactRIO device (Fig.1). This industrial unit is a reconfigurable embedded system containing a processor running a real-time operating system (RTOS), FPGA, and interchangeable industrial I/O modules.

A prototype system, called MSS2, has been built and successfully tested using a test bench based on PXI crate. Two systems are currently being assembled for two experimental magnets at CERN, for the COMPASS solenoid and for the M1 magnet at the SPS beam line.

Upgraded Magnet Safety System (MSS2)

An analog interface ASIC containing the safety measurement channels, deciding whether a safety parameter has been reached, thus generating an alarm. Detectors are made with 3 purpose-built signal conditioning modules:
- A dual/differential voltage/detector module - DVM
- A dual bridge measurement module - DBBM
- A dual resistance measurement module - DRM

A logical decision unit LCS determining the current machine status based on received parameters and alarms. The main electronic card of this unit is the hard-wired Logic Module - HLM based on ALTERA FPGA.

An application interface API/IPC between the logi unit and the actual machine which is the magnet with services. This interface controls main breakers, quench heaters, power converter, etc.

Diagnostic Tools

For past analysis, there are two UNS-based systems for data acquisition, as shown in Fig.8.
- The Announcer is a fast digital data acquisition with a resolution of 1 ms, storing all logical events from MSS to be able to discriminate events clearly.
- The Magnetic Diagnostic System (MDS) acquires the analog safety parameters by slow data acquisition at a rate of 1 ms and a post-mortem after a magnet quench (before and 5 min after at a rate of 100 Hz).

For MSS2, the announcer and MDS for small application is implemented in the real-time embedded processor.

IMPLEMENTATIONS OF MSS2

MSS2 Test Bench

MSS2 cards are built and tested in-house. A test bench has been developed to test the hardware elements (internal cabling, crates) and the response of the system to digital or analogue stimuli (Fig.6).

This test system is based on PH-Crate with Analogue and Digital Cards and permits carrying out tests in manual or automated modes.

Conclusions

The evolution of MSS to MSS2 permits to:
- Reduce the systems size by integrating the annunciator in the cRIO processor and a new design of the analogue card.
- Simplify and improve system maintenance by limiting the number of custom analogue cards to one and integrating industrial material like cRIO.