Automation of LN2 filling of Clover detectors: A new control system in INGA at IUAC

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Introduction

The Indian National Gamma Array (INGA) facility at IUAC used for nuclear structure studies of nuclei populated at extreme conditions (i.e., high excitation energy and at large angular momentum) and can accommodate maximum 24 high purity Ge Clover detectors [1]. The Ge detectors are required to operate at cryogenic temperatures for suppressing thermal noise and hence providing better energy resolution. Due to this, an automated system for periodic liquid nitrogen (LN2) refilling is an essential part of facility operation. In this paper we are describing a new control system implemented for automation of the process to maintain adequate LN2 level in the Clover detectors. This system is designed based on most recent industrial technologies using time tested architectures, while also supporting the latest Internet of Things (IoT) interface.

1. System Description

The in-built cryogenic dewar of Clover detectors can hold LN2 for more than 12 hours before sufficient drop in its level due to evaporation. To replenish the liquid, an LN2 distribution system with remotely actuated LN2 flow control valves is incorporated. The distribution system consists of three main LN2 distribution lines followed by 24 separate filling lines for individual detectors. The process of filling of main lines proceeded by the filling of individual detectors by automatic opening/closing of control valves one by one

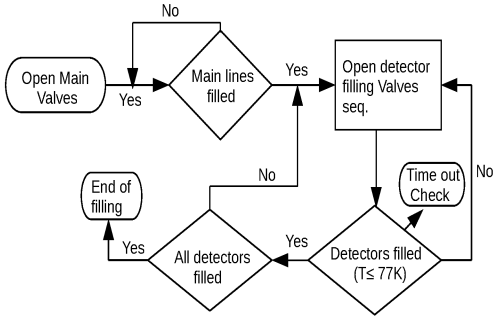

FIG. 1: Algorithm for automatic LN2 filling of detectors

in sequential manner form the two stages of complete filling operation. The operation of automatic LN2 filling in Clover detectors is described in Fig. 1. Due to large number of filling channels and uninterrupted running of in-beam experiments, it is essential to operate the control system in automatic mode for maximum facility uptime and operational efficiency.

2. Implementation

The control system implementation is shown in Fig. 2, consisting industrial controller, local control hardware, monitor/control modules, power supplies and relays along with the front panel (control switches and status LEDs). An industrial grade MODBUS/RTU [2] based data acquisition and control modular system forms the back bone of the control system. Along with the control operation, the system takes care of safety, operational requirements (user interface and methodology), maintenance and upgradation (if any) and connectivity

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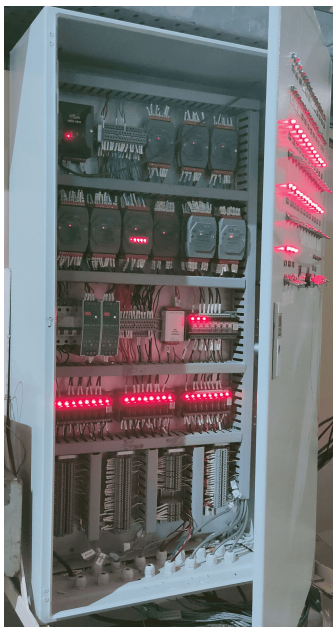

FIG. 2: Internal view of control system along with front panel.

requirements also.
The industrial controller is the key component of the system that constantly monitors and controls the opening/closing of valves based on read-back signal provided by industrial grade time-tested PT100 sensors mounted at the overflow port of the detectors as per instructions from automation computer. The time delay interlocks of 1 minute for closing of valves after reaching cut-off temperature ($\leq$77 K) for each detector is also incorporated for ensuring proper overflow of LN2. A time window is also provided to check whether the sensor temperature reached $\leq$77 K within it, else a error signal will be reflected through status LEDs and control valve get closed.
The system supports SCADA architecture as well as supports MQTT protocol for IoT technologies [3]. A GUI is developed using LabVIEW^{TM} [4] and the MODBUS/TCP interface for necessary automation algorithm implementation.

Results and Conclusion

The control system has been assembled and successfully tested locally as well as remotely in automatic/manual control modes for few detectors in which PT100 sensors has been mounted. Once all sensors at the position, the system can provide unattended and efficient automatic LN2 filling operation along with ruggedness, reliability and convenient operation.

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