DISTRIBUTED REMOTE TEMPERATURE MONITORING SYSTEM FOR INDUS-2 VACUUM CHAMBERS

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Abstract

Indus-2, a 2.5 GeV Synchrotron Radiation Source (SRS) at Indore has a large vacuum system. The vacuum envelope of Indus-2 ring comprises of 16 dipole chambers as vital parts. Each chamber has 4 photon absorbers & three beam line ports blanked with end flanges. Temperature monitoring of critical vacuum components during operation of Indus-2 ring is an important requirement. The paper discusses a distributed, 160 channel remote temperature monitoring system developed and deployed for this purpose using microcontroller based, modular Temperature Monitoring Units (TMU). The cabling has been extensively minimized using RS485 system & keeping trip relay contacts of all units in series. For ensuring proper signal conditioning of thermocouple outputs (K-type) & successful operation over RS485 bus, many precautions were taken considering the close proximity to the storage ring. We also discuss the software for vacuum chamber temperature monitoring and safety system. The software developed using LabVIEW, has important features like modularity, client-server architecture, local and global database logging, alarms and trips, event and error logging, provision of various important configurations, communications handling etc.

INTRODUCTION

In Indus-2 ring vacuum components , temperature is monitored at different points. This is decided considering the interaction of synchrotron radiation (SR) with the vacuum components. At 2Gev, 300mA, estimated radiated power in the ring is 187 kW and it has the potential to cause material damage to chamber walls. 64 water-cooled photon absorbers & 48 water-cooled end flanges were installed on dipole chambers to dissipate SR power. It is necessary to ensure that these component temperatures are under control. This will also ensure low out gassing rate of photon absorbers. The developed system has provision of monitoring 160 channels. The data is being successfully logged along with alarm & trip event occurrences. . This distributed monitoring system has 20 TMUs. Each TMU (Shown in Fig.1) monitors temperature of eight channels. The front panel has communication status LED, Trip status LED, cold junction compensation (CJC) sensor & thermocouple terminating connectors. The back panel has RS485 in & out 9-pin D-connectors. The cabling has been extensively minimised informing temperature of 160 channels over pair of wires with a facility to define customised commands & easy future modifications. The set point trip relay contacts of all units were taken in series with the help of second pair of wires in communication cable. The mains power supplies of all units were distributed from single point making hardware reset easy for all units at once.

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TECHNICAL DESCRIPTION

Temperature measurement is done using K-type thermocouples. RC filter is used for rectifying common mode & differential mode noise [1]. The circuit is compatible for both grounded & un-grounded type of thermocouples. It also has provision for detection of open thermocouple with the help of –1V voltage bias to one thermocouple end for keeping amplifier output to negative saturation with open thermocouple. The ADC used is Successive approximation type. This ADC is chosen for keeping the design universal for faster signal measurement. Multiplexer channel switching is line synchronized for overcoming the noise pickup especially 50Hz. In 20 ms interval, 50 measurements are taken & averaged with equal interval for switching before & after measurement. Temperature resolution is 1°C. The

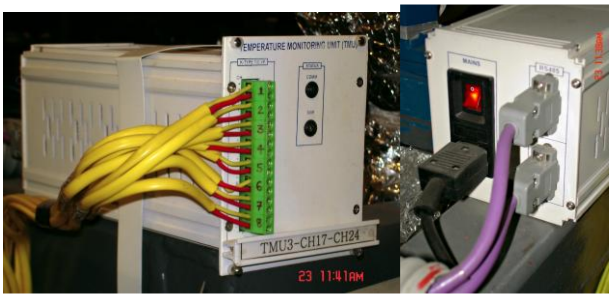

Figure 1: Front & Back Panel of TMU

linearization of thermocouple is done with the help of lookup table. Half Duplex RS485 communication is used in which all units are acting as slaves while computer in control room works as master. RS485 driver is optically isolated from the circuit for overcoming the ground loops & limiting the noise sources interference in analog measurement circuit[2]. Terminating resistors on the extreme end units are used to get rid of signal reflections. The twisted, shielded cable (characteristic impedance (Z0) 120Ω,) is used with one pair of wires along with shield to each unit. The power supply transformer was with a shield between primary & secondary windings to minimise noise coupling. For restricting CJC error, sensor (LM35) was located close to the front panel and termination of compensating cables. The CJC sensor output was added by feeding this input to the OFFSET input of instrumentation amplifier (AD620) as.

OPERATION AND INTERLOCK

There is provision for two types of set points called Alarm Set Point & Trip Set Point. Alarm set point can be changed remotely whereas trip set point is programmed in EPROM. The operator is supposed to find out the cause behind the alarm & take appropriate action as soon as alarm is detected. Since alarm has the second priority, it's raised in computer software itself after observing the temperature data. Trip set point is hardwired interlock (single contact). In PC software, user can identify the unit generating the alarm as this data is passed by the unit through the communication frame. In controller unit status of spare contact of trip relay is reed back & its status is sent in the frame. Considering the importance of trip relay, a maintenance frame was incorporated. After issuing this command all the trip relay will be activated & their status will be reed back. This insures normal behaviour of all trip relays from control room only. Each unit has single trip relay with failsafe logic (normally activated). The N/O (normally open) contacts of all trip relays are connected in series & single contact is given to Machine Safety Interlock System (MSIS). If any channel among 8 crosses trip set point, the trip relay is deactivated which results in opening the contacts. Necessary action will be taken through the interlock to dump the beam in the ring. All units respond to the computers query on RS485 bus & reply to it as given in the protocol document.

SOFTWARE & COMMUNICATION

Some important features of software are

1. Event & Data logging.
2. Alarm handling with unique set point for each channel.
3. Detection of open T/C states.
4. Client-server architecture.
5. Only server part should be running for logging & alarm handling.
6. Error reporting.
7. GUI can run from other n/w console.
8. Trend plotting, comparative temperature analysis, etc.
9. TRIP test facility.
10. Relays misbehaving during TRIP test will be identified beforehand.

The communication on RS485, checksum verification and error reporting is done by the system. Invalid frames if received are kept in log for analysis. The trip test is an automated process and it keeps track of timings and contact debouncing delays etc. it is very important to keep log of all activities handled by the system and events occurring for analysis and debugging of problems related to communication & overall system. All alarm instances such as a high temperature alarm, failure of connection with central database, error in communication, thermocouple open condition etc are flashed on the GUI for immediate attention of operator. All critical status indicators are made blinking type to avoid any problem of system hanged or dead screen.

Figure 1: GUI Panel for TMU

CONCLUSIONS

The system is working successfully over past 4 years. No problems are noticed in RS485 communication and temperature monitoring. It clearly indicates the successful use of RS485 communication in the noisy environment of accelerator is possible after taking proper precautions.

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