

Thermal Control System Upgrade - Report.

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Motivation - Under the new upgrade of the CMS detector the working temperature of the trackers had been reduced to -27 Celsius degrees. Though the thermal sensors themselves (Murata and Fenwal thermistors) are effective at these temperatures, the max1542 PLC (programmable logic controller) cards, interpreting the resistance of the thermal sensors into DC counts usable by the DCS (detector control system), are not designed for these temperatures in which the counts exceed their saturation and therefor had to be replaced. In my project I was in charge of handling the emplacement and calibration of the new PLC cards to the TOB (tracker outer barrel) control system.

Preparation - The newly ordered “out of the box” PLC cards had to be reprogrammed for the experiment needs. The parameters suitable for our usage, for each of the electronic devices on the card, was inputted into the flash memory of each of the cards 16 channels (corresponding to 16 different sensors). Initial testing of counts received at limit resistance was executed to make sure the cards were properly made and match our needs.

18 cards were made for this upgrade replacement plus 2 extras and 15 more for future use. There have been one card detected as defected and marked to not be used, the rest were numbered and documented as well as their flash memory and output data for future reference if will be needed.

An automation script has been written in Murgee software and used to replace all the parameter inputting, leaving only the change of resistors and the documentation to be done manually. Reducing the programming routine by approximately 20%.

Implementation - For a temperature interpretation of the counts, first a function connecting any number of counts received by a specific channel to the corresponding resistance had to be calculated. Therefor after connecting the cards in their place in the CMS electronics counting room, each channel was tested by 20 different resistors (imitating the resistance of the sensor in different

temperatures) between 10 to 180 kOhms corresponding to varying temperatures between 25 to -30 Celsius degrees. The data was documented, sorted and analyzed by Matlab curve fitting toolbox to receive the three parameters of the quadratic polynomial function connecting the temperature to counts. Those parameters are used by the online controlling system, to calculate from the PLC counts output the thermistor resistance. Anyone connected to the system is then able to know the temperature using the known manufacture behavior of the thermistor.

To reduce human work time on sorting the data, I used a copyable excel format based on cell referencing to pull the data received from the testing into a uniform format concluding table. To test the data credibility two tests were implemented in it. One to ensure the connection of all channels in all the tests and the other to check the tendentiousness of the counts in respect to resistance.

The data analysis was done by a single program written and executed in Matlab simply called 'card_curve_fitting'. The program is designed to receive an input of the new card numbers to be analyzed (of which the test data have been saved using the mentioned format) as one array and produce a final report including all requested parameters and their calculation errors sorted for each channel in a final format (suitable to be used by the online controlling system). Along side, the program produces a plot of the function curve for each of the channels, and a matlab structure containing all relevant data, calculated parameters and the credibility of the fit for reliability testing of the results. The program has been tested over old cards to see the matching of the results to old fittings done by other programmes in the past (the programmes were not reusable).

Project closure - The final results file of the TOB PLC cards calibration have been submitted to the DCS for examination and application from now on. A zip pack including the written script, example files and instruction manual have been made so others could easily repeat or continue this work. Explanations and side notes have been added to the program so adjustments could also be made by others in the future.

Results - Resulted parameters have been authenticated as reasonable for the real time temperature. Analyzing program has been tested as reliable and time saving. The PLC programming automation program unfortunately can not be used again in the future due to hardware and software old age (authentication of the Murgee software license can not be achieved without internet connection).

Conclusions - Project requirements were successfully achieved in reasonable time frame. Human work time had been able to be significantly reduced by the use of automation methods and if there were usage instructions to the old fitting tools.