Comparing PLC Project Code After a Major Fault

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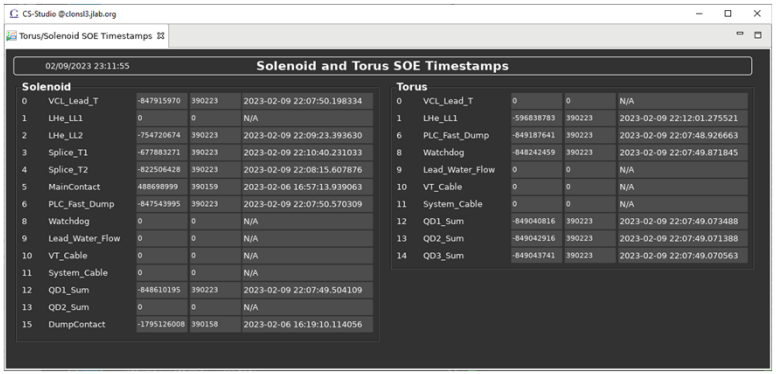
On February 9, 2023 both the torus and solenoid superconducting magnets in Hall B initiated a fast dump. The sequence of events module which timestamps the fault signals on both magnets indicated that the earliest signal was on the torus PLC itself (Torus bit 6), figure 1. The fact that the watchdog signal (Torus bit 8) also failed in close proximity in time indicates that there was an issue with the PLC itself.

One of the main advantages to using a PLC over some other control hardware is that changes to the code can be done online while the PLC is running. This allows (mostly, depends on the exact changes being done) uninterrupted controls, e.g. valve positions will be maintained if updating other sections of code. Whenever a change to the code is made online this must also be saved locally, otherwise the next time connecting to the PLC there will be a conflict as the local (on the PC) and remote (on the PLC) no longer match. When this happens the software will prompt as to which version should be used. The upload choice takes what is on the PLC and uploads it to the PC, the download choice takes what is on the PC and downloads it to the PLC. In nearly all cases the upload option is selected in order to preserve any online edits made to the PLC.

When connecting to the torus PLC after the fast dump, it unexpectedly brought up the choice to either upload or download the code. This was unexpected as there should have been no changes to the code since January 12, 2023 when the code was updated to use the same polarity change logic as the solenoid. As per the usual procedure, the upload option was selected and after connecting it was found that the PLC had a major fault relating to power-up, also unexpected as the PLC is on UPS power and the UPS had no events stored in its built-in log

- **Both torus and solenoid magnets fast dumped**
  - **Logs indicated it was the torus PLC that went first**
- **Found that torus PLC code didn't match last known local save**
- **A comparison between the code was performed**



SOE Timestamps

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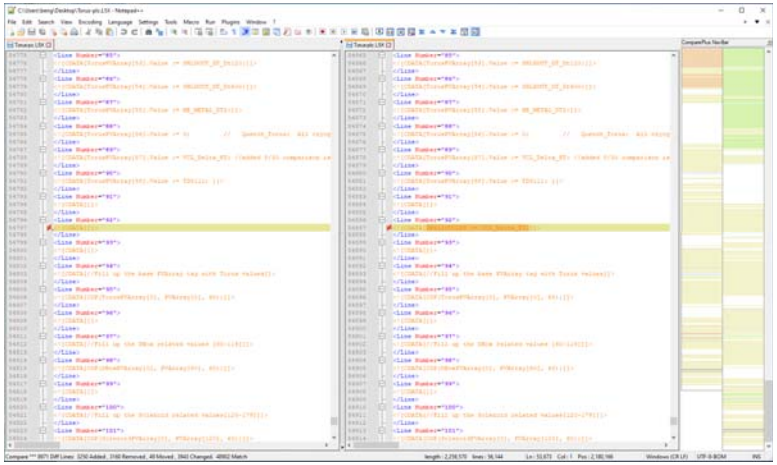
When saving the code uploaded from the PLC, it was noticed that the code did not match the local copy on the PC, namely the recently added polarity change code was missing. Both the code uploaded from the PLC after the failure and the most recent local copy were exported to an XML format and compared, see figure 2.

The comparison listed 8971 lines different, with those further breaking down to 3250 added, 3160 removed, 49 moved, and 3943 changed. The reason for the discrepancy in numbers is some lines had multiple properties, e.g. moved and changed. Manually viewing the differences, it was found that the vast majority of them were merely tag values being different between the saves. This is expected behavior as many of the tags are just sensor data and would expect to be different. However, some small code changes were noticed other than the missing polarity change code as well.

All the changes were incorporated into the current running PLC code to make the versions match. After manually viewing the file comparison, a Rockwell Automation software package (an optional install) was found that functionally performs the same task (converting to L5X, an XML file, and then running the comparison). Since this is provided by the vendor, it has some added features such as the ability to ignore tag value changes, which greatly reduced the differences (only 53 in total with nearly 30 of them being code comments that were different).



Code Comparison

Red = Missing Line
Green = New Line
Yellow = Changed Line