CLARA GUN TEMPERATURE CONTROL USING OMRON PLC

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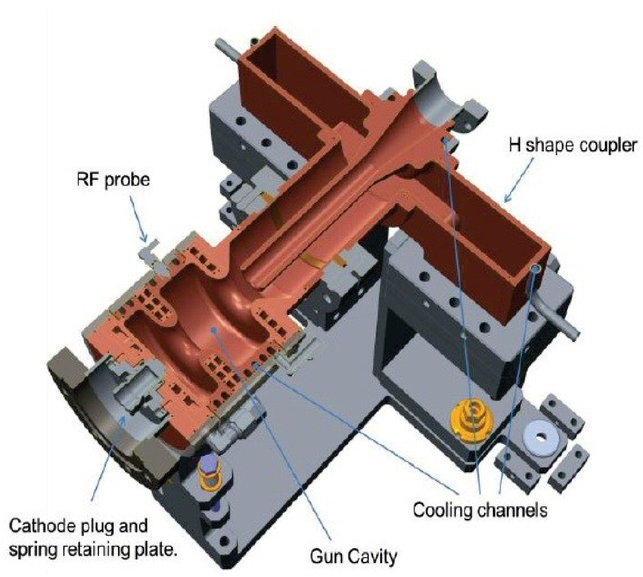
STFC Daresbury Laboratory is currently commissioning Phase I of CLARA (Compact Linear Accelerator for Research and Applications), a novel FEL (Free Electron Laser) test facility focused on the generation of ultra-short photon pulses of coherent light with high levels of stability and synchronization. In order to maintain phase stability the CLARA gun requires a precision water temperature control system to maintain a gun cavity temperature within 0.028°C. This is achieved by mixing two water circuits with temperatures close to the desired set point. Two temperature measurement systems were evaluated for precision and reliability, the resultant system uses a single Omron PLC which provides all the precision read back and control loops. High resolution input modules and averaging achieve precision temperature monitoring while two PID loops control the coarse and fine temperature control. EPICS control is achieved using the FINS protocol communicating with a Linux IOC.

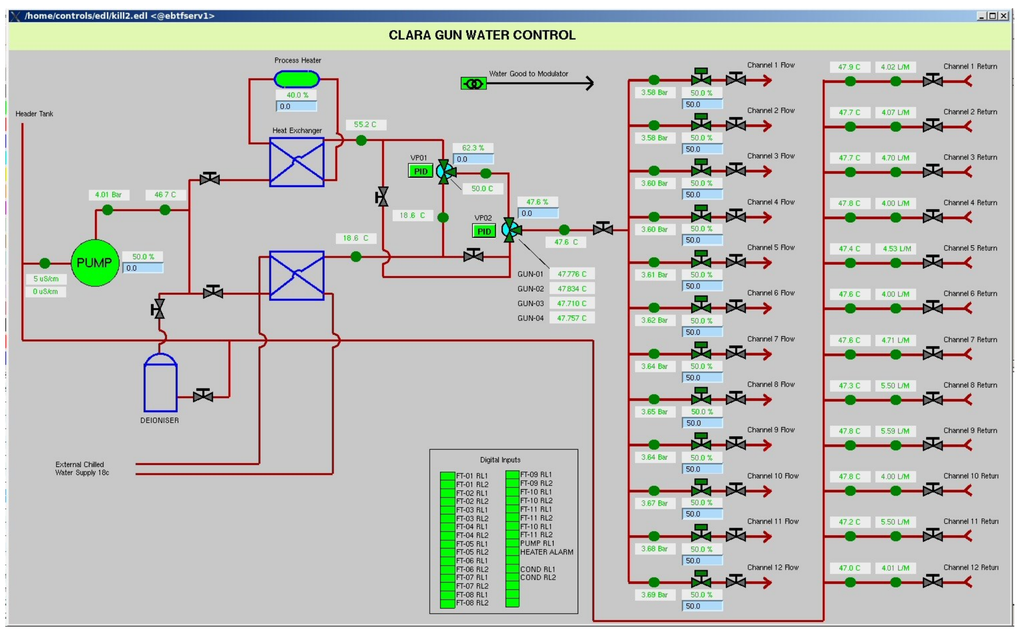
CLARA

The purpose of CLARA is to test and validate new FEL schemes in areas such as ultra-short pulse generation, temporal coherence and pulse-tailoring. Seeded FEL experiments which require interaction between a short laser pulse and the electron bunch place extremely high demands on the RF gun stability. For example, the jitter of the launching phase of the beam in the magnetic bunch compression mode should be less than 300 fs, which, in terms of the S-band RF phase, is 0.3°. To provide such a phase stability the required cavity peak to peak temperature stability should be better than 0.028°C.

CLARA Gun



Temperature Control



The gun temperature control operates by mixing two water temperatures close to the operating point. Two valves are PID controlled one produces a temperature just above the operating point which is then mixed with a manually set lower temperature to produce the fine temperature control.
The flow and return are split into 12 water circuits each with pressure, flow and temperature feedback the plc also controls a electrically controlled proportional valve in each circuit

To prevent operation when the water flow or temperature is out of specification the system provides a hard wired interlock to the RF Modulator.

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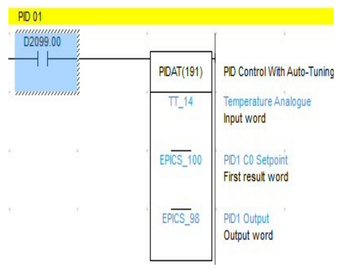
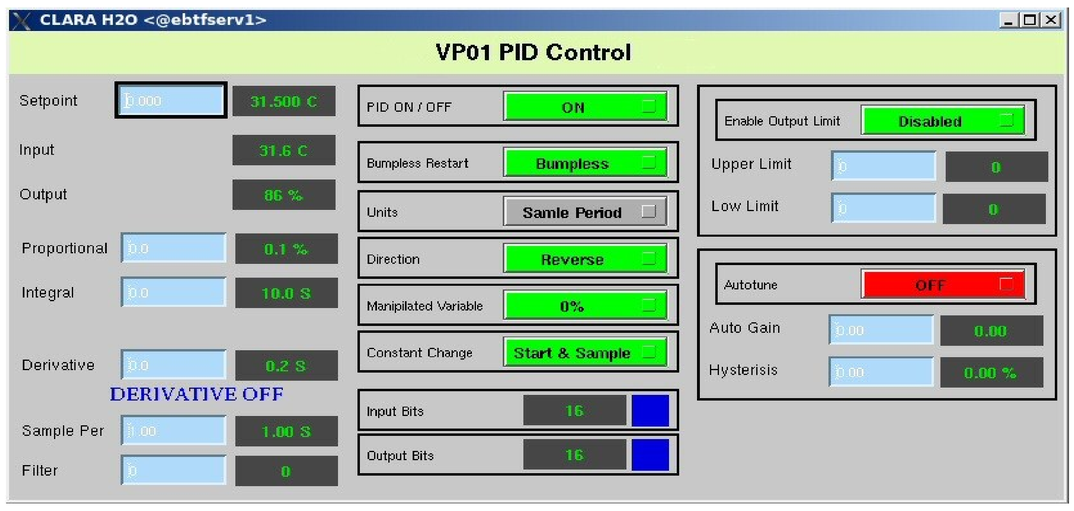
Temperature Acquisition

Two temperature input devices were evaluated the Omron PH41U and the Gantner A105.
The results were almost identical both producing very good resolution and stability. On further investigation both use 24 bit converters from competing manufacturers.
The Omron CJ2 PLC is the preferred method for the low level plant interface; a distinct reliability advantage can be gained if the temperature read back can be fed directly into the PLC. Due to the evaluation results being so close it allowed a decision to be made based on compatibility with existing systems, therefore it was decided to use the Omron ADC unit..
If the control loops are also executed via the same PLC then the temperature control system becomes a standalone system immune to network disturbances and IOC reboots.

PID Control

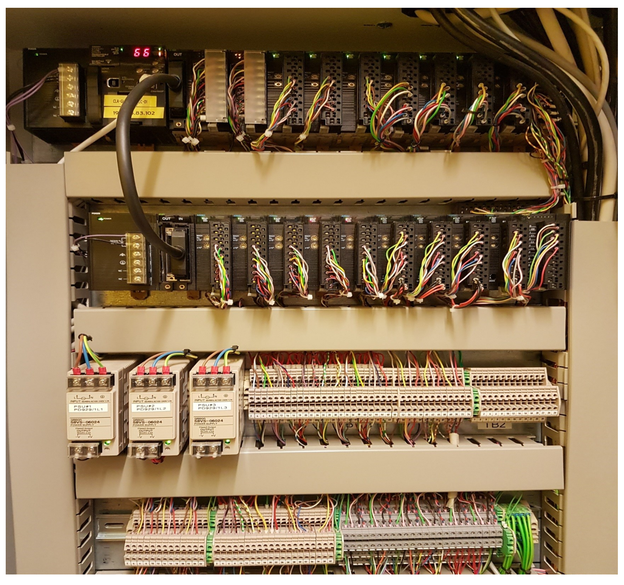


The function block appears to only have three parameters but memory space has to be reserved for setting all the other parameters and also for working memory internal to the routine.
All the control addresses are then mapped back to EPICS read and writes..



This EDM display shows the full functionality of the PLC PID function block

Hardware



The complete system is mounted in a wall mounted enclosure.

There are 21 temperature measurements in the system 17 having 0.1°C resolution and 4 have 0.001°C resolution.

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Dell R220 rack mount PC running a Linux IOC provides the EPICS interface using the Omron FINS protocol.

Conclusion

There has generally been a limitation to the use of PLC's for high resolution data acquisition and control because of the lack of suitable of high resolution modules especially in mid-range PLC's. This is no longer the case; PLC's can be used to provide precision measurement and control.
We have used CJ2 PLCs for several years with an excellent reliability record. Initially they were used for digital control and interlocking but the potential to provide a complete control solution is now being utilised. Communication via the EPICS FINS interface is also very robust. The CLARA gun is awaiting commissioned but this control method is also being used for the CLARA Linac temperature control which has been successfully RF conditioned while under temperature control.