# Development of the New CTF3 Klystron-Modulator Control System

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## 1. Introduction

The actual LPI Klystron-Modulator (MDK) control system is 10 years old and uses components that are no longer supported by industry. The policy for the new control system is to use as much as possible industrial elements. These new control elements are integrated into the equipment they will control and also into the overall accelerator controls scheme. In this design, the local control interface is based on a Programmable Logic Controller (PLC) from Siemens [1] with analogue and digital input & output signals that handle the slow changes of the equipment. Additionally, to enable acquisition and interlocking of fast signals of short duration (µS) that are also present in the modulators, a pulse surveyor protection and monitoring system is being developed. This will be connected to the PLC through a PROFIBUS network [2]. This paper describes the local control system, its interface hardware and software and its use with the CTF3 Klystron-Modulators.

## 2. New design

The control and protection system collects information from the MDK and sends commands to it, as shown in Figure 1.

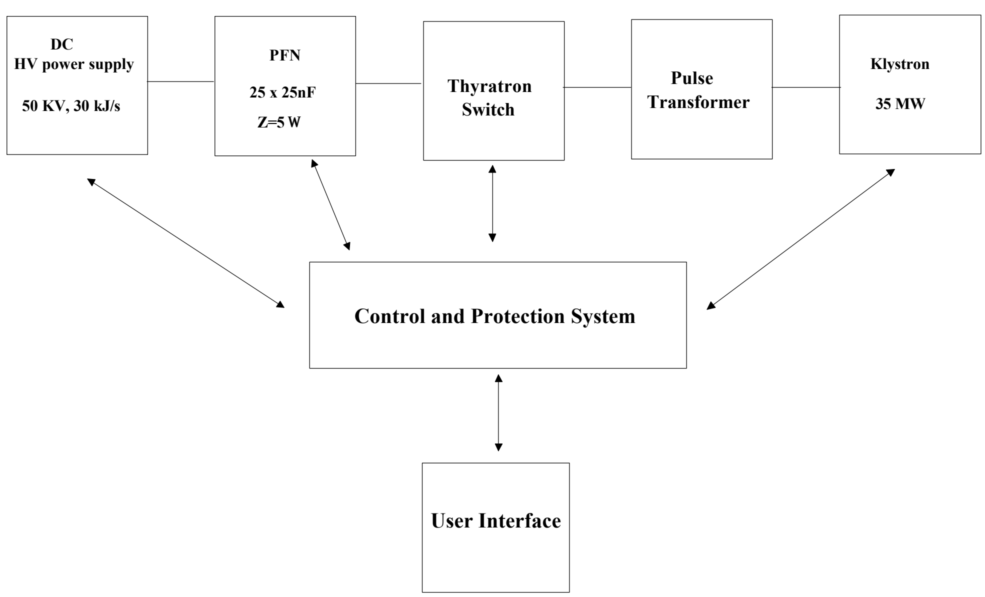


Figure 1. MDK layout.

## 2.1 Signals and commands to be treated

Tables 1 to 6 show the location of the interlocks, measurement signals and control commands that are to be treated by the new PLC control system.

| **Interlock (contact)** | **Analogue signals to be measured** | **Control commands or references** |
|---|---|---|
| -Doors<br>-Earth rod<br>-Filter temperature<br>-Thyratron fan<br>-Faraday cage Fan | -Thyratron current<br>-EOLC (end of line diode circuit) current<br>-Front line current | -Ross relay |

Table 1. PFN signals.

| **Interlock (contact)** | **Analogue signals to be measured** | **Control commands or references** |
|---|---|---|
| -Contactor ion pump power supply<br>-HV ion pump cable connected | -Focal current A,B,C<br>-Premagnetisation current<br>-Klystron heater current<br>-Klystron heater voltage<br>-Thyratron heater current<br>-Thyratron heater voltage<br>-Pump voltage<br>-Pump current<br>-Pump state | -Focal A,B,C current reference (Potentiometers)<br>-Premagnetisation current reference (Potentiometers)<br>-Klystron heater current reference (PLC)<br>-Thyratron heater current reference (PLC)<br>-Contactor ion pump power supply |

Table 2. Focusing coil and heater power supply signals.

| **Interlock (contact)** | **Analogue signals to be measured** | **Control commands or references** |
|---|---|---|
| -Doors<br>-Emergency stop | -Average current (master, slave1, salve 2)<br>-Output voltage (master, slave1, salve 2)<br>-Status (master, slave1, slave 2)<br>-HV output state<br>-V divisor | -Voltage reference<br>-HV on<br>-Fast inhibit<br>-Remote on |

Table 3. High voltage power supply signals.

| **Interlock (contact)** | **Analogue signals to be measured** | **Control commands or references** |
| --- | --- | --- |
| -Emergency stop<br><br>All the interlocks are routed to the PLC to be treated. | All the klystron fast signals are treated by the pulse surveyor crate linked to the PLC | All the control signals are coming form the PLC |

Table 4. The control rack signals.

| **Interlock (contact)** | **Analogue signals to be measured** | **Control commands or references** |
| --- | --- | --- |
| -Water flow | -Klystron voltage<br>-Klystron current<br>-Body water in temperature<br>-Body water out temperature<br>-Tank temperature | |

Table 5. The klystron tank signals.

| **Interlock (contact)** | **Analogue signals to be measured** | **Control commands or references** |
| --- | --- | --- |
| -Contactor focal A,B,C<br>-Contactor Premagnetisation<br>-Contactor klystron heater<br>-Contactor thyratron Heater<br>-Contactor HV supply<br>-Contactor trigger amplifier | | -Contactor focal A,B,C<br>-Contactor Premagnetisation<br>-Contactor klystron heater<br>-Contactor thyratron heater<br>-Contactor HV supply |

Table 6. Low-power distribution signals.

## 2.2 The MDK can be found in one of four control states:

OFF, HEATER, STANDBY, PULSING

To each of these states, the corresponding interlock conditions have to be satisfied that allow appropriate commands to be sent. When an interlock is activated, the MDK goes to a predetermined state corresponding to the level of the activated interlock.

### 2.3 Hard-wired interlocks

Personal security interlocks are treated both by software and hardware. For example, opening a door of the Faraday cage will cause the HV power supply to be disconnected from the 380 V and the PFN shorted to earth potential even if the PLC were to be faulty. Other interlocks, such as the klystron water flow, which would be very damaging for the klystron, also have hard-wired contacts that prevent power being applied to the klystron.

## 3. Local control of an MDK.

The new control system for CTF3 MDKs is based on a Siemens S7-300 PLC, which is integrated into each modulator's control and protection system. Slow changing signals are monitored and directly connected to the inputs of the PLC. The faster signals are treated by a new pulse surveyor crate (under development) which will be linked to the PLC through a Profibus network. For now, the old pulse surveyor cards are linked directly to the new PLC digital inputs. Local supervision and control commands are made with an industrial PC which is linked to the PLC via the Profibus network. Remote control of an MDK will be possible using with a VME card connected to the actual CTF3 control network. The general layout of the control system is shown in Figure 2.

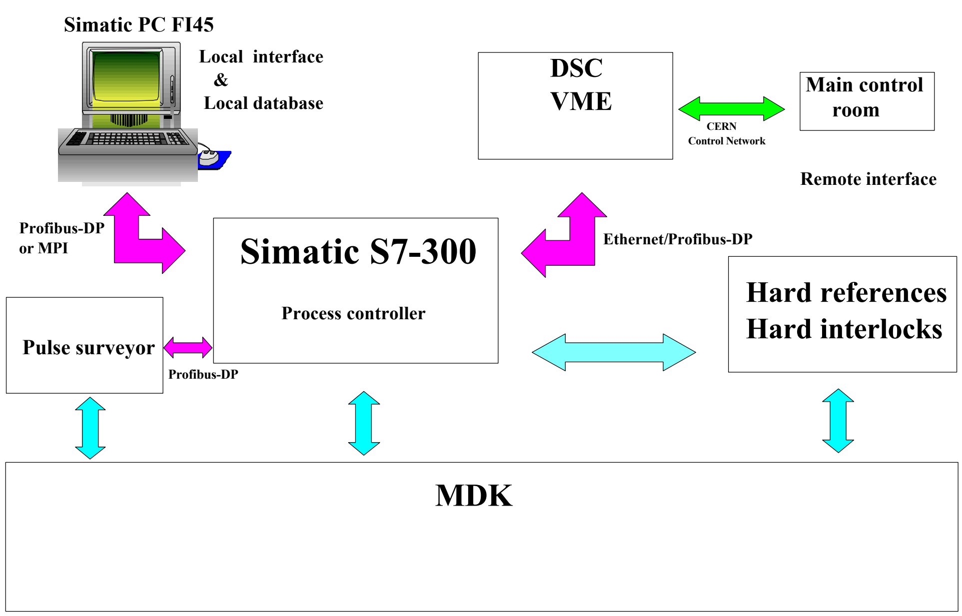


Figure 2. Control layout.

## 3.1 The PLC hardware

The PLC hardware contains:

- 1 CPU S7-318-DP (Siemens)
- 1 power supply 924V/10A)
- 72 digital inputs
- 24 analogue inputs
- 8 digital outputs
- 4 analogue outputs
- 16 relays

The PLC cycle has to be shorter than 10 ms as the maximum pulse-to-pulse repetition rate of the MDK is 100 Hz, and for this reason the CPU 318 was chosen. It has a bit-operation time of 100 nS and the Profibus-DP coupler that is also integrated can follow this data rate.
To achieve accurate measurements and settings, the PLC analogue to digital and digital to analogue converters have 16 bit resolution.

## 3.2 The PLC software

During each cycle the PLC looks at all the interlocks and signals corresponding to the MDK operational state and makes on-line a decision to ensure the security of the MDK equipment and local operators. Periodically all the information contained in the PLC is sent to the General User Interface (see bellow, 3.3) through an OPC server (see bellow, 3.4) to be shown on the user panel. To allow after the event diagnostics to be made, all the faulty interlocks are stored in a database. The PLC works in stand alone mode, even if the GUI is faulty, and there is a watchdog to ensure that the PLC is running. If the PLC becomes faulty this then event will switch off the MDK.

## 3.3 The General User Interface (GUI)

The GUI is an industrial PC running under Windows NT linked to the PLC through the Profibus network. A Bridgeview [4] application program running in partnership with a OPC server, allows the user to see the MDK status and to send commands to it.

## 3.4 The OPC server

The OPC server (Object Linked Embedded (OLE) for Process Control) [3] installed on the GUI is linked to the PLC through the Profibus network. It receives periodically all of the interlock information and all measurements. It sends commands to the PLC when needed. The OPC server is read by, and written to, using the Bridgeview control command application program.

### 3.5 The local control command program

This user application program displays graphically the operating states of the MDK. It allows the user to locally command the MDK, set up the interlock levels of the measured signals, and set the HV reference or the heating parameters. The display is designed to help the user to rapidly find where a fault has developed. In the future, this application will be able to send detailed electronic messages to the user when an error occurs, and thus shorten the delay before repair.

### 3.6 The new pulse surveyor card.

The new pulse surveyor card is still being developed [5] and will deal with all the fast measured parameters coming from various parts of a klystron-modulator. These Signals are:

- Klystron voltage
- Klystron current
- Eolc (end of line diode circuit) current
- Thyratron current
- PFN voltage

The new pulse surveyor card, will be fully controlled by the PLC. Interlock levels, time window widths and signal attenuation are set via the PLC. In addition, on each card, there is an AD converter and an on-board memory which will store the last 100 waveforms. This will be very helpful to diagnose a malfunction of the MDK. Once an error occurs, the storage is stopped and, if asked, the digitised waveforms are downloaded to the GUI for visualisation. The layout of the pulse surveyor card is shown in Figure 3.

## 4. Conclusion

This control system has been tested and is in operation on the new MDK33 klystron modulator. The results are very encouraging and the system is easy to use and permits rapid diagnostics. The remote control interface of the MDK is still under development, and will be completed soon to enable the new modulator to be integrated into the CTF3 controls system for start-up at the end of this year.

Due to the flexibility of the new PLC control system, programmed optimisation of all parameters is feasible. In particular, the requirements for having automated control of the high power parameters during RF conditioning of all waveguides and accelerating sections become possible without reducing any of the MDK protection conditions that apply during normal operation.

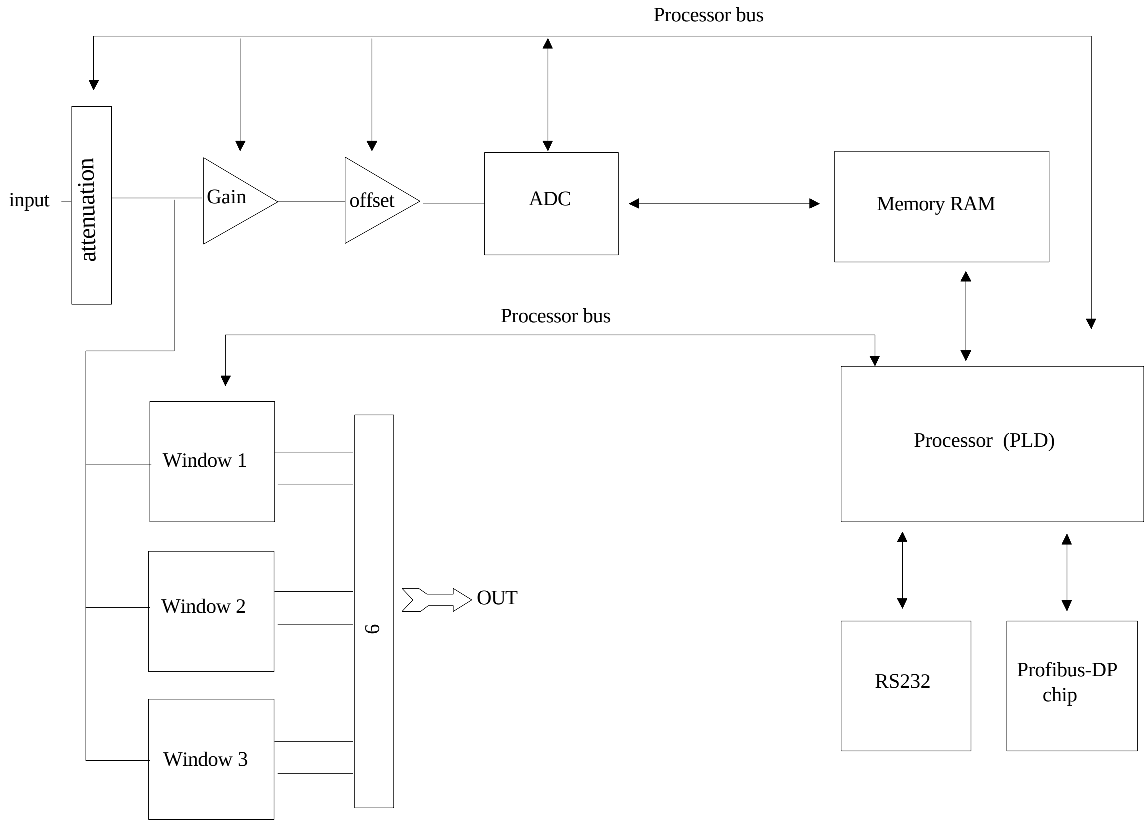


Figure 3. New pulse surveyor card layout.

## 5. Reference.


1) Siemens. http://www.siemens.ch/adf
2) Profibus. http://www.profibus.com/.
3) OPC Foundation. http://www.opcfoundation.org/.
4) BridgeView. National Instruments. http://www.natinst.com
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11) Fault data acquisition project for the LPI modulator. Alan Campbell. CERN/PS/LP Note 93-66 (Tech).