A PLC-BASED SYSTEM FOR THE CONTROL OF AN EDUCATIONAL OBSERVATORY

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Abstract

An educational project that aims to involve young students in astronomical observations has been developed in the last decade at the Basovizza branch station of the INAF-Astronomical Observatory of Trieste. The telescope used is a 14" reflector equipped with a robotic Paramount ME equatorial mount and placed in a non-automatic dome. The new-developing control system is based on Beckhoff PLC. The control system will mainly allow to remotely control the three-phase synchronous motor of the dome, the switching of the whole instrumentation and the park of the telescope. Thanks to the data coming from the weather sensor, the PLC will be able to ensure the safety of the instruments. A web interface is used for the communication between the user and the instrumentation. In this paper a detailed description of the whole PLC-based control system architecture will be presented.

INTRODUCTION

A non-automatic dome at the INAF-Astronomical Observatory of Trieste, in Basovizza, hosts the telescope Celestron C14 and the solar telescope Coronado HELIOS. These telescopes are used for a project that proposes a modern tool to support the teaching of astronomy, through the study and experimentation of its observation methods. More information about this educational project can be found in [1].

Figure 1: Paramount ME mount.

The telescopes are installed on a german equatorial mount (Fig. 1), that allows automatic pointing of the telescope and tracking. The totally completed "Paramount ME" mount, through the dedicated software "TheSkyX", and an appropriate control system, allows the remote management of the telescope. Although the telescope could be fully remotely controlled, the operations on the other equipments requires the physical presence of an operator. In particular the opening/closing of the roof is manual as well as the switching of the dome instrumentation. The aim of this paper is to describe a new PLC-based control system aimed to make the dome and its hosting instrumentation fully robotic ensuring in this way safety and remote operations.

OVERVIEW OF THE SYSTEM

The whole instrumentation is placed in one of the buildings of the astronomical station. This building consists of two rooms: the first is the control room that contains the computers for the observations; the second room, with a sliding roof, contains the telescope and its instrumentation (CCD camera, filter wheel, focuser).

The roof is moved transversely by a three-phase synchronous motor. Since the total extent of the telescope exceeds the height of the roof, it is mandatory that the telescope is in park position when the roof is in motion. Near the telescope, there are some outlets, for switching on and off the telescope, the CCD camera, the CORONADO for the daytime observations, and an auxiliary one.

Currently, the steps necessary to perform an observation are the following:

1. Switch off the lights near the building
2. Switch on manually the power supply of the dome
3. Turn on the PC
4. Open the dome holding the button that moves the motor of the roof
5. Remove the cap that closes the telescope
6. Turn on the telescope and other equipments (with several switches for each specific outlet)
7. Initialize the mounting
8. Perform the homing of the telescope
9. Start the observation with TheSkyX software.

At the end of the observation, all these operations have to be performed in the opposite order.

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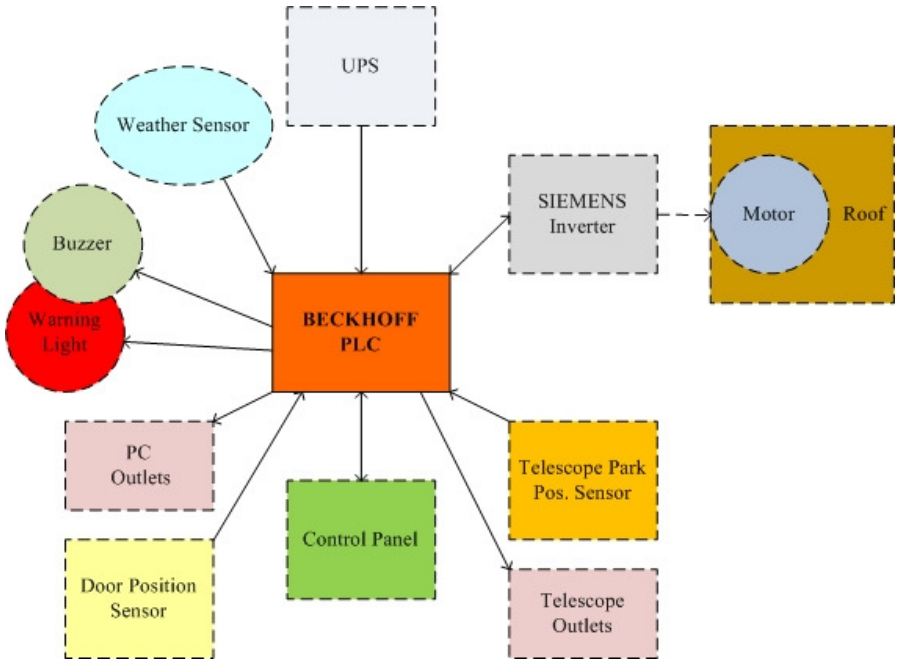

Figure 2: General system overview.

THE NEW CONTROL SYSTEM

In the next months this system will be updated and remotely controlled through the installation of a Beckhoff PLC[2]. This upgrade will mainly allow to remotely control the movement of the roof of the building, to park the telescope and to control all the other devices that will be needed for the observation operations (see Fig. 2).

The design of the PLC implementation will also take care of two important aspects:

1. Human safety
2. Instrumentation safety

Since the total extent of the telescope exceeds the height of the roof, it is preferable not to have human presence in the telescope room while the remote observation are in progress and mechanical parts are in motion.

The CPU *CX1030* will be installed in the control room with the necessary Beckhoff modules needed to control the devices hosted in this room.

The functions that will be controlled by the Beckhoff modules in the control room are (Fig. 3):

- Power on and off the PC in the control room
- Switch on and off the warning light and buzzer that announce the movement of the roof
- Manage the weather signal that will come from the weather sensor *Boltwood Cloud II*
- Manage the movement of the roof through the *SIEMENS MICROMASTER440* inverter
- Read the signal of the sensor that notifies if the door leading to the telescope room is open or closed
- Manage the control panel. This panel will allow to check whether the equipment is operated manually or remotely. In case of door opening with the remote management enabled, the equipment will be deactivated, for safety reasons.

In the telescope room the decentralization features of the Beckhoff PLC are exploited and a new row of PLC modules is foreseen. The *EK1100* module will assure the continuity of the EtherCAT communication with the CPU in the control room.

The functions that need to be controlled in the telescope room are the following (Fig. 4):

- Power on and off the electrical outlets: TELESCOPE, CCD, CORONADO, AUXILIARY
- Read the status of the position of the telescope. Two positioning sensors will be placed on the telescope in order to control if the telescope is in park position. This will allow the system to close the roof remotely without any problem
- Move the telescope in the park position if needed (i.e. if the signal of the weather sensor warns about a rainy weather). This will happen through the movement of the joystick. A simple interface circuit will be built to allow this movement. This choice was made due to the proprietary protocol of the telescope which does not allow the possibility to be interfaced.

Table 1 shows in detail the features and the use of each Beckhoff module.

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Table 1: Description and Use of the Beckhoff Modules Foreseen

Module	Features	Use	Q.
CX1030	Beckhoff CPU. Intel® Pentium® M, 1.8 GHz clock frequency, 64 MB Compact Flash card, 256 MB DDR RAM, 2 x RJ 45 interfaces, TwinCAT 2 PLC runtime, NC PTP runtime, NC I runtime	Basic CPU Module	1
EK1100	EtherCAT Coupler	Connect the terminals via EtherCAT	1
EL1002	Digital Input, 2 Channels	Control of the telescope park position	1
EL1004	Digital input, 4 Channels	Management of the manual switch of the instrumentation and the control panel; weather and door sensors signals detection; control of the status of the outlets	4
EL2004	Digital output, 4 Channels	Management of the control panel, warning system and power the instrumentation, command of the status of the outlets, joystick movement	6
EL6731	PROFIBUS Master/slave Terminal	Communication with the *SIEMENS* inverter for the roof movement	1
EL9011	End cap	-	2

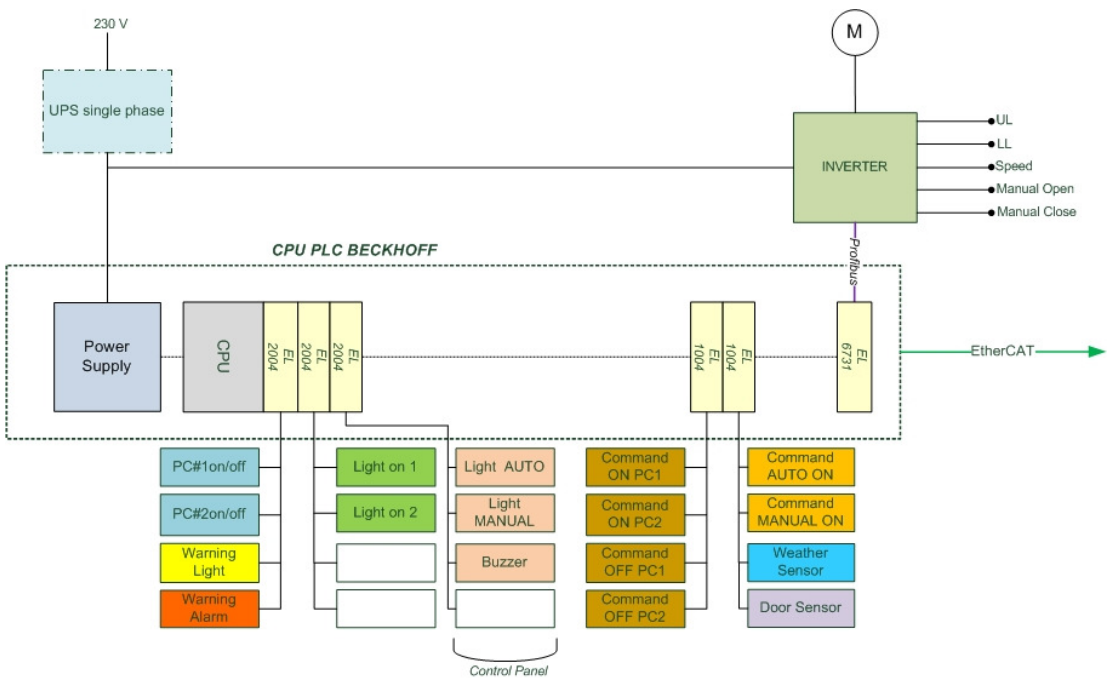

Figure 3: Functions controlled by the PLC modules in the control room.

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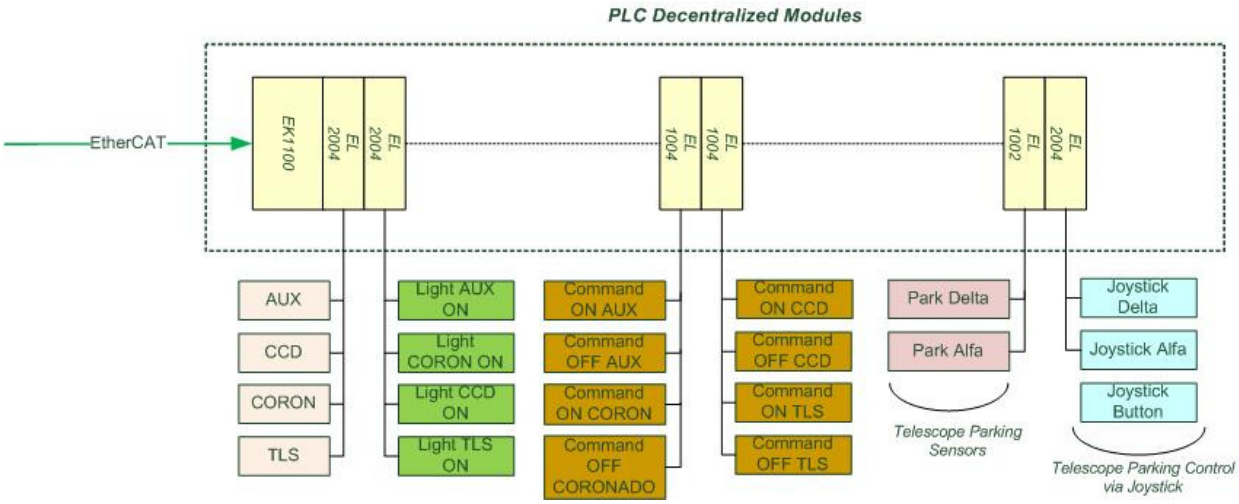

Figure 4: Functions controlled by the PLC modules in the telescope room.

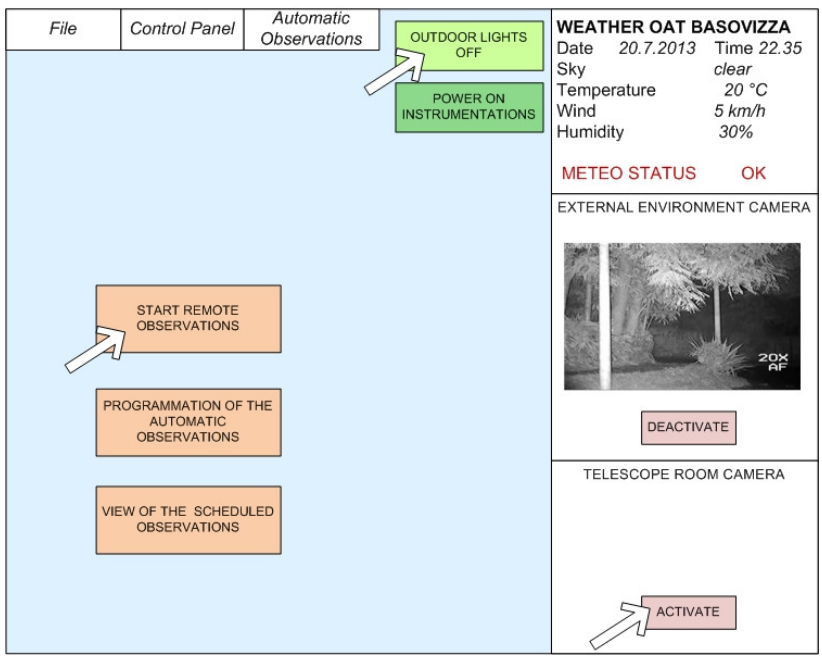

Figure 5: Example of the software interface.

The Software Interface

The remote operations will be available through a web interface, installed on a Windows web server in the observatory main building. There will be an authentication system, with different authentication levels, to log the accesses. The web browser (i.e. Fig. 5) will show live weather situation using the weather sensor and two webcams: one showing the surrounding environment and the other the telescope room. From the web interface it will be possible to start the observations (turn off the lights, open the roof, power up the telescope and the control room computers). The software will be connected to the PLC library using the ADS system. From the web interface it will be possible to start the observations allowing fully robotic safe operations.

REFERENCES

[1] http://scuole.oats.inaf.it/svas-en.html, 2013.
[2] https://www.beckhoff.com, 2013.

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