

## DESIGNING VIRTUAL REALITY APPROACH FOR PLC APPLICATIONS DEVELOPMENT

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**Abstract:** The paper is a brief description of our long-time experience and research in the field of engineering education in the transition era of the information age (student time) to experience age (ready to go in practice time). Our approach proposed by this article adds one immersive to life tool for exploring the practice through a virtual reality environment. The engineering subject is a programmable logic controller (PLC) training environment for specific applications. The virtual reality glasses and gloves are main “bridges” between labs setup and 3D virtual industrial universe. The simulations become powerful through 3D libraries designed in dedicated CAD software, and an optimized interface composed of inputs, outputs and parameters that makes it easy to control the 3D virtual object from an automation software.

**Keywords:** industrial processes, PLC, engineering education, virtual reality, learning by playing, new simulation paradigms.

### 1. VIRTUAL REALITY APPROACH FOR PLC

The virtual product development is a complex approach in the design process of industrial engineering. The virtual product development fulfills a wide range of testing tools in the virtual reality (VR) environment [8].

In this research work, VR allows the researchers to create visual simulation tools for testing purposes, without incurring some heavy costs of trial and error methods by producing real samples. The research involving VR can, therefore, be used to create new approaches that support both industry and teaching communities.

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**Fig. 1.** Real industry hardware used for controlling a virtual environment

Different testing techniques performed in the virtual reality environment before getting to prototype production, can increase productivity and decrease development time conserving the resources. As an illustration of different possibilities of performing a wide range of tests in the VR environment [8], this paper shows an example of a simulation environment for an industrial process controlled by the programmable logical controller e.g. S7-1200 series developed by Siemens (Fig. 1).



**Fig. 2.** Siemens PLC software communicating with virtual reality software

The TIA Portal software is directly connected with the Programmable Logical Controller (PLC) through the standard LAN interface [6] (see Fig. 2). The ladder (LAD) program implemented in TIA and PLC configurations also are downloaded into the hardware device using this LAN interface [5-7]. The Virtual Reality Software is installed on same PC with TIA software and configured to communicate with the PLC controller through it. Virtual reality hardware tools (glasses and gloves as presented in Fig. 2) relate to VR Software and these are used by human operators to control objects in VR.



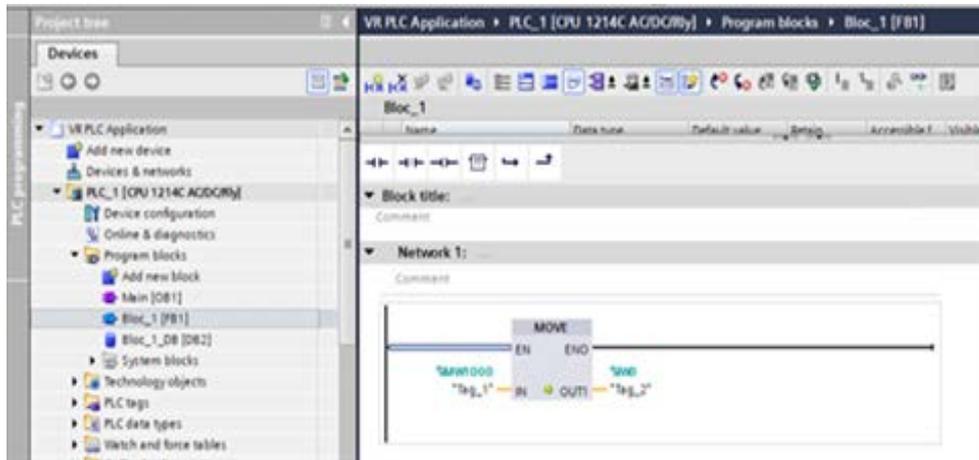


Fig.4. The LAD block "Move value" instruction for transferring In and Out values

As mentioned before, the common programming language compatible with a PLC controller is ladder logic (LAD) diagram used for implementation of algorithms presented in this research work. The LAD development techniques are widely used in programming PLCs where sequential control of a process or manufacturing operation (Fig. 4 and Fig. 5) is required [2]. It is a graphic programming language which can be used to transcribe relay diagrams and is suited to combinational processing [1,2,6,7]. This technique provides basic relay related graphic symbols as: *contacts, coils, and other block instructions (move, timer, counter, etc.) (as presented in Fig. 4 and Fig. 5).*

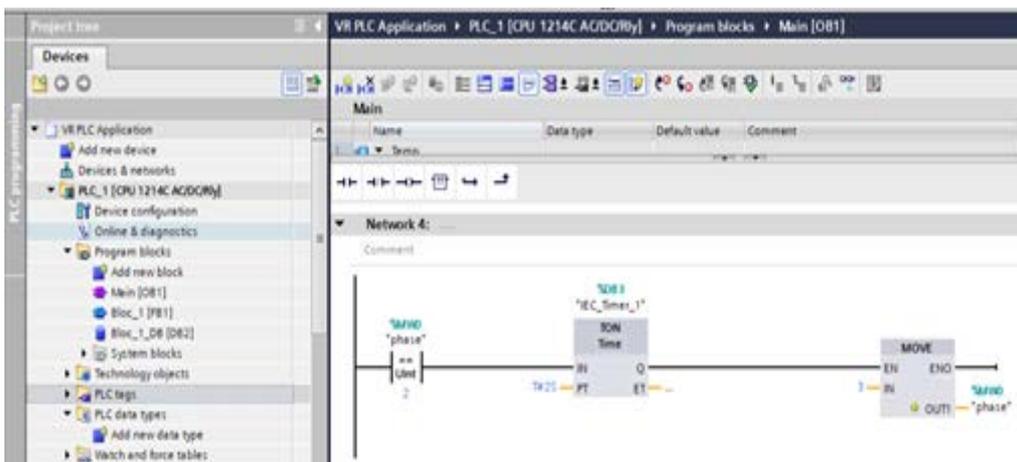


Fig. 5. Motor control delay using TON timer block

The system comprises of the main line for objects transport (e.g. box containers) and a subordinate line on which lighter objects are segregated (Fig. 6, Fig. 7). In the real industrial process, the second conveyor line is driven by two rpm motors.

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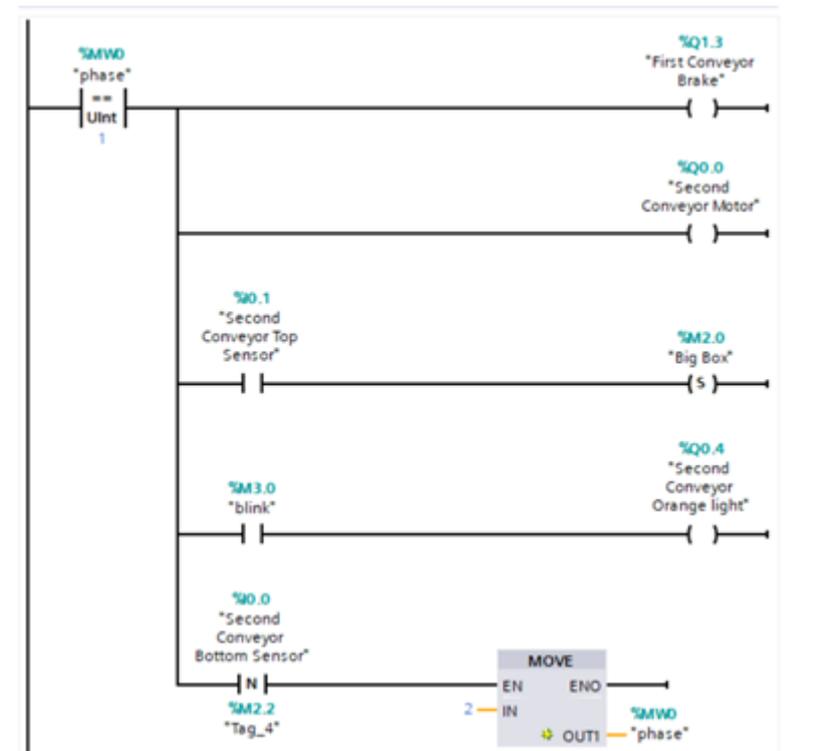


Fig. 6. The Ladder logic (LAD) setup of second conveyor motor

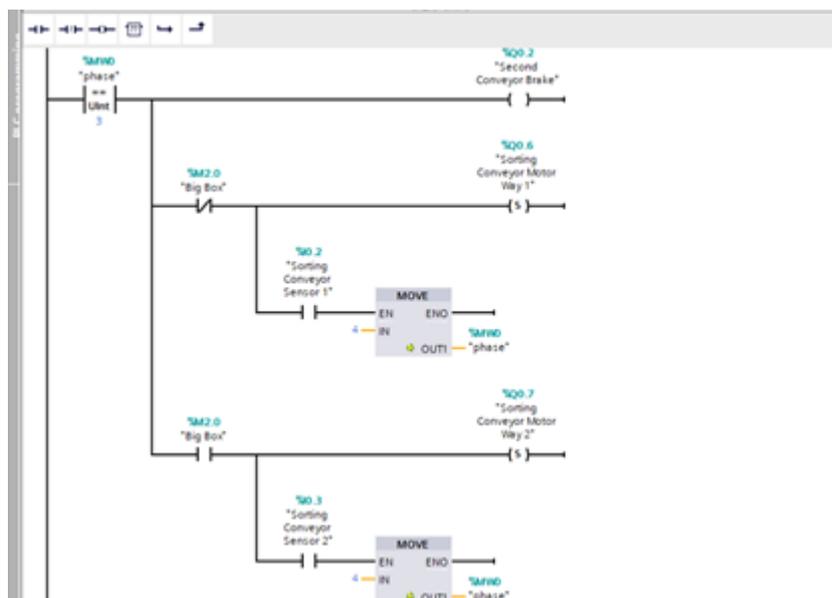


Fig. 7. The Ladder logic (LAD) setup of sorting conveyor motors

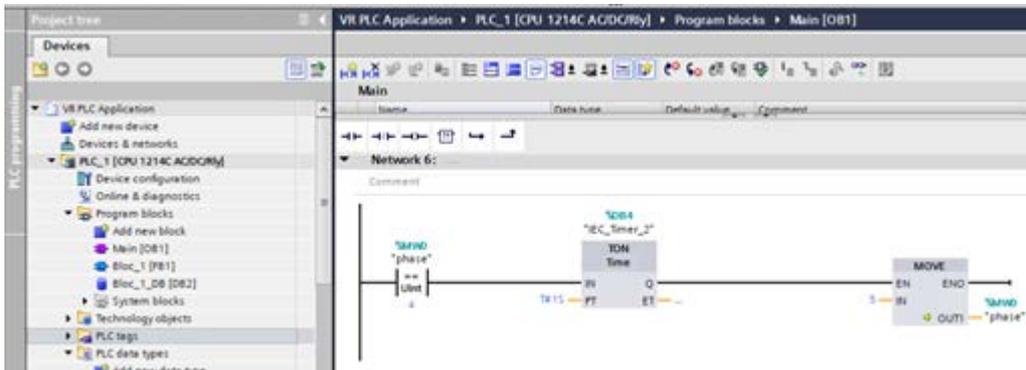


Fig. 8. Setting a delay in control of motor for sorting operation

The hardware section of this research work is composed from one S7-1200 PLC and other accessories (power supply, network connection, etc.) [3-4]. On the other hand, the software section of this work is developed in the TIA portal v13 (see Fig. 8, Fig. 9) in order to control and design the VR industrial process to work correctly. In this section of the paper, the LAD Programming concept is presented to control the hardware (see Fig. 9) which manipulates the objects in the VR environment.

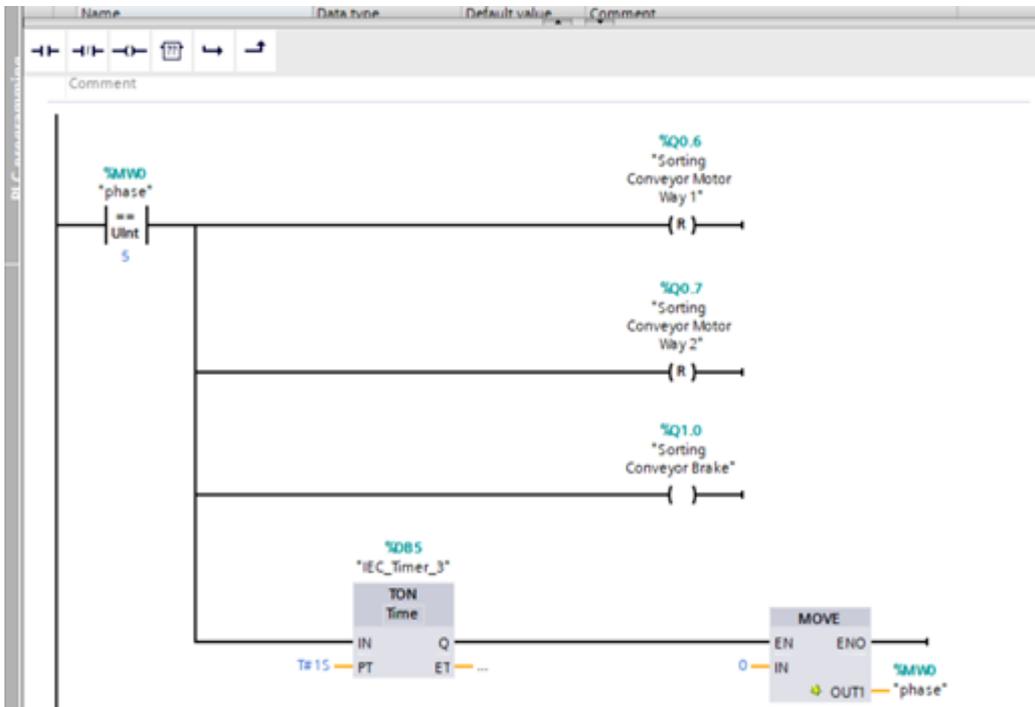
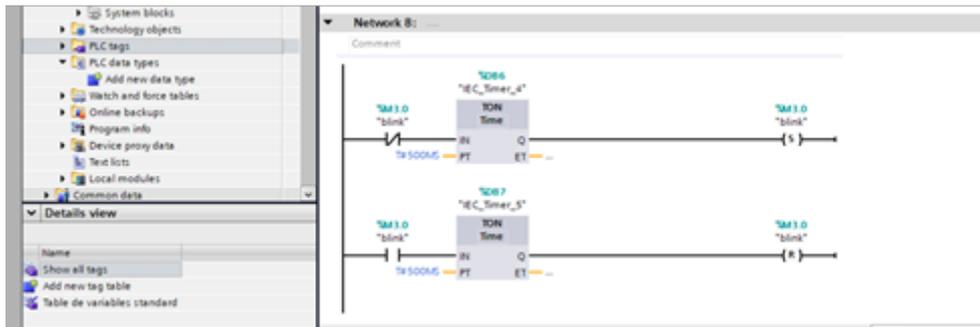


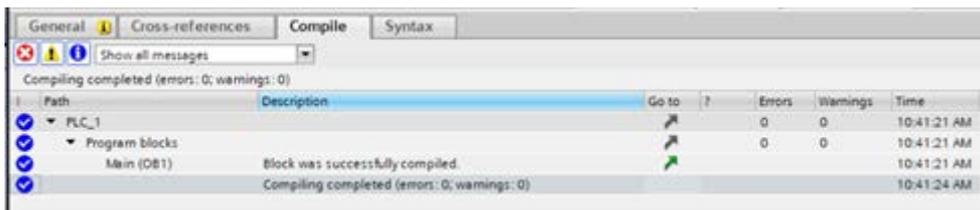
Fig. 9. The Ladder logic (LAD) setup of the second conveyor line

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**Fig. 10.** The Ladder logic (LAD) setup for sensors temporization setup

The objects in the VR environment (conveyor belt, motors, sensors in Fig. 10, etc.) are connected to the PLC hardware environment through The Virtual Reality software.



**Fig. 11.** Compiling the developed software

After developing the software routines for the PLC controller, these routines are compiled (as presented in Fig. 11) and downloaded to the hardware through a LAN interface.

The system is now prepared for controlling the VR environment. In the next section the design of the objects in Virtual Reality software and the connection between the Hardware and the VR are presented [8].

### 3. DESIGN OF VIRTUAL ENVIRONMENT AND FINAL RESULTS

We need to create a virtual model (a CAD model) of a scene that includes the industrial machines, sensors, buttons, switches and other elements specific to real industrial process, so that users can get as close as possible to real-life experience.

The simulation can run in real-time, controlled by the PLC hardware system (note that: the main PLC and the automation software must be connected and turned on) or by a built-in virtual controller implemented in VR or by other computer software using an IP connection. In developing the model, it is necessary to plan all movements that are performed by individual components or sub-assemblies in the VR environment, in order to properly set up a process control relationship, as well as consider the orientation of the coordinate system.



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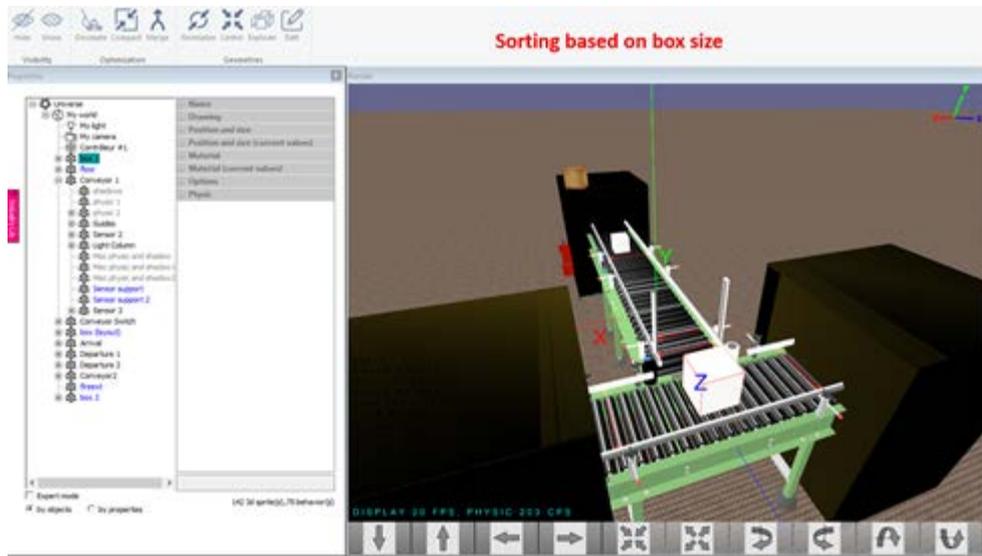


Fig. 14. Setup if the conveyor 2 sensors

Virtual reality headsets are used to test the developed application in this work. The project presents an overview of hardware and software tools used to program a PLC hardware CPU for controlling a sorting system in VR environment. This approach presents a new concept used for example in a simple belt conveyor application to remove or sort the object depending on physical properties without having to build the real industrial system.

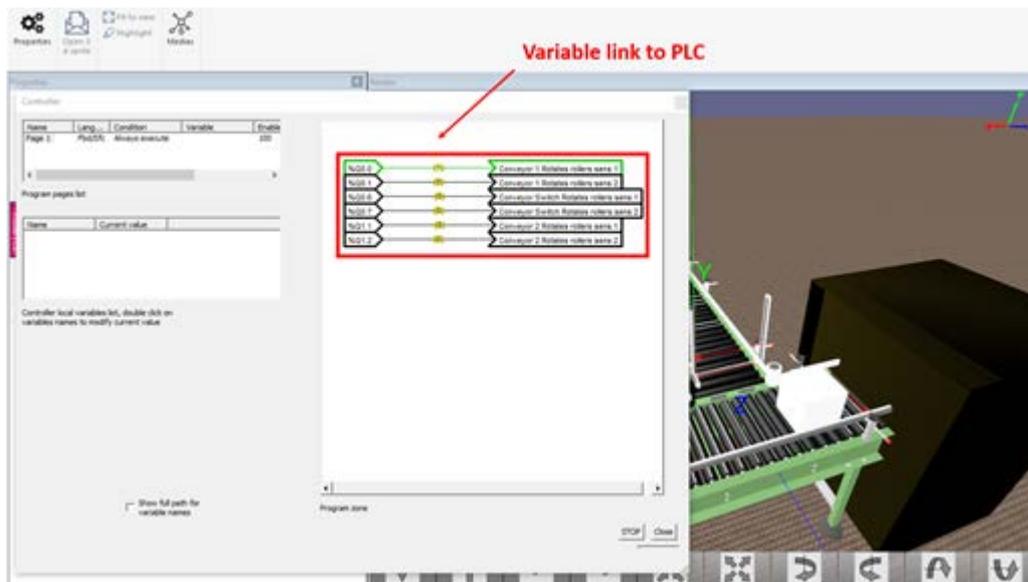


Fig. 15. Setup the connection between the PLC and the virtual software

#### 4. CONCLUSIONS

PLC ladder programming is highly demanded in many industrial fields. The success of such programming approach depends strongly by the accuracy of the process understanding. The information exchange and interaction between PLC and controlled process normally is based on accumulated knowledge base. For new processes, or when the process control philosophy is changed, the quality of the programming can be improved by using instruments and software tools that allow virtualization of the targeted environment or the process.

Virtual reality is a complex approach but allows fulfilling the complete range of tests. For non-experienced users, this approach can be accepted, or improved if the methods are known, or similar with other experiences- like gaming.

Through the proposed method, we have “copied” part of the environment we interact with and allow our gestures to send commands in virtual software.

The simulation can run in real-time, controlled by a PLC (virtual commissioning: the main PLCs and automation software drivers are included in the product) connected to the PC or by a built-in virtual controller or by a computer software using an IP connection.

The „compound” of PLC-software for virtual reality control runs PC with current specifications, the only restrictions are related to use dedicated graphical card with 8GB memory space, and memory speed over 10 Gbps (gigabits per second).

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