

## USING DIRECT HMI SIMULATOR AS A REMOTE OPERATOR PANEL

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**Abstract:** The paper observes using of a Windows based PC human-machine interface simulator as a remote operator panel. The main functions of a real intelligent terminal are described. The basic graphic primitives and their visual interpretation are presented. Making software for operator panel PC simulation is explained. Several examples of using a PC based HMI simulators are given.

**Key words:** Human-machine interface, simulation, industrial automation

### 1. INTRODUCTION

A HMI, aka Human-Machine Interface, is a device or software that allows its user to communicate with machineries and production plants by translating a huge amount of complex data into accessible information. In this way the operator has all the necessary tools to control the production process. Contextualizing this definition in the world of Industrial Automation, it's clear how the more responsive and user-friendly the HMI, the more efficient and cost-effective the job. HMI is the interface between the process and the operators – in essence an operator's dashboard. This is the primary tool by which operators and line supervisors coordinate and control the industrial and manufacturing processes in the plant. HMIs serve to translate complex process variables into usable and actionable information.

Displaying near real-time operational information is the domain of the HMI. Visual process graphics give meaning and context to motor and valve status, tank levels and other process parameters. HMIs give operational insight into the process and enable control and optimization by regulating production and process targets. Basically, a HMI device enables visualization and control of applications. Depending on the plant, the device's features can change, in terms of connectivity, technology and even dimensions. Therefore, in Industrial Automation can be found HMIs that vary from standard 4.3 inches devices to sophisticated wide screen more than 15.6 inches displays. That's why anyone can find the right solution. In order to simplify even more the operators' job, the touch

screen technology (capacitive or resistive) is available, allowing an intuitive interaction with machines and production plants.

Modern HMIs must automatically focus the operator's attention on the problem. They must enforce standard operating procedures and ensure timely, easy identification of abnormal conditions. Advanced situational awareness design must help the operator see what is happening, focus on the problem and deliver relevant screens instantly. Modern HMIs must provide more than process visualisation. They must connect people, applications, and machines for greater collaboration, efficiency, and economy. The HMI must expose the relevant information, to the appropriate people, at the right time to enable them to make better decisions [1-3].

### 2. HMI PC BASED SOFTWARE, PROTOCOLS

The most important features of having HMI are high quality graphics for realistic representations of machinery and processes, alarms, trends, simulation, messaging, animation of equipment based on operator standards, hardware cost reduction and communication such as Serial Ports, Data Highways, Ethernet etc. The PC software for making HMI projects offers many possibilities including libraries of graphic primitives with relevant parameters, animations, making own graphic objects, VB based macro language etc. On Fig. 1. is presented the common view of a project window with its user interface elements. On Fig. 2. are shown Control Elements on the Main Screen [6].

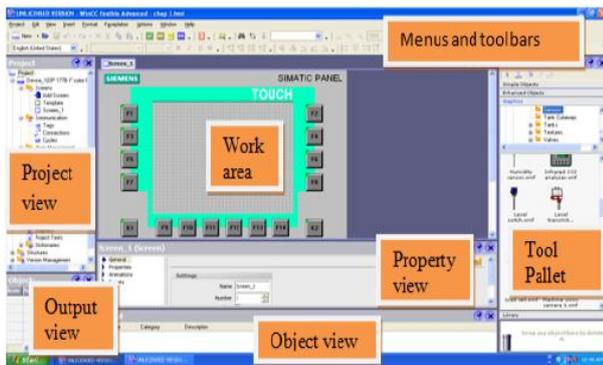


Fig. 1. User Interface Elements

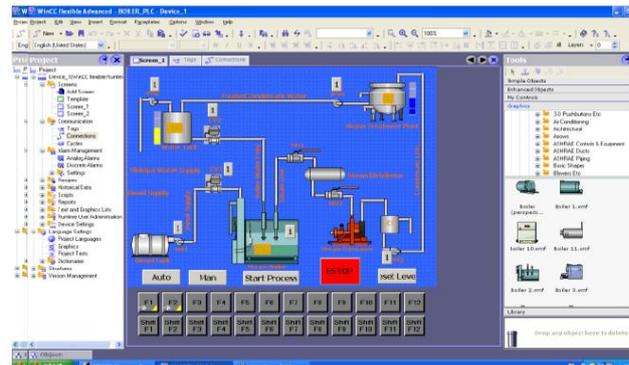


Fig. 2. Control Elements on the Main Screen

Some of basic parametrizable graphic primitives (objects) are:

- **Bit Lamp** object displays the state of a designated bit address. If the bit state is OFF, the State 0 shape will be displayed. If the bit state is ON, the State 1 shape will be displayed.
- **Word Lamp** object displays the state according to the value of a designated word register. Up to 256 states are available. When the value of the register is 0, State 0 appearance of the object is displayed, and value 1 displays State 1, and so on.
- **Set Bit** object provides two operation modes: manual or automatic. Manual mode can trigger a designated bit address to change the state between ON and OFF when the object is touched. In automatic mode, the bit is automatically activated when a pre-defined condition occurs, touching the button will not be effective.
- **Set Word** object provides two operation modes: manual or automatic. Manual mode can change the value in a designated word address when the object is touched. In automatic mode, the word register is automatically activated when a pre-defined condition occurs, touching the button will not be effective.
- **Numeric Input** object and Numeric Display object can be used to display the value of a designated word register. Numeric Input object can be used to input a value into a register via a keyboard.
- **Bar graph** object displays data as a bar graph in proportion to its value.
- **Meter** object can display the value of word device by meter.

An example of parametrization of 'Meter object' is shown on Fig. 3.

Another usable features of PC software for making HMI projects are macros. The macros provide the additional functionality the application may need. Macros are automated sequences of commands that are executed at run-time. Macros allow to perform tasks such as complex scaling operations, string handling, and user interactions with the projects. All the HMIs support many of PLC (Programmable Logic Controller) communication protocols. Some of them are shown on Fig. 4 [5].

In the communication between PLC and HMI, HMI may be a master or a slave depending on design requirements.

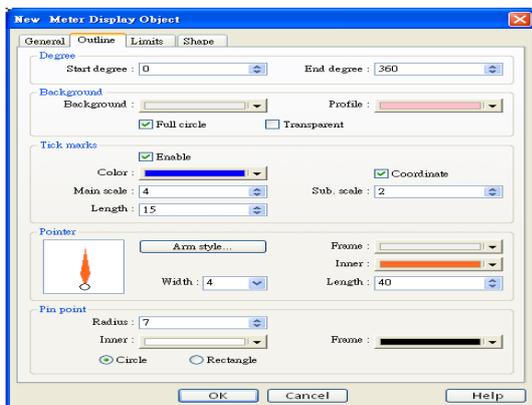


Fig. 3. Parametrization of 'Meter object'

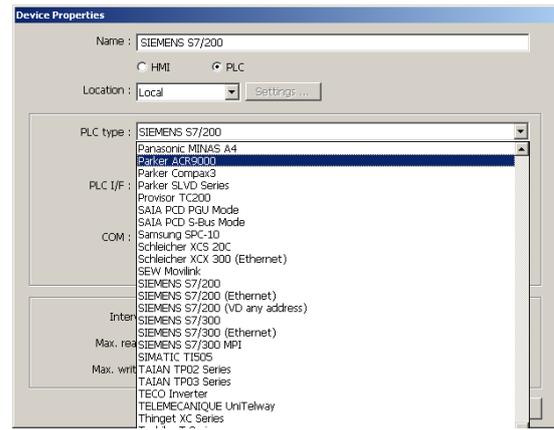


Fig. 4. Some HMI - PLC communication protocols

### 3. OFF-LINE AND ON-LINE SIMULATIONS

Simulation of the HMI operator device reduces risk and optimizes commissioning. One can dramatically save time when creating and testing a project by using simulation feature. Online/Offline simulation saves time because it does not require downloading a project to the HMI touch screen. In 'Simulation' mode, the PC computer displays a screen that simulates what is seen as if the HMI were executing the project file. One can use the mouse on the computer to simulate the touch operation of the touch-screen on the HMI.

**3.1. Off-line simulation** allows a project engineer to view their project look and operational 'feel' quickly without having to spend time downloading the project to the HMI (Fig. 5.). This simulation is great for visually seeing how the screen may look, or how the numeric keypad operates, etc. In this simulation mode, the PC acts as the HMI brain. The PC creates a dummy memory-map of all PLC registers used in the project, so there will never be a "PLC No Response" generated with the off-line simulator. All the dummy-PLC registers are initialized to {0} when the simulation is started. Some actions are not possible within off-line simulation such as:

- The real time clock can be displayed (It uses the PC's time clock), but it cannot be changed. Changing the clock settings from within the off-line simulation mode is disabled.
- Some functionality of the project may not work as expected because it requires some pre-initialized values within the PLC registers. Since all registers in the PC start at value {0} they may produce unwanted results, such as alarms that occur when the bit is clear {0}.

**3.2. On-line simulation mode** is similar to the Off-line simulation except that the PC tries to communicate with the PLC instead of creating dummy-PLC registers in memory (Fig. 6.). On-line simulation has two modes, 'Normal' mode and 'Direct' mode. In the Normal mode, the PC computer requires an HMI touch screen. In the 'Direct' mode, the PC acts as the HMI and does not require the physical touch screen. The PC will directly connect to the PLC using the PC's COM port(s). If the PLC port selected in the project is for RS232, the simulation will then utilize the PC's COM port selected

Off-line simulation: Simulate project operation on PC without any connection.

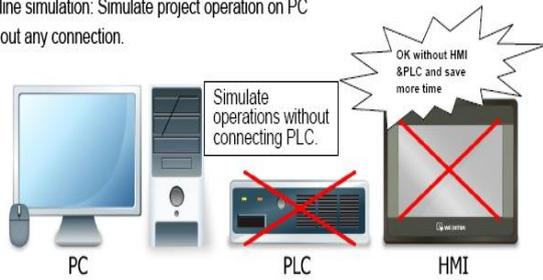


Fig. 5. Off-line simulation

On-line simulation: Simulate project operation on PC and PLCs are directly connected with PC.

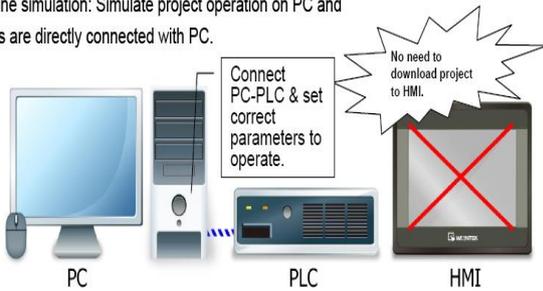


Fig. 6. On-line simulation

in the application software. The communication parameters will be initialized the same as what the project dictates. This 'direct' mode will usually operate for a short time, and then it will disconnect communications and one may immediately run it again. Because the on-line simulation mode communicates to a real PLC, the simulation will show actual bit register states and word register values. Also, if there is a problem in communicating with the PLC, the same error will show up on the simulator screen as if the project were downloaded to the HMI.

#### 4. PC BASED HMI ON-LINE SIMULATION OF SPECIFIC CONTROL SYSTEMS

##### 4.1. Energy Management System Controller (EMSC) visualization system

The data acquisition part of the experimental setup is arranged by a personal computer which USB ports connected to: digital oscilloscope, NIdata acquisition modules, measuring instrumentation and the EMSC. The experiments control and data acquisition, recording and visualization is performed by the computer, using the instrumentations specific software, LabView for NIdata modules and EMSC application software.

EMSC visualization system (VS) is intended for visualization and supervisory control of the processes controlled by EMSC. It is based on personal computer with an appropriate communication channel to EMSC. The application software is worked out using adapted touch screen terminal developing system. This system holds out many possibilities to make full colored windows with various objects such as bit lamps, word lamps, function keys, (multi) switches, slide objects, numeric and ASCII keyboards, animation objects, bar-graph and meter objects, pictures, text, alarms etc. Additional advantage is the application software compatibility with an original industrial touch screen terminal (Fig. 7., Fig.8.) [3-5].

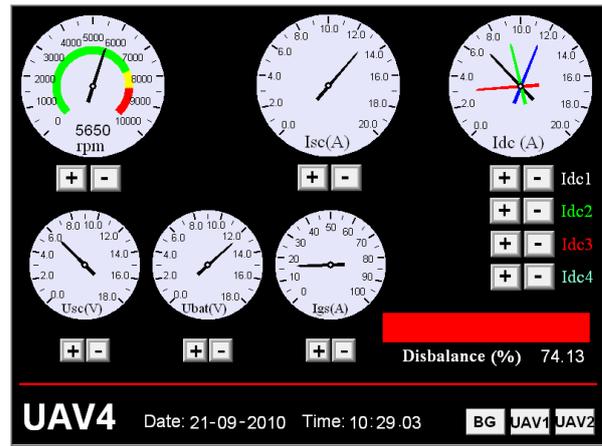


Fig. 7. EMSC with EMS simulator and VS

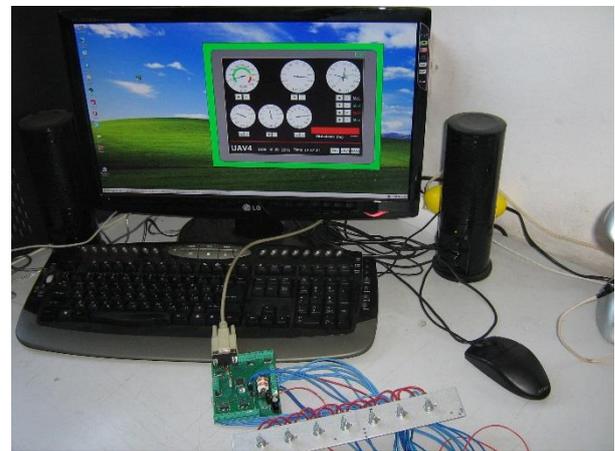


Fig.8. Visualization of main EMS parameters

##### 4.2. Graphical User Interface for ROBKO-11

Considering using of "ROBKO-11" robot by disabled people there rise a need to create a specific HMI graphical interface. The remote control system based on PC (laptop) was upgraded as follows:

- It was created a software application "Graphical User Interface" considering the special needs and possibilities of disabled people. The only action required was a mouse use.
- It was used robot's mnemoscheme on the laptop's screen with organized virtual buttons so the single robot axes could be activated by the mouse.
- By the continuous pressing over the left mouse button the duration of axis action was controlled.
- By creating of five-stage virtual keyboard on the laptop screen the power supply to the axis motors could be controlled, so the joint movement velocity could be precised.

So created Graphical User Interface is shown on Fig.9. Suitable windows for ROBKO-11 programming may be viewed on the PC screen. The manipulator is presented on the right side of the image. The arrows show the different degrees of freedom that may be activated by the mouse

cursor. Similar situation is displayed on the middle part of the window. The arrows point the movements of the mobile platform. On the left side of the window the movements of the manipulator as well the



Fig. 9. Graphical User Interface for ROBKO-11

mobile platform may be observed. This way the sequence of executed steps may be watched [2].

**4.3. HMI simulation of a flowmeter test bench**

There are many ways to use HMI simulation. One of them is the design of complex control systems in the prototype stage of development. In this case the HMI simulation allows testing of the control algorithms in parts, free of the real object. Moreover the different screenshots of simulated images could be used as a part of manuals and documentation. Fig.10. shows a testbench of flowmeters control system (Fig. 11) [1,5].



Fig.10. Testbench of flowmeters control system

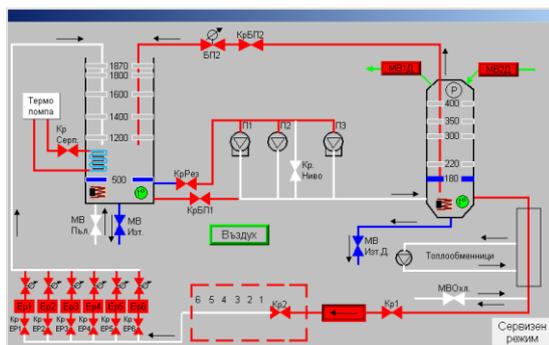


Fig. 11. HMI image of a flowmeter control system

**5. CONCLUSIONS**

The experimental results of using direct HMI simulation prove satisfactory performance. They point the common use of HMI simulators in following cases:

- The control system operates in non-hazardous industrial environment.
- The visualization system is not necessary all the time connected.
- Development of (parts of) control system on the testbench - in laboratory.
- Making of documentation and manuals.

In many cases direct HMI simulation is time- and cost-effective alternative of HMI use.

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