PLC as Embedded System in IoT

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AWES

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Outline

- Introduction
- The proposed system architecture
- Software implemenation
- Hardware implementation

Introduction

The evolution of the Internet has led to a great influence on the software industry and the development of companies.

Networked control systems are widely adopted in industry because of the big facilities provided for plant control.

Accessing local control systems and remote telemetry units (RTUs) remotely became a primary requirement.

This work presents a method for connecting a PLC (Programmable Logic Controller) to a server and hence to the internet for the sake of remotely access.

The work starts with building a local network for interconnecting a PLC with its Ethernet extension, an HMI (Human Machine Interface) touch screen, a supervisory PC, a smartphone, and a hub/switch.

The PC is connected to the internet and the server program is updated to get a global network that can be accessed via the internet worldwide without the need for public (real) IP.

A web site is designed and used through the PC to reach the PLC system.

An Android application is also developed with Java and published in google play of Android smartphones in order to add another means for controlling the PLC control system.

The home temperature control is adopted just as a case study to prove the work of the overall control system.

The Proposed System Architecture

For home monitoring and control, a new, independent, reliable, and cheap home supervisory system is performed using web services and Android app.

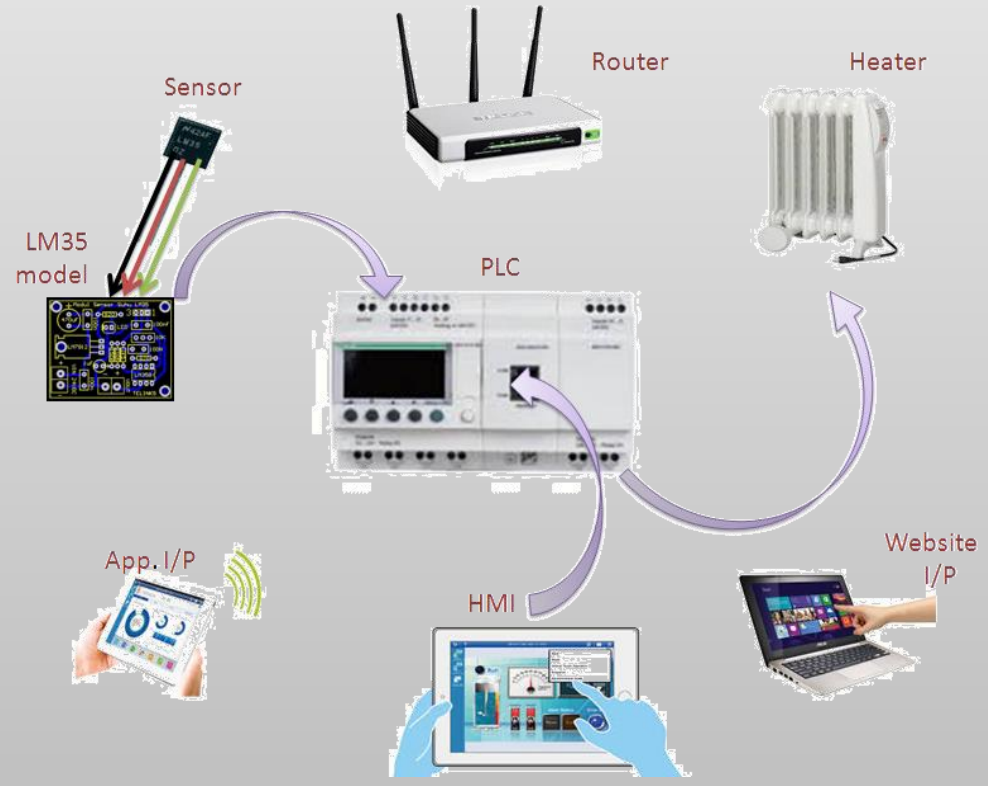
The system contains a web server, Ethernet communication interface, Zelio PLC, PC computer, router (hub/switch) and Android compatible smartphone app.

The system is generic means that different applications with minimal design complexity can be customized with capability of new thread creation in its software.

The authorized persons can remotely control and monitor networked field devices at home or factory with smartphone supporting Wi-Fi and Java.

A phone GUI is designed by Java app for accessing and controlling the desired devices at home via server overcoming the need for real IP.

The infrastructure of the proposed system comes with three tiers: Home tier, Home Gateway (PC), and Remote tier.



Remote tier is the authorized users accessing the system with smartphone app.

Home tier consists of Home Gateway and the physical devices.

Home Gateway provides data translation services between home environment and remote environment.

The Home Gateway is simply a web server that manages and controls system components by enabling hardware interface modules to invoke their tasks

Software Implementation

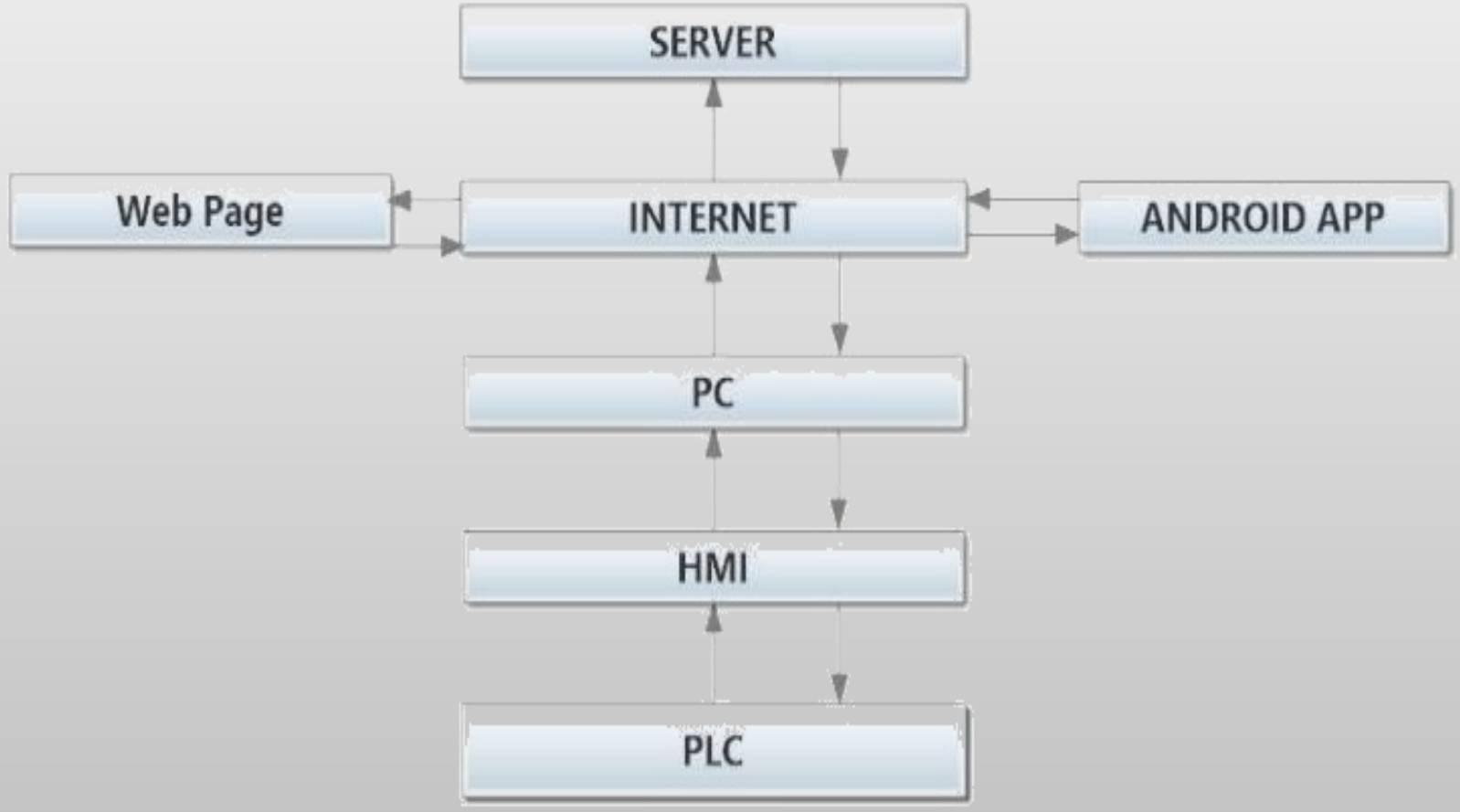
There are three parts for software designed to the proposed home automation system: server program, Android app, and PLC controller firmware.

The server program is a web site designed with HTML, PHP making use of free services provided by a free web hosting company (ATSPACE.COM).

Data is exchanged between server and clients with HTTP protocol, JSON (JavaScript Object Notation) and XML services provided by the free server.

Configuration stage and sensor/actuator control stage have been performed on control network to realize connection between remote used and the gateway.

Figure below shows a diagram of linking of the PLC control system to the Internet.



The Gateway enters the configuration stage immediately after it is begin connection to the internet over http.

During this stage the Ethernet port of the HMI touch screen is connected to the Local Area Network (LAN) depending on static IP address.

Static IP address is used instead of an IP obtained from Dynamic Host Configuration Protocol (DHCP) in order to get optimum communication.

Reception of string commands from the web page or the smartphone app is translated into a suitable control action.

These actions are control signal actuation or sensor reading.

Web services are easy to access using communication means and application programming interfaces (APIs).

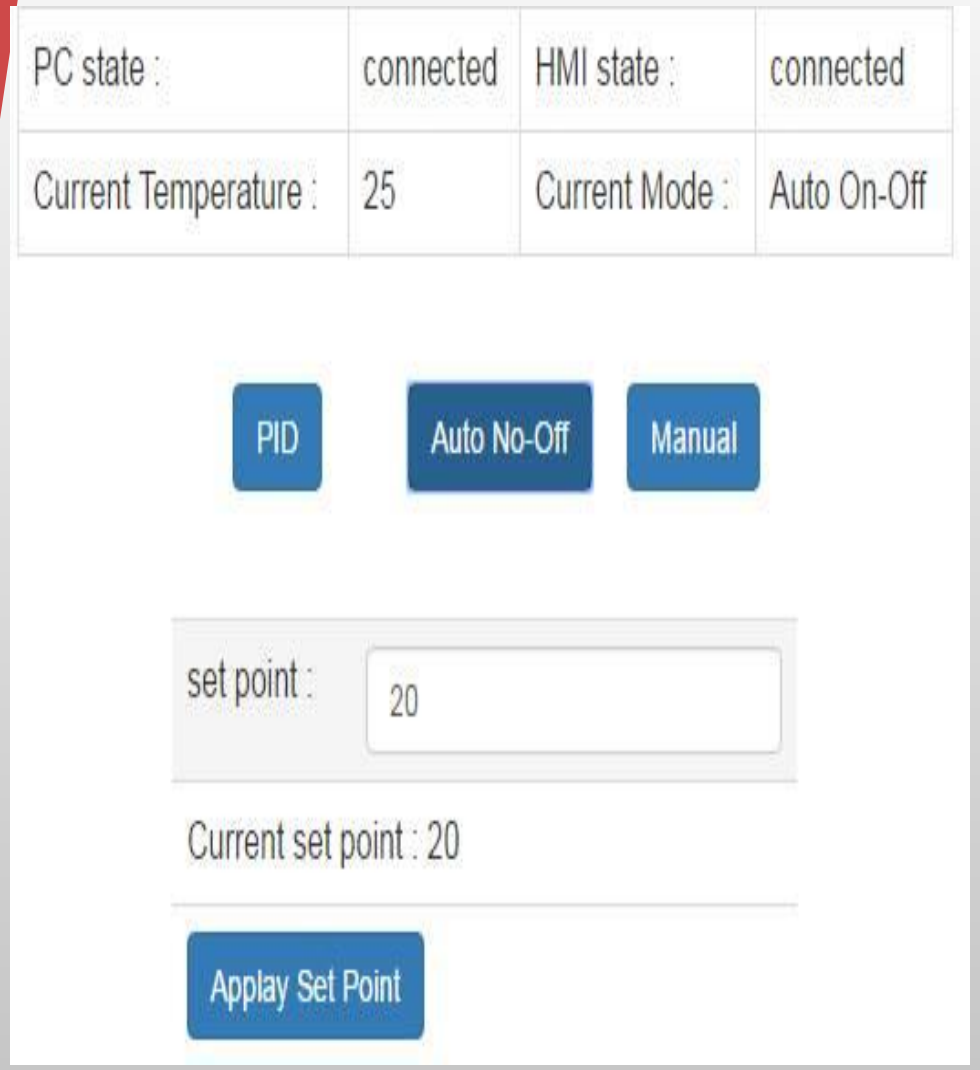
Two types of web services are available: Simple Object Access Protocol (SOAP) and Representational State Transfer (REST).

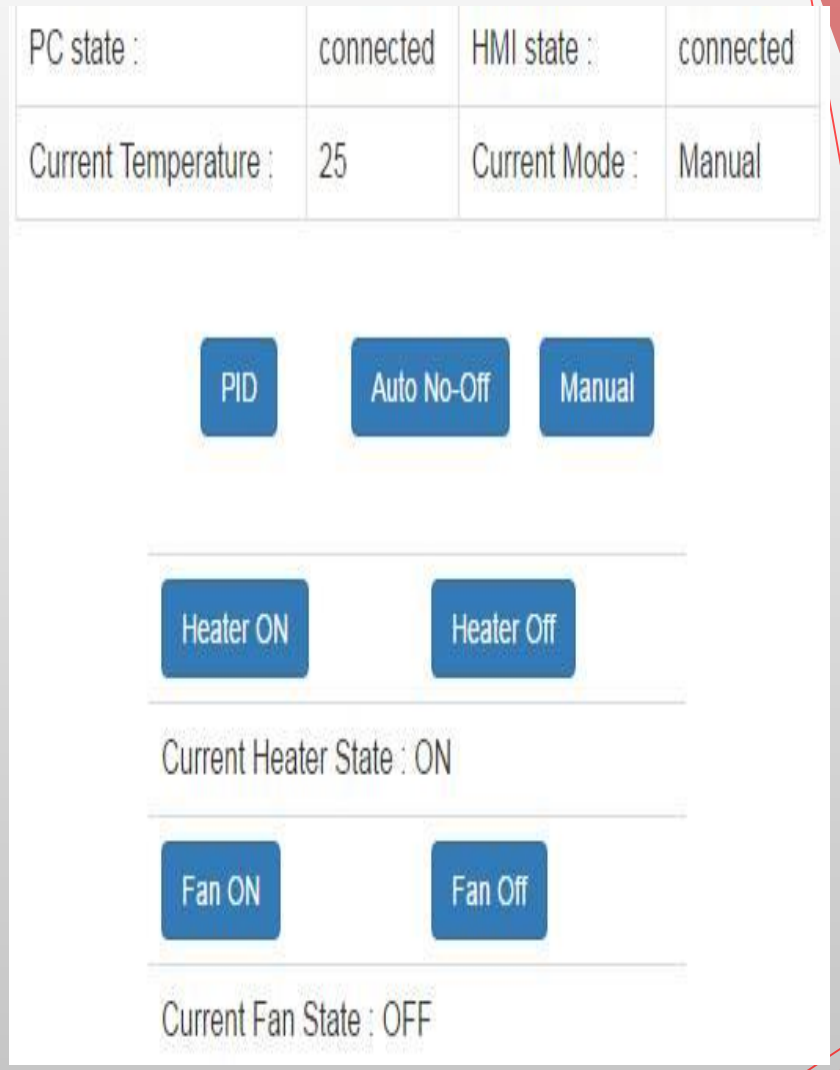
Both SOAP and REST are two standard protocols for IoT.

REST is similar to SOAP but more lightweight scheme; hence it is used for web service that returns JSON responses to connect between the remote user and the web server.

JSON is a lightweight means for information exchange that is easy for people to read and write.

It is also easy for machines to produce messages instead of using XML. The web site designed for the desired task is displayed in **Figure below:**


PC state :
connected
HMI state :
connected
Current Temperature :
25
Current Mode :
Auto On-Off
PID
Auto No-Off
Manual
set point :
20
Current set point : 20
Applay Set Point

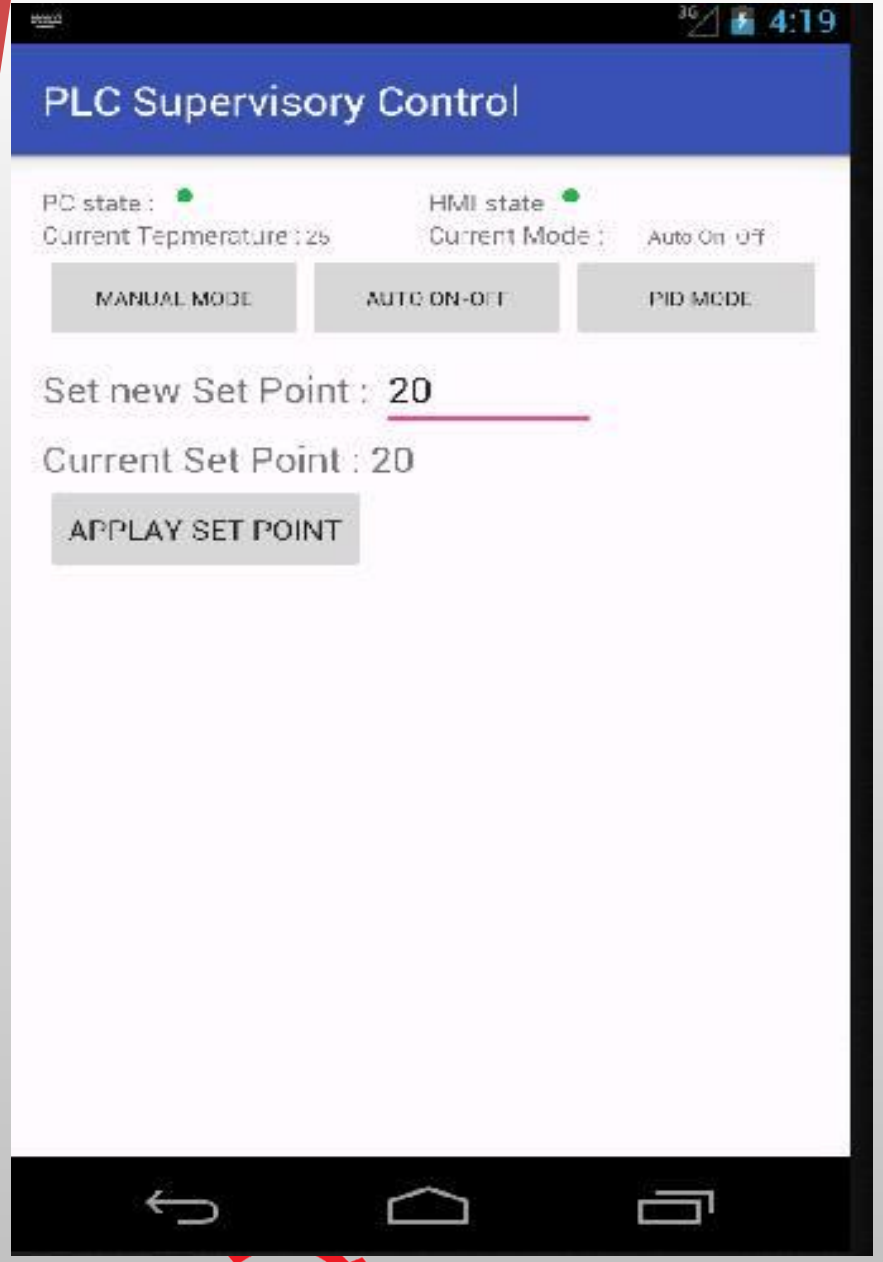

PC state :
connected
HMI state :
connected
Current Temperature :
25
Current Mode :
Manual
PID
Auto No-Off
Manual
Heater ON
Heater Off
Current Heater State : ON
Fan ON
Fan Off
Current Fan State : OFF

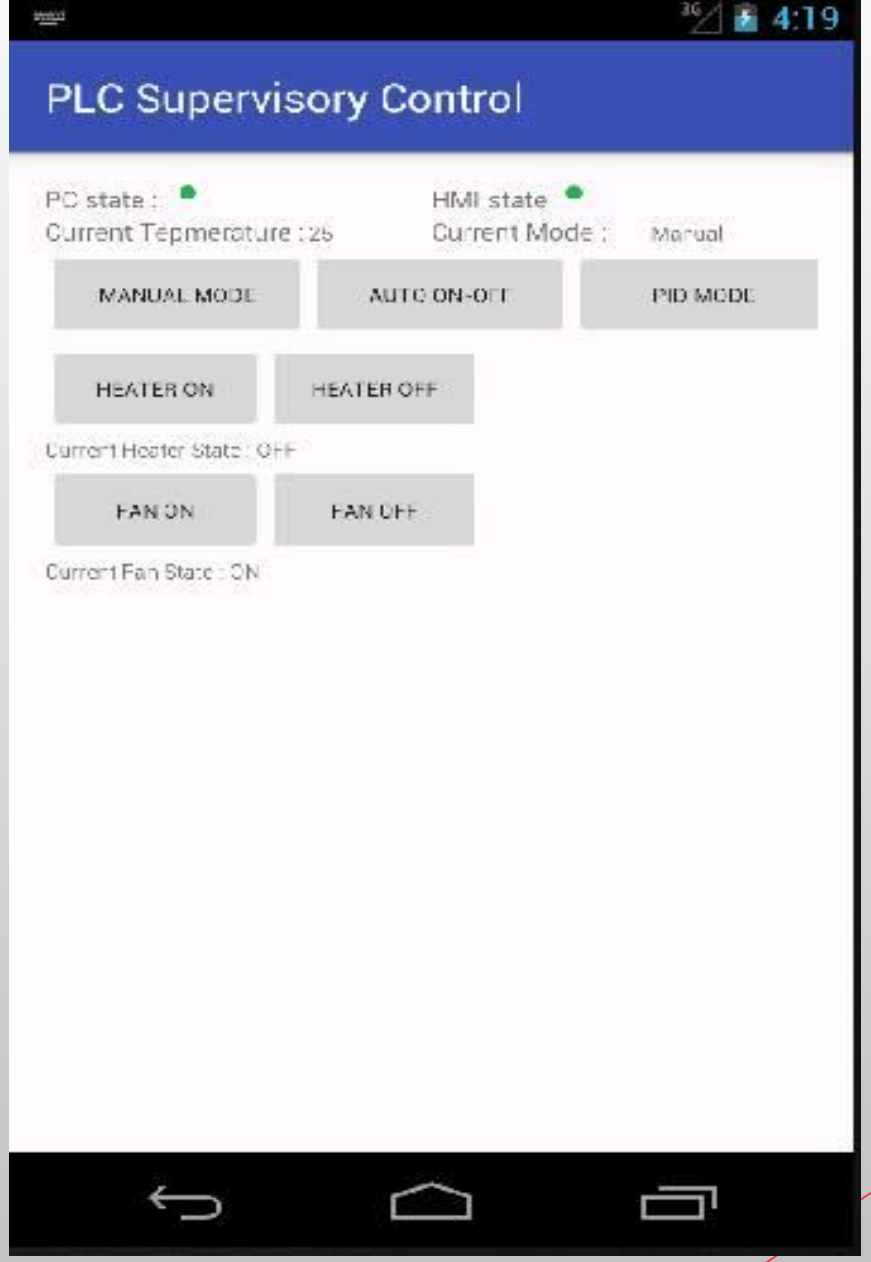
Several methods are there for building smartphone application such as Windows Mobile, Symbian, iOS and Android.

Most smartphones support Android OS; therefore, it is adopted in the development of our application depending on JAVA programming language and the Software Development Kit (SDK).

The designed smartphone app allows full interaction with the home control application.

Figure below illustrates the designed Java graphical user interfaces for our Android app.


4:19
PLC Supervisory Control
PC state :
HMI state
Current Tepmerature : 25
Current Mode :
Auto On-Off
MANUAL MODE
AUTO ON-OFF
PID MODE
Set new Set Point : 20
Current Set Point : 20
APPLAY SET POINT


4:19
PLC Supervisory Control
PC state :
HMI state
Current Tepmerature : 25
Current Mode :
Manual
MANUAL MODE
AUTO ON-OFF
PID MODE
HEATER ON
HEATER OFF
Current Heater State : OFF
FAN ON
FAN OFF
Current Fan State : ON

The user has to setup the port number and the IP address of the web server in the app to satisfy successful communication.

Synchronization between the app with the web server should be satisfied to retrieve the actuator and sensor information.

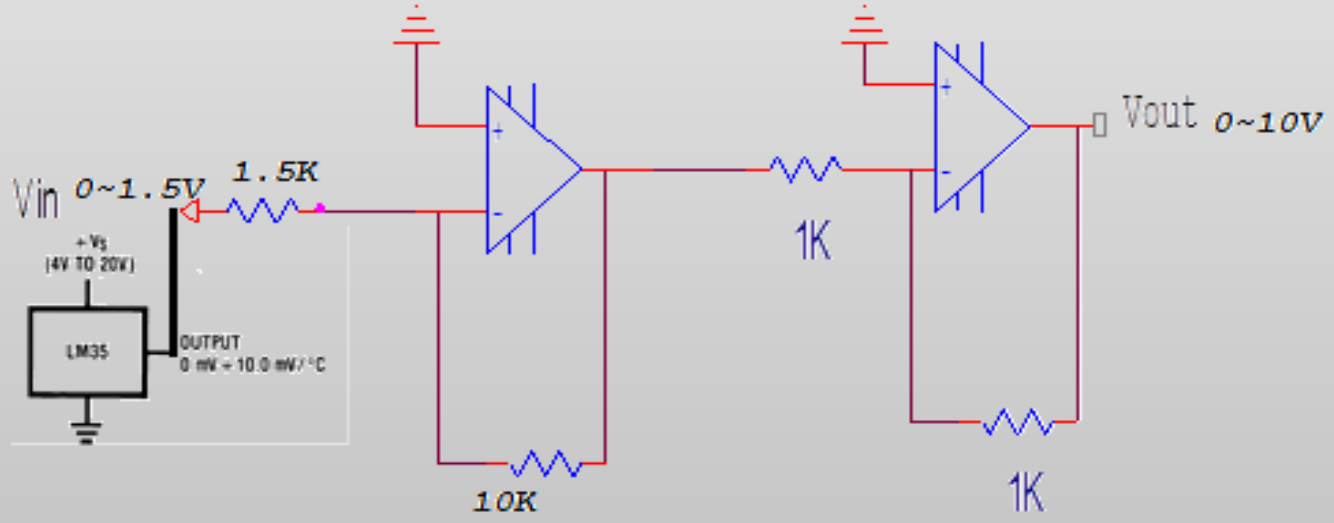
The communication between the PLC and HMI is satisfied with a cable connecting the RS485 port of the HMI to the SR3NET01BD Ethernet extension.

The Ethernet port of the HMI is connected to the hub/switch to enter the LAN network.

Hardware Implementation

1. LM35 temperature sensor: The LM35 is a low-cost high accuracy temperature sensor, with linear relationship between its output voltage and Centigrade temperature.

In order to input the sensor to any of the PLC analog inputs, a signal conditioning circuit is required.



2. Zelio PLC SR3B261BD: It is a low-cost high efficiency simple controller that can be used for several control applications.

It has 16 inputs, six of them are analog, and 10 relay outputs.

The operating voltage is 24VDC, and the output relay voltage can be 24VDC or 240VAC.

3. Analog I/O extension module SR3XT43BD: To use Zelio Logic smart relay with analog I/O, it is fitted with analog I/O extension module having 10-bit resolution.

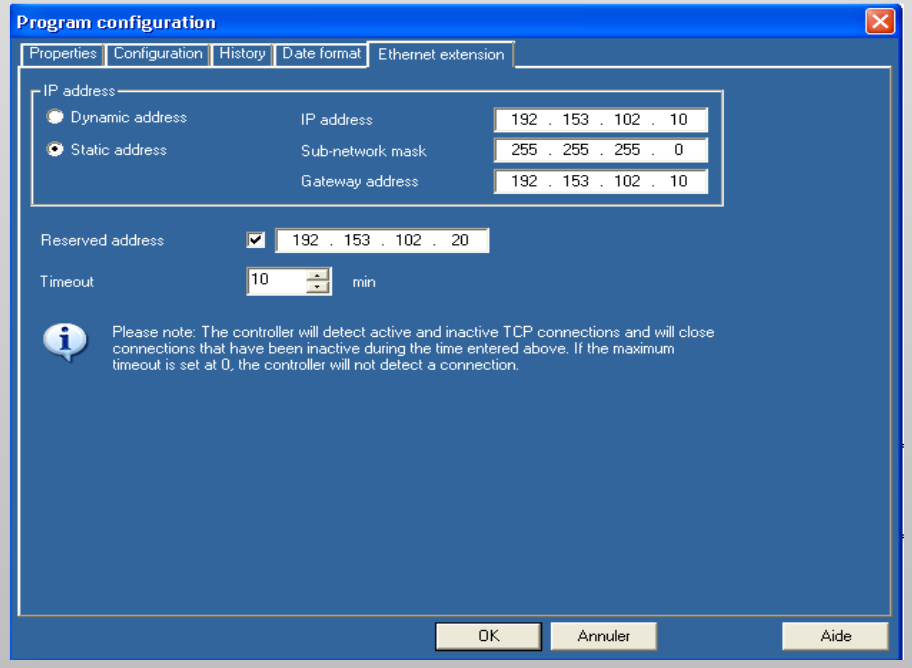
It has three inputs; 0-10 V, 0-20 mA and Pt 100 type signals and the outputs produce 0~10V.

4. Ethernet extension module SR3NET01BD: It is compatible with all versions of Zelio SR3 series.

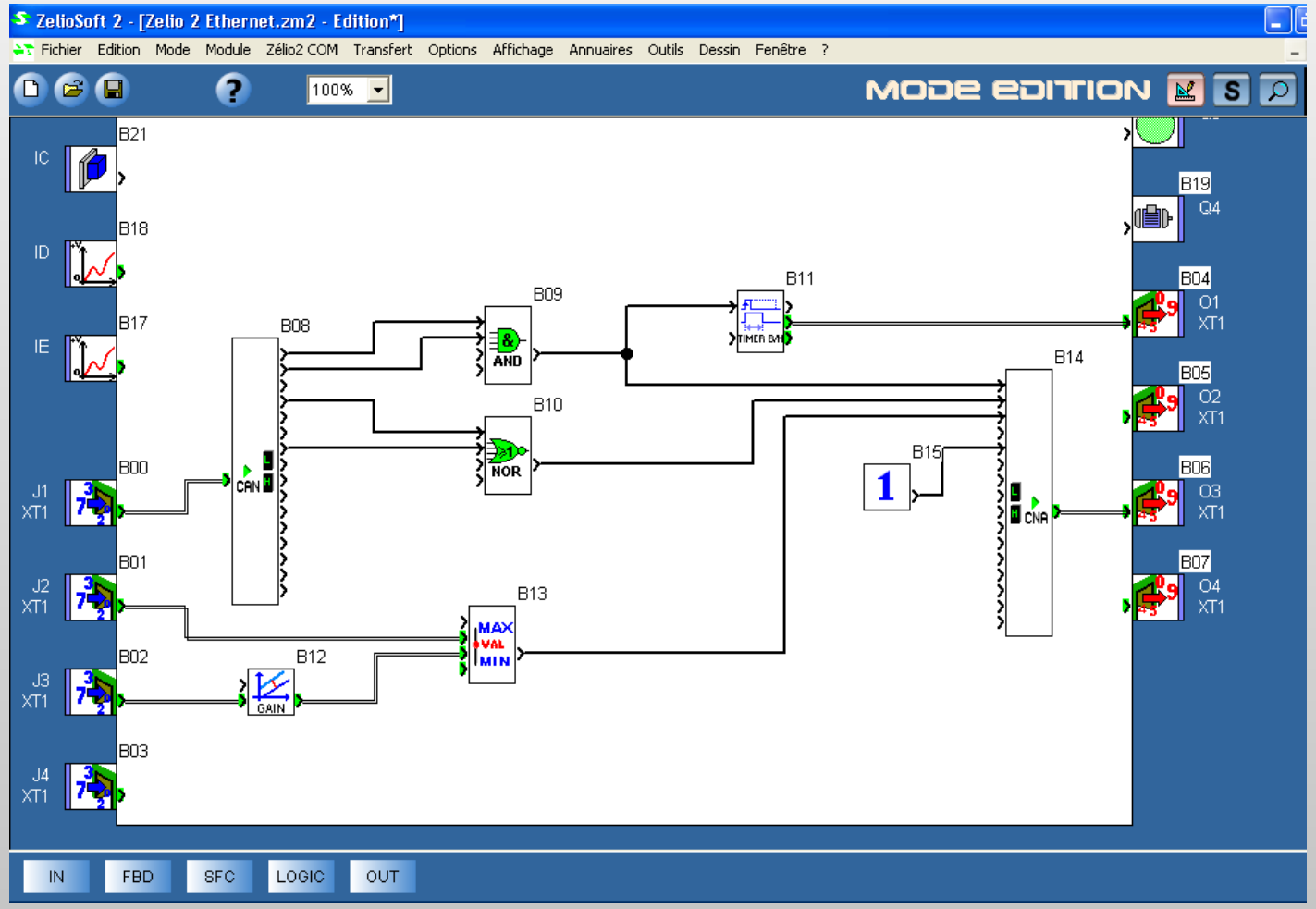
It provides a means for connecting the PLC with HMI or hub/switch or Modbus.

It manages up to 4 connections simultaneously.

Its IP address is configured as static as shown below:

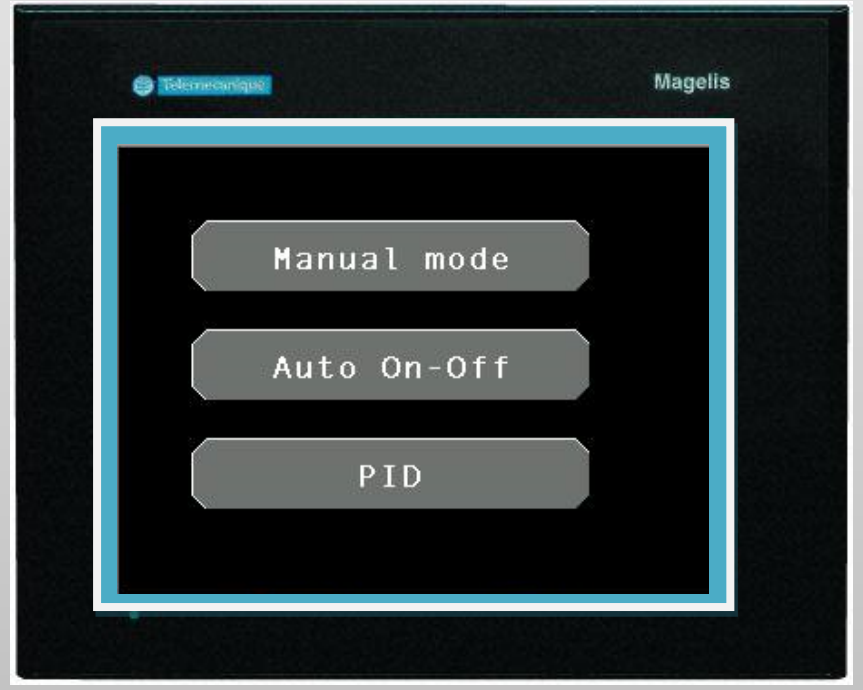


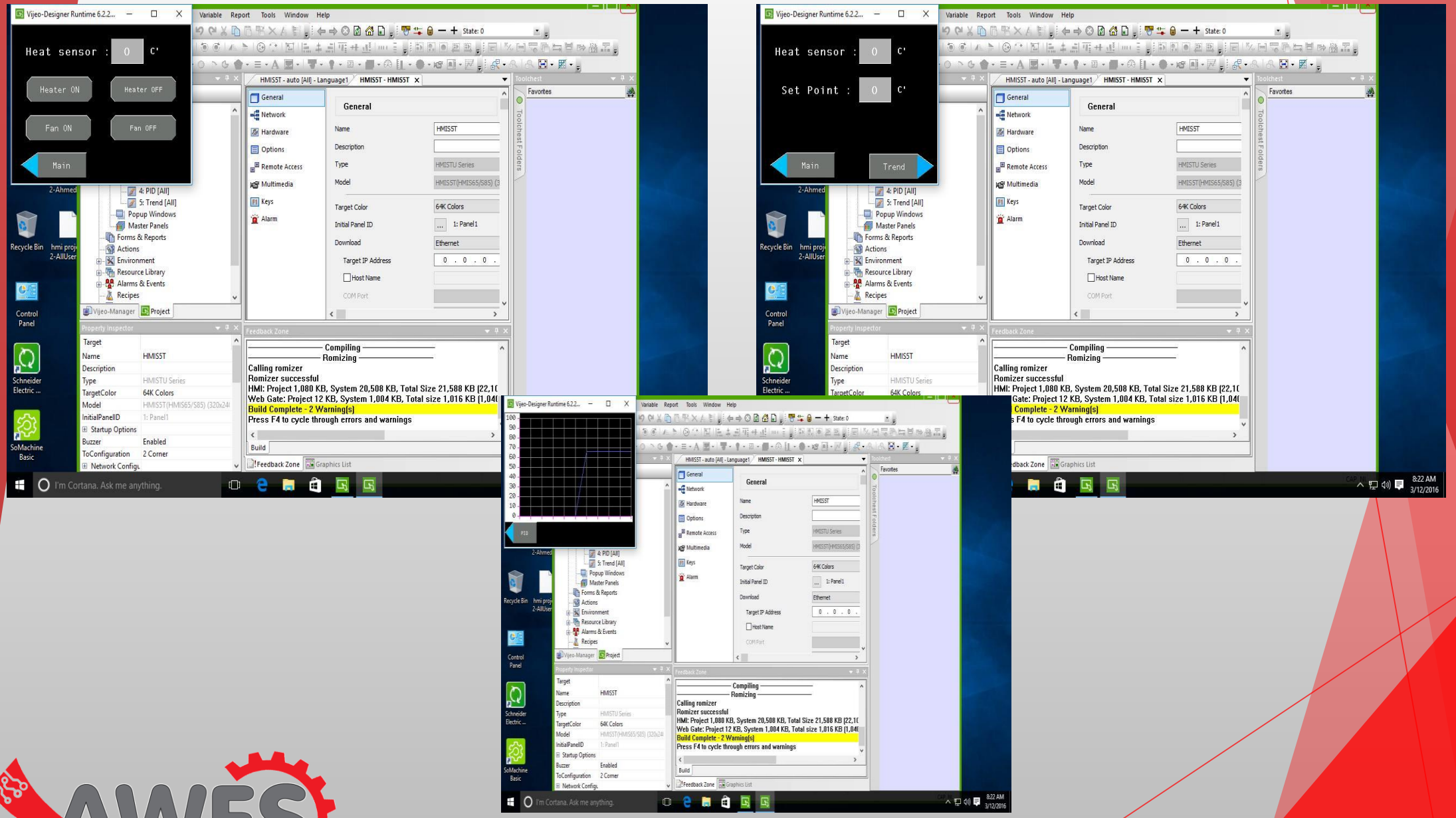
Four input words (J1XT1 to J4XT1) and four output words (O1XT1 to O4XT1) are accessible via the function block (FBD) as shown:



5. HMI touch screen Magelis HMIS5T: it is a Human Machine Interface product with the following specifications: 24VDC, 3.5 inches, color, TFT graphic touch screen with serial (RS485) and Ethernet ports.

It is connected via the serial port to the PLC across the Ethernet communication module and connected to the hub/switch via the Ethernet port to make the PLC part of the LAN network.





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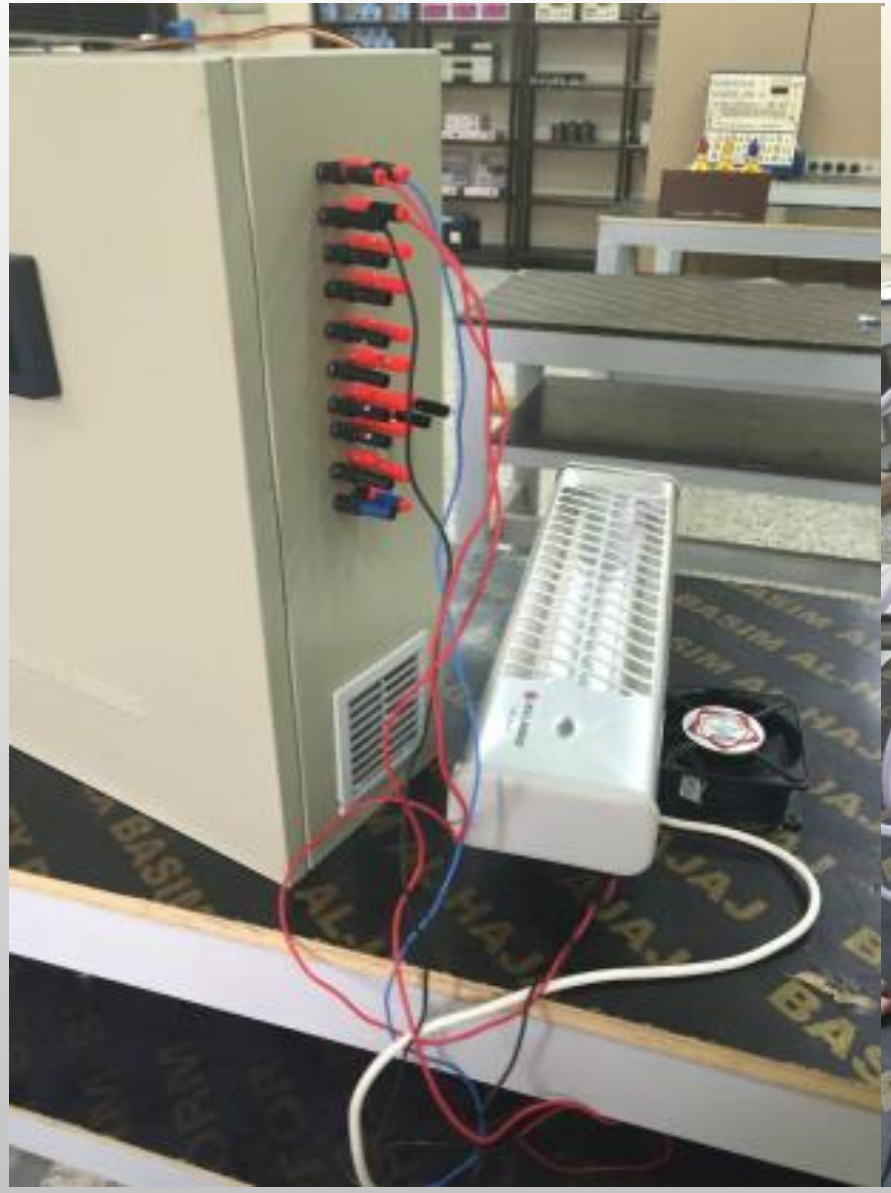
Other accessories: There are some other accessories needed to complete the whole panel of the proposed system such as:

24VDC power supply, small heater, small Fan as a cooler, any type of hub/switch or router, case (panel box), wiring, fusing, banana terminals, power switch, and laptop (for displaying web site).



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CONCLUSIONS

A novel, low-cost, and flexible home control and monitoring system using web technologies and Android smartphones has been proposed and built.

The proposed model utilized some web services and protocols for data delivery and reception.

Android smartphone with Wi-Fi support can be depended for accessing and controlling home environment after setting up the app.

The hardware controller used is a PLC with some needed accessories to satisfy a generalized home or industrial control system.

This generalized system has been built (but not restricted) to temperature measurement of home as a case study to prove its operation.

The system proved a good mixture of industrial-wise devices such as: PLC, analog units, sensor, actuator, heater, fan, HMI screen, etc. with internet and network technologies such as: servers, Ethernet interfaces, web sites, Android app, LAN network, some important protocols and IP, IoT, etc.

Thanks for Listening

Time for Questions