

# Design and Implementation of a Wireless Level Control System

Gabriela Bucur

Universitatea Petrol-Gaze din Ploiești, Bd.București, nr. 39, Ploiești  
e-mail: gbucur@upg-ploiesti.ro

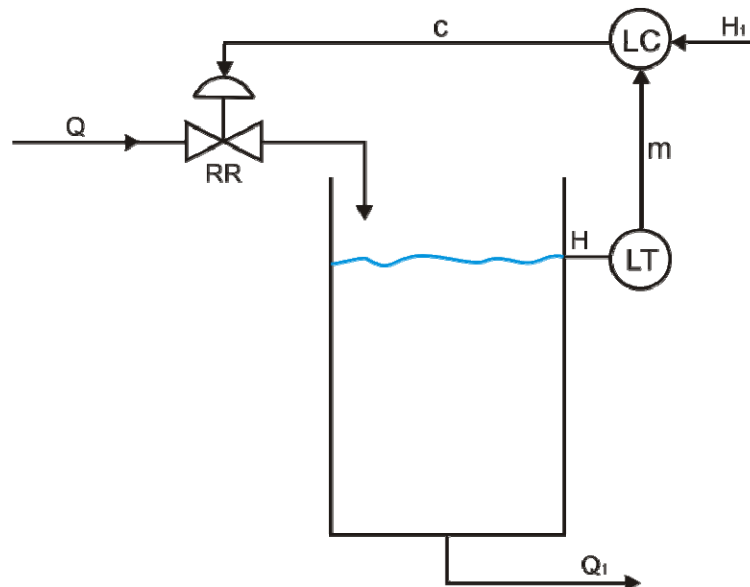
## Abstract

*This paper presents the way to control the liquid level in a tank by using a wireless controller. The ADAM-6022 dual loop PID controller is a PC-based stand alone controller. With an excellent accuracy  $\pm 0.15\%$ , the ADAM-6022 is an ideal controller to use in industrial environment. This system is based on the most advantages offered by a wireless network. The original characteristic of this paper is the automation structure and the networking elements connection.*

**Key words:** control system, wireless network, level, data transmission.

## Level Control System Configuration

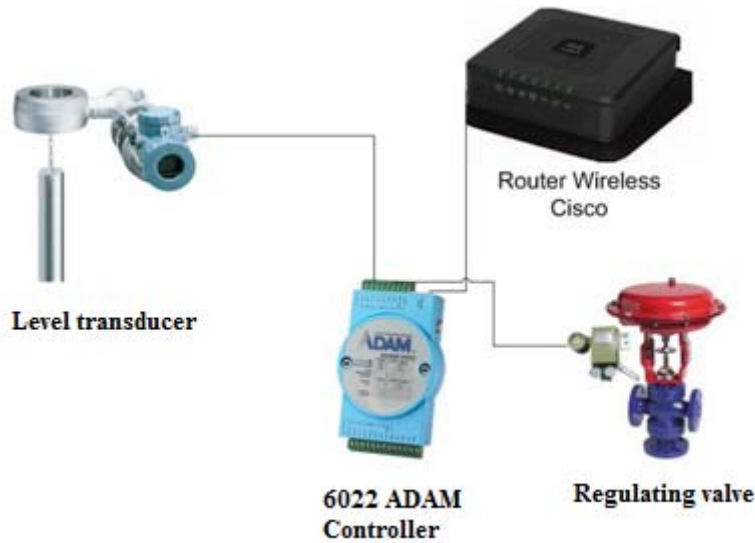
The classical configuration of a level control system is presented in Figure 1 [1].



**Fig. 1.** Level control system configuration:

LT – level transducer, LC – level controller, RR – regulating valve, Q - flow, H - level,  $Q_1$  – perturbation signal,  $H_1$  – reference signal, m – measure signal, c – command signal,

For this application, the electrical connections for all the level wireless control system components are shown in Figure 2.



**Fig. 2.** Electrical connections for all level wireless control system components

The Level transducer is a Fisher 249 Displacer Sensor with FIELDVUE DLC3010 Digital Level Controller. The DLC3010 is a communicating, microprocessor-based instrument that can be configured to sense the level, interface level, or density of liquids. In addition to the normal function of providing a 4 to 20 mA current signal, the DLC3010, uses HART communications protocol, gives an easy access to information which is critical for the process.

The regulating valve modifies the working fluid flow by modifying the fluid section. This has a pneumatic actuator, the control pressure range is 0.2...1 bar and the maximum movement of the valve is 25mm, PN 40, DN 50, fixed by steel flanges.

The ADAM-6022 Controller is an Ethernet-enabled dual-loop PID controller for general purpose PID control applications. There are three analog inputs, one analog output, one digital input and one digital output for each loop usage. The analog input channels have a 16-bit, universal signal accepted design. They provide programmable input ranges on all the channels. They accept various analog inputs +/-10V, 0~20mA and 4~20mA. The analog output channel is a 12 bit with 0~10V, 0~20mA and 4~20mA acceptable input type. Each analog channel is allowed to configure an individual range for several applications. The digital input can be configured as an emergency shutdown trigger input and the digital output is designed as a common alarm output [3].

Also, one can use a standard web browser to connect to the web server and to watch a web page. The website is simply the IP address of the ADAM-6022 module we want to connect. Before we open the web page, we need to type correct user name and password. Below is the default user name and password. After we type the correct user name and password, we should be able to see the web page and see what's happening on the module.

The wireless router is used for controller configuration and also for connection, tracking and modifying the reference signal, tracking alarms, from everywhere in the world, using an internet connection. To connect the controller, a user name and password are needed. For this control structure, a CISCO router was used. The wireless connection to the process controller is secured by the authentication and encryption protocol WPA2, using AES encryption algorithm.

## Controller Application Description

The controller is connected to a PC (laptop) with a wireless interface via the CISCO router. The network was choosing to be the PID UPG, from all the available wireless networks. The access password is written and one can make the settings for the ADAM controller. Next, only the most important menu will be described [2].

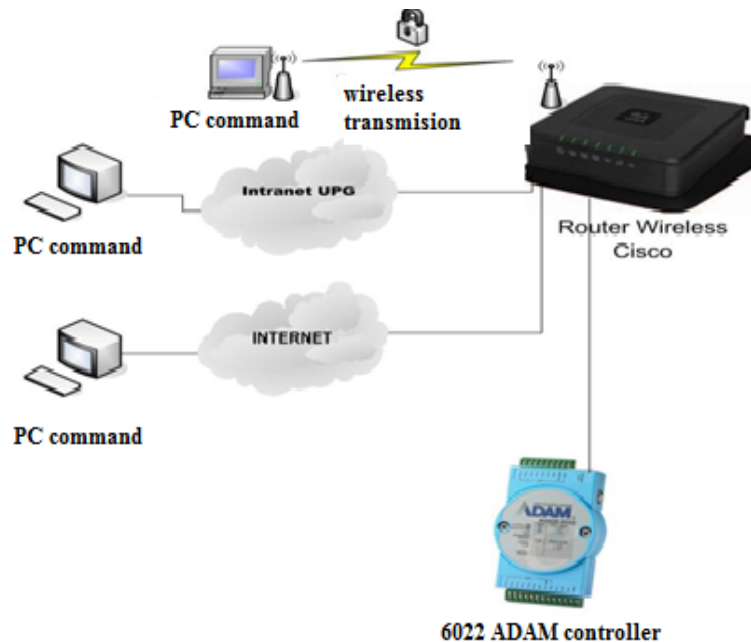


Fig. 3. Connection to 6022 ADAM controller

## PID Loop Configuration

ADAM-6022 is designed as a standalone PID controller. The PID menu offers many visualization and control facilities for all the process parameters (fig. 4).

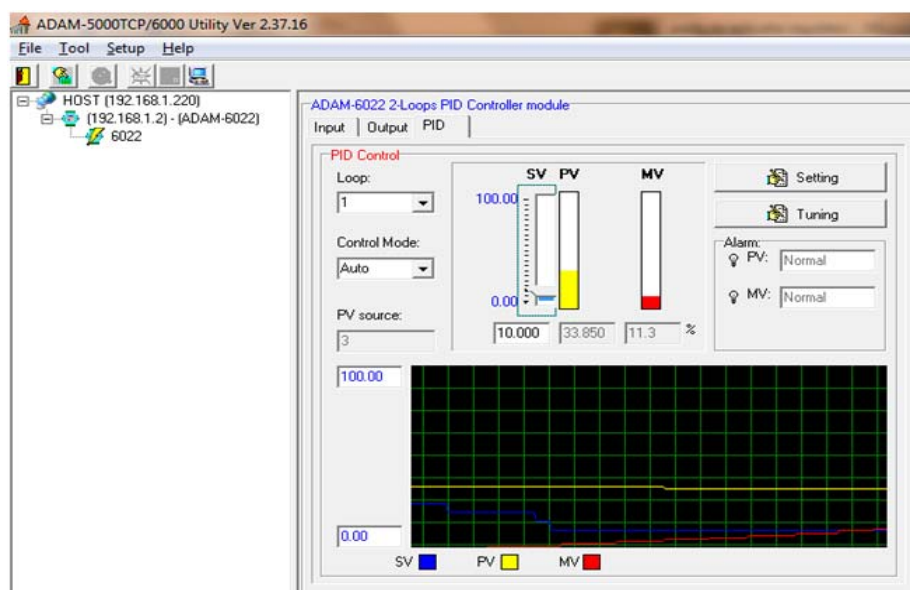
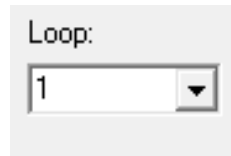
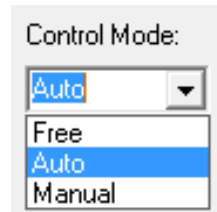


Fig. 4. PID Menu

This menu offers the possibility to choose the control for one of the two closed loops; the selection of the desired loop determines the change of the entire page containing the values for the control loop.



The user can choose one of three function modes for the controller: Free; Auto; Manual.



In the Free mode, the controller is a simple input / output interface, it can track the inputs and the outputs, it can modify or calibrate the values of inputs and output parameters and it can directly command the actuators.

In the Auto mode the 6022 ADAM itself contains all the systems [3].

In the Manual mode the user is the controller of the system; the user can change the inputs and to directly generate commands for actuators.

In this configuration menu, there is a real time trend chart to show the values changing of SV, PV and MV (fig. 5). It is very helpful for user to monitor and diagnose the PID control situation.

All three bar graphs are percentage represented, for a large domain of controller applications. SV means Setpoint Value, PV – Process Value, MV - Controlled Output Value. The interconnection of these values is shown in Figure 6.

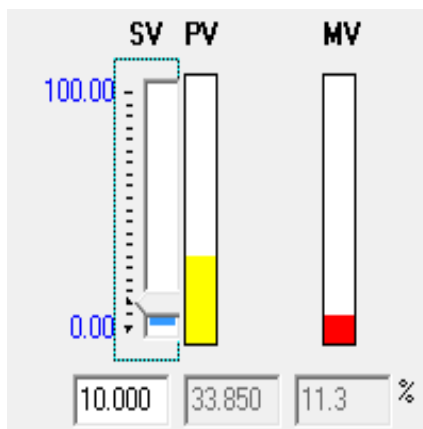


Fig. 5. Bar graphs for important parameters

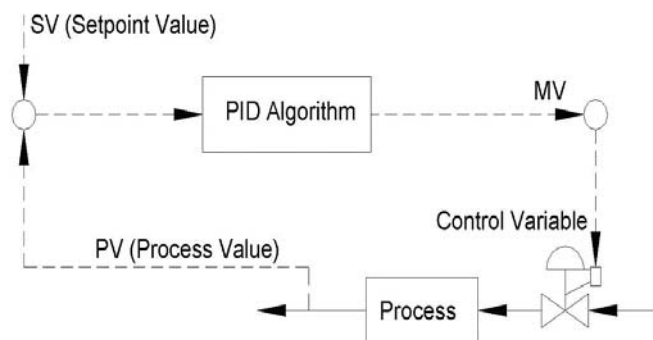


Fig. 6. Interconnection of set-point values

### PID parameter tuning

This menu offers the same facilities available in the PID Menu [3]. Supplementary, in this page, the P, I, D parameters can be adjusted to achieve the optimal control result. The real time trend chart provides a powerful tool for the user to supervise the parameters adjustment result (fig. 7).

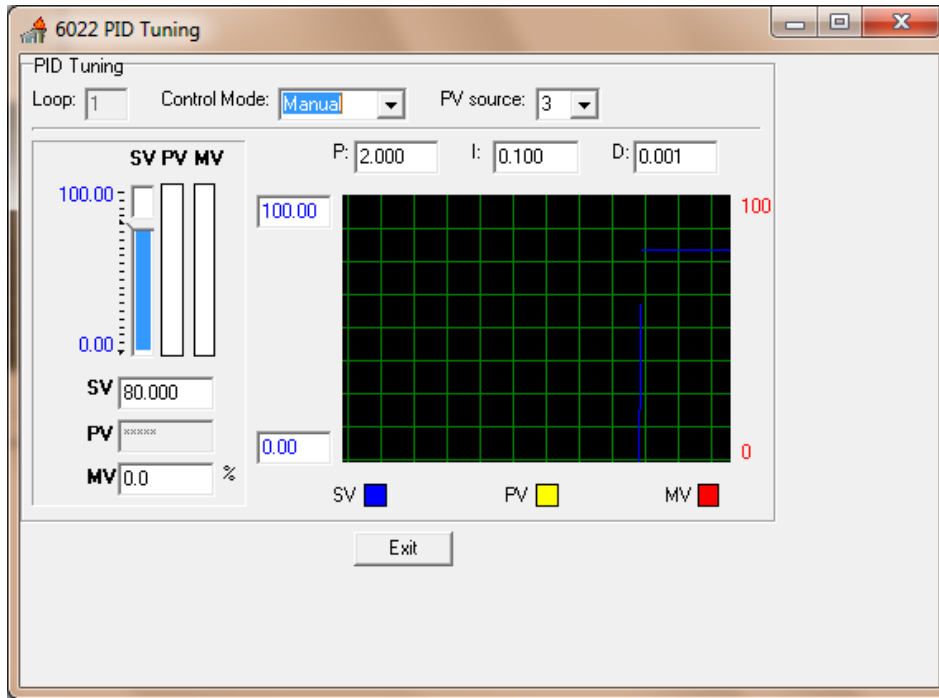


Fig. 7. Tuning Menu

## System Operating

To choose the P, I, D parameters one can use the Seborg method.

The control PID algorithm is:

$$c = c_0 + K_p \left( e + \frac{1}{T_i} \int_0^t e dt + T_d \frac{de}{dt} \right), \quad (1)$$

with numerical expression:

$$c_k - c_{k-1} + K_p \left[ (e_k - e_{k-1}) + \frac{T}{T_i} e_k + \frac{T_d}{T} (e_k - 2e_{k-1} + e_{k-2}) \right] \quad (2)$$

For this application, four experimental cases have been taken into consideration (Table 1):

**Table 1.** Experimental P, I, D parameters

No.	Step signal	Perturbation	P	I	D	Control time	Obs.
1	+10%	yes	2.000	0.250	1.000	2 min	$\varepsilon < 4\%$
2	+10%	yes	2.000	0.250	3.000	40 sec	oscillations
3	+10%	yes	2.000	0.250	5.000	30 sec	oscillations
4	+10%	yes	0.100	0.050	3.000	25 sec	$\varepsilon < 2\%$

In the next four figures (8 to 11), which correspond to Table 1, a real time trend chart is presented. It shows how the SV, PV and MV change, in a capture image screen.

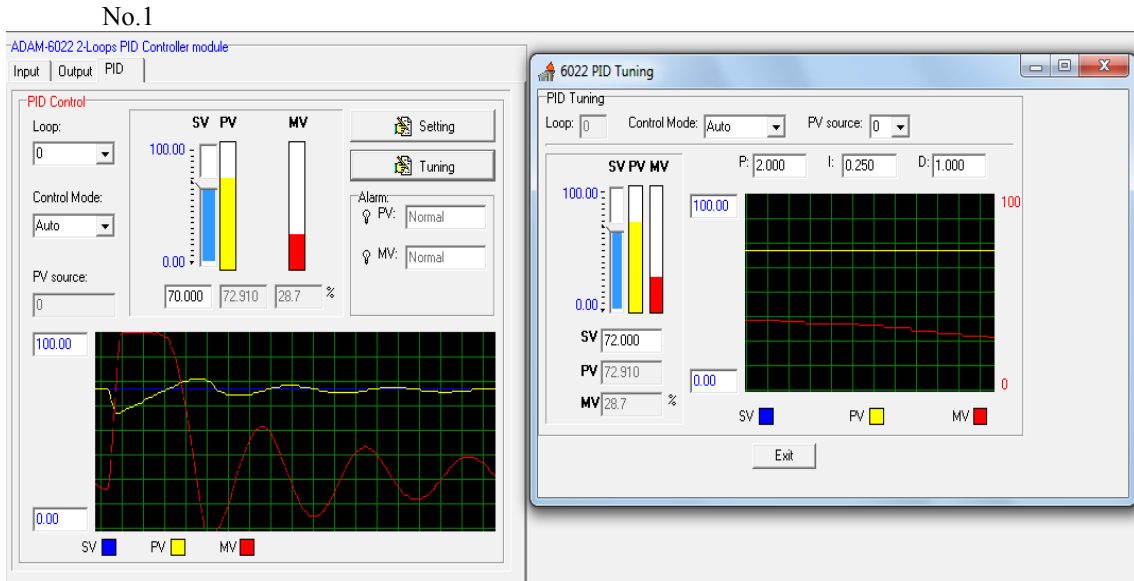


Fig. 8.

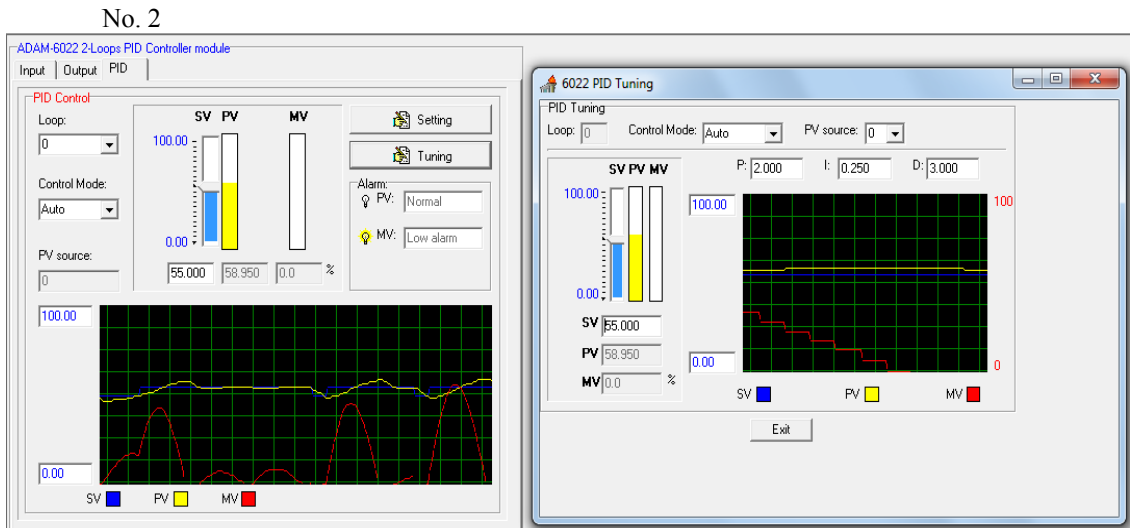


Fig. 9.

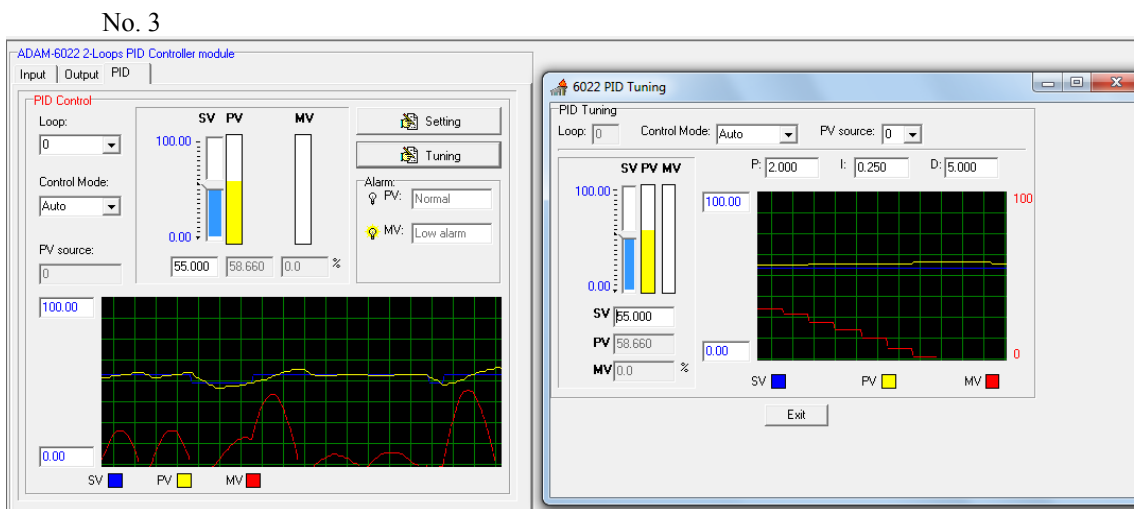


Fig. 10.

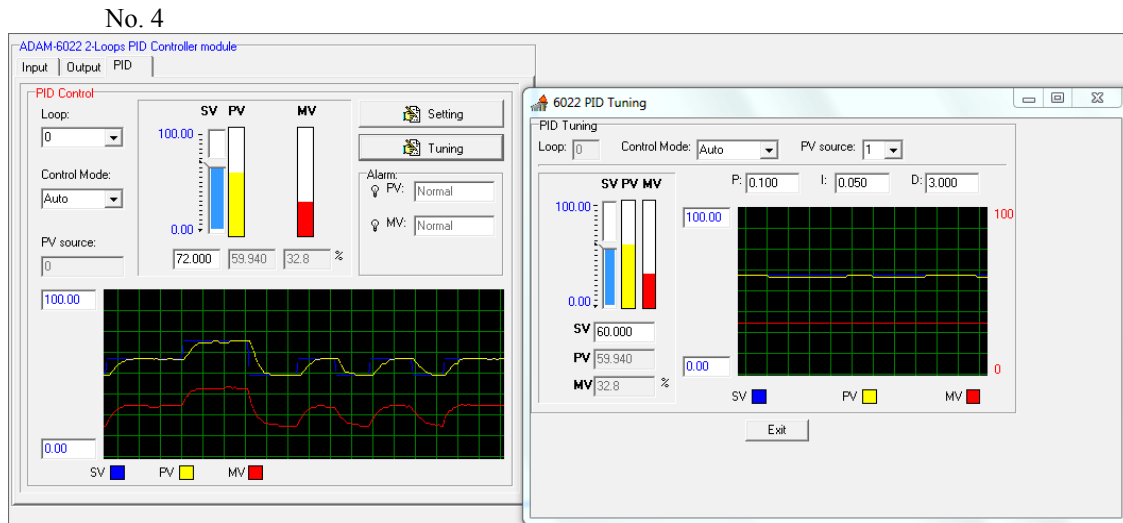


Fig. 11.

## Conclusions

The user can see that the numerical wireless controller is relatively easy to operate. ADAM-6022 utility software can help to select the input and range configuration, to set-up the operating parameters (SP, SV and PV) for the desired control process. ADAM-6022 utility software also integrates the trend chart to help the user to monitor and debug the control settings.

Using the internet one can obtain an efficient control process, characterized by speed, security, safety and large volume of data transmission.

## References

1. Bucur, G., Popescu, C. – *Automatizări industriale*, Editura Universității Petrol-Gaze din Ploiești, Ploiești, 2006.
2. C a n g e a , O. – *Transmisia și criptarea datelor*, Editura Matrix Rom, București, 2008.
3. \* \* \* – *ADAM - 6022 Manual.pdf*.

## Proiectarea și implementarea unui sistem wireless de reglare a nivelului

### Rezumat

*Lucrarea prezintă proiectarea și implementarea unui sistem de reglare automată a nivelului utilizând un regulator numeric comandat wireless. Utilizând facilitățile internetului se poate obține o reglare eficientă a parametrului dorit, proces caracterizat prin viteză, siguranță, securitate și volum mare de transmitere a datelor.*