ISSN 1726-5479

SENSORS & TRANSDUCERS

vol. 147
12/12

Sensor Market Trends

International Frequency Sensor Association Publishing

IFSA

Sensors & Transducers

Volume 147, Issue 12
December 2012

www.sensorsportal.com

ISSN 1726-5479

Sensors & Transducers Journal (ISSN 1726-5479) is a peer review international journal published monthly online by International Frequency Sensor Association (IFSA).
Available in electronic and on CD.

Sensors & Transducers Journal

Contents

Volume 147
Issue 12
December 2012

www.sensorsportal.com

ISSN 1726-5479

Research Articles

Authors are encouraged to submit article in MS Word (doc) and Acrobat (pdf) formats by e-mail: editor@sensorsportal.com
Please visit journal's webpage with preparation instructions: http://www.sensorsportal.com/HTML/DIGEST/Submition.htm

International Frequency Sensor Association (IFSA).

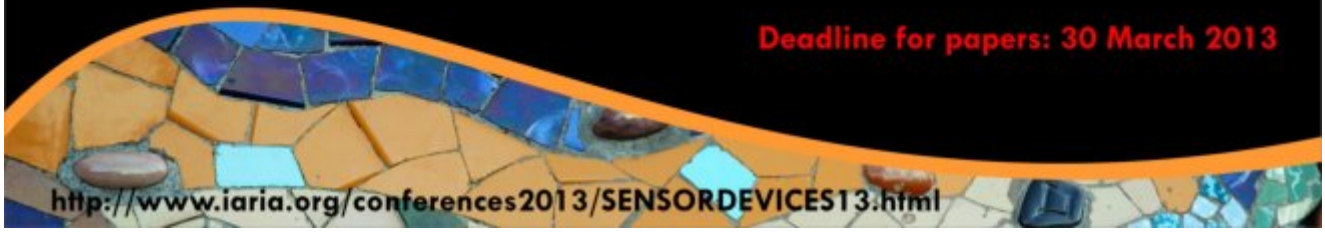
The Fourth International Conference on Sensor Device Technologies and Applications

SENSORDEVICES 2013

25 - 31 August 2013 - Barcelona, Spain

Tracks: Sensor devices - Ultrasonic and Piezosensors - Photonics - Infrared - Gas Sensors - Geosensors - Sensor device technologies - Sensors signal conditioning and interfacing circuits - Medical devices and sensors applications - Sensors domain-oriented devices, technologies, and applications - Sensor-based localization and tracking technologies - Sensors and Transducers for Non-Destructive Testing

Deadline for papers: 30 March 2013



http://www.iaria.org/conferences2013/SENSORDEVICES13.html

The Seventh International Conference on Sensor Technologies and Applications

Deadline for papers: 30 March 2013

SENSORCOMM 2013

25 - 31 August 2013 - Barcelona, Spain

Tracks: Architectures, protocols and algorithms of sensor networks - Energy, management and control of sensor networks - Resource allocation, services, QoS and fault tolerance in sensor networks - Performance, simulation and modelling of sensor networks - Security and monitoring of sensor networks - Sensor circuits and sensor devices - Radio issues in wireless sensor networks - Software, applications and programming of sensor networks - Data allocation and information in sensor networks - Deployments and implementations of sensor networks - Under water sensors and systems - Energy optimization in wireless sensor networks

http://www.iaria.org/conferences2013/SENSORCOMM13.html

The Sixth International Conference on Advances in Circuits, Electronics and Micro-electronics

CENICS 2013

25 - 31 August 2013 - Barcelona, Spain

Deadline for papers: 30 March 2013

Tracks: Semiconductors and applications - Design, models and languages - Signal processing circuits - Arithmetic computational circuits - Microelectronics - Electronics technologies - Special circuits - Consumer electronics - Application-oriented electronics

http://www.iaria.org/conferences2013/CENICS13.html

Sensors & Transducers Journal, Vol. 147, Issue 12, December 2012, pp. 87-94

www.sensorsportal.com

Sensors & Transducers

ISSN 1726-5479

http://www.sensorsportal.com

An Experimentation on Anti-Reset Windup Scheme for Level Process Station

[1] I. Thirunavukkarasu, [2] Mohammed Ibrahim Fareed Abuaiah, [3] V. I. George, [4] S. Shanmuga Priya

[1, 3] Dept. of Instrumentation and Control Engineering, MIT, Manipal-576 104, Karnataka, India
[2] IAESTE Intern Student - An-Najah National University, Palestine
[4] Dept. of Chemical Engineering, MIT, Manipal-576 104, India
E-mail: itarasu1881@gmail.com

Received: 2 October 2012 /Accepted: 18 December 2012 /Published: 31 December 2012

Abstract: This paper represents how to eliminate the undesired effect occurred in the PI or PID controller called integrator-windup by using four different methods. These different methods are known as anti-windup strategies. A Simulink-Matlab program has been used to investigate the results and the performance of the four anti-windup strategies, using the parameters and values from two published papers [1-2]. The controller, actuator, saturation and planet transfer function are used to build the general structure of a control feedback system. Finally, the modifications were made in the "Level Control Trainer" program that was made by InTouch-windows maker program to solve the problem that happens by the integrator windup in a real time system for level control station was done experimentally. *Copyright © 2012 IFSA.*

Keywords: PID controller, Anti-reset windup, Actuator saturation, Conditional integrator.

1. Introduction

In this experiment the modifications were made on "Level Control Trainer" program that was made by InTouch-windows maker program. This program is responsible to control the water level in a tank by using PID controller. The aim of this experiment is to add saturation level to obtain the integrator windup (for studying research) [3]. After that we measured the saturation level in real time by using millimeter, to know the maximum and minimum saturation (U_{max} and U_{min}) for the water level. Finally we added anti-windup controller to solve the problem that happens by the integrator windup.

1.1. Level Controller Station Description [5]

Level control trainer is designed for understanding the basic principles of level control. The process setup consists of supply water tank fitted with pump for water circulation. The level transmitter used for level sensing is fitted on transparent process tank. The process parameter (level) is controlled by microprocessor based digital indicating controller which manipulates pneumatic control valve through I/P converter. A pneumatic control valve adjusts the water flow in to the tank. These units along with necessary piping are fitted on support housing designed for tabletop mounting. Level control trainer is designed for understanding the basic principles of level control. The process setup consists of supply water tank fitted with pump for water circulation. The level transmitter used for level sensing is fitted on transparent process tank. The process parameter (level) is controlled by microprocessor based digital indicating controller which manipulates pneumatic control valve through I/P converter. A pneumatic control valve adjusts the water flow in to the tank. These units along with necessary piping are fitted on support housing designed for tabletop mounting.

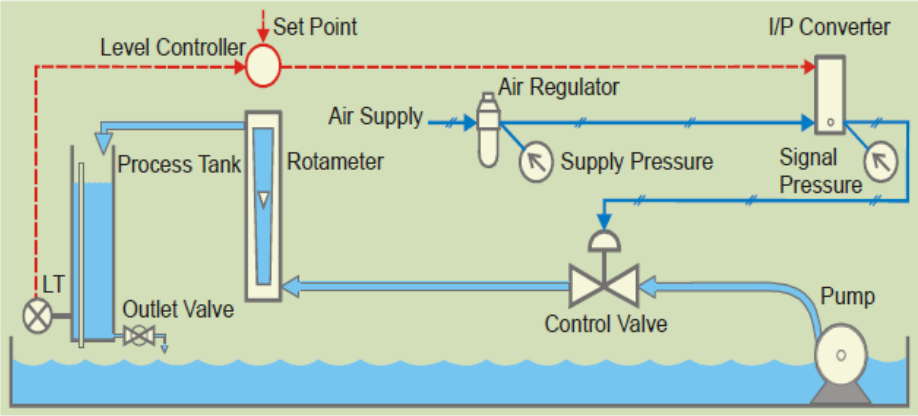


Fig. 1. General scheme for level control station.

1.2. InTouch-windows Maker Program [6]

A Human Machine Interface (HMI) software application shows a graphical representation of a manufacturing environment. The tools, materials, and processes used to create a product appear as visual elements in an HMI application's windows. Plant operators interact with an application's graphical interface to monitor and administer the manufacturing processes.

Fig. 2 shows the core components of the InTouch HMI that you use to build and run applications.

As its name suggests, you use Application Manager to create and manage InTouch applications. The application development environment, called WindowMaker, includes a set of graphic and other development tools to build your applications. You run your applications using WindowViewer.

2. Experimental Process

2.1. Level Control Station

The Level Control Station is shown in Fig. 3. This station is responsible to control the water level in a small tank by using PID controller (UT321 – YOKOGAWA shown in Fig. 4) connected to a computer by ADAM USB wire connection. The water level in the tank can vary between 0 to 100 cm. The

simulation program that is responsible for sending the variable data to the PID controller is In-Touch-windows maker as shown in Fig. 5.

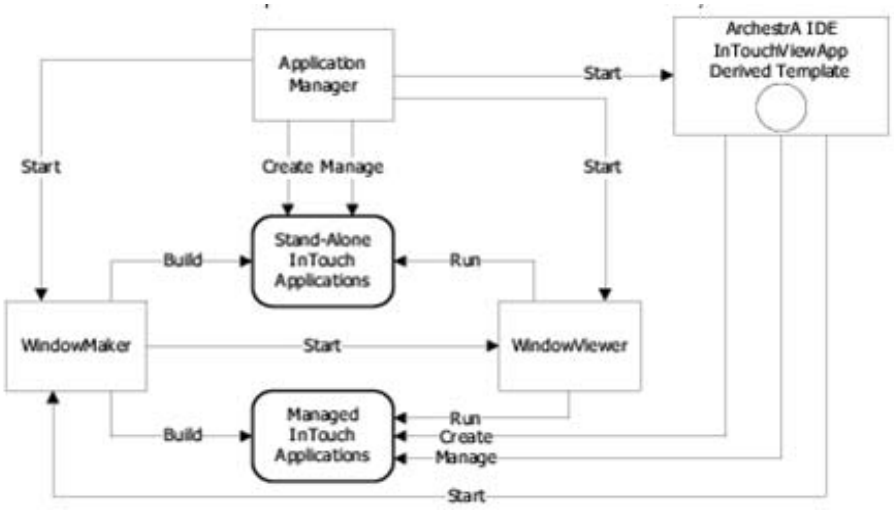


Fig. 2. Flow chart of In-touch Software.

Fig. 3. Level control station.

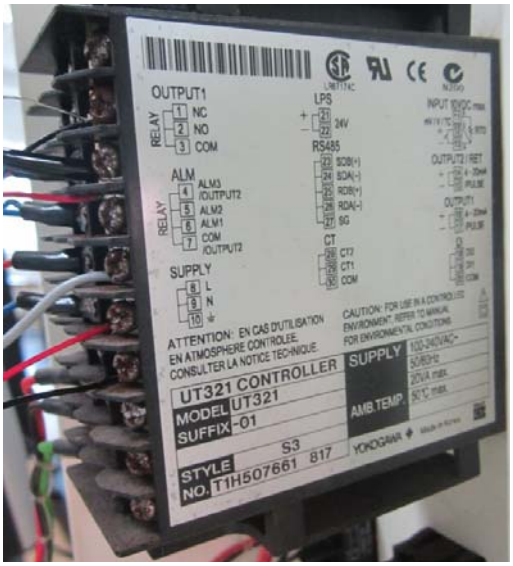


Fig. 4. UT321 PID Controller.

Table 1 shows the variable and the modes in the 'Level Control Trainer' program that used for controlling the PID.

2.1.1. Current Measurement

Before making an Anti-Windup mode in the level control program we must measure the output current from the PID controller in different water level (0 cm to 100 cm) to define the maximum and minimum saturation level (U_{max} & U_{min}). We disconnect the positive output wire from the PID and the connected the multimeter (AC mA) as shown in Fig. 6. Table 2 shows the current value in different water level.

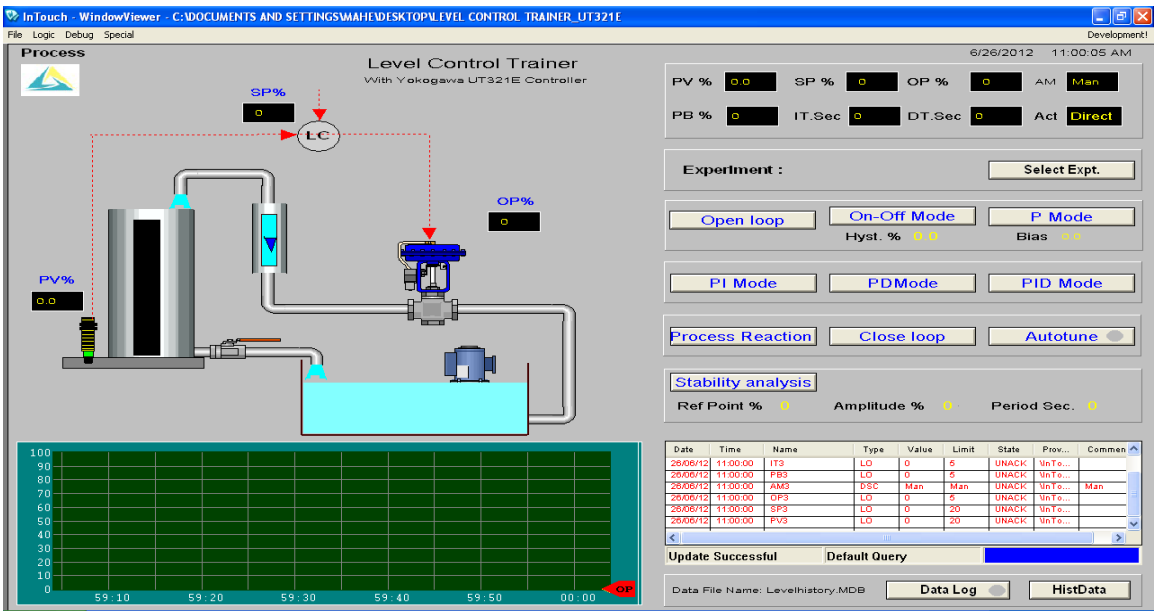


Fig. 5. InTouch-windows maker 'Level Control Trainer'.

Table 1. Level Control Trainer program Mode & Variable.

Mode/Variable	Details
Open-Loop	Study of open loop response (manual control)
On-Off Mode	Study of on/off controller
P Mode	Study of proportional controller
PI Mode	Study of proportional integral controller
PD Mode	Study of proportional derivative controller
PID Mode	Study of proportional integral derivative controller
Process Reaction	Tuning of controller (open loop method)
Close loop	Tuning of controller (closed loop method)
Autotune	Tuning of controller (using auto tuning method)
Stability analysis	To study stability of the system (bode plot)
PV	Process value
SP	Step point
AM	Auto/manual
PB	Proportional band
IT.sec	Integral time
DT.sec	Derivative time

Table 2. Current value for different water level.

Water level (cm)	Current value (mA)
0	4
10	5.5
20	7.2
30	8.8
40	10.3
50	11.9
60	13.5
70	15.5
80	16.8
90	18.9
100	20.01

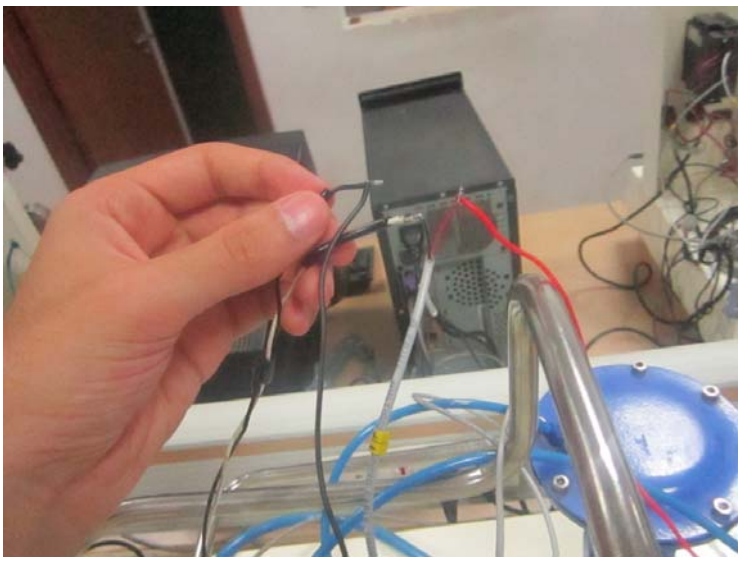


Fig. 6. Measure the output current value from the PID controller.

2.1.2. Reprogramming

After we study and collect the information about integrator windup problem we modified the level controller program to obtain the Anti-Windup strategy in real time implementation [6, 7]. This done by added the Anti-Windup mode and saturation level to the main program as shown in Fig. 7. Then we reprogramming the original code to controlling the hardware actuator by calculate the error between PV and SP, then we toke this error as a feedback to the controller to limit the actuator movement between defined U_{max} and U_{min} automatically.

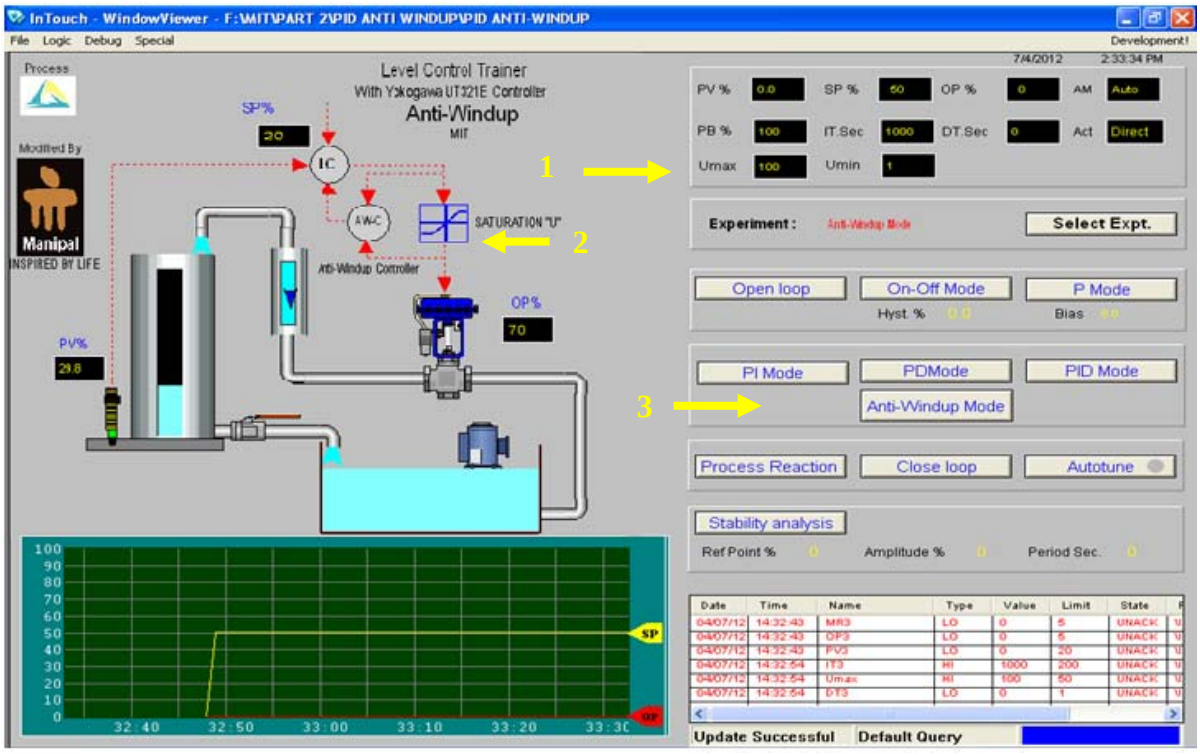


Fig. 7. Level controller program with Anti-Windup controller.
(Umax & Umin '1', saturation and Anti-Windup graph '2', Anti-Windup Mode '3').

2.1.3. Final Result

Fig. 8 and Fig. 9 are showing the difference between PID and Anti-Windup result for the real time processing value (PV), step point (SP), and operating response (OP). And Fig. 10 and Fig. 11 are showing the current output at two saturation levels (10 and 80).

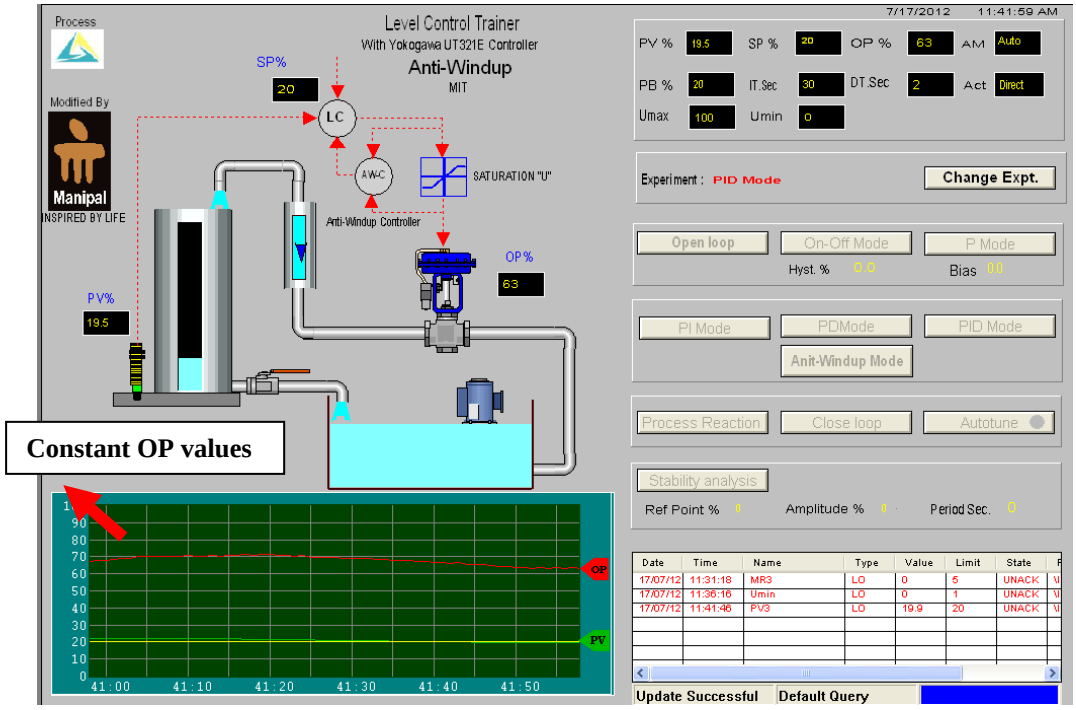


Fig. 8. OP, PV and SP response in PID Mode.

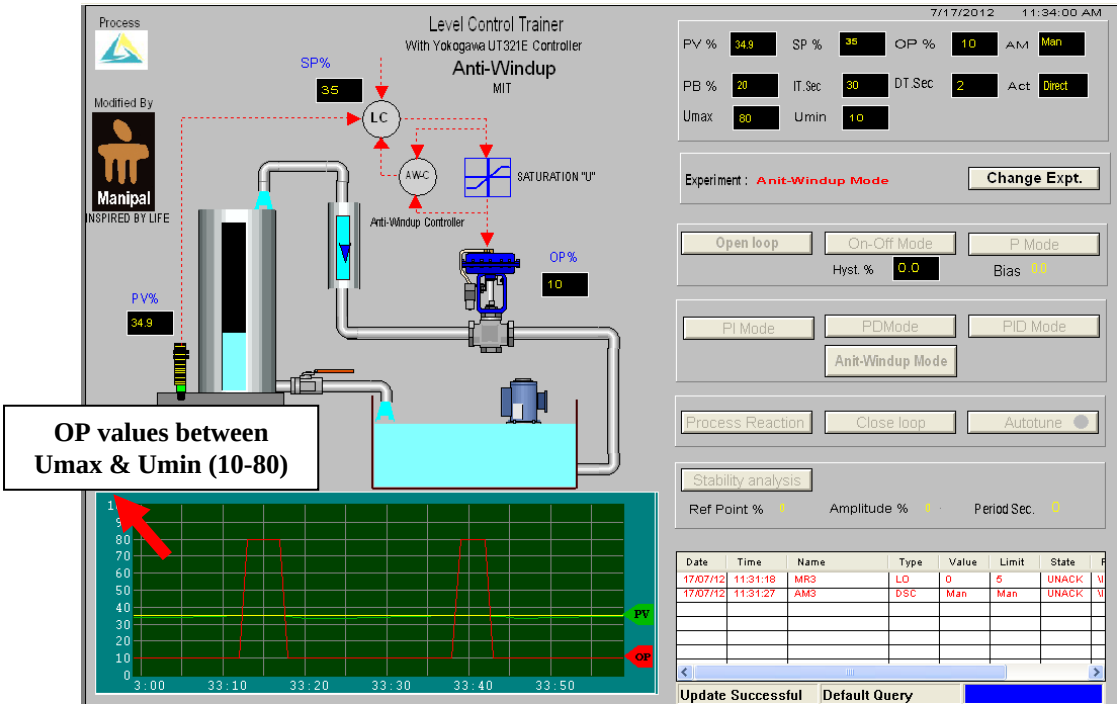


Fig. 9. OP, PV and SP response in Anti-Windup Mode.

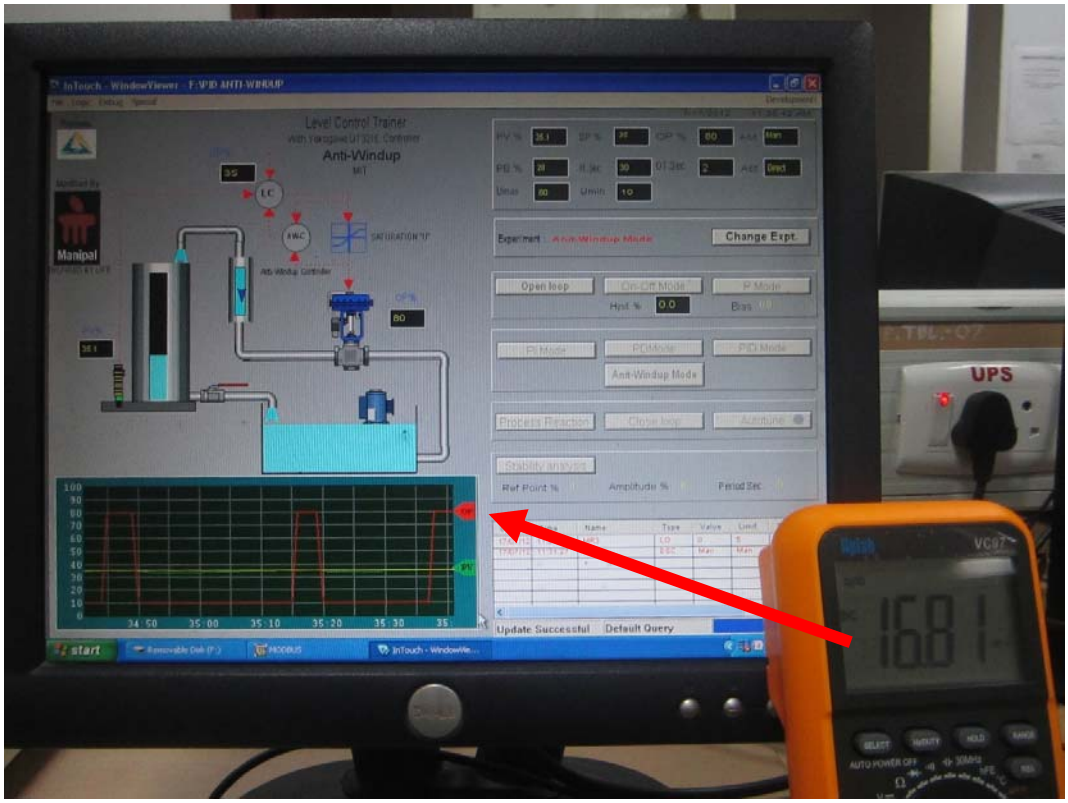


Fig. 10. The output current value at Umax = 80.

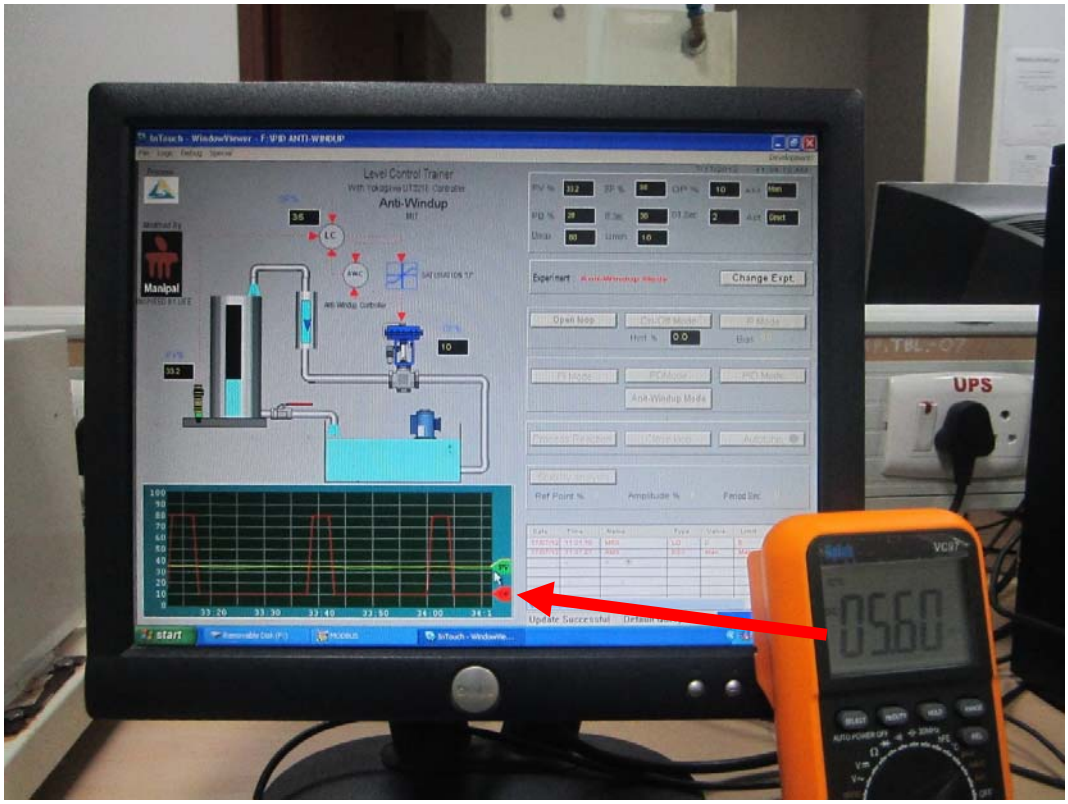


Fig. 11. The output current value at min = 10.

3. Conclusion

The integrator windup is a very common problem in the PID controller system, accrued when we have actuator saturation. There are four different methods called anti-windup strategy to solve this problem, each strategy has its own advantage and disadvantage at the same time, e.g. the limited integrator give the high overshoot compared with the other method, so it's the least desirable method. The proposed method gives a very good response, because it takes the advantages of the two anti-windup strategies (conditional integrator and back-calculation). Also the response of the controller with and without Anti-Windup in real time system and how it use to limit the actuator and pervent him to exceed a defined values (Umax & Umin) when a saturation is accured.

4. References

[1]. C. Bohn and D. P. Atherton, An Analysis Package Comparing PID Anti-Windup Strategies, *IEEE Controls System*, April 1995.
[2]. L. Rundqwist, Anti-Reset Windup for PID Controllers, Ph. D. Thesis TRFT-1033, Department of Automatic Control, *Lund Institute of Technology*, Lund. Sweden, 1991.
[3]. Visioli, Modified anti-windup scheme for PID controllers, *IEE Proc. -Control Theory Appl.*, Vol. 150. No. 1, January 2003.
[4]. M. Zhuang and D. P. Atherton, Automatic Tuning of Optimum PID Controllers, *Proc. IEEE,* Part D, Vol. 140, No. 3. pp. 216-224, 1993.
[5]. Level Control Trainer, Instruction manual.
[6]. InTouch HMI: Visualization for your Manufacturing Enterprise/Help.
[7]. http://en.wikipedia.org/wiki/PID_controller#Integral_term, 17th July 2012.

Sensors & Transducers Journal

Guide for Contributors

Aims and Scope

Sensors & Transducers Journal (ISSN 1726-5479) provides an advanced forum for the science and technology of physical, chemical sensors and biosensors. It publishes state-of-the-art reviews, regular research and application specific papers, short notes, letters to Editor and sensors related books reviews as well as academic, practical and commercial information of interest to its readership. Because of it is a peer reviewed international journal, papers rapidly published in *Sensors & Transducers Journal* will receive a very high publicity. The journal is published monthly as twelve issues per year by International Frequency Sensor Association (IFSA). In additional, some special sponsored and conference issues published annually. *Sensors & Transducers Journal* is indexed and abstracted very quickly by Chemical Abstracts, IndexCopernicus Journals Master List, Open J-Gate, Google Scholar, etc. Since 2011 the journal is covered and indexed (including a Scopus, Embase, Engineering Village and Reaxys) in Elsevier products.

Topics Covered

Contributions are invited on all aspects of research, development and application of the science and technology of sensors, transducers and sensor instrumentations. Topics include, but are not restricted to:

- Physical, chemical and biosensors;
- Digital, frequency, period, duty-cycle, time interval, PWM, pulse number output sensors and transducers;
- Theory, principles, effects, design, standardization and modeling;
- Smart sensors and systems;
- Sensor instrumentation;
- Virtual instruments;
- Sensors interfaces, buses and networks;
- Signal processing;
- Frequency (period, duty-cycle)-to-digital converters, ADC;
- Technologies and materials;
- Nanosensors;
- Microsystems;
- Applications.

Submission of papers

Articles should be written in English. Authors are invited to submit by e-mail editor@sensorsportal.com 8-14 pages article (including abstract, illustrations (color or grayscale), photos and references) in both: MS Word (doc) and Acrobat (pdf) formats. Detailed preparation instructions, paper example and template of manuscript are available from the journal's webpage: http://www.sensorsportal.com/HTML/DIGEST/Submition.htm Authors must follow the instructions strictly when submitting their manuscripts.

Advertising Information

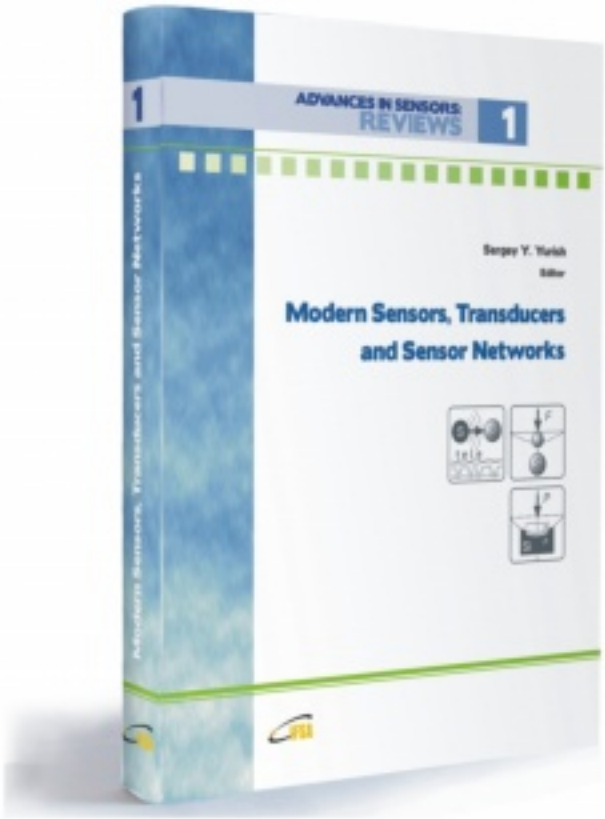
Advertising orders and enquires may be sent to sales@sensorsportal.com Please download also our media kit: http://www.sensorsportal.com/DOWNLOADS/Media_Kit_2012.pdf

International Frequency Sensor Association Publishing

ADVANCES IN SENSORS: REVIEWS 1

Sergey Y. Yurish
Editor

Modern Sensors, Transducers and Sensor Networks



Modern Sensors, Transducers and Sensor Networks is the first book from the Advances in Sensors: Reviews book Series contains dozen collected sensor related state-of-the-art reviews written by 31 internationally recognized experts from academia and industry.

Built upon the series Advances in Sensors: Reviews - a premier sensor review source, the *Modern Sensors, Transducers and Sensor Networks* presents an overview of highlights in the field. Coverage includes current developments in sensing nanomaterials, technologies, MEMS sensor design, synthesis, modeling and applications of sensors, transducers and wireless sensor networks, signal detection and advanced signal processing, as well as new sensing principles and methods of measurements.

Modern Sensors, Transducers and Sensor Networks is intended for anyone who wants to cover a comprehensive range of topics in the field of sensors paradigms and developments. It provides guidance for technology solution developers from academia, research institutions, and industry, providing them with a broader perspective of sensor science and industry.

Order online:
http://sensorsportal.com/HTML/BOOKSTORE/Advance_in_Sensors.htm

www.sensorsportal.com