



IEEE



TCSET'2014

“MODERN PROBLEMS OF RADIO ENGINEERING, TELECOMMUNICATIONS, AND COMPUTER SCIENCE”

**Proceedings
of the International Conference
TCSET'2014
Dedicated to the 170th anniversary of
Lviv Polytechnic National University**

**Lviv-Slavske, Ukraine
February 25 – March 1, 2014**

**Ministry of Education and Science of Ukraine
Lviv Polytechnic National University**

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**Міністерство освіти і науки України
Національний університет “Львівська політехніка”**

**СУЧАСНІ ПРОБЛЕМИ
РАДІОЕЛЕКТРОНІКИ,
ТЕЛЕКОМУНІКАЦІЙ,
КОМП’ЮТЕРНОЇ ІНЖЕНЕРІЇ**

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“Львівська політехніка”**

2014

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Dear Colleagues!

I want to congratulate You, participants of XII International conference "Modern problems of Radio Engineering, Telecommunications and Computer Science", dedicated to 170th Anniversary of Lviv Polytechnic National University – the oldest technical education and research establishment of Ukraine and Eastern Europe. During its existence, the University approved itself as intellectual centre, centre of national culture, freedom of opinion and expression. Generations of teachers, professors and scientists provided the authority for the University.

During all the times of development, Lviv Polytechnic has been preparing intellectual and spiritual elite of the nation. Our graduates work in all the spheres of our state national economy as well as in many countries of the world. A lot of our graduates occupy the highest positions in the sphere of education, science, management, business, and financial structures. According to the result of rating which is held annually and is based on the experts estimation, Lviv Polytechnic National University in recent years belongs to five best Universities of Ukraine.

Nowadays, Lviv Polytechnic includes 16 educational – research institutes, 63 directions and 114 specialities on the master level. There are 30 000 of students at the University, perspective research is being held, as well as the development of scientific schools, cooperation with world scientific – education centres, formation of innovation infrastructure.

The University also comprises the Distance Learning Institute, the Research and Development Department, Special Design Bureau of Electromechanical Systems (SDBEMS), centre "Crystal", "Elvit" research and development designing Institute, International Institute of Education, Culture and Links with Ukrainian Diaspora and other subdivisions. Educational process is provided by 262 Doctors of Science and more than 1000 – Candidates of Science.

Significant proportion of the achievements of Lviv Polytechnic belongs to the Institute of Telecommunications, Radio and Electronic Engineering. There are 125 representatives of professors and teachers staff of the Institute, among them – 41 Doctors of Science, which is more than 30% and more than 53% of Candidates of Science.

The Institute conducts research on the theory of circuits and signals, radio electronic and infocommunication devices and systems, micro – nanotechnologies, laser technologies, microwave technology and antennas etc.

The Institute scholars fruitfully cooperate with scholars of different Universities and research institutions of Ukraine, Poland, Germany, Austria, the USA, Canada, France, Russia and other countries of the world.

I wish all the participants of the conference TCSET'2014 creative communication, great inspiration and further cooperation.

Sincerely Yours,

A handwritten signature in black ink, appearing to be 'Yuriy Bobalo'.

Yuriy Bobalo

Chair of Organizing Committee

Rector, Lviv Polytechnic National University

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Simulation of the Antenna Azimuth Position Control System with Fuzzy PID-like Controller

Oksana Mnushka

Abstract – The paper deals with antenna azimuth control system, which controlled by using conventional proportional-integral-derivate (PID) controllers and both Mamdani-type and Takagi-Sugeno-type fuzzy logic controllers (FLC). In order to obtain system response to various external perturbations the simulation model was developed in Matlab / Simulink environment. System responses with FLC and PID-controller for four various external perturbations are compared.

Keywords – Fuzzy logic, Robust control, Perturbations, simulation, PID.

I. INTRODUCTION

To install a satellite antenna on the vehicle the problem of the antenna accurate positioning in the direction to the satellite must be solved. Satellite antenna orientation errors, which occur during the vehicle movement, cause a substantial reduction of the received signal level [1]. Setting up the angular position of the antenna for both azimuth and elevation is made by means of equipment, which uses control systems with similar parameters. The paper deals with simulation of the antenna azimuth position control system as subsystem of antenna tracking control system.

II. SIMULATION MODEL

In general, the closed control system (Fig. 1) consists of a generalized controlled object ("Plant"), a controller ("Controller") and a sensor ("Sensor") to measure the current level of output signal ($y(k)$). The error signal ($e(k)$) as the difference between required ($r(k)$) and current ($y(k)$) states of the controlled object is the input signal of the controller. The control signal ($u(k)$), according to which the state of the controlled object is changed, is the output signal of the controller.

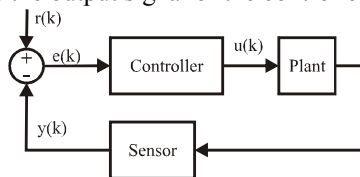


Fig. 1. Generalized model of a closed loop control system

Considering the above notation, the link between input and output variables is given in Eq. (1):

$$\begin{aligned} e(k) &= r(k) - y(k), \\ \Delta e(k) &= e(k) - e(k-1), \end{aligned} \quad (1)$$

where $\Delta e(k)$ – change of error; k – iteration number.

The simulation model of the control system (Fig. 2) was developed and implemented in Matlab / Simulink

and it consists of sources of signal and perturbations, controllers, controlled object, sensors and an oscilloscope (on Fig. 2 the fragment of the model is shown).

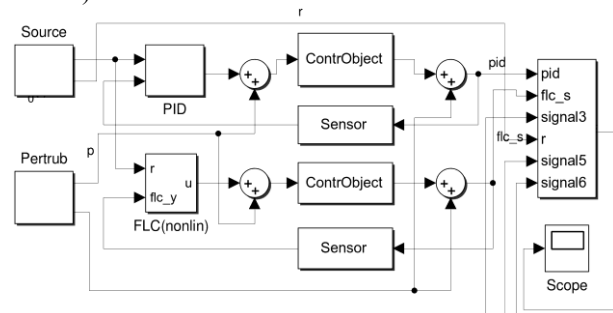


Fig. 2. The simulation model

To verify the developed simulation model we consider the well-known antenna azimuth positioning system [2] with the discrete transfer function $W(z)$ given in Eq. (2) as the generalized controlled object.

$$W(z) = \frac{0,000274(z + 2,959)(z + 0,2037)}{(z - 1)(z - 0,983)(z - 0,3679)}. \quad (2)$$

Let fuzzy PID-like controller (Fig. 3) consists of input and output gains - proportional (K_{fp}), integral (K_{fi} , K_{fiu}) and derivative (K_{fd} , K_{fdu}); a fuzzy logic controller; a derivator; an integrator, adders and a multiplexer.

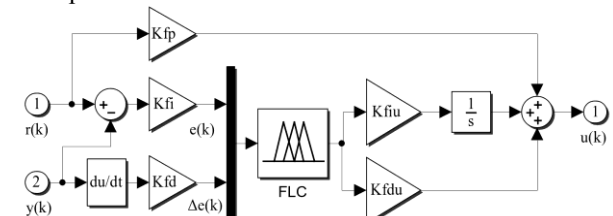


Fig. 3. Fuzzy PID-like controller

The detailed cross-reference rules sets between inputs and output for both Mamdani-type (M) and Takagi-Sugeno-type (TS) FLC were obtained and are defined in Tables I and II, in which next abbreviations are used: N – Negative, NB – Negative Big, NM – Negative Medium, Z – zero, P – Positive, PM – Positive Medium, PB – Positive Big, Min – Minimum, Max – Maximum.

TABLE I

MAMDANI-TYPE FLC RULES SET

$\Delta u(k)$		$e(k)$		
		N	Z	P
$\Delta e(k)$	N	NB	NM	Z
	Z	NM	Z	PM
	P	Z	PM	PB

TABLE II

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TAKAGI-SUGENO-TYPE FLC RULES SET

$\Delta u(k)$	$e(k)$	
	N	P
$\Delta e(k)$	N	Min
	P	Max

III. SIMULATION AND RESULTS

The parameters of the PID-controllers (Fig. 2) were calculated by Matlab and Simulink tools (pidtune() for classical PID-controller and Control Design PID Tuner for Simulink pid(z) block). The parameters of the FLC were calculated in accordance with recommendations contained in [3] and Eq. (2). Appropriate coefficients of the simulation model for sample time $T_s=0.01$ s and amplitude $A=10$ are: a) PID-controller: $K_p = 2.32$; $K_i = 0.393$; $K_d = 0.424$; b) Pid(z)-block: $K_p=0.9665$; $K_i=0.0267$; $K_d=0.3819$; c) FLC: $K_{fi}=3.18$; $K_{fd} = 0.6007$; $K_{fiu} = 0.1237$; $K_{fdu} = 0.7055$.

On Figures 4-8 abbreviations are: O – system without controller, M – Mamdani-type FLC, TS – Takagi-Sugeno-type FLC, PIDz – optimized pid(z) controller.

1. Step response. As seen from Fig. 4, the system without controller has an overshoot of about 35%, with M-FLC about 18%, with TS-FLC about 8%, oscillations are negligible in the responses of the controlled systems.

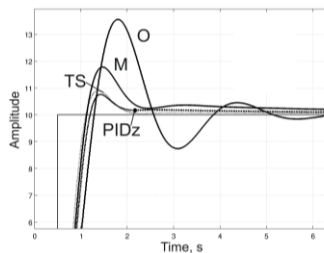


Fig. 4. Step response

2. Step response with step perturbation, which had an amplitude of $0.15 \cdot \max(A)$ and started in 4 s (Fig. 5).

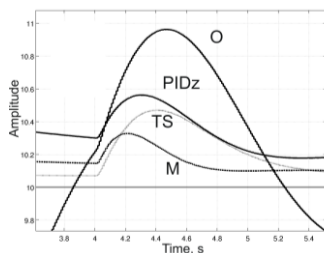


Fig. 5. Step response with step perturbation

System with TS-FLC was returned to the initial state in about 0.9 s and amplitude changes correspond to about 1/10 of the perturbation amplitude. For other variants the following results were obtained: time was about 1.5 s and amplitude changes correspond to about 1/5.

3. Step response with big short pulse perturbation (Fig. 6). All controlled systems have the similar results. The system was returned to the initial state in about 1 s.

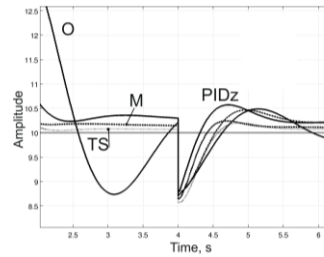


Fig. 6. Step response with big short pulse perturbation

4. Step response with ramp perturbation (Fig. 7). The overshoot for TS-FLC was of about 10%, for M-FLC about 18%. Simulink pid(z)-controller could not stabilize the system.

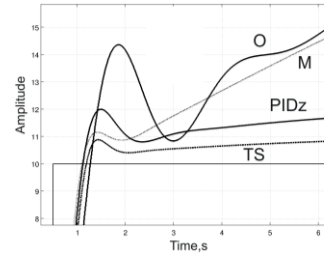


Fig. 7. Step response with ramp perturbation

5. When changing the transfer function of the controlled object (for example, we plugged $1/(z \pm \alpha)$ in series with controlled object) (Fig. 8), once again TS-FLC was more robust than other controllers.

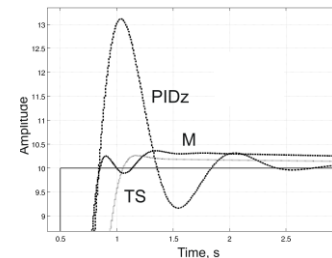


Fig. 8. Step response with changed transfer function

IV. CONCLUSION

To conclude, the advantages of FLC in comparison with conventional PID controllers were observed under the action of various external perturbations. In the considered systems Takagi-Sugeno-type FLC is more robust to external perturbations in comparison with Mamdani-type controller.

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