THE PUBLISHING HOUSE
OF THE ROMANIAN ACADEMY

PROCEEDINGS OF THE ROMANIAN ACADEMY, Series A,
Volume10x, Number 1/2009, pp. 000–000

ACTUATOR CONTROL IN CONTINUOUS FLUX USING WINER FILTERS

Luige VLĂDAREANU*, Ovidiu I. SANDRU**, Lucian M. VELEA***, Hongnian YU****

*Institute of Solid Mechanics of Romanian Academy,
C-tim Mille 15, Bucharest 1, +40213126736, luigiv@arexim.ro
**Politechnica University of Bucharest
Splaiul Independentei 125, Bucharest 5, Romania
***Industrial Engineering and Technology VTC-srl
Burla Vasile 24, Bucuresti 1, +40213157478, lmvelea@arexim.ro
**** Department of Computing, Engineering and Technology
Staffordshire University, Stafford ST16 9DG, UK

Abstract. The paper presents a new real time control method in continuous actuator flux in which linear Winer filters with a finite impulse response are used for mathematical modelling of the correlation between actuators. By implementing this method in complex system automations, it is possible to determine the behaviour, functional parameters and performances of the actuators in real time. This paper presents theoretic considerations, the actuators real time control system architecture, mathematic modelling, experimental results and comparative measurement graphs related to the method's performances. The mathematical modelling is based on the Winer-Hopf equations and resolves, with the help of mathematical software known as Winer filters, the problem of filtering the white noise which disturbs feedback of the components of the testing systems actuators. These lead to the possibility of predicting actuator performances through indirect measurements without the measurement signals being generated by the tested actuator as they are in the case of direct measurement methods. Thus, this method allows for the development of complex systems while reducing trial time and increasing measurement precision. Theoretic and experimental results have shown that the behaviour errors of the actuators that have been tested through the proposed method are less than 0.9% while the testing duration is over 30 times less.

***Key Words*:** actuator control, real time control, complex automations, mathematic modelling, PLCs

1. INTRODUCTION

The new tendency in complex automations is to use PLCs (Programmable Logical Controllers) in decentralized and distributed structures, which confer multiple capacities and facilities on equipment, installation, engineering plant producers and users. Hence we can envision, design and build pyramidal structures with PLCs and PCs for automatic control of complex processes, for monitoring and management of process parameters, as well as constructing redundancy structures which endow the systems with maximal safety during functioning and, above all, high reliability [1,2,3,9]. These structures allow the interconnection of several automation systems for controlling, monitoring and centralized dispatching of processes within complex mechanisms.

The decentralized and distributed structure of PLC systems must be understood as an intelligent interface between the process and the central control system within the pyramidal structures of controlling, monitoring and dispatching processes. The same structure could be perceived as an intelligent system that, during the control of some unique processes, equipments and engineering lines, is distributed over large working area. In both cases the human factor is only in supervising the processes' progress. The philosophy of decentralized and distributed structures is based upon the creation of some intelligent islands wherein the execution elements connected through the specific communication network of the PLCs are concentrated [1, 4, 5, 10]. The main advantage of using systems in decentralized and distributed structures is that they may lead to controlling, monitoring and supervising several processes which are meant to create a unique final process. Thus many interconnected processes, which are all part of the final process, are created. The paper presented here offers a new actuator control solution for continuous flux trials, based on the concept of open architecture systems.

For real time control of the actuators in order to determine the characteristics, functional parameters and performance several technical solutions are known which consist of measuring the input signals (accelerations, currents, power, torque, etc.) directly from the transducers mounted onto the actuator. To this end, the tested actuator is connected to a charge, usually passive, and integrated into the control system and the actuator's control signals are measured as shown in Figure 1. Note the large number of measure transducers which should be mounted/dismantled at the testing of a new actuator.

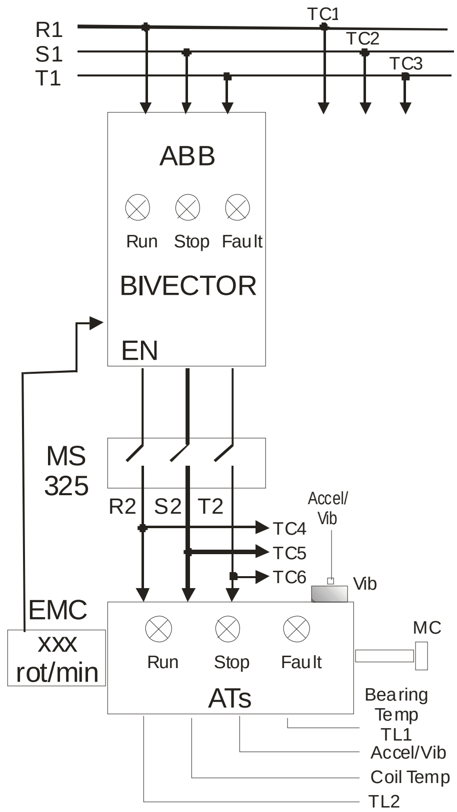


Fig. 1. The direct measuring method of the actuators

The disadvantage is mainly that [6,7,12], in order to determine the characteristics, the functional parameters and the actuator performances in continuous flux testing, it is necessary to move the measurement transducers and the command elements from the tested actuator to another actuator, which leads to longer periods needed for the operation, less reliable measurements performed with human intervention, the possibility of bad couplings between the measurement transducers and the actuator which can lead to measurement errors, etc.

2. THE CONTROL METHOD

The control method allows real-time control for determining characteristics, functional parameters and performances of progressive actuators without the entry signals generated by the tested actuator which leads to a reduction in trial duration, higher measurement precision and the ability to perform complex trial regimes. In conformance with the method presented herein, in order to control actuators in real time a high performance measurement of the characteristics for functional parameters of a reference servo-actuator is performed. Its role is that of reference point for measurements and represents the charge of the trial actuator, coupled with the reference actuator by means of a coupling transducer and connected to a control system with open architecture, which together with a process computer PC-SERVER, with high speed and high computation power, generates the mathematical model of the servo-actuator in off-line mode and the mathematical model of the tested actuator on-line mode, allowing a correlation between them by means of mathematical modelling and teach-in functions in the off-line mode of the servo-actuator. It also generates complex trial regimes of the tested actuator, like Dirak-type characterization on starting signal, right signal, movement laws with predefined functions as regards speed/acceleration: trapezoidal, sinusoidal, etc. Finally, according to the presented method, we obtain real-time control of actuators without the entry signals being generated by the trial actuator by means of direct measurement.

A total of 6 phases have been identified for this method which presented in Figure 2, with reference to the system architecture presented in Figure 3. **A first phase (A)** which consists of choosing a SVA servo actuator with high performance, as a reference for measurements, and which becomes the charge for the ATs testing actuator. **In the next phase (B),** a mathematical model is generated off-line of the SVA servo actuator, as a reference for measurements, which will represent the charge of the tested actuator, coupled through a coupling transducer by an actuator of the same class as tested actuator, using a control system with an open architecture SCADA and a PCS PC-server process system with high speed and large calculation capability. The generation of the signals necessary to obtain the motion laws for the mathematical modelling without coupling to the test actuator, but coupled with an actuator from the same class as the test actuator, is done by the TIN (teach-in) instruction module.

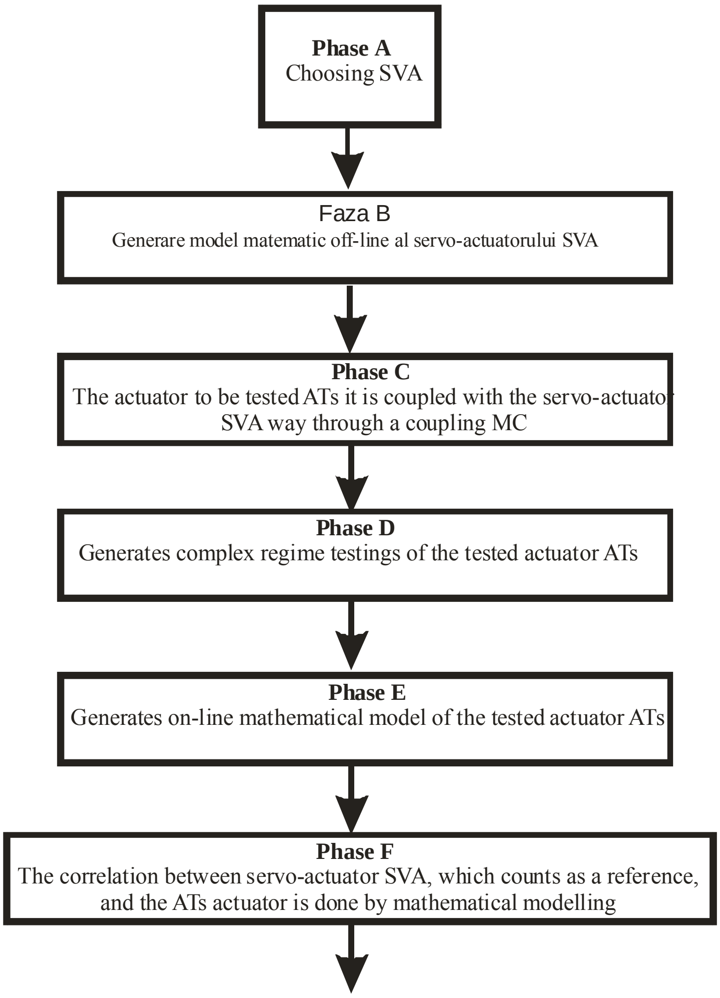


Fig. 2. The structure of the control method

In phase (C) previous to the measuring procedure in continuous flow, the ATs tested actuator is coupled with the SVA servo actuator through an MC coupling module. **In phase (D)** we generate the complex trials systems of the ATs tested actuator, motion laws with predefined functions for speed and/or accelerations of trapezoid, sinusoidal type, etc. **In the following phase (E)** we generate on-line the mathematical model of the ATs tested actuator performed by the mathematical modelling module of the (MMA) tested actuator through modelling with the method considered to be the best in the (B) off line phase, using the SCAD control system with open architecture and the PC-server process server system. **In phase (F)** we achieve, through mathematical modelling, a correlation between the SVA servo actuator, which matters as reference, and the ATs actuator.

3. THE SYSTEM ARCHITECTURE

The system architecture consists of a high performance servo-actuator module, which mechanically engages the test actuator through a couple, in conformance to certain complex trial regimes, and sends measurement signals to the open architecture control system ***n***. Based on these signals, which are processes by a powerful high-speed PC – Server (PCS) process computer, the mathematical model of the servo-actuator is generated off-line and that of the tested actuator is generated on-line The correlation functions between the two are also generated. The resulting information allows statistical characterization, diagnosis and determination of characteristics, functional parameters and the tested actuator's performances. This way the method leads to real time control for actuators, without the input signals being generated by the tested actuator through direct measurement. A real time open architecture control system has been developed for determining the characteristics, parameters and performance of high performance servo-actuators, which represents the charge of the tested actuator and serves as a reference for measurements. The two actuators are coupled rigidly through a mechanical system, on which there is a torque transducer.

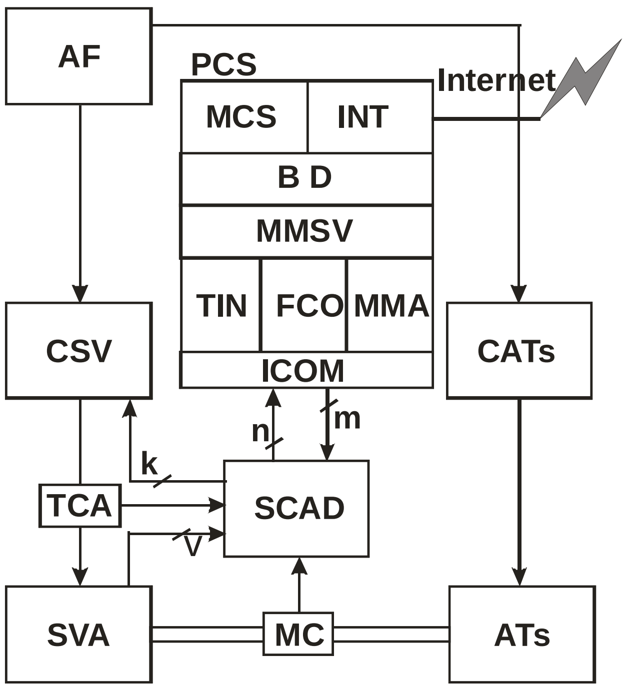


Fig. 3 The real time system architecture of the actuators

The open architecture control system together with a PC-SERVER process computer generate the mathematical model of the servo-actuator in off-line and the mathematical model of the tested actuator in on-line In the off-line state using the training functions (teach-in), the mathematical model of reference is determined for groups of test actuators by generating complex trial regimes. Regimes have been chosen which can define the actuators' transfer function, such as characterization of a entry signals such as Dirac type, stair type, movement laws with predefined functions for speeds/accelerations: trapezoidal, sinusoidal, etc. The system enters a state where it is necessary to introduce new actuator groups, which can be tested in order to "learn" the control system for "working" with the new actuator group which has to be tried. On-line the actuator tested through signals generated by open architecture system is subjected to the same complex trial regimes in order to determine the mathematical model. The resulting data is processed by the process computer which generates the correlation function between the actuator group's mathematical reference model and that of the tested actuator.

The high performance **servo-actuator module** (SVA) set on the test actuator (ATs) through a coupling module (MC), conformant to complex trial regimes generated by the servo-actuator force controller (CSV) and sends ***v*** measurement signals to the open architecture control system (SCAD) in order to determine the correlation functions and the mathematical modelling of the tested actuator. Conversion of energy from the force charge module (AF) to the servo-actuator module (SVA), depending on the control signals generated by the open architecture system (SCAD), is done by a servo-actuator force controller (CSV). In parallel, a test actuator controller (CATs) ensures conversion of energy from the force charge module (AF) to the tested actuator (ATs) after a normal regime without parameters variation.

Using this and other prediction methods [8, 11, 12] a database is generated containing the reference performances of the tested actuators' groups, which in comparison with the data processed on-line will allow monitoring of the actuators' performances. Moreover, the stored information ensures the diagnosis of tested actuators and sending it through the internet allows remote monitoring and dispatch. The final advantage is in obtaining real time control of the actuators without the input signals being generated by the tested actuator through direct measurements. Studies have led to a control system whose architecture is presented in Figure 3.

4. THE MATHEMATICAL MODELING OF THE CORRELATION BETWEEN ACTUATORS USING WINER FILTERS

In testing the actuator systems in real time, useful signals are affected by an added disturbance. Due to negative influences on the outputs (answers) of such a system (which is noted with Σ), the issue is the deletion of the disruptive unwanted noise component, so that the main features of the expected signal can be preserved. To solve this problem we propose a software filter based on mathematical principles of operation.

For mathematical modelling of the presented issue, we will use the following set of conventions and assumptions. With $\{s[n] \mid n \in \mathbb{N}\}$, we note one of the useful signals transmitted by the system Σ (whose information we intend to maintain during the transfer); with $\{w[n] \mid n \in \mathbb{N}\}$, we note the white noise that occurs during system operation Σ; with $\{d[n] \mid n \in \mathbb{N}\}$, we note the desired signal (the part of the signal $\{s[n] \mid n \in \mathbb{N}\}$, that (still) ensures the proper functioning of the system Σ, which generally considered to be $d[n] = s[n-D]$ and D an number entire fixed n≥D); with $\{x[n] \mid n \in \mathbb{N}\}$ we note the input signal to the filter; with $\{y[n] \mid n \in \mathbb{N}\}$ we'll note the signal output from the filter, and we note with $\{e[n] \mid n \in \mathbb{N}\}$, the error of the functioning filter. Among these mathematical entities (in the theory they will be regarded as sequences or stochastic processes) we assume the following relationships: $x[n] = s[n] + w[n]$ (the noise $w[n]$, is interposed over signal useful additive $s[n]$) and $d[n] = y[n] + e[n]$ (the $e[n]$error of the functioning filter, influence in plus the quality of information offered). The sequences (processes) $\{s[n] \mid n \in \mathbb{N}\}$, $\{w[n] \mid n \in \mathbb{N}\}$, $\{d[n] \mid n \in \mathbb{N}\}$, are presumed to be stationary in the broad sense and the average 0. To simplify the exposure we make the assumption that the filter to be built, is linear and has a finite response to an impulse. It is known that filters characterized by these conditions are theoretically represented, with the help of relations of the form:

$$y[n] = \sum_{j=0}^{l-1} h[j]x[n-j], \forall n \geq l-1 \tag{1}$$

where the natural number $l \geq 1$ represents the length of the filter, and the scalars $h[j], 0 \leq j \leq l-1$, are its coefficients. Stochastic filters as defined by the relationship (1) are built on the basis of a number of previous observations, which is why this issue has been given the name: length of the filter. The length of a filter is determined by the designer depending on the accuracy of operation observed. The scheme graphic of the functioning of a linear filter is presented in Figure 4.

Fig.4. The scheme graphic of a linear filter

In practical terms, actual knowledge of such a filter implies the length and its coefficients, or at least has the method for determining them. Within this paper, the coefficients for a fixed length of filter, will be determined from the error minimizing quadratic

$$\xi_l = E\left(e^2[n]\right), \tag{2}$$

where: $e[n] = d[n] - y[n]$, and E represents the average operator $\mathfrak{F} \ni X \to E(X) = \int\limits_{\Omega} X(\omega) dP(\omega)$ of the probabilistic space $(\Omega, \mathfrak{F}, P)$ governing the production of white noise that disrupts the functioning of the system Σ

To achieve this goal, we will continue by solving the equations

$$\frac{\partial E\left(e^2[j]\right)}{\partial h[j]} = 0,\ 0 \le j \le l-1, \tag{3}$$

which represent the minimum conditions of the function ξ_l.

It now remains to show that, by solving this system of equations, we will obtain the coefficients $h[k], 0 \le k \le l-1$, of an optimal filter which ensures a minimum squared error operation. For this, first notice that

$$\frac{\partial^2 E\left(e^2[n]\right)}{\partial h[k]\partial h[j]} = 2\gamma_{xx}[k,j], \forall\, j,k \in \{0,1,..,l-1\} \tag{4}$$

and then the matrix $\Gamma_{xx} = \left(\gamma_{xx}[j,k]\right)_{j,k}$, determines a squared form

$$Q(\xi) = \xi \Gamma_{xx} {}^t\xi = E\left(\sum_{k=0}^{l-1}\sum_{j=0}^{l-1} x[n-j]x[n-k]\xi_j\xi_k\right) = E\left(\left(\sum_{j=0}^{l-1} x[n-j]\xi_j\right)^2\right) \tag{5}$$

positively defined, where $\xi = \left(\xi_0, .., \xi_{l-1}\right)$, and ${}^t\xi$ is the transposed line matrix ξ.

The Winer-Hopf system determined earlier can now be expressed in the matrix form as follows:

$$\Gamma_{xx} {}^t h = {}^t\gamma_{xd}, \tag{6}$$

where $h = \left(h[0], .., h[l-1]\right)$, $\gamma_{xd} = \left(\gamma_{xd}[0], .., \gamma_{xd}[l-1]\right)$, and ${}^t h$, respectively ${}^t\gamma_{xd}$, designate the matrix's transpose h, respectively γ_{xd}. Because the squared form Q is positively defined $\det\Gamma_{xx} \ne 0$.

Thus, the solution for the optimal filter coefficients is

$${}^t h = \Gamma_{xx}^{-1}\, {}^t\gamma_{xd}. \tag{7}$$

In practice, to resolve system (6) we may apply numerical methods, like the method known as Gauss-Sidel, or Levison-Durbin, etc. To get the minimum amount of average quadratic errors for the Winer filter, we replace the solution system (6) with

$$\xi_l = E\left(e^2[n]\right) = E\left(\left(d[n] - \sum_{j=0}^{l-1} h[j]x[n-j]\right)^2\right) \tag{8}$$

and we get $\min \xi_l = \gamma_{dd} - \gamma_{xd}{}^t \Gamma_{xx}{}^{-1}{}^t\gamma_{xd}$.

If the signal $\{s[n] | n \in \mathbb{N}\}$ produced by the system testing of the actuators, and background noise $\{w[n] | n \in \mathbb{N}\}$ do not correspond, as usually happens in practice, then

$$\gamma_{xx}[k,j] = \gamma_{ss}[k,j] + \gamma_{ww}[k,j],\ \forall j,k \in \{0,1,..,l-1\}, \tag{9}$$

where $\gamma_{ss}[k,j] = E\left(s[n-k]s[n-j]\right)$ si $\gamma_{ww}[k,j] = E\left(w[n-k]w[n-j]\right)$.

Finally we wish to determine the form of the Winer-Hopf system (4) when the desirable signal is of the form $d[n] = s[n-D]$, $D \in \mathbb{Z}$, and the processes $\{s[n] | n \in \mathbb{N}\}$ and $\{w[n] | n \in \mathbb{N}\}$ are not corresponding.

The case D = 0 is known as the "filter", if $D > 0$ it is known as "prediction", "filter with prediction", or "extrapolation" and if $D < 0$, under the name "smoothing", "Filter with delay", or "interpolation".

For this we first need to observe that in the established conditions:

$$\gamma_{xd}[j] = \gamma_{ss}[D,j],\ \forall D, j \in \{0,1,..,l-1\}. \tag{10}$$

Indeed,

$$\begin{aligned} \gamma_{xd}[j] &= E\left(d[n]x[m-j]\right) = E\left(s[n-D]x[n-j]\right) = \\ &= E\left(s[n-D]s[n-j] + s[n-D]w[n-k]\right) = \\ &= E\left(s[n-D]s[n-j]\right) = y_{ss}[D,j], D, j \in \{0,1,...,l-1\} \end{aligned} \tag{11}$$

Taking into account relations (9) and (10) the Winer-Hopf system (5) is transformed into the system:

$$\sum h[k](y_{ss}[k,j] + y_{ww}[k,j]) = y_{ss}[D,j], 0 \le j \le l-1 \tag{12}$$

Note that it is possible to determine coefficients $h[j]$, $0 \le j \le l-1$, of a Winer filter, from the condition that the error estimates $\{e[n] | n \in \mathbb{N}\}$ and the input data $\{x[n] | n \in \mathbb{N}\}$ be orthogonal, i.e.from the condition of having satisfied the following relations

$$E\left(x[n-j]e[n]\right) = 0,\ 0 \le j \le l-1. \tag{13}$$

In truth, the Winer-Hopf system from which the coefficients of a Winer filter are determined is equivalent to the system $\dfrac{\partial E\left(e^2[j]\right)}{\partial h[j]} = 0,\ 0 \le j \le l-1,$ which will be shown to be equivalent to the system $E\left(x[n-j]e[n]\right) = 0,\ 0 \le j \le l-1$. To prove the last statement we use the relations:

$$\frac{\partial E\left(e^{2}\left[j\right]\right)}{\partial h\left[j\right]}=2E\left(\frac{\partial e\left[n\right]}{\partial h\left[j\right]}e\left[n\right]\right),\ 0\le j\le l-1. \tag{14}$$

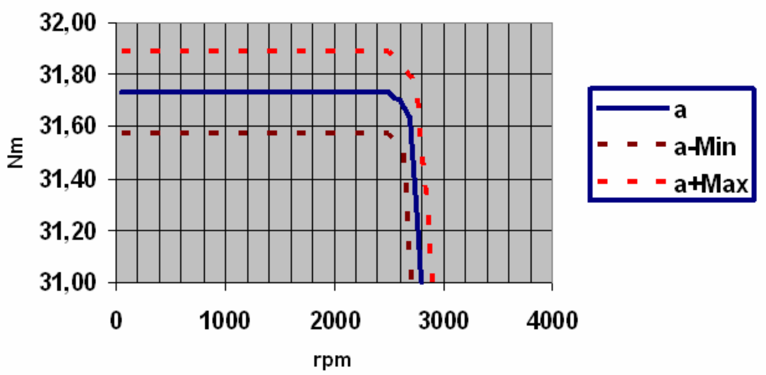
because: $e\left[n\right]=d\left[n\right]-y\left[n\right]=d\left[n\right]-\sum_{k=0}^{l-1}h\left[k\right]x\left[n-k\right]$, it is obvious that

$$\frac{\partial e\left[n\right]}{\partial h\left[j\right]}=-x\left[n-j\right],\ 0\le j\le 0. \tag{15}$$

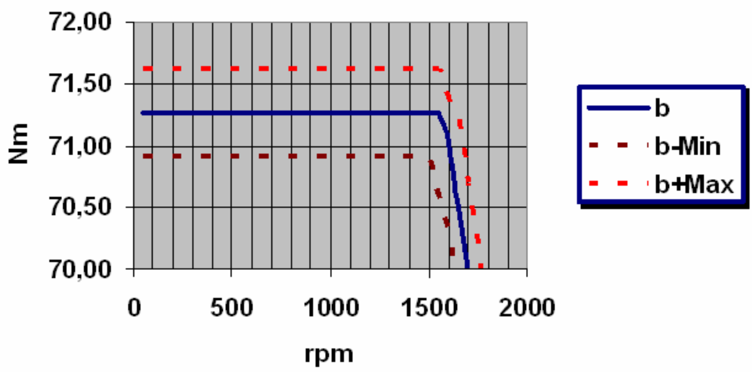
By replacing the derivatives (15) in $E\left(\frac{\partial e\left[n\right]}{\partial h\left[j\right]}e\left[n\right]\right)$, $0\le j\le l-1$, because of the relations (14) we obtain the desired result.

5. EXPERIMENTAL RESULTS AND CONCLUSIONS.

The resulting graphs of the actuators' characteristics are compared in figure 5 with the first being measured directly and the second obtained through correlation and mathematical prediction by Winer filters, using a reference actuator according to the proposed control method. Thus, it can be seen in both figures that the measurement error is less than 0.9%.



a)



b)

Fig. 5. Comparative torques' graphs related to the method's performances

Figure 5 presents the behaviour of the tested actuator measured directly, where the mechanical rated power 3,8 KW (a), 4,2 KW (b), current to continuous torque 9,8A (a), 15A (b) and rated speed 3000 rpm (a) respectively 1500 rpm (b). The experimentally measured range of the tested actuator is represented by a-Max, b-Max for maximal values and a-Min, b-Min for minimal values.

The performances achieved for the control system, that allow control of the actuators through the presented method, consist of the processing and monitoring with +/- 0.5 % accuracy computer graphic displays of the following parameters: apparent, active, reactive power, phase and line currents, phase and line tensions, distortions measurement, harmonics up to level 15, frequency, cosine, vibrations on 3 axles with graphic representation of the medium value of the vibrations and monitoring, temperatures in the engine's bearings and coiling, torque at the engine’s shaft.

This method is based on an innovative **EU** solution patented by the authors, winner of the gold medal at the Geneva World Convention 2008, and has been implemented both for industrial applications but also as a trial stand for students from universities with electric profile, namely for preparing their masters degree or other postgraduate studies.

The main advantage of this new method is that it allows real time control for determining the characteristics, the functional parameters and performances of the actuators, in continuous flux, without the input signals being generated by the tested actuator. This leads to a decrease in trial duration, an increase in the accuracy of measurements and the realisation of complex trial regimes.

Theoretic and experimental results have shown that the characterisation errors of the actuators tested through the proposed method, as opposed to the direct measurement method, are less than 0.9% while the testing duration is over 30 times shorter.

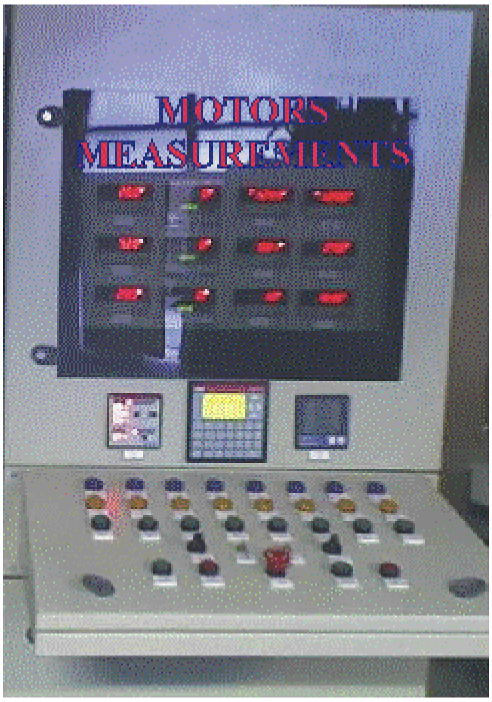


Fig. 6. The actuators control device in continuous flux

The device created based on the newly proposed control method is shown in Figure 6. Other theoretic studies and experimental trials are still being carried out in order to improve the characterisation error of the tested actuators, both through identifying some mathematical prediction models of high precision in determining the characteristics of the tested actuators as well as through the development of mathematical models using the fuzzy method.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to the Research and Educational Ministry (MEC) and Romanian Academy for its support of the program of work reported herein. The work took place as part of research project no. 263/2007-2010 in the framework of Grants of CNCSIS Program IDEAS, PN II (National Program for Scientific Research and Innovation Technologies). We also acknowledge the excellent collaboration with the Technical University of Cluj Napoca in the field of scientific and applicative research and to ABB Company for the excellent collaboration in the applicative technical field.

REFERENCES

1. ANTÓNIO ESPÍRITO SANTO, MARIA R. A. CALADO, et.all, *Position Control of Linear Switched Reluctance Actuator With a Digital Signal Processor,* WSEAS Transation on Power Systems, Issue 2, Volume **1**, February 2006, pg. 366-372, ISSN 1790-5060
2. VLADAREANU L., *Top technologies in Solid Mechanics*, cap.7, Advanced Engineering in Applied Mechanics, Published by Romanian Academy Printing House 2006, pp.29, pg. 397-434, ISBN-13 978-973-27-1370-9; ISBN-10 973-27-1370-4
3. SOLC FRANTISEK, MICHAL VASINA, *Modeling and Control of SMA Actuator, WSEAS Transaction on Circuits and Systems,* Issue 9, Volume **3**, November 2004, pg.1840-1845, ISSN 1109-2734
4. VLADAREANU L., *Real Time Control with PLC in the Solid Mechanics*, vol.1, Ed. Bendic 2005, Seria Universitaria, pp.232, ISBN 973-684-432-7
5. HOOMAN J., ONNO VAN ROOSMALEN **,** *Formal Design of Real-Time Systems in a Platform-Independent Way,* Volume **1**, no. 2 (June 1998), Published as Parallel and Distributed Computing Practices (ISSN 1097-2803
6. CHIEN S.I., J. LUO**,** *Optimization of Dynamic Ramp Metering Control with Simultaneous Perturbation Stochastic Approximation,* WSEAS Transaction on Control and Intelligent Systems, 2008 Issue 1, volume **36**/2008, pg. 1808-1820, ISSN**:** 1480-1752
7. VLADAREANU L., ION I., VELEA L.M., MUNTEANU M.S., MELINTE O., GAL A., *A New Method for Real Time Control of Actuators in Continuos Flux,* Proceedings of the 9th WSEAS International Conference on Automation and Information (ICAI `08), Bucharest, Romania, June 24-26, 2008, Published by WSEAS Press, pg.303-308, ISBN: 978-960-6766-77-0, ISSN: 1790-5117
8. BRATOSIN D., SIRETEANU T., *A nonlinear Kelvin-Voigt model for soils,* Proceedings of the Romanian Academy, Vol. **3,** No.3, 2002, pp.99-104, ISSN 1454-9069
9. CAPITANU L.,VLADAREANU L., ONISORU J.,IAROVICI A., *The Knee Prosthesis Simulator Control,* Proceedings of 19th International Conference on Tribology, Serbiatrib 2007, Kragujevac, Serbia, 2007, pp. 93 - 100..
10. YU HONGNIAN, LIU Y., YANG T.C., *Closed-loop Tracking Control of a Pendulum-driven Cartpole Underactuated System,* Proceedings of the Institution of Mechanical Engineers, Part I, Journal of Systems and Control Engineering, 2008.
11. SIRETEANU T., MITU A.M., GHITA GHE., SERBAN V., *Modification of the building dynamic response due to structural damaging during strong earthquakes,* Proceedings of the Romanian Academy, Series A, Volume **7,** Number 2, 2006, pp.143-151.
12. YUAN XIAOFANG, YAONAN WANG, LIANGHONG WU, *Adaptive Inverse Control of Excitation System with Actuator Uncertainty,* WSEAS Transation on Systems and Control, Issue 8, Volume **2**, August 2007, pg.411-418, ISSN 1991-8763.

Received August 29, 2009