BULETINUL Universităţii Petrol – Gaze din Ploieşti	Vol. LVIII No. 2 bis / 2006	127-136	Seria Tehnică

Smart Solutions for Bridge Crane Remote Control

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Introduction

The current elevator installation of drive systems are made with asynchronous motor with winding rotor or asynchronous motor with two levels of speed and controlled from command cabin, from height. The specific literature offers many solutions regarding the driver with variable speed and remote command.

The local providers – Mechanical Manufactories from Timisoara, didn't integrate the systems with variable speed and neither the wireless command from distance.

Other distributors from Romania (PRODMORECO Timisoara – with Finnish funds, ACMES Bucharest – distributor of YALE products – see Attachment A3) offer remote control classic solutions, but unintelligent.

The "elevator installation" system, although is used and analysed (from many years) in classic engineering mode, like a simple and well-known electro mechanic structure, is analysed now from a new point of view, correlating to:

- performance coefficients associated to a optimal kinematical solution (limited shock)[3], [4];
- dynamical behaviour enforced by macroscopic conditions (balancing charge) and by the control of parameters/status variables through the specific modulating loops;
- control and robustness while you can made a mathematic model with fuzzy elements;
- the inclusion of neuronal-fuzzy parameters, accessible for operator to increase safety in work;
- a superior user-friendly work using remote control;
- voice command for movement and introduction of an additional function for form's recognition in order to avoid the obstacles and accidents.

This paper was approached in many else stages of theoretical research (comparative studies of solutions, analytic solutions, models, simulations) and experimentally.

Radio remote control

A new solution of rolling bridges represent wireless command, and as part as this solution emphasizes the radio command.

For the radio command realization of rolling bridges are necessary the radio remote control and a receiver of the remote control.

The remote control frequency of work (transmitter of the remote control) has to respects the laws, and can be choose (for the command of industrial equipments) from the range of ultrahigh frequencies. The maxim ray of act of radio remote control depends on several factors, among which the power of the transmitter remote control and usually is 100 m. The remote control can deliver a single signal, with his amplitude or duration modulation, or more signals depending on the solution chooses. The number of commands provided by remote control has to be at least the same with those from remote controls with thread.

The remote control receiver is assembled in open field and it's synchronized to work in the same range of frequency with the transmitter.

The voice remote control

Among the most dynamics and active companies, from the realization area of integrated circuits, able to memorize and recognize the human voice, must be noted Sensory Californian company (sensoryinc.com) who has a series of products based on a new technique, named " neurone recognition net", likewise with logic of recognition and search used by the human brain. This technique assure an remarkable decrease of the physic support ensure a 99% precision, toward the maximum 96% how much offers the most DSP complex ensembles. Exploiting this technique, Sensory presented and commercialized two integrates specifics to this application, named RSC-164 and RSC-264. Both can to operate in combination with PC or can be programme to work individual.

Each of these devices has implemented a logic unit on 8 bits at 4 MIPS (based on a nucleus Intel 8051) (fig.1)[5], [6], an analogue- numerical converter and a numerical- analogue converter and the proper filters, 64 Kbytes of ROM memory, 384 bytes of RAM memory, a bus used for the interconnection with an extern memory and a series of outputs for different users. All these are founded inside of a capsule PLCC with 68 pin or of a capsule QFP with 64 pin.

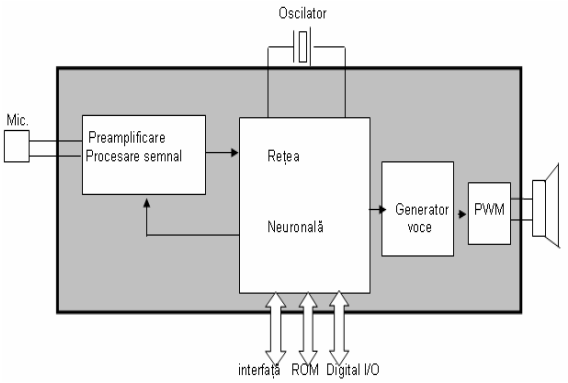


Fig. 1. The block scheme of the voice command module.

These circuits offer many functions on pin and is very difficult their use in an application. Fortunately, from some mouths the company Sensory commercialise a product named "The voice command module", which contains such circuits, a circuit of memory and another components which notably simplify his use.

As part of the application made by us, for the control by voice command of the drive systems, were researched and implemented the possibility of recognize module utilization, named <Direct Voice 364>, produced by SENSORY. Was proposed and utilized this product because is easy to incorporate it in an elevator installation system.

The vocal command module executes the recognition of a word or phrase by comparing real-time generated models with a teach word. The generated model by the voice module is based on

a digital reconstruction of a vocal command. Each word that is wanted to be recognizing by the voice module has to be teaching first of all by it.

This module allows his teaching with words or phrases, grouped in 1-3 sets of commands and recognizes expressions and words with an accuracy of 99%. More, the module has a very low answer time and a very good immunity at noise.

Forwards will be analyzed "The Voice Module" M1 from Sensory (fig.2). This device (totally made with SMD technology) presents a very compact form and it's used at interconnection with external components, three connectors with step of 2, 54 mm between the pins JP1, JP2 and JP3 (fig.3).

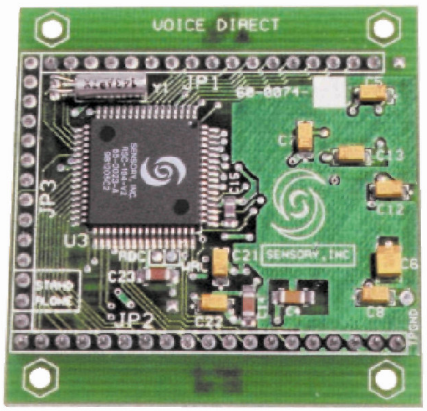


Fig. 2. The voice recognition module, Sensory.

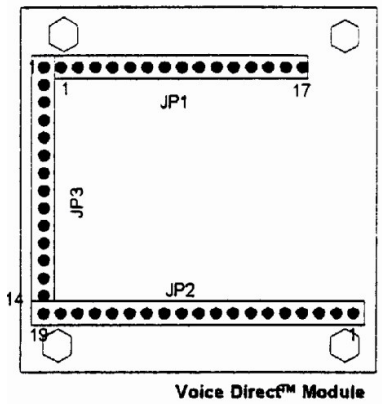


Fig. 3. The connectors disposure and the pins numeration.

With the exception of 17 JP1 pin, connecters JP1 and JP3 aren't external connected. The automation system projected, exclusively use the JP2connector. This module must be supplied with 5 volts continuous voltage applied through the 4 (plus), 3 and 5(minus) pins. The 6 and 7 pins of the internal PWM have to be connected at mass by two resistances. At the first pin must be applied the signal from microphone while to the 8th pin is available the output signal for loudspeaker. The output information bus is connected to the 12-19 pins. Every line has different values, meaning that the first line (the 12th pin) has the value "1", the second (the 13th pin) has the value "2" and so on until the eight line (the 19th pin) who has the value "8". If the memory of the circuit is integrally used with all the 60 available expressions, when it's recognized, for instance, the third word memorized, the third output line (the 14th pin) enters for a short moment a high level logical, and, for instance, the seventh output line (the 18th pin) when the seventh word memorized is recognized. If still the circuit recognizes the word, which, for instance, occupies the eleventh place in memory, what output line will be activated in this case? The answered is intuitive: The line 8th (the 19th pin) together with line 3rd (the 14th pin) because 8+3=11.

The 10th and 11th are used for another functions. The 11th line checks the training section: pressing the P3 button begins the introduction phase for words or sentences. Whole process is drive by the vocal synthesis system created with the Sensory chip. In order to interrupt the teach phase is necessary a short push-button of P3. A long push (at least one second) cancels all the information contained in the EEPROM memory and training cycle must be reassumed. In order to begin the vocal recognition is necessary to push-button P1 and to follow the vocal commands. But, in order to do a "hands-free" command, for a normal operation, we provide a registration circuit that appeals the Tl and T2 transistors and the logical net from U2gates (fig.4).

The audio signal generated from microphone, is amplified with the transistor Tl and transmitted to the input of voice recognition module M1 (the 1st pin); the same signal is, also, transformed through the diode D1 in a digital impulse, that through the gate U2a, activated the mono stable U2c. At this stage is verified the transistor T2 status mounted in parallel with the button P1. The

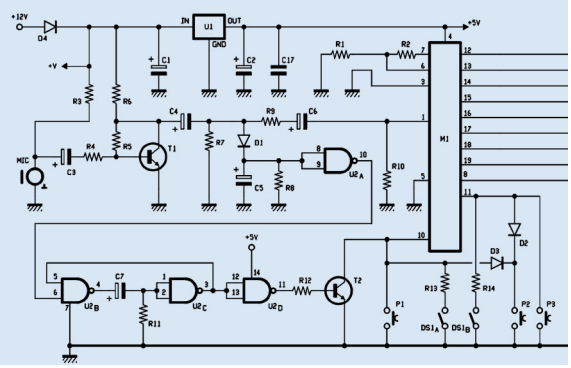


Fig. 4. The electronic scheme of input circuit in the module of vocal recognition.

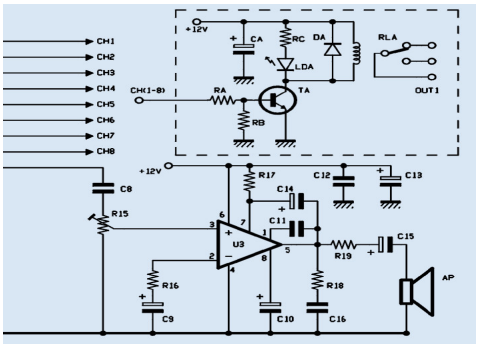


Fig. 5. The electronic scheme of output circuit from the module of vocal

lower sensibility of the microphone can keep the ambient noises of low frequency, during the phase of recognition, the parasite noises that can be overlapped over the words or expressions pronounced by user during the process of recognition. In practice, for the device activation has to speak at 10-20 centimeters far from microphone and this distance must, also, maintained during the process of recognition. The audio signal generate by the voice recognition module (this contains almost 500 memorized expressions) is available at the 8th pin; this signal is sent to the integrator U3 for amplification. The used chip for this study is the audio amplifier TBA820M able to provide a power of 1 watt at a task of 8 W (fig.5).

The RC group connected to the pins of the circuit has the role of "band filter" for the filtration of the signal transmitted to loudspeaker. The amplified signal, from the 5th pin, is gone at a loudspeaker with resistance of 8 W connected between output and mass. The volume can be regulated by potentiometer R15 witch has the cursor is connected to the input (the 3rd pin) of audio amplifier TBA820M. The eight lines of output (the 12-19th pins) each command a relay and the relay status are displayed by a pin of the luminescent diodes. When the line is active is generated the saturation of proper relay command realy. The transistor activation is generated the instantaneous activation of the luminescent diode and is accomplished the relay command. The contacts relay can be used in the command scheme of every electronic device, as of example at the control of a safety lock gate. Imagine how interesting can be such a system how open the enter door, just pronouncing "Open the door!". And also, the fact that anybody somebody else how tried to opens, with same systems, same door, will realized that the words isn't recognized! For the supply of the circuit is necessary 12 volts continuous voltage; the alimentation can be able to provide a current of at least 200-300 Ma. This voltage is provided directly to the supply circuit of relays. The same voltage is used for obtain, with help of the specialized circuit U1, the 5V stabilized voltage, necessary for supplying the module of vocal recognition manufactured by Sensory.

Driver remote control

One of the latest realizations of the Aurel company, represent a module XTR destined transmitting of dates, characterized by big speed of transfer and a big band of crossing by. The area of utilization can be expanded to the possibility of transmitted audio signal, through width modulation (PWM) of a rectangular signal.

TR-434 is presented in a metallic capsule, parallelepiped form, with the sizes of 8 x 23 x 33mm, and the connect pins are disposed on two rows, the step among these being 2,54 mm.

For a maximally explore of this possibilities of this module, is necessary the knowledge of the mode of operation, as well as the conditions to obtain optimum results.

Here are several important rules that should be respected:

- the input (5V) is made from a good stabilise and filtrate source;
- the alimentation circuit + 5V will be so short as we can and will make the direct connection between the output of the source and the module, without the existed ramifications at another floors. For these will be the separate routes;
- between the 17(+ 5V)pin and the 10(GND)pin is fit up a condenser of 100nF who filter the possible interferences of the radiofrequency section;
- the distance among the module and the other components shall be of minimum 5mm. First of all it's about microprocessors and microcontrollers, when the generator of tact isn't shield. The same caution will be taking for the pill where is connected antenna.

For XTR-434, the amplitude of digital signal applied to entrance controls the frequency modulation. Practise, the logical level 1 causes an aberrance of the frequency between pre-established limits, while the logical level 0 is interpreted as the absence of modulation.

The demodulator FM of reception section, or further, the floor of impulses reform, have to function with rectangular signals who has the fill factors between 30% and 70% and the period of time of 2ms.

The optimum fill factor is about 50 % , when we want to use the module for transfer of signals PWM, this thing isn't possible.

Transmitter scheme

In the diagram circuit of the transmitter (fig.6), the hybrid module work in regime of transmitter, while is activated just the emission section, and the reception is deactivated. These conditions are obtained by applying the logical level 1 to the 16 pin and logical level 0 to the 15pin (U3).

The input command of the transmitter (the 14th pin) is controlling by modulated impulses sequence, applied by the resistor R7 and Zener diode DZr.

The impulses are obtained from an oscillator with NE555. This works in the non-stable regime, with the frequency of 50kHz.

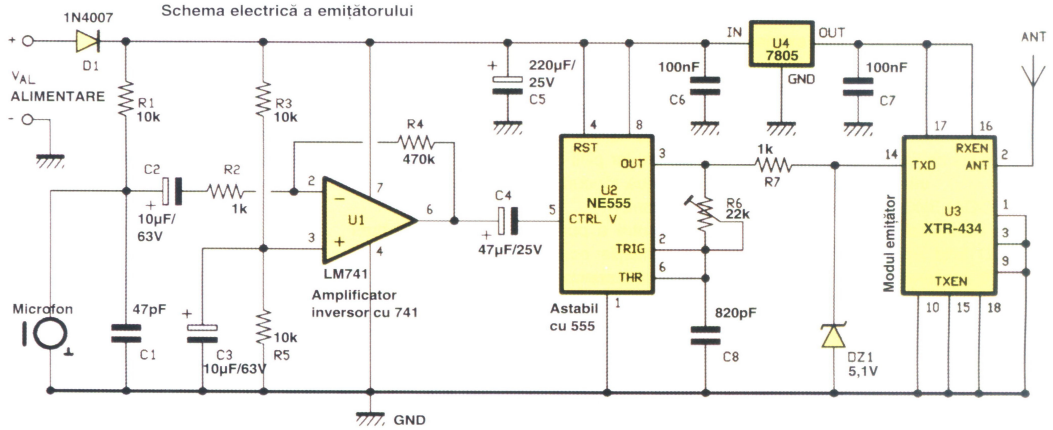


Fig. 6. The transmitter electrical scheme.

From the semi adjustable tuning R6, at the 3rd pin, is obtained a rectangular oscillation with frequency of 50kHz. This tuning is done with the signal input connected at mass, so there is no modulation of signal.

Non-stable with NE555 works the in these conditions:

- if the output is " high"(V+), the condenser connected between the 2, 6 and mass pins, C8 has to loaded;
- if the output (3 pin) is " down"(OV), the condenser discharged.

When is used the 7th pin, is necessary a supplementary resistor assembling between" +" and R6, for the condenser's C8 loading. Without an additional resistance, the loaded isn't possible cause the internal transistor npn is locked.

In the first case we obtain a signal with a loading factor of 50%, and in the second case, this value is relative.

The modulation is made through the signal captured by microphone, which offers to the system the possibility of reproducing the sonorous signals from the environment. The activation is automatic.

Working with the ratio modulation (PWM), in order to obtained a discreet and without distortions reception, the selection of a carrier frequency of 50kHz isn't accidental.

On the receiver module (fig.7) will be installed the recognition voice module:

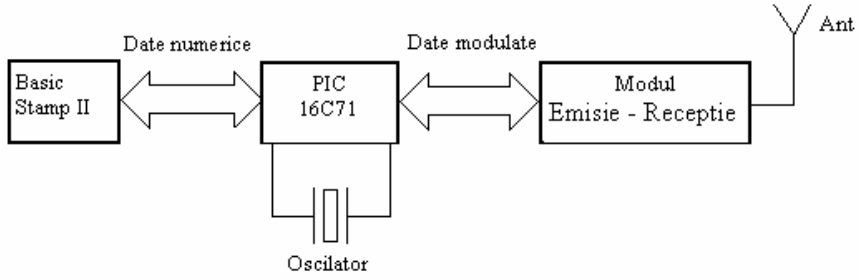


Fig. 7. The block scheme of receive-transmission module used.

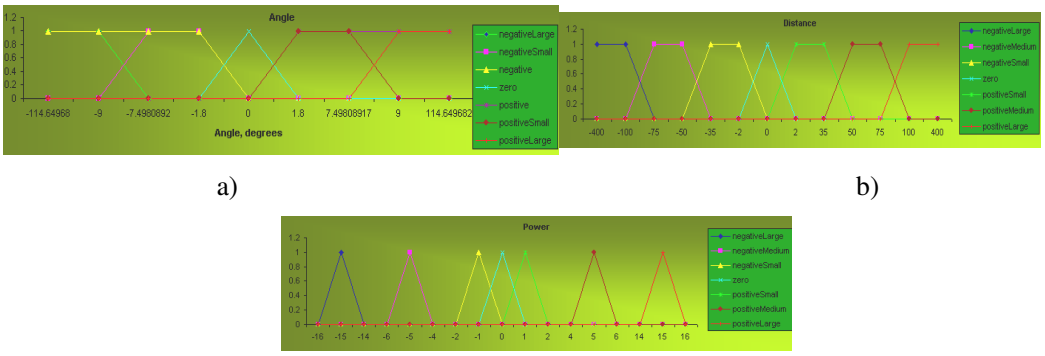
After the instruction of module, will be passed in the listen mode CL and will provide the specific commands depending of <the voice commands received>. These shall be grope in two categories:

- basic commands: forward, back, high down, left, right;
- derived commands from logic fuzzy: slowly, normal, speedster (ex. slowly high; fast low etc.). For each word pronounced, will be activated the transmission procedure, and each word be encoded with a value. The movement procedures are implemented in the reception algorithm; the movements are accomplished just when one of the mentioned commands is received and has one from the values of codification accordingly.

Solutions regarding the bridge crane optimization

The study of a fuzzy regulator model (FLC)

For the control of speed and position, will implement in a natural way the restriction of limited shock using tables of rules 'if… and … then ' type (fig. 8).



a) b)

c)

Fig. 8. Fuzzy diagram for position of an bridge crane:a) angle; b) distance; c) power.

The elements witch justifies the use of fuzzy control technique, are:

- an incomplete or ambiguous knowledge of some elements or parameters from systems;
- a robust behavior relative to the variation of the structure/parameters of system (starting with load that has to be transported and finishing with the electromotor parameters) and regarding base of knowledge available;
- possibility of directly transliteration of operator knowledge into FLC rules table.

The use of the standard regulate techniques (PID) isn't efficiency since the non-linearity of the system. It's used an adaptive tuning with standard model, but this model is very complex (5^{th} grade) but don't include perturbations such as wind, variable adherence etc.

A fuzzy control of a system emulate with a formalism based on a linguistic variables, which accomplish a human qualified.

By his anticipative nature, FLC, is able to detect and to limit the variation (or a gradient) of some parameters. In the digital structures is comfortable the procurement and the stockage of some parameters variation. In this application hold up:

Δx – position error;

$v = (\Delta x) / T$ – speed; T- period of sampling from the digital tuning algorithm;

$a = (\Delta v) / T$ – acceleration;

$s = (\Delta a) / T$ – shock.

An example of fuzzy rules used for a bridge crane control have been shown in figure 8, the scheme of the elevator installation it's presented in the next figure (fig.9).

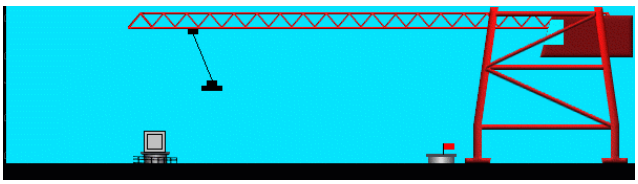


Fig. 9. The scheme of an elevator installation.

As a first approach of a fuzzy control is the running of fuzzy process stages - logical inference – non-fuzzy for inputs (distance, angle of balancing) and output (motor torque).

Examples of fuzzy 'quantification' for these variables:

- zero, near, environment, far, very far (for distance);

- negative big, negative little, positive little, positive big, zero (for the angle cable with the vertical).
- negative big, negative little, positive little, positive big, zero(for motor torque).

Will be done the FLC synthesis with the Mamdani and Larsen methods, trying different methods of process of non fuzzy work (COG, COM, MOM).

For the solution of this stages is called up at these programs: Matlab Fuzzy Toolbox (Mathworks), Fuzzytech (Inform Software) etc., as much as they are proper at the background of theme and can be brought with finance from the research contract.

The neuronal network use

The neuronal network use for:

- integration of the intelligent system concept, with capacity of learn;
- derivation of some rules tables or their accordance with neuronal adaptive nets help (method and the program ANFIS) based on scream inferences Sugeno and method error invert propagation;
- analysis of an adaptive tuning configurations with neuronal-fuzzy components.

The essential elements of an neuronal-fuzzy implementations for a bridge crane command are reproduce below.

This study wants a new approach through the study of a genetic algorithm for the neuronal nets. The methods based on the invert error propagation and the method of least squares can drive us (just for their derivable character) at the lockout of local extreme nonlinear functions. Genetics algorithms (AG), based on the principle ' the best survive' from the evolution of people theory, hasn't this disadvantage. An application can be the determination of fuzzy functions. AG use different possible solutions, selections, concepts like reproduce, crossing, mutation, generation, gene, chromosomes – from biology.

The adjusting structure fuzzy uses 2 FLC:

- for movement;
- for the balancing load control.

The parameters of these two circuit controllers are choose through GA, so the placement is done precisely, with minimum of time and minimum oscillations until the end.

A mathematical model (simplified), derived from a Lagrange equation, is nonlinear:

$$\begin{aligned} &(m_1 + m_2)\cdot x'' + m_2 L\theta''\cos\theta - m_2 L\theta'^2 \sin\theta = F \\ &m_2 L^2\theta'' + m_2 L x''\cos\theta + m_2 gL\sin\theta = 0 \end{aligned} \tag{1}$$

where: m_1 - the truck mass; m_2 – the mass charge; L - length cable; θ - the cable position with vertical; x - the truck position; F – traction steam for truck translation.

The characteristic variables are: x, x', θ, θ'. If is considered an unique FLC, will be necessary 3^4 rules (at minimum fuzzy sets: 3) and their charterage should be very difficult. With these two FLC from the next tuning structure, this disadvantage disappears.

x_f and θ_f are the position (geometrical drawing) and respective the angle of final suspension. The inputs in the fuzzy regulators are:

$\varepsilon_x = x_f - x$ its truck linear error position; $\Delta\varepsilon_x$ its variation; $\varepsilon_\theta = \theta_f - \theta$ its cable error position; $\Delta\varepsilon_\theta$ its variation.

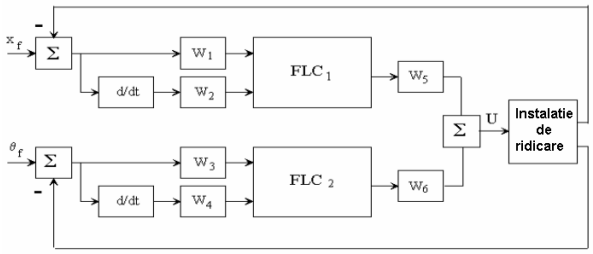


Fig. 10. Tuning structure with two FLC.

$W_1 \ldots W_6$ regulators parameters. Because FLC have some rules (9), their change can have dramatic effects about behaviour of the loops. Shall grouped in a chromosome with 6 genes: W= [W1,…, W6]. Shall formulate a criterion function of performance (which contain relatives indicator to accelerations, angles of deviation and speed), with forms for the start-up of the installation and its stop.

AG will go through the stages: selection, crossing and mutation.

The analysis of automat tuning loop robustness

The physical systems modulation concerning the projection of tuning systems involves always a compromise between the simplicity of the model and the accuracy with which this reflect the behaviour of real system. It's the same if the nominal model is obtained through theoretical or identification methods, usually needs to purposely ignore the complicated parts of a system, to obtain a model that befits the mathematical further processes. The differences between the real installation and the nominal model are noted errors of model or the uncertainty of the system.

The robust tuning problematic: it's given a nominal installation and the limits of its improbability norm) should be induce a fixed compensative which drives us to a closed circuit system with satisfactory performances for all the installations and perturbation signals admissible.

Taking count of the model uncertainties as well as of parametric one (for instance the charge transported from the elevator installation) shall analyse the stability/ robustness performance of tuning systems searched.

Conclusions

Contributions at the scientific knowledge development

These results from:

- Conception, the projection and the realization of a voice command wireless system, able to recognize obstacles and to take intelligent decisions using circuits, schemes and general-purpose or stiff structures. Regarding the first variant, the command is of binary type, following to study the possibility application neuronal-fuzzy command.
- Configuration of systems with electrical driver adjustable and performance with asynchronous motors and static converters of voltage and frequency for main elevator installation sub assemblers. Shall use theoretical researches results (the models, simulations) and previous experimental, the solutions concerning an own equipment utilization with inverter PWM.

The obvious advantages are: material saving, reduces the expenses of keeps, elimination of die times and increase of manoeuvrability in operating varied spaces**.**

Appear complex incidents regarding: electromagnetic compatibility, compatibility with equipments and wireless processes, vocal command and obstacles recognition, a distant assurance enforced for the remote control, security elements.

Contributions at the economic development:

- The electro mechanic equipment realization for vocal command at distance of elevator installations and the technological transfer regarding the extension of the solution;
- Increase of the degree of security and productivity activities of the elevator installation through the transfer of the attributions of classic operator to another member of the team and produce of supplementary function of recognize the obstacles.

Original aspects:

- The conferment of the circuit controller (through the modification depending on appurtenance and the fuzzy rules) utilizing specific methods, specially of BP type (back propagation) to decrease the implementation lass the classic circuit controllers and the fuzzy circuit controllers;
- An new approach by a study of genetic algorithms for the neuronal nets;
- The module of the remote control recognizes the vocal commands and memorizes the command used in a work process for the reconstitution of the history run of the installation.

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