OPTIC SENSOR FOR THE JOINT OF A WALKING ROBOT

Todor Stoyanov Djamiykov, Mladen Stoilov Milushev, Marin Berov Marinov

Department of electronics, TU-Sofia, Kl. Ohridsky blv. 8, 1756 - Sofia, Bulgaria, (+3592)9652142, e-mail: tsd@tu-sofia.bg

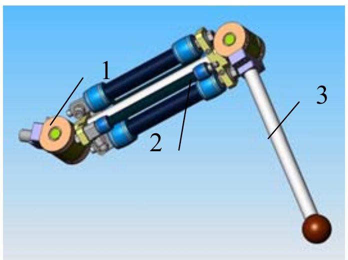
This paper illustrates the process of study and choice regarding a sensor for motioning of walking robots. Typical for all walking machines is the need of a effective force-to-weight ratio. Based on preset parameters a sensor prototype for a six-legged mobile robot joint had been chosen. To meet the requirements all possibilities for reaching the goal by using optrons with air entrance, integral illumination-frequency commuter and photodiode lineal had been investigated. Explicated are the characteristics and the basic conceivable parameters of diverse variants.

Keywords: walking robot, fluidic muscles, modular control, mechatronic

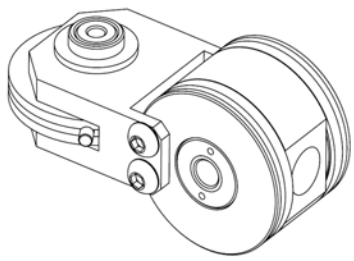
1. INTRODUCTION

Presently, the implementation of fluidic muscles guarantees elasticity similar to that found in nature and force matching the one of electrical drives. Further it allows the accomplishment of a configuration featuring geometry and proportions matching the biological pattern and aimed at reaching a maximal reproduction. This concept had been used to create a mobile walking robot's prototype motioned by fluidic muscles.

Fluidic muscles generate one-direction-forces. Hence, the prototype of one motioned segment had been developed under application of two antagonistic muscles where the force of the contracting muscle always counteracts the extending one. Since one muscle contracts and turns the joint the other muscle extents thus determining the required position of the segment. Following this principle a three-segment-leg's prototype (Fig. 1-A) had been developed. Fig. 1-B features the joint design for segments 1 and 2.



A



B

Fig. 1 Mechanical leg and robot's joint.

The robot's control architecture is hierarchical. It comprises three levels: joint/segment, leg/module and body. Each level features intelligent units for interpretation of sensorial information and provides services to the upper level. The smallest functional unit is a joint/segment. The essence of controlling this functional unit lies in the actuator's pressure and force control. Since the airflow (fluid) entering and leaving the muscle is the only altering control-loop- variable, the valve has three positions: intake-close-exhale.

The task of controlling a joint relates to the pressure and force control in the contracting-extending muscles, e. g. control of the joint's rotation angle. The joints control block (Fig. 3) uses internal sensor information, i. e. information about reflex development, via the external annulling input.

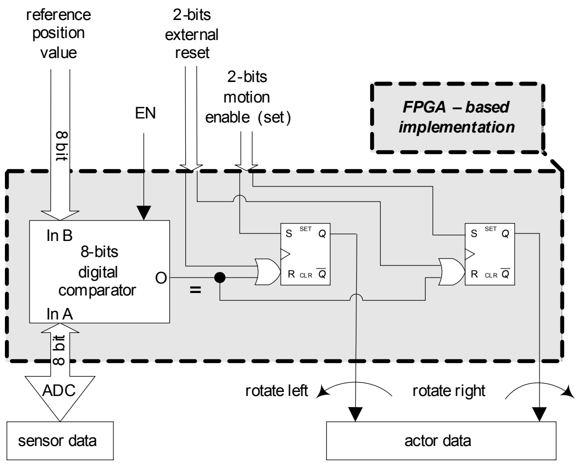


Fig. 2 Block diagram of the implemented joint's control

Accounting for the chosen mechanical construction of the joint, optoelectronic sensors must satisfy the following technical parameters:

А – *Measurement scope* +/- 20°; ***Б*** – *Measurement accuracy* – 1° within a range of 45°; ***В*** – *Sensitivity*, minimum – 1°, assumed diameter 50mm and 19 mm for 45º - 0,5 mm per grade; ***Г* -** *Velocity* -70ms; ***Д*** – *Output signal* – impulses/code; ***Е*** – *Electrical power* – 5 V; ***Ж*** – *Sizes* maximum 15x15x15 mm; ***З*** – *Initial positioning*, capacity for determination of the joint's position at the time of the systems opening start.

The so far described prerequisites provide for the possible technical solutions to be analyzed.

2. DECISION WITH PHOTOINTERUPTER

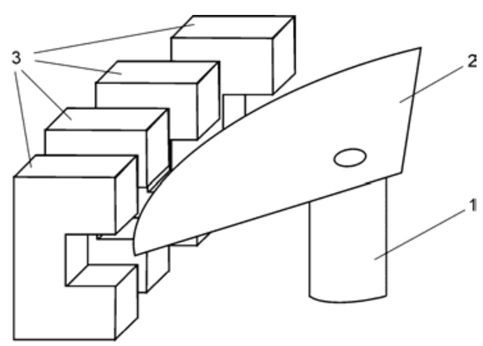


Fig. 4. Scheme of decision with photointerupter

The first possible decision for measuring the angle of turning round could be the using of optron with the air entrance. Similar optrons together with moving wheel with openings are used in the computers' mousse. Such optron is photointerrupter **ROHM's RPI1133**. On the fig.4 is shown the exemplary position of the optrons – between them is moving a non-transparent blind, which is firmly fixed on the shaft for receiving information for the angle of articulation's turning.

For achieving a accuracy of the measuring of 1° in the range of the measuring is necessary to be situated more than 40 single optrons on the non-transparent blind's periphery. In the presence of models, those have sizes of 3 mm in the width that gives 120mm total length of the sensor with all optrons. This size is unallowable big and it's impossible to be situated in the mechanic-constructive decision of the articulation. The electrical supply should be realized for many LED and photodiodes. This is attended of lots of conductors and bigger consumption.

Using of similar sensor's construction can be efficient (a little number of single optrons, terminals, simple supply and treatment), if is used for indication of reaching the end position by turning the articulation. End left and right positions are indicated.

3. DECISION WITH OPTOELECTRONIC TRANSDUCER ILLUMINATION-FREQUENCY

More functional decision of the angle sensor can be realized if it's used optoelectronic transducer illumination-frequency – TSL253 photo electricity with frequency, fig 4.the sensor is with 3 terminals and sizes 5x5x3 mm.

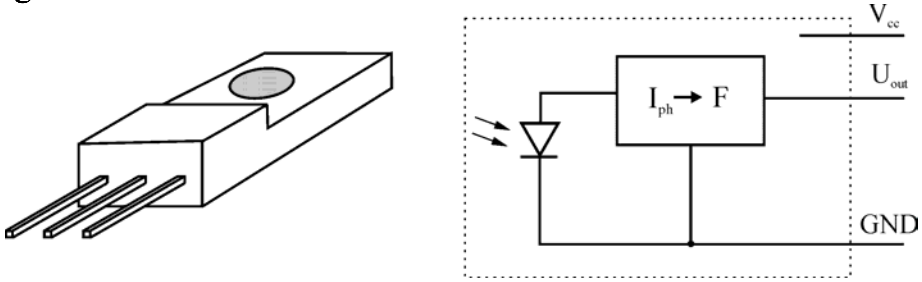


Fig. 5. Optoelectronic sensor TSL253

For measuring the angle of shaft's turning round with optosensor is necessary to be realized optical connection with modification of the coefficient of letting trough of the medium, trough which pass the energy fluxes .The possible decision would look like it's shown on fig.6 .

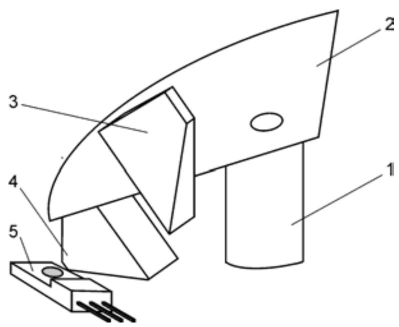


Fig. 6 Scheme of the sensor with optoelectronic transducer illumination-frequency

On the shaft 1 is fixed firmly the non-transparent blind 2, that is turning round together with it. The blind is moving in the space between emitter 3 and receiving diaphragm 4. By moving the blind it shades part of the flux, which falls on the receiving diaphragm. This way in the receiving side the photo receiver indicates modification of the falling on him energy flux depending on angle position of the non-transparent blind 2. For emitting characteristic could be saved: $F_{out} = E.(a.b).R$ position, where: F_{out} – the beginning frequency, E – illumination in the plane of the receiving diaphragm, R - sensibility of the integral sensor $\frac{Hz}{W}$, a and b are geometrical sizes of the diaphragm in front of the integral sensor defining the sizes of the received energy flux.

Shading of a part of the receiving diaphragm from the blind by its moving could be mathematically defined: $\left| \begin{array}{l} a=const. \\ b=b_{max}-x \end{array} \right.$

Where: x –is the linear size with which is decreased the diaphragm because of the shading. The surface of the receiving diaphragm is right proportional the angle of shaft's turning. $S_d=a.(b_{max}-x)$

The diaphragm's surface would have maximal value if x=0. This happens when the angle displace is maximal. The blind is out of the spreading area of the energy flux. There would be minimal value of the diaphragm's surface if the blind shades totally the emitter. She is turned in such position that she is entirely between the emitter and the receiver. If we suppose that the other elements in the formula for the pre-characteristic are constant in the time the end dependence pre-characteristic is $F_{out}=Const.(b_{max}-x)$, where : $0 \le x \ge b_{max}$ for turning angle of x in the range +/- 20°. Graphically the pre-characteristic is shown on the fig. 7-A.

The last characteristic could be easily transformed in relation to angle's displace of the shaft, by the space between the receiving diaphragm and the shaft's axis: $x = r.\alpha$, the range of the angle's displace is +/- 20° and the point of reference for the sizing of the sensor construction. As bigger the distance between the receiving diaphragm and the shaft's axis is, the longer the sensitive surface of the receiving part should be. Graphically the pre-characteristic is shown on the fig.7-B.

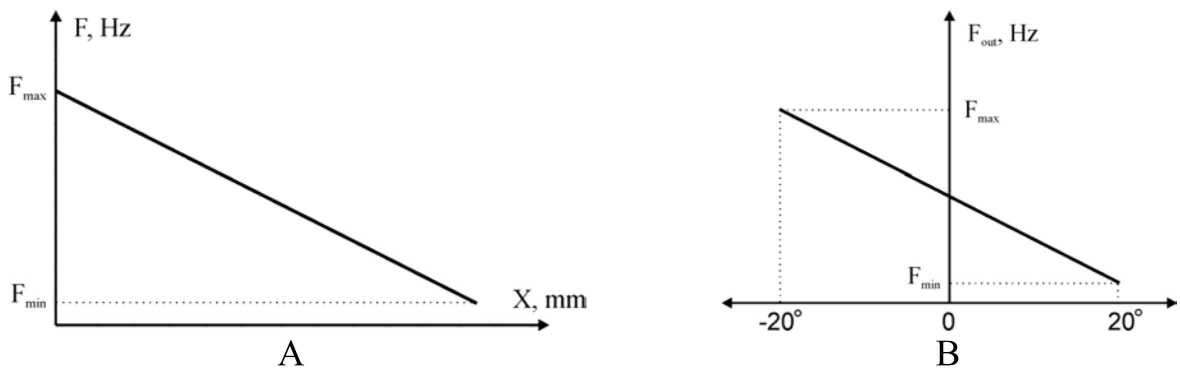


Fig. 7 Transfer function of the sensor

A special feature the pre-characteristics is that, that by null value the turning angle α, the frequency, that is generated in the sensor's terminal is in the middle of the range, between F_{max} and F_{min}.. By mechanically fixing of the non-transparent blind this value of the frequency can be tuned on the suitable value. On the other hand the characteristic's slope could change by moderation the emitting flux of the lightening diaphragm.

4. DECISION WITH INTEGRAL LINEAR SENSOR

Other possible decision is using integral linear sensor type TSL1401 this sensor is linear situated photodiodes with sizes 70x70mm built in electron scheme for control their work. The sensor has 128 photodiodes moving CCD register analog output step and control logic. The one gives the tact of information's extraction by the photodiodes, and the second the time for accumulation of charge of the photodiodes. On the output of the line constantly in the time coming out impulses for each photodiode with amplitude corresponding with the lighted in the moment.

For the realization the sensor for turning round based on TSL1401 should be used functional scheme fig.6 as the receiving diaphragm is replaced by the linear sensor TSL1401. Extra requirement to the mechanical situating is the distance between the photosensitive surface and non-transparent blind to be minimal. This is because of the fact, that the end of the blind shades the flux on the line photodiodes and if the created shade is not with sharp borders, the transition from dark to light pixels could be in several elements. This effect is undesirable, because the error by measuring the situation the shade would be increased.

On the fig.8 is shown the exemplary output signal from the sensor in case of lightened of the half of the pixels.

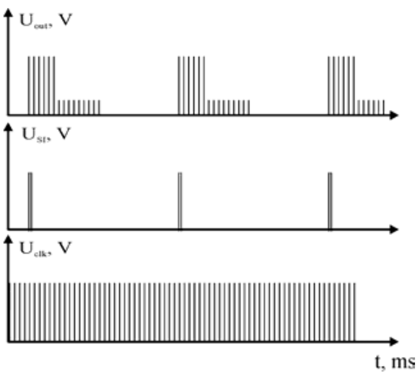


Fig. 8 Output signal of the sensor TSL1401

The achieved signal is suitable to be treated by the robot's control module, because the momentary angle situation corresponds with the number of lighted pixels. By the counting of this number of pixels could be made conclusions about the moment situation of the articulation. On the other hand, the great number of sensitive elements allows reaching higher accuracy and sensibility than the necessary three pixels by modulation of 1°.

5. CONCLUSION

Resulting from the considered prerequisites and parameter analyses of diverse variants and regarding a future concrete fulfillment and field-testing solutions making use of the integral illumination-frequency commuter along with the linear optosensor TSL1401 are highly recommendable.

ACKNOWLEDGEMENT

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6. REFERENCES

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