International Journal of Bioelectronics 2016

ISSN 2448-7732

Simulation of a positioning system for temperature sensors used in the study of specific absorption rate.

Guerrero López Geshel David, Aguilar Salas Jesús, Cepeda Rubio Mario Francisco Jesús, Lares Francisco Javier.

Instituto Tecnológico de la Laguna, Blvd. Revolución y Clzda Cuauhtémoc S/N, col. Centro, CP 27000, Torreón, Coahuila.

Summary

In the present work the design and simulation of a positioning system for optical fiber temperature sensors used in the study of specific absorption rate (SAR) is described. This system is used in an experimental laboratory SAR measurement to characterize the temperature distribution in a biological tissue substitute (called phantom), when subjected to electromagnetic radiation.
The sensors will be placed inside the phantom by means of an automated precision positioning and which in turn is controlled from a computer. A computer carry out logging and graphing of temperature spectrum obtained by optical fiber sensors. The measurements were made with an accuracy of 0.5 ° C in a range of -100 to 330 ° C. The positioning system has a capacity of 2 kg. While the visualization software interface presents a user friendly 3D. According to simulations made so far with the measurement system the results have been satisfactory.

Keywords*: Positioning system, Specific Absorption Rate (SAR), temperature measurement, 3D interface*.

1. Introduction

Currently mobile phones, are an integral part of modern telecommunications system. In many countries it used by more than 50% of the population, and the market is growing rapidly. At the end of 2009 there were about 6900 million mobile phone contracts worldwide. In some places, these devices are the most reliable or the only ones available.

Given the large number of mobile phone users, it is important to investigate, understand and monitor the potential impact on public health.

The phones communicate with each other by emitting radio waves through a network of fixed antennas called "base stations". Radio frequency waves are electromagnetic fields but, unlike ionizing radiation such as gamma or X rays, cannot cleave chemical bonds nor cause ionization in the human body [1].

To manage the irradiation parameters is necessary to know the temperature at which the irradiated tissue rises, it is essential to have a highly reliable temperature measurement system.

The temperature measurement is carried out with thermometry systems that can be invasive or non-invasive. Using conventional sensors (RTDs, thermistors, thermocouples, etc.) is not satisfactory in some applications. This because the currents and voltages induced electromagnetic interference, and since there are metallic elements, a self-induction heating occurs. Both factors produce erroneous readings as a result of using these sensors [2].

The comparison between two measurement methods such as: thermal system (fiber optic temperature sensors) and electric field scanning, show better behavior of the thermal system, since experimenting with different frequency ranges from 3 to 6 GHz these sensors can measure without any problem given that they not show frequency dependence [3].

According to the standard for transmitters used in human ear proximity, the IEC 62209-1 procedures: 2005 standard are applicable. IEC 62209-2: 2010 is applicable for radio frequency exposure in the band span from 30 MHz to 6 GHz, and can be used to measure multiple simultaneous exposures of radio sources used in close proximity to the human body. Definitions and assessment procedures are provided for the following general categories of device types: mounted in the body, resting on the body, desk, in front of the face, hand, and portable [4]. Is feasible the use of fiber optic sensors due to measurements have no restrictions of electromagnetic interference, or frequency dependence.

2. Methodology

The design of the measuring system was divided into two parts: design and simulation of the positioning system to insert the fiber optic sensors within the phantom and development of 3D interface for the representation of the obtained temperature patterns.

Figure 1 shows the block diagram of the entire temperature measurement system in a general way. Integrated images belong to the simulation model.

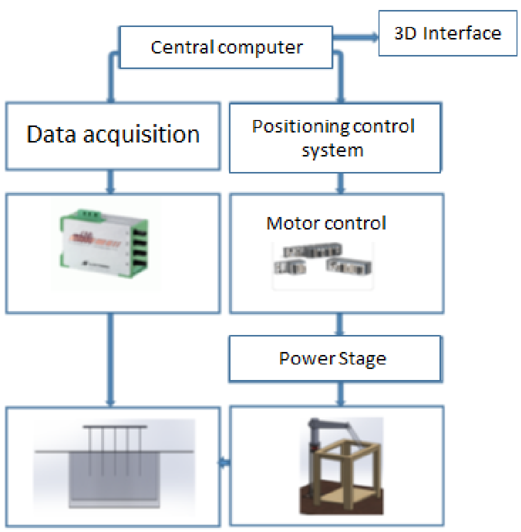

Fig. 1 Block diagram of the measurement system

2.1 Positioning

The positioning system was designed taking into account the needs of the project, since when carrying out the measurement, a number of conditions must be considered to avoid problems of any kind, among which are: overheating by metallic elements, interference between the mechanical elements, limited paths and load capacities.

For the positioning system an automated structure consisting of polymers materials, specifically Nylamid, was designed and simulated. The choice of this material was based in its mechanical, dielectric and thermal properties that are suitable to simulate the positioning system.

The configuration of the positioning system is known as robotic arm with 5 freedom degrees. Such configuration mimic the movement of a human arm, which is positioned by a number of drive axles, waist, shoulder, elbow, wrist and hand. Figure 2 shows the final assembly.

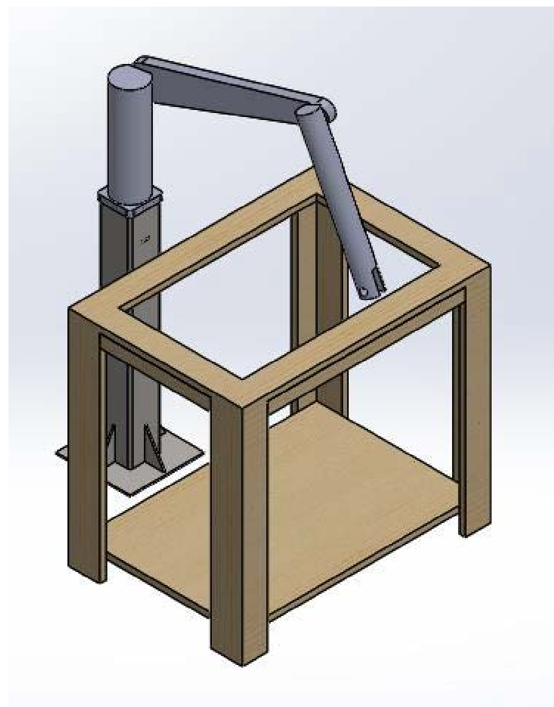

Fig. 2 Robotic arm assembly

The simulation of the elements trajectories was performed in a simplified form, since if an assembly is inserted with too much detail a series of errors arising in position relations, may occur.

The system trajectories show the outline of each of the main links, thus it is determined whether the work area coverage is satisfied. By simulating the trajectories it is determined that the lengths of the links are correct.

Figure 3 shows the rotational movement of the arm, working in optimal configuration, it is appreciable that full coverage of work area is accomplished. The rotation is 360 ° in the link 0, the link 1 positioned 70 ° to the axis Y (vertical), and the link 2 with an angle of 150 ° to the underside of link 1.

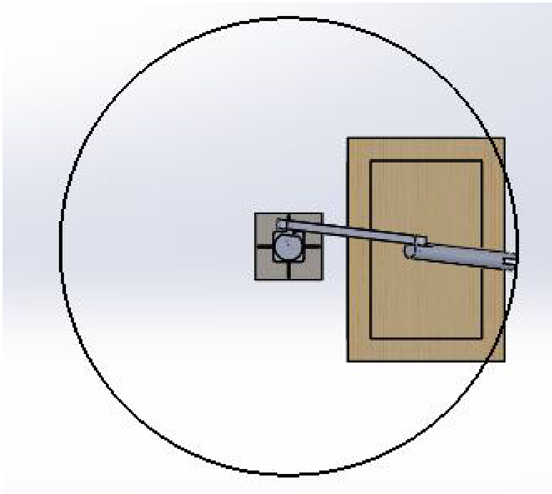

Fig. 3 Maximum length path

In Figure 4, the rotational movement of the link 1 is shown, where is easily appreciable the positions that this can take, it should be mentioned that this link will be limited in working angles, because as shown in the figure the work table interfere, but an angle of 90 degrees relative to the Y axis is sufficient to cover the area of interest.

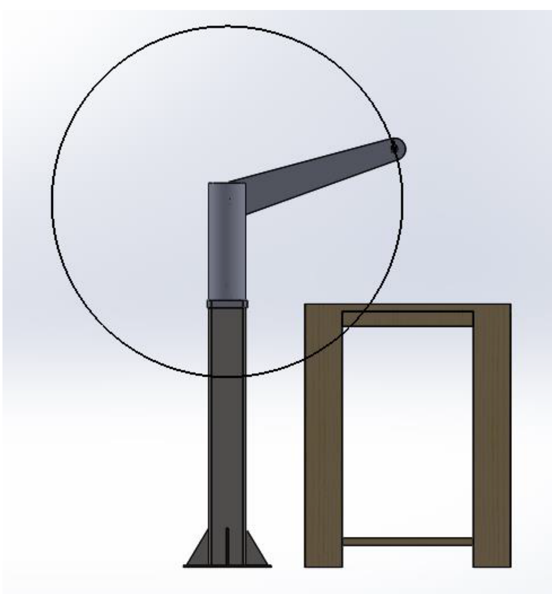

Fig. 4 Link 1 path

Figure 5 shows the rotational movement of link 2, in the figure the link is shown in an angle of 90°.

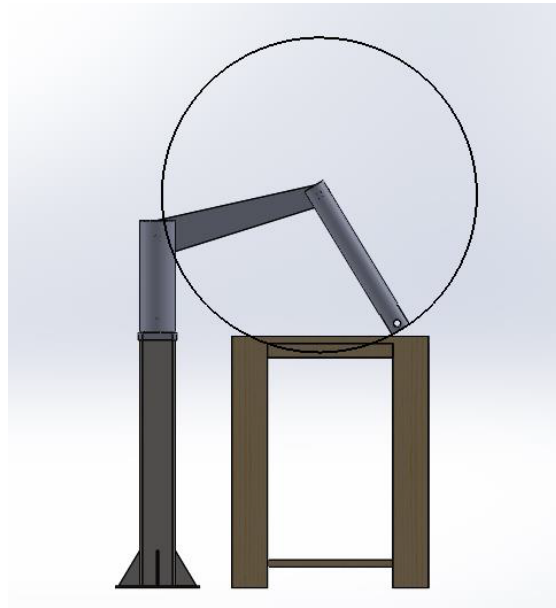

Fig. 5 Link 2 path

The simulation is important because it is the base to determine the necessary engine for the prototype. The modeling and simulation was performed in the program SolidWorks® using the simulation tool motion study, establishing a maximum length configuration reached by the arm in 1.20 meters, so the maximum torque is generated and can be analyzed analytically by taking into account the maximum length of the arm and its weight. The torque can be determined by the formula.

$$M = F * D \tag{1}$$

Where *M* represents the generated moment, *F* is the applied force and D represents the distance.

As there are a number of factors to consider, it is more feasible to perform a simulation model and a study of movement that allow the consideration of these factors: gravity, friction between elements, external forces, weight of materials etc.

For the simulation the gravity value that was taken is 9806.65mm/s^2, a coefficient of friction greased rubber of μ_k = 0.43 and dynamic friction velocity of V_k = 10.16 mm/s.

The determination of the torques will be represented in a graph of torque - time. Figure 6 shows the location of the motors.

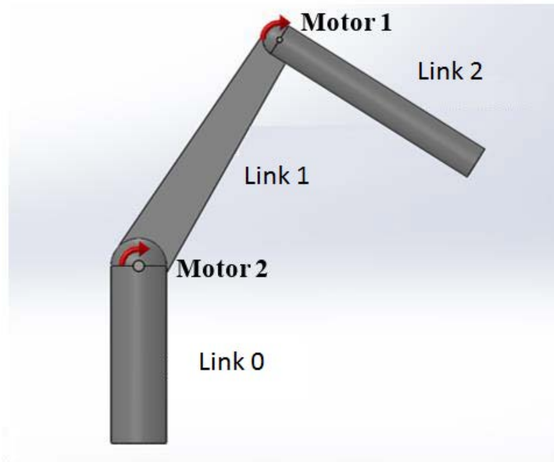

Fig. 6 Motor location

The Motor 1 is positioned between the link 1 and 2, by making the simulation, by assigning properties of a high density polymer to the elements, the graph shown if Figure 7 is obtained.

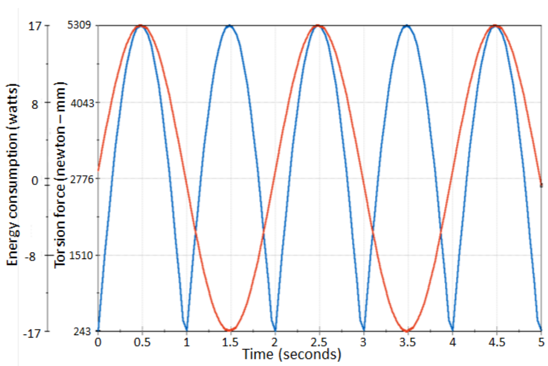

Fig. 7 Graph of energy and torque vs time for motor 1

The graph shows the power consumption and the torque generated in a time period of 5 seconds in a simulation considering friction conditions between elements and gravity. The simulation yields the following results, maximum torque generated 5309 Newton-mm or 54 kg-cm, with a power consumption of 17 watts present when the maximum torque is generated.

A similar simulation was realized for the motor 2 taking into account the same parameters and the maximum length of extension, this way the maximum possible torque is generated thus having a safety factor to support the correct operation of the prototype. For motor 2 the results are shown in Figure 8.

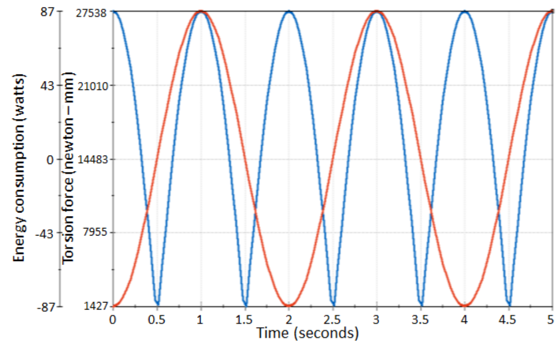

Fig. 8 Graph of energy and torque vs time for motor 2

The engine 2 support a charge that generates a torque of great magnitude, because it has larger length and weight, the maximum torque is bigger compared to the previous one, with a magnitude of T = 27,538 Newton-mm or 280 Kg-cm and a power consumption of 87 watts.

For positioning of the sensors a head capable of inserting at least 4 temperature sensors was designed, this considerably increased the number of samples obtained in a measurement.

The head was designed with Nylamid. The head configuration is a row of 4 catheters with a spacing of 1 cm. Figure 9 shows the diagram of the head.

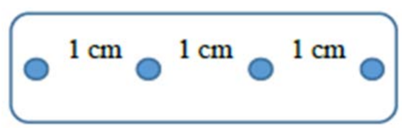

Fig. 9 Diagram of the head

2.2 Graphic interface

A program was developed to simulate the acquisition and representation of the temperatures, it was simulated in LabVIEW® with block language, due to its ease of programming. This interface can display the data acquired from the sensor, for the simulation, a program with a 3D image with .stl extension was created. The 3D image is the model of the human head and it is shown in Figure 10.

The inset image corresponds to a model made in a program that generates 3D images, by 2D images obtained through ultrasound or MRI. Four sensors will be positioned at any point of interest to know the distribution of temperature in that specific The inset image corresponds to a model made in a program that generates 3D images, by 2D images obtained through ultrasound or MRI. Four sensors will be positioned at any point of interest to know the distribution of temperature in that specific area.

Fig. 10 3D image of a human head

The representation of the temperature is displayed as color spectrum, which depending on the intensity have a temperature value. The scale of each sensor was set in a range from 35° to 40°C thus low magnitude changes are monitored.

A simulation of four thermometers was realized to verify the operation of blocks program, four bars type slide were implemented, which with increasing its value generates a small variations of temperature that is reflected in a color change.

The programming of the interface integrates some functions easy implementation like: recognition of 3D images, sensors mapping, 3D image modification, among others. The program is shown in Figure 11, where the tools that facilitate image interpretation are displayed, this makes understanding results more friendly.

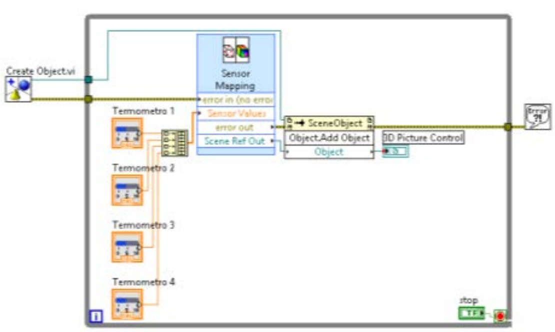

Fig. 11 Block diagram of mapping system

Figure 12 shows the developed interface, used to map the temperature changes, it was created with a simple form to facilitate understanding of the program and the objective of the simulation.

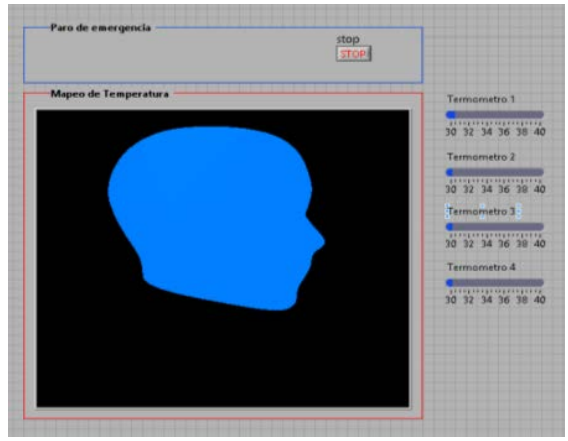

Fig. 12 Mapping Interface

A temperatures simulation is shown to illustrate the operation of the developed program. Four measuring points were implemented in the model of the head as shown in Figure 13.

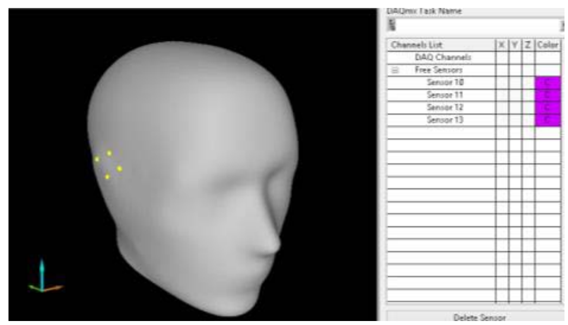

Fig. 13 Sensors location

A dramatization of temperatures was made to observe generated changes, this is shown in Figure 14, where an image is displayed in increments of 25°C, ensuring that the interface works in the simulation.

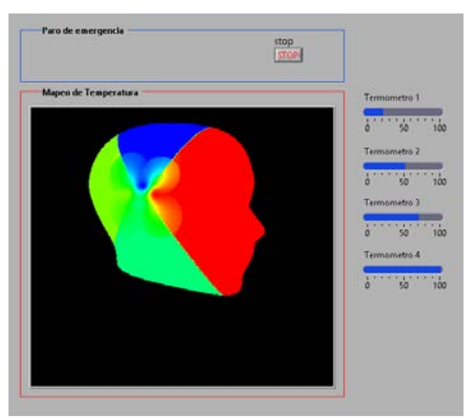

Fig. 14 Temperature mapping

3. Results analysis

The results obtained in the simulation show the required dimensions for the positioner, resulting in the necessary torques and work area.

The graphical interface was simulated with large increases in temperature to display to better visualize the performance.

4. Conclusions

The simulation of the positioning system met the objectives since it was possible to determine the torque required to move the components of the positioner, however to obtain maximum torque values was above 100 Kg-m, making acquisition difficult by high costs, for which based on this simulation the dimensions of each of the links should be rethought so the volume can be reduced and therefore weight is reduced and then less torque is needed so the engine power can be reduced.

Cost is important for the realization of this project that is why simulations are an important part of it, so the costs can be reduced by proper selection of equipment.

As for the generated interface satisfactory results were obtained, the next step is the implementation of the same with fiber optic sensors, to determine times of sensing, thermal response, etc. [5].

References

[1] OMS. (Octubre 2014). *Campos electromagnéticos y salud pública: teléfonos móviles.* Available: http://www.who.int/mediacentre/factsheets/fs193/es/

[2] R. Ellingsen, "Fiber optic probe for temperature measurements in biological media," ed: Google Patents, 2001.

[3] Y. Okano and H. Shimoji, "Comparison Measurement for Specific Absorption Rate With Physically Different Procedure," *Instrumentation and Measurement, IEEE Transactions on*, vol. 61, pp. 439-446, 2012.

[4] IEC, "NUEVA NORMA IEC 62209-2 LA EXPOSICIÓN HUMANA A CAMPOS DE RF DE LOS DISPOSITIVOS DE COMUNICACIÓN INALÁMBRICA CUERPO MONTADO Y PORTÁTILES," 2010.

[5] J. E. Chong, L. Leija, C. P. Pennisi, and W. H. Fonseca, "Optical fiber based thermometry system for a hyperthermia laboratory," in *Engineering in Medicine and Biology Society, 2001. Proceedings of the 23rd Annual International Conference of the IEEE, 2001, pp. 3036-3039 vol.3.*