Design of Tactile sensor using dynamic wafer technology based on VLSI technique

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Abstract -**The study had been accomplished in the desire to obtain real time control analysis with tactile sensors. This has lead to the design and fabrication of a cost-effective artificial tactile sensor. This wafer technology is based on Potentiometric principles. In the process in-depth study has been made keeping in view the reliability, accuracy, data processing, and flexibility. Very large scale integration (VLSI) computing array techniques have been incorporated to develop an independent logic control for real time analysis.**

Keywords: **Tactile sensor, VLSI computations, real time control, Potentiometric technique**

I. INTRODUCTION:

Tactile sensor systems are an essential pre-requisite for the implementation of complex manipulation and exploration tasks using robots. There is an increasing need for measuring forces acting between human hands and the environment. In particular forces acting at the palm and fingers are critically important for understanding human manipulation [1][2][3], acquiring skills, human perception and human intentions.

In this paper, a new approach has been put forward for detection of forces. Instead of a direct binary data representing rigid body, inter-segmental work has been enhanced providing each segment with its own logical and control unit using VLSI technique with an analog output first which is later obtained as digital data. Instead of using a rubber, pressure sensitive plastic material is the source of input. Real time control is obtained by the substrate level integration.

First the paper describes the basic principals and the source of interpretation of this tactile sensor. An Anatomically based, physiological study is presented in order to explain the principal of the perception of touch. Static and dynamic simulations of the model have been studied. A prototype tactile sensor is then designed and built and experiments have been performed to measure the static real time control and dynamic real time control responses. Experimental responses evaluate the model. Results of the comparison and their impact on sensor design and preference are discussed.

II. METHOD

The basic anatomic structure of the skin consists of the following [4]. The upper part consists of the three important layers, the Epidermis, Dermis and the Hypodermis or subcutaneous layer, which is perceived as the input source. The center part is the Papillary layer or the Dermal Papallae, which acts as flexible contact electrodes of the sensor. Attached to the dermal papillae are the Meissner's corpuscles, which are the touch receptors and regulators of the sense of touch. The following design is the basic perception of the skin structure presented in the most simplified form. The dermal papillae are the area of concentration.

A. Construction of the VLSI sensor

The sensor described above can be utilized to measure touch force or contact pressure at minute level with the minimum amount of pressure. Each sensor consists of the conducting plastic (input source) and flexible ridges oriented construction to provide a firm contact and read minor changes in pressure from all directions of input as shown in fig1 (anatomical diagram of the dermal papillae).

This ridges wafer has been designed with such structural manipulation as to meet the underlying universal physiological principle which terms the perception of pressure in a healthy individual from 0.3 - 0.5N. Since forces within 0.5 to 1.2N are sufficient to cause the venous return

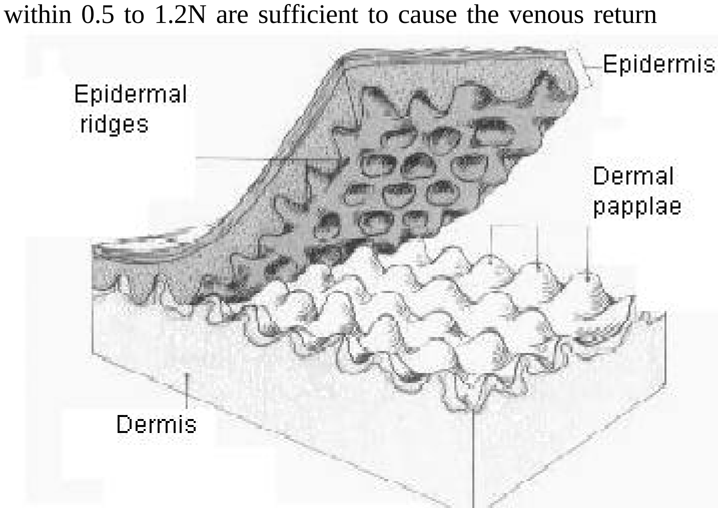

Fig 1 Construction of dermal papplae

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Abstract

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of blood, the very similar correlation is with the threshold of touch in this aspect.

During the input pressure when the force reaches e.g. 1.5N or so, the regulator element or the computing element of the sensor processes the data. The regulator element [4][5] consists of an analog comparator, a data latch, an adder, an accumulator shifter, an instruction register and a two-phase clock as shown in figure 2. Regular instructions are sent over a global dual bus that communicates with each sensor element. With this technique of dual bus data transportation bottlenecks are avoided which had been a critical problem with the past data manipulations. This VLSI technique allows each sensor cell to sample the local pressure, store the transuded value and pass the stored data to neighboring cells [5].

upper part (wafer A) is 20 - 25% fibrous, while 80% of the material is porous. The porosity of the material faces easy

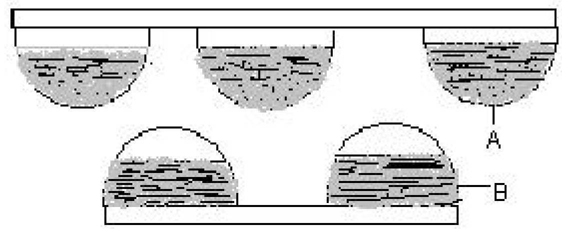

FIG 3 Structural an material properties of the ridges

deformation, which adds maximum feasibility for a better data resolution and real time analysis. Fig 3 shows the structural construction. This assembly of the wafer helps to

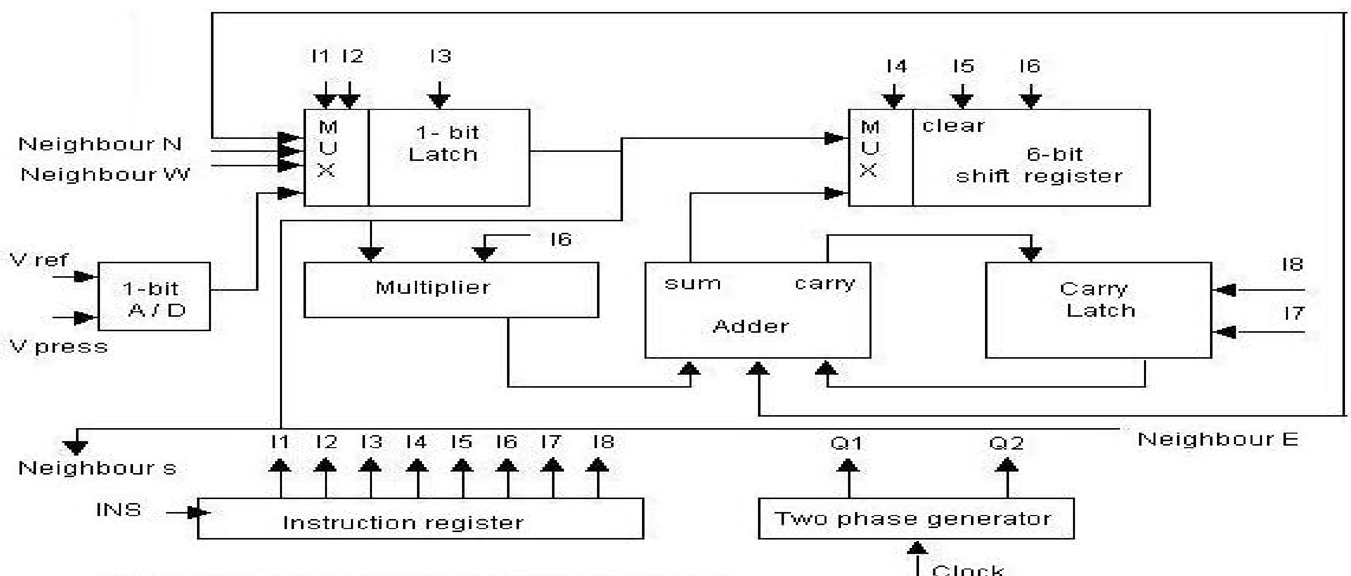

FIG 2 The VLSI computing element of the sensor

detect and read minute changes at the input level.

B. Construction of the dynamic wafer:

The dynamic wafer technology is a new technique devised to pick analog signals for real time analysis of the data. The wafers are designed to provide firm contact and accurate positioning so as to pick small signal and enhance localized data retrievance.

c. Structural properties

A composite material of fibro- porous nature is used to construct the dynamic wafer. The characteristics of this wafer are similar to those of the dermal papallae.

The lower part, (wafer B) is of fibrous nature, providing strong grounds for better contact and data manipulation. The

D Potentiometric arrangement property:

The ridges of the wafers are specially wound with very thin copper wire. These copper wires provide intermediate resistance to the flow of potential. Both wafers A and B are wound with copper wires at a thickness of 1 mm. The wafer A has been wound up to 3

mm from top to bottom while the copper wire wafer B is wound at 3 mm from bottom to top. As shown in figure 4.

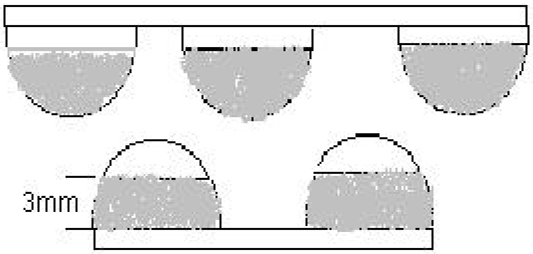

FIG 4 Copper wire wound on ridges

The base of the wafer B i.e. in between the ridges is drawn with strong thick copper wire which is 2mm in diameter and stretches in all directions between the ridges as shown in Fig 5.

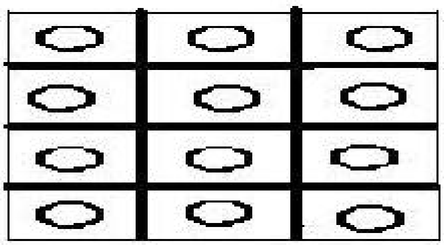

FIG 5 thick copper strips between ridges

A reference oriented amplifier network is designed and placed just before the regulatory or the computing element (VLSI). This circuit compares the reference value with the potential values received from the Potentiometric structure of the wafers. The reference values can be set to desired values as per applications and may be left at ground level.

III. EXPERIMENTS AND RESULTS

In order to test the validity of the model, dynamic and static experiments were performed using the prototype tactile sensor. The outputs of tactile array and VLSI computation array were feeded to the printer ports of the computer (Pentium III) and recorded in a wave plotting software. Fig 6 shows a typical analog wafer response to touch force applied normal to the palmer surface of the fingertip.

As can be seen in the figure the general behavior of the model response, which shows a steady rise in the force on the proximal surface of the finger with respect to clock time in the regulatory element. In response to the rise in force, there is decrease in resistance as the ridges meet, increasing the further contact of the surfaces. As shown in fig 6(a) with respect to rise in force, there is a sharp rise in voltage in fig 6(b) and as soon as it reaches the bottom which allows a firm contact with the copper strip, a steady line of voltage is achieved as shown in fig 6(b). Whatever may be the magnitude of the force, there is a set limit which disallows overshoot and sudden mechanical load.

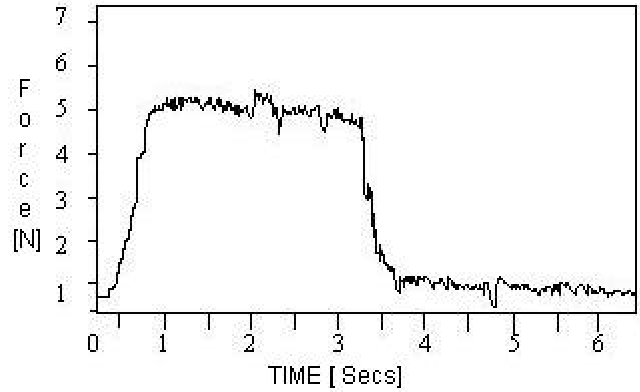

FIG 6(a) Experimental input response for finger area force

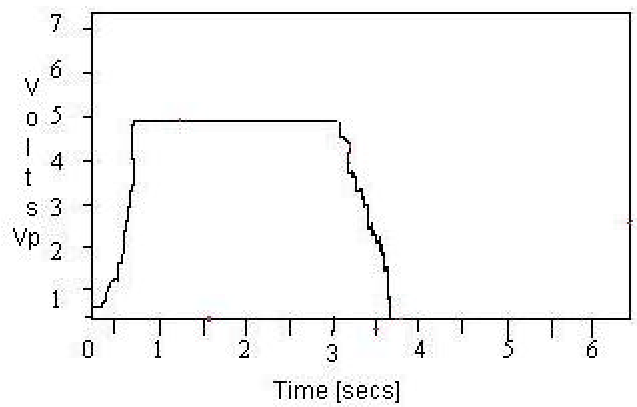

FIG 6(b) Experimental output response for finger area force

The second experiment is performed by bringing in contact a solid cylindrical body with the wafer tactile sensor. Fig 7(a) shows the ideal projection of the tactile wafer response with the rise in force and maturity level of the input. Fig 7(b) shows the analog response of the cylindrical body.

The interesting thing here is the uneven spikes in voltage at end of the wave. This is because when a cylindrical body is grasped, a full response is obtained for the wafer (ridges) that is fully in contact as shown in fig 5(b), while some parts of the wafer are partially activated i.e. the ridges which are partially pressed show differed resistances and hence differed Voltages and peaks which show small uneven peak of rise in voltage

The A/D converter sample this unevenness as the curves of the body and a perfect digital signal response for a cylindrical body is obtained.

Hence this technology is extremely useful to obtain precise and accurate images also.

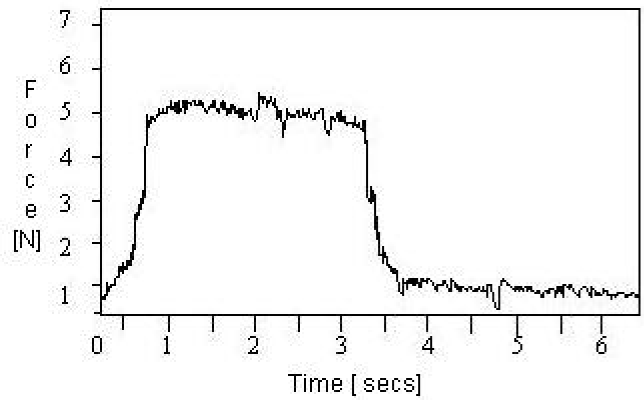

FIG 7(a) Experimental input response for a cylindrical body

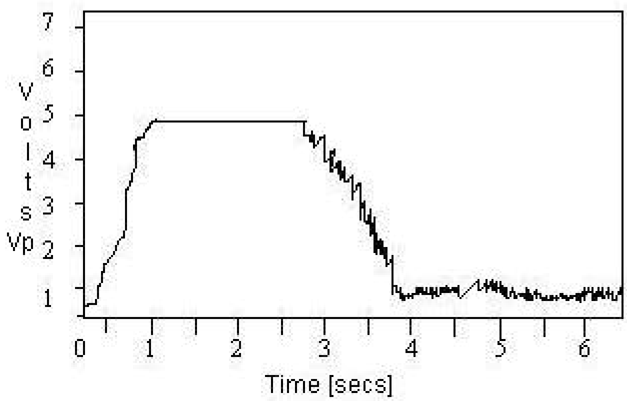

FIG 7(b) Experimental output response for a cylindrical body

IV. DISCUSSION

A new type of wafer technology for tactile sensor is evolved using Potentiometric technique based on VLSI computations.

Hand surfaces of robots for industrial use and offcourse for bionic hand can be fabricated with such a sensor. The wafer technique measures the change in voltage for minute to large magnitudes of input. Perceived action of touch phenomenon is described and an anatomical and physiological view has been presented which forms the basis of the wafer technique. The model is simulated and compared with experimental data for two types of input forces both at the finger level and palm (for cylindrical body).

The comparison shows that the model explains certain key linearities that are observable in the tactile sensor analog outputs. Further more with the release of the force, a small settling time is observed with small spikes of overshoot due to sudden drop in resistance. The small settling time is beneficial when multiple input sources are handled at the same time. This technique is a powerful one also for detecting accurate images of the object in contact.

V. CONCLUSION

Efforts have been made to enhance work on tactile sensing which plays a very important role in robotic industry and artificial prosthesis. New technique of wafer fabrication has been brought forward for real time control. Cost-effectiveness and precision parameters have been considered

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