The Concept of a Full Screen Tactile Display (FSTD) Driven by Electrochemical Reactions

Ryszard Kowalik, Irena Postawka

Department of Optoelectronics, Technical University of Gdańsk,
Gdańsk, Poland

Abstract:
A concept of a full screen tactile display driven by electrochemical reactions is presented. It is based on theoretical considerations of electrochemical reactions which occur during electrolysis. The basic calculations of electrochemical equations are discussed. A model of one cell and full size tactile display is proposed. A project of a driving and controlling system of a tactile display is presented.

1. Introduction

The blind computer users due to braille displays and speech synthesisers have had a good opportunity to work with sighted people. But nowadays more and more software is designed in graphic environment such as f.e.Microsoft Windows. For sighted people it is a great advantage because they do not need to type long and difficult to remember commands and instead of that they only manipulate graphical object on the screen clicking or dragging with mouse or trackball. This kind of man-computer interaction requires good hand and eye co-ordination what is impossible for the blind. Solution of a problem full screen tactile display is still incomplete although a lot of efforts have been undertaken [1], [2]. The main barrier to overcome in a tactile displays is a driving mechanism of a system which is always very complex, large and expensive. Although the several projects of electrotactile, thermal and mechanical displays was presented the problem of a full size tactile display is still unsolved [3], [4], [5].

The concept of a tactile display driven by electrochemical reactions is a new aproach to the problem of driving system. It is based on theoretical considerations of electrochemical reactions which occur during electrolysis. A preliminary basic calculations let us to assume that products of electolysis could be a good medium to drive the tactile points of a display.

2. The size and resolution of a FSTD

The main assumption of presented model is that tactile display will represent full monitor screen e.g. 80 columns and 25 rows of text and it will be able to present a simple graphic images as plots, schemes and maps. All points will be placed regularly in distance about 2,5-3 mm from each other. ASCII signs will be representing by 8-point braille code formed into 4x2 points cells with one point wide break between them. So, full screen size requires 239 points in each row (160 points for 80 ASCII signs and 79 breaks between them) and 124 points in each column (100 points for 25 rows and 24 breaks between them). For presentation of images all points will be active together with breaks between braille cells. Assuming that size of one point is about 2 mm and distance between them is about 1 mm the size of a full display is about 370x720 mm.

3. Driving system of a FSTD

To avoid a problem with mechanical part of a tactile display the idea of driving points by products of electrochemical reactions is proposed. The main advantage of this idea is that driving medium of a tactile point is placed inside the point. Therefore no more space is needed for the driving system. Theoretical considerations and calculations convinced about the reliability of that approach.

The passage of an electric current in electrolyte causes an electrochemical reactions. The oxygen and hydrogen mixture is produced as a result of electrolysis. If that process takes place in limited volume the gas mixture causes an increasing of a pressure inside an electrolytic cell. Making an assumption that cell is cylindrical a force arising during electrolysis can be calculated.

$$F = S * P \qquad (1)$$

F – *force*

S – *cross– sectional area*

P – *gas pressure*

In according to Dalton's right:

$$P = P_{H2} + P_{O2} \qquad (2)$$

P_{H2} – *hydrogen pressure*

P_{O2} – *oxygen pressure*

then from (1) and (2) :

$$F = S * \frac{2}{3} * \frac{E}{V} * (n_{H2} + n_{O2}) \qquad (3)$$

E – average kinetic energy
V – gas volume
n_{H2} – *hydrogen molecule quantity*
n_{O2} – *oxygen molecule quantity*

Since:

$$E = \frac{3}{2} * \frac{R * T}{N_A} \qquad (4)$$

and

$$n = \frac{m}{\mu} * N_A \qquad (5)$$

then:

$$F = \frac{S * R * T}{V} * \left(\frac{m_{H2}}{\mu_{H2}} + \frac{m_{O2}}{\mu_{O2}} \right) \qquad (6)$$

T – temperature °K
N_A – *Avogadro constant*
R – gas constant
m_{H2} – *hydrogen mass*
m_{O2} – *oxygen mass*
μ_{H2} – *hydrogen molar mass*
μ_{O2} – *oxygen molar mass*

Hydrogen and oxygen mass can be calculated from Faraday's right:

$$m = k * Q \qquad (7)$$

$$k = \frac{\mu}{v * N_A * e} \qquad (8)$$

k – electrochemical equivalent
Q – electric charge
v – amount of electrons to obtain one gas molecule
e – electron charge

then:

$$m = \frac{\mu * Q}{\nu * N_A * e} \qquad (9)$$

Because in (6) a ratio $\frac{m}{\mu}$ is calculated then from (7) and (8):

$$\frac{m_{H2}}{\mu_{H2}} = \left(\frac{Q}{\nu_{H2} * N_A * e} \right) \qquad (10)$$

$$\frac{m_{O2}}{\mu_{O2}} = \left(\frac{Q}{\nu_{O2} * N_A * e} \right) \qquad (11)$$

and because an electrolytic cell is cylindrical then:

$$V = S * H \qquad (12)$$

S – *cross - sectional area of cylinder*
H – *hight of cylinder*

Finally, the calculated force is:

$$F = \frac{R * T * Q}{H * N_A * e} * \left(\frac{1}{\nu_{H2}} + \frac{1}{\nu_{O2}} \right) \qquad (13)$$

When process of electrolysis takes place in an elastic cylindrical cell the force could cause an increasing in size of a cell. As it is seen from (13) the force is not depending on cross-sectional area of cylinder but on the height. Because for the tactile display the increasing in height of a point 1 mm is enough to be perceptible and electric charge of 10 mC is enough to cause electrolysis then estimated force for:

H = 1 mm
Q = 10 mC
T = 300 °K

is equal:

F = 0.194 N

That force is strong enough to sustain a tactile point of a display.

4. A model of a tactile cell.

A model of one cell of a tactile display is presented below as an example of utilisation of a force arising during electrolysis. A tactile point has a form of cylinder 2 mm in diameter and 5 mm height. It should be made of elastic material with internal surface covered with catalyst which enables hydrogen to oxidise in room temperature. The cylinder is filled with weak water solution of sulphuric acid and two electrodes are dipped into that liquid. The amount of 29636 cells are mounted on a non-conductive surface with an array of 124 row collection lines and 239 column collection lines. During the passage of current through the electrolyte inside a single cell the mixture of hydrogen and oxygen is produced and the pressure inside a cylinder increases. Because cylinder's walls are elastic the pressure causes increasing of size of a tactile point. Simultaneously due to presence of catalyst the oxygen and hydrogen molecules forms the water molecules again. The amount of catalyst should be fitted to the time of oxidation to keep a pressure during several seconds. For a longer time the active tactile points must be refreshed periodically.

5. Controller of a tactile display

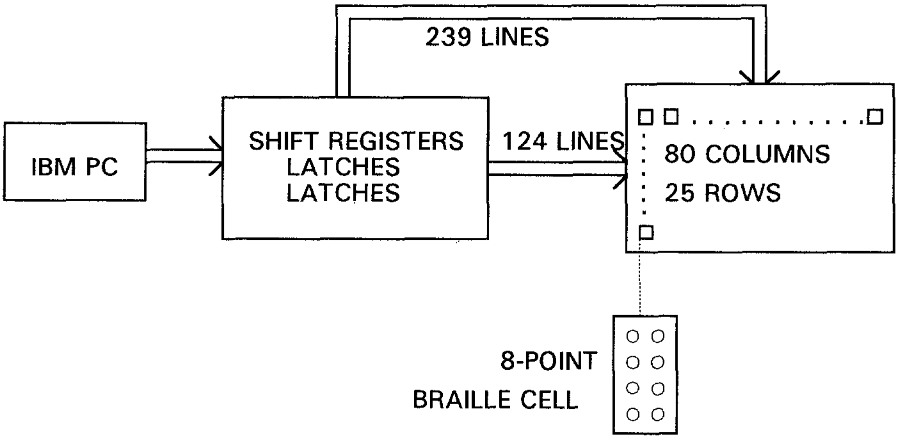

Fig.1. Block diagram of a control system.

The block diagram of a control system is presented on the figure 1. Tactile display is controlled by IBM PC computer via the interface. That interface consists of 124-channel latch connected with rows of FSTD and 239-channel shift register connected with columns of FSTD. Information regarding each consecutive column is latched in a set of latches and proper tactile points in that column are excited by passing an electric current and starting an electrochemical reaction. That cycle repeats 239 times column by column until full tactile display will be activated. The time of 239 cycles should be short enough to keep all excited points in high position. After it the new information about the status of a display could be passed to the first and next columns. Even if information does not change the display must be activated at regular intervals to sustain the outline of a display.

6. Conclusions

Tactile display presented in this paper is a theoretical model which has not been constructed yet. Although the results of calculation and simplicity of a controller are very encourage the problem of selection of elastic material and type of catalyst is still unsolved. We are looking for a co-operation with specialists in chemistry for better recognition of possibility of practical realisation of our project.

7. References

[1] Gill J.: Access to Graphical User Interfaces by Blind People, RNIB, London, 1993
[2] Fricke J., Bähring H.: A Graphic Input/Output Tablet for Blind Computer Users, Proc. of 3rd ICCHP, Vienna, 1992
[3] Brümmer H.: Elektrotaktiles Blindenschrift-Display mit Sprachaussgabe, Proc. of EuroDisplay Conference, Frankfurt, 1989
[4] De Baetselier E., Du M., De May G.: A Thick Film Resistor Circuit as a Prosthesis for Blind Persons, 9th European Hybrid Microelectronics Conference, 1993
[5] Shinohara M., Saida S., Shimizu Y., Mochizuki A., Sorimachi M.: Development of a 3-D Tactile display for the Blind: System Design, Proc. of 3rd ICCHP, Vienna, 1992.