VOLUME-6 | ISSUE-1 | JANUARY-2017 • ISSN No 2277 - 8179 | IF : 3.508 | IC Value : 78.46

Original Research Paper

A STUDY ON PIN CONSTRAINED DESIGN OF DIGITAL MICROFLUIDICS BASED BIOCHIPS

Engineering

KEYWORDS: -digital microfluidics; electrode addressing; fluid handling operations;

Sudip Roy | Jr. System Analyst, Bankura University, Bankura , West Bengal.

ABSTRACT

Digital Microfluidics based biochips is expected to open up new application areas in the field of Clinical diagnostics, drug discovery, DNA sequencing and other bio-chemical applications. Fluid handling operations such as Droplet dispensing, mixing, splitting, incubation etc. can be performed within a 2D array of electrodes and the number of independently controllable input pins required to activate the electrodes is an important cost driver. So, reducing the number of independently controllable input pins for electrode addressing is an important area of research. This paper depicts a comparative study of different control pin allocation methods.

INTRODUCTION

A distinctive Micro-fluidic biochip is like a two dimensional array of electrodes [1]. A unit cell comprises of two parallel glass plates. The bottom plate having an array of separately controllable electrodes whether the top plate is grounded. A droplet containing any biological samples is placed on the aquaphobic surface of the electrode as referred in the figure 1. The droplet bearing biological sample is moved to its contiguous cell by activating the control electrode of the concerned cell and simultaneously the electrode under the droplet is deactivated. This process creates an imbalance in the interfacial tension which causes the droplet to move. So, the electrowetting method can move the droplet to any position within the two dimensional array and the change in the sequence of control voltage activation of the electrodes leads to the successful completion of various fluid handling operations [2].

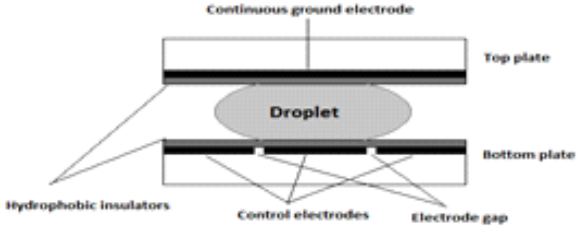

Figure 1. A unit cell of Digital Microfluidic Biochip.

Electrode addressing, with a reduced number of control pins, has been receiving considerable importance. The easiest and most common droplet control scheme as stated in [1], [2], [3], [4], [5], [6], [7], assigns an individual control pin for each electrode that can be activated separately as shown in Figure 2. In this method, termed as Direct-addressing, droplet movement is free to any location without any encumbrance. However, increasing system complexity steps up the manufacturing cost and wiring complexity, causing the entire design process very complicative.

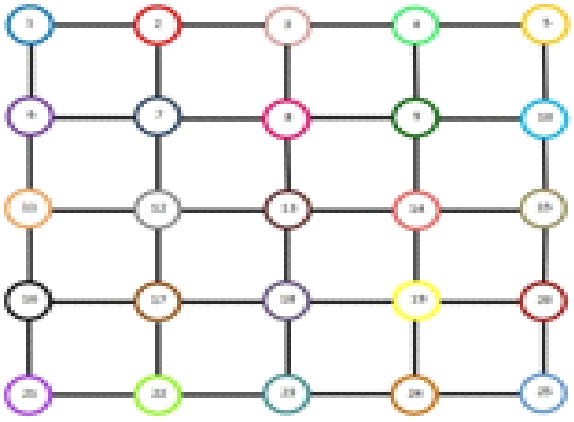

Figure 2: Control Pin Allocation based on Direct Addressing.

Thus, this met) are required for a transport bus, regardless how many number of electrodes it contains. This method is restricted only to a linear array.

Cross-referencing scheme as presented in [1], [2], [3], [4], [5], [6], [7], [8] minimizes the number of control pins by substituting X×Y microfluidic array with X+Y control pins. Here, the set of electrodes are placed orthogonally like a cross '+' with each other as presented in figure 3. An electrode is activated by triggering the corresponding row and column pins. Although, a reduced control pin representation is incurred, this design cannot deals with the concurrent movement of more than two droplets, inducing a serious drawback for high throughput bioassays (e.g. DNA sequencing, air quality mohod is best suited for small/medium scale microfluidic array.

Multiphase bus method [1], [2], [3], [4], [6], where n control pins (typically n=4nitoring).

In another method, array partitioning, as presented in [1], divides an array into several partitions and set of pins are assigned for each partition. However, it is specific towards a target microfluidic application. .

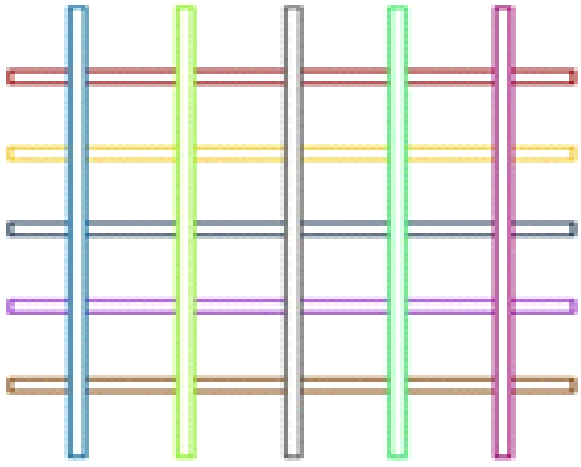

Figure 3: Control Pin Allocation based on Cross-referencing.

An alternative approach, as presented in [1], [4], [8], any cell and all of its four neighbourhood cells are assigned with different control pins which can be compared with a well known vertex colouring problem of graph theory [9].

CONTROL PIN ALLOCATION BASED ON CONNECT-5 SCHEME:

The procedure for allocating control pins can be described as follows: In the first row, pins are assigned in a cyclic consecutive order until the value of n (dimension of the n × n microfluidic array) is encountered. In the next row same order is followed but with a three times circular right shift/two times circular left shift. This process is

VOLUME-6 | ISSUE-1 | JANUARY-2017 • ISSN No 2277 - 8179 | IF : 3.508 | IC Value : 78.46

carried out until all the cells are assigned pins. Shifting direction once selected must remain unaltered throughout the allocation process [4][8]. Figure 4 and figure 5 shows the control pin allocated structure for a 5x5 and 10x10 microfluidic array.

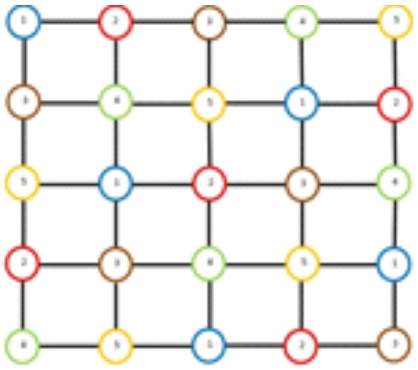

Figure 4: Control Pin Allocation for a 5x5 microfluidic array based on Connect-5.



Figure 5: Control Pin Allocation for a 10x10 microfluidic array based on Connect-5.

CONCLUSIONS:

Among different existing control pin allocation methods Connect-5 is the optimal one, which is finally used to allocate control pins to microfluidic array of different sizes like 5x5, 10x10, etc. This method is expected to reduce cost and lead to the miniaturization of mixed technology disposable biomedical devices for the emerging healthcare market.

REFERENCES:

[1] T. Xu and K. Chakrabarty, "Droplet-trace-based array partitioning and a pin assignment algorithm for the automated design of digital microfluidic biochips", Proc. IEEE/ACM International Conference on Hardware/Software Codesign and System Synthesis, pp. 112-117, 2006.

[2] Tao Xu and Krishnendu Chakrabarty," Broadcast Electrode-Addressing for Pin-Constrained Multi-Functional Digital Microfluidic Biochips." DAC 2008, June 8-13

[3] W. Hwang, F. Su and K. Chakrabarty, "Automated design of pin-constrained digital microfluidic arrays for lab-on-a-chip applications", Proc. IEEE/ACM Design Automation Conference, pp. 925-930, 2006.

[4] Tao Xu, William L.Hwang, Fei Su and Krishnendu Chakrabarty, "Automated Design Of Pin-Constrained Digital Microfluidic Biochips Under Droplet-Interference Constraints." ACM Journal on Emerging Technologies in Computing Systems, vol 3, No.3, Article 14, Pub. date: November 2007.

[5] Fan, S. K. et al., "Manipulation of multiple droplets on N×M grid by cross-reference EWOD driving scheme and pressure-contact packaging", Proc. IEEE MEMS Conf., pp. 694-697, 2003.

[6] T. Xu and K. Chakrabarty, "A cross-referencing-based droplet manipulation method for high-throughput and pin-constrained digital microfluidic arrays", Proc. Design, Automation and Test in Europe (DATE) Conference, DOI: 10.1109/DATE. 2007.364651, pp. 552-557, 2007.

[7] Pranab Roy, Rupam Bhattacharjee, Hafizur Rahaman, Parthasarathi Dasgupta," A new algorithm for routing-aware net placement in cross-referencing Digital Microfluidic Biochips." IEEE Computer Society Annual Symposium on VLSI, 2012.

[8] T. Xu and K. Chakrabarty, "Automated design of digital microfluidic lab-on-chip under pin-count constraints", Proc. ACM International Symposium on Physical Design, pp. 90-98, 2008

[9] R. Diestel, Graph Theory, Springer, Berlin, 2005.