American Journal of Biomedical Sciences
ISSN: 1937-9080
nwpii.com/ajbms

# Development of Integrated Circuits Using Artificial Conducting Liquid (Synthetic Plasma) - A Novel Research

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*Received:15 March 2018; | Revised:26 April 2018; | Accepted:31 May 2018*

## Abstract

Biomedical engineering is the most immerging field nowaday. Research carried out till date is based on solid medium. The presented paper claims the feasibility of liquid medium based integrated electronic circuits which give similar response to that conventional electronic integrated circuit. Authors have utilised conducting plasma as liquid conducting medium. A few research has been done based on liquid electronic circuit where liquid has been investigated and analysed as an alternative of solid state. In this paper, liquid based differential amplifier and astable multivibrator integrated circuits have been designed successfully. The proposed circuits have been tested using different density liquids in order to achieve stability and the results give almost similar response. Presented electronic circuits have a wide range of application in physics, engineering and biomedical science domain. The presented research could be considered as the bridge between engineering and biomedical science.

**Keywords:** Synthetic plasma, Biomedical science,Liquid based electronic circuits, Liquid integrated circuit

## 1. Introduction

Shivprasad Kosta and his team (2011) have put the concept of a liquid memristor that says liquid based electronic circuits are feasible with proper instrumentation [1]. Shivprasad Kosta et al(2013) [2] made the use of different parts of human body like skin, live tissues to demostrate memristor circuit.

  

The authors have given the novel idea to develop human machine interface technology and cyborg implantation (2012). S P Kosta and his team successfully proved that live cell, human tissue, skin or human blood (artificial blood) could be an appropriate medium for electronic conductivity [3-5]. In 2005, Marc Simon Wegmueller et al. presented human body could be a transmission medium at low frequency for human LANs having low power [6]. Every human being live cells are surrounded by a tissue made up of a fatty acid bilayer with proteins implanted in it even though human body is neutral in nature [6-7]. Yogesh Patil et al. (2013) claimed regarding presence of nano particles in live human body and it could be the very good alternatives of conductors [8]. In the past, a few researchers (2015) have done noticeable experiment to charge low voltage battery automatically using human body surface (skin) [9]. Some of the scientists (2009) have done experiments on human live cells and they had been utilized in neural recording system [10].

The authors have presented liquid based astable multivibrator and differential multivibrator circuit in this paper. Astable multivibrator circuit has been used to obtain electronic pulses. In said fashion, astable multivibrator circuit could be utilized for any application which is related to pulses regularity. It could be effectively utilized for human heart beats. Now a day, human community is are suffering from uneven heart beats. So for providing solution to this problem, human body friendly pace maker is implanted with proper clinical care.So as a part of the said noble application, liquid based astable multivibrator integrated circuit is systematically developed and presented here. Sincere confession is required here that development of these kinds of circuits is first time in the history so there are some human errors which can be removed by proper designing however novel idea has been approached in the next few liquid based integrated circuits. Similar fashion, integrated circuit of differential amplifier has also been presented here. It is clear from the previous study and references that conducting liquid can be very good alternative of resistor and capacitor replacement. In this regards, differential amplifier circuit has been chosen where output can be obtained from appropriate resistance (R) and capacitor (C) configuration. Of course, for different values of R and C results can be vary so here proper distances have been maintained to get stable values of capacitance and resistance. Here the positive and negative ions of the conducting liquid plays a major role to decide the values of capacitance and resistance.

## 2. Materials and Methods

Here, synthetic plasma has been chosen as alternative of conducting liquid. The similar liquid has been chemically designed in applied science laboratories. The said product could be considered as red blood cells so similar composition has been maintained. Depending upon the type of synthetic plasma, it can be developed in different methods with the help of chemical isolation, recombinant bio technology or synthetic production. Developed synthetic plasma has similar characteristics as conventional red blood cells so developed liquid can be used for current conduction. The developed liquid should have following behaviour.1. It should be flexible in use and environment friendly with human body having different kinds of blood groups, 2. It also means that developed plasma can be processed to vanish all agents such as viruses and microorganisms which cause disease, 3. It must be shelf stable which is contrast to natural blood because in natural blood clouting takes place if temperature differs or after a longer time.

Human blood could be considered as conducting medium for electricity. Wegmueller and his team (2007, 2009) stated that for short distance communication, human body could be utilised as a wireless communication medium [12-13]. Current coupling is possible in human body parts like muscle and human blood sad by Wegmueller (2010) [14]. Some scientists(2005,1998) proved that using the ionic property of human body fluids, circuit implantation is possible in to humans [14-15]. Kosta and his team (2013, 2016) successfully noted that desire response of low frequency electronic circuits based on liquid medium can be achieved with proper instrumentation [16-17]. Killol Pandya(2017) has also claimed that even copper wires could be replaced by very thin diameter plasma liquid filled silicon tubes [19].Ethically it is not possible to use actual human blood for experimental purpose so artificial blood like synthetic plasma has been made

  

in applied science. Different density plasma liquid has been produced and analyzed to check the stability of plasma liquid. The intension behind different density liquid is to make a human friendly circuit which can be implanted in to the human body having different blood groups.

### 2.1 Astable multivibrator

**Conventional circuit**

Fig 1 shows astable mutivibrator circuit. Here, two stable states are formed which change one by after another having maximum transition rate due to the accelerating positive feedback. This can be done due to coupling capacitors which instantly transfer change in voltage because the capacitor voltage cannot change immediately. At any instant of time, one transistor is ON while the other transistor is OFF. In similar manner one capacitor is fully charged and one remains uncharged. The charged capacitor gradually discharges and the whole process repeats, which makes change in transistor states of both transistors.

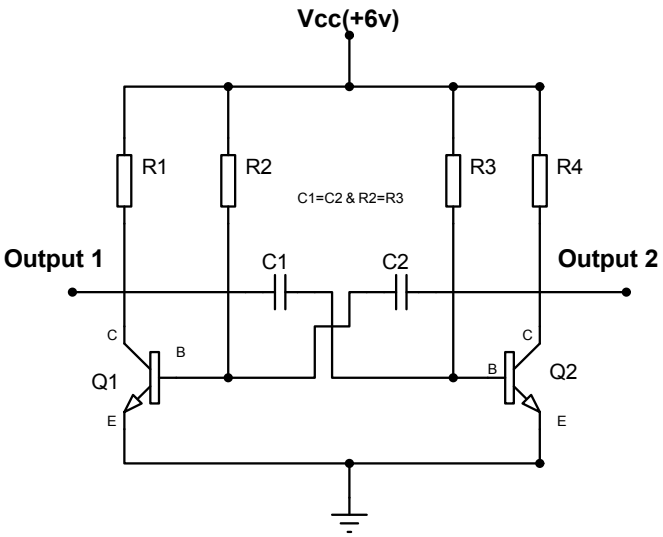


**Figure 1: Conventional basic astable multivibrator circuit**

Liquid based electronic circuit is feasible to demostrate with preoper mechanical instrumentation said by Killol pandya and S P Kosta(2016)[11,18]. From the base of their study, authors have successfully developed a liqid based astable multivibrator integrated circuit. The layout of liquid atable multivibrator IC is shown in fig 2. Here, instead of small beakers as alternative of each components, a big beaker has been utilised to develop an IC. To maintain proper distance between each component wire pair, a mechanical wooden block has been made in mechanical workshop having similar size holes through it at proper distance so copper wires can be easily pass through them. The said wooden block should be placed at the top of big beaker for a smooth physical structure.

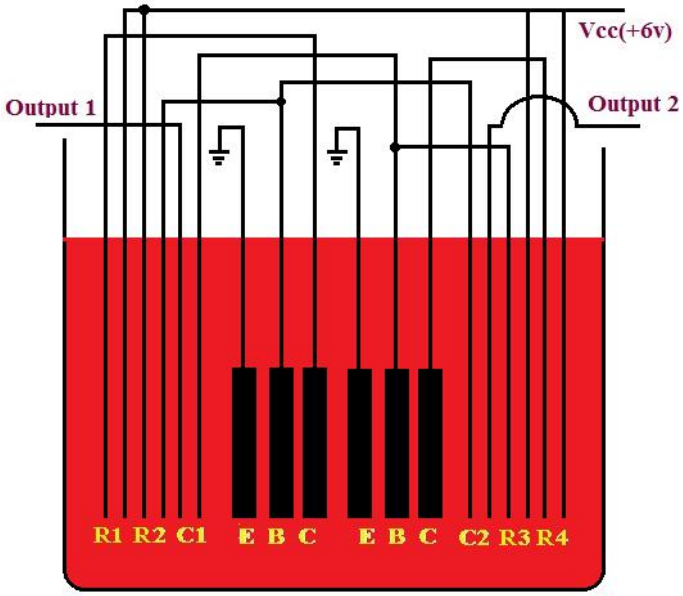


**Figure 2: Layout of liquid astable multivibrator IC**

**Result:**

Fig 3 shows output 1 and output 2 having a phase shift of 1800 as both the transistors are on and off but not at a same time.

Here by using function generator, AC sinusoidal voltages are given to the base terminals of both the transistors (out of phase) and similar sinusoidal waveforms can be obtained as an output. So both the output show stable condition, but not at a similar time. Of course R is in Ω s and C is in Farads.

Discussion:Here the value of C2 capacitor is similar of C1 capacitor value. And in similar fashion, R2=R3. Now due to these specifications, so astable multivibrator gives two very short square wave output by each transistor. Fig 3 shows that voltage per division is fixed at 5Volt and it shows electronic pulse wave on digital CRO screen.

  

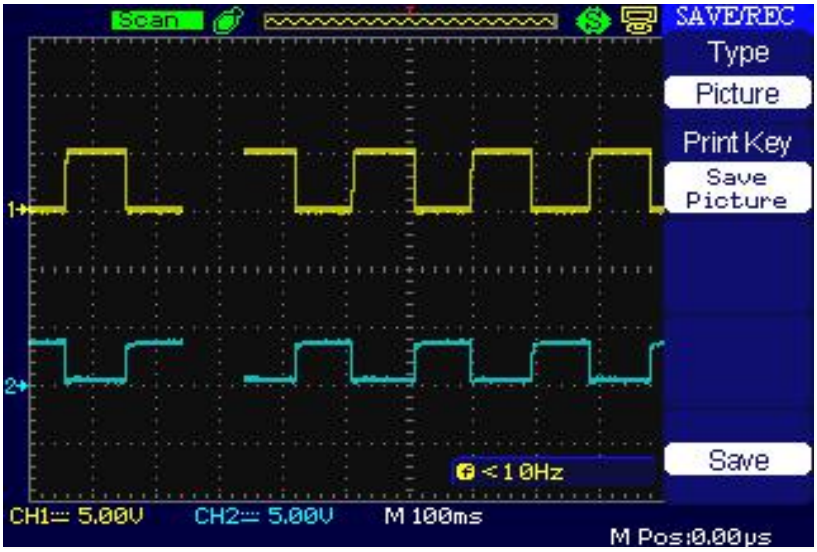


**Figure 3: Output of astable multivibrator circuit**

## 2.2 Differential amplifier circuit

### Conventional circuit

The following fig 4 shows differential amplifier circuit. It is the combination of inverting and non-inverting amplifier. Fig 5 shows liquid differential amplifier IC layout. Similar like astable multivibrator circuit, here also big beaker is used to develop an IC and wooden block has been made to keep and maintain similar distances between pairs of copper wires. Throughout the experiment, normal room temperature has been maintained so in future, similar concept could be introduced in human implantable circuit in biomedical science.

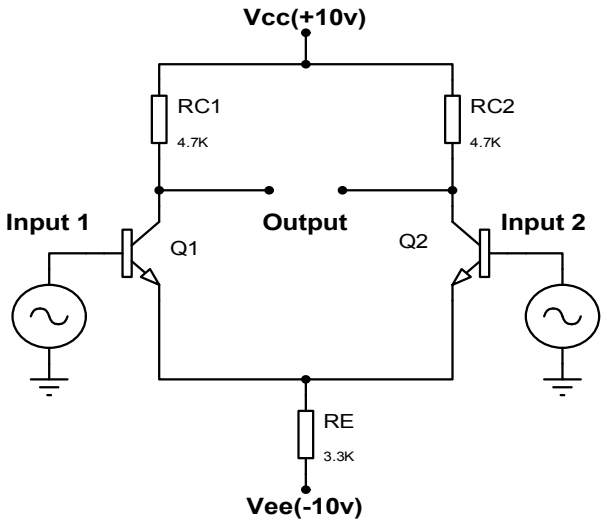


**Figure 4: Conventional basic differential amplifier circuit**

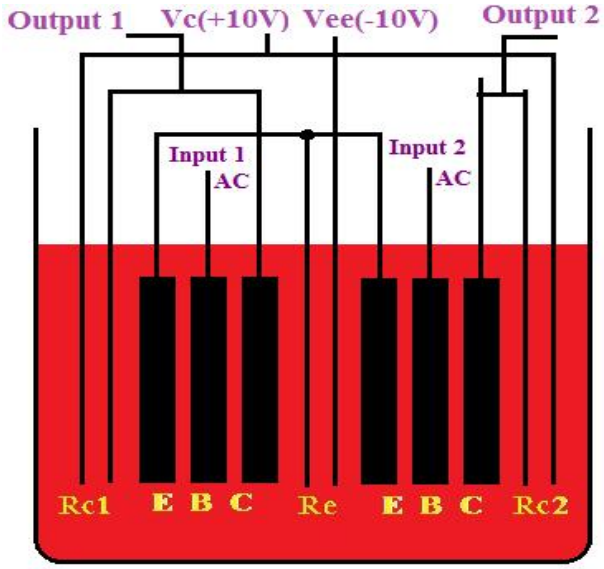


**Figure 5: Layout of liquid differential amplifier IC**

### Result:

The differential amplifier amplifies the differences between the two input voltages. It can be called as analog circuit with two similar frequency sinusoidal inputs and one sinusoidal output. Here, two inputs can be given as balanced input or one input is grounded to form a phase splitter circuit.

Fig 6 shows output of the proposed circuit if the input is in the form of AC sinusoidal voltage. Here also desired output can be achieved with 1800 phase shift.

  

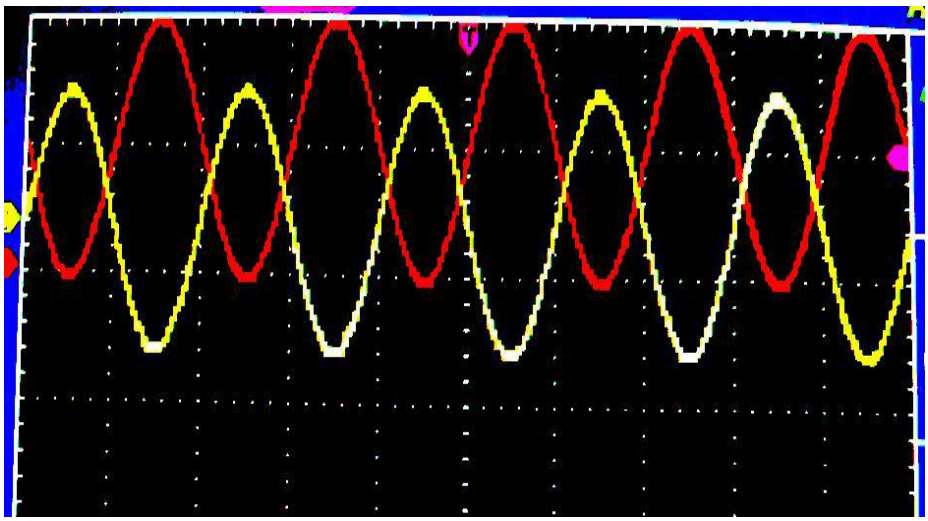

**Figure 6: Output of differential amplifier circuit**

## 3. Discussion

In the differential amplifier output, if it is not like a desired one then only one output from any of the collectors can be considered (by neglecting the other collector output). But in such a case, gain should be half of the desired one. This kind of output is called single ended output. To avoid this kind of gain, differential to single ended converter is utilized. Here output of the differential amplifier is not zero even though both the input voltages are similar because of difference in gain but this is possible only for the ideal case.

In both the cases, the basic liquid (synthetic plasma) remains similar like the previous research. It means conducting characteristics of synthetic plasma have been utilised to develop different low frequency electronic components. Similar like the previous study, appropriate distance between two copper wires have been maintained to demonstrate accurate component value.

In this paper, liquid based integrated circuit concept for astable multivibrator circuit and differential amplifier circuit have been proposed. To demonstrate both the circuits, big transparent beaker, filled with conducting plasma have been used to develop liquid integrated circuit concept. The results shows that desired response could be achieved with this concept also. So the proposed circuit could be considered as the extended research of liquid based electronic circuit.

The proposed mechanism has very big impact in liquid electronic circuits. The presented research could be considered as first step towards human implantable circuits where even copper wires could be replaced with implantable material. It can play a major role of human-machine interface in biomedical science domain.

## 4. Limitations

The research deals with liquid characteristics so proper instrumentation is the critical issue to be solved. Sometimes, the results are not stable because of liquid behaviour. Also the temperature plays a major role in result optimization so it would be keep constant as room temperature.

## 5. Conclusion

The novel concept of liquid based electronic circuit has been successfully demonstrated and presented here. The results shows that it is feasible to design integrated circuit using conductivity of liquid. By systematic transformation from solid state to liquid state, the presented research has been developed. The different density liquid has been utilised for experiments to check the stability of the liquid and it also shows desired response. The claimed research could be viewed as first step towards human machine interface. With the help of medical people, liquid based implantable circuit could be investigated using the similar concept therefore said research could be considered as the bridge between electronics engineering and biomedical science.

  

**Acknowledgement**

Authors are extremely thankful to Charotar University of Science and Technology (CHARUSAT) for providing resources and support.

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