ABSTRACT

Molecular communication (MC) has emerged as a new domain of communication and networking that operates at nanoscopic to macroscopic scale. MC uses molecules to encode, transmit and receive data. This model is inspired by biology, where cells employ MC to establish both intra-cellular and inter-cellular information links. With current research focus to interconnect the molecular communication environment with external environment, it is imperative to design external devices working on molecular communication schemes to be interfaced with in-vivo molecular network. However, diffusion based MC suffers from various limitations related to range of communication, synchronization between transmitter (T_x) and receiver (R_x), and low information rate arise in a diffusion based system due to uncertainty in propagation and type of channels which are mostly concentration based or timing based. These issues are addressed by novel Dielectrophoresis (DEP)-based relay model proposed in this thesis.

In first work we model T_x and channel that can be interfaced with Lab-on-Chip (LOC). The T_x is modeled by a DEP based three electrode sorting device, which sorts at least two information molecules from heterogeneous population. After segregation information molecules are stored separately, and can be released into the channel with predefined sequence. The microfluidic channel is embedded with interdigitated electrode pairs, along the length of microfluidic channel, which when energized by the asymmetric potential capable of transporting molecules released by T_x in the same order, in which they are released from T_x.

To avoid synchronization between T_x and R_x, it becomes imperative to use in-sequence delivery of molecules. However, due to uncertainty in propagation they may not arrive in-sequence. To over come this limitation, DEP planar electrodes are modeled as relays used in telecommunications. We describe the theoretical system model and analyze the effect of introducing DEP relays in diffusive channel in terms of probability of in-sequence delivery of molecules. Then we derive the minimum distinguishable distance required between two molecules for maintaining the sequence at R_x and for avoiding Inter symbol interfernce (ISI). Further, using these probabilities and minimum distinguishable distance we derive the expression for information rate for the molecular communication system assisted with DEP based relays.

In the last part of our work, we characterize DEP relay assisted MC system using analogue transmission line. The transmission line technique is used to evaluate the reflection and transmission coefficient which are used to determine signal strength at any node. The concentration signal in diffusive channel is subjected to frequency dependent attenuation. In order to show the attenuation in concentration signal due to in diffusive channel. We analytically derive the concentration profile of information molecule in microfluidic channel subjected to frequency based attenuation without DEP phenomena. To study the frequency response of information molecules diffusing between two consecutive

electrodes towards R_x we derive the transfer function of inter relay segment of DEP relay assisted MC system using transmission line parameters.

Keywords: Molecular Communication, In-Sequence delivery, Information rate, Channel Capacity, Transmission line, Dielectrophoresis, Relays, Lab-on-Chip (LOC), Attenuation.