FPGA based Magnetic field control for guiding Magnetotactic bacteria

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Abstract

This poster describes a prototype for guiding the bacteria through the control of magnetic field along a known path. These bacteria can be used in applications like MEMS and Micro total analysis. FPGA is used for the control of magnetic field and ultimately bacteria is guided along the magnetic path.

Introduction

Magnetotactic bacteria (or MTB) are a group of bacteria that orient along the magnetic field lines of Earth's magnetic field. These bacteria have organelles called magnetosomes that contain magnetic crystals, which aid in aligning with the magnetic field. MTB's can be used in various applications like MEMS, Micro Total Analysis Systems and lab-on-chip.
Magnetotactic bacteria can be guided along a predefined path by controlling the magnetic field. Magnetic field can be created using solenoid coils and the field strength is varied by changing the current through the coil, these bacteria can sense the magnetic field and can align itself towards the field to move towards the North Pole. By changing the magnetic field along a predetermined path, these bacteria can be guided. We propose an idea to control the path of Magnetospirillum magneticum (AMB-1) that can be used in drug delivery systems.

Materials and Methods

We used a 44 AWG coil of thickness 50 micrometer to make a tiny mesh that creates a path for the bacteria by creating the magnetic field. Altera DE2 board is used to provide the current supply for the coil and also to change the direction and the strength of magnetic field. We used the AMB-1 Magnetobacteria for the experiment.

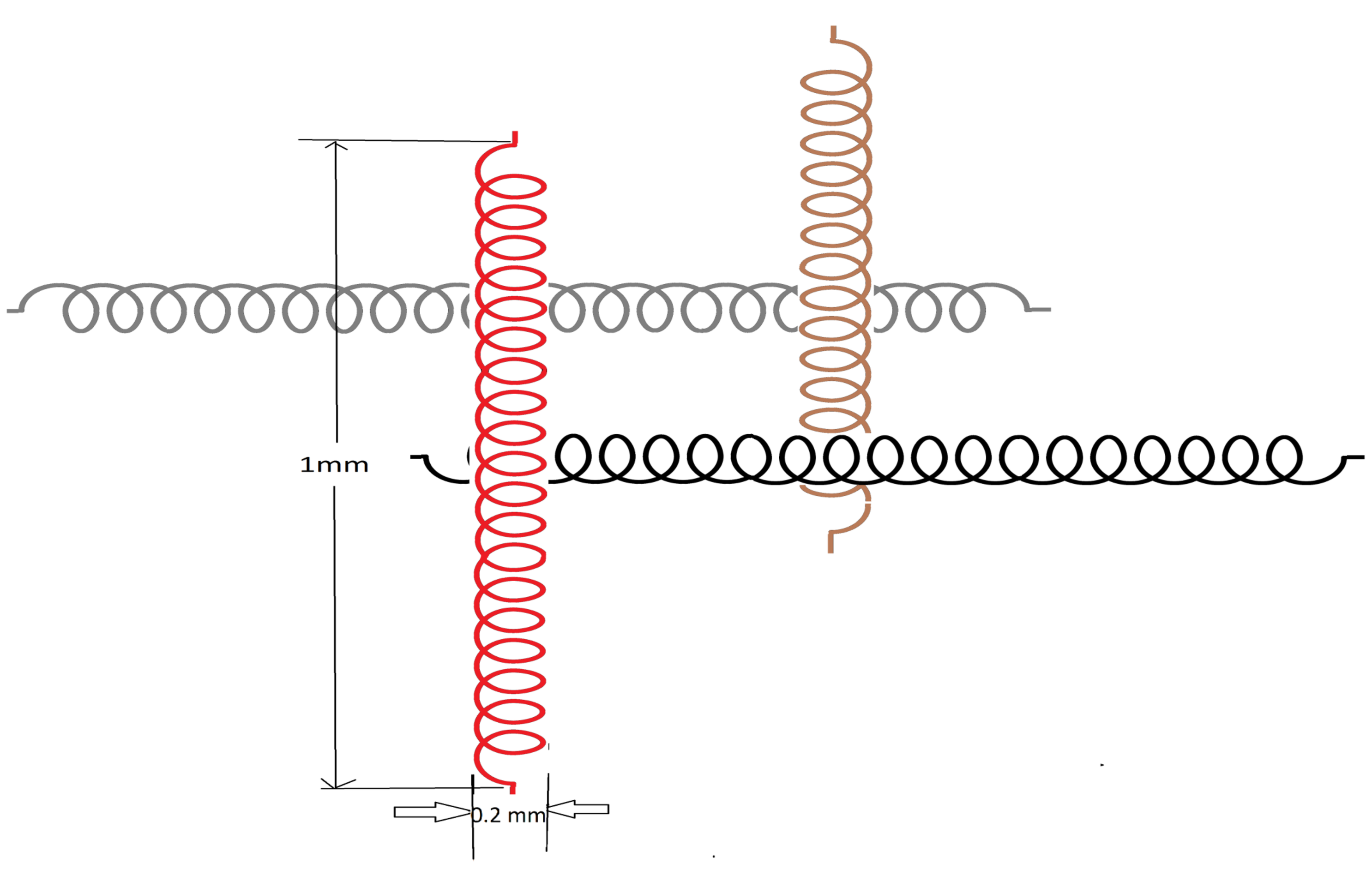


Figure 1: 2x2 mesh design

FPGA device

Field Programmable Gate Arrays are an integrated circuit that are reprogrammable. They are configured using the Hardware Description Language like verilog and VHDL. FPGAs contain an array of programmable logic blocks and an hierarchy of configurable interconnects that connects the logic block together. The logic blocks has the memory elements in which the code used to configure the device are stored.

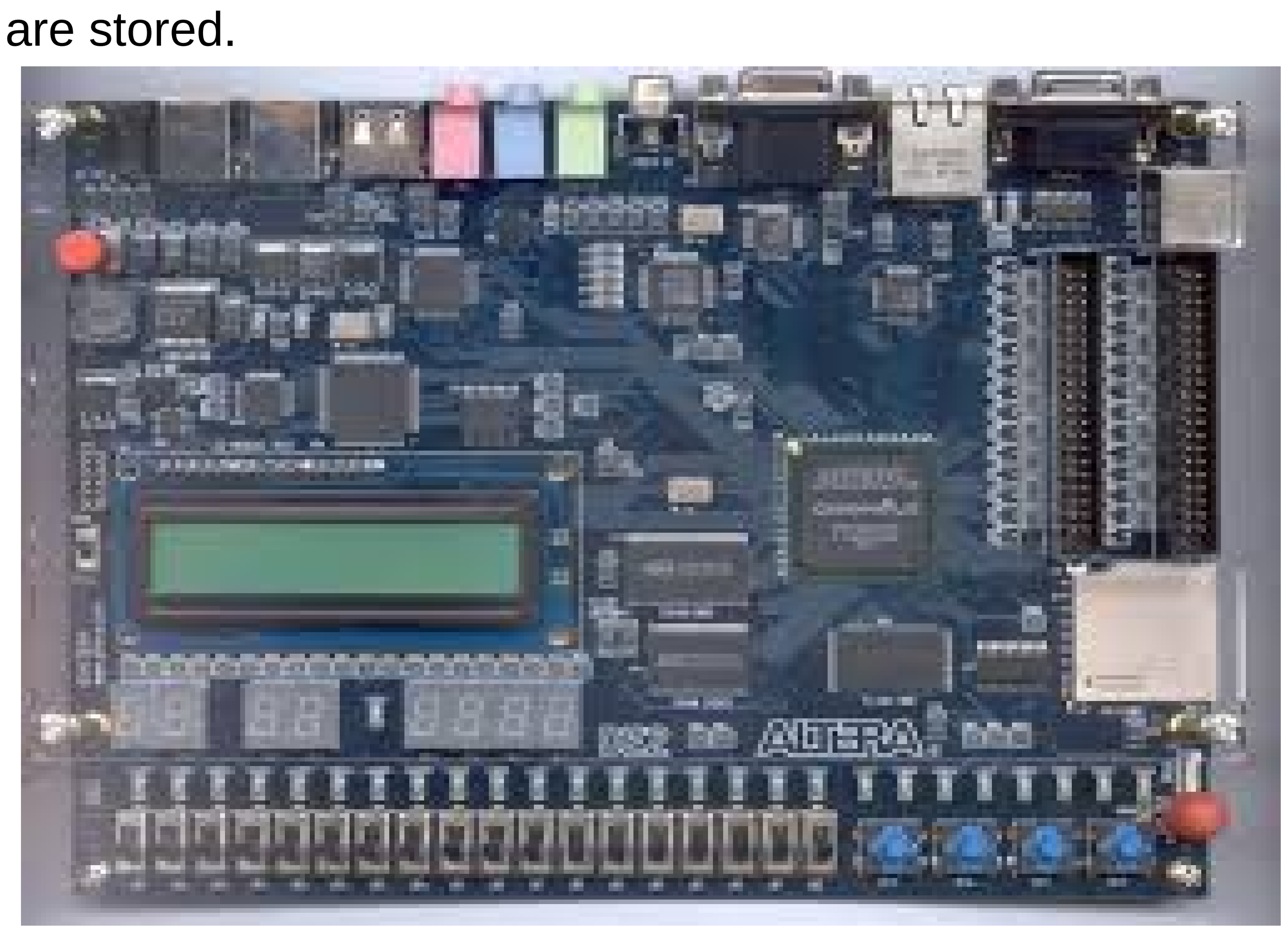
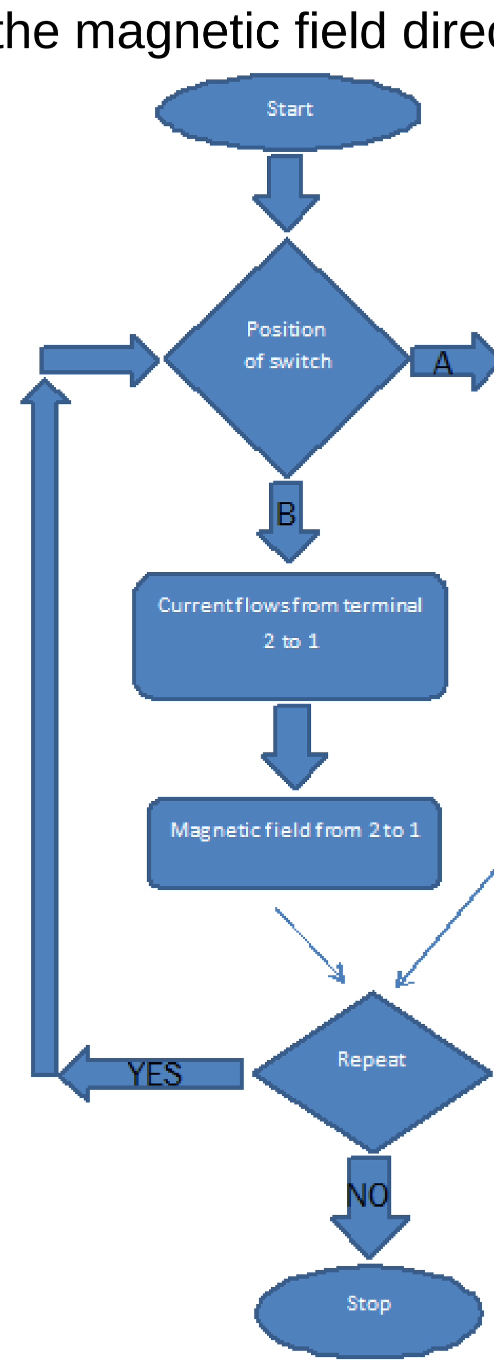


Figure 2: FPGA device – Altera De2

Configuring FPGA

The FPGA logic blocks are configured using verilog language. The device is configured to pass current through the 44 AWG coil. The current through the coil generates the magnetic field. The point of entry of current in the coil acts as a south pole of magnet while the away point in coil acts as north pole. The device is also configured to vary the direction of current flowing through the coil, which changes the magnetic field direction.



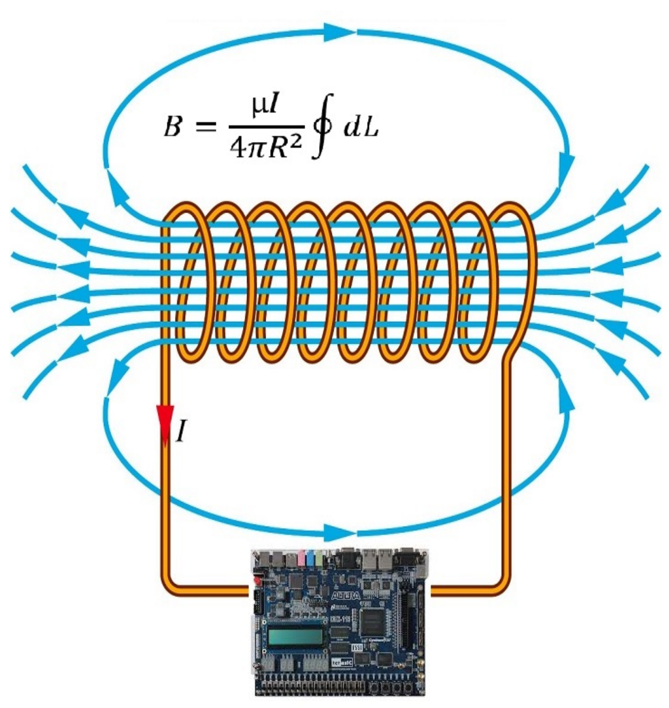


Figure 4: FPGA experiment

Figure 3: Algorithm

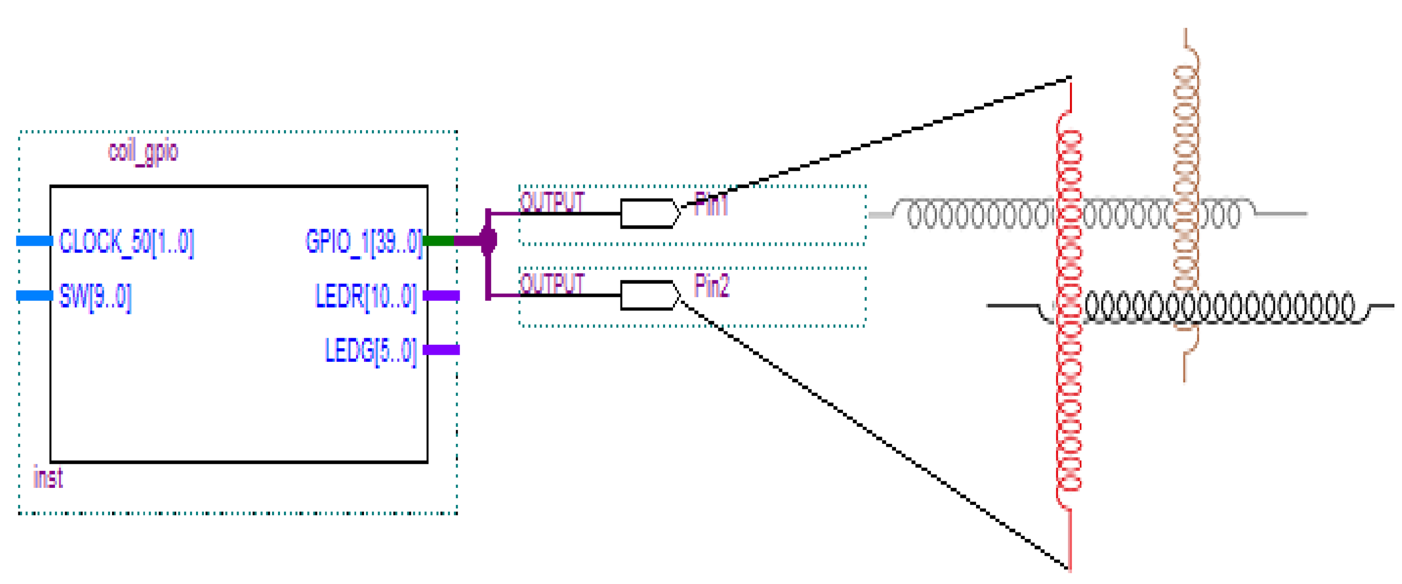


Figure 5: Schematic design of FPGA Configuration

Discussion

We have made a very small mesh to create a path for the bacteria to move. We used FPGA board Altera DE2 to pass the necessary current through the tiny coil and also able to change the current direction in the coil and presence of current in particular portion of mesh alone. We can also sense the magnetic field generated by the coil.

Conclusion

We focus on making an FPGA mesh for guiding the MTB by controlling the magnetic field generated by the mesh. We also focus on implementing this idea for making a programmable drug delivery system using bacteria.

Acknowledgements

1) Walder André, Sylvain Martel, 'Acting on Nanoparticles Embedded in magnetotactic Bacteria to Implement Propulsion and Steering for Microrobots, International Conference on Nanotechnology, August 2 - 5, 2007, Hong Kong

2) M. Godoy, A. J. Moreno, et.al, Micrometric periodic assembly of magnetotactic bacteria and magnetic nanoparticles using audio tapes, JOURNAL OF APPLIED PHYSICS 111, 044905 (2012).