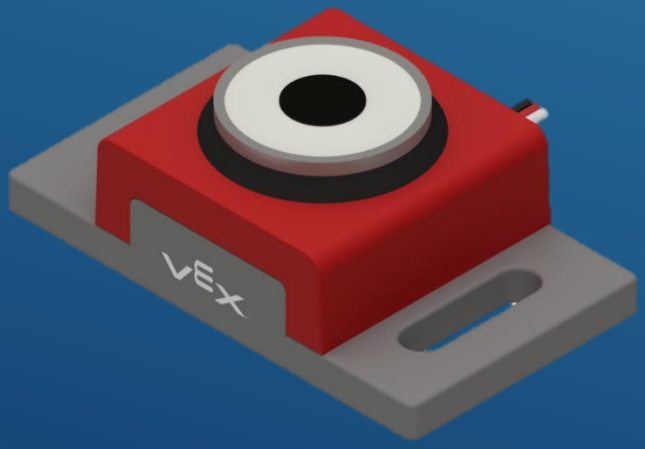
VEX ELECTROMAGNET

Make It Real CAD Engineering Challenge



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CONTENT

INTRODUCTION

One of the greatest obstacles of vex robotics competition are the size limitations, that's why many teams design complex deployable mechanisms to expand beyond the limits after the start of the match, however many times is really difficult to build them without using motors or pneumatics. Instead with a simple programmable command the electromagnet will shut off releasing the mechanism and let gravity or some rubber bands do the rest.

The VEX electromagnet is thought as a new and versatile actuator for many different applications in vex robotics, especially when is necessary to hold different mechanism and release them at a certain time in the simplest way.

DESCRIPTION

An electromagnet is a type of magnet in which the magnetic field is produced by electric current. An electric current flowing in a wire creates a magnetic field around the wire (see fig.1). To concentrate the magnetic field, in an electromagnet the wire is

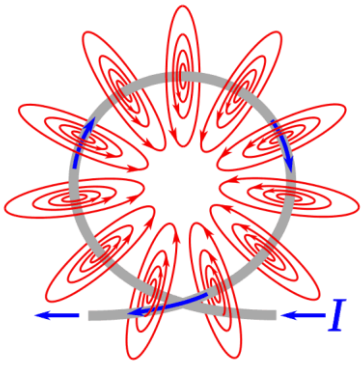
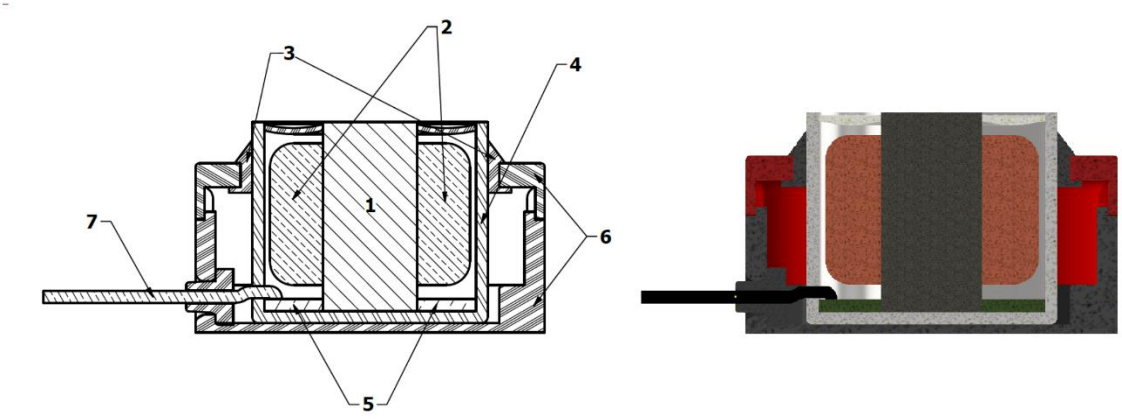


Fig. 1

wound into a coil with many turns of wire the magnetic field of all the turns of wire passes through the center of the coil, creating a strong magnetic field there

The VEX electromagnet is a simplified and smaller adaption to VEX robotics from many electromagnets used as door holders. It can be used to attract and hold any steel vex part like c-channels or plates but it cannot attract the aluminum or plastic parts.

Components Description



Please refer to annex 2

The drawing show a cross-section of the electromagnet with the important components highlighted. The ferromagnetic iron core (1) is surrounded by the copper coil (2) inside of the Steel Cylindrical Wall (4) which is fixed to the plastic structure (6). The plastic structure (6) includes the mounting holes for

mounting the electromagnet to a VEX part. At the top part of the Steel Cylindrical Wall (4) the rubber support (3) keeps it in place while protect the plastic structure (6) from radial forces. The 3-Wire Cable (7) transmit the current from the VEX cortex microcontroller digital output to the circuit board (5) on which is mounted the power control circuit (not specified) of the electromagnet

Technical Specifications

- Compatible with all VEX Microcontrollers and 3-Wire Extension Cables
- Weight: 43 grams (Calculated using inventor)
- Compatible with VEX ARM® Cortex®-based Microcontroller Digital Outputs.
- Input:

  Black: ground

  Red: power input

  White: control signal
- Approximated holding force: 20 newtons (2 kg)
- 3.3 volts supply
- Attracts any vex steel part

Force exerted by magnetic field

The attraction force in Newtons between the electromagnet and a normal VEX steel part is simplified by the equation:

$$F = \frac{\mu^2 N^2 I^2 A}{2\,\mu_0 L^2}$$

μ = Magnetic permeability of the Iron core ≈ 2.4π x10^{-3}

N= Number of turn of the coil

I= Electric Current in Amperes = 0,001 (connected as a digital output)

A= Cross-sectional area of the Electromagnet in square meters = π x10^{-6}

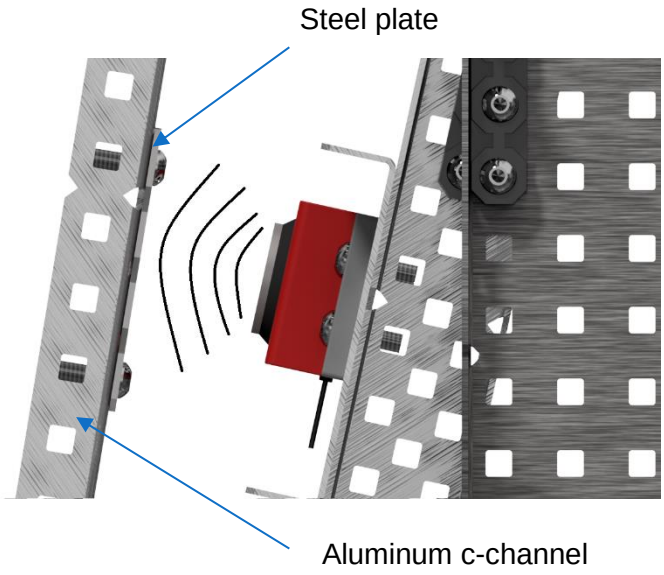
μ_0 = Magnetic Permeability of free space ≈ 4π x10^{-7}

L= length of the electromagnet in meters = 0, 0016

A and L are measured directly using inventor, the electric current of a digital output of the VEX cortex microcontroller is found on the official specification. The force depends on the number of turns of the coil, applying the formula we obtain that 800 turns are enough to produce approximately 20 newtons force, equal to 2 kg weight

HOW THE PART WOULD BE USED?

The electromagnet can be used to attract and hold any steel vex part like c-channels or plates, if is necessary to use it with a non-ferromagnetic part such as aluminum or plastic is enough to add a small steel plate to be attracted by the electromagnet.



The plate should be as paralel as posible with the electromagnet when they are making contact.

A single electromagnet can hold a 2kg weight structure but more can be used together at the same estructure to multiply the holding force .

Programing

The vex electromagnet can be programed as a digital output similar to pneumatic solenoid.

Here is an example using robotC:

```
#pragma config(Sensor, dgtl1,  electromagnet,  sensorDigitalOut)
//*!!Code automatically generated by 'ROBOTC' configuration wizard               !!*//


//                                        sample program
//
//     hold an estructure with the electromagnet and release it at the 5th second of the match


//++++++++++++++++++++++++++++++++++++++++++++++++| MAIN |++++++++++++++++++++++++++++++++++++++++++++++++
task main()
{
  SensorValue[electromagnet]=1;         //Turn on the electromagnet

  time1[T1]=0;                         //set time to 0 at the beginning of the match

  while (true)
  {

    //...

    if(time1[T1]==5000)                  //wait for the 5th second of the match
    {
      SensorValue[electromagnet]=0;     //Release the elctromagnet
    }

  }

}
//++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

HOW INVENTOR WAS USED?

Software version used: Autodesk inventor professional 2017

In this project we started modeling the plastic structure based on the available VEX sensors. Next we model all the internal components according to force the calculations taking care that everything fits correctly, we found very useful the project geometry function to speed up the sketches. And finally we proceed with the assembly.

Rendering

For rendering the images we used ray tracing to get realistic views of the model, for the animation we used the inventor studio environment, and the presentation block for the exploded view

Drawing

We used the drawing function to present some measures of the assembly and to show all the important components in a cross-section view.

CONCLUSION

What We Learned?

We have been competing in this challenge for about 3 years and every time we greatly improve our skills in modeling, simulation and presentation. This time even if the model was relatively easy, we were very careful with details to present it in the most professional way and so we learn to use many new functions and characteristics of the program.

Also we made a huge research about electromagnetism much further than we learned in school because we know this new part idea requires a lot of supporting information.

We will surely use everything we learned here in the future both in the robotics team and in our college and professional career. And Inventor will be an essential tool to shape all our engineering ideas.

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