Reverse Engineering Online Challenge:Deconstruction of the VEX IQ Brain

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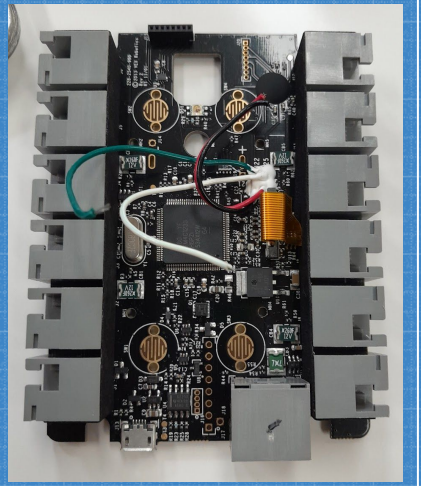
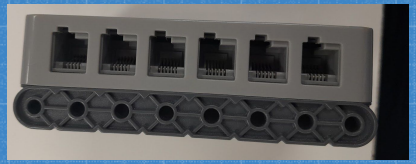
Introduction

When brainstorming ideas for the Reverse Engineering Challenge numerous options came to mind for electronics that could be taken apart. One that stood out to us was the VEX IQ Brain. The VEX IQ brain is arguably the most crucial component of the robots in the VEX IQ robotics competition. Without it our robots are merely clusters of vex pieces assembled into something we call a robot. We can write endless lines of code, but without the brain its useless. Luckily our teacher had a dead Gen 1 VEX IQ brain which would not only allow us to delve into the powerhouse of our robots but also possibly compare the Gen 1 and Gen 2 brains.



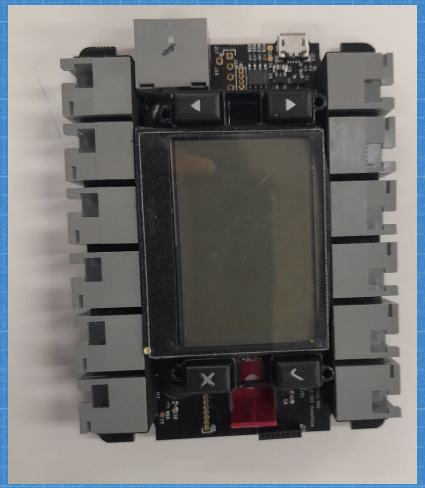
VEX IQ Robot Brain(Gen 1)-A glimpse before destruction



To begin with we started with a Gen 1 VEX IQ Brain, we made sure it didn’t function by testing it with multiple batteries.As you can see the plastic casing is still intact, so there has been no prior tinkering with the brain.

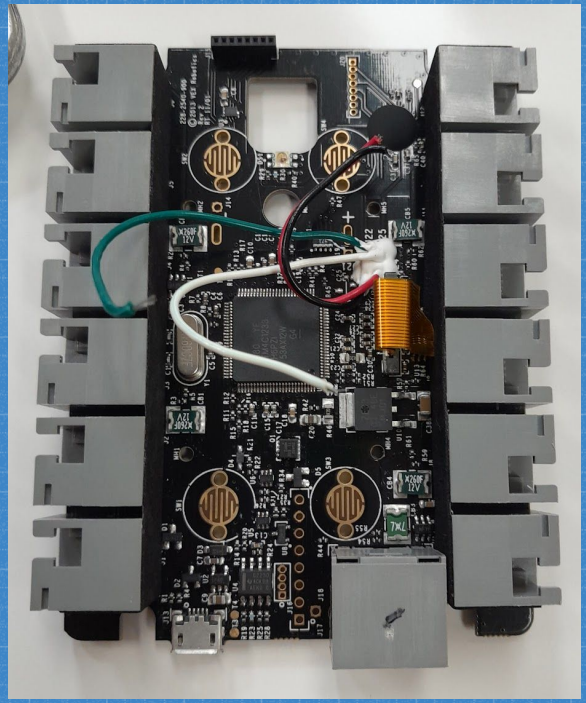
Deconstruction Process

Start

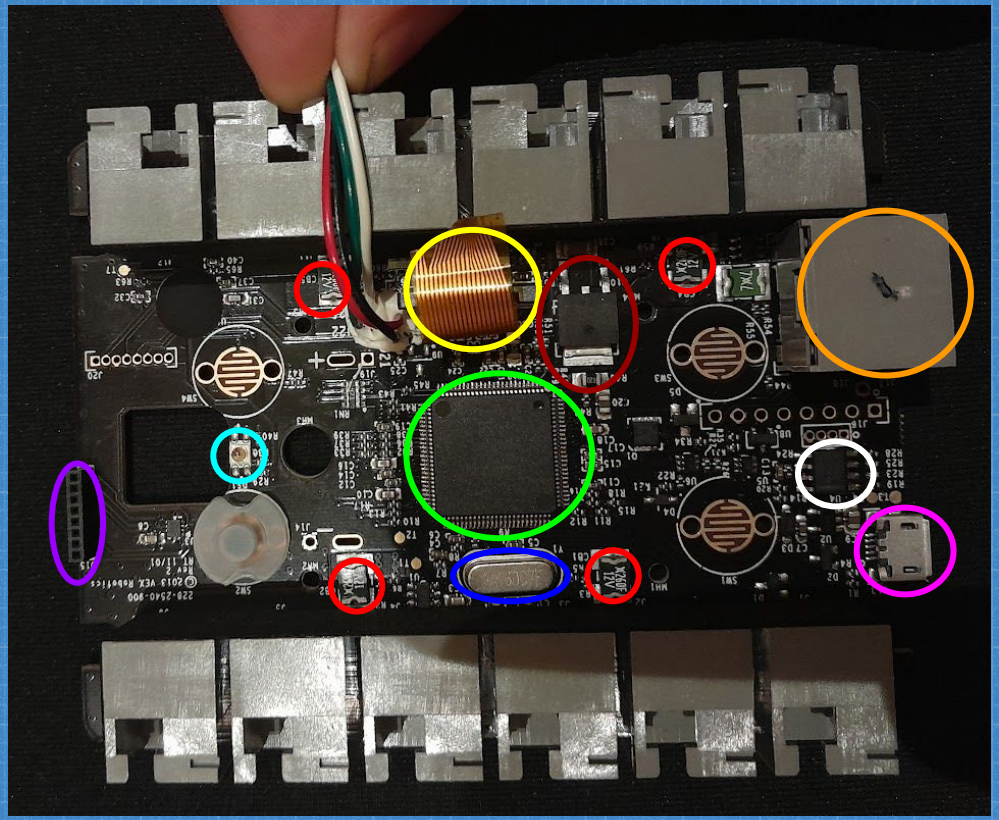


Case
Removed

LCD Screen Disconnected + Buttons removed.
Motherboard-
End of Deconstruction



Frontside Components of VEX IQ Brain



Key:

= Resettable Fuse

= Microcontroller

= Crystal Oscillator

= FPC Cable

= LED

= Radio Module Connector

= Tether Port

= Micro USB Port

= Shift Register

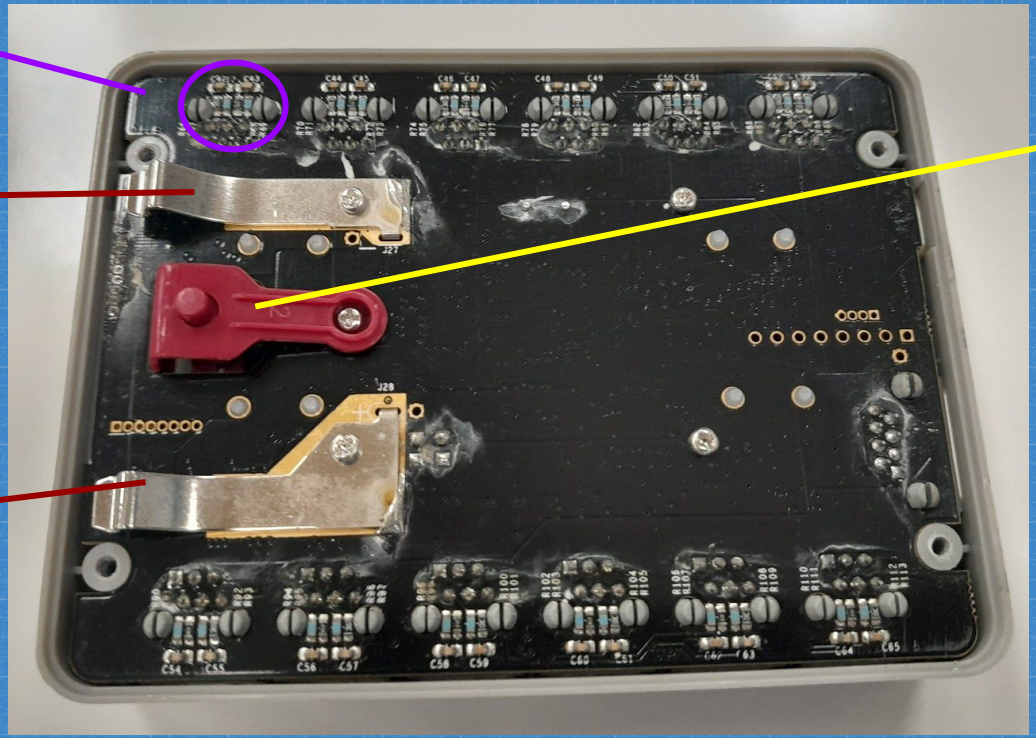
= Memory Chip

Components of a VEX IQ Brain(Backside)

Group of Resistors and Capacitors

Negative Battery Connector

Positive Battery Connector



Radio Module Ejector
Used to eject the radio module,this is done by pressing the red button on this ejector.

Image of the backside of brain with cover

Components of a VEX IQ Brain

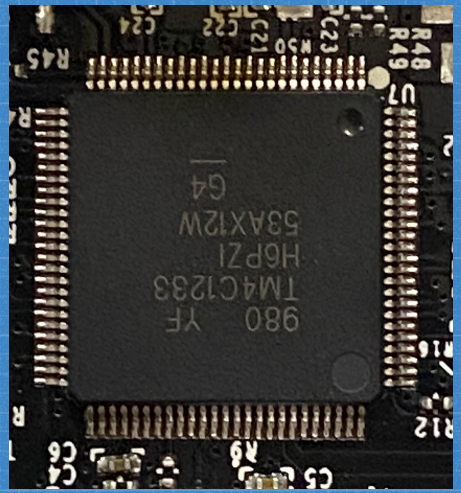
LCD(Liquid Crystal Display) Display

The LCD Display on the VEX IQ Brain acts as a simple display to show information. It is the main and only visual component on the VEX IQ Brain that the user interacts with as well. What is displayed on the screen is controlled by the buttons.

16 Ohm 0.5W Internal Magnet Speaker

This is the speaker used for all the iconic beeps that comes from the brain, they are all produced from this little magnetic speaker tucked away on the backside of the LCD Display.

Components of a VEX IQ Brain



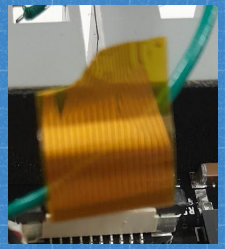
Texas Instruments Tiva TM4C1233H6PZ Microcontroller

The microcontroller is the brain of the brain,it takes in inputs, process them, and then provides outputs,and this is all done at a speed 80 mhz,which in a roughly 100 million operation per second. Its vital to have a powerful microcontroller for the VEX IQ Brain as it manages various tasks,input from the wireless controller, input from the 12 ports,running students code,displaying information on the LCD Display, and working with other components of the motherboard to achieve tasks. A microcontroller has a CPU and all its peripherals under one chip, compared to a microprocessor where it has a more powerful CPU but has to rely on external peripherals. So in terms of the VEX IQ Brain being a small device where space is a constraint and not a lot of processing power is needed, the microcontroller is the better option.

Specs of the Microcontroller:

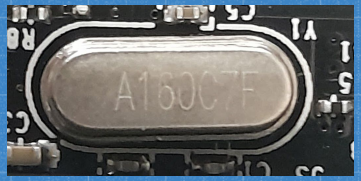
- **Frequency (MHz)80**(Computation power)
- **Flash memory (kByte)256**(non-volatile memory storage,meaning even if the brain shuts down it will keep the data,ex:code is stored here)
- **SRAM (kByte)32**(Static Random Access Memory,memory used for storing active data,faster than DRAM)
- **ADC type 12-bit SAR**(Analog to digital converters)
- **Number of GPIOs** 105(For managing inputs and outputs)

Components of a VEX IQ Brain

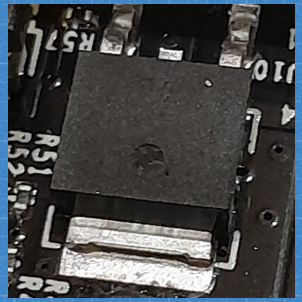


FPC Cable
An FPC cable is a flexible printed circuit.This FPC Cable was used as a connector between the LCD Display and motherboard.

Resettable Fuse
While the Resettable Fuse use may not be visible to us when interacting with the brain, it helps protect the brain from overcurrent faults that could damage the circuit,making them essential to the health of our brains. There are 4 of these located on the brain's motherboard

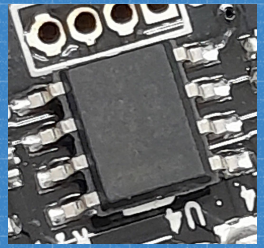


Crystal Oscillator
Crystal Oscillators have many uses, but for the VEX IQ Brain is is used mostly to provide a steady clock signal which is needed to help synchronize the many components on the motherboard which make up the brain.



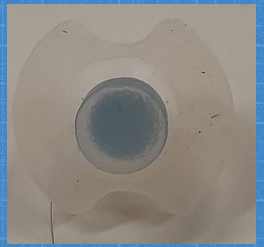
Memory Chip
A memory chip provides storage for programs and data, and it does just that in the VEX IQ Brain storing codes,software, and more.

Components of a VEX IQ Brain

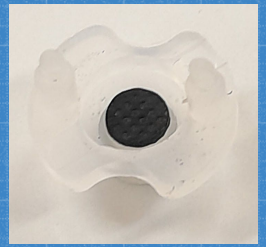


Shift Register
An shift register is a digital circuit that stores and moves that data serially.It can be used in a variety of applications, one common application that can relate to the VEX IQ brain is the use of the shift register with a LED Display. In this case the shift register would play the role of managing the data shown on each individual LED that makes up the LED Display.

Buttons



Rubber Piece



Conductive Pad(Backside of Rubber Piece)

Metal Contact(Switch)-
This would go into the switch category of motherboard components as thats how its marked on the motherboard with a SW.

External Button Plastic Piece

The mechanism that makes all 4 buttons function uses all these 4 components. The external plastic piece is the one the user interacts with, the one that we push. That push, pushes down on the rubber piece, this leads to the black conductive pad(backside of rubber piece) to be pushed down, causing it to come in contact with the metal contact/switch on the motherboard.The contact/receiver takes the input and sends the signal using the various components of the motherboard which leads to an output of some kind.

Components of a VEX IQ Brain

LED
On the motherboard there is a led light which is used to help indicate the status of the brain. To help the light be visible all the way to the top of the brain where the user interacts with it, a clear plastic piece(might be magnified) is used to let the light shine through directly to the top where there is a slot for the light to be visible to the user.

Tether Port
The tether port is used for wired communications with the controller, and for controller charging.

USB 2.0(Micro USB) port
The micro usb port has many uses as essentially any wire with a micro usb end can plug in. One main use of it is to connect a laptop to the brain for downloading code and updating firmware.

Radio Module Connector
The radio module connector is what its name says it is.The connector for the radio module. We did not have a radio module in class to test how it connects, or functions with the other parts like the radio module ejector. However using images of the radio module, we can infer that it connects into this port/connector shown on the left as there is a gap for something to be inserted on the radio module, and the only thing on the motherboard that is that tall and wide is this port/connector.

Smart Ports
The brain has 12 smart ports on 2 sides. These ports are used for connecting any other electronic VEX IQ components to the brain.

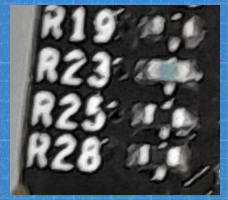
Components of a VEX IQ Brain

Semiconductor Devices

The motherboard of the VEX IQ Gen 1 Brain, like many other motherboards, is filled with a variety of semiconductor devices. All those tiny little black and grey components are all semiconductor devices. There are many different types of semiconductor devices that could be seen on this motherboard from transistor, to resistors, to diodes, the list is endless. All these components play a role in managing electricity and the flow of electricity throughout the motherboard.

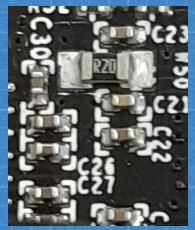
Resistors

On the motherboard there a lot of components marked on the motherboard with an R. These are resistors, they play a role in limiting and regulating the flow of electricity within the motherboard.



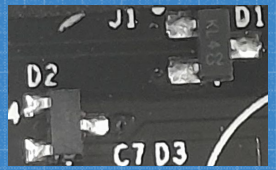
Capacitors

On the motherboard there a lot of components marked with a C, these are capacitors. They play the role of storing and releasing energy.



Diodes

On the motherboard there a few components marked with a D. These are Diodes. Diodes allow electricity to flow from one direction but restricts flow from the opposite direction.



Summary of Components of a VEX IQ Brain

Through the deconstruction process were exposed to multiple new components and their functions and roles within the VEX IQ Brain.wWe gained an understanding of how even the tiniest components like resistors, capacitor, and diodes are vital to brain being able to function as they are essential to the control of the flow of electricity within the motherboard. We also figured out how certain unique things about the VEX IQ brain occur, like the sounds that come from the magnetic speaker, the light that comes from the LED, and how the LCD Display functions along with the buttons. Along the way we found lots of other components that were also critical to the function of the brain, like the crystal oscillator, memory chip,resettable fuses, and shift register. There are also lots of connectors and ports on the brain as well, where without them the brain would have limited functionality. This includes, smart ports, micro USB,tether port, radio module connector, and the FPC cable. On the backside we found there to be the components that interact with the battery and the radio module ejector. It's important to note that the variety and amount of components on the motherboard are endless, and we tried our best to identify some of the most important ones, some are too small to put a name to the piece.

Gen 1 vs Gen 2 Comparison

When we were first presented with a VEX IQ Gen 1 Brain we were not only excited to see what's inside, but we also wanted to see if we could compare it to a Gen 2 Brain and see what they changed internally. However due to limited resources on VEX IQ brains we could not find images of the internals of a VEX IQ Gen 2 brain, and we didn’t want to take apart a useable brain that we had in class. So we just did some research to see some changes that were made.

- One difference that is visible externally is that the Gen 2 brain does not include a radio module feature like the Gen 1, instead the wireless compatibility is built-in.
- The second, probably most significant difference, is the gyro sensor and capability. In the Gen 1 there was no internal gyroscope or accelerometer, instead it was outsourced to a Gyro Sensor, which had a 1-axis gyroscope. However in the Gen 2 brain there is a 3-axis gyroscope and 3-axis accelerometer located within the brain.
- Replaced LED Display from Gen 1 for a Color Screen
- MicroSD Card Slot added in Gen 2
- 4x speed, 12x ram, 32x flash compared to Gen 1 Brain, meaning the microcontroller must have improved.

Apart from that we can assume that most internal components stayed the same between the Gen 1 and Gen 2 VEX IQ Brains.

Conclusion

While reverse engineering the VEX IQ Gen 1 Brain we learned a lot. The challenge gave us a chance to develop some of our engineering skills, for example being able to identify pieces, attention to detail, hands-on technical skills, conducting research, and compiling a report.We also learned about a variety of different components used in the VEX IQ Brain,that are also used in other electronics. We learned why these components are needed and what are their functions and roles within the VEX IQ Brain. This challenge also provoked us to do some research on the differences and similarities between the Gen 1 and Gen 2 VEX IQ Brains. Overall we learned a about a variety of different electronic components that make up the powerhouse of the entire VEX IQ competition. The VEX IQ Gen 1 Brian may seem complicated at first, but digging in helped us understand what is happening underneath the hood, how even the tiniest of components are essential to the function of the VEX IQ brain.

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