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# **MicroMaster**

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**Abstract**

Ever since I can remember, I have been fascinated by electronics. There is something about it that is indescribably cool to me about electronic machines. But its not the machines themselves that fascinate me, it is the power to create and manipulate them that causes a chain reaction of dopamine, bringing a sense of satisfaction or accomplishment. Not everyone feels this way, but some do and there is no explanation why. We are all born different from each other, and some of us were born to be engineers. For some of us, the only way to achieve fulfillment or satisfaction in life is to create. It becomes a hunger, a need, and a drive. But all too often, all over the world, a lack of access to education and materials prevents a disproportionate number of youth from making it a reality.

I would consider myself privileged, in that I had access to electronics at a young age. My family didn’t have much money for education and educational materials, but my father was a car mechanic. He would bring home spare electronic parts for me and I would create things. I made a hat with a fan on it and a headlamp. I was about seven years old. At the age of twelve, I was designing sophisticated websites, coding in HTML. But when I got to highschool, there were no classes on coding, no electives about engineering or electronics. I do remember being forced to read “Ethan Frome” and feeling every bit as desperate for something more as Ethan himself. Somewhere along the way, I got lost, but ended up finding myself as an infantryman in the 82nd Airborne.

Some people bring Bibles to Afghanistan, but I brought “Godel, Escher, and Bach” by Douglass Hofstadter and read it in foxholes. I remember looking through the library of books that was donated to us and finding “The Soul of a New Machine” among Tom Clancy novels and Cliff Kusslers. Even in the darkest of places, a dream can be kept alive with the right materials and I am living proof.

I have seen the efforts of mankind to create a better world through force and I am hardly convinced that it can be done. However, I am not convinced that it can’t be done. Did Douglass Hofstadter not improve my world? Did I not relate to the drive and passion of the characters in The Soul of a New Machine? It can be done, but it can’t be done if we cater only to the privileged.

Talent and drive are qualities that are equally distributed across every demographic and across every income level. Therefore, in order to create an ethical educational product, it must be affordable, accessible, compatible, and of the highest quality. Believing isn’t the same thing as knowing, but what I do know is that it is possible to create an educational tool that meets these criteria, and what I believe is that the MicroMaster Mini can inspire and empower engineers all over the world by providing them with a tool that is not only educational, but also something they will use throughout their entire career.

**Introduction**

Over the past 20 years, there has been an explosion in hobby and amateur embedded programming and development with the advent of inexpensive and easy to use prototyping platforms like Arduino and Raspberry Pi. Although these prototyping platforms help flatten the learning curve for embedded programming and prototyping, the learning curve is still rather steep and possibly beyond the reach of a typical high school student or even a college student that is not an engineering major. Writing embedded programs is a long and sometimes arduous process, especially for a beginner.

An embedded device typically consists of a microcontroller and peripheral devices that “talk” to the microcontroller using any one of a number of communication protocols. Over the past 15 years, there have been several open sourced devices developed that can emulate a microcontroller and talk to a virtually endless list of peripheral devices such as servos, real time clocks, and sensors of every variety. These devices, the Bus-Pirate, the Shikra, and the Hydrabus, are all derivative of each other and all use the same clunky interface that may take hours to set up and learn from. Often times, it is easier for an engineer or student to simply write their own code than to try dealing with the complexity of the Bus-Pirate interface. As an engineer who owns a bus-pirate, I can tell you that every time I am forced to use this device, it takes at least a half an hour worth of combing the internet for instructions on how to make it work and I have used it many times in the past. Although these devices are supposed to make it easy for developers and students to test and operate peripheral devices, the juice is often times not worth the squeeze and these devices end up collecting dust on a shelf or shoved in the back of a parts drawer, instead of on the desk where they belong.

The MicroMaster Mini is a device that is under development by MicroMaster LLC that intends to change all that and put the power of these devices in the hands of students and engineers at an affordable cost. Its highly intuitive interface can be understood by a child, with no manual required. But make no mistake, the MicroMaster Mini is also a professional engineering tool that a young engineering student will use throughout the course of their entire career. The MicroMaster Mini saves professional engineers time and money by demystifying the interface of the Bus Pirate with a highly sophisticated serial terminal interface. All this is made possible by a device that costs less than a textbook or a graphing calculator, bringing it well within the financial reach of high-school and college students who are interested in learning about electronics as well as professional engineers interested in a tool that will save them time and money. If the MicroMaster Mini saves an engineer an hour of development time, it has paid for itself. If the MicroMaster Mini can reach a generation of aspiring engineers, then it will prove to be invaluable.

The role of a MicroMaster Mini in embedded engineering is to confirm that the programmer is using the correct transaction sequence to communicate with the device in the way that they intend. It often times behooves an embedded engineer to use a device like this before they begin writing code, so they can confirm that the code they are intending to write will work with the device. Once code has been written, it often doesn't work. The MicroMaster Mini is a multi-featured tool, which can also help diagnose problems in a working system. Due to its real time operating system and sophisticated (in that it is easy to use) interface, the MicroMaster Mini can also serve as a “test-bench” of sorts, to confirm that an embedded system is operating as it is supposed to.

The MicroMaster Mini aims to solve the biggest problem facing the Bus-Pirate, Shikra, and Hydrabus, which is that they are difficult to use and take time to implement. The MicroMaster Mini on the other hand, is a device which can be understood and implemented in a matter of minutes instead of a matter of hours. The MicroMaster Mini requires no manual due to its integrated help feature. It can easily be understood by someone with no understanding at all of electronics, sparking a rich and fascinating journey into the realm of electronics and embedded engineering. All of its functionality is at the fingertips of the user, saving what matters most to all of us, time.

The MicroMaster Mini’s capacity for education in electronic engineering is vast. With only a few hours of training on a MicroMaster Mini, a student can gain a deep understanding of the way electronic devices communicate with each other, by seeing and controlling what is happening in real time. The MicroMaster Mini takes the knowledge out of a textbook and brings it to life. Education is not just about how much information can be crammed into a students brain, it is also about inspiring students to become. The MicroMaster Mini has the ability to spark a dream as well as help a student follow through with that dream as they delve into the world of logic, circuits, and code.

**Overview**

The MicroMaster Mini, like the Bus-Pirate, Shikra, and Hydrabus before it, is a small circuit board that communicates to a computer via a serial communications port. The user simply plugs it into a computer, opens up a serial terminal via a free application like Putty, and the user is ready to go. There is no additional software to install, but most importantly, a serial terminal is cost effective, bringing the cost of a $500 tool to a tool that costs $75 or less. Graphical User Interfaces (GUIs) are expensive to program and maintain, so a serial terminal interface is often preferred by engineers and students alike. A tool that could do everything a MicroMaster can do, but with a GUI, could reasonably cost up to $1000. Although serial terminal interfaces are arcane by today’s standards, they can put very powerful tools in the hands of programmers for less than the cost of a calculator.

The MicroMaster Mini’s serial terminal interface mimics that of a GUI, instead of the single command style prompt used by similar devices. A serial terminal interface must rely solely on the host computer’s keyboard for input and text characters for output so a mouse cannot be used. Command prompt style interfaces are inherently difficult to use and always require a manual, even for those who are familiar with the device. The MicroMaster Minis interface however, uses a system of “pages” (similar to pages in a web browser) which are easily navigable. Each “page” contains a useful diagnostic tool for a particular communications protocol. When the user presses “h” on any page, a screen will appear that explains precisely how to use the page and any caveats, pitfalls, or advice which are important to understanding how the device works. When the user presses any key, they are returned to the page. Although the MicroMaster is rich with features and is capable of doing a number of things other devices cannot, it is this ingenious interface which is the key factor in saving engineers and students time.

In addition to the basic functionality of the Bus-Pirate and Shikra, the MicroMaster allows the user to sequence, monitor, and change the format of transactions in real time. Other devices can simply send a single transaction to test functionality, but the MicroMaster Mini takes it another step further in allowing the user to send a sequence of transactions and monitor SPI and I2C transactions in real time. This is a significant improvement over the competition. Being able to monitor sequences of messages in real time allows the user to operate and test the device as it was intended. I2C and SPI devices are often very complicated and require this type of testing to confirm that they are working in the manner intended.

I2C is the most common communication protocol in embedded systems, particularly in the hobbyist world. The MicroMaster Mini is the only device in its price range that can handle a function of I2C called “clock-stretching”. Clock stretching is the most common reason people cannot get their I2C device to communicate, yet these devices which propose to be diagnostic devices cannot handle clock stretching and simply fail without warning when they encounter it. A device that can handle “clock-stretching” is invaluable to an embedded engineer. Not only can the MicroMaster send and receive messages that “clock stretch”, it can monitor and record those messages with a program called a sniffer. Once again, the MicroMaster Mini is the only device in its price range that can “sniff” transactions that “clock stretch”. In addition to that, the MicroMaster Mini can also shift its I2C voltage level between 1.8V, 3,3V, and 5V.

The MicroMaster Mini implements the CAN protocol with an onboard CAN transceiver. The most inexpensive CAN tool on the market, besides the MicroMaster Mini, is around $115 dollars. The hydrabus purports to work with the CAN protocol, but it requires an adapter, which does not exist.

The Bus-Pirate, HydraBus, and Shikra are all known as what is called “pen-test” devices or penetration testing. Penetration testing involves checking to see if information can be extracted from a microcontroller or microprocessor to test the security of the device. The MicroMaster Mini Version 0 will not have this capability, but we intend to add it to future releases. These other devices also work as programmers for certain microcontrollers and logic analyzers, however, they are not the best tools for these features and there are far superior devices for performing these tasks at a miniscule cost. As an engineer, I would not recommend using a Bus-Pirate or Hydrabus as an analyzer or pen-tester, so for that reason, these features have been placed on “the back burner” and likely won’t be available on the MicroMaster Mini until later releases.

The MicroMaster Mini will have a web based bootloader. What that means is that the user will be able to update the code from a website with the click of a button, instead of downloading software or using a Linux command prompt. This web-based bootloader will work on any operating system, with the only caveat being that the user must use Google Chrome or Microsoft Edge. This is a major improvement over the other devices in its class.

The MicroMaster Mini will have a rich online curriculum for both individual and classroom learning. The website will contain tutorials and experiments which can be performed at home or in a lab environment. The educational materials will be provided to the user for free.

**Specifications**

Note: These specifications are subject to change.

· Processor

o TM4C123GH6PM operating at 80 Mhz

· Protocols Available

o I2C

* Programmable Pull-ups
* SMBus compatible\*
* Adjustable to 1.8V 3.3V and 5V\*
* I2C address search
* I2C message sequencer and monitor\*
* I2C sniffer

o SPI

* Speeds up to 8Mhz\*
* Capable of the four modes of SPI as well as TI and MicroWire framing formats\*
* SPI message sequencer and monitor\*
* 3 Wire bi-directional protocol mode

o UART

* Adjustable to any speed between 300 and 115200 Hz\*
* UART message streamer with the ability to transmit a message while the UART is streaming incoming messages. The streamer can also be put into different modes including text, hexadecimal, and MIDI. \*
* Adjustable Parity bits and stop bits

o One Wire

* Search ROM algorithm
* Message Monitor and Sequencer \*

o CAN\*

* CAN sniffer\*
* Ability to transmit an receive messages simultaneously\*
* On-board CAN transceiver\*

· Additional Functions

o 4 General Purpose Digital Inputs\*

o 4 General Purpost Digital Outputs\*

o 4 Analog to Digital Converters\*

o 1 Pulse Width Modulation outputs\*

· Power Supply

o Up to 500mA of current

o Adjustable to 1.8V, 3.3V, and 5V\*

Bootloader

* Web based\*
* Encrypted (secure)\*

\* - Features with an asterisk represent features that are either expanded upon or absent in the Bus Pirate.

**Comparison with existing Products**

| **Feature** | **MicroMaster Mini** | **Bus-Pirate** | **HydraBus** | **Shikra** |
| --- | --- | --- | --- | --- |
| digital IO | x | x | x | x |
| ADCs | x | x | x | x |
| I2C | x | x | x | x |
| SMBus | x |  |  |  |
| I2C Sniffer | x | x | x | x |
| I2C level shifter | x |  |  |  |
| I2C monitor/sequencer | x |  |  |  |
| Adjustable Power supply | x |  |  |  |
| Two serial terminals | x |  | x |  |
| SPI sniffer | x | x | x | x |
| SPI sequencer/monitor | x |  |  |  |
| One Wire Protocol | x | x | x | x |
| One Wire Search | x | x | x | x |
| One Wire Sniffer |  |  | x |  |
| 2 wire protocol |  | x | x | x |
| 3 Wire protocol | x | x | x | x |
| CAN protocol | x |  | x (adapter) |  |
| CAN sniffer | x |  | x (adapter) |  |
| UART | x | x | x | x |
| AVR programmer |  | x | x | x |
| Flash Rom |  | x | x | x |
| OpenOCD |  | x | x | x |
| Script Engine |  | x | x |  |
| Black Magic Probe |  |  | x |  |
| LCD | x | x | x |  |
| OLED | x |  |  |  |
| Logic Analyzer |  | x | x |  |
| Oscilloscope |  | x | x |  |
| Scriptable with python |  | x | x | x |
| PWM | x | x | x |  |
| Still being developed | x |  | x |  |
| Current meter in power supply | x |  |  |  |
| Error logger | x |  |  |  |
| Real Time Operating System | x |  | x |  |
| Web Bootloader | x |  |  |  |
| Integrated Help | x |  |  |  |
| Modular | x |  | x |  |

**MicroMaster LLC**

MicroMaster LLC is a disabled veteran owned and operated small business based in Lynn, Massachusetts, founded in 2021. After the release of the MicroMaster Mini, MicroMaster LLC intends to keep developing the MicroMaster Mini as well as other MicroMaster products in the fields of microcontroller education and diagnostics. The following is a brief introduction to the main members of the company.



STEPHAN BOURGEOIS (PRESIDENT AND CTO)

Stephan Bourgeois is the President and Chief Technical Officer for MicroMaster LLC. He graduated from the University of Massachusetts Lowell with a degree in Electrical Engineering. Stephan is an expert in embedded firmware architecture and proficient in many other aspects of embedded systems engineering.



JOEL SURETTE (CEO)

Joel Surette Is the Chief Executive Officer for MicroMaster LLC. Joel graduated from Salem State University to complete his degree in Business Admin with a concentration on finance and a minor in Economics. Joel is an expert in financial management with great instincts for money management.



CAN ALTINELLER (PRINCIPAL HARDWARE ENGINEER)

Can (pronounced “John”) is the Principal Hardware Engineer for MicroMaster. He graduated from the Florida Institute of Technology. Can is an robotics software and hardware engineer, specializing in the TM4C123G processor, with two open source projects to his name

**Conclusion**

The MicroMaster Mini is a device that is affordable, compatible, intuitive, and of the highest quality. The MicroMaster Mini is a device that I wish I had as a child and a device that I would use as an electrical engineer today. The MicroMaster Mini is affordable enough to be distributed to schools all over the world. The goal of MicroMaster as a company is to create a rich online set of tutorials, experiments, and educational material to accompany students for both independent and classroom learning. Although the MicroMaster Mini is targeted towards students at the highschool level and beyond, this is a device I would have benefited greatly from at a much younger age. A professional engineer would also benefit from this device because of the time it saves compared to its competitors. Thus, the MicroMaster Mini is a professional grade tool that can be given to a child, at an affordable cost.

The MicroMaster Mini is not for every child. Not all children feel the intense desire to create electronic machines, but some do and those children are in every classroom all over the world. In order for the MicroMaster Mini to do the most good, it must be distributed homogeneously among humanity, not merely to the privileged few who can afford expensive educational materials. Children who have a fascination with electronics are a resource that should be fostered, not a market to be capitalized on. Although there is a real market for the MicroMaster Mini among hobbyists and engineers, students would greatly benefit from a rich online curriculum of tutorials and experiments regarding electronic devices. It is the goal of MicroMaster LLC to deliver the first MicroMaster Minis to underprivileged schools, not merely to bootstrap with the success of the MicroMaster Mini among the privileged, only to give away a small portion to charity.

The argument can be made that an expensive educational tool is unethical. Educational materials that are by design not within the reach of every student, promote inequality in STEM education whether good intentioned or not. The MicroMaster Mini has been designed to be within the reach of every student, or at least within the reach of charitable giving. MicroMaster LLC’s mission is to create a company founded on the principles of diversity and equality with a product that fosters both, while still creating professional grade products for students and engineers of every age, demographic, income, and skill level.