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Declassified Bonus Edition

A special edition curated by our first guest editor

sparkfun

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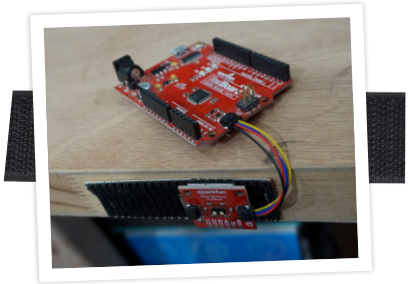
Drifting Trike & Exploring Mineshafts P.18



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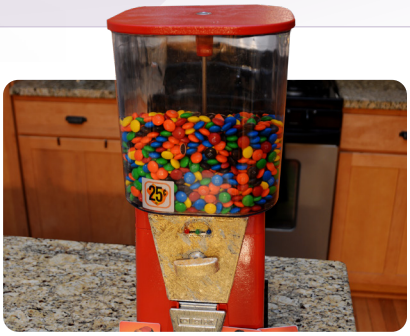

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Bonus Content to Volume 47, No. 506
March and April 2021

ISSN 1757-0875 (UK / US / ROW distribution)

www.elektor.com
www.elektormagazine.com

Elektor Magazine, English edition
is published 6 times a year by

Elektor International Media
78 York Street
London W1H 1DP
United Kingdom
Phone: (+44) (0)20 7692 8344

Head Office:
Elektor International Media b.v.
PO Box 11
NL-6114-ZG Susteren
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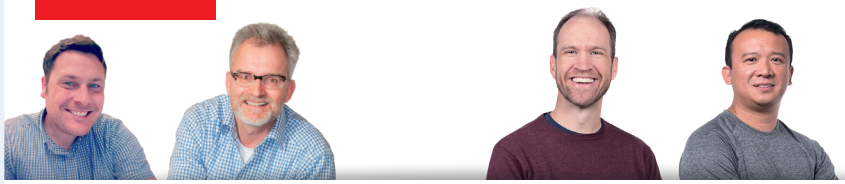


Declassified Bonus Edition

Surprise! The close collaboration between Elektor and SparkFun Electronics continues. This special Bonus Edition of Elektor features five must-read articles for you to enjoy on a variety topics, from DIY circuit board organization to RFID technology. Each week, we are declassifying a free bonus article, and you will have this complete digital Bonus Edition by early April 2021.

You are probably wondering: "What is all the secrecy about?" Well, like the SparkFun guest-edited March/April edition of Elektor—which is now available at Elektor.com and SparkFun.com—this Bonus Edition has been months in the making. Rather than the tell the world about it back in mid-2020, we decided to keep the project secret while our teams worked on all this great content. Plus, we love surprises.

Most Elektor and SparkFun community members have electronics workbenches where they solder, prototype, code, and test electronics. In "Must-Haves for Your Electronics Workspace" (p. 04), SparkFun and Elektor engineers talk about the essential aspects of their workspaces and what you can add to your workbench to bring it to the next level.

Looking for a smart, inexpensive way to organize all your circuit boards? Derek Runberg offers a nice solution in "DIY Circuit Board Organization" (p. 08). As you will learn, a few bucks and some Dual Lock reclosable fastener can go a long way. A well-organized workspace is definitely in your future!

The SparkX Lab is where SparkFun Founder Nathan Seidle and his engineers rapidly prototype new products. Elektor engineer Mathias Claussen shares his thoughts on several of those designs in the article, "SparkX Standouts." Flip to page 10 for details about a 2-D barcode scanner breakout, the SparkX Magnetic Imaging Tile, the Qwiic IR thermometer, and more.

When Rob Reynolds (Creative Technologist, SparkFun) discovered that his family was consuming a bit too much candy (i.e., M&Ms), he decided to engineer a solution. In "Manage Your Sweets with RFID" (p. 14), Rob describes the design, construction, and programming of an RFID-controlled sweets dispenser. Even if you don't care to curb your candy consumption, you'll find the project interesting and instructive.

Ever wonder how much doing a 360o spin on a drift trike will slow you down? Curious about the optimal speed for entering a 360o? Avra Saslow and Cassy Grace decided to tackle these questions with a drift bike, SparkFun's OpenLog Artemis, and a little ingenuity on a steep hill in Boulder, Colorado. Check out the article on page 18 for a mix of engineering and daredevilry.

Enjoy this Bonus issue. And be sure to share your thoughts and feedback with us at ElektorMagazine.com, SparkFun.com, and on social media!

extra

THIS EDITION

guest edited by SparkFun (USA)

Bonus Content
March and April 2021

Must-Haves for Your Electronics Workspace

Whether electronics hardware is your profession or your hobby, having the right setup in your workspace can greatly impact your work. At SparkFun, one can hardly take a step without running into some sort of work in progress and — across nearly every team — technical folks have built up their at-home and in-office spaces to support their efforts. We asked a few people about what they consider essential in their workspace, what is on their wish list, and what tips they have for someone just setting up their space.

Alex Wende
Electrical Engineer

Do your research

The best advice I could give is to start small and do your research to understand what you need. I didn't get the tools I had overnight; I got them one at a time as I needed them. When starting out, you don't need the top of the line; however, you also get what you pay for. The expensive test equipment will come with features you'll probably never use or precision you don't really need. The inexpensive tools can end up causing more problems than they solve — like having a low-quality multimeter that gives inaccurate readings or an oscilloscope that doesn't have a high enough sampling rate to show the short voltage spike that's killing parts on your circuit. To find the best value, buying used helped me save a lot of money when I started out. I found good deals on equipment from local ham radio meetups, flea markets, or places like eBay®. When I needed to upgrade, I used those same resources to resell my equipment and help pay for a more expensive tool once I outgrew the first one.

Essentials

- Multimeter
- Temperature-controlled soldering iron
- Flux and solder wick
- Hot air rework station
- Current limiting power supply
- Microscope with a wide working distance so I can use the microscope and solder at the same time.
- Rigol® DS1054Z - 4CH/50MHz oscilloscope

Wishlist

- Upgraded microscope with variable magnification and a camera port so that I don't have to take photos with my phone through an eyepiece.
- Differential probe and current probe for my oscilloscope for those projects that pop up occasionally where a multimeter isn't the right tool for the job.

Marcus Stevenson
Machine Operator

Less cleaning = more doing

Wait to buy any tool until you are completing a project that demands said tool. This will help you avoid buying gadgets you don't need. Also, multitools and 1000-piece tool sets are overrated, and you will only end up using (and eventually losing) a few specific pieces from essential sets. Just buy pieces and take good care of them. One of the main goals of any workspace should be to make it extremely easy to clean up and stay organized. If you have space, hang everything on a pegboard instead of using a toolbox, bins, or drawers. It's always easier to find the tool you need and keep your space clean this way. The more often you tidy up, the less time you will spend cleaning overall. Less time cleaning is more time doing.

Essentials

- Masking/painter's tape — hold things in place temporarily
- Hobby knives and extra blades — useful for everything
- Smartphone tripod and shutter remote — record what you're doing and share it
- Desktop vinyl cutter/pen plotter — cheapest way to transfer vectors to sheet material
- Ghinger® fabric scissors — sharpest scissors ever, and you can get them re-sharpened
- Mini Broom — dust is evil

Wishlist

- Vacuum former — great for mold/prop making
- Benchtop drill press — perpendicular holes every time
- Cordless hot glue gun — uses 18V drill battery

Wesley Furuya
QA Specialist

Keep frequently used tools nearby

Purchase the tools you will actually use. Having worked in both technical support and product development, I have found tools for the job vary based on job functionality. For example, in tech support, I used my oscilloscope significantly more to hunt down hardware issues and monitor PWM signals. However, in QA, I use a logic analyzer significantly more to test/debug code and check for hardware communication issues. Storage/organization is a key part of efficiency. Keep frequently used tools readily available and within reaching distance. You'll save time not walking back and forth to grab things. It also helps to be consistent in returning tools to where you expect them to be. Nothing is a greater waste of time than hunting for a "lost" item.

Essentials

- Computer with dual monitors
- Hand-held digital multimeter
- Logic analyzer — the Saleae® software is great for first-time users.
- BlackBoard Qwiic with logic level switch
- Qwiic cables
- Raspberry Pi 3B+
- SD Card Reader — USB 3.0-compatible helps for faster read/write times.
- iFixit® kit
- Qwiic pHAT
- A surge-protected power strip with enough outlets
- A decent sized whiteboard

Wishlist

- LRC Meter
- Vector network analyzer
- Function generator
- Hot air rework station
- Desktop CNC mill — metal capable

Pearce Melcher
Technical Research

Start with the basics

I love working on things on the side and developing my own products in my spare time. My workspace is highly geared towards building and testing prototypes. It's fairly rudimentary. But I'm someone who loves having the right tool for the job. As far as advice for a worskspace: "start simple" doesn't necessarily mean cheap but cover the basics — tweezers, screw driver set, soldering iron, fume extraction (could even just be a desktop fan), and strippers/cutters. From there, add what you need and update things as you hit pain points. That way, you know a lot more about what you need when you're ready to really step up your home workspace. And with any workspace, the value of a comfortable chair can't be overstated.

Essentials

- BK Precision® 1550 power supply
- iFixit Pro Tech Toolkit
- Hakko® FX888D soldering station

Wishlist

- 3D printer
- Large clean surface
- More professional soldering station

The Dream

- Pick and place/oven combo

Pearce Melcher builds and tests prototypes in his workspace, which includes a nice work desk and separate spot for soldering.

Derek Runberg
Partnerships, Services & Technical Content

Buy smart

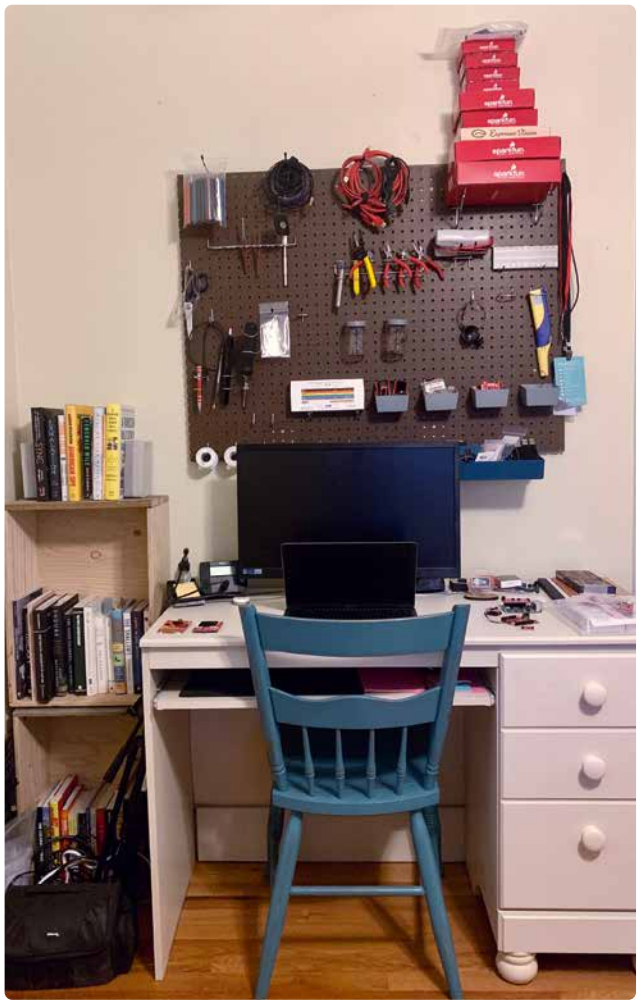
Don't go expensive and high end right away. Start cheap and wear out tools first. When you go to replace them, go for the next level of quality up from there. My shop is filled with tools that I bought once and got high end only to use them once and then they sit there collecting dust — or, even worse, they don't meet my needs and I bought something I will never use.

Essentials

- My computer
- USB cables
- Power supply
- Multimeter
- Jumper wires
- Breadboard
- Soldering iron and solder

Wishlist

- DIY reflow/hot plate
- Full set kits of different components to choose from/panel mounted components
- More storage bins
- Enclosure collection
- Fume/exhaust fan



Avra Saslow keeps things organized. The pegboard and bins are great solutions.

Avra Saslow
Technical Content Creator

Organization is key

I know it seems simple, but organization is key to an effective workspace. The expansive list of tools and resources at your disposal as an electronics enthusiast is a double-edged sword. While it's incredible to have access to such convenient and effective tools, it simultaneously presents the problem of accumulating so much stuff that your workspace becomes utterly chaotic. And if you don't know where anything is, that defeats the purpose of having a workspace in the first place! You'll want to know where all of your tools and boards are, so make sure to get a pegboard + bins, or a component cabinet. It'll make a world of difference when looking for that one piece! This also extends to using something like the Insulated Silicone Soldering Mat, which protects your workspace from the superheated tip of a soldering iron, as well as guides you to organize small components into buckets so that you can find them quickly when soldering.

I want to work on materializing my electronics project in the real world, and creating beneficial and aesthetically pleasing physical accessories for them, rather than them openly sitting as a connected network of circuit boards and sensors on my desk. Hence, my outlandish wish for a laser cutter.

Essentials

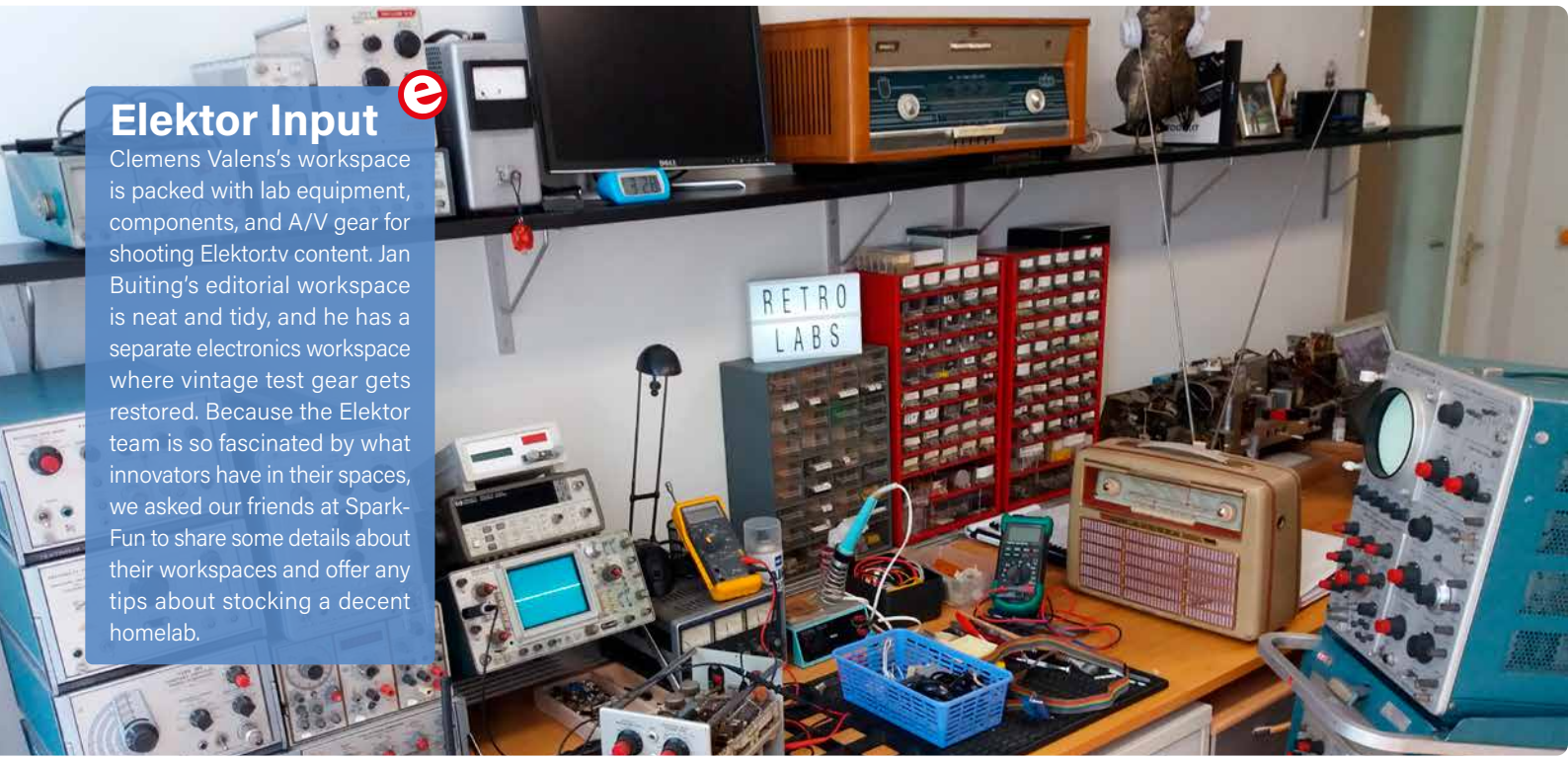
- Pocket screwdriver set
- Hakko FX-901 cordless soldering iron

Outlandish Wishlist

- Laser cutter — perhaps a 40W CO_2 Laser

Elektor Input

Clemens Valens's workspace is packed with lab equipment, components, and A/V gear for shooting Elektor.tv content. Jan Buiting's editorial workspace is neat and tidy, and he has a separate electronics workspace where vintage test gear gets restored. Because the Elektor team is so fascinated by what innovators have in their spaces, we asked our friends at SparkFun to share some details about their workspaces and offer any tips about stocking a decent homelab.



Long-time Elektor readers know Jan Buiting is serious about retro electronics ("retronics"). Take a look inside his amazing retro lab!

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DIY Circuit Board Organization

By Derek Runberg (SparkFun)

Would you like a simple, inexpensive solution for organizing your electronics workspace and circuit boards? All you need is some Dual Lock reclosable fastener and a little creativity.

The best ideas often come from solving everyday problems. For me it was a need to keep a LIDAR unit in the proper orientation on my desk while running some test code. My desk, like many of yours, is half paperwork, half pile of parts, with a coffee cup or three thrown in for good measure. Between the lack of flat surface and the LIDAR wiring harness, it was a futile task to keep anything pointed in the right direction. In a fit of frustration, I decided to clear my desk off. In doing so, I came across a section of 3M Dual Lock (reclosable fastener) that was the right size to fit on the back of the LIDAR unit. I stuck it on to the unit and then to the front edge of my desk, and it stayed in place (**Figure 1**). The desk edge was vertical enough and that spot was within a reasonable distance from where I was working that it became the foundation of an idea.

Over the course of a few weeks, as I tested code and boards for potential projects, I found myself adding Dual Lock to the back of the development boards and sticking them to the same spot on the edge of my desk — within reach, out of the way and not getting buried.

A Qwiic solution

Then, March 2020 came around and with it, the landing of our Stay-at-Home orders from federal and local governments. I was grounded. Looking to use the time wisely, I started to organize my workspace — organizing and picking up development boards, getting things into bins drawers, etc. Spring cleaning at its most extreme.

When I came to my collection of SparkFun Qwiic boards, which were housed in a plastic divided case, I noticed the case was quite full and one compartment was bleeding into another. My collection had obviously outgrown its original storage and organization system. I dumped the whole container out onto my desk to go through it and think about what the next iteration would be — a bigger container, drawer bins, a tackle box? Then, I noticed that about half of the boards had Dual Lock on the back of them (**Figure 2**). The idea crystallized. I could use Dual Lock to store my Qwiic Boards! The benefits and applications started flooding into my head. I ordered a roll of Dual Lock and set to work adding it to the back of the rest of my Qwiic boards. It all seemed to come together and make sense.

- The width of the Dual Lock was roughly the same dimensions as most of our Qwiic boards.
- Qwiic boards are usually one sided, leaving the back a perfectly flat substrate for the Dual Lock.
- A solution using Dual Lock would be expandable and grow as more boards come in.

Now, what would be the best way to use Dual Lock to store the boards? Above my desk, I have drawer bins of all of my other components and under that is a set of monitors. There is a gap between the two that just screamed to be filled by something. I cut a short piece of floor molding from a previous project to length, added a full length of Dual Lock to the board and then screwed it to the wall in this gap. I then stuck all of my Qwiic boards to Dual Lock across the board. They were visible, accessible and within reach anytime I needed them (**Figure 3**). Done!

Chapter two of this saga took place while I was holding the roll of the leftover Dual Lock in my hands wondering where to store it — the inevitable snowball effect of accumulating leftover parts from organizing and cleaning up the parts and materials you already have. Armed with the roll, I started placing sections of Dual Lock around my shop in places that I thought would be useful to be able to mount sensors and/or development projects. I added Dual Lock to walls, my ceiling, a window frame (to hold a GPS antenna, so I don't have to go outside) and a few of my webcams. I also used some on the back of my most used single board computers and microcontroller development boards. In essence, I created a system for storage as well as mount points for projects around the shop. A few months passed, my system held up pretty well.

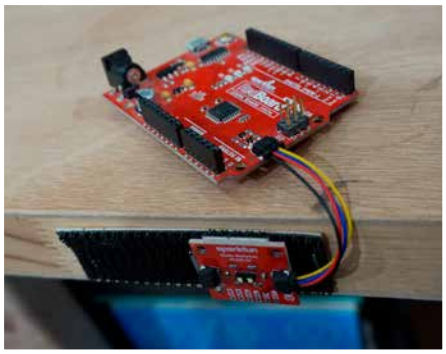

Figure 1: My original application of Dual Lock to avoid having to clean my desk.

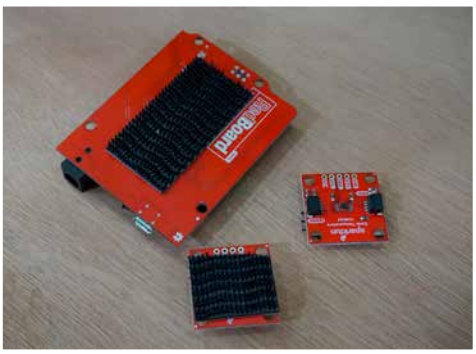

Figure 2: Dual Lock is just the right width for most Qwiic boards, and with the boards being single sided, it sits nice and flat.

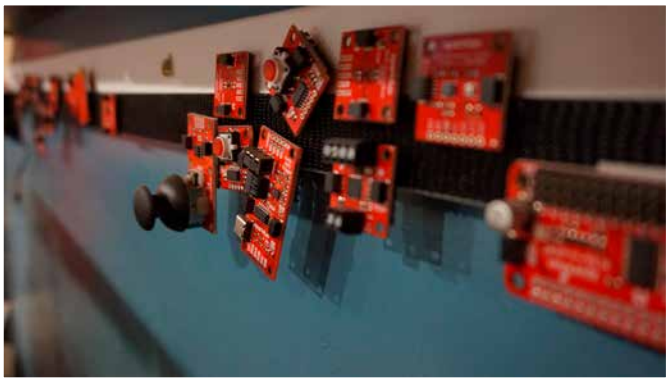

Figure 3: My finished and accessible Qwiic storage area!

Figure 4: Project with replaceable parts using Dual Lock to mount in the enclosure.

Use in projects

Then as summer 2020 came and the weather improved, I found that more and more of my projects were planned to be outdoors, in the elements, which meant enclosures would be needed, which then also meant trying to fit and mount everything into said enclosure. Enter Dual Lock once more (**Figure 4**)! Normally, when I build projects with SparkFun boards that require enclosures, I use off-the-shelf enclosures from my local hardware store. One downside is that these enclosures really aren't designed to mount or store lots of small components in them. To get around this, I typically attach standoffs to the SparkFun boards and then epoxy those in place. Once cured, I can then unscrew the boards from the standoffs when needed.

Now, equipped with Dual Lock, the mess of dealing with epoxy and finding the right orientation to make everything fit became simple. By applying Dual Lock to the interior surfaces of the enclosure, I was able to fit everything in, keep it all from rattling around and reduce the number of penetrations into the enclosure for things like screws and bolts. As an added bonus, the Dual Lock enables me to stick boards and components together in a sandwich formation. This is really handy for projects with a battery in them as batteries are the trickiest thing to mount and keep rigid in a project.

The lifespan of the projects I build are usually relatively short. I build something for a tutorial or a blog post and then it lives its life out for a bit until it needs to be parted out for the next great idea. The application of Dual Lock has made it easier to remove parts for later projects, made projects more modular and decreased the time to build them because I don't have to execute a complicated enclosure scheme. Even for my more permanent projects around the house, I find it's been a handy strategy as I can easily upgrade or replace parts without the need to completely rebuild the project.

A smart solution

In the end, I have found that the way I approach storage and use of my components has been greatly impacted by this simple tool that we all walk by in the hardware store. I am not saying that it is for everyone and every application, but for me, it has simplified projects in an elegant enough way for me to add it to my toolbox of tricks and tips. We will see how things play out over time in terms of the hold of the adhesive and the lock itself. For now, the flexibility and ad-hoc nature of Dual Lock has won me over.

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Elektor Input

"When I first learned about Derek's solution, I thought, 'Hey, I can do something like this with Dual Lock and many of the tools and parts on my workbench.' And then other possibilities started coming to mind. I knew right away that many of the engineers and makers in Elektor's community would find it useful too." - C. J. Abate (Elektor)

SPARK X Standouts

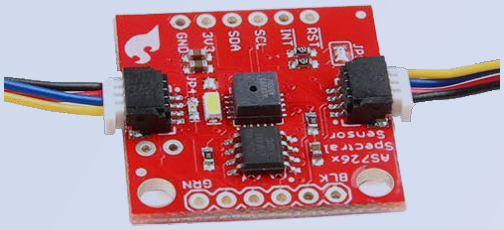

Figure 1: Qwiic connections.

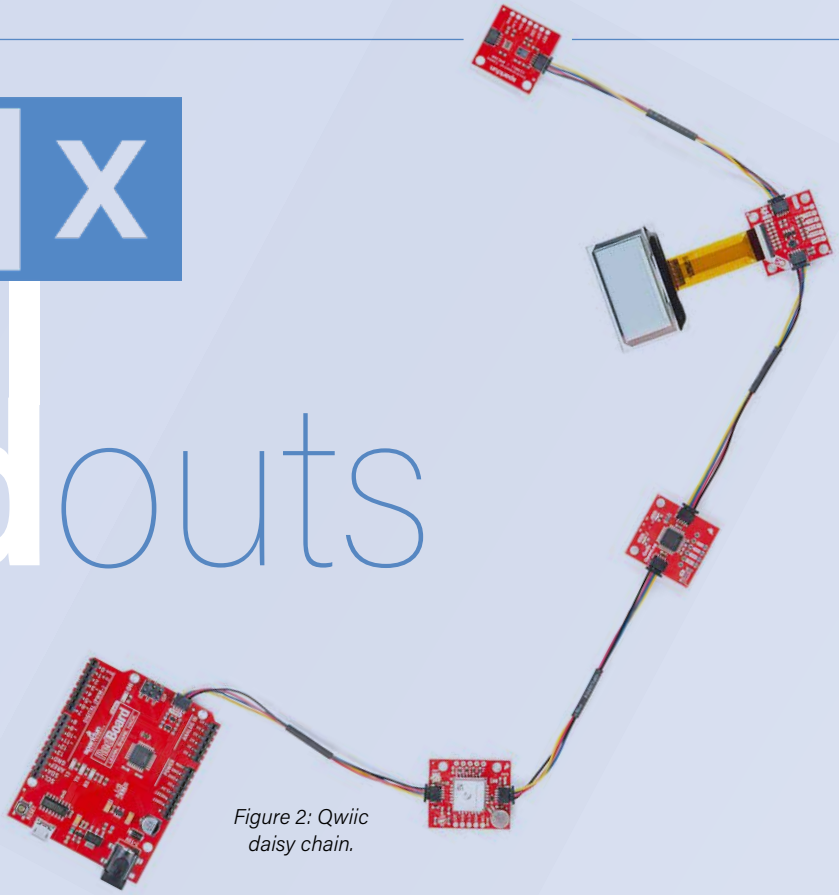

Figure 2: Qwiic daisy chain.

By Mathias Claußen (Elektor Labs, Germany)

Way back on Februrary 1, 2017, SparkFun's founder Nathan Seidle wrote a blog post ('Step 1: Go') about the process of setting up the SparkX Lab, which is where the team's creative engineers rapidly develop experimental products. Since then, Nathan and his team have developed some truly cutting-edge designs. Let's take a look at some of their more peculiar creations.

"Pick like six parts from the SparkFun SparkX section", Elektor's content director said. "Choose whatever you like. It shouldn't be too hard". That's when you feel like a child in front of a candy store with all the nice stuff on display. You're allowed to pick some but crave to taste all of it. Much later, the parts actually got selected and here I present eight that caught my attention.

SparkFun SparkX Lab

But first, what is SparkX Lab? This starts with the founder of SparkFun, Nathen Seidle, having been the company's CEO for over 13 years. In a 2015 blog post titled 'Nate the Engineer', Nathan disclosed that as an engineer doing CEO tasks he felt it was time to step back and spend some time to return to building stuff [1]. The CEO became NtE (Nate the Engineer) and decided to launch SparkX, he blogged [2], a place for focused, experimental development projects.

That's well-formulated but roughly seven years since the start, the description may not fit altogether. Today, SparkX is kind of an R&D lab with the benefit that a product will be released even if it isn't sleek and polished. This actually permits access to cutting-edge development by the SparkFun engineers. If a project gets favorable feedback it qualifies for more iterations later and subsequently may make it to the regular SparkFun product lineup.

Qwiic — prototyping with I²C was never easier

SparkFuns's Qwiic Connect System (**Figure 1**) uses a 4-pin JST connector to allow quick access to the device's I²C bus and provides 3.3 V for the supply voltage. As on an I²C bus there can be many devices in a chain structure using only four wires. Omitting power there are only three left so it's a convenient way of attaching new peripherals.

As seen in **Figure 2** a chain of sensor boards displays and other devices can be built rapidly and rearranged even faster. As the JST connector is polarized, damaging components by incorrect wiring is avoided. Any Qwiic device that is meant to acts as a slave on an I²C bus will offer at least two Qwiic ports for daisy-chaining. Also, with this approach no soldering is required, and components can be attached in no time. Have a look at SparkFun's lineup of Qwiic-compatible devices and development boards on their website [3].

If you would like to add a Qwiic-compatible board to your exist-

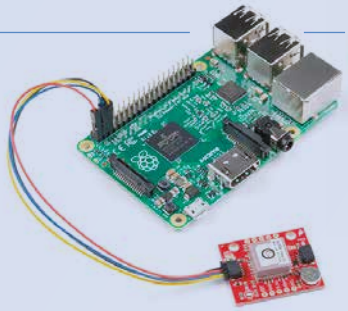

Figure 3: Qwiic adapter cable for Raspberry Pi.

Figure 4: Qwiic adapter for Grove.

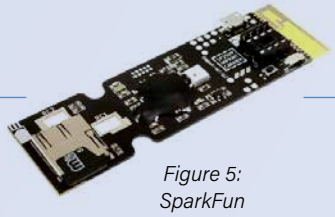

Figure 5: SparkFun HARP.

Figure 7: A look at the ICs of Robotic Finger Sensor v2.

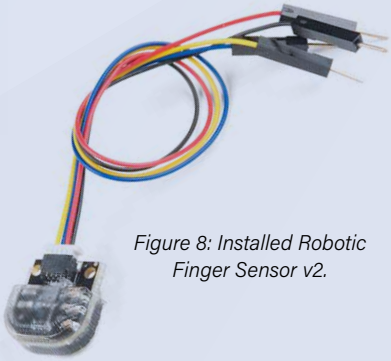

Figure 8: Installed Robotic Finger Sensor v2.

Figure 6: Robotic Finger Sensor v2.

Figure 9: OpenLog Artemis.

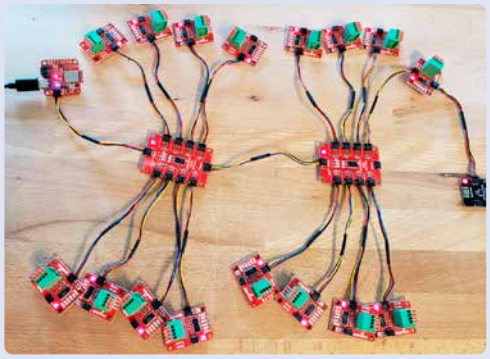

Figure 10: A lot of sensors connected to an OpenLog Artemis

ing Raspberry Pi or Grove-compatible system, don't worry, there's bound to be an adapter for it (**Figures 3 and 4**).

Prototype HARP (hardware alternate-reality puzzle)

Escape Room meets Embedded Hardware, that's the best way to describe this device. The Prototype [4] (**Figure 5**) has been around for three years now and SparkFun did a great job so even a Google search for certain terms doesn't immediately reveal any complete solutions. If you have a look at the product page you will not find much information about the device, just the starting point and some images. It is a mystery cast in electronic hardware. If you enjoy solving puzzles, you are sure to like this one. I'd like to talk more about it, but I don't want to spoil the plot. Grab one for yourself if you're triggered.

Robotic Finger Sensor v2

Those of us who work with robotic arms know that homebrew and cheap ones aren't sensitive when it comes to handling fragile or squishy things. This makes grabbing those objects reliably a real challenge.

Figure 6 shows the Robotic Finger Sensor V2 device [5] attached to a robot arm. To supply measurement data, the device is actuated by a pressure sensor type LPS25HB from STMicroelectronics, and an infrared distance sensor type VCNL4040 from Vishay. Those ICs can be seen in **Figure 7** and are normally hidden under a rubber cover. As those chips connect with I²C they can inform the robot not to squeeze components too hard, or drop them if not enough force is applied. You can hook up this sensor using the Qwiic connection or you can use the included adapter cable to attach it to a breadboard.

Figure 8 shows the sensor with the adapter cable installed. For convenience, an Arduino library is provided so integration in existing Arduino-based projects should be doable with minimum effort.

SparkFun OpenLog Artemis

This one spun straight out of SparkX and made it into SparkFun's catalog. As its name suggests, the OpenLog Artemis (**Figure 9**) is an open logging device based on SparkFun's Artemis module. A set of sensors can be connected to a Qwiic connection (I²C bus) and get automatically detected for data acquisition activity.

As seen in **Figure 10**, connecting a bunch of sensors was never easier and logging is done by way of a CSV file on a FAT32 or FAT16 formatted SD card. For configuration or logging without an SD card you can use the attached USB-C port for a link to your PC. A serial terminal will do the trick. The integrated 9-DOF IMU and the clever power management solution make this board a nice starting point for DIY data acquisition. **Figure 11** shows the board and its connections.

The Artemis module comes preprogrammed and ready to use. **Figure 12** shows that access is given to GND, RX, TX, 3V3, VIN, PIN32 and PIN11. You can also see the Qwiic connector that permits attaching an I²C device in a jiffy. With a lithium polymer battery charger added and low power in mind, this is a small and inter-

Figure 11: OpenLog Artemis with battery, USB, and Qwiic connectors.

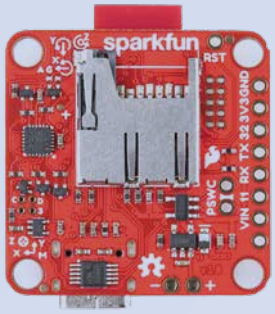

Figure 12: OpenLog Artemis viewed from rear.

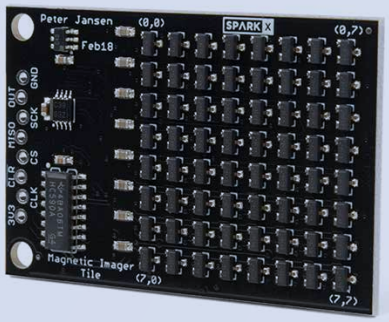

Figure 13: Magnetic Imaging Tile PCB.

Figure 14: 2-D Barcode Scanner Breakout.

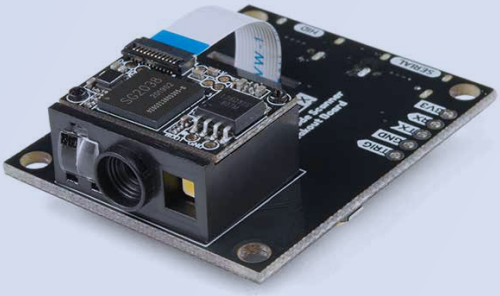

Figure 15: 2D Barcode Scanner Breakout, first version.

esting choice for data logging and more.

Magnetic Imaging Tile

As magnetic fields can not be directly seen by the human eye, we need a bit of assistance. And this is where the SparkX Magnetic Imaging Tile comes in (**Figure 13**). Featuring an array of 8×8 DRV5053VA Hall-effect sensors, the video [6] demonstrates what this device is capable of visualizing.

Each Hall-effect sensor is sampled by a 16-bit ADC connected over SPI. With the right software and tools, this combo can spew up to 2000 FPS to capture. For the inspection of moving or fast changing magnetic fields, this brings in a new tool for visualization. It might be interesting to to check what this device can see on a PCB. Combined with a fast MCU, a display and some batteries, this could form a unique portable imaging system.

2-D Barcode Scanner Breakout

Having barcode functionality can be very handy, be it 1-D or 2-D. For tasks like setting up links, entering Wi-Fi credentials for guest networks, or giving instructions to robots, a barcode or QR code is an easy-to-use solution.

While the classic 1-D barcodes familiar from the supermarkets contain limited information, 2-D barcodes or QR codes do open up lots of new possibilities. **Figure 14** shows the current 2-D Barcode Scanner Breakout featured at [7]. **Figure 15** is the previous iteration. Combined with the ability to renumerate on your USB CDC (serial) device, HID or Keyboard, it's a great companion when combined with a PC.

Browsing the scanner's datasheet reveals a lot of codes that can be processed. As the Breakout board offers access to all interfaces suitable for a PC or a microcontroller, I already have a few ideas for incorporating the scanner in upcoming projects.

Qwiic IR Thermometer - MLX90614

This little breakout board [8] offers an MLX90614 contactless temperature sensor as seen in **Figure 16**. While advertised for contactless temperature monitoring during a pandemic — a define use case — this one offers a temperature range from -70 °C to +382 °C with accuracy down to 0.5 °C, and 0.02 °C resolution. So, not only can human body temperature be monitored, but also the temperature of a 3-D printer or your cup of coffee (To Go).

A nice detail is the ability to disable the power LEDs and the pull-up resistors on the PCB. This results in an easy-to-use sensor for temperature monitoring, all contact-free.

SparkFun Qwiic GPIO

This small and practical PCB has evolved from a SparkX product to a full-production store item. Following the previous models, you can see that this started as a breakout for an NXP TCA9534 with Qwiic connectors (**Figure 17**) and in its second iteration got the easy-to-

Figure 16: Qwiic IR Thermometer — the MLX90614 rules.

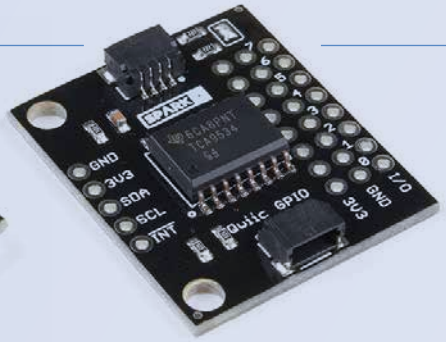

Figure 17: SparkFun Qwiic GPIO, first version.

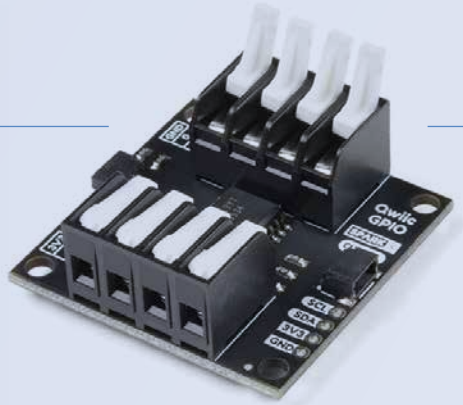

Figure 18: SparkFun Qwiic GPIO, second version.

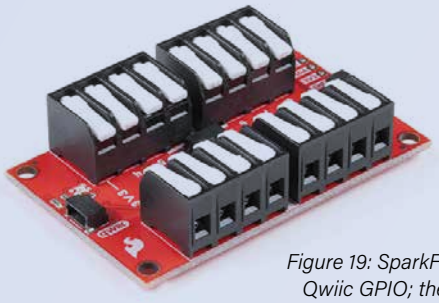

Figure 19: SparkFun Qwiic GPIO; the final, store-ready version.

use latch terminal added to for wire connections (**Figure 18**). The final, stock product is pictured in **Figure 19**.

The TCA9534 is a well-supported I²C port expander. Arduino comes with a matching library, and the Raspberry Pi also gets support through libraries. This great little board allows eight GPIOs to be added to your project with just a click and a bit of software. Since all three I²C address bits for this chip can be adjusted, eight boards with eight GPIOs each can be connected, resulting in a whopping total of 64 GPIOs you can add [9].

Upcoming SparkX products

SparkX is meant for the rapid development of new products, even if they aren't finished and they have some rough edges. Visit the SparkX site [10] frequently and subscribe to the SparkX newsletter so you don't miss a thing.

200649-01

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[1] Blog post from Nathan: https://www.sparkfun.com/news/1853
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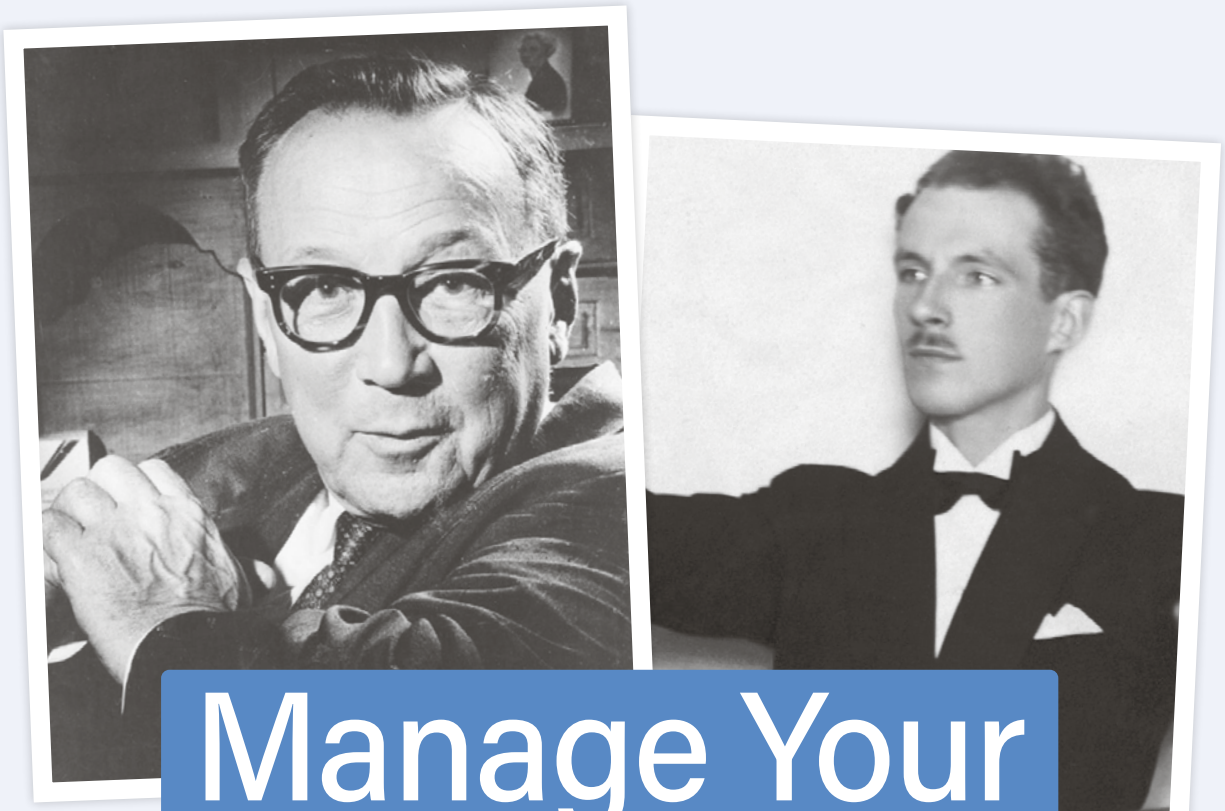
[3] SparkFun Qwiic: https://www.sparkfun.com/qwiic
[4] The Prototype: https://www.sparkfun.com/products/14379
[5] Robotic Finger V2: https://www.sparkfun.com/products/14687
[6] Magnetic Imaging Tile in action: https://www.youtube.com/watch?v=vxOuoWygxy0
[7] 2D Barcode Scanner Breakout: https://www.sparkfun.com/products/16441
[8] Qwiic IR Thermometer - MLX90614: https://www.sparkfun.com/products/17522
[9] SparkFun Qwiic GPIO: https://www.sparkfun.com/products/17047
[10] SparkX: https://www.sparkfun.com/sparkx

Questions or Comments?

Do you have questions or comments about his article? Email the author at mathias.claussen@elektor.com or contact Elektor at editor@elektor.com.



Manage Your Sweets with RFID

By Rob Reynolds (USA)

Radio Frequency Identification, or RFID, has been around in some form since the mid 1940s. Léon Theremin's listening device for the Soviet Union and Sir Robert Alexander Watson-Watt's Identify Friend or Foe (IFF) system were both developed and used during WWII as early examples of using radio frequency to identify objects.

Now, seventy-five years later, we use RFID technology for everything from office security and access control, to high-speed roadway toll payments, to hospital infant tracking, to race timing, pet identification, and even counterfeit prevention in the pharmaceutical industry. The list of applications is extremely long, but they all come down to the same three things — an RFID tag, an RFID reader and a computer or microcontroller to control what happens with the information.

Design considerations

We currently have quite a range of RFID options from which we can choose to fit our needs. We have active tags, which have their own power source and can continually broadcast their own signal; passive tags, which have no power of their own, but are powered by the radio frequency energy transmitted from the RFID reader; and semi-passive tags, which like the passive tag uses the energy from the reader to trigger its response, but like the active tag, does contain a battery. However, in the semi-passive case, that battery usually only powers a sensor and runs the associated circuitry.

As far as RFID readers go, they can operate in the low frequency, high frequency, and ultra-high frequency ranges. And while all of these possibilities allow you to really customize your project and make it just right for your specific situation, for those just starting out with RFID, it can also cause issues if you're not careful.

With all of these options for both readers and tags, it's quite possible to get components that aren't compatible. For example, if you pick up our SparkFun RFID Starter kit, and want to add additional tags for your project, picking up some MIFARE Classic Laundry tags for their small size is going to lead to disappointment, as they're 13.56 MHz tags while the ID-12LA reader in our starter kit reads 125 kHz tags. Or if you need to read tags at a greater distance, you'll need to make sure you use something like our Simultaneous RFID Reader (**Figure 1**), which, with the

Sir Robert Watson-Watt (left) and Léon Theremin (right), the undisputed godfathers of RFID. Images courtesy of Royal Air Force Museum (left) and efeméeridesdoéfemello.com (right).

proper antenna, can read multiple RFID tags at a distance of about 4.5 meters. Of course, as with all RFID projects, this will require the proper tags, in this case the EPCglobal Gen2 tags.

What RFID can do

With Automatic Identification and Data Capture (AIDC) devices and technology racing forward, now is a great time to start working with RFID devices. Can you imagine going to the supermarket, filling your cart, and then just walking out as an RFID reader captures the information from the tags on every one of your items? It may sound a bit futuristic, but right now our Simultaneous RFID Reader is capable of reading up to 150 tags per second. Pair that with the proper antenna, and you'll get a reading range of almost 5 meters! Not only does that make it seem like checkoutless shopping might not be too futuristic, but it sounds like you might even be able to create that type of system yourself!

Meanwhile @home

So to give a little RFID demo in a real-world scenario, I thought I would open up, and share with you a little bit about my family. Since the start of the pandemic, we've all been spending all of our time together at home, and during that time I've learned something. We have a serious problem with M&Ms consumption. I think we're about two purchases away from having shareholders send us thank you notes and Christmas cards. As I was deemed the person with the most self-control, my wife asked if I could come up with a way to limit our daily intake of these sweet candy treats. This seemed like a perfect project to demonstrate RFID technology. So, I bought an old coin-operated candy vending machine on eBay and went to work. If you're thinking of recreating this project, be aware that apparently there are different types of dispenser mechanisms in vending machines like these. One type is designed for a single large gumball or toy capsule, and the other type is for materials like birdseed or animal feed like you might find at the zoo. I'm not really sure if it would make a difference, but just in case, I requested the latter mechanism in my machine.

As is the case with most projects where you're starting with an enclosure and working backwards, I did have to make some slight modifications. The dispenser mechanism was too large to accommodate the RFID reader and standard size servo. And even with the crank mechanism stripped of all of its gears and the reader pressed all the way against the front of the machine, I was still unable to pick up the RFID tags through the thick metal, so I had to 3D print a replacement face. The knob turns, but is purely decorative. Additionally, I printed a custom piece to hold the servo motor in place to spin the dispenser. And finally, I laser cut a small stand for the candy machine so that the dispenser chute was high enough to fit a small bowl underneath it. Across the front I etched a quote from Ralph Waldo Emerson, which reads "Moderation in all things, especially moderation."

The coin drop mechanism (**Figure 2**), while a beautiful piece of mechanical engineering, was too bulky and thick for my needs.

To close off the hardware side of things, **Figure 3** shows the servo motor, RFID Reader, and several LEDs behind the faceplate, with an RTC tucked down on the left side, all controlled by a SparkFun Redboard.

The program

The code is simple and straightforward. Due to its size — easily covering two full pages in this magazine — a snippet is shown here, see **Listing 1**. The full program can be downloaded from my github space [1]. The

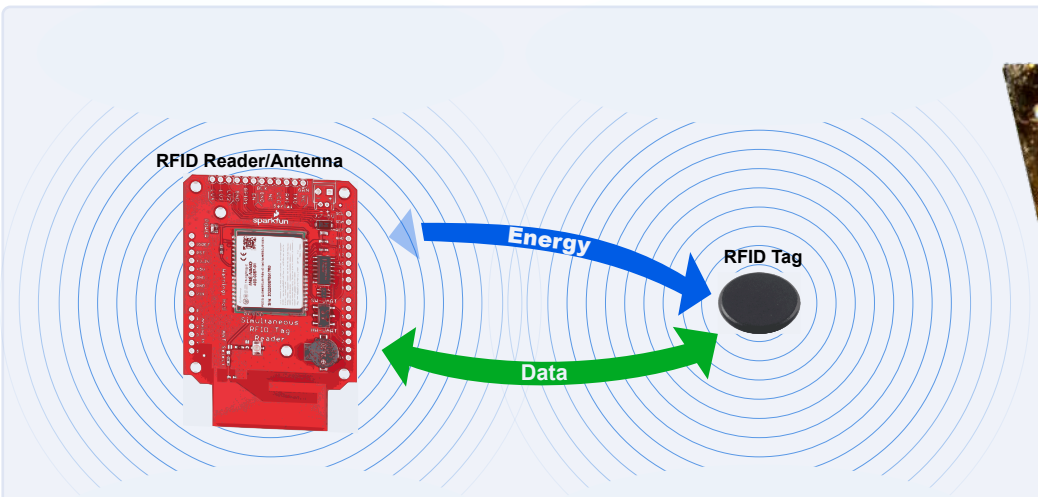


Figure 1: The SparkFun Simultaneous RFID Reader is a powerful system for fast, reliable data transfers to/from passive RFID tags.

Figure 2: The coin drop mechanism in the vending machine. Sadly, it turned out to be too bulky for use or even modification in my application.

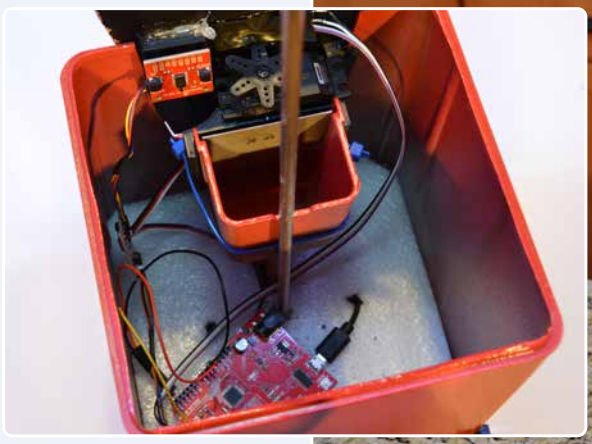


Figure 3: Internal view of the RFID-controlled sweets dispenser.

Figure 4: The sweets dispenser system, ready for everyday use by all in the household.

program also lists the boards and devices that went into building the project.

The program monitors when each card is swiped, keeps track of those swipes, and when the date changes, resets the swipe count for each card. There's one step that I should have added to the code, but I did not, thinking it would only be a short-term build. As it stands, if the system is power-cycled, all of the daily counts reset to zero, as instructed in the setup loop. The proper thing to do would have been to add `EEPROM.write` and `EEPROM.read` lines for each card, so that even if the board lost power, just like the battery backed RTC, the card count would be sustained through the power cycling.

With the machine in place (**Figure 4**), each family member now has their own RFID card. I've limited us to two servings of M&Ms per day, monitored with the SparkFun Qwiic Real Time Clock module. The script keeps track of the date from the RTC, and when the date changes, all cards are reset to zero, for another day's ration of treats! Oh, and if things get out of hand and I sense a mutiny, I also made an emergency card that bypasses the daily limit. And yes, it has been used on several occasions.

Onwards with RFID!

If you want to see the M&Ms dispenser in action, you can find a video, with a short explanation of RFID, over on Youtube [1]. If you're inspired to build your own, you can find the Arduino sketch in my Github repository [2]. You can then head over to SparkFun's RFID page for more instruction, ideas, and inspiration! If you wind up building your own RFID project, be it for asset tracking, access control, or even candy distribution, share it with us! We always love to see what the community is building!

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[1] Youtube video: https://youtu.be/5TgjOcn0IIY
[2] Program code: https://github.com/ThingsRobMade/RFID_Gumball_Machine

Listing 1: Extract from: RFID M&Ms® Dispenser program

```
void dad(){
  dadServings++;
  Serial.print("This is serving #");
  Serial.println(dadServings);
  if (dadServings > 2){
    Serial.println("That's enough for you today");
    for(int y = 0; y < 10; y++){
      digitalWrite(bluLight, HIGH);
      digitalWrite(redLight, LOW);
      delay(300);
      digitalWrite(bluLight, LOW);
      digitalWrite(redLight, HIGH);
      delay(300);
    }
    digitalWrite(redLight, LOW);
    delay(1000);
  }

  else{
    digitalWrite(greLight, HIGH);
    Serial.print("Candy dispensed at ");
    String currentTime = rtc.stringTime();
    Serial.println(currentTime);
    gumballServo.write(110);  // tell servo to go to position in variable 'pos'
      delay(3250);    // waits 15ms for the servo to reach the position
      //}
      gumballServo.write(90);
      digitalWrite(greLight, LOW);
      delay(2000);
      }
  }

void mom(){
  momServings++;
  Serial.print("This is serving #");
  Serial.println(momServings);
  if (momServings > 2){
    Serial.println("That's enough for you today");
    for(int y = 0; y < 10; y++){
      digitalWrite(bluLight, HIGH);
      digitalWrite(redLight, LOW);
      delay(300);
      digitalWrite(bluLight, LOW);
      digitalWrite(redLight, HIGH);
      delay(300);
    }
    digitalWrite(redLight, LOW);
    delay(1000);
  }

  else{
    digitalWrite(greLight, HIGH);
    Serial.print("Candy dispensed at ");
    String currentTime = rtc.stringTime();
    Serial.println(currentTime);
    gumballServo.write(110);   // tell servo to go to position in variable 'pos'
      delay(3250);             // waits 15ms for the servo to reach the position
      //}
      gumballServo.write(90);
      digitalWrite(greLight, LOW);
      delay(2000);
      }
  }
```

Trike Drifting & Exploring Mineshafts with SparkFun's OpenLog Artemis

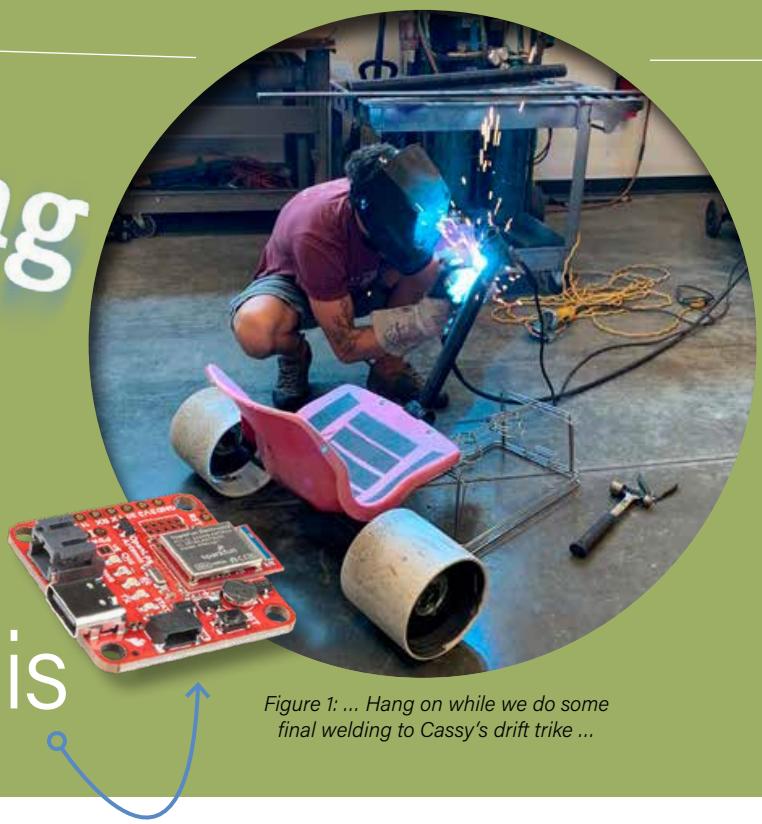

Figure 1: ... Hang on while we do some final welding to Cassy's drift trike ...

By Avra Saslow (USA)

There are an infinite number of questions to be asked about the world around us. Why is my mail so banged up when it's delivered? Where did the damage occur, and how large was the force? What is the ambient light when lightning bugs decide to come out and flicker? When is it reliably warm enough to transfer my tomato plants outside in the spring? How much does doing 360s on a drift trike slow you down on your ride, and what is the optimal speed at which to enter a 360?

As much as I can hypothesize the answers to these questions, I'll never truly know without collecting data, which can sometimes be very difficult to capture. Luckily though, the SparkFun OpenLog Artemis has the capabilities to answer all these questions for us. It is the ultimate plug-and-play partner; it enables me to be an everyday scientist and ask questions about the world around me, and allows for fast feedback through its data logging and sensing capabilities. As a stand-alone, it automatically logs from an on-board triple-axis accelerometer, gyro, and magnetometer. However, it can auto-detect practically any additional Qwiic sensor ranging from LiDAR distance sensing, u-blox GPS modules, weather sensors, or whatever fits the project. Plus, it writes the data to a microSD card in CSV format (comma-separated values) to make the data easy to manipulate and understand.

Seriously — it's that easy to collect data on nearly anything. No soldering is involved in hooking up additional sensors, and no coding is required for logging various types of data. It's the kind of thing you want in your pocket at all times, just in case something comes up and you need to collect data. Or, it's perfect to have in conjunction with an IoT device to always record a back-up log in case the network goes down or is overloaded with data.

Fortunately, here at SparkFun, we have crazy enough people to dream up crazy fun ideas to test with the OpenLog Artemis. Let's start with that last question we asked: *How much does doing 360s on a drift trike slow down your ride*?

Project 1: Analyzing Optimal Speed for 360s on a Drift Trike

You may or may not be already familiar with what drift trikes are — if you aren't, you're not alone! Drift trikes are tricycles that have low traction rear wheels made of PVC so that the rider can intentionally lose traction and counter-steer down steep, paved hills. Basically, you send a drift trike down a very steep downhill, in which the rider drifts around corners, or brakes by doing a 360. Its origins are from California in the 70s and has the same rebellious and thrill-seeking vibe as the early skate culture.

One of the very coolest employees at SparkFun, Cassy, is an experienced trike drifter and has built her own (**Figure 1**). She wanted to test out some questions she's had for a long time about the speed in which she should 360; she's familiar with the instinct that tells her when to turn, but wanted additional data to really understand it.

If she doesn't go fast enough into a 360, she basically stalls out and rolls backwards (the 360 turns into a 180). However, she also doesn't want to get going so fast that the 360 becomes unsafe. Furthermore, she wanted to understand how much she actually slowed down with a 360.

So we used the OpenLog Artemis as an easy method to collect this data and understand it. For this project we didn't even need to connect

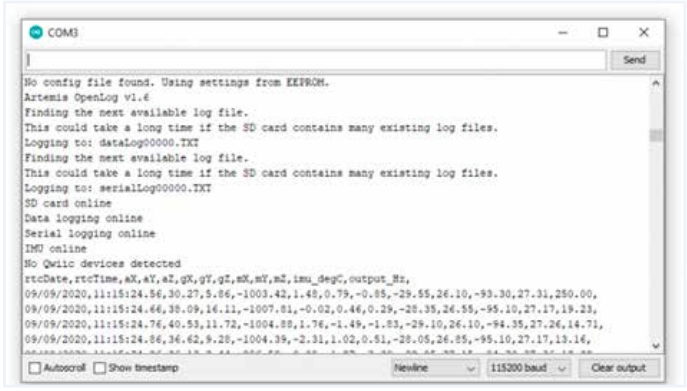

Figure 2: The main menu presented by OpenLog Artemis shows important system configuration data.

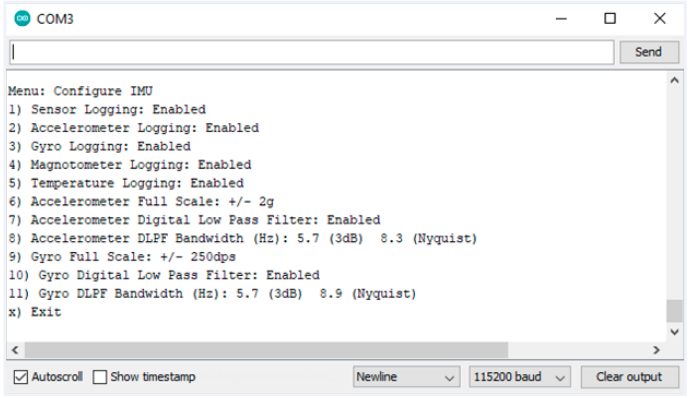

Figure 3: OpenLog Artemis main menu for access to peripherals, and more.

Figure 4: Not Cassy pictured, but I gave the drift trike a few tries ...

Figure 5: ... Cassy getting ready to bomb down a road ...

Figure 6: ... The moment right before she did a 360!

additional sensors — its built-in ICM-20948 Inertial Measurement Unit (IMU) 9-Degrees-Of-Freedom (9-DOF) sensor has all the sensing capabilities we'll need.

We powered the OpenLog Artemis up with a 1 Ah lithium-ion battery. One of the nice features of the board is that it doesn't automatically start logging data, therefore conserving storage space. It only begins logging data once the reset button has been pressed. Plus, if it senses that you haven't logged something within two seconds, it goes into sleep mode. And by our calculations, using a 200 mAh battery will draw such a low current that it would run a little less than a decade.

Before sending the OpenLog Artemis down the hill with Cassy, we loaded in a blank FAT32 microSD card and opened up a serial monitor to configure the settings. As shown in **Figure 2**, there's a main menu that pops up in the serial terminal with a list of messages conveying:

- this is the first time the OLA has been powered up, so the default settings are being logged;
- the OLA software version (V1.6);
- the sensor data is being logged to a txt file called `dataLog00000.TXT`;
- any incoming data on the RX pin will be logged to `serialLog00000.TXT`;
- the microSD is online and formatted correctly;
- the IMU has been found;
- no additional Qwiic devices are detected.

The columns of data scrolling up the screen are: RTC date, RTC time, IMU accelerometer readings (unit: milli-*g*), IMU gyro readings, IMU magnetometer readings (unit: nT), IMU temperature (unit: °C), and the logging rate (unt: Hz).

Furthermore, the main menu allows access to configure IMU logging, terminal output, serial logging, analog logging, peripheral device logging, power options, and SD card file transfer (**Figure 3**). For this specific project, we really only needed to configure the IMU and remove some of the sensor noise for easy interpretation of the data.

After the configuration, the OpenLog Artemis was ready to collect some data, so we found an empty, steep road on an early Tuesday morning and sent the system down with Cassy (**Figures 4, 5, 6**). She gained quite a bit of speed, and then leaning in really hard to her left side, quickly spun the handlebars, 360'd, and straightened out once more. It was exhilarating to watch! We sent her down a few more times to really get good data (the PVC pipe wheels make quite a bit of noise when drifting, so we had to be quick about collecting data).

We took the SD card and loaded the CSV with data into a prototyping software called Jupyter Notebooks. Jupyter Notebooks is a web application that makes data analysis incredibly easy, due to its capabilities of combining text and code, as well as its support for Python and the hundreds of associative libraries.

The code shown in **Listing 1** demonstrates the quick prototyping mentality of loading the CSV into a dataframe (i.e. a table of data with rows and columns), taking the speed of the *x*, *y*, and *z* axes from the IMU, and quickly visualizing if there is a major drop in speed during the 360.

Turns out, while doing a 360 does slow down Cassy's speed a little bit, it doesn't slow her down nearly as much as she thought (**Figure 7**). Furthermore, other data analyses comparing the multiple runs she took found that the average speed in which she did a 360 was around 12 mph (~19 kmh).

Listing 1. Openlog Artemis programming example.

```
#-------------------------------------------------------------------------------
# Import necessary libraries
#-------------------------------------------------------------------------------

import pandas as pd
import numpy as np
import math
import matplotlib.pyplot as plt
from scipy import signal
from scipy.signal import argrelextrema

#-------------------------------------------------------------------------------
# Read in data from csv and determine acceleration values
#-------------------------------------------------------------------------------

data = pd.read_csv('dataLog00018.TXT')#load in data

data.shape[0]
d = data.iloc[:10][["aX","aY","aZ"]] #just getting accelerometer values

x = []
y = []
for i in range(1,data.shape[0]): #this computes a discrete integral to relate acceleration to velocity
    #pythagorean theorem to isolate values
    x.append(math.sqrt(sum((data.iloc[:i][["aX","aY","aZ"]].sum(0))**2))) #all measured in gravity, or
9.8 m/s^2
    y.append(i)#i is time

myInt = 100000
speedList = [j / myInt for j in x]
#print(speedList)


#-------------------------------------------------------------------------------
# Find the local minima to determine Cassy's slowest speed during the entire run
#-------------------------------------------------------------------------------

speed = np.array(speedList)
minimums = signal.argrelextrema(speed, np.less)#still a np array
#print(minimums)
index = [0,1] #these are minor minima, so we can remove excess noise in data
local_minima = np.delete(minimums, index)
local_minima_list = np.array(local_minima).tolist()
#print(local_minima_list)


#-------------------------------------------------------------------------------
# Plot time vs. speed
#-------------------------------------------------------------------------------

#the log time in between readings is .1000 seconds
plt.figure(figsize=(15,15))
plt.ylabel('speed in meters/sec', fontsize=15)
plt.xlabel('time in .1 sec intervals', fontsize=15)
plt.title("Cassy's change in speed doing 360s on a trike",fontsize=20)
markers_on = local_minima_list
plt.plot(y,speedList, color='mediumslateblue', linewidth=3,marker="x",markersize=18,
markevery=markers_on)
plt.xlim([0, 175])
```

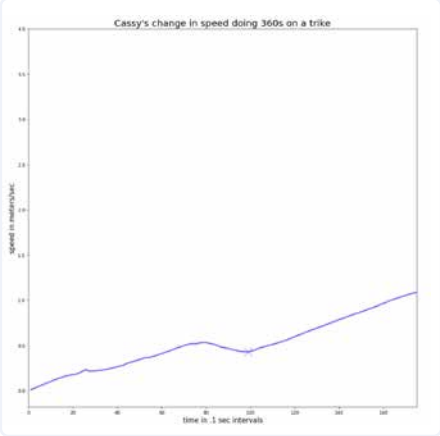

Figure 7: Cassy's change in speed doing 360s on a trike.

Project 2: Exploring Mineshaft Air Quality

SparkFun's Creative Technologist Rob Reynolds, had wanted to use the OpenLog Artemis as his right-hand tool for some cave exploration — specifically to understand how ambient light, cave height, and air quality changed the further into a cave he went. Unfortunately, due to wildfires in Colorado this summer, he was never able to test the OpenLog's capabilities outside of SparkFun's headquarters. However, I had a chance recently to explore an old mineshaft in a small mining town in Colorado, and thought the OpenLog Artemis might be the perfect adventure partner (**Figure 8**).

In this project, I did have the opportunity to connect additional sensors, including humidity, air quality, and distance sensors, to help answer questions about the height of the cave, and the general air quality. Using all Qwiic sensors, it simply took daisy-chaining them together and ultimately connecting them all to the OpenLog Artemis.

Similar to the drift trike project, the only initial setup involved configuring the settings through a serial terminal. This time, I had the opportunity to actually configure the peripherals attached to the OpenLog Artemis, and enable or disable features of the sensor, as can be seen in **Figure 9**.

Other than that, not a line of code is needed to be written for the OpenLog Artemis to register which sensors are connected and how it should log their respective data. I powered it up with a lithium-ion battery, inserted a blank microSD card, and took it along with me into the mineshaft below.

Figure 8: The mineshaft selected to do the air quality data logging experiment using OpenLog Artemis.

I didn't venture far, but I was mostly interested in air quality in the mine; these mines are notorious for having a wide variety of toxic elements seeping out of the ground, and I was curious if that fostered any kind of life that might affect the air quality. Furthermore, since it remains fairly wet, dark, and dank, I hypothesized that the higher the humidity levels were, the poorer the air quality levels would be too.

Back at a computer, I was able to upload the data as a CSV file (already formatted with sensor data following traditional OpenLog Artemis data) as a dataframe in Jupyter Notebooks again. By removing some of the sensor noise, and plotting values, I was able to visualize how the humidity and air quality might be intertwined in a mineshaft. There's a scientific computing library that specifically assists with technical computations and statistical analysis called scipy. With a few lines of code to isolate the humidity and air quality values, scipy can easily run linear regression and produce an r-squared value that will give insight as to whether there's a correlation between the two variables or not.

```
from scipy import stats

slope, intercept, r_value, p_value, std_err = scipy.stats.linregress(humidity, air_quality)

print(r_value**2)
```

The code above produced an r-squared value of .63, meaning that 63% of the variation in air quality can be attributed to the variation in humidity. Thus, there is a moderate positive relationship between the two variables. Further analyses could investigate if ambient light has an effect on air quality (perhaps mold grows faster in darker areas), or logging the GPS location to understand where exactly the air quality gets bad in the depths of the mine.

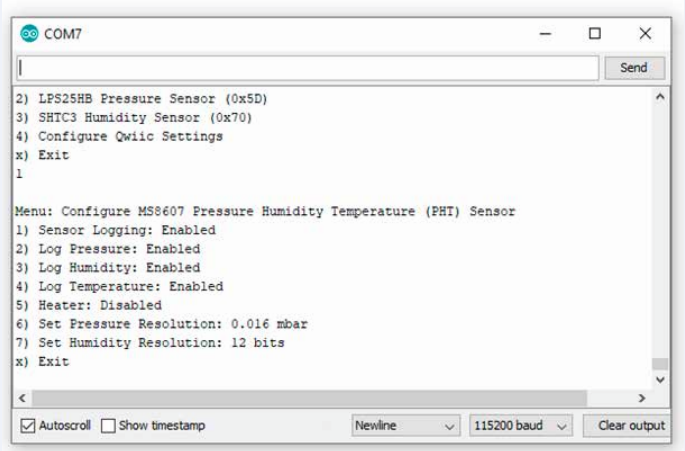

Figure 9: To be able to data-log my mineshaft exploration I had to do a proper configuration of the sensors.

A note on seismography

There is one particular library built for the OpenLog Artemis that is particularly cool: it can log seismography data. Using the SM-24 Geophone [1], the OpenLog Artemis logs Fast Fourier Transformed frequency and amplitude data to an SDcard just like it would any other type of data from a sensor. **Figure 10** shows an example of SM-24 Geophone captured, FFT-processed data in a live graph. If you read this article digitally, the image should play, i.e. scroll horizontally, being an animated gif.

In the configuration menu, the user can change the amplitude threshold — to only log seismic events that exceed a set threshold — and the Artemis Real Time Clock — each seismic event is data- as well as time-stamped, but the RTC can be synchronized accurately to GNSS as well.

The geophone logger means that you could leave the OpenLog Artemis (for up to 10 years as mentioned above), and it could log seismic events in a location, perhaps near a fracking site or in multiple locations around a city that are susceptible to earthquakes. Alternatively, it could be useful in a mineshaft to ensure it doesn't all come crashing down suddenly.

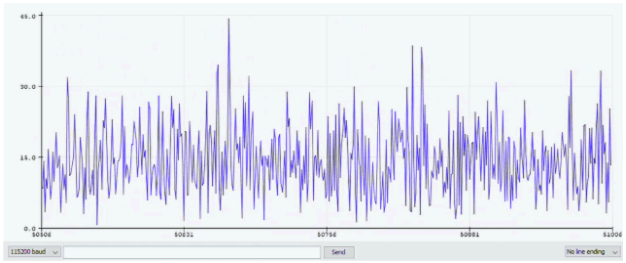

Figure 10: Seismic activity captured with an SM-24 Geophone and FFT-processed to give a live graph (animated-gif).

Final thoughts

It doesn't get any easier with the OpenLog Artemis — it requires no code to boot up, and adding additional peripherals doesn't require any soldering. It's a pocket-sized setup that is as easy to carry around as it is to collect data instantaneously.

The OpenLog Artemis is not only useful in answering everyday questions (I would seriously like to track my mail at some point to see where/when/what kind of damage was inflicted upon it), but it can also be useful in collecting data as a backup to IoT solutions, particularly when it can remain dormant and last for nearly a decade. So, the real question is, what questions will you begin answering with the SparkFun OpenLog Artemis? Be sure to keep us posted along the way!

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Related Products

Looking for the main products described in this article? Elektor and SparkFun have you covered!

- **SparkFun OpenLog Artemis**
  www.elektormagazine.com/esfe-en-openlog1
- **Geophone - SM-24**
  www.elektormagazine.com/esfe-en-openlog2