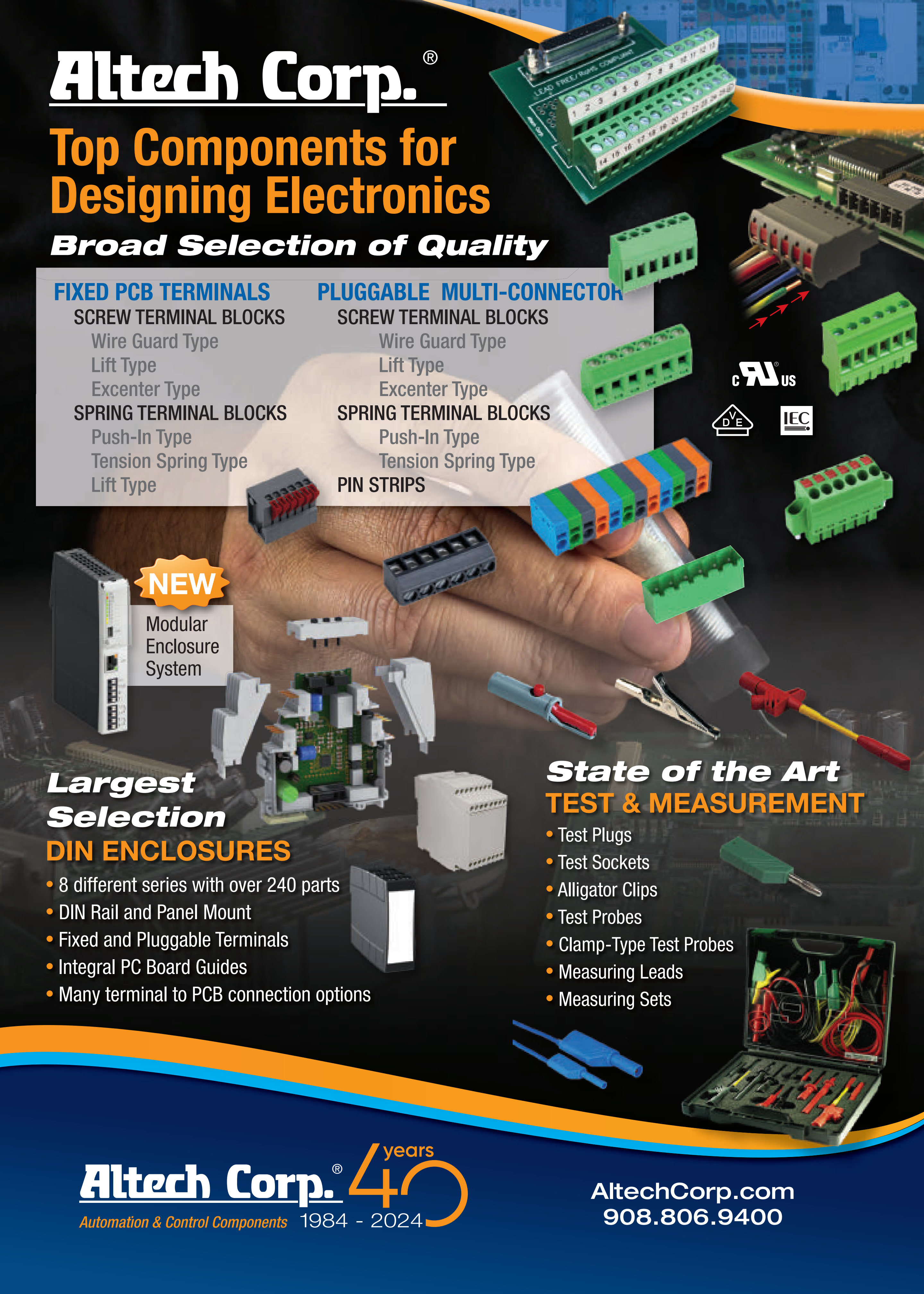

Altech Corp.®
Top Components for Designing Electronics
Broad Selection of Quality
FIXED PCB TERMINALS
SCREW TERMINAL BLOCKS
Wire Guard Type
Lift Type
Excenter Type
SPRING TERMINAL BLOCKS
Push-In Type
Tension Spring Type
Lift Type
PLUGGABLE MULTI-CONNECTOR
SCREW TERMINAL BLOCKS
Wire Guard Type
Lift Type
Excenter Type
SPRING TERMINAL BLOCKS
Push-In Type
Tension Spring Type
PIN STRIPS
NEW
Modular Enclosure System
Largest Selection
DIN ENCLOSURES
• 8 different series with over 240 parts
• DIN Rail and Panel Mount
• Fixed and Pluggable Terminals
• Integral PC Board Guides
• Many terminal to PCB connection options
State of the Art
TEST & MEASUREMENT
• Test Plugs
• Test Sockets
• Alligator Clips
• Test Probes
• Clamp-Type Test Probes
• Measuring Leads
• Measuring Sets
Altech Corp.®
Automation & Control Components
40 years
1984 - 2024
AltechCorp.com
908.806.9400

Electronic Design®

THE AUTHORITY ON
EMERGING TECHNOLOGIES
FOR DESIGN SOLUTIONS

SEPTEMBER/OCTOBER 2024
electronicdesign.com

MAKERS:
FROM NOVICES TO PROS

IN THIS ISSUE

FEATURES

8 **The Maker Movement: Then and Now**

12 **Arduino's CEO on the Commercial Future of Open-Source Hardware**

16 **Raspberry Pi 5 Taps into AI with a New Add-On Kit**

18 **So...You Want to Convert Your Gas/Diesel ICE Vehicle to Electric?**

22 **IoT for Dummies: Arduino's New Plug and Make Kit**

26 **A Sampling of Resources for the Maker Community**

30 **Circuits of Chaos: Building Lorenz, Chua, and Rossler Strange Attractors**

34 **What Makers Want**

36 **From Maker to Market: The Dynamic Journey of Bringing Innovations to Life**

40 **Navigating the Prototype-to-Production Pipeline**

43 **Open for Business: Open-Source Silicon**

46 **So...The Z80 is Rising from the Dead—with an On-Chip DAC?**

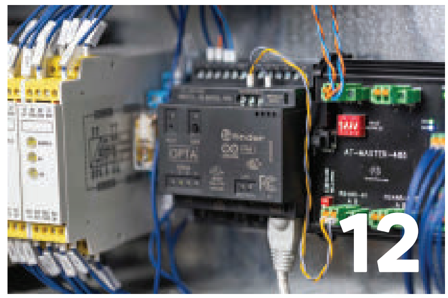
COLUMNS & DEPARTMENTS

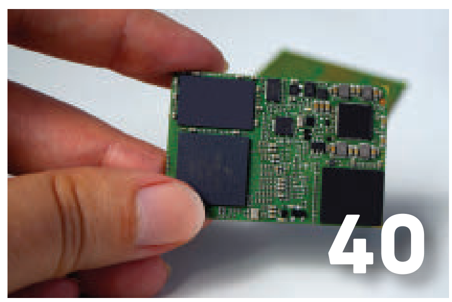
4 **Editorial**
What Makes a Maker?

5 **Ad Index**

6 **Watch & Connect**

49 **Lab Bench**
Initial Results from *Electronic Design's* Maker Survey





Cover images: 158320809 © Monstarrrr | Dreamstime.com

Editorial

BILL WONG | Senior Content Director

What Makes a Maker?

Are makers hobbyists? Engineers? Teachers? All of the above?

ADAM SAVAGE of MythBusters fame noted, "Humans do two things that make us unique from all other animals; we use tools and we tell stories. And when you make something, you're doing both at once."

Every episode included cobbling together some new creation to prove or disprove a theory. Adam and Jamie Hyneman might be considered professional makers.

This brings me to the topic of focus: What is a maker and what is the Maker Movement?

One might think that it would be people who like to attend Maker Faires, a group that tends to be very broad, from young students to full-time engineers. The fairs and Make magazine cropped up in the early 2000s, so one might assume that the movement is relatively new. However, this type of thing has been going on for decades.

It's possible to trace the Maker Movement back to early ham radio events and computer events like the Trenton Computer Festival (TCF), which are still going on. I gave a presentation on Creating Bug-Free Embedded Software a while back at TCF.

The main driving factor in these events is teaching and learning, as well as the do-it-yourself (DIY) aspect of creating something new.

What Has Changed for Makers

While the need to learn hasn't changed, the tools and opportunities have significantly evolved over the years. Dealing with vacuum tubes and wire-wrap tools, coding in assembler, and learning how to solder have morphed into low-cost modules like Raspberry Pi and Arduino. These utilize surface-mount chips that even the best engineers and technicians find difficult to hand-solder to a printed circuit board.

One trend that's been around a long time is the use of de facto standard interfaces for development kits. New processors, sensors, and peripherals are usually introduced on a circuit board that utilizes one of these interfaces. Making a system is a matter of plugging boards and modules together.

3D printers are the other major change in the last couple decades. Why cut up sheet metal when a 3D printer can deliver an enclosure with color and precision?

The other thing that's made it easier for makers is the open-source movement for both hardware and software. This ready exchange of ideas and technology has been further facilitated by internet sites specifically targeting maker-style projects like hackster.io.

From Maker to Product

Crowdfunding websites such as Kickstarter and GoFundMe have changed how entrepreneurs can get a company started. Companies and distributors also recognize that many maker ideas are being turned into products, providing hardware, tools, and services to address it.

One example is the Raspberry Pi Compute Module that's used by Sfera Labs in its Strato Pi DIN-rail, programmable-logic-controller (PLC) servers. The compute module provides similar functionality to the Raspberry Pi board but in a more rugged, production-oriented module.

Not all makers will move onto STEM competitions or become an engineer, programmer, or scientist. Nonetheless, they will get a better understanding of the technology they're playing with and be able to affect what products are eventually created and sold.

What's remarkable these days is the availability and accessibility of technologies like wireless IoT, artificial intelligence, and machine learning, and much more that's both inexpensive and easy to use for even novice or budding engineers.

Take the Survey

We are interested in your feedback and encourage you to take this survey about the Maker Movement. We will be presenting the results in the near future. ed

Inside Electronics Podcast:

The Evolution of AI from Theory to Reality

322680569 © Alexandersikov | Dreamstime.com

Artificial intelligence (AI) is transforming from a hot topic and buzzword to a real set of commercial solutions for business, industrial, medical, military, and consumer applications. The challenge in developing AI and machine-learning (ML) solutions ranges from determining what kind of AI methodology should be implemented to training and deploying AI- and ML-based solutions.

In this podcast, we talk to Sam Fok, CEO of Femtosense, a company working on using sparse AI for real-time edge applications with silicon, IP, and software tools to create neural networks.

AD INDEX

ABC TAIWAN ELECTRONICS CORPORATION 7
ALTECH CORPORATION 0
COILCRAFT, INC 2
KEYSTONE ELECTRONICS CORP. 11
KOA SPEER ELECTRONICS, INC. 15
PICO ELECTRONICS INC 29
ROCHESTER ELECTRONICS, INC 39
TAEJIN TECHNOLOGY CO., LTD. 21
YUAN DEAN SCIENTIFIC CO., LTD. 25

FOLLOW US ON FACEBOOK AND TWITTER

(ElectronicDesign) (@ElectronicDesgn)

ElectronicDesign

EDITORIAL
Market Leader - Electronic & Mechanical Group: **Michelle Kopier,** *mkopier@endeavorb2b.com*
Senior Content Director: **Bill Wong**, *bwong@endeavorb2b.com*
Executive Editor: **David Maliniak,** *dmaliniak@endeavorb2b.com*
Managing Editor: **Roger Engelke,** *rengelke@endeavorb2b.com*
Editor-at-Large: **Alix Paultre,** *apaultre@endeavorb2b.com*
Senior Editor: **James Morra,** *jmorra@endeavorb2b.com*
Technology Editor: **Cabe Atwell,** *catwell@endeavorb2b.com*
Technology Editor: **Andy Turudic,** *andyt@endeavorb2b.com*

CONTRIBUTING EDITORS
Lee Goldberg, Bill Schweber, Murray Slovick, Steve Taranovich, Alan Earls

ART DEPARTMENT
Group Design Director: **Anthony Vitolo,** *tvitolo@endeavorb2b.com*
Art Director: **Jocelyn Hartzog,** *jhartzog@endeavorb2b.com*

PRODUCTION
Production Manager: **Brenda Wiley,** *bwiley@endeavorb2b.com*
Ad Services Manager: **Deanna O'Byrne,** *dobyrne@endeavorb2b.com*

AUDIENCE MARKETING
User Marketing Manager: **Debbie Bouley** *dbouley@endeavorb2b.com*
Article Reprints: *reprints@endeavorb2b.com*

SUBSCRIPTION SERVICES
OMEDA, 847-559-7598 or 877-382-9187
electronicdesign@omeda.com

LIST RENTAL
List Rentals/Smartreach Client Services Manager: **Kelli Bery,** *kberry@endeavorb2b.com*

SALES & MARKETING
Gregory Montgomery, *gmontgomery@endeavorb2b.com*
AZ, NM, TX
Samantha Nelson, *snelson@endeavorb2b.com*
AL, AR, SOUTHERN CA, CO, FL, GA, HI, IA, ID, IL, IN, KS, KY, LA, MI, MN, MO, MS, MT, NC, ND, NE, OH, OK, SC, SD, TN, UT, VA, WI, WV, WY, CENTRAL CANADA
Elizabeth Eldridge, *eeldridge@endeavorb2b.com*
CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT, EASTERN CANADA
Stuart Bowen, *sbowen@endeavorb2b.com*
AK, NORTHERN CA, NV, OR, WA, WESTERN CANADA
AUSTRIA, BELGIUM, FRANCE, GERMANY, LUXEMBURG, NETHERLANDS, PORTUGAL, SCANDINAVIA, SPAIN, SWITZERLAND, UNITED KINGDOM
Diego Casiraghi, *diego@casiraghi-adv.com*
ITALY
Helen Lai, *helen@twoway-com.com*
PAN-ASIA
Charles Liu, *liu@twoway-com.com*
PAN-ASIA

DIGITAL
VP of Digital & Data Innovation: **Ryan Malec,** *rmalec@endeavorb2b.com*

ENDEAVOR BUSINESS MEDIA, LLC
30 Burton Hills Blvd, Ste. 185, Nashville, TN 37215 | 800-547-7377
www.endeavorbusinessmedia.com

CEO: **Chris Ferrell**
President: **June Griffin**
COO: **Patrick Rains**
CRO: **Paul Andrews**
Chief Digital Officer: **Jacquie Niemiec**
Chief Administrative and Legal Officer: **Tracy Kane**
EVP, Design & Engineering Group: **Tracy Smith**

Video ▸ **Hannover** Maker Faire Expands the Design Community

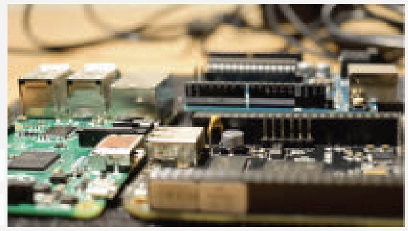
Now the third largest event of its kind in the world, the Hannover Maker Faire saw 15,800 participants pass through its doors this year—an increase of 10% over the previous year. The event took place at the Hannover Congress Centrum, giving makers, educational institutions, and companies a platform to present themselves and their projects for the 10th time. The diversity of the offerings was reflected in maker projects addressing applications from cutting-edge technologies like AI and quantum computing to traditional craft techniques such as spinning and forging.

www.electronicdesign.com/55140646

Video ▸ **Maker Kits** Focus on Up-and-Coming Electronic Engineers

Funduino kits target younger and beginning electronic makers, because having tools and projects that are age- and skill-appropriate are important. It's also important not to "dumb down" the tech as to make it more a toy than a tool. The kits offer more than 1,500 different controllers, sensors, actuators, 3D printers, robots, and accessories, with a free learning platform at *www.funduino.de* that offers instructions, tips, and tricks in the areas of Arduino microelectronics, DOBOT robotics, or 3D printers.

www.electronicdesign.com/55141060



The Best SBCs with Integrated AI Hardware

Discover how single-board computers with integrated AI processing power are driving everything from edge applications to industrial automation.

www.electronicdesign.com/55134569

New Aerodynamic Theory Could Improve Wind Farm Design and Operation

Developed by MIT, the first comprehensive model of rotor aerodynamics could enhance the design of turbine blades and wind farms, and how wind turbines are controlled.

www.electronicdesign.com/55136167

Indy Autonomous Challenge 2024: AI at High Speed

The IAC held the seventh edition of its autonomous racing competition, setting new world autonomous speed records for top speed on a racetrack and fastest passing overtake.

www.electronicdesign.com/55142641

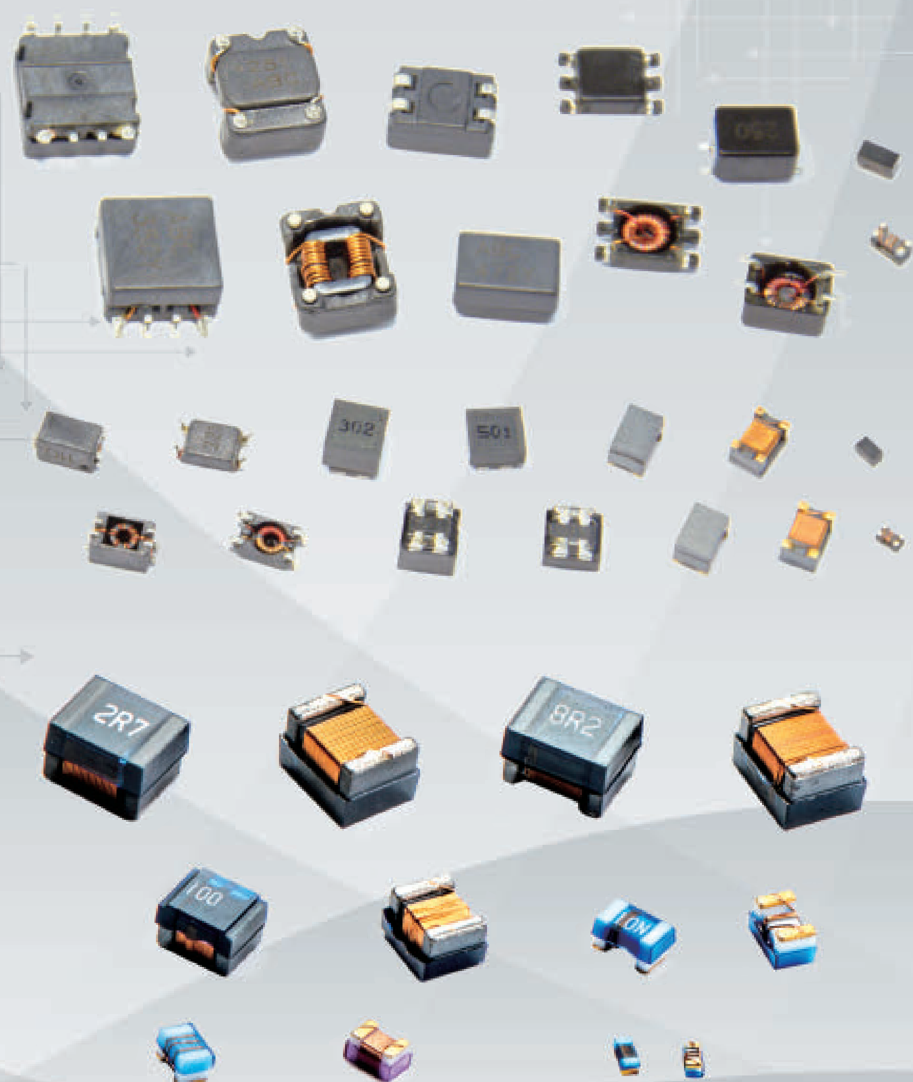
ATEC Electronics Group

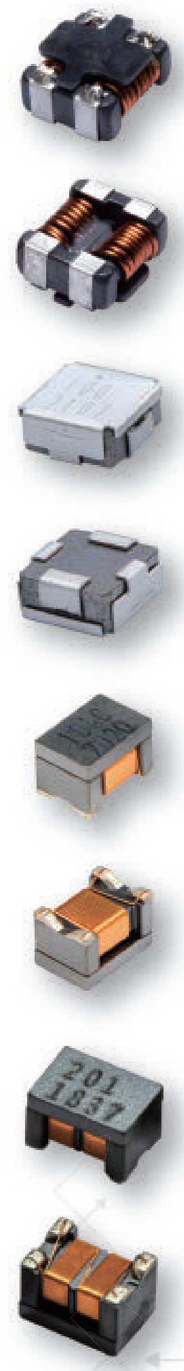
New

Automotive series products Click for more information

Trusted manufacturer by leading industry leaders for high quality **Inductors and transformers**
Possessing **45** years of professional experience.

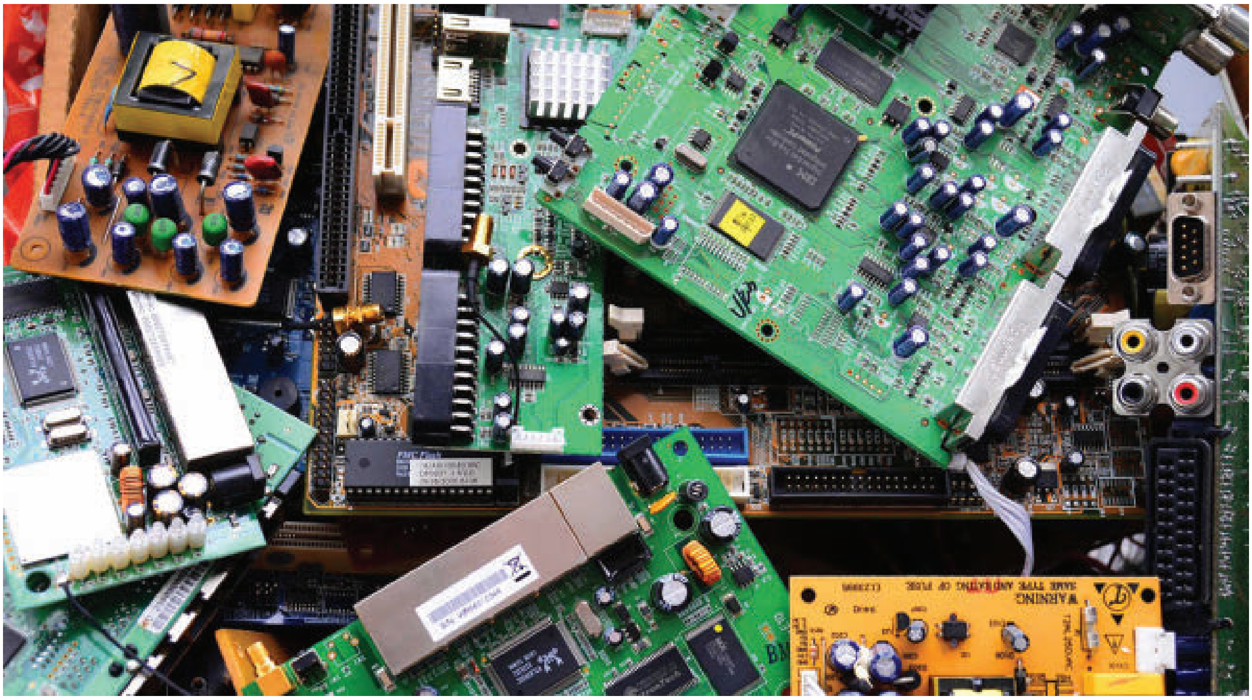
- High quality product with customization available
- Products are designed for various applications
- Automotive grade products are compliant with AEC-Q200





ABC-ATEC ELECTRONICS GROUP
ABC TAIWAN ELECTRONICS CORP.
Tel:+886-3-478-8188 Fax:+886-3-488-0648
Email: abcsa@atec-group.com www.atec-group.com

WILLIAM G. WONG | Senior Content Director



76036740 © Bokstaz | Dreamstime.com

The Maker Movement: Then and Now

Makers have been coming up with interesting projects and products courtesy of the latest open-source hardware and software.

THE MAKER MOVEMENT consists of a diverse group of people, organizations, and companies that make learning about technology fun and possibly profitable. The do-it-yourself (DIY) mentality actually goes back much farther when it comes to electronics and tinkerers have been around forever.

Numerous things have changed over time to make the impact of the movement more widespread and diverse. Prototype board ecosystems like Arduino, Raspberry Pi, and BeagleBoard provide a hardware and software environment, while 3D printers simplify precise creation of physical devices. Open-source software like GNU gcc compiler and Linux have transformed not only the DIY space, but commercial and industrial markets as well.

Turning ideas into prototypes and then into products has been facilitated by websites like Kickstarter, which streamline the process of accessing capital and selling products.

Before There Were Makers

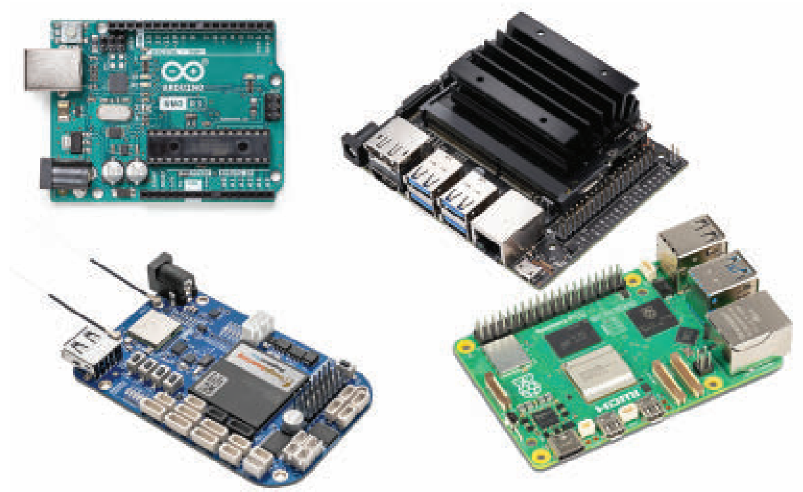
Ham radio operators were once at the forefront of electronics with vacuum-tube amplifiers. Companies like Heathkit sold kit versions that allowed makers to put together electronic devices from scratch. It was possible to run down to a local Radio Shack and pick up wires, solder, tubes, and diodes for projects. However, in most cases, the background and support when it came to electronics and software was a bit more difficult to come by.

Vacuum tubes led to transistors and, in turn, small integrated circuits *(Fig. 1)*. Building something from scratch entailed soldering and oftentimes metal work. The idea of incorporating software into projects arrived much later.

It's possible to trace the Maker Movement back to early ham radio events and computer events like the Trenton Computer Festival (TCF), which are still running today. I gave a presentation on Creating Bug-Free Embedded Software a while back at TCF. The audience was a mix of students, adults, engineers, and programmers with various backgrounds.

The PC revolution tended to dominate the "maker space" in the 70s, 80s, and into the 90s, although it was more the PC space at that point with hobbyists and emerging companies early on. One had to be rather dedicated to experiment in this space, as the plethora of boards and software we now have wasn't nearly as robust. Computer clubs were distributing software on floppy disks and bulletin board systems (BBS) using dial-up modems that predated the internet.

Magazines like *Mini Micro Systems, Microsystems Journal, Dr. Dobbs Journal*, and *Byte Magazine* were sources of hardware and software information. There were plenty of electronics publications such as *Electronic Design*, though they catered to, and were more generally available to, professional engineers and programmers. Publications like *PC Magazine* and *Computer Shopper* targeted end-users. I was the first PC Labs Director at *PC Magazine* and also wrote for all of those publications at some point.



2. The Arduino Uno R3 (top left), NVIDIA Jetson Nano (top right), BeagleBone Blue (bottom left), and Raspberry Pi (bottom right) are major open-source hardware platforms with massive matching software and hardware ecosystems. *Arduino, Beagleboard.org, Raspberry Pi, NVIDIA*

Maker Formalization

The maker movement we know today emerged after the internet was in full swing, along with the open-source movement. Linux and open-source software like the gcc and Eclipse IDE changed both the commercial and non-commercial development environment. It also changed how OEMs viewed the market—the tools and often the development platforms were no longer a focus of income, but rather a way to sell the hardware and software products built using these tools.

The National Computer Conference (NCC), Comdex, and Consumer Electronics Show (CES) catered to professionals. CES is still around and numerous, more focused shows are available these days for that crowd. In 2006, the Maker Faire arose along with *Make magazine*.

The rise of Makerspaces emerged, too. These locations essentially rent space, often as a subscription service, and access to tools that the typical user would not be able to afford. It once included things such as 3D printers when they were expensive, but plenty of higher-end systems would be found in one of these shops now. Even lower-end printers are useful in this type of environment, as the people taking advantage of the hardware, software, and services range from novices to experts.

Changing Technology Made for Makers

The growth of hardware platforms like Arduino, BeagleBone Arduino, and NVIDIA's Jetson *(Fig. 2)* has led to the matching growth of commercial development kits based on these form factors. Any new sensor, microcontroller, or microprocessor is likely to show up with a development or evaluation kit that aligns with one of these form factors.

Matching software support is also part of the ecology. It includes IDEs, run times, operating systems, and more. For me, this is actually more important than the hardware side because it includes instructional material, and makers are all about learning.

The next piece to the puzzle is the associated websites. The internet and general access to information makes the old BBS and floppy disks pale in comparison. A typical download of a gigabyte of information or tools would have been impossible until recently.

The sites have turned into commercial stores thanks to the increasing number and quality of products. The demand for turning prototypes into products has

1. Tube amplifiers were built from scratch and available as kits to complement the commercially available products. *71297871 © Zvonko59 | Dreamstime.com*

3. 3D printers have changed the quality of what makers can make. *130360854 © Stokkete | Dreamstime.com*

"Humans do two things that make us unique from all other animals—we use tools and we tell stories. And when you make something, you're doing both at once."

spawned versions such as the Raspberry Pi Compute Module.

The final piece of the puzzle involves 3D printers *(Fig. 3)*. One of the biggest challenges facing makers when building a project that someone else designed is acquiring the parts. The hardware platforms just mentioned are only part of the mix. Getting arms for robots, or little parts, or even boxes for holding a project, were difficult to get or build prior to 3D printers.

These days, 3D printers are readily available, and design files are easily exchanged and enhanced. A project that has a case containing a Raspberry Pi can be adjusted to fit an additional expansion board or to accommodate a new sensor.

Makers and STEM Competitions

I wanted to make mention of STEM competitions like the Regeneron International Science and Engineering Fair (ISEF). I've written about these competitions numerous times, and I'm still involved with the Mercer Science and Engineering Fair (MSEF). The competitions tend to include the cream of the crop of makers.

Adam Savage of *MythBusters* fame noted, "Humans do two things that make us unique from all other animals—we use tools and we tell stories. And when you make something, you're doing both at once."

That's sort of what makers are all about. Telling the stories is often about teaching others as well.

One of My Maker Contributions

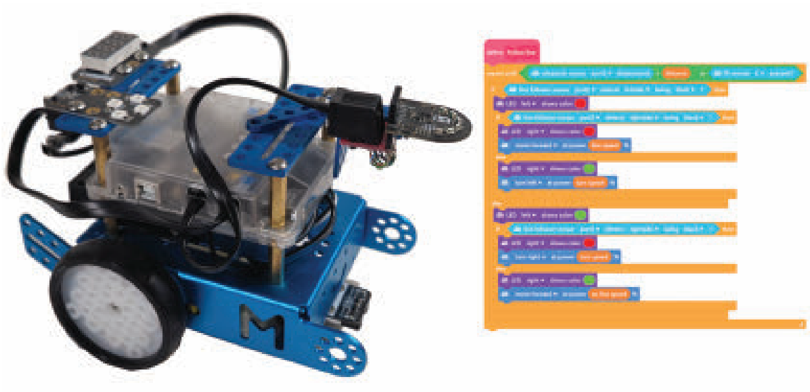
I've been lucky enough to have played with and built things starting with vacuum tubes through to machine-learning (ML) and artificial-intelligence (AI) projects using NVIDIA's Jetson platforms.

I picked up the Makeblock Mbot for my grandson to teach him how to program *(Fig. 4)*. My daughter competed at ISEF using a similar robot, but she learned Basic, Prolog ,and Java along with basic electronics to get her robots to work.

The maker project I did to enhance the Mbot was built around Pololu three-channel FOV (field of view) time-of-flight (ToF) distance sensor based on Texas Instruments' OPT3101 ToF-based long-range proximity and distance-sensor analog front end (AFE). The module adds LEDs and interface support to the OPT3101. I added an adapter and driver software for the graphical Mblock programming software used with the Mbot. Mblock is based on MIT's Scratch.

Scratch is another example of how tools and hardware are being tailored for a wider variety of people, and it makes the introduction of different technologies easier. This is especially true for AI/ML, which can be very complex, Still, that can also be easily utilized with the right framework.

Here's hoping that you try out your own maker project if you haven't done so already. ed



4. This Mbot robot includes a Texas Instruments OPT3101 ToF range finder maker project that I built. *William Wong/Electronic Design*

JAMES MORRA | Senior Editor

Arduino's CEO on the Commercial Future of **Open-Source Hardware**

Fabio Violante, CEO of Arduino, explains how open-source hardware is moving from the "maker" space into the commercial market.

ARDUINO HAS BECOME one of the key building blocks of the open hardware movement. Arduino, the platform, is designed to be modular, affordable, and easy for virtually anyone to use. The company behind it has rolled out development boards in droves over the last decade and a half and the software to program them all.

Besides students, tinkerers, and other makers, it's also widely used by engineers for rapid prototyping of IoT and other electronic projects, with the goal of turning them into commercial products down the line.

"Today's new generation of engineers grew up building with Arduino," said Massimo Banzi, Arduino's co-founder and chairman, when the company announced plans to expand its U.S. operations around a year ago.

But with many of these engineers now moving into high-level engineering and product development roles, CEO Fabio Violante wants to make it as easy as possible for them to take Arduino's hardware along for the ride.

Arduino is going all-out to give them high-performance hardware with ruggedness and reliability for use in industrial control, robotics, and other systems. The company introduced Arduino Pro to help remove some of the obstacles that had made it difficult to move Arduino-based prototypes to mass production with the same hardware. The company has claimed more than 1,000 customers are already

Fabio Violante, CEO of Arduino. *Images courtesy Arduino*

on board with its Pro hardware, which, importantly, is compatible with the vast resources of Arduino's open-source community, said Violante.

The Arduino Pro line spans everything from industrial-grade computer modules—highlighted by the Portenta line of system-on-modules (SOMs) that can run everything from a real-time operating systems (RTOS) to Linux—and intelligent sensors—including its Nicla family of voice, vision, and sensor processor boards—to the Arduino Pro IDE and other software development tools with more of the features that the "pros" are accustomed to.

The latest member of the Pro family is the Arduino Opta, its secure, modular programmable logic controller (PLC) targeting the industrial IoT. PLCs are widely used in the world of industrial automation, and they can be programmed to control the movement of robots and other machinery on factory floors. While compact and relatively limited in terms of its I/O, Arduino said the Opta's combination of computing power, flexible programming, modular design, and affordable price will help make industrial control more accessible.

The Opta is based on Arduino's Portenta H7 module, giving it the ability to tolerate harsh temperatures and other tough industrial conditions. The cube-shaped device also enables expansion modules to add different functions.

As opposed to the proprietary connectors used on factory floors, Opta leverages Wi-Fi, Bluetooth, Ethernet, and other connectivity standards. Arduino worked with Blues Wireless to roll out wireless modules that can bring cellular or LoRa connectivity to any Opta and then connect it to a cloud, including Arduino's cloud.

Opta is also embedded in Arduino's ecosystem, offering access to thousands of code libraries, tutorials, and other resources that customers can use to rapidly prototype, troubleshoot, and even collaborate on projects.

We reached out to Violante to discuss where Opta fits into Arduino's future and hear the CEO's thoughts on the future of open-source hardware in the commercial space. This discussion has been edited for clarity.

How has Arduino's user base evolved since it announced Arduino Pro?

Since announcing the Arduino Pro range, our user base has significantly diversified and expanded. Arduino was already a popular platform in the professional market as a rapid prototyping tool. However, with the introduction of Arduino Pro, we have seen a substantial increase in professional engineers, developers, and industrial stakeholders who now use our platforms for full-scale, end-product development. This evolution reflects a growing recognition of the ease of use, reliability, scalability, and versatility of Arduino solutions for professional and industrial applications.

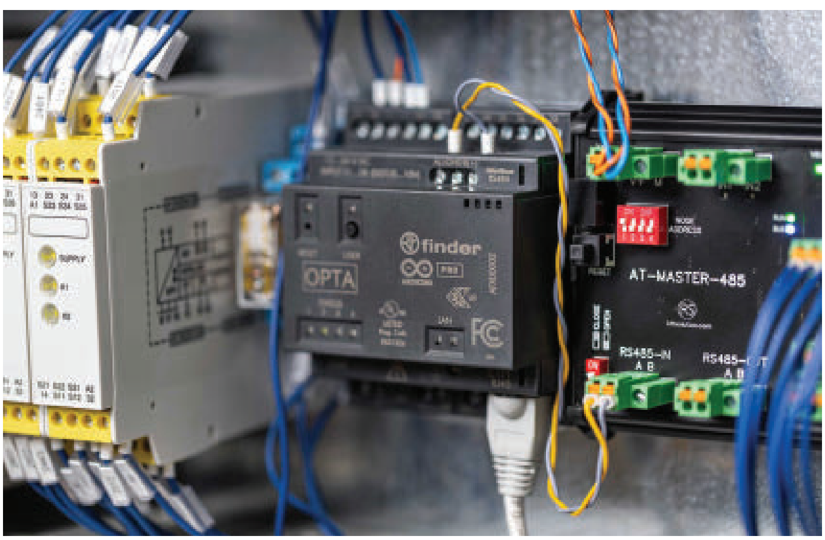
Arduino said the Opta is easy to integrate in industrial control and robotics systems.

How is that evolution shaping the design of Arduino's hardware platforms?

The evolution of our user base toward more professional and industrial applications has directly influenced the design of our hardware platforms. We now prioritize features such as enhanced performance, connectivity, and integration capabilities.

For example, our Pro line, including products like the Portenta and Opta, incorporates robust processing power, advanced security features, extended temperature range, and form factors more suitable for professional applications. These enhancements are designed to meet the specific needs of professional developers and industrial environments, ensuring our products are not only innovative, but also reliable and scalable.

This evolution is also benefiting our other target segments, from hobbyists to artists to educators. The Arduino GIGA R1 board, for example, shares the same powerful STM32H747 microcontroller of the Portenta H7, with a prototyping-friendly form factor and an affordable price point for the general public.



Arduino's Opta is a secure, compact, and modular programmable logic controller (PLC).

Opta was the company's first offering for programmable logic controllers. Why does the company call it a "micro-PLC"? Is it related to the expansion modules that can be plugged into it?

We refer to Opta as a "micro-PLC" because it combines the core functionalities of traditional PLCs with the compact form factor and flexibility of Arduino's ecosystem. The term "micro" signifies its smaller size and the modular nature that allows for expansion through various plug-in extension modules. This design enables users to customize and scale their automation solutions without the constraints typically associated with larger, more rigid PLC systems.

You have previously said of the Opta, "We lower barriers to industrial automation, enabling a broad range of projects that were unthinkable or unapproachable not long ago." Can you elaborate on that? What can developers do with the Opta and other open-source hardware that they couldn't—or typically wouldn't—do with proprietary hardware?

Opta and other open-source hardware lower the barriers by offering affordability, flexibility, and ease of use to anyone. Opta can be programmed with both the Arduino language and traditional IEC PLC languages. For example, users can write functions and blocks in Arduino code that can then be called from Ladder Logic. This breaks the barriers of predefined functions provided out of the box in the traditional world. Additionally, having a vast ecosystem of libraries available for Arduino, users can easily solve complex integration problems.

This approach helps companies cope with the skill shortage affecting the automation engineering world, by tapping into a broader population of young talents familiar with Arduino because they learned it in schools and universities.

Finally, with Opta, developers can create sophisticated automation solutions

Open-source platforms foster innovation by allowing users to modify, enhance, and share their projects. This collaborative environment encourages experimentation and customization, enabling projects that may have been financially or technically unfeasible with proprietary systems.

without the steep costs or proprietary restrictions of traditional hardware.

Open-source platforms foster innovation by allowing users to modify, enhance, and share their projects. This collaborative environment encourages experimentation and customization, enabling projects that may have been financially or technically unfeasible with proprietary systems. Developers can now rapidly prototype, iterate, and deploy automation solutions tailored to their specific needs, accelerating innovation and reducing time-to-market.

AI is becoming a bigger and bigger topic in industrial automation and robotics. What challenges will this present, and how is Arduino trying to address them?

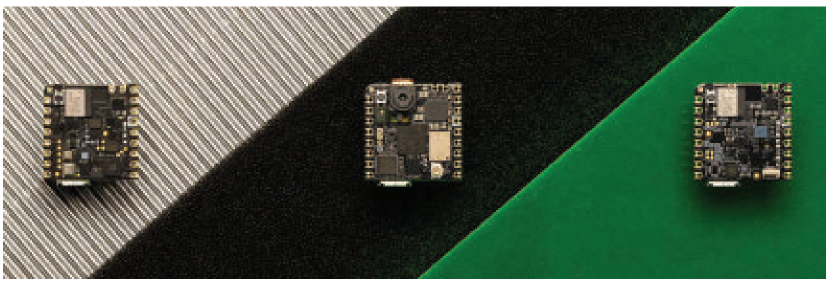
AI integration in industrial automation presents challenges such as data processing, real-time decision-making, and ensuring system reliability. Arduino addresses these challenges by providing hardware platforms with robust processing capabilities and seamless integration with AI frameworks.

Our Pro range, including the Portenta H7, is designed to handle complex algorithms and data-intensive tasks at the edge. Additionally, we offer extensive libraries and tools that simplify the implementation of AI and machine-learning models, enabling developers to harness AI's potential effectively and efficiently. In the edge AI space, we also offer a range of miniaturized, intelligent, low-power sensors (video, environmental, and audio) with the Nicla family.

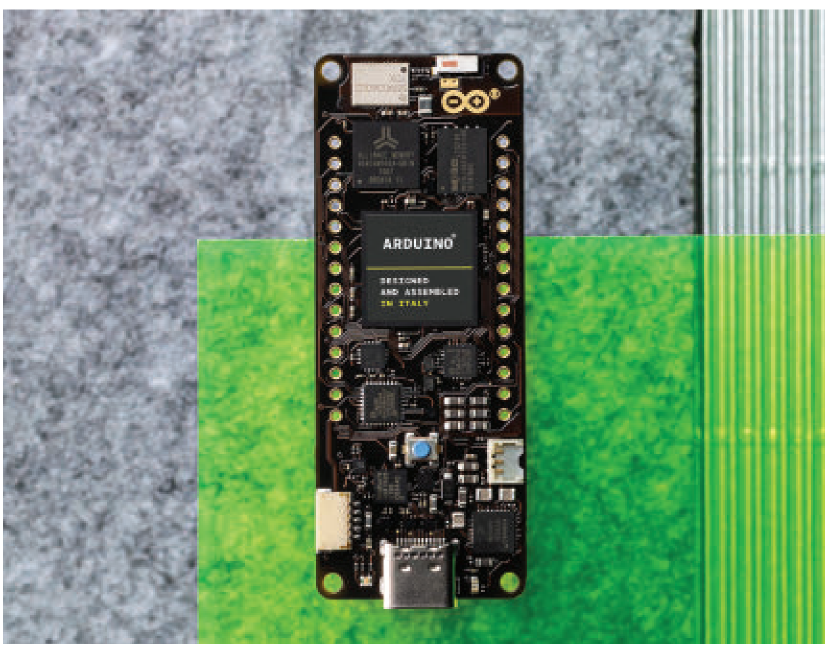
Arduino is not alone in expanding out of the maker and educational markets. Raspberry Pi, too, is becoming more widely used in industrial automation. What do you think the future holds for the commercial use of open-source hardware?

The future of open-source hardware in the commercial market is incredibly promising. As industries continue to prioritize innovation, customization, and cost-efficiency, open-source hardware offers unparalleled advantages.

We anticipate widespread adoption across various sectors—including healthcare, agriculture, and IoT—driven by the benefits of collaborative development and rapid prototyping. The flexibility to adapt and improve solutions will empower businesses to stay competitive and responsive to market demands, fostering a new era of technological advancement and democratization. ed



The industrial-grade Nicla family features voice, vision, and a wide range of other sensors.



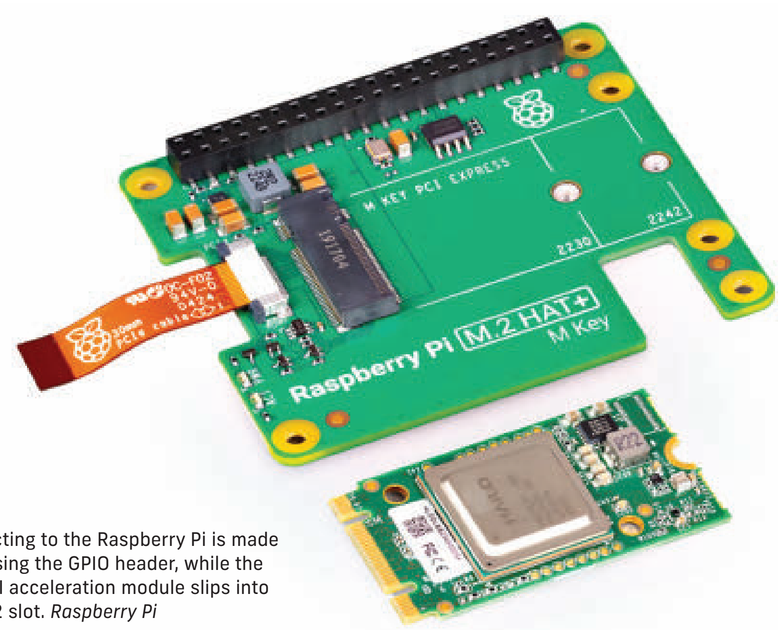
At the heart of the Opta is the Portenta H7 processor module.

CABE ATWELL | Technology Editor

The Raspberry Pi AI Kit comes with an M.2 HAT+ and Hailo AI acceleration module capable of pushing 13 TOPS.
Raspberry Pi and 132826092 © Blackboard373 | Dreamstime.com

Raspberry Pi 5
Taps into AI with a New Add-On Kit

The Raspberry Pi AI Kit comes with an M.2 HAT+ and Hailo AI acceleration module capable of pushing 13 TOPS.



Connecting to the Raspberry Pi is made easy using the GPIO header, while the Hailo AI acceleration module slips into the M.2 slot. *Raspberry Pi*

WE'VE SEEN THE artificial-intelligence (AI) boom escalate for several years and it shows no signs of slowing. Nearly every industry is taking advantage of the technology, spurring innovation in everything from manufacturing to big-data analytics.

AI has also found its way into the development and maker markets, where users have utilized its advantages to build everything from robots to facial recognition systems. Furthermore, manufacturers are now integrating AI processing capabilities into their latest single-board computers and add-on boards for increased capabilities.

New AI Kit Aligns with Pi 5

The Raspberry Pi Foundation is just one of the institutions that's taken advantage of AI for increased innovation with its new Raspberry Pi AI Kit. The kit, designed for use with the Raspberry Pi 5, the Foundation's flagship board, allows users to experiment with a myriad of AI platforms.

"Developed in collaboration with Hailo, the AI Kit offers an accessible way to integrate local, high-performance, power-efficient inferencing into a wide variety of applications," said Raspberry Pi's Naush Patuck. "It's available now from our network of Raspberry Pi Approved Resellers."

The kit includes Raspberry Pi's M.2 HAT+ with a Hailo AI acceleration module *(see figure)*. The AI module is a neural-network inference accelerator capable of pushing 13 TOPS (teraoperations per second). It's built around the Hailo-8L chip, which uses the M.2 2242 form factor and comes preinstalled in the M.2 HAT+. The M.2 HAT+ provides a communication bridge between the AI module's M.2 interface and the Raspberry Pi 5.

When connected, the Raspberry Pi 5 automatically detects the Hailo module and makes the neural processing unit (NPU) available for AI applications. This includes machine vision, which takes advantage of built-in "rpicam-apps" camera applications in the Raspberry Pi OS, facilitating post-processing tasks.

The kit also comes with preinstalled Hailo Tappas post-processing libraries, allowing users to create advanced AI applications with only a few hundred lines of C++ code. Software installation is made easy by incorporating a few packets via "apt" and then performing a simple reboot. On top of that, the Raspberry Pi AI Kit integrates an API into the GStreamer framework, along with native Python and C/C++ applications.

The Hailo-8L chip frees up the Raspberry Pi 5 CPU by offloading AI tasks directly on the module, suiting it for any number of AI applications. In addition, Hailo offers models for users to find pre-trained neural-network models optimized for the AI Kit. Raspberry Pi updated its AI framework to support the camera subsystem, which is documented in a "getting started" guide. ed

ANDY TURUDIC | Technology Editor

So...You Want to Convert Your **Gas/Diesel ICE Vehicle to Electric?**

235671862 © Blackfarm | Dreamstime.com

Andy shows the many approaches used by engineers to convert ICE vehicles to electric propulsion and provides "how to get started" guides and references.

Got a classic car
That's got a clapped out driveline?
Make it electric

THE AVAILABILITY OF almost full torque from a stop is what differentiates an electric vehicle from its ICE counterpart. Since many of us drive on the streets most of the time, such low-end torque produces a force that then transforms into a grin on your face. Once you've driven an electric vehicle, it's really tough to go back. And it's not a whole lot more complicated to hotrod a classic car as electric if you know the recipe and where to look for resources.

With that, let me introduce what some of my engineering friends, colleagues, and acquaintances are up to in the after-hours EV conversion space. Many of them are breathing new life into the cars that were dear to them earlier in their lives.

Lightening Bolts and Back to the Future

So, what happens when a Chevy Bolt EV gets totaled? If you're Seattle-area's Bill Carlson, a lead software engineer for Microsoft where he develops some game called Minecraft, you buy a rear-ended Bolt at a salvage auction and then meticulously disassemble it. You label and document each and every wire with the goal of transplanting everything, including the instrument cluster and center display, into a de-ICE'd DeLorean.

Bill actually succeeded with pulling off the crazy transplant, demonstrating a test drive a few months ago on his YouTube channel, where he's documented his build, and recently did a complete rework of the wiring to where it's no longer a prototyped ratsnest. Bill's deBoltean (he calls it "Project Lightning"), amazingly, still works and will likely be the first DIY EV conversion with Apple CarPlay. Note that with 1-in. smaller diameter tires, the 92-mph speed-governed Bolt EV system would result in a speed barrier for the DeLorean of 88 mph. Just sayin'...

Tesla Goes International

Also in the Seattle area is Mark, who's an EE at a stealth startup doing AI Computer Systems Architecture. Mark is working on converting the 1952 International pickup, which he got from his farmer-grandfather and that he drove in high school, to electric propulsion. Wanting a bit more than what the stock truck frame and suspension could offer for handling performance, Mark commissioned renowned chassis-builder Art Morrison, whose Seattle-area shop mandrel-bent a full-custom tube chassis for the truck.

Now that the chassis is done, and with a change to using a Tesla drive unit instead of the Ford, Mark just bought a "donor" Tesla Model 3 at a salvage auction. My eight-year-old engineering apprentice and I will be driving up in my Bolt EV for a "battery dropping party"...the stuff I do to guilt people into writing contributed articles in the future for us here, LOL. Mark plans to use a T2C from EV-Controls to pull everything together control-wise—it handles CANbus communications with the drive units and the battery-management system.

Heavy Metal Meets Plastic

A similar propulsion and control approach is being used by "428RC," a Mechanical Engineer in Florida, who's converting a 1962 Corvette on a tubular steel racing chassis that features a C5 suspension system. He's planning a Tesla-based all-wheel drive and on using Chrysler Pacifica batteries, though. One interesting approach in fit-up was his use of 3D printing to create mock, easy-to-handle, full-size, front and rear Tesla Model 3 plastic drive units.

Honda Owner Can't Leaf It Alone

SF Bay area-based Viet, a software engineer, picked up a smashed Nissan Leaf at an insurance auction, cannibalized it for all the parts he thought he might need, and then de-ICE'd his Honda CRX, methodically installing the Leaf "stack" (a factory assembly of motor, gearbox, inverter, and charger) into the engine bay. He then mechanically reconfigured the Leaf's battery cells and shoehorned them into the trunk area of the car.

His choice to coordinate all of the Leaf pieces was a solution from Resolve-EV, though Leaf-integration solutions are also available from Thunderstruck-EV and the open-sourced "Zombieverter." Viet got the car to be California road legal, drove it for about six months, and then tore a good part of his build back down in a new build...a front and rear Leaf stack in the CRX for AWD. He has a most-excellent build thread of it all, here.

de-ICE'd 'berg Ahead

Electronic Design's resident tree-hugging hippie, Lee Goldberg, acquired an already-converted motorcycle with a compromised Leaf battery system that needed to be reworked. An introduction to his project series is here. Still a work in progress, Lee promises to get back to it soon and write about his efforts on *Electronic Design*.

Forking Around

Electronic Design's now-retired analog editor, Paul Rako, acquired an already-converted Honda Civic, but reworked its battery system to a low-CG arrangement of deep-cycle, lead-acid Trojan batteries—the best option we had for mobility energy storage back then. He replaced the electric motor with a 9-in., DC forklift-derived-design brushed electric motor, fabricating an adapter plate for it to couple to the existing Honda tranny. Some details on the car and its "old school" build can be found on Paul's website, here.

"Duncan," a retired Mechanical Engineer living in New Zealand, built a Locost-7 and equipped his EV using "old school" methods, using a 48-V brushed forklift motor for propulsion and a Chevy Volt battery pack. Duncan enjoys racing the car, and its winning performance comes from "overvolting" the forklift motor to where it had signs of internal arcing at its 340-V battery voltage while pushing 1200 A through it. His build thread, starting a decade and a half ago, is here. Duncan continues to explore the limits of powering the car, increasing voltage and current.

EV Conversions as Engineering Testbeds

The open-source movement has also been embraced by the DIY electric-car enthusiasts with a hotbed of activity being spearheaded by two European electrical engineers on the Open Inverter Forum.

Johannes, from Germany, and Damien, from Ireland, started out as EV hobbyists, but both have quit their day jobs to make the world a better place. They have produced a number of controllers for EV conversion that enable the use of salvage vehicle components for propulsion and charging.

Both engineers have performed a number of ICE conversions as engineering-development testbeds, featured in detail on Damien's and Johannes' YouTube channels. Johannes recently completed a brave road trip from Germany to Sweden and back, charging his converted VW Tourag with high-speed public chargers using a newly developed, open-source, CCS charge controller during the trek. Don't expect polished, adrenaline-rush, video production from these guys as these are more in the vein of engineering documentation and project status updates than a salty *National Geographic* documentary.

Damien's EVBMW online store offers a number of open-source traction control solutions for various EV drive units, as well as boards to control such devices as Tesla on-board HV battery chargers. The development of many of the solutions involved meticulous CANbus sniffing and emulation, one aspect of reuse that OEMs unnecessarily hold close to their vest.

Right to repair is one thing, but reusing salvage components to convert ICE vehicles to electric propulsion is the ultimate use of resources and avoids a serious e-waste problem that our throwaway society is generating.

Plug and Chug

One major coup that Johannes has recently released, among many control boards in the OIF web store, is his volunteer team's crack of the protocols used at public high-speed chargers, including European Tesla Superchargers (which use CCS protocols, unlike North America). The 380 Euro CCS controller fully supports CCS1 (North America) and CCS2 (Europe), and it's been tested on numerous charger brands and features:

- A configurable CAN interface for BMS and vehicle communication
- Two Contactor drivers for charge port contactors
- A lock motor driver with optional feedback for locking the connector to the charge inlet
- Three LED drivers for red, green, and blue
- Three temperature sensor inputs to measure charge inlet pin temperatures
- A pushbutton input
- An analog input for a separately measured charge port inlet voltage (optional)

Besides running DC fast-charge sessions, the controller can also handle AC charging sessions and forwards CP and PP current limits via CAN to a separate on-board charger.

The open-source hardware design for the CCS controller, which uses an STMicroelectronics STM32F103RE and a Qualcomm QCA7005 homeplug modem, can be found here, with the open-source software repository being here. The populated CCS Controller circuit board is available for pre-order here.

Where to Start

The first thing everyone seems to ask for is a book on how to convert an ICE car to electric. While books can be found on Amazon, eBay, etc., they're primarily "old school," low-voltage, forklift-derived, motor-based conversions that are now considered obsolete. With the recent glut of EVs, the availability of low-cost components from cars made by Nissan, Tesla, Prius, and others usually means 400- to 800-V battery systems and high-efficiency three-phase induction, or permanent-magnet, motors.

A great place to start is to study the build threads in online forums that include DIY Electric Car and the Open Inverter Forum. Johannes recently released a conversion book that covers modern conversion techniques, available here for purchase as a downloadable PDF.

Who knows, your first EV-conversion project might help you end up where one of the members of the DIY Electric Forum has...

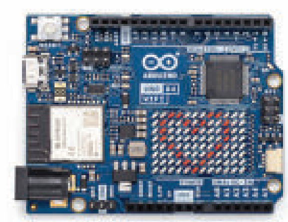
Choosing a battery for your Hypercar build.

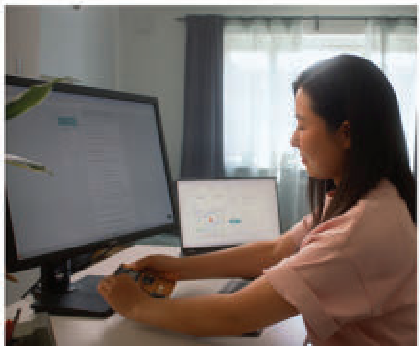
For those of you itching to get back into circuit design stuff, check out an article from Sariel Hodisan, which rounds out the Analog Computing series. I plan to pull it all together in one place by producing an Analog Computing TechXchange. ed

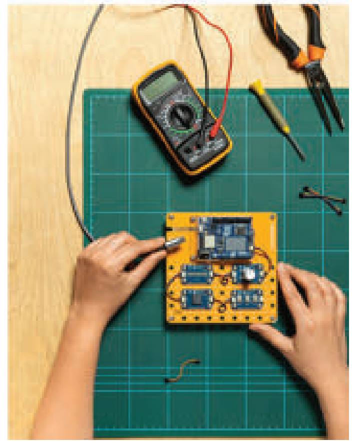
All for now,
-AndyT

ANDY'S NONLINEARITIES blog arrives the first and third Monday of every month. To make sure you don't miss the latest edition, subscribe to our *Electronic Design Today* newsletter.

ANDY TURUDIC | Technology Editor







IoT for Dummies:

Arduino's New Plug and Make Kit

The Arduino Plug and Make Kit provides a 10-minute, cloud-based IoT solution that includes QWIIC and smartphone-based sensors, transducers, and actuators.

THE RECENTLY INTRODUCED Arduino Plug and Make Kit seems perfect for Makers and engineers wanting to quickly incorporate remote sensing or actuation in non-mission-critical applications. It also works for those who are unfamiliar with the entire process required to enable connectivity to mobile devices and computers via the cloud. Development of IoT devices is easily accomplished by Makers, engineers, artists, and, yes, even analog designers who are novices at microprocessors, programming, and network connectivity.

The Arduino Plug and Make Kit includes:

Arduino UNO R4 WiFi main board

This 5-V board features a switching regulator capable of up to 24-V input operation and is based on the 32-bit Renesas RA4M1 Arm Cortex-M4 as the main microcontroller. An Espressif ESP32 S3 is also embedded as a Wi-Fi and Bluetooth connectivity processor, with UNO-compatible header pins and a QWIIC connector provided on the board for hardwired connections.

"Last year we teamed up with Arduino for the development of the new Arduino UNO R4, the quintessential board for rapid prototyping—upgrading the device to a 32-bit Arm architecture, opening up a new range of possibilities. Now we are extremely happy to see our RA4M1 Microcontroller and Buck Regulator ISL854102FRZ technology being deployed within Arduino's Plug and Make Kit to foster the new generation of innovators, lowering the barriers to entry into technology," said Mohammed Dogar, VP and Head of Global Business Development and Ecosystem at Renesas Electronics.

Modulino sensors and actuators

A set of seven small circuit boards with QWIIC connectors provide a buzzer, 6-axis IMU ("Movement"), temperature and humidity sensor ("Thermo"), buttons, knob, RGB

"We're proud to support Arduino on its mission to allow anyone to innovate, whether in harsh industrial environments or in the comfort of their homes."

—Alessandro Maloberti, Partner Ecosystem Director, STMicroelectronics

8-LED strip ("Pixels"), and time-of-flight proximity sensor ("Distance") functionality.

"We're proud to support Arduino on its mission to allow anyone to innovate, whether in harsh industrial environments or in the comfort of their homes. The intuitive Modulino nodes incorporate the high technological standard of our STM32C0 microcontrollers and our sensors, both MEMS (LSM6DSOX, LPS22HB) and Time-of-Flight (VL53L4CD). This is the kind of solution that truly puts great potential into people's hands, giving them the best tools along with the freedom to explore," said Alessandro Maloberti, Partner Ecosystem Director, STMicroelectronics.

The Modulino Base

This FR-4-based physical chassis is designed to enable users to bolt down the Arduino Uno R4 and Modulinos for semi-permanent mechanical robustness. The board is perforated to accommodate one Arduino UNO R4 WiFi and several Modulino boards, and it can sit on a bench or tabletop with its provided metal standoffs. These components are shown in the *figure*, banana for scale not included.

What's in the box of the Arduino Plug and Make Kit? Banana not included. *Andy Turudic | Electronic Design*

Online resources to swiftly integrate with the Arduino ecosystem

These include a dedicated content platform in multiple languages, free and easy-to-use programming tools, a smartphone app to monitor and control IoT devices, and readily available Arduino Cloud templates to get up and running in minutes.

Seven Example Projects for Component Assembly

The Arduino Plug and Make Kit experience starts with seven example projects that enable anyone to assemble components in a snap, without soldering or breadboards, and to control the new device via intuitive Arduino Cloud dashboards, even from their smartphone:

- **Weather Report:** Never forget your umbrella, with a visual forecast for rain!
- **Hourglass:** Who needs an egg timer? Customize your own digital hourglass.
- **Eco Watch:** Make sure your plants thrive in the perfect temperature and humidity.
- **Game Controller:** Level up with your very own human interface device (HID) gamepad.
- **Sonic Synth:** Get one step closer to being a rockstar, DJ, or sound engineer.
- **Touchless Lamp:** Control lights with a simple gesture.
- **Smart Lights:** Turn the lights on and off from your couch, via your smartphone.

Getting Started: Creating a Thing in Arduino's Cloud

The development process is initiated by going to Arduino's cloud development site and signing in with either a Google, Facebook, Apple ID, Github, or Arduino account. The next step is to create a Thing—a virtual entity that lets you link your physical device to the cloud; it includes variables, sketch, and metadata.

After plugging in the Arduino UNO R4 WiFi into the laptop with the provided USB cable (Type C, though a Type A adapter is supplied), the Arduino UNO R4 WiFi is detected and automatically configured to communicate securely with the Arduino Cloud. The process can take up to five minutes, so don't unplug the device during the configuration process.

The next step to adding a Thing is to return to the dashboard and click on "Thing," then select the board that was just configured and select it as an Associated Device. After that, select "Configure" under "Network" and enter the Wi-Fi name and password for your Wi-Fi network to which the Device will attach. The system unfortunately does not auto-detect the networks within range, so the network information needs to be manually entered.

IMPORTANT: Remember to go to the "Sketch" tab and upload the sketch to load the credentials onto the board, because the entered network information is currently sitting on the laptop's browser.

There's also an optional provision for smart-home integration, which configures the Thing to work with Amazon Alexa or Google Home. Furthermore, one can forward data from the Arduino UNO to a URL via a "Webhook" that can be user-configured, too. An example is provided that shows how to use Arduino Cloud with webhooks to save sensor data in online spreadsheets.

Try an Arduino Course from Your Computer or Smartphone

From here, simply follow the "Smart Lights" course example and create a "Template." Copy and paste the code examples and upload the resulting sketch to the UNO R4. With the free cloud plan, uploads are performed via the USB tether to the user's laptop or desktop computer. At this point, the dashboard on the laptop can control the RGB LED colors and turn them on and off.

Downloading the Arduino Remote app enables the control dashboard to be manipulated from the screen of an Apple or Android mobile device. Thanks to the kit provided by Arduino, This Old Analog Guy was able to control the RGB LEDs on the Modulino with his iPhone in about 10 minutes by following the easy-to-understand instructions in Arduino's Smart Lights course.

One interesting feature of the phone remote app is that the phone's sensors can be incorporated as variables for use by the code running on the Arduino R4 thanks to the connectivity provided by the Arduino Cloud. As a result, one could write code where tilting the phone creates a graded set of colors on the LED display Modulino, for example. Some of a phone's sensors could include:

- GPS coordinates (location on map, geofencing)
- Accelerometer data
- Compass
- Tilt
- Gyro
- Magnetometer
- Barometer

Kit Plus Connectivity Facilitates Maker Aspirations

A simple plug and play of sensors, actuators, transducers, and other devices using the QWIIC I^2C connector system creates a super-fast way to prototype a concept. The integration of Wi-Fi and Bluetooth connectivity on the Arduino UNO R4 WiFi not only enables remote control of devices hardwired to the Arduino R4, but also allows for access to the sensors on a mobile phone itself. In addition, sensor data can be logged in to remote spreadsheets, and integration with home automation is possible.

The Arduino Cloud is available as a free service with minimal capability—additional services are possible for a few dollars a month (use coupon code "ELECTRONICDESIGN" for a free trial period of the Arduino Cloud service) that include such things as over-the-air (OTA) updates of the firmware on the Arduino R4. For those who enjoy YouTube as a learning tool, *The DroneBot Workshop* is a great resource to supplement the Arduino site's tutorials for connecting the Arduino Uno R4 WiFi to the Arduino Cloud:

Arduino's Plug and Make Kit can be purchased for about $90 from the Arduino Store, as well as from major worldwide distributors including DigiKey, Farnell, Mouser Electronics, Reichelt, the RS Group, and many other official partners. ed

ANDY'S NONLINEARITIES blog arrives the first and third Monday of every month. To make sure you don't miss the latest edition, subscribe to our *Electronic Design Today* newsletter.

YUAN DEAN
Scientific Co., LTD.

DC-DC Converters

0.25W~150W
1"x 1"/ 2"x 1"/Half-Brick
SIP/SMD/DIP Package

Recommended >

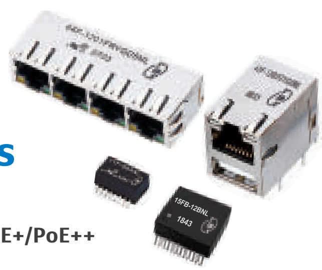
Compact Size
0.94" x 0.54"

Ultra-wide 10:1 Input

8:1 Wide Input Range

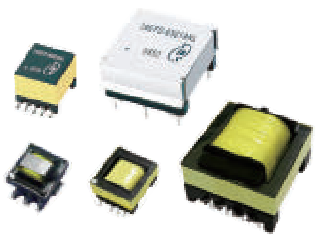
LAN Filters
RJ45 Connectors

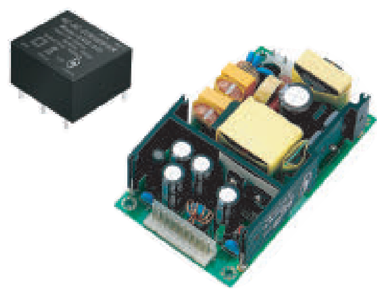
1xN,2xN Port
1G/2.5G/5G/10G Base-T with PoE+/PoE++



Transformers

Inductor
Pulse Transformer
Telecom Transformer
High Frequency Transformer





AC-DC Converters

0.5W~300W
SIP/DIP Package
Module/Open Frame

CONTACT US

No.61, Keji 3rd Rd., Annan Dist., Tainan City 70955, Taiwan
TEL:+886-6-3842899 FAX:+886-6-3843288
E-mail : info@yds.com.tw Website : www.yuandean.com

c UL us CE REACH RoHS COMPLIANT ISO 9001 2015 CERTIFIED ISO 14001 2015 CERTIFIED Indian Register Quality Systems

ALIX PAULTRE | Editor-at-Large

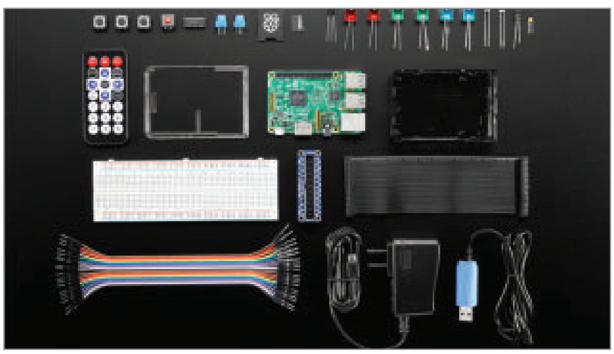
A Sampling of Resources for the **Maker Community**

A wide array of kits and tools are available for Makers and others interested in tinkering and creating electronic systems.

HOBBYISTS AND TINKERERS have been around as long as there have been devices and mechanisms to puzzle over and understand. The current Maker community takes the tinkerer heritage and blends it with the hacker mentality that began with people like Captain Crunch (John Draper) and the phone phreaking movement.

With the democratization of technology and easier access to components and core systems, tinkerers and hackers have turned from taking existing things apart to making their own projects. The electronics community has risen to this demand for tools and development kits for the electronic hobbyist, with a large variety of solutions based on popular computer platforms like Arduino and Raspberry Pi. Here are some of the kits you can get today to start your hobbyist journey.

Raspberry Pi Starter Kit Connects to the Particle Cloud


Adafruit

Particle partnered with Adafruit to make a kit that eases the creation of IoT solutions by connecting a Raspberry Pi 3 to the Particle Cloud. The Particle Pi Starter Kit contains the basics along with added sensors to address IoT applications. Connecting a Pi to the Particle Cloud with the kit simplifies tooling, setup, and scripting to perform simple tasks like toggling a pin, blinking an LED, or reading a sensor value. Over-the-air updates enable safe reprogramming of code running on your Pis one at a time in the Web IDE or as a fleet of devices in the console.

Batch script execution enables you to remotely execute custom scripts on groups of Raspberry Pis using the exec command. It can remotely collect and publish data to the Particle Cloud, or store it locally by logging it on your Pi. Able to integrate with IFTTT, Google Cloud, or Microsoft Azure, the kit is designed with the home tinkerer and maker in mind. Its remote control lets you use the particle connection to send a tweet, access IFTTT, or trigger a remote actuator over the web, or you can remote into your Pi through the Particle Cloud.

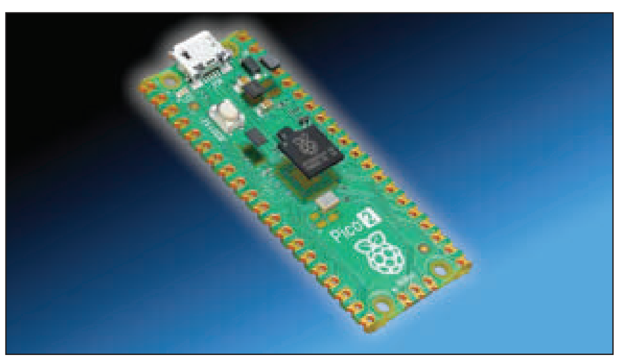
Related links:
Particle
Adafruit
Particle Cloud
Particle IoT Starter Pack

Next-Gen Raspberry Pi Pico 2 MCU Board Boosts Performance, Retains Compatibility

Offering a higher core clock speed, double the memory, more powerful Arm cores, optional RISC-V cores, as well as new security features, the Raspberry Pi Pico 2 improves performance while retaining compatibility with earlier versions of the series.

Providing upgraded interfacing capabilities, it's programmable in C/C++ and Python, and uses the RP2350 high-performance secure microcontroller. Features include a comprehensive security architecture built around Arm TrustZone for Cortex-M, with package options to expand the range of addressable applications.

The novel dual-core dual-architecture of RP2350 allows you to choose between a pair of standard Arm Cortex-M33 cores or a pair of open-hardware Hazard3 cores, enabling the use of a RISC-V architecture in a well-supported environment. The MicroPython language lets you write programs and connect


Raspberry Pi

hardware using PIO, SPI, and I2C interfaces. The security architecture includes secure-boot ROM, is extensively documented, and available to all users without restriction.

Related links:

Raspberry Pi

Raspberry Pi Pico 2

Mouser

Expansion System Enhances Arduino Opta microPLC

The DIN-rail D1608x Pro Opta Digital Expansion improves the Arduino Opta's real-time control, monitoring, and predictive-maintenance abilities. It adds 16 programmable inputs for connecting digital sensors and eight more relays to operate machines. The I/Os are managed from the Opta base unit, using the open Arduino ecosystem or PLC IDE IEC 61131-3 programming environment.

Programmable as digital 0 to 24 V DC or analog 0 to 10 V, you can choose between eight EMRs at 250 V AC for 6 A each, or eight SSRs at 24 V DC for 2 A, with up to five snap-on modules managed to multiply and mix I/O sets.

The DIN-rail Opta Digital Expansion extends hardware capabilities, enabling I/Os to work with PLC IDE for IEC 61131-3 PLC languages. Its low code approach and pre-mapped resources are leveraged with real-time remote monitoring via intuitive Arduino Cloud dashboards and secure communication to a wider set of connected devices.

Options include the Pro Opta Ext D1608E, with 16 digital programmable voltage inputs and eight electromechanical relays at 250 V AC and 6 A, and the Pro Opta Ext D1608S, with 16 digital programmable voltage inputs, eight solid-state relays at 24 V DC and 2 A. All units operate from -20 to +50°C.

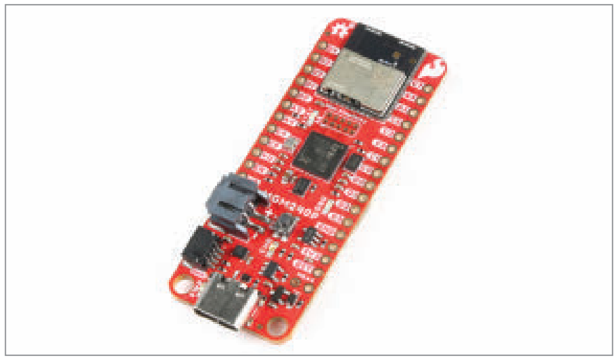
Related links:

Arduino

Arduino Opta

D1608x Pro Opta Digital Expansion

Kit Enables Development and Prototyping of Matter-Based IoT Devices



SparkFun

SparkFun's Thing Plus Matter is an accessible board that combines Matter and SparkFun's Qwiic ecosystem for easy development and prototyping of Matter-based IoT devices. It leverages the MGM240P wireless module from Silicon Labs to ensure secure connectivity for 802.15.4 with Thread and Bluetooth Low Energy 5.3 as well as Silicon Labs' Matter IoT protocol for home automation. SparkFun's Thing Plus development boards are Feather-compatible and use the Qwiic connector protocol for solderless I2C circuits.

The Thing Plus Matter kit includes Qwiic and lithium-polymer (LiPo) battery connectors, as well as multiple GPIO pins capable of complete multiplexing through software, a MCP73831 single-cell LiPo charger, MAX17048 battery fuel gauge, and a µSD card slot for external memory.

Built around the EFR32MG24 wireless SoC with a 32-bit Arm Cortex-M33 core processor running at 39 MHz, it integrates 1536-kb flash memory and 256-kb RAM. The MGM240P works with common 802.15.4 wireless protocols (Matter, Zigbee, and OpenThread) as well as Bluetooth Low Energy 5.3, and Silicon Labs' Secure Vault for Thread applications.

Related links:

SparkFun

Thing Plus Matter

Arduino Nano Matter Module Leverages the Matter Standard for IoT Connectivity

Mouser

The ABX00112 Arduino Nano Matter module, based on the MGM240S microcontroller from Silicon Labs, leverages the Matter standard for IoT connectivity and is usable by both hobbyists and professionals. The 18- x 45-mm, energy-efficient Nano Matter module serves projects using connectivity options like Bluetooth Low Energy and OpenThread, with a range of peripherals and I/Os in the Arduino ecosystem for device connectivity and project functionality.

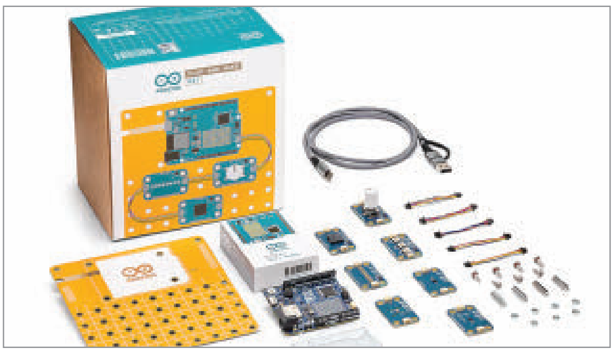
Working with Matter-compatible devices using Arduino as the software layer for rapid prototyping, the module employs Thread for IoT mesh networking communication, plus an integrated MGM240SD22VNA with a 32-bit Arm Cortex-M33 processor optimized for complex calculations and signal processing.

It offers dual-mode connectivity, with both IEEE 802.15.4 Thread for mesh networking and Bluetooth Low Energy for short-range communication. Connecting to the computer over USB with access to a SWD interface, no external debugging device is needed. The ultra-low-power board has a length of 45 mm and width of 18 mm.

Related links:
Arduino
ABX00112 Arduino Nano Matter module
Wireless Development Tools

Arduino Plug and Make Kit Eases Entry for Early Engineers

Arduino



The Plug and Make Kit is an easy way to get started with Arduino, with everything you need for your first seven projects, so you can start with the one that sparks your interest. These include a weather report, which includes a visual reminder to take an umbrella when needed, a digital hourglass, an eco watch to make sure your plants live in perfect temperature and humidity, and HID (human interface device) gamepad, Sonic Synth for music creation, and management, a smart lamp, and a way to control lights with a gesture. Each is an activity that teaches the basics of do-it-yourself electronics.

Resources and support is available via Arduino Cloud—a dedicated content platform in multiple languages to walk you through the entire Arduino ecosystem, with instructions on using Modulino nodes. The components just connect together—no breadboard, jumper wires, or soldering are needed—using Qwiic cables to connect Modulino nodes and the Arduino board.

Related links:
Arduino
Plug and Make Kit

Maker Bundle Includes Book and Dev Kit

Amazon

Based on the latest issue of Make: Electronics, with a section on Arduino that shows you how to write properly structured programs instead of just downloading other people's code, the development bundle contains what you need to complete the experiments listed in the book. Created with the author, Charles Platt, the ProTechTrader electronics kits are an excellent introduction for the new electronics enthusiast.

The kit, geared toward beginners, includes a solderless breadboard for circuit prototyping and close to 200 components. Each component is clearly labeled for easy access, and it's housed in a durable and easy-to-carry double-sided plastic organizer. Features include a multimeter, soldering iron, and an Arduino Uno-compatible controller.

Related links:
ProTechTrader
Arduino
Make: Electronics
Development Bundle ed

LOOKING FOR MORE?:
Please check out our other Embedded News here.

DC-DC CONVERTERS

Your Path to Optimized Designs

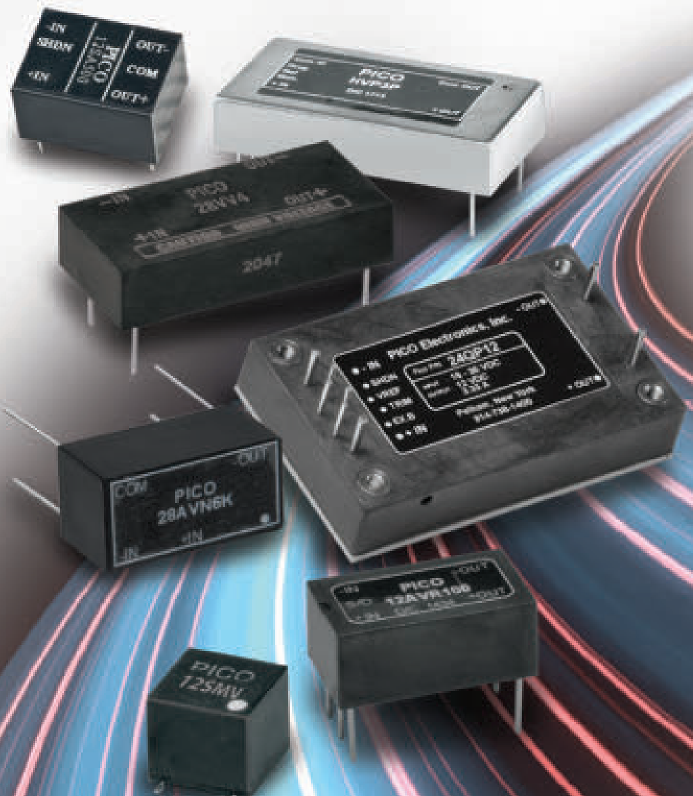
Outputs to 10,000 VDC - Optimize Your Designs, Custom Units Available

- Outputs to 10,000 VDC, 1-300 Watt Wide Input Voltages Available
- Programmable Regulated Proportional Isolated
- Over 2,500 Standard Modules including Surface Mount
- Ruggedized Encapsulated for Harsh Envirionments

Optional Military Upgrades Available:

Expanded Operating Temperature

Selected MIL-STD Screening Options



PICO
ELECTRONICS

Engineering Assistance:
info@picoelectronics.com

800-431-1064

www.picoelectronics.com

TÜVRheinland
Precisely Right.

Certified to
AS9100D
ISO 9001:2015

ANAB
ACCREDITED
ISO/IEC 17021
MANAGEMENT SYSTEMS CERTIFICATION BODY

VISA MasterCard AMERICAN EXPRESS

100% MADE IN USA

SARIEL HODISAN | Analog Circuit Engineer, Applied Materials

Circuits of Chaos:
Building Lorenz, Chua, and Rossler Strange Attractors

Here's a look at the output waveforms from a recently released open-source Chaotic Circuits PCB that includes Lorenz, Chua, and Rossler Strange Attractors.

Editor note: *I had indicated that a circuit board with Strange Attractors was under its designer's evaluation at the time we published our Analog Computing blog on the Lorenz Attractor. I'm pleased that Sariel has completed his evaluation, the board is fully functional, and he's given our readers this exclusive first look into the operation of a circuit board he graciously open-sourced. This means any of you, including schools, can have a little fun and make any or all four of its attractor circuits. All that's needed is a power supply and an oscilloscope with X-Y capability, as was mentioned in the Analog Computing blog.—AndyT*

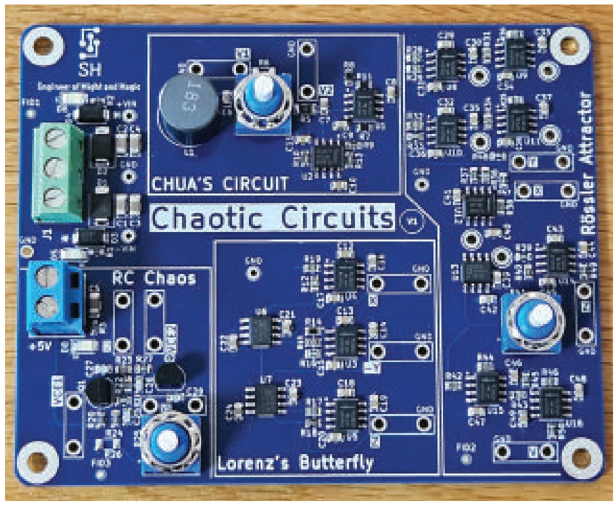
TO MOST PEOPLE, "chaos" means confusion or randomness, but in mathematics, "mathematical chaos" refers to a deterministic behavior governed by precise nonlinear equations. A system is chaotic when it shows extreme sensitivity to initial conditions. In chaotic systems, the state doesn't settle into a fixed point or predictable oscillation, but continuously evolves in a manner that's highly sensitive to initial conditions and is hard to predict.

Designing and simulating electronic circuits that display chaotic behavior isn't difficult. Chaos can be observed in virtually all aspects of life, including biology, geology, chemistry, finance, psychology, medicine, all branches of engineering and physics, economics, and countless other areas.

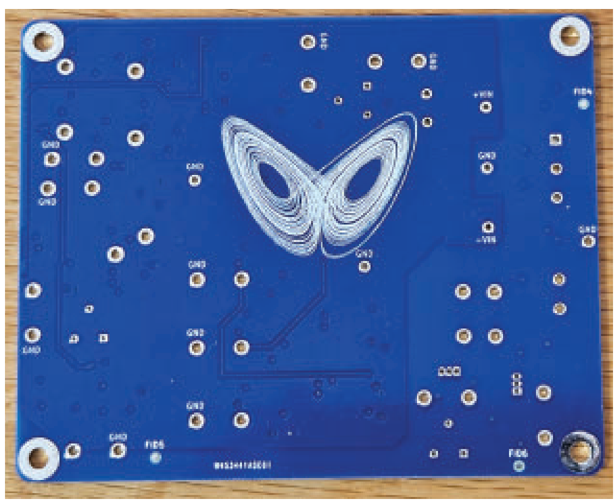
Chaotic electronic circuits demonstrate the important aspects of chaos theory and are easy to implement. Some of these circuits can be used as analogs for other chaotic systems from different fields, sharing similar mathematics and thus making it easier to study them without modifying the real system.

Chaotic circuits divide into two types: pure chaotic circuits, and analog-computing circuits for chaotic systems. The first type consists of electronic circuits that are unstable, have some positive feedback, and show negative resistance. These circuits oscillate periodically but can also become chaotic, with output voltages changing in a highly unpredictable manner.

The second type includes electronic circuits that act as analog computers or smaller analog-computing blocks. These circuits, composed of summers, integrators, dividers, multipliers, and inverters, solve nonlinear differential equations in real-time. The solutions to these equations represent the output of a chaotic circuit.



1. Top view: Chaotic Circuits PCB with four types of chaos circuits. *Images courtesy of Sariel Hodisan*



2. Bottom view: Chaotic Circuits PCB.

To demonstrate chaos and gain hands-on experience, a circuit board was designed with four chaotic circuits *(Figs. 1 and 2).* Two of them represent unstable circuits, while the other two are analog-computing blocks that solve a set of nonlinear differential equations. All of the circuits shown in this article can be easily simulated in any SPICE program (such as LTSpice) with the same parts and values shown in the successive circuits.

Circuit #1: Chua's Circuit

This circuit was developed by Leon Chua (in 1983), whose notoriety is based on being the first to postulate the existence of the memristor. His 1971 paper identified a theoretical symmetry between the nonlinear resistor (voltage vs. current), nonlinear capacitor (voltage vs. charge), and nonlinear inductor (magnetic flux linkage vs. current).

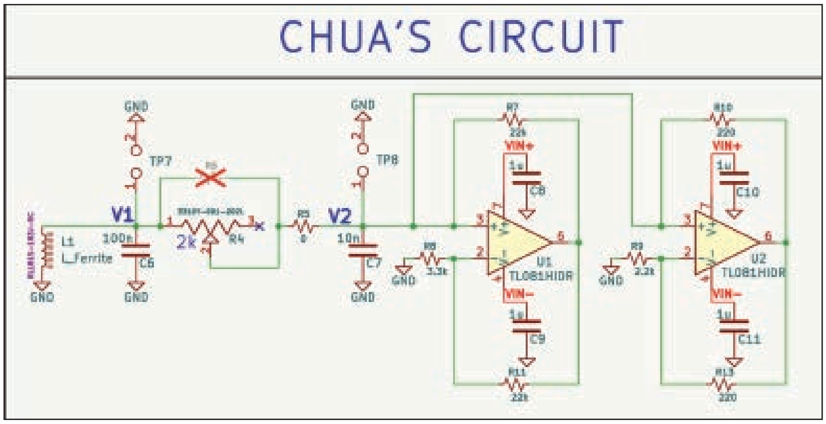
As a professor, his area of specialization was in nonlinear circuits. Chua was the first to design an electronic circuit that showed chaotic phenomena. Until then, there were only computational approaches that solved a nonlinear set of equations exhibiting chaotic behavior.

Chua's original circuit utilized a superficial nonlinear negative resistor (for sustained oscillations). Over the years, many researchers have invented numerous ways for practical implementation of the negative resistor. *Figure 3* shows the implementation of Chua's circuit.

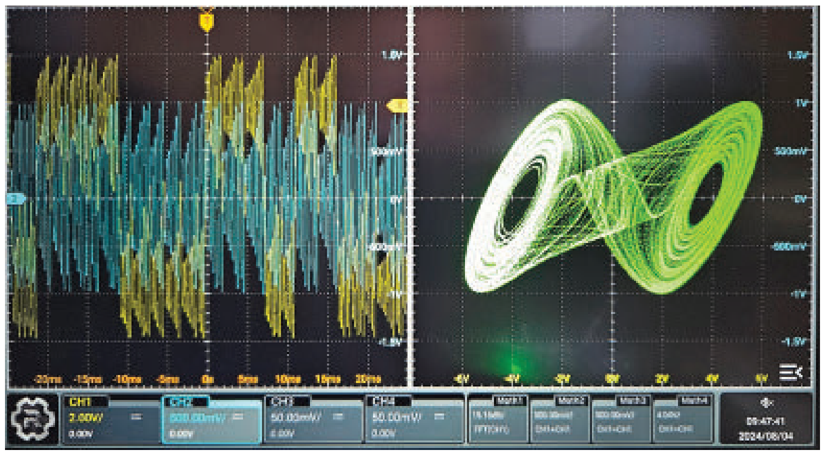
When Chua's circuit is analyzed using Kirchhoff's circuit laws, a set of three nonlinear ordinary differential equations is obtained. Depending on the values of the capacitors, inductor, and series resistor, this system can become chaotic.

In the lab, the variable resistor (R4) was tuned until the circuit entered a chaotic working point, which was found to be around 1,500 Ω. The same result was obtained in simulations.

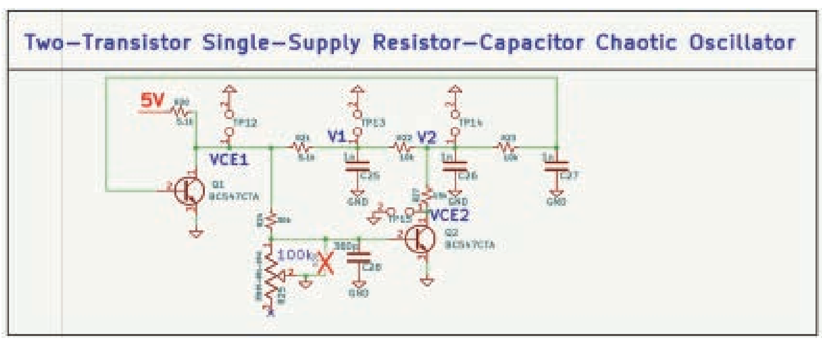
To observe the chaos in this circuit, the nodes V2 and V1 (as shown in the schematic) are plotted in X-Y mode, with V1 versus V2, respectively. By varying the resistance of R4, the circuit can be set to sustained oscillation (a circle in the phase plane) or a steady state (a singular point in the phase diagram). Once R4 reaches about 1,500 Ω, the circuit operates in chaos, and a Strange Attractor ("Chua's Attractor") in the shape of a double scroll appears on the screen *(Fig. 4).*



3. Chua's circuit.



4. Chua's circuit output showing double scroll attractor phenomenon.



5. A simple two-transistor Chaotic Oscillator.

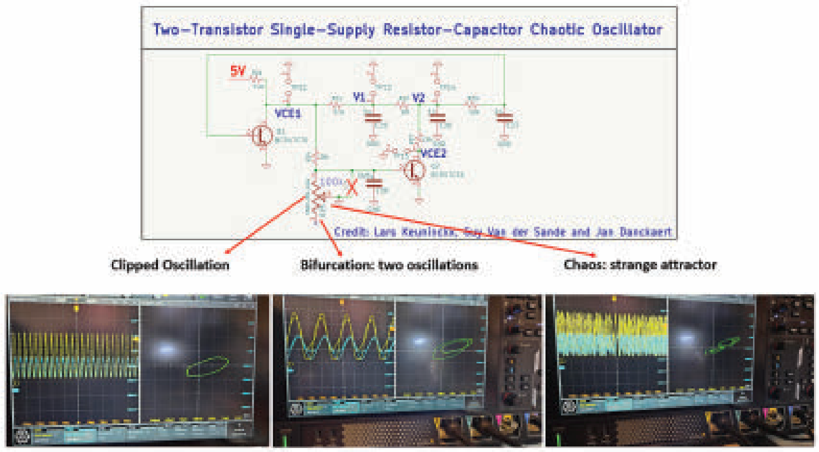
Circuit #2: Simple RC Chaotic Oscillator

Chua's circuit requires an inductor and several active components to create a nonlinear negative resistor. However, chaos can be achieved with even simpler circuits.

A few years ago, a fictitious author named Kajnjaps published a simple circuit on several websites. This circuit, which requires no operational amplifiers or inductors, demonstrates chaos with just two transistors. Kajnjaps is a pseudonym for one of the authors of the IEEE paper titled, "Simple Two-Transistor Single-Supply Resistor-Capacitor Chaotic Oscillator."

The circuit uses a lowering potentiometer (R25) to determine its behavior *(Fig. 5)*. When R25 is high, the biasing to the lower part of the circuit (Q2) is cut off. This part has no influence over the upper part, which behaves as a normal RC oscillator that oscillates steadily depending on the RC values of the feedback network.

As R25 is lowered, Q2 starts to conduct and interfere with the RC oscillation, causing bifurcation (two oscillation frequencies). When R25 is lowered even further, chaos emerges. This behavior is demonstrated in *Figure 6*. In the circuit, the attractor can be observed in the phase plane (X-Y) by plotting V1 against the VCE1 voltages.

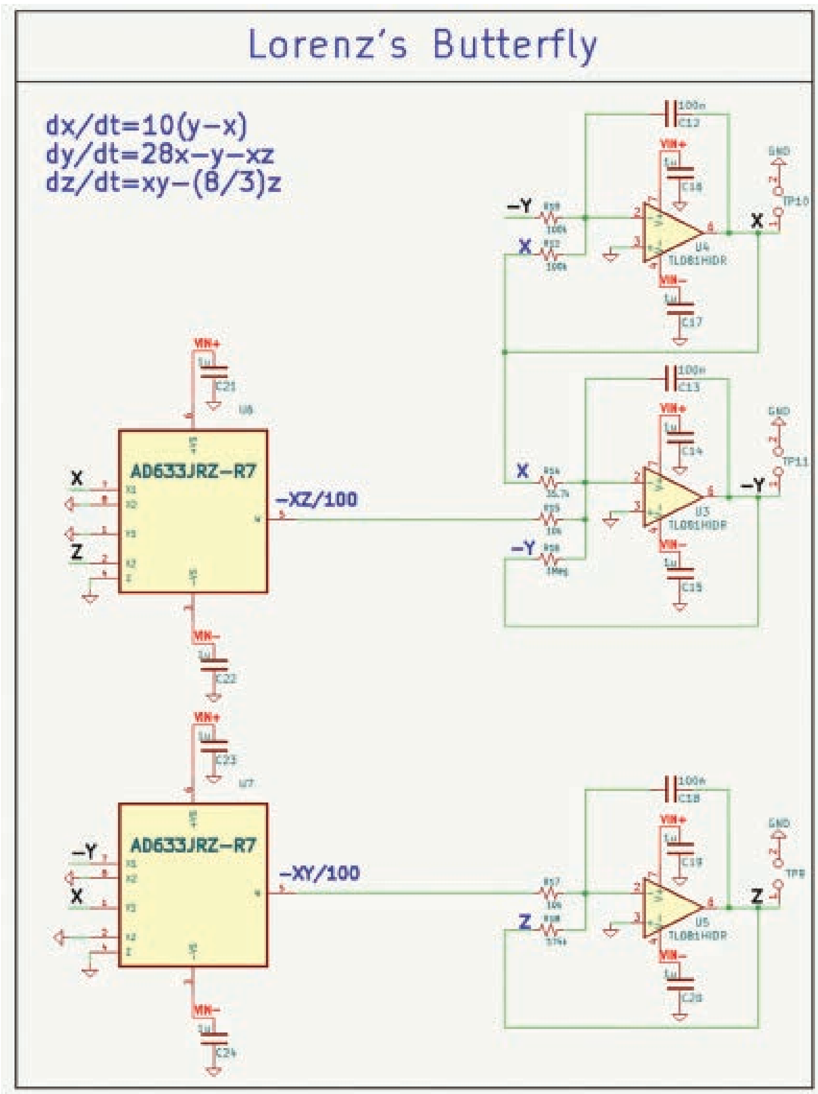


6. Varying R25 in the 2-transistor Chaotic Oscillator.

Circuit #3: Lorenz Butterfly Simulation Through Analog Computing

This circuit *(Fig. 7)* is not actually chaotic, as it lacks a negative resistor necessary to create chaotic behavior. Instead, this is a small Analog Computer block that solves the three Lorenz equations upon power-up of the circuit. This circuit is based on the work of Paul Horowitz, author of *The Art of Electronics*. The amplifiers and multipliers were substituted with more readily available off-the-shelf components.

This analog-computing circuit solves these equations in real-time. The phase plane of the Z output versus X output displays the Lorenz Attractor, also known as the Butterfly Attractor, one of the most renowned strange attractors.



7. Analog Computer PCB implementation for solving the Lorenz equations

On the test bench, the circuit on the PCB takes time for chaos to form. Eventually, the system collapses into a steady state because the circuit includes an integrator as part of the solution to the differential equations. As with any integrator, it eventually saturates and requires a reset.

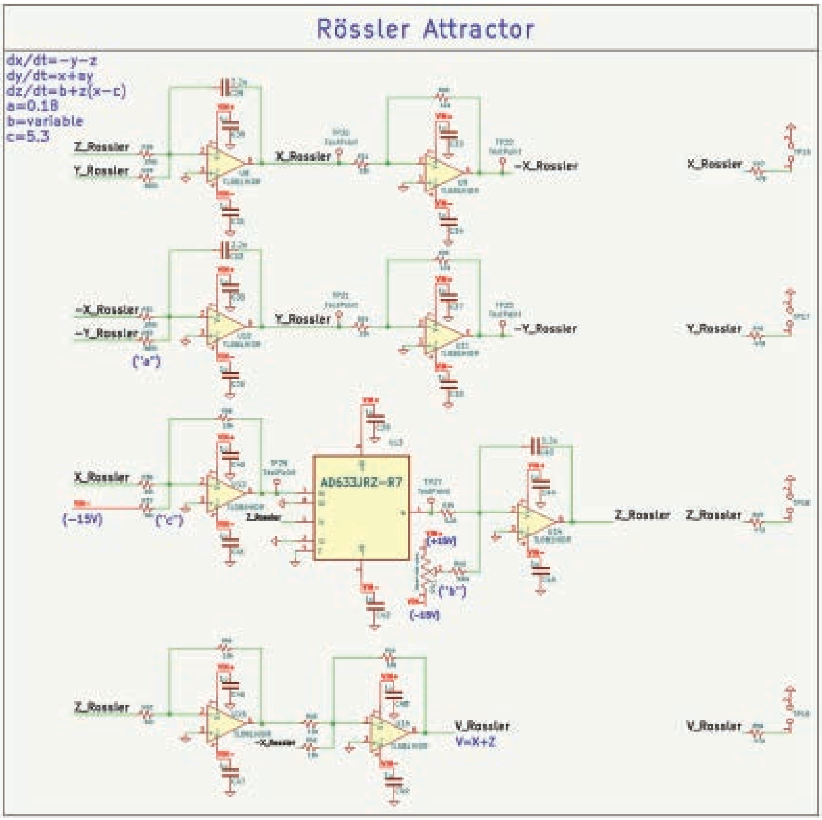
The implemented circuit doesn't have a periodic reset, so the equations are solved for a brief time until the integrators saturate. At times, even when powered, chaos isn't observed, since it depends greatly on the initial conditions of the circuit, and even random noise, which can cause the circuit to enter or avoid chaos.

Circuit #4: Rossler Attractor

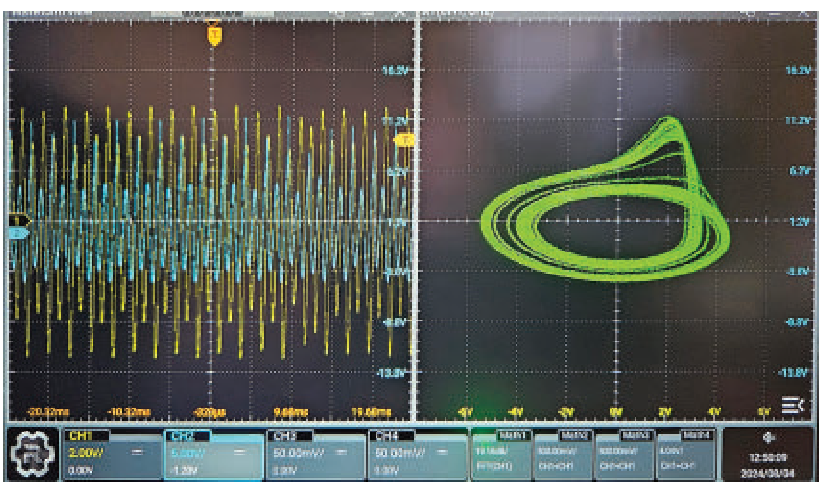
The Rossler Attractor, discovered by Otto Rossler in 1976, comprises a set of three nonlinear differential equations known for their chaotic behavior. Despite its simplicity, this attractor's trajectory forms a complex, beautiful, twisted spiral when visualized (in the XYZ plane).

The Rossler attractor can be modeled using a simple Analog Computer circuit *(Fig. 8)* that solves the equations' set in real-time. (Notice how two variables were combined to show the attractor in 2D view instead of 3D). These equations are able to model chaotic chemical reactions, demonstrating how chemistry can exhibit chaos. This circuit was designed by Glen Kleinschmidt.

Figure 9 shows the attractor's oscilloscope screen.



8. Rossler Attractor Analog Computer PCB solution.



9. Rossler Attractor output display.

Conclusion

This work has shown how easy and fun it is to build chaotic circuits. Chaos can be deliberately created by solving nonlinear differential equations using analog circuits or by creating special negative resistors, though even simple transistor circuits can become chaotic.

Circuit designers might be designing a nonlinear analog circuit (like a PLL or amplifier) and, without noticing, encounter chaotic behavior in simulations or in the lab.

The circuit schematic and layout, Gerber files, BOM, and assembly position files are available on GitHub.

These files can be sent directly to any PCB manufacturer to produce a Chaotic Circuits board, which is well-suited for school lab exercises. All of the components are inexpensive and easy to obtain and solder, so the board can be hand-assembled or these circuits could be created on a breadboard according to the schematic. However, breadboarding does create functioning risks for chaotic circuits due to the substrate parasitics. ed

CLIFF ORTMEYER | Head of Solutions, Newark

What Makers Want

This article gives an overview of maker priorities and the most important issues impacting them.

IT'S A WONDERFUL TIME to be a maker, whether you're a seventh grader probing the guts of a computer or an accomplished designer who's inventing blockbuster new products over the weekend.

Electronics are embedded in seemingly everything, including human beings, and they're smaller, smarter, and increasingly leveraging AI. The pace of change is accelerating to the point that new products go obsolete in years or months, not decades. And that's okay.

Importantly, the playing field between big companies and clever individuals has leveled quite a bit. Affordable electronic blocks, modules, components, development kits, tools, training, and platforms bring new product innovation within reach of literally everyone. Today's maker can be tomorrow's founder—and continue to make!

As a distributor with a robust community of millions of global makers, we spend lots of time channeling the maker mindset (because most of us are makers ourselves), and we've documented what we think almost every maker wants. The goal is to help you navigate your maker journey from the moment you pick up your first tiny screwdriver.

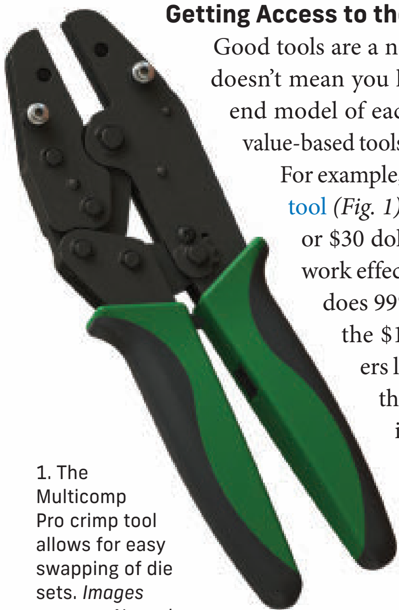
We think makers basically want four things.

Access to Popular Maker Product Platforms

Some makers prefer popular products to learn all they can about the process of making interesting applications from a variety of components. Raspberry Pis and Arduinos are common development kits—actually single-board computers—with a plethora of documentation and stories on how they work and how you turn them into complete products. These platforms can cut thousands of dollars and weeks of time off a new product or prototype compared to designing and manufacturing your own printed circuit board.

Meanwhile, seasoned makers often gravitate to the newest, most advanced components so that they can make their devices smarter, smaller, and, consequently, more economical. Why not use one chip that supports Wi-Fi and Bluetooth instead of separate ones? At Newark, you can find a full range of both mainstream and bleeding-edge components.

Getting Access to the Right Tools



1. The Multicomp Pro crimp tool allows for easy swapping of die sets. *Images courtesy Newark*

Good tools are a need, not a want. But that doesn't mean you have to buy the highest-end model of each one. Look for quality, value-based tools that will get the job done.

For example, we all need a good crimp tool *(Fig. 1)*. It's worth spending $25 or $30 dollars for one that lets you work effectively and efficiently and does 99% of what's possible with the $150 version. Many makers like to replicate the bench they use at work, affordably if they can help it.

As your skills develop, you might want to move up the tool-quality ladder. Do you need an uncompromising solder joint for your invention? It might well be worth buying a premium soldering iron so that the quality of your work is on target every time *(Fig. 2)*.

Your oscilloscope should probably have a similar interface to the one the pros use at work, and be versatile enough to move around quickly and easily *(Fig. 3)*. The good news is you can likely get away with an affordable lower-end model of a respected brand.

Where to Access Maker Information

In most cases, a fellow maker has already done what you want to do. So why not learn from their mistakes and successes? Today, it's easier than ever to borrow their tips, tricks, hacks, shortcuts, and end-arounds.

Or maybe you're looking for new ideas on what to make. Fellow makers can help you discover new ideas and expand your understanding of what's possible. YouTube is a good source for how-to information, but as good as its algorithm is, YouTube ultimately becomes hit or miss. We've worked to organize learning content in several other places.

The element14 Community is the industry standard for electronics information-sharing. It has popular technical blogs, videos, and webinars that provide knowledge on the latest in electronics trends such as the Internet of Things and wireless technologies. Hackster offers detailed how-to content on a staggering range of products and projects. You can get any product you need (nearly one million of them) on Newark.com.

2. An LCD display on the Multicomp Pro Solder Station helps with configuration.

3. The Multicomp Pro 4 channel handheld oscilloscope comes in 70- and 100-MHz models.

We aspire to be the go-to content hub for engineers, whether they want hardcore design information like reference designs, datasheets, and training, or simple fun, inspiration, and friendship.

Getting Access to Other Makers

Makers are among the most self-motivated people you'll ever meet. But networking is important for both learning and basic human connection. That's why we call it the maker community. In this post-COVID work-from-home era, online communities are essential.

So, if you're looking for cool project ideas, collaboration, answers, and a social experience, you can find friendly makers on element14 Community. And you can view first-person how-tos from inspirational people on Hackster.

Overall, these four things are atop the typical maker's wish list. They're what we think are the essential considerations for making swift progress in your maker's journey. Whatever your focus and whatever your dreams, it's going to be wild and fun.

Everything is electronics these days, and it's all coming at us fast. Equip yourself, buckle up, and help change the world. ed

KEVIN WALSETH | Manager, Technical Marketing, DigiKey

From Maker to Market: The Dynamic Journey of Bringing Innovations to Life

Moving from a concept to distribution is a complex and multifaceted process that requires careful planning, strategic thinking, and a deep understanding of the market.

IN THE RAPIDLY evolving world of innovation and entrepreneurship, the journey from a budding idea to a product on the market is both exhilarating and challenging. The "maker to market" process is a complex and multifaceted path that transforms a simple concept into a tangible product for customers.

The success of this journey relies on carefully navigating several critical stages, each playing a vital role in shaping the outcome. These stages—conceptualization, research, evaluation, design, prototyping, funding, marketing, production, distribution, and support—are vital to ensuring that the product not only meets market needs, but also stands out in today's competitive landscape. Along the way you may need to take advantage of vendors, distributors, and funding platforms like Kickstarter.

Makers Concept: Where It All Begins

Perhaps the birth of a great idea occurred in a dream, came to you in the shower, or sprung up due to a persistent problem. Either way, you've got a concept worth exploring. So, begin your process by defining your problem, brainstorming, researching, and even block diagramming. A concept is creating an idea or design to solve a problem. However, before a problem can be solved, you must thoroughly understand it. Only after a problem is understood can it be effectively addressed and solved.

One practical method for solving problems is brainstorming, a group problem-solving technique that involves the spontaneous contribution of all ideas from all group members. Note the phrase "all ideas." For brainstorming to be effective, the most important rule is that there are no bad ideas.

The Power of Research for a Successful Product

Once an idea is conceived, the next critical step is research. While you've probably done a bit of Googling, now is the time to get serious about researching your idea. You'll need to review platforms, evaluate price points, and perform a competitive analysis. It's also a great time to investigate existing intellectual property.

Consider different technologies that you may incorporate into your idea. What's available? How accessible is it? Is the technology something you can learn, or will you need help? By understanding the market, innovators can tailor their products to meet the specific needs of their target audience, setting the stage for a product that resonates with consumers.

Evaluating Potential and Risks in Delivering a Product

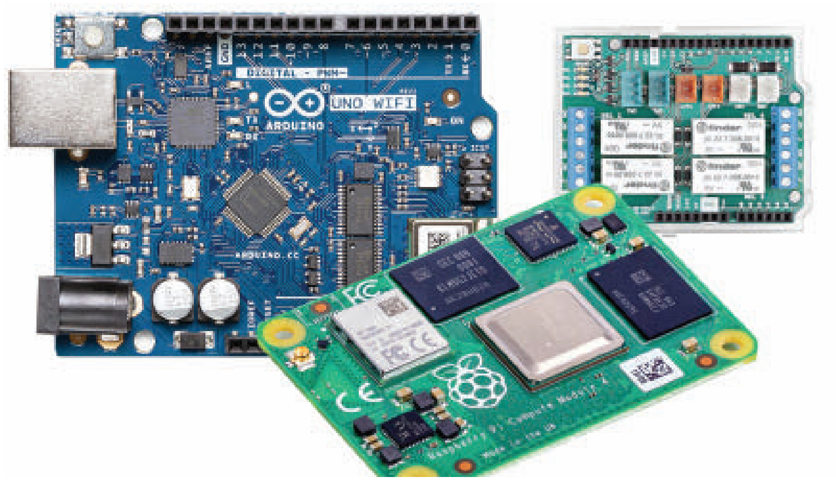
As the research phase concludes, the focus shifts to evaluation. Before you spend a lot of time designing your project, you must carefully evaluate it. First, weigh the pros and cons of your project. Consider possible team members, test your technology, and establish a realistic timeline. Does everything check out? If so, you're ready to design!

To make your product succeed, you need to meet the market's needs. Examine your previous roadmap step. Research results on the state of current solutions and see how your idea compares. Ask around or conduct a survey to find out what might be the most useful to customers and what features they seek.

After thinking through your ideas and how you might implement them, narrow down your list to the more manageable and profitable few. This stage isn't just about identifying the strengths of an idea, but also about acknowledging its weaknesses and finding ways to address them.

Makers: Designing for Success

Design is where ideas begin to take physical form. The design journey begins with a spark of creativity or a response to a market need. This initial phase involves brainstorming and conceptualizing the product. Designers and engineers collaborate to develop a clear vision, focusing on functionality, aesthetics, and user experience. The design stage is marked by extensive research to understand market trends, consumer preferences, and potential competitors.



Prototyping platforms like the Arduino (left) and an expansion cape (right), or the Raspberry Pi Compute Module (bottom), enable developers to build on a solid hardware foundation with plenty of software support. *Arduino and Raspberry Pi org*

Designers sketch out ideas, create detailed plans, and use various tools and techniques to bring their concepts to life. The goal is to create a product that not only meets a specific need, but also stands out in the marketplace. A strong design phase sets the foundation for a successful product by addressing both practical and emotional aspects of the user experience.

Prototyping: Testing the Waters

Prototyping is the stage where designs are put to the test. The prototyping phase can also be fun and exciting because this is where the proverbial "rubber meets the road."

When prototyping, you truly discover if your idea and design actually work as expected. Using prototyping platforms like Arduino, BeagleBoard, or Raspberry Pi often make the task easier *(see figure)*. During this phase, prepare yourself for heartache, setbacks, and, most importantly, lessons learned. This is when errors and oversights are discovered and rectified.

Prototyping includes the fabrication and assembly of your printed circuit board (PCB). Depending on the complexity of your PCB design, these prototypes can be either handmade by you or produced using one of the many prototype shops available online or possibly locally. Also included in this phase is testing, such as the initial turn-on test (aka the "smoke" test), which involves energizing your PCB for the first time to ensure it either works as desired—or it smokes.

After your design is working as intended, with no required or desired design changes, the following tests—depending on the end-user of your design—should be considered: lifetime testing, failure-analysis (FA) testing, highly accelerated stress test (HAST), compliance certifications, user ability studies, shock and vibration testing, temperature testing, and failure mode and effects analysis (FMEA). Depending on the successes and failures of the design phase, there may or may not be many iterations to your prototype.

Securing Funding: Fueling the Vision

Money may be the root of all evil, but it's also the most necessary of all evils. Once a product has been designed and prototyped, the next challenge is securing the necessary funding to bring it to market. Whether through venture capital, crowdfunding, or traditional loans, securing the right financing is crucial for scaling production, marketing, and distribution.

If you need to create accounts, round up investors or apply for grants or fellowships. There's no time like the present. Set up crowdfunding accounts, take a trip to the bank, or start saving.

Once the desired funding source is identified, it's important to prepare for it properly. Each type requires a specifically formulated plan to achieve success. For example, bootstrapping while already heavily laden with personal debt would make things difficult, if not impossible. Yet, a small company that's still trying to define itself would not prepare to meet with venture capitalists until further along in their growth.

Marketing: Crafting the Narrative

With funding secured, the focus shifts to marketing. Marketing is a critical stage that determines how the public perceives a product. In today's global market, where consumers are bombarded with countless choices, effective marketing captures attention and drives sales.

Makers are a passionate group, inspired by their surroundings and buoyed by creativity and creation. That passion can sometimes shield a maker from the reality that their idea isn't nearly as interesting to others as it is to themselves. It's time to generate buzz amongst the outside world.

When you're considering a marketing plan, you'll need to think about your branding, steps you'll take to foster public relations, conventions and conferences you might attend, and networking opportunities. It's also the right place in the process to begin planning packaging and to start a website—go viral!

Production: Bringing Maker Ideas to Life

As marketing efforts ramp up, the next phase is production—the stage where ideas are transformed into tangible products.

Ahhh, production time. The sweet smell of your final bill of materials (BOM) is in the air; you're ready to start making some serious decisions. First, you need to decide what the demand might be—how much should you order? You also need to think about the manufacturing supply chain, which will involve making decisions about board houses, manufacturers, and assembly houses.

In production, the design you've created is built. To build your product effectively, the manufacturing process must be designed to generate your product with the right quality, quantity, and cost to succeed. Expect some design changes to suit production, as well as running design improvements to the product.

Distribution: Navigating the Final Hurdle

Once production is complete, the focus shifts to distribution, the final hurdle in the journey from maker to market. For engineers and makers trying to move into production, distribution can frequently be forgotten, ignored, or underestimated. Distribution, an essential and complicated part of the process, is where your end-customers will have their first physical interaction with your product.

To make certain that this first impression is a good one, besides being a fantastic product, you need to get it to customers promptly and in a professional, protective package. For this, it's important to consider where and how to keep your product, how it will be packaged to ensure it's professional yet reasonably inexpensive, who will physically make the shipment when it is ordered, and what method of shipping will be used and how much it will cost.

Support: Sustaining Success

The journey from maker to market doesn't end with the sale of a product. The final stage—support—is where long-term success is determined. Now that you've successfully entered your choice market, it's time for maintenance.

During this phase of your process, you'll focus on processing potential returns, troubleshooting early problems, scaling your operation, offering warranties, and gathering positive reviews. Your reputation will be key if you find a way to manage it. Remember that support is ongoing, and you're not off the hook yet. With your product out on the market, one incredibly important foundation of your business will be supporting current and future customers with their questions and problems.

The Continuous Cycle of Innovation

The journey from maker to market isn't linear but rather a continuous cycle of innovation. In industries driven by rapid change and technological advances, the need to innovate never ends. Once a product is launched, the focus shifts to the next big idea, and the cycle begins all over again.

Each stage of the journey, from conceptualization to support, builds upon the previous one, creating a dynamic and evolving process that drives progress and shapes the future of industries. Moving from a concept to distribution is a complex and multifaceted process that requires careful planning, strategic thinking, and a deep understanding of the market.

For industries driven by innovation, this journey is both a challenge and an opportunity that offers a chance to bring new ideas to life, solve real-world problems, and make a lasting impact on the world. By navigating each stage of the journey with diligence and creativity, innovators can turn their ideas into successful products that resonate with consumers and withstand the test of time. ed

JIM BENEKE | Vice President, Tria Technologies

Navigating the **Prototype-to-Production Pipeline**

Electronics companies can speed up the process of a new product introduction by embracing less-rigid approaches to development.

PROTOTYPING IS A vital part of the electronic design process. But a prototype is not just a proof of concept: It gives you access to physical hardware to test and debug before moving the product into mass production.

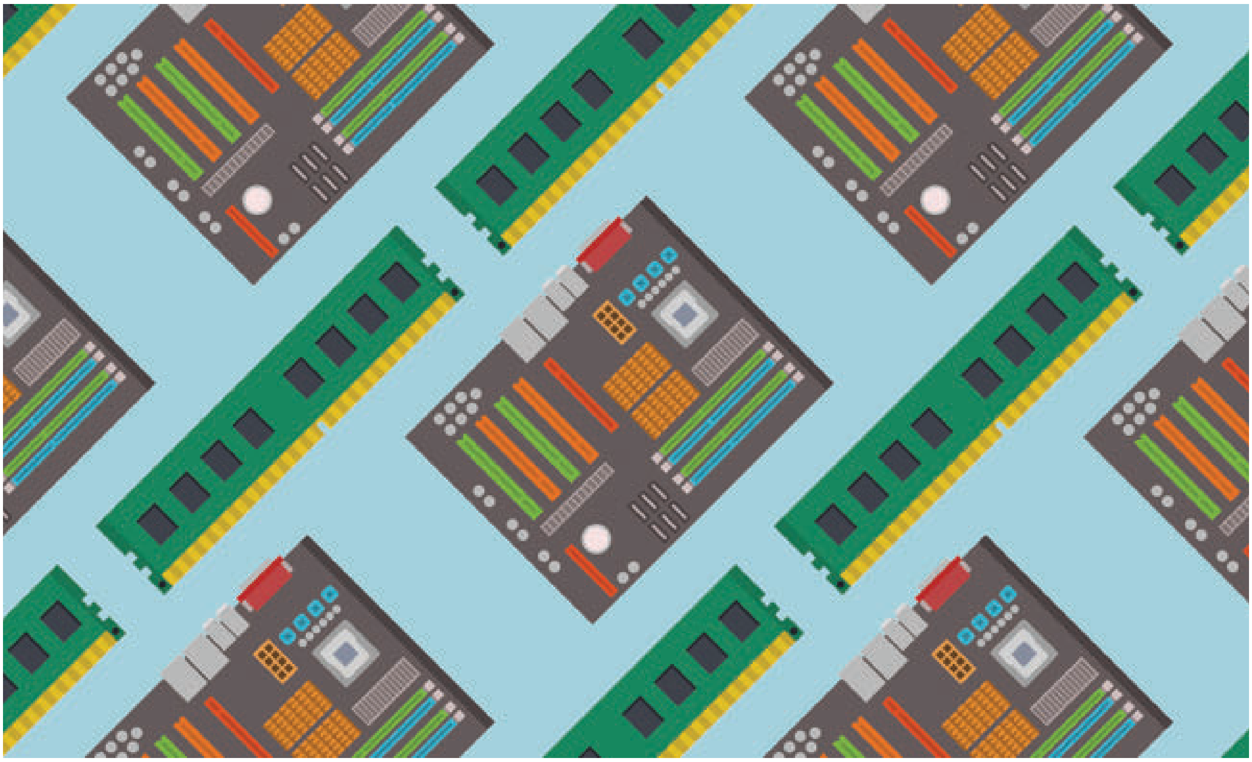
More broadly, it gives engineers, executives, and anyone else invested in its success the ability to see how the final product is likely to perform in a specific application.

For engineers under pressure to reduce time-to-market and respond faster to changing customer needs, the differences between prototype, demo, and production hardware are blurring. Engineering teams that look at prototyping as part of a continuous process instead of a separate step in the design phase can better navigate the transition. Closer collaboration between design and production will help with meeting time, quality, and cost targets.

Prototyping Electronic Designs as Early and Often as Possible

Teams can use several different approaches to create working prototypes earlier, iterate the design through successive versions, and ultimately push it to initial production. These techniques and strategies include:

- Applying lifecycle-management tools such as a "digital thread" to manage changes in design throughout the project, from the start to the end of its life.
- Using iterative design not only in the prototyping phase, but also in early production to help reduce risk and enable later modifications for cost optimization.
- Adopting advanced simulation and regression testing techniques to make sure changes to the software and firmware throughout the device's lifecycle are consistent across product generations.



Showvector

- Building off-the-shelf compute and I/O modules into the design, minimizing development cost and reducing risk when moving to production.
- Coordinating with manufacturers and other engineers downstream to evaluate cost-benefit implications through launch and beyond.

Design teams can use these strategies to test the concept or implementation early, avoiding costly rework. One advantage of the step-by-step approach is that engineers can create smaller batches of hardware and then take them out in the field for testing before a commercial launch.

Upstream benefits are also possible when implementing these strategies. Changes identified after production get applied to new iterations of the product design and then vetted through new prototypes. Production and maintenance-support engineers can share feedback on their experience with each generation of the product.

The wider team can identify ways in which the design might be redone to enable more efficient manufacturing and in-field servicing. Data from service records can inform changes to circuitry and software that reduce stresses on components, boosting reliability.

The "Digital Thread": Redefining the Electronic Design Process

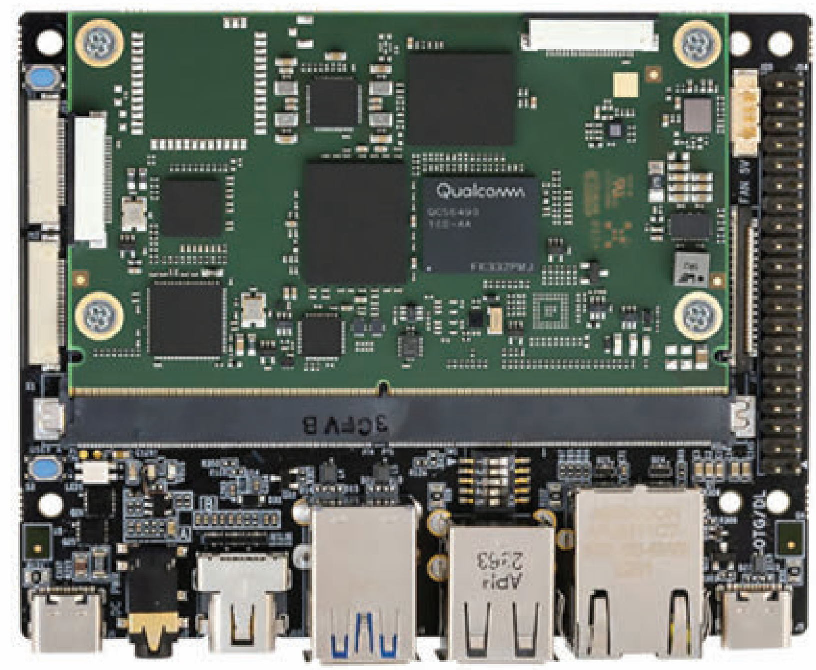
This prototype-to-production-to-prototype cycle fits in with another approach to design that's just now entering the electronic design vocabulary: the digital thread. The digital thread is an alternate way of saying "all data associated with each product variant or instance on its journey from initial assembly to the end of its lifecycle."

The digital thread captures data on the performance of the product, and it can reveal reliability and other issues with the design. This is valuable information that you can feed back into the design process. Engineers could use it to inform decisions on the software, hardware, or firmware architecture of the design. In many cases, software and firmware updates that incorporate data captured from the digital thread can help give a new lease of life to existing production hardware.

Additionally, more engineers are taking up system-level tools to help define the initial specifications for a product, using simulations to try out different control and user-interface schemes.

These virtual environments can even act as digital twins, potentially incorporating data from a digital thread. Such an approach, to some extent, mimics the development process used in a cloud environment. Before the engineering team sends updates to production software running in the field, they run the altered software in a "sandbox" in the cloud. These tests ensure software updates will not activate dormant bugs or introduce unwanted behavior.

Today, companies building Internet of Things (IoT) devices are employing similar strategies to test firmware and software changes on a combination of virtual and physical platforms before issuing over-the-air (OTA) updates.



Shown is Avnet's Vision-AI Development Kit. *Images courtesy Avnet/Tria Technologies*

The physical modules tend to be arranged into hardware labs called device farms that typically contain multiple copies and versions of the prototype or final product. Then, developers perform regression tests across them with each new software revision and only commit the changes to a production release if they all pass. This strategy is effective in supporting a phased transition from prototype to production.

One consequence of this less-rigid prototype-to-production design process is that the underlying hardware is constantly changing. The manufacturer may decide to replace components, change circuit designs, or even swap out entire boards from one generation of the product to the next to support improvements in cost and reliability. They may also need to redo the design due to component shortages or other supply-chain issues.

Keeping copies of these different implementations in a device farm or in virtual form as digital twins enables testing across the different variants to ensure new software doesn't lead to bugs and other problems in certain devices.

Keeping the Hardware the Same from Prototyping to Production

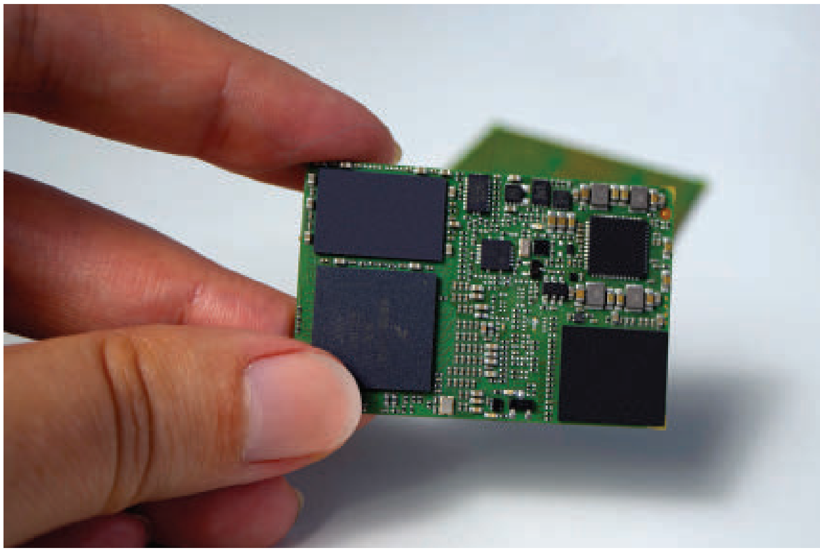
In the past, design teams bought development platforms specifically for prototyping. The development hardware now available from some suppliers is equally at home in production systems. Many of the development boards on the market can be cost-effective in volume. Using the same hardware eases the transition to production, as it minimizes fewer changes before the commercial launch date.

A cost analysis may show the benefits of moving some logic and analog functions into an application-specific integrated circuit (ASIC) or replacing them with a programmable solution. To accommodate the longer design and manufacturing times of ASIC design, early production models can still use systems-on-chips (SoCs) and standard parts combined with FPGAs.

Some development platforms come with design files that support the transition to a production version. With these designs, the core building blocks remain the same, while other parts can be removed or left unpopulated without a penalty on performance. By using modules designed around standards such as the Open Standard Module (OSM), designers are able to mix custom daughterboards or carriers with standard offerings, depending on the situation.

To allow for flexibility in the transition from prototype to production, design teams should employ a strategy that minimizes software incompatibilities at each turn. To some extent, this is possible even if I/O components change in the transition to production hardware.

For example, Linux-based designs often employ the concept of a device tree. At boot, the kernel auto-discovers hardware components and matches them to drivers in its boot image. Another option is to use the digital thread to connect boot images to appropriate targets, as each instance of the target will have an associated ID and database entry. These tactics facilitate obsolescence management in long-lived product lines.



The Open Standard Module format allows for a combination of chip-down design alongside a module approach, supporting rapid prototyping and an easier transition to production.

Components may be designed out during the product's lifecycle. The software will continue to work if the system can load the appropriate driver at boot time and the application programming interface (API) employed by the driver is at a sufficiently high abstraction layer.

Manufacturers may use device trees coupled with digital twins to check how applications change across different generations of hardware. If problems emerge, tests on the different iterations can quickly pinpoint the cause of the behavior change.

Digital-twin models expedite a more in-depth analysis of how well systems are performing in the field. Utilizing data from the field captured by services such as Avnet's IoTConnect, companies can check on the status of the systems and use what they learn to guide the development of software updates to boost performance. The PLM infrastructure coupled with a digital-thread database provides a way to deliver insights to the relevant hardware in the field.

Prototyping isn't going anywhere, but it is evolving. By rethinking how best to transition from early prototypes to field trials to full production, designers can smooth out the process and meet increasingly tight schedules. As devices are expected to change and adapt up to the point when they're finally retired from service, the trick is to adopt a more flexible design approach that continues through the device's lifecycle. ed

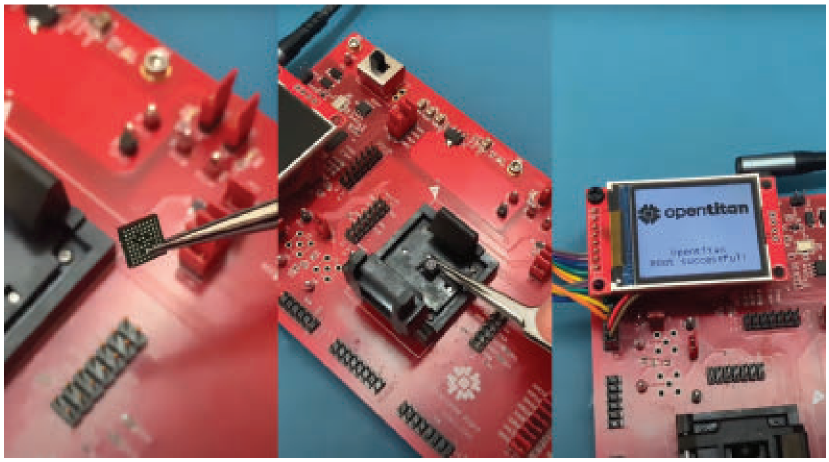
JAMES MORRA | Senior Editor

Open for Business:
Open-Source Silicon

A look behind OpenTitan, the world's first commercial-grade open-source chip, and how it could change the landscape of hardware security.

THE COMPANIES BEHIND Google's OpenTitan project recently announced the commercial availability of what they called the world's first chip with open-source hardware security baked directly into it.

While OpenTitan will be the first commercial-grade chip on the market modeled on Linux and other open-source software, Dominic Rizzo, one of the founders of OpenTitan, said he's confident it will not be the last. Under development for half a decade and based on OpenTitan's discrete "Earl Grey" chip design taped out in mid-2023, the chip is designed to be a universally accessible hardware root of trust (RoT).



OpenTitan enters the market as the first commercial-grade open-source chip. *lowRISC*

The milestone shows that the concept of open source is not inherently incompatible with silicon, said Rizzo, now CEO of zeroRISC, a startup building a secure embedded operating system (OS) that can take advantage of the OpenTitan hardware RoT and the firmware that will run on top of it. "It's not proprietary, and it's not a test chip, but it's going to be a very high-volume security chip," he told *Electronic Design*.

In its capacity as the hardware RoT, the chip is designed to make sure that the hardware in a system, and software running on it, remains in their intended, trustworthy state. It ensures components in a system boot securely using only authorized, verifiable code. And it's hardened against fault injection and other physical attacks on the hardware, which is relevant to many of the tiny devices comprising the Internet of Things (IoT).

The concept of open silicon has been gaining ground in the semiconductor industry lately, largely due to the rapid growth of the open RISC-V instruction set architecture (ISA). The RISC-V ISA acts as the interface that the software uses to communicate with the processor's hardware. Companies can adopt it to develop CPU cores or other IP without being limited by the same constraints as Arm or other architectures. The "Ibix" CPU at the heart of the OpenTitan chip is itself based on RISC-V.

Even though the underlying architecture is open to all, most companies are building CPU cores and other IP based on RISC-V themselves behind closed doors, using it as any other tool in the toolbox.

But according to Russo, the companies and other partners behind the OpenTitan project are taking the concept of open hardware a step further by building the chip itself and the IP inside as a collective.

"Silicon Commons": Designing Chips Out in the Open

Google launched OpenTitan in 2019, building on the development of its own in-house hardware RoT, called Titan. Besides the formal partners in the project, including a wide range of semiconductor firms and academic partners, the OpenTitan chip was developed by a large and growing community of independent coders and other contributors worldwide. The project is supported and maintained by lowRISC, a neutral, independent non-profit.

While it was based on the same principles behind Linux and other efforts in open-source software, OpenTitan presented unique difficulties. Designing a modern chip is a large, enormously complex engineering problem that can take several years and as many as thousands of engineers to tackle. Rizzo said the high cost of hardware development relative to software also raises the difficulty level.

The inability to update or upgrade the underlying hardware after it's manufactured adds to the complexity. "There are huge risks with silicon," said Rizzo. "You sort of get one shot with it, and it works, or it doesn't."

The other problem is related to personnel. Many of the engineers with experience in the world of open-source software aren't as familiar with the traditional "waterfall" model of hardware design. In contrast, many hardware engineers who are in the best position to contribute to OpenTitan and other open chip designs aren't as clued into the ins and outs of open-source product development.

To navigate these potential risks, lowRISC and the other companies behind OpenTitan worked out a framework for building open-source silicon called Silicon Commons. The model merges the tenets of open-source software development such as continuous integration (CI) with a commercial approach to chip design. For lowRISC CEO Gavin Ferris, the new chip marks the first time anyone has been able to make "open-source silicon work in the same way as open-source software."

The model sets out stringent rules for documentation so that third-party companies and engineers can dive in and start contributing to the chip's development as soon as possible. Silicon Commons also mandates the use of standard interfaces whereby different types of IP can be integrated or removed from the final blueprint of the silicon chip, and it sets out quality standards backed by rigorous testing and verification.

The core differences between open and closed approaches to chip design. *zeroRISC*

The approach also defines the roles and responsibilities of all companies and other partners in the project so that they can make decisions and evaluate potential improvements to the chip as a group.

"The development process was open, and problems are solved in a collaborative way in the open-source repository," Rizzo told *Electronic Design*. "The way it worked is we spent years building out a high-quality, open-source ecosystem of digital IP. But while OpenTitan is open source, it's a very practical, non-ideological type of open source where we make open what it's feasible to make open."

He added, "When it comes to getting the chip out the door, that's where the open-source rubber meets the proprietary road." Though the most differentiated IP in the new OpenTitan chip is open, he said the group spent the final stages of the development process working with chip companies to fill in the blanks with proprietary IP that would have been more trouble than it was worth to build from the ground up.

Open hardware such as Raspberry Pi and Arduino is becoming more widely used in the commercial market. But open-source chip design was a largely untested concept before Google launched OpenTitan.

Rizzo said it was critical to choose a technology that would be worth it for the companies and other partners to invest in over the long term. He added that it made sense to focus on hardware security since it's relevant to virtually every electronic device and embedded system, and it's possible for OpenTitan to differentiate itself. "Building a secure microcontroller is significantly harder than building a general-purpose MCU."

"Everyone wants to be able to buy off-the-shelf components they can trust and that they can verify they can trust," said Rizzo. "Having hardware that handles the basics of security is valuable from that perspective."

The Root of Trust: The Heart of Hardware Security

Traditional security starts in the OS. But OpenTitan and other chips in its class are vital because the most pernicious and stealthy attacks target the firmware beneath it and the hardware further down.

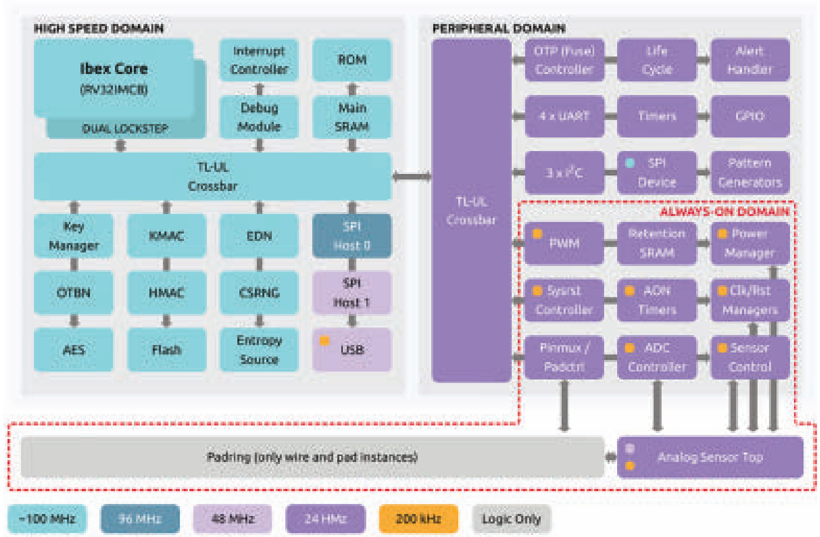
The hardware RoT contains all cryptographic keys in a system. Since the code is inaccessible and verifiable, it's inherently trusted. The rest of the system can trust the hardware and software that runs on top of it remains secure, and that it hasn't been manipulated. As a result, the RoT acts as the foundation for the secure operations of the system, and it underpins the secure-boot process.

The 32-bit CPU core at the heart of OpenTitan is complemented by specific building blocks for hardware security and hardened accelerator cores for different types of cryptography.

In any case, OpenTitan is not in a class by itself. While they're all developed under lock and key, many other chips currently on the market can act as the hardware RoT in a system or that integrate the RoT into a CPU such as Microsoft's Pluton security processor. But the companies behind OpenTitan contend that its open-to-all design process makes it much harder to compromise.

The IP inside the OpenTitan chip is transparent, said Rizzo, meaning that anyone can inspect and evaluate it for security vulnerabilities and potential improvements can be tested and verified before incorporating them into the register-transfer-level (RTL) code of the chip. He said more transparency makes OpenTitan more trustworthy since it means mistakes are more likely to be noticed and the evolution of the underlying silicon can be traced over the long term.

While the silicon RoT can be used in server motherboards and computer peripherals as well as PCs, smartphones, and other consumer hardware, he said OpenTitan could make the biggest difference in under-secured IoT devices. "The IoT is a challenging space for security, and it feels as if it's not being solved where security needs to start, which is inside the silicon, the hardware."



OpenTitan serves as the silicon root of trust (RoT) in a system. *OpenTitan*

While zeroRISC is not in the business of selling the OpenTitan chip itself, it's partnering closely with other companies that contributed to OpenTitan to supply it to customers through an early-access program.

Besides the discrete hardware RoT, the OpenTitan project also announced that it's developing a secure silicon subsystem that will give anyone the ability to integrate OpenTitan as a building block in third-party SoCs and chiplets. OpenTitan's first secure execution environment, code-named "Darjeeling," and another on-chip subsystem with support for secure external flash, called "Chai," are in development. The startup said it plans to put out a development kit for the OpenTitan RoT, too.

Is There a Future for Open-Source Chip Design?

While OpenTitan is the world's first commercial open-source chip, Rizzo is confident many more are coming. He said OpenTitan is valuable in the world of hardware security, but it could be even more valuable as a blueprint for the next generation of open-source chips.

Though it will probably never be as widespread in the electronics industry as open-source software is in the technology industry, Rizzo said he sees the concept of open silicon expanding to encompass many different types of chips and even other types of IP. The concept, he added, may even present a potential solution to the constant pains in modern chip design, including the rapidly increasing costs.

He explained that open-source silicon could help save companies money by allowing them to reuse building blocks instead of independently building proprietary versions of the same IP for every SoC, expanding the role that third-party IP plays today. The approach could reduce the complexity of the chip design as well, giving engineers more time to focus on differentiating themselves in other areas.

"I really think open-source silicon is going to become as sticky as something like Linux," said Rizzo. ed

ANDY TURUDIC | Technology Editor

So...**The Z80 is Rising from the Dead**—with an On-Chip DAC?

DARPA has enabled an ecosystem of Open-Source CAD tools and foundry services that make it possible for startups and individuals to design analog and digital chips for <$1,000.

Open-Source CAD tools
And multi-project foundries
Make chip design cheap

Birth and Death of the Z80

The first microprocessor was allegedly the 10-µm, 4-bit, Intel 4004, which was developed by Federico Faggin and available for purchase in November of 1971. A scant five months later, Intel introduced the 8-bit 8008, also fabricated on their 10-µm e-mode PMOS process on two-inch wafers. In 1974, the non-binary-compatible 8080, again developed under Faggin, came to market featuring much higher speed 6-µm NMOS technology.

That same year, Faggin would leave Intel to co-found Zilog, developing the company's first product, the 5-V-only Z80 microprocessor that was backwards compatible with the 8080 instruction set.

The 5-µm NMOS Z80 was introduced in July 1976 and continued to be produced by Zilog for 48 years, with the company announcing the 4-µm Z80's discontinuation on April 15, 2024.

Z80 Reincarnated

Less than a week after Z80's discontinuation, and within a couple of days of hearing of the Z80's demise, a veteran classmate of mine (more on that later), Renaldas Zioma, took it upon himself to prototype a Z80 in 130-nm CMOS. Most of the heavy lifting for the processor was already in place with a VHDL core already designed by Guy Hutchinson:

"TV80 is a Z80-compatible synthesizable Verilog core. The TV80 core aims to be an area-efficient core which closely mimics the original operation and cycle timing of the Zilog Z80. The core has been used by the author/porter in multiple silicon tapeouts as a utility processor or programmable state machine." - Github

Renaldas' target would be a multi-project wafer run in 130-nm CMOS, which would become open for new designs the following day and close for submissions six weeks later. The constraints of 29 pins, including power and ground, of the shuttle on the Z80's 40 pins would mean that its 16-bit address and 8-bit control buses would need to be multiplexed as a 3-way interleaved 8-bit bus, which was implemented as a 4-way multiplexed interleave for simplicity. Not his first rodeo on the Open-Source CAD tools and process shuttle, Renaldas was the first tapeout on that August 2024 shuttle run. Now he waits for about nine months to have his baby on the bench.

Birth of a Cheap Chip

Back in mid-2017, DARPA (Defense Advanced Research Projects Agency) announced a program to increase innovation and provide innovators—startup companies and individuals[!]—with the ability to design and prototype full custom ASIC chips.

"The design portion of the initiative will focus on developing tools for rapidly designing and realizing specialized circuits. Unlike general-purpose circuitry, specialized electronics can be much faster and more energy efficient. Although DARPA has consistently invested in these application-specific integrated circuits (ASICs) for military use, ASICs can be costly and time-consuming to develop. New design tools and an open-source design paradigm could be transformative, enabling innovators to rapidly and cheaply create specialized circuits for a range of commercial applications." - DARPA

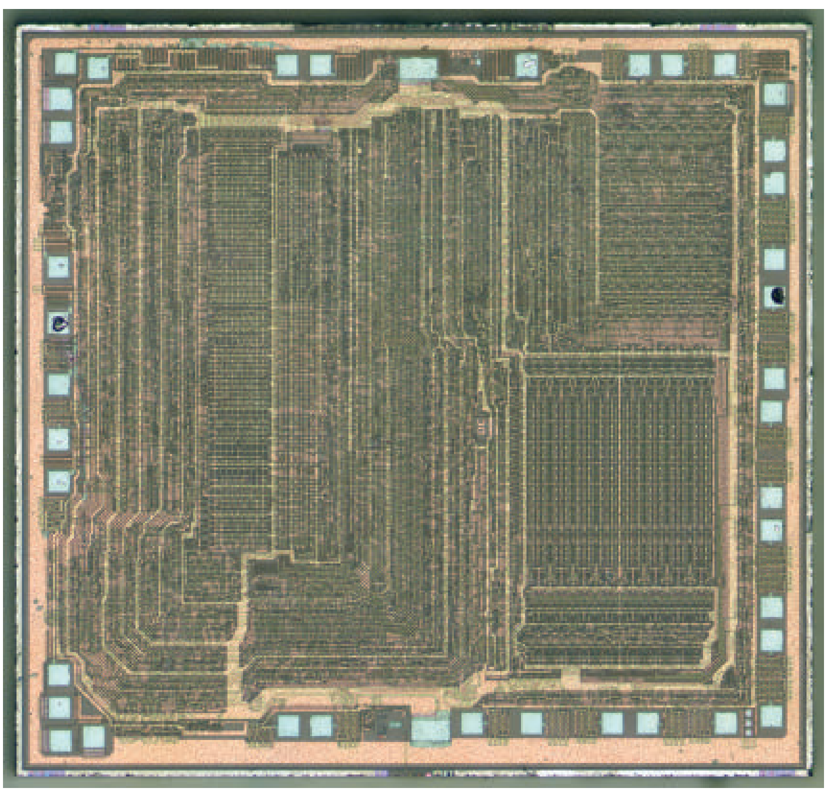
Google, allegedly a big fan of Open Source (what corporation wouldn't be a fan of free IP?), partnered with Skywater Technology to sponsor up to 100 projects on each multi-project wafer shuttle as part of the DARPA funding program. Startup eFabless provides the design framework of Open-Source tools, a standardized processor-based chip that handles probing and testing capability as well as selecting which user tiles of 512 get selected for power, ground, and I/O access.

"All projects created as part of the chipIgnite program will utilize a full chip reference design template that implements the physical IO for the chip as well as provides a common management area to support test and evaluation of the user's design. The program also includes an optional automated open-source design flow for implementing projects that enables users to generate layouts for their digital projects from RTL. The chipIgnite program will provide users a guaranteed reservation to ensure their project is included." - Skywater Press Release

At some point in time, Google seems to have dropped out of its benevolent free chips program, based on nothing new being published by researchers since 2022.

To add another layer of confusion, eFabless now offers Tiny Tapeout, which is a service that includes a "Zero to ASIC" course on analog chip design, an easy-to-install Open-Source full chip design toolset, support on Discord, and biweekly calls that include the ability to ask questions from Harald Pretl, a professor at Johannes Kepler University. He's been intimately involved in bringing up the standard cell libraries and additional analog capabilities. For under $1,000, Tiny Tapeout includes:

- **Free design tools:** Free access to design tools for implementing a project.
- **Dedicated tile space:** One tile offering 160 x 100 µm of area, and up to 1,000 standard cells.
- **Fabrication and packaging:** Tiny Tapeout takes care of fabricating and packaging the project into the Tiny Tapeout ("chipIgnite") chip, turning designs into functional silicon. Submitting a design requires a Github account and sharing the now-Open-Sourced design on a public repository for everyone else to use, which is crucial to building more complex chip designs over time.
- **Development board:** A development board plus carrier board featuring your fabricated chip, which also includes all of up to 512 tiles of designs submitted.



1990-vintage Z80 die shot. *ZeptoBars*

- **Digital datasheet and testing instructions:** Gain insights with a digital copy of the datasheet that details each of the projects implemented on the chip and instructions on how to test them.

Z80 Gets an On-Chip DAC?

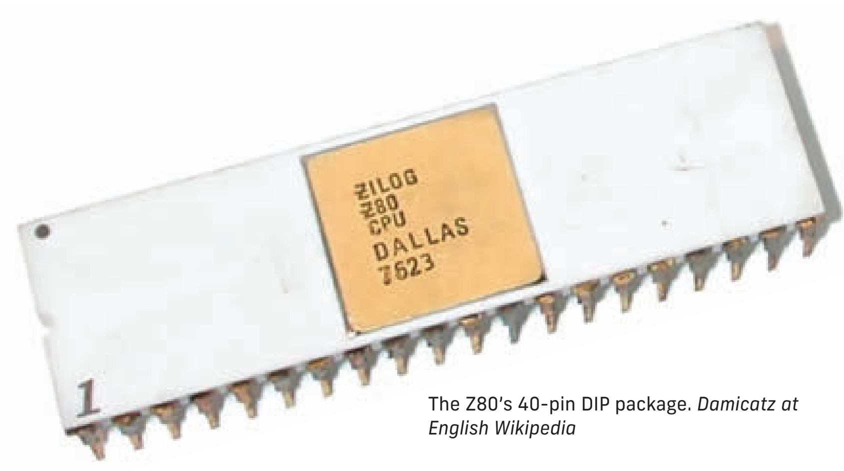
With the Tiny Tapeout philosophy of anyone being able to design a chip, and with the online class teaching chip design all the way from tools installation through tapeout and evaluation of a chip, I signed up for the beta version of the course. I did this primarily to be able to share this experience with our readers who may be interested in designing an obscure, discontinued, or original-design analog, digital, or mixed-signal chip.

"I've heard a lot about advances in processes for digital ICs and would be interested in hearing about what advances have been made in processes for analog IC's." - Eric Magnuson, *ED* reader comment on the day Z80 died

One of the turnoffs for Big Corp regarding offerings like Google Open Silicon and Tiny Tapeout is that any IP that's instantiated is fully documented and licensed for subsequent reuse by a third-party participant in the program. For a limited resources startup, or an individual, though, it's like having access to a full department of ASIC designers with zero cost for the tools to do a full chip design. Want to design a chip to control the speed of your HO-gauge loco? Now you can, versus rotting your retirement away in front of your 85-in. TV watching *Futurama* reruns.

Now in its eighth tapeout run (due Sept. 6), at least six prior runs' worth of simulated, if not bench-tested, designs are available for reuse or instantiation into a larger design. Analog designs began trickling in with the fifth Tiny Tapeout, including such functional blocks as comparators, op amps, temperature sensors, SAR ADCs, DACs, etc.

Some of the interesting ones, out of hundreds of them, include:



The Z80's 40-pin DIP package. *Damicatz at English Wikipedia*

- Analog Comparator
- DDS DAC
- Gilbert Mixer
- Simple FET Op Amp
- Instrumentation Amplifier for EKG
- 4-bit R2R DAC
- MOS Bandgap
- 1.8- to 5.4-V Dickson Charge Pump
- 12-bit SAR ADC
- AY-3-8913 Programmable Sound Generator
- 128x8 ROM
- 10-bit Moving Average Filter
- FIR Filter with Adaptable Coefficients
- 4-bit Flash ADC with Binary Encoder
- 10-MHz PWM Generator
- Over a dozen neuron projects on this tapeout

If one was inclined to do so, Renaldas' Z80 could be easily bolted to one or more of these Open-Source designs using free Open-Source tools, creating, for example, a Frankensteined Z80 with three on-chip DACs for an application, such as generating an RGB display output. With 130-nm CMOS, a Z80 chip core would be severely pad limited, and it would take a couple of dozen cores to balance a fill to the padframe should an actual chip be eventually broken out. Imagine doing 256 cores of the Z80 on a chip...

What to Do?

Having signed up with Tiny Tapeout back in July, I have yet to install the CAD tools and watch the course materials due to the amount of work in this editor job that I've piled on for myself, let alone decide what to do for my chip design. With I/O bandwidth limitations of 75 MHz, it's too slow for many of my aspirations, so I'm open to suggestions in the comments as to what may be interesting to do. I plan to provide updates here on Nonlinearities as I progress through the process. I missed the September 6 tapeout, but a couple of others are coming up as well.

In any case, you, dear reader, can easily do a <75-MHz analog design for under $1,000...if you can find the time to do it, as money is no longer the problem. Then you need to think about what chip you'd like to do, which is the toughest part of this process—a standard building block or cell to contribute to this design revolution (likely what I'll do), some discontinued oldie but goldie (Pong's been sorta done), a chip that will compute Pi to a bazillion digits (1024's been done), or perhaps an implantable empathy chip for billionaire warmongers' brains like the one in Palmer Lucky's skull. ed

All for now,
AndyT

WILLIAM G. WONG | Senior Content Director

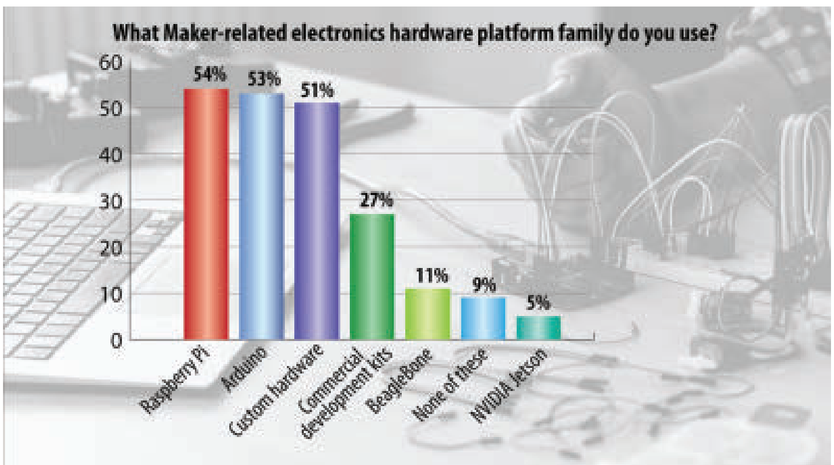
Initial Results from *Electronic Design's* **Maker Survey**

Here are the latest results from Electronic Design's Maker Survey that asks about the tools you use, product-inspired projects, and more.

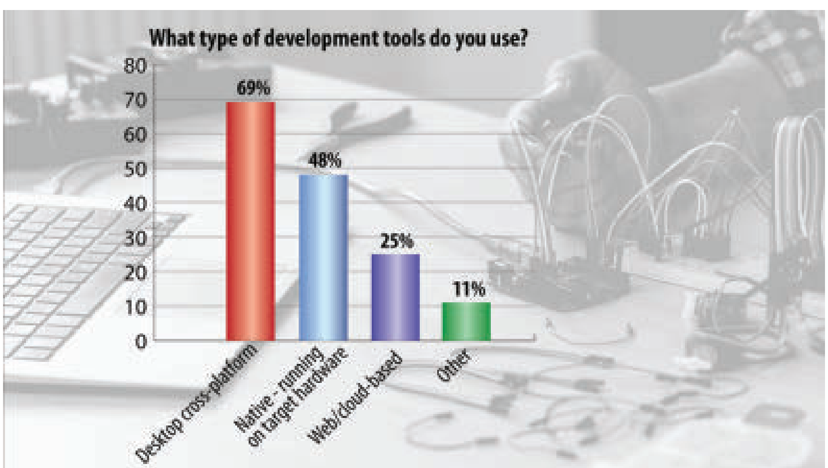
PRESENTED HERE ARE the latest results of our ongoing Maker Survey. Take it if you haven't already done so. We will be following up with more coverage in the future. I did a quick snapshot of the results so we could get this article into this issue.

What Tools are Makers Using?

Not surprisingly, Raspberry Pi and Arduino are the two most popular development platforms for makers, followed by customized hardware and other commercial platforms *(Fig. 1)*. The latter often provide Raspberry Pi and Arduino headers so that developers have access to the plethora of expansion options available in the respective ecosystems.



1. Not surprisingly, Raspberry Pi and Arduino are the two most popular development platforms for makers. *Tony Vitolo/Electronic Design*



2. Desktops remain the platform of choice for development. *Tony Vitolo/Electronic Design*

We did ask a few questions about the tools that developers are using. Of course, 3D printers showed up in the list, along with the modules and boards already mentioned. We also asked where they built their software. Desktops remain the platform of choice for development, although a significant number use web-based tools, which have become more prevalent *(Fig. 2)*.

Going the web-based tool route has a number of advantages, but it also brings about challenges ranging from connecting to a target device to providing debugging support. Likewise, some platforms are only available with web-based tools, while in other cases there's a desktop or native tool that may differ in functionality or interface because of web-based limitations.

More Maker Results to Come

I plan on following this article up with a more detailed examination of every question, as more of you have a chance to take the survey.

READ THE FULL VERSION of this article online at *Electronic Design*.


ENDEAVOR
INSIDE ELECTRONICS
Electronic Design


SCAN
HERE