Farnell Newark element14

Essential Design Tips for Engineers

Series 1

Supporting Your Research & Design

Component distributors are more than just a stockist of products. At element14, we work closely with engineers and our suppliers to bring the best technology, support and information together to help our customers create innovative electronic systems.

We've pulled together some of the most helpful and interesting hints and tips from leading electronic component manufacturers to create this book. Whether you are using boards, semiconductors, passives, connectors, relays, sensors or LEDs, you'll find ideas and inspiration for your next project. You'll also get ideas for improving your testing and debugging, as well as learning about the processes we use when developing for some of the world's largest electronics companies.

Whatever your next project, whether you are an educator, hobbyist, professional engineer, purchaser or maintenance professional, we've got the products you need, available quickly and easily from our local websites. We look forward to working with you.

Regards

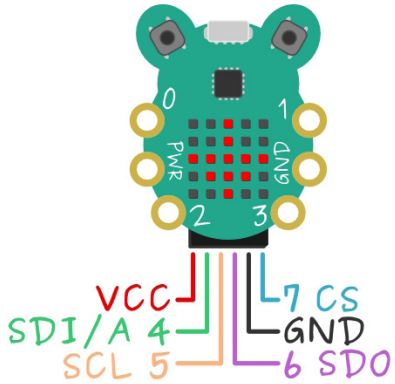
Steve Carr
Head of Global Marketing

Contents

Development Boards

Extend CodeBug I/O Options

CodeBug offers a range of inputs and outputs through Blockly programs. In addition to the six legs, there are also four expansion pins at the bottom that can be enabled as I/O. Take care as these four pins are not protected by a current limiting resistor.



Connect a Raspberry Pi® to a VGA Monitor

Want to use the Raspberry Pi with an old VGA monitor? Good news: the HDMI output can be used with a cheap passive HDMI to VGA cable, provided you tweak a few values in the /boot/config.txt file. Edit the file to have the following lines, and adjust hdmi_mode to match your monitor's resolution.

```
hdmi_drive=2
config_hdmi_boost=4
hdmi_group=1
hdmi_mode=16
hdmi_force_hotplug=1
disable_overscan=0
```

Add a Touchscreen to BeagleBone

Adding a touchscreen to the BeagleBone is easy using the CT43 display Cape from element14. It provides a 4.3" 480 x 272 screen with LED backlight and capacitive touch, and a board ID EEPROM enables plug-and-play functionality with the Debian operating system.

Cellular Communication Made Easy

For applications or prototypes that need long-range cellular communications, interfacing to a mobile phone is an easy solution. Motorola's Moto Mods™ Development Kit is the fastest way to produce a complete system, using a board that snaps inside the Moto Z phone using strong magnets. Personality Cards demonstrate how to use sensors, integrate audio or add a display and the HAT adaptor lets you plug Raspberry Pi HATs into the MDK.

Semiconductors

Using USB in Industrial Applications

One of the benefits of USB is the ability to power a remote device through the USB port. Unlike consumer applications, where devices share a common ground, industrial equipment is often powered from different building ground references, resulting in the USB cable creating a ground loop, which introduces noise that can corrupt data transmission or even damage equipment. This problem can be eliminated by breaking that ground loop with a USB isolator, such as the Analog Devices ADuM3160 or ADuM4160. Both of these devices will galvanically isolate the USB devices while seamlessly allowing communication between the two systems, ensuring reliable operation in an industrial environment.

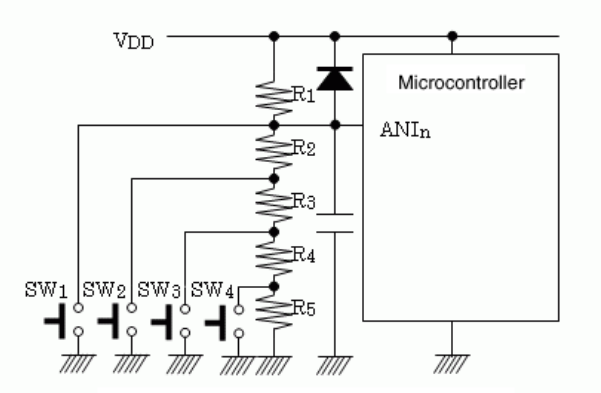
Steps to Good Boost Converter PCB Layout

In power conversion designs, PCB layout is critical. Placing and routing components in the following order is an optimised approach that will ensure good results:

1. **Output Capacitor:** ensure it is close to the IC to reduce parasitic inductance
2. **Inductor and Snubber:** as close to the IC as possible to reduce radiated EMI
3. **Input Capacitor and VIN Pin:** less critical than the output components
4. **Small Signal Components:** passive components for the analogue and logic functions
5. **Signal ground and polygon plane:** ensure no large currents are flowing in the signal ground

Expanding Key Switch Inputs on Microcontrollers

The number of available microcontroller input ports that can be used for key switches can be limited, presenting challenges in some applications. An alternative approach is to use an analogue input, which can support multiple keys, for example the 4-key application shown below.



Secure Cloud for IoT Applications

The AWS Zero Touch Secure Provisioning Platform offers the industry's first end-to-end security solution for Internet of Things (IoT) devices that connect to the Amazon Web Services' (AWS) cloud, helping IoT devices complying quickly and easily with AWS's mutual authentication IoT security model. The Microchip AWS-ECC508 provides a secure authentication method and simplifies management of the private keys in a large-scale production environment. It complies with AWS IoT just-in-time registration, offering mutual authentication between devices and the remote server. With a simple I2C connection to the host microcontroller, it provides a flexible and cost-effective solution for security and authentication in IoT applications.

Semiconductors

Simple Low-Power WANs with LoRa®

The STM32 Nucleo pack, FSK/OOK RF transceiver modem and LoRaWAN™ software expansion package for STM32Cube provide a complete solution for low-power, wide-area networks (LPWANs) connectivity for IoT and M2M end-node devices. LoRa is:

- **Long range:** >15 km / 9 mi range
- **Low-power:** 5-10 year expected battery lifetime
- **Low-cost:** from end-node sensor cost to upfront infrastructure investment
- **Secure:** with embedded end-to-end AES-128 encryption of data
- **Geolocation:** enables indoor/outdoor tracking without GPS

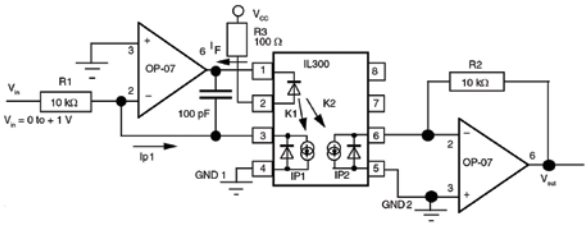
Better Protection with eFuses

Semiconductor eFuses are alternatives to old-style one-shot fuses and positive temperature coefficient (PTC) resettable fuses. They have several advantages:

- Rapid (typically less than 10 µs) response
- Minimal parameter shift with temperature
- No degradation or change of on resistance after a fault
- Programmable current limit
- Enable and fault pins for control logic
- Soft–start and voltage clamp to limit inrush current spikes
- Choice of latch–off or auto–retry
- Reverse current blocking

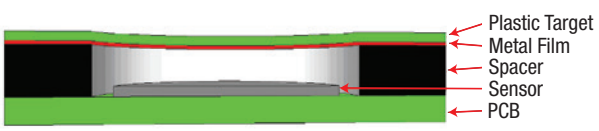
Optoelectronic Isolation in Power Supplies

To ensure high efficiency and better regulation, power supplies need a feedback loop from the output voltage. When isolation is required, particularly in AC-DC supplies that must withstand 3750 VAC to meet international standards, optoelectronic feedback provides an ideal solution.



Overcoming Disadvantages of Capacitive Touch

Standard capacitive touch systems normally do not work through metal coverings, require special software for electrically noisy environments, and are unreliable in the presence of water or other contaminants. Microchip's mTouch™ Metal Over Capacitive technology overcomes all of these limitations without compromising power consumption or design simplicity.



Passive & Electro-Mechanical

Relay Coil Suppression Techniques

When an electromechanical relay is de-energized rapidly by a mechanical switch or semiconductor, a substantial voltage transient, which can be 1,000 to 1,500 V in a 12 V relay, is produced. This creates EMI, semiconductor breakdown, and switch wear problems, which is best prevented by using the following suppression techniques:

- A bilateral transient suppression diode
- A reverse-biased rectifier diode with a Zener diode in series
- A metal-oxide varistor (MOV)
- A reverse-biased rectifier diode with a series resistor
- A resistor, or reverse-biased rectifier diode, where conditions permit tracking without GPS

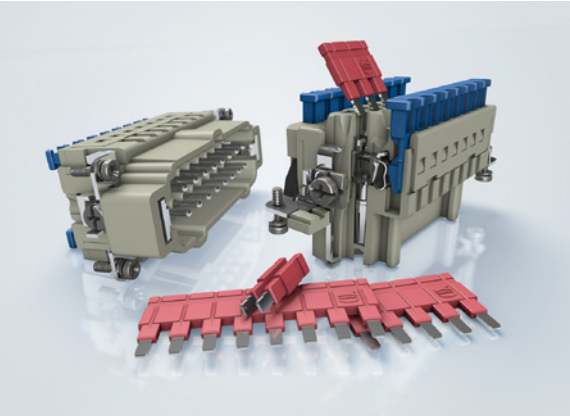
Best Capacitors for Decoupling

All capacitors have some equivalent series resistance and inductance (ESR and ESL). These parasitic elements can cause power droop and high-frequency noise in digital systems. Choosing the appropriate device can significantly decrease ESL, improving performance.

AVX MLC Capacitor	Typical ESL at 0.01pF
Axial leaded	2000 pH
0805 SMD	1400 pH
0508 SMD	700 pH
KCAP	300 pH
DCAP	50 pH

Tool-Less Connectors Save Time

The need for ever-more connections in modern systems can significantly increase commissioning time and cost. The HARTING Han® ES Press is an example of a new approach, where conductors can be hand-inserted, reducing effort and eliminating the need for specialist tools.



Rugged Connections

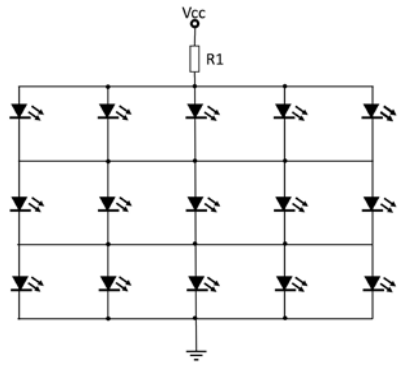
From industrial and process control to portable systems used in harsh environments, equipment needs to be ruggedized. Connectors often present a challenge, with designers resorting to specialist components to ensure robustness and reliability.

Our wide range of connector suppliers includes devices for the most challenging applications, as well as ruggedized versions of familiar everyday connectors. The Amphenol D-sub family, for example, are replacements for commercial connectors with industrial variants that are waterproof to IP67, as well as Mil-DTL-24308 approved and QPL listed connectors for defence applications.

Opto, LED Lighting & Sensors

Matrix Connection Improves LED Reliability

Connecting LEDs in strings is an established approach for lighting applications, but aging LEDs can fail, breaking the circuit. A better approach is to connect LEDs in a matrix, where a failure does not stop the others working: the only impact is a slightly higher current in the parallel LEDs.



SMPS Topologies for LED Lighting

There are a number of different SMPS topologies, all of which have different benefits for LED lighting applications.

Topology	Comments
Charge Pump	Limited I_{out} range No inductors
Buck	Chopped I_{in} $V_{out} < V_{in}$
Boost	Extra components needed for isolation $V_{out} > V_{in}$
SEPIC	Smooth I_{in} Two inductors
Buck-Boost	Single inductor Up to 4 switches needed
Flyback	Can be isolated Multiple outputs possible

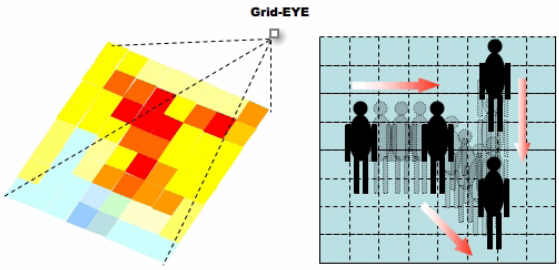
Improving Accelerometer Accuracy

There are two types of noise in accelerometers: electronic noise and mechanical noise from the MEMS cell. The signal to noise ratio is often greater than the quantization error, resulting in a reduction of the effective number of bits.

Oversampling and decimation is an established way of improving the signal to noise ratio, with an oversampling factor of 4, improving SNR by 6dB: effectively an extra bit of resolution. A factor of 64 adds 3 bits due to an SNR improvement of 18dB. Designers can therefore trade off accuracy against speed and power consumption by using oversampling techniques.

IR Eyes Save Energy

Panasonic Grid-EYE sensors are ideal for energy-saving or comfort applications that need to detect the presence of people or temperature distribution in an 8 x 8 grid. The MEMS sensor can detect sudden changes with a 10 images/second capability.



Test & Measurement

Debugging Serial Busses with Oscilloscopess

The increasing use of serial busses to save board space, pin count, cost and power in embedded systems means that new debugging approaches are required. Conventional oscilloscopes and logic analysers can trigger on the start of a message, but their state and pattern triggers are impractical for identifying specific message content.

The optional serial triggering and analysis capability of Tektronix oscilloscopes make them a powerful tool for embedded system designers, removing the need for edge triggering by using common bus's conditions or data instead. The scopes also display the data and address in clear hex or binary, further speeding up debugging.

Thermal Inspection Finds Problems Fast

When investigating issues in electronic and electrical systems, a thermal camera is a valuable tool to quickly identify hot-spots troubleshoot problems in components from breakers and fuses to connections and semiconductors on boards.

Choosing the Right Probes

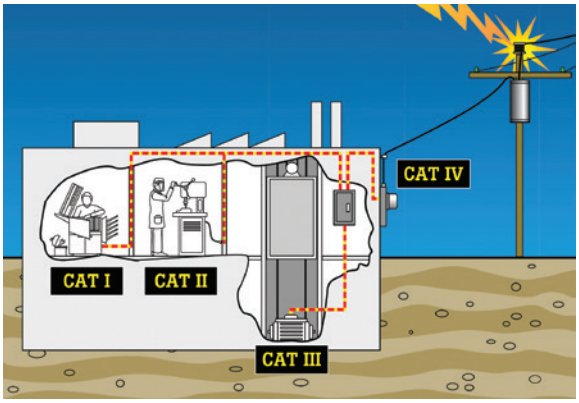
Sometimes it can be very difficult to make contact with the exact point that you need during testing: using probes with high density, multi-layer circuit boards and closely spaced components is difficult and can cause damage.

- Single point probes are the most common, but are typically too large for modern circuit boards
- Sharp probe tips get at small contact points, and are usually not plated to allow re-sharpening
- Hooks and Pincers and IC clips allow connections to be left in place

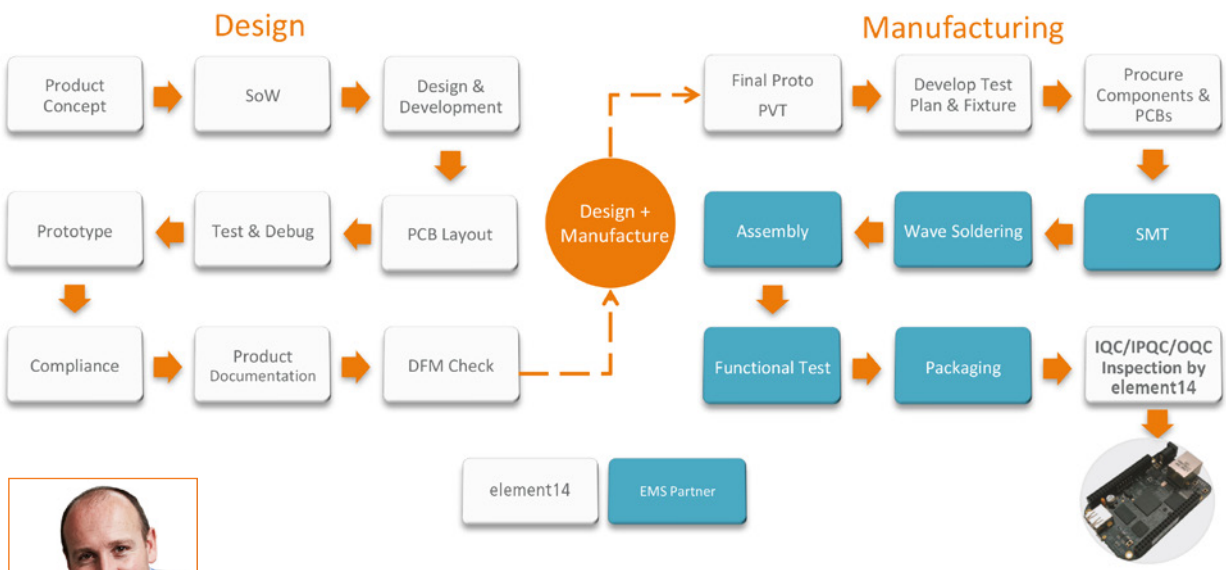
In addition to the importance of safety insulation, don't forget the importance of leads: dissimilar metals can act like thermocouples and affect voltage measurements in the micro Volt range.

Safer Multimeter Measurements

Multimeters often fail because they have been subjected to transients caused by motors, power conversion equipment or lighting strikes. The voltage rating will not tell you how well that meter was designed to survive high transient impulses, so make sure you choose meters rated for the appropriate over-voltage category.



Our Development & Manufacturing Process



Richard Curtin
Director of Strategic Alliance
& Technology Partnerships

Stringent design and manufacturing processes are essential to ensuring high quality and minimising the risks associated with new product development. At element14, we create custom embedded platforms, single board computers and system-on-modules for the leading electronics companies using world-class processes to ensure we get things right first time.

Products such as the Raspberry Pi and BeagleBone Black, as well as development boards for the leading semiconductor manufacturers and products for medical, industrial, consumer, and automotive applications, have been developed by our team of more than 130 engineers based in the USA and China using the 18-step process shown in the diagram.

Electronic design begins with a well-defined product concept and a clear statement of work (SoW) to ensure that everyone understands the requirements and scope of the project. The product is then designed, the PCB is laid out and then the first devices tested and debugged, producing a prototype for the customer to evaluate.

Once the customer has confirmed the product complies with the requirements, creation of product documentation is essential. We then conduct a design for manufacture (DFM) check, making any changes that are necessary to create a final prototype of a product that can be built and tested reliably and cost-effectively.

We also develop a test plan and fixture to optimise functional testing during production, and then source the PCBs and components (we have a lot of experience of working with component manufacturers!). Manufacturing is outsourced to an EMS partner, but we always maintain control over quality with our inspections for Incoming Quality Control (IQC), In-process Quality Control (IPQC) and Outgoing Quality Control (OQC).

element14.com/design-services
designengineering@element14.com

Design in Action

Futurehome

The crowdfunded project, Futurehome, lets customers control, automate and monitor their home from anywhere in the world. The smartphone app controls a wide range of devices such as lighting, heating, alarms and electronic locks.

A critical part of the system is the home automation gateway, which connects the smart devices and communicates with the app on the user's phone. The project team asked us to help develop and manufacture this vital part of the project.

In a joint project between our AVID Technologies and Embest divisions, we helped Futurehome develop a gateway that integrates the Pi Compute module and a custom wireless baseboard. We also developed an attractive case, and supplied the finished product in high-quality retail packaging.

futurehome

CodeBug

element14 is the largest supplier of development boards and manufacture the Raspberry Pi, as well as numerous development systems for a wide range of semiconductor companies. CodeBug offers the opportunity to learn about programming and hardware concepts to anyone of any age.

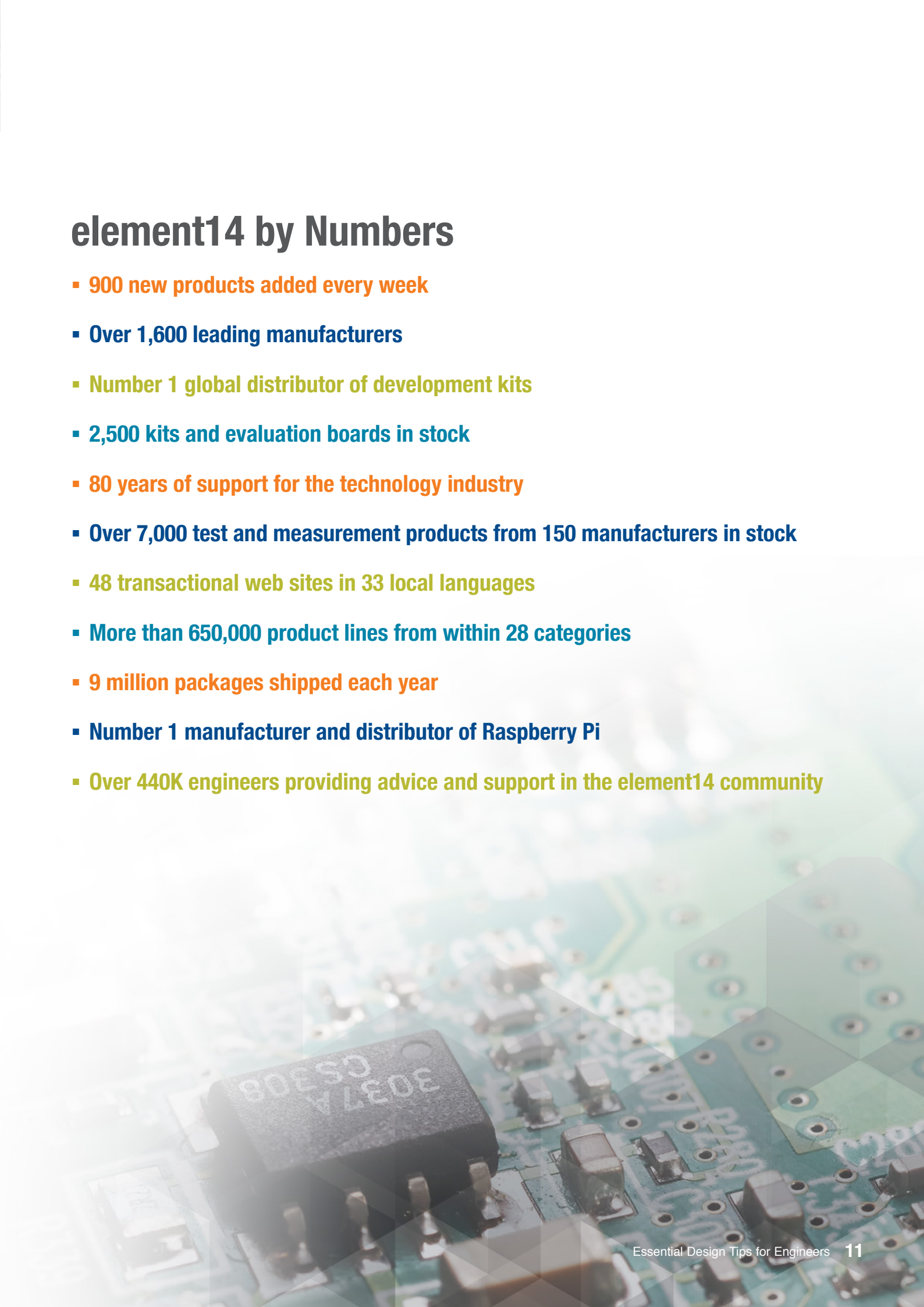
element14 helped the project move from concept to production by providing prototyping, compliance testing and manufacturing services, supplying CodeBug in consumer packaging ready for sale.

Since launch we have promoted CodeBug extensively through our element14 community, helping the project build momentum from its crowdfunded beginnings to shipping large volumes to educate the next generation of coders.

CodeBug™

element14 by Numbers

- 900 new products added every week
- Over 1,600 leading manufacturers
- Number 1 global distributor of development kits
- 2,500 kits and evaluation boards in stock
- 80 years of support for the technology industry
- Over 7,000 test and measurement products from 150 manufacturers in stock
- 48 transactional web sites in 33 local languages
- More than 650,000 product lines from within 28 categories
- 9 million packages shipped each year
- Number 1 manufacturer and distributor of Raspberry Pi
- Over 440K engineers providing advice and support in the element14 community



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Registered office: Farnell House, Forge Lane, Leeds LS12 2NE