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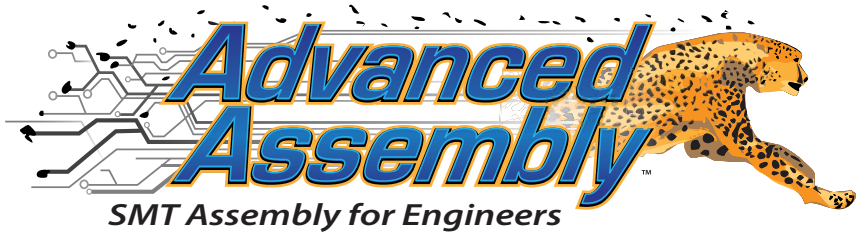

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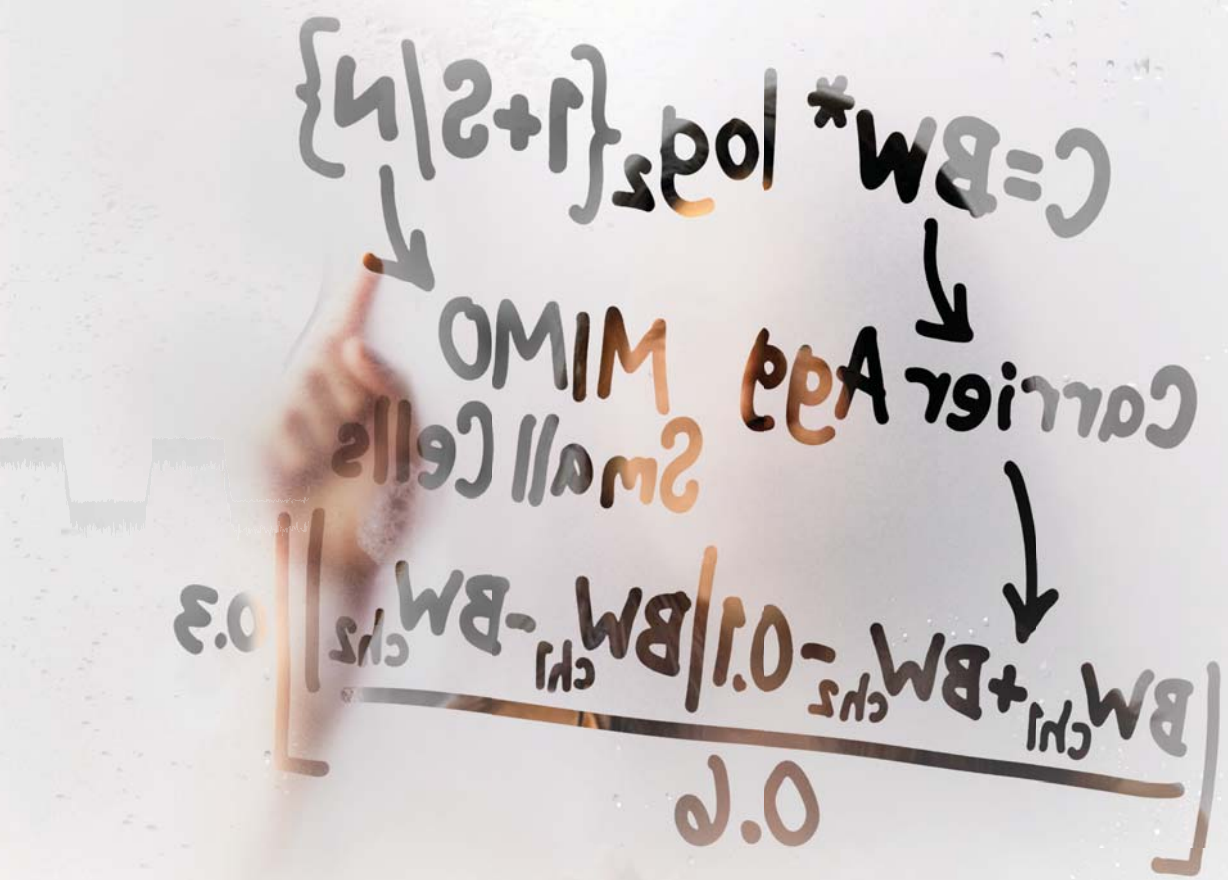

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THE GOLD STANDARD

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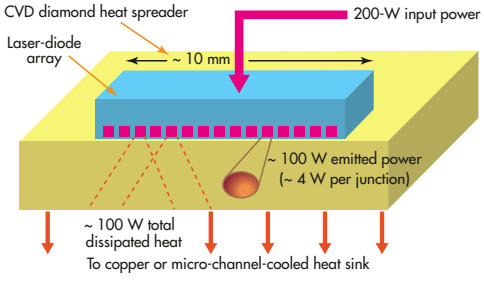

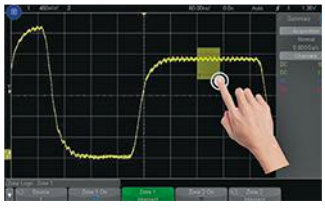

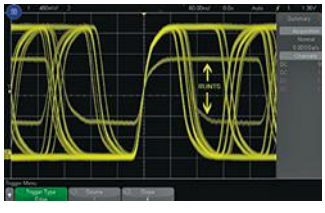

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GOGGLE DISPLAY HELPS SWIMMERS COUNT STROKES

http://electronicdesign.com/embedded/goggle-display-helps-swimmers-count-strokes

Wearables have officially hit the water—swimmers now can track, store, and project key information, including heart rate and swimming speed, on their goggles.

Q&A: MACOM'S DOUG CARLSON

http://electronicdesign.com/digital-ics/qa-macom-s-doug-carlson-discusses-gan-s-market-potential-and-trajectory

With mainstream adoption of gallium nitride (GaN) at a crossroads of technology innovation and supply-chain transformations, MACOM Vice President of Strategy Doug Carlson discusses GaN's market potential and trajectory.

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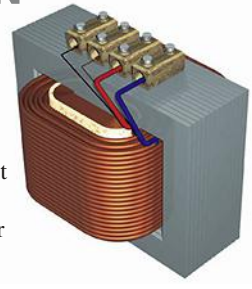

When the right off-the-shelf part just can't be found, you may want to consider designing a custom transformer to fit your specific requirements.

5 THINGS TO KNOW ABOUT SOFTWARE TESTING

http://electronicdesign.com/test-measurement/top-five-things-know-about-software-testing

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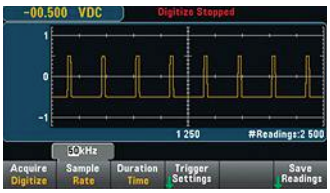

Trend chart

Histogram

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FAA Defines Drone Rules

The Federal Aviation Administration (FAA) has held up the commercial use of drones because there were no rules in place. Its recent change may be approved by now, but it will open up at least some opportunities for drone pilots to take to the sky. Until now, drone use required special permission from the FAA. Of course, these limitations have not stopped use by hobbyists and developers, but commercial users got smacked down.

At this point, hobbyists and non-commercial users can operate drones like Parrot's Bebop Drone (*see the figure*) as long as they stay below 400 feet. Users must notify air-traffic control when using a drone within 5 miles of an airport. Drones must be within visual line-of-sight (VLOS). These are essentially the rules for RC planes that have been in use for decades.

Parrot's Bebop Drone has an HD camera that uses digital image stabilization to send back real-time video for first-person flight control. (See more photos at *http://www.parrot.com/usa/gallery/bebop-drone.)*

The proposed drone rules are restrictive, but they should make commercial drone usage more common. Drones will have to be piloted by someone who is at least 17 years of age and has passed an FAA test and been vetted by the Transportation Security Administration (TSA). There had been discussion of requiring a pilot's license, but that was deemed too restrictive.

The maximum altitude is 500 feet and the max weight is 25 kg. Operation has to be during daylight hours and VLOS. Speeds must be under 100 miles/hour. The drone can not be flown over people not related to the operator's mission (so it could be used by a film crew). A microUAS (under 2 kg) option has been proposed that would loosen this restriction for certain certified operators.

The new rules will make it easier for vendors to deliver equipment that meets these requirements. It will finally allow more general use of drones for commercial purposes. Hopefully these rules can be amended in the future to be more flexible as more experience is gained and more sophisticated drones are made available.

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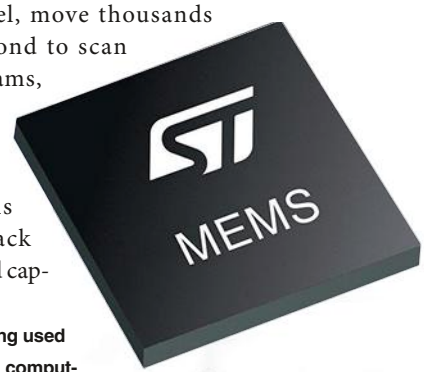
News & Analysis

MEMS MIRRORS Show Promise in Perceptual Computing

While traditional forms of device input—keyboards and mice—remain commonplace, perceptual computing enables "computers to work around us, rather than us continuing to work around them" by understanding our intentions in a more natural way (*see "Interview: Barry Solomon Discusses Intel's Perceptual Computing SDK" on electronicdesign.com*). Now, the adoption of tiny microelectromechanical system (MEMS) mirrors could further developments in human-computer interaction. The mirrors use the same electrostatic principle that causes our hair to stand on end to sense motion.

The micro-mirrors, provided by Geneva-based STMicroelectronics as part of the perceptual computing initiatives at Intel, move thousands of times per second to scan infrared light beams, painting an invisible grid on objects in front of it. The light is then reflected back from the object and captured and analyzed for 3D imaging and gesture applications.



MEMS mirrors are being used to advance perceptual computing technology, which promotes human-computer interaction through the use of electrostatic principles. *(Image courtesy of STMicroelectronics)*

MEMs technology fosters smaller, more robust systems for a variety of consumer devices, ultimately delivering more immersive experiences. It also has the ability to sense other environmental factors and actuate or move liquids, further integrating devices.

Previously, STMicroelectronics helped develop an extremely thin projection engine that fits into the screen of a laptop or tablet computer. It offers an ultra-wide field of view of almost 90°. ■

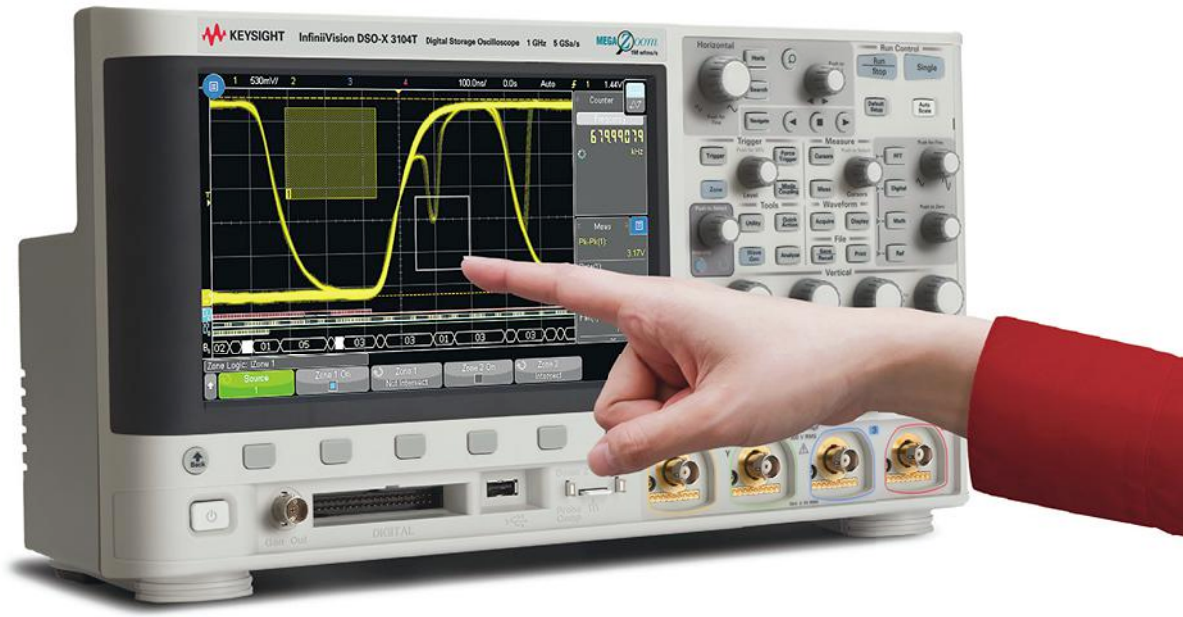
SILICON NANOFIBERS Boost Electric-Vehicle Battery Performance

CONVENTIONALLY PRODUCED LITHIUM-BATTERY anodes are made using copper foil coated with a mixture of graphite, a conductive additive, and a polymer binder. Graphite's performance, however, has been nearly tapped out, so researchers have begun experimenting with other materials. Silicon has proven effective, but it often suffers from significant volume expansion that can degrade the battery.

Enter a new paper-like material, developed by researchers at the University of California, Riverside's Bourns College of Engineering, which has the potential to increase the amount of energy that can be delivered per unit weight. For use in the batteries of electric vehicles and personal electronics, the material consists of sponge-like silicon nanofibers that are 100 times thinner than human hair.

The nanofibers were produced through electrospinning, where 20,000 V to 40,000 V are applied between a rotating drum and a nozzle, emitting a solution composed of tetraethyl orthosilicate (TEOS). TEOS is a chemical compound frequently used for semiconductors. The nanofibers are then exposed to

Touch. Discover. Solve.



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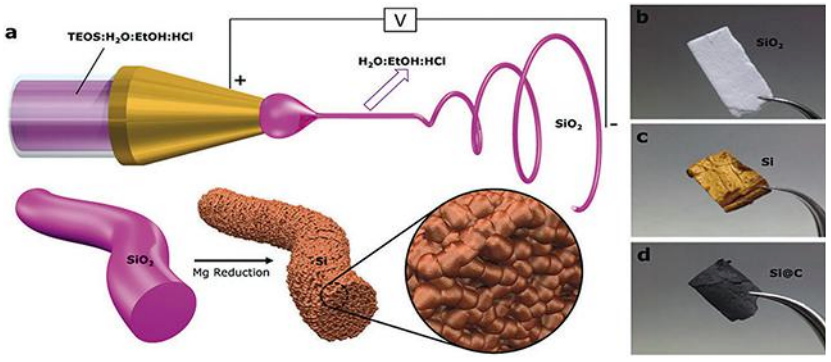
* Refer to Keysight document 5992-0140EN for product specs, and 5989-7885EN for update rate measurements.
** Competitive oscilloscopes are from Tektronix publication 48W-30020-3

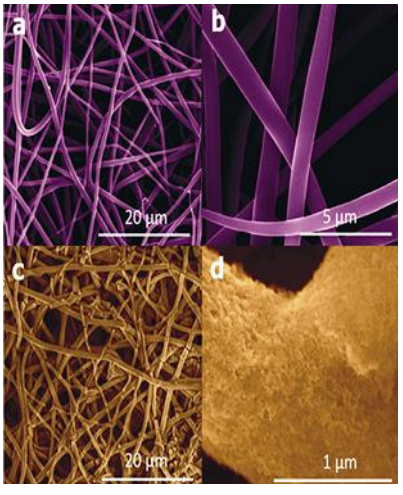


At right is a schematic representation of the electrospinning process and subsequent reduction process (a). Digital photographs of (b) as-spun SiO2 nanofibers paper, (c) etched silicon nanofiber paper, and (d) carbon-coated silicon nanofiber paper as used in the lithium-ion half-cell configuration. *(Image courtesy of the University of California, Riverside.)*

a magnesium vapor that produces the sponge-like silicon fiber structure.

The nanofiber structure created in the lab circumvents the battery-degradation issue inherent with traditional silicon—it allows the battery to be cycled hundreds of times without degrading significantly. The technology is also scalable. The team was able to produce several grams of silicon nanofibers at a time, even at the lab scale. Typical free-standing materials grown using chemical vapor deposition, such as carbon nanotube or silicon nanowires, have only previously been produced in very small microgram quantities.

According to the team, "Eliminating the need for metal current collectors and inactive polymer binders while switching to an energy dense material such as silicon will significantly boost the range capabilities



Above, scanning electron microscope images of (a) SiO2 nanofibers after drying, (b) SiO2 nanofibers under high magnification (c) silicon nanofibers after etching, and (d) silicon nanofibers under high magnification. *(Image courtesy of the University of California, Riverside.)*

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of electric vehicles." Looking toward the future, the team will implement the silicon nanofibers into a pouch-cell-format lithium-ion battery, a larger-scale battery format that can be used in electric vehicles and portable electronics.

The findings were published in the paper, "Towards Scalable Binderless Electrodes: Carbon Coated Silicon Nanofiber Paper via Mg Reduction of Electrospun SiO2 Nanofibers," for the *Nature Scientific Reports* journal. It was written by Mihri Ozkan, professor of electrical and computer engineering, Cengiz Ozkan, professor of mechanical engineering, and six of their graduate students. ■

CONTROLLER PLATFORM Mitigates Wasted Kilowatt-Hours

ALONG WITH THE SURGE in mobile phones, tablets, and computers is the fact that more of these devices are being left plugged into the wall, wasting billions of kilowatt-hours per year. A new solution hopes to cut that wasted power to zero, which could save more than 200 million gallons of oil in a year. The energy-efficient platform is designed with a power-management architecture to achieve zero no-load power consumption and dynamic load regulation.

Designed in partnership with STMicroelectronics and Flextronics, the highly integrated platform—built on the STCH01 controller—suits high-power-density smartphone and tablet adapters. The STCH01 embeds a controller and two power FETs, and is used in conjunction with the STWK01 no-load wakeup controller.

The STCH01 leverages a power-conversion topology to maximize efficiency and shrink the size of the power transformer by 30%, compared to previous flyback solutions. Low electromagnetic emissions are further reduced using the IC's intelligent jitter function. It comes equipped with a full set of protections to ensure more reliable designs with minimal external components. ■

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Keep an Eye Out for QUAD

These diverse drones are getting more intelligent—and gaining better eyesight.

LOOKING FOR A QUADCOPTER?

There are literally hundreds now available from a range of companies. Larger, higher-end drones often employ gas engines, but the plethora of small- to medium-size unmanned aircraft systems (UASs) use electric motors to lift the craft and provide an extremely stable platform.

There are fixed-wing and copter UAS systems. Fixed-wing systems typically have longer range and flight times, but copters have the ability to hover, move slowly, and rise vertically. While the typical UAS copter has four propellers, there are versions sporting any number of propellers. More are normally used for heavier payloads.

These electric drones are usually quiet. Unfortunately, they also tend to be limited by battery performance. Still, the increasing complexity of their on-board computers and their improved sensor systems make flying easier, even allowing for autonomous and semi-autonomous operation.

To get a flavor of what is available I took a look at the Parrot Bebop, the DJI Inspire 1, and the tiny Zano Micro Drone *(Fig. 1)*. The Parrot Bebop is the one most will notice because of Parrot's distribution channels, as well as one of its target markets: consumers. Still, while its HD camera is capable of delivering professional-quality videos, the DJI Inspire 1 is likely to be the option professional videographers will consider. It has retractable landing gear to provide a clear 360-deg. field of view for the gimbal-mounted camera that can be independently controlled.

The Zano Micro Drone is more of a research and hobbyist platform. It is not likely to be found at your local Target, but—based on what we saw at this year's Consumer Electronics Show—there are a number of new drones in this class that might be, before long.

HI-RES VIDEO WITH THE PARROT BEBOP

The Parrot Bebop may look like many other drones on the market, but it takes a digital approach to stable, streaming

COPTERS

(b)

1. Parrot Bebop (a) has a front-facing HD camera that uses digital image stabilization to provide a real-time video feed to the remote pilot. DJI's Inspire 1 (b) transforms so the gimbaled camera has an unobstructed view and allows dual-user controls. One is for the aircraft and the other is for camera. The Zano (c) is an open-source, tiny drone designed for research and hobbyists.

video. It starts with a fixed, 14-megapixel camera with a fish-eye lens that can record 1080p video. This provides a 180-deg. field of view and allows for digital image stabilization.

The Bebop's digital image stabilization is impressive because it is done on-board by Parrot's P7 system-on-chip (SoC). The SoC has dual ARM Cortex-A9 cores and a quad-core GPU. It also includes an image signal processor (ISP) that helps with the video heavy lifting. The SoC runs Linux and has 8 Gbytes of flash for storing videos. The 802.11 a/b/g/n/ac Wi-Fi support delivers streaming video to an app on a smartphone or tablet for first-person piloting. Many other UAS copters have line-of-sight (LoS) visual requirements.

The digital image stabilization provides a stable image on the controller display, as well as providing smooth recorded video. The stabilization is done by not presenting the full camera image, but rather, a subset that has been processed to eliminate both optics-related distortion and movement. While it is possible to get raw footage, the stabilized image makes more sense. This approach reduces the bandwidth needed to send video to the controller. It also provides a better view that helps when piloting the Bebop.

The copter has the usual 3D mix of accelerometers, gyros, and magnetometers. It also uses ultrasonics for elevation detection up to 8 m, along with a pressure sensor for altitude information. There is also a downward looking camera that analyzes the ground to determine horizontal speed and direction. In addition, it features GPS/GLONASS support. This allows for a "return home" option that can be initiated from the control panel.

The Bebop uses four three-blade propellers powered by three-phase, brushless motors. Flight time is just over 10 minutes. Batteries are easily swapped and two are included with the unit. The main cowling is magnesium, which acts as a heat sink. The foam propeller guards are optional and normally used indoors.

The control application supports virtual touchscreen controllers. There is also the Skycontroller *(Fig. 2)*, which holds a tablet still running the control application. An adjustable shade is positioned above the tablet for outdoor use. The

2. Parrot's Skycontroller holds a tablet and provides a pair of joysticks and status indicators.

Skycontroller is compatible with 3D headsets like Oculus Rift, allowing for an immersive option; the Bebop view follows the movement of the headset. The Bebop is $499, while the addition of the Skycontroller increases this to $899.

Parrot provides an open-source SDK. This handles the Bebop and Skycontroller as well as other Parrot drones. The Bebop uses the MAVLink (Micro Air Vehicle Link), an open-source protocol, from QgroundControl used by a number of small unmanned platforms. It is compatible with APM, Pixhawk, and the PX4 open-source, open-hardware autopilot project. Pixhawk can run on platforms like Linux, as well as platforms like NuttX RTOS that runs on microcontrollers like the STMicroelectronics STM32F series.

The Parrot Bebop camera can do limited panning without movement because the image presented is lower than what the camera captures. It has to turn to view something behind and it would have difficulty looking down.

TRANSFORMING DJI INSPIRE 1

The DJI Inspire 1 can do some of the camera tricks that Bebop cannot, owing to the DJI Inspire 1's 3-axis, ZENMUSE X3 camera gimbal *(Fig. 3)*. This type of camera mount is common, especially on larger drones. It allows quick movement of the camera. Dynamic control of the joints can provide mechanical stabilization for the camera mount, allowing almost any type of device to be used. For example, a conventional digital camera could be replaced by a thermal imaging system.

The Inspire 1 has an angular vibration range of ±0.03 deg. The other advantage of this approach is that the entire image can be utilized, versus a digital approach where the perimeter must be reduced.

The X3 camera has a nine-element lens and a 12 Mpixel resolution. It can handle single images and burst mode, in addition to video up to 4K at 30 frames/s. It can utilize a 64

3. The DJI Inspire 1 uses a gimbal to allow the camera to aim anywhere within a hemisphere around and below the drone without additional movement.

Gbyte Micro SD card.

The Inspire 1 has the usual complement of sensors (including GPS) that is great for outdoor use, but not as much help indoors. This is where the Vision Positioning System (VPS) comes into play *(Fig. 4)*. This is not an absolute location system like GPS: Rather, it tracks the vehicle's surroundings, providing information to the autopilot to assist in providing a stable platform.

The VPS includes a camera and an ultrasonic sensor. The ultrasonic sensor has a limited range, but this is less of an issue indoors, especially in close quarters. The camera is used to detect movement in a fashion similar to the Bebop. In both cases, the camera software requires a view that has patterns it can detect, so it does not do well with a wall or floor that is very uniform in color. Mirrored or transparent surfaces do not work well, either. A cluttered image, such as a carpet, works very well.

The other neat aspect of the Inspire 1 is its retractable landing gear. Actually, each pair of rotors is part of a frame that pivots up when flying and down when landing. This eliminates any vehicle obstructions from the viewing space of the camera regardless of where it is pointed.

The drone has a 5700 mAh, LoPo 65 battery that provides about 18 minutes of flight time. It has a 4500 m ceiling and a max ascent time of 5 m/s. It moves at speeds up to 22 m/s. It uses Wi-Fi communication.

The Inspire 1 uses two remote-control units. One handles the flight controls while the other controls the camera. The

4. The Inspire 1's Vision Positioning System uses a camera and an ultrasonic sensor (the two circles on the bottom) to detect position changes.

system allows the two to operate independently of each other. The pilot uses LoS, although he can see what the camera is recording. The problem is that the camera may be looking in a direction other than what the pilot and control thinks is forward. The plus side is that a second person can concentrate on what is being framed by the camera instead of worrying about the orientation and position of the drone.

The reason for this approach is that one of the primary applications for the Inspire 1 is for movie making. It means that a qualified pilot can handle the flying, while a director or cameraman can work the camera. It is possible to use a single controller, as well.

SWARMS OF ZANOS AHEAD?

The Zano Micro Drone is a Kickstarter project from the Torquing Group. The micro drone is designed for researchers and hobbyists. The software is open source and the small size, on 2.5-in by 2.5-in, also means a low-cost solution. Swarms of Zanos are not out of the question.

The Zano weighs only 55 grams, but has a 5-megapixel HD video camera, IR obstacle avoidance using four sets of sensors, plus ultrasonic sonar and a high-resolution air-pressure sensor to get altitude information. The camera can deliver 720p at 60 frames/s or 1080p at 30 frames/s. There is an on-board speaker driven by a 2-W Class D audio amplifier plus a high sensitivity digital microphone allowing for interesting video conferencing options.

Of course, the 8-by-8 color LED array is not quite up to video conferencing standards, but it does provide better visual feedback than most drones. The array can also be used as a photo flash in addition to displaying information. This can be especially useful in swarms where particular drones need to be identified. The Zano also has multicolor landing lights.

The Zano may be small, but it has a top speed of 25 mph. It cannot get too far away since its flight time is restricted to a little over 10 minutes. There is a charging port and extra battery. Like the Parrot Bebop, the Zano uses digitally stabilized video, but it does not do it in real time. Instead, it handles this in post processing using a supercomputer on the cloud. The video stream includes additional position information. While the service is free, it has the

advantage of putting a lot of compute power behind the camera, but not in the air.

The Zano has a 330 DMIPS Microchip PIC32MZ microcontroller. This is a 32-bit, MIP-based processor. The system has bidirectional motor control using a full H-bridge. A microSD card provides storage.

Lantronix supplies the xPico Wi-Fi module for the Zano. The 802.11b/g/n module has a 30 m range. There is also a low-bandwidth mesh networking module as well, for communication with nearby Zanos.

OriginGPS provides the small GPS module. It is actually cycled to reduce power as well as providing fast startup. Of course, the system has the usual 3D magnetometer, accelerometer, and gyroscope subsystems.

Like the Bebop, the Zano is flown using an Android or iOS app on a smartphone or tablet. One of the more interesting features is the "Follow me" capability. The Zano will follow at a prescribed distance while using its collision-avoidance sensors to stay clear of obstacles.

The software development kit (SDK) is divided into two major parts. The first addresses APIs used by control applications like the iOS and Android apps. The other is a set of high-level hooks that can be used by scripting languages, potentially allowing control of a Zano via a Web application.

DRONING ON

These three products hardly skim the growing population of quadcopters, but they do provide insight into the capabilities and trends. For example, the Parrot Bebop's older sibling, the AR.Drone 2 *(see "Smart phone Controls Low-Cost Quadrotor" on electronicdesign.com)*, was larger, with a less powerful processor and lower-resolution camera.

The Federal Aviation Administration's rules for commercial use of flying unmanned vehicles like these drones will be finalized soon. Developers and hobbyists have already been able to fly within certain limits, but commercial use has been restricted. Still, the Bebop and Inspire 1 are likely to find uses in the commercial space, especially for filming.

Drones have progressed significantly over the years. The ability to pack more storage, sensors, and processing power into a smaller package has allowed vendors to deliver some amazing products like the Bebop, Inspire 1, and Zano. Still, there is a lot more to be done. Support like the Zano's mesh networking is on the cutting edge of research—research that will eventually emerge in commercial implementations.

In short, interesting times lie ahead for these drones. Don't be surprised if one of the next-generation quadcopters shows up ringed with 3D video cameras sporting multiple multicore processor chips. ed

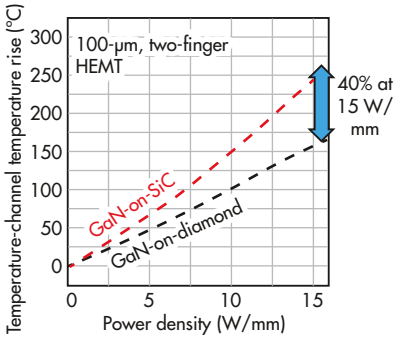
BRUCE BOLLINGER and THOMAS OBELOER | Element Six Technologies

Applications Abound for Synthetic-Diamond Semiconductor Substrates

Synthetic diamond's unique properties can transform thermal management, enabling semiconductor design engineers to overcome reliability and power-density challenges within smaller footprints.

Thermal management in semiconductor applications often makes it tough to optimize performance. Synthetic chemical-vapor-deposition (CVD) diamond helps overcome those limitations by significantly lowering gate junction temperatures, thus enhancing power densities and efficiencies as well as extending lifetimes. As technology and economic drivers push systems to higher frequencies, higher voltages, and higher ambient operating temperatures, synthetic diamond heat spreaders and gallium-nitride (GaN)-on-diamond wafers will see increased use in thermal-management schemes for high-power semiconductor devices.

Synthetic CVD diamond's room-temperature thermal conductivity runs as high as 2000 W/mK, five times that of copper and 10 times that of aluminium nitride. Further, because diamond transports heat equally well in all three dimensions, it can act as an excellent heat spreader. Metallized diamond heat spreaders and GaN-on-diamond wafers both drastically lower thermal resistance and, in turn, the gate junction temperature of semiconductor devices, leading to higher power densities.



1. A plot of thermal-resistance measurements (peak channel temperature, derived from Raman measurements) demonstrates the heat-transfer superiority of GaN-on-diamond compared to GaN-on-silicon-carbide.[3] (Source: University of Bristol)

HIGH-POWER RF

High-power radio-frequency (RF) power amplifiers are used in military and commercial applications such as radar systems, electronic warfare, and cellular base stations. The latest high-power RF PAs consist of GaN epitaxial material, which performs exceptionally well at higher frequencies, boosts efficiency, and handles higher power densities.

However, these GaN RF devices have very small hotspots that can generate heat fluxes 10 times that of the sun's surface. As a result, thermal-management challenges often severely limit their intrinsic performance advantages. GaN-on-diamond wafers eliminate this thermal limitation by bringing the diamond within less than one micron from the heat-generating gate junction.

In one example, TriQuint fabricated identical high electronic mobility transistors (HEMTs) on GaN-on-diamond substrates and GaN-on-SiC substrates. The University of Bristol employed micro-Raman methodology to measure thermal resistances of the two transistor types, and found that the thermal resistance

> “Metallized diamond heat spreaders and GaN-on-diamond wafers both drastically lower thermal resistance and, in turn, the gate junction temperature of semiconductor devices.”

of the GaN-on-diamond HEMTs was at least 40% lower than that of the GaN-on-SiC HEMTs[1] *(Fig. 1)*.

GaN-on-diamond technology delivers two very important benefits. First, it makes possible devices that are more than three times smaller than what is attainable with other approaches, making them less expensive and providing much more power in a smaller form factor.[2] Second, devices are able to run in ambient temperatures as much as 50% hotter, thereby lowering the cost of cooling subsystems and ultimately saving on-going energy expense.

HIGH-VOLTAGE POWER DEVICES

High-voltage power devices, such as insulated-gate bipolar transistors (IGBTs), have the advantage of higher efficiency and higher switching frequencies, but generate significant heat that demands extreme thermal-management solutions. For IGBTs, an effective thermal-management solution once again is to bring diamond as close to the heat-generating source in the form of metallized heat spreaders.

High-voltage IGBT applications typically involve switching or converting power for electrical vehicles, train and aerospace

GROWING SINGLE-CRYSTAL DIAMOND SUBSTRATES FOR POWER DEVICES

BY DON TUITE

POWER SEMICONDUCTORS that need to carry high voltages and dissipate high power losses require synthetic single-crystal diamond material. A few companies do that by growing electronics-grade diamond at a few percent of atmospheric pressure in an ionized bath of hydrocarbons and hydrogen. For most producers, however, the process starts with a tiny seed of diamond, although some experimentation is now occurring with iridium. The seed material isn’t incorporated into the final substrate material; the seed substrate can actually be reused again and again.

In the process, the seed substrate is heated to a temperature between 700 and 1000°C in a mixture of a carbon-based gases that includes methane, ethane, or ethylene and hydrogen—a less toxic mix than the metal-organics that are used to develop certain III-V semiconductor materials.

When a powerful microwave source ionizes the gas mixture, diamond grows on top of the seed. In this scenario, the higher the microwave power, the faster the growth rate. The approach has achieved rates of up to 200 microns per hour. Defect rates are currently on the order of 10^2 per cubic centimeter.

Diamonds are particularly helpful in the fact that they have only one possible crystal structure—a simple cube of eight atoms. Consequently, crystal defects tend not to propagate.

To obtain a large enough substrate on which to fabricate power-electronics devices, suppliers create larger-area substrates through a “tiling” process. This involves a mosaic of cut and polished single-crystal diamonds assembled into a tightly packed, flat array. Tiling is made possible via growth reactors that can produce 100-mm wafers.

“Scaling to this area for single wafers can be accomplished relatively painlessly,” says eVince Technology *(evincetechnology.com)*. “For practical applications, achieving high-yield production does not require a 100% defect-free substrate, so long as the wafer has a regular grid-iron pattern of high-quality areas of low-defect single-crystal diamond.”

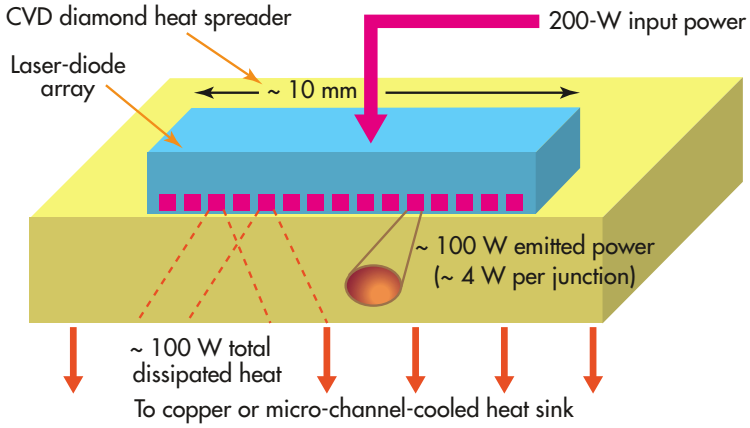
Again, in the reactor, the mosaic is heated to between 700 and 1000°C in a mixture of either methane or ethylene and hydrogen at around 1.0 atmosphere. The microwave source ionizes the gas into a plasma that liberates carbon from whichever gas is used.

The carbon atoms bind with the seed substrate to form new diamond. As the diamond film grows, it generally matches up the crystal pattern at the tile boundaries to form a homogenous single-crystal diamond substrate. Some boundary defects are inevitable, but the thicker the growth layer, the lower the percentage of tiling defects. Layers as thick as 10 mm and more have been successfully grown, says eVince.

The final step is to save the seed layer for further use. Before starting the new growth, a graphite “damage layer” was applied on top of the seed layer. After deposition, the newly grown laminations of diamond film can then be separated from the tiled seed substrates, which can then be reused.

According to eVince Technology, “By cycling the implantation and growth stages, multiple free-standing substrates can be produced in the same growth run. These substrates can then be used either for device production, or the ones with the fewest edge defects can be employed as starter tiles to create even larger substrates.”

power generators, and alternative-energy distribution. In one test case using a 1200-V IGBT, a metallized diamond heat spreader replaced a ceramic substrate. It more than halved the junction-to-case thermal resistance, which in turn more than doubled the IGBT's power rating.



2. A typical synthetic-diamond application would consist of this 200-W laser-diode array mounted on a diamond heat spreader. The same approach could be used for power devices.

LASER-DIODE ARRAYS

High-power laser-diode arrays are found in material processing (*e.g.*, welding and surface treatments), medical applications (*e.g.*, tattoo removal and laser surgery), and applications for pumping high-power solid-state lasers. These arrays require significant thermal management to optimize performance. Adding a diamond heat spreader between the diode array and the submount effectively transports the heat away from small emitter hotspots.

However, the coefficient of thermal expansion (CTE) mismatch between the diamond heat spreader and the laser-diode gallium arsenide (GaAs) can cause reliability issues, as well as the condition known as a "smile"—a slight bend of the horizontal line connecting the emitters. Ongoing research and development efforts are looking for ways to effectively solve this CTE-mismatch issue.

Figure 2 illustrates a 100-W laser-diode array with multiple emitters closely spaced on a single chip. The light output from these emitters is either used directly or collimated with a lens

array into a single-beam laser. High power output and wavelength stability from these arrays, in addition to their reliability, are of utmost importance.

Using metallized heat spreaders to cool laser-diode arrays can significantly increase beam intensity and beam quality, since it allows for closer spacing of the individual emitters in the arrays. In addition, or alternatively, diamond heat spreaders can extend the lifetime of the diode arrays.

SEMICONDUCTOR ASSEMBLY AND TEST

Certain steps in the test and assembly of packaged semiconductor devices requires that temperature either be kept low enough to prevent device damage, or kept constant across the entire package for optimum assembly quality. Metallized diamond heat spreaders have the ability to transport heat both laterally and vertically at very fast rates. As a result, these spreaders can rapidly pull heat away from, and spread it evenly across, hot devices.

One example involves cooling of devices during functional test. The device under test needs to operate under a test pattern without a heat sink attached, which may cause it to quickly overheat. Using CVD diamond effectively addresses this cooling issue without resorting to active water impingement cooling.

In another case, using diamond to rapidly spread heat across a substrate while a flip-chip die is being bonded to it makes it possible to apply the same amount of heat to every solder joint at the same time. This ensures high-quality across an array of 1000 solder joints. ed

BRUCE BOLLINGER leads worldwide business development for synthetic diamond applications at Element Six Technologies. He has over 20 years of experience in manufacturing, business development, and marketing, as well as seven years of operations management experience in Asia. Bollinger received a BS in electrical engineering from Washington University, St. Louis, Mo., and completed his Master of Business Administration at the Harvard Business School, Boston, Mass.

THOMAS OBELOER, business development manager at Element Six Technologies, holds a master's degree in mechanical engineering. He has more than 20 years' experience with advanced thermal management, mainly in the field of advanced materials such as CVD diamond.

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JOHNNIE HANCOCK | Keysight Technologies *(formerly Agilent Technologies electronic measurement business)*

Zone Triggering Demystifies Scope Glitches

Isolating trigger events directly via touchscreen displays helps remove ambiguity when isolating glitches.

Oscilloscope vendors generally overcome the challenges of ever-greater signal complexity in many of today's digital designs by keeping pace with advances in overall technology. For example, the newest oscilloscopes incorporate advanced parametric-based triggering, such as pulse-width triggering, rise/fall-time triggering, setup-and-hold-time triggering, and serial bus protocol modes.

Even with those triggering options, though, customer feedback suggests that many of today's engineers and technicians avoid using some of them and stick with the old tried-and-true edge-based triggering. The feedback also indicates that engineers don't use some of the advanced trigger modes primarily because of unfamiliarity and ease-of-use issues.

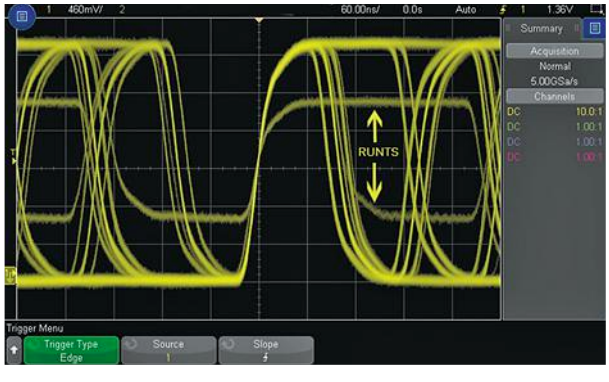
Explaining the details of all those trigger modes would take many pages. However, there's another new—and easier—way to trigger on complex and infrequent signal anomalies: zone triggering. It's best explained by comparing parametric-based triggering with zone-based triggering via examples of isolating random and infrequent signal anomalies.

TRIGGERING BASICS

Essentially, oscilloscopes take continuous pictures (real-time acquisitions) of electrical phenomena (signals) and subsequently display/graph them as continuously updated voltage-versus-time waveforms. The challenge when capturing repetitive signals is that the picture-taking process of the oscilloscope must be synchronized to the input signal under test. Otherwise, the scope would only display a blur of superimposed, unsynchronized waveforms.

Since the earliest days of oscilloscopes with calibrated timebases, all have been able to trigger on signal edge crossings—either on positive-going (rising) or negative-going (falling) edge transitions at a user-defined threshold (traditionally called the trigger level). For decades, this has been the most commonly used oscilloscope trigger mode.

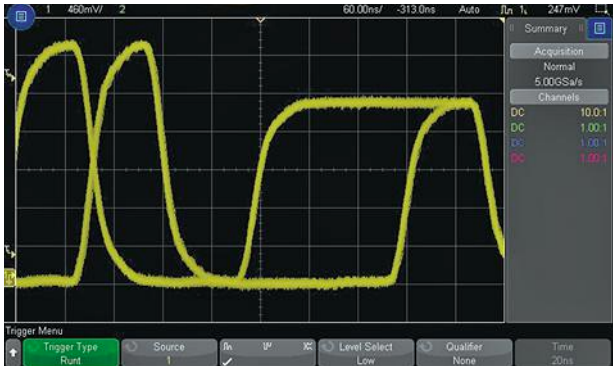
If the scope user attempts to observe simple and repetitive waveforms, such as a digital clock or sine waves, edge triggering works perfectly fine. However, if the user tries to view a complex digital pulse stream of data, or desires to synchronize to an infrequently occurring signal anomaly that may be buried within a digital pulse stream (*e.g.*, a glitch), simple edge triggering can be very limiting. Dealing with those situations is what has led to the multiple trigger types available in the latest scopes.



1. Infrequently occurring "Runt" (under-amplitude) pulses in a data stream present a troubleshooting problem.

TRIGGERING ON "RUNTS"

Consider the example of an oscilloscope using edge trigger to display a digital pulse stream of data that contains occasional



2. Engineers can trigger on positive or negative runt pulses of any width using the parametric-based Runt trigger mode, available in many contemporary oscilloscopes. Setting up the trigger function may be a challenge to those who don't use it every day, though.

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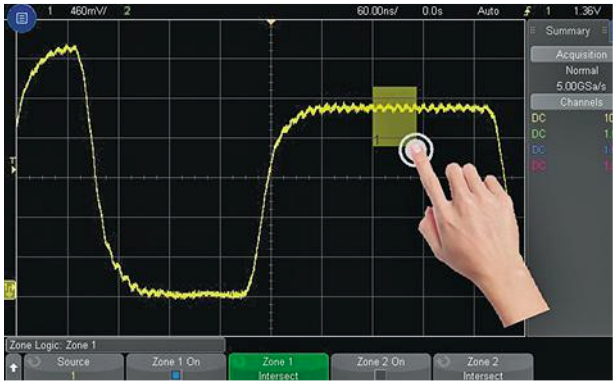


3. "Zone triggering" on a touchscreen scope simplifies Runt trigger setup, which in this case is on the widest positive runt.

positive and negative "runt" pulses *(Fig. 1)*. Runt pulses represent digital pulses that are unable to reach their intended high or low logic levels.

Setting up the scope to trigger on only runt pulses, rather than on just any edge crossing, would likely help find the root cause of the errant logic-level pulses. That's why most of today's mid-range and higher-performance oscilloscopes incorporate parametric-based trigger modes, including "runt trigger" and "zone trigger."

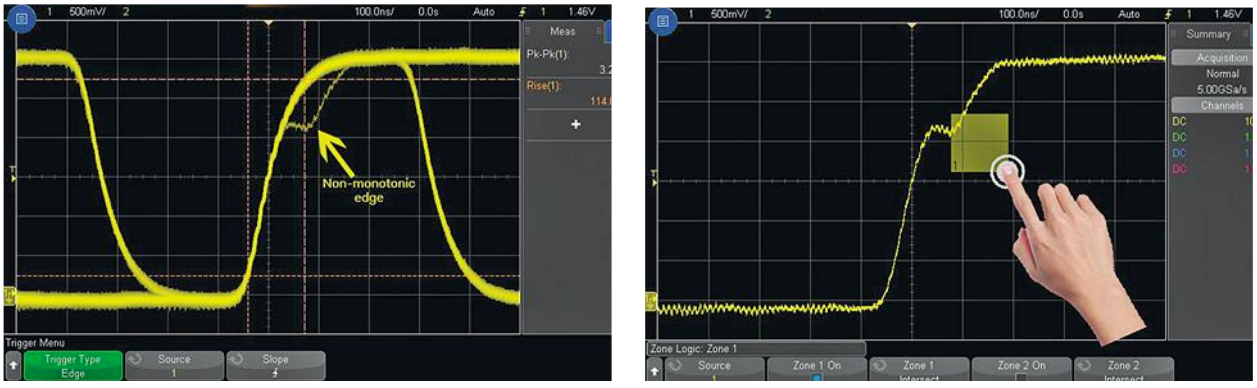
RUNT TRIGGER

Although the documented procedure of how to set up parametric runt triggering is based on using Keysight's InfiniiVision 3000T X-Series oscilloscope, the process is very similar for other vendor's oscilloscopes. The step-by-step runt-trigger process is as follows:

1. Select the trigger menu that shows the available trigger modes.
2. Select the runt-trigger mode.
3. Establish a lower-level threshold that defines the maximum low-logic level.
4. Establish an upper-level threshold that defines the minimum high-logic level.
5. Select whether to trigger on either positive runts, negative runts, or runts of either polarity.

Figure 2 shows the scope triggering on positive runts using the above procedure. However, by examining the display for repetitive acquisitions, it is possible to see that the scope has actually triggered on two different runts, one that's narrower than the other.

If someone using this setup wanted the scope to trigger uniquely on only one of the runts, it would be necessary to further qualify the trigger condition by entering a timing qualification to isolate either the narrower or wider positive runt pulse.



4. Zone triggering isn't limited to capturing runts (left). Here, the zone has been set to trigger on all rising edges, and a random and infrequent non-monotonic event is clearly observable. Having revealed the non-synchronous repetitive event (left), zone triggering makes it easy to trigger only on that event (right).

ZONE TRIGGER

To achieve the same results using the same scope's zone trigger mode, the setup procedure is:

1. Draw a box (or zone) with the oscilloscope's touchscreen (or mouse) in order to delimit the area of the infrequent wider positive runt.
2. Select "must intersect."

With that setup, the oscilloscope synchronizes solely on repetitive occurrences of the wider positive runt pulse *(Fig. 3)*. As long as the scope's waveform update rate is fast enough to show a random and/or infrequent event simply by employing conventional edge triggering, then the zone trigger can synchronize on it.

Zone trigger makes it much easier and more intuitive to set up than any of the recently available advanced parametric trigger modes. For the engineer using the scope, it's basically as easy

as touching what to trigger on. When the trigger condition is met, it's captured by the scope.

TRIGGERING ON A NON-MONOTONIC EDGE

Another triggering challenge involves a signal with an infrequent non-monotonic edge *(Fig. 4, left)*. Such signals usually exhibit a normal/continuous rising edge. Sometimes, though, the rising edge experiences a momentary stall, and following that, continues rising to its final high logic level. A signal that has this type of infrequent non-monotonic edge may appear as a "ghost" waveform if the scope's waveform update rate is fast enough to show it.

Uniquely triggering on just the signal that exhibits non-monotonicity requires that engineers first select what they deem the most appropriate trigger mode among the scope's parametric-based modes *(Fig. 4, right)*. A really experienced scope user would likely know that the Rise/Fall Time trigger mode is the best option.

However, for many oscilloscope users, determining the appropriate trigger-mode selection could turn into more of a guessing game. Even if the user knows which mode to select, setting up all of the qualification parameters correctly could turn out to be more trouble than it's worth. To illustrate, triggering on a non-monotonic edge using the Rise/Fall Time trigger mode includes the following setup steps:

> "The newest scopes, with zone triggering, take advantage of touchscreen displays to simplify triggering and make it more intuitive."

1. Measure or estimate the rise time of "normal" edge.
2. Select the Rise/Fall Time trigger mode.
3. Select "Rising Edge."
4. Establish a lower threshold level at approximately 10%.
5. Establish an upper threshold level at approximately 90%.
6. Select the ">" time qualification.
7. Enter a time value that's slightly greater than a "normal" edge rise time.

Zone trigger offers a more straightforward and easier way to synchronize the scope's display only to signals that contain the non-monotonic edge. Again, it simply involves drawing a box (zone) in the area of the "ghost" waveform and then selecting "must intersect." As in the previous example,

(continued on p. 38)

DESIGN NOTES

17V Input, Dual 1A Output Synchronous Step-Down Regulator with Ultralow Quiescent Current

Design Note 537

Haoran Wu

Introduction

The LTC®3622 dual 1A synchronous monolithic step-down regulator enables compact, high efficiency supplies for battery powered systems and portable devices as well as general purpose point-of-load regulation. The tiny 14-pin, 3mm × 4mm DFN package takes input voltages from 2.7V to 17V, producing two adjustable ±1% accurate outputs from 0.6V to V_{IN} while delivering up to 1A output current on both channels.

The LTC3622's quiescent current with both channels enabled is as low as 5µA in Burst Mode® operation and less than 0.1µA in shutdown. The switching frequency is fixed at 1MHz or 2.25MHz with a ±50% synchronization range to an external clock. Selectable Burst Mode operation yields the highest efficiency, while pulse-skipping mode minimizes ripple for noise-sensitive applications.

Dual 1A Outputs, 3.3V and 5V, at 1MHz

Figure 1 shows a dual output converter that takes an input voltage range of 5V to 17V, and produces 1A outputs at 3.3V and 5V.

The two channels can operate in phase or with 180° phase shift, selected by tying the PHASE pin to GND or $INTV_{CC}$. This provides users the flexibility to separate the channels' switching edges to minimize any noise coupling. There are two peak current limit levels for the LTC3622 – 1.8A or 1A, selected via the I_{LIM} pin. This selectable current limit allows smaller size inductors in lower current designs to minimize solution size and cost.

Under heavy load conditions, the regulator operates in continuous inductor current mode with small output ripple and high efficiency. Two discontinuous conduction modes (DCM) are available at light load to achieve high efficiency and minimize energy consumption. To further reduce power loss and extend battery life at very light loads or no load standby conditions, Burst Mode operation can be selected by tying the MODE/SYNC pin to $INTV_{CC}$. In this case, the LTC3622 IC only consumes 5µA at no load. Burst Mode operation may

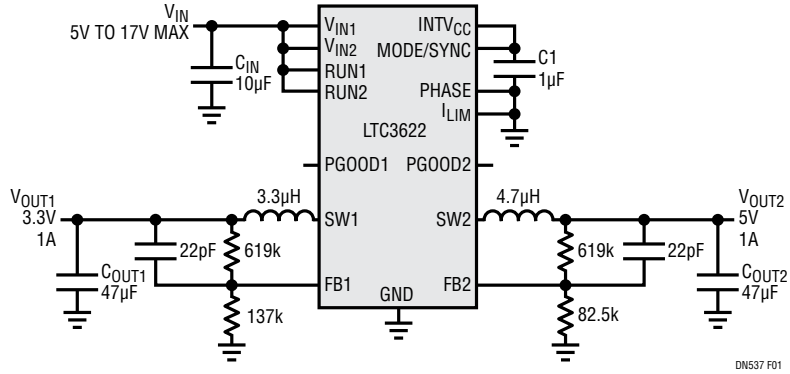


Figure 1. A Dual-1A Converter with 3.3V and 5V Outputs, f_{SW} = 1 MHz

increase output voltage ripple. On the other hand, if minimizing V_{OUT} ripple is critical, pulse-skipping mode can be selected by grounding the MODE/SYNC pin. This results in lower ripple than in Burst Mode operation with the trade-off of slightly lower efficiency. Furthermore, connecting the MODE/SYNC pin to an external clock synchronizes the switch clock to the external clock and puts the part in pulse-skipping mode. Figure 2 shows the efficiency from $12V_{IN}$ to $5V_{OUT}$ in burst and pulse-skipping modes.

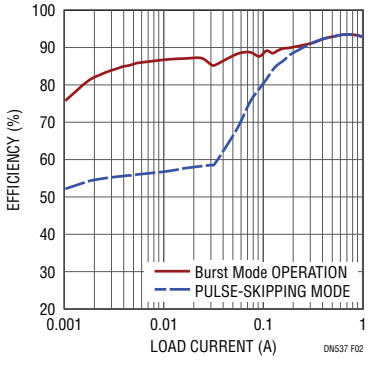


Figure 2. Efficiency of the 5V Output of the Dual Supply Shown in Figure 1, V_{IN} = 12V, V_{OUT2} = 5V, f_{SW} = 1MHz

The LTC3622 is a reliable current mode regulator with fast, cycle-by-cycle overcurrent protection and excellent line and load transient response. When the input voltage decreases, the duty cycle increases and slope compensation is required to maintain a stable current feedback loop. The LTC3622 has internal circuitry to accurately maintain a constant peak current limit and stable loop even at high duty cycles.

In applications such as battery powered systems, the input voltage can have a very wide range. As V_{IN} drops close to V_{OUT} and the converter duty cycle approaches 100%, the LTC3622 enters dropout operation to maintain V_{OUT} regulation. During dropout, the part transitions in and out of sleep mode depending on the output load current. This significantly reduces the quiescent current while keeping V_{OUT} regulated, thus prolonging the run time of the input battery supply. Figure 3 shows that the LTC3622 can achieve high efficiency from microamps to full load while in dropout.

To simplify design and minimize component count, the LTC3622 has internal loop compensation. If needed, a feedforward capacitor in parallel with upper side

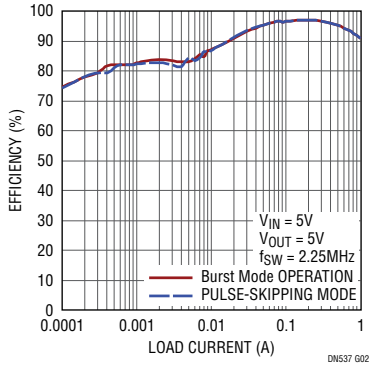


Figure 3. Efficiency vs Load Current in Dropout, V_{IN} = 5V, V_{OUT2} = 5V, f_{SW} = 1MHz

feedback resistor can be added to further increase the phase margin. Thanks to its current mode control, the LTC3622 supply is stable with a wide range of output capacitance. In the dual supply shown in Figure 1, each channel output only needs one small 1206 size, 47µF ceramic capacitor. Figure 4 shows the transient response of the 5V output. With a 10% to 100% load step, the peak-to-peak voltage excursion is about ±330mV. More capacitors can be added to further reduce the V_{OUT} transient. In this case, the LTpowerCAD™ design tool and LTspice® simulation tool can be used to optimize the design with the built-in LTC3622 model. Both tools are available as a free download at www.linear.com.

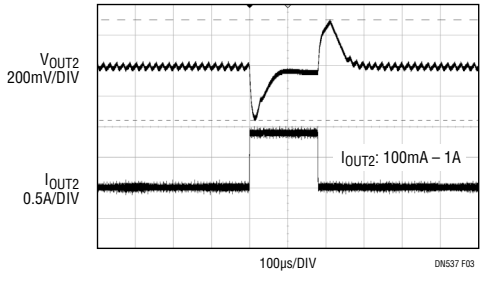


Figure 4. Transient Response of the 5V Supply Shown in Figure 1, V_{IN} = 12V, V_{OUT2} = 5V, I_{OUT2} = 100mA-1A, Burst Mode Operation

Conclusion

The LTC3622 is a dual 1A, high efficiency synchronous monolithic step-down regulator with ultralow quiescent current. It solves the problems of converter efficiency and space constraints posed by battery-powered systems, point-of-load supplies and portable devices.

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SELinux 101: What You Should Know

Originally integrated into the mainline Linux kernel over a decade ago, SELinux is a framework and set of tools used to harden Linux systems against potential threats.

The profound growth in Internet-connected devices has heightened the need for secure systems, beyond the traditional bounds of enterprise IT gateways and servers. Embedded devices from wearables to automobiles, consumer devices, factories, and much more are being connected to the Internet at astounding rates.

SELinux BACKGROUND

SELinux is a framework and set of tools originally developed by the United States NSA that is used to harden Linux systems against potential threats. These threats can include deliberate attacks, misuse, and software vulnerabilities including viruses and malware. SELinux was originally integrated into the mainline Linux kernel over a decade ago.

Traditional UNIX and current Linux systems rely on a security model called Discretionary Access Control. In the DAC model, access to system resources is based on the identity of the (user) processes and to the groups to which that user belongs. It is characterized by a set of users and groups, to which each process and file system object belongs, together with file system attributes that include *read*, *write*, and *execute* in three categories for every file system object.

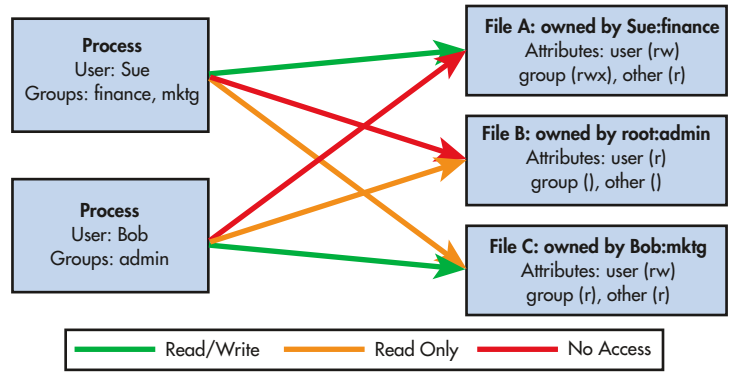
For example, a file called logo.png might belong to user chris and group tools. The file's attributes could be *user:read-write, group:read, other:none*. This configuration would allow user "chris" to have read-write access to the file, any user in group "tools" would have read access, while any other non-root users on the system not in group "Tools" would be denied access. This is the traditional DAC access model.

Figure 1 illustrates these concepts in simplified form. In the figure, we define two users and three file system objects. User Sue belongs to groups "finance" and "mkgt," while user Bob belongs to the "admin" group. File A is owned by Sue and is a member of the finance group. File B is owned by the root user, and is in the admin group. File C is owned by Bob and belongs to the mktg group.

Figure 1 depicts the access rights for each user on each file, together with the attributes for each file. Each user has read/write access to files that they respectively own, but only Bob in the admin group has any access to the file owned by root, because he is a member of the admin group, and File B is also.

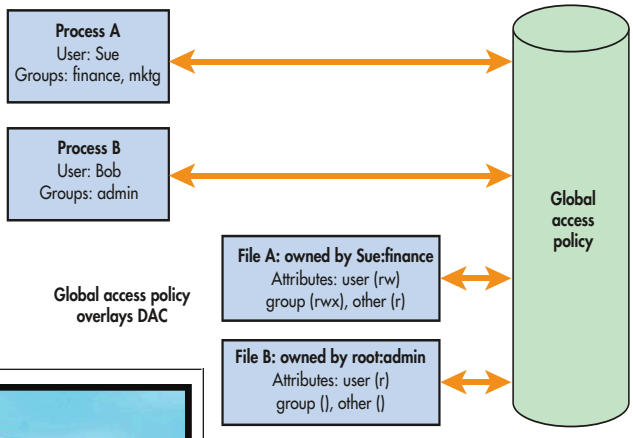
By contrast, SELinux-enabled systems are built around a security model called Mandatory Access Control. MAC-based systems extend the security architecture beyond users, groups and file permissions. SELinux uses the Linux Security Modules (LSM) framework of the Linux kernel to extend the security capabilities of stock Linux systems. The fundamental model for SELinux MAC involves a subject (process), attempting to perform an action (read, write, allocate memory, etc.) on an object (system resource). In security circles, this architecture is often referred to as a subject-access-object model.

Discretionary and mandatory access control systems differ in a fundamental way. The best way to understand the difference is the following: In a simple Linux system using only the usual DAC access mechanisms, a user can make his own deci-



1. Illustrated above are access permissions based on a DAC model.

sions and specify the access permissions for the resources that he owns. In other words, the access permissions for his own resources are at his own discretion. In a MAC system, access permissions for every resource on the system, independent of ownership, is centrally controlled by a system-wide security policy. MAC security policy overlays DAC, but does not eliminate it. That is, assuming the global SELinux policy allows user



2. In the illustration above, the SELinux MAC global policy overlays a traditional DAC.

Sue to read access file A, Sue still must have traditional DAC read permissions to read file A. In SELinux, all actions by subjects on objects must be explicitly granted by the SELinux policy.

This explanation might sound complicated, but the fundamental concepts are not difficult. Let's assume that a subject (often a process acting on behalf of a user) wishes to open a file on a specific file system. A rule must be created that instructs SELinux to allow that specific process to execute open and read/write permissions for that particular file. Of course, this example is overly simplistic, but describes the conceptual behavior.

SELinux uses a global set of labels that must first be attached to each subject and object in the system. When a Linux system is initially configured for SELinux, or when the SELinux policy is changed, a special system process traverses the entire file system and applies (or relables, as it's called in the SELinux vocabulary) every file in the file system according to templates supplied with the SELinux framework.

A central database contains a set of rules that explicitly defines the access rights to a specified object for any given action by a subject. This set of rules associates the labels from subject and objects to grant access rights based on these labels. Collectively the set of access rules is referred to as the system policy. Several policies can exist on the same system. A global SELinux configuration file selects which policy is to be used during the uptime of a Linux system. Many

Linux distributions support several policies. Some embedded Linux distributions ship with a minimum policy, which provides an initial framework that allows the embedded developer complete control and customization of the system's behavior.

SELinux is architected such that the mechanism for governing access control is entirely separate from the policy that is used to enforce a given security model. The kernel is responsible solely for control, and makes no decisions as to whether the requested action is allowable or not. A policy rule either allows a particular action by a subject on an object, or it does not. The kernel knows nothing of this policy, and acts only to allow or deny actions based on the rules that make up the policy.

SELinux has three modes:

Disabled—The infrastructure is present and operational, but has been effectively turned off.

Permissive—SELinux is enabled and fully functional, but by default allows all actions. Actions are logged for use in creating custom rules. It is useful for development.

Enforcing—SELinux is working and preventing unauthorized actions.

Policy names can vary depending on the Linux distribution in use. Some common policy names and descriptions follow:

minimum—Simple entry-level policy that provides for a small number of protected domains for applications such as http server, ftp server, etc. Most processes in a minimal policy will run unconstrained.

standard—Typical policy often used for desktop applications.

mls—Supports a multi-level policy for highly critical systems such as those used in military and government applications.

refpolicy—This is the SELinux reference policy published on github that can be used for a variety of systems and makes a good starting point for building a comprehensive customized policy. It has its roots in the original NSA example policy.

SELinux SECURITY CONTEXT

In a traditional Linux system, users are typically associated with humans that interact with the system. In SELinux, a user is not generally associated with a specific human (user account) as it often is in traditional Linux systems, but more often represents a class of users. For example, a typical SELinux embedded system configured with a minimal policy might have six users by default: sysadmin, system, root, staff, user, and unconfined. In typical SELinux syntax, these user classes would be named system_u, user_u, etc. However, there is nothing in SELinux that enforces this naming style—it has become convention in the design and management of SELinux policy to decorate the label with an underscore and letter representing one of user (u), role (r), or type (t).

A role is used in SELinux systems to control which domains a user is allows to occupy. Roles in a typical embed-

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Wireless Modules Simplify Product Design

The exponential growth of the Internet of Things (IoT) is going to require more wireless networking—using wireless modules and gateways that have already been verified and approved could be a solution.

THE INTERNET OF THINGS (IoT) means networking, and a lot of that will be wireless. One way to simplify IoT designs is to use wireless modules and gateways that have already been verified and approved. This allows a designer to concentrate on the application hardware and software. Meeting FCC requirements and gaining approval of wireless hardware is a viable alternative for high-volume or very compact applications, but many applications are better served by prepackaged solutions.

In this case, the typical IoT configuration is a gateway providing connectivity to cloud-based services. This might be a PC, tablet, or smartphone for some consumer devices. In the case of industrial and embedded consumer applications, however, the gateway is often similar to Freescale's IoT Gateway *(see "IoT Gateways and Triple-Core Micros at FTF 2014" on electronicdesign.com)*. Low-power ARM processor use in these types of gateways is common, as are low-power processors being used in the connected devices.

There are other alternatives available, like Imagination Technologies' MIPS architecture, as well as Intel's Quark *(see "How Many Quarks Does It Take to Make an IoT?" on electronicdesign.com)*. The Quark powers gateways like ADI Engineering's White Oak Canyon IoT Gateway, Portwell's PI 81A0, AAEON's AIOT-X1000, and Super Microcomputer's E110-8Q IoT Gateway *(Fig. 1)*. The E110-8Q has a pair of Mini-PCIe slots and a ZigBee module slot.

The challenge is finding the right wireless support for these platforms. Mini-PCIe modules are one way to have a flexible platform and gain access to the required wireless protocols. Luckily there are lots of options available, like Advantech's EWM-W148H half-size Mini-PCIe card that supports Bluetooth 4.0, as well as 802.11 a/b/g/n. Need GPS? Check out Versalogic's VL-MPEu-G2 GPS receiver.

1. Supermicro's E110-8Q uses a low-power Intel Quark X1021 SoC with on-board TPM support. It has a pair of Mini-PCIe slots and a ZigBee module slot.

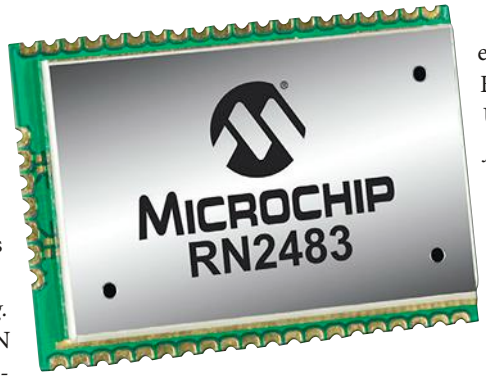
2. Lantronix's xPico Wi-Fi module can be found in the Zano Micro Drone.

Modules that plug into slots are good for gateways, but many embedded applications have more rugged needs; in these cases, modules that can be soldered make more sense. They also eliminate the cost and size of connectors required by other modules.

There are lots of options in this space. There is no standard form factor, although a vendor often has a line of pin-

compatible modules. One good example of these, the Lantronix xPico Wi-Fi module *(Fig. 2)*, is used in the Zano Micro Drone *(see "Keep an Eye Out for Quadcopters" on page 18 of this issue)*. The xPico has a serial interface and supports soft-AP and client modes simultaneously.

Microchip's RN2483 module *(Fig. 3)* supports the sub-GHz LoRaWAN (Low Power Wide Area Network) protocol. The LoRa Alliance's LoRaWAN is designed for long range (over 15 km) connectivity and millions of nodes. Battery life when using this type of module in a system is targeted at more than 10 years. The interface uses an ASCII command set like many modules with a serial interface.



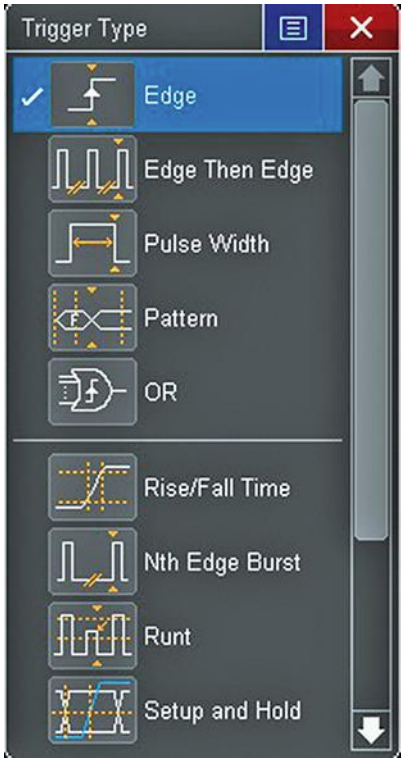
3. Microchip's RN2483 module supports the sub-GHz LoRaWAN protocol designed for long-range connectivity.

Even cellular support is available with surface-mount modules. Take MultiTech's MultiConnect Dragonfly, for example. It has an ARM Cortex-M4 that is mbed-compatible. It handles cellular, LTE, HSPA+, and other variants, as well as providing GPS/GLONASS support.

Modules are available for just about every wireless protocol including ZigBee, Z-Wave, Bluetooth, and DECT ULE *(see "Connectivity Options Abound for the Internet Of Things" on electronicdesign.com)*. Many have built-in antennas, but this will be yet another choice for designers. Though convenient, these antennas lack the range and sensitivity of larger antennas. Cabling is often necessary to allow for their external placement.

Of course, the advantages of this modular approach include FCC approval and systems that typically work out-of-the box. Protocol stacks tend toward embedded, and hardware often accelerates security support that is increasingly important to customers. Designers often can provide multiple products with different protocol support by using the appropriate module.

Sometimes the swap can be transparent depending upon the wireless protocol, as well as the device protocol. Other times it may require software changes to the application or system drivers. ed



5. A scope with zone triggering has multiple parametric-based trigger modes available on its control panel.

(continued from p. 32)

the scope isolates the non-monotonic edge *(Fig. 5)*. This produces the same results as using the Rise/Fall Time parametric trigger mode, but with fewer steps and a more intuitive process.

LOOKING AHEAD

Nearly 80 years ago, oscilloscopes with uncalibrated sweeps were eclipsed by instruments with calibrated timebases and amplitude triggering. Today, after more decades of innovation, we're moving to another plateau.

We have recently seen some very clever advances in selective triggering, using a host of manually selected parameters. The newest scopes, with zone triggering, take advantage of touch-screen displays to simplify triggering and ultimately make it more intuitive.

If a scope has a fast enough waveform update rate to reveal infrequent signal anomalies, then the cutting-edge zone-trigger capability can be used to quickly and intuitively isolate rogue signal behavior. ed

JOHNNIE HANCOCK, product manager at Keysight Technologies Oscilloscope Products Division, is currently responsible for worldwide application support activities that promote Agilent's digitizing oscilloscopes. He began his career with Hewlett-Packard in 1979 as an embedded hardware designer and holds a patent for oscilloscope trigger hysteresis calibration. He holds a degree in electrical engineering from the University of South Florida.

(continued from p. 35)

ded Linux system configured with a minimal policy might include staff_r, user_r, object_r, sysadm_r, system_r, and unconfined_r using the convention of decorating the name with an underscore 'r'.

In SELinux, all subjects and objects are associated with a type which taken together governs the access permissions for specific users. The combination of user:role:type is called the security context. (Additional fields called sensitivity and category exist to support multi-level security policies, but these are often unused where MLS is not required.) In SELinux-enabled systems, common Linux utilities have been enhanced to show the security context as an aid to troubleshooting access permissions and designing new security modules for custom applications. For example, most relevant utilities will honor the –Z switch to show SELinux security context output. In order to implement security context, SELinux applies labels to every file system object in the system. SELinux-enabled systems perform this file system labeling upon first boot, or when the policy is changed. You can also manually relabel the file system.

SELinux POLICY TYPES

One of the criticisms of SELinux is that it is very complex and difficult to design, configure, and manage the security policy. Indeed, the reference policies that come with most distributions have thousands of rules. The minimum policy used as the basis of this article, which originates from the Yocto Project contains just short of 4,000 allow rules. SELinux running on a complex multi-user server might contain anywhere from tens of thousands to even 100,000 or more allow rules.

SELinux access rules are constructed based on a security context, consisting of the triplet user:role:type. In order for a process to access a system object, they must be in the same domain. Consider the domain as synonymous with the type field of the context. Access rules allow the process to transition to the domain of an object, while other rules allow the process to access specific resources based on user and sometimes role.

SUMMARY

SELinux can be used as one element of an overall security architecture. It can potentially limit the damage in case a software vulnerability or malicious attacker gains access to an application.

It is important to understand that while many SELinux-enabled distributions come with default policies, these are virtually never used without modification in production systems. Some level of design, implementation and most importantly, validation is required before a system can be deployed confidently. While some may criticize SELinux as being difficult to master and configure, it is little different from learning any new programming language or operating system. ed

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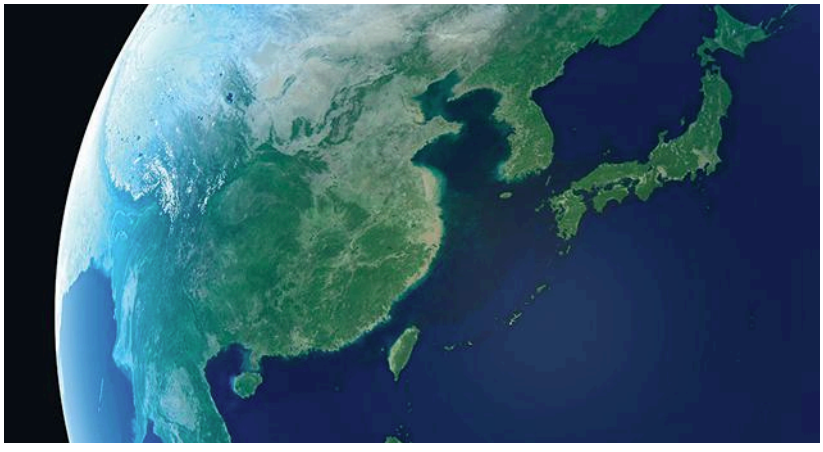


Image courtesy of Thinkstock

US. Distributors Expand in the East

Demand for specialized services and high-quality electronic component solutions has U.S. distributors betting on success in China this year.

VICTORIA FRAZA KICKHAM | DISTRIBUTION EDITOR

CHINA REMAINS THE first stop on U.S. companies' business tour of Asia, as new opportunities continue to arise, especially for suppliers of specialty products and services. Connector solution specialist PEI-Genesis is one such firm, opening its doors for business in Zhuhai, China, this month. PEI-Genesis will serve customers across the country, providing its hallmark service of high-mix, low-volume configured connectors for a wide range of applications. Company President and COO Russ Dorwart says the opening was a long time coming and that the company will fill an important and growing need in the region.

"China is the fastest-growing market in the world for our harsh-environment connectors. Both our suppliers and our customers have asked us to come to China to help support their growth," said Dorwart, adding that PEI's management team began researching the opening of a China facility five years ago. "Suppliers in China are focused primarily on high-volume, low-mix business, and very few companies have our assembly capability or connector focus."

Dorwart also points to PEI-Genesis' strength as a drop-in solution for customers that its supplier partners can't serve directly. The distributor delivers millions of different part numbers in 48 hours while also offering engineering and design support. "Everything we have learned about the Chinese market in our five years of exploration tells us that we will succeed there using our model," Dorwart said.

Success will mean hitting the $28 to $30 million mark in the region by 2020, putting PEI's Asia business on par with its European segment, which the company built through similar efforts 15 years ago.

"We believe that if we can transplant our model to China, it has the potential to be as large a market for us as the U.S. or Europe," Dorwart said. "Europe is roughly 25% of our expanding global sales and we expect China to be a similar portion of our sales within four to five years."

DUPLICATING SUCCESS

PEI-Genesis' Zhuhai facility mirrors its warehousing and production facilities in Great Britain and the United States—an essential element to delivering the company's value proposition to the Chinese market, Dorwart said. The facility uses the same proprietary automation, the same process flow, and the same software as its South Bend, Ind., and Southampton, UK, locations, where it builds custom-made connector solutions. The duplication makes it easier to train local employees and leverage best practices across all three factories, Dorwart added.

"Our Zhuhai facility will enable us to assemble and ship connectors in 48 hours with flawless quality, just as we do in the U.S. and Europe," he said. "We are very excited about this because we will be the first distributor in our industry to open such a facility in China."

Although PEI-Genesis won't be manufacturing product in China until the end of the month, its business license was effective April 1, allowing the distributor to begin trading in the local currency

and fill orders for standard, non-custom parts. The location was almost completely staffed by early March, with just a few positions in finance and IT remaining to be filled, according to Jane Fischetti, PEI-Genesis' general manager, Asia and South America distribution. Fischetti has overseen the project, with the help of a consulting firm that assisted with navigating the legal maze of setting up shop in China. She managed most of the work from PEI's home office in Philadelphia after hiring an operations manager in China last year. In all, the facility will employ about 30 people.

"China is the fastest-growing market in the world for our harsh-environment connectors." —Russ Dorwart, president and COO, PEI-Genesis

Fishchetti noted that the hiring process went smoothly, and she pointed to local enthusiasm for working in a Western company as a key advantage.

"There is this sense that a lot of the people want to work for a Western company; they see that as a value to their career path," Fischetti explained, adding that the cultural atmosphere has been positive as well. "Everyone has been extremely welcoming; I have never felt safer or more welcome. I really feel that that's something that should be said about the Chinese people."

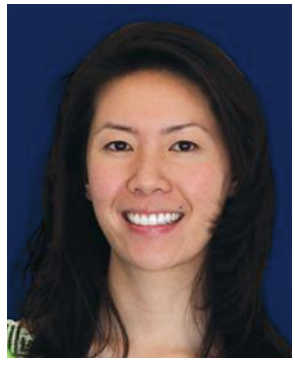
PEI-Genesis is using those positive attributes, in combination with its established supplier relationships in the region, to ramp up business right away. The company's initial focus is on railway and mass transit business, commercial air, oil and gas, solar, and industrial markets. Fischetti points to rail/mass transit as the greatest opportunity initially, explaining that PEI-Genesis' supplier partners have introduced the distributor to potential customers in the region. PEI has also begun working with some commercial air contractors through a partnership with one of its connector manufacturers. The solar market is new for PEI, but Fischetti is optimistic about those prospects as well.

"Our suppliers say they really need distribution there to support them" with solar market customers, she said.

PEI-Genesis' initial geographic focus is on China alone, but the plan is for the Zhuhai facility to support other countries in the region as well. Today, all global business outside of Europe and China is handled by the distributor's New York office; that business includes South America, India, Korea, Japan, and the rest of Asia.

SMALL COMPANIES EXPAND, TOO

California-based Amidon Inc. is another distributor focused on growing in China, having established a location in Shenzhen in late 2013. The company also has a small warehousing location in Hong Kong.



"We're making a big push getting things into the Mandarin language and into the right hands." -Julie Yuan, managing director, Amidon Corp.

Julie Yuan, managing director of the specialty provider of ferrites, iron powder cores, and custom inductors and transformers, says the firm had a soft start the first year and plans to build business this year through more concentrated sales and marketing efforts. Amidon has served customers in the region for years, but decided to build on the business a few years ago by opening a location closer to existing and potential customers. Amidon supports contract manufacturers and small manufacturers in government, medical, consumer electronics, and similar industries across Asia, and has a special focus on small-quantity orders.

This year, Amidon is focused on continuing to support local customers' need for small-quantity orders and getting a better handle on the need for particular products that are hard to find locally.

"Over there, it's very different because we don't have that same sense of knowledge that we have here," Yuan said, noting that she will head to China in late May for a series of customer visits. "The first year, we went to see [about the business potential in the region]. For the second year, now [we're examining issues such as] what needs to be stocked? What will be a constant mover? Is this a project that comes up regularly? We want to get a better mindset of how to do our stocking."

The small distributor is also focused on marketing its services to a wider audience. Amidon launched a Chinese-language website last year and is working closely with supplier partners on marketing materials. A close partnership with ferrite components manufacturer Fair-Rite has been a particular advantage, Yuan added. "We have translated some of their marketing materials into Mandarin and are co-branding together," she said. "We're making a big push getting things into the Mandarin language and into the right hands."

Yuan hopes that by the end of this second year in China that Amidon has a better sense of where local customers are turning to fill the demand that she agrees clearly exists throughout the region. That better sense of where customers are getting parts and what happens to bids Amidon doesn't win will go a long way toward helping her and her management team better structure their local business for success.

"That is what I'm hoping for by the end of the year—that we'll have the clarity to target the market even better and build on the good start we have already developed," she said. ■

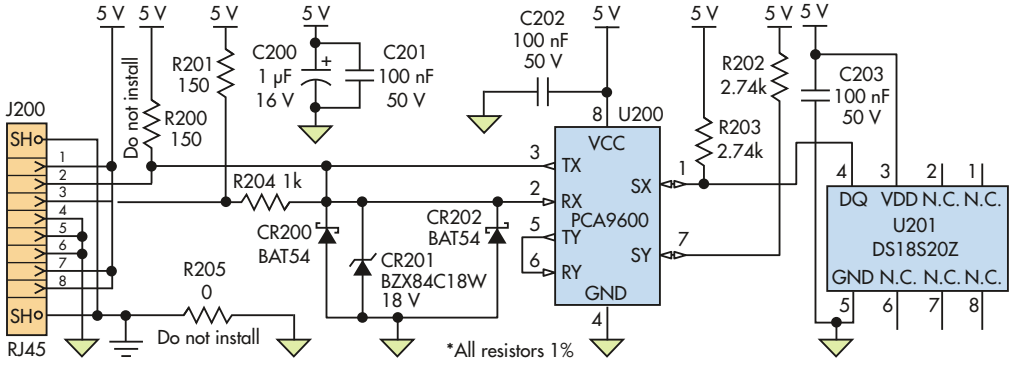
Standard Bus Buffer Easily Extends 1-Wire Signal Off Board

GIRISH CHOUDANKAR | EMPHATEC INC. gchoudankar@emphatec.com.

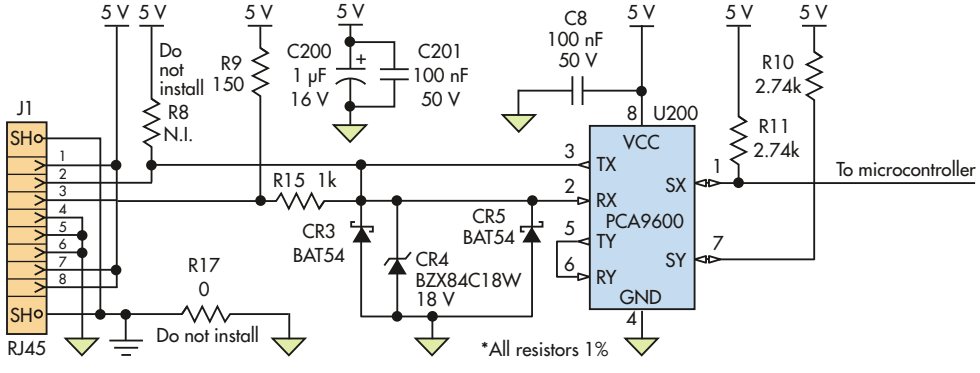
THE LOW SPEED associated with Maxim's 1-Wire devices makes them a good choice for measuring physical parameters such as temperature in HVAC applications. They're also useful for tightly constrained digital I/O ports, since they require only one data line and ground.

The basic microcontroller interface for temperature sensing with either an external supply or a so-called "parasite supply" is simple, as seen in the product datasheet. However, remote temperature sensing with the DS18S20 functioning as a peripheral unit to a main board may require a complex hardware and software solution.

One interface option is a balanced transmission line (CAT5x or similar)—these cables are readily available, which avoids the cost involved in making specialized cables. The 300 meters of CAT5 twisted-pair cable adds significant levels of both capacitance (≈52 pF/m) and inductance (≈525 nH/m) to the interface, which may result in ringing and waveform distortion of the digital signals. Interfacing to network cable also has subtleties that may lead to complex design.



1. The remote-sensor board interface provides drive and RJ45 interconnection for the 1-Wire device (DS18S20). Note: R205 is added in case the shield and system ground need isolation, and can be replaced by ferrite beads. Since the shielded cable is generally not used, these resistors are marked as "Do not install."



2. The interface on the microcontroller side accepts the CAT5e cable signal via the J1 RJ45 connector and bidirectional bus buffer U3, then passes it to the microcontroller. Note: R17 is added in case the shield and system ground need isolation, and can be replaced by ferrite beads. Since the shielded cable is generally not used, these resistors are marked as "Do not install."

While working on choosing between either a complex hardware/software solution or network cable, I found the NXP PCA9600, an I^2C dual bidirectional-bus buffer. It enables long buses to be driven in point-to-point or multipoint applications. (The 100-ksample/s speed of the I^2C bus is well above the speed of the 1-Wire interface, and if needed, optocouplers can be used to provide optical isolation between bus nodes.)

A receiver interface *(Fig. 1)* and a transmitter interface to the microcontroller *(Fig. 2)* show the approach, which was successfully tested with a sensor using 10 ft. of CAT5e cable. As an added benefit, no software modification was needed for the implementation.

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Feedback-Controlled Constant-Current Limiter Includes Digital On/Off Control

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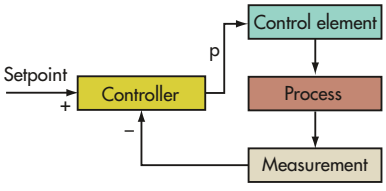
A CURRENT-LIMITING CIRCUIT is often needed to protect the most expensive parts of the circuit from transients such as current spikes, which occur when a power supply is driving a large capacitive load, an H-bridge is starting an inductive motor, or a current-limiter circuit is driving power LEDs.

This versatile high-side current limiter uses negative-feedback control based on general process-control principles *(Fig. 1)*. Figure 2 illustrates a practical implementation. Here, the process being controlled is the output current, which has very nearly the same value as the input current. A measurement is performed across the sense resistor R1. Its value defines the setpoint (the maximum allowed current).



1. The design begins with a standard closed-loop control approach, comparing the desired setpoint value of the maximum allowed current to the actual value, and a control signal p.

PNP transistor Q1 represents the controller, while its collector current I_{cq1} is the control signal p. Resistor R3 and the P-channel MOSFET Q2 together form the control element. It is important to emphasize that the controller doesn't perform any action on the control element (the control signal p is zero) until the input current reaches the setpoint current.

Transistor Q2 is not conducting at power-on until the input voltage reaches the V_{gs} threshold voltage, which for most MOSFETs is 3 to 5 V, and the further increase of the input voltage fully turns on Q2. Therefore, Q2 can act as a switch, assuming that the input current hasn't yet reached the setpoint current. The V_{gs} voltage is limited by the choice of the Zener diode D1, which is 7.5 V in this particular design.

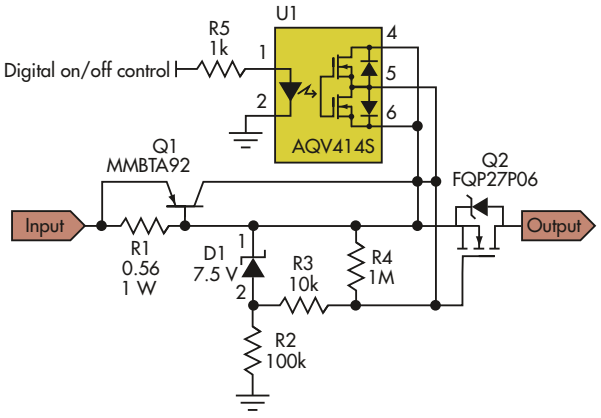
The PNP transistor chosen (MMBTA92) has a V_{be} threshold voltage of approximately 0.56 V. With R1 equal to 0.56 Ω, this sets the current limit to 1 A. Q1 starts to conduct when the voltage across R1 exceeds 0.56 V or when the input current exceeds 1 A. Its collector current then starts to flow through R3.

Based on the relationship that $V_{gs} = 7.5 - R3 \times I_{cq1}$, any increase in the collector current of Q1 (the control signal p) decreases voltage V_{gs} and subsequently decreases the output current of Q2, which in turn decreases the voltage across R1. This completes the negative feedback loop. It is important to note that in the control mode ($I_{cq1} > 0$), Q2 operates in an active mode. So, it is necessary to observe the safe operating area (SOA) of a chosen MOSFET.

The voltage of Zener diode D1 needs to be larger than the required V_{gs} voltage, corresponding to the maximum (limited) output current. R3 determines the sensitivity of the control element. While higher values will make the control loop more responsive, this will also increase the loop gain, which may lead to oscillations around the setpoint. A value of R3 = 10 kΩ was determined empirically as the optimal value without oscillations in the output current around the setpoint.

The addition of a small solid-state relay driven directly from a microcontroller pin allows external ON/OFF control of the limiting function. Optocoupler-MOSFET U1 (AQV414) is a normally closed device that holds Q2 switched off when the digital control input is low and allows Q2 to be conductive when it is high. Resistor R4 ensures that the gate-source capacitance of Q2 is completely discharged when the circuit is powered off, as a precaution, but it is not necessary when U1 is used.

This design idea is part of a more complex driver circuit that powers LEDs connected in series (three 10-W LEDs) with 48-V drive and current up to 1 A. The application is limited not only to the specified current and voltage, though, as the input voltage can be hundreds of volts by choosing a proper P-channel MOSFET that operates in its SOA.

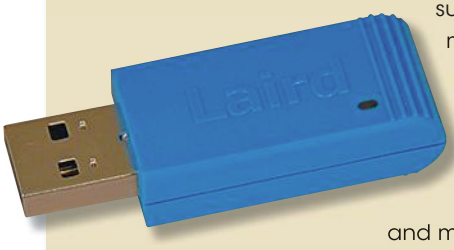


2. The closed-loop function includes Q1's collector current as the control signal and R3/Q2 as the loop-control element, with the loop's setpoint established by the current through R1.

ILIJA UZELAC is a post-doc at the Georgia Institute of Technology, Atlanta, with a PhD in physics and a master's degree in electrical engineering from the School of Electrical Engineering, University of Belgrade, Serbia.

Intelligent BLE Dongle Converts Legacy Devices

LAIRD'S BT900-US intelligent Bluetooth Low Energy (BLE) dual-mode dongle is designed to fit into a wide range of operating systems. It's suitable for converting legacy devices, as well as for Internet of Things (IoT) applications, without complicated installation or software support requirements. The company's smartBasic programming language further helps simplify embedded design and module integration, acting as a bridge between software and hardware. The BT900-US carries FCC modular, IC, CE, and Bluetooth SIG approvals. It can be used for barcode scanners, point-of-sale terminals, PCs, laptops, and other devices.



LAIRD
www.lairdtech.com

Controller Automatically Switches Between Touchscreen Settings

WITH THE TrueTouch CYTT21X/31X capacitive touchscreen controllers, more advanced features can be built into today's smartphones, e-readers, and tablets. Developed by Cypress Semiconductor, they support input from a passive stylus with a tip as fine as 2.5 mm, essential for writing in languages that require enhanced character recognition (e.g., Chinese, Korean, and Japanese). The CYTT21X supports a face-detection feature that prevents unintended touches, eliminating the need for infrared proximity sensors. The controllers automatically switch between glove, stylus, and finger tracking without requiring the user to switch settings. The ARM Cortex-M-based controllers include up to 48 I/Os with an I^2C interface, and up to 44 I/Os with an I2C and SPI interface.

CYPRESS SEMICONDUCTOR
www.cypress.com

Industrial-Node Computer Supports up to 8-GB DRAM

NEMATRON ANNOUNCED the nPC20 industrial-node computer, the latest member of its fanless, rugged, industrial-strength embedded PC lineup. The nPC20 incorporates the ATOM Dual Core E3826 1.46-GHz CPU or ATOM Quad Core E3845 1.91-GHz CPU; DRAM ranges from 2 to 8 GB. It supports dual video output via one HDMI port and one VGA video port. It comes with a 24-V dc power supply (ac power supply is optional). The PC can be installed with a Microsoft Windows Professional (32-bit) or Ultimate (64-bit) operating system. I/O includes dual Gigabit Ethernet ports, two USB 3.0 ports, one audio line output, and one serial communication port. The nPC20 can be mounted via a DIN rail utilizing the side, or a back-adjustable DIN rail bracket.I

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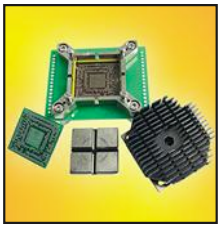
IC Socket for High Speed Applications



Ironwood's GT sockets are ideal for prototyping and testing almost any BGA or QFN device application. These IC sockets provide excellent signal integrity yet remain cost effective. Innovative elastomer interconnect technology that delivers low signal loss (1dB at 75GHz) and supports BGA or QFN packages with pitches down to 0.15mm was utilized in these sockets.

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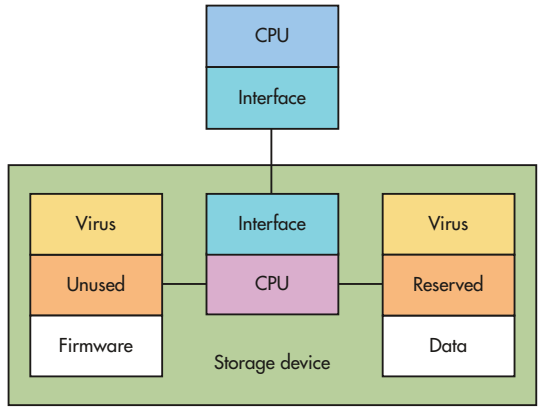
Hacking Hard Drives and Other Nasties

Securing your system is harder than you think when it is possible to hack a hard drive so that the virus cannot be detected and removed.

The Catch-22 quote, "Just because you're paranoid doesn't mean they aren't after you," seems tame these days as revelations from Edward Snowden (*see "Prism, Big Data and Double, Secret Probation" on electronic design.com*) and Kaspersky Labs continue to emerge. One of the latest from Kaspersky Labs is that a very advanced group of hackers called the Equation Group could be an organization like the NSA (*see "Kaspersky Lab Discovers Equation Group: The Crown Creator of Cyber-Espionage" on electronic design.com*).



1. Researchers at Kaspersky Labs have discovered hard drives that had a virus in firmware that allowed another part of the virus to be hidden on a hard disk.

Tracking down and dealing with nebulous attackers is no easy chore. It is hard enough for the Global Research and Analysis Team (GReAT) at Kaspersky Labs—and they know what to look for. In this instance, one of the attacks was via hard disk drives that had their firmware hacked (*see the figure*). Essentially the firmware was replaced so a virus was included in addition to providing the normal drive functionality. The additional changes to the firmware allow data to be hidden in the main storage area. This can be accomplished easily, since the drives are already set up with spare sectors to be remapped in the event of another sector going bad.

This finding resulted in an ominous warning from GReAT director Costin Raiu, who noted, "Another dangerous thing is that once the hard drive gets infected with this malicious payload, it is impossible to scan its firmware. To put it simply: for most hard drives, there are functions to write into the hardware firmware area, but there are no functions to read it back. It means that we are practically blind, and cannot detect hard drives that have been infected by this malware."

The hacked drive can essentially store a copy of a virus or even a hacked operating system in the main storage area of the device that survives a format request since the firmware is the program that performs the formatting. This information can replace a newly installed system and this is completely transparent to the rest of the system, including any antivirus or disk-checking software. A secure boot system may be able to detect a problem, assuming it is not spoofed as well. That can be a much harder job, but not impossible especially given the difficulty in hacking the hard drive in the first place. The approach works regardless of whether a drive is a hard disk or a solid-state disk. Its approach can even work on encrypted disks.

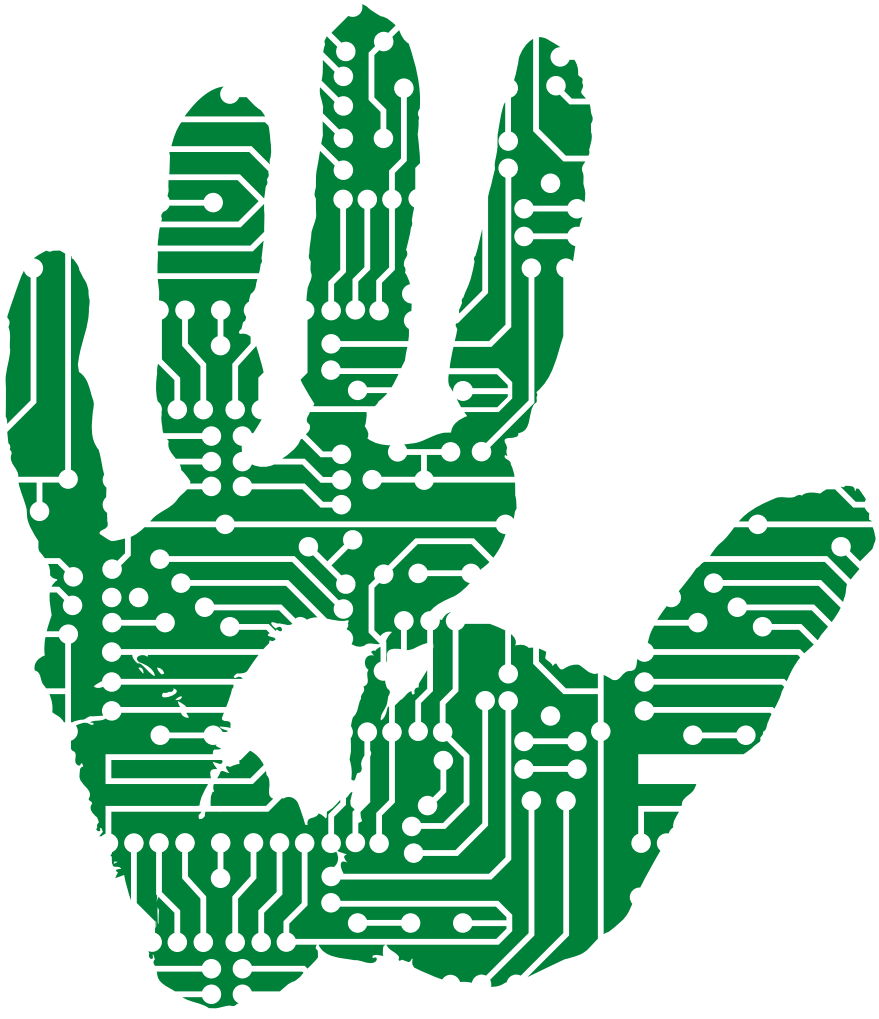
AN IoT CHALLENGE

The approach of hiding malicious code in a way that it cannot be detected is not new. It is also an approach that is becoming more of an issue with the rise of the Internet of Things (IoT), which offers even fewer mechanisms to analyze and detect problems that arise within a network.

Embedded developers need to understand the security threat issues and build secure systems that will not inadvertently be employed in compromising situations. This can be challenging, since building the application alone is usually hard enough--but it cannot be overlooked, because a majority of systems are connected in some fashion. Even air-gap computer security measures can be overcome using USB flash drives if systems are not configured properly.

This issue also relates to counterfeits and the gray market. More intelligent devices have more places to hide nefarious software, and it is much easier to insert software into a device in hand rather than via remote means.

It is all a matter of who, or what, you can trust.



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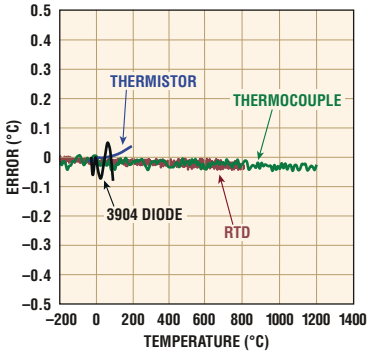

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