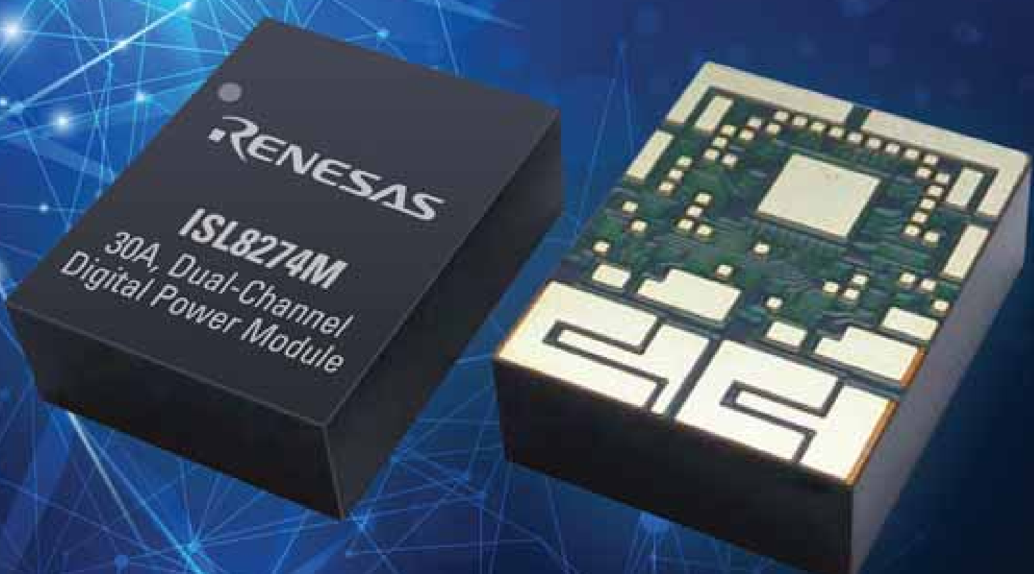
June 2018
Volume 124
Issue 1984
£5.90

www.electronicsworld.co.uk

Electronics WORLD

THE ESSENTIAL ELECTRONICS ENGINEERING MAGAZINE

Powering FPGA applications
with the Renesas ISL8274M digital power module



INSIDE THIS ISSUE

TEST & MEASUREMENT SUPPLEMENT
Starts on page 27

Latest
- New light technique could help diagnose illnesses

Embedded
- Back from Hannover Messe

SPECIAL REPORT
Industrial Electronics:
* PLCs vs PACs
* Transformeless design
* Industry 4.0

IoT Security Suite

Making the Complex Simple

SAMA5D2 Xplained Ultra Evaluation Board (ATSAMA5D2-XULT)

The IoT Security Suite for the SAMA5D2 MPU enables rapid and easy use of its advanced security features, such as ARM® TrustZone® technology and hardware cryptography, without a long learning curve. The suite covers the security requirements for IoT device manufacturers in a single, easy-to-use package. It supports storing, encrypting, decrypting and exchanging keys between devices and applications, and its easy-to-use APIs save you time.

Features

- Trusted Boot – Root of Trust (RoT) verified startup
- Firmware Protection – Encryption and execution of authenticated firmware
- Trusted Device ID – Unique device certificate tied to the RoT
- Secure Storage – Secure storage of keys, certificates and data
- Secure Communications – Authenticated device pairing and IoT cloud communications
- Secure Firmware Update – Securely upgrade firmware remotely

Download the IoT Security Suite Evaluation Kit (free) to get started.

microchip DIRECT

MICROCHIP

www.microchip.com/SAMA5D2

CONTENTS

REGULARS

20

COLUMNS

32

FEATURES

T&M SUPPLEMENT

Cover supplied by RENESAS ELECTRONICS See p10-11

Disclaimer: We work hard to ensure that the information presented in Electronics World is accurate. However, the publisher will not take responsibility for any injury or loss of earnings that may result from applying information presented in the magazine. It is your responsibility to familiarise yourself with the laws relating to dealing with your customers and suppliers, and with safety practices relating to working with electrical/electronic circuitry – particularly as regards electric shock, fire hazards and explosions.

TAX ON ROBOTS?

The world's first robot tax was introduced in South Korea last year. It was created amid fears that a rise in automation and robotics was threatening human workers, leading to mass unemployment in the country. But, this so-called robot tax was not actually a tax at all. Instead, the country limited tax incentives for investments in automation, lessening the existing tax breaks. Essentially, it was just a revision of existing tax laws.

Regardless of its name, however, South Korea's announce-ment sparked several debates across the world as to whether a robot tax would be advantageous. Bill Gates famously called for a technology levy, suggesting that a tax could balance the government's income as jobs are lost to automation. The levy was suggested to slow down the pace of change and garner funds for the local government to increase job opportunities in other sectors.

Fewer Workers, Fewer Tax Contributions

Some see a tax on robotics as absurd an idea as a tax on pencils, and potentially damaging to the progress of the machine economy and an impediment to productivity.

While most manufacturers and those in the robotics sector would disagree with imposing a tax on robots, the debate does raise questions of how employment is taxed in Britain and how technology can affect this. The obvious fear is that by replacing people with robots, national insurance contributions will drop, lessening a country's ability to support its people.

A possible alternative answer to this problem could be switching to a system where, rather than paying tax per employee through national insurance contributions (NIC), NIC would be calculated around a company's overall operating costs. Using this method, NIC could take account of the impact of all forms of advanced technology, not just robots.

Much of the debate about the potential robot tax has focused on the threat robots and automation pose to the human workforce. However, robots don't always replace a human job, but often work alongside people to reduce the risk of injury – especially in the supply chain.

Consider this example: TM Robotics recently introduced a robot box-opening cell to its range of industrial equipment. This type of automation would typically be used by companies like DHL and UPS that deliver products directly into manufacturing plants and retail warehouses, helping them reduce the risk of injuries from knives and other sharp objects used for opening boxes. In this instance, a robot tax would undermine a company's ability to deliver a safe environment for its workers.

Robots are tools and they will create work, especially new kinds of work - taxing them would be a tax on net job creation

The bottom line is that robots create jobs, they don't take them away. This is supported by the UK government's recent 'Made Smarter' review on digitalisation in industry. The review concluded that, over the next ten years, automation could boost UK manufacturing by £455bn, with a net gain of 175,000 jobs.

Robots are tools and they will create work, especially new kinds of work – taxing them would be a tax on net job creation. ●

Nigel Smith, Managing Director, TM Robotics (www.tmrobotics.co.uk)

EDITOR: Svetlana Josifovska
Tel: +44 (0)1732 883392
Email: svetlanaj@electronicsworld.co.uk

SALES: Suzie Pipe
Tel: +44 (0)20 8306 0564
Mobile: +44 (0)7799 063311
Email: suziep@electronicsworld.co.uk

DESIGN: Tania King

PUBLISHER: Wayne Darroch

ISSN: 1365-4675
PRINTER: Buxton Press Ltd

SJP business media
2nd Floor,
52-54 Gracechurch Street,
London, EC3V 0EH

SUBSCRIPTIONS:
Subscription rates:
UK - 1 year digital only £53.00+VAT
UK - 1 year print and digital sub £68.00
UK - 2 year print and digital sub £109.00
UK - 3 year print and digital sub £143.00
International - 1 year digital only £53.00
International - 1 year print and digital sub £164.00
International - 2 year print and digital sub £290.00
International - 3 year print and digital sub £409.00
Tel/Fax +44 (0)1635 879361/868594
Email: electronicsworld@circdata.com
www.electronicsworld.co.uk/subscribe

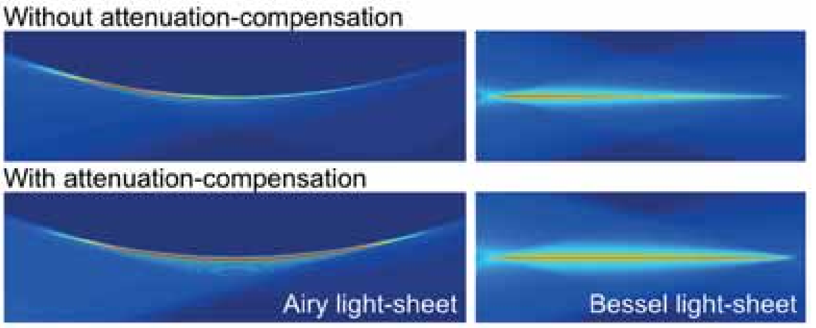
Follow us on Twitter @electrowo

Join us on LinkedIn

NEW LIGHT TECHNIQUE COULD HELP DIAGNOSE ILLNESS

A new method of using light to scan the human body non-intrusively has been developed by researchers at the University of St Andrews, UK. The technique allows light to be shaped so it can reach greater depths within biological tissue, enabling the acquisition of high-quality three-dimensional (3D) images. It also allows making detailed 3D images of biological specimens without dissection or having to rotate specimens for multiple images.

The new method adds value to two existing imaging techniques, Bessel-beam- and Airy-beam-based light-sheet microscopies.



Attenuation-compensated light-sheets reach greater depths

"We've recently discovered particular beam shapes that retain their shape when travelling through biological tissue. These beams, called Airy beams and Bessel beams resist the effects of scattering but still become dimmer as they travel deeper. We now show that they can be enhanced to give us more control over their shape, such that they get brighter as they propagate. When the increase in intensity is matched with the decrease of brightness when travelling through tissue, a strong signal and a clear image can still be acquired from deep within the sample," said Dr Jonathan Nylk of the School of Physics and Astronomy at St Andrews.

This latest research builds on previous advances in light-sheet imaging, in which a thin sheet of light runs across a sample to section it – without cutting or damaging it. The use of curved Airy light-sheets was shown to give sharp images over a volume ten times larger than previously possible.

The new techniques are expected be useful not only for light-sheet microscopy but also for further improving optical-imaging techniques.

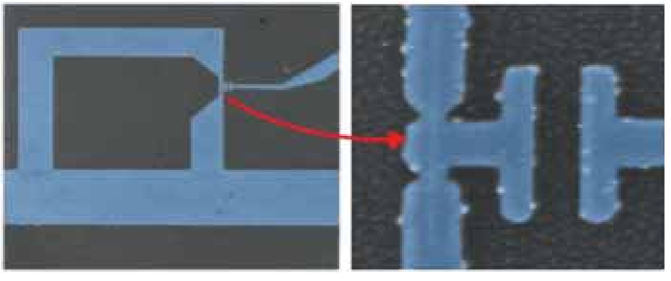
It is hoped that the development will lead to better understanding of cancer and diseases that affect the brain such as Alzheimer's, Parkinson's and Huntington's.

A QUANTUM COHERENT DEVICE AIMS TO SET A NEW STANDARD FOR MEASURING CURRENT

A team of international university researchers has successfully demonstrated a quantum coherent effect in a new quantum device made of continuous superconducting wire, called the Charge Quantum Interference Device (CQUID). This is an important milestone in demonstrating a robust new quantum standard for current, one that could re-define the ampere (A), to be discussed by the global measurement community later this year as part of the redefinition of the international system of units (SI).

The device acts opposite to the better known superconducting quantum interference device (SQUID), used as an ultrasensitive sensor for magnetism. Instead of sensing a magnetic field via its influence on the current flow (moving charge) like a SQUID, the CQUID works seemingly in the opposite way, sensing charge as a result of quantum interference due to the flow of magnetic flux.

"The duality between the CQUID and SQUID devices originates from the fundamental relationship between charge and phase in quantum mechanics, made possible in these devices with superconducting materials. We can think of it as the charge and magnetic flux, or the superconductor itself and the vacuum (insulator) around it, suddenly having the opposite roles," said Sebastian de Graaf, Senior Researcher at the National Physical Laboratory (NPL) Teddington, UK, that's involved in the research.



False colour electron micrograph of the device, and a close-up on the CQPS junctions and the gated island. Blue indicates the niobium nitride film

For the first time the CQUID demonstrates interference of coherent quantum phase slips (CQPS) in a device made of more than one CQPS junction. This fundamental quantum circuit element is the dual and opposite to the Josephson junction, and underlines the CQUID's potential.

"The interchanged roles of current and voltage in a CQPS circuit compared to a Josephson junction opens up the potential for a new, broad range of technologies, as well as a precise and robust standard for current as the fundamental quantum standard for voltage, which today is realised by arrays of Josephson junctions," said de Graaf.

In the circuit, the CQPS junction is built by embedding a superconducting nanowire in a very-high-impedance environment. A superconducting film made from niobium nitride (NbN) with a total thickness of only 3.3nm was deposited one atomic layer at a time. The film was then patterned into narrow wires just a few nanometres wide.

Using modular digitiser acquisition modes

BY **OLIVER ROVINI** AND **GREG TATE**, SPECTRUM INSTRUMENTATION

Modular digitisers offer many acquisition features, acquiring multiple channels of input data and transferring it at high rates to computers for analysis. They also offer multiple acquisition modes that efficiently use on-board memory and decrease dead time between acquisitions. This is especially true with signals in low-duty-cycle applications such as echo ranging (including radar, sonar, LIDAR and ultrasound) and transient data collection applications, such as time-of-flight spectrometry and other stimulus-response-based analysis.

Basic Acquisition Configurations

Typical modular digitisers generally offer two operating modes, standard and FIFO (first in first out). Standard mode uses the acquisition memory as a ring buffer, just like an oscilloscope. Data is written in the digitiser's ring memory until a trigger event occurs, resulting in pre- and post-trigger values being included in the recorded data.

This mode is used primarily with the digitiser's data acquisition software, for viewing, logging and post-processing of captured signals, and for verifying the digitiser's setup and performing preliminary processing on the data.

FIFO is a streaming mode, designed for continuous data transfer between digitiser and an external host computer.

The main difference between standard and FIFO modes is that the standard modes are limited to on-board memory, while FIFO modes transfer data continuously to a PC or external memory and can therefore run much longer. The complete, installed acquisition-memory is used as a buffer, providing reliable data streaming.

Multiple Recording Modes

Both standard and FIFO modes offer three recording methods for more efficient use of the acquisition memory in low-duty-cycle applications, such as short duration events followed by long quiescent intervals. The acquisition methods optimised for the capture of this type signal are Multiple Recording (segment) mode, Gated mode and ABA (dual time base) acquisition; see Figure 1. Each mode sections the memory and makes multiple acquisitions within it. The dual-time-base ABA mode reduces the sampling rate between triggers, saving memory space but providing a view of occurrences during the dead time.

Application Examples

The example in Figure 2 shows a multiple recording mode acquisition of the acoustic output of an ultrasonic range finder. The device outputs 40kHz bursts and determines range by measuring the time until an echo is received.

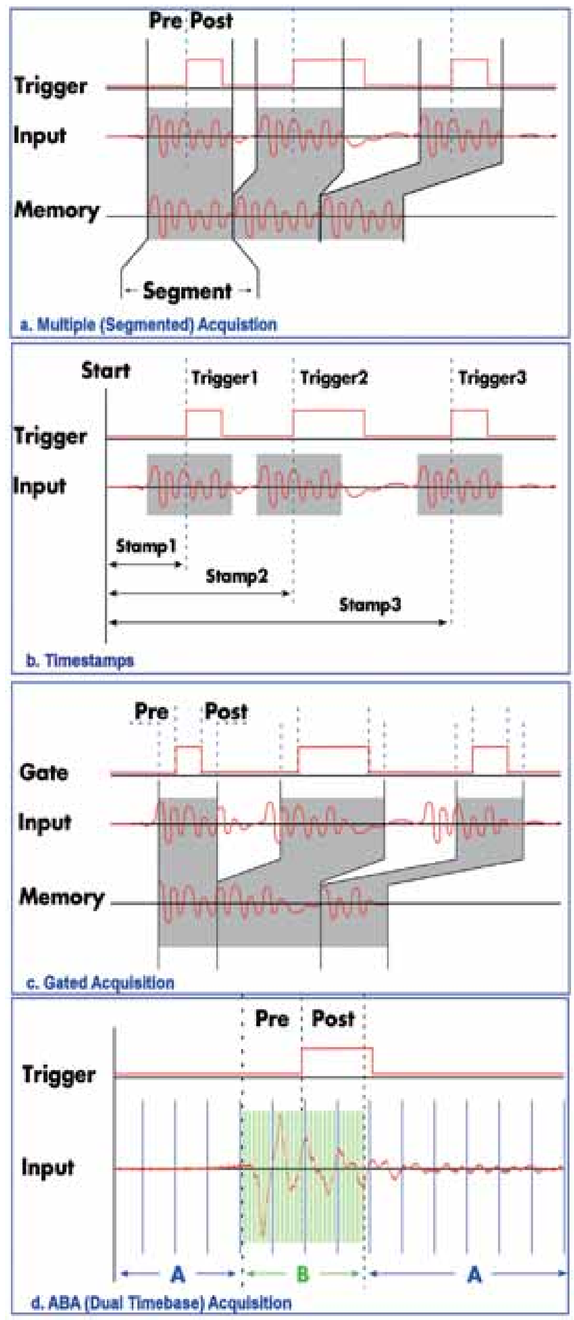


Figure 1: A summary view of multiple, gated and ABA acquisition modes and associated time-stamps

The bursts occur in groups of five at 15µs spacings, with processing taking place in the 450ms dead-time between bursts. The acoustic signal was picked up using an instrumentation microphone with a bandwidth of 100kHz.

The left side of the figure shows the acquisition setup. Each segment consists of 32kS with 1kS of pre-trigger and 31kS of post-trigger recording; the sample rate is 7.8MS/s. The upper trace is a preview of the entire acquisition, showing the multiple bursts and processing intervals. The centre trace is a zoom view showing five segments, each marked with a time stamp at its start.

The bottom trace is a zoom view of the first burst in the acquisition. The software displaying this data shows the segments closely as they are stored in memory; however, the view incorporating the measured spacing is generally more useful.

The upper trace in Figure 3 shows the entire acquisition. The centre display is a single segment of data recorded at the selected sample rate (B sampling clock). The time stamp shows the trigger time. The bottom trace is the continuous 'A' data sampled at one sixteenth of the selected sample rate. Note that the continuous record shows information between pulses that is not evident when using the multiple recording mode.

Figure 4 shows an example of a gated acquisition used on a simulated laser signal. The gate signal marks the laser being triggered. It's applied to the second channel of the digitiser, set up as trigger source with a threshold level of 150mV. The resultant acquisition shows both the laser pulse and gate signal. Note that a pre- and post-area of 128 samples adds additional samples to the gate area.

Use of the gated acquisition mode allows the capture of eighteen pulses (with a total duration of 1.8s) using only 8kS of acquisition memory.

Apt Use of Modes

The use of special acquisition modes like multiple recording, gated acquisition and ABA reduces the memory required to capture and analyse low-duty-cycle signals. Since only significant events are captured, this improves the efficiency of the acquisition, which in general means data transfer and analysis need less time.

Smart acquisition modes also ensure that important events are not missed. Fast trigger re-arm times and optimised acquisition efficiency help capture complex bursts of signals even at very high event rates. These features make modular digitisers the instruments of choice for a wide range of echo ranging and stimulus-response-type measurement applications. ●

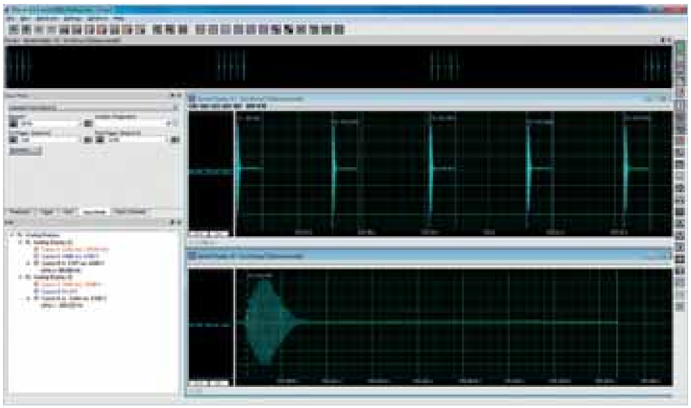


Figure 2: A multiple recording capture of the 40kHz acoustic output of an ultrasonic range finder

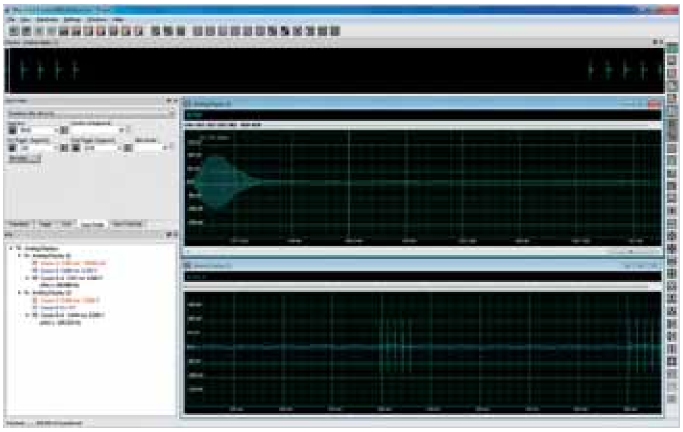
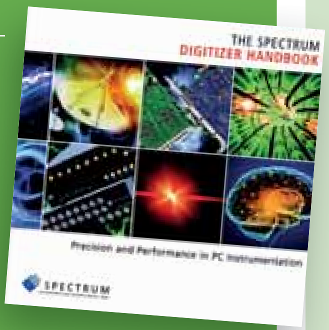


Figure 3: The same ultrasonic burst captured using the dual time-base ABA acquisition mode. Note the lower 'A' trace has the continuous signal data captured at the slower sample rate. The upper trace is a single segment taken at the higher (B time-base) sampling rate

FREE BOOKS



This article is adapted from *"The Digitizer Handbook – Precision and Performance in PC Instrumentation"* by Spectrum Instrumentation.

To receive a free copy, go to https://spectrum-instrumentation.com/en/contact-us and tick the box marked "Please send me a copy of the Digitizer Handbook" , adding "EW" in the Comment section.

Long-term critical cleaning

BY **MIKE JONES**, VICE PRESIDENT, MICROCARE

When it comes to selecting a new, long-term critical cleaning process, the challenge is to sort through all the conflicting claims made by the manufacturers of the products being considered.

Start a Scorecard

Cleaning processes need to be fast, safe, sustainable and affordable. While this is challenging, there is a tool that can be used to select the optimal solution, the so-called 'cleaning scorecard'.

Many companies only look at the cost of a machine or a drum of solvent, believing the lowest-priced machine or cheapest cost per litre are the best choice, but this is completely wrong, as there are many other factors to consider.

The cleaning scorecard should focus on the 'total cost per part' cleaned, not 'cost per litre'. The size of the cleaning system should not be measured in inches but in production or cleaning capacity, determined by the number of units cleaned per day or week. Alternatively, estimate the total surface area of all parts to be cleaned to come up with your score, taking into consideration parts that may require different, more costly cleaning methods, like fragile components.

> **Cleaning processes need to be fast, safe, sustainable and affordable**

Once the capacity has been decided, the best cleaning technology should be evaluated. For example, benchtop cleaning machines are slow but small and cheap, whereas high-volume systems are larger and more efficient, but of course more expensive.

When you have scored the best technology, 'test drive' the equipment, if possible. Request a report on the cleaning process, solvents, temperatures, times and results to ensure the system performs to your cleaning specification.

Average Productivity

When comparing different cleaning technologies, it is essential to evaluate the average productivity of the system in terms of assemblies per hour. This is crucial to calculating the cost-per-part-cleaned because operational and labour expenses are usually accounted as hourly costs.

First, look at the cycle time to work out the average throughput, since this can dramatically affect operating expenses. There are many factors that can alter this score; for example, loading and unloading a machine as well as its type – i.e. a vapour or water cleaner. Then calculate and compare the total cleaning costs from each machine, including the cost to purchase and set it up, to its consumables like water, solvent and electricity. Re-calibrate the figures into one standard unit of measure to determine the total cost per part cleaned.

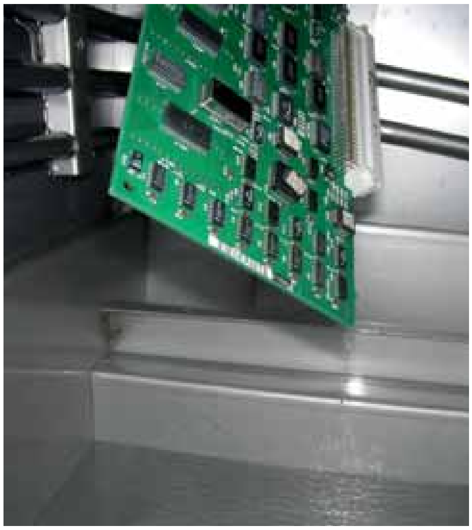
Operating Costs

Most equipment manufacturers can offer a guideline on operating costs, but be sure to include direct operating costs like loss of solvent and consumables.

'Drag-out' should be considered, which is the loss of solvent due to it being trapped in, on or around the clean parts as they move through the system. High-boiling solvents like water and hydrocarbons are prone to high drag-out losses, but the chemicals are relatively cheap. Low-boiling solvents can minimise drag-out, but cost more.

Use equipment that helps reduce drag-out losses; for example, newer vapour degreasers use extra refrigeration, superheat and hoists to minimise losses and save money. Aqueous systems use air knives and extra drying chambers, which cut solvent losses but add to the electric bill.

Solvent run-off from PCB undergoing vapour degreasing



Loading parts into a vapour degreaser

Don't Forget the Environment

Health, safety and environmental regulations must be at the top of the list when scoring your long-term cleaning method and should shape your choices.

Companies with cleaners containing normal propyl bromide (nPB) may find it highly effective with a very attractive price; however, the toxicity standards are being tightened and their use will become problematic. The European Chemicals Agency has listed nPB as a 'Substance of Very High Concern', so REACH may place a complete ban on it in the future. This would certainly have a negative impact on any company that invested in a cleaning method that suddenly became non-compliant.

Vapour degreasing

Labour and Maintenance Costs

Labour can be a hidden cost. When using an automated machine, many think labour is minimal; but consider the technicians performing inspection, re-cleaning and drying the parts.

Large machines such as aqueous systems can have complex maintenance problems. Due to their size, there are many moving parts and processes from water-treatment and recycling, to the alkaline additives used to boost the cleaning power that leave a residue in the system – all of this must be maintained.

Vapour systems will require filters to be replaced, and the solvent in the degreaser needs to be boiled down and removed, usually resulting in the loss and disposal of approximately 10% of the solvent in the machine each quarter.

Your Final Score

There are many boxes to fill on the cleaning scorecard leading to the right decision:

1. Consider the cleaning requirements and how they could change, and average these into a daily or hourly rate of required throughput.
2. Compare different cleaning technologies. Send samples to the equipment makers to prove the ability of their systems to clean them to your specifications.
3. Examine up-front capital costs, including floor space and installation, and then tackle energy, solvent and labour costs.
4. Plug all the cost data into a performance index of 'total cost per part cleaned'.
5. Select the option that minimises that total. ●

POWERING YOUR FPGA APPLICATIONS

By Xiao Li, Senior Applications Engineer, and Billy Yang, Principal Applications Engineer, Renesas Electronics

FPGAs are widely used in a variety of products due to their many advantages, including short development time, cost effectiveness and flexibility to reconfigure or update in the field. Many new FPGAs employ advanced technology to achieve low power consumption and high performance. They use a new fabrication process that tends to require a lower core voltage, which extends the supply voltage range and increases current capability. Many FPGAs also have varying power supply requirements for each power rail. These power rails may have a different voltage output requirement, sequencing requirement and noise sensitivity. Power module devices are ideal for addressing these power supply requirements.

A power module includes the controller, FETs, inductors and the majority of the passives encapsulated in a single package, leaving only the input and output bulk capacitors outside to complete the system design. Digital power modules combine the benefits of power modules and digital power. By using a digital power module, designers can shorten development time and quickly update power monitoring and sequencing control functions, which analogue solutions can't provide. Benefiting from improved voltage regulation accuracy and advanced digital control techniques, digital power modules have quickly become more competitive in FPGA applications. This article examines the ISL8274M from Renesas, and explains how its main features satisfy the requirements for powering FPGAs; see Table 1.

Digital Power Modules Adapt to FPGAs

Analogue and digital power modules are both suitable for FPGA power supply applications. However, digital power management provides many additional benefits such as real-time monitoring, digital control with fast transient response, reduced bill of materials (BOM) and simplified design effort. The digital power module solution is flexible and can adapt to the changing FPGA power requirements of lower voltage, higher current and additional rails with less effort. A new voltage rail is easily added to the power management system through the PMBus. Renesas's proprietary Digital-DC (DDC) communication bus is used to provide a communication channel between power devices, enabling trouble-free communication, sequencing, interleaving and fault spreading. Today, many digital power modules can achieve excellent output voltage regulation accuracy with the exact set-point reference.

The ISL8274M is a general-purpose step-down digital power module and features PMBus communications and numerous other characteristics that satisfy the requirements for FPGA power supplies. It has two channels, which can operate as two separate power rails for different FPGA parts, or connect in parallel to support the same rail with a high current capability requirement. Moreover, the ISL8274M has an internal DDC serial bus that enables communication between other Renesas power devices, allowing easy configuration and implementation of power-up sequence, fault protections and monitoring. Its general application circuit is shown in Figure 1.

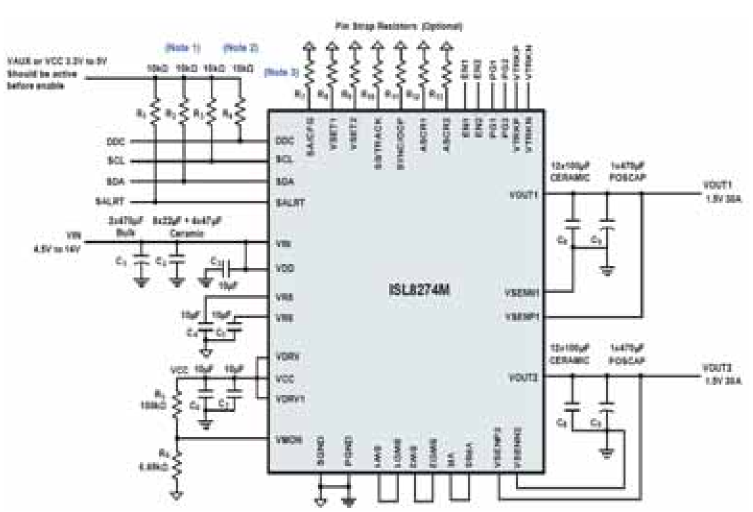


Figure 1: General application circuit of the ISL8274M

Digital ChargeMode Control Scheme

The ISL8274M uses Renesas's patented ChargeMode™ control scheme, which has the ability to achieve a fast response when loading the transient with a fixed switching frequency and to support an all-ceramic output capacitor design. Delays are reduced between the error-sampling instant and the moment the PWM is generated using a multi-rate sampling technique and digital filter. This is also an easy compensation control scheme, achieved without the need for extra passive RC components for a compensation loop design as required by an analogue module. For any in-system change, new compensation can be easily reconfigured by the PMBus command or PIN-strap setting. A reference design is provided by the manufacturer for the user's convenience.

Soft-Start with Adjustable Ramping Time

It may be necessary to set a delay from the time when an enable signal is received until the output voltage ramps to its target value. The ISL8274M provides designers with an easy process through the PowerNavigator™ GUI design tool to reset both the delay and ramp times precisely and independently. The ISL8274M also provides pre-bias protection by sampling the output voltage before initiating an output ramp in the event a pre-bias condition exists at the output stage prior to startup. Figure 2 shows the soft startup process, with startup rising time equal to 5ms.

Power Sequencing/Voltage Tracking

A group of power modules for different rails or multiphase operation can be configured to power up in a predetermined sequence. This feature is especially useful when powering advanced processors, such as FPGAs, that require one supply to reach its operating voltage prior to another supply reaching it in order to avoid latch-up. With the ISL8274M, multiple device sequencing is configured by issuing PMBus commands to assign the preceding device in the sequencing

ISL8274M Key Features		
• Complete digital power supply • 30A/30A dual-channel output current – 4.5V to 14V single rail input voltage – Up to 95.5% efficiency • Programmable output voltage – 0.6V to 5V output voltage settings – ±1.2% accuracy over line/load/temperature	• ChargeMode™ control loop architecture – 296 kHz to 1.06 MHz fixed switching frequency operations – No compensation required – Fast single clock cycle transient response • PMBus interface and/or pin-strap mode – Fully programmable through PMBus – Pin-strap mode for standard settings – Real-time telemetry for VIN, VOUT, IOUT, temperature, duty cycle, and switching frequency	• Advanced soft-start/stop, sequencing, and tracking • Complete over/under voltage, current and temperature protections with fault logging • PowerNavigator™ support • Thermally enhanced HDA package

Table 1: Key features of the Renesas ISL8274M digital power module

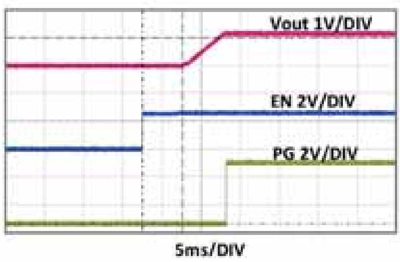


Figure 2: ISL8274M startup performance

chain, as well as the device that follows the sequence.

The ISL8274M integrates a voltage tracking scheme that allows one of its outputs (Channel 1 or Channel 2) to track a voltage that is applied to the VTRKP and VTRKN pins, with no external components required in two optional modes that are based on the specific application.

Protection Functions and Monitoring

A full list of protection functions is supported by the ISL8274M, including power input under-voltage/over-voltage (UV/OV), driver voltage, two levels of output current under-current/over-current (UC/OC) (average and peak), output voltage, and temperature under-temperature/over-temperature (UT/OT). Each protection has both a fault limit and warning limit. The user can set the corresponding fault limit value easily through PMBus commands. There are also different fault response options to choose from, including hiccup mode. Additionally, the designer can configure the response function through the PMBus command. The ISL8274M is able to monitor a wide variety of system parameters using PMBus commands.

The most complete set of protection functions and monitoring features are provided by the ISL8274M from Renesas. These functions protect the power system operation in a safer, more robust manner and provide increased system design flexibility to the designer.

Evaluation Board/User Guide

An evaluation board and detailed user guide for customer testing and evaluation are available for the ISL8274M. A photograph of the evaluation board is shown in Figure 3. Additional details can be obtained from the https://www.intersil.com/en/tools/reference-designs/isl8274meval1z.html website.

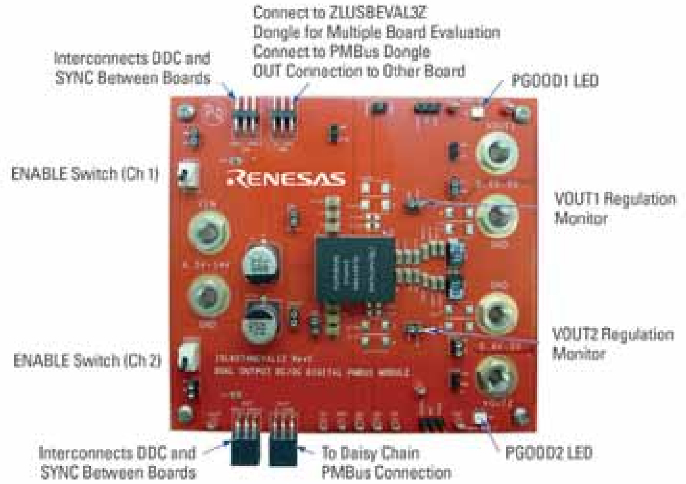


Figure 3: Evaluation board image of ISL8274M

PowerNavigator

The PowerNavigator GUI software offered by Renesas will help accelerate the design, testing, finalisation and debugging of your power design. It connects to development boards through PMBus to set various adjustable system parameters and threshold values. The final configuration is simply stored to non-volatile memory.

PowerCompass

The PowerCompass tool helps users quickly identify parts that match their specific requirements, set up multiple rails, perform high-level system analysis, and generate custom reference design files. The tool is available exclusively as a web app, from which users can also work offline.

iSim Design & Simulation Tool

Renesas provides a power web-based simulation tool called iSim, which is an easy-to-use, interactive power management and op-amp design tool. iSim allows the user to quickly select supporting components and design and simulate their circuit and system.

Conclusion

The ISL8274M digital power module leverages the Renesas patented ChargeMode control architecture to provide the highest efficiencies with better than 90% on most conversions. It provides a single clock cycle fast transient response to output current load steps common in FPGAs that process power bursts. Their compensation-free design keeps the module stable regardless of output capacitor changes due to temperature, variation or ageing. Its power density, high efficiency and fast transient response address demanding single and multi-rail power requirements. Learn more about the ISL8274M from the http://www.intersil.com/products/isl8274m website. ●

Detailed instructions and video tutorials on the PowerNavigator, PowerCompass, and iSim Design & Simulation Tool are available online and can help the user get started easily:

- http://www.intersil.com/powernavigator
- http://www.intersil.com/en/powercompass.html
- https://www.intersil.com/en/tools/isim.html

Colour sensing for embedded applications

By **Dr Dogan Ibrahim**, Professor at Near East University, Cyprus

Objects are usually recognised by their colour and shape, for example, "red apple", "green leaves" and so on. In electronics, a colour sensor detects or senses the colour of an object, for applications such as object recognition, product sorting, object tracking and counting, electronic games, entertainment, determining the freshness of perishable goods, and much more.

There are many wavelengths in the electromagnetic spectrum that the human eye cannot see. As shown in Table 1, the regions of visible light have wavelengths between approximately 380nm and 750nm.

The Eye

As light enters the eye through its lens, it is focused on the retina situated at the back of the eye. The retina has rods and cones with pigments that absorb light. There are over 100 million rods and over six million cones in each eye, concentrated around the retina.

The rods and cones are sensitive to visible light and they pass information to the optic nerve at the back of the eye. The rods help in low-level lighting vision (i.e. at night) and don't have much effect on colour vision. The cones are situated in the centre of the retina, enabling the eye to distinguish colours.

There are three types of cones depending on their sensitivities to the wavelength: long (L), medium (M) and short (S), associated with red, green and blue, although the colour reception is wider and there are overlaps; see Figure 1.

Colour Standards

The International Commission on Illumination (Commission Internationale de l'Eclairage), or CIE for short, looks after the topics of colour and its measurement. In 1931, the CIE established that there are three primaries known as XYZ for measuring colour. The tristimulus system is for visually matching a colour under standardised conditions against the three primary colours – red, green and blue; the three results are expressed as X, Y and Z, respectively, called tristimulus values. The possible sets of tristimulus values are represented in a two-dimensional chromaticity diagram (Figure 2), where x and y are the horizontal and vertical axis variables, respectively. (The boundaries and colour names are adapted from Brand Fortner, "Number by Colour", Part 5, SciTech Journal 6, p32, May/June 1996).

After determining the X, Y and Z values, the CIE 1931 chromaticity diagram coordinates x and y can be calculated using the following:

$$x = \frac{X}{X+Y+Z}$$

$$y = \frac{Y}{X+Y+Z}$$

$$z = \frac{Z}{X+Y+Z}$$

and, $$x + y + z = 1$$

Usually a colour is specified by its chromaticity and luminance as xyY. Then, X and Z can be obtained as follows:

$$X = \frac{x}{y}Y$$

and

$$Z = Y * \frac{(1-x-y)}{y}$$

Colour	Wavelength
violet	380–450 nm
blue	450–495 nm
green	495–570 nm
yellow	570–590 nm
orange	590–620 nm
red	620–750 nm

Table 1: Spectrum of visible light

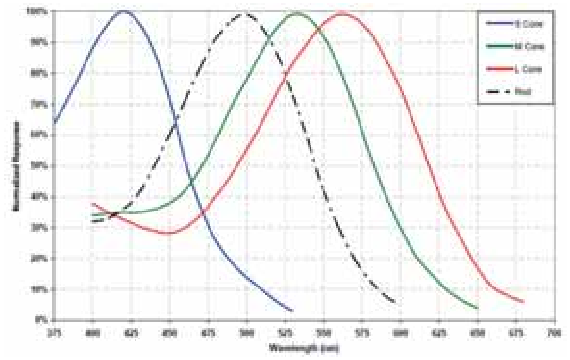


Figure 1: Eye rod and cone responses

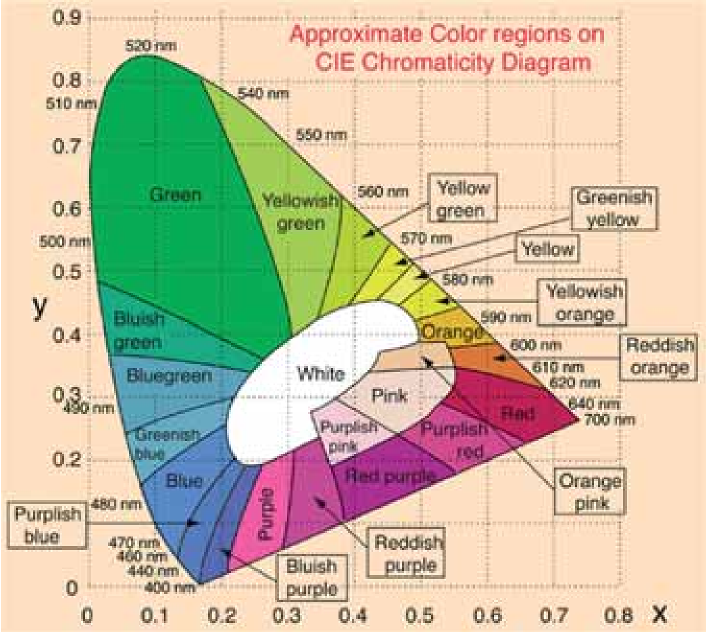


Figure 2: The chromaticity diagram

Colour Sensors

There are several colour sensors available for use in embedded applications. Figure 3 shows the TCS230 colour sensor popular with Arduino users. This sensor includes an 8 x 8 array of photodiodes and uses a current-to-frequency converter whose output frequency depends on the light intensity of the detected colour. The sensor operates between +2.7 and +5.5V and provides the light intensities of red, green and blue, one at a time. Red, green, blue and clear filters are used together with the photodiodes.

Spectral Click (Figure 4) is a multispectral light-sensing device, using a state-of-the-art sensor IC for very accurate chromatic white colour sensing. It provides a direct reading of the XYZ colour coordinates, consistent with the CIE 1931 2° Standard Observer colour coordinates. It provides mapping of the XYZ to the xyY coordinates of the two-dimensional colour gamut.

Cable connections over very long distances without transformers are not encouraged due to the risk of high voltage build-up and noise effects

This Click board also provides accurate correlated colour temperature (CCT) measurements and colour point deviation from the black-body curve for white light colour. Additionally, Spectral Click features a near-IR (NIR) wavelengths sensing channel, and two programmable LED channels with constant current.

The multispectral sensor IC used on the Spectral Click is the AS7261, an XYZ chromatic white colour sensor and NIR with electronic shutter and smart interface. This is a very advanced multispectral sensor, which includes a 6-photodiode array element. Every photo element is filtered through Gaussian filters, implemented through nano-optic deposited interference filter technology, designed to meet the XYZ standard observer filter characteristics, compliant with the CIE 1931 standard. This technology ensures minimal drift of colour readings and temperature stability.

It should be noted that filter accuracy will be affected by its angle of incidence, determined by an integrated aperture and internal microlenses, which is ±20.5° for the AS7261 IC. The measurements from the photo elements are digitised by the 16-bit ADC converter and processed by the Cognitive Light Engine (CLE). Besides the raw XY and Z values, the CLE calculates all the calibrated and mapped values available on this device. After the specified integration time, those values are available in their respective registers, and are accessible via the smart high-level UART interface driven by simple AT commands, or the I²C communication protocol bus. Even the temperature sensor can be accessed via its register.

There are two integrated, programmable LED drivers on the AS7261 sensor. The first LED constant current driver can be programmed up to 10mA and can be used as a status indicator. It is also activated during sensor firmware

Figure 3: TCS230 colour sensor

Figure 4: Spectral Click board

programming. The second LED driver is used to drive the light source that illuminates the surface to be measured. It can drive high-brightness LED with up to 100mA.

Both LED drivers are available through the communica-tion interfaces. The Spectral Click sensor is available on a mikroBUS-compatible board, and is supported by the mikroSDK software library.

Project: Colour Measurement

An example project is shown in Figure 5, showing how the Spectral Click colour-sensor board can be used in a microcontroller application. The Spectral Click board is plugged into mikroBUS socket of an EasyPIC V7 PIC microcontroller development board, which is equipped with an LCD readout. A medium-performance PIC18F45K22 microcontroller, driven from an external 8MHz crystal clock, is mounted on the development board. In operation, the sensor detects the colour of the object close to it, and its XYZ colour coordinates are displayed on the readout every second.

The Software

The software was developed using the mikroC for PIC integrated development environment (IDE), which includes a text editor, C compiler, simulator, debugger and a utility to upload the compiled program to the target microcontroller (MCU). In addition, several interactive utilities, such as terminal emulator, UDP/TCP interface, USB interface and LCD character design, are also provided. Rich built-in library functions are offered to interface to peripheral devices and make the programming task easier.

Listing 1 gives the project's complete program. The built-in UART establishes communication between sensor and microcontroller through specific AT commands, where the UART is output from the MCU's PORTC.

At the beginning of the program, the interface between the LCD and microcontroller development board are defined, where the LCD is connected to the MCU's PORTB. Then, function SystemInit is called to configure ports B and C as digital outputs.

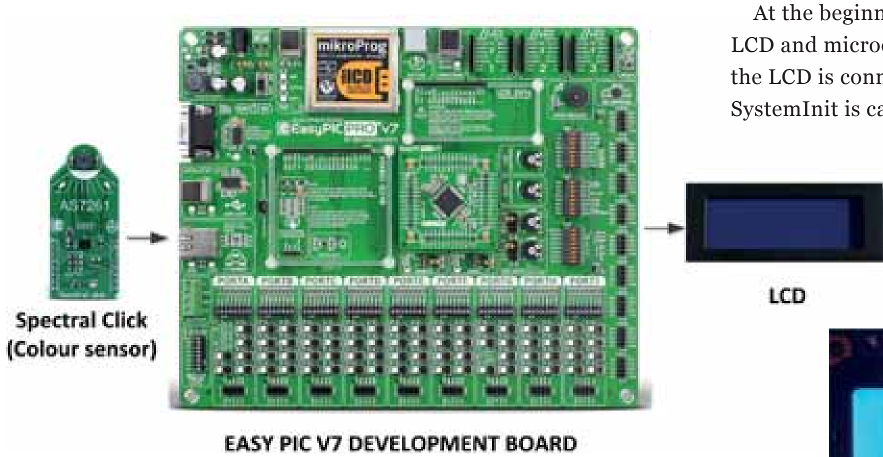


Figure 5: Project setup

Figure 6: XYZ colour coordinates with a light green object

The UART baud rate is set to 115200. The sensor is initialised by configuring its gain and mode.

The remainder of the program runs in an endless loop, with the sensor configured to return the raw XYZ colour coordinates as integer numbers by sending the AT command ATXYZR. Other commands are also available; for example, to return the calibrated XYZ values as floating-point numbers; to return the calibrated xy values of the CIE 1931 colour gamut; to configure the sensor; and so on. The program then reads the raw XYZ colour values and displays them on the second row of the LCD, every second. The text RAW XYZ VALUES is displayed on the first row of the LCD.

Figure 6 shows the LCD display when a light-green object is held in front of the sensor. The XYZ colour coordinates are displayed as 4, 6 and 2, respectively. Using the formula presented here and referring to Figure 2, we can see that on the colour chromaticity diagram this corresponds to an x value of 0.333 and a y value of 0.500. ●

```
/*******************************************************

 COLOUR SENSOR PROGRAM

 ========================

This program reads the raw XYZ colour coordinates
using the Spectral Click sensor board together with
an Easy PIC V7 microcontroller development board.
The sensor board is mikroBUS compatible and is
connected to mikroBUS socket 1 of the development
board. The program displays the raw XYZ colour
coordinates every second on an 2x16 character LCD.

*******************************************************
**/
// Lcd pinout settings
sbit LCD_RS at RB4_bit;
sbit LCD_EN at RB5_bit;
sbit LCD_D7 at RB3_bit;
sbit LCD_D6 at RB2_bit;
sbit LCD_D5 at RB1_bit;
sbit LCD_D4 at RB0_bit;

// LCD pin directions
sbit LCD_RS_Direction at TRISB4_bit;
sbit LCD_EN_Direction at TRISB5_bit;
sbit LCD_D7_Direction at TRISB3_bit;
sbit LCD_D6_Direction at TRISB2_bit;
sbit LCD_D5_Direction at TRISB1_bit;
sbit LCD_D4_Direction at TRISB0_bit;

char buffer[20];
char dat;
//
// Send data through UART including a carriage-
return
//
void UART(char str[])
{
 UART1_Write_Text(str);
 UART1_Write(0x0D);
}
//
// Initialise the UART,LCD, and the sensor
//
void SystemInit()
{
 ANSELB=0;
 ANSELC=0;
 LCD_Init();
 UART1_Init(115200);
 UART("AT");
 UART("ATGAIN=2");
 UART("ATTCSMD=2");
 Delay_Ms(1000);
}

//
// Start of MAIN program. Initialise the system, send
AT command to the
// sensor to request the raw XYZ colour coordinates
and then display
// these coordinates on the LCD
//
void main()
{
 SystemInit();
 while(UART1_Data_Ready() == 1)dat=Uart1_Read();

 while (1)
 {
 UART("ATXYZR");
 UART1_Read_Text(buffer,"\n",255);
 lcd_out(1,1,"RAW XYZ VALUES");
 lcd_out(2,1,buffer);
 Delay_Ms(1000);
 lcd_cmd(_LCD_CLEAR);
 }
}
```

Listing 1: Project program

A report from Hannover Messe

BY **LUCIO DI JASIO**, MICROCHIP TECHNOLOGY

I am writing this on the way home after spending three days in Hannover, Germany, where I visited one of the largest Industrial IoT (aka Industrie 4.0 for the German speakers) exhibitions in Europe. Hannover Messe is the home of CeBIT, which started as a computer show, and in the 90s was one of the largest consumer electronics shows in the world, now, however, eclipsed by CES in Las Vegas, US.

The humongous fairgrounds (I counted 27 pavilions) are kept in continuous use and top shape by the very efficient organisation of Deutsche Messe.

Figure 1 shows blue skies above the Hannover Messe's grounds; but don't be fooled, because for most of the week the weather was cold and rainy, bar the five minutes preceding this shot, on Thursday afternoon, when the clouds parted and the sun warmed up the air.

It is said that Hannover Messe attracts over 200,000 visitors in its week, resulting in a city under siege.

Figure 1: The fairground of Hannover Messe

Hotel rooms are booked months in advance, with prices ranging from 500 to 1,000 Euro per room, per night, for those that failed to secure one in advance. Being one of those late comers myself, I ended up finding a room nearly 100km south of Hannover (in Göttingen), commuting daily to the event via a high-speed ICE train. Despite the unusual arrangement, this turned out to be great, as the train's speed made the commute a breeze (about 20 minutes) and delivered me each morning in front of the west entrance of the Messe with perfect timing and in great comfort.

Looking for the IIoT

As you might know from my previous articles, I am among the IoT sceptics. This is not because I don't see the relevance of the new connectivity technologies, or I don't appreciate the potential disruptive ideas that connected/embedded products can bring to consumers, but rather because of the vagueness of the term IoT itself and the massive hype surrounding it. So, whenever someone utters this acronym, my first question is: "What kind of IoT would that be?", followed by "Why?".

My primary reason to visit Hannover was to find out what 5,000 exhibitors thought IIoT meant

In fact, I find "Why" most important, because I've come across too many IoT ideas that are pure hobby projects or explorations of sorts without a clear purpose. Too many design teams I encountered were busy developing "things" without a clear strategy, or a financial model, or a clear revenue path to compensate for the added cost and complexity of their products once data is collected and sent to the Internet.

The Industrial IoT, or IIOT, label seems a bit more specific, but only a tiny bit. Industrial applications are so many and so varied. My primary reason to visit Hannover was to find what 5,000 exhibitors thought IIoT meant.

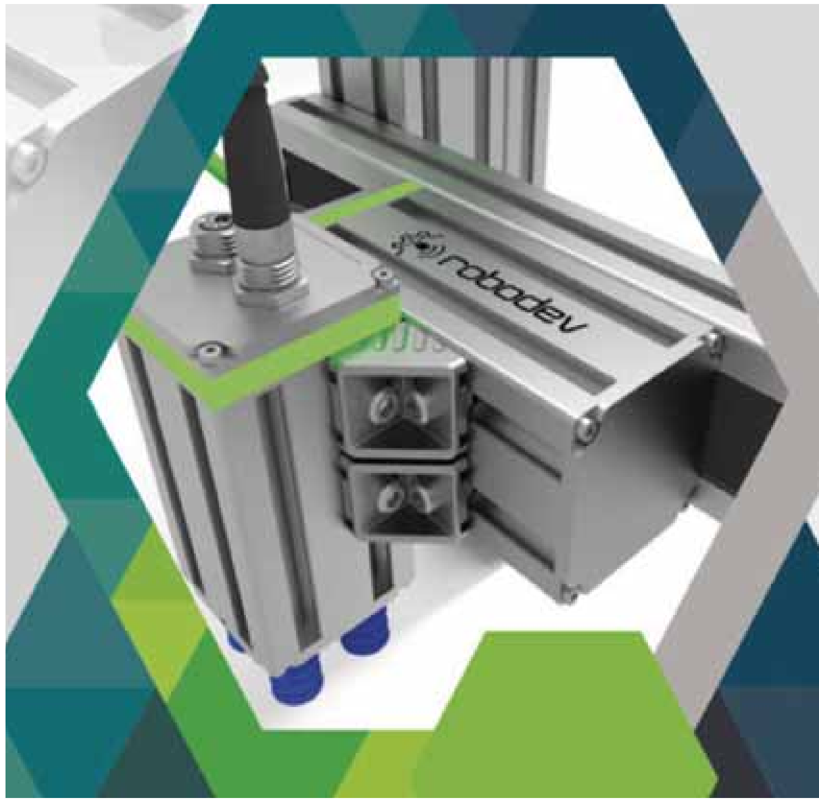


Figure 2: Robodev's rapid development factory automation solutions

The Answer is 42

For those familiar with the Douglas Adams classic *'The Hitchhiker's Guide to the Galaxy'*, it won't be a surprise to learn that, after a week of intense investigations, I found out the answer to be exactly 42!

No, seriously! IIoT meant something completely different to each one of those exhibitors. In every booth, each company had a perfect excuse to claim ownership of the term and offered a slightly twisted explanation of why the Internet of Things was making their latest product (all of them, even) better, newer, shinier.

I found some of those interpretations a stretch too far, so I ignored them to shave a few miles off my daily excursions. Four huge pavilions, for example, were filled with "metal works", consisting of cast metal parts (some truly impressive), CNC machined parts and equipment/tools.

Beyond being the pride of the many German (but not only) companies at the show, I completely understood how their presence was simply to tag along to get some of the IIoT light shine on them, if only by proximity.

Cloudy

The more serious interpretations of the term IIoT were found in the other four sections of the exhibition: Digital Factory, Energy, Motion and Drives, and Research and Technology.

But even there I found its definition mostly cloudy.

A couple of mantras were being repeated over and over, with a relatively convincing tone and/or relationship to the product/demo displayed:

- "Integration of all factory systems" was touted mostly by the dominant (German) players, although it was clear that their interpretation of integration was relatively self-serving: Integration is great when all parts come from the same vendor!
- "IIoT is to feed the coming artificial intelligence era" was another frequently-used claim, hinting at the potential benefits of the upcoming AI revolution and its huge appetite for raw data.

When looking in detail, though, most of the IIoT solutions proposed by hardware manufacturers consisted basically of slapping an Ethernet interface, usually a Linux box, onto an existing industrial controller and calling it "Cloud-connected". Motion and drive companies would show lots of fast-moving robots, doing what robots do inside their glass enclosures, but claiming remote configuration and control from "the Cloud" (...for easier hacking...?). Whereas software and consulting companies would display some entertaining toy constructions (often Lego, or 1800 German handcraft toys), and suggestive (stock) images of large factory floors, with word "security" used profusely in large font.

As is now a tradition, a daily "live hacking" show demonstrated how the earlier-mentioned Linux box, used to claim Cloud connectivity by the poor hardware manufacturer victim du jour, was found to be misconfigured and quickly hacked into to the amusement of the audience. Applause!

And Then a Few Pearls

Among so much stuff though, I was glad to find some pearls, at least to my very opinionated eyes.

In the factory automation area, for example, Robodev, a small start-up from the Karlsruhe area, Germany, used Cloud connectivity to offer a rapid development environment to connect and sequence the operation of small robotic components. The company's graphical user interface worked from inside any browser, and its modular mechanical system (Figure 2) allows engineers to assemble small factory flows with the same ease that children assemble Lego blocks. Brilliant!

In a corner of Halle 6, in less than 50m of exhibit frontage, you could find both AWS (the Amazon Web Services) and the Google Cloud booths almost side by side, conveniently separated visually by a mysterious ivory and glass impenetrable monolith that turned out to be Accenture's booth.

Clearly Google and Amazon are among the few who can speak of Cloud and IoT with authority, and they did offer the two important things I was looking for:

- Testimonials of real applications where the Cloud/IoT solution had been put to work in practice, and provided a new and often disruptive business model.

  The Amazon booth, the larger of the two, was rather rich with compelling examples in logistics, agricultural and energy solutions.

- Demonstrations of real-world applications of artificial intelligence applied to the data provided by Industrial IoT solutions. Google was perhaps the most convincing here with partner stations demonstrating "adaptive applications" and "preventive maintenance" such as Tellmeplus and Relayr among the many featured. The Google brand name in the world of AI is perhaps even larger than its brand name in Cloud and quantum computing, conveniently underpinned by its global infrastructure's size and strength.

Much to my delight (and with a bit of pride, I must confess), at the Google Cloud booth, I found a Microchip representative demonstrating how simple and low-cost sensor nodes can be implemented without compromising on security by using Secure Elements (ATECC608A); see Figure 3.

A secure element is a minuscule 8-pin device that can offload all the crypto-authentication needs of an application that aspires to connect to the Google IoT Core Cloud. Secure elements provide Elliptic Curve cryptography support, key generation and secure storage (of keys and certificates), to achieve a complete "chain of trust" from the sensor node to the Cloud server with small and low-power microcontrollers at the cost of a few kilobytes of code and a pair of pins (it's just an I²C device, after all).

So, you won't need to add a power-hungry quad-core Intel processor running Linux (Raspberry Pi 3?) to push your sensor-node data securely to the Google Cloud, just a tiny 8-pin chip with the power budget of an LED will suffice.

Figure 3: The Google IoT core demo of the ATECC608 secure element

A Smile for Confidence

I left the Google booth and headed for the train home with a smile on my face. In the previous days I had seen a lot of IoT hype and I was starting to doubt there was any new substance to it. After it all, I remain convinced that this was just not the right exhibition for me. The words Industrial and IoT here were linked by a very thin (invisible!) thread, and most visitors seemed simply happy to find these buzzwords stitched onto the same old (industrial) product they were happy to continue to buy. Only in the very end, in that obscure corner of Halle 6, a glimpse of true novelty and pragmatism restored my confidence that somebody will actually make these "things" happen. ●

Figure 1: Profibus

Industrial Ethernet boosts Industry 4.0 applications

By Steve Hughes, Managing Director, REO UK

Industry 4.0 is thriving. The increased use of automation in a wide variety of applications has put manufacturers under significant pressure to ensure their equipment communicates effectively and in real time.

During the 2017 Confederation of British Industry (CBI) conference, Duncan Logan, founder and CEO of Rocketspace said: "It's innovation if you're already doing it; disruption if you have your head in the sand." This is the difference between successful companies and those that will inevitably get left behind in today's technologically advanced society.

It's from this philosophy that we're seeing the era of Industry 4.0 emerge and steer the ever-changing processes of manufacturing. Industry 4.0 is the collective term for the technological concepts behind value chain organisation. The Internet of Things (IoT) is just one of several elements of Industry 4.0, facilitating the concept of the 'smart factory'.

The convergence of automation and connectivity as part of Industry 4.0 has made it possible for manufacturers to connect their equipment, so everything from machinery and motors to mobile devices and IT systems can communicate with each other and record data. Embracing this trend improves business competitiveness as efficiencies improve and quality customer experience is maintained.

In the water treatment sector, companies are digitalising their systems to increase energy efficiency and minimise water consumption. The level of contamination of domestic and industrial wastewater differs greatly chemically and biologically, so plant managers are required to monitor the process for safety and control purposes. Failure to generate and provide necessary data can be costly and time-consuming, so having interconnected devices not only improves productivity, but also supports administrative processes and compliance.

IT/OT Convergence

By embracing trends like Industry 4.0 and enhanced levels of factory automation, the need for fast and reliable data has made Fieldbus communications such as Profibus and Profinet more important.

Fieldbus is the term given to an industrial network system for real-time distributed control, providing manufacturers with a resource to connect a wide range of instruments in a plant. Being able to connect various devices to a centralised control system is essential for modern businesses to record real-time insights and carry out forecasting.

Delays or interruptions in real-time systems can produce substandard results in the form of wasted product, or decreased productivity because of poor-performing machinery. For industrial plant installations, managers are therefore required to consider the environment the equipment must operate in to ensure the reliability of components.

> **Failure to generate and provide necessary data can be costly and time-consuming for plant managers**

Unlike the requirements for IT equipment, which is intended for use in controlled environments, components used in industrial settings must be designed to operate in harsh conditions. This includes being able to tolerate varying and extreme temperatures, vibration and electrical noise.

Electrical noise is generated by most modern electrical devices. Variable speed drives (VSDs), switching power supplies (SMPSs) and thyristor power switching are common examples of noise sources in an industrial environment. This noise can cause problems with data transfers, resulting in delays and even corrupt messages communicated across the network.

As the use of automation increases in every sector, businesses need to find ways to reduce the problems surrounding electrical noise and provide electrical isolation to equipment to prevent damage.

This should be a priority for manufacturers of all sizes. As Joe Gemma, president of the International Federation of Robotics, said: "Automation is a central competitive factor for traditional manufacturing groups".

Improving power control and connectivity will help businesses enhance the efficiency of their production processes. To do this, plant managers can use equipment or Fieldbus interfaces that feature Ethernet-based communication protocols, including the industrial Ethernet communication standard Profinet and the industrial network protocol Ethernet/IP. These protocols are designed to specifically operate in industrial environments, allowing simple control of a plant's IT/OT and other information, like a machine's speed control, operating levels and temperature.

Ethernet-based protocols like this offer faster and more reliable communication between devices, compared to traditional serial-based protocols like Profibus and CANBus. This is because Ethernet-based protocols have been specifically developed from 10Mbit/s to 1Gbit/s to meet the demands and speed of increasingly-complex production facilities; earlier serial communication protocols were simply not designed to operate at this level.

Connecting Power Quality

Transmitting and receiving a vast amount of data at a consistent rate allows managers to collect and examine the data for trends. This information can then be used to schedule maintenance and ensure that cost preventative processes are carried out to mitigate any unplanned downtime, which can result in production and financial losses. For example, by monitoring the current and voltage levels in an impressed current cathodic protection (ICCP) system, engineers can lengthen the interval between site surveys, as well as improve corrosion control of the asset, be it a bridge or pipeline, and thus significantly increase the return on investment.

Figure 2: Profibus in application

Ethernet-based protocols are readily utilised in Cloud-based solutions, providing manufacturers with a simpler transition to Industry 4.0 applications. Integrating Profinet and Ethernet/IP compatibility into the Fieldbus interface means manufacturers can ensure reliable communication so the product is handled carefully, without causing damage.

Real-Time Insights

Whether it's conveying, sorting or packaging in the food and beverage industry, or applying the latest coating for rust prevention in the industrial sector, manufacturers must keep pace with market requirements. By building a reliable, centralised control system, businesses can use real-time insights to effectively manage their plant and reduce costs. ●

PLCs vs PACs – making the right choice

By Jonathan Wilkins, Marketing Director, EU Automation

According to Hennik Research's Annual Manufacturing Report 2018, 85% of manufacturers are ready to invest in digital technology to help develop Industry 4.0. As more technologies enter the factory, manufacturers need to be certain they are investing in the right equipment to control their systems. Automated systems are a crucial part of Industry 4.0, and an industrial control system coordinates the devices, systems and networks used to manage industrial processes.

Control Systems

There are several types of industrial control systems, including Supervisory Control and Data Acquisition (SCADA) and Distributed Control Systems (DCS). They each contain several components to provide local and overall management.

Depending on the application, a SCADA or DCS system may be more appropriate, but all automated systems are built with a programmable logic controller (PLC) or (the newer) programmable automation controller (PAC) – industrial computers that control individual machines or stations in manufacturing environments. These are vital to manufacturing operations since they control factory-floor automation equipment. For example, PLCs can be used to locally manage processes in conjunction with control devices such as sensors and actuators.

Before PLCs and PACs, manufacturers used relay control systems to handle discrete functions and independent loop controllers for analogue functions. These expensive systems took up a vast amount of facility space, they were time-consuming to adapt and difficult to maintain.

PLCs and PACs

In the 1960s, Dick Morley built the first PLC as a cheaper and more efficient alternative to relay systems. Since then, the technology has advanced to control a growing number of intelligent devices. Compared with relay systems, PLCs offer more functionality and can be programmed more quickly and efficiently with PC-based software.

PACs are a newer addition to the automation market and are generally more complex than PLCs. However, many industry professionals cannot agree on what differentiates PLCs from PACs because advancements in modern technology have reduced the gap between the two. One main difference, however, is the way they are programmed: PACs with C and C++, and PLCs with ladder logic.

The programming with C and C++ makes PACs more adaptable and efficient, as an engineer can reprogram them by writing a new set of code. On the other hand, PLCs' programming language uses symbols representing electrical schematics of relays. This form of programming is sequential, making PLCs largely inflexible. Nevertheless, the way the two computers are programmed creates distinct capabilities for each.

Unlike PLCs, PACs can multitask easily by operating in multiple domains such as motion-, discrete- and process-control

PLCs are single micro-processor-based devices. They are typically programmed to carry out simple execution scans; they have limited memory and discrete input/output (I/O) capacity.

PACs normally use two or more processors, like using a PC and a PLC together.

PACs are also made up of various computer-based applications, making them more flexible to program. Unlike PLCs, PACs can multitask easily by operating in multiple domains such as motion-, discrete- and process-control.

Applications

How each technology is programmed alone will not determine its use in a specific automation system. To determine which is best, manufacturers need to consider the application where they'll be used and the scalability of each in the future.

PLC's programming makes it ideal for controlling simple applications with minimal I/O requirements. PLCs should be used for basic control schemes where complex analogue and motion controls are not necessary. In other words, there is no need to pay a higher price for a PAC if the application does not require a higher level of functionality.

However, PLCs were developed for more functions. Modern PLCs have built-in networks, enabling them to communicate with other PLCs, human machine interfaces (HMIs) and SCADA systems. Because of this, a PLC might be enough to fulfil all plant's automation needs.

PACs are also used because of their interoperability. They are optimal for large applications but can be scaled down for use on smaller ones. Their modular design makes them useful in simplifying expansion processes, as adding or removing components is easy to execute. Their compatibility with other components also allows PACs to communicate with other PLCs and higher-level computing systems such as manufacturing execution systems (MES) and enterprise resource planning (ERP) systems.

Programmers are starting to push PACs one step further by integrating third-party applications and real-time control. Companies may soon be able to run PC applications, such as Windows, in real time, maximising flexibility and integrating control and information. Using PACs alongside other networks can improve the efficiency of the entire business.

Based on differences in programming and capabilities, it appears that a PAC is the logical choice to control an automated system. However, manufacturers need to consider what they need for the facility now and in the future, so they can make the best choice.

There is no need to install a PAC to run machinery that uses simple programming. Similarly, if manufacturers are looking for a technology that will grow in capabilities as the business grows, it's better to invest in a PAC than having to replace PLCs in the future.

Future-Proof

As more intelligent technology is introduced, the capabilities of PLCs and PACs must evolve to maintain control.

Internet connection allows PLCs and PACs to collect real-time information about manufacturing operations and share it with manufacturers across the world. Connectivity also enables manufacturers to remotely control PLCs or PACs and change their functions, allowing businesses to adapt manufacturing operations without shutting down systems and increasing downtime.

For PLCs and PACs, connecting to a central system and the Internet introduces a cyber-security risk. Manufacturers must manage the security of their systems to reduce a risk of an attack impacting their facility, like the worm Stuxnet did. An attack on a PLC or PAC can have serious implications, which manufactures must consider.

There are many similarities between a PLC and a PAC, and each technology has a time and a place where it works best. ●

PACs are pushed one step further by integrating third-party applications and real-time control

Who needs a transformer?

By Kansal Mariam Banu Shaick Ibrahim, Design Engineer, Microchip

Applications that are sensitive to cost or operate in harsh conditions may benefit from not using a transformer. A magnetic-less design could be applied anywhere when two known, fixed Ethernet devices need to communicate over a known distance, for example such as the same PCB board or backplane, as in a VME chassis.

To appreciate non-typical transformerless application development constraints, it is first necessary to understand the physical network services and signalling, and the functions that transformers provide in typical applications. A typical network configuration consists of a point-to-point connection through a cable between two physical-layer devices.

Figure 1 shows a schematic for a typical transformer interface for physical layers (PHYs) that employs current-mode drivers. The transmitter and the receiver of each node are DC-isolated from the network cable by 1:1 transformers. Transformers provide the functions of DC isolation from the cable and DC biasing at the physical layer. Isolation is necessary to meet the IEEE 802.3 AC and DC isolation specifications for cabled configurations.

Similarly, Figure 2 shows a schematic for a typical transformer interface for PHYs that employs voltage-mode drivers and on-chip terminations.

Configuration

To meet the operational requirements of non-typical transformerless network applications, it is necessary to implement physical-layer component transmit and receive separation and bias. To meet the specific safety requirements for the application, high-voltage DC isolation is also needed. For non-typical applications, the isolation the transformer provides can be realised using non-polarised capacitors.

A typical network configuration provides the services of auto-negotiation, auto-MDI-X, and 10Mbit/s and 100Mbit/s operation. Auto-MDI-X refers to versions of the medium dependent interface (MDI) that detect if the connection needs a crossover, and automatically chooses the MDI or MDI-X (with crossover) configuration to match the other end of the link.

Auto-negotiation and auto-MDI-X should be disabled in a transformerless application and a current-controlled PHY, done because both PHYs are under local control. With a voltage-controlled PHY, it doesn't matter if auto-negotiation is enabled or disabled.

The system designer can configure a specific speed and duplex on both devices to ensure proper communications. Based on lab testing at Microchip, two PHY devices can link

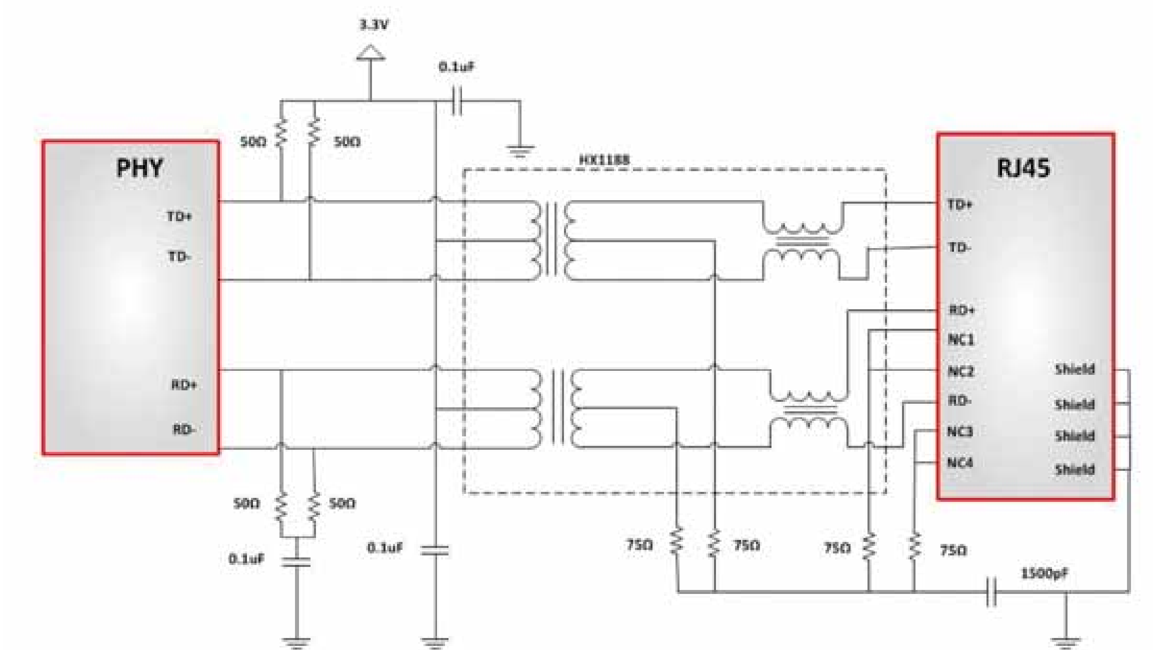


Figure 1: Typical transformer isolation for PHYs, employing current-mode drivers

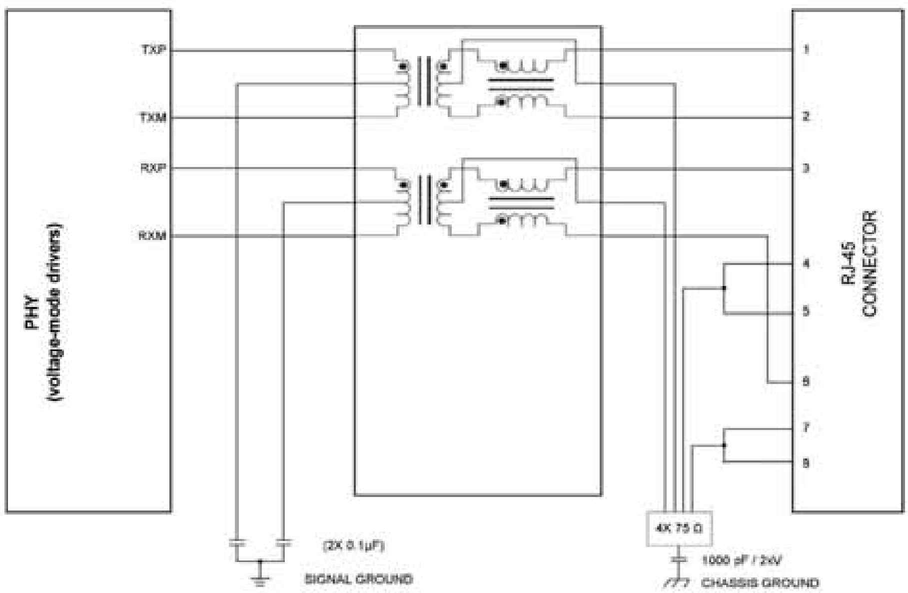


Figure 2: Typical transformer isolation for PHYs that employs voltage-mode drivers and on-chip terminations

and communicate successfully with both auto-MDI-X and auto-negotiation enabled, but there are a few seconds of delay from reset to link. Disabling auto-negotiation and auto-MDI-X will prevent this delay during system start-up.

The IEEE 802.3-2008 specification requires the TX and RX lines to run in differential mode. The TXP and TXN lines form a differential pair and need to be designed to 100Ω differential impedance for long distances and 50Ω differential impedance for short distances. The RXP and RXN lines also form a differential pair and need to be designed to appropriate differential impedance targets.

Auto-Negotiation

The purpose of the auto-negotiation function is to configure the transceiver automatically to the optimum link parameters, based on the capabilities of its link partner. Auto-negotiation is a mechanism for exchanging configuration information between two link partners and for automatically selecting the highest performance mode of operation supported by both sides. It can be disabled by clearing the auto-negotiation enable bit of the PHY basic control register. The transceiver will then force its speed of operation to reflect the information in the PHY basic control register speed-select LSB and duplex mode. These bits are ignored when auto-negotiation is enabled.

Auto-MDI-X

Auto-MDI-X facilitates the use of Cat3 (10baseT) or Cat5 (100BaseTX) UTP interconnect cable without consideration of the interface wiring scheme. If a user plugs in either a direct connect LAN cable or a crossover patch cable, the transceiver can configure the TXPx/TXNx and RXPx/RXNx twisted-pair pins for correct transceiver operation. The internal logic of the device detects the TX and RX pins of the connecting device. Since the RX and TX line pairs are interchangeable, special PCB design considerations are needed to accommodate the symmetrical magnetics and termination of an auto-MDI-X design.

Software-based control of the auto-MDI-X function can use the auto-MDI-X control bit of the PHY special control and status indication register. When the auto-MDI-X control bit is set to 1, the auto-MDI-X capability is determined by the auto-MDI-X enable and auto-MDI-X state bits of the PHY special control and status indication register.

Physical Connection

Figure 3 shows the physical connections for the Microchip LAN9XXX devices that have integrated PHYs with current-mode drivers. The LAN8XXX products and the KSZ88X1 also have current-mode drivers.

The transmitter output is designed to sink current into a transformer. When the transformer is not used, load resistors must be connected at each device to develop the output voltage.

The RX pins are configured with 50Ω to the supply for auto-MDI-X operation where they may be configured as TX pins. If auto-MDI-X is disabled and the RX pins are for receive mode only, then the external termination can be tied in any way possible, as long as there's a 100Ω-differential across the pins.

Figure 4 shows the physical connections for the Microchip KSZ8081/KSZ8091 Ethernet PHY transceivers with voltage-mode drivers and on-chip terminations. With the voltage-mode implementation, the PHY transmit drivers supply the common-mode voltages to the two differential pairs. With on-chip terminations, no external load resistors are needed.

Distance Considerations

When designing a system to connect two Ethernet devices without transformers, the distance between the two devices impacts the hardware required. As a general guideline, any distances less than a meter would fall into the short distance

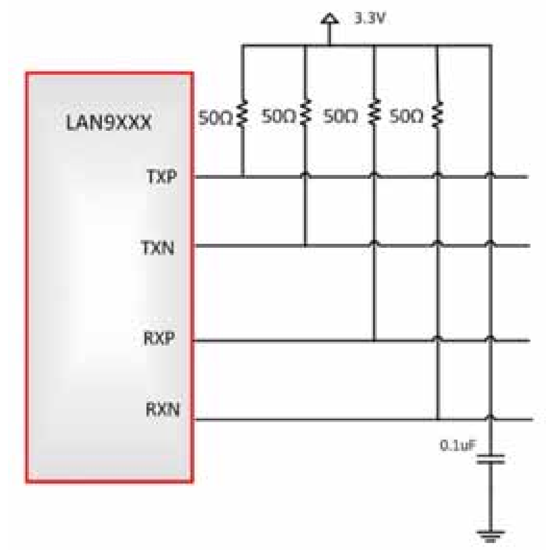


Figure 3: Load resistors in transformerless application for PHYs that employs current-mode drivers

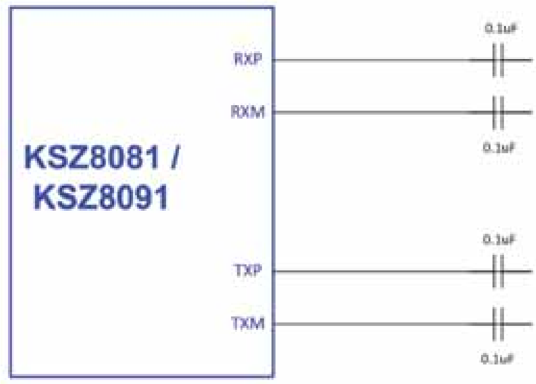


Figure 4: No-load resistors in transformerless application for PHYs that employs volt-mode drivers and on-chip terminations

category, when 50Ω resistors can be combined to give a single 25Ω resistor.

For long-distance communications (over a meter), both Ethernet devices should have terminating resistors on each analogue pin. Examples of long-distance configurations include backplane-connected devices or long-cable-connected cards. Proper laboratory validation should be performed to provide optimum resistor placement. Cable connections over very long distances without transformers are not encouraged due to the risk of high voltage build-up and noise effects.

Examples

The LAN9XXX devices do not require DC blocking capacitors at the RX pins. When connecting to another Ethernet device, it may be necessary to include capacitors. An example of connecting to the LAN9115 single-chip 10/100 Ethernet controller is shown in Figure 5.

A PHY with voltage-mode drivers and on-chip terminations can be connected to a PHY with current-mode drivers and external terminations. ●

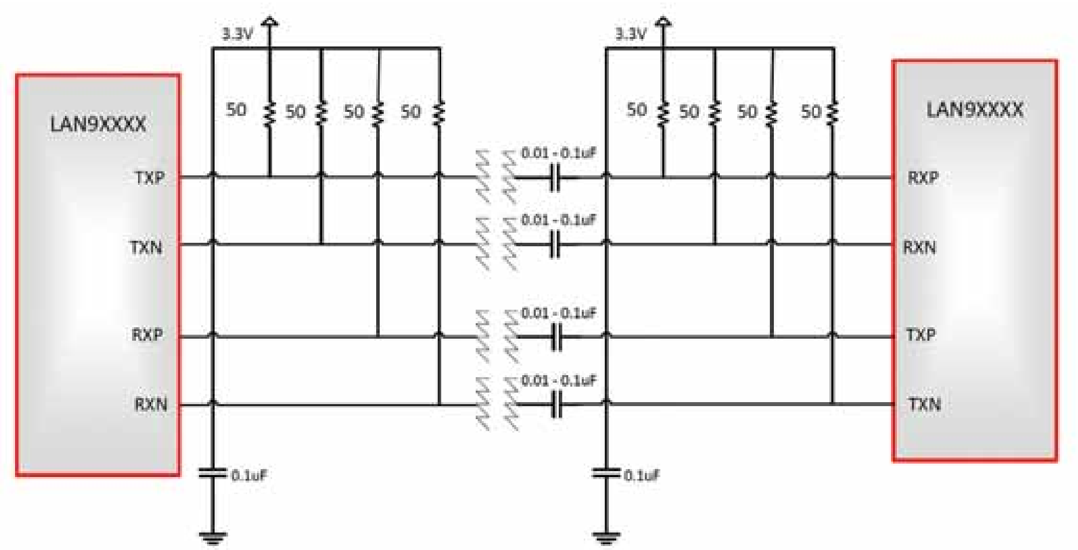
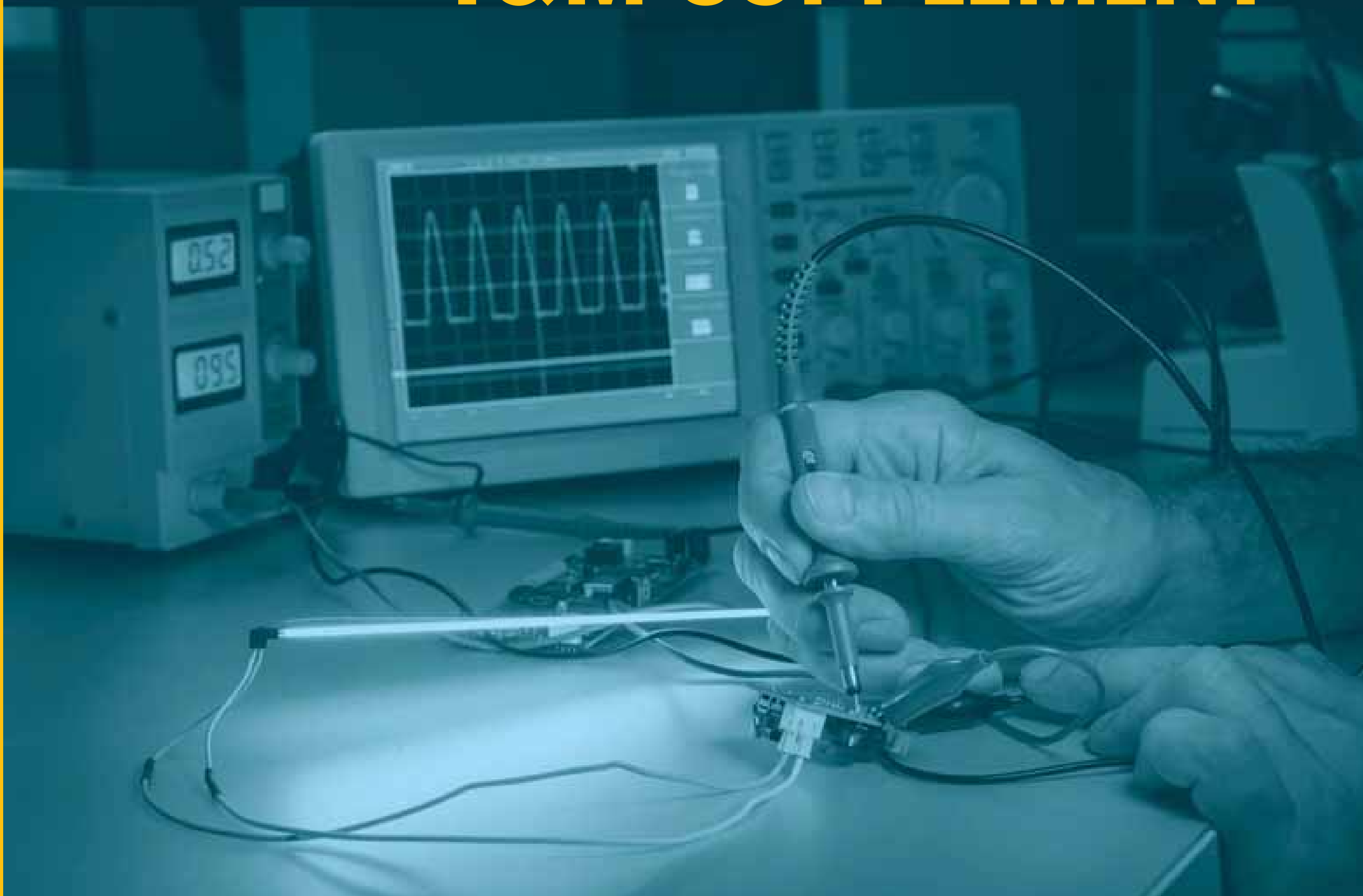


Figure 5: Other devices may require a DC-blocking capacitor

www.electronicsworld.co.uk

Electronics WORLD

T&M SUPPLEMENT



Contents

Effective debugging of USB 3.1 and PCIe interfaces

By Guido Schulze, Product Manager, Rohde & Schwarz

Growing data volume and ever-increasing processing and transmission speeds have become major challenges for board designers. The most widely used fast data interfaces are the DDR memory interfaces (DDR2, DDR3 and DDR4, including the low-power variants) and the USB and PCI Express (PCIe) serial communications interfaces.

USB is now used everywhere, from standard PC and consumer electronics to automotive, industrial and medical applications. The USB interface not only offers higher data rates of 5Gbit/s for the USB 3.1 Gen 1 (SuperSpeed) standard and 10Gbit/s for the Gen 2 (SuperSpeed+) standard, it also has improved power and charging functionality thanks to the USB Power Delivery specification.

Another key innovation is the uniform connector. The USB Type-C slim plug can be connected in any orientation and is suitable for mobile devices. It features fast data rates, handles up to 100W (5A and 20V power delivery modes) and even supports DisplayPort and Thunderbolt.

The PCIe interface is also enjoying more widespread use. Originally developed for the computer industry, it is now found in many embedded applications for connecting auxiliary devices and components to the CPU, or for converting from USB or UART to PCIe.

The powerful PCIe 4.0 (Gen 4) is nearly ready for introduction and offers a maximum data rate of 16GT/s. However, embedded applications are adequately served by the first- and second-generation interfaces, which operate at 2.5GT/s and 5GT/s, respectively.

Generally, each new interface generation supports the operating modes of earlier generations. That is why devices frequently boast Gen 2 or Gen 3 interfaces yet operate at the first generation's maximum data rate of only 2.5GT/s during dedicated operation, and must be tested accordingly.

Signal Integrity

Secure data transmission via a digital serial interface such as USB or PCIe relies on error-free transmission of binary signals in the physical layer. The key components in the transmission chain are the transmitters, transmission line and receivers. Developers must ensure that signals in these parts comply with the relevant interface standards.

In practice, the challenge lies primarily in the board design. On the one hand, the signal integrity of the transmission line must be considered because the plugs, vias and relays, for example, could affect the transmission of signals over PCB lines or cables. On the other hand, the fast data interface must be protected against interference from nearby components. Signal lines that run too closely together, for example, could result in crosstalk even though USB and PCIe use differential signalling.

In most cases, transmitters and receivers are standard components whose specifications have been tested by the manufacturer. However, this does not rule out faults in the wiring, or problems with the quality and stability of the reference clock or the power supply, which is why these must also be tested during board development.

Eye Diagrams and Histograms

Displaying a digital signal in an eye diagram is an effective way of assessing its quality. The signal bits are written separately on top of each other and accumulated into a diagram. A typical eye diagram is a result of the many bit transitions from 0 to 1 and 1 to 0; see Figure 1.

Several quality parameters for a signal transmission can be determined from the eye diagram. For example, the horizontal axis shows the eye opening over time and the jitter at the sides of the eye (bit transitions), while the vertical axis shows the vertical eye opening and noise.

USB and PCIe interface standards define masks for eye diagram tests that make it easy to assess whether the minimum required eye opening for reliable data transmission is provided. Figure 2 shows an example from the PCIe CEM Gen 2 specification at a data rate of 2.5Gbit/s.

Histograms enable circuit designers to learn valuable details about jitter distribution and amplitude noise by observing the bit transitions horizontally and the eye centre vertically. An example measurement using a 6GHz oscilloscope is shown in Figure 3. The test signal comes from a PC plug-in board with a PCIe Gen 2 interface (2.5GT/s mode).

In the histogram, a Gaussian jitter distribution can be seen on the right edge of the eye. The histogram is also good for other measurements such as peak-to-peak jitter (max-to-min) and RMS jitter (standard deviation).

CDR Trigger for Fast Eye Diagram Tests

A time reference is required to correctly overlay the bit sequences for the eye diagram. In addition to transmitting data, parallel data interfaces such as the DDR memory interface also transmit a clock signal that defines the precise start and end times for the transmission of each data bit. Serial data buses such as USB or PCIe embed the reference clock in the data signal, and the receiver has to use clock data recovery (CDR) to extract it. The extracted clock signal is then used to sample the incoming data stream.

CDR uses a regulating component such as a phase-locked loop (PLL) or delay-locked loop (DLL) to follow frequency variations. While this ability to flatten out frequency variations is excellent for stable data transmission, it makes testing more difficult. The traditional approach of using the test instrument's clock for reference reduces the test margin and can even make testing impossible. Some standards also use frequency modulation, such as spread spectrum clocking used by PCIe (~ 30kHz triangular modulation) to reduce electrical emissions.

For all these reasons, it is necessary to take the behaviour of the receiver's CDR into consideration to successfully test embedded clock signals. Oscilloscopes that use the hardware CDR option to display the eye diagram give users a clear advantage. Its behaviour with respect to PLL order, bandwidth and damping can be configured to test in line with different protocol specifications that describe the receiver's CDR in detail; see Figure 4.

With this hardware CDR option, the extracted clock signal is used as trigger source (Figure 5), ensuring that the data bits are all synchronised.

An oscilloscope with acquisition rate of up to one million waveforms per second and hardware CDR can very quickly overlay a large number of data bits to produce an eye diagram with high statistical reliability. Whereas traditional software CDR analysis is performed during post-processing of the individual waveforms, which is inconvenient and time consuming.

Preventing Contacting Errors

Correct probe contacting is key to reliable results when measuring fast signals. The most common method is to use the solder-in tip module; see Figure 6. For all methods, the contacts should be kept as short as possible to minimise additional inductance and capacitance. This also applies to soldered connections; the solder contacts should not exceed lengths of two to three millimetres.

Fast data interfaces primarily use differential lines for signal transmission. A differential probe is used to tap the two V_P and V_N signals. An additional ground connection is highly recommended to ensure a stable and reliable test environment with

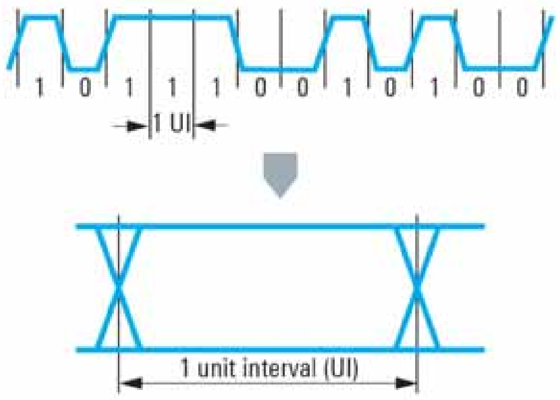
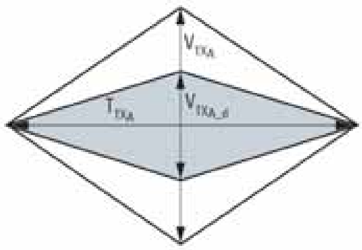


Figure 1: Eye diagram of a data signal (UI = 1/data rate)



Parameter	Min.	Max.	Unit
V_{TXA}	514	1200	mV
V_{TXA_d}	360		mV
T_{TXA}	287		ps

Figure 2: Eye mask from the PCIe 2.0 specification (2.5GT/s mode)

Figure 3: Eye diagram of a signal as specified in PCIe Gen 2 (2.5GT/s), including mask test and histogram, measured with an R&S RTO2064 oscilloscope

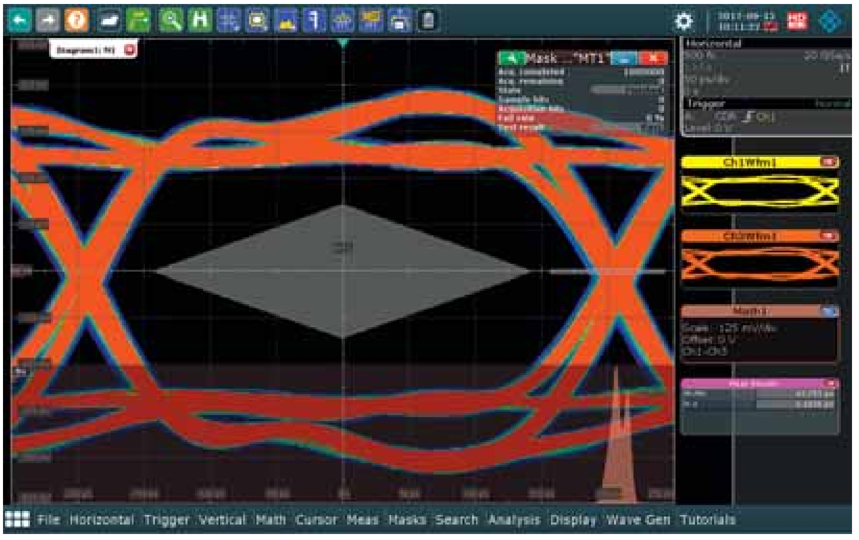


Figure 4: The R&S RTO oscilloscope's configurable hardware CDR

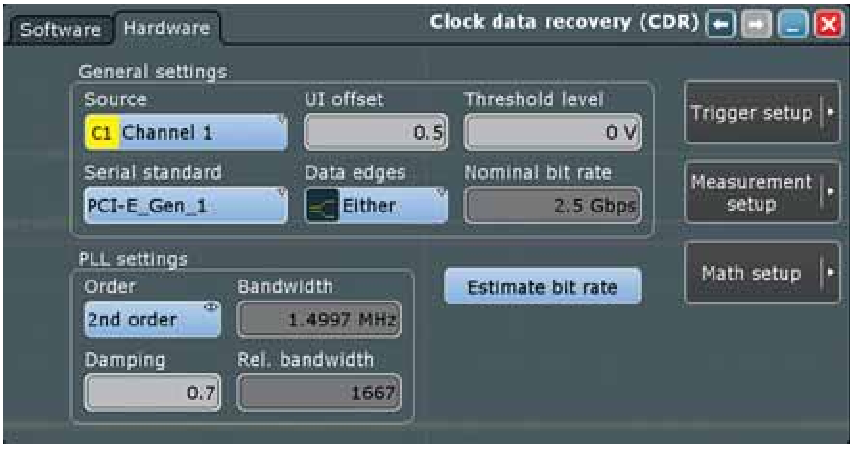
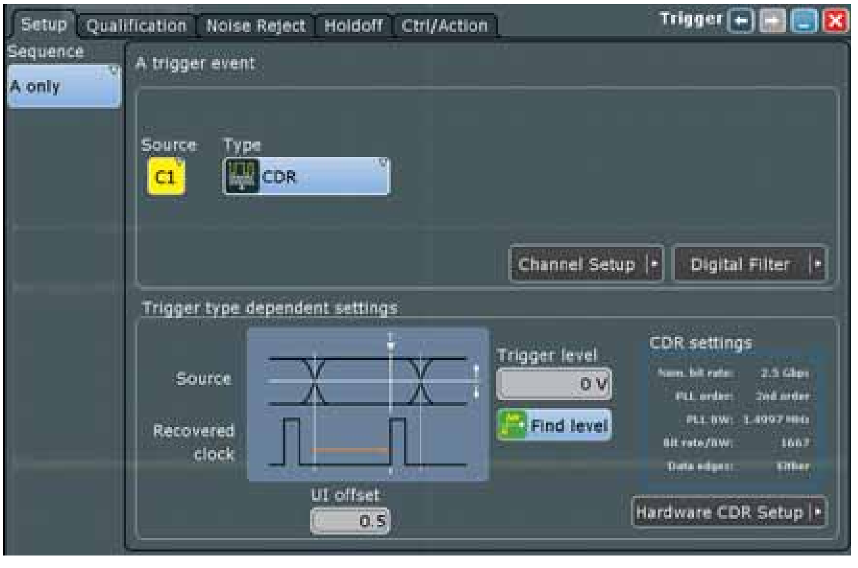


Figure 5: Selecting the CDR as the trigger source when using the R&S RTO-K13 hardware CDR option



minimal parasitic effects and a good common mode rejection ratio (CMRR).

Compliance Tests for USB and PCIe

Standardisation committees such as the USB Implementers Forum (USB-IF) and PCISig define compliance tests for their data interfaces. For signal-integrity measurements, these tests typically require that the oscilloscope bandwidth cover the fifth harmonic of the data signal. In the case of a high-speed USB data signal at a data rate of 480Mbit/s, for example, a suitable oscilloscope would need a minimum bandwidth of 1.2GHz (480Mbit/s is equivalent to 240MHz, which is then multiplied by five).

During compliance testing, test fixtures are used to contact the DUT (device under test). For USB 2.0 tests, it is essential to use a test fixture set that supports the various test environments and provides suitable contacts for high-speed and legacy tests of USB devices, hubs and hosts. The high-speed signal quality test additionally requires the 'USB 2.0 hi-speed signal quality test fixture' set, which is available only from USB.org.

Certified test fixtures for PCIe are generally available only from the PCISig consortium, both for testing PCIe motherboards (PCI Express compliance load board – CLB) and testing add-in cards (PCI Express compliance base board – CBB). The CLB/CBB test fixtures are available for each PCIe generation. Later generation fixtures support the earlier generations.

Debug During Start-Up

For circuits with USB or PCIe interfaces, it is important to check signal integrity and analyse the protocol data. Typically, errors occur when establishing the connection between transmitter and receiver and when receiving faulty data. Serial interfaces such as USB and PCIe run through a handshake procedure when establishing the connection, during which the two transmission partners compare their capabilities regarding data rate, etc., and agree upon suitable transfer functions.

An example is a protocol analysis of a USB 3.1 Gen1 interface using a trigger and decoding option.

Figure 6: Using the R&S RT-ZMA10 solder-in tip module to contact a high-speed interface

Figure 7 shows how easy it is to configure the decoding. The user selects the channel and polarity of the differential signal (very important in case the signal needs to be inverted because the probe was soldered in backwards) and then simply ensures that the switching thresholds for logical one and zero lie correctly in the centre of the data signal, to provide reliable decoding results.

The software defines the PLL configuration for the CDR based on the relevant USB standard. Using the extracted embedded clock signal as the reference clock, it defines the bit and word boundaries for each waveform acquisition for decoding the data.

An example result is shown in Figure 8. The top of the screen shows data bursts with zoomed details. The decoding is shown in the centre of the screenshot with zoomed protocol details. The individual protocol elements are colour-coded for easier readability. Protocol data can also be listed in a table. Additional protocol details are available for each data frame.

It is also possible to trigger on protocol details. As shown in Figure 9, the user can select many different protocol elements, including frame start, frame contents and frame errors as the trigger type. Through targeted triggering on individual protocol elements, data from other interfaces and function blocks can be acquired, time-correlated and then analysed. This is how cross-interference from other functional units such as serial interfaces, analogue sensors, radio interfaces, power supplies and others can be detected in densely-packed embedded designs.

Rohde & Schwarz oscilloscopes support this type of complex debugging with their multi-domain capability. The oscilloscope's traditional time domain analysis functionality is combined with additional protocol, logic and spectrum analysis functions and even function and pattern generators – all in a single instrument. ●

Figure 7: Configuration dialogue when using the R&S RTO-K61 option to decode USB 3.1 Gen 1

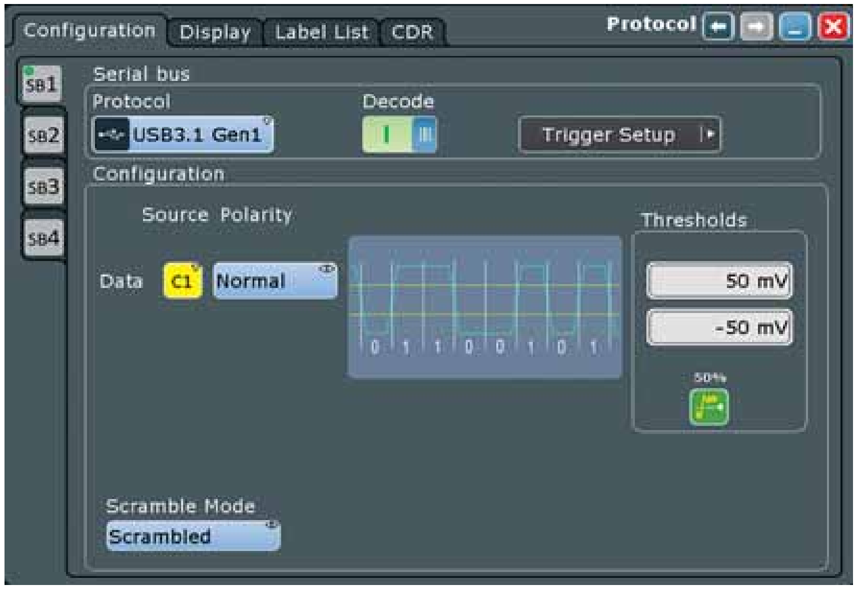
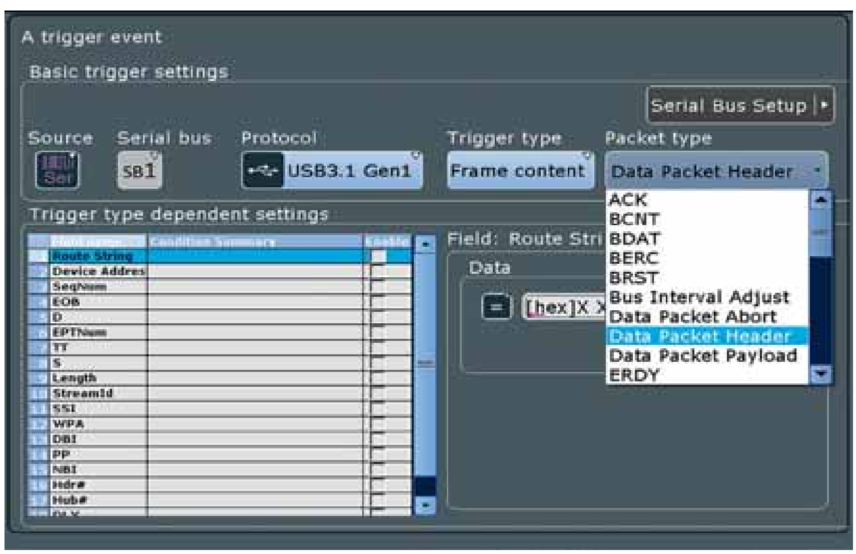


Figure 8: Example of data decoding in line with USB 3.1 Gen 1

Figure 9: Configuring the trigger type to be a data packet header in line with USB 3.1 Gen 1



Real-time or sampling oscilloscope – which is best for an application?

By Boon Campbell, Business Development Manager, Keysight Technologies

What is the best oscilloscope for your application? Today's electronics industry requires a broad spectrum of test equipment, with the oscilloscope being one of the most fundamental tools used by engineers and technicians. Oscilloscopes provide critical insight into signal properties, suggesting further design work, targeting manufacturing issues, or performing compliance and protocol testing according to international standards.

Oscilloscopes fall into two groups: real-time and sampling (also called equivalent-time oscilloscopes), and it's important to understand the difference between the two.

Real-time oscilloscopes digitise a signal in real time. Imagine a repetitive AC signal; the real-time oscilloscope acts like a camera, taking a series of frames during each cycle. The number of frames captured depends on the oscilloscope's bandwidth, memory depth and other attributes.

On the other hand, a sampling oscilloscope takes only one shot of the signal per cycle. By repeating this one shot, but at slightly different instants, the sampling oscilloscope can reconstruct the signal with high degree of accuracy.

Figure 1: The Keysight 86108B precision waveform analyser plug-in module installed in the 86100D digital communication analyser

Trigger

Sampling oscilloscopes are designed to capture, display and analyse repetitive signals. If a single random event needs to be captured within a waveform, a real-time oscilloscope should be selected. Looking at intermittent signals during product design or manufacturing, real-time oscilloscopes trigger on specific events such as a rising voltage threshold, a set-up-and-hold violation or a pattern trigger. The real-time oscilloscope will capture and store continuous sample points around these triggers and update the display with the captured data. However, there are oscilloscopes that don't require a trigger; see Figure 1.

> *Sampling oscilloscope electrical and TDR channels can be integrated into a module to reduce cost, or remote heads can be used to improve accuracy*

Bandwidth

The frequency of the signal under test and its harmonics will determine the bandwidth of the oscilloscope to fit the needs. Sampling and real-time oscilloscopes cover a wide bandwidth range and there is an overlap. A sampling oscilloscope can acquire any signal up to its analogue bandwidth regardless of the sampling rate, whereas a real-time oscilloscope must gather many samples after the initial trigger to accurately display a waveform. A typical rule of thumb for real-time oscilloscope bandwidth is 2.5 times the signal frequency to reproduce the signal's best fidelity. This means a lower bandwidth is enough in a sampling scope, as long as there's a trigger feature.

Memory Depth

Memory depth is an important specification only for real-time oscilloscopes. This type instrument captures an entire waveform on each trigger event, by capturing a large number of data points in one continuous measurement.

For a real-time oscilloscope, memory size is directly tied to the sample rate. The more memory there is, the more samples (sampling rate) can be captured for each waveform. The higher the sampling rate, the higher the effective bandwidth of the oscilloscope.

There is a simple calculation to determine the sampling rate for a specified time-base setting and a specific amount of memory (assuming a screen 10 divisions wide):

Memory depth / [(time per division setting) * 10 divisions] = sample rate (up to the maximum sample rate of the ADCs).

The memory depth concept does not apply to sampling oscilloscopes because only one instantaneous measurement of waveform amplitude is taken at the sampling instant.

Analogue-to-Digital Converter Bits

Sampling oscilloscopes can have an analogue-to-digital converter (ADC) as high in resolution as 14 bits. This gives them a very large dynamic range, enabling the viewing of signals from a few millivolts to a full volt without attenuation. Hence, sampling oscilloscopes maintain very low noise levels at all volts-per-division settings.

A real-time oscilloscope is limited in its dynamic range to 8-10 bits depending on the model, but typically will show an effective bit number of around 6-8 bits. Because of a real-time oscilloscope's lower signal-to-noise ratio, it is designed with attenuators to correctly display signals at specific volts-per-division settings.

Frequency Response

Frequency response is another key selection criterion. Sampling oscilloscopes do not use digital signal processing (DSP) correction, so their frequency response rolls off slowly and looks more Gaussian in shape.

Real-time oscilloscopes can implement digital signal processing to correct their frequency response. For instance, Keysight's 8GHz S-Series oscilloscope (Figure 2) has very flat frequency response across its bandwidth, which means its gain will not vary by more than 1dB across the entire band.

Clock Recovery

The clock recovery component of an oscilloscope measurement is used for building real-time eyes, mask testing and jitter separation. A recovered clock is a reference clock within the oscilloscope, used for measurement comparisons.

In many applications, real-time oscilloscopes have software clock recovery and selectable hardware clock recovery frequencies. The advantages are that this method is not prone to hardware errors and the sample's edges will land where they need to be, regardless of the data rate.

Applications

Like real-time oscilloscopes, sampling oscilloscopes offer eye diagrams, histograms and jitter measurements. With high bandwidth, modularity and lower price, they typically fit manufacturing environments better than the real-time variety.

Many sampling oscilloscopes have modular systems consisting of a mainframe and various electrical, optical and TDR modules, allowing the user to customise the measurement hardware to fit the problem. Sampling oscilloscope electrical and TDR channels can be integrated into a module to reduce cost, or remote heads can be used to improve accuracy. Optical channels are always integrated creating a well-controlled 4th-order Bessel-Thomson frequency roll-off.

When making jitter measurements, clock recovery systems play a significant role. Understanding the clock recovery algorithm and the transfer function used will help determine the final oscilloscope selection.

The sampling oscilloscope has slightly lower jitter and higher dynamic range, making it ideal for characterisation in a controlled environment, assuming a repeatable signal. However, real-time oscilloscopes are great if there's need to trigger on difficult-to-find events.

Real-time oscilloscope users can choose from a long list of compliance, protocol triggering and decode and analysis applications, including jitter.

Best Fit

If measurements of a repetitive waveform with lower jitter and higher dynamic range are required, a sampling oscilloscope is a good choice. In addition, sampling oscilloscopes have the advantages of a lower initial cost and modular upgrades, making them well suited for ongoing electrical and optical manufacturing test applications.

Real-time oscilloscopes come in a variety of bandwidths and capture single-shot events as well as repetitive signals. ●

Figure 2: 8GHz MSOS804A high-definition oscilloscope

The automotive industry needs and deserves better tools

By Jeff Phillips, Head of Automotive Marketing, National Instruments

Now is an exciting time for everyone working in the transportation industry; we are at the verge of a technological and social disruption. Numerous innovations will define how we will get from point A to B in the next decade. Level 5 (hands-off) autonomous driving will reshape the automotive industry and the way we all use and own cars, creating new business models, high-tech start-ups and services. The expected advent of the driverless cars creates the need for advanced safety systems and advanced methods for vehicles to communicate with each other and with the surrounding infrastructure. This in turn leads to intensified research in telecommunications techniques to meet those needs. It goes without saying that these trends will impact the way vehicles are designed and tested.

It is easy to get excited and distracted by futuristic panoramas, but we should not forget the existing challenges of designing and manufacturing reliable and safe vehicles. Challenges such as configuring tests whilst dealing with shortening time-lines, centralisation of electronic control units (ECUs) and the lack of enterprise data management solutions.

> *For test engineers, the data problem is worsened because of the sheer volume of data being collected*

Test Configuration

Across the world, validation engineers at automotive firms (both OEMs and Tier 1 suppliers) describe the same challenge. Conversations are often dominated by statements such as: "There's not enough time to do the test" and "there's no budget for new equipment". With many of these systems now directly controlling or feeding into safety-critical systems, the challenge of testing them to ensure safety and reliability has never been more important.

Critical to this is the seemingly simple task of setting up the test. Automotive components that were once simple (e.g. headlights or mirrors) are now complex electromechanical systems that incorporate an ECU, sensors, actuators and communication elements to "talk" to the rest of the vehicle. Validating the behaviour of these subsystems now requires different testing methodologies. Formerly testing doors, windows, steering columns, lighting and seats were exclusively physical tests, involving shaker tables, environmental chambers, actuators and data acquisition systems as tools. But, now that these components incorporate more sensing, computation and control, physical components have evolved into vehicle sub-systems that require design and test methodologies that mimic powertrain design. As the design teams adapt to this new reality, modelling, software design, regression testing, hardware-in-the-loop (HIL) rests and system integration are creating test challenges that can't be addressed by taking longer or spending more money.

The solution to this challenge requires specialised tools for one-off tests that can then transition to programmatic tools for automation, or to doing the same test over and over through a variety of variables – length of time, temperature, weather elements, crash forces, etc. This type of specialisation can be seen in adjacent industries, such as semiconductors, where tool specialisation has reduced the overall test costs while allowing vendors to get to market faster. This same trend will find its way into the transportation industry. In fact, you can start to see some of this specialisation in products like National Instruments's FlexLogger, which provides a configuration-based interaction for data logging.

To Centralise or Not to Centralise the ECU

As intelligence and processing close to the sensors or actuators were added to automotive components, the number of ECUs per car grew exponentially. Logically, this meant that the component designs were more modular, with less failure propagation. As we charge toward Level 5 autonomous cars, fusion of data from various sensor systems will certainly impact the current trend of decentralising the ECU.

One school of thought is to bring subsystems together under one centralised ECU, sometimes called a "fusion ECU". Centralising the processors simplifies

Data gathering and analysis statistics

software updates, data aggregation, data streaming and critical path testing. This will surface where OEMs choose to own differentiation, doing the direct development in-house and depending on the Tier 1 suppliers for fully-integrated end-to-end sensor systems. For example, with regards to electric vehicles, many OEMs are looking to isolate their intellectual property (IP) – braking, charging, powertrain – into a single ECU, and relying on the industry for "commodity" ECUs to reduce testing burden, drive cost down and distribute liability. It's critical for the entire value chain to understand how these systems come together and share standards.

Regardless, the challenge of validating the behaviour of the embedded software on the ECU will increase, and the ability to quickly create and build up hardware-in-the-loop (HIL) testers will become critical. Traditional HIL systems from major vendors often lack flexibility and do not scale well. Their business model is to build the entire system end to end, which obviously sounds very attractive. That model worked well in the past, but two critical developments are changing the landscape. First, the sheer pace of change in the market makes these 'black box' testers too costly as changes require building a new black box. Second is the evolution of advanced driver-assistance systems, or ADAS. As ECUs do more, and merge information from various suppliers, the know-how and IP in them is even more important, especially since IP is proprietary and yet ECUs will require modifications and appropriate test systems.

Consider how Subaru used a flexible, modular platform to alleviate the above concerns and ultimately reduce test time to one-twentieth of what was estimated to test its novel hybrid powertrain.

Subaru used NI's HIL technology to simulate actual road conditions for electric vehicle testing, eliminating environmental factors and reducing test time and costs.

Historically, this level of in-house ownership was in the engine control. However, the ADAS systems are the new "powertrain" in the sense of being the critical path of innovation and ownership, which means owning the IP here will be just as – if not more – critical. Combine this lack of flexibility for future-proofing in traditional HIL systems with a heavy price mark-up for the customised service these vendors provide, and engineers are looking for other solutions. Further, there's the issue of scale based on the cost. Even the small vehicle systems contain considerable software logic and need to be tested economically.

Data Management

Many experts have described how the amount of data being collected is growing exponentially. For the transportation industry, this trend will only continue as our automobiles move toward Level-5 autonomy. Data from sensors such as radar, camera and LIDAR will be combined to depict the world around the car. Biometric sensors will help understand the state and health of the driver. Systems such as lane-change assist and adaptive cruise control will be actuated based on this data. To shine a brighter light, the imminent explosion of AI capabilities in this domain is just around the corner.

For test engineers, the data problem is worsened because of the sheer volume of data being collected, the extra step of validating the collected data, and the need to analyse such large data sets nearly instantaneously. Just look at any accident for an example of the instantaneous data-processing challenge. The potential impact of better decisions is vast.

Consider this scenario: A crash occurs. Data from the sensors on the car are analysed and an error in an autonomous driving algorithm identified. If the data used to test these systems is the same as is used to monitor and evaluate them, then the next steps could be to change the algorithm or machine-learning network and fix the error. The new code is automatically updated to the fleet of cars using it. The same data generates a new test parameter in the validation of the system to ensure the error isn't repeated.

This scenario is in the realm of what we may see in the next decade from autonomous driving algorithms, artificial intelligence and the Internet of Things. However, we don't see this happening yet, because although we're storing loads more data, we are not really analysing it.

Central to this is an enterprise data management requirement that makes it easy to store, share, find and analyse measurement data. While this is challenging, there are several examples where automotive companies can implement solutions for impressive results. Toyota showed a 50% reduction in the man-hours needed to analyse data; Deutz a 90% reduction in data analysis times; and Jaguar Land Rover increased the percentage of analysed test data from 10% to 95%, with 20x reduction in time – all because of a standardised, enterprise implementation of data management and analysis.

Automotive Test Evolution

Cars are becoming supercomputers-on-wheels, and OEMs are becoming software-centric companies. The changes in the automotive industry not only affect the OEMs and their suppliers, but also car dealerships and rental companies, and government regulations and insurance companies. Paramount to these changes are the systems and methodologies we apply to validate and test these components – cost, time-to-market, reliability and, most important, assured safety.

The approach and the components used to define these new test systems are not entirely new. We've seen the same technologies evolve the testing landscape in semiconductors and aerospace/defence, the latter obviously with a high focus on safety and with many similar autonomous capabilities. ●

The challenges of testing remote SIM provisioning in M2M

By Jens Christoph, Director, eUICC Test Solutions, Comprion

The use of universal integrated circuit cards (UICCs) in the machine-to-machine (M2M) environment poses new challenges to everyone involved. Once permanently installed or even soldered into a system such as a car, wind wheel or refrigerator, the card profile – in particular, the operator subscription – can only be changed over the air.

As soon as the UICC is soldered, we speak of an embedded UICC, in short eUICC or eSIM.

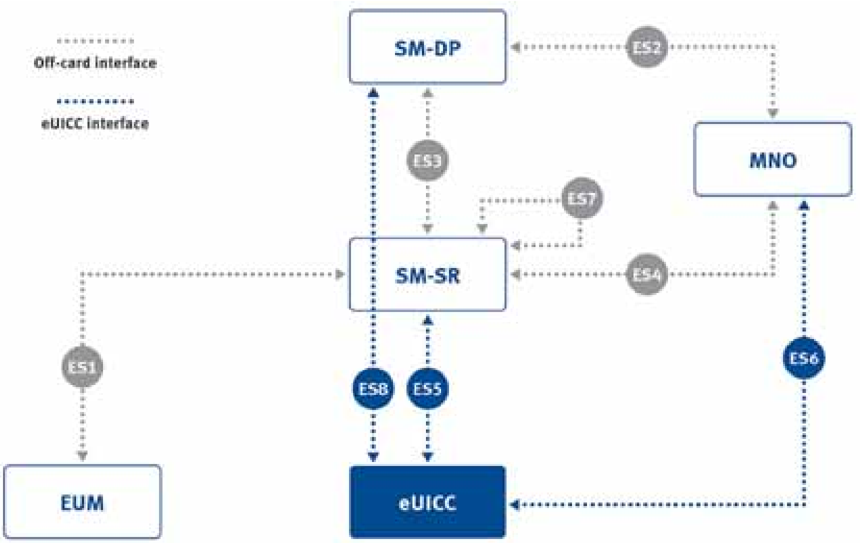


Figure 1: GSMA eUICC architecture in M2M environment

Testing eUICCs

When the UICC is embedded in the M2M device, accessing it and testing its functionality can be difficult. Moreover, testing the complete over-the-air (OTA) communication chain between the eUICC and the back-end server, such as the MNO (Mobile Network Operator), SM-DP (Subscription Manager Data Preparation) and SM-SR (Subscription Manager Secure Routing), is complex due to numerous elements involved. Consequently, the testing industry needs to test three essential components:

- the eUICC itself;
- the eUICC in combination with a device;
- the provisioning process that brings the profile to the eUICC, including the server back-ends involved.

The M2M Ecosystem

To promote inter-device communication and innovation, an M2M initiative of the GSMA – the trade body that represents the interests of mobile operators worldwide – has defined a global architecture framework, called the GSMA Embedded SIM Specification. This framework enables remote provisioning and management of profiles on an eUICC and subscription changes from one operator to another.

It defines the components, interfaces, functions and actors/roles, as well as related procedures; see Figure 1 for the complex interactions between the participants.

The eUICC ecosystem mainly consists of the following:

Actors/roles:

- eUICC Manufacturer (EUM);
- Mobile Network Operator (MNO);
- Subscription Manager Data Preparation (SM-DP);
- Subscription Manager Secure Routing (SM-SR);
- Embedded UICC (eUICC).

Off-card interfaces connecting two off-card (or remote) entities:

- ES1 – interface between the entities EUM and SM-SR;
- ES2 – interface between the entities MNO and SM-DP;
- ES3 – interface between the entities SM-DP and SM-SR;
- ES4 – interface between the entities MNO and SM-SR;
- ES7 – interface between the entities SM-SR and SM-SR.

On-card interfaces connecting an off-card entity to the eUICC:

- ES5 – interface between SM-SR and the eUICC;
- ES6 – interface between the MNO and the eUICC;
- ES8 – interface between SM-DP and the eUICC.

The actors/roles take over various functions, summed up by the GSMA in three management areas: platform, profile and eUICC; see Figure 2.

What's New in the Card?

The eUICC is structured into a hierarchy of different security domains, each with specific access rights and privileges. The ISD-R (Issuer Security Domain Root) is a special security domain for securing critical access to the eUICC. Using the ISD-R is the only way to create a new

Figure 2: Allocated functions

instance of ISD-P (Issuer Security Domain Profile) that works as a container for a given mobile network operator's profile; see Figure 3. Access to the profile data within such a container is restricted to the profile owner, or MNO.

Each on-card security domain corresponds to one off-card role on the server side. Access to the ISD-R is controlled by the SM-SR (Subscription Manager Secure Routing). The SM-SR is the only instance with access to the necessary keys that can create new containers, delete those no longer needed, and activate or deactivate profiles.

After the SM-SR has created a new profile container (ISD-P), the new ISD-P is handed over to the profile owner, who subsequently loads the profile data into that container, handled by the SM-DP (Subscription Manager Data Preparation).

As soon as a profile has been loaded and activated, the MNO has access to its contents, like with a traditional UICC. Each role can be assigned to different security realms with their own certificates and keys, guaranteeing access to the data necessary for specific tasks.

Card and Server Communications

Communication between the various security domains and their respective back-end servers is specified by several different interfaces, including detailed descriptions for both functionality and protocol security.

The interfaces can be separated into two groups, as shown in Figure 4.

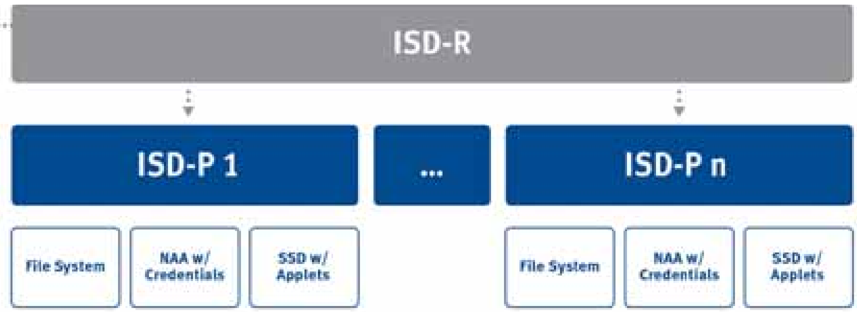


Figure 3: Security domain structure on an eUICC

When the soldered eUICCs cannot be physically accessed any more, stability of the communication channels is an absolute must. The infrastructure must ensure that the service provider has continous contact with the mobile equipment and the embedded UICCs. This is the only way to maintain profiles and update and upload new services, which imposes some serious requirements on system tests for the interfaces.

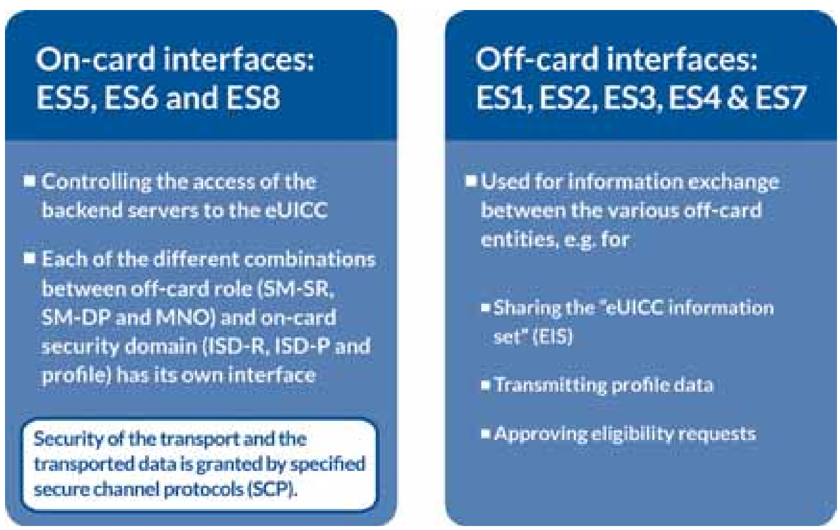


Figure 4: The on-card and off-card interfaces

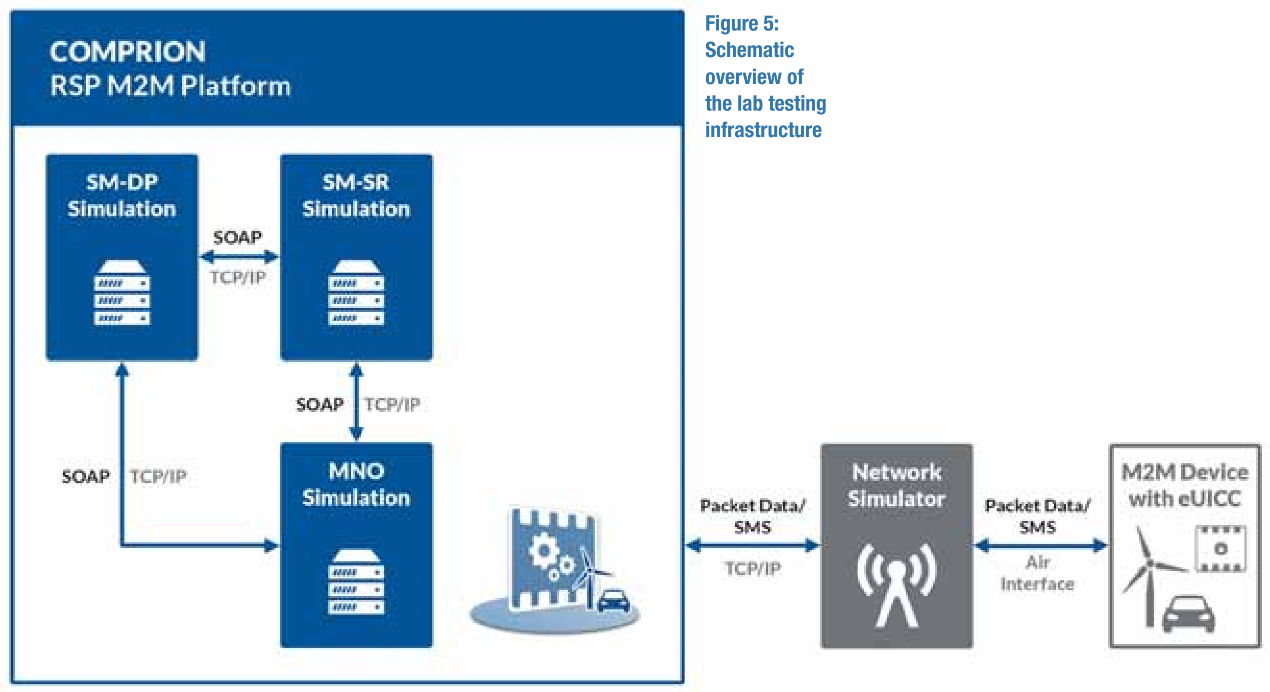


Figure 5: Schematic overview of the lab testing infrastructure

Testing Remote SIM Provisioning

Setting up a fully-functional remote SIM provisioning infrastructure is a challenging task. As a first step for gaining experience or implementing proofs of concept, it is recommended to set up a remote SIM provisioning infrastructure in a lab environment. A typical lab testing infrastructure (Figure 5) consists of simulated remote entities (SM-DP, SM-SR, MNO and EUM) and a mobile network simulator.

The mobile network simulator connects the simulated remote entities with the M2M device including the eUICC (here the device under test, or DUT) via the air interface emulated by the simulator. In this case, the network simulator provides Short Message Service (SMS) and Data Packet Service (DPS) used by the secure channel protocols for communication between the on-card interfaces of the simulated remote entities and the DUT.

The remote entities (SM-DP, SM-SR, MNO and EUM) can be simulated on a standard PC. Here, it is important to follow the technical requirements of the GSMA as defined in *'SGP.02 Remote Provisioning Architecture for Embedded UICC Technical Specification'* and to implement the functionality as well as the off- and on-card interfaces accordingly.

The off-card interfaces are implemented as web services that transport messages between the remote entities by WSDL (Web Services Description Language) files, defined by the SGP.02 specification. Implementation is based on Simple Object Access Protocol (SOAP), a network protocol that provides the envelope for sending web service messages over the Internet as specified by the W3C. A SOAP message is transferred using common Internet protocols, mostly HTTP(S) and TCP.

The implementation of the on-card interfaces is based on secure-channel protocols defined in *'3GPP TS 31.115 Secured Packet Structure for (Universal) Subscriber Identity Module (U)SIM Toolkit Applications (SCP80)'* and *'GlobalPlatform Card Specification*

Application	SOAP	
	HTTP	HTTPS
Transport	TCP	
Internet	IP (IPv4, IPv6)	
Network Access	Ethernet ...	

Figure 6: SOAP messages using HTTP(S) and TCP

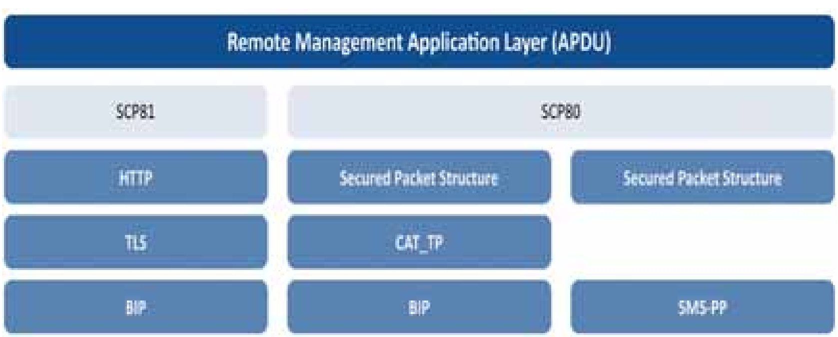
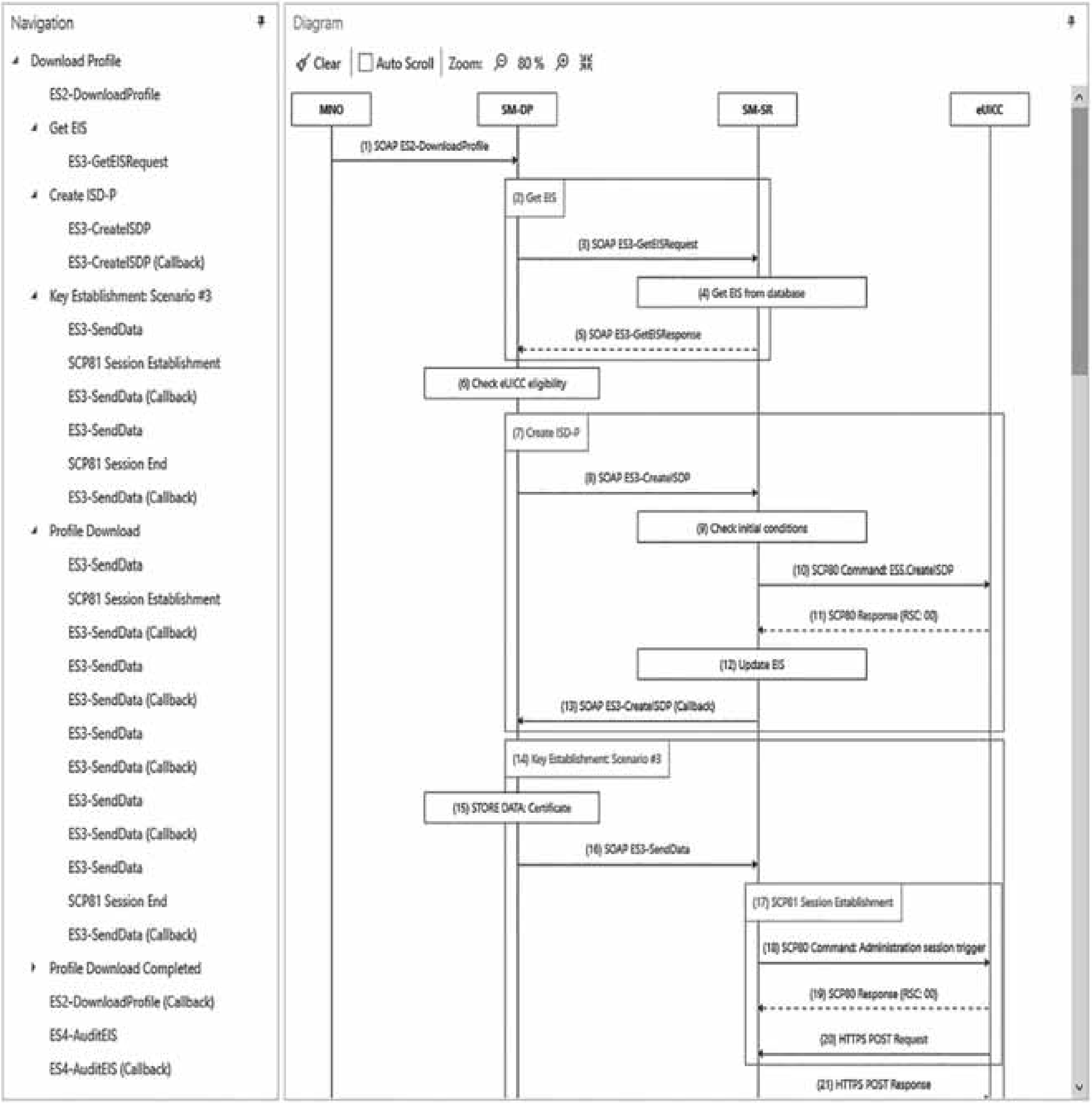


Figure 7: Remote APDUs using secure channel protocols

Figure 8: Visualisation of a profile download procedure



Amendment B: Remote Application Management over HTTP (SCP81)'. In this context, the purpose of a secure channel protocol is to provide a secured communication channel for exchanging remote management commands between remote entities and the eUICC with remote application protocol data units (APDUs).

The lab infrastructure described here, with remote entity simulation allows the execution of all remote SIM provisioning procedures defined in SGP.02 with additional extended logging and visualisation capabilities as shown in Figure 8.

New Opportunites

An ecosystem built around the new eUICC and the dedicated remote SIM provisioning process creates many new opportunities for new services, but also many new technical challenges. As in all areas, a new trend calls for a comprehensive framework of new rules, and subsequent standardisation. Most of this basic work is already done, but the real world brings more requirements. All involved players must understand that only extensive preliminary testing helps to make sure that all processes based on this technology work reliably. ●

CONGATEC LAUNCHES COM EXPRESS TYPE 6 MODULE

Congatec introduced the conga-TR4 COM Express Type 6 module based on the new AMD Ryzen Embedded V1000 processors. Setting a new benchmark for high-end embedded computer modules, AMD Ryzen Embedded V1000 processors deliver up to 3x more GPU performance than competitive solutions, and up to 2X increase in performance over previous generations. With a TDP that is scaleable from 12W to 54W, congatec products based on these new processors can benefit from multiple performance leaps across the TDP range and enormous optimisation potential regarding size, weight, power and costs (SWaP-C) at a high level of graphics performance.

The new congatec modules are aimed at embedded computing systems with demanding graphics performance in medical imaging, professional broadcasting and infotainment, digital signage, control rooms and video surveillance, among others.

www.congatec.com

ASSEMBLY BENEFITS COMBINED WITH SAVINGS IN TIME

With its new VX25 large enclosure system, Rittal is offering tangible installation benefits, thanks to its new, improved functionalities. These include better accessibility, greater installation depth, tool-free assembly and a completely new base/plinth system.

Most of the improved functions of the VX25 large enclosure system are due to a new frame section which provides better accessibility through all four sides. The outer of the two available mounting levels can now also be directly populated from outside without any additional parts. This reduces assembly time by around 30 minutes, compared to conventional methods.

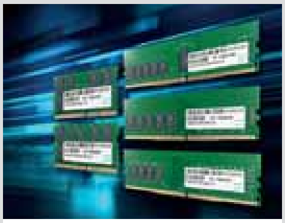
The same applies to the new option of installing mounting plates from the back, which is a great improvement, particularly when heavily-populated mounting plates are being installed. The 20mm of added installation depth provides more room for manoeuvre for particularly deep installations.

www.rittal.co.uk

APACER UPGRADES TO NEW-GENERATION DDR4-2666 MEMORY MODULES

The rapid confluence of artificial intelligence (AI) and the Internet of Things (IoT) have increased performance demand in computing power and transfer speed. In response to the successive upgrade in Intel's and AMD's servers, desktop processors, and mobile processors platforms, as well as the increased support of adaptation of the DDR4-2666 specification, Apacer has outpaced its competitors in the mass production of DDR4-2666 memory modules for server and industry applications. Apacer's DDR4-2666 memory is compatible with the latest Intel Purley and AMD EPYC processor platforms, fully highlighting the company's ambition to the top supplier for the long-awaited overhaul in the global server market and officially propelling industrial memory into the high-performance, high-bandwidth realm of DDR4-2666.

http://industrial.apacer.com/en-ww



NEW BACK-BIASED DIFFERENTIAL LINEAR HALL SENSOR IC FROM ALLEGRO

Allegro MicroSystems Europe has introduced a new high-precision, back-biased, programmable Hall-effect sensor IC. Allegro's ATS344 includes differential Hall elements and is packaged in a custom back-biased package that includes an integrated magnet.

This new device incorporates a 2-wire current mode PWM output in order to help minimise pin-count for remote sensors. It also includes on-chip EEPROM technology, capable of supporting up to 100 read/write cycles, for flexible end-of-line programming of calibration parameters. The ATS344 is ideal for automotive applications requiring high resolution detection of long stroke (> 5mm) linear motion.

The integrated back-bias magnet greatly simplifies packaging for the customer, requiring only a ferrous target to detect.

www.allegromicro.com


Widest selection of electronic components
In Stock
MOUSER ELECTRONICS
mouser.co.uk
ORDER WITH CONFIDENCE
Authorised Distributor of semiconductors and electronic components