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Innovation and technology in action

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- Improving display-caused eye strain with sensors
- The power of wireless power technologies

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Smart Home automation, battery-powered overdrive pedal for guitar effects, and more

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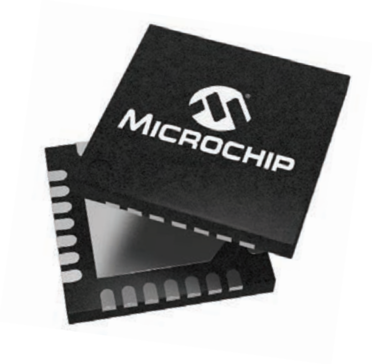

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Technology will shape the future of train stations in the next 10 years

By Dave Ashton, CEO of Loco2

The rail industry is going through a revolution. It is now easier than ever to buy train tickets through apps and websites for travel almost anywhere in Western Europe. Tickets are immediately available on mobile devices, which also offer live arrival and departure information. In many cities, contactless payment secures travel and, as we all know, Uber has reinvented the taxi sector.

Train stations are modernising, too. Earlier this year I took a train journey through China, from Beijing in the north, all the way to Hong Kong. It was 3500km-long, through Xian, Chengdu, Guilin and Shenzhen.

What impressed me the most – beyond travelling overland at 300km an hour – was their stations. Looking more like Heathrow Terminal 5 than St Pancras, their modern stores and restaurants accommodate tens of millions of passengers every year, with free Wi-Fi and technology-enabled, comfortable lounges.

China has had both the challenge and luxury of building its transportation and communication infrastructure almost from scratch in the last 25 years. That can't happen in Europe: rail stations in many major cities have been around since the 19th century, even though there's still a lot of modernising planned for the next decade. We expect better passenger experiences – and not just whilst travelling, but to make life easier for people passing through these stations.

Clearly, technology will underpin this innovation and development, serving both the growing rail demand and making people's lives better. The concept of smart railway stations is sometimes called "living transport hubs", and they are coming soon.

Here are my predictions of what train stations will offer in the next decade.

1) Sleepover stations

Train stations appeared during the Industrial Revolution, largely as soot-covered depots for trains to collect more coal and/or drop off passengers, so the last thing anyone wanted was to sleep there. It's not that way any more – passengers want to be comfortable not just whilst travelling, but between connecting trains, too.

Within a few years, we expect large sleeping islands appearing inside train stations for passengers to sit back and relax, looking a lot more like homes than the train stations of yesteryear.

2) Supermarket aisles

Craig Graeme, Transport for London's director of commercial development, believes the transport system has the potential to be a "supermarket aisle". He said: [Modern day] passengers are time-poor, with very busy lives. We need to work out what they need and give it to them in the most convenient format."

Imagine getting to your home station's parking lot, and your groceries are bagged and waiting for you to pick up – or, even better, already in your car. 'Click and collect' services at underground stations in North London already do some of this, enabling commuters to do their shopping online and collect it on their way home at their local train stations. We are also likely to see stations offering Amazon or e-Bay lockers for the collection of online purchases on the way home.

3) Takeaways on-demand

According to the UK consumer market research group NPD, over the past decade the takeaway delivery market has grown from £2.4bn to £4.2bn as of February 2018, a 73% increase.

With the unstoppable rise of online food ordering, train stations will increasingly collaborate with food delivery firms like Deliveroo, JustEats or UberEats to offer passengers on-demand takeaway service. Passengers could order their takeaway from a restaurant or fast-food establishment through apps and input the name of the train station where they wish to collect their meals. Ideally, one day, meals could be delivered directly to your reserved seat on the train or in the waiting lounge.

4) Mobile health clinics

A new report by the British Heart Foundation urges the NHS (as part of its long-term plan) to place nurses at England's train stations to offer general health checks, helping identify the millions of people with undiagnosed high blood pressure and other conditions. We expect the NHS to trial mobile clinics at some train stations to encourage people to be more aware of their health and provide easier access to services.

Train stations could partner with the NHS or private firms to integrate other related facilities, such as pharmacies, for commuters to pick up their prescriptions whilst on the go.

5) Sqeezing in a workout

Trying to squeeze in a daily workout at the gym is a common struggle for time-poor Britons. The future train station can help here too, by offering gyms and swimming pools.

As train stations become 'living hubs' for passengers, signs suggest they will incorporate personal services that are generally popular with people, with fitness being high on the list. I can see this becoming a trend among commuters who might want to augment rush-hour travel with a workout.

6) Drop-in workspaces

In 2014, Network Rail and The Office Group opened three drop-in workspaces at King's Cross, Liverpool Street and Leeds, as part of a joint venture called *"The Station Office Network"*, an initiative intended to provide mobile offices in train stations across UK's major cities. This was set up four years ago and could become the norm. Major stations across the country could attract workers to use their amenities, and drop-in workspaces will enable people to be flexible and productive before or after their journey. Based on the initiative, stations will naturally offer Wi-Fi/broadband, private offices, meeting rooms and shared drop-in desk areas, supporting a broad range of business activities for rail passengers.

7) Virtual ticketing agents

Some train stations are already adopting a novel, hybrid concept of a virtual walk-up ticket office and ticket vending machines connected to a video-linked call centre. The German town of Essen, in cooperation with Essener Verkehrs-AG (EVAG), has already equipped its central station with these, and Greater Anglia in the UK has also rolled out virtual ticketing agents across rural rail stations in East Anglia.

Ticketing in particular has seen rapid changes in the last decade, with smartcard-based systems fast overtaking traditional paper ticketing on many of the world's major transport networks.

8) Integration with other transport modes

As the idea of driverless cars starts to entice urban dwellers, there are debates about whether they will replace high-speed rail and other forms of transport. Train stations are an obvious focal point for operating fleets of connected and autonomous vehicles (CAVs), and the ability to assimilate this technology will be critical.

The Milton Keynes central station is the UK's first Smart Station Demonstrator for future innovations within the rail sector by testing the impact of automated buses and metro, private vehicles with automated parking and driverless cars. EW

Gesture recognition with ultrasound

A research team at the Fraunhofer Institute for Photonic Microsystems (IPMS) is using a new class of ultrasonic transducers to reliably detect distance changes, movement patterns and gestures in distances under half a meter. The tiny components are cheap to make, allow for high sound pressure, and provide a flexible frequency design for optimal balance of distance and sensitivity.

Gesture controls such as swiping, pinching and tapping have been imposed by the smartphone on many other systems. A wide range of equipment for industrial control or public kiosks use these gestures now too, but need environments free from external disturbances such as noise, dirt and even light. Hence, research has focused on alternatives that provide non-contact, three-dimensional recording of distance, movement and gesture for communication with robots, as well as in surgical settings and household appliances.

Fraunhofer IPMS scientists have developed an architecture that can generate and receive ultrasound to 300kHz. Reflected sound waves are analysed by measuring how long it takes a wave to travel between a sensor and a reflecting object, or how frequencies shift due to the Doppler effect. Evaluation of the ultrasound provides spatial resolution of natural movements and gestures in the sub-centimetre range at distances to half a meter. The system promises many advantages over other technologies, such as optical sensors.

"Compared to camera-based systems, our ultrasonic sensors enable the construction of significantly cheaper electronic and software systems due to longer signal transit times. Our transducers are not susceptible to stray light and allow for reliable data acquisition from optically transparent surfaces as well," said Sandro Koch, Fraunhofer IPMS group leader.

For this development, the researchers implemented a new class of electrostatic micro-electro-mechanical systems (MEMS) bending actuators. The Fraunhofer IPMS proprietary nano-e-drive (NED) principle relies on the high strength of electrostatic fields in nanometre-sized electrode gaps to allow sensing mechanical movements with displacements in ranges of several microns.

Fraunhofer researchers expect that high air flows converted into high sound pressure will support further development to provide increased signal-to-noise ratio for low-frequency ultrasonic transducers. The resonance frequency and thus the detection range and spatial resolution can then be defined by the geometry of the NED bending actuators.

The systems are CMOS-compatible and considerably more compact than other systems. EW

Gesture control in cars

Northern Manufacturing & Electronics 2019

Northern Manufacturing & Electronics, the Northern partner exhibition to the very popular Southern Manufacturing & Electronics Show, returns to EventCity, Manchester, the UK, on October 2nd and 3rd. As the North's only dedicated electronics exhibition, the event is a vital showcase for components, production hardware and electronics manufacturing services.

The quantity and diversity of companies taking part – around 300 this year – ensures a show with tremendously broad appeal, allowing visitors from many different backgrounds to solve a wide variety of production issues within a single visit. Within one show, it's possible to find PCB makers, component distributors, enclosure specialists, CEMs, test equipment manufacturers and designers among a whole host of others. This ability to address multiple issues with outstanding efficiency is one of its most significant attractions. Its location near the heart of Manchester makes it highly accessible and within easy reach of the substantial swathe of electronics enterprises throughout the North, Scotland, Wales, Northern Ireland and Eire.

Products on show

Around 40% of visitors arrive in search of components, and these visitors will be well catered for in 2019. A few of the products on show for 2019 include membrane keyboards from Calman Technology, TFT LCD displays from Crystal-Tech Electronics, pressure sensors and transducers from ESI Technology and power supplies from Luso Electronics. Shown also will be the ruggedised connectors from Fischer Connectors, tough enclosures from Extreme Cases, specialist sensors and machine vision components from Keyence UK. Bespoke component makers include Protool Plastics, Peli Products (UK), J Coker (Rubber) and Whitehorse Plastics.

Electronics assembly, PCBs and wiring services will also be well represented this year. Turner Electronics, European Circuits and Scotland's LCL Electronics return for 2019, alongside Manufacturing Services Ltd, CIE Electronics, Wireco and Hallmark Electronics. Systems and machine build specialists include Tritec Systems, Sourceways and Eurotherm by Schneider Electric.

Electronics production hardware is another sizeable part of the event. A few examples include marking, printing and traceability systems from Brady and Dakota Integrated Solutions, workspace storage from Bott and stock control systems from Talliscan. PACE Europe will present soldering, de-soldering and rework stations, while UNIS Group is exhibiting its industrial electronics repair and refurbishment services.

A new initiative

A new initiative for 2019 is the show's partnering with a number of national and regional business organisations, making use of their expertise and local insight to fine-tune the exhibition towards the needs of the manufacturing supply chain throughout the region. The backing of the event by the two main regional aerospace and automotive business organisations, the North West Aerospace Alliance (NWAA) and the Northern Automotive Alliance (NAA), is of particular significance. The aerospace industry in the North West makes up nearly 25% of the UK's £32bn aerospace business, which also employs about 25,000 skilled workers and supports a rich eco-system of suppliers around the country.

The North West automotive cluster employs roughly 16,200 people and directly generates some £9bn, or 12%, of the overall UK automotive manufacturing output, placing it as the second biggest region for automotive manufacture in the UK. The North West boasts a particular concentration of subcontract service providers with specific understanding of these areas. One such exhibitor is HTK Europe Ltd, a specialist automotive wiring harness sub assembly manufacturer.

Free entry

The show's excellent free seminar programme is yet another reason to attend. Within a busy two-day programme, an impressive range of expert presenters will touch on a wide range of technical and operational issues in a series of hour-long sessions over both days of the show. The programme has been developed to appeal to a broad range of industrial professionals from all branches of manufacturing, engineering design and production. As with the show, entry to the seminar sessions is entirely free, making this an outstanding opportunity to hear world-class presenters describe the most recent developments in manufacturing, engineering and industrial business management.

Entry to Northern Manufacturing & Electronics 2019 and on-site parking is free with easy access by road and public transport from central Manchester. To register online for free tickets simply visit www.industrynorth.co.uk. EW

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Analogue output modules of a 0-5V to -5V - +5V signal converter

By Dr. Murat Uzam, Academic and Technical Author, Turkey

This series of columns is dedicated to a project of thirteen analogue input modules and seven analogue output modules for a 5V microcontroller, which connect to its ADC and DAC channels.

This month's column covers the third and forth analogue output modules, or analogue output modules 1 and 2 for a 0-5V to -5V - +5V signal converter. These provide voltages from -5V to +5V; module 2 requires three DC power supplies (+5V, -12V and +12V) and module 1 two DC power supplies (-12V and +12V).

Output module 1

Figure 1 shows module 1's circuit, with its connections shown in Figure 2. We've assumed that V_{IN} comes from the DAC output of the 5V microcontroller with $0.00V \leq V_{IN} \leq 5.00V$. When $0.00V \leq V_{IN} \leq 5.00V$, $V_{OUT} = 2V_{IN} \leq 5$. Input voltage range V_{IN} = 0.00-5.00V and therefore the output voltage range V_{OUT} is -5.00V to +5.00V. The relationship between V_{OUT} and V_{IN} is shown in Figure 3.

Jumper S1 (shown as a switch) is used to select either 0-5V operation mode (S1 open) or 0-5V to -5V - +5V mode (S1 closed). The design is used to level-shift the unipolar 0-5V input voltage signal to a bipolar -5V to +5V output voltage signal. When $0.00V \leq V_{IN} \leq 5.00V$, the operational amplifier LM358P-A, with bipolar supply voltages, acts with the transfer function:

$$V_{OUT} = \left(1 + \frac{R1 + P1}{R2}\right) V_{IN} - 5$$

By adjusting P1 we obtain R1 + P1 = R2, hence:

$$V_{OUT} = 2V_{IN} - 5$$

The buffer amplifier (a voltage follower) LM358P-B is used on the output of LM358P-A. Two series Schottky barrier diodes D1 and D2 divert any V_{OUT} overcurrent to the positive or negative power supply. A ferrite bead is connected in series with the output path to add isolation and decoupling from high-frequency transients. A TVS (Transient Voltage Suppressor) filters and suppresses any V_{OUT} transients.

This circuit can supply up to 20mA output current.

Table 1 shows input and output voltages for this module, assuming $0.00V \leq V_{IN} \leq 5.00V$. Its prototype circuit board is shown in Figure 4.

Circuit calibration when S1 is closed: By adjusting P1, ensure that when V_{IN} = 0.00V, V_{OUT} = -5.00V and, also, when V_{IN} = +5.00V, V_{OUT} = +5.00V. When S1 is open there's no need for calibration.

Analogue output module 2

Figure 5 shows the circuit diagram of analogue output module 2 for a 0-5V to -5V - +5V signal converter, with its connections to the 5V microcontroller shown in Figure 6.

As in the previous module, we assume V_{IN} comes from the MCU's DAC, with $0.00V \leq V_{IN} \leq 5.00V$. When $0.00V \leq V_{IN} \leq 5.00V$, $V_{OUT} = 2V_{IN} \leq 5$. The input voltage range V_{IN} = 0.00V to 5.00V and therefore the output voltage range V_{OUT} = -5.00V to +5.00V; see V_{OUT} and V_{IN}'s relationship in Figure 3.

The bottom part of Figure 5 is identical to that of module 1, whereas the top part produces the +5.00V reference voltage. R3, D3 (a 10V Zener diode) and C3, together with the buffer amplifier LM358P-1A, provide a 10.00V reference voltage from a +12V power supply. This 10.00V reference voltage is then divided by resistors R4 and R5 to obtain a +5.00V reference voltage. Next, the +5.00V reference voltage is connected to the non-inverting input of the buffer amplifier LM358P-1B, whose output is fixed as a +5.00V reference, capable of sourcing up to 20mA.

Table 1 shows voltages for this module, with its prototype circuit board shown in Figure 7.

For proper operation make sure that R4 = R5.

Circuit calibration with S1 closed: By adjusting P1, ensure that when V_{IN} = 0.00V, V_{OUT} = -5.00V and, also, when V_{IN} = +5.00V, V_{OUT} = +5.00V. When S1 is open, there's no need for calibration. EW

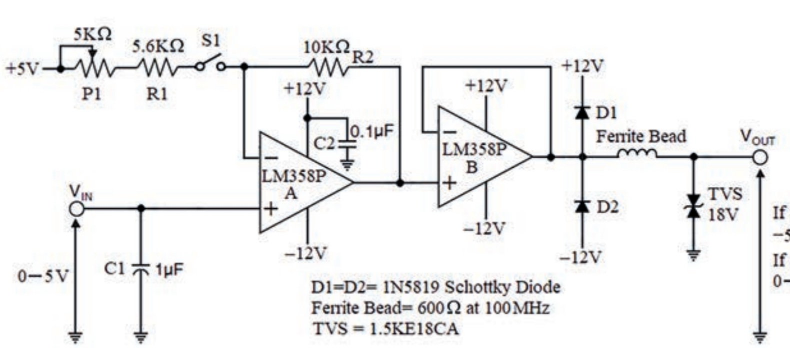


Figure 1: Circuit diagram of the analogue output module 1 for a 0-5V to -5V - +5V signal converter

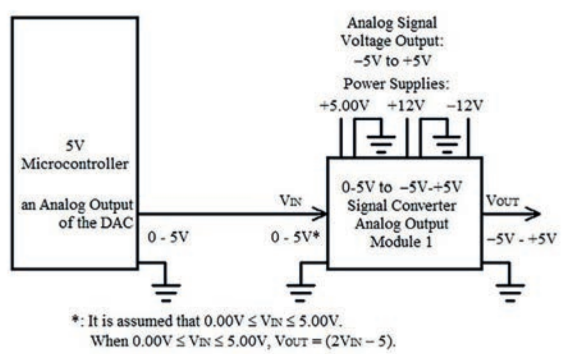


Figure 2: Connections of the analogue output module 1 for a 0-5V to -5V - +5V signal converter

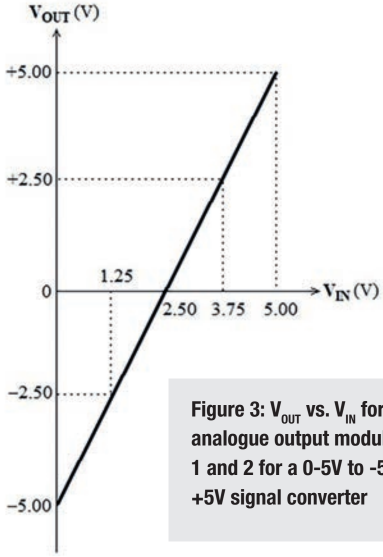


Figure 3: V_{OUT} vs. V_{IN} for analogue output modules 1 and 2 for a 0-5V to -5V - +5V signal converter

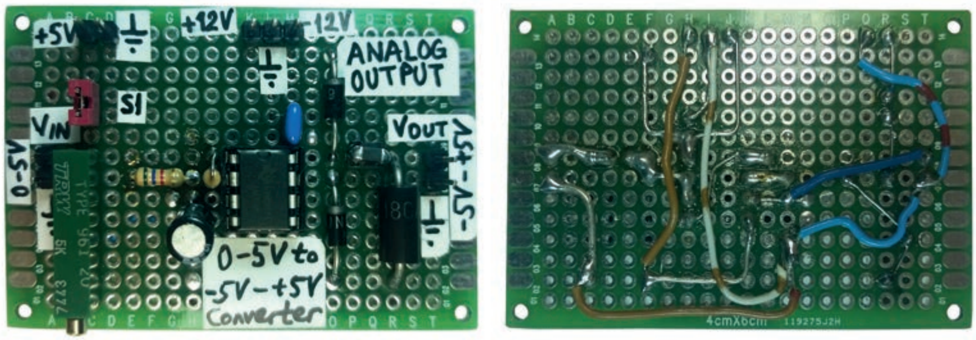


Figure 4: Analogue output module 1 for a 0-5V to -5V - +5V signal converter

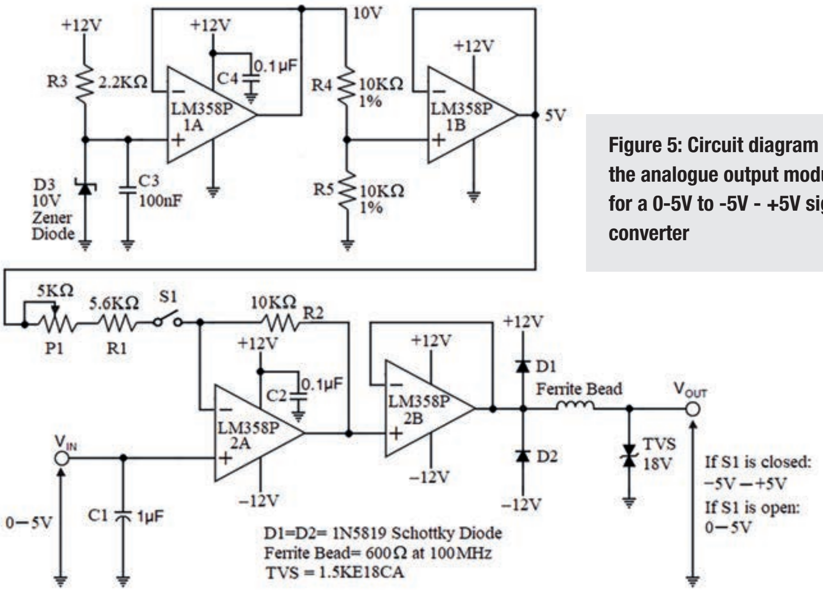


Figure 5: Circuit diagram of the analogue output module 2 for a 0-5V to -5V - +5V signal converter

V_{IN}(V)	V_{OUT}(V)
5.00	+5.00
..	..
4.50	+4.00
..	..
4.00	+3.00
..	..
3.75	+2.50
..	..
3.50	+2.00
..	..
3.00	+1.00
..	..
2.50	0.00
..	..
2.00	-1.00
..	..
1.50	-2.00
..	..
1.25	-2.50
..	..
1.00	-3.00
..	..
0.50	-4.00
..	..
0.00	-5.00

Table 1: Input and output voltages for analogue output modules 1 and 2 for a 0-5V to -5V - +5V signal converter, assuming $0.00V \leq V_{IN} \leq 5.00V$

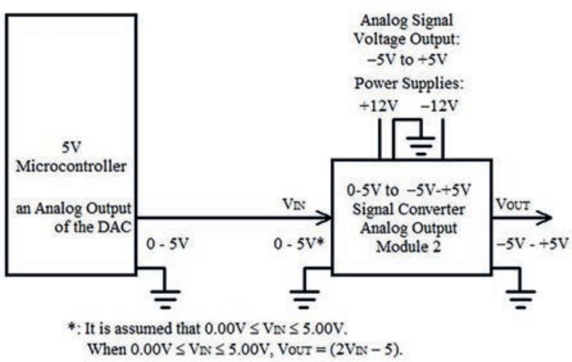


Figure 6: Analogue output module 2's connections to a 5V microcontroller

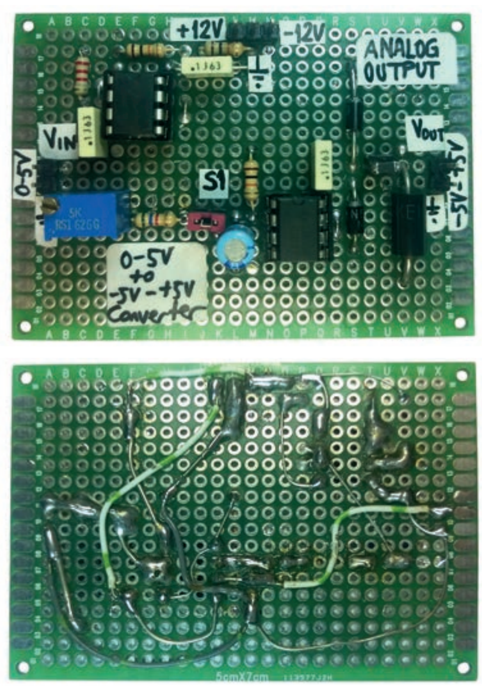


Figure 7: Analogue output module 2's prototype circuit board, top and bottom views

Orthogonal perspectives

By Ian Beavers, Product Engineering Manager, Analog Devices

Question:

I am using a MEMS inertial measurement unit (IMU) in a self-balancing guidance control system for a personal transportation platform. Can I expect a consumer-targeted IMU to eliminate all misalignment errors between sensors if all the core sensor elements are on a single piece of silicon?

Answer:

No, this is generally not a safe expectation for your design. Industrial-grade IMUs, which use robust discrete sensors with optimal packaging and calibration, offer much better alignment precision than consumer-targeted IMUs residing on a single piece of silicon.

Consumer- and industrial-targeted IMUs tend to specify axis alignment behaviors differently. Consumer IMUs typically lump all misalignment errors into a single cross-axis sensitivity specification. Industrial ones, such as ADIS16490, specify alignment precision more directly using two different specifications: axis-to-axis misalignment error and axis-to-package misalignment error. The axis-to-package misalignment error describes how well the alignment in each axis relates to mechanical features within the IMU package. Axis-to-axis misalignment error describes how well the alignment of each accelerometer and gyroscope axis fits into the ideal case of mutual orthogonality. This is why the axis-to-axis misalignment error is commonly known as orthogonal error.

The mathematical relationship between cross-axis sensitivity (CAS) and axis-to-axis misalignment error (A2A_MAE) is:

$$\mathbf{CAS = \sin(A2A\_MAE)\quad A2A\_MAE = asin(CAS)} \qquad (1)$$

The effect of non-orthogonality occurs between sensor axes, across sensors, or from package misalignment between sensors and their enclosure. On an industrial-targeted IMU, these specifications are fully described in the datasheet after factory calibration. For discrete components, the cross-axis sensitivity specification does not account for assembly variances for each PCB.

Ideally, multiple axes within gyroscopes and accelerometers are mutually orthogonal. However, it is a common misconception that, since a multi-axis gyroscope or accelerometer can be designed within one discrete MEMS component, each of the axes are perfectly orthogonal with the others. Although all inertial sensors in these devices are on a single piece of silicon, inherent errors introduced at fabrication and manufacturing variances can still accumulate an orthogonal error. The resulting

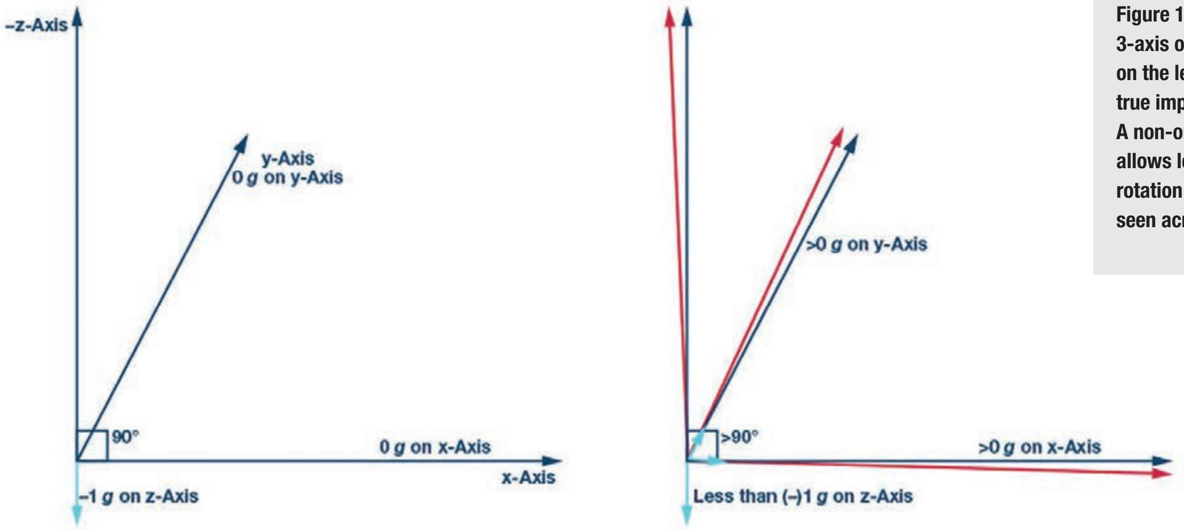


Figure 1: An ideal 3-axis orthogonal case on the left reflects the true impact of a vector. A non-orthogonal error allows leakage of rotation or force to be seen across all axes

equivalent alignment precision is actually not very impressive compared to fully-calibrated, industrial-specific IMUs.

A quick survey of consumer-targeted devices reveals that cross-axis sensitivity is often in the range of 1% to 5%. Using the relationship in Equation 1, the equivalent axis-to-axis misalignment errors are 0.57° to 2.87°. However, it could also be defined in units of milliradian, equal to 0.057°. Industrial-grade IMUs are typically much more precise.

We can also use this relationship to translate the axis-to-axis misalignment error of an industrial-targeted IMU of 0.018° into an equivalent cross-axis sensitivity of 0.031%:

CAS = sin(A2A_MAE) = sin(0.018°) = 0.00031 = 0.031%

Orthogonality errors

To understand the effect of non-orthogonal errors, let's assume that one accelerometer axis is pointed perfectly upward and the device is exactly level. The accelerometer on this z-axis is ideally measuring the total effect of gravity. If the other two axes were perfectly orthogonal, they would not measure any vector of gravity. However, due to non-orthogonality errors, the horizontal axis would measure some portion of the gravity vector. For example, if a device offers a cross-axis sensitivity of 1%, its equivalent response to gravity will be 10mg, which equates to an alignment error of 0.6°. Conversely, if the first axis is not orthogonal to the level frame, it will measure less than the complete gravity vector.

Orthogonality errors are especially stable components of the total error from an accelerometer. They may therefore yield to corrections based on one-time calibration.

To determine the orthogonality error of accelerometer axis pairs, the static response of each axis to gravity is measured as the accelerometer is rotated through all possible 90° orientations. This can be done using either a precision gimbal mount or on a known orthogonal surface.

It can be a challenging proposition to effectively calibrate out the orthogonal errors across the full operating conditions after mounting components onto a PCB. Inertial calibration requires observation of each sensor response, while the devices are experiencing well-controlled motion profiles. These types of profiles often require highly specialised equipment and expertise to operate effectively over time.

In contrast to an industrial-targeted IMU pre-calibrated for mounting, each mounted consumer MEMS device on a PCB would need to be calibrated against the other sensors, environmental performance and temperature.

Performance

Performance from an industrial IMU, with its three gyroscope axes and three accelerometer axes, leverages a calibration step after discrete components are mounted on a PCB in a rugged module. This single factory-calibration identifies and compensates not only for the non-orthogonality of the MEMS devices themselves, but also for any assembly related skew, minimising errors associated with variances from assembly, cross-axis and temperature. EW

Modelling thermal throttling of processors in consumer electronics

By Tom Gregory, Product Manager, Future Facilities

Whether mobile phones, laptops, wearable tech or tablet computers, changing consumer demands mean that today's electronics devices are thinner, lighter and more portable than ever before. At the same time, consumers are also demanding higher processing power to support the growing use of 4K video and for content creation and gaming on mobile devices.

To achieve higher levels of processing, electronics devices need advanced, faster processors, with more cores. But, with higher processing speeds come greater power consumption and more heat. If this heat is not managed properly, engineers not only face reliability issues, but also risk making products that are physically too hot to touch or wear.

To address this problem, modern processors are designed to slow down and switch off processor cores or other functions when not in use. As just one example, watching a video or playing a game requires high performance processing, whilst other common tasks such as web browsing or listening to music do not. To run a processor constantly at higher level will inevitably overheat the device; thus, today's processors are designed to respond quickly to changing requirements (and environmental conditions). This means they can assess and adjust hundreds of times a second to ensure that the user never notices a change in performance and the device doesn't overheat.

Help from phase change materials

Thermal throttling is combined with other thermal management solutions to ensure the device doesn't overheat. Phase-change materials (PCMs) are increasingly used to absorb high heat fluxes for short periods when the processor needs to run at peak performance; in changing from solid to liquid, PCMs absorb heat. At peak performance, the phase change material will melt, absorbing some of the heat. When peak performance is not required, PCM cools and solidifies. However, it's worth noting that PCMs only operate correctly with variable heat loads; they must first allow the PCM to solidify in order to be ready to absorb the next high heat load.

Control algorithms

Along with the physical use of phase-changing materials, sophisticated control algorithms are also being developed to control the performance of the processor and ensure that it doesn't overheat. These algorithms also help the end user get the best possible experience from a product or device.

To develop such a control algorithm, an understanding of how quickly heat will dissipate from the device is vitally important. At the same time, thermal management of the device must also be able to handle the required performance. For maximum reliability and user experience, the device's thermal management and control systems should be designed together, as early as possible in the design phase.

Thermal simulation solutions

In addition to considering thermal implications early in the process, engineers should also go beyond traditional prototypes and physical testing, running thermal simulations to predict the temperature and dissipation inside each device. By creating a virtual 3D model, and then using Computational Fluid Dynamics (CFD) to simulate the heat transfer and air flow, engineers get a better idea of how their products behave in different environments at different processor speeds.

In the past, design engineers typically would run a steady-state simulation to predict a device's temperature when running at full power for a prolonged period of

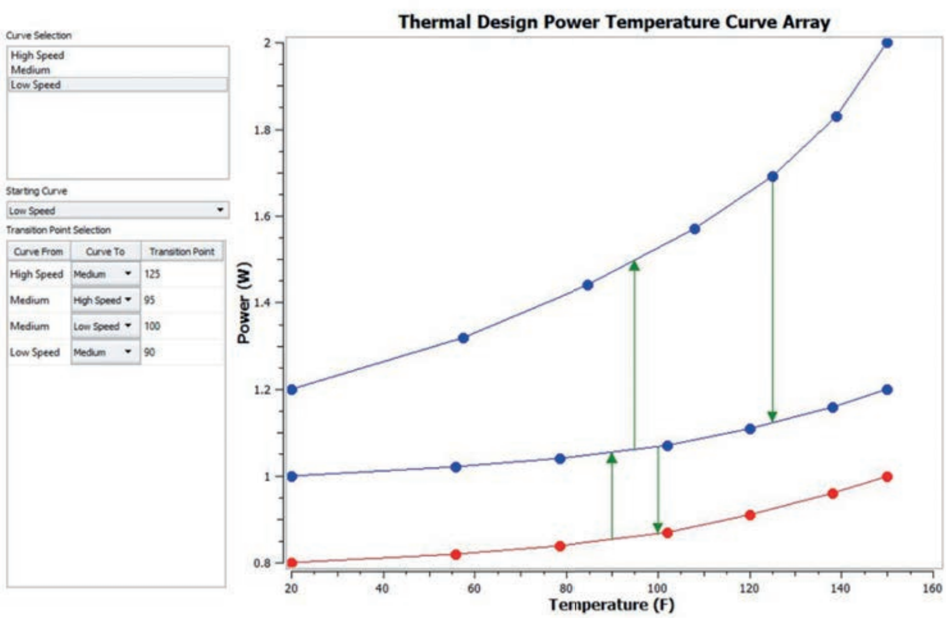


Figure 1: Defining multiple temperature-dependent power curves in 6SigmaET

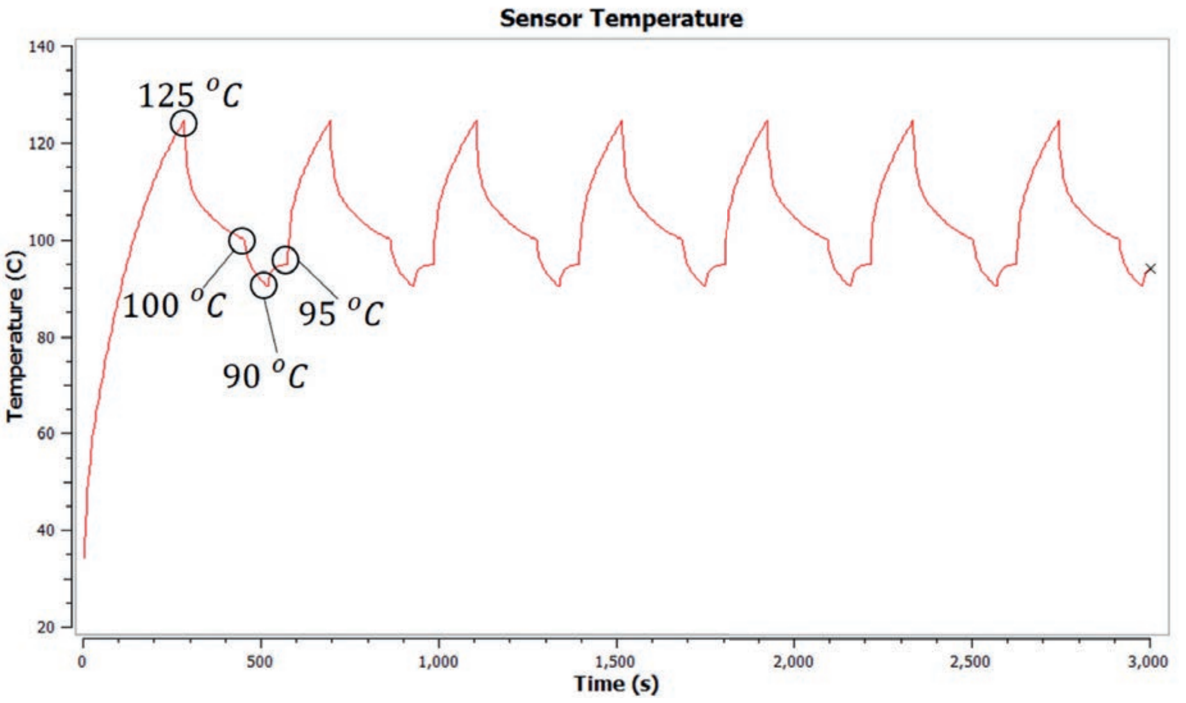


Figure 2: Plot of CPU temperature over time demonstrating thermal throttling

time. This was done because running time-varying simulations were not practical, due to computational and software limitations.

A steady-state solution, however, is not suitable for consumer electronics, which can't run indefinitely on full power. Thus, transient simulation is typically required to verify the thermal management of a modern consumer device.

Today, thermal simulation software should also simulate the thermal throttling of a processor. To achieve this, 6SigmaET has been working with leading semiconductor and consumer electronics companies to develop functionality for co-simulation processor control schemes with thermal simulation.

For a simple control scheme, the utilisation of a process can be varied automatically with temperature. If a processor has multiple power schemes, then the component modelling object can transition between these power schemes based on temperature.

For more complex schemes, however, where the response is based on a combination of workload and device temperature, 6SigmaET can integrate with other tools or use custom code developed in specialist packages such as Matlab, to define the control scheme.

For maximum reliability and user experience, the device's thermal management and control systems should be designed together, as early as possible in the design phase

Sensor data can also be output from 6SigmaET during the solution and input directly into the device's control scheme. Once processed, the scheme can be used in thermal simulation, achieved during each time step, predicting temperature changes over time. If the temperature in the simulation exceeds a particular limit, the control scheme can then be modified. Improvements to heat spreading and PCM can also be simulated and tested for effectiveness before physical prototyping.

To ensure that new devices are right first time, design engineers are using thermal simulation to verify their devices' thermal design. Such software must be capable of co-simulation of modern thermal throttling algorithms. EW

Touch in flexible displays: which technology will prevail?

By IDTechEx analysts

The technologies seeking to unseat ITO (Indium Tin Oxide) are by now themselves old, at least in the sense that they have been around for fifteen years. They seem to have been forever in the waiting mode, anticipating the arrival of their major breakthrough. A key differentiator has long been higher flexibility and foldability over ITO. The question now is how will different technology options fare, given that flexible displays are already emerging?

The road to flexible and/or foldable displays has been long. After years of development, the first milestone on the technology roadmap was the commercialisation of plastic rigid displays around 2014-2015, i.e. PI-based rigid backplane.

From late 2018 to early 2019, a number of foldable displays products were launched, with most display companies ramping up their capability to develop and manufacture flexible/foldable displays. Since all flexible touch displays will require some type of flexible touch technology, the market for flexible touch solutions has finally opened and will remain so until disrupted by another user interface solution.

Film

In general, two approaches have emerged: film and on-cell types. In the first, a flexible film is bonded to the OLED device; in the latter, touch layers are deposited and patterned directly on to or as part of the thin film encapsulation (TFE) process. Another key parameter is the ability to sustain ever-tightening foldability requirements. A thinner solution will offer higher foldability, but this may need to be balanced by considerations of mechanical robustness and lifetime.

Table 1 shows a comparison of the two approaches. Film type is simplest to implement. Crucially, it decouples the production yield of the touch layer from that of the display layer. Furthermore, the films can be manufactured using lower cost assets. The scaleability to larger sizes will also be simpler and production speeds likely higher, since R2R film production techniques can be deployed. Therefore, the film-based approach is a more accessible technology that offers an easier and chepar path to larger-area flexible displays.

However, this approach falls short on performance. Material choices are now available that offer high flexibility and foldability. Metal-mesh films are likely to be adequate for medium levels of folding. The picture for higher bending degrees becomes hazier; however, technology options such as silver nanowires have already demonstrated that they meet the technology need for high bending levels. Clearly, all technology choices require further improvement, and current problems are unlikely to be fundamental showstoppers. So the transparent conductive layer choice itself is not a performance bottleneck.

The real limitation of the film-based approach is that it requires an additional substrate and a bonding layer. This increases overall thickness, which in turn lowers flexibility. In future, combining touch with other layer functionalities may partially alleviate this shortcoming. This trend toward combinations will perhaps accelerate with wider availability of CPI films. Candidates for function-combination include the hard-coat layer, the polariser, the barrier film (if used), and so on. The evolution of this trend will have important implications for the long-term viability of film-based solutions.

On-cell

The other approach is on-cell. Here, the touch layers are deposited and photolithographically patterned in line directly on top of the OLED-TFT stack. In the future it might be possible to weave the patterned touch electrodes as part of the TFT structure, although that can require a difficult manufacturing challenge.

The key advantage of this approach is that it eliminates the additional substrate, resulting in a thin and flexible solution. The challenge however is that it dramatically increases the cost of production defects in the touch layer, since the entire stack – including the OLED and the TFT – will be thrown away. Success here, therefore, requires outstanding production know-how and optimisation.

Furthermore, this process ties up more expensive production assets on a usually low-cost item, the touch layer. It is also likely to require slow and controlled deposition within the narrow parameter space, limited by the already-deposited materials and layers. Importantly, it is not clear if this approach can be readily scaled to larger areas. This is because it would require the inline TFE as well as the patterned touch electrode deposition processes to be scaled up without compromising quality or cost.

In the future it might be possible to weave the patterned touch electrodes as part of the TFT structure, although that can require a difficult manufacturing challenge

In general, we expect that all display makers will build some know-how for both just in case, but no single approach will prevail in production soon. Those with sufficient technology know-how and intellectual property protection will pursue the on-cell approach for then current display sizes. They will also continue to make progress on translating this technology to ever larger areas, often chasing after high-priced, high-performance, premium display positioning. Others will pursue a film-based strategy, with its easier and low-cost access to touch technology for flexible displays.

In the medium term, we envisage the emergence of a more diverse range of flexible displays, each with different performance, further sustaining the existence of multiple approaches in the market.

Note that the battle between film-type vs on (or in)-cell type also applies to rigid displays. Here, too, both approaches are used, although trends may shift the balance one way or the other. EW

Parameter	Film type	On (or in) cell
Cost of defect (importance of yield)	Low	High
Production complexity	Low	High
Ability to do R2R	High	Low
Ease of technology access/implementation	High	Low
Overall thinness (thus flexibility)	Low (unless multi-function substrates are developed)	High
Ease of scale-up to larger areas	High	Low
IP Risk	Low	High

Table 1: A comparison between film and on-cell approaches

Introduction to neural networks

By Mark Patrick, Mouser Electronics

Artificial intelligence (AI) seems to be on everyone's mind at the moment. And it is not difficult to see why: AI is expected to have a profound impact on our society, becoming part of our daily lives, to the point that we won't even know it's there, but everyday tasks will be easier and more seamless.

At the heart of any AI-based system is an artificial neural network, or ANN. Largely modelled on the human brain – the ultimate biological neural network – an ANN aims to emulate the brain's processes.

Within the human nervous system, neurons, the basic working unit of the brain, are excitable cells for the transmission of electrical signals to other nerve, muscle or gland cells. Most neurons have a cell body, an axon and dendrites; see Figure 1. Axons extend from the cell body and often split into many smaller branches before ending at nerve terminals. Dendrites extend from the cell body and receive messages from other neurons. Neurons connect with each other via synapses. External stimuli, for example eye or skin neurons, can influence how the synapse bonds are shaped, and it is their 'thickness' that forms our learning.

Like the biological structure, an ANN uses units of computation as neuron inputs to which a weight factor is added to indicate the strength of the synaptic connection. Learning takes place by adjusting the weights given to each input.

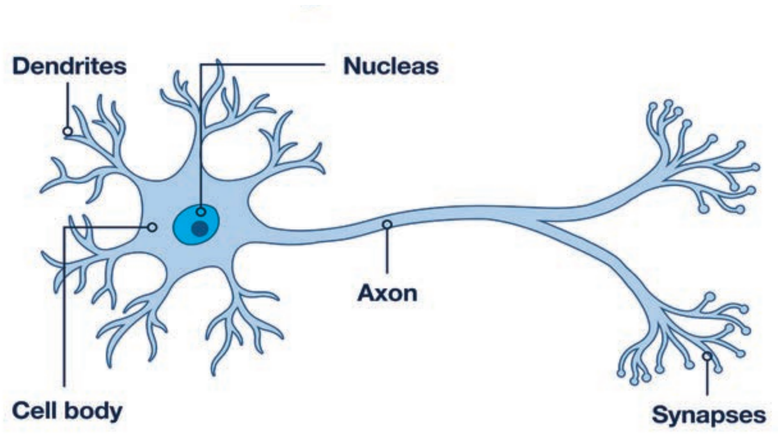
Just like the human brain, an ANN needs to learn – a process called "training" – which involves feeding the neural network with set input and output pairs. For example, in a computer-vision application this might be hundreds of images of animals (input), and the corresponding species name (output) of each image. The training process involves adjustment of weights so that for a given animal image the network's prediction result is high. Achieving a high prediction result requires that the network be trained with a large number of images of each animal type. In this way, when the network encounters a picture it hasn't seen before, it can predict the identity of the animal with a high degree of accuracy. This prediction phase of an ANN is called "inference".

Neural network architecture types

The architecture of a neural network varies and, like many parts of the human brain, can suit different tasks. Two popular network architectures are recurrent neural network (RNN) and convolutional neural network (CNN).

In handwriting or speech recognition applications, for example, the RNN uses an architecture of multiple successive node layers. These networks are also regularly used for computer translation tasks, for example translating text from

Figure 1: A biological neuronal network



one language into another. Predicting the next word as the message is typed is another example, as done by many messaging applications today.

A CNN can interpret images, as in computer vision, facial recognition and vehicle registration-plate detection. Its architecture is similar to the animal world's visual cortex, where successive receptive field areas overlap to build a complete visual image. These multilayer neural networks have a single input and output but may have many hidden convolutional layers.

A complex core

ANNs are highly complex, combining skills and expertise from data science and neuroscience. Their complexity had put them out of reach for most commercial applications for a long time, the sole preserve of academic and research communities. However, with the rise of computational capabilities, always-on connectivity and demanding applications, industry initiatives are making neural networks accessible to all. Neural network frameworks have opened up the development of machine-learning-based applications and put high-level AI capabilities in the hands of product designers and engineers.

TensorFlow is an example of an open-source software library framework, initially developed by Google for its internal research and production systems but made publicly available in 2015. With a focus across a range of different types of neural networks, TensorFlow includes a comprehensive set of libraries, workflows, models and tools to develop and train neural networks. It supports a range of programming languages from Python to JavaScript, as well as other hardware environments for CPUs and GPUs. Deployment on low-compute devices, such as Android, iOS and Raspberry Pi, is also possible for edge-based inference.

Caffe is another deep-learning framework that supports a variety of computing platforms, programming languages and capabilities for neural network development, training and application. Created at UC Berkeley, the Caffe website has a wide range of code examples, and is believed to offer the fastest image-classification CNN implementations available, capable of processing over 60 million images per day.

The next time you ask your smartphone assistant a question, take a moment to appreciate the behind-the-scenes complexity

AI is all around us

Neural networks are working all around us, and many are already on our smartphone and smart home devices. Since none have the built-in computing power to respond promptly, their inferences take place in the Cloud.

So, the next time you ask your smartphone assistant a question, take a moment to appreciate the behind-the-scenes complexity and how neural networks respond to your query. EW

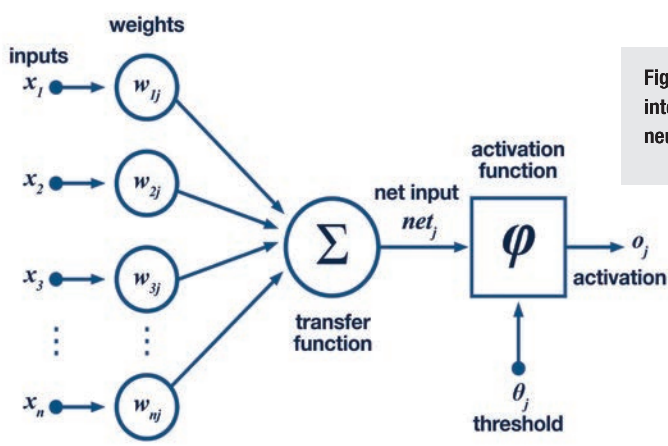


Figure 2: Mathematical interpretation of an artificial neural network

Q&A with...

Phil Sorsky

VP of international service providers at CommScope

...who discusses the advances of 5G

What's the status of 5G in the UK now?
We're currently entering a cautious, early adoption phase of next-generation wireless technology. A small number of users will receive a first taste of 5G in certain geographic locations, via specific applications, none of which are ubiquitous or optimised for cost just yet.

The technology will primarily focus on enhancing mobile broadband, which is all about delivering enough bandwidth to users so that, when demand for bandwidth accelerates, they can enjoy the same level of service as with 4G.

While this is rightly creating optimism in the market, there is already limited radio frequency (RF) infrastructure – including base station antenna sites – available for the 3.5GHz spectrum. These bands underpin 5G, and such macro-cell upgrades and outdoor small-cell deployments will be critical for operators, many of which are already network-capacity stretched.

What must operators do to make 5G happen?
Setting up 5G is about new spectrum, mostly higher frequency signals that don't penetrate walls very well. So, when thinking about users inside spaces such as buildings, enterprise areas, airports and underground train stations, we'll start to see custom-built systems that will bring that bandwidth.

However, 5G will enable service providers to keep up with the intense subscriber demand for more wireless bandwidth by adding capacity to their networks. Technologically, 5G performance allows providers to eliminate network bottlenecks by adding more small cells, fibre and mobile edge computing to their networks. The industry has been most successful when using fibre to achieve these goals.

Are there any examples of 5G deployments to date?
Italy is certainly making strides with 5G. Millions of tourists flock to its historical landmarks and venues every day, creating unique challenges for network operators in keeping people realiably connected.

To address this, businesses across Italy are investing in new, digital infrastructures, giving users first-class, in-building wireless experience. INWIT, Italy's largest provider of host services, is today collaborating with CommScope to deliver superior mobile voice and data services, 5G ready.

What's next for wireless connectivity?
When it comes to connecting to the network, wireless has clearly won the battle; now we need to see how far 5G can take that. As fixed wireless-access penetrates residential markets, and open interfaces in 5G networks promise to make new vertical markets more accessible, the possibilities are endless.

This year we will see the first deployments of 5G. What follows in wireless connectivity will be more, better and faster, as the future of 5G continues to shine brightly ahead.

What about CommScope's involvement with 5G?
We recently made a few key announcements, including a collaboration with Nokia, to develop passive-active antenna solutions for optimal tower-space usage, increased cell-site capacity and laying out the groundwork for a 5G-ready future.

We also announced a new suite of 3.5GHz antennas for macro and small cells to help increase network capacity and migration to 5G. With these new antennas, customers using newly-licensed spectrum bands will be able to increase capacity in existing LTE networks and prepare for future 5G networks.

The power of wireless power

By Ori Mor,
VP Research and Development,
Wi-Charge

Wireless technology has been very popular with consumers for many years. When we speak of wireless technology we immediately think of radio, cordless phones, audio equipment, household and personal care appliances, among other everyday products. Smart devices and home networking have advanced wireless connectivity even further, enhancing ease of use and utility for many systems. However, wireless networking is one thing, wireless power quite another, and this technology lags behind in consumer awareness and adoption.

Without plugs

Wireless power technologies charge devices without plugs, which means there's no need for wires and cables throughout a house or through walls, floors or ceilings. Unlike magnetic induction ("Qi") charging pads that require direct contact with a phone, long-range wireless power has taken the next step in this evolution, promising to charge smartphones and small devices from several meters away. Smart home appliances, such as Google Home and Amazon Echo smart speakers, or smart locks and light fixtures, could be powered without being close to power outlets. Wireless power will also end the rule of batteries, which require constant recharging or replacing.

Why do so many products still use batteries and power cords – technologies invented a century ago?

At the heart of any wireless power technology is the electromagnetic (EM) frequency spectrum. Technologists have focused on just two EM bands so far: radio frequency (RF) and infrared (IR), where we've seen the most innovative leaps and the potential for wireless power commercialisation.

The range of 100GHz to 10THz, between the RF and IR bands, has produced the fewest breakthroughs. Commonly referred to as "the THz gap", we have little knowledge on the possible impact of this frequency range on health.

Outside the RF and IR bands, visible light and ultra-violet (UV) are not viable options for wireless power.

Differing power requirements

Understanding power needs and deliverability are the two most important aspects when considering wireless power.

All devices have differing power requirements; see Table 1 for examples. Much of the current focus of wireless power innovations is on devices that require 10mW to 5W. Those below 10mW can use battery power quite conveniently without constraints on performance and usability; those above the 5W threshold, however, require too much power for current wireless power technologies.

Beyond the question of how much power is required, an important consideration is where the device will be charged and, more specifically, how far from the power source. Today, with Qi charging, we essentially look at charging on a pad in the immediate proximity of a power source. More useful would be charging at desk-sized distances, for, say, an office worker, who can charge a phone and computer peripherals whilst working at a desk.

Room-sized charging provides even greater convenience: phones could be charged anywhere within a room, and wireless speakers or indoor security cameras could be powered without being close to a power outlet. Ultimately, there will be outdoor charging, where walking within towns could charge a phone or another portable device.

To convert these into distances: pad charging covers several centimetres between transmitter and receiver, desk charging to about a meter, room-sized charging to about 10 meters, and outdoors beyond this. And, it would be just perfect if a technology can charge a phone at room-sized distances!

Batteries not included

So, why do so many products still use batteries and power cords – technologies invented a century ago? The simple answer comes down to design and proven functionality. Product manufacturers have relied on these two key approaches to delivering power for so long that they seemingly can't break away with the old ways of designing products. Very early in the design process, product designers have to choose between using batteries for electronic power or connected cords based on the functionality they're trying to achieve.

Using a battery-powered wireless device is the most common choice, given its ease of use and functionality – but batteries need to be recharged and replaced and have a fairly low energy capacity, leaving products with sometimes drastic feature limitations. Cords, on the other hand, are dependent on proximity to a power source, which limits usability and often erases the convenience of a device.

A good example of the benefits and deficiencies of cord-connected devices and battery-powered wireless technology can be found in indoor security cameras. Corded affords more functionality, allowing video streaming without draining the battery. But, it also limits the range where it can be placed because of the power outlet or the effort in running a powerline and installing the camera in the most ideal location.

A battery-powered camera, on the other hand, gives greater flexibility and ease of installation but may only be able to stream an insignificant amount of video at a time, limiting the camera's usefulness.

Wireless power delivery

There are two key factors that guide the safe amount of energy delivered to a device:

Device	Typical power consumption
Smoke detector	0.0001W
Wireless motion sensor	0.03W
Smart door lock	0.1W
Nest smart thermostat	1W
Smartphone charger	2-10W
Nano drone (toy)	5W
Notebook PC	20W
Refrigerator	150W
Electric vehicle charging	2,500-80,000W

Table 1: Typical power consumption of commonly used devices

Wi-Charge wireless power cradles

distance and power. Distance is limited by the physical phenomenon of diffraction, whilst power is limited by safety regulations.

Diffraction is a physical property of waves, i.e. how beams diverge as they exit the source of energy.

Diffraction is important because, in practice, we want small energy receivers – enough to fit inside a phone or, at least, not make the phone unnecessarily larger. With significant diffraction, the beam widens with increased distance between transmitter and receiver, lessening the available energy. This also raises a potential safety concern: if the receiver captures only a small portion of the transmitted energy, what happens to the rest? If radiated into the nearby environment, it might expose people, pets and objects to unwanted energy, which could be a safety concern.

If the receiver captures only a small amount of energy, an engineer might be tempted to increase the transmitted power so that, even with low receiver efficiency, enough will reach the device. However, this is where we might run into safety regulations. No-one wants a radio tower in the kitchen, so regulatory bodies like the FCC and FDA work on safety standards for safe exposure limits to various energy types.

The limits for RF and IR are vastly different. One reason is that IR naturally exists in the world: some 50% of the sun's energy is IR, which means our ancestors have evolved to comfortably live with it. In contrast, RF is man-made radiation that's been around for only 100 or so years.

Enough diffraction?

We determined that little or no diffraction is preferred to too much, but what factors drive how much diffraction we get?

Amount of diffraction received is determined by the ratio of aperture (the size of the transmitter) to the wavelength of energy used. The larger this ratio, the smaller the beam widening.

Because IR frequencies are much higher than those of RF, wavelengths are much shorter. Thus, for practical transmitter sizes, IR light has almost no divergence whereas RF diverges a lot.

When we talk about practical transmitters, we know that a dish the size of a giant radio telescope can send relatively narrow beams of RF energy into space, but who has room for one of those in their home?!

In contrast, a laser pointer, for example, has a thin beam of light that practically doesn't expand, even though it comes out of a very small aperature.

Finding the sweet spot

Is it possible to find a technology that is powerful enough, can provide energy over room-sized distances and yet safely charge a phone?

When engineers start thinking about wireless power delivery, RF may seem the best way. After all, RF is used for many communications technologies, it is a widely accepted and standardised means of transmission, with many commoditised components readily available. But because of safety reasons, RF is very limited for practical power transmission. It is best suited for peripheral devices like wireless mice or keyboards in a desktop environment – applications that don't require operation beyond a meter. Supporting the wide range of consumer products that represent real-world solutions is simply not possible with RF technology. So, 0.1W is the theoretical best-case maximum power that can be delivered to a phone-sized receiver.

By contrast, IR meets the needs of 21st-century consumer technology into several important ways. By focusing infrared in a tight beam, its power resists diffraction and can usefully travel longer distances. Like a laser pointer that focuses light and doesn't dissipate its light energy, IR can carry over a great distance without the beam losing its shape or power. Calculations at room-sized distances reveal delivery of 10W of power using IR is feasible and more than enough to power most smart devices.

Beyond the power cord

Wireless power presents significant opportunities to move beyond power-cord-dependent and battery-operated devices, and the technology to implement new innovations is available today. While IR power for large appliances like laptops and some smart appliances that require higher power levels may still be a few years away, IR technology has the ability to deliver power safely and efficiently to most smartphones, home speakers and other common consumer electronic products.

IR is safer and far more efficient than RF, and can easily be implemented into new consumer goods. In addition, it removes the impracticality of power cords for a wide range of electronic devices and provides much-improved performance thresholds for many battery-dependent devices.

With wireless power, indoor cameras can be installed with ease and stream limitless video. Smart door-locks could add face recognition and Cloud storage. Long-range wireless power may not necessarily power a TV today, but it has the potential to some day bridge the gap between batteries and wired connections. Charging a phone from across the room, and using wire-free surround speakers and many other everyday devices, will soon be possible with wireless power – it's an alternative that consumers will benefit from, and with the right wireless power technology will soon be a reality. EW

Improving display-caused eye strain with high-accuracy colour sensors

By Dave Moon, Senior Product Marketing Manager, Advanced Optical Solutions Group, ams

With modern optical filter techniques, we can now use colour filters to match the accuracy of the human eye at a cost suitable for high-volume applications

The human eye's discrimination of colours has underpinned the work of painters throughout history. Artists instinctively understand that visible light is a complex spectral phenomenon, and the proportion of red, indigo, violet, green and other colour components of white light vary in sunlight. Moreover, the colour of sunlight changes from place to place and from time to time.

Similarly, colour varies widely between different types of artificial light sources, where they can be even more pronounced and have a profound effect on electronic products. Electronic device manufacturers now understand the impact of ambient light colour on the perceived colours from a display and how to dynamically change them with illumination.

This article discusses the effectiveness of white-balancing technology and its dramatic impact on both authenticity and accuracy of colours displayed on screen.

The effect of changes in the illuminant

The spectral content of the illuminant (ambient light) affects the eyes' perception of a viewed object's colour. Viewed in daylight, at noon, objects reveal an emphasis on blue hues, because daylight consists of a distinct combination of sunlight and skylight. The same objects viewed under artificial lighting, say from an incandescent bulb (which may have a Correlated Colour Temperature [CCT] of 2700K), will appear more golden yellow. See Figure 1 for a comparison of the spectral content of various illuminants.

This effect is readily perceived by the eye when viewing an image printed on paper under different lighting conditions: the colours change as the illuminant changes. However, displays do not work this way. Until the integration of ambient light sensors in smartphones and laptop computers became common practice, a display's controller remained impervious to the characteristics of ambient light in which the display is being viewed. For this reason, displays had a fixed preset white-point colour temperature of 6500K for liquid crystal displays (LCDs) and, more recently, organic light-emitting diode (OLED) screens. 6500K was represented by the industry standards body CIE as the D65 reference illuminant shown in Figure 1, and its CCT value is similar to bright noon-time daylight, with its spectral power distribution with a strong blue component. This means that images on screen will appear very similar to those on a printed page in the same ambient condition of noon-time sunlight. Both display and printed images will give particular emphasis to blue hues. But when viewed under warmer lighting environments, such as a warm-white 3000K LED for instance, printed images appear more yellow-orange, since the illuminant has more red/yellow and less blue.

Without means of adjusting the display's white-point, electronics manufacturers have simply offered a single, fixed D65 white-point preset for their displays, resulting in images appearing with the same strong blue emphasis as before.

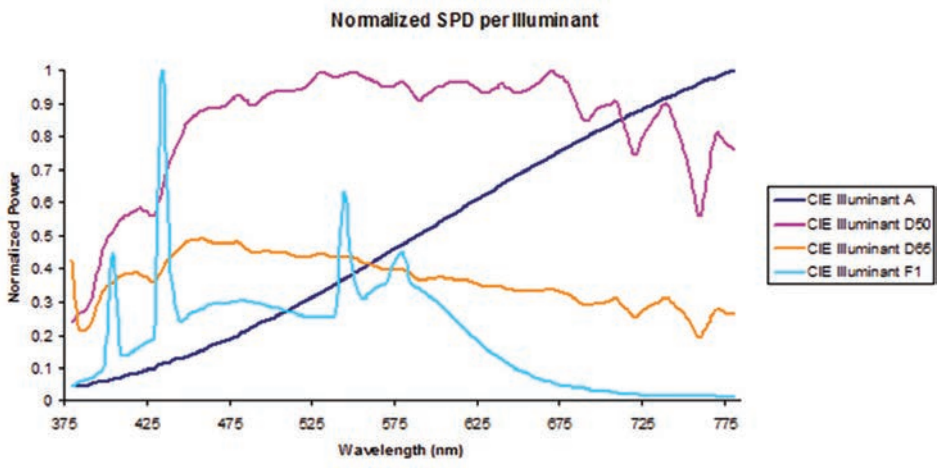


Figure 1: Spectral power distribution (SPD) of various standard CIE illuminants – fluorescent light (F1) has sharp peaks at green and orange wavelengths. This is in contrast with the broad spectrum of daylight (D50, D65) and incandescent light (A)

[Image credit: SchwartzD under Creative Commons license]

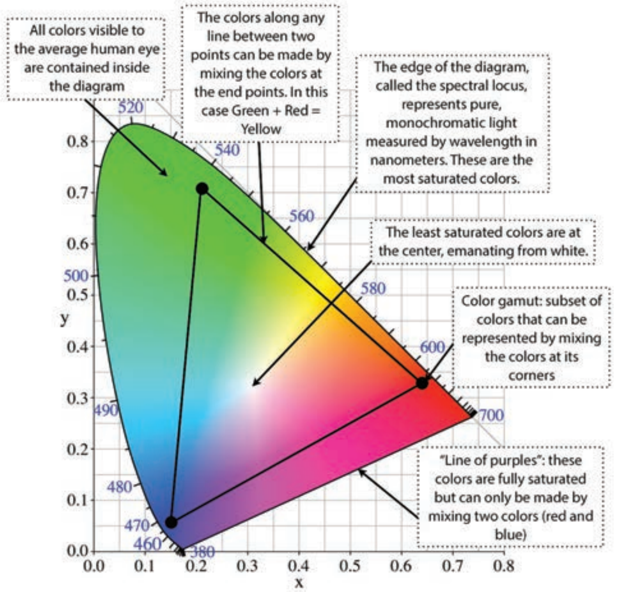


Figure 2: The standard CIE chromaticity diagram explained

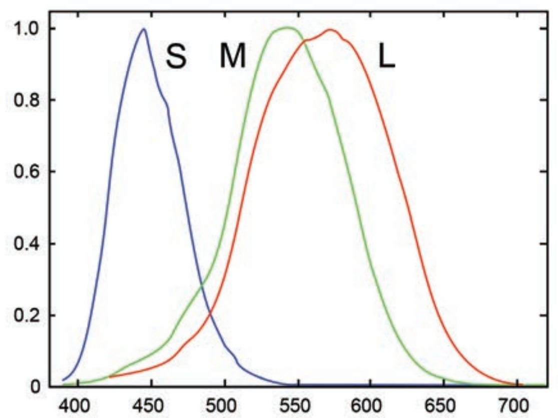


Figure 3: Normalised spectral sensitivity of human cone cells of short, middle and long wavelength types

Printed vs displayed content

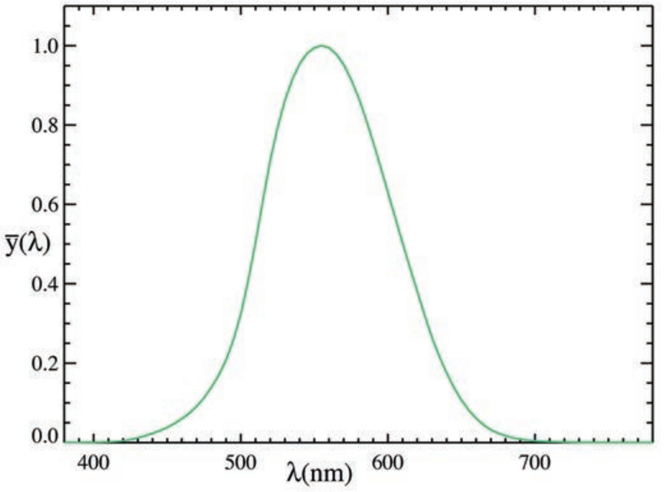
We can read content from paper for many hours with minimal eye-strain. But, viewing the same content on a display with a fixed D65 white-point, emitting a significant amount of blue light, has detrimental effects, causing eye strain and disrupting sleep.

Science has shown the photobiological effects in the human eye, and hence the brain, of how blue light stimulates the waking-time physiology. Blue light suppresses the production of melatonin, the body's natural relaxing agent that helps us get a good night's sleep. The absence of melatonin makes people feel awake, potentially affecting the body's circadian rhythms.

Smartphone OEMs looking to differentiate in a slowing market can now offer a new feature called "paper-like" viewing on their displays. This is created by shifting the display's D65 cool-blue white point to a warmer colour temperature, made possible by a new generation of high-accuracy XYZ colour sensors.

With modern optical filter techniques we can now use colour filters to match the accuracy of the human eye cheaply enough for high-volume applications. These optical filters are deposited directly on to the die of optical sensor products. Traditional RGB colour sensors offer ±10% CCT, whereas CIE XYZ colour-filters' accuracy is ±1-5%.

CCT accuracy needs to stem from the colour space standard developed in 1931 known as the CIE xy chromaticity diagram; see Figure 2. Colour can be divided into brightness (or luminance, measured in lux) and chromaticity (measured in xy chromaticity parameters). The chromaticity diagram in Figure 2 is a tool which shows how the human eye will experience light with a given spectrum; it does not specify colours of objects, since the chromaticity observed while looking at an



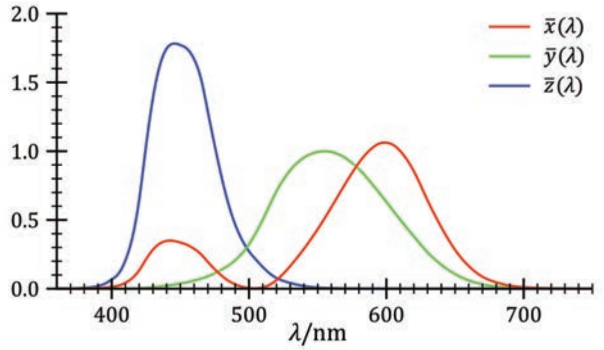


Figure 4: The green channel photopic response is closest to what humans see – from the CIE photopic luminosity function

Figure 5: The CIE1931 2° Standard Observer colour matching functions or XYZ tristimulus human eye response

object depends on what colour ambient-lighting surrounds the user.

Artificial light sources tend to have warmer colour temperatures, with residential lighting the warmest (2700-3100K). Office lighting is typically 3100-4500K, whereas daylight colour temperatures range from 6000K at noon to as high as 15000K just before sunrise or just after sunset on a cloudless day.

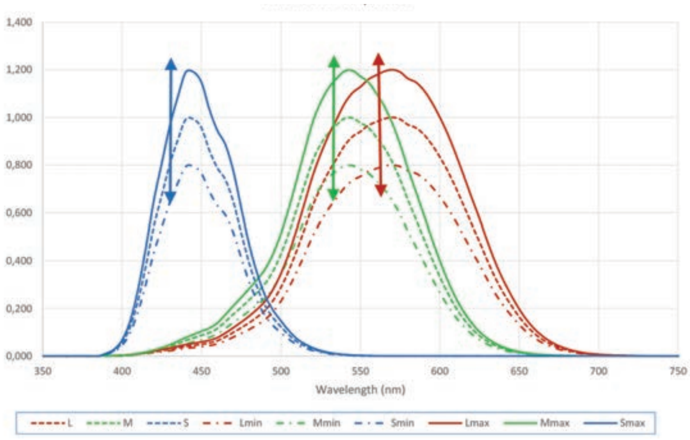


Figure 6: Chromatic adaptation

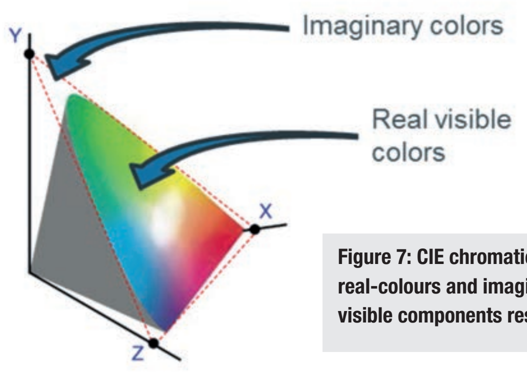


Figure 7: CIE chromaticity diagram real-colours and imaginary non-visible components response

Colour vision

Viewing a display with a white point that differs from its surroundings affects our perception of individual colours. A colour display with a neutral or cool white-point viewed in an environment with warm lighting will appear bluer than it would in a cool ambient-lighting environment. Adjusting the white point of the display to match the ambient lighting will minimise – if not eliminate – this effect.

The CIE chromaticity diagram captures the human perception of visible light wavelengths between 380nm and 780nm in the electromagnetic energy spectrum. Figure 3 shows the normalised spectral sensitivity of the human-eye's cone cells to short, medium and long wavelengths. This is driven by the neural responses of the short, middle and long cone cells of the retina, with peak sensitivity to wavelengths in the red, green or blue portions of the visible light spectrum.

The wavelength sensitivities of the cones span a rather wide range and overlap each other; each curve is normalised in the graphic for simplicity. The relative response of the three types of cone cells in the retina is sufficient to explain colour vision, and colour can be characterised by numerous sets of colour-matching functions, all of which are linear transformations of each other.

Figure 4 shows how the middle wavelength response was then defined as a photopic view and is used to define Illuminance (in lux) because the green wavelengths are closest to what we see (we are more sensitive to green and less to red and blue).

The lux is a measure of visible light illuminating a point on a surface from all directions above it, and is the unit of measure for brightness.

The XYZ tristimulus human eye response (Figure 5) was defined and is known as the CIE1931 2° Standard Observer; it provides a connection between visible spectrum wavelengths and the physiological perceived colours for colour vision.

The visual system in humans is very complex, tightly coupled to our brain. The human brain is capable of identifying an object's colour even when lighting changes. The way we see colours is not fixed but a relative perception. When the light-source type changes, humans change their perception of viewed colours because there is a dynamic relationship between an object's surface, type of light source and our eyes.

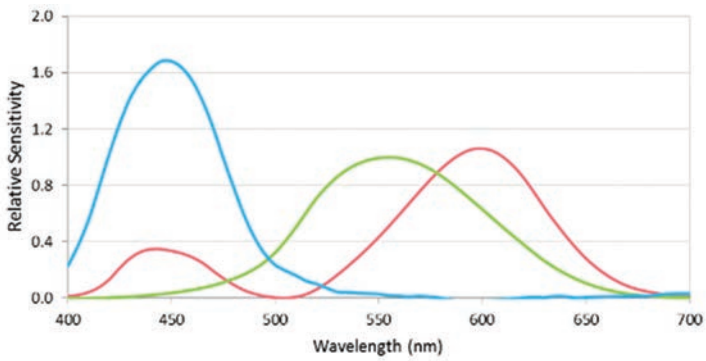


Figure 8: The XYZ spectral power distribution of the TCS3430

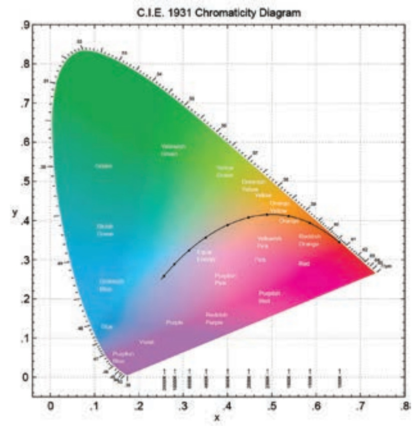


Figure 9: The CIE1931 colour space chromaticity diagram – illustrating the Planckian locus

Our visual system adjusts the relative response of the long, medium and short cone cells in response to the spectral content. Our eyes have a chromatic adaptation mechanism to understand different ambient light conditions. This is how we react to make white and grey objects look white and grey under different ambient light conditions. The optical gain adjustments for this chromatic adaptation principle are shown in Figure 6.

Figure 7 shows the real-visible colours of the chromaticity diagram and the complex imaginary components – shown in the XYZ triangle edges outside the chromaticity diagram.

RGB colour sensors are capable of measuring the real colours shown on the chromaticity diagram, where XYZ colour sensors are more accurate in measuring both real as well as complex imaginary colours. The spectral power distribution (SPD) response for a particular colour sensor is shown in Figure 8.

XYZ spectral response is based on the human eye, thereby providing more accurate information on how people perceive a colour. While there are methods to convert RGB values to XYZ, the RGB colour primaries are not an exact colour-matching function, so the resulting values from the conversion do not match how the human eye perceives colour.

By closely matching the colour response of the human eye, the data from an XYZ sensor can detect differences in colour similar to the way a human would. Using a high-accuracy XYZ colour sensor that outputs a measure of the CIE XYZ tristimulus values of incident light provides the best results when measuring ambient lighting conditions.

In Figure 9, the solid curve in the middle is called the Planckian locus. Each dot on the locus corresponds to a black-body colour temperature, which corresponds to CCT values. Adjusting the white point of the display to the ambient colour temperature assumes that the display actually knows the colour temperature of the ambient light. Since both fluorescent and LED light sources do not always fall squarely on this Planckian locus, it is better to drive the white point to the actual chromaticity coordinate values of the ambient lighting, rather than defaulting to the corresponding colour temperature on the Planckian locus.

A modern display

Figure 10 shows how this adaptive display technology works. In light boxes, two smart phones are shown in two identical pictures. Paper-like technology is demonstrated by changing the light-source. Doing so also changes our perception of the reflected colours.

Figure 10: Paper-like demo showing how pronounced blue light is in warmer lighting environments

Figure 11: Recommended RGB multipliers for a given colour temperature

In the figure, the display on the right lacks an XYZ colour sensor and continuously emits D65 light. The left display has a TCS3430 colour sensor accurately measuring any changes in ambient lighting conditions; a display algorithm (Figure 11) is used to enable print-like readability.

The display has an 8-bit RGB multiplier value, so the values on the y-axis range from 0 to 256 recommendations ($2^8 = 256$), and the values on the x-axis are the measure of colour temperature values from the XYZ colour sensor. From Figure 10, for a 6500K measured colour temperature, the recommended RGB primary display driver values should be set to 256 red, 256 green and 256 blue – driving the display to a D65 white point. When a lower colour temperature is measured from a 2700K incandescent light, for instance, 256 red, 195 green and 130 blue should be displayed.

When the 6500K light bulb is illuminated, the left display measures the ambient light, applies the algorithm-recommended RGB values of 256 red, 256 green, 256 blue to drive the display to the exact same white point of the right display, making both displays look the same. The printed backboard colour content flows smoothly into content for both displays.

When the 6500K bulb is turned off and a warmer 3000K fluorescent is switched on, the ambient lighting gets warmer, and the left display automatically adjusts to a warmer white-point to match the new 3000K ambient light. The printed images appear more yellow-orange due to the blue light component being reduced.

The perceived colours we see in the printed picture are slightly changed. The display without the colour sensor continuously displays the same blue-rich D65 white-point in the warmer 3000K environment. In this case, it's clear how much bluer the right display looks, whereas the display on the left automatically adjusts its white point in reponse to the 3000K lighting environment to produce print-like readability.

Turning off the 3000K bulb and turning on an even warmer 2700K incandescent results in the ambient light growing even warmer with more yellow-orange due to less blue light content. Also, the left display and our perceived colours of the printed picture content are further changed. The left display automatically adjusts its white point to match the 2700K ambient-lighting environment in Figure 11, where the right D65 white-point display emits the same rich blue-light content.

By closely matching the colour response of the human eye, the data from an XYZ sensor can detect differences in colour similar to the way a human would

Optical filter advancements

Smartphone, computer and TV OEMs traditionally offered fixed white-points for their displays, with either a manual or time-of-day single preset white-point, with limited effectiveness since it couldn't cover varying lighting conditions. Fortunately, through advancements in optical filter techniques that yield human-eye-level accuracy at a price appropriate to the high-volume consumer electronics market, a suitable means of automatically measuring ambient lighting conditions and enabling paper-like viewing of a display is now possible.

Changing ambient lighting conditions profoundly affects our perception of viewed colours in both reflected-light environments and when viewing content on an electronic display.

Displays with fixed D65 white-points have now conclusively been shown to have physiological effects on our bodies. Automatically adjusting a display's white-point to an optimised setting under changing ambient lighting condition has noted physiological benefits – minimising the eye strain that digital technologies impose on us, whilst also allowing us to sleep better at night. EW

ADC fit for an audio test platform

By Niall McGinley, Applications Engineer, Analog Devices

Audio is being integrated into almost every electronic device, with a much wider variety of media sources available to consumers today than ever before – all with high-fidelity audio delivery. Gone are the days of static and unwanted distortion in audio systems, and even with the move to the Cloud for audio playback, streaming services offer listeners high-fidelity music. The audio space now requires more memory, more processing power, greater accuracy and better definition, yet in smaller packages. With voice recognition, the ability to distinguish a vocal command from a noisy environment will require high-quality hardware embedded in the devices. Hence, the key will be the dynamic range achievable and the ability to filter out noise and interference.

This growing number of audio modules has also led to an increased need for audio test platforms that offer multifunction flexibility and high-fidelity performance.

In search for a solution

Incorporating these requirements into a modern audio test platform comes up against limiting factors, including cost, size and power dissipation. In general, ADCs with 24-bit resolution and above are used for high-fidelity audio in the audio test space for increased dynamic range. For signal integrity, low distortion and excellent noise immunity are also required.

One product that can help ease these common constraints is the AD7768 from Analog Devices, a multichannel, 24-bit, Σ-Δ ADC. It is available in both 4- and 8-channel versions and, due to its SINAD performance, it's a proven fit for the audio test space. The AD7768/AD7768-4, with its multiple channels, allows a smaller system with increased channel density, keeping channel-to-channel crosstalk to a minimum, while allowing simultaneous testing of different devices.

Test case

To explore this ADC's capabilities, typical audio tests have been carried out to measure the performance of various consumer audio devices. The main test uses the AD7768 evaluation board, the EVAL-AD7768FMCZ, in conjunction with the SDP-H1 platform. Many possible test tones were considered, including IMD (intermodulation distortion) tones, logarithmic chirps and level tests.

The two test tones chosen were:

1. 1kHz sine wave at –60dBFS, useful for dynamic range tests since it keeps the device from muting, which artificially quiets the output.
2. IMD SMPTE test, 60Hz/7kHz, 4:1 (12dB ratio), –20dBFS. The IMD test shows nonlinear distortion products, produced as a result of multiple tones mixing. In this case, the 7kHz signal is modulated by the 60Hz tone at 7kHz, ±60Hz.

To tune the AD7768 to the required bandwidth, we must first make a few calculations to determine the required master clock (MCLK) and decimation rate. The MCLK used is 12.288MHz and the decimation rate is ×64 to give an output data rate (ODR) of 48kSPS. Other combinations could be used for a power vs bandwidth trade-off.

The setup is shown in Figure 1. It uses the EVAL-AD7768FMCZ board, AC-coupled from the on-board SMB

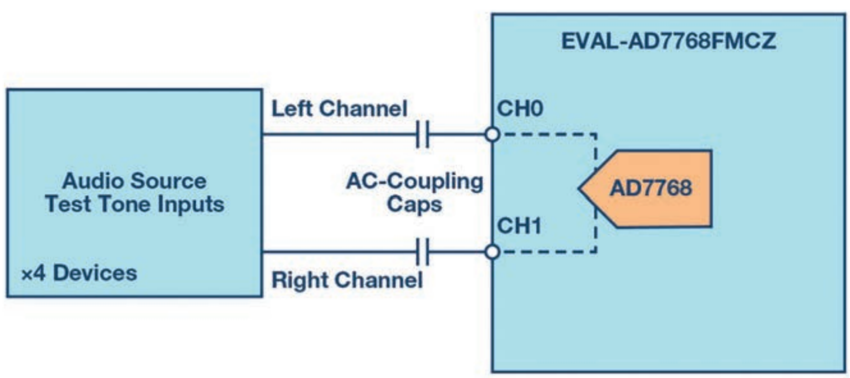


Figure 1: Connection diagram

Device	Frequency (Hz)	Dynamic Range (dB)	IMD Second-Order (dB)	IMD Third- Order (dB)
Known good source	1000.5	101.2	–143.4	–139.2
Mobile phone	1000.5	101.2	–121.3	–125.8
Laptop	1000.5	89.6	–119.4	–119.5
Mobile phone over Bluetooth link	1000.5	93.7	–110.6	–118.3
MP3 player	997.6	99	–94.9	–104.7

Table 1: Test-tone results

connectors to the audio device. Up to four stereo outputs on the eight channels can be tested at once. Further circuit optimisation can be performed, for example by adding a high-pass filter to remove noise below 20Hz.

Table 1 shows the results for both the low-amplitude input signal and the IMD test, which vary significantly from device to device. It was quite interesting to observe that the inexpensive MP3 player showed good dynamic range but, under the IMD test, significant distortion was introduced. The frequency output of this device demonstrated lack of quality and its output drive capability limited the maximum testable IMD level. Hence, for comparison purposes, we limited the test tone to –20dBFS for all devices.

The audio output of the laptop has many different driver and processing options. These have been developed to match the response of the human ear for a more pleasant sound, but result in some frequencies being altered. Hence, when these effects are turned off, the laptop shows the worst dynamic range, whilst sounding just as good as the other sources.

Figure 2 shows the IMD range seen across the devices from the known good source (orange) to the poor-quality MP3 player (green). The IMD products are clearly visible at 7kHz and ±60Hz for both the MP3 player and the phone.

Differentiating factors

The AD7768/AD7768-4's maximum ODR is 256kSPS. This ODR can be tuned to typical audio bandwidths

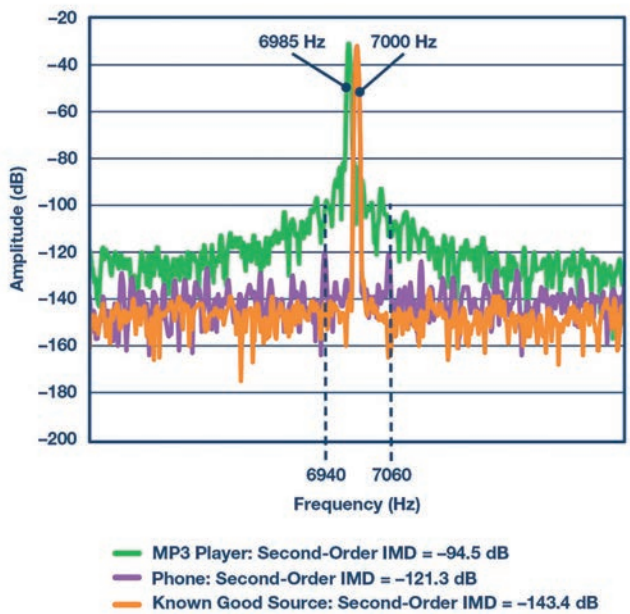


Figure 2: IMD SMPTE test samples, 7kHz input

The audio space now requires more memory, more processing power, greater accuracy and better definition, yet in smaller packages

of 48kSPS, 96kSPS or 192kSPS, by adjusting the MCLK and/or decimation rate, depending on the application.

Many modern test platforms are moving toward modular systems where thermal requirements are a concern. The AD7768/AD7768-4 allows the trade-off between signal bandwidth or dynamic range for power consumption, allowing a wider range of uses. This flexibility is shown in Figure 3, which plots dynamic range vs ODR.

Having more channels is also an advantage, for the following reasons:

1. Test speed

Eight channels or four stereo devices can be tested simultaneously, effectively reducing test duration and cost by a factor of four.

With a rising number of audio modules in our environment, future audio test platforms will increasingly be mindful of the requirement for speed, and the economies therefrom.

2. Performance

End-system performance can be further boosted by combining multiple channels; say, combining four channels into one will allow up to 6dB improvement in dynamic range over those shown in Figure 3.

3. Smaller packages

A multichannel audio platform may have size restrictions because of increased channel densities, limited system- or factory-floor space, or simply a move to modular benchtop instrumentation. Combining eight ADCs into one package allows the test platform to follow this trend toward smaller devices. EW

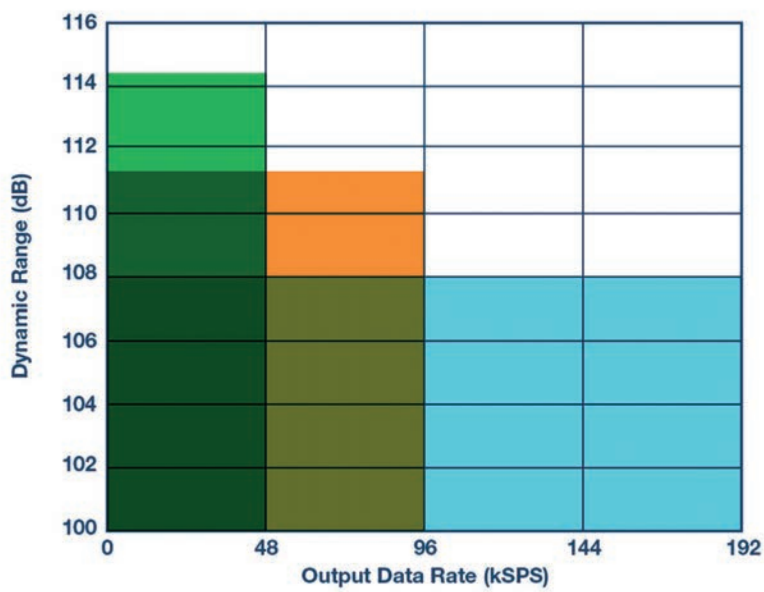


Figure 3: Dynamic range vs ODR (per channel)

Improved HMI is central to the wide adoption of Smart Home automation

When it comes to commands in electronic systems, the smartphone has significantly raised the bar, and now everyone expects intuitive and seamless operations

By Gavin Moore, Customer Engineering Support Manager, Bridgetek

Bringing automation to the domestic environment has been talked about extensively over the last twenty years, yet full-scale adoption has been surprisingly slow. There are several reasons for this: The hardware was initially too expensive, and there was the inconvenience of installing all that cabling. There was also a limited number of electricians with the necessary skillset to do this type of work.

Fortunately, over time, most of these issues faded away. The cost of electronics (sensors, actuators, etc.) steadily decreased and is no longer a barrier. Further, the widespread implementation of wireless communication helped to all but dispense with wireline connectivity, making home automation more convenient and cheaper to install. The only remaining difficulty now is one of integration – the industry needs a way to make the various different smart technologies work harmoniously for the end user. Until now, this has proven elusive.

The market's fragmented nature has prevented this integration, with lighting and heating companies developing their own proprietary systems, with little provision for interoperability. Hence, installations have consisted of many disparate, isolated subsystems for heating, lighting, security, etc, from different suppliers. Each subsystem uses its own control mechanism of various degrees of sophistication that the user must access through a separate human-machine interface (HMI), leaving the whole smart-home experience unsatisfactory and consumers disappointed.

When it comes to the command of electronic systems, the smartphone has significantly raised the bar, and now everyone expects intuitive and seamless operations.

Innovation starts at home

There's no doubt the labour-saving benefits of home automation are fuelling public interest. Smarter living will also reduce energy consumption and pollution levels, helping the environment. Also, with an ageing population, there are countless possibilities for home automation technology to lead to quality-of-life improvements.

Focusing on a centralised architecture with a consistent HMI style will prove beneficial to end users and, hence, the adoption of home automation. The challenge so far has been combining the communication protocols used by different subsystems into an interoperable platform.

The engineering team at Bridgetek is tackling integration by developing a specific HMI solution, called PanL. This platform allows direct control of lighting, air conditioning, heating and security systems, and enables upgrades to the functionality of domestic appliances. PanL does away with separate apps or control units for each system, offering only one touch-enabled HMI for everything, which can also be voice-activated; see Figure 1. Moreover, with this approach, systems can be

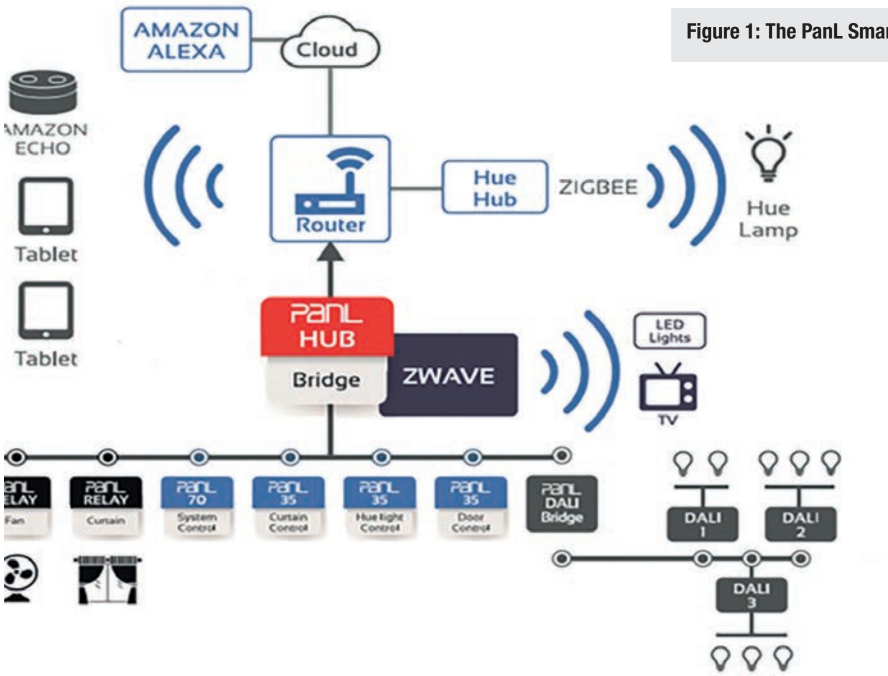


Figure 1: The PanL Smart Living solution

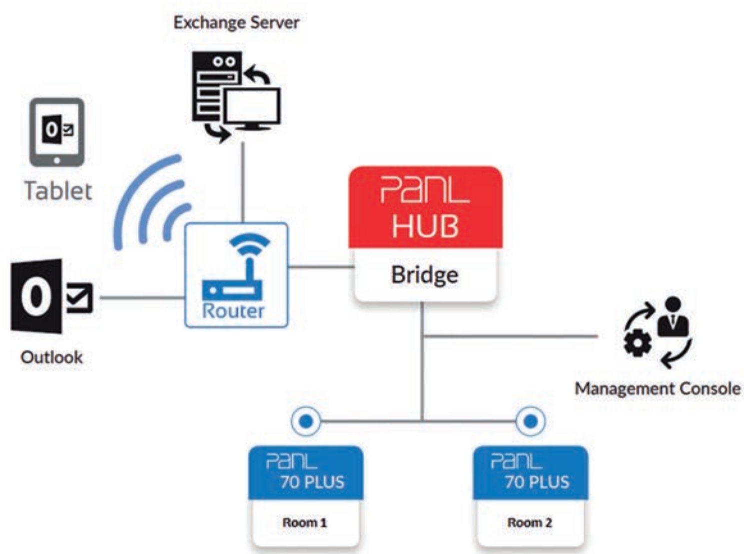
coordinated with one another; for example, lighting and heating can be scheduled to come on at the same time, or a security system activated once the doors are locked and lights are out.

Figure 1 shows PanL Hub at the centre of a home automation arrangement. It interfaces with a diverse range of hardware through an array of wireless and wired connectivity options, including RS485, Wi-Fi (802.11b/g/n), Z-Wave, Zigbee, Bluetooth Low Energy (BLE) and Ethernet (including PoE), and proprietary protocols like DALI and Philips Hue lighting. Accessories like lighting- and relay controllers can be programmed to switch on and off AC or DC loads such as fans for air conditioning, motors for closing/opening curtains, or magnetic actuators for locking/unlocking doors. There are two display unit models, a compact 3.5-inch 320x480-pixel PanL35 and a larger, 7-inch 800×480-pixel PanL70. Amazon Voice Service has been integrated into this system as an alternative to the touch units, so users can activate different functions through an Alexa-controlled Echo smart speaker.

Beyond the domestic environment

There are countless places outside the home where similar installations could be equally advantageous: healthcare, agriculture, retail and utilities sectors are just a few. In an office, the PanL Room Manager (Figure 2) is a better option, since it is an intelligent meeting-room booking system that, much like the home automation solution, comprises a hub and suitable accessories, such as HMI units with built-in RFID transceivers located outside each meeting room. The RFID technology allows access to authorised personnel when it encounters their badges which integrate an RFID tag.

Figure 2: The PanL Room Manager solution



HMI complexities

It has taken a long time for smart home technology to happen, mostly because of the market politics involved. Increased use of automated systems in domestic environments will establish once the user experience is more intuitive and the unnecessary HMI complexities eliminated. Fortunately, we are seeing this technology finally gathering pace. EW

Battery-powered overdrive pedal for guitar effects

By Michael Matthew, Dialog Semiconductor

Amplified guitars appeared in the early 1930s. In those days, however, early recording artists strove for clean, orchestral sounds. In the '40s, DeArmond manufactured the world's first standalone effect. At that time, amplifiers were valve-based and bulky.

The '40s to the '50s saw competitive individuals and bands frequently turning up their amps to overdrive levels, and distorted sound became increasingly popular. In the '60s, transistor amplifiers became available, with the Vox T-60 appearing in 1964, to further achieve the distorted sound, which by then was very sought after. This is when the first standalone distortion effect was born!

Analogue and digital processing of music signals can provide new sounds, and active overdrive effects now recreate the overdriven clipping of those early valve amps.

While distortion is usually unwanted, and to be minimised in an amplifier, the opposite is true in terms of this effect. Clipping produces frequencies not present in the original sound, partially the reason for its appeal in the early days. Strong and almost square-wave-related clipping produces very harsh sounds that are inharmonic to their parent tone, while soft clipping produces harmonic overtones and, so, generally, the generated sound depends on the amount of clipping and depletion with frequency. It's our strong belief that the quality of an overdrive pedal (Figures 1 and 2) depends on the proportion of harmonic to inharmonic tones throughout and the ability to preserve the harmonic tones at higher amplifications.

Preserving existing signals

Here, we present an overview of a circuit for preserving existing signals and producing those overdrive sounds. Using Dialog Semiconductor's SLG88104V – a 375nA quad-channel CMOS input operational amplifier – we achieved a low-power overdrive pedal that is less bulky and using only two AA batteries, which are widely available and less expensive than 9V PP3 batteries. If desired, AAA batteries can be used instead, although the extra capacity of the AA make it the better choice. Further, the circuit will optionally work on 4.5V (1.5V centre line +3V) or 6V (3V centre line +3V) if desired.

We used the non-inverting topology of the amplifier as a base for the gain stages due to its high input impedance and easy adaptation for frequency selection:

$$A_{Gain} = 1 + \frac{R2}{R1}$$

As we've seen, the gain in this setup is solely dependent on the feedback. If we convert this as a high-pass topology, gain will be dependent on feedback and input frequencies as per some overdrive arrangements. Further, if the filter feedback circuitry is doubled, then the topology will apply one range of responsive gains to the input and then a second different set of responsive gains. This setup can both, clarify the design and allow a more frequency directional/ selective amplification; see Equations 1 and 2 and Figure 4.

This topology is an important crux relied upon by the final overdrive circuitry which will incorporate it as a main core several times to maintain a working model.

If we look at things more simply, then for a certain frequency f:

$$A_{Gain} = 1 + \frac{2\pi fC1R2}{2\pi fC1R1+1} \quad (1)$$

and

$$A_{Gain} = 1 + \frac{2\pi fC1R2}{2\pi fC2R3+1} \quad (2)$$

The actual equation for A_{Gain} at a particular frequency f is thus:

$$A_{Gain} = 1 + \frac{R1R2+R3R2+\left(\frac{R2}{2\pi fC1}\right)+\left(\frac{R2}{2\pi fC2}\right)}{\left(R1+\frac{1}{2\pi fC1}\right)\left(R3+\left(\frac{1}{2\pi fC2}\right)\right)} \quad (3)$$

which breaks down further to produce a final formula:

$$A_{Gain} = 1 + \frac{2\pi fC1R1}{2\pi fC1R1+1} + \frac{2\pi fC2R2}{2\pi fC2R3+1} \quad (4)$$

As evident, this is analogous to the addition of the simplified Equations 3 and 4, except for the inherently constant unity gain of the amplifier. In summary the frequency response gain of each high-pass feedback topology leg is compounded. The aim of such arrangements is to obtain a more uniform amplification of the input signal over the frequency range so that at higher frequencies, where the op-amp's gain is reduced, we can introduce more gain. At low voltages the sound can be preserved through those low frequencies, even though the headroom is not very high.

The circuit

SLG88103/4V has built-in input protection to protect against overvoltage at its inputs. Extra protection diodes have also been added at the initial overdrive stage for extra robustness.

The first stage, with its high input impedance, serves as a preamplifier for the overdrive stage. Its gain is about two, although varying with frequency. At this stage, care needs to be taken to minimise the amplification, since any amplification at this stage is multiplied into the overdrive amplification.

Continuing on to the overdrive stage, where the signal will undergo large gains, frequency-selective amplification again ensures that the higher frequencies get a boost for more consistent amplification, and consecutively we induce clipping using two diodes in forward-conductive mode. A simple low-pass filter forms the tone, leading to a simple volume potentiometer and a buffer to drive the output.

Only three of the on-board operational amplifiers are used, and the last remaining one is wired appropriately as per "proper setup for unused op-amps". If desired, 2 x SLG88103V devices can be used instead of a single one.

A low-power light-emitting diode indicates the on-state. The importance of using a low-power version can't be understated, due to the low quiescent currents and running power of the SLG88104V. Indeed, the power indicator LED will be the circuit's main consumer of power. In fact, due to the extremely low 375nA quiescent current, the power usage for the GreenPAK SLG88104V is very small.

Most of the power loss is through the decoupling low-pass capacitors and the emitter-follower resistor. If we measure the complete circuit's quiescent current, it turns out to be only about 20μA, increasing to around 90μA when the guitar is in action. This is very small compared to the 2mA consumed by the LED and is the reason using a low-power LED is imperative.

Figures 1 and 2: Guitar overdrive pedal

On average, a single AA alkaline battery contains around 2000mAh. A decent new pair of batteries producing 3V should then be able to source over 4000mAh.

With the LED in place, our circuit draws 1.75mA, from which we can expect over 2285 hours or 95 days of continuous usage. Because overdrives are active circuits, ours can produce a hell of a kick at minimal current usage. As a side note, the AAA batteries should half as long as the AAs.

As with any pedal, the user needs to adjust the settings to find the sound just right for them. Turning the amp's mid and bass higher than treble seem to give really cool overdrive sounds for us (as treble was harsher). It then resembled the warmer old-fashioned type of sound. EW

Recycle and reuse – a scheme for EEE makers

By David Palmer-Jones, Chief Executive, SUEZ UK

Consider the amount of electronic and electrical equipment (EEE) in the modern home and how much of it is stored in drawers, cupboards and attics, with no prospect of being used any time soon.

These items are squirrelled away for a variety of reasons, but it is undeniable that most have reached the end of their lives. A 2015 survey for the REPIC compliance scheme found that one in ten people hoard unwanted EEE. Across UK households as a whole, that's a lot of EEE and a potential goldmine if the components and materials used in their production (including gold, of course) are harvested.

There's the added challenge that, when householders do dispose of their old electricals, there's every chance it will go in the 'residual' black-bin rubbish collection and end up in incineration or landfill. Another conclusion from the REPIC survey was that 20% of householders regularly throw away old and used electrical items. Over 40% said they did not know how to recycle such equipment.

Numbers are difficult to pin down, but a report for the recycling charity WRAP, also in 2015, estimated that UK households throw away more than 350,000 tonnes of EEE waste each year. We also know that 1.3 million tonnes of EEE were placed on the UK market in 2017 and only around 40% of waste EEE (WEEE) is collected for recycling.

We are not alone: around 9.5 million tonnes of WEEE were generated across the EU in 2012.

Recyclability

Many EEE components are critical raw materials, expensive to mine and frequently imported, a system not sustainable for the future. Reclaiming missing EEE and reducing the tonnes thrown into the bin could be a significant boost to making the manufacture of these products more resource-efficient.

There are two major areas to address. One is retrieval of used EEE, known as UEEE, and preventing further build-up. The other is recognising that the retrieval of each generation of products when they become WEEE is vital. This will require significant practical changes for designers, manufacturers, retailers and consumers alike.

Last July, the European Union approved its Circular Economy package, a bundle of directives designed to boost sustainability and 'close the loop' on products so they are returned for reuse or recycling rather than ending up in landfill or incinerators. The directives will be incorporated into UK law before Brexit – whenever and however that happens. The environment secretary Michael Gove has promised to match or even improve the rules we have inherited from Brussels. He has responded specifically to public pressure over plastics and marine litter, but is also mindful of the wider issues of resource efficiency.

The UK Department for Environment, Food and Rural Affairs has developed a resource and waste strategy for sustainable practices across the country, published last December. There is particular concern in Whitehall over how much of the domestic EEE, such as vacuum cleaners, kettles and electric tooth brushes, is not recycled. But the principle also applies to phones, PCs and other consumer equipment.

That principle underpinning the Circular Economy package is extended producer responsibility (EPR), whereby those involved in a product's value chain take greater responsibility for the recycling (or reuse) of that product, and typically contribute more toward the cost of doing so. Incidentally, the same applies to the products' packaging.

Helping the economy

Last summer, SUEZ UK recycling and recovery produced *'A Vision for England's Long-Term Resources and Waste Strategy'*, proposing a series of initiatives across all products, not just EEE, and calculating that smarter use of our resources could deliver up to £9bn to the UK economy in gross value.

Extended producer responsibility schemes will help meet the growing public appetite to reduce litter and environmental pollution and help us reuse and recycle more of what we consume. Producers currently make largely unsustainable products that are difficult or impossible to recycle and are simply thrown away, with the consumer and environment picking up the disposal cost. If, through extended producer responsibility, the use of recycled materials in new products was incentivised, manufacturers would quickly take greater interest in getting their materials back.

This is not uncharted territory, as most of those involved in any EEE supply chain will already be party to an EPR arrangement in which they contribute to the retrieval costs: WEEE, batteries, packaging and end-of-life vehicles are the four established regimes in England. The agreement has encouraged manufacturers and retailers to become recyclers.

One believer is AO, which recycles fridges at a facility in Shropshire and is developing a second facility to process white goods in the South-East. The company offers the opportunity to take back old machines when new appliances are delivered. AO finds that this makes sense from a logistics and the environment point of view.

It also makes sense economically, with one leading white-goods retailer on the High Street making an annual profit of several million pounds by encouraging consumers to take back unwanted products and working with partners to refurbish, reuse and re-sell them. This practice could apply to anyone putting electrical or electronic goods on the market.

Moving target

WEEE is a moving target. It is the highest-growing waste stream in Europe, where product types, technology and materials used in EEE are all evolving quickly. Changing consumer behaviour, consumption and disposal patterns combine to make it harder to predict individual WEEE levels, creating uncertainty for those planning capacity to collect and/or treat WEEE, and to producers seeking to budget their future costs.

Data is crucial. EPR schemes will only work properly when it is known how much EEE is put on the market and where it goes; see box at the right. Additionally, design is a key determinant of the recyclability of a product, and producers could be incentivised with tax breaks to use more recycled materials, or penalised if they refuse. SUEZ believes that VAT relief on the labour involved in repair, disassembly and reinstallation of reusable, tested and warrantied components would make a real difference. A regulated, quality, secondary marketplace for tested and warrantied products is essential for these 'as-new' components.

All this can drive consumer behaviour – assuming consumers have a clear and easily understood system of product labelling, and a transparent, simple guide to environmental performance. Manufacturers, retailers, recyclers and regulators alike must buy into a widely adopted set of standards.

The current public and political concern about the environment offers a golden opportunity. This is a chance not only to place the UK at the forefront of environmental sustainability but to use efficient resource-management and sustainability to reach new levels of productivity and economic competitiveness across key industries such as electronics and electricals. EW

Security concerns

Fewer than one in ten consumers use household recycling schemes for used WEEE, with one-third saying that concerns over personal data discourage recycling of electrical products, according to the charity WRAP.

The reservations are reflected in its 2017 report, '*Switched on to Value: Powering Business Change*', which also concluded that consumers don't know how to discard unwanted electrical items. Concerns about personal data also discourages more than a third of households from handing over an electrical product. But 83% of respondents were interested in giving electricals back to retailers through take-back and trade-in schemes, such as Argos pioneered with mobile phones, which can provide customers with the reassurance that data will be safely wiped from their devices.

Cash in the attic?

An EU-wide project has been assessing how a stronger marketplace can be established for retrieving metals used in EEE and at the same time make European businesses less exposed to imports. In 2017, the European Commission established the ProSUM project, stating that "reliable and unhindered access to certain raw materials is a growing concern within the EU and across the globe". Twenty-seven critical raw materials (CRMs) were identified, and the ProSUM project has focused on rich sources of CRM: WEEE, end-of-life vehicles, batteries and mining wastes.

For WEEE and batteries, a significant challenge is data reliability of input and output waste streams at treatment facilities. An increasing number of products are said to arrive for treatment with their most valuable components missing, so it is argued that clearer data on this would give a better idea of material losses.

Another challenge is that many waste products with high metal content are valuable and traded with little information on their fate or whereabouts. More work is urgently required to substantiate the amount of waste products managed outside official extended producer responsibility regimes, estimated to apply to around 60% of WEEE. It is also proposed that regular surveys be undertaken to measure the amounts of EEE and batteries in households.

Electronic and electrical equipment ends up in the bin, destined for incineration or landfill

Crystal Display Systems and Taicenn partner over product support

Displays, touchscreen and embedded specialist Crystal Display Systems (CDS) has partnered with embedded specialist Taicenn to promote and support its products in the UK and Europe. The support covers industrial and rugged embedded boxed PCs as well as industrial touch-panel PCs, and other industrial products such as rugged IP65 stainless steel keyboards, all designed specifically for systems and applications that require excellent performance, high-level reliability and stability, long supply period and technical support.

CDS's executives say that Taicenn is the best-kept secret in the embedded world for highest quality and reliability as well as new and innovative products with major blue-chip OEMs.

The CDS Taicenn range of panel PC displays incorporates the TBOX PCs with an industrial and reliable monitor into the smallest packages.

www.crystal-display.com

Rittal redesigns its AX and KX enclosure ranges for Industry 4.0

Rittal has redesigned and redeveloped its popular enclosure ranges – the AX and KX – to perfectly fit Industry 4.0 applications.

Digital transformation brings new challenges for products, their operating environment and operational availability. This launch marks a transformation of AE – a standardised product made by Rittal for over 50 years, but digitalisation and automation in the era of Industry 4.0 are creating new enclosure challenges.

"We understand the principles behind digitalised industry, and we have developed a new generation of compact and small enclosures in response. In conjunction with the introduction of our Blue e+ range and the VX25 large enclosure system, this means all our core products have been entirely redesigned, fit for Industry 4.0," said Uwe Scharf, Rittal's Managing Director, responsible for the IT and Industry Business Units and Marketing.

www.rittal.co.uk

New FDH36 rugged bulkhead housing from OMC

OMC has introduced its new FDH36 rugged bulkhead-mount housing for fibre-optic receivers and transmitters. The new device incorporates an ST connector and has been developed as the ST version of OMC's popular FDH1 transmitter and receiver housing. The robust design of the FDH36 helps it withstand the harsh operating environments often found in industrial, automotive, mass transit and similar applications, including off-road vehicles.

The new FDH36 consists of an all-metal, rugged turret design with a square base flange. The flange features mounting holes in each corner and is designed to bolt down firmly to the bulkhead, ensuring a robust and secure fixing. As well as offering greater physical resilience than plastic housings, the FDH36's metal construction also helps with screening against RF interference.

OMC's fibre optic systems are used in braking systems on trains, military radar systems, and other applications.

www.omc-uk.com

Miniature SMD test terminals from Nicomatic are suitable for repeated use

Nicomatic, the leading manufacturer of high-performance interconnect solutions, offers a range of surface-mount test terminals to attach a large range of test or oscilloscope probes to test zones on PCBs. Miniature C12000 series' devices present a mechanical test hook interface on the SMD PCB which enables the operator to clip a test probe from a test rig or oscilloscope to the PCB. Measuring just 2.5 x 1.3 x 1.5mm, the devices can be used separately or with others. Compared to parts available on the market, the Nicomatic series C12000 test terminals have a larger surface for efficient soldering onto PCBs. They are also less prone to oxidation thanks to pure tin bright tin plating with nickel under layer. Therefore, repeated testing can be securely performed, thanks to better material hardness.

www.nicomatic.com

Northern Manufacturing & Electronics 2019 in October

Northern Manufacturing & Electronics Show returns to EventCity, Manchester, on October 2nd and 3rd. As the North's only dedicated electronics exhibition, the event is a vital showcase for components, production hardware and electronics manufacturing services.

The quantity and diversity of companies taking part – around 300 this year – ensures a show with tremendously broad appeal, allowing visitors from many different backgrounds to solve a wide variety of production issues within a single visit. Within one show, it's possible to find PCB makers, component distributors, enclosure specialists, CEMs, test equipment manufacturers and designers among a whole host of others.

The event's location near the heart of Manchester makes it highly accessible and within easy reach of the substantial swathe of electronics enterprises throughout the North, Scotland, Wales, Northern Ireland and Eire.

For more information, contact Phil Valentine, Managing Director, European Trade & Exhibition Services, Tel: +44 (0)1784 880890 | Fax: +44(0) 1784 880892 | philv@etes.co.uk

www.industry.co.uk

Apacer 3D TLC SV250 solid state drives

Apacer 3D TLC SV250 SSD is now available in various form factors including 2.5", M.2 2280 and M.2 2242, and in module form for buyers who expect the highest performance in industrial applications.

Made with original ICs from Toshiba, 3D TLC SV250 SSD series offers capacities from 30GB to 960GB, and up to 3,000 P/E cycles. It has sequential read/write speeds of 560 and 520MB/s, respectively. It also functions smoothly in temperatures ranging from -40 to 85 degrees C.

In case of an unexpected hard shutdown, the SV250 series devices are protected by DataDefender, which is a combination of hardware and firmware technology designed to improve data integrity. The SV250 series devices are self-encrypting drives that are protected by TCG Opal 2.0, which uses advanced AES encryption to prevent unauthorised access to data.

www.apacer.com