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## INSIDE THIS ISSUE

**Technology**
- Testing vertical cavity surface emitting lasers

**Series**
- Design problem solvers
- Analogue I/O modules

**Latest Product**
- Highly-accurate precision power analyser

ALSO IN THIS ISSUE:
Special report on Automotive Electronics

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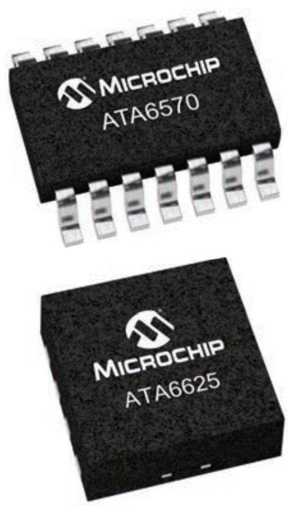


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# CONTENTS

## REGULARS




## COLUMNS




## FEATURES



Cover supplied by ANALOG DEVICES
more on pages 10 and 11

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# APPLE'S STRATEGY TOWARD 3D SENSING IS PUSHING THE VCSEL INDUSTRY

The vertical cavity surface emitting laser (VCSEL) industry took a turn last year with the release of the latest iPhone which contained an innovative 3D sensing function based on these devices. Now, market research firm Yole Développement states that more than 3.3 billion VCSEL units will be shipped by 2023, with the industry experiencing a compound annual growth rate (CAGR) of 31%. This explosion is changing the future for all players in the VCSELs supply chain, from OEMs, integrators, device manufacturers and foundries to equipment and material suppliers.

**Exceedingly good sales of the iPhone X triggered the interest of other smartphone brands in the breakthrough 3D sensing function**

"In 2017 Apple released the iPhone X with a 3D sensing function based on VCSEL technology," said Pierrick Boulay, Technology and Market Analyst at Yole. "This smartphone integrates three different VCSEL dies for the proximity sensor and the Face ID module, and made the VCSEL market explode in 2017, propelling overall revenue to about $330 million."

In its report *'VCSEL – Technology, Industry and Market Trends'* Yole presents an in-depth analysis of the VCSEL industry with its supply chain and competitive landscape, focusing not only on consumer applications but automotive, too, with 3D sensing and light detection and ranging (LiDAR) expected to drive the VCSEL market forward.

Data communications was the first industry to start integrating VCSELs, especially in short-distance data communication, due to their low power consumption and competitive price compared to edge emitting lasers, or EELs. Driven by the development of data centres and fuelled by the popularity of the Internet, VCSEL production boomed in the 2000s. Since then, new VCSEL applications emerged, like laser printers and optical mice, albeit with limited growth.

Only in 2014, almost 20 years since first use of the technology in datacom, VCSELs started to make their way into high-volume smartphones. And this, coupled with sensors for proximity and autofocus functions, was only the beginning of the VCSEL success story.

Exceedingly good sales of the iPhone X triggered the interest of other smartphone brands in the breakthrough 3D sensing function. Less than a year after the release of Apple's flagship smartphone, its competitors followed suit, integrating 3D sensing technologies into their offerings. Xiaomi and Oppo were quickest on the draw, with the Xiaomi Mi8 and the Oppo Find X models introduced in the second quarter of 2018. Other leading smartphone players like Huawei, Vivo and Samsung are also expected to integrate VCSELs into their flagship models by 2019. In this context, the increased demand for VCSELs will persist over the next five years, potentially multiplying the business opportunity more than tenfold.

"This trend is likely to cause rapid evolution in the VCSEL industry in the coming years in the form of investment, new entrants and mergers and acquisitions," said Pars Mukish, Business Unit Manager SSL and Displays at Yole.

To be able to follow a growing demand for VCSELs, over 100 metalorganic chemical vapour deposition (MOCVD) reactors will be needed, which will please the suppliers of that equipment, such as Aixtron, Veeco and Taiyo Nippon Sanso. Hence, Yole expects strong investment and proliferation in the VCSEL industry with the entry of new players, mostly from the LED industry, whose technology is similar.

Since 2016, there have already been several mergers and acquisitions, like Austria's firm ams acquiring Princeton Optronics, and Osram's move on Vixar, as well as investments in manufacturing or supply chain reinforcement, like Apple's $390m investment in Finisar.

Once VCSEL hype reaches its peak, Yole expects a consolidation phase with more M&A occurring at all levels of the supply chain and the support of different strategies, including:

- Vertical integration – from system to module or module to component;
- Application diversification – from datacom to sensing;
- Business diversification – from LED or EEL devices to VCSELs.

*By market research and strategy consulting company Yole Développement (http://www.yole.fr)*


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# CARS COULD BORROW MAGNETIC NAVIGATION TECHNIQUES FROM ANIMALS

Research by the US Air Force has found that magnetic navigation techniques used by some animals could help autonomous vehicles find their way without maps or GPS.

The study used computer modelling to investigate the feasibility of animals using rare and unique combinations of magnetic properties as a waypoint or marker to help them navigate.

"We wanted to better understand how various animals use the Earth's magnetic field to aid them in navigation, and to understand how those methods could be applied to help autonomous vehicles navigate without external aids," said Dr Brian Taylor from the US Air Force Research Laboratory and the study's author.

The study used a moment-to-moment approach to explore animals' navigational skills and then mimic them by using their locations' magnetic signatures as navigational markers. Closed loops for various locations and in different conditions were executed by software, proving that "from an engineering perspective, the results show how a simple algorithm with little prior knowledge of its environment can successfully navigate to different specified points", said Dr Taylor.

"If multimodal sensing is used for distinct phases of navigation (e.g., magnetoreception for mid-course navigation and vision for terminal guidance), this approach may provide a way for engineered systems to autonomously navigate without external positioning aids," he added.

The algorithm has a limited prior knowledge of the environment, so a detailed map does not need to be created or maintained. This will save on resources, especially in situations where creating a map would be logistically difficult, or in cars and unmanned systems, saving on costs, size, weight and power linked to processing and storage space.

**Learning from animals may remove the need for GPS in vehicles**

"This type of algorithm may succeed without needing a high measurement frequency, easing the computational burden of running the algorithm in real-time/online setting where resources are limited," added Dr Taylor.

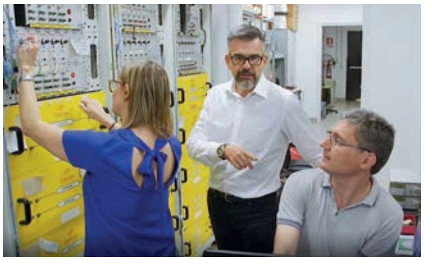
# EU SCIENTISTS HARNESS PHOTONICS TO DEVELOP FASTER HIGH-CAPACITY INTERNET NETWORKS

A group of EU-funded researchers have combined vertical cavity surface emitting lasers (VCSELs) with silicon photonics to develop long-wavelength, high-capacity communications for the very first time, paving the way for light-speed metropolitan connectivity, and new smart on-demand television and assisted-living services.

Used for the first time in the Apple iPhone X to scan a user's face for Face ID, portrait mode photos and animoji (animated emojis), a VCSEL is a specialised laser diode that can revolutionise fibre-optic communications by improving efficiency and increasing data speeds. The devices are cheap to manufacture and more efficient than traditional lasers.

Smart services will require a massive overhaul of the current Internet infrastructure. Data bottlenecks are caused by a large volume of sophisticated devices running music, video, gaming, AI and VR, a problem certain to become worse in the future.

VCSELs are super-fast components, with theoretical transmission rates up to 112Tb/s; for example, sending 28,000 HD movies will take a mere second. Thanks to their rapid data transmission and low power consumption, they have traditionally been used in data communications for short distance intra-connections in data centres. Nowadays, they are considered ideal for long wavelength and high-capacity communication, which has not been used before to connect cities.



**VCSEL testing**

"VCSELs are a buzzword at the moment. They have the advantages of low driving current, high light-power conversion efficiency and high directivity. This makes them ideal choice for transmitting huge amounts of data in a low-cost, energy-efficient way," said Pierpaolo Boffi, Associate Professor at Politecnico di Milano, Italy, and project coordinator. "VCSELs will help us target the site of bottlenecks: the metropolitan area networks (MANs) interlinking users within a geographical area where all the Internet traffic from a local area flows, and cope with the exponential growth in users and increasingly sophisticated services."

"Our researchers are developing a flexible network architecture that will be optimised for metropolitan applications based on aggregated signal flows. A tenfold reduction in power consumption will be achieved by exploiting the full wavelength spectrum and the space dimension in a multi-core fibre," added Professor Boffi.

### LIGHT-SPEED NETWORKS

**US internet technology giant Cisco predicts that internet traffic will grow to an unprecedented 3.3 trillion gigabytes (3.3 zettabytes) per year until 2021.**

**As soon as three years from now, Internet usage will reach three trillion Internet-video minutes per month, which is also five million years of video per month, or one million video minutes every second, according to the Cisco report.**

# Signal processing for digitisers – part 1

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

Modular digitisers enable accurate, high-resolution data acquisition for quick transfer to a host computer. Signal-processing functions, applied in the digitiser or host computer, enhance the acquired data to extract useful information from a simple measurement.

Modern digitiser support software incorporates many signal processing features, which include waveform arithmetic, ensemble and boxcar averaging, Fast Fourier Transform (FFT), advanced filtering functions and histograms. This article, in two parts, will investigate all these functions and provide typical examples of common applications for these tools.

### Analogue Calculation (Waveform Arithmetic)

Analogue calculation includes addition, subtraction, multiplication and division of acquired waveforms, applied to data to improve signal quality or to derive alternative functions. One example is the use of subtraction to combine differential components into a differential waveform with reduced levels of common-mode noise and pickup; another calculates the product of current and voltage waveforms to compute instantaneous power.

Each of these arithmetic functions is applied to waveforms on a sample-by-sample basis, on the assumption that the waveforms being combined have the same record length.

Figure 1 shows the setup path for selecting analogue calculation. The first example of waveform arithmetic is to subtract one signal component from another to derive the differential signal; see Figure 2. (Differential signals are commonly used to improve signal integrity.)

In the Figure 2 example, the P and N components of a 1MHz clock (shown in the two right-hand panels) are combined using the subtraction operation, with the resultant shown on the left. The 'Info' pane at the left centre uses parameters to measure the peak-to-peak and average value of each waveform. Note that

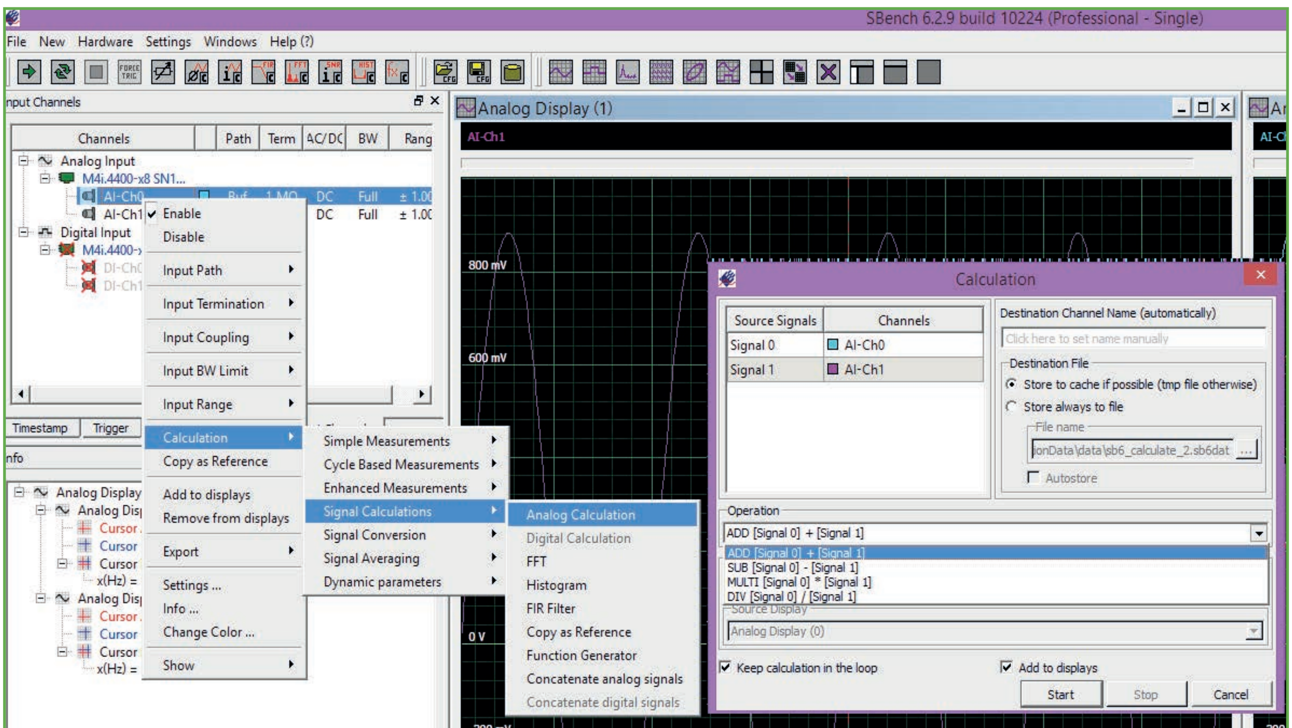



**Figure 1: Processing functions are selected depending on the signal. Here, the 'Calculation' dialog box is set up to add signals A1-Ch0 and A1-Ch1**

the differential signal has twice the peak-to-peak amplitude and a near-zero mean value. Note also that the common mode noise on the differential components has been eliminated.

The second example, shown in Figure 3, multiplies a voltage waveform by a current waveform to obtain the instantaneous power. The source waveforms are the voltage across the power field-effect transistor (FET) and the FET channel current in a flyback-mode switching power supply. The product of those waveforms represents the instantaneous power dissipated by the FET. The current waveform (upper right grid) shows a linearly-increasing ramp during FET conduction, peaking at 600mA. The voltage across the FET is at a minimum during conduction but rises to a peak of 260V when the device is off.

The product of those two waveforms is shown in the left grid. This is the instantaneous power waveform, which shows that significant peaks occur during the transitions between the on (conduction) and off states. The average (5.111W) and peak power (44.25W) are determined using parameters and appear in the info pane at left centre.

These examples show how analogue calculations can be used to derive other important waveforms from the ones initially acquired.

## Averaging

Averaging is a signal-processing tool used on acquired signals to reduce the effects of noise and non-synchronous periodic waveforms. The function requires multiple acquisitions and a stable trigger. Signal components that are not synchronous with the trigger timing, including random noise, are reduced in amplitude, depending on the waveform characteristics and the number of acquisitions added to the average.

Most oscilloscopes perform ensemble averaging, meaning that the same sample locations in multiple acquisitions are averaged together. If a stable trigger is available, the resulting average has a random noise component lower than that of a single-shot record.

## Summed Averaging

Summed averaging uses a fixed number of acquisitions and is repeated addition, with equal weight, of the same sample locations from successive waveform acquisitions. When the maximum number of sweeps is reached, the averaging process either stops or resets to start again.

Figure 4 shows the concept of a summed ensemble average; the arrows indicate the $n^{th}$ point. The amplitude value of the $n^{th}$ point of each acquisition is summed with those of the other acquisitions. The sum is then divided by the number of acquisitions to determine the $n^{th}$ value of the average, taking account of all sample points in the acquisition group. The resultant averaged waveform has the same number of points as each acquired waveform.

Averaging is supported for both normal acquisition and multiple (segmented) acquisitions. Multi-averaging calculations derive the average of consecutive segments of the multiple recording acquisition.


**Figure 2: The subtraction function is used to combine two differential components into a differential signal**


**Figure 3: The multiplication function is used to compute instantaneous power from the current and voltage waveforms of a switched-mode power supply**

### Improvements

When a signal is averaged, additive broadband Gaussian noise will be reduced by the square root of the number of averages, so averaging four acquisitions can improve the signal-to-noise ratio by two to one. Similarly, non-synchronous periodic signals will be reduced in the average. The degree of reduction depends on the phase variation of the interfering signal from acquisition to acquisition. Signals synchronous to the trigger, such as distortion products, will not be reduced in amplitude by averaging.

Figure 5 shows a typical example where averaging is useful. The acquired signal (left) is a linearly-damped sine wave with additive vertical noise. Note that, as the sine amplitude decreases in the presence of fixed amplitude noise, it disappears into the noise.

Averaging 1024 acquisitions increases the signal-to-noise ratio to a point where the sine wave can be discerned through the whole waveform.

The principle limitation of the summed ensemble average is that it requires multiple repetitive waveforms with a stable trigger.

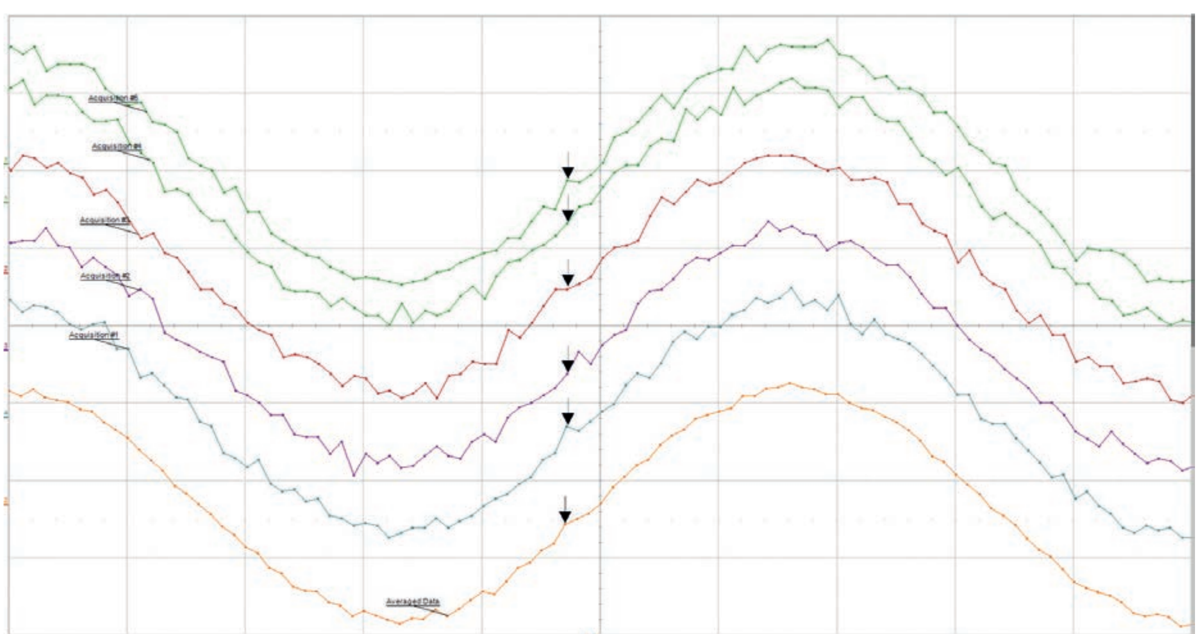



**Figure 4: Summed ensemble averaging adds the n$^{th}$ point of multiple acquisitions and then divides the sum by the number of acquisitions to determine the averaged value for the n$^{th}$ point**

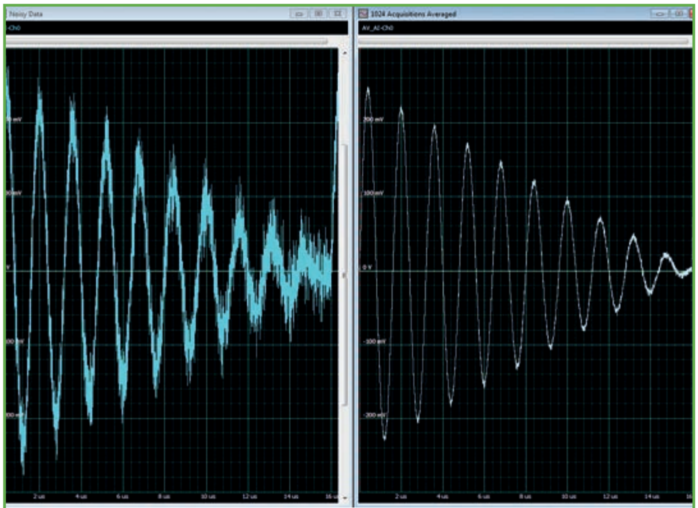


Figure 5: Example of summation averaging to improve signal-to-noise ratio. With 1024 acquisitions averaged, the sine wave is visible above the noise

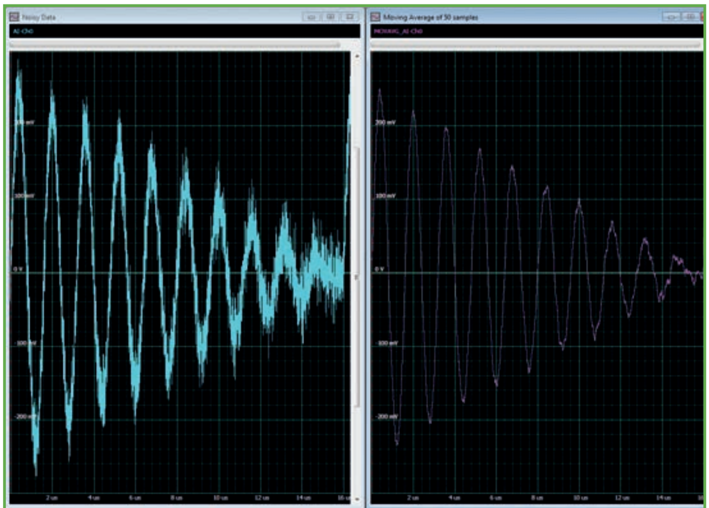


Figure 6: An example of a moving average using 50 adjacent samples of the acquired signal (left), showing the resultant smoothing at right

### Moving Average

The moving average, sometimes called a "boxcar" average or "smoothing", takes an average of a user-defined number of symmetrically-placed adjacent samples. For a sample size of five, the process is defined mathematically by the following equation:

**Averaged Sample = [sample (x-2) + sample (x-1) + Sample (x) + sample (x+1) + sample (x=2)] / 5**

The number of samples used in the average must be matched to the period of variations in the waveform, otherwise the moving average can reduce the amplitude of narrow features.

Figure 6 shows an example of using a moving average of 50 adjacent samples, at left (note the smoothing and elimination of noise compared to the acquired waveform shown on the right).

The advantage of a moving average is that the signal need not be repetitive. The tradeoff is that in creating a smoothed waveform there is a corresponding loss of high-frequency information. Care must be exercised in setting the number of samples averaged.

### Fast Fourier Transform

The Fast Fourier Transform (FFT) maps the acquired waveform from time domain (amplitude versus time) into frequency domain spectrum (amplitude versus frequency), allowing observation of the frequency components that make up the signal. The FFT does not improve signal quality directly, but shows the structure of the signal and provides information on how to remove undesirable spectral components.

The frequency spectrum resulting from an FFT has a discrete time axis just as the time-domain signal has discrete time samples. Samples in the spectrum, often referred to as bins or cells, are spaced at the resolution bandwidth (f) which is inversely proportional to the acquired signal's record length. So, to increase frequency resolution of the FFT spectrum, the acquired signal's record length must increase.

The frequency range or span of the spectrum display is one half of the sample rate at which the signal was acquired; hence, to increase the span, the sampling rate must increase.

Vertical scaling of the FFT can be in linear units of volts or logarithmic units expressed in decibels (dB). The decibel scale can be referenced to full scale of the digitiser range (dBFS), one milliwatt (dBm), 1μV (dBμV), or to the largest peak in the spectrum, which is assumed to be the modulated carrier (dBc). ●

The second part of this column will appear in the next issue

## FREE BOOKS

**This article is adapted from *"The Digitizer Handbook – Precision and Performance in PC Instrumentation"* by Spectrum Instrumentation. To receive a free copy, go to https://spectrum-instrumentation.com/en/contact-us and tick the box marked "Please send me a copy of the Digitizer Handbook" , adding "EW" in the Comment section.**

# AUTOMOTIVE ADAS NEED LOW EMI/EMC EMISSION SWITCHING CONVERTERS

By Tony Armstrong, Marketing Director, Power Products Group, Analog Devices, Inc.

The ADAS market is expected to reach $60bn globally by 2020, according to Allied Market Research. This is a CAGR of 22.8% between 2014 and 2020, which represents a significant opportunity for semiconductor content.

ADAS is an acronym for Advanced Driver Assistance Systems, commonly found in many of today's new automobiles. These systems usually facilitate safe driving and can provide the driver with an alert if the system detects risks from surrounding objects such as errant pedestrians, cyclists or even other vehicles on an unsafe trajectory. Furthermore, these systems typically provide dynamic features such as adaptive cruise control, blind spot detection, lane departure warning, driver drowsiness monitoring, automatic braking, traction control and night vision. There's increased focus on safety and comfort whilst driving, supported by governmental safety regulations, and these are the main growth drivers of ADAS in automobiles for the latter half of this decade.

This growth does not come without challenges for the industry, which include pricing pressure, inflation, complexity and difficulty in testing these systems. Moreover, it should come as no surprise that the European automotive industry is one of the most innovative markets, and hence seeing major adoption of ADAS. Nevertheless, both the American and Japanese auto makers are not far behind. The ultimate goal is an autonomous driving machine without the need for a person being behind the wheel.

## System Challenges

Generally speaking, an ADAS system incorporates a microprocessor to gather all the input from the numerous sensors within the vehicle and then process them so they can be easily presented to the driver in a clear and concise way. Moreover, these systems are usually powered directly from the vehicles main battery that is a nominal 9V to 18V, but could be as high as 42V due to voltage transients within the system, and as low as 3.5V during a cold-crank condition. Thus, it is clear that any DC/DC converters within these systems must be able to handle the wide input voltage range of 3.5V to 42V, at minimum.

Many ADAS systems use a 5V and 3.3V rail to power their various analogue and digital IC content; however, the processor I/O and core voltages that are typically used will have operating requirements in the sub-2V realm, and could be as low as 0.8V. Furthermore, the system is usually mounted in a part of the vehicle that is both space and thermally constrained, thereby limiting the heat sinking available for cooling purposes. While it is commonplace to use a high voltage DC/DC converter to generate a 5V and 3.3V rail directly from the battery, in today's ADAS systems a switching regulator must also switch at 2MHz, or greater, rather than the historical switching frequency of sub-500kHz. The key driving force behind this change is the need for smaller solution footprints while also staying above the AM frequency band to avoid any potential interference.

Finally, as if the designers task is not already complicated enough, they must also ensure that the ADAS system complies with the various noise immunity standards within the vehicle. In an automotive environment, switching regulators are replacing linear regulators in areas where low heat dissipation and efficiency are valued. Moreover, the switching regulator is typically the first active component on the input power bus line, and therefore has a significant impact on the EMI performance of the complete converter circuit.

There are two types of EMI emissions: conducted and radiated. Conducted emissions ride on the wires and traces that connect up to a product.  Since the noise is localised to a specific terminal or connector in the design, compliance with conducted emissions requirements can often be assured relatively early in the development process with a good layout or filter design, as already stated.

However, radiated emissions are another story altogether. Everything on the board that carries current radiates an electro-magnetic field.  Every trace on the board is an antenna and every

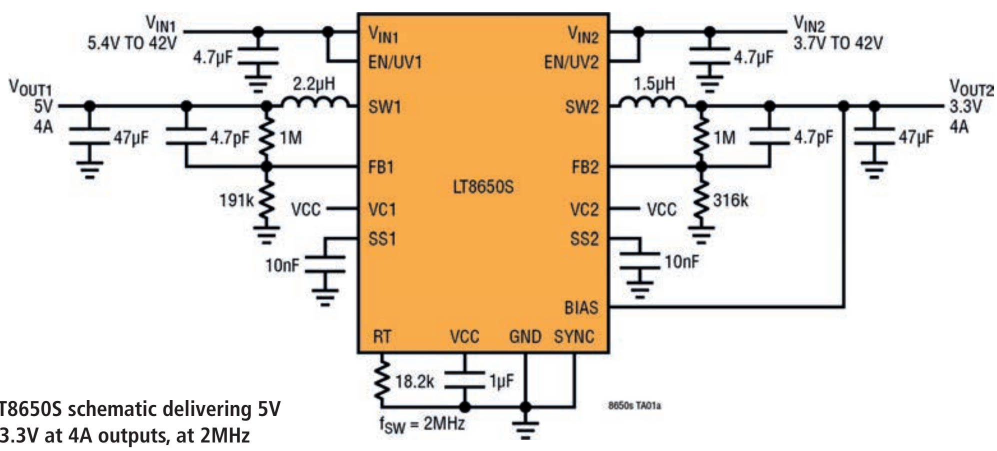



**Figure 1: LT8650S schematic delivering 5V at 4A and 3.3V at 4A outputs, at 2MHz**

copper plane a resonator. Anything, other than a pure sine wave or DC voltage, generates noise all over the signal spectrum. Even with careful design, a power supply designer never really knows how bad the radiated emissions are going to be until the system gets tested; and radiated emissions testing cannot be formally performed until the design is essentially complete.

Filters are often used to reduce EMI by attenuating the strength at a certain frequency or over a range of frequencies. A portion of this energy that travels through space (radiated) is attenuated by adding metallic and magnetic shields. The part that rides on PCB traces (conducted) is tamed by adding ferrite beads and other filters. EMI cannot be eliminated but can be attenuated to a level that is acceptable by other communication and digital components. Moreover, several regulatory bodies enforce standards to ensure compliance.

Modern input filter components in surface mount technology have better performance than through-hole parts. However, this improvement is outpaced by the increase in operating switching frequencies of switching regulators. Higher efficiency, low minimum on- and off-times result in higher harmonic content due to the faster switch transitions. For every doubling in switching frequency, the EMI becomes 6dB worse while all other parameters, such as switch capacity and transition times, remain constant. The wideband EMI behaves like a first order high pass with 20dB higher emissions if the switching frequency increases by 10 times.

Savvy PCB designers will make the hot loops small and use shielding ground layers as close to the active layer as possible. Nevertheless, device pin-outs, package construction, thermal design requirements and package sizes needed for adequate energy storage in decoupling components dictate a minimum hot loop size. To further complicate matters, in typical planar printed circuit boards, the magnetic or transformer style coupling between traces above 30MHz will diminish all filter efforts since the higher the harmonic frequencies the more effective unwanted magnetic coupling becomes.

### Dual DC/DC Converter with Low EMI/EMC Emissions

It was because of the application constraints described above that Analog Devices's Power by Linear Group developed the LT8650S – a high input voltage capable, dual output monolithic synchronous buck converter that also has low EMI/EMC emissions. Its 3V to 42V input voltage range makes it ideal for automotive applications, including ADAS, which must regulate through cold-crank and stop-start scenarios with minimum input voltages as low as 3V and load dump transients in excess of 40V. As can be seen in Figure 1, it is a dual channel design consisting of two high-voltage 4A channels, delivering voltages as low as 0.8V, enabling it to drive the lowest voltage microprocessor cores currently available. Its synchronous rectification topology delivers up to 94.4% efficiency at a switching frequency of 2MHz, while Burst Mode operation keeps quiescent current under 6.2µA (both channels on) in no-load standby conditions, making it ideal for always-on systems.

The LT8650S's switching frequency can be programmed from 300kHz to 3MHz and synchronised throughout this range. Its 40ns minimum on-time enables $16V_{IN}$ to $2.0V_{OUT}$ step-down conversions on the high voltage channels with a 2MHz switching frequency. Its unique Silent Switcher 2 architecture uses two internal input

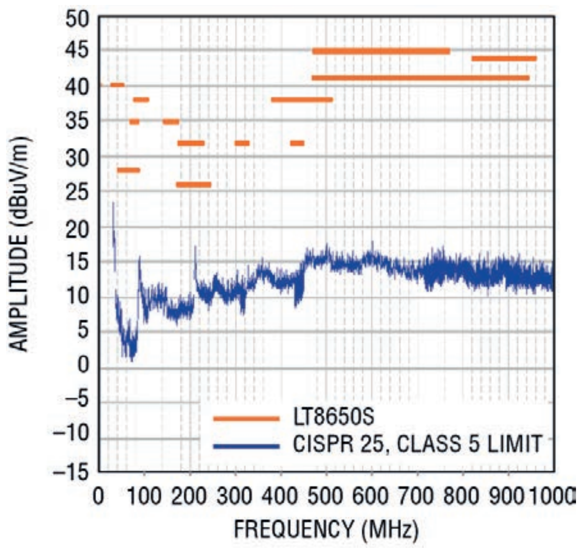



**Figure 2: LT8650S radiated EMI performance graph**

capacitors as well as internal BST and $INTV_{CC}$ capacitors to minimise the area of the hot loops. Combined with very well controlled switching edges and an internal construction with an integral ground plane and the use of copper pillars in lieu of bond wires, the LT8650S's design dramatically reduces EMI/EMC emissions. See Figure 2 for emissions output characteristics. This improved EMI/EMC performance is not sensitive to board layout, simplifying design and reducing risk even when using two layer PC boards. The LT8650S can easily pass the automotive CISPR25, Class 5 peak EMI limits with a 2MHz switching frequency over its entire load range. Spread spectrum frequency modulation is also available to lower EMI levels further.

The LT8650S utilises internal top and bottom high efficiency power switches with the necessary boost diode, oscillator, control and logic circuitry integrated into a single die. Low ripple Burst Mode operation maintains high efficiency at low output currents while keeping output ripple below $10mV_{p-p}$. Finally, the LT8650S is packaged in a small thermally-enhanced 4mm x 6mm 32-pin LGA package.

### Conclusion

There can be no doubt that the proliferation of ADAS systems in automobiles is not going to end any time soon. Furthermore, it is also clear that finding a power conversion device that meets all the necessary performance metrics so as not to interfere with the ADAS system is not a simple task.

Fortunately for the designers of these systems there are now "best-in-class" power converters from Analog Devices's Power by Linear Group that greatly simplifies their task while simultaneously delivering all the performance they need without requiring sophisticated layout or design techniques. ●

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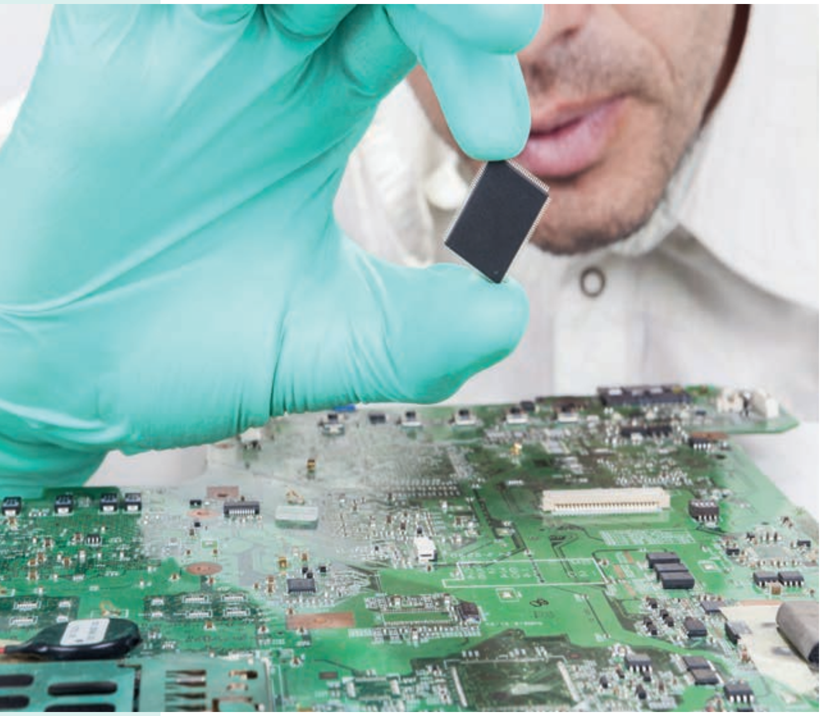


# Materials compatibility and contact cleaners

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

Contact cleaners are widely used throughout industry. They flush particulate from hard-to-reach places and refresh electrical connectivity on switches, relays, potentiometers and other devices. They're harmless and enormously helpful.

In a perfect world, a contact cleaner would be non-flammable and have strong dielectric properties; it could even be sprayed on live electrical circuits without concern. Sadly, we don't live in an ideal world and we need to be very careful about what we use.

## Removing Contact Barriers

Our connection to electronic devices is growing. They play a major role in every area of life, from the alarm clock in the morning, to the car and mobile phone every day. These devices are becoming smaller yet more intricate, increasing the complexity of identifying and managing faults. Critical cleaning plays a huge role in guaranteeing the quality of the electronic device coming off the production line. The smallest contaminant can form a barrier between contacts, affecting device operation.

Critical cleaning is top of the agenda for many electronic device manufacturers; however, do companies give enough time and consideration to the effect it can have on the parts being cleaned?

Material compatibility is a critical area to investigate before any cleaning process is undertaken. Look at what you need to clean – does it include many different materials? Perhaps it has an LCD made from transparent polycarbonate, contains inks, or rubber platens for printers in ATM machines; see Figure 1. If you are unsure about the materials of construction, it is important to test before widespread deployment of a cleaner.

A strong cleaning solvent is frequently the preferred choice; it delivers great results and cleans quickly. However, it may attack soft plastics, rubber and conformal coatings, or remove inks. It cleans effectively and solves the problem of contamination easily, yet it can damage some of the component materials.

## Modern Contact Cleaners

When in doubt, contact cleaners could be the answer. Modern contact cleaners are growing in popularity for their effectiveness and simplicity. Companies seek mild cleaners for many reasons, but the most common motive is materials compatibility. Strong cleaners may dissolve, craze or attack softer substrates (Figure 2). A mild plastic-safe cleaner is the answer, but be careful to check its credentials – does it have the right properties, performance and pricing?

> **Companies seek mild cleaners for many reasons, but the most common motive is materials compatibility**

Contact cleaners must be non-conductive, fast-drying, non-flammable and safe on all materials. There are many that sacrifice at least one of those criteria or are so mild they are ineffective. For these reasons, it is important to investigate your cleaning choice thoroughly and use one that covers all bases.

If your electronic device is made from materials including plastic, it's important to check if the cleaner has a low Kauri Butanol (Kb) value. Kb value tests the cleaning strength of a solvent. Ideally, if delicate materials are part of the device that requires cleaning, a low Kb value of between 15-40 is ideal. This Kb range indicates that the contact cleaner is mild and suitable for all surfaces.

Many new contact cleaners on the market are effective, safe, environmentally-friendly and affordable; see Figure 3. These new chemistries, although mild, clean very well, dissolving light oils and grease, and removing silicone residues and adhesives. Many are non-flammable, so they can also be used safely to clean connectors, wiring harnesses, relays, mechanical devices and a host of related equipment even during operation. This makes it an ideal cleaning solution for electronic devices, especially those that are delicate and require sensitive cleaning, or whose operation can't be interrupted.

It is important to remember that not all contact cleaners will be right for the job. The key points to look for are:

1. Does it clean well?
2. Is it compatible with all materials of construction?
3. Does it have a low Kb value?
4. Is it non-flammable?
5. Does it have strong dielectric properties?
6. Is it worker-safe?
7. Is it environmentally and regulatory-compliant?
8. Does it meet the required price point?

Always assess the electronic device that requires cleaning and run a materials compatibility check. Before its widespread use, test the cleaner. If this is not possible, be conservative and use a mild cleaner with a low Kb value. Alternatively, speak to an experienced manufacturer of critical cleaning products for help with specific cleaning specifications.


**Figure 1: As an example, ATM machines contain many materials, and their compatibility should be investigated before any cleaning process is undertaken**

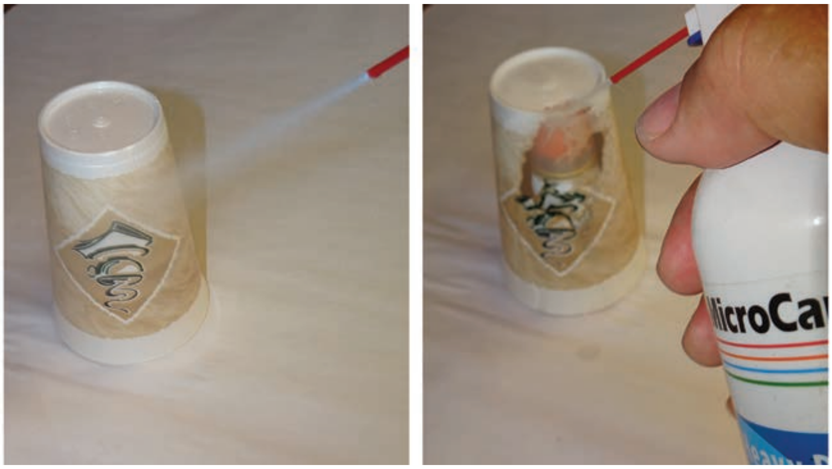


**Figure 2: (left) A plastic-safe, very mild, contact cleaner that leaves the Styrofoam cup unaffected; (right) A heavy-duty flux remover melts the cup**


**Figure 3: Many new contact cleaners are effective, safe, environmentally-friendly and affordable**

BY **DR MURAT UZAM**, ACADEMIC AND TECHNICAL AUTHOR, TURKEY

# 0-5V analogue input module 2

This column is dedicated to a project involving 13 analogue input modules and seven analogue output modules for use with a 5V microcontroller through its ADC and DAC channels.

In the last issue we discussed the 0-5V analogue input module 1, which accepts DC input voltages from 0V to +6.26V, requiring +6.26V DC power. In this issue, we focus on the second analogue input module, or the 0-5V analogue input module 2, which accepts up to +12V DC inputs and requires two DC power supplies, +6.26V and +12V; see Figures 1 and 2. In the design of the module, we assumed that the input voltage range ($V_{IN}$) = 0-12V. When 0V ≤ $V_{IN}$ ≤ 5V, $V_{OUT}$ = $V_{IN}$, and when 5.01V ≤ $V_{IN}$ ≤ 12V, $V_{OUT}$ will be equal to a value from 5.01-5.07V, due to the characteristics of the LM358P-A op-amp used.

The relationship between $V_{OUT}$ and $V_{IN}$ is shown in Figure 3. It can be seen that input voltages up to 12V work without damaging the circuit, and are output from it as a value from 5.01-5.07V.

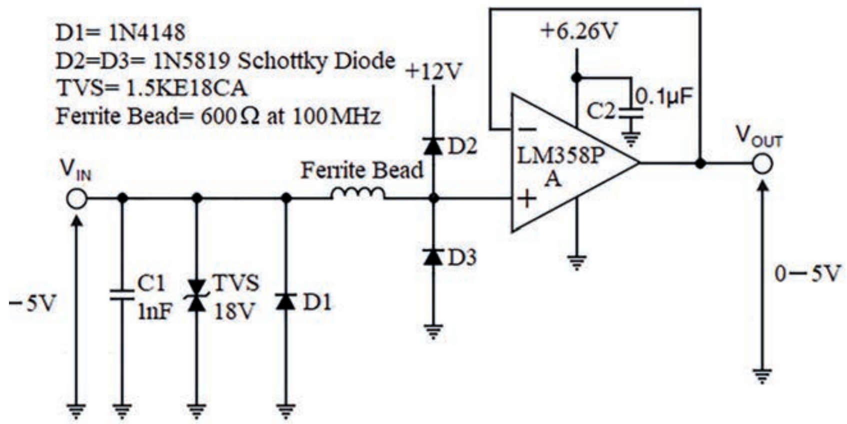



Figure 1: Schematic diagram of 0-5V analogue input module 2 to be used with an ADC input of a 5V microcontroller

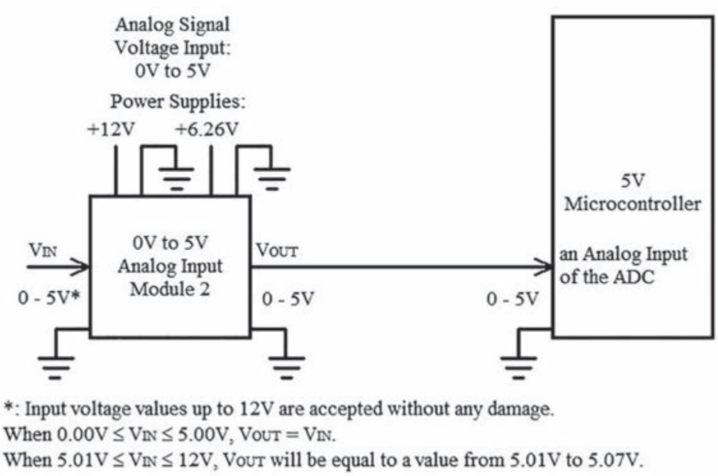



Figure 2: 0-5V analogue input module 2 is connected to the analogue input of a 5V microcontroller

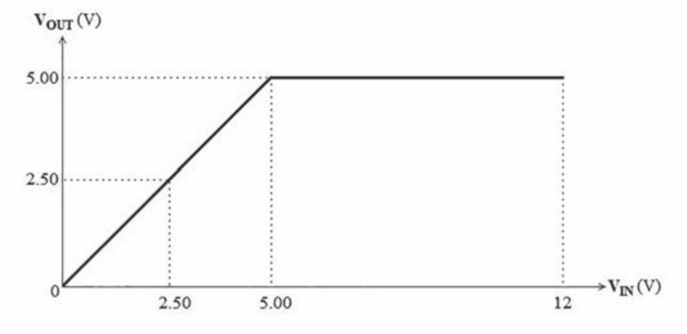



Figure 3: $V_{OUT}$ vs $V_{IN}$ for the 0-5V analogue input module 2 shown in Figure 1

The analogue input $V_{IN}$ can be subjected to electrical surge or electrostatic discharge on the external terminal connections, but the transient voltage suppressor (TVS) in the circuit provides highly effective protection against such discharges.

$D_1$ is used to protect the circuit from accidental reverse polarity on $V_{IN}$. A ferrite bead in the input path adds isolation and decoupling from high-frequency transient noises. External Schottky diodes generally protect the operational amplifier. Even when internal ESD protection diodes are provided, the use of external diodes lowers noise and offset errors. Dual Schottky barrier diodes $D_2$ and D3 divert any overcurrent to the power supply or ground. The operational amplifier LM358P-A, with a +6.26V supply voltage, acts as a voltage limiter, provides high input impedance and is connected as a buffer amplifier (voltage follower).

Table 1 shows example input and output voltages for the 0-5V analogue input module 2, with Figure 4 showing the top and bottom views of the circuit's prototype circuit board.

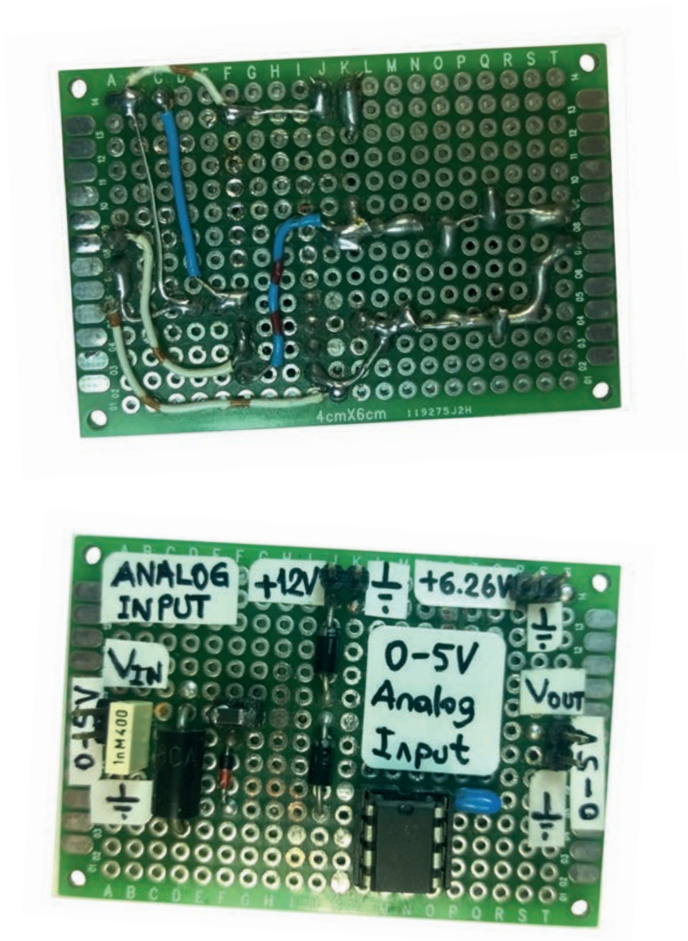



Figure 4: Top and bottom views of the prototype circuit board of the 0-5V analogue input module 2

| $V_{IN}$(V) | $V_{OUT}$(V) |
|---|---|
| 12.00 | 5.0X |
| .. | 5.0X |
| 10.00 | 5.0X |
| .. | 5.0X |
| 5.00 | 5.00 |
| .. | .. |
| 4.00 | 4.00 |
| .. | .. |
| 3.00 | 3.00 |
| .. | .. |
| 2.50 | 2.50 |
| .. | .. |
| 2.00 | 2.00 |
| .. | .. |
| 1.00 | 1.00 |
| .. | .. |
| 0.00 | 0.00 |

Table 1: Some example input and output voltage values for the 0-5V analogue input module 2

This series continues in the next issue

# Different ways of using a multiplying DAC

## QUESTION:

Can a multiplying digital-to-analogue converter (MDAC) be used other than as a DAC?

## ANSWER:

Most digital-to-analogue converters (DACs) are operated with a fixed positive reference voltage and output voltage or current proportional to the product of the reference voltage and a set digital number. However, with the so-called multiplying digital-to-analogue converters this is not the case. Here, the reference voltage can vary, often in the range of ±10V; the analogue output can then be influenced dynamically via the reference voltage and the digital number.

### Applications

With corresponding wiring, the MDAC module can output a signal that is amplified, damped or inverted with respect to the reference. This makes it suitable for waveform generators, programmable filters and programmable gain amplifiers (PGAs), and applications where offset or gain must be adjusted.

Figure 1 shows a 14-bit MDAC with a downstream amplifier that can amplify or attenuate a signal based on the DAC's programmed number.

### Circuit Calculation

The output voltage ($V_{OUT}$) for the circuit is calculated as follows:

$$V_{OUT} = -Gain \times V_{IN} \times \frac{D}{2^n}$$

The output voltage is affected or bounded by the operational amplifier's supply voltage, apart from the gain and the set number D of the DAC. In the case shown, the amplifier supplied with ±15V should produce a maximum voltage of ±12V for an adequately large control range. The gain is determined by resistors $R_2$ and $R_3$:

$$Gain = \frac{R_2 + R_3}{R_2}$$

All three resistors should have the same temperature coefficient of resistance (TCR), which need not be the same as the TCR of the DAC's internal resistors. Resistor $R_1$ is adjusts the internal resistor ($R_{FB}$) in the DAC to the resistors $R_2$ and $R_3$ according to the following relationships:

$$R_1 + R_{FB} = R_{FB} + R_2 \,||\, R_3$$
$$R_1 = R_2 \,||\, R_3$$

The resistors must be selected such that the op-amp is still within its operating range at the maximum input voltage (the DAC can handle ±10V at $V_{REF}$). It should also be noted that the amplifier's input bias current ($I_{BIAS}$) is multiplied by the resistance ($R_{FB}$ + $R_2$ || $R_3$), with a considerable effect on the offset voltage; the main reason we selected this op-amp, with its very low input bias current and very low input offset voltage. To prevent instabilities in the closed-loop control system or so-called ringing, a 4.7pF capacitor was

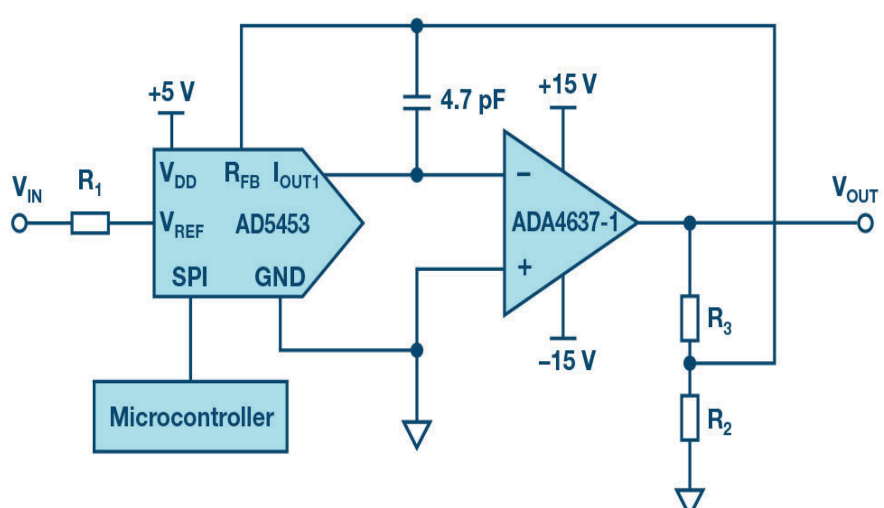
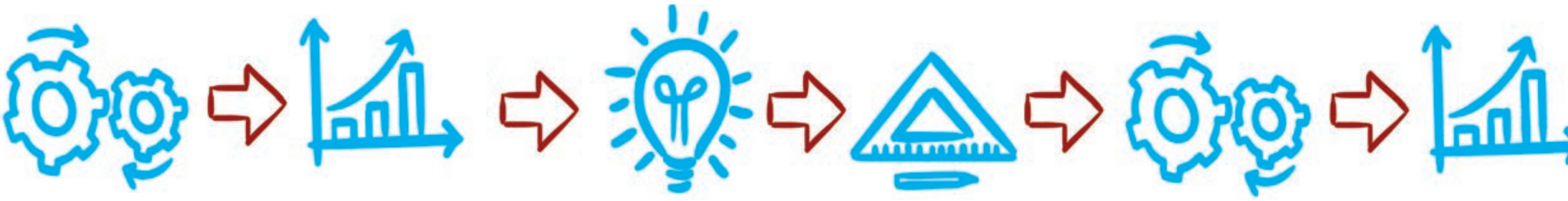



**Figure 1: Circuit with variable gain (PGA)**



BY THOMAS TZSCHEETZSCH, STAFF FIELD APPLICATIONS ENGINEER, ANALOG DEVICES

inserted between $I_{OUT}$ and $R_{FB}$, especially recommended for fast amplifiers.

As mentioned earlier, the offset voltage of the amplifier is multiplied by the closed-loop gain. When the gain is set with the external resistors by a value corresponding to a digital step, this value adds to the desired one, producing a differential non-linearity error. If large enough, it can lead to non-monotonic behaviour of the DAC. To avoid this, it is necessary to select an amplifier with low offset voltage and low input bias current.

### Advantages over Other Circuits

In principle, standard DACs can also be used if an external reference is allowed, but there are some major differences between them and MDACs. Standard DACs can only process unipolar voltages of limited amplitude at the reference input. In addition, the reference input bandwidth is very limited. This is typically indicated on the data sheet by the multiplying bandwidth value. For the AD5664 16-bit DAC, for example, this value is 340kHz.

Multiplying DACs can also use bipolar voltages, which can also be higher than the supply voltage at the reference input. The bandwidth is also much higher, some 12MHz for the AD5453.

Multiplying digital-to-analogue converters are not used widely but offer numerous possibilities. Apart from the self-built PGA with a high bandwidth, mobile applications are also very appropriate because of the MDAC's low power requirements, less than 50μW. ●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# The origins of today's industrial robots, and where they're headed next

BY MARK PATRICK, MOUSER ELECTRONICS

Ever since the American inventor George Devol unveiled his industrial robot in the 1950s, the advancement and proliferation of robotics has come fast. In the 1970s there were 200 industrial robots in use in the US; by 2015 that figure reached 1.6 million and the International Federation of Robotics forecasts it to nearly double before the end of this decade. It's easy to understand why: robots have become an irreplaceable part of many industries, particularly manufacturing.

## Foundations for The Future

The foundations for today's robots were laid in the 1980s, as engineers started to incorporate sensors and early machine vision into their designs. As these technologies evolved – and computer hardware prices fell – there was enormous acceleration in the development of industrial robotics. Initially, these were rudimentary mechanical systems, programmed to do the same tasks repeatedly; however, they quickly grew in complexity, and even possessed some 'intelligence'.

This was further aided by the evolution of computer software; nowadays, robots benefit from artificial intelligence (AI), by learning from past experiences and making better decisions, without human involvement. Their intelligence is enabled by the myriad sensors that gather data and then feed it into advanced analytics and machine-learning software. This way, robots can interpret what the sensors are detecting and change their own actions to better complete a task. Those involved in robotics today are striving to give robots real intelligence, like that of the human brain.

## Human-Robot Partnership

As robots become more intelligent, they can handle more sophisticated tasks, more efficiently than people. Now we're seeing a new class of robot emerge, the so-called 'collaborative robot' or 'cobot', designed to work alongside people.

Cobots are new to the robotics scene: they're generally smaller and lighter than conventional industrial robots and can be moved around or trained to undertake different tasks more easily. Most importantly, though, is their safety focus, which enables them to operate in environments where they'll be close to or in direct contact with people. This is possible through advanced technologies, including computer vision and force-limited joints, which sense when people are nearby and alter the cobot's behaviour accordingly.

**From working alone to working alongside people, robots continue to evolve**

This combination of cobots and humans can be truly transformational, because it unlocks skills that exceed what either a human or a robot can do on their own; for example, in a manufacturing line, a cobot can move a heavy object whilst a person guides it perfectly into place. Ultimately, this blend of person and machine means products can be built more quickly and more accurately than if either were working alone. Indeed, building on the success of early cobots in construction, manufacturing and healthcare, the cobot market is expected to reach a billion dollars by 2020, with some 40,000 machines in use worldwide, according to market analysis firm ABI Research.

## The Key Enabler

While modern industrial robots trace their origins back to the mid-20th century, their capabilities are a world away from those early machines. Thanks to advancements in electronics and computer software, today's cobots can safely operate alongside people, and perform an ever-increasing variety of tasks, from welding to surgery.

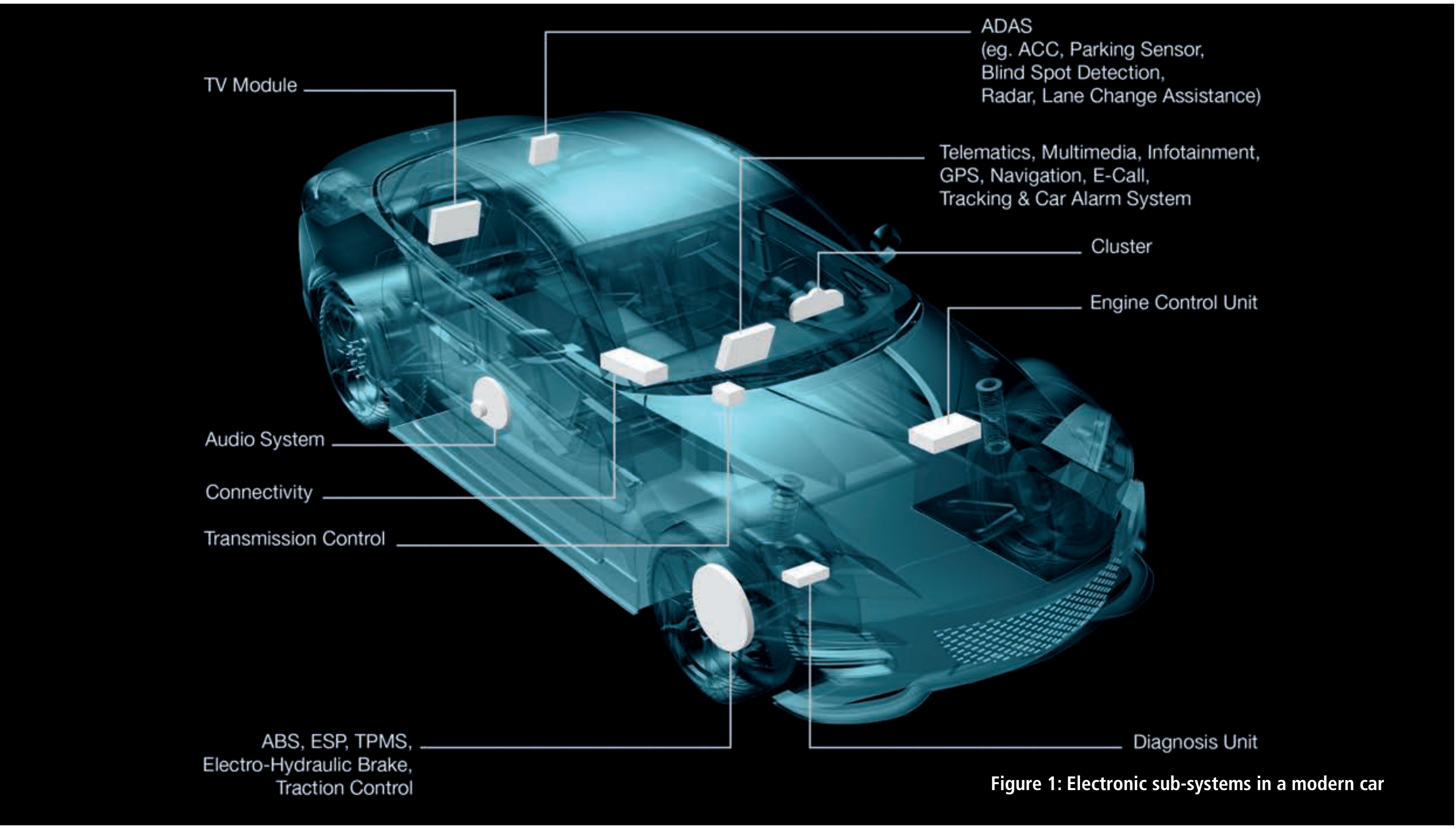


Figure 1: Electronic sub-systems in a modern car

# Meeting advanced automotive design challenges with MEMS-based timing devices

By Graham Mostyn, Applications Engineering Director, TCG

The 20th century saw mostly mechanical enhancements being made to vehicles, such as automatic transmissions, power steering, windshield wipers and cruise control. Today, there's a completely new set of innovations being enabled by silicon, wireless communication and the Internet. The convergence of telecommunications and information processing, known as vehicle telematics, is directed primarily at providing features that improve driving safety and convenience.

## Safety and Convenience

Advanced driver assistance systems (ADAS) alert the driver to potentially hazardous situations and, in some cases, control the vehicle automatically. They employ radar and surround-view cameras, generating the data for intelligent image processing, to detect nearby objects and road features, assess their location and determine their speed of movement. For example, ADAS can provide tactile feedback to the driver through the steering wheel if the car starts veering from its lane. Similarly, it can apply the brakes automatically if, for example, it detects that the car in front is too close.

Other safety aspects are provided by connectivity, which might include making e-calls in case of an emergency, and using navigation services to identify road hazards in real time. In-vehicle infotainment (IVI) provides in-car content services such as entertainment, GPS navigation, smartphone and phone application integration with the car's touchscreen and hands-free voice recognition functions. Vehicle management services allow a user to track their vehicle if stolen, for example, and provide maintenance recommendations and updates through software.

Automotive manufacturers have three main challenges in implementing this smart, connected technology:

1. Reliability – the safety and security of passengers and pedestrians depend on it.
2. Operation under extreme temperatures. Depending on its placement within the vehicle and the influence of weather and driving conditions, electronics within a vehicle can experience temperatures ranging from -40°C to +150°C. Whereas traditional industrial electronic components are rated from -40°C to +85°C, automotive applications demand 105°C (Grade 2) and 125°C (Grade 1) reliability outside the vehicle engine compartment, with 150°C (Grade 0) or higher for engine and transmission applications.
3. Size and weight are primary concerns, since in-vehicle electronic systems are numerous and complex.

## MEMS Oscillator and Clock Technology

Many components, such as oscillators and clocks, are based on MicroElectroMechanical Systems (MEMS), and prove ideal to meet the challenges and demands of automotive innovation.

Quartz resonators have provided the frequency-determining elements in oscillators and clocks for many decades, and they work well in most applications. However, MEMS have enabled the replacement of quartz crystals with tiny MEMS resonators, offering benefits such as high reliability (including AEC-Q100 certification), shock resistance, stable frequency output over extended operating temperatures, small size and low power consumption.

Quartz crystals are millimeter-sized slivers of pure quartz (silicon dioxide), with a silver layer on each side, connected by conductive epoxy to contacts and housed in a hermetic package – either ceramic or metal, filled with dry nitrogen. Each resonator is ground to the desired frequency before assembly. MEMS resonators are created from pure silicon wafers and produced in a semiconductor foundry using standard lithographic processes.

The resonator consists of a tiny polysilicon beam (30μm × 50μm), suspended by silicon supports above a polysilicon ground plane; see Figure 2. The beam flexes when attracted to the ground plane by electrostatic – as opposed to piezoelectric – forces; see Figure 3.

Approximately 100,000 resonators can be produced on each silicon wafer with conventional silicon lithography and MEMS-specific etch steps that create the 3D structure. A "cap wafer" is also produced and etched, with depressions corresponding to each resonator structure. These two wafers are accurately aligned, pressed together in a vacuum and annealed in a high-temperature furnace. The fusion bond between the two is extremely strong; see Figure 4.

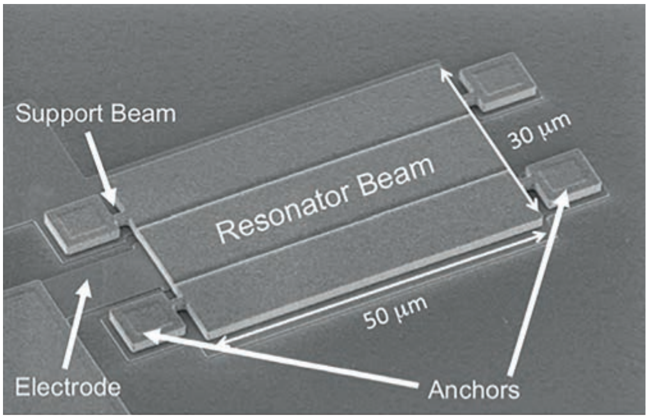



Figure 2: A SEM photomicrograph of a MEMS resonator before packaging

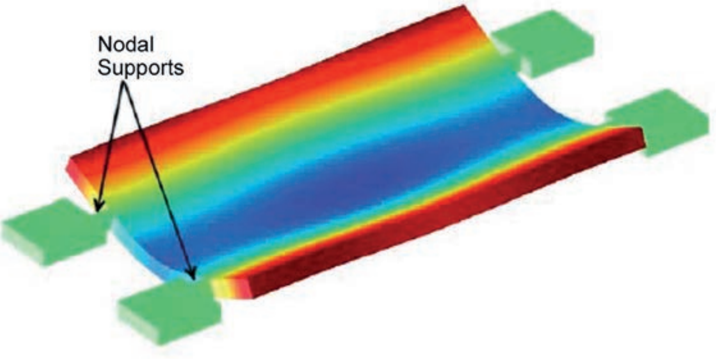



Figure 3: Resonator flexing under electric excitation

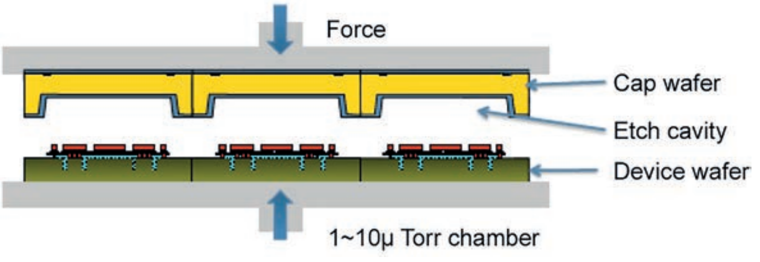



Figure 4: Bonding multiple resonators on a wafer

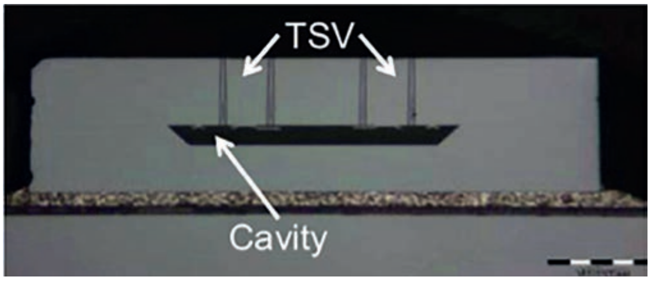



Figure 5: Resonator die with the MEMS structure inside a hermetically-sealed cavity. Through-silicon vias (TSVs) enable resonator connections to be brought to the die's surface

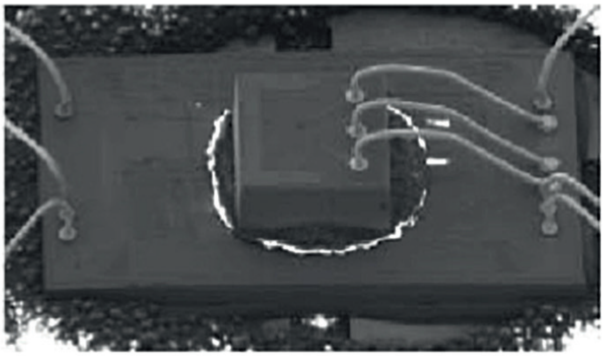


Figure 6: Resonator die bonded on top of a CMOS oscillator ASIC


Figure 7: The packaged integrated oscillator

From this, MEMS dice are created, with the resonator encased in a hermetically-sealed cavity formed by the cap wafer's depressions; see Figure 5.

Vacuum and a heat process remove any contaminants, resulting in an ultra-clean cavity that's directly responsible for the high reliability of the MEMS resonator. Connections to the resonator in the cavity are brought to the outside of the die by using through-silicon via (TSV) technology, which preserves the hermetic seal. In contrast, the ceramic or metal package that contains a quartz crystal and an ASIC oscillator die is larger and can't achieve this level of cleanliness. Also, outgassing from its mounting epoxies causes some frequency drift.

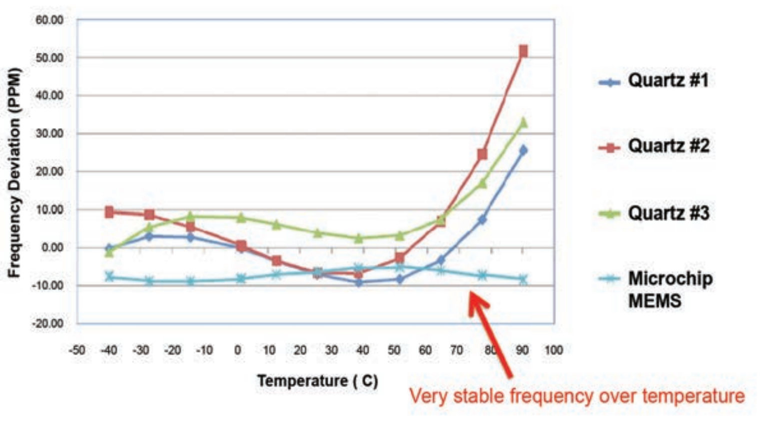



Figure 8: Comparison of frequency stability of quartz and MEMS oscillators

## Shock Resistance

Each MEMS die is bonded on top of a CMOS oscillator die and connected using industry-standard wire bonding (Figure 6). The whole assembly is packaged using standard plastic injection moulding (Figure 7) to create the final product. Unlike quartz, no final hermetic package assembly is required.

Since the MEMS resonator has very small mass – certainly by orders of magnitude when compared to quartz blanks – the resonator alone can theoretically withstand one million g. In practice, the MEMS device can withstand many tens of thousands of g, whereas quartz devices are only able to withstand 50-100g.

## Stable Frequency Output

The MEMS resonator has a strong but predictable temperature characteristic. Its CMOS oscillator design incorporates a highly accurate temperature sensor which, together with a fractional-N phase lock loop, provides an automatic correction to the frequency. The MEMS resonator can operate above 200°C. Today's MEMS oscillator designs provide very stable frequency to at least 125°C, as shown in Figure 8.

## Small Size

The resonator die is only 400μ², and rapidly falling CMOS technology nodes have enabled CMOS oscillator dice sizes of less than 1mm². The newly-introduced DSC6000 family of MEMS from Microchip is available in packages as small as 1.6mm × 1.2mm.

## Automotive Applications

ADAS long-range radar is designed to identify the speed, azimuth and elevation of multiple objects, such as cars, pedestrians, etc., in a complex urban traffic scenario.

Simply put, radar systems transmit microwave beams into the environment, which are then reflected off objects and picked up by the receiver; see Figure 9. The time difference between the transmitted and received signals and the Doppler frequency shift of the latter are used to determine both, the range and relative speed of the object. This measurement is simplified by frequency modulation of the transmitted signal, called chirp, created by a digital signal processor (DSP) block and then analogue modulated by the baseband block. The received reflections are also converted to baseband and then digitised for use as range and speed data in the DSP. The azimuth can be obtained with the steerable beam technology.

The power management IC (PMIC) ensures that all functions receive clean DC power from the car battery. Overall control of the system is provided by the microcontroller (MCU). Data from the system, and from vehicle actions, is transmitted by the controller area network (CAN) bus to the engine and vehicle controller, and then presented to the car's systems and its driver.

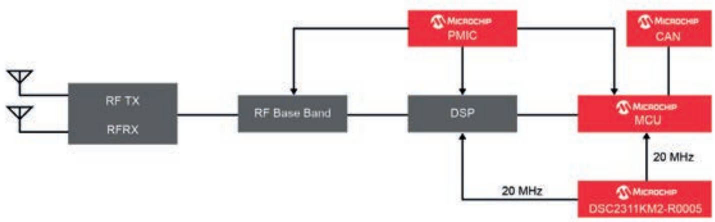



**Figure 9: Block diagram of an ADAS long-range radar**

## In-Vehicle Infotainment

Infotainment systems provide driving information and entertainment services. Figure 10 shows a specialised automotive-application processor interfacing with a touch panel display. A radio (including GPS, satellite and terrestrial services) and CD/DVD drives provide music, video and navigation via the audio system and display. A Bluetooth and/or Wi-Fi module provides a connection to smartphones, and a camera provides surround-view pictures to enable the driver to safely reverse or maneuver the vehicle.

An MCU handles overall control of the system, communicating via the vehicle's network (usually a CAN bus) with functions such as temperature control, door locks or tire pressure monitoring. A DSC400 clock provides a very low jitter 100MHz HCSL clock reference for the end system's PCIe communication with Flash memory; it also supplies a 12.288MHz reference for digital audio. A separate DSC6100 oscillator provides a 12MHz source for the MCU function of the application processor.

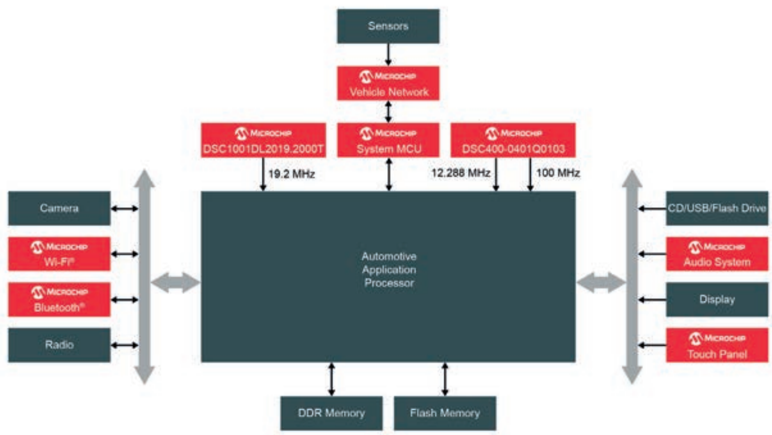



**Figure 10: Block diagram of an in-vehicle infotainment head unit**

## Connectivity

Connected smart cars with GPS, multimedia, advanced engine control and driver assistance need networking protocols that offer much higher bandwidth than CAN supports. To meet the requirements for in-vehicle connectivity, Microchip offers transceivers that support media-oriented systems transport (MOST) technology, with data transfer speeds up to 150Mbps, USB 3.1 Gen 2 (up to 10Gbps) and 100Base-T1 Ethernet (up to 100Mbps).

Microchip's integrated network interface controllers (INICs) for MOST networks operate with a distributed network clock. A back-up clock is also required, and the use of a tiny 1.6mm × 1.2mm DSC6100 at 18.432MHz and 24.576MHz for this purpose is under evaluation.

The high data rates of USB 3.1 and 100Base-T1 Ethernet need clocks with reduced jitter (phase noise). A noisy clock will introduce bit errors in the data streams.

Figure 11 includes the block diagram of an Ethernet/USB reference design. A DSC2311 running at 25MHz has approximately 400fs (rms) of integrated jitter over the 100kHz-20MHz offset bandwidth, with performance well above the minimum standard.

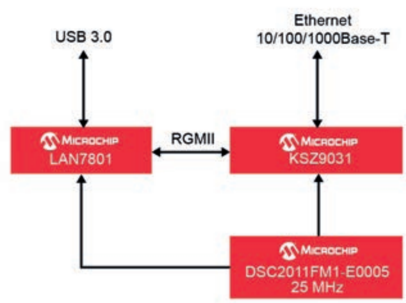



**Figure 11: In-vehicle networking block diagram**

## Perfect Match for Next-Generation Cars

Silicon MEMS-based timing devices are a perfect match for the smart, connected cars of tomorrow, offering high reliability that includes AEC-Q100 certification, wide operating temperatures, superb shock and vibration resistance, high accuracy (±10ppm) and small size.

Microchip offers a full range of MEMS-based timing solutions. These include both, single output oscillator drop-in replacements for traditional quartz oscillators, and multiple output clock generators that provide highly reliable and accurate reference clocks without the need for an external reference crystal. ●

# Emergency eCall available when needed!


By Tony Armstrong, Marketing Director,
Power Products, Analog Devices

Electronic systems must remain operational, regardless of external operating conditions, meaning that any glitch in their power supply, however momentary, must be accounted for in the design stages.

The most common way to cover downtime is with uninterruptible power supplies (UPS), ensuring reliable, continuous operation. One obvious example where this is needed is for backup of safety and critical equipment, maintaining operation during a power outage.

Another example is readily found in handheld electronic devices. Dependability is crucial, so handheld equipment is carefully engineered with lightweight power sources for reliable use under normal conditions. However, no amount of careful engineering can prevent potential mistreatment, like when a device is dropped and its battery comes out. Such events are unpredictable, and important data stored in volatile memory will be lost without some form of safety net – namely a short-term power holdup system that stores sufficient energy until the battery is replaced or the data transferred to permanent memory.

These examples clearly demonstrate the need for an alternative power source to be instantly available, just in case there's an interruption of the primary power source.

### Automotive Needs for Power Backup

In automotive electronic systems there are many applications that require continuous power, even when the car is parked, such as remote keyless entry, security and even infotainment systems, which usually incorporate navigation, GPS and eCall functionality. These systems, particularly the GPS, have to be always on for emergency and security purposes.

eCall is a safety feature that's becoming more pervasive in newer vehicle models; in April 2018 it became mandatory on vehicles sold within the EU. It's a simple bit of technology: in the event of a collision in which a car's airbags are deployed, eCall automatically contacts the emergency services using cellular networks. It sends GPS-generated data to relay the time and location, and adds the type of vehicle and fuel it uses to the emergency message, while a microphone in the car allows the driver to speak directly to the call handlers.

The eCall system also shares the direction the car was travelling in when the incident occurred, allowing authorities to know which side of a freeway might be affected. eCall enables the ambulance, police and fire crew to reach the location quickly, armed with as much information as possible.

An individual can also activate eCall by pressing a button, so if someone falls ill or has been injured when airbags have not been deployed, help can still be easily summoned.

### Storage Media

Having acknowledged the need for backup power for any given system, the question then arises: what to use as a storage medium for this power? Traditionally, the choice has been between capacitors and batteries.

Capacitor technology has played a major role in power transmission and delivery applications for many decades. For example, traditional thin-film and oil-based capacitor designs performed a variety of functions, such as power factor correction (PFC) and voltage balancing. However, in the past decade, substantial research and development has led to significant advances in capacitor design and capabilities. The results are called supercapacitors, or ultracapacitors, and they are ideal for use in battery energy storage and backup power systems. Supercapacitors may be limited in terms of their total energy storage, but they are still energy dense. Furthermore, they can discharge high levels of energy quickly and recharge rapidly. They are also compact, robust and reliable, and can support a backup system during short-term power-loss events. They can easily be placed in parallel, stacked in series, or combined to deliver the voltage and current demanded by an application.

## Supercapacitors

A supercapacitor is more than just a capacitor with a very high level of capacitance. Compared to standard ceramic, tantalum or electrolytic capacitors, supercapacitors offer higher energy density and higher capacitance in a similar form-factor and weight. And, although supercapacitors require some "care and feeding", they are augmenting or even replacing batteries in data storage applications requiring high-current/short-duration backup power.

Furthermore, they are also used in many high-peak-power and portable applications that need high current bursts or momentary battery backup, such as UPS systems. Compared to batteries, supercapacitors provide higher peak-power bursts in smaller form-factors and feature longer charge-cycle life over a wider operating temperature range. Supercapacitor lifetime can be maximised by reducing the capacitor's top-off voltage and avoiding high temperatures (> 50°C).

Batteries, on the other hand, can store a lot of energy, but are limited in power density and delivery. Due to the chemical reactions within a battery, they have limited charge cycles. As a result, they are most effective when delivering a modest amount of power over a long time, since pulling many amps out of them very quickly severely limits their useful operating life. Table 1 shows a summary of specifications for supercapacitors, capacitors and batteries.

## New Backup Power Solutions

With all these available options, there are IC solutions for use as a backup power supply for almost any electronic system.

The Analog Devices Power by Linear group's LTC4040, shown in Figure 1, is a complete lithium-battery backup power-management system serving 3.5-5V supply rails that must be kept active during a main power failure. It uses an on-chip bidirectional synchronous converter to provide high-efficiency battery charging as well as high-current, high-efficiency backup power. When external power is available, the device operates as a step-down battery charger for single-cell Li-Ion or LiFePO4 batteries, while giving preference to the system load. When the input supply drops below the adjustable power-fail input (PFI) threshold, the LTC4040 operates as a step-up regulator, capable of delivering up to 2.5A to the system from the backup battery. During a power-fail event, the device's PowerPath control provides reverse blocking and a seamless switchover between input and backup power.

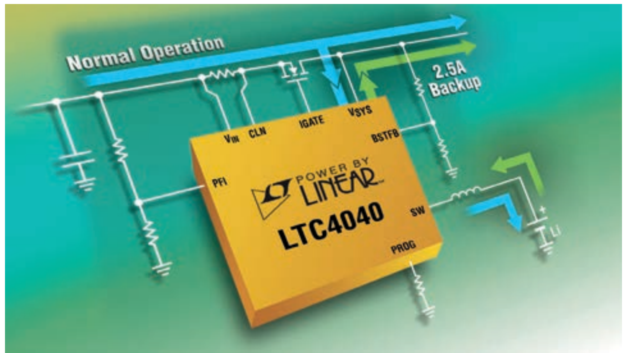



Figure 1: The LTC4040 backup power management system

Typical applications for the LTC4040 include fleet and asset tracking, automotive GPS data loggers, industrial backup, USB-powered devices, and automotive telematics, toll collection, security and communications systems.

The LTC4040 also includes optional overvoltage protection that protects the IC from input voltages greater than 60V, using an external FET. Its adjustable input-current limit function enables operation from a current-limited source while prioritising system load current over battery charge current. An external disconnect switch isolates the primary input supply from the system during backup. The device also includes input current monitoring, an input power loss indicator and a system power loss indicator. ●

| PARAMETER | SUPERCAPACITORS | CAPACITORS | BATTERIES |
|---|---|---|---|
| **Energy storage** | W-sec of energy | W-sec of energy | W-Hr of energy |
| **Charge method** | voltage across terminals i.e. from a battery | voltage across terminals i.e. from a battery | current & voltage |
| **Power delivered** | rapid discharge, linear or exponential voltage decay | rapid discharge, linear or exponential voltage decay | constant voltage over long time period |
| **Charge/discharge time** | ms to s | ps to ms | 1-10 hrs |
| **Form factor** | small | small to large | large |
| **Weight** | 1-2g | 1g to 10kg | 1g to >10kg |
| **Energy density** | 1-5Wh/kg | 0.01-0.05Wh/kg | 8-600Wh/kg |
| **Power density** | high, >4000W/kg | high, >5000W/kg | low, 100-3000W/kg |
| **Operating voltage** | 2.3V – 2.75V/cell | 6V – 800V | 1.2V - 4.2V/cell |
| **Lifetime** | > 100k cycles | > 100k cycles | 150 to 1500 cycles |
| **Operating temperature** | -40 to +85°C | -20 to +100°C | -20 to +65°C |

Table 1: Supercapacitor vs capacitors and batteries

# On the road to autonomous driving with ACF bonding

By Jan-Bart Picavet, Product and System Sales Manager, Hot Bar Technology, Amada Miyachi Europe

There's no doubt that the automotive industry is heading firmly towards autonomous driving. Investment in advanced driver assistance (ADAS) and similar electronic systems is steadily growing, all of which require smaller components and lower costs. To meet these demands, anisotropic conductive film (ACF) bonding is becoming increasingly prominent and a technology of choice.

Used to interconnect vehicle cameras and printed circuit boards (PCBs), and widely applied to collision and lane departure warning systems (LDWS) and park-assist applications, ACF bonding solutions are cheaper than other connectors. The ACF approach uses pulsed heat technology with close loop controls to bond ADAS camera interconnections, saving money and reducing component size.

## Rapidly Moving Towards Autonomous Driving

The technology available in cars today was typically designed some seven or eight years ago, and current research and development focuses on autonomous driving.

In the past, only high-end car models used ADAS, collision warning, LDWS, auto-park/reverse, night vision, drowsiness monitoring, distance warning/autonomous emergency braking and blind-spot detection systems, but now these functionalities are also found in the middle market segment of mainstream cars. Many of these systems use high-resolution cameras that produce a tremendous amount of data which needs handling by processors in real time. Hence, shrinking the size of these cameras is paramount, so they can fit into smaller and tighter spaces; for example, front-facing windscreen cameras fitting behind the rear-view mirrors, without impacting the view of the road.

The same principle applies to other electronic systems in vehicles, many of which need surrounding awareness, determining appropriate navigation paths and obstacles, and recognising signage – especially in autonomous driving. As production volumes of such systems ramp up, manufacturers are looking to have fully automated production lines with process monitoring and no operator involvement.

## Connecting Cameras to PCBs

ADAS systems require electromechanical interconnection between forward-facing cameras and the PCB where the data is processed. In the past, this connection was made with board-to-board or zero-in-force (ZIF) connectors, which are costly and take up a lot of space. Also, traditional connector insertion requires flexing beforing being locked into place.

An alternative today is anisotropic conductive film (ACF) bonding, where parts are joined together with glue containing conductive particles. The process involves automatic placement of ACF on the PCB or flex cable. With accurate alignment of parts and the application of precise heat and force, ACF bonding systems make a strong and reliable electromechanical interconnection; they are lead- and flux-free, making the process an excellent choice for connections on many substrates, including glass.

ACF bonding effectiveness relies on full control of the process parameters. It is ideal for smaller pitches because the particle size is smaller than those of traditional alternative HSC connectors. With other joining technologies, the average pitch size is about 200 microns, but ACF bonding technology can handle pitches as small as 30 microns. This allows for more contacts to be placed side by side, and, if the application requires 100 electrical contacts, the finer the pitch the smaller the flex cable will be. However, with such small pitches, alignment of parts is critical for ACF applications to work properly – alignment that should ideally be done automatically.

Automotive components operate in demanding conditions, in a wide temperature range (from freezing to over 100°C) and to automotive specifications. They may cycle from very cold to very hot, so connection robustness is a must to ensure safe design.

With ACF bonding it is imperative for the process to accurately control the heat input into the parts. This can be a challenge – automotive designers want parts to be as thick as possible, which can make it difficult to bring in the proper amount of heat for a successful ACF bonding process, for proper curing of the glue.

In addition to temperature control, planarity of PCB flex tooling will affect the force across the application, which in turn affects the results.

Another advantage to ACF technology that automotive makers will like is that it can be used within an automated assembly process.

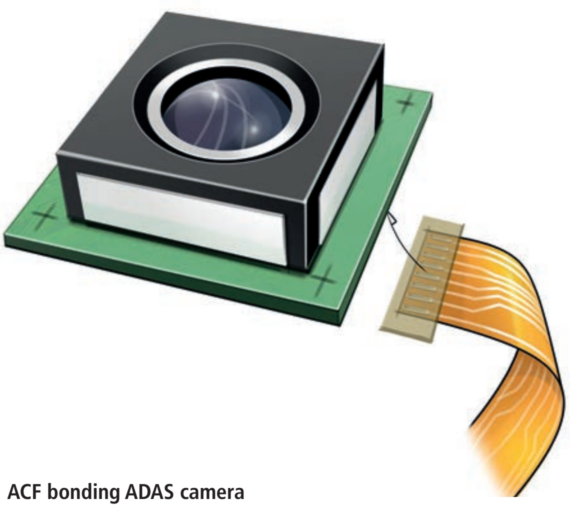
## Constant Heat or Pulsed Heat Technology

ADAS applications that require an interconnection between PCB, flex cable and camera use ACF bonding with constant and/or pulsed heat (closed loop controls). With pulsed heat, the entire temperature/time profile can be controlled. The bonding process starts at ambient temperature, heats up, maintains the reflow temperature and then cools down the process tools until a stable ACF connection is established. No cleaning is required after the process.

**The technology available in cars today was typically designed some seven or eight years ago, and current research and development focuses on autonomous driving**

Amada Miyachi Europe has several systems that use pulsed heat technology with closed loop controls for ACF bonding of ADAS camera interconnections. Its UNIFLOW4 power supply for temperature control provides targeted heating and precision temperature control. An external MG3 digital weld monitor is used to monitor all process parameters, providing high-precision, real-time, dynamic measurement of all the welding variables.

The company also offers the tools required for process development, production monitoring, data collection, MES communication and analysis to support ISO, GMP and TQM requirements. ●



ACF bonding ADAS camera

Camera for automotive use

# RF-controlled vehicle for harsh environments

By Rüştü Güntürkün and Selim Dilhan Türk, Dumlupinar University, Turkey

We've created a remotely-controlled vehicle for inaccessible environments, although it can be used in other areas too.

The system consists of three main parts: mechanical, electronics and software. The interface program was written in Microsoft Visual 6.0, and we used the Pic Basic Pro language for programming its microcontrollers. We chose the ARX-34 RF transceiver modules for their affordability and ease of use.

## System Structure

Figure 1 shows our system; the communications card includes a transmitter that sends data fed to it from the PC's serial port. The receiver then sends this data on to the control card that includes microcontrollers as a vehicle-user interface. There is also a camera with its own RF receiver-transmitter module pair, so that images can be transmitted directly to the PC without the involvement of the main microcontroller.

The user interface program opens the PC's first serial port for the program to work. Clicking the LINK button activates the system, allowing the user to control the vehicle. Because the serial port is asynchronous, and per the RS-232 standard, the signal levels and transmission are not the TT logic (TTL) that MCUs understand. To convert data from the serial port to TTL requires the MAX232 signal converter located on the communications card.

## The Interface Program

Before using Microsoft Visual Basic 6.0 to create the user interface, we tested the system with a Hyper Terminal program that works with Microsoft Windows, and obtained positive results.

First, a Microsoft Comm Control 6.0 object is installed, which enables the serial port in Visual Basic. Visuals of the interface were made beforehand, and stored in the Hyper Terminal program. The program code in Visual Basic is shown in Figure 3.

The receiver located on the control card receives the data and transmits it to the microcontroller. Data communication is asynchronous when made through the serial port, so commands come in 8-bit groups. We considered this when selecting a microcontroller and chose the Microchip PIC16F628A, with a serial communication unit (USART). Incoming data is stored in the MCU's register, and commands from the user interface are retrieved through software.

The vehicle has two wheels and two DC motors on each side, so it can turn in any direction, and an L293D motor driver IC. Right and left rotation depend on the speed difference between wheels; see Figure 5. The motors' high torque helps move the vehicle, whereas their low spin prevents it from going off-road.

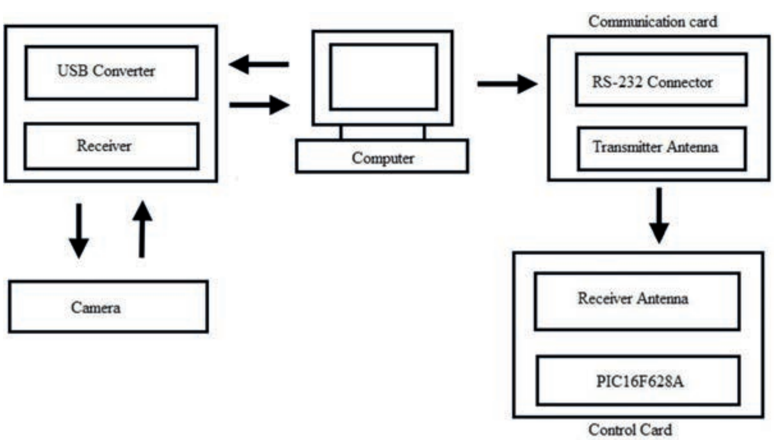



Figure 1: Block diagram of the system

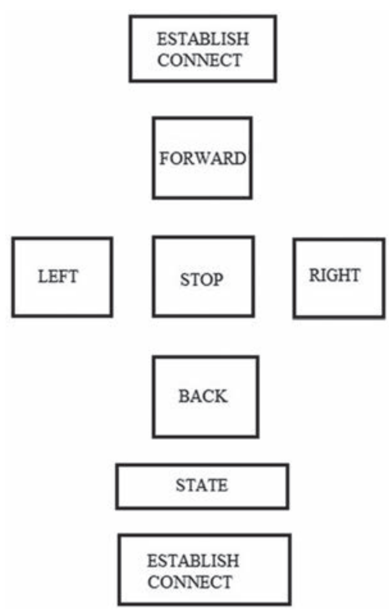



Figure 2: Interface program state diagram

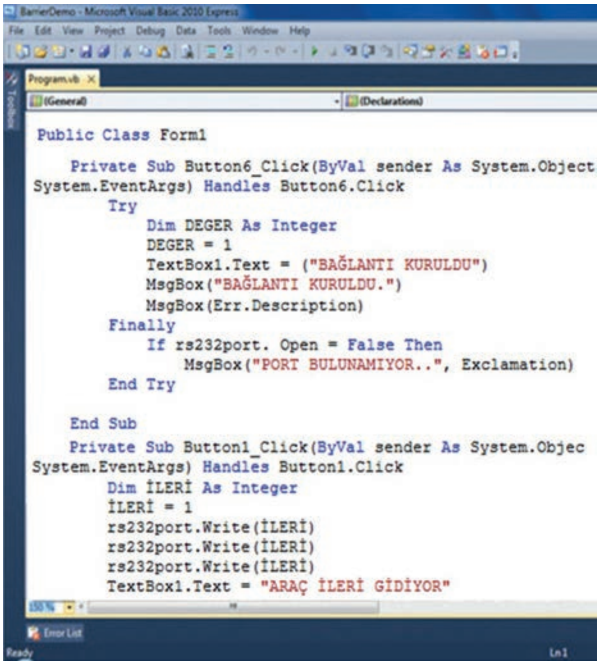



Figure 3: Program code

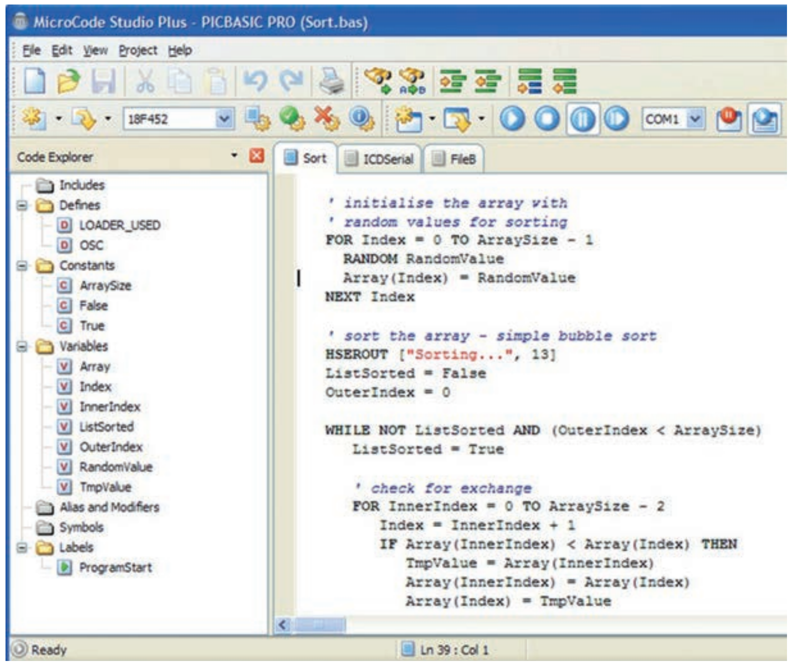



Figure 4: Creating the Microchip MPLAB IDE HEX file

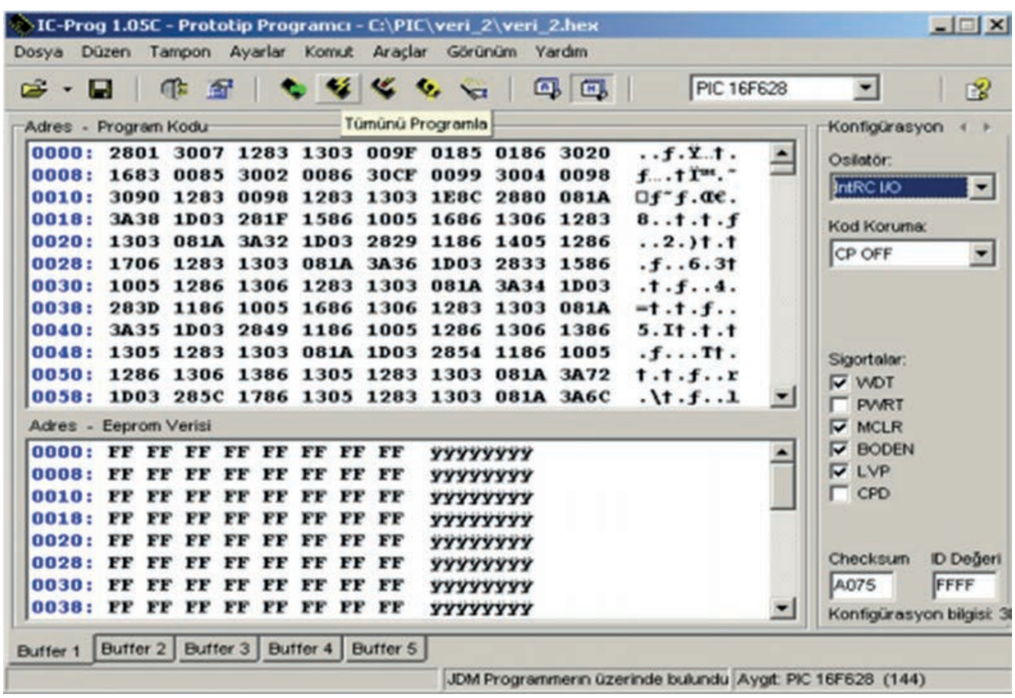
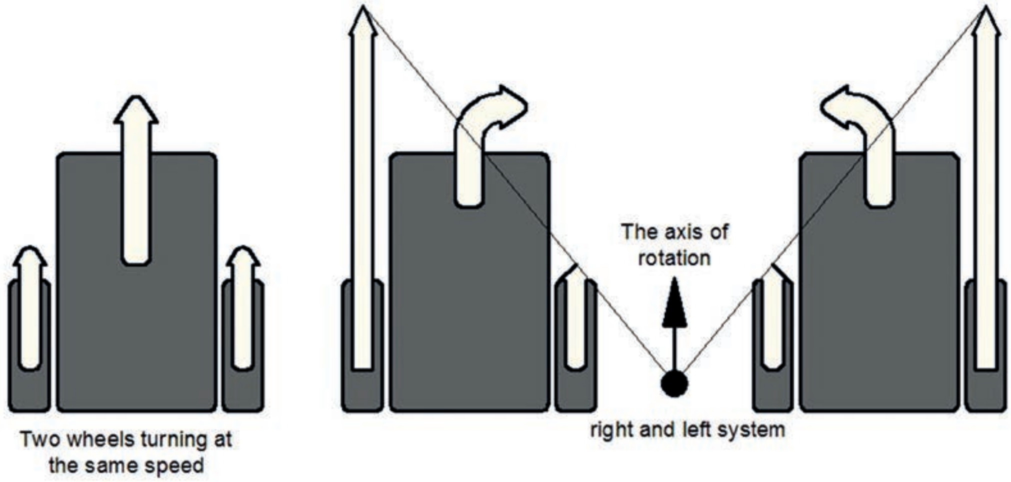



Figure 5: Installing the HEX file into the microcontroller

Figure 6: Rotation structure of the vehicle




## Microchip MPLAB IDE Compiler

Converting PIC Basic Pro codes to HEX codes is achieved with the Microchip MPLAB IDE software; however, for PIC Basic Pro codes to work on the Microchip MPLAB IDE, a software called CC5X is needed, too. As seen in Figure 4, after choosing the appropriate PIC model and writing the code, clicking the "Build" tab will create the HEX file.

To install the HEX code we used IC-Program, which supports the 12Cxx, 16Cxxx, 16Fxx, 16F87x, 18Fxxx, 16F7x, 24Cxx, 93Cxx, 90Sxxx, 59Cxx, 89Cx051, 89S53, 250x0, 80C51 microcontroller families, EEPROM and microprocessor series, and successfully converts hexadecimal code to assembly. The installation of the HEX file into the MCU through the IC-Program is shown in Figure 5.

With the camera in the vehicle, the user can control its direction via the PC; see Figure 7. The vehicle is suitable for research, exploration and recon in industrial, mining and military applications. Its only limitation at this stage is that its design is closely related to the coverage zone of the RF receiver-transmitter module pair, which work within 75m in enclosed spaces and about 100m in open areas. Stronger RF modules must be used to extend the coverage area. ●

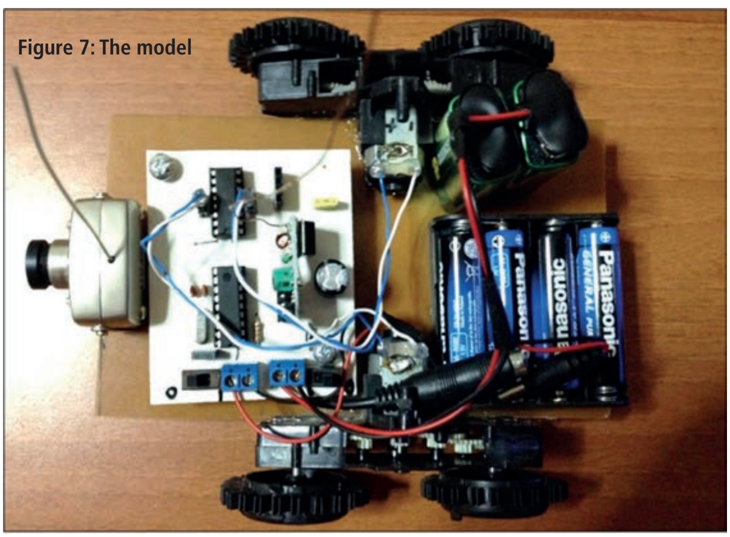


Figure 7: The model

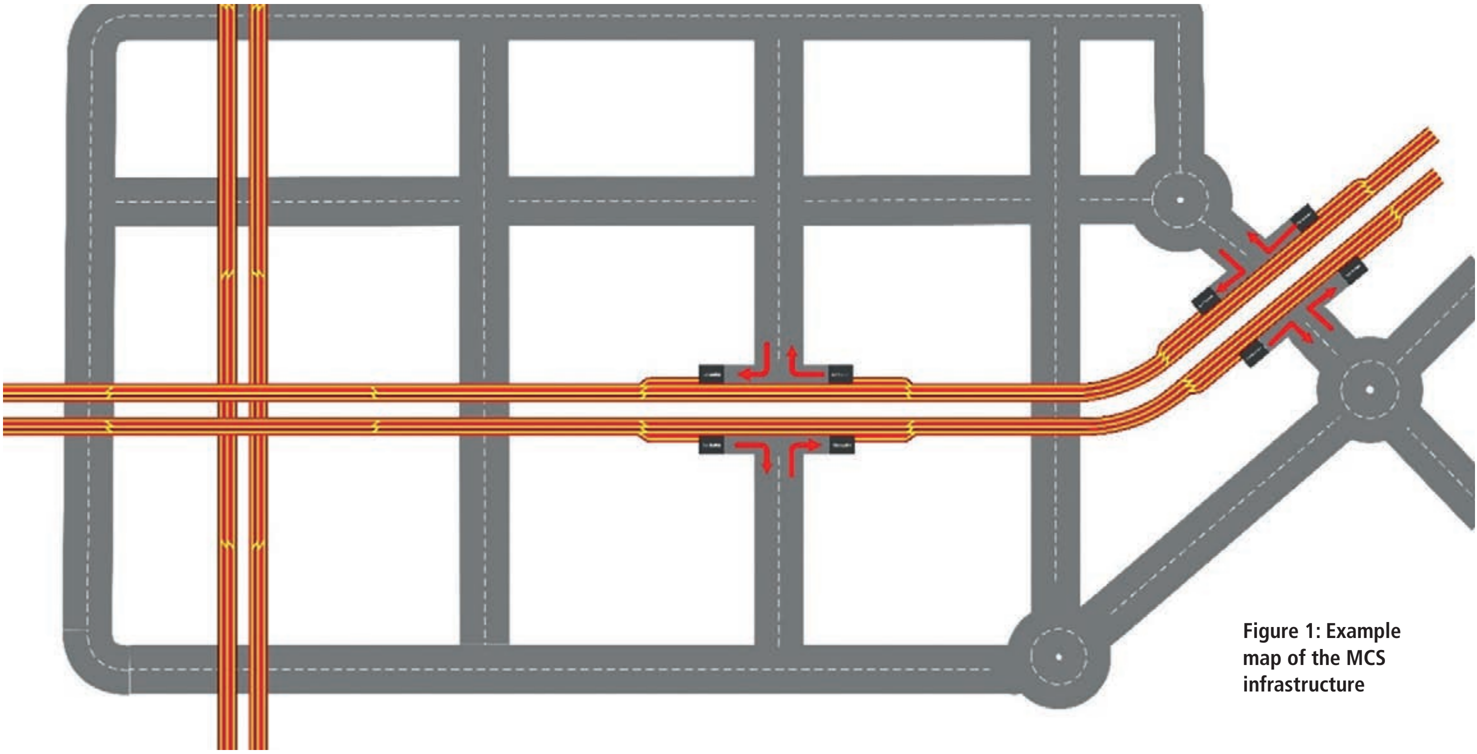


Figure 1: Example map of the MCS infrastructure

# MetroCar – a novel transportation system for cities

By Mehmet Bozuyla and Abdullah T. Tola, Pamukkale University, Turkey

Busy modern lives continue to shape our cities, especially through problems such as growing traffic volumes and increasing pollution. Public transport systems are viewed as a suitable method that can alleviate some of these problems and improve safety, security, time, cost and the environment, among other things.

| | MetroCar | Autonomous Car | Metro | Personal Car |
|---|---|---|---|---|
| Suitability | High | Low | High | High |
| Travel Comfort | High | High | Low | High |
| Hygiene | High | High | Low | High |
| Personal Security | High | High | Low | High |
| Effective Time | High | High | High | Low |
| Traffic Density | Low | High | Low | High |
| Traffic Lights | No | Yes | No | Yes |
| Grade-Separated | Yes | No | Yes | No |
| Vehicle Cost | Low | High | High | Variable |
| Vehicle Power | Electrical | Variable | Electrical | Variable |
| Infrastructure | High | Low | High | Low |
| Driver | Positive | Positive | Positive | Negative |
| Traffic Safety | High | Low | High | Low |
| Implementation | High | Low | High | High |

Table 1: Comparisons of the MetroCar, autonomous and personal cars, and the metro

The most used public transport systems are buses, trams, trains and in some cities the underground, or metro. The metro has been proven to be the most efficient solution, since it is the fastest and most convenient way of moving around cities, largely unhampered by traffic. Overall, however, personal cars are still the preferred method of transport, offering greater comfort and more personal space, and they are more hygienic. Combining cars and the metro should then also combine their advantages.

## Autonomous Cars

Autonomous transport systems have evolved rapidly over the last few years and, in the near future will apply to both, the personal car as well as public transport, including the metro. Until then, however, we suggest a concept for a MetroCar System (MCS) for cities that combines the personal car with metro systems. With MCS, passengers will be on-board their personal vehicles whilst driven autonomously on metro-type roads, then switch to manual driving on other roads.

We've assumed a standard car for our system, which we named the MetroCar. This is a small, one-seater vehicle that's fully electric, powered externally on the metro network and batteries elsewhere. Vehicle size and weight are reduced considerably to

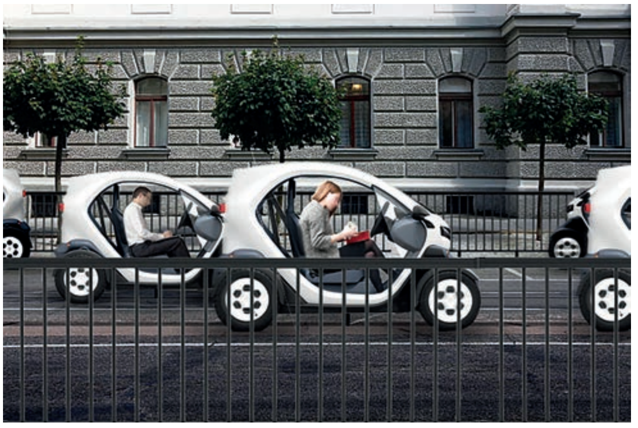


Figure 2: Artist impression of MCS

ensure low power consumption yet allow passenger comfort.

The MCS needs a new infrastructure, built of grade-separated narrow roads reserved for MetroCars only. As with other grade-separated transit systems, this will largely avoid traffic jams.

It's worth noting that the MCS is not a railway system, since the MetroCar has a set of tyres for driving on public roads. However, when on the "guideway", the MetroCar obtains its power externally and charges its batteries. An example map of an MCS infrastructure is shown in Figure 1, where the coloured lines are MCS roads and the grey lines are public roads.

Since the MCS infrastructure will only serve the city's major arteries, the MetroCar can be driven manually everywhere else.

Let's assume a person travels from home to office. From their house to an MCS entry/exit point, as well as from the MCS entry/exit point to an office building, the car will be driven manually. At the MCS entry point, the driver requests permission to join the "metro" system, which, once allowed, will take over the vehicle's controls. This means that the driver no longer has control over the vehicle whilst in this mode; see Figure 2.

We believe this to be one of the best transport solutions in cities; see its advantages and benefits in Figure 3 and comparisons with other transport systems in Table 1.

We simulated and verified our MCS with a multi-agent programmable modelling environment – the NetLogo software. Each car is modelled as an agent, able to communicate with others in the network, the main server and link servers; see Figure 4.

## Obvious Solution

The proposed novel transportation system, which we called the MetroCar System (MCS), provides simple traffic control, reducing traffic jams and increasing movability around cities. The system is suitable not only for cities, but also large private areas such as airports, hospitals, universities and showground campuses, shopping centers and entertainment/theme parks. This can be an intermediate solution before fully-autonomous cars replace current transport systems. ●

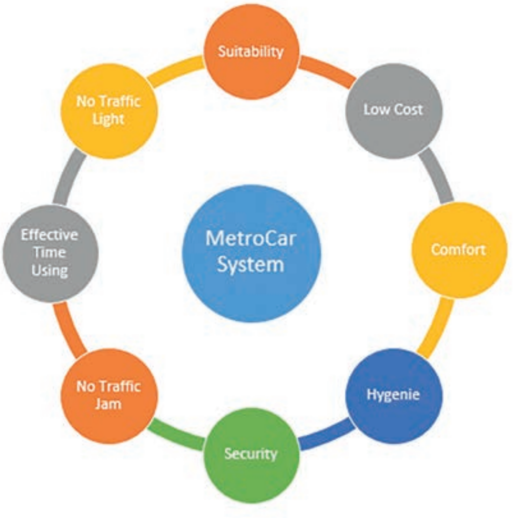



Figure 3: MetroCar advantages and benefits

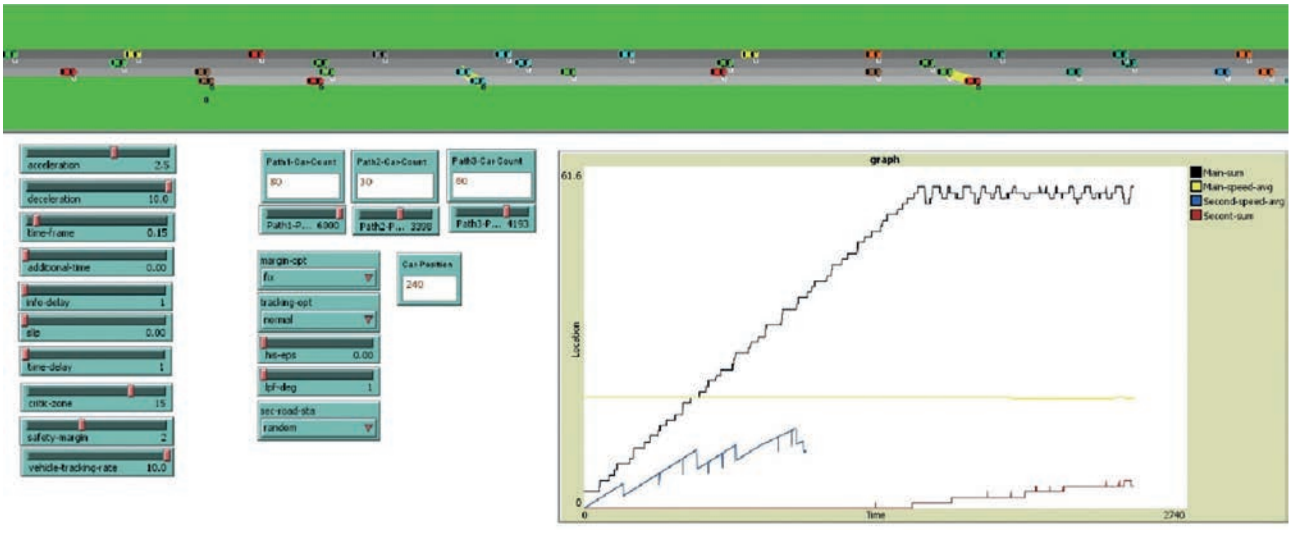



Figure 4: NetLogo simulation interface

# Using heuristic distance functions in path planning of mobile robots

By Zeynep Batik, Gokhan Atali, Durmus Karayel and S. Serdar Ozkan, Sakarya University, Turkey

The subject of robotics has always been of great interest to researchers. This holds true now more than ever, with robots found in a growing number of sectors, including domestic use – especially mobile robots.

Path planning and localisation in mobile robots are complicated tasks, depending on many parameters, not least finding the optimum path between a starting and destination point, the robot's power consumption and charging, and its navigation in varied environments without colliding with other objects.

## Finding the Shortest Route

To find the shortest route in path planning for mobile robots, there are several computer algorithms available, including A*, D*, and their derivatives – incremental A*, focused D*, Lite D* and Delayed D*.

Biswas et al. used a camera on the robot to detect objects around it. This team developed an algorithm based on image processing, where the acquired data is sent to a controller for calculating the robot's path.

Although there are other studies with completely different approaches to this task, in our study we also selected image processing for path planning; see the setup in Figure 1.

## Robot Localisation

Pre-planning of the robot's route is very important to reduce the time it takes it to move from A to B, and the power it needs to do so. This is the reason we used a heuristic-based algorithm – heuristic search algorithms choose the optimal path to reach a target by evaluating all probable routes, and are used in applications such as decision making, planning and looking for the shortest path.

In our study, we combined the Manhattan, Euclidean and Diagonal heuristic functions with the A* algorithm. Although exhaustive, the A* algorithm avoids considering inappropriate paths, making the task much simpler.

**Manhattan Heuristic Function:** In the Manhattan heuristic function, while planning the path between a starting and destination point, the robot can move in a horizontal and vertical axis:

$$h_1(n) = |x_s - x_g| + |y_s - y_g| \qquad (1)$$

**Euclidean Heuristic Function:** Equation 2 helps calculate the route using this function, when the robot follows a straight line from its starting point. This is a costly and long exercise, since many extra points are considered. This function is normally preferred to use in the A* algorithm as it plans the shortest path better than any other heuristic function.

$$h_2(n) = \sqrt{(x_s - x_g)^2 + (y_s - y_g)^2} \qquad (2)$$

**Diagonal Heuristic Function:** This function is obtained by combining the Manhattan and Euclidean heuristic functions:

$$h_3(n) = h_1(n) + (\sqrt{2} - 2) * min\{|x_s - x_g|, |y_s - y_g|\} \qquad (3)$$

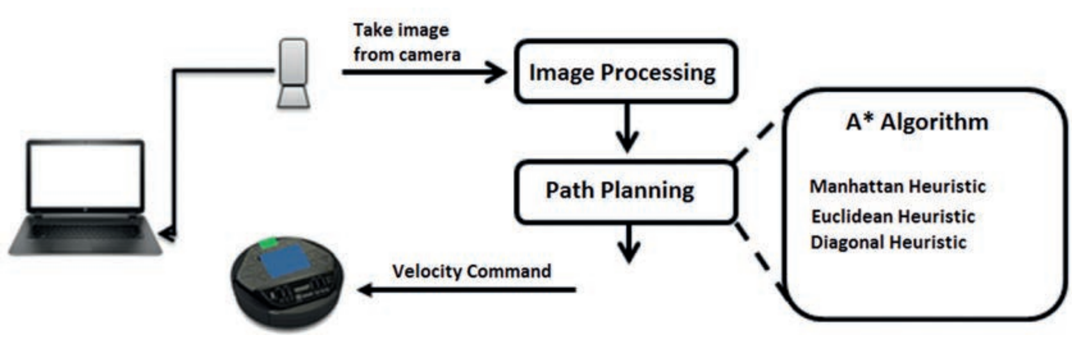



**Figure 1: The block diagram of the proposed image-processing-based path planning**

The graphs of the three functions are shown in Figure 2.

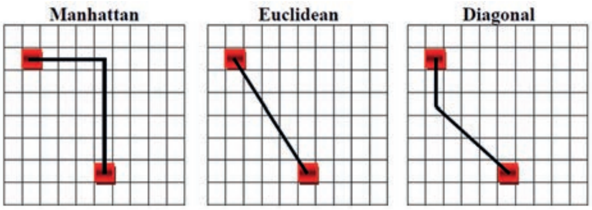



**Figure 2: Heuristic functions**

## General Structure of the A* Algorithm

A* is a search algorithm that uses Equation 4 to find the shortest and least expensive travel route:

$$f(n) = g(n) + h(n) \qquad (4)$$

where, f(n) = total cost function, g(n) = distance function, and h(n) = Heuristic function.

The distance function is described as the distance travelled between a starting and current node. The h(n) heuristic function stands for the length of straight line between a current and end nodes, also known as the "top view distance". The algorithm considers all nodes, from the starting to the one with lowest f(n) value. See the flow chart of the A* algorithm in Figure 3.

## Graphical User Interface

Additionally, we developed a graphical user interface based on a MATLAB-GUI, which easily analyses the effects of heuristic function parameters on path planning.

To determine the direction of the mobile robot in the working area, we placed red objects as intermediate targets. As seen in Figure 4, when the "take from camera" button is selected, an image is captured and processed, then the positions of the robot and object are determined by translating the coordinates taken from this image into real-world coordinates.

Following that, we identified the reach of the mobile robot in two stages: first, we determined the shortest path for the robot to move from a starting point to an intermediate target, and then found the shortest path for the robot to move from intermediate target to end point. The effects of each parameter on the path planning were analysed with the Manhattan, Euclidean and Diagonal heuristic functions; see Table 1.

In the global path-planning part, the shortest paths for a Kobuki robot were found by the Euclidean (Figure 5a), Manhattan (Figure 5b) and Diagonal distance (Figure 5c) heuristic functions with the A* algorithm.

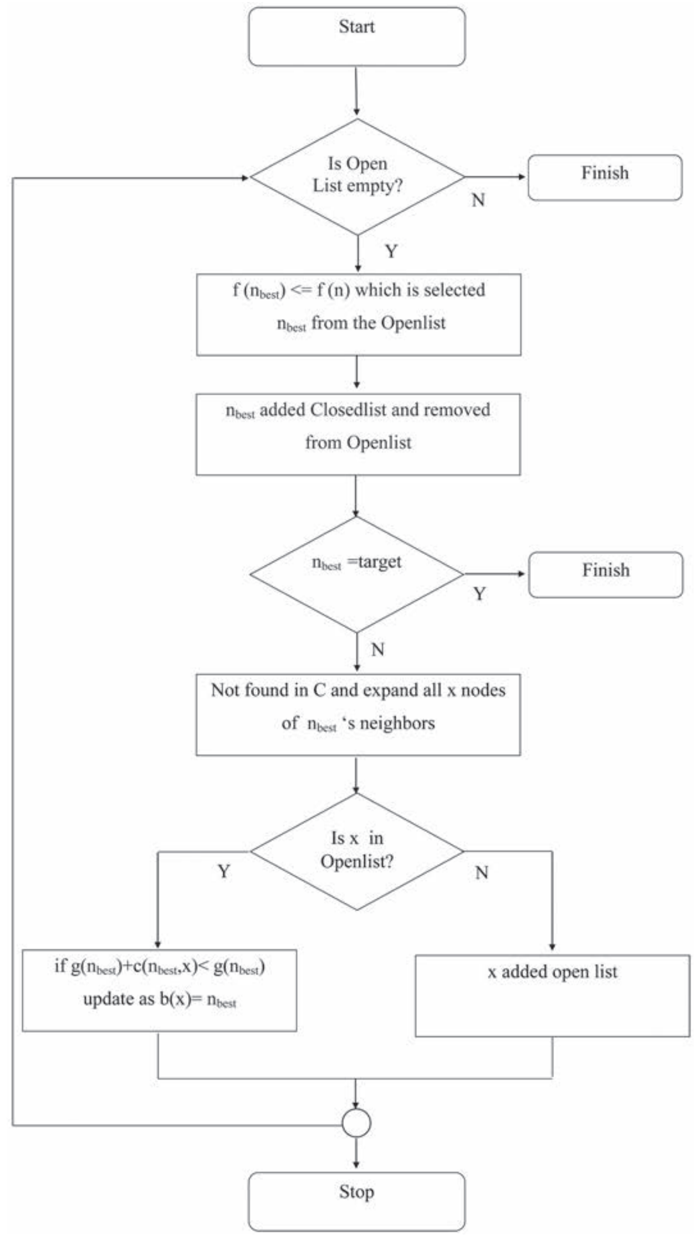



**Figure 3: Flow chart of the A* algorithm**

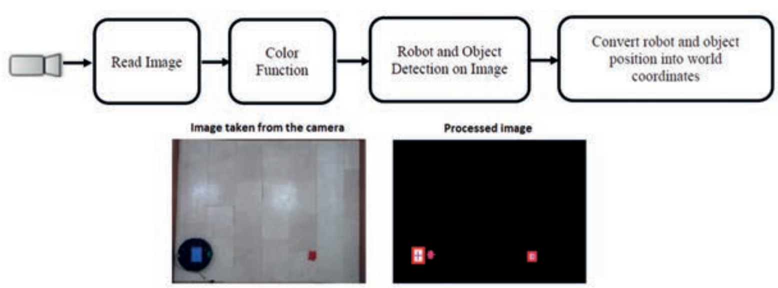
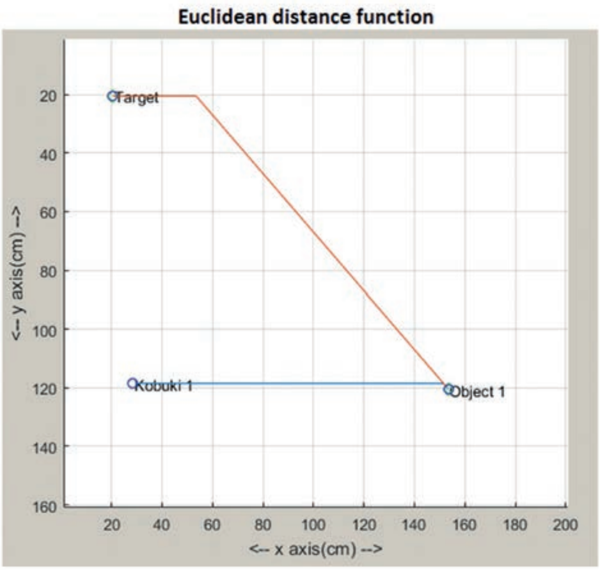



**Figure 4: (Top) block diagram of the image processing and (bottom) obtained images**

| Heuristic Function | Elapsed time (seconds) | Object Distance (cm) | Target Distance (cm) |
|---|---|---|---|
| Manhattan | 61.49 | 12.7 | 23.3 |
| Euclidean | 30.42 | 12.51 | 16.6 |
| Diagonal | 26.81 | 12.58 | 17.4 |

Table 1: Heuristic function results

(a)




## Tests and Results

We then tested the performance of the robot for each path, in simulated and real-life setups.

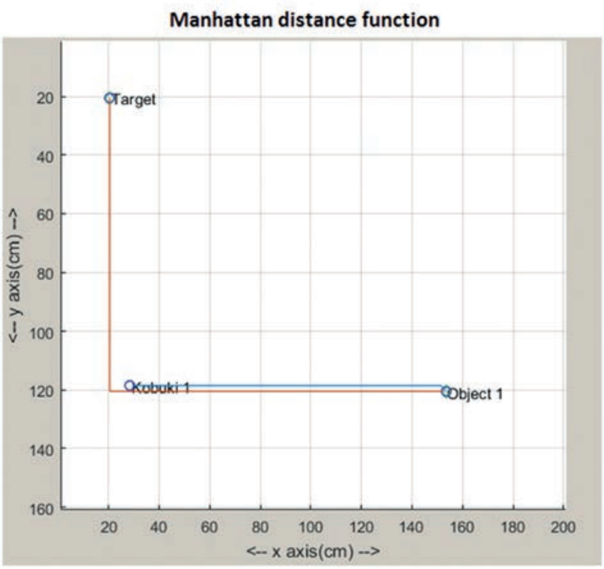
We did a detailed analysis and comparisons for each method with the Manhattan, Euclidean and Diagonal heuristic distance functions. The shortest path, minimum elapsed time and lowest energy consumption were examined, identifying the advantages and limitations of each distance function.

The results from both simulations and experiments showed that the Euclidean heuristic function is more effective than the others. Our results also revealed that image processing is very effective for path planning in mobile robots.

Our system is very cheap, since it does not need the expensive hardware and sensors required by other approaches, yet we achieved the same function with the same precision.

Our study was for a static environment, but the same setup can easily work for dynamic environments too, by further developing the software. ●

(b)




(c)

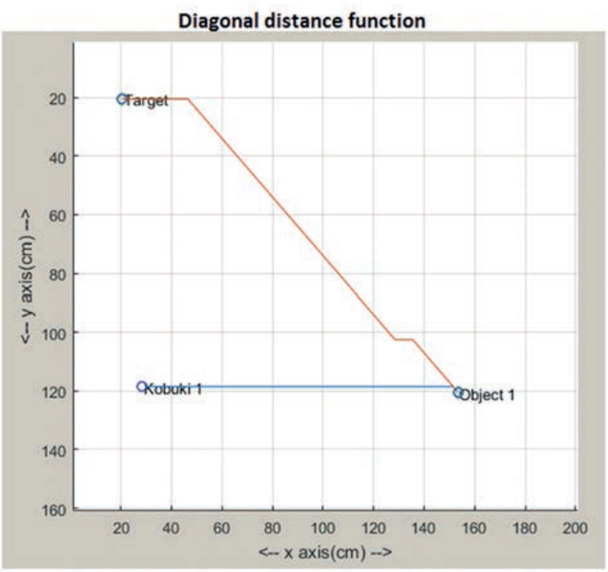



Figure 5. The interface designed by using the A* search algorithm. The shortest paths obtained with (a) Euclidean, (b) Manhattan, and (c) Diagonal distance heuristic functions

Some AGVs use magnetised or coloured guide tape to navigate

# Towing the line

By Jonathan Wilkins, Marketing Director, EU Automation

When automated guided vehicles (AGVs) were first invented in the 1950s, they did simple things. The first AGV, introduced in 1953 by Barrett Electronics, performed a simple towing action, its position guided by a wire in the floor. Since then, the growing adoption of industrial automation has led to a rapid market increase, with AGVs used for various tasks across many industrial applications. Researchers now predict that the AGV market will be worth some $1.5bn by 2024.

## The Role of the AGV

Automated guided vehicles are predominantly used for materials-handling. This can range from on-time delivery of parts to the production line, to round-the-clock transit.

Depending on the application, AGVs can function in isolation or in fleets. This makes their use scaleable depending on need, so a plant manager can make a specific decision on the number of vehicles in a facility.

Investing in AGVs has a lot of advantages, from reducing labour costs in materials-handling, to increasing safety on the factory floor. Since AGVs are equipped with cameras and sensors, they can easily operate around people and infrastructure. They also require no human input, reducing the risk of human error caused by distraction or fatigue.

Plant managers can adapt AGVs to different tasks on the factory floor. Sensors can improve traceability and accuracy of processes, monitoring the position of each vehicle in the facility. This information can be integrated into the company's enterprise resource planning (ERP) or materials resource planning (MRP) systems.

## Navigation

Depending on the application, there are different types of vehicle navigation methods. A plant manager can choose a very simple system, similar to the earliest AGVs, or more advanced navigation methods.

To navigate around the factory, early AGVs followed a wire embedded in a slot in the floor. The wire transmits a radio signal, detected by a sensor on the AGV, guiding it around the facility. Although this navigation technique is still used today, there are a variety of other methods to choose from.

Some AGVs use guide tape that is either magnetised or coloured to navigate. Sensors on the AGVs detect the tape and this is used to guide the vehicle. This method is also used in laser target navigation, where reflective tape is mounted on walls, poles or machines, with the AGV then calculating the distance using the laser transmitter and receiver.

Guide tape and laser navigation are more adaptable than the buried-wire method, as manufacturers can easily re-route the AGV by moving the tape.

In inertial navigation, reference points are embedded in the factory floor at x,y coordinates. The AGV uses information from a sensor, a gyroscope and a wheel encoder to determine its location. Changes can be made to the pathway by simply altering the reference points, making this method more flexible than other alternatives. However, some change to factory infrastructure is still required, and the vehicle cannot make independent route-planning decisions.

The next step up from inertial navigation is open-path navigation, where the vehicle can move independently from one place to another, transitioning from a guided to a self-driving vehicle.

### The Next Stage

Traditional AGVs perform defined, pre-programmed movements around a facility, which leads to some difficulty changing the vehicle's route once specific infrastructure is in place. Recently, more flexible and intelligent vehicles have been introduced, able to make decisions in situations they haven't encountered before.

These advances help the vehicle overcome problems previously experienced in the factory. In a changing environment, a self-driving vehicle may be a better fit to deal with the unexpected. This type of vehicle operates without a driver or a fixed pre-programmed input, directly controlling the steering, acceleration or braking. Laser-based perception and navigation algorithms can be used to dynamically navigate around a factory.

Self-driving vehicles can use an on-board computer and more sensors to complete increasingly complex tasks, including making decisions. Independent and intelligent navigation methods can even mean the plant managers do not need to modify factory environments or the infrastructure. One such navigation technique is natural feature guidance, where the vehicle records and stores images and calculates its position in relation to existing features.

**Guide tape and laser navigation are more adaptable than the buried-wire method, as manufacturers can easily re-route the AGV by moving the tape**

### Smart System

An on-board programmable logic controller (PLC) can be integrated to reduce errors and make decisions. Connected to the plant's central control system, the vehicle can analyse the reliability and efficiency of its routes and adapt them accordingly. It can use machine learning to be more efficient in new situations.

The vehicles can also use vision-based guidance systems, such as cameras. This way, plant managers gain a 3D virtual view of the operational environment, so if the AGV comes across anything unplanned or unusual, the operator can easily find the reason and correct it.

AGVs have changed a lot since the 1950s and are now capable of a lot more than simple towing. As more factories automate processes to meet consumer demand, advancing AGVs will be a core component of the smart factory. AGVs are smarter and more dynamic, with improved sensor technology and increased autonomy, progressing from guided vehicles following a set path, to autonomous, independent, decision makers. ●

Depending on the application and requirements, AGVs can function in isolation or in fleets


# electronica 2018

It may be hard to believe, but it's been two years since last Electronica, and, this year, November 13-16, Messe Munchen in Germany will open its doors to yet another massive electronics exhibition. The event's organisers have added another hall (C6), bringing the total to 17, expanding the exhibition space to over 180,000m$^2$. They expect almost 3,000 exhibitors from 50 countries and about 73,500 visitors from 84 countries, and some 8,000 participants at the show's conferences and forums. There will be four conferences including a new one this year, and sixteen forums, two of which are new.

### A Large Networking Range

The show's organisers have improved digital support for further networking between exhibitors and visitors, as well as among visitors themselves, provided in the form of the classic Electronica Matchmaking and the new Electronica Connect tool. For further inspiration and business opportunities, there will also be the Electronica Experience and North by North East (NxNE), as well as IMPACT – Design for a Cause.

The new hall C6 will give visitors the opportunity to come to grips with electronics, as well as showcasing career opportunities within the field. Electronica Experience will feature live demos, applications and presentations, as well as a job market, to facilitate networking between exhibitors, students and school pupils.

IMPACT – Design for a Cause will be part of the Electronica Experience, featuring engineering associations Hackster and Element14 among others, for a look into the future influences of electronics on communications, the environment, medicine and other areas. There will pitches, presentations and discussion panels.

### Opening Speech

This year's Electronica will be opened by Jeremy Rifkin, US social theorist, known not only for identifying current developments in the economy and society at an early stage, but also for his work on the global networking of industrial and social processes in the "*Supergrid*". His books "*The End of Work*", "*The Third* electronica 2018

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*Industrial Revolution*" and "*The Zero Marginal Cost Society*" will be foundation for Rifkin's keynote speech the evening of Monday, November 12, before opening the new Electronica Experience with another talk the following day.

## Energy Focus

This year the focus of Electronica is on smart energy systems, automotive electronics, artificial intelligence (AI), robots and digital security.

Energy systems in Europe are undergoing a historic transition, as the switch to sustainable generation is bringing increasing decentralisation with huge ramifications for the entire value chain. Smart energy is the umbrella term for a wide range of technologies in this area relating to energy storage, consumption control and conversion. Electronica's 2018 motto, say the organisers, is "Connecting everything – smart, safe & secure". In addition to showcasing products and services from a wide range of sectors, all with some connection to this broad topic, the Power Electronics Forum will focus on power electronics, smart grid and energy storage.

**Electronica's 2018 motto, say the organisers, is "Connecting everything – smart, safe & secure"**

## AI Range

In June 2018, Electronica commissioned a market research institute survey of 7,000 consumers, representing wide cross-sections of their relevant populations in the US, China, Japan, Germany, France, the UK and Italy. Over 80% of respondents said they would like easier lives through electronic devices and aids. However, many have very different views on what AI, robotics and digitalisation should and shouldn't do. For example, 71% of consumers think that, even in the future, electronic devices should only assist humans and that human thought processes should not be replaced with AI.

**Smart energy is the umbrella term for a wide range of technologies in this area relating to energy storage, consumption control and conversion**

## HIGHLY-ACCURATE PRECISION POWER ANALYSER

The new Yokogawa WT5000 is the first in a generation of precision power analysers offering measurement accuracy of ±0.03% at 50/60Hz. It also combines stability, noise immunity and plug-in modularity.

The instrument helps designers evaluate power consumption, loss and efficiency of electrical and electronic devices in a wide range of sectors, including electric vehicles, renewable energy and energy-efficient technologies. Being a platform, Yokogawa states that the instrument will stand the test of time through a selection of modules for measuring various parameters.

The WT5000 incorporates up to seven input channels, and can carry out two harmonic measurement functions simultaneously, each to the 500th order and up to 300kHz fundamental waveform. Using the WT5000 equipped with the /MTR1 and /MTR2 options, it is possible to evaluate up to four motors simultaneously with one unit.

**http://tmi.yokogawa.com/eu/**

## 10.1" PCAP TOUCH SCREEN SOLUTION FOR RASPBERRY PI

Inelco Hunter now offers pre-assembled display kit for use with the Raspberry Pi, turning it into a complete system with a 10.1" projective capacitive touch screen.

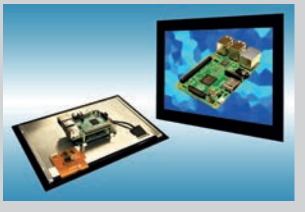
The Raspberry Pi is mounted onto the rear of the interface PCB using supplied pillars and screws. The display can be either panel- or flush-mounted and provides a resolution up to WXGA.

Its uses are limitless, encompassing a very wide range of applications, such as industrial or home automation, medical devices, IoT products, communication systems and so on.

Its features include a wide-view-angle IPS TFT display; multi-touch input PCAP touchscreen; pinch, zoom, rotate; and others.

Its specifications include screen dimensions of 255mm x 174mm x 9mm (including the touch panel), screen view area of 218mm x 137mm, brightness of 450cdm (typ.) and resolution of 1280 x 800 pixels among others.

**www.inelcohunter.co.uk**



## FULLY INTEGRATED, MONOLITHIC, POWER-MONITORING IC WITH REINFORCED ISOLATION

Allegro MicroSystems has released a fully integrated, small form-factor, power-monitoring IC with reinforced voltage isolation. Allegro's ACS724 and ACS711 current sensor ICs are commonly used in Internet-connected power outlets and IoT devices. The ACS71020 improves upon these ICs by including power-sensing functions and by eliminating power and isolation components that would otherwise increase the cost and size of systems.

The ACS71020 uses Allegro's innovative Hall-effect current sensor IC technology with line voltage sensing (to voltage levels > $500V_{RMS}$) and a dedicated metrology engine that calculates power levels. This enables the first power monitor IC that can be powered from the same voltage supply as the system microprocessor, without needing digital isolators or multiple power supplies.

The new IC simplifies common power measurements by offering digital computation of parameters including active, reactive and apparent power.

**www.allegromicro.com**


## TE CONNECTIVITY PROVIDES AERODYNAMIC ROOFLINE SYSTEM FOR NEW HIGH-SPEED TRAIN

TE Connectivity (TE) has developed an innovative electrical roofline solution to support the efficient design of the new Siemens Velaro Novo high-speed trains. The system is based on aerodynamic design, reducing drag and energy consumption on its high-speed train, and reducing noise during operation.

"It is a priority to create solutions that enable a more sustainable world. So, we are proud to have developed a low-profile, fully-insulated electrical roofline solution that is part of the sustainable innovation," said Thomas Brendel, TE Connectivity's senior global account manager.

"We helped reduce weight and energy consumption through compact, lightweight design and robust products designed for harsh environments that also lower maintenance costs," said Brendel. "The TE system allowed Siemens designers to move the high voltage system below the roofline, creating a much-improved aerodynamic profile for the train."

**www.te.com**

## Electromagnetic Pollution

The article '*Selecting the right mains filter for your application*' by Keith Armstrong (EW Sep. 2018) provides extremely useful guidance. It describes the construction of several types of filter, identifies their characteristics and indicates how the manufacturer's data can be used during the process of selection.

It includes a section on the design considerations involved in installing such filters in the equipment under review. This is especially useful in that it illustrates the fact that skin effect 'encourages' noise currents to remain outside the conducting enclosure and that internal interference is contained within the enclosure. Signals within the enclosure are 'clean' whilst those outside the box are 'dirty'.

In each of the five circuit diagrams, the bottom conductor is identified by the earth symbol. This conveys the impression that unwanted current flows through this conductor back to the source where it flows into the soil via grounding grids; rather like rainwater flowing through a pipe into a soakaway. Such a depiction ignores the basic lesson of Transmission Line Theory. At any instant, current is flowing in both directions along any conductor.

Capacitive coupling between the live, neutral and earth conductors of the supply cable ensures that current flows to and fro across the gaps between them. Inductive coupling ensures that electromagnetic energy flows along the path defined by the routing of the cable. When it arrives at the discontinuity presented by the mains supply distribution box, much of the transient energy is reflected back to the filter. This energy is reflected straight back to the distribution box, then it bounces back and forth between the two units.

This process does not last long, since the cable also acts as an antenna. Current which is not captured by the other two conductors escapes out into the environment. This can be defined as 'antenna-mode current' and can be measured with a current transformer clamped round the cable.

The process is not restricted to the cable between distribution box and filter. That energy which is not reflected at the distribution box continues outward into the power distribution wiring where the process continues. When a switch opens, the transient energy stored in the supply line disappears into the environment as a brief burst of radio-frequency radiation.

Mains filters may well protect the unit-under-review from interference, but they do this by dumping the unwanted electromagnetic energy into the environment.

The only way of minimising this form of pollution is to include resistors to absorb the unwanted energy. This could be a resistor in parallel with each selected inductor, or a resistance in series with each selected capacitor. The sections on Differential-Mode Damping and Common-Mode Damping in the article www.designemc.info/16DesignGuidelines.pdf describe the technique.

**Ian Darney,**
**The UK**