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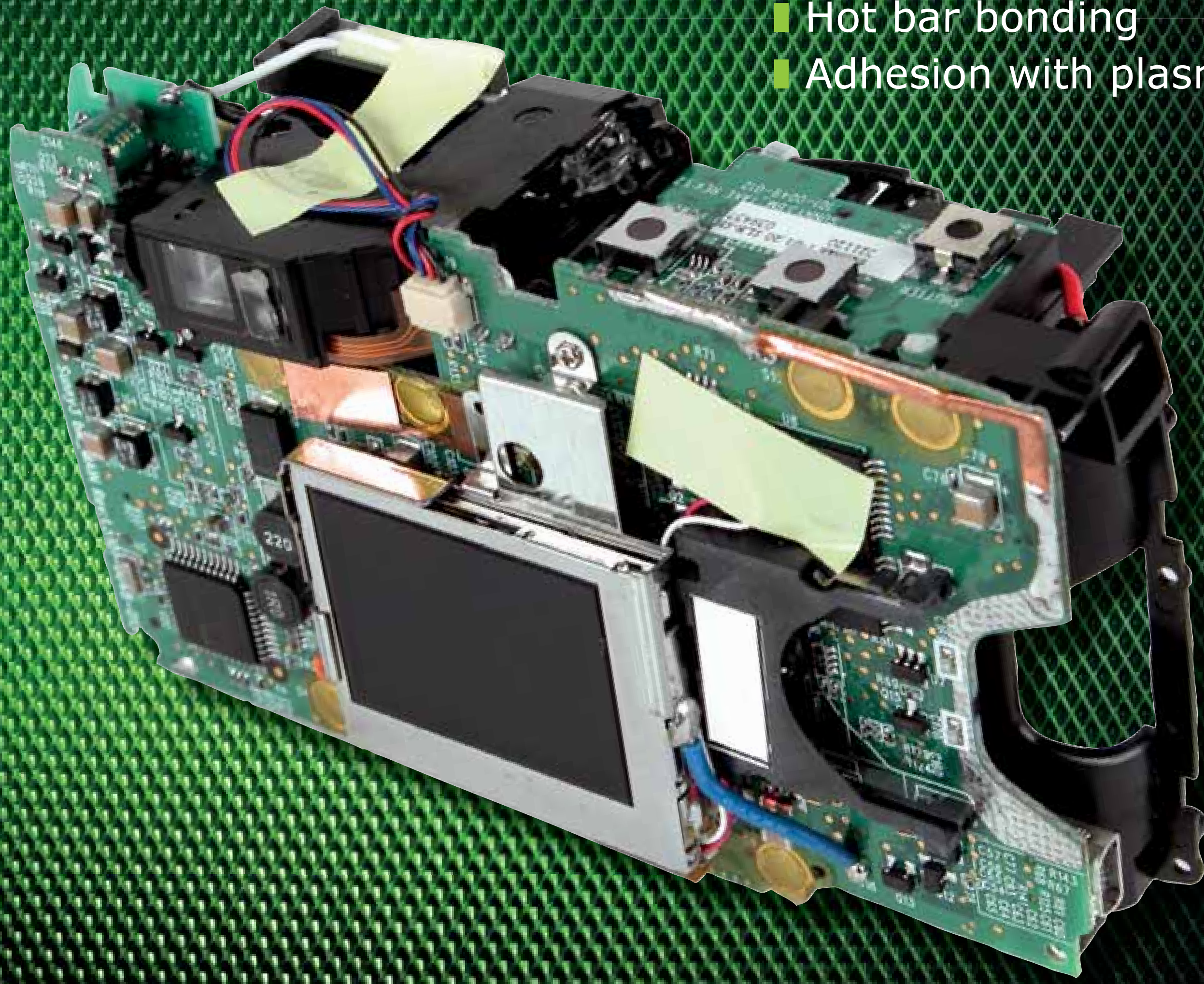

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INTERIOR LIGHTING WILL CREATE NEW DRIVING EXPERIENCES

When it comes to automotive lighting, first thing we think of are headlights and turn indicators, i.e. we focus on the exterior. However, many important lights are to be found inside the vehicle. A car's interior lighting can influence driver concentration, reduce fatigue and create positive emotions, such as a feeling of luxury or sportiness. This was confirmed by a survey published some years ago by BMW and the Technical University of Ilmenau, and is even more applicable today when users want unique experiences and customisation.

The difference between LEDs for automotive interior and exterior lighting is that inside the car they need to be especially compact without losing performance, whereas externally the focus is on a larger spread of light. Many lighting manufacturers have responded to market demands with comprehensive LED ranges, offering 20 times smaller and over three times brighter devices than a generation ago.

Interior Lighting Trends

In LED interior lighting, the trend is miniaturisation. The smaller the individual component, the greater the versatility for integration into new products.

Manufacturers are also seeing more demands from end users for new personal driving experiences. Ambient lighting lets drivers select personalised colours for their interior lighting. This ability to customise the lighting adds an emotional component to the rather more functional use of traditional interior lighting. A touch of personality enabled by lighting within the vehicle transforms the car from an object that serves a purpose to a feel-good zone.

New Application Areas

In addition to decorative aspects, there are new areas of application for ambient lighting at the functional level. For example, cars could use different-colour lighting to inform drivers which mode they are driving in – sports or economy. Or, dynamic lighting sequences could be used in semi-autonomous vehicles to tell the driver to take control of the steering wheel, or to relay other information.

In keeping with the idea of dynamic lighting in autonomous vehicles, interior lights will significantly shift their role in functionality. Depending on whether the passenger wants to work or relax, for example, the lighting scenarios can be very different, with either directional spotlights over a workstation or indirect lighting in the roof liner.

A touch of personality enabled by lighting within the vehicle transforms the car from an object that serves a purpose to a feel-good zone

As this technology becomes more commonplace, and with the emergence of autonomous cars, new applications will also appear in the visualisation sector. Ford and other companies have already predicted that heads-up and thin-film transistor displays will soon not only show navigation and vehicle information but also be used for communication and entertainment.

Future Trends

In the future, the focus on interior lighting will be more on the interplay between light and the vehicle for conveying information. This information will relate to everything from driving mode and battery-charge level, to the time of day and the weather – and much more. ●

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NEW EUROPEAN PROJECT SET UP TO IMPROVE ELECTRIC VEHICLE DRIVETRAINS

A new European Horizon 2020 project will develop innovative electric drivetrains for third-generation electric vehicles. The project, called ModulED and coordinated by technology research institute Leti, will bring together ten European organisations, universities and automotive-industry value-chain companies. The aim is to improve drivetrain performance to meet new environmental and efficiency requirements and make electric vehicles cheaper.

The team will use technologies from diverse industries, such as integrating the frequency, voltage and high-temperature benefits of wide-bandgap semiconductors fabricated with gallium nitride, which will allow electronic circuitry that changes direct current into alternating current (DC-AC) be integrated directly into the motor. Then, they'll make the motor architecture modular for easier production, and create transmission and cooling systems compatible with hybrid vehicles. In addition, they'll optimise braking systems to recover energy in the braking phase.

"Electric vehicles are a key component of the EU's commitment to limit climate change, but current electric vehicles face challenges preventing large market acceptance, including consumer resistance due to cost and limited driving ranges," said Bernard Strée, project coordinator at Leti. "ModulED will target these challenges via the manufacturing process, including the mass-production context, increased value-chain involvement and lifecycle analysis for optimised duration and minimised environmental impact."

The three-year €7.2m project involves BRUSA Elektronik AG (Switzerland), Punch Powertrain NV (Belgium), ZG GmbH (Germany), Siemens (France), Efficient Innovation (France); RTWH Aachen University, Chalmers University and Eindhoven University of Technology, and Leti's sister institute, Liten.

The ModulED project brings together ten European research institutes, universities and automotive-industry value-chain companies

A TECHNOLOGY TEAM BRINGS MRAM TO THE NEXT LEVEL

Spin Transfer Technologies (STT) and Tokyo Electron Ltd will jointly develop the next generation ST-MRAM (spin-torque magneto-resistive random-access memory).

ST-MRAM is a persistent memory of the SRAM- and DRAM class but with higher performance, promising previously unachievable levels of speed, density and endurance.

In MRAM, a magnetic field is applied to electrons to manipulate their spin, thus control the resistance of the bit (1 or 0). In ST-MRAM, a spin-polarised current is applied instead, which drives the bit up or down. Depending on the direction of this current, the spin of the electrons can be changed from one direction to the other, thus changing the magnetic polarity and hence the resistance of the bit.

SRAM is used in nearly all mobile, computing and industrial applications. It is fast, with high endurance, but also costly, power-hungry and volatile. ST-MRAM is more compact and cheaper, requires little power and is non-volatile, retaining data for a very long time without power. DRAM, on the other hand, is the most widely used memory type in electronics, present in almost all devices. It is slower but much less expensive than SRAM, and otherwise shares SRAM characteristics of long life, power inefficiency and lack of persistence.

ST-MRAM is meant to supersede both; however, conventional ST-MRAM does not match the benefits of SRAM – it lacks speed and wears out in seconds or minutes of operation rather than operating reliably for over 10 years of continuous use. So, to fully match or exceed SRAM performance, further improvements to ST-MRAM are needed.

For that, STT will contribute its high-speed, high-endurance perpendicular magnetic tunnel junction (pMTJ) design and device fabrication technology, along with TEL's ST-MRAM deposition tools and knowledge of unique formation capabilities of magnetic films. The team plans to offer solutions for both the embedded SRAM and (eventually) standalone DRAM markets.

"Industries have outgrown the capabilities of SRAM and DRAM, leaving the market open for the next generation of technology," said Tom Sparkman, CEO of STT. "We believe the adoption of ST-MRAM will materially exceed current expectations."

The proper use of a digitizer's front-end signal conditioning

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

Modular digitizers and similar measuring instruments need to match many signal characteristics to the fixed input range of their internal analogue-to-digital converters (ADC). Digitizer front-ends must also minimise the loading of the device being tested and provide appropriate coupling; filtering may also be needed to reduce the impact of broadband noise.

Figure 1 shows a block diagram of a modular digitizer. Each input channel has its own front end (in green) that can be set up independently of the others. The front end provides appropriate input coupling and termination, along with range selection and bandwidth-limit filtering.

Front-End Features

Maximizing the versatility of a modular digitizer requires that the front-end circuits have the following:

1. A selection of input terminations to offer matching impedances or minimised loading with high impedance input.
2. Choice of either AC or DC coupling, as needed.
3. Filtering to minimise noise and reduce any harmonic component, if present.
4. Multiple input ranges, allowing the capture of various input signal levels while minimising noise and distortion to maintain signal integrity.
5. Internal calibration to maximise accuracy.

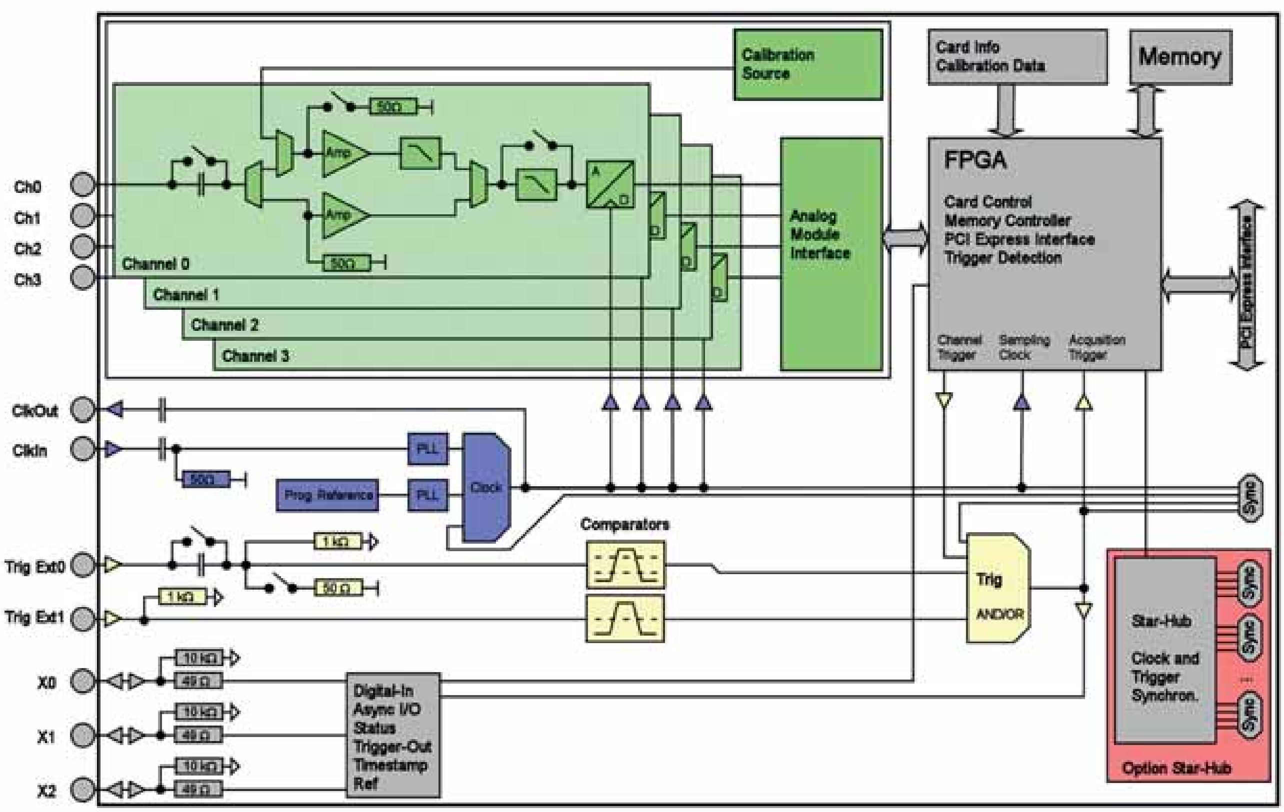


Figure 1: Modular digitizer

Input Termination

A measuring instrument should terminate the source properly. For most radio frequency (RF) measurements, this means a 50Ω termination – a matching termination minimises signal losses due to reflections. Figures of importance for 50Ω matching are return loss or voltage standing wave ratio (VSWR); both indicate the quality of the impedance match.

If the source device has a high output impedance, then it is better matched with a 1MΩ termination that minimises circuit loading and which allows the use of high-impedance oscilloscope probes that further increase load impedance.

Impedance matching to other standard terminations, like 600Ω for audio, can be accomplished by using a 1MΩ termination combined with an external 600Ω termination.

Since there is an engineering trade-off in designing with selectable input impedance between convenience and signal integrity, some modular digitizer suppliers only offer 50Ω termination. If high impedance termination is needed or indeed both high impedance and 50Ω, check that the manufacturer offers them.

Input Coupling

Input coupling in a measurement instrument allows to AC- or DC-couple the measuring instrument to the source. DC coupling shows the entire signal, including any DC offset (non-zero-mean signals); AC coupling eliminates any steady-state mean value (DC).

AC coupling is useful for ripple measurements on the output of a DC power supply, for example. Without it the DC output would require a large signal attenuation, making the ripple harder to measure accurately. With AC coupling, a higher input sensitivity can be used, resulting in better ripple measurement.

The key specification for AC coupling is its low frequency cutoff (lower -3dB point) of the AC-coupled frequency response, which determines how much a low frequency signal will be attenuated by the coupling. It is also related to recovery time, the time it takes for the input level to settle after the DC level is first applied to the instrument. Generally, the lower the cutoff frequency, the larger the coupling capacitor and the longer the settling time.

Some modular digitizers offer only AC or DC coupling, not both. This is an engineering trade-off to reduce complexity, because a digitizer with fixed coupling doesn't have to deal with components like relays or switches. The application will determine if a fixed or selectable coupling is needed, but selectable coupling offers greater flexibility.

Input Voltage Ranges

The digitizer's ADC generally has a fixed input range. The simplest interface is a single input with a fixed input range matching the ADC's. Although simple, this is not very practical in a measuring instrument, unless the single range is exactly the one needed. To bring the input signal swing into the ADC range requires either an attenuator or an amplifier.

An attenuator is a simple voltage divider, generally resistive, which reduces the amplitude of the input signal. When designed with quality components, it does not degrade signal integrity significantly. One issue that appears when attenuators are in the signal path is that the instrument's internal noise amplitude scales (relative to the input of the attenuator) with the front-end attenuation. So, for a digitizer with a 58µV_{rms} noise level, with an added 10:1 attenuator the noise level (referenced to the input) is 580µV, still the same relative percentage of the attenuated full-scale range.

Amplifiers are another story. Even when properly designed, they tend to introduce noise into the signal path. This is somewhat compensated for by the fact that the digitizer's internal noise decreases by the gain of the amplifier when referenced to the input. Amplifiers can also introduce distortion, further degrading signal integrity.

Another limitation of amplifiers is their fixed gain-bandwidth product. If you attempt to increase their gain, then the bandwidth must fall proportionally. This can be seen on high-sensitivity ranges where the bandwidth is reduced.

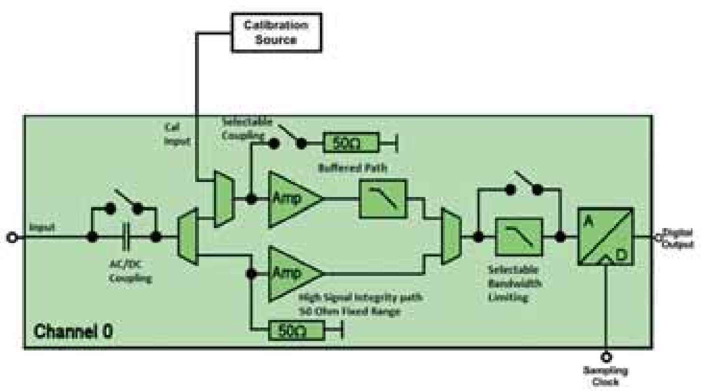


Figure 2: Block diagram of a digitizer showing all the elements of a full-featured front-end, including dual input paths, coupling, termination impedance, filtering and internal calibration

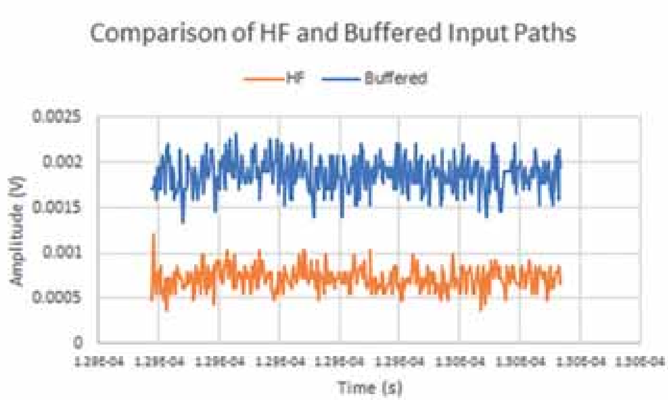


Figure 3: Differences in the response of HF and buffered paths. There's a higher peak-to-peak noise level in the buffered path despite its bandwidth being half that of the HF path

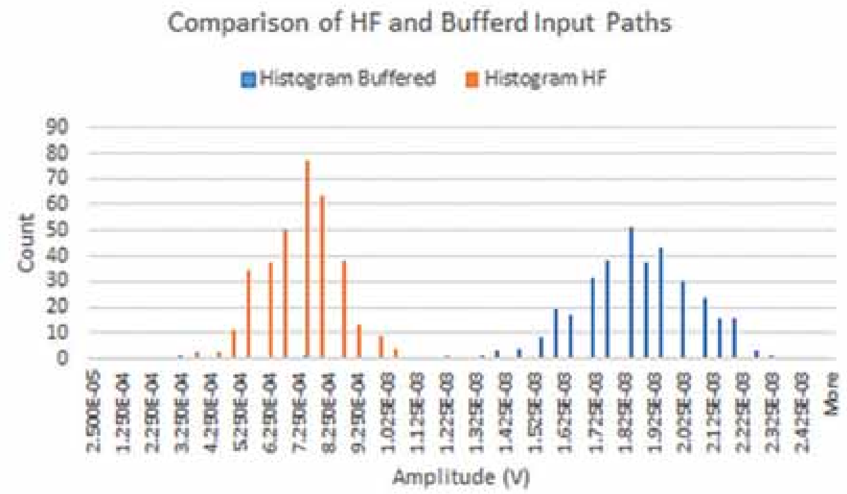


Figure 4: Histogram of data values for HF and buffered signal paths, showing the narrower distribution of the HF path indicating a lower noise level

Signal Path Differences

Figure 3 shows a comparison of the response of the HF and buffered paths to a 256-step ramp on the digitizer's 500mV range. In this figure we are looking at a single step in each path (note that adjacent steps have been selected for each path, so they don't overlap).

You'll note that the peak-to-peak noise in the buffered path is higher than in the HF path. The HF path design has been optimised to minimise noise and, despite having twice the bandwidth of the buffered path, it still shows less noise. The price paid for this performance is a reduced number of available input ranges and the need for 50Ω termination. It's also worth noting that if you select a modular digitizer that only offers equivalent of a buffered path, you are 'stuck' with the higher noise level.

Figure 4 shows histograms of these waveforms; the spread about the mean for the HF path is smaller than that for the buffered path, meaning there's less variation or noise in the HF path.

The measure of this phenomenon is the standard deviation. In this example, the standard deviation of the HF path is 0.125mV, while that of the buffered path is 0.183mV. This quantises the differences in noise level between the two signal paths for the same input signal. It should be noted that both responses also contain noise components from the signal source as well as from the digitizer.

The advantage of the higher signal integrity of the HF can also be seen in the frequency spectrum of the sine wave acquired by the digitizer using both input signal paths; see Figure 5. The figure shows the Fast Fourier Transform (FFT) of the acquired signals through each input path. Cursors mark the spectrum peak and that of the highest spurious. The HF path has a spurious free dynamic range of 80.9dB compared with 60.7dB for the buffered path. Note also that the noise baseline is lower in the HF signal path.

Improving Signal Integrity

No matter which signal path you choose, there are some general rules to help get the best signal integrity. The first is to use as much of the input range as possible. If the signal has a stable amplitude, then select an input range that uses at least 90% of that range. Do not overdrive the ADC. If you exceed the full-scale range, the result will be distortion or clipping that will produce unwanted harmonics and decrease signal integrity.

If available in your digitizer, use the bandwidth-limiting filters, which can help reduce noise.

Built-in Calibration

Because a modular digitizer is incorporated into the PC environment where there may be variations such as PC power supply voltages and temperature, a software driver should be included that provides routines for an automatic on-board offset and gain (buffered signal path only) calibration of all input ranges of the buffered signal path. Each digitizer card should contain a high-precision built-in calibration reference to help keep the digitizer calibrated, despite any changes in the environment or ageing. Good practice is to ensure that you perform a calibration once the digitizer is operational and has had sufficient time to reach a stable operating temperature, typically 10-15 minutes.

Best Front-End for Best Results

The front end of the modular digitizer needs to provide all the features necessary to ensure accurate, repeatable measurements. Multiple input ranges, AC/DC coupling, filtering and built-in calibration all help ensure maximum signal integrity and accuracy. A well-designed front end will allow the user to condition the input signal appropriately, ensuring it covers as much of the ADC range as possible without overdriving it. Only then can the digitizer achieve the best measurement accuracy and precision. ●

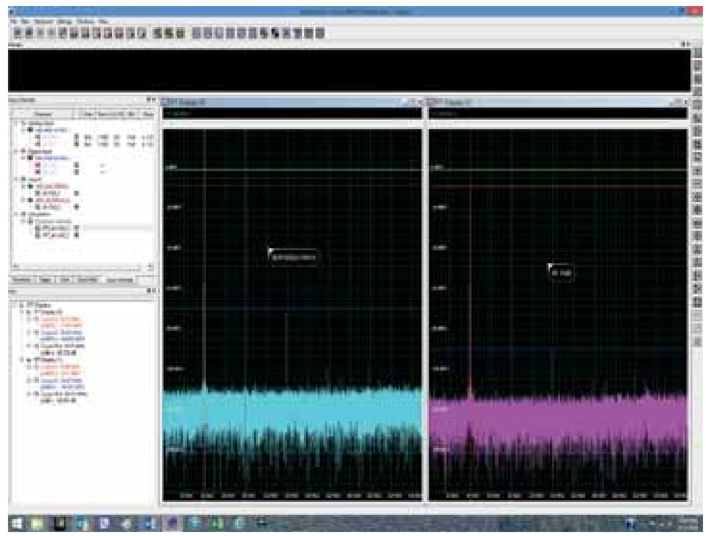
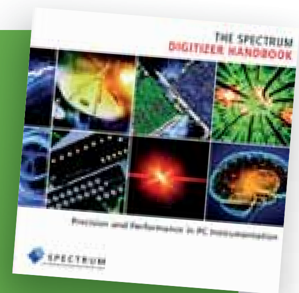


Figure 5: Frequency spectrum of buffered (left side) and HF (right side) paths



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.

Conflicting regulations and no-clean fluxes challenge PCB makers

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

Despite the advent of "no-clean" soldering, experts judge that over 50% of all companies are still cleaning their PCBs. Pre-cleaning solves numerous assembly problems and makes a stronger, more durable circuit. But, with components getting smaller, temperatures hotter and tolerances tighter, new environmental restrictions and workplace safety rules are changing the acceptable cleaning answers. So, if cleaning is more critical than ever, how can companies future-proof their assembly processes?

No-Clean Fluxes

Most PCBs are assembled today with no-clean solder pastes. Although no-clean flux formulations are intended to remain on the board with minimal residues, those residues can still attract moisture, inhibiting conformal coating bonding or making them aesthetically unacceptable. Plus, there are more residues on modern boards than just fluxes – adhesives, fingerprints, particulate, marking inks, epoxies and other materials also must be removed for the circuit to operate successfully.

Another industry-wide trend during the past decade has been the growing demand for mobile devices. Powerful but portable electronic designs force circuit-board manufacturers to pack more components into tighter spaces, which in turn creates a greater likelihood of insufficient, weak solder joints, bridging, dendrite growth and other soldering faults.

Denser spacing also makes traditional cleaning a more challenging task.

All these parameters put pressure on PCB manufacturers to find an affordable, effective and flexible cleaning protocol, a process that works today and in future designs.

Finding the Right Cleaning Process

Here's a rule many engineers overlook: when selecting a cleaning process, start with the contamination. A savvy engineer understands contamination and matches the cleaning process to it, not the other way around.

The flurry of new flux chemistries makes finding the right cleaning process complex, almost like shooting a moving target, in addition to the usual worries of throughput, floor space and the financial implications. Conflicting regulations today also push companies in different directions: employee safety, waste disposal, global warming, volatile organics, halogens, recycling, and more. All these constraints limit the cleaning choices, often forcing engineers to "stick with the devil they know" – even though the hardware, chemistry and the results themselves may be fraught with difficulties.

> **If cleaning is more critical than ever, how can companies future-proof their assembly processes?**

Here's the "new" news: modern solvent-cleaning is the most effective, affordable and green cleaning choice today. There is a wide variety of high-quality, brand-name solvent and equipment vendors to choose from, so no engineer needs to settle for an inflexible, monolithic, cleaning process.

Modern Formulations

Solvent-based cleaning is a simple thermodynamic process, requiring minimal oversight and management. The high density, low viscosity and low surface-tension of solvents allow them to clean effectively even under the tight standoffs


Circuit boards

that aqueous systems cannot penetrate. The readily-adjustable cleaning strength of solvents also enables engineers to tailor their cleaning process as fluxes and pastes, not to mention other contaminants evolve. Lastly, everybody knows solvents are also easier to use for touch-up cleaning on the benchtop rather than slow-drying hydrocarbons, alcohols or aqueous solutions. With the unstoppable trend of PCB miniaturisation crashing into the deployment of no-clean and lead- and halide-free soldering formulations, water-based products just don't cut it.

Highly-advanced cleaning chemistry manufacturers now have products that are completely ozone-safe and meet certain requirements, like the EU's rules of Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), for example. They are also approved under the US Significant New Alternatives Program (SNAP), are US Toxic Substance Control Act (TSCA) registered, and some of the newest choices have virtually no global warming impact. These innovative new solvents are not only gentle on the planet but also deliver consistent and reliable cleaning with lowest overall costs.

Modern flux and paste formulations have an important role in today's electronics assembly. In turn, modern, nonflammable, environmentally-progressive solvent cleaning can make a substantial and relatively inexpensive enhancement to the performance, reliability and longevity of electronic devices. Formulations are now cleaner, greener and safer to avoid the expense and global warming impacts of aqueous cleaning technologies, as well as the environmental challenges of the old-style chlorinated solvents. ●


Lead-free fluxes

Spinning the wheels of a little 'Tesla'

BY **LUCIO DI JASIO**, MICROCHIP TECHNOLOGY

After Microchip's acquisition of Atmel in 2016, I have frequently had the opportunity to visit Norway to keep in touch with my new team-mates. Trondheim – the birthplace of the AVR – is a beautiful city, on the south shore of a large fiord. Despite its northerly position, the climate there is quite pleasant – if you avoid September to April.

Because of the mountainous terrain surrounding the city, Trondheim is rather isolated from a ground transportation perspective. A drive to Oslo is not impossible, but considering the weather and the distances involved, traveling by air is advisable for most of the year. Hence, you'd not expect the place to be a major automotive hub, and indeed you won't see that many cars around – unless they are electric, the percentage of which is extremely high. This is due to very high taxes on all combustion-engine vehicles by a very progressive government that, despite the country's massive oil production (mostly for export), ruled strongly in favour of environmental protection and the health of its citizens, instead of protecting the automotive industry lobbies.

My E-vehicle Prototype

I had become rather envious of my Norwegian colleagues, who commute to work in their futuristic Teslas. This is especially true when experiencing the 'ludicrous mode' acceleration and watching them experiment with self-driving, albeit not fully autonomous yet.

The complexity and enormous progress made in this field in the last few years is impressive, and I wanted to experiment with it myself. So, during the recent Christmas holidays, I took out my own electric vehicle prototype – the Mikroe Buggy Kit; see Figure 1.

This is an ingenious kit that requires only a soldering iron and less than 10 minutes to assemble, and yet it has the potential to be an extremely open and powerful development platform. The chassis is made of several PCBs, cleverly interlocked, offering mechanical and electrical expansion. There are three mikroBUS connectors to fit the almost infinite choice of sensors and actuators offered by the Click modules – 436 of them, last time I checked. Two will fit in the front of the little vehicle, and one in the back.

Figure 1: Mikroe Buggy

Giving Buggy a Brain

There is also a 52-pin connector on the baseboard, which allows us to give the little vehicle a "brain"; otherwise it's a lifeless set of motors and lights. This connector is common to all Mikromedia and Clicker 2 boards, giving access to a very large selection of microcontrollers and architectures.

While all are acceptable options, the Mikromedia's QVGA displays are a bit of a waste, laid flat on the bottom of the little rover. The Clicker 2 boards seem to make much more sense, as they use the available PCB area to add two more Click connectors, bringing the total to five.

More important, perhaps, is the latest batch of PIC18FK Clicker 2 boards that feature the PIC18 'K40 microcontrollers and where the common serial-to-USB interface was replaced with an XPRESS interface. The XPRESS interface provides the serial-to-USB capabilities of a classic (FTDI) USB bridge, but adds mass storage (MSD) support through drag-and-drop drop programming of the target (PIC) processor.

As soon as one of these new Clicker 2 for the PIC18FK boards are connected to a PC (Mac or Linux box), they are seen by the host operating system as a (virtual) hard drive. Writing a compatible hex file to this drive will result in immediate programming of the

PIC18 with the contained executable – no bootloader or hardware programming tools required.

Clicker 2 boards are also pre-loaded with a MikroElektronika (serial) bootloader, which remains available until overwritten Adding a Clicker 2 for PIC18FK board to a buggy makes the kit simultaneously compatible with MPLAB X IDE, Mikroe MikroC compiler and IDE, and even with the MPLAB Xpress Cloud IDE.

Thanks to MPLAB Xpress it is possible to programme and test the first example in a couple of minutes, without installing a single kbyte of code on a PC and at no additional expense. So, I mounted a brand-new Clicker 2 on the buggy, saw no smoke, and carried on!

More specifically, the buggy comes with a Li-Ion battery that fits nicely under the baseboard, and which is charged directly from the USB port. Mine came fully charged, so I was pleased to see that the charge (red) LED was not lit and, when I removed the cable, the power (green) LED stayed on.

A new drive called “XPRESS” was listed on my system, with an apparent capacity of 2Mbytes. In it was a “README.html” file that redirected my browser to the MPLAB Xpress web page.

Next, I fired up my favourite terminal program (CoolTerm) and checked the available virtual serial ports. Sure enough, there was a new one (I am a Mac user, so it showed up with a complex path/name, but PC users should find a familiar COMx new identifier) and a connection was immediately established, although nothing intelligible was coming from it. I guess the Mikroe serial bootloader didn’t appreciate my random typing.

As a side note, Windows users will need to install a special driver to enable the virtual serial port feature (it’s a Windows thing),

Figure 2: Clicker2 for PIC18FK

Pin Module

Easy Setup | Registers | Notifications : 5

Selected Package : QFN64

Pin Name ▲	Module	Function	Custom Name	Start High	Analog	Output
RA1	TMR2	T2IN		☐	☐	☐
RB7	Pin Module	GPIO	BRAKES	☐	✓	✓
RC0	EUSART4	TX4		✓		✓
RC1	EUSART4	RX4		☐		☐
RC2	Pin Module	GPIO	LEFT_B	☐		✓
RC3	MSSP1	SCL1	SCL1	☐		☐
RC4	MSSP1	SDA1	SDA1	☐		☐
RC6	Pin Module	GPIO	LEFT_F	☐		✓
RC7	Pin Module	GPIO	RIGHT_B	☐		✓
RD3	Pin Module	GPIO	BEAMS	☐	✓	✓
RD5	MSSP2	SDI2	SDI2	☐	☐	☐
RD5	MSSP2	SDO2	SDI2	☐	☐	☐
RD6	MSSP2	SCK2	SCK2	☐	☐	✓
RF0	Pin Module	GPIO	TURN_L	☐	✓	✓
RF2	Pin Module	GPIO	BTN1	☐	☐	☐
RF3	Pin Module	GPIO	BTN2	☐	☐	☐
RG6	Pin Module	GPIO	RIGHT_F	☐	✓	✓
RH0	Pin Module	GPIO	TURN_R	☐		✓
RH1	Pin Module	GPIO	HEAD	☐		✓

Table 1: MCC pin module, pinout configuration

downloadable from the very same MPLAB XPRESS page. Most likely, if you have previously used other Microchip tools/demos, that driver has already been installed in your system.

Reassured by all the positive checks, I fired up MPLAB X IDE and wrote some code. How hard was it going to be to blink a couple lights, right?

Turning the Blinkers On

It has become a habit for me to fire up MPLAB Code Configurator (MCC) for every new project – I no longer have the patience to re-write the same (but slightly different) basic drivers for each new device. The on-board PIC18F67K40 was also relatively new to me, and MCC provides a lot of comfort in these situations. I set the device clock speed to maximum (64MHz) and let the tool automatically configure the rest of it.

While waiting for artificial intelligence (AI) to truly start powering these rapid development tools, we still need to use our brains to fill in the application details. In this case, if I wanted to turn on the buggy blinkers – yellow LEDs on each corner of the vehicle, or turn indicators – I had to “connect a few dots”.

While both buggy and Clicker 2 come with a very nicely-illustrated user manual, there is a (naming) translation required each time a signal crosses the 52-pin connector between the two. For example, pin number 9 on the right side of the connector is suggestively referred to as TURN-L in the buggy manual but shows as RF0 in the manual of the Clicker 2 for PIC18FK.

The translation map is obviously different for every buggy combination, with any Clicker 2 board featuring different processors with different pinouts, so it must be done carefully by hand once the two boards have been mated. Between the wheel motors, headlights, beams, blinkers, break lights and the five mikroBUS connectors, there is enough to get the head spinning.

Fortunately, the PIC18'K40 family has plenty of peripherals, connected via the Peripheral Pin Select (PPS) multiplexers. On small-pincount devices this is equivalent to a full matrix, where each pin can be connected to a peripheral. But on a large device (64-pin), such as the model featured on the Clicker 2 board, every peripheral input/output can be assigned to at least 16 different alternatives. This is not a full matrix, but it's a huge simplification with great flexibility. Thanks to MCC, turning the map into actual initialisation code for the peripherals, PPS and I/Os of the device is a matter of a few mouse clicks; see Table 1.

With the project skeleton generated, it was easy to add just a few (less than ten) lines of code to turn all four blinkers on; see Listing 1.

```
/**
 Project:
 Buggy Blinkers

 File Name:
 main.c

 Summary:
 Get all four blinkers ON!

 Generation Information :
 Device : PIC18F67K40
 The generated drivers are tested against the following:
 Compiler : XC8 1.35
 MPLAB : MPLAB X 3.40
*/

#include "mcc_generated_files/mcc.h"

void main(void)
{
 SYSTEM_Initialize();

 puts("Hello Buggy!");

 while (1)
 {
 TURN_L_Toggle();
 TURN_R_Toggle();
 __delay_ms(500);
 }
```

Listing 1: Blinkers on

Spinning the Wheels

The whole point of building the buggy for me was to have something autonomous to drive around, so the next step was to spin its wheels. It has four-wheel drive, and each wheel has a little DC motor driving it. The documentation refers to four PWMs, so I assumed each wheel was independently controlled, which is not the case. The motors are controlled in pairs (left and right side), to steer the buggy, an act that involves quite a bit of dragging, like a tank on tracks. It is the difference in speed between the pairs that makes the rover change direction. There is a single DC motor driver (DRV8833) per side (pair of wheels), with two inputs, marked A (or C) and B (or D), respectively.

IN A/C	IN B/D	Function
0	0	Free spinning
0	PWM	Reverse
PWM	0	Forward
1	1	Brake, hold

Table 2: Motor driver functions

Table 2 shows the association between the logic state of those inputs and the actual function performed by the controller.

Thanks to the ability provided by the PPS to steer peripheral signals to different pins, only two PWM modules are needed to control direction and speed of both motor pairs of the buggy. Changing the PPS assignments dynamically is not difficult, but the logic can get messy, quickly. So, I created a small group of support functions that I placed in a file called buggy.c to encapsulate some of the motor control logic; see Listing 2.

```
/*
 ** Buggy.c
 */
#include "buggy.h"

#define SPEED_CTR_C 0x0A // PWM6 DC controls speed
for port C
#define SPEED_CTR_G 0x08 // CCP4 DC controls speed
for port G

void LEFT_forward(void){
 RC6PPS = SPEED_CTR_C; // RC6 is LEFT A
 RC2 = 0; // RC2 is LEFT B
 RC2PPS = 0;
}

void LEFT_backward(void){
 RC2PPS = SPEED_CTR_C; // RC2 is LEFT B
 RC6 = 0; // RC6 is LEFT A
 RC6PPS = 0;
}
...
```

```
void goForward( uint8_t time)
{
 RIGHT_forward();
 LEFT_forward();
 while( time--){
 __delay_ms(100);
 }
 RIGHT_free();
 LEFT_free();
}

void turnRight( uint8_t time)
{
 LEFT_forward();
 RIGHT_brake();
 while( time--){
 __delay_ms(100);
 }
 LEFT_free();
 RIGHT_free();
}

void spinRight( uint8_t time)
{
 LEFT_free();
 RIGHT_free();
 __delay_ms(100);

 RC7 = 1; // RIGHT backward max
 RC6 = 1; // LEFT forward max
 while( time--){
 __delay_ms(100);
 }
 LEFT_free();
 RIGHT_free();
}
```

Listing 2: Buggy.c motor control logic

Inside it, I defined the first building blocks, short wheel pair control functions such as: LEFT_forward(), LEFT_backward(), etc. Then, I combined those into vehicle control functions such as: goForward(), turnRight() and spinRight().

Listing 2 shows the very rudimentary code (with blocking loops that would not be acceptable in a more complex application), but it did prove that I could get the wheels spinning and gave me a first sense of what this kit can do.

On the (Long) Way to Autonomous Driving

I quickly discovered that the buggy moves fast! This is a good thing, but it immediately brings up the issue of speed control. Experimenting with different PWM duty cycle values gave me a sense of the problems ahead. Buggy steering is heavily affected by the surface under its wheels, impacting the turn speed/radius. There is also a fair amount of friction in the wheels' reduction gears. This again brought up the issue of speed control, even when moving straight, since the friction changes (as I should have expected) depending on whether the vehicle starts from a standstill or is already in motion.

In the End (for Now)

In a few more hours of fiddling with the very first crude code, and later adding an accelerometer, a distance detector (Ping) and a wireless link, I was humbled by the complexity of the problems at hand and realised that this little kit has the potential to keep me entertained for a very long time.

The problems I encountered are the same for any autonomous-driving vehicle software: position/orientation detection and speed control before obstacle avoidance and, ultimately, path.

Let us know of your experiences with similar educational kits. ●

Figure 1: The three Nucleo development boards

Embedded design with the Nucleo development boards

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

The Nucleo family of low-cost development boards are small but powerful, based on the 32-bit STM32 ARM Cortex architecture and manufactured by STMicroelectronics (ST). They are compatible with popular hardware (such as Arduino, ST-LINK and ST Morpho) and software, including the easy-to-use Mbed, making them accessible to users from wide technical backgrounds. Currently there are over 30 different Nucleo boards compatible with each other, catering for the needs of almost all users.

Figure 1 shows the Nucleo development boards in three sizes: small (Nucleo-32), short (Nucleo-64) and long (Nucleo-144), where the numbers refer to the on-board MCU pin-count.

The Nucleo-32 is compatible with Arduino Nano, whereas Nucleo-64 and Nucleo-144 with Arduino Uno; they also have ST Morpho extension connectors that carry the MCU pins. These three groups are further divided into three sub-groups: ultra-low power (green), mainstream (blue) and high performance (magenta).

The ultra-low-power green boards, such as Nucleo-L011K4, Nucleo-L031K6 and Nucleo-L432KC, are based on the STM32 L family, for low-power applications, such as watches, smart meters, etc. There are three sub-categories in this family:

- L0, ARM Cortex-M0+
- L1, ARM Cortex-M3
- L4, ARM Cortex-M4

About half of the STM32 blue Nucleo boards are in the mainstream category, including Nucleo-F303K8, Nucleo-F042K6 and Nucleo-F303RE, with three further sub-categories:

- F0, ARM Cortex-M0+
- F1, ARM Cortex-M3
- F3, ARM Cortex-M4

The high-performance magenta boards have large memories and faster MCUs. This group includes Nucleo-F410RB, Nucleo-F401RE and Nucleo-F722ZE. There are also three sub-categories in this category:

- F2, ARM Cortex-M3
- F4, ARM Cortex-M4
- F7, ARM Cortex-M7

There are many Arduino Nano/Uno-compatible shields on the market, which can easily be used with the Nucleo boards, offering hundreds of readily-available, cheap and tested sensors and drivers.

Figure 2: Application setup

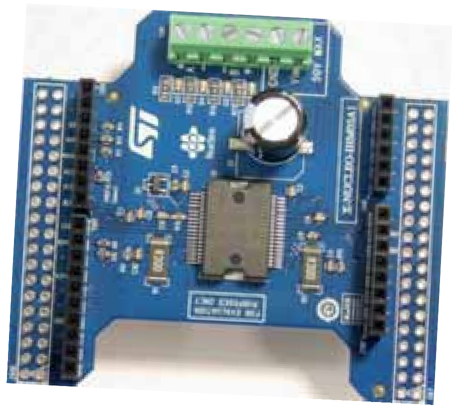


Figure 3: Bipolar stepper motor expansion board

Example Nucleo-64 Development Boards

The Nucleo-L476RG (Figure 2) is an ultra-low-power, low-cost board, incorporating the STM32L476RGT6 microcontroller. Its basic features include ARM Cortex-M4 MCU with FPU, 1MB flash and 128kB SRAM memory, 16 timers, three 12-bit ADCs, two 12-bit DACs, communication interfaces (USARTs, I2Cs and SPIs) and so on. It also supports a broad range of integrated development environments (IDEs), including IAR, Keil, ARM Mbed and GCC-based.

The ARM Cortex Family

Currently, ARM is the most popular processor, with the ARM 32-bit architecture most widely used in mobile devices. The ARM architecture offers the best MIPS-to-watts and MIPS-to-cost ratio in the industry and the smallest CPU size. The small size, low power consumption and low cost make ARM the ideal processor for embedded applications. ARM processors are based on the Thumb instruction set.

Over the last 20 years or so, ARM had developed many 32-bit processors. Around 2003, ARM decided to improve its market share by developing a new series of high-performance processors, resulting in the Cortex family, with its three processor series: Cortex-M, Cortex-R and Cortex-A.

Figure 4: Digital output expansion board

Cortex-M

Cortex-M series processors are built around the ARMv6-M (Cortex-M0 and Cortex-M0+) and ARMv7-M architectures (Cortex-M3 and Cortex-M4). They offer quick and deterministic interrupt responses, high performance, ease of use, low power consumption, and are low cost.

The Cortex-M3 and Cortex-M4 are very similar in architecture and have the same instruction set (Thumb 2), with additional digital signal processing functionality and an optional floating-point unit in the Cortex-M4, making them perfect for IoT and wearable applications.

Cortex-M0 and Cortex-M0+ are more suitable for cost-sensitive and lower-performance applications. Cortex-M7 is a high-performance processor that can handle fast digital signal processing and single- or double-precision floating-point operations.

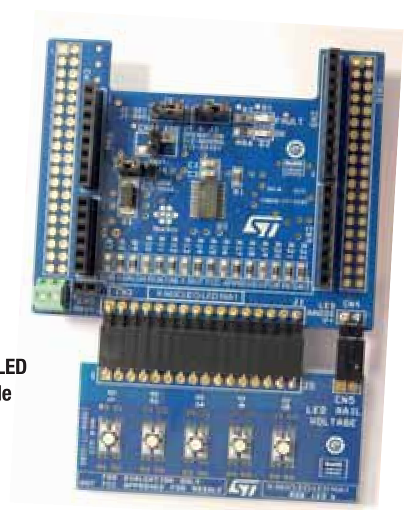


Figure 5: 16-channel LED driver module

Cortex-R

The Cortex-R series consists of processors higher in performance than those of the Cortex-M series, with Cortex-R7 operating at clock rates exceeding 1GHz. They are commonly used in hard-disk controllers, network devices, automotive applications and specialised high-speed microcontroller applications.

Cortex-R4 and Cortex-R5 are early members of the series and can be used at clock speeds of up to 600MHz.

Cortex-A

The Cortex-A processors are the highest performers in the ARM stable, designed for real-time operating systems in mobile applications such as mobile phones, tablets, GPS devices and so on. They support advanced features for Android, iOS, Linux, Windows, etc., and have advanced memory management underpinned by virtual memory. Early members of the family include the Cortex-A5 to Cortex-A17, based on the ARMv7-A architecture. Latest members are the

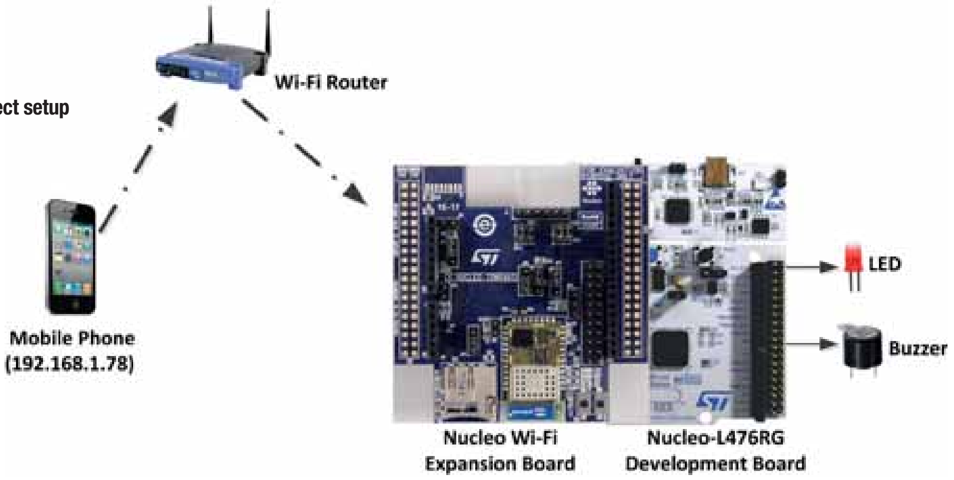


Figure 6: Project setup

Cortex-A50 and Cortex-A72 series, designed for low power and very high performance.

A comparison of the various Cortex-M series processors is shown in Table 1.

PROCESSOR	DESCRIPTION
Cortex-M7	High performance processor, used in applications where Cortex-M4 is not fast enough
Cortex-M4	Similar architecture to the Cortex-M3 but includes DSP and floating-point arithmetic
Cortex-M3	Very popular, low power consumption, medium performance, debug features, used in microcontroller applications
Cortex-M1	Designed mainly for programmable gate array pplications
Cortex-M0+	Lower power consumption and higher performance than the Cortex-M0
Cortex-M0	Low power consumption, low to medium performance, smallest ARM processor

Table 1: Cortex-M processor comparison

Nucleo Expansion Boards

Many expansion boards are compatible with the Nucleo development boards. They plug on top of the Nucleo boards to provide sensor, driver, actuator and other functionalities. Here are some examples:

Bipolar Stepper Motor Expansion Board

The bipolar stepper motor driver expansion board (Figure 3) is compatible with the Arduino UNO R3 connector. The operating voltage is 8-50V with 2.8A phase current. Dual independent PWM controllers are provided with overcurrent and thermal protection.

Digital Output Expansion Board

This expansion board (Figure 4) provides digital output channels with galvanic isolated power solid-state relays. The operating voltage is 10.5-30V with up to 700mA output current per channel.

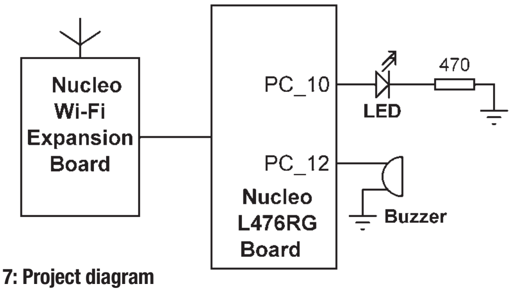


Figure 7: Project diagram

16-Channel LED Driver Expansion Board

This is a 16-channel LED driver expansion board (Figure 5) with constant-current output channels, each rated 3-40mA. Thermal shutdown and open/short LED detection are also provided. The brightness of each channel can be controlled separately.

Example Project Using the Nucleo-64 Board

This project uses the ARM Cortex-M4 based Nucleo-L476RG development board with a Wi-Fi expansion module. An LED and a buzzer are connected to the system. The boards are controlled from a mobile phone by sending TCP data packets; see Figures 6 and 7. For this project we used Mbed software, an online platform and operating system for developing applications based on the 32-bit ARM Cortex-M microcontrollers. A free online IDE is provided with online text editor and compiler, accessible through a web browser. Developed programs are compiled online and then uploaded to the target ARM microcontroller.

In addition to Mbed, complex ARM programs for the Nucleo family can be developed, compiled and debugged using one of the following IDEs (code size limited versions and/or the full IDE of these tools are available on the Internet, free of charge):

- Embedded Workbench for ARM (EWARM) by IAR Systems
- MDK-ARM by Keil
- TrueSTUDIO by Atollic
- System Workbench for STM32 (SW4STM32) by AC6

The Mbed program of this project is shown in Listing 1. It connects to the local Wi-Fi access point and then creates a TCP/IP link over port 5000, waiting to receive data packets from the mobile phone. ●

>

```
/*************************************************************
                    TCP/IP COMMUNICATION
                    ====================

In this program the Wi-Fi expansion board is plugged on top of the
Nucleo-476RG board. The program creates a TCP/IP connection over
the network and reads commands in the form of data packets.

*************************************************************/
#include "mbed.h"
#include "SpwfInterface.h"
#include "TCPSocket.h"
DigitalOut led(PC_10);              // LED
DigitalOut buzzer(PC_12);                                   // Buzzer

#define UARTTX D8                   // PA_9
#define UARTRX D2                   // PA_10
#define NODEBUG false
SpwfSAInterface spwf(UARTTX, UARTRX, NODEBUG); // Wi-Fi interface
#define IP "192.168.1.78"           // Mobile IP address

int main()
{
 TCPSocket socket(&spwf);
 int count;
 char buffer[80];
 char * ssid = "BTHomeSpot-XNH";          // AP name
 char * pwd = "49345abarb";               // AP password
 led = 0;                       // LED OFF
 buzzer = 0;                                                // Buzzer OFF

 spwf.connect(ssid, pwd, NSAPI_SECURITY_WPA2); // Connect to Wi-FI
 socket.connect(IP,5000);                 // Create a TCP socket

 while(1)                           // DO forever
 {
 count = socket.recv(buffer, sizeof buffer);  // Receive a command
 if(count > 0)                      // Command received?
 {
 if(buffer[1] == '1')                             // IF ON command
 {
         if(buffer[0] == 'L')                       // L command?
                 led = 1;                           // LED ON
         else
                 buzzer = 1;                        // Buzzer ON
 }
 else
 {
         if(buffer[0] == 'L')                       // L command?
                 led = 0;                           // LED OFF
         else
                 buzzer = 0;                        // Buzzer OFF
 }
```

Listing 1: Mbed program listing

Addressing the electronics waste crisis

By Stephen Harding, Managing Director, Gough Engineering

An equivalent of 4,500 Eiffel Towers of electronics waste (e-waste) was generated across the world in 2016. E-waste is growing, especially with falling costs and decreased lifespan of electronic equipment, and, sadly, the methods to deal with this waste in an environmentally-friendly and cost-effective ways are not widely used.

While currently there's a lot of discussion about how to solve the plastics waste crisis, the e-waste crisis is just as large and important, yet mostly ignored. In Britain, we each throw away on average some 20-25kg of e-waste every year.

E-waste is considered anything attached to a plug, whether a phone, laptop, fridge, electronic toothbrush or radio or television set. Across businesses and households, these items are simply thrown away with the usual waste, or left piling up in a cupboard somewhere.

With an enormous amount of waste building up, and more than £40bn of recoverable materials binned or mothballed every year, we are not only adding to landfill but also wasting precious metals.

Dangers of e-Waste

When items are thrown into landfill or incinerated, dangerous metals and carcinogens are released into the air, soil and water. A typical 15-inch computer monitor may contain 1.5lb of lead, but also dioxins, polychlorinated biphenyls (PCBs), cadmium, chromium, radioactive isotopes and mercury, among many other toxic materials.

Jakob Rhyner, vice-rector of the United Nations University (UNU), says that "most e-waste is not properly documented and not treated through appropriate recycling chains and methods".

A recent investigation found that most e-waste is exported to countries with lower environmental standards, filling up their landfills and putting people's lives at risk. In one part of China, the pollution of groundwater from e-waste landfill was so bad at one point that drinking water had to be brought in from elsewhere.

It's not just consumers who are increasingly disposing of e-waste. The growing use of sensors and connected devices in industrial environments means more electronic items to dispose of. Businesses undergoing digitalisation therefore need a strategic plan for this waste, to ensure that it won't just pile up in a corner, damage the environment or waste precious materials.

From every standpoint this problem is likely to get worse in the future, unless e-waste recycling is taken seriously and dealt with responsibly.

Recycling e-Waste

Between 2009 and 2012, the European Union (EU) had a project called *"Recovery of Electronic Waste through Advanced Recycling and Demonstration (REWARD)"*, aimed at improving e-waste recycling rates and recovering reusable materials.

The project was meant to have a prototype facility for recycling electrical and electronic equipment products, to demonstrate responsible reuse, recycling and recovery (RRR), boosting these by 95% through size reduction, smart sensor sorting, advanced density separation and improved recovery techniques.

Similar projects continue to this day, with the EU placing an emphasis on innovative technologies to reuse waste. EU Commission environmental spokesperson Enrico Brivio says: "The more valuable our waste becomes due to pressures on our resources, the more we will need the technologies and innovation to pump it back into the economy, instead of burying or burning it."

Precious Metals

In a typical electronics application, hundreds of materials are of little reusable value, but many components contain high-value materials, such as gold, silver and platinum.

In mobile phone handsets, for example, gold concentrations can be 300-350 grams per tonne, whereas for computer circuit boards it is 200-250 grams per tonne. Some items can be even richer in gold than its concentration in primary ores, hence it makes sense to save as much of the product as possible, carefully to separate waste from useful material.

Well-designed and appropriate materials-handling in a recycling plant is a most important way to ensure that e-waste is effectively used. The plant manager must ensure that right screening and sorting equipment is used for the material on the production line. It is not possible to use a one-size-fits-all approach to all e-waste, as devices have different metals and components. The way for them to be reused will also differ; materials such as gold need to be in solid format, others should be extracted as a powder.

Recycling Steps

When recycling a fridge, for example, one stage of the recycling process involves shredding the unit to separate insulation foam, electronic matter, metals, plastics and gases. These materials are then further separated and handled differently to ensure their safe management and, where applicable, reuse.

Insultation foam, for example, is ground into a powder to release the gases contained within. Before the grinding process, it is essential to ensure that no valuable electronics or metals are mixed in with the foam. Recycling-plant managers must use effective screening and separating systems that can sort the shreds of polyurethane from steel fragments or gold-containing circuitry.

Once the valuable materials are removed and the foam ground, the polyurethane powder is then further screened. It can then be mixed with adhesives to be reused for moulding into products.

The recovery of waste powder can be as high as 90%.

When the polyurethane powder is screened, the powder can easily accumulate and block the mesh, a phenomenon known as "screen blinding". This can be prevented by using screens that include an ultrasonic resonator and vibratory motors, guaranteeing a consistent rate of throughput and reducing the chance of downtime from a blocked mesh.

The more valuable our waste becomes due to pressures on our resources, the more we will need the technologies and innovation to pump it back into the economy, instead of burying or burning it

The average weight of polyurethane foam from one refrigerator is 6.36kg with around 93,200 tonnes of polyurethane foam wasted every year. Polyurethane foam plastics do not degrade easily, building up quickly over time. This means that sorting and recycling the product is the best way to sustainably deal with this waste.

Unified Effort

While companies and consumers disposing of electronic waste have a responsibility to ensure that the process is done in an environmentally-friendly, ethical and responsible way, for plant managers in recycling plants there is not only a financial incentive, but also an environmental benefit in ensuring that the waste is adequately serviced. This can be helped by consulting a materials-handling expert. ●

Tiny MEMS in the big wide world of applications

By Mark Patrick, Mouser Electronics

Micro-electro-mechanical systems (MEMS) are at the heart of many modern devices. Portable and wearable electronics, TVs, medical devices such as pacemakers, cars and even movie theatres all use MEMS, and the applications continue to increase. Compared to their macro-sized counterparts, MEMS-based sensors and actuators are not only much cheaper, but are more integrated, more reliable and easier to make in large numbers. MEMS versions of RF filters, variable capacitors and oscillators have supplanted their more cumbersome and less reliable larger counterparts.

Tiny but Mighty

MEMS are characterised predominantly by their microscopic proportions, which are at the micron level. As opposed to semiconductor devices at this scale, MEMS have an additional mechanical aspect to their construction, to sense certain conditions or actuate a process within its environment.

The idea to miniaturise electro-mechanical systems has been with us since the 1960s at least, pioneered by visionaries like Richard Feynman. It is only in the last thirty years, however, that manufacturing processes and microelectronics technology have made MEMS production at the commercial scale possible.

One of the first volume applications for MEMS technology was in automotive airbag systems. In the early 1990s, MEMS-based accelerometer chips were developed by Analog Devices as impact sensors, and their low price, reliability and size saw them become standard in the automotive industry.

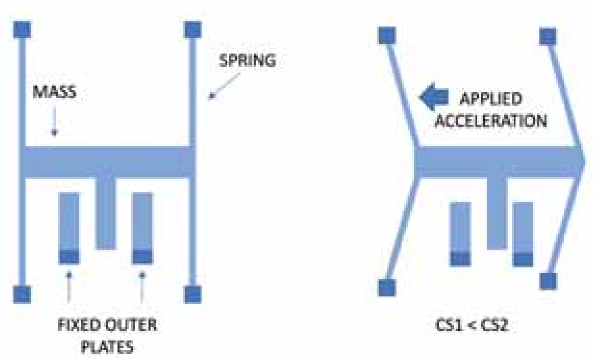


Figure 1: Schematic of a MEMS linear accelerometer design, where capacitance is measured between the moving mass and the fixed outer plates

Since then, MEMS development has exploded, leading to high-resolution inkjet printers and digital projectors, game consoles and smartphones. MEMS adoption in smartphones has pushed this technology into yet a higher gear, and it is now widely used in wearable consumer electronic devices.

Smartphones ushered in a new era of mobile computing that demands an increasing breadth of features in ever-shrinking form-factors, all without price rises – challenges readily met by MEMS. MEMS allow traditional devices such as microphones and speakers to become smaller, using less power. For other applications, like optical image stabilisation, motion detection or the digital compass it is the only way that functionality can fit into a space-constrained smartphone handset.

Accelerometers and gyroscopes allow the phone to detect motion, automatically rotating screens or views, depending on the phone's orientation; optical image stabilisers with integrated gyroscopes help take stunning imagery; and two capacitance-type MEMS microphones can fit into a tight space, enabling sophisticated noise-cancellation.

The Scope of MEMS

Made using microfabrication techniques borrowed from the semiconductor industry, such as photolithography and etching, MEMS technology covers a wide variety of devices. Nowadays, almost every mechanical sensor or transducer has a MEMS equivalent. A full MEMS chip includes a micro-mechanical element along with a signal-conditioner, all on a single piece of silicon.

Accelerometers are a most common and important class of MEMS device today; see Figure 1. The simplest design consists of a spring-mounted mass with fixed outer plates. When moved, changing capacitance between the moving mass and the fixed outer plates measures acceleration along the axis of movement. This can be expanded to two or three dimensions by clever stacking and mounting of multiple accelerometers, or by suspending a 3D moving mass inside a structure with fixed outer plates in the required positions.

When combined with MEMS-based gyroscopes, accelerometers can form advanced motion sensing devices like the 3D accelerometer and gyroscope available from companies such as STMicroelectronics, which detects both motion and rotation along all three axes.

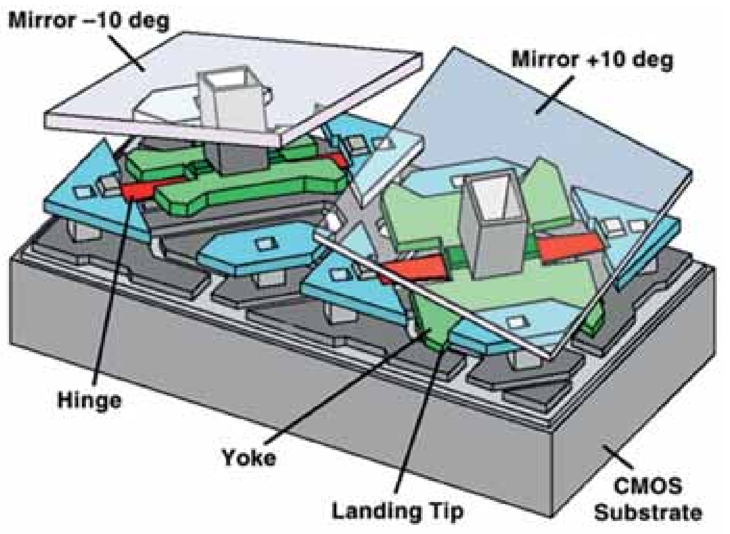


Figure 2: DMD arrays consist of millions of tiny micro-mirrors which act together to build an image

Optical MEMS

Digital Micromirror Devices (DMD) were originally pioneered by Texas Instruments and are another widely used type of MEMS devices, focused on optics. DMD chips (Figure 2) consist of an array of millions of tiny, microscopic mirrors, each mounted on a yoke and with adjustable angle (usually to ±10 degrees), depending on the electrical state of the CMOS substrate.

In the on state, the mirror reflects light toward the target, illuminating the pixel; in the off state, the light is directed elsewhere. To produce grayscale, pulse-width modulation (PWM) is used to quickly toggle the mirror on and off, the ratio of time-on to time-off producing various intensities of light being projected. To create colour, the light source can either alternate between red, green and blue, or three DMD arrays can be used, one for each colour.

DMDs are used for a wide range of applications including consumer and professional projectors, TVs, head-up displays, and so on.

Pressure Sensors And Medical MEMS

MEMS pressure sensors are relatively simple devices: a movable diaphragm with an attached electrode moves in response to pressure. Change in capacitance is measured in relation to a fixed electrode, which determines the pressure exerted on it; see the Omron MEMS pressure sensor shown in Figure 3.

Although the basic concept is simple, MEMS pressure sensors are incredibly versatile and come in a variety of form-factors and designs to accommodate different applications, from microscopic barometric sensors to measuring automotive tire pressures, and medical applications such as catheter pressure sensing.

Undoubtedly, however, the most exciting and novel applications of MEMS technology today lie in the medical industry. From improving macro-sized hospital equipment and portable medical instrumentation, to enabling medical wearables and point-of-care devices, the potential of MEMS technology to improve medicine is only just starting to become clear.

The medical MEMS field is simply booming with development projects, such as glucose-monitoring contact lenses from Google, transdermal skin patch sensors for detecting electrolyte balance, electronic drug delivery pills, implantable electronics and ingestible sensors.

While this field promises a lot, it is not easy to introduce completely new and untested technologies into the medical marketplace. Advanced biomedical devices not only require interdisciplinary development efforts by both technologists and medical professionals, but extensive testing and certification before a medical MEMS is approved for widespread use.

Even using the MEMS technology available today, astonishing medical outcomes can be achieved. Many of the sensors and actuators perfected in the consumer sector also have novel medical applications; pressure sensors, for example, can measure the pressure of expelled air to diagnose respiratory conditions. Tiny sensors in catheter or endoscopic tubes monitor cardiac and oesophageal conditions or even safeguard neonatal health.

The medical MEMS field is booming with development projects, such as glucose-monitoring contact lenses from Google, transdermal skin patch sensors for detecting electrolyte balance, electronic drug delivery pills, implantable electronics and ingestible sensors

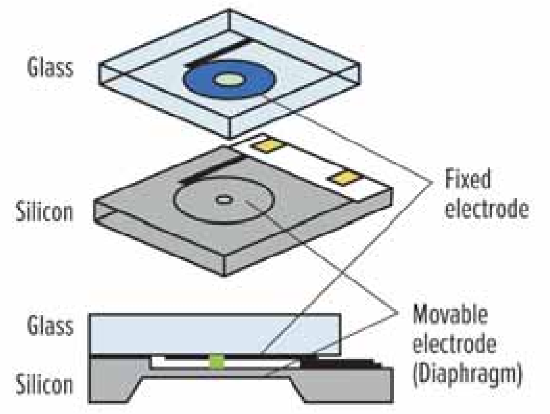


Figure 3: Example of a MEMS pressure sensor where an electrode on the movable diaphragm enables change in capacitance to be measured

Just the Beginning

Accelerometers are another MEMS device that crossed over from consumer electronics into medical devices. Besides fitness tracking, accelerometers can be used for patient-down monitors (now becoming popular with the elderly) and CPR-assist devices. Combined with a gyroscope to detect orientation, they can help with endoscopic and catheter navigation as well as provide advanced positioning detection; for instance, to gain information on the posture and position of a patient to deliver the right electrical impulse in a cardiac pacemaker.

This is just the beginning of the use of MEMS in medicine. In the future, they will be widely used to improve the quality of patients' lives and enhance the effectiveness of the diagnostic process and drug administration. ●

The role of static analysis in secure software development

By Bill Graham, GrammaTech

When should static analysis be applied? The answer is easy – whenever code is being developed. However, this is a simplification; the longer answer is: it should be part of a structured and secure development process.

Static analysis is an important part of a modern software development tool suite, which when applied correctly and early can have a significant impact on code quality, security and safety. In today's connected and complex operating environment, static analysis plays a critical role.

Security First

Security-first design integrates security as a top priority in the software development lifecycle (SDLC). To implement it, developers and project managers can expect at least the following steps while progressing through the cycle (Figure 1):

1. Requirement definition: At the requirement stage, security-specific requirements can be introduced, along with known "abuse cases" (cases an attacker might follow) and risk analysis.

2. Design and architecture: As candidate architectures become available, reviews must include security aspects not necessarily included before. At this stage, testing plans should be created with security analyses on perceived abuse cases.

3. Code development: At the coding stage, following security guidelines and coding standards is critical. The use of automation tools such as static analysis is key to ensure that no vulnerabilities are introduced into the product.

4. Integration and test: As the overall system starts to take form, subsystem and system testing will find any vulnerabilities before integration and market introduction.

5. Deployment and maintenance: When a product enters the market and is widely adopted, security vulnerabilities become exponentially costlier to fix. As a product goes through maintenance and revision, security is an ongoing concern, and new vulnerabilities and threats need to be fed back into the system iteratively.

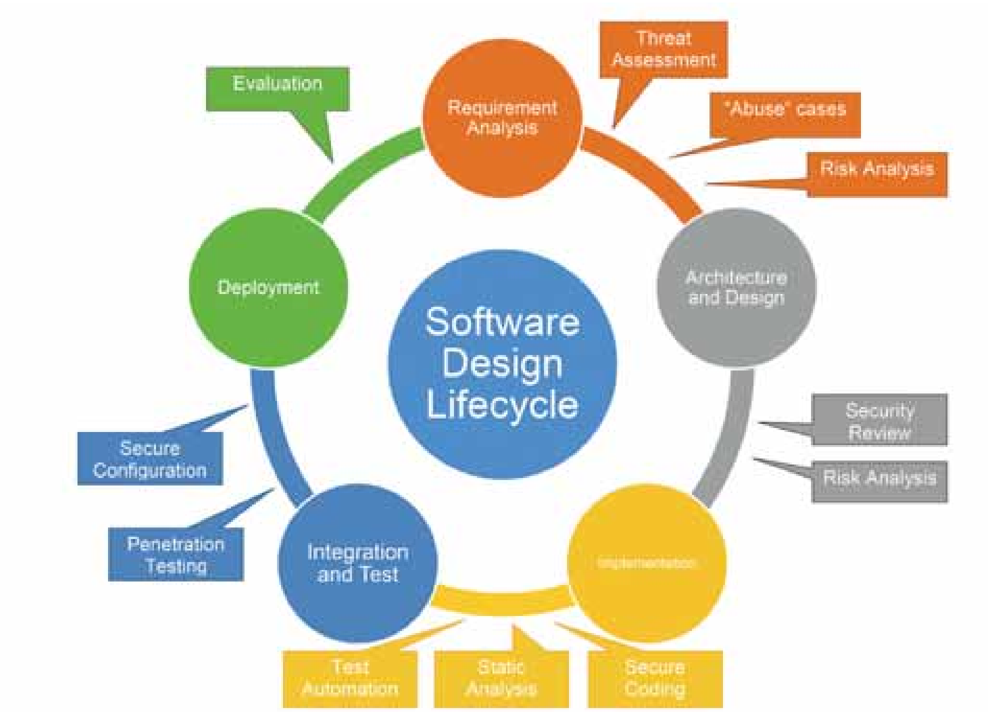


Figure 1: Security processes superimposed over the software development lifecycle

Improving Security

Static analysis tools like GrammaTech's CodeSonar provide critical support in the coding and integration phases of development. Ensuring continuous code quality in both the development and maintenance phases greatly reduces the costs and risks of security and reliability issues in software, providing benefits such as:

- Continuous source-code quality and security assurance;
- Tainted-data detection and analysis;
- Third-party code assessment;
- Secure coding standard enforcement.

SDLC Dynamic and Static Analysis

- **Dynamic Application Security Testing (DAST):** All dynamic testing tools require program execution to generate useful results. Examples include unit testing tools, test coverage, memory analysers and penetration test tools.

  Test automation tools are important for reducing the testing load on the development team and, more importantly, detecting vulnerabilities that manual testing might miss.
- **Static Application Security Testing (SAST):** Static analysis tools work by analysing source code, bytecode (e.g., compiled Java) and binary executable code. No code is executed in static analysis, but rather the analysis is done by reasoning about the potential behaviour of the code.

  Static analysis is relatively efficient at analysing a codebase compared to dynamic analysis, and both types of tools can and should be used even beyond product development and into maintenance.

Static analysis is an important part of a modern software development tool suite, which when applied correctly and early can have a significant impact on code quality, security and safety

Static analysis tools also analyse code paths that are untested by other methods and can trace execution and data paths through the code. Static analysis can be incorporated early during the development phase for analysing existing, legacy and third-party source and binaries before these codes are incorporated into the product. As new source is added, incremental analysis can be used in conjunction with configuration management to ensure quality and security throughout. Figure 2 shows the type of testing tools applied at different stages of the SDLC. Analysis tools like CodeSonar provide critical support in the coding and integration phases of development.

Although adopting any class of tools helps productivity, security and quality, using a combination of these is recommended, since no single class of tools is the 'silver bullet'. The best approach automates the use of a combination of tools from all categories and involves a risk-based rationale for achieving high security within budget. ●

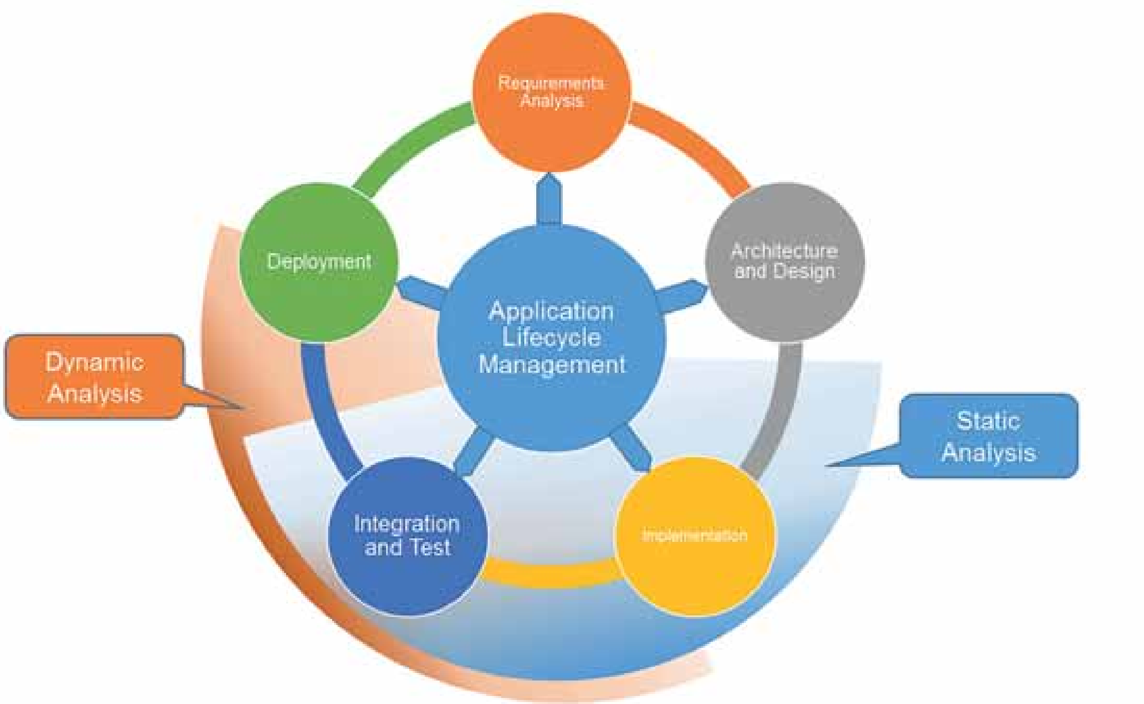


Figure 2: The application of various tool classes in the context of the software development lifecycle

Modern integrated consumer electronics systems

By Stojce Dimov Ilcev, Durban University of Technology (DUT), South Africa

Modern consumer electronic systems, such as smart TVs, IPTVs, computers, smartphones and other home equipment have become a large part of our lives, and now most of them are heading toward complete connectivity. Yet at the same time energy efficiency is becoming increasingly important.

A higher level of comfort and security as well as lower energy consumption can be achieved by using intelligent control and monitoring systems for all consumer electronic devices. This may mean more wiring to connect sensors and controllers, especially when part of wireless networks such as Bluetooth, ZigBee, Wi-Fi, WLAN and others.

All such systems, however, require greater planning and installation work.

Smart Home Systems

The smart home, or home automation (Figure 1), has become more elaborate but also more affordable in recent years, thanks to using existing, known platforms, which helps lower the cost to the consumer.

Home automation is a growing sector and a popular trend for homeowners who want the latest technology. It is also a great tool for making homes environmentally friendly.

Home automation systems can control many systems, including entertainment equipment, washing machines and dishwashers, light levels and ambients, and handle foodstuff checklists and house security, among others. These systems can easily be connected for remote monitoring or operation, via PCs, laptops or smartphones.

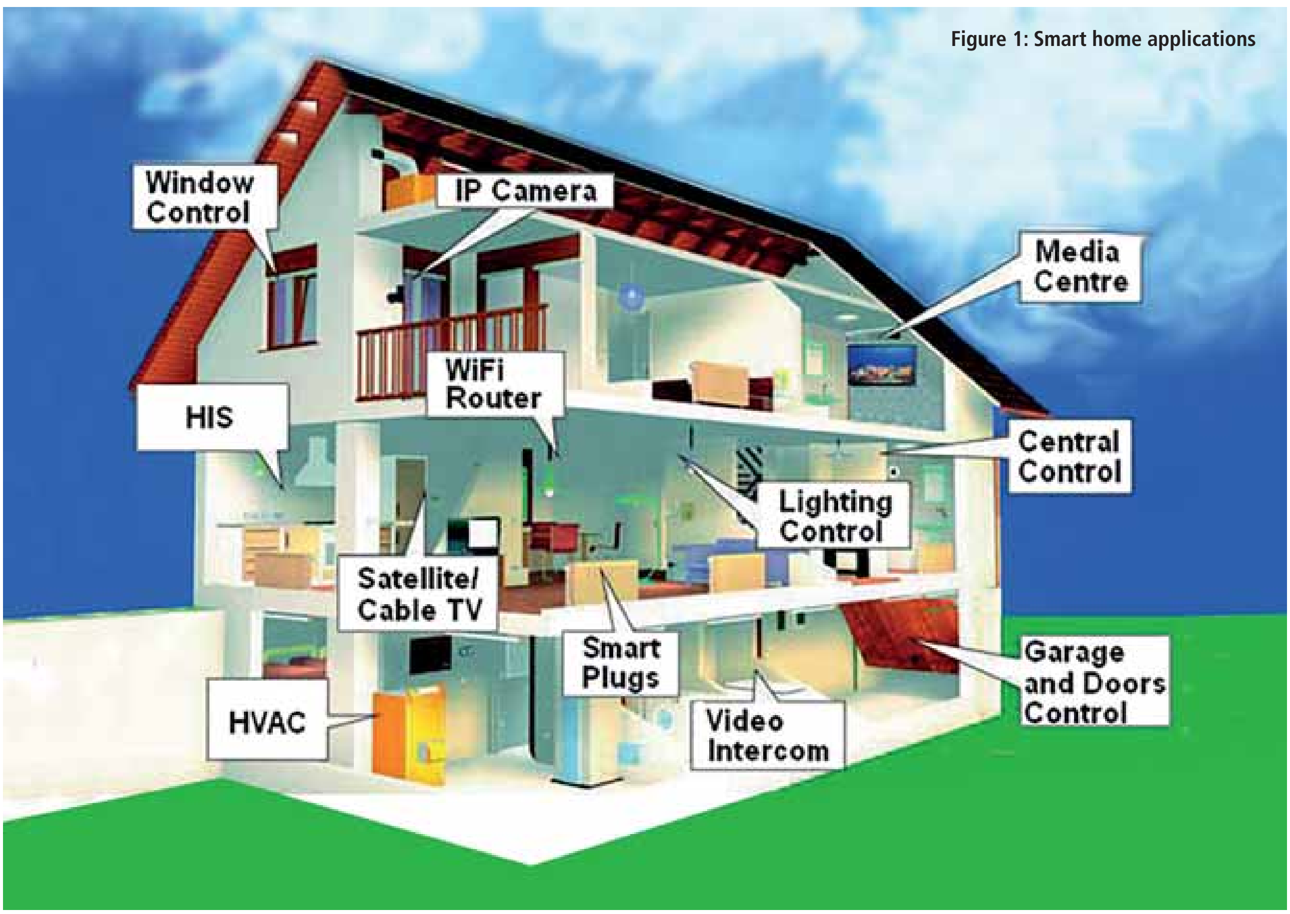
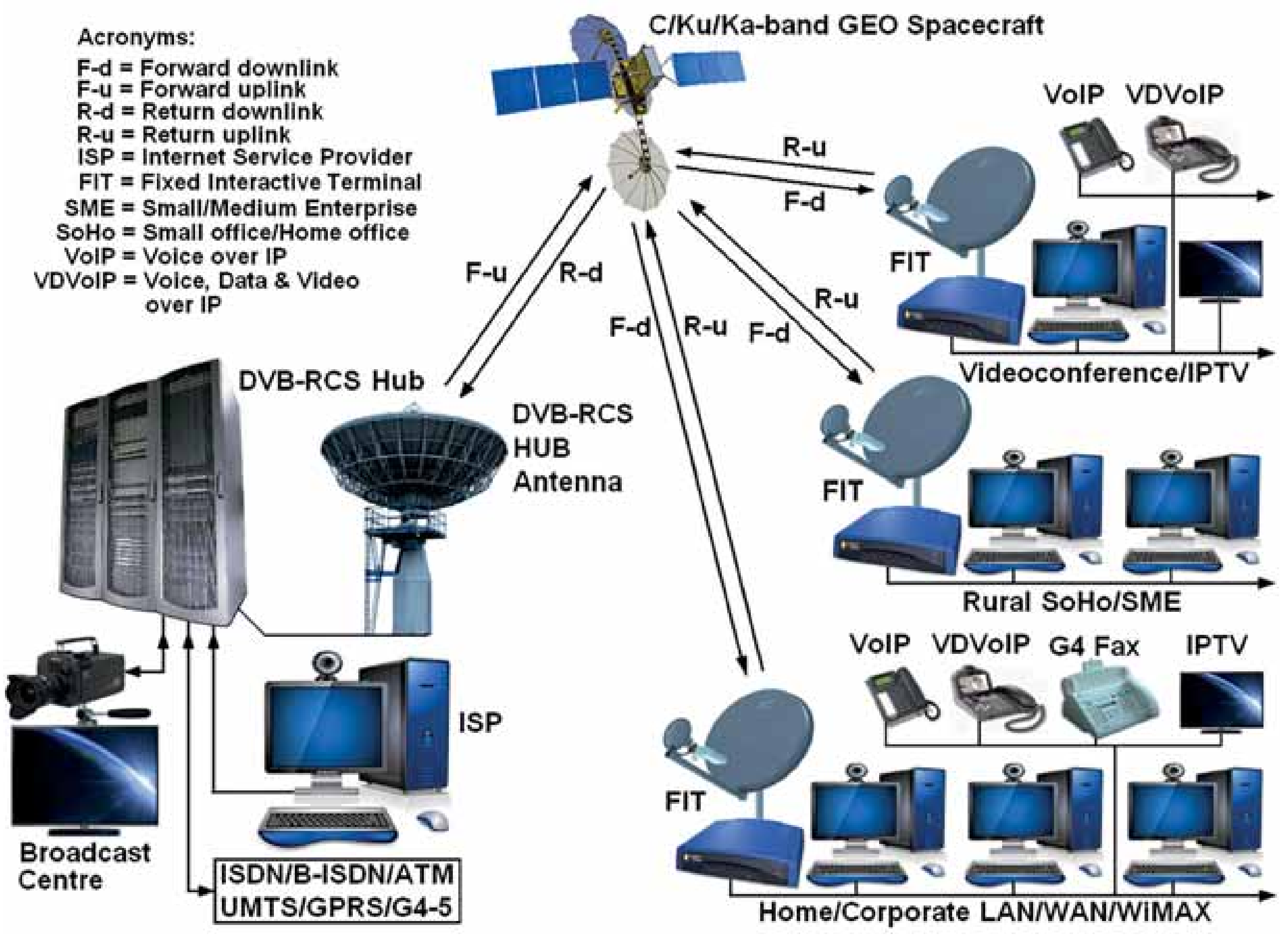


Figure 1: Smart home applications

Figure 2: DVB-RCS satellite network for home and corporate solutions

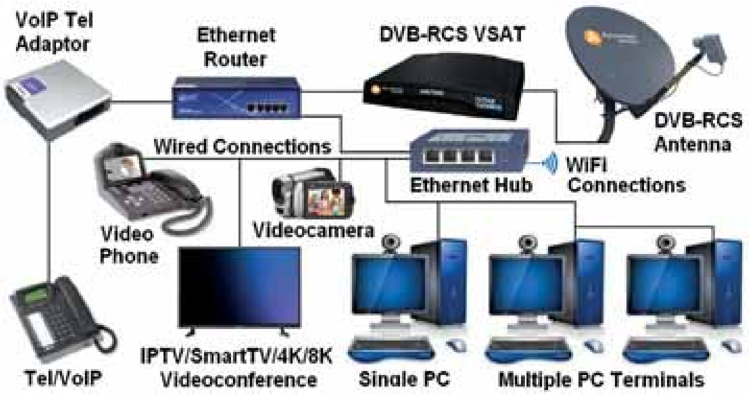


Smart Home Applications

Home owners who want to sell their homes faster may benefit from adding smart features that will make their properties more appealing to tech-minded buyers. As of now, automation in any home can include centralised control of lighting; audio and video distribution; heating, ventilation and air conditioning (HVAC); security; gates; locks; cameras; and more.

- Window control allows active management of daylight that enters the home, for increased comfort, energy saving and protection of fabric and furnishings. At the press of a button, motorised shades and drapery transform harsh glare into pleasing light, enhance privacy while preserving exterior views, reduce solar heat gain, provide ultraviolet protection of expensive furnishings and artwork, and can change daytime into nighttime for rest and sleep.
- Intelligent house systems (HIS) are designed to make creature comforts more enjoyable. With a tap of a button or a control panel, owners can dim the lights, close the curtains, set a comfortable temperature and cue up favorite films or music in a "home theater" environment.
- Climate control (HVAC) includes comforts like bathroom-floor heaters, towel warmers, radiators and even drawer warmers that heat up at a certain time.
- Lighting control can add a layer of security, especially when people are not at home. Living-room lights can turn on automatically at a certain time for a given period to avoid an empty-house look. In other instances, to minimise a large carbon footprint, a motion sensor could switch off the lights after a certain period has expired, if no movement is detected.
- Video intercom – A live video of the front door can stream to a device anywhere in the house or garden.
- Media centre – Today's home entertainment systems offer many functionalities, such as broadcasting high-resolution movies and sound in one room, whilst playing something else in a different room.
- Control of doors and windows. With keyless and remote-entry door locks, a house owner will never have to leave worrying that a door or window is not locked – a smartphone app will take care of this automatically. Some manufacturers make versions that also send a text or e-mail when a door opens. Locks can be programmed with multiple entry codes, allowing the home-owner to see who comes and goes – and when.

Figure 3: DVB-RCS satellite LAN for home office and entertainment room



- A security camera based on wireless Internet Protocol (IP) can easily send and receive data via a computer network or the Internet. This can be either centralised, requiring a central Network Video Recorder (NVR) to handle recordings, video and alarm management, or decentralised without an NVR.
- Smart plugs, also known as Wi-Fi-enabled plugs, are one of the easiest and most affordable smart-home upgrades anyone can make to their home. They easily fit into existing outlets and are controlled from a smartphone app. Using smart plugs, systems such as lights or television can be turned on or off remotely, their energy consumption tracked and a specific energy-management schedule implemented.

Home Interactive Satellite Internet and Broadcasting

The Digital Video Broadcasting-Return Channel via Satellite (DVB-RCS) is a satellite Internet and broadcasting system that can be applied to smart homes, buildings and cities (Figure 2). This network connects Internet facilities of Internet Service Providers (ISPs) and broadcasting content via a DVB-RCS hub and antenna with Very Small Aperture Terminals (VSAT) or Fixed Interactive Terminals (FIT) via Geostationary Earth Orbit (GEO) satellites at C, Ku and Ka-bands.

Depending on the hub's capacity, a DVB-RCS network can connect from ten to a thousand VSAT units, each of which can then connect 100 PCs, IPTVs or other consumer equipment in homes, corporate offices, rural small-office/home-office (SoHo) and small/medium enterprises (SME) through Local Area Networks (LAN), Wide Area Networks (WAN), WiMAX and Wi-Fi. In addition, home offices can be connected to the Integrated Services Digital Network/Broadcasting (ISDN/B), ISDN, Asynchronous Transfer Mode (ATM), Universal Mobile Telecommunications System (UMTS), General Packet Radio Service (GPRS) and cellular G4/G5 setups.

The home VSAT configuration largely consists of an indoor satellite transceiver (FIT) and an outdoor dish antenna, installed on a rooftop. The VSAT interactive (satellite receiver and transmitter) unit usually connects in-home LAN services equipment, including for broadband, IPTV, videoconferencing, voice over IP (VoIP) telephones, videophones, Voice, Data and Video over IP (VDVoIP), cameras and others.

Smart Home Satellite Broadband Office

New satellite technologies and techniques are increasingly being used in the smart home and office; see Figure 3. The main units are a DVB-RCS satellite interactive dish and IP VSAT transceiver. A satellite antenna connects via a GEO satellite to the DVB-RCS hub.

The interactive VSAT remote modem station is the brain of the modern home electronic setup that connects all the electronic equipment, providing a greater forward-link capacity and IP throughput, single channel per carrier (SCPC) transmit capability in point-to-multipoint networks, and wider IF bandwidth. The terminal has been designed with the key IP features to fulfill the needs of enterprise, office or home via cable, a digital subscriber line (DSL) and Wi-Fi. The attractive design and small form-factor make it a cost-effective, desktop, high-speed solution, since it receives up to 200Mb/s (hub to VSAT) with Ethernet throughput of up to 100Mb/s; up to 9.5Mb/s transmit (VSAT to hub) in time division multiple access (TDMA) mode; and up to 20Mb/s transmit in SCPC mode for point-to-multipoint networks. This IP satellite modem supports Internet/intranet access, email, file transfer, VoIP, VDVoIP, video streaming, backup services, private networking, video-on-demand, distance learning, multicasting, IPTV and other broadband functionalities.

> **Home owners who want to sell their homes faster may benefit from adding smart features that will make their properties more appealing to tech-minded buyers**

The VSAT modem connects all Internet and broadband consumer equipment via an Ethernet router, VoIP adaptor and wired or wireless (Wi-Fi) hub, supporting the following:

- Internet Protocol television (IPTV) – unlike downloaded media, IPTV offers the ability to continuously stream source media. As a result, a client media player can begin playing content such as a TV channel, for example, almost immediately – known as streaming media.
- Smart television (Smart TV) provides interactive features like the Internet or web services on a PC and offers video search capabilities.
- Ultra High Definition television (UHDTV) is a modern TV format that provides new services for home or mobile consumers. The first 4K UHDTV standard was originally designed to describe digital cinema, with image resolution of 4096 by 2160 pixels, or 8,847,360 pixels in total. The 8K TV or UHDTV2 standard is still in development, aiming to provide image resolution of 7680 by 4329 pixels, for or 33,177,600 pixels in total. ●

Hot bar bonding in the wearable technology market

As the market for wearable technology grows rapidly, Jan-Bart Picavet, Product Engineer for Hot Bar Technology at Amada Miyachi Europe, describes the need for advanced hot bar bonding methods

The most popular type of technology these days is portable, and as electronic devices continue to shrink, we are rapidly moving toward wearables. Forbes analysts predict the net value of the wearables industry will increase by $20bn in the next four years.

To keep up with demand, new concepts and manufacturing techniques are being adopted. Flexibility is a facet new to electronics, requiring very specific and innovative techniques, including the developments in bonding that make wearable products possible.

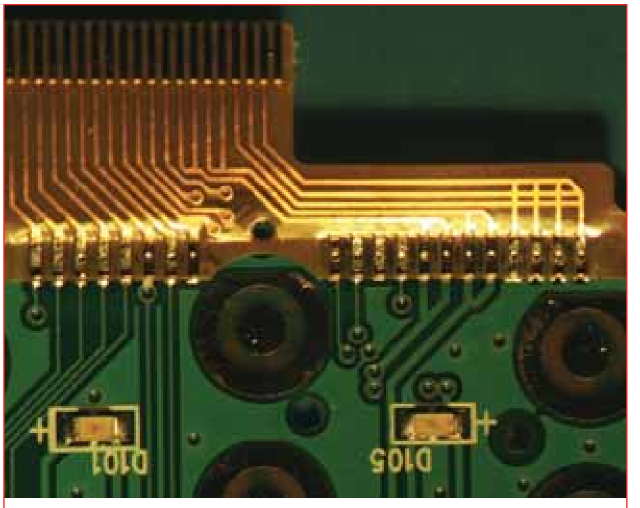


Figure 1: Selective reflow soldering FPC-PCB

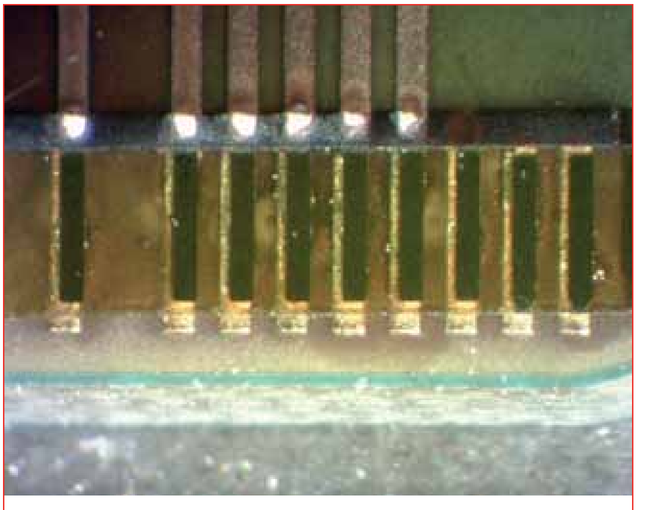


Figure 2: Fine-pitch selective reflow soldering FPC-PCB

The Wearable Tech Market

Generally, if a piece of technology can be worn as a watch or part of clothing it's considered wearable.

The most prevalent wearables on the market today are related to health and wellbeing. They include sensors that attach to the body to monitor vital signs, such as heart rate or blood pressure. And, as sensors become smaller, more specific and more accurate, more complicated functions could easily be monitored; for example, sonograms and ultrasounds could be added to monitor an injury or a condition. Doctors could use information logged by a wearable device to get a broader picture of the patient's day-to-day health and in the future they will be able to receive information directly from the device.

Health devices can expand into self-monitoring applications, whether out of curiosity or progress-tracking in exercise or sport. In addition, lighting can be incorporated into wristbands and footwear, for safety.

Glow-in-the-dark bracelets and clothes have been around for many years and require chemical reactions and pre-exposure to light. But clothing with actual battery-powered light-producing designs are a different story. Whether for Halloween costumes or fashion experiments, this technology is already in use and in demand.

Figure 3: ACF-bonding smartwatch application detail

Figure 4: Heat-seal bonding in a display FPC-PCB

Hot-Bar Bonding

Hot-bar bonding is a general expression used to describe many processes of controlled heating and cooling using a thermode (or hot bar) under pressure/force to create a connection between materials in a product. To make wearable technology possible, the electronics must be small and flexible, including the internal sensors, connections and monitors. Nowadays, sensors are so small that they need to be positioned with great precision, and traditional batteries can't be used any more, creating the need for flexible, printed batteries. Flexibility requires new materials and ways of connecting components, and hot-bar bonding offers a solution.

Type Of Processes Available

There are several types of bonding technologies available today, all of them suitable for wearables.

Hot-Bar Reflow Soldering

Hot-bar reflow soldering is a selective soldering process where two pre-fluxed, solder-coated parts are heated to a sufficient temperature to melt the solder. As the parts cool and solidify, they form a permanent electro-mechanical bond. This is the best process for components that require low production costs or high electrical conductivity.

Pressure is applied during the entire cycle until the solder has solidified to prevent disconnection between parts. Hot-bar reflow soldering is typically used to connect a flexible printed circuit (FPC) to a PCB (Figures 1 and 2), and with small wires and coax cables, or very light and/or small components such as those needed in wearable technology.

ACF Bonding

The process of creating electrical conductive adhesive bonds between flexible and rigid circuit boards, glass panel displays and flex foils is referred to as Heat-Sealing or ACF Final Bonding. Anisotropic Conductive Film (ACF) laminating, or pre-bonding, is the first step in the ACF process where adhesive material is applied. This technology is used when a fine pitch is required and where selective reflow soldering can't be used.

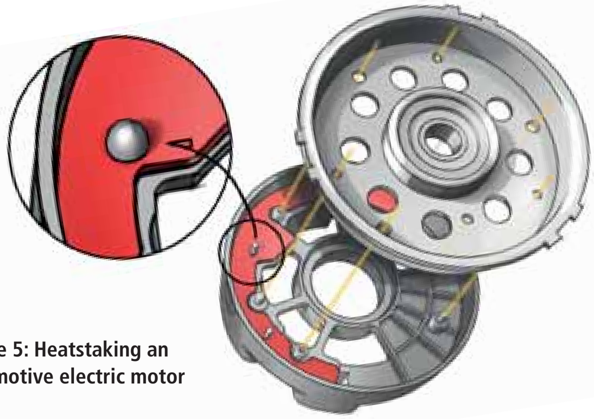


Figure 5: Heatstaking an automotive electric motor

ACF technology is the preferred solution for small-pitch connections. The interconnection is made, for example, between flexible and rigid circuit boards, glass panel displays and flex foils; see Figures 3 and 4. The ACF material feeds from a reel; it consists of adhesive filled with conductive particles and a protective layer.

Before laminating the ACF to the substrate, the tape is pre-cut to the required length. This is done using the half-cut method, leaving the cover layer intact for tape transport. The ACF is then positioned over the bond surface, and by applying temperature and pressure ACF lamination is achieved.

Flexibility is a facet new to electronics, requiring very specific and innovative techniques, including the developments in bonding that make wearable products possible

Once ACF laminating is completed and the flex aligned to match the traces on the substrate, the thermode (hot bar) is again actuated and, finally, the parts heated to bonding temperature under controlled pressure. The fine pitch and flux-free process achievable with this technique are often needed in the small electronics used in wearable technology.

Heat Staking

Heat staking is a pulsed heat process to join two or more parts, at least one of which is made of plastic. The process deforms the plastic material using heat and force for a set process time; the bond is made by partially deforming the plastic part to affix it to the other.

Heat staking makes it easy to bond metal to plastic, and is commonly used in high-volume/low-cost applications like automotive (Figure 5), IT and consumer electronics.

Well Prepared

To keep up with growing demand for technology on the go and new monitoring systems, manufacturers must be informed in the techniques needed to make them. Hot-bar bonding processes not only make miniature and flexible products possible, but by directly soldering or ACF-bonding flexible circuit boards eliminate the need for connectors, making the process cheaper and easier to mass produce. ●

Solving complex adhesion problems with plasma

When traditional chemical adhesives fail to bond dissimilar materials, engineers often turn to plasma treatments. By Jeff Elliott, California-based technical writer

Whether bonding metal to plastic, silicon to glass, polymers to other polymers of different durometers, biological content to polymeric microtiter plates or even bonding to polytetrafluoroethylene (PTFE), plasma can be used for adhesion.

Adhesion can be promoted by increasing the surface free energy through several mechanisms, including precision cleaning, chemically or physically modifying the surface, and increasing surface area by roughening and primer coatings, says Michael Barden of PVA TePla, a company that designs and manufactures plasma systems.

“It is not a question whether plasma is effective or not,” says Barden. “Plasma is the king of surface activation and the best technology available. It just depends on the circumstances of the application.”

Plasma is a state of matter, like a solid, liquid or gas. When enough energy is added to a gas it becomes ionised into a plasma state. The collective properties of ions, electrons and radicals can be controlled to change the properties of surfaces without affecting the bulk material. In this way, plasma is a powerful tool in solving surface preparation problems such as precision cleaning and decontamination, increasing surface wettability and adhesion promotion. In addition, plasma can also be used to polymerise monomers onto surfaces through Plasma Enhanced Chemical Vapour Deposition (PECVD) to provide thin film coatings. The net effect is a tremendous improvement in bonding – in some cases the bond can be made up to 50 times stronger.

Increasing Surface Energy

For most applications, plasma treatments are used to increase the material’s surface free energy, which is defined as the sum of all intermolecular forces on its surface, such as the attraction or repulsion forces exerted on another material.

When a substrate has a high surface energy, it tends to attract. For this reason, adhesives and other liquids often spread more easily. This wettability promotes superior adhesion using chemical adhesives.

On the other hand, low surface-energy substrates – such as silicone or PTFE – are difficult to adhere to without first altering the surface to increase the free energy. There are several plasma methods to increase surface energy, including physical and chemical plasmas along with PECVD coating. In addition, plasma can increase the surface area of bonding by nano-roughening.

> **It is very difficult to find any uniform treatment that works with all the different components on a printed circuit board**

Surfaces that are highly ordered, or very crystalline, tend to have very low surface energies. To disrupt that order, the surface is bombarded with ionised plasma gas, such as helium, nitrogen or argon, which are the most common and affordable. According to Barden, the selection gas is determined by the amount of ion-momentum required to disrupt the surface order.

PVA-plasma equipment

"To create more of an effect, gases with higher atomic masses can be used," he explains. "At one end of the spectrum you can use helium for a light impact on the surface, whereas argon, with 20 times the atomic mass, will impact it with much higher force, creating a surface with a high dispersive effect, so-called 'high wettability'."

Another method of increasing this energy is to create a polarisable group on the surface with chemical plasma; for example, O2 plasma creates surface hydroxyls that allow liquids to spread through hydrogen-bonding mechanisms.

Adhesion to Non-Stick Coatings

Plasma technology can help control the surface chemistry of PTFE to improve bonding, not only for adhesives, but also inks, coatings and biomaterials. PTFE and other fluoropolymers are known for their low coefficients of friction, exceptional chemical resistance and biocompatibility. They also offer a high melting point, low dielectric constants and low flammability. However, PTFE has an inherently low surface energy and poor polarisability, preventing it from bonding adhesively to other materials, hence making its use limited.

"When a surface is highly hydrophobic, like Teflon, it's very difficult to bond to it," says Barden. "If you apply a liquid or adhesive, it just won't spread effectively."

Fortunately, the adhesion properties of PTFE can be dramatically improved using PECVD techniques. The process creates a coating with polar functional groups on the surface that act as excellent anchors to either hydrogen bond or covalently attach hydrophilic coatings. Although ammonia gas plasma activation is traditionally used for this purpose, PVA TePla has developed an alcohol PECVD process that improves bonding strength 1.5 times over ammonia and 8.5 times over the untreated surface.

The process also extends surface-activation lifetimes. Whereas downstream processing and staging time was once confined to a six-hour window, it now extends several weeks, providing more manufacturing flexibility.

This technique opens the door to new methods of chemically engineering the surface properties of PTFE. The ability to selectively prep the surface with primary amines, hydroxyls and carboxylic acids means that engineers can now broaden the use of this material in medical technology.

Adhesion of Biological Molecules

Gas plasma can also provide surface conditioning of in vitro diagnostic platforms prior to the adsorption of biological molecules (protein/antibody, cells, carbohydrate, etc.) or biomimetic polymers. This includes precision cleaning of the substrate at molecular level, along with raising the surface energy to improve assimilation of the intended content.

"Microtiter and multi-well plates are often made of polystyrene, which is extremely hydrophobic. Water will bead on it," says Barden. "However, if you treat polystyrene with oxygen plasma it becomes very hydrophilic, so water spreads everywhere. This allows aqueous solutions with biological content to spread and deliver biomolecules to the surface while providing a hydrogen bonding platform to adhere to them."

However, some in vitro diagnostic substrates require more selective surface chemistry to immobilise a customer's proprietary molecules. For this, PVA TePla has recently developed methods for chemically preparing various polymer platforms for selective adhesion promotion and conjugation of bio-active molecules. This is achieved by providing specific chemical functionality or linker chemistries at the surface, enabling conjugation of a wide variety of molecules, ranging from small-molecule drugs to peptides and larger biopolymers such as carbohydrates and antibodies. Amino, carboxylic, hydroxyl and epoxy functionalities are important examples of the chemistries that are readily obtainable using gas plasma surface treatment.

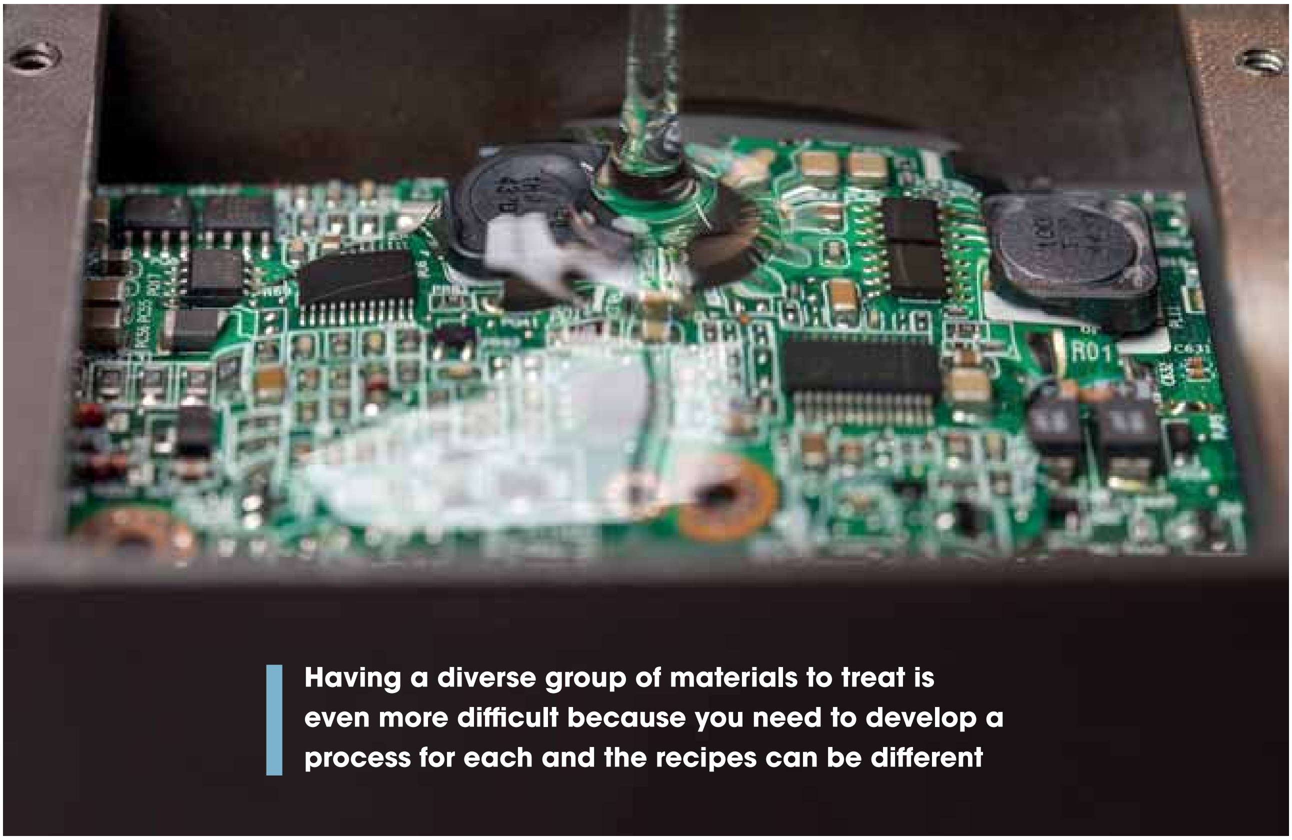
Silicone Ovemoulds

Silicone overmoulding is often used to protect electronic boards from outdoor weather conditions. Silicone is often preferred because of its low water absorption, wide usable temperature range (typically -50°C to 204°C), thermal stability, electrical resistance and stability under ultraviolet light exposure.

Unfortunately, the topography of a PCB means the silicone must bond to many types of materials, including polymers, metals, alloys, ceramics and the FR-4 board itself, all of which have unique surface energies and chemistries. Without proper adhesion, silicone can begin to delaminate, not only at the edges of the board but also in the form of small air pockets on or around components, leading to moisture ingress and subsequent corrosion or electrical shorts.

From a surface chemistry perspective, having a diverse group of materials to treat is even more difficult because you need to develop a process for each and the recipes can be different. It is very difficult to find any uniform treatment that works with all the different components on a printed circuit board.

"In terms of surface energy, the best strategy is to deposit a thin



Having a diverse group of materials to treat is even more difficult because you need to develop a process for each and the recipes can be different

film coating over everything, so the silicone has only to bond to one surface energy. A process using plasma can basically harmonise the many surfaces and turn them into one," says Barden.

To accomplish this, PVA TePla has developed a specific process starting with a precision cleaning/surface activation treatment, followed by the deposition of an inert chemical primer that serves as a tie layer for the overmoulding and provides a uniform surface energy for the silicone to bond.

Primers

Historically, chemical primers have been used to activate difficult polymer or metallic surfaces to promote adhesion. However, many of these primers are comprised of solvents – and catalysts – that are toxic, caustic or carcinogenic, or may leach.

As an alternative, PECVD can be used to deposit thin films of silicon dioxide on the substrate as an intermediate layer to improve the adhesion between a surface and a functional/linker coating or directly to a coating of choice. Within this family, the most popular are hexamethyldisiloxane (HMDSO) and tetramethyldisiloxane (TMDSO).

HMDSO, specifically, is an affordable and flexible reagent that is commercially available in high-purity liquid form. The volatile, colourless liquid can be plasma-polymerised to create various surface coatings. Depending on the ratio of oxygen to HMDSO, the property of the surface can be hydrophobic or hydrophilic.

Guide wires are a good example. To ease insertion, guide wires are often treated with proprietary surface coatings. However, stainless-steel guide wires are very resistant to the adhesion of such coatings and other organic thin films. This problem can be solved by first applying a thin siloxane layer via a PECVD process, followed by a second PECVD process that applies a coating that readily grafts to slippery coatings.

Quantifying Adhesion Improvement

To conduct adhesion testing experiments, Barden says the customer often already has proprietary and sometimes confidential techniques and equipment in place. However, to provide qualitative data on adhesion improvement, certain goniometers can be used to measure surface free energy and the respective dispersive/polar components.

Contact angle goniometers measure the angles of liquids on the substrate surface to determine their energy. Although these tests often use water, this only measures the polar component, so other organic liquids can be used to measure dispersive components as well.

"By completely measuring the surface free energy, we can come up with a measure of the quantitative change that occurs before and after plasma treatment," says Barden. "On the customer end, they can then correlate those measurements with their actual bonding experiments to ensure the best possible bond is." ●

Dealing with complaints

By Sarah Perry, Managing Partner at law firm Wright Hassall

Whatever your business, there is a chance that over time you will receive a complaint from one of your customers about the goods or services you provide. It's easy to perceive any such complaint as an unjustified attack on your reputation, or to believe the customer is merely using the complaint to delay or even avoid payment. Unfortunately, some will take the complaint personally and defend their good name by "having it out" with the complainant, without considering the consequences, which can be serious.

Gemma Carson, Head of Dispute Resolution at law firm Wright Hassall, says such a response can do far more harm than good.

"Lawyers often become involved when a complaint causes someone to react badly. The supplier's injured pride causes them to fire off an angry email or call – a response that frequently spells disaster for the business and proves costly, too," said Carson. "Emotions can run high on both sides of the argument, and it is easy to get involved in a heated debate about the rights and wrongs, mistakes and failures, or actions and inactions of one party or another. The situation can quickly escalate at this point, and easily get out of control."

Due Consideration

The real problems arise if allegations or threats are made to take certain actions without due consideration given to the terms of the original commercial agreement between the two parties. Although it might be satisfying at the time, a knee-jerk reaction will rarely improve a situation.

"There is plenty that can be done to get your feelings across whilst reducing the risk of things getting any worse; it should begin with a careful consideration of the content of the complaint," said Carson. "The pressure may be on, with the complaining customer demanding immediate action, but don't be rushed, take your time and make no commitments – and definitely no threats.

Carson states that if you feel aggrieved by the nature of the complaint, then sum up all your outrage and hurt into a simple message – without sending it; instead, leave it as a draft and wait, allowing the anger to subside.

Personal, face-to-face meetings will often help resolve issues before they can escalate

"E-mails written in haste have a nasty habit of biting back later, particularly when a complaint turns into a dispute," said Carson. "It is also important to check whether a service agreement and/or a contract exists between the parties. You should read any agreements carefully and check what they contain."

With an agreement in place, you may be able to respond to the complaint by highlighting any relevant contractual terms that may help manage the situation.

It's important to be proactive when dealing with a complaint. Ignoring an issue won't resolve it. Carson advises dealing with a complaint promptly to prevent escalation.

"Personal, face-to-face meetings will often help resolve issues before they can escalate. It is best to either raise the matter directly or, if you suspect it to be more serious, to seek legal advice before making contact," said Carson. "If it does feel serious, ensure that you retain all relevant information relating to the complaint, including documents, correspondence and any products or specimens from the same batch. It can help to carry out and document any inspections of equipment or machinery.

Effective Remedy

Early intervention can prove very effective when a dispute cannot be resolved easily. Adopting more collaborative methods of dispute resolution, including mediation, conciliation and negotiation, as opposed to the traditional adjudicated court proceedings or arbitration, can deliver better outcomes. Early intervention options can offer significant benefits:

- **Speed:** A dispute can often be resolved quickly.
- **Costs:** The costs of dealing with a dispute can be significantly reduced compared to traditional court proceedings.
- **Flexibility:** Offer more flexible and commercially-focused resolutions to disputes.
- **Relationships:** Increase the chance of preserving working/commercial relationships.
- **Publicity:** Allow a confidential resolution process; privacy is beneficial.
- **Concurrency:** These approaches to dispute resolution can often be used in conjunction with other methods when needed.

It can also be wise to seek legal advice early on.

"Seeking early legal advice does not necessarily mean a serious legal dispute has arisen," said Carson. "Dispute resolution advice is very effective when delivered soon after the complaint is received, but your lawyers need not take an active role in the issue. They can offer strategic legal guidance focused on resolving complaint situations and diffusing potential disputes, whilst preserving the commercial relationship for the future."

The most important legal factor to remember is that making a rash statement, taking a knee-jerk decision to stop providing your services or products, or sending angry e-mails, may cause a serious breach of contract. This could potentially lead to a threat of injunctive proceedings.

"In simple terms, a breach of contract can entitle the party affected by it to terminate the contract and then bring legal proceedings against you for damages," said Carson.

Avoiding an Injunction

An injunction is a court order that forces the person against whom it is made to do something, or indeed to refrain from doing something, depending on what the person applying for it wants to happen – in this case the continuation of supply.

Whilst the costs of resisting an injunction will depend on the facts and circumstances of a case, injunctions are expensive and time-consuming, and always stressful. Costs can quickly escalate, running into thousands and even tens of thousands of pounds. Factors that affect the costs include the urgency of the application, the number of witnesses involved, and whether the application is with or without notice. Carson advises contacting a legal team immediately upon receipt of an injunction.

"It is also critical that you not take any steps which might breach the terms of the injunction in any way," she added. "A breach of an injunction is generally punishable as contempt of court, which in some circumstances can lead to serious financial penalties or even imprisonment."

You should also be sure to preserve any evidence that might be relevant to the case, if it does not amount to a breach of the injunction.

Carson added: "The best advice to avoiding the risk of an injunction is to simply think before acting and to avoid 'knee-jerk' reactions to complaints." ●

A rushed angry call or email to deal with a complaint frequently spells disaster for a business

RITTAL COOLING UNITS NOW WITH NEW OUTPUT CLASS

Rittal's is extending its Blue e+ range of cooling units, with an output class as low as 1.6kW, extending the existing range of 2 to 6kW.

The Blue e+ cooling units feature inbuilt, innovative, patented hybrid technology, which combines an inverter-driven cooling circuit with an independent heat pipe to provide passive cooling. This has a significant role in delivering the unit's exceptionally high efficiency ratings.

All units in the new range can be operated in all standard grids worldwide thanks to the innovative multi-voltage capability. Permissible input voltage ranges from 110V (single-phase) to 480V (three-phase) in conjunction with a mains frequency of 50Hz or 60Hz.

Blue e+ units also excel in terms of connectivity, safety and handling. The units feature a graphical touchscreen control panel which displays all key information at a glance.

www.rittal.co.uk

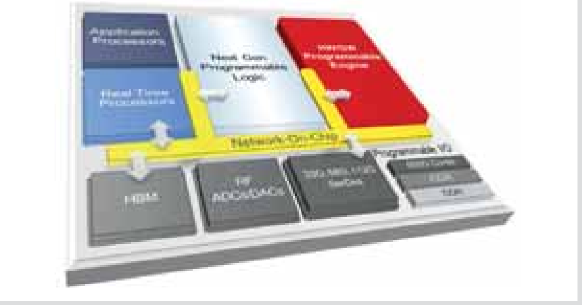
XILINX UNVEILS A NEW ADAPTABLE COMPUTING PRODUCT CATEGORY

Xilinx launched its adaptive compute acceleration platform (ACAP), a multi-core heterogeneous compute platform that can be changed at the hardware level to adapt to the needs of a wide range of applications and workloads. An ACAP's adaptability can be done dynamically during operation, which Xilinx claims will outperform CPUs and GPUs.

At its core ACAP has a new generation of FPGA fabric with distributed memory and hardware-programmable DSP blocks, a multicore SoC, and one or more software-programmable yet hardware-adaptable compute engines, all connected through a network on chip (NoC). An ACAP also has highly integrated programmable I/O functionality, ranging from integrated hardware programmable memory controllers, advanced SerDes technology and leading edge RF-ADC/DACs, to integrated High Bandwidth Memory (HBM) depending on the device variant.

Software developers can use tools like C/C++, OpenCL and Python.

www.xilinx.com



INTEGRATED, HIGH SENSITIVITY, CURRENT SENSOR IC FOR < 5A APPLICATIONS

Allegro MicroSystems Europe has introduced its first fully-integrated, GMR-based current sensor IC with ultra-high sensitivity for applications that require < 5A current sensing.

The ACS70331 current sensor IC incorporates giant magneto-resistive (GMR) technology that is 25 times more sensitive than traditional Hall-effect sensor ICs to sense the magnetic field generated by the current flowing through the low resistance, integrated primary conductor. This new device has been designed to sense very small currents with 1mA resolution in a very low series resistance package of only 1mΩ. The QFN package has a 3mm x 3mm solder footprint, providing a much smaller sensing footprint at a much lower resistance over competitive shunt and op-amp based solutions.

Key applications include handheld and laptop adaptor chargers, radios and walkie talkies, IoT load detection, small surveillance, and other motor control applications.

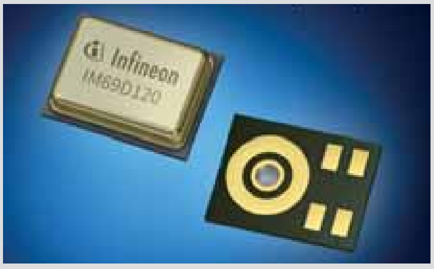
www.allegromicro.com

INFINEON'S NEW XENSIV MEMS MICROPHONES NOW AT MOUSER

The global distributor Mouser Electronics is now stocking IM69D120 and IM69D130 XENSIV MEMS microphones from Infineon Technologies. The high-performance, low-noise microphones are ideal for applications such as high-quality audio capture, voice user interface, active noise cancellation and audio pattern detection in monitoring systems.

Infineon XENSIV microphones are designed for applications that require low self-noise, wide dynamic range, low distortion and a high acoustic overload point. Infineon's dual-backplate microelectromechanical systems (MEMS) technology enables high linearity of the output signal within a dynamic range of up to 105dB. The dual-backplate MEMS technology is based on a miniaturised symmetrical microphone design, similar to that in studio condenser microphones, which generates a truly differential signal. The technology allows improved high frequency immunity for better audio signal processing.

www.mouser.com

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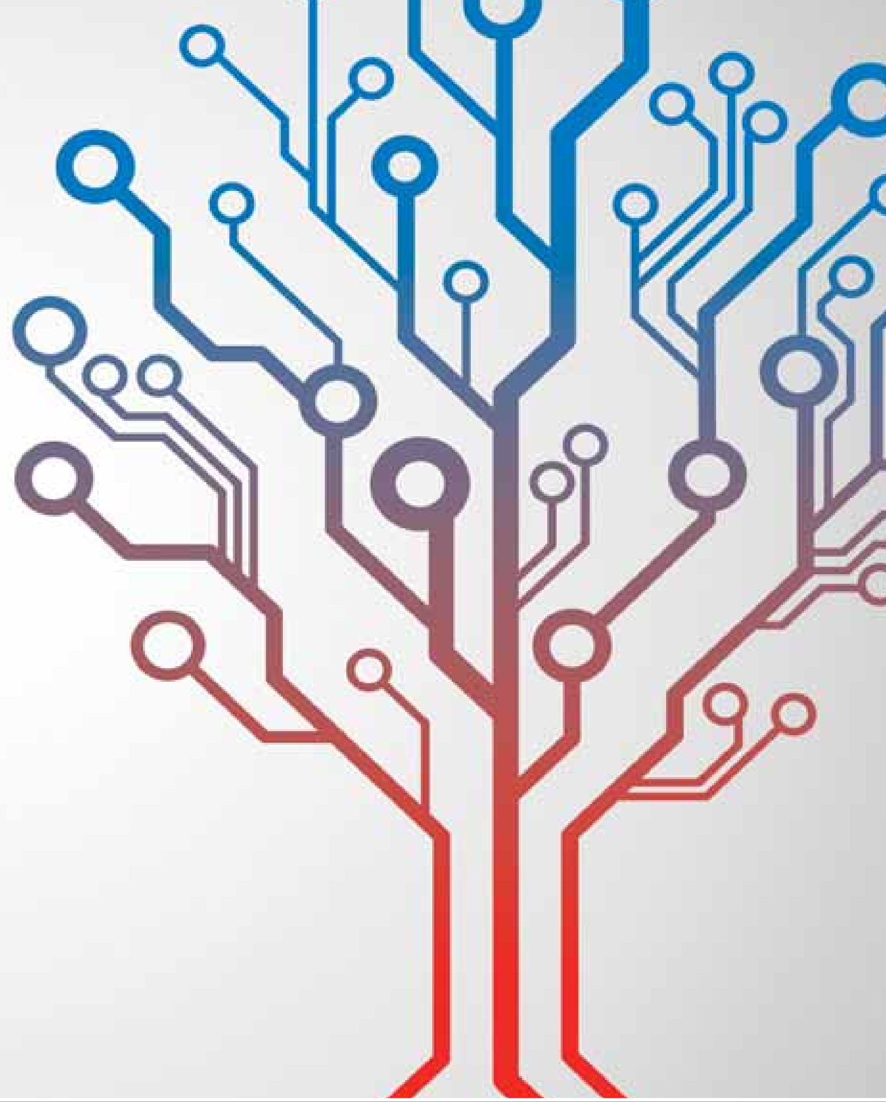

You have a desire to make technology smarter, more efficient and accessible to everyone. Microchip has a passion for developing products and tools that make it easier for you to solve your design problems and adapt to future needs. Microchip's portfolio of more than 1,200 8-bit PIC® and AVR® microcontrollers is not only the industry's largest—it incorporates the latest technologies to enhance system performance while reducing power consumption and development time. With 45 years of combined experience developing commercially available and cost-effective MCUs, Microchip is the supplier of choice due to its strong legacy and history in innovation.

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