PRODUCTS IN FOCUS

- SENSOR TECHNOLOGY
- INTERNET OF THINGS
- EMI FILTERS
- DRIVER ASSISTANCE
- DEEP LEARNING
- DISPLAY TECHNOLOGY
- EMBEDDED SOFTWARE
- MODEL SIMULATION
The challenges faced by electronic designers into 2020 are varied, according to a recent survey conducted by ByteSnap Design. The embedded systems consultancy ByteSnap Design has conducted research into what electronic design businesses expect to happen in the future and what their biggest concerns were.

The survey, which was carried out while the company was exhibiting and presenting at the Engineering Design Show (EDS) in October, involved asking visitors what they felt their greatest challenges were going into 2020.

Executives and engineers provided some interesting insights into the constraints facing the industry today and going forward. Despite the survey taking place prior to the General Election being called, 20% of respondents said their biggest challenge was political uncertainty, especially Brexit. And, in the light of the on-going election, that's a figure that is likely to have increased.

The survey found that 20% of those questioned felt that finding new business was a key concern; 18% that finding the right talent and skillsets was a challenge for their organisation; 18% cited meeting project lead times as critical, while 17% were concerned about obsolete technology.

Brexit was the biggest challenge, however, with the UK's potential exit from the European Union having a host of implications for electronic design companies.

Respondents were concerned about how the UK and European companies would continue to do business in the event of the UK leaving the EU. For example, there remains a high degree of ambiguity around tariffs and taxes, employment of European workers, grants and exemptions, and licensing and regulations, including the Radio Equipment Directive.

As a result of this many businesses are taking a “wait and see” approach, which would explain why investment decisions are being put on hold. Companies are unwilling to commit to new projects and award new contracts that may be impacted by Brexit.

In the worst cases, according to the survey, component buyers are already looking away from the UK and even Europe, to avoid having to change agreements in a post-Brexit future.

A sizeable number of respondents said that employing the right people was also a major challenge. By far the greatest concern out of various human resource challenges for the electronics sector is recruiting new hires.

A lack of appropriate skills and an understanding of embedded technology was a big issue for the industry.

Respondents recognised that in Europe the electronics industry faces competition from both China and Eastern Europe, where both labour costs and sometimes components are cheaper.

But while Brexit is set to impact the electronics industry and skill shortages are likely to persist, the industry’s sales effort must go on.

Neil Tyler
Editor, New Electronics
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The growing use of distributed energy resources such as grid tied solar inverters has resulted in the power conversion community looking to improve the output quality and efficiency of the power conversion process. Silicon vendors are coming up with new control processors with features and hardware support to implement algorithms efficiently, and in response the power conversion industry is turning to model driven development as a solution. However, the model’s performance needs to get closer to the final product performance so as to reduce the risk of hardware changes and delays.

Consider a simplified diagram of a grid-tied residential solar inverter (Figure 1). The solar radiation on the solar panel generates dc proportional to the intensity of the radiation. The converter converts this dc to ac. Current and voltages from various points in the signal chain are sensed by appropriate sensors and will be fed to the control processor in the inverter. The algorithm running on the control processor analyses these signals and controls the power modules such that the generated current and voltage are of required frequency, magnitude, and phase with the grid. In this case, the solar panel acts as the power source, and the grid and appliances act as the sink. In a different power conversion system, the sources and sink would be different, but most of them will fall into the structure shown in Figure 2.

The primary aim of a power conversion system/algorithm designer is to arrive at the right components and algorithms for the block’s control processor and converter hardware and meet the desired performance for all source and load variations. So, it is important to clearly know the environment the system is going to operate in while designing the system.

In a model driven development, the designer first creates the model of the converter, simulates the expected variation, and verifies that the model works as expected. Most often the modelling tools will provide models and library blocks for modelling sources and sinks. For example, Simscape Power Systems from Mathworks has models for grids, photovoltaic (PV) panels, and various loads that can be used to simulate and verify various use cases of the system.

Structuring the Model
It is important to structure the model in a modular way with the right interfaces. Modelling tools typically provide various options to group the components at appropriate levels of abstraction and for reuse. Simulink has provisions to create subsystems, library models, or reference models.

A top-level view of a Simulink model can be seen in Figure 3. Here, the power converter and control processor are encapsulated into a subsystem labelled as ADInverter. Solar panel and grid models available with Simscape Power Systems are used to model the source with provisions to configure intensity and temperature.

The ADInverter subsystem can be further partitioned hierarchically into control processor and control algorithm blocks.

All blocks other than the control algorithm running on the control processor are hardware blocks. So, the accuracy of simulation reflecting all the constraints of these components is the most important criteria.

The interfaces of these blocks are analogue signals and the most appropriate choice for these are continuous models. The block control algorithm is meant for running on a MCU and should only use discrete states and fixed steps. It’s better to keep that as a separate model with different configuration and solver settings and reference that model from the top-level model.

Solver Step Size and Data Types
The speed and accuracy of the simulation is mainly decided by the solver type and step size. A small step size will give more accurate results but will make the simulation run slower. A continuous solver with a variable step size should work in most cases.

However, when the switching frequencies are high, manual

Figure 1: Solar inverter system
adjustments for the maximum step size may be required, e.g. PWM generation at a switching frequency of 100 kHz (as shown in Figure 4a, see page 8) may become distorted (as shown in Figure 4b) if the step size is large. It is always a good idea to check the output of the fast switching devices to confirm that the step size is sufficient.

Since the control algorithm runs on a MCU, it should be using a discrete model with a fixed step size. The step size used should be the greatest common divisor (GCD) of the sampling period used in the system. Most often the modelling software chooses this automatically.

The data types used also decide the accuracy of simulation. Simulation with double precision arithmetic will always be more accurate than a simulation with single precision arithmetic. For simulating the hardware blocks, it is recommended to use the highest data type supported by the modelling software. But for the control algorithm, we want to get the performance of the algorithm the same as it runs on the control processor and not more accurate. So we should be using the data type supported by the control processor. Modelling software may support automatic conversion from a floating-point data type to a fixed point that will help to make the development faster.

**Sampling Period and Precision**

The current and voltage signals sensed by the sensors at various points in the power conversion signal chain are made available to the algorithm through analogue-to-digital converters (ADCs) of the control processors. The sampling rate for the ADC is mainly decided by the switching frequency of power modules and how fast it should be controlled. The sampling frequency has significant impact on the control algorithm performance and dynamics. So, simulation should be done by choosing the appropriate sampling rate for the system. The ADCs for control processors accept input only in predefined ranges. The output of the sensors should be normalised in a way that the range of the sensed signal fits exactly in the range of the ADC.

The resolution and accuracy of an ADC also varies from one processor to another and this plays a significant role in algorithm performance. High accuracy ADCs help to control the output better and help to simplify the algorithm and to reduce the control frequency for a specified control criteria. To get an accurate simulation, these characteristics should be reflected in the model.
Products in Focus | Power Conversion

**Code Generation**

All silicon vendors provide evaluation platforms for developing algorithms on their processors. It would give additional confidence on the performance of the algorithm if we can run and verify the algorithm performance on the evaluation hardware, but compilers for the embedded processors normally accept only C/C++ code and is typically time consuming to develop these codes manually during the modelling and verification stage. So, in the past, this stage has been pushed to the later stages of development.

Fortunately, most of the modelling software now supports the provision to generate codes automatically from the model. The model for the control algorithm can be configured to generate codes with predefined API. The simulation tools also provide a PIL option to run the generated code on the target directly from the modelling environment. In PIL simulation, the input and output of the control algorithm are exchanged with the evaluation board through interfaces such as UART.

Typically, the modelling and simulation software provide support for generating C code - targeting a broader range of processors. It is important to make use of such features to get the best performance out of the processor.

Modelling tools provide provision to replace part of the codes with custom codes or an entire algorithm block with a different code. For power conversion algorithms, optimised code can be generated by providing handwritten optimised routines for common algorithm blocks such as direct quadrature zero (DQZ) transforms, phase-locked loop (PLL), etc.

Apart from the control algorithm code, the control processor also needs codes for configuring the peripherals such as ADC, PWM, etc. and a framework code for maintaining the timings and other functionalities of the system. The modelling tools can be used to generate the code for these as well. However, the framework codes are expected to do much more than run the control algorithm.

**HIL Simulation**

The simulation of the power modules and the system normally runs on a host PC. Even in PIL simulation, only the control algorithm runs on the target control processor. All other parts of the system are simulated by the modelling software on the host machine. Since this simulation takes so many resources and as much execution time, it is not possible to run these in real time in the software. The system dynamics and performance of ADCs and PWMs are not verified in such testing. HIL simulation hardware overcomes this drawback by using field programmable gate arrays (FPGAs) to simulate the converter components, sources, and sinks. It helps to run the entire simulation in real time and to see the actual effect of ADC sampling and PWM control. The HIL hardware is typically provided by separate vendors with a provision to interface control processors. It should be noted that HIL platforms won't be able to simulate the detailed switching characteristics of the power modules. These effects should be analysed separately to minimise the risk while taking it to the final product.

**Conclusion**

While modelling tools have greatly improved during recent years, it should be noted that there are some characteristics such as electromagnetic compatibility (EMC) that cannot be verified in a simulation environment. It is important to identify these characteristics and analyse and verify through alternate methods.

The steps explained here, have been successfully employed in designing and developing control algorithm targeting ADSP-CM41x processors for an inverter with 3-level ANPC topology.
Automotive-grade ATPG

Siemens IC test for Zero DPPM

The Tessent test software brings advanced automation to the challenges of zero-defect ICs for automotive electronics.

The Tessent TestKompress with Automotive-grade ATPG software tool addresses the need for very high-quality ICs for automotive electronics by targeting defects within cells, at the transistor level. Traditional test methods are designed to capture defects in the interconnect between cells, and therefore miss a large, and growing, number of defects that occur in today's complex transistors. Capturing these otherwise undetectable defects helps the makers of digital ICs meet the ISO 26262 goal of zero defective parts per billion (DPPB).

Tessent TestKompress with Automotive-grade ATPG contains a suite of fault models and test pattern generation applications that can be used separately or together. The software is the result of decades of research in cell-aware, layout-aware, and defect-oriented test and modeling. These technologies were developed in collaboration with foundries, fabless companies, and integrated device manufacturers (IDMs). Tessent TestKompress with Automotive-grade ATPG has been validated on millions of tested devices representing mature planar process nodes, as well as state-of-the-art FinFET processes.

With Tessent TestKompress Automotive-grade ATPG, users can target not only the cell-based faults, but can also start to introduce the same layout-based technology to address critical area-based interconnect and cell-neighborhood faults. Enabling structural test to reach DPPM levels that would otherwise only be possible by combining ATPG patterns with extremely expensive functional or system-level tests.

Mentor’s fault model extraction makes TestKompress cell-aware stand out from the crowd. The fault extraction uses layout-annotated Spice representation of the cells to identify the location of possible transistor, bridge, open, and port defects. The extraction process automatically ranks bridges and opens on critical area, allowing ATPG to focus on the most important defect locations.

As the automotive electronics industry creates larger and more complex chips at the most advanced process nodes, they can rely on the Tessent family of products from Siemens to help them meet their required IC quality. To learn more, download the white paper: [https://go.mentor.com/55fOr](https://go.mentor.com/55fOr)

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Mouser Electronics has signed a global distribution agreement with SEARAN, a provider of Bluetooth wireless connectivity. The SEARAN product line provides developers with a royalty-free software development kit (SDK), supporting devices from leading semiconductor manufacturers, including STMicroelectronics, Texas Instruments and Renesas Electronics.

SEARAN’s wireless audio player software (Linux or FreeRTOS) and wireless speaker software (FreeRTOS) provide applications that enable wireless audio streaming from an audio player to a headset or a speaker via A2DP and AVRCP Bluetooth profiles. SEARAN wireless headset software provides an application for either Linux- or FreeRTOS-based platforms that enables audio streaming and phone calls from a smartphone to a headset via Hands Free Profile (HFP), A2DP, and AVRCP Bluetooth profiles.

SEARAN data packet software is an SDK for either Linux- or FreeRTOS-based platforms enabling data transfer over Bluetooth Low Energy for any device, Bluetooth SPP for Android devices, and iAP for iOS devices with MFI authentication. It is built on SEARAN’s ultra-small Bluetooth stack, dotstack, designed for low-cost, low-power embedded devices. Bluetooth SIG-compliant, it runs on most popular platforms and operating systems.

OMC has introduced two new surface-mount LEDs, an ultra-narrow 15° beam LED and a 60° beam LED. Both LEDs are produced by OMC in a range of package styles, beam angles and all popular LED wavelengths, plus infrared versions. The devices join the SMD emitter series launched in late 2018.

The SMT LEDs provide designers with more choice and flexibility for a very wide range of applications, including signalling, indication, sensing and communications.

With SMT LEDs, the LED body is generally injection moulded from non-optical material which is pre-manufactured before the LED die is mounted. As a result, the majority of SMD packages do not incorporate any lensing, emitting light in a wide beam angle which generally exceeds 100°.

OMC uses a proprietary post die-mount encapsulation process and is able to cost-effectively integrate narrow angle lensing into a range of surface-mount emitters.

The new narrow 15° angle and the 60° angle SMT LEDs open up design possibilities for engineers needing to provide a clear human-machine interface and ensure precision and accuracy. They are especially targeted at high-intensity applications where the beam needs to be seen from a distance, such as signalling, indication, sensing and communication.

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Panasonic Factory Solutions and Siemens Factory Automation Services have signed a global agreement.

Initial systems such as the NPM VF odd-shape mounter for the assembly of THT (Through Hole Technology) components from Panasonic Industry have already been integrated at the Siemens site in Vienna, Austria.

Panasonic Industry is currently working towards connecting the products and solutions to the Siemens systems Teamcenter and MindSphere.

Commenting on the announcement Nils Heininger, Division Director of Panasonic Factory Solutions, said: “We are very proud to announce the partnership with Siemens Factory Automation Services. Our high-quality and reliable production solutions such as laser markers, insertion machines for THT components as well as complex software solutions such as PanaCIM were able to convince the supply chain management of the Siemens AG and we are looking forward working together.”

“The collaboration is an important milestone on the way to digitalizing the supply chain, and our goal is to connect as many machines and plants as possible to Siemens MindSphere in our factories,” explained Andreas Wipper, Purchasing Council Manager Production Machines & Equipment, Siemens Supply Chain Management.

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According to a report by the World Health Organization (WHO), each year about 1.35 million people die in traffic accidents and another 20 to 50 million are injured. One of the main causes is driver inattention. Consequently, many automotive manufacturers offer driver assistance systems that detect tiredness. But it’s not just microsleep at the wheel that causes accidents. Talking or texting on smartphones and eating or drinking while driving put a growing number of people at high risk too.

Until now, driver assistance systems have been unable to identify these activities, however, ARRK Engineering has been running a series of tests towards automatically recognising and categorising mobile phone use and eating/drinking.

Images were captured with infrared cameras and used for machine learning by several Convolutional Neural Network (CNN) systems. This created the basis for a driver assistant that can reliably detect various scenarios at the wheel and then warn the driver of any hazardous behaviour.

For years, the automotive industry has installed systems that warn in case of driver fatigue. These driver assistants look to analyse, for example, the viewing direction of the driver, and automatically detect deviations from normal driving behaviour.

“Existing warning systems can only correctly identify specific hazard situations,” explained Benjamin Wagner, Senior Consultant for Driver Assistance Systems at ARRK Engineering. “But during some activities like eating, drinking and phoning, the driver’s viewing direction remains aligned with the road ahead.”

For that reason, ARRK Engineering ran a series of tests to identify a range of driver postures so systems can automatically detect the use of mobile phones and eating or drinking. For the system to correctly identify all types of visual, manual and cognitive distraction, ARRK tested various CNN models with deep learning and trained them with the collected data.

In the test setup, two cameras with active infrared lighting were positioned to the left and right of the driver on the A-column of a test vehicle. Both cameras had a frequency of 30 Hz and delivered 8-bit grayscale images at 1280 x 1024 pixel resolution.

“The cameras were also equipped with an IR long-pass filter to block out most of the visual spectrum light at wavelengths under 780 nm,” said Wagner. “In this manner we made sure that the captured light came primarily from the IR LEDs and that their full functionality was assured during day and night-time.”

In addition, blocking visible daylight prevented shadow effects in the driver area that might otherwise have led to mistakes in facial recognition. A Raspberry Pi 3 Model B+ sent a trigger signal to both cameras to synchronize the moment of image capture.

With this setup, images were captured of the postures of 16 test persons in a stationary vehicle. To generate a wide range of data, the test persons differed in gender, age, and headgear, as well as using different mobile phone models and consuming different foods and beverages.

“We set up five distraction categories that driver postures could later be assigned to. These were: ‘no visible distraction,’ ‘talking on smartphone,’ ‘manual smartphone use,’ ‘eating or drinking’ and ‘holding food or beverage,’” explained Wagner.

“For the tests, we instructed the test persons to switch between these activities during simulated driving.”

After capture, the images from the two cameras were categorized and used for model training.

Training and testing
Four modified CNN models were used to classify driver postures: ResNeXt-34,
ResNeXt-50, VGG-16 and VGG-19. The last two models are widely used in practice, while ResNeXt-34 and ResNeXt-50 contain a dedicated structure for processing of parallel paths. To train the system, ARRK ran 50 epochs using the Adam optimiser, an adaptive learning rate optimisation algorithm.

In each epoch, the CNN model had to assign the test persons’ postures to the defined categories. With each step, this categorisation was adjusted by a gradient descent method, so that the fault rate could be lowered continuously.

After model training, a dedicated test dataset was used to calculate the error matrix which allowed an analysis of the fault rate per driver posture for each CNN model.

“The use of two cameras, each with a separately trained CNN model, enables ideal case differentiation for the left and right side of the face,” said Wagner. “Thanks to this process, we were able to identify the system with the best performance in recognising the use of mobile phones and consumption of food and beverages.”

Evaluation of the results showed that the ResNeXt-34 and ResNeXt-50 models achieved the highest classification accuracy, 92.88 percent for the left camera and 90.36 percent for the right camera. This is absolutely competitive with existing solutions for detection of driver fatigue.

Using this information, ARRK has extended its training database which now contains around 20,000 labelled eye data records.

Based on this, it is possible to develop an automated vision-based system to validate driver monitoring systems. ARRK Engineering’s experts are already planning another step to further reduce the fault rate.

“To further improve accuracy, we will use other CNN models in a next project,” noted Wagner. “Besides evaluation of different classification models, we will analyse whether the integration of associated object positions from the camera image can achieve further improvements.”

In this context, approaches will be considered that are based on bounding box detection and semantic segmentation.

The latter enable, in addition to classification, different levels of detail regarding the localization of objects. In this way, ARRK can improve the accuracy of driver assistance systems for the automatic detection of driver distraction.

ARRK Engineering is part of the international ARRK Group and specialises in all services relating to product development. With the expertise in Electronics & Software, CAE, Materials, Acoustics, Composites, Car Body, Powertrain, Chassis, Interior & Exterior, Optical Systems, Passive Safety and Thermal Management, the company develops integrated and independent products for its customers, supporting them with many years’ experience as strategic development partners. Together with its sister companies, ARRK Engineering is working to implement product developments, from virtual development to prototypes and small series production.

The ARRK Engineering Division operates worldwide from sites in Germany, Romania, the UK, Japan, and China. The Engineering Division is headquartered at P+Z Engineering GmbH in Germany. ARRK Engineering employs over 1,200 staff members.
PCAP touchscreens

Projected Capacitive Touch Screens (PCAP)

A PCAP Touchscreen allows users to control devices using a printed glass or plastic coverlens. An infinite amount of customer-specific designs are possible all perfectly tuned to the operating environment of the device.

SCHURTER continuously invests in state-of-the-art production facilities, such as glass printing systems, cleaning machines and optical bonding equipment. This allows us to quickly and efficiently develop prototypes and individual solutions using the latest technology.

Paul Berning (engineer): “We prefer to test SCHURTER’s PCAP products using the customers specific equipment. In this way, we can carry out the most complete test possible and give the customer exactly the product they had in mind!”

During the start-up phase of a new project, our engineers are involved in the product development. We prefer to create a joint engineering team together with our customer. The advantage of this is that all of the customers wishes (e.g. to be used in a humid environment, to be operated with a glove, etc.) are fully mapped out at an early stage. All parameters are envisaged, and the customers is advised of the possibilities and a clear list of priorities is established.

When the first design is ready, the product is tuned. During this part of the development, all parameters are optimized, taking into account the external factors and the main priorities are established. Wherever possible, testing is carried out using the customer’s specific equipment.

Sensors
SCHURTER has the most modern, fully automatic glass printing line to realise the front glass in the desired design to the highest quality standard. In addition, SCHURTER laminates touchscreen sensors in our dedicated cleanrooms with special laminators. Using an autoclave, the last air residues are then removed, to produce an optically perfect product. SCHURTER offers a standard range of sensors and we also develop and produce customised sensors. We always find a perfect solution for every display.

EMC standards
Our products comply with our customer’s EMC (electromagnetic compatibility) requirements. Other electrical devices in the immediate vicinity must not affect the operation of the product. Conversely, the product must not interfere with the other devices. The EMC requirements are discussed during design to ensure that the Touch Screen operates correctly in its environment.

Curious about our competencies in the field of PCAP competencies?
Contact us to discuss the possibilities for your company!
A multitude of factors are conspiring to increase the amount of “noise” interference that can disturb the functionality and even damage electronic devices, starting with the sheer number used in our vicinity at any given time.

Today’s automobiles provide a prime example. In a single vehicle you can find Wi-Fi, Bluetooth, satellite radio, GPS systems, LED lights, air conditioning, power steering, anti-lock brakes, rear-view cameras and other instrumentation. Numerous items also operate using dc motors, including power seats, adjustable mirrors, windshield wipers, power windows and sunroofs.

This same example could also apply to items ranging from Wi-Fi or Bluetooth-enabled appliances like washing machines, espresso machines, medical instruments and even medical implants.

To accomplish this, the industry has typically employed shielding along with EMI filters in various configurations to eliminate unwanted noise.

However, even some of the traditional solutions for eliminating EMI/RFI are no longer sufficient given increases in operating circuit frequency, noises of higher frequencies that expand the affected frequency range and the miniaturisation of electronic devices.

If that wasn’t enough, many electronic devices are more easily affected by noise, even with less energy, due to circuits today that operate at lower voltages.

This is leading many OEMs to avoid options such as 2-capacitor differential, 3-capacitor (one X-cap and 2 Y-caps), feed-through filters, common mode chokes or combinations of these for alternatives, such as monolithic EMI filters that deliver noise suppression in a substantially smaller package.

EMI/RFI Noise
When electronic devices receive strong electromagnetic waves, unwanted electric currents can be induced in the circuit and cause unintended operations – or interfere with intended operations.

EMI/RFI can be in the form of conducted or radiated emissions. When EMI is conducted, it means the noise travels along the electrical conductors. Radiated EMI occurs when noise travels through the air as magnetic fields or radio waves.

Even if the energy applied from the outside is small, if it is mixed with the radio waves used for broadcasting and communication, it can cause loss of reception, abnormal noise in sound, or disrupted video at places where the radio waves for broadcasting and communication are weak. If the energy is powerful, devices can be damaged.

Sources of noise includes natural, such as electrostatic discharge, lighting and other sources; and artificial noise such as contact noise, leaking from devices that use high frequencies, unwanted emission and others.

Noise can even be generated from a circuit inside an electronic device and cause interference with another circuit in the same electronic device.

Usually, EMI/RFI noise is common mode noise, so the solution to all but eliminate unwanted high frequencies with an EMI filter, either as a separate device, or embedded in circuit boards. This also helps OEMs meet regulatory standards that limit the amount of noise that can emitted.

EMI filters normally consist of passive components, such as capacitors and inductors, in order to form circuits.

“The inductors allow dc or low frequency currents to pass through, while blocking the harmful unwanted high frequency currents. The capacitors provide a low impedance path to divert the high frequency noise away from the input of the filter, either back into the power supply or to the ground connection,” explained Christophe Cambrelin of Johanson Dielectrics, a company that manufactures multi-layer ceramic capacitors and EMI filters.

Traditional common mode filtering approaches include low pass filters comprised of capacitors that pass signals with a frequency lower than a selected cut-off frequency and attenuates signals with frequencies higher than the cut-off frequency.

A common starting point is to apply a pair of capacitors in a differential configuration, with one capacitor between each trace and ground of the differential input. The capacitive filter in each leg diverts EMI/RFI to ground above a specified cut-off frequency.

Because this configuration involves sending a signal that is opposite in phase through two wires, the signal-to-noise ratio is improved while unwanted noise is sent to ground.

“Unfortunately, the capacitance value of an MLCC with X7R dielectric (typically used for this function), varies significantly with time, bias voltage, and temperature,” said Cambrelin.

“So even if the two capacitors are tightly matched at room temperature, with a low voltage, at a given time, it very likely that they end up with...
a very different value once time, or voltage, or temperature have changed. This mismatch between the two lines will cause the response near the filter cut-off to be unequal and therefore it will convert common mode noise to differential noise.

Another solution is to bridge a large value ‘X’ capacitor across the two ‘Y’ capacitors. The ‘X’ capacitor shunt delivers the desired effect of common mode balancing, however, with the undesired side effect of differential signal filtering.

Perhaps the most common solution and an alternative to low-pass filters is the common mode choke.

A common mode choke is a 1:1 transformer where both windings act as both primary and secondary. In this approach, current through one winding induces an opposing current in the other winding. Unfortunately, common mode chokes are also large, heavy, expensive, and subject to vibration induced failure.

Still, an ideal common mode choke with perfect matching and coupling between the windings is completely transparent to differential signals and presents very high impedance to common mode noise.

One disadvantage of common mode chokes is the limited frequency range due to parasitic capacitance. For a given core material, the higher the inductance used to obtain lower frequency filtering, the greater the number of turns required and consequent parasitic capacitance that defeats high frequency filtering.

Mismatch between windings from mechanical manufacturing tolerance can cause mode conversion, where a percentage of the signal energy converts to common mode noise and vice-versa. This gives rise to electromagnetic compatibility and immunity issues. Mismatches also reduce the effective inductance in each leg.

Common mode chokes do have a major advantage over other options when differential signals (to pass) operate in the same frequency range as the common mode noise that must be suppressed. With a common mode choke, the signal pass band can extend into the common mode reject band.

**Monolithic EMI Filters**

Despite the popularity of common mode chokes, a better alternative may be monolithic EMI filters. When properly laid out, those multilayer ceramic components provide superior rejection of common mode noise. They combine two balanced shunt capacitors in a single package, with mutual inductance cancellation and shielding effect. These filters from Johanson Dielectrics utilize two separate electrical pathways within a single device attached to four external connections.

To prevent confusion, it should be noted that a monolithic EMI filter is not a traditional feed-thru capacitor. Although they look identical (same package and external look), their design is very different and they are not connected in the same way.

Like other EMI filters, monolithic EMI filters attenuate all energy above a specified cut-off frequency and only selecting to pass required signal energy while diverting unwanted noise to ‘ground’.

The key, however, is the very low inductance and matched impedance. With monolithic EMI filters, the terminations connect internally to a common reference (shield) electrode within the device, and the plates are separated by the reference electrode.

Electrostatically, the three electrical nodes are formed by two capacitive halves that share common reference electrodes all contained in a single ceramic body.

“Being very well-balanced, a monolithic EMI filter introduces almost no conversion of common mode noise to differential signals, or vice-versa. Furthermore, having a very low inductance makes it particularly effective at high frequencies,” explained Cambrelin.

The balance between capacitor halves also means piezo-electric effects are equal and opposite, cancelling out. This also affects temperature and voltage variation, so components age equally on both lines.

“Compared to the common mode choke solution, this device provides significantly more RFI suppression in a substantially smaller package. It also rejects a much wider frequency band,” said Cambrelin.

If there is a downside to these monolithic EMI filters, it is that they cannot be used if the common mode noise is at the same frequency as the differential signal.

“When this is the case, the common mode choke is a better solution,” concluded Cambrelin.