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Technology Roundup:

Logic Devices for Automotive

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Achieve robust designs with Six Sigma—Part I

By John X. Wang, Maytag Corporation

Here's a complete blueprint for implementing Six Sigma product design including such proven techniques as Voice-of-Customer (VOC) and Critical-to-Quality (CTQ) to Kano modeling. See how Six Sigma bridges critical gaps between R&D, product and process. Developing "best-in-class" robust designs is crucial for creating competitive advantages. Customers want their products to be dependable–"plug-and-play." They also expect them to be reliable–"last a long time." Furthermore, customers are cost-sensible; they anticipate that products will be affordable. Becoming robust means seeking win–win solutions for productivity and quality improvement. So far, robust design has been a "road less traveled."

Very few engineering managers and professionals are aware of robust design methods; even fewer of them have hands-on experience in developing robust designs. As a breakthrough philosophy, process, and methodology, Six Sigma offers a refreshing approach to systematically implement robust designs. This chapter outlines a process for engineering robust designs with Six Sigma and provides a road map.

SIX SIGMA AND ROBUST DESIGN

Six Sigma is a rigorous and disciplined methodology that uses data and statistical analysis to measure and improve a company's operational performance. It identifies and eliminates "defects" in product development, manufacturing, and service-related processes. The goal of Six Sigma is to increase profits by eliminating variability, defects, and waste that undermine customer loyalty.

- A best-in-class robust design starts with three categories of static response metrics: the smaller-the-better, the nominal-the-best, and the larger-the better. Each of these characteristics should be measurable on a continuous scale.
- A smaller-the-better response is a measured characteristic with an ideal value of zero. As the value for this type of response decreases, quality improves.
- A nominal-the-best response is a measured characteristic with a specific target (nominal) value that is considered ideal.
- A larger-the-better response is a measured characteristic with an ideal value of infinity. As the value for this type of response increases, quality improves.

Besides static responses, dynamic responses are also encountered when developing engineering products. A dynamic response is a characteristic that, ideally, increases along a continuous scale in proportion to input from the system. Dynamic responses should be related to the transfer of energy through the system. To develop robust products, dynamic formulations are recommended for the maximum benefit of the application of a Parameter Design methodology (See Chapter 7). Using a dynamic response provides the greatest long-term benefits, but it requires the most engineering know-how.

The Six Sigma approach for engineering robust designs depends heavily on formulating the Voice-of-Customers (VOCs) and Critical-to-Quality (CTQ) characteristics through experiments. The following steps provide a thorough, organized framework for planning, managing, conducting, and analyzing robust design experiments.

1. **Identify project and organize team**
2. Develop VOC models
3. Formulate the CTQs based on VOCs
4. Control the energy transformation for each CTQ
5. Determine control and noise factors for each CTQ
6. Establish the control factor matrix

These steps, although specified sequentially, should not be used as a "cookbook approach" to experimentation; instead, they should be used in an iterative way. During each stage of development, consider the decisions that were made in earlier steps. Your team may need to revisit previous steps in light of insights gained farther along in the process.

IDENTIFY PROJECT AND ORGANIZE TEAM

Six Sigma provides a product development team with the tools to improve design capability. The first step in the robust design process is to identify the project (Figure 1) and organize a team. This section shows how to develop the project-selection criteria and successful project characteristics.

As with any project, effective planning and selection of the right team can make the difference between success and failure. Project selection should be based on the potential for increasing customer satisfaction, increasing reliability, incorporating new technology, reducing cost, reducing warranty service, and achieving best-in-class.

The characteristics of a successful project are (1) a clear objective, including the desired outcome; and (2) a cross-functional team that includes suppliers, thorough planning, and management support. Management sponsorship and support is critical for team success.

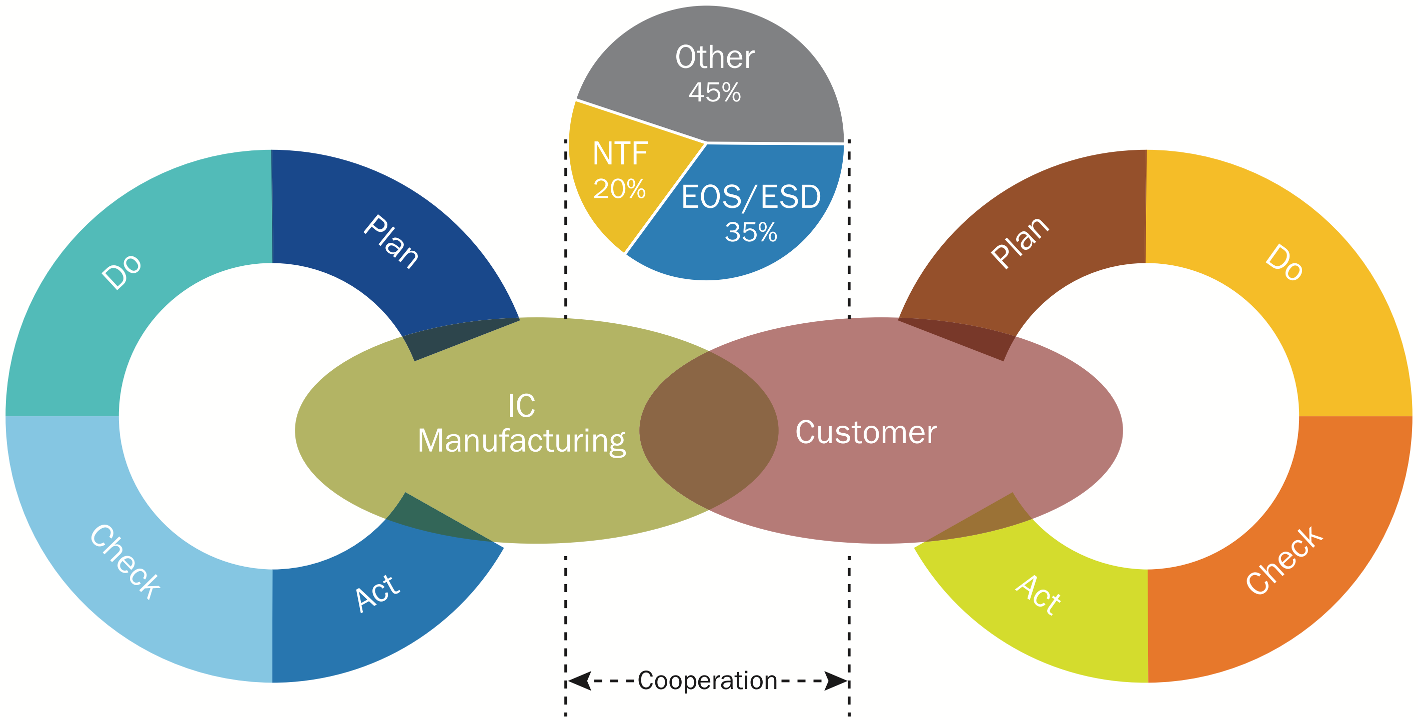
Management's role is to provide necessary resources, empower the team, and remove obstacles to progress. ■

Figure 1- Identify a robust design project

C supplier, customer cooperation methodologies drive up electronics system quality

Yorgos Christoforou, Khaled Terras, and Roger Habets, NXP Semiconductors

With increasing complexity of automotive electronic systems, one of the most important winning features of modern integrated circuits is quality. This trait is what most IC customers recognize and expect. Although IC manufacturers have been extremely successful in reducing defects, on the other hand a significant part of the quality drive for printed-circuit-board module makers is originating from reducing electrical overstress (EOS), electrostatic discharge (ESD), and cases of no-trouble-found (NTF) (see chart to right).



- EOS is any kind of electrical overload resulting in damage or malfunction of an electrical component or system.
- ESD is a specific type of EOS originating from triboelectric or inductive charging and encountered in manufacturing environments or applications.
- NTF is a category that contains cases of failures that appear only under very specific functional and environmental conditions which have been impossible to reproduce by the analyst and as soon as these conditions cease to exist, the failing behavior disappears.

Contrary to manufacturing related issues, problems related to system EOS/ESD robustness or marginal/intermittent performance cannot be solved by the IC supplier alone. Solution of these difficulties requires the involvement of the PCB module maker and the car manufacturer as well. This is because the conditions leading to these types of failures can only be understood in the context of the application where the IC originally failed.

This article describes the way IC manufacturers may address EOS/ESD/NTF issues by working closely with customers. As part of this process, customers are engaged into cooperation around these specific failure modes during tailored workshops where running issues are analyzed in depth. After identifying all relevant details, containment actions are derived and permanent solutions are sought, based upon a Plan-Do-Check-Act (PDCA) loop. The cooperation continues in the frame of Quality Update Meetings, until all issues are closed permanently.

Value proposition

The large fraction of EOS/ESD/NTF (or in short EEN) issues in the supply chain and their inter-boundary nature should trigger the IC manufacturer to create a structured approach to actively focus on the following targets:

Failing-Parts-Per-Million (FPPM) reduction

As PPM is a major quality performance indicator in the electronics business for both the IC supplier and the PCB-module maker, it is essential to reduce it over time in a controlled way. Note that 1 FPPM (one failing-part-per-million failure rate) product inside a car that contains 10,000 parts would lead to 1% of cars of this type failing. This is not acceptable.

FPPM reduction can only be achieved collaboratively, through information exchange. Given the present trend of continuously increasing complexity in electronics, quality levels that were good-enough yesterday are no longer sufficient today. The new era of sub-FPPM (hence FPPB – Failing-Parts-Per-Billion) quality is about to commence.

Rootcause analysis throughput time (TPT) reduction

Because in customer support services time is money, rootcause analysis throughput time is a key parameter for any quality professional. Reducing analysis throughput time helps the entire supply chain to eliminate unnecessary cost and increase customer satisfaction.

The benefits from this approach can be summarized to be:

Reduction of quality costs: The amount of bottom line savings increases exponentially as one moves upwards along the supply chain from the IC supplier to the car maker. Keep in mind, the costs of poor quality related only to EOS/ESD could easily reach 5% of the turnover; for a 200M€ business the actual losses due to EOS/ESD can reach the 10M€, a considerable amount. Similar amounts are spent for servicing NTF issues.

Freeing-up a considerable amount of resources: Hence resources can be allocated to more profitable activities like R&D, or process improvements. A low complexity EOS/ESD issue can keep an R&D team busy for approximately 400 man-hours whereas NTF rootcause analysis can end up costing 1,000 man-hours.

Acceleration of the PDCA loop: By optimizing throughput time and efficiency, rootcause analysis can happen close to the source (to the environmental conditions in which the failure originally appeared), leading to an acceleration of the complaint-handling PDCA loop. This creates a lean infrastructure on which to perform rootcause analysis extending from the IC manufacturer to the car.

Electrical over-stress and electrostatic discharge (EOS/ESD)

The field of EOS/ESD is a complex one, mainly due to the multiple mechanisms that may lead to such events. To assure that no latent damaged parts are ever delivered to customers, IC manufacturers must spend a continuously increasing effort in screening outlying devices during wafer-test (WT) and final-test (FT) using advanced techniques like for instance the Moving Limits. In the frame of the EOS/ESD/NTF program, companies can take this one step further by teaming up with PCB module makers to reach even lower zero-defect targets.

In the frame of this cooperation the following points are addressed:

Development of EOS/ESD robust systems: Cooperation on EOS/ESD starts during the design phase in the form of module design and layout reviews.

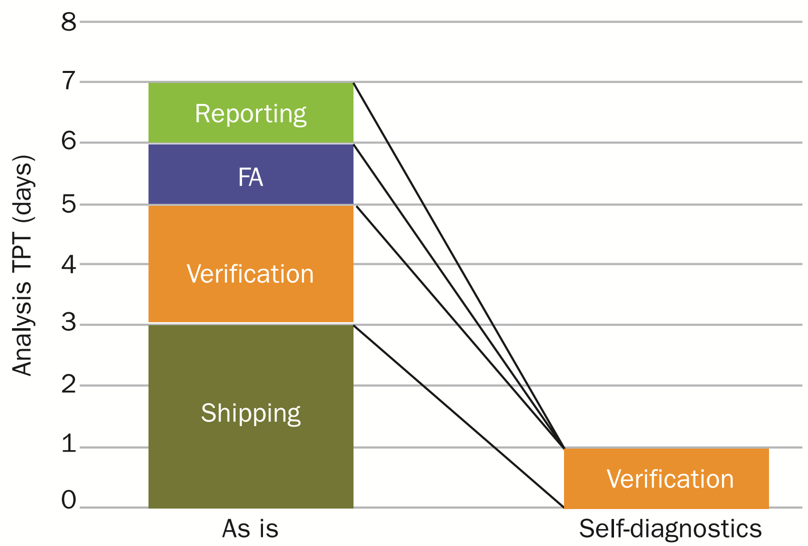
EOS/ESD is a failure mode that depends strongly on the design of the module. The latter should be able to resist all types of EOS, such as ESD (electrostatic discharge), EMI (electromagnetic interference), LU (latch-up), OVS (over-voltage stress), or any other type of electrical misuse [see Ref. 1]. These are aspects to be considered during design phase since the protection strategy and components have to be timely chosen.

Troubleshooting manufacturing facilities: Under this category are found EOS/ESD process capability investigations of customer manufacturing facilities. Although manufacturing facilities may be designed to follow the IEC61340 or S20.20 ESD recommendations, ESD control target levels have to continuously be updated (reducing trend) for the assembly facilities to be able to cope with (1) the continuous miniaturization of the IC manufacturing processes and (2) the increase of the package dimensions to accommodate more complex integrated systems [see Ref. 2].

Design for testability for EOS/ESD: Being able to verify whether a module has been pre-damaged during the module assembly process, specific leakage current tests can be included in the in-circuit test (ICT) or end-of-line test (EOLT) during module assembly. The data can then be used to perform advanced screening as, for instance, Part-Averaging-Testing (PAT) as recommended by the Automotive Industry Council (AEC) in the AEC-Q100 specification or Moving Limits, which is a more efficient technique.

Another similar but more thorough approach is to perform leakage tests at the beginning and then at the end of the test program. This allows better detection of damages introduced during testing itself. For the above tests to be implemented care has to be taken from the design phase of the module so that accessibility to the required module nodes can be guaranteed.

Fast and cost-effective rootcause analysis through self-diagnostics and failure signature comparison: An interesting property of EOS and ESD IC failure signatures is that they repeat themselves over time to a level such that they allow a significant statistical analysis to be performed. As an example, 90% of the EOS/ESD failures of a LIN transceiver during car manufacturing carried exactly the same electrical failure signature for a large number of car makers. Using this information, the electrical fingerprint of the failure can be used with very high confidence to recognize the failure mechanism easily al-



Rootcause analysis throughput-time is reduced by using "fingerprint" recognition.

ready at car manufacturing. The consequence is that the rootcause analysis throughput time seen by the car maker can be reduced from some weeks down to some hours (see below).

Rootcause analysis throughput-time is reduced by using "fingerprint" recognition.

No trouble found (NTF)

There are several possible rootcauses for having a technical-complaint classified as NTF. Many different situations can make the module fail but when the incriminated IC is tested separately, it looks to be good.

There are two very critical steps that should be followed to avoid this:

Failure isolation (FI): On a failing module containing sometimes hundreds of electronic components, one needs to isolate the electrically failing devices. Some examples of failure isolation techniques [see Ref. 3] are: In-circuit-test electrical verification, functional-test verification, visual inspection, X-ray, thermal imaging, Time Domain Reflectometry (TDR), impedance measurement, and curve tracing measurement. The purpose of these techniques is to pinpoint the electronic components in a system that are really failing electrically and not due to a global failure of the system. These devices should then be selected for further analysis.

Failure confirmation (FC): Once the actual failing devices are localized, a test called the ABA swap test is used as the ultimate verification for the failing device being at the origin of the system's failure. In an ABA swap test the suspected IC is removed from the failing module and is placed in a known-good module. If the failure follows, the IC is confirmed as valid failure. However, in practice some aspects of the ABA swap test make it unattractive for customers:

- Desoldering and resoldering the ICs to a known-good module requires the use of very tight soldering/desoldering guidelines and ESD precautions. The analyst worries that the IC may get damaged and the precious failure

information may be lost.
- The analyst worries that important failure mode information may disappear after the part has been submitted to soldering/desoldering.
- Reproducing the failure requires significant efforts from many disciplines and as the exact amount of time needed to reproduce the failure is not known, one is quickly brought in front of a dilemma: Complete the ABA preanalysis or send the part back to the supplier for a full analysis? Usually the second solution is followed; the part is shipped to the IC supplier for analysis.

However, statistical analysis shows that only 30% of the NTF cases were found to be real failures. The remaining 70% could not be confirmed by either the IC supplier or the PCB module maker upon return of the part. This example suggests that there is a lot of space for improving the pre-analysis of those components at the first place.

Improving pre-analysis

To facilitate customers in pre-analysis the following initiatives can be taken:

Make ABA swap test possible through the use of a socket: A known-good module of the customer is selected and a socket is placed on it, able to carry the IC being tested. When this IC is suspected to fail, it is desoldered and placed in the known-good module carrying the socket, enabling an IC test without resoldering. Note that the analyst does not need to have any knowledge of the IC.

Provide application specific test boards: Dedicated test boards are supplied to customer with appropriated on-site training to enable quick checks and measurements on suspected ICs. This enables a faster and easier characterization of the failure.

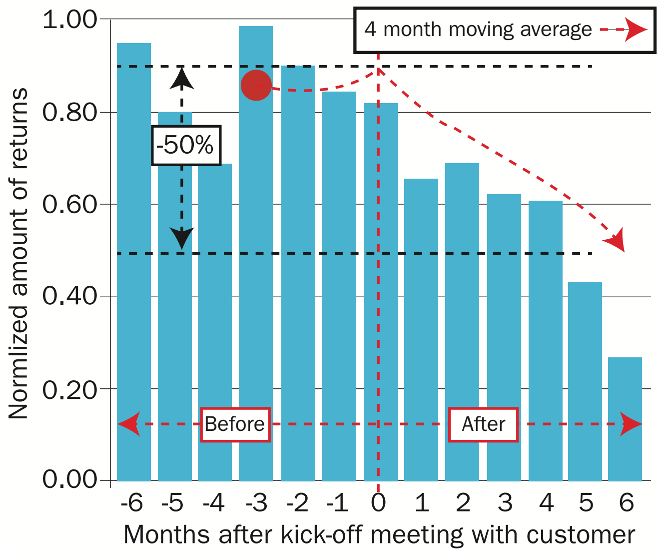
Provide automated I/V curve tracer: An automated curve-tracer traces the I/V characteristics of all the IC's pins with reference to the ground and compares them to the reference curve trace. This is a static test whose value lies in its simplicity. The user needs not have any knowledge of the product to be tested; the result of the comparison is given by means of a digital screen.

Perform accurate data collection: To improve failure conditions description and thus data collection quality, companies can develop product-family related failure description checklists.

Conclusions and results

Since the initial deployment of a dedicated EEN Program in 2008, NXP Semiconductors has seen consistent increases in customer coverage, reaching an average yearly EEN complaints reduction rate of 20% at PPM level.

Careful analysis of the program's effectiveness showed that for a group of 50 customers addressed during the period 2010-11, the amount of EEN related complaints were reduced by an average of at least 50% in the six months following the kick-off meeting (see chart to the right). However, the positive results of the program are not only be explained by the increase of awareness and technical knowledge among the participants, there is also a psychological component to acknowledge: by defining a common, ambitious, zero-defect goal both the IC supplier and PCB module maker feel committed into providing a timely and sustained solution to the addressed issues.



Decline in the 4-month moving average shows the efficacy of customer cooperation for permanently solving EOS/ESD/NTF issues.

(NXP Semiconductors)

Decline in the 4-month moving average shows the efficacy of customer cooperation for permanently solving EOS/ESD/NTF issues. (NXP Semiconductors)

References

1. White Paper "First-Mate-Last-Break grounding contacts in the automotive industry. A chance to reduce the number of failures in electronics," ZVEI - Zentralverband Elektrotechnik- und Elektronikindustrie e.V.

2. Industry Council White Paper II: A Case for Lowering Component Level CDM ESD Specifications and Requirements, (http://www.esda.org/documents/IndustryCouncilWhitePaper2.pdf)

3. Michael Lane "System Level Failure Analysis Process: Making failure analysis a value add proposition in today's high speed low cost PC environment," ASM International, 2004

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The authors are with the Zero-Defect EOS/ESD/NTF Customer Focus program from NXP Semiconductors.

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Engineering in 1994 and completed his MBA, Marketing Module, in 2001 at Kellogg University Chicago. He has many years of experience in operations and quality management, project and program management as well as in product and account management. He has been active on an international scale in various disciplines. Roger Habets was the head of NXP's Zero Defect Team on EOS/ESD/NTF in 2009 and 2010.

Yorgos Christoforou is senior quality assurance project manager with Automotive Business Unit at NXP Semiconductors. Since 2007 he has been managing a large portfolio of automotive customers with respect to EOS/ESD/NTF Quality Improvement. In 2012 he took over the responsibility of driving the quality improvement with overall NXP's strategic key-accounts. Yorgos holds a BSc on Information Technology from the University of Athens (Greece) and a PhD on Analog Design from the Universite Joseph Fourier de Grenoble (France). He has authored several articles in international conferences. His professional interests cover the areas of design, manufacturing, qualification and quality performance of integrated circuits. He is an active member of the ESD Association.

In 2011, project leader of Zero Defect EOS/ESD/NTF reduction program team within NXP, Khaled Terras has more than six years of field experience in supporting and collaborating with automotive customers especially in the area of quality and EOS/ESD/NTF complaint reduction. Khaled holds a master's degree in management and quality from Versailles Saint Quentin University and an engineering degree in electronics, computer science, and micro-waves from IFITEP school in Paris. ■

New BMW X6 gets lighting facelift

By Carolyn Mathas, EDN

The BMW X6 features LED taillights, Xenon headlghts, interior lighting and fog lights courtesy of automotive lighting and components company, HELLA. Intelligent battery sensors, rain and light sensors, and overhead control units were also supplied by HELLA. The Sports Activity Coupe was redesigned, replacing the horizontal light guide rods of the past with low profile light guides, giving the impression of floating light strips.

The tail lamp's light strip was created with a new manufacturing process. The process uses vibration welding with infrared preheating to attach the low profile light guides directly to the lens. Infrared provides a very clean and uniform welding connection. This represents the first redesign of the X6 since it was launched in 2008. ■

NXP Semiconductors logic in automotive applications

As a leading supplier of logic products to the automotive industry, NXP Semiconductors focuses on quality: quality of product, quality of supply and quality of support. Quality that is perfectly represented by our Q100 logic range – proven either by decades of reliable use in automotive applications or by exceeding the levels of reliability outlined in the automotive industry's AEC-Q100 standard. Amongst other things, this standard outlines:

- Rigorous stresses such as high temperature operating life (HTOL) and highly accelerated stress testing (HAST) that, when combined, simulate the aging of a device in an automotive environment
- Manufacturing practices to limit the potential for non-typical outlier products to be delivered to automotive customers NXP's logic products are used in a wide variety of automotive applications including instrument clusters, body control modules and engine control units.

I/O expansion

Input and output (I/O) expansion devices such as analog and digital multiplexers are used extensively to reduce the complexity, pin count and ultimately cost of any microcontroller based solution. The sensor interface of a gasoline engine control unit, shown in **figure 1**, is often an analog multiplexer function such as the 4051. It selects one of eight inputs to be passed to the single output. Using such a device enables eight analog sensors to be interfaced sequentially to a single analog to digital converter (ADC) of a microcontroller. Important parameters to consider when selecting an analog multiplexer are the ON resistance, variation of ON resistance with input voltage, or ON resistance flatness, and the ON-state leakage current. The ON resistance determines how much the sensed signal is attenuated. Any variation of ON resistance with input voltage will lead to signal distortion while high ON-state leakage will result in additional signal loss. The combined effect of these parameters on the sensed signal determines the required accuracy of the microcontroller's ADC.

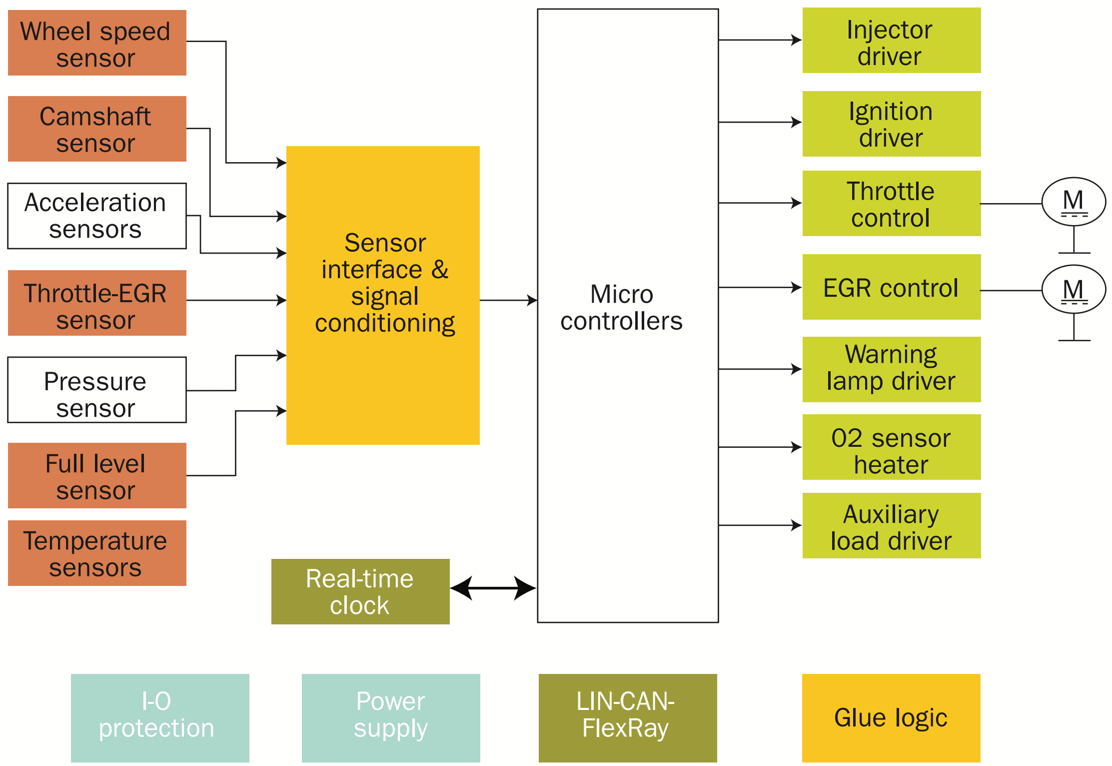


Figure 1 Gasoline engine control unit block diagram

NXP's 5 V range of 8:1 analog multiplexers includes the 74HC4051-Q100 and 74HC4851-Q100. The 74HC4051-Q100 has 4 μA maximum ON-state leakage current at 125 C and the RON v VIS characteristic shown in **figure 2**. This results in 0.04% total harmonic distortion (THD). The 74HC4851-Q100 has a similar RON v VIS characteristic to that of the 74HC4051-Q100, but only 1 μA ON-state leakage current at 125 C. It also has an added injection current control feature which enables the user to apply signals of amplitude greater than the supply voltage to the switch terminals.

NXP's next generation 3.3 V range of 8:1 analog multiplexers includes the NX3L4051-Q100. This has 2 μA maximum ON-state leakage current at 125 C, and the combination of the sub 1 ohm ON resistance and sub 0.35 ohm ON resistance flatness leads to a typical THD of just 0.02%. The 74HC4051-Q100, 74HC4851-Q100 and NX3L4051-Q100 are all available in the industry standard 16-pin TSSOP package as well as NXP's innovative smaller footprint leadless DHQFN and HXQFN packages.

Display drivers

Display drivers integrate serial-in parallel-out shift registers, which are common

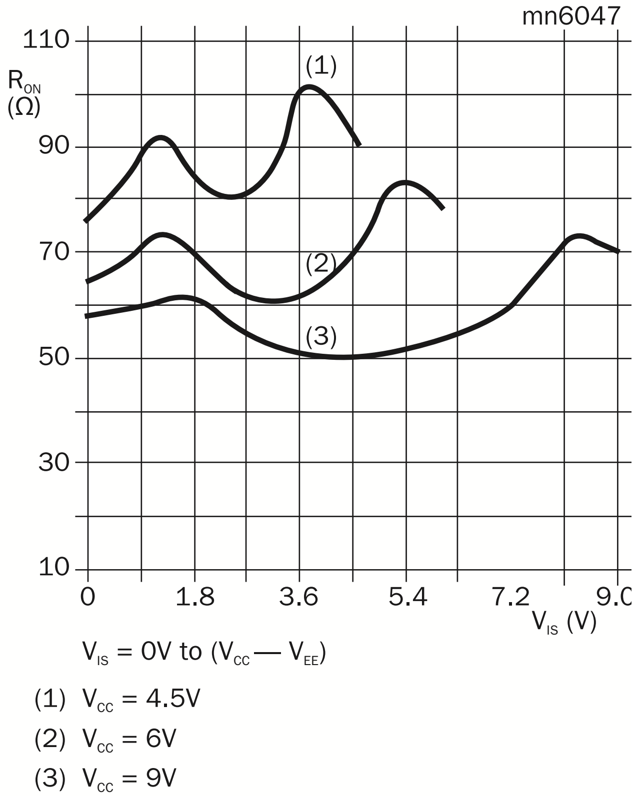


Figure 2 RON v VIS 74HC4051

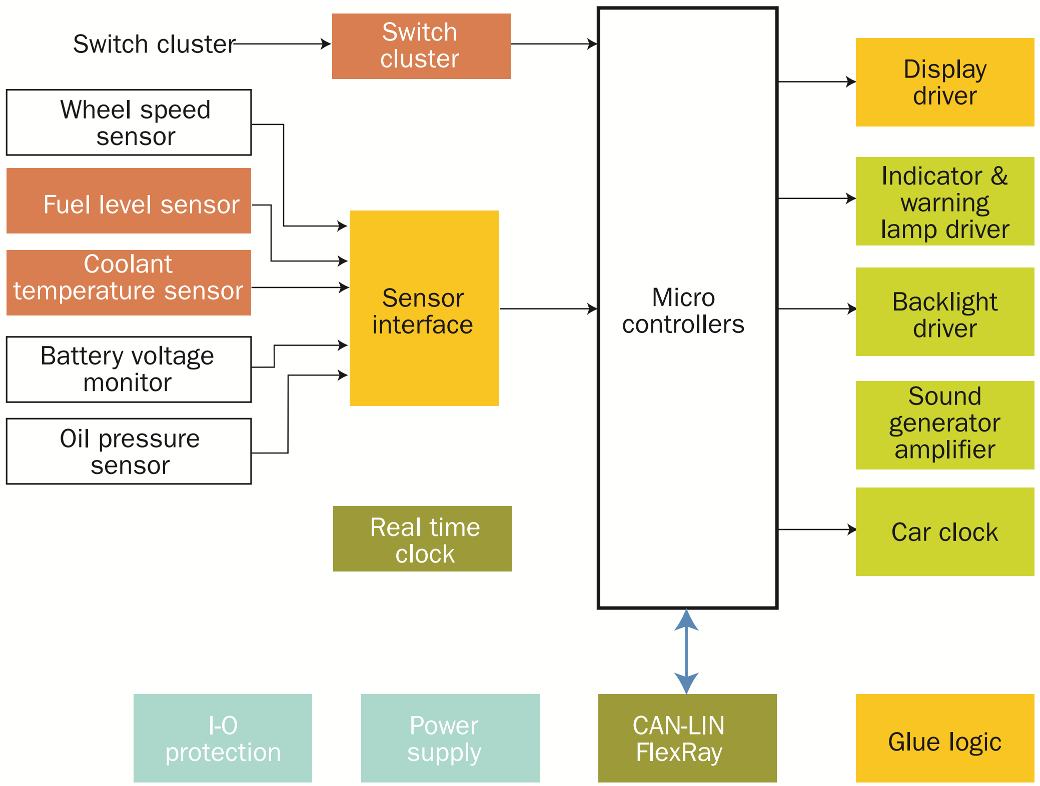


Figure 3 Instrument cluster block diagram

I/O expansion devices, with MOSFET LED drivers. They reduce the size, complexity, pin count and ultimately cost of any microcontroller based solution. The display driver shown in the instrument cluster block diagram in **figure 3** is often a logic LED driver such as the 596 or 4894 functions. They allow the microcontroller to enter 8-bit data serially using just two of its I/O pins – one connected to the input clock, the other connected to the serial input. Once the 8-bit data has been loaded into the LED driver's shift register a third microcontroller I/O pin is used to clock the 8-bits to the open-drain outputs which drive the LEDs. Logic display drivers include serial outputs which allow the cascading of devices as shown in figure 4. The result is that three microcontroller I/O pins can be used to control 16-bit, 24-bit or even higher bit width solutions. As well as bit width, important parameters to consider when selecting a display driver are output current drive and output voltage rating. They determine the suitability of the device for the given display, be it a grid or panel, seven-segment or single indicator.

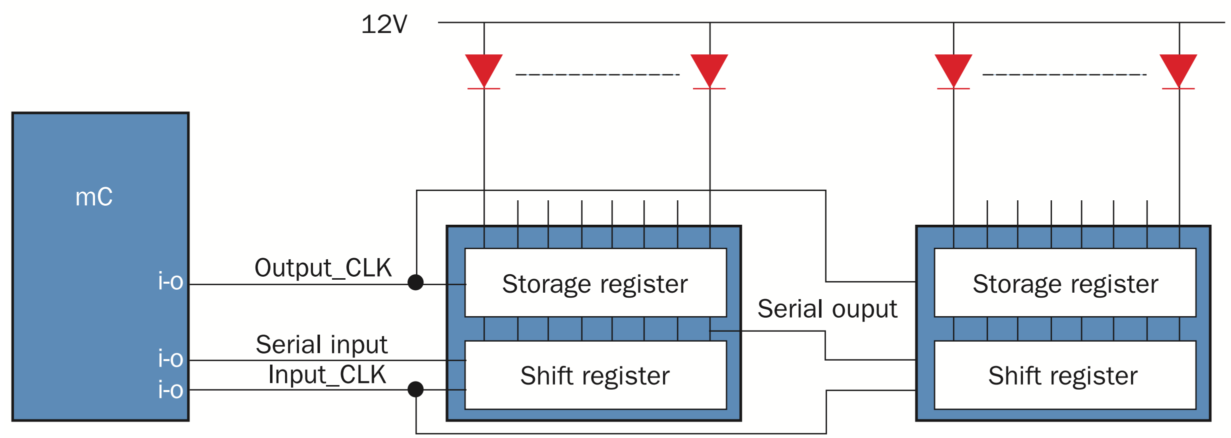


Figure 4 Cascading of 8-bit display drivers

NXP's range of shift register based, open drain output display drivers includes the HEF4894-Q100. It combines a 12-bit shift register with 15 V / 40 mA open-drain outputs. A wide 5 V to 15 V supply range allows it to interface to standard 5 V microcontrollers. For higher current applications NXP has introduced the NPIC6C596-Q100, 8-bit shift register with 33 V / 100 mA open drain outputs which also maintains the standard 5 V control interface. Both devices are available in the industry standard SO and TSSOP packages, while the NPIC6C596-Q100 is also available in NXP's innovative smaller footprint leadless DQFN package.

Buffers, line drivers

Buffers and line drivers are used when the output drive capability of a microcontroller is not sufficient to drive the output load. They reduce the size and ultimately cost of any microcontroller based solution. The body control module demux drivers shown in **figure 5** often use a logic line driver such as the 244, 573 or 125 functions. They provide the higher output drive capability that allows the body control module to drive pumps for wiper/washer control, or motors for power window control. In some cases body control modules use multiple line driver circuits. If all these outputs are switched at the same time, it may result in high EMI and system instability due to the high output drive. To avoid this latched drivers are used. In latched drivers the output only changes on a HIGH to LOW transition of the LE (Latch Enable) input, as a result the microcontroller can sequentially enable each driver, or combination of drivers, to reduce EMI. The most important parameter to consider when selecting a buffer-line driver is output drive, which can be used together with the supply voltage to determine if the resultant output voltage will be sufficient to switch the target load.

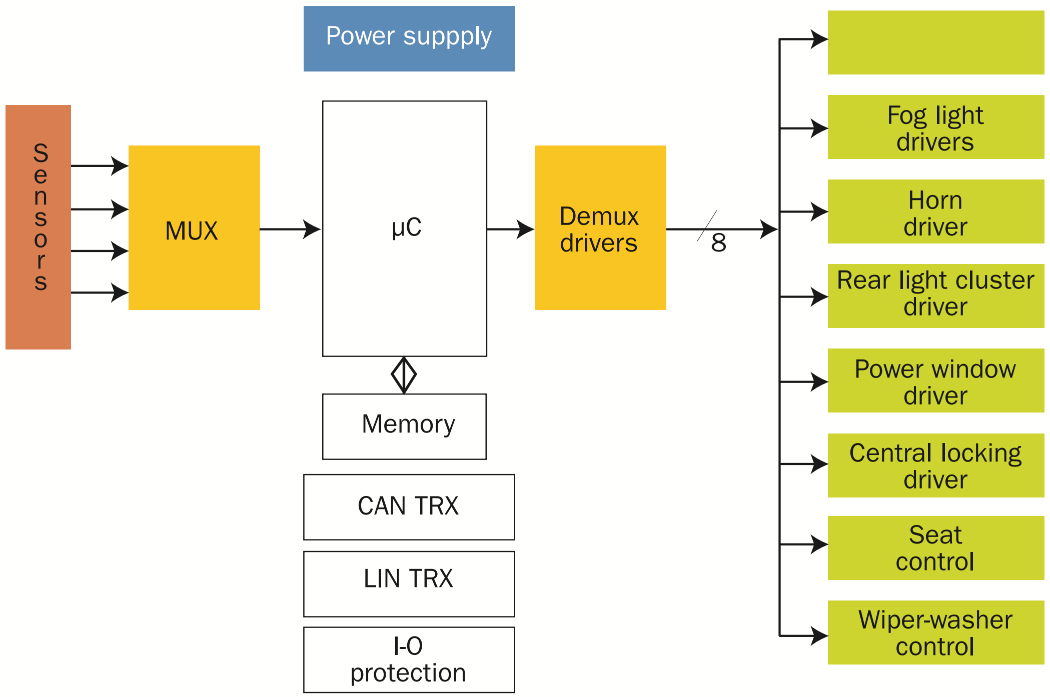


Figure 5 Body control module block diagram

NXP's range of buffers / line drivers includes the 74AHCT244-Q100, 74HC573-Q100 and 74LVC1G125-Q100. The 74AHCT244-Q100 is an 8-bit solution for 5 V applications and has 8 mA drive capability. Also with 8 mA drive at 5 V supply, the 74HC573-Q100 is an 8-bit latched solution for 3.3 V and 5.0 V applications that use multiple devices. It has the additional advantage of having flow through architecture (data inputs opposite data outputs), allowing for easier board layout. For lower voltage, higher drive applications the LVC family can be used. The 74LVC1G125-Q100 is a single driver solution for 1.65 V to 5.5 V applications, with an output drive of 24 mA at 3.3 V and 32 mA at 5.5 V.

8-bit solutions such as the 74AHCT244-Q100 and 74HC573-Q100 can be found in the industry standard SO and TSSOP packages as well as NXP's innovative DQFN leadless package. Single bit solutions such as the 74LVC1G125-Q100 can be found in the industry standard TSSOP5 package as well as NXP's innovative leadless HSON6 package. ■

For more information see:

http://www.nxp.com/products/automotive/logic/analog_switches/

http://www.nxp.com/products/automotive/logic/shift_registers/

http://www.nxp.com/products/automotive/logic/buffers_inverters_drivers/#overview

http://www.nxp.com/products/automotive/logic/latches_registered_drivers/

USB hub and card reader applications in the automobile

By Henry Muyshondt, SMSC

USB and flash memory cards have become ubiquitous in the consumer and industrial worlds. USB implements a high speed serial bus that runs at up to 480 Mbps. Many operating systems provide native support for this technology with many hundreds of millions of devices shipped to date.

But USB is not only used to transfer data between devices, it also provides a means to charge portable devices. As consumers expand their digital lifestyle to have their content always available, more and more devices take advantage of the economies of scale afforded by the explosion of interconnections that ensue. Car makers are embracing this trend as their vehicles integrate into the digital world.

Vehicles are also becoming storehouses of content and information. They can include large amounts of storage capacity for entertainment content and navigation information. One of the most popular memory formats today is Secure Digital (SD). The SD interface is also used in embedded applications to attach devices like WiFi (or WLAN), Bluetooth transceivers, and GPS receivers with an SDIO interface. SD memory can be used to replace rotating media like hard disks, CD and DVD media. A state of the art 32-GB card holds the equivalent of close to 7 DVDs! Car makers can use memory cards both as a connection to consumers and as a mechanism to upgrade different systems within the vehicle, be they navigation systems or any other devices that require software.

The USB and Flash media interfaces are thus very useful in automotive applications. For this purpose, SMSC recently introduced the TrueAuto Quality USB82640 and USB82660 USB hub and card reader combination products, specifically designed for the stringent requirements of the automotive environment.

Automotive quality requirements

Before getting into the specific functions of the interfaces, let's first consider automotive quality requirements. Devices intended for the automotive market have to be designed, validated, characterized, qualified, fabricated and supported specifically for use in automotive applications. Cars have very long lifecycles and any failure in the field is very costly in terms of repair time and customer satisfaction.

TrueAuto is SMSC's proven automotive quality process. When integrated circuits initially designed for consumer applications, are used in automotive applications, they have to be qualified according to the Automotive Electronics Council's qualification requirements (AEC-Q100). This standard, however, only covers minimum common requirements for the qualification of an automotive IC. Many car companies and tier one automotive suppliers require extensive additional qualification tests, as AEC-Q100 alone does not lead to the ultra-low defect rates that they require. In addition, AEC-Q100 primarily focuses on the qualification phase of the product cycle of an IC. Other phases such as the design and production of the IC, customer support and the handling and investigation of returns are not covered in detail. In order to reach the automotive goal of near zero defect rates, all phases of the IC product cycle need to be addressed thoroughly. TrueAuto robustness begins with SMSC's design for reliability techniques within the silicon IC itself.

Automotive-grade excellence and testability are designed into the IC. The IC is fully characterized over many operating parameters to prove the quality of the design under various conditions. What's more, product qualification is focused on the most demanding customer expectations and meets or exceeds automotive reliability standards and customer specific requirements.

Memory for storage

Portable memory cards are used by passengers to transfer information created on computers, portable media players or cameras into the car. Car makers also incorporate gigabytes of microcode into some of today's most sophisticated vehicles. Storage is also required for navigation systems' map data.

Maps for a large country, like the United States, can fit in under 2GB of memory. An SD card of this size can be purchased at retail for less than $5.00, making it very cost effective compared to the typical DVD player used in many automotive navigation systems. In addition, reliability is increased as there are no moving parts associated with it.

The high speed data transfer enabled by an SD interface can simplify software updates for other components in the car, like a head unit. Yet these in-box use cases must provide data access with true automotive-grade reliability, whether the memory devices connect to internal peripherals or provide external consumer access.

This is an excerpt of an article that appeared in Electronic Engineering Times Europe, February 2011. You can download the complete article in PDF format. ■

Challenges in automotive radio design

By Harald Koch , EE Times

Fueled by the growth of new technologies, consumer expectations for automotive entertainment are growing rapidly. Entertainment electronics from the home have found their way into the vehicle, merging with car-specific functions such as navigation, hands-free phone control, and telematics. The new term "infotainment" describes the complete ecosystem of electronic devices for information and entertainment inside the automobile. Audio and video devices, as well as navigation systems and telematics, are merging into single, fully-integrated systems, which naturally creates new challenges for system designers.

Much of the responsibility for the quality of the infotainment system rests with the in-car radio. Along with the reception of real-time audio and video programming, the playback of stored content also adds to the complexity of an in-dash receiver. Bulky CD drives (which require quite a bit of space) have long been considered a standard feature in cars. However, accommodations for flash memory in the form of SD-cards and memory sticks is also becoming quite common, supporting the trend in infotainment to integrate external devices. In addition, customers now expect high-end car entertainment systems to provide interfaces and support for phones, audio/video players and external memory of any kind. The industry-standard USB interface is making great market headway, while a growing number of infotainment systems also integrate Bluetooth and wireless local area network (WLAN) connections.

Apart from physical connections, the radio head unit also has to offer audio decoding capabilities, drivers, and a suitable user interface for media playback/integration. All of these functions result in complicated car infotainment systems and subsystems that require significant software and hardware effort.

Despite all of these new features, automotive entertainment still centers on the traditional AM/FM receiver. Thanks to technological breakthroughs such as new integrated circuits, filters, amplifiers, and antenna designs, sound quality has improved with each new generation of receiver. Broadcasting technology itself has also been upgraded through the Radio Data System (RDS) extension, which offers specialized features for mobile receivers.

In comparison to analog radio, terrestrial digital broadcasting systems, such as digital audio broadcasting (DAB), HD-Radio, Digital Radio Mondiale (DRM), and satellite radio, offer a suite of attractive advantages, although they are still striving to achieve mainstream customer awareness and high-volume market success. Each of these digital standards requires very specific hardware to receive and decode the audio data.

Design, quality challenges

Traditionally, including more radio functions has required additional hardware. As a result, available space within the automotive radio-head unit has effectively disappeared. The compact nature of the electronics has also caused power consumption and heat dissipation problems. For complex radios, active cooling is mandatory to stay within a safe operating temperature range. Exceeding that limit may result in performance degradation or playback dropouts, as well as increased stress on the entire system.

Because of the expected long lifetime of a car and the rather extreme automotive operating conditions, OEMs are demanding a very high level of quality and reliability for the automotive infotainment system. As a result, the components, especially the integrated circuits, have to demonstrate that they can withstand the changing temperatures, vibrations, and humidity that they will face over the lifetime of a car. For the automotive industry, it is mandatory to qualify a part according to the common AEC-Q100 standard, which was developed by major automotive car manufacturers. Parts that were originally developed for consumer applications often fail to fulfill these requirements, and are typically eliminated early in the selection process.

The close proximity of electronic systems within the radio-head unit can cause interference and electromagnetic compatibility (EMC) issues, which can result in serious performance problems. This is especially true for sensitive analog building blocks such as the receiver front end and signal lines. Designers must work carefully, using shielding and rigorous testing, to verify that the effects of EMC and interference can be controlled.

Cost is also a major design factor, and the need to minimize cost is passed throughout the entire supply chain. OEMs not only need to consider the price of the components when doing economic calculations, but also the development time for the design-in and debugging of the system. It is critical to avoid errors that come up in late project stages, so OEMs typically rely on proven vendors with a history of reliable parts that have already been used in the automotive industry.

RF challenges

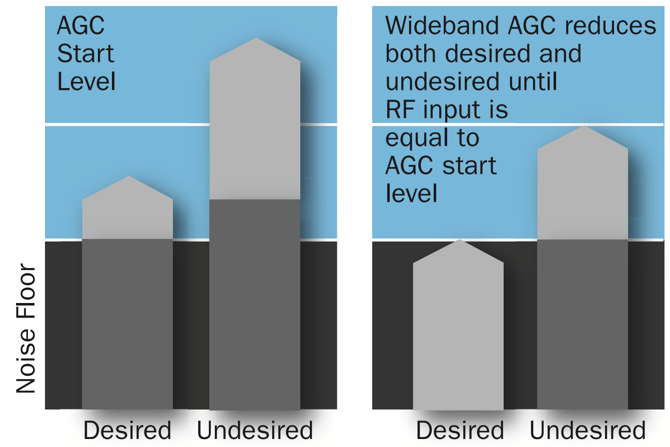
Improvements in car-radio reception over the last decade can be attributed to the introduction of digital signal processing (DSP). However, the fact remains that an analog receiver front end is required to amplify and down convert the radio-frequency (RF) signal and apply basic filtering before the signal is converted to a digital one. Despite the addition of DSP, the efficiency of the entire infotainment system still depends on the quality of the analog receiver. For several reasons, the RF requirements for automotive applications are significantly more demanding than those for stationary radios.

Dynamic Signal Behavior " Automatic Gain Control (AGC)

Receiving conditions for an automotive radio range from extremely low-level signals (such as when passing under a bridge) to absolute maximum peaks (while passing by a roadside transmitter). In the first situation, the sound quality depends heavily on the performance of the antenna as well as on the ability of the receiver to separate and pick up weak signals. Since automotive antenna systems are designed to fit the trim of the car rather than the performance expectations of the customers, the need for a high-quality receiver increases. At the other end of the dynamic range, the receiver also needs a mechanism to protect the input stage from too much signal, preventing what is often referred to as "overload." The mechanism of choice for this function is automatic gain control (AGC), which is effectively a closed-loop circuit that senses the signal strength and attenuates (reduces) the input signal when necessary. A receiver that can detect and successfully handle signals that are transmitting at extremely low as well as very high power levels is said to have good dynamic range.

Blocking

The presence of strong undesired channels (which is common in many urban areas) can be a major problem for quality radio reception in a car. To avoid overload and distortion, all of the incoming signals can be attenuated by AGC circuitry. However, as a result, the desired channel might then be lower than the overall noise floor (see graphic) which results in dropouts, hisses, and cracks in the AM/FM reception.



Optimally, the receiver's input stages should be designed to tolerate and manage large signals, which minimizes the need to use the AGC circuits. When a receiver is well-designed, it is not overly dependent on its AGC circuitry, and these problems can be avoided. Strong neighboring channels can be filtered out at a later point much more effectively, and without negative impact on the desired channel.

To address this problem, some silicon receiver manufacturers have developed filtering technologies that immediately reject strong undesired channels. Using this additional technology can result in a noticeable improvement in signal robustness for automotive radios.

Multipath interference

Radio waves reflect off of obstacles, like buildings or mountains, so that the same signal arrives at the antenna from different directions with different time delays and different intensities. These signals interfere with each other, making it hard to receive a desired signal. It is even possible that the signals overlay each other in a phase-reversed orientation, completely cancelling out the signal on that frequency. Any signal degradation due to this phenomenon is known as multipath interference, and it is a significant concern in automotive applications where the receiving environment changes continuously.

A good way to deal with multipath interference (also known as frequency selective fading) is to add a diversity function to the system. In an antenna diversity system, the signals are received at multiple antennas, which increases the probability that at least one antenna has good reception.

Temperature drift

A major difference between the consumer electronics and automotive markets is the variations in temperature experienced by the receiver. An automotive receiver needs to maintain its performance at very high and very low temperatures. If a receiver cannot do that, it was likely designed for use in low-cost consumer devices. For an automotive receiver, the most critical performance indicators like sensitivity, selectivity, and noise figure need to be guaranteed and proven across -40°C to +85°C to handle the climatic conditions of most countries in the world. (Note that the heat dissipation of other hardware in the radio unit also adds to the temperature.)

Summary

Next-generation automotive radio platforms pose new challenges to both OEMs and suppliers. The rapidly accelerating technologies represented by current infotainment systems require robust product design followed by thorough product qualification.

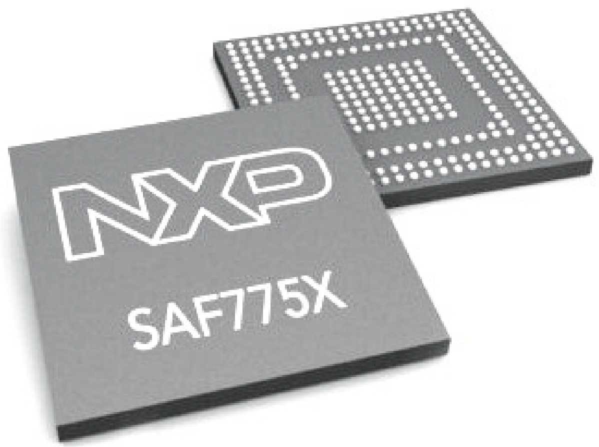
An automotive infotainment system requires a high-quality, reliable receiver that not only offers seamless integration and supports the functionality of a wide variety of new infotainment systems, but also satisfies the vigorous demands of the unique automotive RF environment.

—Harald Koch is automotive marketing manager at Microtune Inc

Two radio tuners integrated on single chip enable compact car radios

By Christoph Hammerschmidt, EE Times Europe

A few years ago, NXP introduced FM dual-tuner phase diversity in car radio applications, using two tuners for better reception. However, up until now, both tuners were separate devices, external to the DSP chip. This separation was required to avoid interference and because different process technologies were used for analog RF tuners and digital signal processing technologies. With the in-



NXP Semiconductors introduced a combined car radio and audio system fully integrated on a single IC. The SAF775x is the third generation of NXP's popular car radio and audio DSP product family and is the industry's first single-chip multi-tuner RFCMOS IC with embedded AM, FM, and DAB tuners. With improved audio processing power, the new product achieves excellent reception and performance. At the same time, the SAF775x helps to significantly lower system costs via a reduced bill of materials.

troduction of the SAF775x, NXP once again managed to set a new milestone in radio processing, by integrating two independent tuners onto a single die and creating a much more compact solution to significantly lower system cost. This integrated dual-tuner device offers more than twice the processing power of previous generations, enabling superior radio performance and better all-round reception quality.

Another aspect of the SAF775x is its open programmability. The IC includes an 'open' Tensilica HiFi 2 Audio DSP for customers to program their own features, or to run those of third-party software vendors. This gives car radio manufacturers the choice and flexibility to differentiate their car infotainment solutions without resorting to expensive external ICs. Automotive tier one Visteon works closely with NXP throughout silicon development to ensure early adoption of NXP tuner and DSP technology.

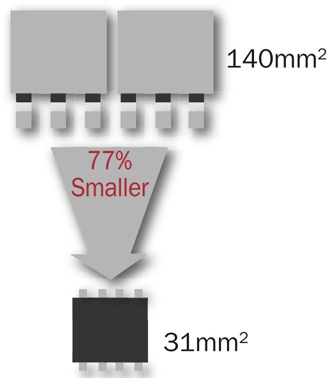
Advanced audio processing is another benefit that the new SAF775x brings to the market. Customers may wish to use the HiFi 2 Audio DSP for audio processing from third party vendors such as Arkamys or AM3D. Another innovative application that can run on this HiFi 2 Audio DSP is active noise cancellation of engine sound: uncomfortable harmonics interfering with music playback and the general driving experience are removed by means of audio software processing. In combination with 3rd party software, the SAF775x offers an inexpensive way of damping the unwanted noise and replicating the desirable engine sound. ■

For more information visit *www.nxp.com.*

Automotive qualified dual power-SO8 MOSFETs offers 77 percent smaller footprint than DPAK solution

By Paul Buckley, EE Times Europe

Fully AEC-Q101 qualified, the NXP LFPAK56D range offers best-in-class performance and reliability, while delivering a 77 percent smaller footprint than the equivalent DPAK solution which typically requires two devices. The LFPAK56D range is in volume production and is available immediately.



NXP Semiconductors N.V. has introduced the LFPAK56D portfolio which is a range of dual Power-SO8 MOSFETs specifically designed for automotive applications such as fuel injection, ABS and stability control.

LFPAK56D combines two fully isolated MOSFETs into a single package designed to meet the rigorous requirements of the automotive industry. With the industry's widest range of RDSon values across five voltage grades, it provides the best performance, current handling and reliability on the market. The new range of dual Power-SO8 MOSFETs offers customers complete flexibility and freedom to pick the device that best matches the application and module requirements, while also achieving a much higher power density.

Designing with LFPAK56D lowers costs through simpler PCB assembly, ease of inspection and shrinking module size. Smaller modules also means a significant saving in weight, which is particularly attractive to manufacturers focused on reducing CO_2 emissions.

Building on NXP's expertise in LFPAK56, which was the first power-SO8 package on the market fully qualified to AEC-Q101, NXP is now introducing the same reliable 'copper clip' bonding technology to dual Power-SO8 MOSFETs in LFPAK56D. This copper clip technology is what gives the package its advantage in low package resistance, inductance and high maximum ID rating. ■

More information about the LFPAK56D power MOSFET at *www.nxp.com/LFPAK56D*

How hybrid electric vehicles can pay off

By Dr. Edward Lovelace, XL HYBRIDS

This past year has seen the U.S. surpass 388,000 alternative vehicles sold representing 3 percent of new car sales and average market growth of 35 percent per year since 2001. Back then, the only hybrid electric vehicle (HEV) with annual sales over 10,000 was the Toyota Prius, which was first introduced in 1997[1]. While other alternatives have emerged, including plug-in hybrids (PHEV) and the extended range electric vehicle (EREV) subset, full electrics (EVs), hydraulic hybrids in the commercial vehicle sector, and other alternative fuel combustion engine vehicles; hybrids remain the predominant alternative option with the Prius selling more than100,000 vehicles per year over the last seven years, reaching a cumulative total of more than1,000,000 vehicles in 2011.[2]

As in previous years, several news reports have questioned and examined the value and future of HEVs. Now, as the U.S. enters the second decade of HEV sales, the question is still examined:

"Why do people buy a hybrid vehicle?"

According to the New York Times research compiled by TrueCars.com, only two HEV models (and one diesel) have a fuel and maintenance savings payback for the incremental cost of the alternative powertrain technologies within a five- to ten-year period at current and recent historical high gas prices.3 Furthermore, payback is dependent on incentives including the federal tax credit up to $7,500.

These analyses are simplified by assumptions about the conventional vehicle purchase choice that consumers are comparing, which is often not the same vehicle in a non-hybridized option (e.g. your purchase choice may not be between a Chevy Cruze and Volt). But there is some evidence that with the current offerings, the market will begin to level off as early adopters, technology enthusiasts, green purchasers, and those with more complex return on investment assumptions become saturated as indicated by recent market studies suggesting only 35 percent of HEV owners are purchasing another HEV for their next vehicle.4

Moving forward

To continue growth of the alternative
vehicle market some of the strategies that may be considered include:

- Attempting to increase the appeal of the "alternative fuel" segment (e.g. who really needed thousands of songs in their pocket a decade ago, but there's no denying how much people want that now)
- Driving down the cost of the incremental technology
- Focusing on sectors and technology solutions that maximize the financial payback.

The rest of this article will focus on the financial payback aspect, and the technology and application forces that are driving financial payback in some HEV sectors.

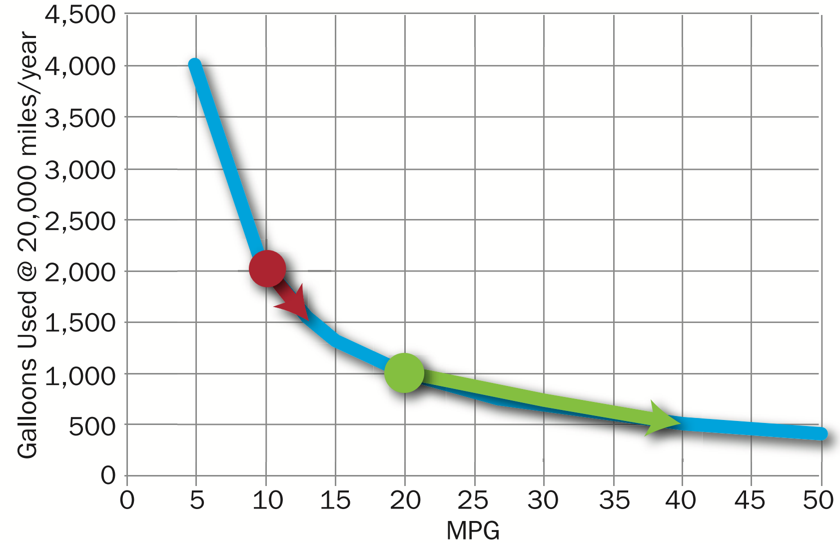


Figure 1. Mpg improvements needed for the same fuel consumption reduction from different baseline mpgs.

Financial payback and baseline MPG

Financial payback for the incremental cost of an HEV is primarily driven by a reduction in fuel costs. In the case of

HEVs, the fuel costs are just the gasoline costs, while electricity costs should be factored in if using a PHEV, EREV or EV. So obviously payback will be function of miles traveled per year and miles per gallon fuel economy of the conventional comparison vehicle. Consider an mpg-versus-fuel-used-per-year graph at 20,000 miles/year representing a high mileage application. It is evident that to save an equivalent 500 gallons on a 10-mpg vehicle the HEV fuel economy must be 13.3 mpg, whereas to save the same 500 gallons versus a 20-mpg conventional vehicle the fuel economy must be doubled to 40 mpg.

Relevance to fleets

This type of comparison is particularly relevant to fleet operations. In fleet operations several drivers are at work: specific services need to be performed by the fleet, fuel costs are a bottom line profit margin driver for the business, and interruptions or changes to fleet operations can negatively impact costs. For these reasons, fleet managers typically focus on the purchase of the minimum number of different vehicle models to satisfy the business needs. Increasing the volume purchases of each vehicle type and reducing the variety typically improves the cost efficiency of maintenance, operation and purchasing for fleets. Naturally when considering developing a "greener" fleet, managers prefer to look for a cleaner, more fuel-efficient version of the vehicles they are already using that serves business needs, that the field personnel are familiar with, and that can provide a reasonable financial payback. Taking into account the previous discussion, one strategy of fleet managers is to begin by focusing on their lower mpg vehicles with the highest annual mileage usage. These will have larger fuel cost reductions for the same percentage mpg improvement (or conversely for the same fuel cost reduction they will need a lower percentage mpg improvement).

Right battery pack size

From a technology perspective, the electric powertrain components that enable fuel usage reduction in an HEV are, at their most basic, an energy storage battery, a traction motor and a motor drive that controls the power flow from the battery to the motor and subsequently the vehicle driveshaft during acceleration, and then controls power flow back to the battery during deceleration. There exists now, as the industry has expanded, a wide array of HEV powertrain solutions with multiple motor/generators, clutches, gears and belts, and electrical power converters but in the end, they are primarily putting energy towards the driven wheels to reduce the energy required from the combustion engine.5

Given the basic HEV elements, there are two key modes of operation with reference to the battery pack and the energy stored in it: charge depleting and charge sustaining. In a charge depleting controller, the battery energy is incrementally drained during operation with the expectation that the battery will be recharged externally. This is the primary operating scenario for PHEVs, EREVs and of course, EVs. HEVs, by contrast, without the external charging plug, operate in charge sustaining mode where the electric energy depleted from the battery to contribute to propulsion is managed so that regenerative energy returned to the battery during braking is sufficient to maintain the battery state of charge (SOC) within an acceptable band dictated by battery life concerns.

The follow-on design question is then how to size the battery pack for fuel consumption payback. Cost studies including a 2012 report6 from the U.C. Davis, Institute for Transportation Studies, support previous works that the initial battery energy transfer during hybrid operation is the best utilized in terms of fuel consumption reduction. Increasing battery size does reduce fuel consumption but at a lower rate increasing payback. In comparing HEV, PHEV-20 (PHEVs with a 20-mile electric range), PHEV-40, and EVs the study showed the lowest breakeven gasoline fuel price was achieved with the HEV utilizing only a 1 kWh battery pack.

Today, at these current battery costs and with careful design-to-value minimizing complexity and battery ratings, there is real opportunity to introduce HEVs to replace conventional high mileage, low mpg, commercial class vehicles and achieve payback that are not dependent on government incentives. In addition to the fuel consumption reduction simply from the HEV power transfer to and from the driveshaft, payback may also be reduced by other secondary factors such as reduced brake wear and the potential for downsized gasoline engine selection.

There are of course many other design considerations in HEV powertrain design and matching with the best vehicle applications, but fuel consumption payback is a significant criterion with some of the key issues and trends discussed above. These payback trends will all certainly reduce as battery energy costs continue to decrease from above $1000 per kWh price point (for small HEV packs) to below $300 per kWh (for larger EV packs in future years). ■

Dr. Edward Lovelace is the chief technology officer of XL Hybrids. He has 23 years of leadership experience in electric power

conversion technology and product development. He is the former CTO and executive vice president of engineering at Free Flow Power, a renewable generation project development company focused on hydropower. Ed has also been director of engineering development at Satcon, a leading U.S. alternative energy electric power conversion company, and prior to that was with the General Electric Aircraft Engine business. He has a Bachelor of Science and a Master of Science in mechanical engineering, and a Master of Science and doctorate in electrical engineering from MIT.

Notes:

1 HybridCARS, *"Hybrid Monthly Dashboard,"* 2006 – 2012.

2 Toyota Motor Corporation, annual sales data.

3 *"Payoff for Efficient Cars Takes Years,"* by Nick Bunkley (based on TrueCars.com analysis), New York Times April 4, 2012

4 *"Only 35 Percent of Hybrid Owners Buying Hybrids Again,"* Polk market survey, April 9, 2012.

5 Miller, John, *"Propulsions Systems for Hybrid Vehicles,"* 2004, pp. 53-90

6 UC Davis – ITS, *"Energy Saving and Cost Projections for Advanced Hybrid, Battery Electric, and Fuel Cell Vehicles in 2015-2030,"* UCD-ITS