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ON THE COVER

Airbus Helicopters will provide four additional H225M multirole utility helicopters to the Royal Thai Air Force (RTAF) as part of their fleet strengthening program. Specially equipped with emergency flotation gear, fast roping, cargo sling, search light and electro-optical systems, these new multirole helicopters will be used for combat search and rescue missions, search and rescue flights, and troop transport operations. To learn more, read the applications brief on page 38.

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Figure 1. Commercial-grade OpenVPX chassis are commonly used for benign-environment defense applications and for prototyping. With powerful reverse-impeller blowers directly above the card guide, there is efficient cooling for even the hottest OpenVPX cards.

Ruggedizing Commercial-Grade Computers into MIL-Hardened Systems

As performance capabilities for embedded computing products expand, the requirements for commercial-grade and MIL ruggedized systems blur into similar specifications. There are increasing demands to take feature-rich, successful industrial/commercial enclosure systems into MIL or other harsh environment applications. Similarly, engineers are designing up-front computing platforms that they can expand into harsher environments.

Preparing for Rugged Design During Commercial Chassis Development

It would be easy if the same system platform could be used in both commercial and MIL applications. One would just design and build one system and be done. Of course, the requirements for hardened designs are significantly costlier, thus not practical in most commercial applications. The rugged chassis platforms need to survive extreme temperatures, shock and vibration, EMI susceptibility, and more. Therefore, many engineers are starting with commercial-grade chassis platforms in the backplane architecture that meets both requirements.

OpenVPX is widely used in ruggedized designs and offers high-performance across the board. One such example is a design that started with an air-cooled enclosure for 3U OpenVPX boards. To keep power uniformity, the designer utilized VITA 62 power supplies in the commercial version. These power supplies can meet the harsh environments for avionics applications. The VITA 62 cards meet MIL-461 for EMI, MIL-810 for shock/vibration/environmental and MIL-704 for aircraft power. These PSUs were utilized in this enclosure by employing card guides that are designed to accept conduction-cooled boards. These card guides allow OpenVPX boards that are conduction-cooled to be used in the air-cooled system. This is advantageous during prototyping, where you may need to mix-and-match module types. Further, by employing a DC PSU in the commercial version, the designer was able to keep the same type of PSU for the rugged version.

The 9-slot backplanes featured some VITA 67 slots for RF. By only having the cutouts for the VITA 67 slots, the designer was able to keep flexibility during prototyping and for various end-customer requirements. The housings/con-

Figure 2. For ruggedized versions of the enclosures, thicker extrusion rails with double screws can be used. They are also commonly used in commercial-grade chassis to prevent bowing from the extreme insertion forces of 6U OpenVPX boards.

tacts could be filled in as required by the application.

When RTM (Rear Transition Module) slots are required, it is beneficial to have a chassis with the fans above the card cage. With a reverse-impeller blower approach, the air is pulled from below the cards up to the fans directly above the modules with the heat exhaust blown 90 degrees out the rear of the enclosure. Most cabinet enclosures that hold these subracks employ this airflow configuration where cool air is directed to the front of the cabinet with the heat going to the back. The air is then recirculated in this fashion.

In the subrack chassis platform, the fans could potentially be placed in the rear of the box, but RTMs would impede the airflow. In that instance, the enclosure would need to increase in size and weight so that the fans can reside above the RTM section. But, the extra height and weight is typically not desired.

Figure 1 shows an OpenVPX chassis with hot-swappable RiCool blowers above the card cage. This enclosure has multiple RTMs plugged into the rear of the backplane. Another advantage of the placement of the fans is cooling efficiency. With the high-wattage boards of OpenVPX, this approach with the fans directly above the boards ensures adequate cooling. The dual fans are typically 110 CFM each, but for more extreme cooling needs, the fans can go up to 191 CFM each displacing up to 3.6 inches of water of static pressure.

Taking the chassis in the example above to a MIL-grade system requires a few changes. The sheet metal would be designed with thicker material and the extrusions would be reinforced. Figure 2 shows an example of a rugged OpenVPX extrusion that is used both in 6U OpenVPX designs and in MIL rugged designs. The very thick extrusion is specially designed to handle the high insertion forces of 6U OpenVPX boards. The hardened aluminum prevents bowing and cracking of the board interface point. With a double-screw design, the extrusion is further reinforced. The boards can be recessed in the card cage or have an outer panel with EMI filtering. The backplane and PSUs are typically conformal coated to protect against moisture, dust, salt-fog, etc.

Finally, the fans would need to meet MIL spec requirements. In this case, they can be placed in the rear with extra space allotted for the airflow for the RTM slots. Figure 3 shows the back of the same type of rugged enclosure, but with cabling from a VME64x P2 area as opposed to pluggable RTMs.

Another option for the designer is to shift to an ATR type of enclosure. This requires a completely different approach utilizing conduction-cooled modules. The type of ATR used depends on the number of slots and cooling requirements. 3U OpenVPX boards can fit in a ½ ATR with a width of 4.88". They are typically top-loaded, but for small systems, a front or rear-loaded approach can be beneficial.

Figure 4a shows a rear-loaded ATR for a 3-slot 3U OpenVPX backplane. This allows the IO to go straight to the panel, in a secure and reliable format. Most importantly, it saves space and weight in the process. Figure 4b shows a top-loaded configuration for larger backplanes. The drawback of this size is you don't have the space for supplemental air-cooling. So, the OpenVPX boards cannot dissipate too much heat. The small ATR in Figure 4a was designed to cool at least 125W. If extra width is allowable and air-cooling is available, a heat exchanged version can provide the enhanced thermal management. The enclosure in Figure 4b is fully sealed, with a 2nd enclosure wall on the outside that allows supplemental airflow to pass over the fins of the enclosure. This design requires extra width such as a 5/8 ATR size. Versions have been simu-

Figure 3. Other elements of ruggedizing the enclosure include thicker walls, a recessed card cage for EMI protection, filtering, and MIL-grade versions of fans, connectors/cabling, and PSUs.

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Figures 4a & 4b. For medium to high slot counts, a top-loaded approach for OpenVPX boards is common, as shown in Figure 4b (bottom). For smaller slot counts, a rear-loaded configuration, as shown in Figure 4a (top), allows a compact size in a rugged and secure I/O format.

lated that cool up to 800W using this approach. (Although, in this case, the width increased beyond the 5.28 inches of the 5/8 width).

Taking Established Systems to the Extreme

Another trend in the market is for established Small Form Factor (SFF) systems in commercial applications expanding into rugged environments. This opens up products such as Software Defined Radios (SDR) that are used in passive RADAR, Wi-Fi/cellular, massive MIMO testbed, and SIG-INT applications to go into new markets and deployments. This includes Mil/Aero applications, outdoor use, and mobile-vertical mounted designs. One such example is the National Instruments X310 USPR™ SDR that has dual RF wideband daughtercard slots covering DC – 6 GHz with up to 160 MHz of baseband bandwidth, multiple high-speed interface options (PCIe, Dual 1/10 GigE), and a large user-programmable Kintex-7 FPGA. By employing a ruggedized conduction-cooled approach, this successful commercial product could meet many more application requirements.

Figure 5 shows an example of the compact SDR in a rugged, conduction-cooled, IP67 package. Working with the engineers of the original product, thermal simulation could be performed to find the optimal cooling approach. A

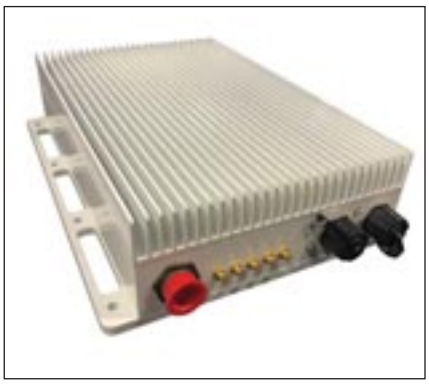

Figure 5. Small form factor and specialty devices like this Software Defined Radio can be ruggedized for weatherproof and MIL-spec requirements.

key factor is milling out the heatsinks to properly fit the FGPA and hotter items inside the system. Perhaps the trickiest part of these designs is handling the I/O so that they can meet IP67 sealing for weatherproof needs. The sealed connectors take more space than the commercial I/O connectors. Therefore, care needs to be taken for proper placement and routing of these interconnects. Sometimes decisions need to be made with the customer regarding which features are most critical to meet certain size/space requirements. The designs can be made with enhanced features such as provisions for panel or pole mounting.

Design for Rugged Early in the Process

It is advisable to plan ahead for rugged designs and ideally to plan the commercial and rugged versions together. When they are designed after-the-fact, at times sacrifices need to be made and product cohesion is more difficult to maintain. Planned ahead, the rugged designs can leverage multiple uses of key components of the embedded chassis platform. Although pre-planning is ideal, it is not a requirement. By working with the chassis manufacturer that is skilled in both commercial and rugged designs, you can ensure the systems can be well-suited to both types of applications.

This article was written by Justin Moll, Vice President of US Market Development, Pixus Technologies (Waterloo, Ontario, Canada). For more information, visit ***http://info.hotims.com/72990-500****.*

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An Introduction to PCM Heat Sinks

With the exception of thermal storage heat sinks, the term heat sink is a misnomer. Standard heat sinks for electronics cooling are actually heat exchangers, taking the heat from the electronics, and transferring it to a fluid, either air or coolant. Phase Change Material (PCM) heat sinks are the only heat sinks that actually act as a (temporary) sink for heat. They are emerging in the thermal management realm to solve thermal problems in systems where active solutions cannot be used. When there is no place to dissipate the heat generated by electric components, a PCM heat sink is capable of absorbing the generated waste heat [1].

Phase Change Materials (PCMs) store thermal energy by the phase change from solid to liquid. This is an advantage, since the latent heat from melting or freezing is at least 1-2 orders of magnitude higher than the energy stored by the specific heat over a representative 10°C change in temperature. PCM applications in electronics thermal management include:

- Stabilizing temperature during pulsed operation [2]
- Short-term thermal storage, where a suitable heat sink is not available [3]
- Protection from failure during coolant interruptions, when the cooling system is temporarily unavailable.

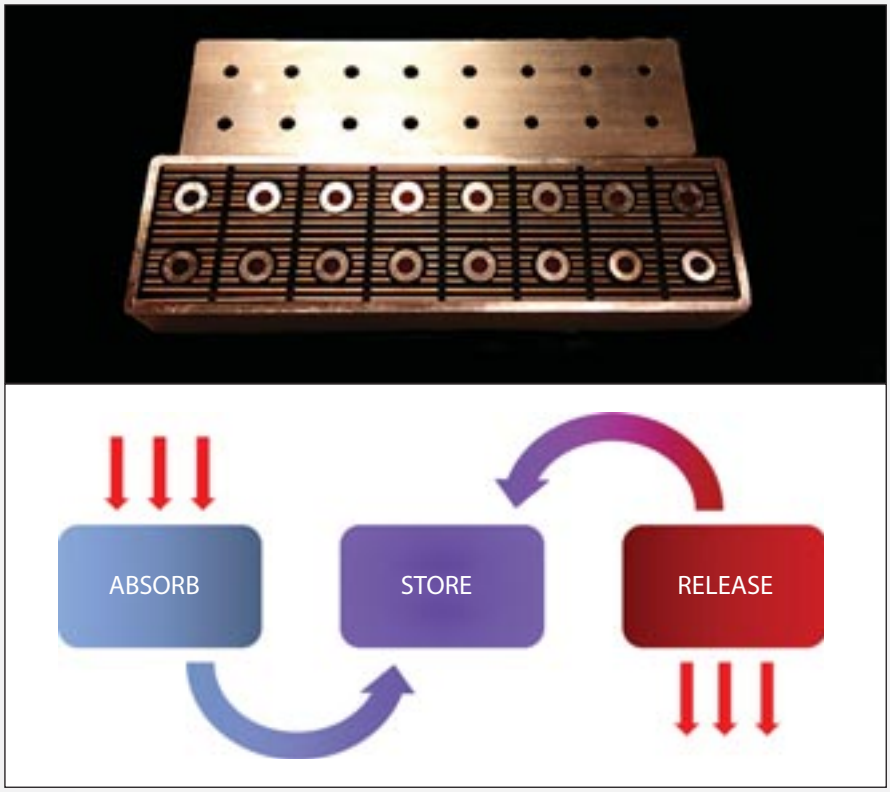

Figure 1. PCM Heat Sink Example Showing Fins to Enhance Conductivity.

How PCM works

PCM refers to any material that requires a large amount of energy to undergo a phase change. The energy required to transition between solid and liquid phases is known as the latent heat of fusion. Materials with a high latent heat of fusion can store a significant amount of heat during a phase transition while maintaining a near constant temperature around the material's melting point. This property is advantageous for electronics cooling applications with transient loading. During transient operation, the thermal energy can be stored in the PCM while the heat is generated, without the temperature of the source increasing significantly. While the heat source is off, the PCM can refreeze so it is ready to absorb energy during the next heating cycle. This solution works well provided there is enough PCM to store all of the waste heat and the thermal resistance of the PCM heat sink is low enough to handle the required heat flux.

The thermal benefit of using a phase change material for transient loading is illustrated in Figure 2. The slope represents the temperature rise per unit of energy absorbed. During the melt, a large amount of energy is stored with very little change in temperature. A constant temperature is particularly appealing in applications with ergonomic requirements, but is beneficial in several applications to prevent components from failing during transient power spikes.

PCM Selection

The melt temperature and application will dictate the type of PCM that can be used (Table 1). For most electronics applications, paraffin waxes and non-paraffin organics are a good choice because they are relatively inexpensive and stable through many thermal cycles. For high temperature applications, metals and salts (non-hydrated) can be used.

Paraffin and Non-Paraffin Organics

Paraffin and non-paraffin organics are ideal phase change materials because they melt and freeze congruently

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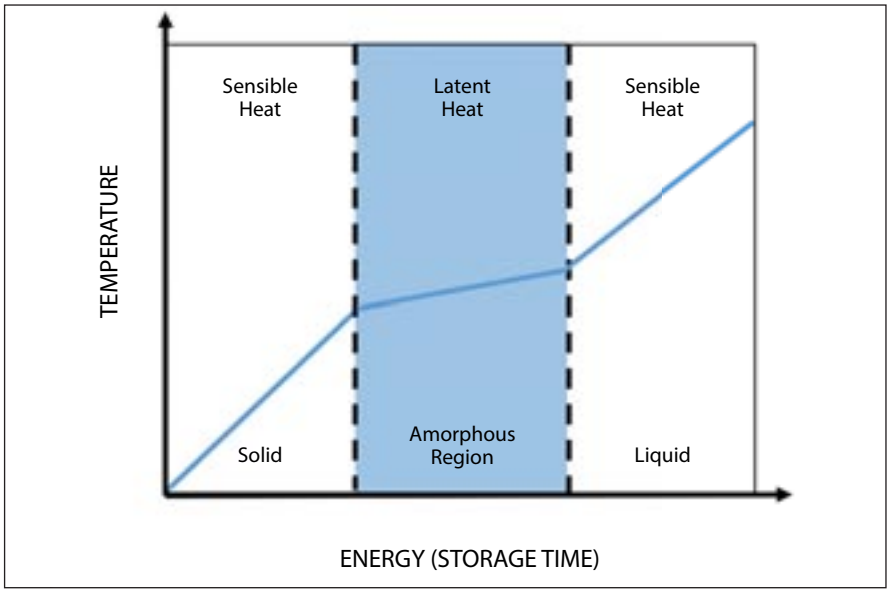

Figure 2. Phase Change Material Transient Behavior. The "Latent Heat" region has a slight slope, since it includes the specific heat in the amorphous region.

(i.e. have the same composition before and after freezing) and can therefore be used for applications requiring material stability through several cycles. The major drawback to these materials is their thermal conductivity, which is typically around 0.2 W/m-K. Paraffins, which are alkanes or saturated hydrocarbons, are inert phase change materials. Non-paraffin organics, other than fatty acids, are mildly corrosive and are more expensive than paraffin materials.

Both paraffin blends and pure component paraffins are commercially available for purchase. Paraffin blends are generally much less expensive and exhibit similar properties to pure component paraffins. The performance can be comparable to pure component paraffins, but when selecting a material, it is important to take a close look at how the latent heat value is reported. Manufacturers will often release the differential scanning calorimetry data of the blend, along with the latent heat value. The Differential Scanning Calorimeter curve (DSC), as seen in Figure 3, will reveal how the latent heat value is determined. The area under the melting peak is used to calculate the latent heat of fusion. Oftentimes, the latent heat value reported includes some of the sensible heating storage outside of the phase change region. This means that in order to see the full amount of energy storage reported, the material would need to be exposed to temperatures below the onset of melt temperature and above the end of melt temperature.

Hydrated Salts

Salt hydrates are a group of inorganic salts that contain a certain number of water molecules. The hydration level is noted in the chemical formula as "hydrated compound · nH_2O", where n is the number of water molecules per molecule of salt. Salts can have several different hydration levels. For example, $CaCl_2$ has three different hydration levels, $CaCl_2 \cdot 2H_2O$, $CaCl_2$

Property or Characteristic	Paraffin Wax	Non-Paraffin Organics	Hydrated Salts	Metals	Salts
Heat of Fusion	High	High	High	Med.	Very High
Thermal Conductivity (W/m-K)	~ 0.2	~ 0.2	~ 0.5 – 1.0	Very High	~ 0.5-1.0
Volumetric Storage Capacity (MJ/m^3)	~ 190	~150	~300	~840	~600
Melt Temperature (°C)	-20 to 100+	5 to 120+	0 to -140+	150 to 800+	200 – 800+
Latent Heat (kJ/kg)	200 to 280	90 to 250	60 to 300	25 to 300	150 – 1000+
Corrosive	Non-Corrosive	Mildly Corrosive	Relatively Corrosive	Varies	Corrosive
Economics	$$	$$$ to $$$$	$	$$ to $$$	$
Thermal Cycling	Stable	Elevated Temperature Can Cause Decomposition	Stable but need caution	Stable	Stable but need caution
Weight	Medium	Medium	Light	Heavy	Light

Table 1. PCM Types Include Paraffin Waxes, Non-Paraffin Organics, Hydrated Salts, Non-Hydrated Salts, and Metals.

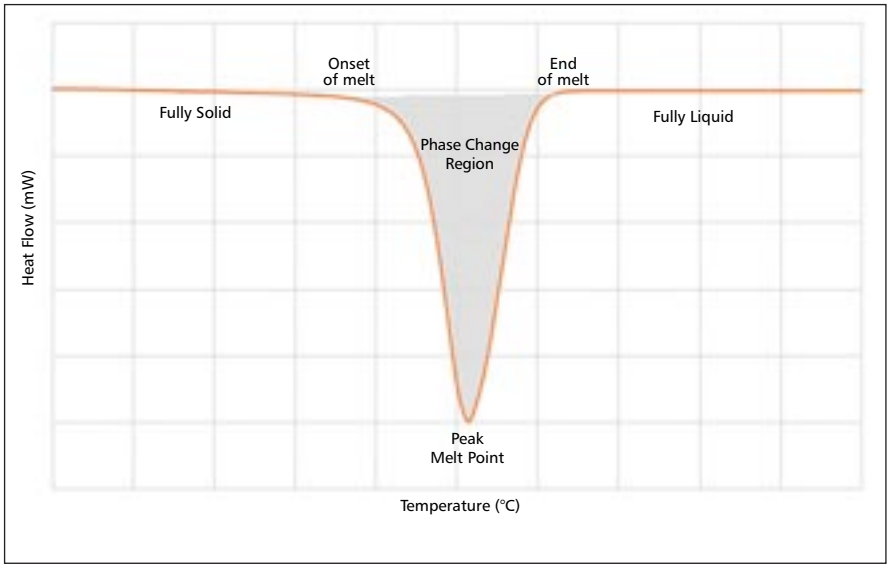

Figure 3. Example Differential Scanning Calorimeter curve (DSC) for a phase change material. The phase change region indicates the latent thermal energy storage.

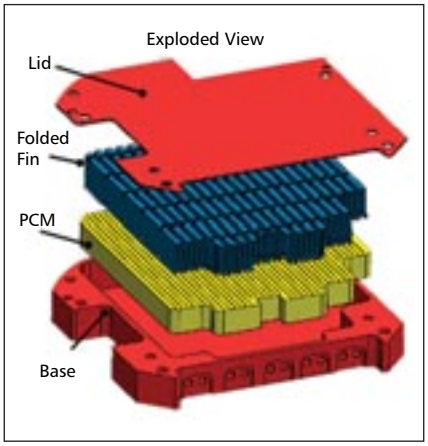

Figure 4. PCM Heat Sink Schematic. Folded fins are commonly used to increase the effective thermal conductivity. Heat pipes can also be added for larger systems, or systems operating at higher heat flux.

·4H_2O, and $CaCl_2$ ·6H_2O. The lowest water content corresponds to the highest melting point for a hydrated salt series. Hydrated salts have the following advantages when compared with organic PCMs for low temperature applications:

- High storage capacity with respect to both mass and volume, allowing light and compact thermal energy storage systems,
- Inexpensive, about \$2/kWh$_{thermal}$ to \$16/kWh$_{thermal}$,
- Relatively high thermal conductivity, more than twice of paraffins, reducing the required structures for thermal enhancement.

Hydrated salts are rarely used in PCM heat sinks, since the designer must overcome several problems: subcooling, phase separation, and corrosion. Recent research has shown that these problems can be mitigated, making hydrated salts suitable for some specialized electronics cooling applications.

Subcooling: Some phase change materials do not solidify immediately upon cooling to its melting temperature, so that solidification begins at a temperature well below the melting temperature. This phenomenon is called subcooling or supercooling. The most common way to address the issue is to disperse a nucleating agent in the PCM system. The added nucleating agent provides sites to initiate the crystallization of the PCM with a much lower subcooling, allowing a warmer heat sink to be used to regenerate the PCM. The most effective agent is one with a crystal structure similar to the PCM. Take $CaCl_2$·6H_2O with a melting point of 29°C as an example. Its subcooling is nearly 20°C without a nucleating agent. ACT's nucleating agent $SrCl_2$·6H_2O is able to minimize the subcooling of $CaCl_2$·6H_2O to less than 2°C.

Phase Separation: When a PCM has only one component, it will melt congruently, having the same homogeneous composition before and after its phase change. With a eutectic system, the liquid phase transforms completely to its solid phase with the same composition. Non-eutectic mixtures, like some salt hydrates, can separate into multiple phases when heated. When $CaCl_2$·6H_2O (melting point 29°C) is heated, instead of melting to a liquid, it forms solid $CaCl_2$·4H_2O and a dilute liquid phase first. With further heating, the solid $CaCl_2$·4H_2O dissolves into the excess water of the dilute liquid phase, transforming completely to liquid phase CaC_2·6H_2O. Phases with different densities can occur in the intermediate step. The heavier $CaCl_2$·4H_2O sinks down, with the lighter dilute liquid floating on the top. Potential solutions to handle the situation include adding more water, or reducing the thickness of the PCM by separating it into shallow PCM compartments. A third solution is to add another salt hydride to form a eutectic, e.g., $CaCl_2$-6H_2O and $MgCl_2$-6H_2O.

Corrosion: While hydrated salts are generally compatible with plastics, metal containers and metallic heat transfer enhancements [4] [5] are usually required for electronics cooling. Some salts are very corrosive to certain metals. Tests conducted at ACT with several hydrated salts such as $CaCl_2$·6H_2O and $CaCl_2$·6H_2O - $MgCl_2$·6H_2O) have identified suitable enclosure materials. More than 1-year corrosion life test data has been collected, and the corrosion tests have been run under both isothermal conditions (30°C, 50°C, and 80°C) and cyclic conditions with repeated heating and cooling, Carbon steel and aluminum both show good corrosion resistance with less than 0.5 mil/year corrosion rate.

High-Temperature Phase Change Materials (Salts and Metals)

Phase change material melting from -10 to 100°C is used for thermal management in a variety of commercial and military applications, e.g., building thermal management, electronic cooling, and supplemental cooling for energy weapons, to name a few. Salts,

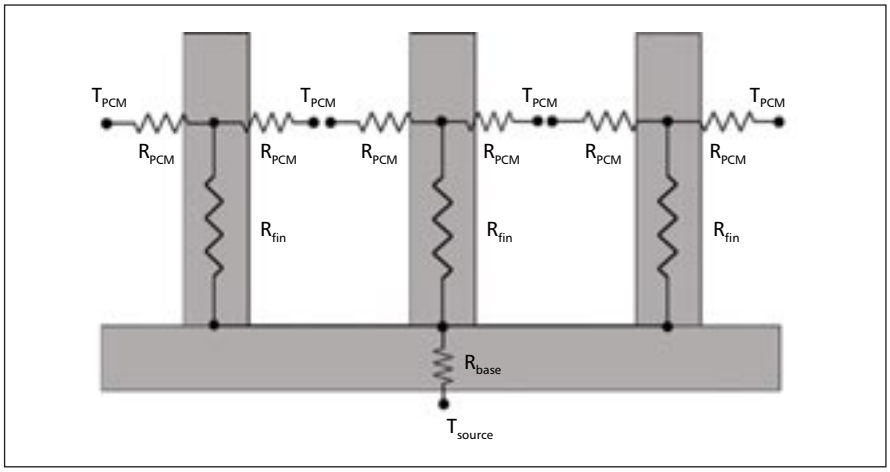

Figure 5. Simplified Thermal Resistance Network.

and metals, which are phase change materials with higher melting temperatures, are also attractive. One application is storing high quality heat from concentrated solar radiation and using it to generate electricity. Inorganic salts have been intensively studied, and precursor developments[6] have identified promising storage medium for the high temperature applications. Pilot-scale units have demonstrated its technical and cost feasibility.

PCM Challenges

Most PCMs used for electronics cooling have a very low thermal conductivity, effectively insulating a heat source in high heat flux applications. If there is a large temperature gradient through the PCM, the surface in contact with the heat source may reach its maximum temperature before all of the PCM latent heat is utilized (melted). In order to fully utilize the latent heat of the material, thermal enhancements may be required. Aluminum or copper fins are commonly used to improve the heat transfer through the PCM. Other thermal enhancements such as nanoparticle impregnation have been experimented with [7], but the nanoparticles have not been shown to increase the thermal conductivity significantly enough to make the material viable for most applications. Further, the nanoparticles settle out after very few cycles without a stabilizer [8]. For this reason, finned structures and heat pipes are most commonly used in industry to better distribute the heat into the PCM (Figure 4).

During phase change, the density of a material changes. Depending on the material, different features are used to compensate for the volumetric change. Typically, the PCM volume is controlled during filling so that there is still some void space at the highest expected temperature. If the higher pressure can occur, a pressure relief feature may be required.

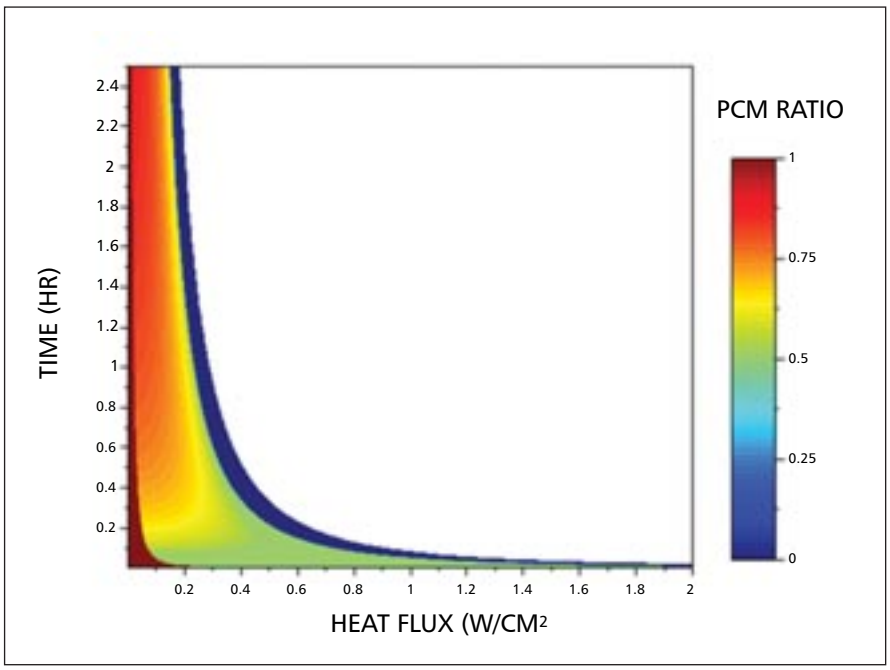

Figure 6. PCM heat sink selection guide, showing the PCM/Thermal-Enhancement mass ratio as a function of time and heat flux.

PCM Heat Sink Design

Advanced Cooling Technologies, Inc. (ACT) has developed a simple figure that can indicate whether PCM is suitable for an application and whether thermal enhancements are required. Average PCM heat sink properties were used to generate this figure, based on ACT's experience with PCM heat sink design. The PCM material properties are an average of several paraffins used in practice and the fin material is aluminum. The model also assumes that no more than a 10°C temperature rise to overcome thermal conduction resistance is allowed. A simple energy balance and resistance network, shown in Figure 5, can be iterated to find a goal temperature gradient from the base of the heat sink to the PCM.

For applications with a known storage time and heat flux, Figure 6 will indicate whether a PCM heat sink solution is a suitable thermal solution. The PCM ratio represents the amount of PCM required relative to the volume of aluminum in the fin enhancement structure. PCM ratios near zero indicate an all metal solution would be required to remove the flux. PCM ratios near unity indicate a

PCM structure without any metal enhancement structure would be required.

A closer estimation of the mass, volume, and thermal performance of a PCM heat sink can be obtained using ACT's heat pipe calculator at **https://www.1-act.com/resources/pcm-calculator/**. The expected transient performance for three different PCM options suitable for your application is plotted. This calculator assumes a generally conservative fin design. High performance custom solutions with heat pipes can be designed upon request.

Conclusions

PCM heat sinks are used in several electronics cooling applications including temperature stabilization during pulsed operation, short term thermal storage when a suitable heat sink is not available, and protection from failure during loss of coolant scenarios, to name a few. If the thermal storage capacity of PCM is suitable for an application, a PCM heat sink can reduce system size, cost, maintenance, and power requirements.

The specific phase change material and enclosure selected is dependent on the specific application requirements. Paraffin waxes and non-paraffin organics are most frequently used, but hydrated salts, non-hydrated salts, and metals can be used in some specialized applications.

PCM heat sink design challenges include the low thermal conductivity of most PCMs. Thermal enhancement such as fin or heat pipes are generally used to improve the thermal conductivity.

This article was written by Rebecca Weigand, Product Development Engineer; Ying Zheng, R&D Engineer II; William G. Anderson, Chief Engineer; and Richard W. Bonner III, Vice President, R&D; Advanced Cooling Technologies, Inc. (Lancaster, PA). For more information, visit ***http://info.hotims.com/72990-501.***

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Eye Tracking Technology

Improving the Skills Gap, Efficiency, and Quality Assurance in Aerospace Manufacturing

The Tobii Pro Glasses 2 wearable eye trackers

Much debate surrounds the skills shortage burdening the manufacturing sector of aerospace and defense (A&D). Industry 4.0, the Baby Boomer retirement wave, and a lack of properly trained workers underpins this issue, and while it's widely acknowledged, there's no clearly defined way to address it.

Figures vary on how extensive this issue is and what impact it will have on productivity– Deloitte forecasts that by 2025 the U.S. manufacturing sector as a whole will see a trained worker shortfall of about 2 million. The Aerospace Industries Association (AIA) claims almost 40% of companies in its network "predict an 'extreme' impact on their business growth caused by this labor shortage." At the center of this is a dependence on those with skills in science, technology, engineering, and mathematics (STEM). STEM workers are in high demand, and while there's a steady stream of graduates with relevant qualifications, ongoing education and training is needed to keep pace with the rapid technological changes taking place within the A&D manufacturing industry.

VR headsets retrofitted with eye tracking allows researchers to test workers in a number of different scenarios. Heat maps can visualize points of concentration within the workers' field of vision.

Research suggests one fifth of the industry's revenue was generated by products developed in the five years to 2015, and it's unlikely this trajectory of technological innovation will change. This presents the issue of finding new specialists with highly advanced skillsets for the job at hand, or finding the resources needed to upskill existing staff.

One example of this is additive manufacturing, which is becoming increasingly more widespread in the A&D sector for building new parts and completing existing components – such as NASA's new (largely 3D printed) rocket engine prototype. The space agency claims this technique could reduce costs by up to 33 percent and cut manufacturing time in half. The financial benefits for commercial enterprises

are obvious, but at the moment this gateway to increased productivity is being stalled by the talent gap.

What Is Eye Tracking and Why Is It Useful?

The idea of applying more technology to address issues stemming from the implementation of other technology might sound strange, but it's proving effective. It's already being used within a number of industrial sectors to identify the causes of inefficiencies, errors and hazards, and enhance training and onboarding.

Eye tracking is exactly what you might assume it is – the observation and recording of human eye movement and fixations. Wearable eye trackers, like Tobii Pro Glasses 2, project invisible, near infrared light beams into the wearer's eyes, the reflection of these beams is picked up by small HD cameras also attached to the glasses; and then using advanced algorithms, it's possible to calculate where a person is looking in precise detail. A built-in scene camera on the glasses captures the surrounding environment which is run through special software to provide a live view of where a person's gaze falls within the environment. It's also possible to record this information and view it later, or compile aggregated data if multiple tests are carried out. New advances in the glasses now allows them to be fitted under a face mask or safety helmet, making it easier to run eye tracking studies in the intense industrial conditions often found in aerospace manufacturing.

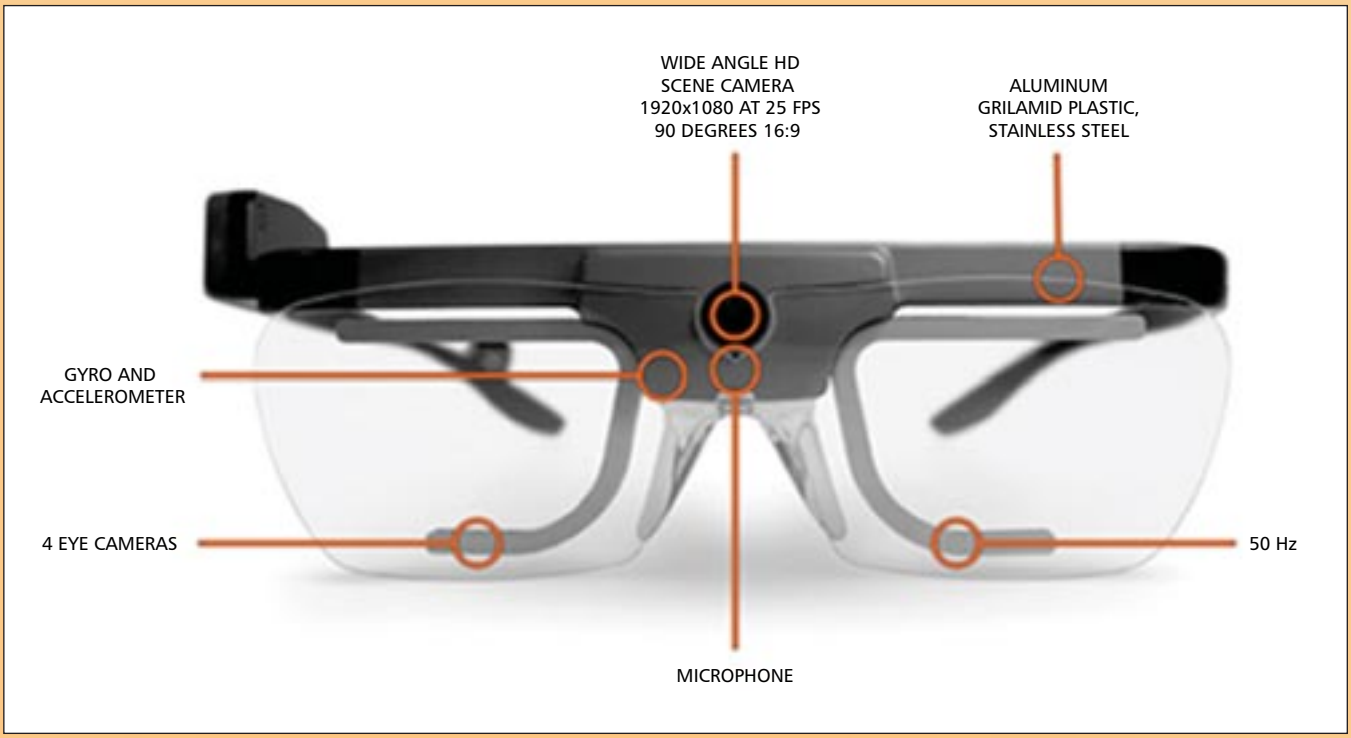
Eye tracking data can:

- uncover subconscious or instinctive behaviors;
- provide a visual representation of best practice;
- help understand performance in dangerous or time-critical situations;
- provide evidence of attention patterns linked to accident or injury;
- reveal information on cognitive load/overload, and
- highlight areas for further investigation.

There's also use cases where eye tracking has been applied to test and improve the usability of various components – NASA is currently using Tobii Pro Glasses 2 as a research tool to improve the display interfaces of their spaceflight vehicles.

Reducing the Skills Gap and Increasing Productivity in A&D Manufacturing?

The value of eye tracking data lies in what it reveals about human intent and cognitive processes. Eye movements very often precede action and reveal information about mental processes and cognitive load. Within a factory, for example, many processes are so familiar to workers that they're carried out instinctively and often people make adapta-



Features of the TobiiPro Glasses 2 wearable eye trackers.

tions to the way they perform these tasks. Sometimes these behaviors are subconscious or so small that the person doesn't realize they're doing them. Using eye tracking technology, you're able to see these actions and the effect they have on workflow – do they make it more efficient, or highlight roadblocks in the system? Eye tracking data can answer many questions you may have about your processes. For example, are instructions too complicated and require repeated checking by workers? What method does your best performing worker use to complete a particular task? What visual patterns precede an accident or mistake in the quality assurance process?

Eye tracking data and video also provide a very detailed and clear explanation of how to perform certain tasks, making it possible to incorporate this information into training materials and resources. For the A&D manufacturing sector, it paves the way for the valuable skillsets of the outgoing workforce to be better understood and preserved, and for the training of new workers to be dramatically enhanced.

Eye tracking delivered substantial improvements to the operations of one company in the aerospace manufacturing sector which produces aircraft components. The business experienced issues with its inspection processes, which forced it to increase resources to cope with the volume of problems not being picked up by the manufacturing inspectors. By using eye tracking to study the observation methods and visual attention of the manufacturing inspectors and comparing this to the same data obtained from the quality assurance inspectors who were detecting the problems, it was possible to see how issues were going unseen and at the same time illustrate how the manufacturing inspectors could improve their methods. The company was able to reduce inspecting times significantly and cut errors in half.

In another case, the insight from an eye tracking study identified substantial savings in the onboarding time of new workers at a metal foundry. Eye tracking glasses were worn by the workers at H&H Castings while they performed the task of pouring molten metal into molds. The study identified the best techniques for carrying out this dangerous and technical process and by incorporating this knowledge into training protocols, the company expects to cut two days off each worker's training time. Similarly, a major car manufacturer reduced training time for new production line staff from six to four weeks and lowered visual inspecting errors by 50% thanks to the information gathered from their eye tracking study.

Improving Safety

Various studies indicate that up to 90% of all workplace accidents are the result of human error, with situational awareness often the root cause of mistakes. Eye tracking allows you to study human attention and pinpoint what environmental distractions or attention patterns precede an accident. In the metal foundry example, the eye tracking study also revealed visual patterns associated with spills. By understanding why worker attention was diverted, it was possible to implement training to prevent this from occurring in the future. This technique can be applied

Eye tracking can provide key insights for improving workplace safety and performance in an industrial setting.

with virtually any manufacturing process, to highlight not just ailments to situational awareness, but also to help identify environmental factors, such as poorly designed equipment configurations, problematic workshop layouts, or even issues with lighting and visibility, which inhibit safe operations.

Reshaping A&D Manufacturing and Training

Just like 3D printing, robotics, and the Internet of Things, VR is among the advanced manufacturing tools propelling the fourth industrial revolution. New products are already available that add eye tracking to VR headsets. The beauty of VR is that it provides a safe environment in which to train with absolutely no consequences. It's already being used for flight simulation, maintenance training, and a raft of other processes within the aerospace and manufacturing sector. Once a 3D environment is created it removes virtually all physical, financial, and geographic boundaries attached to training and assessment. Imagine being able to simultaneously educate multiple workers in a virtual world before exposing them to the risks or consequences of the real task, or being able to create functioning prototypes for testing purposes without the manufacturing costs or space requirements normally attached. With integrated eye tracking you're able to ascertain how people are interacting with and responding to the stimuli within the virtual world, making it a valuable tool for training and assessment.

A&D is the leading net exporting industry in the United States, generating a trade surplus of $86 billion in 2017 according to the AIA. For a sector already leading the charge amid the fourth industrial revolution, harnessing the benefits of eye tracking will only stand to further cement its place as an industry leader. While the rapid integration of new technology is presenting teething problems for manufacturing worldwide, it also stands to support it and foster its growth.

This article was written by Mike Bartels, Senior Research Director, Tobii Pro Insight Research Services (Danderyd, Sweden). For more information, visit ***http://info.hotims.com/72990-503****.*

Streamlining EMC Solutions for Avionics Interfaces

Lightning strikes to jet airliners are common – about once every 1000 flight hours. The DO-160G standard, Environmental Conditions and Test Procedures for Airborne Equipment, is a standard for the environmental testing of avionics hardware. Many airplane manufacturers specify DO-160G Section 22, lightning induced transient susceptibility, as a requirement for critical systems like guidance, radars, communications, engine control, and heat and air controls. Aircraft fuselage, wing and tail flight controls, wing tips, fin tips, engine nacelles, and landing gear are the areas most likely to be hit by lightning strikes.

Modern aircraft are designed with fly by wire systems for flight controls. Fly by wire means that inputs from either flight control computers or pilot manual inputs are transmitted electrically

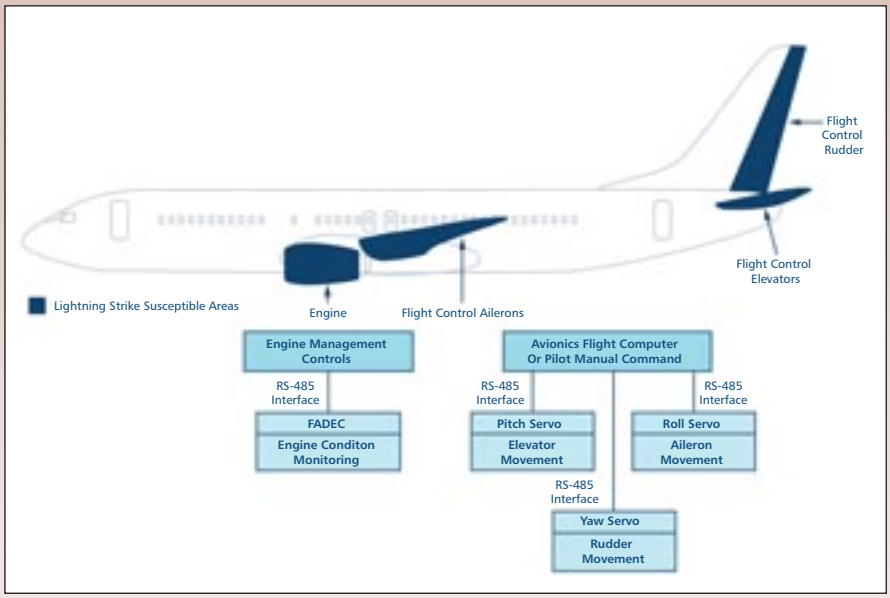


Figure 1. Lightning strike susceptible locations on a commercial aircraft and communications interface between system components.

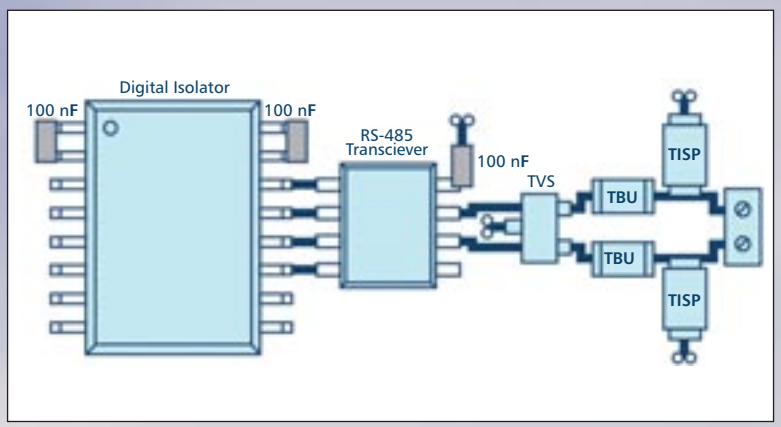


Figure 2. Typical RS-485 lightning surge discrete EMC protection solution.

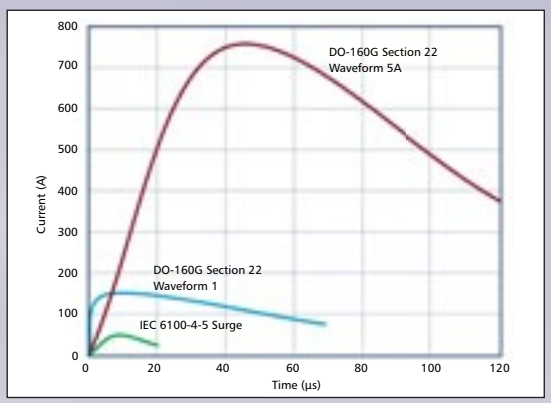


Figure 3. DO-160G Section 22 Waveform 1 and Waveform 5A, and IEC61000-4-5 Surge Waveform.

to a servomotor, which controls flight control actuators. Communication interfaces for these flight control systems can be implemented on an RS-485 physical layer. Communication interfaces for aircraft engine management control can also be implemented with an RS-485 physical layer. The full authority digital engine control (FADEC) systems installed on aircraft engines are responsible for monitoring temperatures, pressure, and fuel flow, among other parameters.

If the RS-485 communication interface is damaged from indirect lightning, then the engine condition monitoring will fail in service, and/or closed-loop feedback for flight control systems can be compromised.

The DO-160G Section 22 lightning standard simulates the transient voltages and currents introduced into avionics as a result of the magnetic field generated by a direct lightning strike surge through the aircraft airframe (fuselage). Table 1 shows that commercial aircraft typically require DO-160G Section 22 lightning protection between Level 1 and Level 4 for Waveform 3 and Waveform 4/Waveform 1. Aircraft equipment is divided into three zones, and each zone has an associated electromagnetic compatibility (EMC) environment. The most severe EMC environments are located in the Category A and Category B zones, which are areas of the aircraft that are not environmentally controlled. Flight control avionics are located in the Category A and Category B zones. These areas are harsh EMC environments, with DO-160G Section 22 Lightning Level 3 or Level 4 protection required.

Typical Solutions Require Multiple Components

Figure 2 shows an isolated EMC protected RS-485 circuit layout example, which provides protection against industrial levels of induced lightning surge (IEC 61000-4-5 Surge). This circuit uses several discrete components, including two TISP surge protectors, two transient blocking units (TBUs), and one dual TVS. A similar circuit

can be used to protect against DO-160G lightning transients. A discrete EMC protection solution presents a number of challenges for the circuit designer:

- Picking and electrically matching the EMC protection components to the RS-485 interface. The high voltage breakdown characteristics of the RS-485 transceiver needs to be matched to the EMC protection device's breakdown voltages and performance characteristics.
- Testing and confirming compliance to the DO-160G EMC standard.
- If the first design does not meet specification, then multiple design iterations may need to be performed. This will increase time to

Equipment Category	Inputs/Outputs Category	DO-160G Waveform 4/ Waveform 1	DO-160G Waveform 3	DO-160G Level
Category A: Critical Equipment	Power supply Signal: exposed area	750 V, 150 A 750 V, 150 A	1500 V, 60 A 1500 V, 60 A	4 4
Category B: Essential, Hazardous Equipment	Signal: externally mounted (fuselage, wings) Signal: belly fairing (aircraft lower surface), radome (radar cover)	750 V, 150 A 300 V, 60 A	1500 V, 60 A 600 V, 24 A	4 3
Category C: Essential, Major Equipment	Signal: pressurized area (connection between two equipment bays, or between two decks on a multideck aircraft) Signal: electronics bay (on the same deck in a multideck aircraft)	125 V, 25 A Not applicable	250 V, 10 A 100 V, 4 A	2 1

Table 1. Typical DO-160G Section 22 Lightning Requirements for Commercial Aircraft.

Level	DO-160G Waveform 3	DO-160G Waveform 4/ Waveform 1	DO-160G Waveform 5A	IEC 61000-4-5
4	1500V, 60A	750V, 150A	750V, 750A	4000V, 49A
3	600V, 24A	300V, 60A	300V, 300A	2000V, 24.5A

Table 2. DO-160G Section 22 Pin Injection Level 4 and Level 3 Compared to IEC 61000-4-5 Lightning Level 4 and Level 3.

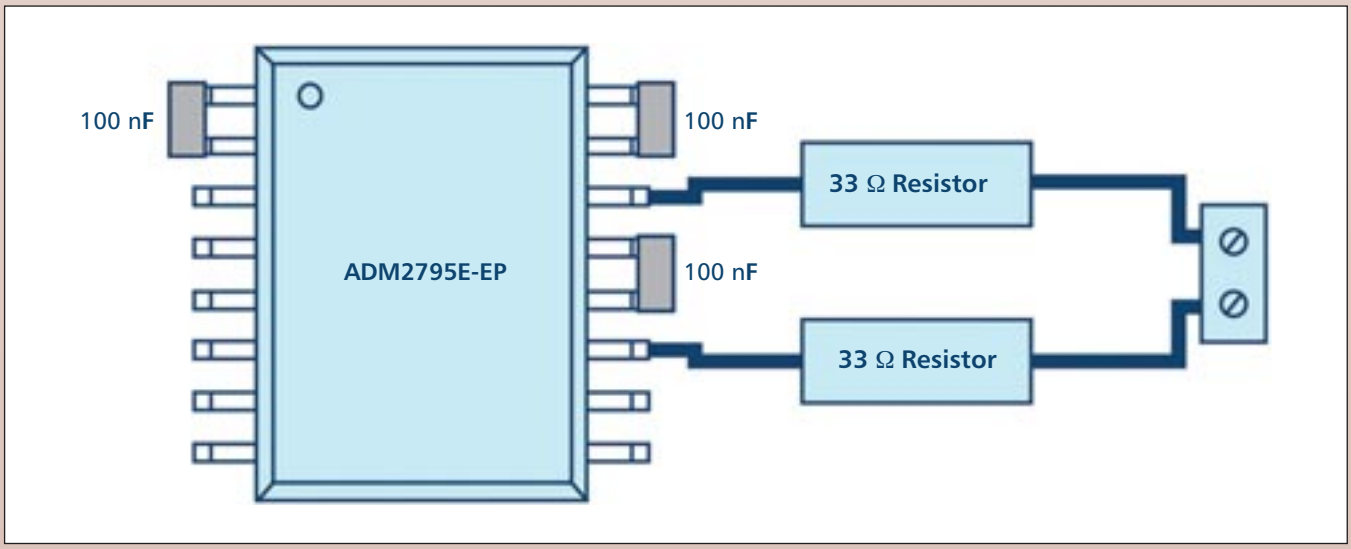


Figure 4. The ADM2795E-EP certified DO-160G lightning protection solution, which saves the designer significant PCB area.

market for the design, leading to schedule and cost overruns.
- Typical discrete EMC protection solutions for avionics applications consume significant printed circuit board (PCB) area. This adds significant cost and weight to the avionics communications port.

Providing Certified Protection in a Small PCB Area

Table 2 details the open-circuit voltage (VOC) and short-circuit current (ISC) as specified in the DO-160G Section 22 lightning induced transient susceptibility standard for Waveform 3, Waveform 4/Waveform 1, and Waveform 5A for pin injection testing. The peak currents for the DO-160G Level 4 tests are much greater than standard industrial surge IEC 61000-4-5 peak currents. The waveform shape and rise/decay times for the DO-160G standard are significantly longer than those specified by the IEC 61000-4-5 standard, as shown in Figure 3.

Analog Devices' EMC protected RS-485 transceivers provide certified DO-160G EMC protection on the RS-485 bus pins with Section 22 lightning protection. They also provide Section 25 ±15 kV electrostatic discharge (ESD) air discharge protection. For Section 22 lightning, the devices provide protection against Waveform 3, Waveform 4/Waveform 1, and Waveform 5A to Level 4. Due to the high amounts of energy associated with the DO-160G Section 22 lightning standard, the transceivers were tested using external 33 Ω or 47 Ω A pin and B pin bus current limiting resistors for testing to GND2. These resisters were required in addition to the integrated EMC protection circuitry. However, when testing to GND1, no current limiting resistors are required. Figure 4 shows the total PCB area occupied by the ADM2795E-EP EMC protection solution. When compared to discrete solutions, the device saves the avionics designer up to 70% in valuable PCB area, as well as associated cost and weight savings.

This article was written by Richard Anslow, Product Applications Engineer, Analog Devices (Norwood, MA). For more information, visit ***http://info.hotims.com/72990-502****.*

Hardware Design of a High Dynamic Range Radio Frequency (RF) Harmonic Measurement System

Radio frequency (RF) circuit elements that are traditionally considered to be linear frequently exhibit nonlinear properties that affect the intended operation of many other RF systems. Devices such as RF connectors, antennas, attenuators, resistors, and dissimilar metal junctions generate nonlinear distortion that degrades primary RF system performance. The communications industry is greatly affected by these unintended and unexpected nonlinear distortions. The high transmit power and tight channel spacing of the communication channel makes communications very susceptible to nonlinear distortion.

To minimize nonlinear distortion in RF systems, specialized circuits are required to measure the low-level nonlinear distortions created from traditionally linear devices, i.e., connectors, cables, antennas, etc. Measuring the low-level nonlinear distortion is a difficult problem. The measurement system requires the use of high-power probe signals and the capability to measure very weak nonlinear distortions. Measuring the weak nonlinear distortion becomes increasingly difficult in the presence of higher-power probe signals, as the high-power probe signal generates distortion products in the measurement system.

Measurement Requirements

Nonlinearities in RF and microwave systems can take many forms. Historically, nonlinearities are found in circuit elements such as diodes, transistors, amplifiers, mixers, and others. In addition, nonlinearities have been found in other circuit components and are generated by different mechanisms.

One of the less common nonlinear mechanisms is passive intermodulation (PIM) distortion, which occurs in antennas, cables, connectors, metal-to-metal junctions, and various components. A recent development has led to the exploitation of nonlinearities in electronic circuits to detect and track nonlinear targets.

Circuit elements exhibit nonlinear properties either by design or by consequence. By design,P-N junctions, such as diodes, are inherently nonlinear, and this property is exploited for their use in frequency mixers, which are used to upconvert or downconvert signals from one frequency to another.

The operation of mixing two signals together to create a new frequency is a nonlinear operation. By consequence, many RF and microwave circuit elements exhibit unintended nonlinear properties.

An example is the RF amplifier. Amplifiers are intended to operate linearly, boosting the input signal without creating extraneous frequencies at the output. In practice, creating a linear amplifier is not possible and additional frequency content is generated that distorts the desired signal. Much research has been done to linearize amplifiers. The unintended frequency content generated by the nonlinear properties of the amplifier interferes with other radar and communication systems, as well as affects the sensitivity of the receiver.

There are other nonlinear effects that are subtler and do not manifest as often. Among these is PIM, which is observed when high-power signals interact with components that are weakly nonlinear. Such components do not exhibit measurable nonlinear distortion under normal conditions. In communication systems, the PIM produced can fall close to the fundamental band and

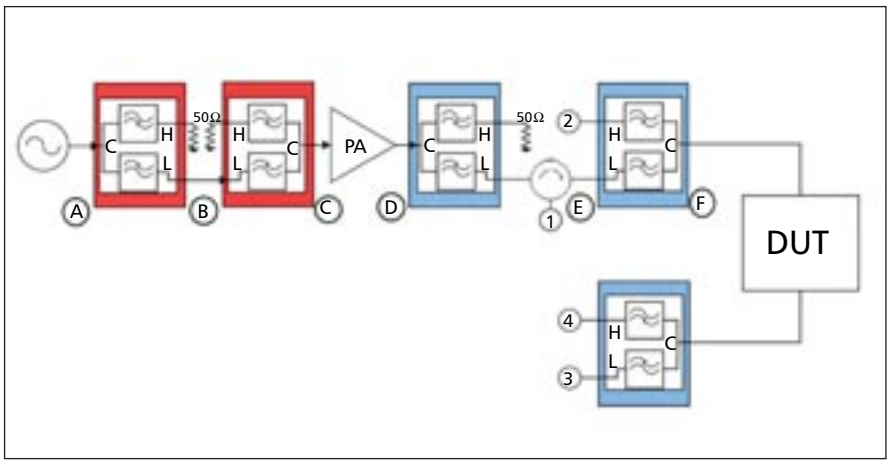


Figure 1. Block diagram of the linear/nonlinear measurement system with specific test locations.

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interfere with adjacent communication channels. To combat this, much research has gone into linearizing communication systems. For close-in intermodulation distortion (IMD), the frequency separation between the fundamental signal and PIM is too small to effectively filter out. Additionally, the communication channels change frequency quickly to accommodate multiple users. So, adaptable filters with large Q values would be needed; however, reconfigurable, high Q filters do not exist. For this reason, adaptive techniques are used to predict and cancel the nonlinearities. Such techniques include predistortion, feedforward linearization, channel equalization, etc.

Measuring weakly nonlinear RF circuit components requires specialized RF hardware, which itself must be highly linear and devoid of any self-generated nonlinearities. If the measurement system is not highly linear, the measurements will reflect the distortions caused by the test hardware in addition to the device under test (DUT).

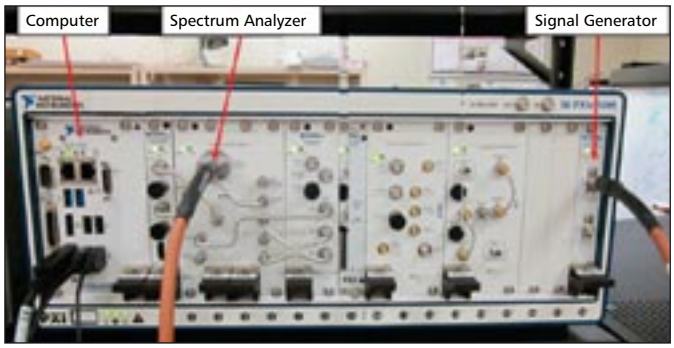


Figure 2. The NI chassis with computer, signal generator, and spectrum analyzer.

Commercially available high-dynamic-range PIM measurement systems are accessible today. These systems are typically designed for specific frequencies, usually around the cell band. They use a two-tone test setup and achieve up to 170 dBc of dynamic range using high Q filters that are fixed in frequency, but lack frequency agility. A commercially available nonlinear vector network analyzer, PNA-X, demonstrates far more flexibility than the fixed frequency PIM testing systems, and has the ability to vary tone spacings and tone amplitudes. The PNA-X system also tracks intermodulation (IM) products and harmonics, keeping track of all the nonlinear terms; however, it lacks the dynamic range necessary to measure nonlinear distortion from weakly nonlinear devices, as they are specified to generate harmonics lower than 60 dBc.

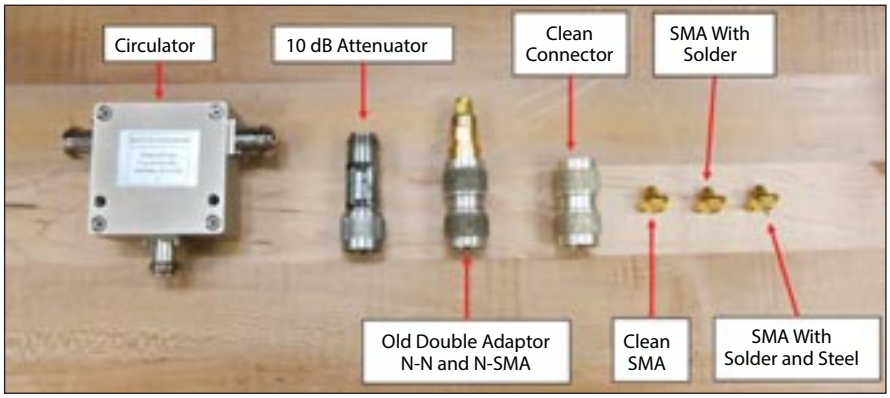


Figure 3. Devices tested for second harmonic characterization.

An alternate approach to measuring low-level nonlinear distortion from weakly nonlinear targets uses the second harmonic to characterize the nonlinearities of passive RF circuit elements. The measurement system achieves the high dynamic range, of the order of 175 dBc, necessary to measure weakly nonlinear devices while covering a 20% bandwidth, something the PNA-X and other commercially available systems cannot accomplish. The measurement system is also low-complexity, not requiring complicated feedforward cancellation circuits.

Creating a High-Dynamic-Range Harmonic Measurement System

To measure harmonics generated by devices that are not traditionally nonlinear, a high-dynamic-range (DR) measurement system must be developed. The measurement system must create a highly linear probe signal and must have the ability to measure very weak nonlinear signals in the presence of the large fundamental probe signal.

There are two important aspects of designing a high-DR harmonic measurement system: the use of a high-DR receiver to measure the weak nonlinear signals in the presence of the high-power probe signal, and generation of a highly linear probe signal used to probe a DUT. Both the receiver and probe signal generator have their unique problems that must be addressed to generate high-fidelity, linearized signals.

The measurement system was developed to measure second harmonic responses from weakly nonlinear targets. The system also collects data on the linear, fundamental responses from DUTs. The system was designed to measure both the pass-through and reflected linear and second harmonic response. This allows for full characterization of devices. The linear frequency range spans 800 to 1000 MHz and the second harmonic frequency range is 1600 to 2000 MHz. A block diagram of the measurement system is shown in Figure 1. The second diplexer is flipped to give the harmonics traveling in the reverse direction a path to a 50-| termination. Wherever possible, all inputs and outputs are terminated in 50 | at both the fundamental frequency and second harmonic.

A National Instruments (NI) PXI-5651 signal generator was used to create the probe signal. Next, Mini-Circuits RBF-272 diplexers were used in a low-pass configurations to linearize the probe signal and filter out any second harmonic generated by the signal generator. To boost the power of the probe signal, a Mini-Circuits power amplifier (PA) was used. The probe signal is amplified to 10 W (+40 dBm). The power amplifier is a nonlinear device and generates significant harmonics that need to be filtered. The NI chassis and RF components are shown in Figure 2.

Since the fundamental frequency power is at 10 W, high-power custom diplexers from Reactel were used. The high-power diplexers are rated up to 100 W continuous wave input power. They are cavity diplexers that provide greater than 80 dB of rejection in the stop band. The passband attenuation is less than 0.4 dB. In addition to the diplexers, an isolator is used to isolate the power amplifier output from the DUT and avoid mismatches. The insertion loss of the isolator is 0.2 dB; thus, the power delivered to the DUT was approximately +39 dBm.

Test results from a single diplexer showed the diplexers' ability to pass the fundamental frequencies, from 800 to 1000 MHz, and attenuate the second harmonics, from 1600 to 2000 MHz.

One cavity diplexer attenuates all harmonics, from 1600 to 2000 MHz, by at least 80 dB with less than 0.4 dB attenuation at the fundamental frequencies, from 800 to 1000 MHz.

The high-frequency path of the diplexer was also tested. Again, the diplexer attenuates the unwanted fundamental frequencies (here it is from 800 to 1000 MHz) by more than 80 dB and it passes the desired harmonic frequencies, 1600 to 2000 MHz, with less than 0.4 dB of loss. Since the diplexers have very little loss in the pass band, they do not absorb a significant amount of pass band energy.

The receiver hardware is straightforward. The probe signal, at the fundamental frequency, is separated from the second harmonic using another high-power diplexer. The spectrum analyzer has an 80-dBc dynamic range; coupling this with the 80-dB of loss provided by the Reactel diplexer yields a system dynamic range of over 200-dBc; however, the theoretical 200-dBc dynamic range is unachievable, as in practice, the system would be noise-limited before 200-dBc can be achieved. The noise floor of the receiver is measured to be less than 135 dBm. With the probe signal measured to be greater than 40 dBm and the noise floor below 135 dBm, the system's dynamic range is estimated to be greater than 175 dB.

System Test Results

The high-DR measurement system was used to measure the second harmonic response from a variety of circuit elements. The passive devices tested are shown in Figure 3. The two-port devices were tested for their input and output harmonic generation while the

one-port devices could only be tested for their reflected harmonic generation.

Since the spectrum analyzer has one input port, the fundamental and second harmonic at the output of the DUT must be measured via two separate measurements. Therefore, the loading conditions of the two measurements are slightly different. The spec- trum analyzer is matched to 50 W throughout the bands of interest with an input reflection coefficient of less than 20 dB, which provides a 99% power transfer. The differences between the loading conditions for the fundamental and second harmonic measurements is therefore expected to be negligible compared to using a 50 W termination.

Conclusions

As the frequency spectrum gets more crowded and the demand for wireless communication increases, nonlinear distortions generated by passive elements become more relevant. Commercially available nonlinear measurement systems are expensive and either lack the dynamic range needed to make the sensitive measurements, or are fixed in frequency and do not provide the flexibility required. Robust feed-forward systems have been constructed that provide both the flexibility and dynamic range needed to make the sensitive measurements, but these systems are complex and require iterative tuning and optimization algorithms.

The alternate method for characterizing nonlinear distortion from weakly nonlinear devices uses absorptive diplexers to separate the harmonic response from the high-power probe signal, thus increasing the system's dynamic range. The method is also capable of measuring the reflected harmonic from devices. The method is relatively simple to implement and it is cost-effective for measuring weak nonlinear responses of circuit elements.

The method demonstrated the capability of achieving 175-dBc dynamic range over a 22% bandwidth. The system is capable of producing over 10W (+40 dBm) of probe signal power while measuring second harmonics generated by a DUT as low as 135 dBm, resulting in the 175 dBc dynamic range. These passive RF circuit elements are not traditionally thought to exhibit nonlinearities, which require a high-DR nonlinear measurement system.

This work was done by Ram M. Narayanan of Penn State University; Kyle A. Gallagher, Anthony F. Martone, and Kelly D. Sherbondy of the US Army Research Laboratory Sensors Directorate; and Gregory J. Mazzaro of The Citadel. For more information, visit the Army Research Lab Sensors Directorate at ***www.arl.army.mil/www/default.cfm?page=32****.*

Using RISC-V to Simplify Data Logging in Space

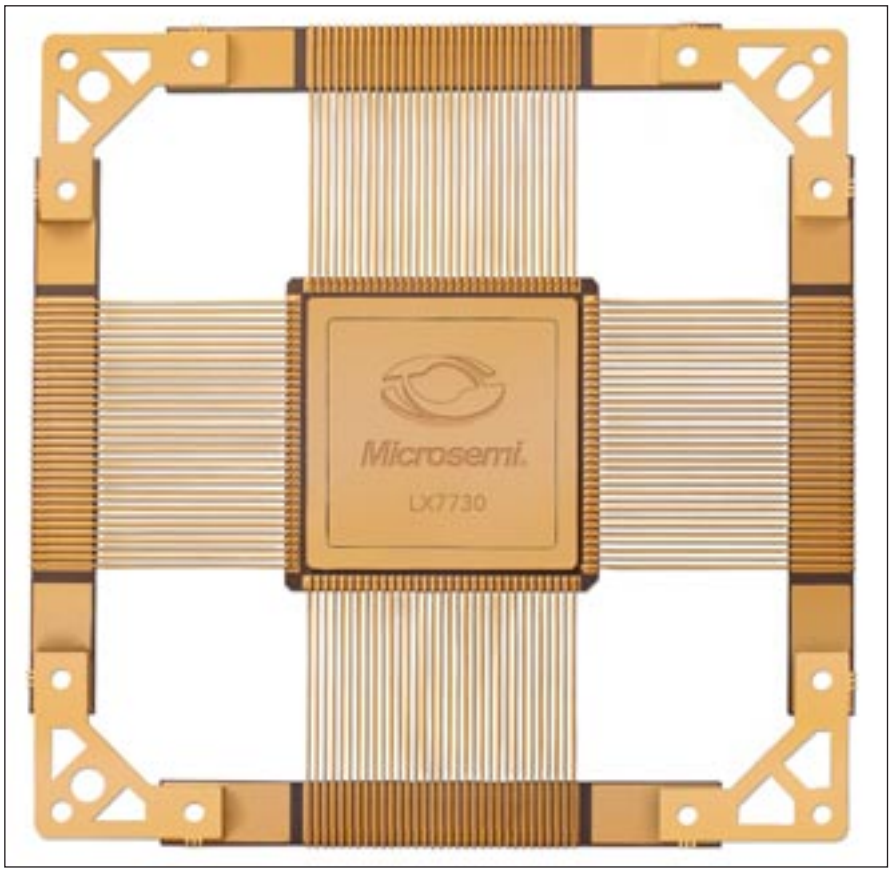
Worldwide demand for low Earth orbit satellites is increasing at an unprecedented pace, driven by diverse needs such as faster and more affordable Internet access, and faster revisit rates with finer resolution for imaging data. The satellite payload instruments performing communications or imaging functions are becoming increasingly sophisticated and capable and require the collection of increasing amounts of telemetry data to ensure the safe and reliable operation of the satellite.

This is accomplished using multiple large, power-hungry, and heat-generating circuit cards that contain a variety of discrete components for monitoring payload health. The component count of these I/O cards and the area and power they consume can all be significantly reduced by leveraging the latest advances in radiation-hardened mixed-signal integrated circuits (ICs) combined with a new open instruction set architecture (ISA) for reduced instruction set computing called RISC-V.

Critical Telemetry Functions

Telemetry allows health monitoring and fault detection, isolation, and recovery from the satellite ground station, but also allows the satellite to autonomously control payload instrument loading to manage power consumption and thermal dissipation, which may be necessary to avoid overloading and to preserve the life of the satellite.

Today, telemetry data is captured by large circuit cards, commonly referred to as I/O cards, laden with discrete components such as analog multiplexers, analog to digital converters, current drivers, and voltage references. These components capture data regarding voltage levels and current consumption, temperature, mechanical strain, pressure, and magnetic field strength, all of which are necessary for monitoring the health of the payload. These I/O cards are typically very large, occupying 12 to 18 square inches of precious space inside each payload equipment. Complex payloads, such as digital channelizers for communications applications, or signal processing systems for imaging or radar applications, are often chassis-based and can require multiple I/O cards for telemetry purposes. Telemetry I/O cards burn power and generate heat as well as add considerably to the bill-of-materials cost of the payload equipment. Further, circuit cards designed around discrete devices are not flexible or configurable.



Microsemi's LX7730 radiation-tolerant Telemetry Controller

Cutting Size, Cost, and Power

Recent advances in the technology of radiation-hardened mixed signal ICs have resulted in a higher level of integration that can minimize component count and reduce the area consumed by these I/O cards. Functions such as multiplexers, amplifiers, filters, ADCs, and DACs that were previously accomplished with small-scale integration and discrete components can now reside in a single IC. This allows data to be read and processed from sensors that monitor critical satellite parameters with a dramatic reduction in board space. Such integration has the added benefit to satellite manufacturers of increased reliability due to fewer components and reduces time and cost required for screening, testing, and qualification of these numerous components since this is now accomplished in one effort with a single IC. Microsemi's LX7730 Telemetry Controller is an example of this advancement. It integrates these functions into a compact 132-pin quad package and is QML-qualified for both class Q and class V requirements for the most demanding space applications.

The benefits of this approach can be seen in applications such as the Ganymede Laser Altimeter (GALA), one of the scientific instruments being tested for use onboard the European Space Agency (ESA) Jupiter Icy Moon

Explorer (JUICE) mission scheduled to launch in 2022. This altimeter system will measure the distance of the spacecraft to the surface of Jupiter's icy moons Ganymede, Europa, and Calisto by calculating the time it takes a laser beam to travel to the surface, be reflected, and return to the telescope within the instrument.

Laser altimeter system supplier Hensoldt Optronics chose the LX7730 telemetry controller to provide processing housekeeping for instrument data including temperatures, voltages, and supply currents. Within its small footprint, the LX7730 device takes an active part in several closed-loop controls necessary for an accurate laser operation with low electromagnetic interference (EMI) levels. Regular calibration procedures reduce temperature and lifetime dependent drifts and ensure the required accuracy of the acquired digitized values.

Additional benefits of this system architecture are available by leveraging the emergence of the RISC-V ISA, which has opened the door for inexpensive and extremely flexible processing that can be performed locally to the telemetry source, enabling datalogging, health monitoring, and load control to be performed autonomously at the payload, and relieving the satellite central computer system of the processing burden of managing telemetry in remote payload units. RISC-V is an open ISA whose instructions are also frozen, which enables several key benefits for space design. Because the instruction set is frozen, any software written for a RISC-V core will run forever on any RISC-V device. This is ideal for space applications where a code base may be reused multiple times on many different programs spanning decades.

In addition, the open ISA enables vendors to create soft CPUs tailored for customers' specific requirements. These soft RISC-V cores can also have their RTL shared. This could be critical for designs where inspection is needed to enable trust for security-conscious applications. RISC-V processors have already been integrated into radiation-tolerant field programmable gate arrays (FPGAs) for spaceflight applications. An FPGA configured to implement a RISC-V processor can be used in each payload for telemetry processing purposes, firstly reading telemetry data from the mixed signal telemetry acquisition IC, secondly performing processing and decision-making using data from the mixed signal device, and thirdly reporting health status information to the satellite central computer using the prevailing command bus protocol. FPGAs are commonly used to implement standard spacecraft control buses such as MIL-STD 1553, SpaceWire, and CAN bus, as well as non-standard bus protocols that are proprietary to the satellite integrator.

A complete telemetry-gathering system can be implemented using a highly integrated IC and an FPGA integrating a RISC-V processor. This system can be demonstrated with Microsemi's Six Sensor Demo that utilizes the company's RTG4 FPGA in a RISC-V environment connected via SPI to the LX7730 Telemetry Controller. The controller IC is used to acquire data from a small network of sensors connected to it and displays the measured values on a laptop screen via a GUI. The FPGA sends the address, data and read/write bits of the SPI frame to the IC that returns the ADC data to the FPGA. Finally, the FPGA applies the necessary scaling to the ADC output and sends the scaled data to the GUI through a UART.

The latest solutions for telemetry-gathering greatly simplify datalogging tasks and free up the main processor for other tasks. At the same time, high levels of integration of the mixed signal functions dramatically reduce the overall size and weight of the telemetry logging subsystem while increasing reliability, thus addressing three critical requirements in today's satellite systems.

This article was contributed by Microsemi Corp., a wholly owned subsidiary of Microchip Technology, Chandler, AZ. ***For more information, visit http://info.hotims.com/72990-555.***

Novel Characterization Methods for Anisotropic and Mixed-Conduction Materials

Seven new characterization methods have been developed for the specialized materials used in state-of-the-art electronic and optoelectronic devices.

Air Force Research Laboratory, Arlington, Virginia

State-of-the-art electronic and optoelectronic devices require electronic materials with specialized properties that cannot be characterized with standard methods, or that must be characterized with extra precision. As a result of this research, the following new materials characterization methods have been developed:

I. Carrier density gradient analysis method: Semiconductor uniformity is essential for all semiconductor applications, including optoelectronic light emitters & sensors, IC's, and logic devices. This method extends the van der Pauw method of electrical characterization so that one can measure small variations in the doping density of semiconductor samples typical to semiconductor devices.

II. Fourier-domain mobility spectral analysis: This method allows for electrons and holes of differing mobilities to be separated out from magnetotransport data. The experimental system of interest was lightly n-type quantum wells of Hg1-xCdxTe, which revealed ambipolar conduction of both electrons and holes.

III. Heterodyne 4-point method for electrical characterization of time varying conductivities: A new method was developed to improve the sensitivity of Hall measurements by orders of magnitude. This heterodyne Hall effect technique uses ac signal multiplication to measure a pure Hall resistance Rxy (B) in arbitrarily shaped samples.

IV. Anisotropic conductor characterization: With five contacts, it was demonstrated in a black phosphorus nanolayer that three independent four-point resistance measurements can determine the three independent components of an in-plane anisotropic resistivity tensor. Also, a detailed method for measuring in-plane and cross-plane conductivities of a superlattice has been formally described.

V. Heavy-tail transient analysis: Disordered systems exhibit a range of timescales and manifest slow switching transients, or "heavy-tail" relaxations, which limit performance. An equation was derived that fits all classes of heavy-tail functions and was experimentally applied in both the low- and high-disorder limits in 2D transistors of black phosphorus.

VI. Disorder scaling in non-ohmic conductivity of 2D materials: In 2D conductors, the gated conductivity is typically non-linear, with changes in the surface adsorbed gases leading to changes in both the doping level and the mobility. We demonstrate that all of the characterization curves at different adsorbate concentrations, dopings, and disorder can all be collapsed onto a single universal curve that is characteristic of that particular material.

VII. Percolation model for electrical and thermal conductivity in disordered media: Disordered porous media are described in a modified percolation model that is adapted for polymer composites under uniaxial pressure. Percolation is also shown to describe thermal conductivity in metal-organic frameworks fabricated by combustion synthesis.

This work was done by Matthew Grayson of Northwestern University for the Air Force Research Laboratory. ***For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Electronics & Computers category.*** *AFRL-0270*

Circuit Models for Robust, Adaptive Neural Control

Understanding a nematode's simple circuit could provide a foundation for understanding much more complex behaviors.

Air Force Research Laboratory, Arlington, Virginia

This project seeks to reproduce the neural circuits used by the nematode Caenorhabditis elegans for locomotion. Caenorhabditis elegans is a small (~1.2 millimeter) nematode found in rotting fruit in many parts of the world. It feeds on bacteria and is neither parasitic nor pathogenic. Although capable of sexual reproduction, most laboratory strains reproduce primarily as self-fertilizing hermaphrodites, with each adult hermaphrodite producing approximately 300 progeny (Figure 1).

C. elegans is a very simple organism, with only 959 somatic cells in the adult hermaphrodite. Although the total number of cells is small, they are differentiated into the standard array of tissues: 302 neurons, 95 body muscle cells, 32 gut cells, etc. In addition, the position, morphology, and lineage of each cell are reproducible from animal to animal. Because of the small size of the animal, the relatively small number of neurons, and the reproducible nature of the nervous system, it has been possible to provide an almost-complete synaptic connectivity map of the adult hermaphrodite nervous system (Figure 2).

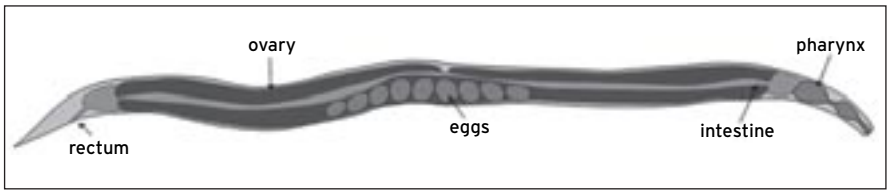


Figure 1. Basic anatomy of an adult hermaphrodite C elegans nematode.

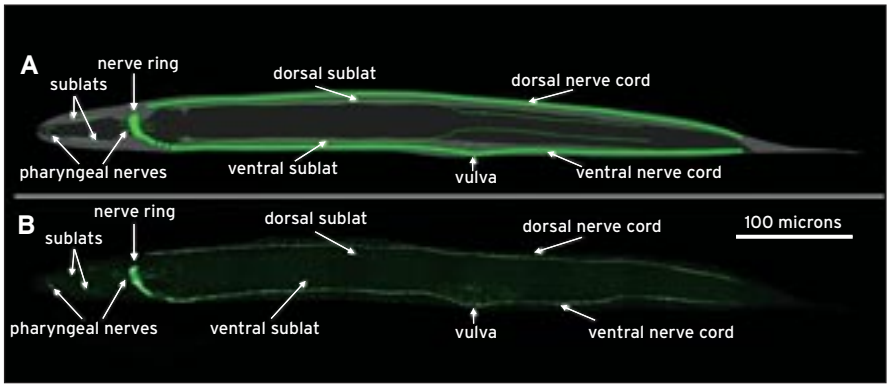


Figure 2. Synaptic connectivity map of C. elegans nervous system.

Utilizing only 113 neurons, this simple circuit drives the 95 body wall muscles to generate surprisingly complex and adaptive locomotion behavior. Recent advances in C. elegans electrophysiological techniques, which have resulted in a surge of new data, have made it possible to build an accurate computational model of C. elegans locomotion.

Taking the perspective that the best way to understand something is to construct it, this interdisciplinary project aims to reproduce the locomotion neural circuitry used by C. elegans to drive a virtual model in a highly detailed 3D C. elegans simulator. The goal of this project, therefore, is to develop an understanding of the basic motifs used by nature in developing complex, adaptive control systems. This goal can be further refined into three specific project objectives:

1. Develop a biologically accurate computational model of the locomotion circuitry used by C. elegans.

2. Validate the model by demonstrating that it produces the various locomotion modalities in a physics-based simulation environment.

3. Verify that the model accurately reproduces the robustness and adaptability seen in the living organism using comparative video analysis.

It is believed that the locomotion circuit used by C. elegans forms the basis for a number of more complex circuits found in higher order organisms. In other words, understanding this simple circuit could provide a foundation for understanding much more complex behaviors.

This work was done by Roger Mailler, The University of Tulsa, for the Air Force Research Laboratory. ***For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Electronics & Computers category.*** *AFRL-0269*

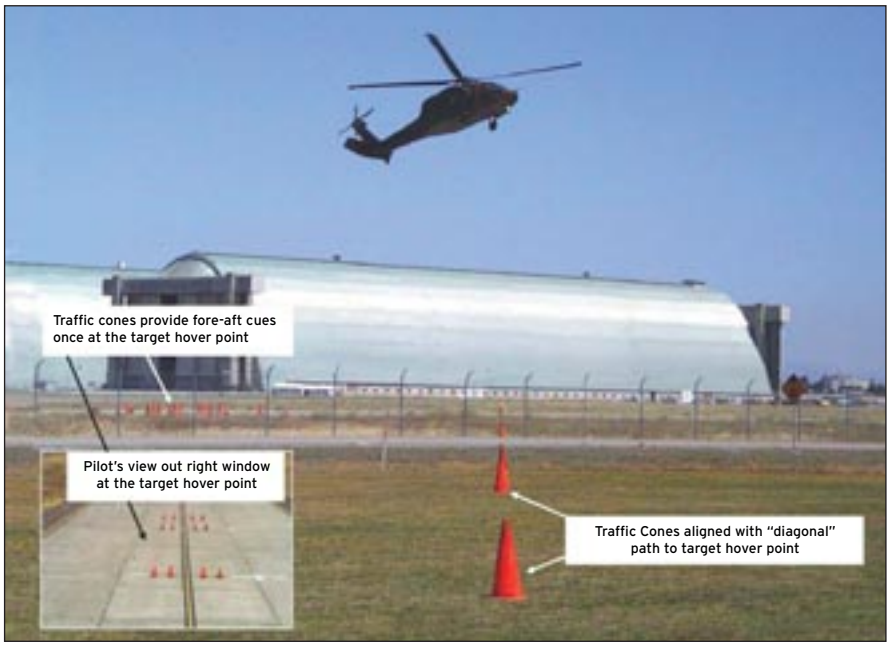
Evaluation of Aeronautical Design Standard – 33 Using a UH-60A Black Hawk

Flight tests determine whether performance standards developed for scout and attack class rotorcraft can be applied to utility helicopters.

Army Research, Development, and Engineering Command, Redstone Arsenal, Alabama

In 1982, the U.S. Army Aeroflightdynamics Directorate (AFDD), then assigned under the U.S. Army Aviation Systems Command (AVSCOM), began development of a new handling qualities specification for military rotorcraft. This effort resulted in the U.S. Army's initial Aeronautical Design Standard–33 (ADS-33A), "Handling Qualities Requirements for Military Rotorcraft," published in May 1987. It was initially applied to the RAH-66 Comanche Helicopter program, meaning the handling qualities requirements generally related more to scout and attack classes of rotorcraft. As more data became available and lessons learned emerged from using ADS-33A, refinements were implemented into ADS-33B and ADS-33C).

In 1990, ADS-33C was assessed using an AH-64A Apache by the U.S. Army's Airworthiness Qualification Test Directorate (AQTD) at Edwards Air Force Base, California. Testing was performed during the day and at night in the Degraded Visual Environment (DVE). The results of that test led to development of the next version of the specification, ADS-33D.



Hover MTE traffic cones course layout for UH-60A Black Hawk testing.

In 1996, the U.S. Army Aviation and Troop Command found ADS-33D met the definition of a performance specification, and issued a new designation, ADS-33D-PRF. To better understand the applicability and compliance testing issues of applying ADS-33D-PRF to utility helicopters, a flight test assessment was recently conducted with a UH-60A Black Hawk helicopter.

The objectives of this flight test were: a) to assess the required compliance testing and evaluate the criteria in ADS-33D-PRF to determine if it adequately addresses the utility helicopter mission; b) to tailor existing ADS-33D-PRF Section 4 Mission Task Elements (MTEs) in a good visual environment and develop new flight test maneuvers specifically designed to adequately evaluate the handling qualities of utility helicopters, with and without external slung loads; c) to correlate the results of quantitative testing with those from the qualitative evaluations; d) to establish a handling qualities baseline of the UH-60A (using the general criteria outlined in ADS-33D-PRF) against which the effects of future modifications to the aircraft may be better compared or quantified; and e) to document the UH-60A response characteristics in order to provide data to support refinement of AFDD's UH-60A mathematical models.

The test aircraft was a sixth-year production UH-60A Black Hawk. The UH-60A is a twin turbine engine, single rotor, semi-monocoque fuselage, rotary-wing aircraft. The main rotor system has four blades made primarily of titanium and fiberglass.

The propulsion system has two T700-GE-700 engines without the hover infrared suppressor system installed. The non-retractable landing gear consists of the main landing gear and a tail-wheel. The aircraft is equipped with a cargo hook capable of carrying up to 8000-lb external loads.

Dual cockpit controls consist of the cyclic stick, collective stick, and pedals. Pilot flight control inputs are transferred from the cockpit to the rotor blades by mechanical linkages and hydraulic servos. The aircraft is equipped with an Automatic Flight Control System (AFCS), which enhances the stability and handling qualities of the helicopter. It is comprised of four basic subsystems: stabilator, stability augmentation system (SAS), trim systems, and flight path stabilization (FPS).

The research instrumentation and data acquisition system for this test consisted of sensors, signal conditioners, pulse-code modulation (PCM) encoder, time code generator, and data recorder. The helicopter sensors included air data, accelerometers, rate and attitude gyros, and control position sensors at several points in the control system. These sensor signals were passed through filters, digitized, and encoded in a PCM stream, which was recorded onboard and simultaneously transmitted to the ground telemetry (TM) station. A time code generator received the broadcast time from the TM station and supplied this to the on-board recorder and the PCM stream.

Externally-mounted test instrumentation included a nose boom incorporating a sideslip sensor and airspeed probe, a low airspeed detection system, laser reflectors attached to the left and right step fairings, and a telemetry antenna attached to the fairing below the stabilator.

The ground-based telemetry (TM) station provided not only PCM-stream recording, processing, and real-time presentation, but also video coverage from a "pan and tilt" camera located on an antenna tower. The laser tracker system provided helicopter position data with accuracies to within ±6 inches. Aircraft position data were further transformed from the laser reflector located on the side of the helicopter to the pilot's eye position by including the aircraft attitudes and distances from the reflector to the pilot. Aircraft control positions, angular rates, and attitudes, along with aircraft ground speed and position information from the laser, were presented on four 8-channel, thermal-paper strip charts.

This work was done by David R. Arterburn of the University of Alabama in Huntsville, and Chris L. Blanken and Eric L. Tobias for the Army RDECOM Aviation & Missile Center. ***For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Electronics & Computers category****. ARDEC-0003*

Synthetic Aperture Radar for Helicopter Landing in Degraded Visual Environments

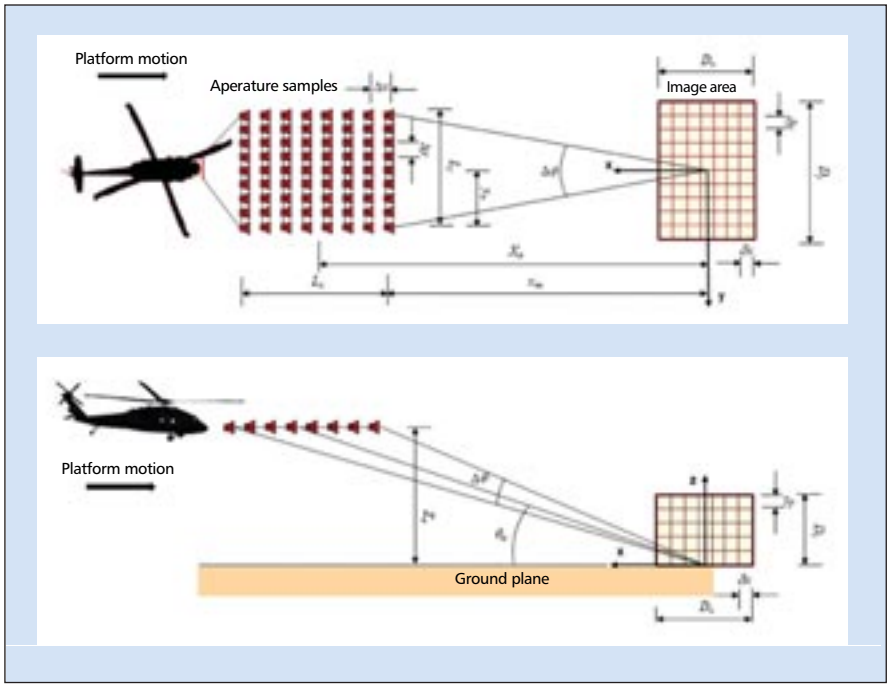
New technology could give helicopters the ability to overcome zero-visibility brownout conditions during landing.

Army Research Laboratory, Adelphi, Maryland

The development of sensors to assist helicopter landing in degraded visual environments (DVEs) is currently an important US Army requirement addressing the Survivability of Future Vertical Lift Platforms program, one of the Army's modernization priorities.

Over the past three decades, dozens of rotary-wing aircraft crashes have been responsible for a large number of casualties to US and coalition forces in different parts of the world. Out of these crashes, at least 75% have occurred in brownout conditions, where dirt or dust is stirred up and recirculated by the rotor blades, creating low- or zero-visibility environments for the pilots. Research and development efforts to mitigate this issue starting in the early 2000s recommended several possible solutions based on optical, IR, and radar sensors. Unfortunately, most of these solutions have proven to be either ineffective or they involved unacceptable size, weight, power, and/or cost (SWAP-C), leaving the Army with a capability gap to be filled.

The US Army Research Laboratory (ARL) is currently working on a sensor solution to this problem based on millimeter-wave (MMW) imaging radar technology. The main idea behind this sensor is to combine a linear antenna array with the radar platform motion to obtain a high-resolution 3-D terrain map of the landing zone. This information would be passed to the pilot via a helmet-mounted display to assist in deciding whether the landing zone is safe. Several previous efforts in developing similar sensors, based on passive or active MMW technology, have focused heavily on 2-D antenna arrays working in scanning mode to obtain a terrain map. These efforts generally produced devices that proved either too expensive, unreliable, and/or inaccurate for the required task. The ARL-proposed solution leverages advanced radar imaging methodology, together with the current boom in commercial MMW RF technology (driven by developments in autonomous car navigation and 5-G wireless communications), to produce a reliable, low-SWAP-C sensor prototype addressing this requirement.



Schematic representation of the helicopter-borne radar system operating as FLSAR, showing the relevant sensing geometry from a) top view and b) side view. The small antenna diagrams mark the aperture sample positions. (Drawing not to scale.)

The proposed radar system will use a linear antenna array and the forward-looking synthetic aperture radar (FLSAR) concept to achieve the stated goals. A linear antenna array mounted on the rotorcraft's front end will provide the required cross-range resolution, while the transmitted signal bandwidth (up to 1 GHz) will provide downrange resolution. To achieve resolution in the vertical dimension, the radar will exploit small elevation angle deviations in the helicopter flight path, which naturally occur when the pilot prepares for landing. Overall, this new radar sensor concept represents a significant shift in implementation from a hardware-heavy solution to an emphasis on signal processing and computational power, with large potential cost savings and performance improvements.

As part of this research, a detailed analysis of the 3-D imaging performance of the proposed radar system was performed by investigating the point spread function (PSF). The emphasis was on synthetic aperture radar (SAR) and antenna array processing, which are key to this sensor's implementation.

This work was done by Traian Dogaru for the Army Research Laboratory. ***For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Electronics & Computers category.*** *ARL-0217*

Pulsed Microwave Plasma Instrumentation for Investigation of Plasma-Tuned Multiphase Combustion

Instrumentation developed to support the investigation of electromagnetic wave interaction with energetic materials and flames could help develop microwave-sensitive energetic materials that produce effects such as microwave ignition, acceleration of burning rate, extinguishment, and re-ignition.

Air Force Research Laboratory, Arlington, Virginia

Strategies to control solid rocket propellant regression rate require a robust throttling technique applicable to high performance propellant formulations. Currently, several methods to control and throttle either motors or subscale propellant strands exist, including chamber pressure control (e.g. pintle nozzles or rapid depressurization quench), infrared laser irradiation of the burning surface to increase burning rates, development of inherently unstable combustion chamber geometries (producing either local pressure or velocity perturbations), and electrically sensitive hydroxylammonium nitrate (HAN)-based formulations in which burning rate is controlled by a voltage potential. However, these techniques are limited in that they either can only be used with low flame temperature (low specific impulse) propellants, result in low propulsion system mass fraction (pintle), are only capable of producing a single perturbation, or are formulation specific.

To gain control over a combustion process, combustion plasma enhancement has been demonstrated in electrothermal-chemical (ETC) launchers, in which solid gun propellant ignition flame spread, pressurization rate, and global propellant burning rate improvements were observed. With ETC enhancement, burning rate improvement of up to 35% is possible and further enhancement is speculated to be possible with higher solid loading. However, ETC launchers (e.g. capillary plasma generation) are capable only of single plasma injections or have limited volume.

In consideration of a microwave – rather than ETC – generated plasma, the microwave transparency of many propellant ingredients may enable large volume plasma generation in complex grain

shapes, and microwave plasma seeding techniques are limited in number of plasma events by only energy availability. Unlike pintle throttling techniques, modification of a motor for microwave enhancement requires no moving parts and is simplified by utilization of the motor casing as an in-situ waveguide, requiring only the addition of an RF pressure window transition for magnetron interfacing. The use of microwave seeded plasmas within motors for control may also reduce aerodynamic loss (compared to pintle) and may enable throttling of higher performance propellant formulations (e.g. aluminized composites) that have flame temperatures too high to be easily controlled with pintle nozzles.

Pulsed microwave seeded-plasma generation is a multi-shot technique that has been used to gain control over combustion processes. This technique exploits low duty cycle, high-power microwave pulses, for precise control over plasma growth. One strategy for pulsed microwave plasma generation involves operating in a subcritical regime, below the threshold for ionization in the ambient gas, where microwave energy deposition to the flame is facilitated through interaction of high field strengths produced from a ~100 kW pulsed source with weak electron populations produced from chemiionization radicals. This strategy allows for preferential coupling to regions of locally high ionization while avoiding parasitic gas breakdown and absorption at other locations. Previously, this approach was demonstrated for both laser-generated ionization and in atmospheric pressure hydrocarbon flames.

Successful attempts at microwave supported plasma enhancement of premixed gas-phase flames resulted in an increase in flame speed, a ~500°C increase in flame temperature, and extension of lean flammability limits. The high field strengths able to be produced using pulsed techniques (order 10-100 kV/m) require only very low levels of ionization to rapidly establish plasma seeding and growth. However, seeding and growth are possible at much lower field strengths through non-equilibrium thermal ionization of a small amount of an easily ionizing dopant.

The use of a novel alkali metal doping technique for efficient, targeted low-power (field strength) microwave energy deposition to the flame structure in order to seed the formation of a combustion-enhancing plasma has been demonstrated. With this technique, the propellant is doped with a small quantity of material containing easily ionizing atoms, such as alkali earth metals (e.g. sodium in the form of sodium nitrate, $NaNO_3$). In doing so, microwave energy can be targeted to free electrons in a propellant flame, in order to produce the formation of plasma seeding (see illustration).

Propellant containing dopant (e.g. sodium in the form of sodium nitrate, $NaNO_3$) decomposes from thermal energy provided from combustion, producing

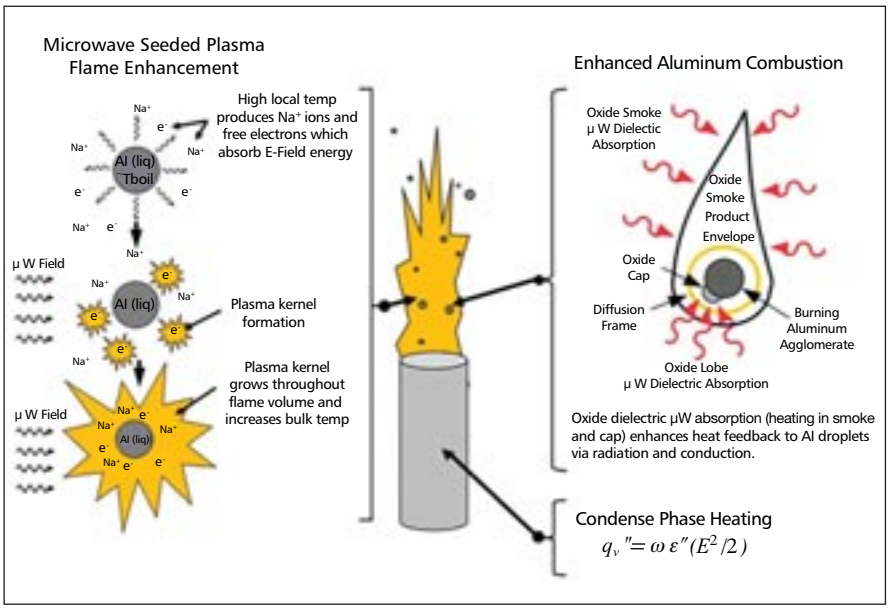


Illustration of possible mechanisms for burning rate enhancement. Plasma kernel seeding frequently occurs around Al particle flame structures due to high local flame temperatures and subsequently grows through the flame volume. Direct energy absorption (dielectric loss) to oxides (smoke and oxide cap) can occur. Condensed phase heating can also contribute to the burning rate enhancement.

Na+ ion and electron in the flame. During microwave radiation, these ions and free electrons in the flame become energy deposit sites, producing plasma kernels which grow throughout the flame. Plasma kernels form near combusting Al agglomerates due to high local flame temperatures. Including plasma combustion enhancement, two other rate enhancing mechanisms have been identified and are being studied: (1) condense phase heating in Maxwell- Wagner effect due to conductive particles in a non-conductive dielectric matrix (HTPB bind, AP) and (2) combustion enhancement of burning Al agglomerates in the flame.

This work was done by Travis Sippel, James Michael, Stuart Barkley and Keke Zhu of Iowa State University for the Air Force Research Laboratory. ***For more information, download the Technical Support Package (free white paper) at www. aerodefensetech.com/tsp under the Electronics & Computers category.*** *AFRL-0271*

Multirole Utility Helicopters

Airbus Helicopters
Marignane Cedex, France
+33 (0)4 42 85 60 51
http://helicopters.airbus.com

Airbus Helicopters will be providing an additional four H225M (previously known as the Eurocopter EC725) multirole utility helicopters to the Royal Thai Air Force (RTAF) as part of their fleet strengthening program. This follow-on order will bring the RTAF's H225M fleet up to 12 units by 2021.

Specially equipped with emergency flotation gear, fast roping, cargo sling, search light and electro-optical systems, these four new multirole H225M helicopters will join RTAF's existing fleet of six H225Ms for combat search and rescue missions, search and rescue flights, and troop transport operations. The air force will also be receiving two H225Ms from its earlier order, by end of this year.

This latest contract will also cover on-site technical support and continuing airworthiness management organization services, fully supported by Airbus' Thailand team.

Featuring state-of-the-art electronic instruments and a 4-axis autopilot system, the 11-ton-catergory twin-turbine H225M offers a combination of endurance and fast cruise speed, combined with a 700 NM range that can be extended with air-to-air or hover in-flight refueling capabilities. Powered by two powerful Makila 2A1 engines, the H225M's five-blade rotor provides an exceptionally low vibration level, and the modular Spheriflex design of rotor mechanical assemblies allows for lower maintenance.

Using the proven military heritage of Airbus' Puma and Super Puma rotorcraft, the H225M was designed and is equipped for high survivability. Its airframe has reinforced structural main frames and is equipped with high energy-absorbing landing gear, along with self-sealing and crashworthy fuel tanks. Cockpit protection is provided by armored and energy-absorbing crew seats, while the cabin can be equipped with armor plating in the floors and walls or fitted with armor-plated carpets. The rotor blades' multi-box construction enhances their resistance to bullet impacts.

Contributing to the H225M's survivability is a radar warning receiver, missile approach warning system, laser warning receiver and chaff/flare dispensers. The engine exhausts can be fitted with infrared suppressors, with protection against sand and ice provided by inlet design and multi-purpose air intakes.

As a true multi-purpose and versatile military asset, the H225M enables military forces to deploy wherever and whenever needed. Operating both from ships and from land, even in icing conditions, this helicopter has an all-weather capability supported by night vision goggle compatibility. Close to 90 units are currently in service, achieving 100,700 flight hours to-date.

For Free Info Visit ***http://info.hotims.com/72990-550***

Aircraft Parachute Recovery Systems

BRS Aerospace
South St. Paul, MN
651-457-7491
www.brsaerospace.com

BRS Aerospace has engaged Wichita State University's National Institute for Aviation Research (WSU-NIAR) to develop testing protocols for evaluating the safety and performance of aircraft parachute recovery systems in General Aviation (GA) and Vertical Take-Off and Landing (VTOL) aircraft. Working with WSU-NIAR's Crash Dynamics and Virtual Engineering laboratories, BRS Aerospace will develop whole aircraft parachute recovery system Supplemental Type Certificates for a range of existing general aviation aircraft and approvals for new models currently under development in addition to advanced VTOL technology.

BRS is a recognized authority on whole aircraft parachute recovery systems with more than 35,000 such systems installed on more than 350 models of airplanes. The company is also in the early stages of developing vehicle recovery systems technology that will allow VTOL aircraft to reach safety levels equivalent to standards established in the automotive industry.

Already working with a number of new VTOL aircraft manufacturers, BRS Aerospace was represented at the UBER Elevate Summit 2018 as one of four critical gap technologies neces-

sary for the successful development of the electric-powered VTOL ecosystem. Uber is promoting electric-powered VTOL urban transportation development.

BRS Aerospace already offers a parachute recovery system as a retrofit to Cessna 172/182 aircraft and as standard equipment on the popular Cirrus line of aircraft. BRS has delivered whole aircraft parachute systems to aviation segments including Light Sport Aircraft, experimental aircraft, ultralights, unmanned vehicles, military aircraft, and FAA/EASA Type Certified airplanes. A recent independent statistical analysis concluded that when deployed, the ballistic recovery system significantly reduced the odds of experiencing a fatal aircraft accident. BRS has documented a total of 386 lives saved when the ballistic recovery system was deployed.

BRS Aerospace's whole aircraft parachute system for fixed-wing aircraft design calls for a parachute ballistic launcher to be installed in the aircraft with a pilot-initiated activator located in the cockpit. Upon activation, a ballistic rocket propels a parachute into the airstream to slow the airplane and float it down into a survivable vertical landing.

BRS Aerospace was founded in 1980 in South St. Paul, MN and has manufacturing facilities at the South St. Paul Municipal Airport and in Pine Bluff, N.C. Their system has been successfully deployed multiple times and the company has documented 386 lives saved as a result of its safety device.

NIAR, located in Wichita, KS, operates on a nonprofit budget and is the largest university aviation R&D institution in the U.S. It supports the aviation industry by providing research, development, testing, certification and training.

For Free Info Visit ***http://info.hotims.com/72990-551***

Deployable – Instrument Landing System

Thales Group
Cedex, France
+ 33(0)1 57 77 86 26
www.thalesgroup.com

The United States Air Force's (USAF) activities to establish air superiority and support ground combat units often require the use of secure airfields in remote and challenging areas. Thales Deployable – Instrument Landing System (D-ILS), a compact and movable variant of the standard ILS, can help them accomplish this mission.

Over the last three years, Thales has received three orders from the USAF under the D-ILS contract. These orders allowed Thales to deliver a total of five D-ILS used by the USAF for initial testing and evaluation. The first Production Unit (PU) was scheduled to be delivered to the Air Force before 2019. Under the program, the Air Force plans to purchase an additional 28 Production Units bringing the total deployable complement to 34. These systems will be used in airfield environments where the ability to provide precision guidance to aircraft on final approach during low visibility or low-ceiling weather conditions is critical while also being able to quickly set-up, activate, break-down and re-locate the systems.

Thales D-ILS will provide the equivalent of fixed-based instrument landing system capability at tactical airfields and in harsh environments such as areas of natural disaster or humanitarian relief efforts. Thales D-ILS is based on the commercial-off-the-shelf Thales ILS 420 – the next generation fixed-based, dual frequency ILS. The D-ILS system can be easily transported via truck, rail or transport aircraft and quickly deployed. More than 700 fixed-base systems have been chosen worldwide for civil and military applications. In fact, Thales currently deploys over 99 percent of the instrument landing systems at U.S. airports, and an installed base of over 11,000 navigation aids deployed around the world.

Thales Deployable ILS have already been deployed in Italy, Qatar and Mexico.

For Free Info Visit ***http://info.hotims.com/72990-554***

Weapons Calibration App

Double Shoot
Ramat Gan, Israel
+972-52-9208000
www.double-shoot.com

Double Shoot, an Israeli company that is pioneering advanced systems for zeroing high accuracy weapons and scoring systems, recently unveiled a unique and innovative smartphone application for zeroing weapons, range scoring, and comparison. The versatile application can be used with a variety of assault rifles and machine guns.

Double Shoot's unique application is a response to the manual weapon zeroing process currently being used by armies and security forces around the world. This manual process is slow and requires a great deal of ammunition, making it expensive while not delivering a high level of accuracy. The new application developed by Double Shoot streamlines the zeroing process, making it significantly more efficient by saving 30-50% in training time and ammunition. Optimizing the entire process of shooter training, the application turns every shooting range into a smart shooting range.

Double Shoot utilizes an advanced image processing system deployed via smartphone, combined with data-based analysis within a restricted web interface in order to provide a wide spectrum of reports, not only to individuals and instructors, but to entire units, HQ and the staff levels. The system, intended for both military and police forces, works even when the smartphone is in airplane mode, and can be installed on both Android and iOS phones.

The company has been awarded a Certificate of Patent in Israel and has filed an international patent application.

For Free Info Visit ***http://info.hotims.com/72990-552***

Drone-Elimination Fire Control System

Smart Shooter Ltd.
Kibbutz Yagur, Israel
+ 972-72-3202111
www.smart-shooter.com

Smart Shooter's SMASH fire control system adds digital precision to in-service rifles and ammunition. It has been successfully tested by US Special Operations Forces and other military agencies, and it officially entered operational service with the Israel Defence Forces in early 2018. The latest and most advanced variant – SMASH 2000 Plus – has the capability to lock, track and accurately hit conventional targets as well as small, fast and maneuverable tactical unmanned aerial vehicles (UAVs), day and night.

SMASH is fully ruggedized and can be added to a wide range of legacy small arms including the M4 and other AR-15 variants. The system constantly scans for potential ground and UAV targets and – once confirmed – constantly works out firing solutions to provide the user with the optimal moment to fire, promising to hit the target and nothing else. Markers in the sight HUD provide maximum situational awareness when it is needed most.

In essence, the SMASH family of Fire Control Systems was designed, developed and manufactured by Smart Shooter to ensure that each round hits its designated target, day or night, while keeping friendly forces and uninvolved population

safe. SMASH 2000 is designed for the rigors of close-quarter combat, aiming to help shooters hit and eliminate their targets with the first round. However, the system enables the user to instantly revert back to free-fire mode through the reflex sight and fire the rifle manually (bypassing the Fire Control System). With another click of a button, the Fire Control System can be turned on again. The system continuously calculates the required aiming point in order to hit the target, taking into consideration the respective movement of both the target and the shooter. This dynamic aiming point is continuously displayed through the eye-piece providing the shooter with an unprecedented hit-ratio for each shot.

The company combines proprietary target acquisition and tracking algorithms with sophisticated image-processing software and then embed them in rugged hardware solutions to cost-effectively upgrade rifles and other infantry firearms, turning them into 21st century smart weapons.

The SMASH 2000 system includes: target detection and acquisition; automatic target tracking and continuous designation of calculated aiming point; see-through reflex sight; alternate day/night operation mode; and optional video recording capability for debrief purposes. The SMASH 2000 'Plus' includes all of the features of the SMASH 2000 system, with an enhanced counter-drone/UAS mode that provides the operator with a line-of-sight automatic detection system as well as an accurate kinetic shoot-down capability.

The system is rugged and compact and can be easily and rapidly installed on almost any infantry rifle and firearm, while its modular software and design approach enables the SMASH family to constantly evolve, regularly rolling out new capabilities and updates. Future iterations will include SMASH 2000M offering x4 magnification in addition to the FCS capabilities; and SMASH 2000N offering improved night vision capabilities.

For Free Info Visit ***http://info.hotims.com/72990-553***

Defense-Grade FPGAs

Xilinx, Inc. (San Jose, CA) announced availability of its Defense-grade XQ UltraScale+ portfolio of products, providing the benefits of its UltraScale+ architecture plus extended temperature and ruggedized packages to address the needs of the aerospace and defense industry. The new products encompass the XQ Zynq® UltraScale+ MPSoCs and RFSoCs, as well as XQ UltraScale+ Kintex® and Virtex® FPGAs.

The XQ UltraScale+ product portfolio includes the industry's first defense-grade heterogeneous multiprocessor SoC devices, combining flexible and dynamically reconfigurable high-performance programmable logic and DSP, 16Gb/s and 28Gb/s transceivers, quad-core Arm® Cortex™-A53 embedded processors, and dual-core Arm Cortex-R5 embedded processors. In addition, optionally available features include high-speed 4Gsps ADCs and 6.4Gsps DACs, Arm Mali™-400 GPU, 4k60 H.265/H/264 video codec, and ruggedized packages with support of -55°C to 125°C and 256-bit physical unclonable function (PUF).

For Free Info Visit http://info.hotims.com/72990-510

Additive Manufacturing (AM) Materials and Services

Goodfellow (Coraopolis, PA) offers a new line of additive manufacturing (AM) materials and services that can be expertly tailored to the design, function and product life of an application. Raw materials currently being offered include: metal, alloy and ceramic powders; metal and alloy wires; and polymer monofilaments.

In terms of manufacturing services, Goodfellow can provide comprehensive AM services, from initial drawing to post-production finishing. To be more specific, Goodfellow has the capability to: fine-tune your component design or create the design for you; assist in choosing the best AM process for achieving your desired results; produce finished parts using AM technology or, if more appropriate, traditional manufacturing methods; provide materials or finished parts in quantities from prototype to large-volume production.

For Free Info Visit http://info.hotims.com/72990-512

Tolerance Compensation Clamps

Destaco (Auburn Hills, MI) recently launched its TCC-2E Series Tolerance Compensation Clamps (TCC) that are designed to provide greater flexibility in welding and assembly applications requiring the clamping of components of differing thicknesses or tighter tolerances. The new TCC-2E model, which is directly interchangeable with Destaco's 82M-3E Series Power Clamps, is especially suitable for flexible manufacturing applications in the automotive and aircraft industries.

The TCC-2Es are available in a variety of sizes. They feature an enclosed body that protects the internal mechanism and have been tested to be maintenance-free for 3 million operating cycles. Various cylinder designs with unlockable non-return check valves, hold-open devices and rod-lock units are available to meet the needs of every unique application.

For Free Info Visit http://info.hotims.com/72990-542

Pico-ITX Single Board Computer

WinSystems (Arlington, TX) announced its Intel E-3800 processor-based computing platform in the Pico-ITX form factor. Measuring a mere 3.9 inches by 2.8 inches (100 mm by 72 mm), the ITX-P-3800 delivers low-power performance, endurance and versatility. The proven design of this rugged single board computer (SBC) accelerates time to market for new products while assuring that they will perform reliably in critical applications for many years – even under harsh operating conditions. Equally important, it gives embedded and industrial IoT designers the flexibility to create unique designs via easy-to-use expansion and configuration settings.

ITX-P-3800 single board computers include dual Ethernet and four USB channels, and accommodate a wide range of DC input power: + 9V to + 36V. They combine powerful Intel E3800 processors with a functional I/O set including four RS-232 serial ports plus a Mini-PCIe connector for easy expansion. The smaller header-based connectors allow the SBC to be used within a small box or container.

For Free Info Visit http://info.hotims.com/72990-511

Composite Forming Facility

Rhodes Interform (Wakefield, UK), a specialist in bespoke composite and metal forming machinery, has recently completed the installation and testing of a 'world class' composite forming facility at the University of Sheffield's Advanced Manufacturing Research Centre (AMRC) in the UK. The state-of-the art facility, comprised of a 10,000 kN hydraulic press with six axis loading, high pressure RTM, twin die transfer tables, thermal fluid heating system and die splitter, is capable of a wide range of composite forming including Open and Closed Molding, Resin Transfer Molding (RTM), Prepreg, Compression Molding and Thermoplastics. The project attracted funding from the Government's Advanced Manufacturing Supply Chain Initiative (AMSCI). The machine will be available for use by companies looking to develop their composite capability through Research and Development.

For Free Info Visit http://info.hotims.com/72990-535

Dual Tank/Dual Action Ultrasonic Agitation Flow Cleaner

Omegasonics (Simi Valley, CA) recently introduced the new 815BTX, an innovative dual tank bench top ultrasonic cleaning machine. The model's left tank utilizes Bio-Solv, a biodegradable, non-hazmat cleaning detergent developed by Plural that is far superior to sodium-hydroxide (NaOh). Alternatively, the unit's right tank simply uses hot water. Its programmable dual action cleans 3D parts safely and efficiently. Ultrasonic technology is used to optimize the cleaning of precision areas and is combined with agitation to thoroughly remove support material. The 815BTX also features programmable alternating cycles to provide hands-off cleaning from start to finish.

For Free Info Visit http://info.hotims.com/72990-538

Shop Management Software

Adion Systems (Vancouver BC), developers of ProShop software, recently debuted a new generation of shop management software ideal for Industry 4.0 practitioners. ProShop offers an integrated, comprehensive set of modules for managing the shop's typical ERP operations. In addition to "front office" activities such as estimating, quoting and purchasing, ProShop includes MES (Manufacturing Execution System) and QMS (Quality Management System) control, monitoring and collection capabilities. Among the MES functions are: tracking machine utilization, cutting tool management, media-rich work instructions, part inspection data, and more, including integration with coordinate measuring machine data.

ProShop also offers an integrated, comprehensive set of modules for managing the shop's QMS such as ISO-9000, AS9100, API and ISO 13485. These include standards, equipment, users, training, audit reports, non-conformance reports, corrective actions and the like, basically all of the tasks required to be in compliance with the various quality systems in place at the worksite. The program may be hosted in the cloud or on site, depending on the customer's preference.

For Free Info Visit http://info.hotims.com/72990-514

CAD/CAM Software

OPEN MIND Technologies AG (Needham, MA) recently released hyperMILL® 2019.1 with a range of new features and enhancements including greater blending capabilities, 3D-optimized roughing & finishing, global fitting, rotational abilities for CAD electrode applications - and virtual machining simulation. Developed with Industry 4.0 in mind, hyperMILL® VIRTUAL Machining enables constant real time bi-directional communication between the machine tool controller and a remote hyperMILL® VIRTUAL Machining simulation, significantly improving manufacturing workflow.

Two new functions in hyperMILL® for 3D Z-level Shape Finishing will result in reduced programming time and improved milling. These include an "Automatic Face Extension"capability that can be used during programming to extend the selected milling surfaces, eliminating the need to modify the milling faces in the CAD system beforehand. Barrel cutters (in addition to general, tangential and conical barrel cutters) can also now be used for 3D Z-level Shape Finishing. 3D Optimized Roughing has also been enhanced, to ensure that multiple allowances are taken into account when free tool geometries are used.

For Free Info Visit http://info.hotims.com/72990-543

5-Axis Vertical Machining Center

Mitsui Seiki's new Vertex 100 5-axis vertical machining center has been engineered to fulfill manufacturers' demands for a compact, high-speed machine capable of high-precision milling of larger parts such as blisks for aircraft engines. The Vertex 100 can machine workpieces 1,250 mm in diameter and 850 mm tall while occupying only 3 m × 4.2 m of shop floor space. X-Y-Z axis strokes are 1000 mm, 900 mm, and 750 mm respectively. Maximum swing diameter is 1480 mm.

From CAT 40 to HSK-A100 taper sizes the Vertex 100 is supplied with multiple spindle options (15,000 rpm, 25,000 rpm and 30,000 rpm). A large 60-tool standard automatic tool changer handles maximum tool lengths of 300 mm and maximum tool diameters of 125 mm (CAT40/HSK A 63) or 160 mm (CAT 50/ HSK A 100), offering maximum flexibility for job shop applications. Larger capacity tool changers are an additional option. The machine's tilt/rotary table, designed and built by Mitsui Seiki and supported by the rigid and robust cast iron base, provides high precision and rotation speed up to 100 rpm. The table's C-axis motors are direct drive while the A-axis has tandem direct drive motors. The machine is capable of workpieces up to 1250 mm (49.25") diameter.

For Free Info Visit http://info.hotims.com/72990-544

Scan System

SCANLAB GmbH (Puchheim, Germany) has announced series production of its high-end excelliSCAN scan system. This premium scan head has proved its suitability for reliable industrial deployment in series micro-machining and has now itself gone into series production. Last but not least, the scan head's built-in intelligence predestines it for integration in automated fabrication environments that leverage Industry 4.0 and IoT (internet of things).

The scan system features novel SCANahead servo control as well as galvanometer scanners with highly precise digital angle sensors. And its built-in intelligence can be compared to autonomous driving – the scan head autonomously calculates its own control parameters and anticipates in real time for optimal navigation of curves. This servo innovation breaks through the irreconcilability between higher dynamics and maximum precision, thus providing an appreciable productivity boost to users. Additionally, contour fidelity is substantially improved at high marking speeds, e.g. when traversing sharp corners and circles. Control is furnished as standard by the powerful RTC 6 control board, now available as an Ethernet variant.

For Free Info Visit http://info.hotims.com/72990-520

Hybrid Press Brake

Cincinnati Incorporated (CI) (Harrison, OH), a U.S.-based, build-to-order machine tool manufacturer, will introduce a 150-ton version of a new hybrid model. New features found on this press brake are an ergonomic sliding overhead control arm, unique built in storage cabinets, LED lighting, protective cylinder covers and side and rear guards. CI's CIberlink generates daily log files of machine production with the ability to monitor machine status in real time on a desktop dashboard.

This hybrid press brake brings the advantages of servo-motor pump technology to CI's existing lineup of hydraulic and electric drive press brakes. Unlike fixed-speed induction motors that drive the pump in conventional hydraulic systems, the servo-motor driven pump only runs during the working portion of the stroke, conserving energy while the ram is stationary. Ram speed of 550 ipm and precision ram repeatability of +/-.0002" assure fast and consistent production. The generous 14" stroke and 21" open height tackle challenging part shapes and tool heights.

For Free Info Visit http://info.hotims.com/72990-530

AGD Group 1 Digital Indicators

The L.S. Starrett Company (Athol, MA) has introduced a range of Digital Electronic Indicators conforming to true AGD (American Gage Design) Group 1 dimensions, providing the ability to replace traditional mechanical indicating applications in the smallest AGD size specification class. Starrett 2700 Electronic Indicators are the first digital gages to match true AGD Group 1 dimensions (1.70"/ 43mm diameter).

Gages feature a .400" (10mm) travel, accuracy of ± .0001" (0.002mm) on the F2715 models and accuracy of ± .0002" (0.004mm) on the F2714 models. The gages can store and view 200 readings internally. Stored readings can be downloaded with included software and a USB style cable. Starrett 2700 Digital Indicators have a CR2032 cell long-life battery that can last up to 3,000 hours under typical use. Gages are output-compatible for SPC documentation via cable or wirelessly using a Starrett DataSure® Data Collection device. Switchable resolutions are .001/ .0005/ .0001/ .00005 or .001/ .0005/ .0001 in inch. In metric readouts, switchable resolutions are 0.02/ 0.01/ 0.002/ 0.001 or 0.02/ 0.01/ 0.002 mm.

For Free Info Visit http://info.hotims.com/72990-531

Gear Grinding Platform

Norton | Saint-Gobain Abrasives, one of the world's largest abrasives manufacturers, announced the introduction of its new Norton Xtrimium™ range of gear solutions designed for high performance gear grinding in extreme, tight tolerance environments. Highlighting the new range is an innovative dual-worm wheel design that enables two operations in one grinding wheel. Norton Xtrimium Dual-Worm Grinding Wheels feature a unique design with a high-performance vitrified bond section for grinding and a fine-grit resin section for polishing the gear teeth, enabling one wheel to perform what traditionally required two wheels. In addition, improved surface finishes of Rz = 1.0 mm and Rpk = 0.05 mm, and reduced harmonics (noise) are realized.

For Free Info Visit http://info.hotims.com/72990-532

5-Axis Machining Centers

Doosan Machine Tools (Pine Brook, NJ) recently introduced its new DVF Series of compact 5-axis machining centers. The DVF 5000 comes standard with an 18,000 RPM integral 40 taper spindle. A FANUC 31iB5 CNC controller makes full 5-axis simultaneous control possible, giving complete contouring capabilities. It also features a 500 mm diameter (630 mm option) built-in rotary table. Available table supports allow a maximum weight of 880 lbs and minimize any table deflection. The rotary table is designed for user-friendliness and consummate work efficiency, minimizing interference as the part is machined. Doosan also offers a DVF 5000 5-Face version with a FANUC 0iMF CNC controller and a 12,000 RPM directly-coupled spindle.

The DVF 8000 is a larger full 5-axis machining center that incorporates many of the features of the DVF 5000, but has a larger (800 mm diameter) rotary table which can support a maximum weight of 3,086 lbs. Each machine comes with a 60-tool servo-driven automatic tool changer that can be expanded up to 120 tools, giving the customer more tooling to tackle complex parts that have varying profiles. An oil cooled spindle controls heat to minimize thermal issues.

For Free Info Visit http://info.hotims.com/72990-534

Automation Solutions

Fastems LLC (West Chester, OH) has a broad array of automation solutions aimed to handle high mix, low volume production available. Among its more popular modules are its recently renewed FMS ONE, a fully configurable machine tool pallet automation system. Further, the latest generation of Manufacturing Management Software (MMS) is being highlighted showing its new features for manually operated work cells, and its extended capability for controlling robotic automation. This new software was only recently launched at IMTS. Additionally, a compact loading robot cell called Halter Load Assistant was recently demonstrated in partnership with Halter CNC.

Fastems' automation equipment includes a variety of extendable and flexible manufacturing systems, robot applications, and control software; stacker cranes; conveyors; loading/unloading stations; pallet magazines and assembly organizers; and raw material stations to name a few. These automation systems have open interfaces and can be incorporated with virtually any modern CNC machine tool and auxiliary equipment brands. Typical applications range from joining two machine tools together with Flexible Palletized Container (FPC) to highly sophisticated, factory-wide flexible manufacturing systems.

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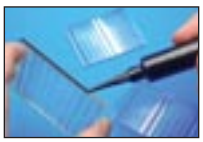

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Circle-Segment End Mills

Emuge Corp. (West Boylston, MA) has introduced "circle-segment" cutters, an innovative class of end mills designed to enable substantially more material removal with fewer passes in 5-Axis machining, over 80% cycle time reductions and up to 50% smoother surface finishes. Circle-segment tools are a totally new end mill design, exclusive to Emuge

Emuge circle-segment solid-carbide end mills are offered in four geometries: barrel-shaped, oval form, taper form and lens shape. Oval and taper form mills are ideal for curved shapes such as blades or straight-walled pockets, freely engaging more of the cutting edge. Barrel design mills provide highly effective flank milling to the sides of spiral grooves and similar applications, while lens shape mills excel in narrow channels or in lands on molds.

Specific CAM system software, such as hyperMill (Open Mind) or Mastercam® recent versions are required to support and compute the geometries of Emuge circle-segment end mills to achieve the performance levels the tools were designed for.

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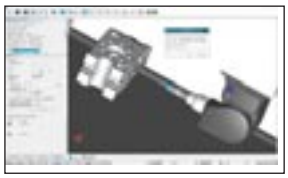

Measurement Software

Hexagon's Manufacturing Intelligence (North Kingstown, RI) has launched PC-DMIS 2018 R2, the latest edition of its measurement software. This is the second of two major releases that were scheduled for PC-DMIS in 2018, with continued service pack updates to ensure maximum reliability of the platform.

PC-DMIS 2018 R2 introduces a new reporting workflow, making it easier to create customized reports with simple drag and drop and an intuitive slideshow-style interface. A new QuickPath tool expands on existing QuickFeature functionality to simplify feature creation with a safe path. PC-DMIS 2018 R2 also introduces the ability to add run charts from qs-STAT into the PC-DMIS report. Improved Probe Utility allows users to mark favorite tip configurations, create required tip angles by simply clicking on CAD, and buy replacements with Shopping Cart tools; a new e-Store is coming soon to hexagonmi.com.

Other notable improvements within PC-DMIS include a new 2D Radius Gauge for quick checks on the go, added MoveInspect XR8 support, improved QuickFixture workflow with snap-to-grid capability, NX 12 DCI and Catia v5 R27 DCI & DCT support, added support for the HP-L-5.8 sensor, improved Q-DAS support, added Measurement Strategy Editor parameter sets, and Vero SMIRT integration.

For Free Info Visit http://info.hotims.com/72990-540

Additive Manufacturing Software

The additive manufacturing Software 4D_Additive from CT CoreTechnologieGmbH (Moembris, Germany) has interfaces for an independent and precise data exchange with all common CAD systems and 3D Printers. It supports CAD formats such as Catia, Nx, Solidworks, Jt, Step and many others. The tool comprises various additive manufacturing specific functions like automatic nesting and support generation.

The mature geometry kernel of 4D_Additive is equipped with sophisticated 3D data analysis and repair tools as well as direct modeling capabilities based on the exact BRep.

This technology ensures watertight models that do not deviate from the original CAD model like "tesselated" i.e. approximated models in STL format. The system offers functions e.g. for direct modeling, generation of offset surfaces and defeaturing to enable a precise modification of critical areas as well as the reduction of complexity and an efficient error compensation. Freely selectable scaling parameters allow the models to be scaled differently along the three major axes to compensate for shrinkage or distortion.

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Overcome antenna crosstalk issues with simulation.

Visualization of the electric field norm and 3D far field due to a transmitting antenna. Antennas are intentionally large in this tutorial model.

Multiple antennas are needed to create more complex communication systems on airplanes. But this arrangement of transmitters and receivers can cause aircraft operation issues due to crosstalk, or cosite interference. Simulation helps you analyze the crosstalk effect on an aircraft and in turn find the best antenna placement.

The COMSOL Multiphysics® software is used for simulating designs, devices, and processes in all fields of engineering, manufacturing, and scientific research. See how you can apply it to antenna simulation.

comsol.blog/antenna-crosstalk

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