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The OpenVPX-Based SOSA Standard Targets Weapons Systems Compatibility p52

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MARCH 2020 mwrf.com

EM CO-SIMULATION

Fast-Tracks Design Success

Introducing component models to an EM simulator leads to greater accuracy p25

Planar Monolithics Industries, Inc.

Coaxial Monopulse Comparators

PMI designs and manufactures a variety of Coaxial Monopulse Compartors for beamforming antenna applications up to 21.2 GHz. Form, fit and functional designs can also be replicated to specific requirements. Standard models with various options are available at PMI's website:

http://pmi-rf.com/Products/monopulse_comparators/features.htm

- Amplifiers - Solid State
- Attenuators - Variable/ Programmable
- Bi-Phase Modulators
- Couplers (Quadrature, 180, Directional)
- Detectors - RF / Microwave
- DLVAs, ERDLVAs & SDLVAs
- Filters & Switched Filter Banks
- Form, Fit, Functional Products & Services
- Frequency Converters
- Frequency Sources
- Frequency Discriminators & IFM
- Frequency Synthesizers
- Gain & Loss Equalizers
- Integrated MIC/MMIC Assemblies (IMAs)
- IQ Vector Modulators
- Limiters - RF / Microwave
- Log Amps
- Miscellaneous Products
- Monopulse Comparators
- Multifunction Integrated Assemblies (IMAs)
- Phase Shifters & Bi-Phase Modulators
- Power Dividers/Combiners (Passive & Active)
- Pulse Modulators - SP1T
- Rack & Chassis Mount Products
- Receiver Front Ends & Transceivers
- Single Side Band Modulators
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- Switch Matrices
- Switch Filter Banks
- Switches - Solid-State
- Systems - Radar Sense & Avoid
- Systems - Fly Eye Radar
- Threshold Detectors
- USB Products


MPC-20R2G21R2G-CD-LNF


PMC-24-7D5-SFF


PMC-3G3D5G-6D8-SFF


PMC-33D7-6D8-SFF

PMI Model No.	Frequency Range (GHz)	Gain (dB)	Noise Tempera-ture	Phase Balance	Amplitude Balance (dB)	Size (Inches) Connectors
MPC-20R2G21R2G-CD-LNF https://www.pmi-rf.com/product-details/mpc-20r2g21r2g-cd-lnf	20.2 - 21.2	0 to +10	100 K	±3°	±0.3	6.25" x Ø4.8" x 2.0" SMA (F)

PMI Model No.	Frequency Range (GHz)	Insertion Loss (dB)	Isolation (dB)	Phase Balance	Amplitude Balance (dB)	Size (Inches) Connectors
PMC-24-7D5-SFF https://www.pmi-rf.com/product-details/pmc-24-7d5-sff	2 - 4	0.8 - 7.5	18	±10°	±1.0	3.23" x 3.23" x 0.43" SMA (F)
PMC-3G3D5G-6D8-SFF https://www.pmi-rf.com/product-details/pmc-3g3d5g-6d8-sff	3 - 3.5	0.8 - 6.8	23	±5°	±0.4	3.23" x 3.23" x 0.43" SMA (F)
PMC-33D7-6D8-SFF https://www.pmi-rf.com/product-details/pmc-33d7-6d8-sff	3 - 3.7	0.8 - 6.8	24	±7°	±0.5	3.23" x 3.23" x 0.43" SMA (F)
PMC-9G10G-7D9-SFF https://www.pmi-rf.com/product-details/pmc-9g10g-7d9-sff	9 - 10	1.9 - 7.9	18	±6°	±0.6	3.48" x 3.48" x 0.43" SMA (F)
PD-CD-001-1 https://www.pmi-rf.com/ product- details/pd-cd-001-1	9.3 - 9.9	8.0	30	±7°	±0.5	2.35" x 1.7" x 0.5" SMA (F)
PMC-9D5G10D1G-7D6-SFF https://www.pmi-rf.com/product-details/pmc-9d5g10d1g-7d6-sff	9.5 - 10.1	7.6	20	±5°	±0.5°	3.48" x 3.48" x 0.43" SMA (F)


PMC-9G10G-7D9-SFF


PD-CD-001-1


PMC-9D5G10D1G-7D6-SFF

Dixie Crow Symposium 45 - 2020
Museum of Aviation at Robins AFB, Georgia
March 23 to 25, 2020
Booth #: TBD
https://www.pmi-rf.com/events/dixie-crow-symposium-45-2020

FIDAE 2020
Santiago International Airport, Pudahuel, Diego Barros Ortiz 2300, Santiago, Pudahuel, Región Metropolitana
March 31 to April 5, 2020
Booth #: Hall C Stand C54
https://www.kallman.com/shows/fidae-2020

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Editorial

DAVID MALINIAK | Editor

Closing *the* Circles

Returning to this industry, but embarking on a new path, is in a way like coming full circle.

Sometimes it seems that life goes in circles. After an absence from the EOEM B2B media world of over seven years, I've come back around to a wonderful opportunity to take the editorial reins here at *Microwaves & RF (MWRF)*. I look forward to exploring the world of high-frequency design and development. I'll have the pleasure of picking the brains of the industry's leaders in pursuit of the information you need to get your job done efficiently and effectively. As always, you'll find deep dives into technical topics, the latest new products and technologies, and industry news and insights both here in print and online at *www.mwrf.com*.

Of course, I follow some tough acts. For one, *MWRF* is the "House that Mr. Microwaves Built," and "Mr. Microwaves" is none other than Jack Browne, who continues to contribute to the magazine through his work on the Defense Electronics supplement, an edition of which appears in this issue. Jack led *Microwaves & RF* for many years, and we're grateful to have his estimable experience and industry knowledge to tap.

My immediate predecessor, Chris DeMartino, did a fine job helming the magazine for some five years or so. Chris has returned to his engineering roots with Modelithics, but he didn't run off and forget us. Rather, he got busy co-authoring this issue's centerpiece article on electromagnetic co-simulation with measurement-based models.

Hmm… simulation, models, and the mysterious black art of analog design… where have I seen that before? Of course! In my last stint at our sister publication, *Electronic Design*, I covered electronic design automation (EDA) as well as test and measurement. That closes yet another circle of life for me. I always enjoyed those beats because they're both so foundational to the discipline of electronic engineering itself.

In joining the team here at Endeavor Business Media, I'm pleased to find some familiar faces. Bill Wong, an old colleague, does double duty as content director of our group and editor of *Electronic Design*. Roger Engelke Jr. is another veteran who does a ton of unsung behind-the-scenes editorial work. And Tony Vitolo, with whom I go back the longest, is our group design director, making us all look good by ensuring that our pages stay modern and attractive.

I'll be hitting the road soon for some of our industry's key conferences and exhibitions, such as the International Microwaves Symposium (June, Los Angeles). I'll be sure to let you know what I see and hear. And, if you should run across me, stop and say hello so we can close that circle, too. mw

Microwaves&RF MARCH 2020

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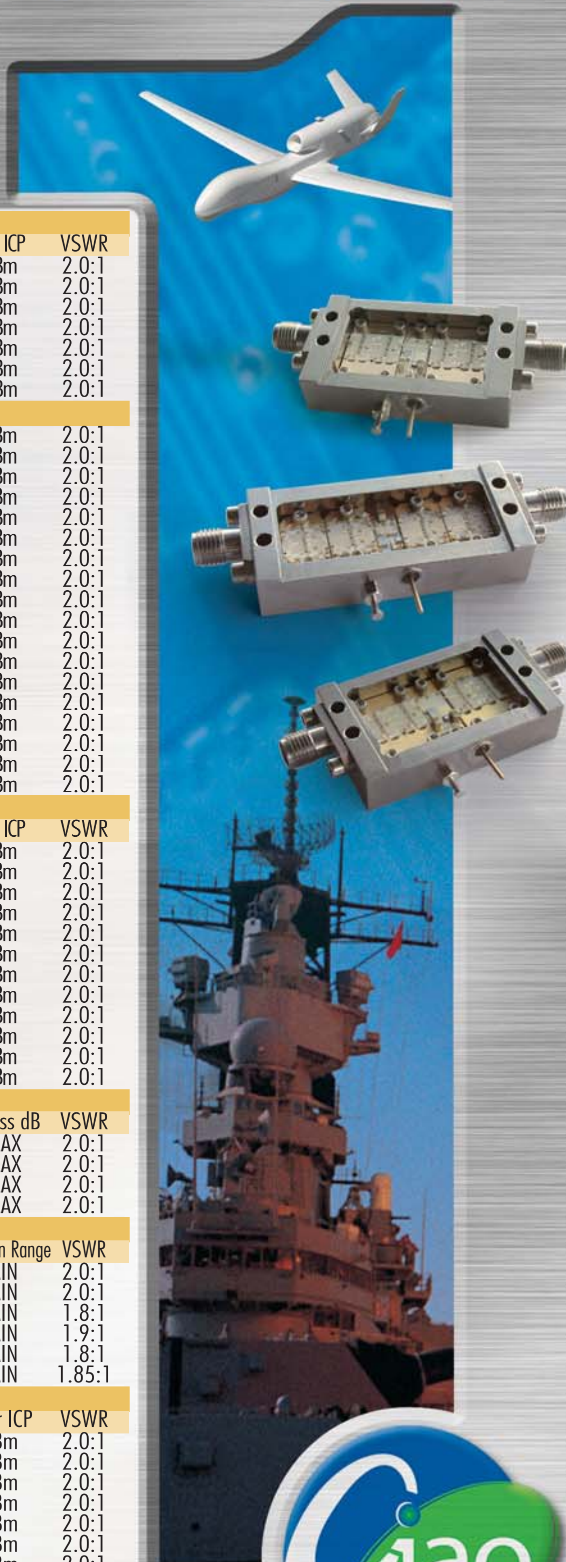

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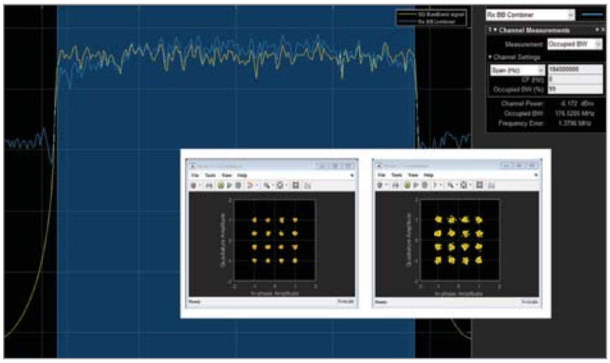


Exploring Hybrid-Beamforming Architectures for 5G Systems

One way to gain higher throughput in 5G NR systems is to start with a Simulink model—a tool that can perform architectural analysis and multidomain simulation in hybrid-beamforming applications.

https://www.mwrf.com/technologies/systems/article/21123317/algorithms-to-antenna-exploring-hybridbeamforming-architectures-for-5g-systems

How Much Do You Really Know About Communications Electronics?

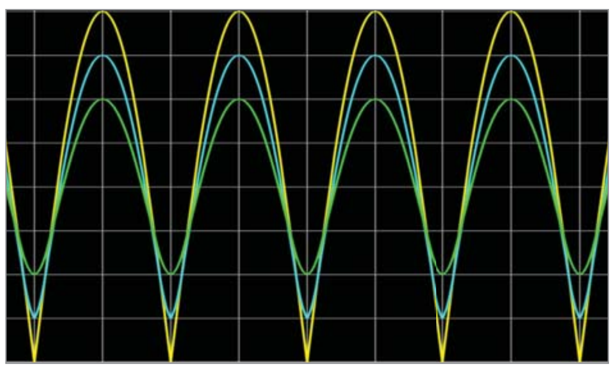
As communications wends its way into virtually every electronic product, having a solid understanding of the technology becomes essential. Here are steps you can take to achieve that goal.

https://www.mwrf.com/technologies/systems/article/21124052/how-much-do-you-really-know-about-communications-electronics

Does a Third-Party Product Analysis Make a Difference?

You get a second opinion before a major surgery. So, why not for major product decisions?

https://www.mwrf.com/technologies/systems/article/21125636/does-a-thirdparty-product-analysis-make-a-difference



Stuck in the Middle: How to Choose Your Next Bandpass Filter

The seemingly ubiquitous bandpass filter plays an important role in reducing noise and radiation in an array of applications. Here's a synopsis of the most popular options available.

https://www.mwrf.com/technologies/components/article/21120720/stuck-in-the-middle-how-to-choose-your-next-bandpass-filter

GaAs

MIXERS

FUNDAMENTAL / IQ / SUB-HARMONIC

Part Number	Freq. Range	Description
CMD258C4	7.5 - 13 GHz	High IP3 I/Q Mixer
CMD313	6 - 45 GHz	Fundamental Mixer
CMD310C3	20 - 32 GHz	Sub-harmonic Mixer

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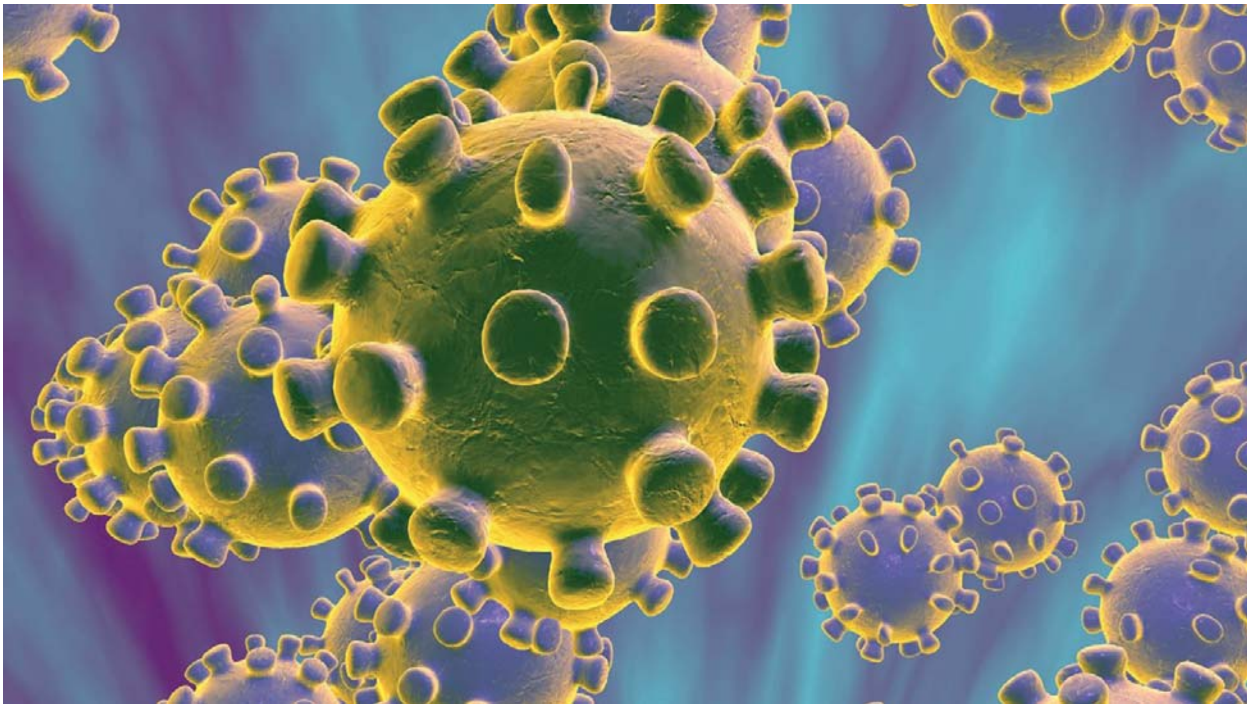
News

IMPACT OF CORONAVIRUS on Distributors of Electronic Components



A quick snapshot of where things currently stand.

Over the last months, there has been a great amount of global media coverage on the new coronavirus (COVID-19). The range of data differs from facts and figures to unrefined conspiracy theories. So before jumping into an investigation of the effect of coronavirus on distributors of electronic parts, we'll give a short update.

THE CURRENT CORONAVIRUS SITUATION (MARCH 02, 2020)

Factsheet from the World Health Organization (WHO) Report (March 02, 2020):

- **Origin:** Wuhan city in Hubei province, mainland China
- **Infected:** 88,948 globally
- **Death toll:** 2,915 in China, 128 outside of China

The quantity of contaminated individuals is expected to top mid-February, as stated by epidemiologists.

Mortality of coronavirus has just outperformed the affirmed passing of the last more prominent plague, SARS. The SARS infection cost 773 lives in a timespan from 2002 until 2003. It is evaluated to have cost the worldwide economy around $40 billion. It is undeniable, that coronavirus will affect financial development figures all around the globe. It is expected to be substantially more costly than SARS, influencing each industry branch worldwide. These conditions have already hit stock markets on a global scale.

IMPACT ON THE ELECTRONICS INDUSTRY

The electronics industry isn't making an exemption here. In the most recent weeks almost every maker has given out explanations on how the coronavirus and initiated quarantine in China is influencing their lead times. Moreover, numerous organizations have declined to participate in significant exchange

fairs—for example, Embedded World. Coordinators of the Mobile World Congress in Barcelona even cancelled the event.

HOW ARE DISTRIBUTORS OF ELECTRONIC COMPONENTS PREPARED?

Distribution companies have a significant role in the electronics industry. They give certainty on part accessibility to an incredible number of manufacturing companies worldwide. That is the reason we asked two key players the effect of coronavirus on the distribution business and what they have learned from SARS outbreak 18 years ago.

We'd like to thank Teri Ivaniszyn, **Digi-Key Electronics** vice president, Operational Excellence, and Geoff Breed, vice president marketing – Europe, **TTI, Inc.** for answering our questions.

1. What were your first steps in communication regarding this issue?

GB: TTI strives to provide the most up-to-date information and communication on such serious and critical topics. We have prepared a full and live update on our global websites, so that customers have a centralized and consistent resource for information. We are continually working closely with all our suppliers to understand and communicate the actual situation and any consequential effects that it might bring on.

TI: "The health and safety of our team members, customers and business partners is of primary importance. We fully support any workplace accommodations that reduce potential risk and encourage compliance with government guidelines dealing with the issue.

- We are proactively communicating with our supplier partners to gauge the impact for them.
- ECIA (Electronic Component Industry Association) has provided us insights and analysis on the topic to monitor the situation.
- We have relationships with multiple logistics carriers and will utilize all of them to best serve our customers.
- Carrier partners such as UPS, FedEx, DHL and Maersk are working to mitigate impact on customer's cargo plans."

2. To what extent is your line card affected by the virus outbreak and the restrictions by Chinese government?

GB: It is still too early to say. We know that suppliers who have manufacturing in the area have delayed resuming production and return of staff for another week after the Chinese New Year. Beyond that, we are working on a daily basis with our supplier partners to understand any further restrictions.

TI: We anticipate minimal impact to our line card and may in fact see increased demand for safety related products and devices.

3. The last mentionable virus outbreak was in 2002/2003 with the SARS virus. How did this affect your supply chain then, and what measures did you implement to conquer future comparable disaster, such as coronavirus now?

GB: Of course, it is very difficult to be completely prepared for any such issue, as they are relatively infrequent. SARS was 17 years ago, and the face of our industry has changed dramatically in this period.

At TTI we always look ahead and try to minimize issues of any kind by keeping the widest and deepest inventories in the market. We also forecast well ahead with our supplier partners to make sure the pipeline is in place. Our world class inventory management systems ensure that "if" supply chain issues deepen, we protect our customers to the fullest.

TI: The depth of product Digi-Key carries minimizes the effect for our customers. Industry research and analysis have predicted the possibility of

short-term slowdowns in automotive, airlines, travel and entertainment. But if history repeats itself as with the 2003 SARS crisis, a single-quarter decline in China's GDP growth was largely offset by higher growth in the subsequent two quarters.

ECIA research also points out:

- China is now in the internet commerce age, with consumers increasingly shopping more online. [...]
- During SARS and other prior outbreaks, the markets have typically proved resilient.
- Analysts found that among companies they covered none suffered long-term effects from the 2003 SARS outbreak."

This interview has shown the impact of coronavirus on distributors of electronic components is incalculable at this point. Make sure to stay updated on relevant topics in the electronics industry. ■

HANNOVER MESSE Postponed

Coronavirus concerns prompt fair officials to delay 2020 event until July.

CITING CORONAVIRUS CONCERNS, Deutsche Messe announced March 4 that it will postpone Hannover Messe to July 13-17 in Hannover, Germany.

The world's largest industrial trade show was scheduled to launch its 73nd annual show on April 20-24, but with more than 200,000 people expected to attend and containment of the coronavirus not yet assured, show officials made the decision to push back this year's event.

Deutsche Messe officials said they could not fully implement the recommendations of the Hannover Regional Healthy Authority, which had suggested stringent safeguards, including banning attendees from risk areas from attending and using fever measuring stations at all entrances.

"Their implementation would impair the staging of the event to such an extent that the event would not fulfill its purpose or would do so only with considerable restrictions for exhibitors and visitors," Deutsche Messe officials said in a press release.

Fair organizers said the later date might even have a role in jumpstarting the global economy, which has been roiled over concerns about the spread of the coronavirus, which infected 92,000 people worldwide and resulted in more than 3,000 deaths.

"With the July date, we offer our exhibitors the earliest possible time slot to present their innovations to a global audience and to initiate business," said Dr. Jochen Köckler, Chairman of the Board of Management of Deutsche Messe AG. "In view of the global economic challenges triggered by the coronavirus in the first half of the year, the new date offers great opportunities. Thus the world's most important industrial trade fair can provide important impetus for the global economy at an early stage."

The VDMA, which is the German Engineering Federation, also backed the postponement. "In regards to the current challenges caused by the coronavirus, postponing Hannover Messe until July is the best possible option," said VDMA Chief Executive Thilo Brodtmann. "We assume that the situation will calm down in the coming months and that the mechanical engineering industry will then benefit from a reviving business situation." ■

MPU PERFORMANCE

Boost, Enhancements Bolster Ecosystem Support

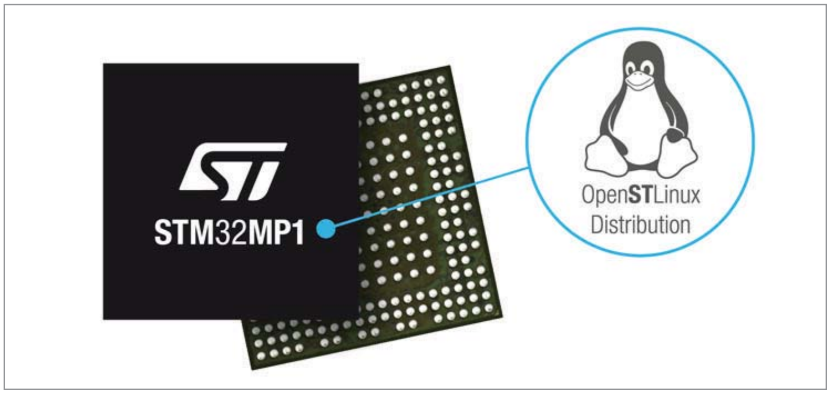
THANKS TO NEW SOFTWARE functionalities, a significant performance bump, and new authorized partners, STMicroelectronics's STM32MP1 32-bit microprocessor (MPU) family has been expanded to serve more demanding applications in smart homes, industrial systems, health and wellness systems, etc. The latest STM32MP1 MPUs now run at clock speeds of 800 MHz while maintaining software and pin-to-pin compatibility with earlier 650-MHz devices.

Now running dual Arm Cortex-A7 application processor cores at 800 MHz and the Cortex-M4 core at 209 MHz, the new STM32MP1 MPUs deliver more performance in voice and audio processing, video-decoding quality at HD levels, more powerful artificial-intelligence capabilities in neural-network and machine-earning applications, and a better user experience in Android systems. The devices feature compute Land 3D graphics accelerators combined with power-efficient, real-time control and high feature integration.

The popular human-machine interface (HMI) toolkit, Qt, and its QML-based GUI applications, can be deployed on STM32 MCUs as well as on the STM32MP1 platform, drastically reducing development costs while accelerating customer product delivery. The scalability provided by both STMicroelectronics and Qt's tool suite can easily leverage the resources of the STM32MP1 MCUs, especially the 3D HW GPU accelerator to optimize a smooth rendering for HMI industrial/IoT applications.

Capitalizing on the flexible STM32MP1 architecture, security has been enhanced to protect the customer's code through features like secure boot by authentication, available one-time-programmable fuses for customers, and a secure operating system (Open Portable Trusted Execution Environment, or OP-TEE). A complete security toolset including Keys Generator, Signing Tools, STM32CubeProgrammer, and Hardware Security Module (STM32HSM) allows for secure provisioning of customers' code into the device.

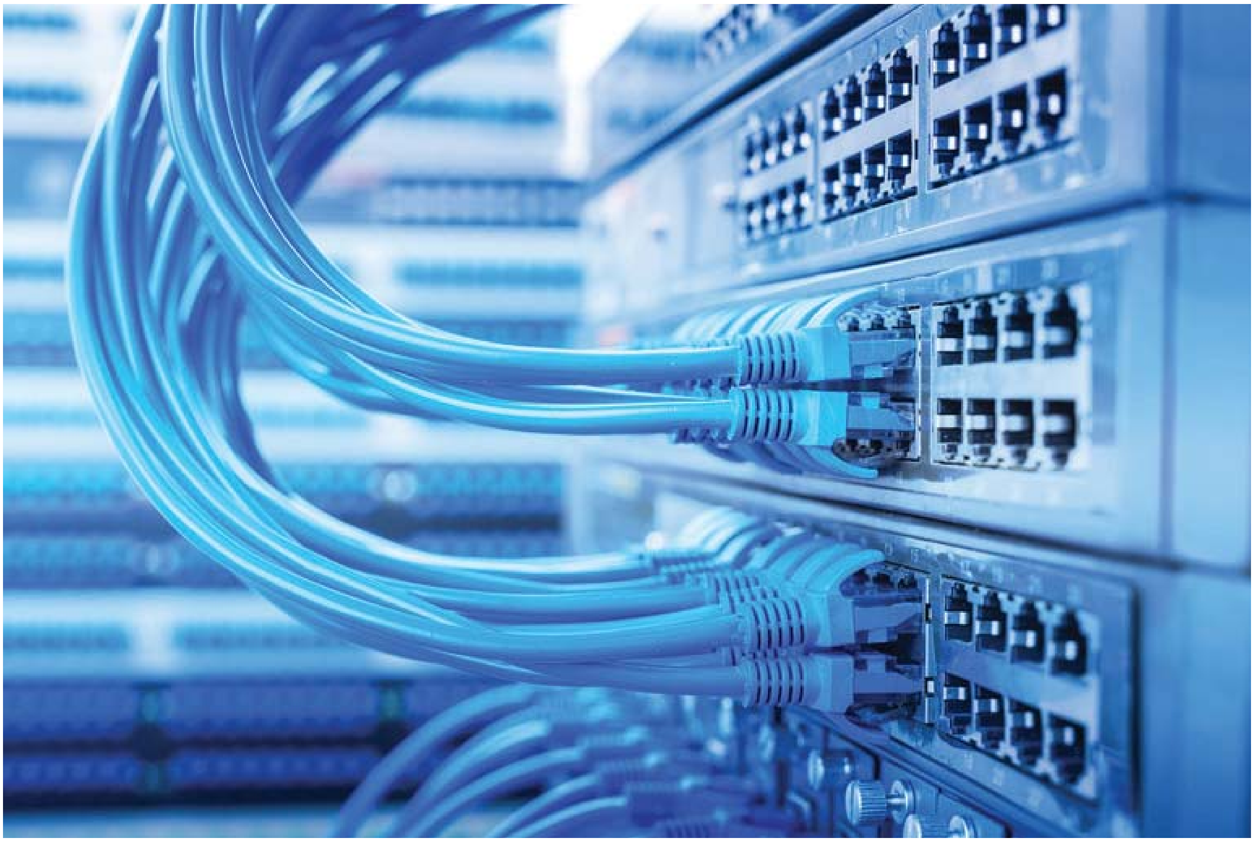
The OpenSTLinux distribution, a mainlined open-source Linux with all of the essential building blocks for running software on the application-processor cores, is now supplemented with Android developer packages and cloud support to accelerate customer development.



STMicroelectronics's authorized partners greatly expand users' capabilities and speed their development progress using the STM32MP1 MPUs. In addition to embedded software and software-development tools, partners contribute expertise in training and engineering services. For example, ST works with multiple system-on-module makers, including Phytec, when local support and system flexibility is required, as well as system-in-package maker Octavo Systems for space-constrained application designs.

STM32MP1 MPUs are industrial-qualified with a junction temperature from –40 to 125°C combined with 100% activity rate over 10 years. Devices supporting Cortex-A7 at 800 MHz are in production now and start at $4.83 for orders of 10,000 pieces. Other pricing options are available. ■

THOMAS LEWIS | Ethernet Alliance member



The "Interoperability Inside" Logo

The Ethernet Alliance's Gen2 Certification Program delivers Power over Ethernet standards and interoperability, and ultimately helps improve ROI.

With exponential growth in the Internet of Things and the countless number of sensors, cameras, controllers, and other remote devices being widely deployed around the world, Power over Ethernet (PoE) has become a leading solution for more streamlined deployments and greater cost savings. What's more, as power demands increase for such things as wireless access points needed to serve an increasingly mobile-connected public, the issues of standards conformance and assured interoperability of equipment have come to the forefront.

In particular, what has been needed to overcome confusion in the PoE ecosystem, and prepare equipment suppliers, end users, and installers for a growing and more complex Ethernet ecosystem, is a readily available testing suite that delivers on the interoperability promise of IEEE 802.3 PoE standards.

In response, many of the individuals involved in standards development convened under the auspices of the Ethernet Alliance to launch a second generation of its PoE Certification Program. Much like the renowned "Intel inside" branding associated with personal computers, the certification program is based on

Gen2 PoE Logo Program Benefits and Beneficiaries

Logo Benefits	PoE System Stakeholder Benefitted			
	IC Vendors	End Equipment Manufacturers	System Installers	End Customer
Ease of Installation			✔	✔
Enhanced Customer Support @ Lower Cost	✔	✔	✔	✔
Improved End Customer Perception of PoE	✔	✔	✔	
Reduced evaluation costs, faster time to market		✔		✔
Avoid unnecessary development/lost opportunity costs	✔	✔		

marking equipment with "EA Certified" PoE logos to identify port attributes. It brings a multitude of benefits across the entire ecosystem—all of which have a positive impact on ROI. The logo delivers an "Interoperability Inside" promise to the various stakeholders in a PoE-deployed system.

In developing the certification program, the team first identified the key benefits for all principles working in the PoE space as summarized in the *table* above. These include:

STREAMLINING INSTALLATION

The logo itself is visually straightforward, simply showing "arrow out, power out" and "arrow in, power in." Clearly, the number on the load needs to be less than or equal to the number on the switch. This was a key issue in Gen1 of the certification program.

Now, however, instead of switches primarily sending the same type of power across all ports (Type 2 for example), a more likely future scenario on a 24-port chassis might be having four ports rated to send Type 4 power, four to eight of Type 3, and the rest being Type 2. For installers, that's going to be a lot more challenging as PoE installations become increasingly complicated. The "EA Certified" solution allows for installers to just quickly look at the switch port labeling instead of having to open an instruction manual and identify exactly which ports are set at a particular power level.

ENHANCED CUSTOMER SUPPORT

Overall, equipment manufacturers with the "EA Certified" PoE logo can not only expect fewer calls, but they can also achieve lower support costs for customer calls by deferring those from non-certified suppliers, particularly in an environment where there's diminishing support from system vendors.

In the future, the first question customers can expect when reporting an interoperability challenge is "Does both sides of the cable have the logo?" Whichever side does not have the logo will become the focus of any continued debug effort. Further upstream in the ecosystem, IC vendors can much more quickly focus their attention in debug efforts as well.

For equipment installers, the logo will improve outcomes with end users by significantly decreasing installation times and the likelihood that installed equipment will experience a load that causes a fault. Consequently, installers can save time and increase PoE deployments with greater troubleshooting capabilities, with the added benefit of greatly reducing call backs.

IMPROVED END-CUSTOMER PERCEPTION

Because the logo signifies a range of benefits, having it increases the value proposition of PoE for the end customer. This is very much in line with the aforementioned "Interoperability inside" model and can positively impact everyone in the channel.

Many working in the PoE space share an opinion that one of the top things hindering PoE adoption at a higher percentage, other than its power limitations, is that there's no one broadly defined and accepted vision of PoE. Too much confusion exists in the market. Despite having a standard for decades, no one recognized test suite translates the standard into certification tests and an easily identified mark.

To overcome this, the Ethernet Alliance is leveraging its expertise and recognition as a leader of advancing Ethernet technologies to establish a logo that clearly defines PoE so that people will look for it as part of their decision-

The logo itself is visually straightforward, simply showing "arrow out, power out" and "arrow in, power in." Clearly, the number on the load needs to be less than or equal to the number on the switch. This was a key issue in Gen1 of the certification program.

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making when purchasing equipment.

REDUCED EVALUATION COSTS, FASTER TIME TO MARKET

Consider a smaller end-equipment manufacturer that might only ship 100,000 switches, and maybe only one model that integrates the PoE feature. Hypothetically, the company may only be shipping 5,000 PoE models. Even if you already have an existing validation suite to test for PoE functionality under the IEEE 802.3at standard, there's still a whole lot of work to get ready for the latest standard and to validate your switch at a black-box level.

By trusting in the Ethernet Alliance PoE certification and logo, you needn't worry about the nuts and bolts of incorporating a PoE feature. Providing end-equipment manufacturers with this level of confidence ultimately saves on evaluation costs and allows them to significantly reduce equipment cycle timelines in order to bring products to market faster and cheaper.

ALLEVIATE ADDITIONAL DEVELOPMENT COSTS

Because the Ethernet Alliance PoE certification program is the first test validation platform that assures conformance to IEEE 802.3bt, switch and end-device manufacturers now have a means other than relying on data from chip and PoE controller suppliers, which might not deliver full confidence of compliance to the standard.

An affordable official third-party test suite alleviates companies from having to develop a program in-house thats confirm its equipment is IEEE 802.3bt-compatible. And, pursuing the certification program and logo attribution provides the opportunity to identify issues early on prior to installation, avoiding the high cost of fixing problems post deployment. These costs, in particular, are extremely painful to both the pocketbook and long-term perceived quality of the manufacturer. Just one of these "in field" interoperability issues could cost millions of dollars in new development and/or foregone opportunity costs.

For companies wanting to fully leverage their PoE deployments, there's now an option that makes a lot of sense from a pure ROI point of view. Looking at the *table* again, it's hard to imagine a scenario that doesn't return on an investment of ~$25,000-30,000 (annualized) for the end-equipment manufacturers themselves. While hard to estimate, lower customer-service costs alone will offset the modest costs, and avoiding (or deferring to the non-logoed side of the troubling system) even one significant interoperability issue can easily save a company thousands of dollars in debug.

The evolution of Ethernet is continuing at a notable pace and PoE is positioned to experience considerable growth over the coming years. Interoperability of PoE equipment and assured reliability of devices for end users is essential. Once earned, the "EA Certified" PoE logo visual aid delivers benefits for all stakeholders in the PoE space.

To learn more about the Ethernet Alliance PoE Certification Program, visit *https://ethernetalliance.org/poecert/*. mw

THOMAS LEWIS is an Ethernet Alliance member and Marketing & Applications Manager for Power over Ethernet (PoE) Solutions at Texas Instruments. In this role, he's responsible for all elements of the marketing strategy and applications support for its PoE product portfolio.

JAY ALEXANDER | Senior Vice President and Chief Technology Officer, Keysight Technologies
JEFF HARRIS | Vice President, Global Marketing, Keysight Technologies

Technology Predictions from a [Precision] Electronic Test Thinktank

What does a [Precision] Electronic Test Thinktank expect to unfold in 2020? From new test tools, to the 5G outlook, to digital twins, to the "Interaction of Things," many potentially transformative advances loom on the horizon.

Measurement-based tools of many kinds are key enablers for the technology-based products and solutions we incorporate into our daily lives, and it will transform as disruptive technologies come into play.

- In 2020, advanced applications related to 5G will explode, using higher frequencies and smaller geometries. To support this growth will be:
    - New classes and labs for design and simulation, over-the-air testing, antenna systems, and measurements will be incorporated into the core engineering curriculum.
    - New measurement science (hardware, software and calibration) will be developed and made part of mainstream offerings.
    - Developers of new electronic products and solutions will use different tools, specifications, and terminology to specify and validate their designs.
- Use of software for implementing technology will remain prevalent in 2020, especially in networking and position or navigation-based smartphone applications. As a result, software-on-software measurement will see a strong surge and, therefore, so will emphasis on interoperability among software tool chains. New standards and certifications will be created, impacting development processes, as well as the marketing required to ensure consumers are aware of what a software-centric product can and cannot do.
- In 2020, expect a substantial rise in specialized processors, such as GPUs and chips, which implement artificial-intelligence (AI) architectures that determine how a network processes and routes information and maintains security, privacy, and integrity. Quantum computing and engineering will continue to be in an aggressive hype phase in 2020, but the ability to control, measure, and error-correct quantum systems as the number of qubits grows will be important from the start.
- As measurement and operation of the computer blends, those interested in building practical quantum computers will require knowledge about measurement technologies and techniques before quantum computing goes into the mainstream.

DATA SILOS WILL BE CONNECTED TO EXTRACT DEVELOPMENT INSIGHTS

Leading companies collect data but typically store it in functional silos: R&D design, pre-production validation, manufacturing, operations and services.

- In 2020, companies will start connecting these silos of data using modern cloud architectures, such as private on-premises clusters, or public sites like AWS or Azure. With the data centrally available, teams will correlate performance through the development process, from early design to manufacturing to field deployment, and close the loop back to design. The benefits for these teams include the rapid collection and reformatting of data, faster debugging of new product design, anticipation of manufacturing issues, and improved product quality.
- To achieve these gains, teams will invest in a computing infrastructure, determine how to store the data (including file location and data structure), as well as choose analytic tools to select and process data to identify anomalies and trends. In addition, teams will change the way they work to shift attention to data-driven decisions.

5G AND THE DATA CENTER

New 5G capabilities in 2020 will put pressure on networks, revealing new data-center and network chokepoints.

- Industrial IoT applications will escalate access requests and mobile automotive IoT applications will stretch latency demands. Edge computing will become more important to process the increased access requests and meet stringent latency requirements.
- Higher data speeds will create more demands for faster memory, faster data buses, and faster transceivers in the data center. Meeting the speed and flexibility demands will be one reason, but customer traceability through the network for application monetization will be the main driver to upgrade to the latest standards.
- In 2020, we will see advanced design, test, and monitoring capabilities that ensure networks and products deliver the performance and failsafe reliability expected. The industry will experience closer collaborations between chipset and product manufacturers, software companies, network carriers, cloud-hosting companies, and international standards organizations to build tomorrow's networking infrastructures.

CHALLENGES WILL ABOUND TO GET 5G TO MATURITY

5G represents technical evolution and revolution on many fronts, creating new technical challenges that span many domains.

- In 2020, the industry will move from a small group of early-movers that have commercialized initial 5G networks, to a global community in which multiple operators in every continent and many countries will have commercial 5G networks.
- The early adopters will add scale, and those who launch in 2020 will quickly resolve issues in their initial deployments. Second-generation devices and base stations will be added to the market, and the standards will have another new release in 3GPP's Rel-16.
- Key technical challenges for the industry in 2020 will be to ensure performance in mid-band (3.5 to 5 GHz) frequencies, moving millimeter-wave (mmWave) to mobility, transition planning to a full standalone (SA) 5G network, and resolving architectural decomposition and standards for centralized radio area network (RAN) and mobile-edge computing (MEC).

THE "INTERNET OF THINGS" WILL BECOME THE "INTERACTION OF THINGS"

IoT will rapidly move into the mainstream with widening commercial acceptance, increasing public-sector applications, and accelerated industrial deployments.

- In 2020, we will see an increased level of "smart" experiences when the "Internet of Things"—a collection of devices connected to the internet—becomes the "Interaction of Things"—a collection of things that are communicating and working effectively and efficiently with each other.
- Powerful devices will work with other powerful devices to act quickly and efficiently in the background independent of direct human intervention. Mission-critical applications, such as remote robotic surgery in the area of digital healthcare or autonomous driving in the area of smart mobility, will feel the impact of this shift.
- While these applications will benefit from the "Interaction of Things," new solutions will be developed to ensure they don't suffer from the "Interference of Things," especially when communication failure and network disturbances can bring about devastating or life-threatening consequences. The same will be true of Industry 4.0 applications and smart city applications. Uptime will not be optional.

DIGITAL TWINS WILL MOVE TO THE MAINSTREAM

Digital twins, or the concept of complete replicate simulation, are the nirvana of design engineers.

- In 2020, we will see digital twins mature and move to the mainstream as a result of their ability to accelerate innovations. To fully realize the technology's benefits, companies will look for advanced design and test solutions that can seamlessly validate and optimize their virtual models and real-world siblings to ensure that their behaviors are identical.

2020 WILL NOT BE THE YEAR OF THE AUTONOMOUS VEHICLE: ACTIVE CRUISE CONTROL, YES, BUT WE HAVE A COUPLE YEARS TO GO FOR AUTONOMY

The quantity and sophistication of sensors deployed in vehicles will increase in 2020. However, fully autonomous

vehicles will require more ubiquitous 5G connectivity and more artificial intelligence. Here's where we see the industry on each of those areas:

- The ratio of fleets sales with EV or HEV powertrain will grow from single-digit percentage ratio to double digits in 2020, tripling the shipped units compared to last year.
- The first C-V2X network will hit the streets in China, but they will be operating on an LTE-V network until 5G Release 16 evolves the standard.
- The technical advances for sensors and in-car networks will continue to evolve on a fast pace, needing faster in-vehicle networks. In 2020, Gigabit-Ethernet-based in-car networks become a reality and significantly improved sensor technology enables AI developers to hit new performance levels.

SYSTEM-LEVEL DESIGN, TEST, AND MONITORING WILL EXPERIENCE A DRAMATIC TRANSFORMATION

The connected world will force a shift in how performance, reliability, and integrity are evaluated.

- In 2020, realizing the full potential of sensor systems connected to communication systems connected to mechanical systems will require new ways to test at the system level.
- Today, tests are available for radar antennas and a radar transceiver module. However, testing a multi-antenna radar system integrated into a car will require a different testing approach. The same is true for data centers, mission-critical IoT networks, automobiles, and a wide range of new, complex, 5G-enabled applications.
- This year, the electronics industry will emphasize system-level testing as the definitive, final step to assure end-to-end performance, integrity, and reliability across the increasingly connected world.

EDUCATION WILL SHIFT TO PREPARE THE NEXT GENERATION OF ENGINEERS

Universities will adopt holistic, integrated, and multi-disciplinary curricula for engineering education.

- Academia will tap into industry partnerships to keep up with the accelerating pace of technology and incorporate certification programs, industry-grade instrumentation, and automation systems into teaching labs to train students on current, real-world applications.
- To address IoT, universities will combine methodology from basic electronics, networking, design engineering, cybersecurity, and embedded systems, while increasing emphasis on the impact of technology on society and the environment.
- To address AI, automation, and robotics, universities will mainstream currently niche topics like cognitive science and mechatronics into required learning mw

JAY ALEXANDER is senior vice president and chief technology officer of Keysight Technologies. He leads the company's centralized technology development team to focus on addressing top opportunities and market trends. His role is to optimize Keysight resources to grow in areas that provide competitive advantage across the electronic design and test ecosystem, and to leverage its world-class technology and platform offerings. Alexander earned a Bachelor's in electrical engineering from Northwestern University and a Master's in computer science from the University of Colorado at Boulder. He is a licensed professional engineer and a senior member of the Institute of Electrical and Electronics Engineers (IEEE). He holds 24 U.S. patents.

JEFF HARRIS leads global marketing for Keysight Technologies including product marketing, brand, corporate communications, in addition to all of the company's digital marketing channels. He has led the transformation of Keysight's global brand, content strategy, and digital channel transformations creating awareness and influencing customer preference. Harris also drives thought-leadership initiatives to surface stories of how Keysight accelerates innovation and helps customers win in their markets. He holds Bachelor of Science and Master of Science degrees in Electrical Engineering from George Mason University and is an avid follower of technology.

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EM Co-Simulation with Measurement-Based Models Leads to First-Pass Design Success

Utilizing measurement-based passive-component models within an electromagnetic simulator enables simulations that accurately predict measured performance.

When simulating high-frequency filters with discrete passive components, it's important to consider several factors to achieve simulation results that correspond to actual measured performance. One such aspect is the metallization that connects components together, as these metal interconnects impact the overall filter performance. In addition, component parasitics should be incorporated into a simulation to ensure that the simulated results accurately predict the filter's response.

Fortunately, electromagnetic (EM) simulation software, such as Sonnet Suites from Sonnet Software *(www.sonnetsoftware.com)*, makes it possible to incorporate metal interconnects into a simulation. However, EM simulations that include ideal passive-component models often expose a discrepancy between simulated and measured performance, because ideal component models don't account for the parasitics that are present in real-world parts.

To help overcome these challenges, Modelithics *(www.modelithics.com)* offers measurement-based passive-component models that aid filter designers who use discrete passive components. These part-value, scalable models accurately capture substrate-dependent parasitic behavior so that they serve as true representations of real-world components in the context of their physical environment. Thus, incorporating Modelithics passive-component models into a filter simulation helps to accurately predict real-world performance and achieve first-pass design success.

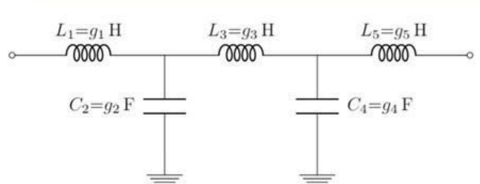
Modelithics Microwave Global Models are available for use with various simulation software tools, including Sonnet Suites. In addition to part-value and substrate scalability, these models offer advanced pad features that facilitate accurate EM co-simulations.[1] Designers can therefore utilize the combination of Modelithics models and Sonnet's EM solver to account for real-world component parasitics and metal interconnects in a simulation.

To demonstrate this combination, this article presents a workflow for a fifth-order Butterworth bandpass filter that features Modelithics passive-component models and Sonnet's EM software. Measured data is presented at the conclusion to compare simulation versus measurement results.

STARTING WITH A LOWPASS PROTOTYPE

As stated, the filter that will be designed here is a fifth-order Butterworth bandpass implementation. Intended for GPS applications, the

g_1	g_2	g_3	g_4	g_5
0.6180	1.6180	2.0000	1.6180	0.6180



1. Shown are the coefficient values for the maximally flat, five-element lowpass prototype filter along with the corresponding schematic.

filter provides lower and upper cutoff frequencies of 1,050 and 1,700 MHz, respectively, thereby allowing it to pass the L1, L2, L3, and L5 GPS bands.

The design process begins by determining the coefficients for a maximally flat, five-element lowpass filter with ω_c = 1 rad/s and $R_S = R_L = 1\ \Omega$.[2] This lowpass prototype will later be transformed to a bandpass network. *Figure 1* displays the coefficient values for the maximally flat, five-element lowpass prototype filter along with the corresponding schematic. Note the symmetry in the *g* values, which results in fewer unique component values in the filter design.

Because the filter is being designed for a 50-Ω reference environment, the coefficients must be scaled in impedance based on the following equations:

$$L' = R_0 L_i, \qquad C' = \frac{C_i}{R_0}$$

Applying these equations to the filter shown in *Figure 1* results in a new 50-Ω-referenced filter with updated component values *(Fig. 2)*.

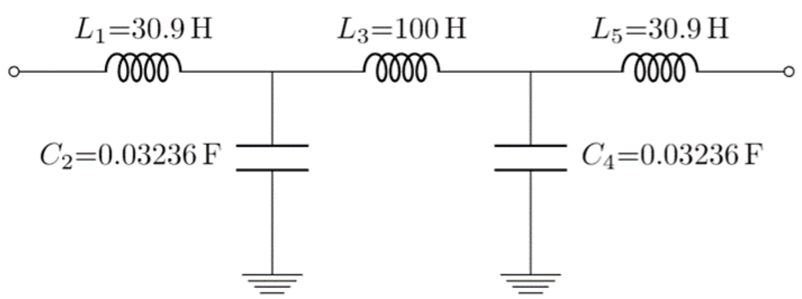
The lowpass filter prototype must now be converted to a bandpass implementation via frequency mapping. This conversion involves transforming the series inductors to series-LC circuits, while the shunt capacitors are transformed to parallel-LC circuits. *Figure 3* illustrates the element transformations. In *Figure 3*, note that:

$$\omega_0 = \sqrt{\omega_1 \omega_2}$$

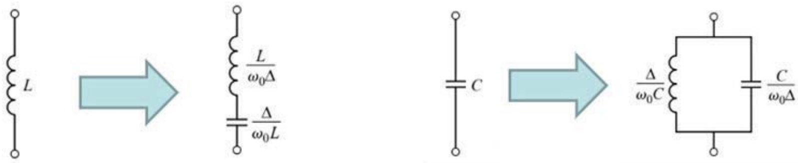
and:

$$\Delta = \frac{\omega_2 - \omega_1}{\omega_0}$$

Figure 4 depicts the schematic of the bandpass filter that's produced after transforming the lowpass prototype; its derived component values appear in *Table 1*. Furthermore, *Figure 5* plots the filter's calculated frequency response.



2. After scaling impedances, the 50-Ω-referenced lowpass filter has the part values shown in this schematic.



3. After transforming series inductors to series-LC circuits and shunt capacitors to parallel-LC circuits, the lowpass filter prototype was converted to a bandpass implementation via frequency mapping.

CREATING THE DESIGN IN SONNET SUITES

After determining the ideal component values of the bandpass filter, the next step is to create the design using the Sonnet *Project Editor*. Be aware that the calculated frequency response shown in *Figure 5* didn't account for the metal interconnects that will be present in the real-world filter. In contrast, creating the design in Sonnet Suites makes it possible to include these interconnects in the simulation.

For this design, we chose 10-mil-thick Rogers RO4350B laminate as the substrate. *Figure 6* shows the filter layout in the form of a CAD (DXF) file, which was ultimately sent to a printed-circuit-board (PCB) manufacturer for fabrication. In this case, the line widths are set to 21.7 mils. One can clearly see the various gaps between traces that indicate component locations on the PCB.

It's important to point out that what's simulated must replicate what will eventually be built. Therefore, when simulating the filter in Sonnet, one should

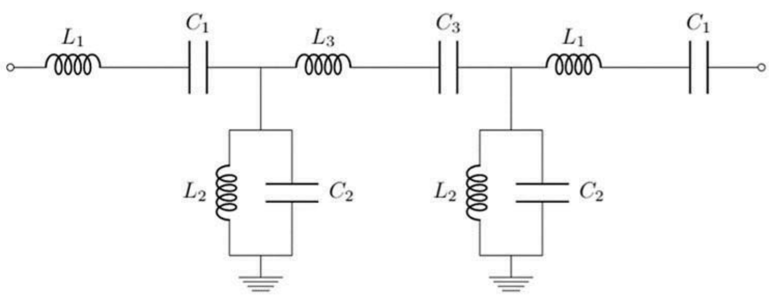
Component	Value
C1	1.876 pF
C2	7.923 pF
C3	0.580 pF
L1	7.566 nH
L2	1.791 nH
L3	24.49 nH

Table 1: These component values were derived for the bandpass network.

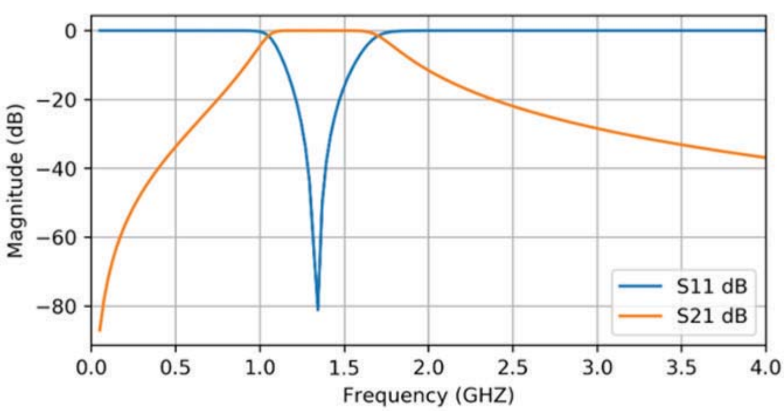
ensure that the component models are attached to the correct reference planes in the filter geometry. A gap of 15 mils between pads is included in the default pad arrangement for the filter's 0402-size components.

Because the 40-mil-long parts will be centrally placed on the pads, the ports must be broken out 12.5 mil into each pad to coincide with the edge of the part (12.5 + 15 + 12.5 = 40). *Figure 7* presents a depiction of this arrangement. This example illustrates the advanced pad

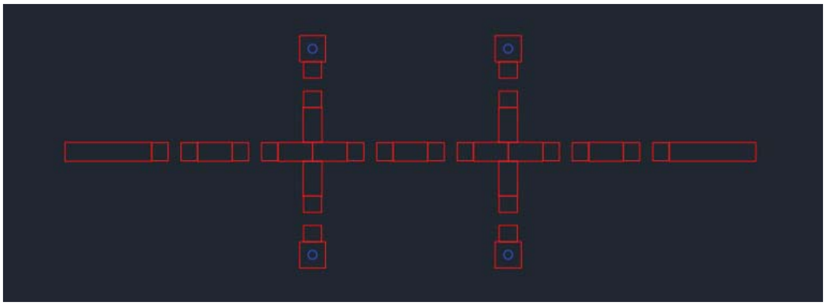
The combination of Modelithics measurement-based models and Sonnet's EM simulator represents an effective way to design high-frequency filters with discrete passive components.



4. This is the schematic of the bandpass filter that's produced after transforming the lowpass prototype; its derived component values appear in *Table 1.*



5. Shown is a plot of the filter's calculated frequency response.

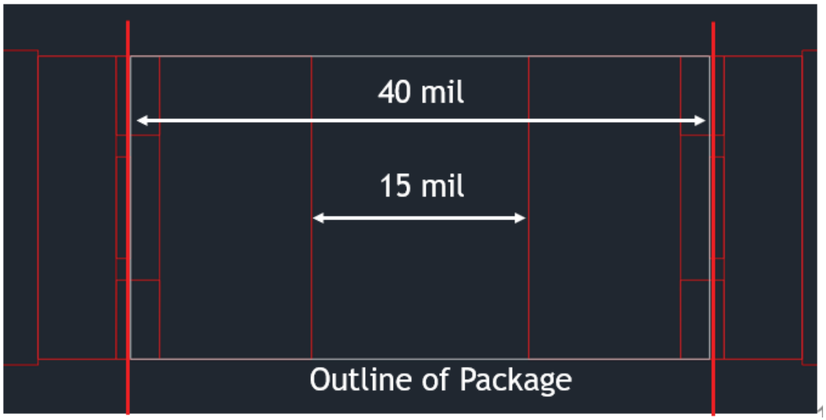


6. From this rendering of the filter layout in the form of a CAD (.dxf, or Drawing eXchange Format) file, a PCB manufacturer fabricated the boards.

features of the Microwave Global Models, which provide the needed flexibility for placement of the reference planes.

Now, we can use Sonnet Suites to import the DXF file of the filter layout. During the importation process, users can specify the layer mapping followed by the box size and cell size. Sonnet also provides users with options for importing vias.

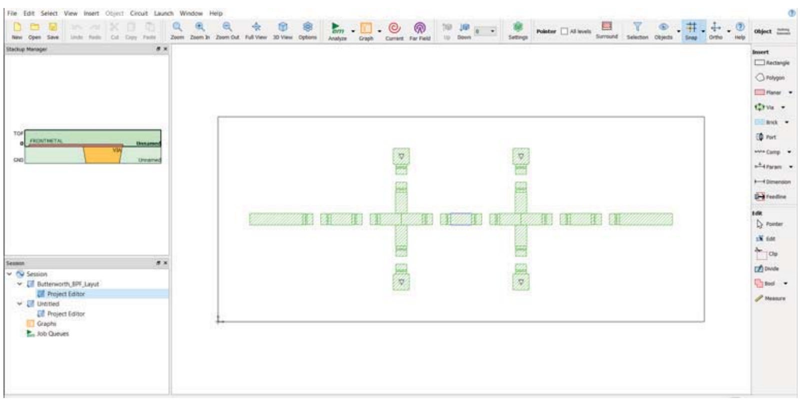
Figure 8 shows the Sonnet project after successfully importing the layout. The left-hand side of the Sonnet interface contains the *Stackup Manager*, which is where one may specify vias and top-layer metal *(FRONTMETAL)*. We specified the top dielectric, which is set to air by default, for a thickness of 100 mils to minimize the shielding effect of the lossless metal top cover. Lastly, we added ports to the conductor edges where the filter's input and output are located. In this case, we used the default port settings.



7. This illustration depicts the physical component (shown in white) and the pad arrangement (shown in red). The solid red vertical lines denote the model reference planes located at the edges of the terminations of the physical component.

SIMULATING WITH IDEAL COMPONENT MODELS

Next, the component models are added to the Sonnet project. Before adding the models, we created variables for each of the component values derived earlier *(Table 1, again)*. In this case, we added variables for C1, C2, C3, L1, L2, and L3, with each one assigned its corresponding part value. In addition, each variable must be specified as optimizable, with the optimization range set to the range



8. This screen capture shows the Sonnet project after successfully importing the layout. The left-hand side of the Sonnet interface contains the *Stackup Manager*, which is where one may specify vias and top-layer metal *(FRONTMETAL)*.

of part values for the corresponding part family (the part families will be revealed later). We set these variables to be optimizable because the filter will eventually require tweaking to achieve the desired performance.

Now we add the Modelithics component models to the design. Users can choose from a wide range of models that can be sorted either by type or by vendor. For this design, we chose the TDK *(www.tdk.com)* MHQ1005P inductor part family for all inductors and the Kemet *(www.kemet.com)* CBR04C part family for all capacitors.

An important parameter to note for a Modelithics component model is *Sim_mode*. For this initial simulation, *Sim_mode* is set to 1 for all component models. This setting allows a component model to simply behave as an ideal element, meaning that real-world factors like parasitic, pad, and substrate effects aren't considered. Furthermore, each model's value is set to the corresponding variable created earlier.

By executing a simulation with the *Sim_mode* parameter of all component models set to 1 for ideal mode, one may determine the performance impact of the metal interconnects (microstrip lines) themselves. In other words, the metallization incorporated into the Sonnet project represents the only real difference between this filter design with ideal models and the initial filter sche-

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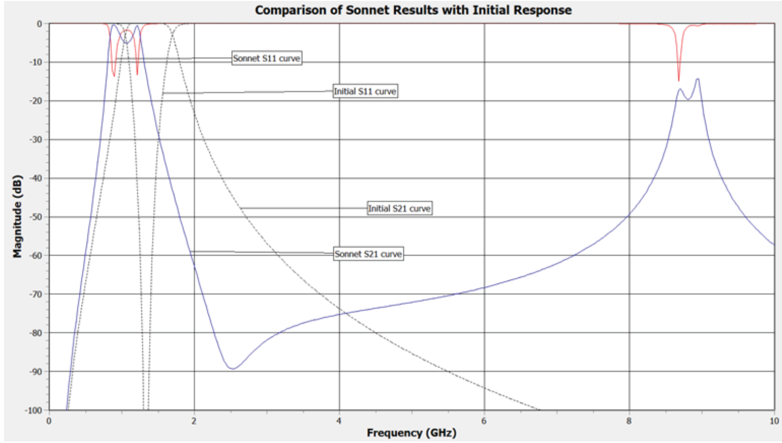
matic shown earlier *(Fig. 4, again)*. To determine the impact of metallization on performance, it's a simple matter of comparing the simulation results to the initial calculated frequency response *(Fig. 5, again)*.

Before simulating, we specified a linear frequency sweep from 0.05 to 10 GHz with 401 measurement points. In addition, we selected the *Adaptive* option to improve the simulation time by interpolating solutions when appropriate.

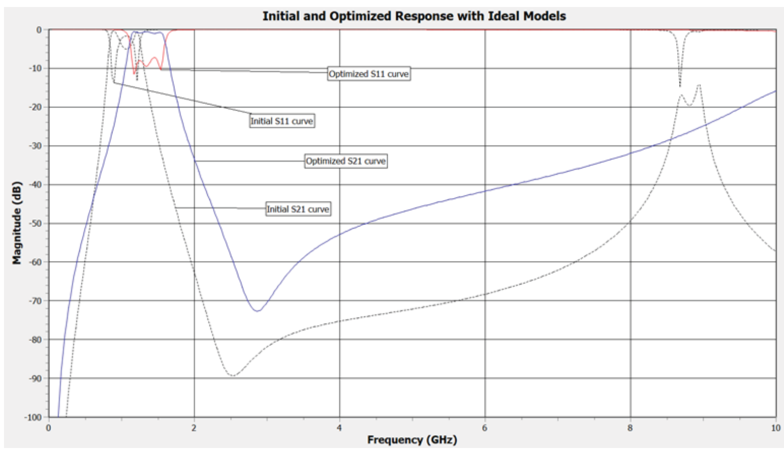
Figure 9 shows the results of the Sonnet simulation with ideal component models (blue and red traces). For comparison purposes, *Figure 9* also displays the calculated frequency response of the initial filter schematic shown in *Figure 5*, which didn't account for the physical effects of metal traces (dashed black traces). The Sonnet simulation predicts a response that's shifted downward in frequency compared to the response of the initial filter. In addition, the passband response is obviously not flat. Thus, we must optimize the filter to obtain the ideal component values that result in the filter's optimal performance.

Performing an optimization requires defining one or more sets of optimization goals. In this case, we defined three sets of goals. For the passband, the optimization goals are an S_{21} value greater than −1 dB and an S_{11} value less than −10 dB. For the lower and upper rejection bands, we're shooting for an S_{21} value of less than −20 dB.

Figure 10 shows the simulated results of the optimized filter along with the results of the previous Sonnet simulation with the initial component values. The filter's response is now shifted upward in frequency to correspond with the design goals. In addition, we've achieved the desired flat passband. *Table 2* shows the values of the optimized filter's ideal components. (It should be noted that this step of performing an optimization with ideal models isn't necessary, but it's included here to illustrate the progression of part-value changes as more and more real-world effects are included).



9. Shown are S-parameter results of the Sonnet simulation with ideal component models (blue and red traces). For comparison purposes, we include the calculated frequency response of the initial filter schematic presented in *Figure 5.*

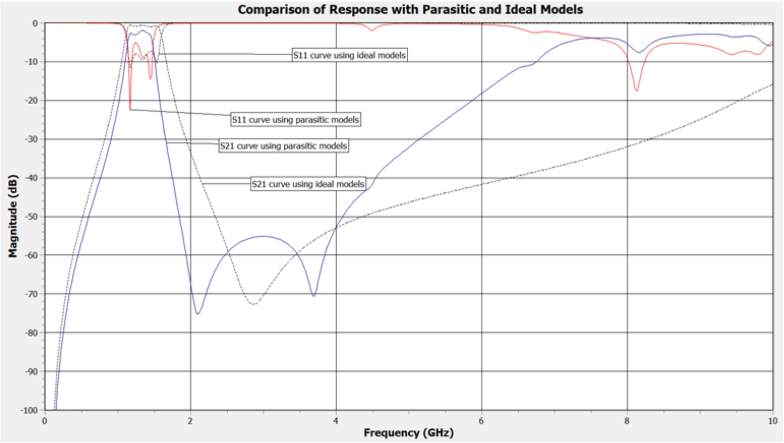


10. This plot compares the simulated results of the optimized filter (blue and red traces) with the results of the previous simulation with the initial component values (dashed black traces).

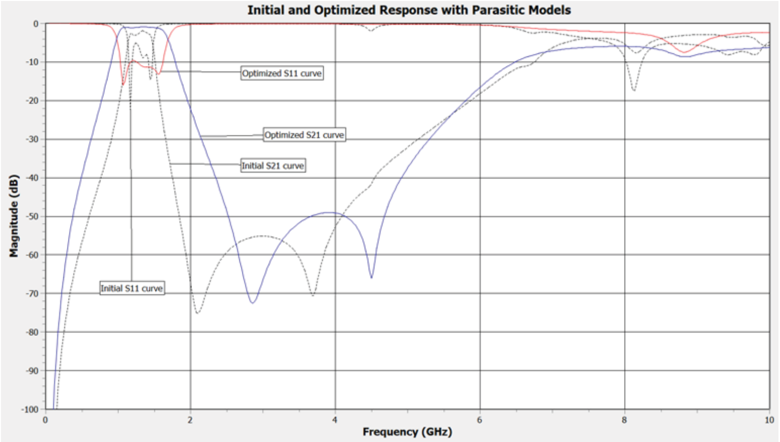
MOVING FROM IDEAL TO REAL-WORLD COMPONENT MODELS

Optimizing the filter using ideal component models is a good starting point for determining the final component values. However, there's room for improvement, because the ideal component models didn't account for real-world parasitic and substrate effects. Therefore, the next step is to update the component models to include these effects, providing an even more accurate prediction of the manufactured circuit's behavior.

Incorporating parasitic and substrate effects into a Modelithics model requires setting its *Sim_mode* parameter to the proper value. To include these effects, the *Sim_mode* parameter can now be set to 2 for all models. Note that with this setting, pad effects are removed (i.e., de-embedded) from a Global model. In this case, it's correct to employ this setting because the pads are already accounted for in the EM simulation. However, we can enable pad effects by setting a model's *Sim_mode* parameter to 0.



11. Here, the blue and red traces depict the simulated results when using parasitic models, while the dashed black traces show the previous simulated results obtained when using ideal models with equivalent values.



12. By optimizing the filter with the parasitic models, we met the design goals (blue and red traces). For comparison, we show the previous simulation results that were obtained using parasitic models with the initial values.

Component	Value
C1	21.395 pF
C2	6.019 pF
C3	0.623 pF
L1	0.700 nH
L2	1.014 nH
L3	15.393 nH

Table 2: Optimizing the filter with ideal component models resulted in these part values.

Because the component models now account for parasitic and substrate effects, they essentially represent real-world components rather than ideal ones. The next step is to perform a simulation with these models while leaving their inductance and capacitance values unchanged from the optimized filter with ideal component models. *Figure 11* shows the results of this simulation (blue and red traces). For comparison, we again show the response of the optimized filter that contains ideal component models with identical values (dashed black traces).

Neglecting to account for parasitic effects in a simulation can lead to simulated results that deviate significantly from real-world performance *(Fig. 11, again)*. It's clear that simulating the filter with the real-world models resulted in a passband response that's both narrower and more lossy than the passband response of the filter with ideal component models having equivalent inductance and capacitance values. Thus, a filter manufactured using components with the same values as the ideal component models would not achieve the design goals.

To meet the design goals, we must perform a final step of optimizing the filter with the parasitic effects included. For this optimization, we use the same optimization goals specified earlier. Note that once the optimization is complete, the component values must be changed to the closest available discrete, or "real-life," part values available in the given component family. These real-life values correspond to the values of the real inductors and capacitors that will be used when building the filter.

Figure 12 shows the final simulated results of the optimized filter using parasitic models with real-life values. These values, listed in *Table 3*, resulted from adjusting the optimized component values to the closest available manufacturer part values. For comparison, *Table 3* also shows the component values of the optimized filter with ideal models along with the initial component values.

As *Figure 12* demonstrates, the filter now achieves the desired performance. Further refinements could be made by adjusting lengths and widths of the interconnects to fine-tune the filter performance after the component values are set to the closest available manufacturer part values.

	Initial Value	Value of Optimal Ideal Model	Final Real-World Part Value
C1	1.876 pF	21.395 pF	12 pF
C2	7.923 pF	6.019 pF	3.3 pF
C3	0.58 pF	0.623 pF	0.9 pF
L1	7.566 nH	0.7 nH	0.7 nH
L2	1.791 nH	1.014 nH	2.4 nH
L3	24.49 nH	15.393 nH	12 nH

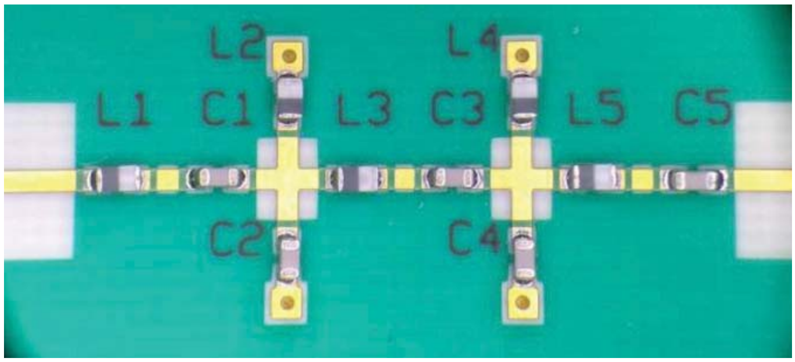
Table 3: Real-world part values that correspond to true optimal filter performance are compared with the component values of the optimized filter with ideal models, as well as the initial component values.

MEASURED DATA AND CLOSING

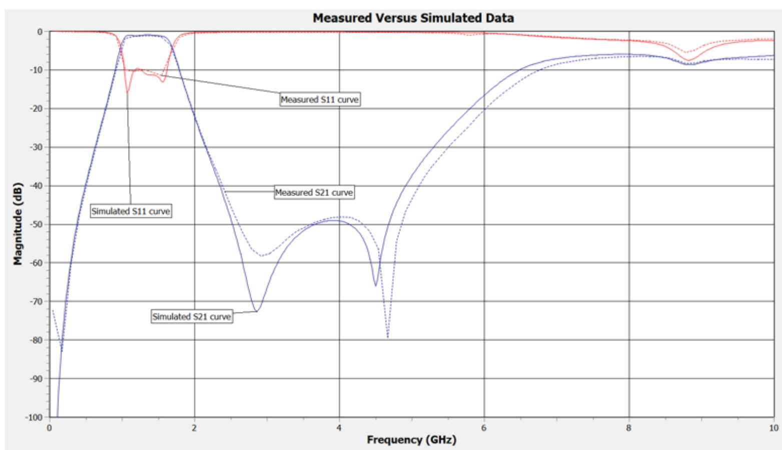
To validate the simulated results, we built and measured three filters *(Fig. 13)*. We populated the filter PCBs with the same TDK inductors and Kemet capacitors from the final simulation and probed all measurements. Through a thru-reflect-line (TRL) calibration, we moved the reference planes to match those used in the simulation.

Figure 14 shows the measured data from one of the filters we built (dashed traces) along with the results of the final simulation (solid traces). It's clear that the measured 3-dB frequencies, as well as the S_{21} and S_{11} values within the passband, are almost identical to the simulated results, thus validating the workflow presented.

In closing, the combination of Modelithics measurement-based models and Sonnet's EM simulator represents an effective way to design high-frequency filters with discrete passive components. The example highlighted in this article demonstrates that incorporating Modelithics models into a Sonnet project can help achieve first-pass design success. In contrast, simulating high-frequency filters with ideal passive-component models can create headaches for designers, because the simulated results may not be a true indication of the filter's performance. mw



13. This is one of the three filters that was built. The performance of each was nearly identical.



14. The measured data (dashed traces) indicated good agreement with the final simulated results (solid traces).

THE AUTHORS would like to thank Greg Kinnetz of Sonnet Software for his support.

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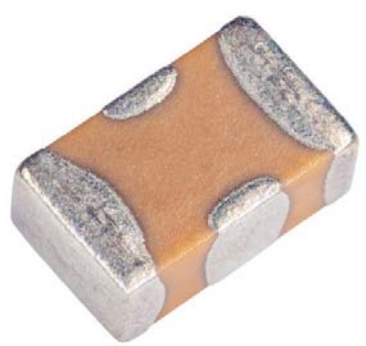
JEFF ELLIOTT | Technical Writer

Advanced EMI Filters Cut Costs on Brush DC Motors

EMC requirements are driving up the cost of low-priced, but noisy, brush dc motors. Monolithic EMI filters reverse this trend.

Brush dc motors are inexpensive and easy to operate, providing a good balance of performance and price. As a result, billions are manufactured annually worldwide and used in such industries as automotive, aerospace, medical, appliances, and manufacturing, and billions more will be sold over the next 10 years.

However, increasing electromagnetic-compatibility (EMC) requirements, along with more crowded and "noisy" electronic environments, are threatening to drive the cost of these low-end motors to a level on par with more expensive brushless motors.



Monolithic EMI filters provide significantly more RFI suppression for brush dc motors while rejecting a much wider frequency band. The EMI filter isn't affected by the amount of dc current required.

At issue is the electromagnetic interference (EMI) generated by the brushes rubbing against commutators, an inherent drawback of the design. To counteract the noise, a combination of shielding and filtering components is required. This not only drives up the cost, but many EMI/RF filters for brush dc motors will not let them meet today's higher EMC requirements.

"Many EMI filtering products do not filter out all forms of noise generated, and many cannot handle higher dc currents without a corresponding increase in their costs," explains Christophe Cambrelin of Johanson Dielectrics, a company that manufactures a variety of

multi-layer ceramic capacitors and EMI filters.

To address these concerns, companies such as Johanson offer more advanced EMI filters that only slightly increase costs of brush dc motors while meeting the evolving EMC requirements.

NOISY ELECTRONICS

Electronic devices receiving strong electromagnetic waves often induce electric currents in the circuit and interfere with intended operations. EMI can even physically damage equipment. Making the problem worse, increases in operating circuit frequency expand the affected frequency range while miniaturization of electronic devices shrinks the distance between noise source and affected circuits. If that wasn't enough, many electronic devices are more sensitive to noise, even if it has less energy, because circuits today operate at lower voltages.

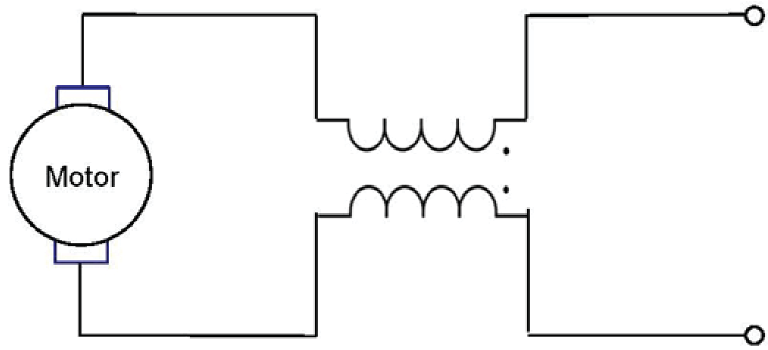
As a result, industries such as the automotive sector are increasingly turning to brushless dc motors. With these, the commutation is done electronically. Therefore, there's significantly less noise generation (no noise generated by mechanical commutation), but the complexity and cost of implementation are increased.

So, given a choice, OEMs prefer the relatively low price of brush dc motors given the quantities involved.

EMI FILTERING

EMI/RFI interference is either radiated or conducted over frequency range of between several hundred hertz to several gigahertz.

Radiated noise is generated by voltage applied at varying levels to the wiring. To confine radiations in the motor housing, several precautions should be taken by manufacturers of brush dc motors. The most important is that the motor-housing material should be metal, and the housing should also have a metal cap. If the cap is plastic, users need to cover it with a shield of metal or metallized PCB.



A common-mode choke doesn't filter out differential-mode noise and can only handle limited dc current, without driving up the cost.

Electronic devices receiving strong electromagnetic waves often induce electric currents in the circuit and interfere with intended operations. EMI can even physically damage equipment.

When EMI/RFI is conducted, the noise generated travels along the electrical power leads and is then radiated. Shielding is ineffectual against this conducted noise, so filtering with a separate device is required.

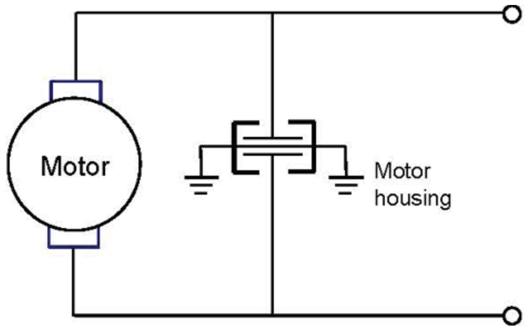
Traditional common-mode filtering includes low-pass filters comprised of capacitors that pass signals with a frequency lower than a selected cutoff frequency and attenuate signals with frequencies higher than the cutoff frequency. Options for OEMs are two-capacitor differential, three-capacitor (one X-cap and two Y-caps), feedthrough filters, common-mode chokes, LC filters, and combinations of these.

To meet increasing EMC requirements, however, low-cost devices such as two-capacitor differential filters are insufficient because unmatched capacitors generate a different filtering of each line, and thus there's mode conversion (i.e., part of the common-mode noise is transformed into differential-mode noise, and vice versa). Traditional three-capacitor filters are adequate, provided the EMC requirements are only at relatively low frequencies (<150 MHz, such as AM/FM radios in cars).

Although three-capacitor filters provide good filtering, they are generally ineffective at filtering noise in telecom frequency bands. Other devices like feedthrough filters offer good rejection over a wide frequency band but become expensive when the power line must carry a several amps of current. In addition, feedthrough filters are single-ended devices, and therefore may introduce mode conversions (like 2-cap filters).

"Regardless of the noise generated, if high dc current is required, you need a large, expensive feedthrough filter, which eliminates brush dc motors as a low-cost alternative," says Cambrelin.

For brush dc motors, a possible alternative to the low-pass filter is a common-mode choke. When a common-mode signal (same ac current) travels through each winding of the common-mode choke, the magnetic field coming from each winding adds up, and the impedance therefore increases signifi-



Monolithic EMI filters are effective from 50 kHz to 6 GHz and filter both common- and differential-mode noises. The filter also has virtually no limit to the amount of dc current because it works in parallel with the motor and no dc current flows through it.

> "When you first test the motor in the lab, the EMI filter may perform well, but everything changes when you apply PWM signals on the power leads. You want to filter out the noise, but not unintentionally filter out the PWM signal."

cantly. On the other hand, when a differential signal (opposite ac current) goes through each winding, the magnetic field coming from each winding subtracts from each other and impedance decreases significantly.

That's why common-mode chokes block common-mode noise but let a differential signal go through. Similar to feedthrough filters, it takes a larger and more expensive common choke to carry a significant current (more than 1 A rms).

Despite the popularity of common-mode chokes, a better alternative may be monolithic EMI filters. Compared to common-mode chokes, monolithic EMI filters provide significantly more RFI suppression in a substantially smaller package. A monolithic EMI filter also rejects a much wider frequency band and isn't affected by the amount of dc current required because it's mounted in shunt (between lines and ground).

EMI filters combine two balanced shunt capacitors in a single package, with mutual inductance cancellation and shielding effect. These filters, such as those from Johanson Dielectrics, use two separate electrical pathways within a single device attached to four external connections.

Like other EMI filters, monolithic EMI filters attenuate all energy above a specified cutoff frequency, only selecting to pass required signal energy while diverting unwanted noise to ground. The key, though, is the filter's low inductance and matched impedance. With monolithic EMI filters, terminations connect internally to a common reference (shield) electrode and the plates are separated by the reference electrode.

Monolithic EMI filters can be effective from 50 kHz to 6 GHz and filter both common- and differential-mode noise. The filter also has virtually no limit on the amount of dc current because it works in parallel to motor and no dc current flows through it.

PWM SIGNALS

Regardless of the type of filter, an often-overlooked factor is the fact that many brush dc motors are controlled by pulse-width-modulated (PWM) signals, says Cambrelin. With PWM signals, the voltage is switched on and off quickly between a few kilohertz and tens of kilohertz. The total power supplied is based on the time the switch is on compared to the off periods.

PWM signals are particularly suited for motors because the motor's time constant is very long compared to the period of a PWM signal. That's why a brush dc motor acts as if the average of the PWM signals was applied on the power leads.

"When you first test the motor in the lab, the EMI filter may perform well, but everything changes when you apply PWM signals on the power leads," explains Cambrelin. "You want to filter out the noise, but not unintentionally filter out the PWM signal. If you don't choose the right filter, the motor may not even start."

This can be a problem for users unfamiliar with developing differential LC filters.

With monolithic EMI filters, there's no need for special skills in filtering. The filter's response (i.e., rejection of common-mode noise vs. frequency) is provided directly by the manufacturer. Companies such as Johanson Dielectrics are also working on a device for brush dc motors that will let users mount the monolithic EMI filter on the housing without manufacturing a PCB.

"EMI issues are just going to become more of a problem with the higher frequencies with Bluetooth, Wi-Fi, and now 5G devices," says Cambrelin. "That means EMI filters will have to handle wider frequency ranges while letting appropriate signals pass through. This will help OEMs meet regulatory standards in most countries that limit the amount of noise that can be emitted."

For an online tool that helps simplify filter choice, go to *https://s21plotter.johansondielectrics.com*. mw

JEFF ELLIOTT is a Torrance, Calif.-based technical writer. He has researched and written about industrial technologies and issues for the past 20 years.

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NC State Helps Army Model Civilian Evacuations

JACK BROWNE | Technical Contributor

A new computation model may help the speed and efficiency of armed forces in evacuating civilians during emergencies. *(Courtesy: Army Research Labs)*

MILITARY TROOPS are often faced with civilian evacuations which involve moving people of all ages and managing vehicles and communications systems of all types. The task is never simple, but researchers at a major university have stepped up with an innovative model that may help military troops expedite the evacuation of civilians during a disaster or when humanitarian relief efforts are needed.

The model, developed at sports powerhouse North Carolina State University in Research Triangle Park, N.C., was funded in part with support from the U.S. Army. It helps planners to plan the placement and timing of vehicles, troops and equipment during an evacuation to move civilians safely and effectively away from an area of danger. It also predicts requirements for food, water and shelter over extended periods of time to minimize stress on evacuees.

"What sets this tool apart from other models is that it is designed for use in both planning and during operations," said Brandon McConnell, corresponding author of a paper on the new model and a research assistant professor in NC State's Edward P. Fitts Department of Industrial and Systems Engineering. "In terms of specificity, we're talking about where a given truck will be at any point in time during an operation."

(Continued on page 42)

Airborne Radio Meets DoD's Latest Security Requirements

THE ARC-210 RT-2036(C) is a military radio with the flexibility of SDR technology, and the first airborne VHF/UHF radio to meet MUOS security requirements.

Communications security can mean the difference between success and failure in battle. Rockwell Collins has taken a major step in fortifying the security of its airborne radios by developing the first airborne VHF/UHF radio that meets the military security requirements for the U.S. Department of Defense (DoD) Mobile User Objective System (MUOS). Rockwell Collins' sixth-generation ARC-210RT-2036(C) VHF/UHF radio recently passed Do Not Harm (DNH) testing performed by the Space and Naval Warfare Systems Command (SPAWAR) using the most current MUOS test signal waveforms.

The ARC-210RT-2036(C) secure military radio *(see figure on page 42)* provides total frequency coverage of 30 to 1850 MHz, spanning VHF, UHF, and L-band frequencies. It provides a variety of channel bandwidths, as wide as 30 MHz and as fine as 5 kHz, with the capability to perform software-defined-radio (SDR) channel tuning in 1.25- or 8.33-kHz increments. The versatile and secure military radio features a wide range of waveform options, including SINCGARS, Soldier Radio Waveform

(Continued on page 42)

NC State Helps Army Model Civilian Evacuations

(Continued from page 41)

Research on the novel evacuation model was published in the *Journal of Defense Analytics and Logistics* and was based on evacuation activities in South Korea, but could be applied to many different settings.

Research for the model was funded by means of a short-term innovation research grant from the Army covering nine-month study periods. Dr. Joseph Myers, mathematical sciences division chief at the Army Research Office, an element of U.S. Army Combat Capabilities Development Command's Army Research Laboratory (ARL), explained: "The tool will need fine-tuning before it can be implemented—it would benefit from a user-friendly interface, for one thing—but it highlights the potential that operational models have for helping the military achieve its objectives both in or out of wartime."

U.S. Army Captain John Kearby, first author of the paper and former NC State graduate student, noted: "There is a tremendous amount of complexity associated with the Army's South Korea noncombatant evacuation mission, and that presents a great opportunity for investigation and improvement. The goal of this research was, and is, to encourage the development of better and more robust evacuation plans." de

Airborne Radio and the DoD

(Continued from page 41)

(SRW), and Joint Precision Approach and Landing System (JPALS) waveforms.

"We're at the forefront of this new technology and one step closer to bringing certified MUOS capability to airborne operations," said Troy Brunk, vice president and general manager, Communication, Navigation, and Electronic Warfare Solutions for Rockwell Collins. "The benefits of MUOS, which include improved mobility, frequency capacity, access and signal quality, will provide the communications our warfighters need for continued success in the future."

The MUOS satellite communications (satcom) system is used by the DoD for air and ground communications, extending to the UHF range for increased capacity and signal quality. It allows troops to access any combination of voice, video, or data with the assurance that information is not being blocked or intercepted. The ARC-210 RT-2036(C) radio, which performs well in rough

terrain and beyond-line-of-sight operating conditions, started with MUOS testing in 2013. For the U.S. Air Force, the first MUOS-certified ARC-210 RT-2036(C) radio will be installed aboard an F-16 fighter. ■

SMART Embedded Computing Joins SOSA Consortium

SMART EMBEDDED COMPUTING has joined the Sensor Open System Architecture (SOSA) Consortium in support of U.S. Army, Navy and Air Force efforts to develop an open command, control, communications, computer intelligence, surveillance and reconnaissance (C4ISR) weapons system standard. The SOSA Consortium, which is managed by The Open Group (www.opengroup.org), has members from all three branches of the military, prime contractors, and embedded computer suppliers, teaming to develop an open standard that can be applied for compatibility of embedded computing systems in commercial and military applications. So far, the working SOSA standard has been based on variants of the Open VPX embedded computing standard.

The company is a long-time innovative supplier of single board computers (SBCs) and other modular digital electronic components and subsystems based on high-speed processors. As an example, the model MVME8105 is a 6U VME SBC based on a 2-GHz processor and as much as 4 GB DDR3, 512 kb MRAM nonvolatile memory and 8 GB eMMC NAND flash memory. As a member of the SOSA Consortium, the company will contribute its expertise in design and manufacturing to achieve the compact computing power needed for tri-service next-generation electronic weapons systems, such as modular communications, EW, radar and signal intelligence (SIGINT) systems. ■

(News Shorts continue on page 62)

SOSA Keeps Weapons Systems in Order

DAVID MALINIAK | Editor

WE TEND TO BE GRATIFIED when our electronic gadgets play nice with each other, and conversely, frustrated when they don't. For example, back when I favored Android mobile devices, I had great fun "rooting" my phones and flashing custom ROMs that came from who-knows-where. I'd do a little tinkering with the source code myself, sometimes dropping in patches for bugs, and then compiling the result. But on occasion, those neat-looking custom ROMs would break things and cause connectivity problems.

My wife and daughter both had iPhones, and texting reliably between my no-longer-stock Android phones and their iPhones eventually became so problematic that my exasperated spouse put her foot down and demanded that I ditch Android and get with the Apple program. When I relented, I was chagrined to find that with iPhones, everything just… works. No glitchy connectivity, no text messages that never arrive (or arrive hours after being sent). Compatibility—what a concept!

If getting a text to one's spouse is a big deal, how much bigger of a deal is it when systems compatibility is a matter of life and death? This is literally the case with military weapons systems, especially when one service branch's systems need to talk to those of another.

The Sensor Open System Architecture (SOSA) has been around for a while now, and it holds great promise for achieving full compatibility between sensor-based systems of the Air Force, Army, and Navy. It's by no means a trivial undertaking for these three branches to find common ground on which their respective systems can cooperate. But the SOSA effort represents an opportunity for them to, for starters, agree on specs for backplanes and modules for future weapons systems.

This centerpiece of this edition of Defense Electronics is Technical Contributor Jack Browne's "status report" on SOSA: how and why it came about, where it's been, and most importantly, where it's going. For designers of these nascent weapons systems of tomorrow, it's a must-read for keeping up-to-date on the modernization of our armed forces' equipment. And for the eventual "consumers" of these systems—the men and women in uniform who must rely on them—it could mean the difference between staying alive, or not. de

AMCOM COMMUNICATIONS
The RF Power House

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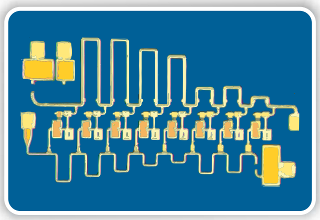
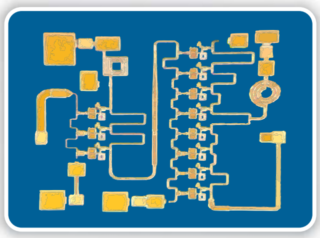
New Broadband GaAs MMIC offerings from AMCOM!

AMCOM's AM06013033WM-XX-R is a broadband GaAs MMIC which operates between 6 and 13 GHz with 28 dB gain and 33 dBm output power. This MMIC is available in both bare die form (AM06013033WM-00-R) and packaged form (AM06013033WM-EM-R).The EM package is a ceramic package with a flange and straight RF and DC leads for drop-in assembly. The MMIC input and output are internally matched to 50 Ohms.



AMCOM's AM00020026WM-00-R is a broadband GaAs MMIC Distributed Power Amplifier die which operates between DC and 20 GHz. This amplifier has 13.5 dB gain, and 26 dBm output power. The chip input and output are internally matched to 50 Ohms.



AMCOM's AM02018026WM-00-R is a broadband GaAs MMIC Distributed Power Amplifier die which operates between 2 and 18 GHz. This amplifier has 23.5 dB gain, and 26 dBm output power. The chip input and output are internally matched to 50 Ohms.

GaAs MMIC PAs

Model	Freq(GHz)	Gain(dB)	P1dB(dBm)	Psat(dBm)	Eff(%)	Vd(V)
AM003536WM-XX-R	0.01-3.5	23	35	36	20	20
AM002535MM-XX-R	0.03-2.5	24	34	35	25	20
AM012535MM-XX-R	0.03-2.5	20	33	33.5	20	20
AM009023WM-XX-R	0.05-9	21	21	23	20	12
AM008030WM-XX-R	0.05-10	18	30	31	20	12
AM012020WM-XX-R	0.1-2	30	16	17	8	8
AM011037WM-XX-R	0.2-1.0	31	37	37.5	40	8
AM103026MM-XX-R	0.9-3.2	22	25	26	10	14
AM132740MM-XX-R	1.3-2.7	26	38	39	30	14
AM142540MM-XX-R	1.4-1.8	25	39	40	35	14
AM153040WM-XX-R	1.4-3.4	18	37	38	30	12
AM143440WM-XX-R	1.5-1.8	20.5	38.5	39	35	12
AM143438WM-XX-R	1.5-1.8	20.5	37.5	38	30	12
AM153540WM-XX-R	1.5-3.5	18	39	39.5	35	14
AM183030WM-XX-R	1.6-3.3	30.5	30.5	31.5	20	8
AM183031WM-XX-R	1.6-3.3	31.5	31.5	32.5	25	8

GaN MMIC PAs

Model	Freq(GHz)	Gain(db)	Psat(dBm)	Eff(%)	Vd(V)
AM00010037WN-00-R	DC-10	13	37	25	28
AM00010037WN-SN-R	DC-10	13	37	23	28
AM003042WN-00-R	0.05-3	24	42	35	40
AM003042WN-XX-R	0.05-3	23	42	33	40
AM206041WN-00-R	1.8-6.5	32	42	27	28
AM206041WN-SN-R	1.8-6.5	30	41	23	28
AM408041WN-00-R	3.75-8.25	33	42	27	28
AM408041WN-SN-R	3.75-8.25	31	41	23	28
AM07512041WN-00-R	7.75-12.25	28	42	27	28
AM07512041WN-SN-R	7.75-12.25	27	41	22	28
AM08012041WN-00-R	7.5-12	22	42	20	28
AM08012041WN-SN-R	7.5-12	21	41	20	28

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DAVID MALINIAK | Editor

RFSoC Board Aligns with SOSA Reference Architecture

Pentek's latest RFSoC board puts it on the vanguard of SOSA Technical Standard adoption.

WITH THE LAUNCH of its Quartz model 5550 RFSoC board, Pentek stakes out a leadership position in the defense/aerospace sector's adoption of the Sensor Open System Architecture (SOSA) Technical Standard and the reference architecture it defines. To that end, the board implements connector technology that enables a major goal of the SOSA reference architecture—backplane-only I/O. It incorporates the ANSI/VITA 67.3D VPX backplane interconnect standard for both coaxial RF and optical I/O. In addition, the 5550 includes a 40-GbE interface and a shelf-management subsystem that are also required by the SOSA reference architecture.

The 3U OpenVPX board, equipped with PCI Express Gen 3 capabilities, comprises an eight-channel analog-to-digital converter (ADC) and digital-to-analog converter (DAC) and is based on the Xilinx Zynq UltraScale+ RFSoC FPGA. It's aimed squarely at applications in communications, electro-optics, electronic warfare, and radar and signals intelligence.

Pentek's modular approach to hardware and software enables quick adaptation to new and changing customer requirements. The Model 5550 uses the Model 6001 QuartzXM eXpress module containing the RFSoC FPGA and all needed support circuitry implemented on a carrier module designed specifically to align with the technical standard for the SOSA reference architecture. This allows for easy upgrades to third-generation RFSoC modules when available.

The Model 5550 is pre-loaded with a suite of Pentek IP modules to provide data capture and processing solutions for many common applications. Modules include direct-memory-access (DMA) engines, DDR4 memory controller, test signal and metadata generators, data packing, and flow control. The board also comes pre-installed with IP for triggered waveform and radar chirp generation, triggered radar-range gate selection, wideband real-time transient capture, flexible multimode data acquisition, and extended decimation. For many applications, the Model 5550 can be used out-of-the-box with these built-in functions, requiring no FPGA development.

The front end accepts analog IF or RF inputs on eight coax connectors located within a VITA 67.3D backplane connector. After balun coupling to the RFSoC, the analog signals are routed to eight 4-GS/s, 12-bit ADCs. Each converter has built-in digital downconverters with programmable 1x, 2x, 4x, and 8x decimation plus independent tuning. The ADC digital outputs are delivered into the RFSoC programmable logic and processor system for signal processing, data capture, or routing to other resources. A stage of IP-based decimation provides another 16x stage of data reduction.

Eight 4-GS/s, 14-bit DACs deliver balun-coupled analog outputs to a second VITA 67.3D coaxial backplane connector. Four additional 67.3D coaxial backplane connections are provided for clocks and timing signals.

The Model 5550 also uses the VITA-67.3D backplane connector for eight 28-Gb/s duplex optical lanes to the backplane. With two built-in 100 GigE UDP interfaces or a user-installed serial protocol in the RFSoC, the backplane interface enables gigabit communications independent of the PCIe interface.

For cases in which IP development proves necessary, Pentek's Navigator Design Suite streamlines the process. The suite includes the Navigator FDK (FPGA Design Kit) for custom IP and Navigator BSP (Board Support Package) for creating host software applications. The Navigator FDK includes the board's entire FPGA design as a block diagram that can be edited in Xilinx's Vivado tool suite. All source code and complete documentation is included. Developers can integrate their IP along with the factory-installed functions or use the Navigator kit to replace the IP with their own. The Navigator FDK Library is AXI-4 compliant, providing a well-defined interface for developing custom IP or integrating IP from other sources.

Serving as a ready-to-use Quartz development platform, the Model 8257 is a low-cost 3U VPX chassis well-suited for developing applications on Pentek's Model 5550 Quartz RFSoC board. Providing power and cooling to match the 5550 in a small desktop footprint, the chassis allows access to all required interfaces and the Model 5901 rear transition module. The 8257 can be configured with optional real-panel dual MPO optical connectors to support the 5550's dual 100-GbE interfaces and coaxial RF connectors.

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SRIDHAR KANAMALURU | Curtiss-Wright Defense Solutions

Take the Proper Steps to Flight-Test-Instrumentation Design

Real-time monitoring during test flights demands FTI equipment that provides highly accurate, comprehensive data, which means that engineers adhere to specific design parameters.

FLIGHT-TEST-INSTRUMENTATION (FTI) equipment acquires flight avionics and aircraft structural and environmental parameter data for real-time monitoring during test flights and for offline analysis. Solutions for FTI include data-acquisition units (DAUs), recorders, switches, gateways, cameras, and RF transmitters and transceivers. FTI encoders and RF transmitters deliver real-time monitoring, while offline analysis involves analyzing data recorded during the test flights.

Designers of FTI equipment must meet unique environmental (physical and electromagnetic-interference, or EMI) and size, weight, and power (SWaP) requirements. In practice, the design of RF equipment for FTI applications is both a science and art, with expertise honed through experience and knowledge of flight test industry needs and practices.

Most FTI equipment installation occurs only during the test phase for airborne platforms; it must function without affecting the test platform dynamics and functional performance. In addition, FTI equipment is often installed in space-constrained locations without adequate airflow or cooling, which makes the operating environment more challenging. This puts a premium on compact equipment that draws very little prime power, and operates optimally in both high and low temperatures, as well as under severe shock, vibration, and humidity environments as specified by environmental standards like MIL-STD-810.

What's more, one must consider EMI, both in how it might impact or be impacted by other aircraft equipment. FTI RF equipment must be designed to meet EMI requirements, as dictated by standards such as MIL-STD-461. The FTI RF equipment should have long mean time between failure (MTBF) and require very little field adjustment or maintenance. Finally, it's preferable that FTI equipment be deployed as a line replaceable unit (LRU).

The RF solutions used in FTI telemetry (TM) applications include transmitters, transceivers, transponders, and receivers. In the U.S., the RF frequency bands for FTI transmitters, transceivers, transponders, and FTRs are specified by the Range Commanders Council (RCC).

RF transmitters handle real-time (downlink) transmission of flight test data, as well as mission and safety critical data, to a ground receiver station. The transceivers fulfill a similar role, except they offer bidirectional links (i.e., uplinks and downlinks) between the airborne test platform and the ground station. The bidirectional links enable the ground station to select or modify the list of test parameters that are transmitted on the down-link, during the test flight. Today, the transmitter RF frequency bands are in the L-, S-, and C-bands, with a planned migration to C-band in the near future for most U.S. test ranges. FTI transceivers operate at S- and C-band, with C-band operation being the most common in the U.S.

MODULATION MODES

Most TM transmitters use constant envelope modulation schemes (e.g., SOQPSK) to allow the transmitter power amplifiers (PAs) to operate at close to saturation, thereby achieving high efficiency (low prime power draw) for a given RF output power. Many FTI customers prefer to program their transmitters to specific output powers (e.g., 1, 5,

10, or 20 W) for each flight or mission. This requires RF designers to use innovative biasing schemes to maintain the PA at close to saturation at each required output power level.

New modulation schemes are being introduced, including the use of low-density parity coding (LDPC) and space-time coding (STC), to overcome multipath interference and improve the RF link distance. Because the transmitter frequency tuning range is quite wide, the transmitter PA must maintain its output power and efficiency across the entire tuning range. Furthermore, it must keep the harmonics and spurious signals within specifications, especially in the GPS frequency bands.

FTI RF designers have to balance competing constraints, including:

- High output power
- High efficiency (low prime power draw)
- Wide frequency tuning range
- Low inter-modulations, harmonics, and spurious
- Wide operating temperature range (typically –40 to +85°C)
- Low SWaP
- Excellent thermal transfer to the surrounding environment

Many transmitter functional blocks (e.g., modulator, oscillators, and power supply) are based on commercially available standard silicon devices. The PAs, though, offer RF designers great flexibility in choosing device technologies and circuit architectures to address the key application requirements.

Recently, the availability of high-power gallium-nitride (GaN) devices that operate at high junction temperatures, using 28-V dc or higher bias voltages, has alleviated many design constraints. Because they can operate at 28 V dc and higher, meeting MIL-STD-704 requirements, GaN devices are particularly suitable for avionics equipment. Their use also eliminates the power-supply inefficiencies that result from reducing the prime power voltage to those required for silicon power devices.

The use of balanced or push-pull circuit architectures assist in broadband impedance matching or reducing second harmonics. RF designers use their expertise and experience to design bias circuits, some with a microcontroller and other programmed controls, which are able to maintain the high RF output power and high efficiency across the temperature and frequency ranges typical of FTI application requirements.

RF TRANSPONDERS

Most RF transponders used in FTI operate in the C-band, while a few perform in the X-band. For tracking purposes, transponders function as RF beacons by responding to a pulsed query from a ground tracking radar with a known pulsed reply waveform. These RF transponders, for the most part, use very-high-power pulsed waveforms with very low duty cycles so that the PA can operate close to saturation.

RF transponders for FTI must support wide tuning ranges, fast rise and fall times, and minimal pulse droop—all the while keeping the inter-modulation frequencies under specified limits. In addition, the transponder must provide adequate charge storage to keep the bias voltage stable in order to achieve minimal pulse droop. To address EMI requirements, it's imperative that the RF transponder power supply restrict in-rush current during the charging cycle.

Due to their high-power short-pulsed waveforms, RF transponders generate many harmonics. These harmonics must be filtered to ensure co-site interference issues don't crop up, especially in the GPS frequency bands. The RF filters for these transponders must feature low passband insertion loss, steep roll-offs, and high stopband attenuation, all of which pose challenge when designing for SWaP optimization. Another RF filter design challenge is the need to provide a good impedance match in the stopband, so that the power amplifier doesn't exhibit instability when operating across wide frequency and temperature ranges.

For the most part, telemetry receivers are used as ground support equipment, so they do not experience the same SWaP and environmental constraints as transmitters and transponders. The key to successful TM receiver design, as it is to all receiver designs, is a low noise figure, wide frequency tuning range, high sensitivity, and wide dynamic range. The FTI industry has leveraged receiver designs from other applications and has adapted them to demodulate the FTI modulation schemes. These receivers provide the telemetry data for ground recording, real-time mission and safety critical data display, and post-mission analysis.

An example of a recent FTI RF device is Curtiss-Wright's TTS-9800-2 programmable tri-band multimode transmitter *(see figure below)*. The TTS-9800-2 supports transmission in L-band (all), S-band (all), and C-band (lower and middle), and delivers high RF power efficiency. It supports user-programmable multimode transmitter speeds. And its design simplifies RF band selection in the field for flight test applications.

Curtiss-Wright's TTS-9800-2 is a high-efficiency, programmable tri-band multimode transmitter that supports transmission in L-band (all), S-band (all), and C-band (lower and middle).

JACK BROWNE | Technical Contributor

One-Size SOSA Fits the Army, Navy, and Air Force

SOSA, an open C4ISR standard based on OpenVPX, is expected to be critical for modularity and compatibility among future U.S. military weapons systems.

COMPATIBILITY OF SENSOR-BASED WEAPONS SYSTEMS across different branches of the military has long been a goal if not a reality. It's especially critical as electronic systems grow in complexity in response to emerging threats. Efforts at compatibility among different command, control, communications, computer, intelligence, surveillance, and reconnaissance (C4ISR) systems have spawned a large number of standards that serve as design guidelines for specific systems, but not across a wide range of applications.

The U.S. Army, Navy, and Air Force are hoping that will change for future weapons systems, notably as part of electronic-system modernization efforts, through the development and application of an open C4ISR embedded computing weapons system standard format—the Sensor Open System Architecture (SOSA).

The U.S. military has long sought to move away from the enormous expense and challenge of developing specialized, custom electronic systems and toward the use of commercial-off-the-shelf (COTS) components and subsystems plus the economy of low size, weight, and power (SWaP) design practices. The challenges to developing a common standard, or even a group of common standards, stem from the many different contractors and suppliers involved in the effort. Even a single difference, such as a power-supply voltage, throws up a roadblock to compatibility.

SOSA has been in development for several years, with the three armed-forces branches formulating versions of an open standard largely based on the OpenVPX standard introduced by Mercury Systems *(www.mrcy.com)* in early 2009. The OpenVPX standard covers precise definitions for the parameters of a modular electronic system, including its chassis, slots, and the modules that slide into those slots to establish different functions.

The parameters of the OpenVPX standard are available to the public and to any electronics manufacturer interested in competing on military electronic programs and systems development. The goal with using OpenVPX is to provide systems and modules that are fully compatible with all other hardware and software built for similar systems.

The SOSA standard is being developed so that modules such as digital signal processors (DSPs), field-programmable gate arrays (FPGAs), and single-board computers (SBCs) need not be customized for specific interface requirements, such as for different VITA interfaces. Instead, SOSA modules can be interchanged across high-speed, high-power C4ISR electronic weapons systems in response to changing threats without losing functionality or performance.

1. The Bell V280 Valor is one of the aircraft being considered by the U.S. Army as a next-generation rotary-wing aircraft, outfitted with SOSA-compatible electronic systems. *(Courtesy of Bell Textron)*

To make such compatibility possible, SOSA is being created with elements of different OpenVPX VITA standards, such as VITA 65, 46, 48, 48.2, 62, and 49.2. An open standard like SOSA makes it possible to achieve multiple-threat defensive capabilities in limited space, e.g. in unmanned aerial vehicles (UAVs), using systems that can be designed to meet the challenging SWaP requirements of UAV applications.

The SOSA technical standard is still in its developmental stages, with parameters being defined and refined even as electronic suppliers design "demonstrator" systems and modules to investigate performance and compatibility among different operating conditions. SOSA is an attempt to achieve high-performance, high-speed digital communications performance with agreement among the three service branches on modular system parameters, such as voltage supply, cooling approach, connector types, and mechanical tolerances, needed for compatibility among systems produced by many different vendors. Compatibility will help to speed, simplify, and reduce the cost of modernizing C4ISR systems.

FORMULATING SOSA

OpenVPX, one of the many modular systems standards used by the services, has also served as a starting point for developing SOSA standards. Designers of many demonstrator SOSA system backplanes and chassis, for example, employed OpenVPX VITA 66 or VITA 67 profiles for compatibility with other embedded computing systems based on those profiles.

To be described as what the industry calls "SOSA-aligned" products, they must undergo compatibility testing under different operating conditions to ensure they operate as expect-


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ed within different systems and with equipment from different vendors. The SOSA standard is being created under the guidance of The Open Group and its SOSA Consortium *(www.opengroup.org/sosa)*. The development process features the efforts of military and industrial working groups, including the U.S. Department of Defense (DoD), prime contractors, and electronics manufacturers.

The SOSA Consortium is driven by industrial and military sponsors, including Collins Aerospace, Lockheed Martin, and Raytheon Co., as well as the Air Force Life Cycle Management Center, the Joint Tactical Networking Center, the Naval Air Systems Command (NAVAIR), the U.S. Army C5ISR, and the U.S. Army Program Executive Office (PEO) for Aviation. The consortium also owes much progress on a SOSA standard to prime contracting principals, such as BAE Systems, GE Aviation Systems, General Dynamics, Mercury Systems, and Northrop Grumman.

More than 50 embedded computer suppliers are also involved as SOSA Consortium Associates, including Abaco Systems, Annapolis Micro Systems, Bliley Technologies, Curtiss-Wright Defense Solutions, Elma Electronic, Kontron America, Pentek, SMART Embedded Computing, and TE Connectivity. All of these different factions are helping to define a practical standard for SOSA-compatible products such as SBCs, DSPs, and FPGAs.

Although still in development, the first version of the standard is expected to be released by mid-2020. The SOSA standard is an opportunity for the three services to reach agreement on the electronic backplane and module needs of their future weapons systems. As an open standard, SOSA's specifications are available to all consortium members, enabling interested manufacturers to access specifications when developing hardware and software for SOSA mainframes and modules.

SOSA isn't the first attempt at an open embedded computing standard designed to aid multiple branches of the armed forces, and it's not intended to leave previously developed standards behind. A single-page, January 2019 memorandum from tri-service secretaries clearly stated the need for a Modular Open Systems Approach (MOSA) to all future weapons systems. A MOSA would support all standards, such as SOSA, that enable the design and development of compatible weapons systems. Other open standards covered in the MOSA memo, and under the sponsorship of The Open Group, are the Future Airborne Capability Environment (FACE), Vehicular Integration for C4ISR/EW Interoperability (VICTORY), and C4ISR/EW Modular Open Suite of Standards (CMOSS).

MOSA isn't meant to be a single standard for all electronic weapons systems, but rather serve as an umbrella for multiple standards, enabling interface capability and compatibility among them. Tri-service specifiers have long relied on systems developed according to many different standards, and MOSA isn't expected to bundle just four open standards.

Additional open standards supported by MOSA include the Army's Open Mission Systems/Universal Command and Control Interface (OMS/UCI), the Army's Modular Open RF Architecture (MORA), the Navy's Hardware Open Systems Technology (HOST), and the Navy's Unmanned Maritime Autonomy Architecture (UMAA). Compatibility of these different standards according to MOSA guidelines means that MOSA systems will be readily upgradeable in line with tri-service modernization efforts.

SOSA MEANS MODERNIZATION

The Army, Navy, and Air Force are aware of the limitations of an aging inventory of weapons systems and have embarked on numerous modernization programs. For example, the Army's Future Attack Reconnaissance Aircraft (FARA) competition seeks a MOSA approach to the development of FARA avionics systems and an armed reconnaissance helicopter as part of a massive replacement of aging AH-64 Apache helicopters. The Army's Future Vertical Lift (FVL) program is targeting a SOSA-compliant SBC card module, with the Army's Joint Multi-Role Technology Demonstrator (JMR-TD) program designed to encourage the development of next-generation weapons systems, including rotary-wing and tilt-wing aircraft *(Fig. 1 on page 52)*.

The Army's efforts at modernizing its rotary-wing aircraft (by 2028) also include building FARA and Future Long-Range Assault Aircraft (FLRAA), which will also involve integration of SOSA-compatible weapons systems. Another development program, the Air Force Research Laboratory's AgilePod T program, is targeting an ISR module with an open architecture compatible with SOSA.

Crafting an acceptable early SOSA standard will take time and effort, and it will involve the design of various SOSA-compliant modules and assemblies termed as "snapshots" of possible solutions for electronic products meeting the open standard. One of the challenges in developing a successful SOSA standard is arriving at an open architecture that can serve all three branches of the military for at least a 30-year life cycle.

Thus, the path to finding a working SOSA standard will require investments from all parties. This includes the creation of many “demonstrator” systems, which will show that an open standard makes it possible for different products, such as SOSA modules, to operate seamlessly under all operating conditions faced by weapons systems.

The first version (V1) of a SOSA standard is expected from The Open Group later this year. Companies supporting the SOSA architecture according to different tri-service programs, such as Abaco Systems *(www.abaco.com)* with its 3U “SOSA-aligned” SBC3511 SBC module targeting the Army’s FVL program *(Fig. 2)*, will have much to do with the refinement and finalization of a first SOSA open-standard version.

2. The SBC3511 is a 3U SOSA-aligned module developed for the U.S. Army’s FVL program. It’s also compatible with CMOSS and HOST standards. *(Courtesy of Abaco Systems)*

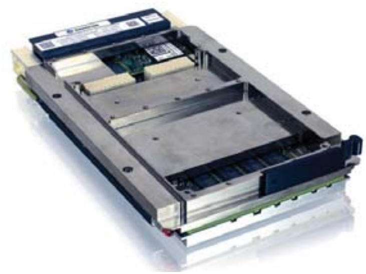
The SBC3511 features an OpenVPX payload profile that’s aligned to the SOSA, CMOSS, and HOST standards. It can operate at speeds to 2.8 GHz and to 4.4 GHz with TurboBoost and comes with as much as 32 GB DDR4 RAM and up to 256 GB of NVMe SSD. The SOSA SBC has a 40-Gb/s Ethernet data plane, extensive security features, and a thermal design that effectively dissipates heat even in space-constrained systems.

TEAM SCHEME

Interest in attaining a usable SOSA standard for the three armed-forces branches has encouraged the teamwork of Open Consortium members. At the AUSA 2019 event in Washington, D.C., Pentek *(www.pentek.com)*, Herrick Technology Laboratories *(www.herricktechlabs.com)*, and Kontron *(www.kontron.com)* showed a SOSA-aligned C4ISR demonstrator system with contributions from all three companies. It gave visitors to the exhibition a chance to see the effectiveness of the SOSA open standard when operating with “plug-and-play” cards from different suppliers.

Based on the OpenVPX backplane, the system combines a Herrick 3U flight-qualified chassis with a Kontron

VX305C-40G SBC *(Fig. 3)* and a Pentek model 71813 XMC board as an embedded computing starting point for EW, communications, and signal intelligence (SIGINT) applications. Elma Electronic *(www.elma.com)* was also part of a multiple-vendor OpenVPX/SOSA demonstrator at the AUSA 2019 event.



3. The VX305C-40G is a 3U SBC that was part of a SOSA-aligned C4ISR demonstrator system on display at the recent AUSA 2019 show. *(Courtesy of Kontron)*

Given the desire of the Army, Navy, and Air Force to modernize weapons systems during the next several years, interest in the SOSA standard is high across the industry, with many OpenVPX cards being adapted to SOSA requirements. The list of manufacturers for SOSA-aligned products is growing quickly and includes innovative suppliers such as Annapolis Micro Systems *(www.annapmicro.com)*, Concurrent Technologies *(www.gocct.com)*, Curtiss-Wright *(www.curtisswright.com)*, Pixus Technologies *(www.pixustechnologies.com)*, and Spectranetix *(www.spectranetix.com)*.

For example, the model SX-430 EW transceiver card *(Fig. 4)* from Spectranetix has been a plug-in part of at least one of the SOSA demonstrators, providing the kind of wideband performance to make it a candidate for a host of defense-related applications. The software-defined-radio (SDR) full-duplex transceiver is aligned to the CMOSS and SOSA standards with an RF/microwave range of 1 MHz to 18 GHz and intermediate-frequency (IF) range of 40 to 160 MHz. As SOSA spreads, the SX-430 is likely to be found plugged into modular systems for all three service customers. de

4. Model SX-430 is an SDR-based EW transceiver card that's aligned to CMOSS and SOSA standards and has been a part of several C4ISR SOSA demonstrators. *(Courtesy of Spectranetix)*

Rugged RF Recorders Snare Signals to 26 GHz

WHEN RF/MICROWAVE SIGNALS must be captured for analysis, few recorders match the range and power of the model RTX 2684 from Pentek in such a small package. Designed to strict size, weight and power (SWaP) requirements and packed into an air-cooled, half-ATR chassis, this RF recorder covers 1 to 26 GHz with instantaneous bandwidth as wide as 500 MHz and with quickly removable QuickPac SSD memory that can hold as much as 61 TB data storage. Well suited for signal intelligence (SIGINT), communications intelligence (COMINT), and electronic intelligence (ELINT) applications, the recorder is the latest addition to Pentek's Talon line of signal recording and playback systems. Designed for the types of hostile operating environments associated with SIGINT applications, the RF recorder weighs just 23 lb and is a candidate for signal surveillance and monitoring systems on small unmanned aerial vehicles (UAVs). The signal recorder incorporates one of the company's model 78141A high-speed transceivers working with 12-b analog-to-digital converters at 3.2 Gb/s to acquire detected signals over the 1-to-26-GHz range. A digital downconverter in the transceiver provides a choice of intermediate-frequency (IF) bandwidth, 125, 250 or 500 MHz, for recording captured signals. Based on a Microsoft Windows workstation with Intel Core i7 microprocessor, the signal recorder saves files to a Windows-native new technology file system (NTFS) data format for ease of access. The RF recorder's computer systems are supported by Pentek's SystemFlow software. The RTX 2684 is designed for operating temperatures from –40 to +50°C and supports redundant array of independent disks (RAID) levels 0, 5 or 6.

PENTEK

www.pentek.com

Modular Switch Supports Composable Data Centers

SWITCHING COMPONENTS AND SUBSYSTEMS for data centers must often pack great power into small packages, per defense/aerospace size, weight, and power (SWaP) requirements. To accomplish this while maintaining system design flexibility, the EnsembleSeries SFM6126 PCI Express (PCIe) switch from Mercury Systems leverages the OpenVPX architecture to provide reliable and secure data distribution building blocks that fit mission-critical applications even where space is tight. The OpenVPX architecture enables large data processing resources in small components and the embedded composable architecture is ideally suited to demanding processing-intensive applications. The processing power of these switch modules enables flawless transfer of large amounts of data from cloud data centers to tactical "edge" environments, although with commercial-like cost structures for affordability in aerospace and military applications.

MERCURY SYSTEMS

www.mrcy.com

TEMPEST Shielding Keeps Signal Information Safe

MODULAR ELECTRONIC DESIGN approaches usually lead to flexible functionality. They can also lead to the TEMPEST-level shielding required to use a PC in a military application. With its modular assembly approach, Equipto Electronics has developed a method for assembling a computer with a customer-specified motherboard that is certified to the strictest standard in the industry for devices operating in NATO Zone 0 environment, the NATO SDIP-27 Level A. Despite meeting the demanding shielding requirements, the computer is a commercial product and follows military guidelines for commercial-off-the-shelf (COTS) cost savings. TEMPEST-level shielding prevents a computer or other electronic device from emanating electromagnetic radiation (EMR) that may contain sensitive or classified information. These shielded computers customer specified ATX motherboards, the latest (i7) microprocessors, Microsoft Windows OS, a card reader for extra security, fiber port options, DB9/DB37 connectors, and high-performance power line filter. The shielded computer system measures: 18.50 × 6.65 × 17.50 in. These shielded PCs represent the latest installment of the company's family of systems provided within enclosures with EMI and radio-frequency-interference (RFI) shielding. Each enclosure is custom-sized and fitted with an array of exclusive features to accommodate different mission requirements. The product lines are RoHS (lead-free) compliant and can meet strict FCC broadcast requirements as well as the TEMPEST shielding requirements.

EQUIPTO ELECTRONICS

www.equiptoelec.com

NEWS SHORTS

L2 Defense Supports U.S. Army North Training

(News Shorts continued from page 42)

THE U.S. ARMY NORTH *(www.arnorth.army.mil.com)* is an invaluable arm of the country's land forces dedicated to homeland protection. Working with civil authorities and the joint armed forces, these troops began life almost 80 years ago during World War II in French Morocco as the Fifth Army, and they continue to provide life-saving operations across the country, also working with Canadian and Mexican authorities. .

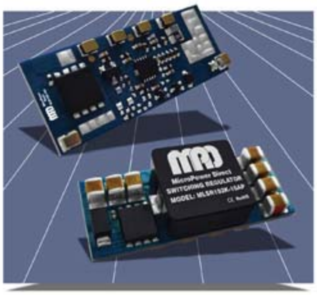
To aid with their continuing education in applying technology to emergency response operations. The Department of Defense (DoD) recently awarded a prime contract to L2 Defense, Inc. to support training and exercises for the U.S. Army North Civil Support Training Activity (CSTA). The four-year indefinite-delivery/indefinite-quantity (IDIQ) contract has a ceiling of $49.4 million.

L2 Defense is known for their capabilities in training, engineering and logistics support for first responders and military personnel and will assist with the coordination, management and execution of nationwide training and exercise events for the U.S. Army's Chemical, Biological, Radiological and Nuclear (CBRN) Response Enterprise as part of the terms of the IDIQ contract. The contract will cover more than 200 training events each year, with the education provided to thousands of different soldiers. The training and support will ensure the readiness of close to 20,000 soldiers in response to domestic chemical, biological, radiological, nuclear and high-yield explosive events. The U.S. Army North works with civil authorities at local, state and federal levels to handle emergencies. ■

The U.S. Army North works with civil authorities and local, state and federal levels to provide emergency responses as part of homeland security. *(Courtesy: U.S. Army North)*

New Products

Switching Regulators Output up to 16 A



RECENTLY RELEASED SWITCHING REGULATORS from Micropower Direct offer high efficiency and high-current output capabilities. The MLSR192K-16A operates with an input voltage from 8.3 to 14 V and produces a regulated output voltage from 0.75 to 5 V. Furthermore, the devices are spec'd to have a typical efficiency of 95% and a 92% minimum efficiency. Switching frequency is 300 kHz, and the devices will produce a maximum ripple voltage of 100 mV p-p. Additional features include –40 to +85°C operating temperature, short-circuit and overcurrent protection, and an industry-standard pinout. The devices come in a 33.0- × 13.5- × 8.3-mm package.

MICROPOWER DIRECT, https://micropowerdirect.com/

Waveform Generators Boast Dual Architecture Design

THE LATEST 4060B SERIES dual-channel function/arbitrary waveform generators from B&K Precision come in 40-, 80-, and 120-MHz models. The new generators provide stable and precise sine, square, triangle, pulse, and arbitrary waveforms with 16-bit vertical resolution. They work with a wide range of applications thanks to its dual architecture design, which combines the cost-effective benefits of DDS and true point-by-point arbitrary performance.

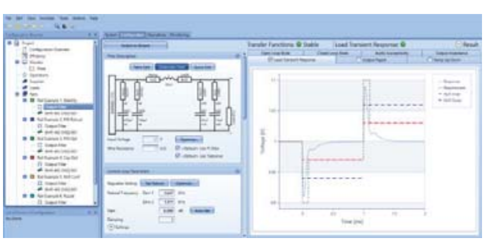
Other features of the 4060B Series include:

- 4.3-in. touchscreen display
- Built-in frequency counter
- 10-MHz reference clock input/output to synchronize multiple instruments
- Standard USB and LAN interfaces for PC connection
- Application software to create and store arbitrary waveforms
- GPIB connectivity with optional USB-to-GPIB adapter
- Two independent channels with one-button phase synchronization
- Linear and logarithmic sweep
- Variable dc offset
- Overvoltage protection

The 4060B Series generators start at $995 and are backed by a three-year standard warranty.

B&K PRECISION, https://www.bkprecision.com/

New Features Enhance Supply Simulation Tool



FLEX POWER DESIGNER is a simulation tool that can be used to help engineers design and create power-supply systems. The tool excels for digital supply circuits and allows for configuration and efficiency simulations to be conducted for entire supply systems. Version 3.2 adds a numeric calculator to help analyze simulated data and includes a resistor suggestion feature. Flex's BMR480 and BMR490 switching converter test boards are now supported in the software, too. Along with the new features, all previous functionality from prior releases is still included in the software, such as a thermal modeling tool that was added in version 3.0. The company's focus on the simulation software is to not just provide a platform to configure switching converters, but also offer a platform that can help architect entire power systems.

FLEX POWER, https://flex.com/

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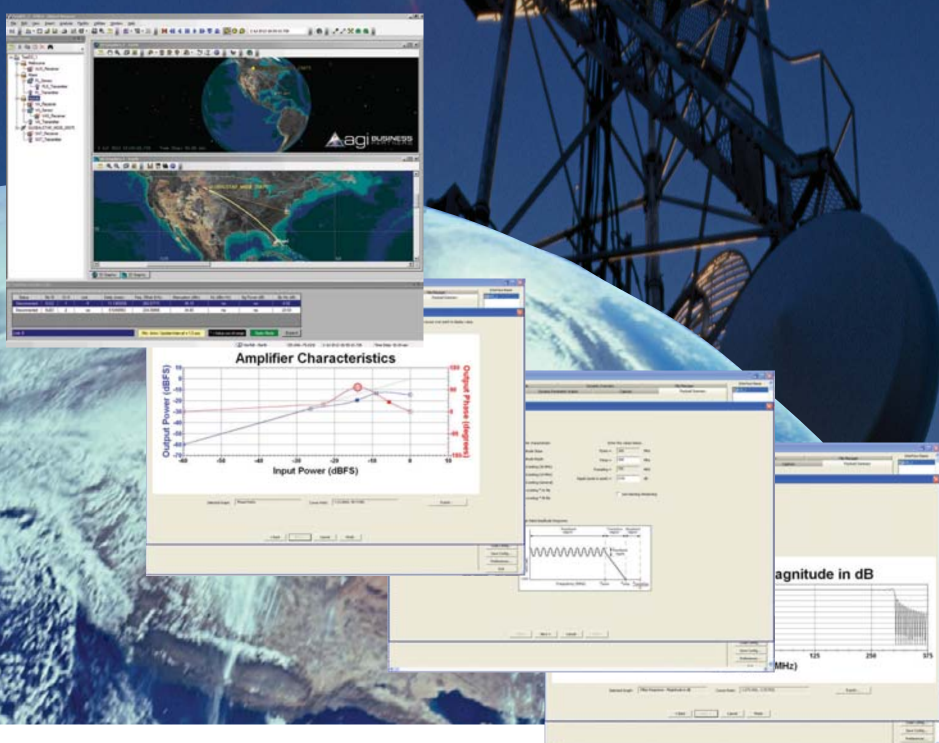

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