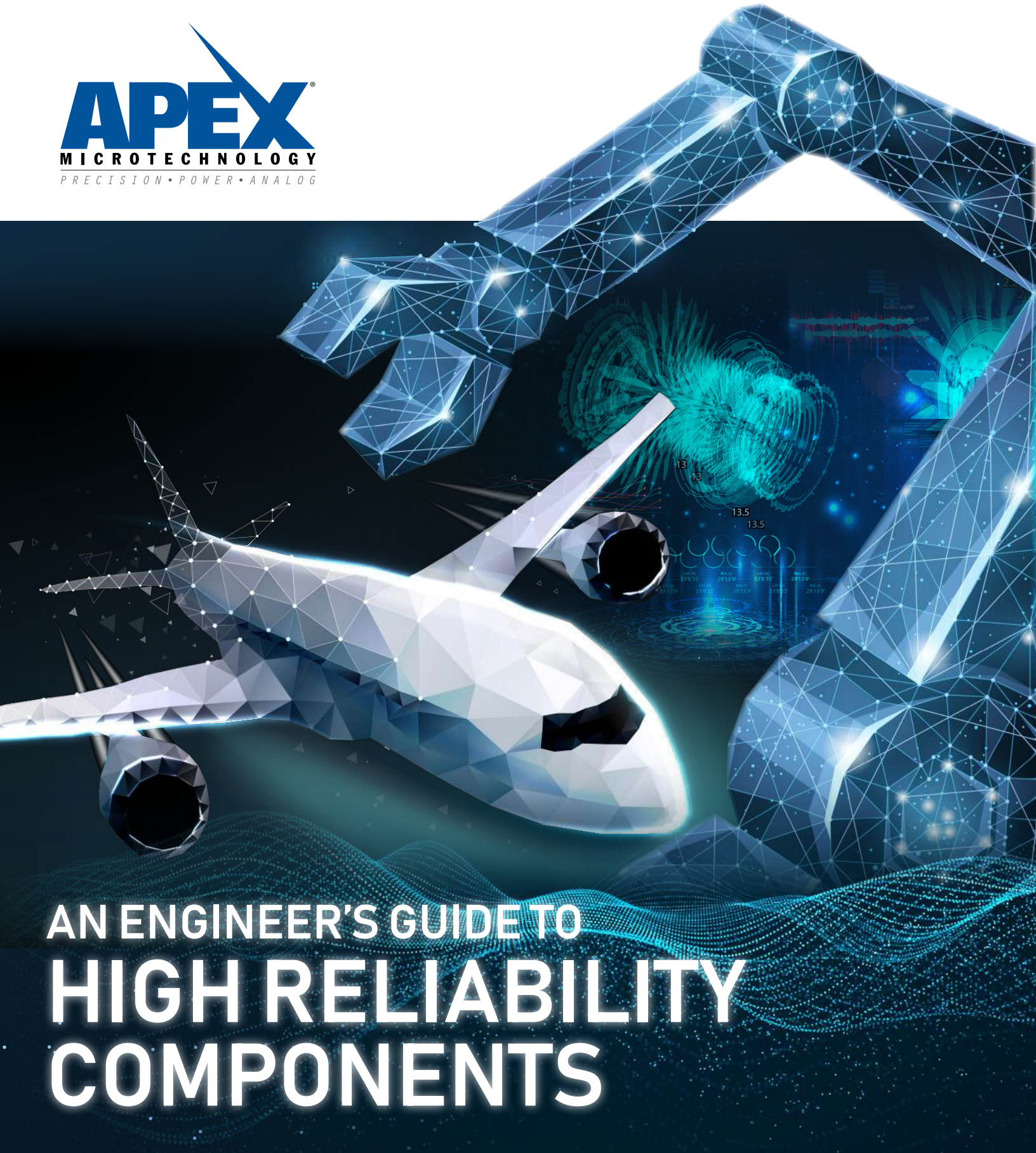
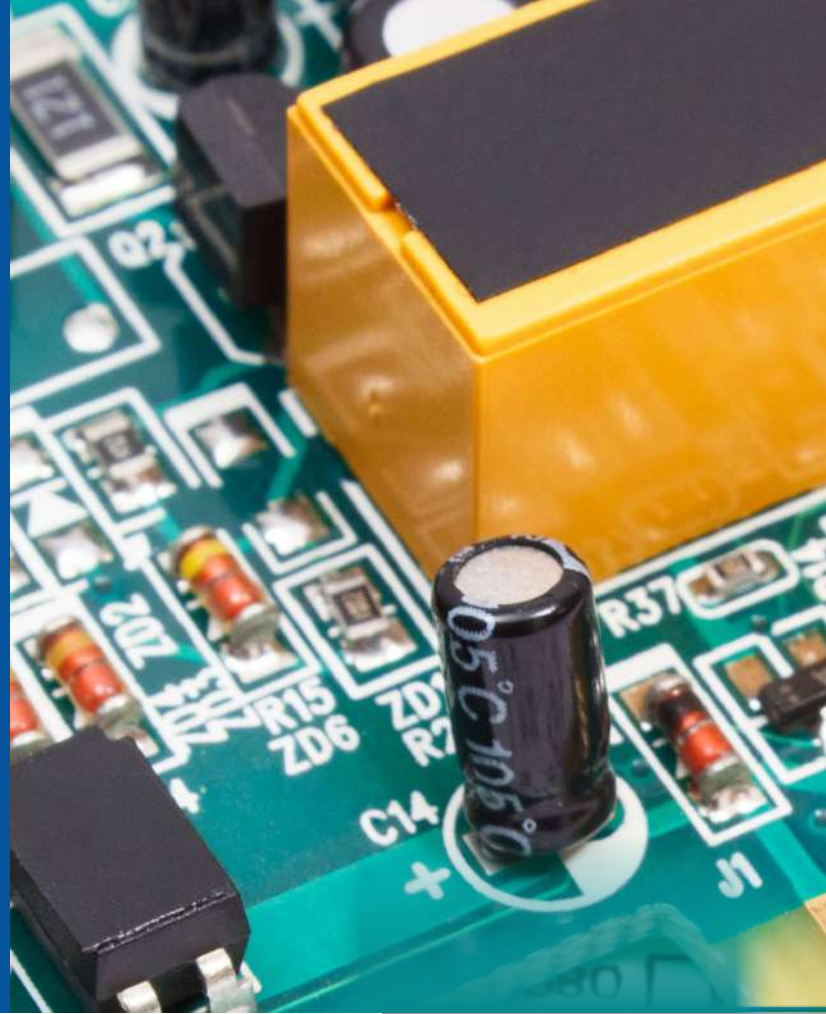




AN ENGINEER'S GUIDE TO HIGH RELIABILITY COMPONENTS

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HIGH RELIABILITY DESIGN



As the world becomes more reliant on electronic devices, achieving high reliability design becomes more important than ever.

Jens Eltze, Director of Business Development
at Apex Microtechnology

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CONNECT WITH MOUSER



**APEX MICROTECHNOLOGY
UNIQUELY DESIGNS HIGH-RELIABILITY
ANALOG POWER ELECTRONIC DEVICES
FOR THEIR CUSTOMERS.**

In today's climate of rapid innovation and technological advancement, the world has become more reliant on electronic devices than ever before. As our dependence on electronics increases, the demand for high-reliability electronics—those that operate with the lowest possible probability of failure—also increases.

One of the most important considerations in designing for high reliability is the reliability of the analog circuits within a system. Analog power electronics are of particular importance, as they are found at the heart of almost every electrical device, ensuring proper power conversion, distribution, and management throughout a system. Without the proper functioning of analog power electronics, the performance of the device as a whole is significantly compromised.

Unfortunately, achieving high reliability in analog electronics tends to be particularly challenging, as analog circuits exhibit an inherent susceptibility to environmental factors such as temperature and device aging. This susceptibility becomes even more severe in use cases like industrial, medical, and military/

aerospace, where environmental conditions can be very extreme and the margin for error is minimal. Designing highly-compact form-factor power analog circuits that operate correctly regardless of environmental factors requires an appreciable amount of design expertise. These kinds of skills are becoming harder to come by in today's markets.

To address these challenges, Apex Microtechnology is working on developing analog solutions that offer the highest reliability possible. Using stringent design, manufacturing, production test, and process control measures, we ensure that all our products meet the highest standards so our customers can feel confident about the reliability of their systems when deployed in the field.

In this eBook, we'll discuss several challenges and solutions toward achieving high-reliability analog design and describe how Apex Microtechnology is working to provide customers with the most reliable analog products.



COTS SOLUTIONS

COTS Solutions for High-Reliability Analog Design

Aaron Bondy, Global Sales Manager at
Apex Microtechnology

Commercial-off-the-shelf (COTS) solutions from Apex Microtechnology can simplify the design of high-reliability analog power electronics.

Today, the demand for high-reliability analog power electronics is greater than ever before. However, achieving high reliability can be a significant challenge, requiring considerable design expertise and experience.

Instead, many engineers turn to commercial-off-the-shelf (COTS) components, which, if from a reliable source, can enable shorter times to market, decreased design complexity, and more reliable designs. Apex Microtechnology provides its customers with a large variety of COTS power analog components uniquely designed and validated to ensure the highest reliability possible for end-users.

In this article, I'll discuss the advantages of COTS components and how **Apex Microtechnology's** unique approach ensures the highest reliability possible.

What is COTS?

In designing analog circuitry on the board level, one can generally take two different paths.

The first path is discrete design, in which engineers design their desired circuit entirely from scratch, using several interconnected individual components. In this scenario, the engineer designs the schematic, chooses the components, and performs the layout of the circuit, all in-house. The engineer also performs design validation and reliability assessment.

The second path is design based on COTS components. COTS is an industry-standard term describing any device that is a general or standard product from an original equipment manufacturer (OEM). COTS products can be bought quickly and in large quantities, without the need for a custom design or a waiting period for availability.

Traditionally, most manufacturers produce COTS products when an apparent market need arises based on customer feedback and requests. Informing design decisions with inputs from many customers allows OEMs to design and release COTS products that can be used to solve many of the commonplace challenges shared among engineers in the field. In the context of analog power electronics, COTS products tend to be designed to provide solutions for a broad application segment that applies to many of the fundamental challenges in power analog design.



5 Reasons the Apex Manufacturing Process Helps Guarantee Long Term Reliability

Attention to every detail is always important when it comes to electronic components and even more critical for high reliability applications. The manufacturing process used to create high reliability components is as important as the electrical design itself. Watch the video to discover how Apex manufacturing processes help guarantee long-term reliability.

COTS vs. Discrete Design

As compared to discrete design, COTS solutions typically offer several important advantages to the system designer.

One of the most significant benefits of a COTS approach is the decreased time to market. In a discrete design, engineers must complete the entire design and validation process from scratch—a process that often takes up to a year, if not longer. COTS products, on the other hand, have already been fully designed, tested, and validated by the OEM. By replacing a discrete design with a COTS solution, an engineer can almost immediately have a working solution—reducing the time to market for the final product by a significant margin.

With respect to high-reliability design, COTS can offer engineers an unmatched degree of assurance in their designs. When designing a discrete solution for high reliability, engineers must consider factors like thermal management while balancing the size, weight, and power (SWaP) tradeoffs inherent in electronic design. With a COTS solution, engineers can take solace in the fact that the OEM has leveraged its extensive design experience to produce components optimized for reliability while balancing SWaP considerations. Engineers can also perform this evaluation themselves; all COTS solutions come with product-specific documentation describing device behavior and specifications. In this way, engineers can choose the COTS solution that best meets the requirements of their application.

Moreover, COTS solutions offer advantages over discrete solutions with respect to product lifecycle and management. For a discrete solution containing many individual components, product and engineering teams will face significant challenges related to component obsolescence and sourcing. Though discrete solutions may appear to be the lower-cost option at the bill of materials (BOM) level, when BOM management and component sourcing are considered, COTS proves advantageous.

By designing a system with high-reliability COTS components, engineers can easily ensure high levels of reliability in their end products in a way that discrete design would not allow.

Apex Designs COTS for Reliability

However, COTS solutions are not the same everywhere. For example, COTS solutions designed for consumer products might have lower reliability targets because the end device or system is not considered mission-critical or capital equipment. On the other hand, demanding applications in the defense and aerospace, high-reliability industrial, and medical market segments tend to require much higher reliability targets; these applications place a high value on maximizing operational uptime, ensuring uninterrupted system functionality, and improving operational equipment efficiency.

Apex Microtechnology offers unique COTS solutions specifically developed for high-reliability applications. As a testament to its commitment to high reliability, the company maintains both ISO 9001 and MIL-PRF-38534 certifications and operates as a Defense Logistics Agency (DLA) DLA Class-H hybrid microcircuit manufacturing facility.

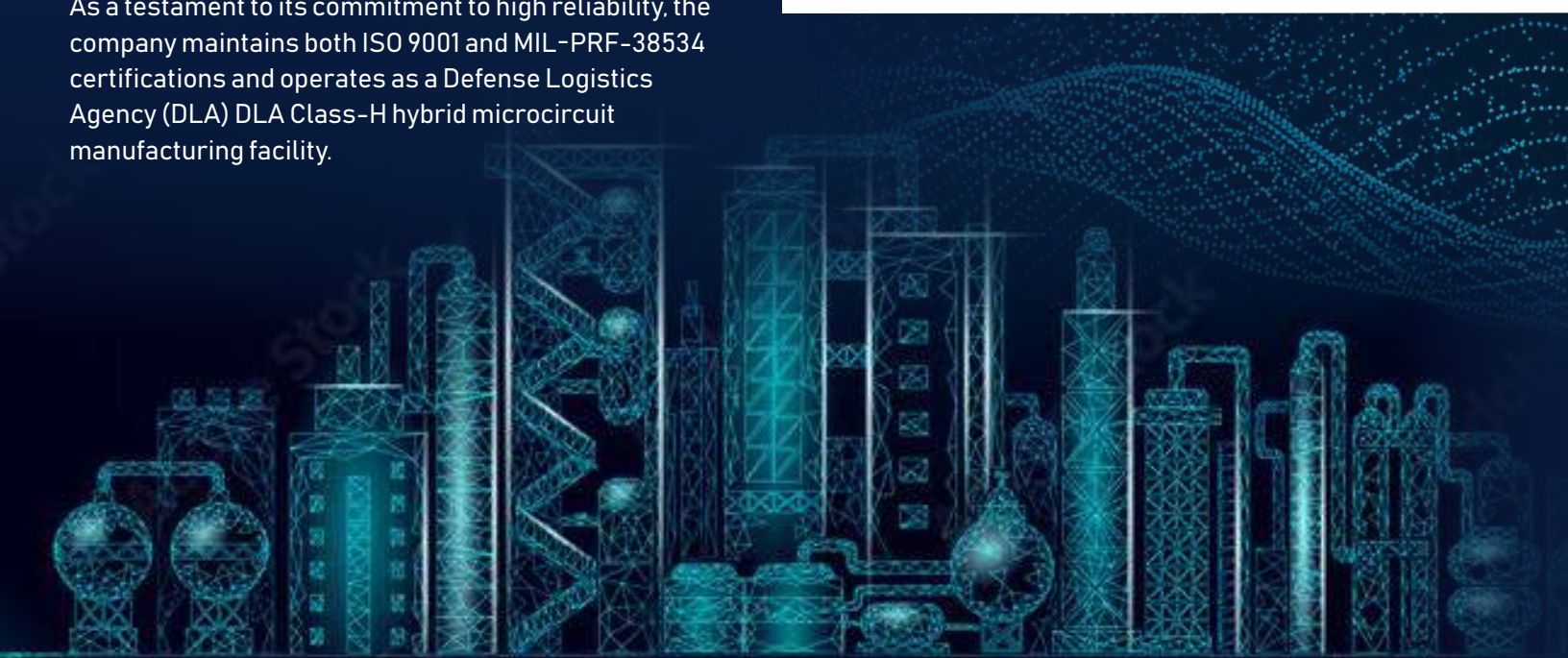
Apex's COTS Process

Underlying the reliability of Apex's COTS solutions is a stringent phase-gate design process. This process contains six phases encompassing the entirety of a product's lifecycle, beginning at ideation, and continuing through production release and into the product's market maturity.

The first phase of the process, Phase-0, is product definition. In Phase-0, the Apex team defines customer needs and identifies major design, performance, and manufacturability risks so that proper considerations and mitigations are put into place.

The next phase, Phase-1, is the conceptual design phase. During this phase, the initial design work begins, and the first measures for reliability are taken. The team considers the electrical design itself, the device packaging, the manufacturing processes required, and the approach for incorporating the device's electrical parametric test program into the process flow. At the end of each phase in the design process, the team reevaluates the product and decides whether to proceed or to stop the project until existing risks have been mitigated.

In Phase-2, a large amount of intensive R&D occurs, with deep-dive efforts placed into each of the critical points—from circuit design, layout, and packaging to processing.



manufacturability, and electrical testing. The mid-point of this phase includes the prototype build and post-prototype review, in which Apex engineers complete design verification testing of the device prototypes. Their goal is to test the device's performance against the design concept and project goals, once again checking for flaws and identifying any potential risks.

Phase-3 consists of product production tests, readiness review, and a pilot production run. In Phase-3, the device in its production form takes shape. This phase is also extremely important because characterization data are gathered, verified, and finalized into a device datasheet. To exit this phase, no issues can exist with the product's reliability or performance.

Next is Phase-4, which is the official product launch and market release—the point at which engineers can find the devices in stock at authorized distribution partners such as Mouser.

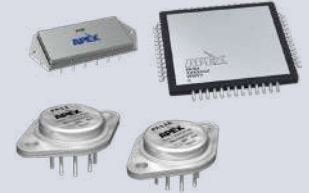
The last phase, Phase-5, covers market review—a valuable method of receiving feedback from customers who can provide insights into how to make the Apex portfolio of COTS products even better as future designs are considered.

Through this entire process, Apex compares its products to the strictest requirements and specifications, ensuring a high-performance, high-reliability power analog solution as the end result.

APEX PRODUCTS MEET OR EXCEED THE STRICTEST REQUIREMENTS AND SPECIFICATIONS, ENSURING A HIGH-PERFORMANCE, HIGH-RELIABILITY POWER ANALOG SOLUTION AS THE END RESULT.

Power Operational (Linear) Amplifiers

- Designed for applications that require high current and high voltage.
- Feature output currents from 0.01A to 100A (peak).
- Provides a compact proven solution for demanding precision power analog applications.



[LEARN MORE ►](#)

PA12 Class A/B Power Amplifiers

- 10A, 90V power operational amplifiers with low thermal resistance.
- Ideal for applications like driving resistive, inductive, and capacitive loads in motors.
- Class A/B output excellent linearity.



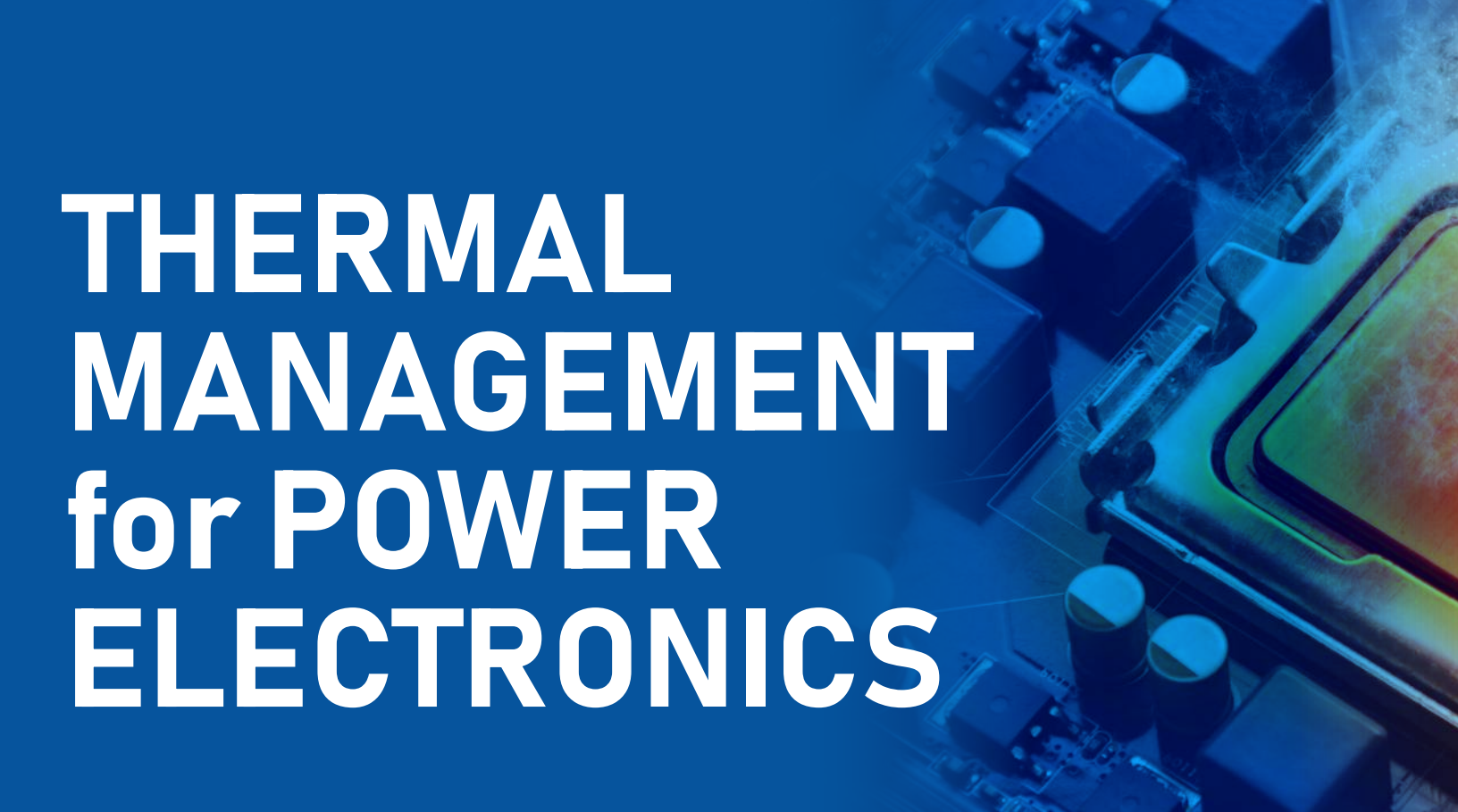
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Winning With COTS

For analog power electronics design, high reliability is among the most important considerations. Compared to discrete analog power solutions, COTS solutions can provide a plethora of benefits to the designer in terms of cost, reliability, and time to market.

However, for the utmost reliability and performance, the COTS manufacturer must be reliable and reputable. In this regard, Apex Microtechnology has earned its place as a trusted partner to the world's industry leaders. Apex has a legacy of more than 40 years of designing and manufacturing high-reliability integrated power analog solutions to enable, advance, and accelerate the development of high technology for complex electronic systems.

THERMAL MANAGEMENT for POWER ELECTRONICS



**To achieve high reliability
in power electronics, thermal
management is a necessary
design focus.**

**Eric Boere, Field Applications Engineer
at Apex Microtechnology**

A major trend in the electronics industry is the drive to make devices both smaller and more powerful. This increase in power density is highly desirable, but achieving it in practice presents a significant number of challenges with respect to maintaining high reliability.

Higher power densities exacerbate thermal issues. No device can ever achieve 100% efficiency, so an increase in power means an increase in wasted power and thus an increase in heat generation. This impact is especially pertinent in analog power electronics, where the efficiencies of class-A/B amplifiers can be as low as 50%. And with small device areas, the heat is more concentrated, making it harder to remove from the system as a whole.

A direct relationship exists between a device's temperature and reliability: The higher the temperature, the less reliable the device. In this article, we'll discuss the ways in which thermal challenges can negatively impact device reliability and some of the thermal management solutions Apex Microtechnology uses to ensure high reliability in analog power electronics.





Thermal generation is one of the most significant limiting factors towards achieving high-reliability power electronics design. Apex Microtechnology uses unique device stack-ups and materials to help manage thermals and ensure high-reliability products.



Thermal Failures: Unexpected Behavior

One reason thermal generation causes unreliability in analog power electronics is the unexpected behavior it can induce in analog circuits.

At their core, analog electronics are composed of components inherently susceptible to changes in their environment. The most fundamental component in analog electronics, the transistor, displays variations in device parameters and behaviors relating directly to its temperature. For example, in metal-oxide-semiconductor field-effect transistors (MOSFETs), key device parameters—such as threshold voltage, carrier mobility, and saturation velocity—all fluctuate based on device temperature.

Most analog circuits are fine-tuned to reliably operate based on the transistor's parameters in well-understood and expected conditions. While the performance of analog systems is tested at edge cases, the increasing power density of modern-day devices is causing temperatures to reach new heights, and device performance can degrade accordingly.

In the context of an entire analog circuit or subsystem, which is composed of hundreds of transistors, the unexpected behavior of each individual device can accumulate and cascade into larger errors that significantly degrade performance for the circuit as a whole.

Thermal Failures: Device Wear and Failure

Beyond unreliability during operation, thermal generation can cause unreliability with respect to device lifetime.

To better understand this concept, we must first consider the composition of an integrated circuit. Looking top-down at the stack-up of an analog power device, one can usually find a metal housing or case around the device on the top, followed by a power die. The power die is soldered to the device substrate, on top of which lives the physical device components. These components are connected to other components via metal traces and/or bond wires. The substrate itself is then solder-connected to a thick base plate, which provides mechanical rigidity and completes the enclosure.



Thermal expansion—the physical expansion of certain materials, often metals, at high temperatures—is one way heat decreases device lifetime. In our stack-up, high temperatures make the different layers in the device want to expand in size. Each layer offers a different thermal coefficient of expansion, causing uneven device expansion and generating stresses in the material. The higher the temperatures, the larger the stresses; the larger the stresses, the sooner the device will break.

Further, the bond wires that interconnect components are susceptible to failures resulting from a combination of high power and high temperatures. Increased power demand can lead to cyclic power stresses detrimental to device lifetime. Consider driving a high-power motor constantly speeding up and slowing down. This process causes power pulses inside analog power electronic devices, and these pulses make the wire bonds inside the devices stretch and shrink continuously. Already mechanically weakened by the high temperatures, wire bonds can start to experience breaks and liftoffs where they connect to a die or substrate.

So, the higher the temperature, the shorter the mean time to failure is for a device. A device failure can lead to a product failure, decreasing the reliability of the system as a whole.

Apex's Thermal Mitigation Techniques

To ensure the highest reliability possible in its analog power electronics, Apex Microtechnology has adopted several thermal management design techniques.

One technique Apex leverages to mitigate thermal challenges is building its device stack-ups to allow for higher thermal conductivity. Apex uses a very rigid packaging style, which consists of thick base plates made from either cold-rolled steel or copper in some of its highest-power devices. These thick plates allow for higher thermal conductivity and a larger thermal mass, which effectively sinks heat away from the device components. The device dies are solder-attached to the substrate in a way that optimizes thermal contact, and the substrate is solder-attached to the base plate in the



same way. The trick here is to make these attachments such that any residual air from the attachment joint is removed. The more consistent the solder attachments between the power die and substrate, and between the substrate and base plates, the better the thermal performance and the faster the heat can be transferred away from the circuits.

Beyond these techniques, Apex approaches thermal management through the materials selected for its stack-ups. Apex has been using beryllium oxide in its designs for a long time. As an electrical isolator and thermal conductor, beryllium oxide has very good thermal properties. Apex is also investing in new materials, such as copper-molybdenum-copper, to replace their traditional copper base plates, allowing for even greater thermal sinking. Further, the company is investigating methods to match the coefficients of thermal expansion between different layers and components within its designs. By matching these coefficients, Apex can design away a lot of the mechanical stresses that occur at high temperatures that eventually lead to premature failures.

Equally important as the device itself is how the device is used on the board level. For example, components should be mounted on heat sinks with a certain flatness to optimize thermal conductivity and allow for the transfer of heat from the components to the heat sink as quickly as possible. Apex is unique in its approach of working directly with its customers to explain and demonstrate best practices for mounting components.

Control Thermals, Ensure Reliability

High reliability is a must-have in modern electronics, but achieving high reliability is becoming increasingly difficult. Trends in the industry, including the drive toward higher power at smaller sizes, are resulting in increased thermal generation, and, as a result, a decrease in device reliability.

Ensuring high-reliability analog power designs requires a strong understanding of thermal management and thermal design. At Apex Microtechnology, we leverage over 40 years of experience to implement the best possible thermal management techniques for ensuring our devices offer customers the highest reliability possible.



PA441 & PA443 350V Low Noise Power Amplifiers

- Next-generation performance based on the PA34X product family.
- Improved specialty high voltage process to offer a 96% reduction in signal noise.
- Ideal for driving high voltage, fine motion systems for piezo positioning applications.



[LEARN MORE ►](#)

VRE107 Low Drift Precision Voltage Reference

- Improved accuracy possible by a multipoint laser compensation technique.
- Low Drift Precision Voltage Reference provides an ultra-stable +5V output.
- Superior stability, accuracy, and quality make these references ideal for precision applications.



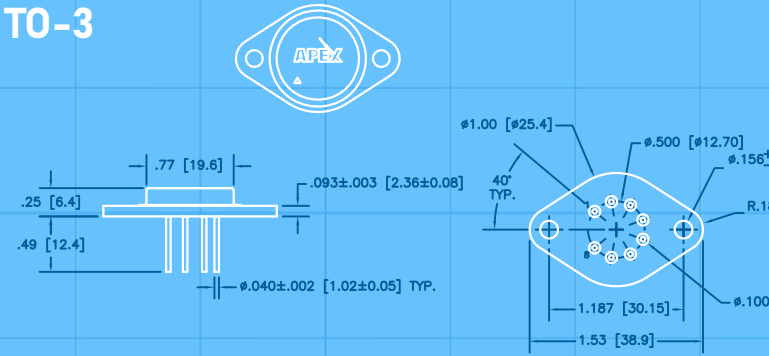
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Making an Airtight Case for Hermetically Sealed Packaging

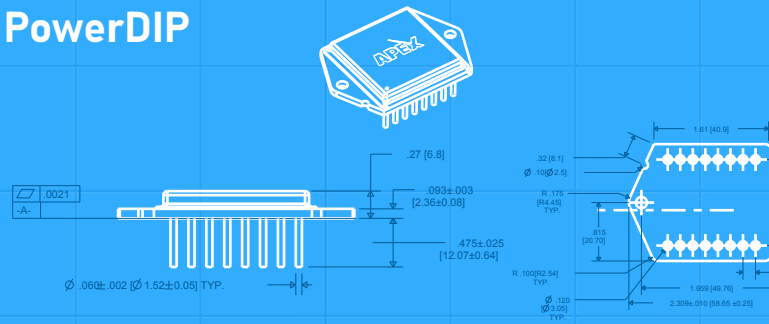
A hermetic seal makes a given object or package airtight, preventing the passage of air, oxygen or other gases. Hermetically sealed packaging is essential to the correct and safe functionality of many electronics, especially for high reliability applications such as aerospace, downhole drilling and industrial.

5 types of high reliability packaging

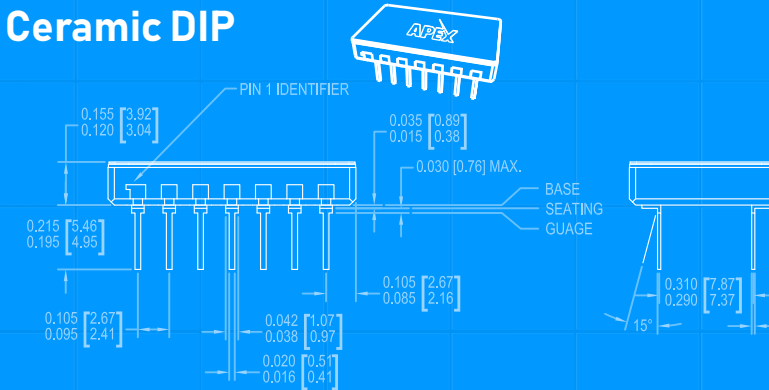
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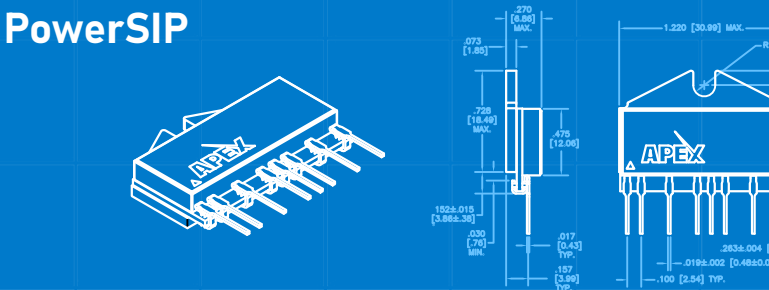
PowerDIP



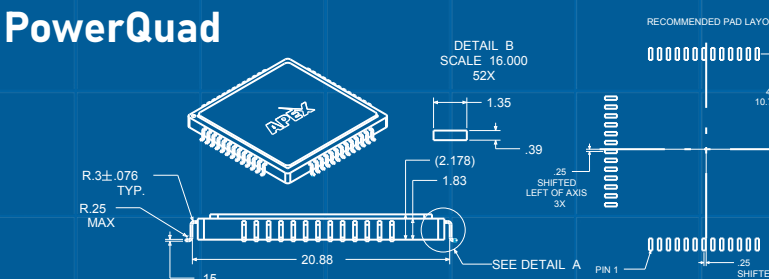
Ceramic DIP



PowerSIP



PowerQuad



Common requirements for high reliability packaging



Metal or ceramic materials



Wide temperature range
(low as -55°C & high as 200°C)



Hybrid products



Nitrogen interior with 0% moisture



Internal ceramic substrates
(electrically isolated & thermally conductive)

Featured applications

Aerospace



Downhole drilling



Motor drives



Heavy robotics



Featured products



**PA12 12A Class A/B
Power Amplifiers**



**SA310 Brushless
DC Motor Driver**



**VRE107 Low Drift
Precision Voltage
Reference**



**PA441 and PA443
350V Low Noise
Power Amplifiers**

*SIP and PQ packages are not hermetically sealed

HIGH POWER in HIGH-RELIABILITY DESIGNS

Achieving high reliability is always a challenge, but it becomes particularly difficult when dealing with high-power applications.

Eric Boere, Field Applications Engineer at Apex Microtechnology

One of the most important considerations in the design of high-power analog power electronics is the reliability of the system. To operate properly with minimal risk of failure regardless of environmental conditions, modes of operation, and device age, the product must be designed to ensure the highest reliability possible.

However, this requirement poses a significant design challenge, as high power can often be at odds with high reliability in analog design. This conflicting relationship has become even more dramatic with the current industry trend of increasing power density.

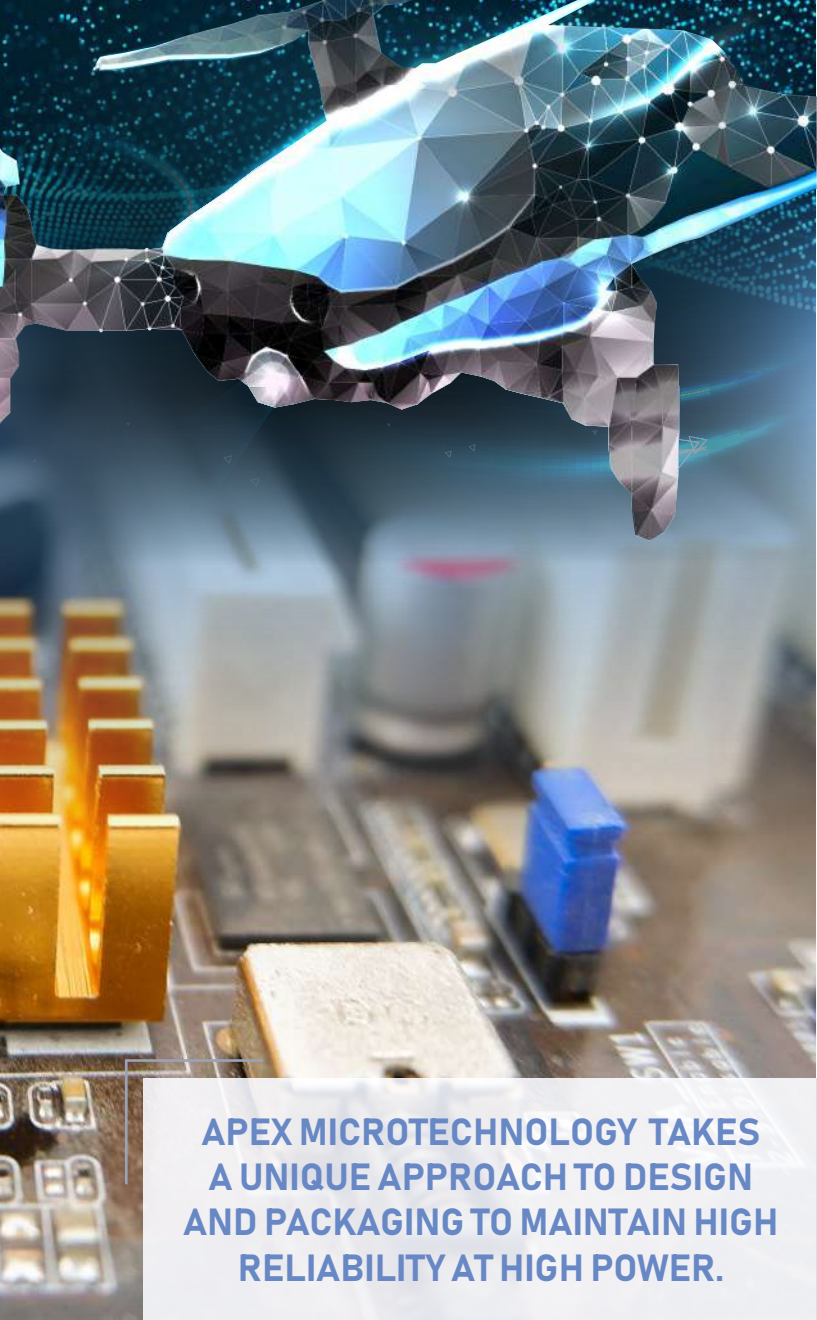
In this article, I'll be discussing several reasons why high power and high reliability can conflict and the ways that Apex Microtechnology approaches these issues to meet high-power demands in high-reliability applications.



Parasitics and Reliability

Simultaneously achieving high power and high reliability in analog power electronics is difficult for several reasons. One of the major reasons is the increased impact of device parasitics—unwanted electrical elements created by electrical components—at high power.

On the component level, metal-oxide-semiconductor field-effect transistors (MOSFETs)—one of the fundamental building blocks of analog electronics—are nonideal devices known to exhibit a variety of parasitics that result from the device structure. MOSFETs are prone to parasitic capacitances, such as gate-oxide capacitance, and



APEX MICROTECHNOLOGY TAKES A UNIQUE APPROACH TO DESIGN AND PACKAGING TO MAINTAIN HIGH RELIABILITY AT HIGH POWER.

resistances, such as channel resistance, which cause the devices to consume unwanted power during device operation. Beyond these components, integrated circuits experience parasitics on a much higher level. Parasitics can occur from the device packaging, bond wires, the substrate layout, and the printed circuit board layout.

In normal, low-power applications, the impact of these parasitics is generally negligible, but for high-power applications, the impact could be significant. That's because high-power applications operate using higher voltages and/or currents, meaning that parasitics on the component, package, and board level experience greater overall losses in the form of IR , $L \frac{di}{dt}$, and $C \frac{dv}{dt}$.

Greater losses result in more thermal generation (i.e., the device gets hotter). High temperatures limit the reliability of analog circuits by causing unexpected device behavior and decreasing the mean time to device failure.

Therefore, the increased impact of device parasitics makes achieving high reliability at high power significantly more difficult.

Architecture and Reliability

High reliability and high power can also be at odds in analog power electronics because of the architectural choices necessary for certain high-power applications. For example, scientific data acquisition and measurement systems commonly require high power. Consider a system like an atomic force microscope. Here, the most important design goal is to achieve the best sensitivity and accuracy possible so that the microscope can detect very small objects while still providing very high-resolution images.

In such an application, a designer is limited in the architectural decisions they can make with respect to their analog power electronics. For example, when a designer is considering amplifiers, a strong choice for the highest efficiency—and, hence, the lowest thermal generation—would be a class-D amplifier. Class-D amplifiers are a form of nonlinear switching amplifiers that rely on the constant turning on and off of MOSFETs in a half-bridge configuration. The problem is that these switching amplifiers produce large amounts of electromagnetic interference from the surge currents (di/dt) and peak voltages (dv/dt).

In applications requiring high sensitivity and accuracy, like data acquisition, this electromagnetic interference is unacceptable, as it will limit device performance. Hence, high-power systems designers must use lower-efficiency linear amplifiers such as class-A/B. The efficiency drops from around 90% range for class-D to 50% range for class-A/B. Beyond amplifiers, the same can be said for switching power supplies and regulators, which may offer higher efficiency but come at the cost of increased electromagnetic interference.

In these cases, a designer of high-power systems is forced to use lower-efficiency architectures, with the same detrimental result to device reliability: Greater thermal generation.

A Quick Note: Cost Considerations

Cost is another reason why simultaneously achieving high power and high reliability is difficult. Materials, technologies, and techniques to achieve higher reliability will always be available, even at higher power, but how much is an engineer willing to spend?

In many cases, the design budget is limited by many factors outside of the designer's control, and tradeoffs must be made to ensure products will be profitable. Ultimately, financial considerations can be a limitation in achieving high reliability.



Apex's Solutions

With over 40 years of experience in designing analog power electronics, Apex Microtechnology has developed several techniques for ensuring high reliability, even at high power.

One technology that Apex is turning to is silicon carbide (SiC) MOSFETs. Owing to its material properties and architecture, SiC—a wide-bandgap semiconductor—offers much smaller parasitics and a higher breakdown voltage than traditional silicon power FETs. Moreover, SiC offers better thermal performance than traditional

silicon, meaning less heat is generated during operation. Overall, a transition to SiC technology has allowed Apex to design high-power power electronics with high reliability for its customers.

Another way that Apex ensures high reliability at high power is through rigid device packaging techniques. These techniques include the use of thick base plates made from thermally conductive materials and pressure-sintered die attaches that ensures minimal voiding and thus greater thermal conductivity between the substrate and base plates. Through both techniques, Apex designs its integrated circuits to sink heat away from the components, thereby lengthening device lifetimes and ensuring proper operation, even at high power and high temperature.

Working directly with its customers, Apex provides guidance on the proper ways to use their devices. Apex's experts can provide design engineers with the appropriate methods for device layout, mounting, and heat-sink selection to maximize the thermal performance of the devices.

In these ways and many more, Apex ensures its customers can balance the tradeoffs between high power and high reliability.

High Power, High Reliability, No Sacrifices

In the design of high-power analog electronics, the need for high reliability is of utmost importance. Unfortunately, technological and economic limitations make simultaneously achieving both high power and high reliability very difficult.

Apex Microtechnology is aware of this problem and is addressing it on many fronts. With a long history of innovation in the power electronics field, Apex can offer its customers a set of solutions to help navigate these tradeoffs so that no sacrifices must be made.

PA99 Power Operational Amplifiers

- Ultra-high 2500V power op-amps designed for output currents up to 50mA.
- Include cascode input circuit configuration that assures high accuracy.
- Flexibility allows customers to tailor slew rate and bandwidth performance.

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HIGH RELIABILITY WITH SiC

HelenAnn Brown, Technical Marketing Manager at Apex Microtechnology

As high reliability becomes more pertinent in power electronics design, many are switching from silicon to silicon carbide (SiC) transistors. Apex Microtechnology offers several unique SiC solutions to help their customers achieve high-reliability analog power electronic designs.

More innovation is occurring in the field of power electronics now than perhaps any other time in history. Emerging technologies such as electric vehicles, solar power, and wind power are driving the power electronics field to new heights and elevated importance. Because of this increased relevance, the need for high reliability in power electronics is greater than ever.

**ONE OF THE MOST PROMINENT
TRENDS IN THE INDUSTRY IS A
MOVE TOWARD HIGHER VOLTAGES
AND CURRENTS.**

At the same time, one of the most prominent trends in the industry is a move toward higher voltages and currents. Unfortunately, this increase in power directly conflicts with achieving high reliability in power electronics, resulting in significant design tradeoffs for engineers.

To address this issue, many engineers are turning to silicon carbide (SiC) field-effect transistors (FETs). In this article, I'll discuss what SiC is, how it impacts device reliability, and how Apex Microtechnology is leveraging SiC to offer higher-reliability products to its customers.

What is Silicon Carbide?

In the field of power electronics, one of the most fundamental components is the FET, typically used as a switching device in power circuits such as amplifiers, switched-mode power supplies, inverters, and motor drives.

Historically, power FETs are made of silicon (Si), a staple in the industry for decades. However, the trend toward higher voltages, currents, densities, and temperatures is causing Si-based power FETs to reach their limits in terms of performance and reliability. As a result, many engineers are starting to adopt SiC-based FETs as a worthy alternative.

A wide-bandgap semiconductor, SiC offers several improved material properties compared to those of Si. These properties include improved switching characteristics, higher efficiency, better thermal stability, and higher breakdown voltages. Compared to Si, SiC has a 5–10x higher breakdown voltage, 3x higher thermal conductivity, and a 2x higher electron saturation velocity. Thus, SiC FETs offer significantly improved performance, especially in high-voltage, high-current power electronic applications.

Silicon Carbide for Greater Reliability

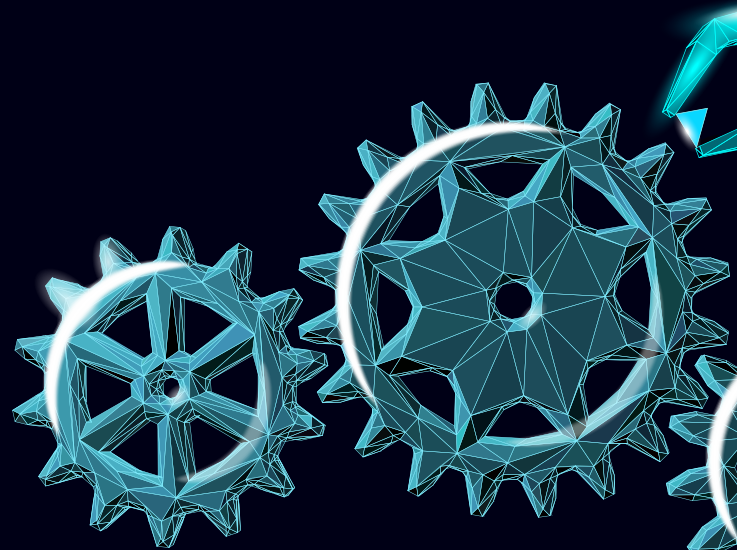
Owing to improved material properties, SiC-based FETs offer greater reliability for analog power electronics.

One way SiC provides higher reliability is through improved thermal performance. On a material level, SiC is much more stable than Si at higher temperatures, meaning it does not need significant derating to continue safe operation. This stability allows for better performance at high temperatures.

Further, because of the wide bandgap of SiC, SiC-based FETs can exhibit extremely high thermal stability, resulting in devices that can safely be used at junction temperatures reaching more than 200°C. By operating with high performance at extreme temperatures, SiC can enable unprecedented levels of reliability for power circuits and designs as a whole.

Beyond thermal tolerance, SiC tolerates higher voltages. With a higher breakdown voltage than Si, SiC is less likely to fail due to transient voltage spikes and power surges, making it a more robust and reliable solution. As a corollary to this advantage, power systems built on SiC may require less surface complexity for reliable operation, potentially enabling designs with simpler layouts, fewer components, and, ultimately, less chance of failure.

Because of its improved efficiency, SiC enables more reliable designs. Thanks to its improved switching characteristics and decreased on-resistances, SiC enables the creation of FETs that dissipate much less power than Si alternatives. This reduced dissipation is not only beneficial in terms of power savings but also device reliability; with less power consumption, SiC FETs will generate less heat, resulting in fewer component and device-level thermal failures.



Apex Takes on SiC

At Apex Microtechnology, we've adopted SiC in many of our product offerings to achieve the highest reliability possible for our customers.

Unlike many other companies with SiC offerings, Apex is unique in the high level of integration offered in their products. **Apex's SiC offerings** all come in modules, meaning the SiC FETs are included with a gate drive switch in one package.

By coupling these two circuit blocks in the same product, Apex provides customers with simplicity of use, avoiding the need for discrete designs and layouts. Instead, customers can purchase a single module and design it directly into their board, guaranteeing high performance and optimal reliability from the start. This approach not only ensures optimized performance for customers but also reduces development costs and design time.

Beyond their ease of use, highly-integrated SiC modules minimize the device footprint, enabling engineers to design systems with minimal area and maximum power density.

Apex's line of SiC-based switching power modules is already available on the market and includes the **SA310**, **SA110**, and SA111. Looking to the future, Apex continues to research innovative ways for integrating SiC into power modules to support more compact, efficient devices.

SiC for the Future

As the industry places more and more emphasis on power electronics, high-reliability design becomes a paramount concern. Simultaneously, trends toward higher voltages and currents are challenging the design of high-reliability systems.

By combining high performance and high reliability across extreme temperatures and voltages, SiC is an attractive solution to these challenges. At Apex Microtechnology, we believe in the power of SiC and offer highly integrated SiC-based modules to enable the highest-reliability designs possible for our customers.

SA310 Brushless DC Motor Driver

- Uses Silicon Carbide MOSFET technology to improve efficiency.
- Three independent half-bridges provide up to 80A peak output current.
- Drive Brushless DC and Permanent Magnet Synchronous motors or DC/AC converters.

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