TECH BRIEF

Optimizing RADAR Efficiency

An Examination of ERZIA's GaN-Based Microwave Solid-State Power Amplifiers in X-Band

ERZIA

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Introduction

Operating within the 8.0–12.0 GHz frequency range, X-Band radar systems have proved vital across various industries, including meteorology, air traffic control, defense, and maritime services. Their exceptional resolution and accuracy make them indispensable in our technology-driven world.

Air traffic control uses X-Band radars for real-time tracking of airborne traffic, while in maritime services, these radars aid in navigation and collision avoidance. Meteorologists utilize X-Band radars for high-resolution weather surveillance, providing early warnings of severe weather. In defense, these radars are used for precise target tracking and missile guidance.

High-power radar systems have traditionally relied on Traveling Wave Tube (TWT) amplifiers. However, the advent of Gallium Nitride (GaN) technology has introduced an alternative: solid-state power amplifiers (SSPAs). GaN-based SSPAs handle higher power densities, operate effectively at elevated temperatures, and can drive TWTs in high-power radar systems.

In lower-power radars, GaN SSPAs serve as the final amplification stage, resulting in smaller, more energy-efficient systems without compromising performance. The incorporation of GaN SSPAs into X-Band radar systems marks a significant advancement, promising improved performance, power efficiency, system longevity, and reduced maintenance.

GAN SSPAS VS TWTA

The pivotal role of power amplifiers in RADAR systems underscores the necessity for robust, reliable, and efficient solutions. Traditional Traveling Wave Tube Amplifiers (TWTAs) have long dominated the field. However, the advent of Gallium Nitride (GaN) based Solid-State Power Amplifiers (SSPAs) has signaled a shift in preference, due to the numerous advantages they present.

A primary advantage of GaN SSPAs is their efficiency. Compared to TWTAs, GaN SSPAs exhibit higher power-added efficiency, converting DC power into RF power more effectively. This reduces power consumption and heat dissipation, critical factors in RADAR system design.

GaN SSPAs also outshine TWTAs in terms of reliability. The solid-state nature of SSPAs, devoid of moving parts, promotes a longer lifespan and reduced maintenance needs compared to TWTAs, which can fail due to issues like cathode poisoning.

Signal integrity is crucial in RADAR applications. GaN SSPAs excel in linearity, ensuring accurate amplification of a broad range of input signals without distortion, preserving the fidelity of the radar signals.

The higher power density of GaN devices permits the design of smaller, lighter amplifiers, advantageous in space-constrained RADAR applications. Furthermore, SSPAs offer operational flexibility, functioning effectively across wider temperature ranges, thus increasing their suitability for varied environments.

Lastly, GaN SSPAs feature graceful degradation. In case of a module failure, the system continues operating at reduced power, contrasting with TWTAs, which can lead to complete system failure.

In conclusion, while TWTAs still hold relevance in certain RADAR applications requiring high output power or extensive bandwidth, GaN SSPAs present significant advantages in terms of efficiency, reliability, signal linearity, power density, operational flexibility, and graceful degradation. Consequently, the incorporation of GaN technology in RADAR systems signals a promising direction in the field of power amplification.

ERZIA COTS CATALOG

ERZIA's proposal features five GaN SSPAs specifically designed for the X-Band frequency range. Within this group, there are three continuous wave (CW) amplifiers with output powers of 20W, 40W, and 80W, offering versatility in applications requiring lower power but continuous operation. In addition to the CW amplifiers, ERZIA's catalog expands its offering to include two pulsed amplifiers, providing higher output powers of 300W and 400W, ideal for radar applications requiring high peak power in short pulses. All have been designed to be ITAR free.

CW AMPLIFIERS

The continuous wave (CW) amplifiers range from 20 to 80 watts, with varying bandwidths on the X-Band frequencies and a gain around 40 to 50 decibels. The efficiency fluctuates between 20% for the 20-watt amplifier and 17% for the 80-watt amplifier. These CW amplifiers can serve as drivers or as final stages in compact radar systems.

Capable of both continuous and pulsed operation, these amplifiers demonstrate improved performance under pulsed operation. Ideal as drivers for higher power stages, or as final amplifiers in compact equipment, these robust and versatile amplifiers are designed to enhance the overall efficiency and adaptability of radar systems. A summary of main characteristics is presented on the following table:

Model	Operating frequency (GHz)	Output power (dBm)	Output power (W)	RF to DC efficiency (typ. %)	Typical power gain (dB)
ERZ-HPA-0800-1100-43	8-11	43	20	20	40
ERZ-HPA-0790-0840-46	7.9-8.4	46	40	19	40
ERZ-HPA-0850-1050-49	8.5-10.5	49	80	17	50

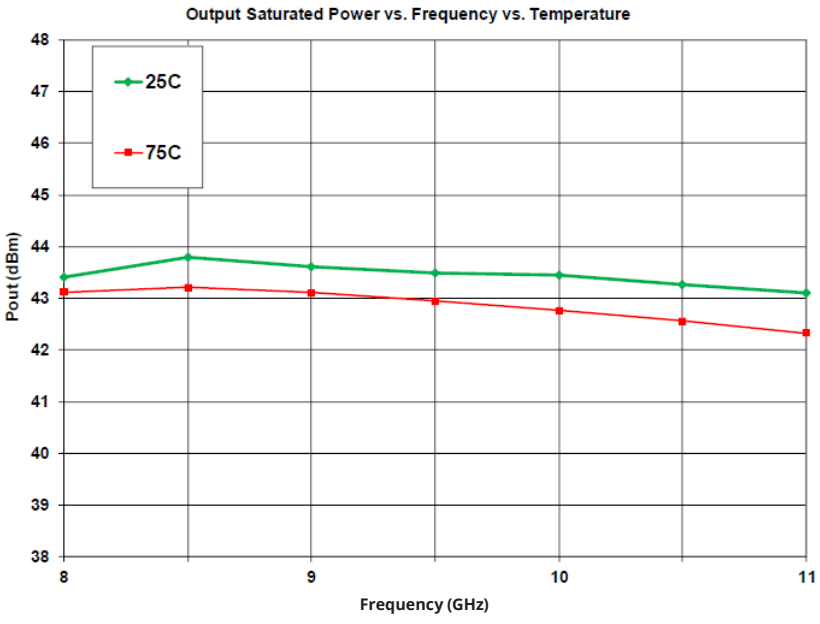
ERZ-HPA-0800-1100-43

The first device highlighted is a compact, high-power X-band amplifier with dimensions of just 125x95x22 mm. Despite its small size, it covers an exceptionally wide bandwidth, from 8 to 11 GHz.

Combined with its 20W output power, 20% efficiency, the capability to operate in both CW and pulsed modes, and a gain of 40 dB, this amplifier showcases tremendous versatility. It can serve as a driver or as a final stage in a variety of applications, making it an ideal solution for space-constrained systems.

Additionally, the amplifier exhibits a Voltage Standing Wave Ratio (VSWR) of less than 2.0:1 for both input and output, ensuring optimal energy transfer with minimal signal reflection. It further boasts minimal degradation with temperature changes across the full band-width, reflecting exceptional thermal stability.

Compact yet robust, this amplifier is a reliable choice that seamlessly fits into numerous X-band RADAR systems. By combining power, efficiency, and versatility within a small package, it epitomizes the capabilities of modern RF amplification technologies.

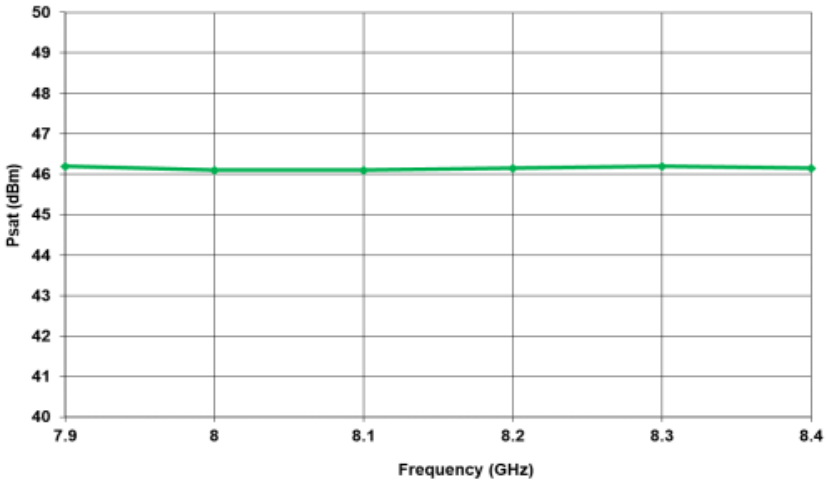


ERZ-HPA-0790-0840-46

The subsequent amplifier highlighted is a meticulously optimized device, specifically tailored for the 7.9 to 8.4 GHz frequency band. With its dimensions measured at 180x120x22 mm, the device provides a powerful output of 40W while maintaining remarkable stability throughout its operating band.

This amplifier is equipped to function in both CW and pulsed modes, exhibiting a broad range of application versatility. Despite its compact size, it upholds the same technical principles and reliability standards as the earlier described amplifier, demonstrating ERZIA's commitment to consistent performance and quality.

Focused on this particular frequency band, this amplifier provides an effective power amplification solution for applications requiring a targeted frequency response. With the combination of compactness, specialized performance, and reliability, this amplifier presents an ideal power solution for modern X-band RADAR systems where space is at a premium.

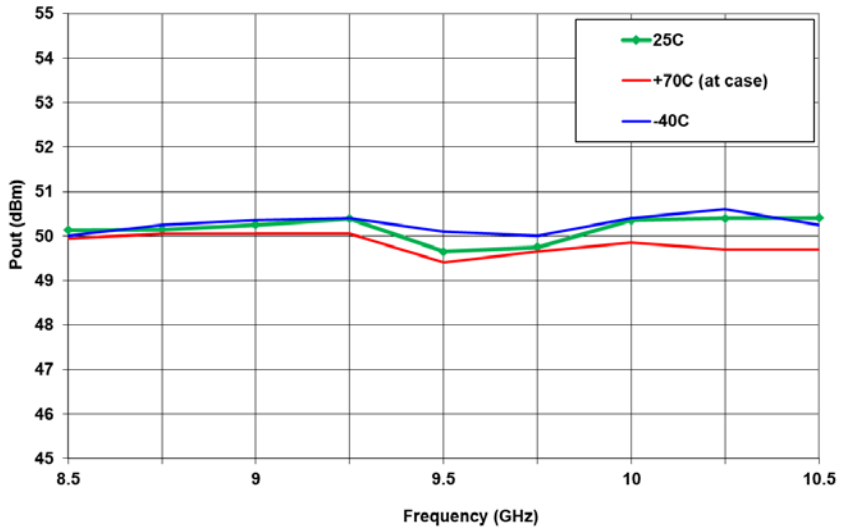


ERZ-HPA-0850-1050-49

The next amplifier in our lineup, while maintaining the general characteristics of its predecessors, delivers a powerful output of 80W, even exceeding 100W at various points.

This amplifier, measuring a compact 240 x 170 x 29.3 mm, can operate in both CW and pulsed modes, demonstrating substantial versatility and adaptability across a range of system requirements. Even with the increased power output, it exhibits remarkable temperature stability, making it a robust and adaptable choice for varying operating conditions.

This amplifier offers a versatile, robust, and efficient solution in the 80-100W range. Its compact size belies its power, making it a compelling choice for applications requiring more substantial power levels in space-constrained X-band RADAR systems. This amplifier provides an ideal balance of high power output, reliability, and compact design.



PULSED AMPLIFIERS

Transitioning from the continuous wave models, we now introduce our range of pulsed amplifiers. Designed to operate at higher power levels, these amplifiers uphold our philosophy of delivering compact sizing and unswerving reliability while providing significantly increased power outputs.

This lineup comprises two models, each confined within a modest dimension of 178x215x42.5 mm. The first delivers an output power of 300W, while the second offers an impressive 400W. Their compact footprint does not compromise their robustness or capability, ensuring substantial power within a surprisingly compact device.

These pulsed amplifiers retain the established reliability of their CW counterparts, while adding an extra dimension of high-power operation. They represent ideal choices for more demanding X-band RADAR applications, where both power efficiency and space optimization are paramount considerations.

Model	Operating frequency (GHz)	Output power (dBm)	Output power (W)	RF to DC efficiency (typ. %)	Typical power gain (dB)
ERZ-HPA-0850-0980-55	8.5-9.8	55	300	23	55
ERZ-HPA-0900-1000-56	9-10	56	400	19	40

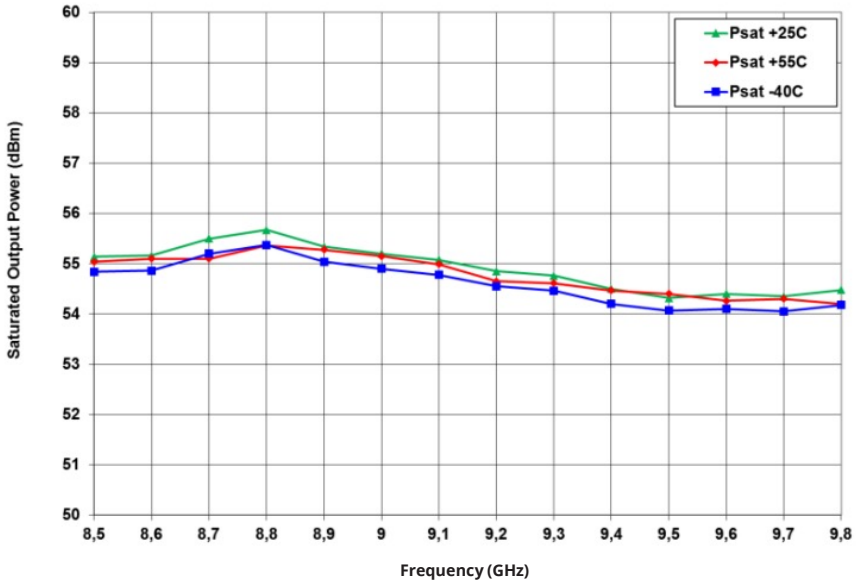
ERZ-HPA-0850-0980-55

The first model in our pulsed amplifier lineup delivers a robust power output of 300W, a performance it can sustain over more than 1 GHz of bandwidth. This unit supports up to a 20% duty cycle, with pulse lengths that can range from 10 ns to 500 µs, underscoring its operational flexibility.

The amplifier also stands out for its stability under varying temperature conditions, providing consistent performance even as environmental conditions change. Coupled with efficiencies around 23%, this amplifier exemplifies both power and efficiency in its operation.

This 300W pulsed amplifier is powerful and versatile, enabling a wide range of pulse widths and duty cycles. Its high efficiency, coupled with its superb thermal stability, ensures that it delivers high power while minimizing energy waste, adding a layer of robustness to system-level performance.

Given these characteristics, this amplifier serves as an excellent final output stage in X-band RADAR systems, providing the high power necessary for signal transmission over considerable distances. Its robust power delivery, combined with broad operational bandwidth, temperature stability, and high efficiency, makes it an ideal solution for demanding RADAR applications.



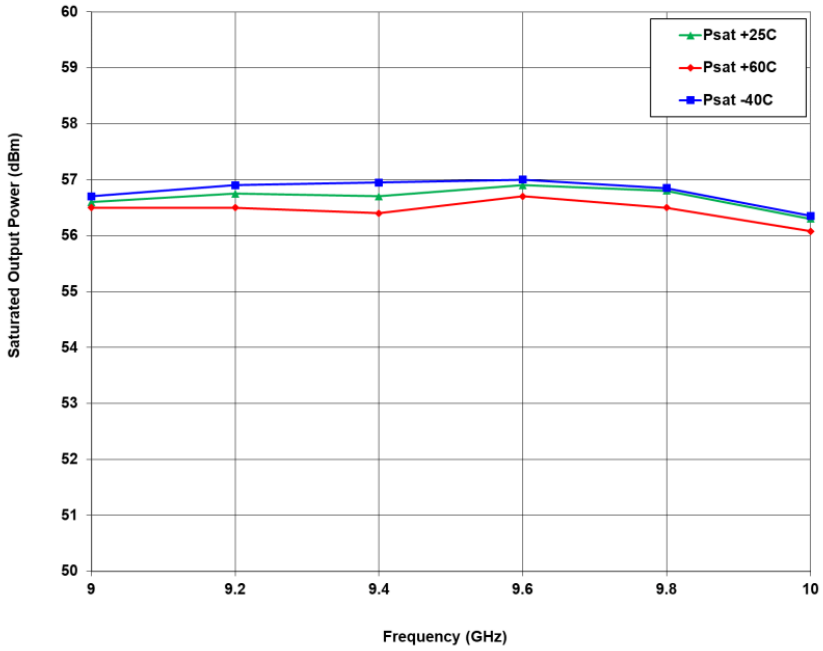
ERZ-HPA-0900-1000-56

Finally, we present the most powerful amplifier in our catalog to date. This pulsed amplifier delivers a minimum output power of 400W, with peaks reaching up to 600W, making it a formidable contender in terms of power output.

This amplifier does not sacrifice the advantages of its predecessors, maintaining the same operational flexibility, thermal stability, and efficiency. It supports a wide range of pulse widths and duty cycles, continuing the versatility that is characteristic of our product line.

Despite its higher power output, this 400W pulsed amplifier ensures consistent performance across different temperature conditions, just like its predecessors. This level of stability is critical in high-demand applications, where changes in environmental conditions could otherwise affect performance.

With its power peaks hitting 600W, this amplifier is not only our most potent offering but also a representation of what is achievable in terms of power, efficiency, and operational stability in X-band RADAR systems. Its outstanding power output combined with the inherited advantages of our amplifier line makes it an ideal solution for the most demanding RADAR applications.



Conclusion

In conclusion, this tech brief has detailed ERZIA's X-band amplifier family specifically designed for RADAR applications. These amplifiers capitalize on the potential of GaN devices, focusing on their inherent benefits and integrating them into a coherent and effective product lineup that offer these benefits:

- GaN delivers high power density, enabling significant power outputs while maintaining compact size and minimizing energy waste for overall system performance and sustainability.
- ITAR-free simplifies international operations and eliminating potential regulatory hurdles.
- Designed to withstand demanding conditions and provide consistent, reliable performance.

Overall, ERZIA's X-band RADAR amplifiers represent a successful blend of GaN technology's advantages with ERZIA's established product design principles. They offer high power, efficiency, compactness, and reliability, making them a compelling choice for various X-band RADAR applications.

NEXT STEPS

X-Band COTS datasheets and ERZIA catalog HPAs can be found here:

ERZIA catalog of High Power Amplifiers:
erzia.com/products/hpa

Custom radar amplifiers for specific applications in X-Band, Ku-Band and Ka-Band are also done by ERZIA every day. Please contact us at sales@erzia.com if you have specific demands.