

App Note 008 -

Advantages of GaN RF Amplifiers with High Peak-to-Average Capability to P1dB Rated Amplifiers

Introduction:

In the realm of RF power amplifiers, two key metrics often come into play:

High peak-to-average capability and P1dB rating. These metrics are crucial for different applications and can significantly impact the performance and efficiency of RF systems. GaN SSPAs have high peak-to-average capability offering significant advantages in applications where signal characteristics involve high dynamic ranges, complex modulation schemes, or high crest factors. This application note aims to compare GaN RF amplifiers with high peak-to-average capability; to P1dB rated amplifiers, highlighting their respective advantages and use applications.

GaN RF Amplifiers with High Peak-to-Average Capability-

GaN (Gallium Nitride) RF amplifiers are known for their exceptional performance in high-frequency & broadband applications >1.0GHz. These amplifiers offer several advantages:

- **High Efficiency:** GaN amplifiers can achieve efficiencies above 40%, making them ideal for applications requiring high power and low heat dissipation. GaN SSPAs are inherently more efficient in dealing with fluctuating power levels. The high peak-to-average capability minimizes energy losses and reduces thermal stress, which is especially beneficial in high-power, wideband applications.
- **High Power Density:** GaN devices can deliver high RF power densities, often exceeding 8 W/mm of gate periphery.
- **Wideband Operation:** GaN amplifiers can operate over extremely wide frequency ranges, thus making them suitable for an extensive range of applications such as EMC/EMI testing, Radar, Electronic Warfare & Telecommunications.
- **High Peak-to-Average Capability:** GaN amplifiers excel in handling signals with high peak-to-average ratios, which is essential for modern communication systems like 5G. Unlike P1dB-rated amplifiers, which may exhibit distortion or reduced performance when handling high peak-to-average signals, GaN SSPAs maintain linearity under these conditions. This ensures better error performance and higher fidelity in the transmitted signal.
- **Comparison with P1dB Rating:** The P1dB compression point is a critical parameter for linearity but focuses primarily on constant-gain performance up to a specific input level. While useful for certain applications, P1dB-rated amplifiers may fail to meet the demands of high-dynamic-range signals, where power peaks exceed the 1dB compression threshold. GaN SSPAs bridge this gap by efficiently managing power beyond this limit, optimizing both linearity and efficiency.

- **Crest Factor:** GaN RF amplifiers offer a significant advantage in terms of **crest factor** compared to P1dB rated amplifiers. The crest factor is the ratio of the peak power to the average power of a signal, and it's particularly important in communication systems that use complex modulation schemes, such as those in 5G networks. As mentioned, **GaN amplifiers** excel in handling signals with high peak-to-average ratios, which means they can efficiently amplify signals with large peaks without distortion. This is crucial for maintaining signal integrity and reducing errors in high-speed communication systems (EW/Military). In contrast, **P1dB rated amplifiers** are optimized for linearity up to the 1dB compression point. These types often struggle with signals that have high peak-to-average ratios, leading to increased distortion and reduced performance.

P1dB Rated Amplifiers-

The P1dB rating, or 1dB compression point, is a critical parameter for assessing an amplifier's linearity and dynamic range. P1dB rated amplifiers are characterized by:

- **Linearity:** P1dB amplifiers maintain a constant gain up to the 1dB compression point, beyond which the gain decreases by 1dB after compression has begun.
- **Dynamic Range:** These amplifiers are designed to handle a wide range of input power levels while maintaining linearity.
- **Reduced Distortion:** Operating below the P1dB point ensures minimal distortion, harmonics, and intermodulation products.
- **Versatility:** P1dB rated amplifiers are suitable for various applications, including wireless communication systems, instrumentation, and military electronics.

Comparison:

| Features | GaN RF Amplifiers | P1dB Rated Amplifiers |
|----------------------------|--|---|
| Efficiency | Moderate (can be Higher based on bandwidth) | Moderate |
| Power Density | Very High | Moderate |
| Frequency Range | Wideband | Moderate to Wideband |
| Peak-to-Average Capability | Excellent | Good |
| Crest Factor | Excellent | Low |
| Linearity | Good | Excellent (up to P1dB point) |
| Distortion | Low | Very Low (below P1dB point) |
| Applications | Instrumentation, 5G, Radar, EW, Military | Wireless Communications, Instrumentation, Military |

Conclusion:

Both GaN RF amplifiers with high peak-to-average capability and P1dB rated amplifiers have some specific unique benefits and are suited for different yet overlapping applications. GaN amplifiers excel in Power-Density & Peak-to-Average capability making them an excellent solution for high-power applications with wideband capabilities. While P1dB rated amplifiers are sometimes preferred for their linearity and reduced distortion over a wide range of input power levels. This wide range is often only required for specific applications.

Key Takeaways:

GaN SSPAs with high peak-to-average capability provide a compelling solution for applications demanding high efficiency, minimal distortion, and robustness under varying signal conditions. They outshine P1dB-rated amplifiers in scenarios requiring advanced modulation, wideband operation, and high peak signal amplification—qualities essential for next-generation communications & testing as well as defense systems.