Insights and best practice

AMPLIFIER KNOW-HOW

TECHNICAL NOTE 0121

AMPLIFIER REQUIREMENTS FOR NEMP TESTING

This document is essential for engineers and testing professionals involved in NEMP simulation, as it provides critical guidance on selecting the right amplifier to ensure accurate waveform reproduction, compliance with test standards, and reliable protection of mission-critical electronic systems against electromagnetic threats. It outlines key amplifier requirements, including bandwidth, gain, pulse fidelity, impedance matching, and protection features, helping readers make informed decisions for their test setups.

The technical note also highlights suitable solutions from the AR amplifier portfolio, such as the AR1BP400 series, which are specifically designed to meet the demanding performance criteria of NEMP testing.

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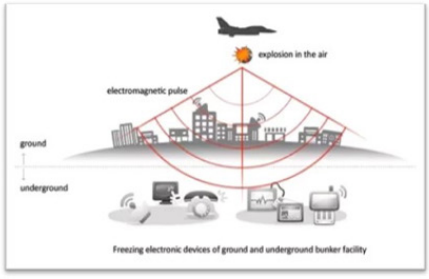
COMPLIANCE TEST SOLUTIONS

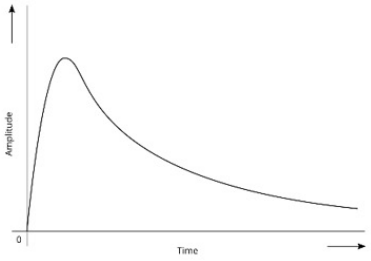
INTRODUCTION

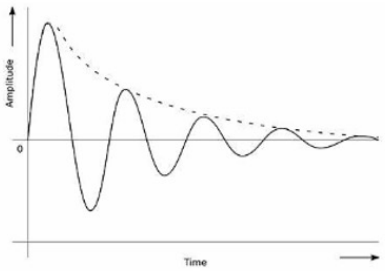
Nuclear Electromagnetic Pulse (NEMP) testing is performed to simulate the intense electromagnetic fields generated by a nuclear detonation. These tests are essential to ensure that mission-critical systems and infrastructure can withstand the damaging currents and voltages induced by NEMP exposure.

Amplifiers are crucial in NEMP testing as they amplify the output of an arbitrary waveform generator to produce the required NEMP waveforms, particularly the fast double exponential waveform. This waveform has a rapid rise time (1–10 ns) followed by a slower decay (50–250 ns), with electric field strengths reaching multiple megavolts per meter near the explosion site.

While immediate proximity to a nuclear detonation results in total system destruction, a broader affected area - extending hundreds of kilometers - can experience widespread electronic disruption. Depending on the electronic circuits involved, disturbances appear as fast double exponential waveforms or damped sinusoidal waves (typically between 2 MHz and 200 MHz). Laboratory simulations of these environments are necessary to evaluate and improve the resilience of electronic systems.







Amplifier Selection Criteria for NEMP Testing

When selecting an amplifier for NEMP testing, several key factors must be considered to ensure accurate waveform reproduction and reliable system operation.

1. Bandwidth
   - The amplifier must support a wide instantaneous bandwidth to accurately replicate the fast rise and extended decay of double exponential waveforms.
   - NEMP test standards - Mil-STD 461 RS105 and Mil-STD 464 - require coverage from 1 MHz to 400 MHz, even though the highest generated powers are typically within 2 MHz to 200 MHz.
2. Gain
   - The amplifier must provide high gain to allow low-power waveform generators (e.g., 0 dBm arbitrary waveform generators) to serve as input drivers.
   The AR1BP400 amplifier series is designed with high gain, ensuring sufficient voltage amplification to meet test requirements.
3. Pulse Fidelity
   - The amplifier should introduce minimal distortion to ensure the output pulse closely replicates the input signal.
   The AR1BP400 amplifier series operating in Class A biasing, provides highly linear performance, faithfully preserving the initial waveform shape. In contrast, Class AB amplifiers tend to clip the peaks of damped sinusoidal waveforms and degrade rise times. For example, a 1 ns rise-time input pulse may degrade to 5–10 ns at the amplifier output when using a Class AB design.
4. Impedance Matching and Stability
   - Proper impedance matching is essential for efficient power transfer and accurate waveform reproduction.
   - While calibration setups use a 50 Ω peak power load, real devices under test (DUTs) present complex impedances with varying resonance characteristics, ranging from short circuit to open circuit.
   The AR1BP400 amplifier series, being a Class A, internally matched wideband amplifier, maintains a stable internal impedance close to 50 Ω, minimizing distortion across varying DUT impedances.
   This intrinsic stability allows the amplifier to instantaneously deliver either voltage- or current-dominant waveforms, depending on DUT characteristics.
5. Protection and Reliability
   - The amplifier must include robust Voltage Standing Wave Ratio (VSWR) protection to handle complex load conditions.
   The AR1BP400 amplifiers offer Thevenin/Norton generator-like behavior, providing:
   Open-circuit protection (maintaining 2V output)
   Short-circuit protection (maintaining 2I output)
   These design features ensure the amplifier operates reliably under varying load conditions without performance degradation

Test Setup Considerations

Radiated Field Testing
Conducted under a stripline setup, where the amplified NEMP signal is radiated to simulate real-world exposure. The electromagnetic field is generated between the radiating line and ground plane creating a transverse electromagnetic (TEM) wave. The EUT is exposed to this field to simulate the effects of NEMP

Selecting the right amplifier for NEMP testing is critical to ensuring accurate waveform reproduction and reliable test results. Amplifiers must offer:

- Wideband operation (1–400 MHz)
- High gain for low-level signal amplification
- Fast rise times and minimal waveform distortion (best achieved with Class A biasing)
- Stable impedance matching for varying DUT conditions
- Intrinsic protection against open- and short-circuit scenarios

The AR1BP400 amplifier series meets these requirements, making it a strong candidate for demanding NEMP test environments. Proper amplifier selection and integration into test setups enable effective simulation of NEMP conditions, ensuring electronic infrastructure is adequately protected from electromagnetic threats.

Why Choose AR for NEMP Testing Amplifiers?

Selecting the right amplifier for NEMP testing is crucial to ensuring accurate waveform reproduction, test reliability, and compliance with industry standards. AR stands out as a trusted partner for high-power amplifiers, offering unmatched expertise, proven performance, and dedicated customer support.

Application Knowledge
With over 30 years of experience in high-power amplifier and antenna design, AR has a deep understanding of Aerospace and Defense applications, enabling us to provide solutions for the most demanding test environments. Our amplifiers and systems have been successfully deployed across multiple Departments of Defense worldwide (USA, UK, France, Germany, Korea, India, Turkey, Israel), consistently delivered on time and within budget.

Customer Acceptance & Compliance
AR's Factory Acceptance Tests (FAT) and Site Acceptance Tests (SAT) meet the most stringent technical requirements, ensuring that our amplifiers perform as expected in real-world NEMP simulations. Our commitment to rigorous testing guarantees reliability and compliance with industry standards.

Proven Performance in Demanding Applications
AR amplifiers are renowned for their market-leading solid-state performance and reliability in applications such as Radar, Electronic Warfare (EW), High-Intensity Radiated Fields (HIRF), Intentional Electromagnetic Interference (IEMI), and Telecommunications. Designed for continuous operation, our amplifiers can run 24 hours a day, 365 days a year, providing unmatched durability in high-stress environments.

Cutting-Edge Technology
AR's commitment to innovation ensures that our amplifiers deliver superior performance, efficiency, and cost-effectiveness. Our advanced air-cooled GaN FET solid-state power amplifier (SSPA) designs enable high-power integration, allowing us to compete with CW TWT amplifiers up to 18 GHz and pulsed applications up to 12 GHz. This makes AR amplifiers ideal for both traditional and modern NEMP testing setups.

Comprehensive Support & Customization
AR provides extensive technical support and customization options to meet specific NEMP simulation requirements. Our dedicated team is available to help integrate AR amplifiers with any NEMP test setup, including:

- Arbitrary waveform generators + stripline configurations
- Injection probe setups with "Probe Calibration" and "DUT Calibration" procedures

Whether you need a turnkey solution or a tailored amplifier system, AR ensures seamless integration into your NEMP testing environment, providing long-term reliability and performance.

By choosing AR amplifiers, customers gain access to industry-leading expertise, robust performance, cutting-edge technology, and world-class support. AR's solutions are trusted worldwide for the most demanding electromagnetic environments, ensuring that your critical electronic systems are tested and protected against NEMP threats.