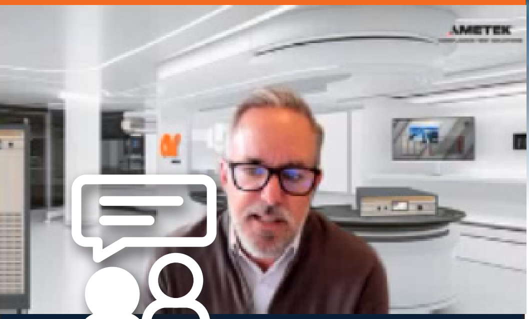
AMPLIFIER know-how

Ask the
Experts

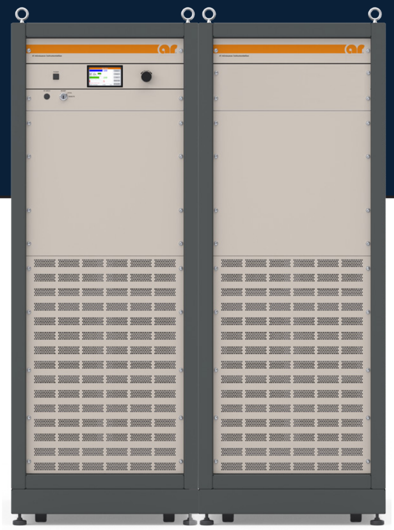
Next-Gen Amplifiers:
Reliable, Scalable, and Ready for Tomorrow's Threats



Nick Jones of AMETEK CTS & AR recently led a deep dive into the transformative rise of solid-state amplifiers — from lab innovation to defence-grade deployment.

The discussion covered the key applications driving innovation — including EMC immunity testing, electronic warfare, and NEMP (Nuclear Electromagnetic Pulse) testing — and highlighted how advances in semiconductor design, cooling methods, and combiner technology are enabling higher power, broader bandwidths, and more compact systems.

This is a summary of the most insightful questions raised during the webinar, along with Nick's expert responses.



Question: Why are solid-state amplifiers becoming more popular than TWTs?

NJ: TWTs have been the go-to for high-frequency, high-power applications for years because they're reliable and robust. But solid-state technology is catching up fast — thanks to advances in transistor materials like GaN (Gallium Nitride). We're now seeing solid-state amps deliver impressive power levels, especially in the 200–300 W range, and they're becoming viable even for mission-critical systems.

Question: What kinds of applications are pushing amplifier development forward?

NJ: It's a mix of cutting-edge and defence-driven needs. Think EMC testing for IoT and autonomous vehicles, bulk current injection for EVs, and high-intensity radiated fields (HIRF) for aerospace and defense. But the biggest push is coming from electronic warfare — especially systems designed to counter drone swarms using RF energy walls. These applications demand serious power and reliability.

Question: What exactly is NEMP, and how do we test for it?

NJ: NEMP stands for Nuclear Electromagnetic Pulse — the kind of pulse you'd get from a nuclear detonation. Obviously, we're not setting off nukes in the lab, but we do simulate those pulses using high-power RF amplifiers and voltage generators. This helps to ensure our critical electrical and electronic infrastructures can be protected against such extreme events.

Question: What's driving the tech behind these amplifiers?

NJ: It's all about materials and cooling. GaN on silicon carbide is a game-changer for thermal performance, and GaN on diamond (yes, synthetic diamond!) is on the horizon. Cooling is just as critical — air-cooled systems are getting smarter and more efficient, which makes them ideal for mobile or rugged environments. And let's not forget combining techniques, which let us scale power without losing efficiency.

Question: Combining is a challenge — what should be considered when aiming for high power across 1–8 GHz?

NJ: Before we get into the challenges, it's worth understanding how combining works in solid-state amplifiers. To reach high power levels, we don't rely on a single massive transistor — we scale up by combining multiple power modules. This is done using two main methods:

- Transmission Line (Corporate Structure) Combining: This uses Wilkinson dividers or hybrid couplers to split and recombine signals in a branching structure — like a corporate org chart. It's efficient at lower frequencies but can suffer losses as frequency increases.

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- Spatial Combining: At higher frequencies, transmission line losses become significant. Spatial combining helps reduce those losses and maintain output power, making it ideal for millimeter-wave applications.

Now, when it comes to 1–8 GHz, it's particularly tricky. This range is in high demand — especially with autonomous vehicles expected to operate around 8 GHz. While there are products that cover parts of this spectrum (like 2.5–7.5 GHz), creating a combiner that performs well across the full 1–8 GHz range is still a technical challenge. Performance tends to drop off at the band edges, making full-spectrum solutions difficult to achieve — at least for now.

Question: Are these amplifiers just concepts, or are they actually in use?

NJ: They're very real. We've delivered systems like an 80 kW pulse amplifier for NEMP testing to defence agencies - they're deployed and operational.

Question: What kind of connectors do these amps use?

NJ: It depends on the frequency and power. For lower frequencies, we might use SC 7/16" or GE 5/8". For higher frequencies, we switch to waveguide connectors. It's all about matching the right connector to the job.

Question: Why is water cooling considered higher maintenance?

NJ: Water cooling works well, but it's more complex. You've got pumps, pipes, and heat exchangers — all of which can be affected by vibration, corrosion, or transport damage. Air cooling is simpler and more reliable, especially if the amplifier needs to be mobile or used in harsh environments.

Question: Is GaN on Diamond available yet?

NJ: Not quite — it's still in development. Bonding GaN to synthetic diamond is tricky, but the benefits in heat dissipation and power density are huge. With global competition heating up, we expect to see it sooner rather than later.

Question: Can you use Class AB amplifiers for NEMP testing?

NJ: Technically, yes — but it's not ideal. Class A amplifiers are better at replicating the clean double exponential and damped sinusoidal waveforms generated needed for NEMP. Class AB might work for some EMC tests, but for NEMP, Class A is the safer bet.

Question: How long can an amplifier run at compression power?

NJ: If it's designed properly and cooled efficiently, it can run indefinitely. We always build in headroom and don't push transistors to their absolute limits. That way, the amp stays reliable and performs consistently.

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QUESTION?

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WANT TO **LEARN MORE?**

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