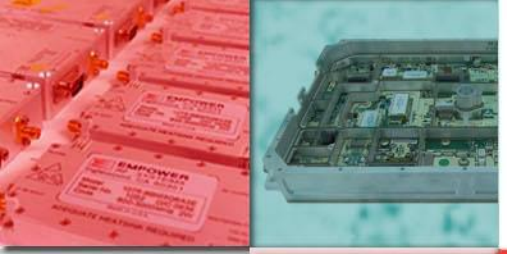


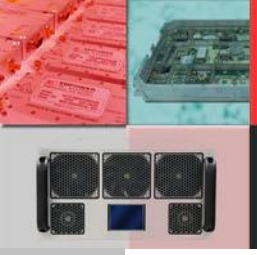
Empower RF Systems

Electronic Warfare Europe
05/13-15/2019

Paulo Correa, Chief Technology Officer
Paulo.Correa@empowerrf.com

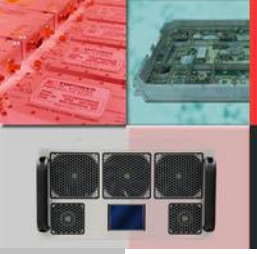
High Power Solid State Advances in Technology

EMPOWER RF SYSTEMS, INC.



High Power Solid State Advances in Technology

- Why This Topic?
- Technology Enablers
- Myth Busting
- Illustrations of Technology Advancements
  - Frequency Hopping GPS Denial
  - Digital At Nominal Power
  - Pulse Shaping
  - Adaptive Digital Pre-Distortion Concept
  - Solid State Higher Power Solution (S, C and X band)
  - Rack mechanical design
  - Relevant illustrations – deployed systems
- Conclusions



Why this Topic?

Responding to what's driving EW and Threat Simulation Requirements

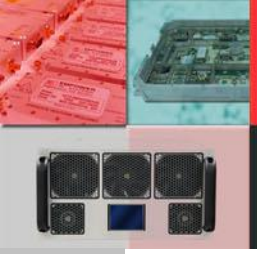
Developments across the electromagnetic spectrum - increasingly complex waveforms and signals environment that requires more than a "dumb" PA.

Requests to support size constrained applications and requirements for mobility.

Aging infrastructure and obsolescence issues facing the EW and radar design community that uses conventional amplifier designs (including TWT) while trying to implement updates elsewhere.

Requests for interoperability of a standard platform (hardware & software) across multiple applications.

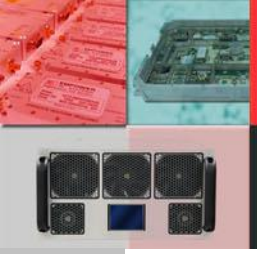
Requirements to "scale" power, bandwidth, pulse widths for dealing with emerging threats.



Technology Enablers

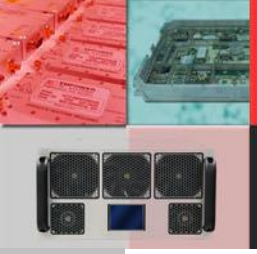
- Developments in ADC/DACs, Fiber and Processors
- Affordable high speed ADCs and DACs
  - Allows for coherently digitizing RMS and envelope signals at the input and output of HPA.
  - Allows full digital peak detection to measure input power, forward and reverse power.
  - Measurement of peak and RMS allows for operation with any kind of modulated signal.
  - Measurement of multiple HPA parameters including efficiency and P1dB.
- Use of fiber optics to interconnect mother board to front and rear panels*
  - Fiber Optic interconnection between front panel, rear panel and motherboard
  - Fast data transfer.
  - No wires in these assemblies other than DC voltages.
  - Radiated emission significantly reduced for enhanced EMC performance.
- New SoC allows high level of integration
  - Microprocessor and FPGA integrated in the same fabric allows an effective combination of signal processing, command and control.
  - Flexible and scalable platform – adds capacity to include new features.
  - Efficiency on size and weight and, at the same time, adding computational power
    - 100X increase in computational power in the same footprint with existing hardware

* US Patent pending



"Myth Busting" with technology enabled SSPA's

- MYTH: pulse width and duty cycle limitations
  - A technology enabled SSPA allows user to operate at full power with 500µs pulse width and 20% duty cycle.
  - Digital signal processing allows operation in CW with the appropriate back off.
  - Duty cycle protection operates at leading edge of the pulse or at the waveform energy.
- MYTH: Solid state can have jitter when combining multiple PAs in parallel
  - Architecture with technology enabled SSPA's guarantees minimum jitter.
  - Common blanking synchronizes on/off of all Pas.
- MYTH: System performance can only be enhanced at the signal generator
  - Output power controlled by a technology enabled SSPA keeps the exciter at a constant setting.
  - Pulse correction at MW/RF chain – releases computational capability of the integrated system controller to optimize the mission.



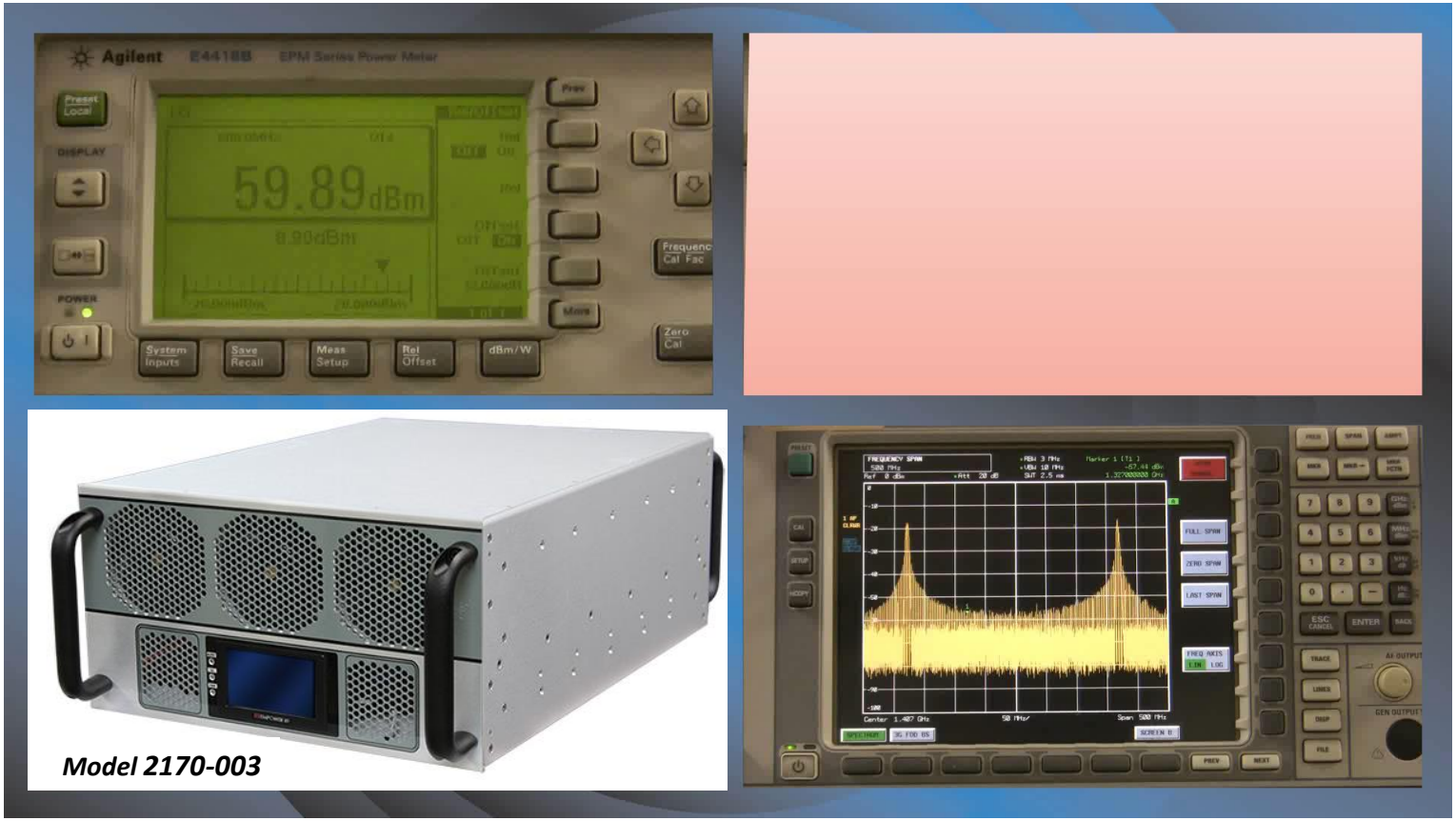
Technology Enabled, Multi-mode / Interoperable Power Amplifiers

- *Multimode* Power Amplifier is an amplifier that can operate in all modes required for its application:
  - Any type of detector
  - Any type of Output Power Management
  - Any type of Modulation
  - Efficient in any mode and maximum power in any mode

- *Interoperable* Power Amplifier is an amplifier that requires no change in hardware to operate in any mode.
  - Can operate in CW and in Pulse with the same peak power w/o any HW change.
  - Can detect RMS or Peak power w/o HW change.
  - Can change from manual gain control (MGC) to automatic gain control (AGC) to automatic level control (ALC).
  - Can operate in Multi-carrier, frequency hopping, barrage, digital modulation, AM modulation Pulse mode and Pulse modulation in any Output Power Management.
  - Can have the same API and user experience.

- *Why Do We Care?*
  - This is a single unit capable of Multi-Domain applications.
  - Designed to stay ahead of the increasing complexities of the signals environment.
  - Higher efficiency and better utilization of size and weight.

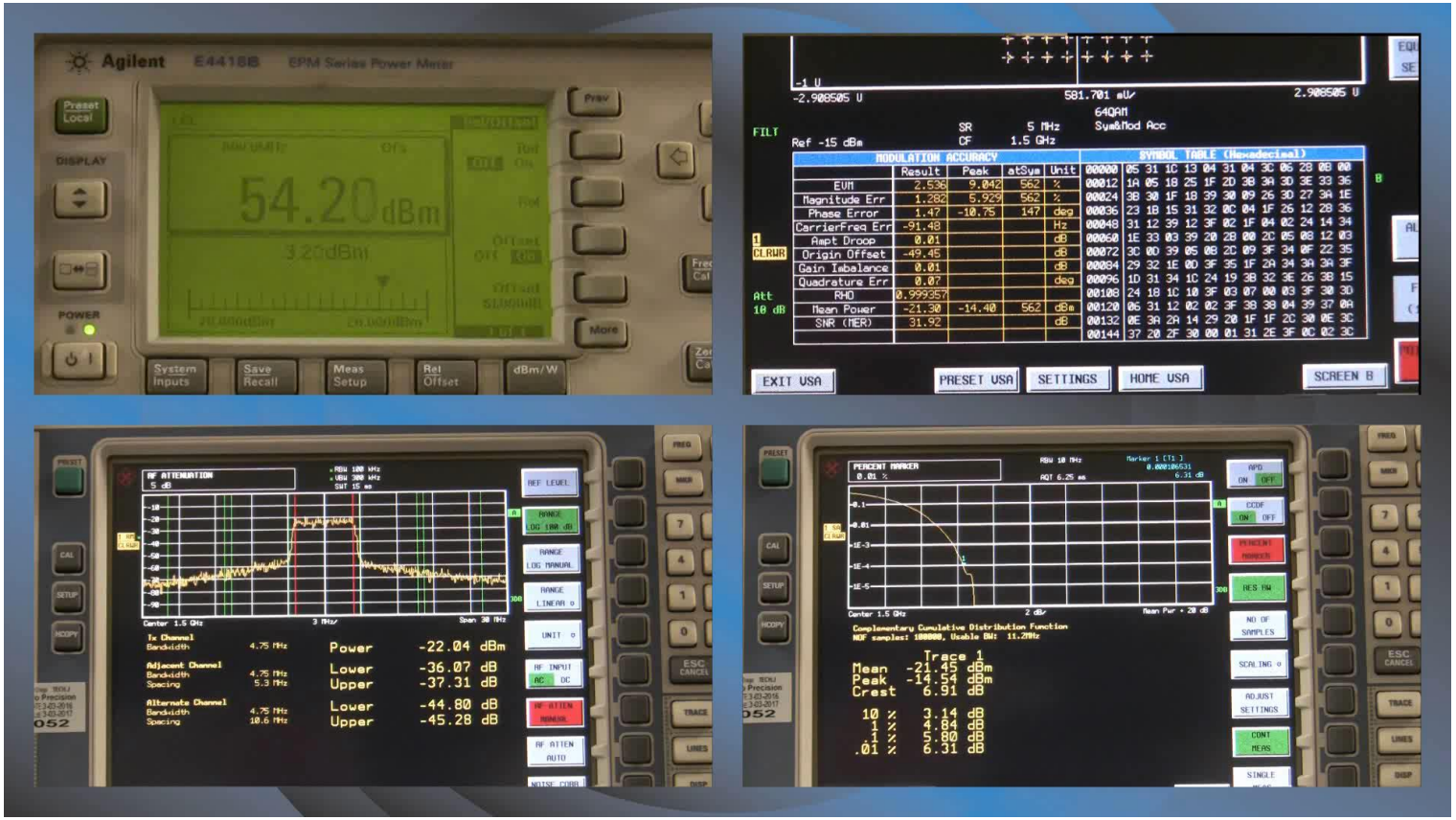
Technology Advancement- Frequency Hopping GPS Denial



Data taken from a 1 – 3 GHz, 1 kW HPA

blanking not required – 10 microsecond hopping between L1 and L2

Technology Advancement - Digital At Nominal Power

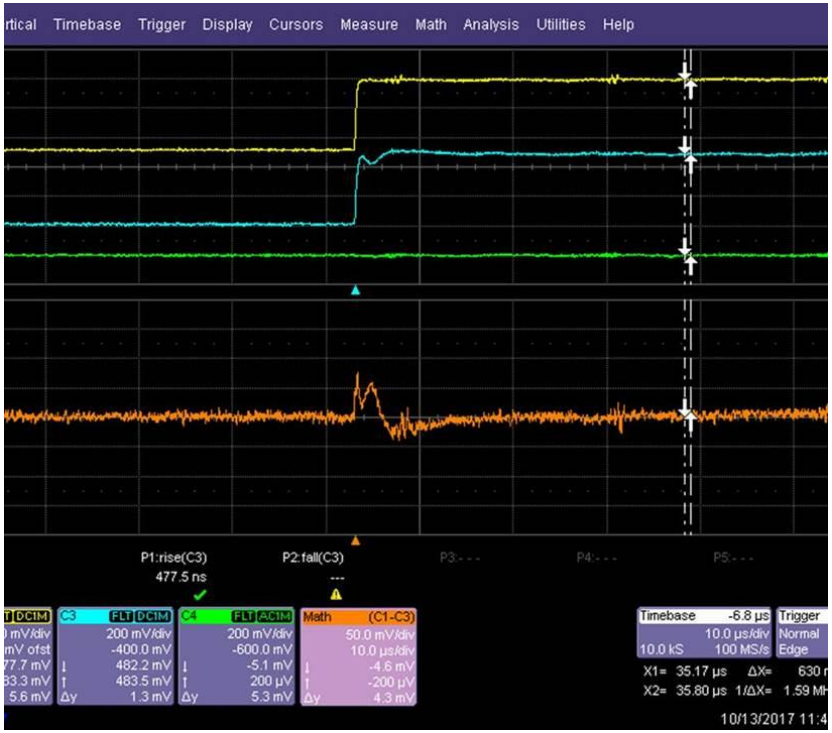


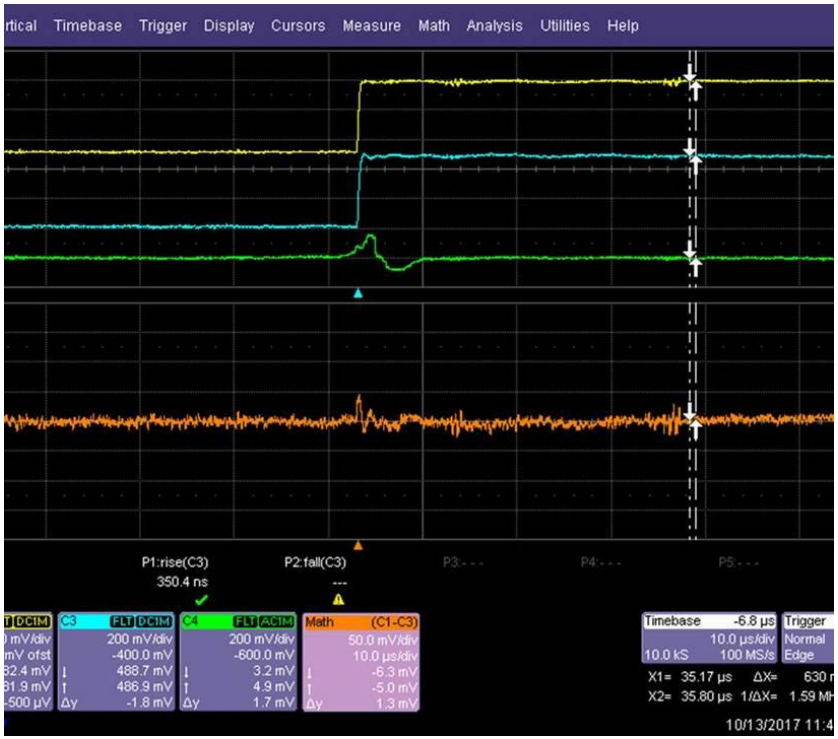
Data taken from a 1 – 3 GHz, 1 kW HPA

"communications grade" signal quality from the same unit used in jamming

Technology Advancement - Pulse Shaping

Pulse correction to enhance the reproduction of the recorded threat



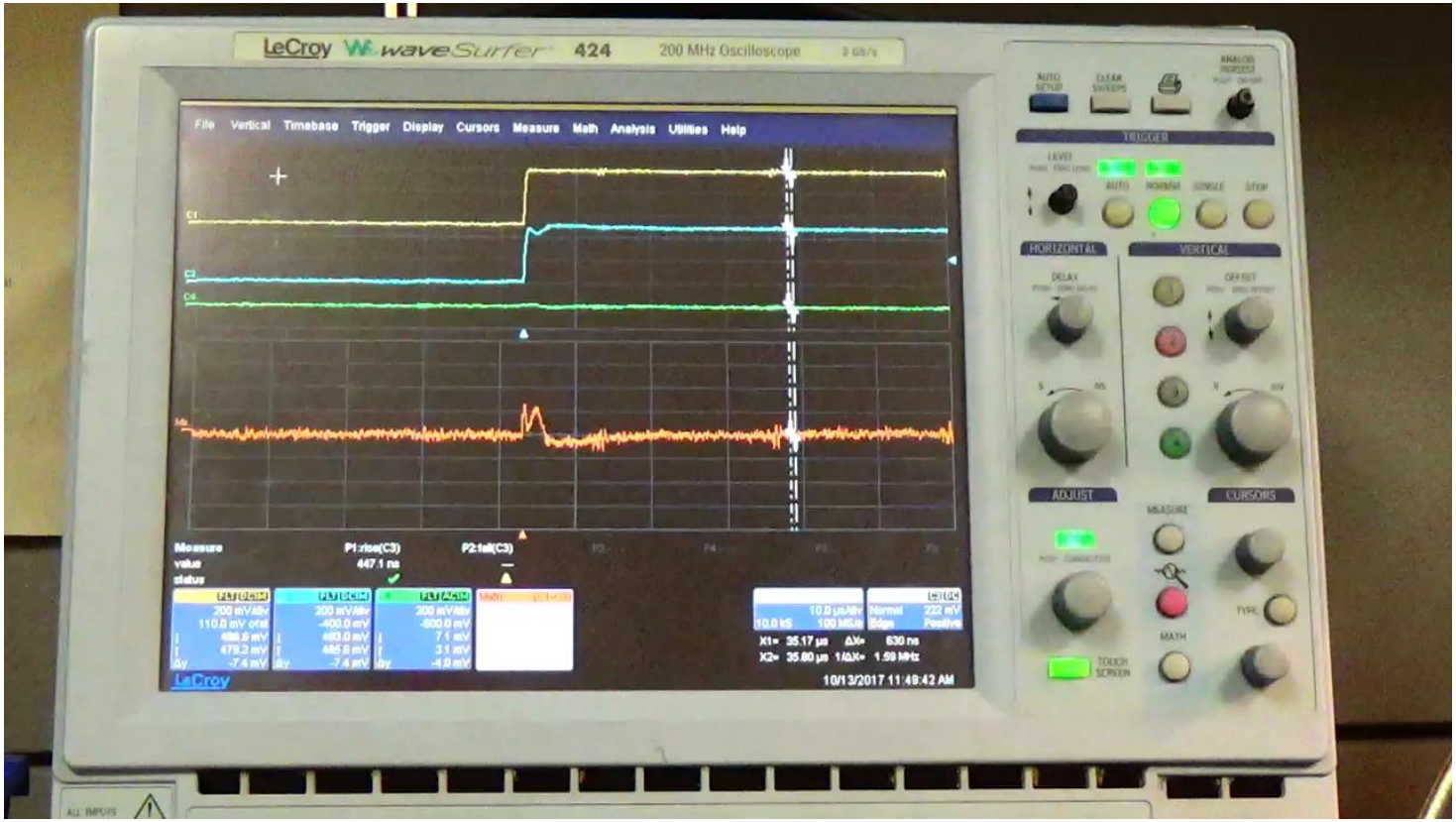


Yellow trace is the input
Blue trace is the output
Green trace is the correction
Orange trace is the error

Left picture is the wiggle in the pulse cause by the PA

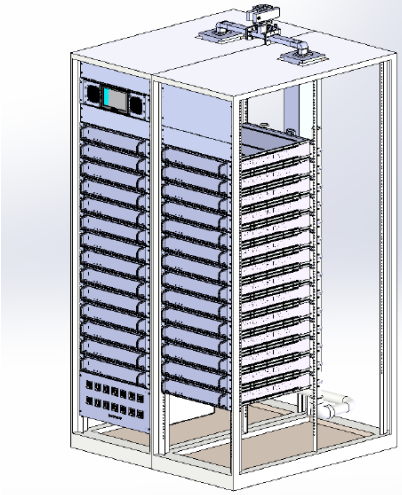
Right picture is applying the correction you can see the wiggle is almost canceled.

Pulse Shaping Demonstration



Technology implementation - scalable, high power

- Solid State Higher Power Solution (S, C and X band)
  - Scalable Power
    - The customer can upgrade the PA to different power levels w/o having to buy a new system
  - A centralized controller allows monitoring and control of the entire system
  - Graceful power degradation in case of fault
  - Hot swappable amplifier up to C-band
  - No single point of failure
  - Low MTTR
  - Enhanced PRF, pulse width and duty cycle



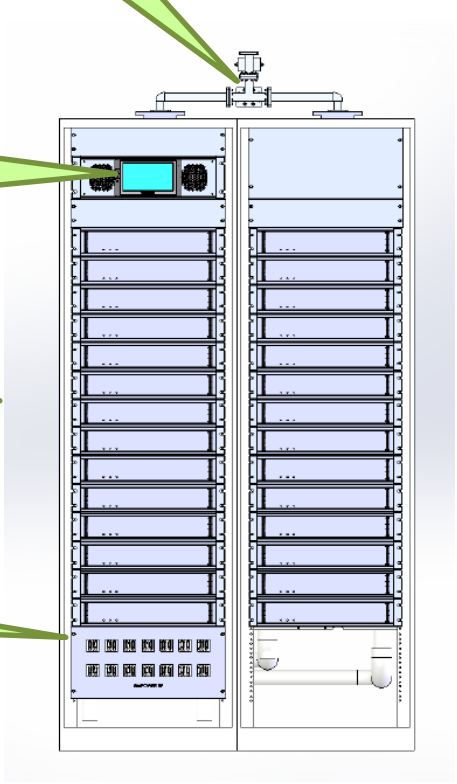
Rack mechanical design

Rack waveguide combiner

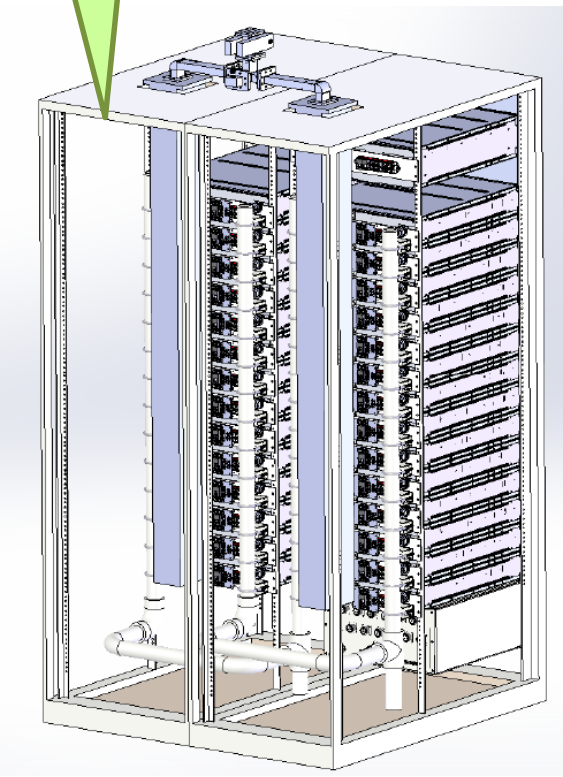
Control System: present only at the left rack, display can be an industrial PC

14 Amplifiers Units per rack

14 Circuit breakers for individual PAs



Rack Rear view



Technology enabled SSPA's – some illustrations of interest

Central Node

2 MHz – 6 GHz coverage
multi-mode, multi-mission

Unmanned Remote Nodes

threat simulator network

20 MHz – 6 GHz coverage - output power up to 1 KW
multi-mode, multi-mission (EW and communications)

Threat Simulators

150 MHz to 450 MHz, 12 KW Pulse
2.9 GHz to 3.5 GHz, 8 & 10 KW Pulse
5.2 GHz to 5.9 GHz, 8 KW Pulse
9.2 GHz to 10 GHz, 8 KW Pulse

scalable power
"system of systems"

Conclusion

"we are moderately prepared for a low end fight, but we have work to do to prepare for a high end fight"

- Threat sophistication is advancing rapidly which makes a flexible, technology enabled HPA essential for EW.
- Technology enabled SSPA brings computing power that has traditionally resided only in a system controller.
- Scalability means shorter time to deployment and an adaptable infrastructure for new requirements.
- Standards based operating systems with technology enabled SSPA's are achievable.
- Leap ahead capabilities in SWaP and SSPA operational adaptability can be brought to this fight now.
- Low speed response kills …

Forward Looking: Adaptive Digital Pre-Distortion

The Resulting Leap Ahead Capability

- The elimination of external filtering and associated insertion loss improving deployment SWaP and cost.
- A single amplifier can perform complex jamming and communications simultaneously