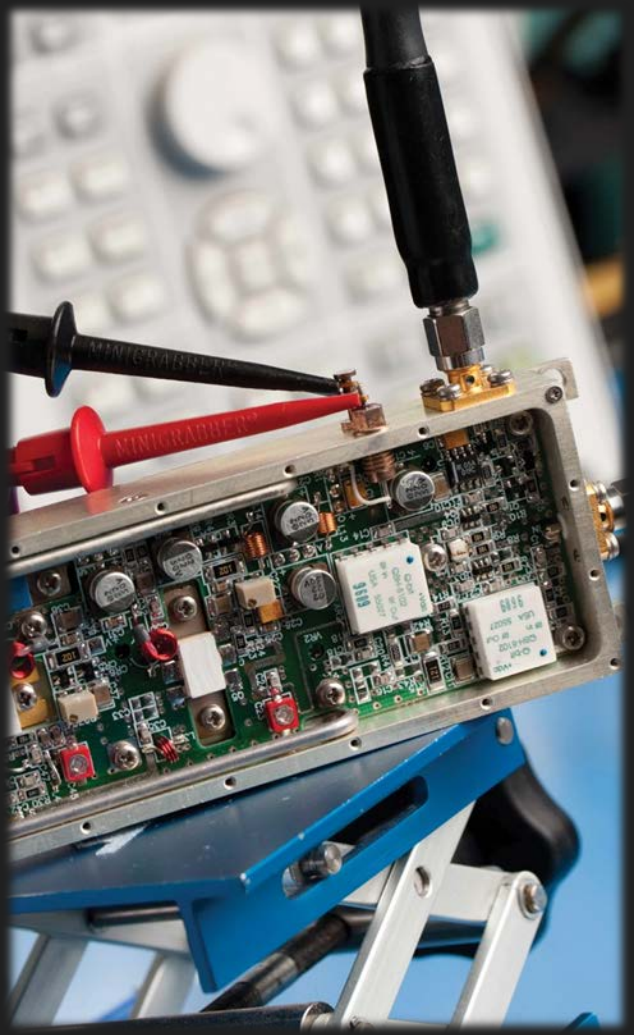


api technologies corp.

POWER AMPLIFIERS

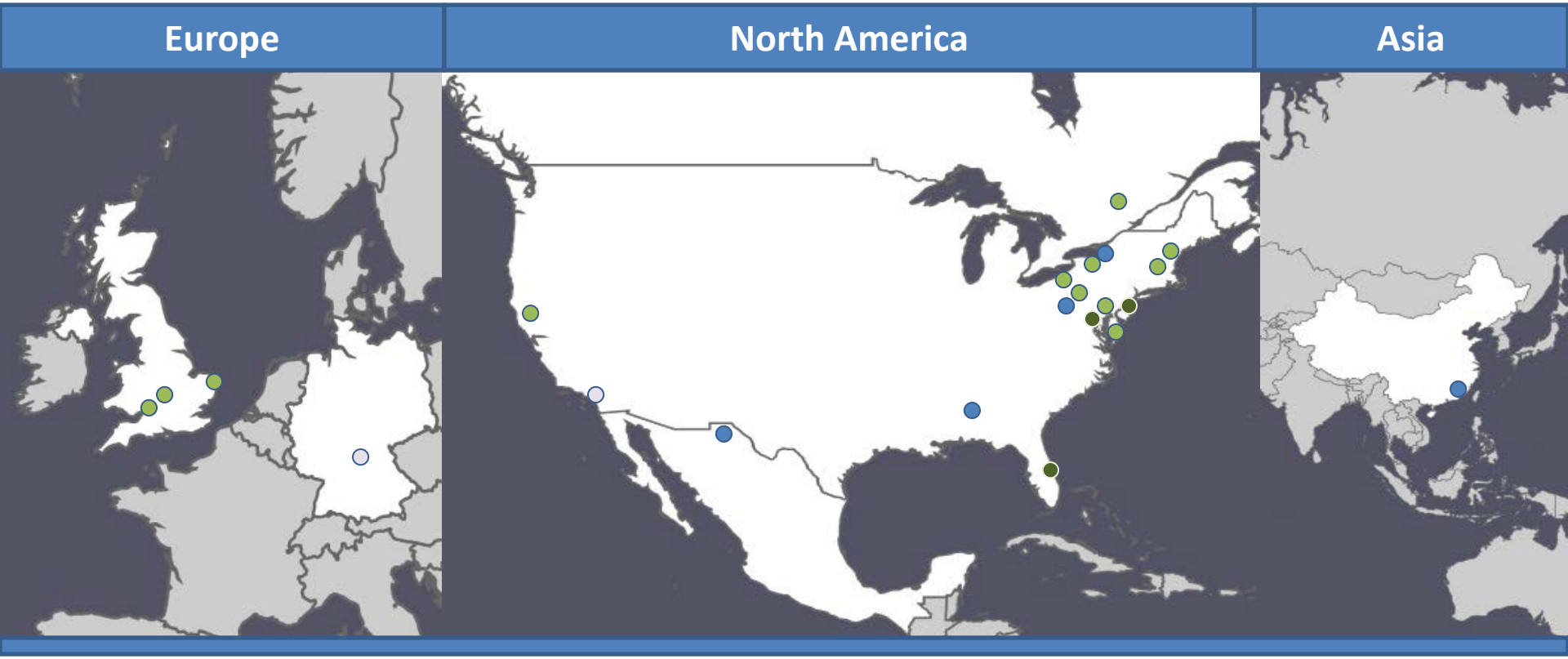
PRODUCT & CAPABILITIES OVERVIEW

COMPANY OVERVIEW

- Premier provider of technically demanding RF/microwave, electromagnetic, power, and security solutions for defense, aerospace, commercial and medical industries
- Founded in 1981; Listed on NASDAQ June 2011 with a new company vision
  - Today, one of the largest non-Prime provider of RF/Microwave and microelectronics products and services
- 1,975 employees worldwide
- 3,000+ customers worldwide
- Revenue breakdown
  - ~75% Domestic / 25% International
  - ~60% Defense & Government / 40% Commercial

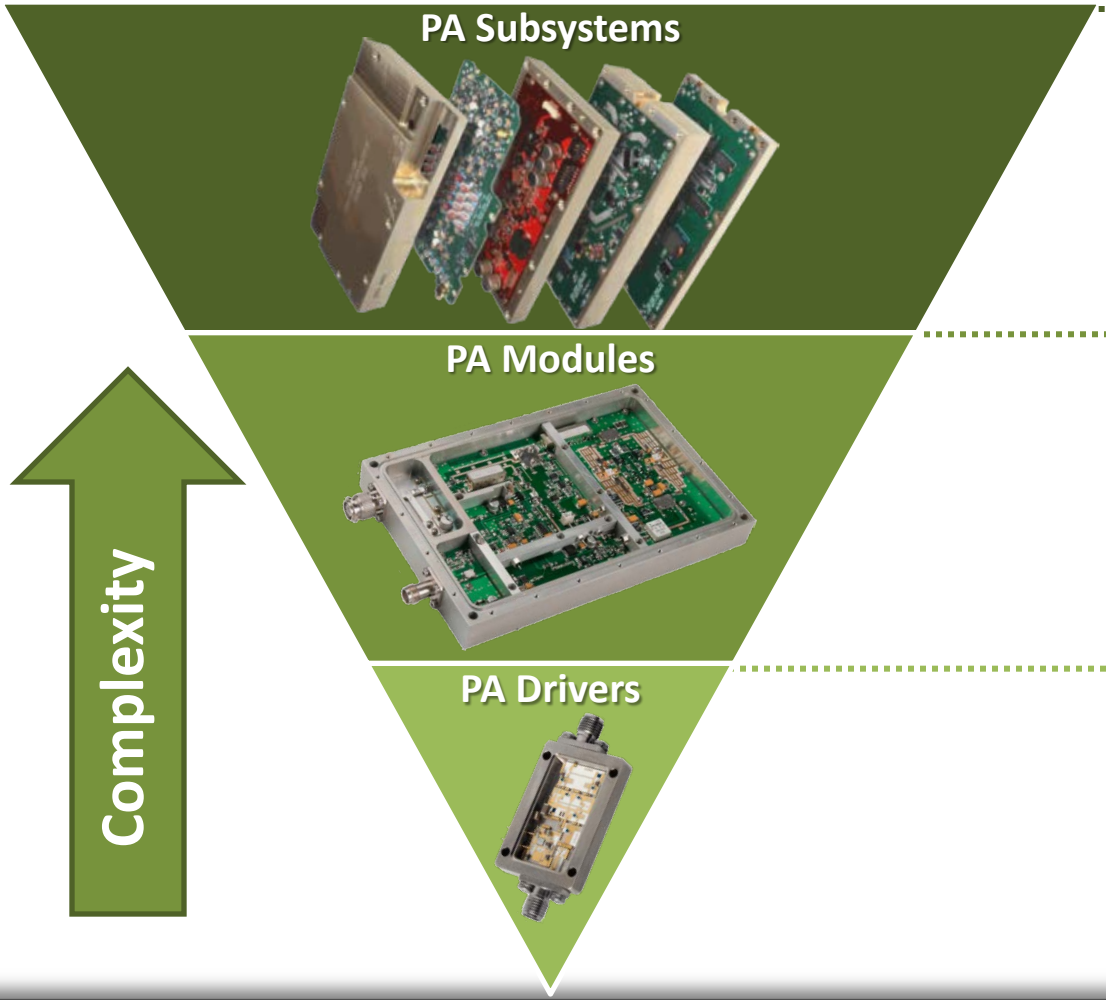
OUR FOOTPRINT

Design & Manufacturing Design Center Manufacturing Center Sales Office



- 12 trusted design facilities worldwide (US, UK, Canada)
- Technology focused: Nearly 20% of our employees are engineers and skilled design professionals
- International manufacturing locations are API companies - not subcontractors; same equipment and processes as U.S.

POWER AMPLIFIER INTEGRATION



Multi-function Amplifier Systems

- Integrated LNA, Filtering, Switching Functions
- Power Conversion
- Digital Control

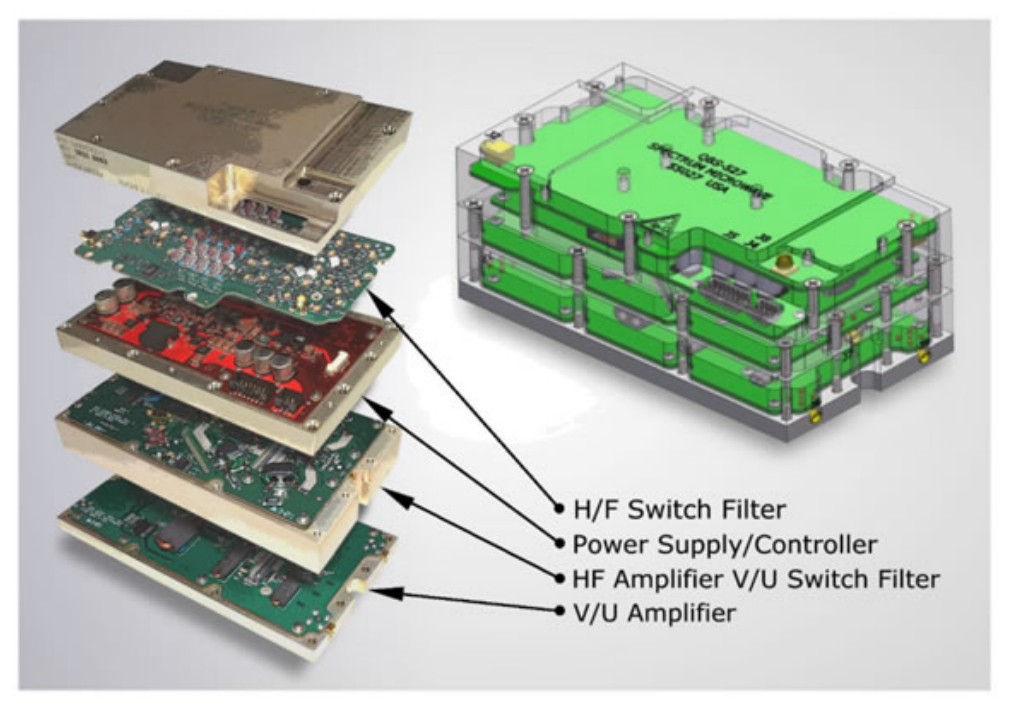
PA Modules - Applications

- Broadband Jamming
- PA Module with Integrated PSU
- Pulsed Radar
- Military Communications
- Co-Site Solutions

PA Driver Optimization

- 3 Stage Amplifier w/ Internal Voltage Regulation
- Class AB Biased for Radar, Jammers
- Balanced Output Stage
- Filtered Input (18 dB/Octave Filter Roll-off)
- Latest GaN Technology

AMPLIFIER SUBSYSTEMS



PA subsystems incorporate multi-band amplifiers, switched harmonic filter banks and high efficiency DC converters with integrated adaptive biasing controls.

Designing and Building Integrated Amplifier Assemblies including:

- **Waveguide Splitter/Combiner**
- **Waveguide Terminations**
- **DC/Control Functions**

TYPES OF API TECHNOLIGES' POWER AMPLIFIERS

Power Amplifier Drivers

- Output Power up to 10 watts
- Includes Class A, and AB Linear Amplifiers
- Operating Frequencies to 26GHz
- Narrow and Broadband

CW Power Amplifiers

- Output Power to 500 watts
- Includes Class A, AB Linear and C
- Operating Frequencies to 26GHz
- Narrow and Broadband

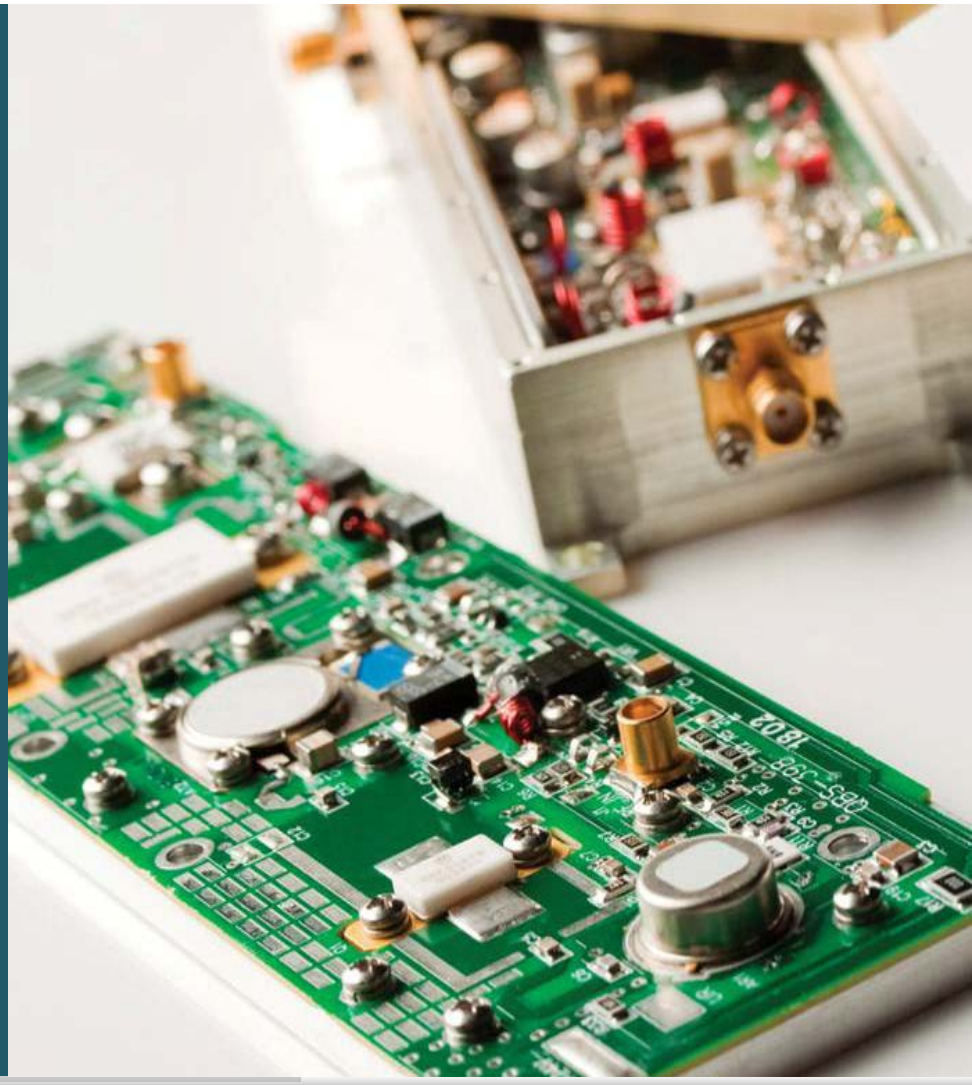
Pulsed Power Amplifiers

- Output Power to 1,000 watts
- Includes Class A, AB Linear, and C
- Operating Frequencies to 26GHz
- Narrow and Broadband

FULL OF STANDARD FEATURES

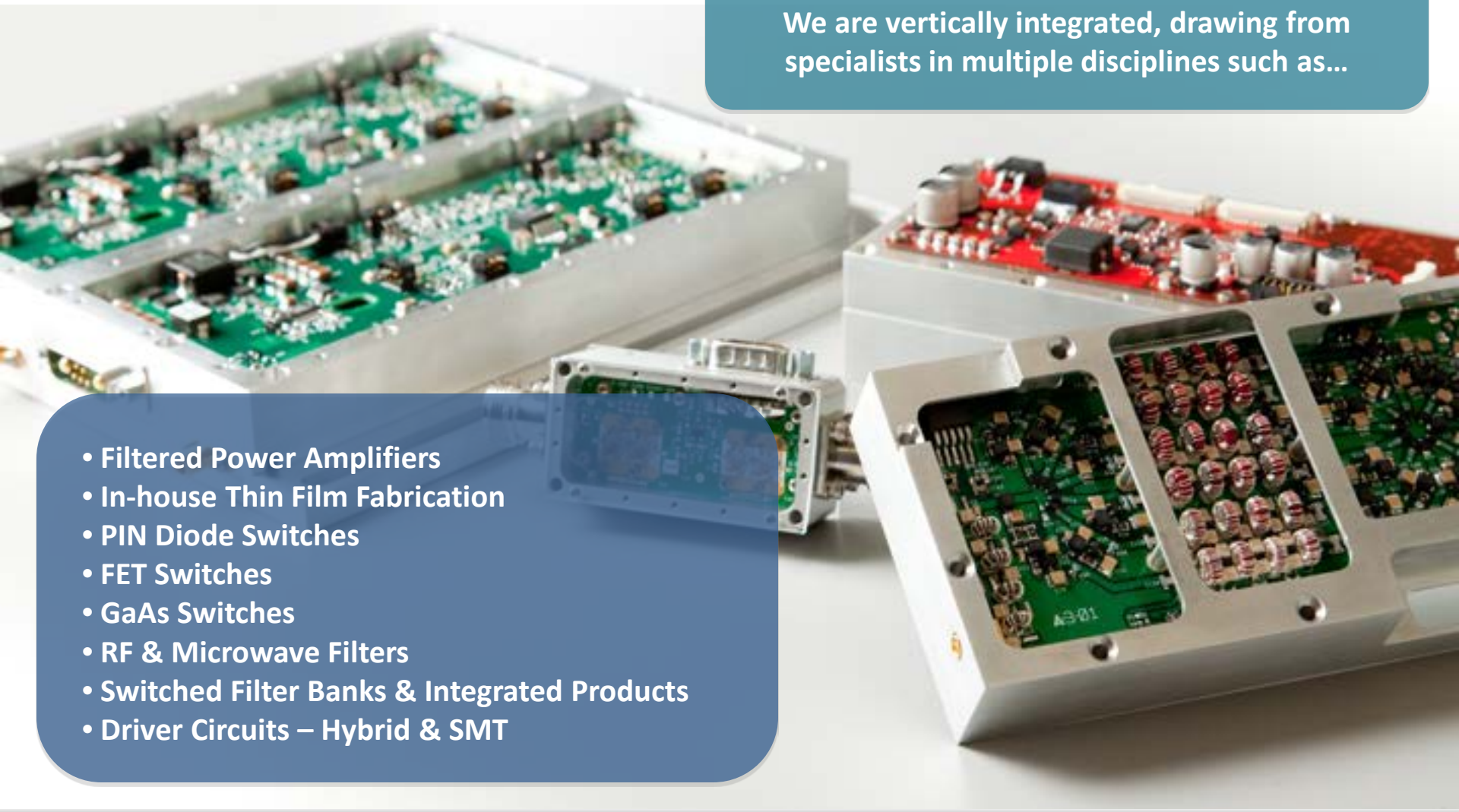
Wide bandwidth and high efficiency are not the only features offered in our full line of higher power amplifiers. API also incorporates many features not normally found in power amplifiers, including:

- **Built-in User Control Interfaces**
- **High input protection circuitry**
- **Built-in monitoring**
- **Voltage Regulators**
- **Thermal temperature compensating circuits**
- **Harmonic Filters**
- **Fault Monitoring**
- **Customizable Control Functions**
- **Custom Designs Available**



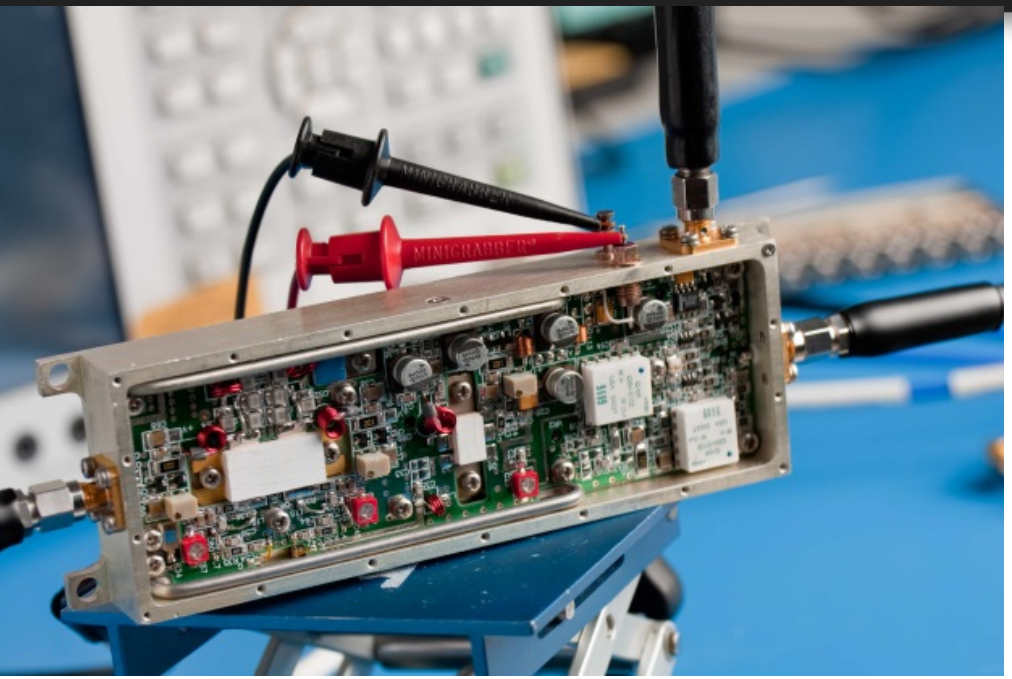
VERTICAL INTEGRATION

More than just single function product designs! We are vertically integrated, drawing from specialists in multiple disciplines such as…



- Filtered Power Amplifiers
- In-house Thin Film Fabrication
- PIN Diode Switches
- FET Switches
- GaAs Switches
- RF & Microwave Filters
- Switched Filter Banks & Integrated Products
- Driver Circuits – Hybrid & SMT

VERTICAL INTEGRATION



Our engineers are experts at amplifier, filter and power supply design. Integrating multiple components in a single housing reduces overall costs and package housing size while optimizing heat transfer.

THE POWER AMPLIFIER ADVANTAGE

The API Technologies Advantage

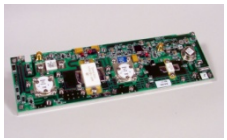
Multiple Technologies: Modular Designs, Thin Film, SMT, Chip-and-Wire, System Integration

Results: Reduced Size, Excellent RF Performance, Improved Thermal Performance

Modular SMT

Surface Mount Amplifier (SMT)

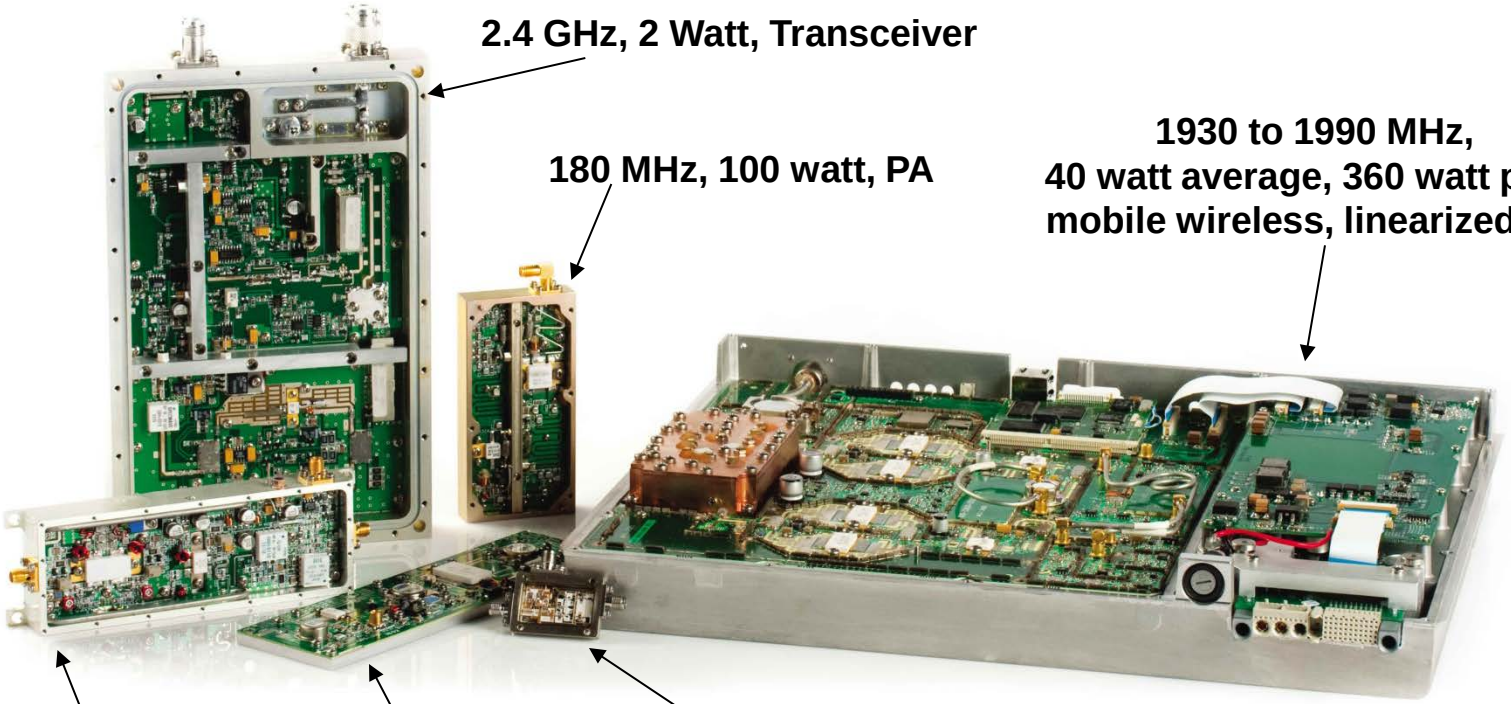
Thin Film Micro-electronic



SMT Pallet

System Integration

POWER AMPLIFIER OVERVIEW

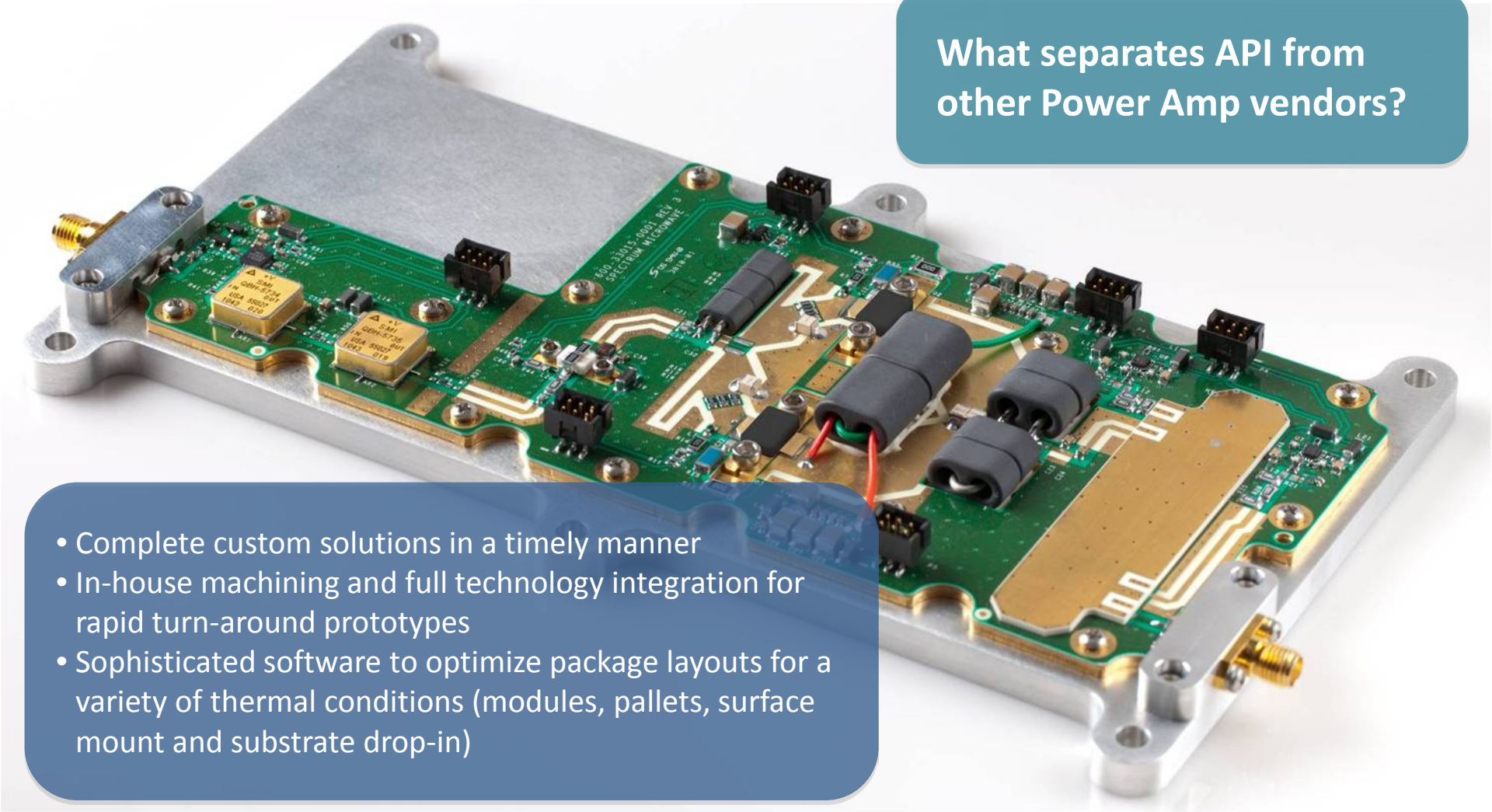


API, a world class leader in amplifier technology, is your full service partner for high performance power amplification requirements.

Designed To Perform

Efficient amplification is a system designer's goal and we design Linear Class A, Class AB and Non-Linear Class C high power amplifiers using the latest technology such as GaN, GaAs and LDMOS. Products include both broadband, high linearity amplifiers, as well as high frequency, narrowband, higher power amplifiers to 100 watts with strict attention to size and value.

FULL CUSTOMIZATION



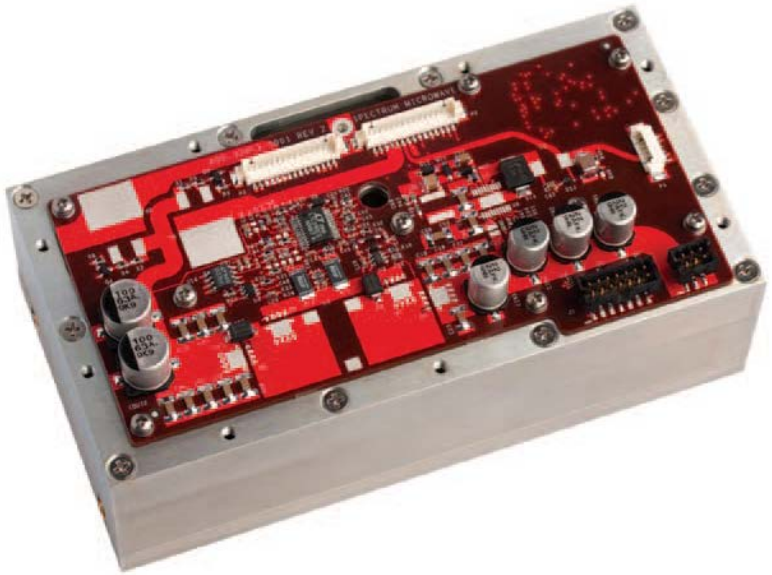
What separates API from other Power Amp vendors?

- Complete custom solutions in a timely manner
- In-house machining and full technology integration for rapid turn-around prototypes
- Sophisticated software to optimize package layouts for a variety of thermal conditions (modules, pallets, surface mount and substrate drop-in)

PERFORMANCE ENHANCEMENTS

API builds added features into its lineup of power amplifiers including:

- Fault Reporting.
- Control & Configuration Monitoring using RS-232, RS-485, MODBUS, I^2C, CAN and other protocols.
- High Efficiency Doherty techniques integrated.
- Optimized for Cross-Cancellation Linearization.
- Drain Boost Efficiency Enhancements Implemented.
- Power & Coupler Feedback techniques employed.

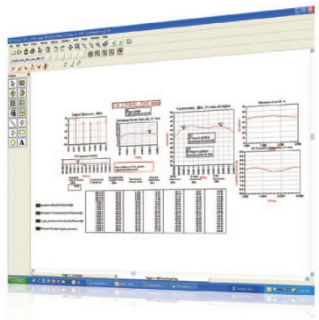


ENGINEERING CAPABILITIES

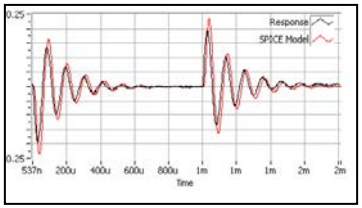
State-of-the-Art Engineering

Using state-of-the-art software and simulation tools, our experience engineering team is able to quickly take a requirement from concept to production.

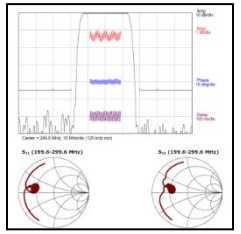
- Ansoft HFSS
- Ansoft Designer
- Microwave Office
- Agilent ADS Design Suite
- SolidWorks
- Labview
- Agilent Genesys
- AutoCAD
- Cadence Allegro
- Sonnet EM Simulator
- PSpice
- PCad
- Or Cad
- Finite Element Analysis for Thermals



3D SolidWorks modeling is used to predict filter profiles as well as to optimize PCB layouts.



orcad
a Cadence product family



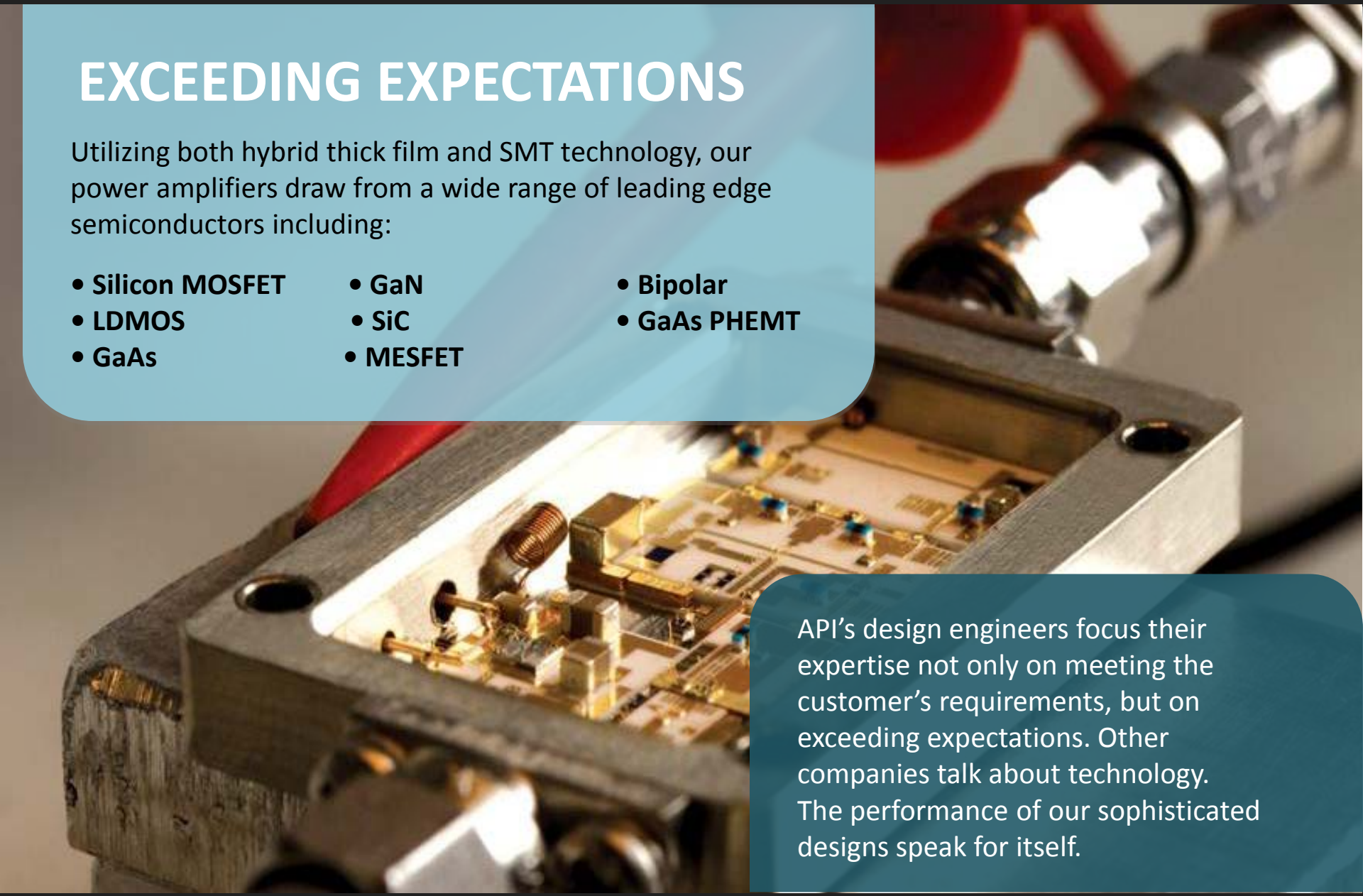
DESIGNED TO PERFORM

- Design Power Amps using GaN transistor technology in both packaged and bare die form
- Nonlinear RF simulation capability of the GaN die
- Detailed theoretical thermal analysis a measurement correlations capability of actual performance
- Unified Design Tools
  - Genesys, Ansoft HFSS, Labview
  - SolidWorks, Cadence Allegro, AutoCAD
  - FLIR Thermal Imaging, Sonnet EM Simulator

EXCEEDING EXPECTATIONS

Utilizing both hybrid thick film and SMT technology, our power amplifiers draw from a wide range of leading edge semiconductors including:

- **Silicon MOSFET**
- **LDMOS**
- **GaAs**
- **GaN**
- **SiC**
- **MESFET**
- **Bipolar**
- **GaAs PHEMT**

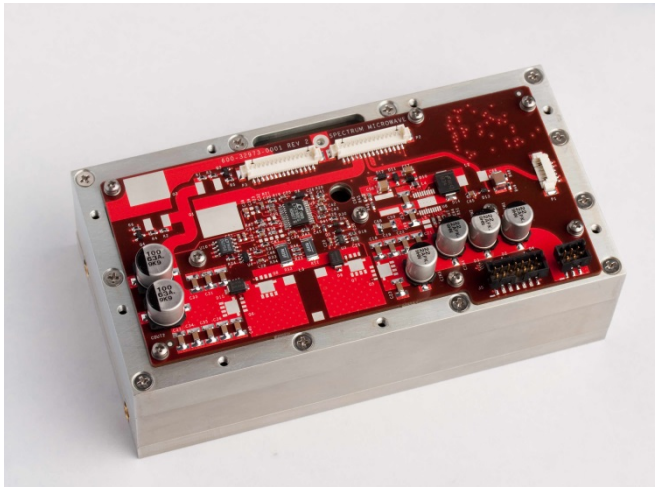


API's design engineers focus their expertise not only on meeting the customer's requirements, but on exceeding expectations. Other companies talk about technology. The performance of our sophisticated designs speak for itself.

SEMI CONDUCTOR COMPARISON

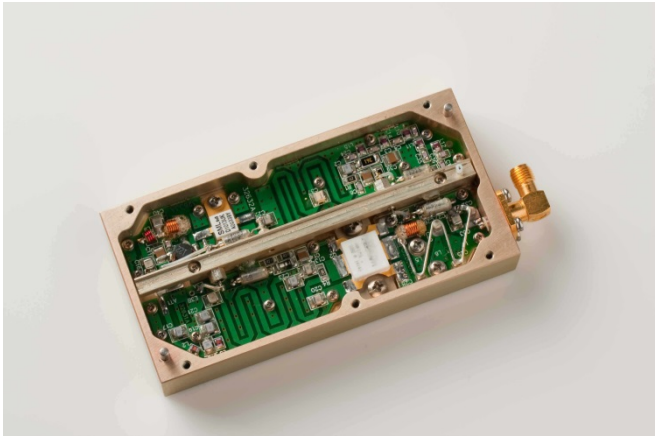
LDMOS

- Linear Applications
- Low Phase Noise Performance
- Low Cost Applications
- Operates at Frequencies up to 3.5GHz
- Not used in rugged designs
- Isolators / Circulators are required in circuit operation



GAS FET

- Linear Applications
- 5X more expensive than LDMOS
- Operates to frequencies up to 26GHz
- Require +10VDC Operation For Linear Applications
- Narrow Bandwidth Operation

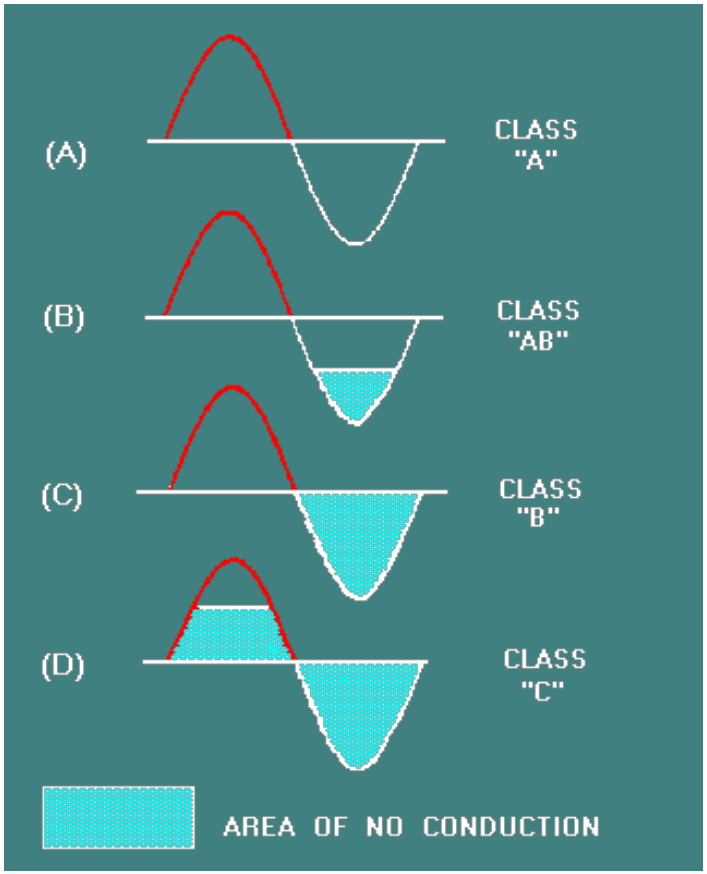


GaN Designs

- Saturated Output Power Applications
- Rugged Designs
- Operates at Frequencies to 26GHz
- Requires input supply voltage >+25VDC
- Suited for wide band operation
- 10X more expensive than LDMOS AND 2x more expensive than GAS Fets.

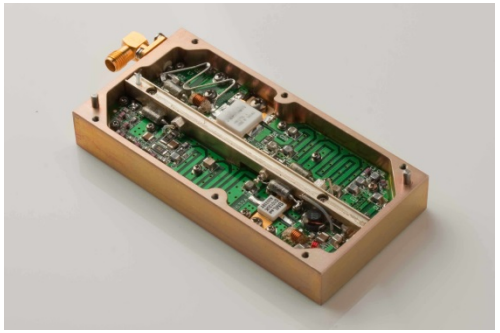
BASIC POWER AMPLIFIER PARAMETERS

Amplifiers, Classes of Operation

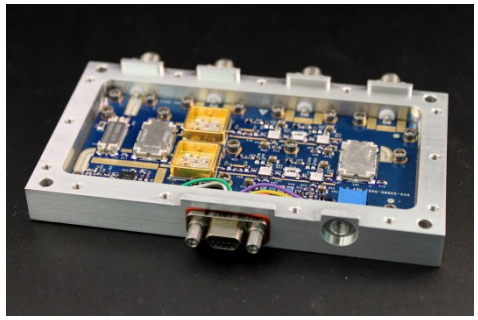


Conduction Angle, Fidelity, Efficiency vs. Amplifier Class

Amplifier Class	Conduction Angle	Fidelity	Efficiency
A	360 °	High	Low
AB	>180° and < 360 °	↓	↑
B	180 °		
C	< 180 °	Low	High



POWER AMPLIFIERS | CLASS A



Class A, Linear, Power Amplifiers

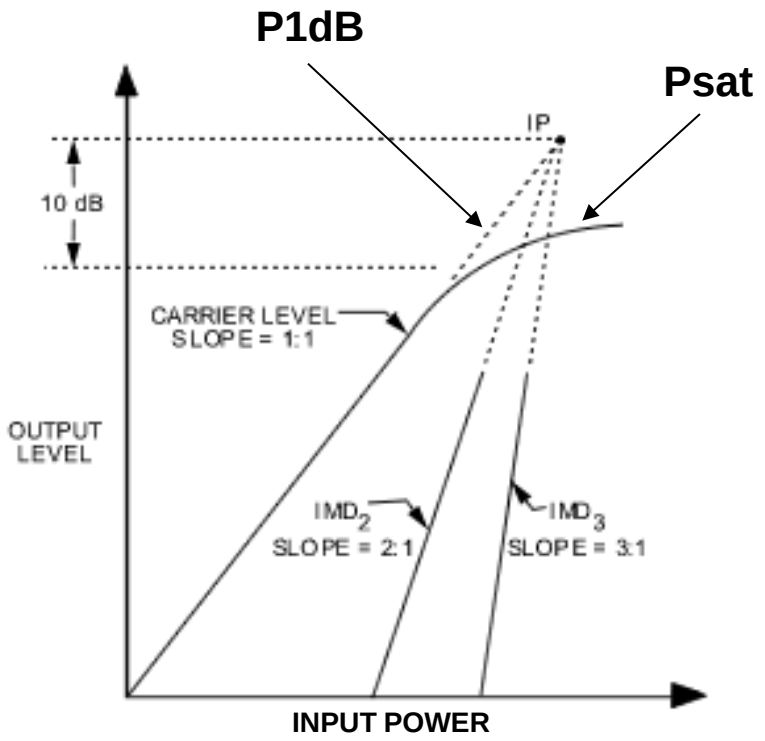
- Best Linearity
- Best Fidelity
- Lowest Efficiency
- Intercept Point is Typically 10 dB above the P1dB
- Intercept Point relates only to Class A amplifiers

$IIP_2 = IMD_2 + Pwr$ (dBm)

$IIP_3 = IMD_3/2 + Pwr$ (dBm)

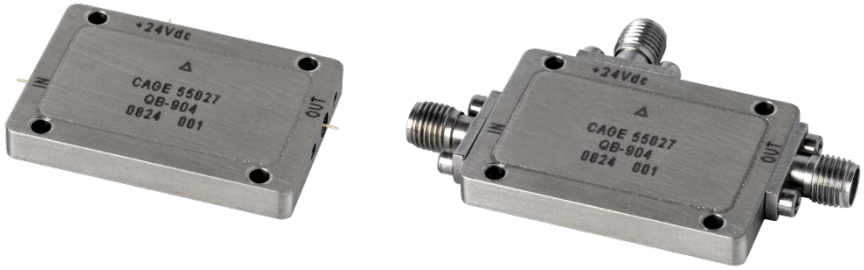
$SFDR_2 = 0.50(IIP_2 - 10\log KTB - NF)$

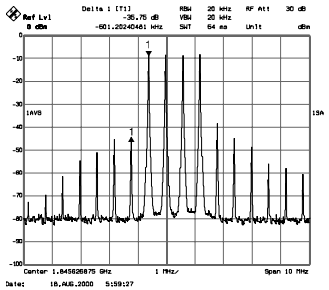
$SFDR_3 = 0.67(IIP_3 + 10\log KTB - NF)$



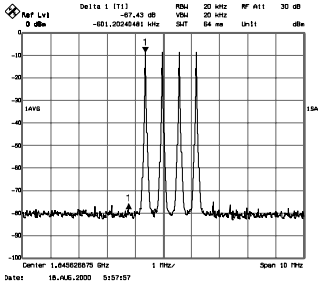
POWER AMPLIFIERS | CLASS AB

- Operate at a quiescent bias “Sweet Spot” for best linearity
- Better Efficiency Than Class A biased Amplifier
- Linearity is bias sensitive

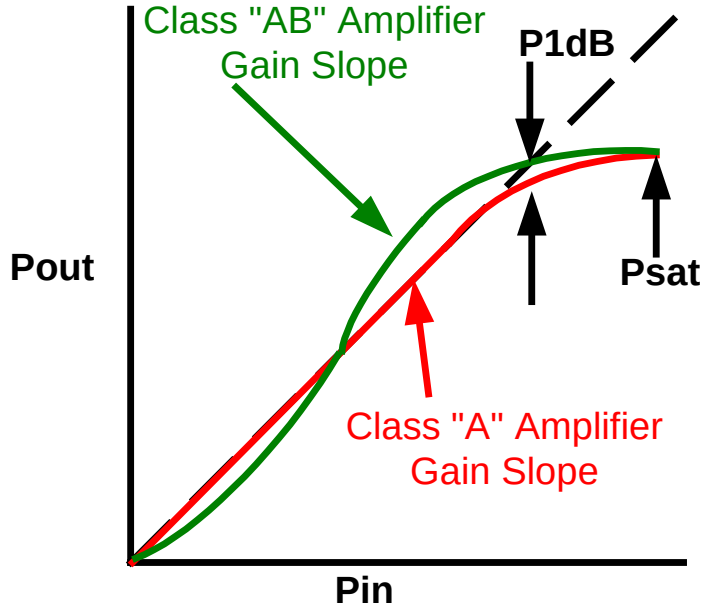




Un-corrected



Linearity Corrected



Gain Slope Comparison, Class A vs. Class AB Amplifier

POWER AMPLIFIERS | CLASS AB

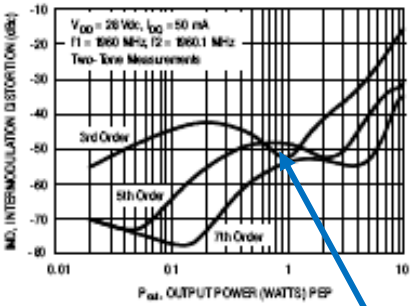


Figure 5. Intermodulation Distortion Products versus Output Power

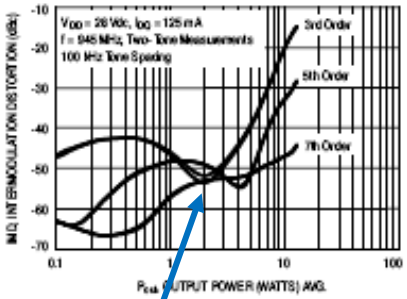
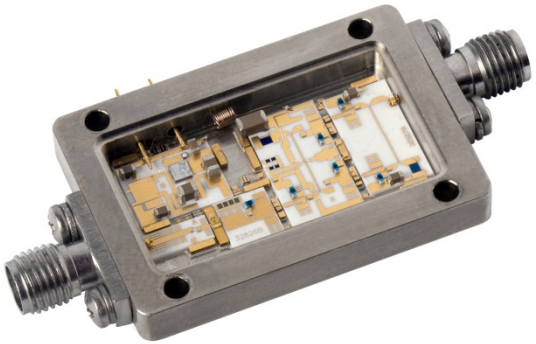
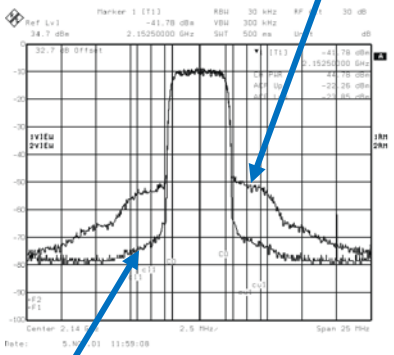


Figure 5. Intermodulation Distortion Products versus Output Power

Quiescent Current Set for "Sweet Spot" at a Particular Power Level



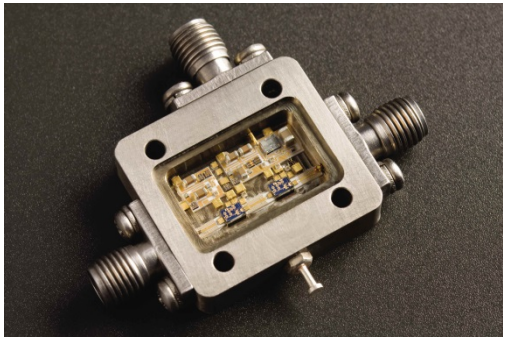
The Effect

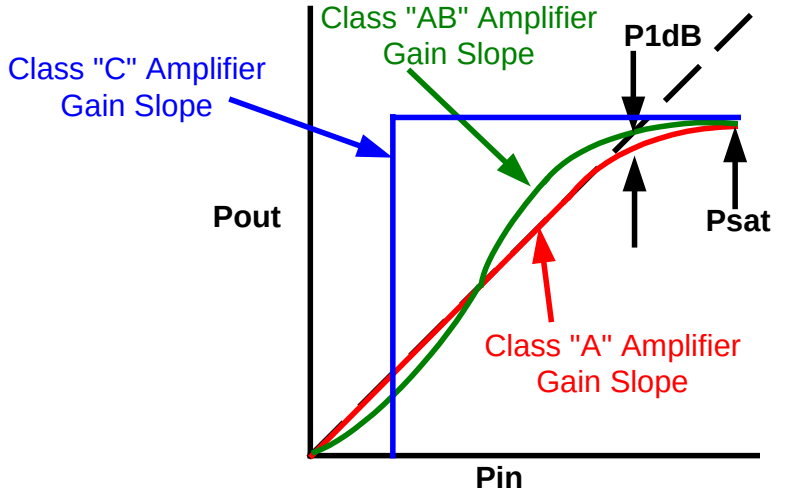


Effects on Digital Modulated Spread Spectrum Signal

POWER AMPLIFIERS | CLASS C

- Biased OFF for < 180 º Conduction Angle
- Better Efficiency Than Class AB biased Amplifier
- Not used for Linear Applications

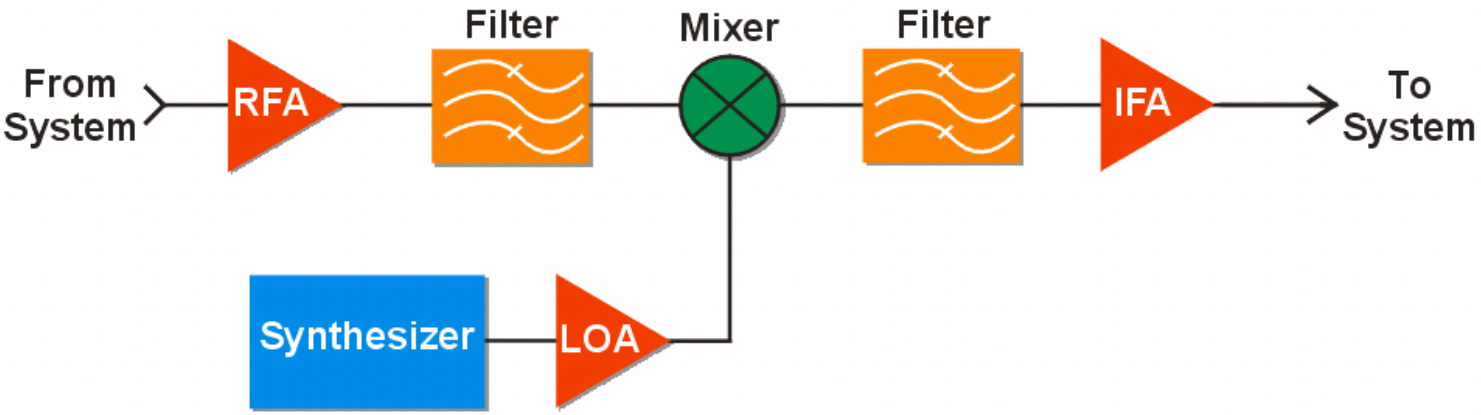




Gain Slope Comparison, Class A vs. Class AB Amplifier

GAIN BLOCKS

- Frequency range: 1 MHz to 18 GHz
- RF/IF drivers and LO buffer amps in Integrated Microwave Assemblies (IMAs)
- Transistor die - extended operating temperature range, -55°C to +125°C
- Power feedback below 1.5 GHz - high reverse isolation reducing load sensitivity
- Frequency selective matching circuits reduces “out-of-band” gain
- Improved efficiency with autotransformers and current sharing
- Utilize the latest technologies: GaN, GaAs, LDMOS

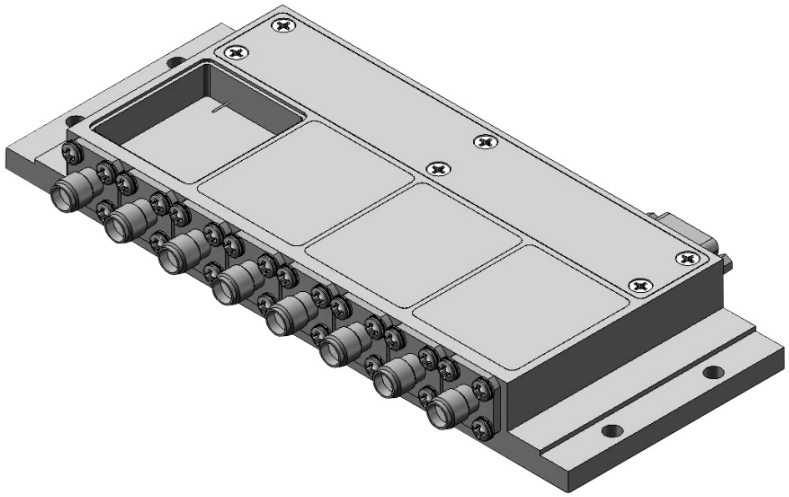


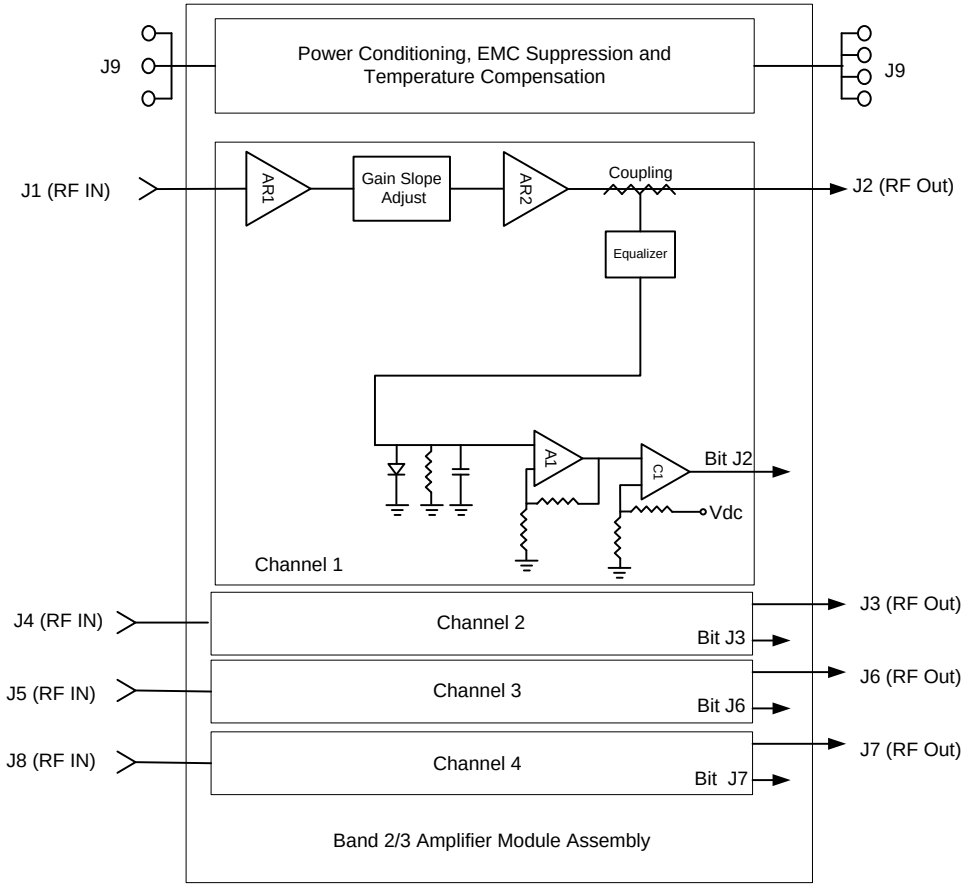
QB-911

Frequency 2-18 GHz (4 phase tracked amplifier assemblies)

Consists of…

- ✓ 2 stage amplifier (4 channels)
- ✓ Broadband detector
- ✓ Gain compensator
- ✓ Digital fault circuits
- ✓ Power conditioning
- ✓ Complex packaging





MANUFACTURING EXPERTISE

- Void-free die attach process for uniform coverage and optimum thermal performance
- Extensive handling and mounting expertise with very large geometry transistor die
- Waveguide combined satellite communication Power Amps up to EHF frequencies.
- Braised waveguide splitter/combiner structures
- In-house Laser Sealing for Hermetic and Environmental Integrity
- In-house Thin & Thick Film
- Precision Hybrid & MIC
- Automated SMT & CCA
- In-house SAW Fab
- Precision Machining
- Comprehensive Metal Works

MANUFACTURING CAPABILITIES

Prototype/ Production Centers

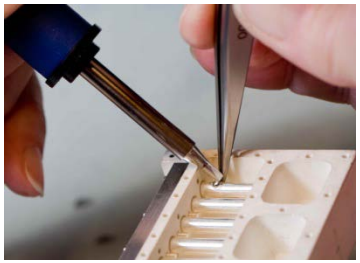
Prototype Machining

CMM (Coordinate Measurement Machine)

Laser Welding

Fabrication & Assembly

J-STD-001, Class 3 Soldering



SMT/Pick n Place

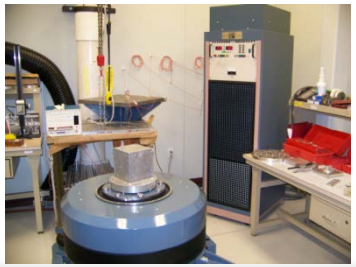
Hybrid Assembly

Electrical & Environmental Testing

Automated Test & Data Recording

Extensive Burn-in and Thermal Cycling Capabilities

Shock & Vibration Testing



EXTENSIVE TESTING

- Full RF/Microwave and Environmental Testing
- Complete ATE Development
- EMC Testing
- 100% Electrical Testing
- Shock Testing & On-site Random and Sinusoidal Vibration to 30g
- Conversion Gain
- Spurious Testing
- IP2, IP3 and IP2H
- Current Draw
- Noise Figure
- Windowed Gain Ripple
- Compression Tests
- Linearity Testing
- LO Leakage Testing
- Image Rejection
- Group Delay
- Temperature Cycling (-55°C to +85°C)

API TECHNOLOGIES' FEATURED CERTIFICATIONS

- All Manufacturing Facilities Certified to ISO 9001:2008
- 6 Certified AS9100 Facilities
- ANSI 20.20 Compliant Facilities
- Department of State ITAR Compliant
- Cleared Facilities & Personnel
- Six Sigma Greenbelts
- Hybrid Lab certified MIL-PRF-38534 (Class H and K)
- QPL MIL-PRF-15733 & MIL-PRF-28861 (Selected Products)
- MIL-STD 790 (DSCC), MIL-STD 1553 (Data Bus), MIL-STD 883 (Hybrid), MIL-STD 202 (Passive), MIL-STD-810 (Systems), MIL-STD 461 A/B/C/D/E (EMC), MIL-STD 1399 Surge (EMC)
- Solder/Assembly J-STD-001 Class 3 and IPC-A-610
- NEBS Approved (Selected Products)
- RoHS Compliant (Selected Products)
- TEMPEST Certifications including: CID/09/15(A), NSTISSAM TEMPEST/I-92, SDIP 27.

Power Amplifier
Points of Contact

Dennis Barrick

- Technical Marketing Manager
- Office: (814) 272-2765
- Mobile: (814) 460-5945
- Email: Dennis.Barrick@APITech.com

Jim Callaway

- Engineering Manager
- Office: 321-426-9011
- Email: James.Callaway@APITech.com