# **AMPLIFIERS TOUR**





APITech offers customizable solutions when more gain, higher power, better linearity or a different bias configuration are desired. APITech engineers pride themselves on designing the best performing amplifiers the industry has to offer.



### The APITech Family of Business

#### **Microwave Components & Systems Business**

- Amplifiers, Mixers, Switches, Oscillators & Sources
- RF/Microwave Filters, Diplexers & Multiplexers, Integrated Multifunction Modules
- Thin Film Substrates, Hybrid Assembly Services

#### **EMI Filter & Components Business**

- EMI Surge Suppression Components & Modules
- Power Line Filters & Power Entry Modules
- Interconnect Devices
- Terminal Blocks & Passive Components

#### **Microwave Components & Systems Business**

- Power Management & Distribution Systems
- AC & DC Power Strips
- Power Monitoring Equipment: Environmental, Electrical, Security, Mechanical

#### **Sensors & Controls Business**

Potentiometers, Temp Sensing Probes, Surge Current Limiters

### **Component Overview**

Leading designer and manufacturer of RF components and integrated microwave assemblies (IMAs)

#### **Products Including**

- Amplifiers (Low Phase Noise, LNAs, High Dynamic Range, Power)
  1 MHz to 18 GHz
- Mixers from DC to 26 GHz
- Voltage Control Oscillators (VCOs) 25 MHz to 18 GHz
- Dielectric Resonator Oscillators (DROs) 2 GHz to 20 GHz
- RF & Microwave Filters
- Switched Filter Banks, Integrated Products
- Rotary Joints, Phase Shifters, Couplers

#### **Products Including**

• Military Electronics, Avionics, Aerospace, and Commercial

### 30 Years Of Design & Manufacturing Experience

- · Over 600 Microwave employees (75 Engineers)
- Access to lower cost manufacturing
  (APITech commercial RF facilities in Mexico & China)
- A | Columbia, MD

Acquired July 2002 (FSY)

- B | Delmar, DE
  Acquired February 2004 (Salisbury Engineering)
  C | Palm Bay, FL
  - Acquired October 2004 (Q-bit)
- D | Philadelphia, PA Acquired February 2005 (Amplifonix)
- E | State College, PA Acquired January 2007 (EMF Systems)
- F | Marlborough, MA Acquired September 2008 (Satcon-Film MicroElectronics) Acquired December 2009 (IDT-MicroNetworks)
- G | Auburn, NY Acquired December 2009 (IDT-Creative Electric) H | Nashua, NH

Acquired XXXXXX 2010 (Sage Electronics)







### Global Design & Manufacturing Locations

### Substrate Manufacturing

• In-house thin & thick film capability

### **Electronics Production**

Precision hybrid, CCA & MIC capability

### **Mechanical Production**

• Precision machined parts

### **Integration & Testing**

Full RF/Microwave and environmental testing

### **Documented Procedures**

ISO 9001:2000 Certified

### **Unified Design Tools**

Genesys, Solidworks

### Personnel

- Over 600 microwave employees
- Over 75 engineers (and hiring)





### **Juarez Operation**

APITech Low Cost Manufacturing Center: MEXICO











### **Dongguan Operation**

### APITech Low Cost Manufacturing Center: CHINA

#### **Domestic Airports**

- Shenzhen
- Guangzhou (also Intl.)





### **Product Line Overview**

### Hybrid Components, Mixers & Advanced Technologies

- In-house thin & thick film capability
- 30 year heritage design database
- Quick turn prototypes (2-4 days)
- Complete testing & ESS capability
- Rapid military to low cost conversion
- Modular assemblies

### Filter Components & Integrated Filter Assemblies

- Complete filter solutions
- In-house machining
- Complete testing & ESS capability
- 20 year heritage design database
- Focused design centers for quick turn prototypes (2-4 weeks)

### Frequency Sources & Integrated Microwave Assemblies

- 80% critical component content
- In-house development of ATE
- 25 IMA engineers with 22 years average experience





### Amplifiers | Packages-Hybrid

### **Hermetically Sealed**

- 100% testing over temperature extremes
- Gross and fine leak
- Constant acceleration up to 10,000g
- 160 hour burn-in at 125°C

#### Ceramic Surface Mount (QBH-8000 series)

- · Alumina substrate and cover
- Thick film metallization
- Utilize both chip & wire, and SMT components
- 100% testing at 125°C

### Generation II (QBH-2000 series)

- Soft substrate (PTFE) designs
- Strictly surface mount components
- Assembled with Sn96

### **Standard Commercial**

• Developed by large manufacturers (i.e. Motorola, Philips)



# Amplifiers | Performance

### **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,  $-55^\circ C$  to  $+125^\circ C$
- Power feedback below 1.5 GHz high reverse isolation reducing load sensitivity (QBH-1401)
- Frequency selective matching circuits reduces "out-of-band" gain
- · Improved efficiency with autotransformers and current sharing
- Low phase noise
- LCA package for cost sensitive programs (< \$35)



### Amplifiers | Hi-Reverse Isolation

- Palm Day (previousl Q-bit) Hi-Reverse Isolation designs are typically 10-15 dB better than general RF amplifiers
- Excellent in Synthesizers, Exciters and Oscillator Assemblies
- Often saves customer the price and real estate of an isolator



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### Amplifiers | Low Noise Performance

### **Low Noise Amplifiers**

- 10 MHz to 6000 MHz
- Low frequency (<500 MHz) designs generally use silicon bipolar transistors and incorporate the low loss benefits of power feedback to adjust gain and VSWR
- High frequency (>500 MHz) designs based on GaAs MESFET and PHEMT technology
- Integrate high Q components (I.e. air coils, low ESR caps)
- Discrete first stage followed by MMICs

#### **QBH-920**

#### QBH-2001

- 30-200 MHz
- 1200-1600 MHz
- 1.4 dB typical noise figure
- 8.0 dB gain
- 3rd/2nd order IP: 42/59 dBm
- +15.0 Vdc/29 mA
- 22.0 dB gain +3.0 dBm P1dB
- +15.0 Vdc/40 mA

• 0.85 dB noise figure



### Amplifiers | Broadband Performance

### Broadband

- Combine low Q resistive feedback networks, voltage shunt and current series, to establish gain window and input/output VSWR
- Use discrete Silicon Bipolar or GaAs MESFET/PHEMPT devices in die form to tightly control the parasitic inductance of wire bonds







### Amplifiers | Low Noise Amplifiers

#### QB-914

- 4.0-8.0 GHz
- Gain: 32 dB typical
- NF: 1.8 dB
- P1dB: 17 dBm
- 3rd order IP: 23 dBm
- +12 Vdc/125 mA





### Amplifiers | High Dynamic Range Performance

### **High Dynamic Range**

- Relatively low noise with excellent linearity (low distortion)
- Bias medium power transistors (<4 watts) at 10-20% loss to achieve an optimum tradeoff between noise figure and distortion
- Low frequency (<200 MHz) designs push-pull configuration using Si bipolar devices in a patented feedback topology (QB-101)
- Used as the input stage in multi-carrier receivers. Allows reception of large input signals without distorting the amplifier output.

#### QB-101

#### **QBH-2001**

Military/Space

- IF Amplifier
- 2-70 MHz
- 22.0 dB gain
  - 4.0 dB Noise Figure
  - 3rd/2nd Order
    - Output IP3 +54 dBm
    - Output IP2 +110 dBm
  - +24 Vdc/400 mA



• 3.0-4.0 GHz

- +36.0 dBm 3rd Order OIP

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### Amplifiers | Architecture/ Topologies

### **Resistive Feedback**

- Ultra wideband with performance over multiple octaves
- Reverse isolation is typically 6 dB higher than the gain
- Easy to integrate making it ideal for multiple gain stages in a small package



### **Resistive Feedback**

- Use twisted-wire transformers, printed 3 dB hybrids, or Lange couplers to combine parallel stages, 90° out of phase
- Maintain excellent input/output VSWR while intentionally mismatching the RF transistor to optimize noise figure, output power, and distortion
- Redundant design if a branch fails, noise figure increases 3 dB and gain drops about 6 dB

### **Push-Pull**

- Baluns (**bal**anced to **un**balanced) connect parallel cascode stages 180° out of phase
- Broadband with excellent gain stability and linearity, especially the 2nd Order OIP. Configuration theoretically cancels evenharmonic distortion products.



### Amplifiers | Ultra Low Phase Noise Performance

#### **Ultra Low Phase Noise**

• We achieve **guaranteed** (100% tested) performance using high performance silicon bipolar transistors in unique circuits up to 2 GHz

#### **Benefits**

- Improves error rate in telemetry apps
- Improved sub-clutter visibility in radar apps
- Better signal to noise ratio in receivers

### TM9119PM

Frequency 100 Hz	Typical -165	Guaranteed -160 dBc/Hz	
1 kHz	-172	-167 dBc/Hz	
10 kHz	-177	-172 dBc/Hz	
100 kHz	-179	-174 dBc/Hz	
1 MHz	-180	-175 dBc/Hz	

APITech is the **only hybrid amp manufacturer** that guarantees low-phase noise performance on it's standard line of parts. We've invested heavily in high-performance test equipment including Agilent network analyzers, low-phase noise signal generators, an enhanced Agilent ES5500 phase noise measurement system, and additional in-house environmental test equipment.





### Amplifiers | Ultra Low Phase Noise Performance

#### **Ultra Low Phase Noise**

Guaranteed performance (100% lot testing) up to 6.0 GHz

### Frequency <2 GHz

• Use silicon **bipolar transistors**. Combine multiple die with high ft in parallel to achieve bandwidth and power



#### 600 MHz @ Pout = +24 dBm

### Amplifiers | Ceramic Lower Cost Amplifiers

### **Ceramic Surface Mount Hybrid**

- Units shipped in feeder tubes, or tape & reel for automated PCB assembly
- Able to convert designs in hermetic packages into cost-effective surface mount solutions for the customer without performance degradation
- Excellent thermal characteristics RF transistor is eutectically attached to a copper carrier, which is soldered directly to the package heat spreader



Package Heat Spreader



### **PCB Materials: Thin Film**

- PCB Materials: Thin Film
- Purchase metallized substrates Alumina (99.5%), BeO and AIN
- State College facility capable of etching circuit patterns with an accuracy of 2.0 mil wide lines and 2.0 mil spacing

### **PCB Materials: Thick Film**

- Purchase Alumina (96%) substrates with machined vias and/or slots for transistor carriers
- Screen print and fire the circuit pattern with the following pastes:
  - Gold wire bonding
  - Palladium silver solder chip components, thermocompression (TC) welding
  - Resistive pastes bias networks/attenuators
- Thick film copper available for high volume applications





### Amplifiers | Generation II Package

### **Generation II Product**

- · Packaged in tape & reel for pick and place applications
- Completely automated assembly with a single reflow to attach components and cover
- No tuning / alignment
- Metal cover provides circuit isolation
- LNA and lower power (P1dB < 26 dBm) designs
- Intended for high volume applications; price < \$15</li>



### Amplifiers | Ceramic Lower Cost Amplifiers

### LCA assembled with high volume processes

- Extensive use of fixtures
  - Screen print solder paste in the array
  - Align and reflow backside heat spreader in the array
  - Eutectic attach transistor in SST (vacuum reflow) using carbon "boats" to align die on copper carrier, 20x20 matrix or larger
- · Automated pick & place of chip components in the array
- Autobonder

### LCA assembled with high volume processes

Customer's needs	APITech's LCA	MMICs
Never Obsolete	✓	End-of-life / Next generation forces system redesign.
True 50 Ohm Match	~	Additional components means additional design time and Real Estate.
Superior Phase Noise	$\checkmark$	Not tested or guaranteed in production.
Guaranteed Performance -55°C to +85°C	✓	Always Typical Values / Graphs.
No External Components Needed		Blocking caps are just the beginning
Low Cost	$\checkmark$	✓

- Frequencies to 4000 MHz
- Output power to 4 watts
- No external biasing or RF matching circuits required
- Available in tape & reel

### Large Cu/Mo Ground Plate



### Amplifiers | Broadband Power Amplifiers

#### QB-904

- Class AB, 3 stage design
- +24 VDC/900 mA @ Pout
- Balanced architecture for good VSWR
- Combination of PHEMPT and GaN device technologies in die form
- 35 dB gain with 4 watts Pout



#### **Specifications**

#### Parameters (Typical at 25°C) **Power Amplifier Models** QB-904 (4 watt) **Amplifier Series** QB-910 (1/2 watt) QB-909 (Medium Gain) Frequency Range (MHz) 2,000-6,000 2,000-6,000 2,000-6,000 Gain (dB) 35 27 17 Gain Flatness (dB) +/- 2.5 +/- 2.0 +/- 1.0 Power Output (dBm) +36 +28 +19 DC Voltage (Vdc) 23-29 23-29 8 DC Current (mA Quiescent) 285 185 100 Noise Figure (dB) 8 7 5.5 SMA Female or Gold Plated 0.015 pin RF Input/RF Oautput Connector DC Input SMA Female or Gold Plated 0.015 pin



# Amplifiers | Performance

#### **Medium Power**

- Frequency range 1 MHz to 6 GHz
- Hybrids are class A with output powers up to 4 watts @ P1dB
- Connect parallel stages in a push-pull or balanced configuration
  - Design miniature 900 hybrid couplers and baluns -adjust the windings to optimize parameters
  - Topology distributes heat throughout the package





### Amplifiers | QB-904 Performance, 4 watts 2-6 GHz

### QB-904

- 3 Stage Amplifier with Internal Voltage Regulation
- Class AB Biased for Radar, Jammers, Communications Transmit Applications
- Balanced Output Stage for Good Broadband Output Return Loss
- 4 watts Output Power over 2 to 6 GHz Band
- Filtered Input (18 dB/Octave filter roll-off)
- Latest Gallium Nitride (GaN) device Technology
- 38 dB Small Signal Gain
- Connectorized or Printed Wiring Board Mount (solder attach 0.015" pins)
- Small Size
- Optional Heat Sink Available





### Amplifiers | QB-904 Performance, 4 watts 2-6 GHz

#### **Specifications**

Parameters (Typical at 25°C)	<b>Typical Specifications</b>				
Frequency Range	2.0 to 6.0 GHz				
Small Signal Gain	38 dB				
Gain Flatness	+/- 3.0 dB				
Input Loss Return	10 dB				
Output Return Loss	12 dB				
Output Power (Psat)	+36 dBm				
DC Voltage (Vdc)	+23 to +29 VDC				
DC Current (mA Quiescent)	285 mA				
Noise Figure (dB)	8 dB				
RF Input/Output Connector	SMA Female or Gold Plated 0.015 pin				
DC Input Connector	SMA Female or Gold Plated 0.015 pin				







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# Amplifiers | QB-910 Performance, 0.5 watts 2-6 GHz

### **Specifications**

Parameters (Typical at 25°C)	<b>Typical Specifications</b>			
Frequency Range	2.0 to 6.0 GHz			
Small Signal Gain	27 dB			
Gain Flatness	+/- 2.0 dB			
Input Loss Return	10 dB			
Output Return Loss	8 dB			
Output Power (Psat)	+28 dBm			
DC Voltage (Vdc)	+23 to +29 VDC			
DC Current (mA Quiescent)	185 mA			
Noise Figure (dB)	8 dB			
RF Input/Output Connector	SMA Female or Gold Plated 0.015 pin			
DC Input Connector	SMA Female or Gold Plated 0.015 pin			



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# Amplifiers | QB-909 Performance 19 dBm, 2-6 GHz

### **Specifications**

Parameters (Typical at 25°C)	Typical Specifications			
Frequency Range	2.0 to 6.0 GHz			
Small Signal Gain	17 dB			
Gain Flatness	+/- 1.0 dB			
Input Loss Return	12 dB			
Output Return Loss	12 dB			
Output Power (Psat)	+19 dBm			
DC Voltage (Vdc)	+8 VDC			
DC Current (mA Quiescent)	100 mA			
Noise Figure (dB)	5.5 dB			
RF Input/Output Connector	SMA Female or Gold Plated 0.015 pin			
DC Input Connector	SMA Female or Gold Plated 0.015 pin			

Single stage amplifier

- Class A biased for radar, jammers, communications transmit applications
- P1dB +18 dBm over 2-6 GHz band
- 18 dB small signal gain
- Connectorized or printed wiring board mount (solder attach 0.015" pins)
- Small size, hermetically sealed





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### Amplifiers | High Frequency Integrated Amplifiers

### **Generation II Product**

- Frequency 2-18 GHz (4 phase tracked amplifier assemblies)
- Consists of...
  - 2 stage amplifier (4 channels)
  - Broadband detector
  - Gain compensator
  - Ditigal fault circuits
  - Power conditioning
  - Complex packaging







### **Quality & Reliability**

### MIL-PRF-38534 Product Screening and qualification capability

- Device screening and groups A, B, C, and D qualification (when required by order)
- Environment testing per MIL-STD-883 test methods

### Other specifications guidelines

- J-STD-001 Class 3 and IPC-A-610, for eutectic attach and general soldering processes
- IPC-7711 and IPC-7721, for rework and authorized repair operations

#### **Quality assurance programs**

- Calibration recall program for test and measurement equipment
- Facility ESD program
- Failure analysis and corrective action system
- Internal ISO audit program
- Operator training program

### Design & Development Process















### Who We Are

### Value-added Integration from Components to Subsystem Solutions

APITech provides rugged, reliable, and efficient subsystems, assemblies, and components for use in the most mission critical defense and military applications, supporting government programs throughout the world. With diverse program experience and preferred supplier status with some of the industry's top premier contractors, our precision-engineered MIL-grade products are ideal for applications where uncompromised reliability and uninterrupted performance is required. APITech is the Electromagnetic Spectrum Innovator at Tier 2.5-4 in the supply chain.



### The Electromagnetic Spectrum Innovator

APITech is an innovative designer and manufacturer of high performance systems, subsystems, assemblies and components for technically demanding RF, microwave, millimeter wave, electromagnetic, power, and security applications.

A high reliability technology pioneer with over 70 over 70 years of heritage, APITech's products are used by global defense, industrial, and commercial customers in applications spanning radar, electronic warfare, unmanned systems, missile defense, harsh environments, space, communications, medical, test and instrumentation, and more.



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