Spectrum Microwave Presentation
Microwave Components & Systems Business | SpectrumMicrowave.com
- Amplifiers, Mixers, Switches, Oscillators & Sources
- RF/Microwave Filters, Diplexers & Multiplexers, Integrated Multifunction Modules
- Thin Film Substrates, Hybrid Assembly Services

EMI Filter & Components Business | specemc.com
- EMI Surge Suppression Components & Modules
- Power Line Filters & Power Entry Modules
- Interconnect Devices
- Terminal Blocks & Passive Components

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

Sensors & Controls Business | specsensors.com
- Potentiometers, Temp Sensing Probes, Surge Current Limiters
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

- **Markets served include:**
  - Military Electronics, Avionics, Aerospace and Commercial
• Over 600 Microwave employees (75 Engineers)
• Access to lower cost manufacturing
  (Spectrum’s 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 June 2010 (Sage Labs)
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)
Spectrum Microwave Low Cost Manufacturing Center: MEXICO
Spectrum Microwave 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
• **Hermetically Sealed**
  - 100% testing over temperature extremes
  - Gross and fine leak
  - Constant acceleration up to 10,000 g
  - 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)*
• 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 (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 Bay (previously 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
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**
- 30-200 MHz
- 1.4 dB typical noise figure
- 8.0 dB gain
- 3rd/2nd order IP: 42/59 dBm
- +15.0 Vdc/29 mA

**QBH-2001**
- 1200-1600 MHz
- 0.85 dB noise figure
- 22.0 dB gain
- +3.0 dBm P1dB
- +5.0 Vdc/40 mA
• 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
• **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**
- 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

**QBH-5674B**
- Military/Space
- 3.0-4.0 GHz
- 15.0 dB gain
- 1.7 dB Noise Figure
- +36.0 dBm 3rd Order OIP
• **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 (balanced to unbalanced) connect parallel cascode stages 180° out of phase
  - Broadband with excellent gain stability and linearity, especially the 2nd Order OIP. Configuration theoretically cancels even-harmonic distortion products
• 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

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Typical</th>
<th>Guaranteed</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 Hz</td>
<td>-165</td>
<td>-160 dBC/Hz</td>
</tr>
<tr>
<td>1 kHz</td>
<td>-172</td>
<td>-167 dBC/Hz</td>
</tr>
<tr>
<td>10 kHz</td>
<td>-177</td>
<td>-172 dBC/Hz</td>
</tr>
<tr>
<td>100 kHz</td>
<td>-179</td>
<td>-174 dBC/Hz</td>
</tr>
<tr>
<td>1 MHz</td>
<td>-180</td>
<td>-175 dBC/Hz</td>
</tr>
</tbody>
</table>

Spectrum 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.
• 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 $f_t$ in parallel to achieve bandwidth and power
• **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
• PCB Materials: Thin Film
  - High circuit density with fine line geometries
  - Purchase metallized substrates - Alumina (99.5%), BeO and AlN
  - 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
• 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
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
## Amplifiers | Ceramic Lower Cost Amplifiers

- **Provides Cost Effective Solution**

<table>
<thead>
<tr>
<th>Customer’s needs</th>
<th>Spectrum’s LCA</th>
<th>MMICs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never Obsolete</td>
<td>✓</td>
<td>End-of-life / Next generation forces system redesign.</td>
</tr>
<tr>
<td>True 50 Ohm Match</td>
<td>✓</td>
<td>Additional components means additional design time and Real Estate.</td>
</tr>
<tr>
<td>Superior Phase Noise</td>
<td>✓</td>
<td>Not tested or guaranteed in production.</td>
</tr>
<tr>
<td>Guaranteed Performance</td>
<td>✓</td>
<td>Always Typical Values / Graphs.</td>
</tr>
<tr>
<td>-55°C to +85°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No External Components Needed</td>
<td>✓</td>
<td>Blocking caps are just the beginning…</td>
</tr>
<tr>
<td>Low Cost</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

- Frequencies to 4000 MHz
- Output power to 4 watts
- Noise as low as 0.8 dB
- 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

<table>
<thead>
<tr>
<th>Parameters (Typical at 25°C)</th>
<th>Power Amplifier Models</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Amplifier Series</strong></td>
<td><strong>QB-904 (4 watt)</strong></td>
</tr>
<tr>
<td>Frequency Range (MHz)</td>
<td>2,000-6,000</td>
</tr>
<tr>
<td>Gain (dB)</td>
<td>35</td>
</tr>
<tr>
<td>Gain Flatness (dB)</td>
<td>+/- 2.5</td>
</tr>
<tr>
<td>Power Output (dBm)</td>
<td>+36</td>
</tr>
<tr>
<td>DC Voltage (Vdc)</td>
<td>23-29</td>
</tr>
<tr>
<td>DC Current (mA Quiescent)</td>
<td>285</td>
</tr>
<tr>
<td>Noise Figure (dB)</td>
<td>8</td>
</tr>
<tr>
<td>RF Input/RF Output Connector</td>
<td>SMA Female or Gold Plated 0.015 pin</td>
</tr>
<tr>
<td>DC Input</td>
<td>SMA Female or Gold Plated 0.015 pin</td>
</tr>
</tbody>
</table>
• **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 90° hybrid couplers and baluns - adjust the windings to optimize parameters
  - Topology distributes heat throughout the package
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
**Specifications**

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<tbody>
<tr>
<td>Frequency Range</td>
<td>2.0 to 6.0 GHz</td>
</tr>
<tr>
<td>Small Signal Gain</td>
<td>38 dB</td>
</tr>
<tr>
<td>Gain Flatness</td>
<td>+/- 3.0 dB</td>
</tr>
<tr>
<td>Input Loss Return</td>
<td>10 dB</td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>12 dB</td>
</tr>
<tr>
<td>Output Power (Psat)</td>
<td>+36 dBm</td>
</tr>
<tr>
<td>DC Voltage (Vdc)</td>
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<td>285 mA</td>
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<td>Noise Figure (dB)</td>
<td>8 dB</td>
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<tr>
<td>RF Input/Output Connector</td>
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<tr>
<td>Frequency Range</td>
<td>2.0 to 6.0 GHz</td>
</tr>
<tr>
<td>Small Signal Gain</td>
<td>27 dB</td>
</tr>
<tr>
<td>Gain Flatness</td>
<td>+/- 2.0 dB</td>
</tr>
<tr>
<td>Input Loss Return</td>
<td>10 dB</td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>8 dB</td>
</tr>
<tr>
<td>Output Power (Psat)</td>
<td>+28 dBm</td>
</tr>
<tr>
<td>DC Voltage (Vdc)</td>
<td>+23 to +29 VDC</td>
</tr>
<tr>
<td>DC Current (mA Quiescent)</td>
<td>185 mA</td>
</tr>
<tr>
<td>Noise Figure (dB)</td>
<td>8 dB</td>
</tr>
<tr>
<td>RF Input/Output Connector</td>
<td>SMA Female or Gold Plated 0.015 pin</td>
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<tbody>
<tr>
<td>Frequency Range</td>
<td>2.0 to 6.0 GHz</td>
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<tr>
<td>Small Signal Gain</td>
<td>17 dB</td>
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<tr>
<td>Gain Flatness</td>
<td>+/- 1.0 dB</td>
</tr>
<tr>
<td>Input Loss Return</td>
<td>12 dB</td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>12 dB</td>
</tr>
<tr>
<td>Output Power (Psat)</td>
<td>+19 dBm</td>
</tr>
<tr>
<td>DC Voltage (Vdc)</td>
<td>+8 VDC</td>
</tr>
<tr>
<td>DC Current (mA Quiescent)</td>
<td>100 mA</td>
</tr>
<tr>
<td>Noise Figure (dB)</td>
<td>5.5 dB</td>
</tr>
<tr>
<td>RF Input/Output Connector</td>
<td>SMA Female or Gold Plated 0.015 pin</td>
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- 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
• **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
Quality & Reliability

ISO 9001:2000 Quality Operating System

• **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

1. Specification Development
2. Simulation & Design
3. Testing
4. Prototyping
5. Manufacturing
6. Logistics