

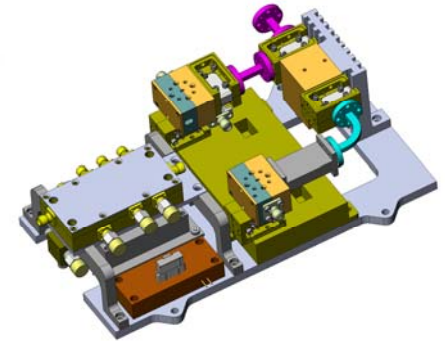
**Integrated Millimeter Wave Electronics**



**Catalog Millimeter Wave Components for Fast Delivery**



**100 MB to 1.48 GB Communication Systems**



**Production MMW Subsystems**

# HXI, LLC

## Company & Millimeter Wave Product Overview

8/4/2011

*\*HXI, LLC is a wholly-owned subsidiary of Renaissance Electronics Corporation.*

# HXI History



HXI was founded in Woburn, Massachusetts as Harmonix in 1992 to develop 60 GHz radios for short range data communications. The founders were a Japanese-American and an ex-Raytheon-M/A-COM engineering manager. In 1998, the company moved to North Andover, MA. Around this time, Harmonix began offering millimeter wave components & subsystems to selected government contractors, subcontractors and educational institutions.



In 2002, Terabeam Corporation, a free space optics (FSO) Manufacturer, acquired Harmonix for its 60 GHz radios. In 2003, Terabeam added resources to market and expand the Harmonix millimeter wave components & subsystems capability worldwide under the HXI name.

From 2004 to 2008, HXI was owned by YDI Wireless/Terabeam Corp./Proxim Wireless. (These names were all used by the parent company during this period.) In 2005, HXI moved its facility to Haverhill, Massachusetts. An E-Band Radio link product, also marketed under the Gigalink brand name, was introduced in 2006 to provide longer ranges for gigabit connectivity.



Today, HXI is a wholly-owned subsidiary of Renaissance Electronics Corporation (REC) of Harvard, Massachusetts and we are located in the REC facility. Our Millimeter Wave Component and Subsystem business supplies government contractors, subcontractors and other customers with key components for advanced communications, military systems and basic research. We continue to produce Gigalink radios for a wide range of customers.

## ***HXI Today***

---

- **Located at 12 Lancaster County Road, Harvard, MA, just off Route 2.**
- **Our customer mix is approximately 90% military and 10% commercial/industrial, as of April 2011.**
- **Among our customers are Boeing, Lockheed Martin, L-3, Northrop Grumman, SAIC, Sierra Nevada, DEAL, NEC, Agilent, Toyota, Samsung, NASA, Naval Research Lab, Air Force Research Lab and various other government contractors, labs and organizations.**
- **We also supply to many educational institutions, such as MIT, Johns Hopkins and Princeton, as well as a number of prominent European and Asian universities. These sales are usually funded by government grants or corporate IR&D funding in support of new communication or radar systems.**

# Component Market Segments

- Our products and services find their way into many military and commercial markets.
- **Military**
  - Radars
    - Helicopter Landing (W-Band)
  - Communications
    - UAV Landing
    - Transmission of high resolution video/images
  - Homeland Security/Imaging
    - Communications surveillance
    - Perimeter surveillance
    - Weapon detectors
  - Satellite Communications
    - Q-Band and Ka-Band
- **Commercial**
  - Radios (V-Band and E-Band)
    - Digital and Analog
    - Data and HDTV Applications
  - Commercial Radars/Sensors
  - Test equipment
  - University research



DoD Photo

## ***HXI Facts***

---

- **Employees:** 15
- **Location:** 12 Lancaster County Road  
Harvard, Massachusetts
- **Parent Company:** Renaissance Electronics Corp., Harvard, MA

### **Senior Management Team:**

- **Tom (Thampy) Kurian, President**
- **Earle Stewart, Business Development Manager**
- **Pat Boyd, MMW Components Manager**
- **Tom Rosa, R&D Manager**

## ***HXI Key MMW Personnel***

---

- **Earle Stewart** – Component Business Development
  - Previously with Alpha/TRG, Alpha/MMIC, Raytheon & Arcom Wireless
  - Programs: Patriot (PAC2), Hellfire missile seeker, SADARM sub-munition, automotive radar, point to point radios, surveillance receivers
- **Tom Rosa** – Director of R&D
  - Previously with Alpha/TRG and Textron
  - Programs: Damocles sub-munition, radiometers, various radars and communication links
- **Pat Boyd** – Senior Engineer
  - Previously with Alpha/TRG, M/A-COM and MDT
  - Programs: Milstar, ACTS, UAV landing system (TALS), FAB-T
  - Expertise: Gunn oscillators, multipliers, switches, amplifiers

## ***HXI Engineering***

---

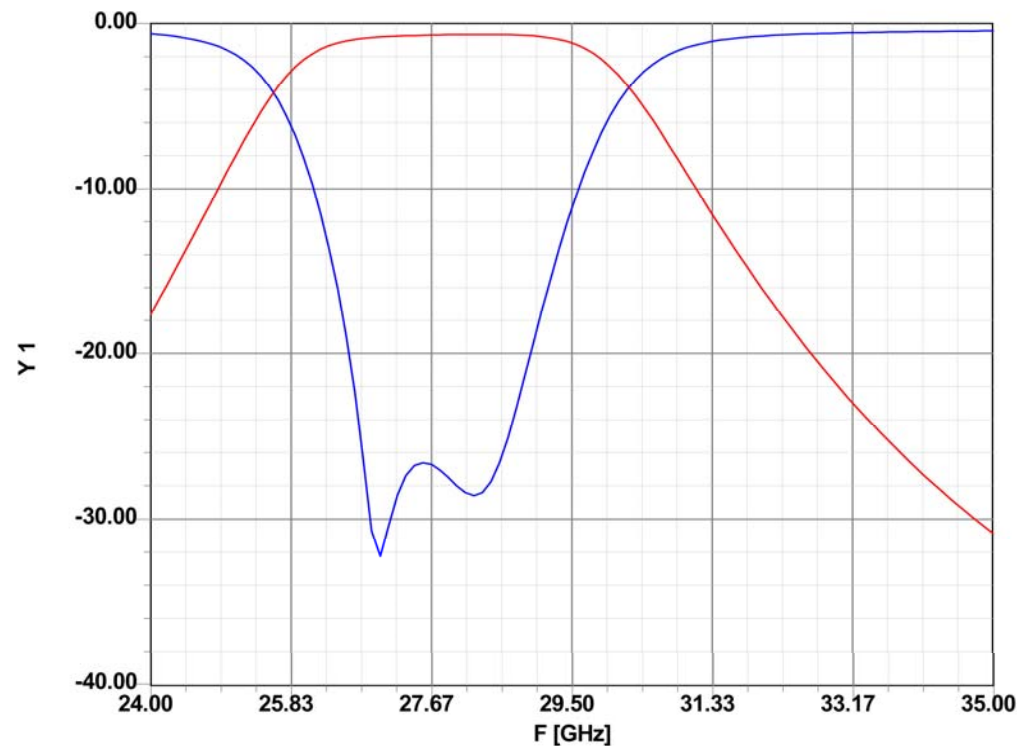
- **Collectively, our engineers have authored or co-authored more than 50 published technical papers on such diverse subjects as:**
  - **Gunn Oscillators and VCOs**
  - **Waveguide Cavity Frequency Multipliers up to 140 GHz**
  - **Millimeter wave (MMW) Harmonic mixers**
  - **MMW High Power Waveguide Circulators**
  - **MMW Bulk Window Switches**
  - **38 GHz MMIC chip set for point-to-point radio**
  - **60 GHz MMIC chip set for satellite communications**
  - **77 GHz MMIC chip set for automotive sensors**
  - **MMW Transceivers for forward-looking automotive radars**
  - **Transceiver modules for MMW point-to-point radios**
  - **Propagation Considerations for Multi-Gigabit, MMW Point-to-point Radios**
- **Our engineers have also presented papers at the following conferences/workshops:**

**IEEE MTT-S Symposium  
SAE TOPTECs**

**Broadband Wireless  
European GAAS Symposium**

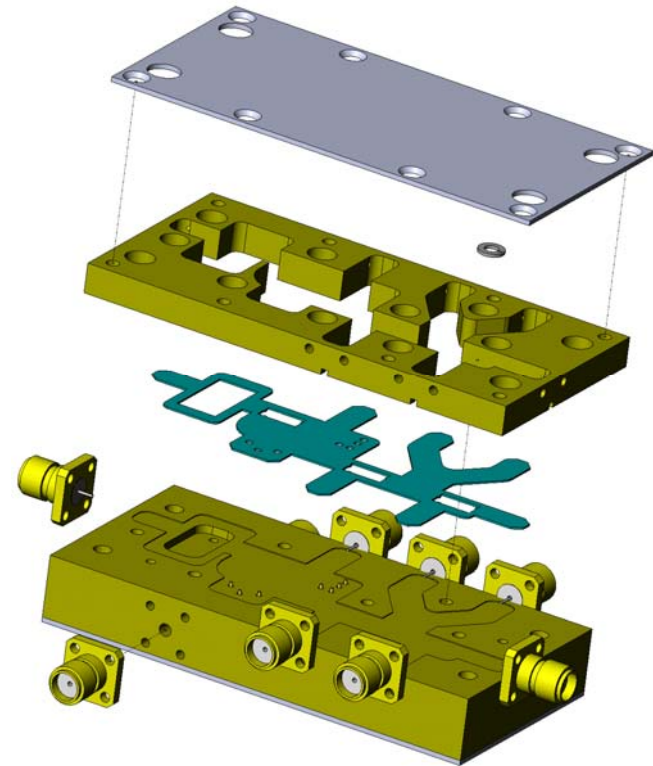
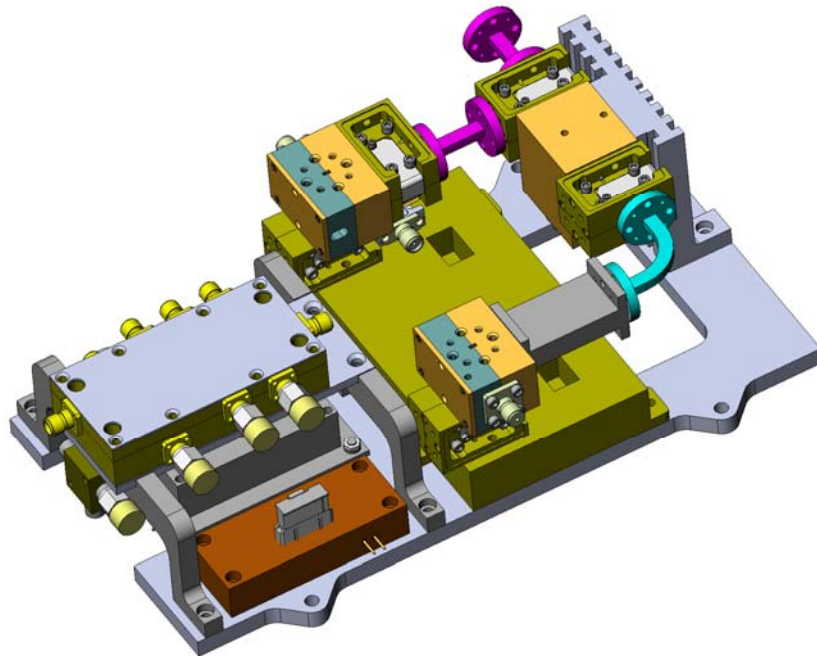
# *Design & Development*

- **Electrical/System Design Software**
  - ANSOFT Designer for MMW circuit design
  - SysCalc for cascade analysis



# Design & Development

- Mechanical Design Software
  - SolidWorks and AutoCAD for mechanical design
  - PADS for Circuit Layout



# Manufacturing - Assembly

## Prototype assembly (in-house)

- Board mount of duroid and alumina
- Semi-auto pick & place of MMICs and other small components
- Plasma cleaning
- Gold wire/ribbon bonding & bond pull

## Production assembly (contracted)

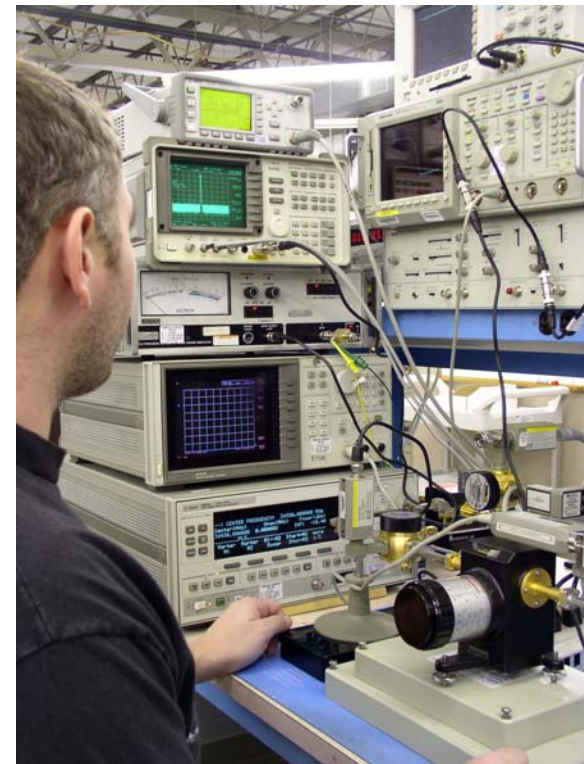
- Nearby contract manufacturers specializing in MMW assembly. Fully automatic pick and place and wire/ribbon bonding are available.
- Relationships with qualified off-shore manufacturers for low cost/high volume.



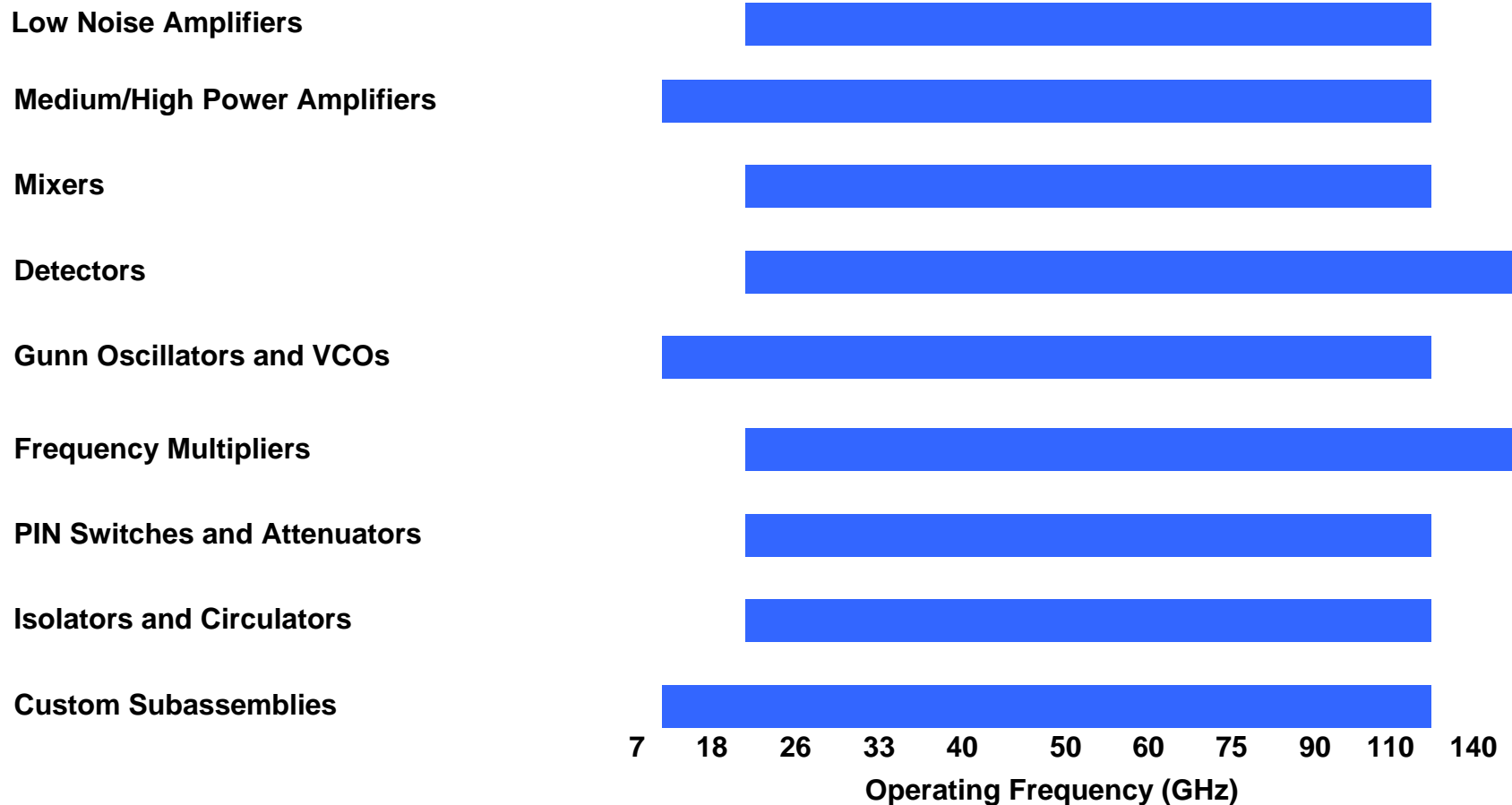
# ***Manufacturing – Testing***

## **Product Integration/Testing (in-house)**

- **Component testing using MMW Test stations to 110 GHz**
  - **Synthesizers**
  - **Spectrum Analyzers**
  - **Scalar Analyzers**
  - **Power measurement**
  - **Noise measurement**
  - **8510 Network Analyzer**
  - **Radio test range**
  - **BER and data communications analysis**
  - **SONET, IP and variable Optical Bit Stream generators/testers**



# ***Standard Component Product Lines\****



**\*Variations available as special order products**

# Low Noise Amplifiers

- 18 GHz to 100 GHz
- Narrowband or broadband frequency coverage
- Coaxial and waveguide versions
- MMIC-Based

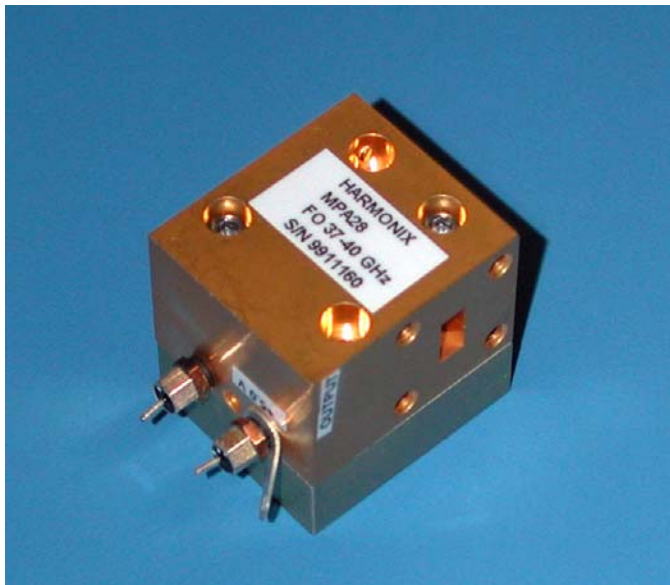
Model *	Frequency Range	Noise Figure
HLNAK-XXX	21- 25 GHz	2.2 dB typical
HLNAA-XXX	33- 37 GHz	3.0 dB typical
HLNAV-XXX	55- 65 GHz	4.0 dB typical
HLNAE-XXX	71- 86 GHz	5.0 dB typical
HLNAW-XXX	92- 96 GHz	5.5 dB typical



\*Sample Listing – See HLNA data sheet on-line for a wider selection.

# Medium & High Power Amplifiers

- 18 GHz to 100 GHz
- Narrowband or broadband frequency coverage
- Coaxial and waveguide versions
- Custom power combining also available
- MMIC-Based



Model *	Frequency Range	P1dB
HHPAK-XXX	21 - 25 GHz	> +30 dBm
HHPAA-XXX	33 - 37 GHz	> +35 dBm
HHPAB-XXX	43.5 - 45.5 GHz	> +30 dBm
HHPAV-XXX	55 - 65 GHz	+16 dBm
HHPAE-XXX	71 - 76 GHz	+15 dBm
HHPAE-XXX	81 - 86 GHz	+15 dBm
HHPAW-XXX	93.5 - 95.5 GHz	+24 dBm (P <sub>SAT</sub> )

\*Sample Listing – See HHPA and HMPA data sheets on-line for a wider selection.

# Mixers & Upconverters

- 18 GHz to 110 GHz
- Narrowband or broadband frequency coverage

Mixer Model *	Frequency Range	Conversion Loss
HBM2803-XXX	33- 37 GHz	6 dB typical
HBM1503-XXX	57- 64 GHz	7 dB typical
HBM1003-XXX	92- 96 GHz	8 dB typical

Upconverter Model *	Frequency Range	Output Power
HBUC2805-XXX	33- 37 GHz	+2 dBm typical
HBUC1505-XXX	57- 64 GHz	+1 dBm typical
HBUC1005-XXX	92- 96 GHz	0 dBm typical



\*Sample Listings – See HBM and HBUC data sheets on-line for a wider selection.

# Detectors

- 18 GHz to 140 GHz
- Full waveguide band frequency coverage
- Miniature designs available

Model *	Frequency Range	Sensitivity
HFD28P	26.5- 40.0 GHz	1000 mV/mW
HFD22P**	33.0 – 50.0 GHz	800 mV/mW
HFD15P	50.0-75.0 GHz	600 mV/mW
HFD12P	60.0 – 90.0 GHz	500 mV/mW
HFD10P	75.0-110.0 GHz	300 mV/mW

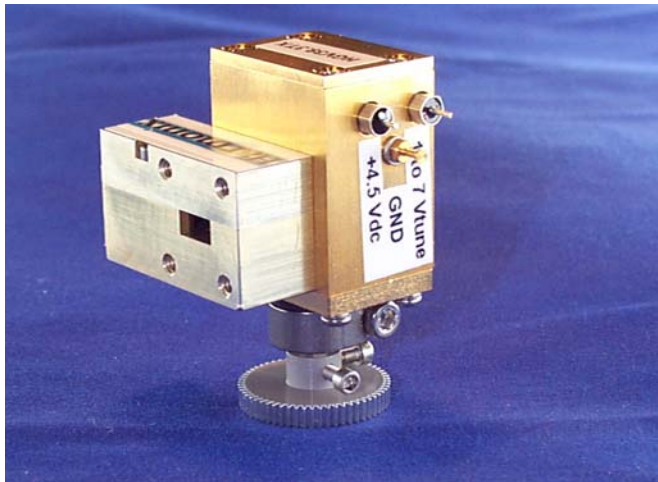
\*Sample Listing – See HFD data sheet on-line for a full listing.

\*\*Custom designs available in this band for MilSATCOM.



# Gunn Oscillators & VCO's

- 7 GHz to 100 GHz models
- Up to 400 milliwatt output power with GaAs diodes
- Some InP versions are available (contact factory)
- Mechanical and varactor tuning available



Gunn Oscillator Model *	Mechanical Tuning Range*	Output Power
HGM9.022690	8.75-9.25 GHz	+26 dBm
HGM22.522442	22.25-22.75 GHz	+24 dBm
HGM35.022328	34.75-35.25 GHz	+23 dBm
HGM60.021815	59.8-60.2 GHz	+18 dBm
HGM94.011610	93.8-94.2 GHz	+16 dBm

Gunn VCO Model *	Varactor Tuning Range*	Output Power
HGV9.0012590	8.975-9.025 GHz	+25 dBm
HGV22.5012442	22.475-22.525 GHz	+24 dBm
HGV35.0012328	34.9725-35.025 GHz	+23 dBm
HGV60.0011915	59.975-60.025 GHz	+19 dBm
HGV94.0011610	93.975-94.025 GHz	+16 dBm

\*Sample Listings – See HGM/HGV data sheet on-line for a wider selection.

# Frequency Multipliers

- 18 GHz to 110 GHz
- Active and passive designs
- Up to full band frequency coverage
- High output power available
- X2, X3 and higher order multipliers

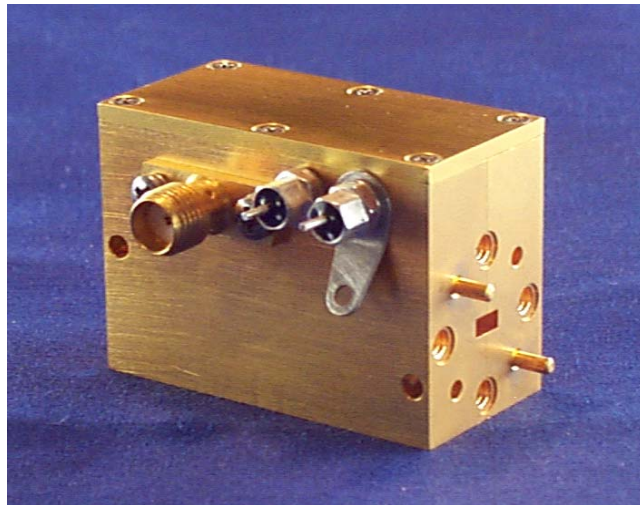


Model *	Mult. Factor	Output Frequency Range	Output Power
HAFMV4-XXX	X4	55-65 GHz	+16 dBm
HAFME4-XXX	X4	71-76 GHz	+15 dBm
HAFME4-XXX	X4	81-86 GHz	+15 dBm
HAFMW3-XXX	X3	92-96 GHz	+18 dBm
HAFMW6-XXX*	X6	93-95 GHz	+18 dBm

\* Sample Listing – See HAFM and HMM data sheets on-line for a wider selection.

# ***PIN Switches & Attenuators***

- 18 GHz to 110 GHz
- Full band versions available
- On/off ratios to 55 dB
- Fast switching times
- SPST, SPDT & multi-throw
- 1W+ power handling (HSWM & HBSW models\*)



## **Switches**

Switch Model *	Frequency Range	Insertion Loss/ Isolation
HSW2801-XXX	26.5-40.0 GHz	1.0 dB / 30 dB
HSWM22801-XXX**	26.5-40.0 GHz	1.6 dB / 23 dB
HSW1501-XXX	55-65 GHz	1.6 dB / 25 dB
HSW1001-XXX	90-98 GHz	2.2 dB / 18 dB
HBSW94-XXX**	93-95 GHz	1.0 dB / 35 dB

## **Attenuators**

Attenuator Model *	Frequency Range	Insertion Loss/ Attenuation Range
HVA2803-XXX	26-40.0 GHz	1.8 dB / 30 dB
HVA1503-XXX	55-65 GHz	3.0 dB / 30 dB
HVA1003-XXX	90-98 GHz	3.5 dB / 30 dB

\*Sample Listings – See HSW, HSWM and HVA data sheets on-line for a wider selection.

\*\*SPDT switch

\*\*\*HBSW94 features 10W CW, 1 kW peak power handling.

# Ferrite Isolators & Circulators

- 18 GHz to 110 GHz
- Compact designs
- Magnetically-Shielded Versions
- High Power Versions



Isolator Model *	Frequency Range	Insertion Loss/Isolation
HMI28	34- 36 GHz	0.3 dB / 20 dB
HMI15	59– 61 GHz	0.7 dB / 20 dB
HMI10	93– 95 GHz	0.8 dB / 18 dB

\*Sample listing – See HMI/HMC data sheet on-line for a wider selection.

Isolator models are listed; circulators (HMC series) have identical electrical specifications. High power versions of these products are also available.

## ***Miscellaneous Components***

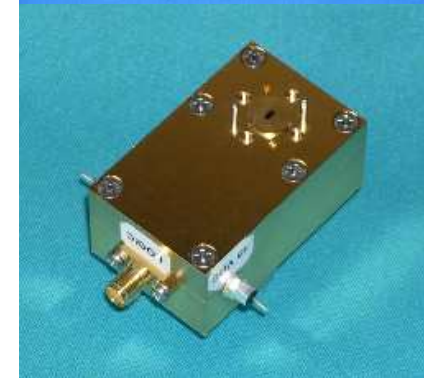
**In addition to our standard catalog components, we produce a number of other components on an as-needed basis to support our subsystem and radio link businesses:**

**Ku-Band Free-Running DRO's**

**V-Band, E-Band & W-Band Magic Tees**

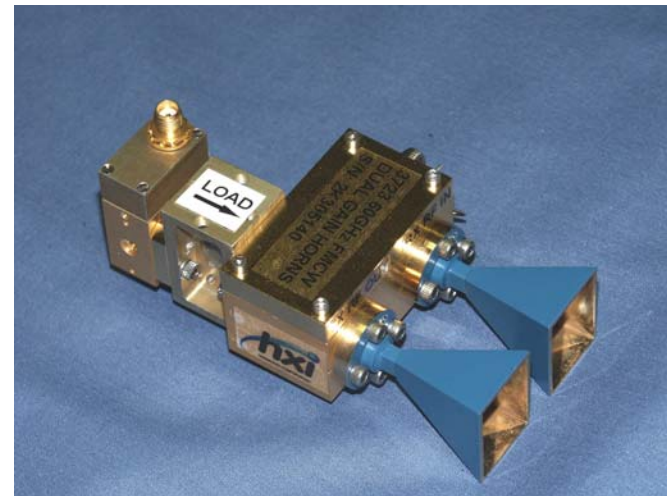
**Waveguide Power Combiners**

**W-Band High Power SPST Switches**



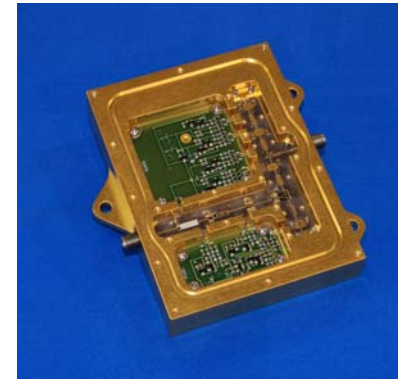
## ***60 GHz FMCW Radar***

- **60 GHz front end for use in industrial sensors**
- **Has been used for railroad crossing obstacle detection, fluid level determination and steel ingot measurement.**
- **Customers have implemented software linearization to obtain 1% linearity. Hardware linearizers can be used to improve linearity to 0.01%.**
- **Architecture can be translated to other MMW frequencies.**

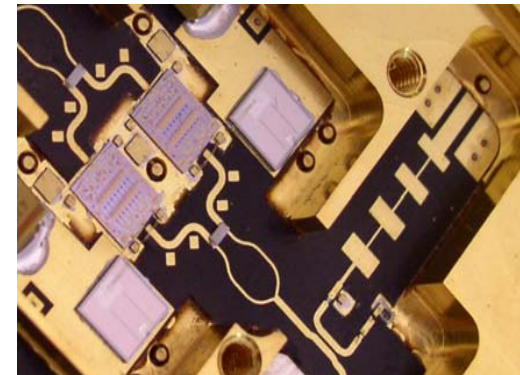


## ***Custom Integrated Assemblies***

- **Require some degree of engineering design**
- **Increased reliability due to MMIC usage and reduced number of connections**
- **Lower production costs**
- **Higher throughput in manufacturing**
- **Decreased size and weight**



**W-Band Integrated  
Radar Transceiver**



**Ka-Band Integrated  
Receiver for UAV  
Autonomous Landing**

## ***Subsystem Development***

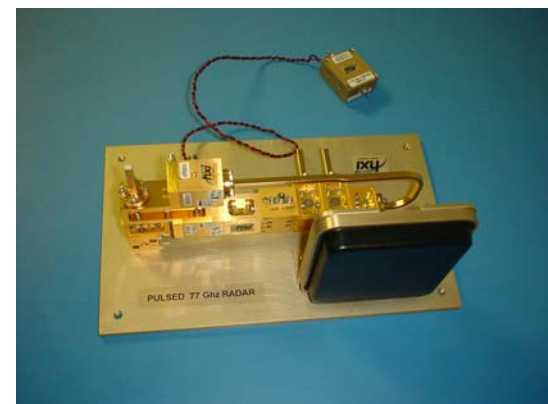
**HXI has the unique experience and capability to work with customers at the system level to define and engineer realizable solutions for communications and radar/sensor applications.**

**We can then provide fast prototyping of these systems using our single function catalog components. This enables our customers to get a fast start on developing radar algorithms or to deploy a new communications system quickly. Changes to the prototype can be made quickly to determine the impact of the configuration change.**

**When it is determined that the system configuration is optimized, we can engineer the subsystem for production by integrating functions into one or more multi-function modules.**



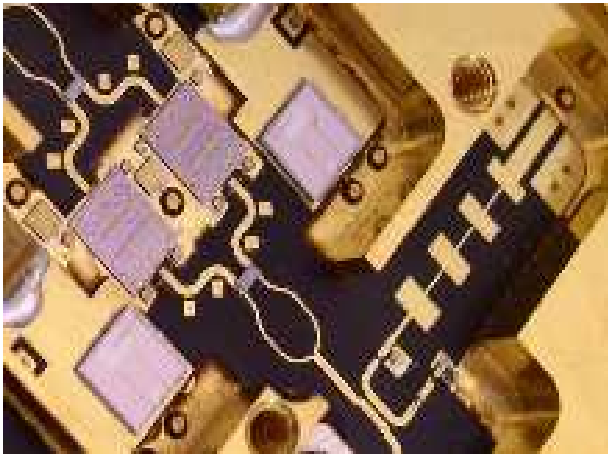
**94 GHz upconverter and downconverter prototype for military FMCW application**



**Prototype for 77 GHz Auto Radar**

## *Ka-Band Landing System Transceivers*

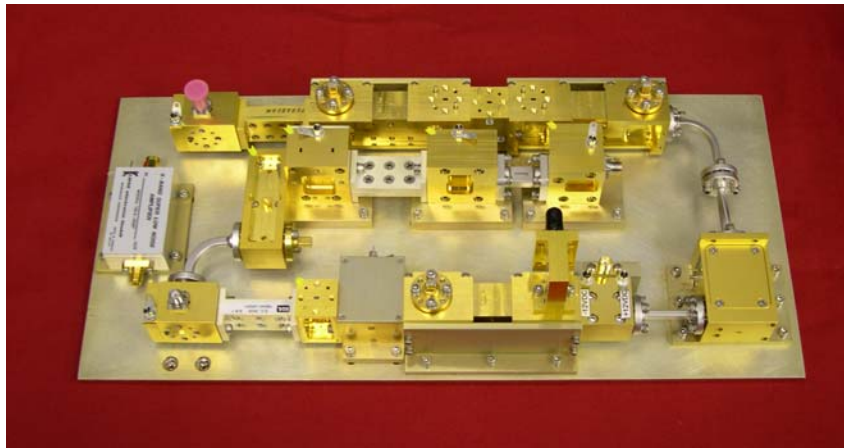
- HXI is the sole source for flight and ground-based transceivers to support automatic landing of the Shadow 200 UAV
- Highly integrated ground-based unit features 17 individual MMW and IF circuit functions, including 3.5W Ka-Band power amplifier and SP4T switch matrix
- Customized quality system put in place for customer.
- Highly interactive engineering development with customer.



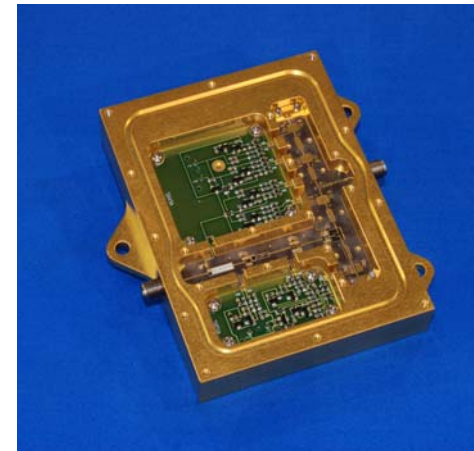
DoD Photo

## ***W-Band Pulsed Radar Transceiver***

- HXI has delivered several W-Band prototypes and pre-production units for helicopter landing systems.
- Subsystem also includes 250 mW power amplifier and high power handling (>10W) Tx and Rx switches
- Highly interactive engineering development with customer.



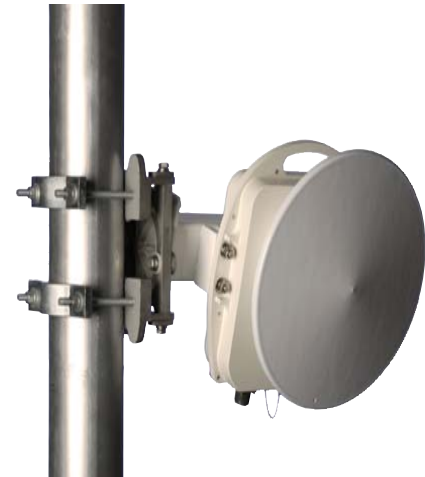
**Prototype**



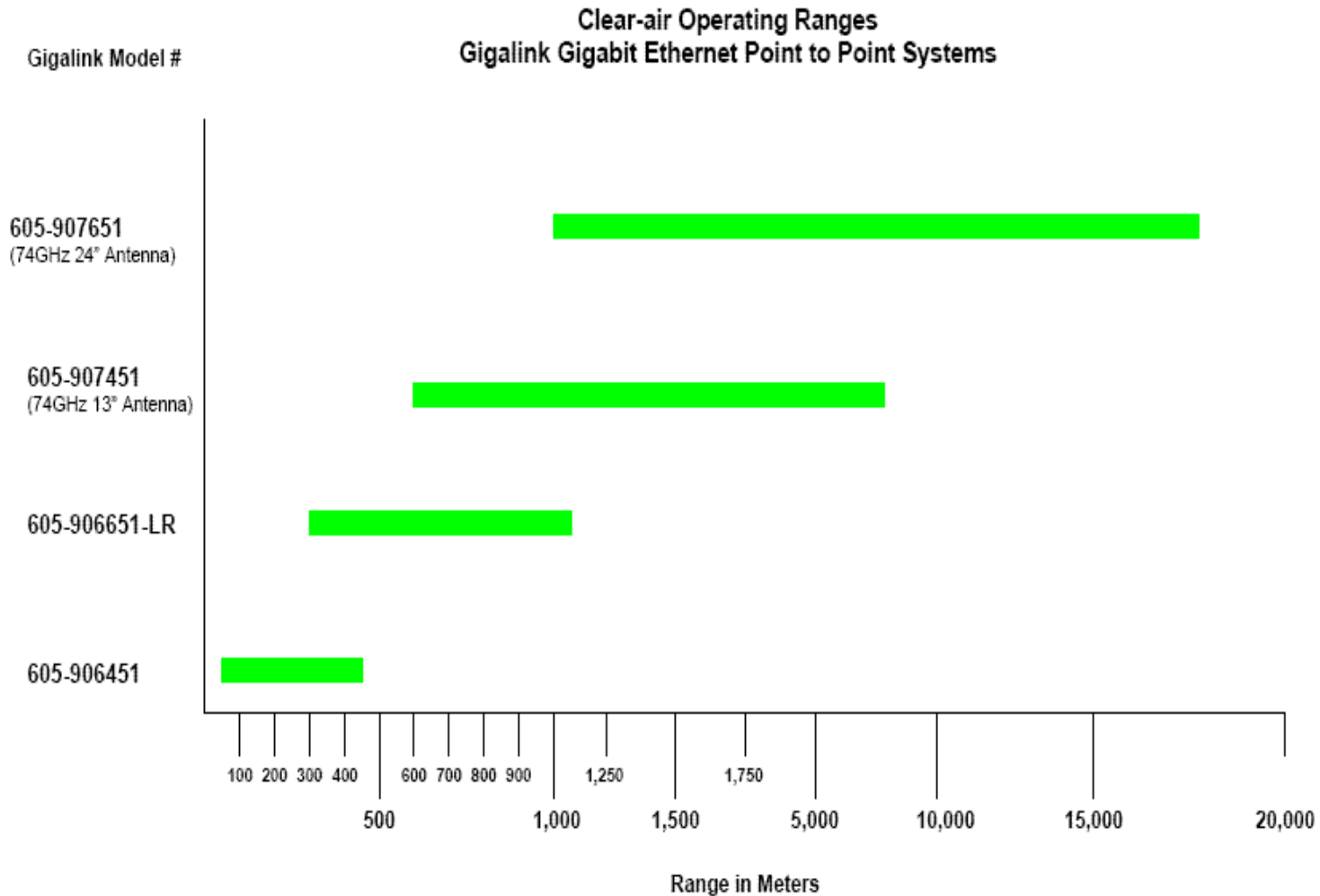
**Production**

## ***60/70 GHz GigaLink® Radios***

- As Harmonix, we were instrumental in securing the FCC allocation of the 60 GHz spectrum in the USA, and we were the first FCC Part 15.255-certified millimeter wavelength system operating in the 57 to 64 GHz band.
- HXI routinely addresses requirements for customized versions of these radios, including analog links, custom antenna configurations, alternate frequency bands, HDTV usage, etc. Among our customers for custom versions are the Air Force and the Department of Energy.
- Full Duplex operation with near-zero latency
- Each link is bench and range tested for dynamic range and bit errors.



# GigaLink<sup>®</sup> System Operating Ranges



## ***GigaLink<sup>®</sup> Specifications – 60 GHz Models***

<b>Parameter</b>	<b>Specification</b>
<b>Operating Band</b>	<b>57.05 to 64.0 GHz</b>
<b>Operating Range</b>	<b>20 to 440 meters (short range model 6451E) 300 to 1,142 meters (long range model 6551E)</b>
<b>Full Duplex Bandwidth</b>	<b>1.25 Gbps</b>
<b>RF Power into antenna</b>	<b>10 milliwatts</b>
<b>Antenna Gain</b>	<b>41 dBi nominal</b>
<b>Antenna 3 dB Beamwidth</b>	<b>0.9 degrees</b>
<b>Mounting</b>	<b>Adjustable azimuth and elevation</b>
<b>Operating Temperature Range</b>	<b>-30°C to +60°C</b>
<b>Input Voltage</b>	<b>100 to 230 VAC, 50/60 Hz or -40 to -57 VDC</b>
<b>Power Consumption</b>	<b>90 watts</b>
<b>Management</b>	<b>Lap-top based software provided (local) SNMP v1 (remote)</b>

## ***GigaLink<sup>®</sup> Specifications – 71-76 GHz Models***

<b>Parameter</b>	<b>Specification</b>
<b>Operating Band</b>	<b>71.0 to 76.0 GHz</b>
<b>Operating Range</b>	<b>600 to 8,200 meters</b>
<b>Full Duplex Bandwidth</b>	<b>1.25 Gbps</b>
<b>RF Power into antenna</b>	<b>10 milliwatts</b>
<b>Antenna Gain</b>	<b>44 dBi nominal*</b>
<b>Antenna 3 dB Beamwidth</b>	<b>0.8 degrees</b>
<b>Mounting</b>	<b>Adjustable azimuth and elevation</b>
<b>Operating Temperature Range</b>	<b>-30°C to +60°C</b>
<b>Input Voltage</b>	<b>100 to 230 VAC, 50/60 Hz or -40 to -57 VDC</b>
<b>Power Consumption</b>	<b>90 watts</b>
<b>Management</b>	<b>Lap-top based software provided (local) SNMP v1 (remote)</b>

**\* 13” Parabolic antenna; 24” antenna with higher gain also available.**

## ***Advantages to Using HXI as Your Component & Subsystem Supplier***

---

- **Fast prototyping using single function modules from catalog**
- **Optimum subsystem configurations using state-of-the-art integration methods**
- **Small company speed and agility**
- **Understanding of radar and radios at the system level**
- **Engineering (and tech sales) personnel average more than 25 years experience in the millimeter wave industry**
- **Knowledge and usage of latest technology and keepers of nearly-lost technology**
- **Small company size with low overhead results in favorable costs compared to competition**
- **Financial strength/profitability of HXI and parent company**