



*Integrated High-Frequency Modules  
for Defense and Homeland Security*



Building on a legacy of high-frequency experience to deliver advanced integrated modules



*"Our high sensitivity radar system required a proven low residual phase noise amplifier—and we needed one fast. Endwave's technical team nailed our performance specification and delivered a fully-compliant prototype in just two weeks."*

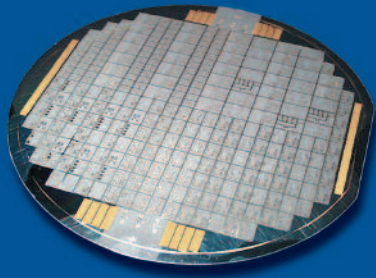
Subcontracts Manager  
A Major US Prime Defense Contractor

*"Endwave has consistently demonstrated expertise in millimeter-wave switching and transmit-receive modules. Because the transceiver and RF switch array are complementary parts of our weapons detection scanner, they were the logical choice to provide both critical pieces. We see Endwave as a valuable partner as we commercialize our homeland security portals."*

Rick Rowe  
CEO, SafeView, Inc.







**Multilithic Microsystems™ (MLMS)**  
The next generation in high-frequency circuits

Consistency and cost are two of the most common challenges encountered in millimeter-wave module production. In response, Endwave has developed Multilithic Microsystems (MLMS). This advanced circuit technology uses flip-chip and electromagnetic coupling methods to minimize expensive semiconductor real estate while eliminating lengthy interconnects and their related variability. MLMS moves passive circuitry onto an inexpensive proprietary substrate that processes with the ease of silicon, yet works past 100 GHz. Only the discrete active FET or PHEMT devices remain, which are then flip-mounted on top of the MLMS substrate. This technology is extremely rugged, withstanding extreme temperature cycling and mechanical shock. With MLMS, a complex transmitter or receiver can be placed on a single, compact substrate with no bondwires in the RF path.



**Epsilon Packaging™ Technology**  
Freeing you of the dependency on machined housings

Conventional millimeter-wave thinking is rooted in the belief that module housings have to be fabricated utilizing costly machining and plating techniques. In many instances, Endwave's Epsilon Packaging eliminates this dependency by replacing costly and heavy weight metal mechanicals with metallized FR-4 and injection molded metallized plastics. The Epsilon Packaging approach is applicable across all of our product lines, and includes revolutionary mixed technology integration, allowing chip-on-board and surface mount technology components to co-exist, thus easing assembly and reducing cost. Electrical shielding is achieved through the use of advanced shallow blind-via slot technology and conductive, metal-clad FR4 lids. Selective permeability techniques prevent hydrogen poisoning while providing field-proven environmental sealing. The end result is a package with no machined metal parts and is mass producible with efficient heat extraction and minimal weight and size.

*As your system integration challenges increase in complexity, you need a high-frequency partner with experience you can lean on.*

As your defense and homeland security systems move *up* in frequency and *down* in budget, turn to Endwave Defense Systems. Advanced technology, quick time-to-market, and consistent, high-quality manufacturing are the hallmarks of our business philosophy. With an unparalleled library of circuit building blocks at our fingertips, we can customize nearly any integrated assembly imaginable—a claim backed by hundreds of thousands of high-frequency modules delivered across various markets. Endwave's two decades of defense heritage include some of the most sophisticated hi-rel military platforms.

#### **Defense & homeland security program experience:**

- *Unmanned Aerial Vehicles (UAV)*
- *Missile Front-Ends, Exciters, and Fuzes*
- *Airborne Warning and Surveillance*
- *Secure Satellite Communications*
- *Attack Helicopters and Other Airborne Programs*
- *Automatic Landing Guidance (ALG) Systems*
- *Intelligent Battlefield Communications*
- *Phased-Array, Monopulse and Fire Control Radar*
- *Microwave Perimeter "Fences"*

A continuous exchange of technology breakthroughs and manufacturing process improvements flows between our defense and commercial business units. This commercial/defense balance allows us to deliver the MIL-SPEC integrity and COTS mentality your applications require today.

#### **Matching the right technology to your application**

With Endwave Defense Systems, you get options. Your application will be considered from all angles, and our solution will carefully weigh your frequency of operation, quantity, environmental conditions, and critical performance criteria. Whether your application requires an advanced hybrid MIC circuit, custom GaAs PHEMT MMIC, or a proprietary flip-chip design using our MLMS technology, we'll employ the best circuit technology for the job. Plus, we have the packaging know-how to combine a variety of technologies—from SMT, to chip-on-board, to bare chip-and-wire—into perfectly integrated modules that fit seamlessly into your system architecture.

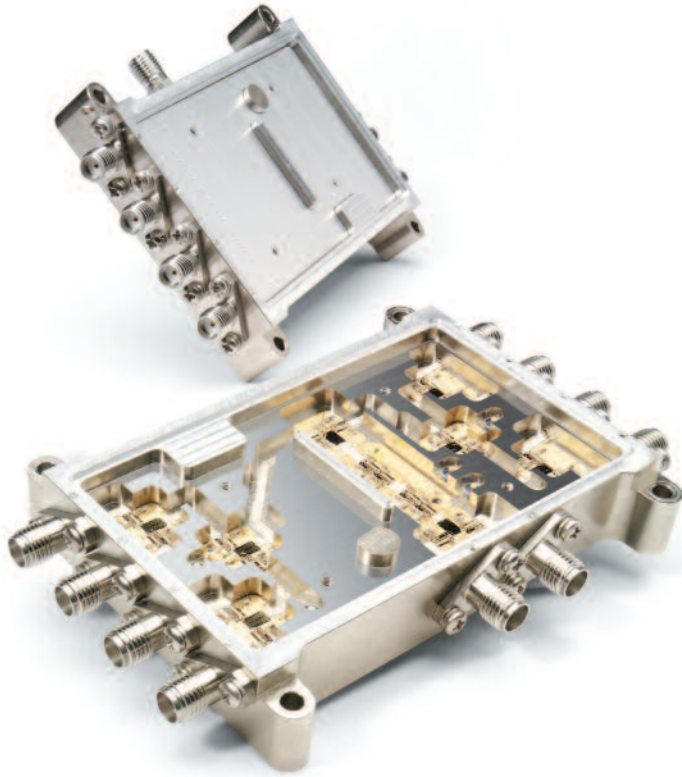
#### **Leverage our secure, flexible, world-class manufacturing facility**

Endwave Defense Systems' premier 20,000 square foot, state-of-the-art manufacturing facility is located in Diamond Springs, CA, approximately 30 miles east of Sacramento. Endwave uses lean manufacturing principles to streamline production, improve efficiencies, minimize waste, and ensure impeccable quality consistent with MIL specifications. In addition to production of custom-designed Endwave solutions, we also offer you our highly-automated, world-class factory for your build-to-print contract manufacturing projects.

Our secure facility is SCIF and ISO-9001-2000 certified, and we recently qualified to the more stringent aerospace AS9100 certification. It is the policy of Endwave to fully comply with all export regulations imposed by ITAR and EAR.

***Endwave. Plug Us In.***

# MFA s



## FEATURES AND SPECIFICATIONS

- *Custom Endwave Designs, or Build-to-Print Manufacturing Services*
- *1 to 94 GHz Frequency Capability*
- *Combine RF, LO, IF, and Digital Electronics*
- *Integrated RF Subsystems:*
  - Amplifier Networks*
  - Filtering & Equalization*
  - RF Power Distribution*
  - Frequency Conversion*
  - Frequency Sources*
  - Switches, Limiters, Detectors*
  - Programmable Attenuators*
  - Micro-Controllers*
- *MMIC, MIC, MLMSTM, Epsilon™, and SMT Technologies*
- *Automated Assembly and Test*
- *Design for Manufacturability (DFM)*
- *W/G and Coax Connector Options*
- *Environmental Screening (ESS)*
- *Hermetic Packaging*

If you can imagine it, and the laws of physics allow it—we can design it. Armed with an unparalleled library of circuit building-blocks at our fingertips, Endwave Defense Systems combines multiple components into a single, efficient, high-performance Multi-Function Assembly (MFA). Take a JCA Amplifier™, a multiplier, a down-converter from Endwave's vast product portfolio—and build from there. Integrate other functionality, such as filter banks, equalizers, power detectors, and digitally controlled attenuators. The power of integration—removing cables, packaging, and cost from your system electronics. From wide dynamic range limiting amplifier distribution systems, to complete RF front-ends, our custom MFA capability positions Endwave as your one-stop shop for all of your RF to millimeter-wave electronics.

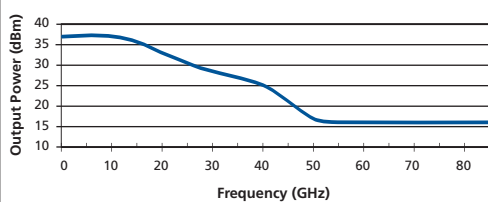
In addition to unsurpassed design capability, we also provide our customers with build-to-print assembly and test services of their proven MFA designs. Our high-volume business base enables us to amortize overhead expenses over a large number of units, leverage our materials purchasing power, and reduce manufacturing costs of your MFAs.

## FEATURES AND SPECIFICATIONS

- Amplifier modules to 94 GHz
- Low noise figure LNAs
- Low phase noise amplifiers
- Medium power amplifiers (< 5W)
- Multi-octave EW & ECM amps
- Narrowband communication amps
- Limiting amps
- Single-ended and balanced configurations
- Automated assembly available

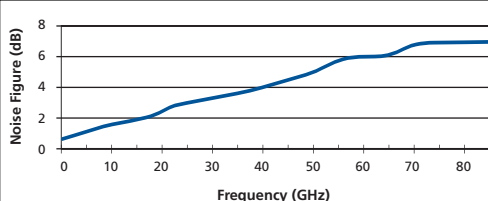
### Medium Power Capability

Typical Amplifier Output



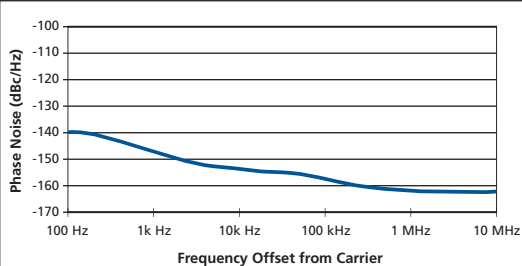
### Ultra Low Noise Figure Capability

Typical Amplifier Noise Figure



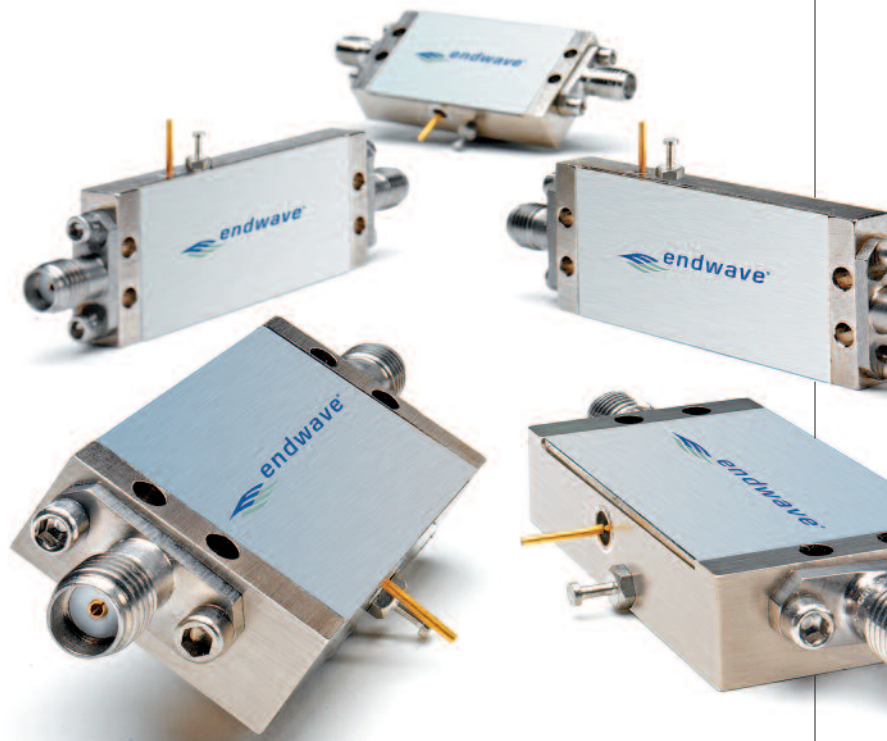
### Low Phase Noise Capability

Residual Phase Noise @ 9.5 GHz



JCA Amplifier search [www.endwave.com](http://www.endwave.com)

## JCA Amplifiers™



At the heart of Endwave Defense Systems lies a comprehensive line of amplifier products, inherited from our 2004 acquisition of JCA Technology, Inc.—a recognized name in solid-state amplifiers spanning RF to millimeter-wave frequencies. JCA Amplifiers use MIC technology and integrate the best available semiconductor devices with precise, repeatable thin-film hybrid construction to achieve tightly tolerated noise, power, and bandwidth performance. Where possible, we also provide MMIC-based amplifier solutions, leveraging our global supply chain strength as one of the largest users of high-frequency MMIC chips to ensure unit-to-unit consistency and the smallest of form factors. Whether you need an LNA to establish the lowest possible noise figure on your radar front-end, or a limiting amplifier to protect your receiver electronics from ECM jamming signals, we have a solution for you. Custom amplifier designs can typically be sampled in a matter of weeks.

#### Options:

- Integrated active & passive functions
- Variable gain control
- TTL switching
- Temperature compensation
- Input/output isolators
- Output detector
- Integrated limiters
- Phase matching
- Higher power
- Gain matching
- Various input/output connectors
- Waveguide interfaces
- Bias-T output
- Hermetic/non-hermetic packaging options

FEATURES AND  
SPECIFICATIONS

**Endwave YIG Oscillators:**

- Low phase noise: -105 dBc/Hz @ 10 kHz (typ.)  
-128 dBc/Hz @ 100 kHz (typ.)
- Outstanding phase hit performance
- Metal injection molding (MIM) packaging
- 2 Base models for cost/performance trade-off

**Mini-YIG Oscillator Features:**

- Broad tunable BW =  $\pm 1$  GHz
- Frequency output, 3–11 GHz
- $P_{out}$  (typ.) = +14.5 dBm buffered
- +8.5V bias @ 100 mA of current
- SMA connectorized, square package

**Micro-YIG Oscillator Features:**

- Lower cost option, small footprint
- Tunable BW =  $\pm 450$  MHz
- Frequency output, 3–10 GHz
- $P_{out}$  (typ.) = +3 dBm unbuffered,  
+10 dBm buffered
- +8.5V bias @ 70 mA of current (buffered)
- SMA connectorized, circular package

*Typical YIG performance*

Parameter	UNITS	Micro YIG	Mini YIG
<b>RF</b>			
Frequency Range	GHz	3–10	3–11
Tuning Range	MHz	$\pm 450$	$\pm 1000$
$P_{out}$ (Buffered)	dBm	10	14.5
<b>PHASE NOISE</b>			
Offset 1 kHz	dBc	-82	-82
Offset 10 kHz	dBc	-105	-105
Offset 100 kHz	dBc	-128	-128
<b>SPURS</b>			
2nd/3rd Harmonic	dBc	-12	-12
Spurious	dBc	-60	-60
<b>DC Supply</b>			
DC Voltage	V	8.5	8.5
DC Current	mA	70	100
<b>Main Coil</b>			
Sensitivity	kHz/mA	$5 \pm 10\%$	$5 \pm 10\%$
Coil Impedance	Ohms	26	10
Modulation BW	kHz	35	10
<b>FM Coil</b>			
Sensitivity	kHz/mA	$150 \pm 20\%$	$150 \pm 20\%$
Coil Impedance	Ohms	1, 2 $\mu$ H	1, 2 $\mu$ H
Modulation BW	kHz	400	400
Deviation	MHz	$\pm 50$	$\pm 50$
<b>Packaging</b>			
RF Interface	–	SMA-F	SMA-F
Outline Option	–	Circular	Rectangular

# Oscillators



Endwave Defense Systems' YIG (Yttrium Iron Garnet) technology provides a frequency source with high spectral purity for microwave communications and instrumentation applications. In addition to their low phase noise characteristic which is virtually independent of the operating frequency, they provide large tunable bandwidths in comparison to Dielectric Resonator Oscillators (DRO). Therefore, a wide frequency band can typically be spanned with a single YIG oscillator where several DROs would otherwise be needed to obtain similar coverage. Endwave Defense Systems provides YIG-tuned oscillators through Ku-Band, and these high fundamental frequencies also help to minimize spurious signals in the overall system design. Endwave YIG oscillators are available in two base configurations, Micro-YIG and Mini-YIG, to address a range of packaging, performance, and budget constraints.

**Options:**

- Customized bandwidths up to  $\pm 1.5$  GHz
- Buffered & non-buffered output power
- Male or female SMA output
- TO-8 board-mount packages
- Other main coil and FM coil options



# Synthesizers



Endwave Defense Systems offers a variety of frequency synthesizers designed for applications where small step size, low phase-noise, broad tuning range, and low power consumption are required. These products are designed to meet the demanding requirements of field portable SatCom terminals, high-resolution radar, control links for UAVs, and test/measurement applications. Our capability includes both VCO and YIG based designs to provide system designers a cost vs. performance option. The lowest phase noise available on the market is achieved through the use of our permanent magnet Mini- and Micro-YIG oscillators. YIGs typically provide low noise performance of -105 dBc @ 10 kHz and -128 dBc @ 100 kHz with tuning to  $\pm 1$ GHz. Standard frequencies range from 4.5 to 13.75 GHz, in a variety of available step sizes. These synthesizers are an ideal replacement for DROs and offer optimal spectral purity with broad tuning ability. Low cost VCO options can be provided with approximately 10 dB higher phase noise levels.

### Options:

- Mini- or Micro-YIG oscillator, or VCO-based oscillator
- Phase lock alarm
- Single or dual RF outputs
- Step sizes from a few Hz to several hundred kHz
- Wide output power range
- Bias voltage range from +5V to +15V
- Outstanding close-in phase noise

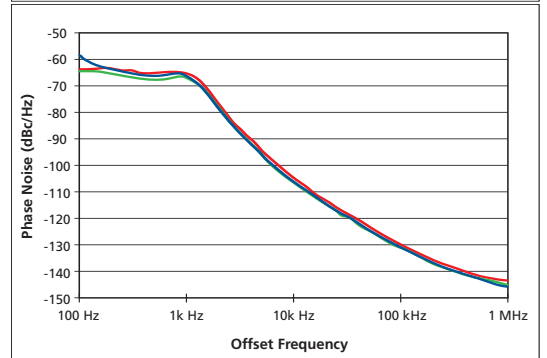
## FEATURES AND SPECIFICATIONS

- 4.5 to 13.75 GHz frequency capability
- Wide tuning range up to  $\pm 1$  GHz
- Typical phase noise: -100 dBc/Hz @ 10 kHz  
-128 dBc/Hz @ 100 kHz
- Single loop and multi-loop configurations
- Robust microphonic & phase hit performance

### Typical synthesizer performance

Parameter	UNITS	SYN A	SYN B	SYN C	SYN D
<b>RF</b>					
Frequency Range	GHz	4.5–7.0	7.0–10.0	10.0–13.75	6.4–7.5
Tuning Range	GHz	1.5	1.5	2.75	1.8
Typical Step Size	kHz	250	250	500	1
RF Outputs	–	Dual	Dual	Single	Single
$P_{out}$	dBm	12	12	11	16
$P_{out}$ Variation	dBm	$\pm 4$	$\pm 4$	$\pm 4$	$\pm 3$
RF Interface	–	SMA-F	SMA-F	SMA-F	SMA-F
<b>PHASE NOISE</b>					
Offset 1 kHz	dBc	-65	-65	-62	-87
Offset 10 kHz	dBc	-105	-105	-93	-92
Offset 100 kHz	dBc	-128	-128	-119	-110
Offset 1MHz	dBc	-143	-143	-138	-125
<b>SPURS</b>					
Harmonic Spurious	dBc	-30	-30	-30	-15
PLL Spurious	dBc	-70	-70	-62	-65
Sub-Harmonics	dBc	-57	-57	-50	-65

Typical SYN A Phase Noise Plot Over Temp

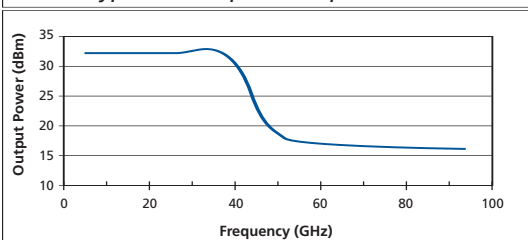


## FEATURES AND SPECIFICATIONS

- 4 to 94 GHz output frequency capability
- Multiplication factors from X2 to X28
- Broadband models: octave plus bandwidth
- Narrowband models: 5 to 20% bandwidth
- Popular output bands (GHz):  
18-26.5, 26-40, 40-60

Parameter	Unit	Doubler Active	Tripler Passive	Quadrupler Active
Input Frequency	GHz	10–20	4.5–5	6.6–10
Output Frequency	GHz	20–40	13.5–15	26–40
Input Power	dBm	+10	+15	+10
Output Power	dBm	+10	+1	+15
Harmonics	dBc	-20	-20	-15
DC Supply	V/mA	+12/240	0/0	+12/410

Typical Multiplier Output Power



## Multipliers



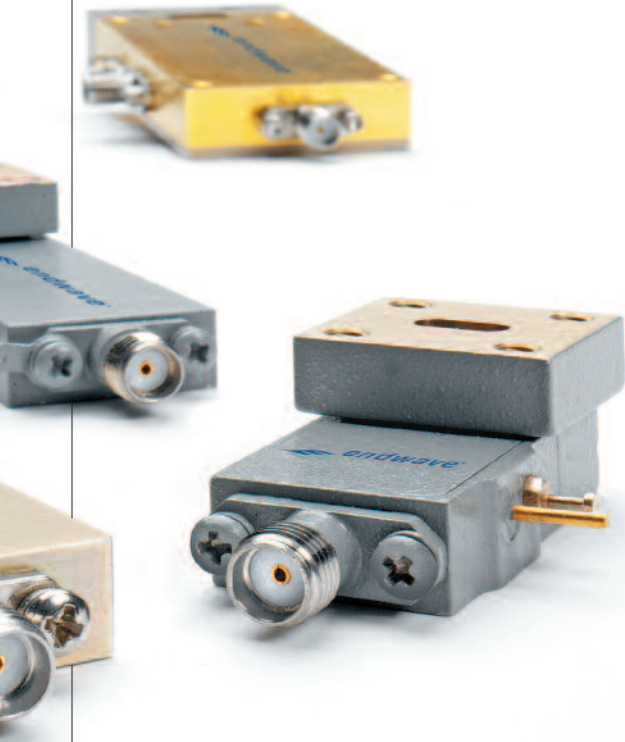
Endwave Defense Systems' frequency multipliers include a comprehensive line of doublers, triplers, quadruplers, and higher order multiplication schemes up to  $N = 28$ . Narrowband passive diode-based models provide superior phase noise to within 1 dB of the theoretical limit of  $20 \log N$ . Active models using FETs or PHEMTs typically have broader bandwidth and slightly higher phase noise, but allow the multiplier module to also provide gain, if necessary. Options include operating voltages from +5V to +24V, and DC bias can be configured for minimal current drain when battery operation is required. Our capability provides multiplier output frequencies from 4 GHz up to 94 GHz. Depending on desired filtering and amplification, output power levels can exceed 2 watts.

### Options:

- Single-ended or balanced design configurations
- Passive, diode-based designs
- Active, FET or PHEMT-based designs
- Output power amplification to > 2W
- Tailor-made input drive level
- Gain control
- Output filtering
- Built-in Test (BIT)
- I/O connector options include coax, waveguide, GPO
- Lower cost, non-hermetic packaging available



# Up/Down-Converters



Endwave Defense Systems' up/down-converter capability spans a wide range of RF & LO frequencies up through 94 GHz, with IF coverage to 20 GHz. A typical lineup for an integrated down-converter assembly includes an RF chain consisting of a low-noise amplifier (LNA), image reject filter, a mixer, and an IF output amplifier stage. Similarly, a typical up-converter lineup begins with an IF pre-amplifier and filter, a mixer, followed by an LO-reject filter and power amplifier chain on the RF output. Various LO configurations are available, and mixer options include single-balanced, double-balanced, triple-balanced, image reject, and sub-harmonic configurations. An optional phase locked source can also be integrated to provide a self-contained on-board synthesizer for generating the LO signal. The complete assemblies are housed in a compact hermetic case and configured with either coaxial or waveguide connectors.

## Options:

- On-board LO source or multipliers
- Input limiters
- Output detector
- Receive signal level (RSL)/receive signal strength indicator (RSSI)
- RF or IF gain control
- I/O isolators
- Lower cost, non-hermetic packaging options

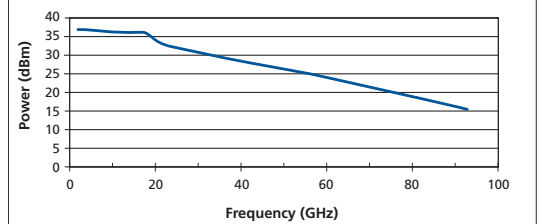
## FEATURES AND SPECIFICATIONS

- Up/down-converters to 94 GHz
- IF coverage to 20 GHz
- Super-heterodyne, image/LO reject, and sub-harmonic topologies
- Up-converter output power to +2W
- Down-converter noise figure to < 3 dB

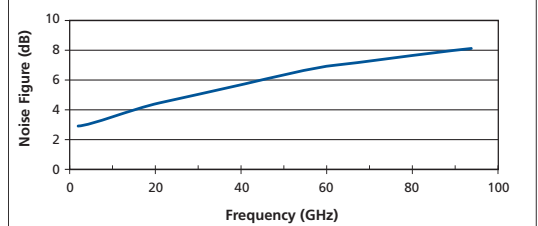
### Typical converter performance

Parameter	Unit	Down-converter	Up-converter
RF Start Freq	GHz	21.2	22.4
RF Stop Freq	GHz	22.4	23.6
LO Start Freq	GHz	6.65	6.65
LO Stop Freq	GHz	7.05	7.05
IF Freq	GHz	1.25	2.45
Conversion Gain	dB	22	29
Flatness (50 MHz)	dB	± 0.25	± 0.25
Noise Figure	dB	5.5	
Intercept Point	dBm	-7 (input)	32 (output)
Input VSWR	:1	1.92	2.0
Output VSWR	:1	1.75	1.8
LO Input Power	dBm	5	8

### Up-converter Saturated Output Power



### Down-converter Noise Figure Capability



# Integrated Transceivers



## FEATURES AND SPECIFICATIONS

- Frequency capability up through 94 GHz
- Integrated transmit, receive, and LO circuitry
- LO multiplication factor,  $XN$  ( $N = 1$  to  $12$ )
- Receiver noise figures to 3 dB
- Transmit output power to 2W
- Linear or non-linear operation
- Low spurious emissions
- Environmentally sealed and tested at temperatures from  $-54^{\circ}\text{C}$  to  $+100^{\circ}\text{C}$

### Sample integrated transceiver specifications

Parameter	Unit	Receiver	Transmitter
RF Frequency	GHz	K-Band	-
LO Frequency	GHz	S-Band	-
IF Frequency	dBm	L-Band	-
Input P1dB	dBm	-70	-
Noise Figure	dB	2.6	-
Conversion Gain	dB	50	-
LO Input Power	dBm	+2	+2
Output Frequency	GHz	-	Q-Band
Input Frequency	GHz	-	S-Band
Multiplication Factor	-	-	X16
Input Power	dBm	-	0
Output Power	dBm	-	+33

You need a transmitter. You need a receiver. And you need them combined into a high-performance, reliable T/R module solution that makes integration into your overall system architecture a breeze. We've become experts in eliminating cross-talk between transmit and receive electronics—avoiding noise figure degradation due to digital logic, modulation, and control signal interference—and suppressing LO leakage that might otherwise weigh down your transmitter linearity. Transceivers are our business, and they exemplify our dedication to providing truly superior integrated modules for high-frequency applications. They are delivered to your exact specifications and come in a variety of form factors.

### Options:

- Integrated LO synthesizers
- Transmitter power detection (accuracy to  $\pm 1$  dB)
- Transmitter gain control options, up to 50 dB
- Receiver gain control options, up to 30 dB
- Receiver limiter protection
- Receiver signal level (RSL)
- Models with on-board EEPROM for data storage/calibration
- Transmit muting function
- TX to RX loopback diagnostics
- Various DC power options
- Multiple I/O Options (coax, waveguide, multipin headers)

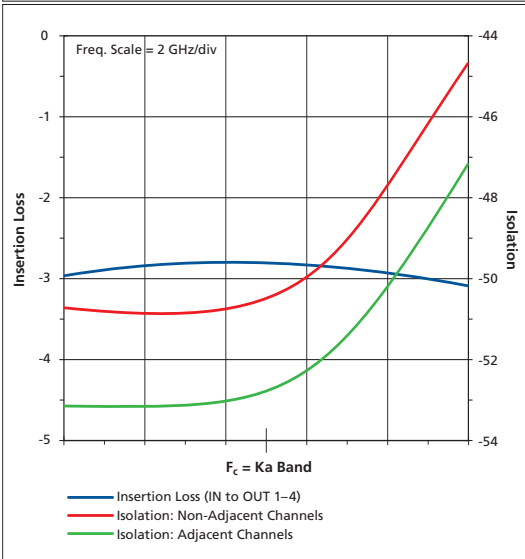
### Popular T/R Frequency Bands:

C-Band: 5.9 to 8.5 GHz
X-Band: 10.7 to 11.7 GHz
Ku-Band: 12.75 to 15.25 GHz
Lower K-Band: 17.7 to 19.7 GHz
Upper K-Band: 21.2 to 26.5 GHz
Lower Ka-Band: 27.5 to 33.4 GHz
Upper Ka-Band: 36 to 40 GHz
V-Band: 57 to 64 GHz
E-Band: 71 to 86 GHz
W-Band: 93 to 95 GHz

FEATURES AND  
SPECIFICATIONS

- 1 to 94 GHz frequency capability
- Complex switch configurations for multiple I/Os
- Models up to SP16T
- High isolation, 35-40 dB typical
- Phase tracking to  $\pm 2$  degrees
- Amplitude matched outputs to  $\pm 0.1$  dB
- Switching speed to 2 nsec

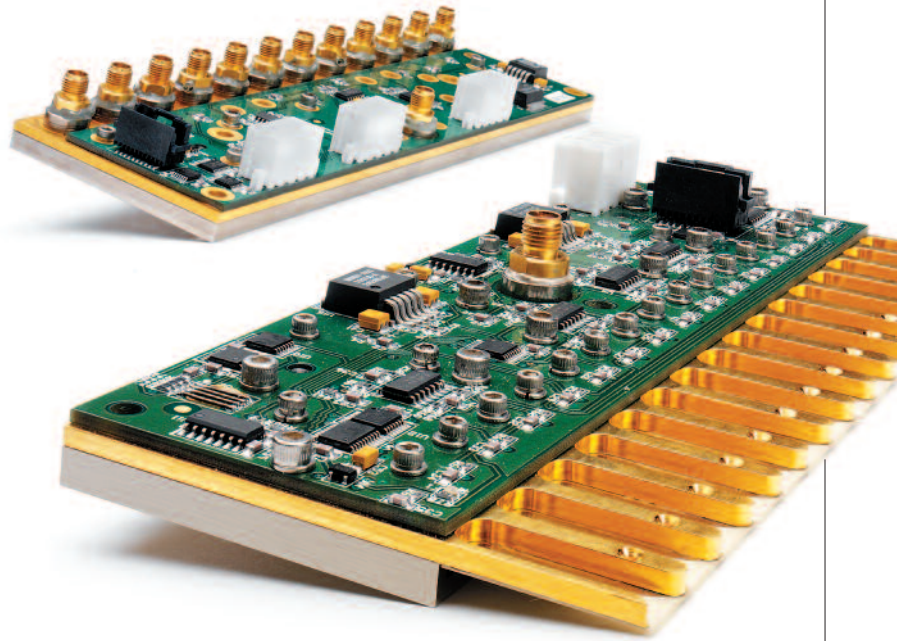
Typical SP4T Switch Array Performance



Switch Type	Insertion Loss	Isolation	VSWR
SPST (Matched)	3.0 dB	25 dB	2:1
SPST (Reflective)	2.0 dB	20 dB	N/A
SPDT (Reflective)	2.0 dB	10 dB	N/A
SP3T (Reflective)	2.0 dB	10 dB	N/A
SP4T (Matched)	3.5 dB	20 dB	2:1

Matched Switch VSWR < 2:1 Under All Conditions  
Reflective Switch VSWR < 2:1 in Low-Loss State Only  
Both FET and Diode-Based Switches Available

# Switch Arrays



In addition to being the leader in TX and RX integration, Endwave is proficient at integrating various switch configurations with other high-frequency components such as filters, isolators, power splitters, limiters, and amplifiers to form custom switch arrays. Harnessing our proprietary library of building-block SPNT switches (where  $N = 1$  to 4), we have developed customized switch arrays up to SP16T in both narrowband and broadband configurations. They are available with reflective or absorptive (non-reflective) topologies and are designed with a focus on low insertion loss, high ON/OFF isolation, and fast switching speeds.

Microwave and millimeter-wave switches are important signal distribution products for many mission-critical defense and security electronics. Applications range from portal scanners for weapons and contraband detection, to electronic beam-steering for missiles employing phased-array radar tracking.

### Options:

- Integrated active or passive components
- On-board driver circuits for single-ended or differential control interfaces (TTL, CMOS, ECL, etc.)
- Low current options
- Connector I/O options include coax, GPO, and waveguide
- Packaging options from surface-mount Epsilon Packaging™ to hermetically sealed modules





**Positioned to be your long-term high-frequency partner**

Originally incorporated in 1991 as Endgate Corporation—a Silicon Valley start-up focused on high-frequency circuits for satellite communications—Endwave Corporation is now a global company with operations in California, Massachusetts and Thailand. In 2000, the company merged with TRW Milliwave, a respected RF subsystem supplier to the defense industry, and renamed the company Endwave. In addition to significant investments in high-frequency research and development, Endwave has invested in acquiring assets from divisions of M/A-COM, Signal Technology Corporation, Verticom, Arcom, and most recently the JCA Technology division from Bookham plc.

In early 2005, Endwave Defense Systems was announced as an Operating Division of Endwave. This dedicated group is leveraging our combined defense experience and modern facilities to quickly deliver modules with more value-added performance and a superior level of integration.

*Endwave Corporation is recognized by the U.S. Small Business Administration (SBA), and our state-of-the-art facilities are ISO 9001-2000, AS9100, and SCIF certified. We are a publicly traded company on NASDAQ under the symbol ENWV.*

**www.endwave.com**



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*Please visit our Web site for a full list of Endwave sales representatives and contacts.*