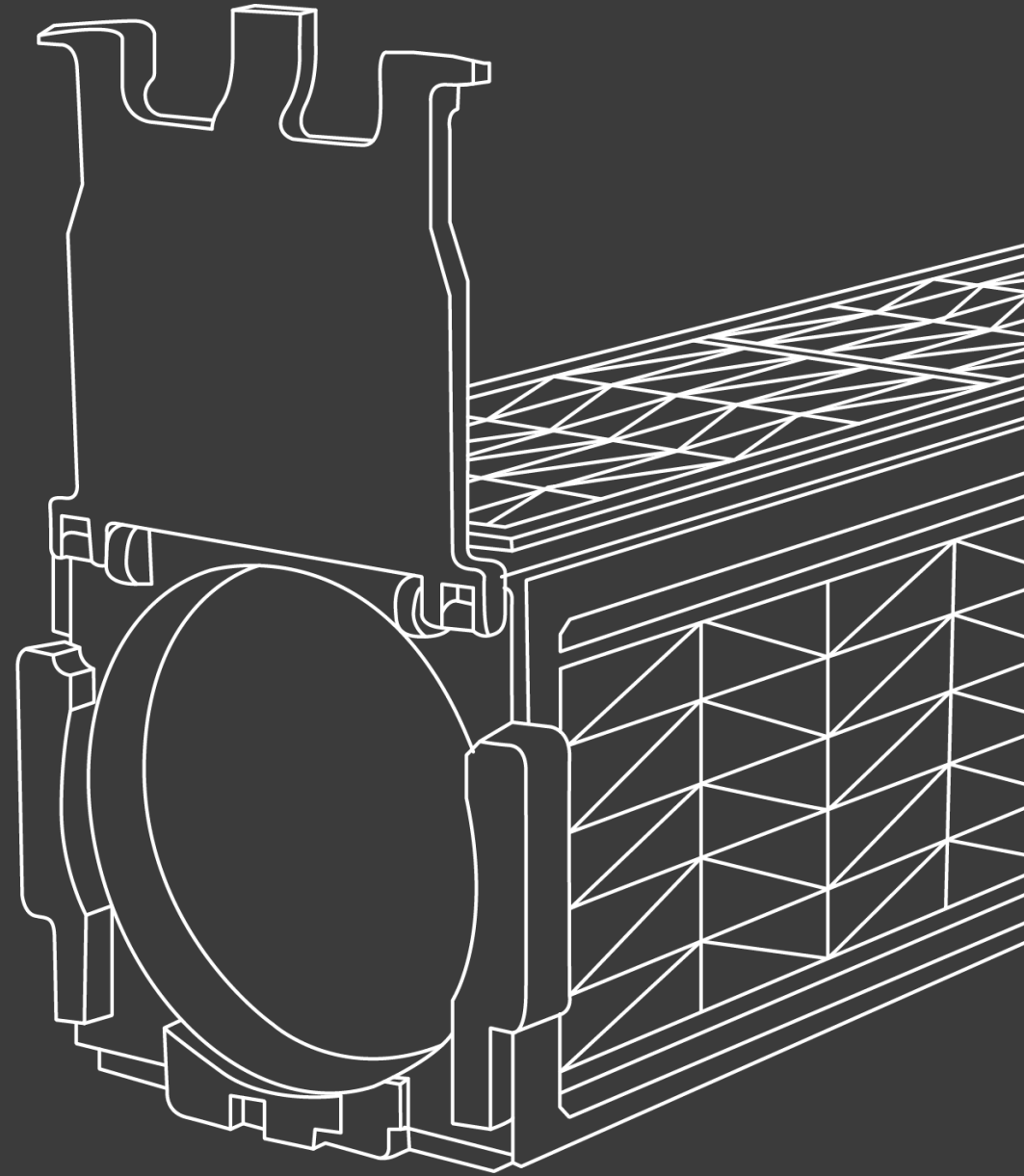


ERA^ΔANT

NEXT GENERATION MILLIMETERWAVE COMPONENTS

SPACE AND THERMAL VACUUM
APPLICATIONS



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INTRODUCTION

Eravant designs and manufactures total solutions for microwave and millimeterwave applications covering DC to 220 GHz.

- **This presentation introduces Eravant's standard product offering for Space and Thermal Vac applications.**
- **Many of Eravant's commercial off-the-shelf products are ready to be converted for use in thermal vacuum/space environments with adjustments to material selection for low outgassing, manufacturing process for compliance, documentation for traceability, and testing for performance verification.**
- All our products, including Limited Run models, are listed on our website at www.eravant.com.

Additional products and presentations are available upon customer request:

- Custom models for components and subassemblies can be configured to customers' specifications.
- Presentations for specific applications such as Instrumentation, 5G and IoT, Communication, and Radar are also available online.
- Presentations for specific frequency bands such as Ka, V, and W band are also available online.
- These presentations can be found on our website at www.eravant.com/publications

SATELLITE FREQUENCY BANDS

A general overview of the different frequency bands used for satellites and ground stations is presented in the table below.

Band	Frequency Range	Usage Example	Downlink Frequencies	Uplink Frequencies	Notes
L-band	1 to 2 GHz	GPS satellites			GPS L1 Band: 1.57542 GHz GPS L2 Band: 1.22760 GHz GPS L5 Band: 1.17645 GHz
S-band	2 to 4 GHz	Satellite radio			XM satellite radio: 2.3325-2.345 GHz Sirius satellite radio: 2.320-2.3325 GHz
C-band	4 to 8 GHz	Satellite TV	3.7-4.2 GHz (Standard C-band) 3.4-3.7 GHz (Extended C-band)	5.925-6.425 GHz (Standard C-band) 6.425-6.725 GHz (Extended C-band)	
X-band	8 to 12 GHz	Military communication and radar satellites	7.25-7.75 GHz (NATO band type 1)	7.9-8.4 GHz (NATO band type 1)	
Ku-band	12 to 18 GHz	Satellite TV	10.7-12.7 GHz	14.0-14.5 GHz	
Ka-band	26 to 40 GHz	Satellite communications	17.7-21.2 GHz (Ku-band)	27.5-29.1 GHz 29.5-30.0 GHz	Ka-band atmospheric transmission window: 35 GHz Water vapor absorption peak: 22 GHz
Q-band	33 to 50 GHz	Satellite Internet (Starlink)	37.5-42.5 GHz (V-band per IEEE)	47.2-50.2 GHz (V-band per IEEE) 50.4-51.4 GHz (V-band per IEEE)	
V-band	50 to 75 GHz 40 to 75 GHz (IEEE Designation)	Military communication satellites (Milstar)			Oxygen absorption peak: 60 GHz Milstar satellite space-to-space crosslink: 60 GHz
E-band	60 to 90 GHz	Satellite communications	71-76 GHz (V-band)	81-86 GHz (W-band)	
W-band	75 to 110 GHz	Earth observation and research satellites			W-band atmospheric transmission window: 94 GHz NASA CloudSAT cloud observation radar satellite: 94 GHz

T-VAC AND SPACE PRODUCT OVERVIEW

Eravant's thermal vacuum and space products are made with materials that meet low outgassing criteria per NASA Reference Publication 1124, Revision 4. The outgassing criteria are as follows:

- **Maximum total mass loss (TML) of 1.0%**
- **Maximum collected volatile condensable materials (CVCM) of 0.10%**

Thermal vacuum and space products also benefit from Eravant's ongoing anti-cocking flange update that is being rolled out to all standard products as old stock are depleted. See this blog for more information:

<https://www.eravant.com/benefits-of-anti-cocking-and-sandblasting-for-rf-performance>

The following slides give an overview of the different product families that Eravant offers for thermal vacuum and space environments.

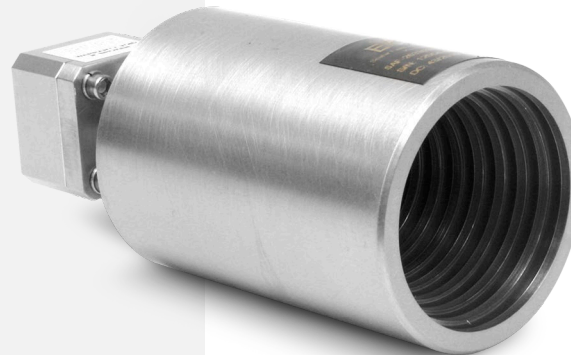
ANTENNAS

CORRUGATED FEED HORN ANTENNAS

18 to 110 GHz

OVERVIEW

- PRODUCT FAMILIES: SAF, SAH
- Conical and choke flange corrugated feed horns.
- Various gain from 10 to 20 dBi.
- Large flare angle conical types for flatter gain across the bandwidth.
- Small flare angle conical types for linear gain across the bandwidth.
- Aluminum 6061-T651 housing with chem film finish.

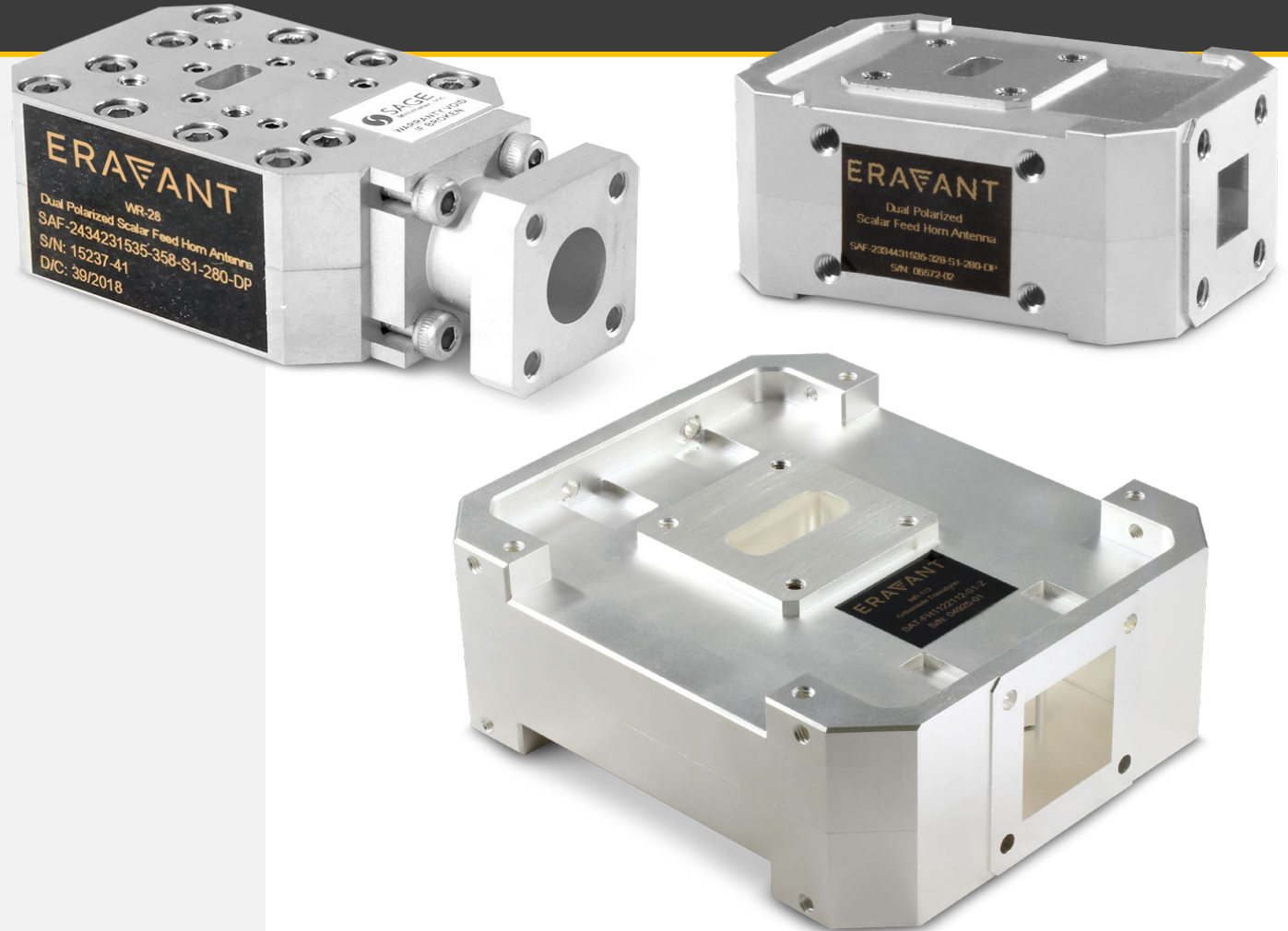


ORTHOMODE TRANSDUCER (OMT)

18 to 110 GHz

OVERVIEW

- Product Family: **SAT**
- Boifot junction orthomode transducer.
- Square port can be converted to circular port with a square to circular mode transition.
- Aluminum 6061-T651 housing with chem film finish.
- 18-8 stainless steel fasteners and hardware.

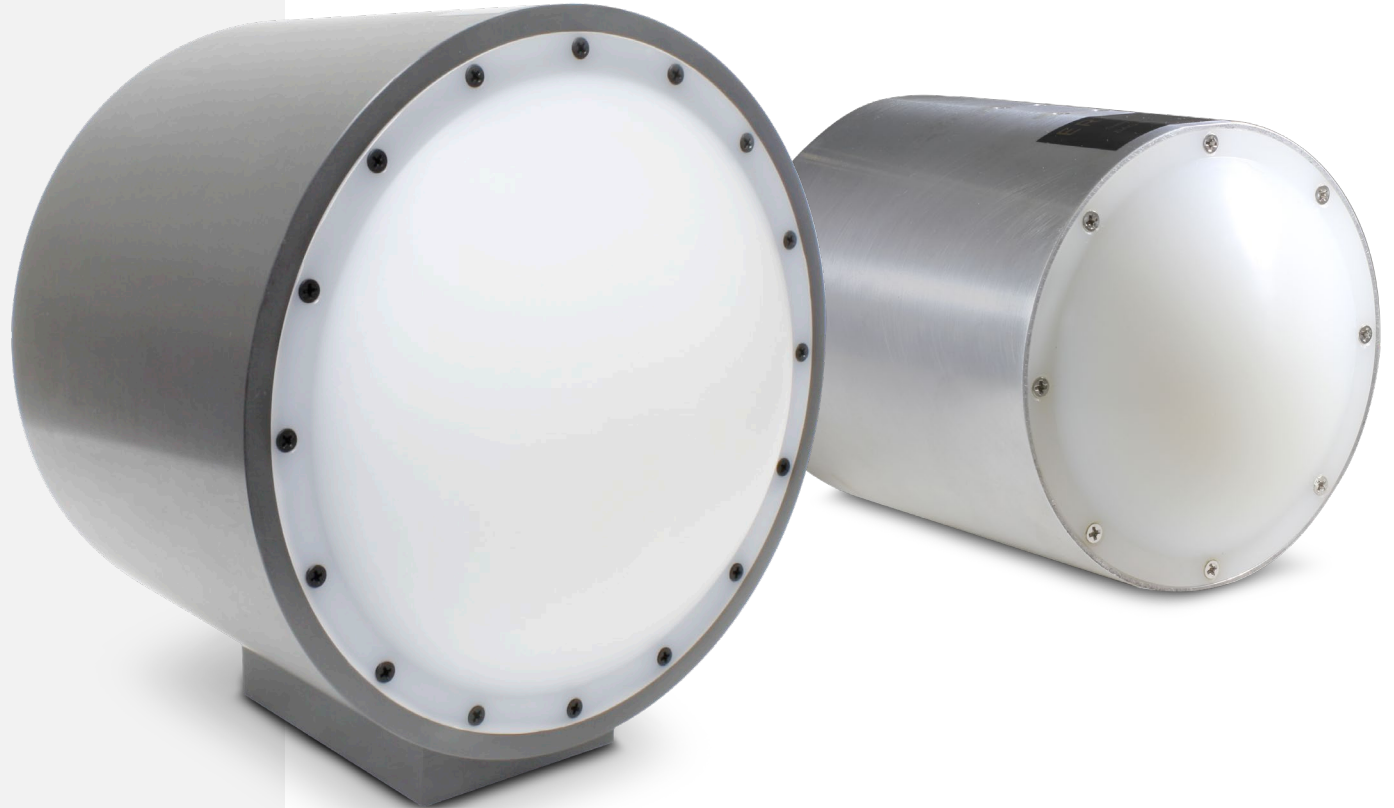


GAUSSIAN LENS ANTENNAS

18 to 110 GHz

OVERVIEW

- Product family: **SAG**
- Gaussian lens antenna with internal corrugated feed horn.
- Standard lens diameters are 3" and 6".
- Aluminum 6061-T651 housing and feed horn with chem film finish.
- Rexolite 1422 Gaussian lens.
- 18-8 stainless steel fasteners and hardware.

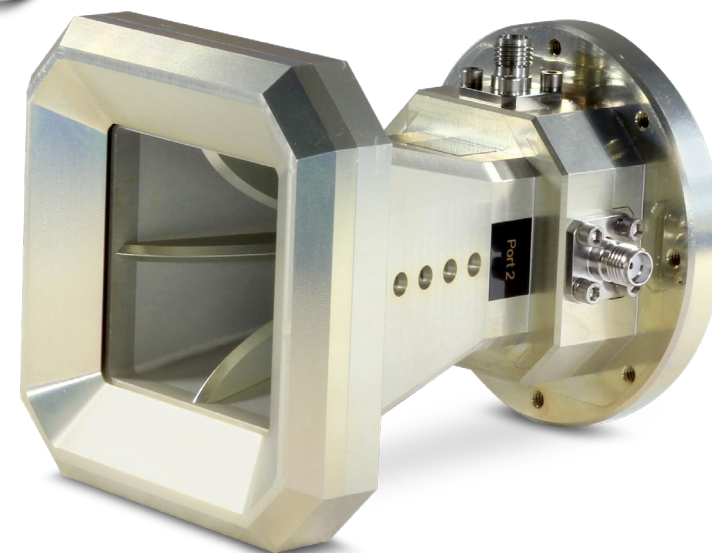
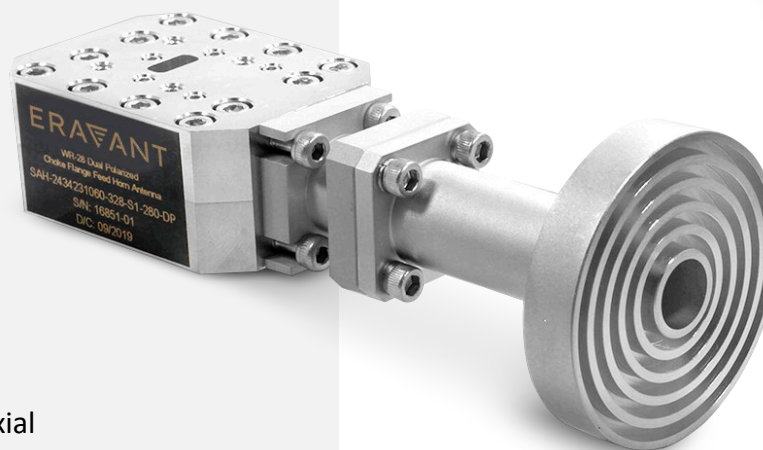
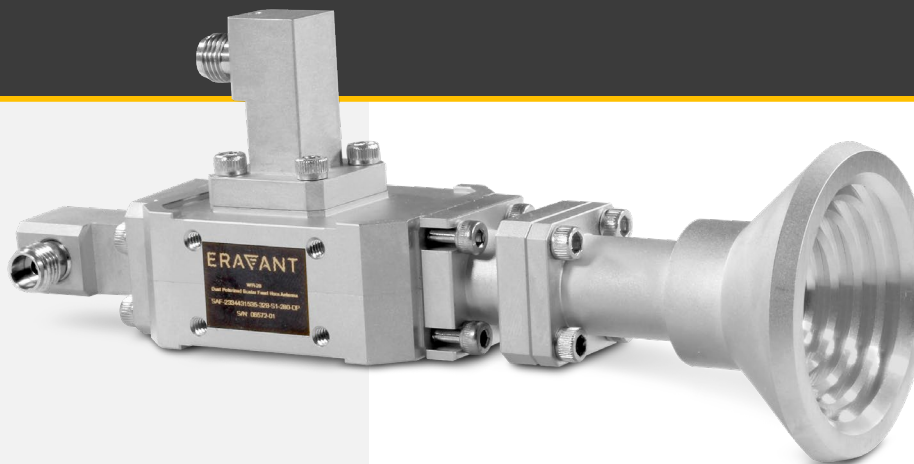


DUAL POLARIZED ANTENNAS

2 to 110 GHz

OVERVIEW

- Product family: SAF, SAH, SAG, SAV
- Two types:
 - Orthomode transducer with mode transition and antenna integrated.
 - Quad-ridge horn antenna with coaxial ports.
- Many antenna configurations for OMT. Refer to blog for more information.
(<https://www.eravant.com/dual-polarized-antennas-from-eravant>)
- OMT waveguide ports can be converted to coaxial ports with waveguide-to-coax adapters.
- Aluminum 6061-T651 housing with chem film finish.
- 18-8 stainless steel fasteners and hardware.



WAVEGUIDE COMPONENTS

WAVEGUIDE SECTIONS, TRANSITIONS, AND ADAPTERS

18 to 110 GHz

OVERVIEW

- Product families: SWG, SWB, SWT, SWR
- Variety of simple waveguide parts, such as:
 - Rectangular and circular waveguide straight sections.
 - Rectangular waveguide bends and twists.
 - Rectangular to rectangular waveguide taper transitions.
 - Rectangular to circular, square to circular, or rectangular to square waveguide mode transitions.
 - Flange adapters for rectangular or circular waveguides.
- Aluminum 6061-T651 housing with chem film finish.

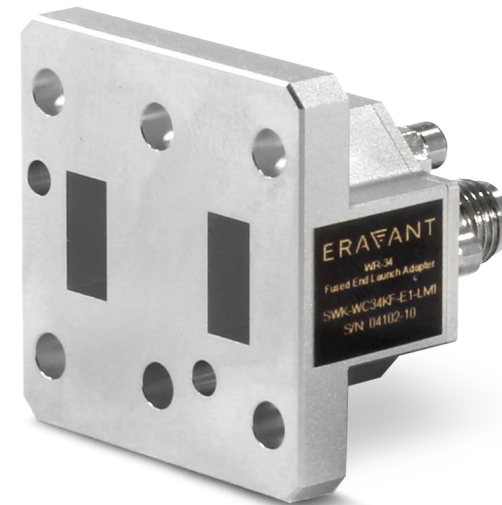
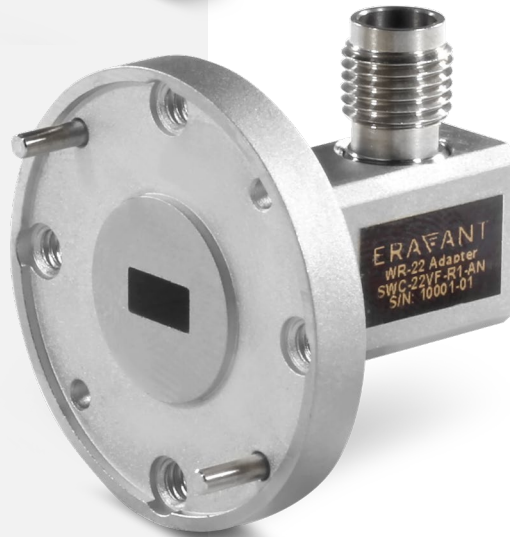
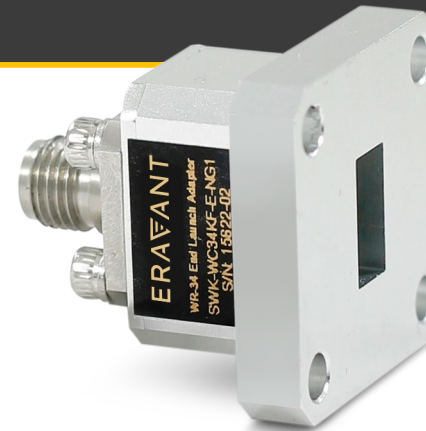
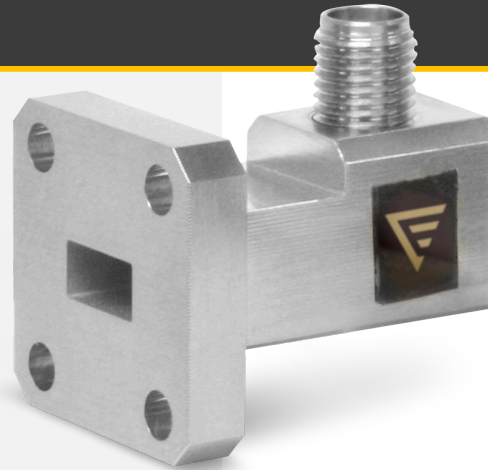


WAVEGUIDE TO COAX ADAPTERS

18 to 110 GHz

OVERVIEW

- Product families: **SWC**
- End launch and right-angle configurations.
- Male or female SMA, 2.92mm (K), 1.85mm (V), and 1mm connectors.
- Aluminum 6061-T651 housing with chem film finish.
- 18-8 stainless steel fasteners and hardware.
- Low outgassing thread-in and flanged coaxial connectors.
- H20E epoxy for thread locking and pin/probe attachment.
- Custom models are available.

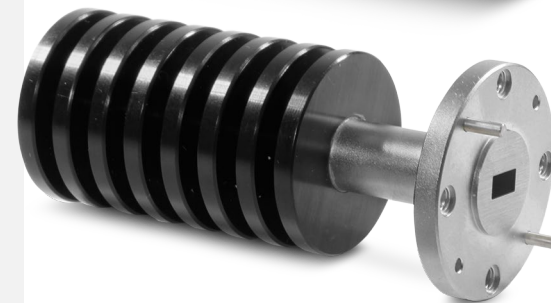


WAVEGUIDE TERMINATION LOADS

18 to 110 GHz

OVERVIEW

- Product families: **SWL**
- Low, medium, and high-power waveguide terminations.
- Aluminum 6061-T651 housing with chem film finish.
- 18-8 stainless steel fasteners and hardware.
- Low outgassing internal matching load.
- H20E epoxy for internal load attachment.



WAVEGUIDE COUPLERS

18 to 110 GHz

OVERVIEW

- Product families: **SWD, SWX**
- Split-block directional, dual-directional, bidirectional, and cross guide type waveguide couplers.
- Dual-directional type can be configured with asymmetric forward and reverse coupling levels.
- Coupling levels: 10, 20, 30, and 40 dB.
- Cross-guide coupling levels: 20, 30, and 40 dB.
- Aluminum 6061-T651 housing with chem film finish.
- Low outgassing microwave absorber for internal matching loads.
- H20E epoxy for internal load attachment.
- 18-8 stainless steel fasteners and hardware.
- C110 copper inserts.



WAVEGUIDE FILTERS

18 to 110 GHz

OVERVIEW

- Product families: **SWF**
- Split-block low pass, band pass, and high pass waveguide filters.
- Aluminum 6061-T651 housing with chem film finish.
- 18-8 stainless steel fasteners and hardware.



UNI-GUIDE™ WAVEGUIDE CONNECTORS

26.5 to 60 GHz

OVERVIEW

- Product family: **SUF**
- Universal waveguide connector that provides a standard waveguide interface from the standard coaxial glass bead feed thru pin.
- Designed to mate with standard 0.012" diameter feed thru pins.
- Compatible with standard 0.480" mounting hole pattern for two-hole flanged coaxial connectors.
- Aluminum 6061-T651 housing with chem film finish.
- H20E epoxy for pin receptacle attachment.



WAVEGUIDE MAGIC TEE AND POWER DIVIDERS

18 to 110 GHz

OVERVIEW

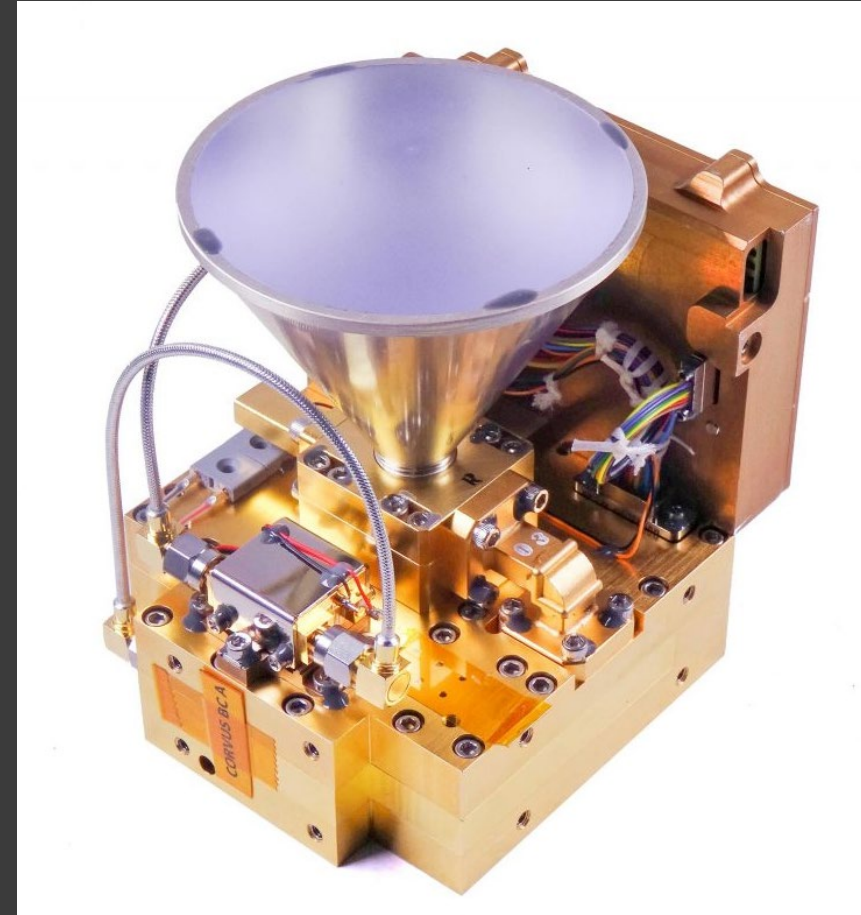
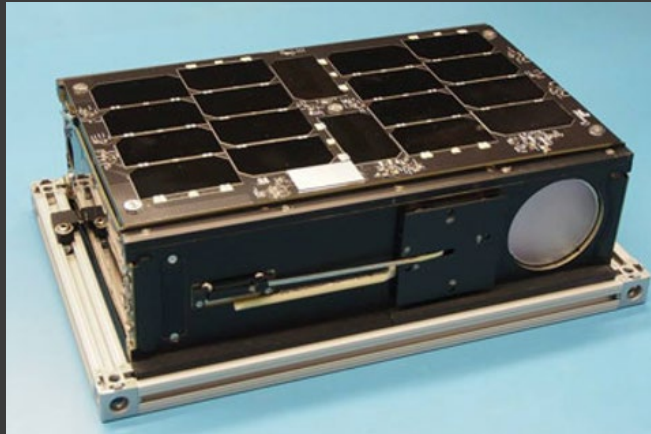
- Product families: **SWM, SWP**
- Split-block waveguide magic tees and power dividers.
- Inline and right angle 2-way, 4-way, and 8-way power divider configurations available.
- 90° twist available to convert ports from H-plane to E-plane orientation.
- Aluminum 6061-T651 housing with chem film finish.
- 18-8 stainless steel fasteners and hardware.



TRANSMITTER MODULES

ERAVANT TRANSMITTER MODULES

- Eravant has developed space qualified transmitter modules for satellite applications. The modules shown in this presentation have been in orbit since 2014 (http://space.skyrocket.de/doc_sdat/perseus-m.htm).
- A technical paper “Low Cost Ka-Band Transmitter for CubeSat Systems” was published in IEEE **2017 Topical Workshop on Internet of Space (TWIOS)**.
- The transmitter was also featured as part of Astro Digital’s complete transmitter package in NASA’s State of the Art of Small Spacecraft Technology online publication, October 2020. (<https://www.nasa.gov/smallsat-institute/sst-soa-2020/communications>)

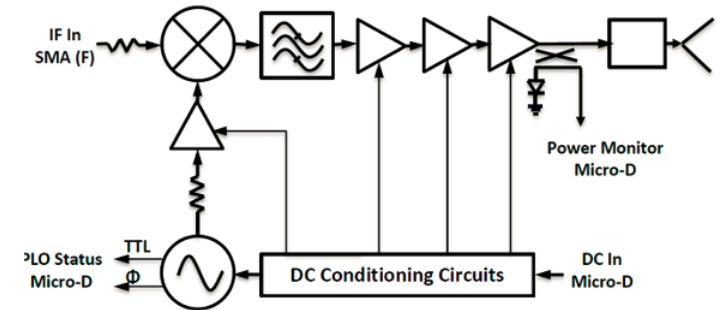
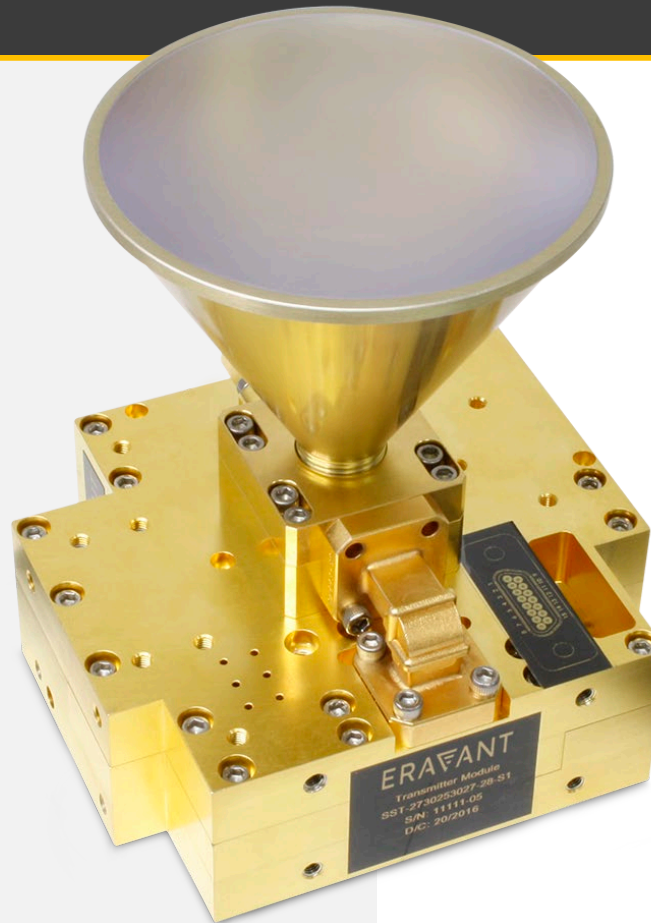


SPACE QUALIFIED TRANSMITTER MODULE

26.7 to 26.9 GHz

OVERVIEW

- Product family: **SSK**
- SSK-ST2730253027-28-C1**
- Features:**
 - 26.7 to 26.9 GHz Bandwidth
 - Circular Polarized Waveform
 - 10 Degree 3 dB Beamwidth
 - +52 dBm EIRP
 - Space Qualified



Electrical Specifications:

Parameter	Minimum	Typical	Maximum
Antenna 3 dB Beam-width		10°	
Antenna Side Lobes		-20 dB	
Antenna Polarization		Circular	
TX Frequency Range	26.7 GHz		26.9 GHz
TX Output P _{1dB}	+27 dBm	+29 dBm	
TX EIRP	+50 dBm	+52 dBm	
IF Frequency Range	0.9 GHz		1.1 GHz
IF to TX Linear Gain		23 dB	
IF P _{in}	0 dBm	+4 dBm	+8 dBm
IF Input VSWR		1.5:1	
Harmonics		-50 dBc	
Spurious		-60 dBc	
Phase Noise	-80 dBc/Hz @ 1 KHz; -90 dBc/Hz @ 10 KHz and -100 dBc/Hz @ 100 KHz		
DC Supply Voltage		+8 V _{DC} /1.5 A	
Case Temperature	-25°C		+65°C

SPACE QUALIFIED TRANSMITTER MODULE

26.7 to 26.9 GHz

OVERVIEW

- Product family: SST
- SST-2730223027-28-S1
- **Features:**
 - 26.7 to 26.9 GHz Bandwidth
 - Linear Polarized Waveform
 - +29 dBm P-1dB
 - Phase Noise: -80 dBc/Hz @ 1 kHz Offset
 - Space Qualified



Electrical Specifications:

Parameter	Minimum	Typical	Maximum
TX Frequency Range	26.7 GHz		26.9 GHz
TX Output P _{1dB}	+27 dBm	+29 dBm	
IF Frequency Range	0.9 GHz		1.1 GHz
IF to TX Gain		23 dB	
IF P _{1n}	0 dBm	+4 dBm	+8 dBm
IF Input VSWR		1.5:1	
Harmonics		-50 dBc	
Spurious		-60 dBc	
Phase Noise	-80 dBc/Hz @ 1 KHz; -90 dBc/Hz @ 10 KHz and -100 dBc/Hz @ 100 KHz		
DC Supply Voltage		+8 V _{DC} /1.5 A	
Specification Temperature		+25 °C	
Operating Temperature	-25 °C		+65 °C

CONCLUSION

- ERAVANT has designed and fabricated total microwave and millimeterwave band COTS (Commercial of The Shelf) components and sub-assemblies to support full industrial applications. The product families are organized into 10 product families:
 - Antennas
 - Amplifiers
 - Coaxial Passive Components
 - Frequency Converters
 - Control Devices
 - Ferrite Devices
 - Oscillators
 - Subsystems
 - Test Equipment
 - Waveguide Passive Components
- While some of these products as shown in this presentation are designed for and manufactured for Thermal Vacuum and Space System applications, the rest only require small process, material, record keeping and qualification updates.

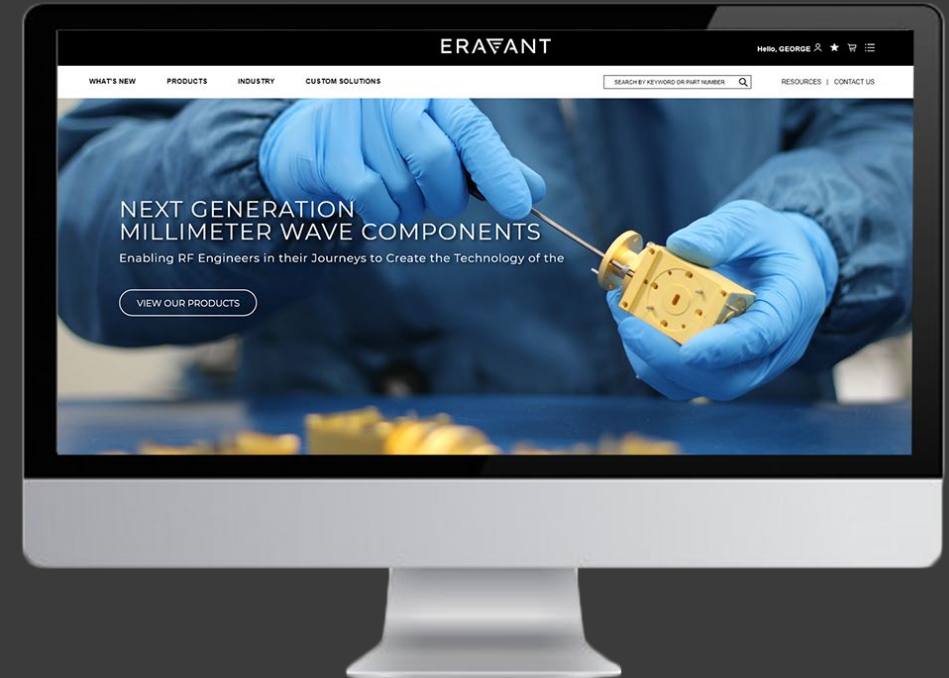
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SWM-60390320-12-SB
Full E-Band Magic Tee

Typical Isolation and Insertion Loss vs. Frequency

SAGE Millimeter, Inc.

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SWM-60390320-12-SB
Full E-Band Magic Tee

Description:

Model SWM-60390320-12-SB is an E band magic tee that covers the entire band from 60 to 90 GHz. This magic tee is a four-port hybrid coupler and/or power divider with two collinear arms, an E plane (difference) arm, and an H plane (sum) arm. The magic tee offers less than 1.0 dB insertion loss and high isolation between the two collinear arms and between the sum and difference arms. All waveguide ports have standard WR-12 waveguides with UG-387/U flanges.

Features:

- Low Insertion Loss and High Isolation
- Compact Package

Applications:

- Test Labs
- Test Instrumentation
- Sub-assemblies

Electrical Specifications:

Parameter	Minimum	Typical	Maximum
Frequency	60 GHz		90 GHz
Insertion Loss		0.35 dB	
Isolation - Sum and Difference Ports		30 dB	
Isolation - Collinear Ports		20 dB	
VSWR		1.5:1	

Mechanical Specifications:

Item	Specification
Sum and Difference Ports	WR-12 Waveguide with UG-387/U Flange
Collinear Ports	WR-12 Waveguide with UG-387/U Flange
Weight	1.2 Oz
Finishing	Gold Plated
Material	Aluminum
Outline	WDM-BE

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PASSIVE FREQUENCY MULTIPLIERS

GRID

TABLE

28 RESULTS

MODEL	MINIMUM OUTPUT FREQUENCY	MAXIMUM OUTPUT FREQUENCY	OUTPUT POWER	MINIMUM INPUT FREQUENCY	MAXIMUM INPUT FREQUENCY	INPUT POWER	OUTPUT PORT	INPUT PORT	DOWNLOADS	VIEW
SFP-06212-S2	110 GHz	170 GHz	0 dBm	55 GHz	85 GHz	+16 dBm	WR-06 Waveguide	WR-12 Waveguide	Datasheet	View
SFP-06319-U6	110 GHz	170 GHz	-3 dBm	36.67 GHz	55.67 GHz	+20 dBm	WR-06 Waveguide	WR-19 Waveguide	Datasheet	View
SFP-06210-S2	140 GHz	220 GHz	-3 dBm	70 GHz	110 GHz	+17 dBm	WR-05 Waveguide	WR-10 Waveguide	Datasheet	View
SFP-223403205-28SF-S1	22 GHz	40 GHz	+5 dBm	11 GHz	20 GHz	+18 dBm	WR-28 Waveguide	SMA (F)	Datasheet STEP File	View
SFP-243423303-28SF-S1	24 GHz	42 GHz	+3 dBm	8 GHz	14 GHz	+20 dBm	WR-28 Waveguide	SMA (F)	Datasheet STEP File	View
SFP-2835F-U9	26.5 GHz	40.0 GHz	+5 dBm	8.37 GHz	13.33 GHz	+20 dBm	WR-28 Waveguide	SMA (F)	Datasheet	View
SFP-273403305-28SF-S1	26.5 GHz	40 GHz	-5 dBm	8.37 GHz	13.33 GHz	+10 dBm	WR-28 Waveguide	SMA (F)	Datasheet STEP File	View
SFP-2235F-S1	33 GHz	50 GHz	+3 dBm	11 GHz	16.67 GHz	+20 dBm	WR-22 Waveguide	SMA (F)	Datasheet STEP File	View
SFP-222VF-S1	33 GHz	50 GHz	+7 dBm	16.5 GHz	25 GHz	+20 dBm	WR-22 Waveguide	2.92 mm (F)	Datasheet STEP File	View
SFP-363573303-19SF-N1	57 GHz	36 GHz	+3 dBm	12 GHz	19 GHz	+20 dBm	WR-19 Waveguide	SMA (F)	Datasheet STEP File	View
SFP-162VF-S1	40 GHz	60 GHz	+5 dBm	20 GHz	30 GHz	+20 dBm	WR-19 Waveguide	2.92 mm (F)	Datasheet STEP File	View